TECHNOLOGICAL EXCELLENCE

SOFIM ENGINE

S30 ENT M23

TECHNICAL AND REPAIR MANUAL

MARCH 2007 EDITION

IVECO MOTORS

FPT POWERTRAIN TECHNOLOGIES

FOREWORD

We strongly recommend that you carefully read the indications contained in this document: compliance with them protects the engine against irregular operation and assures its reliability, safeguarding sea-going and maintenance personnel against accident hazards.

The indications contained in this document pertain to the S30 ENT M23 marine engine and complement the IVECO MOTORS-FPT publication of "Marine Diesel Engines Installation Handbook" that the reader should refer to for anything that is not explained herein.

Technical engineers and fitters are required to comply with safety regulations on work. They have to implement and adopt the device required for individual personal safeguard while carrying out maintenance or checks.

Safety rules are reported in Section 9 of this publication.

Regulations on handling engine are reported at the end of Section 6 of this publication.

In order to start the engine, strictly follow the procedure stated at the end of Section 5 of this publication.

To get the best possible performance out of the engine, it is mandatory to conform with its intended mission profile. The engine must not be used for purposes other than those stated by the manufacturer.

IVECO MOTORS-FPT is available beforehand to examine requirements for special installations, if any.

In particular

- ❏ Use of unsuitable fuels and oils may compromise the engine's regular operation, reducing its performance, reliability and working life;
- ❏ Exclusive use of IVECO Original Parts is a necessary condition to maintain the engine in its original integrity;
- ❏ Any tampering, modifications, or use of non-original parts may jeopardize the safety of service personnel and boat users.

To obtain spare parts, you must indicate:

- Commercial code, serial number and indications shown on the engine tag;
- Part number of the spare as per spare part catalog.

The information provided below refer to engine characteristics that are current as of the publication date.
IVECO MOTORS-FPT reserves the right to make modifications at any time and without advance notice, to meet technical or commercial requirements or to comply with local legal and regulatory requirements.

We refuse all liability
for any errors and omissions.

The reader is reminded that the IVECO MOTORS-FPT Technical Assistance Network is always at the Customer's side with its competence and professionalism.

Publication IVECO MOTORS-FPT edited by:
IVECO PowerTrain
Advertising & Promotion
Pregnana Milanese (MI)
www.ivecomotors.com

Printed **P3D32S001 E** - March 2007 Edition

SECTION CONTENTS

Indications for consultation

Sections 1-2-3 are intended for sales personnel, to provide them with exact knowledge of the product's characteristics and enable them to meet the Customer's demands with precision.

The remaining sections are meant for personnel in charge of carrying out ordinary and extraordinary maintenance; with an attentive consultation of the chapter devoted to diagnosing, they will also be able to provide an effective technical assistance service.

PAGE LEFT INTENTIONALLY BLANK

SECTION 1

OVERVIEW

(continues on next page)

IDENTIFYING DATA

Figure 1

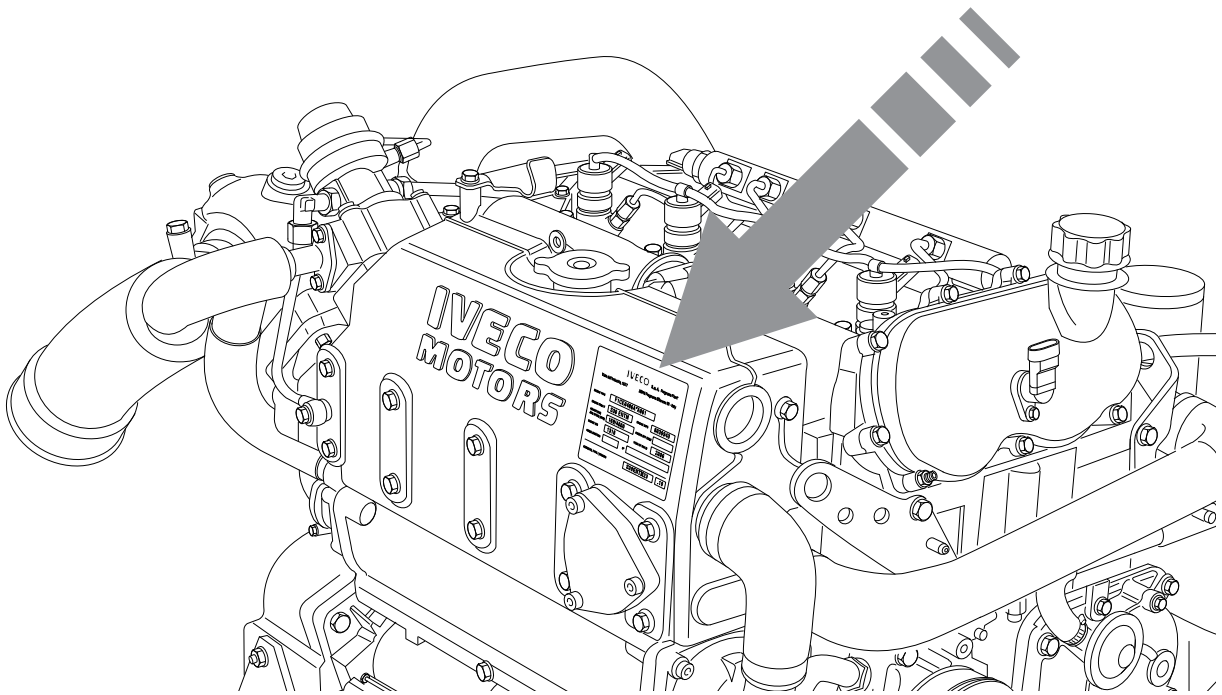
IVECO S. p. A. Pregnana Plant

Viale dell'Industria, 15/17 20010 Pregnana Milanese MI - Italy

ENGINE TYPE	F1CE0486A*A001		
ENGINE FAMILY	S30 ENTM	ENGINE DWG	8039943
POWER (KW) AND SPEED (RPM)	169/4000	POWER SET CODE	
ENGINE S/N	1318	YEAR OF BUILD	2006
HOMOLOGATION		Nº	
COMMERC. TYPE / VERSION	S30ENTM23	.10	

06_004_S

Figure 2

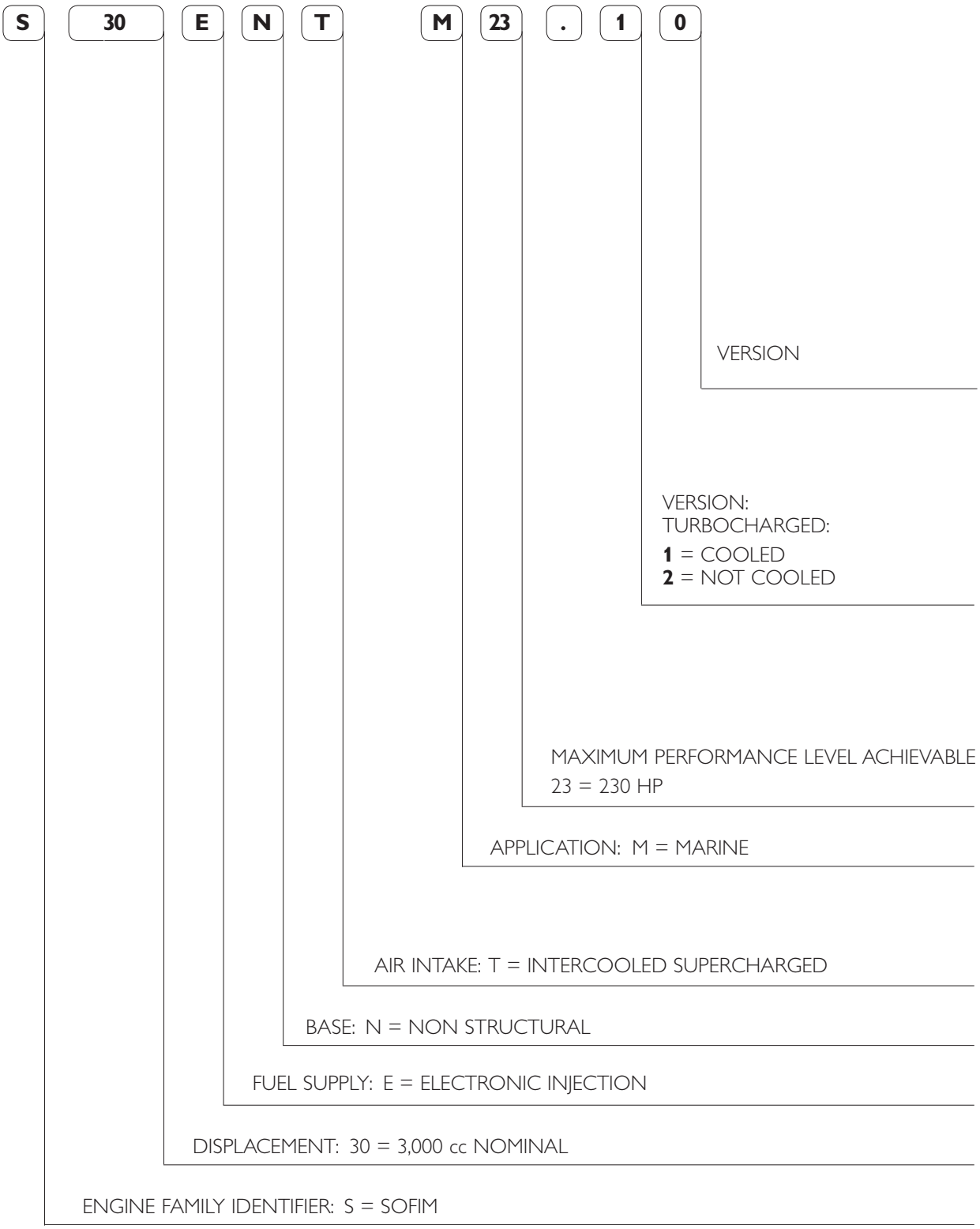


05_003_S

The engine identification data are stenciled on a tag positioned over the engine coolant tank

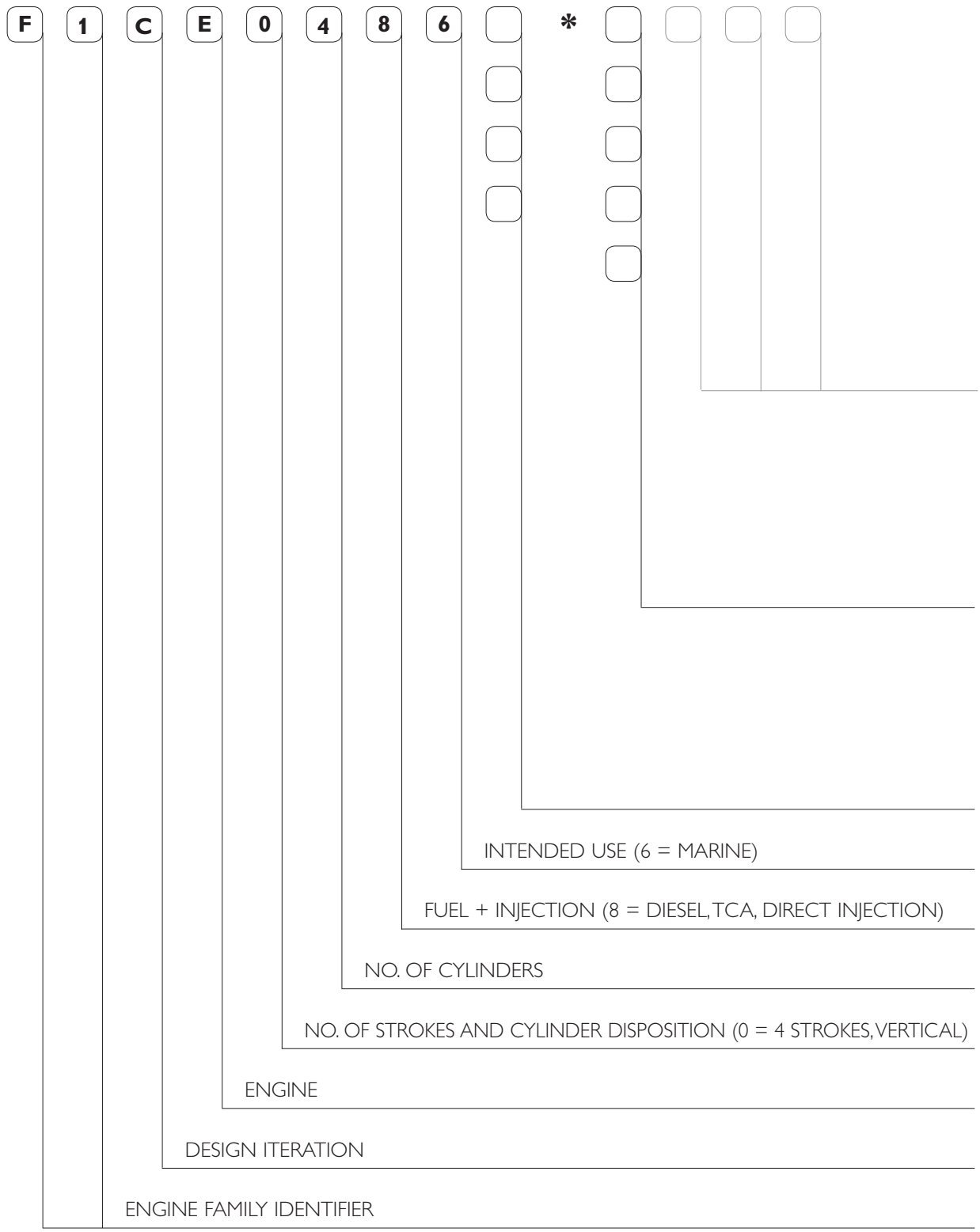
COMMERCIAL CODE

The purpose of the commercial code is to make the characteristics of the product easier to understand, categorizing the engines according to their family, origins and intended application. The commercial code, therefore, cannot be used for the technical purpose of recognizing the engine's components, which is served by the "ENGINE S/N".



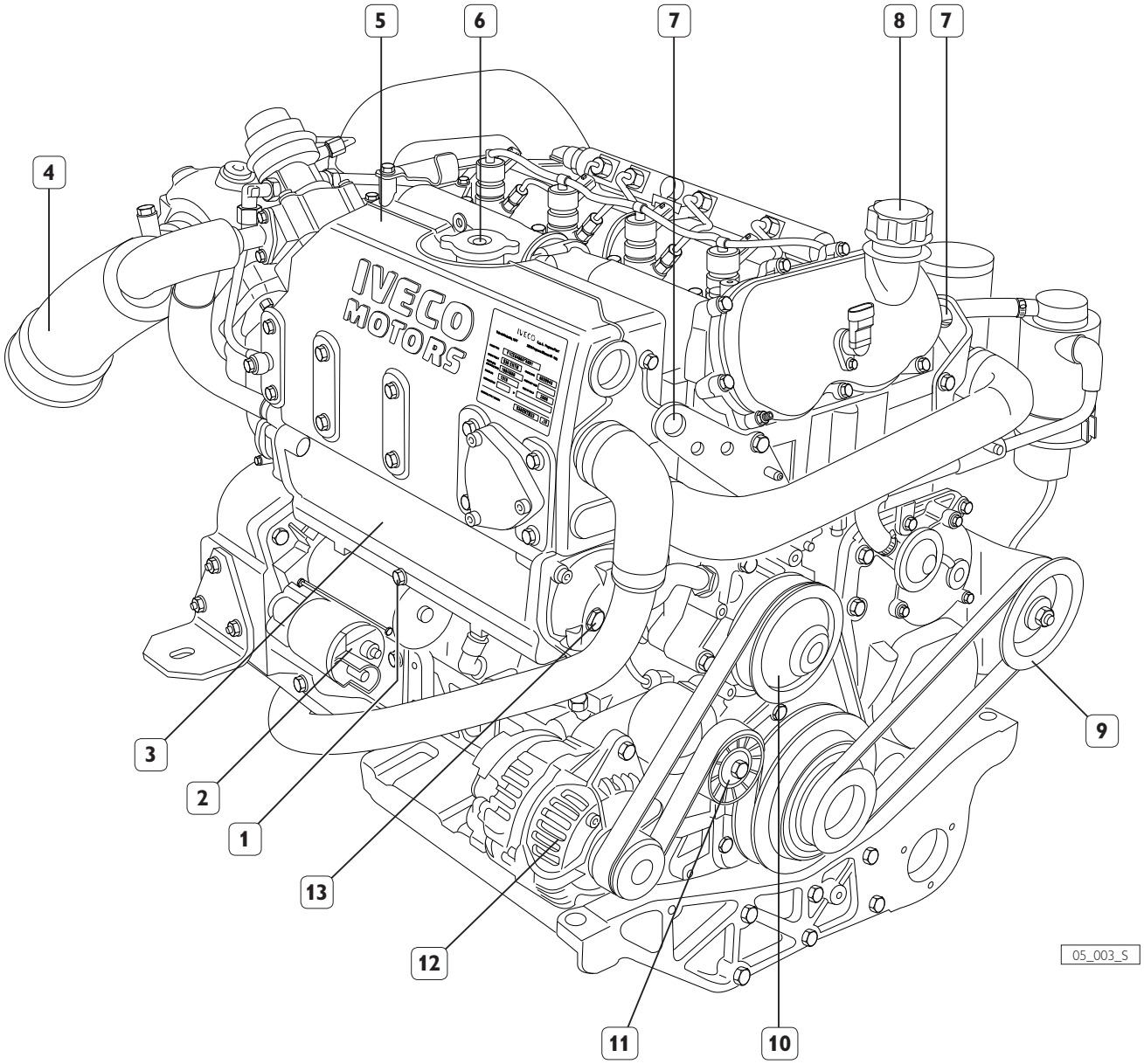
PRODUCT MODEL NUMBER

The model number is assigned by the manufacturer; it is used to identify the main characteristics of the engine, and to characterize its application and power output level. It is stamped on a side of crank-case, close to oil filter.



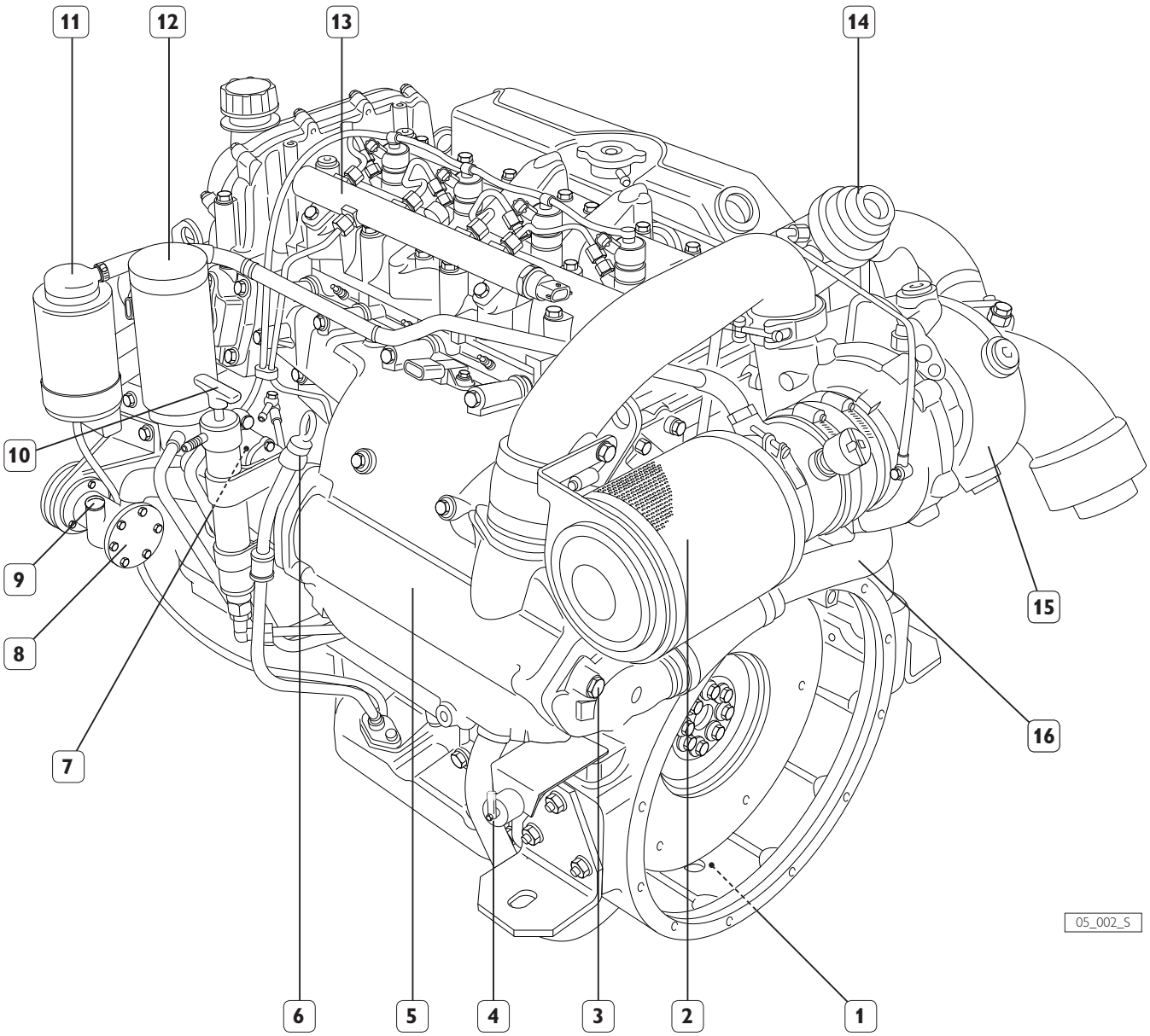
ENGINE PARTS AND COMPONENTS

Figure 3



1. Engine coolant discharge cap - 2. Electric starter motor - 3. Tube bundle engine coolant/sea water heat exchanger - 4. Exhaust gas and sea water discharge pipeline - 5. Engine coolant tank - 6. Coolant refill cap - 7. Lifting eyebolts - 8. Oil refill cap - 9. Sea water pump actuation pulley - 10. Engine coolant pump control pulley - 11. Auxiliary belt automatic tensioner - 12. Alternator - 13. Location of sacrificial anode.

Figure 4



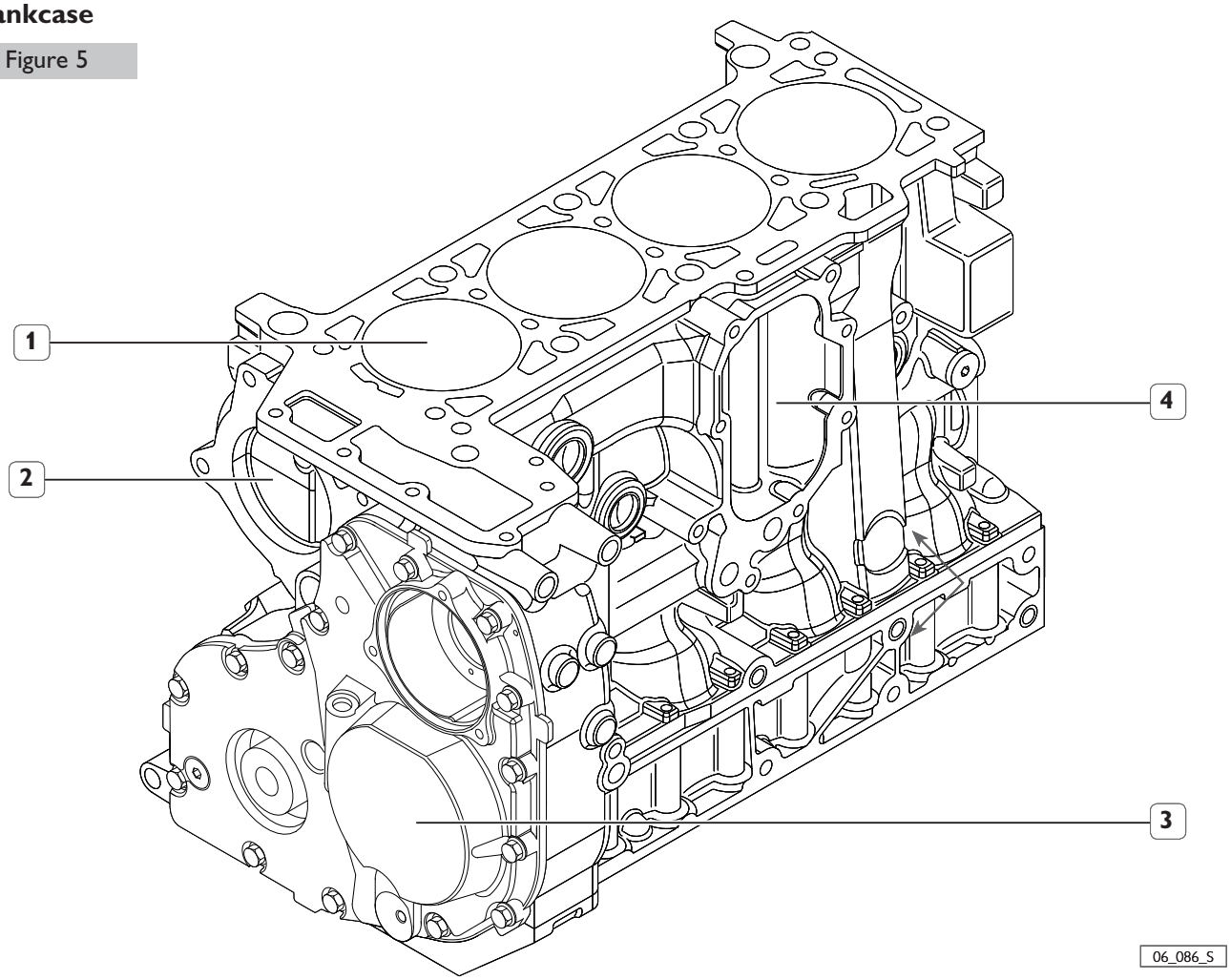
1. Engine coolant discharge cap location - 2. Combustion air filter - 3. Sacrificial anode - 4. Throttle potentiometer - 5. Combustion air-sea water heat exchanger - 6. Oil dipstick - 7. Location of common rail high pressure injection pump - 8. Sea water pump - 9. Sea water inlet - 10. Manual lubricating oil extraction pump - 11. Oil vapor separator - 12. Lubricating oil filters - 13. Common rail distributor - 14. Waste-gate actuator - 15. Cooled turbocharger - 16. Sea water junction pipe from after-cooler to engine coolant/sea water heat exchanger.

ENGINE ARCHITECTURE

The new light IVECO MOTORS-FPT diesel engines improve the excellence of the already well-known SOFIM engine and they position themselves on top of the 2.3 and 3 lt categories for performance, reliability and efficiency. Both adopt highly efficient technical solutions, which are at the origin of their excellent performances. Their high torque, available at high and slow rpms, and their considerable power are optimized for any usage profile and allow a global efficiency which is unparallel for any application. Designed to comply also with future norms on gas emission and noise containment, they represent the synthesis of the most recent technologies and they are manufactured according to ISO 9002 quality standards.
The very high injection pressure of the new "Common rail" perfectly atomizes and distributes the fuel in the considerable air mass provided by turbochargers, in order to create homogeneous mixes, whose combustion generates optimal heat release and it ensures high performances for any mission.
The double overhead camshaft and the hydraulic valve control, up until now used on engines designed for high range vehicles, ensure constant performances over time and reduce noise and maintenance requirements. Internally-refrigerated supercharging generated by turbochargers fitted with waste-gate or VGT valves, provides a timely response to acceleration. An extensive variety of options and the undisputed experience in kinematic chains, allow the IVECO MOTORS-FPT to meet any individual need of the customer.

Crankcase

Figure 5

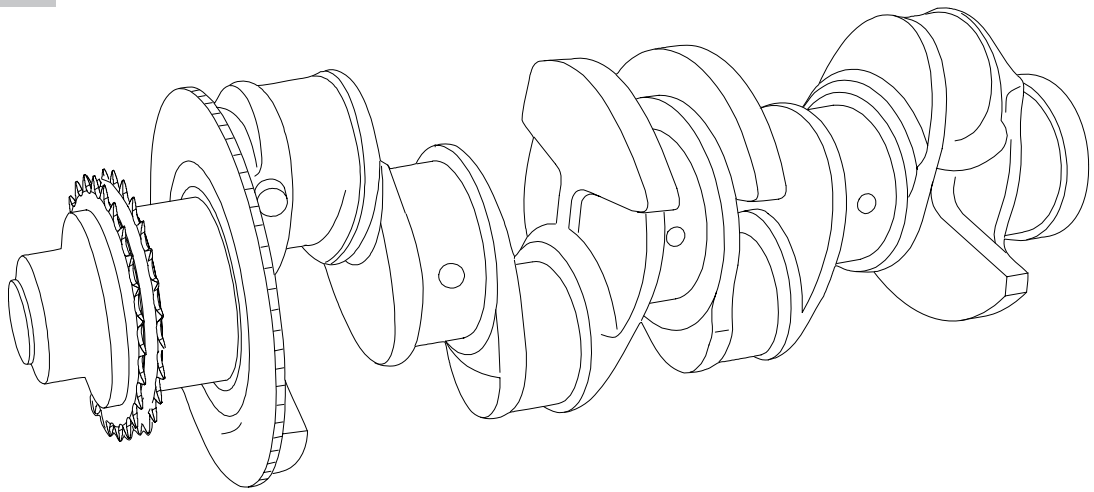


1. Reconditionable integral cylinder barrels - 2. Water pump seat - 3. Oil pump seat - 4. Oil cooler (oil/water) seat.

The engine block is a cast iron structure housing the cylinder liners (with "plateau" finishing), main bearings and the coolant pump seat. Furthermore, the engine block houses the coolant recirculation chambers and the lubrication circuit ducts of the various gears. Cylinder liners will be increased by 0.4 mm.

Crankshaft

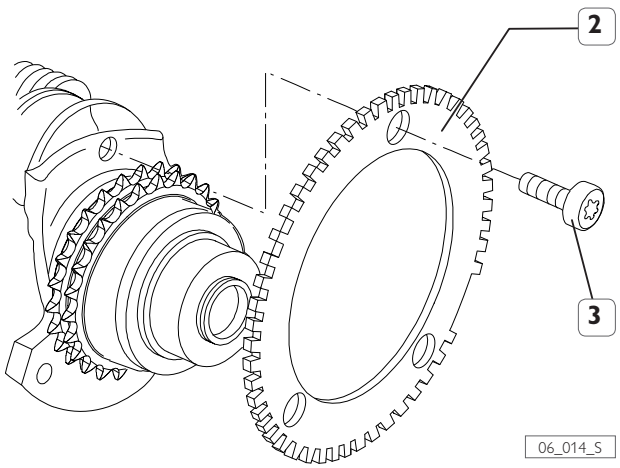
Figure 6



1. Auxiliary gears and distribution control double chain gear.

The cast iron driving shaft rests on five bearings; inside, it houses lubrication oil circulation ducts.
The shaft end is fitted with auxiliary gears and distribution chain gears such as the high pressure feeding pump and the oil pump is fitted with a depressor (G.P.O.D. group).
Main half bearings are made of steel coated with anti-friction alloy.
Front and rear sealing rings are of slide type with radial seal and special tools are required for their assembly and disassembly.

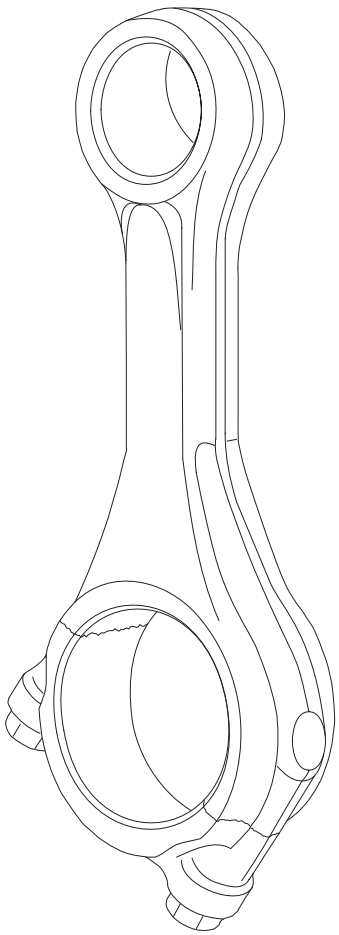
Figure 7



The shaft end is also fitted with a phonic wheel (2) fastened by screws (3) and Loctite 218 which need replacement after every disassembly procedure.

Connecting rods

Figure 8

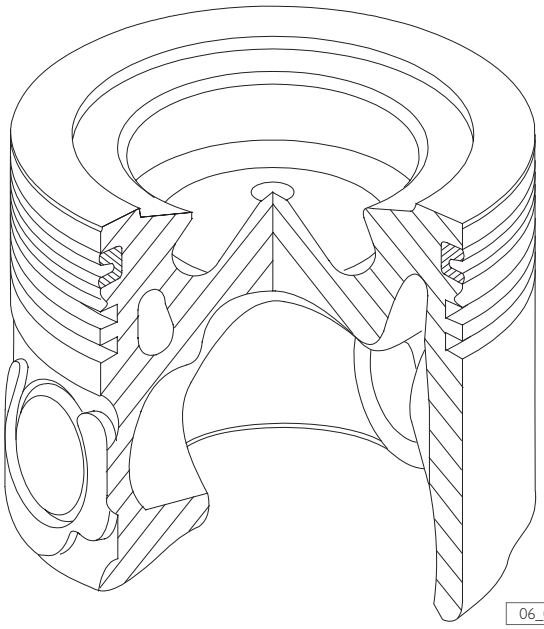


06_088_S

Made out of steel, they are stamped with a skew cut small end and separation of the cap obtained through a fracture technique.
Connecting rod half bearings are made of steel and coated with anti-friction alloy.
Each connecting rod is stamped on the casing and on the cap with a number which identifies their coupling and the cylinder in which it is assembled; furthermore, its weight class specified by a letter is also stamped on the casing.
If its replacement is required, and only one connecting rod type as spare part is available, having an intermediate weight class, it can be used to replace any other connecting rod; if connecting rods are still efficient they should not be replaced even if of different class.

Pistons

Figure 9



06_089_S

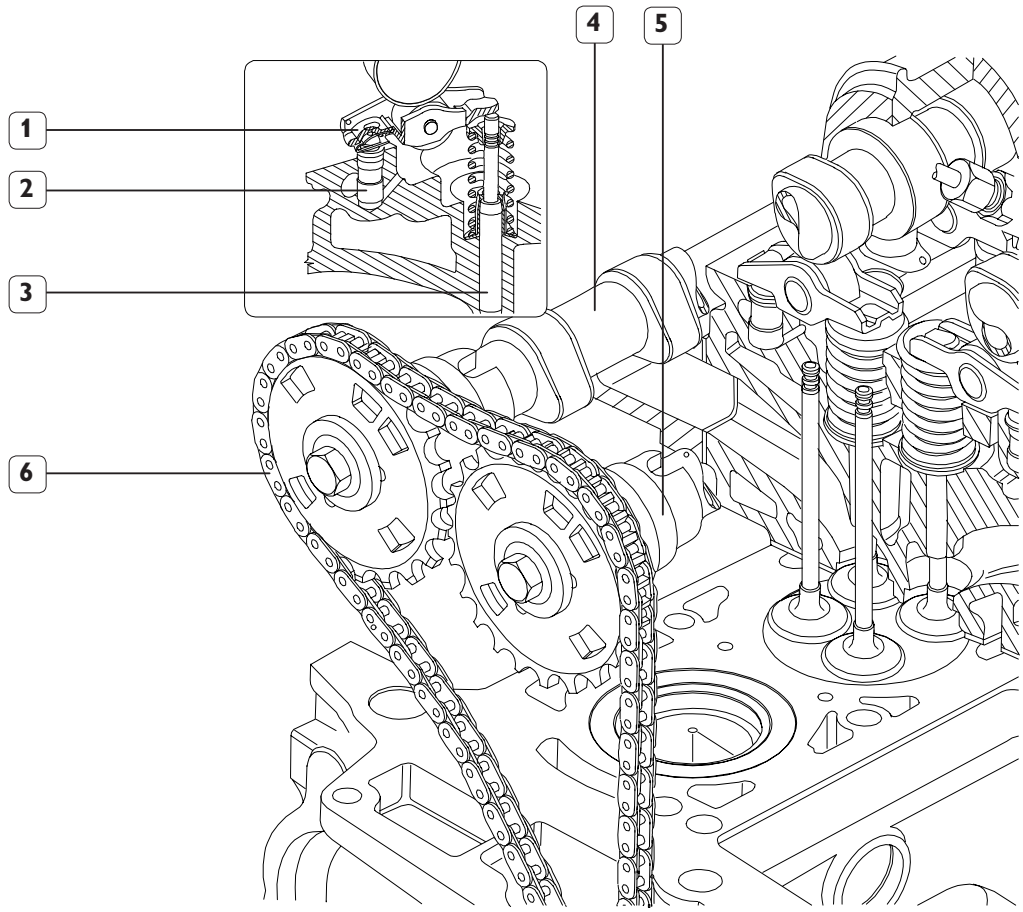
They are part of the high turbulence combustion chamber; annular chambers inside the rim allow the efficient disposal of heat by recirculating the lubrication oil delivered by the nozzles fitted in the engine block.
On the skirt there are three seats for split rings; the 1st one is obtained in a cast iron trapezoidal insert.
Split rings have different functions and different shapes:

- the first seal split ring has trapezoidal shape with ceramic-chrome coating;
- the second seal split ring has rectangular shape and it is of "tapered torsional" type;
- the third ring is fitted with a double oil-scaper pad with inner spring.

The piston crown is engraved with engine type, class and supplier selection, the flywheel symbol showing the assembly direction inside the cylinder liner and the sticker witnessing that the insert adhesion test 1st slot was carried out.

Timing control

Figure 10



1. Rocker arm - 2. Hydraulic tappet - 3. Valve stem - 4. Exhaust side timing shaft - 5. Intake side timing shaft - 6. Control chain.

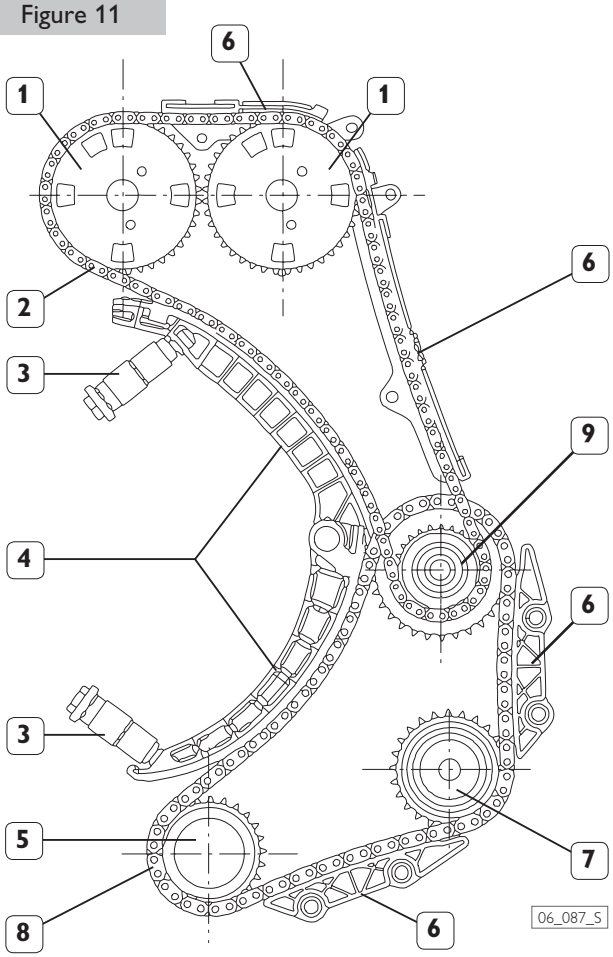
Timing is ensured by a double overheard camshaft and four valves per cylinder with hydraulic tappets.

Control is provided by two chains:

- A double 3/8" chain receiving motion from the driving shaft and transmitting motion to the oil pump and the high pressure pump control shafts;
- A single chain receiving motion from the high pressure pump control shaft gear and transmitting it to camshafts;

Camshafts control gears are interchangeable; slots are provided to measure phase by the relevant sensor.
Rocker arms, one at a time, are kept in contact with the corresponding cam by an hydraulic tappet; this allows the elimination of periodical adjustments.

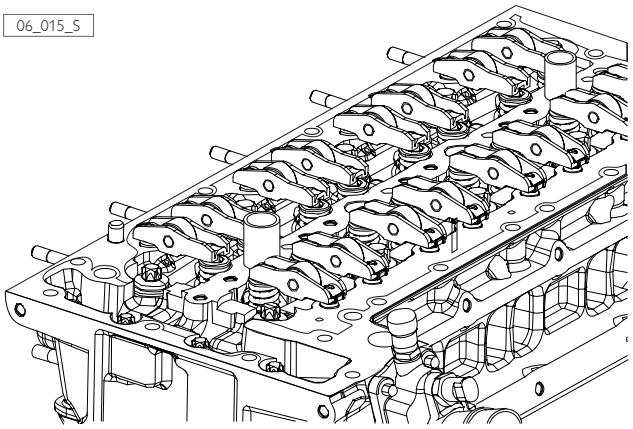
Figure 11



1. Camshafts control gears - 2. Single chain - 3. Hydraulic chain tensioner - 4. Chain tensioner mobile pads - 5. Pilot gear on the driving shaft - 6. Fixed pad - 7. Oil pump control shaft gear - 8. Double chain - 9. High pressure pump control shaft gear.

Cylinder head

Figure 12

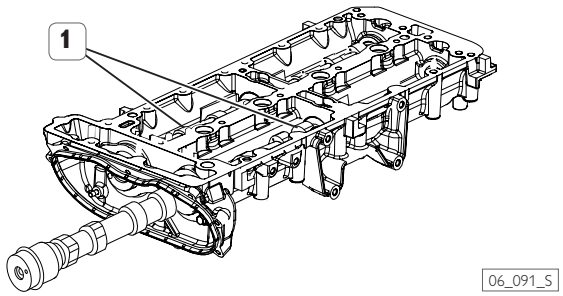


The cylinder head is monolithic and made of cast iron; it is featured by the presence of housings for the following parts:

- ❏ Valves with seats featuring inserted elements;
- ❏ Electronic injectors;
- ❏ Fuel delivery couplings to electronic injectors;
- ❏ Intake manifold;
- ❏ Exhaust manifold;
- ❏ Rocker arms.

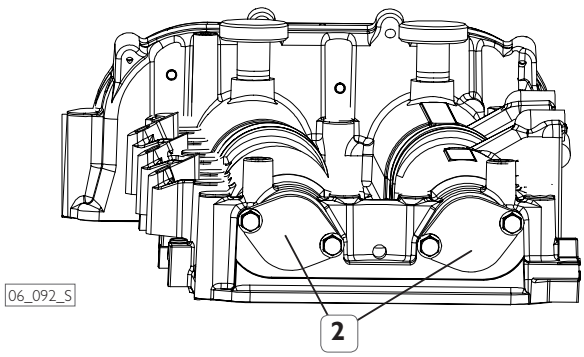
Overhead

Figure 13



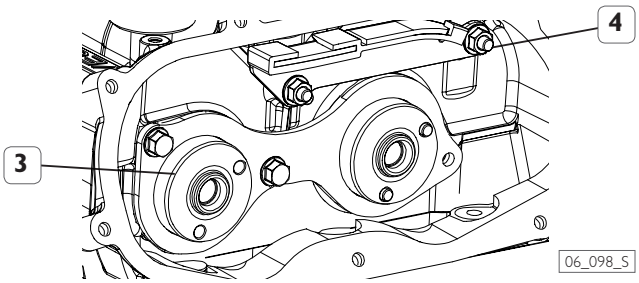
The overhead is fastened to the upper part of the cylinder head, it is made out of aluminium, and it houses (1) the two camshafts for intake and exhaust.

Figure 14



Sealing of the two shafts housed in the overhead is ensured by plates (2).

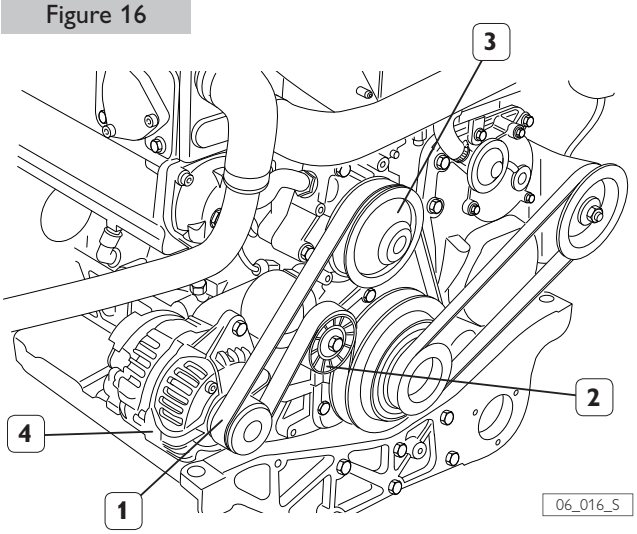
Figure 15



On the opposite side, the shouldering plate (3) and the upper pad (4) complete the positioning of the two camshafts.

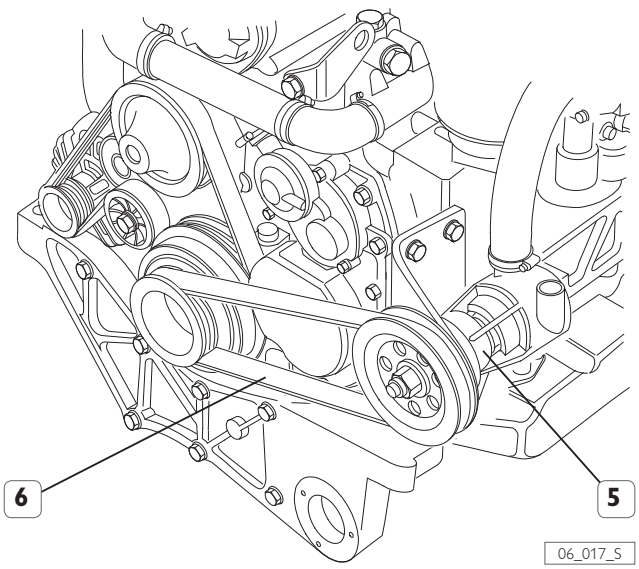
Auxiliary gears control

Figure 16



Motion to auxiliary gears is transmitted by a poly-V belt (1) tensioned by an automatic tensioner (2) which actuates the engine coolant pump (3) and the alternator (4).

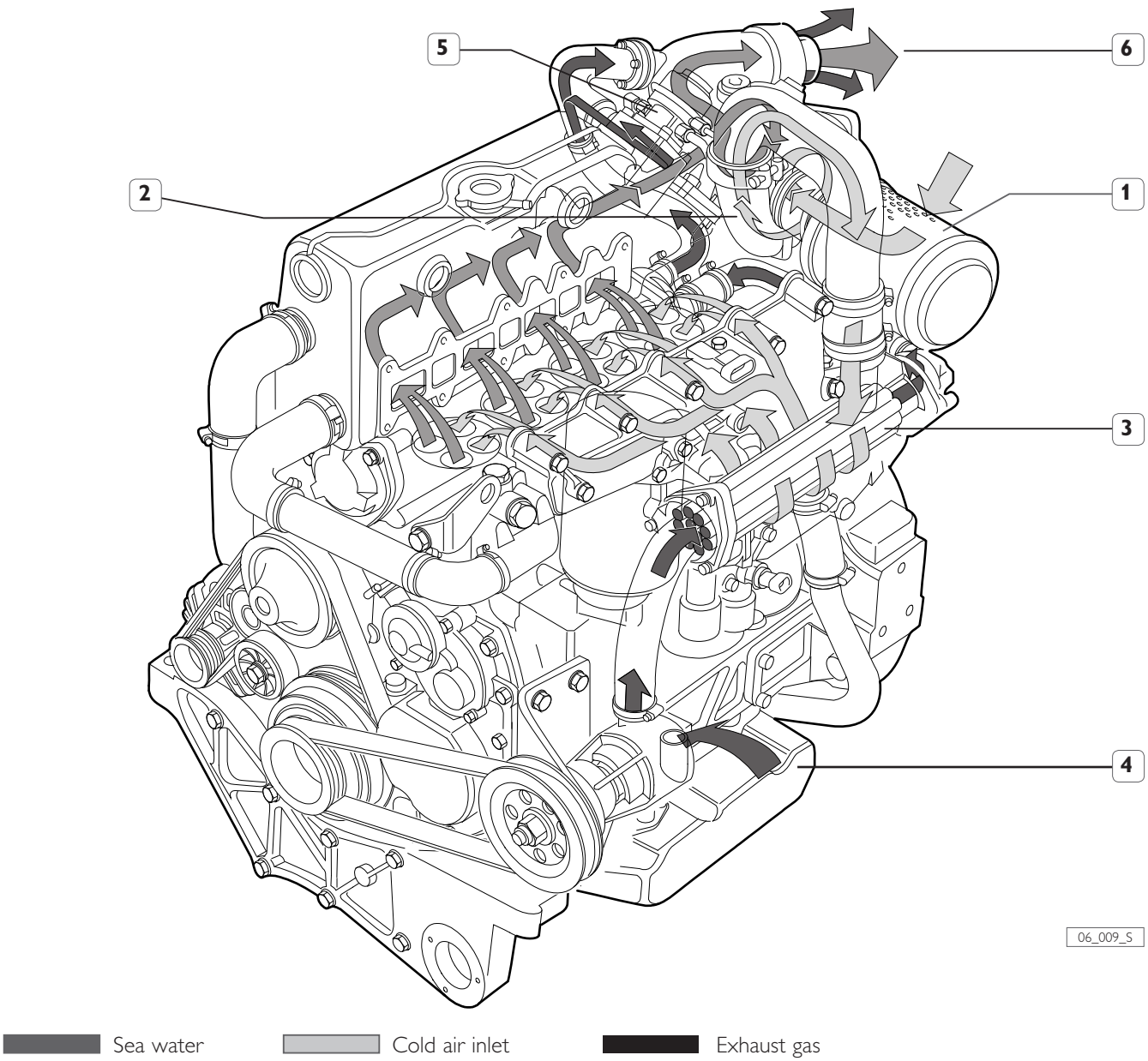
Figure 17



The sea water pump (5) is actuated by the poly-V belt (6) whose replacement must take place every time the component is disassembled.

COMBUSTION AIR INTAKE AND EXHAUST SYSTEM

Figure 18

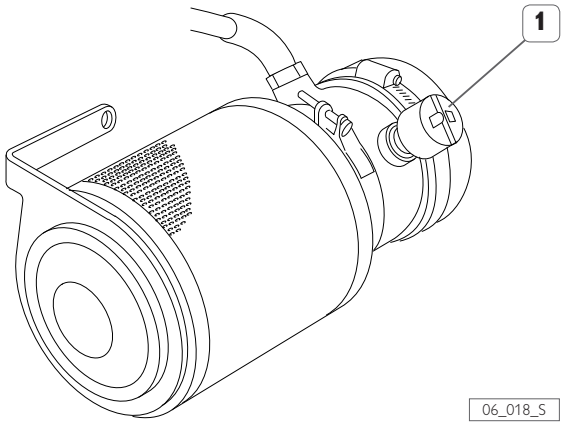


1. Air filter - 2. Turbocompressor - 3. Heat exchanger air/sea-water - 4. Sea water intake - 5. Waste gate valve - 6. Exhaust terminal (riser).

Before reaching the cylinders, supercharging feeding air, intaken through the filter, runs through the heat/sea-water exchanger, thus reducing its temperature, in order to favour a higher engine volumetric efficiency.
The pressure and air temperature sensor located on the induction manifold, provides the ECU of the EDC system with the information enabling a fuel metering adequate to the density of the intaken comburent air and an optimum treatment of the injection advance.
The overboost pressure is controlled by the waste gate valve. According to the air pressure present in the intake manifold, the opening of the by-pass is operated, conveying exhaust gasses directly to the exhaust system, limiting the turbine-compressor shaft rpms and the consequent overboost degree. The turbocharger rotor and the exhaust manifold are cooled off by the circulation of the engine coolant.
The exhaust gas flows into the exhaust terminal and, where applicable (riser), mixed with sea-water to be expelled.

Comburent air filter

Figure 19

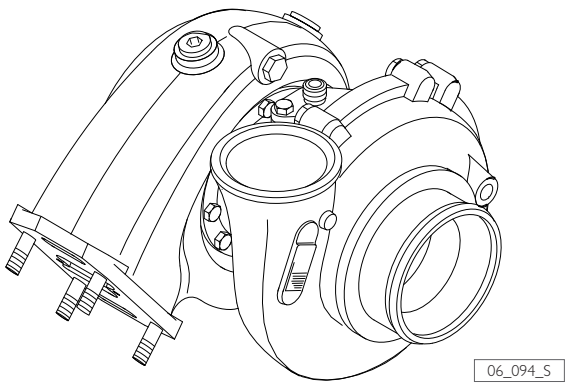


1. Filter clogging sensor.

The combustion air filter is of dry-type, consisting of a filtering cartridge to be replaced on a regular basis. It is provided with a clogging filter as indicating tool.

Turbocompressor

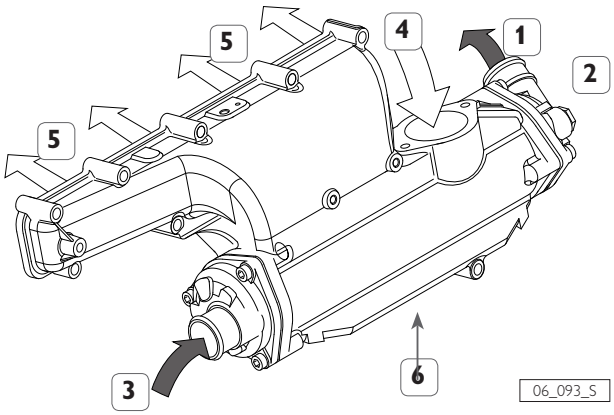
Figure 20



The engine is overboosted by a turbocharger with fixed-geometry turbine whose overboost pressure is controlled by a waste gate valve. The turbocharger group is lubricated by the circulation of the pressurized lubricating oil coming from the overhead, while it is cooled off by the coolant coming from the engine block.

Air/sea-water heat exchanger

Figure 21

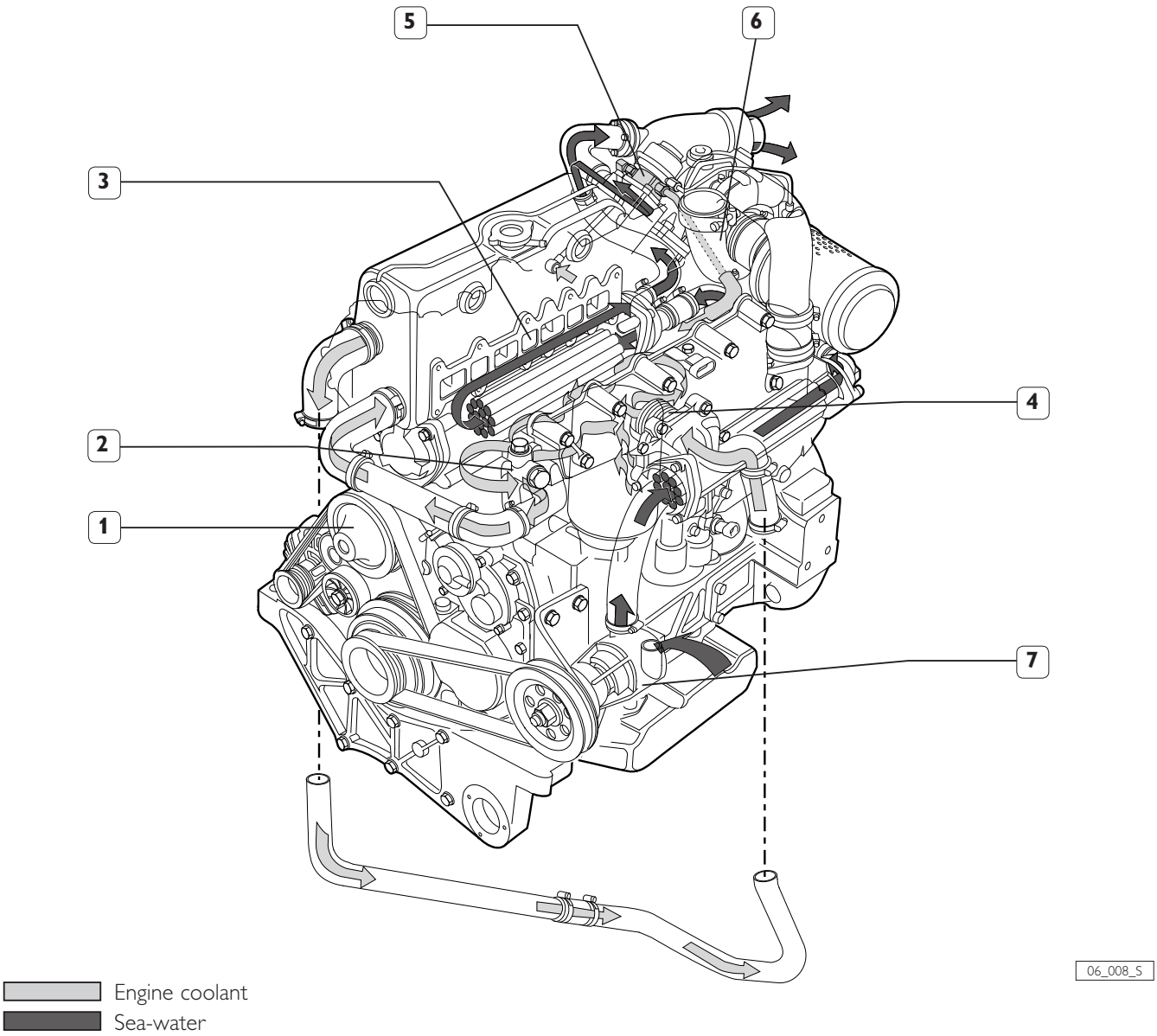


1. Sea-water outlet - 2. Sacrificial anode (Zinc) - 3. Sea-water inlet - 4. Comburent air inlet - 5. Comburent air outlet - 6. Condensate drainage hole.

The flow of water coming from the sea-water pump goes through the tube bundle (3) and, by going through it, absorbs some of the heat of the overheated air of the turbosupercharge, passing through the exchanger coming from the turbocompressor (4).
The outlet water (1) is conveyed towards the fresh water/sea-water heat exchanger, while the turbosupercharged air, cooled down, reaches the induction manifold (5) and from there reaches the cylinders.
Through hole (6) air humidity condensated in water is expelled.
A zinc sacrifical anode is located on the sea water output connection.

COOLING FRESH WATER CLOSED-LOOP

Figure 22

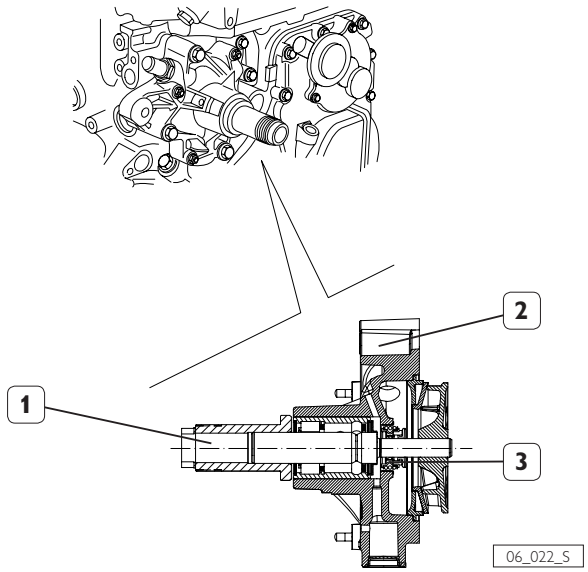


1. Engine coolant pump - 2. Thermostatic valve - 3. Coolant/sea water heat exchanger - 4. Coolant /oil heat exchanger - 5. Waste gate valve - 6. Turbocharger - 7. Sea water pump.

The centrifugal pump (1), actuated by the driving shaft through a poly-V belt, draws the coolant coming from the primary cooling circuit and delivers it to the lubricating oil heat exchanger (4). After the exchanger, the liquid reaches the inside of the engine block in the areas concerned by cylinders' heat exchange. Later on it passes through the thermostatic valve (2) and it is returned to the pump, when the liquid reaches the valve calibrated temperature; if the temperature is exceeded, the coolant is rerouted, proportionally to the achieved temperature, towards the integrated group cooled exhaust manifold- coolant/sea water heat exchanger (3). From here, a portion of the coolant reaches the turbocharger unit for the waste gate valve cooling (5) and the turbine rotor (6), thus it returns towards the exchanger for cooling off its temperature and then it flows back towards the pump (1).

Coolant pump

Figure 23

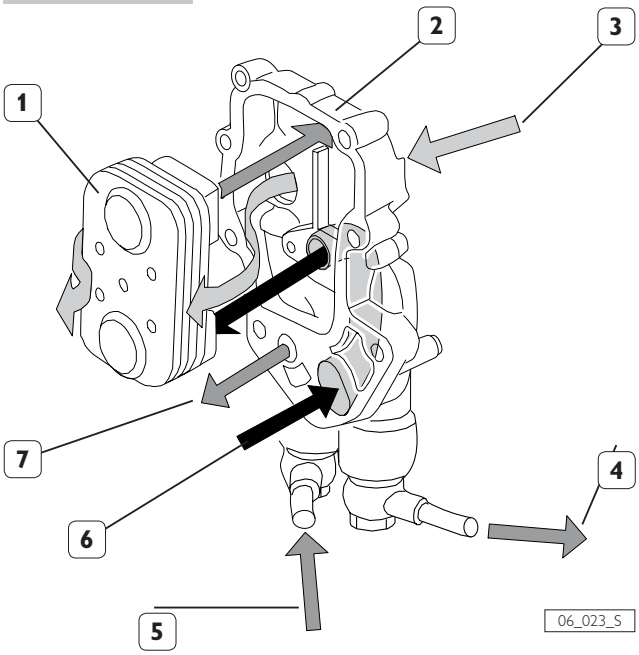


1. Pump shaft - 2. Rotor - 3. Sealing gasket.

The coolant pump is attached to the engine block and it is actuated by a poly-V belt operated by a driving shaft.
The coolant is sucked by the pump and conveyed through the heat exchanger of the lubricating oil and thus through the cooling circuit.
The return of the liquid is regulated by a thermostatic valve which deviates the flow directly into the pump or towards the coolant/sea water heat exchanger.

Lubricating oil/engine coolant heat exchanger

Figure 24

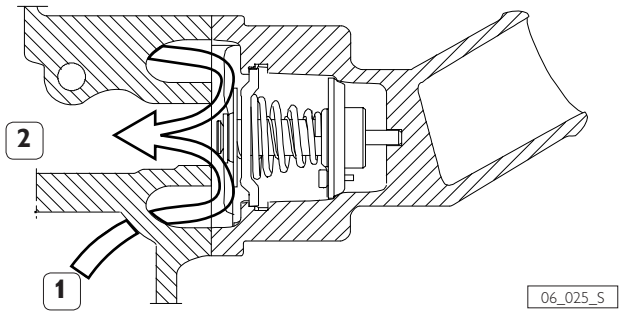


1. Thermal exchange elements - 2. Heat exchanger case - 3. Coolant input - 4. Oil output towards filter - 5. Oil return from the filter - 6. Oil input from the pump - 7. Oil output towards the lubrication circuit.

The lubricating oil heat exchanger is positioned on the LH side, below the air/sea water heat exchanger. It is located between the pump and the oil filter and it consists of five heat exchange elements fitted in a suitable casing which also performs the function of oil flow manifold towards the pump towards the lubrication circuit.

Thermostatic valve

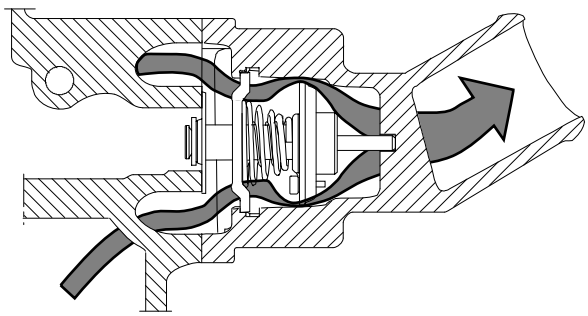
Figure 25



Low temperature operation

When the temperature of the coolant is lower than the set values, the coolant coming from inside the engine (1) recirculate directly towards the centrifugal pump (2).

Figure 26



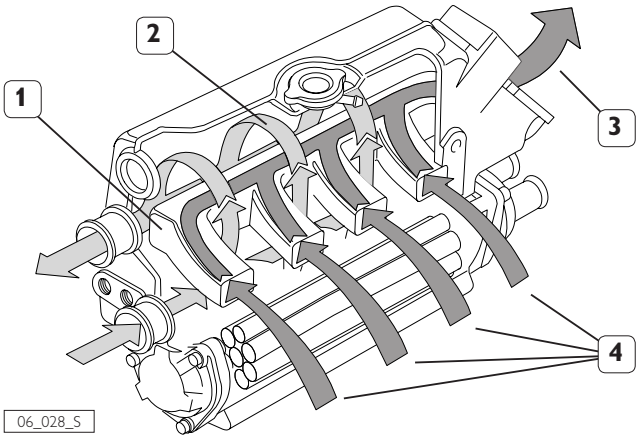
High temperature operation

When the temperature of the coolant is above the set values, the thermostatic valve partially or totally shuts in the recirculation towards the pump and opens the path towards the coolant/sea-water heat exchange (3).

Start of the thermostatic valve opening:	85°C
Start of the power/torque reduction by the ECU EDC:	111 °C
High temperature warning light lights up on the control panel:	113 °C

Exhaust manifold cooling

Figure 27

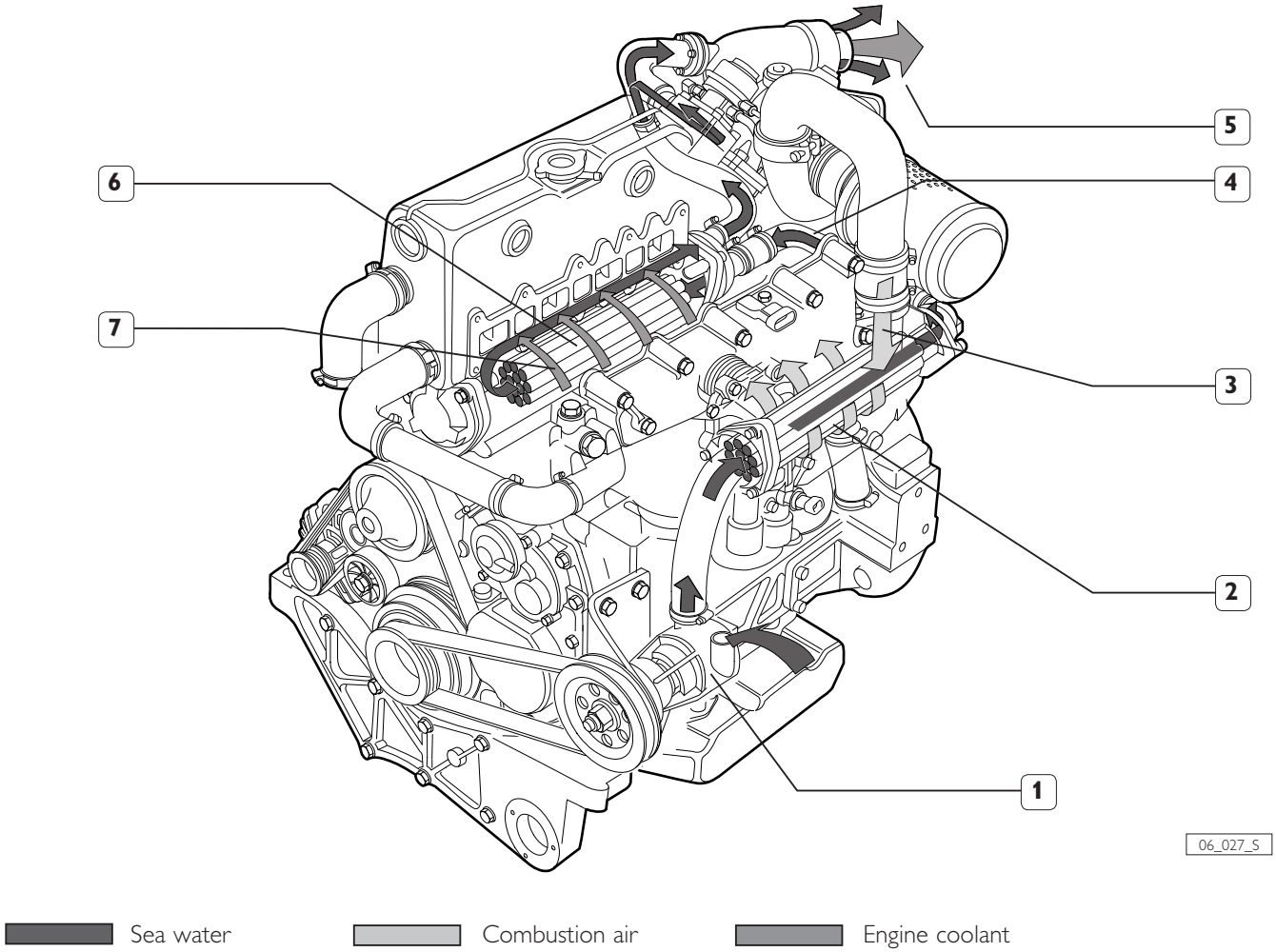


1. Exhaust manifold - 2. Coolant flows - 3. Exhaust gas outlet - 4. Exhaust gas inlet from cylinder head.

The exhaust manifold conveys exhausted gasses from the cylinder head towards the turbocharger rotor and it is integrated with the coolant/sea water heat exchanger.
The coolant reaches the exhaust manifold and continues towards the coolant circuit pump.

SEA-WATER OPEN COOLING LOOP

Figure 28



1. Sea water pump - 2. Overboost air/sea water exchanger (aftercooler) - 3. Combustion air flow flowing into the exchanger - 4. Exchanger connecting pipes - 5.Cooled exhaust terminal (riser) - 6. Engine coolant/sea water exchanger - 7. Engine coolant into the exchanger.

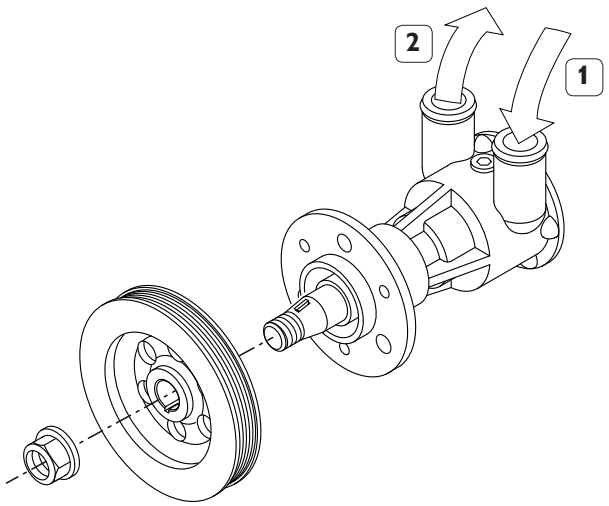
The sea water drawn from underneath the hull is the mean through which engine heat is dissolved and not transformed into mechanical work.

Sucked in by the pump (1), rotated by the poly-V belt actuated by the pulley fitted on the driving shaft, water is directly sent to the aftercooler (2), which reduces its temperature in order to improve the engine volumetric yield and its performances; it then reaches the coolant/sea water heat exchanger (6) and it dissolves the heat given out by the engine and carried by the coolant; temperature control is ensured by the thermostatic valve.

Before being returned into the exhaust manifold and drained to the sea, the water is used to cool off the "riser" (5), the exhaust gasses terminal in which they are conveyed outside the vessel.

Sea-water pump

Figure 29

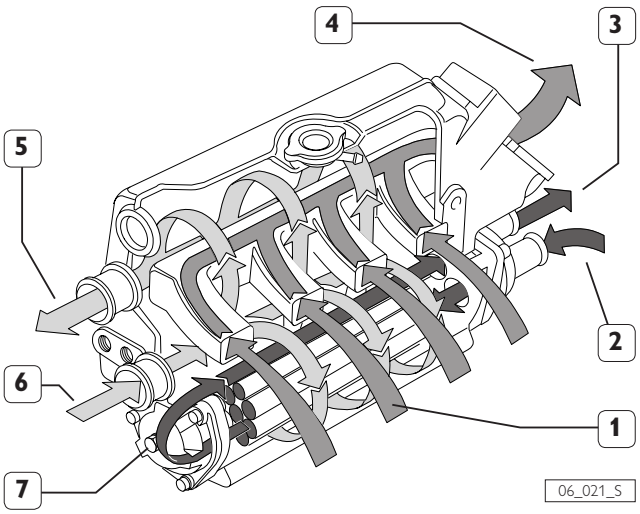


1. Inlet - 2. Outlet.

The sea water pump is actuated by the driving engine by means of the poly-V pump and it delivers the sea water to the overboost air/sea water heat exchanger.

Coolant/sea-water heat exchanger

Figure 30

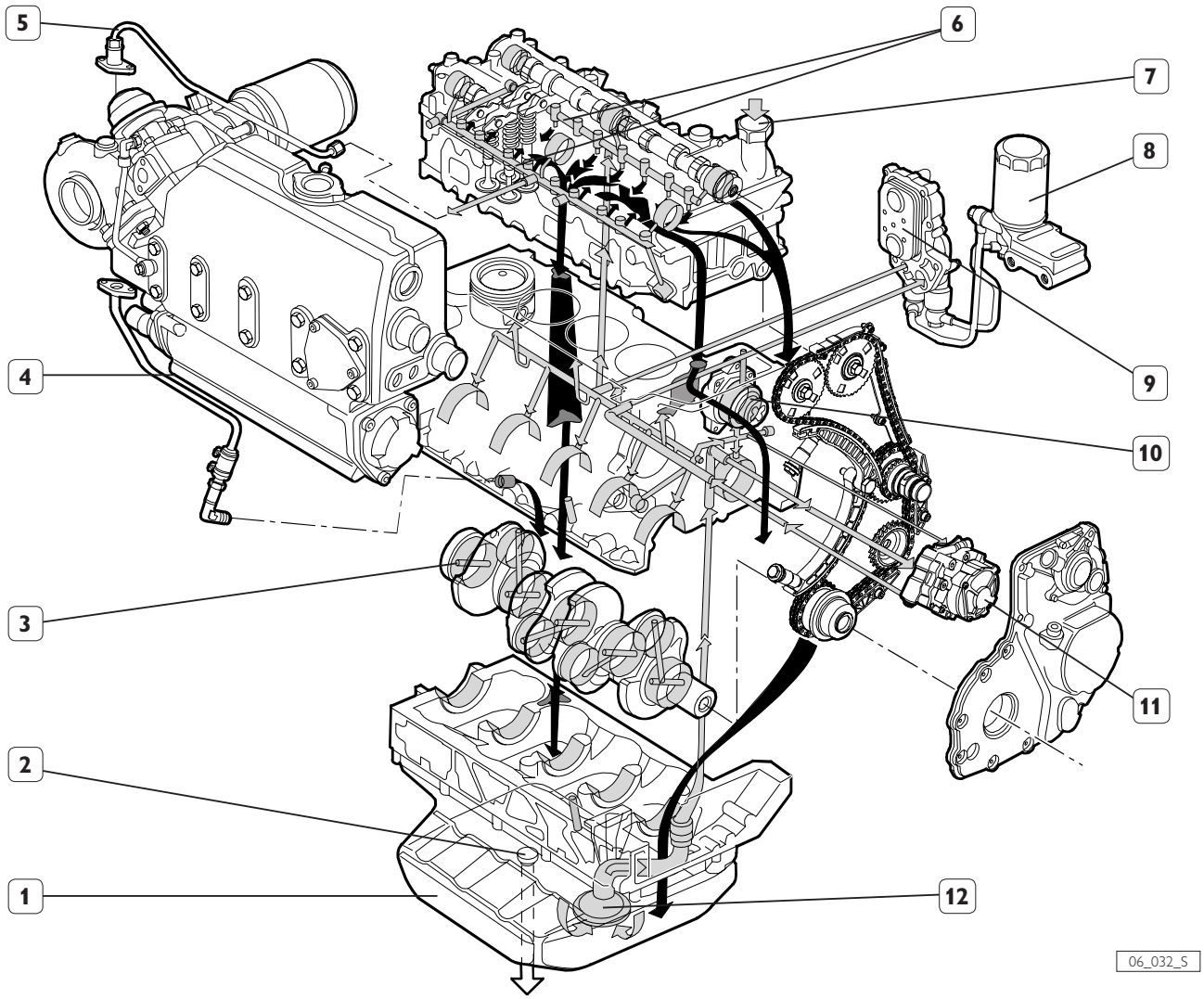


1. Exhaust gasses flow towards the cooled off manifold - 2. Sea water inlet - 3. Seat water outlet towards the exhaust terminal - 4. Exhaust gas oulet - 5. Coolant outlet towards the coolant circuit pump - 6. Coolant inlet from the thermostatic valve - 7. Zinc sacrifical anode.

The engine coolant (6), coming from the thermostatic valve, flows into the exchanger and along the tube bundle in which the sea water coming from the sea water flows, coming from the overboost air heat exchanger (2); once its heat has been given out, the engine coolant cools the exhausted gasses manifold off and exits the heads (1), then it returns to the closed-loop cooling circuit (5).
Sea water coming from the exchanger (3) is delivered to the exhaust manifold of mixed gasses.
A zinc sacrifical anode is located on the inlet/outlet engine coolant side.

ENGINE OIL LUBRICATION LOOP

Figure 31

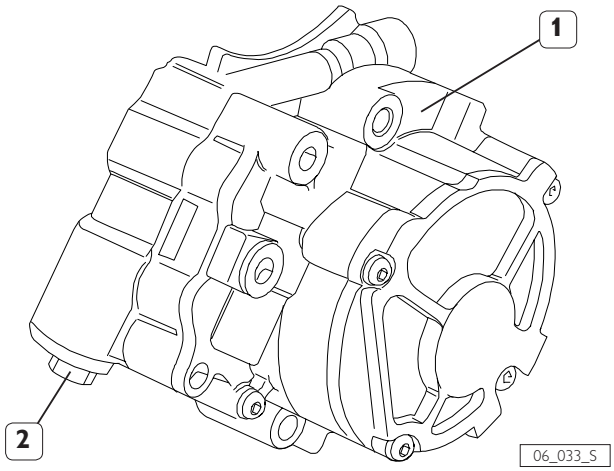


1. Oil sump - 2. Sump oil drain plug - 3. Driving shaft lubricating pipes - 4. Oil drainage pipe into the sump from the turbocharger - 5. Turbocharger lubrication pipe - 6. Camshaft lubrication pipes - 7. Oil filling plug - 8. Oil filter - 9. Lubricating oil/coolant exchanger - 10. Oil vapor filter - 11. Oil pump - 12. Suction rose.

Lubrication of engine gears is by forced oil through a gear pump (11) with has a built-in depressor (GPOD) into the engine block. The pump is actuated by the rotation of the driving shaft by means of toothed wheels kinematic motion, actuated by a double chain.
The pressurized oil is delivered to the heat exchanger (9) located on the engine block coupling flange and sided by the engine coolant, then it reaches the filter (8). From here, the oil moves on towards the engine pipes where it is partly sent to feed the nozzles delivering cooling oil to the pistons, and partly is delivered to internal gears lubrication: main bearings, connecting rod bearings and timing bearings, rocker arms and tappets; shafts and toothed wheels lubrication by motion of auxiliary gears is obtained through suitable pipings.
Camshaft lubricating oil of the turbocharger rotors is picked up from the camshaft lubricating pipes and it gets there after flowing through a pipe external to the engine block (5) connected to the support by means of a dedicated device. Later on flows will converge by gravity into the oil sump.

Lubricating oil pump

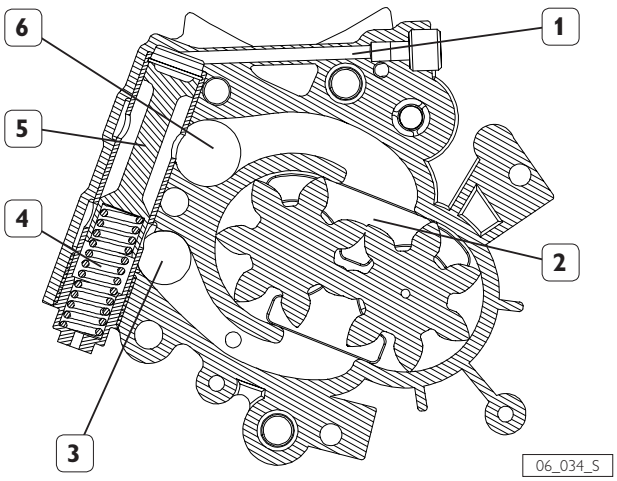
Figure 32



1. Pump casing - 2. Oil pressure adjusting valve.

The lubricating oil pump is controlled by a gear actuated through an auxiliary gear double chain which transfers motion to the two rotor fitted inside the pump casing (1). The pump is provided with an oil pressure adjusting valve (2) which stabilizes the calibration value of the pressure inside the circuit at 4.4 bar.

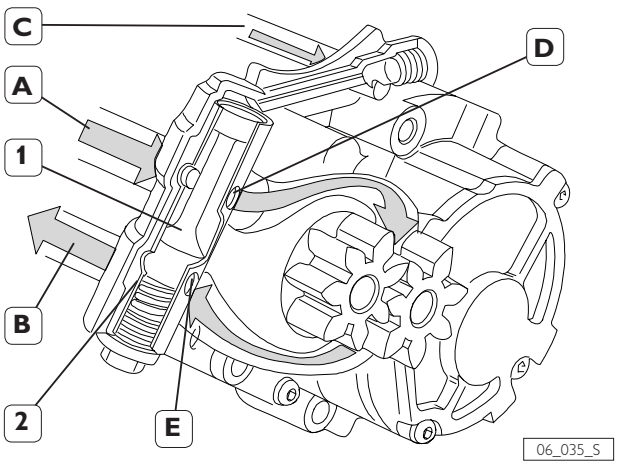
Figure 33



1. Oil inlet pipe to the engine block - 2. Rotor housing - 3. Oil delivery pipe - 4. Pressure adjusting valve counteracting spring - 5. Pressure adjusting valve piston - 6. Sump oil intake pipe.

