C13 ENT M77

Technical and Repair Manual

JUNE 2007 EDITION

TECHNOLOGICAL EXCELLENCE

IVECO MOTORS

FPT POWERTRAIN TECHNOLOGIES

FOREWORD

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

The indications contained in this document pertain to the C13 ENT M77.10 marine engines and complement the IVECO MOTORS-FPT "Marine Diesel Engines Installation Handbook". You should refer to this for anything that is not explained herein.

Technical engineers and fitters must comply with work safety regulations. They must implement and adopt the methods foreseen for personal safety while carrying out maintenance or checks.

There is a reminder of the safety rules in Section 9 of the present publication.

There is a reminder of the regulations for engine handling at the end of Section 6 of the present publication.

To start the engine, you must adhere to the procedure stated at the end of Section 5 of the present publication.

To get best engine performance you must 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 for a prior examination of any requirements regarding special installations, should this be necessary.

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 MOTORS-FPT 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 the indications shown on the engine tag;
- The number of the spare part. This can be found in the spare part catalog.

The information provided below refers to engine characteristics current at the date of publication.
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.

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SECTION CONTENTS

Indications for consultation

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

The remaining sections are intended for the personnel that has the task of performing both ordinary and extraordinary maintenance; by referring carefully to the chapter devoted to diagnosis, they too will be able to provide an effective service of technical assistance.

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SECTION 1

OVERVIEW

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IDENTIFICATION DATA

Figure 1

Identification Tag

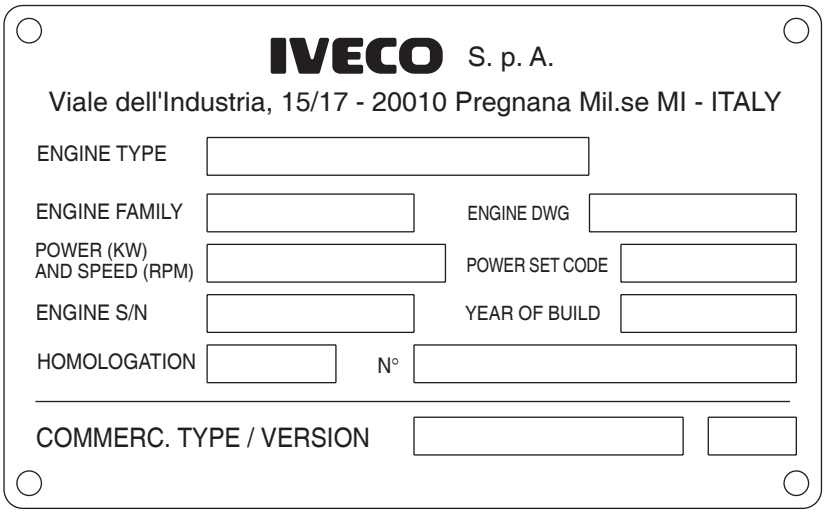

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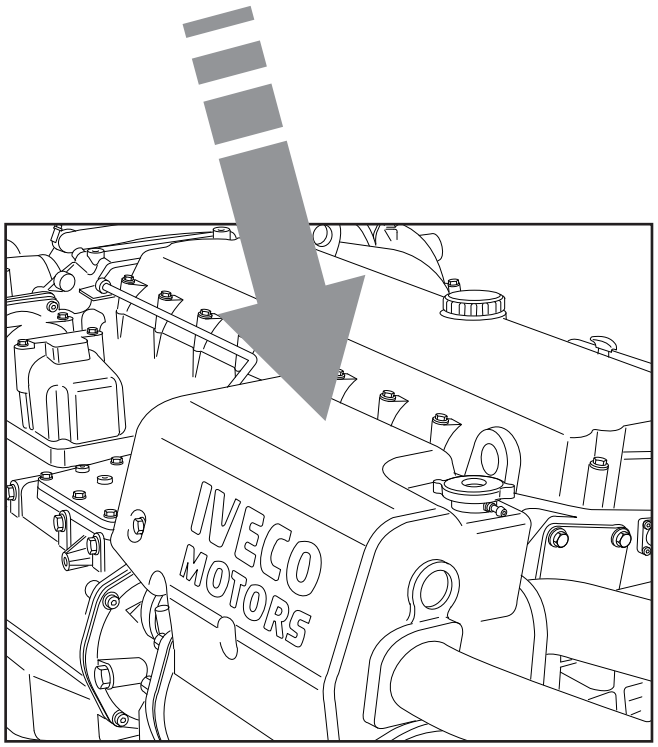
Figure 2

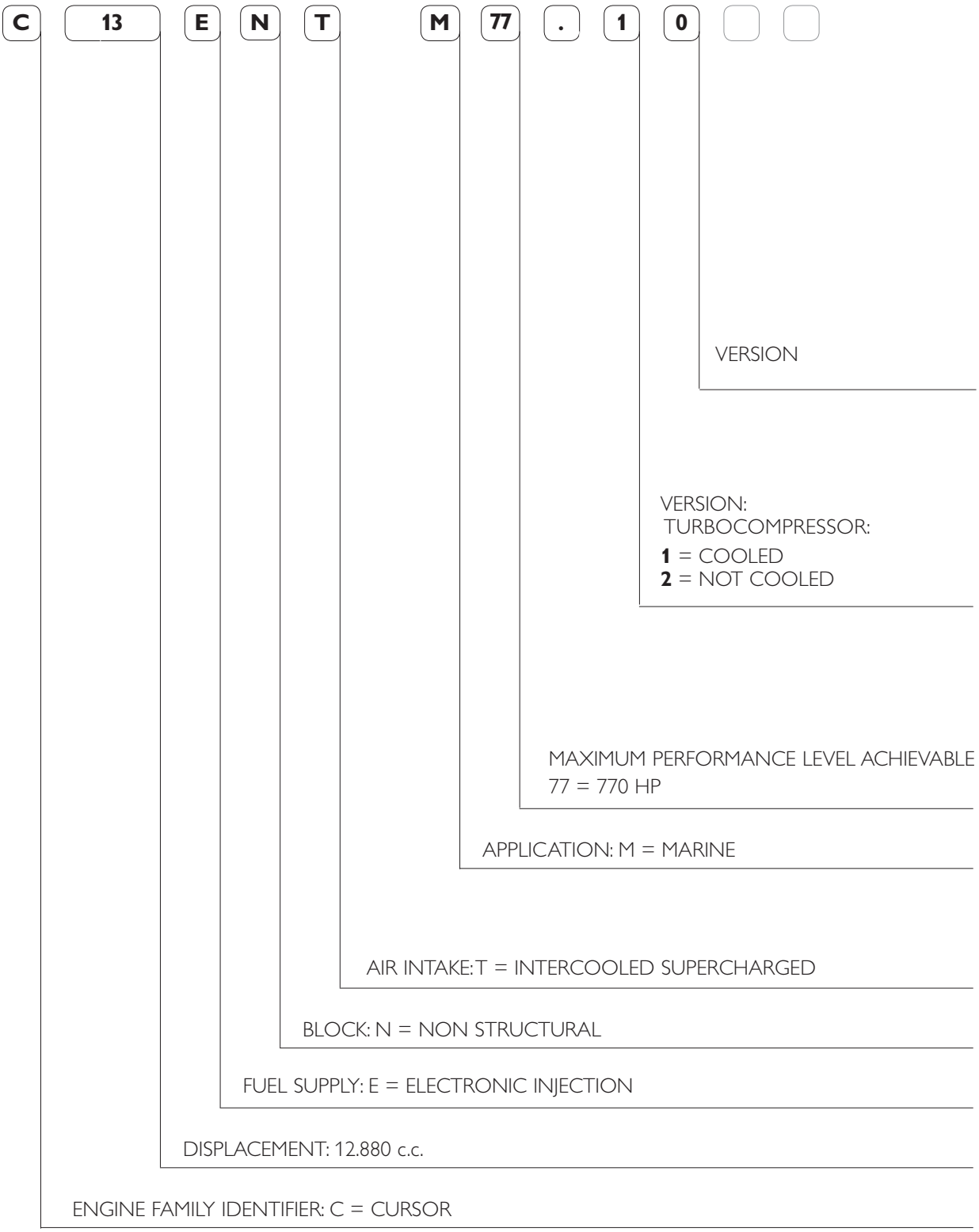


05_001_C

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

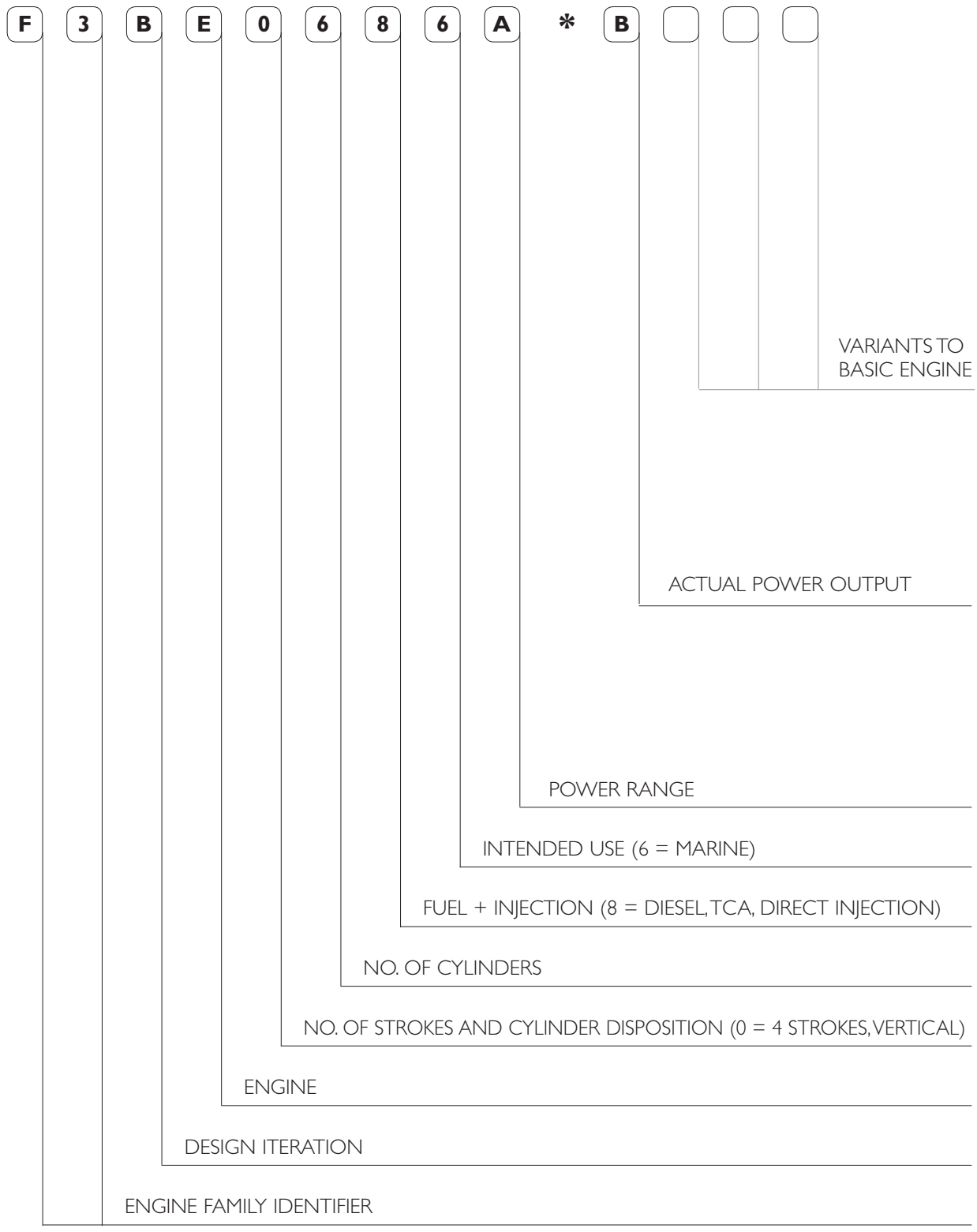
COMMERCIAL CODE

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



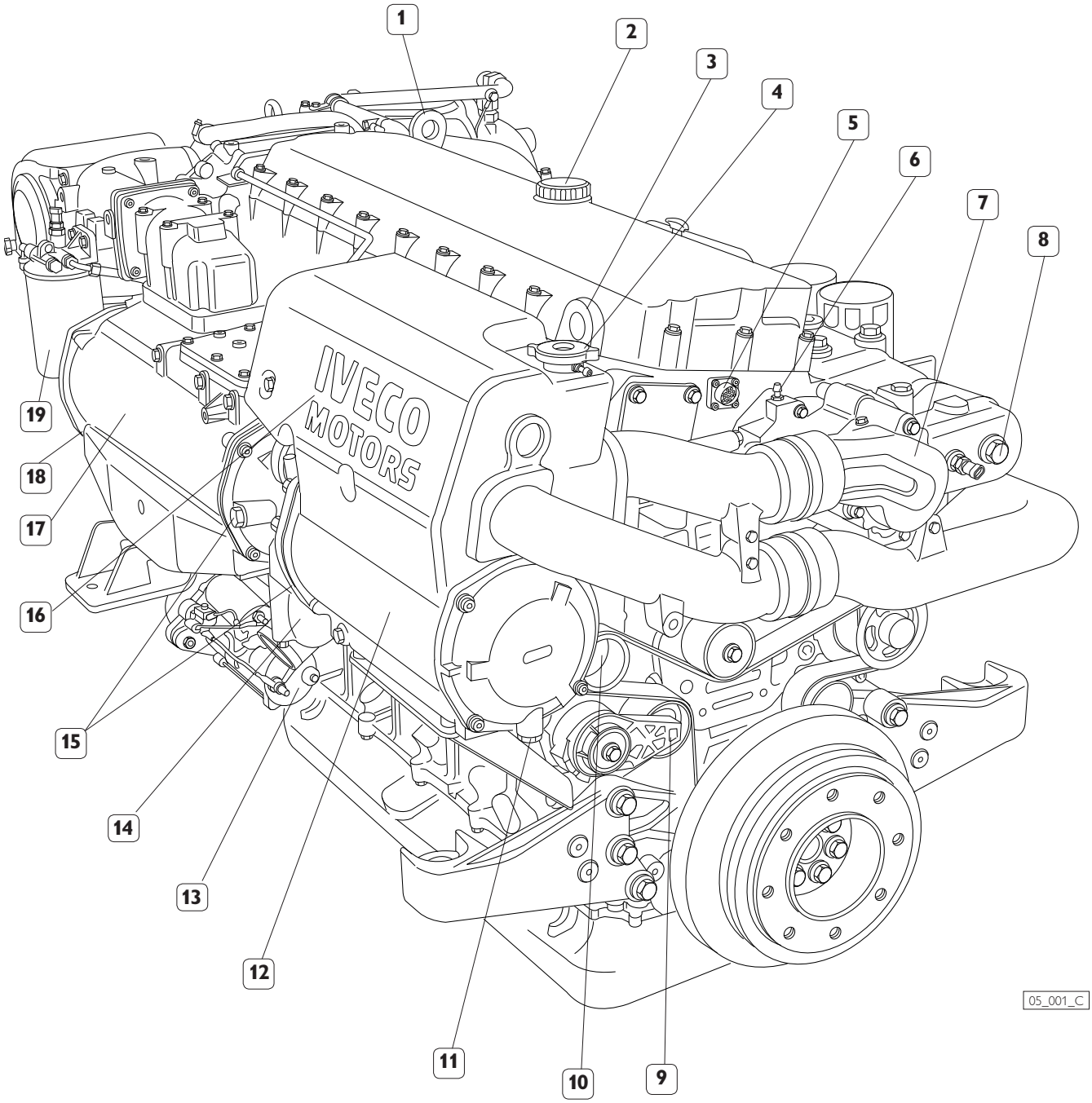
PRODUCT MODEL NUMBER

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 the side of the crank-case.



ENGINE PARTS AND COMPONENTS

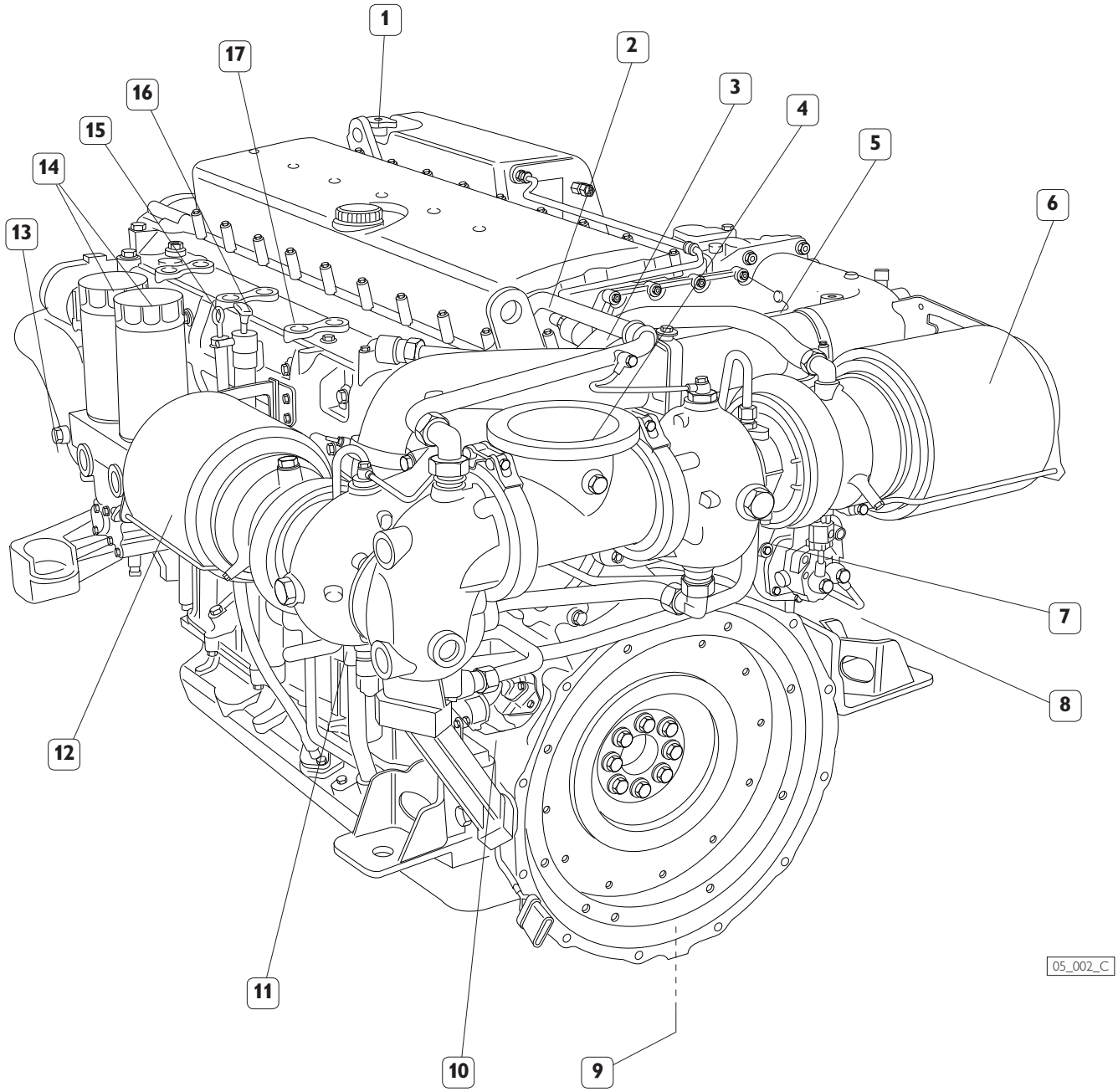
Figure 3



1. Lifting padeye - 2. Lubricating oil refill cap - 3. Lifting padeye - 4. Coolant refill cap - 5. Injector solenoid valve connector - 6. Fuel loop purge fitting - 7. Location of thermostatic valve - 8. Cap for engine coolant outlet to sanitary water heating system - 9. Auxiliary belt automatic tensioner - 10. Alternator location -11. Sacrificial anode and cap for engine coolant discharge. - 12. Coolant-sea water tube bundle heat exchanger - 13. Electrical starter motor - 14. Sea water pump - 15. Sacrificial anode - 16. Engine coolant tank - 17. Air-sea water heat exchanger - 18. Sacrificial anode - 19. Fuel filter.

ENGINE PARTS AND COMPONENTS

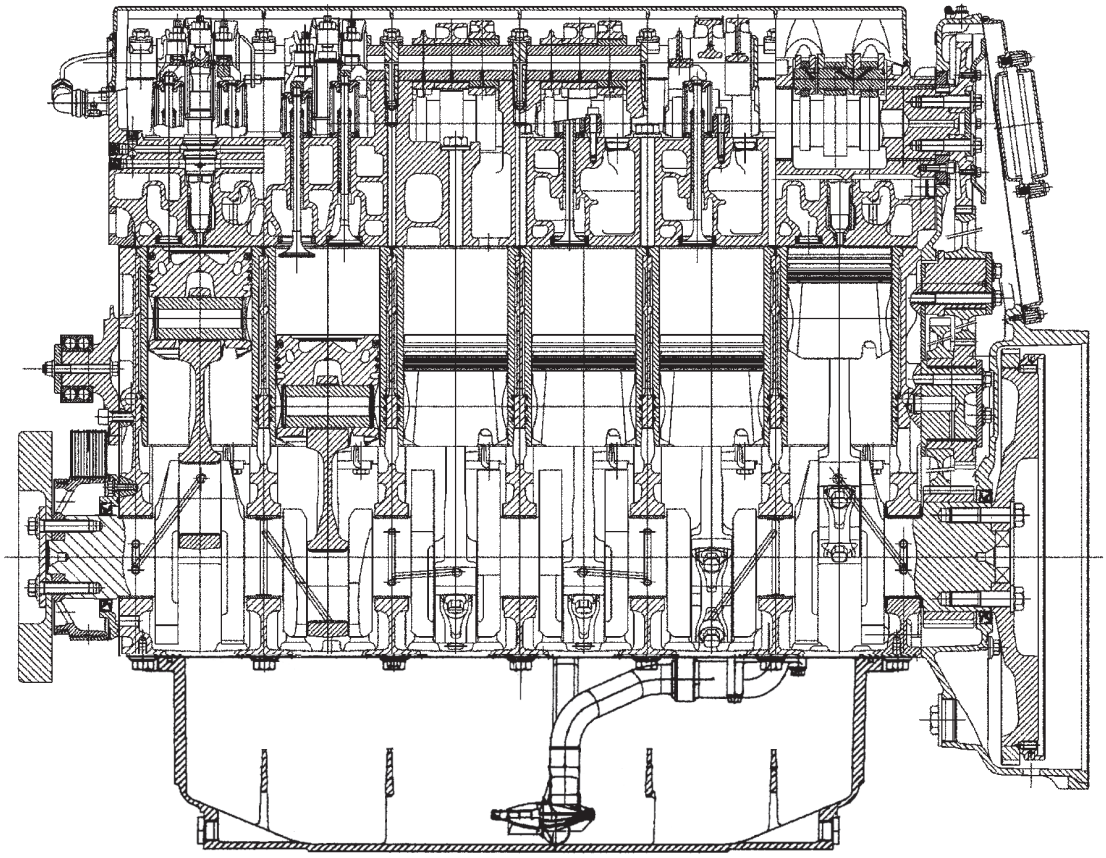
Figure 4



1. Lifting padeye - 2. Lifting padeye - 3. Oil filter clogging indicator - 4. Exhaust gas outlet flange - 5. Timing mechanism and oil vapor filter cover - 6. Intake air filter (A) - 7. Cooled turbo-charger (A) - 8. Fuel transfer pump - 9. Timing phase inspection port - 10. Throttle position sensor potentiometer - 11. Cooled turbo-charger (B) - 12. Intake air filter (B) - 13. Cap for engine coolant discharge and recyrculation from sanitary water heating system - 14. Lubricating oil filters - 15. Lubricating oil dipstick - 16. Manual lubricating oil extraction pump - 17. Cooled exhaust manifold.

ENGINE ARCHITECTURE

Figure 5



With the CURSOR series engines, IVECO MOTORS-FPT has reached unequalled standards in power delivery for industrial, marine, and automotive uses; CURSOR engines are the result of a continuous research process aimed at product improvement, and they inherit no elements of previous propulsion units. They adopt the most rational and effective solutions to achieve, with smaller displacement engines, power outputs that are typical of larger, heavier engines.

The architecture of these engines is characterized by six cylinders in line, four valves per cylinder and roller rocker arms with overhead cam shaft and "bonded" block.

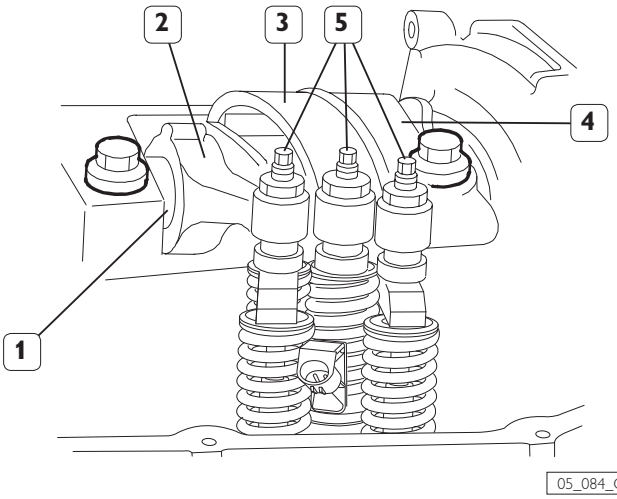
Electronic control extended to all functions ensures reliable and durable operation, offering important benefits in terms of performance and usage.

IVECO MOTORS-FPT's contribution to environmental protection is amply demonstrated by the CURSOR engines' environmental performance: fumes and noise are well below current regulatory requirements and compliance with future limits was the target of the whole design effort.

The 24 valve cylinder head with its camshaft with seven supports, incorporates the intake manifold and the conduits for the cooling and lubrication fluids, as well as for fuel supply.

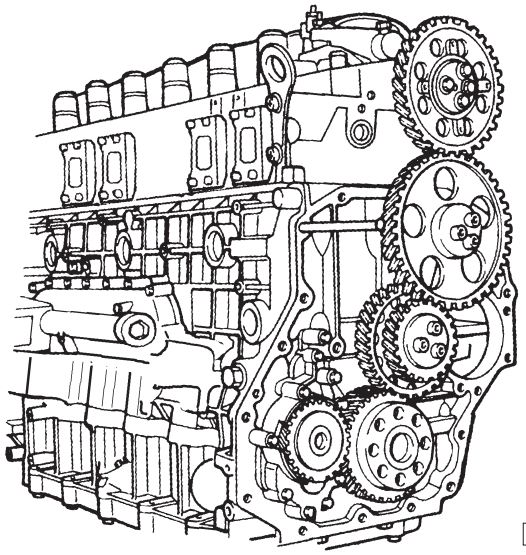
The overhead camshaft with roller rocker arms directly activates both the valves and the EUI (Electrical Unit Injector).

Figure 6



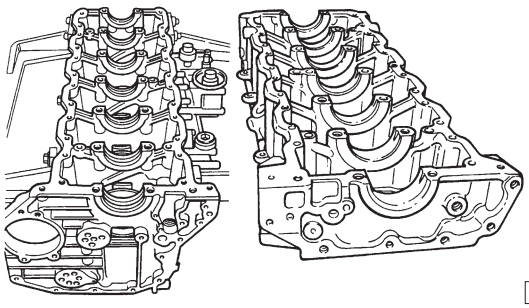
1. Rocker arm shaft - 2. Intake valve rocker arm - 3. Pump injector rocker arm - 4. Exhaust valve rocker arm - 5. Calibration screw.

Figure 7



Timing control is to the rear to reduce torsional effects and it is built with helical tooth gears to contain noise.

Figure 8



Block and sub-block constitute a rigid assembly to reduce vibration and noise and secure the drive shaft with seven shaft supports. Aluminum pistons provide effective heat dissipation.

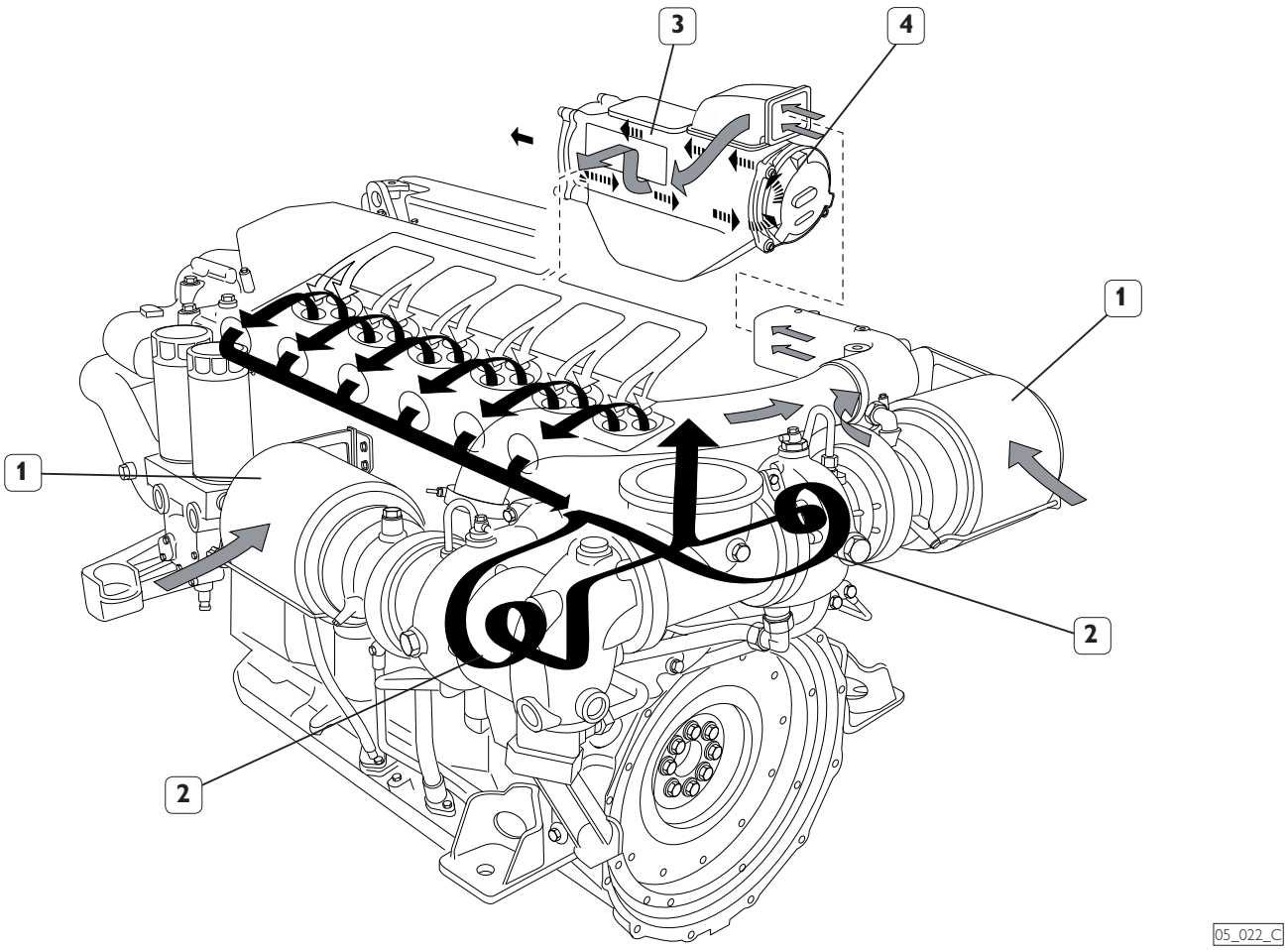
Pump injectors are mounted at the center of the combustion chamber and provide the highest possible thermodynamic efficiency thanks to an injection that is able to reach pressures that exceed 1800 bar. Electrically driven by the electronic control, they deliver fuel at a time that minimizes fuel consumption and contains gas emissions, while maximizing torque and power output.

The EDC, Electronic-Diesel-Control system, constantly monitors environmental and engine operating conditions, providing an optimized injection control to maximize performance at all times. Even when operating in critical conditions, control is optimized. This permits navigation and operation to continue in complete safety.

The electronic unit's control over the entire engine's efficiency provides information about the engine's global performance and other, specific, information for each cylinder, thereby making servicing operations easy; associated with the testing of the working condition of the injection system's electrical and electronic components, it stores information about the most significant events that occur during the engine's operation and allows maintenance personnel to anticipate the onset of faults and resolve them.

COMBUSTION AIR INTAKE AND EXHAUST SYSTEM

Figure 9



1. Air filters - 2.Turbocompressors - 3. Air/sea water heat exchanger - 4. Sea water.

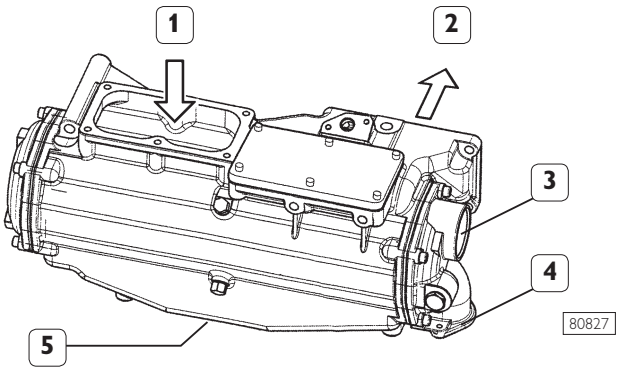
Description and Operation

Air, drawn in and compressed by the turbocompressors, flows through the heat exchanger together with sea water. The latter, by reducing temperature, allows an increase in the engine's volumetric efficiency.
The air density at the inlet of the intake manifold is measured by two sensors, for pressure and temperature, allowing the ECU of the EDC system to calculate fuel dosage relative to the actual quantity of air available for combustion.
Lubricating oil vapors (blow-by) not condensed in the separator, are sent to the engine intake by a gauged hole downstream of the air filters.

Exhaust gas expelled by the engine flows through the cooled exhaust manifold to reach the turbocompressors rotors.
Exhaust manifold and turbocompressor body are cooled by the fresh water loop. Exhaust gases flow into the exhaust terminal and, when provided, they are mixed with the sea water it carries for overboard discharge.

Air/sea water heat exchanger

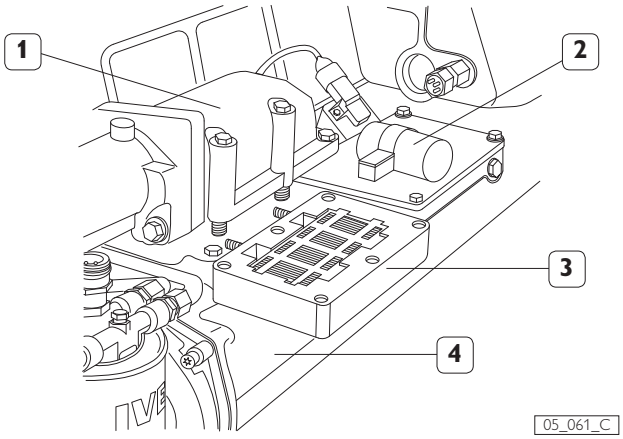
Figure 10



1. Air inlet from the turbocompressor - 2. Outlet for air cooled by the sea water and destined to the intake manifold - 3. Sea water outlet - 4. Sea water inlet - 5. Condensed water outlet.

Combustion air pre-heating (not available at the moment)

Figure 11

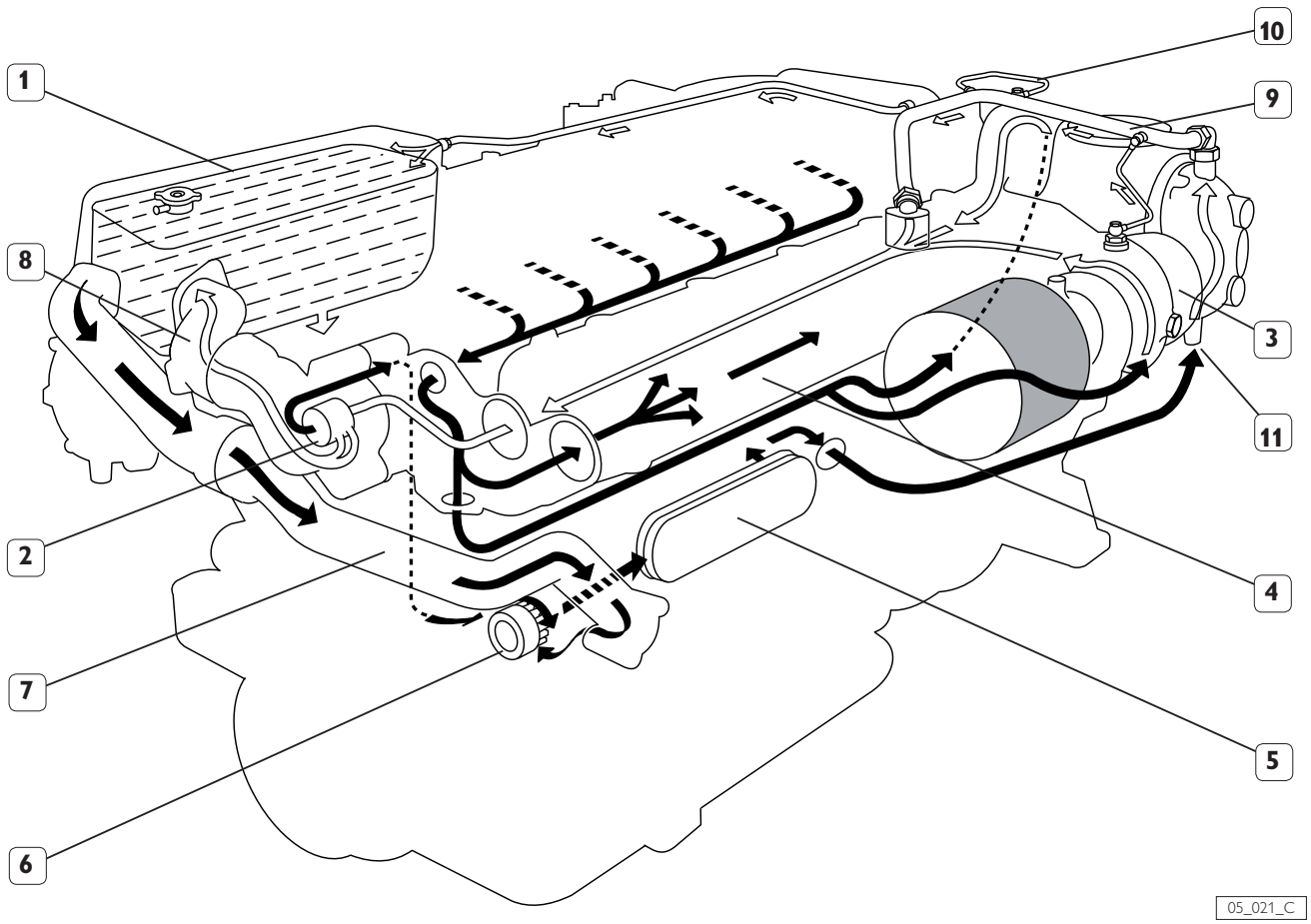


1. Pre-heating junction - 2. Power relay - 3. Electrical heating element - 4. Air/water heat exchanger.

Engine start is guaranteed down to -15 °C without the aid of any pre-heating system. If the engine needs to be used at lower temperatures, there are provisions (on request) for the installation of an electrical heating element driven by the injection system ECU.
When the ECU, through its sensors, recognizes the presence of a temperature below the prescribed threshold, it will energize the power relay that controls the electrical supply to the grid heater.
The heating element will be located at the inlet of the air/water heat exchanger (after-cooler) after replacing the overlying junction.

COOLING FRESH WATER CLOSED LOOP

Figure 12



High temperature liquid Low temperature liquid

1. Coolant (fresh water) heat exchanger - 2. Thermostatic valve - 3. Side turbocompressor - 4. Exhaust manifold - 5. Engine oil/coolant heat exchanger - 6. Coolant pump - 7. Coolant intake duct from heat exchanger - 8. Coolant delivery duct to heat exchanger - 9. Coolant recirculation from turbocompressors and exhaust manifold junction - 10. Coolant recirculation from rear turbocompressor - 11. Side turbocompressor coolant inlet.MARZO 2006

Description and operation

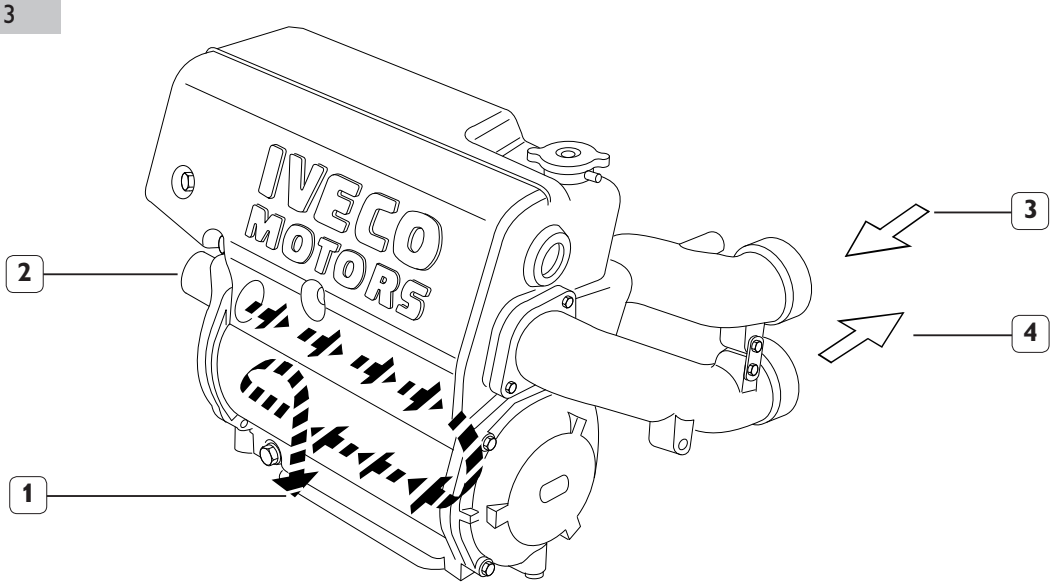
The centrifuge pump, rotated by the drive shaft with a poly-V belt, draws in the coolant coming from the fresh water/sea water heat exchanger or from the exhaust manifold cooling loop and sends it into the block, where it comes in contact with the lubricating oil heat exchanger. It then touches the heat exchange areas of the cylinders and subsequently those of the engine head, from which it exits flowing through the junction fitting that contains the temperature sensors for the instrument panel and the injection system. This junction has the purpose of bypassing the coolant from the engine head to the exhaust manifold and from the exhaust manifold to the thermostat - which routes it according to the temperature either to the water/water heat exchanger or to the recirculation pump.

From the bypass fitting the liquid is then injected into the heat exchange chamber of the exhaust manifold - through which it flows going to touch the body of the waste gate, of a portion the exhaust and of the turbo compressor. When it returns into the bypass junction it comes in contact with the wax actuator of the thermostatic valve. This will throttle flows according to temperature.

Part of the liquid will enter the tank and flow through the tube bundle heat exchanger, releasing heat to sea water, while the rest will go directly to the pump, to be recirculated.

Tube bundle water/water heat exchanger

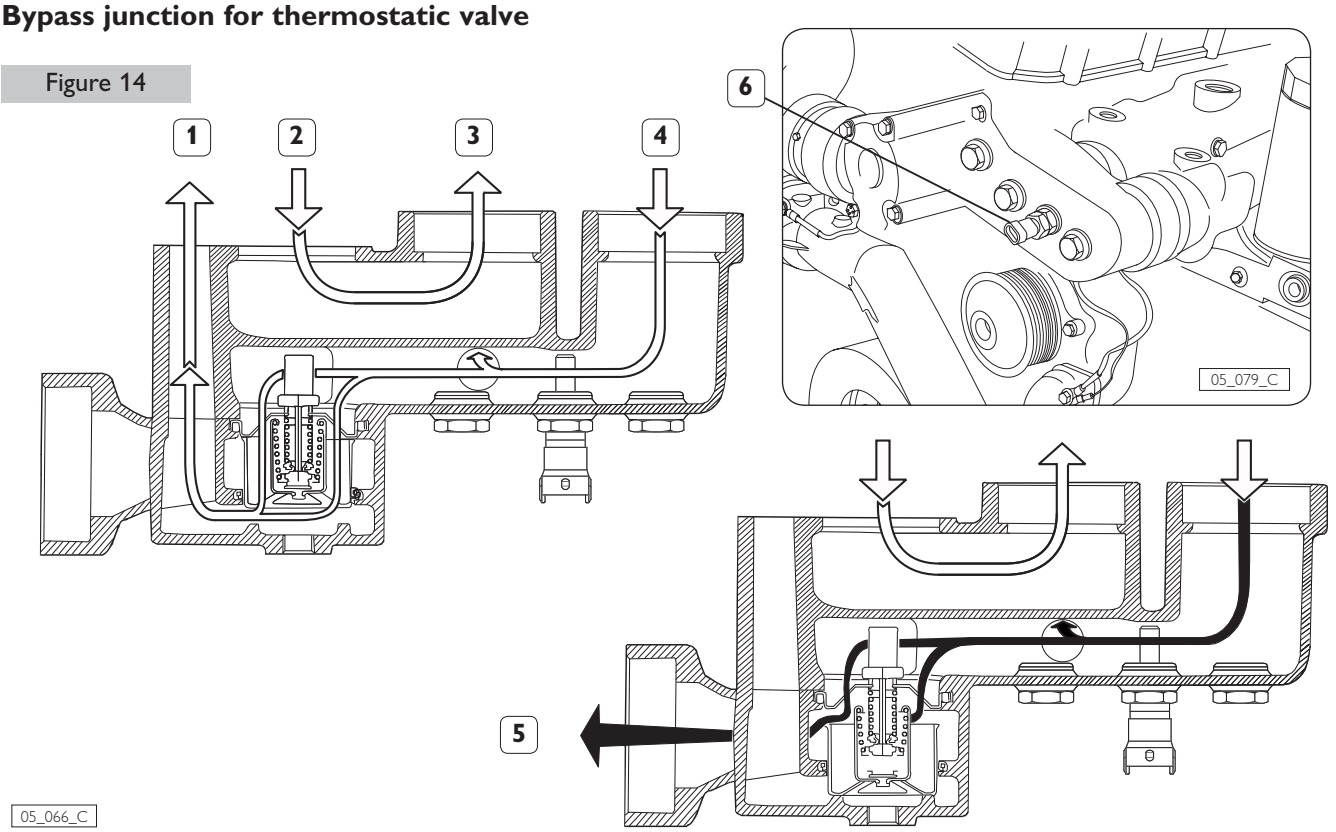
Figure 13



1. Sea water outlet to overboard discharge - 2. Sea water inlet from after cooler - 3. Coolant inlet from thermostatic valve - 4. Coolant outlet to pump.

Bypass junction for thermostatic valve

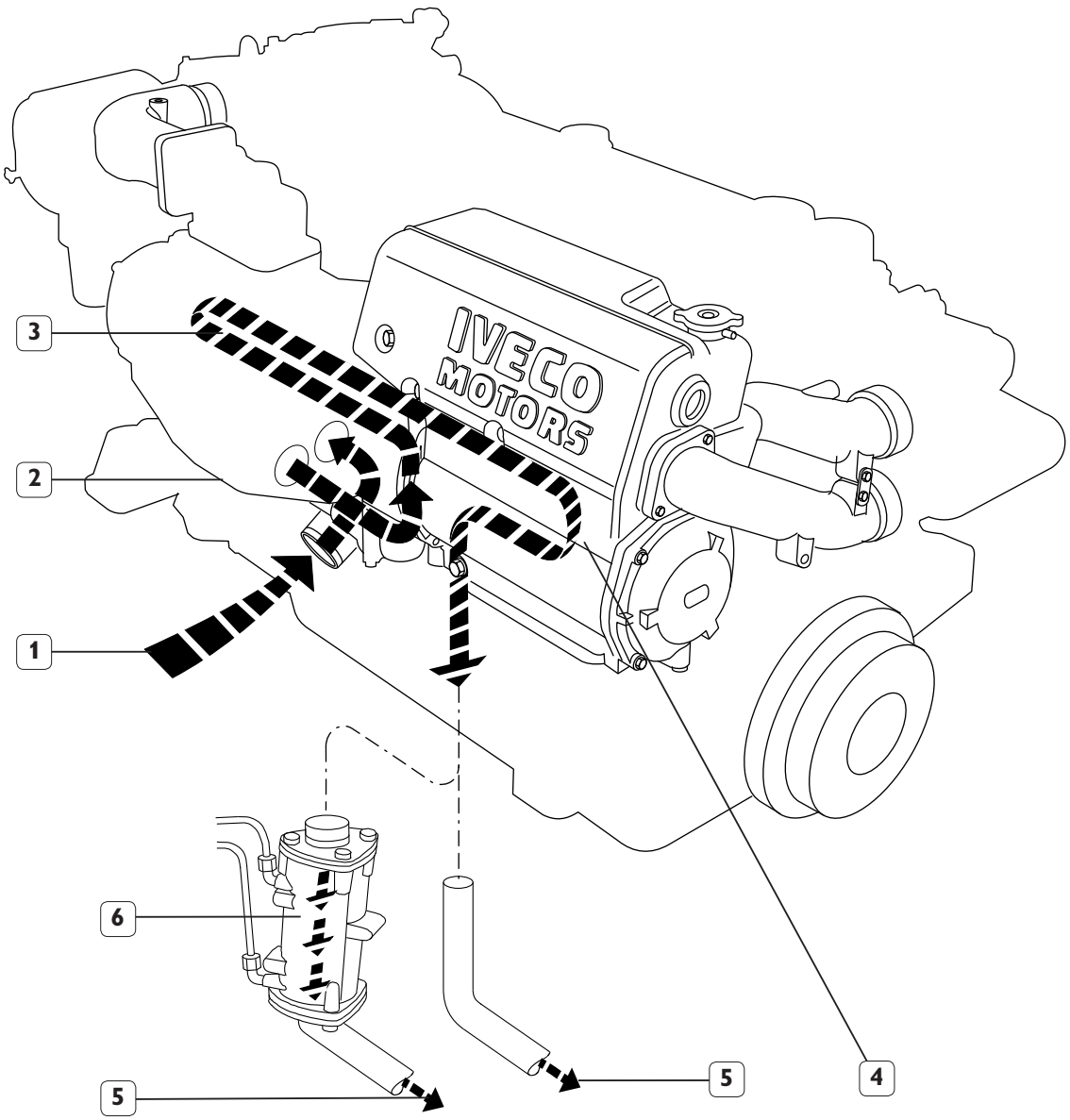
Figure 14



1. Bypass flow to engine - 2. Outflow from engine - 3. Outflow from exhaust manifold - 4. Inflow to exhaust manifold - 5. Flow to sea water heat exchanger - 6. temperature sensor.

SEA WATER OPEN COOLING LOOP

Figure 15



■■■■ Sea water

1. Sea water suction - 2. Sea water pump - 3. Supercharger air heat exchanger - 4. Coolant (fresh water) heat exchanger - 5. Sea water outlet from heat exchangers for overboard discharge - 6. Heat exchanger for gearbox oil (on request).

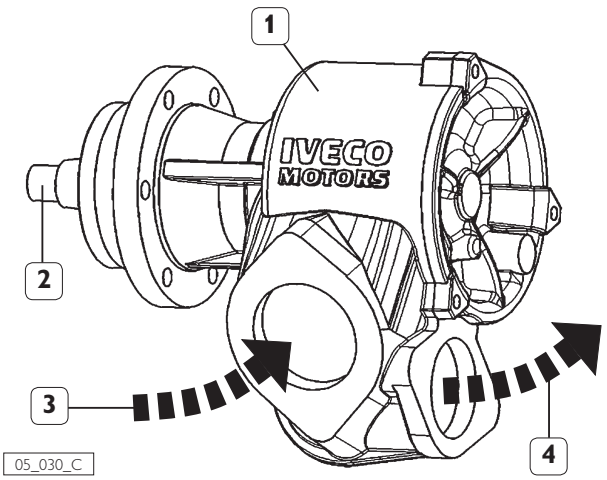
Description and operation

Sea water, drawn from under the keel and necessarily filtered, is drawn by the pump and sent to the supercharger air heat exchanger and from there to the water/water heat exchanger of the closed cooling loop; only after this will it flow through the heat exchanger for the gearbox oil, if one is provided.

The configuration of the discharge lines depends on the choice of a dry "chimney" exhaust, or a mixed one. The outlet pipe will carry the water directly to the overboard discharge or, if the water/exhaust gas mixer solution is adopted, a conduit will connect the outlet of the last heat exchanger with the mixer inflow junction pipe.

Sea water pump

Figure 16

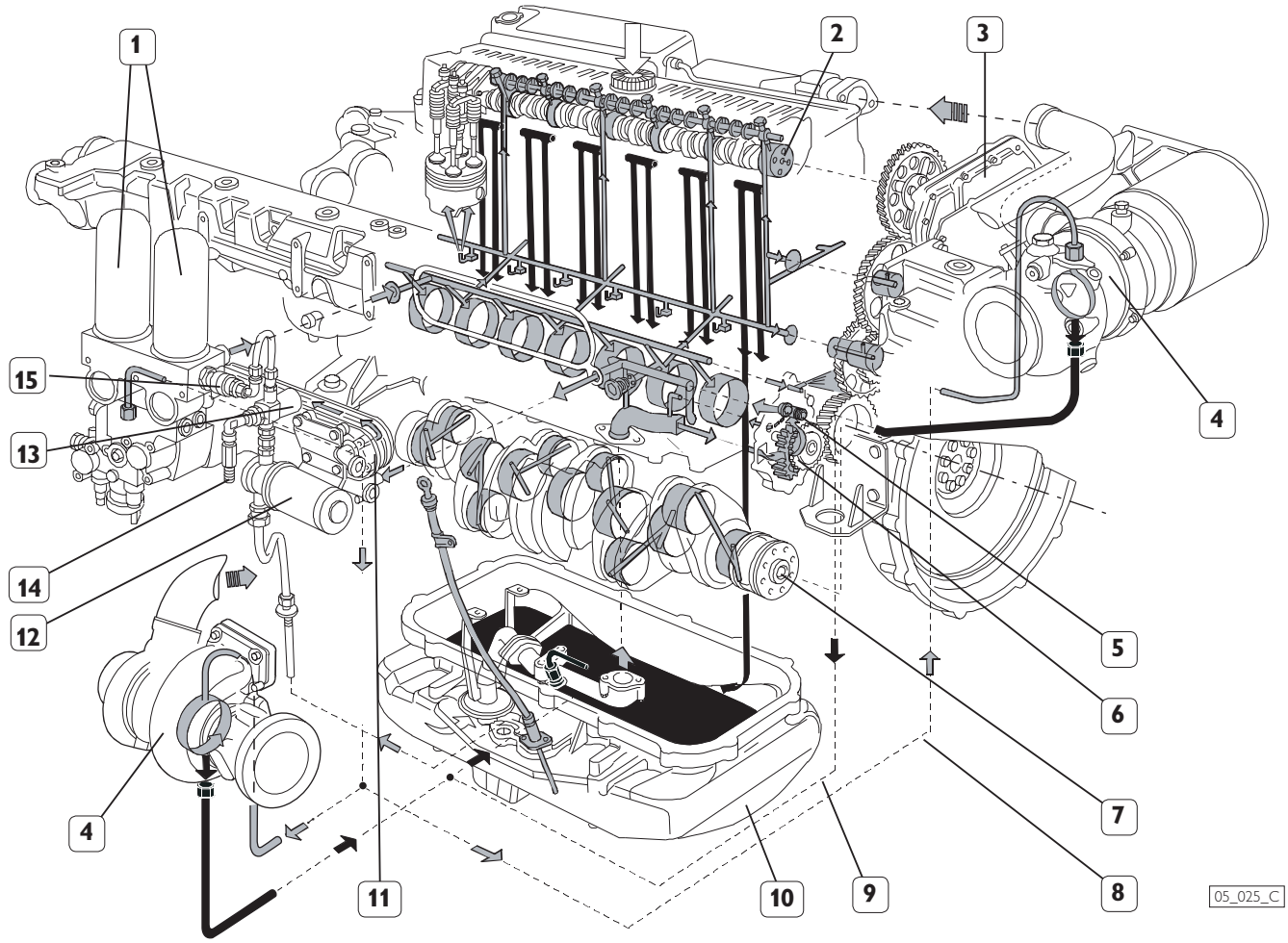


1. Pump impeller seat - 2. Driving gear shaft - 3. Sea water intake - 4. Sea water delivery.

The sea water pump, centrifugal type, is rotated by the gears keyed to the rear of the flywheel.

ENGINE OIL - LUBRICATION LOOP

Figure 17



Sump return oil

Delivery oil

1. Oil filters - 2. Camshaft on cylinder head - 3. Oil vapor condenser and filter (blow by) - 4. Turbocompressor - 5. Oil pump safety valve - 6. Lubrication oil pump - 7. Drive shaft - 8. Turbocompressor lubricating oil flow line - 9. Oil return flow from turbocompressor - 10. Oil sump - 11. Heat exchanger with coolant - 12. Electrical pump for pre-lubrication and oil filling/emptying (on request) - 13. Solenoid valve for switching between the pre-lubrication or oil filling/emptying functions (on request) - 14. Oil emptying junction - 15. One-way pre-lubrication valve.

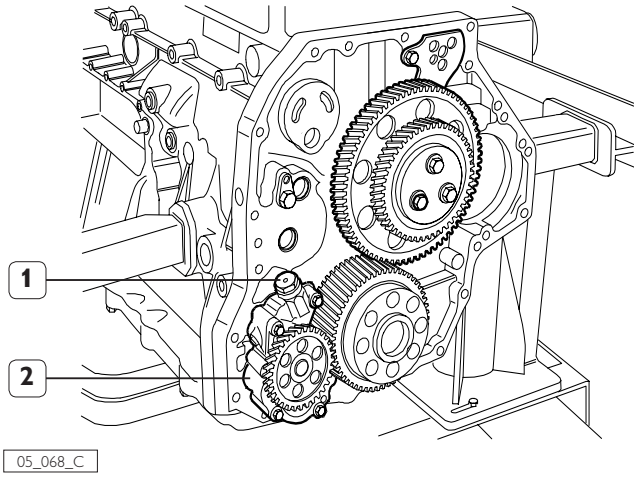
Description and operation

The gear pump, rotated by the gears at the rear of the flywheel sends the lubricating oil directly to the heat exchanger which, incorporated in the block and lapped by the coolant, reduces temperature to maintain optimal lubricating capability. The thermostatic valve that regulates oil flow is located at the inlet of the heat exchanger, opening the bypass pipe if temperature falls below calibration temperature.
From the output of the heat exchanger, the oil is sent to the filter assembly and from this back to the engine block to lubricate all anti-friction elements.

The blow-by vapor condenser, provided with filter and safety valve, is located on the upper part of the timing mechanism lid. The vapors, after returning to the liquid state, will flow from the vapor condensor into the sump. The engine is provided with the pre-lubrication system on request. This can inject enough oil into the engine's ducts to guarantee a totally safe start.
The operation of the electrical pre-lubrication pump (on request), is automatically controlled by the ECU electronic unit.
This system, with the aid of the flow-switching solenoid valve, also permits the oil sump to be emptied and filled.
Detailed descriptions of this operation are provided in Section 3.

Gear pump

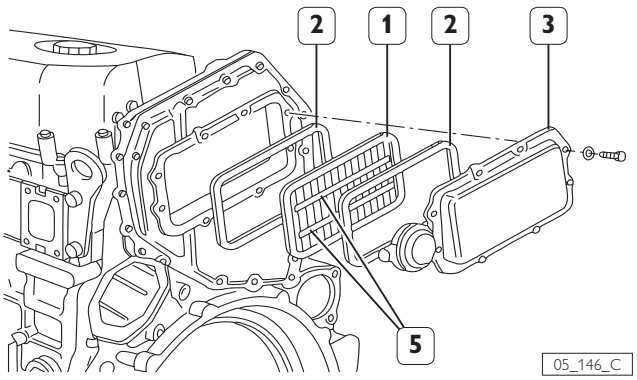
Figure 18



1.Safety valve - 2.Oil pump.

Oil vapor filter

Figure 19

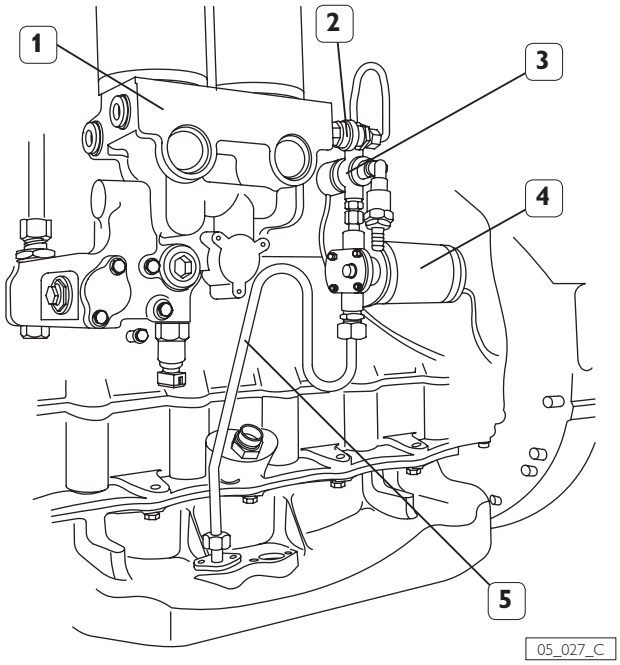


1.Oil vapour filter - 2. Gaskets- 3. Cover - 4. Exit of vapour from the motor extraction system - 5. Reinforcing bars.

The oil vapours go through the filter (1) where their liquid parts condense and flow back in the sump whilst the remaining gas exits from the connection (4) and are sucked by the motor positioned after the air filter.
The filter (1) only works in one direction. Consequently it must be assembled with the two reinforcing bars (4) on the visible side, as shown in the picture.

Pre-lubrication system (on request)

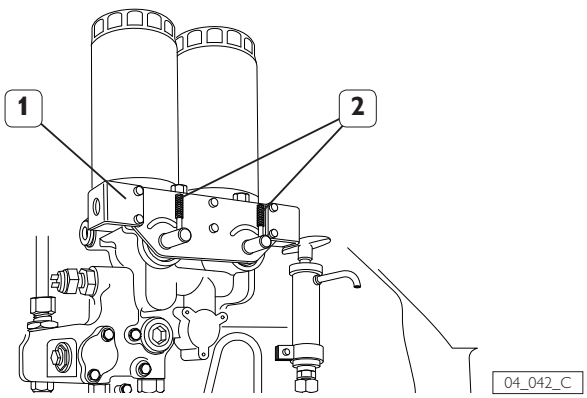
Figure 20



1. Oil filter support - 2. One-way valve to prevent emptying - 3. Switching solenoid valve - 4. Electrical pump - 5. Oil sump inflow and suction pipe.

Commutable filters (on request)

Figure 21

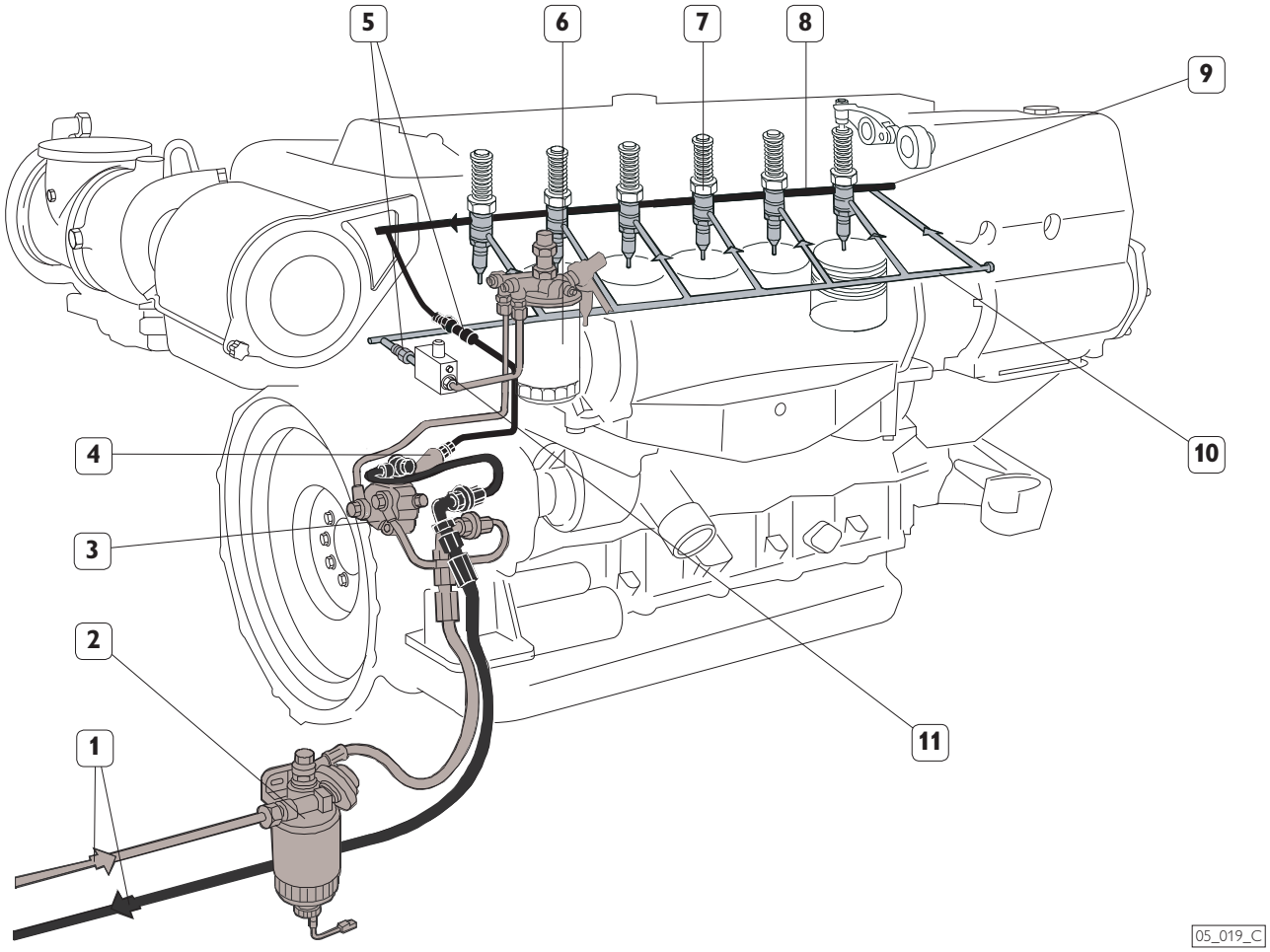


1. Commutable oil filters support- 2. Filters activation/ deactivation levers.

The supports are equipped with levers and, if necessary, they enable the replacement of a filter even if the motor is rotating. If necessary, operate very carefully to avoid risks of burning. Do not exclude both the filters together for any reason.

FUEL LINES

Figure 22



Delivery loop Return loop

1. Recirculation and suction flows from the tank - 2. Pre-filter - 3. Supply pump - 4. Pressure regulating valves - 5. Inlet outlet fittings from cylinder head - 6. Filter - 7. Pumping injector - 8. Recirculation collecting channel - 9. Cylinder head venting point - 10. Collecting channel for intake to injectors - 11. Pulses smoother.

Description and operation

Fuel is supplied at low pressure by means of a gear pump secured to the flywheel bell. When the engine runs, the pump (3) draws fuel from the tank through the pre-filter (2) and sends it through the main filter (6) to the inlet junction on the cylinder head; there, a first longitudinal conduit (10) takes the fuel, through a series of transverse conduits, to the "EUI" pumping injectors. The pulse smoother (11) reduces the violent pressure oscillations caused by the continuous opening and closing of the EUI compression chambers. A second longitudinal conduit, machined at the center of the head, conveys through the housings of the injectors the flow of the fuel that was not injected, to permit it to exit.

Along this section of circuit, the fuel undergoes washing to eliminate any traces of vapors formed as a result of fuel overheating during the pumping phases in the injectors.

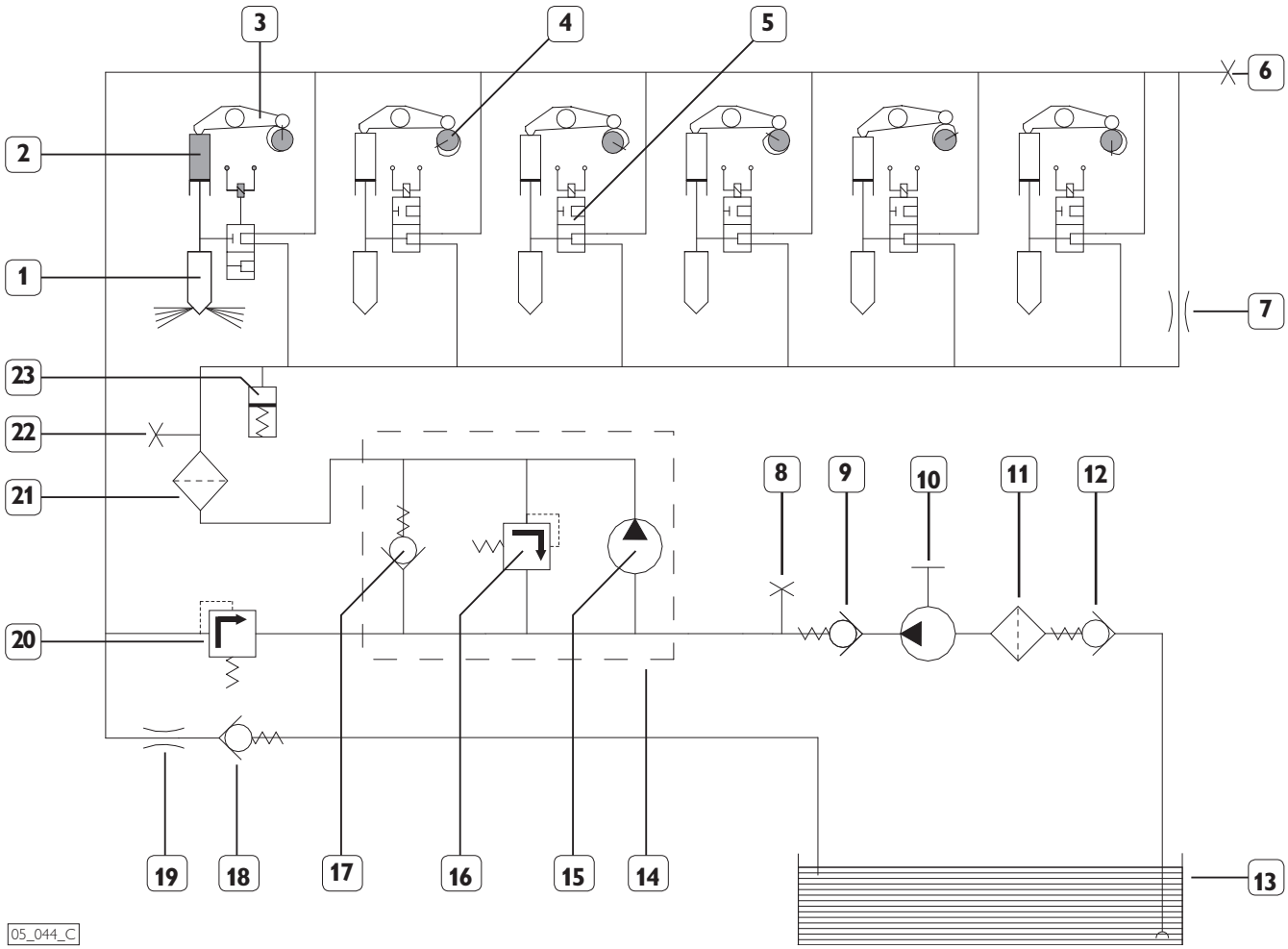
To limit the quantity of fuel to be recirculated to the tank, the fuel flowing out of the head is sent back to the pump and partially reused. The output fitting to the pump is fitted with a valve calibrated to a pressure of 3.5 bar, which allows to maintain, within the injector supply loop, the minimum pressure required to fill the injectors. The fuel not reused by the pump returns to the tank via a calibrated hole and a one-way valve to prevent emptying, calibrated to the pressure of 0.2 bar.

The pressure in the injector supply loop grows as engine RPM increases; it is therefore necessary to limit its maximum value to 5 bar, by means of a valve positioned in the body of the gear pump.

The fittings for venting the loop are located on the pre-filter support, on the filter support and in the front of the cylinder head near the electrical connector of the EUI injector circuit.

Hydraulic schematic diagram

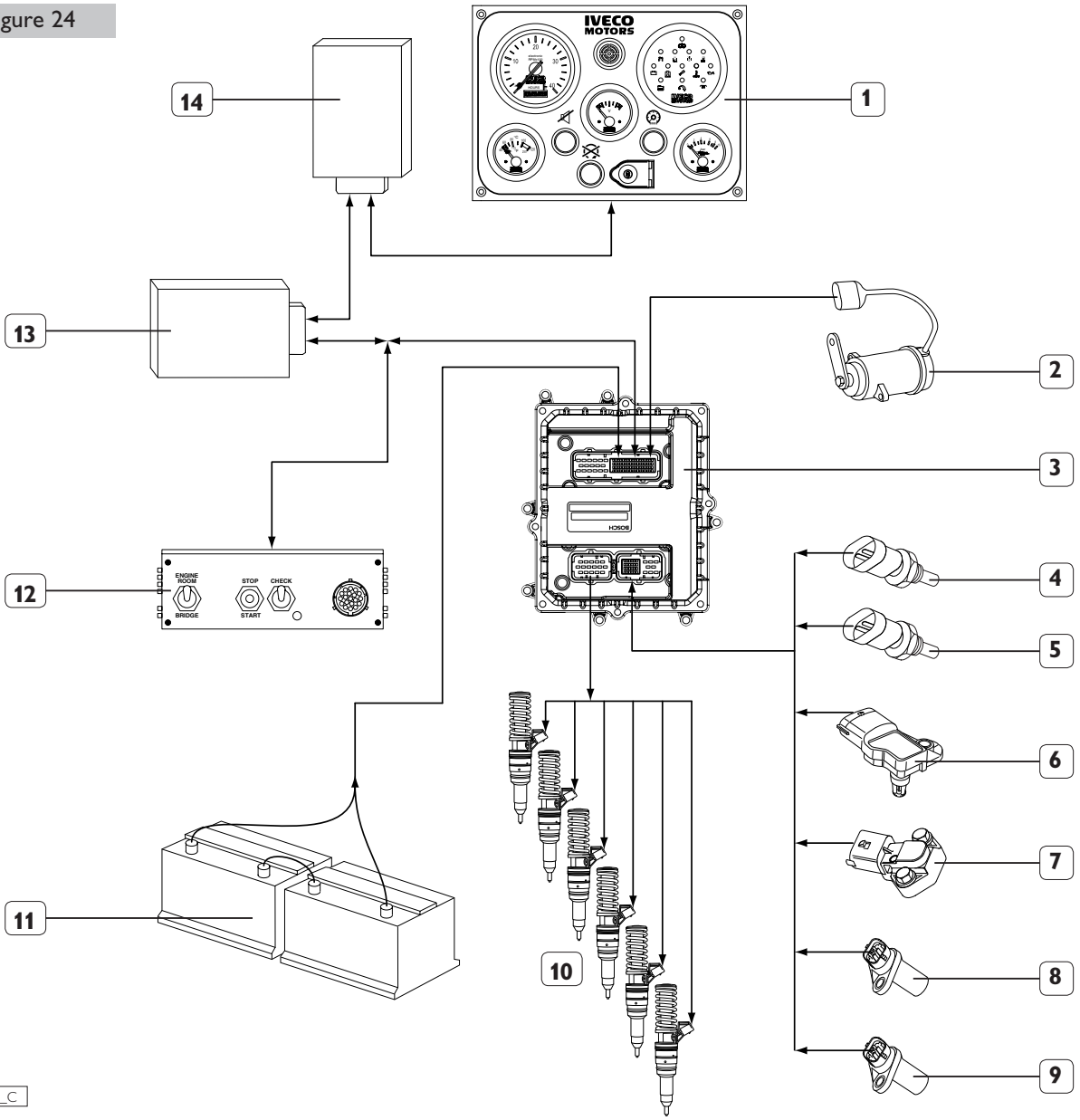
Figure 23



1. EUI injector - 2. EUI pumper - 3. Rocker arm - 4. Actuating cam - 5. EUI solenoid valve - 6. Vent fitting on cylinder head - 7. Calibrated hole - 8. Vent fitting on pre-filter - 9. One-way valve - 10. Hand pump - 11. Fuel pre-filter - 12. One-way valve - 13. Fuel filter - 14. Gear pump assembly - 15. Fuel supply gear pump - 16. Pressure limiter valve (initial opening pressure 5 bar) - 17. One-way valve - 18. One-way valve - 19. Calibrated hole - 20. Pressure regulating valve (initial opening pressure 3.5 bar) - 21. Fuel filter - 22. Vent fitting on fuel filter support - 23. Pulses smoother.

INJECTION SYSTEM - EDC (Electronic Diesel Control)

Figure 24



1. Central electronic unit ECU with atmospheric pressure sensor - 2. Fault indicator light - 3. Blink code request push-button - 4. Main relay - 5. Key control - 6. RPM Gauge - 7. Diagnostics connector - 8. Throttle position sensor - 9. Pumper injectors with electrical control, EUI - 10. Timing sensor - 11. Flywheel sensor - 12. Combustion air pressure/temperature sensor - 13. Fuel temperature sensor - 14. Engine coolant temperature sensor.

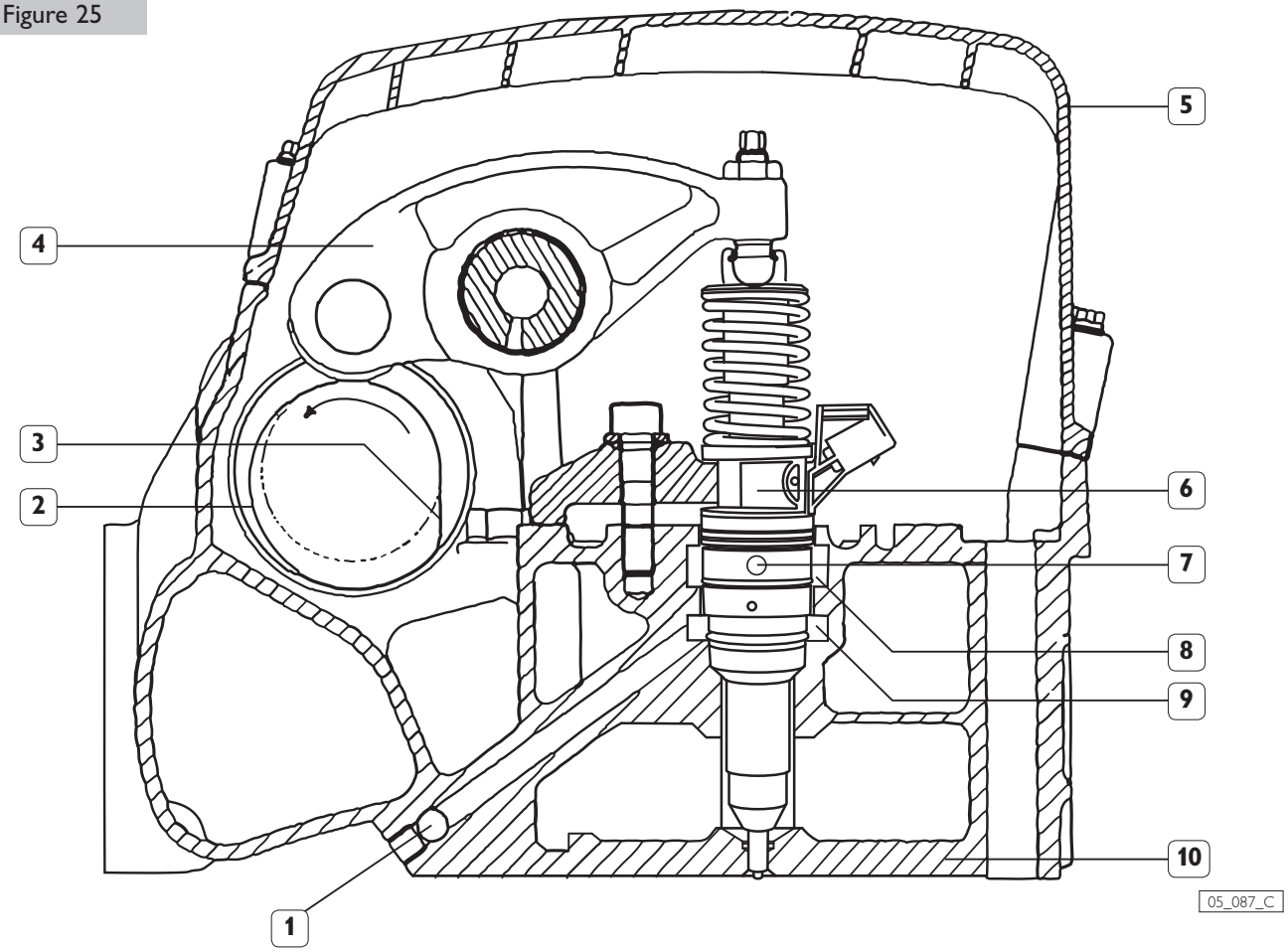
C13 ENT M77 engines are equipped with the modern EDC7 UC31 injection system which drives electrically controlled single pumper injectors, or EUI, Electric Unit Injector. This component gives a prompt fuel supply, extremely small pressure losses and quiet operation, even though injection pressures exceed 1800 bar.

