

**C78 ENS M20.10**  
**C78 ENT M30.10**  
**C78 ENT M50.11**  
**C78 ENT M55.10**

**TECHNICAL AND REPAIR  
MANUAL**

JUNE 2007 EDITION

TECHNOLOGICAL EXCELLENCE

**IVECO  
MOTORS**



## 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 C78 ENS M20.10, C78 ENT M30.10, C78 ENT M50.11 and C78 ENT M55.10 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 12 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.

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

Printed **P3D32C001 E** - June 2007 Edition

**SECTION CONTENTS**

Section	Page
1. OVERVIEW	5
2. TECHNICAL DATA	35
9. ELECTRICAL EQUIPMENT	41
4. DIAGNOSTICS	67
5. MAINTENANCE	89
6. SERVICING OPERATIONS ON INSTALLED ENGINE	95
7. TOOLS	113
8. OVERHAUL	125
9. C78 ENS M20 ENGINE	199
10. SAFETY SYSTEM FOR HOMOLOGATED INSTALLATIONS	211
11. UPDATING	237
12. SAFETY REGULATIONS	249

**Indications for consultation**

The several engine versions are usually explained with common images and descriptions. In cases of considerable differences, they are explained separately.

The specific characteristics of the C78 ENS M20 engine electric system are described in Section 9.

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.

This manual keeps the original contents unchanged over time. In section 11 there is a chronological list of the modifications and updating which characterizes the normal evolution of the products.

PAGE LEFT INTENTIONALLY BLANK

## SECTION 1

## OVERVIEW

	Page
IDENTIFICATION DATA	7
Identification Tag	7
COMMERCIAL CODE	8
PRODUCT MODEL NUMBER	9
ENGINE PARTS AND COMPONENTS	10
ENGINE ARCHITECTURE	12
COMBUSTION AIR INTAKE AND EXHAUST SYSTEM	14
Air/sea water heat exchanger	15
Combustion air pre-heating	15
Intake and exhaust assembly	15
COOLING FRESH WATER CLOSED LOOP	16
Tube bundle water/water heat exchanger	17
Bypass junction for thermostatic valve	17
SEA WATER OPEN COOLING LOOP	18
Sea water pump	19
ENGINE OIL - LUBRICATION LOOP	20
Gear pump	21
Oil vapor filter	21
Pre-lubrication system (on request)	21
Commutable filters (on request)	21
FUEL LINES	22
Hydraulic schematic diagram	23
INJECTION SYSTEM - EDC	24
EUI electrically controlled pumping injector	25
Electrical and electronic components	28
System functions	30
Reference signals	32

PAGE LEFT INTENTIONALLY BLANK

### IDENTIFICATION DATA

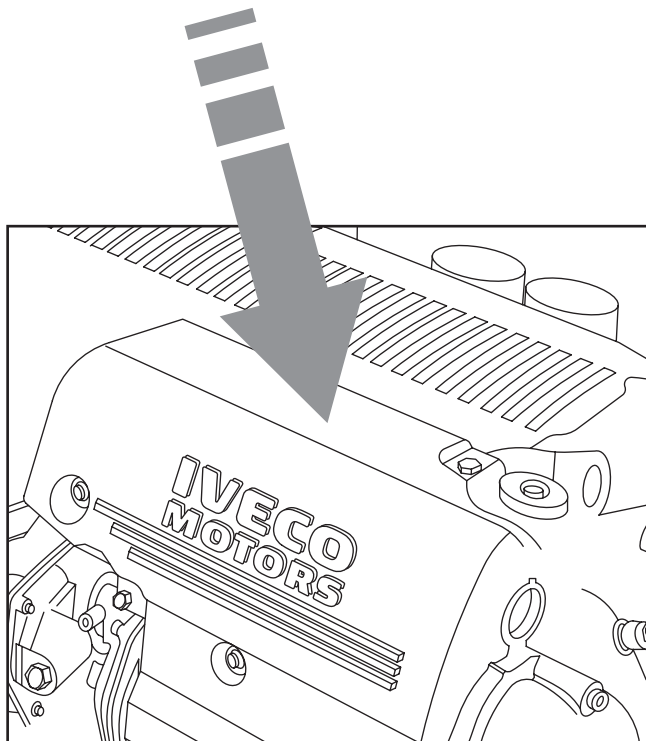
Figure 1

#### Identification Tag

<b>IVECO</b> S. p. A.			
Viale dell'Industria, 15/17 - 20010 Pregnana Mil.se MI - ITALY			
ENGINE TYPE	<input type="text"/>		
ENGINE FAMILY	<input type="text"/>	ENGINE DWG	<input type="text"/>
POWER (KW) AND SPEED (RPM)	<input type="text"/>	POWER SET CODE	<input type="text"/>
ENGINE S/N	<input type="text"/>	YEAR OF BUILD	<input type="text"/>
HOMOLOGATION	<input type="text"/>	N°	<input type="text"/>
COMMERC. TYPE / VERSION		<input type="text"/>	<input type="text"/>

04\_002\_N

Figure 2

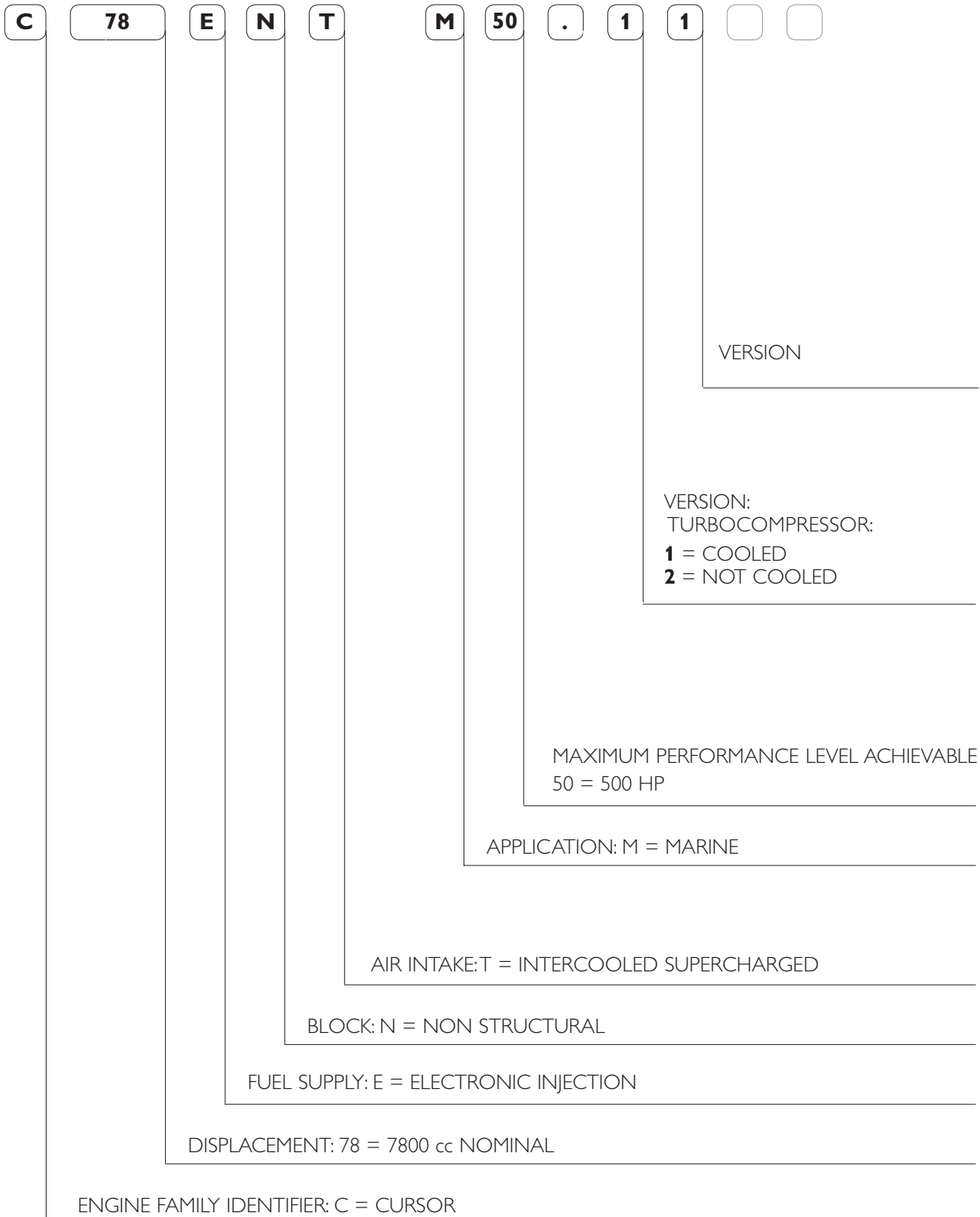


80818

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

**COMMERCIAL CODE**

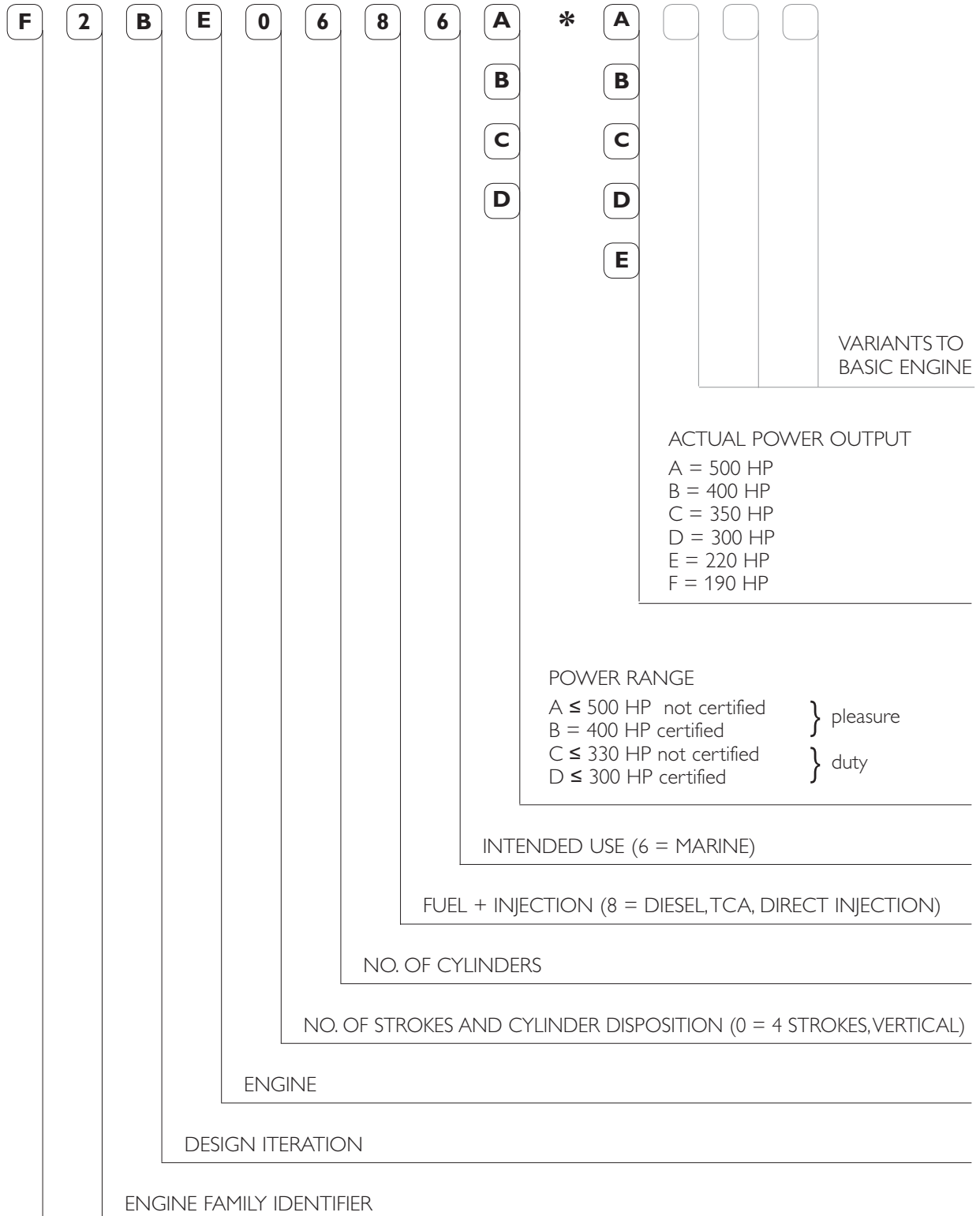
The purpose of the commercial code is to make it easier to understand the characteristics of the product, categorizing the engines according to their family, origins and intended application. The commercial code, therefore, cannot be used for technical purposes and to identify the engine's components,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





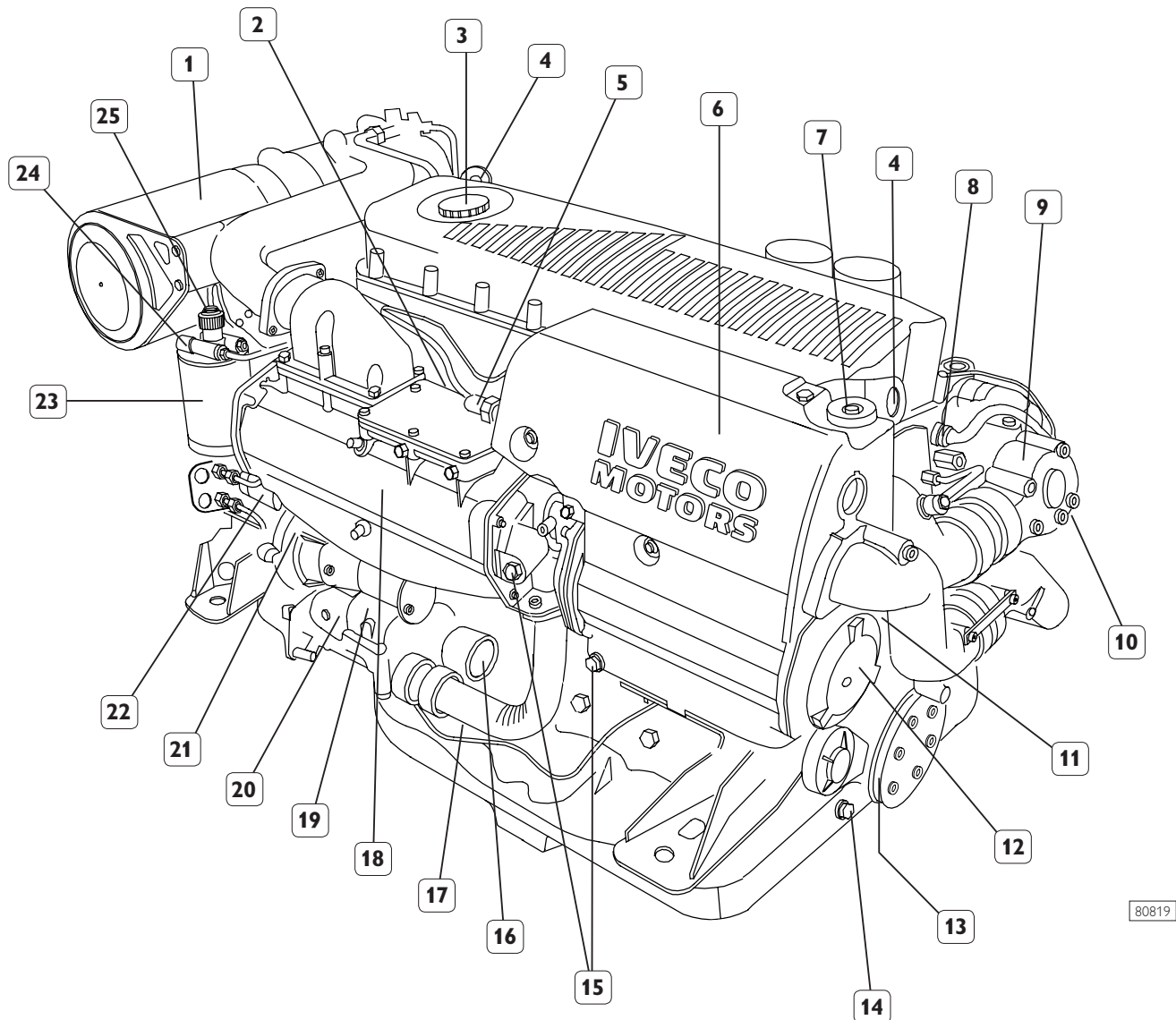
## PRODUCT MODEL NUMBER

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

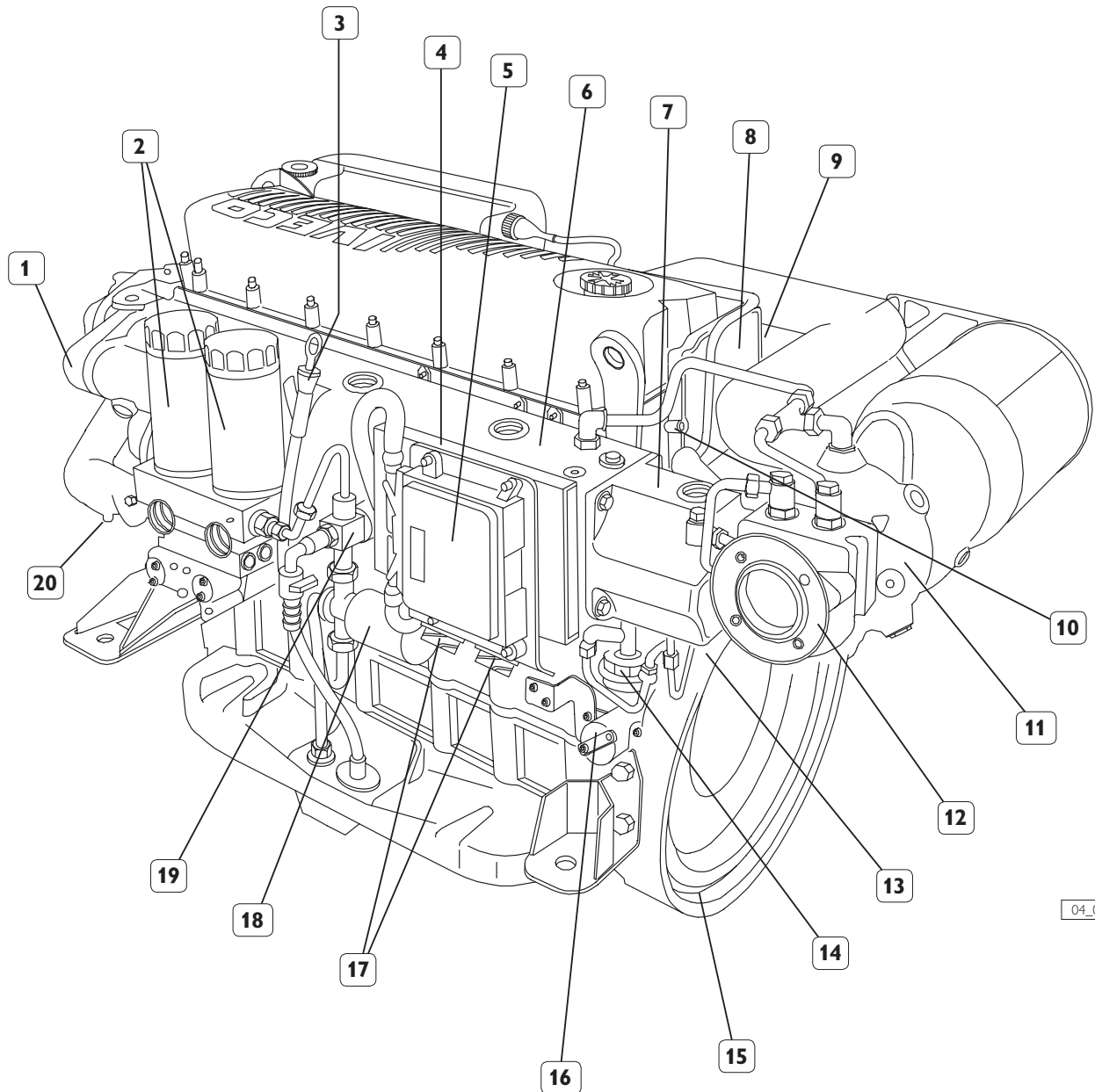
Figure 3



80819

1. Intake air filter - 2. Location of intake air pressure and temperature sensors - 3. Lubricating oil refill cap - 4. Lifting padeyes - 5. Coolant level sensor - 6. Engine coolant tank - 7. Coolant refill cap - 8. Injector solenoid valve connector - 9. Location of thermostatic valve - 10. Cap for engine coolant outlet to sanitary water heating system - 11. Alternator location - 12. Coolant/sea water tube bundle heat exchanger - 13. Auxiliary pulley - 14. Oil drain sump plug - 15. Sacrificial anodes - 16. Sea water intake - 17. Sea water drain plug - 18. Air/sea water heat exchanger (not present on the C78 ENS M20 engine) - 19. Sea water pump - 20. Electrical starter motor - 21. Sea water pump gear - 22. Fuel transfer pump - 23. Fuel filter - 24. Filter clogging sensor - 25. Fuel temperature sensor.

Figure 4

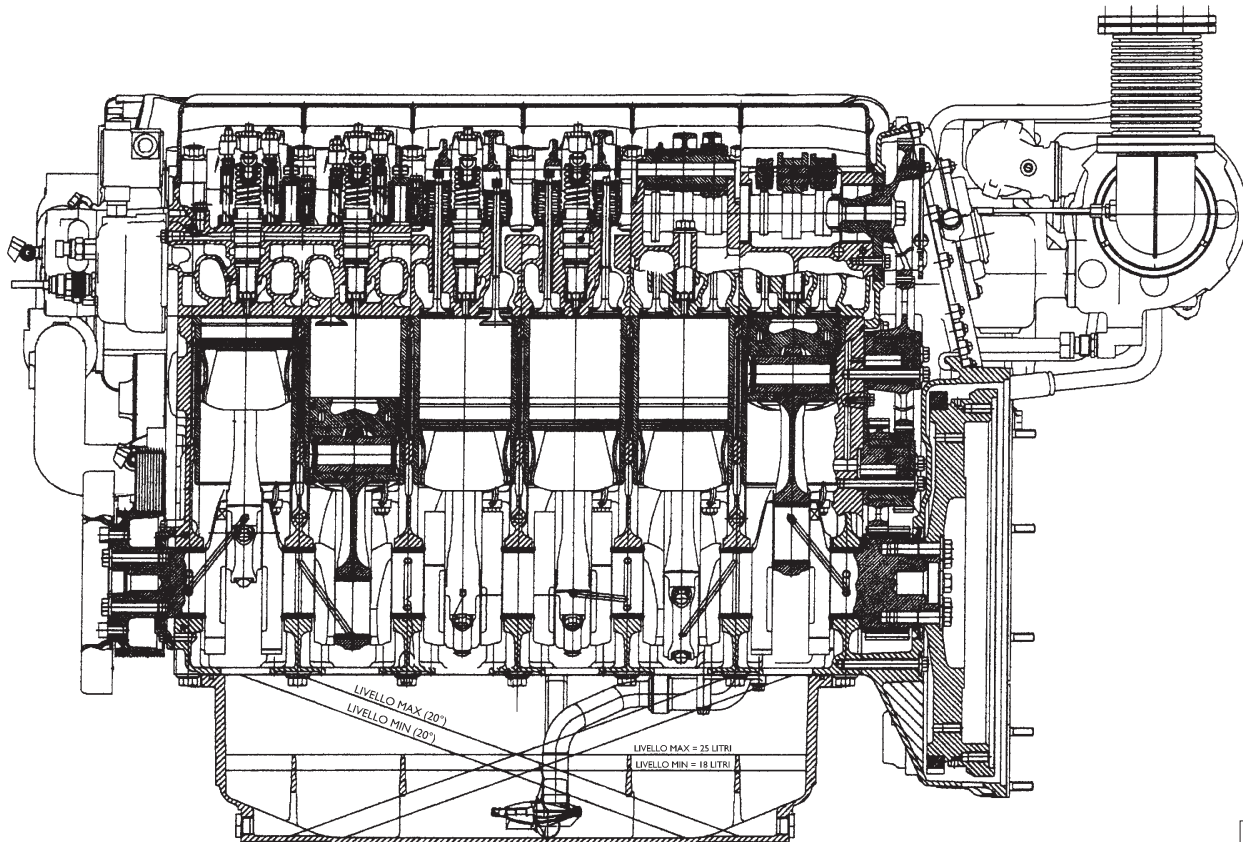


04\_001\_C

1. Coolant feed to exhaust manifold - 2. Lubricating oil filters - 3. Lubricating oil dipstick - 4. Insulated support - 5. Electronic Central Unit - 6. Cooled exhaust manifold - 7. Turbocompressor inlet pipe-fitting - 8. Timing mechanism and oil vapor filter cover - 9. Location of timing phase sensor - 10. Blow-by filter clogging indicator - 11. Cooled turbocompressor - 12. Exhaust gas outlet flange - 13. Phase and engine shaft rotation sensor location - 14. Waste-gate actuator - 15. Timing phase inspection port - 16. Throttle position sensor potentiometer - 17. Electrical equipment wiring connectors - 18. Oil fill-in fill-out/pre-lubrication electrical pump (optional) - 19. Oil fill-in fill-out/pre-lubrication electrical pump solenoid valve (optional) - 20. Cap for engine coolant discharge and recirculation from sanitary water heating system.

## 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.

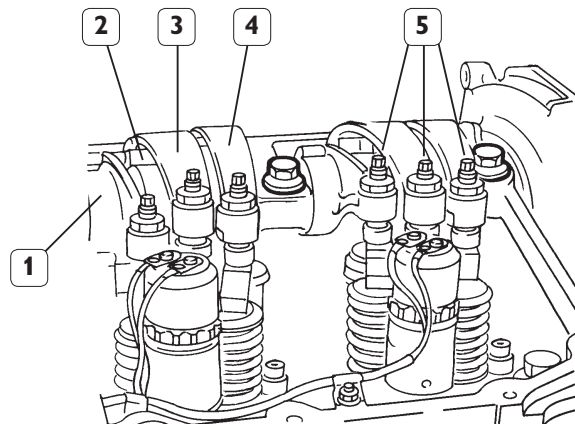
Electronic control extended to all functions ensures reliable and durable operation, offering important benefits in terms of performance and usage.

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.

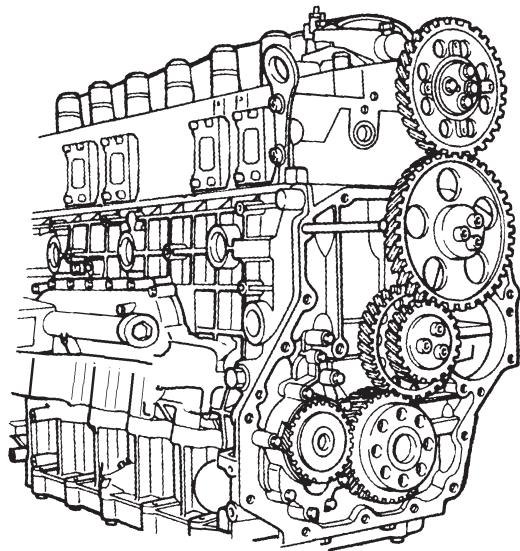
The overhead camshaft with roller rocker arms directly activates both the valves and the EUI (Electrical Unit Injector).

Figure 6



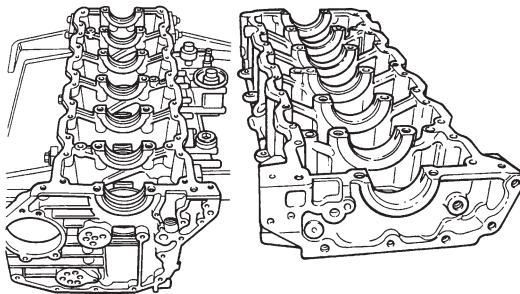
1. Rocker arm shaft -
2. Intake valve rocker arm -
3. Pump injector rocker arm -
4. Exhaust valve rocker arm -
5. Calibration screw.

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.

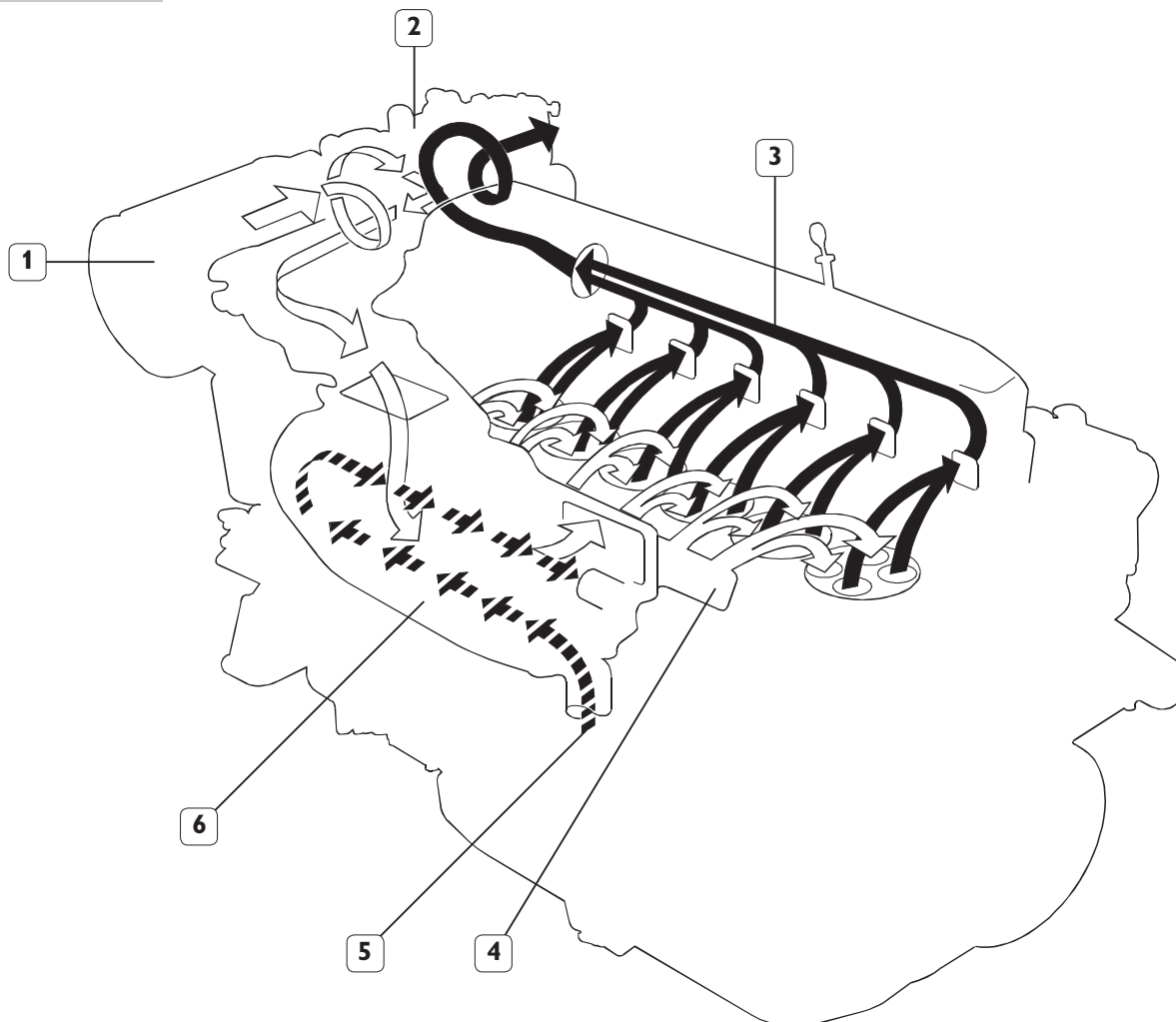
Pump injectors are mounted at the center of the combustion chamber and provide the highest possible thermodynamic efficiency thanks to an injection that is able to reach pressures that exceed 1600 bar. Electrically driven by the electronic control, they deliver fuel at a time that minimizes fuel consumption 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



80826

Intake     
  Exhaust     
  Sea water

1. Metal mesh air filter - 2. Turbocompressor - 3. Exhaust gas manifold - 4. Intake manifold incorporated in cylinder head -  
 5. Sea water inlet from pump - 6. Air/sea water heat exchanger (not present on the C78 ENS M20 engine).

**Description and Operation**

Air, drawn in and compressed by the turbocompressor, flows through the heat exchanger together with sea water. The latter, by reducing temperature, allows an increase in the engine's volumetric efficiency.

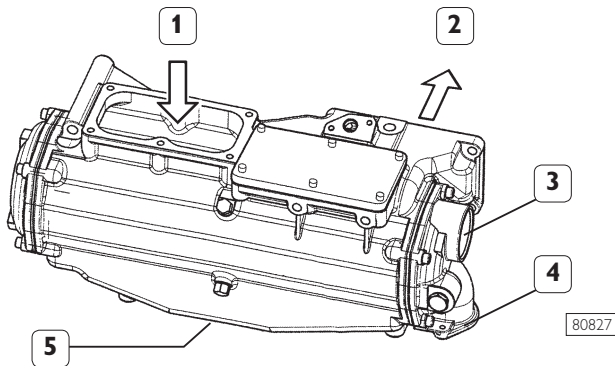
The air density at the inlet of the intake manifold is measured by two sensors, for pressure and temperature, allowing the ECU of the EDC system to calculate fuel dosage relative to the actual quantity of air available for combustion.

Lubricating oil vapors (blow-by) not condensed in the separator, are sent to the engine intake by a gauged hole downstream of the air filter.

Exhaust gas expelled by the engine flows through the cooled exhaust manifold to reach the turbocompressor rotor after traveling through the waste-gate assembly (if present) wherein, depending on the supercharging pressure reached, it may be switched to exhaust - to limit the thrust exerted on the turbocompressor rotor and contain the pressure generated by the compressor within the maximum rated value. Exhaust manifold, waste gate assembly 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

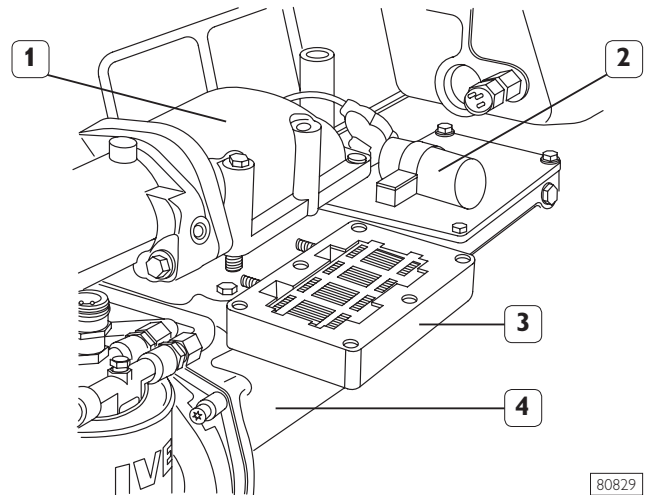
Figure 10



- 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

Figure 12



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

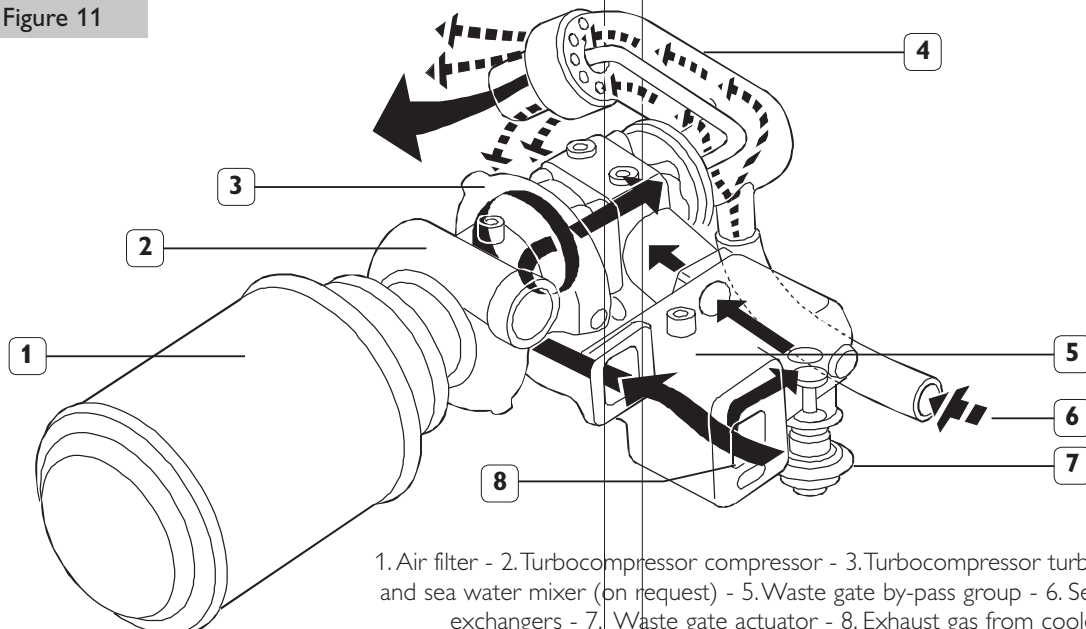
Engine start is guaranteed down to -15 °C without the aid of any pre-heating system. If the engine needs to be used at lower temperatures, there are provisions (on request) for the installation of an electrical heating element driven by the injection system ECU.