Operational principle

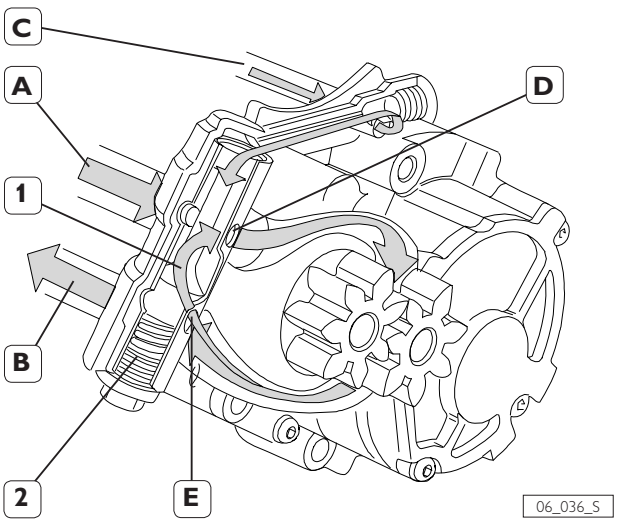
Figure 34



OPERATION WITH THE OIL PRESSURE ADJUSTING VALVE CLOSED

If, in the C pipe delivering the oil from the engine block, pressure is below 4.4 bar, the valve (1) stays closed and prevents the outflow through D and E holes.

Figure 35

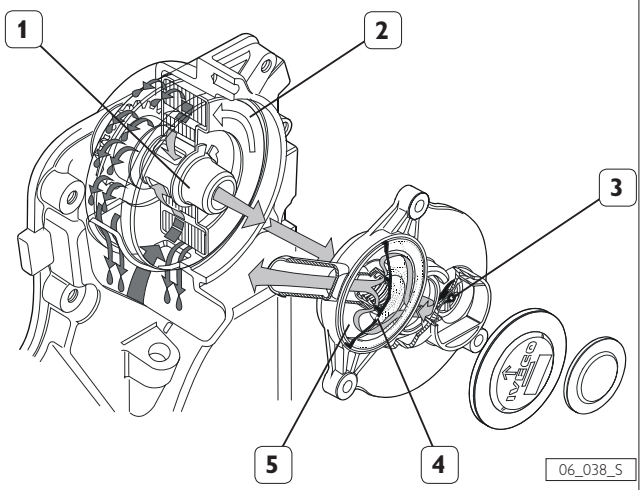


OPERATION WITH THE OIL PRESSURE ADJUSTING VALVE OPEN

If, in the C pipe, oil pressure is equal or higher than the calibration value of 4.4 bar, the valve (1) under the effect of the pressure itself, overcomes the spring resistance (2) and by lowering it establishes the communication with the delivery duct A and the intake duct B, through the holes D and E, with consequent pressure drop. When the pressure returns again to 4.4 bar, the spring (1) takes the piston back (1) to its initial position of closed valve.

Oil vapour recirculation (Blow-by)

Figure 36

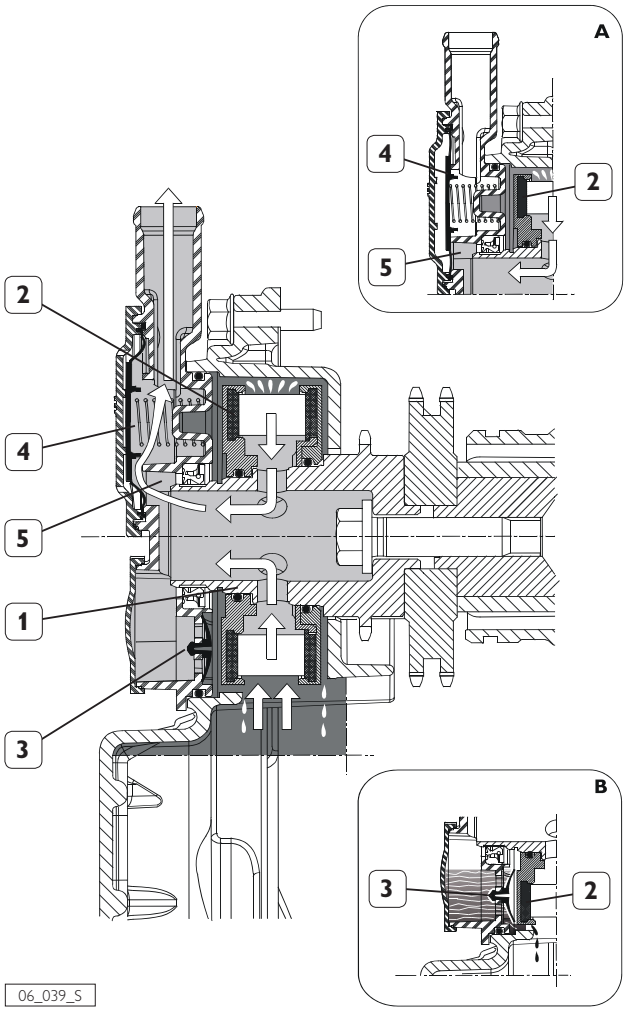


1. High pressure pump control stem - 2. Rotating filter - 3. Umbrella valve - 4. Diaphragm valve - 5. Oil vapors condensation chamber.

Part of the gas produced by the combustion during the engine operation blows by the piston snap ring ports, in the oil sump, and mixes with the oil vapours present in the oil sump. This mixture, conveyed fromthe chain compartment to the top, is partially separated from the oil by means of a device situated on the top side of the distribution cover and is introduced in the air suction system.
This device consists mainly of a rotating filter (2), fit flush on the stem (1), a high pressure/shaft control and a cover where the valves (3 and 4), usually closed, are fitted. The diaphragm valve (4) regulates the partially purified mixture and keeps the pressure inside the chain compartment around a value of ~ 10 to 15 mbar.
The umbrella valve (3) discharges some of the oil still present in the mixture coming from the filter (2) in the chain compartment and the oil condenses in the chamber (5).

Operational principle

Figure 37

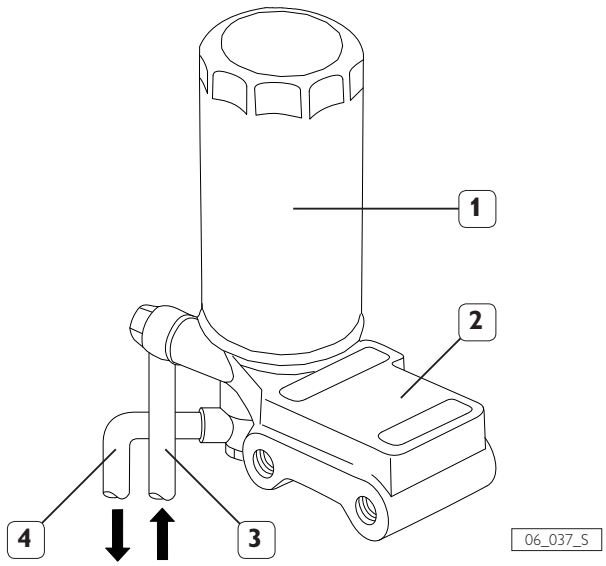


1. High pressure pump control stem - 2. Rotating filter - 3. Umbrella valve - 4. Diaphragm valve - 5. Oil vapors condensation chamber.

The mixture which passes through the rotating filter (2) is partially purified from the oil particles, as a result of centrifugation, and so these particles condense on the cover walls to return to the lubrication circuit. The resulting purified mixture is let in through the stem holes (1) and the diaphragm valve consensus (4) inside the air vent upstream of the turbocharger.
The opening/closing of the valve (4) depends mainly on the ratio between the pressure operating the diaphragm (4) and the depression below it. The oil still present in the mixture coming from the rotating filter (2) and which condenses in the chamber (5) is drained into the chain compartment through the umbrella valve (3) when the pressure that keeps it closed drops as a result of the engine stop.

Oil filter

Figure 38

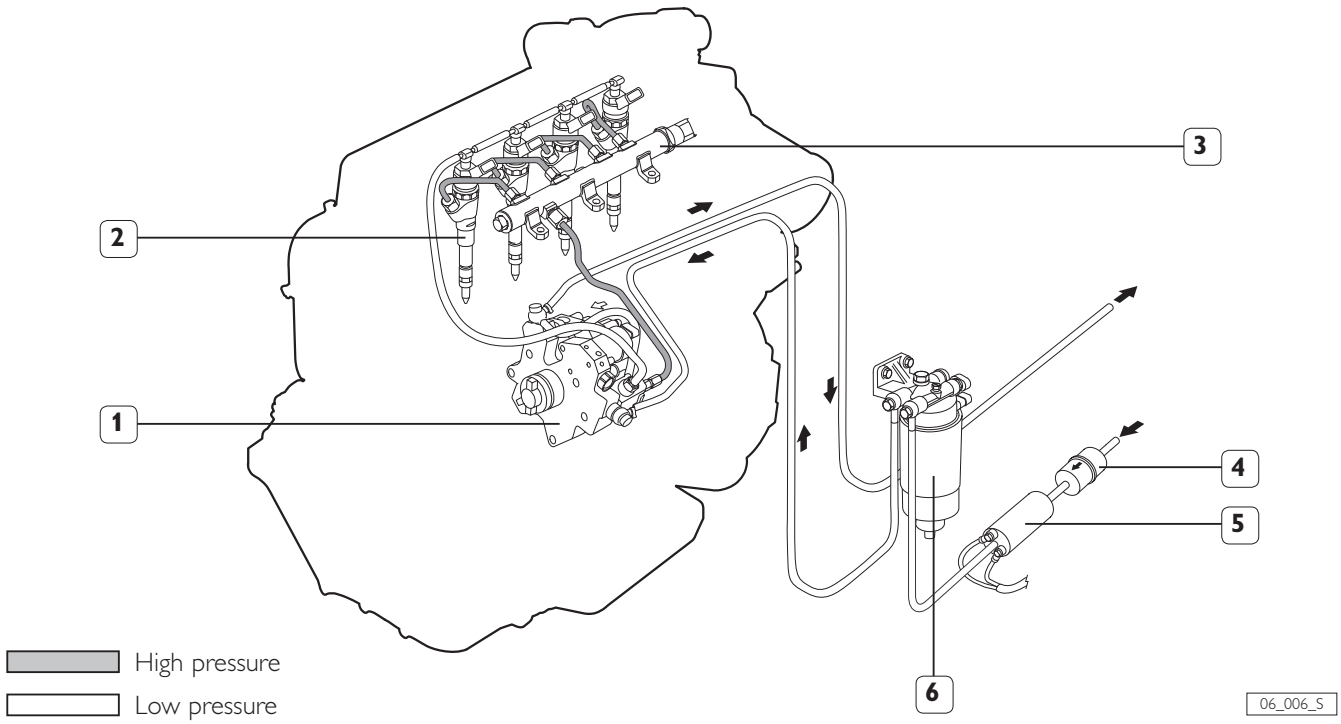


1. Lubricating oil filter - 2. Filter support - 3. Inlet duct for the oil flowing from the heat exchanger - 4. Outlet duct for the oil flowing from engine lubrication.

The oil filter, having a filtering rate < 12 µm and a filtering efficiency of ß > 200, is mounted on the dedicated support and it is provided with a safety valve (opening start at 2.5 bar) with by-pass function, in order to allow the oil to reach the lubrication circuit also in the event of a partial or total clogging of the filter.

FUEL LINE

Figure 39



1. Low pressure mechanical feeding pump and high pressure common rail injection pump - 2. Electro-injector - 3. Common rail - 4. Pre-filter - 5. Fuel electric pump - 6. Filter.

Description and operation

The fuel hydraulic circuit, set up to feed the injection system, can be divided into two separate sections: one in which the flow pressure fuel flows, the other one in which the fuel flow is brought and kept at the injection pressure.

The first section, the low pressure one, provides the filtered fuel to the second one, at a delivery rate capable of ensuring a better high pressure pump efficiency; the second section, which is fed by the high pressure pump, ensures the delivery to the injectors of a suitable amount of fuel at the pressure established by the Electronic Unit programming, required to correctly complete the injection process under the different engine operating conditions.

The low pressure transfer electric pump, assembled on the intake pipe, on the engine LH side, takes the fuel coming from the tank through a pre-filter and delivers it to the pump of the high pressure circuit after it has gone through the fuel filter.

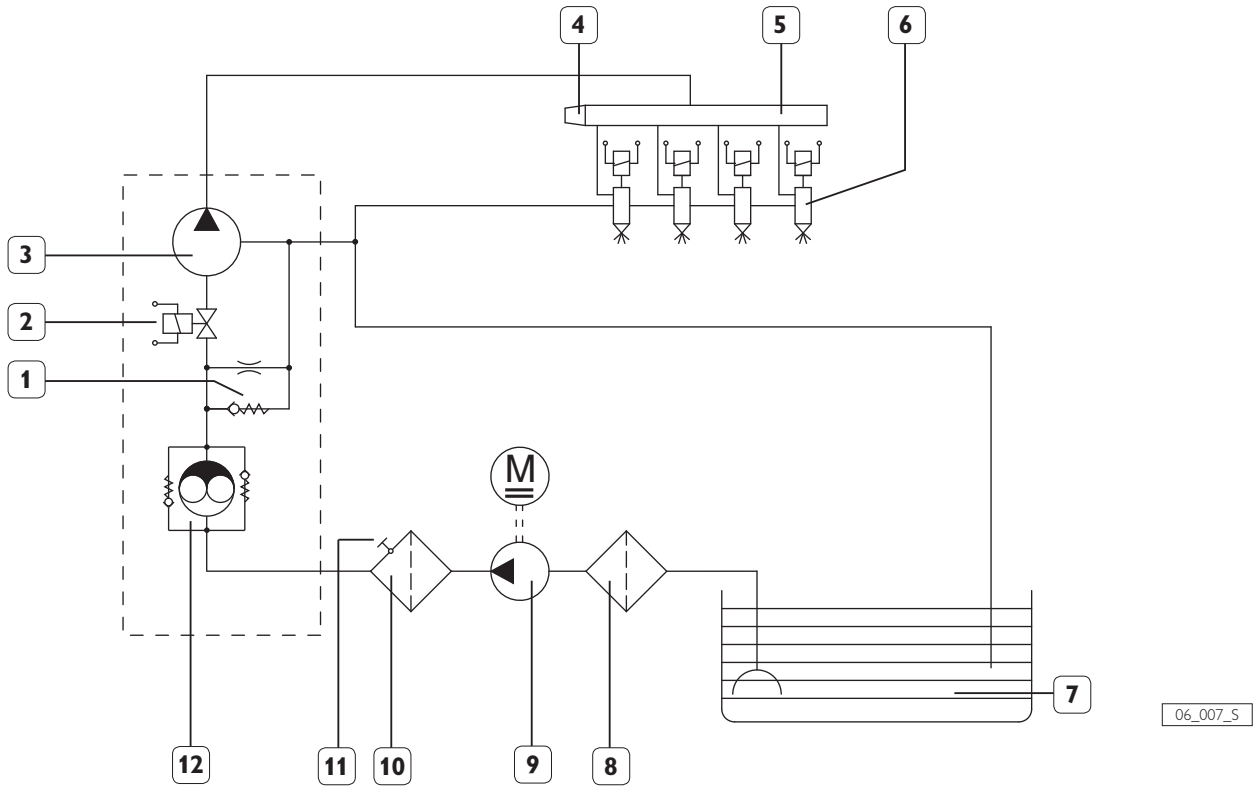
The filter is fitted with a water presence detection sensor and with the relevant device separating water from fuel. The high pressure injection pump is of radial type with 3 pumping elements and it is controlled by the timing chain.

The fuel leaving the high pressure pump, whose delivery is regulated by the pressure adjusting solenoid valve, is sent to the Common Rail distribution unit and it is delivered to the electronic injectors for the management of the injection function controlled by the EDC.

The exceeding fuel returns to the tank through the outlet piping from the high pressure pump and electronic injectors.

Fuel supply system scheme

Figure 40



1. Low pressure limiter valve - 2. Pressure regulating electric valve - 3. High pressure radial pump - 4. Pressure sensor - 5. Common rail - 6. Electro-injector - 7. Fuel tank - 8. Pre-filter - 9. Fuel electric pump - 10. Filter - 11. Vent fitting - 12. Low pressure mechanical feed pump.

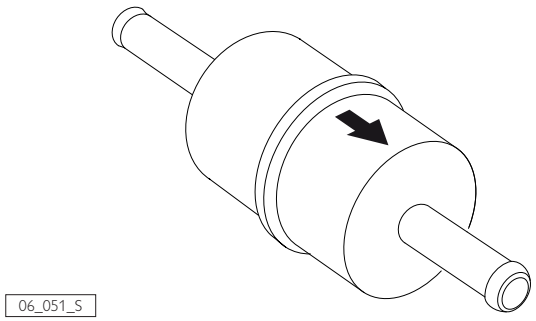
The heart of the system consists of the adjusting solenoid valve (2) and the high pressure pump (3). Fuel intake from the tank (7) takes place through an electric pump (9). During the engine rotation, the pump takes the fuel through the pre-filter (8) and sends it, through the main filter (10) fitted with a drain connection (11), to the mechanical feeding pump (12). The limiting valve, assembled on the high pressure pump stabilizes the pressure at the value of 5 bar, by recirculating the exceeding delivery at the entrance of the feeding pump. The constant pressure fuel feeds the inner pipe for the lubrication of the 3-element radial pump (3) and the inlet of the adjusting solenoid valve. The solenoid valve (2) controlled by the EDC with rapid succession of impulses, regulates fuel delivery to the pump (3) and, as a consequence, it regulates the delivery and the value of the high pressure at the outlet of the pump and provided to the rail (5). The rail simultaneously performs pressure accumulation functions, it delivers fuel to the electronic injectors (6) and it supports and connects the internal pressure sensor (4). The rail internal pressure (4) allows the EDC to measure the value and pilot an adjusting closed-loop solenoid valve in order to always obtain the high pressure value required by the injection mapping. Electronic injectors which are fed at the correct injection pressure, perform their injection function through the EDC into an electromagnetic actuator, and it creates an hydraulic pressure differential which, by acting on the shutter pin, lifts it and opens the nozzles. The optimal duration, instant and pressure for injection are established on the test bench and their values saved in the EDC in planes quoted according to the engine parameters featuring them in every moment. The hydraulic circuit closes towards the tank; the radial high pressure pump and injector exhausted products are collected.

ATTENTION

Avoid any attempt to drain high pressure circuit because this operation will result to be useless and dangerous.

Fuel pre-filter

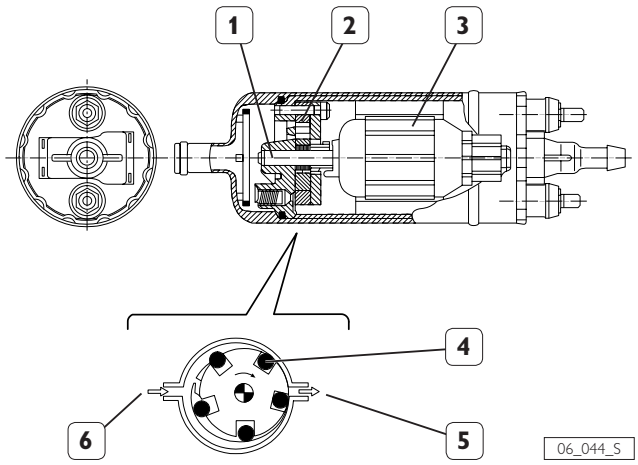
Figure 41



1. Fastener bracket - 2. System bleeding screw - 3. Cartridge - 4. Sensor for detecting the presence of water in the fuel - 5. Manual priming pump.

Fuel electric pump

Figure 42



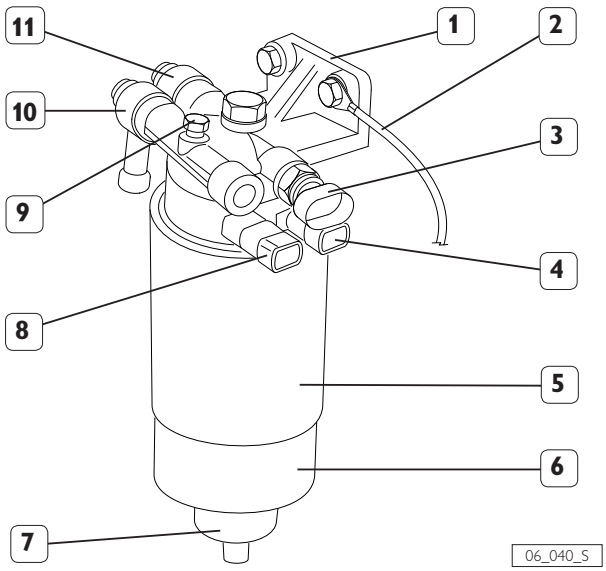
FUEL ELECTRIC PUMP SECTION

1. Pump shaft - 2. Rotor - 3. Brush motor - 4. Roll - 5. Delivery gap - 6. Intake gap.

The fuel rotary electric pump is fitted with a by-pass and it is located on the intake pipe placed on the motor LH side.
It is of roller volumetric type, and the rotor is driven by a brush motor with the energization of permanent magnets.
During the rotation of the rollers fitted on the rotor, volumes adhere to the outer ring and they locate themselves from the intake gap to the delivery gap.
The pump is provided with a non-return valve, in order to avoid the drainage of the fuel circuit when the pump is not running, and of an overpressure valve calibrated at 5 bar to allow the recirculation of the fuel in case the valve maximum calibration value is exceeded.

Fuel filter

Figure 43



1. Fuel filter support - 2. Leads to connect to the negative terminal of the battery - 3. Fuel temperature sensor for EDC - 4. Heating element - 5. Fuel filter - 6. Water accumulation capacity - 7. Sensor to detect the presence of water in the fuel - 8. Fuel filter clogging sensor - 9. Dump valve - 10. Fuel inlet - 11. Fuel outlet.

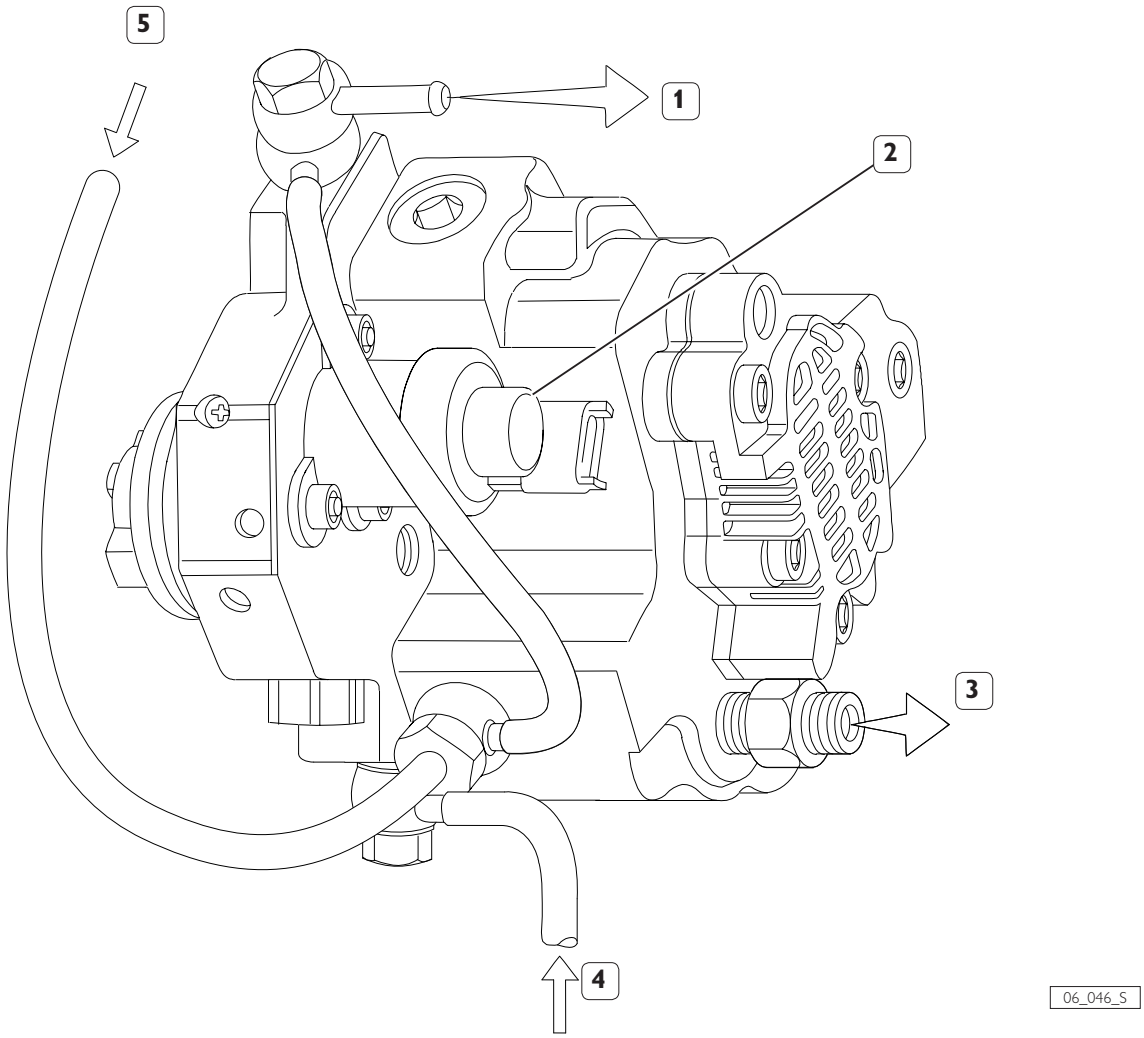
The fuel filter (5) is mounted on the suitable support (1) fitted with an heating element (4) which is provided with a temperature sensor (3) and a filter clogging sensor (8) (differential pressure of operation 1.1 bar).
When the fuel temperature is below 6°C, the ECU EDC powers the heating element in order to increase it up to 15 °C.
The filter is also provided with a water separator to extract water from the fuel, having a capacity of about 100 cm^3 (6).
To eventually drain water residues are collected in the accumulation tank, and they trigger the water presence sensor (7).

Tightening torques

Component	Nm tightening
5. Fuel filter	18±2
7. Sensor to detect the presence of water in the fuel	0.8±1.2
8. Fuel filter clogging sensor	20±2
9. Dump valve	4

High pressure fuel pump

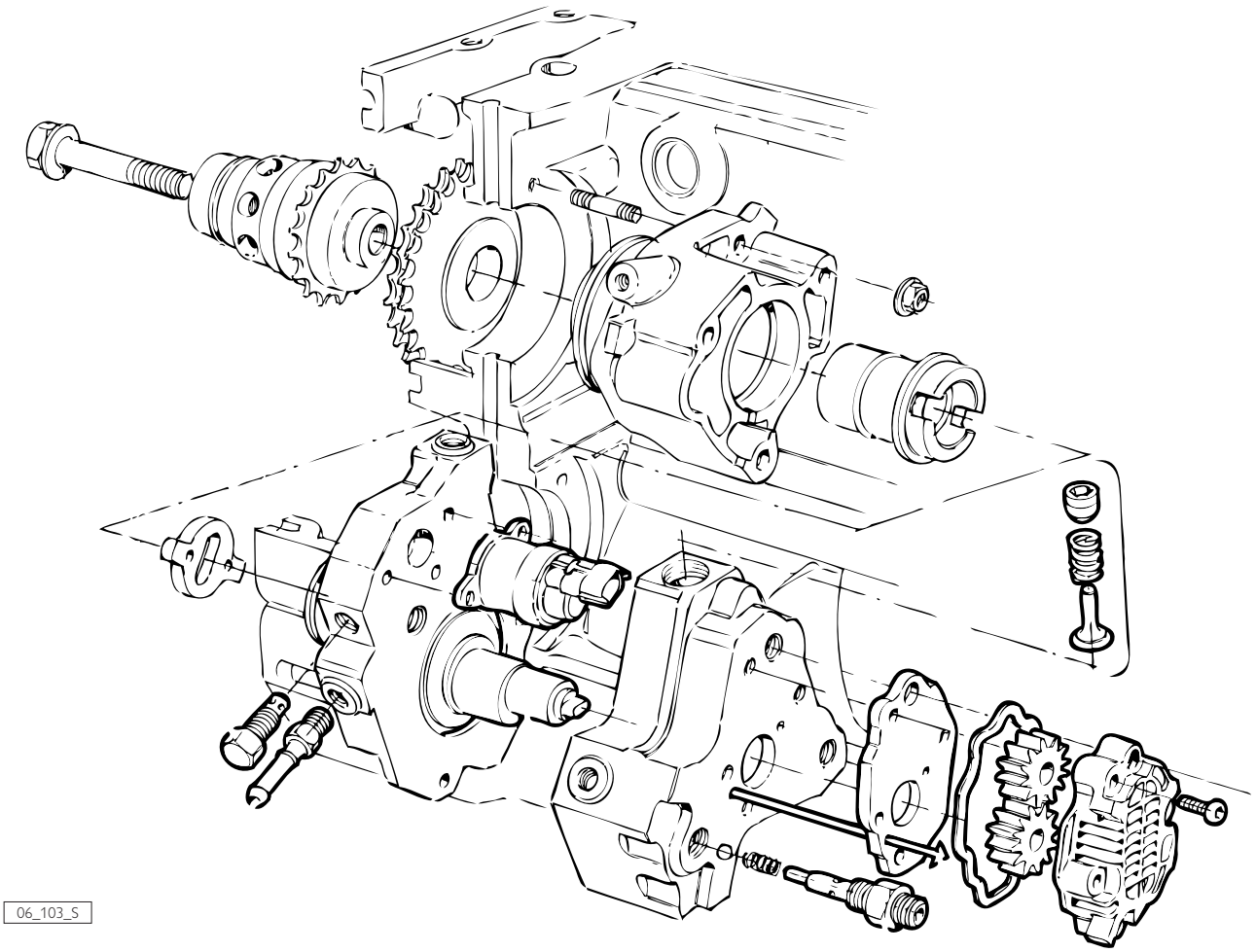
Figure 44



1. Fuel return line to the tank - 2. Pressure regulating solenoid valve - 3. Fuel outflow towards the Common Rail distributor - 4. Fuel inlet from the filter - 5. Fuel return line from electronic injectors.

The high pressure feeding pump is attached to the engine block, on the left hand side of the engine, and it receives motion through a gear actuated by the timing chain.
It is characterized by 3 pumping elements arranged on a radial pattern and it is lubricated and cooled off by the fuel itself, which runs through the channels inside of it.
The pump is fed by the fuel coming from the filter (4), which is then delivered to the Common Rail distributor in a modulated way by the pressure regulating solenoid valve (2).
The exceeding fuel, as well as the return line to the electronic injectors, is recirculated towards the tank (1) in order to be newly used.

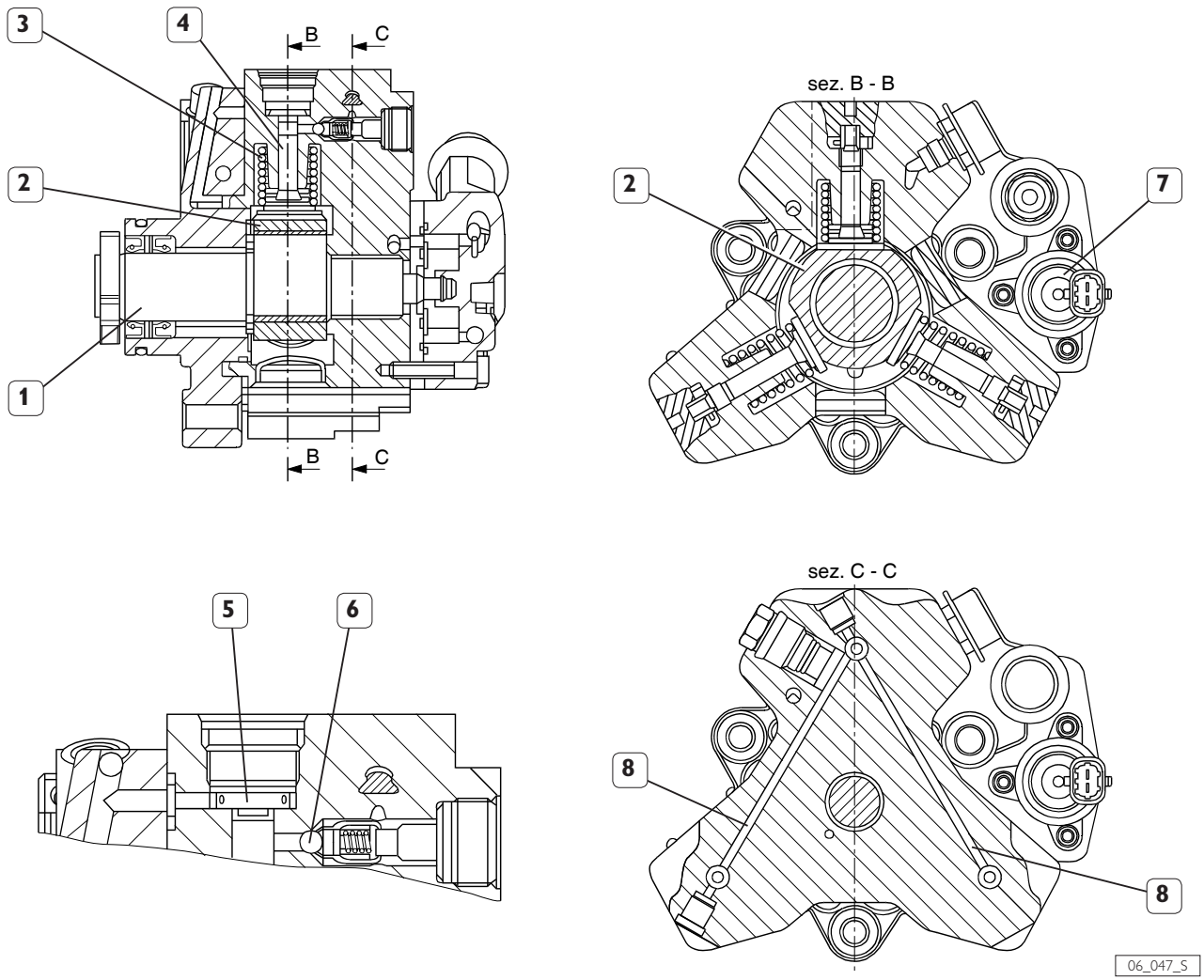
Figure 45



1. Pressure regulator - 2. Modulating valve 5 bar - 3. Fuel filler from the filter - 4. Pump shaft - 5. Delivery valve to hydraulic accumulator (rail) - 6. Fuel return from high pressure pump - 7. Feed mechanical pump - 8. Delivery valve on single pumping element.

High-pressure pump internal structure

Figure 46

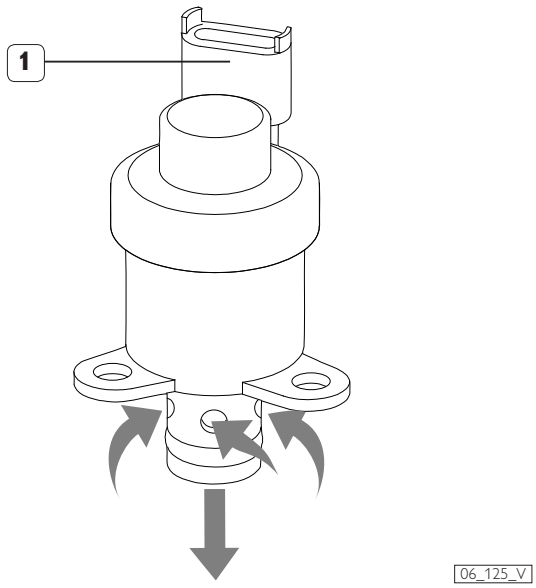


1. Pump shaft - 2. Cam - 3. Return spring - 4. Pumping piston - 5. Cap intake valve - 6. Ball delivery valve - 7. Pressure regulating solenoid valve - 8. Fuel lines for pump feeding.

Internally, the pump features a cam (2) fitted on the shaft (1) connected to the gear actuated by the timing chain.
The position of the cam defines the position of three radial pumping elements, each one consisting of a piston (4) fitted with a return valve (3), a cap intake valve (5) and a ball delivery valve (6).
The peculiar shape of the cam establishes the alternate actuation of the three pumping elements, by establishing an almost constant flow from the pump.
The fuel pressure is regulated by the solenoid valve (7) and it reaches the pumping elements through the lines (8) and thus leading to the Common Rail distributor, where the pressure value is kept constant.

Pressure adjustment solenoid valve

Figure 47

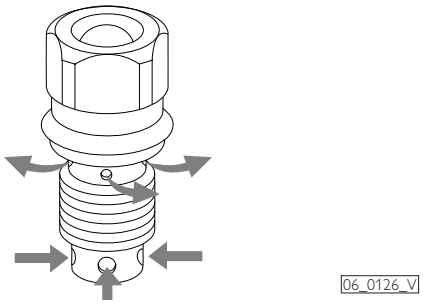


1. Electric connector.

Located at the inlet of the high pressure pump, it allows the adjustment of the fuel flow feeding the high pressure pumping unit, according to the piloting values provided by the Electronic Central Unit. In case piloting values are not available, the valve is normally open, and so it allows maximum fuel delivery to the pump. Electric piloting in PWM produced by the Central Unit, modifies the inlet diameter thus regulating the fuel inflow to high pressure pumping elements.

Low pressure relief valve

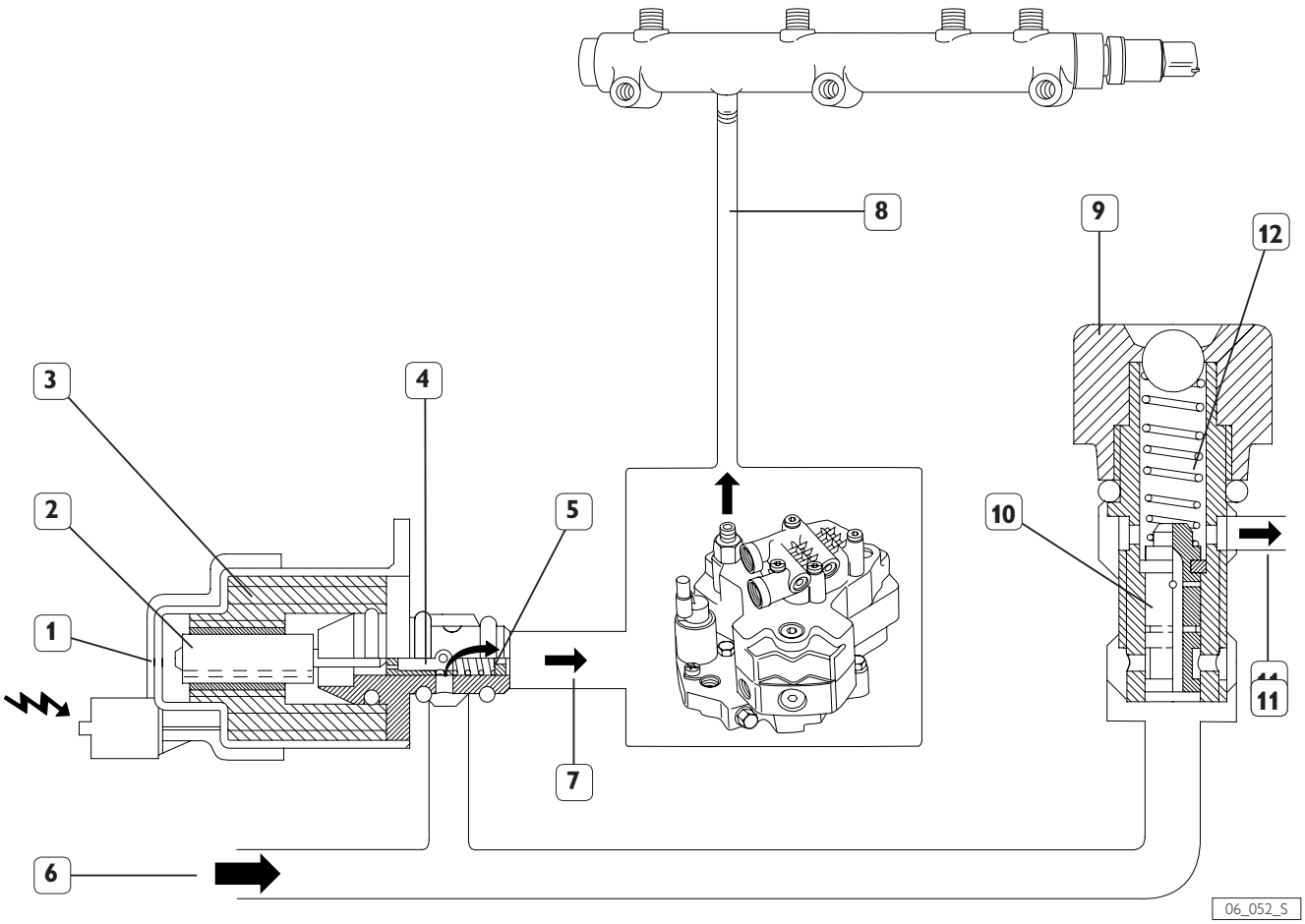
Figure 48



Mounted in parallel configuration with respect to the pressure regulator, its function is to keep the pressure at the regulator inlet constant, a condition required to ensure the system correct operation. When the pressure at the regulator inlet exceeds 5 bar, the cylinder beats the spring elastic resistance and moves upwards; this establishes a communication between the regulator inlet and the drainage. According to the requested engine load, the cylinder reaches a dynamically balanced position which ensures a constant 5 bar pressure at the regulator inlet.

Injection pressure adjustment

Figure 49



1. Pressure regulation solenoid valve body - 2. Iron-magnetic core - 3. Coil - 4. Shutter - 5. Pre-load spring - 6. Fuel inflow (from filters) - 7. High pressure pumping unit feeding - 8. Fuel delivery to rails - 9. 5 bar pressure relief valve - 10. Shutting cylinder - 11. Fuel drainage towards recirculation system - 12. Pre-load spring.

Fully loaded engine regulation

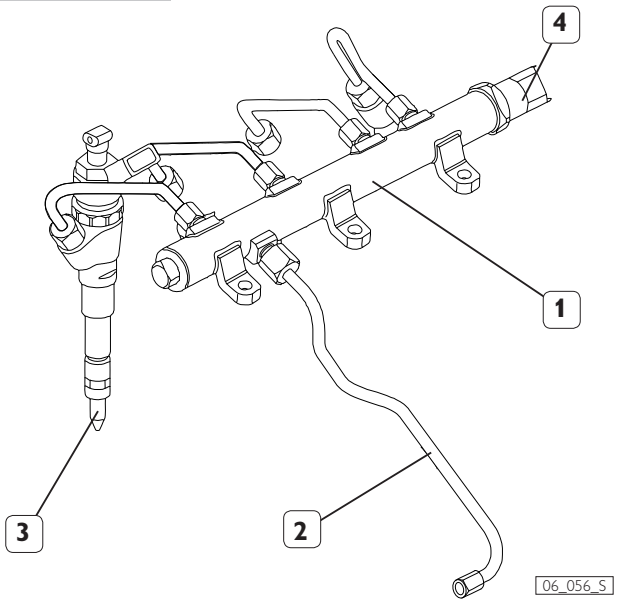
The limited energized coil (3) does not generate any resistance to the pre-load spring thrust (5), allowing the shutter (4) to move in such a way to let a big amount of fuel to flow into the pumping unit. This procedure allows to get very high injection pressures.

Partially pre-loaded engine regulation

The coil energized by PWM modulated impulse control, generated by the Electronic Unit, triggers the shutter, which, by overcoming the pre-load spring resistance, partially closes the fuel inflow hole leading towards the pumping elements, and limits the amount of fuel flowing into the pumping units. This procedure allows to limit the increase of the injection pressure.

Rail and high pressure piping

Figure 50

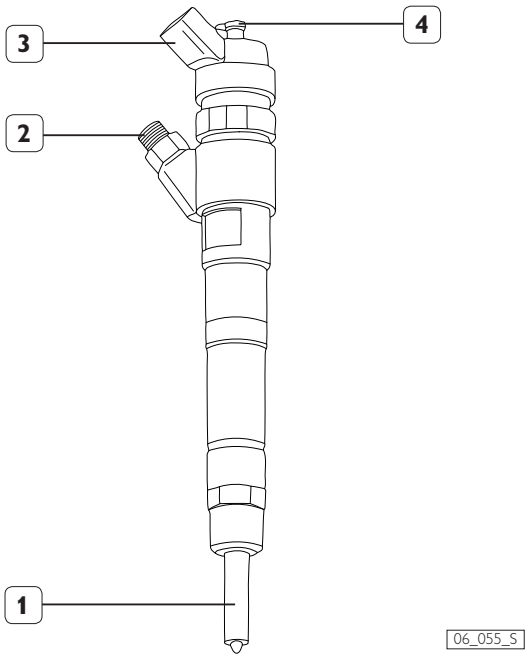


1. Distributor or Common rail - 2. Fuel delivery pipe from the high pressure pump - 3. Electronic injector - 4. Fuel pressure sensor.

The volume inside the rail (about 23 cm^3) is sized to allow a fast pressurization during transition phases, and at the same time to level pressure oscillations caused by the opening and closing of injectors and by the cyclic operation of the high pressure pump. This function is facilitated by the fact that fuel delivery takes place by means of a laminar flow through a calibrated hole.
The internal pressure sensor located at one hand of the rail, corresponding at that injection. High pressure pipes, connected to the rail, are made of metal and connected by means of couplings capable of withstanding the high pressures in play. The presence of pressures exceeding 1600 bars makes their replacement indispensable after each assembly.
In case of interventions on the high pressure circuit, major attention should be placed in preventing dirt from getting into the pipes.

Electro-injector

Figure 51

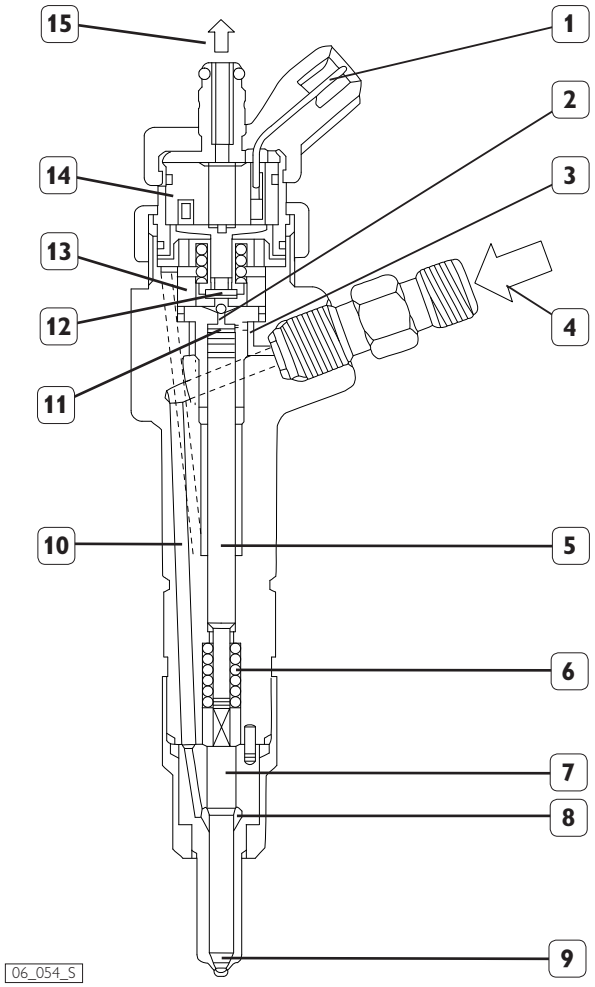


1. Sprayer - 2. High pressure fuel inlet connection - 3. Electric connector - 4. Low pressure fuel outlet towards the return line to the tank.

Injection pressure fuel is always available at the electronic injector inlet; it is calculated by the ECU and maintained constant in the rail.
When an electronic injector solenoid valve is energized by the ECU, the fuel is taken from the rail and sprayed into the relevant cylinder.
The fuel that is instead recirculated inside the electronic injector reaches high temperatures (about 120 °C) and it returns to the tank through the outlet (4) and at the atmospheric pressure.
A co-stamping is located on the electric injector head to fasten the electric connector (3) with the ECU.

Operational principle

Figure 52



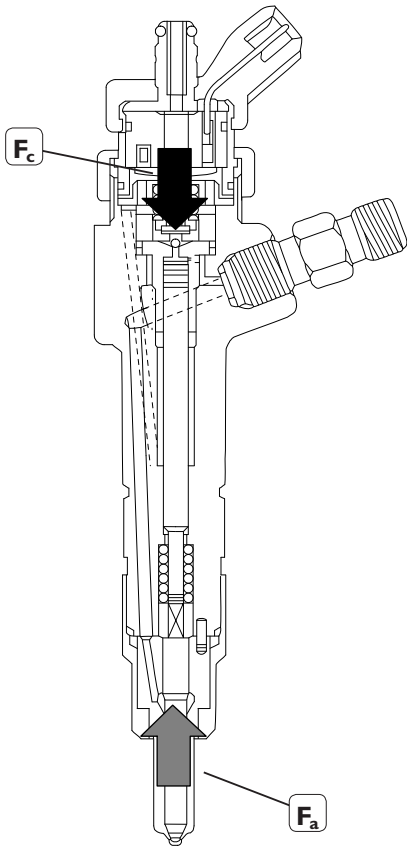
1. Electric connection - 2. Control volume - 3. Control pipe - 4. High pressure fuel inlet - 5. Pressure rod - 6. Spring - 7. Plug - 8. Pressure chamber - 9. Nozzle - 10. Feeding pump - 11. Control area - 12. Ball shutter - 13. Pilot valve - 14. Coil - 15. Low pressure oulet.

The electronic injector is divided in two main parts:

- ❏ Actuator/Sprayer: consisting of pressure rod (5), plug (7) and nozzle (9);
- ❏ Control solenoid valve: consisting of coil (14) and pilot valve (13).

During operation, forces in play will determine the opening and closing of the shutter (12) and, consequently, the possible outflow of fuel from the nozzle (9) can be identified as F_c and F_a.

Figure 53



F_c: Force generated by the fuel pressure on the control area (11) of the pressure rod (5).

F_a: Force generated by the line pressure acting on the pressure chamber (8).

Thus, operation can be divided in three steps:

- ❏ Rest position: $F_c > F_a$

The coil (14) is de-energized and the shutter (12) is in a closing position and it does not allow the inflow of fuel into the cylinder.

- ❏ Injection start: $F_a > F_c$

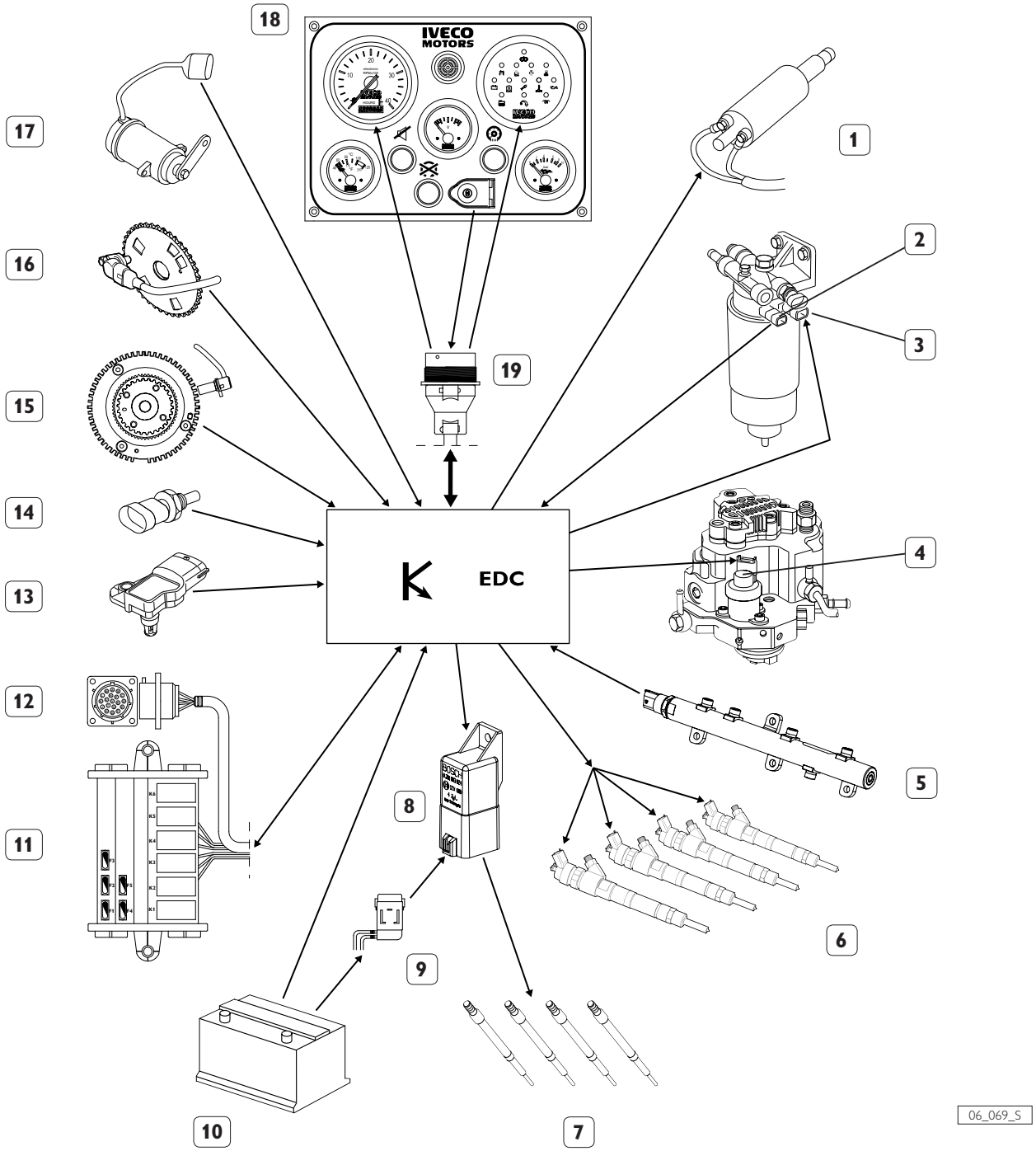
The coil (14) is energized and it triggers the rising of the shutter (12). The fuel in the control volume (2) flows towards the outlet (15) causing a pressure drop on the control area (11). Simultaneously, the pressure in the feeding pipe (10) establishes a force $F_a > F_c$ which cause the plug rising (7) and the fuel inflow into the cylinder chamber.

- ❏ Injection end: $F_c = F_a$

The coil (14) is newly de-energized and the shutter (12) returns to its closing position, establishing a balanced condition of forces, so the plug (7) returns to its closed position stopping the outflow of the fuel from the nozzle (9).

EDC 16 SYSTEM ELECTRONIC AND ELECTRIC MAIN COMPONENTS

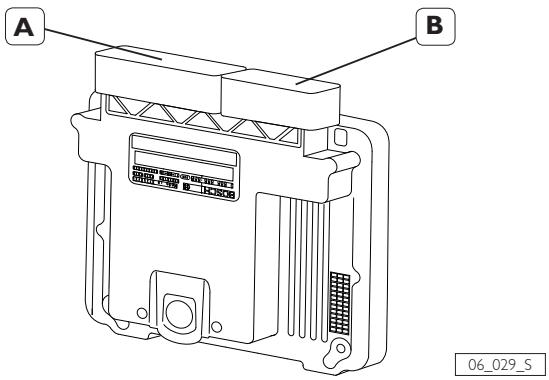
Figure 54



1. Fuel electric pump - 2. Fuel temperature sensor for the EDC - 3. Heating element on the fuel filter - 4. Pressure regulating solenoid valve - 5. Fuel pressure sensor in the rail - 6. Electronic injectors - 7. Engine pre-heating plugs - 8. Engine pre-heating plugs ECU – 9. Plug feeding line protection fuse - 10. Battery - 11. Relay box - 12. J1 connector to connect external diagnostic tools - 13. Combustion air pressure/temperature sensor for the EDC - 14. Coolant temperature sensor for the EDC - 15. Driving shaft sensor - 16. Camshaft sensor - 17. Accelerator position sensor - 18. Control panel - 19. JB connector for control panel wiring.

EDC 16 Electronic Central Unit

Figure 55

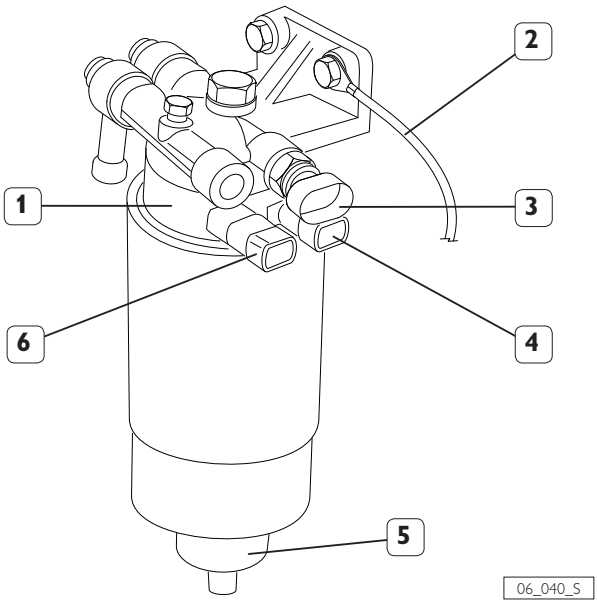


A. Connector for components assembled on engine - B. Connector for connections on the boat side.

The Electronic Central Unit (or ECU) is the component operating the entire injection system. The process begins with the start up of the main program and the run-up procedure that enables to recall into the "RAM" those data which, having characterized the engine management until the previous stop, were stored into the non-volatile memory E^2PROM by the after-run procedure. After the run-up, the test of the blink code light signalling EDC anomalies and the procedures which lead to the start of the engine, follow; during such procedures the presence and consistency of the sensors electric signals are checked. The start of the computer application routine of time and injection advance, is preceded by the analogue-digital conversion of the data coming from the sensors. At the end of the processing, the final data still in digital format are transferred to the various final and power stages, which will control (with the proper ways) the electro-injectors and the system actuators.

Sensors on fuel filter

Figure 56



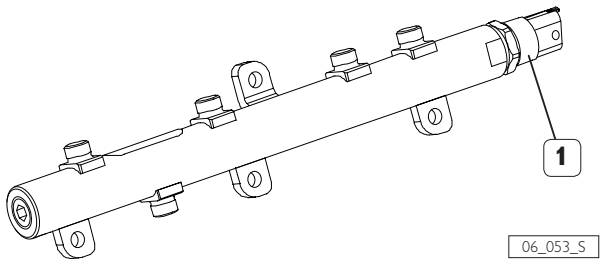
1. Fuel filter support - 2. Connection to the negative terminal of the battery - 3. Fuel temperature sensor for the EDC - 4. Heating element connector - 5. Sensor to detect water presence into the fuel - 6. Fuel filter clogging sensor.

The fuel filter support integrates a series of components as indicated here below:

- Fuel temperature sensor (3): temperature detection is performed through an NTC element which measures the fuel temperature to provide the ECU a piece of information to calculate the volumetric mass (density) of the diesel fuel and eventually adjust the injection time to achieve the optimal dose.
- Fuel heating connector consisting of PTC elements (4): it is fed by the ECU by means of a relay when the fuel temperature is below 3°C;
- Sensor to detect water presence into the fuel (5): it is located in the lower portion of the filtering cartridge to allow, after unscrewing, to drain the water that has eventually accumulated inside. It consists of one/two metal elements immersed in the diesel fuel, connected to an electronic circuit which, following a different electric conductivity of water with respect that of the fuel, generate the signal for the light up of a warning light on the control panel;
- Filter clogging sensor (6) with intervention threshold equal to a differential pressure of 0.6 bar.

Fuel pressure sensor in the rail

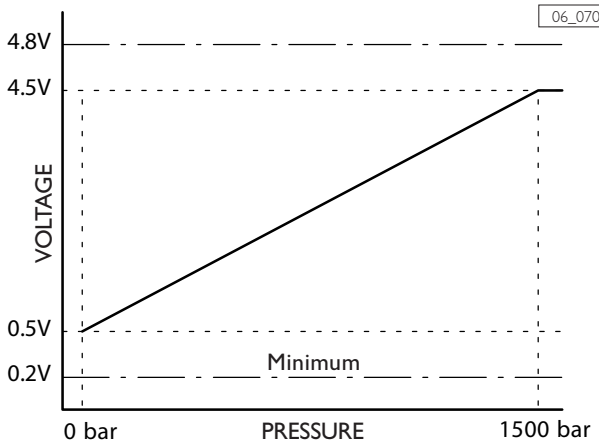
Figure 57



1. Fuel pressure sensor in the rail.

Mounted on one end of the rail, it generates an electric signal proportional to the fuel pressure present inside the rail. The pressure value is used as feedback for the management of the injection pressure and as safety control on its pressure. Information received by this sensor is fundamental to manage the duration of the injection electric control.

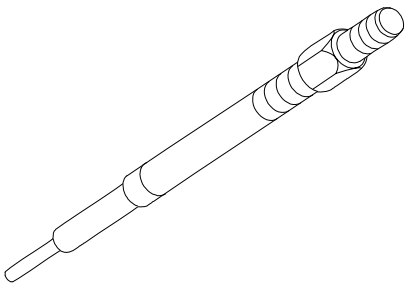
Figure 58



PRESSURE SENSOR OPERATION CHART

Engine pre-heating plugs

Figure 59



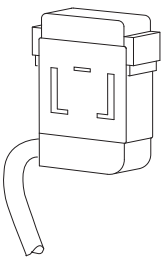
During the start and post-start procedure, the fuel is pre-heated by the plugs, one per cylinder, according to the ECU controlled management.

Control values

- ❏ Feeding voltage (constant): 11 V
- ❏ Maximum absorbed current: 8 A
- ❏ Absorbed current in 5 seconds: 11 to 1.5 A
- ❏ Absorbed current in 30 seconds: 6 to 0.9 A
- ❏ Temperature after 7 seconds: 850 °C
- ❏ Tightening torque: 8 to 10 Nm

Pre-heating plug fuse

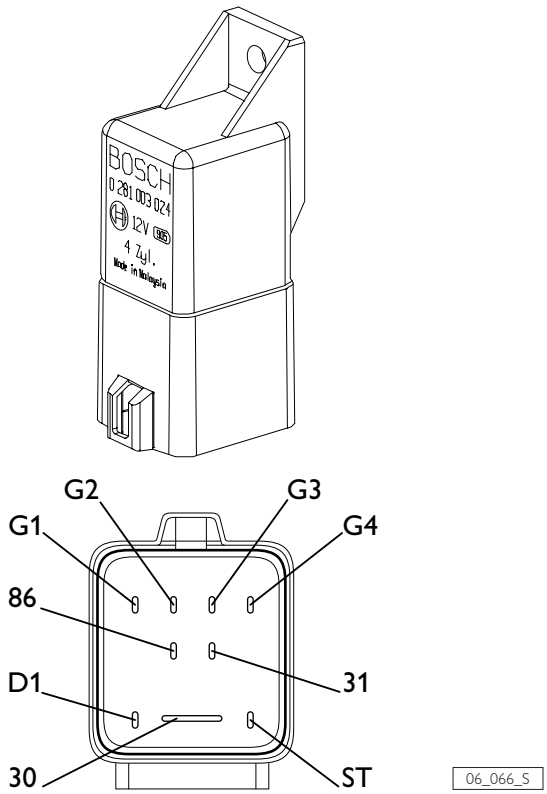
Figure 60



A maxi 60 A fuse is located in serial connection with the electric network of heater plugs.

Engine pre-heating plugs ECU

Figure 61



By means of this control unit, the EDC manages the operation of the plugs by timing the duration of the pre-heating stage according to the engine temperature.
Inside the pre-heating control unit there is a remote control switch controlled by an electronic circuit which broadcasts the "feedback" on whether the plugs are fed or if they absorb an excessive electric current amount.

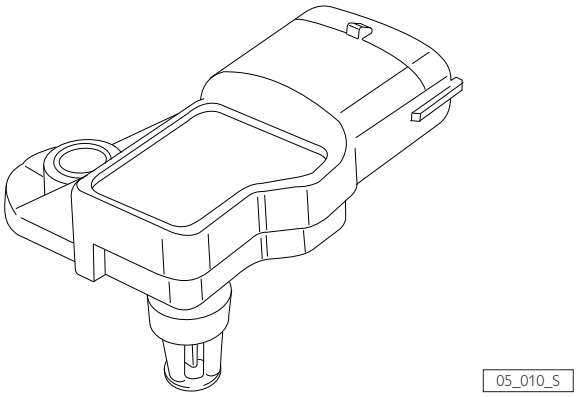
The EDC electronic unit during:
- start-up

- post start-up

times the operation of the pre-heating plug control unit according to the engine temperature.

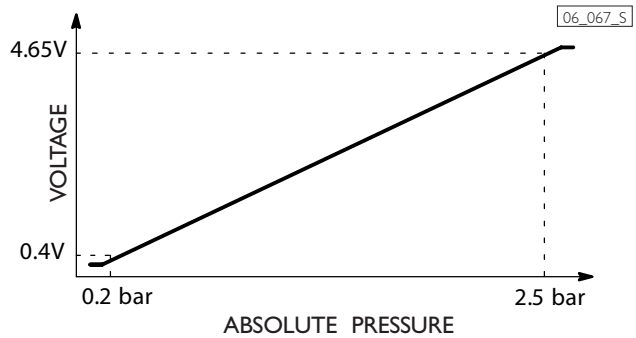
Combustion air temperature and pressure sensor

Figure 62



It is a component which integrates air temperature and pressure sensors of the air blown into the intake manifold from the turbocharger and it is located on the intake manifold.
Temperature and pressure parameters allow the reduction of the air delivery blown into the cylinders in the different steps and operating conditions of the engine, useful to exactly calculate the amount of fuel to be injected at each cycle.
Temperature detection takes place by means of an NTC element whose reference values are shown hereunder.
Pressure detection uses the piezoelectric technology of a semi-conductor component capable of supplying a signal of continuous voltage whose value is proportional to the detected pressure; the voltage trend according to the pressure is of linear type.

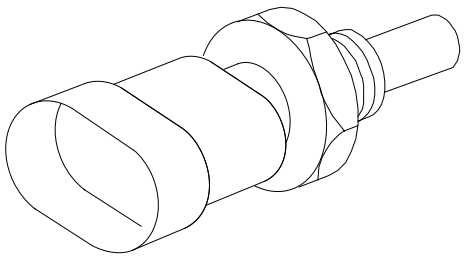
Figure 63



VOLTAGE VALUE TREND
ACCORDING TO THE PRESSURE

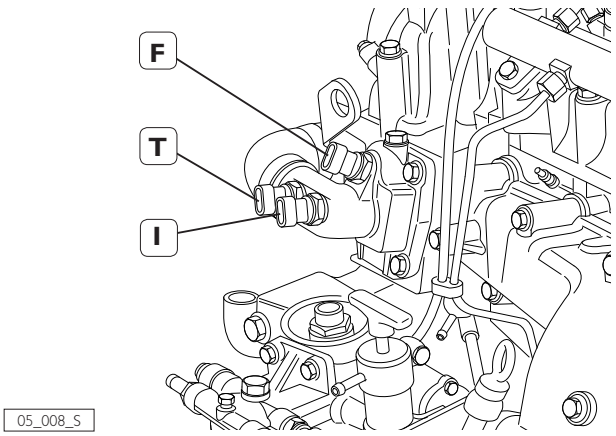
Coolant temperature sensor

Figure 64



It is a sensor fitted with NTC element (resistor with negative temperature coefficient) located on the coolant outlet connector from the thermostat.
It detects the coolant temperature and thus the engine, to allow the electronic unit to perform the supervision of the engine operation status, in order to avoid high temperatures, exceeding which serious damages could be generated to mechanical components. According to the detected data, the ECU can correct the amount of injected fuel in order to prevent, if necessary, the engine temperature to further increase.

Figure 65

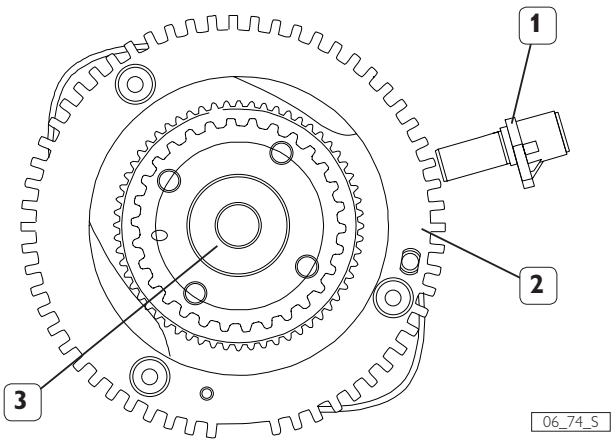


TEMPERATURE SENSOR LOCATION

F. Engine coolant temperature sensor for the EDC -
I. Coolant high temperature sensor - T. Coolant temperature sensor (per detecting instrument).

Driving shaft rpm sensor

Figure 66

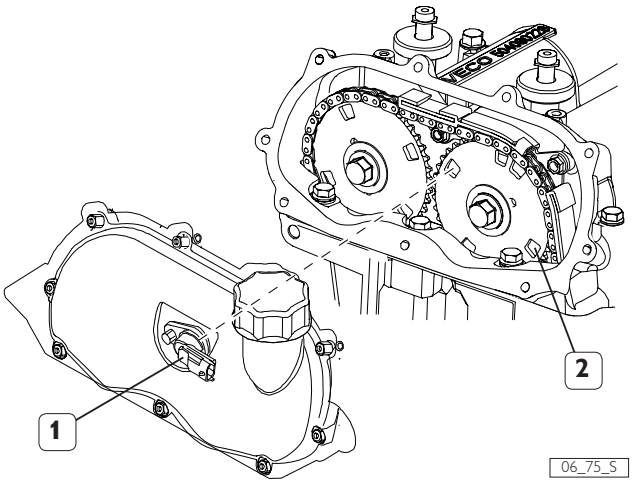


1. Driving shaft rpm sensor - 2. Phonic wheel - 3. Driving shaft.

It is an inductive reluctance variable transducer which through the engine block faces a toothed wheel (or phonic wheel) fitted on the driving shaft. The sensor generates, at the passage of the teeth, a sequence of sinusoidal impulses whose frequency is proportional to the engine rpm; this provides the ECU ith a signal from which the information concerning the engine rpm is drawn.
The impulse amplitude and frequency variation, generated during the wheel rotation by the fact that two teeth of the wheel are missing, allows the ECU to recognize the synchronism signal, i.e. to identify that the driving shaft has completed a revolution and a new counting is now necessary.
Thanks to the synchronism signal and to the perfect positioning of the phonic wheel on the driving shaft, the ECU can calculate an accurate angular position reference of the driving shaft and recognize its absolute position during the entire revolution and, as a consequence, pilot electronic injectors to deliver fuel with the correct advance.
From a conventional point of view, the reference signal identifies the angular position corresponding to a given advance with respect to the PMS of the couple of pistons 1-4.

Timing phase sensor

Figure 67

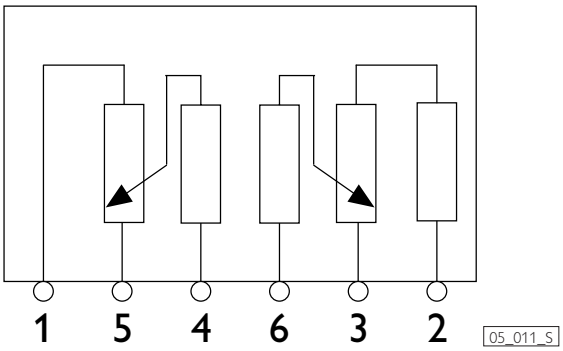


1. Timing phase sensor - 2. Position identification holes.

It is a Hall effect transducer overlooking the toothed wheel fitted on one of the camshafts.
A semiconductor element fitted inside of it, run through by energizing current, is subjected to the variations caused by the magnetic field generated by its permanent magnet. The sensor output signal, resulting from the amplification of voltages that the semiconductor produces under the Hall effect, is the generation of a square wave potential difference, having the same frequency of the magnetic field variation to which it is subjected.
During the rotation of the toothed wheel, in front of the sensor there is a metallic part and the holes drilled in it. Opposite the metal there will be a low voltage output while in the presence of holes the voltage will take a high value.
By means of the phase sensor signal, engine thermodynamic phases are recognized and as a consequence the injectors piloting sequence.
A monitoring function on the signal consistency, implemented in the system Central Unit, allows to identify

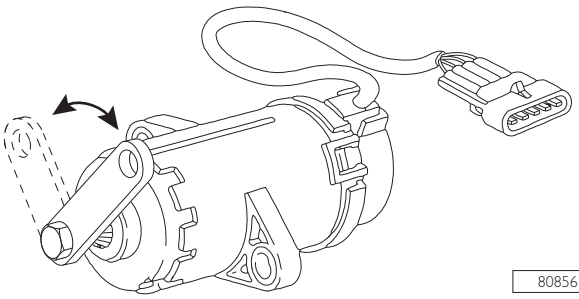
Accelerator position function

Figure 68



It consists of two potentiometers integrated into a single element; with this solution there is no minimum switch.
The ratio between the values of the two potentiometers' voltage signals is equal to 2, (a potentiometer has a double resistance value with respect to the other). Voltage signals detected by the control unit, represent the basic information for the identification of the amount of fuel to be injected.

Figure 69



- ❏ With the accelerator lever at the minimum, the potentiometer rod is placed on the rest position.
- ❏ With the accelerator lever at the end of its travel, the potentiometer rod is located at its max travel position.

Atmospheric pressure sensor

It is integrated inside the control unit.
The purpose of detecting the value of the atmospheric pressure is to allow the adjustment of the amount of fuel injected according to the different behaviour of the engine as the altitude changes.

PAGE LEFT INTENTIONALLY BLANK

SECTION 2

TECHNICAL DATA

PAGE LEFT INTENTIONALLY BLANK

GENERAL SPECIFICATIONS

Cycle Charge Injection		4-Stroke Diesel Supercharged and intercooled Direct
Number of cylinders		4 in line
Bore	mm	95.8
Stroke	mm	104
Total displacement	cm^3	2998
Compression ratio		18 : 1
Direction of rotation, flywheel side		counterclockwise
Minimum idling rpm, no load	rpm	780
Maximum engine rpm, no load	rpm	4000

Allowed engine inclination angles

Maximum longitudinal in continuous operation (static + dynamic)	degrees/360	+16°
Maximum transverse in continuous operation (static + dynamic)	degrees/360	±22° 30'
Longitudinal for oil level check with standard dipstick	degrees/360	0 to +6°

Supercharge

Turbo-charger with water-cooled body		
Maximum pressure	bar	1.9

Lubrication

Oil	type	SAE 5 W 30
Oil compliant with specifications		ACEA E3 / API CF4 / MIL L2104E/F
Total oil capacity on first filling	liters (kg)	7.5 (6.8)
Total oil capacity with sump at minimum level	liters (kg)	5.3 (4.8)
Total oil capacity with sump at top level	liters (kg)	6.8 (6.2)
Oil pressure, warm engine, minimum idling rpm	bar	≥ 0.7
Oil pressure, warm engine, maximum rpm	bar	5
Maximum allowed temperature	°C	130
Oil dipstick valid for static inclination	degrees/360	0 to +6°

Fuel Supply

Fuel oil compliant with standard		EN 590
Low pressure transfer pump		Volumetric roller pump
Flow rate at maximum rpm	liters/h	≤ 190
Fuel return flow rate to tank	liters/h	≤ 185
Filtering: pre-filter filter	µm µm	300 5

Injection System

Type		Common rail
System		Bosch EDC16C8
Maximum injection pressure	bar	1600

Low Temperature Starting

Allowed, without external aids, down to	°C	-15
With air heater (upon request), up to	°C	-25
With additional external heater, up to	°C	-30

Cooling

Closed coolant loop with sea-water heat exchanger			50% mixture of water/antifreeze Compliant with SAE J 1034 specification	
Total coolant quantity	liters		14	
Engine sole capacity				
Expansion tank			standard	
Forced circulation			centrifugal pump	
Flow rate at maximum rpm	liters/h		10800	
Temperature regulation			with thermostatic valve	
initial opening	°C		80° ± 2	
maximum opening	°C		95	
Sea-water line			forced circulation	
Sea-water pump			Volumetric pump	
Sea-water pump height above sea level	m	≤ 2	≤ 2	≤ 2
Max. pump capacity	liters/h		9000	

Exhaust gas expulsion

Upon request		mixed with sea-water

Electrical system

Nominal voltage	V dc	12
Self-regulated alternator:		
Voltage	V dc	14
Maximum current intensity	A	110
Electrical starter motor:		
Nominal voltage	V dc	12
Absorbed electrical power	W	2300
Recommended battery capacity	Ah	≥ 110
Current discharge at - 18 °C (SAE J 537)	A	≥ 800

Drive train coupling

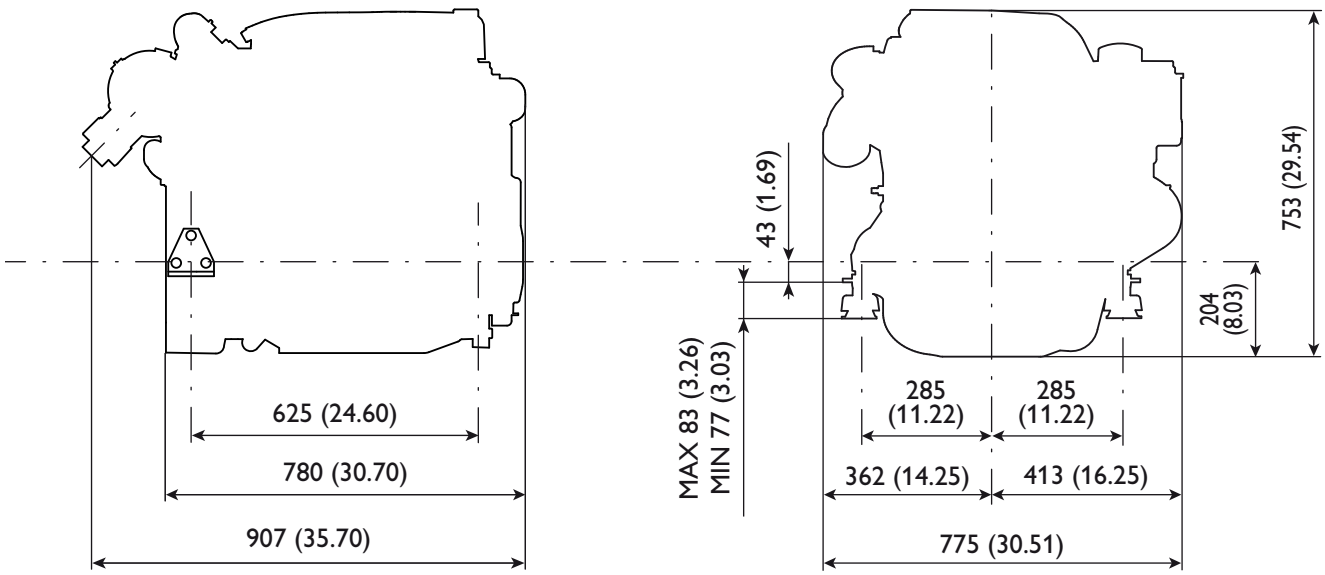
Flywheel diameter	mm (inches)	203.2 (8)
Flywheel case	type	SAE 4

Weights

Without liquids and without marine gear	kg	330

Dimensions

Figure 1



Measurements in: millimeters (inches).

PAGE LEFT INTENTIONALLY BLANK

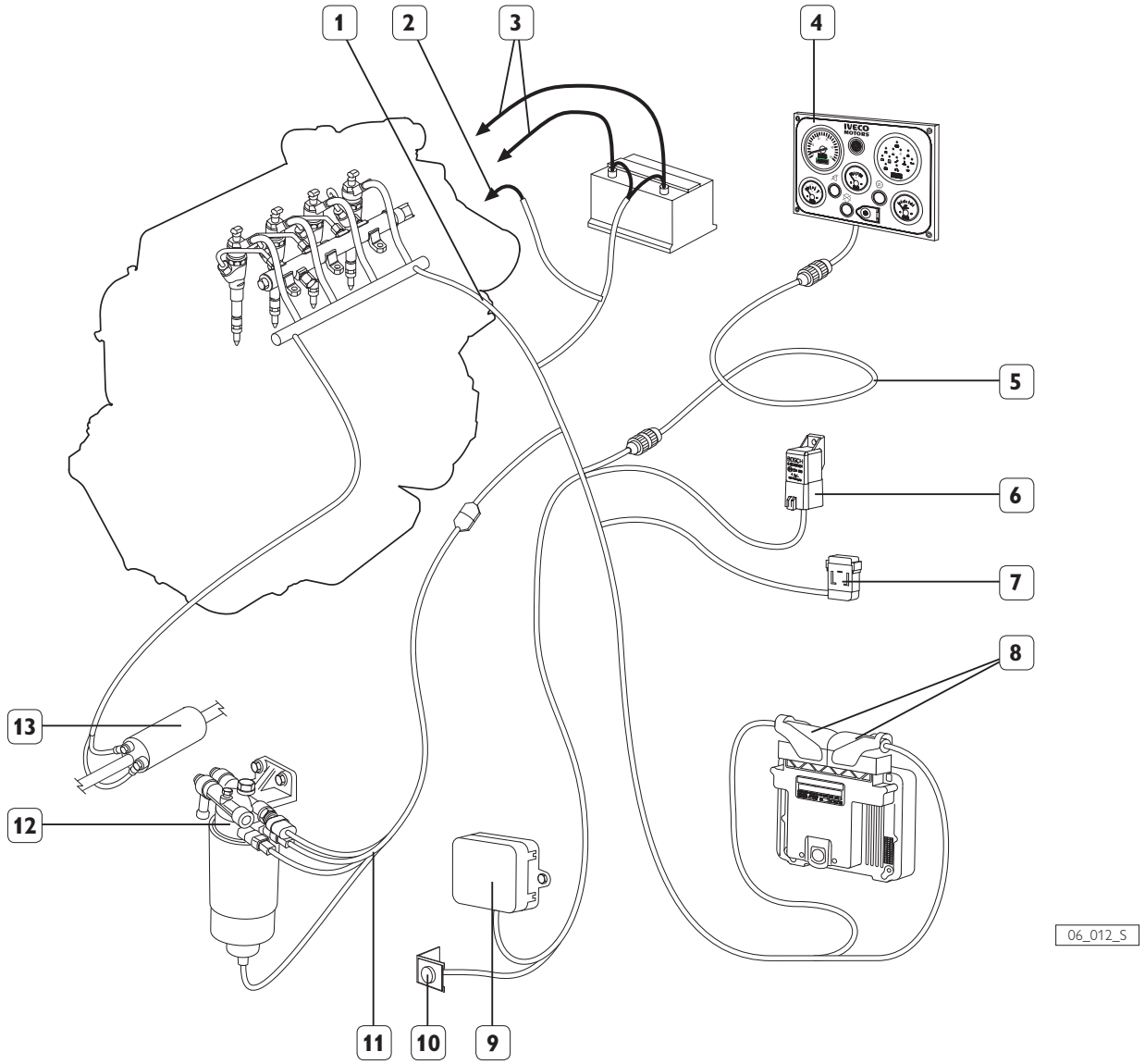
SECTION 3

ELECTRICAL EQUIPMENT

(continues on next page)

OVERALL

Figure 1



1. Engine wiring - 2. +BATT/CC terminal - 3. Power line for electric starter motor and alternator - 4. Indicator and control panel - 5. Extension harness - 6. Engine pre-heating glow plugs electronic control unit - 7. Fuse holder for the engine pre-heating glow plugs electronic control unit - 8. ECU EDC connectors - 9. Relay box - 10. Diagnostic tool connector - 11. Harnessing to be made by construction site personnel - 12. Fuel filter support - 13. Fuel electric pump

The electric equipment of the system carries out the main connections by means of the wiring provided with the engine, to which the power supply, the electronic components assembled on the engine, the electronic central unit of the injection system, the relay box, and the instrument and control panel are connected.
The product overall is apt for the needs of an adequate installation and complies with electromagnetic compatibility limits legislation on electric installations (EMC). Wiring cannot be modified in any way and any possibility of using its wiring lines for different components is absolutely excluded.