Adoption of the overhead camshaft and roller rocker arms for the actuation of engine valves and injectors provides the whole engine with innovative features, making it compact and giving it a high performance to weight ratio.

An overall improvement in performance was achieved by the availability of considerably higher injection pressures than those achievable with traditional injection pumps, together with a completely electronic management of all injection functions and the extreme precision of the injectors.

The presence of individual pumping elements allows to control independently, "cylinder by cylinder", injection duration and advance - computed and optimized in each instant by the central unit according to the engine parameters measured by the sensors.

Figure 25



1. Fuel inflow channel (with view of the section of the longitudinal manifold) - 2. Actuation cam: injector filling profile - 3. Actuation cam: injection pumping profile - 4. Rocker arm - 5. Timing cover - 6. EUI, Electric Unit Injector - 7. Section of the recirculating fuel collector channel - 8. Exhaust chamber - 9. Supply chamber - 10. Cylinder head.

EUI electrically controlled pumping injector

The pumper injector element comprises an injector with its own pumping element actuated, like the engine valves, by the timing camshaft. Fuel metering is achieved by means of a solenoid valve which, by controlling the supply flow of the nozzle during the pumping phase, sets the timing for the beginning and end of the injection.

The technological solution of integrating pump and injector is not new in the engine field; as early as the Fifties, pump injectors were used, with mechanical metering control, on engines for marine, industrial and heavy vehicle applications.

Today, the compactness of this injection system and the benefits deriving from the absence of high pressure pipes - with a consequent elimination of flow resistance and actuation delays -, are enhanced by the presence of an electronic control capable of controlling with extreme precision duration and starting time, matching with unparalleled accuracy the injection to even the most critical operating conditions, as measured by the sensors fitted on the engine.

The pump injector elements are inserted in appropriate seats machined in the cylinder head and are supplied with low pressure fuel flowing through conduits in the casting. The underlying injector inflow channel is supplied with the fuel from the transfer pump, while the channel above, the recirculating fuel manifold, carries the injector washing and cooling fuel and the fuel not used for injection.

To translate the operation of the injector pumper, a roller rocker arm is used. This is driven by a third cam positioned between those for the intake and exhaust valves. The particular profile of the cam meets the requirement of producing a rapid pumping stroke, in order to rapidly obtain the required injection pressures, and a slow, constant pumper return stroke to avoid causing sudden pressure drops in the supply conduits, with the accompanying risk of vapor formation.

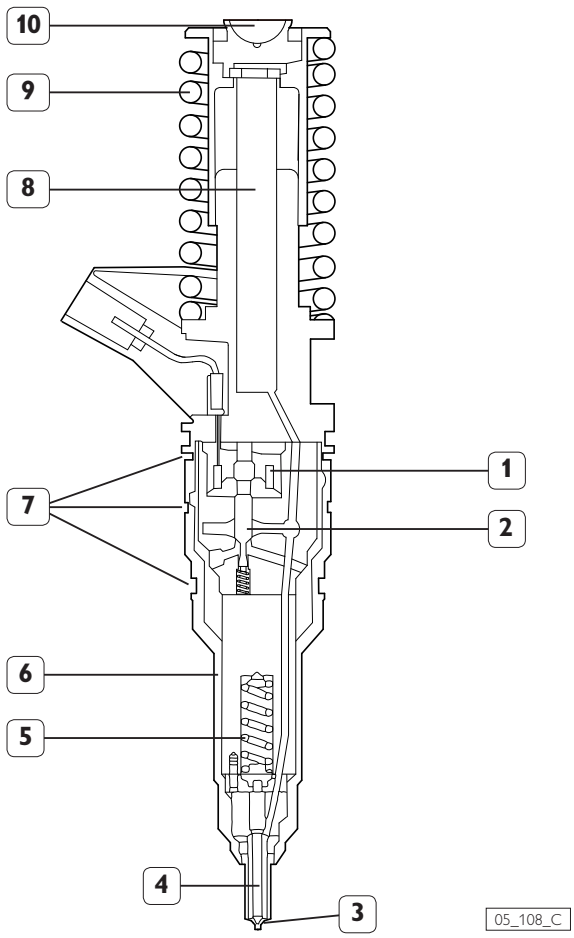
Operation

When the pumper, pushed by the rocker arm, starts the downward stroke, no pumping effect is produced until the moment the solenoid valve is energized, because the fuel is made to circulate at low pressure through the injector to the two inflow and recirculation conduits; only after the solenoid valve is energized is pressure boosted inside the injector. This, once the value for nozzle opening is reached, starts the injection.

When the electrical signal to the solenoid valve ceases, the pressurized fluid, being able to flow out through the channels within the injector, causes injection pressure to drop and thus the nozzle to shut, ending the injection.

The 5 bar limiter valve positioned in the transfer pump and the one-way outflow valve calibrated at 3.5 bar allow injector supply pressure to remain within this range at all times.

Figure 26



1. Solenoid valve - 2. Shutter - 3. Spray nozzle - 4. Nozzle needle - 5. Calibration spring - 6. Nozzle housing - 7. Sealing rings - 8. Pumper - 9. Pumper return spring - 10. Control tappet.

CAUTION

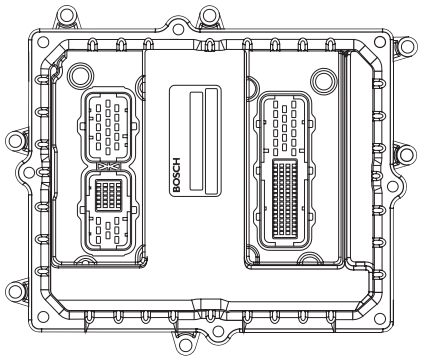
Injectors do not require calibration and because of the components' high level of precision and the complexity of their assembly, none of their components can be replaced.

If replacement does become necessary, contact the IVECO MOTORS-FPT Technical Assistance Service to receive appropriate operating instructions. Prescriptions for removal and re-assembly are provided in Section 6.

Electrical and electronic components

Electronic Central Unit

Figure 27



05_010_C

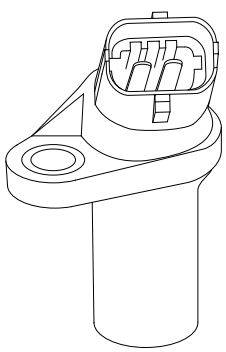
The ECU (Electronic Central Unit) is the component that controls the operation of the entire injection system. Processing starts when the main program is started along with the run-up procedure, which allows to send to RAM the data that had characterized the engine's operation until the previous shutdown and had been stored in the non volatile E^2PROM memory at the time of the after-run procedures.
The run-up is followed by the indicator light test and the procedures that lead to engine start; during these procedures, the presence and consistency of the sensors' electrical signals is also tested. The start of the routine for calculating injection time and advance is preceded by the analog to digital conversion of the data from the sensors.
When processing is completed, the final injection data, still in digital format, is transferred to the several final and power stages that will drive appropriately the solenoid valves of the injectors and the other actuators.

Atmospheric pressure sensor

Positioned within the ECU, this produces the data required to match the injection modes to the volumetric efficiency of the engine, as caused by variations in environmental pressure conditions.

Sensor on flywheel

Figure 28



05_086_C

Inductive with variable reluctance, it faces the outer circumference of the flywheel to detect the passage of three sectors, each one with 18 holes drilled radially on it.
It generates periodic alternating signals due to flux variations in the magnetic circuit produced within it by the presence of a permanent magnet.
The signal from this sensor is processed in the ECU to evaluate:

- Engine RPM;
- Angular position of the engine relative to the top dead center of the piston pairs;
- Angular acceleration of the drive shaft.

It generates the engine RPM information on the instrument panel.
An interruption of the signal from this sensor during engine operation is obviated by an ECU "recovery", by using the signal of the sensor on the timing pulley, which also prevents engine shutdown.

Sensor on the timing pulley

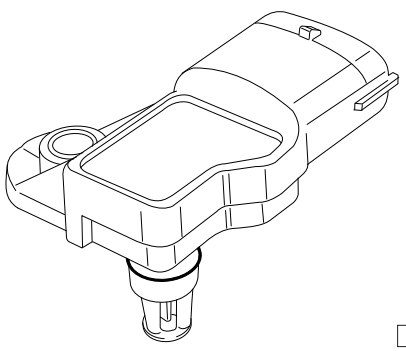
Inductive, like the previous sensor, this generates signals at the passage of 6 +1 projections of a phonic wheel, keyed onto the gearwheel driving the camshaft.
Six equidistant projections provide signals of the succession of the phases in the 6 cylinders; the seventh projection provides the synchronisation signals that allow detection of the typical injection sequence:

1 - 4 - 2 - 6 - 3 - 5.

An interruption of this signal during engine operation is obviated by having the injection sequence always stored in the ECU; if this should occur before the engine is started, a specific phase recognition strategy needs to be implemented.

Combustion air pressure and temperature sensor

Figure 29



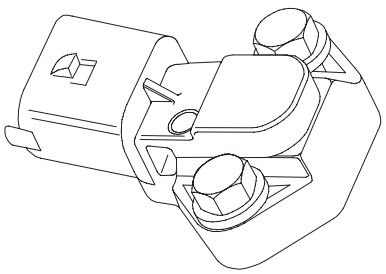
05_082_C

This is a part which integrates the temperature and pressure sensors for the air sent to the turbocharger sucking connection.
Positioned at the inlet of the intake manifold, it produces a signal proportional to the absolute pressure value of intake and supercharged air. This information, together with the temperature data, must allow the matching of injection time and advance to the combustion air density, to enable the

best possible thermodynamic efficiency and avoid noxious emissions and smoke.
The pressure sensor is solid state with an amplifier electronic circuit compensated for thermal drift.
Temperature is detected through a resistor with a negative temperature index.
The green pneumatic sealing ring.

Motor lubricating oil pressure and temperature sensor

Figure 30

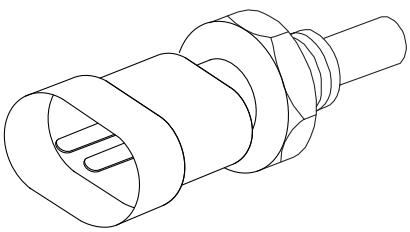


05_062_N

This component is similar to the previous one. The only difference is the level of protection of the sensitive elements. It is placed on the motor crankcase, near the support for the lubricating oil filters and produces a signal which is proportional to the value of the oil pressure in the motor inlet duct. This information, together with the information relating to the temperature, enables the ECU EDC to monitor the regularity of the lubricating system workings.
The data measured are made available on the CAN line to pilot the manometer instrument and the oil low pressure luminous indicator situated on the board panel.

Fuel temperature sensor

Figure 31



05_083_C

A neative temperature coefficient resistor, it is located on the filter support. This provides data to determine the density of the fuel that feeds the injectors, so as to match injection time to the actual quantity to be injected.
The de-rating strategies, adopted when the fuel's critical temperature is exceeded (as determined experimentally) are due to a considerable reduction in its lubricating action that is caused by its increase in temperature. These strategies can at times be observed in a limitation of the engine's top performance.

Coolant temperature sensor

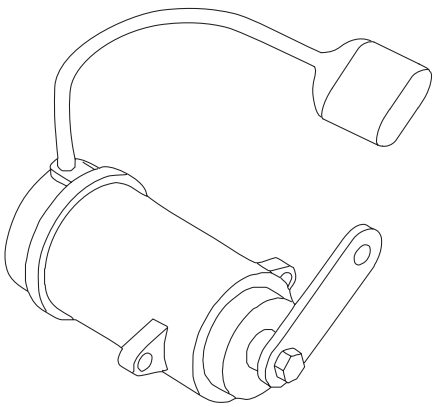
A negative temperature coefficient resistor like the previous sensor, located on the junction where the thermostatic valve is positioned.
It provides the information needed to control injection metering and advance in the different phases of the engine's operation:

- Cold start;
- Warm up;
- Warm;
- Over-temperature.

Recognition of an over-temperature condition leads to the adoption of de-rating strategies to reduce heat production and safeguard the efficiency of the engine as a whole.

Throttle lever position sensor

Figure 32



04_069_N

It provides one of the primary indications for computing the quantity of fuel to be injected.
Operated by the rods of the bridge controls or of the servo drive, it outputs a potentiometric change in the voltage that powers it, according to the throttle position.
A simultaneous safety indication is provided by the internal switch to confirm the position of the throttle: idle/outside idle.
This indication is used by the self-adapting strategies of the potentiometric signal and also in case of faults - to control "limp-home" strategies, which enable to return the vessel to harbor even with a failed potentiometer.

Actuators

These are electromechanical components which, powered with electrical signals, produce mechanical work. They can be categorized according to the modes in which they are electrically driven:

On/Off

Used to control components which react relatively slowly or that simply work at nominal voltage only.
Components of this kind, driven directly by the ECU are:

- EDC fault indicator light;
- Pre-heating indicator light;
- Relays.

Through the relays the ECU controls,

- The pre/post heating electrical element;
- Power stages within the ECU.

PWM

These provide an answer to the requirement of an analog adjustment of mechanical actuators.
The actuators are driven with nominal voltage impulses, but of variable duration, to provide control over the average value of the driving electrical current.
In this system, PWM control is used to drive the injector solenoid valves to obtain fast operation and a limit to the absorbed electrical current.

Electrical heating element (on request)

See figure 11

This replaces the traditional fuel heat starter and is an optional component, given the engine's capability of starting at the minimum temperature of -15 °C; it is interposed between the intake conduit connected to the turbocompressor and the after cooler heat exchanger, replacing the final junction fitting.
It consists of an electrical resistor powered at the system's nominal voltage by a relay controlled directly by the ECU.
Its characteristic positive temperature coefficient causes its electrical resistance to increase as temperature rises, thereby limiting current absorption and, as a consequence, also the maximum temperature achievable.

System functions

Computerized electronic control allows to perform in rapid succession both primary functions, such as calculating injection metering and advance, and secondary functions that are required only in particular conditions.
Activated three times per rotation by the drive shaft, metering and advance control are computed selectively cylinder by cylinder at each injection, while secondary functions such as managing an acceleration or operating intake air pre-heating are controlled only as required.
The electronic unit is also programmed to perform continuous checks of the presence and consistency of the signals coming from the system's sensors, in order to provide timely indications of the occurrence of any failures or to exclude a data item if its content is in contrast with the logical sequence of the events that took place until then.

Run up

Immediately after powering up the system (key to ON), the central control unit **before driving the starter motor** transfers into the main memory the data that characterized optimum engine operation during the previous operating period; they represent the progressive ageing of the engine and change with its usage.
With this function, engine management is continuously optimized from the initial operating phases, regardless of the engine's condition of use.
The data transferred during run up is that stored after the last engine shutdown during the "after run" function.

Starting

This engine function management phase is characterized by the adoption of strategies to obtain a rapid recognition of the engine's endothermic operation.
The most evident of the inhibited signals is recognition of throttle position, which thus does not need to be operated until start-up is complete.

Fuel metering and injection

This takes place by varying the duration of the electrical driving of the injector solenoid valves during the pumping phase; the main data, i.e. quantity of fuel to inject, is calculated based on the following information:

- Throttle position;
- Engine RPM.

The data is further corrected based on the following data:

- Combustion air pressure and temperature;
- Fuel temperature;
- Engine coolant temperature.

The duration of the driving may also be changed to linearize an acceleration gradient, the idle RPM, avoid overspeed conditions or control the onset of extreme engine operating conditions.
To obtain an exact delivery of the quantity calculated, the duration of the driving period of the solenoid valve is related to the value of battery voltage.
Only in case of failures entailing a risk of severe damage to the engine will injection actually be zeroed.

Injection advance control

This is obtained by varying, within the time interval of a revolution of the drive shaft, the instant when the injector's electrical driving starts. Implemented values may differ from one injection to the next, as may the differentiated metering of the cylinders.
The parameters that influence injection advance are:

- Position;
- Engine RPM;
- Combustion air pressure and temperature;
- Fuel temperature;
- Engine coolant temperature.

Values are determined experimentally for best performance in compliance with exhaust gas and sound emissions reduction targets.
Additional dynamic matching is provided during acceleration to give a greater pickup torque to the engine.
Information to check the actual implemented value is given by the impedance change of the injector valve solenoid. This allows corrections to be made until the value is exact: "closed loop" control.

Idle RPM adjustment

This function allows to obtain a constant, reproducible RPM although environmental operating conditions may change.
Adjustment is obtained by controlling metering and the instant when the injection is started, based on processed information received from the sensors.
if battery voltage dips below normal values, the ECU increases engine RPM to improve the charge obtained from the alternator.

Self-diagnosis

This is a constant check of the presence of electrical signals sent by the sensors or delivered to actuators. If anomalies are detected it enables the electronic unit to process data according to a "recovery" programme, to avoid engine shut-down.
The central unit, not only checks the efficiency of sensors, actuators and the wiring connected to these but also checks the consitency of the signals and the information deduced.
It is thus possible to recognise an inconsistency and not use an invalid datum - replacing it with a predefined one - by means of comparison with pre-programmed limit parameters or by assessing their increasing or decreasing gradient.
The "recovery" procedure is complemented by the storing of codes that identify the errors detected. These codes can be decoded by using computerized diagnostic appliances.
The functions stated below are actuated only under special engine operation conditions:

Air pre-heat control

(with optional components)

In the case that even only one among the temperature, water, oil or fuel oil sensors indicates a value below +10 °C, the ECU activates intake air pre-heating, powering up via relay the heating element positioned in the air line.
This pre-heating phase, whose duration is a function of the measured temperature, is indicated by the light of the optical indicator on the panel and ends when the latter starts to blink.
Once start-up is complete, the subsequent post-heating phase, whose duration is a function of temperature, prevents exhaust smoke.

EDC and pre-heating optical indicators

Positioned on the instrument panel, they are driven directly by the central unit of the EDC system.
Normally off, they will light for an instant immediately after powering on the system, to test their operating condition. If the EDC indicator lights up, this signals a possible fault in the injection system or irregular operation of the engine or its components.

Linearization of the acceleration gradient

Noxious exhaust and sound emissions are contained via the implementation of strategies that operate above all on the control of the injection required for accelerations.
During transients, fuel metering and injection advance are controlled with progression modes obtained experimentally and stored in the central unit.

Balancing cylinder torque delivery

This function contributes to reduce engine vibrations and balance its operation.
It is achieved through "cylinder by cylinder" control of injection flow rate and advance; this allows alignment of the angular acceleration of the drive shaft produced by each combustion.
Cylinder balancing, because of its complex software structure, can be performed only during idling, but the data obtained are used, after an appropriate adaptation, at higher RPM values as well.

Rotation speed control

This is the electronic equivalent of speed regulators in traditional injection pumps.
Like these, it regulates:

- Idling and maximum RPM;
- All RPM settings.

Maximum RPM limitation

This feature safeguards the operating condition of the engine, preventing even accidental over-speed conditions.
Limitation strategies are implemented in the following ways:

- Upon exceeding a first safety threshold, fuel flow rate is progressively reduced;
- When maximum RPM is reached, fuel flow is set to zero.

Cut off

This function consists in not injecting fuel during engine deceleration phases.
This is active until a minimum RPM value is reached - below this the thermal operation of the engine could not be restored.

Engine protection function

This can be considered as a recovery program. It does not store fault information and does not entail indications of faults on the panel; it is carried out when the maximum temperature thresholds for fuel, coolant and combustion air have been exceeded.
De-rating is implemented as a reduction in the torque delivered by the engine, to prevent the risk of damage.
In proportion with the nature of the risk, the function is activated when temperatures in excess of 80 °C for combustive air, 102 °C for coolant and 120 °C for engine oil are recognised.

(See Section 4)

Recovery

This is a particular control and management mode, characterized by the adoption of one of many strategies that allow the system to operate even if the self-diagnosis system has recognized the presence of faults.
In nearly all cases, the ability to continue navigation is assured, either with regular or reduced performance levels.
Adoption of a recovery strategy entails storing in memory the fault code and the corresponding limitation of maximum power delivered by the engine. Power limitation due to a recovery strategy is maintained active until the engine is shut down even if the detected anomaly is no longer present.
The indicator light on the instrument panel will light up in the more severe cases.

After run

This takes place after each engine shutdown, and is characterized by a delayed de-energizing of the main relay powering the ECU. During this phase the central unit remains powered for some seconds, during which the data that characterizes the current optimized management of the engine are moved from the main volatile memory to the non volatile EEPROM memory, so that they are available the next time the engine is started.
The data can be summarized as:

- Control modes (idling RPM, torque delivery balancing, smoke limit…);
- The settings of minimum/maximum signal recognition thresholds;
- Fault memory.

The importance of having available at each start the data that optimize engine management and behavior in terms of TORQUE AND POWER YIELD, is such as to prohibit the use of battery detaching devices or engine shut down procedures that differ from those prescribed by the manufacturer (key to OFF) or which may prevent the correct development of the after run function.

Reference signals

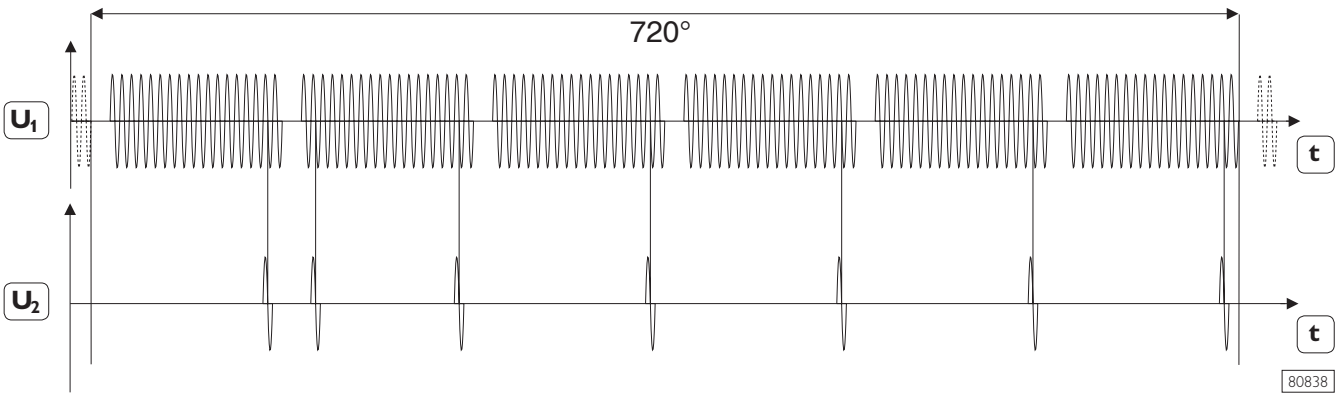
Recognition of the engine's operating phases by the ECU is achieved by analyzing the sequences of electrical pulses generated by the sensors located on the flywheel case and on the timing; the set of these two sequences is called "reference signal set".
The frequency of the signal generated by the flywheel sensor provides engine RPM indication, while each pulse subsequent to recognition of the zeroing defines a precise angular position of the flywheel and consequently the precise position of each pair of pistons in the engine cycle.

The sequence of the cam signal is asymmetrical because of the presence of a tooth that is not equidistant from the others. This allows recognition of the injection sequence: 1-4-2-6-3-5.
The compared analysis of the flywheel and timing signals allows the ECU's software to recognize the different phase of each piston in the pair and its exact position in the thermodynamic cycle, enabling selective management of injection functions in "cylinder by cylinder" mode.
A precise performance of engine management functions (based on the above), depends to a great extent on the precision with which the signals of the two sensors represent what is actually taking place in the engine and consequently on the correct mechanical positioning of these sensors in relation to their references on the engine.

CAUTION

It is imperative to recall that the efficiency of an engine's operation does not depend merely on the factors set out above, but also on all those factors that have long been known to engine professionals who are fully capable of evaluating them correctly.

Figure 33



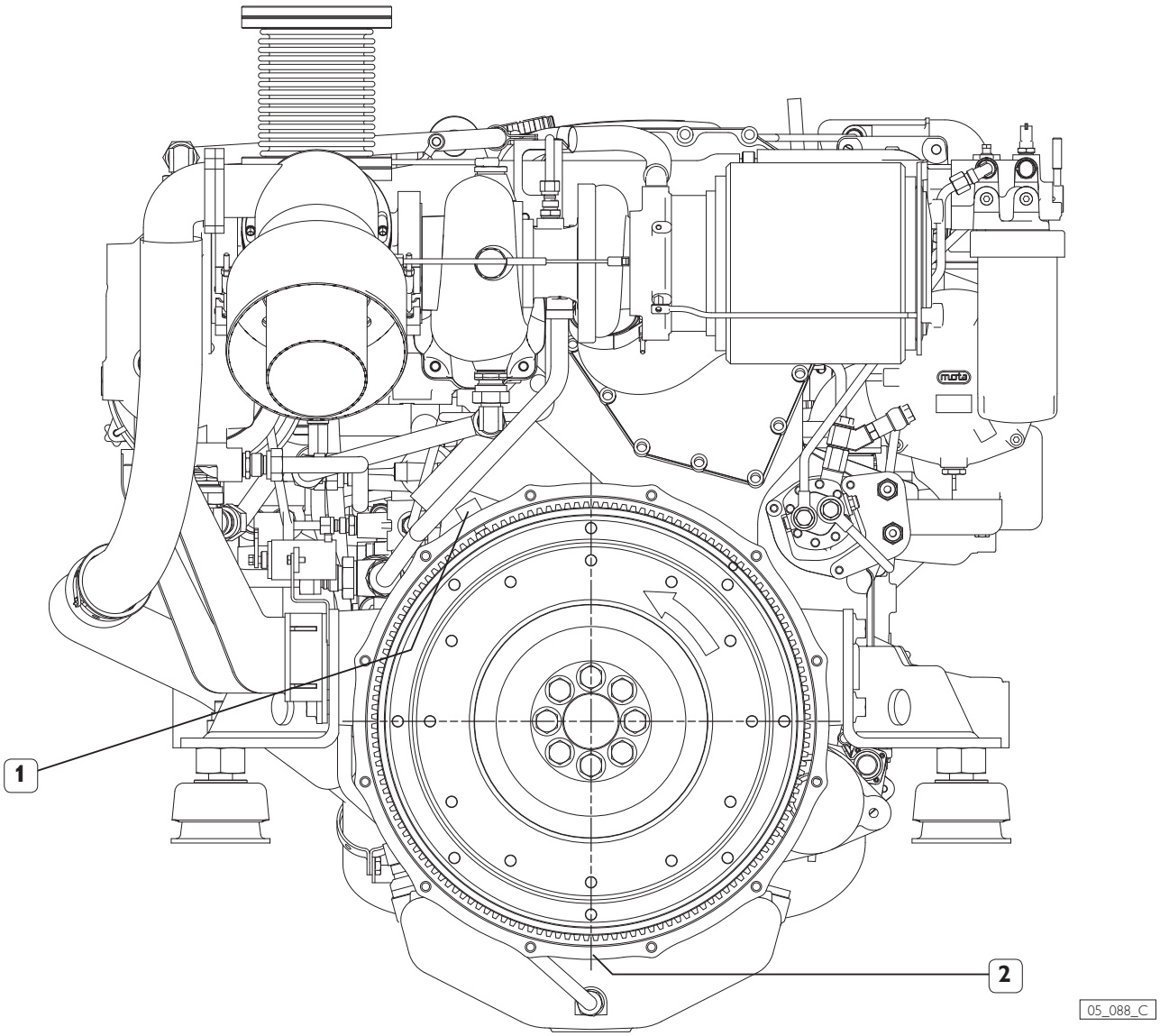
U_1. Profile of the voltage of the FLYWHEEL sensor signal

U_2. Profile of the voltage of the timing CAM sensor signal

Flywheel signal

This is produced by a variable reluctance sensor (pick up) secured to the flywheel case in such a position as to detect the passage of the series of holes drilled radially on the circumference of the flywheel.

Figure 34



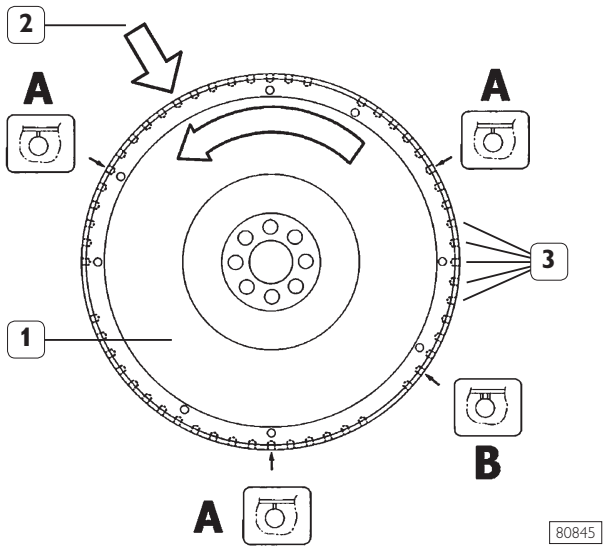
1. Flywheel sensor - 2. Location of the inspection hole

Three series of 18 holes, 6° apart from each other, alternate with an absence of 2 holes every 120° - to enable the sensor to generate pulses for zeroing the count.
Each 18 hole sector represents the engine revolution angle involved in the compression and combustion phases of the different pairs of cylinders and hence of interest for injection purposes.

The signal will be correctly in phase when the sensor is exactly in front of a particular hole of the sector at the time in which the associated pair of pistons reaches the exact top dead center position, otherwise the actual instant when injection starts will be different from the one prescribed by the tune-up and programmed in the ECU, and without the possibility of recognition via the PT 01 diagnostics analysis. The tune-up and phasing operations are described in Section 6.

To make it easier for service personnel to recognize the top dead center position of the three piston pairs, one-notch punches were provided next to the reference hole, whilst a two-notch punch allows to recognize the sector associated with the pair 1 - 6, so as to generate the correct relationship between the two sequences of the flywheel and cam signals.

Figure 35



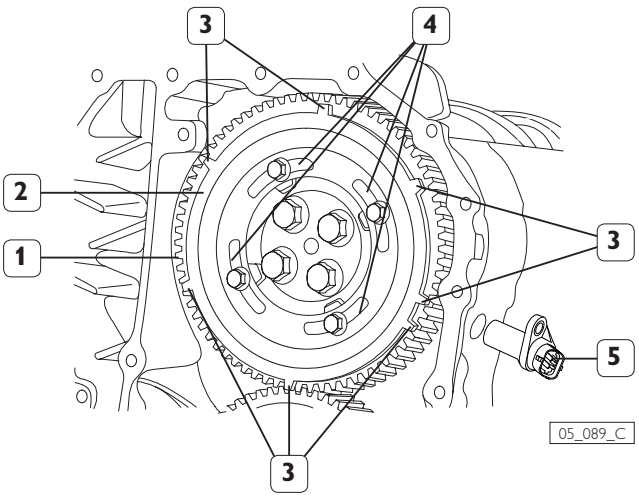
1. Engine flywheel - 2. Position of the flywheel sensor - 3. Radial holes
A. One-notch punch for identifying TDC -
B. Two-notch punch to correlate the phase of the flywheel and cam signals.

This figure shows the position and characteristics of these references, visible through the inspection hole drilled in the lower part of the flywheel case. If for a particular installation this hole should not be accessible, a specific tune-up procedure will have to be followed, as described in the "diagnostics" section 6.

Absence of the flywheel signal due to failure is obviated with a recovery strategy that uses the sequence of the cam signal to recognize engine RPM and the thermodynamic phases of the cylinders.
A simultaneous absence of both sensors' signals will not permit the engine to operate.

Camshaft or timing signal

Figure 36



1. Gear wheel to drive the camshaft. - 2. Phonic wheel - 3. Teeth detected by the sensor - 4. Slotted tuning holes - 5. Camshaft sensor.

This is obtained via a sensor similar to the one located on the flywheel case, but positioned so as to detect the passage of 6 + 1 teeth of a phonic wheel keyed onto the gearwheel driving the camshaft; the presence of a tooth that is not equidistant from the others gives rise to a sequence with a non-constant period that can be used to recognize the exact injector driving sequence.

The method of fastening to the gearwheel, achieved with slotted holes, allows to match the electrical information to the different cam arrangement solutions, and requires accurate phasing, otherwise this can give rise to irregular operation and even cause the engine to fail to start; remember that this signal is the reference for the entire engine control and if it is absent the "recovery" information will be the flywheel signal. In case of absence of the cam signal alone, if it occurs while the engine is running, the injection sequence validated until that time will be used; if it is due to a failure preceding start-up, it will be obviated by a software strategy which by means of successive attempts will enable to start the engine and then adopt the stored sequence: 1-4-2-6-3-5.

The simultaneous absence of both signals will prevent engine operation.

SECTION 2

TECHNICAL DATA

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SPECIFICATIONS

Cycle Charge Injection		4-Stroke Diesel Supercharged and intercooled Direct
Number of cylinders		6 in line
Bore	mm	135
Stroke	mm	150
Total displacement	cm^3	12280
Compression ratio		15.5 ± 0.8 to 1
Direction of rotation, flywheel side		counterclockwise
Minimum idling rpm	rpm	525 ± 25
Maximum engine rpm, no load	rpm	2525 ± 25
Allowed engine inclination angles		
Maximum longitudinal in continuous operation (static + dynamic)	degrees/360	+ 20°
Maximum transverse in continuous operation(static + dynamic)	degrees/360	± 22° 30'
Longitudinal for oil level check with standard dipstick	degrees/360	0 to +10°
Supercharge		
Turbocompressor with water-cooled body	nr. 2 HOLSET	HX 40 M
Maximum pressure	bar	2.2
Lubrication		
Oil	type	FE 5 W 40
Oil compliant with specifications		-
Total oil capacity on first filling	liters (kg)	43 (39.1)
Total oil capacity with sump at minimum level	liters (kg)	29 (26.3)
Total oil capacity with sump at top level	liters (kg)	36 (32.7)
Oil pressure, warm engine, minimum idling rpm	bar	≥ 2
Oil pressure, warm engine, maximum rpm	bar	≥ 5
Maximum allowed temperature	°C	105
Oil dipstick valid for static inclination	degrees/360	0 to +10°
Fuel supply		
Fuel oil compliant with standard		EN 590
Low pressure transfer pump		gear pump
Flow rate at maximum rpm	kg/h	88
Fuel return flow rate to tank	kg/h	≤ 12
Filtering: pre filter	µm	36.5
Filtering: filter	µm	5

Injection system

Type		pump - injectors (EUI)
System		Bosch EDC MS 6.2
Maximum injection pressure	bar	1800

Low temperature starting

Allowed, without external aids, down to	°C	-15
With electrical heating of intake air (optional), down to	°C	-25
With additional external heater, down to	°C	-30

Cooling

Closed coolant loop with sea water heat exchanger		50% mixture of water/Paraflu II or equiv. Compliant with SAE J 1034 specification
Total coolant quantity	liters	45
Engine-only capacity	liters	19.5
Expansion tank		standard
Forced circulation		centrifugal pump
Flow rate at maximum rpm	l/h	42300
Temperature regulation Initial opening Sea water line	 °C °C	with thermostatic valve 68 ± 2 78 ± 2
Sea water line		forced circulation
Sea water pump		centrifugal self-priming
Max. pump capacity	l/h	32000

Exhaust gas expulsion

Optional		stack
Optional		riser

Electrical system

Nominal voltage	Vcc	24
Self-regulated alternator: Voltage Maximum current intensity	 Vcc A	 29 90
Electrical starter motor: Nominal voltage Absorbed electrical power	 V W	 24 5500
Recommended batteries capacity	Ah	≥ 180
Current discharge at - 18 °C (SAE J 537)	A	≥ 1200

Drive train coupling

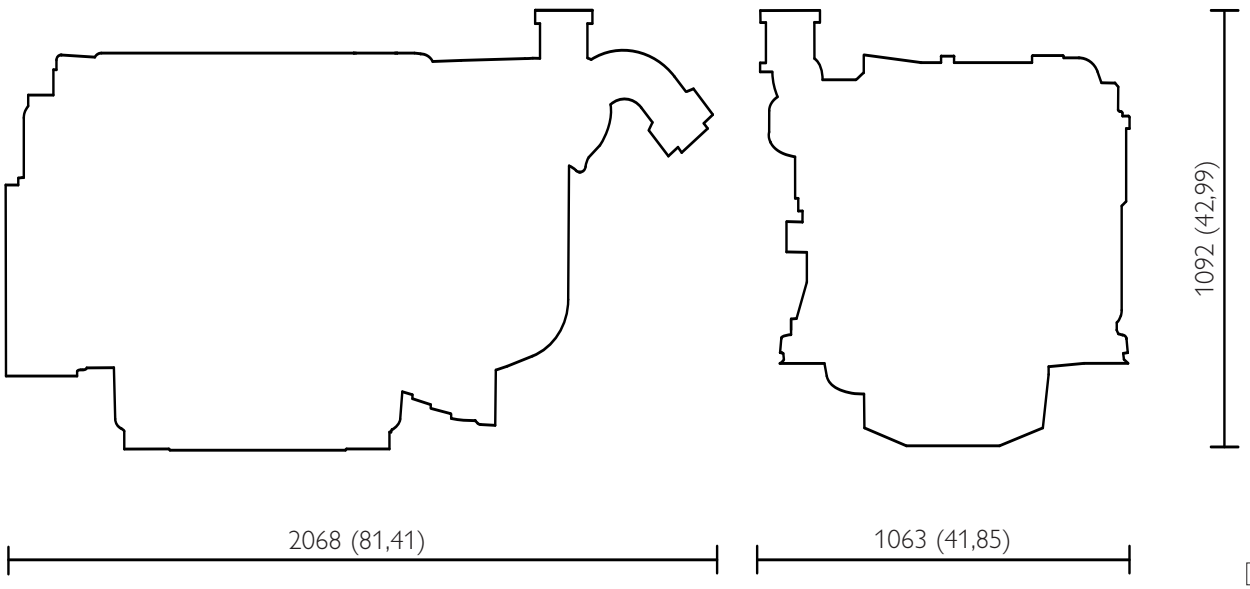
Flywheel diameter	mm (inches)	355 (14)
Flywheel case	type	SAE 1

Weights

Without liquids and without gearbox	kg	1380

Dimensions

Figure 1



Sizes in mm (inches)

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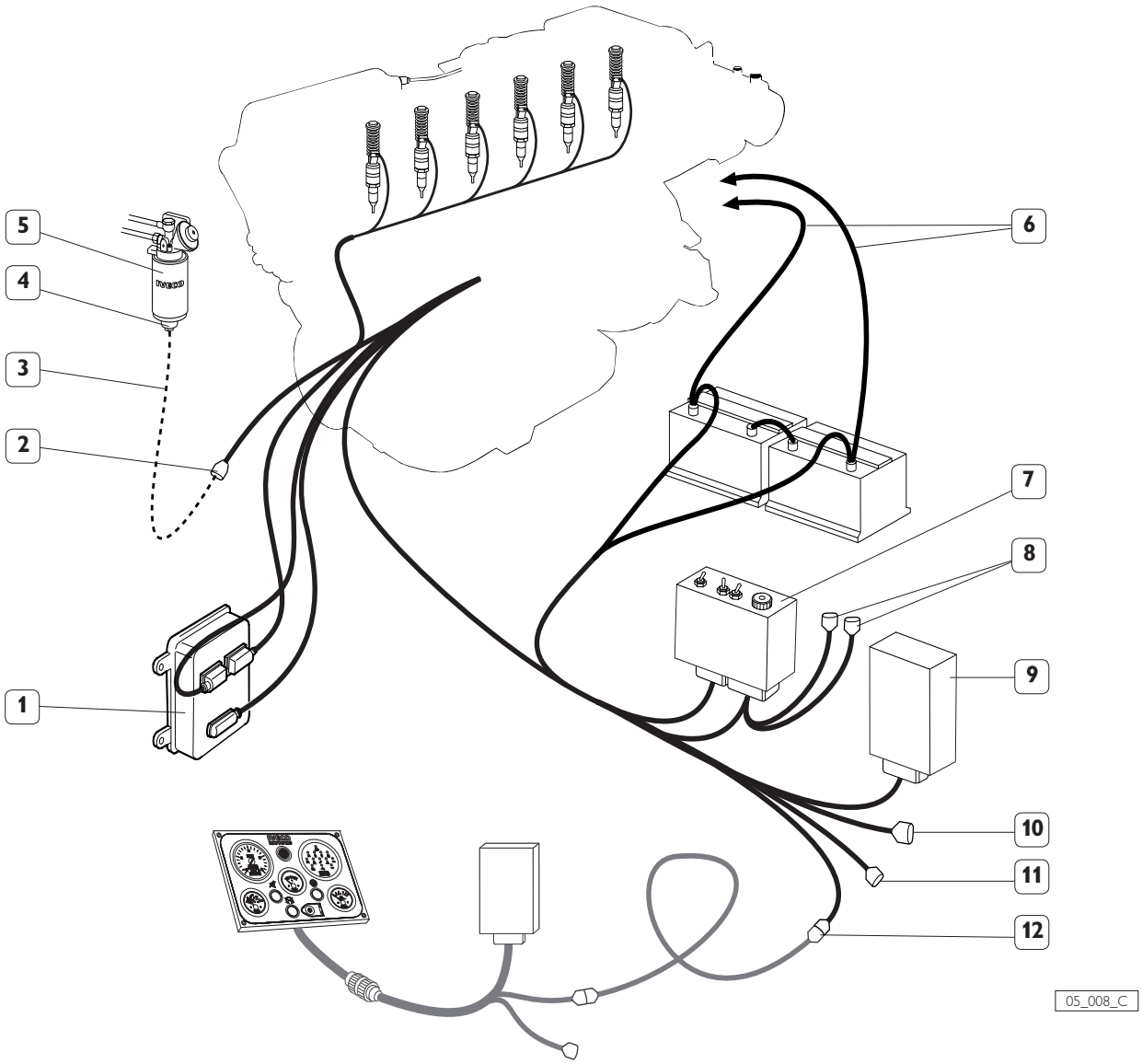
SECTION 3

ELECTRICAL EQUIPMENT

(cont.)

OVERVIEW

Figure 1



1. Electronic Central Unit - 2. M Connector - 3. Wiring harness to be manufactured by the yard - 4. M Sensor for the presence of water in the fuel - 5. Sedimenting pre-filter - 6. Power line for electric starter motor and alternator - 7. Relay box - 8. JECCM and JECCF connectors - 9. Analog to digital converter module -10. JG Connector - 11. JSV Connector - 12. JQA connector set for connection to the main analog instrument panel.

The electric equipment of the system carries out the main connections by means of the wiring provided with the engine, to which are connected the power supply, the electronic components assembled on the engine, the electronic central unit of the injection system, A/D converter module, relay box and the instrument panel.
The overall implementation is suitable for the requirements of an adequate installation and complying with electromagnetic compatibility limits legislation on electric installations (EMC). The wiring cannot be modified in any way and any possibility of bypassing the wiring lines to use different components is completely excluded.

The wiring harness for power supply has to be manufactured by the yard following the indications contained in the "C13 ENT M77 Installation Directive" document.

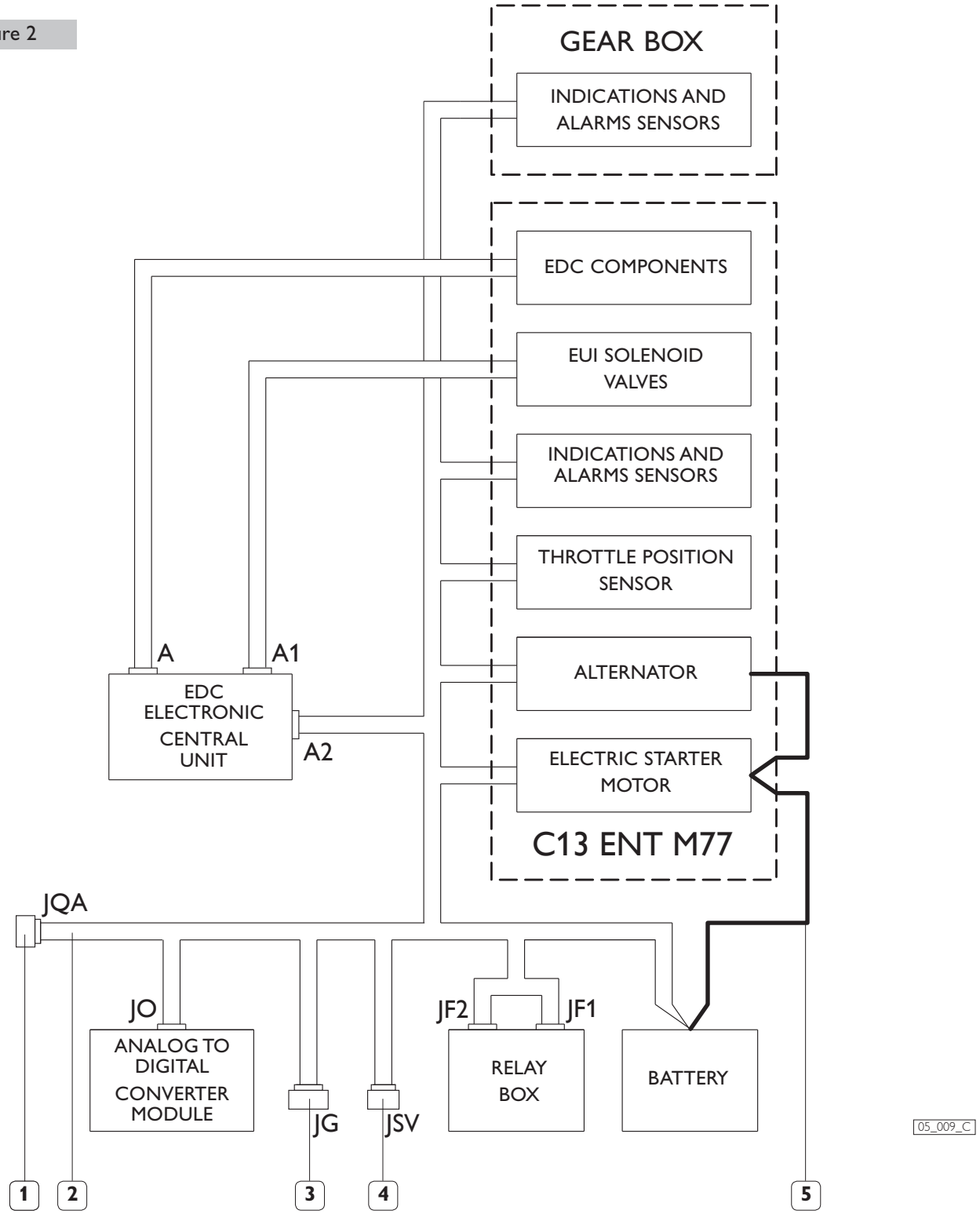
CAUTION

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

Information related to analogue and digital control panel and relative sensors is included in the "C13 ENT M77 Installation Directive" document.

SYNOPSIS

Figure 2

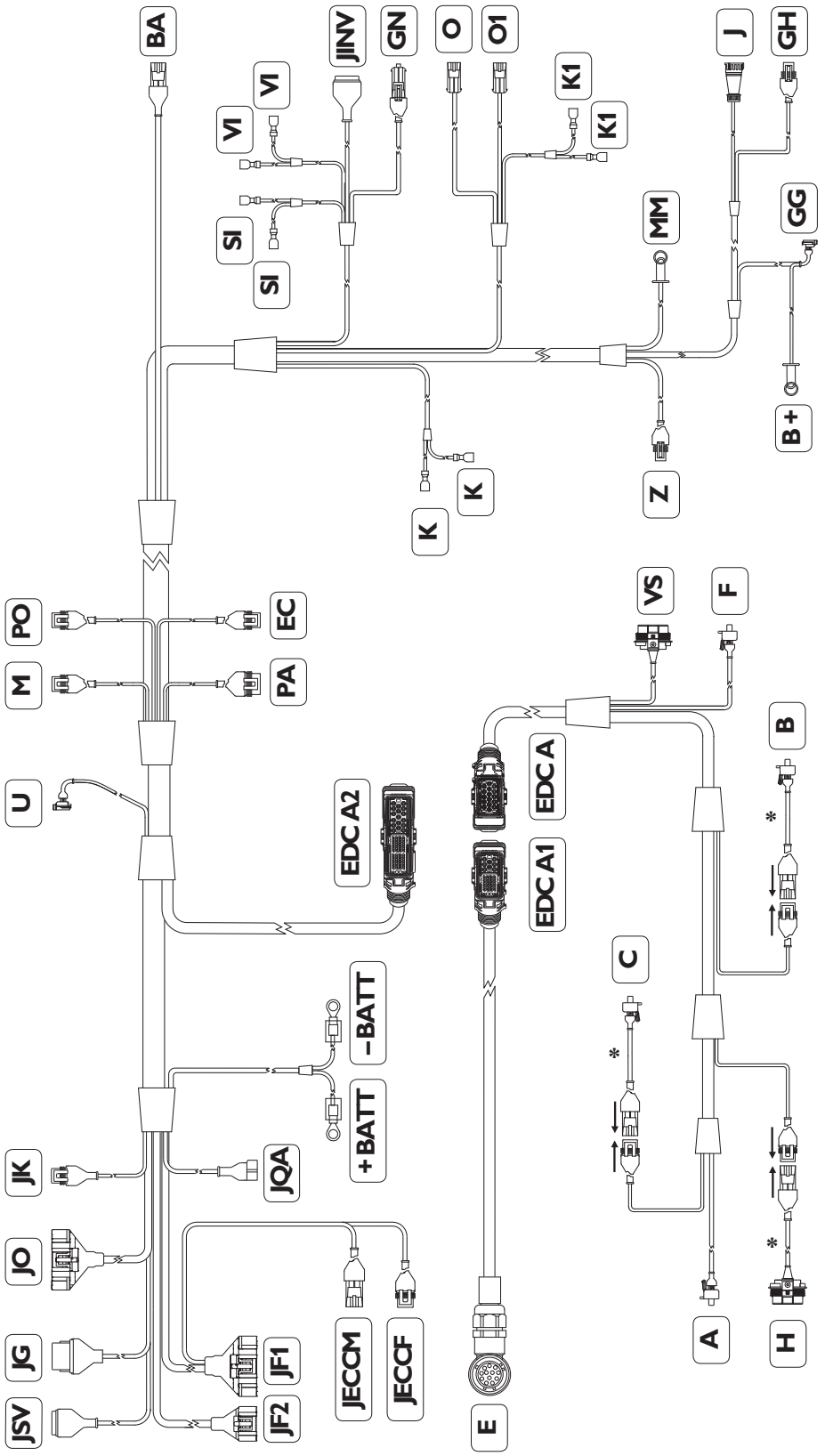


1. Connector for instrument panel connection wire harness - 2. Engine wire harness - 3. Connector for pre-lubricating system - 4. Connector for certified installations by classification Bodies - 5. Power line.

The wire harnesses provided with the engine include the connectors for all optional components which may ordered and their connections to the JQA connector for the indication and control panel.

WIRE HARNESS

Figure 3

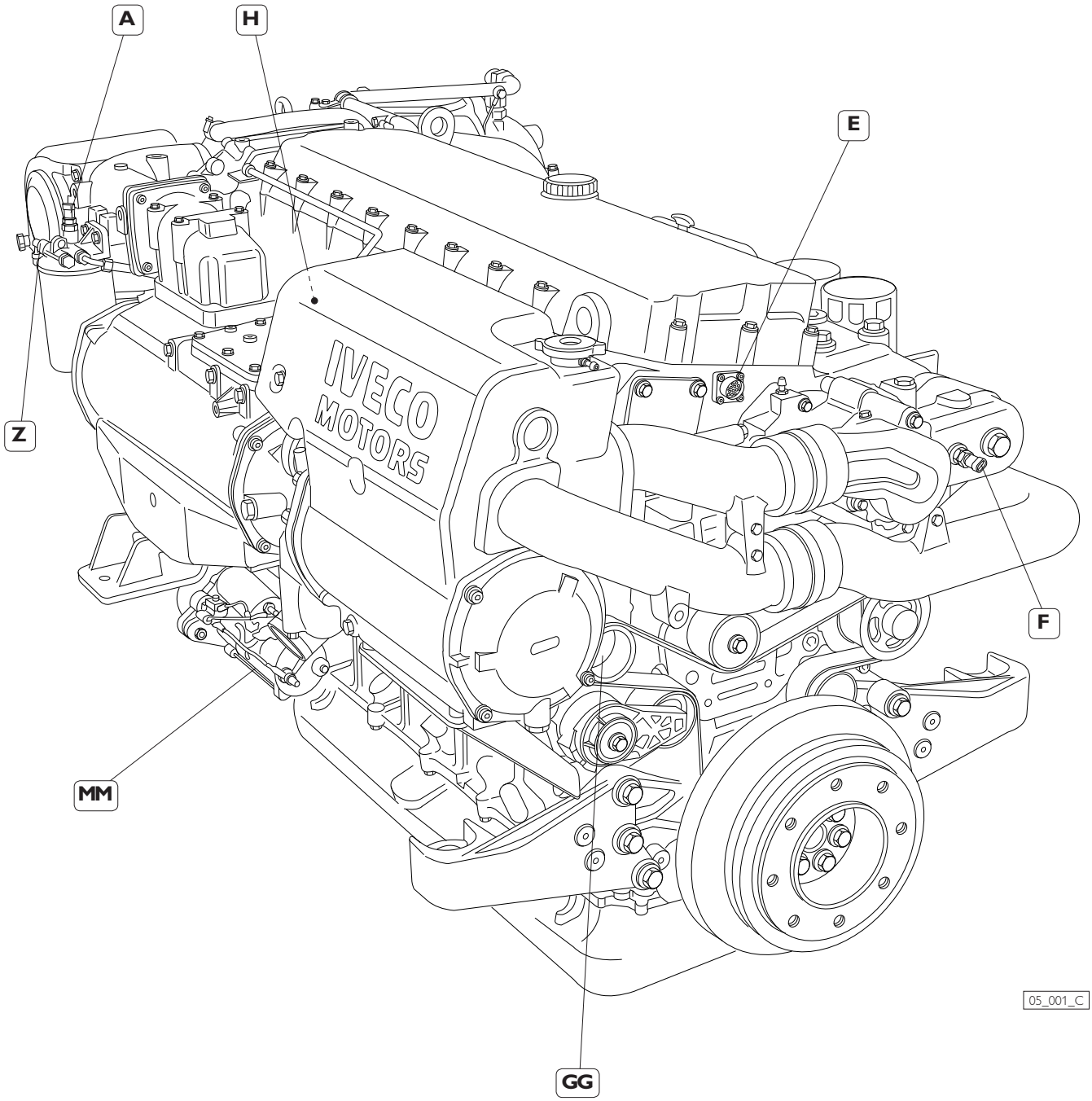


05_003_C

A. Fuel temperature sensor - B. Drive shaft sensor - BA. Additional drive shaft sensor (certified installation) - C. Camshaft sensor - E. EUI solenoid valves - EC. Switching solenoid valve for oil charge/discharge - F. Engine coolant temperature sensor - GG. Alternator - GH. Grid heater power relay - GN. Neutral gear sensor (in installation with no sensor, do not remove the cap of the GN connector to avoid compromising start engine function) - H. Combustion air pressure/temperature sensor - J. Low coolant level sensor - JG. Pre-lubrication control unit - JK. CAN lines connector - JO. Analog to digital converter module - JF1, JF2. Relay box - JQA. Set for connection to interface for analog instruments wire harness - JSV. Overspeed module - JINV. Set for connection to gearbox sensor and external accelerator command - JECCF. Excitation engine stop function - JECCM. Excitation engine stop function - K, K1 Air filter clogging sensor - M. Sensor for detecting the presence of water in the fuel pre-filter - MM. Electric starter motor - O, O1. Exhaust gas temperature sensor - PA. Throttle position sensor - PO. Pre-lubrication electrical pump - SI. Gear box oil temperature sensor U. Clogged engine oil filter sensor - VI. Gear box oil pressure sensor - VS. Engine oil pressure/temperature sensor - Z. Clogged fuel filter sensor - * B, C, H sensor wiring harness.

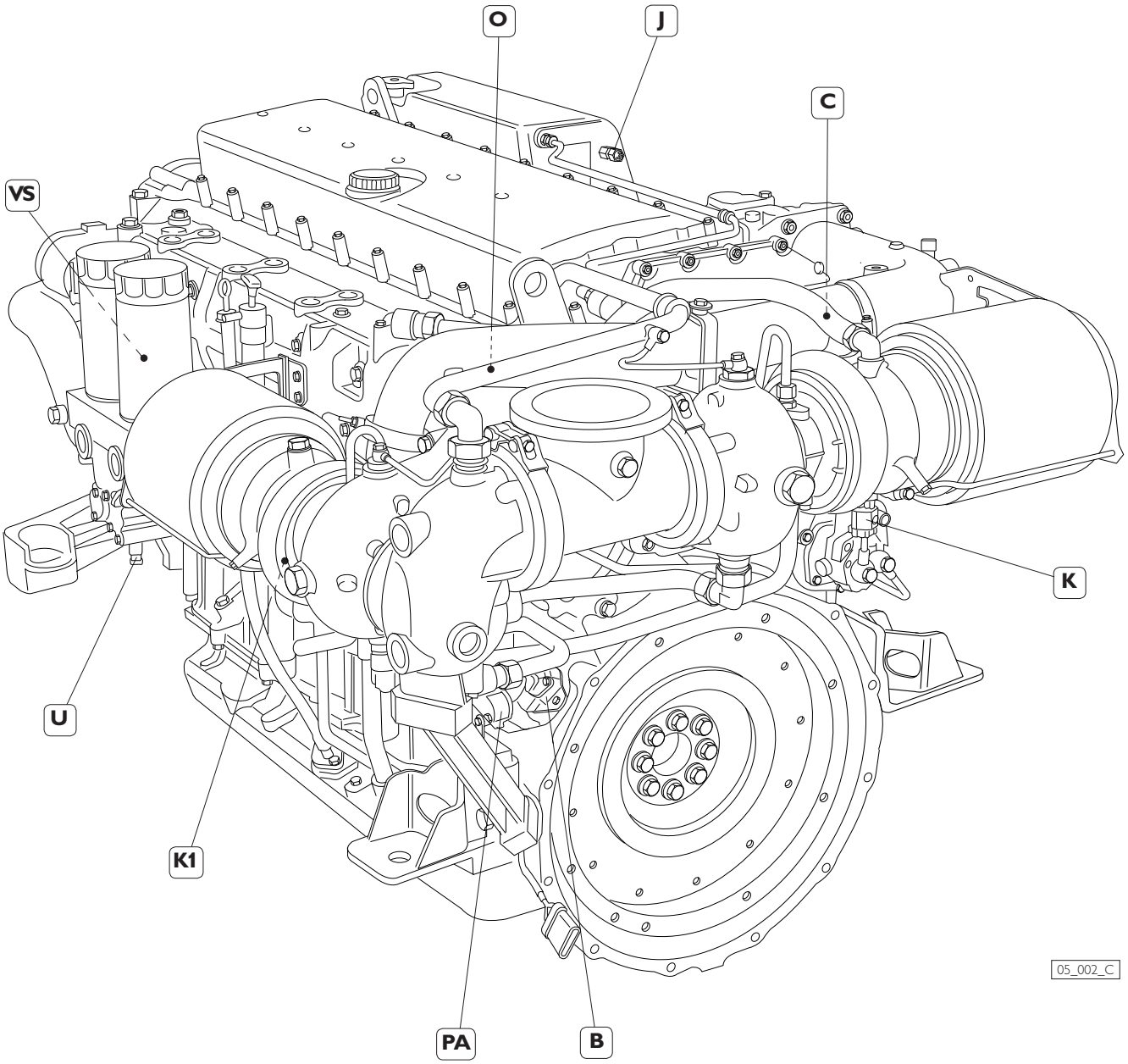
LOCATION OF ELECTRICAL COMPONENTS ON ENGINE

Figure 4



A. Fuel temperature sensor - E. EUI solenoid valves - F. Engine coolant temperature sensor - GG: Alternator - H. Combustion air pressure/temperature sensor for EDC - MM. Starter motor - Z. Clogged fuel filter sensor (for alarm).

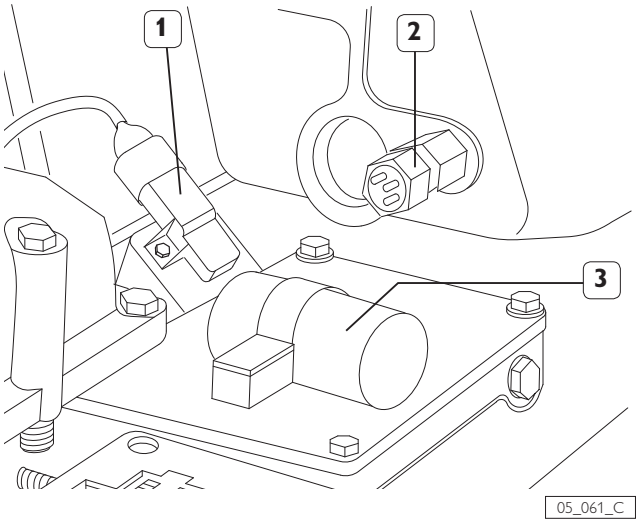
Figure 5



B. Drive shaft sensor for EDC - C. Camshaft sensor - J. Low coolant level sensor - K, K1. Air filter clogging sensor - O. Exhaust gas temperature sensor - PA. Throttle position sensor - U. Clogged oil filter sensor (for alarm) - VS. Engine oil pressure/temperature sensor.

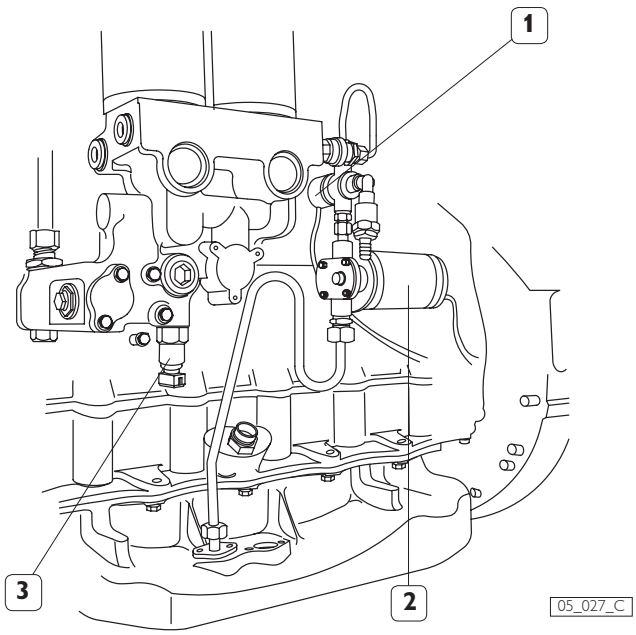
POWER SUPPLY LINE

Figure 6



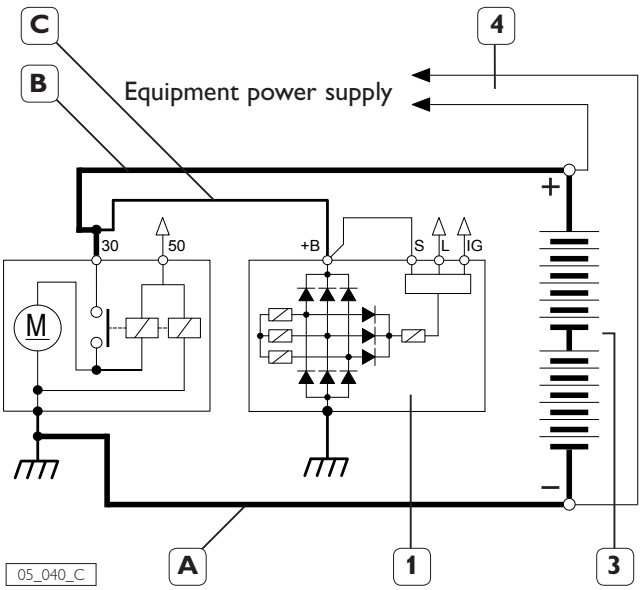
1. Combustion air pressure/temperature sensor (H) - 2. Low coolant level sensor (J) - 3. Pre-heating power relay (GH).

Figure 7



1. Switching solenoid valve for oil charge/discharge (EC) - 2. Pre-lubrication electrical pump (PO) - 3. Clogged oil filter sensor (U).

Figure 8



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

The power supply line, to be built by the yard, comprises:

- A. Connection between the negative pole of the battery and engine ground with a conductor having a cross section of at least 95 mm^2;
- B. Connection between the positive pole of the battery and the terminal "30" of the electrical starter motor, with a conductor having a cross section of at least 95 mm^2;
- C. Connection between the +B terminal of the alternator to the positive +30 terminal of the electric starter motor, to complete the recharge circuit, must be achieved with a conductor having a cross section of at least 40 mm^2.

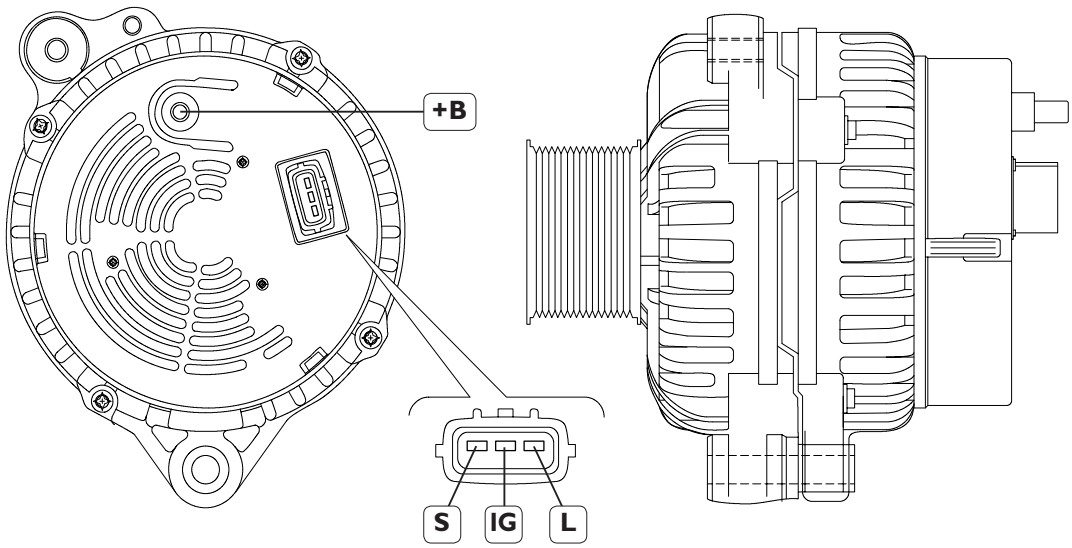
The connection of the electric equipment of the engine to the battery has to be carried out via the two eyed terminals, +B and –B, present on the wiring harness.

CAUTION

If magneto-thermal protecting breakers are installed on the wiring lines of the engine control system, they must not be used to stop the engine and in any case they must be activated only a few seconds after shut-down.

ALTERNATOR

Figure 9



Model "Bosch" 28 V - 40 to 90 A

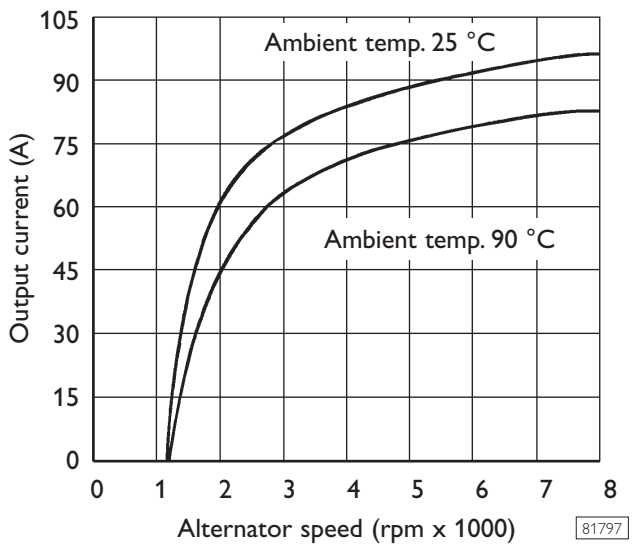
+B. (24 V) Power supply output terminal

S. (Sense) Reference voltage of battery charge status (connected to +B terminal or to be connected to the positive pole of the battery in case of remote installation of the battery);

IG. (Ignition) Regulator enabling signal (connected to voltage +, driven by key switch);

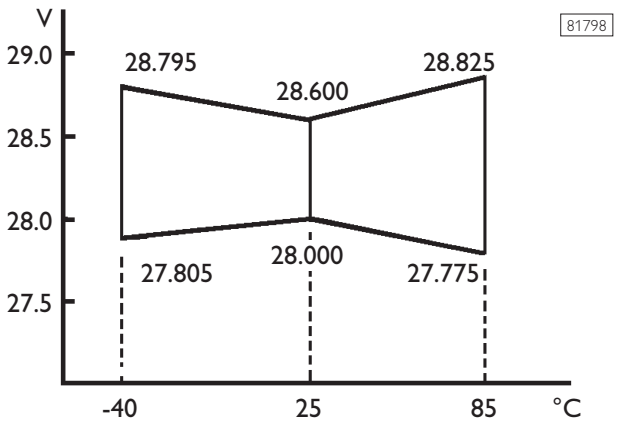
L. (Lamp) Power supply voltage of recharge/alarm indicator light located on the panel.

Figure 10



CHARACTERISTIC CURVES

Figure 11



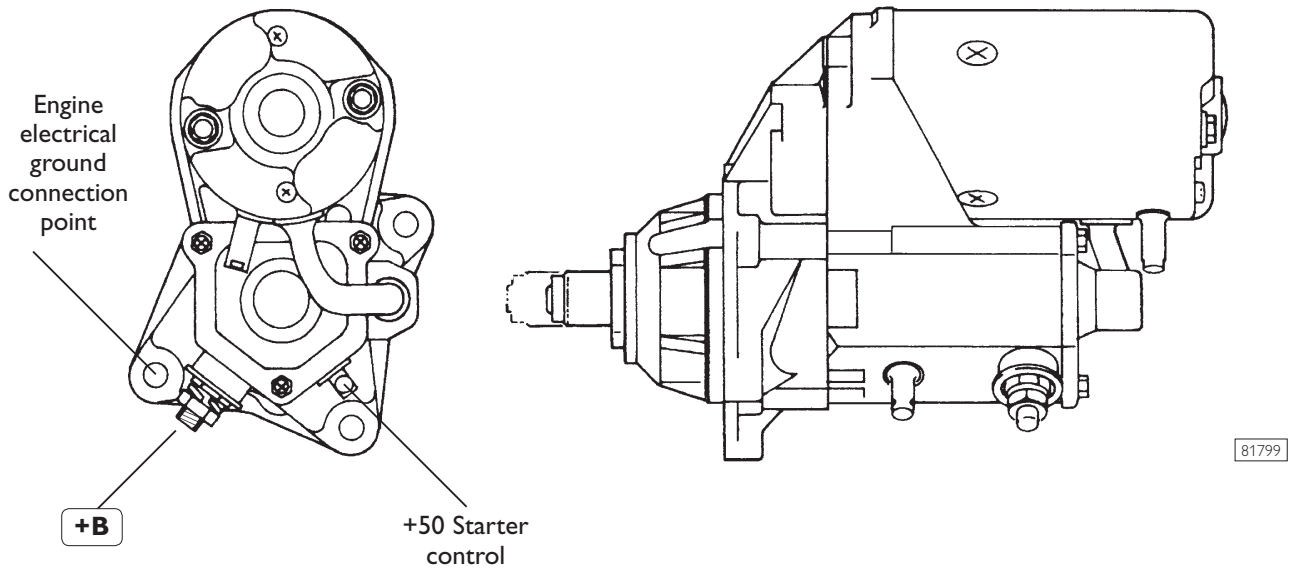
CHARACTERISTIC OF VOLTAGE REGULATOR

Specification

Nominal voltage	28 V
Nominal current min-max	40 - 90 A
Rpm for min power	~ 1800 rpm
Rpm for max power	~ 6000 rpm
Polarity	negative ground
Rotation	clockwise viewed from pulley
Belt	poly V
Belt tension	300 N (30.6 kgf)
Weight	7.8 kg

ELECTRICAL STARTER MOTOR

Figure 12

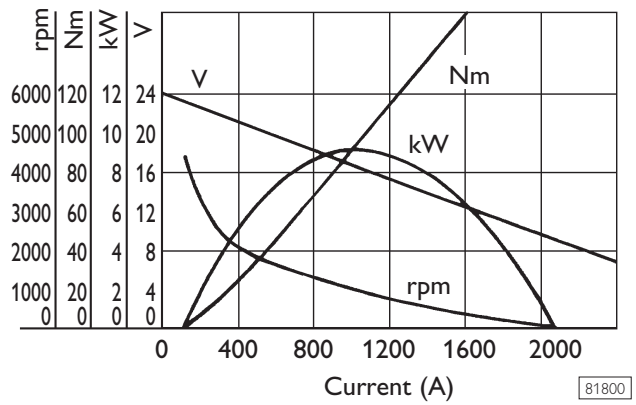


"Nippondenso" model

Specification

Nominal power	5.5 kW
Nominal voltage	24V
Polarity	negative ground
Engagement circuit	positive command
Rotation	clockwise viewed from pinion end
Weight	~ 10.5 kg
Operating voltage	26V MAX (20 °C)
Water resistance	spray test based on JIS D0203 SI

Figure 13

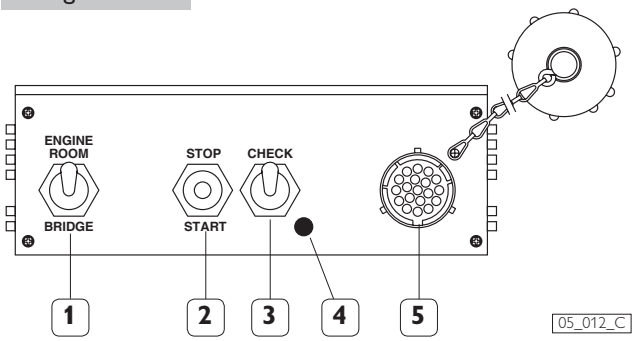


CHARACTERISTIC CURVES

Condition (20 °C)	Voltage (V)	Current (A)	Speed (rpm)	Torque (Nm)
No load	23	120	3800	-
Load	16	690	900	49
Stall	6	1260	0	73.5

RELAY BOX

Figure 14



1. Engine control selector on bridge or engine room - 2. Manual throttle control in engine room - 3. Not used - 4. Not used - 5. Connector for external diagnosis instrument.

This is the main point of interconnection and carries out many interfacing functions with the various components of the system.
The electrical commands positioned on the panel allow to control engine start and stop (2) directly from the engine room, while excluding any possibility that anyone may involuntarily start the engine from the bridge (1), during servicing operations.
Inside the box, anchored to a printed circuit board, are the power management relays of some components and the elements that protect the electrical lines against short circuits or excessive current absorption.
These components perform a similar function to that of fuses, almost completely avoiding the need to restore the electrical continuity of circuits that have been subjected to an anomaly condition. These components can limit and eliminate short circuit currents without melting - restoring their own and the circuit's electrical continuity, once the cause of the anomaly is removed.
On the relay box is located the multipolar connector, protected by a screw-on lid (5), for connection with the computerized diagnostic tools prescribed by IVECO MOTORS-FPT (see Section 4).
This is to be installed and anchored in such a way as to dampen vibrations and stresses when underway, and must be accessible during both servicing operations and when underway.

RPM control

To allow easily to control engine RPM from the "engine room", a simultaneous acceleration/deceleration function (SET+/SET-), active only when the switch (1) is in the "ENGINE ROOM" position, has been implemented in the "start" function.

Acceleration (SET +)

If, when the engine is running, the "start - stop" push-button is held down in the "start" position, then engine rpm are progressively increased (50 rpm per second); the increase ends when the push-button is released, allowing the engine to run at the desired rpm.

Deceleration (SET –)

Moving the "start - stop" push-button back to the "start" position, after releasing it during the rpm increase phase, a progressive reduction in rpm is obtained (50 rpm per second).

When the push-button is release, the function is inhibited and the rpm reached at that point is maintained.

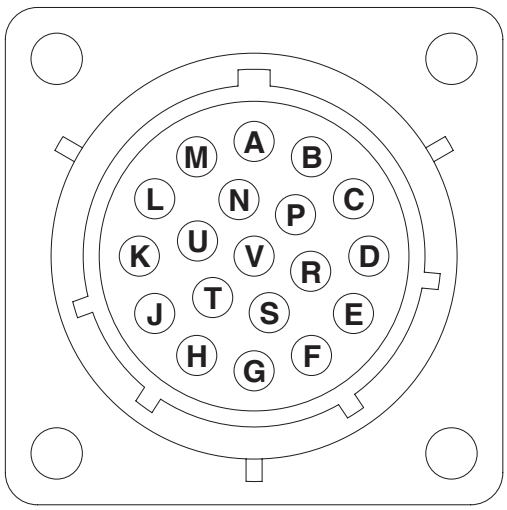
NOTE: Further action on the push-button will alternatively increase - decrease engine rpm. The "stop" function takes priority and always stops the engine.

CAUTION

Never operate the "BRIDGE - ENGINE ROOM" switch when the engine is running.

Diagnosis connector J1

Figure 15



Relay box connectors

Figure 16

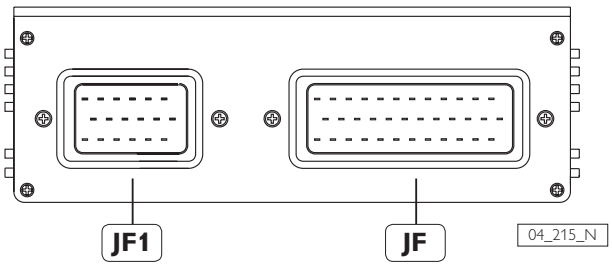
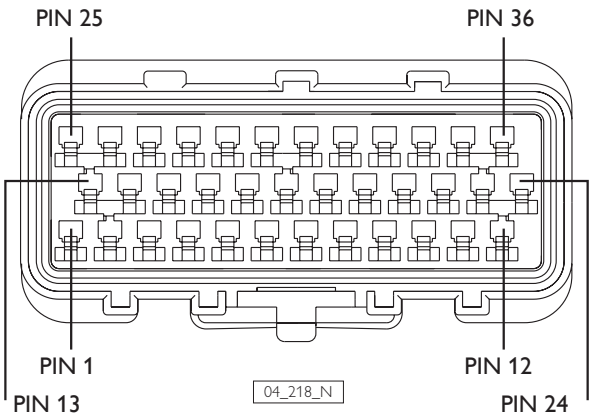
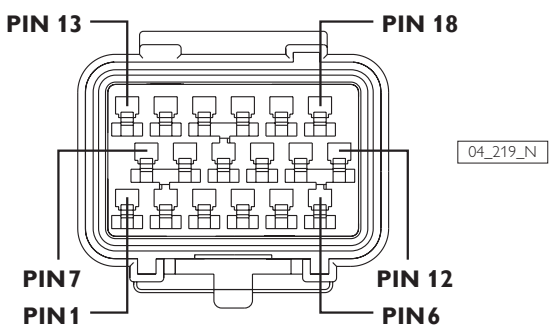


Figure 17



JF CONNECTOR
(view of the wire harness terminal, coupling side)

Figure 18

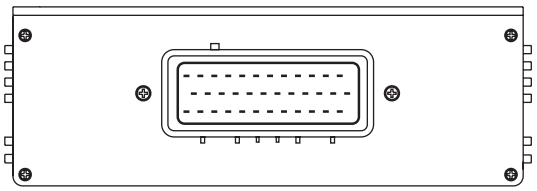


JF1 CONNECTOR
(view of the wire harness terminal, coupling side)

CONVERTER MODULE

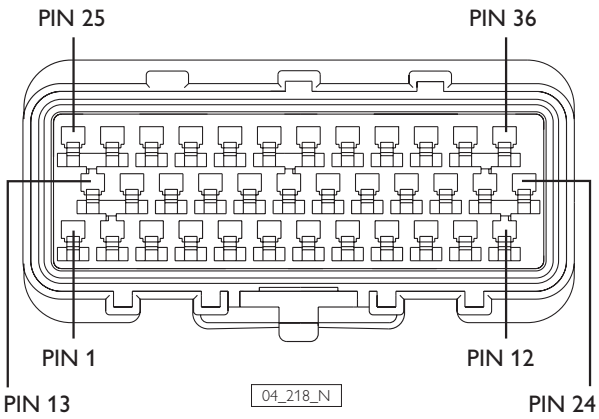
JO module decodes some informations supplied from EDC ECU, translates the signals of some analog sensors and codes all to the CAN lines connected to JQA connector.
The converter is connected by 36 poles connector.