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.

### Intake and exhaust assembly

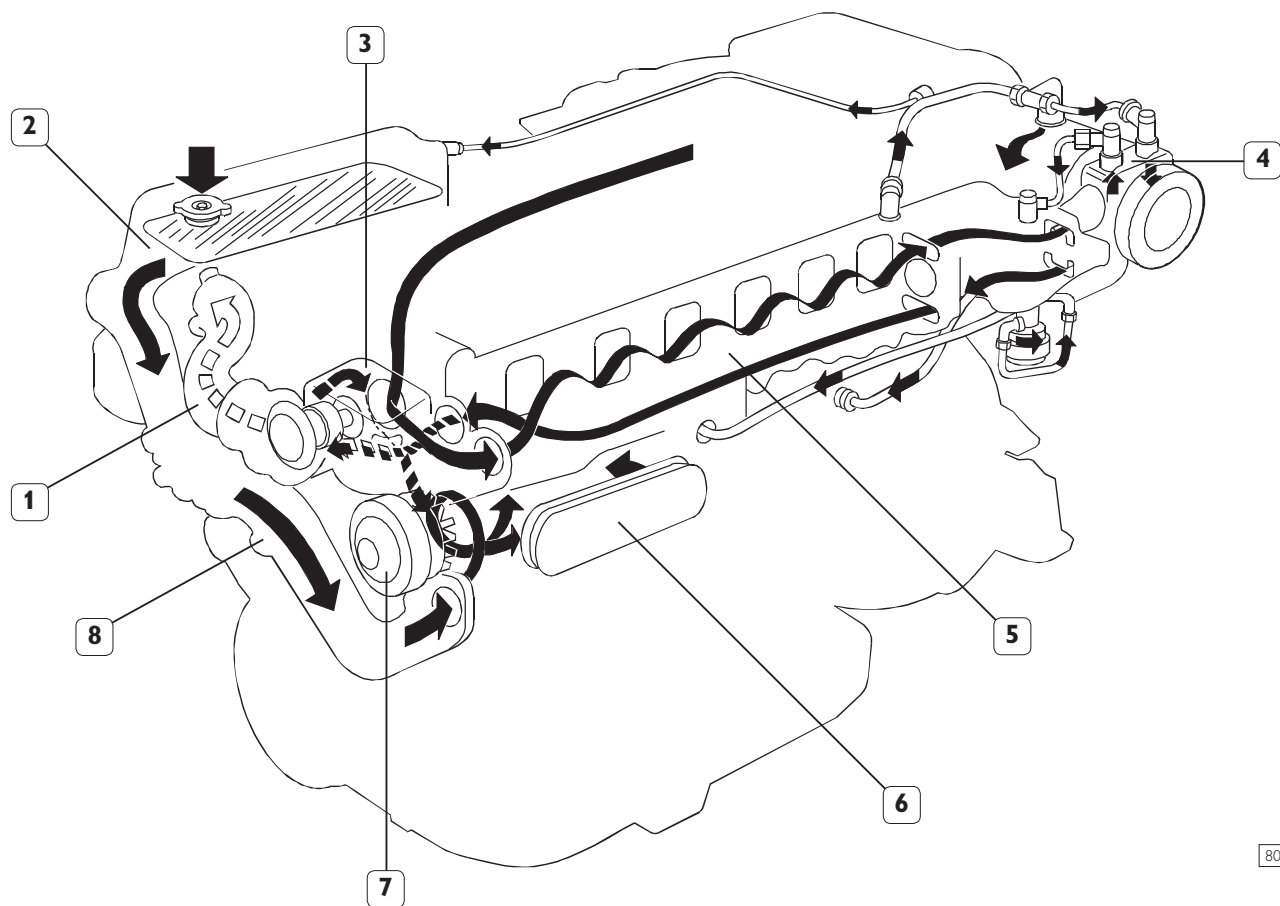
Figure 11



- 1. Air filter - 2. Turbocompressor compressor - 3. Turbocompressor turbine - 4. Exhaust gas and sea water mixer (on request) - 5. Waste gate by-pass group - 6. Sea water from heat exchangers - 7. Waste gate actuator - 8. Exhaust gas from cooled manifold.

**COOLING FRESH WATER CLOSED LOOP**

Figure 13



80830

□□□□ High temperature liquid

■ Low temperature liquid

1. Thermostatic valve/coolant tank junction pipe - 2. Coolant tank incorporated in sea water heat exchanger - 3. Bypass junction for thermostatic valve - 4. Turbocompressor - 5. Cooled exhaust manifold - 6. Engine oil/coolant heat exchanger - 7. Coolant pump - 8. Heat exchanger junction pipe.

**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.

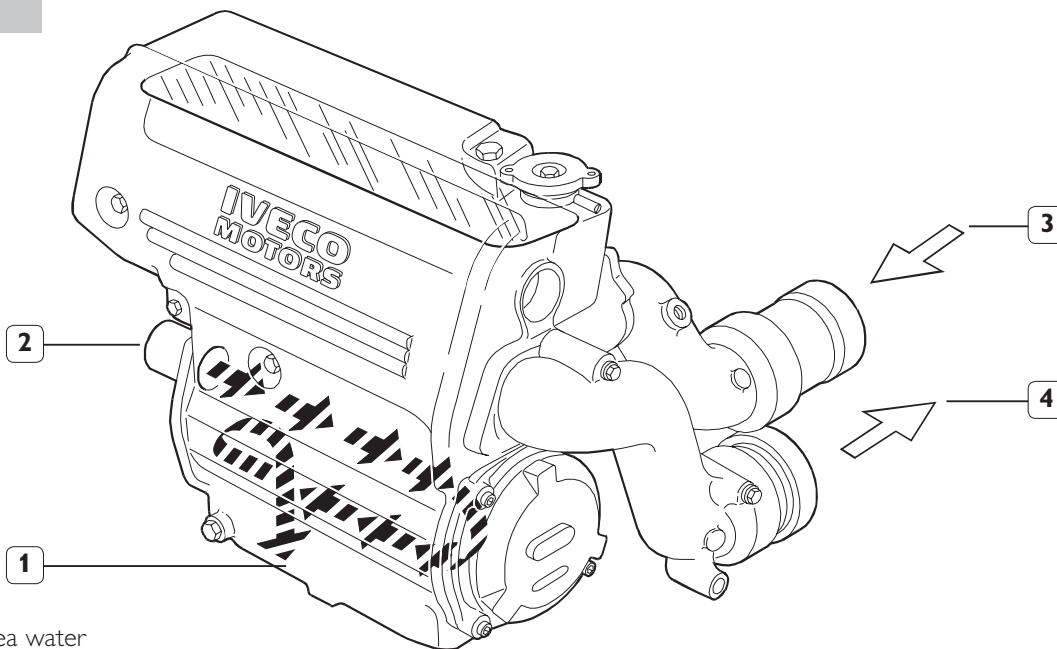
From the bypass fitting the liquid is then injected into the heat exchange chamber of the exhaust manifold - through which it flows going to touch the body of the waste gate, of a portion the exhaust and of the turbo compressor. When it returns into the bypass junction it comes in contact with the wax 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 14



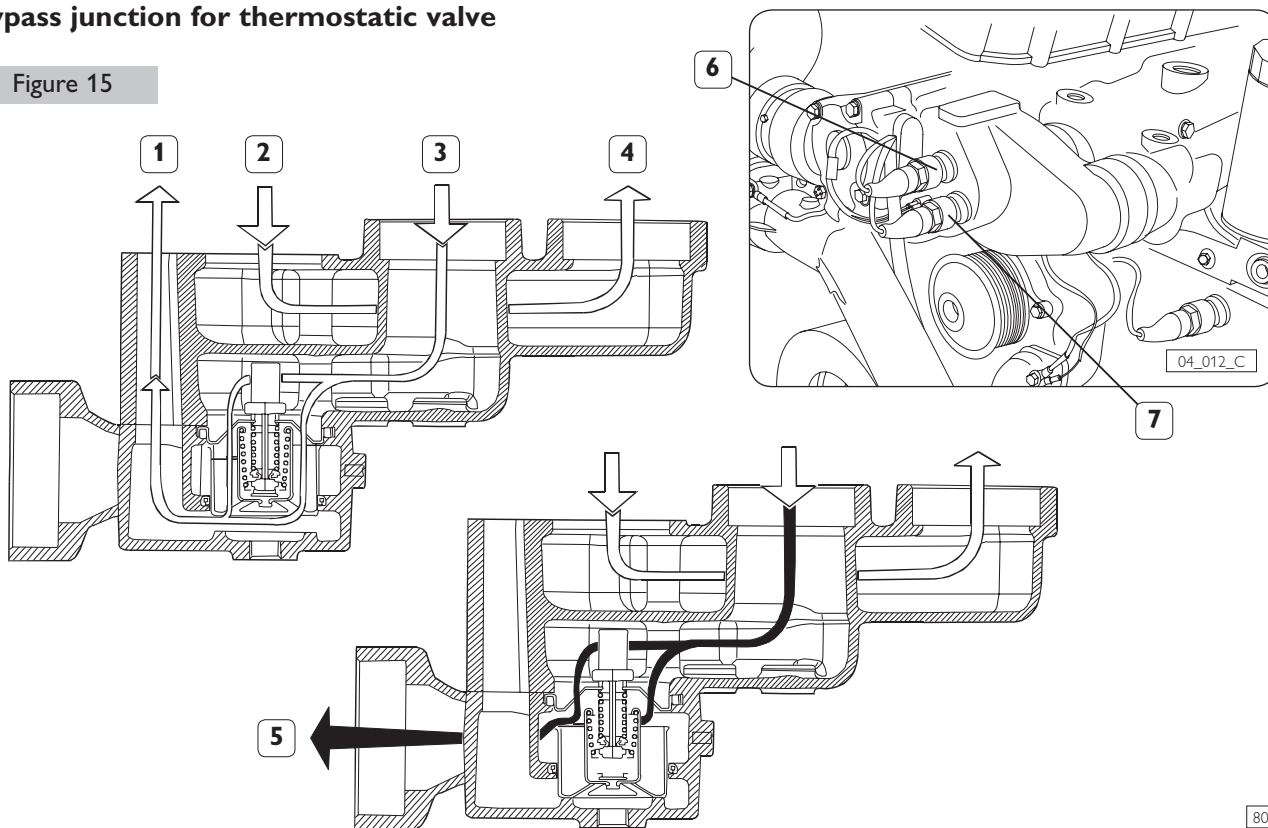
■ ■ ■ ■ Sea water

80831

- 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 15

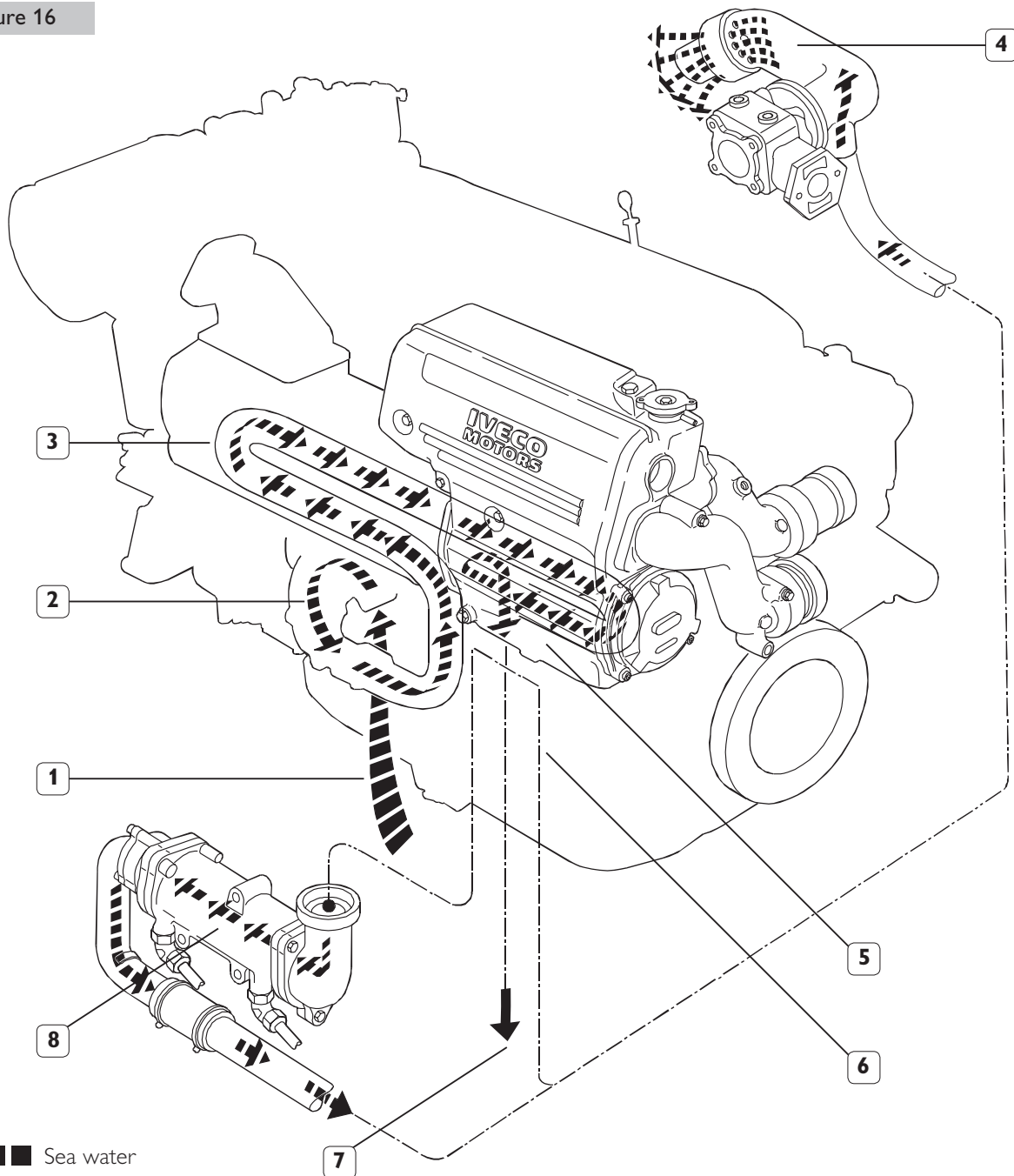


80832

- 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. EDC temperature sensor - 7. Temperature sensor for the control panel and indicators.

## SEA WATER OPEN COOLING LOOP

Figure 16



■■■■ Sea water

80833

1. Sea water suction - 2. Sea water pump - 3. Supercharger air heat exchanger (not present on the C78 ENS M20 engine) -
4. Exhaust gas and sea water mixer (on request) - 5. Coolant (fresh water) heat exchanger - 6. Sea water outlet pipe from heat exchanger for injection into exhaust gas mixer - 7. Sea water outlet from heat exchangers for overboard discharge -
8. Heat exchanger for gearbox oil (on request).

### Description and operation

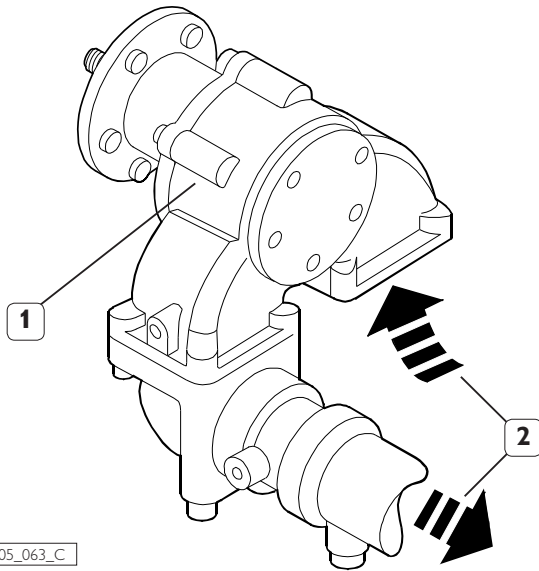
Sea water, drawn from under the keel and necessarily filtered, is drawn by the pump and sent to the supercharger air heat exchanger and from there to the water/water heat exchanger of the closed cooling loop; only after this will it flow through the heat exchanger for the gearbox oil, if one is provided.

The configuration of the discharge lines depends on the choice of a dry "chimney" exhaust, or a mixed one as shown in the figure. 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**

**C78 ENT M30**

Figure 17A



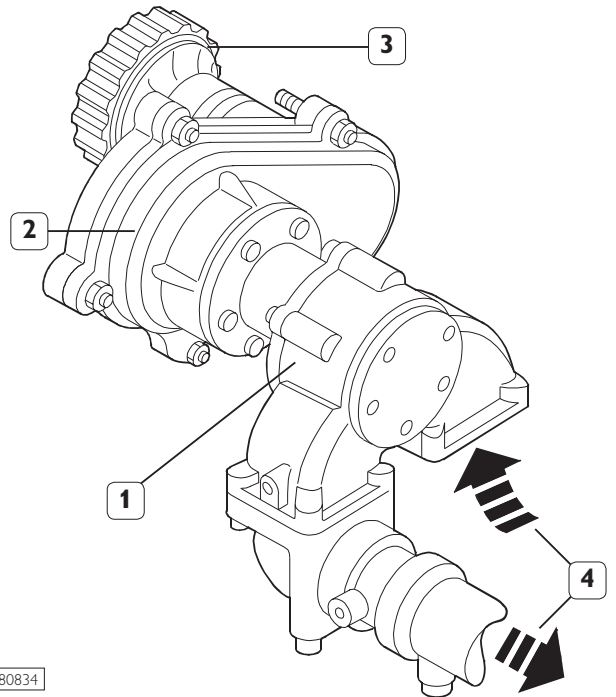
05\_063\_C

- 1. Pump impeller seat -
- 2. Sea water intake and delivery.

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

**C78 ENT M50**

Figure 17B



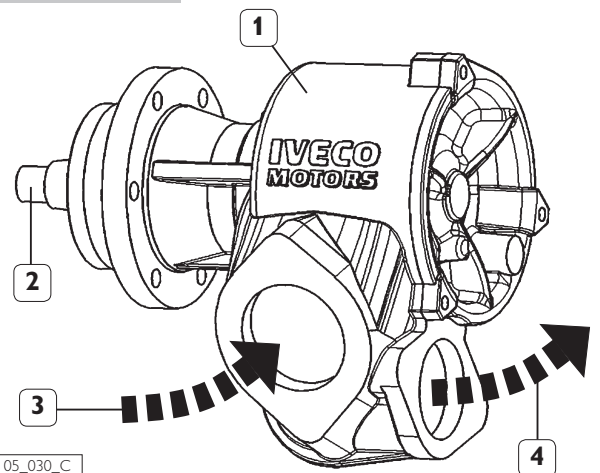
80834

- 1. Pump impeller seat - 2. RPM reducer -
- 3. Driving gearwheel - 4. Sea water intake and delivery.

The sea water pump, of a volumetric kind, is rotated by the gears keyed to the rear of the flywheel; a RPM reducer is interposed to avoid the risk of pump cavitation when at top speed.

**C78 ENT M55**

Figure 17C



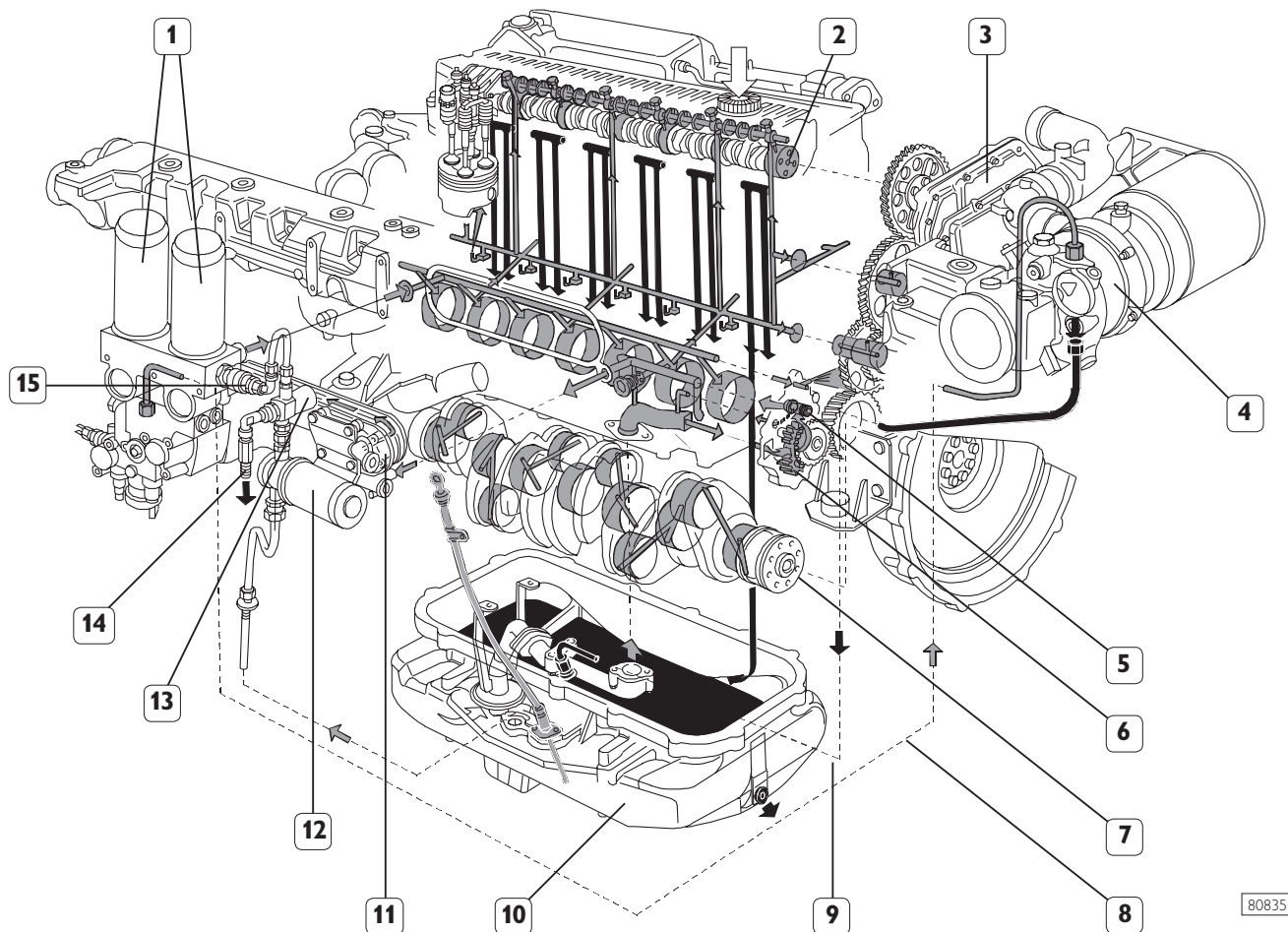
05\_030\_C

- 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 18



80835

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 fly-wheel 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 condenser 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.

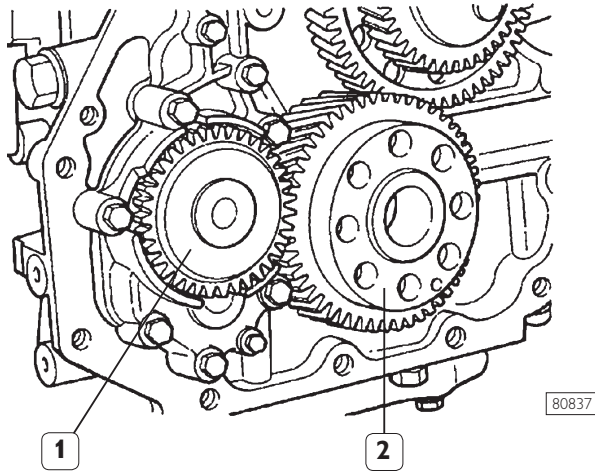
The operation of the electrical pre-lubrication pump (on request), is automatically controlled by the ECU electronic unit.

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

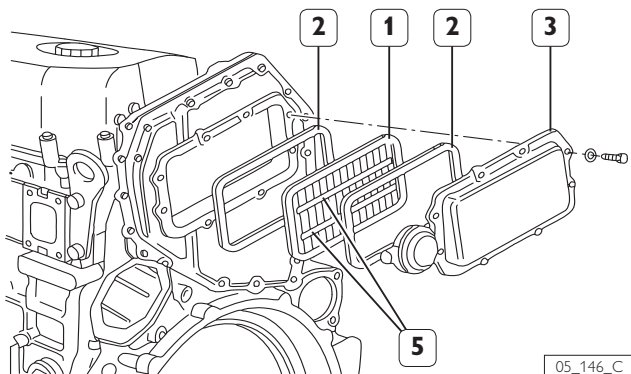
Figure 19



- 1. Gearwheel driving the pump -
- 2. Gearwheel keyed onto the drive shaft.

### Oil vapor filter

Figure 20



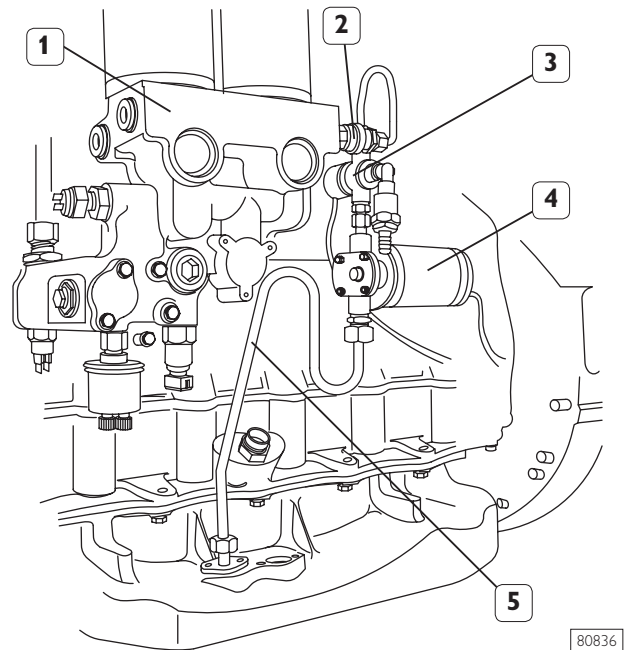
- 1. Oil vapour filter -
- 2. Gaskets -
- 3. Cover -
- 4. Exit of vapour from the motor extraction system -
- 5. Reinforcing bars

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)

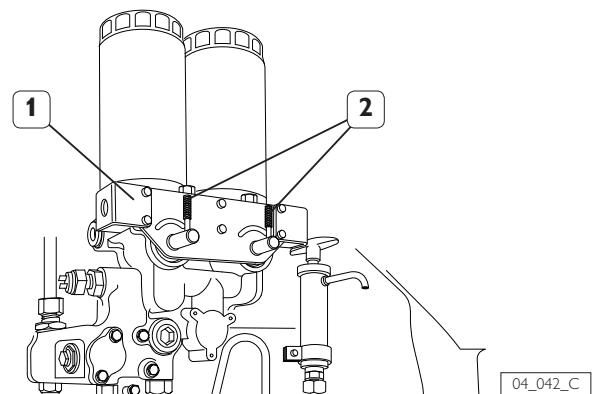
Figure 21



- 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 22

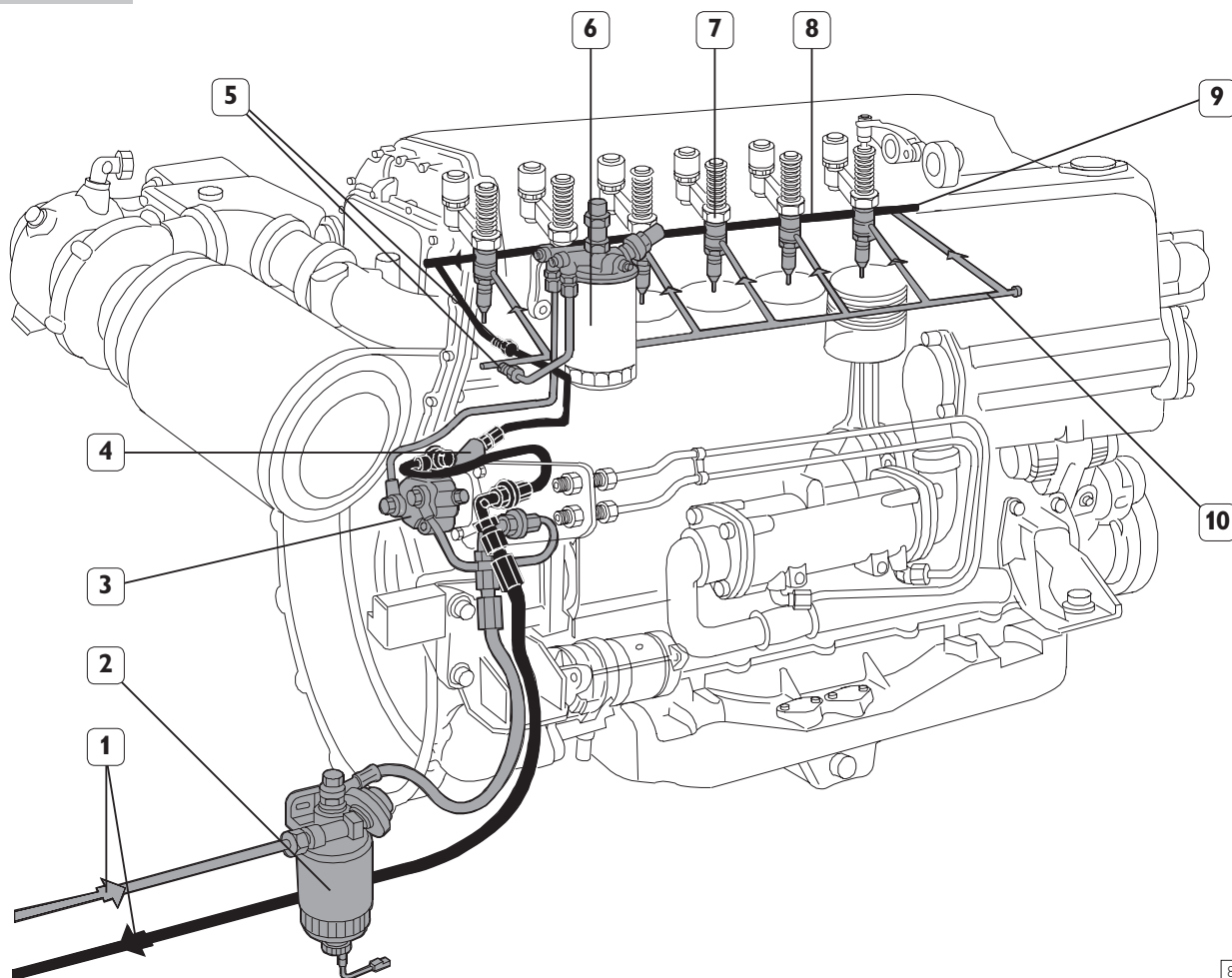


- 1. Commutable oil filters support -
- 2. Filters activation/deactivation levers.

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 23



80839

 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.

## 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. 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

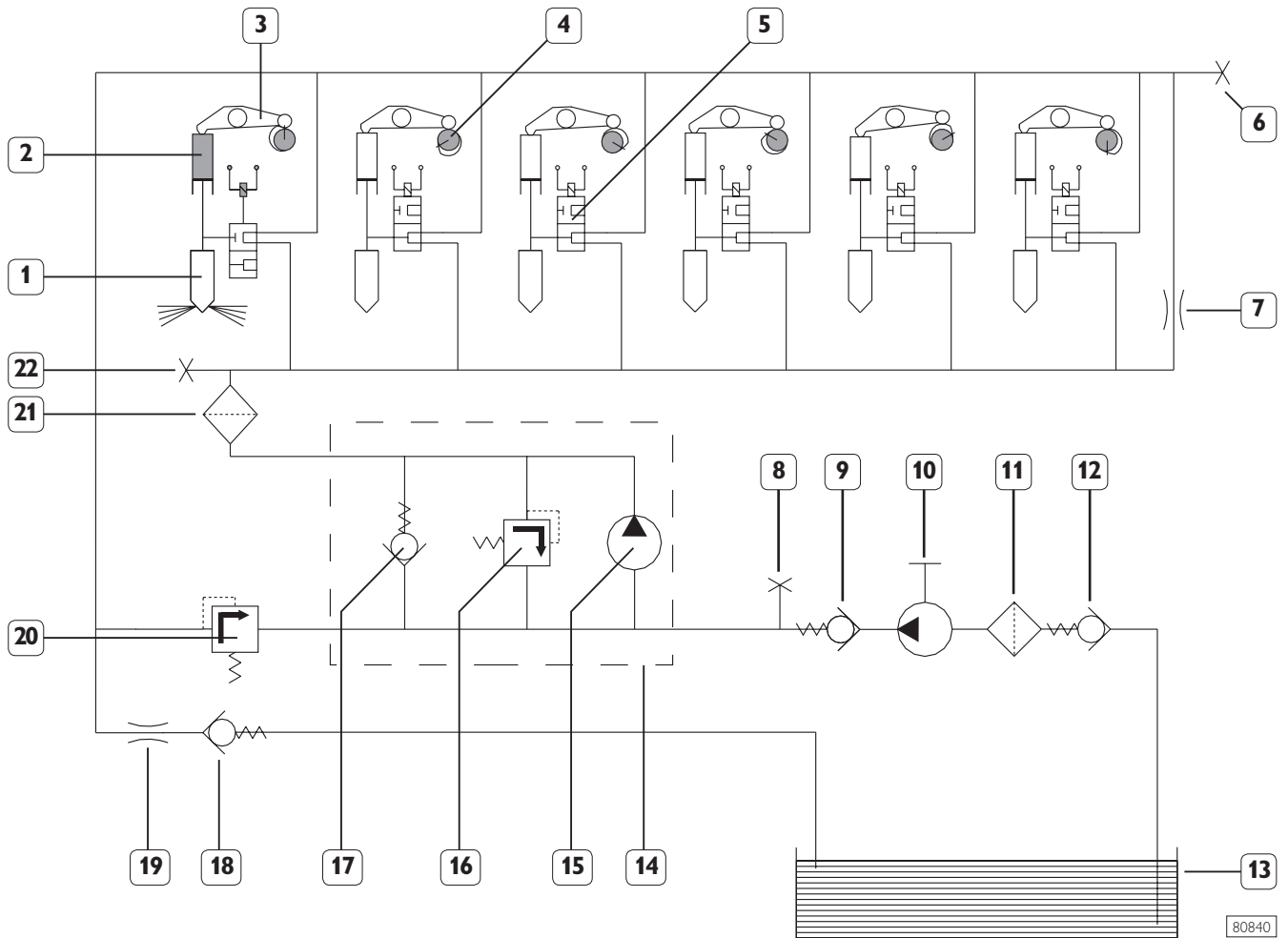
to maintain, within the injector supply loop, the minimum pressure required to fill the injectors. The fuel not reused by the pump returns to the tank via a calibrated hole and a one-way valve to prevent emptying, calibrated to the pressure of 0.2 bar.