Wiring harness for power supply has to be manufactured by the shipyard following the indications contained in the "S30 ENT M23 Installation Directive" document.

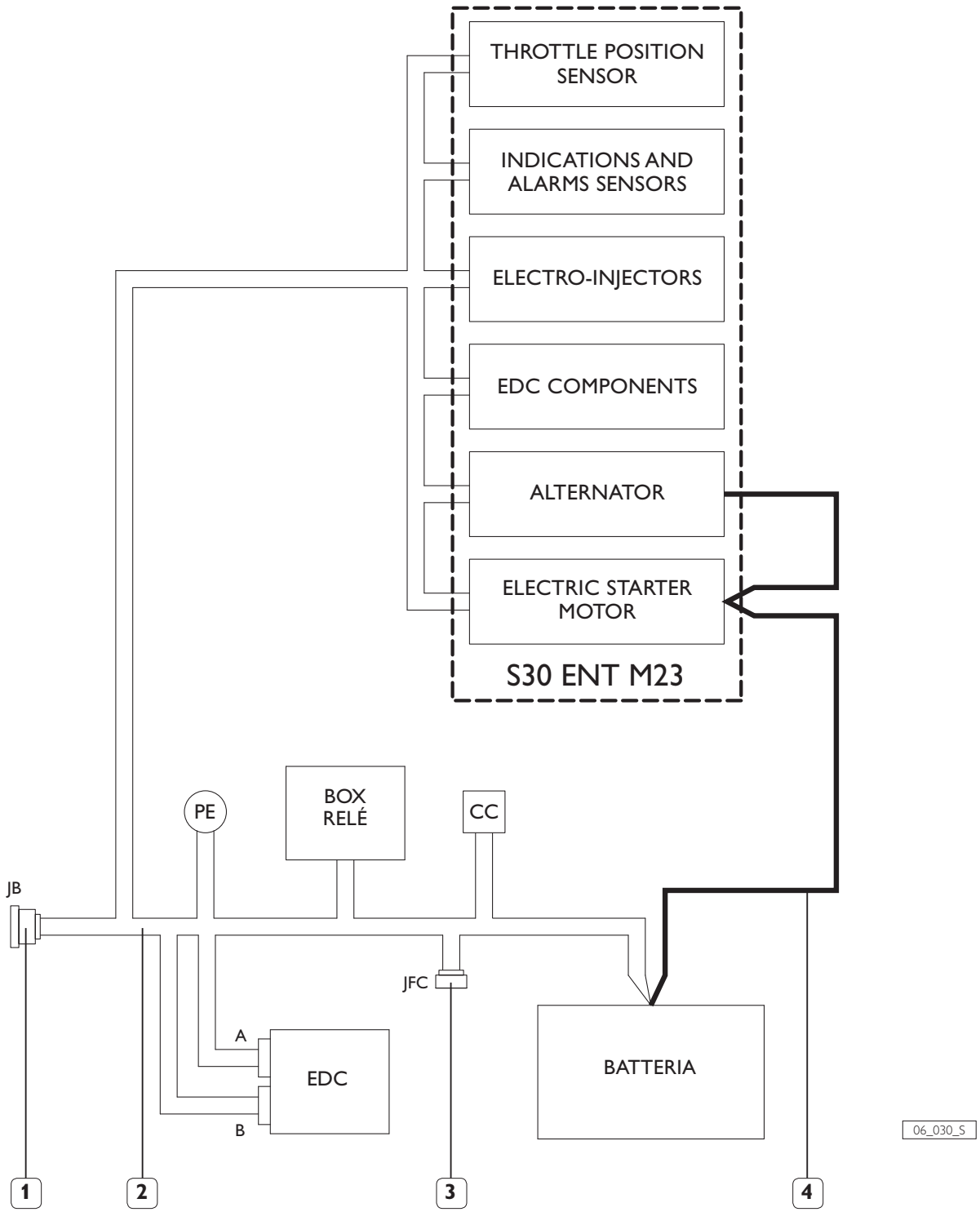
CAUTION

Never use the wiring of the engine equipment to supply any other electrical appliance for the boat.

Information related to analogue and digital instrument and control panel and the related sensors are present in the "S30 ENT M23 Installation Directive" document.

SYNOPTIC

Figure 2

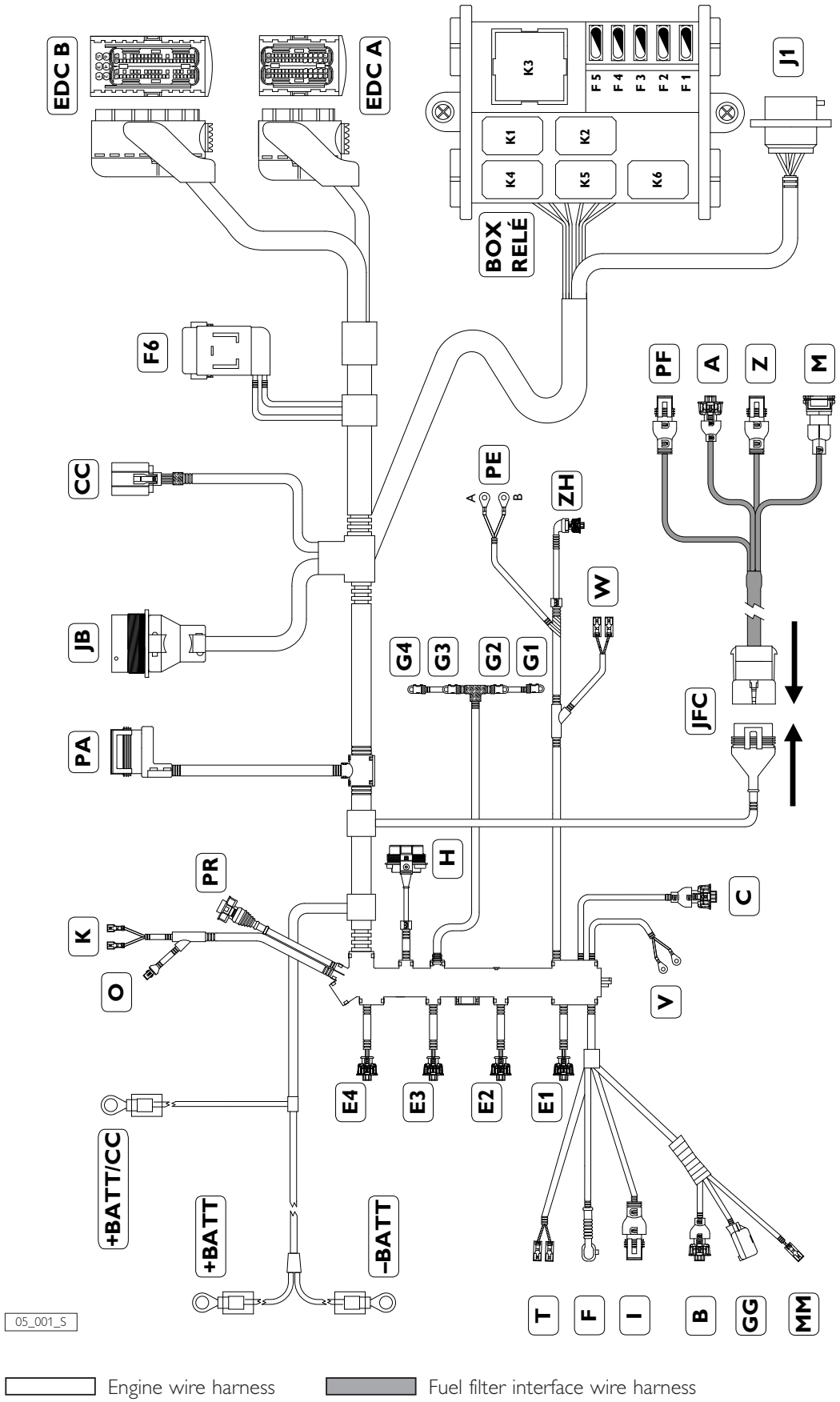


1. Connector for instrument panel connection wire harness - 2. Engine wire harness - 3. Connector for fuel filter wiring - 4. Power line.

Wires supplied with the engine include connectors for all concerned components, connector JB to ensure connection to the warning and control panel, and the JFC connector to allow the connection to the components located on the fuel filter.

WIRE HARNESS

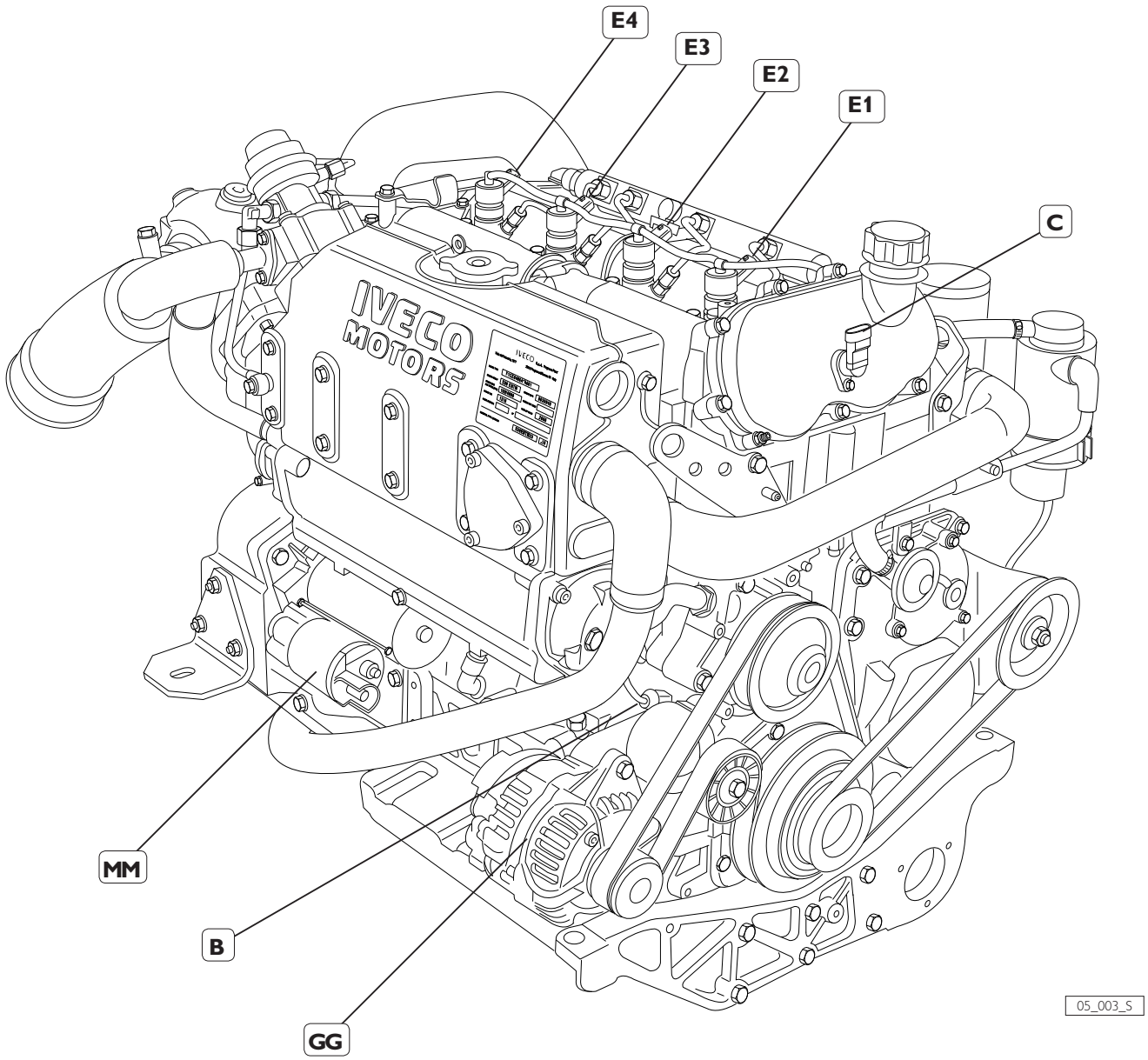
Figure 3



A. Fuel temperature sensor for EDC - B. Drive shaft sensor for EDC - C. Camshaft sensor - F. Engine coolant temperature sensor for EDC - ECF. Connector for the engine stopping functions if stressed - ECM. Connector for the engine stopping function if stressed - H. Combustion air pressure/temperature sensor for EDC - K. Air filter clogging sensor (for alarm) - M. Sensor for detecting the presence of water in the fuel pre-filter (for alarm) - O. Exhaust gas temperature sensor (for gauge) - T. Coolant temperature sensor (for gauge) - V. Oil pressure sensor (for gauge) - E1. Cylinders 1 and 2 electro-injectors - E2.-Cylinders 3 and 4 electro-injectors - E3. Cylinders 5 and 6 electro-injectors - GG. Alternator - JB. Instrument panel connection wire harness - JF1,JF2. Relay box - MM.-Electric starter motor - PA.-Throttle position sensor - PF. Heating element on fuel filter - PR. Rail pressure sensor - SI. Gear box oil temperature sensor - VE. Engine oil pressure/temperature sensor for EDC - VI. High gear box oil pressure sensor (25 bar) - WI. Low gear box oil pressure sensor (7 bar) - ZH. Pressure control solenoid valve.

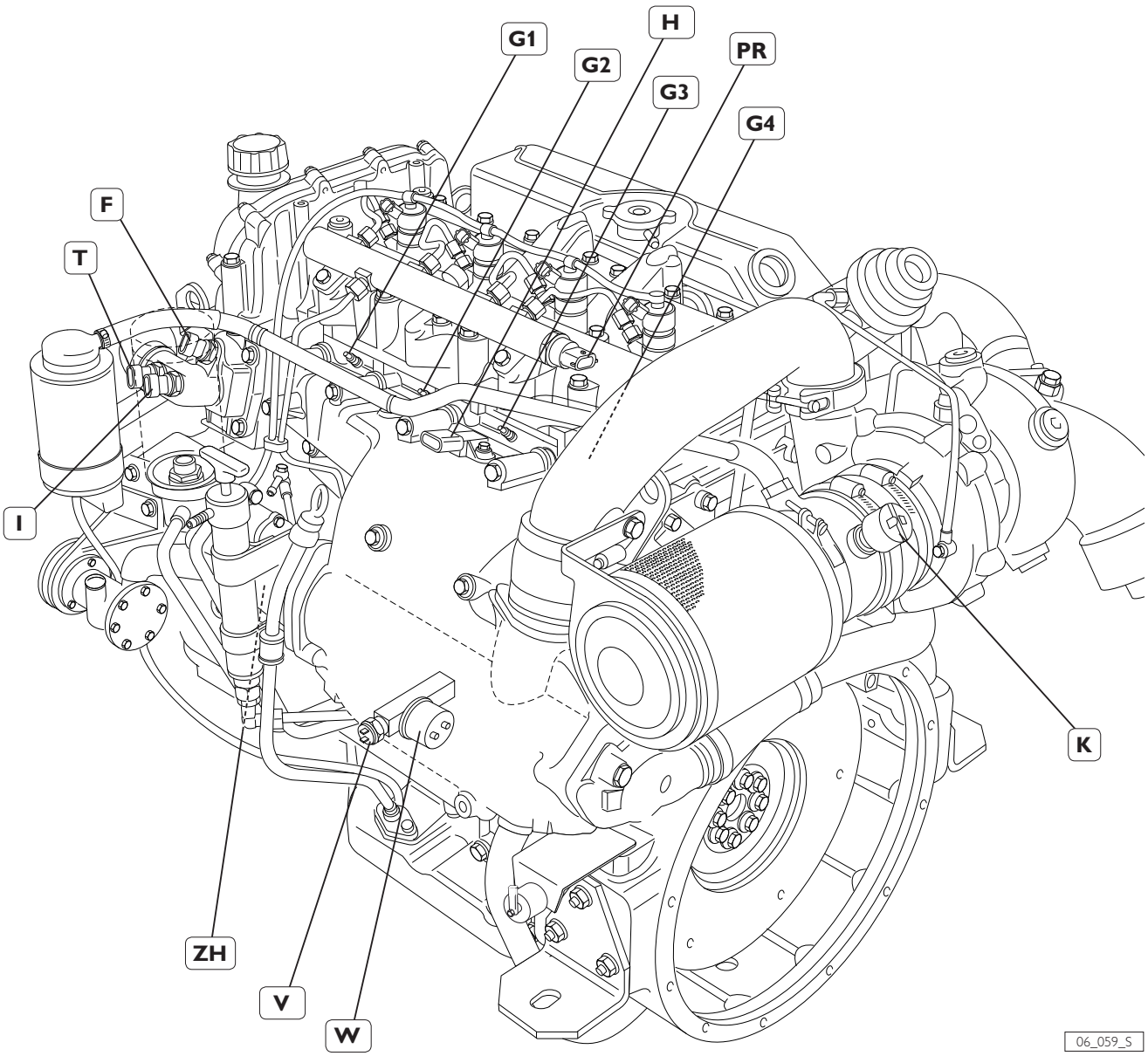
LOCATION OF ELECTRICAL COMPONENTS ON THE ENGINE

Figure 4



B. Drive shaft sensor for EDC - C. Camshaft sensor - E1, E2, E3, E4. Electro-injectors - GG. Alternator - MM. Electric starter motor

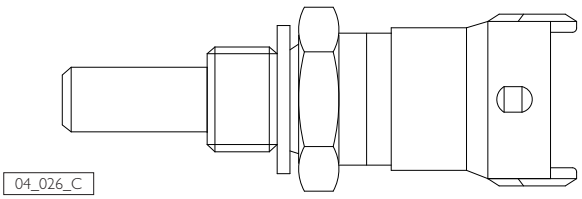
Figure 5



F. Engine coolant temperature sensor for EDC - H. Combustion air pressure/temperature sensor for EDC - I. High coolant temperature sensor - K. Air filter clogging sensor (for alarm) - T. Coolant temperature sensor (for gauge) - V. Oil pressure sensor (for gauge) - G1, G2, G3, G4. Engine pre-heating glow plugs - PR. Rail pressure sensor - W. Low engine oil pressure sensor - ZH. Rail pressure control solenoid valve.

Fuel temperature sensor (A)
Coolant temperature sensor (F)

Figure 6



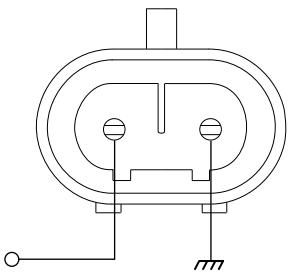
Both functions are performed by the same type of component.
The fuel temperature sensor is connected to the A connector of the EDC electronic unit on Pins 51 and 52.
The coolant temperature sensor is connected to the A connector of the EDC electronic unit on Pins 41 and 58.

Resistance values according to temperature values:

Temperature	Resistance
❑ - 40 °C	48.50 kOhm
❑ - 20 °C	15.67 kOhm
❑ 0 °C	5.86 kOhm
❑ +20 °C	2.50 kOhm
❑ +40 °C	1.17 kOhm
❑ +60 °C	0.59 kOhm
❑ +80 °C	0.32 kOhm
❑ +100 °C	0.18 kOhm
❑ +120 °C	0.11 kOhm

Filter clogging sensor (Z)

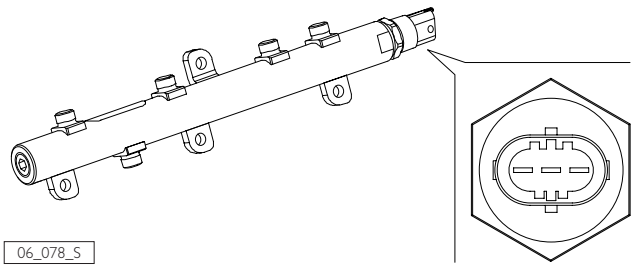
Figure 7



The sensor detects fuel filter clogging when the operating pressure difference between the fuel inlet and outlet exceeds or is equal to 1.075 bar.

Fuel pressure sensor in the rail (PR)

Figure 8

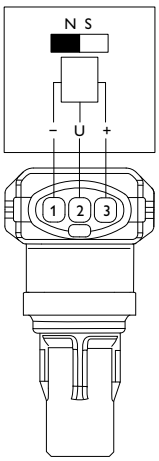


The sensor is connected to the A connector of the EDC 16 on Pins 8, 43 and 28.

Supply voltage: 5 V
Output signal: proportional to the detected pressure .

Camshaft sensor (C)

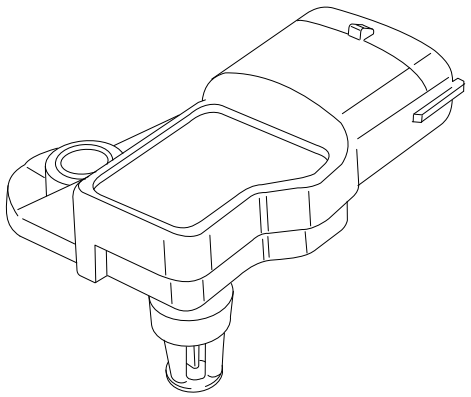
Figure 9



Hall effect-sensor, generating a digital-type output signal, i.e. low or high level voltage.
It is connected to the A connector of the EDC electronic unit on Pins 11, 20 and 50.

Combustion air pressure/temperature sensor (H)

Figure 10



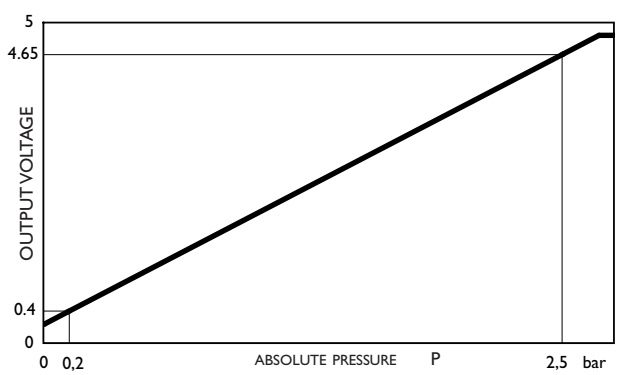
The sensor is connected to the A connector of the electronic unit with the following references:

- ❏ Pin 1 sensor - Pin A23 - ground
- ❏ Pin 2 sensor - Pin A53 - temperature signal
- ❏ Pin 3 sensor - Pin A13 - 5 V power supply
- ❏ Pin 4 sensor - Pin A40 - 0 to 5 V pressure signal

Resistance references according to temperature value:

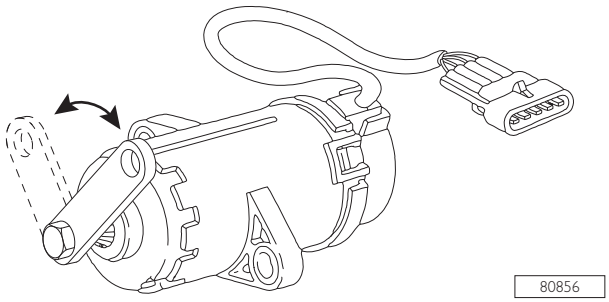
Temperature	Resistance
❏ - 40 °C	48.50 kOhm
❏ - 20 °C	15.67 kOhm
❏ 0 °C	5.86 kOhm
❏ +20 °C	2.50 kOhm
❏ +40 °C	1.17 kOhm
❏ +60 °C	0.59 kOhm
❏ +80 °C	0.32 kOhm
❏ +100 °C	0.18 kOhm
❏ +120 °C	0.11 kOhm

Pressure sensor



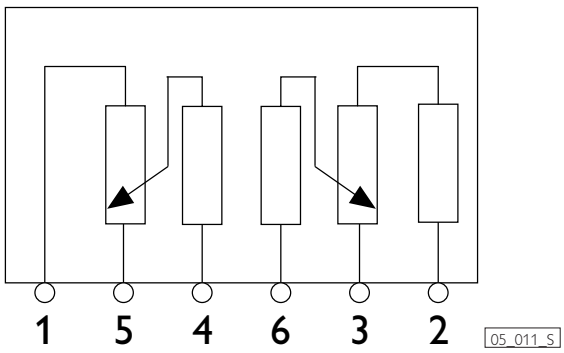
Accelerator position sensor (PA)

Figure 11



The sensor is connected to the EDC electronic unit through pins 9-30-45-31-8-46 of the B connector.
Potentiometers are powered with a 5 Volt voltage supplied by the electronic unit itself.
Potentiometer power supply voltage: 5 Volt
Output signals: proportional to the position of the control lever.

Figure 12

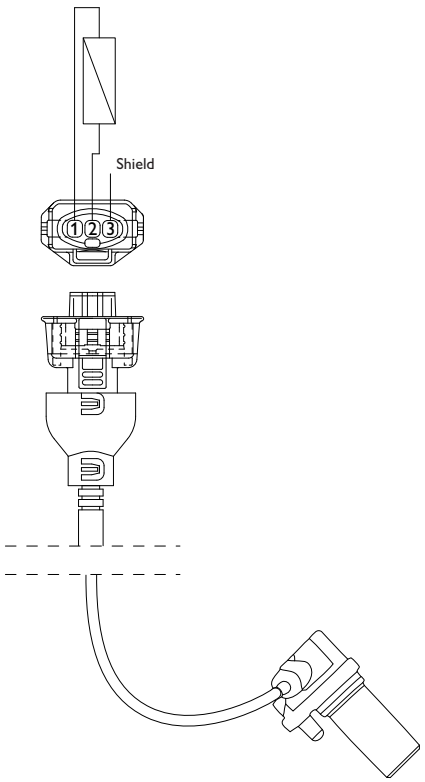


The sensor is connected to the A connector of the electronic unit with the following references:

- ❏ Pin 1 sensor - Pin A46
- ❏ Pin 2 sensor - Pin A45
- ❏ Pin 3 sensor - Pin A30
- ❏ Pin 4 sensor - Pin A9
- ❏ Pin 5 sensor - Pin A8
- ❏ Pin 6 sensor - Pin A31

Drive shaft sensor (B)

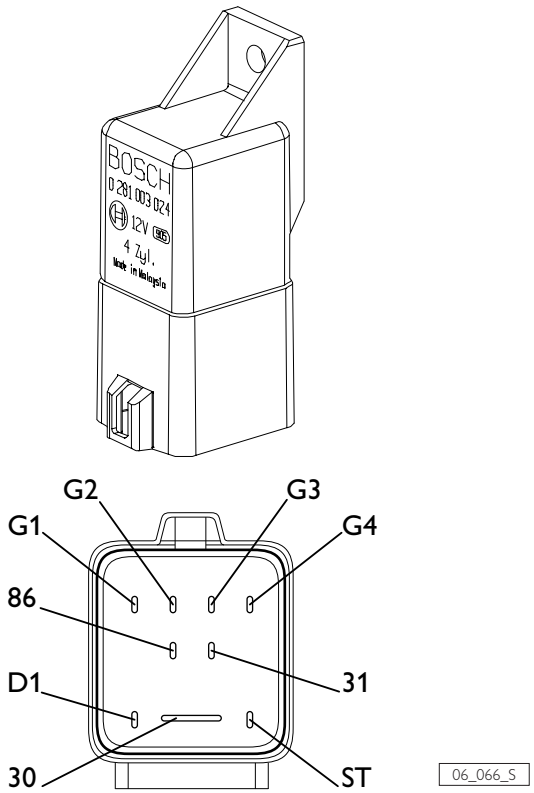
Figure 13



The sensor (B) is connected to pins 27 and 12 of the A connector of the Electronic Unit.

Pre-heating plug electronic unit

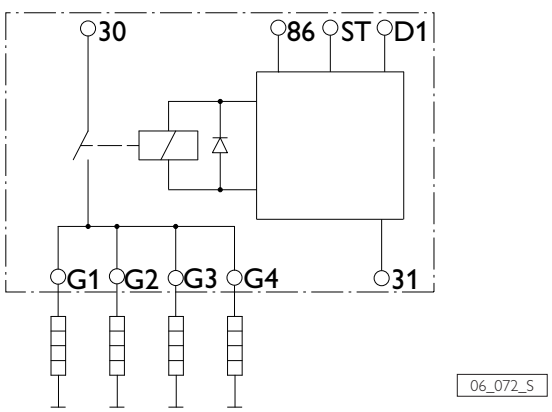
Figure 14



Pre-heating control unit pin-out

31	Ground
86	Start-up switch (+15)
ST	EDC electronic unit (pin B42)
DI	EDC electronic unit (pin B37)
30	Battery positive terminal (+30)
G1/G2/G3/G4	Pre-heading plugs

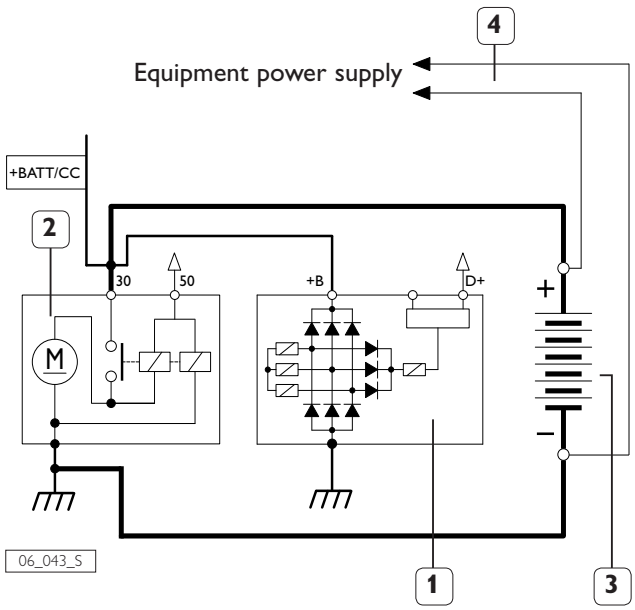
Figure 15



ELECTRIC UNIT DIAGRAM

POWER SUPPLY LINE

Figure 16



1.Alternator - 2. Electric starter motor - 3. Battery - 4. Engine wire harness.

The connection of terminal +B of the alternator to the positive terminal +30 of the electric starter motor consists of a 25 mm^2 diameter conductor or bigger. The connection of the positive +30 terminal of the electric starter motor to the positive pole of the battery, achieved with a conductor having a cross section of at least 70 mm^2, allows to obtain, as shown in the figure, the simultaneous connection of the alternator to the battery. The simultaneous connection of the alternator to the accumulator; on the same terminal, one will have to connect the cable terminal to an eyelet marked as +BATT/CC of the engine harness. The connection between the engine ground and the negative pole of the battery must be achieved according to the guidelines provided in the Engine electrical ground paragraph.

CAUTION

If magneto-thermal protecting breakers are inserted, they must not be used to stop the engine and in any case they must be activated only a few seconds after shut-down.

Supplementary services battery

To assure that the engine can be started with a sufficient quantity of energy, it is advisable to provide for the installation of a supplementary battery, dedicated to supplying power to the on-board electrical services. The power line to recharge it may be constructed according to the indications provided in Chapter 22.

If one engine is installed

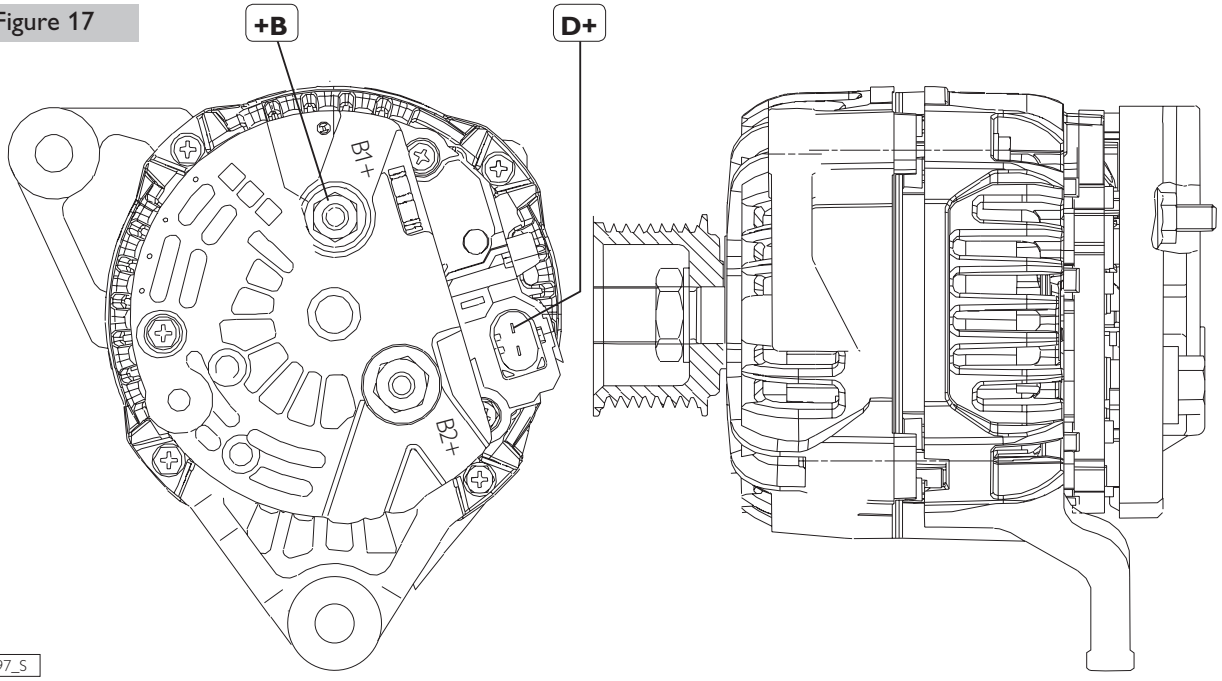
The battery used for services may be recharged interposing on the power supply line a relay actuated by the recharge signal of the alternator's electronic regulator (D+).

If two engines are installed

The presence of two generators allows to keep the recharging functions separated: the generator (G1) recharges the battery (AC1) dedicated to starting both engines and powering both electrical/electronic control circuits, whilst the generator (G2) recharges the battery (AC2) used to power the services. In two-engine applications, it is essential to connect the engine grounds to a common potential; the solution proposed in Chapter 22 fully complies with this need, assuring the full functionality and independence of the two circuits.

ALTERNATOR

Figure 17



06_097_S

"Bosch" Model KCB1 14V - 110 A

+B. (12 V) Power supply output terminal.

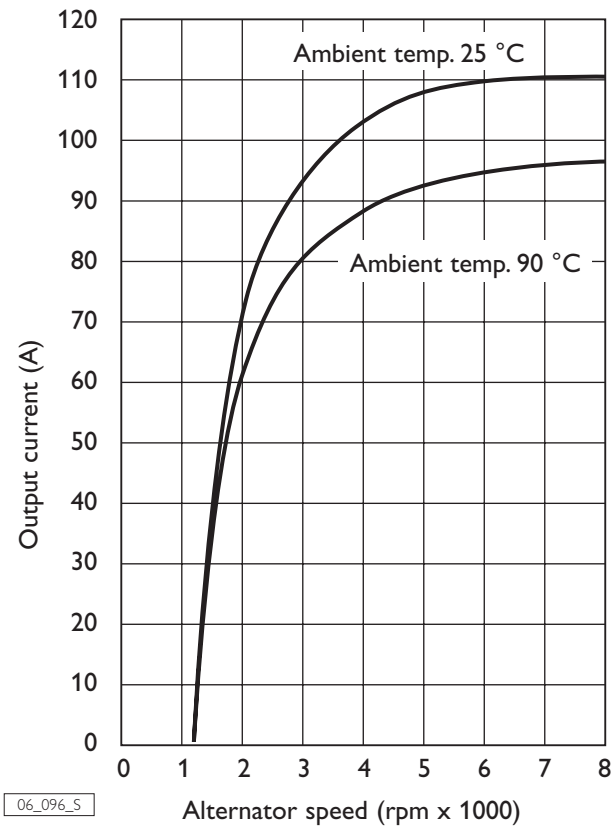
D+. (Lamp) Power supply voltage of recharge/alarm indicator light located on the panel.

Tightening torque for wire terminal nut B+ 12 to 15 Nm.

Specifications

Nominal voltage	14 V
Nominal current max	110 A
Rpm max	12000 rpm
Current max at 1800 rpm	50 A
Polarity	Negative ground
Rotation	Clockwise viewed from pulley
Belt	Poli-V
Poles	12
Weight	5.7 kg

Figure 18

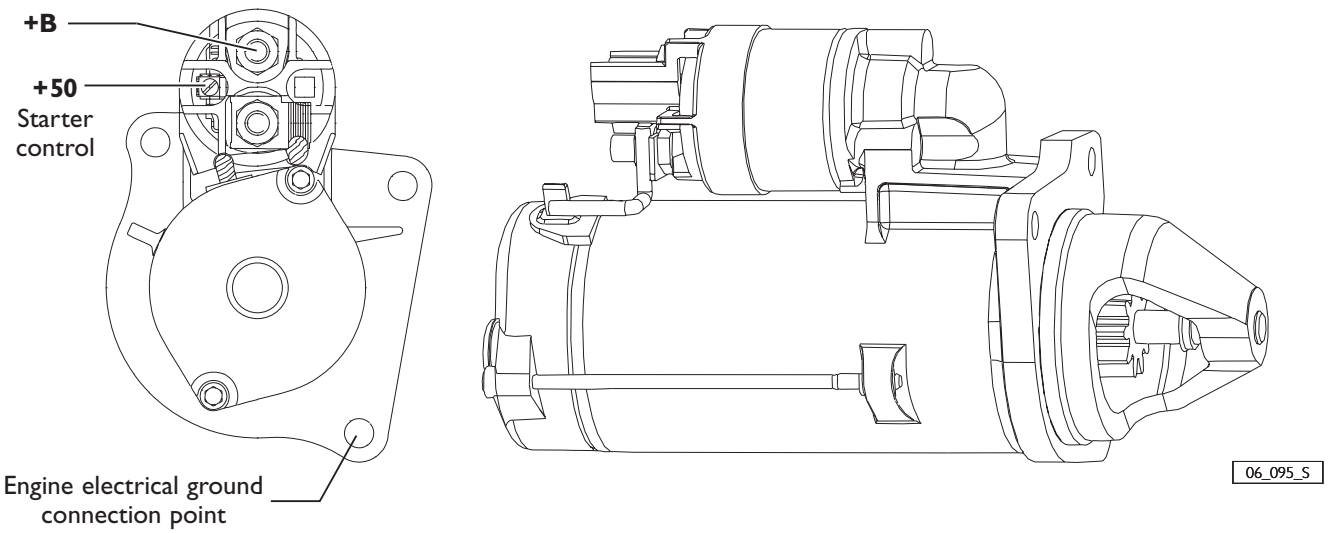


06_096_S

CHARACTERISTIC CURVES

ELECTRICAL STARTER MOTOR

Figure 19

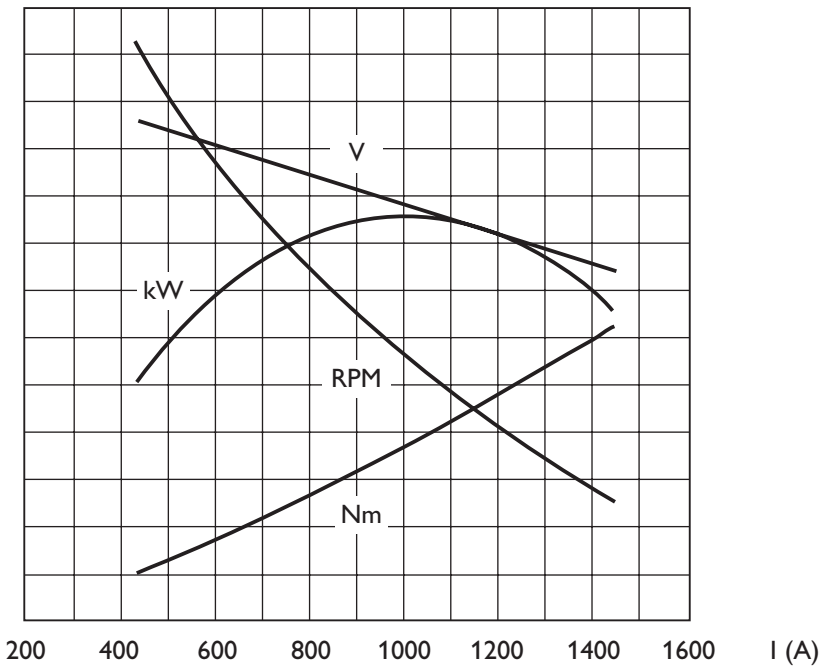


"Bosch" Model - Specifications

Nominal power	2.6 kW
Nominal voltage	12 V
Polarity	Negative ground
Engagement circuit	Positive command
Rotation	Clockwise viewed from pinion end
Operating voltage	13 V max (20 °C)
Water resistance	Water spray test based on JIS D0203' SI'

Figure 20

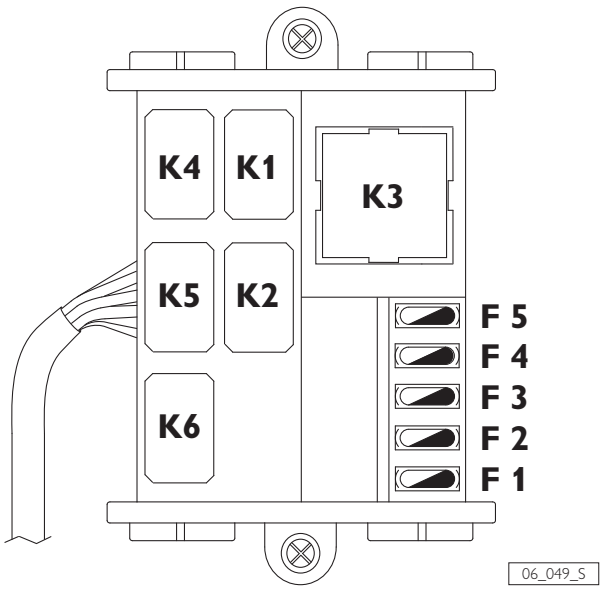
RPM	kW	Nm	V
2600	6,5	130	13
2400	6,0	120	12
2200	5,5	110	11
2000	5,0	100	10
1800	4,5	90	9
1600	4,0	80	8
1400	3,5	70	7
1200	3,0	60	6
1000	2.5	50	5
800	2,0	40	4
600	1,5	30	3
400	1,0	20	2
200	0,5	10	1
0	0	0	0



CHARACTERISTIC CURVES

RELAY BOX

Figure 21



It represents the main point of interconnection and it performs multiple interfacing functions between the different components of the installation.
It is the seat of relays and fuses; components are mounted on a base and thus they can be extracted for interventions such as verification or replacement.

Components to which relays depend on are the following:

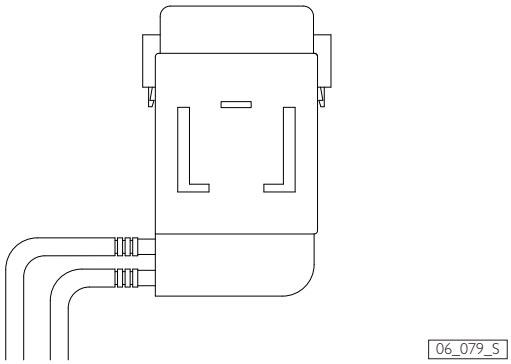
K1	key switch electric discharge
K2	emergency engine shut-down provision
K3	EDC main (power supply)
K4	power supply to terminal 50 of the electric starter motor
K5	fuel electric pump power supply
K6	fuel filter heater element power supply

The components fuses they depend on are the following

F1	fuel electric pump
F2	heating element on fuel filter
F3	power supply to the heater plug control unit (15 A)
F4	EDC (10 A)
F5	EDC (25 A)

Fuse F6

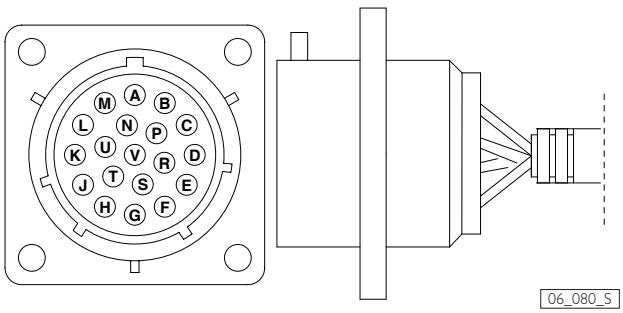
Figure 22



It is a super 60 A fuse fitted in a fuse-holder which will be located according to the Job Site desire; it protects the power line to feed the engine pre-heating plugs.

Connector J1

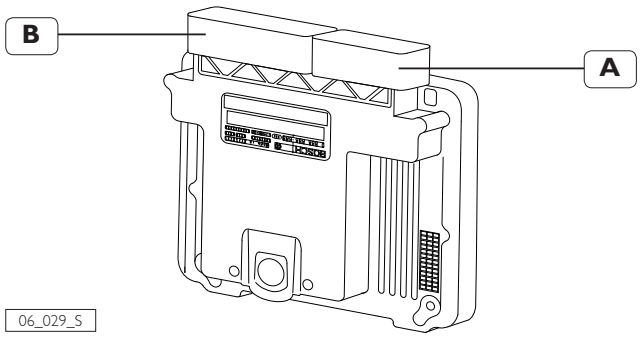
Figure 23



It is the multipolar connector, protected by a screw cap, to which diagnostic tools can be connected, as envisaged by IVECO MOTORS-FPT.

CONNECTIONS OF THE CENTRAL ELECTRONIC UNIT (ECU) EDC 16

Figure 24



A. 60 poles connector - B. 94 poles connector.

The connection of the central electronic unit, the ECU, to the components of the EDC system is achieved by means of three connectors so as to subdivide the wiring harnesses, thereby favoring a quicker identification of the lines during testing operations.

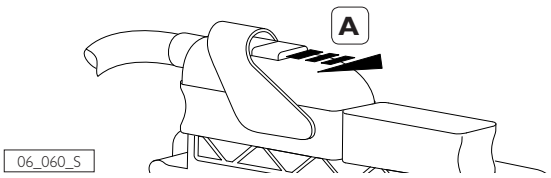
- ❏ B for boat side connections;
- ❏ A for engine mounted components.

The different connectors are polarized and provided with levers to favor the connection and disconnection operations and assure proper coupling.

Modalities to disconnect and connect ECU connectors

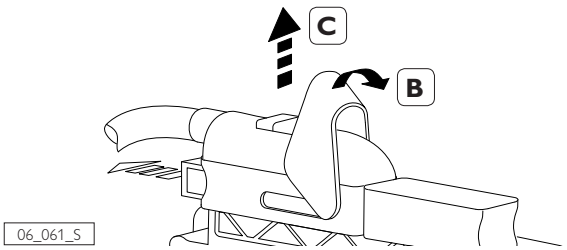
The sequence of operations to allow the removal of connectors from their seat is the following:

Figure 25



A) Extract the retaining element of the extraction lever;

Figure 26



B) Lift the extraction lever and make sure the anchoring frame is extracted from its seat;

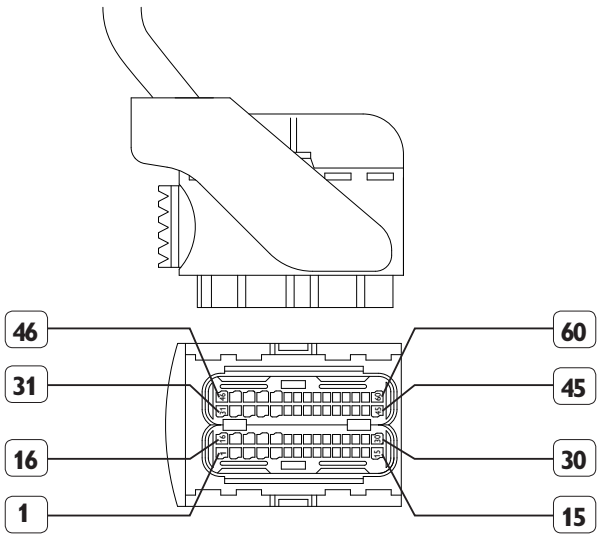
C) Lift the connector without causing oscillations that would compromise the integrity of electric terminals.

To carry out the fitting procedure, remove the connector from its seat, lower the extraction lever and close the retaining element.

Identification of terminal function

EDC A Connector

Figure 27



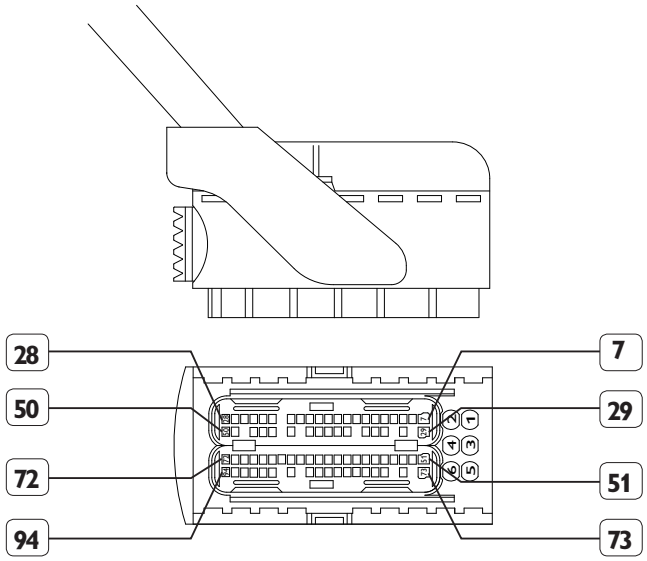
PIN ECU	FUNCTION
1	Injector cylinder 3
2	Injector cylinder 2
3	Not used
4	Not used
5	Not used
6	Not used
7	Not used
8	Power supply ground for common rail pressure sensor
9	Not used
10	Not used
11	Power supply ground for camshaft sensor
12	Crankshaft sensor
13	Power supply positive for combustion air pressure sensor
14	Not used
15	Not used
16	Injector cylinder 1
17	Injector cylinder 4
18	Not used
19	Negative for fuel pressure control solenoid valve on the high pressure pump
20	Power supply positive for camshaft sensor
21	Not used
22	Not used
23	Ground for combustion air pressure and temperature sensor
24	Not used
25	Not used
26	Not used
27	Crankshaft sensor
28	Power supply positive for common rail pressure sensor
29	Not used
30	Not used
31	Injector cylinder 2
32	Not used
33	Injector cylinder 4
34	Not used
35	Not used
36	Not used
37	Not used
38	Not used

39	Not used
40	Combustion air pressure sensor signal
41	Ground for engine coolant temperature sensor
42	Not used
43	Common rail pressure sensor signal
44	Not used
45	Not used
46	Injector cylinder 3
47	Injector cylinder 1
48	Not used
49	Positive for fuel pressure control solenoid valve on the high pressure pump
50	Camshaft sensor signal
51	Ground for fuel temperature sensor
52	Fuel temperature sensor signal
53	Combustion air temperature sensor signal
54	Not used
55	Not used
56	Not used
57	Not used
58	Engine coolant temperature sensor signal
59	Not used
60	Not used

Identification of terminal function

EDC B Connector

Figure 28



PIN ECU	FUNCTION
1	Power supply positive (+B from Main relay)
2	Power supply negative (-B)
3	Not used
4	Power supply negative (-B)
5	Power supply positive (+B from Main relay)
6	Power supply negative (-B)
7	Not used
8	Power supply negative for accelerator position sensor (pin 5)
9	Accelerator position sensor signal (pin 4)
10	Not used
11	Not used
12	Not used
13	Not used
14	Not used
15	Not used
16	Not used
17	Not used
18	Not used
19	Not used
20	Not used
21	Not used
22	Not used
23	Not used
24	Not used
25	Diagnosis line "K"
26	Not used
27	Not used
28	Positive connected to +15 (key switch in ON position)
29	Not used
30	Power supply negative for accelerator position sensor (pin 3)
31	Power supply negative for accelerator position sensor (pin 6)
32	Not used
33	Not used
34	Not used
35	Not used

36	Not used
37	Not used
38	Not used
39	Not used
40	Not used
41	Not used
42	Not used
43	Not used
44	Not used
45	Power supply negative for accelerator position sensor (pin 2)
46	Power supply negative for accelerator position sensor (pin 1)
47	Not used
48	Engine speed output signal
49	Not used
50	Not used
51	Not used
52	Connected to the "D" pin of the engine pre-heating plug control unit
53	Not used
54	Not used
55	Not used
56	Not used
57	Not used
58	Not used
59	Not used
60	Not used
61	CAN line L
62	CAN line H
63	Not used
64	Not used
65	Not used
66	Not used
67	Not used
68	Negative pole for relay energization (K6) of the heating element on the fuel filter
69	Not used
70	Not used
71	EDC warning light control
72	Negative pole for relay energization (K3) of the main EDC relay
73	Not used
74	Not used
75	Not used
76	Not used
77	Not used
78	Not used
79	Not used
80	Not used
81	Not used
82	Not used
83	Not used
84	Not used
85	Not used
86	Not used
87	Not used
88	Not used
89	Not used
90	Not used
91	Negative pole to energize the relay (K5) to power feed the fuel electric pump
92	Engine pre-heating plug warning light control
93	Connected to the "ST" pin of the engine pre-heating plug control unit
94	Not used

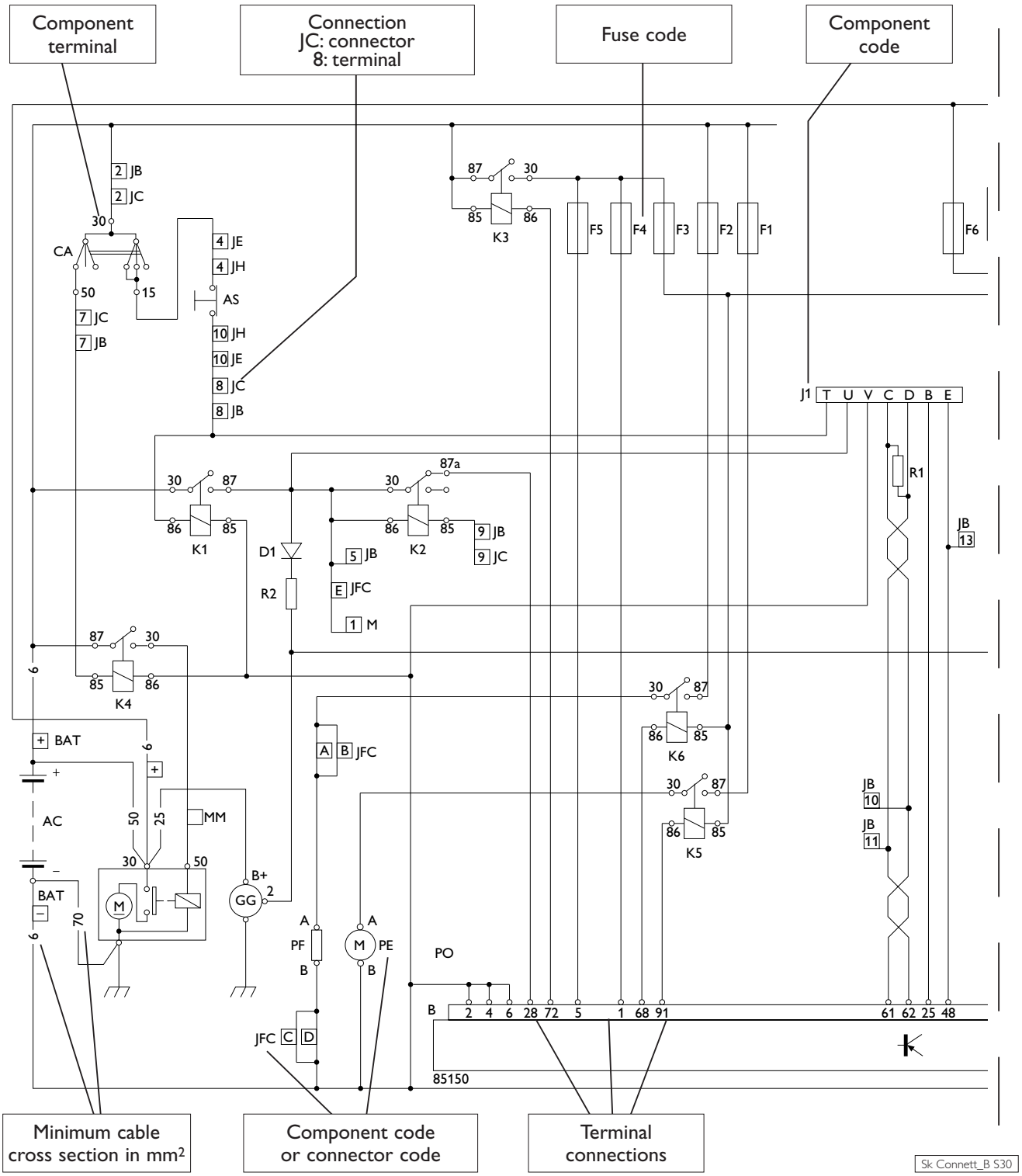
WIRING DIAGRAMS

Wiring diagram key

General conditions for the preparation and interpretation of wiring diagrams

- ❑ Key switch open
- ❑ Engine not running
- ❑ Liquids at efficient levels and pressures

Figure 29



Electrical equipment component code

A	fuel temperature sensor for EDC
B	drive shaft sensor
C	camshaft sensor
F	engine coolant temperature sensor for EDC
H	combustion air pressure/temperature sensor for EDC
I	coolant high temperature sensor
K	air filter clogging sensor (for alarm)
L	instrument panel light switch
M	sensor for detecting the presence of water in the fuel pre-filter (for alarm)
O	exhaust gas temperature sensor
T	coolant temperature sensor (for gauge)
V	oil pressure sensor (for gauge)
W	engine oil low pressure sensor
Z	fuel filter clogging sensor
P1	sound alarm inhibition push-button
R1	120 Ω resistor for CAN line balancing
R2	alternator pre-excitation resistor
AC	battery
AQ	engine shut-off push-button on main panel
AS	engine shut-off push-button on secondary panel
CA	key switch
CC	engine pre-heating glow plugs electronic control unit
CS	engine start push-button on secondary panel
E1, E2, E3, E4	electro-injector
G1, G2, G3, G4	engine pre-heating glow plugs
GG	alternator
MM	electric starter motor
MS	IVECO MOTORS-FPT indications and alarms module
PA	throttle position sensor
PE	fuel electric pump
PF	heating element on fuel filter
PR	rail pressure sensor
QP	main analog instrument panel
QS	secondary analog instrument panel
SA	buzzer
WI	low gear box oil pressure sensor (7 bar)
ZH	pressure control solenoid valve
85150	ECU of the EDC system

(continues on next page)

Electrical equipment component code (follows)

Connectors

A	60 pole EDC engine components
B	94 pole EDC electro-injectors
J1	external diagnostic tool (on the relay box panel)
JB ON ENGINE WIRE HARNESS	set for connection to the main analog instrument-panel or to the interface wire harness for converter module
JC ON MAIN ANALOG INSTRUMENT PANEL	set for connection to the engine wire harness
JD	IVECO MOTORS-FPT indications and alarms module
JE ON MAIN ANALOG INSTRUMENT PANEL	set for connection to the secondary analog instrument panel
JH ON SECONDARY ANALOG INSTRUMENT PANEL	set for connection to the main analog instrument-panel

vIndicator lights

EDC	EDC malfunction
SAC	presence of water in fuel pre-filter
SATA	high coolant temperature
SBLA	low coolant level
SBPO	low oil pressure
SCP	pre-post heating
SIFA	clogged air filter
SIFB	clogged oil vapor filter
SIFC	clogged fuel filter
SIFO	clogged oil filter
SP	pre-lubrication
SS	alternator fault
SSV	runaway engine

Gauges

CG	revolution-counter
MI	gear box oil pressure gauge
MO	engine oil pressure gauge
TA	engine temperature
TI	gear box oil temperature
TS	exhaust gas temperature
V	voltmeter

Remote control switches mounted on the relay box

K1	key switch electric discharge
K2	emergency engine shut-down provision
K3	EDC main (power supply
K4	power supply to terminal 50 of the electric starter motor
K5	fuel electric pump power supply
K6	fuel filter heater element power supply

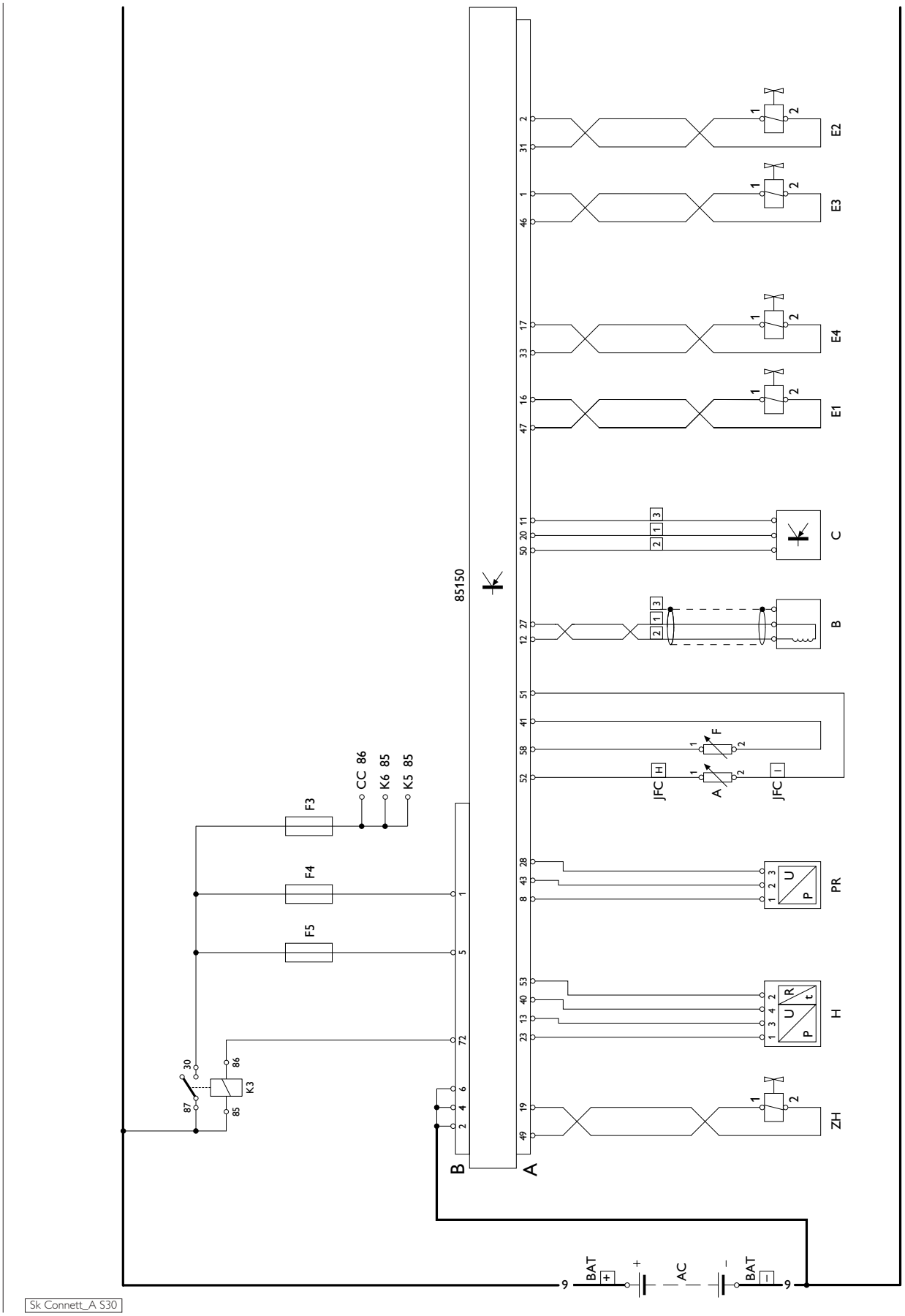
Fuses mounted on the relay box

F1	fuel electric pump
F2	heating element on fuel filter
F3	power supply to the heater plug control unit (15 A)
F4	EDC (10 A)
F5	EDC (25 A)

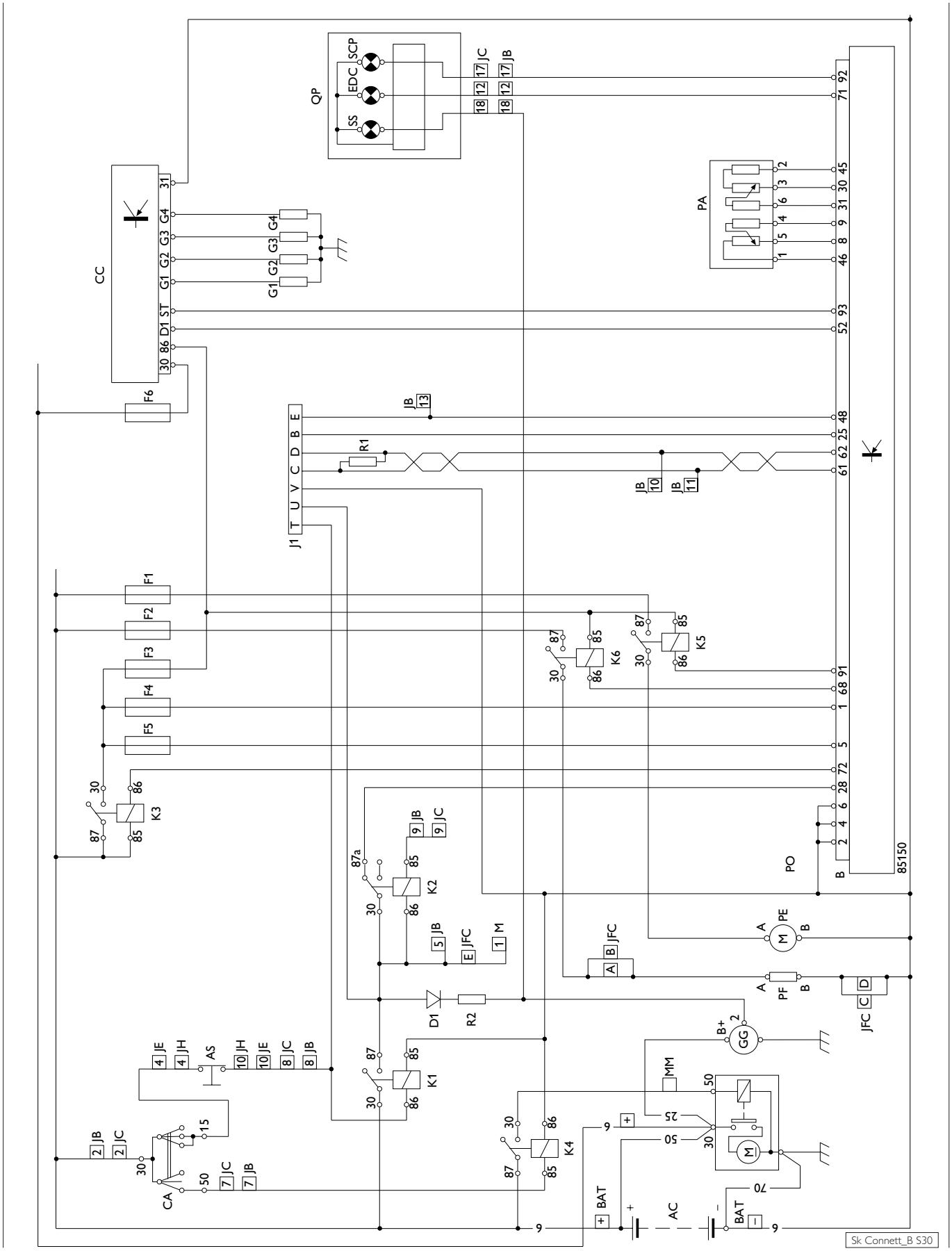
Maxi fuse

F6	heater plug power circuit

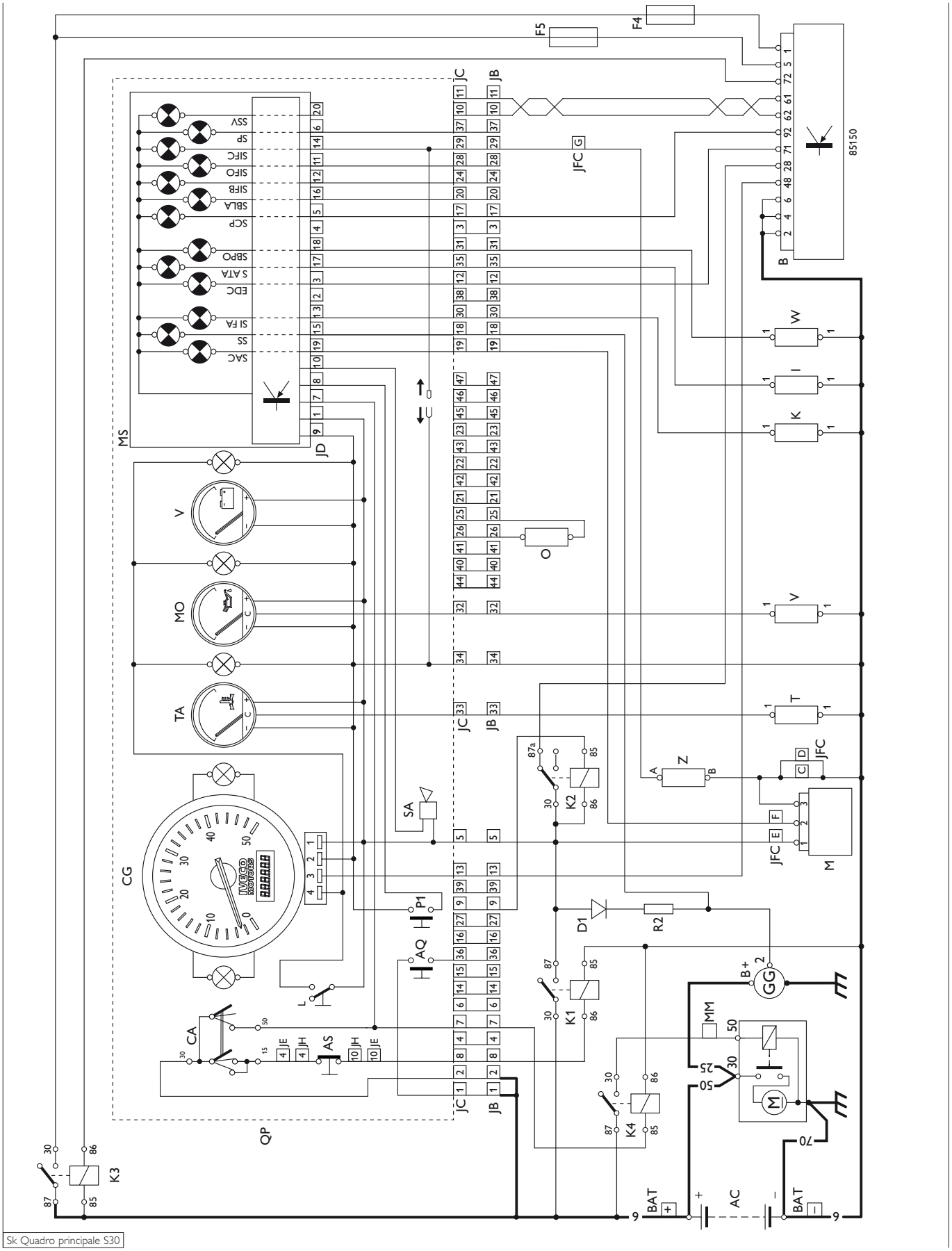
EDC connector A



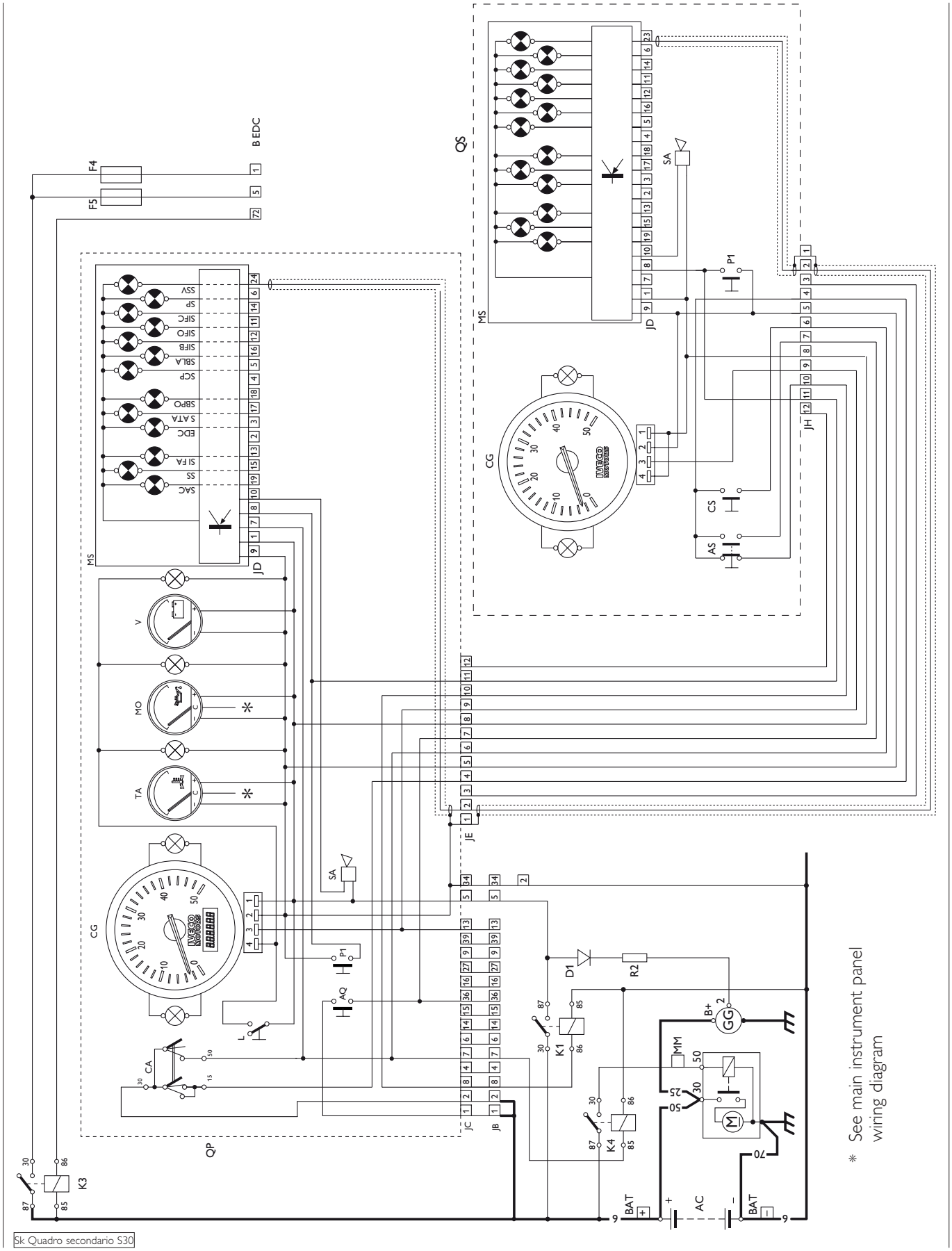
EDC connector B



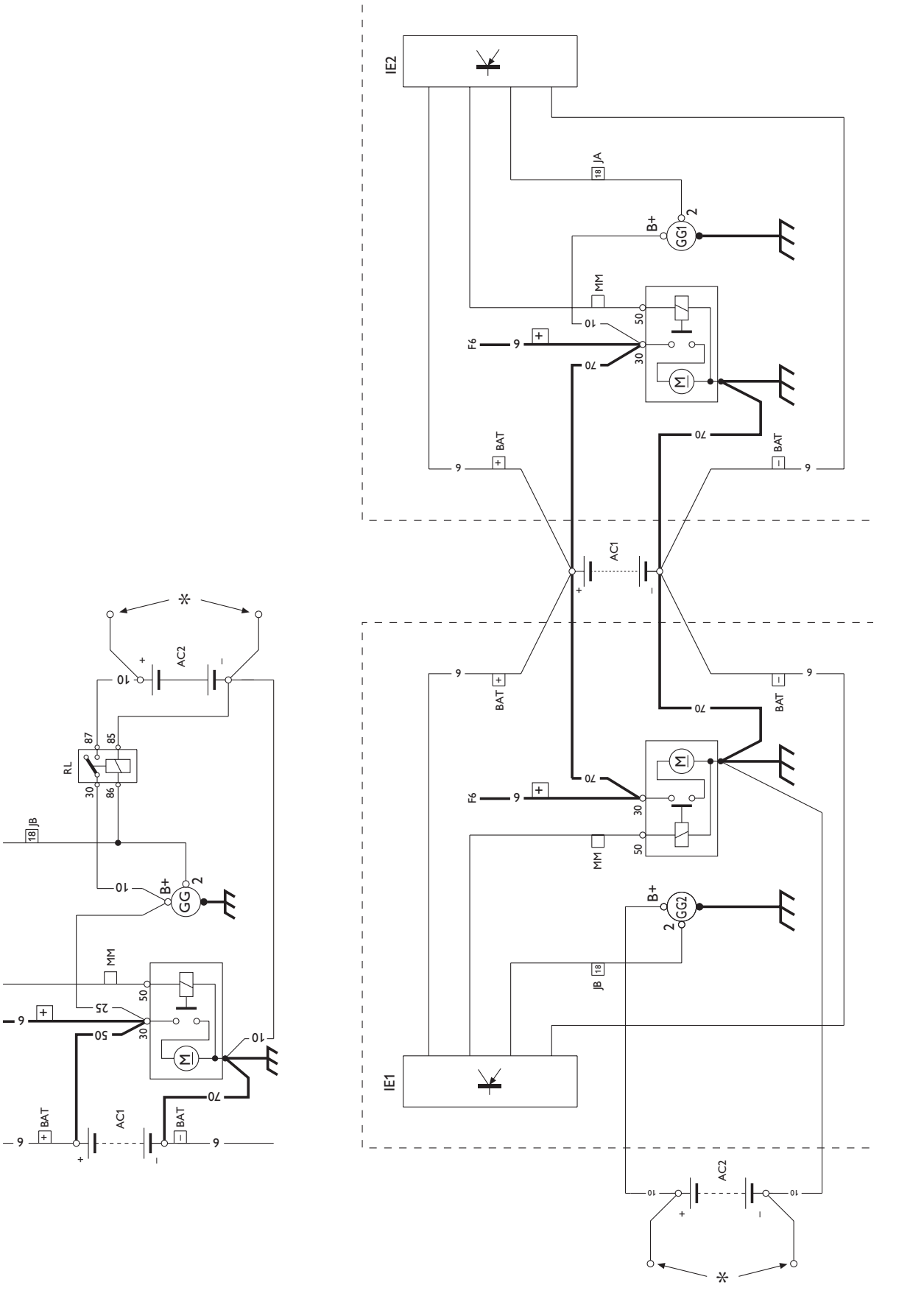
Main analog instrument panel



Secondary analog instrument panel



Supplementary services battery recharge



PAGE LEFT INTENTIONALLY BLANK

SECTION 4

DIAGNOSTICS

PAGE LEFT INTENTIONALLY BLANK

FOREWORD

A proper diagnosis is reached through the competence acquired with years of experience and attending training courses.
When the user complains of poor performance or operating anomalies, due consideration must be given to his/her indications, in order to derive useful information that will orient our actions.
After ascertaining the existence of the anomaly, we recommend starting troubleshooting operations by decoding the self-diagnosing data of the Central Electronic Unit of the EDC system.
The continuous operating tests on the components connected to it and the test of the operation of the entire system periodically carried out while in operation, provide an important diagnostic indication, made available by decoding the "error/anomaly" codes issued by the blinking of the fault indicator light: the "blink-code".
Using computerized IVECO MOTORS-FPT instruments, IT 2000 and PT 01, two-way communications can be established with the central unit, enabling not only to decode the error codes but also to route the investigation in its memory to retrieve the additional information required to determine the origin of the fault.
Every time a problem is notified and its existence is ascertained, you must query the electronic unit in one of the ways indicated and then proceed with troubleshooting with tests and measurements, to obtain a picture of the overall operating conditions and identify the real causes of the fault.
If the electronic unit provides no indications, proceed through experience, adopting traditional diagnostic modes.
Technicians and maintenance personnel are advised, in these cases, to check ratings and technical data prescribed in the "S30 ENT M23 Installation Directive" document.
In order to partly overcome service personnel's lack of experience with this new system, we have provided, in the pages that follow, a TROUBLESHOOTING GUIDE.

The guide comprises two distinct sections:

- The first one, organized by Blink Code, involves the anomalies identified by the EDC 16 unit, mainly electrical or electronic in nature;
- The second one, organized by symptoms, describes the possible anomalies not recognized by the electronic unit, frequently mechanical or hydraulic in nature.

For operation and maintenance instructions, see the indications provided in Section 5.

ECU BEHAVIOUR

Anomalies indicator light

The ECU continuously monitors, with complex self-testing routines, its own operating conditions as well as those of the components connected to it and of the engine.
When anomalies are detected, the alarm indicator light on the indicator and control panel is lighted in manners that provide a first indication on the severity of the problem.

Light off:	no anomaly detected or slight anomaly that does not compromise operating safety
Light on:	significant anomaly, allowing to proceed to a service center
Blinking light:	severe anomaly requiring immediate repairs. If possible, shut the engine down.

Recovery

The recognition of significant or severe anomalies causes the adoption of strategies that allow to use the engine with complete safety, guaranteed by limiting performance within pre-set thresholds according to the severity of the case.

These strategies cause the reduction of the maximum values of torque and power delivered by the engine.
In the case of intermittent anomalies, i.e. recognized by the ECU and subsequently no longer present, performance reduction will continue until the engine is shut down.

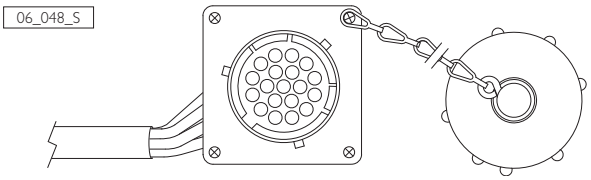
Normal operation will be restored only the next time the engine is started, while the anomaly data will be "saved" in the failure memory.