Figure 19



REAR VIEW OF THE MODULE WITH JO CONNECTOR

Figure 20



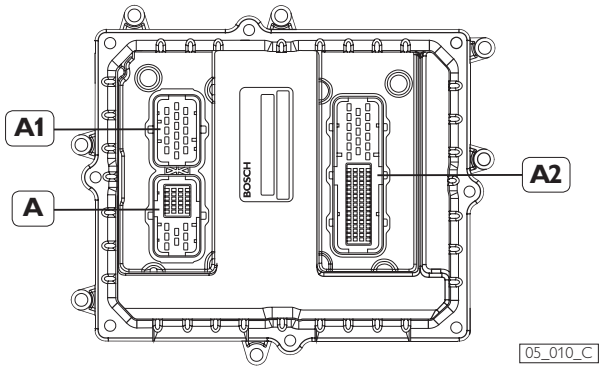
JO CONNECTOR
VIEW OF THE WIRE HARNESS TERMINAL, COUPLING SIDE

Functions of the JO terminals

1	Gear box oil pressure signal
2	CAN L_1
3	CAN H_1
4	Power supply positive (+ B)
5	Power supply positive (+ B)
6	Battery positive with key in ON position
7	Battery positive with key in ON position
8	Power supply negative (ground)
9	Not connected
10	Engaged forward gear signal
11	Pre-lubrication signal
12	Wired to pin 9, JF2 connector
13	Exhaust gas temperature signal (A)
14	Exhaust gas temperature signal (A)
15	Gear box oil temperature signal
16	CAN L_Q for instrument panel
17	CAN H_Q for instrument panel
18	Air filter clogging signal (A)
19	Power supply negative (ground)
20	Not connected
21	Alternator anomaly signal
22	Electronic throttling system enabling
23	Engaged reverse gear signal
24	Low coolant level signal
25	Exhaust gas temperature signal (B)
26	Exhaust gas temperature signal (B)
27	Electronic throttling system
28	Not connected
29	Air filter clogging signal (B)
30	Blow-by filter clogging signal (unavailable)
31	Power supply negative (ground)
32	Not connected
33	Wired to pin D, JSV connector
34	Not connected
35	Oil filter clogging signal
36	Fuel filter clogging signal

CONNECTIONS OF THE CENTRAL ELECTRONIC UNIT (ECU) EDC7 UC31

Figure 21



A. 36 pole connector - A1. 16 pole connector - A2. EDC at 89 poles.

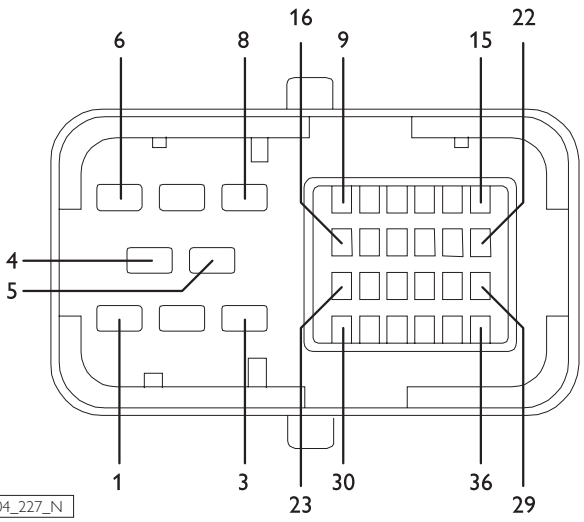
The connection of the central electronic unit, ECU, to the components of the EDC system is achieved by means of three connectors to subdivide the wiring harnesses, thereby favoring a quicker identification of the lines during testing operations.
The different connectors are polarized and provided with levers to favor the connection and disconnection operations and assure proper coupling.
They are dedicated to the following functions:

- ❏ Connector A for engine mounted components
- ❏ Connector A1 reserved for electro-injector connection
- ❏ Connector A2 for boat side connections.

Identification of terminal function

EDC A Connector

Figura 22



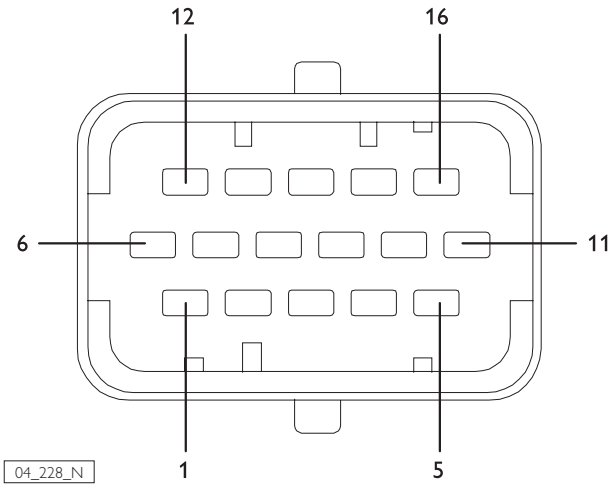
PIN	FUNCTION
1	Not used
2	Not used
3	Not used
4	Not used
5	Not used
6	Not used
7	Not used
8	Not used
9	Camshaft sensor
10	Camshaft sensor
11	Not used
12	Not used
13	Not used
14	Not used
15	Coolant temperature sensor signal
16	Not used

PIN	FUNCTION
17	Not used
18	Fuel temperature sensor ground
19	Flywheel sensor
20	Not used
21	Not used
22	Not used
23	Flywheel sensor
24	Engine oil pressure/temperature sensor ground
25	Intake air pressure/temperature sensor ground
26	Coolant temperature sensor ground
27	Engine oil pressure sensor signal
28	Engine oil temperature sensor signal
29	Not used
30	Not used
31	Not used
32	Engine oil pressure sensor supply (+5V)
33	Intake air pressure sensor supply (+5V)
34	Intake air pressure sensor signal
35	Fuel temperature sensor signal
36	Intake air temperature sensor signal

Identification of terminal function

EDC A1 Connector

Figura 23

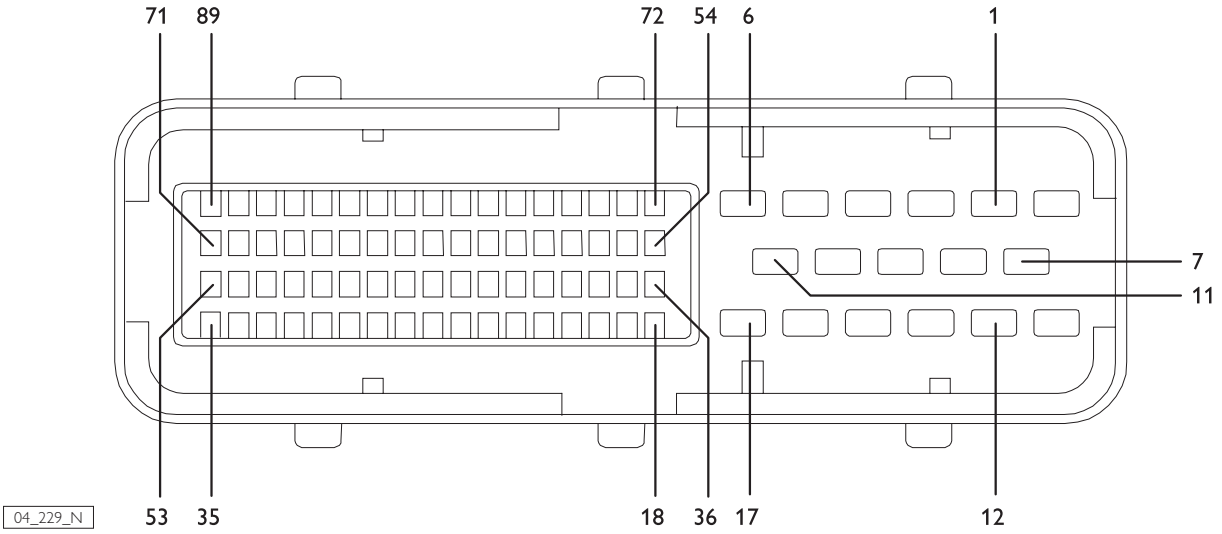


PIN	FUNCTION
1	Solenoid valve EUI cylinder 5
2	Solenoid valve EUI cylinder 6
3	Solenoid valve EUI cylinder 4
4	Solenoid valve EUI cylinder 1
5	Solenoid valve EUI cylinder 3
6	Solenoid valve EUI cylinder 2
7	Not used
8	Not used
9	Not used
10	Not used
11	Solenoid valve EUI cylinder 2
12	Solenoid valve EUI cylinder 3
13	Solenoid valve EUI cylinder 1
14	Solenoid valve EUI cylinder 4
15	Solenoid valve EUI cylinder 6
16	Solenoid valve EUI cylinder 5

Identification of terminal function

EDC A2 Connector

Figura 24



PIN	FUNCTION
1	Not used
2	Positive supply (+B)
3	Positive supply (+B)
4	Not used
5	Negative supply (-B)
6	Negative supply (-B)
7	Not used
8	Positive supply (+B)
9	Positive supply (+B)
10	Negative supply (-B)
11	Negative supply (-B)
12	Pre-heating relay control
13	Not used
14	Not used
15	Not used
16	Not used
17	Negative supply for starter motor relay
18	Not used

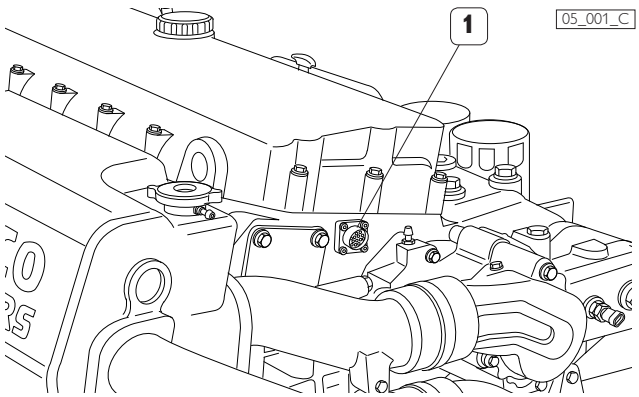
PIN	FUNCTION
19	Not used
20	Not used
21	Neutral gear sensor
22	Not used
23	Not used
24	Not used
25	Not used
26	Not used
27	Not used
28	Not used
29	Digital ground
30	Not used
31	Not used
32	Cranking request signal from relay box
33	Not used
34	CAN L_2 line
35	CAN H_2 line

PIN	FUNCTION
36	Wired to pin 14 relay box
37	Positive supply for starter motor relay
38	Not used
39	Not used
40	Positive connected to + 15 (key switch in ON position)
41	Not used
42	signal from sensor for detecting the presence of water in the fuel pre-filter
43	Not used
44	Not used
45	Not used
46	Not used
47	Engine stop request signal from relay box
48	Idling switch signal
49	Not used
50	Not used
51	Not used
52	Not used
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	Not used
62	Not used

PIN	FUNCTION
63	Not used
64	Not used
65	Not used
66	Neutral gear sensor
67	Not used
68	Not used
69	Not used
70	Not used
71	Not used
72	Not used
73	Not used
74	Not used
75	Pre-heating relay control
76	Not used
77	Positive supply for throttle position sensor
78	Throttle position sensor ground
79	Throttle position sensor signal
80	Not used
81	Not used
82	Not used
83	Not used
84	Not used
85	Cranking control signal from relay box
86	Not used
87	Not used
88	Not used
89	Diagnosis line "K"

EUI SOLENOID VALVE CONNECTOR

Figure 25

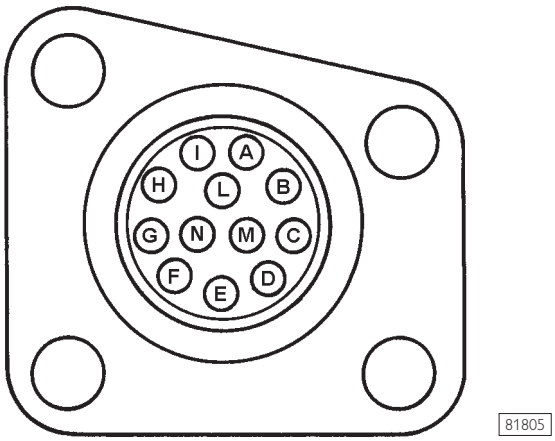


1. Connector E.

The wiring that connects the solenoid valves of the EUI injectors to the ECU is divided into two branches: the first is located in the compartment that houses the distribution elements, connects each solenoid valve to the 12 way through-bulkhead connector, fastened on the front part of the cylinder head; the second is integrated into the engine wire harness connected to the EDC ECU and terminates with the threaded ring nut connector.

Through-bulkhead E connector

Figure 26



VIEW FROM THE ENGINE OUTER SIDE

A	Injector 1 control	Pin ECU A1 13
B	Injector 1 supply	Pin ECU A1 4
C	Injector 2 control	Pin ECU A1 6
D	Injector 2 supply	Pin ECU A1 11
E	Injector 3 control	Pin ECU A1 12
F	Injector 3 supply	Pin ECU A1 5
G	Injector 4 control	Pin ECU A1 14
H	Injector 4 supply	Pin ECU A1 3
I	Injector 5 control	Pin ECU A1 16
L	Injector 5 supply	Pin ECU A1 1
M	Injector 6 control	Pin ECU A1 15
N	Injector 6 supply	Pin ECU A1 2

CAUTION

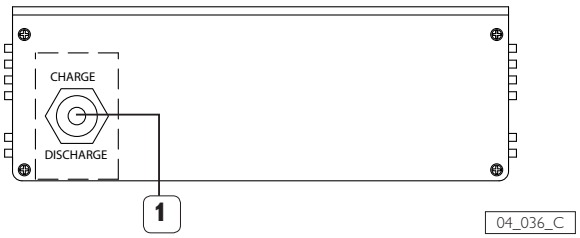
The wiring that connects the injector solenoid valves to the through-bulkhead connector is made with connectors whose insulation is capable of withstanding the challenging conditions of the environment where it is located. These are braided to avoid generation of electromagnetic interference.

For an improved operating efficiency, no junctions or repairs are allowed either along the conductors or on the terminals. If flaws are noted in this wiring portion, it must be replaced with an original spare part.

OPTIONAL EQUIPMENT

Lubricating oil transfer module

Figure 27

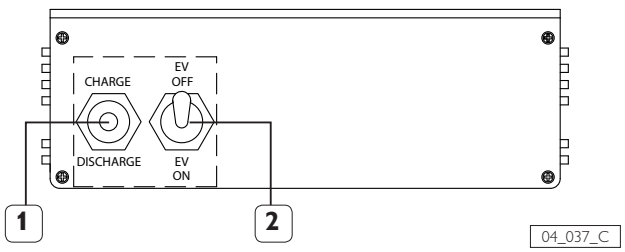


1. Oil intake/exhaust control

Lubricating oil transfer operations are simplified by the presence of an electrical control system connected to the JG connector of the interface wiring harness. Manual control for transfer operations is positioned on the front panel unit.
For safety reasons, control is enabled only with the key switch in the "OFF" position.

Pre-lubrication and oil transfer module

Figure 28



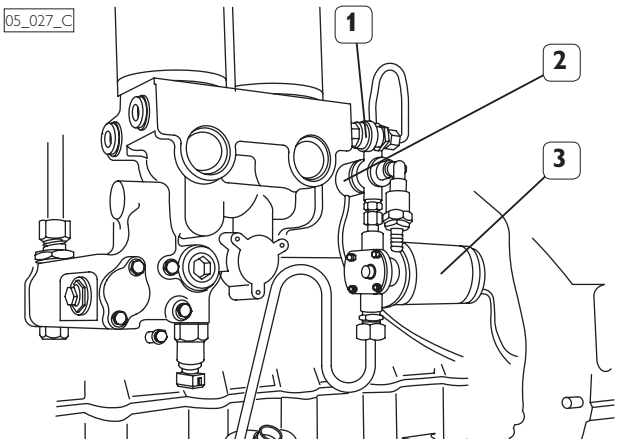
1. Oil intake/exhaust control. -
2. Switching solenoid valve control.

The module is connected to the JG connector of the interface wiring harness.
The task of pre-lubricating the engine's internal components is managed and controlled by the electronic circuit of the module when the key switch is placed in "ON" position. With the key switch in the "OFF" position, the operation can also be performed manually by using the oil intake/ exhaust push-button positioned on the front panel. If the push-button is placed for a few seconds in the "DISCHARGE" position, the filters and the internal engine ducts will be filled.
Lubricating oil transfer sequence:

1. Place the "EV-OFF / EV-ON" (2) switch in the "EV-ON" position, thus energizing the switching solenoid valve to place the emptying/filling junction in communication with the electrical pump and with the oil sump;
2. Use the "CHARGE / DISCHARGE" (1) push-button to complete the desired operation;
3. Place the "EV-OFF / EV-ON" switch back to the "EV-OFF".

Pre-lubrication system

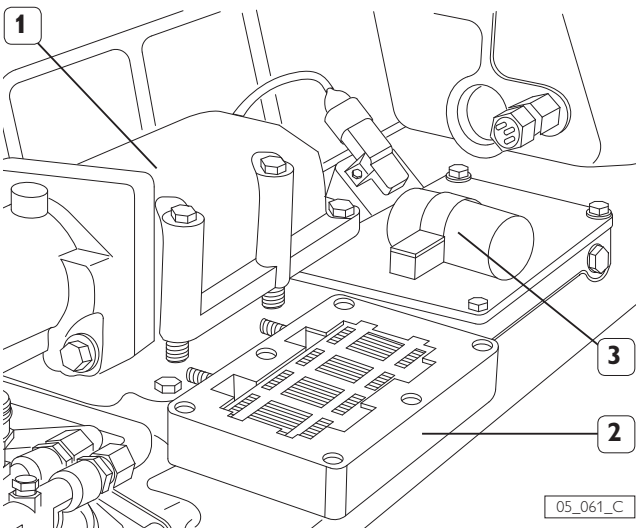
Figure 29



1. One way valve - 2. Switching solenoid valve (EC) -
3. Electrical pump (PO).

Low temperature starting aid (not available at the moment)

Figure 30



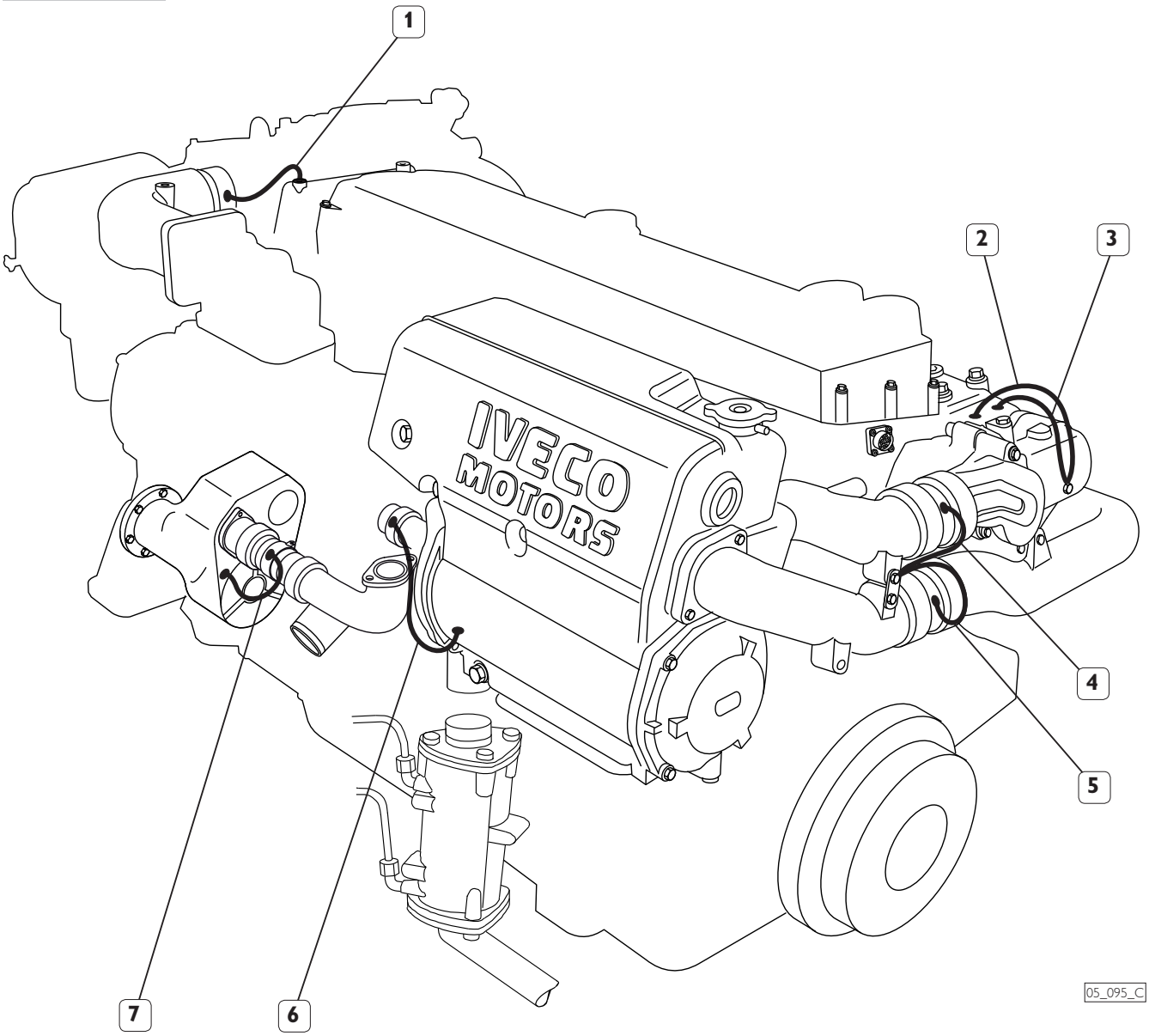
1. Specific junction pipe - 2. Electrical grid heater -
3. Power relay.

When the engine is to be used at temperatures lower than -15 °C, an electrical grid heater (PH) is installed. Its operation is controlled by the electronic unit of the injection system. The element will be placed between the turbocompressor and the air/water heater exchanger (after-cooler), replacing the terminal part of the intake duct.
Connection to the electrical wiring provided is achieved interposing a specific relay (GH) and connection to the power supply grid.
For use at temperatures lower than -25 °C, adoption of an auxiliary preheating system is recommended.

EQUIPOTENTIAL CONNECTIONS TO ENGINE GROUND

To prevent electrochemical corrosion phenomena, some elements included in the cooling circuits are electrically grounded with copper braids with eyelet terminations.

Figure 31



1, 2, 3, 4, 5, 6, 7. Copper braids

CAUTION

To enhance connection efficiency, the screw threads and the surfaces in contact with the electrical terminals must be clean and not oxidized. Thoroughly inspect and remove any impurities before each reinstallation procedure.

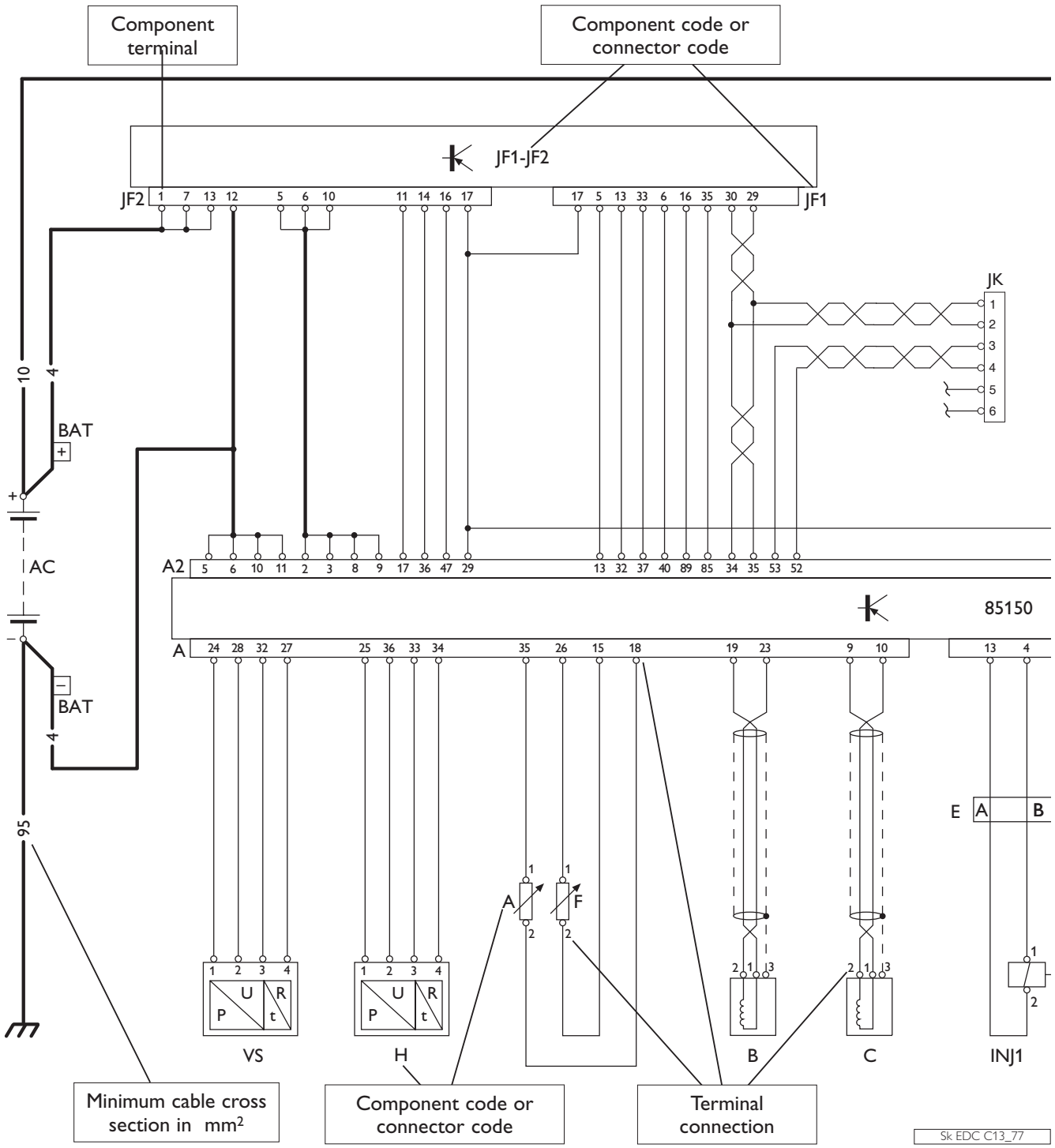
WIRING DIAGRAM

Wiring diagram key

General condition for the preparation and interpretation of wiring diagrams

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

Figure 32



Electrical equipment component code

A	fuel temperature sensor
AC	battery
AQ	engine shut-off push-button on main panel
AS	engine shut-off push-button on secondary panel
B	drive shaft sensor
BA	additional drive shaft sensor (certified installation)
C	camshaft sensor
CA	key switch
CS	engine start push-button on secondary panel
EC	switching solenoid valve for oil charge/discharge
F	engine coolant temperature sensor
GG	alternator
GH	grid heater power relay
GN	neutral gear sensor
H	combustion air pressure/temperature sensor
INJ	EUI injector
J	low coolant level sensor (for alarm)
JG	pre-lubrication control unit
JO	Analog to digital converter module
J2	Digital to analog converter module
JF1, JF2	relay box
K, K1	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)
MM	electric starter motor
MP	pre-lubrication and oil transfer module
MS	IVECO MOTORS-FPT indications and alarms module
O, O1	exhaust gas temperature sensor (for gauge)
P1	sound alarm inhibition push-button
PA	throttle position sensor
PE	emergency shut-down push-button (optional, installer's responsibility)
PH	Grid heater
PO	pre-lubrication electrical pump
QP	main analog instrument panel
QS	secondary analog instrument panel
SA	buzzer
SI	gear box oil temperature sensor
U	Clogged oil filter sensor (for alarm)
VI	gear box oil pressure sensor
VS	engine oil pressure/temperature sensor
X	Clogged blow-by filter (unavailable)
Z	clogged fuel filter sensor (for alarm)
85150	ECU of the EDC system

(continues on next page)

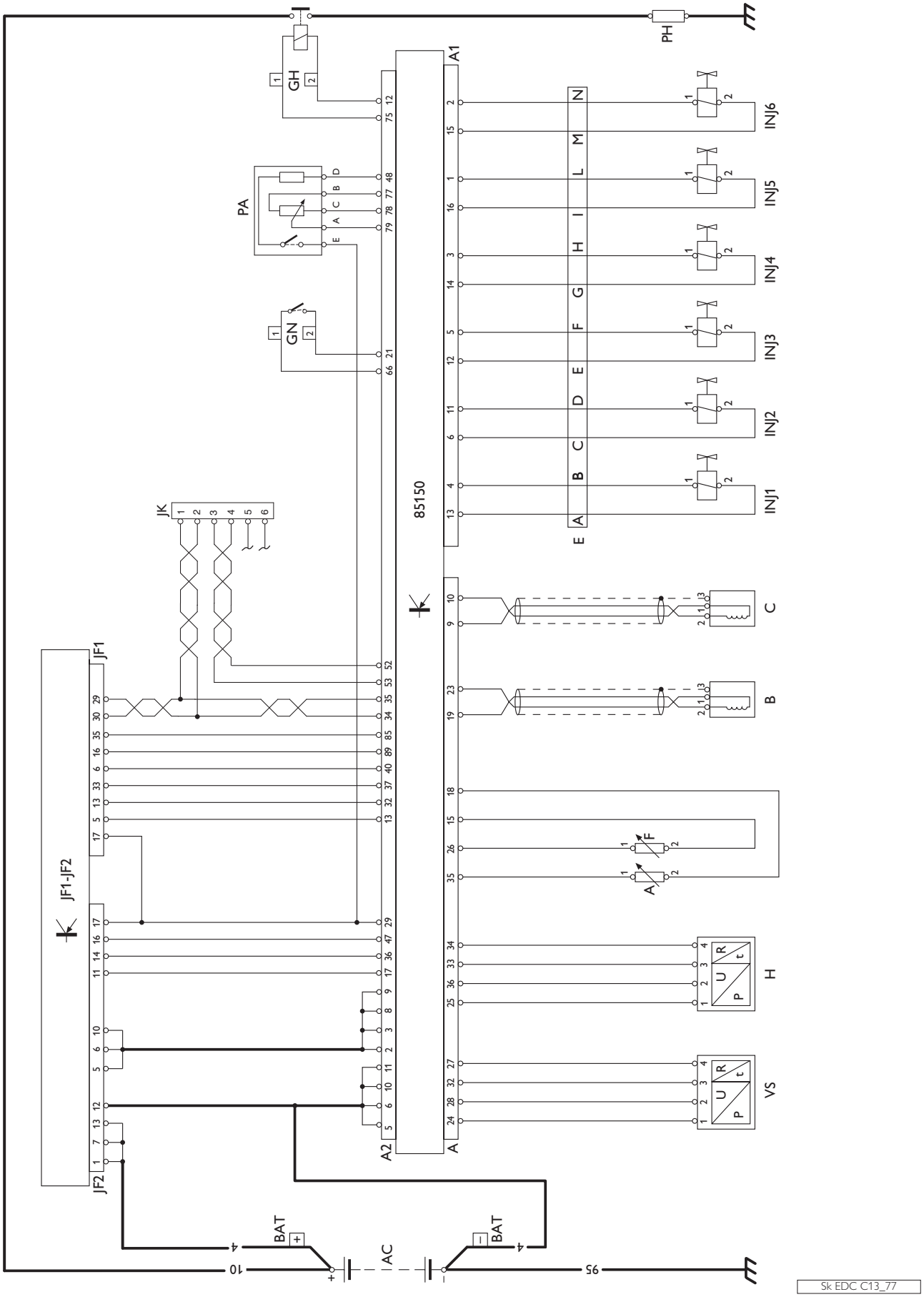
Electrical equipment component code (cont.)

Connectors	
A	36 pole EDC engine components
A1	16 pole EDC electro-injectors
A2	89 poles EDC boat side
E	EUI injectors solenoid valve
J1	on the relay box panel for external diagnostic tool
J3 ON INTERFACE WIRE HARNESS FOR ANALOG INSTRUMENT PANEL	set for connection to optional indicator gauges
J4 ON INTERFACE WIRE HARNESS FOR ANALOG INSTRUMENT PANEL	set for connection to main analog instrument panel
JD	IVECO MOTORS-FPT indications and alarms module
JC ON MAIN ANALOG INSTRUMENT PANEL	set for connection to interface wire harness
JE ON MAIN DIGITAL INSTRUMENT PANEL	set for connection to the secondary digital instrument panel
JF1	relay box
JF2	relay box
JH ON SECONDARY ANALOG INSTRUMENT PANEL	set for connection to the main analog instrument panel
JK	CAN lines
JQA ON ENGINE WIRE HARNESS	set for connection to interface for analog instruments wire harness
JSV	overspeed module
JINV ON ENGINE WIRE HARNESS	set for connection to gearbox sensor and external accelerator command
JECCF	excitation engine stop function
JECCM	excitation engine stop function

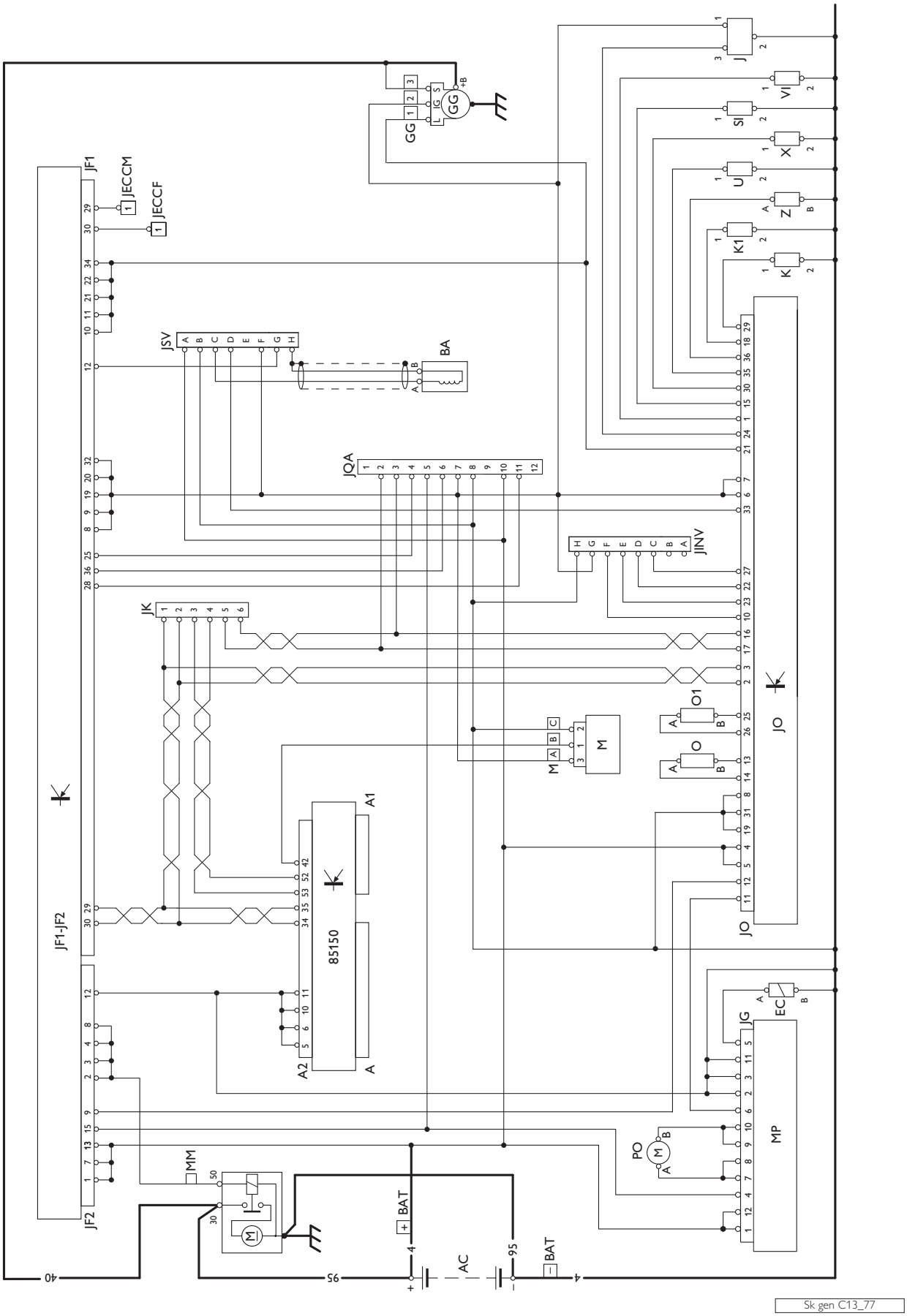
Indicator lights	
EDC	EDC malfunction
SAC	presence of water in fuel pre-filter
SATA	coolant high temperature
SBLA	low coolant level
SBPO	low oil pressure
SCP	pre-post heating
SIFA	clogged air filter
SIFB	clogged oil vapor filter
SIFC	clogged fuel filter
SIFO	clogged oil filter
SP	pre-lubrication
SS	alternator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

Gauges	
CG	revolution-counter
MO	engine oil pressure
TA	engine temperature
V	voltmeter

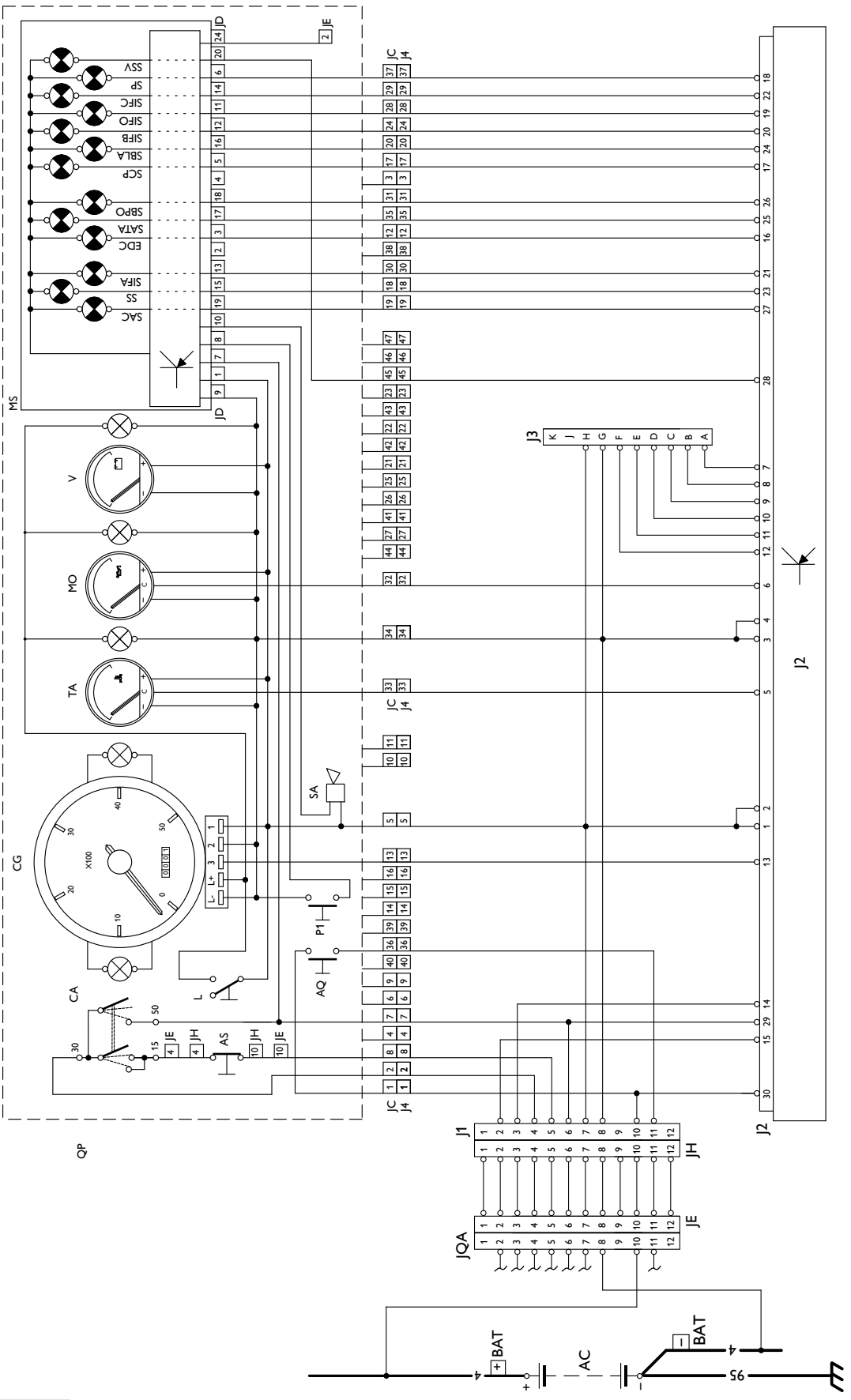
EDC


PH
GH
PA
GN
A1
A2
85150
JK
JF1
JF1-JF2
JF2
INJ6
INJ5
INJ4
INJ3
INJ2
INJ1
C
B
H
VS
BAT
AC
BAT
10
95
Sk EDC C13_77

Assembly

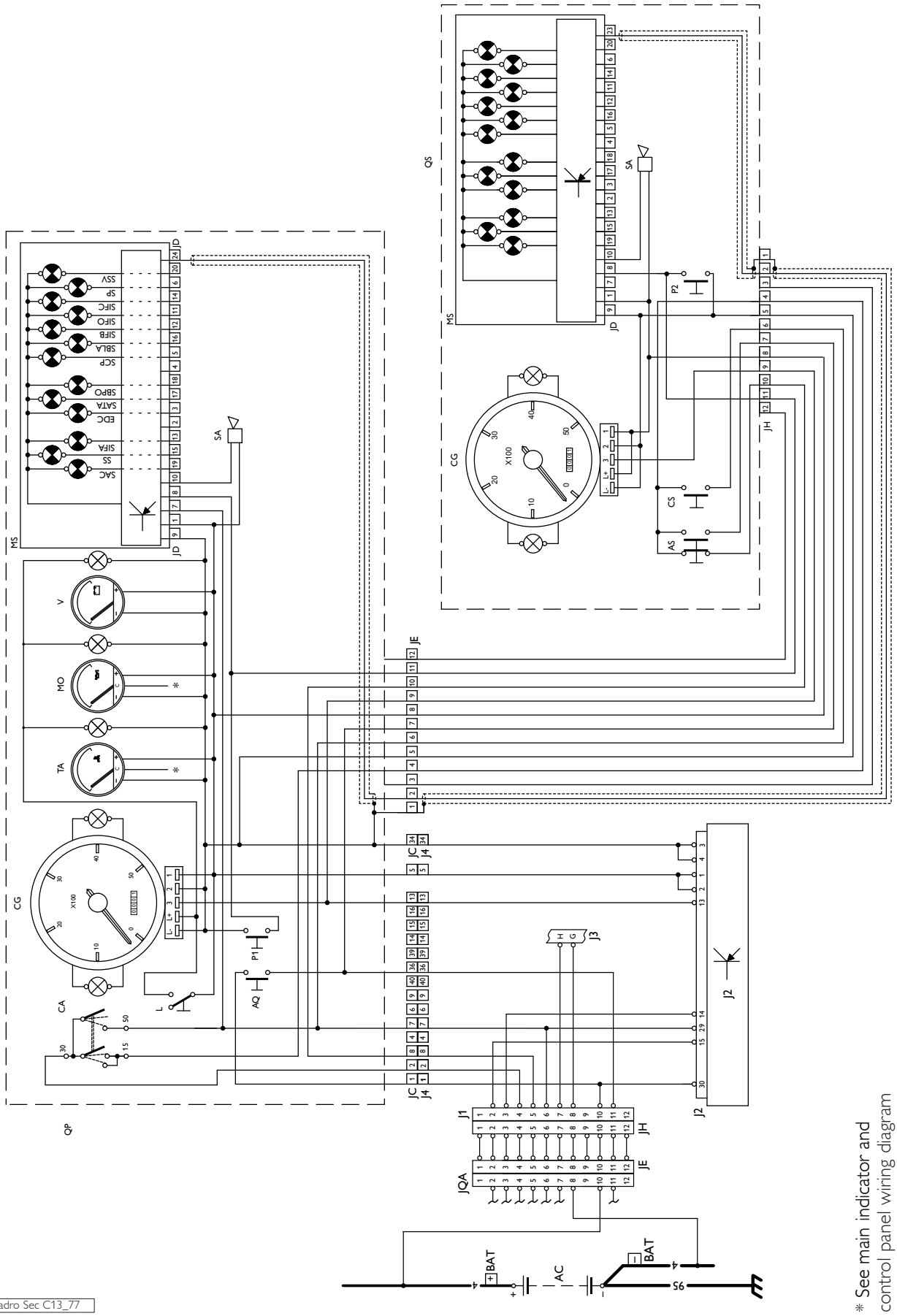

JF1
JECCM
JECCF
JF1-JF2
JF2
JSV
BA
JQA
JINV
JK
JO
O1
O
M
A1
A2
A
85150
GG
+B
IG
S
L
J
VI
SI
X
U
Z
K1
K
EC
JG
MP
PO
MM
+ BAT
AC
BAT
40
95
4
Sk gen C13_77

Main analog instrument panel



Sk_Quadro Di Bordo C13_77

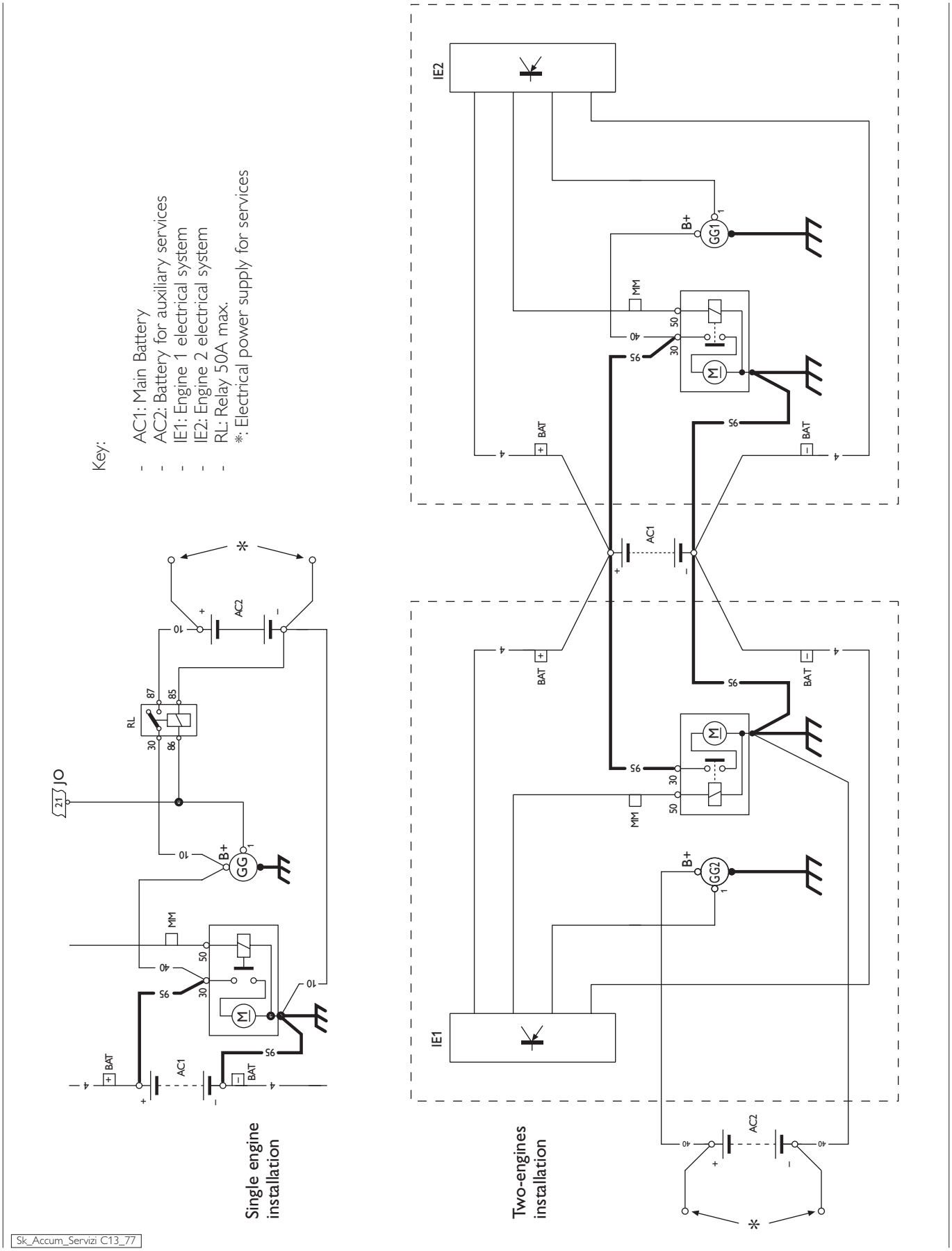
Secondary analog instrument panel



* See main indicator and control panel wiring diagram

Sk_Quadro Sec C13_77

Supplementary services battery recharge



Sk_Accum_Servizi C13_77

SECTION 4

DIAGNOSTICS

(cont.)

Page

FOREWORD

A correct diagnosis is achieved by using the competence acquired with years of experience and attendance at training courses.
When the user complains of poor performance or operating anomalies, due consideration must be given to his/her indications, deriving from them useful information to 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 tests of the operation of the entire system conducted periodically in operation, provide an important diagnostic method, made available by decoding the "error/anomaly" codes.
Using computerized IVECO MOTORS-FPT instruments, IT 2000 and PT 01, two-way communications can be established with the central unit, enabling not only the decoding of the error codes but also to route the investigation in its memory to retrieve 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 via 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 by using your acquired experience, adopting traditional diagnostic methods.
Technicians and maintenance personnel are recommended, in these cases, to check the ratings and technical data in the "C13 ENT M77 Installation Directive" document.
Partly in order to overcome service personnel's lack of experience on this new system, we have provided, in the pages that follow, a TROUBLESHOOTING GUIDE.

The guide is organized by symptoms, describes the possible anomalies not recognized by the electronic unit, frequently mechanical or hydraulic in nature.

For maintenance prescriptions, 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

Recovery

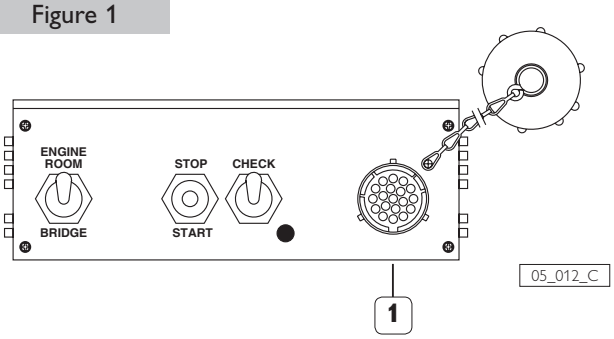
The recognition of significant or sever anomalies causes the adoption of strategies that allow to use the engine with complete safety, guaranteed by limiting performance within pre-set thresholds according to the severity of the case.

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.

Error deletion procedure

Figure 1



Error deleting can be carried out through the PT01 IVECO MOTORS-FPT instrument, connected with the diagnosis connection (1) positioned on the relay box.

CAUTION

The error deleting procedure is intended to eliminate the information relating to the mistakes from the ECU memory, which happened during previous working periods. The errors 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.

ENGINE PROTECTION FUNCTION

The ECU performs an effective control function on the main engine operation parameters.
When the maximum temperature limits of the engine oil, coolant and combustive air are exceeded, the ECU reduces the maximum torque issued by the engine to protect it from damage.

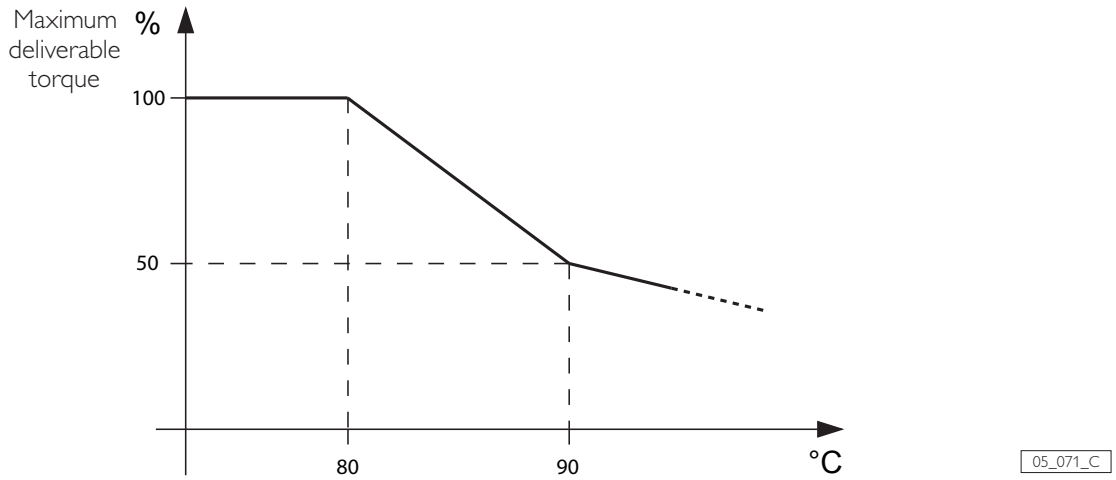
CAUTION

These operating modes ARE NOT CLASSED AS ERRORS, meaning that they do not provoke the memorising of faults and trigger no failure signal on the panel. During the diagnostic process it is therefore important not to overlook this kind of behaviour when there are significant reductions in performance which cannot be traced back to other causes.

In proportion with the nature of the risk, the function is activated when temperatures in excess of 80 °C for combustion air, 102 °C for coolant and 120 °C for engine oil are recognised.
The following diagrams show the trends of the reductions which have been carried out.

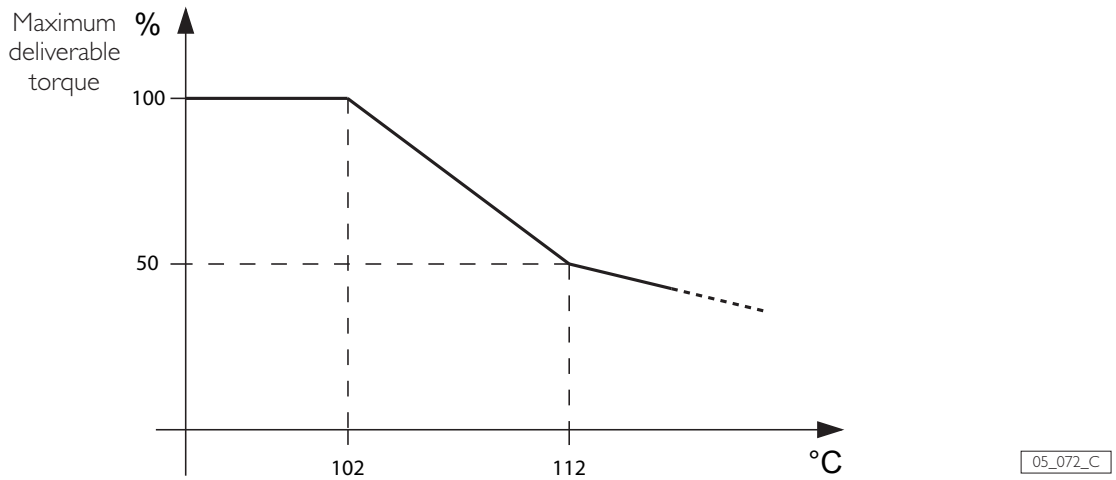
Reduction of optimum performances due to excessive temperature of combustion air

Figure 2



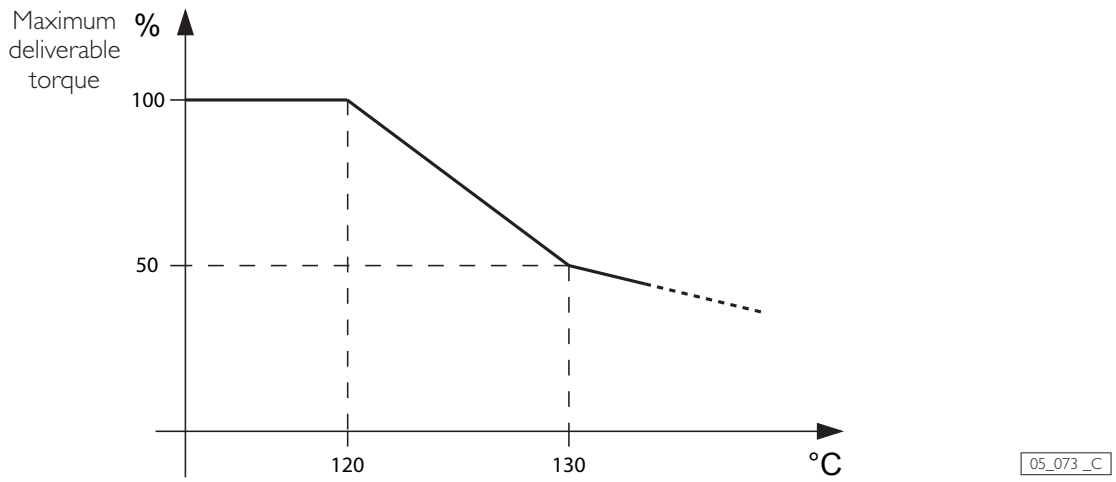
Reduction of optimum performances due to excessive temperature of coolant liquid

Figure 3



Reduction of optimum performances due to excessive temperature of lubricating oil

Figure 4



EDC7 UC31 DETECTABLE FAULT LIST

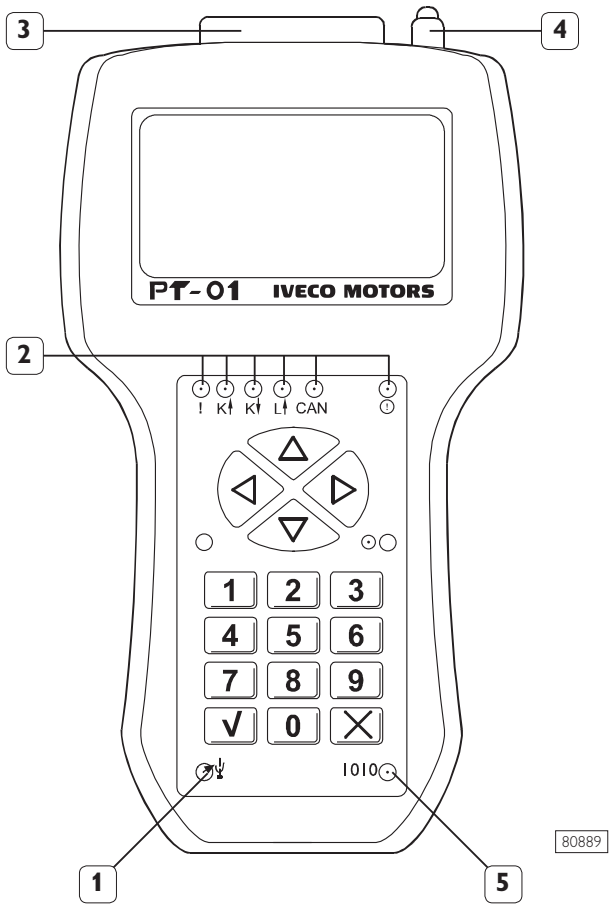
FAULT DESCRIPTION	SHORT CIRCUIT TO POSITIVE	SHORT CIRCUIT TO GROUND	OPEN CIRCUIT	IMPLAUSIBLE SIGNAL
Area 1				
Throttle position sensor	x	x		x
No terminal 15 signals detected (key in position "ON" position)			x	
Terminal 50 always pressed (crank request)	x			
Sensor for detecting the presence of water in the fuel pre-filter	x			
Area 2				
Main relay defect (inside ECU)	x	x		
Battery voltage (value too low or high)	x	x		
Power relay for starting aid (optional)	x			
Power relay for starting aid (optional)		x		
Power relay driver for starting aid (opzionale)	x	x	x	
Grid heater always switched on	x			
Engine 1				
Coolant temperature sensor (thresholds)	x	x	x	x
Coolant temperature sensor (dynamic test)				x
Intake air temperature sensor	x	x	x	
Intake air pressure sensor	x	x	x	x
Fuel temperature sensor	x	x		
Engine lubrication oil pressure sensor	x	x	x	x
Engine lubrication oil pressure value too low				x
Engine lubrication oil temperature sensor	x	x	x	x
Engine lubrication oil temperature value too high				x
Engine 2				
Crankshaft sensor	x	x		
Engine is running with camshaft sensor only		x		
Camshaft sensor	x	x		
Offset between camshaft and crankshaft	x			x
Relay box start button is stuck (closed)			x	
EUI delivery control				
Cylinder 1	x	x	x	x
Cylinder 2	x	x	x	x
Cylinder 3	x	x	x	x
Cylinder 4	x	x	x	x
Cylinder 5	x	x	x	x
Cylinder 6	x	x	x	x
Cylinder balancing			x	x

FAULT DESCRIPTION	SHORT CIRCUIT TO POSITIVE	SHORT CIRCUIT TO GROUND	OPEN CIRCUIT	IMPLAUSIBLE SIGNAL
EUI 1				
Solenoid valve coil EUI injector cylinder 1	x	x		x
Solenoid valve coil EUI injector cylinder 2	x	x		x
Solenoid valve coil EUI injector cylinder 3	x	x		x
Solenoid valve coil EUI injector cylinder 4	x	x		x
Solenoid valve coil EUI injector cylinder 5	x	x		x
Solenoid valve coil EUI injector cylinder 6	x	x		x
Solenoid valve coil EUI injector cylinder 1			x	x
Solenoid valve coil EUI injector cylinder 2			x	x
Solenoid valve coil EUI injector cylinder 3			x	x
Solenoid valve coil EUI injector cylinder 4			x	x
Solenoid valve coil EUI injector cylinder 5			x	x
Solenoid valve coil EUI injector cylinder 6			x	x
EUI 2				
Bank 1 (Solenoid valve coil cylinder 1, 2 and 3) short circuit/not classifyable	x	x	x	x
Bank 1 (Solenoid valve coil cylinder 1, 2 and 3) open circuit		x	x	x
Bank 2 (Solenoid valve coil cylinder 4, 5 and 6) short circuit/not classifyable	x	x	x	x
Bank 2 (Solenoid valve coil cylinder 4, 5 and 6) open circuit	x	x	x	x
Misfire in multiple cylinders	x			
Defective ECU	x	x	x	
Interfaces 1 (CAN-BUS)				
CAN BUS A off	x			
CAN BUS B off	x			

DIAGNOSIS WITH THE PT-01 INSTRUMENT

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

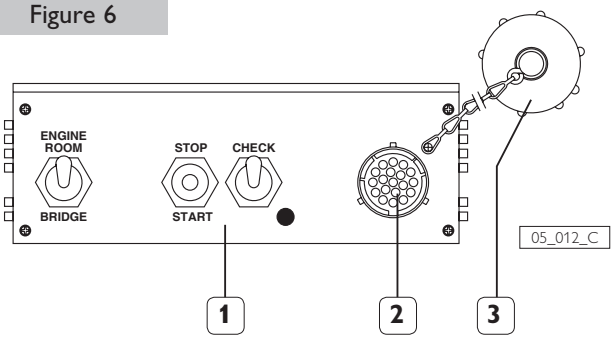
Figure 5



1. USB Indicator light - 2. LEDs signalling communication between instrument and central unit, and correct power supply - 3. Connector to engine diagnosis 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. 6).

Figure 6



1. Relay box - 2. Connector for external diagnosis instrument (J1) - 3. Protective cap.

The instrument is powered directly from the diagnosis outlet. In case of prolonged use with the engine off, the instrument can be powered externally through the connector (4) of Fig. 5.
After establishing a 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. Diagnosis
2. Utility
3. 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 diagnosis procedure, press the **1** key and confirm with the ☑ key.

The instrument displays the following options:

```
1. Identifier
2. Fault memory
3. Parameter reading
```

An 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, related specifically to the central unit system:

IDENTIFIER	PARAMETER	DESCRIPTION
0	HARDWARE VERSION	ECU hardware version
1	SOFTWARE VERSION	ECU software version
2	DATA SET ID	Data set engineering code
3	TYPE OF MOTOR	-
4	MOTOR SERIAL NUMBER	-
5	TYPE OF STATION	Station which carried out the last, first or second level programming (production plant or technical assistance department)
6	STATION NUMBER	Station serial number
7	PROGRAMMING SOFTWARE	Software used at the production plant or at the technical assistance department
8	PROGRAMMING DATA	-
9	DIS	ID Data set identification code recorded in the ECU
10	ALPHACODE	Series of characters which identifies the second level programming
11	IMA/NIMA CODE	EUI injector codes

- 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 intermittent 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 faults, 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 can 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
- Overspeed engine;
- Injectors;
- Pre-post heating control system.

Power supply voltage

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 in two categories:

- Measurable;
- State.

List of measurable parameters
- Motor rotations from flywheel sensor;
- Motor rotations from distribution shaft sensor;
- Injection anticipation;
- Room pressure;
- Battery power;
- Position of accelerator lever;
- Supercharge pressure;
- Lubricating oil pressure;
- Supercharge air temperature;
- Cooling liquid temperature;
- Fuel temperature;
- Lubricating oil temperature;
- Amount of forced fuel;
- Total motor torque.

List of ECU status parameters
- Key on gear (+15);
- Key on start-up (+50);
- Activation request from relè box;
- Stop request from relè box;
- Presence of water in the fuel pre-filter.

Active diagnostics

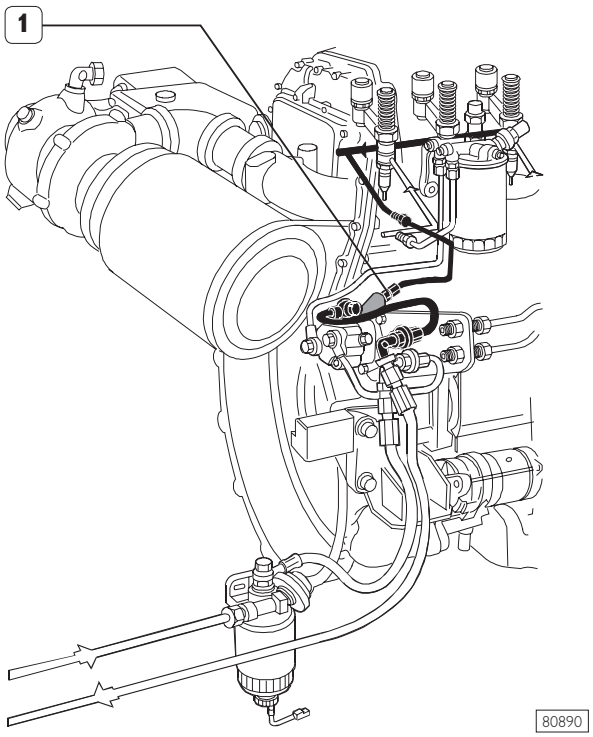
This function is not available at the moment.

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 7



To obtain reliable values, measurement on the line must be taken with a pressure gauge with 10 bar scale end with oil damped indicator. The gauge will be connected through a "T" joint inserted in point (1), upstream of the valve set present on the fuel supply pump. With the engine idling, pressure should be 3.5 bar, with a tendency to increase with engine RPM, until achieving a maximum value of over 5 bar. The measurement is reliable if taken under actual engine loading conditions, i.e. while underway.

Venting the fuel loop

See Section 6.

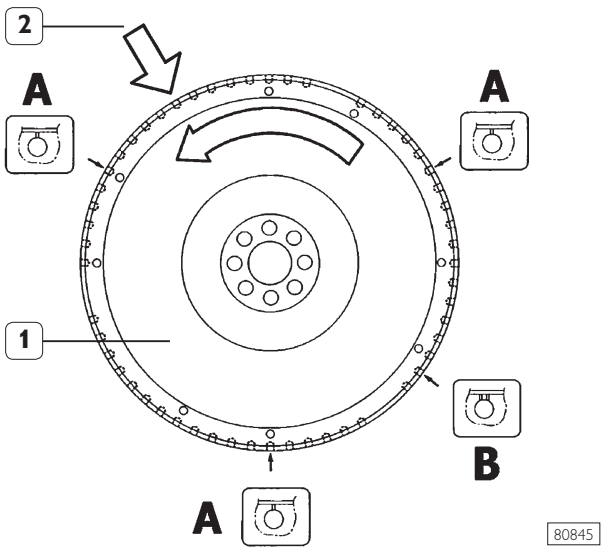
Checking the keying of timing phonic wheel

See Section 6.

Checking the timing phase

The camshaft is correctly in phase when, with the drive shaft in top dead center of the cylinder piston no. 1 at end of compression, the elevation measured on the roller of the rocker arm driving the injector of cylinder no. 1 is between 5.28 mm e 5.38 mm.

Figure 8

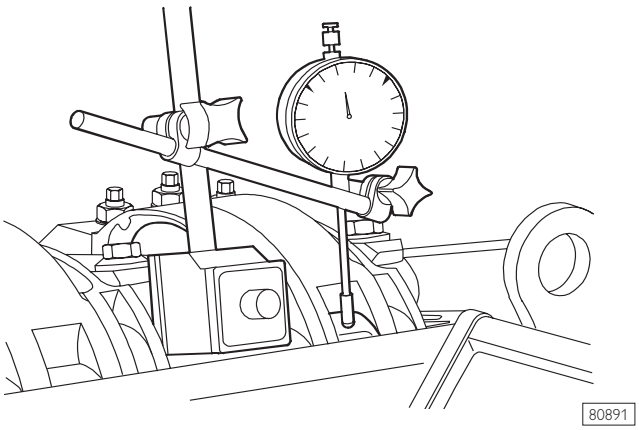


A. Holes marked with a notch - B. Hole marked with two notches - 1. Engine flywheel - 2. Flywheel position sensor.

Procedure

Rotate the drive shaft in the position corresponding at the piston of cylinder no. 1 to end of compression top dead center; from the inspection port below the flywheel case you will be able to see a hole marked with a notch (A) and simultaneously from the seat of the flywheel sensor, indicated with the arrow in the figure, you will be able to see the 11th hole of the sector (identifiable by rotating the flywheel in the normal direction of rotation of the engine, starting to count with no. 1 after the segment lacking holes).

Figure 9

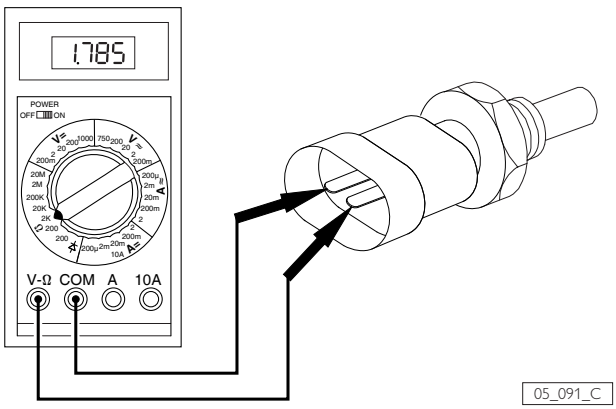


- ❑ Position a magnetic base comparator (1) on the upper plane of the cylinder head with the feeler pin vertical on the roller (2) of the EUI control rocker arm of cylinder no. 1 and pre-load it by about 8 mm;
- ❑ Rotate the drive shaft in the opposite direction to normal rotation until the height of the comparator reaches the minimum value (confirmed by a wide arc of rotation during which the value does not change):
  - Set the comparator to zero;
  - Rotate the drive shaft in the normal direction of rotation until from the inspection port you can again see a hole on the flywheel marked with a notch and the end of the tool 993606612, inserted in the seat of the flywheel sensor, enters the underlying flywheel hole.

The phase is correct if the height indicated by the comparator is 5.33 ± 0.05 mm (between 5.28 and 5.38 mm). Otherwise, the camshaft needs to be set in phase as indicated in Section 6.

Checking component resistance value

Figure 10



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.

Verifica dell'isolamento linee

Figure 11

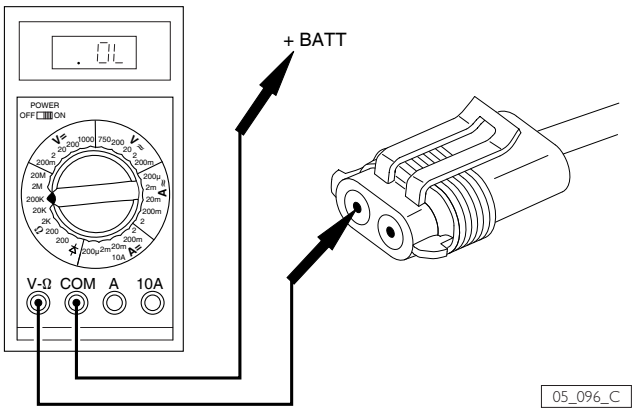
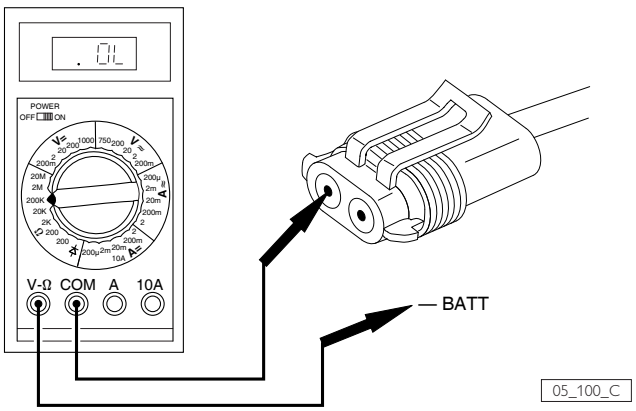


Figure 12



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

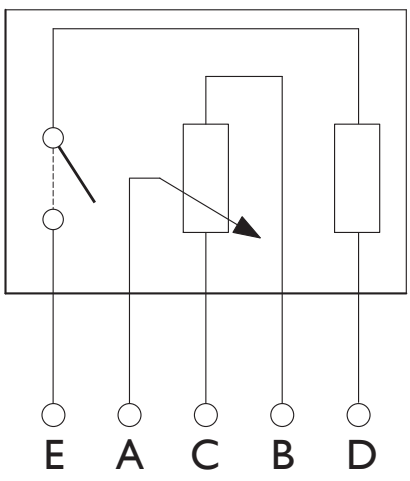
Component	Test conditions	Minimum Ω value	Maximum Ω value
Intake air temperature sensor	-10 °C	8100	10800
Coolant temperature sensor	0 °C	5200	6750
	20 °C	2300	2700
Fuel temperature sensor	50 °C	730	950
Lubricant oil temperature sensor	80 °C	300	360
Flywheel position and rotation sensor	20 °C	800	1000
Camshaft position and rotation sensor	20 °C	800	1000
Safety contact in throttle position sensor	Lever in position 0	Open circuit	
	Lever in position ≠ 0	1000	
Solenoid valve coil EUI Injector	-	0.5	0.6
Electrical heating element (on request)	-	0.2	0.3

CAUTION

Measurements refer only to the reference component.
The actual measurement of small values of resistance requires use of instruments with the SELF-ZEROING function or, if these are not available, subtract from the read value 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.

Throttle position sensor

Figure 13



REFERENCE VALUES

For wired sensors powered by the ECU

Component	ECU connection	Test conditions	Minimum - maximum value
Combustion air temperature sensor signal	A36 A25	Panel key ON	0,5 ÷ 4,5 Vcc
Coolant temperature sensor signal	A15 A26	Panel key ON	0,5 ÷ 4,5 Vcc
Fuel oil temperature sensor signal	A35 A18	Panel key ON	0,5 ÷ 4,5 Vcc
Lubricating oil temperature sensor signal	A28 A24	Panel key ON	0,5 ÷ 4,5 Vcc
Flywheel position and rotation sensor signal	A19 A23	Engine running 600 rpm	> 0,8 Vac
Camshaft position and rotation sensor signal	A9 A10	Engine running 600 rpm	> 0,2 Vac
Combustion air absolute pressure sensor signal	A34 A25	Engine running 600 rpm	0,9 ÷ 1,1 Vcc
Lubricating oil pressure sensor power supply	A27 A24	Engine running 600 rpm	> 1 Vcc
Combustion air absolute pressure sensor power supply	A33 A25	Panel key ON	4,5 ÷ 5,5 Vcc
Lubricating oil pressure sensor power supply	A32 A24	Panel key ON	4,5 ÷ 5,5 Vcc
Safety signal from throttle position sensor	A2 48 A2 29	Lever in position 0	> 4 Vcc
		Lever in position ≠ 0	< 1 Vcc
Throttle lever position sensor power supply	A2 77 A2 78	Panel key ON	4,5 ÷ 5,5 Vcc
Position signal from throttle position sensor	A2 79 A2 78	Lever in position 0	0,3 ÷ 0,5 Vcc
		Lever in position ≠ 0	0.3 ÷> 3 Vcc

GUIDE TO SYMPTOM DIAGNOSIS

Blink Code	Symptom	Part	Possible cause	Recommended tests or action
NO	Engine does not start	Batteries	- Low charge - Faulty terminal connections	- Recharge (disconnecting system wiring) - Clean, check, tighten terminals or replace them
NO	Engine does not start	Electrical starter motor	- Malfunction - Faulty terminal connections	- Check - Clean, check, tighten terminals
NO	Engine does not start	Relay to control power supply to terminal 50 of the electric starter motor (contained in the relay box)	- Malfunction	- Check supply wiring - Check main relay, replace
NO	Engine does not start	Fuel feed pump	- Priming incorrect (air leaking inside)	- Check seal on intake branch - Check pressure
NO	Engine does not start	Fuel circuit	- Incorrect filling (air in fuel circuit)	- Check seal - Bleed circuit
NO	Engine does not start	Fuel filter and pre-filter	- Filter and pre-filter clogged	- Check reservoir - Replace
NO	Engine does not start	Electrical grid heater (if present), at temperatures lower than 0 °C.	- Malfunction - Faulty terminal connections	- Check supply and earth connection - Carry out active diagnosis

GUIDE TO SYMPTOM DIAGNOSIS

Blink Code	Symptom	Part	Possible cause	Recommended tests or action
NO	Engine overheats	Coolant level	- Below MIN level	- Check for leaks - Top up correct level
NO	Engine overheats	Coolant pump drive belt	- Loose tension - Wear	- Check tension - Replace - Verify liquid spillage on the belt
NO	Engine overheats	Coolant pump	- Malfunction	- Check belt tension - Replace
NO	Engine overheats	Thermostatic valve	- Locked, closed or only partially open	- Check coolant liquid - Replace
NO	Engine overheats	Coolant-sea water heat exchanger	- Clogged	- Clean or replace
NO	Engine overheats	Air filter	- Clogged	- Check filter clogged indicator - Replace filter
NO	Engine overheats	Cylinder head gasket	- Compression leaking from cylinder head gasket	- Check water circuit pressure - Replace head gasket

GUIDE TO SYMPTOM DIAGNOSIS

Blink Code	Symptom	Part	Possible cause	Recommended tests or action
NO	Poor performance	Fuel circuit	- Reservoir net filter clogged - Fuel prefilter clogged - Fuel filter clogged - Air in fuel circuit - Fuel pressure too low - Heavy fuel leakage	- Replace clogged filters - Check intake seals - Check pressure relief valve on the fuel gear pump - Check the integrity of the fuel gear pump
NO	Poor performance	Injectors	- Malfunction - Fuel leaking from seal rings	- Check for fuel presence in engine - Call IVECO MOTORS-FPT and follow their instructions to replace the injectors
NO	Poor performance	Air filter	- Clogged	- Check filter clogged indicator - Replace filter
NO	Poor performance	Gas exhaust system	- Leaks from exhaust manifold	- Check and remove cause of leak
NO	Poor performance	Turbocompressor	- Blades inefficient - Bearings inefficient	- Check parts and lubrication circuit - Replace
NO	Poor performance	Control cams	- Wear - Incorrect timing	- Check, replace - Check, restore
NO	Poor performance	Valves	- Excessive or no clearance	- Check, restore correct clearance
NO	Poor performance	Intake air pressure sensor	- Output signal too low (below to the pressure value)	- Using a multimeter on the component, check the output voltage and refer to a manometer
NO	Poor performance	- Intake air temperature sensor - Water temperature sensor - Fuel temperature sensor	- Output signal too high	- Using a multimeter on the component, check the resistance and refer to a thermometer

GUIDE TO SYMPTOM DIAGNOSIS

Blink Code	Symptom	Part	Possible cause	Recommended tests or action
NO	The engine emits grey-white smoke	Water in cylinders	- Leakages from cylinder gasket - Leakages from injector sleeves - Water in intake system - Water in fuel	- Check level and pressurization of water circuit - Check fuel tank, clean as required - Check water in fuel sensor
NO	The engine emits blue smoke	Oil in cylinders	- Excessive oil consumption - Oil leaking in turbocompressor - Oil leaking from valve guides	- Check lubrication oil consumption - Overhaul
NO	Engine stops	Fuel reservoir	- Fuel reservoir empty	- Refill and bleed fuel circuit
NO	Engine stops	Net filter Prefilter Fuel filter	- Filter clogged	- Clean, replace
NO	Engine stops	Fuel circuit	- See item "Poor performance"	- See item "Poor performance"

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SECTION 5

MAINTENANCE

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PERIODICITY OF CHECKS AND MAINTENANCE OPERATIONS

Execution of the operations indicated below requires competence and compliance with the safety regulations enforced in various Countries.
Checks can be performed by the user of the vessel and/or by 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 operations must be performed by IVECO MOTORS-FPT authorized workshop personnel with adequate training and sufficient technical information.