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 24

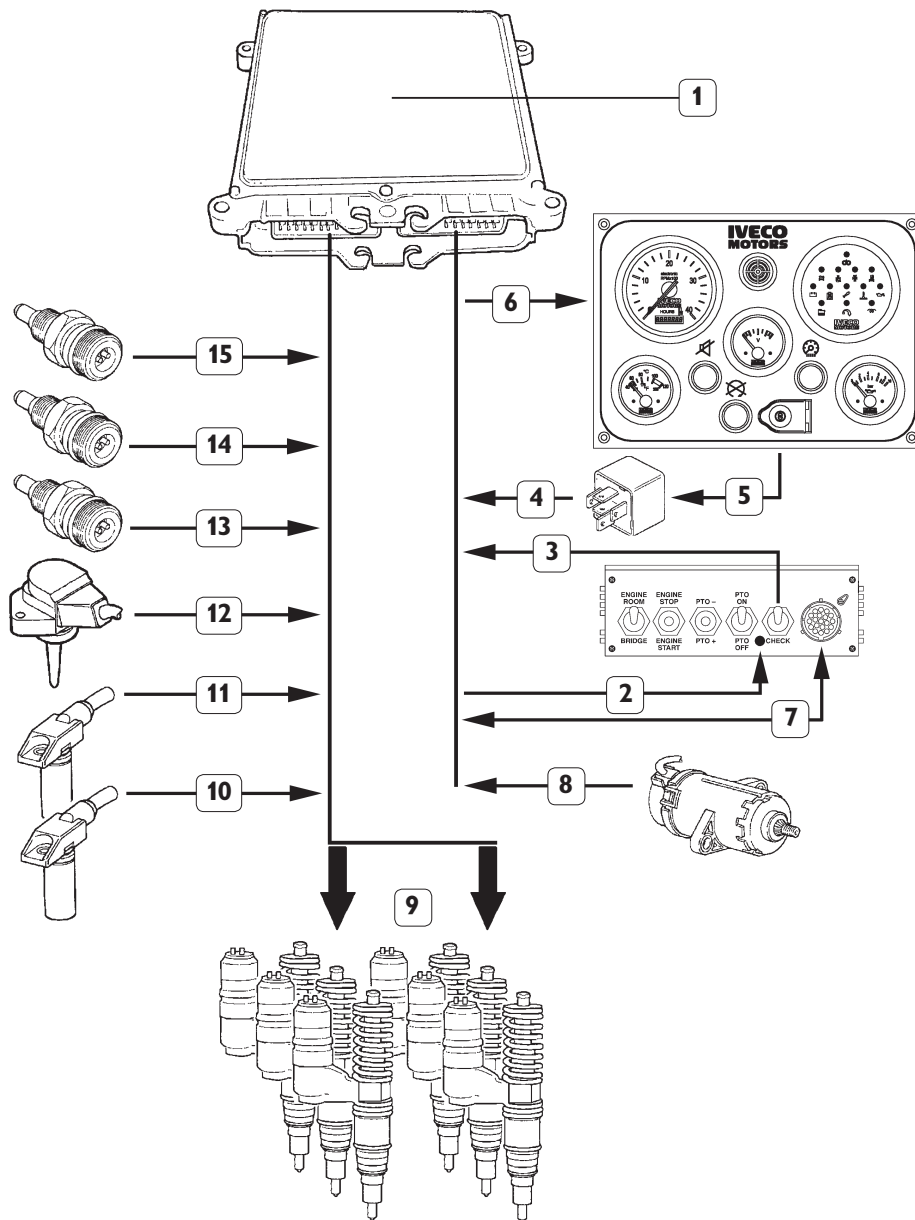


- 1. EUI injector - 2. EUI pumper - 3. Rocker arm - 4. Actuating cam - 5. EUI solenoid valve - 6. Vent fitting on cylinder head - 7. Calibrated hole - 8. Vent fitting on pre-filter - 9. One-way valve - 10. Hand pump - 11. Fuel pre-filter - 12. One-way valve - 13. Fuel filter - 14. Gear pump assembly - 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.

80840

**INJECTION SYSTEM - EDC (Electronic Diesel Control)**

Figure 25



04\_003\_C

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 sensor - 13. Fuel temperature sensor - 14. Engine coolant temperature sensor - 15. Combustion air temperature sensor.

CURSORS engines are equipped with the modern MS 6.2 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 1600 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.

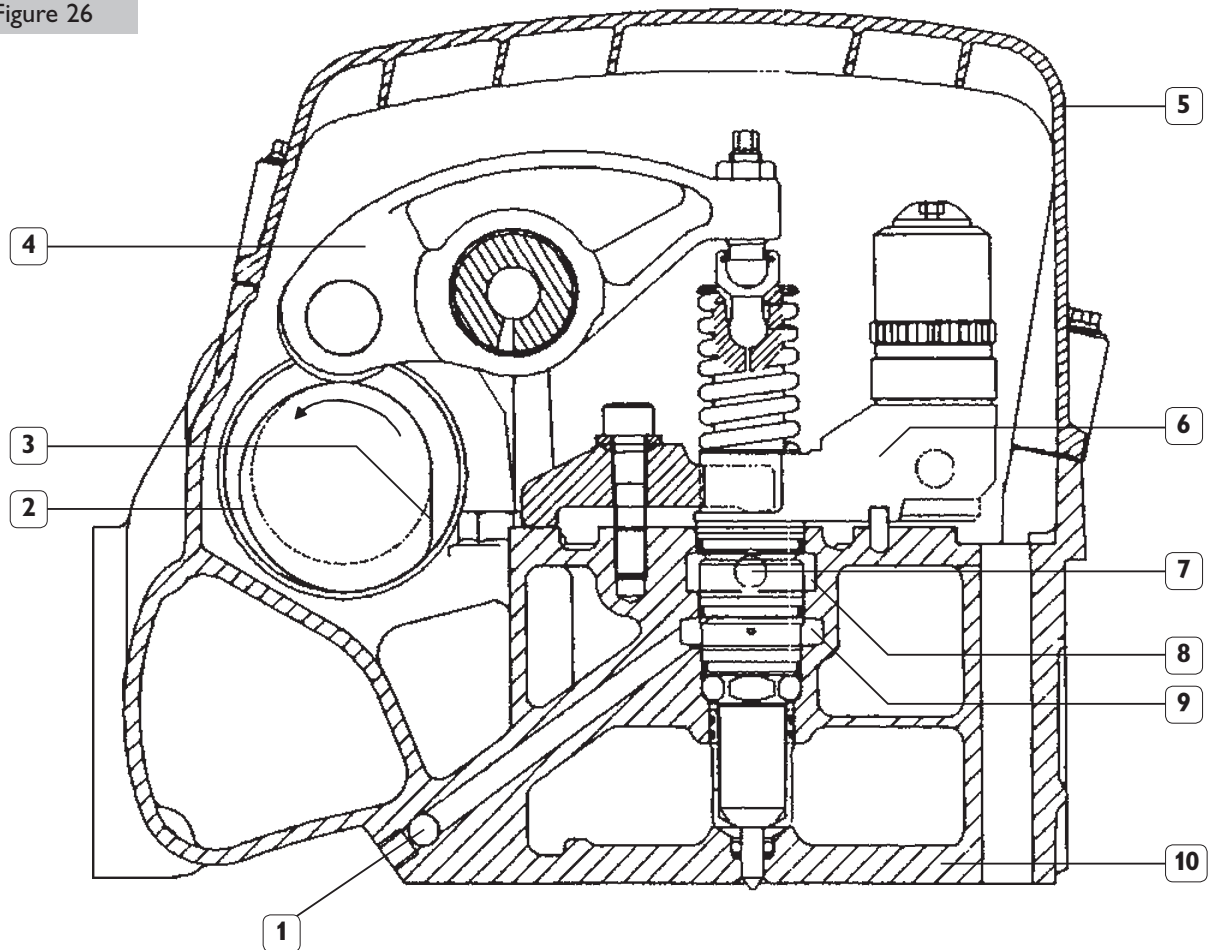
An overall improvement in performance was achieved by the availability of considerably higher injection pressures than

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 26



80847

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.

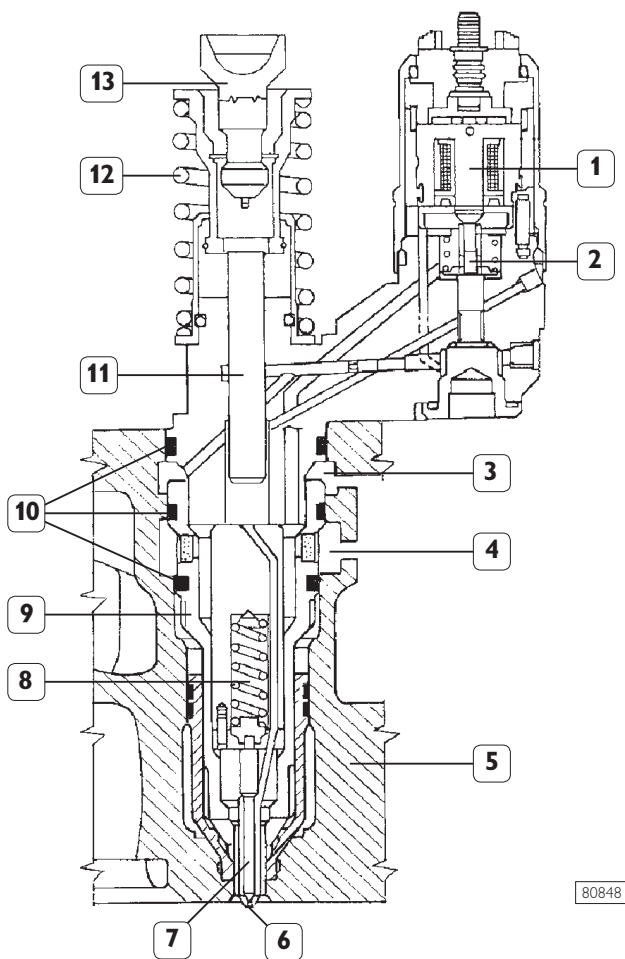
### Operation

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 27



1. Solenoid valve - 2. Shutter - 3. Exhaust chamber in the cylinder head. - 4. Supply chamber in the cylinder head. - 5. Cylinder head - 6. Spray nozzle - 7. Nozzle needle - 8. Calibration spring - 9. Nozzle housing - 10. Sealing rings - 11. Pumper - 12. Pumper return spring - 13. 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.

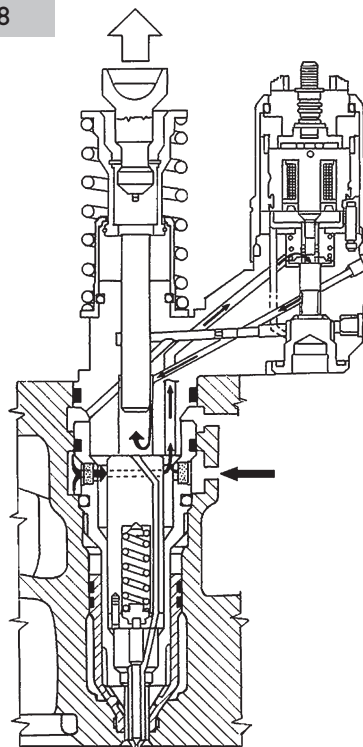
### Delivery characteristic

This term is used to indicate the ratio between driving times and fuel quantities delivered. The delivery characteristic is a non linear function with tight tolerances, typical of any injector family, and is the basis for the injection data stored in the ECU: the "dimensioned plans".

For better engine operation efficiency and for the precision required when controlling the fuel supply system, it is imperative to use certified injectors which comply with the prescribed delivery characteristics, i.e. similar to those used to determine the "dimensioned plans" of the injection times stored in the ECU.

### Filling

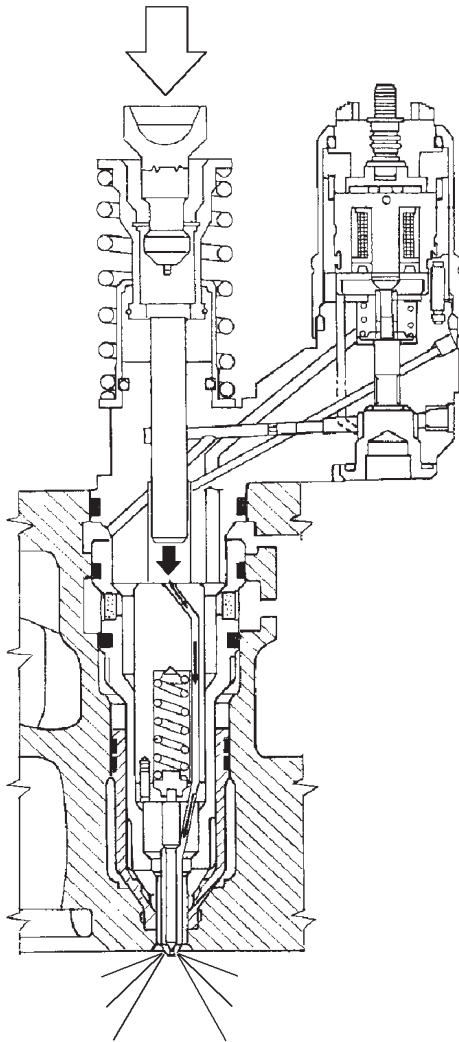
Figure 28



During the pumper return stroke, with the solenoid valve de-energized, the shutter is in a resting position and allows the low pressure fuel to flow through channels inside the injector to saturate the pumping chamber.

## Injection start

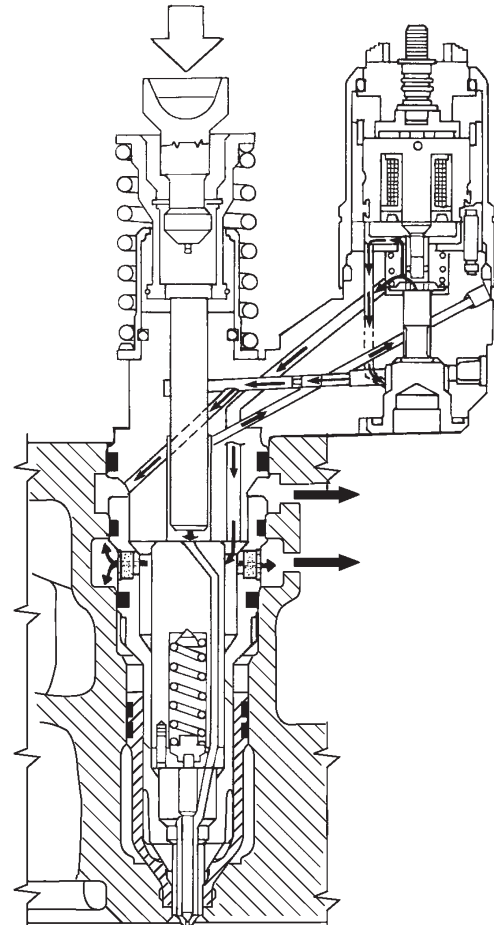
Figure 29



The pumper, thrust by the rocker arm, starts the downward stroke. Since the solenoid valve is de-energized, there is no injection effect because the fuel exits the pumping chamber through the shutter seat, returning to the supply and exhaust chambers. When the solenoid valve is energized, the shutter closes the pumping chamber output, allowing pressure to rise in the chamber. Once the pressure exceeds the value of the calibration spring, the nozzle needle lifts, starting injection.

## Injection end

Figure 30



Once the solenoid valve ceases to be electrically driven, the shutter returns to the resting position, allowing the pressurized fuel to flow out towards the inflow and exhaust channels. The consequent pressure drop causes the calibrated spring to prevail and the nozzle needle returns to the position where it closes the injection holes; injection ends.

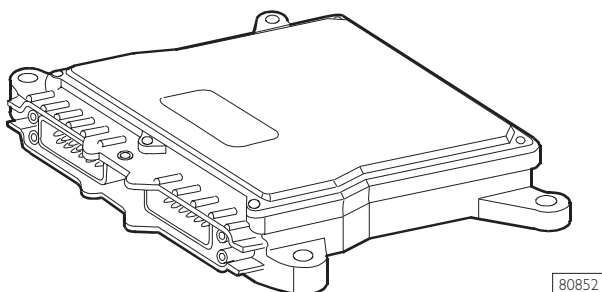
**Washing and cooling**

During the resting phases as well as during injection, the fuel that flows from the transfer pump to the supply conduits is made to circulate in the channels of the injector, to cool its inner parts and cause the fuel not injected and overheated during compression to flow out rapidly to the exhaust chamber. Raising the pressure beyond 1600 bar causes considerable heating in the fuel oil, generating conditions that favor its vaporization. Washing and cooling are therefore necessary to avoid forming vapor pockets in the fuel which could hamper delivery of the correct quantity of fuel oil, with a consequent irregular operation of the engine.

## Electrical and electronic components

### Electronic Central Unit

Figure 31



80852

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<sup>2</sup>PROM 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.

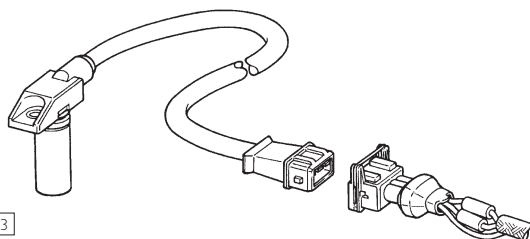
When processing is completed, the final injection data, still in digital format, is transferred to the several final and power stages that will drive appropriately the solenoid valves of the injectors and the other actuators.

### 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 32



80853

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.

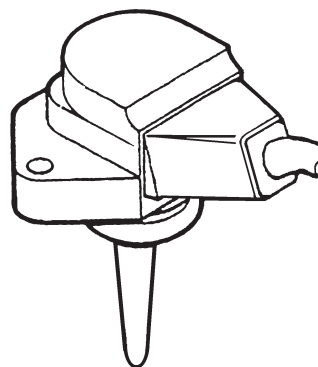
Six equidistant projections provide signals of the succession of the phases in the 6 cylinders; the seventh projection provides the synchronisation signals that allow detection of the typical injection sequence:

**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 sensor

Figure 33



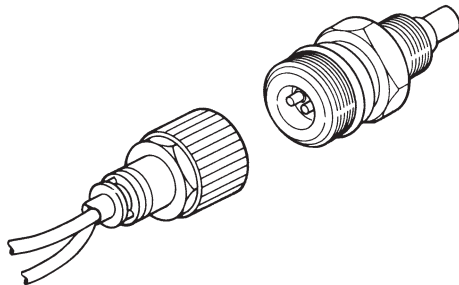
80854

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.

### Combustion air temperature sensor

Figure 34



This has a resistor with a negative temperature coefficient and is positioned on the intake pipe near the pressure sensor. This provides, together with the pressure data, an indication of intake or supercharged air density - to arrive, with the additional information of engine RPM, at the identification of the air mass available for combustion.

#### Fuel temperature sensor

A negative temperature coefficient resistor, like the previous sensor. 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 ones, located on the junction where the thermostatic valve is positioned.

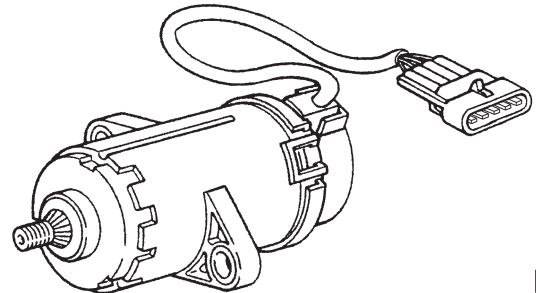
It provides the information needed to control injection metering and advance in the different phases of the engine's operation:

- 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 35



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 12*

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 consistency 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 or the flashing of the "blink code" light.

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.

#### De-rating

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.

It is implemented proportionally to risk severity, upon recognizing temperatures above 75 °C for fuel or 105 °C for the coolant.

#### 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.

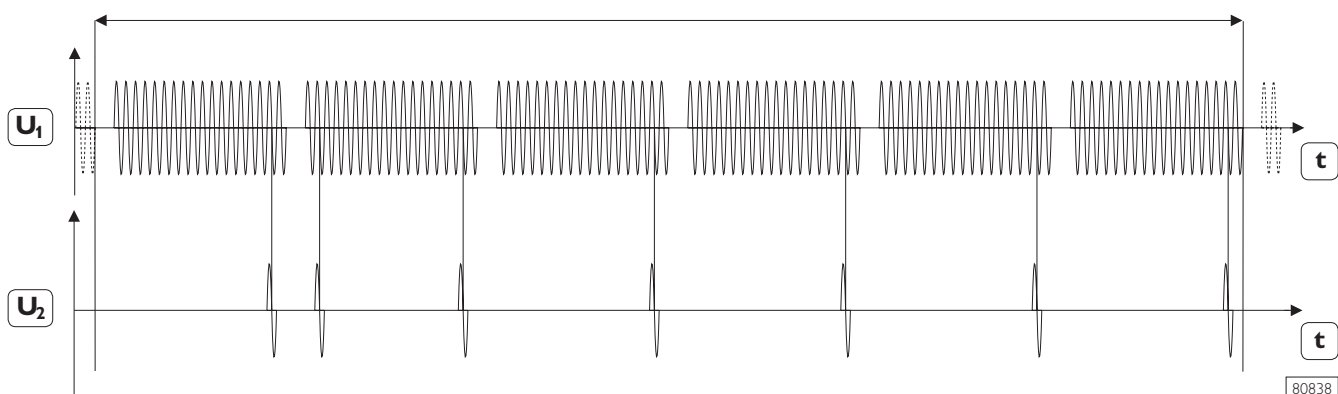
The compared analysis of the flywheel and timing signals allows the ECU's software to recognize the different phase of each piston in the pair and its exact position in the thermodynamic cycle, enabling selective management of injection functions in "cylinder by cylinder" mode.

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 36



U<sub>1</sub>. Profile of the voltage of the FLYWHEEL sensor signal

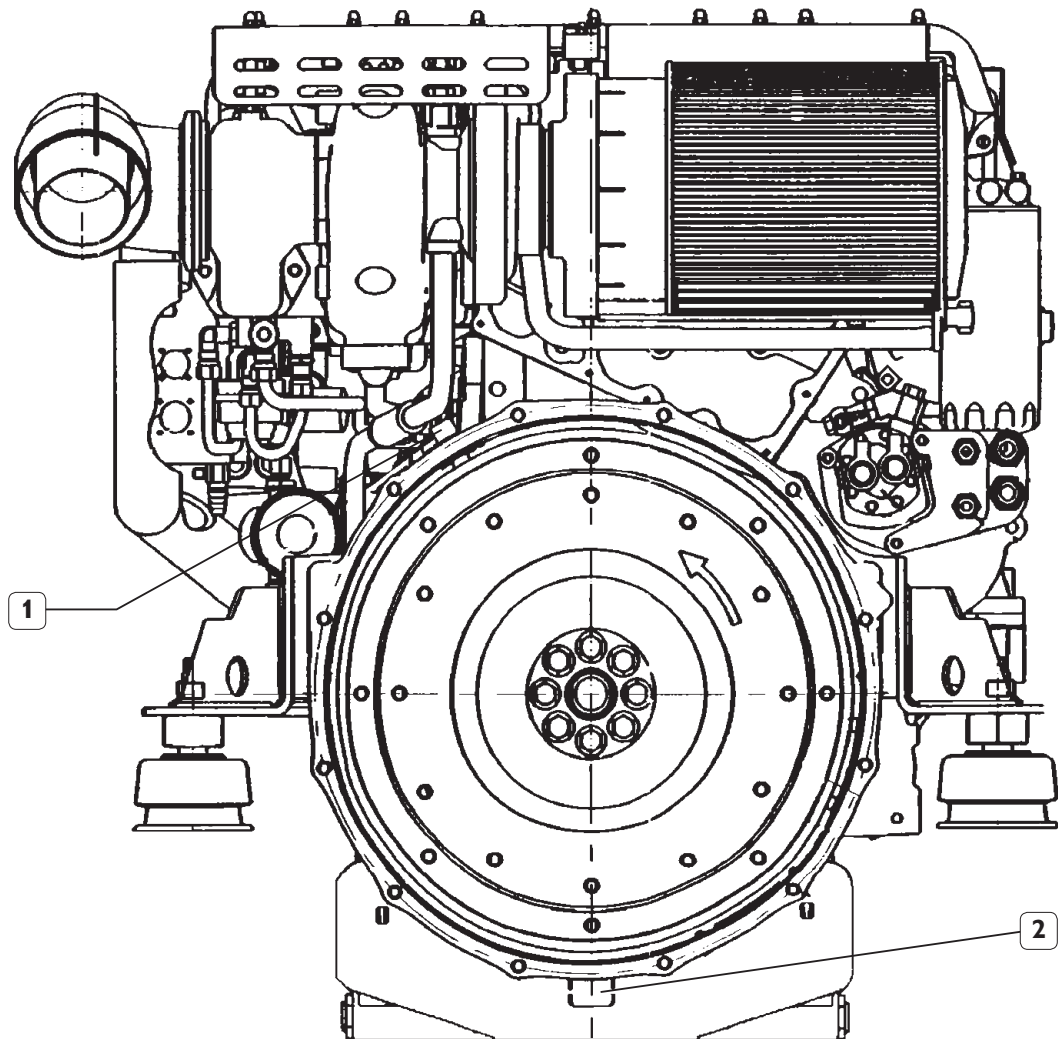
U<sub>2</sub>. Profile of the voltage of the timing CAM sensor signal



### 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 37



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

80844

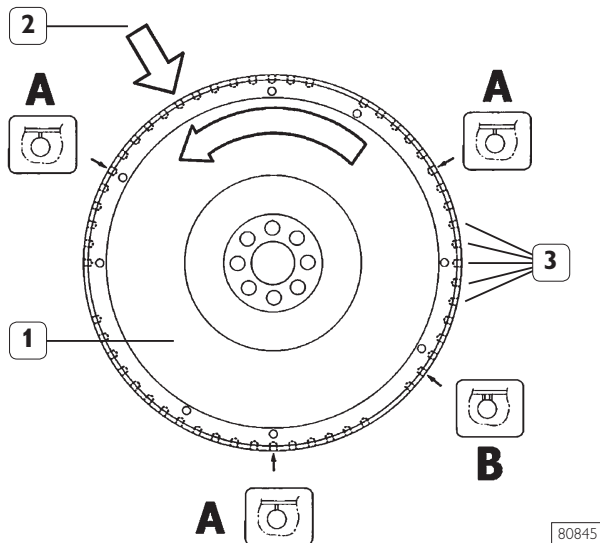
Three series of 18 holes, 6° apart from each other, alternate with an absence of 2 holes every 120° - to enable the sensor to generate pulses for zeroing the count.

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 38



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.

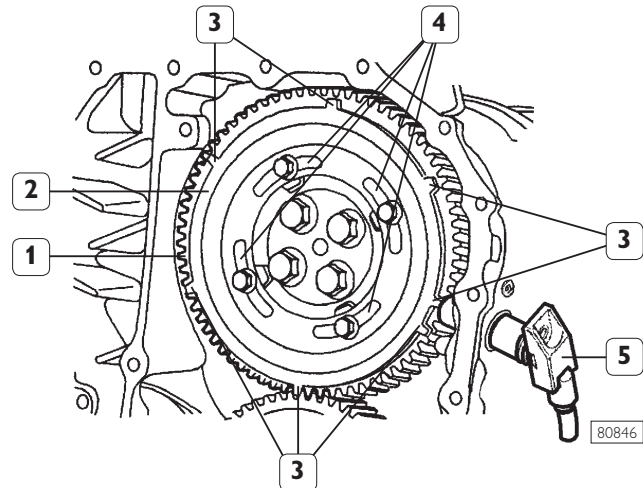
This figure shows the position and characteristics of these references, visible through the inspection hole drilled in the lower part of the flywheel case. If for a particular installation this hole should not be accessible, a specific tune-up procedure will have to be followed, as described in the "diagnostics" 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 39



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

	Page
SPECIFICATIONS	37
Dimensions	39

PAGE LEFT INTENTIONALLY BLANK

## SPECIFICATIONS

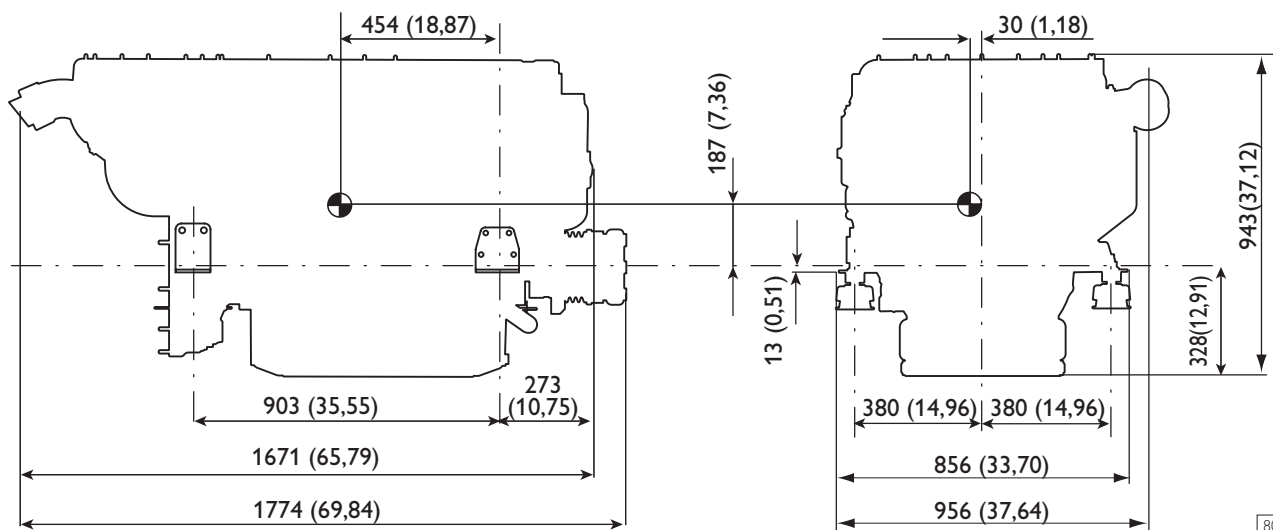
Engine		C78 ENT M30	C78 ENT M50	C78 ENT M55
Cycle		4-Stroke Diesel		
Charge		Supercharged and intercooled		
Injection		Direct		
Number of cylinders		6 in line		
Bore	mm	115		
Stroke	mm	125		
Total displacement	cm <sup>3</sup>	7790		
Compression ratio		16,5 ± 0,8 to 1	16 ± 0,8 to 1	16 ± 0,8 to 1
Direction of rotation, flywheel side		counterclockwise		
Minimum idling rpm	rpm	600 ± 25		
Maximum engine rpm, no load	rpm	2160 ± 25	2800 ± 25	2800 ± 25
<b>Allowed engine inclination angles</b>				
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°		
<b>Supercharge</b>				
Turbocompressor with water-cooled body		KKK K27	KKK K31	HX 55WM
Pressure regulation		-	with separated waste-gate	with integrated waste-gate
Waste-gate maximum opening pressure	bar	-	2,0 ± 0,1	2,6 ± 0,1
<b>Lubrication</b>				
Oil	type	SAE 15 W 40/E 3		
Oil compliant with specifications		ACEA E3/API CF4/MIL L2104E/F		
Total oil capacity on first filling	liters (kg)	31 (28)		
Total oil capacity with sump at minimum level	liters (kg)	18 (16,3)		
Total oil capacity with sump at top level	liters (kg)	25 (22,7)		
Oil pressure, warm engine, minimum idling rpm	bar	≥ 1,5		
Oil pressure, warm engine, maximum rpm	bar	≥ 5		
Maximum allowed temperature	°C	105		
Oil dipstick valid for static inclination	degrees/360	0 to +10°		
<b>Fuel supply</b>				
Fuel oil compliant with standard		EN 590		
Low pressure transfer pump		gear pump		
Flow rate at maximum rpm	kg/h	68	88	88
Fuel return flow rate to tank	kg/h	≤ 12		
Filtering: pre filter	µm	36,5		
Filtering: filter	µm	5		

Engine		C78 ENT M30	C78 ENT M50	C78 ENT M55
<b>Injection system</b>				
Type		pump - injectors (EUI)		
System		Bosch EDC MS 6.2		
Maximum injection pressure	bar	1600		
<b>Low temperature starting</b>				
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		
<b>Cooling</b>				
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	~ 40		
Engine-only capacity	liters	~ 15,5		
Expansion tank		standard		
Forced circulation		centrifugal pump		
Flow rate at maximum rpm	l/h	18900	25200	25200
Temperature regulation		with thermostatic valve		
Initial opening	°C	68 ± 2		
Sea water line	°C	78 ± 2		
Sea water line		forced circulation		
Sea water pump		volumetric self-priming with neoprene impeller	centrifugal self-priming	
Max. pump capacity	l/h	15500	17500	20000
<b>Exhaust gas expulsion</b>				
Optional		stack		
Optional		riser		
<b>Electrical system</b>				
Nominal voltage	Vcc	24		
Self-regulated alternator:				
Voltage	Vcc	29		
Maximum current intensity	A	90		
Electrical starter motor:				
Nominal voltage	V	24		
Absorbed electrical power	W	4500		
Recommended batteries capacity	Ah	≥ 120		
Current discharge at - 18 °C (SAE J 537)	A	≥ 900		

Engine		C78 ENT M30	C78 ENT M50	C78 ENT M55
<b>Drive train coupling</b>				
Flywheel diameter	mm (inches)		355 (14)	
Flywheel case	type		SAE 1	
<b>Weights</b>				
Without liquids and without gearbox	kg	900	910	910

**Dimensions**

Figure 1



80821

PAGE LEFT INTENTIONALLY BLANK



## SECTION 3

## ELECTRICAL EQUIPMENT

	Page
OVERVIEW	43
SYNOPSIS	44
WIRE HARNESS	45
LOCATION OF ELECTRICAL COMPONENTS ON ENGINE	46
POWER SUPPLY LINE	48
ALTERNATOR	49
ELECTRICAL STARTER MOTOR	50
RELAY BOX	51
Relays contained in the relay box	51
RPM control	51
Diagnosis connector J1	51
RELAY BOX CONNECTORS	52
CONNECTIONS OF THE CENTRAL ELECTRONIC UNIT (ECU)	52
ECU connector removal and insertion	52
Identification of terminal functions	53
EUI SOLENOID VALVE CONNECTOR	54
Through-bulkhead E connector	54
OPTIONAL EQUIPMENT	55
Lubricating oil transfer module	55
Pre-lubrication and oil transfer module	55
Pre-lubrication system	55
Low temperature starting aid	55
EQUIPOTENTIAL CONNECTIONS TO ENGINE GROUND	56

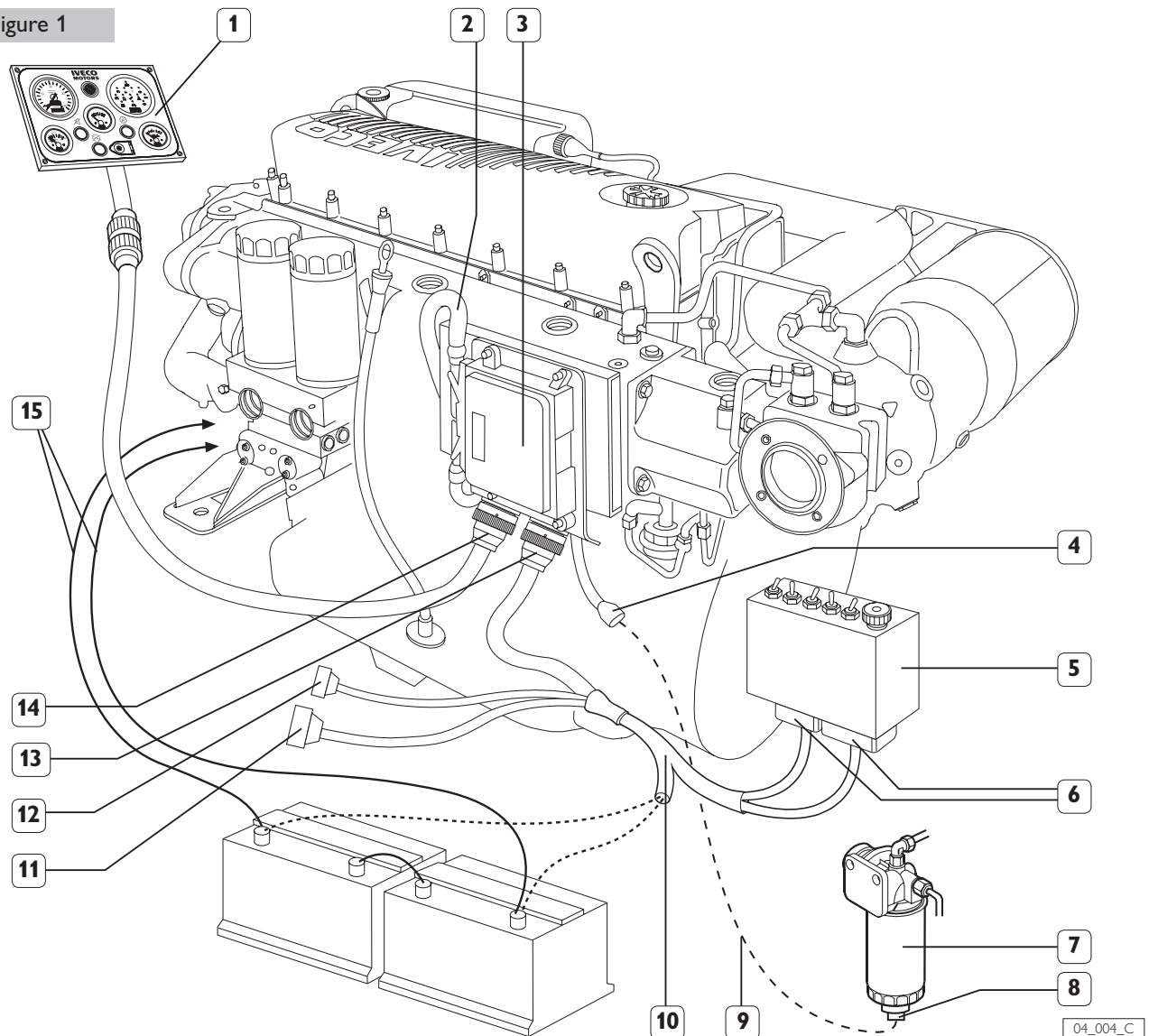
(cont.)