NOTE

Identification of severe anomalies of the accelerator position sensor, causes the ECU to increase the engine rpm from about 800 rpm to about 1050 rpm, in order to achieve a minimum engine thrust and allow manoeuvers.

Error deletion procedure

Figure 1



It will be possible through the IVECO PT01 device connected to the dedicated J1 diagnostic connector.

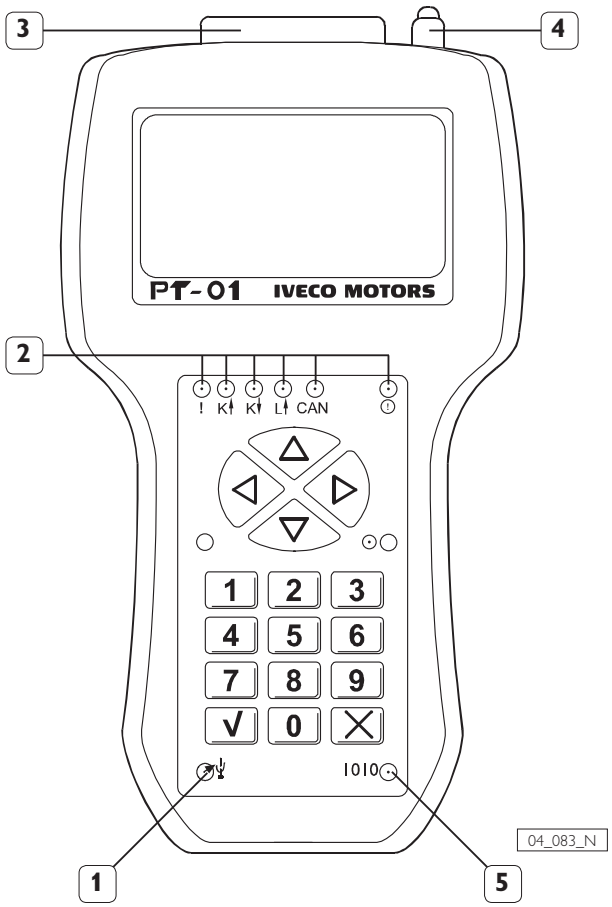
CAUTION

The mistake deleting procedure is intended to eliminate the information relating to the mistakes from the ECU memory, which happened during previous working periods. The mistakes will not be deleted unless the relating cause has been removed. Please remember that some anomalies can be detected by the ECU self-diagnosis only during a complete engine working cycle.

DIAGNOSING WITH PT-01 INSTRUMENT

Engine diagnosing must be done with the IVECO MOTORS-FPT PT-01 instrument.

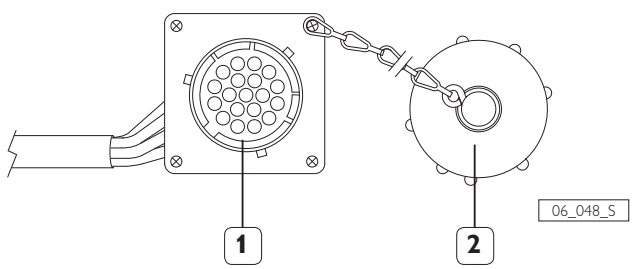
Figure 2



1. USB Indicator light - 2. LEDs signalling communication between instrument and central unit, and correct power supply - 3. Connector to engine diagnosing outlet - 4. Connector for outside power supply - 5. Serial port indicator light.

Connect the instrument with the dedicated cable to the diagnosis connector J1(2) on the relay box (Fig. 3).

Figure 3



1. Connector for external diagnosis instrument (J1) - 2. Protective cap.

The instrument is powered directly from the diagnosing outlet. In case of prolonged use with the engine off, the instrument can be powered externally through the connector (4) of Fig. 2.
After establishing the connection between the instrument and the diagnosing outlet, the instrument displays available applications.

Functions of the Instrument

Through the numeric keypad (0 to 9) select the application and confirm it with the ☑ key.

The second screen shows information about the software version of the selected application.

To start the actual diagnosis procedure, press the ☑ key.

```
1. Diagnosing      ↑
2. Programming
3. Utility
4. Download        ↓
```

CAUTION

The two arrows ↑↓ , when present, signal that other options are available but not displayed.
To display them, use the ↑↓ arrows on the keypad.

To access the diagnosing procedure, press the **1** key and confirm with the ☑ key.

The instrument displays the following options:

```
1. Identifier
2. Fault memory
3. Parameter reading
4. Active diagnostics
```

The operation is selected by pressing the associated numeric key and confirming it with the ☑ key.

To go back to the previous screen, press the ☒ key.

Identifier

This option allows to obtain the following information, relating specifically to the central unit system:

- Operator code;
- Station type;
- Station number;
- Date programmed;
- Release;
- Type of ECU;
- ECU software version;
- Job Number;
- Engine type;

- Original engine type;
- Engine serial number;
- Alphanumeric code.

Fault Memory

This option allows to display the faults that occurred during operation. They are grouped in two categories:

- Intermittent;
- Present.

Faults indicated as intermitted occurred previously but are not present at the time the fault memory is read. Faults indicated as present are such or occurred during the last period of operation of the engine. In this case, shutting the engine down and starting it again will cause the indication to change to intermittent.

First screen

```
1. Present
2. Intermittent
```

NOTE: *When both types of fault are present.*

Second screen

```
Intermittent          ↑
Type of fault         ▶
                      ↓
```

Use the arrows ↑↓ to scroll through the list of present fault, while the symbol ▶ indicates the presence of additional information available for display with the → key. This additional information is about system conditions (temperature, engine rpm, etc.).

Errors detectable by the system and that may be displayed with the instrument are:

Sensors
- Throttle;
- Water temperature;
- Supercharging air temperature;
- Fuel temperature;
- Supercharging pressure;
- Ambient pressure;
- Flywheel;
- Camshaft;
- Quantity of air taken in.

Engine
- Engine overspeed;
- Injectors;
- Pre-post heating control system.

Relays
- Main;
- Fuel filter heater.

Power supply voltage

Indicator lights
- EDC.

Central Unit
- Invalid data set;
- Incorrect data storage;
- Internal fault (Gate Array);
- Sensors power supply;
- Internal fault (re-initialization);
- Incorrect engine shutdown;
- Defective EEPROM.

Parameter reading

Parameters available for display are grouped into two categories:

- Measurable;
- State.

List of measurable parameters
- Engine RPM;
- Injection advance;
- Battery voltage;
- Throttle lever position;
- Supercharging pressure;
- Supercharging air temperature;
- Water temperature;
- Fuel temperature;
- Fuel delivery;
- Fuel pressure.

List of ECU state parameters
- Key set on run (+15);
- Idle switch (in throttle potentiometer);
- EDC indicator light;
- Blink Code push-button;
- Fuel filter heater relay.

Active diagnostics

Active diagnostics consist of electrically commanding the components to verify their operating condition.

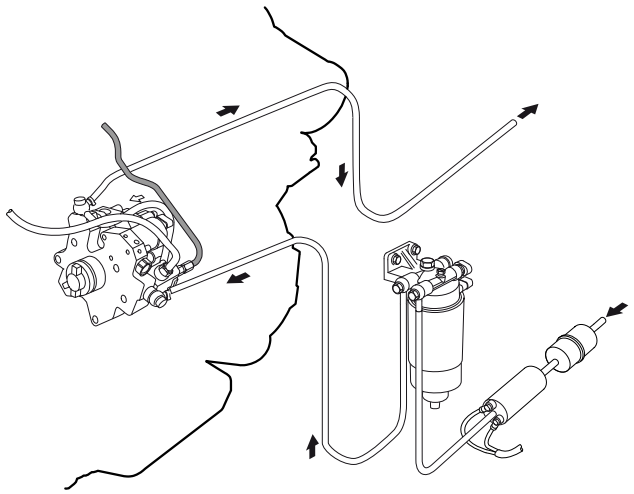
The components driven by the instrument are:
- Fuel filter heater relay;
- EDC indicator light.

MAJOR DIAGNOSTIC ACTIONS

The following is a description of the procedures to carry out the major instrumental measurements mentioned in the diagnostics guide.

Checking pressure in fuel supply line

Figure 4



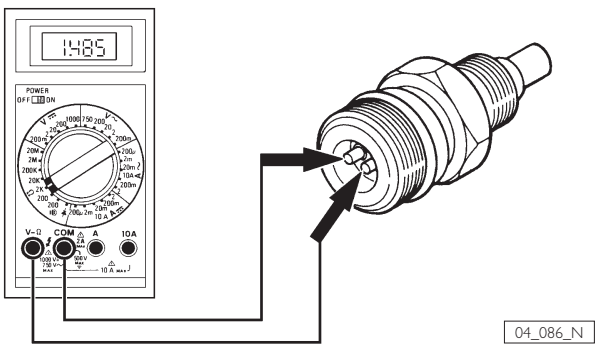
Gauges will be interposed in A and B by "T" unions. Measurements have to be carried out at various engine speeds from minimum to maximum at intervals of 200 RPM.

Acceptable limit ratings

Point	Minimum	Maximum
A	- 50 kPa	0 kPa
B	0 kPa	20 kPa

Checking component resistance value

Figure 5



Ensure that the system is not powered.
The measurement must be taken on each individual component, isolated from its wiring or connected only to the instrument, set as ohmmeter on the appropriate end of scale value (see REFERENCE VALUE table in the pages that follow). At the end, restore the correct connection.

Checking line insulation

Figure 6

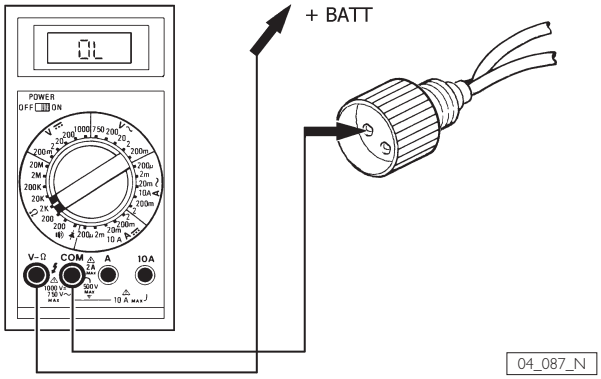
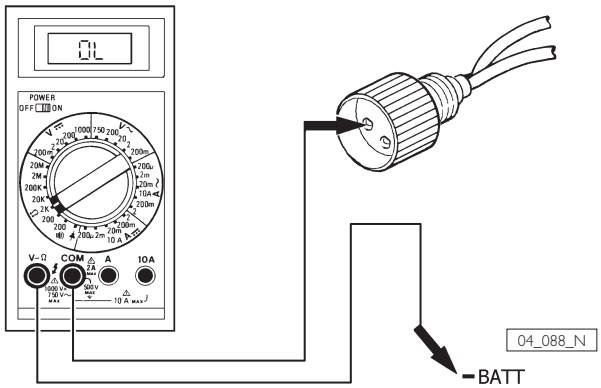


Figure 7



Ensure that the system is not powered. The measurement must be taken on each individual conductor, isolated from all the components to which it is normally connected.The measurement must be taken with the instrument set as ohmmeter on end of scale value ≥ 200 KΩ, and it must be taken both towards the positive potential and the negative battery potential. At the end, restore the correct connection.

REFERENCE VALUES

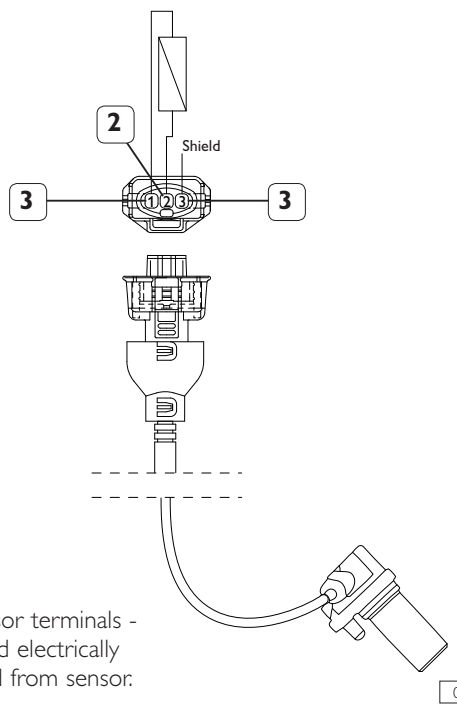
For non hardwired sensors

Component	Test conditions	Minimum Ω value	Maximum Ω value
Intake air temperature sensor	-10 °C	8100	10800
	0 °C	5200	6750
Coolant temperature sensor	20 °C	2300	2700
Fuel temperature sensor	50 °C	730	950
	80 °C	300	360
Flywheel position and rotation sensor	20 °C	800	1000
Electro-injector coil	-	0.2	0.4
Electrical fuel heater element	-	2.5	3
Pressure regulator solenoid valve	-	2.5	3

CAUTION

Measurements refer only to the reference component.
The actual measurement of limited values of resistance requires the use of instruments with the SELF-ZEROING function or, if these are not available, subtract from the value displayed the short-circuit value of the instrument prods.
Measurements closest to reality are taken including the wiring from the ECU to the sensor.
Always check the continuity of the SHIELD conductor from the sensor to the ECU and the latter's good insulation from the other signal conductors.

Sensors wired with shielded wires



1, 2. Sensor terminals - 3. Shield electrically insulated from sensor.

04_073_S

REFERENCE VALUES

For wired sensors powered by the ECU

Component	ECU connection	Test conditions	Minimum - maximum value
Combustion air temperature sensor signal	A53 A23	Panel key ON	0.5 to 4.5 Vcc
Coolant temperature sensor signal	A54 A41	Panel key ON	0.5 to 4.5 Vcc
Fuel oil temperature sensor signal	A52 A51	Panel key ON	0.5 to 4.5 Vcc
Flywheel position and rotation sensor signal	A12 A27	Engine running 650 rpm	> 0.8 Vac
Combustion air absolute pressure sensor signal	A40 A23	Engine running 900 rpm	0.9 to 1.1 Vcc
Combustion air absolute pressure sensor power supply	A13 A23	Panel key ON	4.5 to 5.5 Vcc
Fuel pressure sensor power supply	A28 A8	Panel key ON	4.5 to 5.5 Vcc

GUIDE TO THE DIAGNOSIS OF DTC-FMI ERROR CODES

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
11	01	ENGINE 1 - BOOST PRESSURE SENSOR	EXCEEDED UPPER LIMIT	Positive power reduction and smoke in exhaust.		Check wiring and connectionsPossibly replace sensor. Check in "measurable parameter" environment that atmospheric pressure sensor and turbo charger air pressure sensor values are similar when engine is off.				Possible smoke in exhaust during acceleration. Replace sensor if required.
11	02	ENGINE 1 - BOOST PRESSURE SENSOR	BELOW LOWER LIMIT	Positive power reduction and smoke in exhaust.		Check wiring and connections. Replace sensor if required.				Possible smoke in exhaust during acceleration. Replace sensor if required.
11	08	ENGINE 1 - BOOST PRESSURE SENSOR	SIGNAL NOT PLAUSIBLE	Positive power reduction and smoke in exhaust.	Faulty sensor.	Check wiring and connections. Replace sensor if required.				
12	01	ENGINE 2 - BATTERY VOLTAGE	EXCEEDED UPPER LIMIT	Problematic cranking.	Flat battery, interrupted wiring.	Check battery state with diagnostic tool (measurable parameters). Check wiring and connections.				Replace alternator, regulator or battery.
12	02	ENGINE 2 - BATTERY VOLTAGE	BELOW LOWER LIMIT	Engine does not start. Possible power reduction.	Faulty battery, faulty alternator, faulty ECU.	Check with diagnostic tool.				Replace battery, alternator or ECU if required.

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
14	01	ENGINE 1 - COOLANT TEMPERATURE SENSOR	EXCEEDED UPPER LIMIT	Problematic cold cranking. Possible power reduction.	Faulty sensor;interrupted wiring.	Check wiring and connections. Replace sensor if required.	1 - Measure type: Resistance (KOhm) Measure point 1: Sensor Pin: 1 Measure point 2: Sensor Pin: 2	Connector Not connected; Key +15 OFF;	Min.value: 0.11 KOhm; Max.value: 48.3 KOhm; Typical Value: 2.5 KOhm @ 20°C.	
							2 - Measure type: Resistance (Ohm) Measure point 1: ECU Pin: A58 Measure point 2: Sensor Pin: 1	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	
							3 - Measure type: Resistance (Ohm) Measure point 1: ECU Pin: A41 Measure point 2: Sensor Pin: 2	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	
14	02	ENGINE 1 - COOLANT TEMPERATURE SENSOR	BELOW LOWER LIMIT	Problematic cold cranking. Possible power reduction.	Faulty sensor;interrupted wiring.	Check wiring and connections. Replace sensor if required.	1- Measure type: Resistance (KOhm) Measure point 1: Sensor Pin: 1 Measure point 2: Sensor Pin: 2	Connector Not connected; Key +15 OFF;	Min.value: 0.11 KOhm; Max.value: 48.3 KOhm; Typical Value: 2.5 KOhm @ 20°C.	
							2- Measure type: Resistance (Ohm) Measure point 1: ECU Pin: A58 Measure point 2: Sensor Pin: 1	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	
							3- Measure type: Resistance (Ohm) Measure point 1: ECU Pin: A41 Measure point 2: Sensor Pin: 2	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
14	08	ENGINE 1 - COOLANT TEMPERATURE SENSOR	SIGNAL NOT PLAUSIBLE	Problematic cold cranking. Possible power reduction.	Faulty sensor;interrupted wiring.	Check wiring and connections. Replace sensor if required.	1- Measure type: Resistance (KOhm) Measure point 1: Sensor Pin:1 Measure point 2: Sensor Pin:2	Connector Not connected; Key +15 OFF;	Min.value: 0.11 KOhm; Max.value: 48.3 KOhm; Typical Value: 2.5 KOhm @ 20°C.	
							2- Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A58 Measure point 2: Sensor Pin:1	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	
							3- Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A41 Measure point 2: Sensor Pin:2	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	
15	01	ENGINE 1 - COOLANT TEMPERATURE SENSOR (TEST)	EXCEEDED UPPER LIMIT		Faulty coolant temperature sensor.	Replace sensor.	1- Measure type: Resistance (KOhm) Measure point 1: Sensor Pin:1 Measure point 2: Sensor Pin:2	Connector Not connected; Key +15 OFF;	1- Min. value: 0.11 KOhm; Max. value: 48.3 KOhm; Typical Value: 2.5 KOhm;	
							2- Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A58 Measure point 2: Sensor Pin:1	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	
							3- Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A41 Measure point 2: Sensor Pin:2	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
24	01	ENGINE SPEED - CAMSHAFT SENSOR	EXCEEDED UPPER LIMIT	Possible problematic cold cranking.	No signal, open circuit.	Check wiring and connections.				Flywheel sensor timing signal adopted if camshaft signal is not correct.
24	02	ENGINE SPEED - CAMSHAFT SENSOR	BELOW LOWER LIMIT	Possible problematic cold cranking.	No signal, open circuit, faulty sensor.	Check correct assembly of sensor and phonic wheel, check engine timing.				Flywheel sensor timing signal adopted if camshaft signal is not correct.
25	01	ENGINE SPEED - CRANKSHAFT SENSOR	EXCEEDED UPPER LIMIT	Problematic cold cranking, power reduction (possible noise due to missed pre-injection).	Faulty sensor.	Check wiring and connections.				Camshaft sensor speed adopted if signal is not present.
25	02	ENGINE SPEED - CRANKSHAFT SENSOR	BELOW LOWER LIMIT	Problematic cold cranking, power reduction (possible noise due to missed pre-injection).	Faulty sensor.	Check wiring and connections.				Camshaft sensor speed adopted if signal is not present.
26	01	ENGINE SPEED - FAULT BETWEEN FLYWHEEL SENSOR AND CAMSHAFT	EXCEEDED UPPER LIMIT	Possible power reduction.	Incorrect camshaft phonic wheel assembly.	Check wiring, connections and sensor, check that phonic wheel is fitted correctly.				Longer cranking time.

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
28	01	ENGINE 1 - FUEL TEMPERATURE SENSOR	EXCEEDED UPPER LIMIT	Possible power reduction.	Short-circuit to positive, excessively low temperature is detected.	Check wiring and connections. Replace sensor if required.	1- Measure type: Resistance (Ohm) Measure point 1: Sensor Pin:1 Measure point 2: Sensor Pin:2	Connector Not connected; Key +15 OFF;	Min. value: 0.11 KOhm; Max. value: 48.3 KOhm; Typical Value: 2.5 KOhm @ 20°C.	
							2- Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A52 Measure point 2: Sensor Pin:1	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	
							3- Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A51 Measure point 2: Sensor Pin:2	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	
28	02	ENGINE 1 - FUEL TEMPERATURE SENSOR	BELOW LOWER LIMIT	Possible power reduction.	Short-circuit to ground, excessively high temperature is detected.	Check wiring and connections. Replace sensor if required.	1- Measure type: Resistance (Ohm) Measure point 1: Sensor Pin:1 Measure point 2: Sensor Pin:2	Connector Not connected; Key +15 OFF;	Typical Value: 1 Ohm	
							2- Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A52 Measure point 2: Sensor Pin:1	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	
							3- Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A51 Measure point 2: Sensor Pin:2	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
2A	01	ENGINE 1 - PRE-HEATING RELAY FUEL FILTER	EXCEEDED UPPER LIMIT	Fuel filter pre-heater relay not working.	Filter heater relay short-circuit to positive -Heater always on also at fuel temperature >5°C.	Check wiring and connections. Replace sensor if required.				Battery goes flat.
2A	02	ENGINE 1 - PRE-HEATING RELAY FUEL FILTER	BELOW LOWER LIMIT	Fuel filter pre-heater relay not working.	Filter heater relay short-circuit to ground.	Check wiring and connections. Replace sensor if required.				Battery goes flat.
2A	04	ENGINE 1 - PRE-HEATING RELAY FUEL FILTER	NO SIGNAL	Fuel filter pre-heater relay not working.		Check wiring and connections. Replace sensor if required.				Battery goes flat.
2A	08	ENGINE 1 - PRE-HEATING RELAY FUEL FILTER	SIGNAL NOT PLAUSIBLE	Fuel filter pre-heater relay not working.		Check wiring and connections. Replace sensor if required.				Battery goes flat.
2F	01	ENGINE 2 - GLOW PLUGS RELAY	EXCEEDED UPPER LIMIT	Possible problematic cold cranking.	Short-circuit to positive, glow plugs always on also with ECU off, possible battery deployment.	Check wiring and connections. Replace sensor if required.				
2F	02	ENGINE 2 - GLOW PLUGS RELAY	BELOW LOWER LIMIT		Short-circuit to ground, glow plugs always on.	Check wiring and connections. Replace sensor if required.				

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
2F	04	ENGINE 2 - GLOW PLUGS RELAY	NO SIGNAL	Possible problematic cold cranking.	Faulty wiring.	Check wiring and connections. Replace sensor if required.				
2F	08	ENGINE 2 - GLOW PLUGS RELAY	SIGNAL NOT PLAUSIBLE	Possible problematic cold cranking.	Faulty relay, wiring interrupted.	Check wiring and connections. Replace sensor if required.				
30	01	ENGINE 2 - GLOW PLUG W/LIGHT	EXCEEDED UPPER LIMIT	Warning light always off. Problematic cold cranking. Pre-heater warning light always on.	Short-circuit to positive.	Check wiring and connections.				The driver does not wait pre-heating even when the room temperatures are low, because no warning light signal is enabled. Preheating works, but with cold start-up no indication is available that tells you when to start the motor because the light is always turned on.

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
30	02	ENGINE 2 - GLOW PLUG W/LIGHT	BELOW LOWER LIMIT	Warning light always off. Problematic cold cranking. Pre-heater warning light always on.	Short-circuit to ground.	Check wiring and connections.				The driver does not wait pre-heating even when the room temperatures are low, because no warning light signal is enabled. Preheating works, but with cold start-up no indication is available that tells you when to start the motor because the light is always turned on.
30	04	ENGINE 2 - GLOW PLUG W/LIGHT	NO SIGNAL	Warning light always off. Problematic cold cranking. Pre-heater warning light always on.		Check wiring and connections.				Warning light off during pre-heating. Replace bulb if required.
30	08	ENGINE 2 - GLOW PLUG W/LIGHT	SIGNAL NOT PLAUSIBLE	Warning light always off. Problematic cold cranking. Pre-heater warning light always on.		Check wiring and connections.				Warning light off during pre-heating. Replace bulb if required.

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
31	01	ENGINE 2 - GLOW PLUGS	EXCEEDED UPPER LIMIT	Possible problematic cold cranking.	Short-circuit to positive.	Check wiring and connections. Check electrical system between relay and glow plugs.				Relay unit always on also with ECU off, possible battery deployment.
32	01	ELECTRONIC CONTROL UNIT - INTERNAL ECU FAULT	EXCEEDED UPPER LIMIT		Faulty ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call MOTORS-FPT for instructions on how to replace the ECU.				
33	01	ELECTRONIC CONTROL UNIT - INTERNAL ECU FAULT	EXCEEDED UPPER LIMIT	The engine switching off-data are not memorized. The failures memory is lost, only the present failures and not the intermittent ones can be read.	Faulty ECU EEPROM.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call MOTORS-FPT for instructions on how to replace the ECU.				

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
33	02	ELECTRONIC CONTROL UNIT - INTERNAL ECU FAULT	BELOW LOWER LIMIT	The engine switching off-data are not memorized. The failures memory is lost, only the present failures and not the intermittent ones can be read.	Faulty ECU EEPROM.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call MOTORS-FPT for instructions on how to replace the ECU.				
33	04	ELECTRONIC CONTROL UNIT - INTERNAL ECU FAULT	NO SIGNAL	The engine switching off-data are not memorized. The failures memory is lost, only the present failures and not the intermittent ones can be read.	Faulty ECU EEPROM.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call MOTORS-FPT for instructions on how to replace the ECU.				

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
33	08	ELECTRONIC CONTROL UNIT - INTERNAL ECU FAULT	SIGNAL NOT PLAUSIBLE	The engine switching off-data are not memorized. The failures memory is lost, only the present failures and not the intermittent ones can be read.	Faulty ECU EEPROM.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call MOTORS-FPT for instructions on how to replace the ECU.				
34	08	ELECTRONIC CONTROL UNIT - INTERNAL ECU FAULT	SIGNAL NOT PLAUSIBLE		Wrong ECU programming. Probable electromagnetic interference. Faulty ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call MOTORS-FPT for instructions on how to replace the ECU.				

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
35	08	ELECTRONIC CONTROL UNIT - INTERNAL ECU FAULT	SIGNAL NOT PLAUSIBLE		Wrong ECU programming. Probable electromagnetic interference. Faulty ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call MOTORS-FPT for instructions on how to replace the ECU.				
36	08	ELECTRONIC CONTROL UNIT - INTERNAL ECU FAULT	SIGNAL NOT PLAUSIBLE		Wrong ECU programming. Probable electromagnetic interference. Faulty ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call MOTORS-FPT for instructions on how to replace the ECU.				

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
37	01	ELECTRONIC CONTROL UNIT - INTERNAL ECU FAULT	EXCEEDED UPPER LIMIT		Wrong ECU programming. Probable electromagnetic interference. Faulty ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call MOTORS-FPT for instructions on how to replace the ECU.				
38	02	ELECTRONIC CONTROL UNIT - INTERNAL ECU FAULT	BELOW LOWER LIMIT		Wrong ECU programming. Probable electromagnetic interference. Faulty ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call MOTORS-FPT for instructions on how to replace the ECU.				
39	01	ENGINE 1 - AIR TEMPERATURE SENSOR	EXCEEDED UPPER LIMIT	Problematic cranking, smoke, problematic acceleration.		Check wiring and connections. Replace sensor if required.	Measure type: Resistance (KOhm) Measure point 1: Sensor Pin: 1 Measure point 2: Sensor Pin: 2	Connector Not connected; Key +15 OFF;	Typical Value: 2.5 KOhm @ 20°C	Air temperature sensor and built-in pressure sensor.

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
39	02	ENGINE 1 - AIR TEMPERATURE SENSOR	BELOW LOWER LIMIT	Problematic cranking, smoke, problematic acceleration.	Short-circuit to ground, excessively high temperature is detected.	Check wiring and connections. Replace sensor if required.	Measure type: Resistance (KOhm) Measure point 1: Sensor Pin:1 Measure point 2: Sensor Pin:2	Connector Not connected; Key +15 OFF;	Typical Value: 2.5 KOhm @ 20°C	Air temperature sensor and built-in pressure sensor.
3C	01	INJECTOR - BENCH 1	EXCEEDED UPPER LIMIT	Engine not working properly, possible power reduction.	Injector wiring short-circuit.	Check wiring and connections. Replace injector if required.				Only two cylinders running.
3C	02	INJECTOR - BENCH 1	BELOW LOWER LIMIT	Engine not working properly, possible power reduction.	Short-circuit to ground.	Check wiring and connections.				Only two cylinders running.
3C	08	INJECTOR - BENCH 1	SIGNAL NOT PLAUSIBLE	Engine not working properly, possible power reduction.	Injector electrical system failure.	Check wiring and connections. Replace injector if required.				Only two cylinders running.
3D	04	INJECTOR - BENCH 1	NO SIGNAL	Engine not working properly, possible power reduction.	Injector wiring disconnected.	Check wiring and connections. Replace injector if required.				Only two cylinders running.
3E	01	INJECTOR - BENCH 2	EXCEEDED UPPER LIMIT	Engine not working properly, possible power reduction.	Injector wiring short-circuit.	Check wiring and connections. Replace injector if required.				Only two cylinders running.

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
3E	02	INJECTOR - BENCH 2	BELOW LOWER LIMIT	Engine not working properly, possible power reduction.	Short-circuit to ground.	Check wiring and connections.				Only two cylinders running.
3E	08	INJECTOR - BENCH 2	SIGNAL NOT PLAUSIBLE	Engine not working properly, possible power reduction.	Injector electrical system failure.	Check wiring and connections. Replace injector if required.				Only two cylinders running.
3F	04	INJECTOR - BENCH 2	NO SIGNAL	Engine not working properly, possible power reduction.	Injector wiring disconnected.	Check wiring and connections. Replace injector if required.				Only two cylinders running.
40	01	STAGE "A" INJECTORS CONTROL, CENTRAL UNIT INTERNAL PORTION	EXCEEDED UPPER LIMIT	Engine off.	Internal ECU problem.	Clear failure memory. If the error persists, ensure that the failure does not concern the injectors and call IVECOMOTORS-FPT instructions on how to replace the ECU.				

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
40	02	STAGE "A" INJECTORS CONTROL, CENTRAL UNIT INTERNAL PORTION	BELOW LOWER LIMIT	Engine off.	Internal ECU problem.	Clear failure memory. If the error persists, ensure that the failure does not concern the injectors and call IVECOMOTORS-FPT instructions on how to replace the ECU.				
40	04	STAGE "A" INJECTORS CONTROL, CENTRAL UNIT INTERNAL PORTION	NO SIGNAL	Engine off.	Internal ECU problem.	Clear failure memory. If the error persists, ensure that the failure does not concern the injectors and call IVECOMOTORS-FPT instructions on how to replace the ECU.				
40	08	STAGE "A" INJECTORS CONTROL, CENTRAL UNIT INTERNAL PORTION	SIGNAL NOT PLAUSIBLE	Engine off.	Internal ECU problem.	Clear failure memory. If the error persists, ensure that the failure does not concern the injectors and call IVECOMOTORS-FPT instructions on how to replace the ECU.				

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
41	01	STAGE "B" INJECTORS CONTROL, CENTRAL UNIT INTERNAL PORTION	EXCEEDED UPPER LIMIT	Engine off.	Internal ECU problem.	Clear failure memory. If the error persists, ensure that the failure does not concern the injectors and call IVECOMOTORS-FPT instructions on how to replace the ECU.				
41	02	STAGE "B" INJECTORS CONTROL, CENTRAL UNIT INTERNAL PORTION	BELOW LOWER LIMIT	Engine off.	Internal ECU problem.	Clear failure memory. If the error persists, ensure that the failure does not concern the injectors and call IVECOMOTORS-FPT instructions on how to replace the ECU.				
41	04	STAGE "B" INJECTORS CONTROL, CENTRAL UNIT INTERNAL PORTION	NO SIGNAL	Engine off.	Internal ECU problem.	Clear failure memory. If the error persists, ensure that the failure does not concern the injectors and call IVECOMOTORS-FPT instructions on how to replace the ECU.				

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
41	08	STAGE "B" INJECTORS CONTROL, CENTRAL UNIT INTERNAL PORTION	SIGNAL NOT PLAUSIBLE	Engine off.	Internal ECU problem.	Clear failure memory. If the error persists, ensure that the failure does not concern the injectors and call IVECOMOTORS-FPT instructions on how to replace the ECU.				
42	01	INJECTOR - INJECTOR 1	EXCEEDED UPPER LIMIT	Engine not working properly, possible power reduction.	Short-circuit to positive.	Check wiring and connections. Replace injector if required.	1- Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A47 Measure point 2: Injector Pin:2	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	Only three cylinders running.
							2- Measure type: Resistance (Ohm) Measure point 1: Injector Pin:1 Measure point 2: Injector Pin:2	Connector Not connected; Key +15 OFF;	1- Min. value: 0.5 Ohm; Max. value: 0.9 KOhm; Typical Value: 0.7 KOhm;	
							3- Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A16 Measure point 2: Injector Pin:1	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	
42	04	INJECTOR - INJECTOR 1	NO SIGNAL	Engine not working properly, possible power reduction.	Injector wiring short-circuit.	Check wiring and connections. Replace injector if required.	1- Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A47 Measure point 2: Injector Pin:2	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	Only three cylinders running.

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
							2- Measure type: Resistance (Ohm) Measure point 1: Injector Pin: 1 Measure point 2: Injector Pin: 2	Connector Not connected; Key +15 OFF;	1- Min. value: 0.5 Ohm; Max. value: 0.9 KOhm; Typical Value: 0.7 KOhm;	
							3- Measure type: Resistance (Ohm) Measure point 1: ECU Pin: A16 Measure point 2: Injector Pin: 1	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	
42	08	INJECTOR - INJECTOR 1	SIGNAL NOT PLAUSIBLE	Engine not working properly, possible power reduction.	Injector not working properly.	Check wiring and connections. Replace injector if required.	1- Measure type: Resistance (Ohm) Measure point 1: ECU Pin: A47 Measure point 2: Injector Pin: 2	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	Only three cylinders running.
							2- Measure type: Resistance (Ohm) Measure point 1: Injector Pin: 1 Measure point 2: Injector Pin: 2	Connector Not connected; Key +15 OFF;	1- Min. value: 0.5 Ohm; Max. value: 0.9 KOhm; Typical Value: 0.7 KOhm;	
							3- Measure type: Resistance (Ohm) Measure point 1: ECU Pin: A16 Measure point 2: Injector Pin: 1	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	
43	04	INJECTOR - INJECTOR 1	NO SIGNAL	Engine not working properly, possible power reduction.	Injector wiring open circuit.	Check wiring and connections. Replace injector if required.				Only three cylinders running.

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
44	01	INJECTOR - INJECTOR 2	EXCEEDED UPPER LIMIT	Engine not working properly, possible power reduction.	Short-circuit to positive.	Check wiring and connections. Replace injector if required.	1- Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A17 Measure point 2: Injector Pin:1	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	Only three cylinders running.
							2- Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A13 Measure point 2: Injector Pin:2	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	
							3- Measure type: Resistance (Ohm) Measure point 1: Injector Pin:1 Measure point 2: Injector Pin:2	Connector Not connected; Key +15 OFF;	1- Min. value: 0.5 Ohm; Max. value: 0.9 KOhm; Typical Value: 0.7 KOhm;	
44	04	INJECTOR - INJECTOR 2	NO SIGNAL	Engine not working properly, possible power reduction.	Injector wiring short-circuit.	Check wiring and connections. Replace injector if required.	1- Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A17 Measure point 2: Injector Pin:1	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	Only three cylinders running.
							2- Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A13 Measure point 2: Injector Pin:2	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	
							3- Measure type: Resistance (Ohm) Measure point 1: Injector Pin:1 Measure point 2: Injector Pin:2	Connector Not connected; Key +15 OFF;	1- Min. value: 0.5 Ohm; Max. value: 0.9 KOhm; Typical Value: 0.7 KOhm;	

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
44	08	INJECTOR - INJECTOR 2	SIGNAL NOT PLAUSIBLE	Engine not working properly, possible power reduction.	Injector not working properly.	Check wiring and connections. Replace injector if required.	1 - Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A17 Measure point 2: Injector Pin:1	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	Only three cylinders running.
							2 - Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A13 Measure point 2: Injector Pin:2	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	
							3 - Measure type: Resistance (Ohm) Measure point 1: Injector Pin:1 Measure point 2: Injector Pin:2	Connector Not connected; Key +15 OFF;	1 - Min. value: 0.5 Ohm; Max. value: 0.9 KOhm; Typical Value: 0.7 KOhm;	
45	04	INJECTOR - INJECTOR 2	NO SIGNAL	Engine not working properly, possible power reduction.	Injector wiring open circuit.	Check wiring and connections. Replace injector if required.				Only three cylinders running.
46	01	INJECTOR - INJECTOR 3	EXCEEDED UPPER LIMIT	Engine not working properly, possible power reduction.	Short-circuit to positive.	Check wiring and connections. Replace injector if required.				Only three cylinders running.
46	04	INJECTOR - INJECTOR 3	NO SIGNAL	Engine not working properly, possible power reduction.	Injector wiring short-circuit.	Check wiring and connections. Replace injector if required.				Only three cylinders running.
46	08	INJECTOR - INJECTOR 3	SIGNAL NOT PLAUSIBLE	Engine not working properly, possible power reduction.	Injector not working properly.	Check wiring and connections. Replace injector if required.				Only three cylinders running.

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
47	04	INJECTOR - INJECTOR 3	NO SIGNAL	Engine not working properly, possible power reduction.	Injector wiring open circuit.	Check wiring and connections. Replace injector if required.	1- Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A31 Measure point 2: Injector Pin:2	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	Only three cylinders running.
							2- Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A1 Measure point 2: Injector Pin:1	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	
							3- Measure type: Resistance (Ohm) Measure point 1: Injector Pin:1 Measure point 2: Injector Pin:2	Connector Not connected; Key +15 OFF;	1- Min. value: 0.5 Ohm; Max. value: 0.9 KOhm; Typical Value: 0.7 KOhm;	
48	01	INJECTOR - INJECTOR 4	EXCEEDED UPPER LIMIT	Engine not working properly, possible power reduction.	Short-circuit to positive.	Check wiring and connections. Replace injector if required.				Only three cylinders running.
48	04	INJECTOR - INJECTOR 4	NO SIGNAL	Engine not working properly, possible power reduction.	Injector wiring short-circuit.	Check wiring and connections. Replace injector if required.				Only three cylinders running.
48	08	INJECTOR - INJECTOR 4	SIGNAL NOT PLAUSIBLE	Engine not working properly, possible power reduction.	Injector not working properly.	Check wiring and connections. Replace injector if required.				Only three cylinders running.

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
49	04	INJECTOR - INJECTOR 4	NO SIGNAL	Engine not working properly, possible power reduction.	Injector wiring open circuit.	Check wiring and connections. Replace injector if required.	1 - Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A46 Measure point 2: Injector Pin:2	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	Only three cylinders running.
							2 - Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A1 Measure point 2: Injector Pin:1	Connector Not connected; Key +15 OFF;	Typical Value: 0.1 Ohm	
							3 - Measure type: Resistance (Ohm) Measure point 1: Injector Pin:1 Measure point 2: Injector Pin:2	Connector Not connected; Key +15 OFF;	Min. value: 0.5 Ohm; Max. value: 0.9 KOhm; Typical Value: 0.7 KOhm;	
50	01	ELECTRONIC CONTROL UNIT - MAIN RELAY DEFECT	EXCEEDED UPPER LIMIT	Engine does not start, ECU not powered or ECU always powered and EDC off also at key-on.	Main relay interrupted or short-circuit.	Check wiring and connections. Replace relay if required.				
50	02	ELECTRONIC CONTROL UNIT - MAIN RELAY DEFECT	BELOW LOWER LIMIT	Engine does not start, ECU not powered or ECU always powered and EDC off also at key-on.	Main relay interrupted or short-circuit.	Check wiring and connections. Replace relay if required.				

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
52	04	FUEL PRESSURE - PRESSURE REGULATING ELECTRIC VALVE ERROR	NO SIGNAL	Engine off.	Faulty pressure regulating electric valve.	Check wiring and connections.	Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A49 Measure point 2: ECU Pin:A19	Connector Not connected; Key +15 OFF;	Min. value: 3.2 Ohm; Max. value: 3.6 Ohm; Typical Value: 3.4 Ohm.	High noise.
52	08	FUEL PRESSURE - PRESSURE REGULATING ELECTRIC VALVE ERROR	SIGNAL NOT PLAUSIBLE			Check wiring and connections. Replace ECU if required.	Measure type: Resistance (Ohm) Measure point 1: ECU Pin:A49 Measure point 2: ECU Pin:A19	Connector Not connected; Key +15 OFF;	Min. value: 3.2 Ohm; Max. value: 3.6 Ohm; Typical Value: 3.4 Ohm.	
53	01	FUEL PRESSURE - PRESSURE REGULATING ELECTRIC VALVE ERROR (SHORT CIRCUIT TO POSITIVE)	EXCEEDED UPPER LIMIT		Short-circuit to battery, faulty pressure regulating electric valve.	Check wiring and connections. Replace pressure regulating electric valve if required.				
54	01	FUEL PRESSURE - PRESSURE REGULATING ELECTRIC VALVE ERROR (SHORT CIRCUIT TO NEGATIVE)	EXCEEDED UPPER LIMIT		Short-circuit to ground, faulty pressure regulating electric valve.	Check wiring and connections. Replace pressure regulating electric valve if required.				

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
56	08	ELECTRONIC CONTROL UNIT - INTERNAL ECU FAULT	SIGNAL NOT PLAUSIBLE		Wrong ECU programming. Probable electromagnetic interference. Faulty ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call the IVECO MOTORS-FPTfor instructions on how to replace the ECU.				
5A	01	ELECTRONIC CONTROL UNIT - INTERNAL ECU FAULT	EXCEEDED UPPER LIMIT		Wrong ECU programming. Probable electromagnetic interference. Faulty ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call the IVECO MOTORS-FPTfor instructions on how to replace the ECU.				

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
5A	02	ELECTRONIC CONTROL UNIT - INTERNAL ECU FAULT	BELOW LOWER LIMIT		Wrong ECU programming. Probable electromagnetic interference. Faulty ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call the IVECO MOTORS-FPTfor instructions on how to replace the ECU.				
5B	01	ELECTRONIC CONTROL UNIT - INTERNAL ECU FAULT	EXCEEDED UPPER LIMIT		Wrong ECU programming. Probable electromagnetic interference. Faulty ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call the IVECO MOTORS-FPTfor instructions on how to replace the ECU.				

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
5E	01	ENGINE 1 - FUEL PUMP RELAY	EXCEEDED UPPER LIMIT	Fuel pump on always when engine is off.	Faulty relay, short-circuit to positive in wiring.	Turn key-on: pump must run for approximately 10seconds (it should hum). Check pump relay if pump remains on. Check wiring if all checks are OK.				
5E	02	ENGINE 1 - FUEL PUMP RELAY	BELOW LOWER LIMIT	Fuel pump not working.	Faulty relay, short-circuit to ground in wiring.	Turn key-on: pump must run for approximately 10 seconds (it should hum). Check the pump relay, protection fuse and wiring if this does not occur.				
5E	04	ENGINE 1 - FUEL PUMP RELAY	NO SIGNAL	Fuel pump not working.	Faulty relay, wiring interrupted.	Check wiring and connections. Replace relay if required.				
5E	08	ENGINE 1 - FUEL PUMP RELAY	SIGNAL NOT PLAUSIBLE	Fuel pump not working.	Faulty relay, wiring interrupted.	Check wiring and connections. Replace relay if required.				

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
5F	01	FUEL PRESSURE - RAIL PRESSURE SENSOR OR SIGNAL ERROR	EXCEEDED UPPER LIMIT		Short-circuit to positive. Faulty sensor. Rail pressure not regular.	Check wiring and connections. Replace sensor if required.				CheckDTC103 error.
5F	02	FUEL PRESSURE - RAIL PRESSURE SENSOR OR SIGNAL ERROR	BELOW LOWER LIMIT		Short-circuit to ground, faulty sensor.	Check wiring and connections. Replace sensor if required.				
60	01	FUEL PRESSURE - RAIL PRESSURE SENSOR OFFSET	EXCEEDED UPPER LIMIT		Faulty rail pressure sensor.	Replace sensor.				
60	02	FUEL PRESSURE - RAIL PRESSURE SENSOR OFFSET	BELOW LOWER LIMIT		Faulty rail pressure sensor.	Replace sensor.				
62	01	FUEL PRESSURE - FAULT ON THE FUEL DRUCK CONTROL OF THE RAIL (POSITIVE DEVIATION)	EXCEEDED UPPER LIMIT		High pressure circuit fuel leakage.	Check hydraulic and mechanical efficiency of injectors.				Fuel management and pressure failure in rail.

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
62	01	FUEL PRESSURE - FAULT ON THE FUEL DRUCK CONTROL OF THE RAIL (POSITIVE DEVIATION)	EXCEEDED UPPER LIMIT		Injector jammed in fuel passage open position.	Check hydraulic and mechanical efficiency of injectors.				Fuel management and pressure failure in rail.
62	01	FUEL PRESSURE - FAULT ON THE FUEL DRUCK CONTROL OF THE RAIL (POSITIVE DEVIATION)	EXCEEDED UPPER LIMIT		Pressure regulating electric valve adjuster open movement jammed.	Check efficiency of pressure regulating electric valve adjuster.				Fuel management and pressure failure in rail.
62	01	FUEL PRESSURE - FAULT ON THE FUEL DRUCK CONTROL OF THE RAIL (POSITIVE DEVIATION)	EXCEEDED UPPER LIMIT		Faulty high pressure pump.	Check efficiency of high pressure pump.				Fuel management and pressure failure in rail.

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
63	01	FUEL PRESSURE - FAULT ON THE FUEL DRUCK CONTROL OF THE RAIL (NEGATIVE DEVIATION)	EXCEEDED UPPER LIMIT		Pressure regulating electric valve adjuster open movement jammed.	Check efficiency of pressure regulating electric valve adjuster.				Fuel management and pressure failure in rail.
64	01	FUEL PRESSURE - RAIL PRESSURE ERROR: TOO LOW	EXCEEDED UPPER LIMIT		High pressure circuit fuel leakage.	Check high pressure system. Replace high pressure pump if required.				Fuel management and pressure failure in rail.
65	01	FUEL PRESSURE - RAIL PRESSURE ERROR: TOO HIGH	EXCEEDED UPPER LIMIT		Pressure regulating electric valve regulator jammed.	Check pressure regulating electric valve regulator, replace if required.				
66	01	FUEL PRESSURE - ERROR ON THE RAIL PRESSURE (EXCESSIVE DUTY CYCLE)	EXCEEDED UPPER LIMIT	Negative engine reaction with smoke in exhaust during acceleration.	High pressure circuit fuel leakage.	Check fuel feed system, replace high pressure pump if required. Faulty fuel feed system (fuel pump and filter jammed).				

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
67	01	FUEL PRESSURE - ERROR ON THE RAIL PRESSURE (EXCESSIVE)	EXCEEDED UPPER LIMIT	Engine off.	Pressure regulating electric valve regulator jammed.	Check pressure regulating electric valve regulator, replace if required.				Replace pressure relief valve.
68	02	ELECTRONIC CONTROL UNIT - INTERNAL ECU FAULT	BELOW LOWER LIMIT			Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call the IVECO MOTORS-FPT for instructions on how to replace the ECU.				
68	04	ELECTRONIC CONTROL UNIT - INTERNAL ECU FAULT	NO SIGNAL		Wrong ECU programming. Probable electromagnetic interference. Faulty ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call the IVECO MOTORS-FPT for instructions on how to replace the ECU.				

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
68	08	ELECTRONIC CONTROL UNIT - INTERNAL ECU FAULT	SIGNAL NOT PLAUSIBLE		Wrong ECU programming. Probable electromagnetic interference. Faulty ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call the IVECO MOTORS-FPT for instructions on how to replace the ECU.				
69	01	ELECTRONIC CONTROL UNIT - SENSOR POWER SUPPLY	EXCEEDED UPPER LIMIT	Anomalous engine operation due to incorrectly powered sensors. Reduced power.	Sensor power circuit fault in ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call the IVECO MOTORS-FPT for instructions on how to replace the ECU.				Possible fault indications of various sensors powered by ECU.

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
69	02	ELECTRONIC CONTROL UNIT - SENSOR POWER SUPPLY	BELOW LOWER LIMIT	Anomalous engine operation due to incorrectly powered sensors. Reduced power.	Sensor power circuit fault in ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call the IVECO MOTORS-FPT for instructions on how to replace the ECU.				Possible fault indications of various sensors powered by ECU.
6A	01	ELECTRONIC CONTROL UNIT - SENSOR POWER SUPPLY	EXCEEDED UPPER LIMIT	Anomalous engine operation due to incorrectly powered sensors. Reduced power.	Sensor power circuit fault in ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call the IVECO MOTORS-FPT for instructions on how to replace the ECU.				Possible fault indications of various sensors powered by ECU.

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
6A	02	ELECTRONIC CONTROL UNIT - SENSOR POWER SUPPLY	BELOW LOWER LIMIT	Anomalous engine operation due to incorrectly powered sensors. Reduced power.	Sensor power circuit fault in ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call the IVECO MOTORS-FPT for instructions on how to replace the ECU.				Possible fault indications of various sensors powered by ECU.
6B	01	ELECTRONIC CONTROL UNIT - SENSOR POWER SUPPLY	EXCEEDED UPPER LIMIT	Anomalous engine operation due to incorrectly powered sensors. Reduced power.	Sensor power circuit fault in ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call the IVECO MOTORS-FPT for instructions on how to replace the ECU.				Possible fault indications of various sensors powered by ECU.

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
6B	02	ELECTRONIC CONTROL UNIT - SENSOR POWER SUPPLY	BELOW LOWER LIMIT	Anomalous engine operation due to incorrectly powered sensors. Reduced power.	Sensor power circuit fault in ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call the IVECO MOTORS-FPT for instructions on how to replace the ECU.				Possible fault indications of various sensors powered by ECU.
6C	01	EDC LAMP	EXCEEDED UPPER LIMIT	Warning light not working.	Short-circuit to positive.	Check correct operation of warning light using "Active diagnostic" procedure.				Warning light should come on for approximately 5 seconds at key-on. Check wiring and connections if this does not occur.
6C	02	EDC LAMP	BELOW LOWER LIMIT	Warning light not working.	Short-circuit to ground.	Check correct operation of warning light using "Active diagnostic" procedure.				Warning light should come on for approximately 5 seconds at key-on. Check wiring and connections if this does not occur.
6C	04	EDC LAMP	NO SIGNAL	Warning light not working.	Open circuit, bulb disconnected.	Check correct operation of warning light using "Active diagnostic" procedure.				Warning light should come on for approximately 5 seconds at key-on. Check wiring and connections if this does not occur.

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
6C	08	EDC LAMP	SIGNAL NOT PLAUSIBLE	Warning light not working.	Wiring problems.	Check wiring and connections. Replace sensor if required.				Warning light should come on for approximately 5 seconds at key-on. Check wiring and connections if this does not occur.
6D	08	ENGINE 2 - INTERNAL ECU FAULT (PLAUSIBILTY ERROR +15)	SIGNAL NOT PLAUSIBLE			Check wiring and connections.				Key 15 off during initialisation.
6E	08	ELECTRONIC CONTROL UNIT - INTERNAL ECU FAULT	SIGNAL NOT PLAUSIBLE		Wrong ECU programming. Probable electromagnetic interference. Faulty ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call the IVECO MOTORS-FPT for instructions on how to replace the ECU.				

DTC	FMI	Failing component	Type of Failure	Visible failure	Possible Cause	Repair action	Checks to be performed	Measuring conditions	Values to be detected	Remarks
79	08	ELECTRONIC CONTROL UNIT - INTERNAL ECU FAULT	SIGNAL NOT PLAUSIBLE		Wrong ECU programming. Probable electromagnetic interference. Faulty ECU.	Switch key on/off and wait for a few seconds, clear failure memory. If the error persists, call the IVECO MOTORS-FPT for instructions on how to replace the ECU.				

Symtom	System reaction	Possible cause	Tests or Reccomended Action	Notes
The engine cuts out or fails to start.	The EDC indicator light fails to come on. The starter motor turns but the engine fails to start.	EDC control unit not powered: fuse blown.	Check central unit EDC protection fuse. If the fuse has blown, find and eliminate the cause of the overload before replacing it.	
The engine cuts out or fails to start.	The EDC indicator light fails to come on. The starter motor turns but the engine fails to start.	EDC control unit not powered: themain relay is not powered.	Check the wiring upstream from the main relay to find any break in the circuit.	
The engine cuts out or fails to start.	The EDC control unit is powered, the starter motor turns but the engine fails to start. The rail pressure does NOT reach 200 bar.	Air intake in the supply circuit between the tank and motor pump.	Check the integrity of the pipe and check that the quick couplings on the motor pump inlet are fitted properly. Replace any non-conforming parts.	
The engine cuts out or fails to start.	The EDC control unit is powered, the starter motor turns but the engine fails to start. The rail pressure does NOT reach 200 bar.	Pre-filter clogged.	Inspect and replace the pre-filter if any debris is found inside.	The pre-filter is transparent and any debris is easy to see.
The engine cuts out or fails to start.	The EDC control unit is powered, the starter motor turns but the engine fails to start. The rail pressure does NOT reach 200 bar.	Low-pressure pipe between motor pump and high-pressure pump inlet choked or with large leak.	Inspect the pipe and replace the relevant section.	
The engine cuts out or fails to start.	The EDC control unit is powered, the starter motor turns but the engine fails to start. The rail pressure does NOT reach 200 bar.	Fuel filter greatly clogged (within certain limits it only involves difficult starting).	Replace the filter.	If the filter clogging indicator system has not worked, check the relevant electric circuit and restore its operation.
The engine cuts out or fails to start.	The EDC control unit is powered, the starter motor turns but the engine fails to start. The rail pressure does NOT reach 200 bar.	Rail pressure relief valve jammed open or lost its setting (continually discharges towards the tank).	If fuel has come out of the valve exhaust pipe while driving with the starter motor, change the valve.	

Symtom	System reaction	Possible cause	Tests or Reccomended Action	Notes
The engine cuts out or fails to start.	The EDC control unit is powered, the starter motor turns but the engine fails to start. The rail pressure does NOT reach 200 bar.	Mechanical defect in the gear pump, pressure regulator and the pumping elements of the high-pressure pump.	After checking there is fuel in the tank and excluding every other possibility (see 1st Troubleshooting Section), replace the high-pressure ump together with the pressure regulator.	
The engine starts with difficulty.	The EDC control unit is powered, the starter motor turns but the engine starts only after insisting a long time. Very slow increase in rail pressure.	The fuel motor pump is not powered (no buzzing is heard with the key ON for 9 sec.).	Check that no electric cable has disconnected from the motor pump. Check the wiring between the control relay and the motor pump to identify any break in the circuit.	After starting, with a load request the engine goes into recovery (if due to insufficient fuel reaching the high-pressure pump error 8.1 is detected, see Capter "Error codes").
The engine starts with difficulty.	The rail pressure during starting regularly rises above 200 bar.	Injector mechanically jammed shut.	Perform the Engine Test (cylinder efficiency) to identify the defective injector and replace it.	Depending on the extent of the jamming, the control unit might detect a lack of balance between the cylinders (See Capter "Error codes").
The engine starts with difficulty.	The rail pressure during starting does not reach 200 bar immediately.	Air intake in the supply circuit between the tank and motor pump.	Check the integrity of the pipe and check that the quick couplings on the motor pump inlet are fitted properly. Replace any non-conforming parts.	
The engine starts with difficulty.	The rail pressure during starting does not reach 200 bar immediately.	The motor pump is not powered (no buzzing is heard with the key ON for 9 sec.).	Check the wiring between the control relay and the motor pump.	
The engine starts with difficulty.	The rail pressure during starting does not reach 200 bar immediately.	Low-pressure pipe choked or broken or leaking.	Inspect the pipe and replace the relevant section.	
The engine starts with difficulty.	The rail pressure during starting does not reach 200 bar immediately.	Fuel filter very clogged.	Replace the filter. If the filter clogging indicator systemhas not worked, check the relevant circuit and restore its operation.	

Symtom	System reaction	Possible cause	Tests or Reccomended Action	Notes
The engine fails to reach top performance	(with no derating implemented by the control unit)	Throttle potentiometer does not go to the end of its travel.	Read parameters, check the signal reaches 100%. If it does not, check the physical integrity of the potentiometer and replace it if necessary.	If there are errors saved in the control unit memory, see Capter "Error codes".
The engine fails to reach top performance	(with no derating implemented by the control unit)	Injector jammed shut.	Find the defective injector (cylinder efficiency test with the diagnostic instrument) and replace it.	
The engine fails to reach top performance	(with no derating implemented by the control unit)	Fuel filter greatly clogged.	Change the filter. If the filter clogging indicator systemhas not worked, check the relevant circuit and restore its operation.	
The engine fails to reach top performance	(with no derating implemented by the control unit)	The motor pump is not powered (no buzzing is heard with the key ON for 9 sec.).	Check the wiring between the control relay and the motor pump.	

PAGE LEFT INTENTIONALLY BLANK

SECTION 5

MAINTENANCE

PAGE LEFT INTENTIONALLY BLANK

PERIODICITY OF CHECKS AND MAINTENANCE OPERATIONS

Execution of the operations indicated below requires competence and compliance with the safety regulations enforced in each Country.

Checks can be performed by the user of the vessel and/or by the workshop personnel.

Periodic maintenance operations must be performed by qualified personnel and require the use of tools, work instruments, and suitable protection means.

Extraordinary maintenance procedures are the responsibility of skilled personnel working for Authorized Service Centres holding technical information and specific equipment.

The frequencies described here below, take into account typical usage factors of different engine usage; the most suitable duration of maintenance intervals or the different applications will be indicated by the personnel assigned to interventions according to engine usage and operational conditions.

Step by step operations

Checks	Periodicity									
	Every start	150 hour	300 hour	600 hour	900 hour	1200 hour	3000 hour	6 months (7)	1 year (7)	2 years (7)
Check engine lubricating oil level	■									
Check engine coolant level	■									
Check oil level in the gearbox	■									
Inspect exhaust duct	■									
Drain water from fuel pre-filter(s)		■								
Check/top up electrolyte level in batteries and clean terminals								■		

Periodic maintenance operations	Periodicity									
	Every start	150 hour	300 hour	600 hour	900 hour	1200 hour	3000 hour	6 months (7)	1 year (7)	2 years (7)
Clean air filter (2)			■						■	
Replace air filter										■
Check belt alternator tension and conditions									■	
Check zinc anode corrosion condition			■							
Check oil vapor filter									■	
Replace oil vapor filter (4)										■
Restore battery electrolyte level								■		
Drain/draw water and condensations from tank(s) (1)			■						■	
Replace oil filter(s) (4)				■					■	
Replace engine lubricating oil (4)				■					■	
Replace fuel pre-filter(s) (1)				■					■	
Replace fuel filter(s) (1) (6)				■					■	
Coolant replacement				■					■	
Replace gearbox(es) oil (see data provided by the manufacturer)										
Inspect sea water intake (2)									■	
Adjust valve-rocker arm clearance							■			

Extraordinary maintenance operations	Periodicity									
	Every start	150 hour	300 hour	600 hour	900 hour	1200 hour	3000 hour	6 months (7)	1 year (7)	2 years (7)
Replace water pump and alternator drive belt						■				■
Clean heat exchangers (5)										■
Clean turbocompressor (4)										■
Replace electro-injectors				■						■
Replace coolant pump				■						■
Check wear of sea water pump impeller					■					
Replace alternator				■						■

(1) Maximum period of time concerning the use of good quality fuel, (DIN EN 590 norm); it is reduced depending on fuel contamination, filter clogging and/or water presence warnings in the pre-filter. Filter clogging warning requires filter replacement. If the pre-filter water presence warning system does not switch off after water drainage, the pre-filter must be replaced.

(2) Frequency depends on environmental conditions and efficiency/wear of the product. Following extended period of engine inactivity, due inspections and checks are required before starting.

(3) The anode must be replaced in case corrosion has exceeded the zinc volume by 50%.

(4) Frequencies for lubricants complaint with ACEA E3-96 international specifications (in alternative E2-96) API CF - CH4 (associated to fuels with sulphide percentages < 0.5%), MIL - L - 2104 F. Viscosity degree SAE 15W40.

(5) Considering the peculiar features of installed exchangers, cleaning operations must be exclusively carried out by the IVECO MOTORS-FPT Technical Assistance Network.

(6) Using exclusively filters with the following characteristics:
- filtering degree < 5 μm
- filtering efficiency ß > 200.

(7) These operations must be carried out also in case the expected hours of operations are not achieved.

CAUTION

If a fuel containing a sulphide content exceeding 0.5% is used, or if oils not meeting the specifications requested in the table attached to the USE AND MAINTENANCE booklet are used, oil filter, engine oil filter and oil vapour filter replacement frequencies must be havened or adequate to the engine usage and operating conditions; to this purpose, please refer to the specific personnel assigned to maintenance interventions.

PREPARING THE ENGINE FOR LONG IDLE PERIODS

To prevent oxidation to the internal parts of the engine and to some components of the injection system, if idle periods exceeding two months are expected, the engine needs to be prepared with six-months periodicity, proceeding as follows:

1. Drain the lubricating oil from the sump, after heating the engine;
2. Pour 30/M-type protective oil (alternatively, oil conforming with MIL 2160B Type 2 specifications) into the engine to the "minimum" level marked on the dipstick.
   Start the engine and let it run for about 5 minutes;
3. Drain the fuel from the injection line and from the filter, taking care to avoid letting the fuel come in contact with the auxiliaries belt;
4. Connect the fuel line to a tank containing CFB protective liquid (ISO 4113) and assist the inflow of the liquid by pressurizing the line and turning the engine over for about 2 minutes, after excluding the operation of the injection system. The required operation may be carried out by directly polarizing the terminal 50 of the electric starter motor with positive voltage 12 V, using a conductor prepared for the occasion;
5. Nebulize 30 g of 30/M-type protective oil (about 10 g per liter of displacement:) into the turbocompressor intake, while the engine is turning over as described above;
6. Close with suitable stoppers or seal with adhesive tape all engine intake, exhaust, aeration and venting ports;
7. Drain the residual 30/M-type protective oil from the sump; it may be re-used for 2 more engine preparation operations;
8. Apply tags with the inscription "ENGINE WITHOUT OIL" on the engine and onboard panel;
9. Drain the coolant, if it has not been mixed with antifreeze and corrosion inhibiting agents, affixing tags to indicate that the operation has been carried out.

If external parts of the engine are to be protected, spray protective liquid OVER 19 AR onto unpainted metal parts, such as flywheel, pulleys and others; avoid spraying belts, connector cables and electrical equipment.

ENGINE'S FIRST START/RESTORING NORMAL OPERATING CONDITIONS

1. Drain the residual protective oil type 30/M from the sump;
2. Pour lubricating oil into the engine, as provided by the specifications and in the quantities set out in the Table of Refills;
3. Drain the CFB protective liquid from the fuel line, completing the operations set out in item 3 of "PREPARING THE ENGINE FOR LONG IDLE PERIODS";
4. Remove the caps and/or the seals from the engine's intake, exhaust, aeration and vent ports, restoring normal operating conditions. Connect the turbocompressor intake to the air filter;
5. Attach the fuel lines to the vessel's fuel tank, completing the operations set out in item 4 of "PREPARING THE ENGINE FOR LONG IDLE PERIODS".
   During the filling operations, attach the fuel tank return pipe to a collecting container to prevent residues of CFB protective liquid from flowing into the vessel's fuel tank;
6. Verifiy the quantity of cooling liquid and refill as provided by the specifications;
7. Start the engine and keep it running until idling speed has completely stabilized;
8. Shut the engine down and delete the "errors" which may have been stored in the injection system ECU during the operation stabilization phases. For reset operation, see "Blink code" paragraph in Section 4;
9. Remove the tags with the inscription "ENGINE WITHOUT OIL" from the engine and from the panel.

SECTION 6

SERVICING OPERATIONS ON INSTALLED ENGINE

PAGE LEFT INTENTIONALLY BLANK

FOREWORD

Many of the procedures for carrying out the instructions that follow depend on the configuration of the housing on the vessel and on the disposition of the installation components.

Prescriptions and cautions for use, handling and technical assistance are provided in Section 9.
Technicians and maintenance personnel are reminded of the need to comply with safety rules.

The checks necessary at the completion of an installation or re-embarkation are described in the "S30 ENT M23 Installation Directive" document.

Spare parts will be supplied only if the following data are provided:

- Engine technical code and serial number;
- Part number as per spare parts catalog.

The information provided below refer to engine characteristics which were current as of the publishing date.
The manufacturer reserves the right to make changes at any time and without advance notice, to comply with technical or commercial requirements or to adapt to legal requirements in different Countries.

The manufacturer shall not be liable for any errors and omissions.

The IVECO MOTORS-FPT Technical Assistance Network is always at the Customer's side with its competence and professionalism.

PRESCRIPTIONS FOR WORK ON THE INJECTION SYSTEM

The successful outcome of repair work is assured by the operator's experience and ability and by compliance with the following instructions.

Before performing work involving components of the injection system, take note of the content of the ECU fault memory with the appropriate IVECO MOTORS-FPT diagnosing equipment, writing the results down or printing them.

- ❏ Replacement of the ECU EDC 16 must be authorized by IVECO MOTORS-FPT after specific agreements with the Technical Assistance Service;
- ❏ The electro-injectors cannot be overhaul; their replacement must be authorized by IVECO MOTORS-FPT with the specific agreement of the Technical Assistance Service; for disassembly, follow the indications provided in the specific paragraph of this Section;
- ❏ Keep parts and components clean, making sure that during handling and assembly (starting with the simple replacement of filter and pre-filter) no sludge or foreign matter is allowed to enter the lines, with particular attention to the fuel supply line in the segment downstream the filter;
- ❏ Maintain the proper polarization of all electrical connections;
- ❏ Tighten the threaded connections to the prescribed torque;
- ❏ Make sure that the flywheel and camshaft sensors are positioned so they abut, ensuring they are as close to perpendicular (with respect to the bearing surface) as possible.

CAUTION

- ❏ **Do not disconnect electrical connections without removing power from the circuits first;**
- ❏ **Do not proceed with operating simulations with unsuitable tools and instruments;**
- ❏ **Do not force measuring probes or mechanical tools into the electrical connections;**
- ❏ **Do not proceed with arc welding without first disconnecting electronic system units.**

To proceed with the overhaul of the engine or its parts, you must disconnect the electrical connections of the injection system's components and of the sensors providing indications on the control panel.

To proceed as indicated, we provide below the procedure to avoid the risk that the ECU of the injection system may detect and store errors or system faults.

- ❏ Set the key switch to the STOP position;
- ❏ Wait 10 sec. and disconnect the battery terminals;
- ❏ Disconnect the connections according to the prescriptions set out in Section 3;
- ❏ Remove, if necessary, the entire wiring harness from the retaining bracket;
- ❏ Remove, if necessary, the complete electronic unit after disconnecting the multipolar connectors.

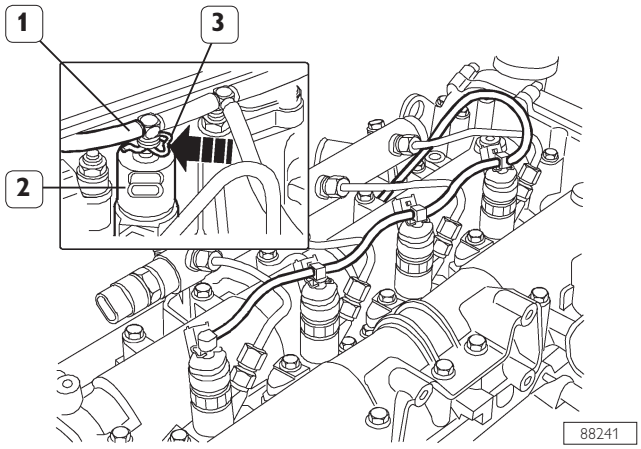
REPLACING THE ELECTRO-INJECTORS

Removal

Make sure the conditions you work in are safe (they may differ depending on the application).

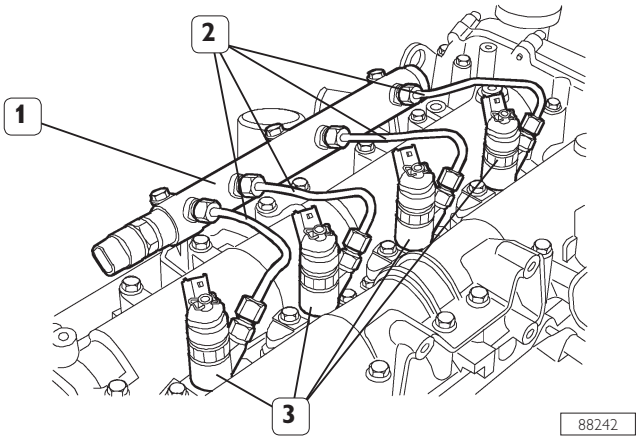
- ❏ Disconnect the battery cables;
- ❏ Disconnect the oil vapour pipes from the tappet cover, then remove it;
- ❏ Remove the engine cable retaining clamps;
- ❏ Disconnect the engine cable from the electro-injector connectors, from the rail pressure sensor and from the intake air temperature/pressure sensor;
- ❏ Disconnect the pipes from the hydraulic accumulator and from the electro-injector fuel manifolds.

Figure 1



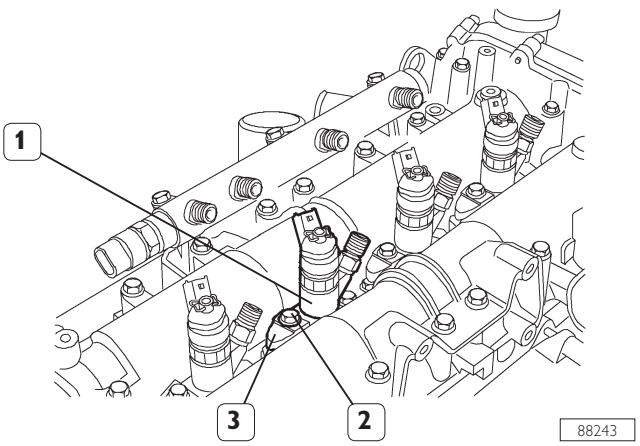
Press the springs (3) in the direction shown by the arrow and disconnect the fittings of the pipe (1) recovering fuel from the electro-injectors (2).

Figure 2



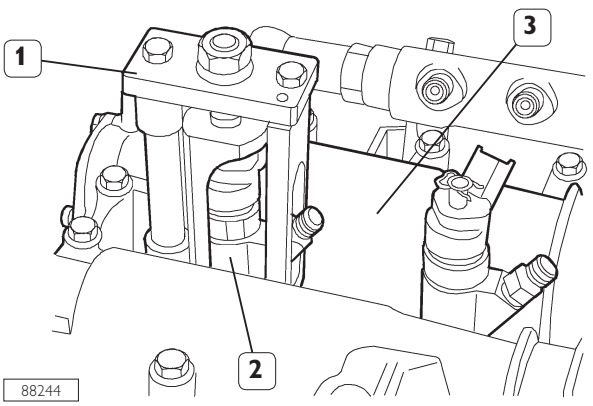
Disconnect the fuel pipes (2) from the electro-injectors (3) and from the hydraulic accumulator (1) (rail).

Figure 3



Take out the screws (2) and the brackets (3) fixing the electro-injectors (1) to the cylinder overhead.

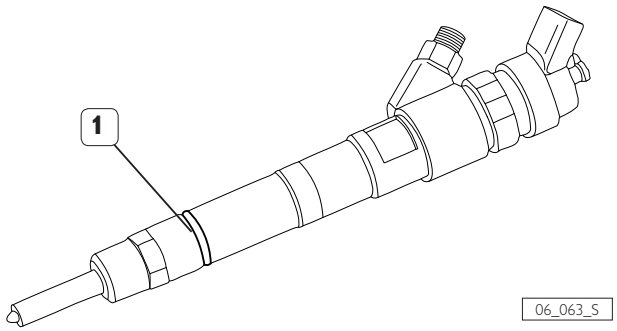
Figure 4



Using tool 99342153 (1) extract the electro-injectors (2) from the overhead (3)..

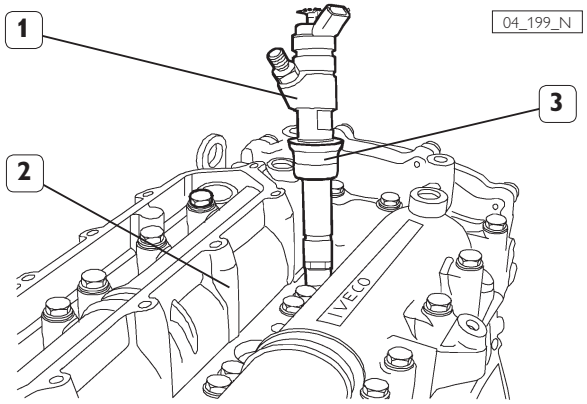
Fitting

Figure 5



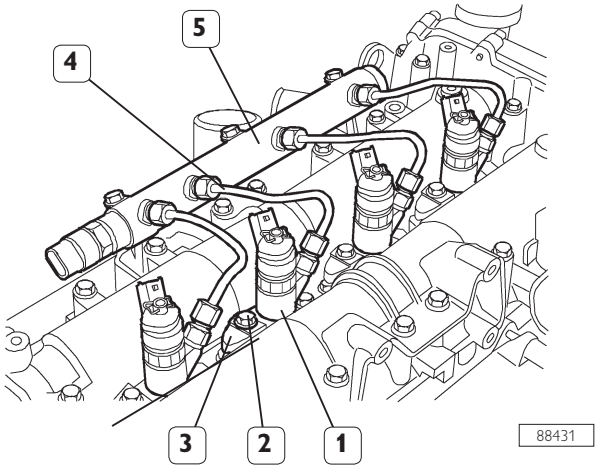
Assembly a new seal ring on the electronic injector (1).

Figure 6



Assemble electronic injectors (1) in their seats on the overhead (2), after the gasket has been removed (3).

Figure 7

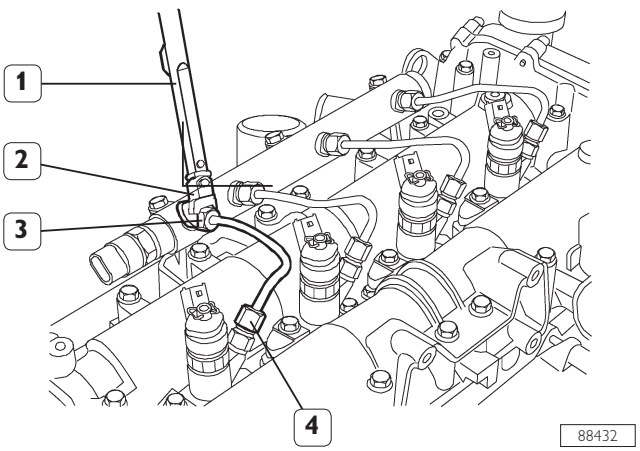


Mount the brackets (3) fastening the electro-injectors (1) and screw down the screws (2) without locking them. Connect the fuel pipes (4) to the electro-injectors (1) and to the hydraulic accumulator (5).
Tighten the screws (2) fixing the electro-injector brackets (3) to the prescribed torque.

CAUTION

Whenever they get removed, the fuel pipes must be replaced with new ones.

Figure 8

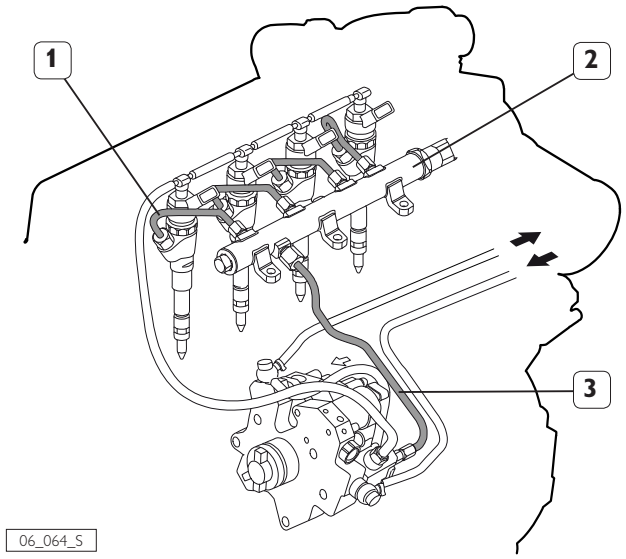


Using the wrench (2) of the 99317915 series and the torque wrench 99389829 (1), tighten the fuel pipe fittings (3) and (4) to the prescribed torque.

FUEL SYSTEM PIPING

High-pressure pipings

Figure 9



1. Piping for electro-injectors - 2. Common rail - 3. Piping for rail supply.

The high-pressure piping, connecting the high-pressure pump, the rail (2) and the electro-injectors, is made of metal and coupled by means of hexagon nut axial junctions.

CAUTION

The high-pressure system may reach very high pressure levels:
DO NOT ATTEMPT TO LOOSEN HYDRAULIC CONNECTIONS TIGHTENING ITEMS WITH THE ENGINE RUNNING.

Tighten axial junction nuts with a torque of 20 Nm.

CAUTION

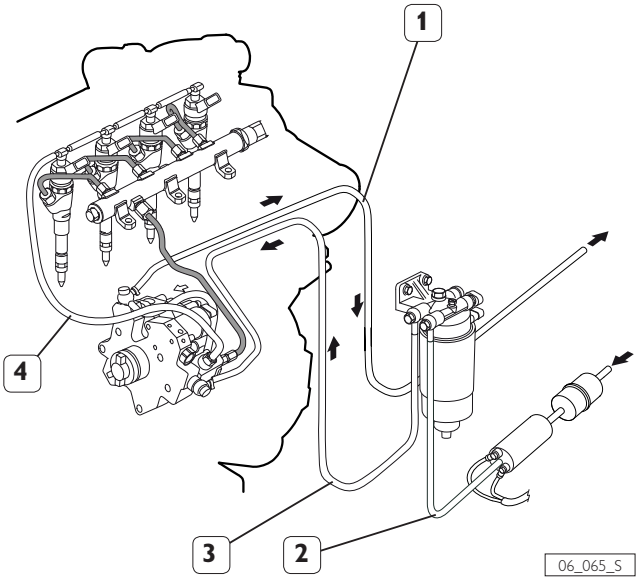
In case piping removal is necessary DO NOT REUSE IT AND ALWAYS REPLACE IT WITH NEW PIPING.

NOTE

The sequence and the description of assembly and disassembly operations are described under Section 8.

Low-pressure pipings

Figure 10

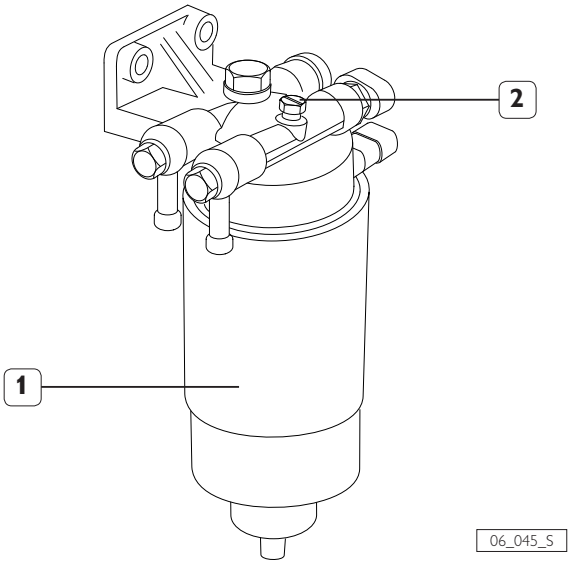


1. Fuel return line to the tank - 2. Electric pump line towards the fuel filter - 3. Fuel filter line towards the high pressure feeding pump - 4. Recirculation line from electronic injectors.

The engine piping completing the low pressure fuel system is made of metal. Coupling is done using eye junctions secured using hexagonal screws.
Coupling water-tightness is obtained using copper washers. In case piping removal is necessary, replace washers with new ones when reassembling.
Tighten low-pressure junction screws with a torque of 12 Nm.

VENTING THE AIR FROM THE FUEL FEED LOOP

Figure 11



1. Fuel filter - 2. Bleeder vent screw.

- ❑ Turn the key on "ON"; so that the ECU EDC feeds the fuel electric pump for a few seconds, thus pressurizing the low pressure feeding circuit.
- ❑ Loosen the vent fitting on the pre-filter.
- ❑ Newly turn the key on "ON" to feed the electric pump until air-free fuel flows out of it.
- ❑ Tighten the vent fitting.

Make sure that the fuel that flows out of the fitting is not dispersed in the environment.