Checks		**Periodicity**						
		Every start	150 hours	300 hours	600 hours	900 hours	1200 hours	Annual (2)
Check engine lubricating oil level		■						
Check engine coolant level		■						
Check oil level in the gearbox		■						
Inspect exhaust duct(s)		■						
Drain water from fuel pre-filter(s)	(1)		■					
Check battery terminal tightening and cleanliness				■				■
Check electrolyte level in batteries	(1)			■				■
Check condition of oil vapor filter with clogging indicator (with the engine running)				■				

Periodic maintenance operations		**Periodicity**						
		Every start	150 hours	300 hours	600 hours	900 hours	1200 hours	Annual (2)
Clean air filter(s)	(1)			■				■
Check belt tension and conditions				■				■
Check zinc anode corrosion condition	(4)			■				■
Restore battery electrolyte level				■				■
Drain/draw water and condensations from tank(s)	(1)			■				■
Replace engine lubricating oil					■			■
Replace oil vapor filter	(8)				■			■
Replace fuel pre-filter(s)	(1) (3)				Max			■
Replace fuel filter(s)	(1) (3)				Max			■
Replace oil filter(s)					■			■
Replace gearbox(es) oil (see data provided by the manufacturer)					■			■
Check seal of one-way valve in pre-lubrication system (as required)					■			■
Clean turbocompressor						■		■
Inspect sea water intake	(1)					■		■
Check wear of sea water pump impeller						■		■
Adjust valve-rocker arm clearance							■	

Extraordinary maintenance operations (5)		**Periodicity**						
		Every start	150 hours	300 hours	600 hours	900 hours	1200 hours	Every 3 years (7)
Clean heat exchangers	(6)					■		■
Check pre-post heating system operating condition (as required)							■	■
Replace water pump and alternator drive belt							■	■
Inspect damper in drive shaft front pulley								■

(1) The periodicity of these operations may vary depending on engine use and environmental conditions of operation.

(2) These operations must be conducted annually even if the specified number of operating hours is not reached.

(3) Maximum time interval for high quality fuel; This may be reduced depending on contamination. The filter is provided with a clogging sensor; if a clogging indication occurs, replace the filter. The pre-filter is provided with a water presence detector; if the presence of water is detected, drain the water from the appropriate drain and if the light stays lighted, replace the filter.

(4) If zinc corrosion exceeds 50% of its volume, replace it.

(5) Instructions provided in Section 6.

(6) Combustion air/sea water exchanger: clean air side and water side. Engine coolant/sea water exchanger: clean the sea water side. Gearbox oil/sea water exchanger (if provided): clean sea water side.

(7) These operations must be performed every three years even if the specified operating hours are not reached.

(8) On every engine oil replacement.

PREPARING THE ENGINE FOR LONG IDLE PERIODS

To prevent oxidation of the internal parts of the engine and of 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:

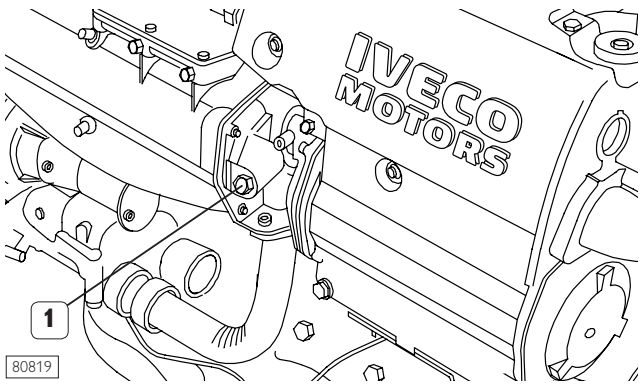
1. Drain the lubricating oil from the sump, after heating the engine;
2. Pour 30/M protective oil (alternatively, oil conforming with MIL 2160B Type 2 specifications) into the engine to the "minimum" level marked on the dipstick.
   Start the engine and let it run for about 5 minutes;
3. Drain the fuel from the injection line, from the filter and from the ducts in the cylinder heads. To do so, loosen the drain cap in the front part of the cylinder head and the fuel inlet junction with the cylinder head, taking care to prevent the fuel from coming 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 24 V, using a conductor prepared for the occasion;
5. Nebulize 30/M protective oil at the rate of about 130 g (10 g per liter of displacement) into the two turbocompressors 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 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 anti-freeze 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. In order to enable the sea water pump priming it is necessary to input water into the forcing circuit.
   Remove the sacrifical anode (1 of Figure 1), introduce 1.5 litres of water into the hole; reassemble the anode and tighten it as required.
   WARNING
   If the engine is activated after a long time, it is necessary to repeat the operations mentioned in item 7.
8. Start the engine and keep it running until idling speed has completely stabilized;
9. 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;
10. Remove the tags with the inscription "ENGINE WITHOUT OIL" from the engine and from the panel.

Figure 1



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SECTION 6

SERVICING OPERATIONS ON INSTALLED ENGINE

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FOREWORD

Many of the procedures for carrying out the instructions that follow depend on the con.tion of the housing on the vessel and on the configuration 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 "C13 ENT M77 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 refers to engine characteristics that were current as of the publishing data.
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 AND ITS COMPONENTS

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 diagnosis equipment, writing the results down or printing them.

- ❑ Replacement of the ECU EDC7 UC31 must be authorized by IVECO MOTORS-FPT after specific agreements with the Technical Assistance Service;
- ❑ The electro-injectors cannot be overhauled; 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 of the filter;
- ❑ Maintain the proper polarization of all electrical connections;
- ❑ Tighten the threaded connections to the prescribed torque;
- ❑ Ensure that the flywheel and camshaft sensors are positioned so they abut, ensuring they are as close to perpendicular as possible with the bearing surface.

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.**

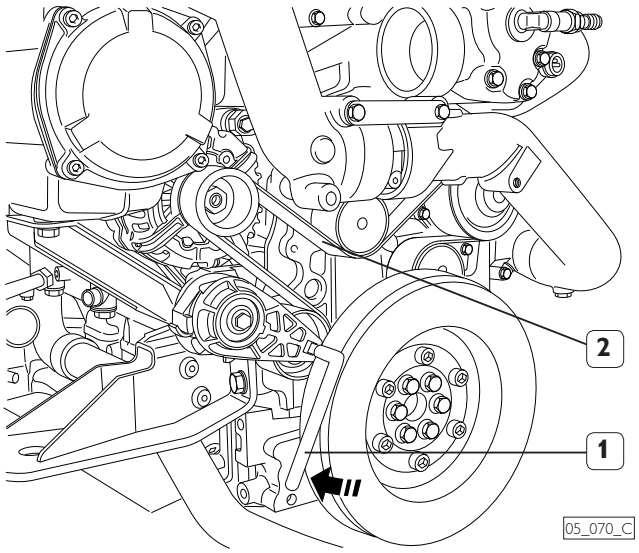
To proceed with the overhaul of the engine or its parts, you must disconnect the electrical connections of the injection system's components and of the sensors providing indications on the control panel.

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.

REPLACING BELT

Figure 1

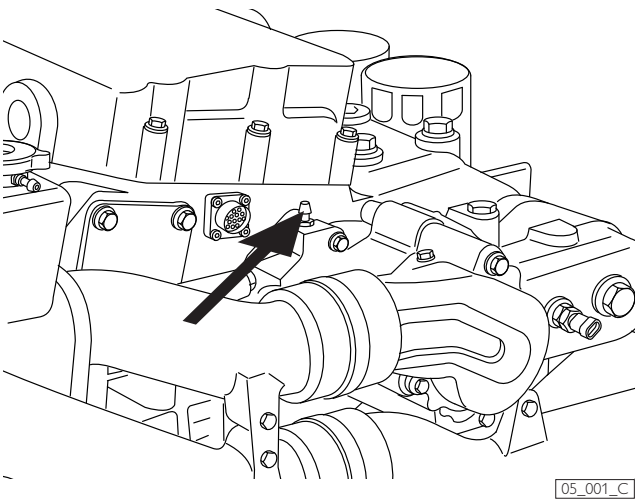


❑ With the tool (1) loosen the tensioning device acting in the direction indicated by the arrow. Extract the auxiliary organ drive belt (2), insert the new belt verifying that it is correctly set onto the pulleys. Release the tensioning device. The automatic tensioning device requires no further adjustment.

REPLACING EUI PUMPING UNITS

EUI Disassembly

Figure 2

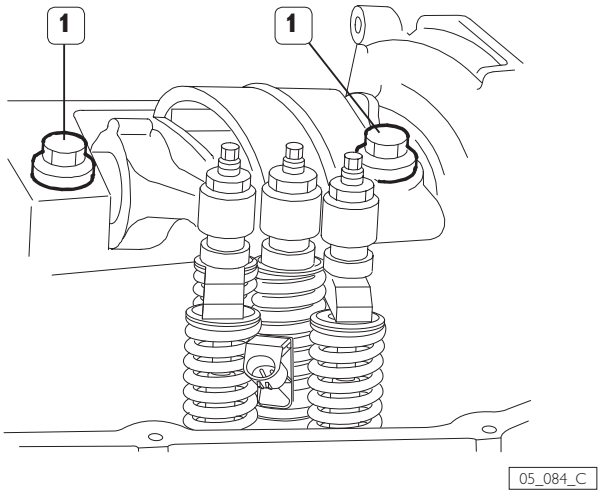


DRAINAGE CONNECTOR ON CYLINDER HEAD

CAUTION

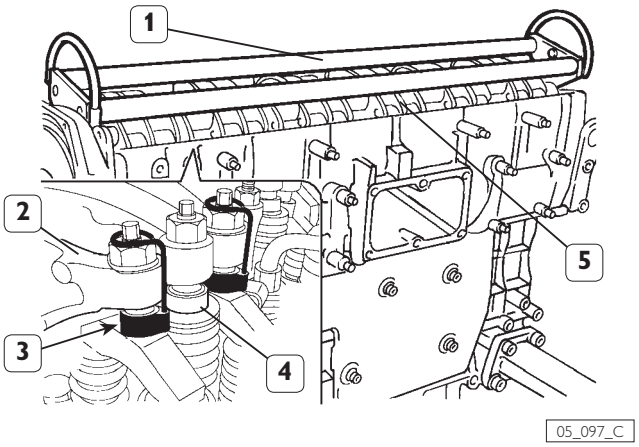
Before extracting the EUI you must empty the fuel inflow and recirculation channels machined in the cylinder head, to prevent the liquid from dripping into the underlying combustion chamber machined in the piston crown. To do so, loosen the drainage cap (1 in Figure 2) located in the front part of the cylinder head and the cylinder head fuel inlet connector. Avoid spilling fuel into the environment and coming into contact with the auxiliary organ belt.

Figure 3



❑ After removing the timing lid, unscrew the rocker arm shaft fastening screws (1).

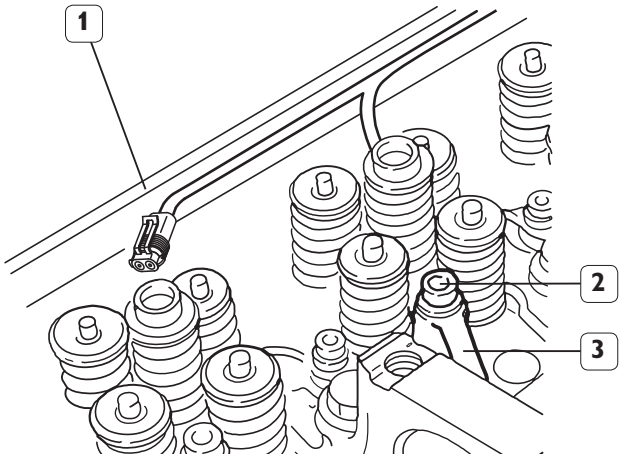
Figure 4



❑ With the tool 99360144 (3) secure the blocks (4) to the rocker arms (2);

❑ Apply the tool 99360553 (1) to the rocker arm shaft (5) and remove the shaft (5) from the cylinder head.

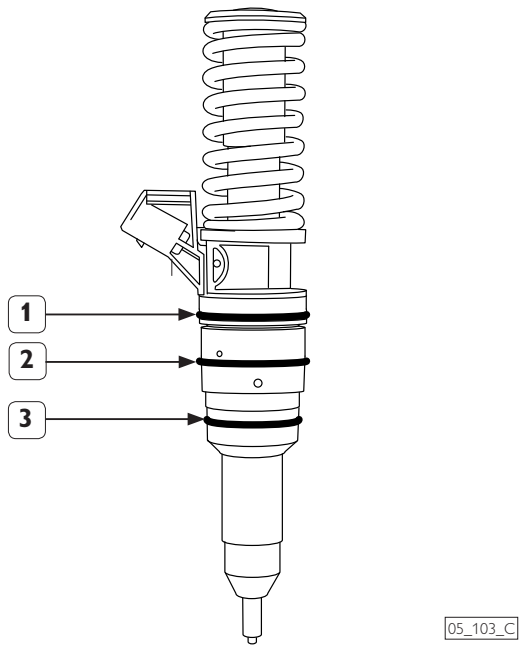
Figure 5



- ❏ Unscrew the screws and remove the electrical connections (1) from the units to be removed;
- ❏ Unscrew the screws (2) fastening the injector brackets (3).
- ❏ Extract the injectors (2).

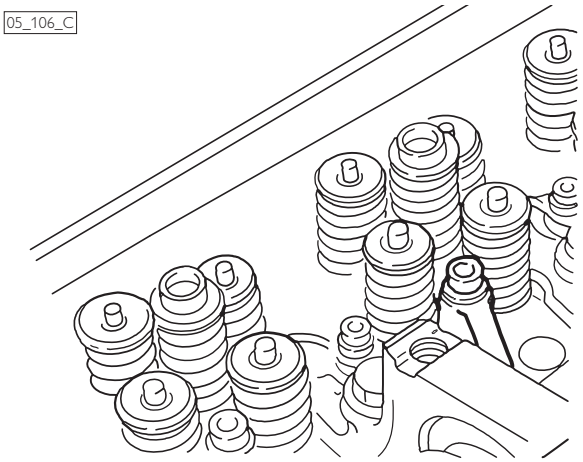
EUI Assembly

Figure 6



- ❏ Mount the seal rings (1) (2) (3) on the injectors. Grease the rings with Vaseline to ease a correct positioning in their seats.

Figure 7



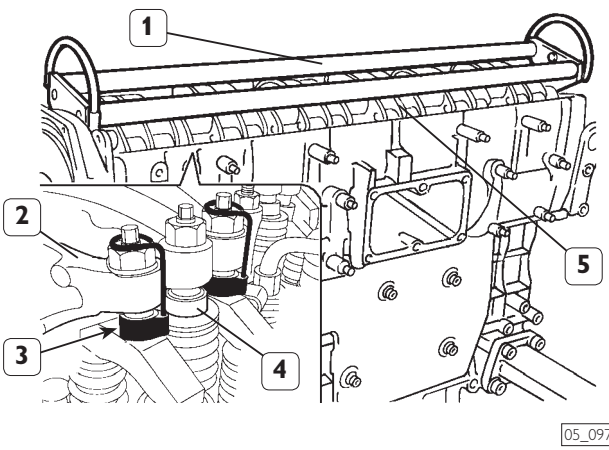
- ❏ Carefully position the injectors (1) into the seats and use a torque wrench to tighten the bracket screws at the torque of 26 Nm;
- ❏ Mount the braces on the valve stems all oriented with the larger hole on the same side.

CAUTION

Before reassembling the rocker arm shaft assembly, ensure that all adjustment screws have been completely unscrewed.

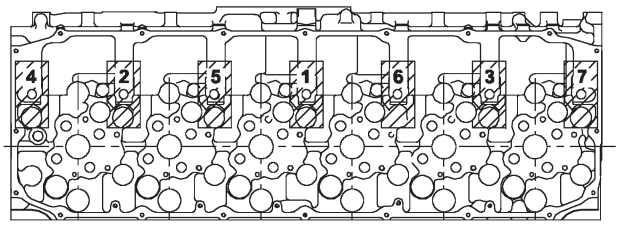
Rocker arm shaft assembly

Figura 8



- ❏ Use the tool 99360144 (3) to fasten the blocks (4) to the rocker arms (2);
- ❏ Apply the tool 99360553 (1) to the rocker arm shaft (5) and mount the shaft on the cylinder head.

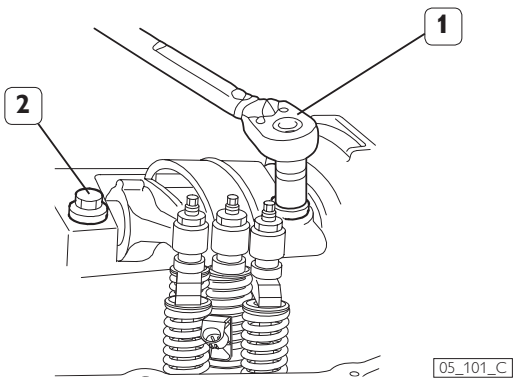
Figure 9



SCHEME OF SCREW TIGHTENING SEQUENCE SECURING ROCKER ARMS

Tighten the screws (1 - 2 - 3) until the rocker arms are brought into contact with the relative seats on the cylinder head, tighten the screws according to the sequence indicated in the figure above and operate in two steps as indicated in the following figure.

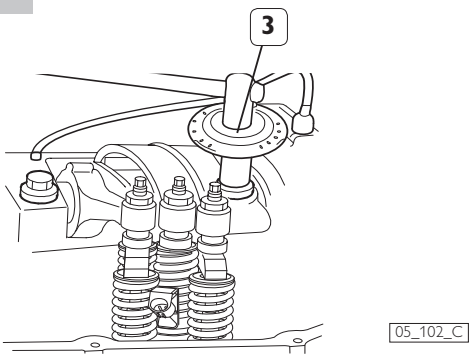
Figure 10



Tighten the rocker arm shaft screws (2) as follows:

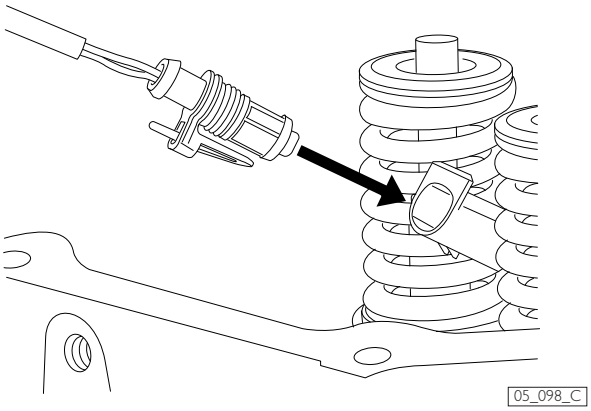
- ❏ Turn the screws until they bear against the rocker arm shaft;
- ❏ Pre-tighten with torque wrench (1) to a torque of 80 Nm (8 kgm);

Figure 11



- ❏ Tighten with tool 99395216 (3), at an angle of 60°.

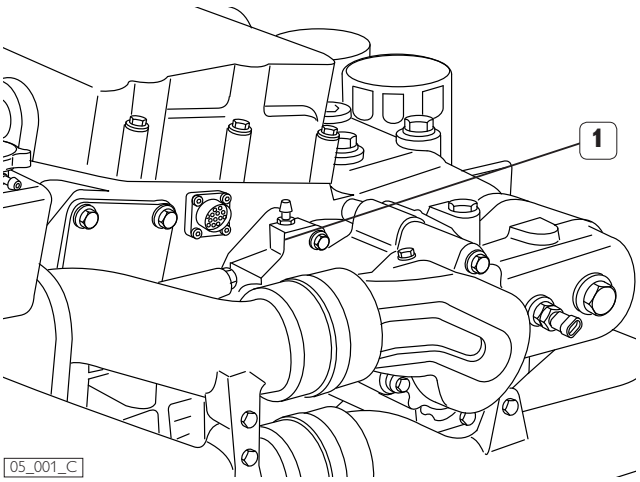
Figure 12



- ❏ Assemble the electric wiring by connecting the connectors with the EUI electro valves.

VENTING THE AIR FROM THE FUEL FEED LOOP

Figure 13



1. Purge fitting on cylinder head.

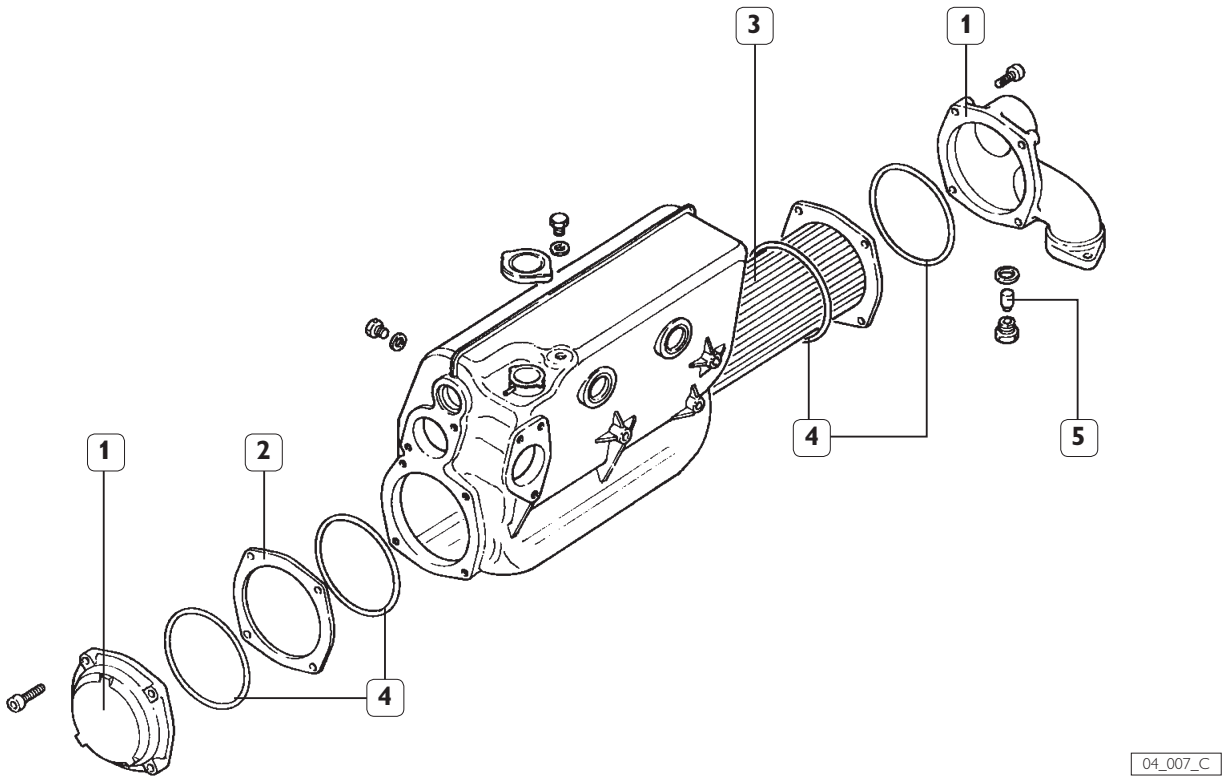
To complete venting the air from the fuel feed loop, act on the hand pump of the prefilter or with the aid of a dedicated electrical pump.
The venting air points are fitted on the pre-filter supplied by IVECO MOTORS-FPT, after the main filter, on the cylinder head near the injectors solenoid valves connector. (see Figure 12). Loosen the vent fitting on the pre-filter and operate the pump until only fuel without air flows out.
Tighten the vent fitting and complete the purge operation on the vent fitting placed on the cylinder head during the initial start-up phases.

CAUTION

Make sure that the fuel that flows out of the fitting does not come in conctact with the auxiliaries drive belt and is not dispersed in the environment.

CLEANING THE ENGINE COOLANT/SEA WATER HEAT EXCHANGER

Figure 14



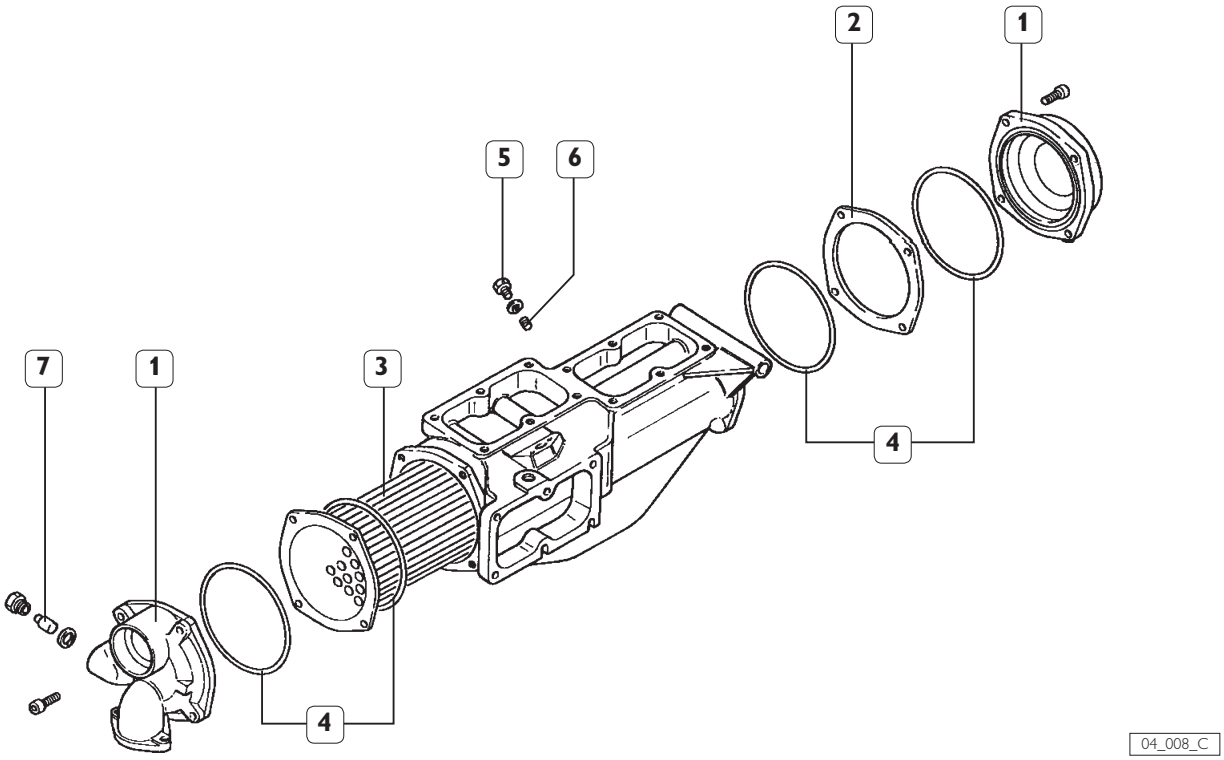
1. Cover - 2. Spacer - 3. Tube bundle - 4. Sealing rings - 5. Zinc sacrificial anode.

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 deposits which may be present in harbors' waters.

- ❏ 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 residuals are entirely removed;
- ❏ Reassemble the tube bundle (3) by correctly positioning spacer (2), sealing rings (4) and covers (1);
- ❏ Check the zinc anode corrosion level (5); replace the anode if corrosion exceeds 50% of the volume.

CLEANING THE AIR/SEA WATER HEAT EXCHANGER

Figure 15



1. Cover - 2. Spacer - 3. Tube bundle - 4. Sealing rings - 5. Plug - 6. Tube bundle fixing screw - 7. 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 deposits which may be present in harbors' waters; surfaces coming into contact with combusting air are subject to oil deposits resulting from the fumes exhausted at the base and sucked downstream of the air filter.

- ❏ Remove tube bundle fixing plugs (5) and screws (6);
- ❏ 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 residuals are entirely removed;
- ❏ Reassemble the tube bundle (3) by correctly positioning spacers (2), sealing rings (4) and covers (1);
- ❏ Reassemble screws (6) in order to suitably secure the tube bundle and relevant plugs (5);
- ❏ Check the zinc anode corrosion level (7); replace the anode if corrosion exceeds 50% of the volume.

ADJUSTMENTS

Adjusting camshaft phase

This consists of ensuring the precise angular position of the camshaft relative to a precise angular position of the drive shaft.

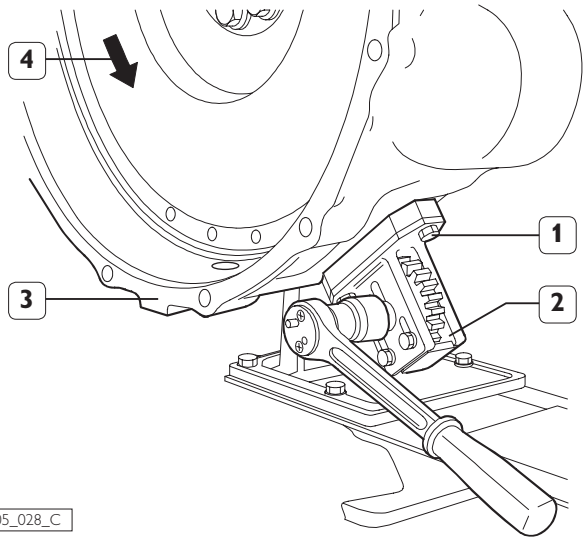
CAUTION

The procedure described below presumes that the initial position of the two shafts is already approximately correct.
Otherwise, during rotation there could be collisions between the valves and the piston crowns.

CAUTION

With engine mounted, the precise drive shaft position references always require checking the timing to identify the phase of operation.

Figure 16



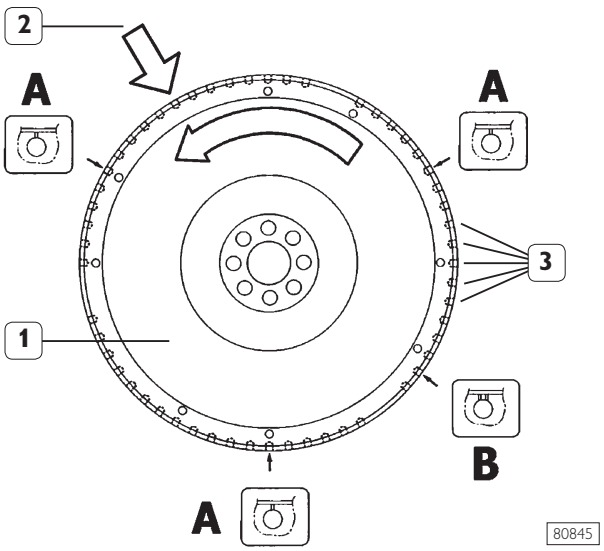
Apply the tool 99360321 (2) and the spacer 99360325 (3) to the gearbox (1). The arrow (4) shows the direction of rotation of the engine when running.

CAUTION

The procedures described require rotating the drive shaft in such a position as to bring pairs of pistons to the top dead center.
These positions can be identified from the inspection hole below the flywheel case where a hole marked with a notch will be visible (A in Figure 16) and simultaneously from the seat of the flywheel sensor indicated by the arrow where the 11th hole of the sector will be visible (identifiable during the rotation of the flywheel in the normal direction of rotation of the engine starting to count with no. 1 after the segment without holes).

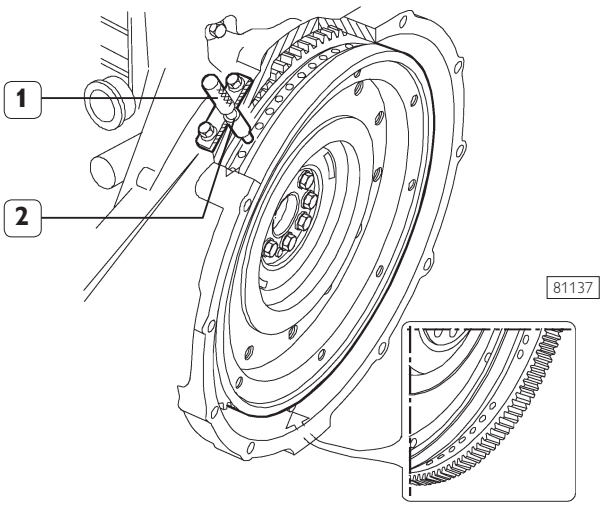
The camshaft is correctly in phase when, with the drive shaft in the top dead center position of cylinder piston no.1 at compression end, the elevation figure measured on the roller of the rocker arm controlling the pumping injector cylinder no.1 ranges between 5.28 mm and 5.38 mm.

Figure 17



1.Engine flywheel - 2. Flywheel sensor position - 3. Radial holes
A. One notch punching for TDC identification - B. Two notch punching to correlate flywheel and cam signal phase.

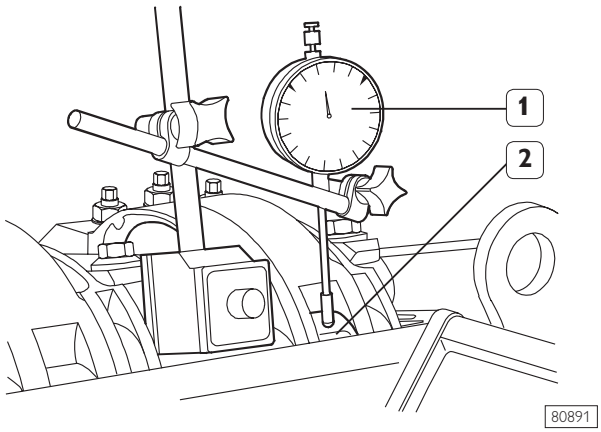
Figure 18



POSITION OF THE INSPECTION HOLE

Positioning the tool 99360612 (1) through the seat of the flywheel sensor (2) in the hole on the engine flywheel.

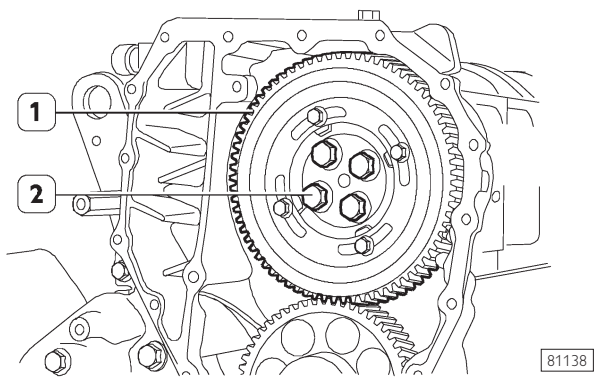
Figure 19



Phasing sequence:

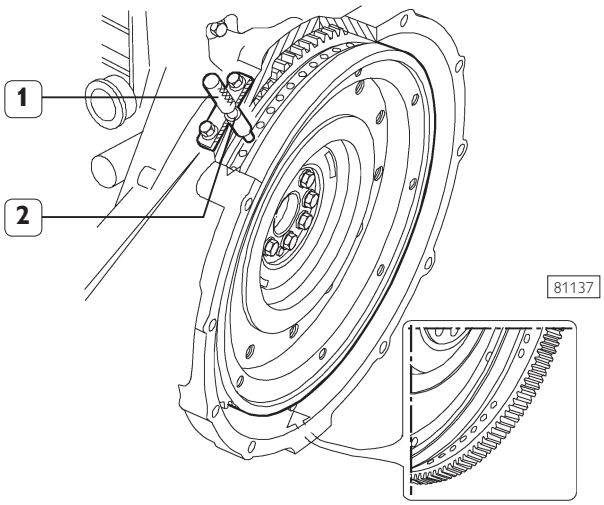
- ❏ With the tool 99360321 (2 in Figure 16) rotate the drive shaft to the position corresponding to the piston of cylinder no. 1 at compression end TDC, from the inspection port below the flywheel case you will be able to see a hole marked with a notch;
- ❏ Position a magnetic base comparator (1) on the upper plane of the cylinder head with the feeler pin vertical on the roller (2) of the pumping injector control rocker arm of cylinder no. 1 and pre-load it by about 6 mm;
- ❏ Rotate the drive shaft in the opposite direction to normal rotation until the height of the comparator reaches the minimum value (confirmed by a wide arc of rotation during which the value does not change);
- ❏ Set the comparator to zero;
- ❏ Rotate the drive shaft in the normal direction of rotation until the comparator shows the value of 5.33 mm.

Figure 20



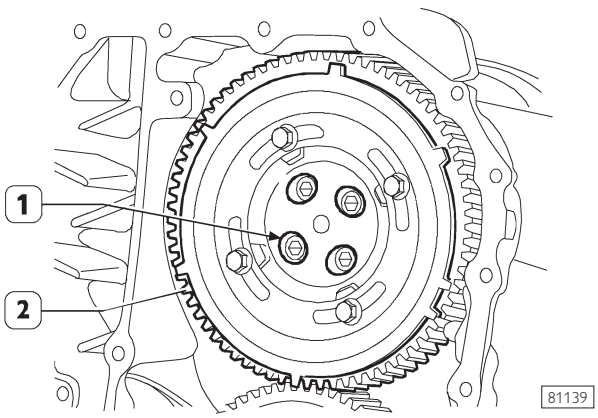
- ❏ Remove the 4 screws (2) and the gear wheel (1).

Figure 21



- ❏ Slowly rotate the drive shaft in the normal direction of rotation until the end of the pivot pin 99360612 (1), inserted into the seat of the flywheel sensor (2), enters the underlying 11th hole of the flywheel, locking it;
- ❏ From the inspection hole verify the presence of a hole on the flywheel marked with a notch, corresponding to the piston of cylinder no. 1 at compression end TDC.

Figure 22



- ❏ Mount the gear wheel (2) on the camshaft positioning it with the slot (1) in symmetrical position relative to the holes for the fastening screws;
- ❏ Tighten to the prescribed value the 4 screws that fasten the gear wheel, checking the stability of the value indicated by the comparator;
- ❏ Remove the pivot pin from the sensor seat and proceed with the next phase verification operation.

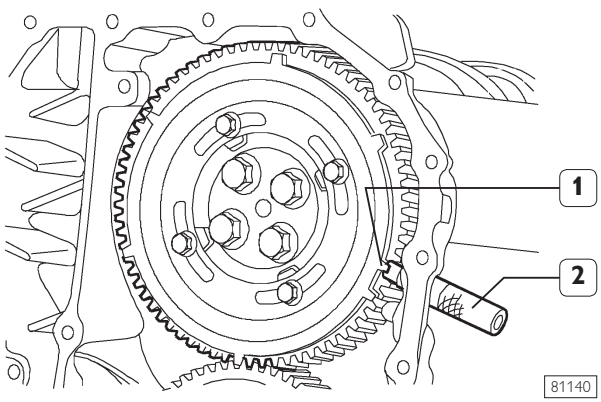
Checking the timing phase

- ❑ Rotate the drive shaft in the position corresponding to the piston of cylinder no. 1 at end of compression top dead center;
- ❑ Position the comparator as described above, verifying its zeroing by rotating the drive shaft in the direction opposite normal rotation;
- ❑ Rotate the drive shaft in the normal direction of rotation until from the inspection hole you can again see the presence of a hole on the flywheel marked with a notch and the end of the pivot pin enters the 11th hole of the flywheel;
- ❑ The phase is correct if the height indicated by the comparator is 5.33 ± 0.05 mm (between 5.28 and 5.38 mm);
- ❑ If this is not the case, you must repeat the phasing operations and subsequent check.

Timing shaft phonic wheel keying

This consists of assuring an appropriate angular position of the phonic wheel relative to the camshaft, thus allowing the associated sensor to provide the ECU with precise phase and drive shaft information.

Figure 23

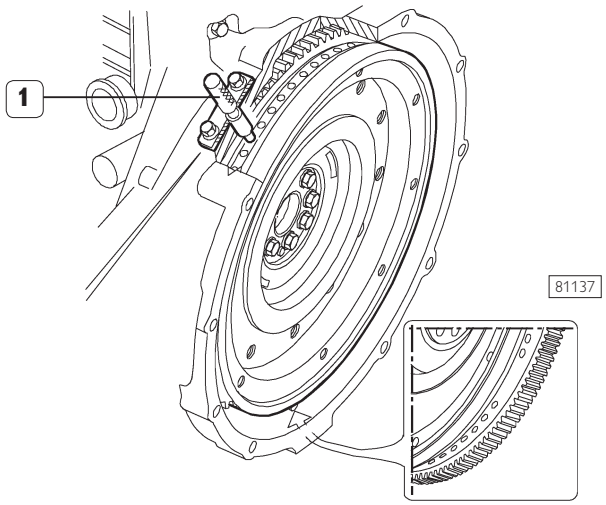


The phonic wheel of the camshaft is correctly in phase when, with the engine flywheel in angular position of 54° before compression end TDC of the piston of cylinder no. 1, the asymmetric tooth of the phonic wheel (1) exactly coincides with the position determined by the tool 99360613 (2).

Alignment sequence:

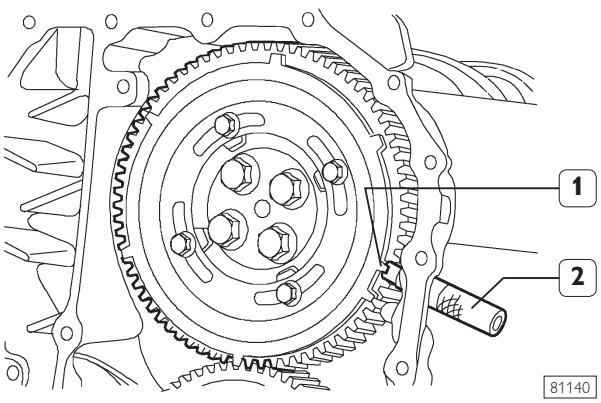
- ❑ Rotate the drive shaft to the position corresponding to the piston of cylinder no. 1 at compression end TDC;
- ❑ Rotate the drive shaft in the direction opposite normal rotation for about 90°.

Figure 24



- ❑ Again rotate the drive shaft in the normal direction of rotation until from the inspection hole below the flywheel case you see the hole marked with two notches and simultaneously from the seat of the flywheel sensor the 2nd hole of the sector is visible (identifiable during the rotation of the flywheel in the normal direction of engine rotation, starting to count with no. 1 after the segment lacking holes);
- ❑ Insert the tool 99360612 (1) into the seat of the flywheel sensor, with the end in the underlying hole of the flywheel to lock it.

Figure 25

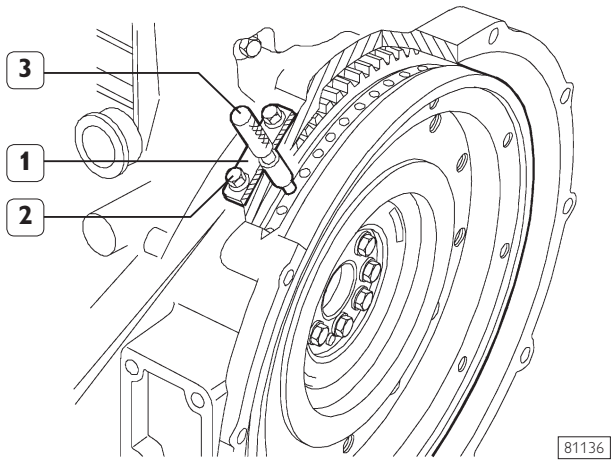


- ❑ In this position, the fork tool 99360613 (2), inserted into the seat of the camshaft sensor, must be inserted exactly into the asymmetrical tooth of the phonic wheel (1).

If the tooth is not positioned correctly, remove the 4 screws that fasten the phonic wheel, correct the position and tighten the screws treated with thread damper to the prescribed value.

Flywheel sensor seat position

Figure 26



The seat of the flywheel induction sensor is located on a plate (1) whose fastening holes are slotted. The screws (2) fasten the plate to the flywheel cover bell.

If in doubt about its proper positioning, or if you need to operate on the flywheel case or on the plate, you should adjust the position with the following procedure:

- ❏ Position the piston of cylinder no. 1 exactly at top dead center;
- ❏ Remove the sensor;
- ❏ Loosen the plate fastening screws (2);
- ❏ Insert the tool 99360612 (3) into the seat of the sensor;
- ❏ Ensure the tool enters the underlying radial hole of the flywheel;
- ❏ Tighten the plate fastening screws.

Adjusting valve clearance and EUI pump position

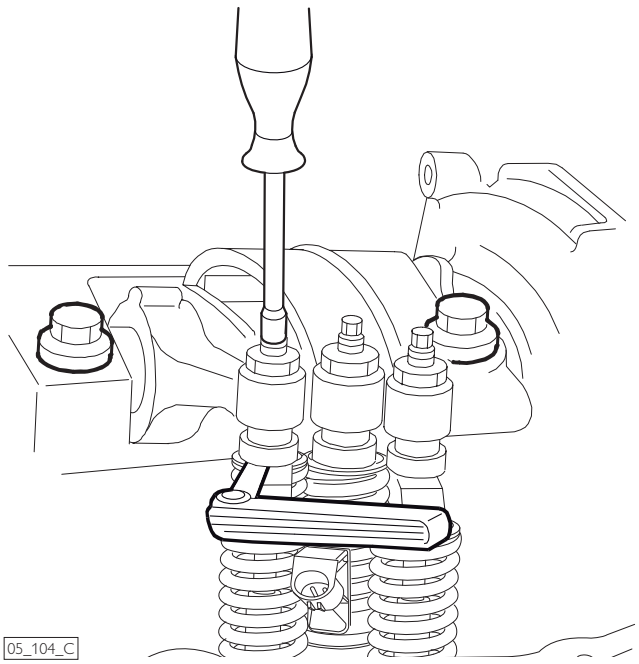
The operations described herein must be carried out thoroughly and carefully to assure the integrity and regular operation of the engine.
Bring the piston of the cylinder whose clearance is to be adjusted to the compression end TDC; the valves of this cylinder will be closed while both valves of the symmetrical cylinder will be open.

The pairs of symmetrical cylinders are:
1 - 6 2 - 5 3 - 4.

Strictly adhere to directions and data given below and on the table in the following page.

Adjusting valve clearance

Figure 27



The specified clearance value, with the engine cold, is:

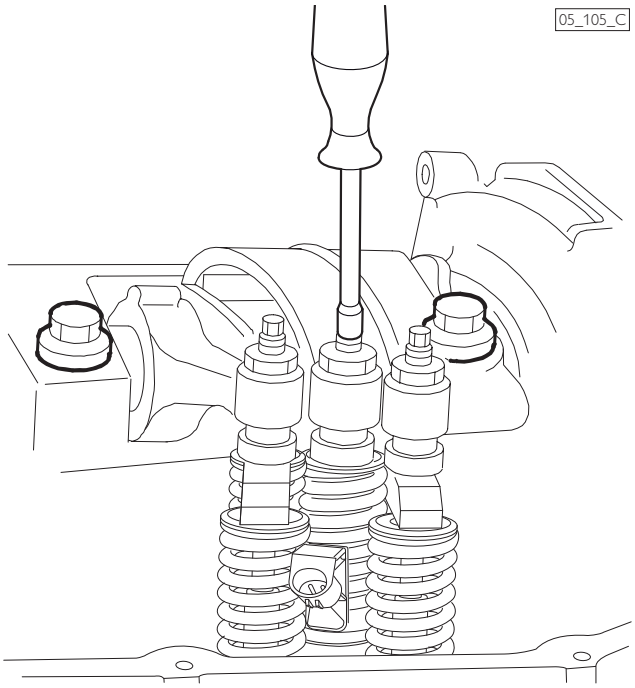
0.40 mm (0.35 to 0.45 mm) intake
0.50 mm (0.55 to 0.55 mm) exhaust.

Sequence:

- ❏ Bring the drive shaft to the proper position for the valves to be adjusted;
- ❏ Loosen the locking nut (1) of the adjustment screw;
- ❏ Insert the blade of the thickness gauge (3) between the rocker arm plate (2) and the valve control bridge;
- ❏ Act on the adjustment screw to obtain a sliding with slight friction of the blade of the thickness gauge;
- ❏ Tighten the locking nut (1) keeping the adjustment screw stationary.

Position of the EUI pump

Figure 28



Sequence:

- ❏ Bring the drive shaft to the proper position for the valves to be adjusted;
- ❏ Loosen the locking nut of the adjustment screw of EUI (6) control rocker arm (5);
- ❏ With the wrench (4) screw the register bringing the pumper to abut against the stop;
- ❏ Tighten the adjustment screw with a torque wrench to a torque of 5 Nm;
- ❏ Unscrew the adjustment screw by 180 to 270° (1/2 to 3/4 of a turn);
- ❏ Tighten the locking nut keeping the adjustment screw stationary.

Combustion sequence 1 - 4 - 2 - 6 - 3 - 5

Rotate with normal direction	Balanced valves cylinder number	Check valve clearance cylinder number	Check EUI clearance pumper number
Cylinder 1 at compression end	6	1	5
+ 120°	3	4	1
+ 120°	5	2	4
+ 120°	1	6	2
+ 120°	4	3	6
+ 120°	2	5	3

CAUTION

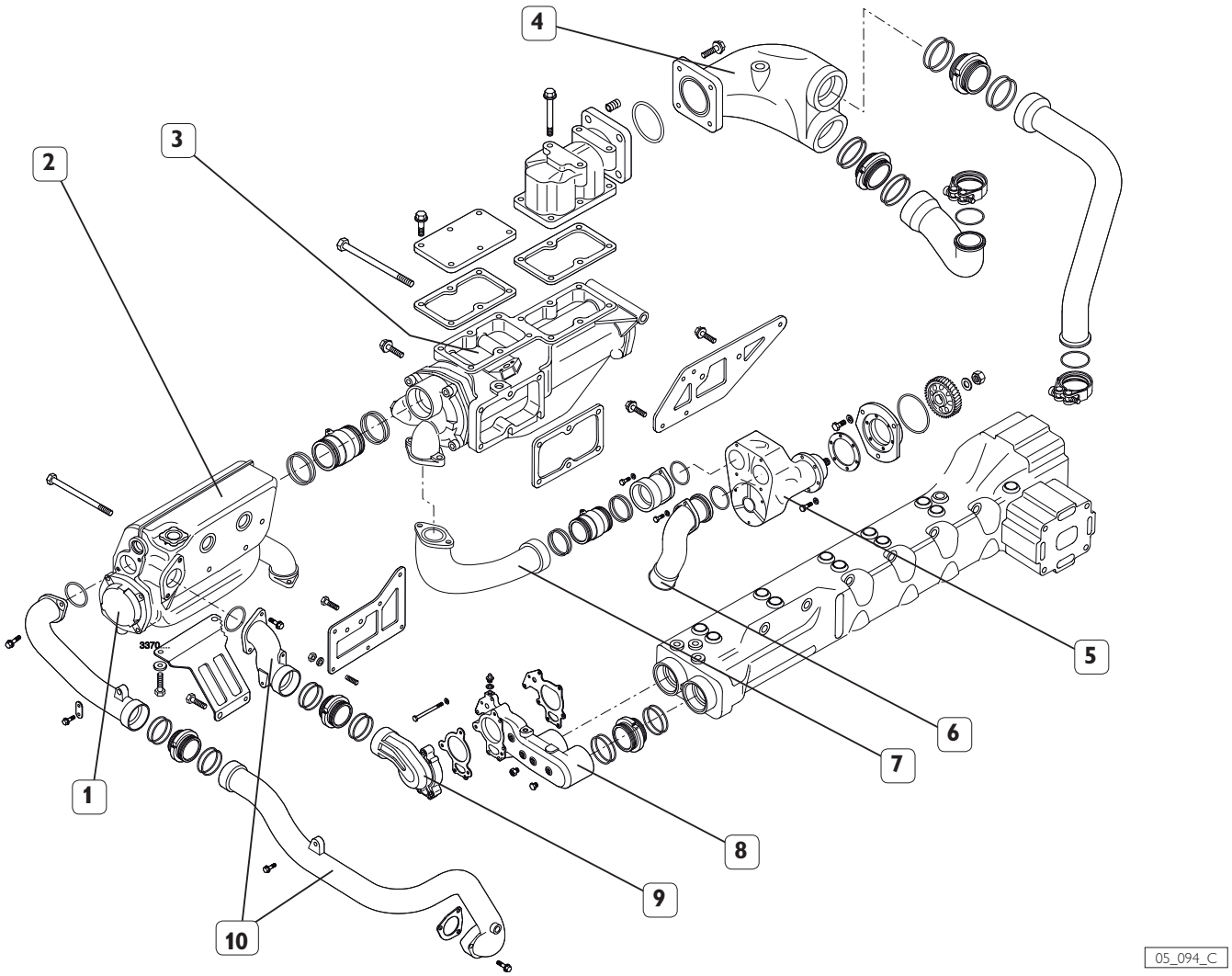
In order to properly carry out the above-mentioned adjustments, follow the sequence specified in the table, checking the exact position in each rotation phase by means of pin 99360612, to be inserted in the 11th hole in each of the three sectors with 18 holes each.

UNCOUPLING MARINE PARTS

The operations described below can all be completed aboard the vessel.
If they take place at an overhaul center, secure the engine to an adequate support.
Extract the liquids from the engine: fuel, lubricating oil and engine coolant, disposing of them according to the procedures prescribed by current regulations.

Intake side

Figure 29



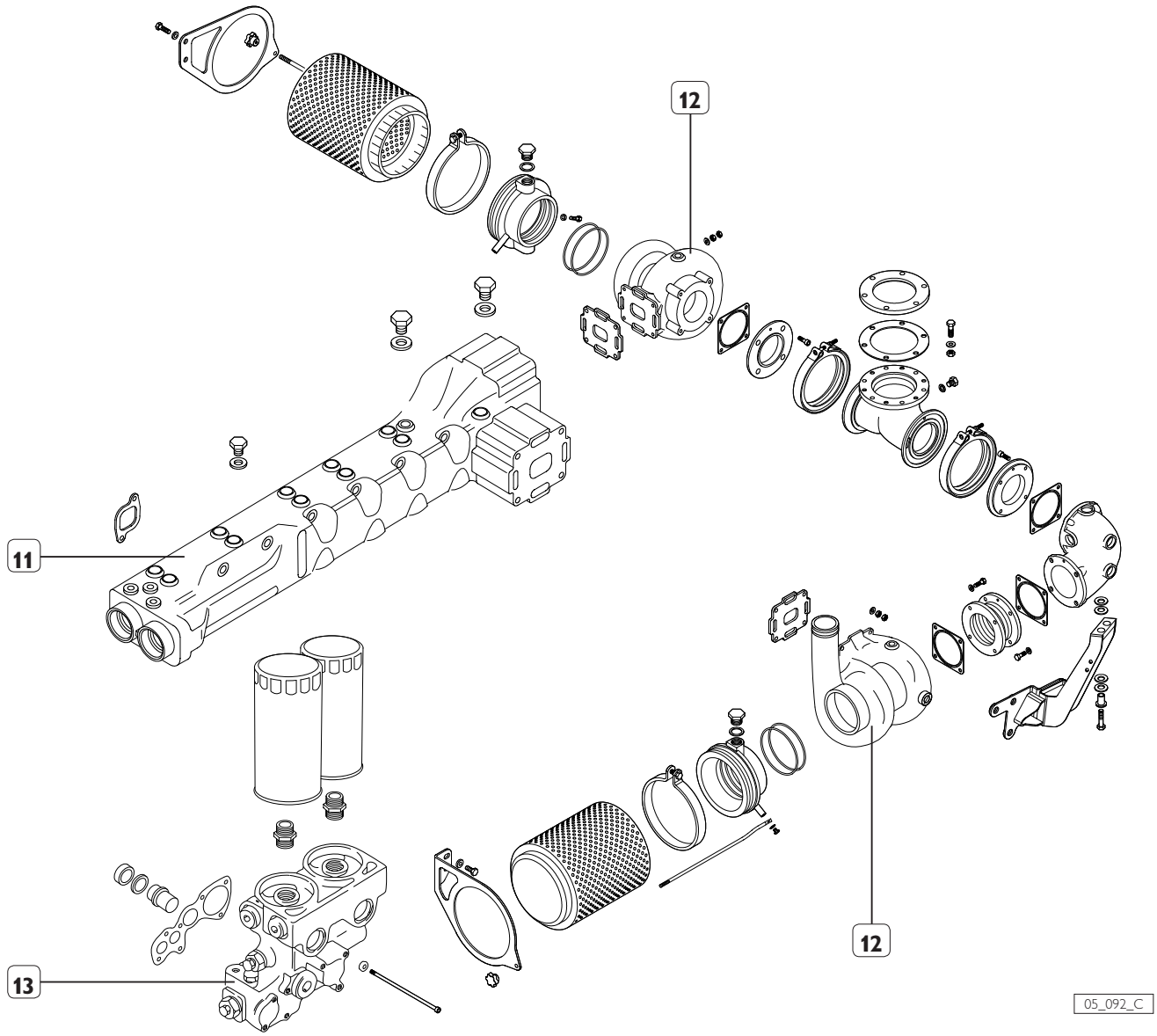
1. Sea water/engine coolant heat exchanger - 2. Coolant tank - 3. Combustion air heat exchanger - 4. Junction lines between the turbocompressor and the combustion air heat exchanger - 5. Sea water pump - 6. Sea water inlet - 7. Sea water loop lines - 8. Cylinder head - cooled exhaust manifold union fitting - 9. Seat of the engine cooling thermostatic valve - 10. Engine cooling loop lines (fresh water loop).

Disconnect all connectors of electrical components on the engine.
Remove the electrical pump for pre-lubrication, its bracket, the oil pipelines and the dipstick.

Remove the fuel filter support and associated pipelines.
Remove the intake air filter and the exhaust gas terminal.
Remove junction lines between the turbocompressor and the combustion air heat exchanger (4).

Exhaust side

Figure 30



11. Cooled exhaust manifold - 12.Turbocompressor - 13. Lubricating oil filter support.

Remove the sea water pipes (7) from pump, combustion air heat exchanger, engine coolant heat exchanger and gearbox heat exchanger if provided. Remove the pipes of the engine cooling loop (10).
Remove the heat exchangers: combustion air (3), engine coolant (1) and gearbox, if provided.
Remove the cylinder head union fitting and exhaust gas manifold (8) complete with the thermostatic valve seat (9).
Remove the sea water pump (5).

Remove the turbocompressors (12) and the attached pipelines for the engine coolant and lubricating oil.
Remove the support of the lubricating oil filters (13).
Remove the exhaust manifold (11).

INSTRUCTIONS FOR DISEMBARKING THE ENGINE

The following is a description of the recommended sequence of 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 engine coolant expansion vessel;
- ❑ Loosen and remove engine anchor bolts;
- ❑ Uncouple the gearbox;
- ❑ Hitch the engine following the prescriptions provided below.

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 exclusively for lifting the engine) must always be used simultaneously.

SECTION 7

TOOLS

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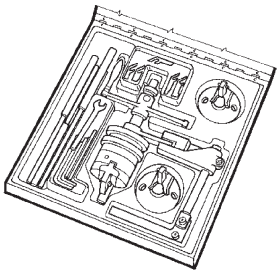
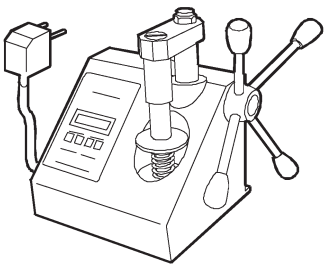
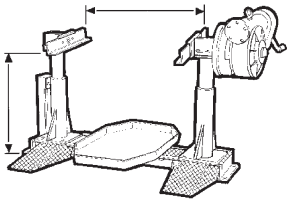
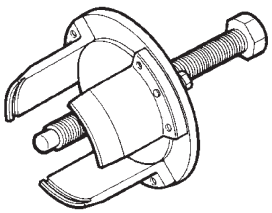
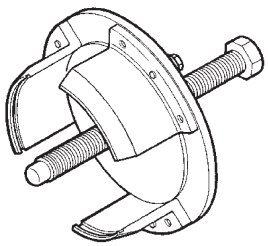
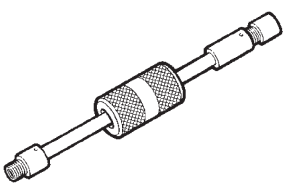
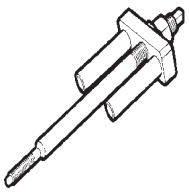
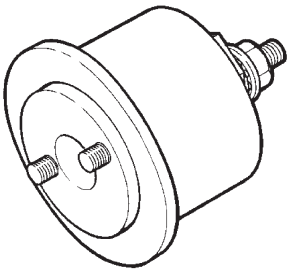
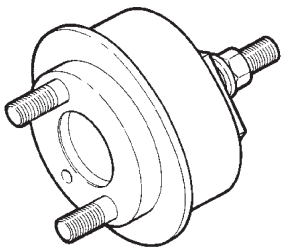
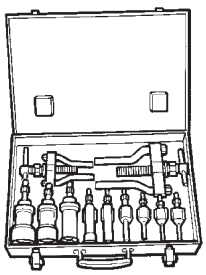
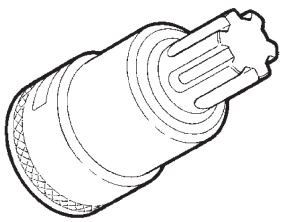
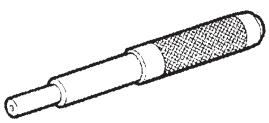
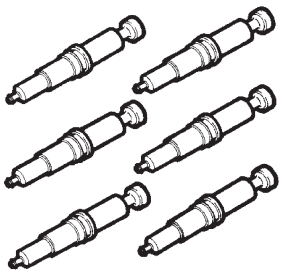
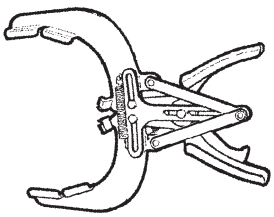
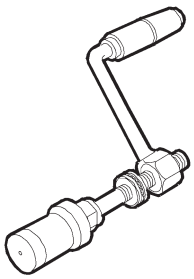
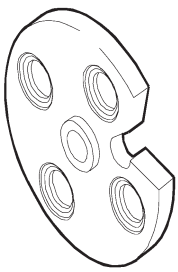
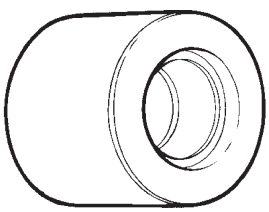
TOOLS

Tool No.		Description
99305019		Full-optional tool-kit to rectify valve seat
99305047		Equipment for spring load check
99322230		Rotary telescopic stand
99340053		Extractor for crankshaft front gasket
99340054		Extractor for crankshaft rear gasket
99340205		Percussion extractor

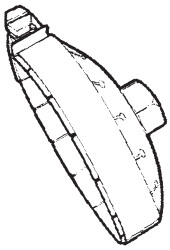
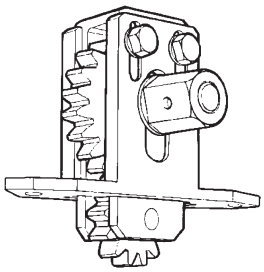
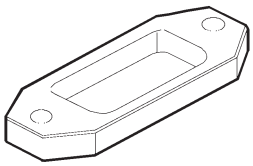
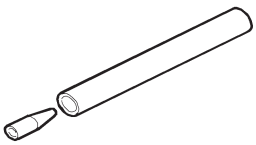
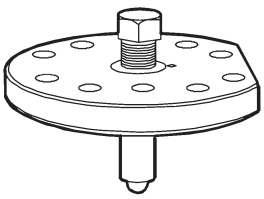
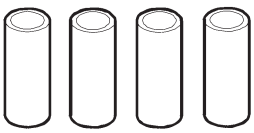
TOOLS

Tool No.		Description
99342149		Extractor for injector-holder
99346250		Tool to install the crankshaft front gasket
99346251		Tool to install the crankshaft rear gasket
99348004		Universal extractor for 5 to 70 mm internal components
99350072		Box wrench for transmission gear support fixing screws
99360143		Battitoio per montaggio - smontaggio guida valvole

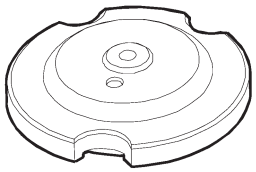
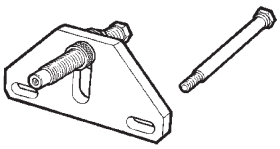
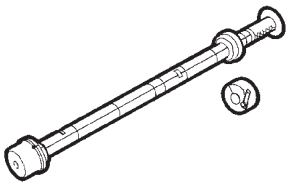
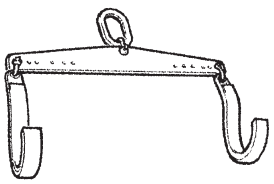
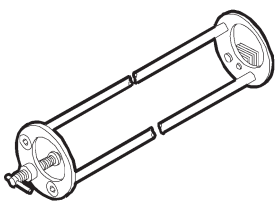
TOOLS

Tool No.		Description
99360144		Tools (12 + 6) holding rocker adjustment screw blocks when removing/refitting the rocker shaft
99360180		Injector housing protecting plugs (6)
99360184		Pliers for assembling and disassembling piston split rings (105-160 mm)
99360261		Tool to take down-fit engine valves (to be used with special plates)
99360262		Plate for take down-fit engine valves (to be used with 99360261)
99360296		Tool to fit back valve guide (to be used with 99360481)

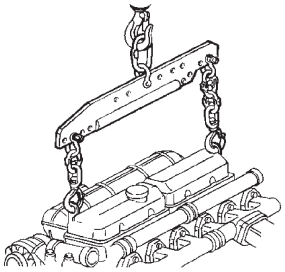
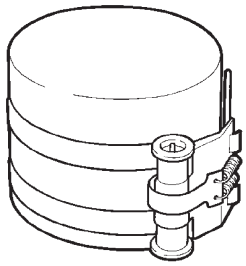
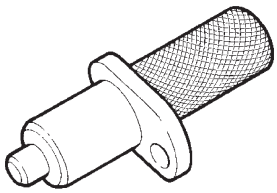
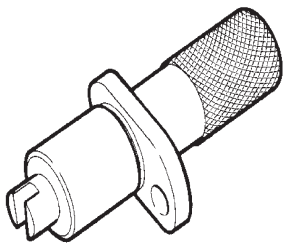
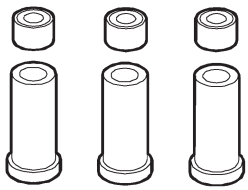
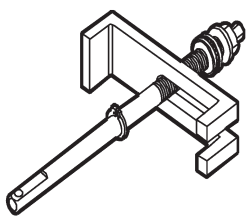
TOOLS

Tool No.		Description
99360314		Tool to remove oil filter (engine)
99360321		Tool to rotate engine flywheel (to be used with 99360325)
99360325		Spacer (to be used with 99360321)
99360329		Tool to install gasket on valve guide
99360334		Compression tool for checking the protrusion of cylinder liners (to be used with 99370415-99395603 and special plates)
99360336		Spacer (to be used with 99360334)

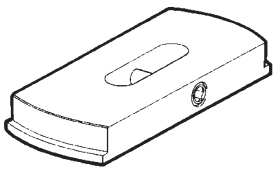
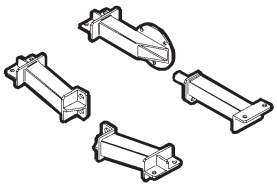
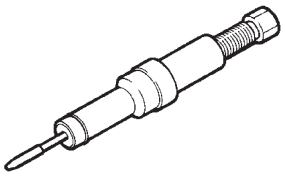
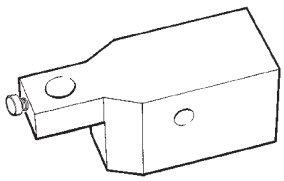
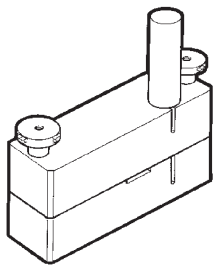
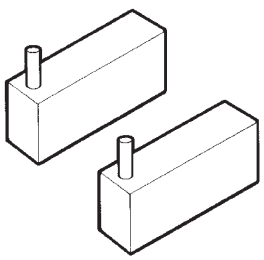
TOOLS

Tool No.		Description
99360337		Cylinder liner compression plate (to be used with 99360334-99360336)
99360351		Tool to stop engine flywheel
99360499		Tool to take down and fit back camshaft bushes
99360500		Tool to lift crankshaft
99360551		Bracket to take down and fit engine flywheel
99360553		Tool for assembling and installing rocker arm shaft

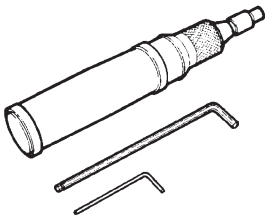
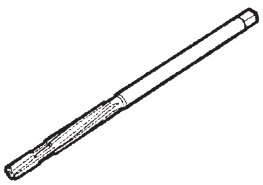
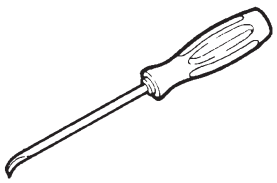
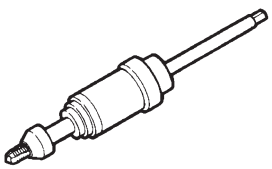
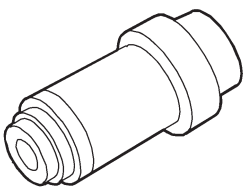
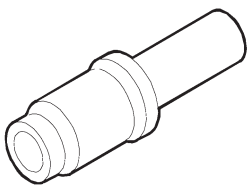
TOOLS

Tool No.		Description
99360585		Swing hoist for engine disassembly assembly
99360605		Belt to insert piston in cylinder liner (60 - 125 mm)
99360612		Tool for positioning engine P.M.S.
99360613		Tool for timing of phonic wheel on timing gear
99360703		Tool to stop cylinder liners
99360706		Tool to extract cylinder liners (to be used with specific rings)

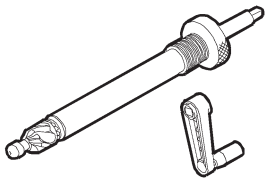
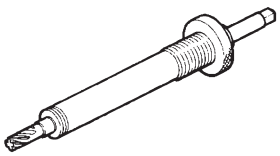
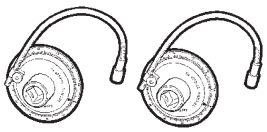
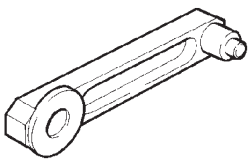
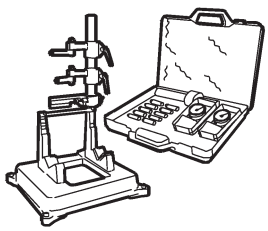
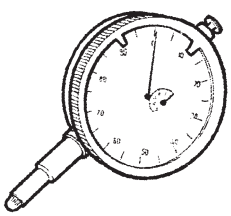
TOOLS

Tool No.		Description
99360726		Ring (125 mm) (to be used with 99360706)
99361035		Brackets fixing the engine to rotary stand 99322230
99365054		Tool for injector holder heading
99370415		Base supporting the dial gauge for checking cylinder liner protrusion (to be used with 99395603)
99378100		Tool for printing engine identification plates (to be used with special punches)
99378101 (A) to 99378106 (F)		Punches (B) for printing engine identification plates (to be used with 99378100)

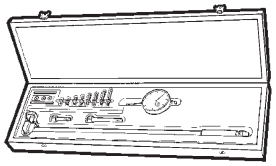
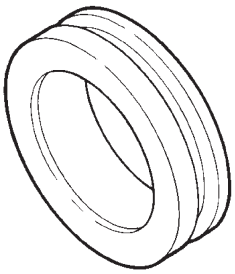
TOOLS

Tool No.		Description
99389834		Torque screwdriver for calibrating the injector solenoid valve connector check nut
99390311		Valve guide sleeker
99390772		Tool for removing injector holding case deposits
99390804		Tool for threading injector holding cases to be extracted (to be used with 99390805)
99390805		Guide bush (to be used with 99390804)
99394015		Guide bush (to be used with 99394041 or 99394043)

TOOLS

Tool No.		Description
99394041		Cutter to rectify injector holder housing (to be used with 99394015)
99394043		Reamer to rectify injector holder lower side (to be used with 99394015)
99395216		Measuring pair for angular tightening with 1/2" and 3/4" square couplings
99395218		Gauge for defining the distance between the centres of camshaft and transmission gear
99395363		Complete square to check connecting rod squaring
99395603		Dial gauge (0 - 5 mm)

TOOLS

Tool No.		Description
99395687		Reaming gauge (50 - 178 mm)
99396033		Centering ring of crankshaft front gasket cap
8093731		Tester PT-01

SECTION 8

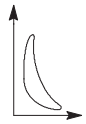
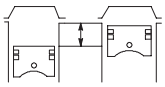
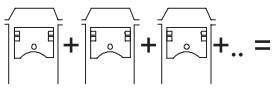
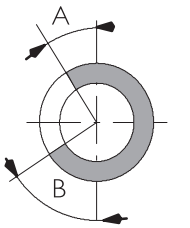
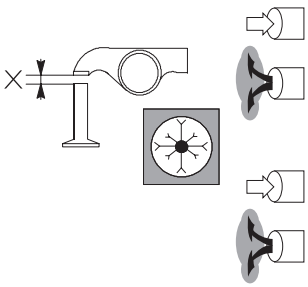
OVERHAUL

(cont.)