## Page

WIRING DIAGRAM	57
Wiring diagram key	57
Electrical equipment component code	58
EDC connector B	60
EDC connector A	61
Main analog instrument panel	62
Secondary analog instrument panel	63
CAN - BUS converter module interface wiring	64
Supplementary services battery recharge	65

## OVERVIEW

Figure 1



1. Instrument panel - 2. Engine wiring - 3. Electronic Central Unit - 4. M Connector - 5. Relay box - 6. JF and JF1 connectors - 7. Sedimenting pre-filter - 8. Sensor for presence of water in the fuel - 9. Wiring harness to be manufactured by the yard - 10. Interface and power supply wire harness - 11. JG connector for prelubricating system - 12. JE Connector for certified installations by classification Bodies - 13. JA Connection - 14. JB Connection - 15. Power line for electric starter motor and alternator.

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, 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 "C78

ENS M20 - C78 ENT M30-M50-M55 Installation Directive" document.

### CAUTION

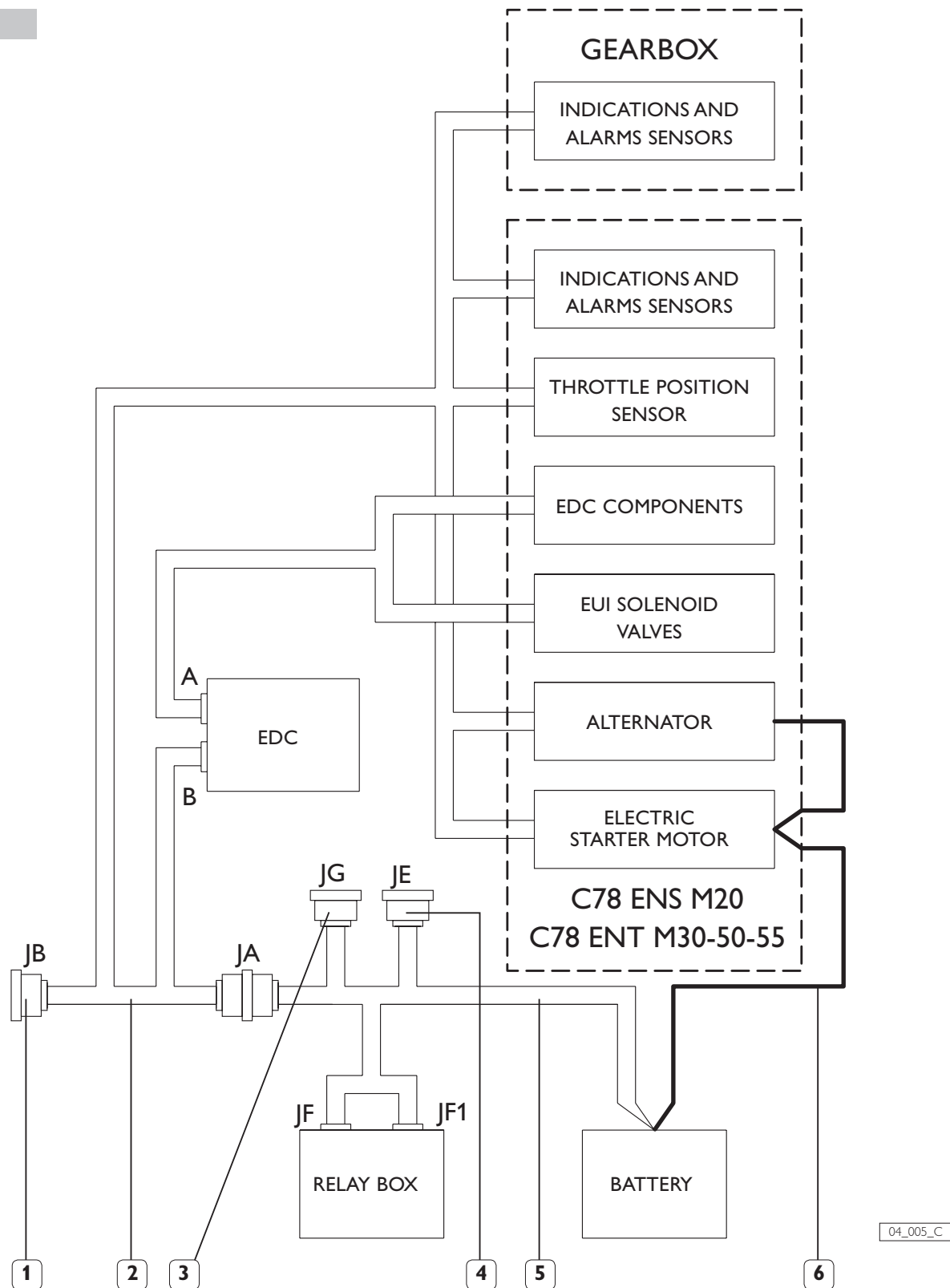
**Never use the wiring of the engine equipment to power any other electrical appliance of the boat.**

Information related to analogue and digital control panel and relative sensors is included in the "C78 ENS M20 - C78 ENT M30-M50-M55 Installation Directive" document.

04\_004\_C

## SYNOPSIS

Figure 2

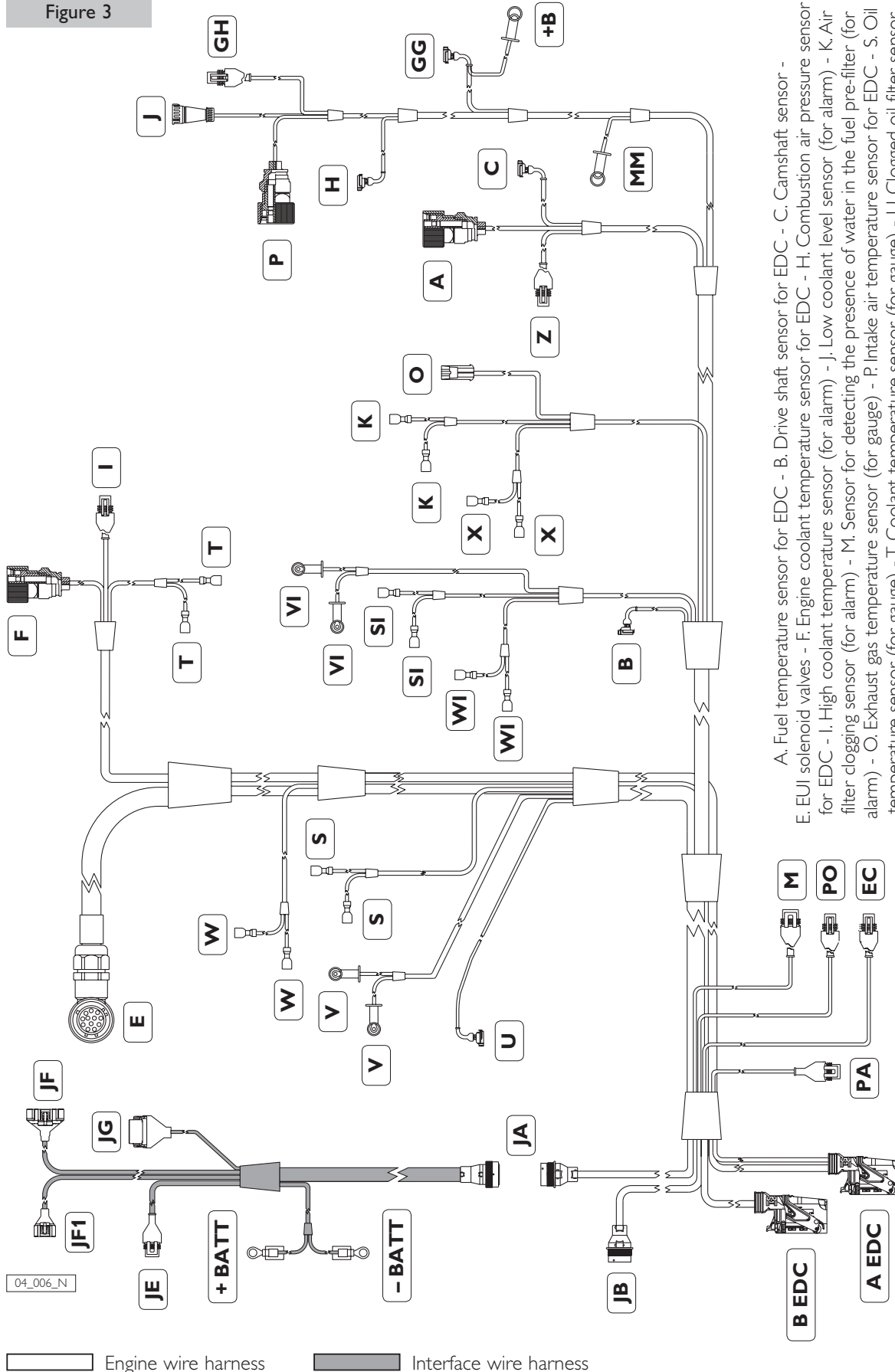


04\_005\_C

The wire harnesses provided with the engine include connectors for all optional components that can be ordered and their connections to the JB connector for the instrument panel.

WIRE HARNESS

Figure 3



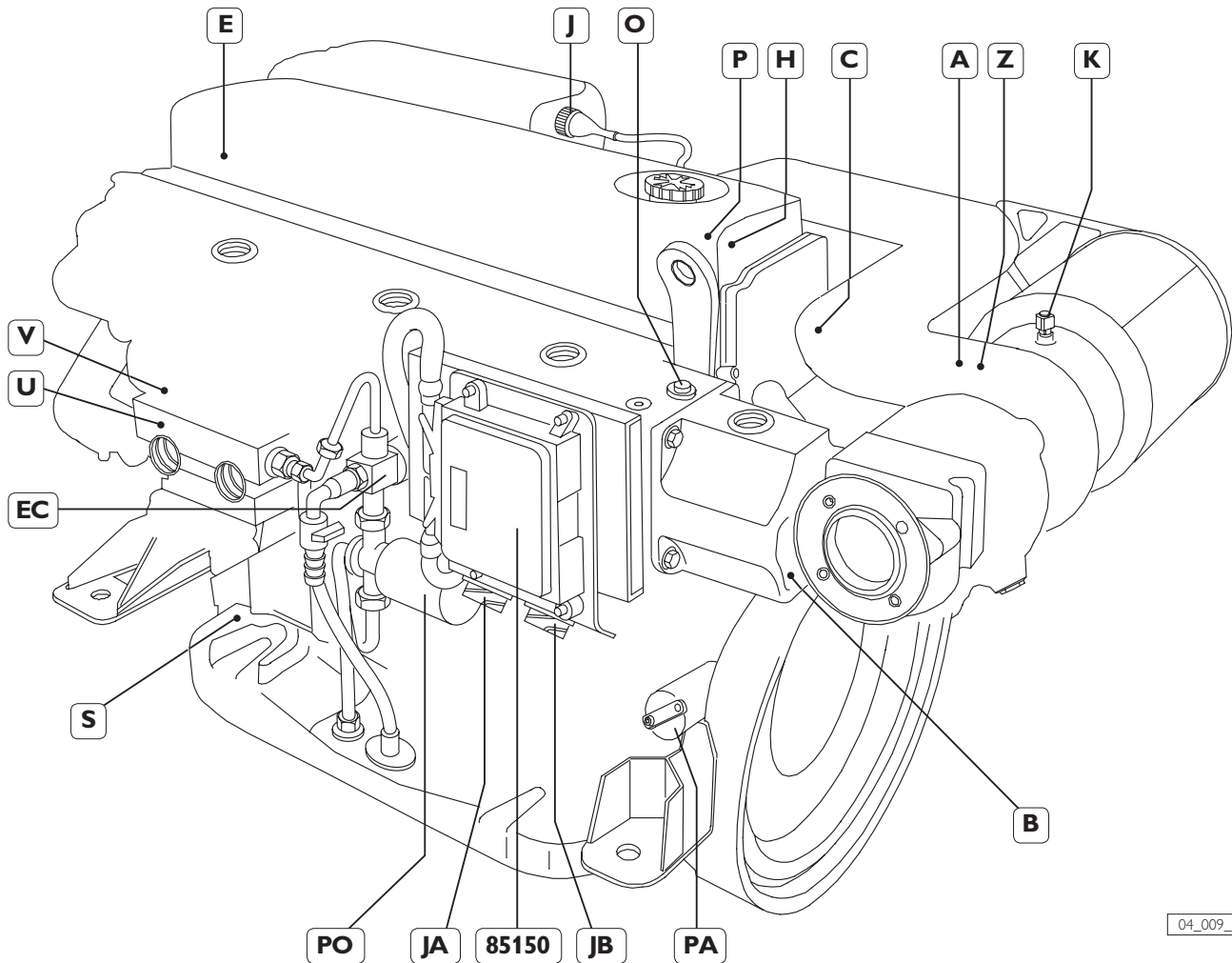
04\_006\_N

Engine wire harness      Interface wire harness

A. Fuel temperature sensor for EDC - B. Drive shaft sensor for EDC - C. Camshaft sensor - E. EUI solenoid valves - F. Engine coolant temperature sensor for EDC - H. Combustion air pressure sensor for EDC - I. High coolant temperature sensor (for alarm) - J. Low coolant level sensor (for alarm) - K. Air filter clogging sensor (for alarm) - M. Sensor for detecting the presence of water in the fuel pre-filter (for alarm) - O. Exhaust gas temperature sensor (for gauge) - P. Intake air temperature sensor for EDC - S. Oil temperature sensor (for gauge) - T. Coolant temperature sensor (for gauge) - U. Clogged oil filter sensor (for alarm) - V. Oil pressure sensor (for gauge) - W. Low oil pressure sensor (for alarm) - X. Clogged blow-by filter sensor (for alarm) - Z. Clogged fuel filter sensor (for alarm) - EC. Switching solenoid valve for oil charge/discharge - GG. Alternator - GH. Pre-heating power relay - JB. Pre-heating power relay - JB. Pre-heating power relay - JB. Instrument panel connection wire harness - JE. Alarms control unit (for Certification Bodies) - JF, JF1. Relay box - JG. Pre-lubrication control unit - MM. Electric starter motor - PA. Throttle position sensor - PO. Pre-lubrication electrical pump - SI. Gearbox oil pressure sensor - VI. High gearbox oil pressure sensor (25 bar) - WI. Low gearbox oil pressure sensor (7 bar).

**LOCATION OF ELECTRICAL COMPONENTS ON ENGINE**

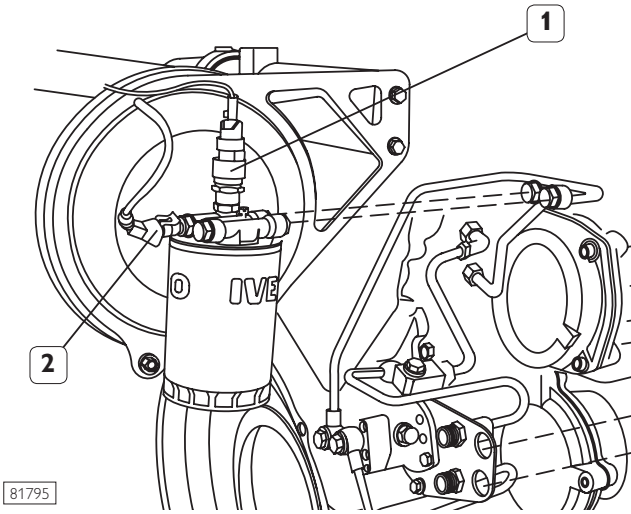
Figure 4



04\_009\_C

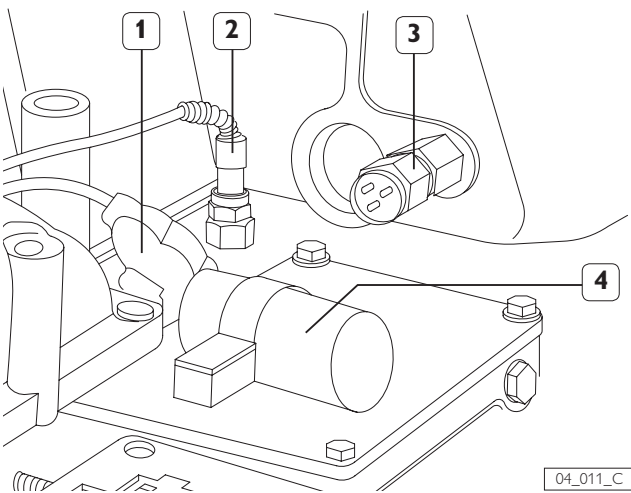
A. Fuel temperature sensor for EDC - B. Drive shaft sensor for EDC - C. Camshaft sensor - E. EUI solenoid valves - H2. Combustion air pressure sensor for EDC - J. Low coolant level sensor (for alarm) - K. Air filter clogging sensor (for alarm) - O. Exhaust gas temperature sensor (for gauge) - H1. Intake air temperature sensor for EDC - S. Oil temperature sensor (for gauge) - U. Clogged oil filter sensor (for alarm) - V. Oil pressure sensor (for gauge) - Z. Clogged fuel filter sensor (for alarm) - EC. Switching solenoid valve for oil charge/discharge - JA. Connection between engine wiring and interface wire harness - JB. Instrument panel connection wire harness - PA. Throttle position sensor - PO. Pre-lubrication electrical pump - 85150. EDC ECU.

Figure 5



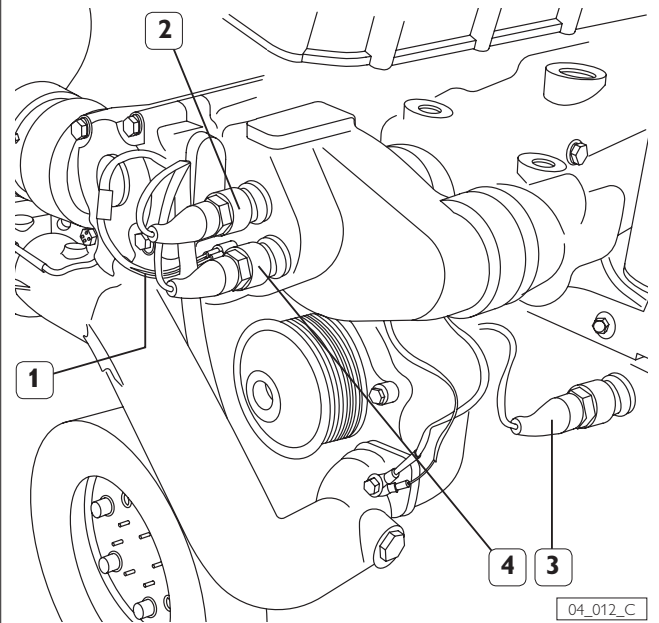
1. Fuel temperature sensor (A) -
2. Clogged fuel filter sensor (Z).

Figure 6



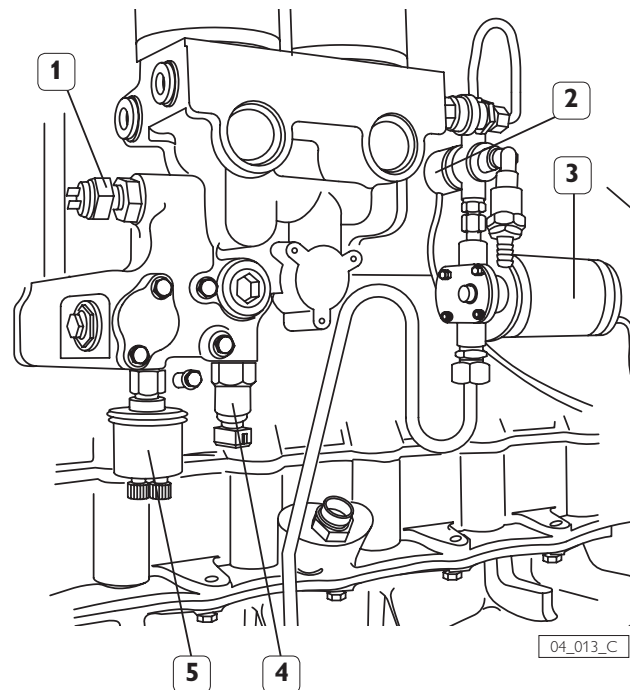
1. Combustion air pressure sensor (H) -
2. Intake air sensor (P) - 3. Low coolant level sensor (J) -
4. Pre-heating power relay (GH).

Figure 7



1. Coolant temperature sensor for gauge (T) -
2. High coolant temperature (I) -
3. Low oil pressure sensor (W) -
4. Engine coolant temperature sensor for EDC (F).

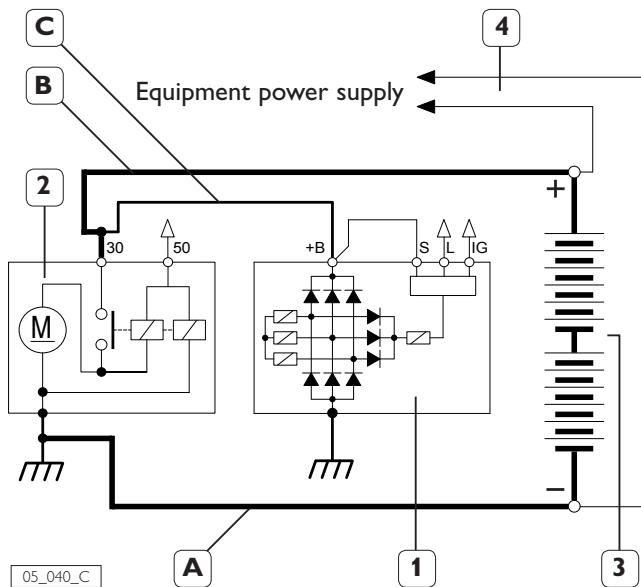
Figure 8



1. Low oil pressure sensor (W) - 2. Switching solenoid valve for oil charge/discharge (EC) - 3. Pre-lubrication electrical pump (PO) - 4. Clogged oil filter sensor (U) -
5. Oil pressure sensor (V).

**POWER SUPPLY LINE**

Figure 9



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 70 mm<sup>2</sup>;
- 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 70 mm<sup>2</sup>;
- 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 10 mm<sup>2</sup>.

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.

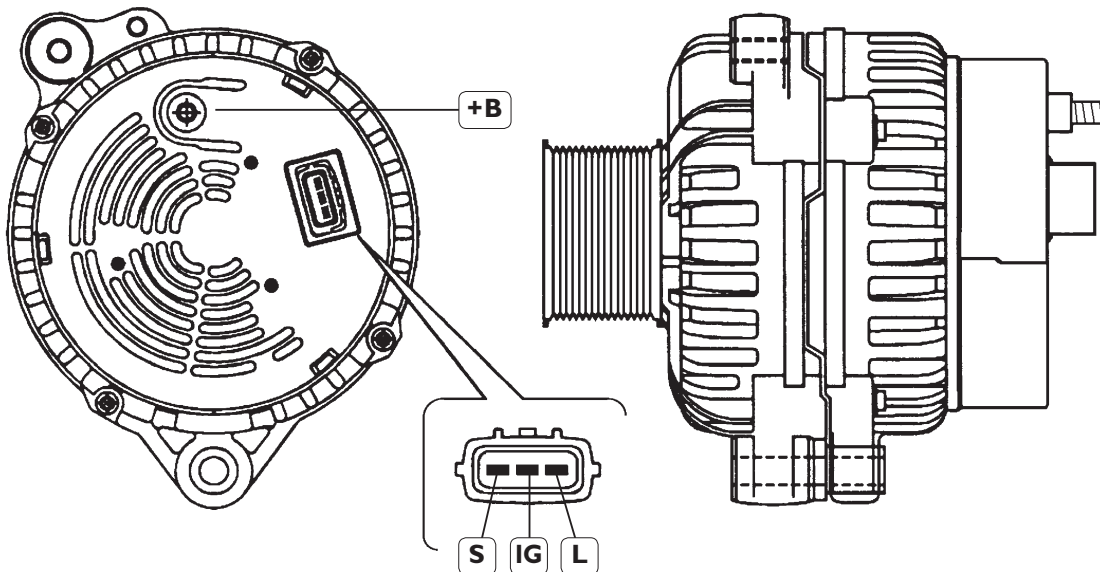
**CAUTION**

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 10

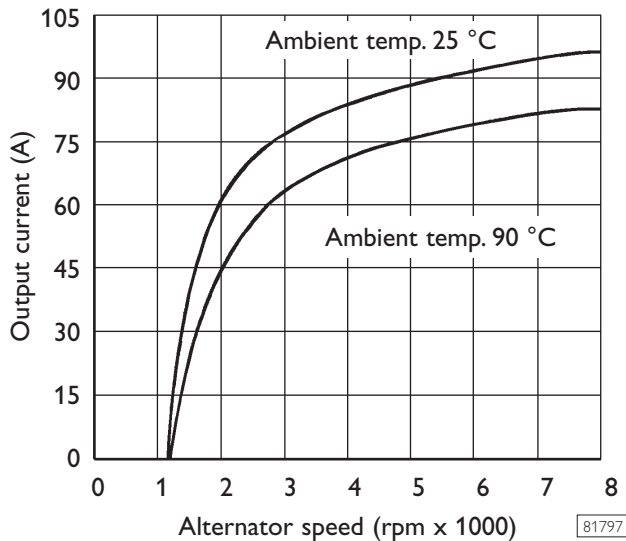


81796

**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.

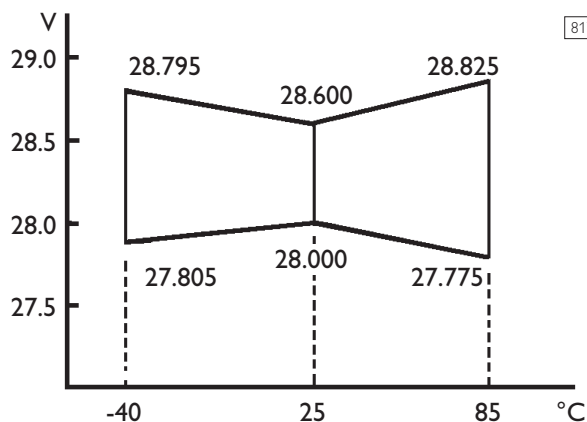
Figure 11



81797

CHARACTERISTIC CURVES

Figure 12



81798

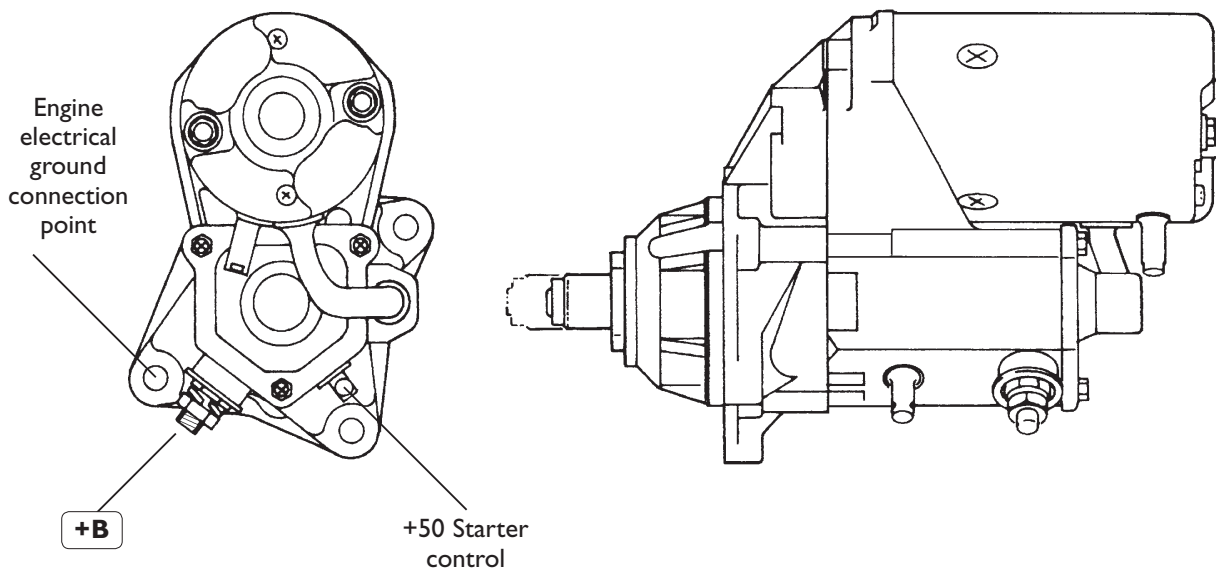
CHARACTERISTIC OF VOLTAGE REGULATOR

**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 13

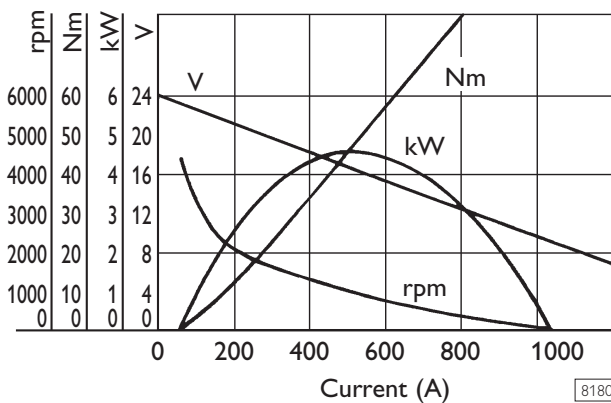


### “Nippondenso” model

#### Specification

Nominal power	4.5 kW
Nominal voltage	24V
Polarity	negative ground
Engagement circuit	positive command
Rotation	clockwise viewed from pinion end
Weight	~ 8.4 kg
Operating voltage	26V MAX (20 °C)
Water resistance	spray test based on JIS D0203 SI

Figure 14

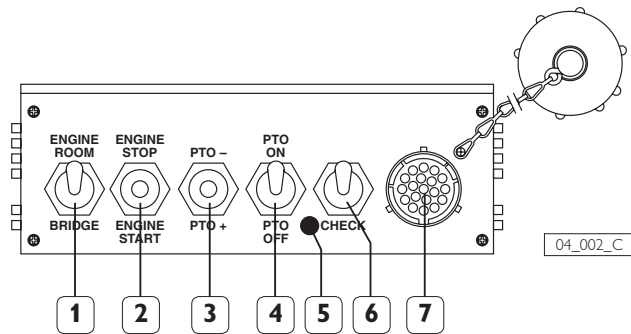


CHARACTERISTIC CURVES

Condition (20 °C)	Voltage (V)	Current (A)	Speed (rpm)	Torque (Nm)
No load	23	90	3500	-
Load	17	530	950	39.2
Stall	6	900	0	49

## RELAY BOX

Figure 15



1. Engine control selector on bridge or engine room (SW1) -
2. Start and stop push button in engine room (SW2) -
3. Manual throttle in engine room (SW3) -
4. PTO ON/PTO OFF selector (SW4) -
5. LED signaling anomalies EDC and blink code (DL1) -
6. Pushbutton for blink code query (SW5) -
7. Connector for external diagnosis instrument(J1)

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.

Engine rpm can be controlled directly from the engine room by the push-button (3) after positioning the switch (4) to ON. Among the controls present on the panel there are also the pushbutton (6) and the "blink code" light indicator (5), these can be used (also during navigation), for indications leading to the identification of failures or improper engine operating conditions (see Section 4).

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 (7), 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.

### Relays contained in the relay box

- K1. EDC main (power supply);
- K2. Key switch electric discharge;
- K3. Emergency engine shut-down provision;
- K4. To enable engine start from engine room;
- K5. Power supply to terminal 50 of the electric starter motor;
- K6. Cranking exclusion when engine is running.

### RPM control

To allow to easily control engine RPM from the "engine room", a simultaneous acceleration/deceleration function (PTO+/PTO-) has been implemented, active only when the switch (1) is in the "ENGINE ROOM" position, and the switch (4) is in PTO ON position.

#### Acceleration (PTO +)

If the (3) push-button is held down in the "PTO+" position when the engine is running, then engine rpm is progressively increased. The increase ends when the push-button is released, allowing the engine to run at the desired rpm.

#### Deceleration (PTO -)

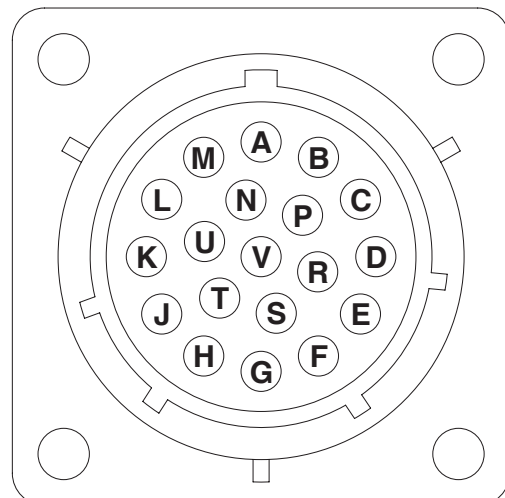
If the (3) push-button is held down in the "PTO -" position when the engine is running, then engine rpm is gradually decreased. The reduction ends when the push-button is released, allowing the engine to run at the desired rpm. The rpm reached at that point is maintained until the engine is stopped (function takes priority and always stops the engine) or switching the (4) push-button in the PTO OFF position.