CAUTION

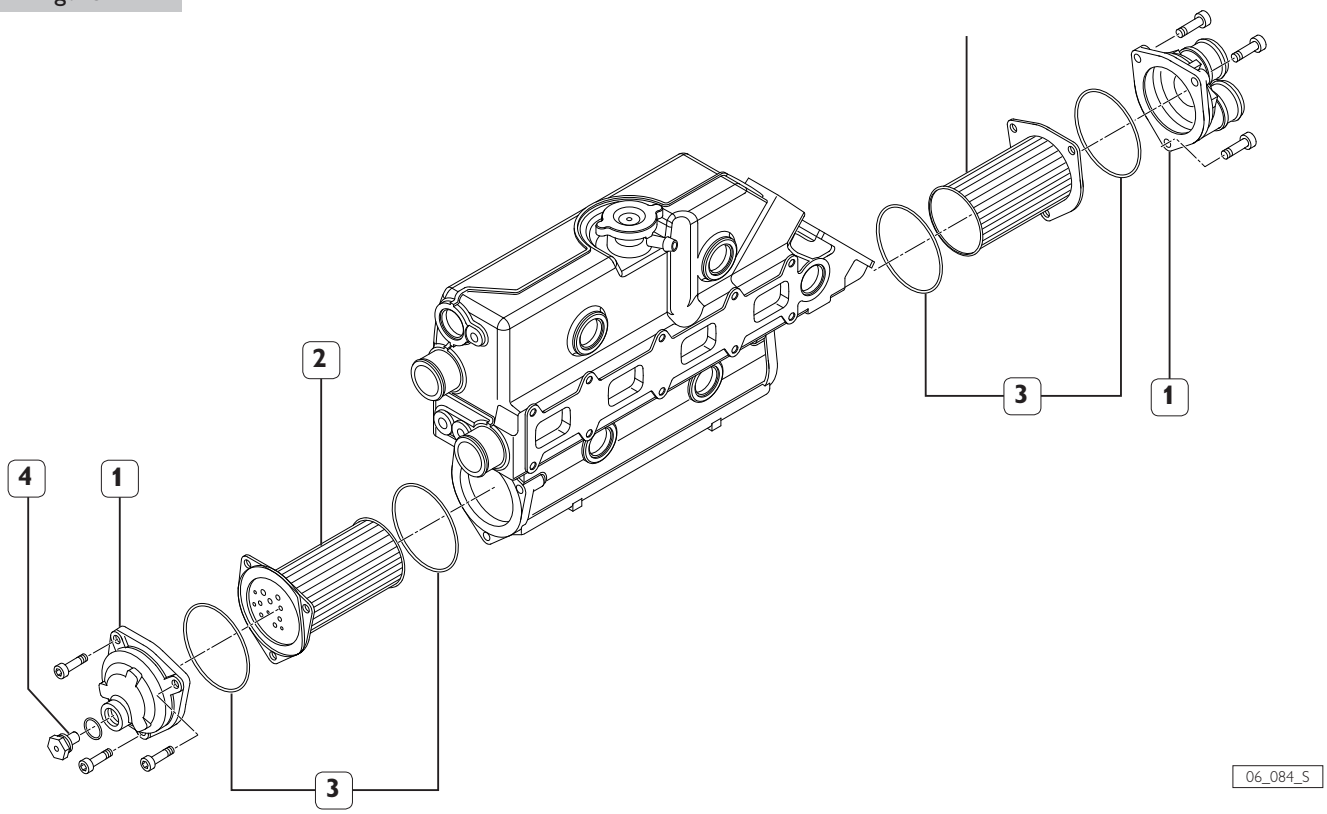
Never attempt to vent the high pressure system, as this is useless and extremely dangerous.

VALVES CLEARANCE ADJUSTMENT

The presence of hydraulic tappets does not require any valve play adjustment operations.

CLEANING THE ENGINE COOLANT/SEA-WATER HEAT EXCHANGER

Figure 12



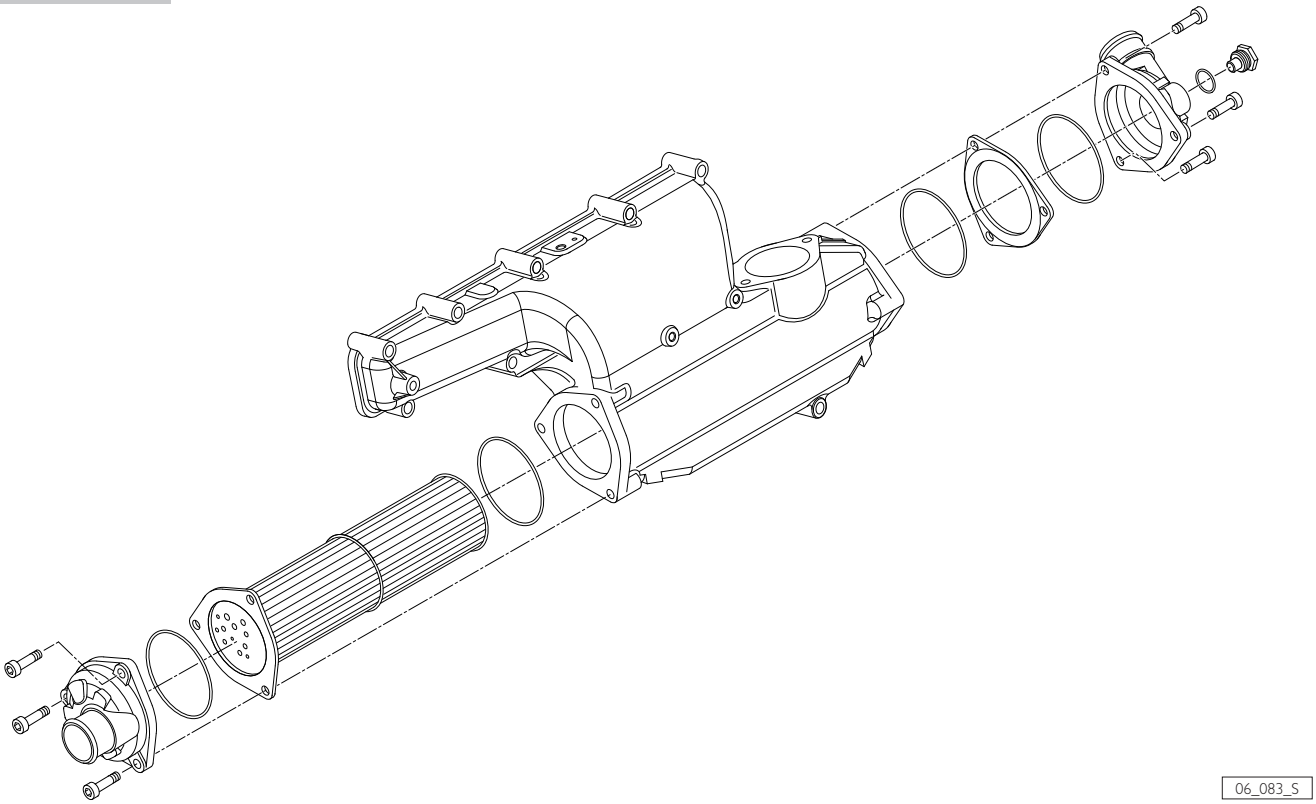
1. Cover - 2. Tube bundle - 3. Sealing rings - 4. Zinc sacrificial anode.

In order to guarantee a perfect operation of the heat exchanger, regularly clean the tube bundle. If the surfaces of the heat exchanger come into contact with salted water, they may be subjected to biological fouling and to hydrocarbon deposit which may be present in harbors' waters.

- ❏ Remove the two elements of the tube bundle (2) from the exchanger body and immerse it for a few minutes in a solution prepared with water and a degreasing scale-remover detergent, observing the detergent manufacturer's directions for use. The cleansing solution should not damage copper, brass, aluminum and tin;
- ❏ Complete tube cleaning by rinsing thoroughly with fresh water, until detergent residues are entirely removed;
- ❏ Reassemble the two elements of the tube bundle (2) by correctly positioning sealing rings (3), and covers (1);
- ❏ Check the zinc anode corrosion level (4); replace the anode if corrosion exceeds 50% of the volume.

CLEANING THE AIR/SEA-WATER HEAT EXCHANGER

Figure 13



1. Cover - 2. Spacer - 3. Tube bundle - 4. Sealing rings - 5. Zinc sacrificial anode.

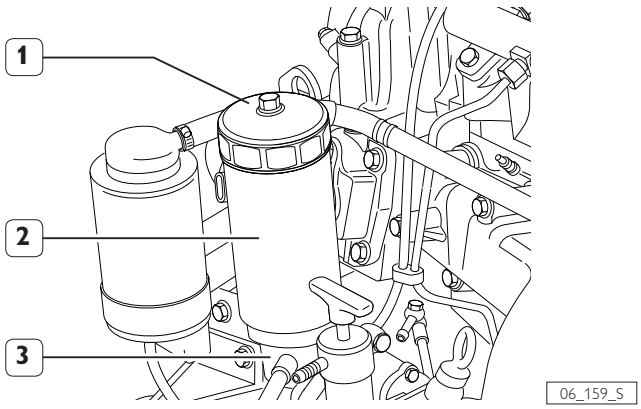
In order to guarantee a perfect operation of the heat exchanger, regularly clean the tube bundle. If the surfaces of the heat exchanger come into contact with salted water, they may be subjected to biological fouling and to hydrocarbon deposit which may be present in harbors' waters; surfaces coming into contact with comburent air are subject to oil deposits resulting from the fumes exhausted at the base and from sucked downstream the air filter.

- ❏ Remove Zinc sacrificial anode (5);
- ❏ Remove the tube bundle (3) from the exchanger body and immerse it for a few minutes in a solution prepared with water and a degreasing scale-remover detergent, observing the detergent manufacturer's directions for use. The cleansing solution should not damage copper, brass, aluminum and tin;
- ❏ Complete tube cleaning by rinsing thoroughly with fresh water, until detergent residues are entirely removed;
- ❏ Reassemble the tube bundle (3) by correctly positioning spacers (2), sealing rings (4) and covers (1);
- ❏ Check the zinc anode (5) corrosion level; replace the anode if corrosion exceeds 50% of the volume.

DECOUPLING OF COMPONENTI OF MARINE ADAPTATION

Some routine maintenance and overhauling interventions require complete access to engine components and thus the removal of equipments which make up marine adaptation; in order to simplify the requested operations, the suggested sequence is described here below.

Figure 14

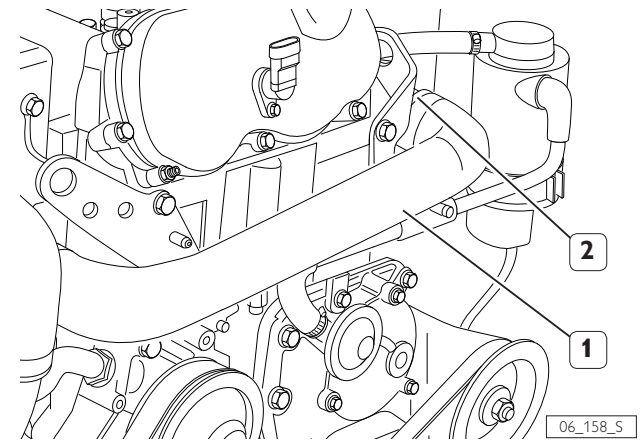


With the tool no. 99360076 (1) unscrew the oil filter (2) from the heat exchanger (3).

CAUTION

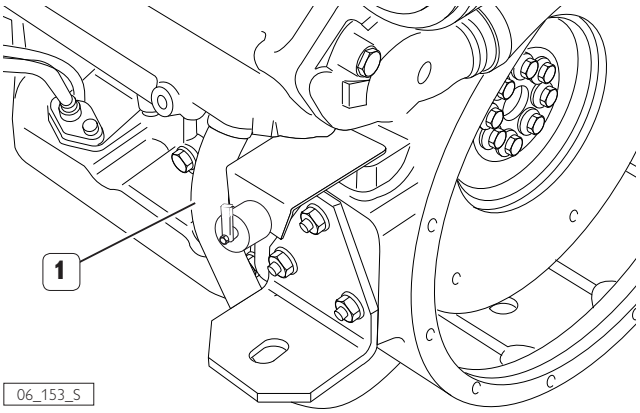
The oil filter contains inside approx. 1 kg of engine oil. Provide tank with enough capacity to contain the liquid. Avoid contact of engine oil with the skin: in case of skin contamination rinse in running water. Engine oil is highly pollutant: provide for disposal in compliance with the law and regulations in force.

Figure 15



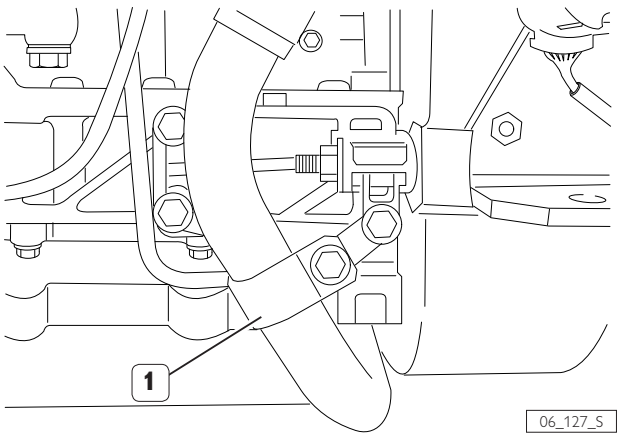
When the circuit has been drained from cooling fresh water, dispose the liquid according to current regulations, disassemble the rear manifold (1) connecting the thermostatic valve (2) to the tank by removing two hose clamps.

Figure 16



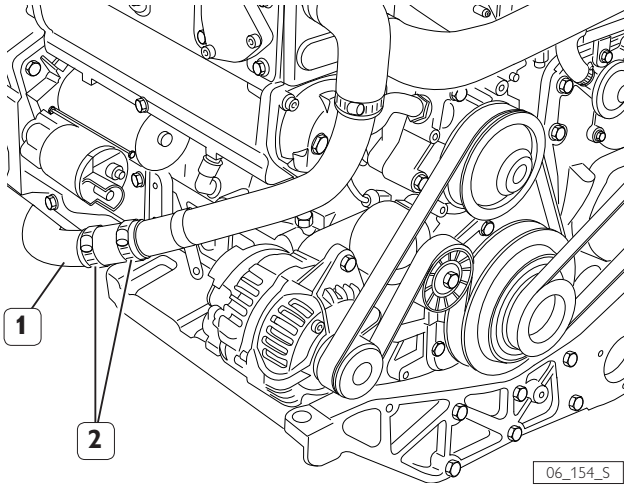
Disassemble the fresh water conduct (1) in the lower part of the engine, by removing 2 pipes with 3 manifolds. (see the details in the next pictures).

Figure 17



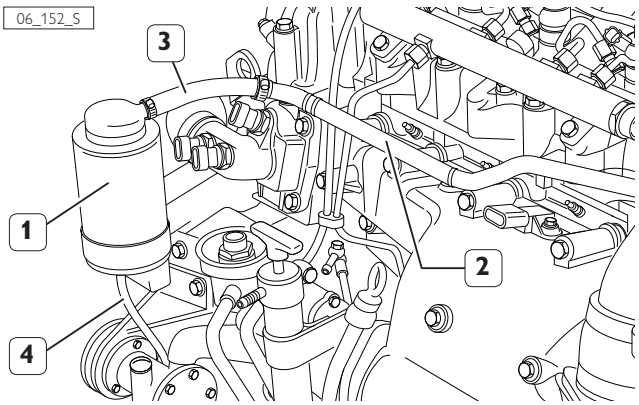
Unscrew the collar (1) and remove the duct on the left hand side.

Figure 18



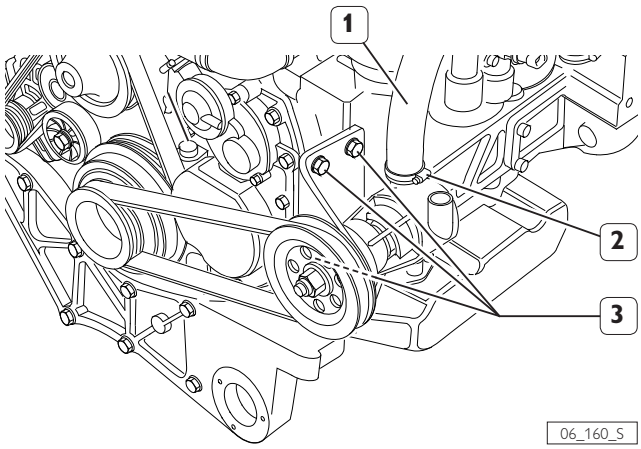
Remove the manifold (1) for fresh water return to the pump by unscrewing the two clamps (2).

Figure 19



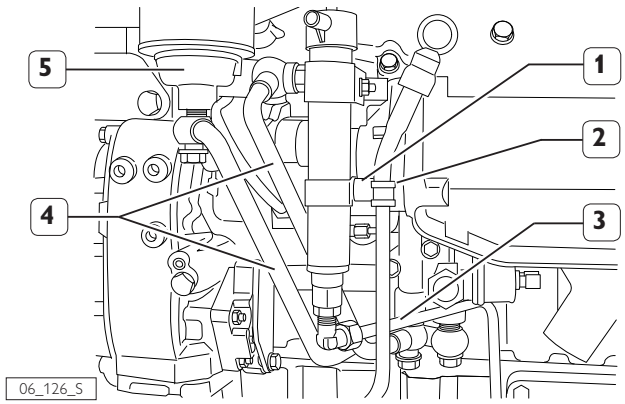
Unscrew the blow-by filter(1), the output pump of the blow-by filter to the metal piping (2), the rubber manifold (3), and the piping (4) for the recovery of the oil collected in the sump.

Figure 20



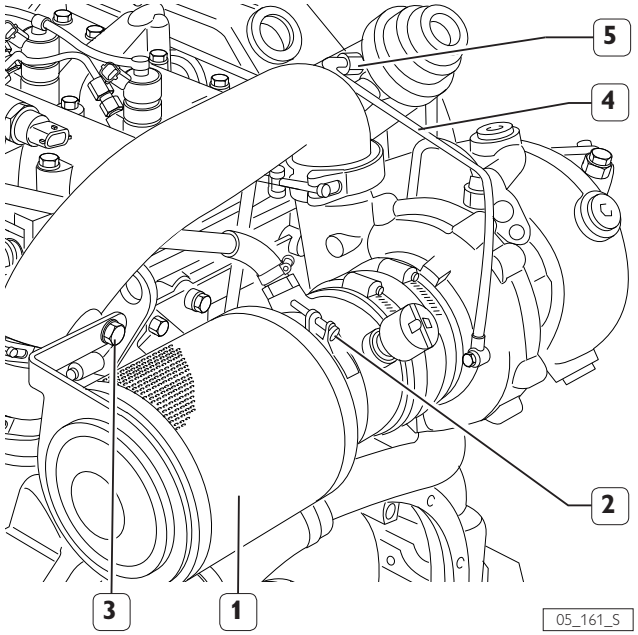
Remove the manifold (1) by unscrewing the clamp (2). Remove the sea water pump by unscrewing the screws (3).

Figure 21



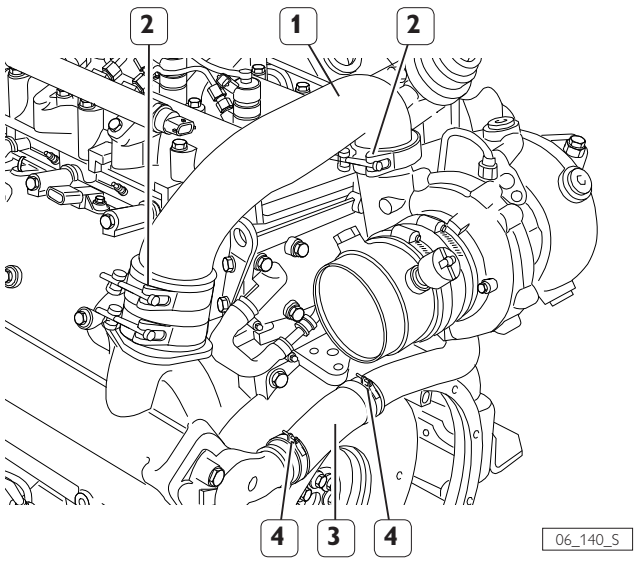
Disassemble the oil dipstick tube (2) with the relevant spacer (1) and the oil pipe (3) connecting the sump emptying pump.
Disassemble the oil input and output pipes (4) from the filter support (5).

Figure 22



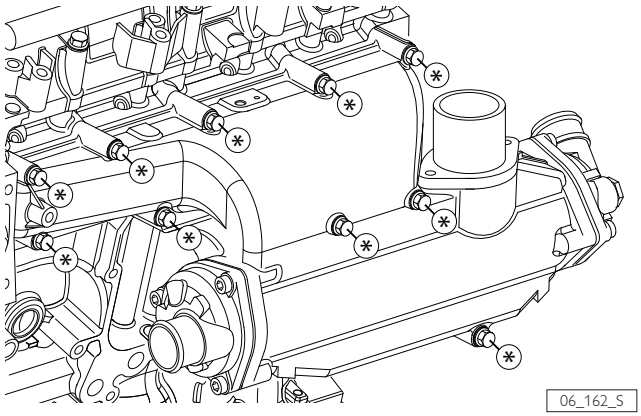
Disassemble the air filter (1) from the support by loosening the hose clamp (2) and the bracket (3). Disassemble the connection (4) between the turbocharger and the pneumatic actuator of the waste-gate valve by unscrewing the nut (5).

Figure 23



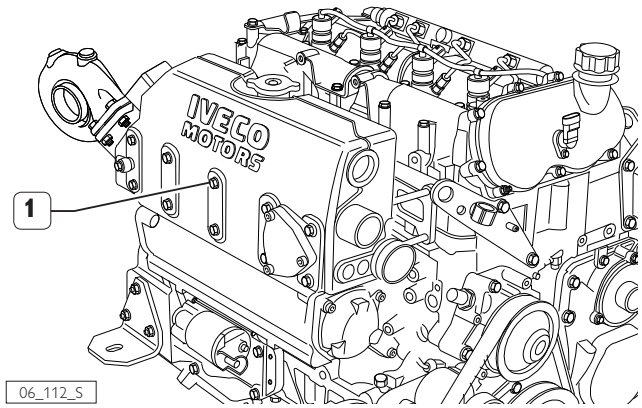
Disassemble the intake pipe (1) by loosening the hose clamp (2). Disassemble the coolant connection pipe (3) by loosening the hose clamp (4).

Figure 24



Disassemble the intake manifold by unscrewing the 10 screws indicated in the picture with the symbol ⊛.

Figure 25



Disassemble the exhaust manifold with the turbocharger, by unscrewing the 10 nuts (1).

INSTRUCTIONS FOR DISEMBARKING THE ENGINE

The following is a description of the recommended sequence of the operations to be completed before extracting the engine from the vessel.

- ❑ After the key switch has been in the OFF position for at least 10 seconds, disconnect the battery terminals and disconnect the connectors from the relay box;
- ❑ Disconnect from the engine the power wiring harness terminals (battery positive and negative);
- ❑ Loosen and remove the fuel pipelines and the pipes of the gearbox heat exchanger, if provided;
- ❑ Loosen and remove the sea-water inlet pipes, engine exhaust pipes, and, if separate, the sea-water loop discharge;
- ❑ Remove the pipeline from the additional engine coolant expansion tank (if provided);
- ❑ Loosen and remove engine anchor bolts;
- ❑ Uncouple the gearbox;
- ❑ Observe the following instructions when hooking the engine.

Handling

The engine must be handled by experienced personnel, using the prescribed tool or a rocker arm that keeps the lifting lines parallel and with adequate equipment in terms of capacity and size. The two eyebolts provided for lifting the engine alone must always be used simultaneously.

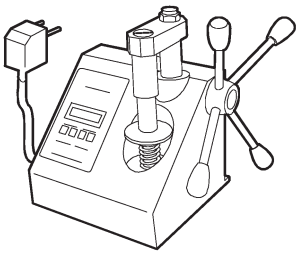
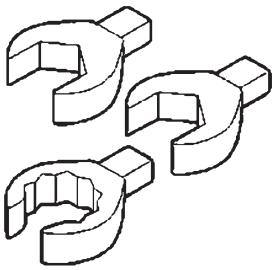
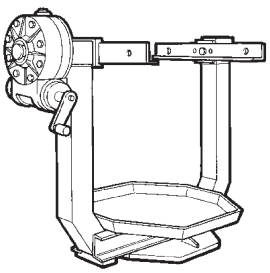
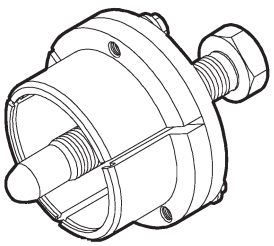
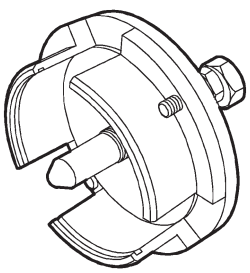
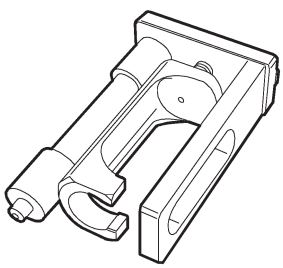
SECTION 7

TOOLS

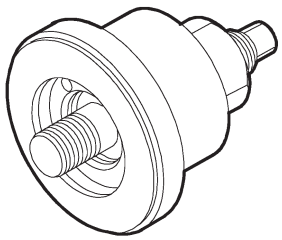
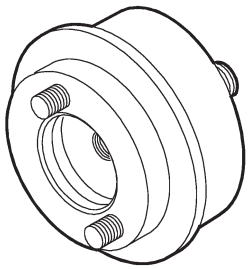
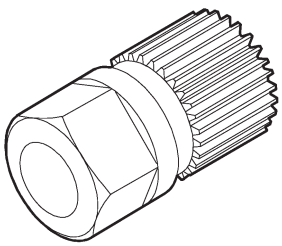
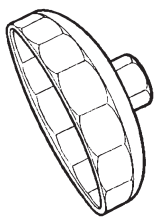
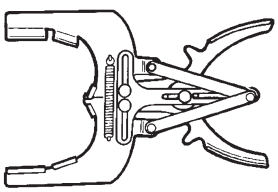
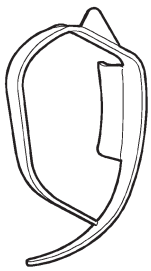
TOOLS

PAGE LEFT INTENTIONALLY BLANK

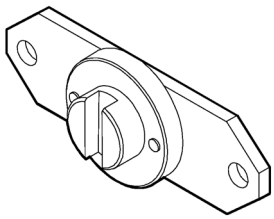
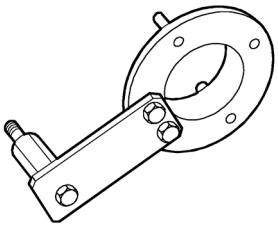
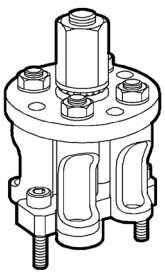
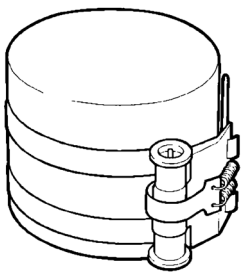
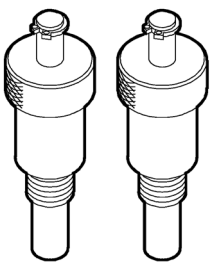
TOOLS

Tool No.		Definition
99305047		Appliance to check spring loads
99317915		Set of six box-type wrenches (14-17-19 mm)
99322205		Rotary telescopic stand for overhauling assemblies (capacity 700 daN, torque 120 daN/m)
99340059		Tool to remove crankshaft front gasket
99340060		Tool to remove crankshaft rear gasket
99342153		Puller for dismantling injectors

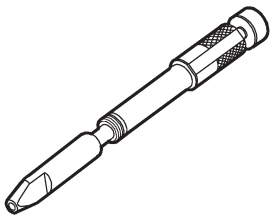
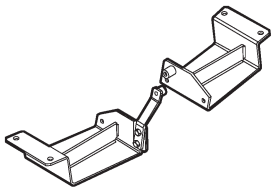
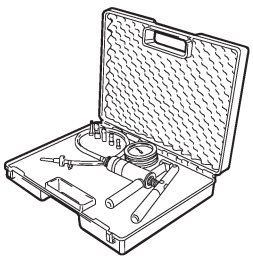
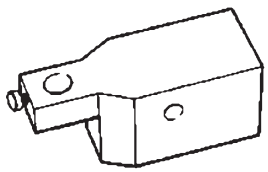
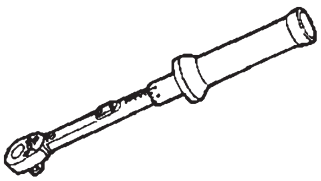
TOOLS

Tool No.		Definition
99346258		Keying device for mounting crankshaft front gasket
99346259		Keying device for mounting crankshaft rear gasket
99358026		Wrench for alternator pulley (free wheel) removal/refitting
99360076		Tool to remove cartridge filters
99360183		Pliers for mounting rings on engine pistons
99360186		Guide for flexible belt

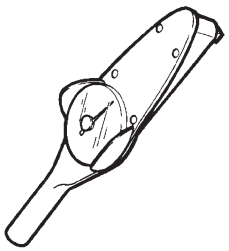
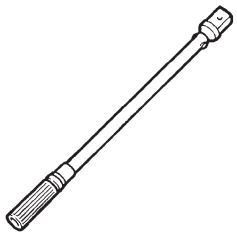
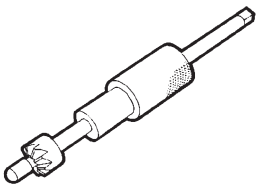
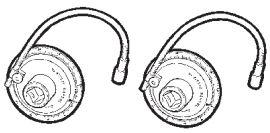
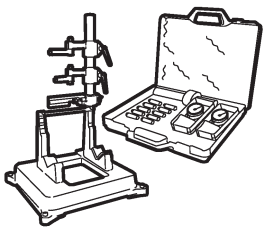
TOOLS

Tool No.		Definition
99360187		Retaining tool for hydraulic power steering control shaft
99360190		Damper pulley retaining tool
99360260		Tool for removing and refitting engine valves
99360605		Band to insert standard and oversized pistons into the cylinders
99360614		Tool (2) for camshaft timing

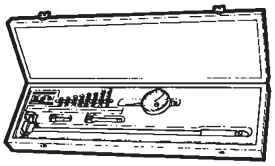
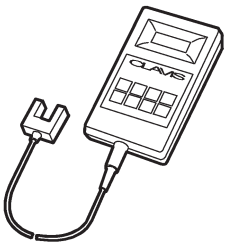
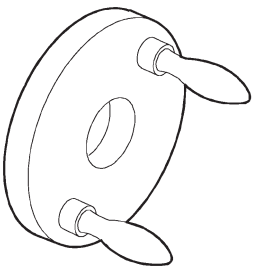
TOOLS

Tool No.		Definition
99360615		Tool for crankshaft timing
99361041		Brackets securing engine to rotary stand 99322205
99367121		Manual pump to measure pressure and vacuum
99370415		Dial-gauge base for various measurements (to be used with 99395603)
99389817		Dynamometric wrench (60 to 320 Nm) with 3/4'' coupling
99389818		Dynamometric wrench (150 to 800 Nm) with 3/4'' square coupling

TOOLS

Tool No.		Definition
99389819		Torque wrench (0 to 10 Nm) with square 1/4" connection
99389829		9x12 coupling torque wrench (5 to 60 Nm)
99394038		Milling cutter to regrind injector seat
99395216		Pair of meters for angular tightening with square 1/2" and 3/4" connection
99395363		Complete square to check for connecting rod distortion
99395603		Dial gauge (0 to 5 mm)

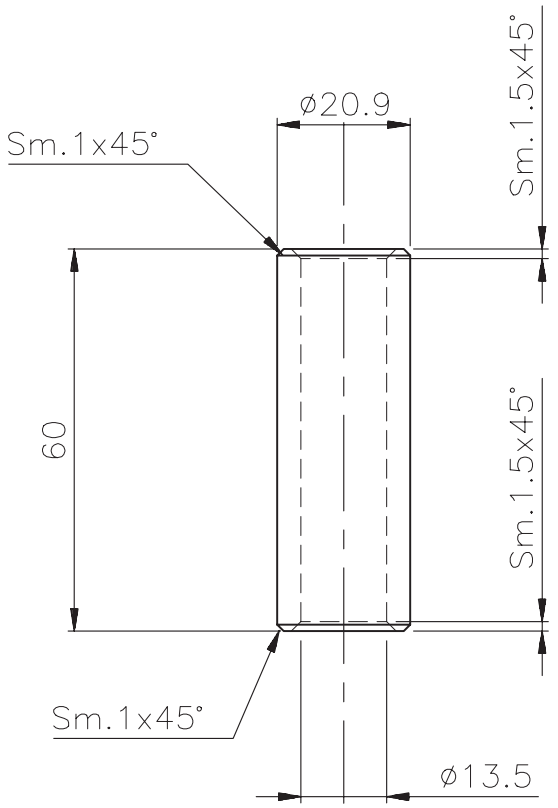
TOOLS

Tool No.		Definition
99395687		Bore meter (50 to 178 mm)
99395849		Belt tension control device (frequency from 10.0 to 600 Hz)
99396039		Centring ring for timing gear cover

EXPERIMENTAL TOOLS

This section shows the working drawings for the experimental tools (S.P.) used in overhauling the engine described in this section, which may be made by the repair shops.

EXPERIMENTAL TOOLS



Modification:

For the permissible errors on the dimensions without tolerance and for other general specifications, see IVECO *STD 10–2311*

MAT.	COVER.	DRAWN	N°DRAWING
Pom / Nylon	/	UTS (B)	SP. 2264

ISO ≤ IT8
∢ ≤ 30'
Ra ≤ 0.4

C/ I.S. 18-0011

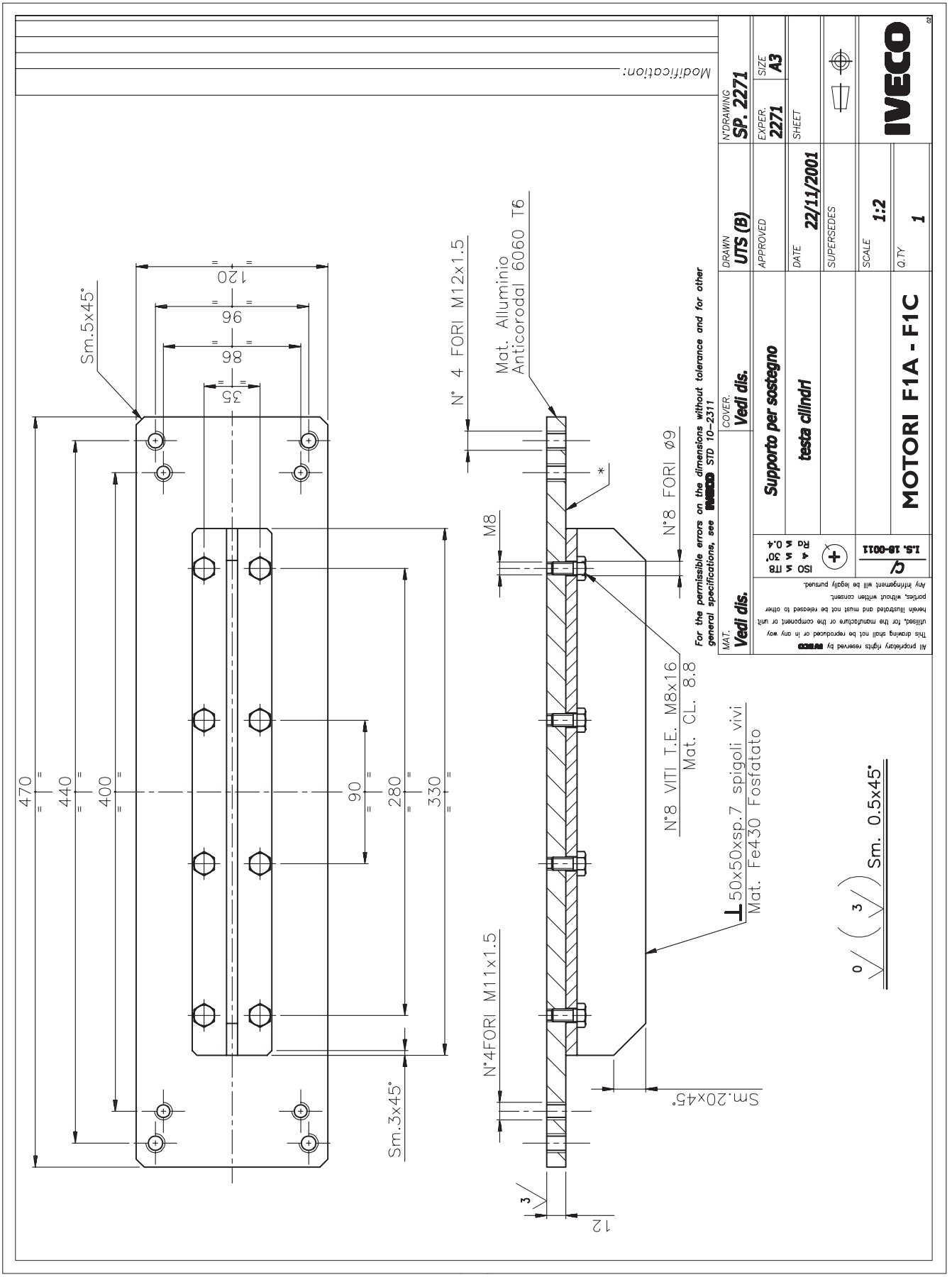
Perni di centraggio sovratesta
e per piantaggio guarnizione
guida valvole

MOTORI F1A - F1C

APPROVED	EXPER.	SIZE
	2264	A4
DATE: 19/06/2001	SHEET	
SUPERSEDES		
SCALE: 1:1		
Q.TY: 2	IVECO	

02

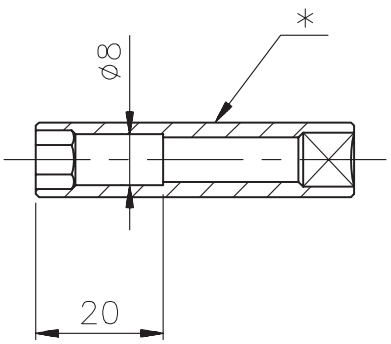
EXPERIMENTAL TOOLS



EXPERIMENTAL TOOLS

VARIA DA ART. COMMERCIALE USAG cod.235EL 1/4" – Ch.8

SOLO PER QUANTO INDICATO



6 Sm. 0.5x45°

Modification:

For the permissible errors on the dimensions without tolerance and for other general specifications, see IVECO *STD 10–2311*

MAT.	COVER.	DRAWN	N°DRAWING
/	/	UTS (B)	SP. 2275

ISO ≤ IT8 ≤ ≤ 30' Ra ≤ 0.4

C/ I.S. 18-0011

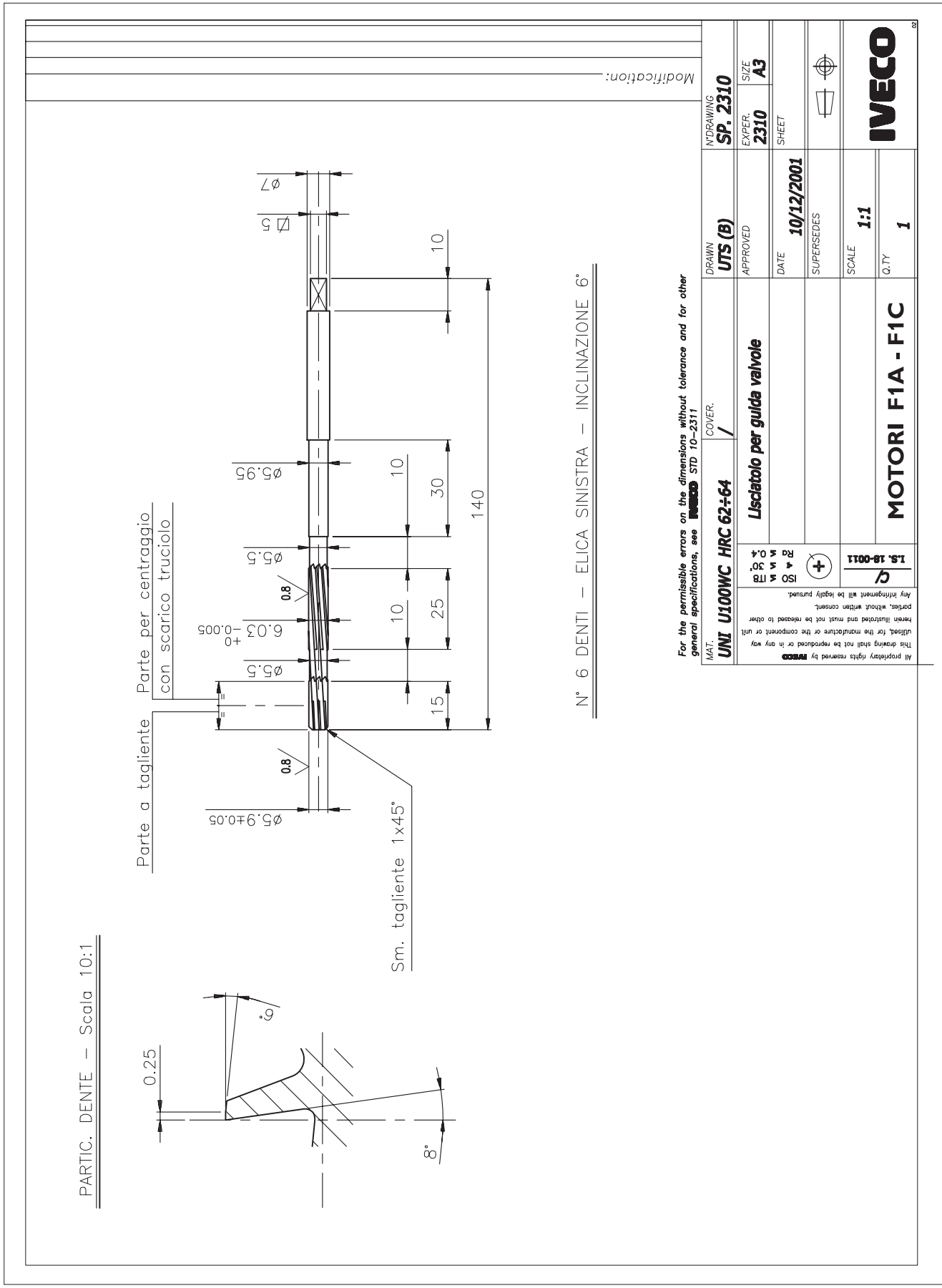
Bussola (8 mm) per montaggio/ smontaggio candelette

MOTORI F1A - F1C

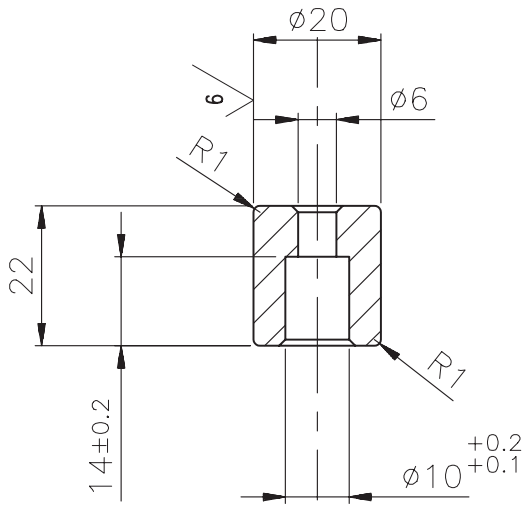
APPROVED	EXPER.	SIZE
	2275	A4
DATE 25/07/2001	SHEET	
SUPERSEDES		
SCALE 1:1	IVECO	
Q.TY 1		

02

EXPERIMENTAL TOOLS



EXPERIMENTAL TOOLS



Modification:

For the permissible errors on the dimensions without tolerance and for other general specifications, see IVECO *STD 10–2311*

MAT.	COVER.	DRAWN	N°DRAWING
39NiCrMo3 Bon.	Fosfat.	UTS (B)	SP. 2311

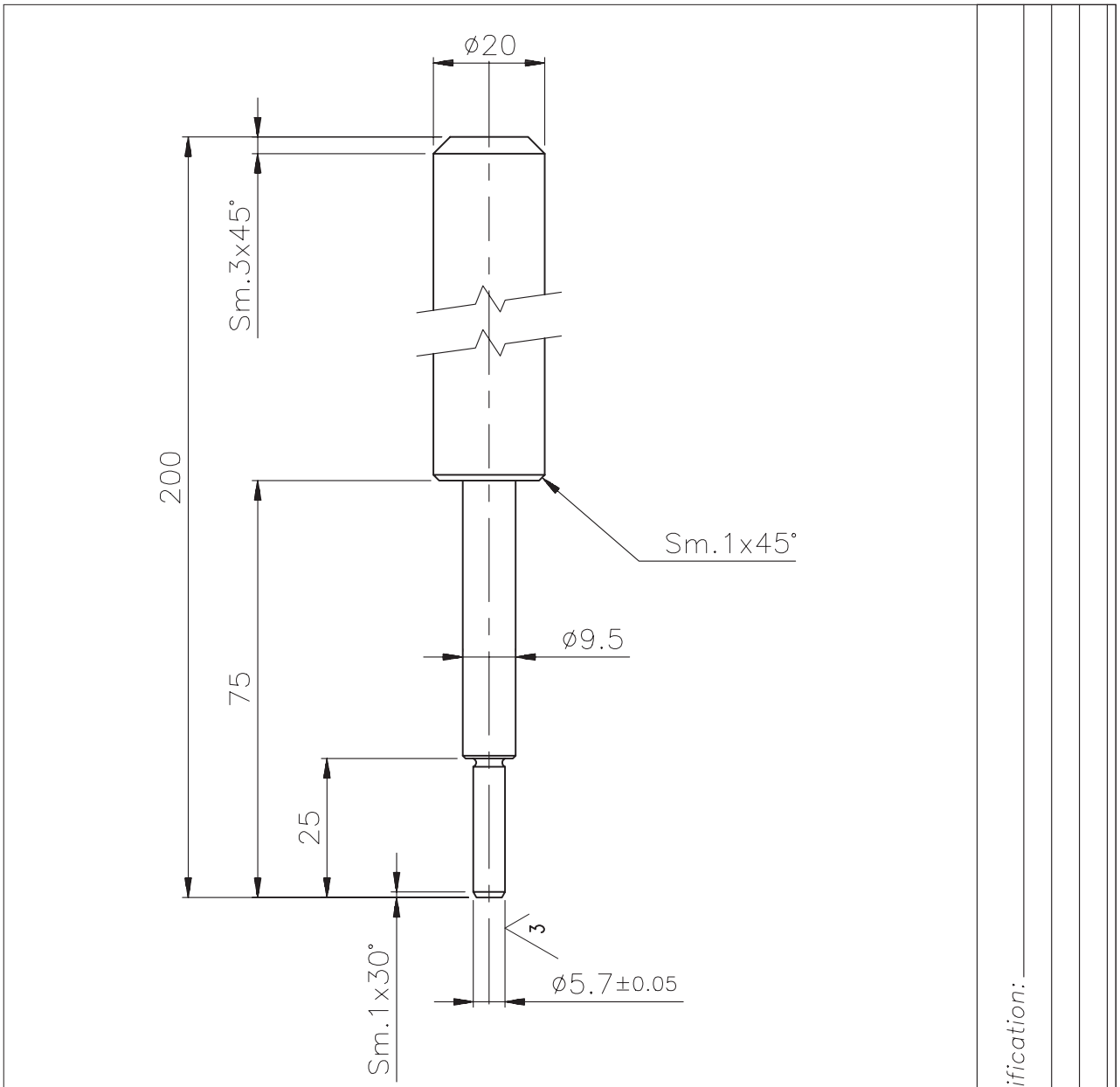
Battitoio per piantaggio	APPROVED	EXPER. 2311	SIZE A4
guida valvole	DATE 10/12/2001	SHEET	
(usare con sp. 2312)	SUPERSEDES		
	SCALE 1:1	IVECO	
MOTORI F1A - F1C	Q.TY 1		

ISO ≤ IT8 ∢ ≤ 30' Ra ≤ 0.4

C/ I.S. 18-0011

02

EXPERIMENTAL TOOLS



For the permissible errors on the dimensions without tolerance and for other general specifications, see IVECO *STD 10–2311*

MAT.	COVER.	DRAWN	N°DRAWING
39NiCrMo3 Bon.	Fosfat.	UTS (B)	SP. 2312

Battitoio per spiantaggio	APPROVED	EXPER. 2312	SIZE A4
guida valvole	DATE 10/12/2001	SHEET	
	SUPERSEDES		
	SCALE 1:1		
MOTORI F1A - F1C	Q.TY 1		

ISO ≤ IT8
4 ≤ 30'
Ra ≤ 0.4

C/ I.S. 18-0011

IVECO

02

PAGE LEFT INTENTIONALLY BLANK

SECTION 8

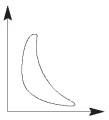
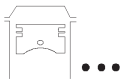
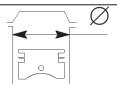
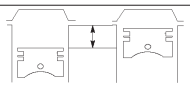
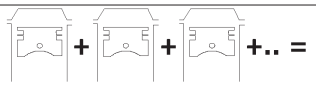
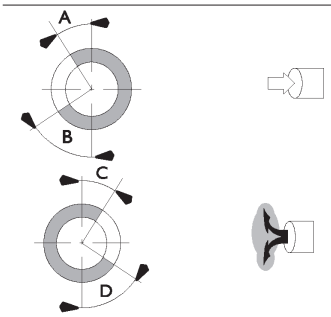
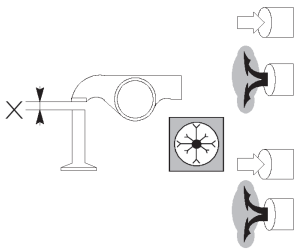
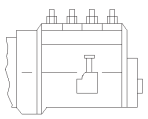
OVERHAUL

(continues on next page)

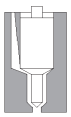
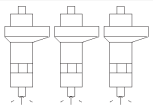
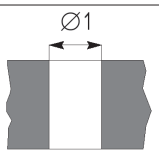
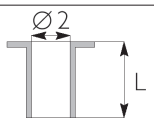
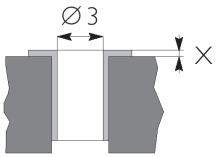
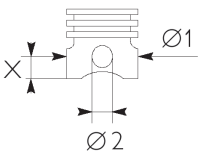
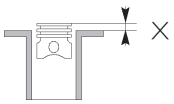
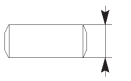
Graph and symbols

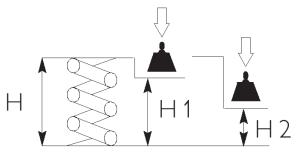
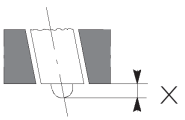
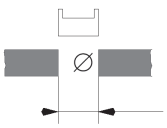
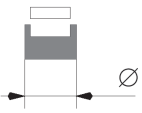
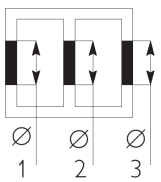
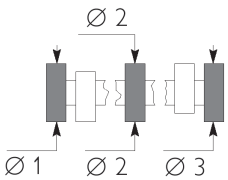
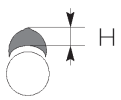
	Surface for machining Machine finish
	Interference Strained assembly
	Thickness Clearance
	Intake
	Exhaust
	Operation
ϱ	Compression ratio
	Preload
>	Oversized Higher than … Maximum, peak
<	Undersized Less than … Minimum
	Selection Classes Oversizing
	Replacement Original spare parts

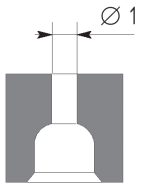
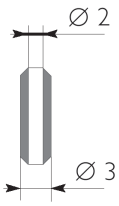
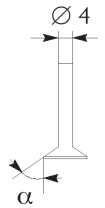
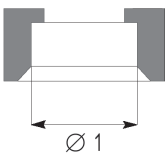
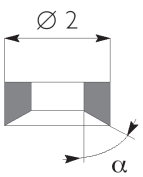
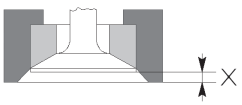
GENERAL SPECIFICATIONS

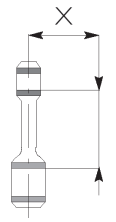
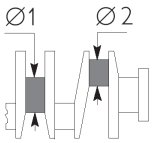
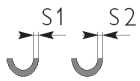
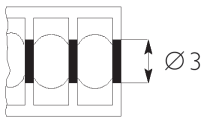
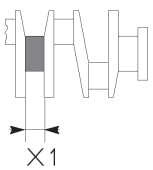
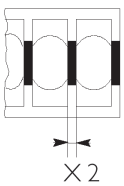
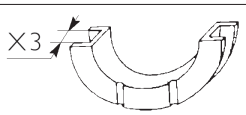
	Engine		S30 ENT M23
	Cycle		Diesel 4 strokes
	Air supply		Turbocharged with intercooler
	Injection		Direct
	Number of cylinders		4 in line
	Bore	mm	95.8
	Stroke	mm	104
	Total displacement	cm^3	2998
	**Timing system**		
	start before T.D.C.	A	24°
	end after B.D.C.	B	26°
	start before T.D.C.	D	70°
	end after B.D.C.	C	24°
	For timing check		
	X	mm	-
	X	mm	-
	Operation		
	X	mm	-
	X	mm	-
	**Supply**		High pressure electronic fuel feed system BOSCH EDC16 Composed of CP3 high-pressure pump, electro-injectors, hydraulic accumulator (rail), EDC control unit, pressure and temperature sensors

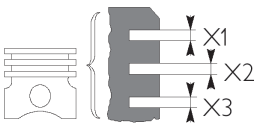
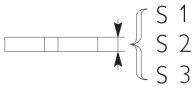
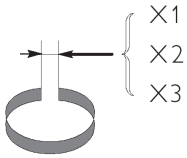
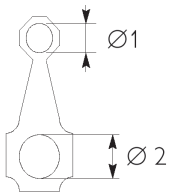
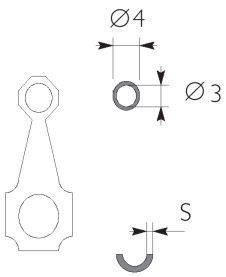
ASSEMBLY DATA - CLEARANCES

	Engine	S30 ENT M23
	Cylinder assembly and crank members	**mm**
	Electro-injectors type	BOSCH
	Injection sequence	1 - 3 - 4 - 2
	Injection pressure bar	1600
	Cylinder liners Ø 1	95.802 to 95.822
	Cylinder liners: outside diameter Ø 2 length L	- -
	Cylinder liners - crankcase seats (interference)	-
	Outside diameter Ø 2	-
	Cylinder liners: (protrusion from bottom of crankcase) X inside diameter Ø 3	- -
	Pistons: supplied as spares type measurement X outside diameter Ø 1 seat for pin Ø 2	 MAHLE 58 95.591 to 95.605 36.003 to 36.009
	Piston - cylinder liners	0.197 to 0.231
	Piston diameter Ø 1	0.4
	Piston protrusion from crankcase X	0.3 to 0.6
	Piston gudgeon pin Ø 3	35.990 to 35.996
	Piston gudgeon pin - pin seat	0.07 to 0.019

Engine		S30 ENT M23
Cylinder head - Timing system		**mm**
	Valve spring height: free spring H under a load of: 339.8 ± 9 N H 1 741 ± 39 N H 2	 54 45 35
	Injector protrusion X	2.77 to 3.23
	Seats for tappets on cylinder head normal Ø	12.016 to 12.034
	Normal diameter tappets	11.988 to 12.000
	Between tappets and seats	0.016 to 0.046
	Camshaft pin seats in cylinder overhead: 1 ⟶ 7 Ø 1 Ø 2 Ø 3	 48.988 to 49.012 46.988 to 47.012 35.988 to 36.012
	Camshaft supporting pins: Ø 1 Ø 2 Ø 3	 48.925 to 48.950 46.925 to 46.950 35.925 to 35.950
	Supporting pins and seats	0.032 to 0.087
	Useful cam height:  H  H	 3.622 4.328

	Engine		S30 ENT M23
Cylinder head - Timing system			mm
	Guide valve seats on cylinder head	Ø 1	9.980 to 10.000
	Valve guides	Ø 2 Ø 3	6.023 to 6.038 10.028 to 10.039
	Valve guides and seats on head (interference)		0.028 to 0.059
IVECO PARTS	Valve guides		0.05 - 0.10 - 0.25
	Valves:	Ø 4 α Ø 4 α	5.985 to 6.000 60° ± 7.5' 5.975 to 5.990 60° ± 7.5'
	Valve stem and relevant guide		0.023 to 0.053
	Seat on head for valve seat:	Ø 1 Ø 1	34.490 to 34.515 34.490 to 34.515
	Outside diameter of valve seats; angle of valve seats on cylinder head:	Ø 2 α Ø 2 α	34.590 to 34.610 59.5° ± 5' 34.590 to 34.610 59.5° ± 5'
	Recessing	X X	0.375 to 0.525 0.375 to 0.525
	Between valve seat and head		0.075 to 0.12 0.075 to 0.12
IVECO PARTS	Valve seats		-

Engine		S30 ENT M23
Cylinder assembly and crank members		**mm**
	Measurement X Maximum error on alignment of connecting rod axes =	125 0.09
	Main journals Ø 1 n° 1 - 2 - 3 - 4 n° 5 Crankpins Ø2	 76.182 to 76.208 83.182 to 83.208 64.015 to 64.038
	Main bearing shells S1* Big end bearing shells - upper S2* - lower * supplied as spare parts	2.165 to 2.174 1.883 to 1.892 1.885 to 1.891
	Main bearing housings Ø 3 n° 1 - 2 - 3 - 4 n° 5	 80.588 to 80.614 87.588 to 87.614
	Bearing shells - main journals	0.032 to 0.102
	Bearing shells - crankpins	0.035 to 0.083
	Main bearing shells	0.254 to 0.508
	Big end bearing shells	0.254 to 0.508
	Main journal for shoulder X 1	32.500 to 32.550
	Main bearing housing for shoulder X 2	27.240 to 27.290
	Half thrust washers X 3	32.310 to 32.460
	Crankshaft shoulder	0.040 to 0.240

Engine		S30 ENT M23
Cylinder assembly and crank members		**mm**
	Type of piston Piston ring slots X 1* X 2 X 3 * measured on Ø of 92.8 mm	- 2.200 to 2.230 2.050 to 2.070 2.540 to 2.560
	Piston rings S 1* S 2 S 3 * measured at 1.5 mm from the external Ø	2.068 to 2.097 1.970 to 1.990 2.470 to 2.490
	Piston rings - slots 1 2 3	0.103 to 0.162 0.060 to 0.100 0.050 to 0.090
	Piston rings	0.4
	Piston ring end opening in cylinder liner: X 1 X 2 X 3	 0.20 to 0.35 0.60 to 0.80 0.25 to 0.60
	Small end bushing seat Ø 1 Connecting rod bearing seat* Ø 2 * connecting rod supplied as spare part	 39.460 to 39.490 67.833 to 67.848
	Small end bushing diameter: outside Ø 4 inside Ø 3 Big end bearing shells supplied as spare part - upper S - lower S	 39.570 to 39.595 36.010 to 36.020 1.883 to 1.892 1.885 to 1.891
	Small end bushing - seat (interference)	0.08 to 0.135
	Piston gudgeon pin - bushing	0.014 to 0.030
	Big end bearing shells	0.254 to 0.508

TIGHTENING TORQUES

Part		Torque Nm		Nm
M15 x 1.5 L 193 fastening screw for cylinder head inside	First stage: pre-tightening Second stage: angle Third stage: angle	130	 90° 90°	13
M12 x 1.5 L 165 fastening screw for cylinder head side	First stage: pre-tightening Second stage: angle Third stage: angle	65	 90° 60°	6.5
M8 x 1.25 L 117/58 fastening screw for side with chain compartment, cylinder head		25		2.5
R 1/2" bevel threaded cap with socket head		25		2.5
R 3/8" bevel threaded cap with socket head		17		1.7
R 1/4" bevel threaded cap with socket head		9		0.9
M26 x 1,5 threaded screw tap		50		5
Screw with flange M6 x 1 for camshaft rear cover fastening		10		1
Screw with flange M6 x 1 for camshaft shoulder plate fastening		10		1
Socket head screw with flange M8 x 1.25 L 30/40/77/100 for over-head fastening		25		2.5
M14 x 1.5 L 10 threaded screw tap		25		2.5
M6 x 1 socket head screw for timing system control cover		10		1
M12 x 1.5 L 125 inner fastening screw for lower cylinder block	First stage: pre-tightening Second stage: angle Third stage: angle	50 ± 5	 60° ± 2.5° 60° ± 2.5°	50 ± 0.5
M8 x 1.25 L 77.5/40 outer fastening screw for lower cylinder block		26		2.6
Socket head screw with flange M11 x 1.25 for connecting rod cap fastening	First stage: pre-tightening Second stage: angle	50	 70°	5
Socket head screw with flange M12 x 1.25 for engine flywheel fastening	First stage: pre-tightening Second stage: angle	30	 90°	3
Socket cylinder head screw for phonic wheel fastening on drive shaft		15		1.5
Connection M10 x 1 for piston cooling nozzle		25		2.5
Bevel threaded cap with socket head R 3/8"x10 oil circuit		17		1.7
Socket head screw with flange M18x1.5 for drive shaft damper pulley fastening		350		35
Bevel cap R 1/8 x 8		7		0.7
Water draining plug M14 x 1.5 L10		25		2.5
Pipe union on block for oil return from turbocharger G 3/8" x 12		50		5
Suction rose M6 x 1 fastening screw		10		1
Socket head nut with flange M8 x 1.25 for depressor - oil pump unit support fastening		25		2.5
Oil pump - depressor unit control pin		110		11
Threaded cap M26 x 1.5		50		5
Socket head screw with flange M8 x 1.5 L35 for oil sump retaining frame fastening		25		2.5
Threaded screw tap with O-ring M22 x 1.5 L10		50 ± 10		5 ± 1

Part	Torque	
	Nm	kgm
Socket head screw with flange M8 x 1.25 L60 for depressor - oil pump unit fastening	25	2.5
Socket head screw with flange M8 x 1.25 L50 for depressor - oil pump unit fastening	25	2.5
Flanged screw M8 x 1.25 L20/30 for camshaft cover fastening	25	2.5
Flanged screw M6 x 1 L20 for blow-by unit fastening	10	1
M14 x 1.5 L10 cap	25	2.5
Socket head screw with flange M8 x 1.25 L40 for suction manifold fastening	30	3
Flanged nut M8 x 1.25 for exhaust manifold fastening	25	2.5
Socket cylinder head screw M8 x 1.25 L65 for Poli-V belt automatic backstand	25	2.5
Flanged screw M10 x 1.25 L22 for Poli-V belt take-up pulley fastening	40	4
Flanged head M12 x 1.75 L30 for camshaft gear fastening	80	8
Timing chain tightener fastener M22 x 1.5	50	5
Timing chain mobile skid fastener	40	4
Socket cylinder head screw M8 x 1.25 x 30 for fixed skid fastening	25	2.5
Socket cylinder head screw M6 x 1 L16/20 for skid fastening	10	1
Socket cylinder head screw M12 x 1.5 for water temperature/pressure sensor fastening	30	3
Socket cylinder head screw M6 x 1.5 for air temperature/pressure sensor fastening	10	1
Socket cylinder head screw M6 x 1 for engine rev sensor fastening	10	1
Socket head screw M6 x 1 for phase sensor fastening	10	1
High-pressure injection system		
Flanged nut M8 x 1.25 for high pressure pump support fastening	25	2.5
Hydraulic accumulator fastening screw M8 x 1.25 L50	28	2.8
High pressure pump fastening screw M8 x 1.25 L58	25	2.5
Screw M8 x 1.25 for fastening of fuel delivery pipe anchoring bracket	25	2.5
Pipe union for fuel delivery pipes to rail and electric injectors: - M14 x 1.5 - M12 x 1.5	 19 ± 2 25 ± 2	 1.9 ± 0.2 2.5 ± 0.2
Socket cylinder head screw for fastening of electric injector retaining bracket	28	2.8
Flanged nut for anchoring bracket support fastening	25	2.5
Pin fastener M12 x 1.25 for high pressure pump	110	11
Flanged screw M6 x 1 for low pressure fuel pipe fastening	10	1
Flanges screw M8 x 1.25 for pipe support bracket fastening	40	4
Filler neck M12 x 1.5 for adjustable pipe union	25	2.5
Filler neck M16 x 1.5 for adjustable pipe union	40	4
Pipe union for multi-way filler fastening to high pressure pump M12 x 1.5 L24	25	2,.5

Part	Torque	
	Nm	kgm
Nut M8x1.25 for turbocharger fastening	25	2.5
Flanged screw M8x1.25 for turbocharger output pipe fastening	25	2.5
Pipe union M22x1.5 for oil return pipe from turbocharger	35	3.5
Pipe union M14x1.5 or M12x1.5 for oil delivery pipe to turbocharger	45	4.5
Flanged screw for fastening of oil return pipe from turbocharger	10	1
Pipe union M14x1.5 for fastening of oil delivery pipe to turbocharger	35	3.5
Screw M8x1.25 for air inlet bracket fastening	28	2.8
Screw M8x1.25 for air inlet fastening	28	2.8
Socket cylinder head screw M6x1 for V-clamp closing ring	8	0.8
Flanged screw M6x1 for oil inlet pipe fastening	10	1
Pre-warming plug M8x1	8 to 11	0.8 to 1.1
Screw M8x1.25 for electric injector retaining bracket fastening	28	2.8
Oil filter cartridge M22x1.5	25	2.5
Socket cylinder head screw M8x1.25 for water inlet pipe fastening	25	2.5
Pipe union M24x1.5 for oil filter cartridge ◆	30	3
Flanged screw M8x1.25 for heat exchanger inner element fastening	25	2.5
Socket cylinder head screw for water pump fastening: - M10x1.5 - M8x1.25	50 25	5 2.5
Flanged screw M8x1.25 for rear cover fastening to cylinder head	25	2.5
Flanged screw M8x1.25 for coolant delivery pipe fastening	25	2.5
Flanged nut M8x1.25 for coolant delivery pipe support bracket fastening	25	2.5
Pipe union M10x1x10 for vapour vent fastening	12	1.2
Flanged screw M8x1.25 for thermostat fastening	25	2.5
Flanged nut M6x1 for electro-magnetic joint fastening	10	1
Ring nut M30x1.5 for electro-magnetic joint	150	15
Socket cylinder head screw M10x1.5 for alternator fastening	50	5
Flanged screws M8x1.25 for power take off cover fastening	25	2.5
Flanged screws M8x1.25 for handling hook fastening	25	2.5
Flanged screws M10x1.25 for engine support fastening	50	5
Depressor pipe union M14x1.5	35	3.5
Oil level sensor M12x1.25	25	2.5
Thermometric transmitter/switch M16x1.5 (conical)	25	2.5
Oil pressure switch M14x1.5	40	4

◆ On the threading apply Loctite 577

ENGINE OVERHAUL - ENGINE DISASSEMBLY AT THE BENCH

Foreword

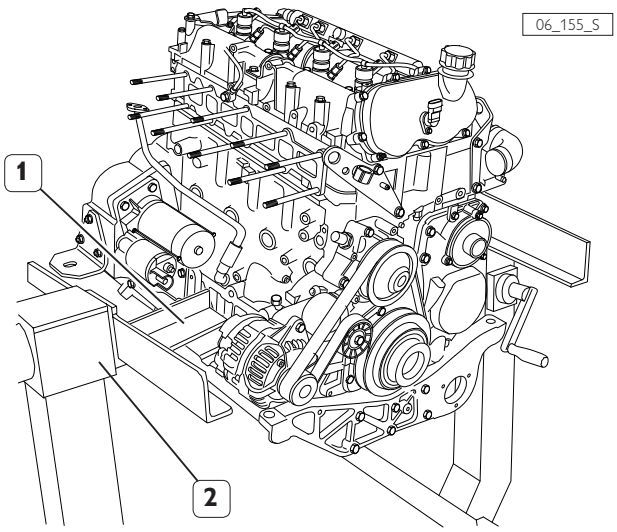
Part of the operations illustrated within this section can be partially executed while the engine is assembled on the boat, depending on the room available for access to the engine and on the equipment application as well.

CAUTION

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.

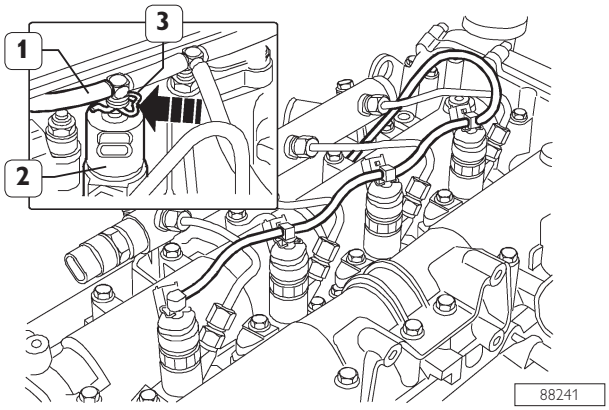
Operations described below refer to the engine without the components for its marine adaptation (see Section 6).

Figure 1



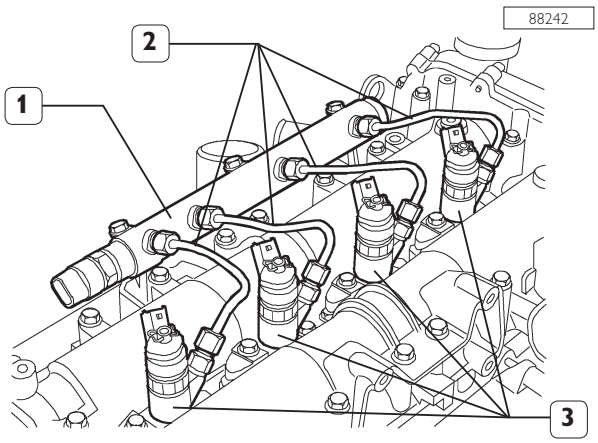
Fit the brackets 99361041 (1) to the crankcase and use these to secure the engine to the rotary stand 99322205 (2). Drain the oil from the engine by removing the plug from the oil sump.

Figure 2



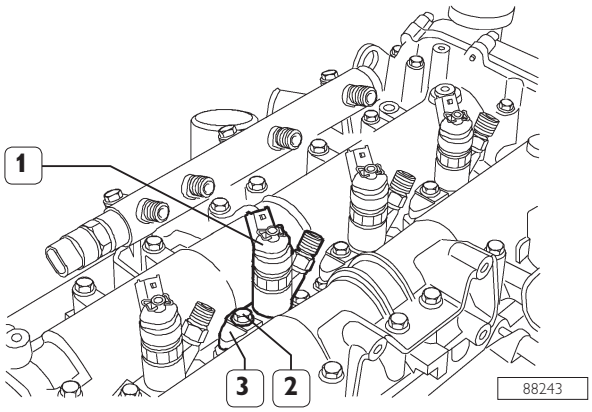
Press the springs (3) in the direction shown by the arrow and disconnect the fittings of the pipe (1) recovering fuel from the electro-injectors (2).

Figure 3



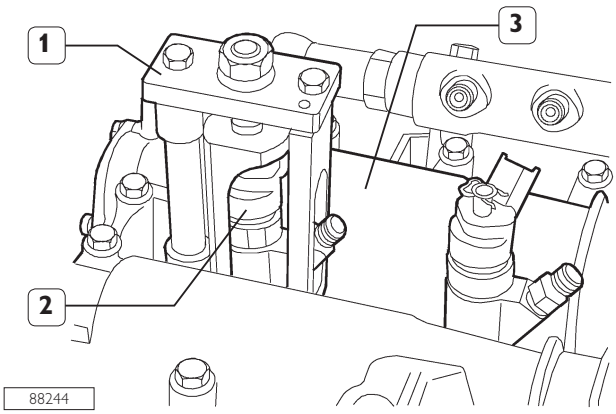
Disconnect the fuel pipes (2) from the electro-injectors (3) and from the hydraulic accumulator (1) (rail).

Figure 4



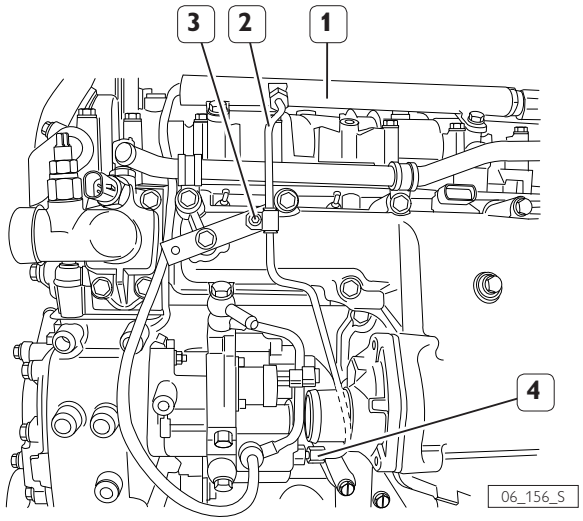
Take out the screws (2) and the brackets (3) fixing the electro-injectors (1) to the cylinder overhead.

Figure 5



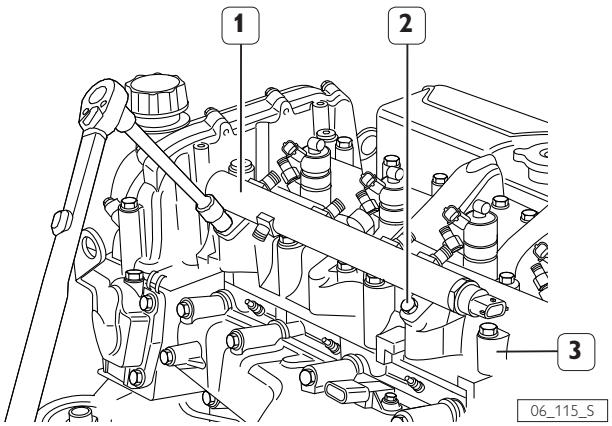
Using tool 99342153 (1) extract the electro-injectors (2) from the overhead (3).

Figure 6



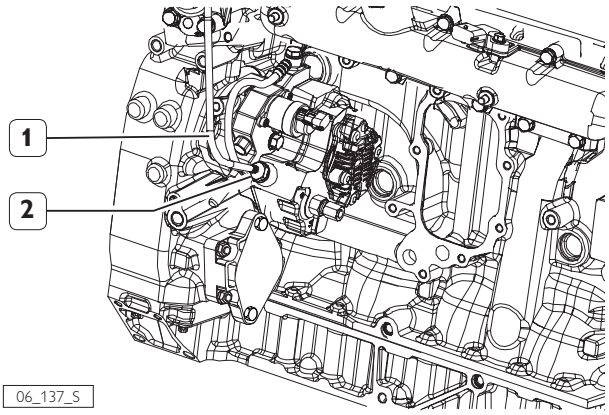
Remove the fastening screw (3) of the pipe retaining bracket (2). Disconnect the pipe (2) from the hydraulic accumulator (1) and the high pressure pump (4).

Figure 7



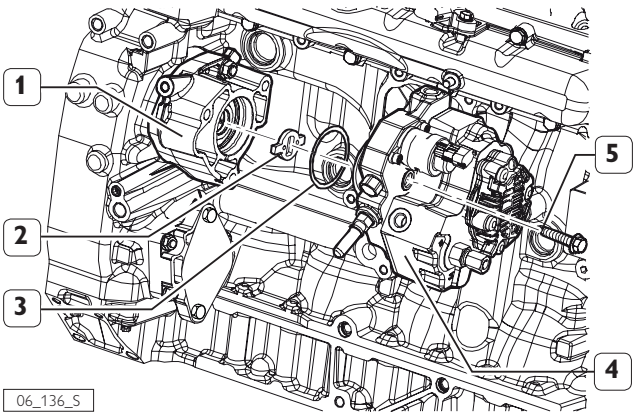
Remove the screws (1) and the hydraulic accumulator (2) from the overhead device (3).

Figure 8



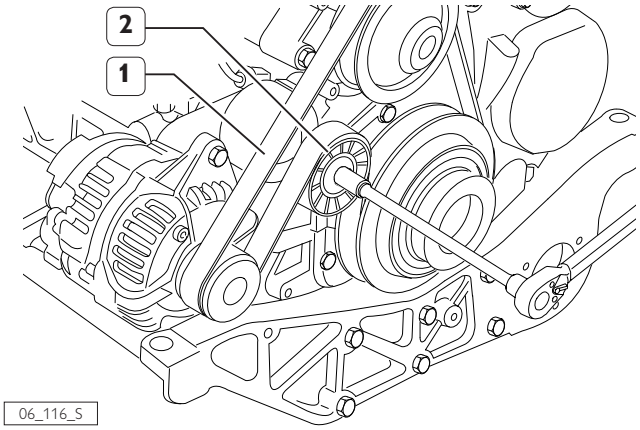
Disconnect the fuel return pipe from the electronic injectors (1) by unscrewing the screw (2).

Figure 9



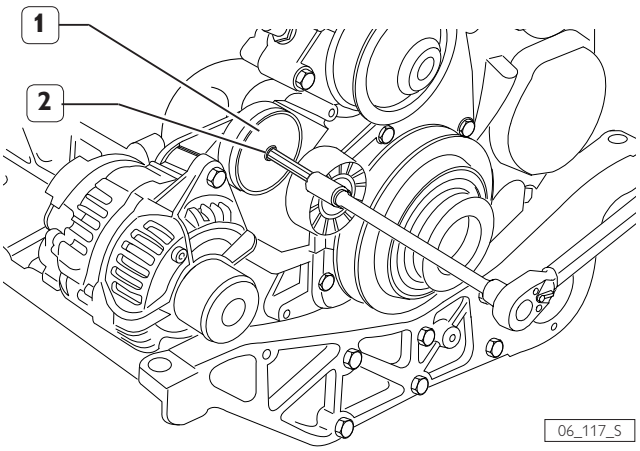
Disassemble the high pressure pump (4) from the support (1) by unscrewing the screws (5); extract the joint (2) and the seal ring (3).

Figure 10



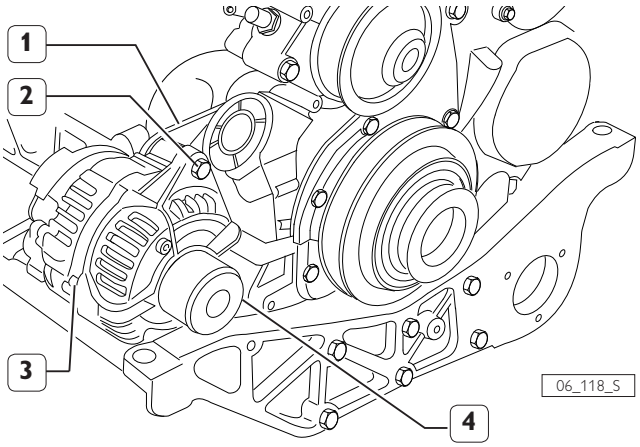
Using the specific wrench on the automatic tightener (2), slacken the tension of the belt (1) and remove it.

Figure 11



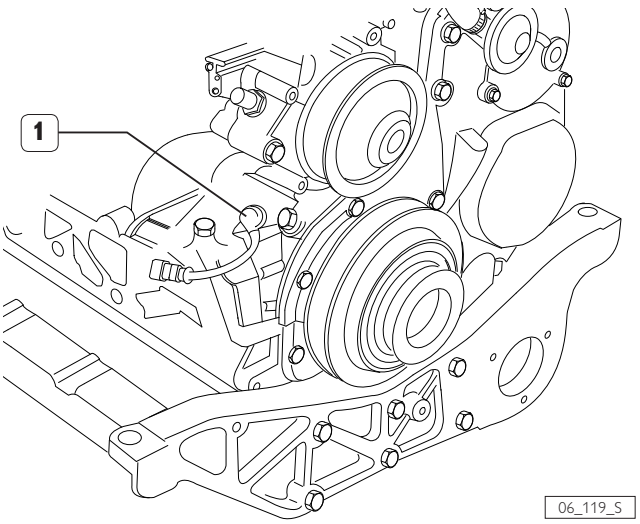
Take out the screw (2) and remove the automatic tightener (1).

Figure 12



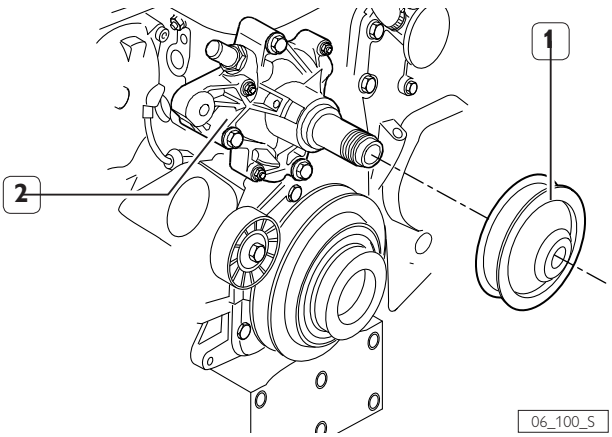
Remove the screw (2), the nut (4) and remove the alternator (3) from the support (1).

Figure 13



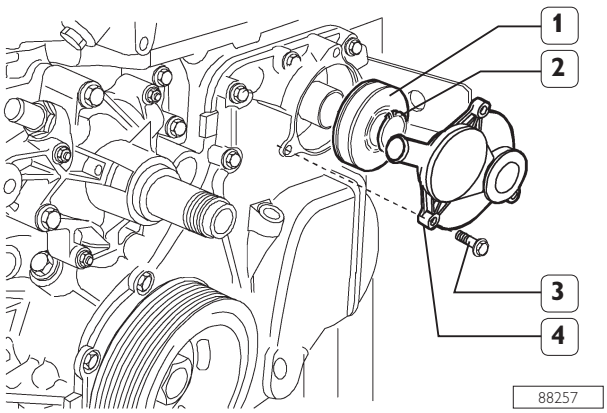
Remove the fastening screw and the rev sensor (1).

Figure 14



Disassemble the pulley (1) from the coolant pump (2).

Figure 15

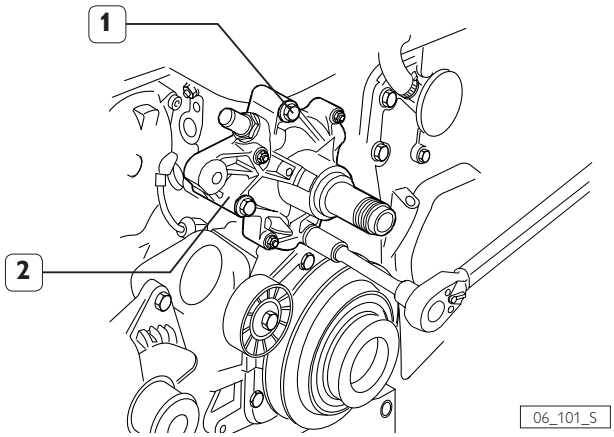


Remove the screws (3) and disassemble the cover (4). Remove the spring ring (2). Extract the centrifugal filter (1).

NOTE

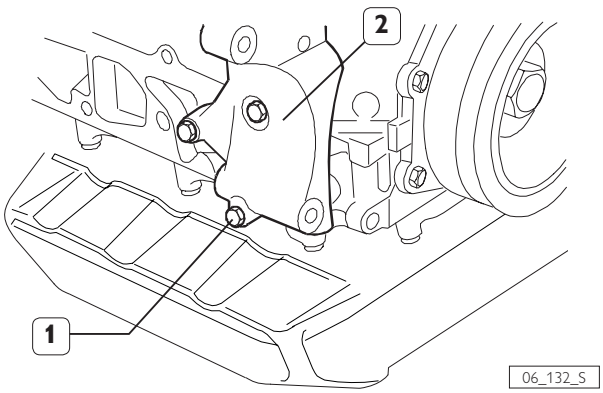
The centrifugal filter (1) and the cover seal ring (4) must be replaced every time they are disassembled.