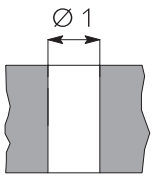
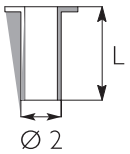
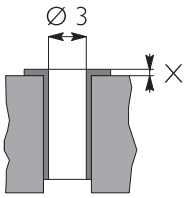
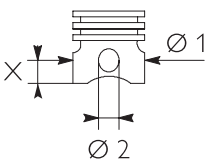
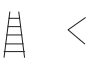
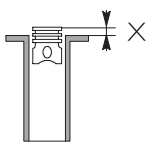
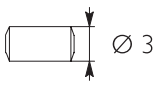
Graph and symbols

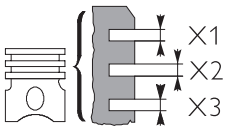
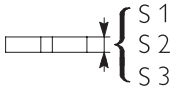
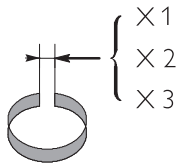
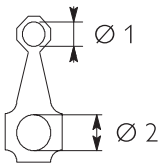
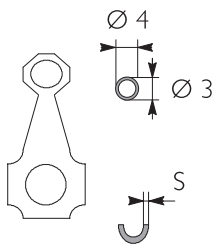
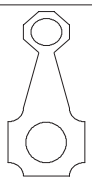
	Surface for machining Machine finish
	Interference Strained assembly
	Thickness Clearance
	Intake
	Exhaust
	Operation
ρ	Compression ratio
	Preload
>	Oversized Higher than … Maximum, peak
<	Undersized Less than … Minimum
	Selection Classes Oversizing
	Replacement Original spare parts

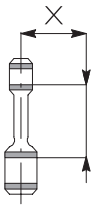
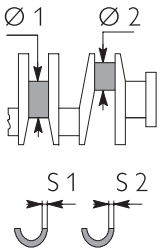
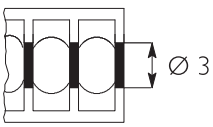
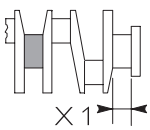
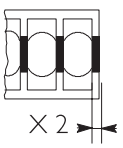
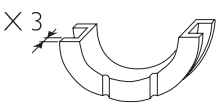
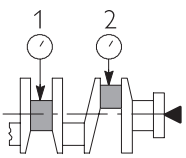
GENERAL CHARACTERISTICS

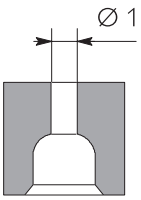
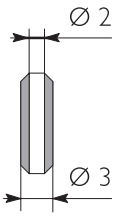
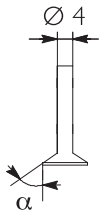
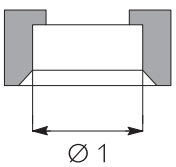
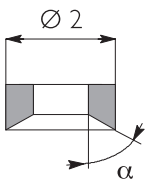
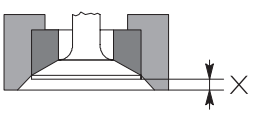
	Engine		C13 ENT M77
			mm
	Cycle		Diesel 4 strokes
	Air feeding		Turbocharged with aftercooler
	Injection		Direct
	N. of cylinders		6 in-line
	Diameter	mm	135
	Stroke	mm	150
	Total displacement	cm^3	12880
ϱ	Compression ratio		15.5 ± 0.8 : 1
	**Valve timing**		
	opens before TDC	A	17°
	closes after BDC	B	30°
	opens before BDC	D	50°
	closes after TDC	C	9°
	For timing check		
	X	mm	-
		mm	-
	Running		
	X	mm	0.35 to 0.45
		mm	0.45 to 0.55

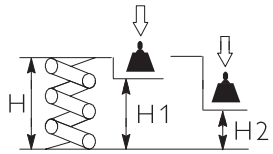
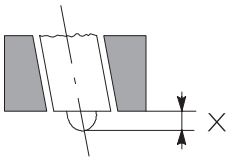
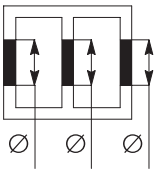
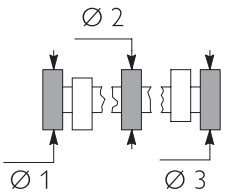
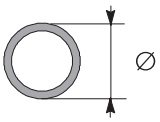
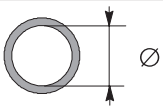
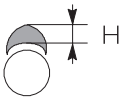
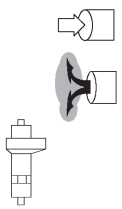
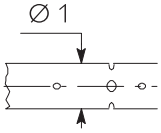
ASSEMBLY CLEARANCE DATA

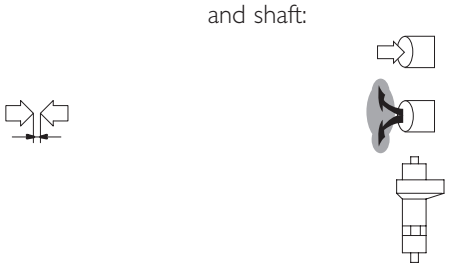
	Engine		C13 ENT M77
Cylinder block and crank mechanism components			mm
	Cylinder sleeve bore Ø 1	upper lower	153.500 to 153.525 152.000 to 152.025
	Cylinder liners: outer diameter: Ø 2 length	upper lower L	153.461 to 153.486 151.890 to 151.915 -
	Cylinder sleeve - crankcase bore:	upper lower	0.014 to 0.039 0.085 to 0.135
IVECO PARTS 	Outside diameter	Ø 2	-
	Cylinder sleeve inside diameter Protrusion * Available dia. class	A* Ø 3 B* X	135.000 to 135.013 135.011 to 135.024 0.045 to 0.075
	Pistons : measuring dimension outside diameter outside diameter pin bore * Class A pistons supplied as spares. ** Class B pistons are fitted in production only and are not supplied as spares.	X Ø 1 A* Ø 1 B** Ø 2	KS 18 134.884 to 134.896 134.895 to 134.907 54.010 to 54.018
	Piston - cylinder sleeve * Available dia. class		0.104 to 0.129 0.104 to 0.129
IVECO PARTS 	Piston diameter	Ø 1	-
	Pistons protrusion	X	0.12 to 0.42
	Gudgeon pin	Ø 3	53.994 to 54.000
	Gudgeon pin - pin housing		0.010 to 0.024

	Engine		C13 ENT M77
			mm
	Piston ring grooves	X1*	3.427
		X2	3.060 to 3.080
		X3	5.020 to 5.040
	* Measured on Ø of 112 mm		
	Piston rings:		
	trapezoidal seal	S1*	3.296 to 3.364
	lune seal	S2	2.970 to 2.990
	milled scraper ring with slits and internal spring	S3	4.970 to 4.990
	* Measured on Ø of 130 mm		
	Piston rings - grooves	1	0.065 to 0.131
		2	0.061 to 0.110
		3	0.030 to 0.070
IVECO PARTS 	Piston rings		-
	Piston ring end gap in cylinder liners:		
		X1	0.40 to 0.50
		X2	0.65 to 0.80
		X3	0.40 to 0.75
	Small end bush housing		
		Ø 1	59.000 to 59.030
	Big end bearing housing	Ø 2	Rated value 94.000 to 94.030
	Selection classes Ø 2	1	94.000 to 94.010
		2	94.011 to 94.020
		3	94.021 to 94.030
	Small end bush diameter		
	outside	Ø 4	59.085 to 59.110
	inside	Ø 3	54.019 to 54.035
	Big end bearing shell	S	
	Red		1.965 to 1.975
	Green		1.976 to 1.985
	Yellow *		1.986 to 1.995
	* Fitted in production only and not supplied as spares		
	Small end bush - housing		0.055 to 0.110
	Piston pin - bush		0.019 to 0.041
IVECO PARTS 	Big end bearing shells		0.127 - 0.254 - 0.508
	Connecting rod weight		g
	Class	A	4756 to 4795
		B	4796 to 4835
		C	4836 to 4875

Engine		C13 ENT M77	
		mm	
	Measuring dimension X		125
	Max. connecting rod axis misalignment tolerance =		0.08
	Main journals Ø 1	Rated value	99.970 to 100.000
	Selection class 1		99.970 to 99.979
	Selection class 2		99.990 to 100.000
	Selection class 3		99.990 to 100.000
	Crankpins Ø 2	Rated value	89.970 to 90.000
	Selection class 1		89.970 to 89.979
	Selection class 2		89.980 to 89.989
	Selection class 3		89.990 to 90.000
	Main bearing shells S1		
	Red		3.110 to 3.120
	Green		3.121 to 3.130
	Yellow *		3.131 to 3.140
	Big end bearing shells S2		
	Red		1.965 to 1.975
	Green		1.976 to 1.985
	Yellow *		1.986 to 1.995
	* Fitted in production only and not supplied as spares		
	Main bearing housings Ø 3	Rated value	106.300 to 106.330
	Selection class 1		106.300 to 106.309
	Selection class 2		106.310 to 106.319
	Selection class 3		106.320 to 106.330
	Bearing shells - main journals		0.060 to 0.100
	Bearing shells - big ends		0.050 to 0.090
	Main bearing shells		0.127 - 0.254 - 0.508
	Big end bearing shells		0.127 - 0.254 - 0.508
	Main journal, thrust bearing X1		47.95 to 48.00
	Main bearing housing, thrust bearing X2		40.94 to 40.99
	Thrust washer halves X3		3.38 to 3.43
	Driving shaft shoulder		0.10 to 0.30
	Alignment = 1 - 2		≤ 0.025
	Ovality ○ 1 - 2		0.010
	Taper ⟩ 1 - 2		0.010

Engine		C13 ENT M77
Cylinder heads - valve train		**mm**
	Valve guide housings in cylinder head Ø 1	15.980 to 15.997
	Valve guide Ø 2 Ø 3	10.015 to 10.030 16.012 to 16.025
	Valve guides - housings in the cylinder heads	0.015 to 0.045
IVECO PARTS	Valve guide	0.2 - 0.4
	Valves: Ø 4 α Ø 4 α	9.960 to 9.975 60° 30' ± 7' 30'' 7.970 to 7.985 45° 30' ± 7' 30''
	Valve stem and its guide	0.040 to 0.070
	Housing in head for valve seat: Ø 1 Ø 1	 49.185 to 49.220 46.985 to 47.020
	Outside diameter of valve seat; angle of valve seat in cylinder head: Ø 2 α Ø 2 α	 49.260 to 49.275 60° - 30' 47.060 to 47.075 45° - 30'
	Recessing of valve X X	 0.45 to 0.75 1.65 to 1.95
	Between valve seat and head	0.040 to 0.090

	Engine		C13 ENT M77
			mm
	Valve outside spring height: free height under a load of: N 454 ± 22 N 840 ± 42	 H H1 H2	 73.40 59 46
	Injector protrusion	X	0.52 to 1.34
	Camshaft bush housing fitted in the cylinder head: 1 ➡ 7	 Ø	 88.000 to 88.030
	Camshaft journal diameter: 1 ➡ 7	 Ø	 82.950 to 82.968
	Camshaft bushing outer diameter	Ø	88.153 to 88.183
	Camshaft bushing inner diameter	Ø	83.018 to 83.085
	Bushings and housings in engine block		0.123 to 0.183
	Bushings and journals		0.050 to 0.135
	Cam lift: 		9.231 9.5607 13.375
	Rocker shaft	Ø 1	41.984 to 42.000

Engine	C13 ENT M77
	mm
Bushing housing in rocker arms: 	45.000 to 45.016 45.000 to 45.016 46.000 to 46.016
Bushing outer diameter for rocker arms: 	45.090 to 45.130 45.090 to 45.130 46.066 to 46.091
Bushing inner diameter for rocker arms: 	42.025 to 42.041 42.025 to 42.041 42.015 to 42.071
Between bushings and housings: 	0.074 to 0.130 0.074 to 0.130 0.050 to 0.091
Between rocker arms and shaft: 	0.025 to 0.057 0.025 to 0.057 0.015 to 0.087

TIGHTENING TORQUES

Part		Torque Nm	Torque kgm
Capscrews, undercrankcase to crankcase (see fig. 1): ◆			
Outside screws 12x1.75	First phase: preliminary tightening	30	3
Inner screws M 18x2	Second phase: preliminary tightening	120	12
Inner screws	Third phase: angle locking	60°	
Inner screws	Fourth phase: angle locking	55°	
Outer screws	Fifth phase: angle locking	60°	
Piston cooling nozzle union ◆		35 ± 2	3.5 ± 0.2
Heat exchanger fixing screws to the block: (see fig. 7) ◆			
	preliminary tightening	11.5 ± 3.5	1.15 ± 0.35
	tightening	19 ± 3	1.9 ± 0.3
Spacer and oil sump fixing screws (see fig. 8) ◆		50	5
Gearbox fixing screws to the block M 12x1.75		63 ± 7	6.3 ± 0.7
Cylinder head fixing screws (see fig. 2): ◆			
First phase	preliminary tightening	60	6
Second phase	preliminary tightening	120	12
Third phase	angle locking	90°	
Fourth phase	angle locking	65°	
Rocker shaft fixing screws (see fig. 3): ◆			
First phase	preliminary tightening	80	8
Second phase	angle locking	60°	
Lock nut for rocker adjustment screw ◆		39 ± 5	3.9 ± 0.5
Injector blocking brackets screws ◆		26	2.6
Shoulder plate fixing bolts to head ◆		23.5	2.35
Engine support bracket fastening screws to cylinder head		19 ± 3	1.9 ± 0.3
Camshaft gear fixing screws: ◆			
First phase	preliminary tightening	120	12
Second phase	angle locking	45°	
Phonic wheel fastening screws to distribution gear		8.5 ± 1.5	0.85 ± 0.15
Exhaust manifold fixing screws (see fig. 4): ▲			
	preliminary tightening	40 ± 5	4 ± 0.5
	tightening	70 ± 5	7 ± 0.5
Connecting rod cap fixing screws: ◆			
First phase	preliminary tightening	60	6
Second phase	angle locking	60°	

◆ Lubricate with UTDM oil before installation

▲ Lubricate with graphitized oil before installation

TIGHTENING TORQUES

Part		Torque Nm	Torque kgm
Engine flywheel fixing screws M16x1.5x58: ◆			
First phase	preliminary tightening	120	12
Second phase	angle locking	90°	
Engine flywheel fixing screws M16x1.5x110: ◆			
First phase	preliminary tightening	70	7
Second phase	angle locking	50°	
Intermediate gear pin fixing screws: Intermediate ◆			
First phase	preliminary tightening	30	3
Second phase	angle locking	90°	
Idle gear link rod fastening screw		24.5 ± 2.5	2.4 ± 0.25
Oil pump fastening screw		24.5 ± 2.5	2.4 ± 0.25
Oil pump suction rose fastening screw		24.5 ± 2.5	2.4 ± 0.25
Front cover fastening screw to cylinder block ◆		19 ± 3	1.9 ± 0.3
Supply pump fastening screw to gearcase ◆		19 ± 3	1.9 ± 0.3
Fuel filter support fastening screw to cylinder head ◆		37 ± 3	3.7 ± 0.3
Turbo-compressor fastening screws and nuts (see fig. 5) ▲			
Water pump fastening screw to cylinder block		25 ± 2.5	2.5 ± 0.25
Pulley fastening screw to hub			
First phase	preliminary tightening	70	7
Second phase	angle locking	50°	
Rocker cap fixing screws (see fig. 9)		9	0.9
Thermostat box fastening screws to cylinder head		24.5 ± 2.5	2.4 ± 0.24
Automatic tightener fastening screws to cylinder block		45 ± 5	4.5 ± 0.45
Fixed tightener fastening screws to cylinder block		105 ± 5	10.5 ± 0.5
Starter fastening screws		74 ± 4	7.4 ± 0.4
Alternator support fastening screw to cylinder block M 10x1.5 - l = 60 mm		44 ± 4	4.4 ± 0.4
Alternator bracket fastening screw to cylinder block M 10x1.5 - l = 35 mm		30 ± 3	3 ± 0.3
Flywheel rev sensor fastening screw		8 ± 2	0.8 ± 0.2
Camshaft rev sensor fastening screw		8 ± 2	0.8 ± 0.2
P.D.E solenoid connector fastening screw		1.62 ± 0.3	0.16 ± 0.03
Overboost pressure sensor fastening screw		8 ± 2	0.8 ± 0.2
Absolute pressure sensor fastening screw		22.5 ± 2.5	2.2 ± 0.2

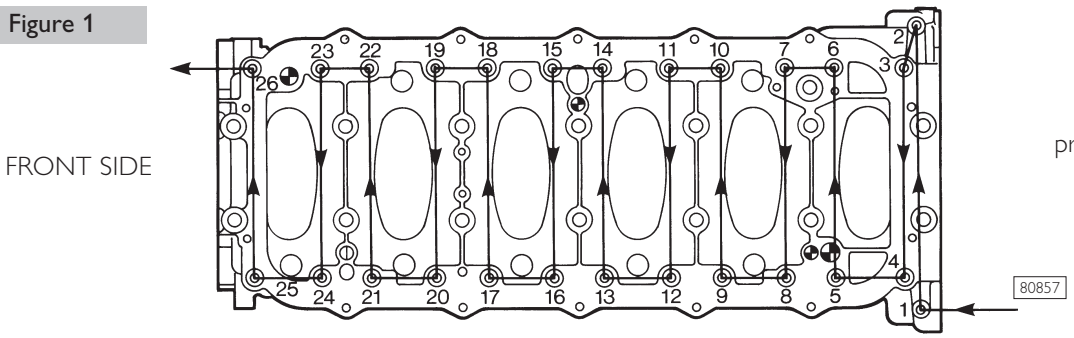
◆ Lubricate with UTDM oil before installation
▲ Lubricate with graphitized oil before installation

TIGHTENING TORQUES

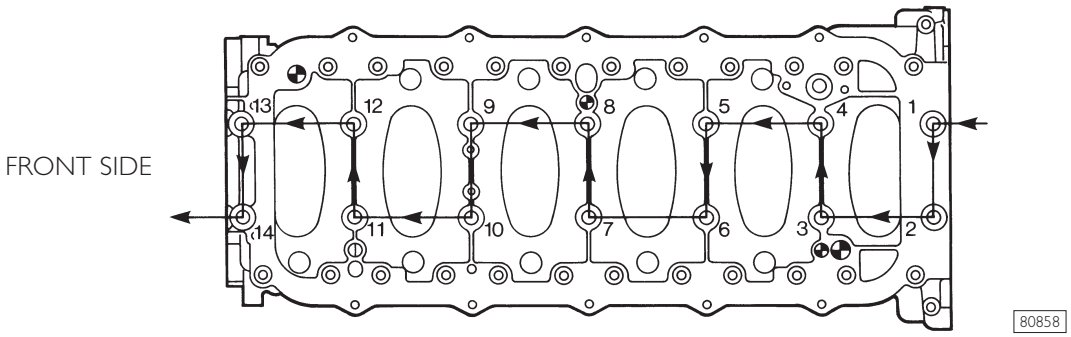
Part	Torque	
	Nm	kgm
Fuel temperature sensor	35	3.5
Coolant temperature sensor	35	3.5
Filter clogging sensor	55 ± 5	5.5 ± 0.5
Oil temperature switch	25 ± 1	2.5 ± 0.1
Oil pressure sensor	25 ± 1	2.5 ± 0.1
Oil filter clogging sensor	55 ± 5	5.5 ± 0.5
Electric wire fastening screw	8 ± 2	0.8 ± 0.2

Underblock fixing screws tightening order

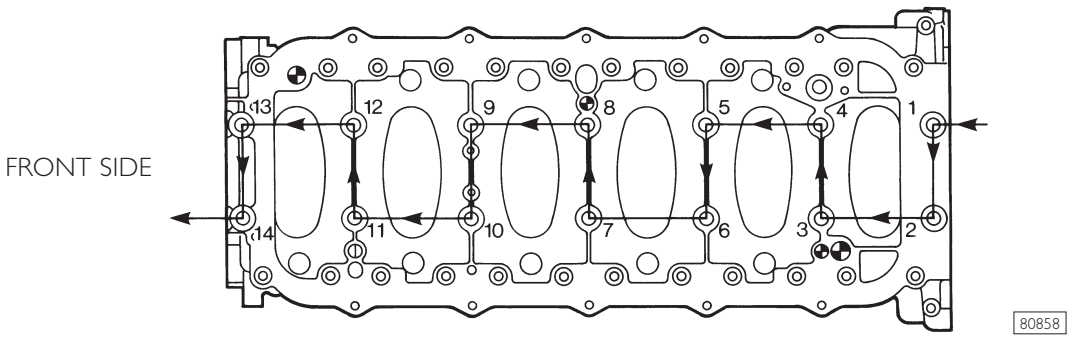
Figure 1



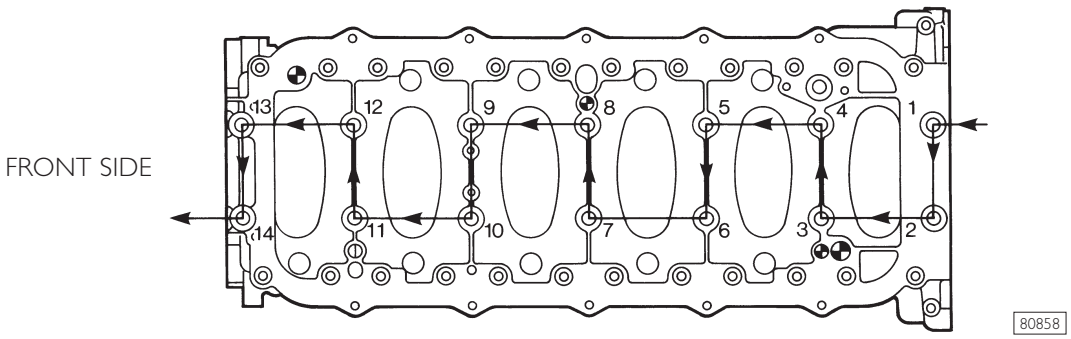
First phase: preliminary tightening of outer screws (30 Nm)



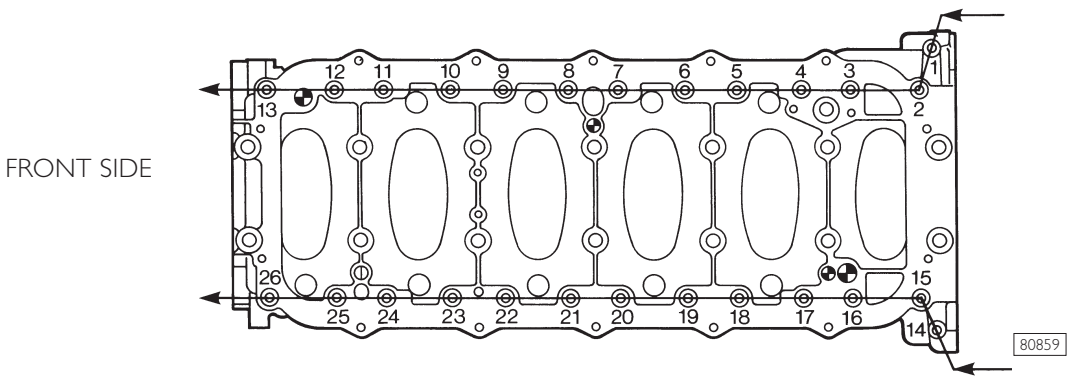
Second phase: preliminary tightening of inner screws (120 Nm)



Third phase: angle tightening of inner screws 60°



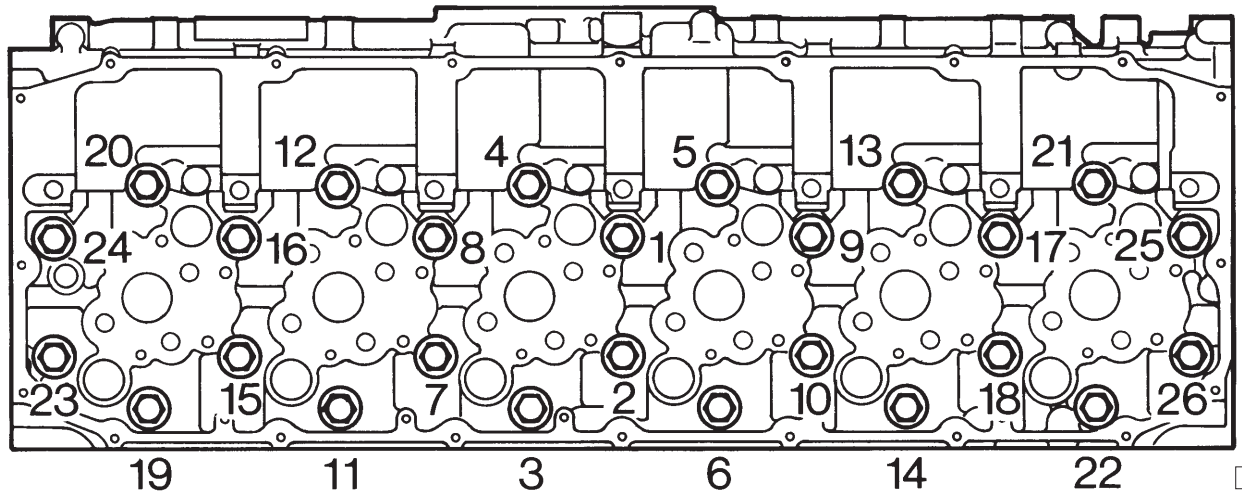
Fourth phase: angle tightening of inner screws 55°



Fifth phase: angle tightening of outer screws 60°

Diagram of cylinder head fixing screws tightening order

Figure 2

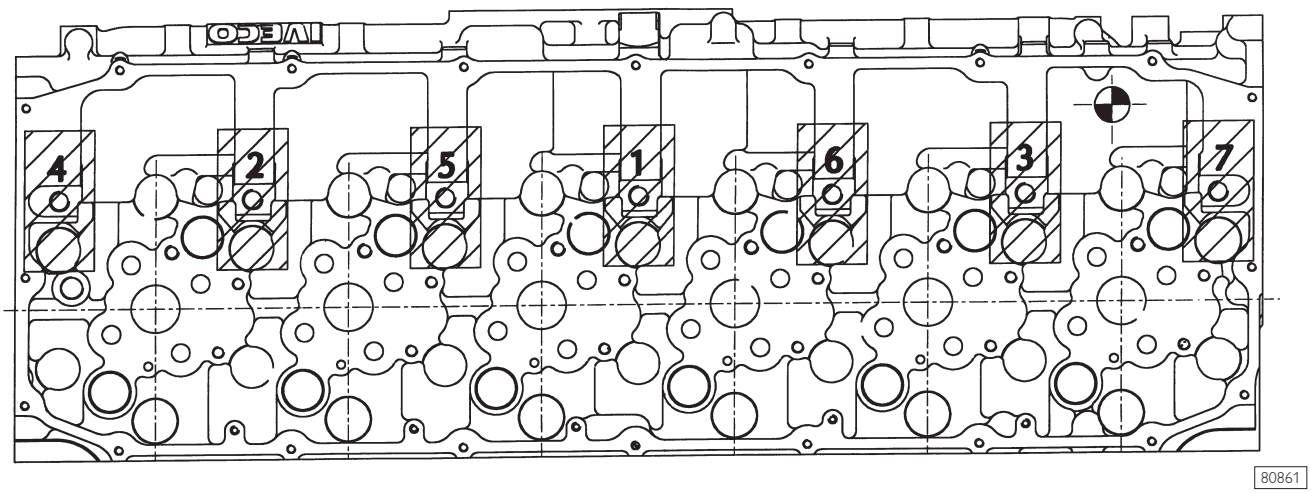


Sequence

❑	First phase	preliminary tightening	60 Nm	Sequence as shown in figure;
❑	Second phase	preliminary tightening	120 Nm	Sequence as shown in figure;
❑	Third phase	angle locking	90°	Sequence as shown in figure;
❑	Fourth phase	angle locking	65°	Sequence as shown in figure.

Diagram of rocker arm shaft fixing screws tightening order

Figure 3

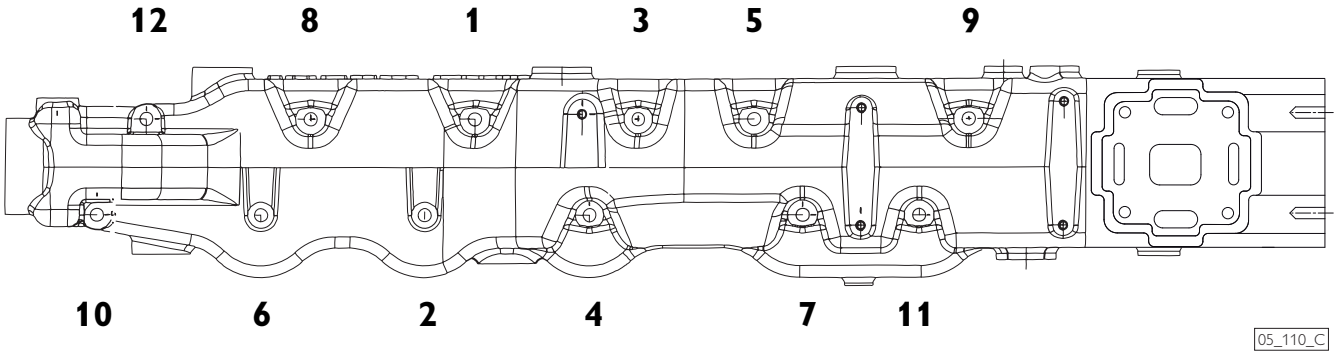


Sequence

❑	First phase	tighten the screws 1-2-3 until they bear down on the rocker arm shaft;		
❑	Second phase	preliminary tightening	80 Nm	Sequence as shown in figure;
❑	Third phase	angle locking	60°	Sequence as shown in figure.

Diagram of exhaust manifold fixing screws tightening order

Figure 4

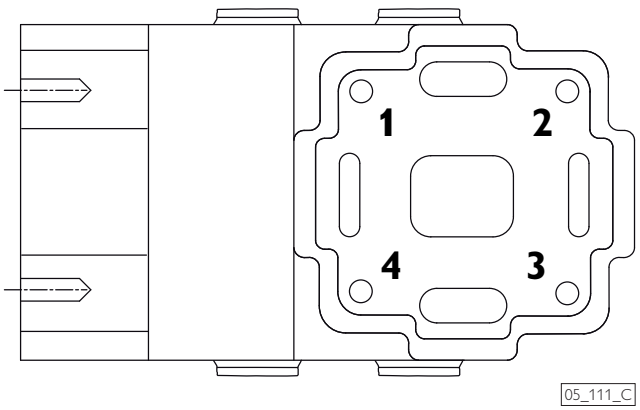


Sequence

- ❑ First phase preliminary tightening 40 ± 5 Nm Sequence as shown in figure;
- ❑ Second phase preliminary tightening 70 ± 5 Nm Sequence as shown in figure.

Diagram between exhaust manifold and turbocompressor fixing nuts tightening order

Figure 5

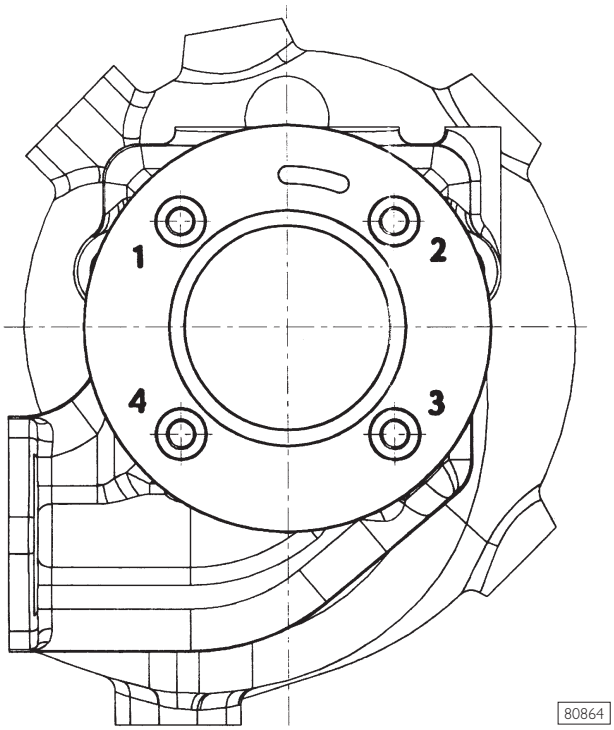


Turbocompressor side nuts

- ❑ Tightening torque: 55 Nm Sequence 4-2-1-3.

Diagram of exhaust flange fixing screws tightening order

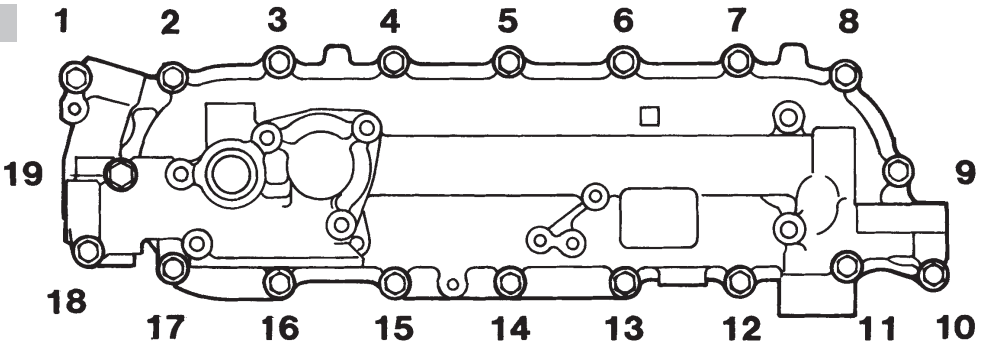
Figure 6



- ❑ Tightening torque: 50 Nm Sequence 2-4-1-3.

Diagram of heat exchanger fixing screws tightening order

Figure 7



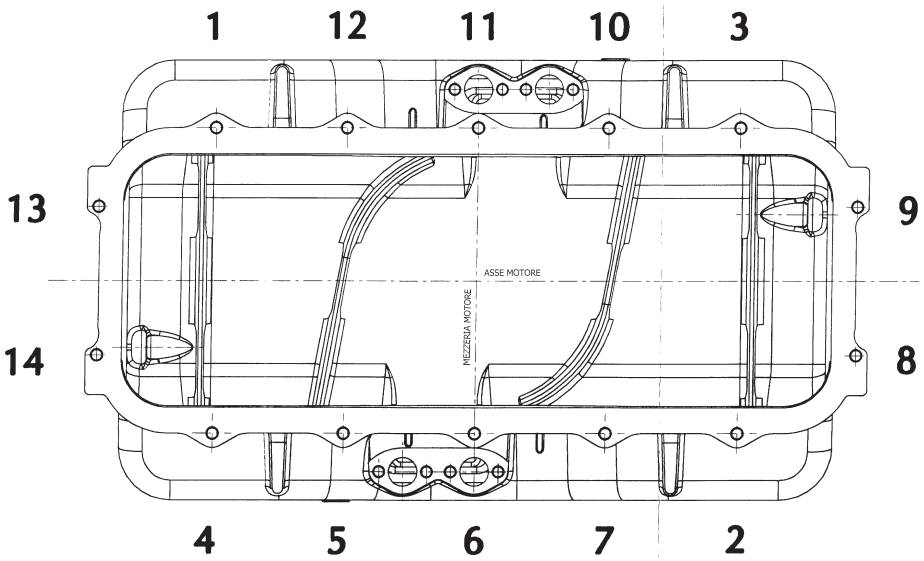
80865

Sequence

❑	First phase	preliminary tightening	11.5 ± 3.5 Nm	Sequence as shown in figure;
❑	Second phase	preliminary tightening	19 ± 3 Nm	Sequence as shown in figure.

Diagram of engine oil sump fixing screws tightening order

Figure 8

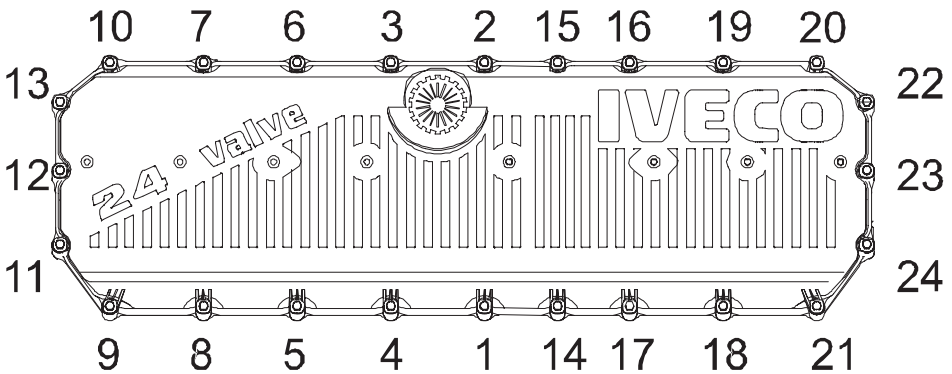


80866

❑ Tightening 50 Nm Sequence as shown in figure.

Diagram of rocker arm cap fixing screws tightening order

Figure 9



05_064_C

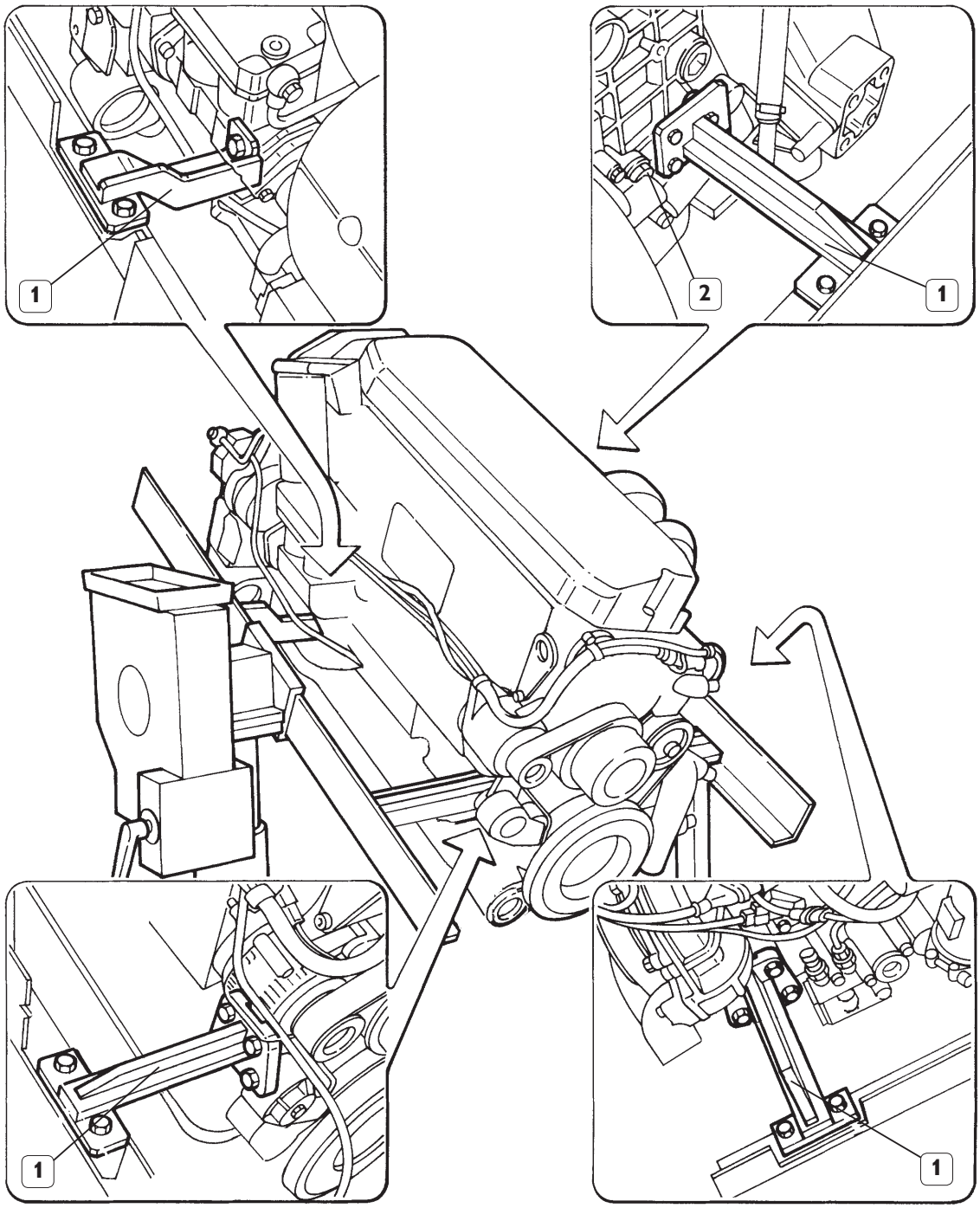
❑ Tightening 10 Nm Sequence as shown in figure.

ENGINE DISASSEMBLY AT THE BENCH

CAUTION

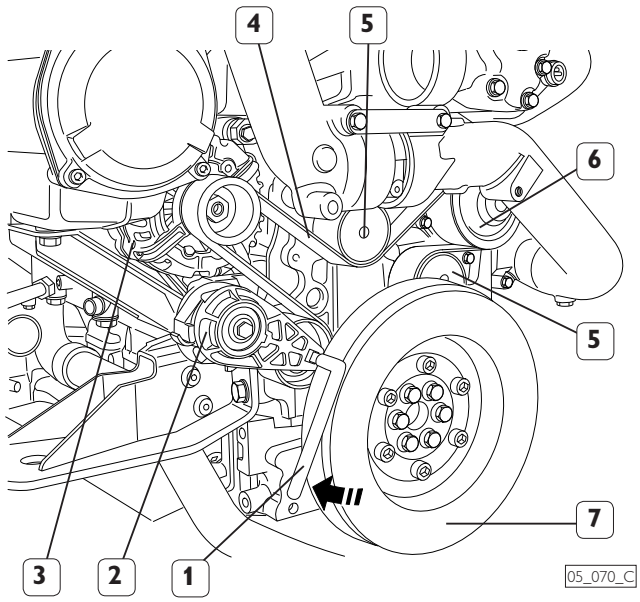
Operations described below refer to the engine without the components for its marine adaptation.

Figure 10



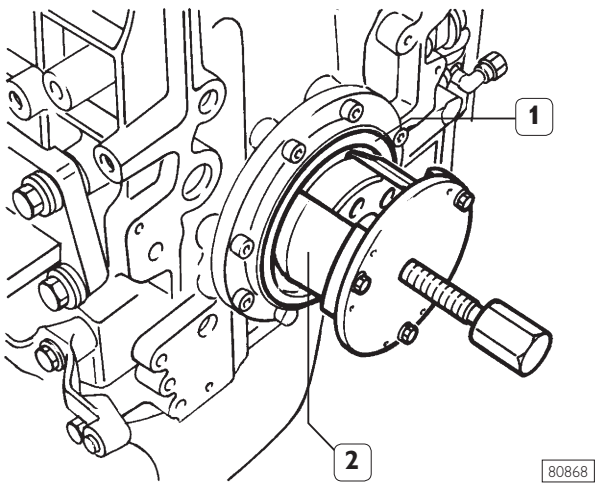
Before securing the engine on the rotary stand:
- Remove the electric engine cable;
- Remove the starting motor;
- Remove the engine supports.
- Remove the oil pressure adjuster valve (2);
- Secure the engine to the rotary stand by means of brackets 993601036 (1);
- Drain lubricating oil off the sump.

Figure 11



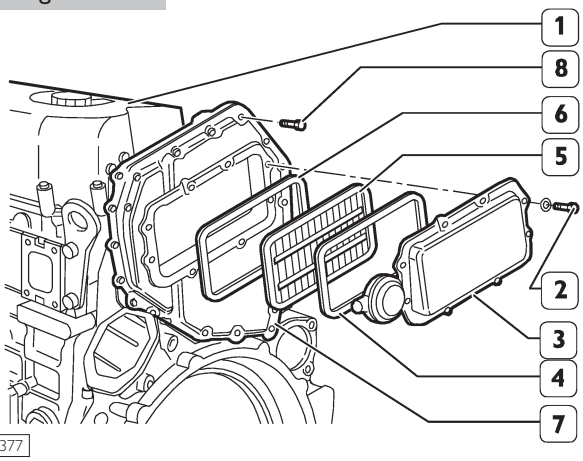
Using an appropriate tool (1), operate in the direction of the arrow, and remove the belt (4) driving the water pump and alternator.
Remove the following components:
- Automatic belt tightener support (2);
- Alternator (3);
- Fixed tightener (5);
- Water pump (6) and piping;
- Damping flywheel (7);
- Disconnect all electric connections and the sensors;
- Remove fuel pump and piping and oil heat exchanger.

Figure 12



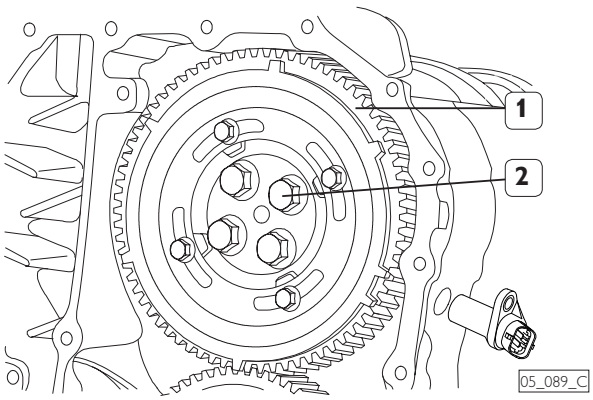
Fit the extractor 99340053 (2) and remove the engine crankshaft seal gasket (1), remove the cover.

Figure 13



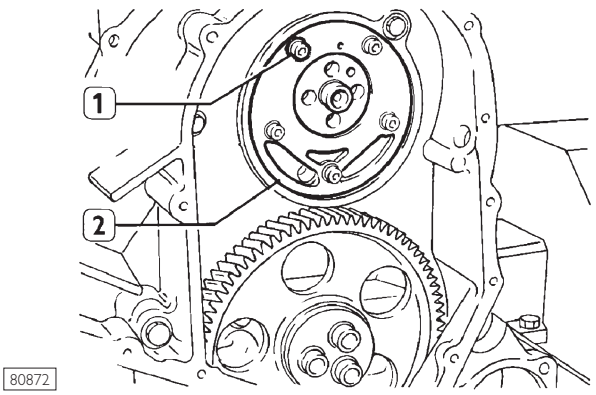
Remove the rocker arm cover (1), take off the screws (2) and remove: the cover (3), the filter (5) and the gaskets (4 and 6).
Take off the screws (8) and remove the blow-by case (7).

Figure 14



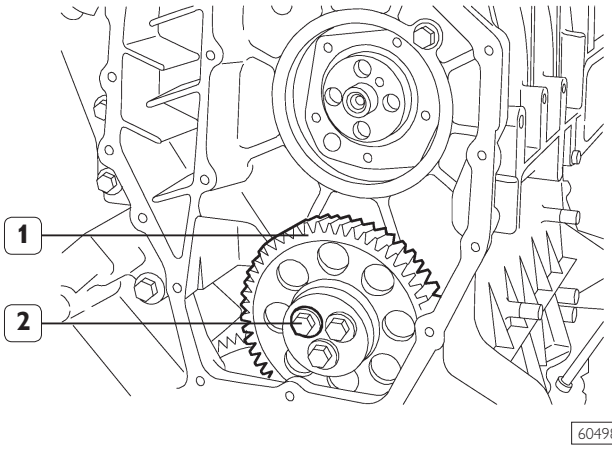
Unscrew the screws (2) and remove the gear (1) with the phonic wheel.

Figure 15



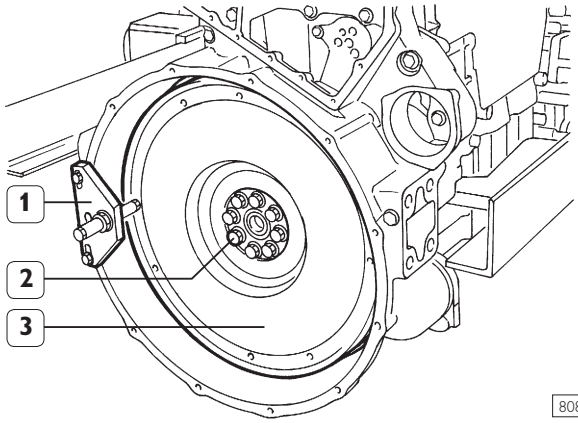
Unscrew the screws (1); tighten a screw in a reaction hole and remove the shoulder plate (3), remove the sheet gasket..

Figure 16



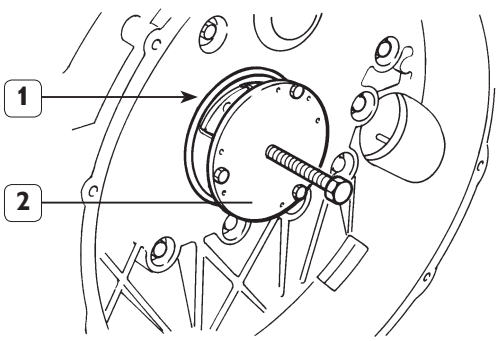
Unscrewthe screws (2) and remove the transmission gear (1).

Figure 17



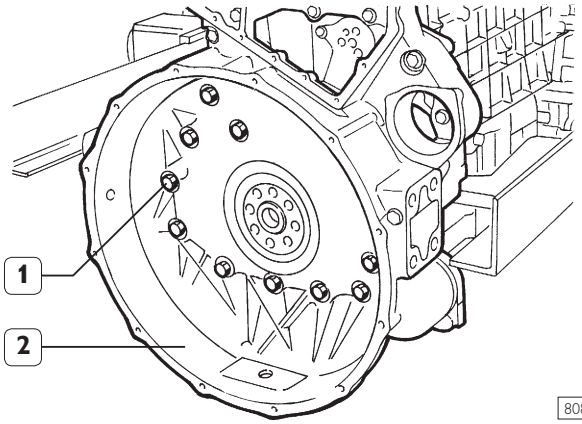
Stop the engine flywheel (3) rotation by means of tool 99360351 (1), untighten the fixing screws (2) and remove the engine flywheel..

Figure 18



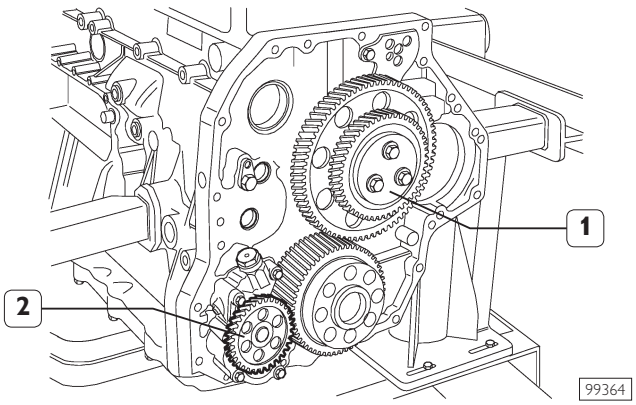
Apply extractor 99340054 (2) and pull out the seal gasket (1).

Figure 19



Untighten the screws (1) and take down the flywheel housing (2).

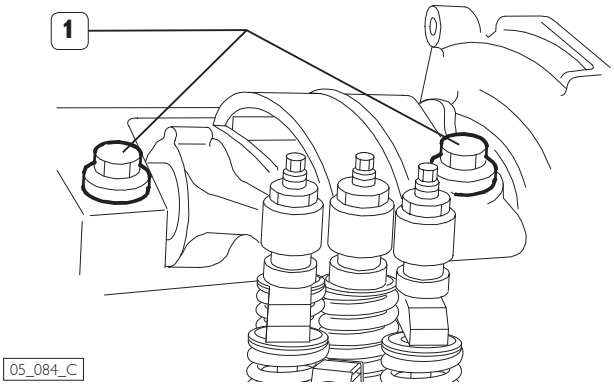
Figure 20



In sequence, take out the following:

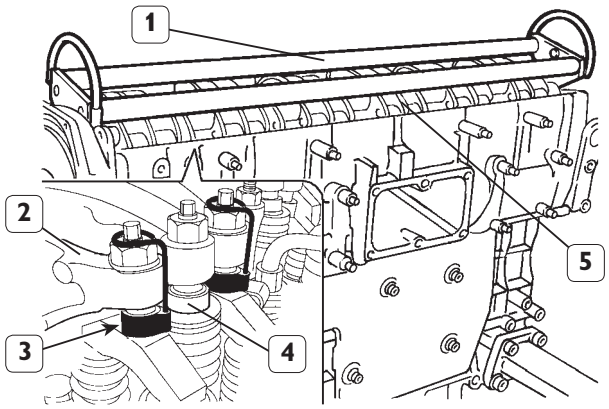
- ❏ Idle gear (1);
- ❏ Oil pump gear (2).

Figure 21



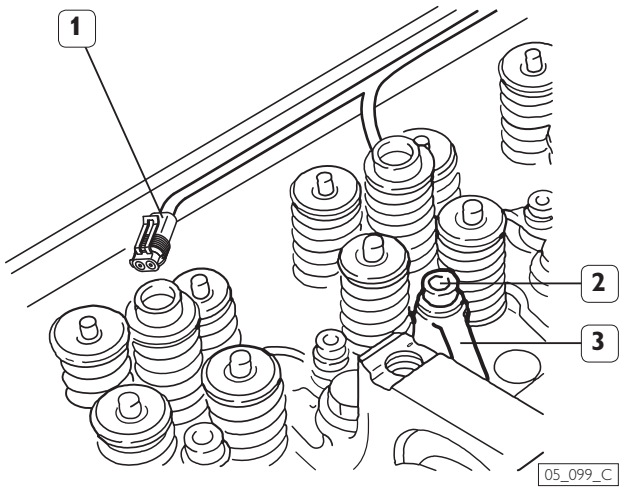
- ❏ Unscrew the screws (1) fixing the rocker arm shaft.

Figure 22



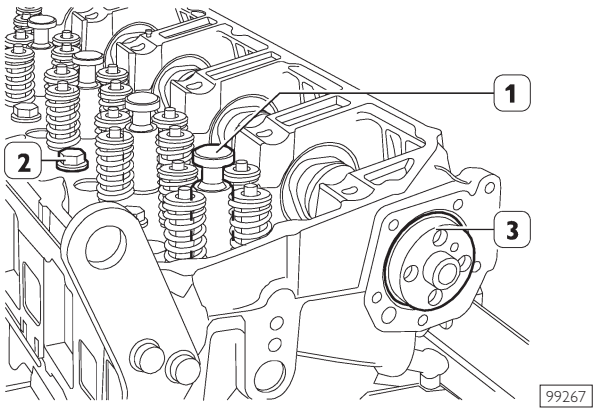
- ❏ Using tool 99360144 (3), secure the blocks (4) to the rocker arms (2);
- ❏ Apply tool 99360553 (1) to the rocker arm shaft (5) and remove the shaft (5) from the cylinder head.

Figure 23



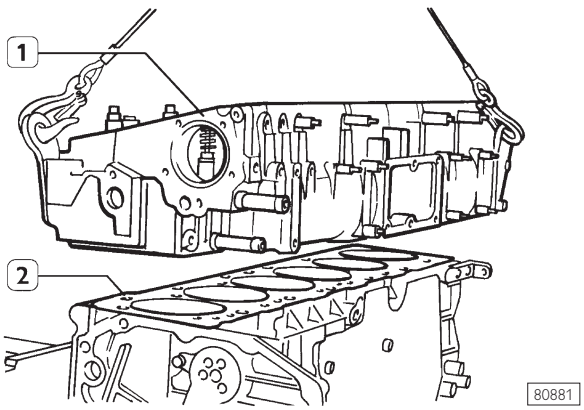
- ❏ Remove electric connections (1) from solenoid valves;
- ❏ Untighten fixing screws (2) of injector brackets (3).
- ❏ Remove injectors.

Figure 24



- ❏ Fit the plugs 99360180 (1) in place of the injectors;
- ❏ Take out the camshaft (3);
- ❏ Take out the screws (2) fixing the cylinder head.

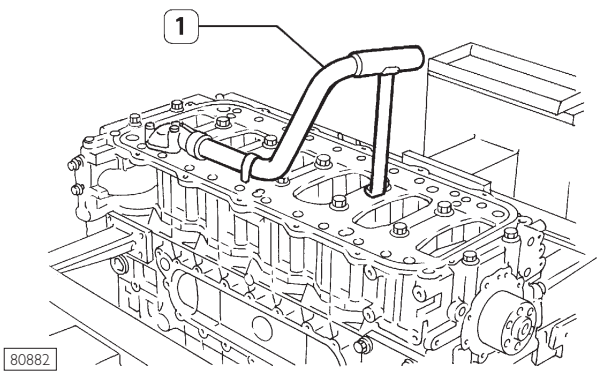
Figure 25



- ❏ By means of wire ropes, lift the cylinder head (1) and remove seals (2).

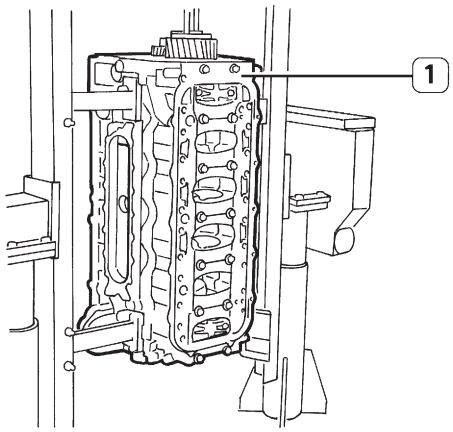
Untighten screws and remove the engine oil sump.

Figure 26



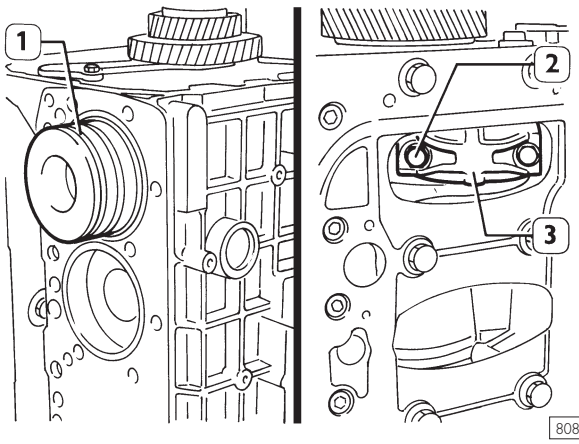
Untighten screws and remove suction rose (1).

Figure 27



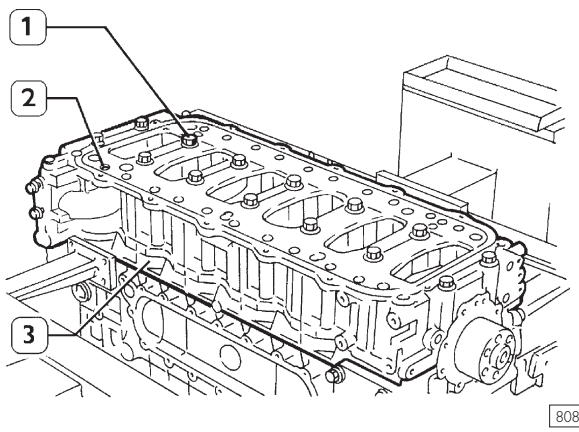
Rotate the block (1) to the vertical position.

Figure 28



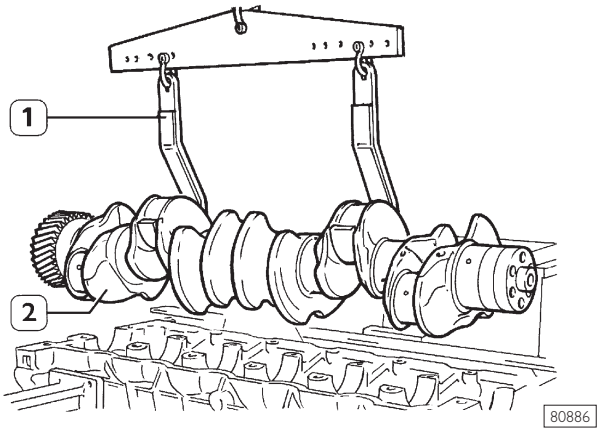
Untighten screws (2) fixing the connecting rod cap (3) and remove it. Remove the connecting rod-piston assembly from the upper side. Repeat these operations for the other pistons.

Figure 29



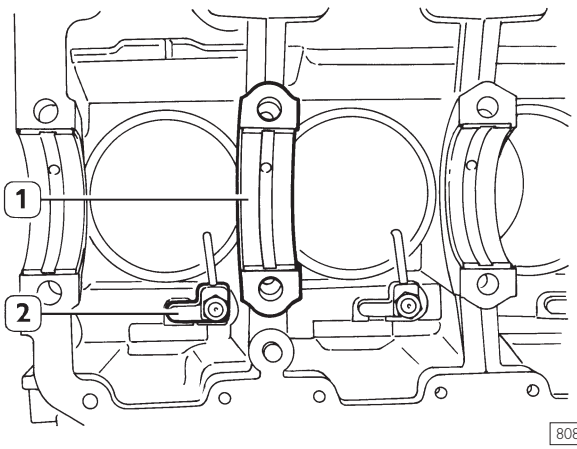
By means of proper and splined wrenches, untighten the screws (1) and (2) and remove the under-block (3).

Figure 30



Remove the crankshaft (2) by means of tool 99360500 (1).

Figure 31



Remove the crankshaft half-bearings (1), untighten the screws and remove oil spray nozzles (2).
Take down cylinder liners as specified in the relative paragraph.

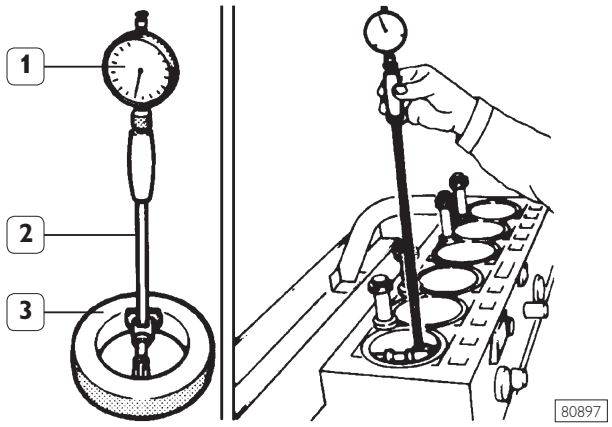
CAUTION

After disassembling the engine, thoroughly clean disassembled parts and check their integrity.
Instructions for main checks and measures are given in the following pages, in order to determine whether the parts can be re-used.

CYLINDER BLOCK

Checks and measurements

Figure 32

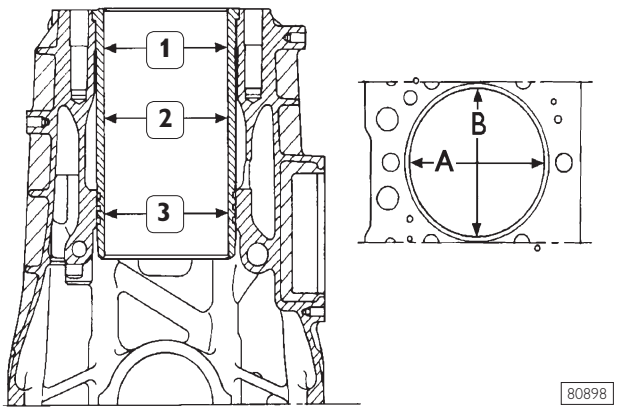


Internal diameter of the cylinder liners is checked for ovalization, taper and wear, using a bore dial (1) centesimal gauge 99395687 (2) previously reset to ring gauge (3), diameter 135 mm.

CAUTION

If a 135 ring gauge is not available use a micrometer caliper.

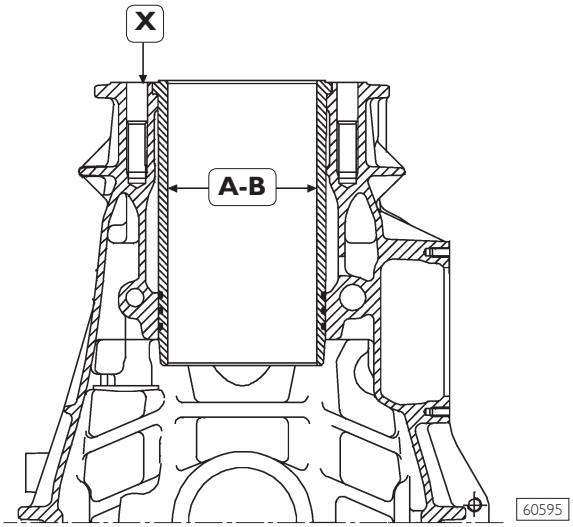
Figure 33



1 = 1st measuring;
2 = 2nd measuring;
3 = 3rd measuring.

Carry out measurings on each cylinder liner at three different levels and on two (A-B) surfaces, to one another perpendicular, as shown in the figure above.

Figure 34



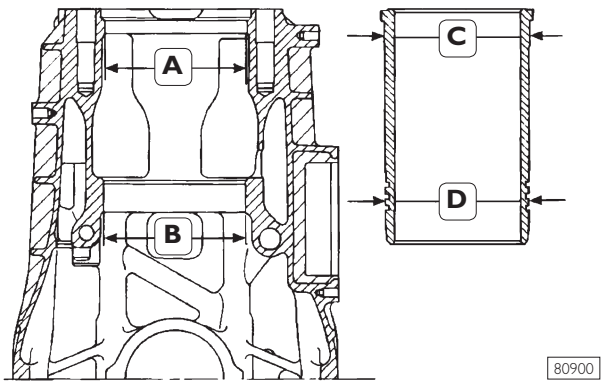
A = Selection class Ø 135 to 135.013 mm;
B = Selection class Ø 135.011 to 135.024 mm.
X = Selection class marking area.

In case of maximum wear exceeding 0.150 mm or maximum ovalization exceeding 0.100 mm compared to the values indicated in the figure, the liners must be replaced as they cannot be ground, lapped or trued.

CAUTION

Cylinder liners are equipped with spare parts with "A" selection class.

Figure 35

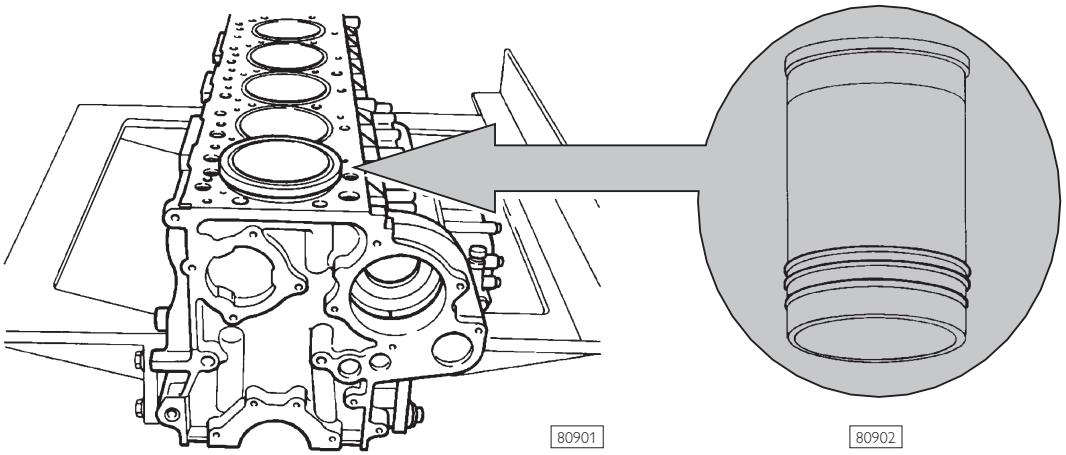


A = Ø 153.500 to 153.525 mm;
B = Ø 152.000 to 152.025 mm;
C = Ø 153.461 to 153.486 mm;
D = Ø 151.890 to 151.915 mm.

The figure shows the outer diameters of the cylinder liners and the relative seat inner diameters.
The cylinder liners can be extracted and installed several times in different seats, if necessary.

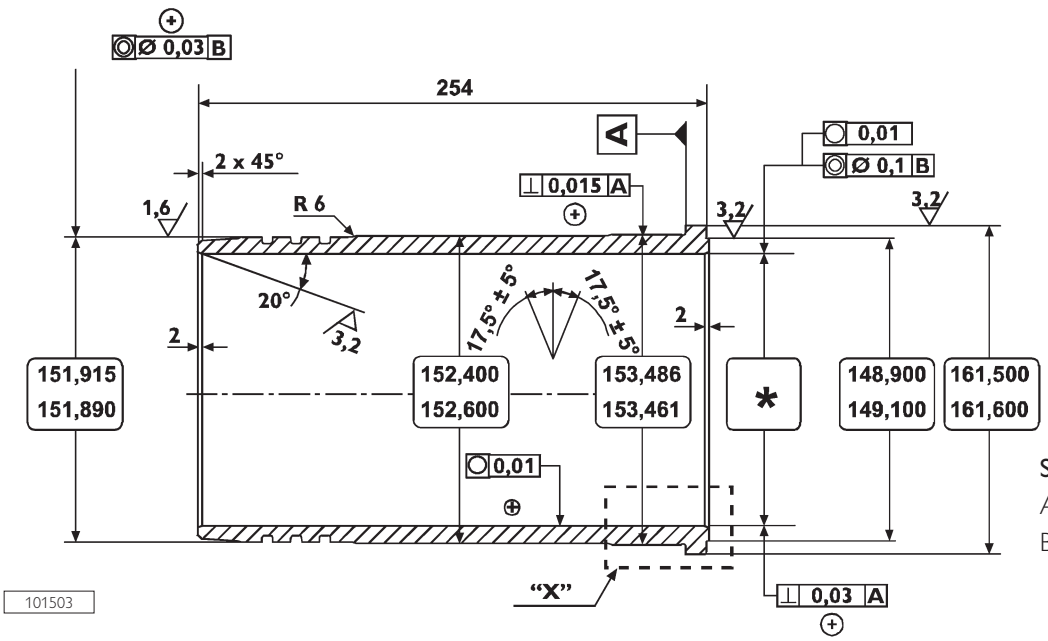
CYLINDER LINERS

Figure 36



BLOCK WITH CYLINDER LINERS

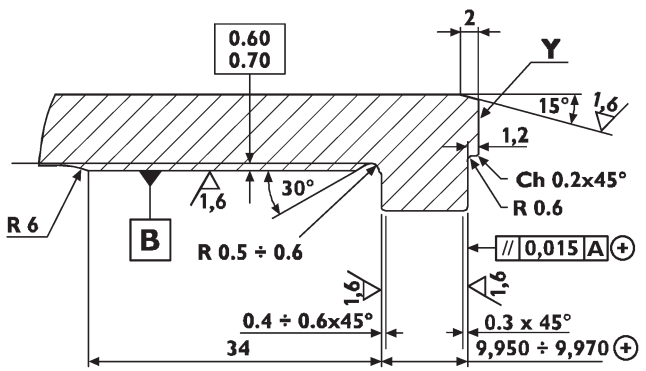
Figure 37



Selection class
A mm 135.000 to 135.013
B mm 135.011 to 135.024

CYLINDER LINERS
MAIN DATA

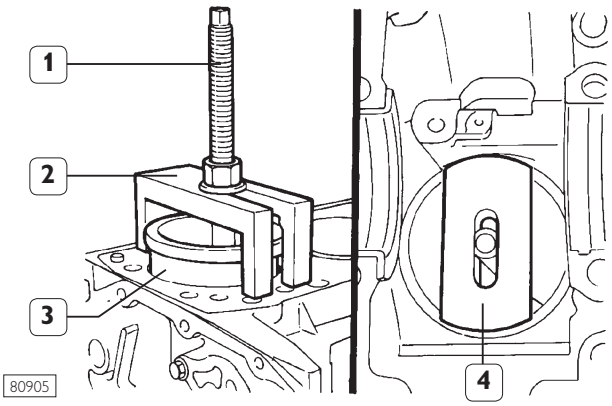
Figure 38



"X" DETAIL
"Y" = Selection class marking area.

Replacing cylinder liners - Removal

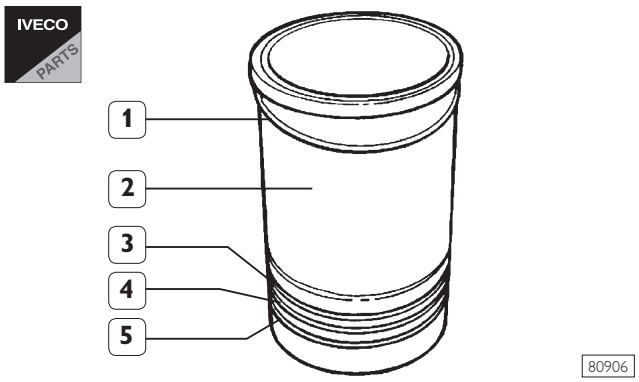
Figure 39



Place components 99360706 (1 and 2) and plate 99360728 (4) as shown in the figure, by making sure that the plate (4) is properly placed on the cylinder liners.
Tighten the screw nut (1) and remove the cylinder liner (3) from the block.

Fitting and checking protrusion

Figure 41

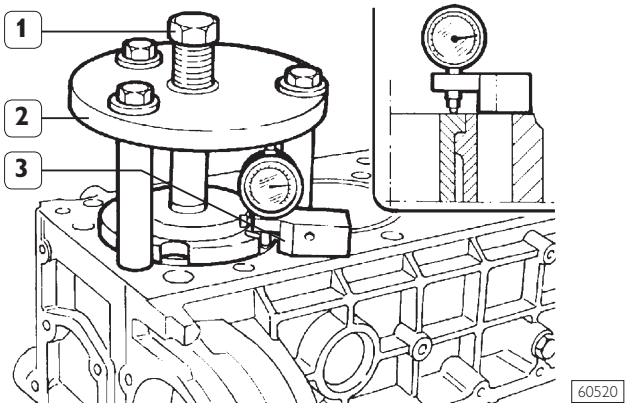


Always replace water sealing rings (3, 4 and 5).
Install the adjustment ring (1) on the cylinder liner (2); lubricate lower part of liner and install it in the cylinder unit using the proper tool.

CAUTION

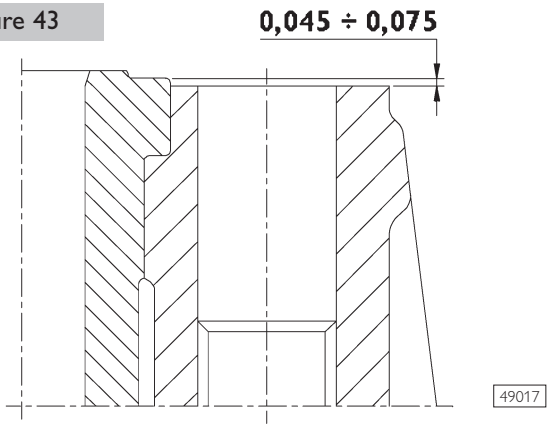
The adjustment ring (1) is supplied as spare parts in the following thicknesses: 0.08 mm - 0.10 mm - 0.12 - 0.14 mm.

Figure 42



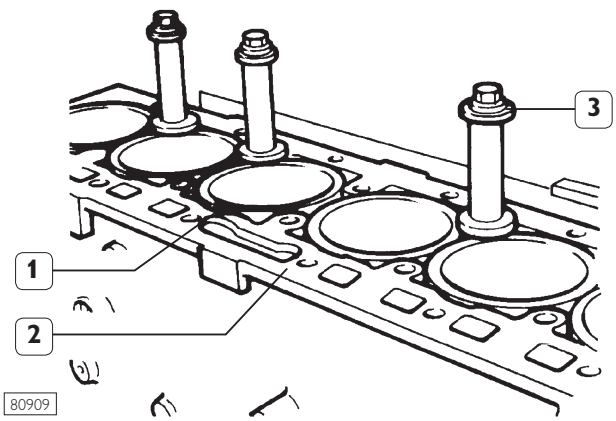
Check the protrusion of the cylinder liners with tool 99360334 (2) and tightening the screw (1) to a torque of 225 Nm.
Using the dial gauge 99395603 supplied as standard with the dial gauge base 99370415 (3), check that the protrusion of the cylinder liner over the supporting face of the cylinder head is 0.045 - 0.075 mm (Figure 43); if this is not so, replace the adjustment ring (1, Figure 14), supplied as a spare part with several thicknesses.

Figure 43



CYLINDER LINER PROTRUSION

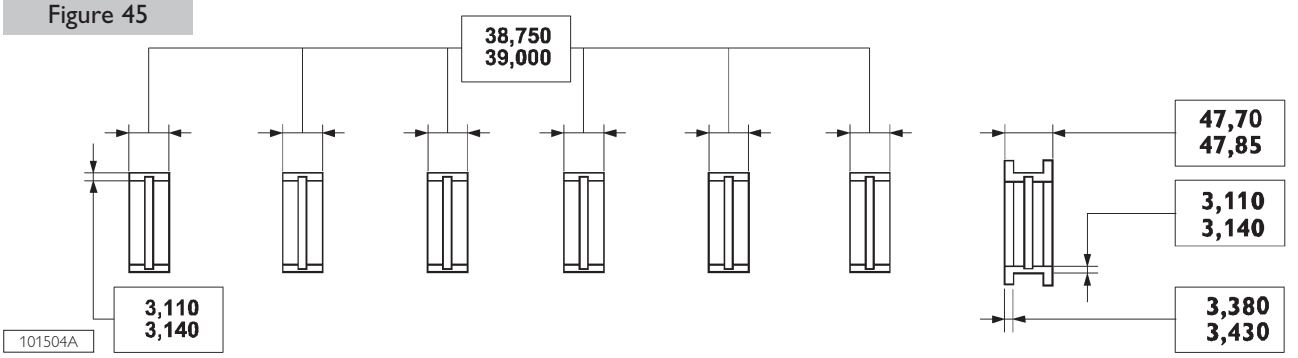
Figure 44



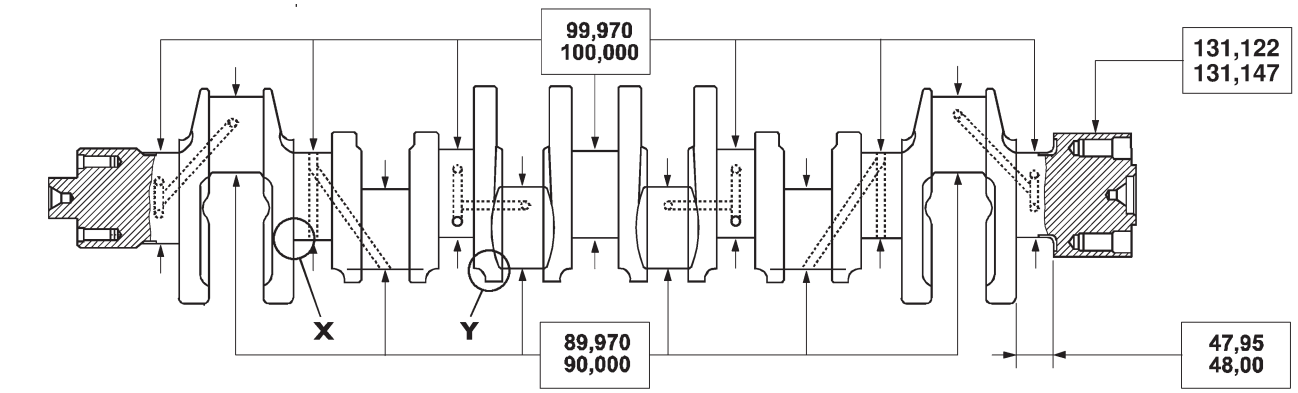
When the installation is completed, block the cylinder liners (1) to the block (2) with studs 99360703 (3).

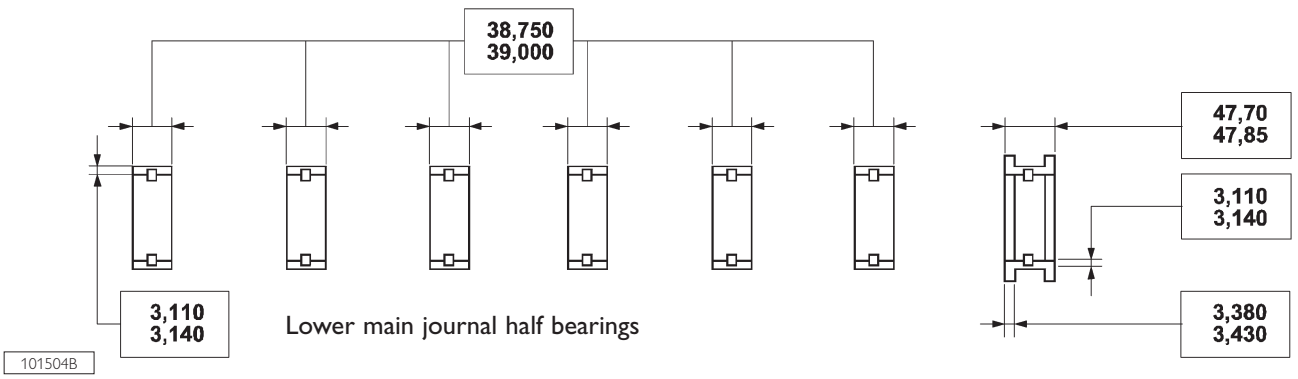
CRANKSHAFT

Figure 45



Upper main journal half bearing



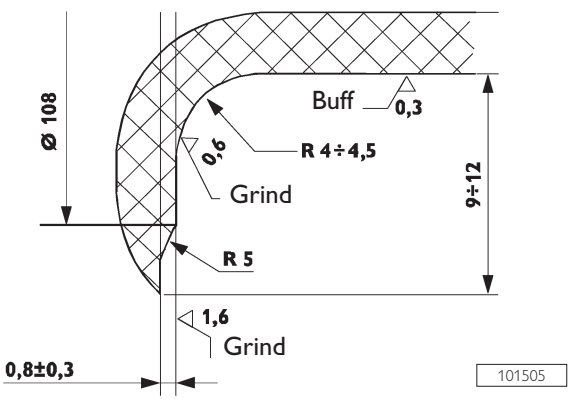


Lower main journal half bearings

MAIN DATA FOR THE CRANKSHAFT PINS AND THE HALF BEARINGS

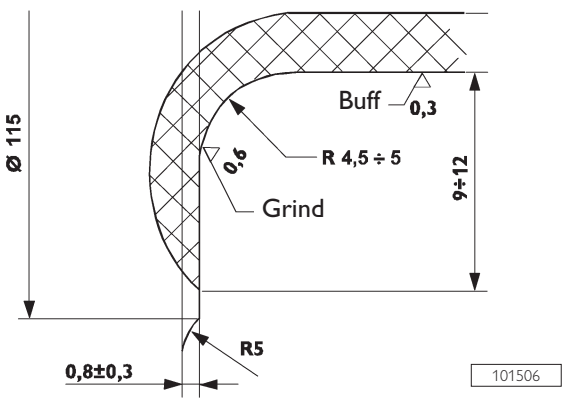
Check the condition of the journals and the big end pins; there must no be signs of scoring, ovalization or excessive wear. The data given refer to the normal diameter of the pins.

Figure 46



X. Detail of main journals connections.

Figure 47

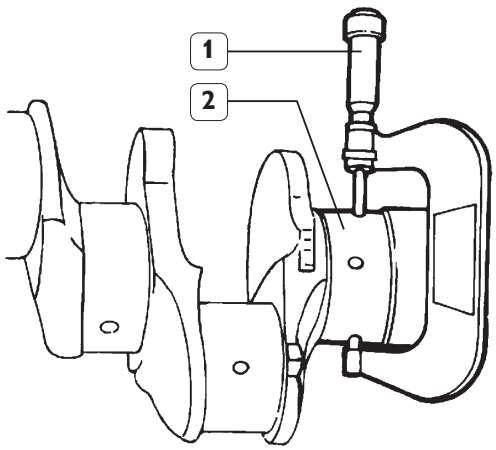


X. Detail of main journals connections.

Measuring main journals and crankpins

Before grinding the crank pins using a micrometer (1), measure the main journals and the crank pins (2) and decide, on the basis of the undersizing of the bearings, the final diameter to which the pins are to be ground.

Figure 48

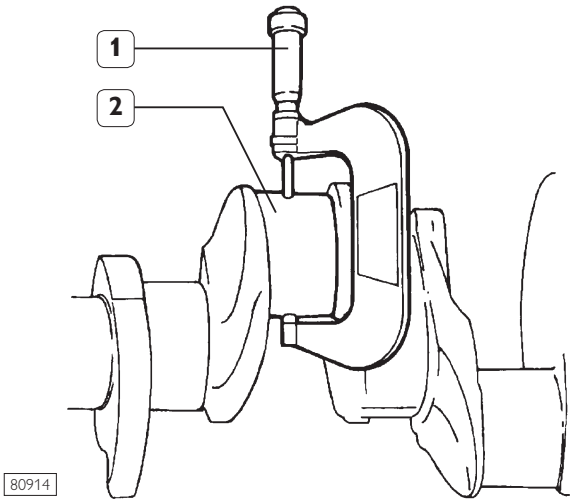


MEASURING THE MAIN JOURNALS

CAUTION

It is advisable to enter the values found in a table (Figure 50).

Figure 49



MEASURING CRANK PINS

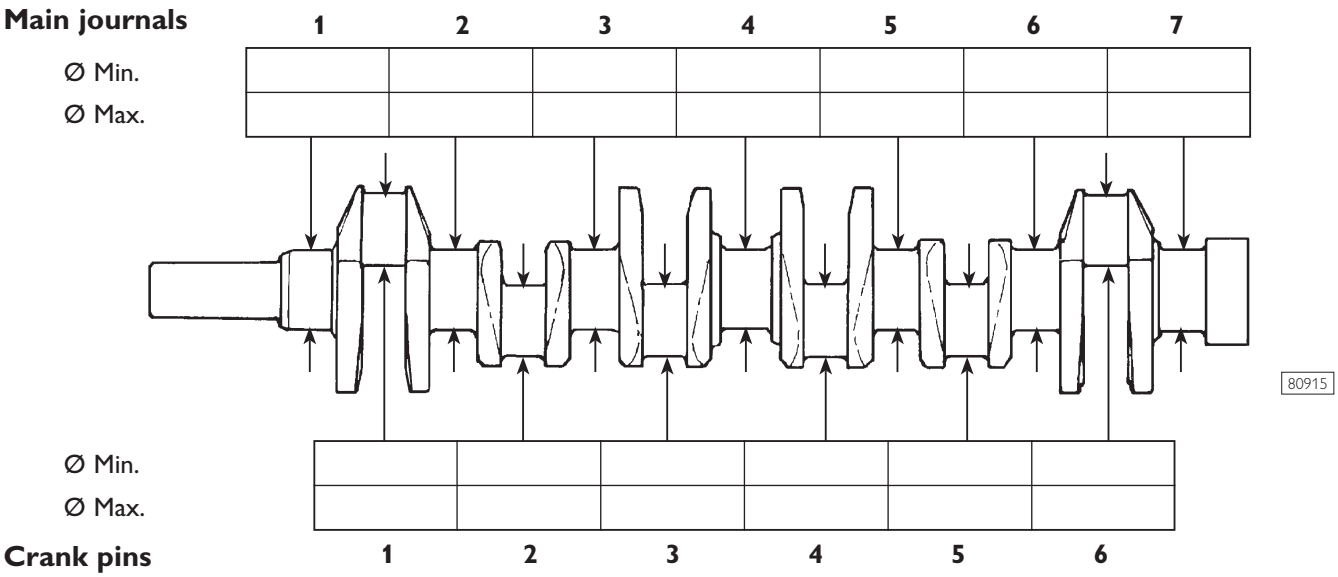
During grinding, pay attention to journal and crank pins values specified in figures 46 and 47.

CAUTION

All journals and crank pins must also be ground to the same undersizing class, in order to avoid any alteration to shaft balance.

Fill in this table with the measurements of the main journals and the crank pins.

Figure 50



PRELIMINARY MEASUREMENT OF MAIN AND BIG END BEARING SHELL SELECTION DATA

For each journal and crankpin, the following operations must be carried out:

Journals

- ❑ Determine the diameter class of the block housing;
- ❑ Determine the diameter class of the main journal;
- ❑ Select half-bearing class to be installed.

Crankpins

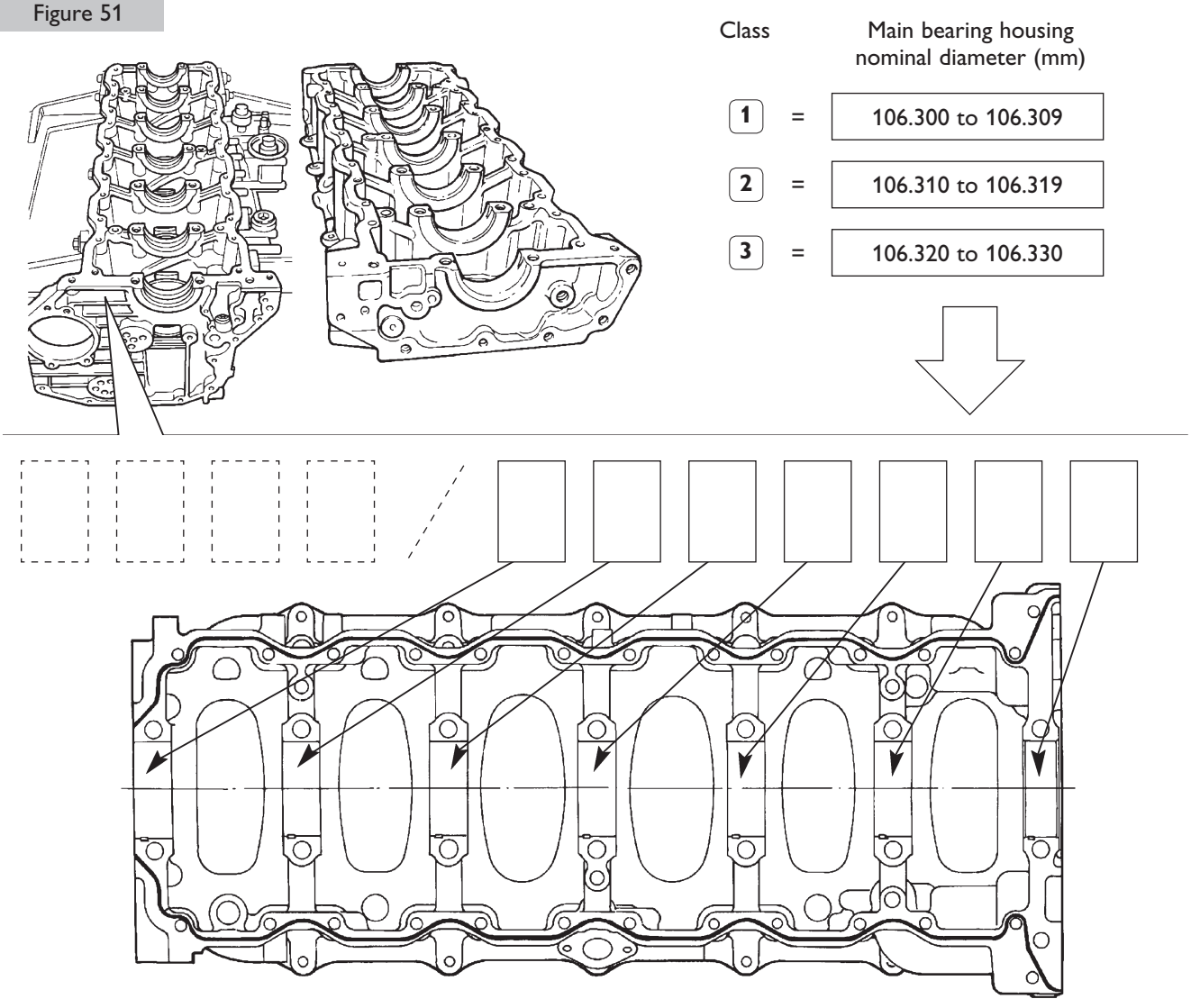
- ❑ Determine the diameter class of the connecting rod;
- ❑ Determine the diameter class of the big end pin;
- ❑ Select half-bearing class to be installed.