### CAUTION

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

### Diagnosis connector J1

Figure 16



04\_084\_C

### RELAY BOX CONNECTORS

Figure 17

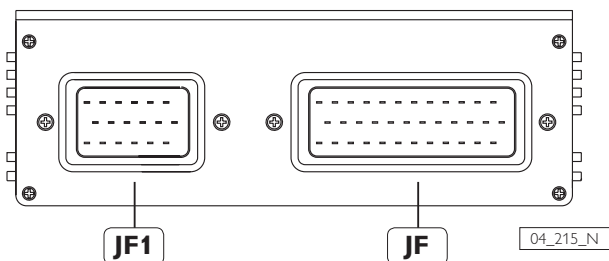
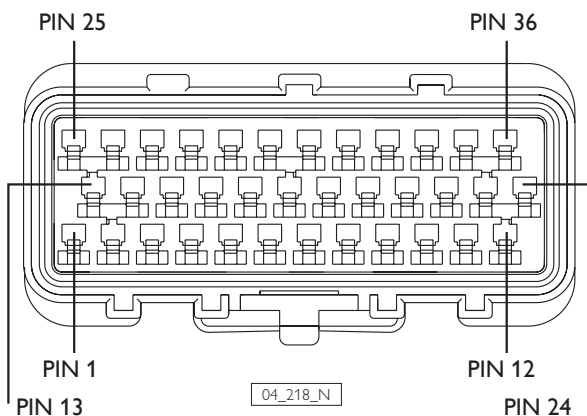


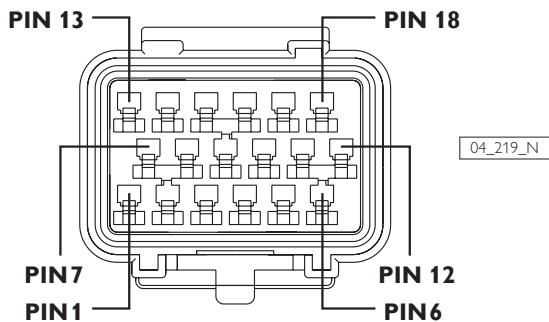
Figure 18



JF CONNECTOR

(view of the wire harness terminal, coupling side)

Figure 19

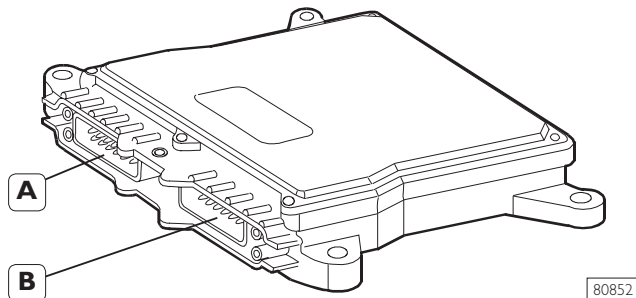


JF1 CONNECTOR

(view of the wire harness terminal, coupling side)

### CONNECTIONS OF THE CENTRAL ELECTRONIC UNIT (ECU)

Figure 20



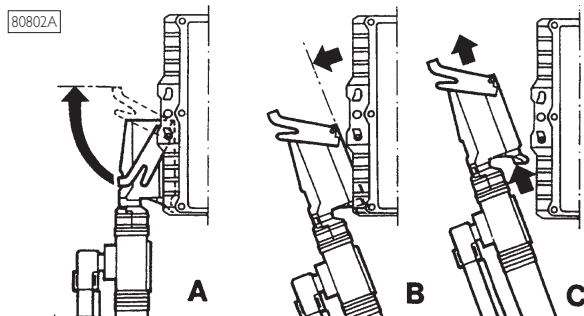
A. Engine component wiring connector -  
B. Vessel side wiring connector.

The connection of the central electronic unit, ECU, to the EDC system, takes place by means of two 35 way connectors mechanically polarized in the latching system to prevent inversion.

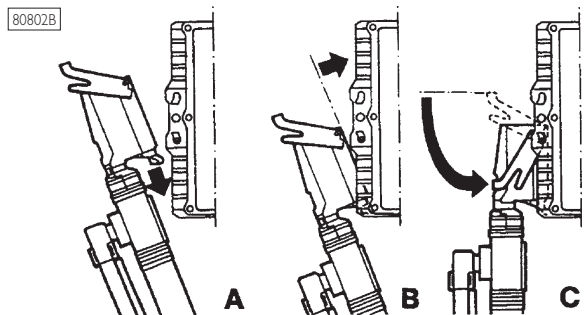
The presence of the two connectors provides for a subdivision of the wiring harnesses - to distribute the large quantity of conductors and at the same favor a quicker identification of lines during testing operations conducted by technical assistance personnel.

### ECU connector removal and insertion

Figure 21



ECU CONNECTORS REMOVAL



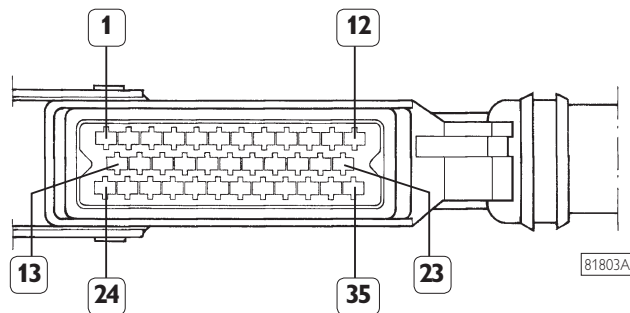
ECU CONNECTORS INSERTION

**Identification of terminal functions**

**A Connector**

Pin	Function
1	Flywheel sensor
2	Camshaft sensor
3	By-pass intercooler control (not used)
4	Intake air temperature sensor ground
5	Coolant temperature sensor ground
6	Fuel temperature sensor ground
7	Not used
8	Not used
9	Not used
10	Not used
11	Fuel temperature sensor signal
12	Intake air pressure sensor signal
13	Flywheel sensor
14	Camshaft sensor
15	Not used
16	Not used
17	Intake air pressure sensor ground
18	By-pass intercooler control (not used)
19	Not used
20	Not used
21	Intake air temperature sensor signal
22	Coolant temperature sensor signal
23	Intake air pressure sensor supply
24	Solenoid valves EUI supply cyl. 1, 2, 3
25	Solenoid valves EUI supply cyl. 4, 5, 6
26	Solenoid valve EUI control cylinder 4
27	Solenoid valve EUI control cylinder 6
28	Solenoid valve EUI control cylinder 5
29	Not used
30	Not used
31	Not used
32	Not used
33	Solenoid valve EUI control cylinder 3
34	Solenoid valve EUI control cylinder 2
35	Solenoid valve EUI control cylinder 1

Figure 22

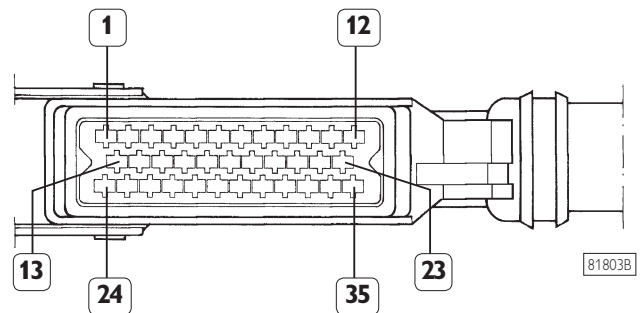


CONNECTOR A

**B Connector**

Pin	Function
1	Negative supply
2	Negative supply
3	Positive supply (from relay K1)
4	Positive supply (from relay K1)
5	Engine speed output signal
6	EDC fault indicator control
7	Not used
8	Not used
9	Engine phase output signal
10	Pre-heating relay control
11	CAN line
12	CAN line
13	Diagnosis line
14	Not used
15	Positive connected to + 15
16	Throttle position sensor supply
17	Idling switch signal
18	Pre-heating indicator control
19	Not used
20	Not used
21	Not used
22	Not used
23	Throttle position sensor signal
24	Diagnosis line
25	Resistor 3.3 kΩ (balancing load)
26	Not used
27	Main relay control
28	Not used
29	Resistor 3.3 kΩ (balancing load)
30	Not used
31	Not used
32	Not used
33	Not used
34	Not used
35	Throttle position sensor ground

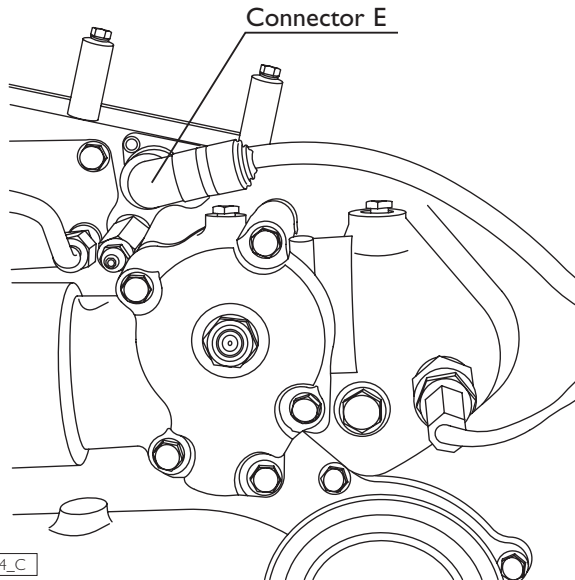
Figure 23



CONNECTOR B

**EUI SOLENOID VALVE CONNECTOR**

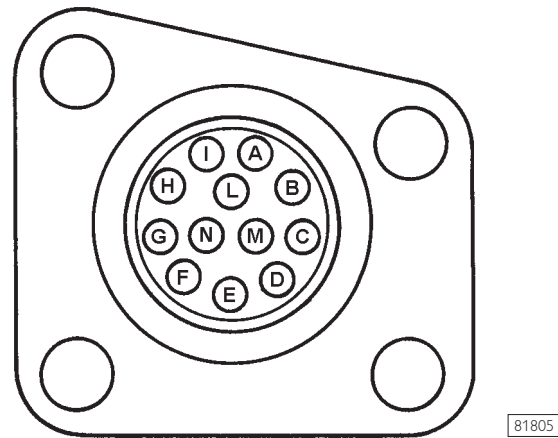
Figure 24



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 25



VIEW FROM THE ENGINE OUTER SIDE

A	Injector 1 control	Pin ECU A 35
B	Injector 1 supply	Pin ECU A 24
C	Injector 2 control	Pin ECU A 34
D	Injector 2 supply	Pin ECU A 24
E	Injector 3 control	Pin ECU A 33
F	Injector 3 supply	Pin ECU A 24
G	Injector 4 control	Pin ECU A 26
H	Injector 4 supply	Pin ECU A 25
I	Injector 5 control	Pin ECU A 28
L	Injector 5 supply	Pin ECU A 25
M	Injector 6 control	Pin ECU A 27
N	Injector 6 supply	Pin ECU A 25

**CAUTION**

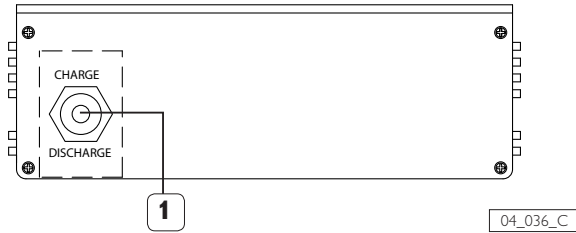
The wiring that connects the injector solenoid valves to the through-bulkhead connector is made with connectors whose insulation is capable of withstanding the challenging conditions of the environment where it is located. These are braided to avoid generation of electromagnetic interference.

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 26

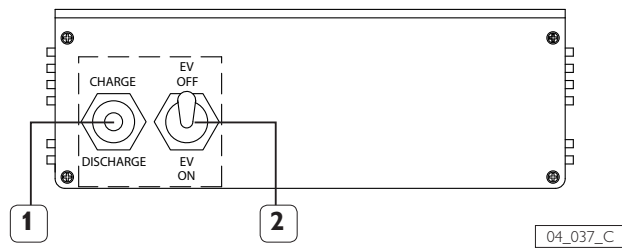


1. Oil intake/exhaust control

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 27



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

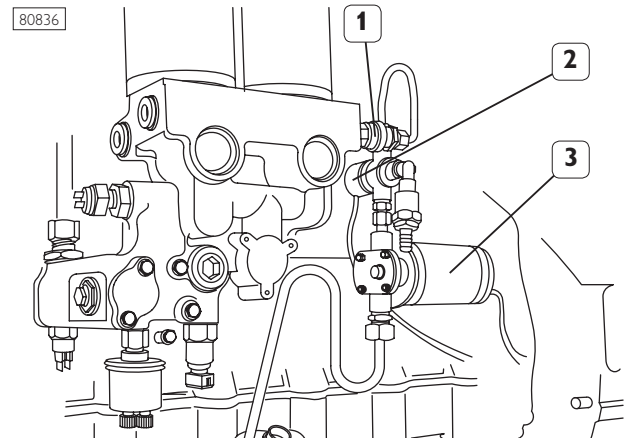
The module is connected to the JG connector of the interface wiring harness.

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

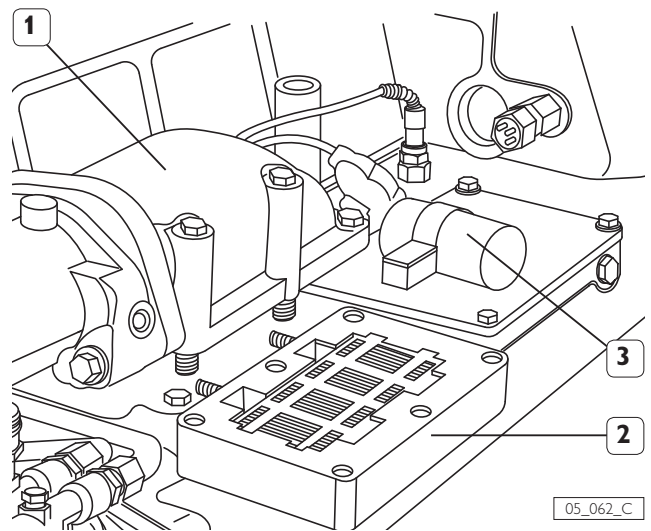
Figure 28



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

### Low temperature starting aid

Figure 29



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.

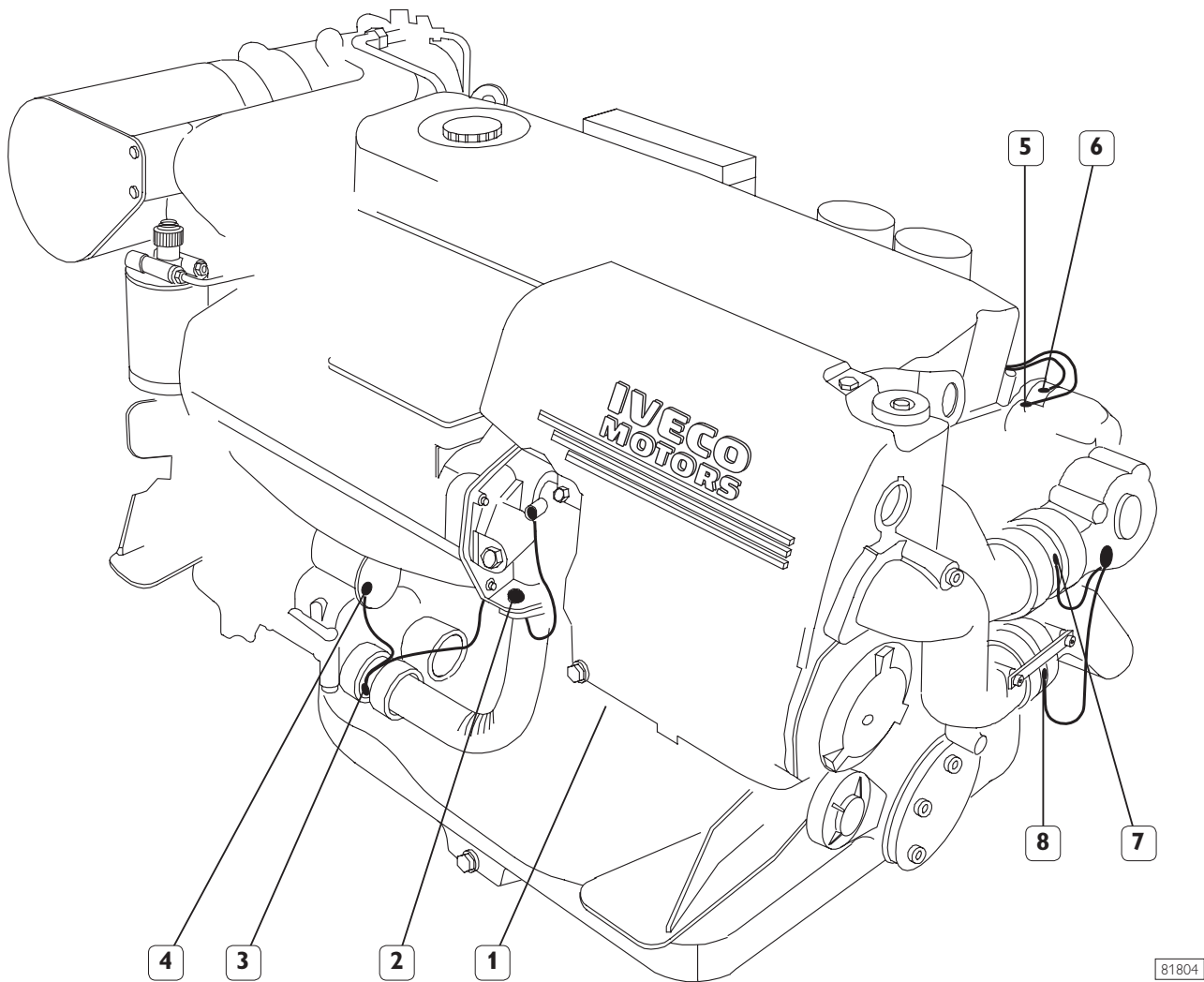
Connection to the electrical wiring provided is achieved interposing a specific relay (GH) and connection to the power supply grid.

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 30



Elements connected to engine ground with metallic braid conductor:

- 1. Sea water outlet junction from water/water heat exchanger (not shown) - 2. Sea water supply pipe to air/sea water exchanger
- 3. Sea water pump outlet junction - 4. Sea water pump closure lid - 5. and 6. Inlet-outlet junction for the fresh water cooling the exhaust manifold - 7. Junction of the pipes supplying fresh water to the water/water exchanger - 8. Junction of the fresh water outlet pipes from the water/water heat exchanger.

### 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.

81804





**Electrical equipment component code**

A	fuel temperature sensor for EDC
AC	battery
AQ	engine shut-off push-button on main panel
AS	engine shut-off push-button on secondary panel
B	drive shaft sensor for EDC
C	camshaft sensor
CA	key switch
CS	engine start push-button on secondary panel
DL1	EDC fault indicator and blink code LED (on relay box panel)
EC	switching solenoid valve for oil charge/discharge
F	engine coolant temperature sensor for EDC
GG	alternator
GH	power relay for starting aid
H	combustion air pressure sensor for EDC
I	high coolant temperature sensor (for alarm)
IN	injectors solenoid valve
J	low coolant level sensor (for alarm)
K	air filter clogging sensor (for alarm)
L	instrument panel light switch
M	sensor for detecting the presence of water in the fuel pre-filter (for alarm)
MC	CAN - BUS converter module for digital panel
MM	electric starter motor
MP	pre-lubrication and oil transfer module
MS	IVECO MOTORS-FPT indications and alarms module
O	exhaust gas temperature sensor (for gauge)
P	intake air temperature sensor for EDC
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
R1	3.3 k $\Omega$ resistor to inhibit speed input
R2	DL1 resistor
R3	alternator pre-excitation resistor
S	oil temperature sensor (for gauge)
SA	buzzer
SI	gearbox oil temperature sensor
SW1	bridge or engine room engine control selector (on relay box panel)
SW2	start and stop push button (on relay box panel)
SW3	manual accelerator throttle control in engine room (on relay box panel)
SW4	PTO ON/PTO OFF selector (on relay box panel)
SW5	blink code emission request push-button (on relay box panel)
T	coolant temperature sensor (for gauge)
U	Clogged oil filter sensor (for alarm)
V	oil pressure sensor (for gauge)
VI	high gearbox oil pressure sensor (25 bar)
W	low oil pressure sensor (for alarm)
WI	low gearbox oil pressure sensor (7 bar)
X	clogged blow-by filter sensor (for alarm)
Z	clogged fuel filter sensor (for alarm)
85150	ECU of the EDC system

*(continues on next page)*

**Electrical equipment component code (cont.)****Connectors**

A	35 pole EDC boat components
B	35 pole EDC engine components
E	EUI injectors solenoid valve
J1	external diagnostic tool (on the relay box panel)
JA	connection between engine wiring and interface wire harness
JA	ON SECONDARY DIGITAL INSTRUMENT PANEL set for connection to the main digital instrument panel
JB	ON ENGINE WIRE HARNESS set for connection to the main analog instrument panel or to the interface wire harness for converter module
JC	ON MAIN ANALOG INSTRUMENT PANEL set for connection to the engine wire harness
JD	IVECO MOTORS-FPT indications and alarms module
JD	ON INTERFACE WIRE HARNESS FOR CONVERTER MODULE external throttle control
JE	ON MAIN ANALOG INSTRUMENT PANEL set for connection to the secondary analog instrument panel
JE	ON INTERFACE WIRE HARNESS FOR CONVERTER MODULE set for connection to the main digital instrument panel
JE	ON MAIN DIGITAL INSTRUMENT PANEL set for connection to the secondary digital instrument panel
JE	ON MAIN INTERFACE WIRE HARNESS set for connection to the alarms control unit (for Certification Bodies)
JE1	ON INTERFACE WIRE HARNESS FOR CONVERTER MODULE set for connection to the 2 <sup>nd</sup> main digital instrument panel
JF	relay box
JF1	relay box
JG	pre-lubrication control unit
JH	ON SECONDARY ANALOG INSTRUMENT PANEL set for connection to the main analog instrument panel
JH	ON MAIN DIGITAL INSTRUMENT PANEL set for connection to the interface wire harness for converter module
JO	converter for digital panels

**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
SIM	expired programmed maintenance interval
SP	pre-lubrication
SS	alternator fault
SSV	overspeed engine

**Gauges**

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

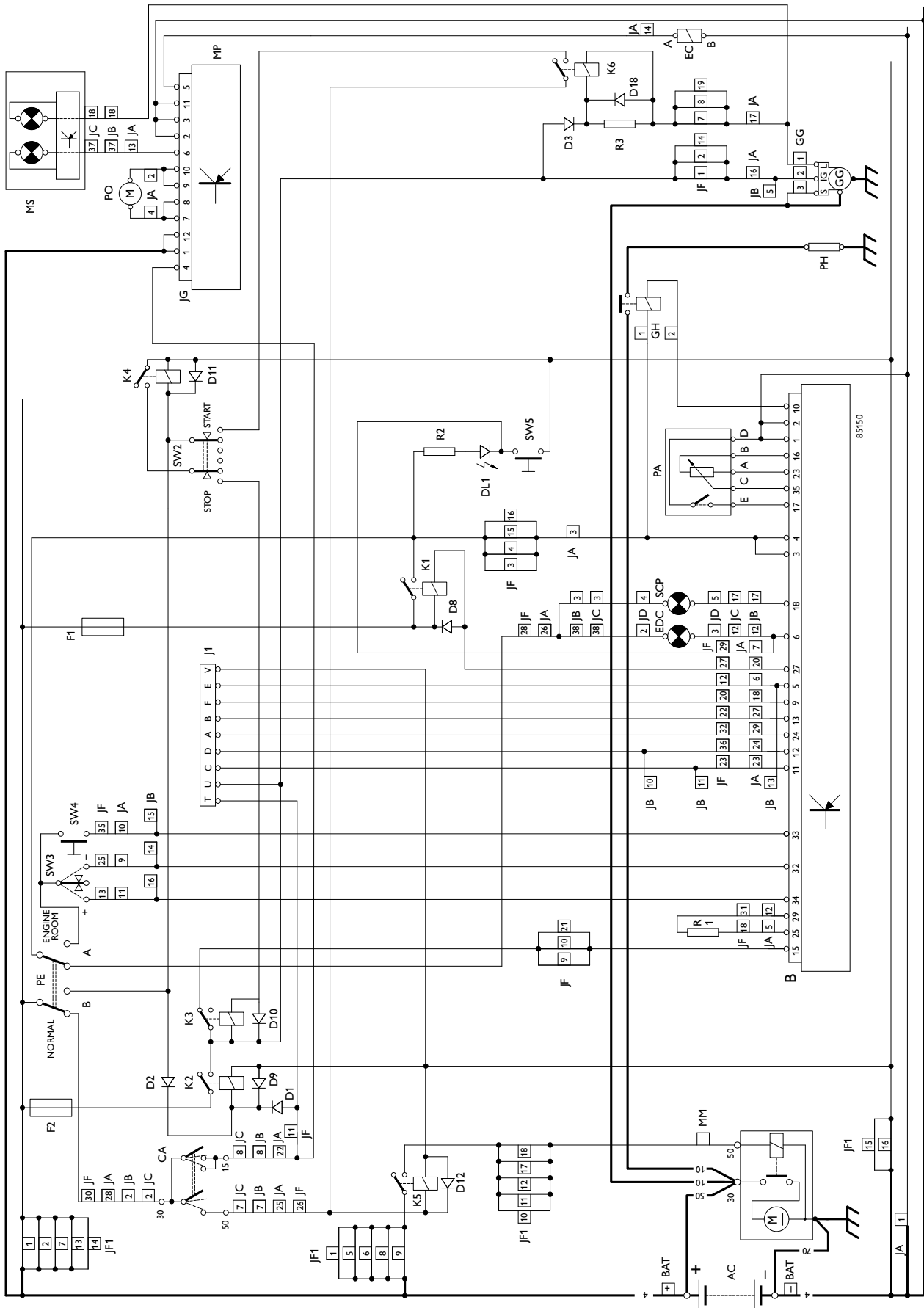
**Relays contained in the relay box**

K1	EDC main (power supply)
K2	key switch electric discharge
K3	emergency engine shut-down provision
K4	enabling start engine from engine room
K5	power supply to terminal 50 of the electric starter motor
K6	cranking exclusion when engine is running

**Fuses contained in the relay box**

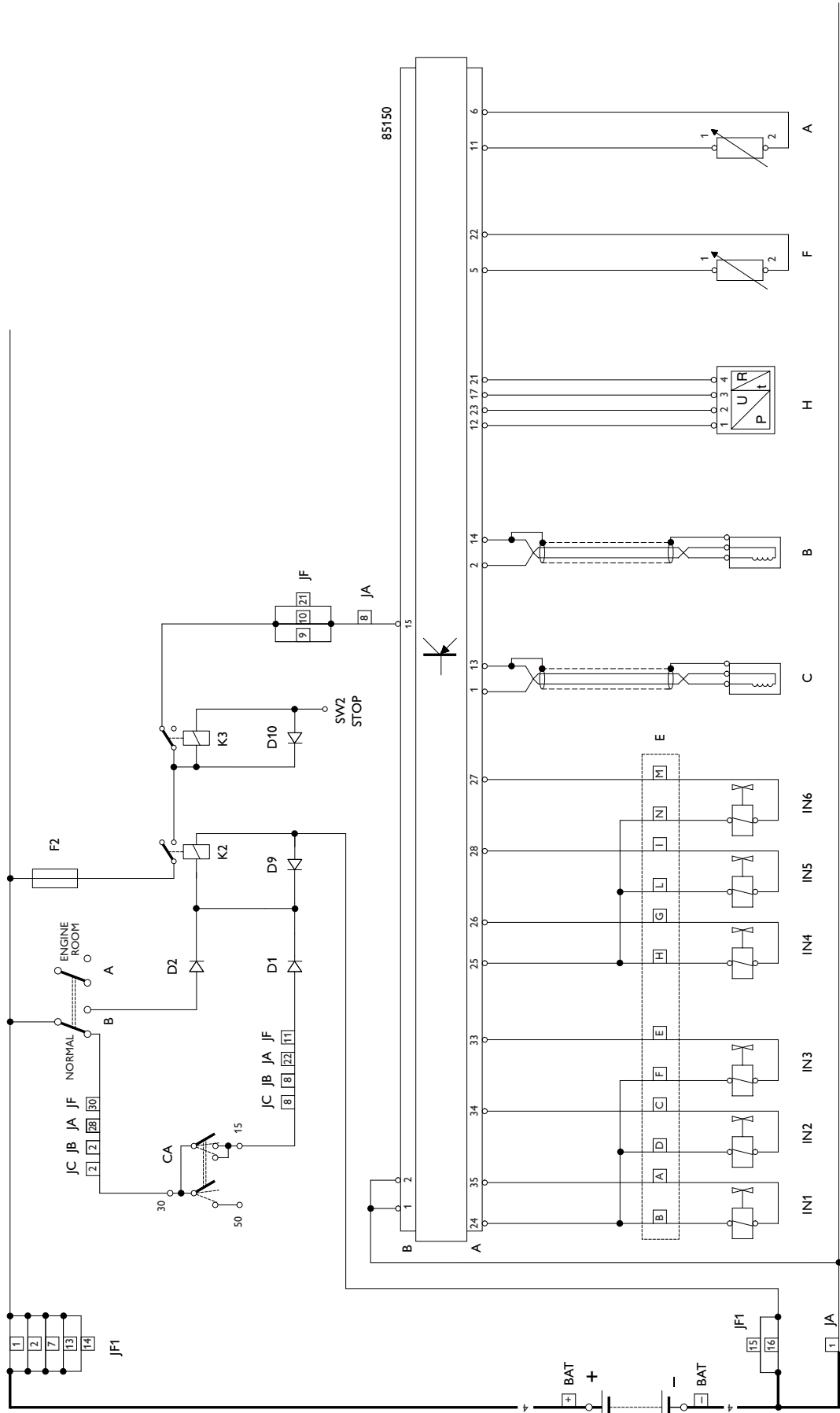
F1, F2	self restoring (not replaceables)
--------	-----------------------------------

### EDC connector B



Schema\_Connettore\_B

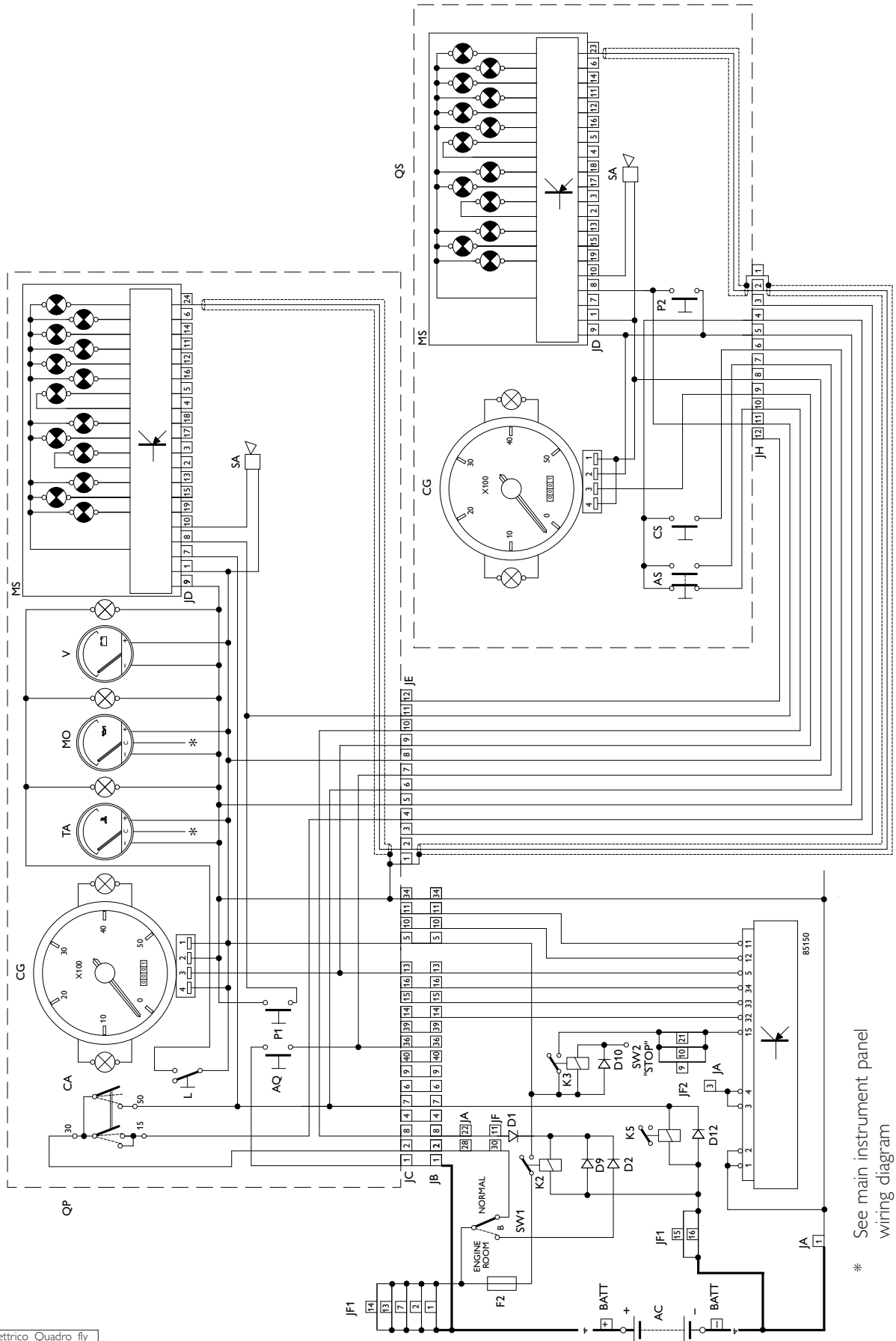
### EDC connector A



Schema\_Connettore\_A2°



### Secondary analog instrument panel



\* See main instrument panel wiring diagram







PAGE LEFT INTENTIONALLY BLANK

## SECTION 4

## DIAGNOSTICS

	Page
FOREWORD	69
ECU BEHAVIOUR	70
Anomalies indicator light	70
Blink code	70
Error deletion procedure	70
Recovery	70
BLINK CODE TABLE	71
DIAGNOSIS WITH THE PT-01 INSTRUMENT	72
Functions of the Instrument	72
Identifier	72
Fault Memory	73
Parameter reading	73
Active diagnostics	73
MAJOR DIAGNOSTIC ACTIONS	74
Checking pressure in fuel supply line	74
Venting the fuel loop	74
Checking the keying of timing phonic wheel	74
Checking the timing phase	74
Checking component resistance value	75
Checking line insulation	75
REFERENCE VALUES	76
For non hardwired sensors	76
Throttle position sensor	76
Sensors wired with shielded wires	76
For wired sensors powered by the ECU	77
GUIDE TO BLINK CODE DIAGNOSIS	78
GUIDE TO SYMPTOM DIAGNOSIS	84

PAGE LEFT INTENTIONALLY BLANK

## 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 issued by the blinking of the fault indicator light: the "blink-code".

Using computerized IVECO MOTORS-FPT instruments, IT 2000 and PT 01, two-way communications can be established with the central unit, enabling not only 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 "C78 ENS M20 - C78 ENT M30-M50-M55 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 comprises two distinct sections:

- The first, organized by Blink Code, concerns anomalies identified by the MS 6.2 unit, of mainly an electrical or electronic nature;
- The second, organized by symptoms, describes the possible anomalies not recognized by the electronic unit, frequently mechanical or hydraulic in nature.

For operation and 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 condition as well as that of the engine and the components connected to it.

When anomalies are detected, the fault indicator light on the instrument panel is lighted in a manner that provides a first indication of the severity of the problem.

- Light off:** No anomaly detected or slight anomaly that does not compromise operating safety;
- Light on:** Significant anomaly, that allows to proceed to a service center;
- Blinking light:** Severe anomaly requiring immediate repairs. If possible, shut the engine down.

### Blink code

Emission of the anomaly codes detected during self-testing and stored in the ECU, starts after the "CHECK" push-button on the relay box panel is pressed and released - when the "BRIDGE - ENGINE ROOM" switch is in the "ENGINE ROOM" position.

The LED located at the side of the push-button and the EDC indicator light on the instrument panel will simultaneously signal, with two series of emissions at different frequencies, the blink codes that indicate the anomaly with decimal numbering.

**Slow blinks** identify the area of the anomaly (engine, injectors, ...), **fast blinks** identify a specific anomaly.

Every time the push-button is pressed and released, only one of the stored codes is emitted; therefore, the procedure must be repeated until an error indication identical to the first one is obtained, which means the entire error memory has been analyzed.