Figure 16



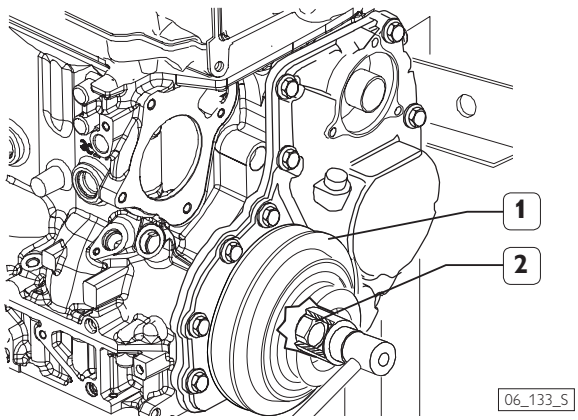
Disassemble the coolant pump (2) by unscrewing the screws (1).

Figure 17



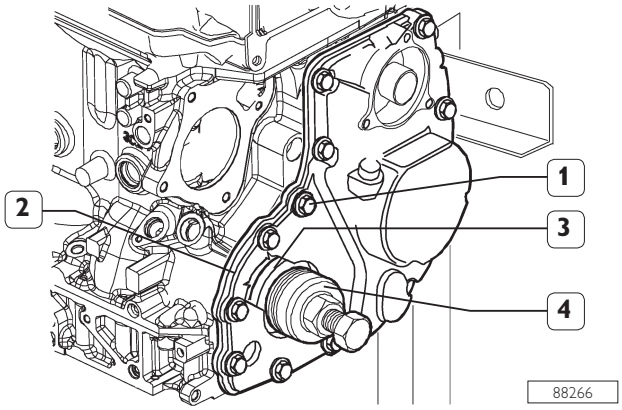
Unscrew the screws (1) and remove the support (2) from the engine block.

Figure 18



Lock the engine flywheel rotation. Remove the screw (2) and disassemble the damping pulley (1).

Figure 19

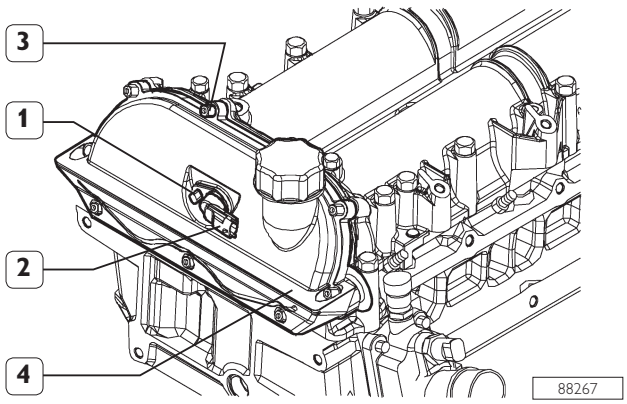


Remove the screws (1) and the distribution cover (2).

NOTE

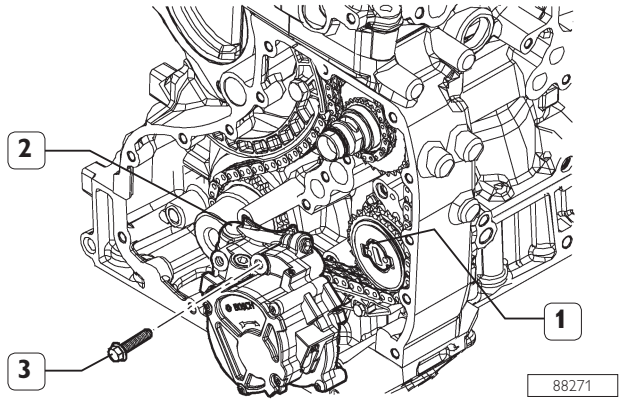
Tool 99340059 (4) is used to remove the seal ring (3) from the cover (2) when the engine is installed.

Figure 20



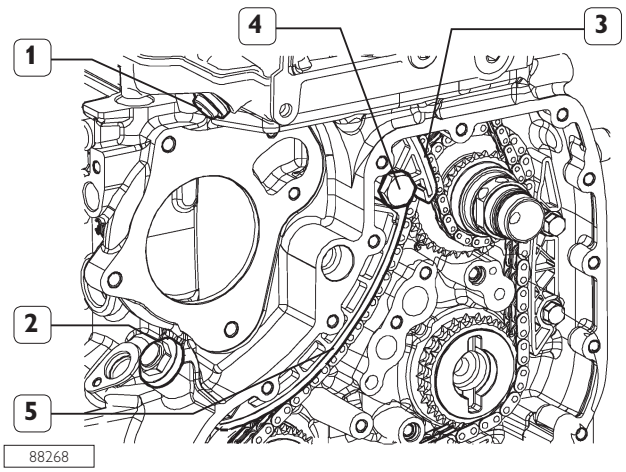
Remove the nut (1) and the phase sensor (2).
Remove the nuts (3) and the cover (4).

Figure 21



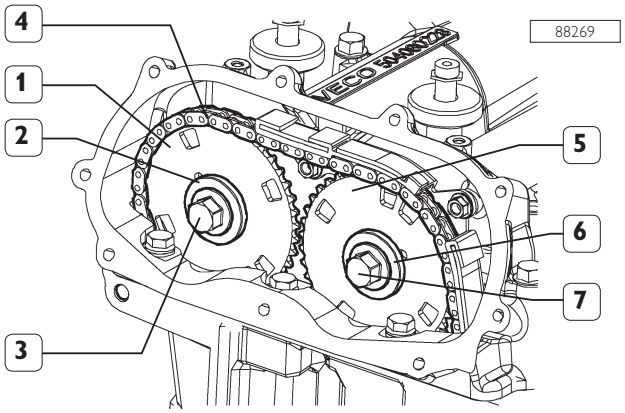
Remove the screws (3) and disassemble the depressor/oil pump unit (2).
Remove the connection key (1).

Figure 22



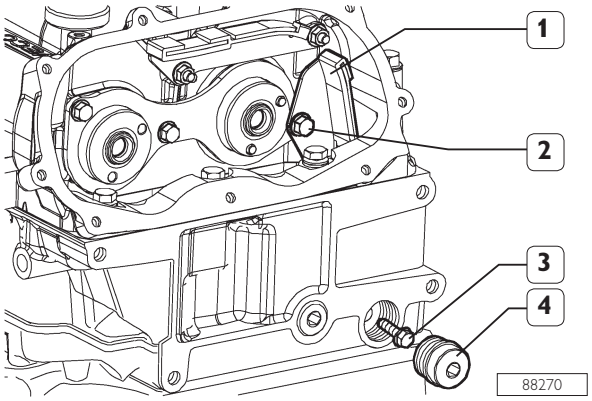
Remove the hydraulic chain tightener: top (1) and lower (2).
Remove the pin (4) and disassemble the mobile skid: lower (5) and top (3).

Figure 23



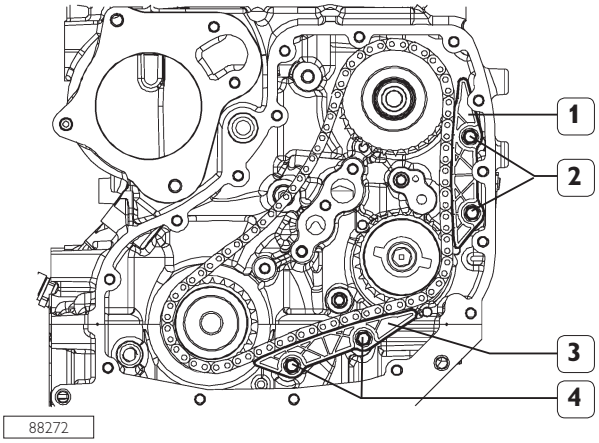
Remove the screw (3), the washer (2) and the gear (1).
Remove the screw (7), the washer (6), the gear (5) and the chain (4).

Figure 24



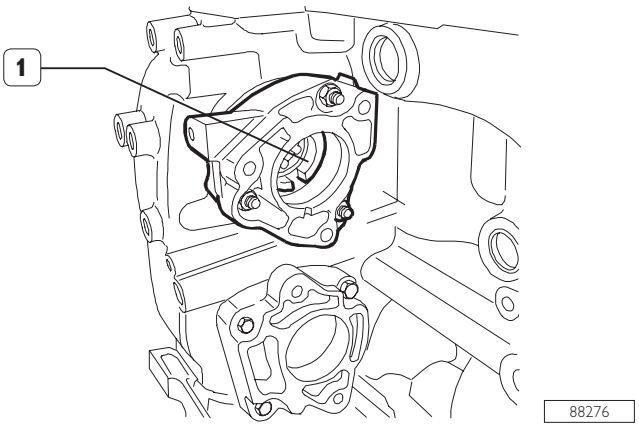
Remove the cap (4), the screws (2 and 3) and the top fixed skid (1).

Figure 25



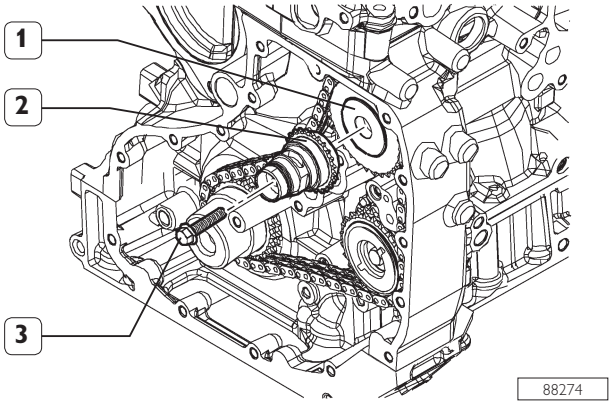
Remove the screws (2) and the side fixed skid (1).
Remove the screws (4) and the lower fixed skid (3).

Figure 26



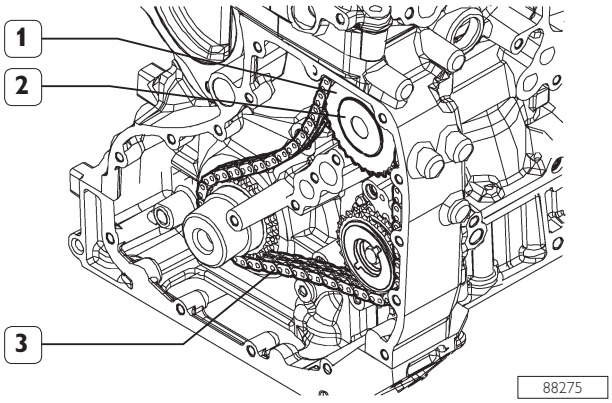
Stop the rotation of the high pressure pump control shaft (1) by inserting the suitable wrench inside it.

Figure 27



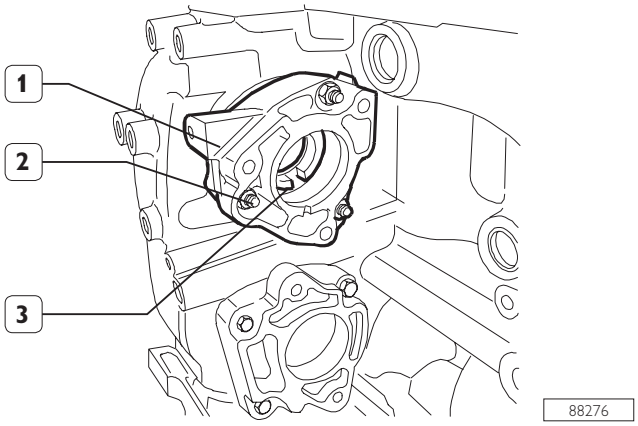
Remove the screw (3) and the stem with the drive gear (2) from the high pressure pump control shaft (1).

Figure 28



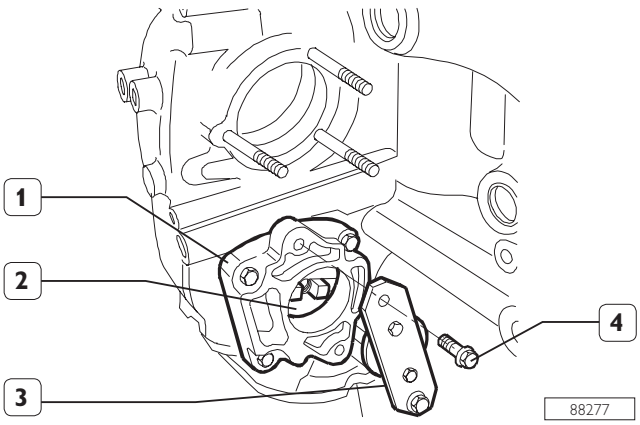
Remove the gear (1) and the chain (3) from the high pressure pump control shaft (2).

Figure 29



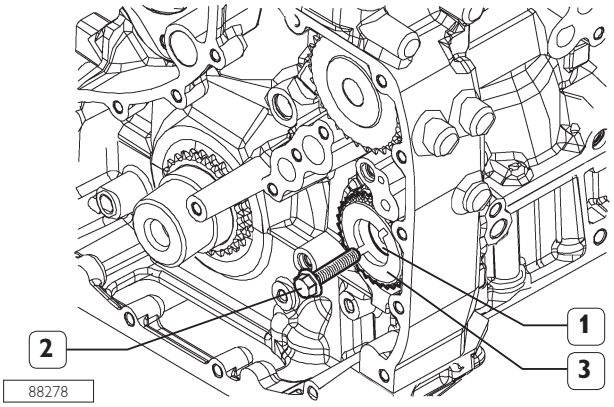
Remove the high pressure pump control shaft (3). Remove the nuts (2) and the support (1).

Figure 30



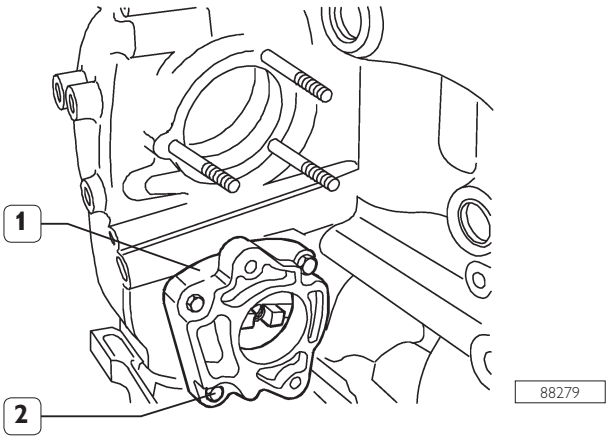
Stop the rotation of the oil pump control shaft (2) by inserting tool 99360187 (3) in the shaft and fastening the tool on the support (1) by means of the screws (4).

Figure 31



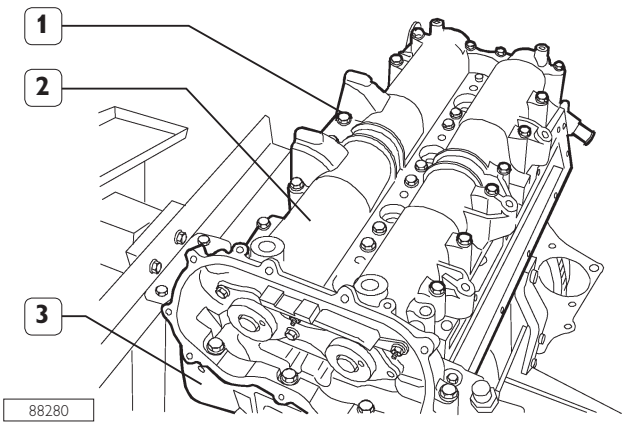
Remove the screw (2) and the gear (1) from the oil pump control shaft (3).

Figure 32



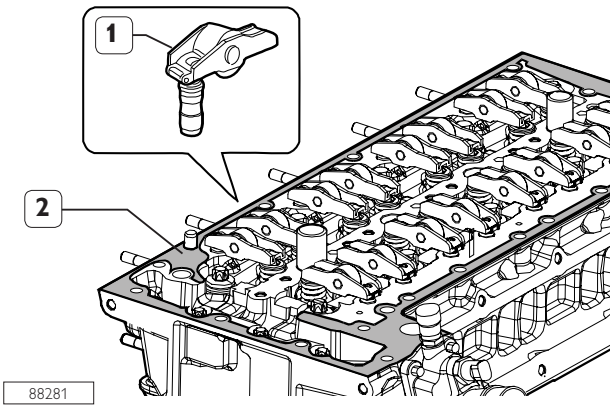
Remove the nuts (2) and the support (1).

Figure 33



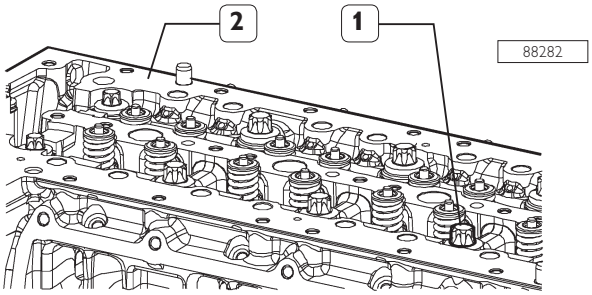
Remove the screws (1) and take off the over-head (2) from the cylinder head (3).

Figure 34



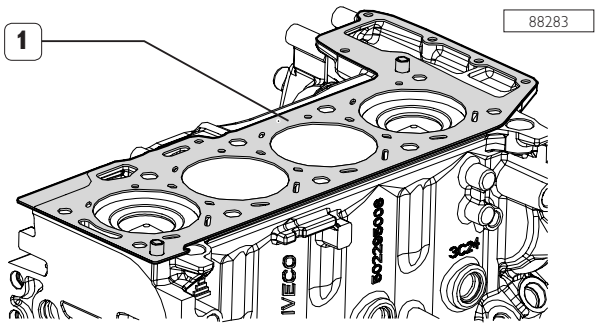
Remove the hydraulic tappets (1) with the rocker arms. Remove the gasket (2).

Figure 35



Take out the screws (1) and remove the cylinder head (2).

Figure 36

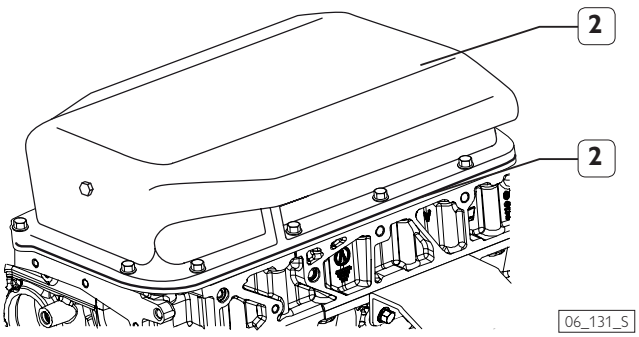


Remove the cylinder head gasket (1).

NOTE

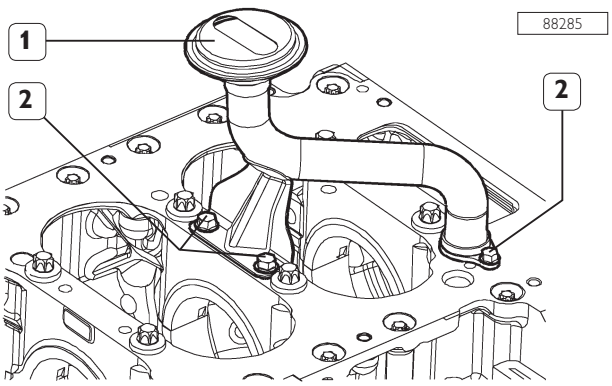
Check the protrusion of the pistons (2) as described under the relevant heading to check the possibility of facing the crankcase if it has deformed.

Figure 37



Remove the screws (2) and take off the oil sump (1).

Figure 38



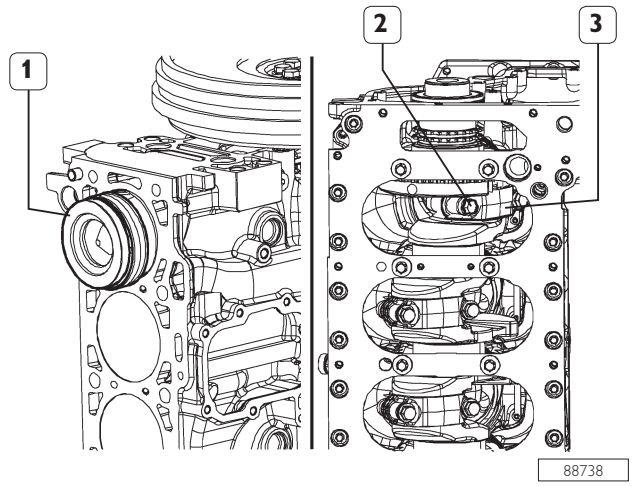
Remove the screws (2) and the suction rose (1).

ATTENTION

The illustrations relating to the oil pan and the suction rose may not mirror those of your model. The following procedures still apply.

CYLINDER BLOCK

Figure 39

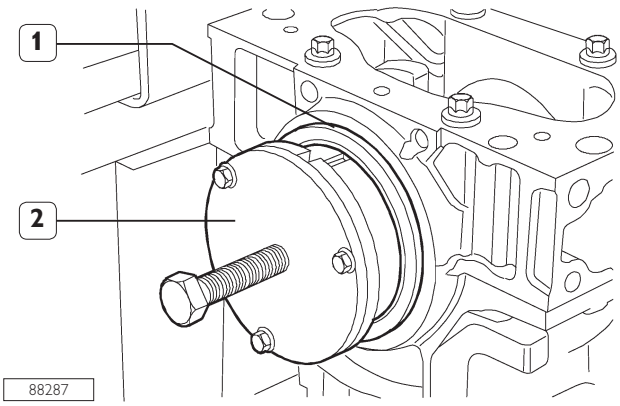


Take out the screws (2) and remove the connecting rod caps (3).
Extract the pistons (1) from the top of the crankcase.

NOTE

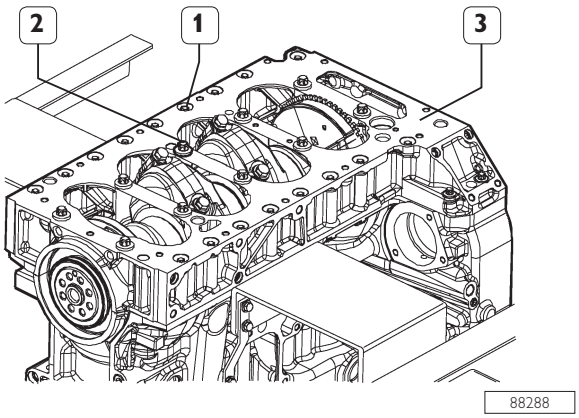
On the same side of the connecting rod and its associated cap, indicate the number of the cylinder from which the connecting rod has been removed.
Keep the bearing shells in their respective housings since, if they are used, they will need to be fitted in the position found during removal.

Figure 40



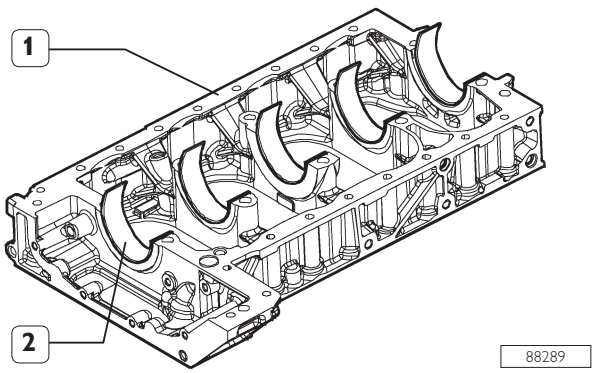
Apply tool 99340060 (2) to the rear O-ring (1) and extract it from the crankcase.

Figure 41



Unscrew the screws (1) and (2) with box-type wrenches and take out the underblock (3).

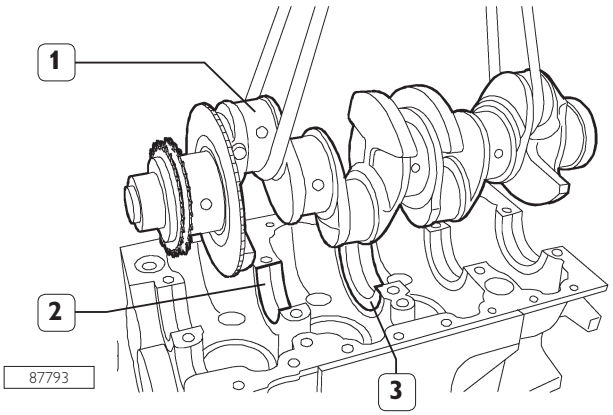
Figure 42



NOTE

Note the assembly position of the top main bearing shells (2) since, if they are reused, they will need to be fitted in the position found during removal.

Figure 43



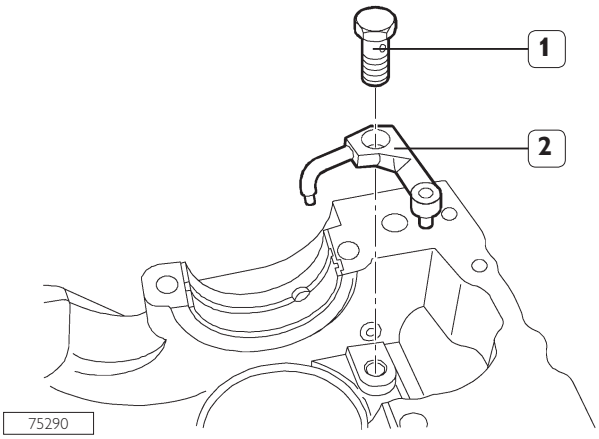
With the aid of a hoist and a rope, remove the crankshaft (1).

NOTE

Note the assembly position of the top main bearing shells (2) since, if they are reused, they will need to be fitted in the position found during removal.

The central half-bearing (3) is fitted with shoulder half-rings.

Figure 44



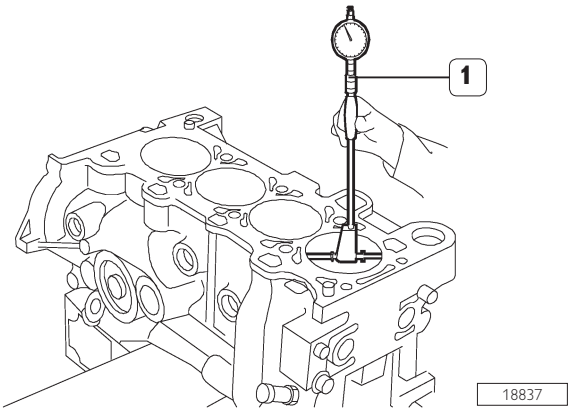
Take out the couplings (1) and remove the oil jets (2).

NOTE

On completing engine removal, it is necessary to clean the removed parts thoroughly and check their integrity.
The following pages give the instructions for the main checks and measurements to make in order to determine whether the parts can be reused.

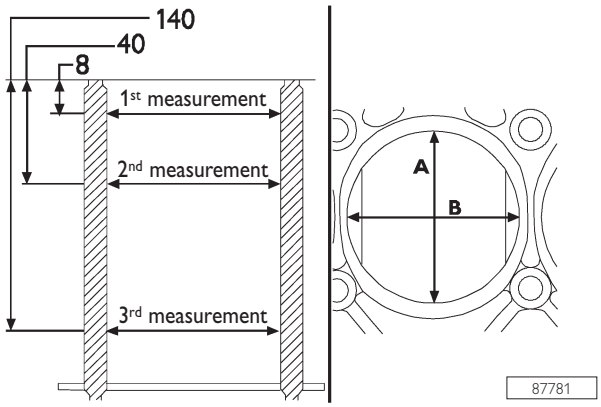
Checks and measurements

Figure 45



Once the engine removal is complete, carefully clean the cylinder block. For the cylinder block transportation use the suitable rings.
Carefully check that the crankcase has no cracks in it.
Check the state of the plugs. If they are rusty or there is any doubt about their seal, replace them. Examine the surfaces of the cylinder liners; they must show no sign of meshing, scoring, ovalization, taper or excessive wear. The inside diameter of the cylinder liners is checked, to ascertain the extent of ovalization, taper and wear, using the bore meter 99395687 (1) fitted with a dial gauge previously reset on the ring gauge of the diameter of the cylinder liner or on a micrometer.

Figure 46



The measurements must be made for each single cylinder at three different heights up the liner and on two planes at right angles to each other: one parallel to the longitudinal axis of the engine (**B**) and the perpendicular (**A**); the greatest wear is generally found on this last plane with the first measurement.
On finding ovalization, taper or wear, go ahead and bore/grind and finish the face of the cylinder liners. The refacing of the cylinder liners should be done in relation to the diameter of the pistons supplied as spare parts oversized by 0.4 mm of the nominal value and to the prescribed assembly clearance.

Figure 47

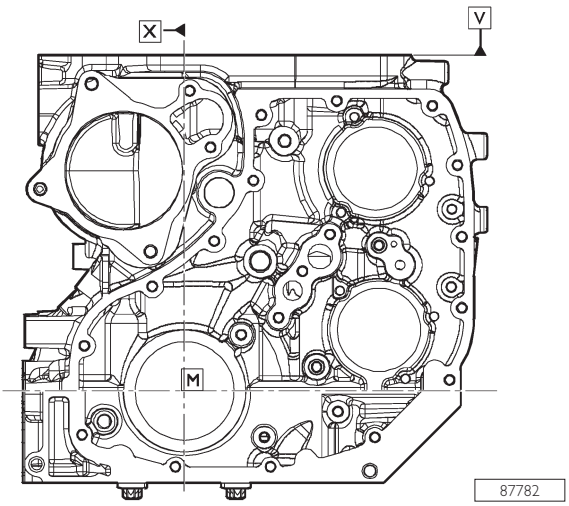
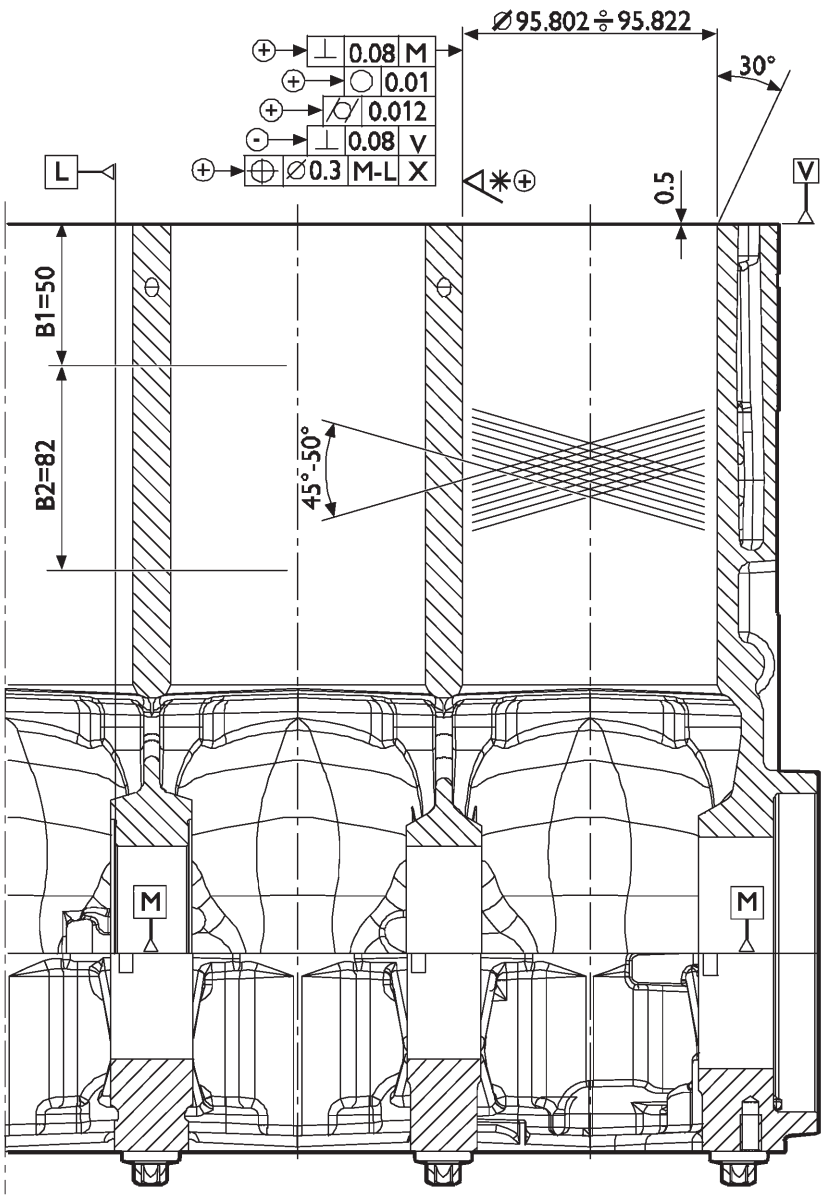


Figure 48



* Surface roughness parameters:

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

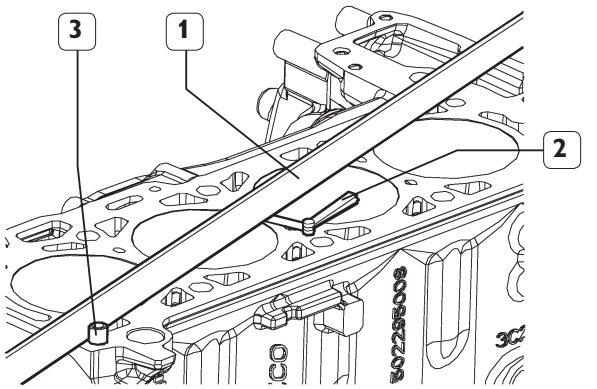
Permissible surface porosity for machined cylinder (see Figure 56)

ZONE B1 = Area of greatest mechanical stress, segment/liner contact: No.2 non-continuous porosities are permissible max. 0.5x0.5; C 100%

ZONE B2 = Surface involved in segment rubbing: No.2 non-contiguous porosities are permissible max. 1x0.8. C 100%

Checking head mating surface on cylinder block

Figure 49



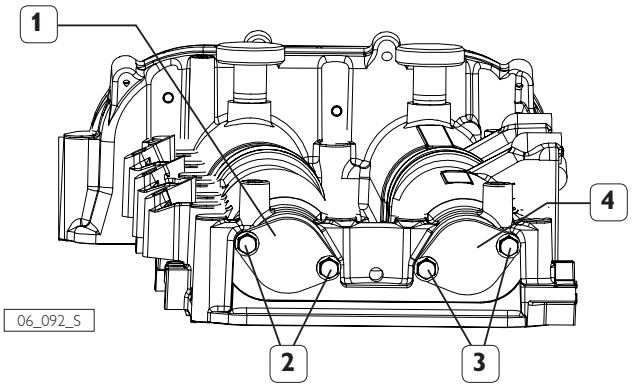
See that the head mating surface, on the cylinder block, has no deformation.
This check can be made, after taking out the grub screws (3), with a surface plate spread with carbon black or with a calibrated rule (1) and a feeler gauge (2). After ascertaining the areas of deformation, level the bearing surface with a grinding machine.

NOTE

The crankcase can only be surfaced after making sure that, on completing the work, the piston protrudes from the cylinder liner by no more than the prescribed value.

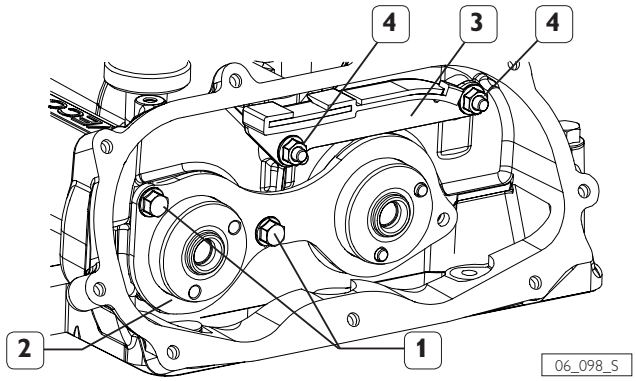
Overhead - Overhead removal

Figure 50



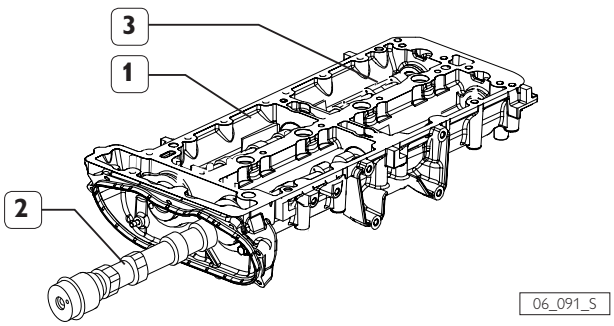
Remove the screws (2 and 3) and the covers (1 and 4) together with the over-head seal rings.

Figure 51



Remove the nuts (4) and the top skid (3).
Remove the screws (1) and the shoulder plate (2).

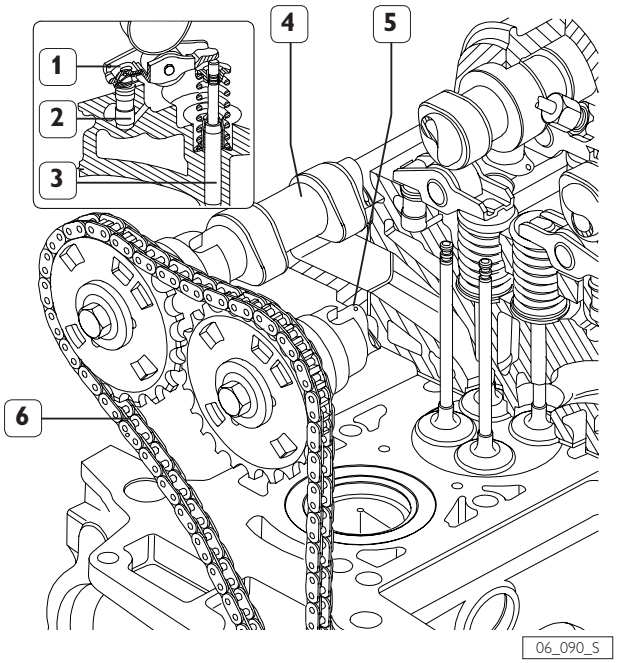
Figure 52



Tilt the over-head (1) and take care not to damage the seats, then take off the camshafts (2 and 3) from the overhead.

TIMING SYSTEM

Figure 53



1. Rocker arm - 2. Reaction hydraulic tappet - 3. Valve assembly - 4. Camshaft on exhaust side - 5. Camshaft on suction side - 6. Camshaft control chain.

Description

The timing system is the type with a twin camshaft in the head and four valves per cylinder with hydraulic tappets.
The control is transmitted by two chains:

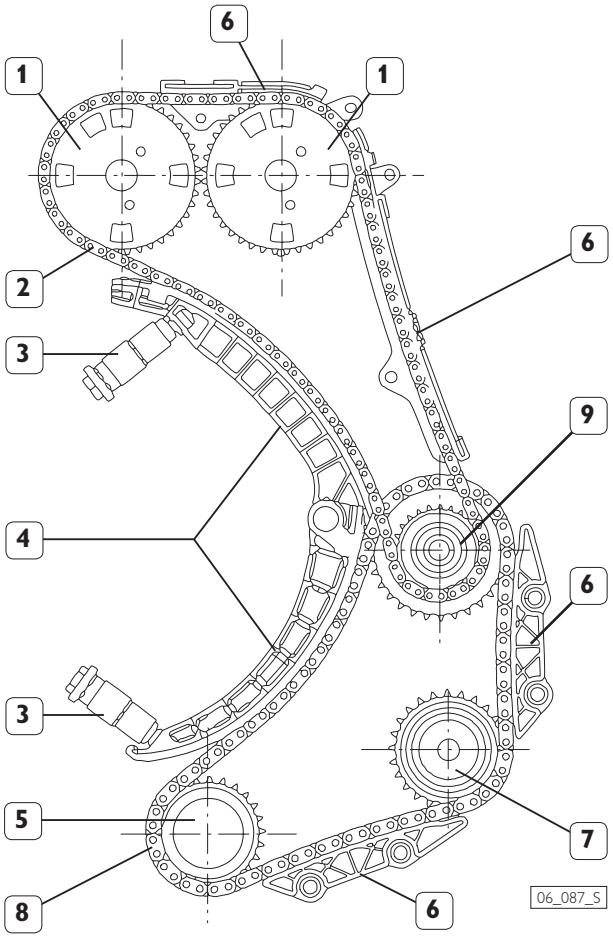
- A double chain by 3/8" is set in motion by the driving shaft and sets the control shafts in motion: oil pump/ depressor - high pressure pump;
- A single chain is set in motion by the high pressure control shaft gear and sets the camshafts in motion.

The camshaft gears are mutually interchangeable and are fitted with slots to make it possible for the phase sensor to detect the phase.
The rocker arms, one for the valve, are kept in contact with the corresponding cam by an hydraulic tappet, thus eliminating the need for regular adjustments.

NOTE

Change both chains, even if only one of them is faulty.

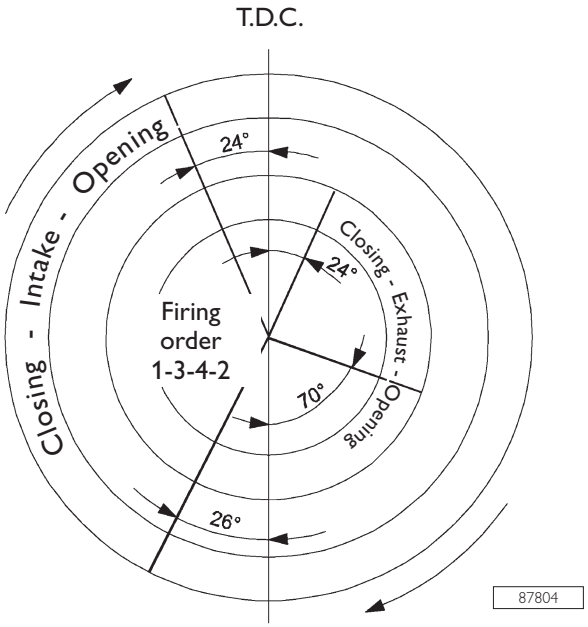
Figure 54



TIMING SYSTEM AND AUXILIARY SYSTEM DIAGRAM

1. Camshaft control gear - 2. Single chain - 3. Hydraulic chain tightener - 4. Chain - 5. Drive gear on driving shaft - 6. Fixed skid - 7. Oil pump/depressor control shaft gear - 8. Double chain - 9. High pressure pump control shaft gear.

Figure 55

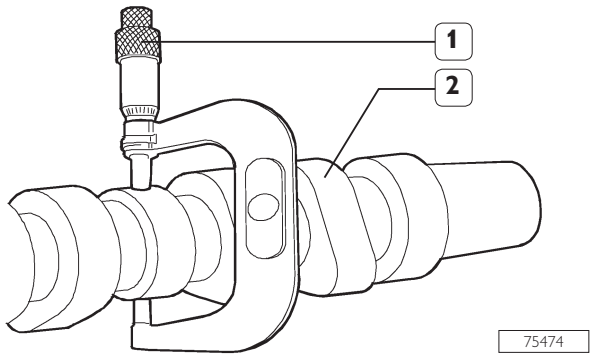


TIMING SYSTEM DIAGRAM

Camshaft - Checks

The surfaces of the shaft supporting pins and of the cams must be finely honed; if there is any sign of meshing or scoring, replace the shaft.

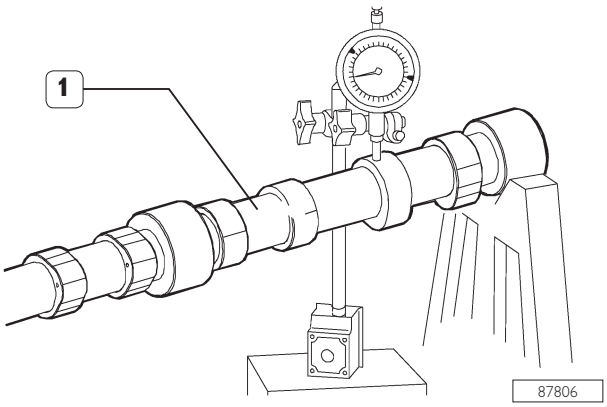
Figure 56



Using a micrometer (1),measure the diameter of the pins (2) of the camshaft and, using a bore meter, measure the diameter of the supporting seats in the overhead.
The difference between these two measurements gives the existing clearance.
The nominal assembly clearance is 0.037 to 0.088 mm.

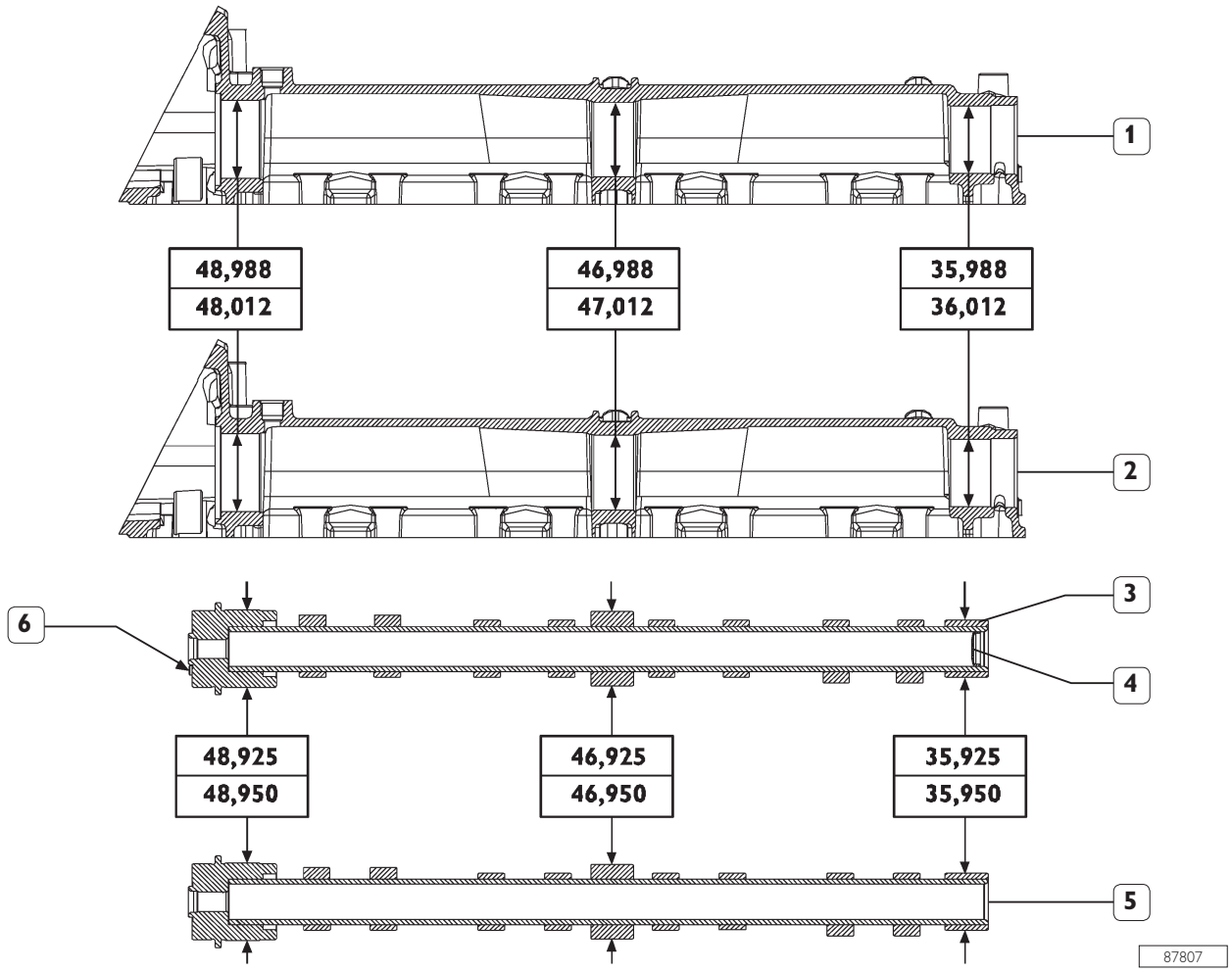
Checking cam lift and pin alignment

Figure 57



Place the shaft (1) on the parallels and use a centesimal dial gauge fitted on the central support to check that the alignment error does not exceed 0.04 mm; otherwise, change the shaft.
Check also the cam lift: it must correspond to the prescribed value; if different values are detected, change the shaft.

Figure 58



MAIN DATA, CAMSHAFT PINS AND SEATS

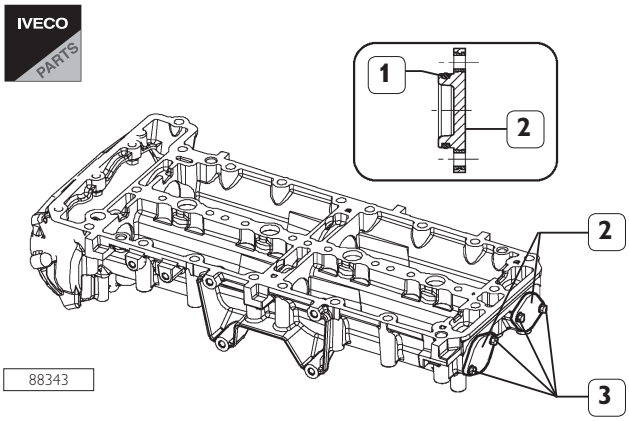
1. Intake valve camshaft seats - 2. Exhaust valve camshaft seats - 3. Intake valve camshaft - 4. Exhaust valve camshaft.

CAUTION

The camshaft (3) which actuates the intake valves can be identified by the cup (4) and by the locating pin (6).

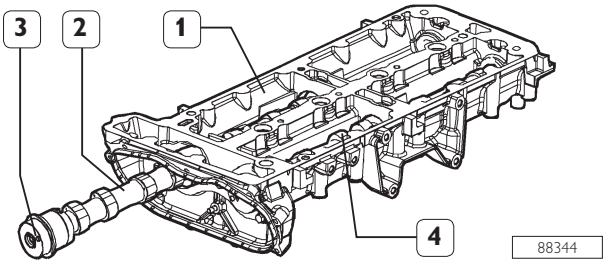
Assembling overhead

Figure 59



Lubricate the new seal rings (1) with engine oil and fit them on the covers (2).
Fit the covers (2) on the overhead, drive in the fastening screws (3) and tighten them to the prescribed torque.

Figure 60

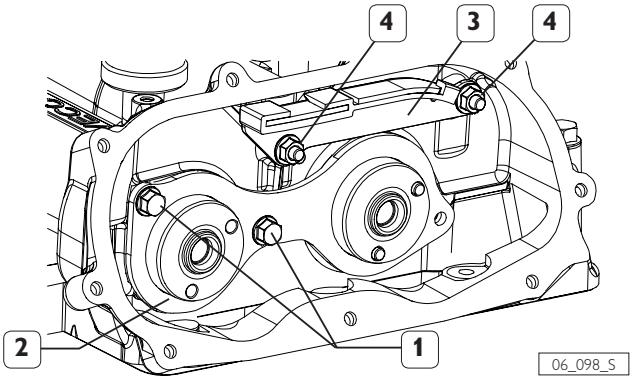


Lubricate the support pins of the suction camshafts (2) and exhaust camshafts (4) and fit them on the overhead (1).

NOTE

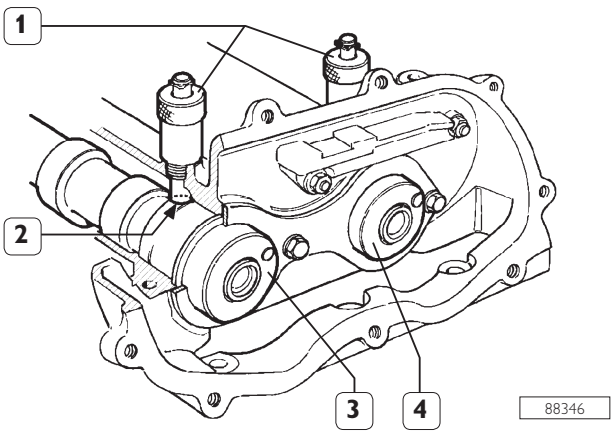
During this operation do not exchange the assembly position of the shafts.
The camshaft which actuates the intake valves (2) can be identified by the locating pin (3) place it on the front end and the cup on the rear end.
In addition, take care not to damage the support seats of the over-head shafts.

Figure 61



Fit the top skid (3) and drive in the nuts (4), then tighten them to the prescribed torque.
Fit the shoulder plate (2) and drive in the screws (1), then tighten them to the prescribed torque.

Figure 62

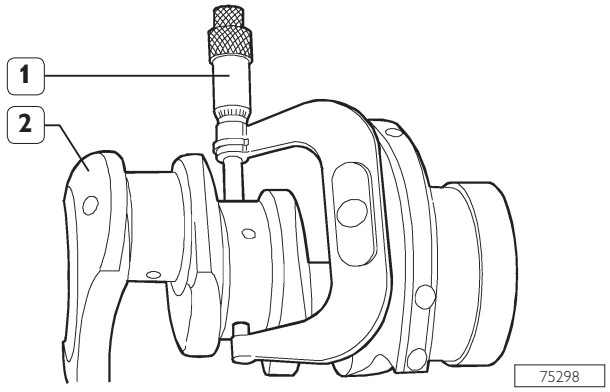


Position the camshafts (3 and 4) in order to be able to insert the pins 99360614 (1) inside the slots (2) through the threaded holes in the overhead? over-head.

CRANKSHAFT

Measuring main journals and crank pins

Figure 63



On finding signs of seizure, scoring or excessive ovalization on main journals and crankpins, it is necessary to regrind the pins. Before grinding the pins (2),measure the shaft pins with a micrometer (1) to establish to what diameter it is necessary to decrease the pins.

NOTE

It is advisable to enter the measurements in a table. See Figure 72.

Figure 64

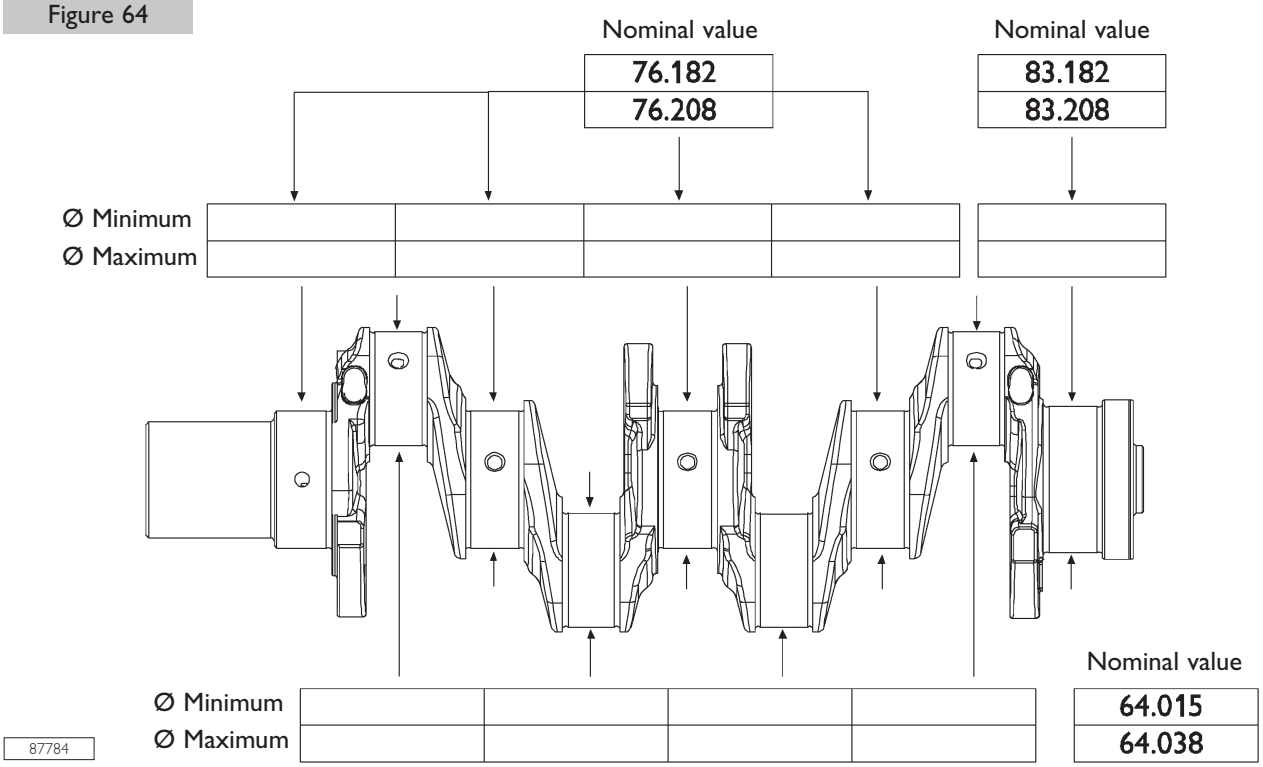


TABLE IN WHICH TO ENTER THE MEASUREMENTS
OF THE CRANKSHAFT MAIN JOURNALS AND CRANKPINS

NOTE

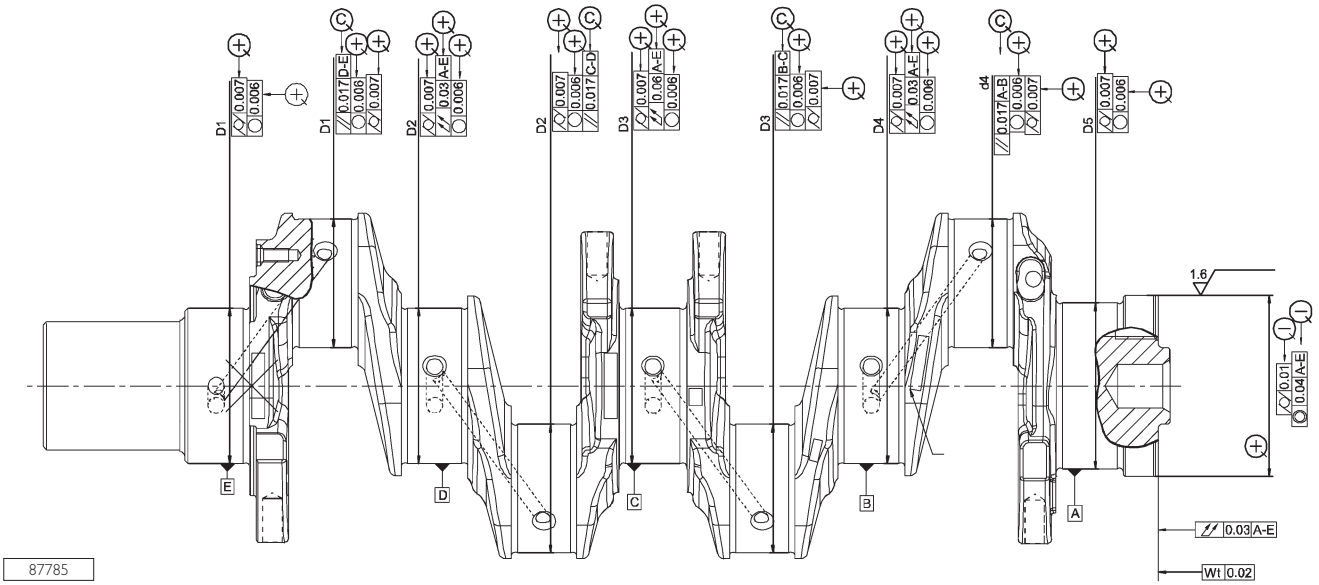
The main journals and crankpins must always be ground to the same undersize class.
The undersizing performed, on the main journals or crankpins, must be marked by punching on the side of crank arm no. 1.

For undersized crankpins, letter M.
For undersized main journals, letter B.
For undersized crankpins and main journals, letter MB.

The undersize classes are: 0.254 - 0.508 mm.

Checking crankshaft

Figure 65

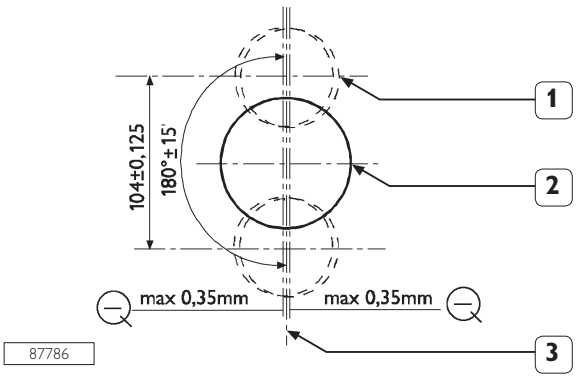


MAIN CRANKSHAFT TOLERANCES

Tolerances	Tolerance characteristic	Graphic symbol
Shape	Circularity	○
	Cylindricality	⌭
Orientation	Parallelism	//
	Perpendicularity	⊥
Position	Concentricity or coaxiality	◎
Oscillation	Circular oscillation	↗
	Total oscillation	⌰

Class of importance ascribed to the product characteristics	Graphic symbol
Critical	Ⓒ
Important	⊕
Secondary	⊖

Figure 66



SYMMETRY BETWEEN MAIN JOURNALS AND CRANKPINS

1. Crankpins - 2. Main journals - 3. Normal position.

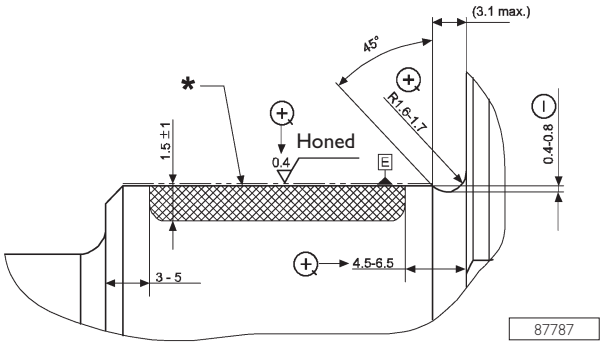
NOTE

The checks on the tolerances indicated in the figures must be made after grinding the crankshaft pins.

After grinding, keep to the following:
Round off the edges of deburring the holes for lubrication of the main journals and crankpins.

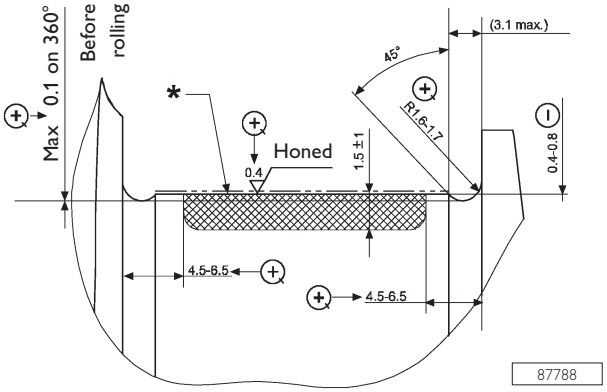
Main data of main journals and crankpins

Figure 67



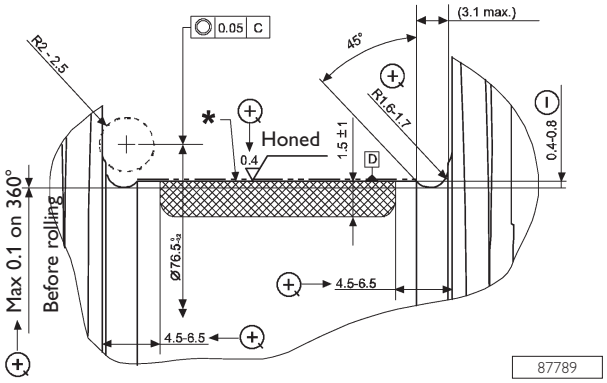
JOURNAL ON TIMING SYSTEM SIDE

Figure 68



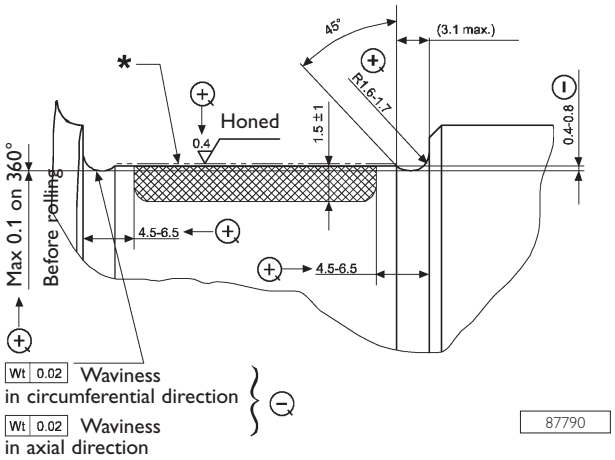
INTERMEDIATE JOURNALS NO. 2-4

Figure 69



INTERMEDIATE JOURNAL NO. 3

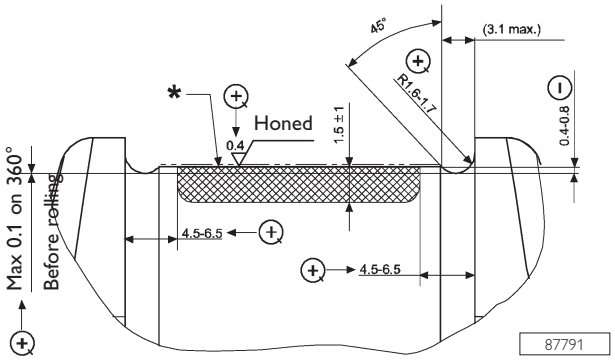
Figure 70



Race area for all main journals (machined by turning)

JOURNAL ON FLYWHEEL SIDE

Figure 71



CRANKPINS

* As far as both values are concerned, for the whole 360°.

NOTE

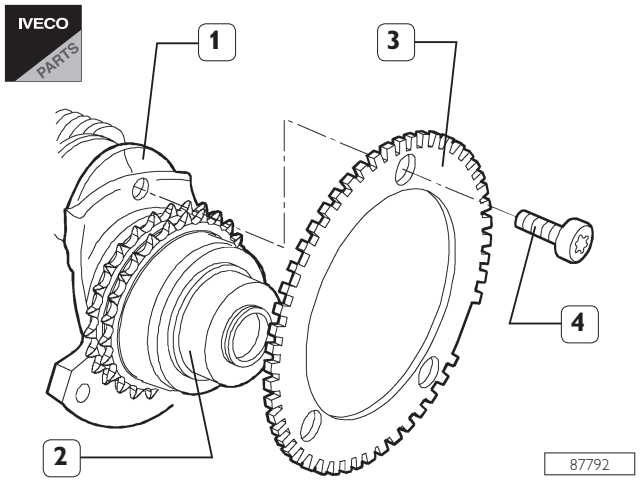
Since, during the 0.254 and 0.508 mm undersizing on the diameter of the crankpins and main journals, the rolled portion of the side races of the pins may get involved, it is necessary to turn the races keeping to the data given in the figure and to do the rolling keeping to the following instructions.
Rolling force:

- **1st main journal 925 ± 25 daN;**
- **2nd - 3rd - 4th - 5th main journal 1850 ± 50 daN;**
- **Crankpin 1850 ± 50 daN.**

- ❏ Rolling turns: 3 approach, 12 effective, 3 out;
- ❏ Rolling speed: 56 rpm;
- ❏ Reduction of the connecting rod pin slot diameter after rolling: 0.15 to 0.30 mm*;
- ❏ Reduction of the journal slots after rolling: 0.15 to 0.30 mm.

* Measured with calibrated rollers Ø 2.5 mm.

Figure 72



Take out the screws (4) and replace the phonic wheel (3).
The screws (4) are coated with Loctite 218 and must be replaced with fresh ones after each disassembly.
They must be tightened to a torque of 10 ± 1 Nm.

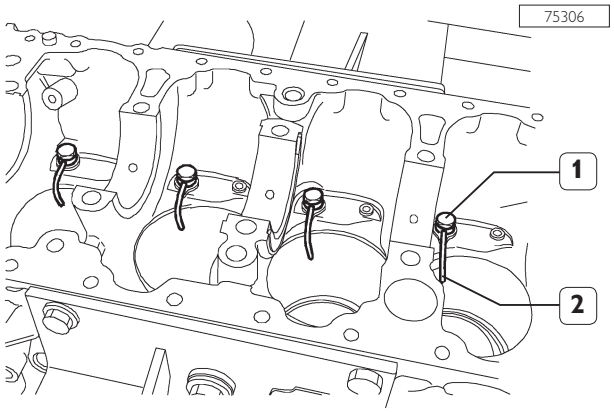
Replacing timing control gear

On finding the timing control gear teeth (1) damaged or worn, remove them from the crankshaft (2) using a suitable extractor.
The new gear is fitted onto the crankshaft by heating it to a temperature of 180 °C for no longer than 15 minutes.
On completing assembly and after the gear has cooled, it must withstand a torque of 150 Nm without slipping.

ENGINE ASSEMBLY

The following parts must be replaced with new ones at the time of assembly: retaining rings, seals and gaskets, screws whose thread is coated with sealant.

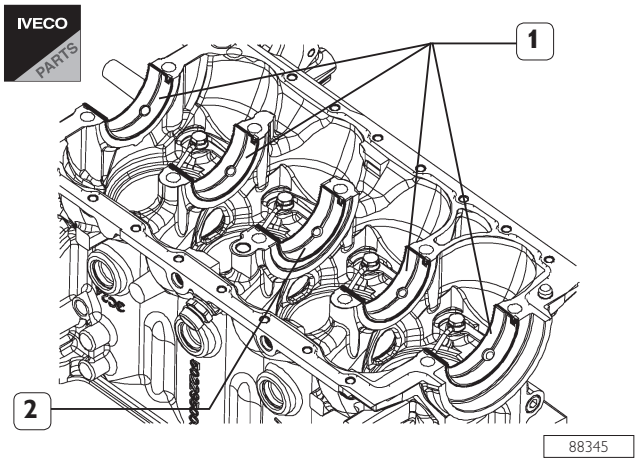
Figure 73



Fit on the oil spray nozzles (2) and tighten the couplings (1) to the prescribed torque.

Assembling main bearings

Figure 74



NOTE

Not having found it necessary to replace the main bearings, they need to be fitted back on in the same sequence and position found upon disassembly.

The main bearings (1) are supplied as spare parts undersized on the inside diameter by 0.254 to 0.508 mm.

NOTE

Do not do any accommodating on the bearings.

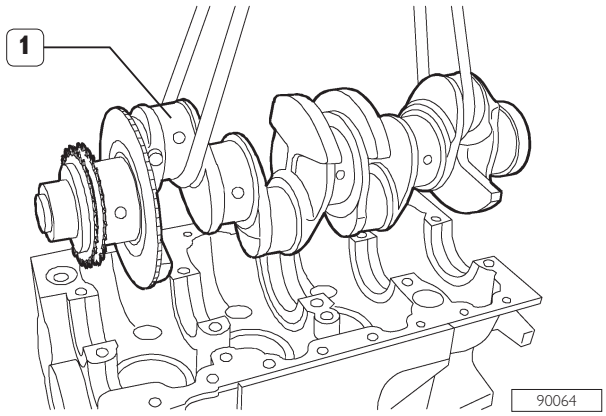
Thoroughly clean the top main bearing shells (1) and position them in the crankcase.

NOTE

The middle half ring (2) is fitted with thrust washers.

Measuring main journal assembly clearance

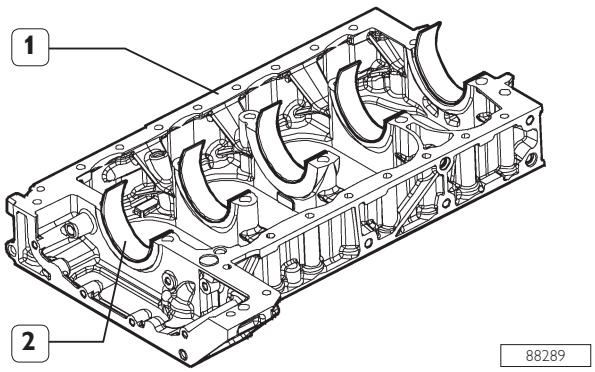
Figure 75



Mount the crankshaft (1).
Check the clearance between the crankshaft main journals and their respective bearings by proceeding as follows:

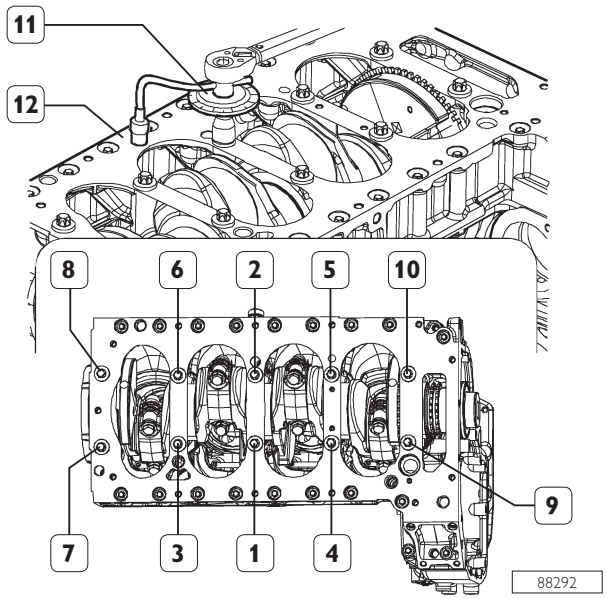
- ❏ Thoroughly clean the pins;
- ❏ Apply a calibrated wire onto the main journals.

Figure 76



Thoroughly clean the bottom main bearing shells (2) and mount them in the crankcase base (1).

Figure 77



Mount the crankcase base (12).
Tighten the screws in the sequence shown in the figure in three steps:

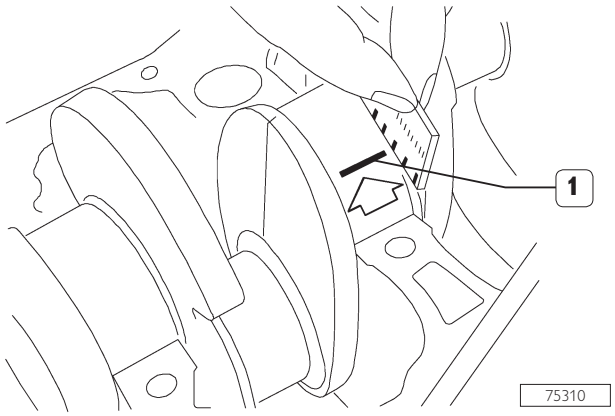
- ❏ Step 1: with a torque wrench, to a torque of 50 Nm;
- ❏ Step 2: closing to an angle of 60°;
- ❏ Step 3: closing to an angle of 60°.

NOTE

Use tool 99395216 (11) for the angle closing.

Then tighten the outer screws to torque 26 Nm.

Figure 78

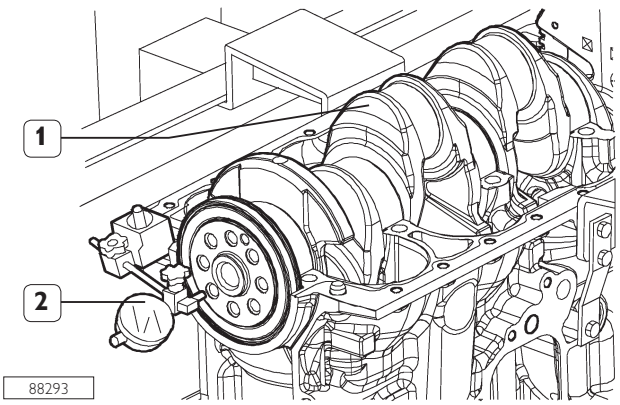


❑ Remove the bottom crankcase.

The clearance between the main bearings and their associated pins is measured by comparing the length of the calibrated wire (1), at the point of greatest crushing, with the graduated scale on the casing containing the calibrated wire.
The numbers on the scale indicate the clearance of the coupling in millimetres, which must be 0.032 to 0.102 mm.
If the clearance is not as prescribed, replace the bearings and repeat the check.

Checking crankshaft end float

Figure 79



The end float is checked by setting a dial gauge (2) with a magnetic base on the crankshaft (1) as shown in the figure.
The normal assembly clearance is 0.060 - 0.310 mm.
If you find the clearance to be greater than as required, replace the rear main bearing shells carrying the thrust bearings and repeat the clearance check between the crankshaft pins and the main bearing shells.

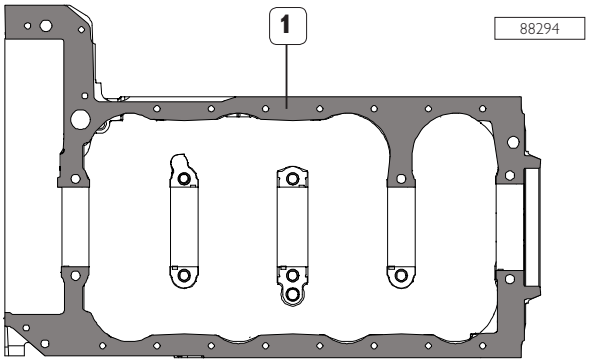
If the end float of the crankshaft does not come within the prescribed values, it is necessary to grind the crankshaft and accordingly change the main bearing shells.

NOTE

The middle main bearing has half thrust washers integrated in it, so it performs the function of a thrust bearing. It is supplied as a spare part only with the normal shoulder thickness.

Thoroughly clean the crankcase/crankcase base mating surface.
Apply, on base, sealant Loctite 510 IVECO no. 93162432, as indicated in the scheme. The sealant must result to be even, not patchy.

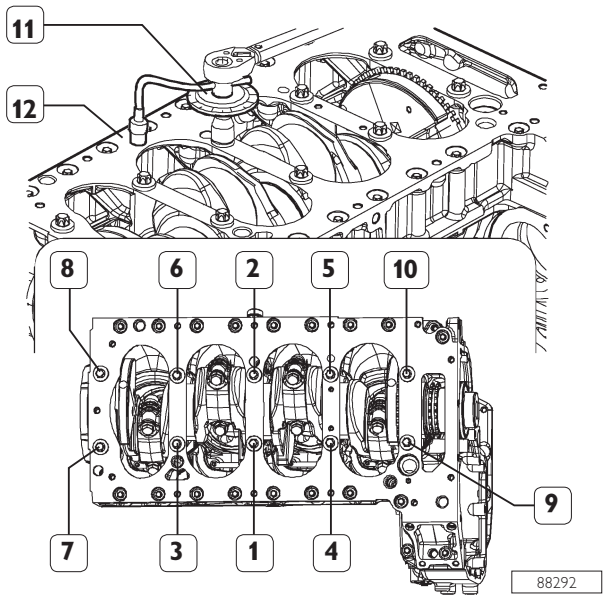
Figure 80



NOTE

Mount the crankcase base within 10 minutes of applying the sealant.

Figure 81



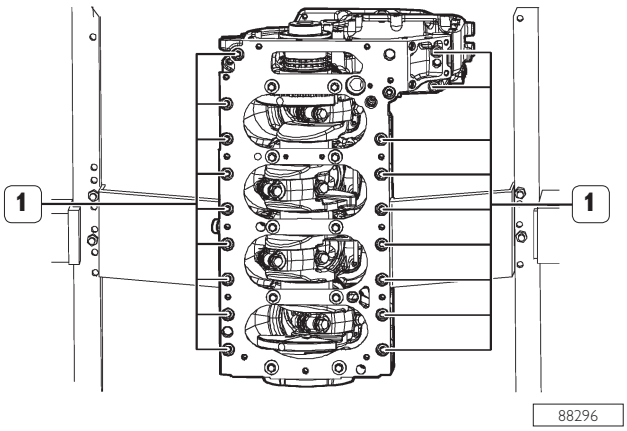
Mount the crankcase base (12) and tighten the fixing screws in three stages, following the sequence shown in the figure:

- ❑ Step 1: with a torque wrench, to a torque of 50 Nm;
- ❑ Step 2: closing to an angle of 60°;
- ❑ Step 3: closing to an angle of 60°.

NOTE

Use tool 99395216 (11) for the angle closing.

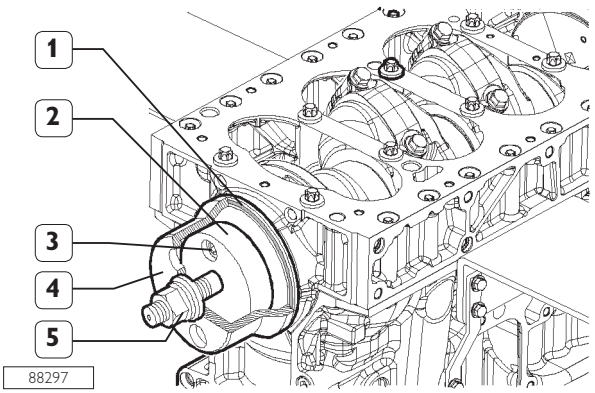
Figure 82



Then tighten the outer screws (1) to a torque of 26 to 30 Nm.

Assembling rear seal

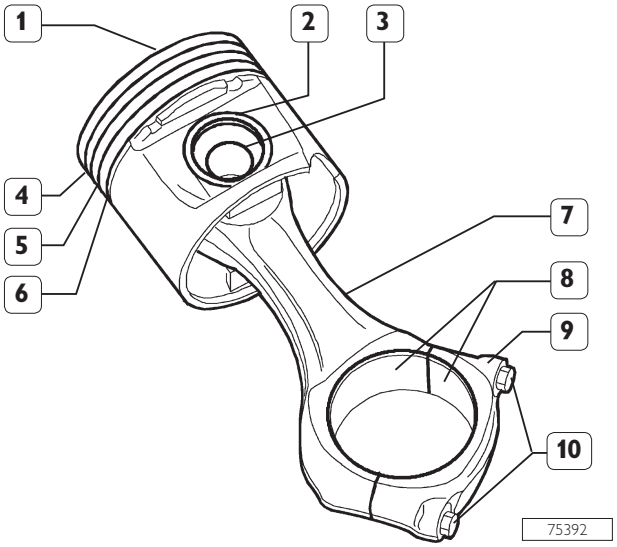
Figure 83



Carefully clean the seal seat.
Lubricate the rear shank of the crankshaft with engine oil.
Fit part (2) of tool 99346259 onto the rear shank of the crankshaft; secure it with the screws (3) and key the fresh seal (1) onto it.
Position part (4) on part (2); screw down the nut (5) to fit the seal (1) fully inside the crankcase.

CONNECTING ROD - PISTON ASSEMBLY

Figure 84

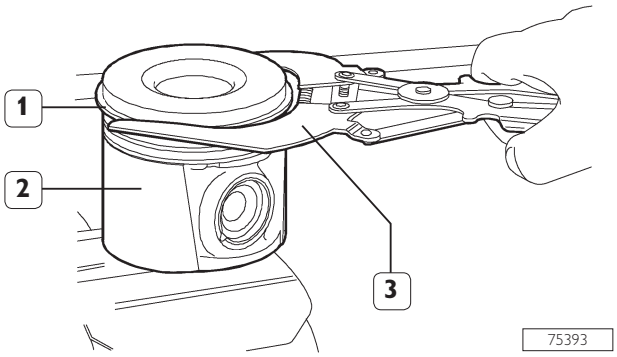


PISTON - CONNECTING ROD ASSEMBLY

1. Piston - 2. Piston ring - 3. Pin - 4. Trapezoidal ring - 5. Oil scraper ring - 6. Slotted oil scraper ring with spiral spring - 7. Connecting rod body - 8. Bearing shells - 9. Connecting rod cap - 10. Cap fixing screws.