Determining the diameter class of the block housing

Two series of numbers are marked on the front side of the block, in the position specified (Figure 51, top).

- ❑ A four-digit number representing the coupling number of block to the relevant underblock;
- ❑ Each of the following seven digits represents the diameter class of the housing they refer to (Figure 51, bottom);
- ❑ Each of these digits may be **1**, **2** or **3**.

Figure 51



Selecting the main and big end bearing shells

CAUTION

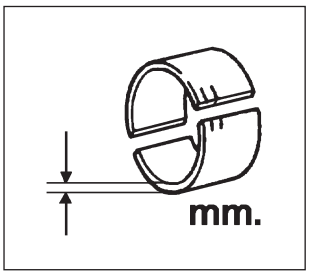
In order obtain the required assembly clearances, main half-bearings and big end half-bearings must be selected as specified below.

This operation makes it possible to identify the most suitable half-bearings for each journal (half-bearings can belong to different classes for the individual journals).

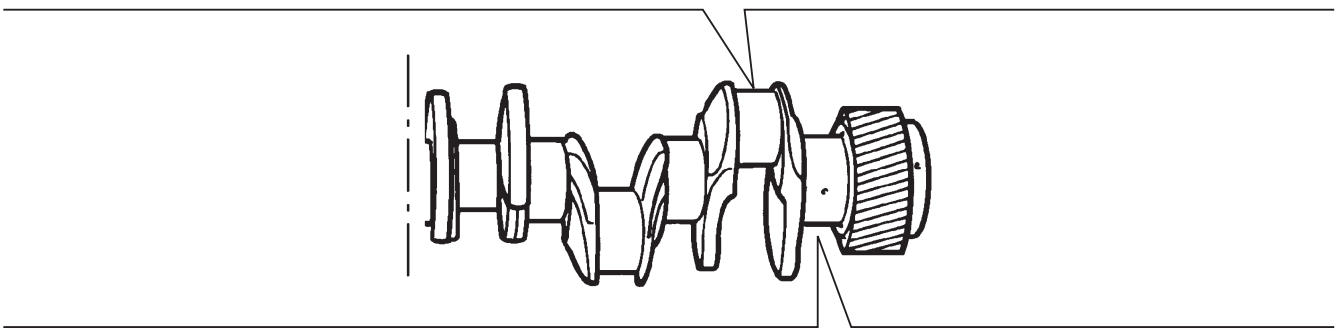
Depending on half-bearing thickness, tolerance classes are selected by colors (red-green- red/black - green/black).

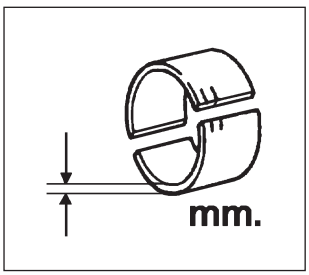
Figure 52 shows the characteristics of main half-bearings and big end half-bearings supplied as spares in standard measures (STD) and admissible oversizing (+0.127, +0.254, +0.508).

Figure 52



Main half-bearings	STD	+0.127	+0.254	+0.508
red	1.965 to 1.975		2.092 to 2.102	2.219 to 2.229
red/black		2.028 to 2.038		
green	1.976 to 1.985		2.103 to 2.112	2.230 to 2.239
green/black		2.039 to 2.048		





Big end half-bearings	STD	+0.127	+0.254	+0.508
red	3.110 to 3.120		3.237 to 3.347	3.364 to 3.374
red/black		3.173 to 3.183		
green	3.121 to 3.130			
green/black		3.184 to 3.193		

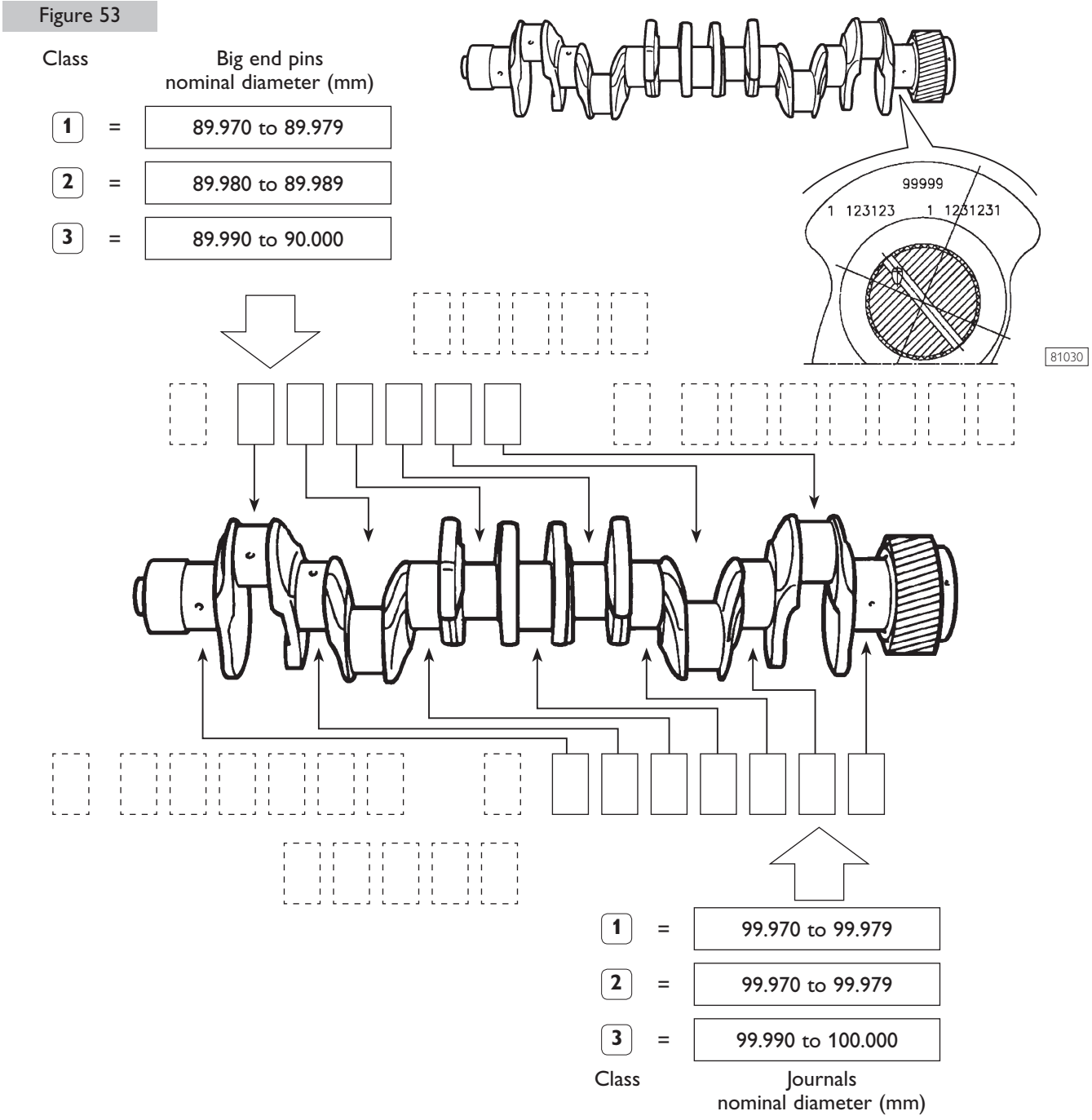
Selection of main half-bearings (nominal diameter pins)

Main journals and crank pins: determining the journal and pin diameter class

Three series of numbers are specified on the driving shaft, in the position specified (Figure 53 top, right):

- A five-digit number representing the shaft serial number;
- Under this number on the left, a six-digit number refers to big end pins and is preceded by a single digit, which indicates pin status (1 = STD, 2 = -0.127); each of the following six digits represents the diameter class of each big end pin it refers to (Figure 53, top, left);
- The seven-digit series, on the right, refers to the journals and is preceded by a single digit, which indicates journal status (1 = STD, 2 = -0.127); each of the following seven digits represents the diameter class of the journal it refers to (Figure 53, bottom).

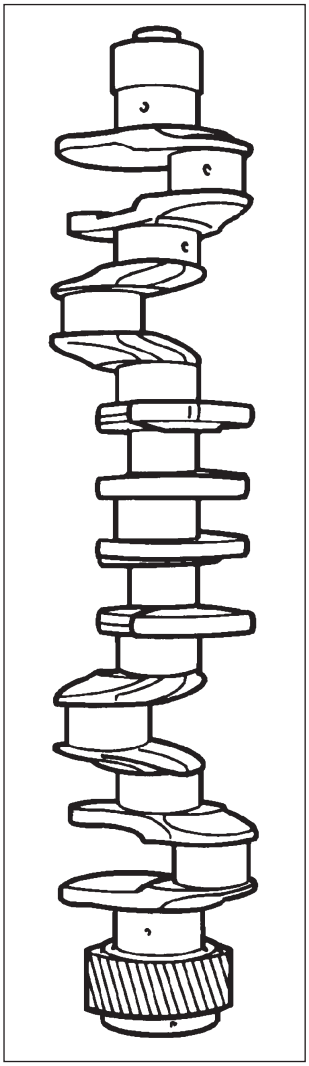
Figure 53

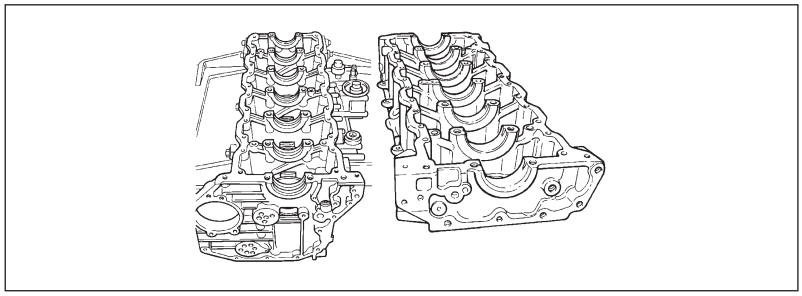


Selection of main half-bearings (nominal diameter pins)

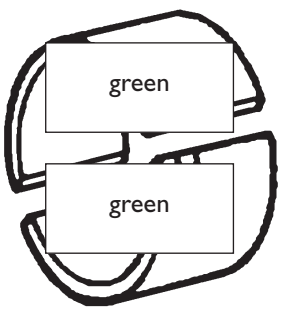
After detecting, for each journal, the necessary data on block and crankshaft, select the type of half-bearings to be used, in compliance with the following table:

Figure 54





STD.	1	2	3
1	green	green	green
	green	green	green
2	red	green	green
	red	green	green
3	red	red	red
	red	red	red



Selection of main half-bearings (rectified pins)

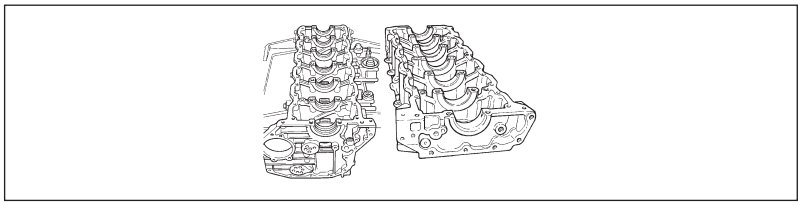
If the journals have been rectified, the procedure described cannot be applied.

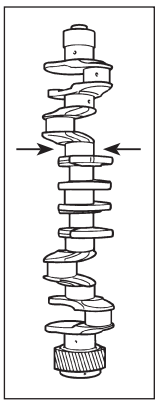
In this case, make sure that the new diameter of the journals is as specified on the table and install the only half-bearing type required for this undersizing.

red/black = mm 3.173 to 3.183

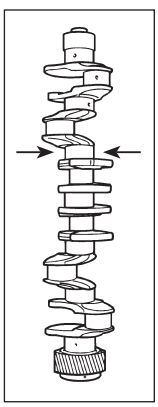
green/black = mm 3.184 to 3.193

-0.127



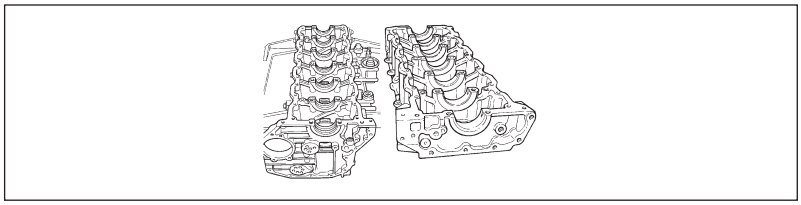


		1	2	3
99.843 – 99.852	1	green/black	green/black	green/black
		green/black	green/black	green/black
99.853 – 99.862	2	green/black	green/black	green/black
		red/black	green/black	green/black
99.863 – 99.873	3	red/black	green/black	green/black
		red/black	red/black	green/black

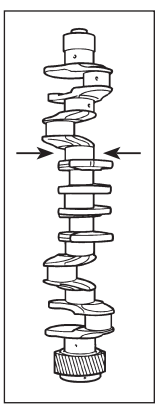


-0.254

red = mm 3.237 to 3.247

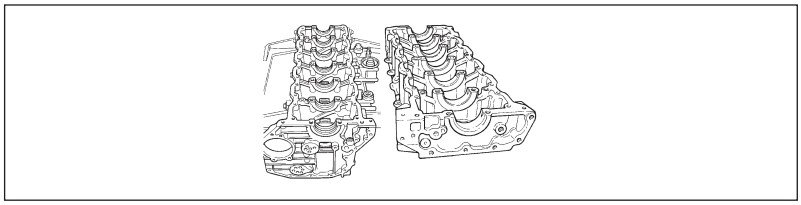


	1	2	3
99.726 – 99.746	red	red	red
	red	red	red



-0.508

red = mm 3.364 to 3.374



	1	2	3
99.472 – 99.492	red	red	red
	red	red	red

Selection of connecting rod half-bearings (nominal diameter pins)

Three indications are marked on the connecting rod, in position "A".

1 Letter indicating the weight class:
A = 4756 to 4795 g.
B = 4796 to 4835 g.
C = 4836 to 4875 g.

2 Number indicating the diameter selected for the housing of the big end bearing:
1 = 94,000 to 94,010 mm
2 = 94,011 to 94,020 mm
3 = 94,021 to 94,030 mm

3 Numbers identifying the cap-connecting road coupling.

The number specifying the diameter class of the half-bearing housing can be **1**, **2** or **3**.
Determine the type of big end half-bearings to be installed on each pin by following the indications given in the table (Figure 56).

Figure 55

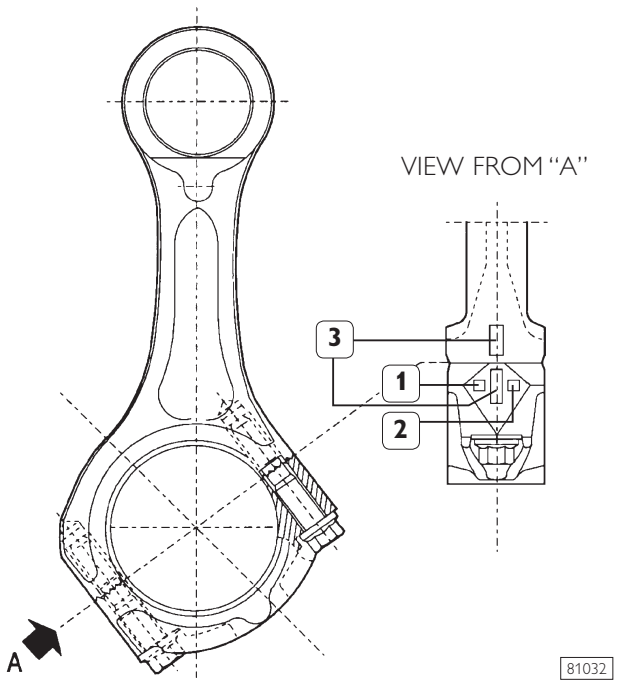
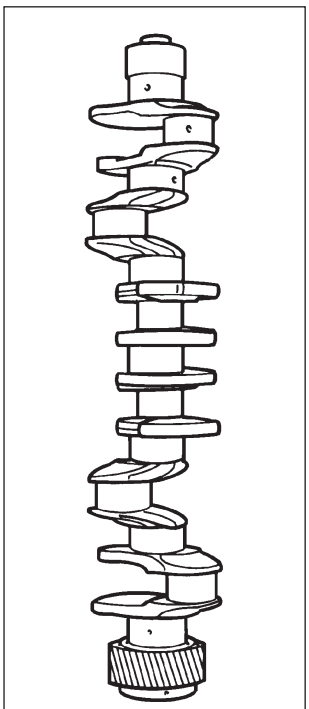
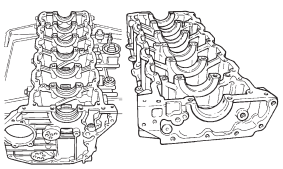


Figure 56

STD.





	1	2	3
1	green	green	green
	green	green	green
2	red	green	green
	red	green	green
3	red	red	red
	red	red	red

Selection of connecting rod half-bearings (rectified pins)

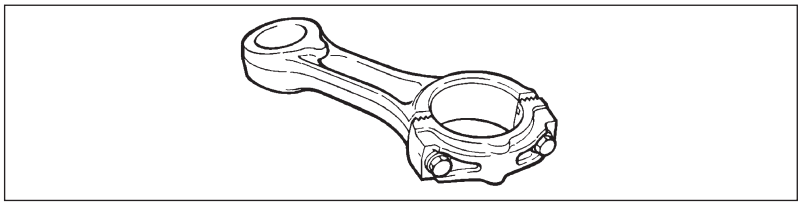
If pins have been rectified, the procedure described must be applied.

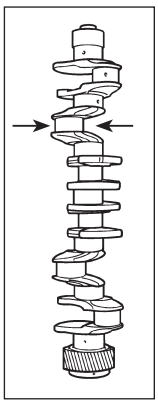
In this case, (for each undersizing) determine the tolerance field the new big end pins belong to, and install the half-bearings identified according to the relative table.

red/black = mm 2.028 to 2.038

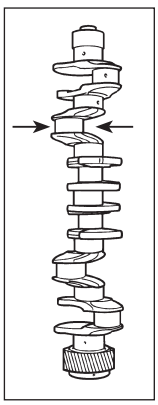
green/black = mm 2.039 to 2.048

-0.127





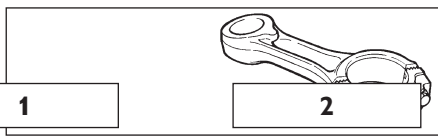
	1	2	3
89.843 – 89.852	green/black	green/black	green/black
	green/black	green/black	green/black
89.853 – 89.862	green/black	green/black	green/black
	red/black	green/black	green/black
89.863 – 89.873	red/black	green/black	green/black
	red/black	red/black	green/black



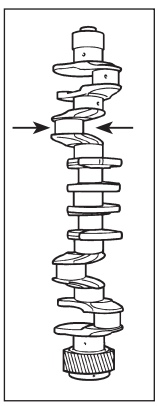
-0.254

red = mm 2.092 to 2.102

green = mm 2.103 to 2.112



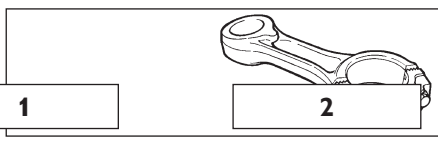
	1	2	3
89.726 – 89.735	red	green	green
	red	green	green
89.736 – 89.746	red	red	green
	red	red	green



-0.508

red = mm 2.219 to 2.229

green = mm 2.230 to 2.239

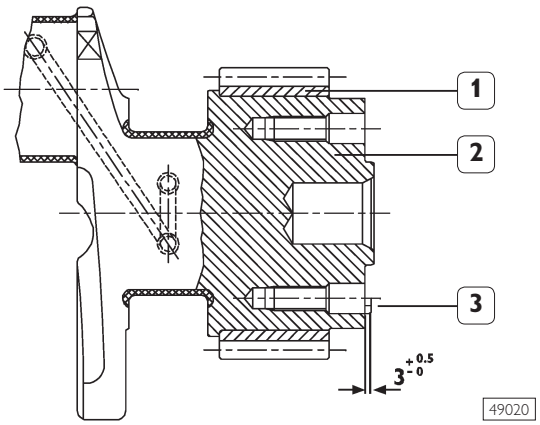


	1	2	3
89.472 – 89.481	red	green	green
	red	green	green
89.482 – 89.492	red	red	green
	red	red	green

Replacing the timing control gear and the oil pump

Check that the teeth of the gears are not damaged or worn, otherwise remove them using the appropriate extractor.

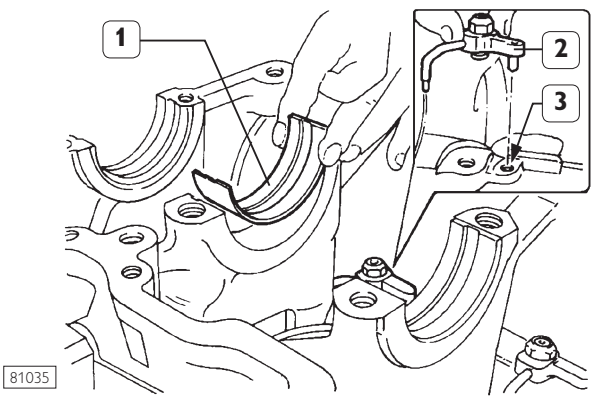
Figure 57



When fitting gear (1) onto drive shaft (2), the gear must be heated for 2 hours max. in a furnace, at a temperature not higher than 180°C.
Let them cool down after the installation.
If changing the pin (3), after fitting it on, check it protrudes from the crankshaft as shown in the figure.

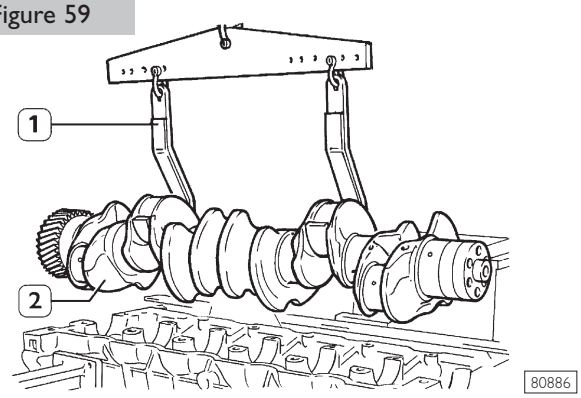
Checking main journal installation clearance

Figure 58



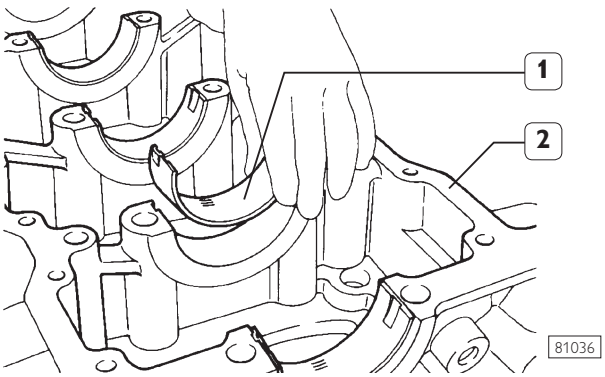
Install the oil spray nozzles (2) and have the dowel coincide with the block hole (3).
Install the half-bearings (1) on the main bearings.

Figure 59



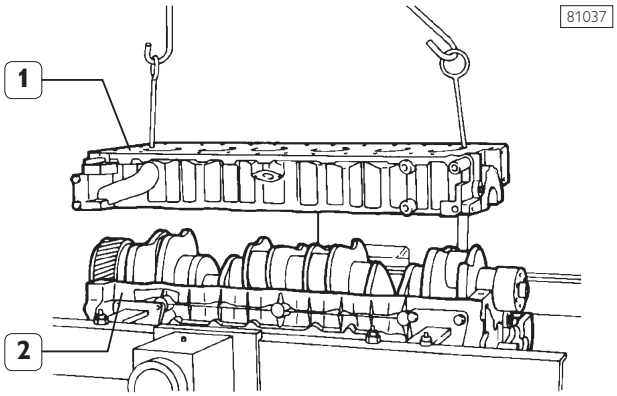
Using the hoist and hook 99360500 (1) mount the driving shaft (2).

Figure 60



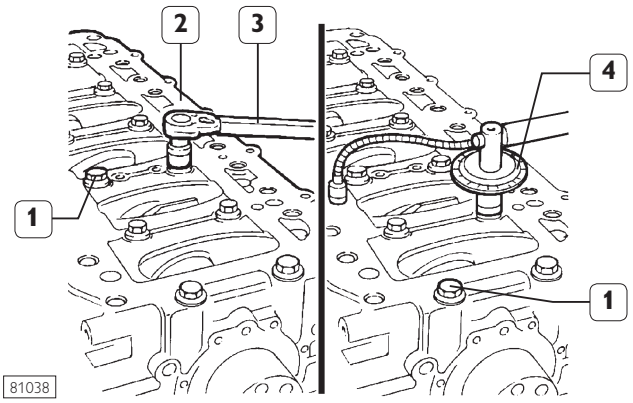
Install the half-bearings (1) on the main bearings in the underblock (2).
Check the installation clearance between the main journals and the relative bearings as follows:

Figure 61



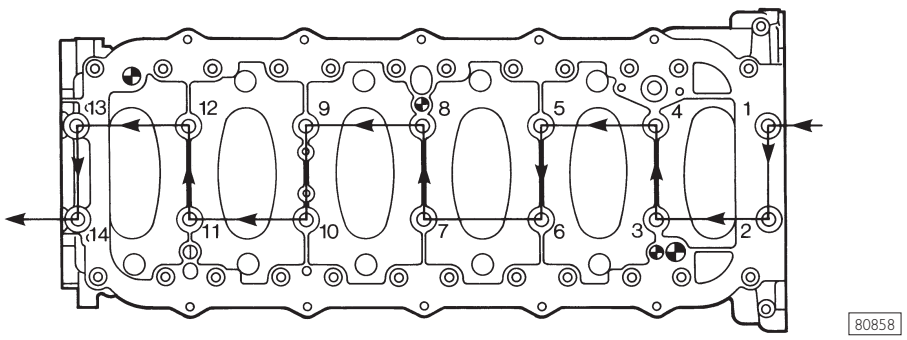
❑ Place a piece of calibrated wire on the journal of the crankshaft (2), parallel to the longitudinal axis; install the underblock (1), by hoist and appropriate hooks.

Figure 62



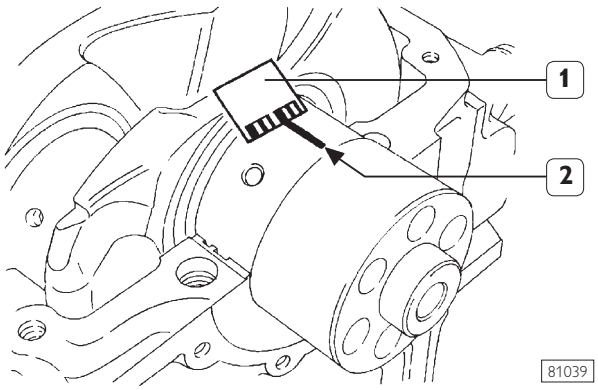
❑ Lubricate inside screws (1) with UTDM oil, and tighten them by dynamometric wrench to 140 Nm torque, thus with 60° angle closing, following the diagram in figure below.

Figure 63



TIGHTENING ORDER OF THE SCREWS FIXING THE LOWER UNDER-BLOCK TO THE BLOCK

Figure 64

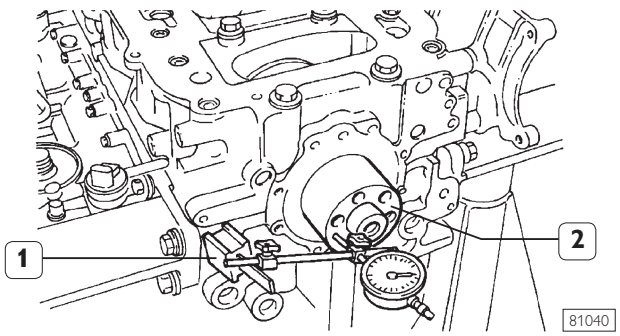


❑ Remove the under-block.

The clearance between the main bearings and the journals is obtained by comparing the calibrated wire length (2) at the maximum deflection point, with the calibrated scale on the coating (1) containing the calibrated wire.
Numbers shown on the scale specify the clearance in coupling millimeters. If the clearance obtained is different from the clearance required, replace the half-bearings and repeat this check.

Checking crankshaft end float

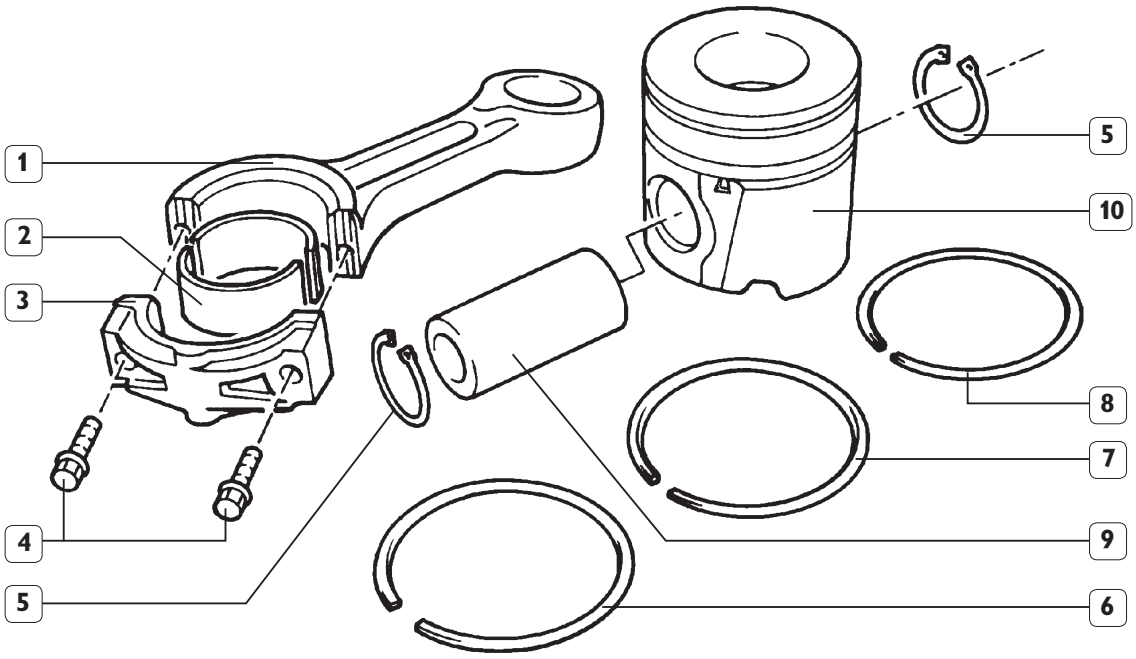
Figure 65



End float is checked by placing a magnetic dial gauge (1) on the crankshaft (2), as shown in the figure. If the value obtained is higher than specified, replace the rear thrust half-bearings and repeat this check.

PISTON CONNECTING ROD ASSEMBLY

Figure 66



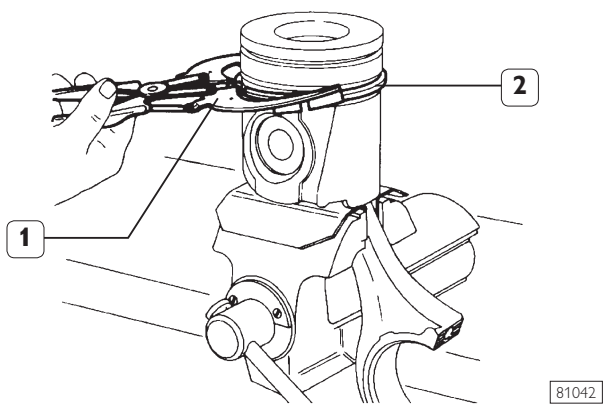
PISTON CONNECTING ROD ASSEMBLY

1. Connecting rod body - 2. Half bearings - 3. Connecting rod cap - 4. Cap fastening screws - 5. Split ring - 6. Scraper ring with spiral spring - 7. Bevel cut sealing ring - 8. Trapezoidal sealing ring - 9. Piston pin - 10. Piston.

Make sure the piston does show any trace of seizing, scoring, cracking; replace as necessary.

Removal

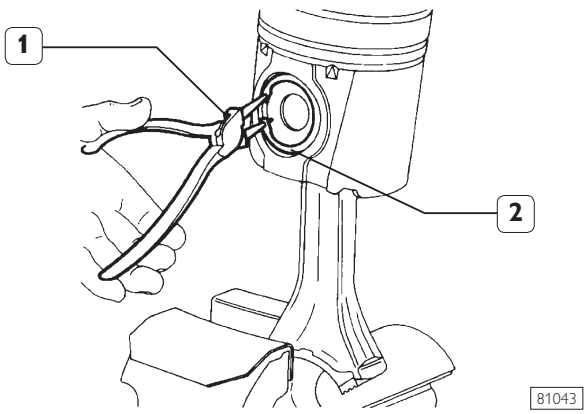
Figure 67



Removal of the piston split rings (2) using the pliers 99360184 (1).

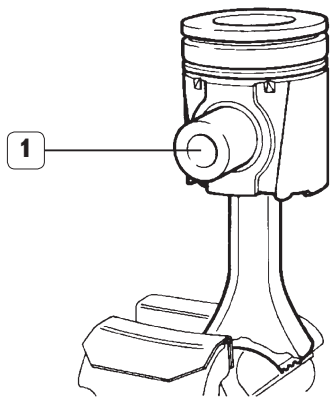
Pistons are equipped with three elastic rings: a sealing ring, a trapezoidal ring and a scraper ring.
Pistons are grouped into classes A and B for diameter.

Figure 68



Remove the piston pin split rings (2) using the round tipped pliers (1).

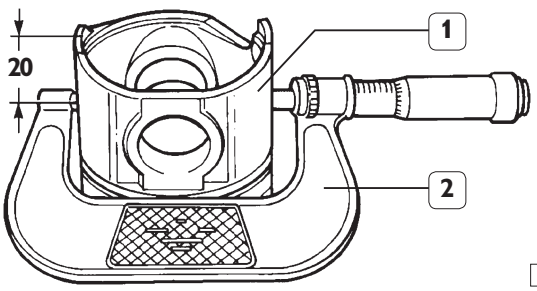
Figure 69



Remove the piston pin (1).
If removal is difficult use the appropriate beater.

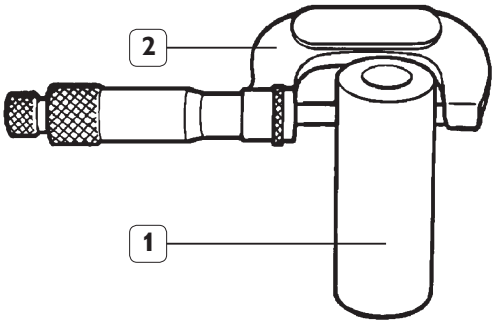
Measuring the diameter of the pistons

Figure 70



Using a micrometer (2), measure the diameter of the piston (1) to determine the assembly clearance; the diameter should be measured at the specified value.

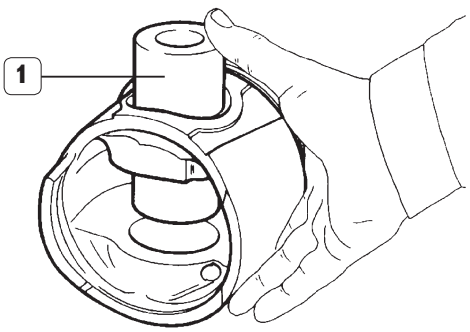
Figure 71



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

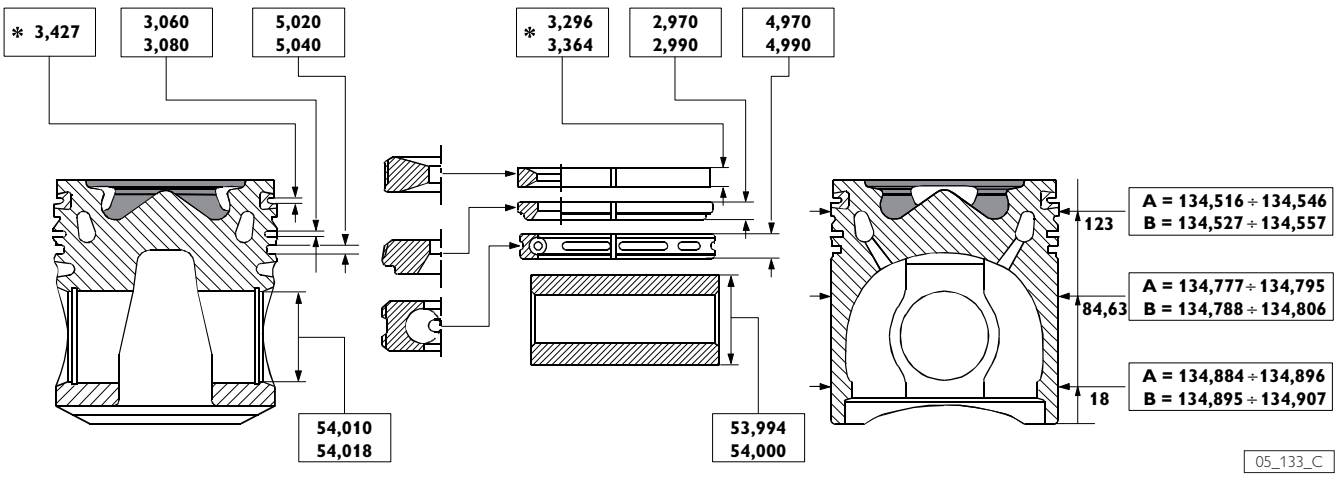
Conditions for correct gudgeon pin-piston coupling

Figure 72



Lubricate the pin (1) and the relevant housing on the piston hubs with engine oil; piston must be inserted with a slight finger pressure and must not fall down because of its own weight.

Figure 73

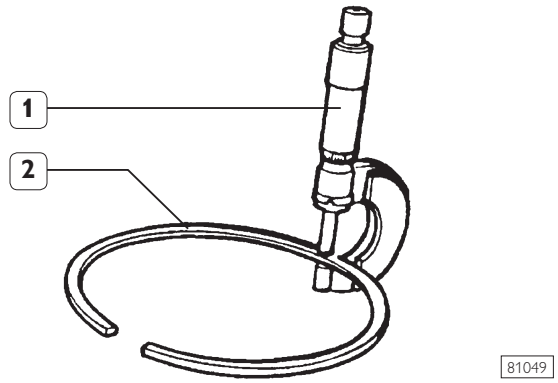


MAIN DATA ON PISTONS, AND PISTONS RINGS

* Values are determined on Ø of 130 mm.

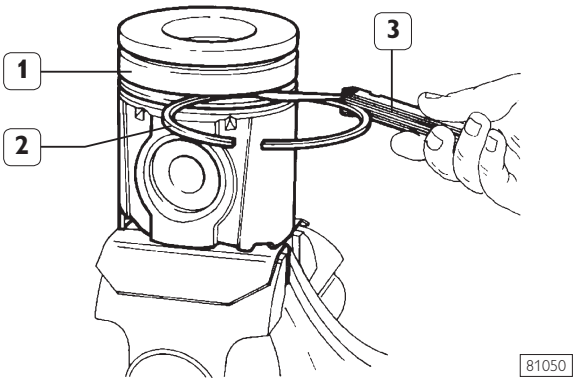
Piston rings

Figure 74



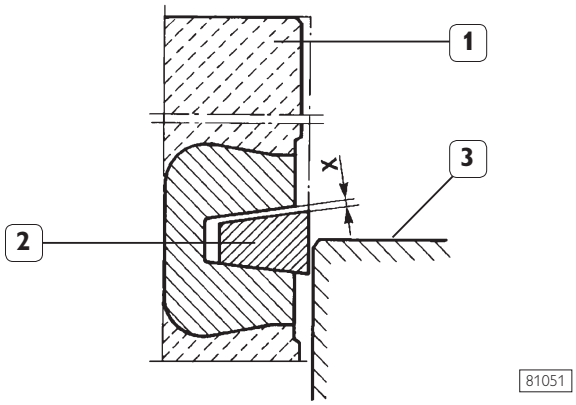
Check the thickness of the piston ring (2) using a micrometer (1).

Figure 75



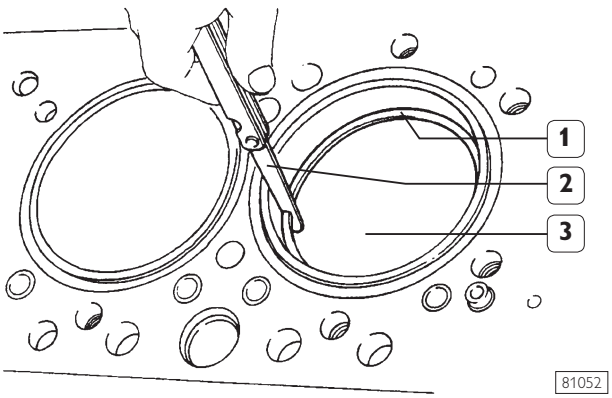
Check the clearance between the sealing rings (2) and the relative piston housings (1) using a thickness gauge (3).

Figure 76



The sealing ring (2) of the 1st cavity is trapezoidal. Clearance "**X**" between the sealing ring and its housing is measured by placing the piston (1) with its ring in the cylinder barrel (3), so that the sealing ring is half-projected out of the cylinder barrel.

Figure 77



Check the opening between the ends of the sealing rings (1), using a thickness gauge (2), entered in the cylinder barrel (3).
If the distance between ends is lower or higher than the value required, replace split rings.

CONNECTING ROD

Data concerning the class section of connecting rod housing and weight are stamped on the big end.

CAUTION

When installing connecting rods, make sure they all belong to the same weight class.

Diagram connecting rod marks

1 Letter indicating the weight class:
A = 4756 to 4795 g.
B = 4796 to 4835 g.
C = 4836 to 4875 g.

2 Number indicating the selection of diameter for the big end bearing housing:
1 = 94.000 to 94.010 mm
2 = 94.011 to 94.020 mm
3 = 94.021 to 94.030 mm

3 Numbers identifying cap-connecting rod coupling.

Figure 78

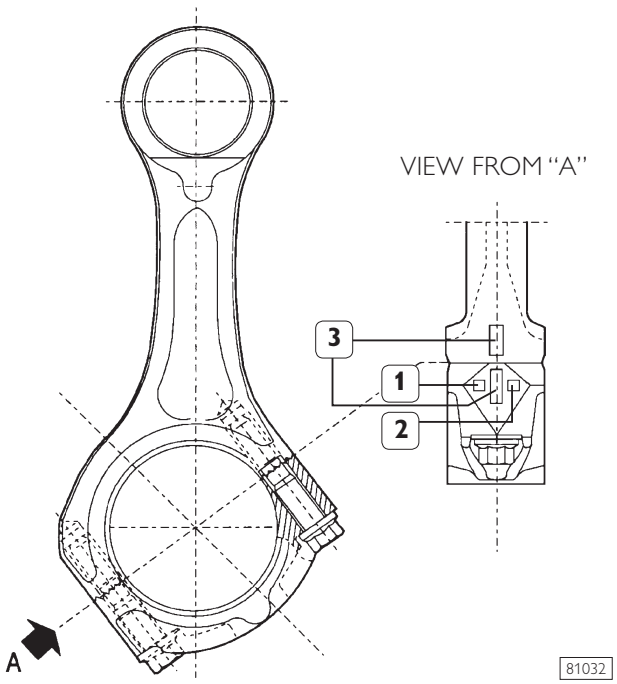
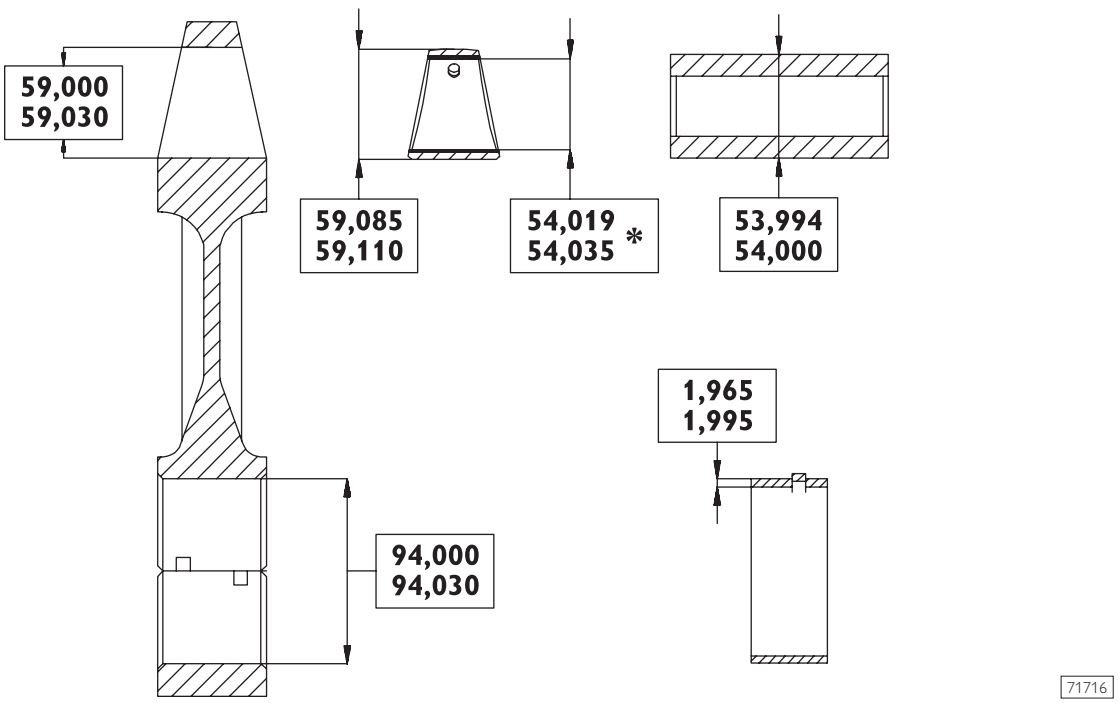


Figure 79

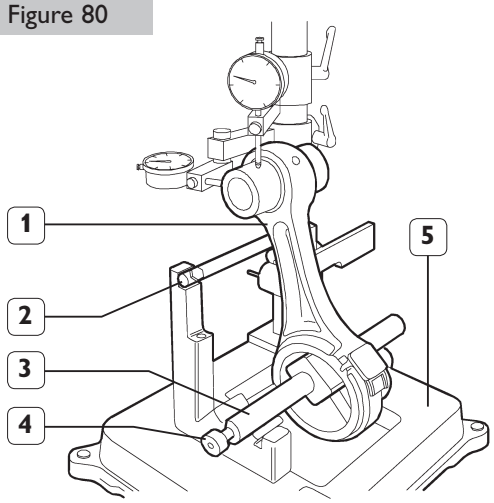


MAIN DATA - BUSH, CONNECTING ROD, PIN AND HALF-BEARINGS

* Values to be obtained after installing the bush.

Checking connecting rod alignment

Figure 80



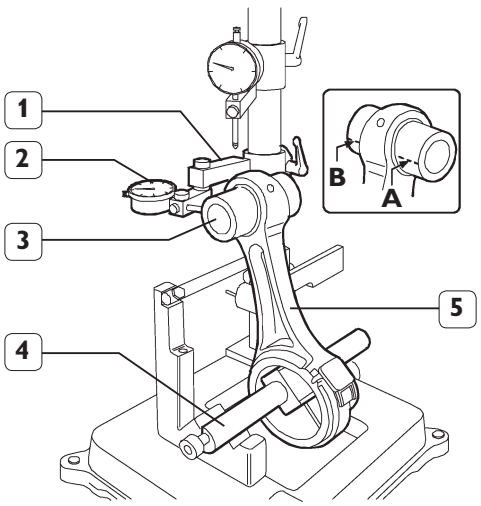
Checking axis alignment

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

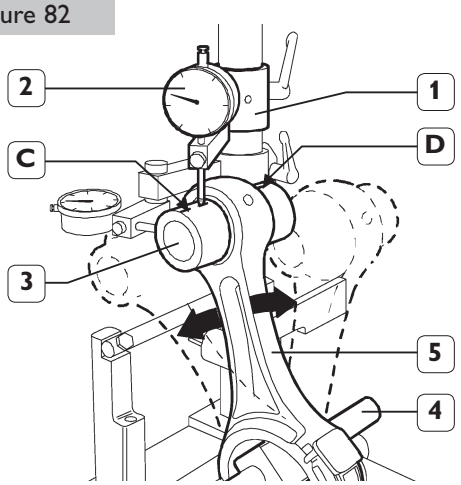
Figure 81



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 82



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.

Mounting the connecting rod-piston assembly

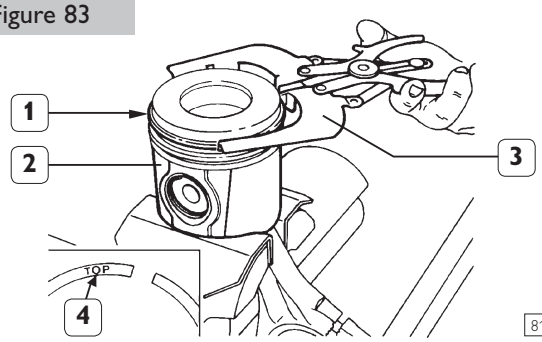
Carry out the steps for removal described on page 161 in reverse order.

CAUTION

The connecting rod screws can be reused as long as the diameter of the thread is not less than 13.4 mm.

Mounting the piston rings

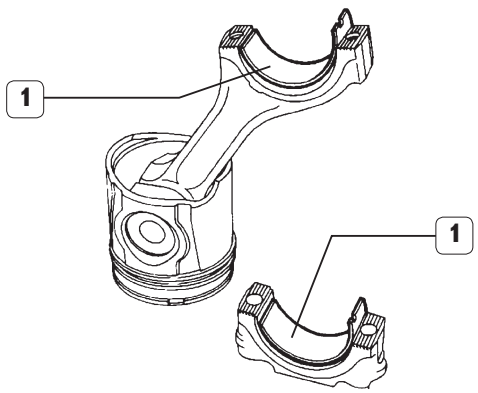
Figure 83



To fit the piston rings (1) on the piston (2) use the pliers 99360184 (3).
The rings need to be mounted with the word "TOP" (4) facing upwards. Direct the ring openings so they are staggered 120° apart.

Fitting the connecting rod-piston assembly into the piston liners

Figure 84

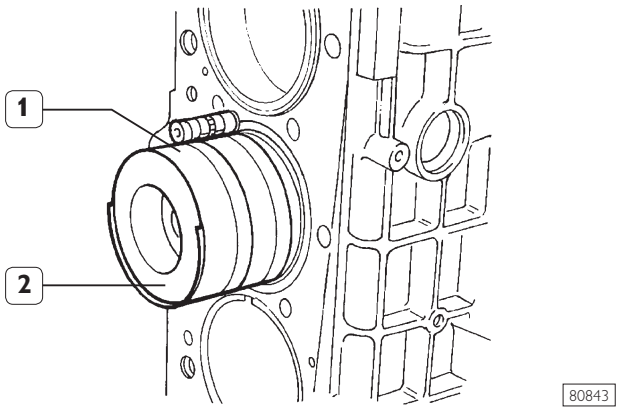


Install half-bearings (1), selected as specified from page 152, on both the connecting rod and the cap.

CAUTION

As spares, class A pistons are provided and can be fitted also to cylinder barrels belonging to class B.

Figure 85



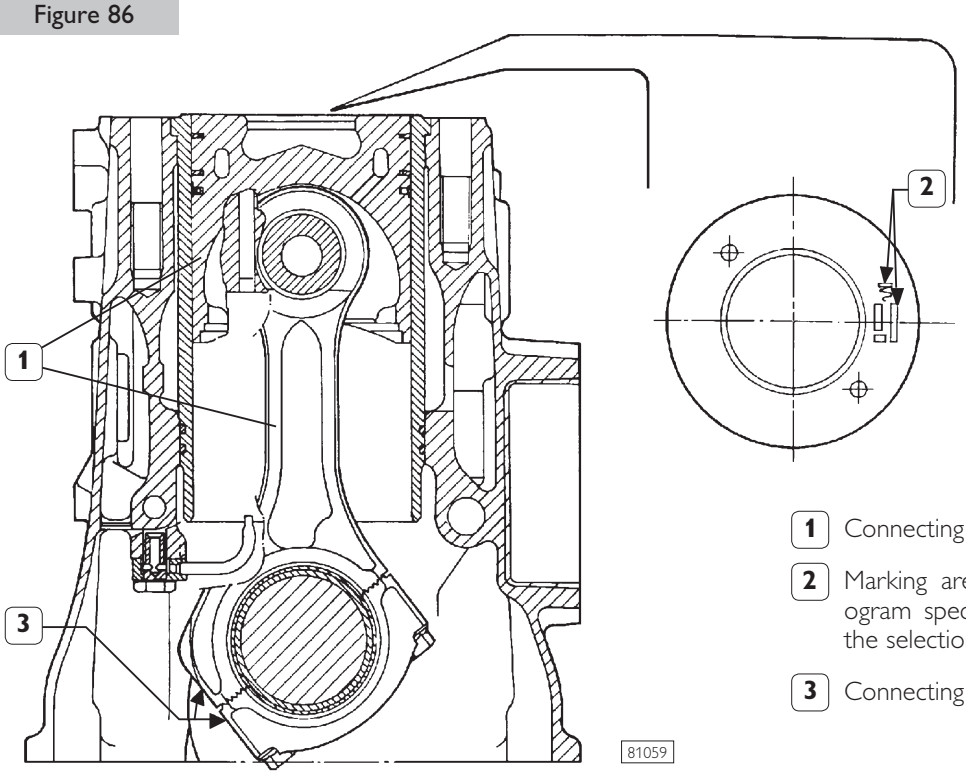
Fit the connecting rod-piston assemblies (1) into the piston liners (2) using band 99360605 (1, Figure 85). Check the following:

- ❏ The openings of the split rings are offset by 120°;
- ❏ All pistons belong to the same class, A or B;
- ❏ Ideogram stamped on the piston crown is placed toward the engine flywheel, or the cavity located on the piston skirt corresponds to the position of the oil spray nozzles.

Piston protrusion check

Once assembly is complete, check piston protrusion from cylinder barrels: it must be 0.12 to 0.42 mm.

Figure 86



1 Connecting rod-piston assembly;

2 Marking area on the piston crown of ideogram specifying the assembly position and the selection class;

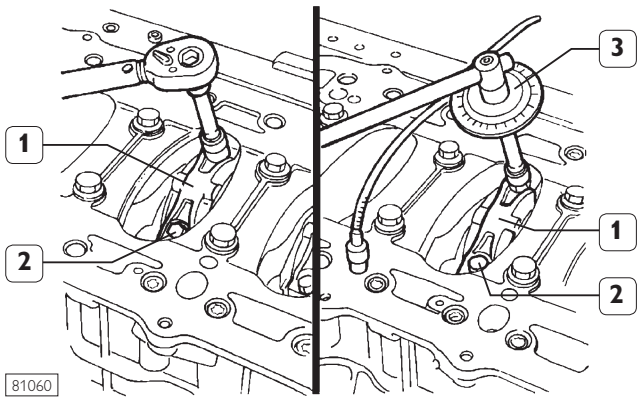
3 Connecting rod marking area (see fig. 78).

Checking assembly clearance of big end pins

To check the clearance proceed as follows:

- ❑ Connect the connecting rods to the relative main journals, place a length of calibrated wire on the latter;

Figure 87



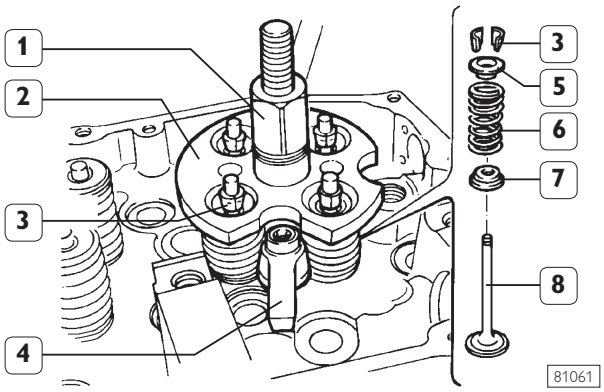
- ❑ Install the connecting rod caps (1) with half-bearings; tighten the connecting rod cap fixing screws (2) to 60 Nm (6 Kgm) torque. By tool 99395216 (3), tighten the screws further at 60° angle;
- ❑ Remove the caps and check the clearance by comparing the width of the calibrated wire with the scale calibration on the envelope containing the wire.

CYLINDER HEAD

Before taking down the cylinder head, check the seal using the appropriate tool; in case of leakage replace the cylinder head.

Valve removal

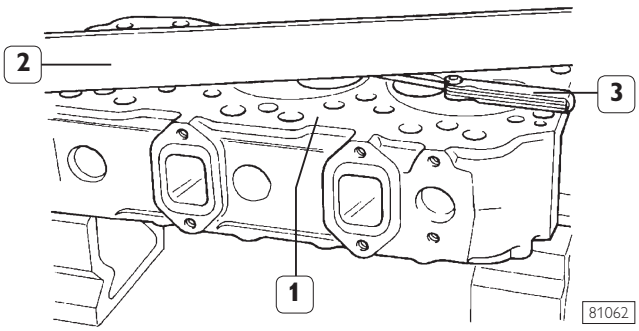
Figure 88



Install and fix tool 99360264 (2) with bracket (4); tighten by lever (1) until cotters are removed (3); remove the tool (2) and the upper plate (3), the spring (6) and the lower plate (7).
Repeat the operation on all the valves. Turn the cylinder head upside down and remove the valves (8).

Checking the planarity of the head on the cylinder block

Figure 89



The planarity (1) is checked using a ruler (2) and a thickness gauge (3). If deformations exist, surface the head using proper surface grinder; the maximum amount of material to be removed is 0.2 mm.

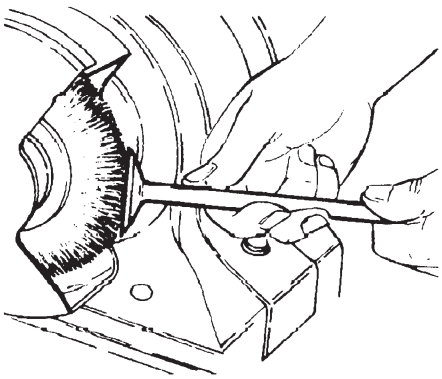
CAUTION

After leveling, make sure that valve sinking and injector protrusion are as described in the relative paragraph.

VALVES

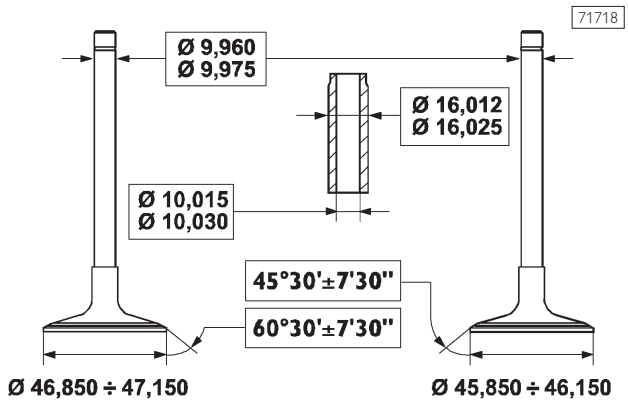
Removing deposits and checking the valves

Figure 90



Remove carbon deposits using the metal brush supplied. Check that the valves show no signs of seizure or cracking. Check the diameter of the valve stem using a micrometer (see fig. 92) and replace if necessary.

Figure 91



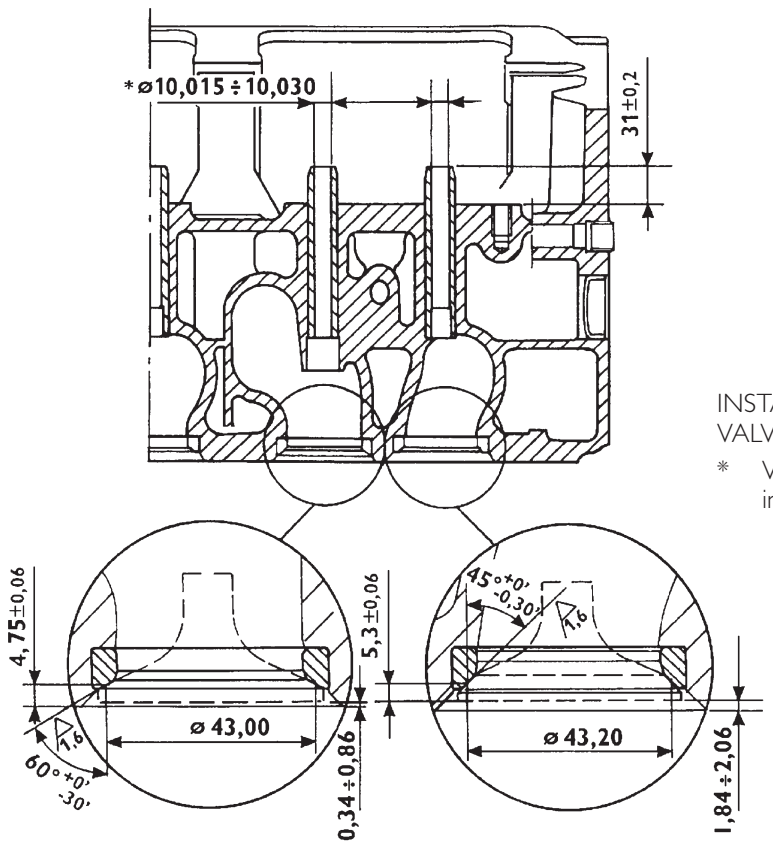
MAIN DATA - VALVES AND VALVE GUIDES

* Values to be obtained after installing the valve guides.

Check, by means of a micrometer, that valve stem diameters are as specified; if necessary, grind the valves seat with a grinder, removing the minimum quantity of material.

Valve guides

Figure 92



INSTALLATION DIAGRAM FOR VALVE GUIDES AND VALVES

* Values to be obtained after installing the guide valves.

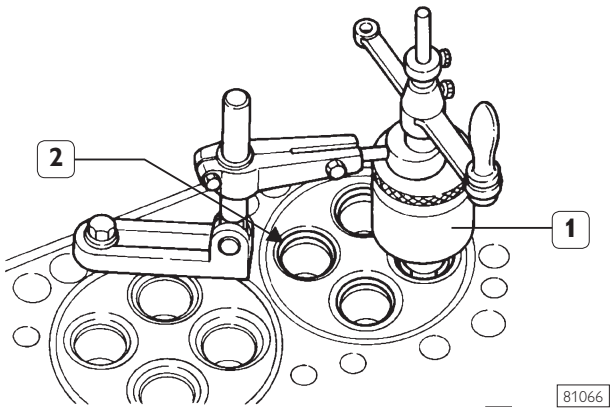
Replacing of valve guides

Remove valve guides by means of tool 99360143.
Install by means of tool 99360143 equipped with part 99360296, which determines the exact installation position of valve guides into the cylinder heads; if they are not available, install the valve guides in the cylinder head so that they project out by mm 30.8 to 31.2 (fig. 92).
After installing the valve guides, smooth their holes with sleeker 99390310.

Replacing - Reaming the valve seats

To replace the valve seats, remove them using the appropriate tool.

Figure 93



Ream the valve seats (2) on cylinder head using tool 99305019 (1).

CAUTION

Valve seats must be reamed whenever valves or valve guides are replaced or ground.

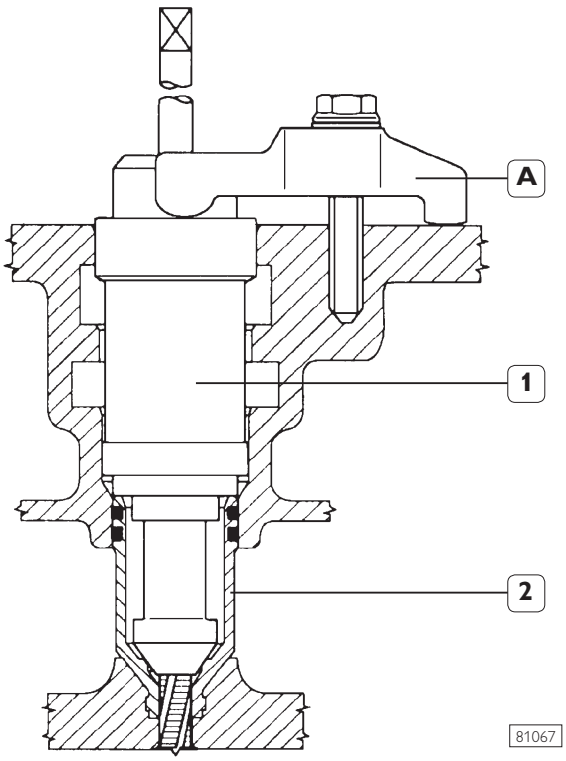
Check the valve seats (2). If you find any slight scoring or burns, regrind themwith tool 99305019 (1) according to the angles shown in Figure 92. If it is necessary to replace them, using the same tool and taking care not to affect the cylinder head, remove as much material as possible from the valve seats so that, with a punch, it is possible to extract them from the cylinder head.
Heat the cylinder head to 80 - 100°C and, using a drift, fit in the new valve seats (2), chilled beforehand in liquid nitrogen.
Using tool 99305019 (1), regrind the valve seats according to the angles shown in Figure 92.
After regrinding the valve seats, using tool 99370415 and dial gauge 99395603, check that the position of the valves in relation to the plane of the cylinder head is:

- ❏ -0.54 - -0.85 mm (recessing) intake valves
- ❏ -1.75 - -2.05 mm (recessing) exhaust valves.

REPLACING INJECTOR HOLDER CASES

Removal

Figure 94

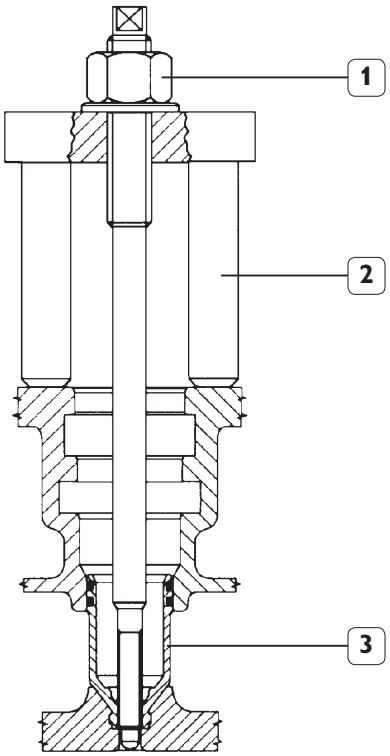


To replace the injector case (2), act as follows:

- ❏ Thread the case (2) with tool 99390804 (1).

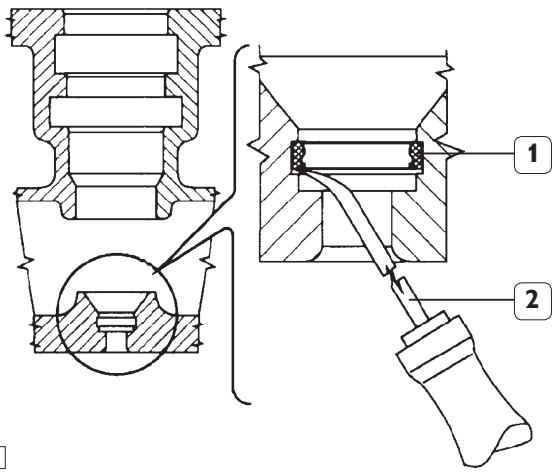
Carry out operations described in figs. 94-97-98-99 by fixing tools to the cylinder head by means of bracket A.

Figure 95



❑ Fasten extractor 99342149 (2) to case (2), by tightening the nut (1), and pull out the case from cylinder head.

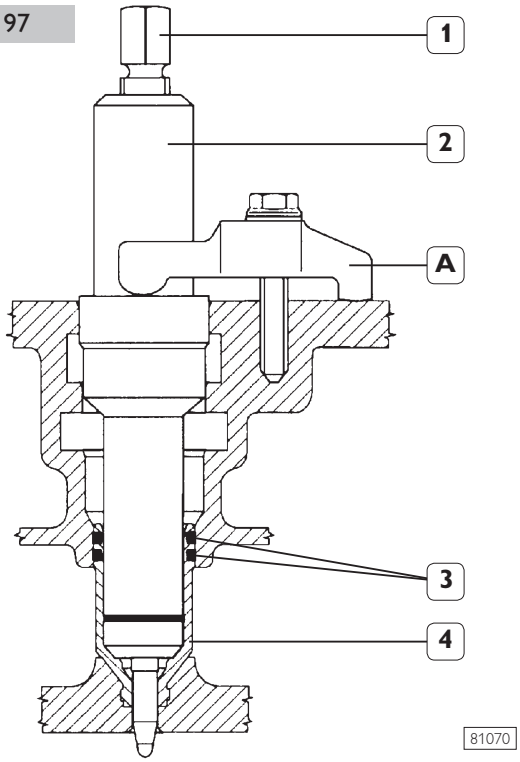
Figure 96



❑ Remove any residue, with tool 99390772 (2), from the cylinder head groove.

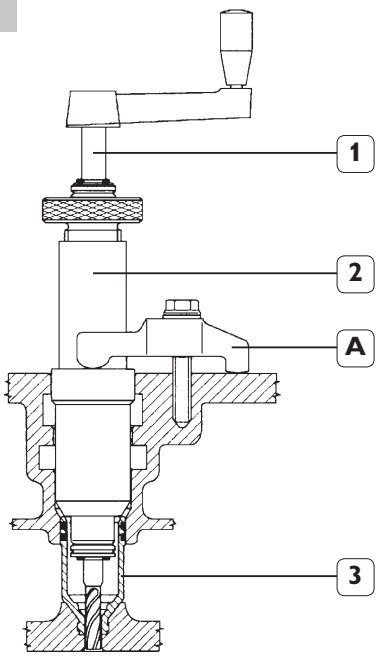
Mounting

Figure 97



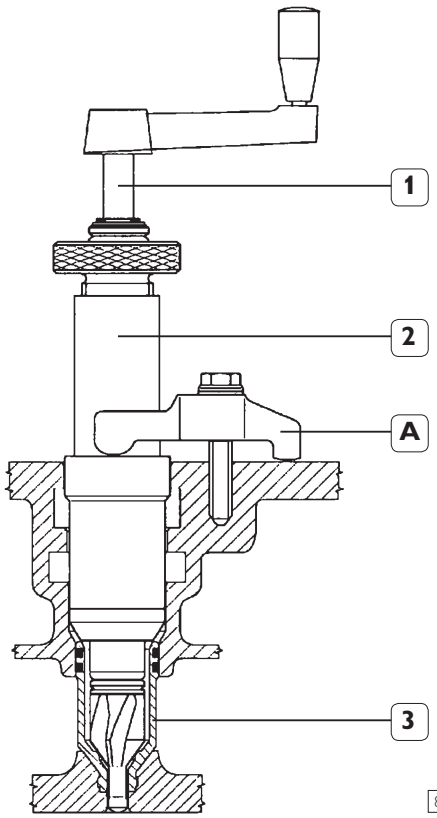
❑ Lubricate sealing rings (3) and fit them to the case (4); fix tool 99365056 (2) to the cylinder head by means of bracket **A**, install the new case, tighten the screw (1), upsetting the case lower part.

Figure 98



❑ Adjust the casing hole (3) with borer 99394043 (1) and guide bushing 99394014 (2).

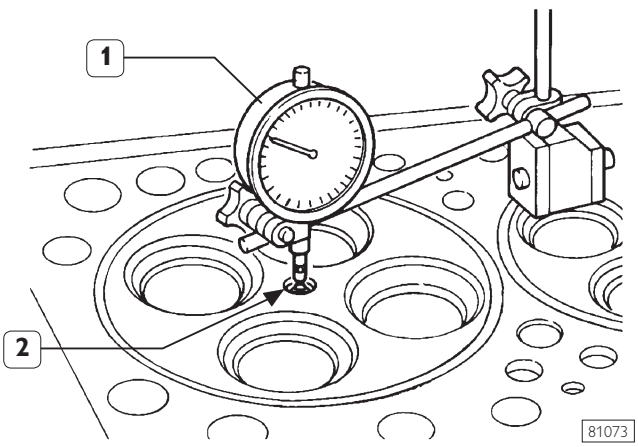
Figure 99



❑ Through miller 99394041 (1) and bushing 99394014 (2), ream the injector seat in the case (3).

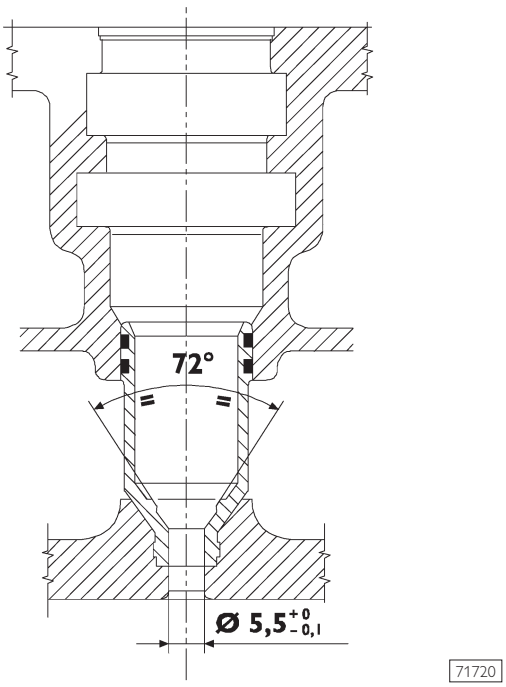
Checking protrusion of injectors

Figure 100



Using dial gauge (1), check the protrusion of the injector (2) which must be 0.52 to 1.34 mm.

Figure 101

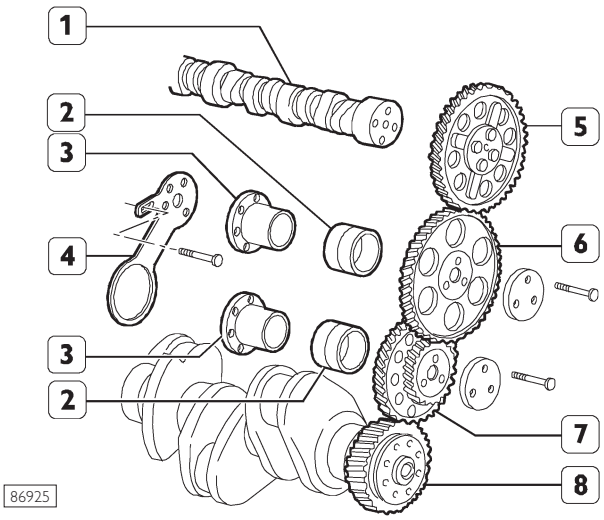


INSTALLATION DIAGRAM FOR INJECTOR CASE

TIMING GEAR

Camshaft drive

Figure 102

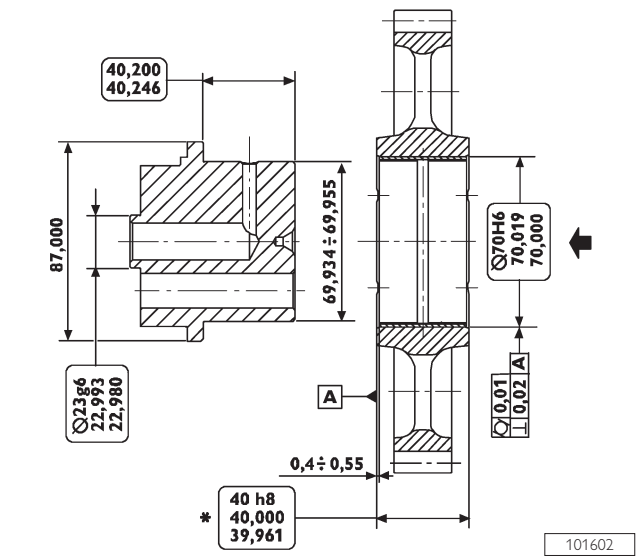


TIMING CONTROL COMPONENT PARTS

1. Camshaft - 2. Bushing - 3. Pin - 4. Articulated rod - 5. Camshaft control gear - 6. Idler gear - 7. Twin idler gear - 8. Drive shaft driving gear.

Idler gear pin
Idler gear

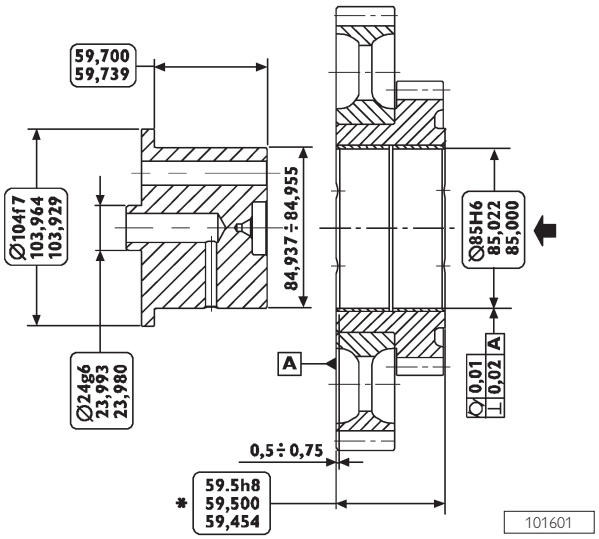
Figure 104



Rated assembling play between idler gear bushings and pins: 0.040 to 0.080 mm.

Twin intermediate gear pin
Twin idler gear

Figure 105



* This measurement is obtained after assembling.

Replacing the bushings

Bushings (2, Figure 102) can be replaced when they are worn. Put up the bushing, then bore it to obtain the diameter shown on Figure 104 or Figure 105.

CAUTION

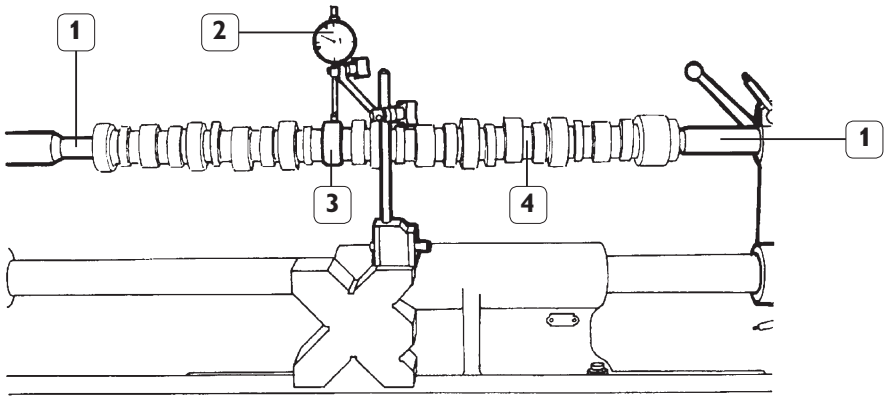
The bushing must be driven into the gear by following the direction of the arrow and setting the latter to the dimension shown on Figure 104 or Figure 105.

Rated assembling play between gear bushings and pins:

- Figure 104 - 0.045 to 0.085 mm
- Figure 105 - 0.045 to 0.085 mm.