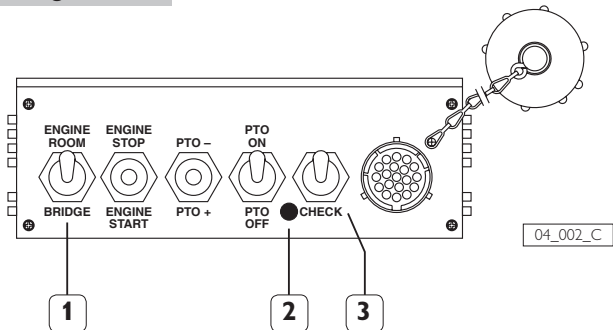
If no anomalies are stored, the light comes on when the push-button is pressed and comes off about 1 second after its release, without any subsequent blinking.

### NOTE

*The blink code diagnostic procedure provides indications about current anomalies as well as past anomalies that are no longer present when the diagnosis is carried out; therefore, it is absolutely mandatory, at the end of every repair operation, to erase the error memory to prevent future notification of repaired anomalies.*

### Error deletion procedure

Figure 1



- Shut the engine down and keep the key switch in the "OFF" position for 15 seconds (after run).
- Approach the relay box. Keeping the "CHECK" diagnostic push-button (3), move the adjacent "BRIDGE - ENGINE ROOM" switch (1) to the "ENGINE ROOM" position, wait for the luminous indicator (4) to switch off position, while keeping the diagnostic push-button pressed for 8 more seconds.
- Release the push-button and move the "ENGINE ROOM" switch to the "BRIDGE" position

### CAUTION

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

Confirmation that cancellation has been carried out is provided by a subsequent query of the blink code; the blink code light (2) should not give out any code.

### Recovery

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

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.

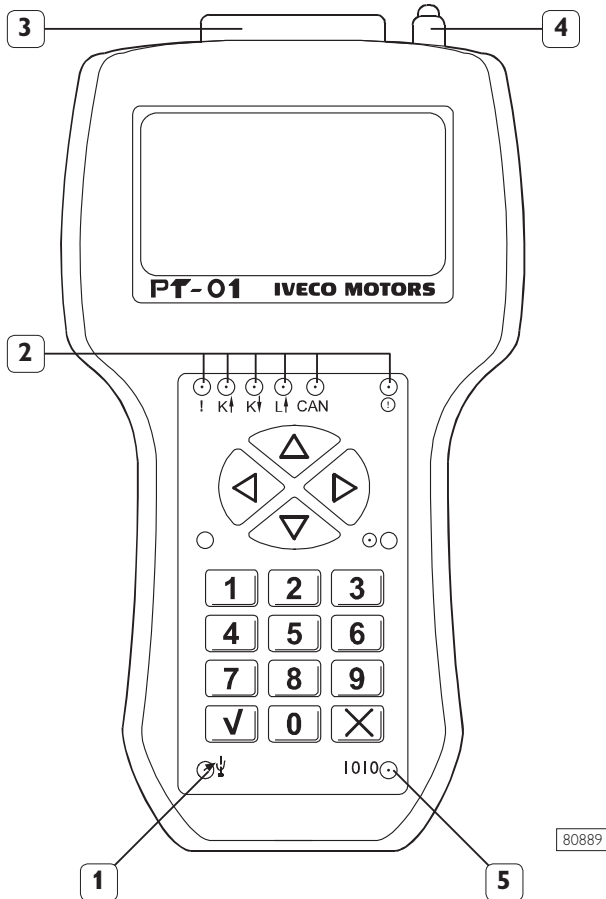
**BLINK CODE TABLE**

Blinking Code	EDC Indicator light	Indicated Fault
<b>Control area</b>		
1.1	(on)	not significant in marine applications
1.2	(on)	not significant in marine applications
1.3	(off)	not significant in marine applications
1.4	on	throttle position sensor
1.5	(off)	not significant in marine applications
1.6	(on)	not significant in marine applications
1.7	(off)	not significant in marine applications
<b>Engine area</b>		
2.1	off	coolant temperature sensor
2.2	off	intake air temperature sensor
2.3	off	fuel temperature sensor
2.4	on	supercharge air pressure sensor
2.5	off	ambient pressure sensor (inside the unit)
2.6	(on)	not significant in marine applications
3.5	off	battery voltage
<b>Injectors</b>		
5.1	on	cylinder 1 injector fault
5.2	on	cylinder 2 injector fault
5.3	on	cylinder 3 injector fault
5.4	on	cylinder 4 injector fault
5.5	on	cylinder 5 injector fault
5.6	on	cylinder 6 injector fault
<b>Engine rpm sensor</b>		
6.1	on	flywheel sensor
6.2	on	timing system sensor
6.4	blinking	overspeed engine
<b>Electronic unit</b>		
9.1	blinking	defective unit
9.2	on	incorrect EEPROM data
9.3	(blinking)	not significant in marine applications
9.4	on	main relay
9.5	on	erroneous engine shut-down procedure
9.6	on	unit data storage operation not completed

## DIAGNOSIS WITH THE PT-01 INSTRUMENT

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

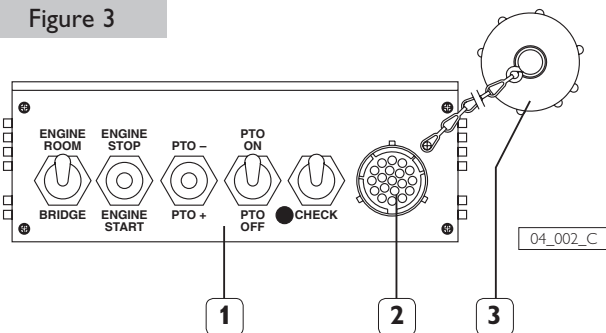
Figure 2



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

Figure 3



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.2.

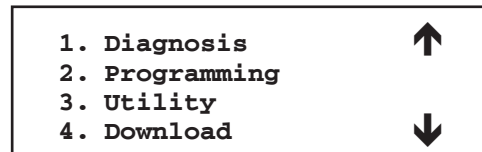
After establishing a connection between the instrument and the diagnosing outlet, the instrument displays available applications.

### 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.



### 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:

- 

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:

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



- Engine serial number;
- Alphanumeric code.

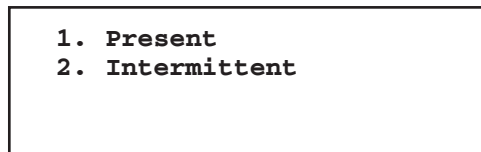
### Fault Memory

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

- Intermittent;
- Present.

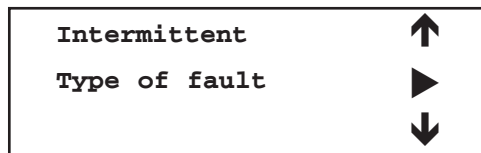
Faults indicated as intermittent occurred previously but are not present at the time the fault memory is read. Faults indicated as present are such or occurred during the last period of operation of the engine. In this case, shutting the engine down and starting it again will cause the indication to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

#### First screen



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

#### Second screen



Use the arrows  $\uparrow\downarrow$  to scroll through the list of present faults, while the symbol  $\blacktriangleright$  indicates the presence of additional information available for display with the  $\rightarrow$  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.

#### Relays

- Main.

#### Power supply voltage

#### Indicator lights

- Pre-post heating;
- EDC.

#### Central Unit

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

#### Parameter reading

Parameters available for display are grouped in two categories:

- Measurable;
- State.

#### List of measurable parameters

- Engine RPM;
- Injection advance;
- Ambient pressure;
- Battery voltage;
- Throttle lever position;
- Supercharging pressure;
- Supercharging air temperature;
- Cooling liquid temperature;
- Fuel temperature.

#### List of ECU state parameters

- Key set to run (+15);
- Idle switch (in throttle potentiometer);
- EDC indicator light;
- Blink Code push-button;
- Pre-post heating resistor relay (\*);
- Pre-heating indicator light (\*).

#### Active diagnostics

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

The components driven by the instrument are:

- Pre-post heating resistor relay (\*);
- Pre-heating indicator light (\*);
- EDC indicator light.

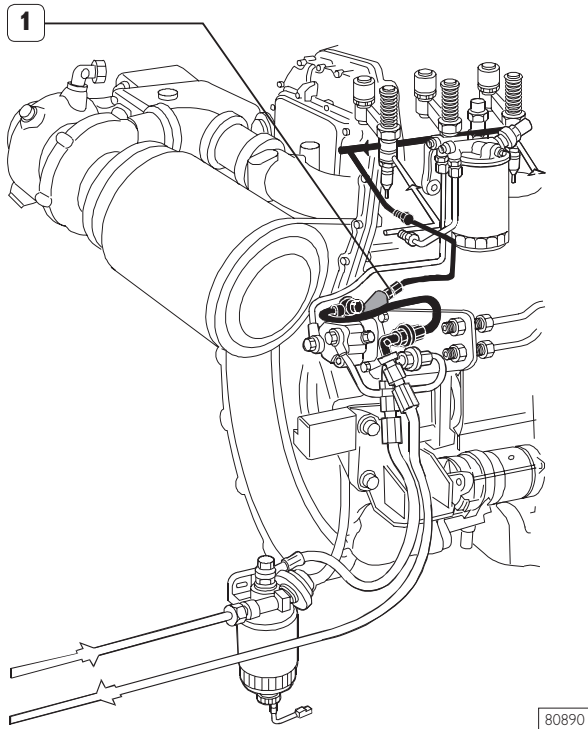
(\*) When present.

## MAJOR DIAGNOSTIC ACTIONS

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

### Checking pressure in fuel supply line

Figure 4



80890

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.

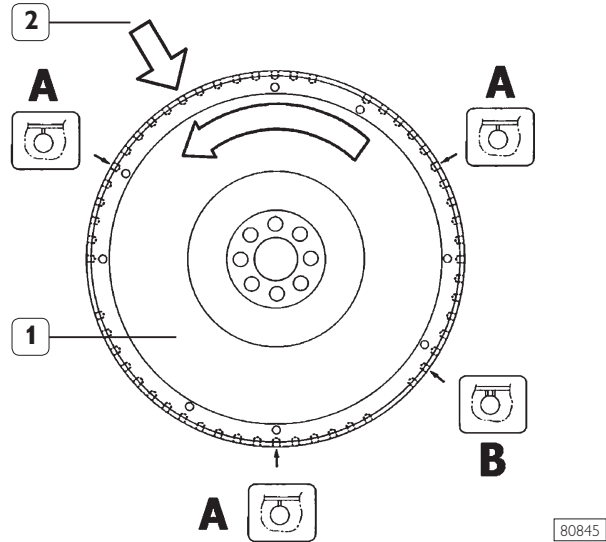
### Checking the keying of timing phonic wheel

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 3.60 mm and 3.70 mm.

Figure 5



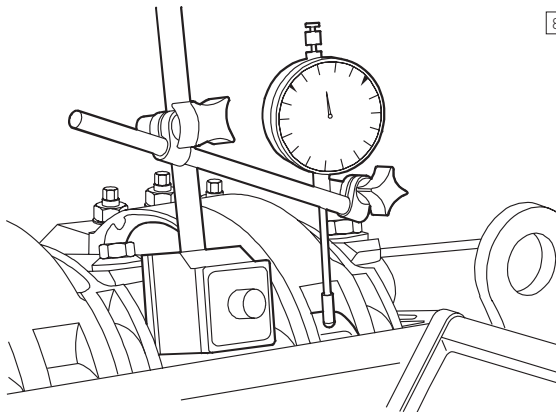
80845

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 11<sup>th</sup> 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 6



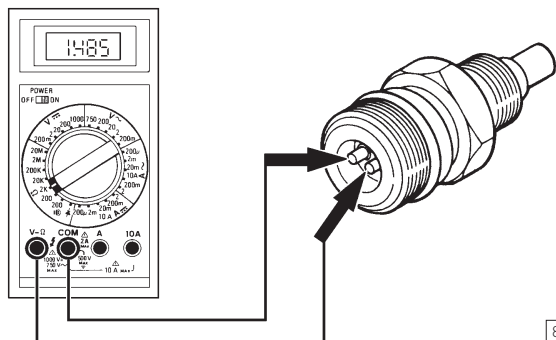
80891

- ❑ 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 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 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  $3.65 \pm 0.05$  mm (between 3.60 and 3.70 mm). Otherwise, the camshaft needs to be set in phase as indicated in Section 6.

### Checking component resistance value

Figure 7

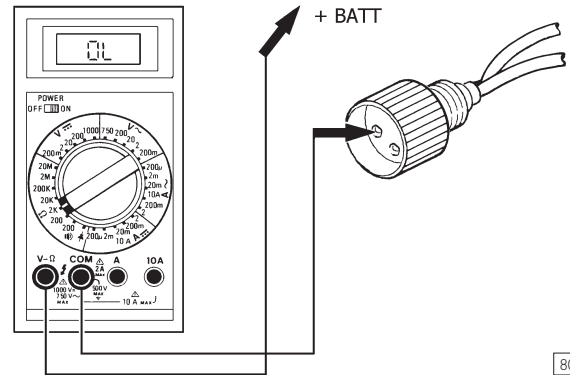


80892

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

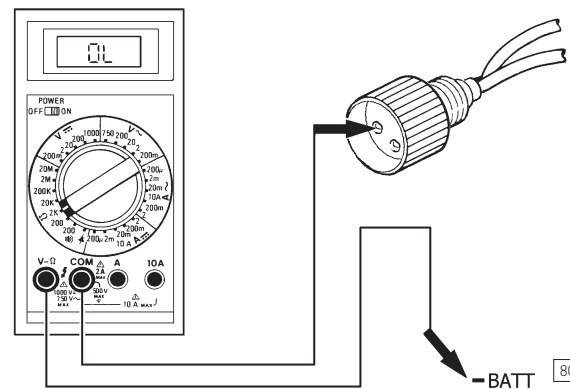
### Checking line insulation

Figure 8



80893

Figure 9



80894

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  $\geq 200$  k $\Omega$ , 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 $\Omega$ value	Maximum $\Omega$ value
Intake air temperature sensor	-10 °C	8100	10800
	0 °C	5200	6750
Coolant temperature sensor	20 °C	2300	2700
	50 °C	730	950
Fuel 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 $\neq$ 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.

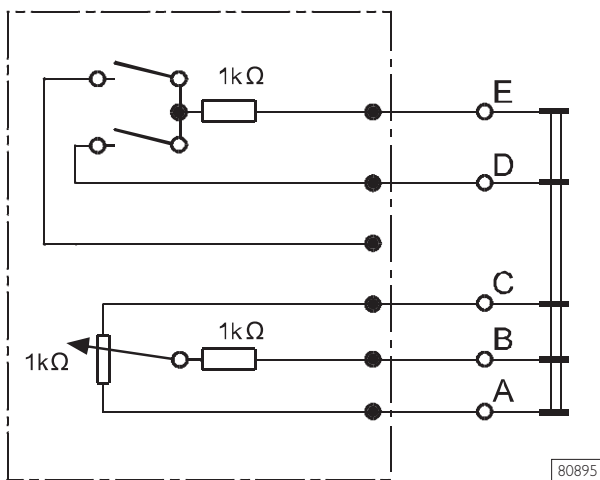
The actual measurement of small values of resistance requires use of instruments with the SELF-ZEROING function or, if these are not available, subtract from the read value the short-circuit value of the instrument prods.

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.

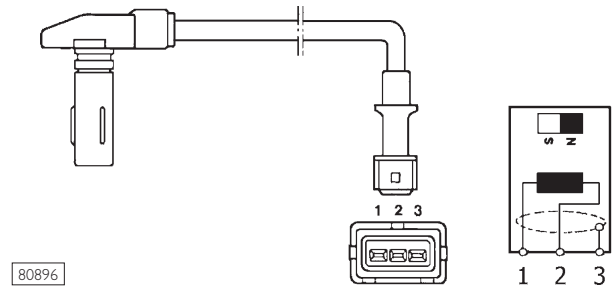
### Throttle position sensor

Figure 10



### Sensors wired with shielded wires

Figure 11



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

**REFERENCE VALUES****For wired sensors powered by the ECU**

Component	ECU connection	Test conditions	Minimum - maximum value
Combustion air temperature sensor signal	A4 A21	Panel key ON	0.5 to 4.5 Vcc
Coolant temperature sensor signal	A5 A22	Panel key ON	0.5 to 4.5 Vcc
Fuel oil temperature sensor signal	A6 A11	Panel key ON	0.5 to 4.5 Vcc
Flywheel position and rotation sensor signal	A1 A13	Engine running 600 rpm	> 0.8 Vac
Camshaft position and rotation sensor signal	A2 A14	Engine running 600 rpm	> 0.2 Vac
Combustion air absolute pressure sensor signal	A17 A12	Engine running 600 rpm	0.9 to 1.1 Vcc
Combustion air absolute pressure sensor power supply	A17 A23	Panel key ON	4.5 to 5.5 Vcc
Safety signal from throttle position sensor	B17 B25	Lever in position 0	> 4 Vcc
		Lever in position $\neq$ 0	< 1 Vcc
Throttle lever position sensor power supply	B16 B35	Panel key ON	4.5 to 5.5 Vcc
Position signal from throttle position sensor	B23 B35	Lever in position 0	0.3 to 0.5 Vcc
		Lever in position $\neq$ 0	0.3 $\div$ > 3 Vcc

**GUIDE TO BLINK CODE DIAGNOSIS**

Blink Code	EDC light	System reactions	Possible cause	Recommended tests or action	Notes
1.1	On	EDC indicator light on for no reason	The resistive load simulator is not detected	Check the integrity of the 3.3 k $\Omega$ resistance between pins B25 and B29 of the EDC connector and the associated wiring.	A resistive load replaces a signal that is not used in this application
		Power reduction. Fast idling with the throttle lever in any position.	Idling switch (in throttle sensor) signal shorted or shorted to ground or shorted to positive or open circuit	Read measurable parameters with the diagnosis instrument to verify the idling switch does not work (switching ON-OFF). Using a multimeter on the component, check the integrity of the idling switch (switching ON-OFF). If the switch is integral, search for a break in the wiring between the throttle connector (wiring side) and the EDC connector pin B17 and B2.	
1.4	On	Power reduction. With the throttle lever at rest, the engine runs at fast idling speed. On moving the lever, the engine speed increases progressively and uncontrollably	No throttle potentiometer signal. Shorted or shorted to ground or shorted to positive or open circuit or defective potentiometer	Read measurable parameters with the diagnosis instrument to verify the potentiometer does not work properly (signal doesn't change between 0% and 100%). Use a multimeter to check the integrity of the potentiometer ( $R_{total} = \text{approx. } 1 \text{ k}\Omega$ ). Check the linear change in resistance of the potentiometer between the minimum and maximum. If the potentiometer is integral, check the wiring between the potentiometer connector (wiring side) and EDC connector pin B16, B23 and B35.	
		Power reduction. Fast idling with the throttle lever in any position.	Throttle: implausible signal between the idling switch (safety contact) and the potentiometer or throttle potentiometer disconnected	Read parameters with the diagnosis instrument to identify the defective part of the throttle (potentiometer or idling switch). a) Using a multimeter on the component, check the integrity of the idling switch (switching ON-OFF). If the switch is integral, search for a break in the wiring between the throttle connector (wiring side) and the EDC connector pin B17 and B2. b) Use a multimeter directly on the component to check the integrity of the potentiometer. If the potentiometer is integral, check the wiring between the potentiometer and the EDC connector.	

**GUIDE TO BLINK CODE DIAGNOSIS**

Blink Code	EDC light	System reactions	Possible cause	Recommended tests or action	Notes
2.1	Off	Starting may be difficult with sub-zero temperatures, greater combustion noise even with the engine warm.	Water temperature sensor shorted or shorted to ground or shorted to positive or open circuit or defective sensor.	Read measurable parameters: with this error, the water temperature read in the control unit will be fixed at 0 °C. Using a multimeter, check the integrity of the sensor (R = approx. 2.5 kOhm at 20 °C) between its pins 1 and 2. If the sensor is integral, check the wiring between the sensor connector and EDC connector pin A5 - A22.	
2.2	Off	No perceivable reaction	Air temperature sensor on intake manifold shorted or shorted to ground or shorted to positive or open circuit or defective sensor.	Read measurable parameters with the diagnosis instrument: with this error, the turbocharging air temperature will be fixed at 20 °C. Check the integrity of the sensor (R = approx. 2.5 kOhm at 20 °C) between its pins 1 and 2. If the sensor is integral, check the wiring between the sensor connector and EDC connector pin A4 - A21.	
2.3	Off	No perceivable reaction	Fuel temperature sensor shorted or shorted to ground or shorted to positive or open circuit or defective sensor.	Read measurable parameters: with this error, the fuel temperature will be fixed at 30 °C. Check the integrity of the sensor (R = approx. 2.5 kOhm at 20 °C). If the sensor is integral, check the wiring between the sensor connector and EDC connector pin A6 - A11.	
2.4	On	Power reduction	Intake air pressure sensor shorted or shorted to ground or shorted to positive or open circuit or defective sensor.	Read measurable parameters with the diagnosis instrument: with this error, the turbocharging pressure will be fixed at 1600 mbar. Using a multimeter on the component, check the supply voltage (U = 5V ± 10%) and the output voltage U about 1V at idling. Check the wiring between the sensor connector (wiring side) and EDC connector pin A12 - A17 - A23.	If the electrics are in order, verify the turbo-compressor (and waste-gate valve if present) works properly.

## GUIDE TO BLINK CODE DIAGNOSIS

Blink Code	EDC light	System reactions	Possible cause	Recommended tests or action	Notes
2.5	Off	No perceivable reaction	Ambient pressure sensor shorted or open circuit or defective sensor	Read measurable parameters with the diagnosis instrument: with this error, the ambient air pressure will be fixed at 970 mbar. The sensor is integrated in the EDC control unit and cannot be replaced separately.	Any paintwork on the engine/control unit without the due precautions may jeopardize correct ambient pressure measurement.
3.5	Off	Fast idling	Battery voltage too low	Read measurable parameters to check the supply voltage. Make the appropriate checks on the voltage regulator, batteries and charging system. If the difference between battery voltage and ECU supply voltage is high check supply wiring and components.	The voltage might not actually be too low, but recognized by the control unit as low.
5.1	On	The engine runs on 5 cylinders	Cylinder 1 injector electric shorted or circuit open	Check correct tightness to torque of the connectors on the injector solenoid valve (from 1.36 to 1.92 Nm). Check the integrity of the injector coil ( $R = 0.6 \Omega \pm 10\%$ ) and replace the injector if defective. If the coil is integral, check the wiring between the solenoid valve and EDC connector pin A24 and A35	Immediately afterwards the engine might keep on turning on 3 cylinders as the injectors are controlled by two power stages.
5.2	On	The engine runs on 5 cylinders	Cylinder 2 injector electric shorted or circuit open	Check correct tightness to torque of the connectors on the injector solenoid valve (from 1.36 to 1.92 Nm). Check the integrity of the injector coil ( $R = 0.6 \Omega \pm 10\%$ ) and replace the injector if defective. If the coil is integral, check the wiring between the solenoid valve and EDC connector pin A24 and A34	Immediately afterwards the engine might keep on turning on 3 cylinders as the injectors are controlled by two power stages.



**GUIDE TO BLINK CODE DIAGNOSIS**

Blink Code	EDC light	System reactions	Possible cause	Recommended tests or action	Notes
5.3	On	The engine runs on 5 cylinders	Cylinder 3 injector electrics shorted or circuit open	Check correct tightness to torque of the connectors on the injector solenoid valve (from 1.36 to 1.92 Nm). Check the integrity of the injector coil ( $R = 0.6 \Omega \pm 10\%$ ) and replace the injector if defective. If the coil is integral, check the wiring between the solenoid valve and EDC connector pin A24 and A33.	Immediately afterwards the engine might keep on turning on 3 cylinders as the injectors are controlled by two power stages.
5.4	On	The engine runs on 5 cylinders	Cylinder 4 injector electrics shorted or circuit open	Check correct tightness to torque of the connectors on the injector solenoid valve (from 1.36 to 1.92 Nm). Check the integrity of the injector coil ( $R = 0.6 \Omega \pm 10\%$ ) and replace the injector if defective. If the coil is integral, check the wiring between the solenoid valve and EDC connector pin A25 and A26.	Immediately afterwards the engine might keep on turning on 3 cylinders as the injectors are controlled by two power stages.
5.5	On	The engine runs on 5 cylinders	Cylinder 5 injector electrics shorted or circuit open	Check correct tightness to torque of the connectors on the injector solenoid valve (from 1.36 to 1.92 Nm). Check the integrity of the injector coil ( $R = 0.6 \Omega \pm 10\%$ ) and replace the injector if defective. If the coil is integral, check the wiring between the solenoid valve and EDC connector pin A25 and A28.	Immediately afterwards the engine might keep on turning on 3 cylinders as the injectors are controlled by two power stages.
5.6	On	The engine runs on 5 cylinders	Cylinder 6 injector electrics shorted or circuit open	Check correct tightness to torque of the connectors on the injector solenoid valve (from 1.36 to 1.92 Nm). Check the integrity of the injector coil ( $R = 0.6 \Omega \pm 10\%$ ) and replace the injector if defective. If the coil is integral, check the wiring between the solenoid valve and EDC connector pin A25 and A27.	Immediately afterwards the engine might keep on turning on 3 cylinders as the injectors are controlled by two power stages.

**GUIDE TO BLINK CODE DIAGNOSIS**

Blink Code	EDC light	System reactions	Possible cause	Recommended tests or action	Notes
6.1	On	Starting the engine takes longer than normal. Power reduction and noise increased.	Flywheel sensor: no signal or implausible signal	Check the sensor is clean and secured correctly. Check the integrity of the sensor (R = 900 $\Omega$ $\pm$ 10%) and replace it if defective. If the sensor is integral, check the wiring between the sensor and EDC connector pin A1 and A13.	The defect is not detected with the engine stationary.
6.2	On	Starting the engine takes longer than normal. Power reduction.	Camshaft sensor: no signal or implausible signal	Check the sensor is clean and secured correctly. Check the integrity of the sensor (R = 900 $\Omega$ $\pm$ 10%) and replace it if defective. If the sensor is integral, check the wiring between the sensor and EDC connector pin A2 and A14.	The defect is not detected with the engine stationary.
6.1	On with 6.2	The engine doesn't run.	Flywheel and camshaft signals electrically corrected but implausible in timing	Check the timing of phonic wheel of the camshaft.	The defect is not detected with the engine stationary. If the engine fails to start (or switches off if it was running), the phonic wheel of the camshaft might be out of step; disconnect the sensor connector to permit starting the engine (in an emergency)
6.4	Blinking	No reaction perceivable, other than the light blinking.	Observed engine overspeed.	Delete the fault memory.	
	Overspeed engine anomaly				
9.1	Blinking	The engine stops or fails to start. No diagnosis possible.	Electronic control unit fault.	Call IVECO MOTORS-FPT and follow their instructions to replace the control unit, if necessary.	Probably no diagnosis possible
9.2	On	Power reduction. Data is not saved on switching off the engine. The fault memory is lost, it is possible to read solely the current faults and not the intermittent ones that occurred previously.	EEPROM fault.	Call IVECO MOTORS-FPT and follow their instructions to replace the control unit, if necessary.	Probably no diagnosis possible
	Incorrect data in EEPROM				

**GUIDE TO BLINK CODE DIAGNOSIS**

Blink Code	EDC light	System reactions	Possible cause	Recommended tests or action	Notes
9.4	On Main relay	The control unit is not supplied and the engine stops or fails to start.	Main relay broken	Check main relay, fuse and supply wiring.	
9.4	On Main relay	The control unit is always supplied and the indicator light stays on even with the key OFF; the batteries run down	Main relay short-circuited on 30-87 leads	Try taking the EDC fuse out and putting it back in and deleting the fault memory. Check main relay, fuse and supply wiring.	Engine switches off normally with the key turned OFF.
9.5	On Wrong engine shut-down procedure	Power reduction	After-run broken off too often	Check the Main Relay, wiring and connections for an uncertain contact.	The trouble is resolved on its own when switching off correctly the next time with the key, unless there is a wiring problem or a defective relay.
9.6	On Data save in central unit not complete	Power reduction	Failure of the internal test procedure that takes place in the control unit each time the engine stops.	Delete the fault memory and try again: if the error remains, call IVECO MOTORS-FPT and follow their instructions to replace the control unit, if necessary.	The engine fails to stop in the preset time when the key is turned OFF.

**GUIDE TO SYMPTOM DIAGNOSIS**

Blink Code	Symptom	Part	Possible cause	Recommended tests or action
NO	Engine does not start	Batteries	<ul style="list-style-type: none"> <li>- Low charge</li> <li>- Faulty terminal connections</li> </ul>	<ul style="list-style-type: none"> <li>- Recharge (disconnecting system wiring)</li> <li>- Clean, check, tighten terminals or replace them</li> </ul>
NO	Engine does not start	Electrical starter motor	<ul style="list-style-type: none"> <li>- Malfunction</li> <li>- Faulty terminal connections</li> </ul>	<ul style="list-style-type: none"> <li>- Check</li> <li>- Clean, check, tighten terminals</li> </ul>
NO	Engine does not start	Main relay	<ul style="list-style-type: none"> <li>- Malfunction</li> <li>- Fuse</li> </ul>	<ul style="list-style-type: none"> <li>- Check supply wiring</li> <li>- Check main relay, replace</li> <li>- Check fuse, replace</li> </ul>
NO	Engine does not start	Fuel feed pump	<ul style="list-style-type: none"> <li>- Priming incorrect (air leaking inside)</li> </ul>	<ul style="list-style-type: none"> <li>- Check seal on intake branch</li> <li>- Check pressure</li> </ul>
NO	Engine does not start	Fuel circuit	<ul style="list-style-type: none"> <li>- Incorrect filling (air in fuel circuit)</li> </ul>	<ul style="list-style-type: none"> <li>- Check seal</li> <li>- Bleed circuit</li> </ul>
NO	Engine does not start	Fuel filter and pre-filter	<ul style="list-style-type: none"> <li>- Filter and pre-filter clogged</li> </ul>	<ul style="list-style-type: none"> <li>- Check reservoir</li> <li>- Replace</li> </ul>
NO	Engine does not start	Electrical grid heater (if present), at temperatures lower than 0 °C.	<ul style="list-style-type: none"> <li>- Malfunction</li> <li>- Faulty terminal connections</li> </ul>	<ul style="list-style-type: none"> <li>- Check supply and earth connection</li> <li>- Carry out active diagnosis</li> </ul>

**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	<ul style="list-style-type: none"> <li>- Reservoir net filter clogged</li> <li>- Fuel prefilter clogged</li> <li>- Fuel filter clogged</li> <li>- Air in fuel circuit</li> <li>- Fuel pressure too low</li> <li>- Heavy fuel leakage</li> </ul>	<ul style="list-style-type: none"> <li>- Replace clogged filters</li> <li>- Check intake seals</li> <li>- Check pressure relief valve on the fuel gear pump</li> <li>- Check the integrity of the fuel gear pump</li> </ul>
NO	Poor performance	Injectors	<ul style="list-style-type: none"> <li>- Malfunction</li> <li>- Fuel leaking from seal rings</li> </ul>	<ul style="list-style-type: none"> <li>- Check for fuel presence in engine</li> <li>- Call IVECO MOTORS-FPT and follow their instructions to replace the injectors</li> </ul>
NO	Poor performance	Air filter	<ul style="list-style-type: none"> <li>- Clogged</li> </ul>	<ul style="list-style-type: none"> <li>- Check filter clogged indicator</li> <li>- Replace filter</li> </ul>
NO	Poor performance	Gas exhaust system	<ul style="list-style-type: none"> <li>- Leaks from exhaust manifold</li> </ul>	<ul style="list-style-type: none"> <li>- Check and remove cause of leak</li> </ul>
NO	Poor performance	Turbocompressor	<ul style="list-style-type: none"> <li>- Blades inefficient</li> <li>- Bearings inefficient</li> </ul>	<ul style="list-style-type: none"> <li>- Check parts and lubrication circuit</li> <li>- Replace</li> </ul>
NO	Poor performance	Control cams	<ul style="list-style-type: none"> <li>- Wear</li> <li>- Incorrect timing</li> </ul>	<ul style="list-style-type: none"> <li>- Check, replace</li> <li>- Check, restore</li> </ul>
NO	Poor performance	Valves	<ul style="list-style-type: none"> <li>- Excessive or no clearance</li> </ul>	<ul style="list-style-type: none"> <li>- Check, restore correct clearance</li> </ul>
NO	Poor performance	Intake air pressure sensor	<ul style="list-style-type: none"> <li>- Output signal too low (below to the precise value)</li> </ul>	<ul style="list-style-type: none"> <li>- Using a multimeter on the component, check the output voltage and refer to a manometer</li> </ul>
NO	Poor performance	<ul style="list-style-type: none"> <li>- Intake air temperature sensor</li> <li>- Water temperature sensor</li> <li>- Fuel temperature sensor</li> </ul>	<ul style="list-style-type: none"> <li>- Output signal too high</li> </ul>	<ul style="list-style-type: none"> <li>- Using a multimeter on the component, check the resistance and refer to a thermomometer</li> </ul>

**GUIDE TO SYMPTOM DIAGNOSIS**

Blink Code	Symptom	Part	Possible cause	Recommended tests or action
NO	The engine emits grey-white smoke	Water in cylinders	<ul style="list-style-type: none"> <li>- Leakages from cylinder gasket</li> <li>- Leakages from injector sleeves</li> <li>- Water in intake system</li> <li>- Water in fuel</li> </ul>	<ul style="list-style-type: none"> <li>- Check level and pressurization of water circuit</li> <li>- Check fuel tank, clean as required</li> <li>- Check water in fuel sensor</li> </ul>
NO	The engine emits blue smoke	Oil in cylinders	<ul style="list-style-type: none"> <li>- Excessive oil consumption</li> <li>- Oil leaking in turbocompressor</li> <li>- Oil leaking from valve guides</li> </ul>	<ul style="list-style-type: none"> <li>- Check lubrication oil consumption</li> <li>- Overhaul</li> </ul>
NO	Engine stops	Fuel reservoir	<ul style="list-style-type: none"> <li>- Fuel reservoir empty</li> </ul>	<ul style="list-style-type: none"> <li>- Refill and bleed fuel circuit</li> </ul>
NO	Engine stops	Net filter Prefilter Fuel filter	<ul style="list-style-type: none"> <li>- Filter clogged</li> </ul>	<ul style="list-style-type: none"> <li>- Clean, replace</li> </ul>
NO	Engine stops	Fuel circuit	<ul style="list-style-type: none"> <li>- See item "Poor performance"</li> </ul>	<ul style="list-style-type: none"> <li>- See item "Poor performance"</li> </ul>
NO	Engine stops	Main relay	<ul style="list-style-type: none"> <li>- Malfunction</li> </ul>	<ul style="list-style-type: none"> <li>- Check main relay, fuse and supply wiring</li> </ul>

PAGE LEFT INTENTIONALLY BLANK



## SECTION 5

## MAINTENANCE

	Page
PERIODICITY OF CHECKS AND MAINTENANCE OPERATIONS	91
PREPARING THE ENGINE FOR LONG IDLE PERIODS	93
ENGINE'S FIRST START/RESTORING NORMAL OPERATING CONDITIONS	93

PAGE LEFT INTENTIONALLY BLANK

## PERIODICITY OF CHECKS AND MAINTENANCE OPERATIONS

Execution of the operations indicated below requires competence and compliance with the safety regulations enforced in 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 (C78 ENT M50 only)					■		■
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:

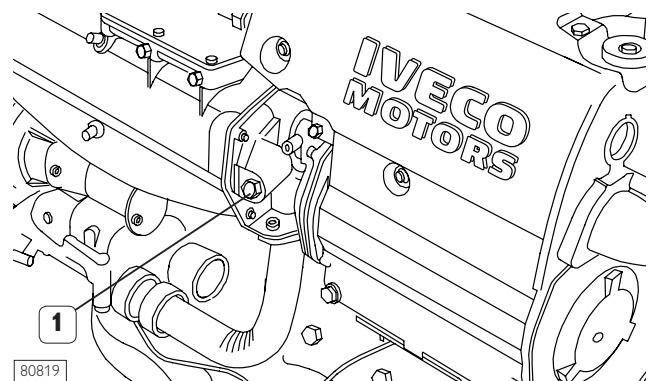
1. Drain the lubricating oil from the sump, after heating the engine;
2. Pour 30/M protective oil (alternatively, oil conforming with MIL 2160B Type 2 specifications) into the engine to the "minimum" level marked on the dipstick. Start the engine and let it run for about 5 minutes;
3. Drain the fuel 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 80 g (10 g per liter of displacement) into the turbo-compressor 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 turbo-compressor 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. Verify the quantity of cooling liquid and refill as provided by the specifications;
7. C78 ENT M55 engine: in order to enable the sea water pump priming it is necessary to input water into the forcing circuit. Remove the sacrificial 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



PAGE LEFT INTENTIONALLY BLANK

## SECTION 6

## SERVICING OPERATIONS ON INSTALLED ENGINE

	Page
FOREWORD	97
PRESCRIPTIONS FOR WORK ON THE INJECTION SYSTEM AND ITS COMPONENTS	98
REPLACING BELT	99
REPLACING EUI PUMPING UNITS	99
EUI Disassembly	99
EUI Assembly	100
Rocker arm shaft assembly	100
VENTING THE AIR FROM THE FUEL FEED LOOP	101
CLEANING THE ENGINE COOLANT/SEA WATER HEAT EXCHANGER	102
CLEANING THE AIR/SEA WATER HEAT EXCHANGER	103
ADJUSTMENTS	104
Adjusting camshaft phase	104
Checking the timing phase	106
Timing shaft phonic wheel keying	106
Flywheel sensor seat position	107
Adjusting valve clearance and EUI pump position	108
UNCOUPLING MARINE PARTS	110
Intake side	110
Exhaust side	111
INSTRUCTIONS FOR DISEMBARKING THE ENGINE	112
Handling	112

PAGE LEFT INTENTIONALLY BLANK



## FOREWORD

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

**Prescriptions and cautions** for use, handling and technical assistance are provided in Section 12.

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 "C78 ENS M20 - C78 ENT M30-M50-M55 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 MS6.2 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.