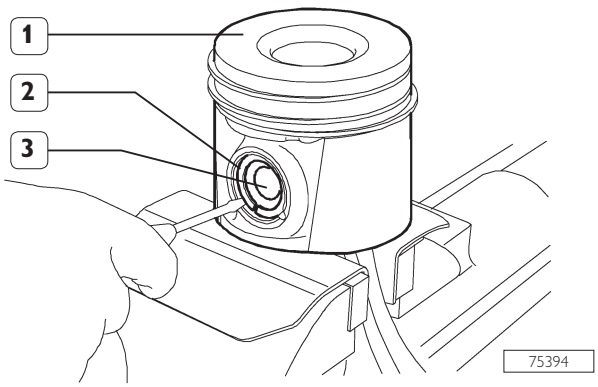
Check the pistons. They must show no signs of seizure, scoring, cracking or excessive wear; replace them if they do.

Figure 85



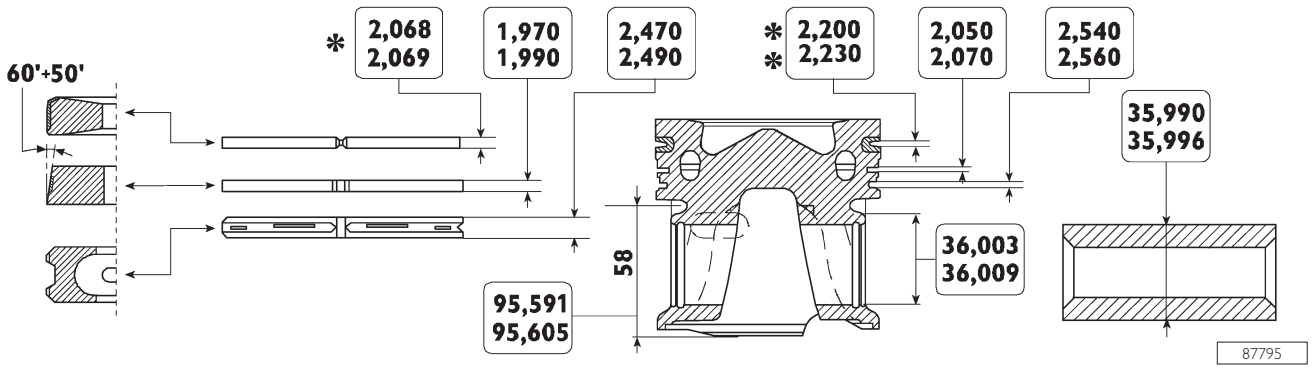
Remove the piston rings (1) from the piston (2) using pliers 99360183 (3).

Figure 86



Remove the piston (1) from the connecting rod, taking out the piston ring (2) and extracting the pin (3).

Figure 87



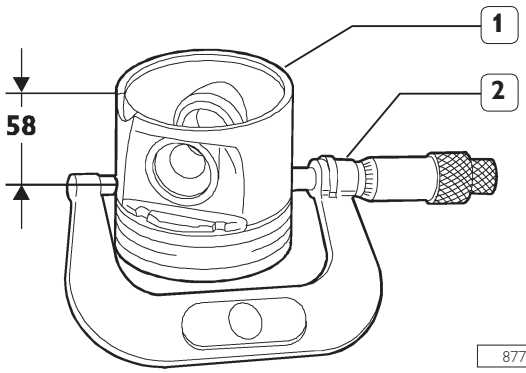
MAIN DATA FOR MONDIAL PISTON, PINS AND PISTON RINGS

* The value is measured at 1.5 mm from the outer diameter.

** The value of the diameter measured is 91.4 mm.

Pistons - Measuring piston diameter

Figure 88

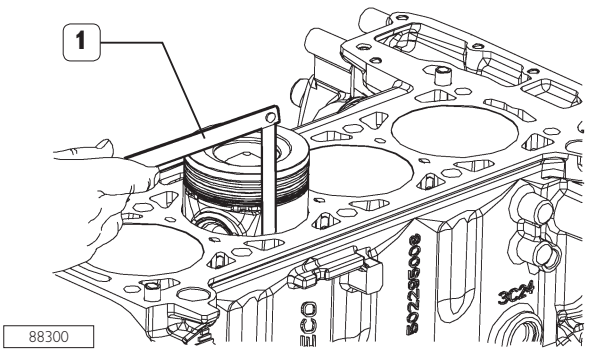


By using a micrometer (2), measure the diameter of the piston (1) in order to establish the assembly play; the diameter must be measured at the height shown in the picture.

NOTE

The pistons are supplied as spare parts with the standard, normal and 0.4mm oversize diameters together with rings, pin and retaining rings.

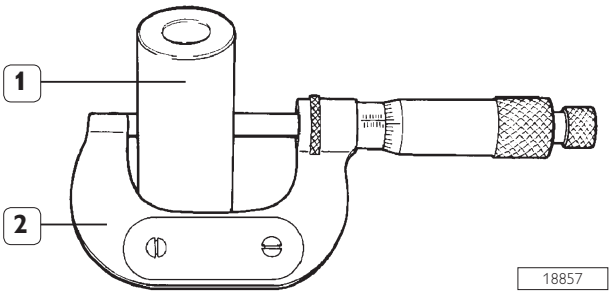
Figure 89



The clearance between the piston and cylinder liner can also be checked using a feeler gauge (1) as illustrated in the figure.

Piston pins

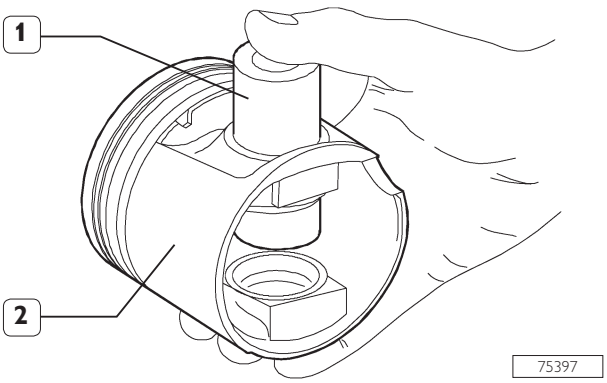
Figure 90



Measuring the diameter of the piston pin (1) with a micrometer (2).

Conditions for correct pin-piston coupling

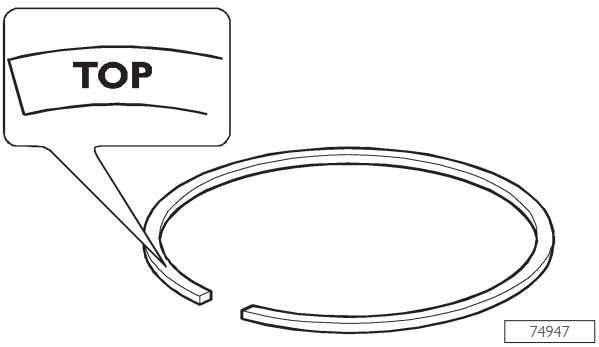
Figure 91



Lubricate the pin (1) and its seat on the hubs of the piston (2) with engine oil. The pin must go into the piston by lightly pressing with the fingers and must not drop out by gravity.

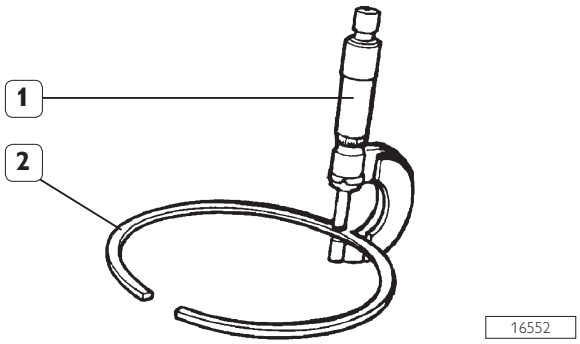
Piston rings

Figure 92



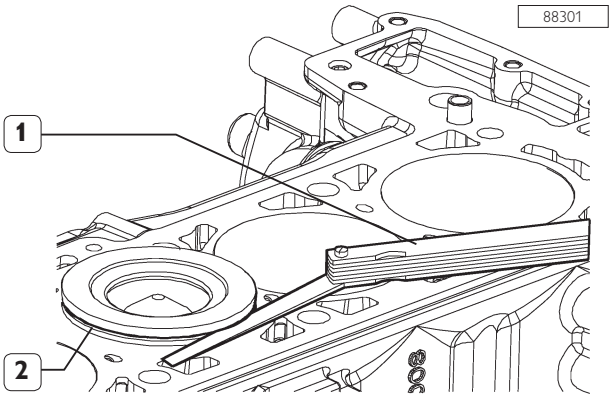
The trapezoidal split rings (1st slot) and the oil scraper rings (2nd slot) have the word TOP etched in them; when fitting them on the piston, the word TOP must be facing upwards.

Figure 93



Check the thickness of the piston rings (2) with a micrometer (1).

Figure 94



Check the clearance between the trapezoidal ring (2) (1st slot) and the associated slot on the piston with a feeler gauge (1), proceeding as follows: insert the piston into the cylinder liner so that the ring (2) comes approximately half way out of it.

Figure 95

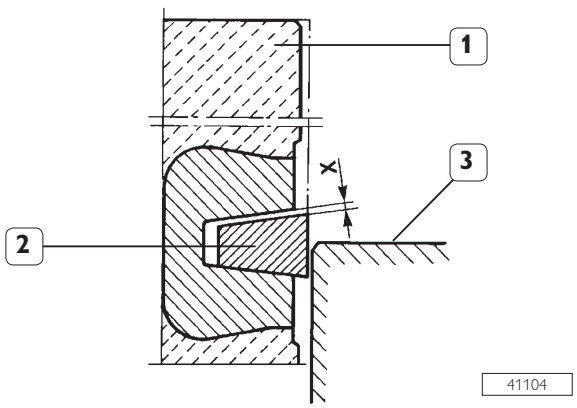
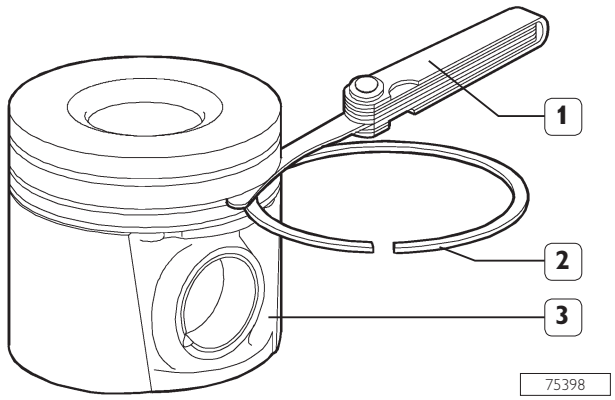


DIAGRAM FOR MEASURING THE CLEARANCE X BETWEEN THE FIRST PISTON SLOT AND THE TRAPEZOIDAL RING

1. Piston slot - 2. Trapezoidal piston ring - 3. Cylinder liner.

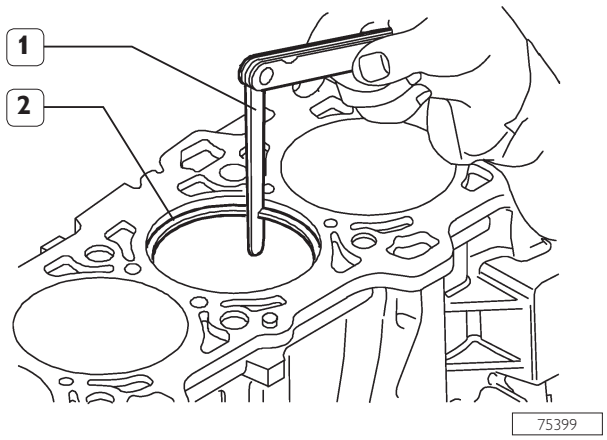
Using a feeler gauge (1, Figure 102), check the clearance (X) between the ring (2) and the slot (1); this clearance must have the prescribed value.

Figure 96



Check the clearance between the piston rings (2) of the 2nd and 3rd slot and the associated seats on the piston (3) with a feeler gauge (1).

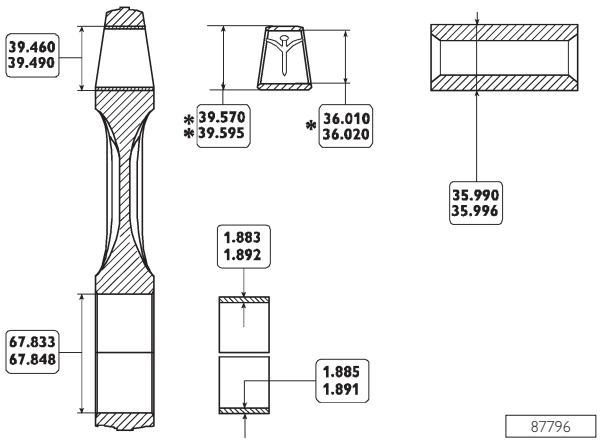
Figure 97



Check the opening between the ends of the piston rings (2) inserted in the cylinder liner using a feeler gauge (1).

Connecting rods

Figure 98



MAIN DATA OF THE CONNECTING ROD, BUSHING, PISTON PIN AND BEARING SHELLS

* Internal diameter to obtain after driving into the small end and grinding with a reamer.

** Dimension cannot be measured in the free state.

*** Thickness of the bearing shell supplied as a spare part.

NOTE

Each connecting rod has its cap marked:

- With a letter: **O** or **X** indicating the diameter class of the big end mounted in production;
- With a number indicating the weight class of the connecting rod mounted in production.

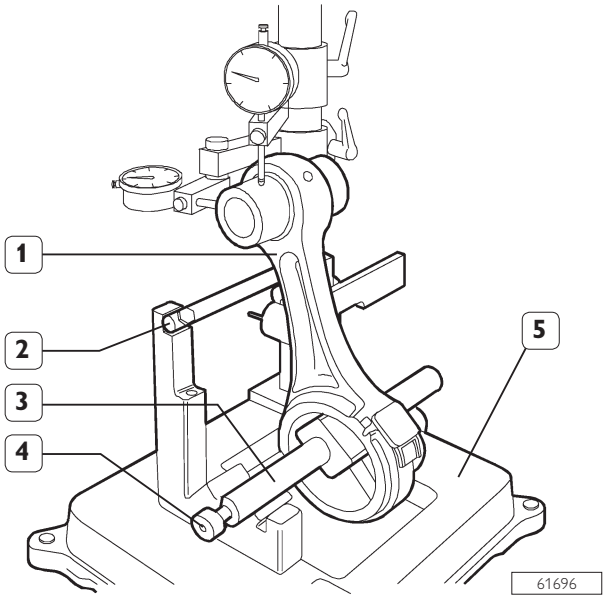
In addition, it could be stamped with the number of the cylinder in which it is fitted.
In the event of replacement it is therefore necessary to number the new connecting rod with the same number as the one replaced.
The numbering must be done on the opposite side to the bearing shell retaining slots.
The connecting rods are supplied as spare parts with the diameter of the big end 67.833 to 67.848 mm marked with the letter **O** and the weight class marked with the number 33.
It is not permissible to remove material.

Bushing

Check that the bush in the small end has not come loose and shows no sign of seizure or scoring. If it does, replace the complete connecting rod.

Checking connecting rods

Figure 99

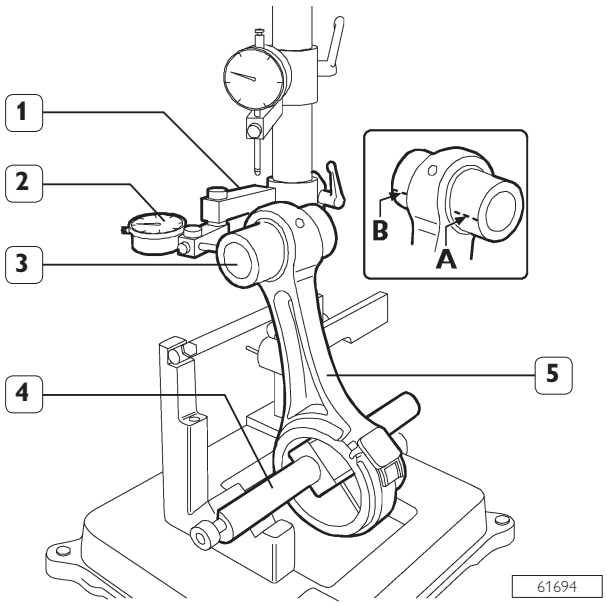


Check the alignment of the axes of the connecting rods (1) with device 99395363 (5), proceeding as follows:

- ❑ Fit the connecting rod (1) on the spindle of the tool 99395363 (5) and lock it with the screw (4);
- ❑ Set the spindle (3) on the V-prisms, resting the connecting rod (1) on the stop bar (2).

Checking torsion

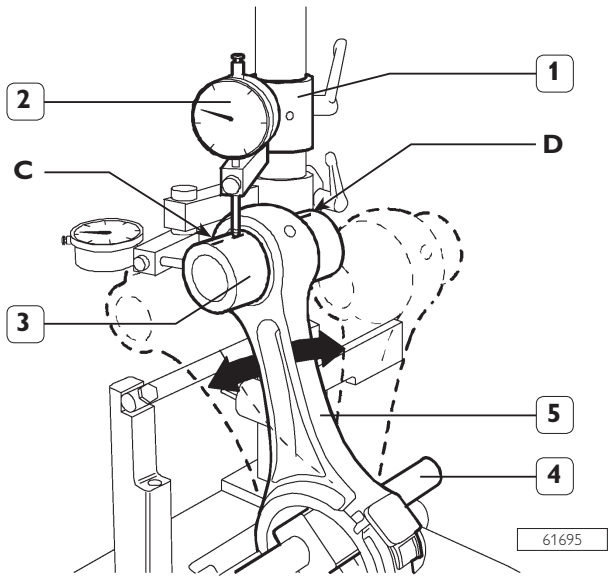
Figure 100



Check the torsion of the connecting rod (5) by comparing two points (**A** and **B**) of the pin (3) on the horizontal plane of the axis of the connecting rod.
Position the mount (1) of the dial gauge (2) so that this preloads by approx. 0.5 mm on the pin (3) at point **A** and zero the dial gauge (2). Shift the spindle (4) with the connecting rod (5) and compare any deviation on the opposite side **B** of the pin (3): the difference between **A** and **B** must be no greater than 0.08 mm.

Checking bending

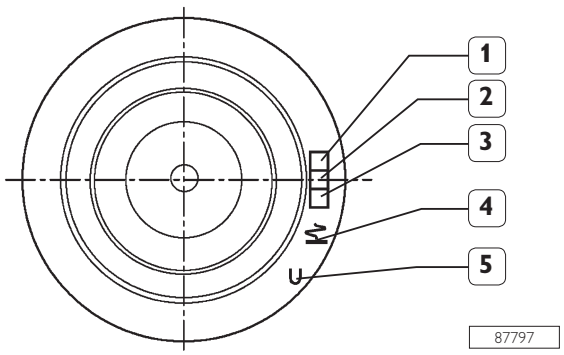
Figure 101



Check the bending of the connecting rod (5) by comparing two points **C** and **D** of the pin (3) on the vertical plane of the axis of the connecting rod.
Position the vertical mount (1) of the dial gauge (2) so that this rests on the pin (3) at point **C**.
Swing the connecting rod backwards and forwards seeking the highest position of the pin and in this condition zero the dial gauge (2).
Shift the spindle with the connecting rod (5) and repeat the check on the highest point on the opposite side **D** of the pin (3). The difference between point **C** and point **D** must be no greater than 0.08 mm.

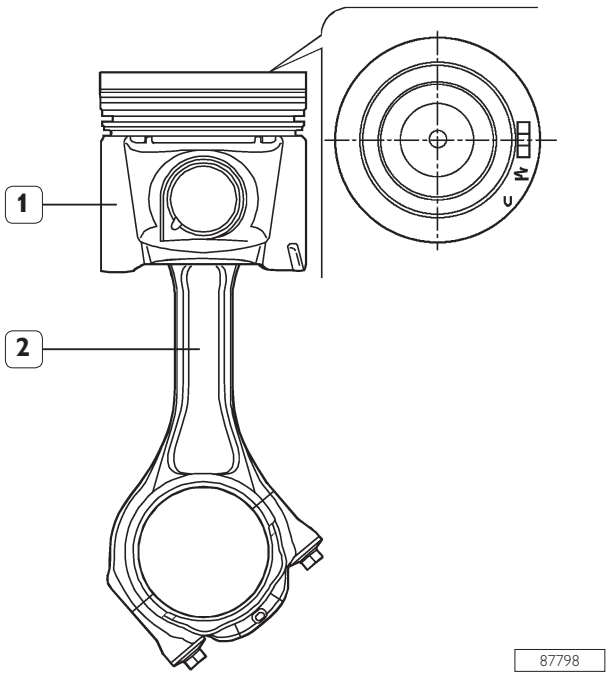
Assembling connecting rod-piston assembly

Figure 102



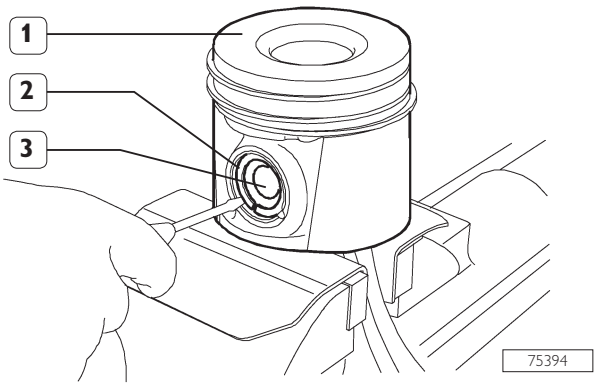
Etched on the top of the piston are: the type of engine (1), class selection (2) and supplier (3) as well as the direction of fitting the piston in the cylinder liner (4). The mark (5) is for passing the 1st slot insert adhesion test.

Figure 103



Connect the piston (1) to the connecting rod (2) together with its cap so that the piston assembly reference, position of the connecting rod and of the cap are observed as shown in the figure.

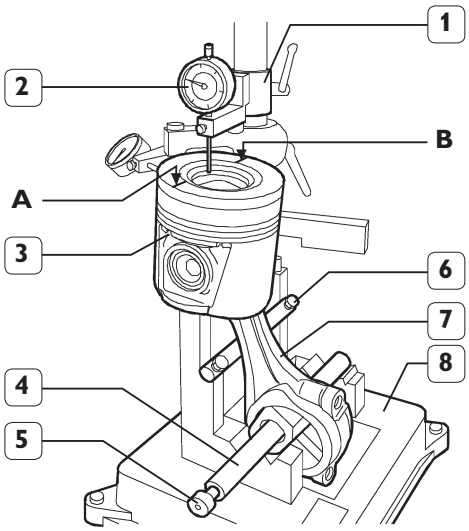
Figure 104



Position the piston (1) on the connecting rod, insert the pin (3) and secure it with the split rings (2).

Checking for connecting rod - piston distortion

Figure 105

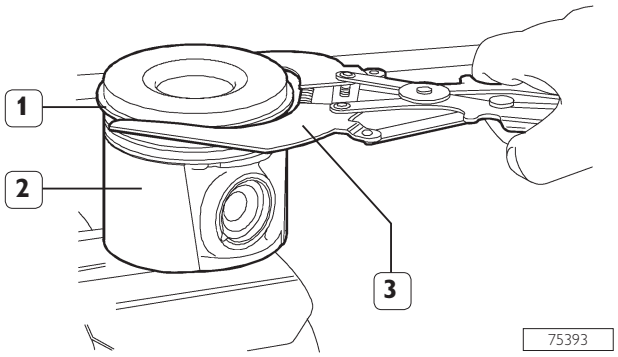


After fitting the connecting rod - piston assembly together, check for distortion with the tool 99395363 (8) as follows:

- ❑ Fit the connecting rod (7) together with the piston (3) on the spindle (4) of tool 99395363 (8) and lock it with the screw (5);
- ❑ Rest the connecting rod (7) on the bar (6);
- ❑ Position the mount (1) of the dial gauge (2) so that this is positioned at point A of the piston with a pre-load of 0.5 mm and zero the dial gauge (2);
- ❑ Shift the spindle (4) so as to position the dial gauge (2) at point B of the piston (3) and check for any deviation.

Assembling piston rings

Figure 106



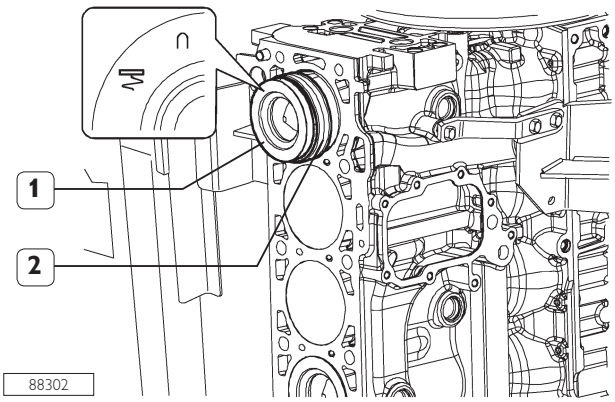
Fit the piston rings (1) on the piston (2) using the pliers 99360183 (3).

NOTE

The 1st and 2nd slot rings need to be mounted with the word "TOP" facing upwards.

Assembling connecting rod - piston assemblies in cylinder barrels

Figure 107



Lubricate the pistons well, including the piston rings and the inside of the cylinder liners.
With the aid of the clamp 99360605 (2), fit the connecting rod - piston assembly (1) in the cylinder liners, checking that:

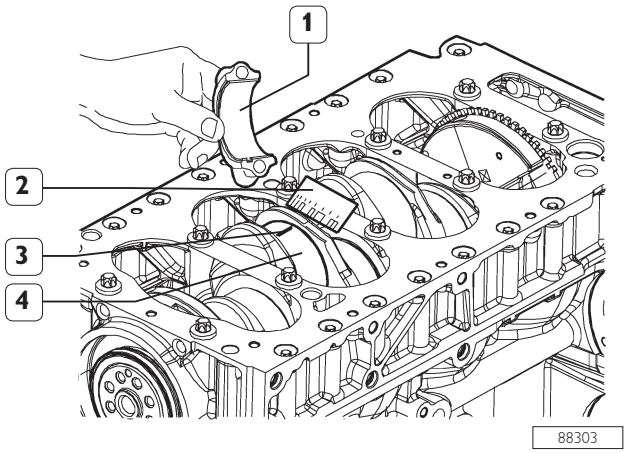
- ❏ The number of each connecting rod corresponds to the cap mating number;
- ❏ The openings of the piston rings are staggered 120° apart;
- ❏ The pistons are all of the same weight;
- ❏ The symbol punched on the top of the pistons faces the engine flywheel, or the recess in the skirt of the pistons tallies with the oil spray nozzles.

NOTE

Not finding it necessary to replace the connecting rod bearings, you need to fit them back in exactly the same sequence and position found on disassembly.

Measuring crankpin assembly clearance

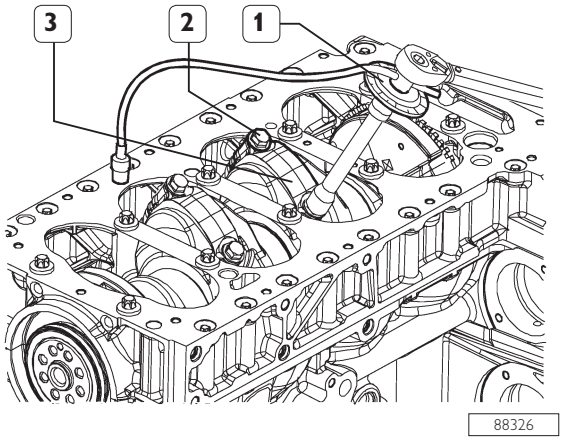
Figure 108



To measure the clearance, carry out the following steps:

- ❏ Thoroughly clean parts (1) and (4) and eliminate all traces of oil;
- ❏ Place a length of calibrated wire (3) on the crankshaft pins (4).

Figure 109



- ❑ Fit the connecting rod caps (3) with the associated bearing shells;
- ❑ Tighten the screws (2) in two steps:
  - Step 1: with a torque wrench, to a torque of 50 Nm;
  - Step 2: closing to an angle of 70°.

NOTE

Use tool 99395216 (1) for the angle closing.

- ❑ Remove the cap (3) and determine the existing clearance by comparing the width of the calibrated wire (3, Figure 116) with the graduated scale on the case (2, Figure 116) that contained the calibrated wire. On finding a clearance other than as prescribed, replace the bearing shells and repeat the check;
- ❑ On obtaining the prescribed clearance, lubricate the connecting rod bearing shells and fit them permanently by tightening the connecting rod cap fixing screws as described.

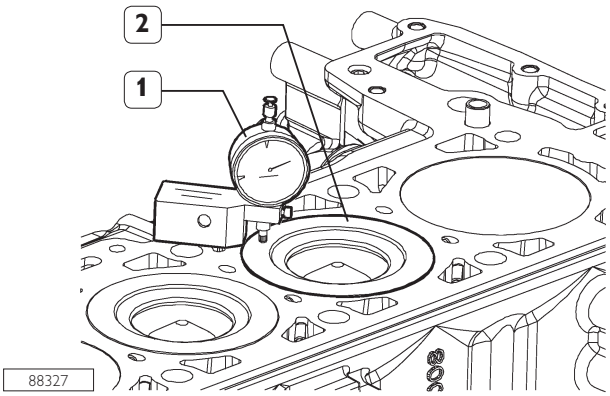
NOTE

The connecting rod cap fixing screws must always be replaced for permanent assembly.

Manually check that the connecting rods slide axially on the pins of the crankshaft.

Checking piston protrusion

Figure 110



At the end of the connecting rod-piston assembly refitting, check the piston protrusion (2) at the T.D.C. compared to the top level of the cylinder block by means of a dial gauge (1) and relevant base 99370415.

NOTE

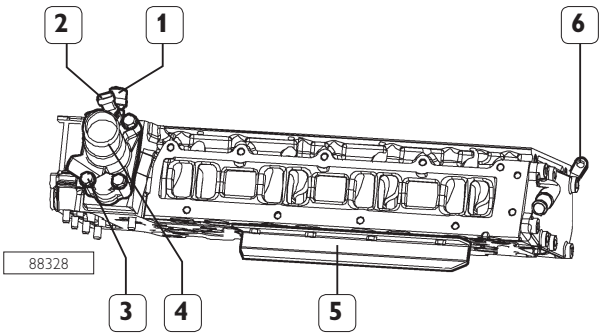
The difference between the minimum and maximum protrusions of the four pistons must be ≤0.15 mm.

The cylinder head gasket in the set of spare gaskets needed for complete engine overhaul is supplied with a single thickness. Clearly, it is supplied separately too.

CYLINDER HEAD

Disassembly

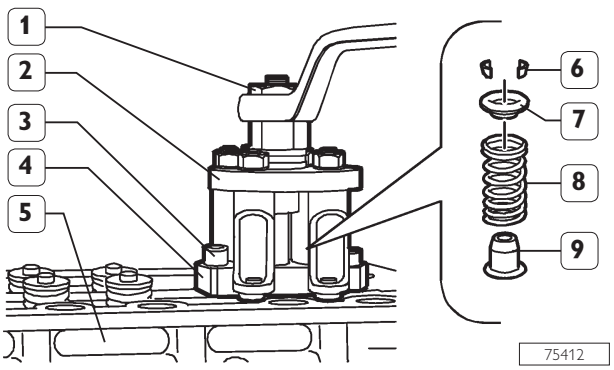
Figure 111



Apply the support SP. 2271 (5) on the cylinder head and tighten the support in a vice.
Remove the brackets (6) for lifting the engine.
Remove the sensors (1 and 2), if needed.
Take out the screws (3) and remove the thermostat casing (4).

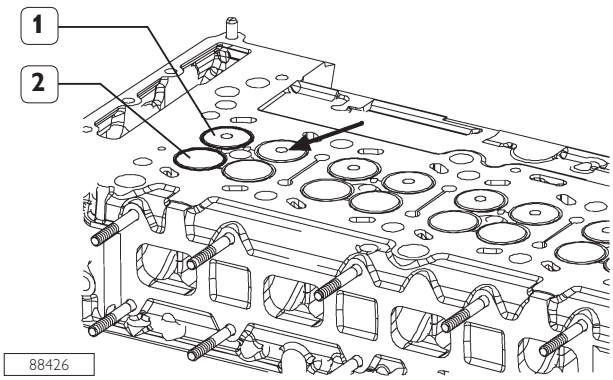
Disassembling valves

Figure 112



Fit part (4) of tool 99360260 onto the cylinder head (5) and secure it with the screws (3).
Fit part (2) of tool 99360260 onto part (4), screw down the nut (1) so that on compressing the springs (8) it is possible to remove the cotters (6). Then take out the plates (7) and the springs (8).
Using suitable pliers, remove the oil seal (9).
Repeat these operations on the remaining valves.
Turn the cylinder head over.

Figure 113



The intake (1) and exhaust (2) valves have the same diameter mushroom.
The central cavity (⟶) of the mushroom of the intake valve (1) is distinguished from that of the exhaust valve (2).

NOTE

Before removing the valves from the cylinder heads, number the valves in order to refit them correctly if they are not changed.

A = intake side - S = exhaust side

Remove the intake (1) and exhaust (2) valves.

Checking cylinder head seal

Check the hydraulic seal using a suitable tool.
Pump in water heated to approx. 90 °C at a pressure of 2 to 3 bars.
Replace the cup plugs if they are found to leak at oil, using a suitable drift for their removal - assembly.

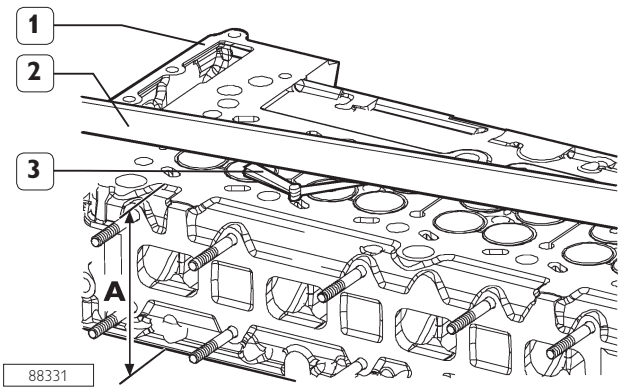
NOTE

Before mounting the plugs, apply Loctite 270 water-reacting sealant on their sealing surfaces.

If there is any leakage from the cylinder head, it must be replaced.

Checking cylinder head mating surface

Figure 114



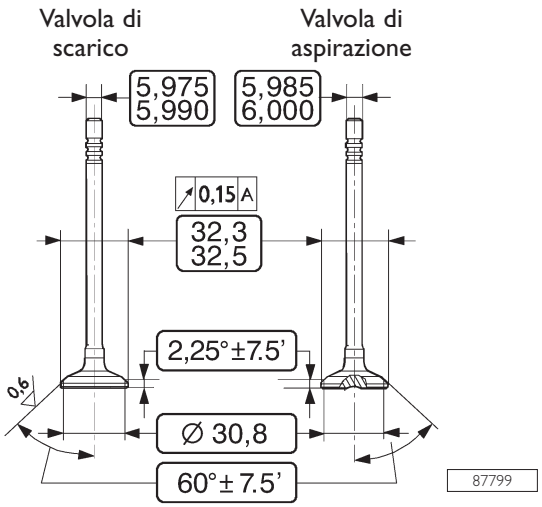
The mating surface of the head (1) with the cylinder block is checked using a rule (2) and a feeler gauge (3).
The deformation found on the entire length of the cylinder head must be no greater than 0.20 mm.
For greater values, regrind the cylinder head according to the values and instructions given in the following figure.
The nominal thickness **A** of the cylinder head is 112 ± 0.1 mm; the maximum permissible removal of metal must not exceed a thickness of 0.2 mm.

NOTE

After regrinding, check the valve recessing and if necessary regrind the valve seats to make the prescribed valve recessing.

VALVES

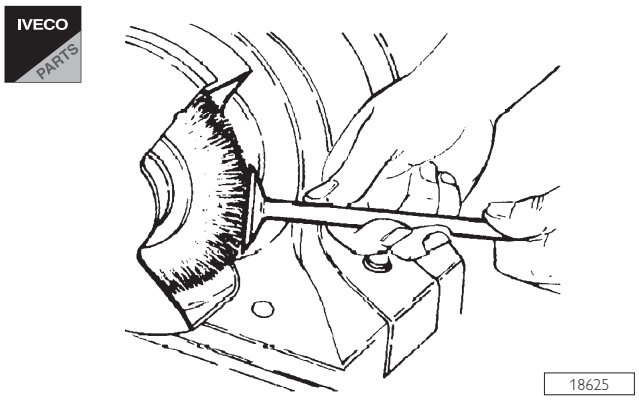
Figure 115



MAIN DATA OF INTAKE AND EXHAUST VALVES

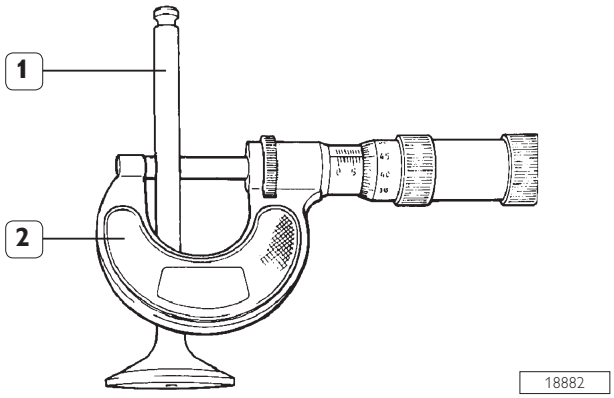
Removing deposits, refacing and checking valves

Figure 116



Remove the carbon deposits on the valves with a wire brush.
Check that the valves show no signs of seizure, cracking or burning.

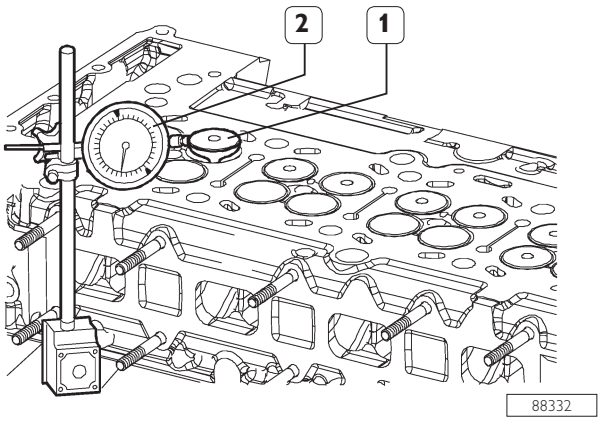
Figure 117



Use a micrometer (2) to measure the valve stem (1): it must have the value shown in Figure 123. If necessary, grind the valve seats by means of the grinding machine 99305018, and remove as little material as possible.

Checking clearance between valve stem and valve guide and centring valves

Figure 118

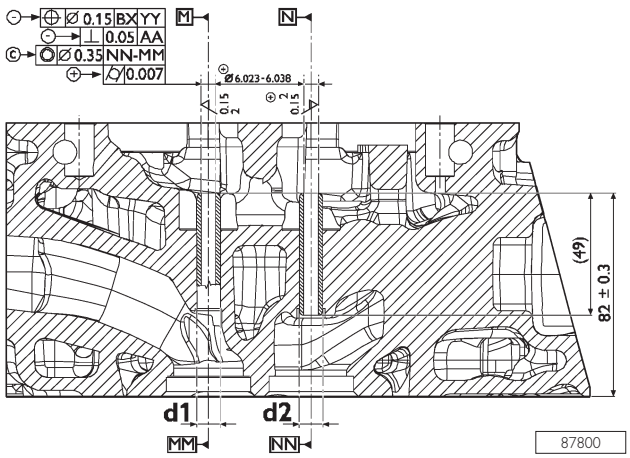


The checks are made using a dial gauge (2) with a magnetic base, positioned as illustrated. The assembly clearance is 0.033 to 0.063 mm.
Making the valve (1) turn, check that the centring error is no greater than 0.03 mm.

VALVE GUIDES

Replacing valve guide

Figure 119

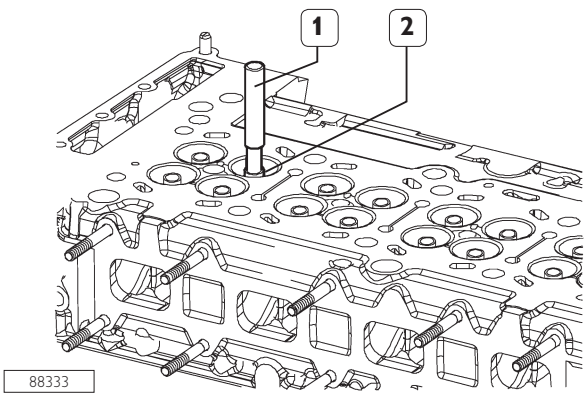


MAIN DATA OF VALVE GUIDES - SEATS

- Valve guide seat inside Ø 9,980 to 10,000 mm;
- Valve guide outside Ø 10,028 to 10,039 mm.

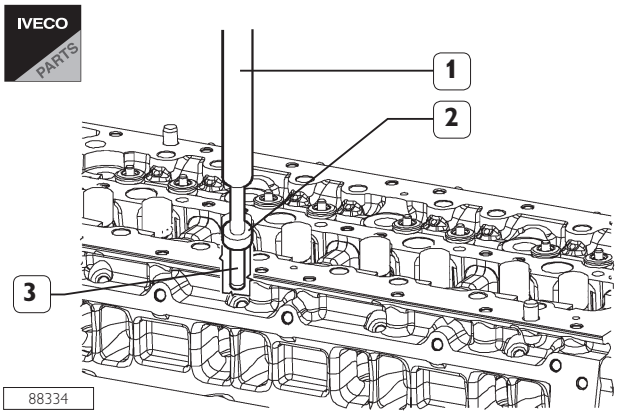
* Measurement to be made after driving in the valve guides.

Figure 120



Remove the valve guides (2) with the drift SP.2312 (1).

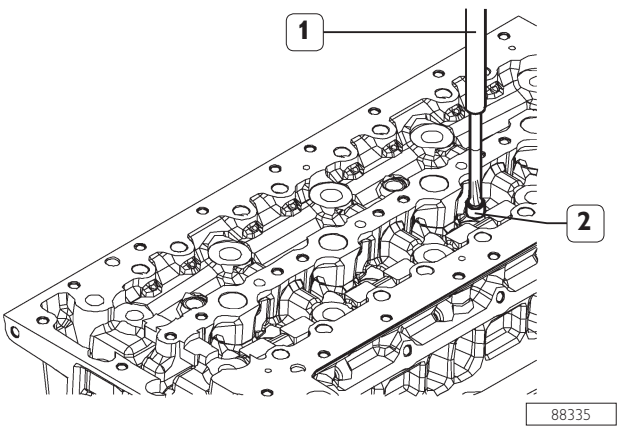
Figure 121



Warm up the cylinder head to 80° to 100 °C and, by means of beater SP.2312 (1) fitted with element SP.2311 (2), fit the new valve guides (3) previously lubricated with engine oil. Driving force 10 to 25 KN.
If the above mentioned tools are not available, fit the valve guides by positioning them in the cylinder head according to the value shown in Figure 127.

Boring valve guides

Figure 122

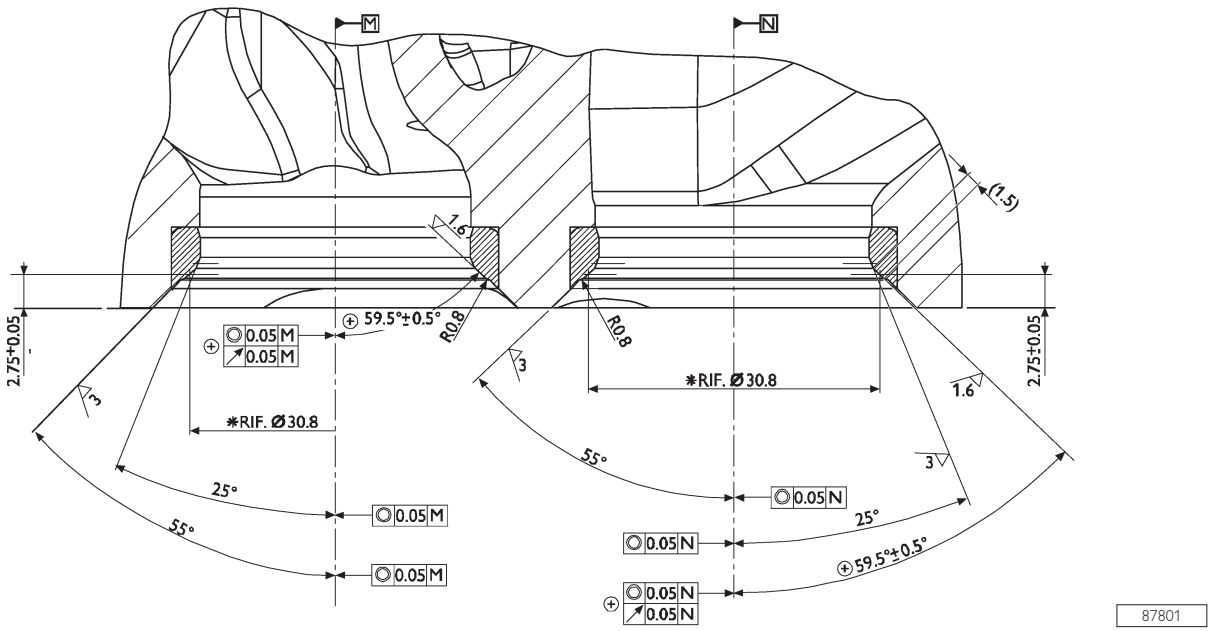


After driving in the valve guides (2), regrind them with the smoother SP.2310 (1).

VALVE SEATS

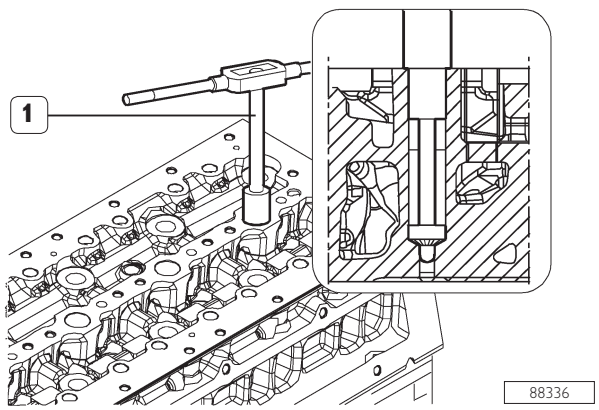
Regrinding - replacing valve seats

Figure 123



Check the valve seats. On finding any slight scoring or burns, regrind them with an appropriate tool according to the angles given in Figure 131.
Having to replace them, with the same tool and taking care not to affect the cylinder head, remove as much material from the valve seats as possible until, with a punch, it is possible to extract them from the cylinder head.
Heat the cylinder head to 80 to 100 °C and, using a suitable drift, fit in it the new valve seats, previously chilled in liquid nitrogen.
Using a specific tool, regrind the valve seats according to the angles given in Figure 131.

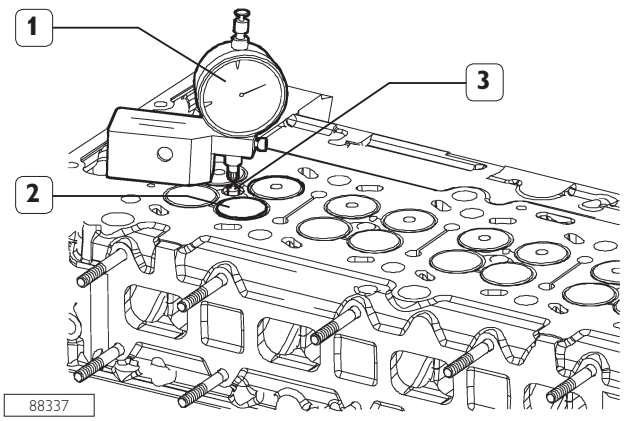
Figure 124



Using the milling cutter 99394038 (1), clean the injector seat of any deposits.

Mount the valves, block the seat of the electro-injectors and glow plugs; using a suitable tool, check the seal of the valves/seats.

Figure 125

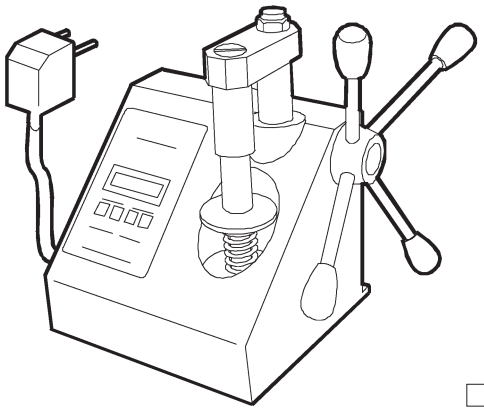


Using a dial gauge (1), check that, from the plane of the cylinder head, the valve recessing (2) and the protrusion of the injector (3) and of the glow plug have the prescribed value:

- Valve recessing: 0.375 to 0.525 mm;
- Injector protrusion: 2.77 to 3.23 mm;
- Glow plug protrusion: 3.78 mm.

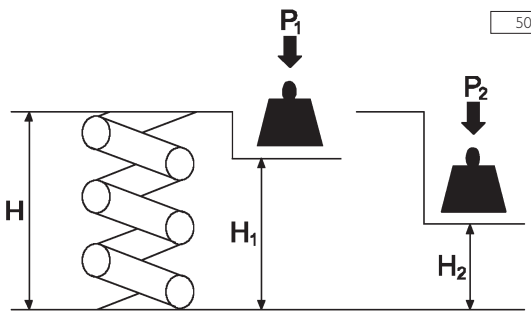
VALVE SPRINGS

Figure 126



Before assembly, check the flexibility of the valve springs with the tool 99305047. Compare the load and elastic deformation data with those of the new springs given in the following figures.

Figure 127

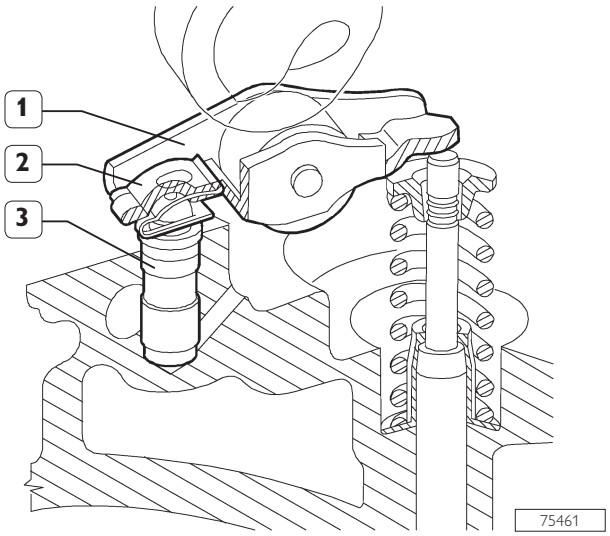


MAIN DATA TO CHECK
INTAKE AND EXHAUST VALVE SPRINGS

	Height (mm)	Under a load of (kg)	
H	54		Free
H1	45	P_1	243 ± 12
H2	35	P_2	533 ± 24

ROCKER ARMS - TAPPETS

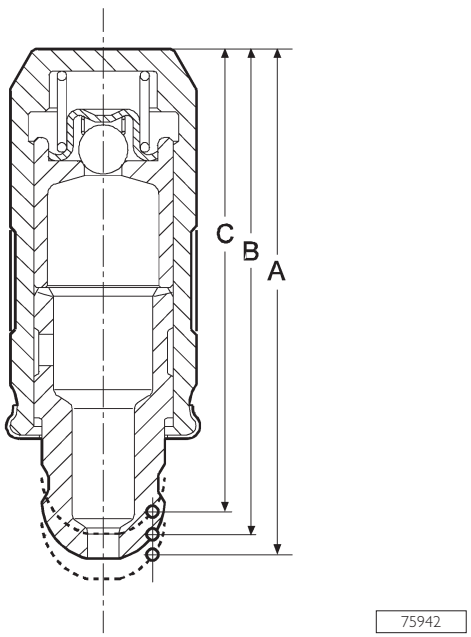
Figure 128



COMPLETE ROCKER ARM ASSEMBLY

The rocker arm assembly is composed of the rocker arm(1), hydraulic tappet (3),made integral with each other by the clip (2).

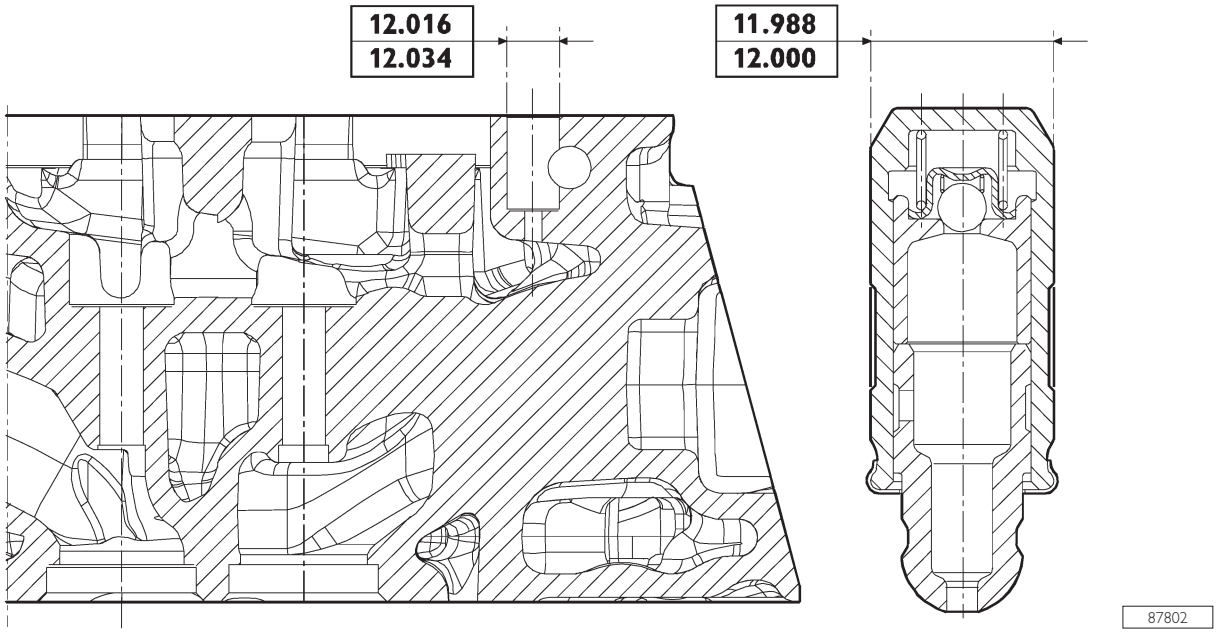
Figure 129



CROSS-SECTION OF THE HYDRAULIC TAPPET

A = 32,44 ± 0,3, end of stroke;
B = 31,30, working position;
C = 29,75 ± 0,25, start of stroke.

Figure 130



MAIN DATA HYDRAULIC TAPPETS - SEATS

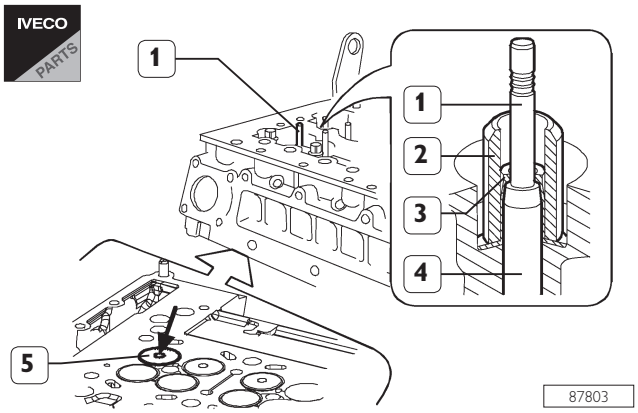
Checks

The sliding surface of the tappets must have no scoring/ dents; replace them if they do.

Using a micrometer, measure the diameter of the tappets and, using a bore meter, measure the diameter of the seats in the cylinder head; the difference in the measurements will give the assembly clearance.

ASSEMBLING CYLINDER HEADS

Figure 131

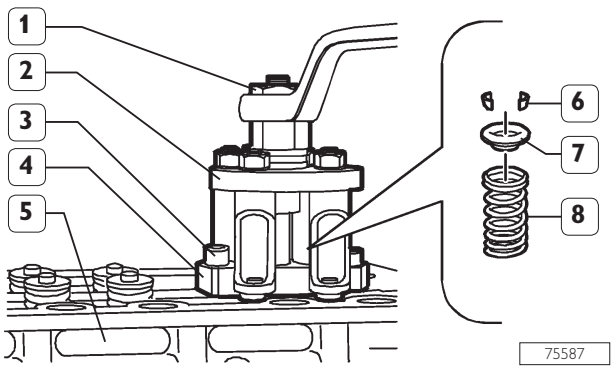


Lubricate the stem of the valves (1) and insert them into the associated valve guides (4) according to the position marked during removal. Using tool SP.2264 (2), mount the oil seals (3) on the valve guides (4).

NOTE

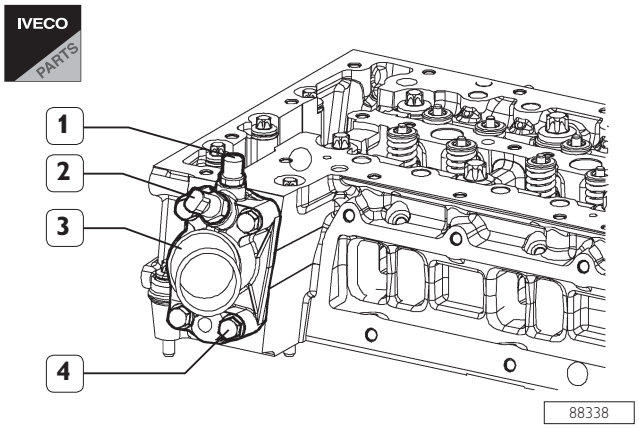
The suction valves (5) are different from the exhaust ones for a slot (⟶) in the centre of the valve head.

Figure 132



Position the springs (8) and plates (7) on the cylinder head (5).
Fit the part (4) of tool 99360260 onto the cylinder head (5) and secure it with the screws (3).
Fit the part (2) of tool 99360260 onto part (4), screw down the nut (1) so that by compressing the springs (8) it is possible to insert the retaining cotters (6); then unscrew the nut (1) checking that the cotters (6) have settled in correctly.
Repeat these operations on the remaining valves.

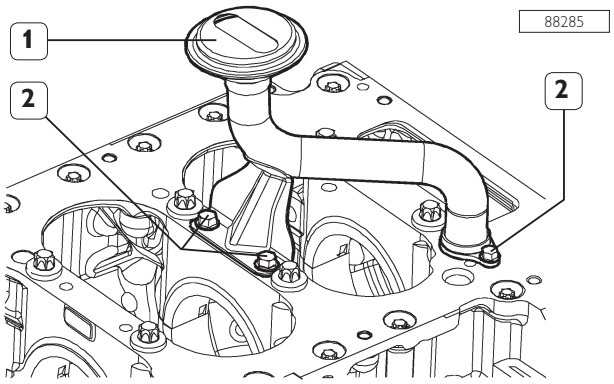
Figure 133



Fit the thermostat casing (3) with a new seal and tighten the fixing screws (4) to the prescribed torque.
Fit the temperature sensors (1 and 2) and tighten them to the prescribed torque.
Fit the brackets for lifting the engine and tighten the fixing screws to the prescribed torque.

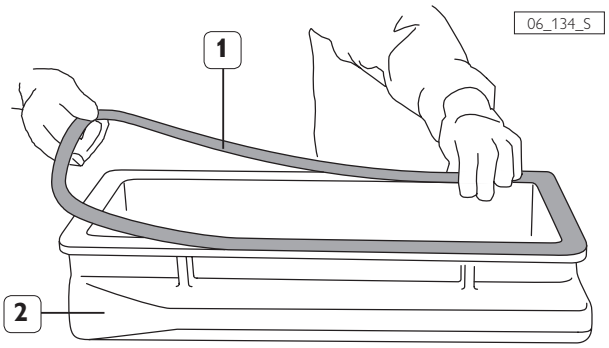
COMPONENTS INSTALLATION

Figure 134



Mount the suction strainer (1) together with the pipe.
Screw down the fixing screws (2) and tighten them to the prescribed torque.

Figure 135



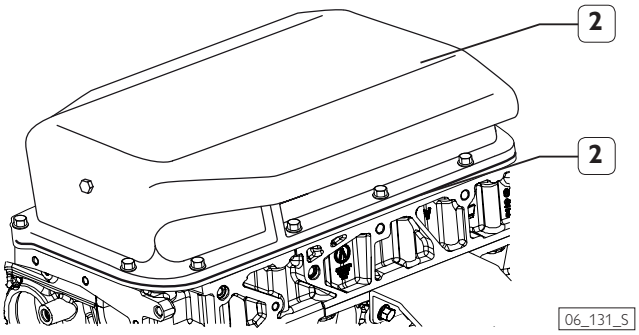
❏ Provide for new gasket replacement (1) of the oil sump (2).

CAUTION

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

Accurately clean the contact surface.
Apply sealing Loctite 5999 on it, on areas around couplings between engine block and front cover, engine block and rear gearbox.
After sealing application, mount the sump within 10-20 minutes.

Figure 136



❏ Assemble oil sump (1). Tighten the screws (2) and lock them to the prescribed torque.

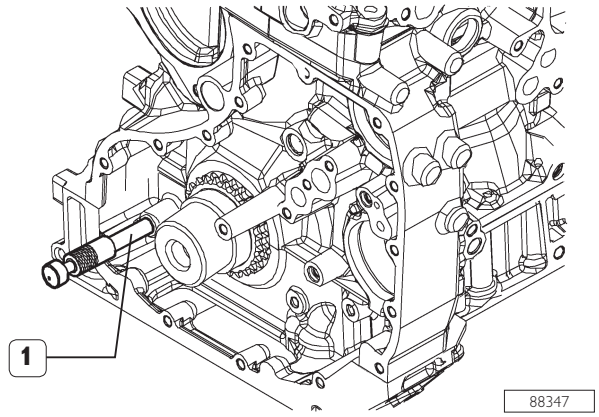
CAUTION

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

PAGE LEFT INTENTIONALLY BLANK

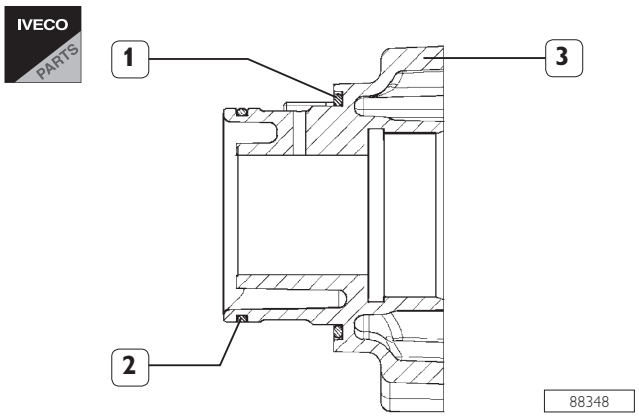
AUXILIARY PARTS CONTROL ASSEMBLY

Figure 137



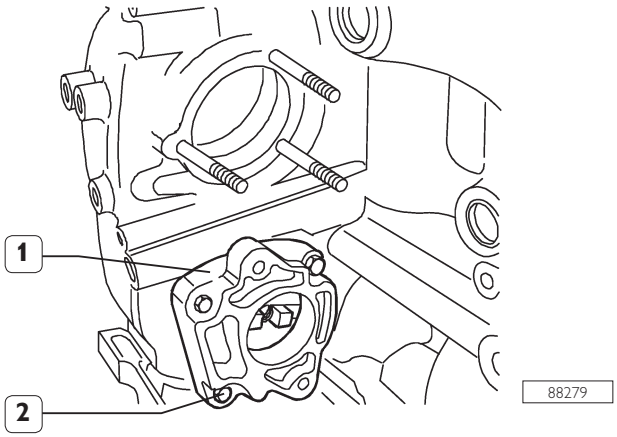
Rotate the driving shaft so that the tool 99360615 (1) can be inserted in the shaft crank hole through the cylinder block hole, in order to stop the engine in the timing system setting condition.

Figure 138



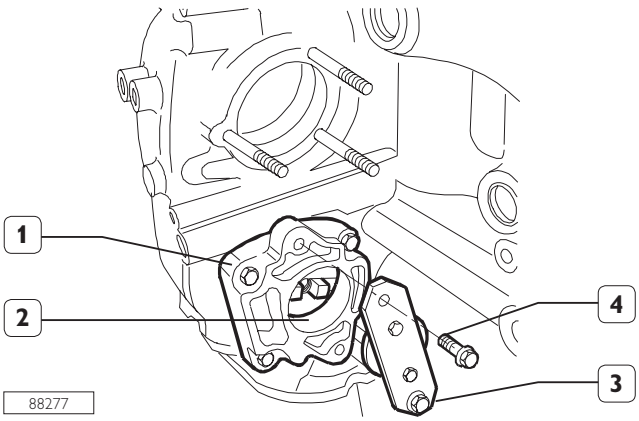
Lubricate the seal rings (1 and 2) with engine oil and fit them on the support (3).

Figure 139



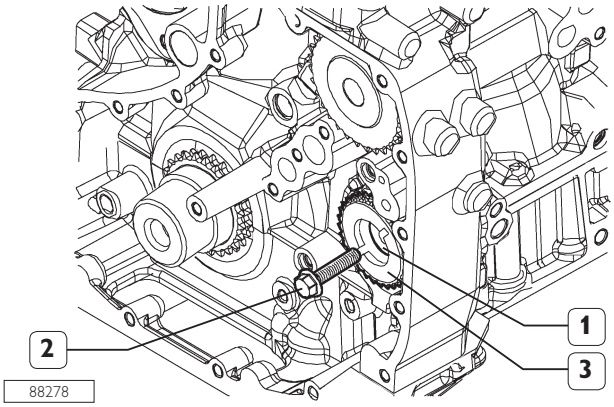
Fit the support (1) and drive in the nuts (2), then tighten them to the prescribed torque.

Figure 140



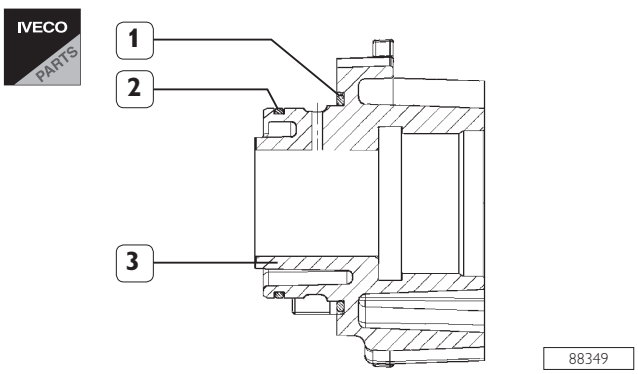
Lock the shaft rotation (2) controlling the hydraulic pump by inserting the tool (3) in it and by locking it to the support (1) with the screws (4).

Figure 141



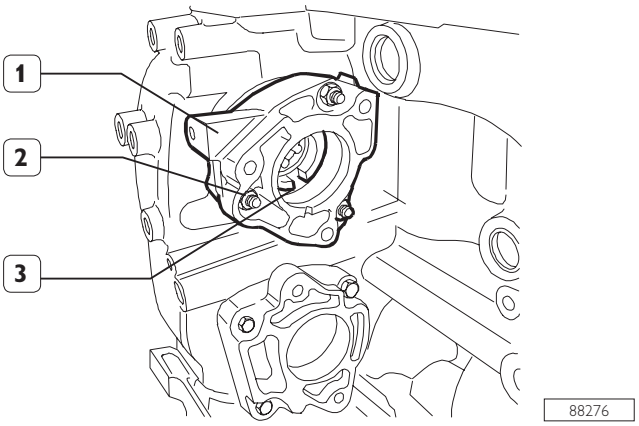
Fit the gear (1) on the stem (3) of the oil pump.
Drive in the screw (2) without locking it.

Figure 142



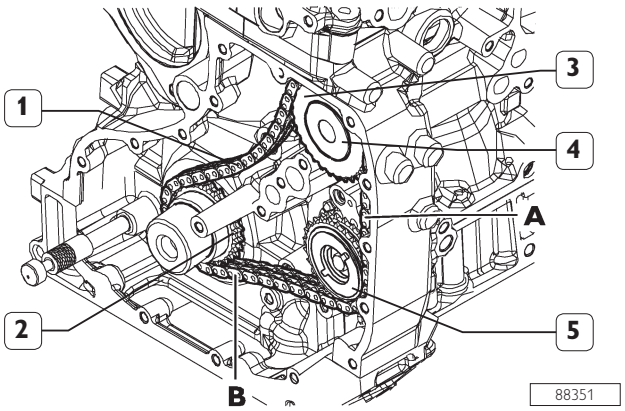
Lubricate the new seal rings (1 and 2) with engine oil and fit them on the support (3).

Figure 143



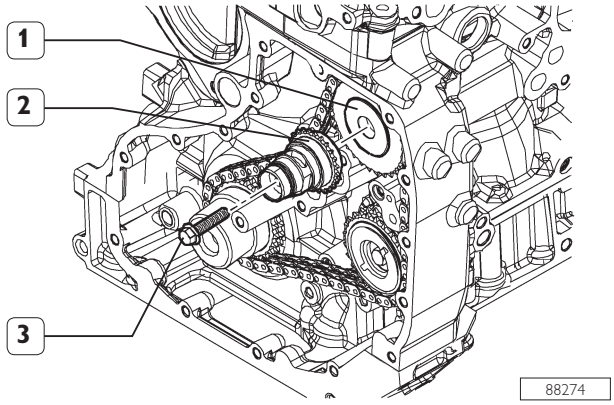
Fit the support (1), drive in the nuts (2) and tighten them to the prescribed torque.
Fit the control stem (3) of the high pressure pump.

Figure 144



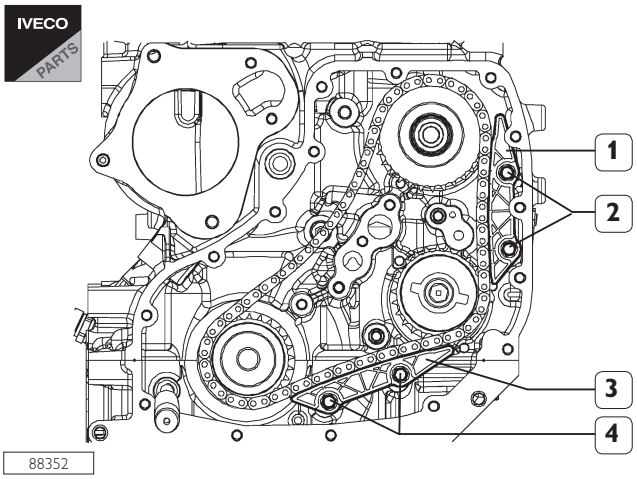
Position the chain (1) on the gears (2, 3 and 5) and fit the gear (3) on the stem (4) so that the chain (1) in tracts **A** and **B** is tensioned.

Figure 145



Fit the stem with the drive gear (2) on the high pressure pump control stem (1).
Drive in the fastening screw (3).

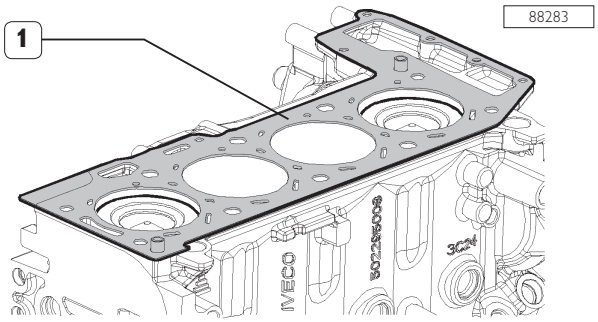
Figure 146



Check the conditions of the fixed skids (1 and 3) and change them if worn out.
Fit the skid (1) and drive in the fastening screws (2), then tighten them to the prescribed torque.
Fit the skid (3) and drive in the fastening screws (4), then tighten them to the prescribed torque.

Cylinder head assembly

Figure 147

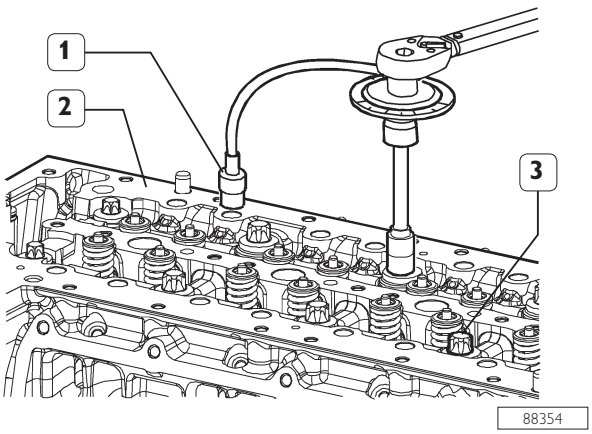


Check that the mating surfaces of the cylinder head and crankcase are clean.
Keep the cylinder head gasket clean.
Place the gasket (1) of the cylinder head with the thickness given in section "Check piston protrusion", with the "TOP" sign facing the head.

NOTE

It is essential to keep the gasket sealed in its package until just before assembly.

Figure 148



Mount the cylinder head (2).
Screw down the fixing screws (3) and tighten them, in three successive stages, following the order and methods shown in the following figure.

NOTE

The angle closure is done with tool 99395216 (1).

Figure 149

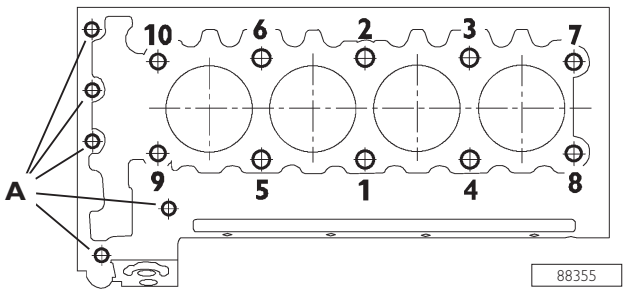
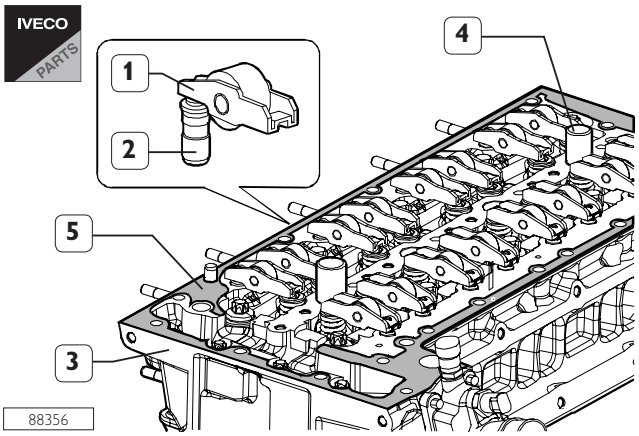


Diagram of the tightening sequence for the cylinder head fixing screws:

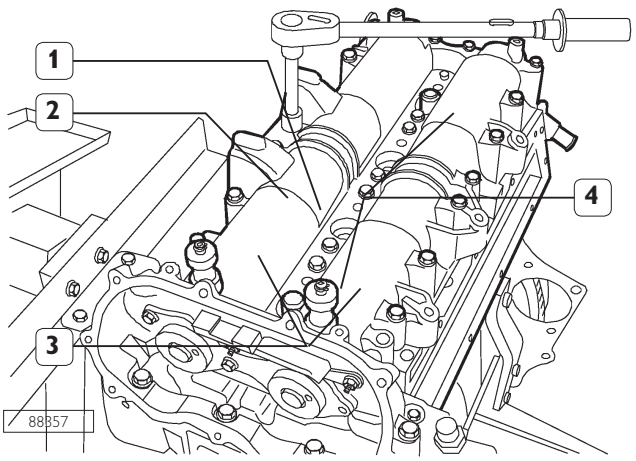
- ❑ 1st phase: pre-tightening with torque wrench:
  - Screws 1-2-3-4-5-6 to a torque of 130 Nm;
  - Screws 7-8-9-10 to a torque of 65 Nm.
- ❑ 2nd phase: angle closing:
  - Screws 1-2-3-4-5-6 90°;
  - Screws 7-8-9-10 90°.
- ❑ 3rd phase: angle closing:
  - Screws 1-2-3-4-5-6 90°;
  - Screws 7-8-9-10 60°.
- ❑ Screws **A**, to a torque of 25 Nm.

Figure 150



Thoroughly clean the hydraulic tappets (2), lubricate them and fit them in the cylinder head (3), positioning the rocker arms (1) on the valves correctly.
Fit on the gasket (5).
Insert the two tools SP. 2264 (4) into the electro-injector seats for subsequent centring of the overhead on the cylinder head.

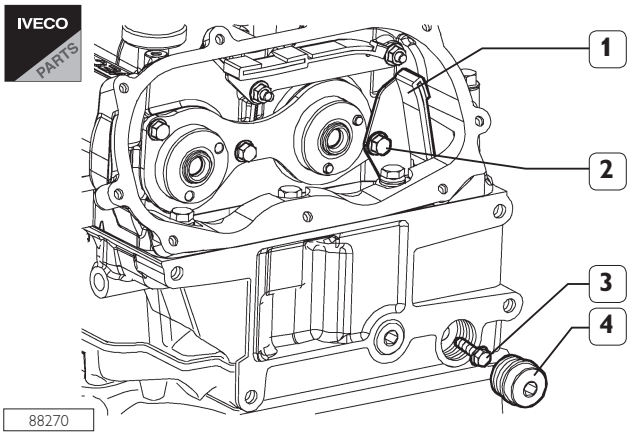
Figure 151



Mount the overhead (1) together with the tools 99360614 (3) for the timing and tighten the fixing screws (2) to the prescribed torque.
Take out the tools SP. 2264 (4).

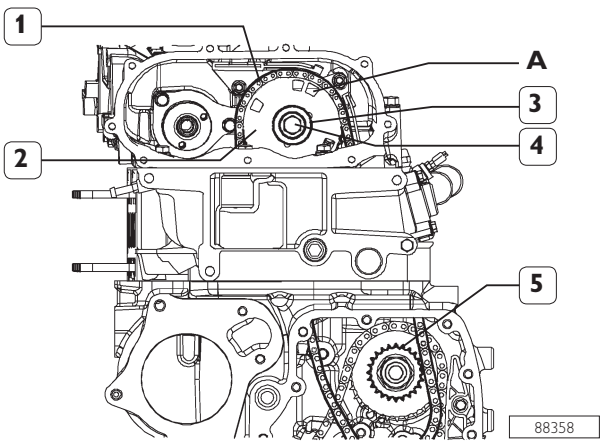
TIMING SYSTEM CONTROL

Figure 152



Fit the top fixed skid (1). Drive in the screws (2 and 3) and tighten them to the prescribed torque.
Fit the rubber cap (4) of the new gasket and tighten it to the prescribed torque.

Figure 153



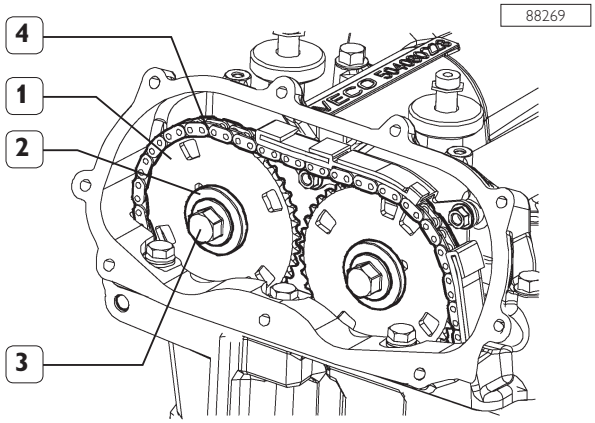
Position the chain (1) on the gear (5) and gear (2).
Mount the gear in such a way that fitting on aspiration valve timing system shaft dowel makes slots **A** to result to be positioned as in figure.

NOTE

The chain arm (1) between the two gears must be tensioned.

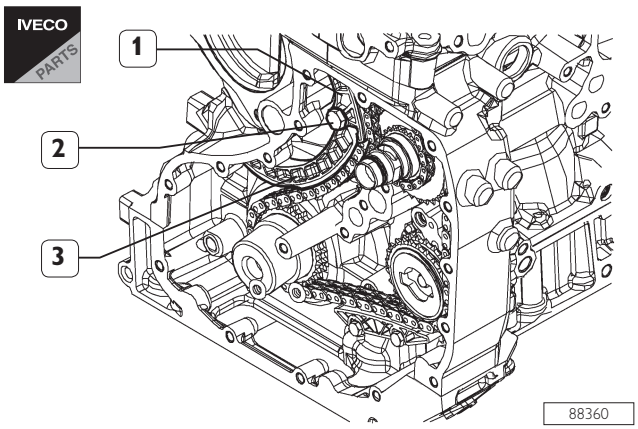
Drive in the fastening screw (4) with the washer (3) without tightening it completely.

Figure 154



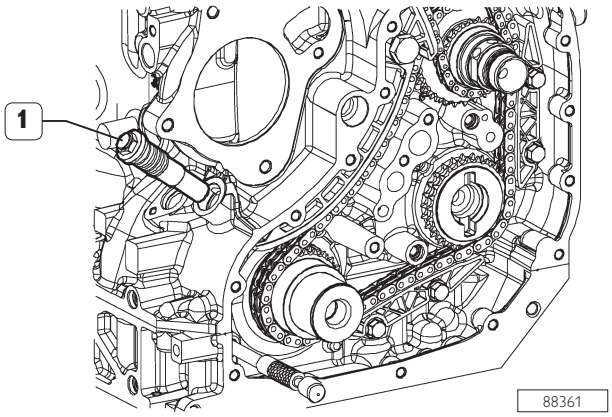
Position the chain (1) on the gear (2) and fit the latter on the camshaft of the exhaust valves.
Drive in the fastening screw (4) with the washer (3) without tightening it completely.

Figure 155



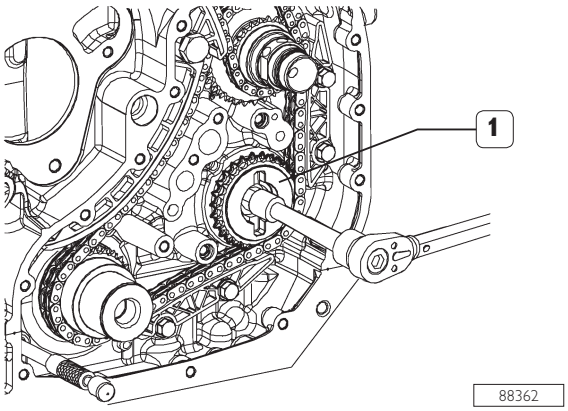
Check the conditions of the mobile skids (1 and 3), if worn out change them.
Position the mobile skids (1 and 3) and clamp them on the cylinder block by the pin (2) and tighten it to the prescribed torque.