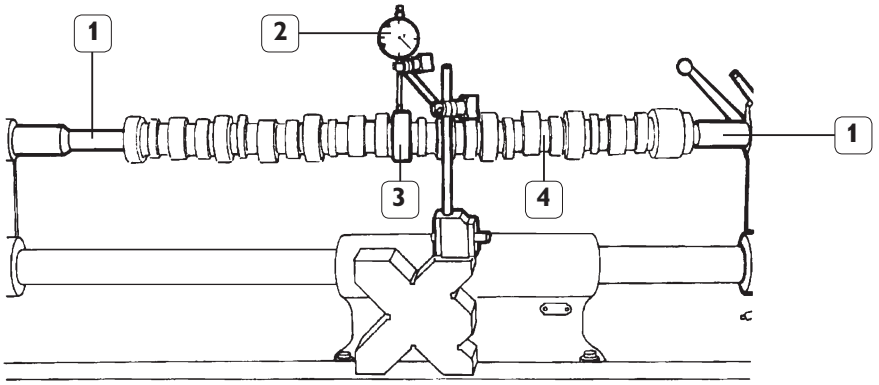
Checking cam lift and pin alignment

Figure 106



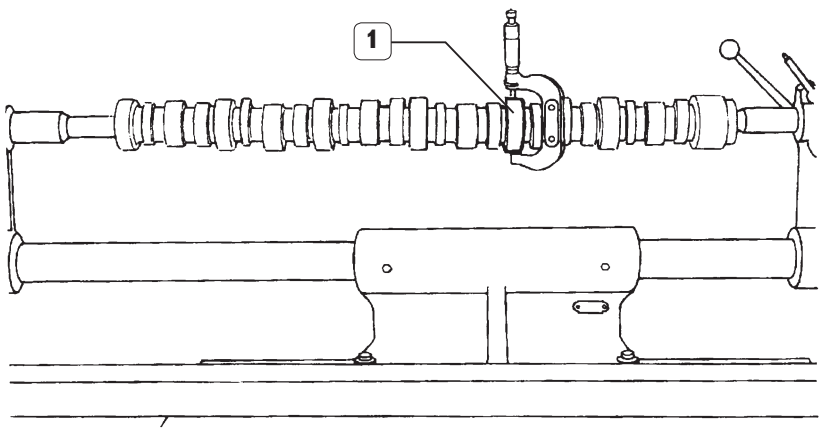
Place the camshaft (4) on the tailstock (1) and check cam lift (3) using a centesimal gauge (2); values are shown in table on page 133.

Figure 107



When the camshaft (4) is on the tailstock (1), check alignment of supporting pin (3) using a centesimal gauge (2); it must not exceed 0.030 mm.
If misalignment exceeds this value, replace the shaft.

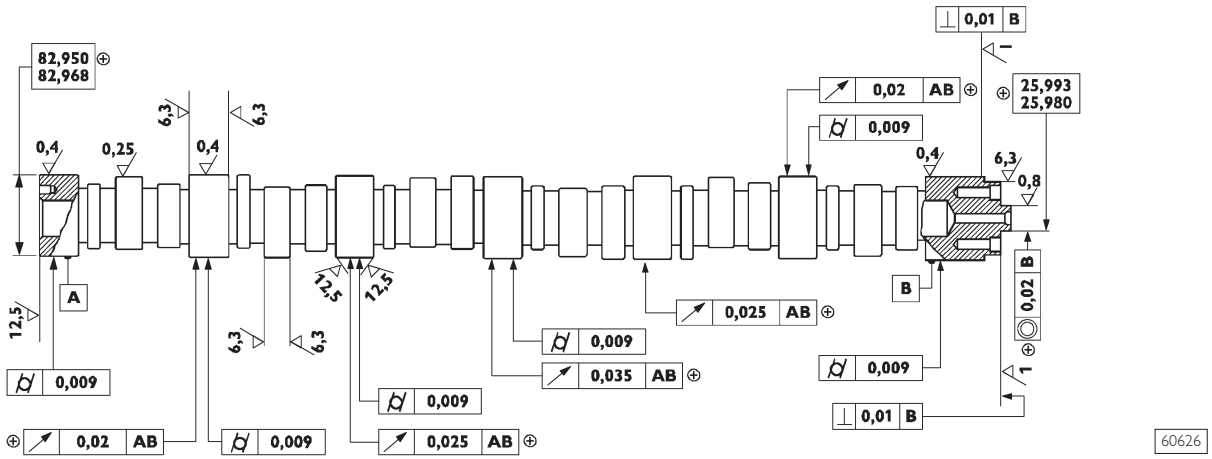
Figure 108



In order to check installation clearance, measure bush inner diameter and camshaft pin (1) diameter; the real clearance is obtained by their difference.
If clearance exceeds 0.150 mm, replace bushes and, if necessary, the camshaft.

Camshaft

Figure 109



MAIN DATA - CAMSHAFT AND TOLERANCES

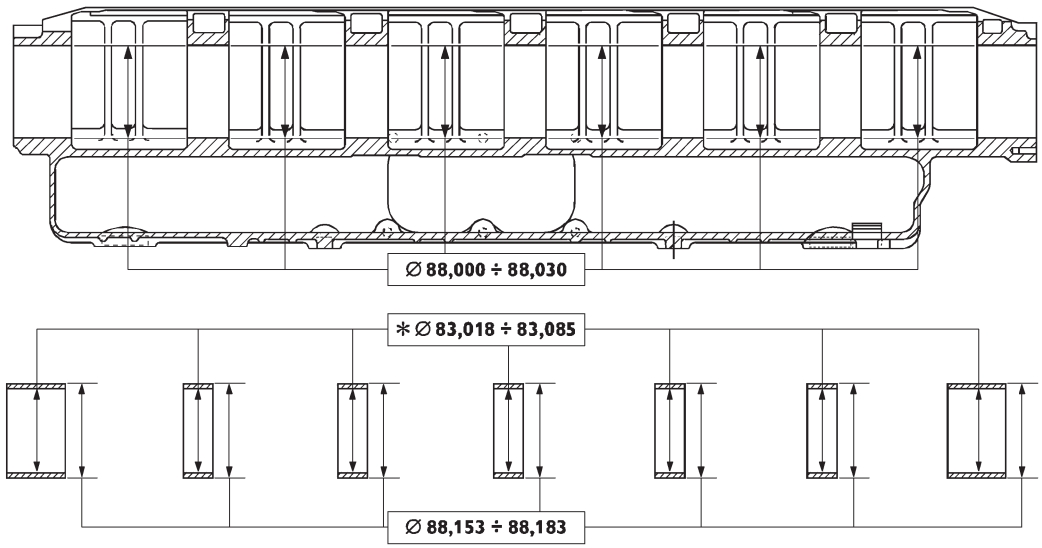
The surfaces of shaft supporting pin and cams must be extremely smooth; if you see any sign of seizing or scoring, replace the shaft and the relative bushes.

Tolerances	Tolerance characteristic	Symbol
Orientation	Perpendicularity	⊥
Position	Concentricity or coaxial alignment	◎
Oscillation	Circular oscillation	↗

Importance class assigned to product characteristics	Symbol
Critical	©
Important	⊕
Secondary	⊖

BUSHES

Figure 110



MAIN DATA - CAMSHAFT BUSHES AND RELATIVE BLOCK SEATS

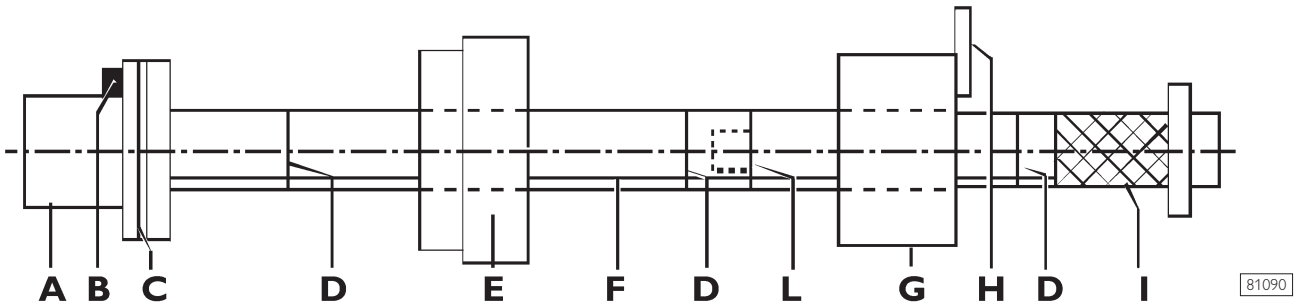
* Bush inner diameter after installation.

The bush surfaces must not show any sign of seizing or scoring; if they do replace them.
Measure the bush inner diameters with a baremeter and replace them, if the value measured exceeds the tolerance value.

To take down and fit back the bushes, use the proper tool 99360499.

Replacing camshaft bushes using beater 99360499

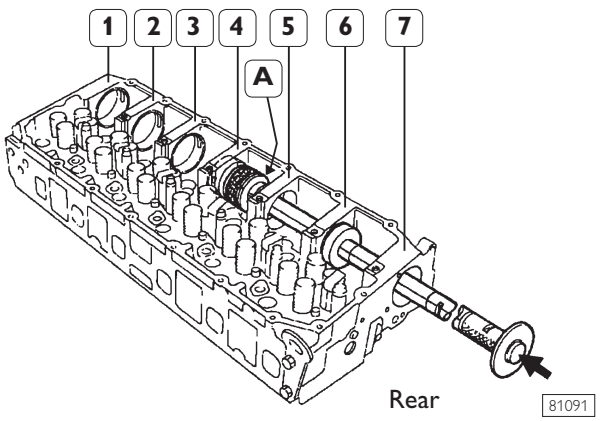
Figure 111



A. Drift with seat for bushings to insert/extract. - B. Grub screw for positioning bushings. - C. Reference mark to insert seventh bushing correctly. - D. Reference mark to insert bushings 1, 2, 3, 4, 5, 6 correctly (red marks). - E. Guide bushing. - F. Guide line. - G. Guide bushing to secure to the seventh bushing mount. - H. Plate fixing yellow bushing to cylinder head. - I. Grip. - L. Extension coupling.

Removal

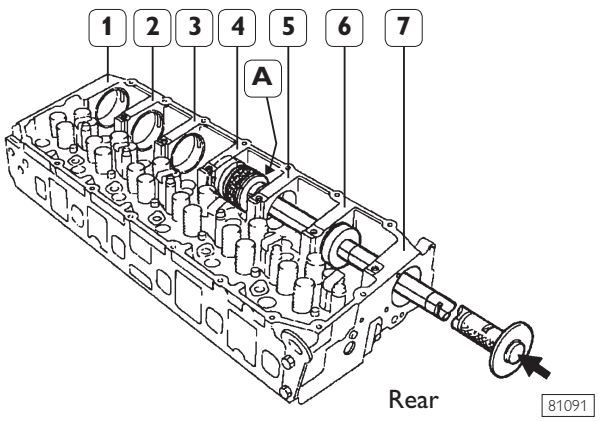
Figure 112



The sequence for removing the bushings is 7, 6, 5, 4, 3, 2, 1.
The bushings are extracted from the front of the single seats.
Removal does not require the drift extension for bushings 5, 6 and 7 and it is not necessary to use the guide bushing.
For bushings 1, 2, 3 and 4 it is necessary to use the extension and the guide bushings.
Position the drift accurately during the phase of removal.

Assembly

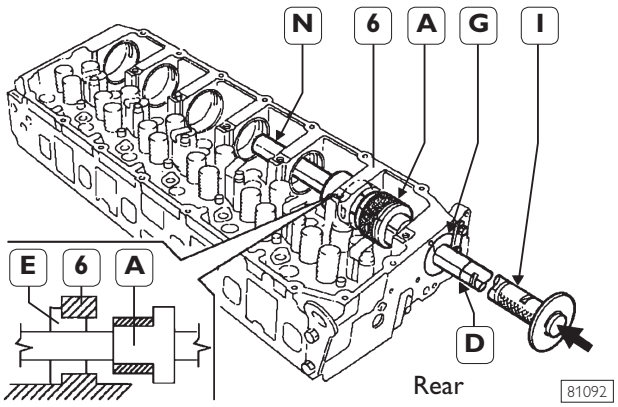
Figure 113



Assemble the drift together with the extension.
To insert bushings 1, 2, 3, 4 and 5, proceed as follows:

- ❏ Position the bushing to insert on the drift (A) making the grub screw on it coincide with the seat (B) (Figure 111) on the bushing;
- ❏ Position the guide bushing (E) and secure the guide bushing (G) (Figure 111) on the seat of the 7th bushing with the plate (H);
- ❏ While driving in the bushing, make the reference mark (F) match the mark (M). In this way, when it is driven home, the lubrication hole on the bushing will coincide with the oil pipe in its seat.
  The bushing is driven home when the 1st red reference mark (D) is flush with the guide bushing (G).

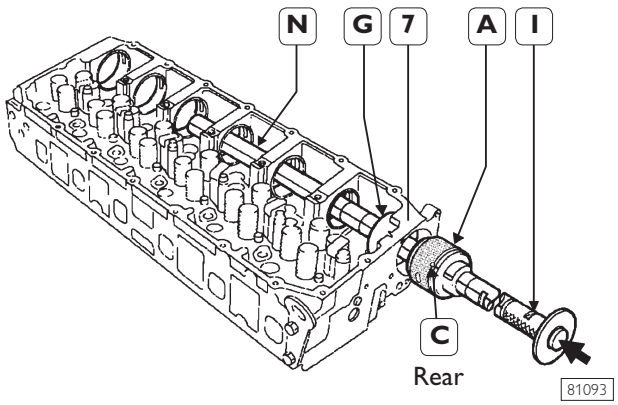
Figure 114



To insert the bushing (6), proceed as follows:

- ❏ Unscrew the grip (I) and the extension (N);
- ❏ Position the extension (N) and the guide bushing (E) as shown in the figure;
- ❏ Repeat steps 1, 2, 3.

Figure 115

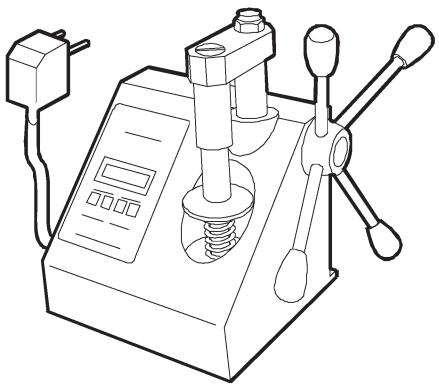


To insert bushing (7), proceed as follows:

- ❏ Unscrew the grip (I) and the extension (N);
- ❏ Refit the guide (G) from the inside as shown in the figure;
- ❏ Position the bushing on the drift (A) and bring it close up to the seat, making the bushing hole match the lubrication hole in the head. Drive it home.
  The 7th bushing is driven in when the reference mark (C) is flush with the bushing seat.

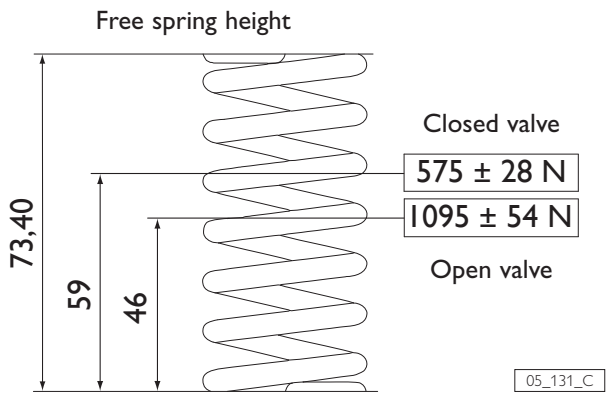
VALVE SPRINGS

Figure 116



Before assembly, the flexibility of the valve springs has to be checked with the tool 99305047.
Compare the load and elastic deformation data with those of the new springs given in the following figure.

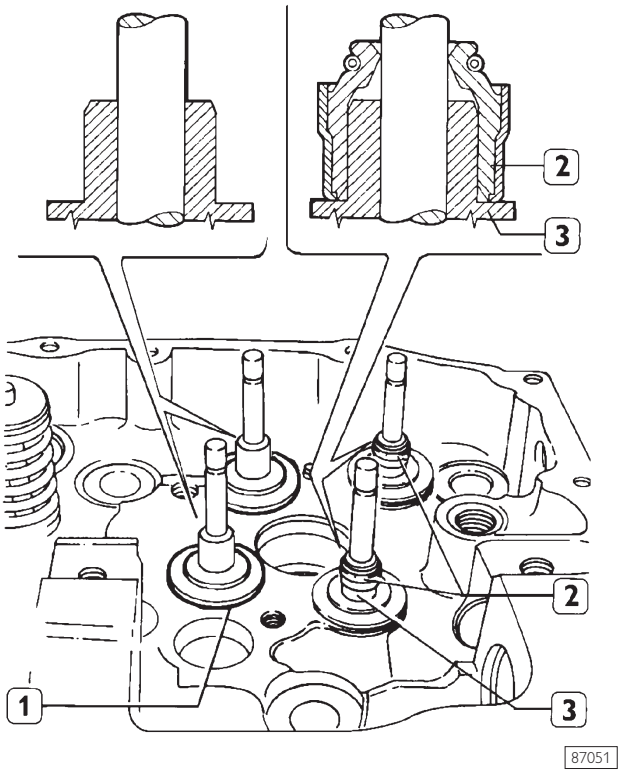
Figure 117



MAIN DATA TO CONTROL INTAKE AND EXHAUST VALVE SPRING

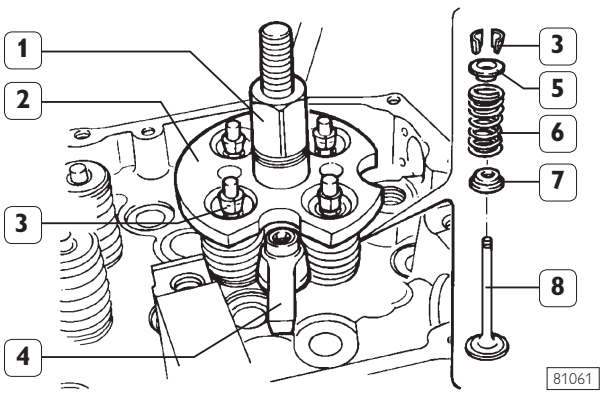
Fitting the valves and oil seal ring

Figure 118



Lubricate the valve stem and insert the valves in the respective valve guides; fit the lower caps (1). Use tool 99360329 to fit the oil seal (2) on the valve guides (3) of the exhaust valves; then, to fit the valves, proceed as follows.

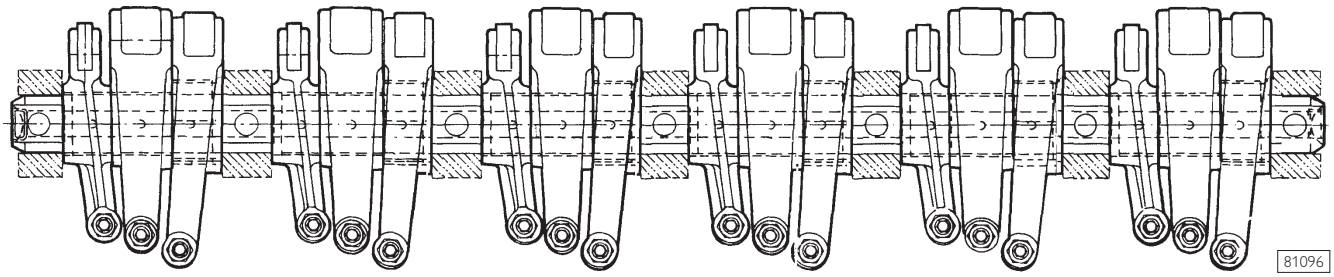
Figure 119



- ❑ Fit springs (6) and the upper plate (5);
- ❑ Apply tool 99360263 (2) and block it with bracket (4); tighten the lever (1) until cotters are installed (3), remove tool (2).

ROCKER SHAFT

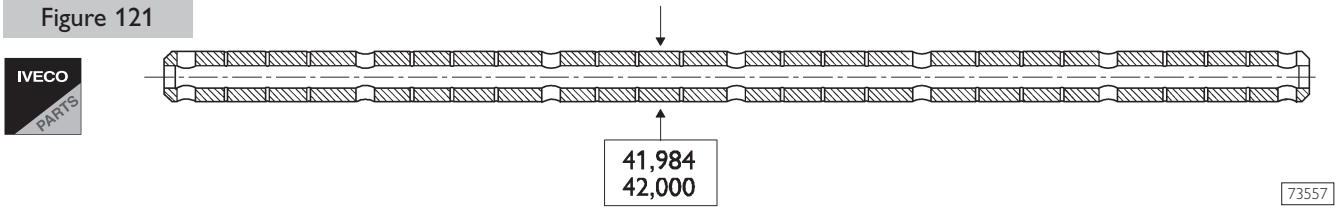
Figure 120



The camshaft cams directly control rockers: 6 for injectors and 12 for valves.
Rockers slide directly on the cam profiles via rollers.
The other end acts on a bar directly supported by the two valves stems.
A pad is placed between the rocker adjusting screw and the bar.
Two lubrication holes are machined inside the rockers.
The rocker shaft practically covers the whole cylinder head; remove it to have access to all the underlying components.

Shaft

Figure 121

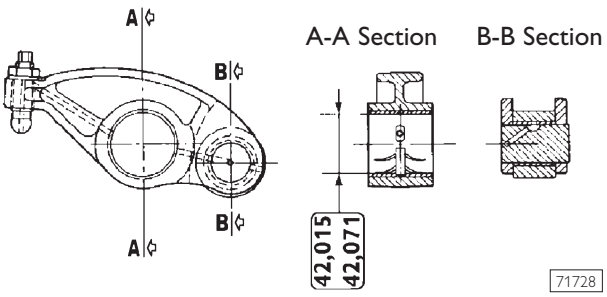


MAIN DATA OF THE ROCKER ARM SHAFT

Check that the surface of the shaft shows no scoring or signs of seizure; if it does, replace it.

Rockers

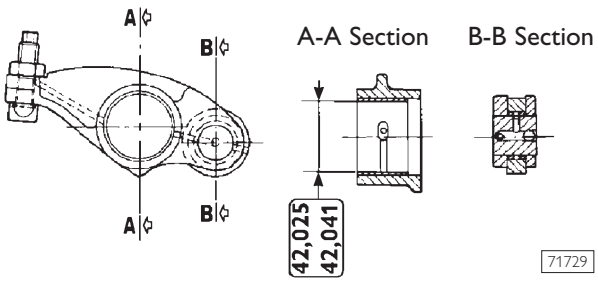
Figure 122



PUMP INJECTOR ROCKER

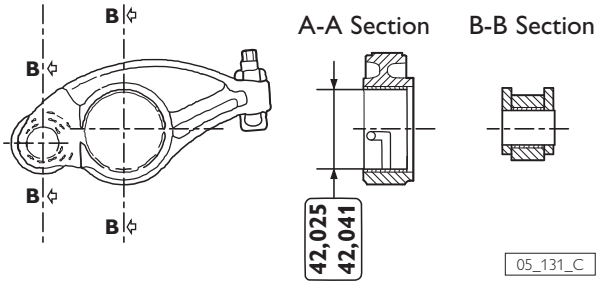
The bush surfaces must not show any trace of scoring of excessive wear; otherwise, replace bushes or the whole rocker.

Figure 123



INTAKE VALVES ROCKER

Figure 124



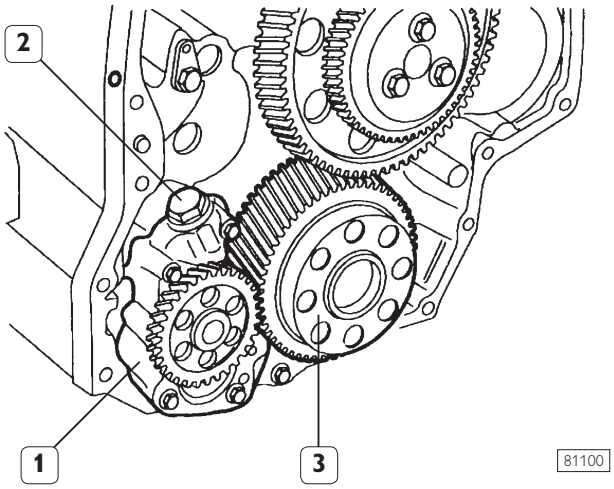
EXHAUST VALVES ROCKER

LUBRICATION SYSTEM COMPONENTS

Description and operation on Section 1.

Oil pump

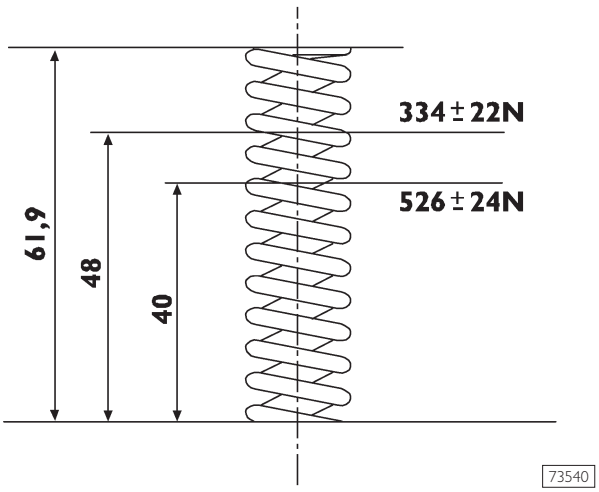
Figure 125



Oil pump (1) contains the overpressure valve (2) adjusted to start of opening pressure 10.1 ± 0.7 bars.
The oil pump cannot be overhauled. On finding any damage, replace the oil pump assembly.
The pump is driven by the gear (3) of the crankshaft.

Overpressure valve

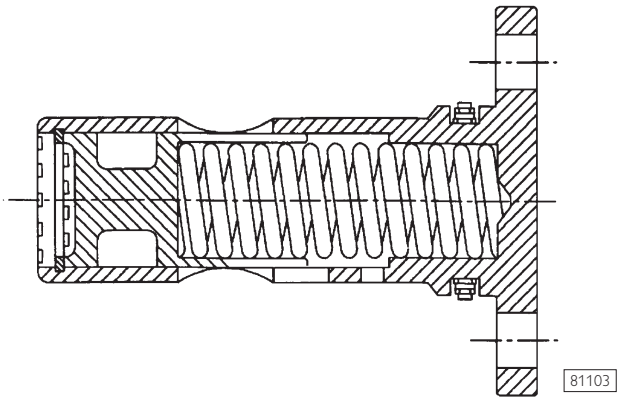
Figure 126



MAIN DATA TO CHECK
THE OVERPRESSURE VALVE SPRING

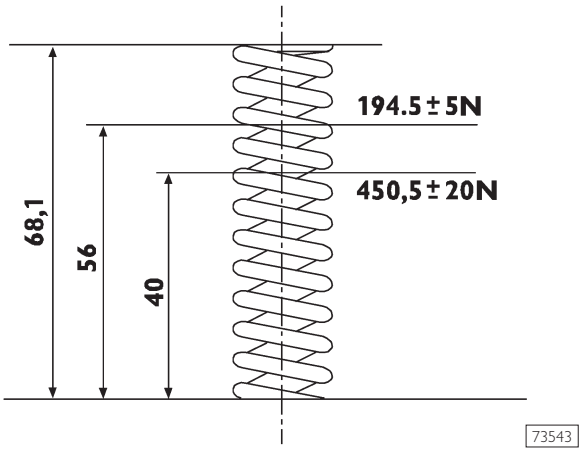
Oil pressure control valve

Figure 127



The oil pressure control valve is located on the left-hand side of the crankcase on the right side of oil heat exchanger.
Start of opening pressure 5 bars.

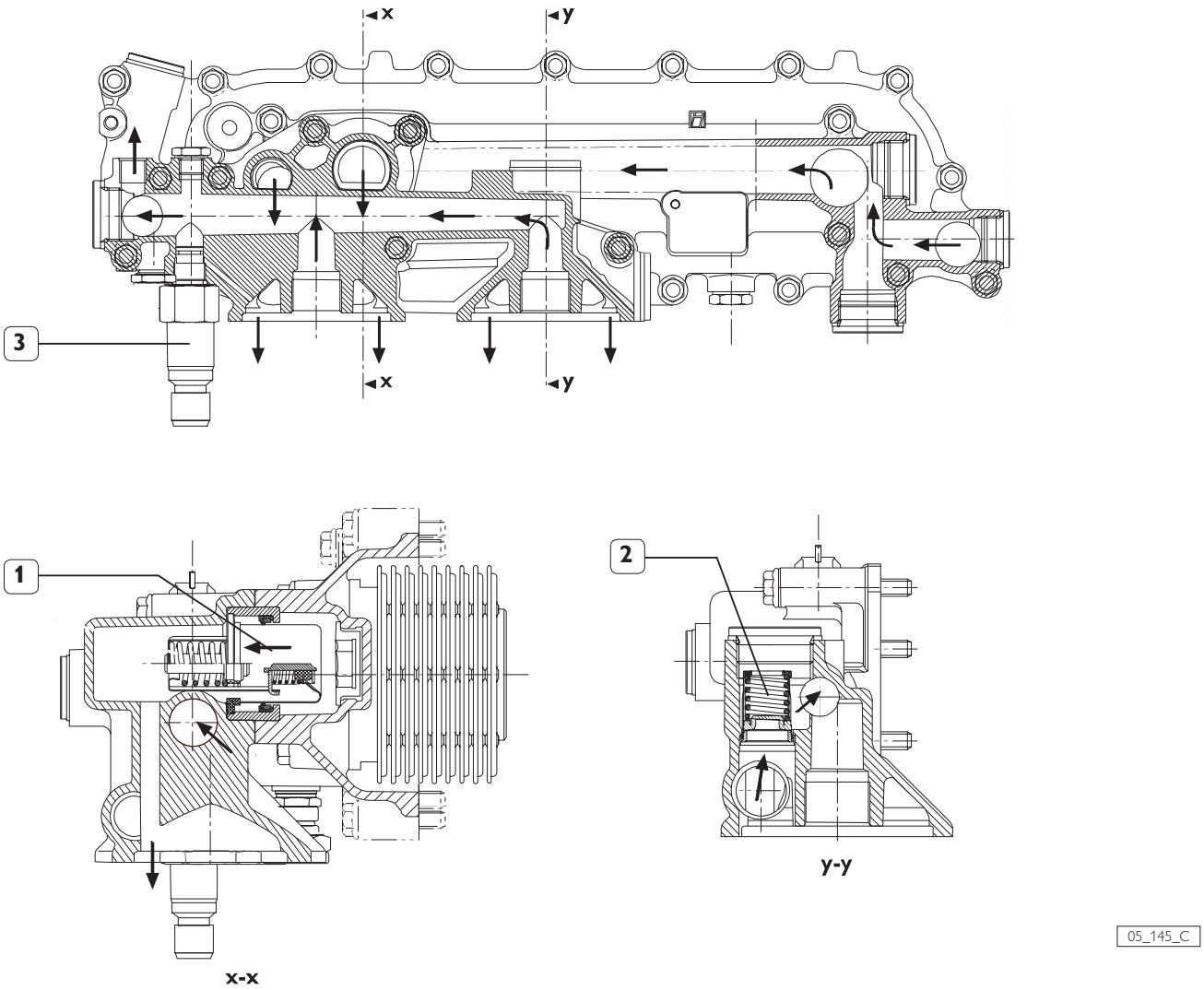
Figure 128



MAIN DATA TO CHECK
THE OIL PRESSURE CONTROL VALVE SPRING

Heat exchanger

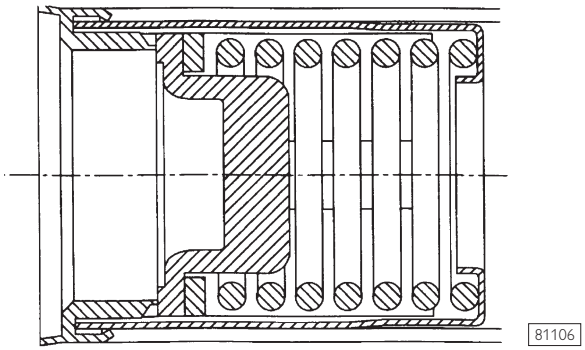
Figure 129



1. Thermostatic valve - 2. Filter by-pass valve - 3. Clogged oil filter sensor.

Filter by-pass valve

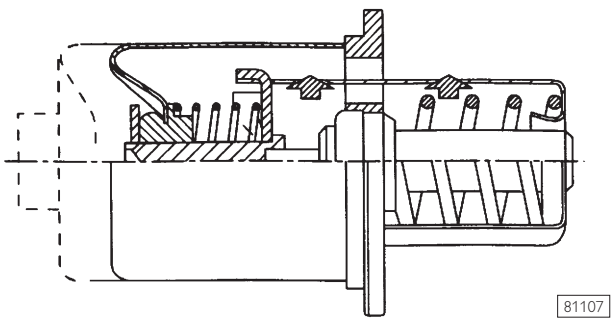
Figure 130



The valve assures the flow of lubricating oil to the engine even under heavily or totally clogged filter conditions and it is calibrated to start opening at a pressure of 3 bar.

Thermostatic valve

Figure 131



The valve allows the flow of low temperature oil within a direct channel to the outlet, thus avoiding heat transfers. In the presence of high temperature oil, the valve shuts the channel, switching the flow into the elements of the heat exchanger with the engine coolant, to stabilize its temperature. It is calibrated to start closing with a travel of 0.1 mm at a temperature of 82 ± 2 °C and its total travel is 8 mm at the temperature of 97 °C.

Oil filter

When mounting the filters, keep to the following rules:

- ❑ Lubricate gasket with oil;
- ❑ Screw down the filters to bring the seals into contact with the supporting bases;
- ❑ Tighten the filter to a torque of 35 to 40 Nm.

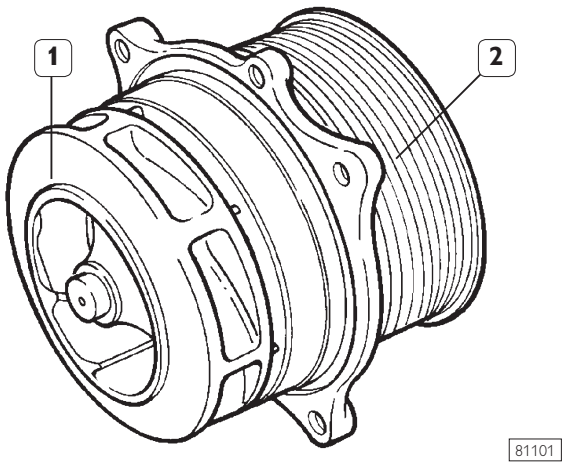
COOLING SYSTEM COMPONENTS

Description and operation on Section 1.

Cooling by forced circulation obtained with centrifugal pump, driven by the drive shaft through a Poli-V belt. Liquid circulation is regulated by a thermostatic valve.

Water pump

Figure 132



1. Impeller - 2. Control Pulley

Make sure that the pump casing has no cracking or water leakage; otherwise, replace the entire pump.

Thermostatic valve

The valve is calibrated to start opening the channel to the sea water heat exchanger at a temperature of 68 ± 2 °C and to shut the channel to the coolant pump completely at the temperature of 78 ± 2 °C.
Check the valve works properly; replace it if in doubt.

Figure 133

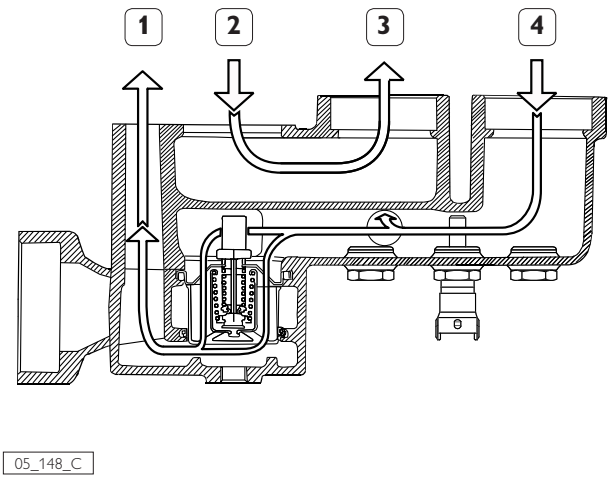
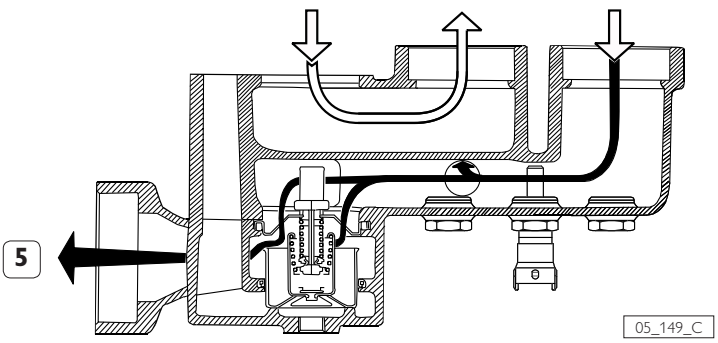


Figure 134



Low temperature liquid

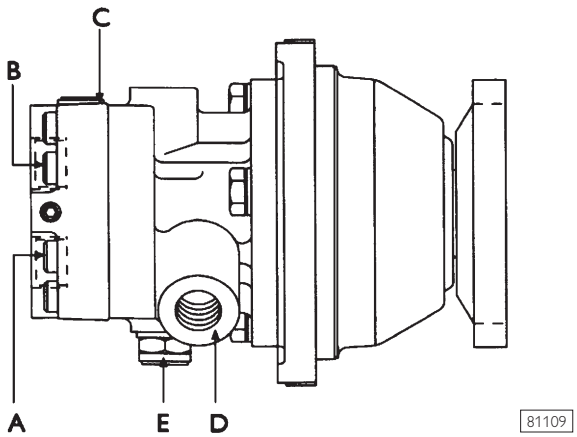
High temperature liquid

1. By-pass flow to the engine - 2. Flow from the engine - 3. Flow from the exhaust manifold - 4. Flow to the exhaust manifold - 5. Flow to the sea water heat exchanger.

FUEL FEED COMPONENTS

Fuel feed

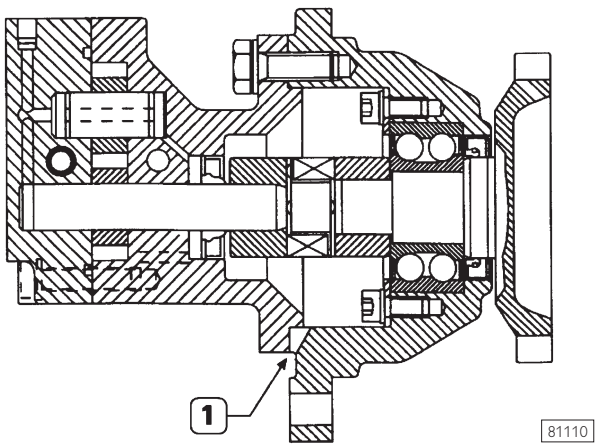
Figure 135



A. Fuel inlet - B. Fuel delivery - C. By-pass nut - D. Fuel return from the pump-injectors - E. Pressure relief valve; opening pressure 5 bars.

Cross-section of the fuel pump

Figure 136

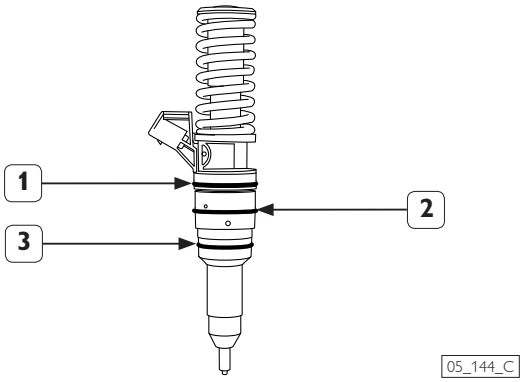


1. Oil and fuel leakage indicator

The seal rings are present on the fuel side and driving side. Any leakage will result in liquid spillage from the provided hole (1).

Injector-pump

Figure 137

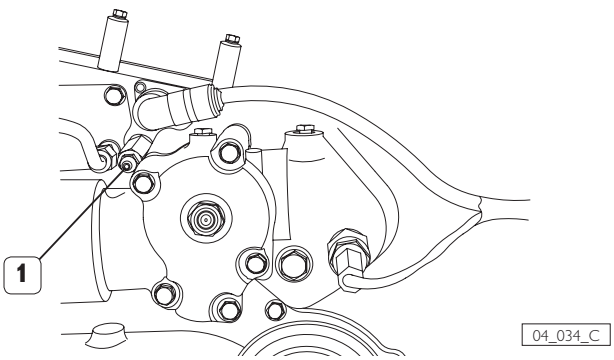


1. Fuel/oil seal - 2. Fuel in/fuel out seal - 3. Fuel seal.

CAUTION

The injectors require no calibration and because of the high level of precision of the components and the complexity of their assembly, none of their parts can be replaced.
If replacement does become necessary, contact the IVECO MOTORS-FPT Technical Assistance Service to receive the appropriate operating instructions. Prescriptions for removal and re-assembly are provided in Section 6.

Figure 138



1. Drainage fitting on cylinder head

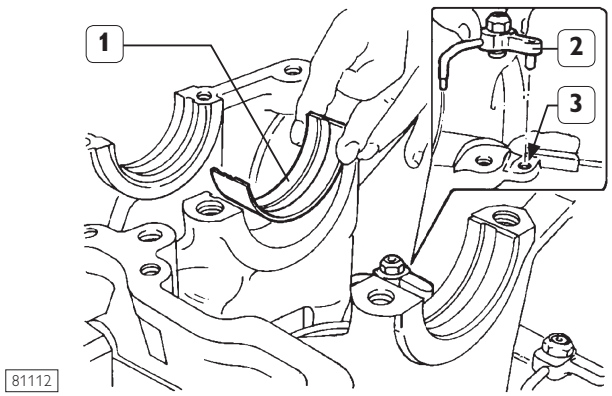
Before extracting the injector-pump, you must empty the fuel inflow and recirculation channels machined in the cylinder head, to prevent the liquid from dripping into the underlying combustion chamber machined in the piston crown. To do so, loosen the fuel inlet junction to the cylinder head and the drainage cap in the front part of the cylinder head (1). Avoid spilling fuel into the environment and contacts with the auxiliary organ belt.

For disassembly see Figures 21 to 24 of this Section.
For assembly see Figures 170 to 175 of this Section.

ASSEMBLING THE ENGINE ON THE BENCH

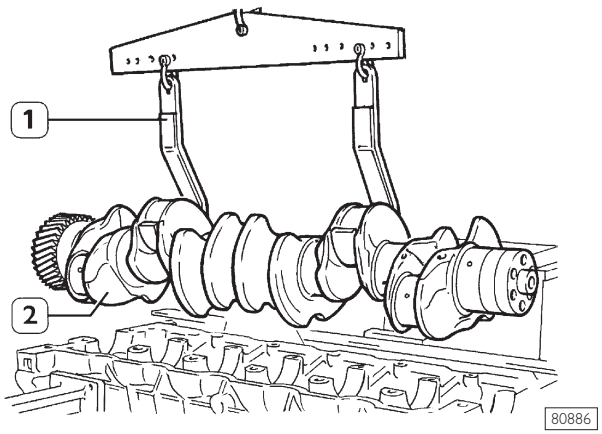
Fix the engine block to the stand 99322230 by means of brackets 99361035.
Install the cylinder liners as described in page 147.

Figure 139



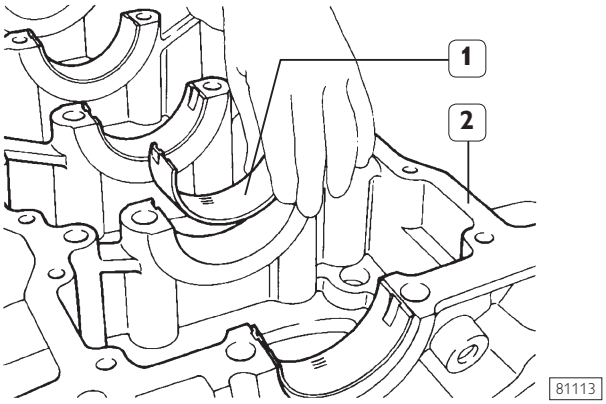
Fit the oil spray nozzles (2), so that the dowel coincides with the block hole (3).
Place the half bearings (1) on the main bearings.

Figure 140



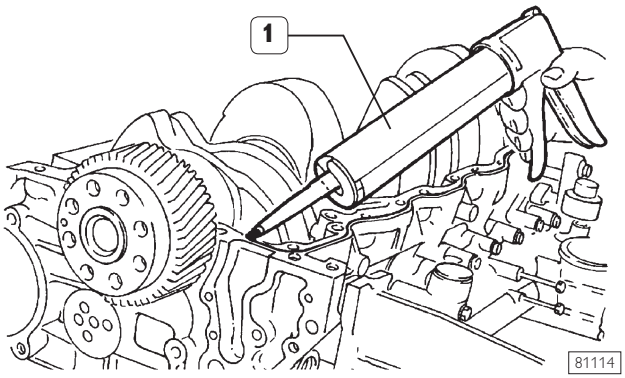
Lubricate the half bearings, then install the crankshaft (2) by means of hoist and hook 99360500 (1).

Figure 141



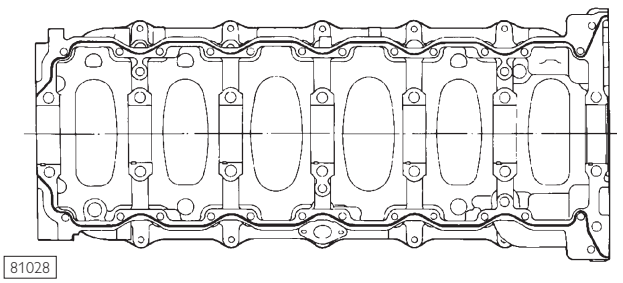
Place the half-bearings (1) on the main bearings in the underblock (2).
Remove the underblock.

Figure 142



By means of suitable equipment (1), apply Loctite 5970 IVECO n. 2992644 sealant to the block, as shown in the figure.

Figure 143

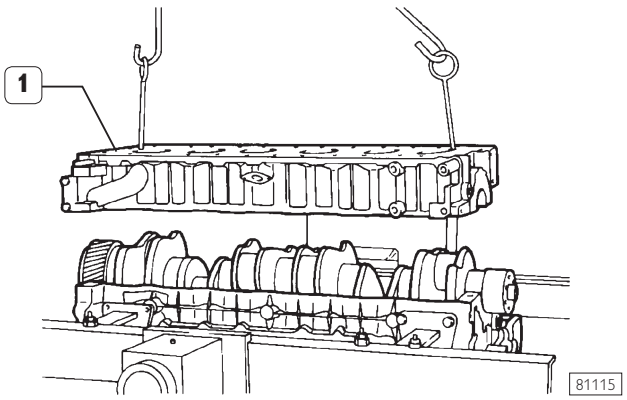


SEALANT APPLICATION DIAGRAM

CAUTION

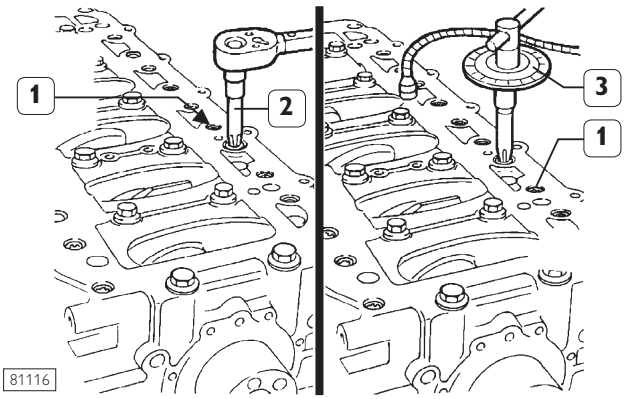
Fit the underblock within 10' since application of the sealant.

Figure 144



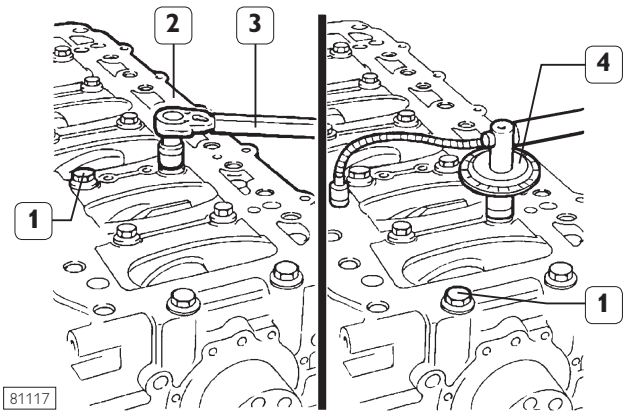
Fit the underblock by means of a suitable hoist and hooks (1).

Figure 145



Fit the underblock and, using a dynamometric wrench (2), close the splined outer (1) screws to 30 Nm torque, according to the diagram shown on next page.

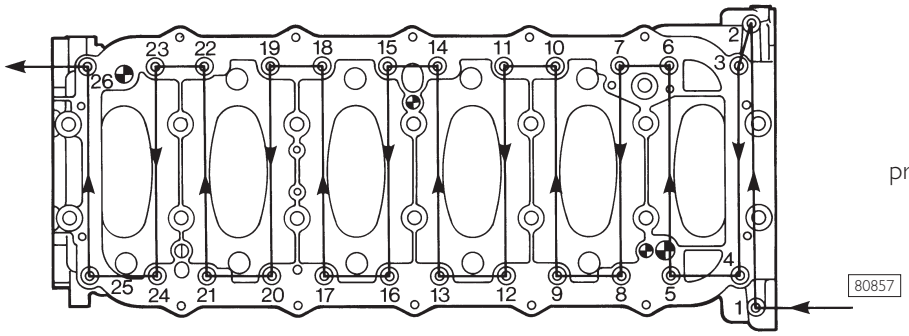
Figure 146



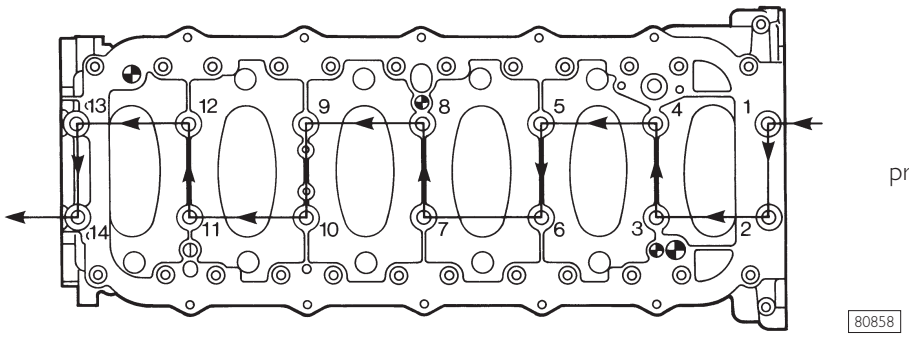
Close the inner screws (1) to 120 Nm torque by means of a dynamometric wrench (3, Figure 146), then with two further angular phases 60° +55° , using tool 99395216 (4).
Tighten again the outer screws (1, Figure 145) with 60° angular closing, using tool 99395216 (3, Figure 145).

Diagram showing the underblock fixing screws tightening order

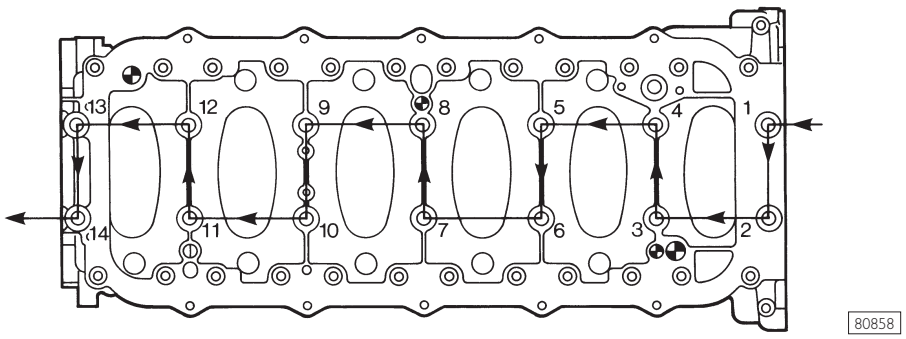
Figure 147



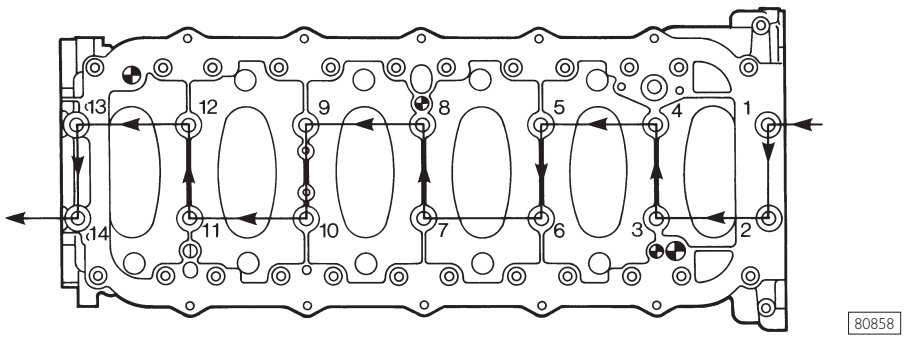
First phase: outer screws preliminary tightening (30 Nm)



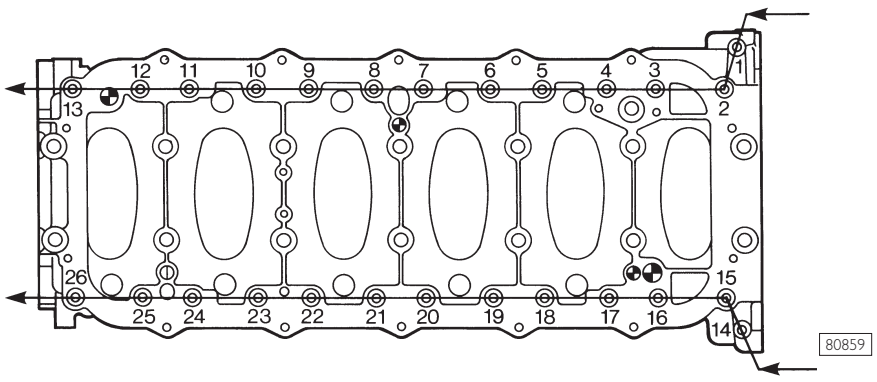
Second phase: inner screws preliminary tightening (120 Nm)



Third phase: inner screws angle closing (60°)

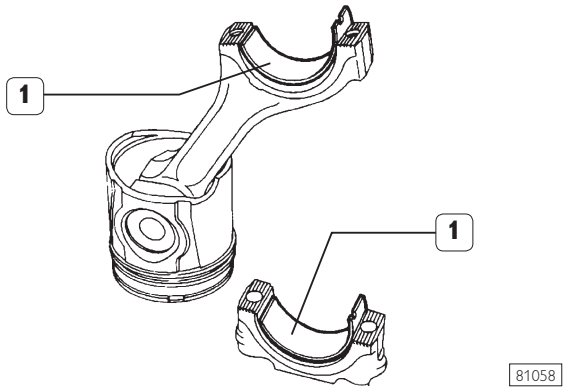


Fourth phase: inner screws angle closing (55°)



Fifth phase: outer screws angle closing (60°)

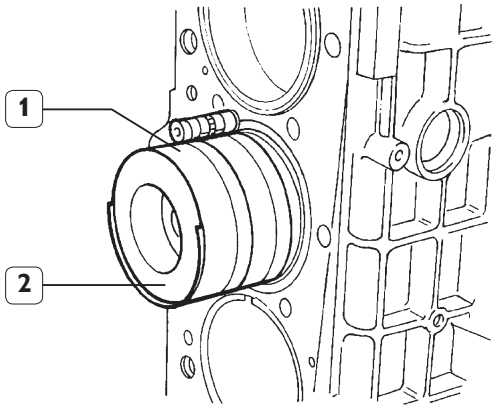
Figure 148



Rotate the cylinder assembly placing it vertically.
Fit the half-bearings (1) on both the connecting rod and the cap.

Fitting the connecting rod-piston assembly into the cylinder liners

Figure 149



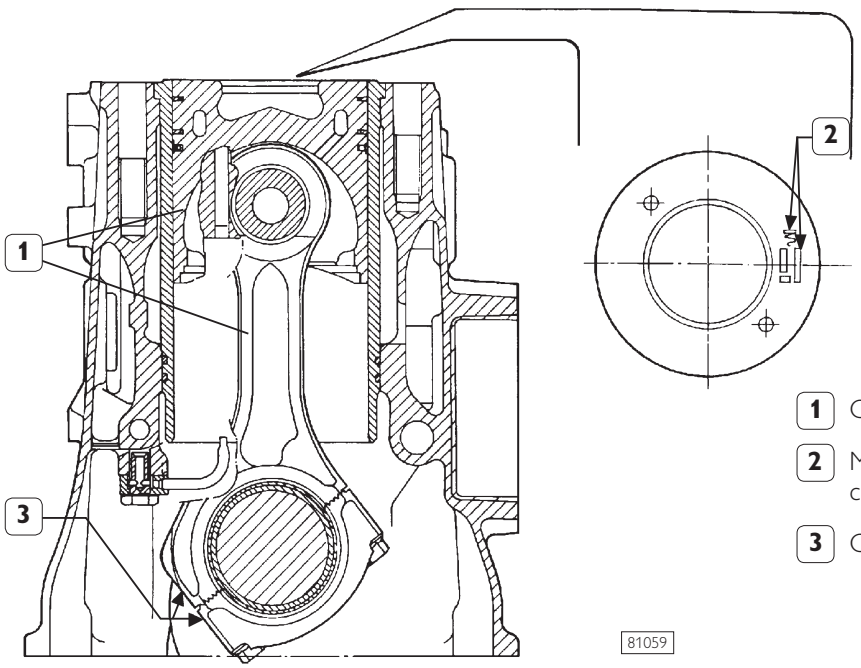
Fit the connecting rod-piston assemblies (2) into the piston liners, using the band 99360605 (1, Figure 149). Check the following:

- ❏ The openings of the split rings are offset by 120°;
- ❏ All pistons belong to the same class, A or B;
- ❏ Ideogram (2, Figure 150), stamped on the piston crown, is placed toward the engine flywheel, or the cavity located on the piston skirt corresponds to the position of the oil spray nozzles.

Piston protrusion check

Once assembly is complete, check piston protrusion from cylinder barrels: it must be 0.12 to 0.42 mm.

Figure 150

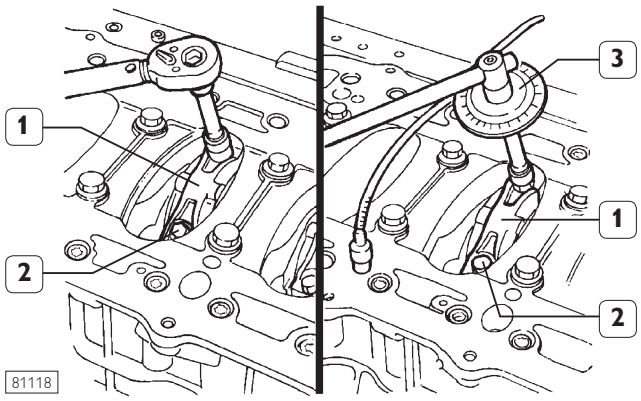


1 Connecting rod-piston assembly;

2 Marking area of ideogram on the piston crown;

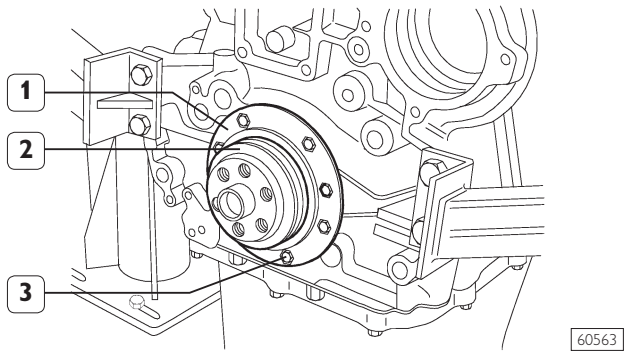
3 Connecting rod marking area.

Figure 151



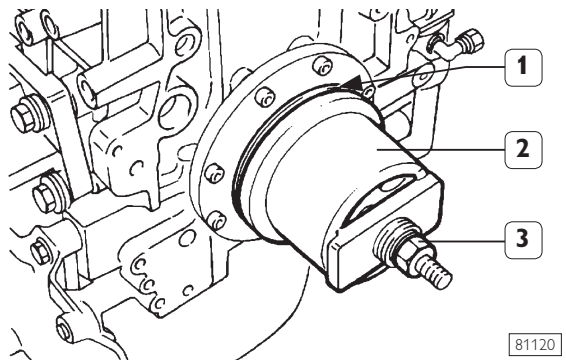
Connect the connecting rods to the relative journals, fit the connection rod caps (1) with half bearings; tighten the fixing screws (2) of the connecting rod caps to 60 Nm torque (6 Kgm). Using tool 99395216 (3), further tighten screws with 60° angle.

Figure 152



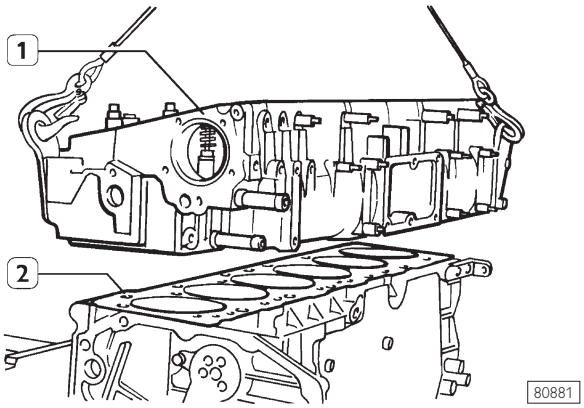
Using the centring ring 99396035 (2), check the exact position of the cover (1). If it is wrong, proceed accordingly and lock the screws (3).

Figure 153



Fit the sealing gasket (1), install the fitting tool 99346250 (2) and drive the sealing gasket (1) by screwing nut (3).

Figure 154



Make sure that pistons 1-6 are exactly at the TDC. Place the sealing gasket (2) on the block.
Fit the cylinder head (1) and tighten screws as shown in figs. 155, 156 and 157.

Figure 155

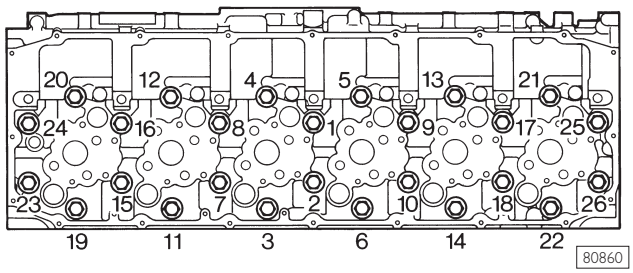
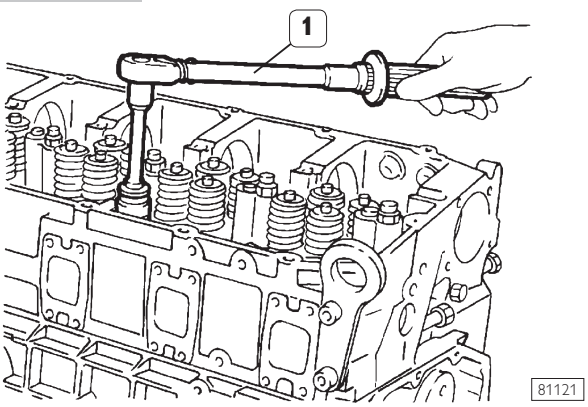


Diagram showing the cylinder head fixing screws tightening order.

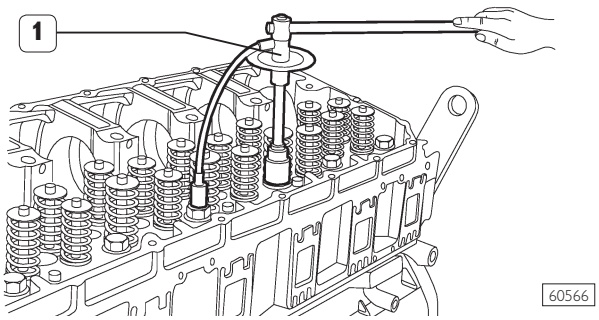
Figure 156



❑ Preliminary tightening by means of a dynamometric wrench (1):

- 1st phase: 60 Nm (6 Kgm);
- 2nd phase: 120 Nm (12 Kgm).

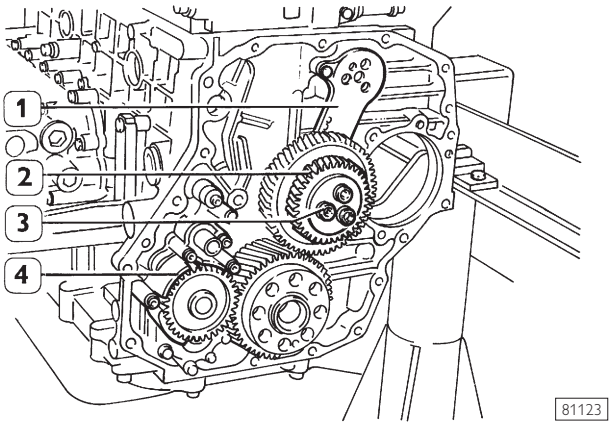
Figure 157



❑ Angle closing by means of tool 99395216 (1):

- 3rd phase: 120° angle;
- 4th phase: 60° angle.

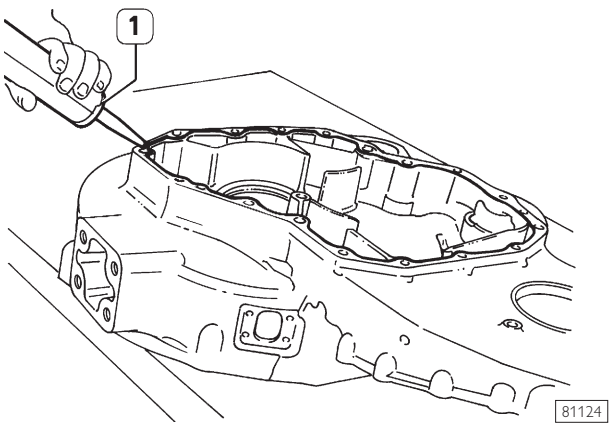
Figure 158



Fit the oil pump (4), intermediate gears (2) with rod (1) and tighten screws (3) in two phases:

- Preliminary tightening 30 Nm;
- Angle closing 90°.

Figure 159

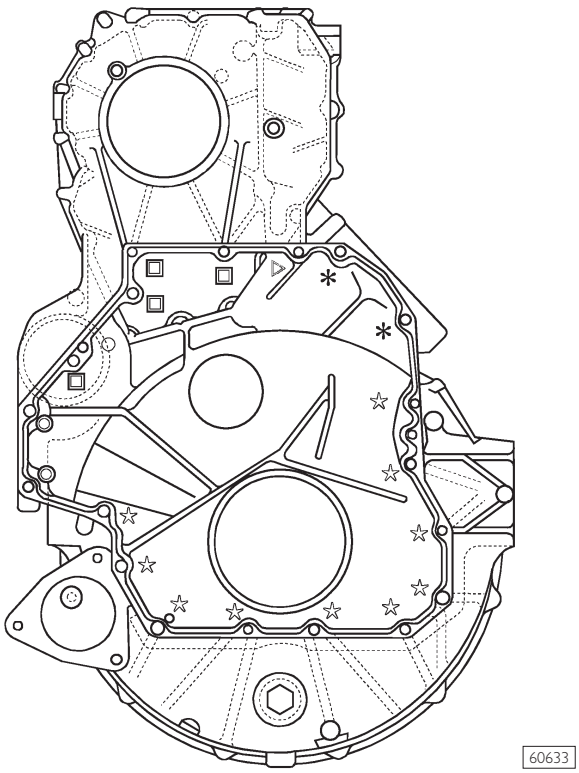


Apply LOCTITE 5970 IVECO n° 2992644 silicone on the gear housing, using appropriate tools (1), as shown in the figure.
The sealer string (1) diameter is to be 1.3 to 2 mm.

CAUTION

Install the gearbox within 10' from the application of the sealant.

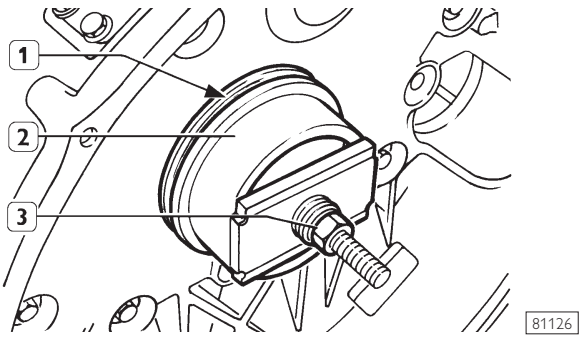
Figure 160



Tighten the screws shown in the figure by means of a dynamometric wrench, in compliance with the following order and tightening torque:

☆	10 screws M12 x 1.75 x 100	63 Nm
*	2 screws M12 x 1.75 x 70	63 Nm
□	4 screws M12 x 1.75 x 35	63 Nm
△	1 screw M12 x 1.75 x 120	63 Nm
▭	2 screws M12 x 1.75 x 193	63 Nm

Figure 161

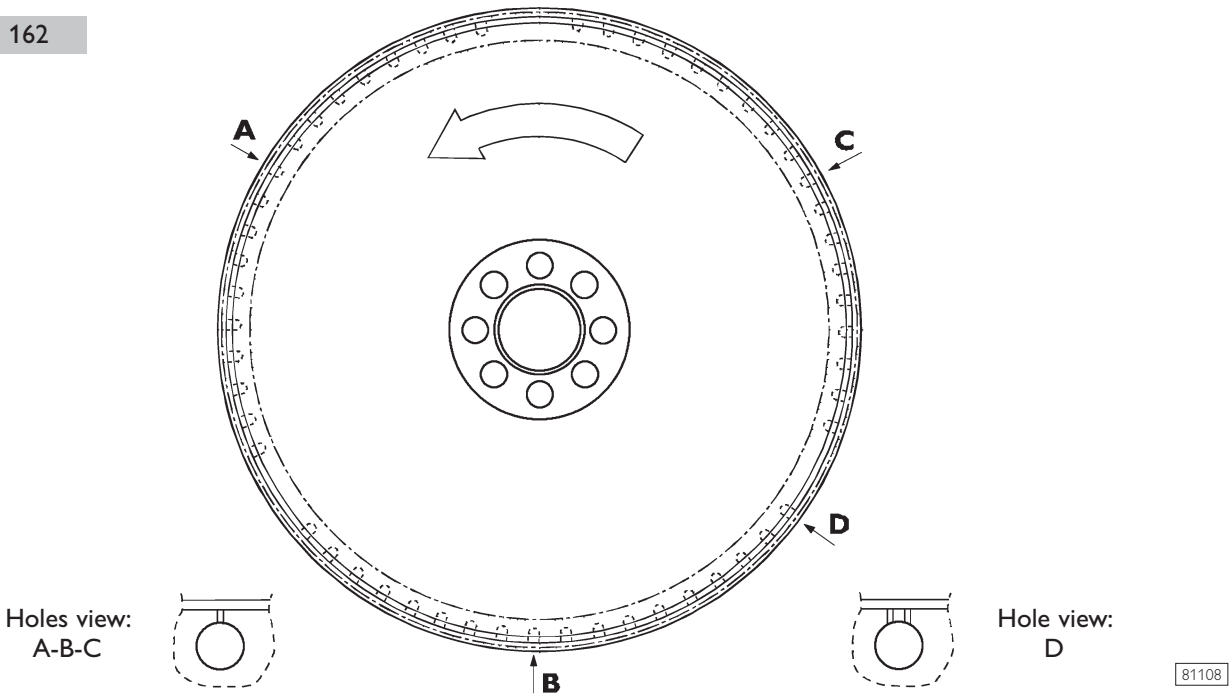


Fit the sealing gasket (1), install the fitting tool 99346251 (2) and drive the sealing gasket by screwing the nut (3).

ENGINE FLYWHEEL

Assembly

Figure 162



DETAIL OF PISTON POSITION MARKS ON ENGINE FLYWHEEL

A. Hole on the flywheel with 1 notch, corresponding to TDC of pistons 3-4 - B. Hole on the flywheel with 1 notch, corresponding to TDC of pistons 1-6 - C. Hole on the flywheel with 1 notch, corresponding to TDC of pistons 2-5 - D. Hole on the flywheel with 2 notches, corresponding to 54° before TDC of pistons 1-6.

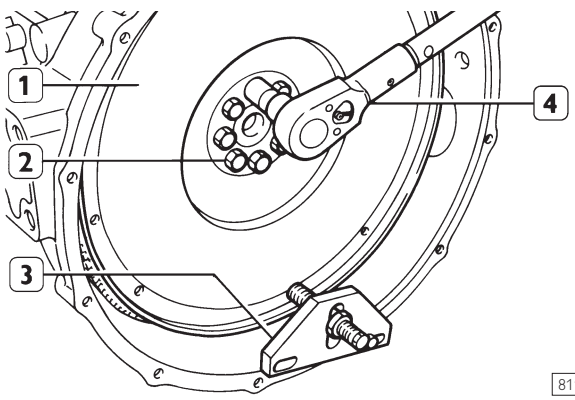
CAUTION

If the teeth of the crown on the engine flywheel for starting engine are very damaged replace the crown. Before fitting, the crown must be heated to approx. 200 °C.

CAUTION

The fixing screws of the engine flywheel can be reused as long as the diameter of the thread is not less than 15.5 mm.

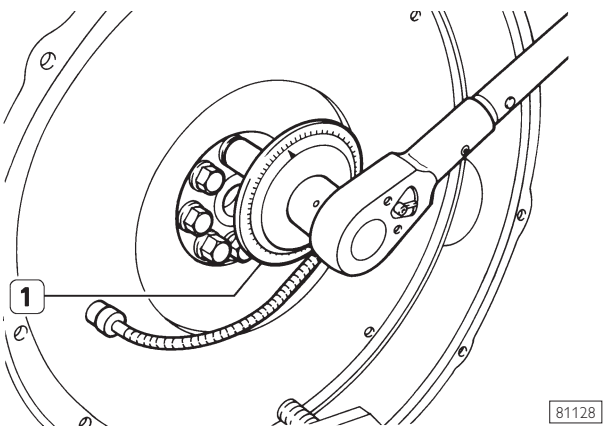
Figure 163



Install the engine flywheel (1), without blocking the fixing screws (2). Block rotation by means of tool 99360351 (3); block screws (2) in two phases.

❏ First phase: preliminary tightening using dynamometric wrench (4) to 120 Nm torque (12 kgm).

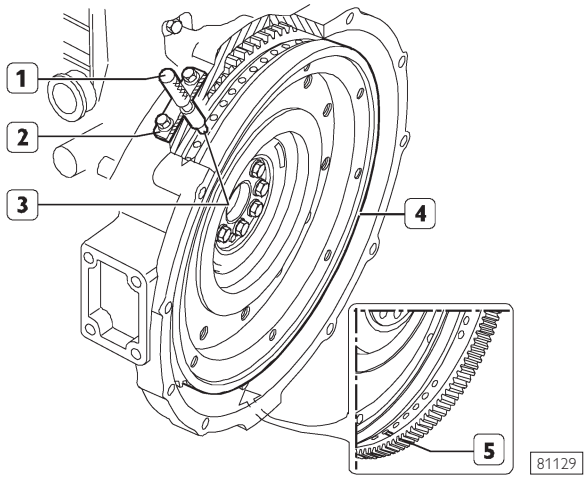
Figure 164



❏ Second phase: 90° angle closing by means of tool 99395216 (1).

FITTING CAMSHAFT

Figure 165

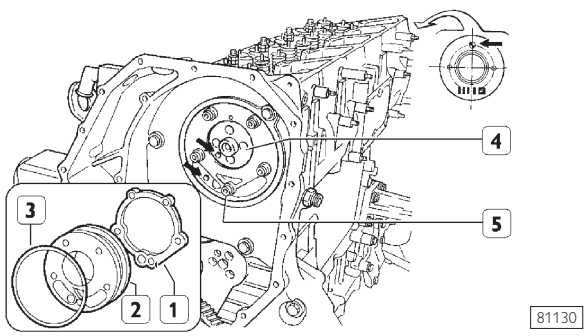


Position the crankshaft with the pistons 1 and 6 at the top dead centre (TDC).
This situation occurs when:

1. The hole with reference mark (5) of the engine flywheel (4) can be seen through the inspection window;
2. The tool 99360612 (1), through the seat (2) of the engine speed sensor, enters the hole (3) in the engine flywheel (4).

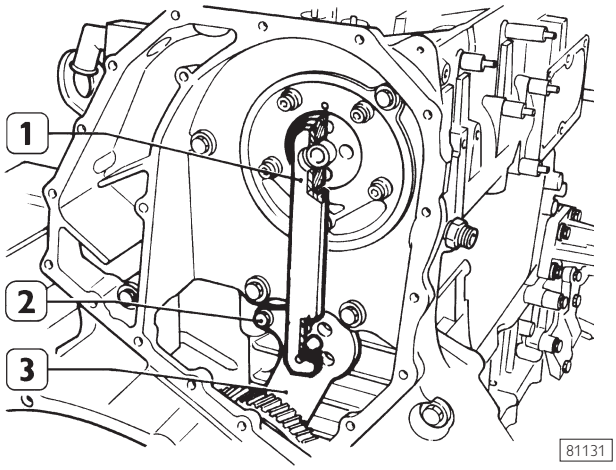
If this condition does not occur, turn the engine flywheel (4) appropriately.
Remove the tool 99360612 (1).

Figure 166



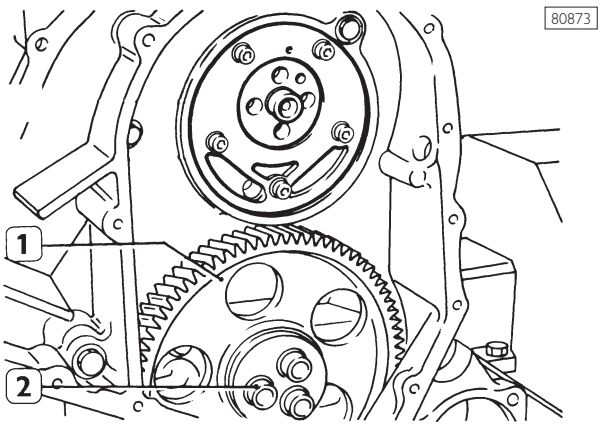
Fit the camshaft (4), positioning it observing the reference marks (➜) as shown in the figure.
Lubricate the seal (3) and fit it on the shoulder plate (2).
Mount the shoulder plate (2) with the sheet metal gasket (1) and tighten the screws (5) to the required torque.

Figure 167



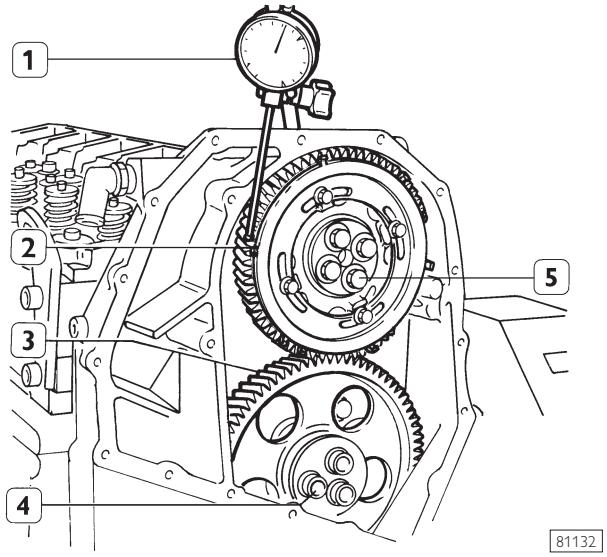
❑ Apply gauge 99395219 (1), check and record the position of the rod (3) for the transmission gear; tighten the screw (2) to the prescribed torque.

Figure 168



❑ Remove the transmission gear (1) and tighten screws (2) by means of proper splined wrench.

Figure 169

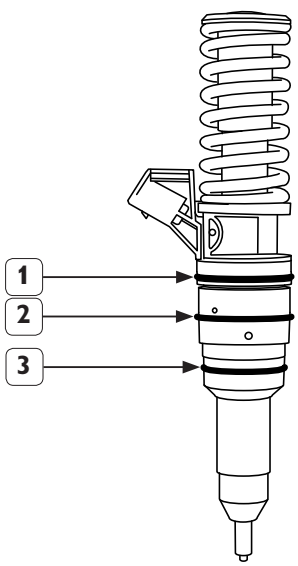


Fit back the gear (2), without fully tightening screws (5) on the camshaft and place it so that the 4 oval holes are centered with respect to the camshaft fixing holes. Using a magnetic gauge, make sure that the gear (2 and 3) clearance is 0.073 to 0.195 mm, otherwise adjust the clearance as follow:

- ❏ Untighten screws (4) fixing transmission gear (3);
- ❏ Untighten screw (2, figure 167) fixing the rod, move the rod (3, figure 167) to obtain the requred clearance;
- ❏ Tighten the rod fixing screw (2, figure 167) as well as the screws (4, figure 169) fixing the gear to the prescribed torque.

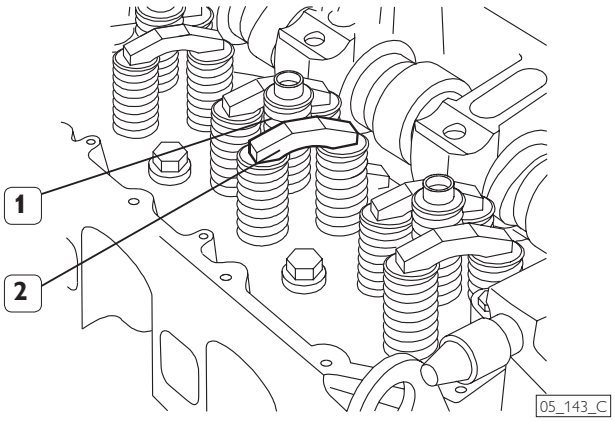
EUI Assembly

Figure 170



- ❏ Mount the seal rings (1) (2) (3) on the injectors. Grease the rings with Vaseline for easier correct positioning in their seats.