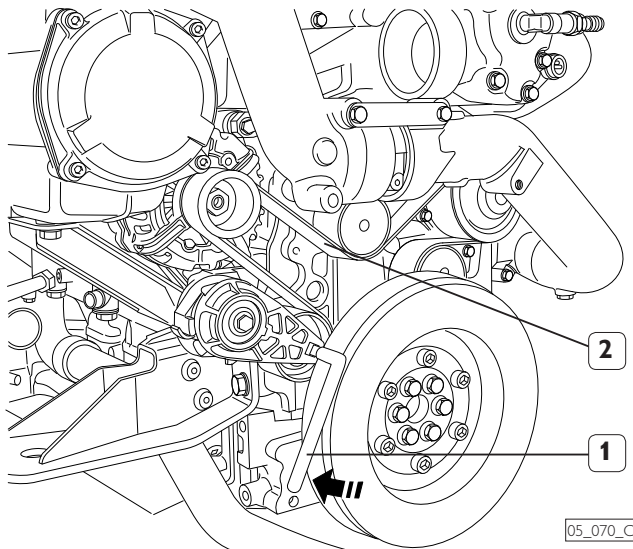
To proceed with the overhaul of the engine or its parts, you must disconnect the electrical connections of the injection system's components and of the sensors providing indications on the control panel.

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;
- Remove, if necessary, the complete electronic unit after disconnecting the multipolar connectors.

## REPLACING BELT

Figure 1

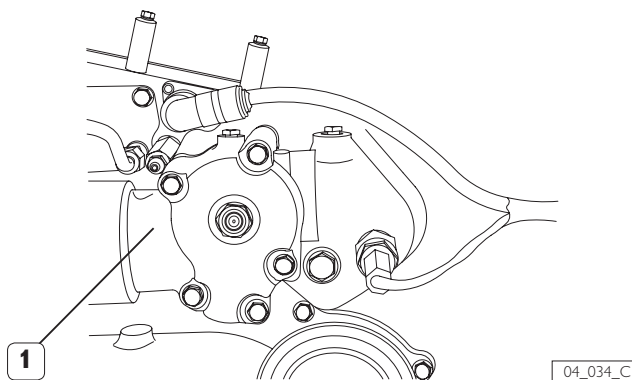


- ❑ With the tool (1) loosen the tensioning device acting in the direction indicated by the arrow. Extract the auxiliary organ drive belt (2), insert the new belt verifying that it is correctly set onto the pulleys. Release the tensioning device. The automatic tensioning device requires no further adjustment.

## REPLACING EUI PUMPING UNITS

### EUI Disassembly

Figure 2

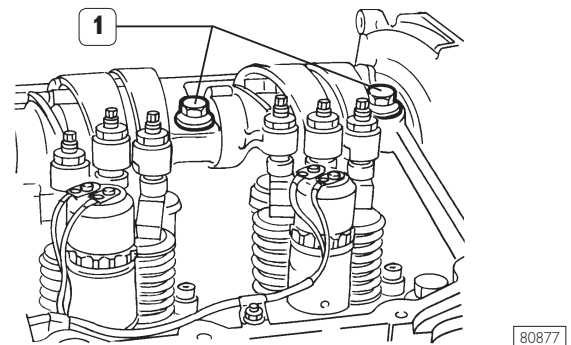


DRAINAGE CONNECTOR ON CYLINDER HEAD

## CAUTION

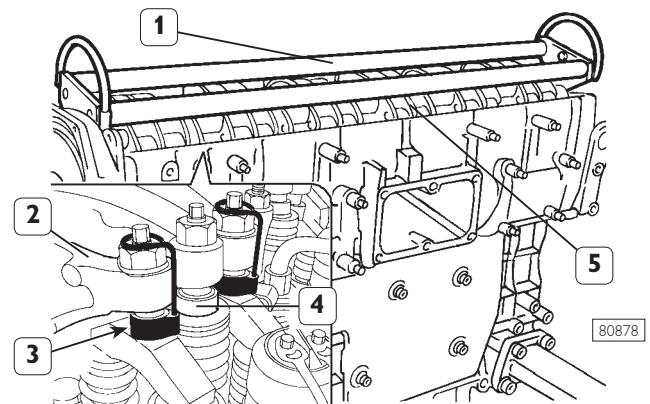
Before extracting the EUI you must empty the fuel inflow and recirculation channels machined in the cylinder head, to prevent the liquid from dripping into the underlying combustion chamber machined in the piston crown. To do so, loosen the drainage cap (1 in Figure 2) located in the front part of the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



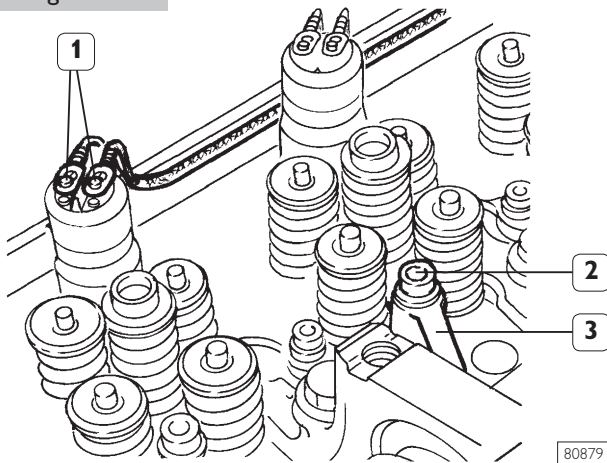
- ❑ After removing the timing lid, unscrew the rocker arm shaft fastening screws (1).

Figure 4



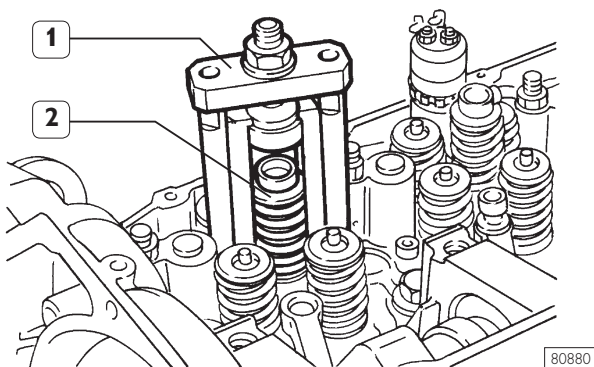
- ❑ With the tool 99360144 (3) secure the blocks (4) to the rocker arms (2);
- ❑ Apply the tool 99360553 (1) to the rocker arm shaft (5) and remove the shaft (5) from the cylinder head.

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).

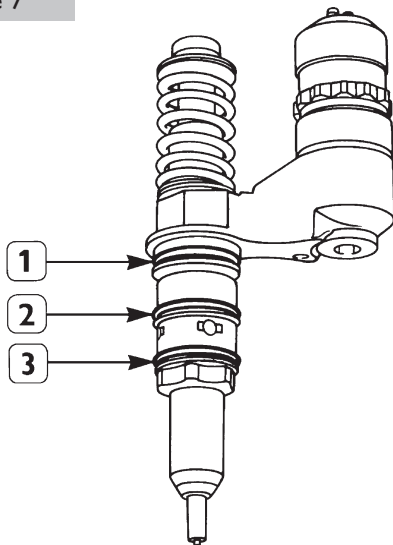
Figure 6



- ❑ Extract the injectors (2).
- If the operation is difficult, use the extractor 99342148 (1).

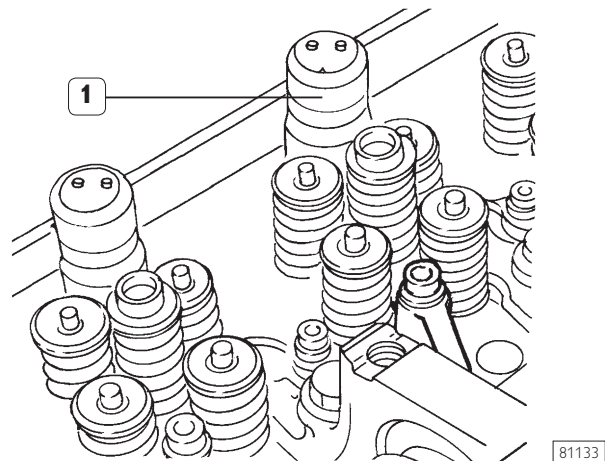
## EUI Assembly

Figure 7



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

Figure 8



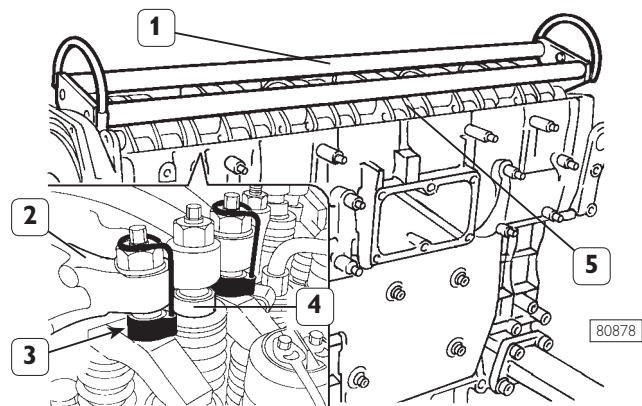
- ❑ Carefully position the injectors (1) into the seats and use a torque wrench to tighten the bracket screws at the torque of 26 Nm;
- ❑ Mount the braces on the valve stems all oriented with the larger hole on the same side.

## CAUTION

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

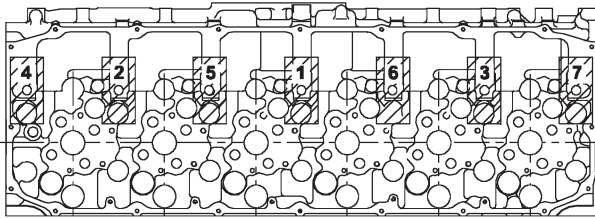
## Rocker arm shaft assembly

Figure 9



- ❑ 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 10

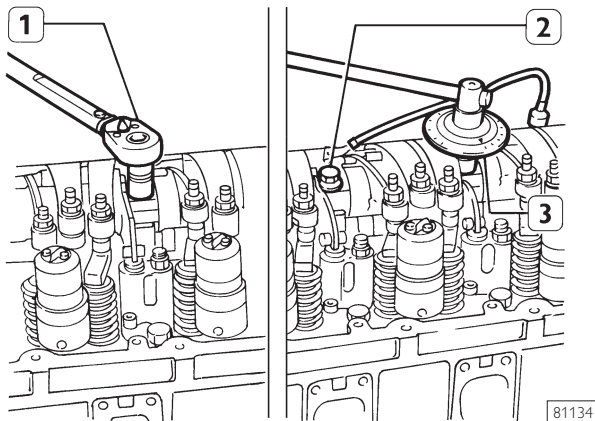


70567A

### SCHEME OF SCREWTIGHTENING 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 11

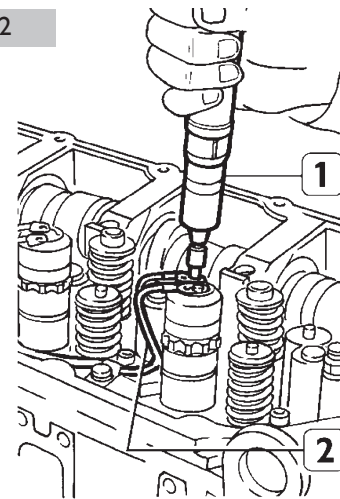


81134

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

Figure 12

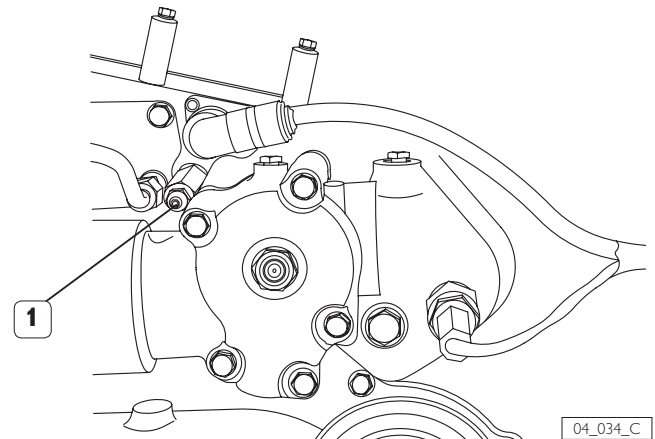


81135

- ❑ Mount the electrical wiring harness (2), fastening its terminals to the injector solenoid valves, by means of a torque screwdriver (1), at a torque of 1.36 to 1.92 Nm.

### VENTING THE AIR FROM THE FUEL FEED LOOP

Figure 13



04\_034\_C

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.

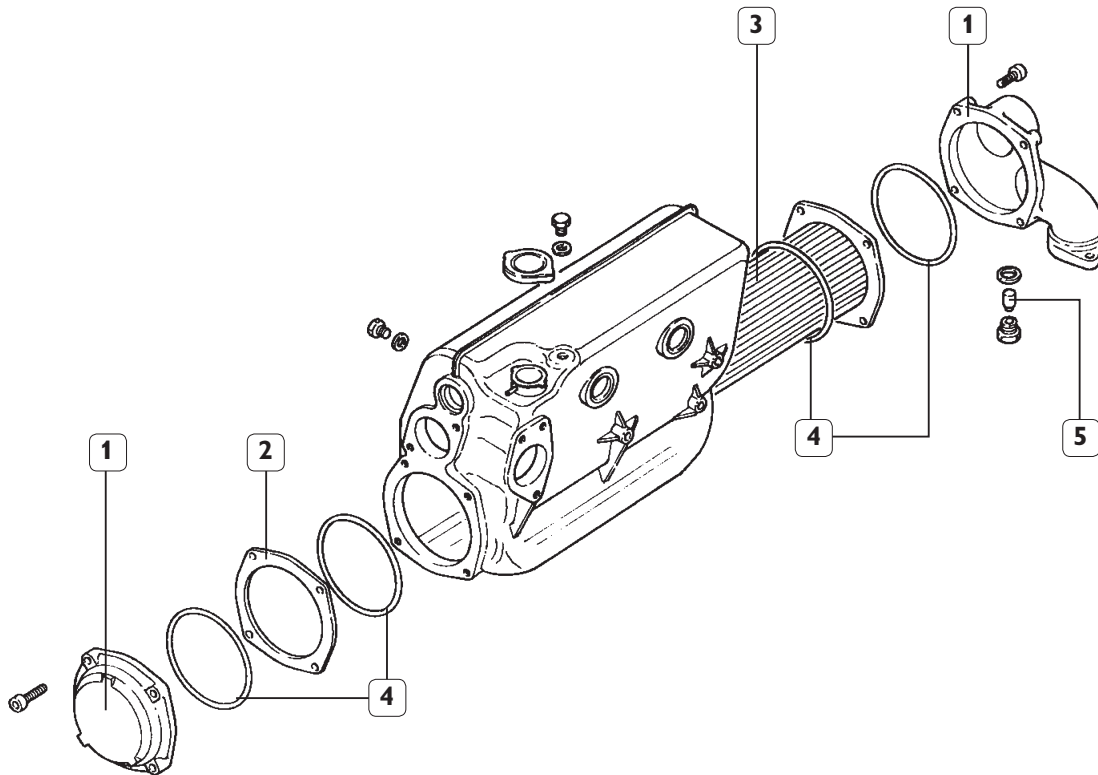
Tighten the vent fitting and complete the purge operation on the vent fitting placed on the cylinder head during the initial start-up phases.

### CAUTION

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

**CLEANING THE ENGINE COOLANT/SEA WATER HEAT EXCHANGER**

Figure 14



04\_007\_C

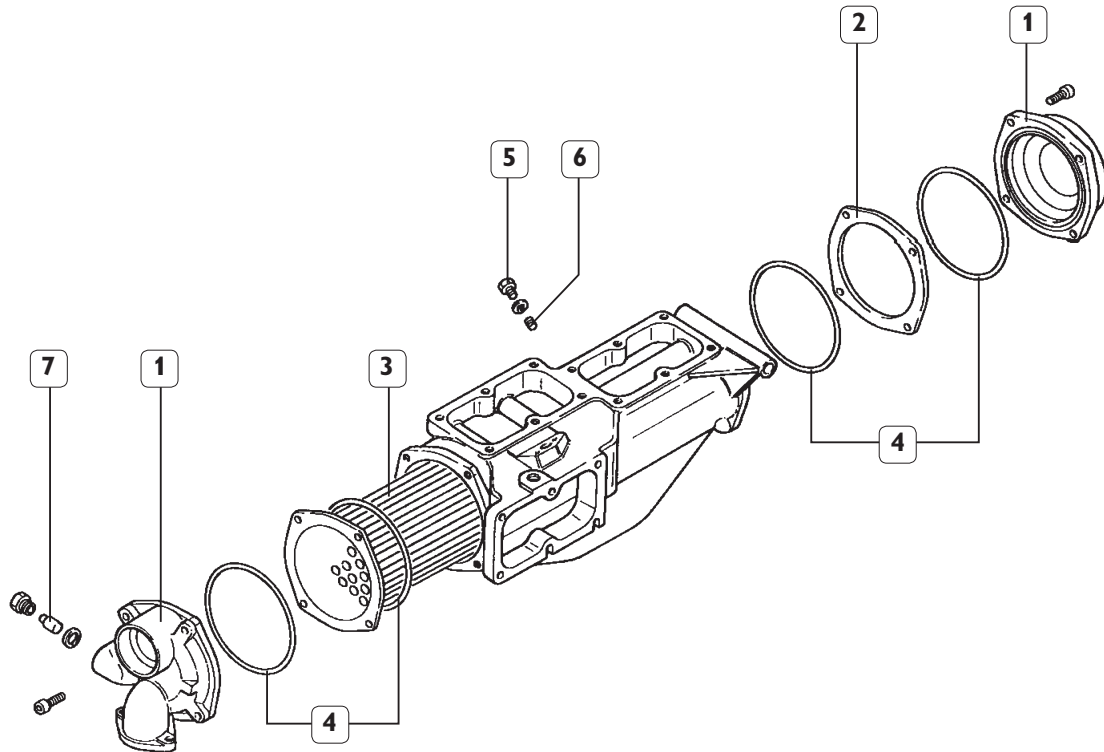
1. Cover - 2. Spacer - 3. Tube bundle - 4. Sealing rings - 5. Zinc sacrificial anode.

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 (not present on the C78 ENS M20 engine)

Figure 15



04\_008\_C

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

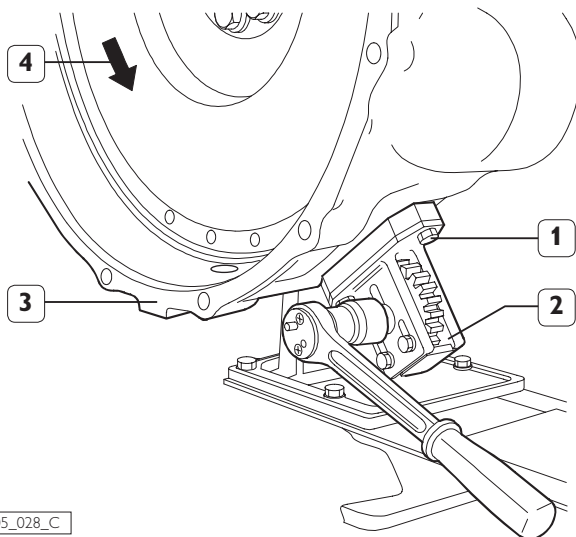
The procedure described below presumes that the initial position of the two shafts is already approximately correct.

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



05\_028\_C

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.

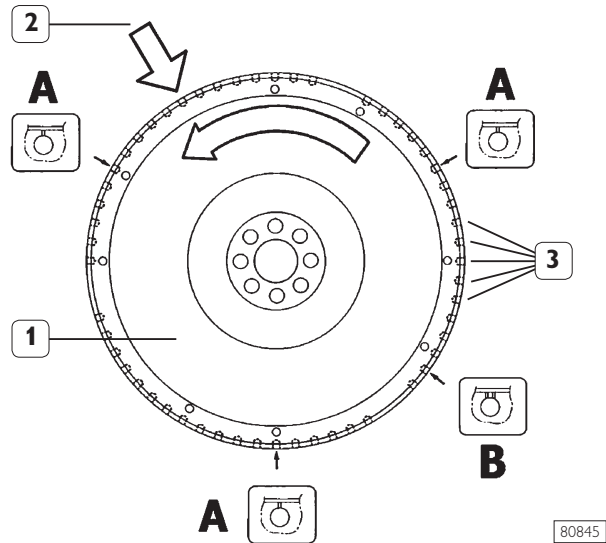
#### CAUTION

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 11<sup>th</sup> 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 3.60 mm and 3.70 mm.

Figure 17

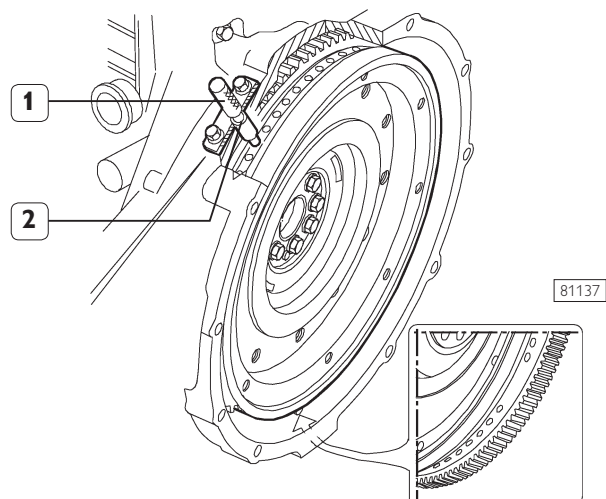


80845

- 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



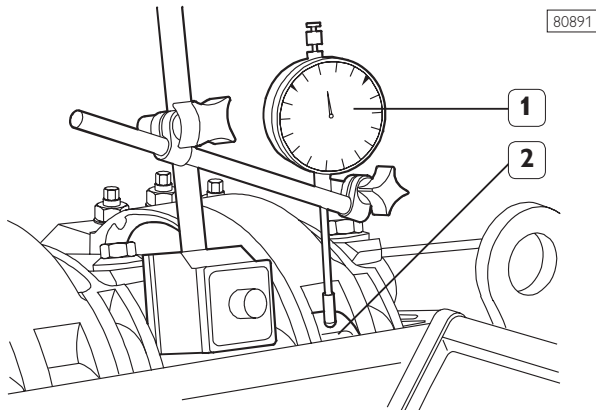
81137

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.



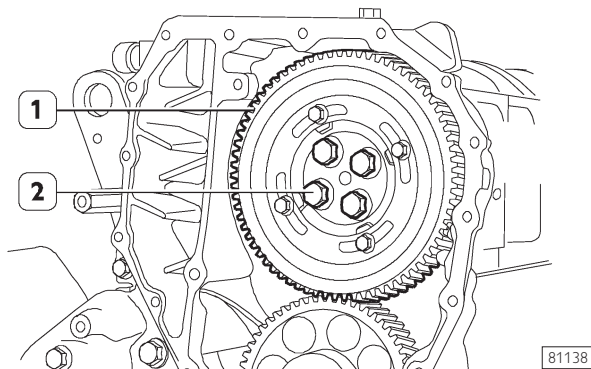
Figure 19



Phasing sequence:

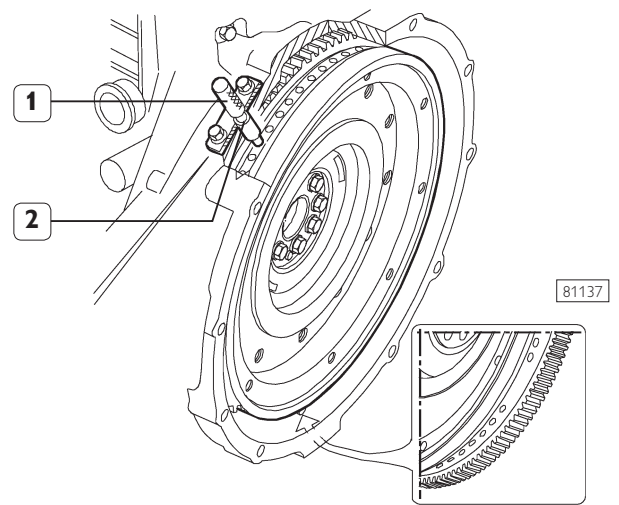
- ❑ With the tool 99360321 (2 in Figure 16) rotate the drive shaft to the position corresponding to the piston of cylinder no. 1 at compression end TDC, from the inspection port below the flywheel case you will be able to see a hole marked with a notch;
- ❑ Position a magnetic base comparator (1) on 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 3.65 mm.

Figure 20



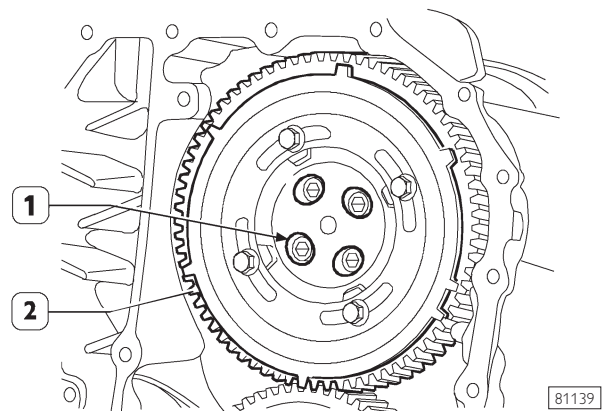
- ❑ Remove the 4 screws (2) and the gear wheel (1).

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 11<sup>th</sup> 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.

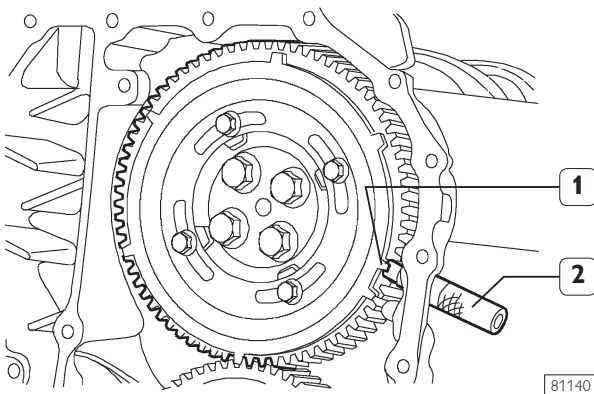
### Checking the timing phase

- ❑ 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 11<sup>th</sup> hole of the flywheel;
- ❑ The phase is correct if the height indicated by the comparator is  $3.65 \pm 0.05$  mm (between 3.60 and 3.7 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

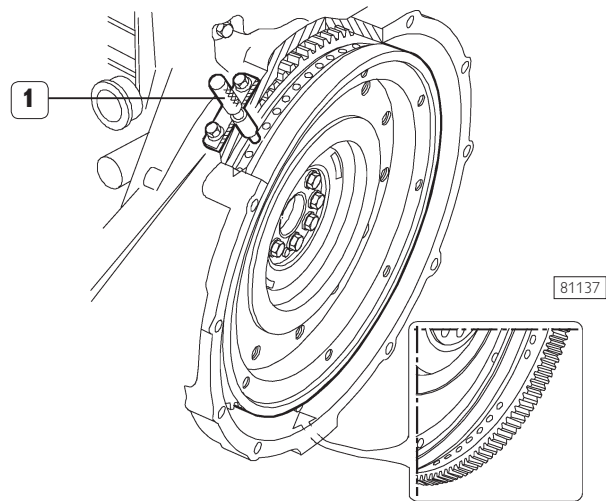


The phonic wheel of the camshaft is correctly in phase when, with the engine flywheel in angular position of 54° before compression end TDC of the piston of cylinder no. 1, the asymmetrical tooth of the phonic wheel (1) exactly coincides with the position determined by the tool 99360613 (2).

Alignment sequence:

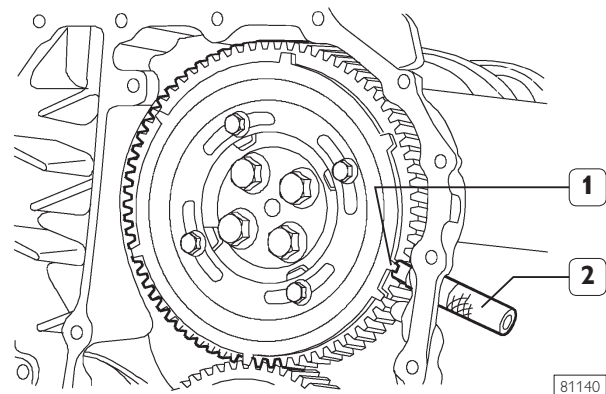
- ❑ Rotate the drive shaft to the position corresponding to the piston of cylinder no. 1 at compression end TDC;
- ❑ Rotate the drive shaft in the direction opposite normal rotation for about 90°.

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 2<sup>nd</sup> 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

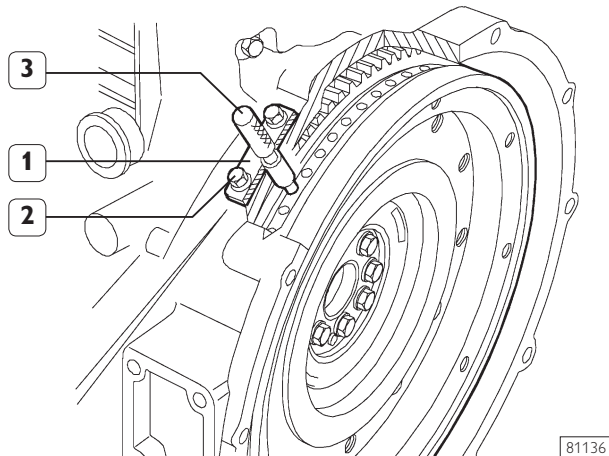


- ❑ In this position, the fork tool 99360613 (2), inserted into the seat of the camshaft sensor; must be inserted exactly into the asymmetrical tooth of the phonic wheel (1).

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.

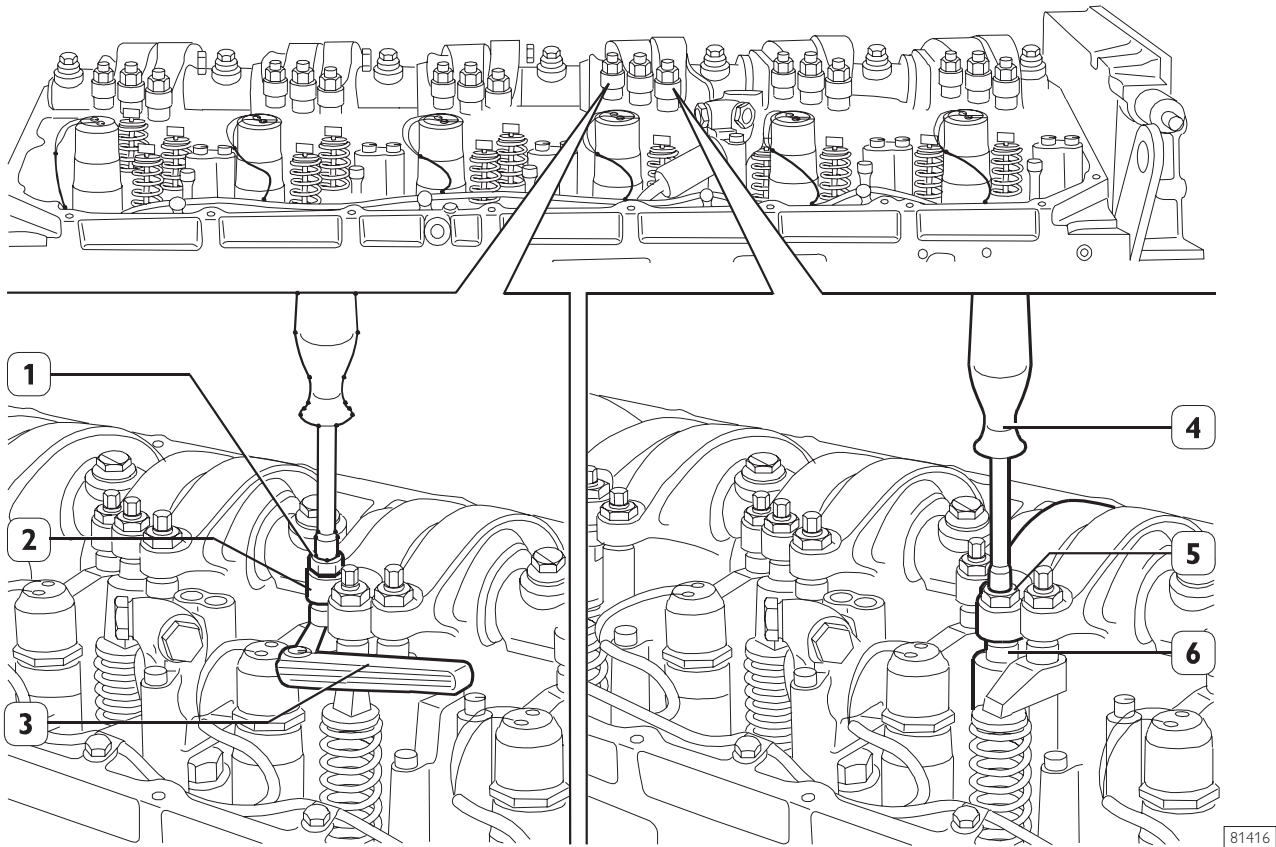
If in doubt about its proper positioning, or if you need to operate on the flywheel case or on the plate, you should adjust the position with the following procedure:

- 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.

Figure 27



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

The specified clearance value is 0,45 mm (0,40 ÷ 0,50 mm) with the engine cold, both for intake and 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

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.