Figure 156



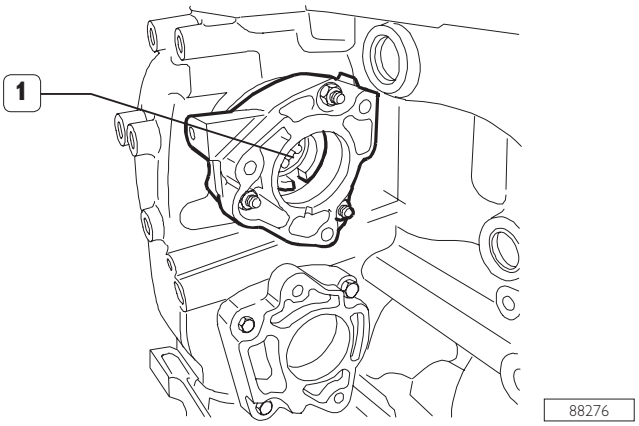
Drive in the chain hydraulic tightener (1) and lock it to the prescribed torque.

Figure 157



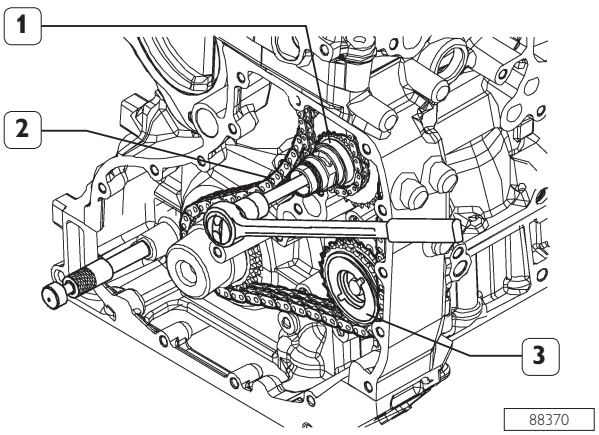
Tighten the fastening screw of the gear (1) on the oil pump control stem to the prescribed torque.

Figure 158



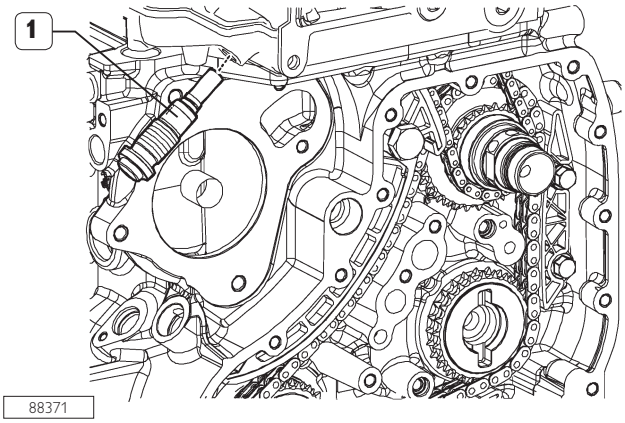
Stop the rotation of the high pressure pump control shaft (1) by inserting the suitable wrench inside it.

Figure 159



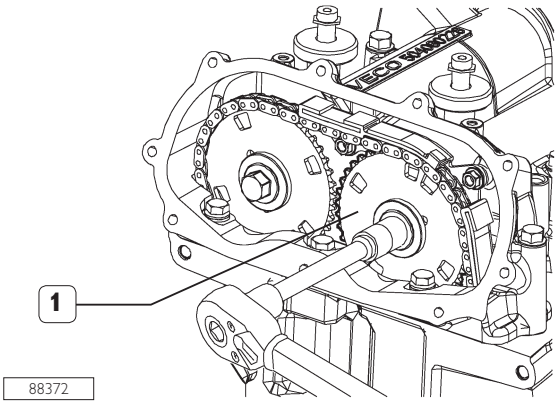
Make sure that the chain (2) and the tract between the gear (1) and gear (3) is tensioned.
Tighten the fastening screw of the stem with the drive gear (1) on the high pressure pump control stem to the prescribed torque.

Figure 160



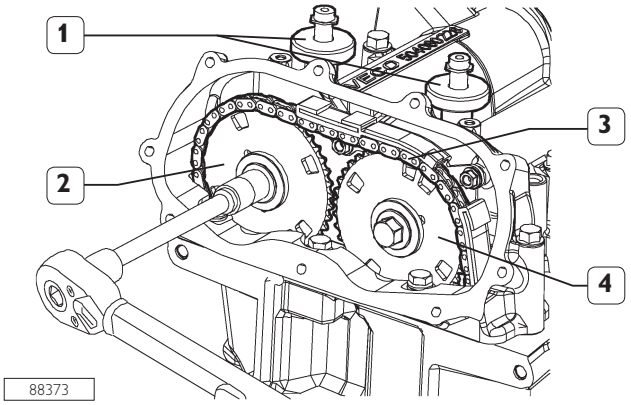
Drive in the chain hydraulic tightener (1) and lock it to the prescribed torque.

Figure 161



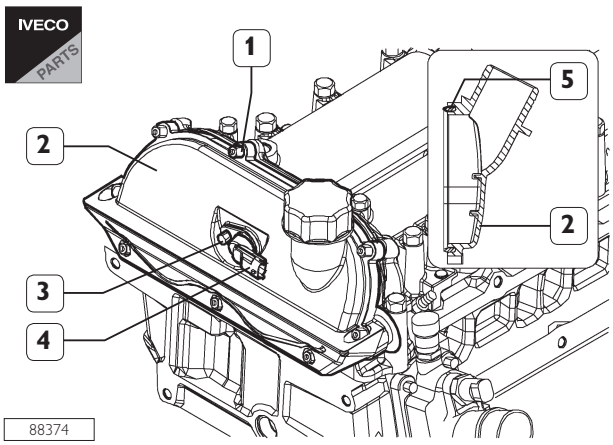
Tighten the fastening screw of the gear (1) on the suction valve camshaft to the prescribed torque.

Figure 162



Make sure that the chain (3) in the tract between the gear (2) and gear (4) is tensioned.
Tighten the fastening screw of the gear (2) on the exhaust valve camshaft to the prescribed torque.
Remove tools 99360614 (1).

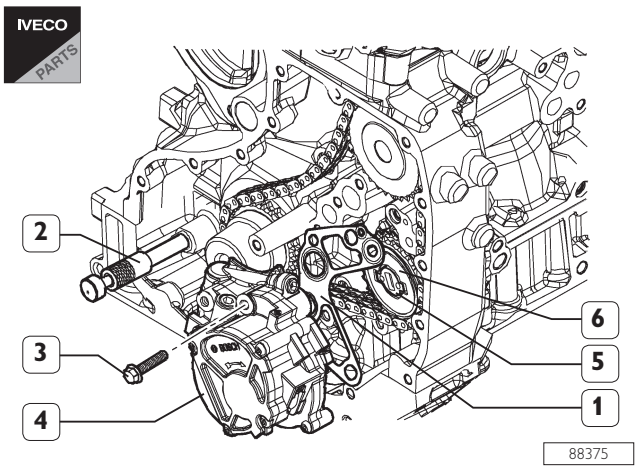
Figure 163



Fit a new gasket (5) in the cover (2).
Fit the cover (2), drive in the screws (1) and tighten them to the prescribed torque.
Fit the phase sensor (4).
Drive in the fastening nut (3) and tighten it to the prescribed torque.

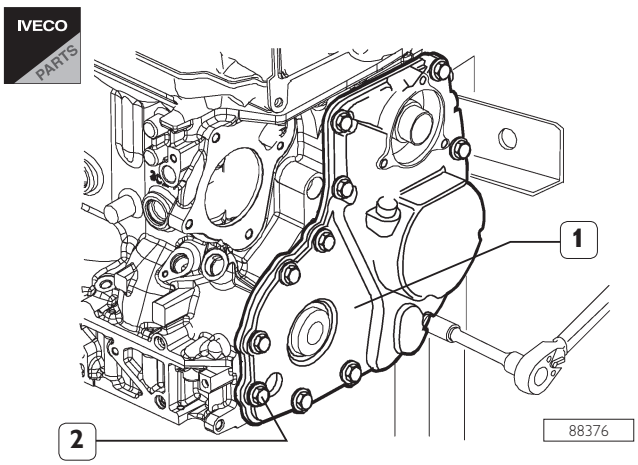
Oil pump assembly

Figure 164



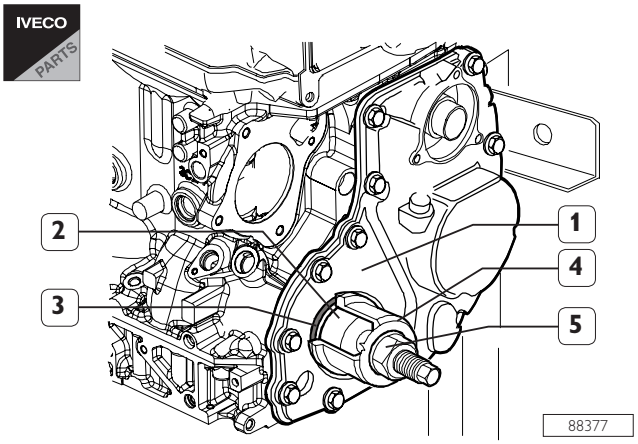
Position the joint (5) in the gear (6).
Fit the oil pump/depressor unit (4) by inserting a new gasket (1).
Drive in the screws (2) and tighten them to the prescribed torque.
Remove tool 99360615 (2).

Figure 165



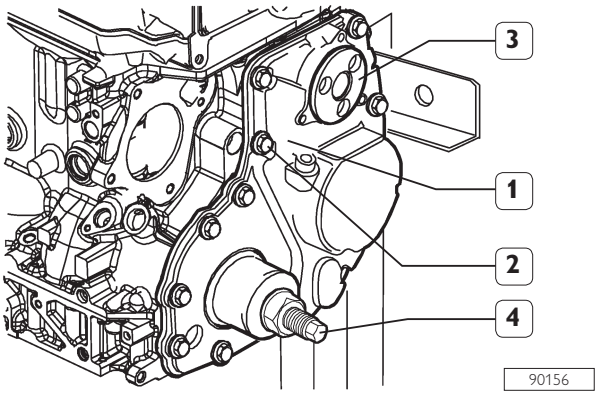
Fit the cover (1) with a new gasket. Drive in the screws (2) without tightening them completely.

Figure 166



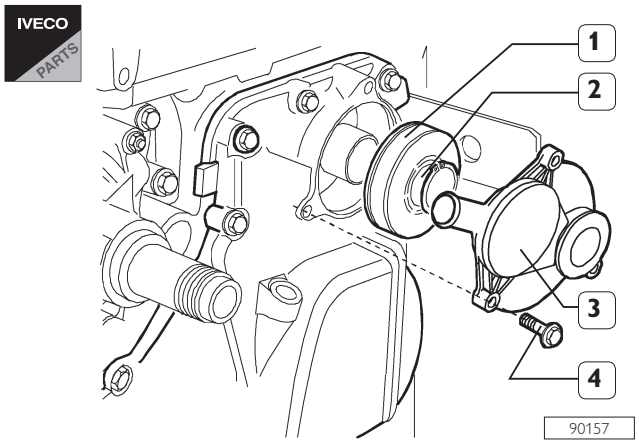
Clean accurately the seat of the cover seal ring (1).
Drive in the element (2) of tool 99346258 in the driving shaft tang.
Lubricate the tang of the driving shaft and the element outside (2) and fit flush the new seal ring on this element (3).
Position the element (4) on element (2), lock the nut (5) until fitting the seal ring (3) completely in the cover (1).

Figure 167



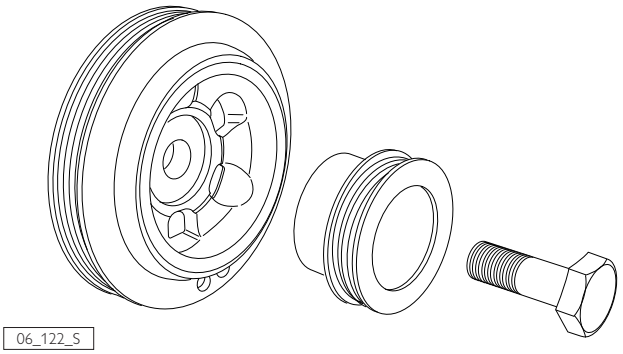
Mount tool 99396030 (3), for centering cover (1), into centrifugal filter seat and tighten screws (2) at prescribed torque.
Remove: 99346258 (4) and 99396039 (3) tools.

Figure 168



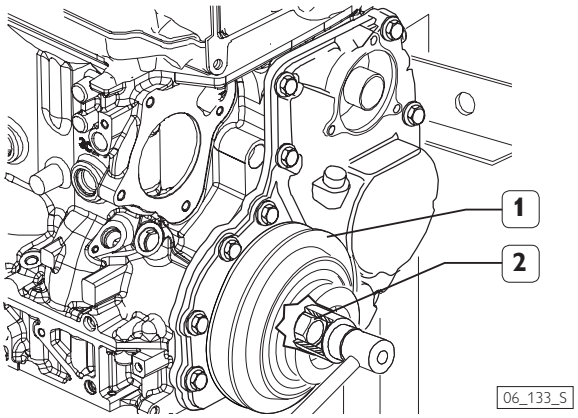
Fit a new centrifugal filter (1).
Fit a new snap ring (2).
Fit the cover (3), drive in the screws (4) and tighten them to the prescribed torque.

Figure 169



Assemble the front pulley and the second pulley for the sea-water pump.

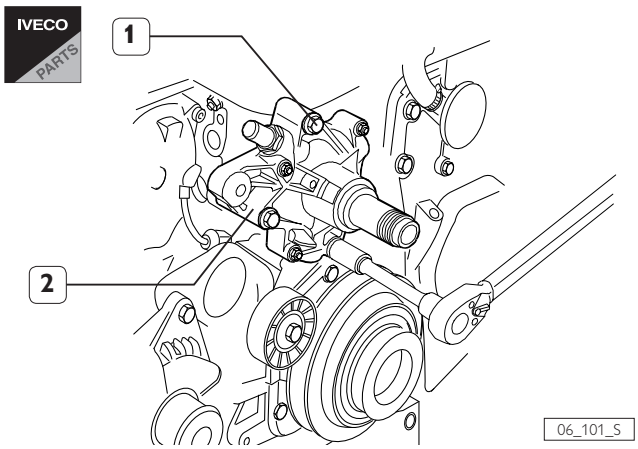
Figure 170



Lock the rotation of the engine flywheel.
Assemble the pulleys (1). Tighten the screw (2), at a torque equal to 350 Nm.

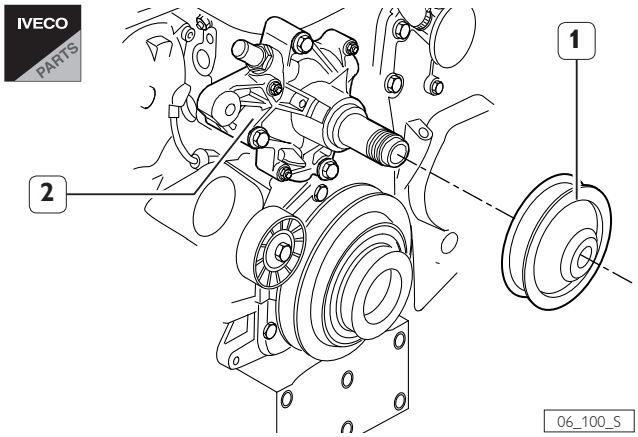
Coolant pump assembly

Figure 171



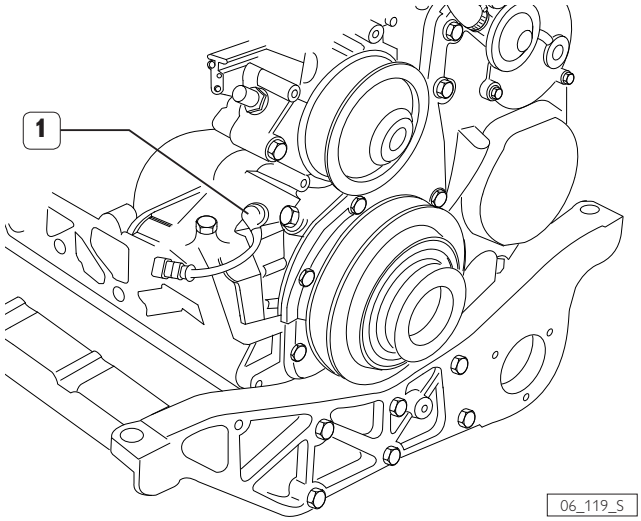
Assemble the coolant pump (2) with a new gasket.
Screw on the screws (1) and tighten them at the prescribed torque.

Figure 172



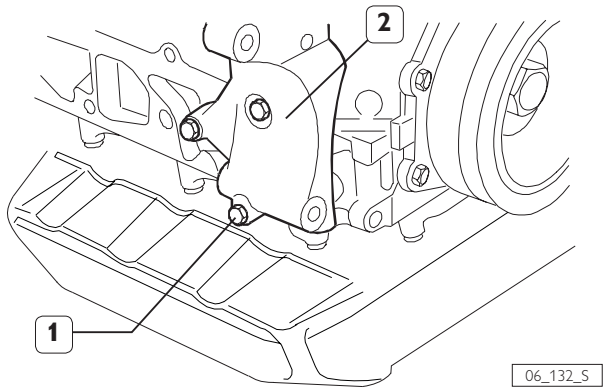
Assemble the pulley (1) on to pump (2).

Figure 173



Assemble the rev sensor (1), screw in the clamp screw tightening to the prescribed torque.

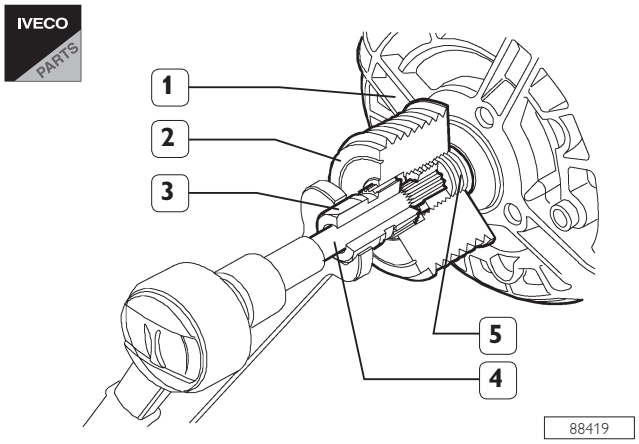
Figure 174



Assemble the support (2), screw in the screws (1) and tighten to the prescribed torque.

Replacement of alternator free wheel

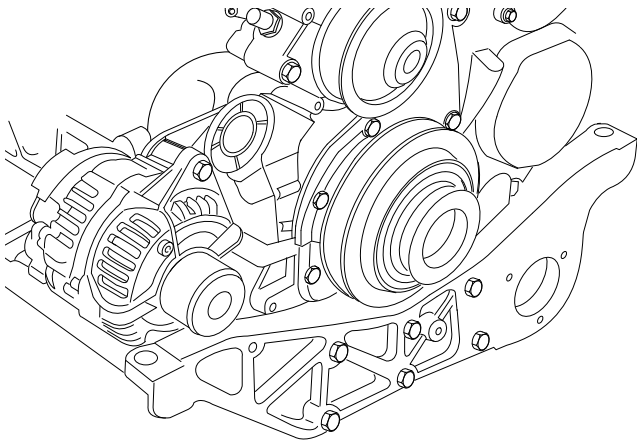
Figure 175



The free wheel (2) function is to prevent that the engine idling oscillations bounce back though the control belt on the alternator (1).
If it is necessary to change the free wheel (2), operate as follows:

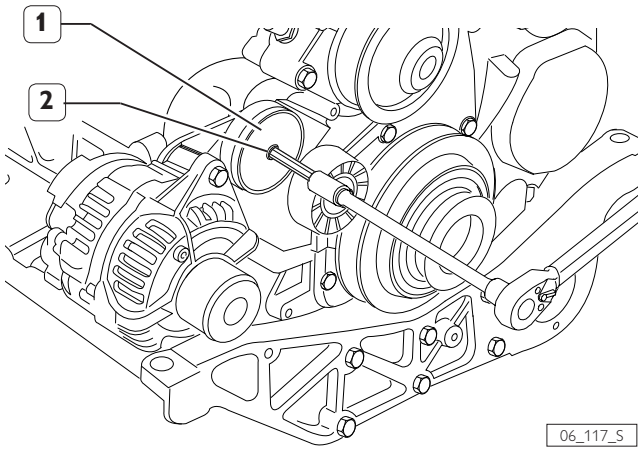
- ❏ Remove the protection cap from the free wheel (2);
- ❏ Apply tool 99358026 (3 and 4) as illustrated in the figure;
- ❏ Stop the rotation of the free wheel (2) with the element (3) and slacken the stem (5) of the alternator (1) with the element (4);
- ❏ Fit the new free wheel (2) by reversing the removal operations. The free wheel (2) must be clamped on the stem (5) by applying a max torque of 85 Nm.

Figure 176



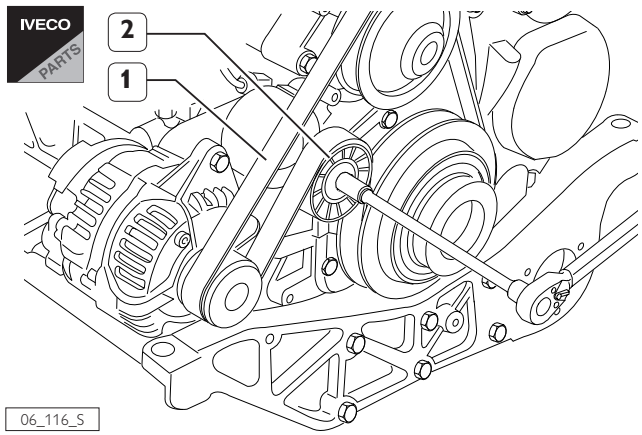
Assemble the alternator (3) on the support (1), secure it with the bolt (4) and the screw (2), and tighten to the prescribed torque.

Figure 177



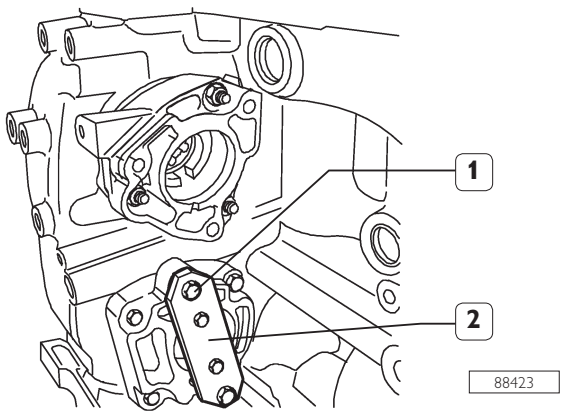
Assemble the automatic belt tightening pulley (1), screw in the screw (2) and tighten to the prescribed torque.

Figure 178



Using the suitable key on the automatic belt tightening pulley (2), assemble the belt (1), and make sure that the ribs are correctly positioned in the respective races of the pulleys.

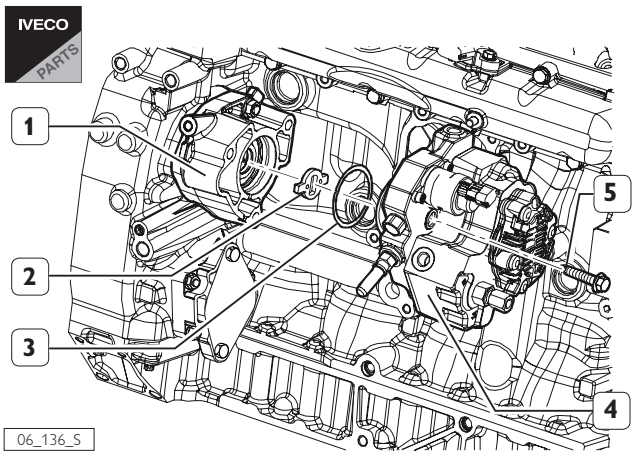
Figure 179



Remove the clamp screws (1) and disassemble the 99360187 tool (2).

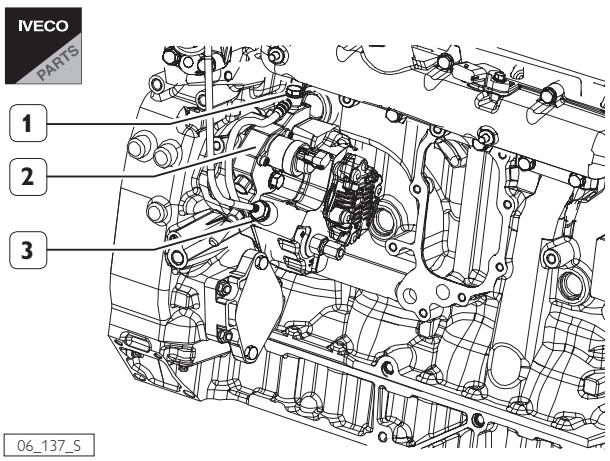
Assembly of high pressure pump

Figure 180



Lubricate a new seal ring (3) and fit it on the high pressure pump (4).
Position the joint (2) on the high high pressure pump stem (4).
Fit the high pressure pump (4) on the support (1), drive in the screws (5) and tighten them to the prescribed torque.

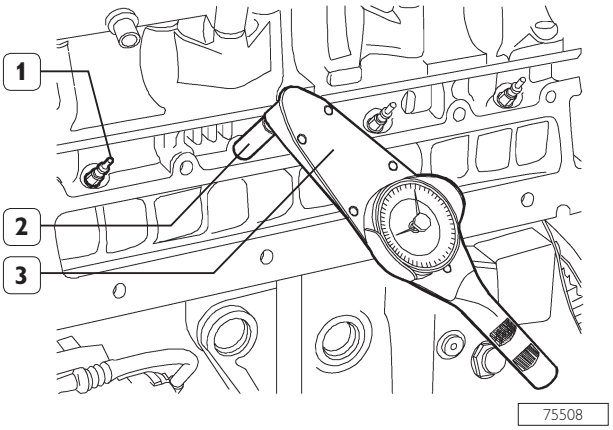
Figure 181



Connect the pipes with new gaskets to the high pressure pump (2), by tightening the connections (1 and 3) at the specified torque.

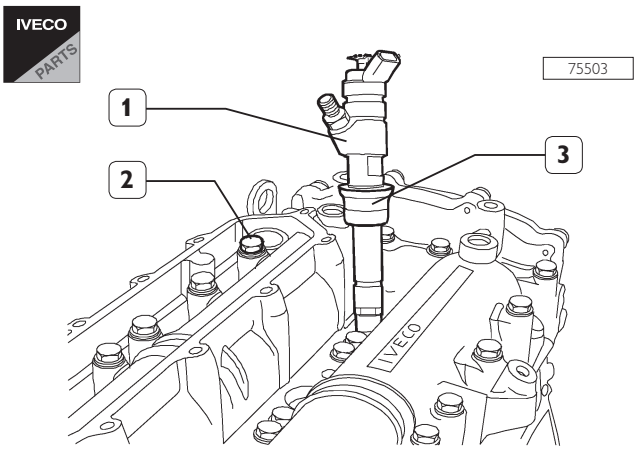
Assembly of fuel supply

Figure 182



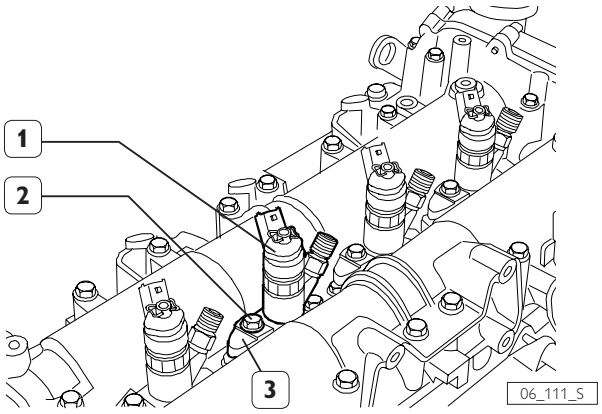
Mount the glow plugs (1) and, using the box-type wrench SP. 2275 (2) and torque wrench 99389819 (3), tighten them to a torque of 8 to 10 Nm.

Figure 183



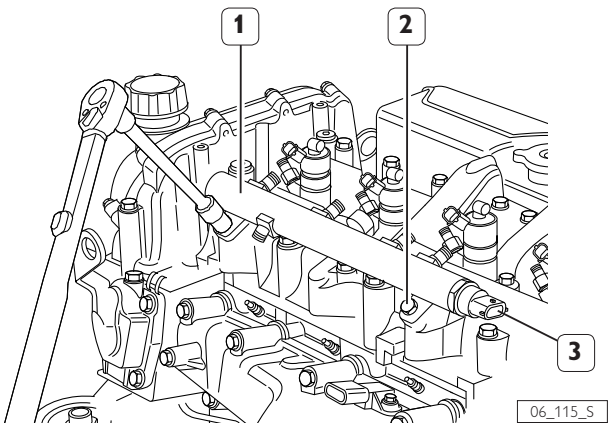
Fit a new seal (3) on the electro-injector (1) and mount this in the overhead (2).

Figure 184



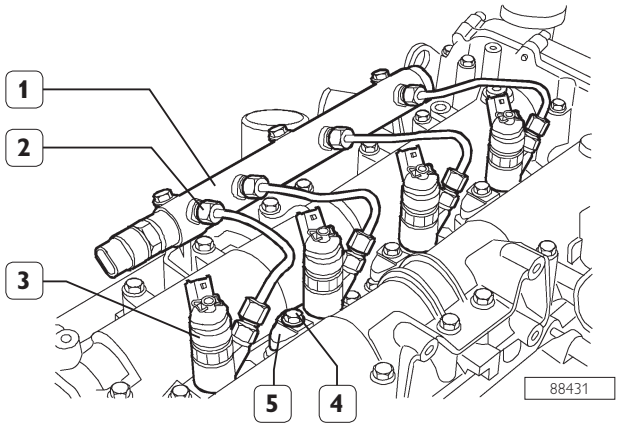
Mount the brackets (3) fastening the electro-injectors (1) and screw down the screws (2) without locking them.

Figure 185



Mount the hydraulic accumulator (1) and tighten the fixing screws (2) to the prescribed torque.
Fit the pressure sensor (3) on the hydraulic accumulator (1) and tighten it to the prescribed torque.

Figure 186

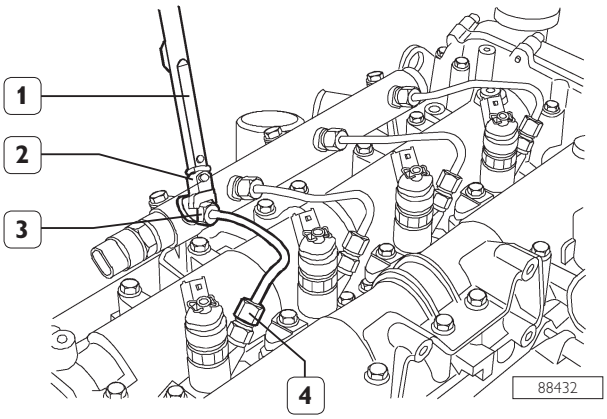


Connect the fuel pipes (2) to the electro-injectors (3) and to the hydraulic accumulator (1).
Tighten the screws (4) fixing the electro-injector brackets (5) to the prescribed torque.

NOTE

Whenever they get removed, the fuel pipes must be replaced with new ones.

Figure 187

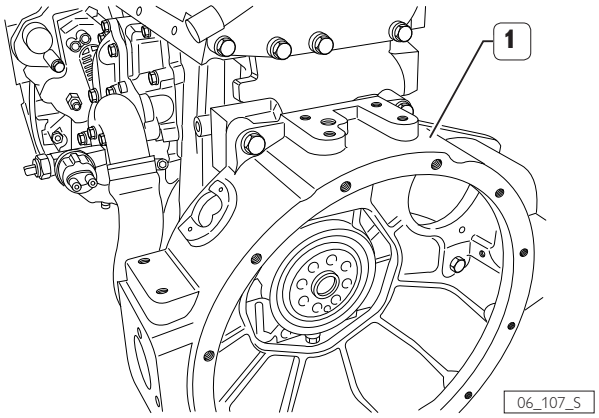


Using the wrench (2) of the 99317915 series and the torque wrench 99389829 (1), tighten the fuel pipe fittings (3) and (4) to the prescribed torque.

COMPONENTS ASSEMBLY FOR MARINE ADAPTATION

Flywheel housing

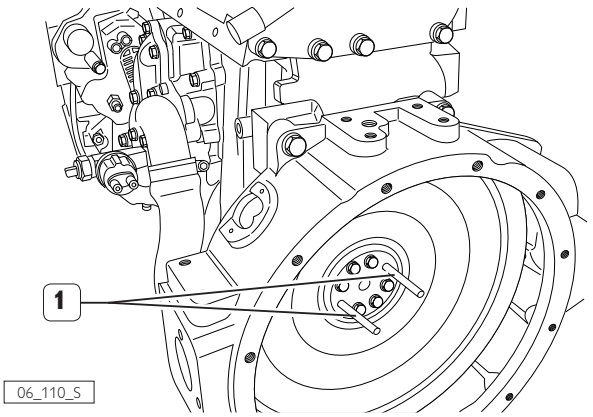
Figure 188



Assemble the flywheel housing (1) using:
2 screws 12MA x 1,25 L = 60 mm (at the top)
2 screws 12MA x 1,25 L = 80 mm (at the bottom)

Flywheel

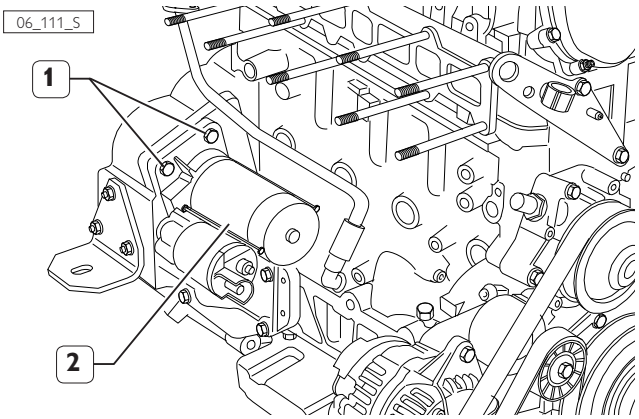
Figure 189



Insert 2 M12 x 1,25 pins (1) in order to lead the flywheel to its seat.
Fit the flywheel and tighten it with 8 screws M12 x 1,25 L = 40 mm.
Tighten according to a cross tightening sequence applying a 140 Nm torque.

Assembly of the starter

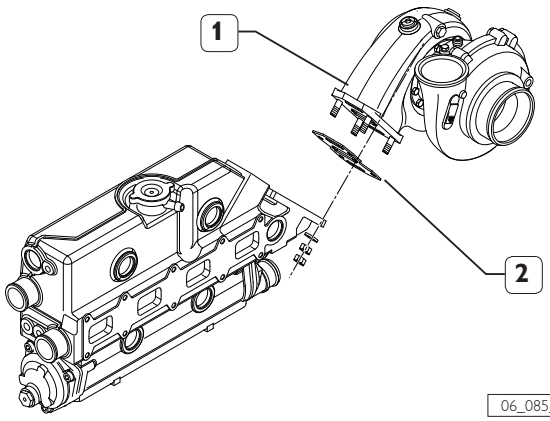
Figure 190



Assemble the starter (2) using, at the top, 2 10MA x 1,25 L = 30 mm screws (1) and their washers; at the bottom use one screw 10MA x 1,25 L = 30 mm with 14 mm head and suitable washer.

Assembly of the turbosupercharger

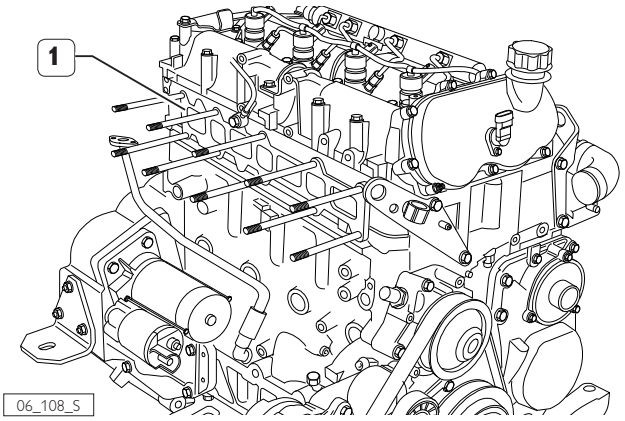
Figure 191



Assemble the turbosupercharger (1) on the exhaust of the heat exchanger by using the right gasket (2) on the turbosupercharger's stud bolts.
Secure the turbosupercharger to the heat exchanger applying 4 spring washers and tightening with 4 + 4 nuts 10MA x 1,5.

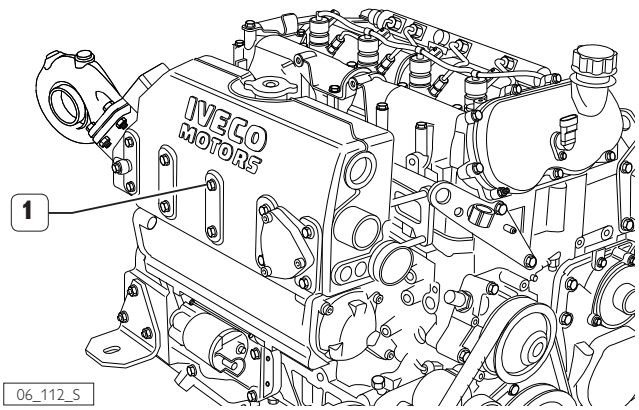
Assembly of the turbosupercharger/heat exchanger group

Figure 192



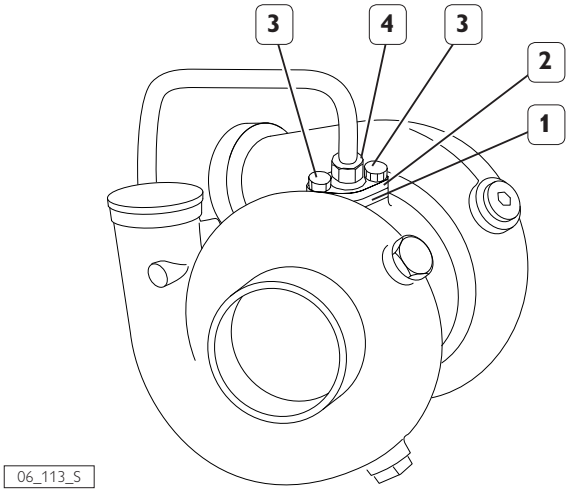
Apply the gasket (1) on the block studs and assemble the turbosupercharger / heat exchanger group by using a sling and a proper lifting device (see following figure).

Figure 193



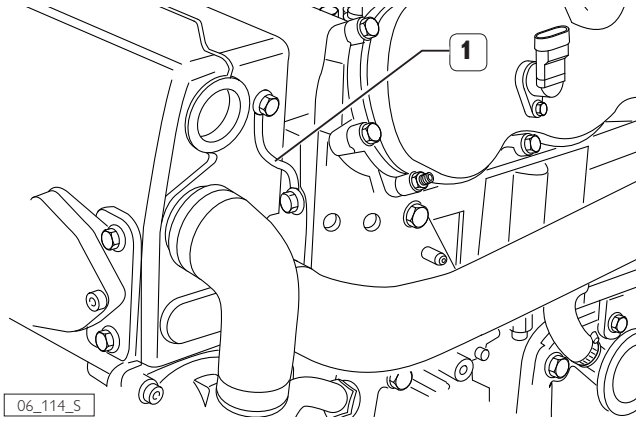
Screw in 10 8MA x 1,5 nuts (1) in order to fix the exhaust manifold and tighten to a 30 Nm torque.

Figure 194



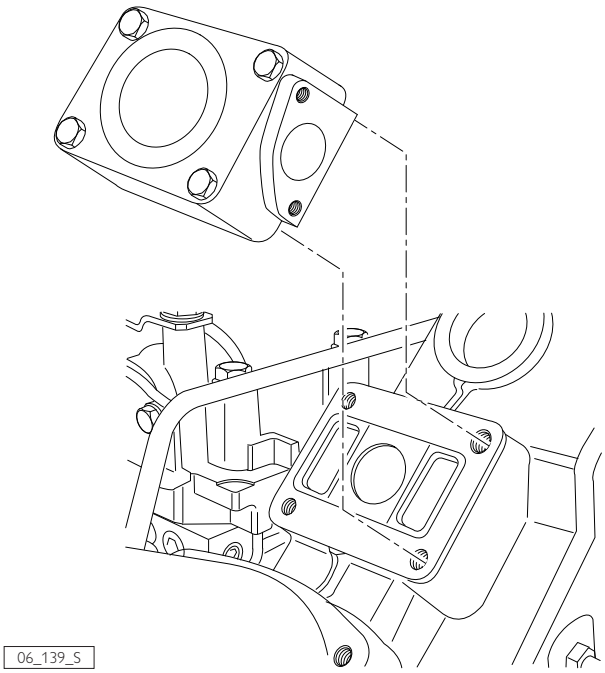
Assemble the gasket (1), connect the flange (2) with n.2 screws (3) M8 x 1,25 L=20 mm and the connector to allow the lubricant to go into the turbosupercharger.
Screw on the 15 mm screw located on the lubricant tube (1) of the turbosupercharger on the block and the 17 mm screw (4) on the turbosupercharger connector.
Insert the gasket and screw in the oil outlet connector from the turbosupercharger by using 2 M8 x 1,25 L = 25 mm screws.
Tighten the hose clamps on the rubber sleeve of the tube between the turbosupercharger and the oil pan.

Figure 195



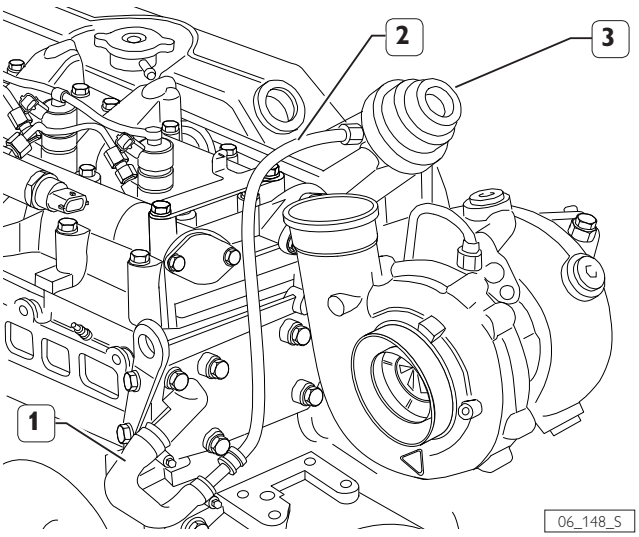
Assemble the deaeration tube (1) coming from the cylinders head in the two tanks using two capstan screws 10MA x 1,25 L = 20 mm.

Figure 196



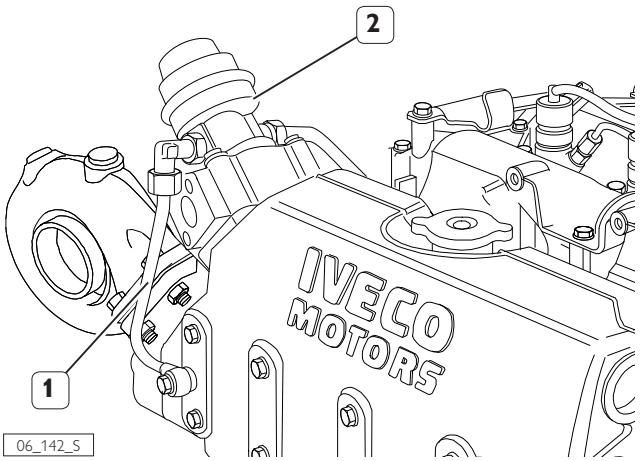
Apply 4 washers on the waste-gate valve's seat and tighten using 4 screws M8 x 1,25 L = 60 mm, making sure that the gasket's relief is positioned upward facing the connector at the top.

Figure 197



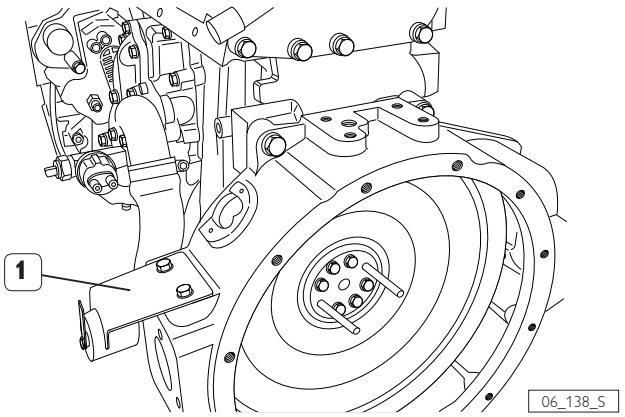
Assemble the group consisting of a rubber tube (1) and a metal tube (2), linking the cylinders head to the cooling of the waste-gate valve (3), by applying two hose clamps on the rubber tube and one clamp with screw 8MA x 1,25 L = 35 mm on the metal tube.

Figure 198



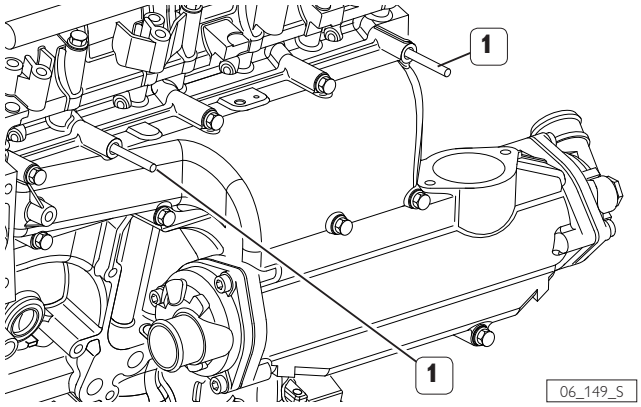
Assemble the tube (1) connecting the outlet of the coolant from the waste-gate valve (2) to the coolant tank by applying two copper washers and two capstan screws 14MA x 1,5 L = 30 mm.

Figure 199



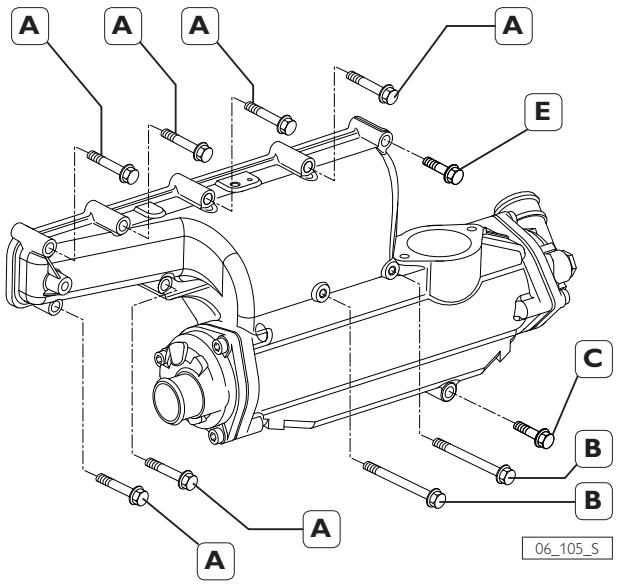
Assemble the potentiometer bracket (1) and tighten with 2 screws 10MA x 1,25 L = 20 mm.

Figure 200



Assemble the induction manifold by applying 2 studs (1) as a guide and make sure that the relief of the proper gasket faces the exterior. Tighten the manifold following the tightening procedures indicated below:

Figure 201

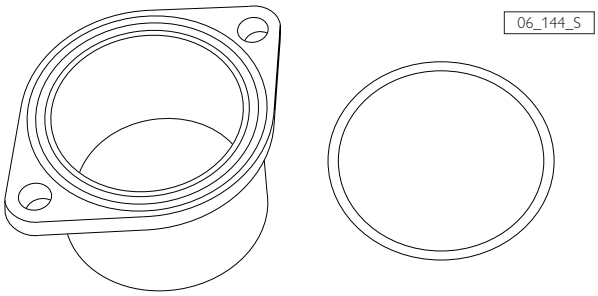


Screws Legend:

A: 8MA x 1,25 L = 70 mm
B: 8MA x 1,25 L = 140 mm
C: 8MA x 1,25 L = 80 mm (*)
D: 8MA x 1,25 L = 40 mm
E: 8MA x 1,25 L = 55 mm

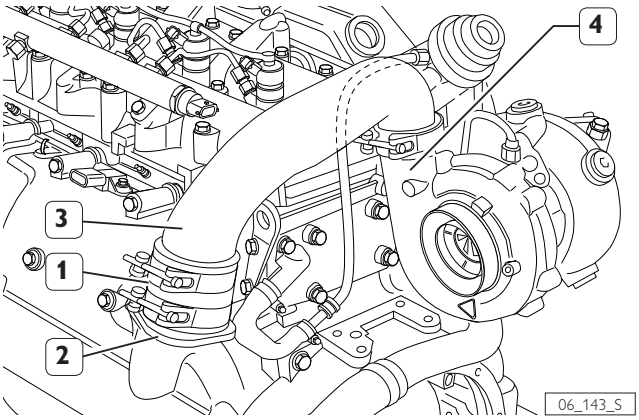
(*) screw on, placing the rear nut on potentiometer support.

Figure 202



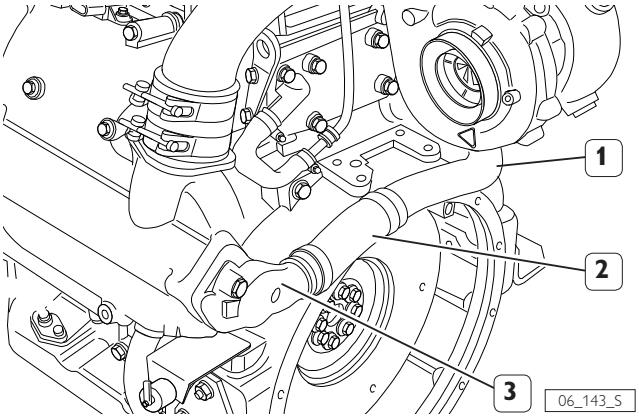
Assemble the metal sleeve on the induction manifold with a Vaseline-lubricated grommet in-between and tighten using 2 screws 8MA x 1,25 L = 20 mm.

Figure 203



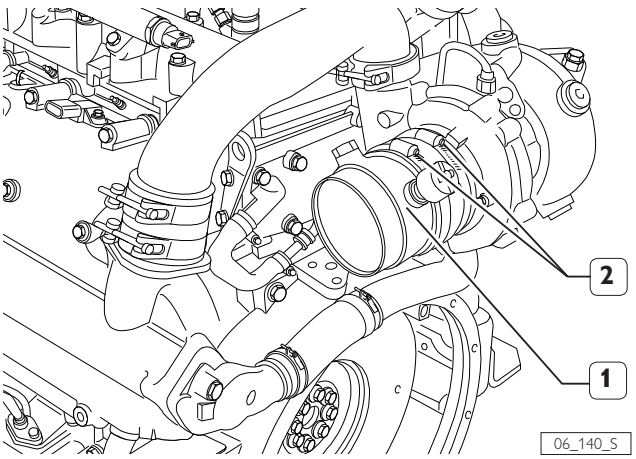
Assemble the rubber sleeve (1) on the metal sleeve (2), previously assembled on the induction manifold. Then insert the metal sleeve (3).
Assemble the other end of the metal sleeve (3) applying a Vaseline-lubricated grommet on the connector (4) of the turbosupercharger. Then assemble the sleeve on the turbosupercharger's manifold and tighten the three hose clamps.

Figure 204



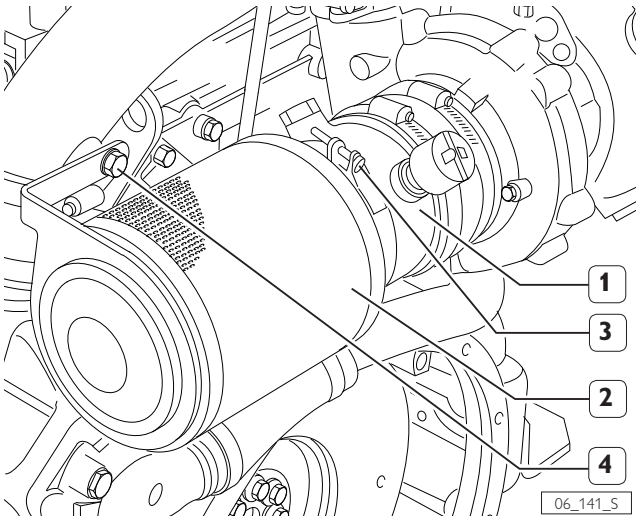
Assemble the coolant-connecting pipe (1), located on the flywheel, by applying two rubber sleeves (2) at both ends facing their respective connecting pipes. Secure the rubber sleeves to the copper tube using 2 hose clamps on each end. Loosen the internal screws on the turbosupercharger's side, if appropriate.

Figure 205



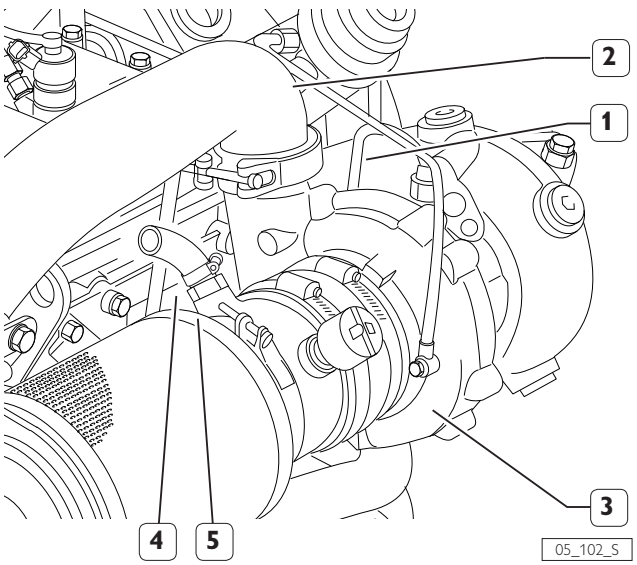
Assemble the air cleaner support (1) on the turbosupercharger's intake side, applying a rubber sleeve and tightening it with two hose clamps (2). In order to facilitate the insertion loosen the internal screws on the turbosupercharger's side, if appropriate.

Figure 206



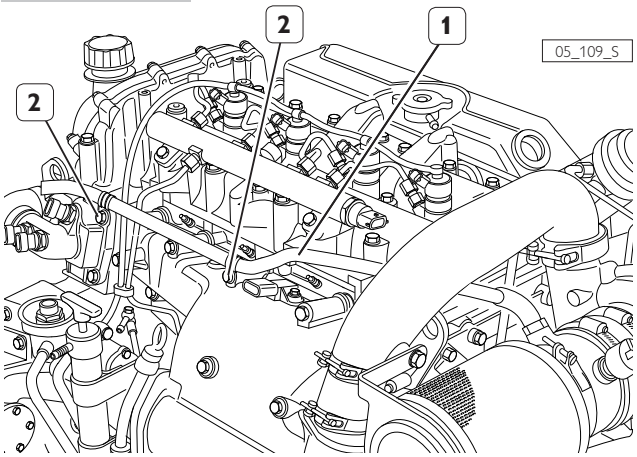
Assemble the air cleaner (2) on its support (1) by fastening it with a hose clamp (3) on the turbosupercharger's side and blocking it on the other side with the suitable bracket (4) which should be secured to the connection pipe between the turbosupercharger and the induction manifold with a rubber washer and a 8MA x 1,25 L = 20 mm screw.

Figure 207



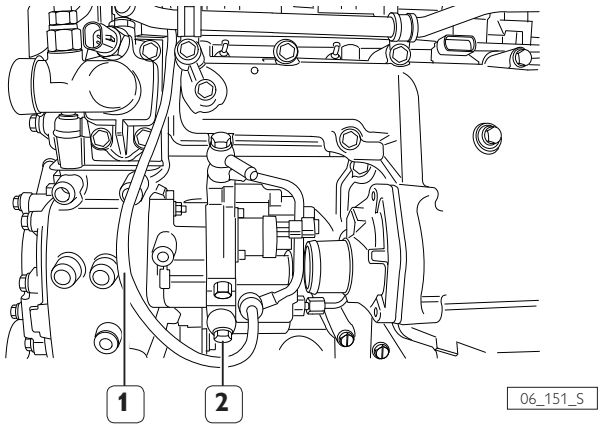
Assemble the connection (1) between the turbosupercharger and the pneumatic actuator of the waste-gate valve by securing it with an 8MA x 1,25 L = 20 mm hose clamp (3) and with a 14 mm nut (2) on the waste-gate valve.
Assemble the rubber sleeve (4) for the induction of steam oil by fastening it with a hose clamp (5).

Figure 208



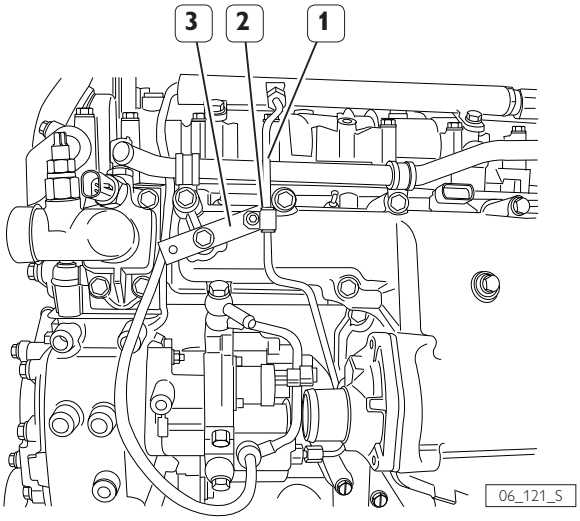
Assemble the oil vapour suction metal pipe (1) by fastening it with two clamps to be applied under the screws (2) that tighten the induction manifold.

Figure 209



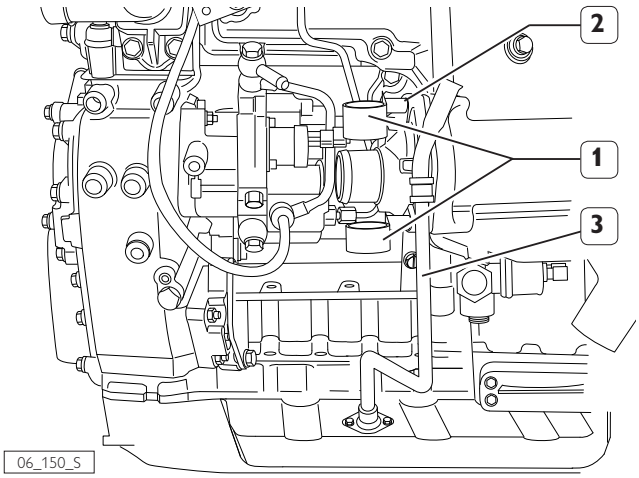
Assemble the fuel blow-by flexible pipe (1) on the high-pressure pump (2), tightening it at the top with a two-connector screw and with a capstan screw with banjo union for the fuel blow-by pipe coming from the injectors.

Figure 210



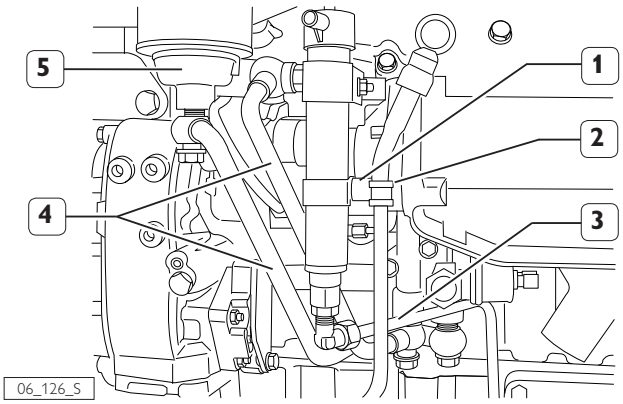
Assemble the pipe (1) running from the high pressure pump to the rail by using a 15 mm high spacer (2) as a middle support on the induction manifold and a bracket with clamp (3) to be fastened with a screw 8MA x 1,25 L = 25 mm.

Figure 211



Assemble the oil emptying pump on two brackets (1) with spacer (2) L = 20 mm and tighten them with socket head screws 8 x 1,25 L = 60 mm.
Fasten the oil dipstick pipe (3) applying a gasket and tightening with a screw 8 x 1,25 L = 20 mm.

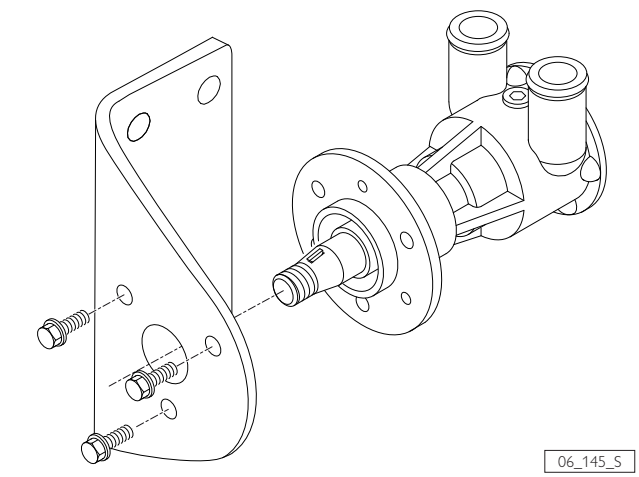
Figure 212



Fasten the spacer (1) L = 20 mm (at the bottom) applying a clamp underneath (2) for the oil dipstick pipe and tighten with a socket head screws 8 x 1,25 L = 60 mm.
Assemble the oil pipe (3) connecting the pan to the emptying pump, insert the pump, insert the lower connector and the screw (at the top) fastening with a screw 8 x 1,25 L = 20 mm and a nut. Tighten the lower connector by using two socket head screws and a screw with nut.

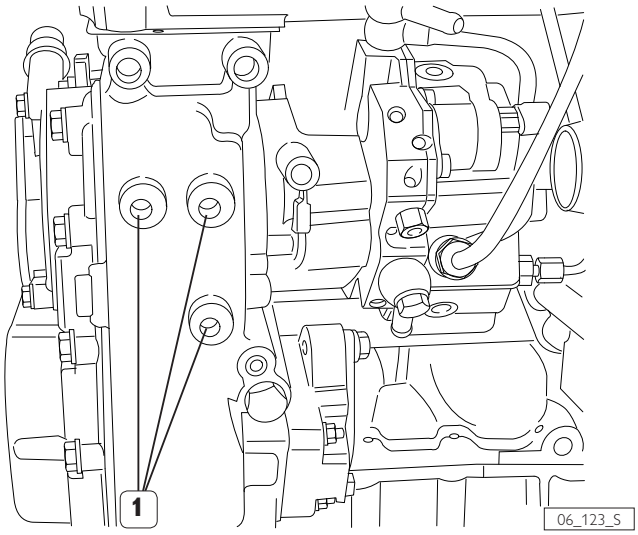
Assemble the oil intake and outlet pipes (4) from the oil filter (5) and fasten them with 4 capstan screws 18MA x 1,25 L = 40 mm.

Figure 213



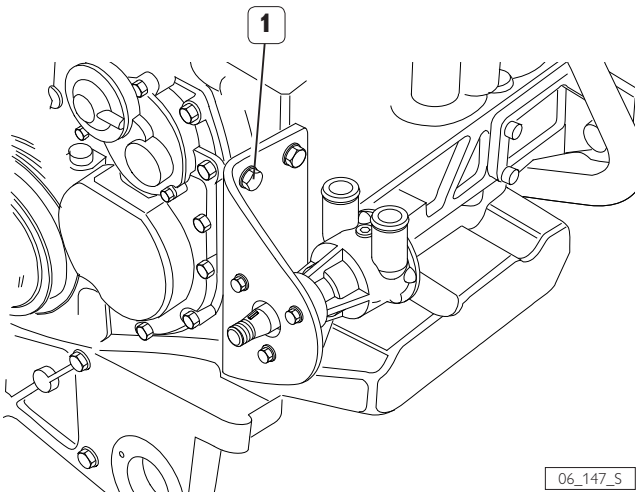
Assemble the seawater pump on the bracket by fastening it with 3 screws 8MA x 1,25 L = 20 mm.

Figure 214



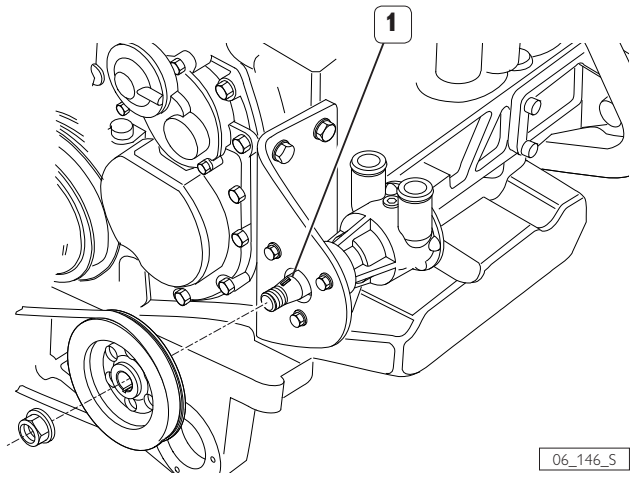
Assemble the seawater pump's bracket by securing it in the three indicated holes (1).

Figure 215



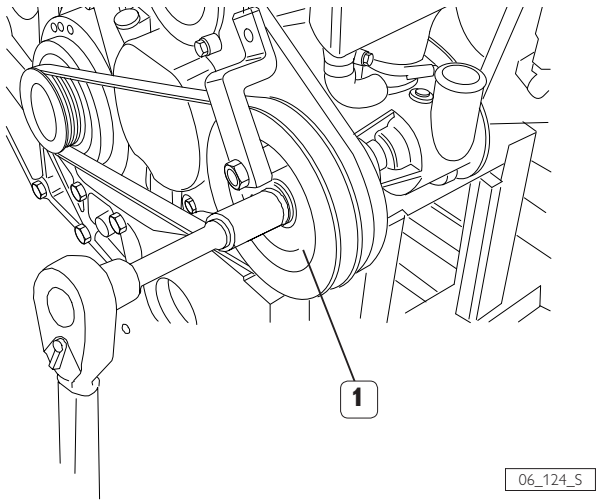
Assemble the bracket with the seawater pump by screwing on by hand 3 screws 10MA x 1,25 L = 30 mm. Apply LOCTITE 577 on the top left screw (1) (clearance hole).

Figure 216



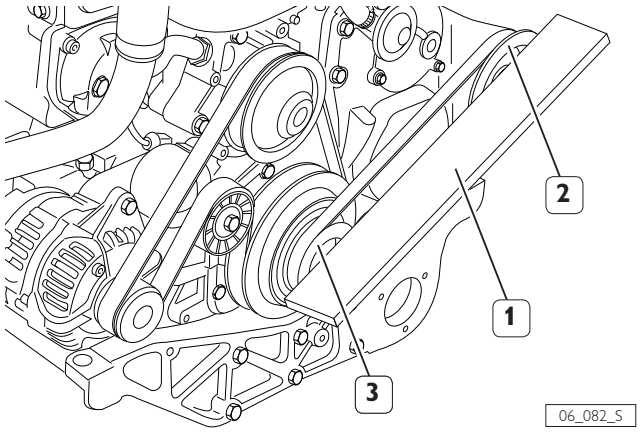
Insert the key in the shaft (1) of the seawater pump, fit the belt on the pulley, and assemble the pulley with a 14MA x 2 nut.

Figure 217



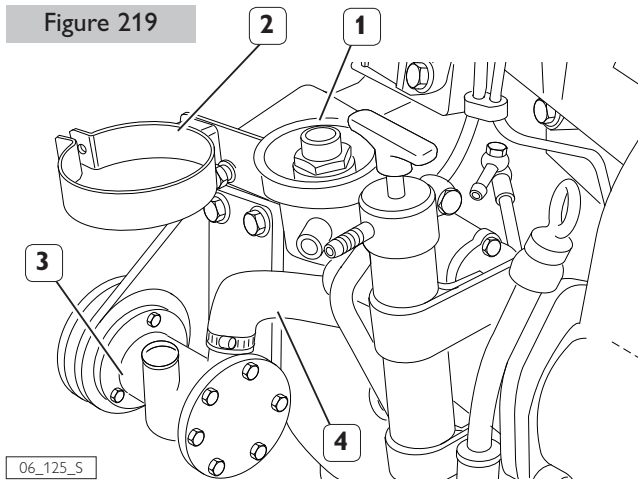
Block the pulley (1) and tighten to an 80 Nm torque.

Figure 218



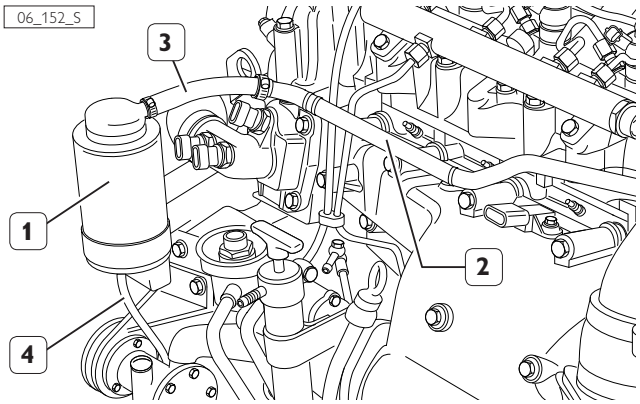
Use a ruler (1) to align the seawater pump's pulley (2) to the engine pulley (3) and tighten the three screws to torque.

Figure 219



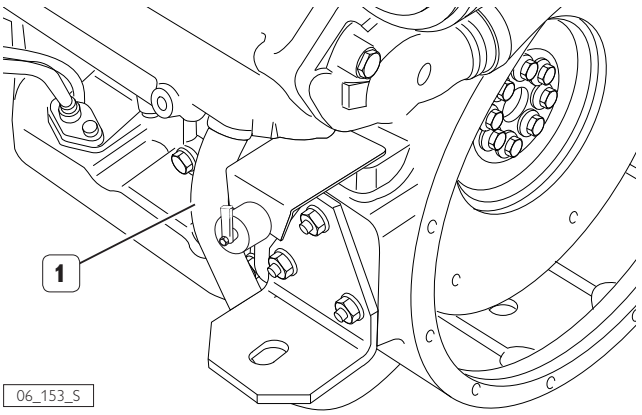
Assemble the support (1) of the oil filter and the holderbat (2) to secure the blow-by filter using 2 screws 12 x 1,25 L = 90 mm.
Assemble the pipe (3) linking the seawater pump (4) to the fresh water/ seawater exchanger and fasten it with two hose clamps.

Figure 220



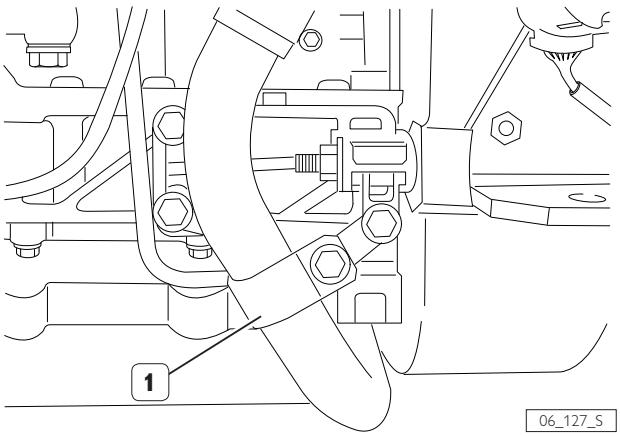
Fasten the blow-by filter (1) with a screw 8 x 1,25 L = 20 mm and suitable nut.
Link the exhaust pipe of the blow-by filter to the metal pipe (2), connected to the air filter, by inserting first a rubber sleeve (3) and fastening it with 2 hose clamps, and then the pipe (4) for oil recovery in the pan.

Figure 221



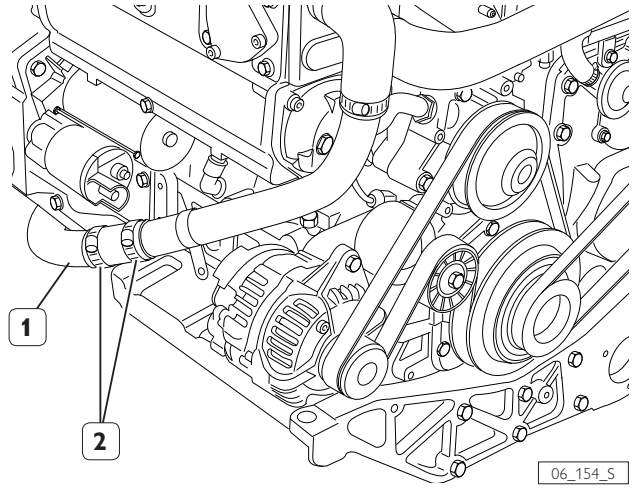
Assemble the fresh water pipe (1) in the lower part of the engine, assembling 2 pipes with three sleeves, and then fastening them with 2 + 2 + 2 hose clamps (see details in the following figures).

Figure 222



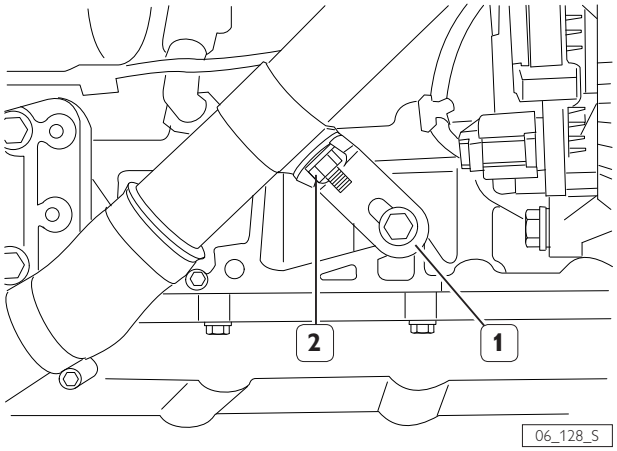
Fasten the pipe on the left side with the collar (1).

Figure 223



Assemble the fresh water pump intake sleeve (1) and fasten it with two clamps (2).

Figure 224

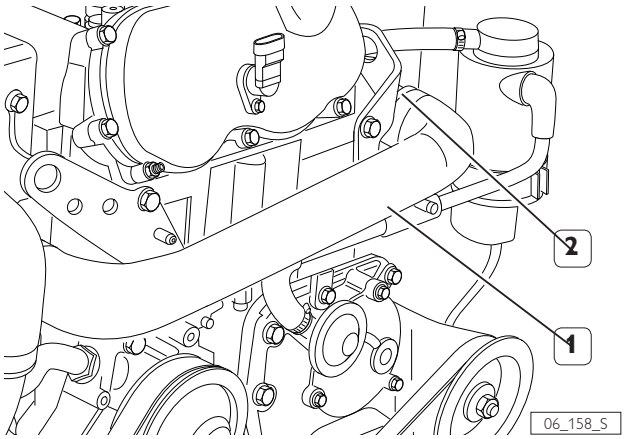


Fastening the pipe:

Left side:
1 screw 10 x 1,25 L= 95 mm screwed in on the stock (1);
1 screw 10 x 1,25 L = 25 mm screwed in at the collar (2);

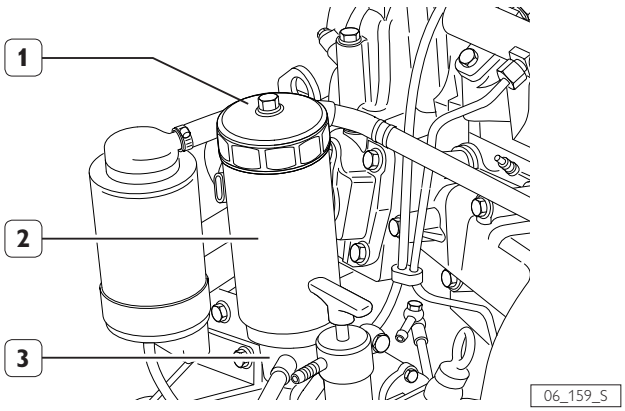
Right side:
1 screw 10 x 1,25 L= 95 mm screwed in on the stock (1);
1 screw 10 x 1,25 L = 25 mm screwed in at the collar (2).

Figure 225



Assemble the rear sleeve (1) linking the thermostatic valve (2) to the tank and fasten it with two hose clamps.

Figure 226



Lubricate the oil filter's grommet (2) with engine oil and screw it in on the heat exchanger (3). With tool 99360076 (1) tighten the oil filter to the prescribed torque.

In order to complete the engine assembly, you need to remove it from the turning stand.

- ❏ With the 99360595 rocker arm lift the engine and unscrew the screws fastening the brackets to the turning stand 99322205;
- ❏ Disassemble the brackets from the engine after you properly laid it on a wooden support;
- ❏ Add the suitable amount of oil and coolant in the engine.

PAGE LEFT INTENTIONALLY BLANK

SECTION 9

SAFETY REGULATIONS

PAGE LEFT INTENTIONALLY BLANK

SAFETY REGULATIONS

Standard safety regulations

Pay particular attention to some precautions that must be followed by all means in any working place and whose non-observance will make any other measures useless or not sufficient to ensure safety to the personnel in charge of maintenance.

- ❏ Be informed and inform the personnel as well of the laws in force regulating safety, by providing information documentation available for consultation;
- ❏ Keep working areas as clean as possible, and ensure adequate ventilation;
- ❏ Ensure that working areas are provided with emergency kits, that must be clearly visible and always fitted with adequate sanitary equipment;
- ❏ Provide for adequate fire extinguishing means, properly indicated and always easy to reach. Their efficiency must be checked on a regular basis and the personnel must be trained on intervention methods and priorities;
- ❏ Provide specific exit points to evacuate the areas in case of emergency, giving adequate indications of the emergency escape paths;
- ❏ Smoking in working areas subject to fire danger must be strictly prohibited;
- ❏ Provide warnings by means of adequate boards signaling danger, prohibitions, and indications to ensure easy understanding of the instructions even in case of emergency.

Accident prevention

- ❏ When working close to engines and equipment in motion, do not wear unsuitable clothes, with loose ends, nor jewels such as rings and chains;
- ❏ Wear safety gloves and goggles when performing the following operations:
  - Filling inhibitors or antifreeze;
  - Topping or replacing lubrication oil;
  - Using compressed air or liquids under pressure (pressure allowed: ≤ 2 bar).
- ❏ Wear a safety helmet when working close to hanging loads or equipment operating at head height level;
- ❏ Always wear safety shoes and clothes adhering to the body, better if provided with elastics at the ends;
- ❏ Use protection cream for your hands;
- ❏ Change wet clothes as soon as possible;
- ❏ In presence of current tension exceeding 48-60 V verify the efficiency of earth and mass electrical connections. Ensure that hands and feet are dry and carry out working operations using isolating foot-boards. Do not carry out working operations you are not trained for;
- ❏ Do not smoke nor light up flames close to batteries and any fuel;
- ❏ Put rags smeared with oil, diesel fuel, or solvents in fireproof containers;
- ❏ Do not carry out any intervention you have not been given all necessary instructions for;
- ❏ Do not use any tool or equipment for any operation different from the ones they have been designed and provided for. Serious injury may occur;
- ❏ In case of test or calibration operations requiring the engine to be in operation, ensure that the area is sufficiently ventilated or use specific aspirators to eliminate exhaust gas. Danger: poisoning and death.

During maintenance

- ❏ Never open the filler cap of the cooling circuit when the engine is hot. Operating pressure would provoke hot liquid to pour out with serious danger and risk of scalding. Wait until the temperature decreases below 50 °C;
- ❏ Never top up an overheated engine with cooler and use only appropriate liquids;
- ❏ Always operate when the engine is turned off: in case particular circumstances require maintenance intervention on the running engine, be aware of all risks involved in such operation;
- ❏ Be equipped with adequate and safe containers for draining engine liquids and exhaust oil;
- ❏ Keep the engine clean from oil, diesel fuel, and/or chemical solvents stains;
- ❏ The use of solvents or detergents during maintenance may generate toxic vapors. Always keep working areas ventilated. Whenever necessary wear a 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 overspeed;
- ❏ Do not use fast screwdriver tools;
- ❏ Never disconnect batteries when the engine is running;
- ❏ Disconnect batteries before any intervention on the electrical system;
- ❏ Disconnect batteries from the system to charge them with the battery charger;
- ❏ After every intervention, verify that the battery clips polarity is correct and that the clips are tight and safe from accidental short circuit and oxidation;
- ❏ Do not disconnect and connect electrical connections in presence of electrical supply;

- ❏ Before proceeding with pipelines disassembly (pneumatic, hydraulic, fuel pipes) check for liquid or air under pressure. Take all necessary precautions by bleeding and draining residual pressure or closing separation valves. Always wear adequate safety masks or goggles. Non-observance of these instructions may cause serious injuries and poisoning;
- ❏ Avoid incorrect or over-torque tightening. Danger: incorrect tightening may seriously damage the engine components, affecting its duration;
- ❏ Avoid priming from fuel tanks made of copper alloys and/or with ducts without filters;
- ❏ Do not modify cable wires: their length must not be changed;
- ❏ Do not connect any other equipment to the engine electrical equipment unless specifically approved by IVECO MOTORS-FPT;
- ❏ Do not modify the fuel or hydraulic systems without having received specific approval from IVECO MOTORS-FPT. Any unauthorized modifications will compromise the warranty assistance and furthermore may affect the engine correct working and duration.

For engines equipped with an electronic control unit:

- ❏ Do not carry out any electric arc welding without having removed the electronic control unit first;
- ❏ Remove the electronic control unit in case of any interventions requiring heating over 80 °C;
- ❏ Do not paint the components and the electronic connections;
- ❏ Do not vary or alter any data filed in the electronic control unit. Any manipulation or alteration of electronic components will totally compromise the engine warranty assistance and furthermore may affect the engine correct working and duration.

Respecting the Environment

- ❏ Respecting the Environment is of primary importance: all necessary precautions to ensure the personnel's safety and health are to 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 the personnel is fully aware of such law instructions and of basic preventive safety measures;
- ❏ Collect exhaust oils in adequate containers with air-tight sealing ensuring that storage is made in specific, properly identified, areas that will be ventilated, far from heat sources, and not exposed to fire danger;
- ❏ Handle batteries with care, storing them in ventilated environment and in anti-acid containers. Warning: battery exhalations represent serious danger of intoxication and environment contamination.

IVECO S.p.A.
PowerTrain
Viale Dell'Industria, 15/17
20010 Pregnana Milanese - MI - (Italy)
Tel. +39 02 93.51.01 - Fax +39 02 93.59.00.29
www.ivecomotors.com