Figure 171



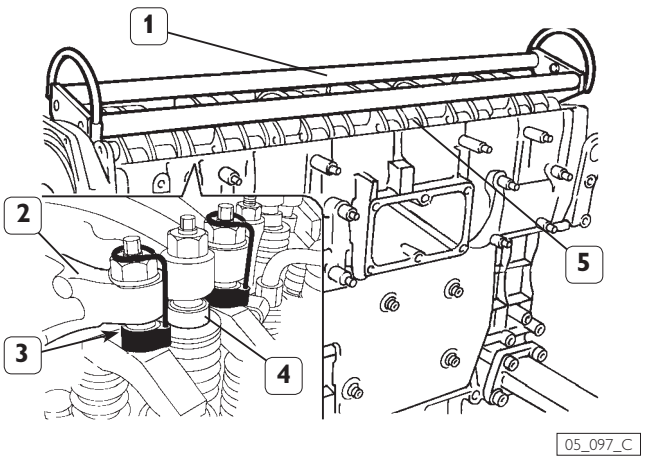
- ❏ Carefully position the injectors (1) into the seats and use a torque wrench to tighten the bracket screws at the torque of 26 Nm;
- ❏ Mount the braces (2) on the valve stems all oriented with the larger hole on the same side.

CAUTION

Before reassembling the rocker arm shaft assembly, ensure that all adjustment screws have been completely unscrewed.

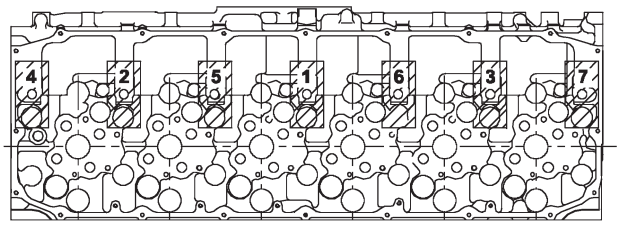
Rocker arm shaft assembly

Figure 172



- ❏ Use the tool 99360144 (3) to fasten the blocks (4) to the rocker arms (2);
- ❏ Apply the tool 99360553 (1) to the rocker arm shaft (5) and mount the shaft on the cylinder head.

Figure 173



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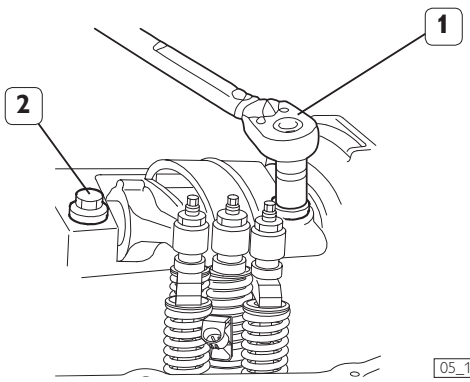
SCHEME OF SCREW TIGHTENING SEQUENCE SECURING ROCKER ARMS

Tighten the screws (1 - 2 - 3) until the rocker arms are brought into contact with the relative seats on the cylinder head, tighten the screws according to the sequence indicated in the figure above and operate in two steps as indicated in the following figure.

Figure 174 A

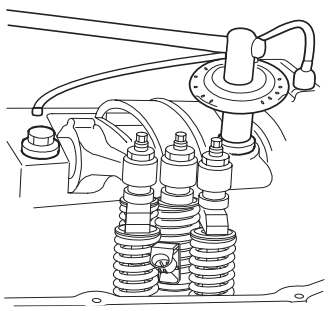


05_101_C

Tighten the rocker arm shaft screws (2) as follows:

- ❑ Turn the screws until they bear against the rocker arm shaft;
- ❑ Pre-tighten with torque wrench (1) to a torque of 80 Nm (8 kgm);

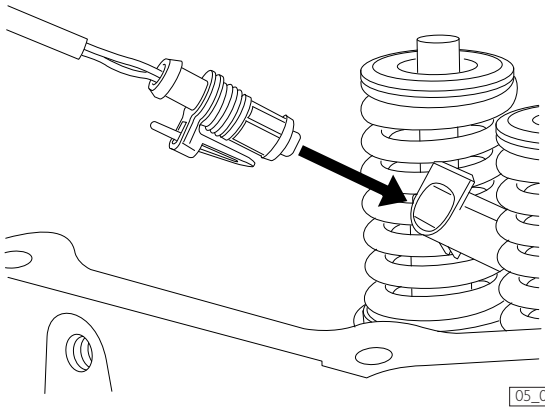
Figure 174 B



05_102_C

- ❑ Tighten with tool 99395216 (3), at an angle of 60°.

Figure 175



05_098_C

- ❑ Assemble the electric wiring by connecting the connectors with the EUI electro valves.valvole EUI.

Adjusting camshaft phase

(see Section 6)

Checking the timing phase

(see Section 6)

Timing shaft phonic wheel keying

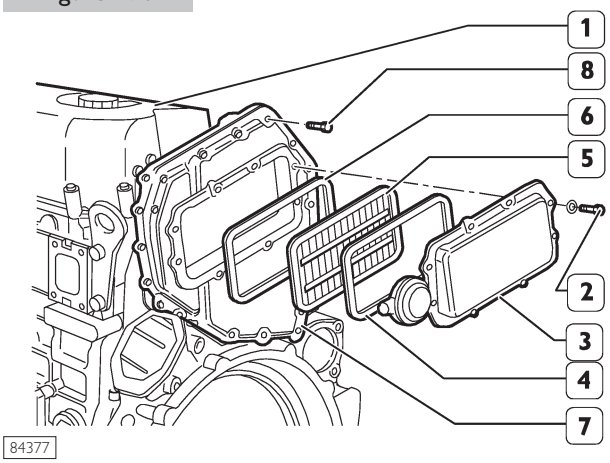
(see Section 6)

Adjusting valve clearance and EUI pump position

(see Section 6)

ENGINE COMPLETION

Figure 176



Fit the distribution cover (1).

CAUTION

The valve rocker arm cover fastening screws (1) shall be tightened according to the sequence shown in Figure 177.

Figure 177

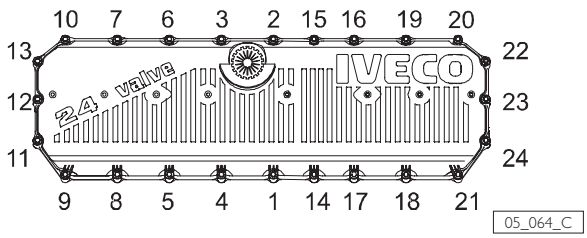
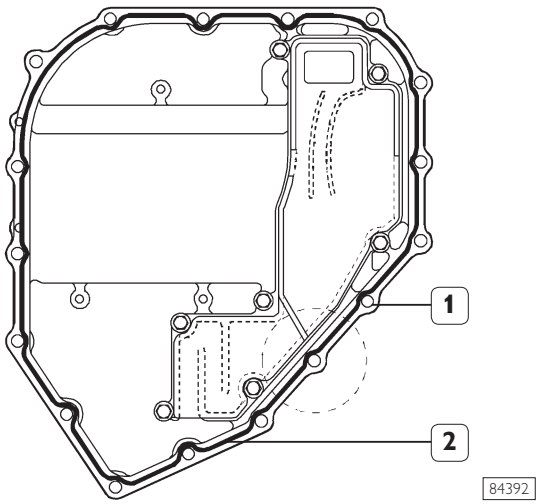


DIAGRAM OF ROCKER ARM CAP FIXING SCREWS TIGHTENING SEQUENCE

Fit the blow-by case (7, Figure 176) and its gasket and then tighten the screws (8, Figure 176).

Figure 178



Apply silicone Loctite 5970 IVECO No. 2992644 on the blow-by case and form a string (2) of Ø 1.3 to 2 mm, as shown in the figure.

CAUTION

Fit the blow-by case (1) within 10' from sealer application.

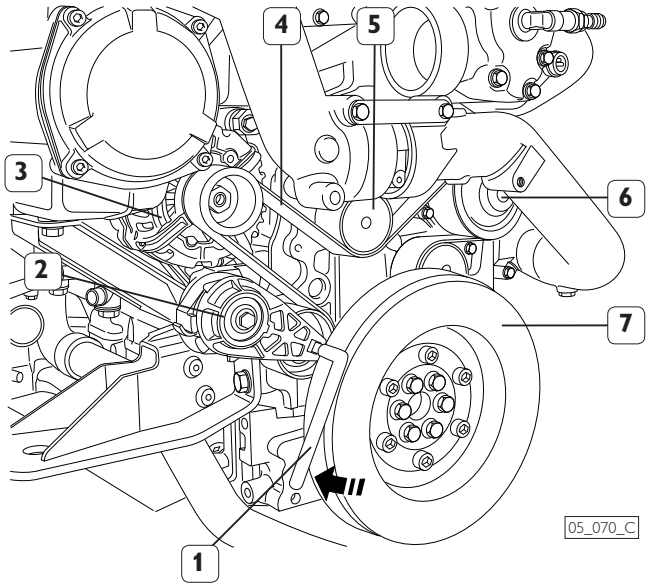
Install the filter (5, Figure 176) and the gaskets (4 and 6, Figure 176).

CAUTION

The filter (5,Figure 176) operation is unidirectional, therefore it must be assembled with the two sight supports as illustrated in the figure.

Fit the cover (3, Figure 176) and tighten the fastening screws (2, Figure 176).

Figure 179



Installing the following components:
belt tensioner (2), alternator (3), fixed tightener (5), water pump (6), damping flywheel (7).

To install auxiliary organ drive belt (4), using the appropriate tool (1) loose the tensioner, as shown by arrow; insert the belt, verifying that it is correctly set onto the pulleys. Release the tensioner.

CAUTION

Automatic tensioners do not require further adjustments after the installation.

- ❑ Rotate the engine and install the oil rose pipe;
- ❑ Place the gasket on the oil sump, position the spacer and fit the sump to the engine block by tightening screws to the prescribed torque;
- ❑ Mount rockers lid tightening screws to the prescribed torque.

Remove the engine from the stand, fit the starter motor and the oil pressure adjuster valve (2, figure 10).

The operations described below can all be completed aboard the vessel.
If they take place at an overhaul center, secure the engine to an adequate support.

Install:

- ❑ Sea water/engine coolant heat exchanger;
- ❑ Combustion air heat exchanger;
- ❑ Oil heat exchanger;
- ❑ Fuel pump;
- ❑ Fuel filter and piping;
- ❑ Intake manifold;
- ❑ Oil filter support and oil filters;
- ❑ Exhaust manifold;
- ❑ Turbocompressor and its oil and water piping;
- ❑ Oil level dipstick and oil vapor vent;
- ❑ Sensors and electrical connections.

Fill the engine with oil and coolant liquid quantity required.

SECTION 9

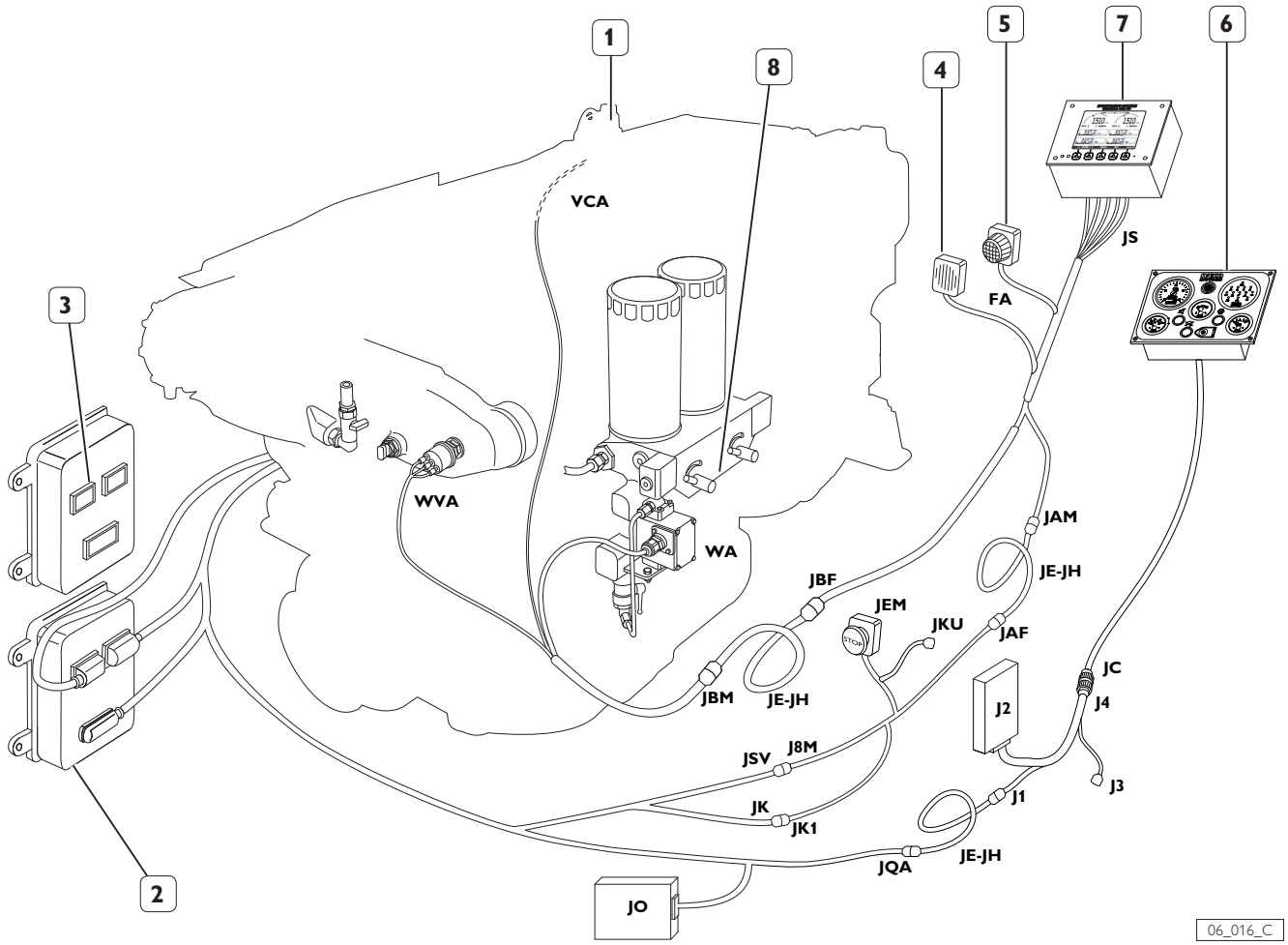
SAFETY SYSTEM FOR HOMOLOGATED INSTALLATIONS

(cont.)

SAFETY SYSTEM FOR HOMOLOGATED INSTALLATIONS

Unit installed

Figure 1



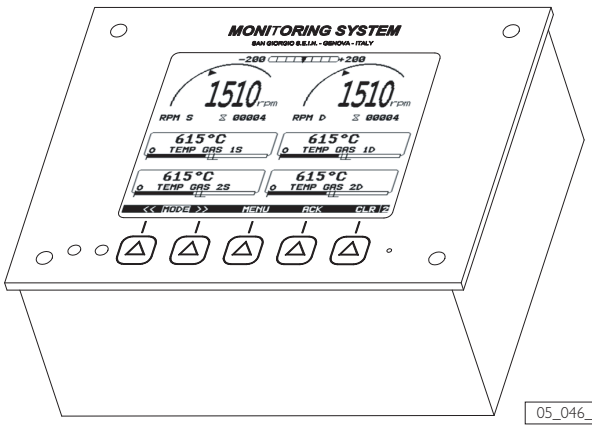
1. Fuel filters which can be replaced when the engine is rotating - 2. EDC electronic unit - 3. EDC auxiliary unit - 4. Acoustic alarm - 5. Warning light - 6. Control panel - 7. Electronic monitoring and alarm management unit - 8. Oil filters which can be replaced when the engine is rotating.

The electric and electronic equipment of engines requiring a conformity declaration issued by the Certifying bodies comprises, in addition to that provided for the standard configuration, a series of components for the measurement, processing and recording of engine operating parameters. The aim of the system is to emit acoustic and optic alarms indicating that set limits have been exceeded. These limits will be programmed in accordance with different homologation requirements and may, when necessary, cut-out the engine in an emergency.

The system is made up of an electronic unit for the acquisition, display and recording of events occurring while the engine is running, using a series of sensors for this specific purpose; the alarm signals produced by the Unit will be emitted by acoustic and optic alarms installed by the Yard or by the Fitter. For boats equipped with only one engine, to offer a higher level of safety during navigation, it is necessary to install a second auxiliary EDC unit alongside the EDC engine controlling electronic unit to enable rapid replacement in the event of a failure.

Electronic monitoring unit

Figure 2



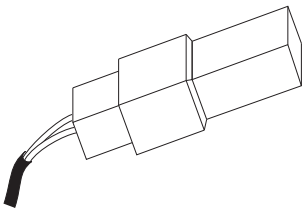
05_046_C

This unit monitors the operation of the specific safety system. With its computerised logic it acquires the electric signals issued by the sensors linked up to it, converting them into physical parameters of temperature, pressures and revs. This data is displayed on the liquid crystal display and processed according to the set parameters to draw attention to any approach towards the critical limits programmed and alarms should these limits be exceeded. Equipped with a built-in clock/calendar function, it is able to record and memorise the last 1000 alarms issued and the values of about 1000 samples of signals from sensors. It also issues electric signals to activate the acoustic and luminous alarm signals as requested by the homologation standards.

Sensors

Some sensors produce electric signals with a value proportionate to their physical entity
(temperature, pressure or rev. speed), allowing the electronic unit to monitor the engine operation to measure tendencies to approach the critical values; others indicate, with commutation by an electric switch, that a set pressure or temperature limit has been exceeded, generating an immediate "alarm" signal.
Given the high level of safety required, many of the monitoring system sensors are connected exclusively to this system; this means that the engine equipment comprises several components to measure the same physical entity but dedicated to different systems. In order to obtain an effective control of the integrity of the wiring, there are several resistors, connected in series with or parallel to the connection lines of the main sensors, which are used to recognise the conditions of cut-out or short-circuit of the connectors. After installation it is best to check that these components are correctly connected to the wiring (Figure 3).

Figure 3



05_047_C

- Line balancing element -

In observance of the provisions of the certifying bodies, the system equipment includes the presence of solutions which make it possible to check the efficiency of the monitoring functions and measure the relative parameters. By way of example, there is a valve which cuts off the oil in the connection of the "Low oil pressure" (WA) sensor, in order to test the efficiency of the related function and an unused extension cable (BA1 – BA1U).

Wiring

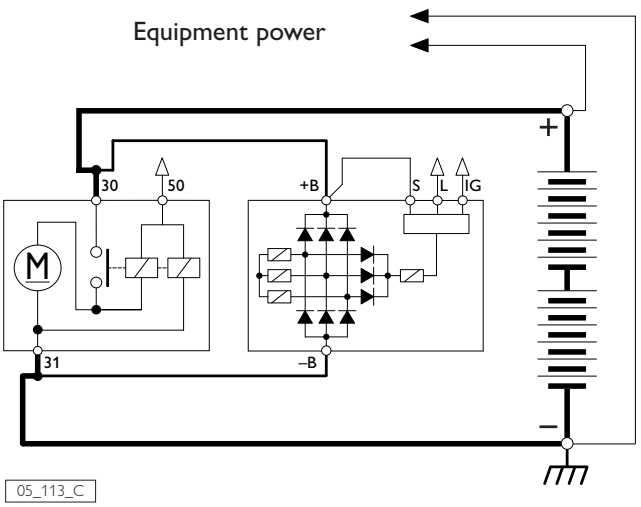
The presence of the Safety system in question in the electrics of the boat requires the use of specific
wiring unlike standard wiring.
The connection of the monitoring unit and the components connected to it are made on the JB-JC wiring used for the connection of the main control panel to the engine wiring.
The electric connection of the system devices is made using connectors. Every multipolar connector is polarised to prevent inversion and is dedicated to a particular function.
The electric diagrams, referred to the identification of the inputs/outputs of the connectors of the
monitoring unit may vary following the programming of particular features of the application.

CAUTION

In order to activate the function which stops the engine in case of excitation, it is necessary to connect the JECCM and JECCF connectors with each other.

Insulated pole power network (optional)

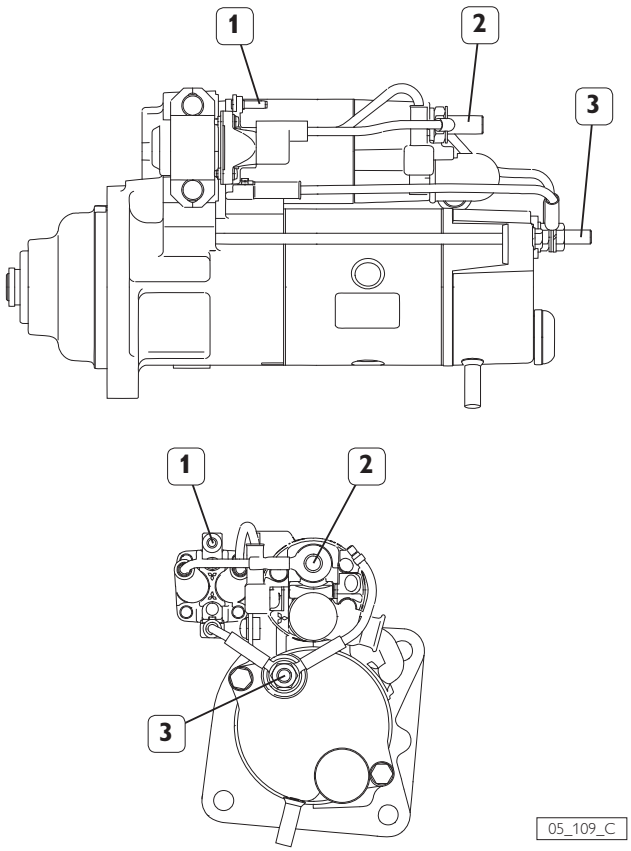
Figure 4



The power network may be carried out in order to avoid using both the structure of engine and the structure of the hull (if this is metallic). For this purpose the electrical starting motor and the alternator required for this equipment are characterized by the presence of the terminals for electrical connections both with the positive and with the negative pole of the battery.

Electrical starting motor

Figure 5



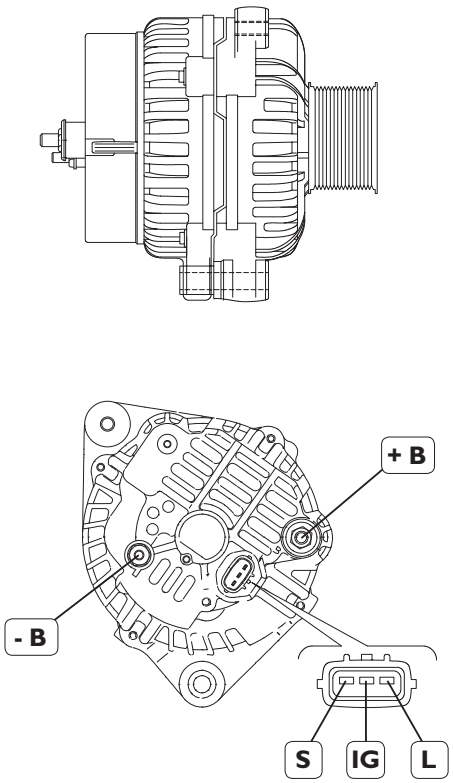
1. Excitation coil command (50) - 2. Positive power pole (+B) - 3. Negative supply pole (-BATT).

Technical characteristics:

- Supply nominal voltage 24 V
- Absorbed power 5 kW
- Terminal connection "50" M5 x 0,8 tightening couple 2-2.5 Nm
- Terminal connection "+B" M10 x 1.5 tightening couple 14.7-17.7 Nm
- Terminal connection "-BATT" M8 x 1.25 tightening couple 9.8-11.8 Nm

Alternator

Figure 6



Technical characteristics:

- Nominal voltage 24 V
- Nominal voltage 90 A
- Terminal connection "+B" M8 x 1.25 tightening couple 12,5 Nm ± 20%
- Terminal connection "-B" M6 x 1 tightening couple 6,0 Nm ± 20%

+B. (24 V) Power supply output terminal;

-B. (0 V) Power supply output terminal;

S. (Sense) Reference voltage of battery charge status (connected to +B terminal or to be connected to the positive pole of the battery in case of remote installation of the battery);

IG. (Ignition) Regulator enabling signal (connected to voltage +, driven by key switch);

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

Auxiliary EDC electronic unit

This is fastened to the side of the unit in use to enable rapid replacement in the event of a failure.
Should it be necessary to replace it, proceed as follows:

- ❏ stop the engine;
- ❏ wait 10 seconds, then disconnect the terminal clamps from the battery;
- ❏ roceed as follows to extract and reinsert the connectors.

Figure 7A

06_015_C

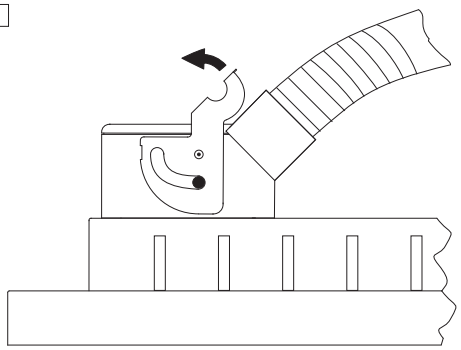
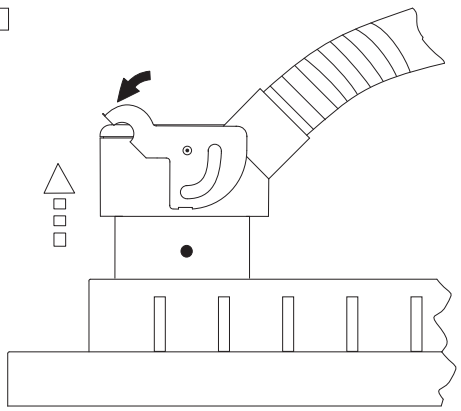


Figure 7B

06_014_C



REMOVING ECU CONNECTORS

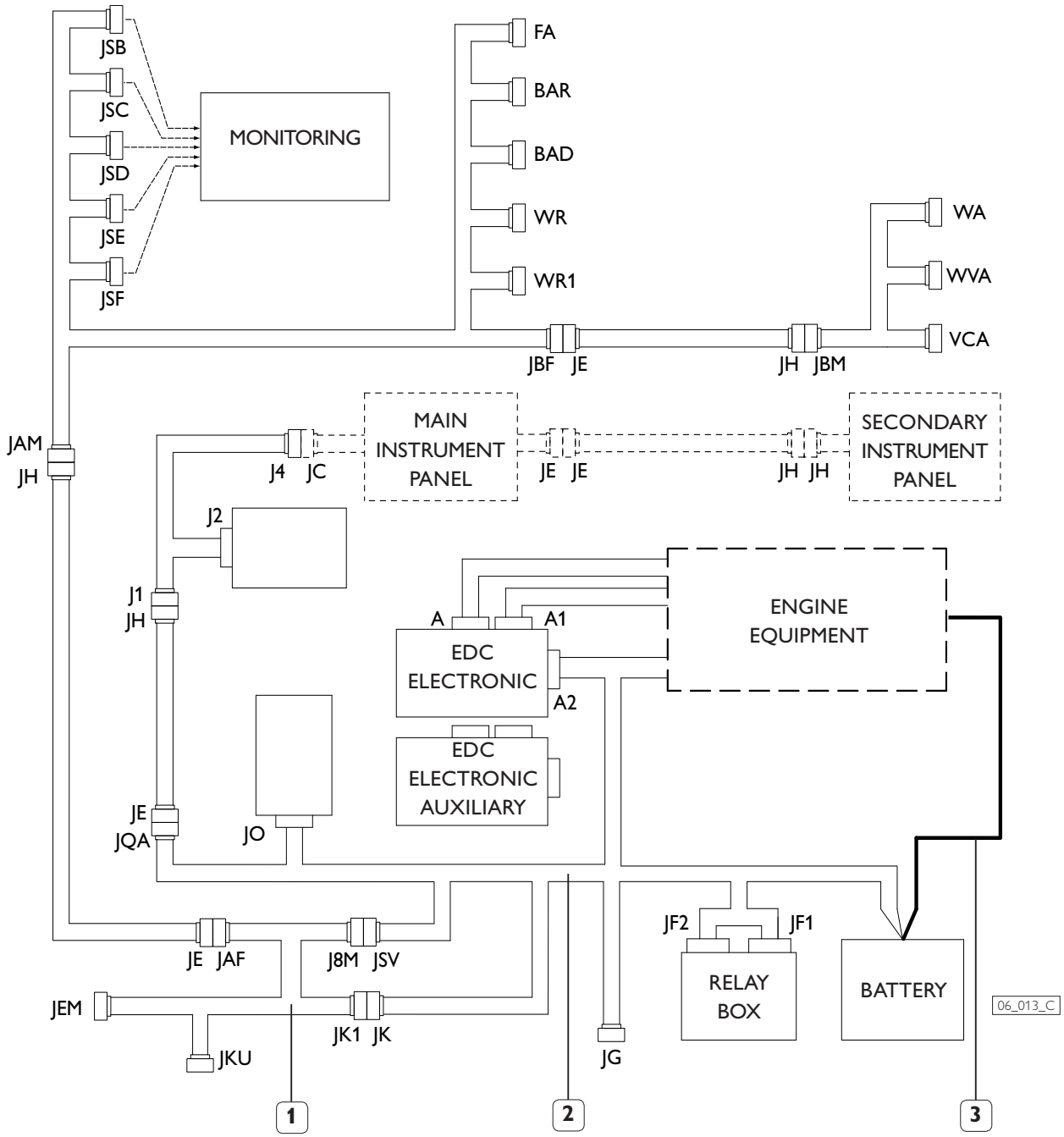
In order to fit connectors on the ECU, follow the above instructions in the reverse sequence.

At the end of the operation:

- ❏ reconnect the battery terminal clamps;
- ❏ start up the engine to run an efficiency test.

Synoptic

Figure 8



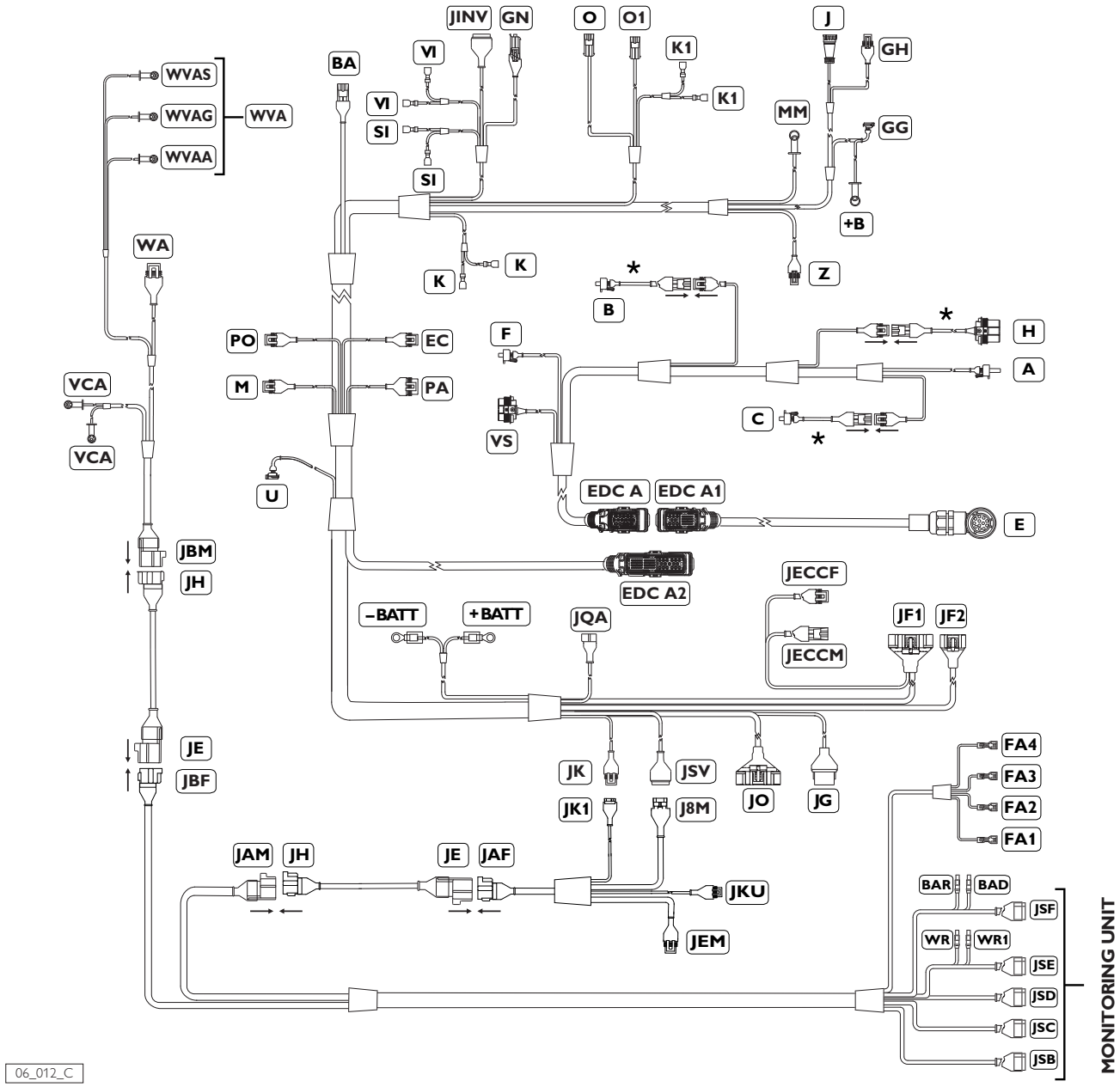
1. Specific wiring harness for installation of monitoring unit - 2. Engine wiring - 3. Power network.

DESTINATION OF CONNECTORS OF THE SAFETY SYSTEM (excluding standard supply connectors)

BAD. Diode for BA - BAR. Resistor for BA - FA. Acoustic and luminous alarms - J8M. Pick-up signal connector and power supplies - JAF. CAN-BUS connector line / Pick-up signal / Power supply for RINA display - JAM. CAN-BUS connector line / Pick-up signal / Power supply from signal cabling - JBF. RINA sensor connector from sensor cabling engine side - JBM. RINA sensor connector - JEM. Connector for cutout switches in the case of an emergency and motor cutout from the engine room - JK1. CAN lines input connector - JKU. CAN lines output connector - JS. Electronic monitoring unit - JSB, JSC, JSD, JSE, JSF. Connectors for monitoring unit - VA. Engine oil pressure sensor - VCA. Fuel pressure sensor - WA. Engine oil low pressure sensor - WR. Parallel resistor for WA - WR1. Series resistor for WA - WVA. Coolant pressure and low pressure sensor.

Wiring

Figure 9

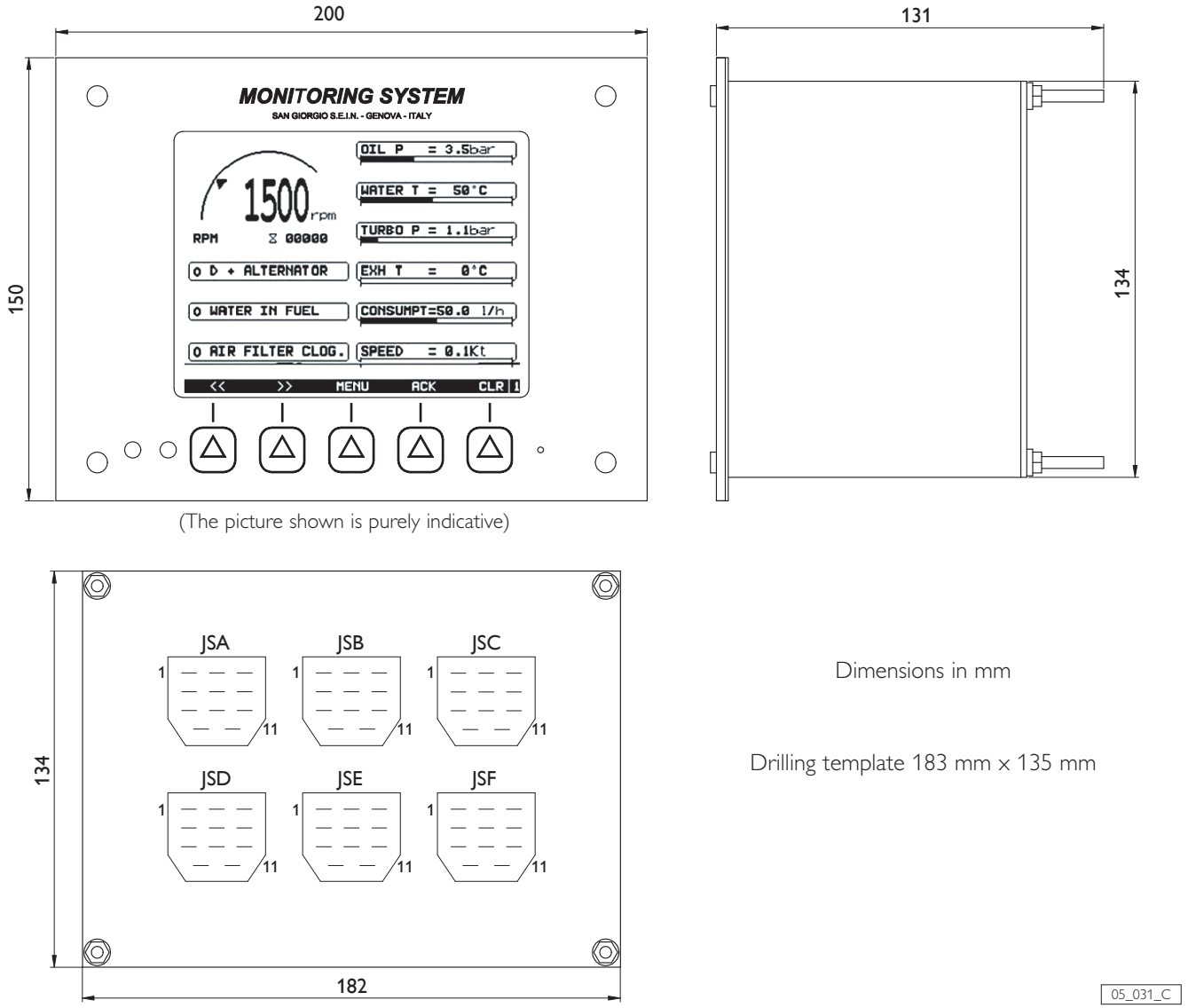


DESTINATION OF CONNECTORS OF THE STANDARD ENGINE (excluding safety system connectors)

A. Fuel temperature sensor - B. Drive shaft sensor - BA. Additional drive shaft sensor (certified installation) - C. Camshaft sensor - E. EUI solenoid valves - EC. Switching solenoid valve for oil charge/discharge - F. Engine coolant temperature sensor - GG. Alternator - GH. Grid heater power relay - GN. Neutral gear sensor (in installation with no sensor, do not remove the cap of the GN connector to avoid compromising start engine function) - H. Combustion air pressure/temperature sensor - J. Low coolant level sensor - JG. Pre-lubrication control unit - JK. CAN lines connector - JO. Analog to digital converter module - JF1, JF2. Relay box - JQA. Set for connection to instruments panel wire harness - JSV. Overspeed module connector - JINV. Set for connection to gearbox sensor and external accelerator command - JECCF. Excitation engine stop function connector - JECCM. Excitation engine stop function connector - K, K1 Air filter clogging sensor - M. Sensor for detecting the presence of water in the fuel pre-filter - MM. Electric starter motor - O, O1. Exhaust gas temperature sensor - PA. Throttle position sensor - PO. Pre-lubrication electrical pump - SI. Gear box oil temperature sensor U. Clogged engine oil filter sensor - VI. Gear box oil pressure sensor - VS. Engine oil pressure/temperature sensor - Z. Clogged fuel filter sensor - * B, C, H sensor wiring harness.

Monitoring unit

Figure 10



(The picture shown is purely indicative)

Dimensions in mm

Drilling template 183 mm x 135 mm

05_031_C

The total integration of the system with the engine equipment means that the installation procedures already listed for the standard version are joined by the placement of the electronic monitoring unit inside a console or dashboard, which can be fitted outside, as well as the preparation of the alarm management components pursuant to the homologation standard: acoustic and luminous signals, cut-out buttons.

GENERAL FEATURES AND REFERENCE STANDARDS

Power supply	12/24 V d.c.
Current absorption	500 mA (approx.)
Performances in compliance with *	R.I.N.A. "Regulation for automation systems" - Section E
Functional, climatic, vibration and EMC tests in accordance with *	IEC 945 "Maritime navigation and radio-communication equipment and system - General requirements - Methods of testing and required test results"

* The test reports are supplied by request

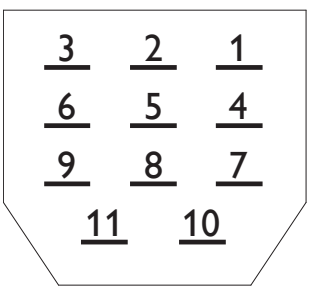
Function of JS connection terminals

pin	JSA Thermocouples	JSB Supply	JSC CAN network
1	-	Supply 12/24 V (+)	CAN (H)
2	-	Supply 12/24 V (+)	CAN (L)
3	-	Mass (-)	-
4	-	Mass (-)	-
5	-	-	-
6	-	-	-
7	-	Mass (-)	-
8	-	N.O. relay 1 - Acoustic signaling	-
9	-	N.C. relay 2 - light signal(2)	-
10	-	Mass (-)	-
11	-	-	-

NOTE: one of the terminals of the following components is connected to the electric mass: VCA, WVA(G), VA, WA, BAD, IA, JE.

pin	JSD Sensors	JSE Signals	JSF Signals and alarms
1	-	-	-
2	Coolant pressure (WVAS)(1)	Engine revs (BA)(1)	-
3	-	-	12/24 V (+) common relay 3 stoppage
4	-	-	N.O. Cut-out relay 3 (JE)(1)
5	-	-	-
6	Low engine oil pressure (WA)(1)	Low coolant pressure (WVAA)(1)	-
7	-	-	Imp. Voltage signal 12/24 V (+)
8	Fuel pressure (VCA)(1)	Engine revs (BAR - BA)(1)	Engine stopping circuit damaged (JEM - JE)(1)
9	-	-	-
10	-	-	-
11	Mass (-)	Engine cut-out (pin 4 JSF)	-

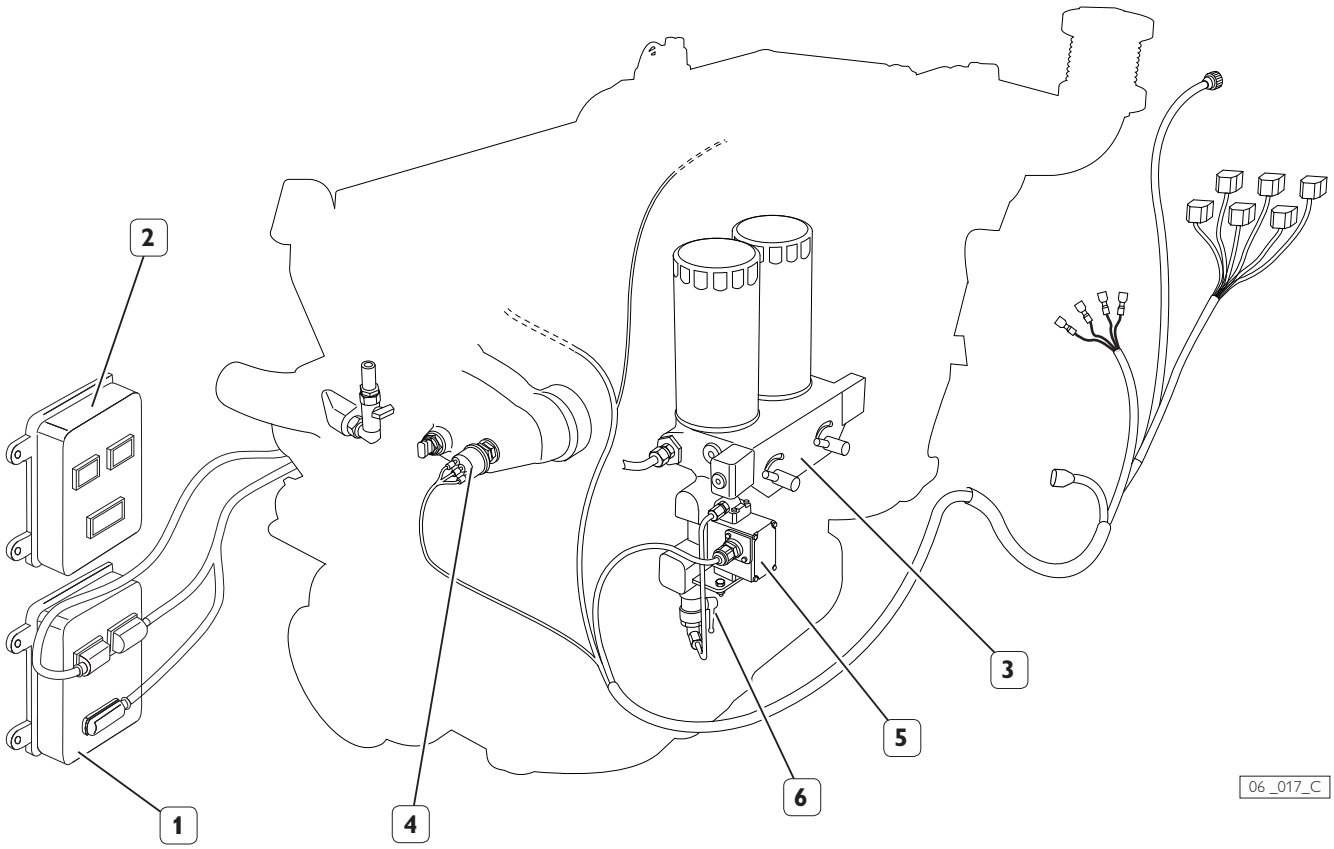
1) Code of the component or sensor to which the terminal is connected
2) The terminal is prepared but not connected with the wiring.



CONNECTORS JS SEEN FROM WIRING SIDE

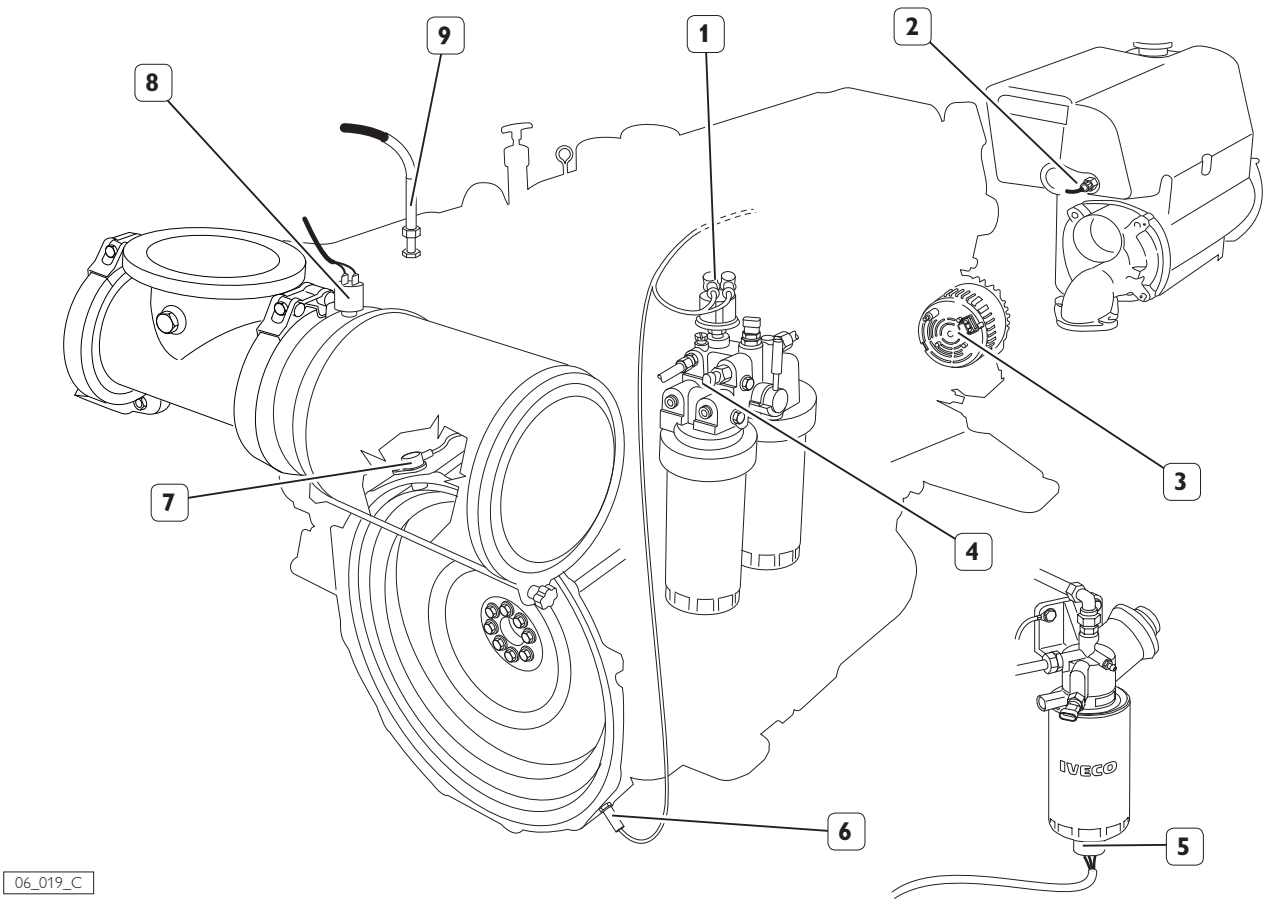
Position of the safety system sensors

Figure 11



1. EDC electronic unit - 2. 2. Auxiliary EDC unit required for boats fitted with one single engine -
3. Oil filters which can be replaced when the engine is rotating - 4. Coolant pressure and low pressure sensor. -
5. Engine oil low pressure sensor (WA) - 6. WA efficiency test tap.

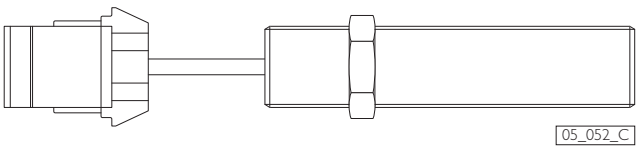
Figure 12



1. Fuel pressure analogical sensor (VCA) - 2. Engine cooling liquid level sensor (J) - 3. Battery recharge signal (L) - 4. Fuel filter congestion sensor (Z) - 5. Presence of water in the fuel sensor (M) - 6. Engine rotation speed sensor (BA) - 7. EDC engine rotation speed sensor (B) - 8. Air filter congested signal (K) Present on both filters - 9. Exhaust gas or thermocouple temperature analogical sensor (O).

Drive shaft revolution speed sensor (BA)

Figure 13

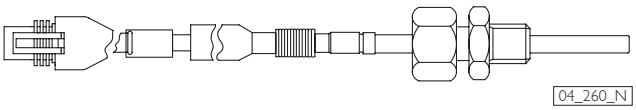


This is of the inductive type and when the engine is running it produces a sinusoidal alternate signal the value of which increases in proportion to the engine rev. speed. The sensor BA enables the measurement of the engine rev- speed using the passage of the holes positioned in a radial arrangement on the outer circumference of the flywheel. The presence of the resistor BAR and the diode BAD can alter the value of the sensor resistance if measured on the JSE connector of the monitoring unit.

Resistance value at 20°C	220 ± 20 Ω
Poles	Isolated

Exhaust gas temperature sensor (O)

Figure 14

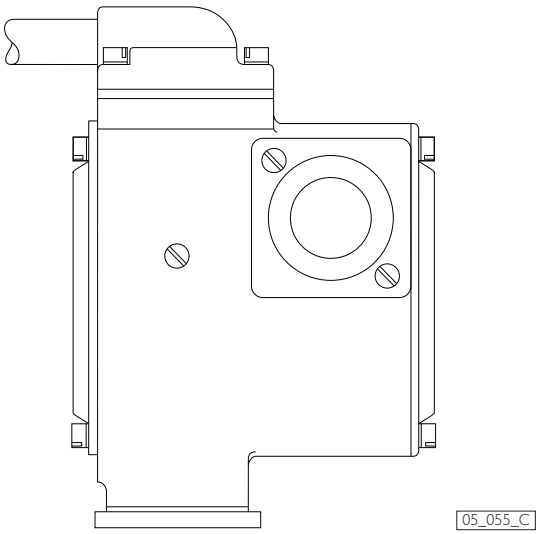


NiCr-Ni thermocouple sensor with insulated poles, providing the signal for the analog indication of exhaust gas temperature.

Temperature	Voltage
°C	mV
100	4.10
200	8.13
300	12.21
400	16.40
500	20.65
600	24.91
700	29.14
800	33.30
900	37.36

Engine oil low pressure sensor (WA)

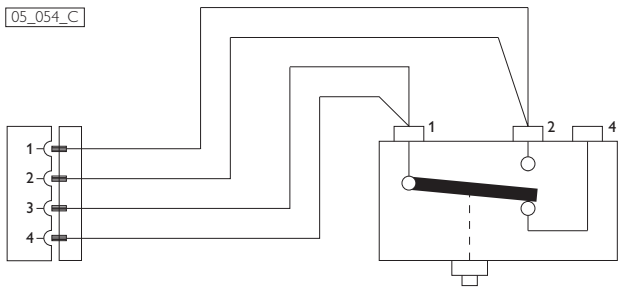
Figure 15



Switch activated by the fluid pressure, which supplies the information for the engine lubricant low pressure alarm.

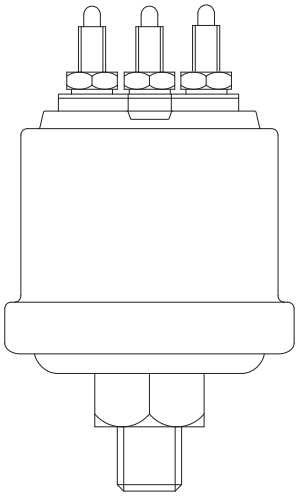
Operating power	from 6 V to 24V
Condition at ambient pressure	normally closed
Commutation pressure:	0.4 / 0.8 / 1.2 bar
Poles	Isolated

Electric diagram:



Refrigerating liquid pressure and low pressure sensor (WVA)

Figure 16



This integrates a component which supplies the rheostatic signal for the analogical indication of the pressure and a switch activated by the pressure which supplies the information for the engine coolant low pressure alarm.

Operating power	12 / 24 V

Rheostat

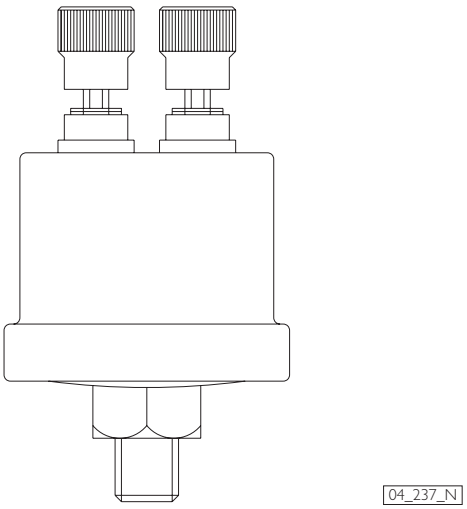
Field of intervention	from 0 to 5 bar
Stamping of the terminals	M - G
Wiring terminals	WVAG - WVAS

Switch

Condition at ambient pressure	normally open
Closing pressure	≥ 0.25 bar
Stamping of the terminals	M - WK
Wiring terminals	WVAG - WVAA

Fuel pressure sensor (VCA)

Figure 17

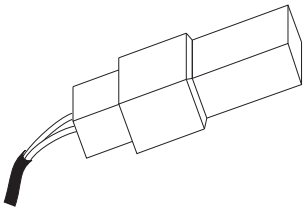


Component which supplies the rheostatic signal for the analogical indication of the fluid pressure.

Operating power	12 / 24 V
Field of intervention	from 0 bar to 10 bar
Poles	Isolated

Line balancing components

Figure 18



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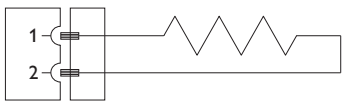
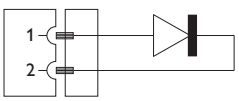
Electric diagram:



05_058_C

Code	Resistor features
WR	1.5 kΩ 1W
WR1	470 Ω 1W
BAR	4.7 kΩ 1W

Electric diagram:



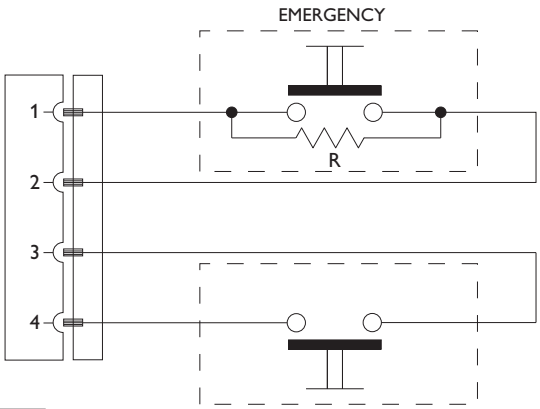
05_059_C

Code	Diode code
BAD	1N 4007

Engine cut-out control buttons (JEM)

Electric diagram:

Figure 19



05_060_C

The balancing resistor R has a value of 10 kΩ.

ELECTRICAL DIAGRAMS FROM THE SAFETY SYSTEM

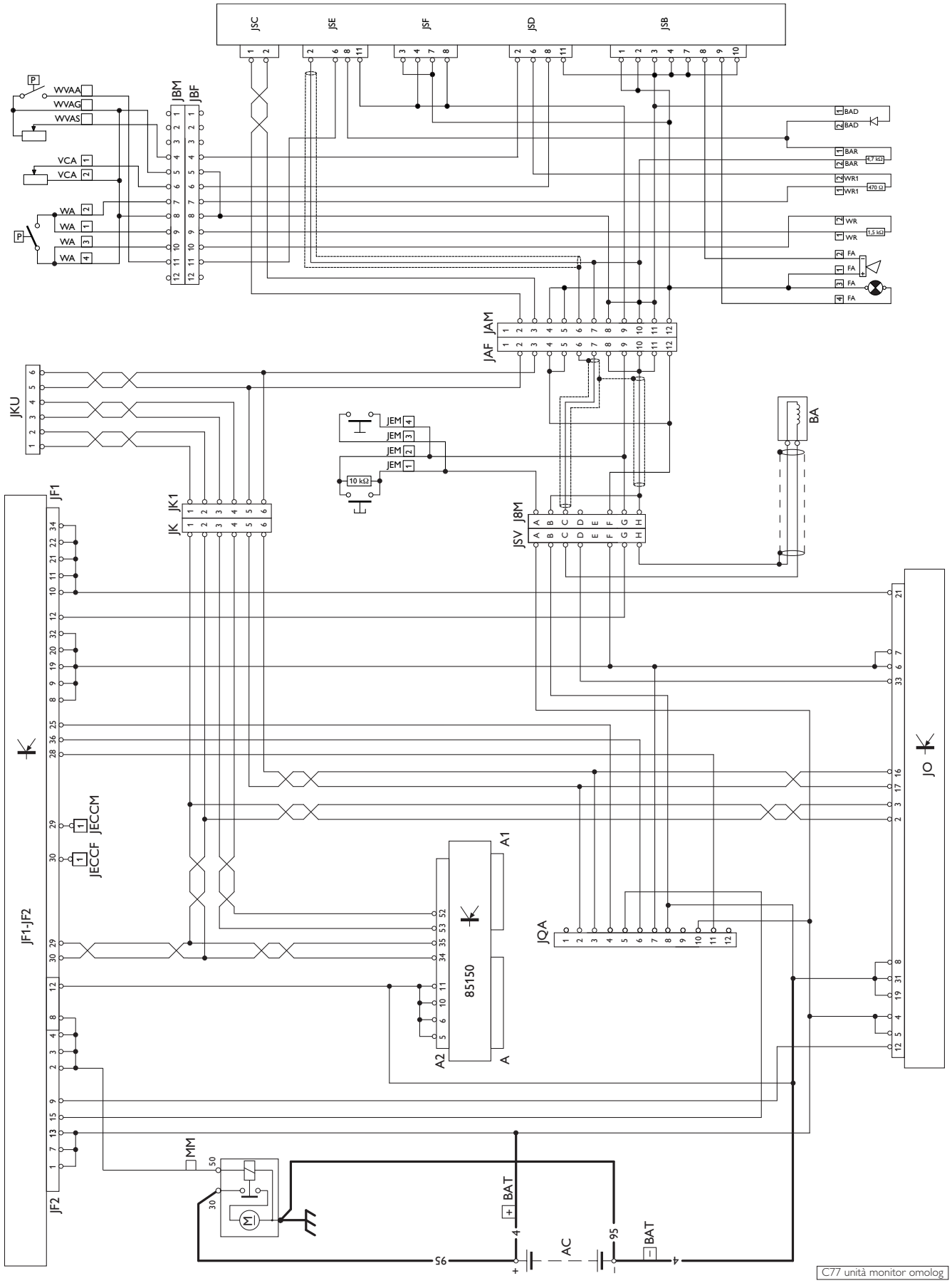
Code of components of the standard version

A	Fuel temperature sensor
B	Drive shaft sensor
BA	Additional drive shaft sensor (certified installation)
C	Camshaft sensor
E	EUI solenoid valves
EC	Switching solenoid valve for oil charge/discharge
F	Engine coolant temperature sensor
GG	Alternator
GH	Grid heater power relay
GN	Neutral gear sensor (if not present, do not remove the GN connector plug in order not to jeopardize the engine start function)
H	Combustion air pressure/temperature sensor
J	Low coolant level sensor
J2	Digital to analog converter module
JF1, JF2	Relay box
JG	Pre-lubrication control unit
JK	CAN lines connector
JO	Analog to digital converter module
JQA	Set for connection to instruments panel wire harness
JSV	Overspeed module connector
JINV	Set for connection to gearbox sensor and external accelerator command
JECCF	Excitation engine stop function connector
JECCM	Excitation engine stop function connector
K,K1	Air filter clogging sensor
M	Sensor for detecting the presence of water in the fuel pre-filter
MM	Electric starter motor
O,O1	Exhaust gas temperature sensor
PA	Throttle position sensor
PO	Pre-lubrication electrical pump
SI	Gear box oil temperature sensor
U	Clogged oil filter sensor
VI	Gear box oil pressure sensor
VS	Engine oil pressure/temperature sensor
Z	Clogged fuel filter sensor

Code of components of the safety system

BAD	Diode for BA
BAR	Resistor for BA
FA	Acoustic and luminous alarms
J8M	Pick-up signal connector and power supplies
JAF	CAN-BUS connector line / Pick-up signal / Power supply for RINA display.
JAM	CAN-BUS connector line / Pick-up signal / Power supply from signal cabling.
JBF	RINA sensor connector from sensor cabling engine side
JBM	RINA sensor connector
JEM	Connector for cutout switches in the case of an emergency and motor cutout from the engine room
JK1	CAN lines input connector
JKU	CAN lines output connector
JS	Electronic monitoring unit
JSB, JSC, JSD, JSE, JSF	Connectors for monitoring unit
VCA	Fuel pressure sensor
WA	Engine oil low pressure sensor
WR	Parallel resistor for WA
WR1	Series resistor for WA
WVA	Coolant pressure and low pressure sensor

Assembly drawing of the safety system harness



METHOD OF USE OF THE SAFETY SYSTEM INTERFACE

The following information relates to the method of use of the system in the configuration which is considered to be the IVECO MOTORS-FPT standard. Information concerning functions which require connection to external systems such as echo sounders and GPS, which are outside the safety system, are voluntarily explained briefly. The programming method which must be carried out by the Supplier or by the Assistance Service technician is not explained. For all the information which are not contained in this document, please refer to the manuals issued by the Supplier.

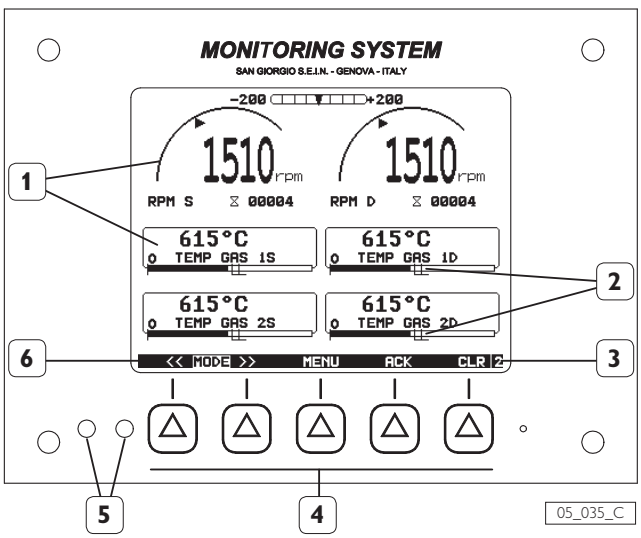
CAUTION

The system is supplied programmed to suit the homologation instructions arranged; every need linked to different programming of the operating characteristics will be met by the information presented by the Constructor with specific documentation. Please remember that the settings, allowed to adapt the system to different installations, will only be possible after the system password has been entered.

Monitoring

The monitoring interface enables a constant verification of the mechanic parameters required by the homologation norms so that it is possible to quickly identify the arousal of an anomalous condition. The information contained in the unit memory also enables the analysis of the events relating to the period preceding the survey. If there is an alarm status, an acoustic signal is emitted and the box containing the anomalous parameter data is visually highlighted through a flashing border.
The function of the keys changes depending on the different displays.

Figure 20



1. Analogue indicators in the form of bars or circles with reference to the parameter, value and unit of measurement - 2. Recognition of the pre-set alarm limits - 3. Page number - 4. Membrane keys - 5. luminous indicators - 6. Key functions.

Basic operations

- ❑ Press the keys "<<" and ">>" to display the sequence of the pages containing the information relating to all the monitored parameters, including maintenance rates and optional information (see the relating figures).

The IVECO MOTORS-FPT standard configuration requires the detection of the following data:

- ❑ Pressure of engine cooling liquid (FRESHWATER PRESS)
- ❑ Low lever of engine cooling liquid (LOW WATER LEVEL)
- ❑ Low pressure of engine cooling liquid (FRESHWATER LOW P)
- ❑ Excessive temperature of engine cooling liquid (HIGH WATER TEMP)
- ❑ Pressure of engine lubricating oil (OIL PRESS)
- ❑ Absence of engine lubricating oil pressure (LOW OIL PRESS)
- ❑ Temperature of engine lubricating oil (OIL TEMP)
- ❑ Oil filter blocked (OIL FILTER CLOG)
- ❑ Presence of water in fuel (WATER IN FUEL)
- ❑ Fuel pressure (FUEL PRESS)
- ❑ Fuel filter blocked (FUEL FILTER CLOG)
- ❑ Injection system failure (INJECT WARNING)
- ❑ The battery is not recharging (BATTERY WARNING)
- ❑ On going pre-lubrication (PRELUBRICATING)*
- ❑ Power System Tension (VOLTMETER)
- ❑ Exhaust gas temperature (EX GAS TEMP)
- ❑ Engine rotation speed from EDC system (ENGINE E)
- ❑ Engine rotation speed from sensor (ENGINE S)
- ❑ Engine rotation speed sensor damaged (PICK-UP L FAULT)
- ❑ Engine stopping circuit damaged (MAN STOP L FAULT)
- ❑ Automatic engine stopping circuit damaged (AUTOSTOP L FAULT)
- ❑ Air filter blocked (AIR FILTER CLOG)
- ❑ Gear oil pressure (GEAR OIL PRESS)*
- ❑ Absence of pressure in the gear oil (LOW GEAR OIL P)*
- ❑ Sea water pressure (SEA WATER PRESS) *

*) Information given only in the presence of the relating parts.

The setting of the alarm threshold must be carried out by the Technical Assistance Service personnel and requires the inputting of a password.

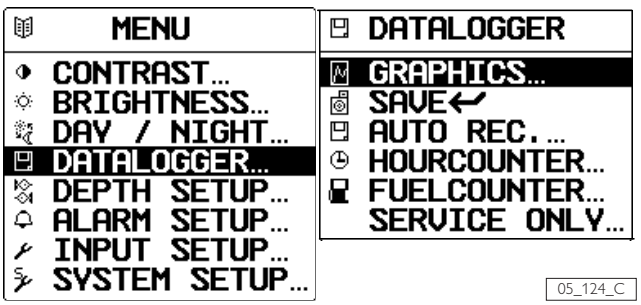
Video mode setting

The interface performances enable the modification of the brightness, the contrast and the image presentation mode, which is characterized by the inversion of the day/night.

- ❏ Press the "MENÚ" key to display the fast choice window.
- ❏ Press the keys "<<" and ">>" to highlight the display mode to be regulated: "BRIGHTNESS", "CONTRAST", DAY/NIGHT".
- ❏ Press the "OK" key to confirm your choice.
- ❏ Modify the parameter setting using the "<<" and ">>" keys
- ❏ Press the "OK" key again to confirm.
- ❏ Press the "CLR" key to exit the "MENU".

Advanced operations

Figure 21



The values of the monitored parameters can be shown in different ways, including a diagram showing their evolution over a period of time.

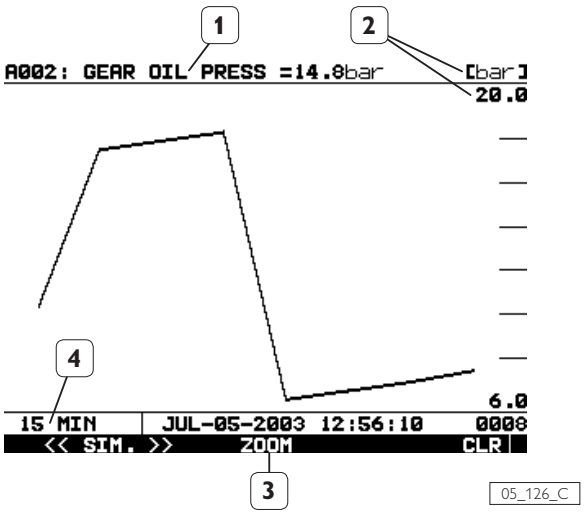
To chose the display mode, do as follows:

- ❏ Press the "MENÚ" key and display the fast choice window.
- ❏ Use the "<<" and ">>" keys to select the "DATALOGGER" option inside the window.
- ❏ Press the "OK" key to confirm and display a second window containing the options which can be chosen.
- ❏ To select the required display mode use the "<<" and ">>" keys.
- ❏ Press "OK" to confirm.

Modalità di visualizzazione

- ❏ "GRAPHICS": this displays the evolution of the parameters value over time; the "ZOOM" key enables the modification of the time period shown on the display.
- ❏ Press the "<<" and ">>" keys to display the diagrams relating to the different parameters.
- ❏ Press the "CLR" key to exit form this mode.

Figure 22



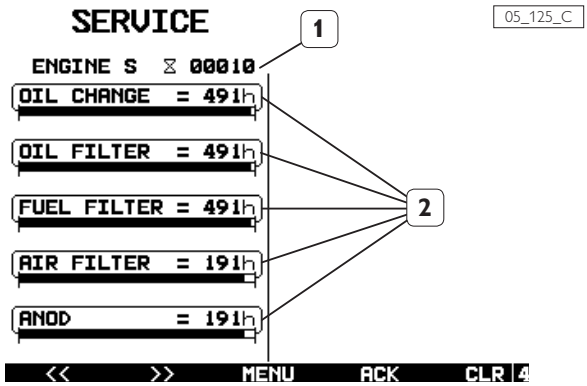
1. Parameter displayed - 2. Outside the stairs and measurement unit - 3. Period selection key (last 15 minutes, 1 hour, 6 hours, 24 hours) - 4. Displayed duration period.

- ❏ "SAVE": this enables the recording of the values of the parameters detected by the system in specific moments of the system working. Recording is carried out when the "OK" is pressed. The following pressures cause other data acquisitions. The recorded values can be shown in all the set modes.
- ❏ "AUTO REC.": this choice enables the modification of the data recording mode. It is not possible to carry out modifications.
- ❏ "HOURCOUNTER": this enables the management of the effective propeller/s movement hours; the data is displayed, as hours (ENGINE) or statistics (STATISTIC) only after inputting the correct password. This data can be used by the Assistance Centres Personnel to add just the programming of the maintenance intervals. From this mode it is possible to select the option "SERVICE RESET", which is explained in the paragraph: "Maintenance rates monitoring".
- ❏ "FUELCOUNTER": (not programmed).
- ❏ "SERVICE ONLY": this is used only for the programming which must be carried out by the personnel of the Technical Assistance Service and requires the inputting of a password.

Maintenance rates monitoring

This unit is programmed to enable the monitoring of the hours during which the engine works before set maintenance interventions. Only the Technical Assistance Service Personnel can modify the data relating to the hours of the different intervals.
The unit hour counter decreases the data according to the effective working hours and, until negative values are reached, it enables the identification of interventions considerably before the need.
After each maintenance intervention, it is the boat user, or the personnel in charge, that must reset the display of initial data used for the counting.
The list of the number of working hours of the engine/s allowed before maintenance interventions can be displayed using the basic operations described in the sequence of pages which can be opened using the "<<" and ">>" keys.

Figure 23



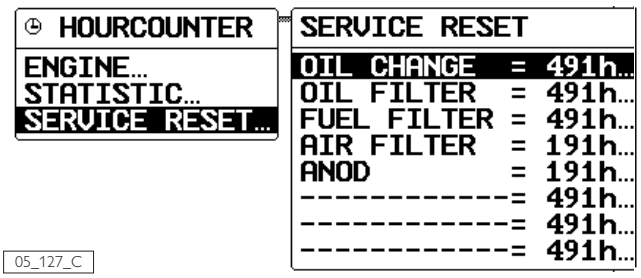
1. Engine working hours indicator - 2. Indicator of the remaining hours before intervention is required.

Maintenance intervals resetting

If one of the listed maintenance interventions has been carried out, to reset the counting data referring to the number of hours after which interventions is required again, do as follows:

- ❏ Press the "MENU" key to display the fast choice windows.
- ❏ Use the "<<" and ">>" keys to select the "DATALOGGER" option inside the window.
- ❏ Press the "OK" key to confirm and display a second window containing the choice options.
- ❏ Select the "HOURCOUNTER" mode by pressing the "<<" and ">> keys.
- ❏ Press the "OK" key to confirm.

Figure 24

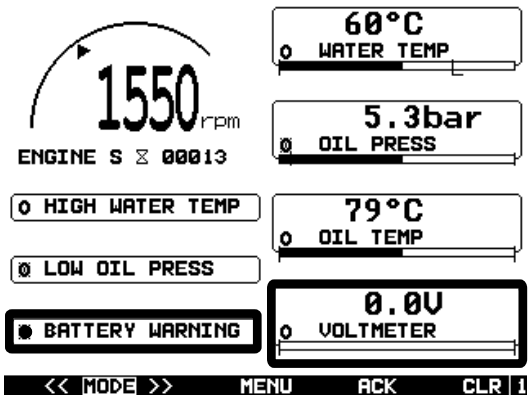


- ❏ Use the "<<" and ">>" keys to select the option "SERVICE RESET", inside the new window.
- ❏ Press the "OK" key to confirm and display the programmed interventions list together with the number of working hours still allowed before the next intervention is required or, if there is a minus sign (-) the hours of delay from the intervention request.
- ❏ Use the "<<" and ">>" keys to highlight the option relating to the intervention which has been finished
- ❏ Press the "OK" key twice consecutively to confirm.
- ❏ Verify that the number of hours shown as a maximum period is displayed. If this is not the case, repeat the last operations of the procedure.

Alarms management

The electronic system carries out in a sequence the verification of all the parameters which must be checked, irrespective of the page shown on the display. Two lower and two higher thresholds are set for each parameter, which respectively refers to the pre-alarm and to the alarm and which sometimes coincide. The programmed thresholds are shown on the bar analogical indicator which relates to the parameter (see the figure). Only the Technical Assistance Service personnel can modify these settings.

Figure 25



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If a parameter value is higher than the set threshold, the acoustic signal is activated and the box representing the indicator is highlighted through a dark flashing border (clear border in the "NIGHT" mode)
Press the "CLR" key to stop the acoustic signal and the border flashing. The border is still displayed. The alarm condition is visually shown until the normal status is reset and the "ACK" key is pressed.

CAUTION

When an alarm signaling occurs, in order to verify that a damage really exists, it might be useful to press the "ACK" key. If the limit has only temporarily been passed, the alarm signaling stops immediately. If the alarm continues it is necessary to carry out the diagnosis of the cause. Once the cause is definitively removed, in order to reset the normal display status, press the "ACK" key.

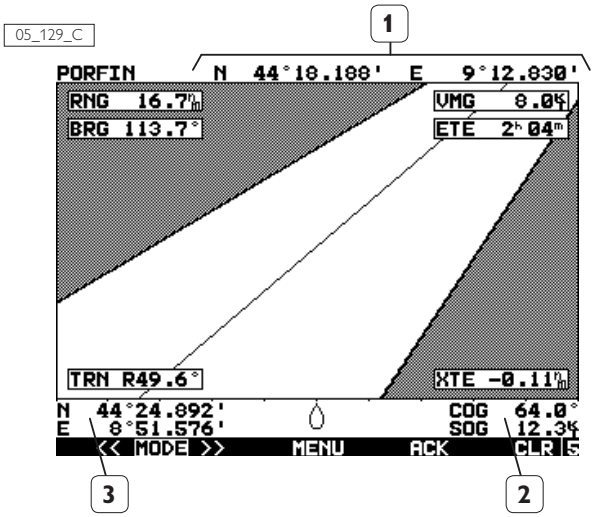
Navigation monitoring

If the interface has been connected with a GPS or self-piloting system (refer to the "JS connectors terminal working" section) which is able to supply navigation data according to the NMEA 0183 protocol, a pointing diagram useful to navigate will be shown among the monitoring pages.

Abbreviations list:
RNG – Distance from the next waypoint
BRG – Direction of the next waypoint
VMG – Real speed at waypoint
ETE – Expected arrival time
TRN – Course direction for waypoint
XTE – Off course mistake

Figure 26

05_129_C

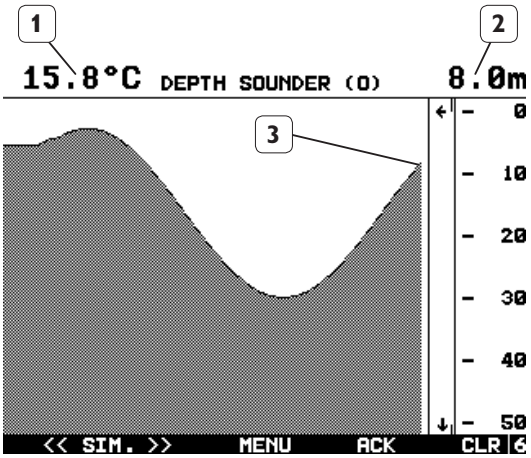


1. Destination (Waypoint) - 2. Course and speed - 3. Position of the moment.

Depth monitoring (Echo sounder)

If the interface has been connected with an echo sounder (refer to the "JS connectors terminal working" section) which is able to supply water depth data according to the NMEA 0183 protocol, a diagram showing the depth evolution and the relating numeric value, including possible temperature, will be shown among the monitoring pages.

Figure 27



1.Water temperature - 2. Depth of the moment - 3. Graphic representation of the sea floor altimetry.

Safety behaviour

In order to guarantee the integrity of the engine and avoid major risks for the crew, The Monitoring Electronic Unit is programmed to cause the automatic stopping of the engine (this operation is carried out through the relay 3 and after connecting the JE connectors).

The following conditions are at the base of the engine automatic stopping:

- Lubrication low oil pressure (LOW OIL PRESS, WA sensor)
- Cooling high water temperature (HIGH WATER TEMP, IA sensor)
- Engine excessive rotation speed (ENGINE S, BA sensor).

SECTION 10

SAFETY REGULATIONS

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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 also inform personnel of the laws in force regulating safety, by making informative documentation available for consultation;
- ❏ Keep working areas as clean as possible, and ensure adequate ventilation;
- ❏ Ensure that working areas are provided with emergency kits. These 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 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 that adhere 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 have exposed flames close to batteries and flammable material;
- ❏ 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 with the engine 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 preventive action 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 or connect electrical connections while the power is connected.

- ❏ Before proceeding with pipeline 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's components, affecting its lifetime;
- ❏ 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's 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 correct operation and lifetime of the engine.

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 fully compromise the engine's warranty of assistance and furthermore may affect the correct operation and lifetime of the engine.

Respecting the Environment

- ❏ Respecting the Environment is of primary importance: all necessary precautions to ensure the personnel's safety and health must be adopted;
- ❏ Be informed and also inform the personnel of laws in force regulating use and exhaust of liquids and engine exhaust oil. Provide for adequate noticeboards and organize specific training courses to ensure that personnel is fully aware of such legal obligations 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 are ventilated, away from heat sources, and not exposed to fire danger;
- ❏ Handle batteries with care, storing them in a ventilated environment and in anti-acid containers. Warning: battery exhalations represent a serious danger of intoxication and environment contamination.

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