81416

**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

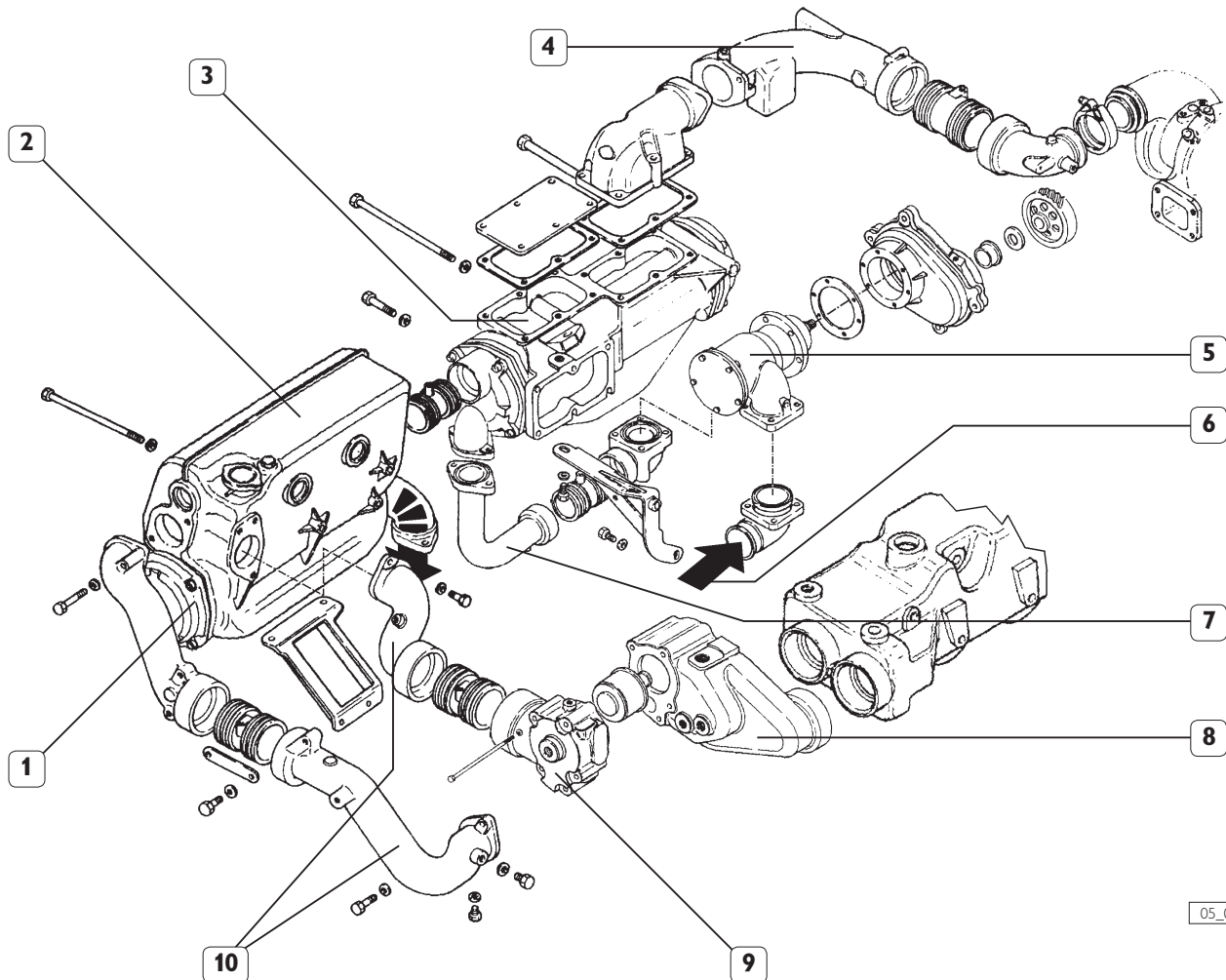
The operations described below can all be completed aboard the vessel.

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 28



05\_026\_C

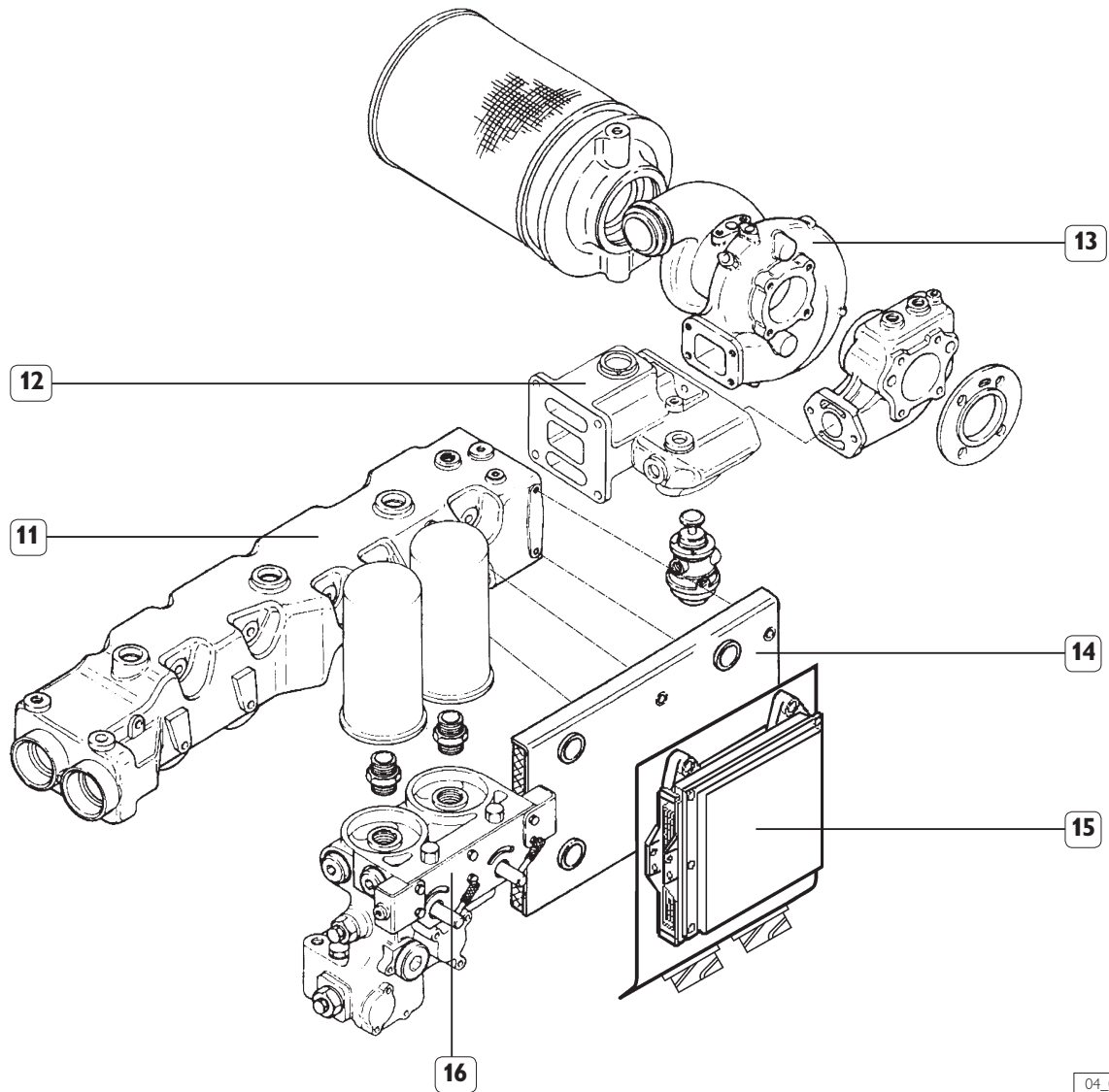
1. Sea water/engine coolant heat exchanger - 2. Coolant tank - 3. Combustion air heat exchanger (not present on the C78 ENS M20 engine) - 4. Junction lines between the turbocompressor and the combustion air heat exchanger - 5. Sea water pump - 6. Sea water inlet - 7. Sea water loop lines - 8. Cylinder 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 and remove the complete electronic unit.  
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 29



11. Cooled exhaust manifold - 12. Junction between engine exhaust manifold and turbocompressor - 13. Turbocompressor - 14 Insulated support - 15. ECU EDC - 16. 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 turbocompressor (13), the junction between exhaust manifold and turbocompressor (12) and the attached pipelines for the engine coolant and lubricating oil.

Remove ECU EDC (15) and its support (14).

Remove the support of the lubricating oil filters (16).

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

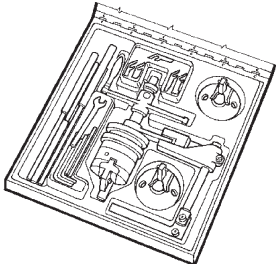
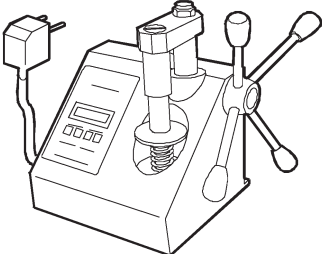
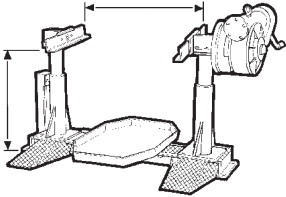
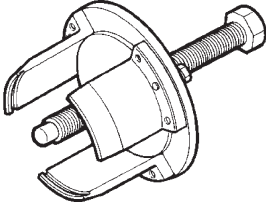
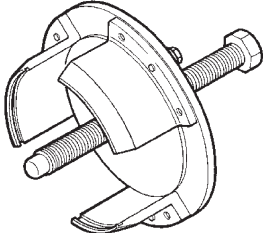
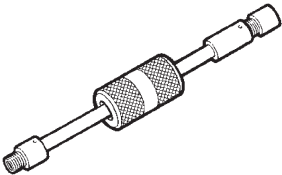
TOOLS

	Page
TOOLS	115

---

PAGE LEFT INTENTIONALLY BLANK

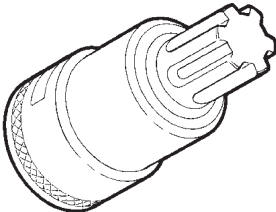
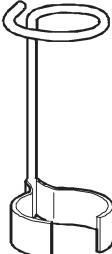
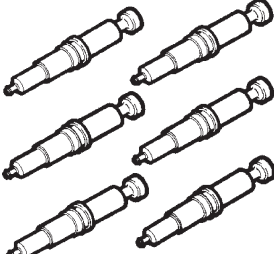
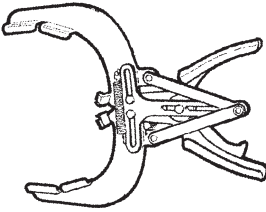
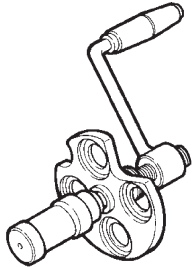
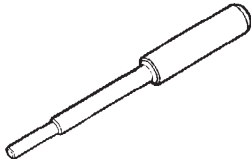
**TOOLS**

Tool No.	Description
<b>99305019</b>	Full-optional tool-kit to rectify valve seat
	
<b>99305047</b>	Equipment for spring load check
	
<b>99322230</b>	Rotary telescopic stand
	
<b>99340051</b>	Extractor for crankshaft front gasket
	
<b>99340052</b>	Extractor for crankshaft rear gasket
	
<b>99340205</b>	Percussion extractor
	

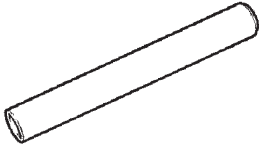
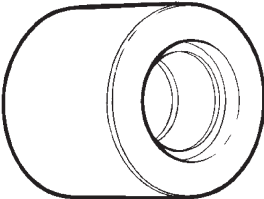
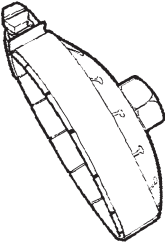
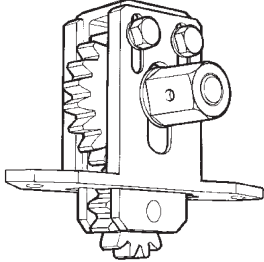
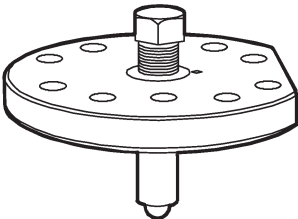
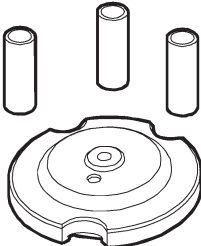
## TOOLS

Tool No.	Description
99342148	Injector extractor
99342149	Extractor for injector-holder
99346245	Tool to install the crankshaft front gasket
99346246	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

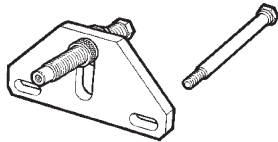
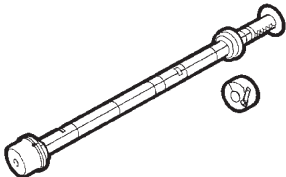
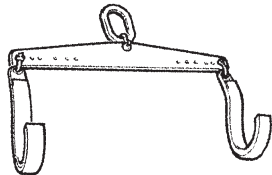

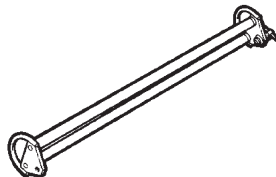
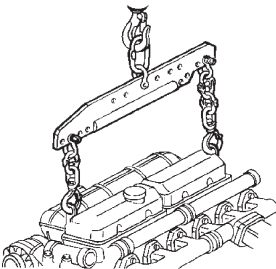
**TOOLS**

Tool No.	Description
<b>99350074</b>	Box wrench for block junction bolts to the underblock
	
<b>99360144</b>	Skid retaining tools (12+6) for rocker arm adjusting screws during rocker arm shaft removal/refitting
	
<b>99360177</b>	Injector housing plug
	
<b>99360184</b>	Pincers for removing and refitting circlips and pistons (105 - 160 mm)
	
<b>99360264</b>	Tool to take down-fit engine valves
	
<b>99360288</b>	Tool to remove valve guide
	

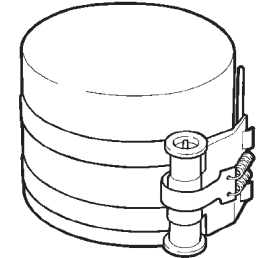
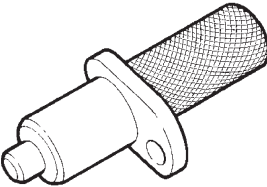
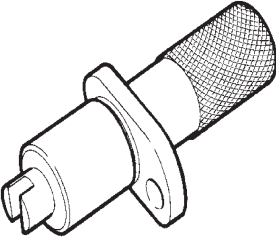
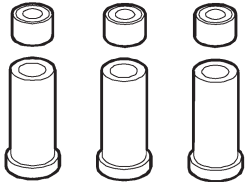
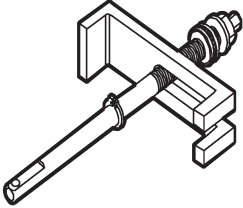
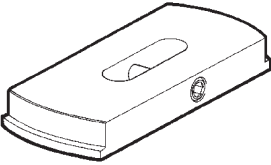
## TOOLS

Tool No.	Description
99360292	Tool to install gasket on valve guide
	
99360294	Tool to drive valve guide
	
99360314	Tool to remove cartridge filters
	
99360321	Tool to rotate engine flywheel
	
99360334	Tool for checking cylinder barrel projection
	
99360335	Cylinder barrel compression cap (to be used with 99360334)
	

**TOOLS**

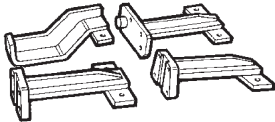
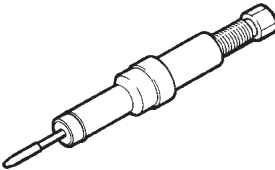
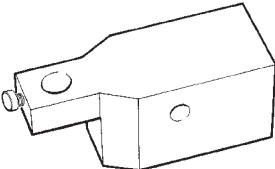
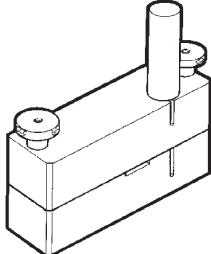
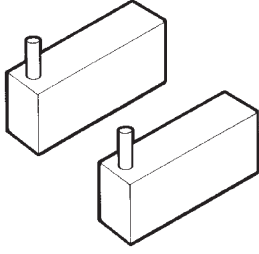
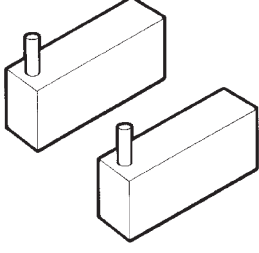
Tool No.	Description
<b>99360351</b>	Tool to stop engine flywheel
	
<b>99360487</b>	Tool to take down and fit back camshaft bushes
	
<b>99360500</b>	Tool to lift crankshaft
	
<b>99360551</b>	Bracket to take down and fit engine flywheel
	
<b>99360558</b>	Tool to lift and transport rocker shaft
	
<b>99360585</b>	Balance for lifting and handling engine
	

## TOOLS

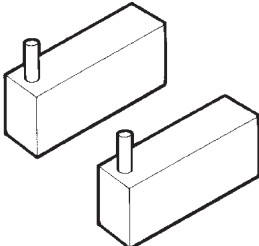
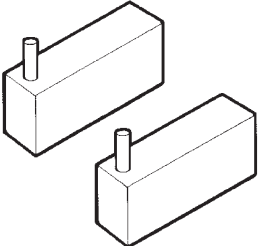
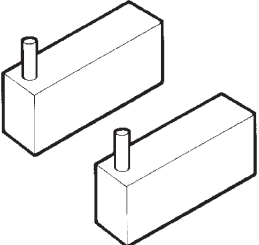
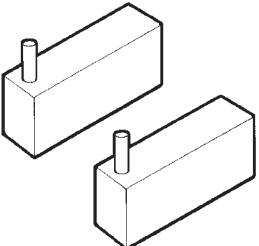
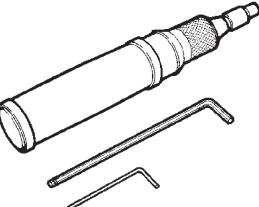
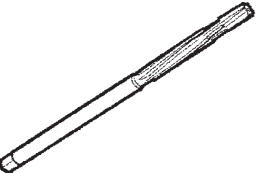
Tool No.	Description
99360605	Belt to insert piston in cylinder liner (60 - 125 mm)
	
99360612	Engine flywheel timing pin
	
99360613	Tool for timing of phonic wheel on timing gear
	
99360703	Tool to stop cylinder liners
	
99360706	Tool to extract cylinder liners
	
99360724	Tool to extract the cylinder liners (to be used with 99360723)
	



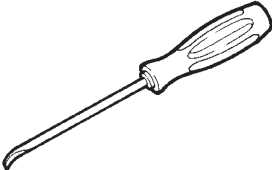
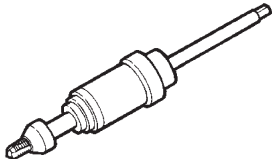
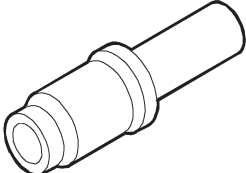
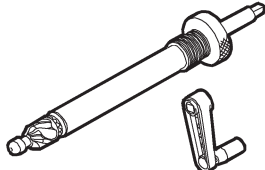
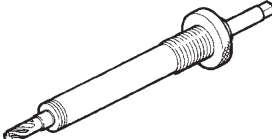
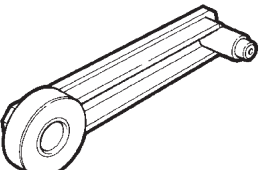
## TOOLS

Tool No.	Description	
99361035		Brackets fixing the engine to rotary stand 99322230
99365054		Tool for injector holder heading
99370415		Tool to detect cylinder liner projections (use with 99395603)
99378100		Tool for printing engine identification plates (to be used with special punches)
99378101		Punches ( <b>A</b> ) for printing engine identification plates (to be used with 99378100)
99378102		Punches ( <b>B</b> ) for printing engine identification plates (to be used with 99378100)

## TOOLS

Tool No.	Description
99378103	Punches ( <b>C</b> ) for printing engine identification plates (to be used with 99378100)
	
99378104	Punches ( <b>D</b> ) for printing engine identification plates (to be used with 99378100)
	
99378105	Punches ( <b>E</b> ) for printing engine identification plates (to be used with 99378100)
	
99378106	Punches ( <b>F</b> ) for printing engine identification plates (to be used with 99378100)
	
99389834	Dynamometric screwdriver to calibrate screws for injector solenoid valve
	
99390310	Valve guide sleeker
	

**TOOLS**

Tool No.	Description
<b>99390772</b>	Tool to remove residues from injector holder
	
<b>99390804</b>	Tool to thread injector holders to be extracted
	
<b>99394014</b>	Guide bush (to be used with 99394041 or 99394043)
	
<b>99394041</b>	Cutter to rectify injector holder housing (to be used with 99394015)
	
<b>99394043</b>	Reamer to rectify injector holder lower side (to be used with 99394015)
	
<b>99395215</b>	Gauge for centre distance check between camshaft and idle gear
	

## TOOLS

Tool No.	Description
99395216	Measuring pair for angular tightening with 1/2" and 3/4" square couplings
99395363	Complete square to check connecting rod squaring
99395603	Dial gauge (0 - 5 mm)
99395687	Reaming gauge (50 - 178 mm)
99396033	Centering ring of crankshaft front cap
8093731	Tester PT-01

## SECTION 8

## OVERHAUL

	Page
Graph and symbols	127
GENERAL CHARACTERISTICS	128
ASSEMBLY CLEARANCE DATA	129
TIGHTENING TORQUES	135
TIGHTENING ORDERS	138
ENGINE DISASSEMBLY AT THE BENCH	142
CYLINDER BLOCK	147
Checks and measurements	147
CYLINDER LINERS	148
Replacing cylinder liners - Removal	149
Fitting and checking protrusion	149
CRANKSHAFT	150
Measuring main journals and crankpins	151
PRELIMINARY MEASUREMENT OF MAIN AND BIG END BEARING SHELL SELECTION DATA	152
Selecting the main and big end bearing shells	153
Replacing the timing control gear and the oil pump	159
Checking main journal installation clearance	159
Checking crankshaft end float	160
PISTON CONNECTING ROD ASSEMBLY	161
Removal	161
Measuring the diameter of the pistons	162
Conditions for correct gudgeon pin-piston coupling	162
Piston C78 ENS M20 - C78 ENT M30	163
Piston C78 ENT M50-M55	164
Piston rings	165

(cont.)

## Page

CONNECTING ROD	166	Rockers	181
Checking connecting rod alignment	167	LUBRICATION SYSTEM COMPONENTS	182
Mounting the connecting rod-piston assembly	167	Oil pump	182
Mounting the piston rings	167	Overpressure valve	182
Fitting the connecting rod-piston assembly into the piston liners	168	Oil pressure control valve	182
Piston protrusion check	168	Heat exchanger	183
CYLINDER HEAD	169	Filter by-pass valve	184
Valve removal	169	Thermostatic valve	184
Checking the planarity of the head on the cylinder block	169	Oil filter	184
VALVES	170	COOLING SYSTEM COMPONENTS	185
Valve guides	170	Water pump	185
REPLACING INJECTOR HOLDER CASES	171	Thermostatic valve	185
Removal	171	FUEL FEED COMPONENTS	186
Mounting	172	Fuel feed	186
Checking protrusion of injectors	173	Injector-pump	186
TIMING GEAR	174	ASSEMBLING THE ENGINE ON THE BENCH	187
Camshaft drive	174	Diagram showing the underblock fixing screws tightening order	189
Intermediate gear pin	174	Fitting the connecting rod-piston assembly into the cylinder liners	190
Idler gear	174	Piston protrusion check	190
Twin idler gear	174	ENGINE FLYWHEEL	193
Replacing the bushings	174	FITTING CAMSHAFT	194
Checking cam lift and pin alignment	175	EUI Assembly	195
Camshaft	176	Rocker arm shaft assembly	195
BUSHES	177	Adjusting camshaft phase	196
Removal	178	Checking the timing phase	196
Assembly	178	Timing shaft phonic wheel keying	196
VALVE SPRINGS	180	Adjusting valve clearance and EUI pump position	196
Fitting the valves and oil seal ring	180	ENGINE COMPLETION	197
ROCKER SHAFT	181		
Shaft	181		

**Graph and symbols**

Surface for machining  
Machine finish



Interference  
Strained assembly



Thickness  
Clearance



Intake



Exhaust



Operation



Compression ratio



Preload



Oversized  
Higher than ...  
Maximum, peak



Undersized  
Less than ...  
Minimum

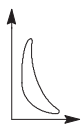
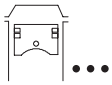

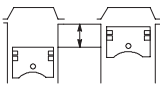
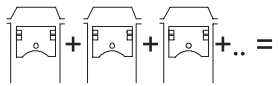
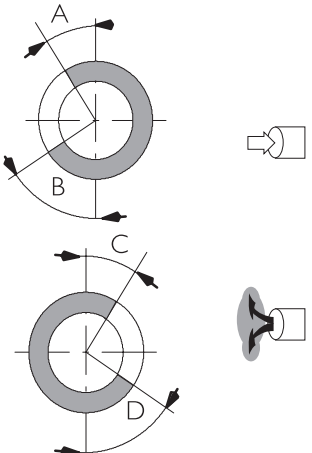
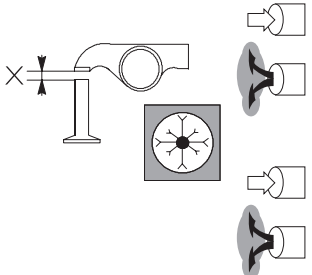


Selection  
Classes  
Oversizing



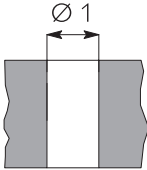
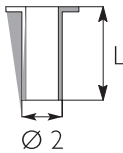


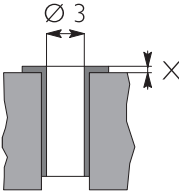
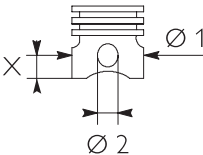


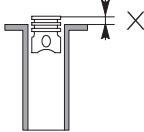
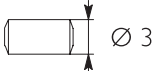

Replacement  
Original spare parts

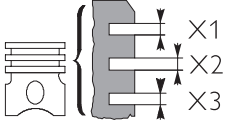
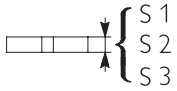


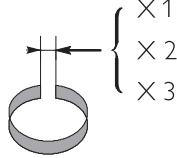
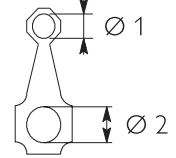
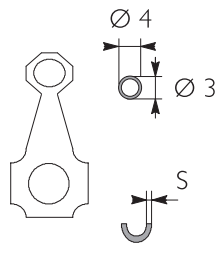



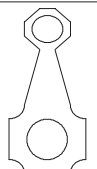
## GENERAL CHARACTERISTICS

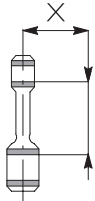
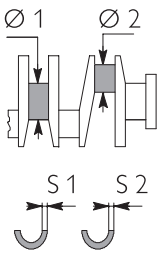
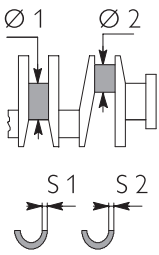
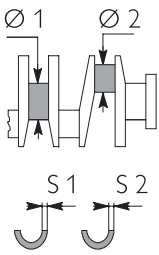
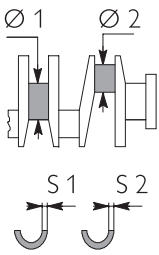
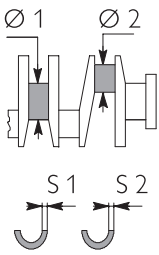
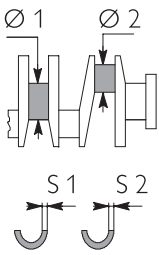
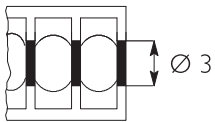
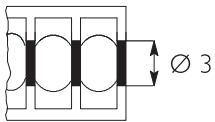


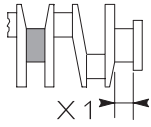
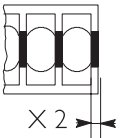
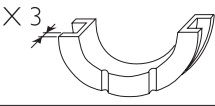

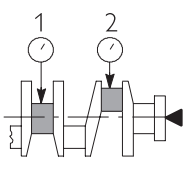
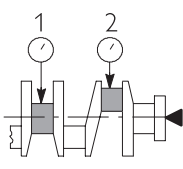
Engine		C78 ENS M20 C78 ENT M30	C78 ENT M50	C78 ENT M55
<b>mm</b>				
	Cycle	Diesel 4 strokes		
	Air feeding	Turbocharged with aftercooler		
	Injection	Direct		
	N. of cylinders	6 in-line		
	Diameter	mm	115	115
	Stroke	mm	125	
	Total displacement	cm <sup>3</sup>	7790	
<b>e</b>	Compression ratio		16,5 ± 0,8 : 1	16 ± 0,8 : 1
	<b>Valve timing</b>			
	opens before TDC	A		17°
	closes after BDC	B		31°
	opens before BDC	D		48°
	closes after TDC	C		9°
	For timing check			
		X	{ mm	-
			{ mm	-
	Running			
		X	{ mm	0.40 to 0.50
			{ mm	0.40 to 0.50

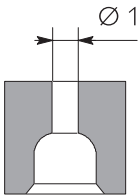
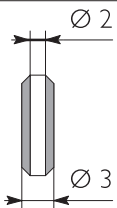


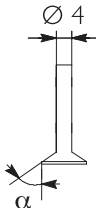



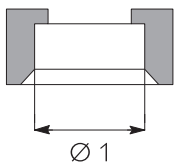


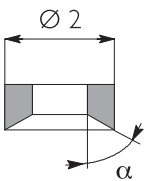


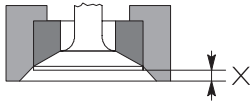







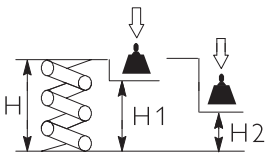
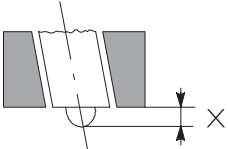
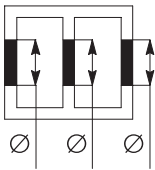
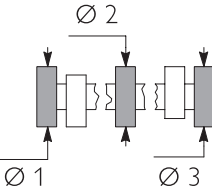
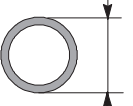
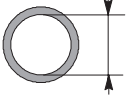




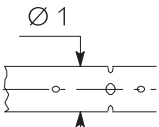
## ASSEMBLY CLEARANCE DATA

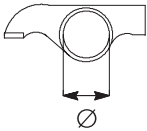

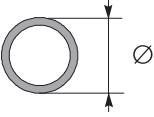

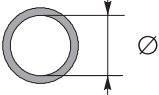




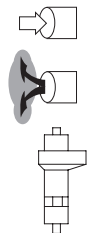
Engine	C78 ENS M20 C78 ENT M30	C78 ENT M50	C78 ENT M55
Cylinder block and crank mechanism components		mm	
	Cylinder sleeve bore  Ø 1	upper lower	130.200 to 130.225 128.510 to 128.535
	Cylinder liners: outer diameter:  Ø 2 length L	upper lower L	130.161 to 130.186 128.475 to 128.500 -
	Cylinder sleeve - crankcase bore:	upper lower	0.014 to 0.064 0.010 to 0.060
	Outside diameter	Ø 2	-
	Cylinder sleeve  inside diameter Protrusion  * Available dia. class	A* Ø 3 B* X	115.000 to 115.012 115.010 to 115.022 0.035 to 0.065
	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	18 114.888 to 114.900 114.898 to 114.910 46.010 to 46.016
	Piston - cylinder sleeve		0.100 to 0.124
	Piston diameter	Ø 1	-
	Pistons protrusion	X	0.32 to 0.69
	Gudgeon pin	Ø 3	45.994 to 46.000
	Gudgeon pin - pin housing		0.010 to 0.024

Engine		C78 ENS M20 C78 ENT M30	C78 ENT M50	C78 ENT M55
mm				
	Piston ring grooves X1 X2 X3 * Measured on Ø of 112 mm	2,71 to 2,74 2,55 to 2,57	3,10 to 3,12 2,56 to 2,58 4.02 to 4.04	
	Piston rings: trapezoidal seal S1* lune seal S2 milled scraper ring with slits and internal spring S3 * Measured on Ø of 112 mm	2,575 to 2,595 2,470 to 2,490	3,000 2,470 to 2,500 3.975 to 3.990	
	Piston rings - grooves 1 2 3	0,115 to 0,165 0,070 to 0,96	0,100 to 0,120 0,060 to 0,100 0.030 to 0.065	
	Piston rings		-	
	Piston ring end gap in cylinder liners: X1 X2 X3	X1 X2 X3	0.35 to 0.50 0.70 to 0.96 0.30 to 0.60	
	Small end bush housing Ø 1 Big end bearing housing Ø 2 Selection classes Ø 2 1 2 3	Rated value	49.975 to 50.000 77.000 to 77.030 77.000 to 77.010 77.011 to 77.020 77.021 to 77.030	
	Small end bush diameter outside Ø 4 inside Ø 3 Big end bearing shell S Red Green Yellow * * Fitted in production only and not supplied as spares	Ø 4 Ø 3	50.055 to 50.080 46.015 to 46.030 2.000 to 2.010 2.011 to 2.020 2.021 to 2.030	
	Small end bush - housing		0.055 to 0.105	
	Piston pin - bush		0.015 to 0.036	
	Big end bearing shells		0.127 - 0.254 - 0.508	
	Connecting rod weight Class A B C	A B C	g. 2890 to 2920 g. 2921 to 2950 g. 2951 to 2980	

Engine		C78 ENS M20 C78 ENT M30	C78 ENT M50	C78 ENT M55
mm				
	Measuring dimension	X	125	
	Max. connecting rod axis misalignment tolerance	=	0.08	
	Main journals	∅ 1	Rated value	82.910 to 82.940
	Selection class	$\left\{ \begin{array}{l} 1 \\ 2 \\ 3 \end{array} \right.$		82.910 to 82.919
	Crankpins	∅ 2	Rated value	82.920 to 82.929
	Selection class	$\left\{ \begin{array}{l} 1 \\ 2 \\ 3 \end{array} \right.$		82.930 to 82.940
	Main bearing shells	S1		72.915 to 72.945
	Red			72.915 to 72.924
	Green			72.925 to 72.934
	Yellow *			72.935 to 72.945
	Big end bearing shells	S2		3.000 to 3.010
	Red			3.011 to 3.020
	Green			3.021 to 3.030
	Yellow *			
* Fitted in production only and not supplied as spares				
	Main bearing housings	∅ 3	Rated value	89.000 to 89.030
	Selection class	$\left\{ \begin{array}{l} 1 \\ 2 \\ 3 \end{array} \right.$		89.000 to 89.009
				89.010 to 89.019
				89.020 to 89.030
	Bearing shells - main journals			0.040 to 0.098
	Bearing shells - big ends			0.035 to 0.093
	Main bearing shells			0.127 - 0.254 - 0.508
	Big end bearing shells			0.127 - 0.254 - 0.508
	Main journal, thrust bearing	X1		39.96 to 40.04
	Main bearing housing, thrust bearing	X2		32.94 to 32.99
	Thrust washer halves	X3		3.38 to 3.43
	Driving shaft shoulder			0.11 to 0.34
	Alignment	1		≤ 0.05
	Ovality	$\left\{ \begin{array}{l} \parallel \\ \circ \end{array} \right.$	2	-
	Taper	$\left\{ \begin{array}{l} \parallel \\ \circ \end{array} \right.$	1 - 2	0.010
			1 - 2	0.010

Engine	C78 ENS M20 C78 ENT M30	C78 ENT M50	C78 ENT M55
<b>Cylinder heads - valve train</b>			<b>mm</b>
 <p>Valve guide housings in cylinder head</p>	Ø 1	12.980 to 12.997	
 <p>Valve guide</p>	Ø 2 Ø 3	8.023 to 8.038 13.012 to 13.025	
 <p>Valve guides - housings in the cylinder heads</p>		0.015 to 0.045	
 <p>Valve guide</p>		-	
 <p>Valves:</p>	 Ø 4 α  Ø 4 α	7.970 to 7.985 60° 30' ± 7' 30'' 7.970 to 7.985 45° 30' ± 7' 30''	
 <p>Valve stem and its guide</p>		0.038 to 0.068	
 <p>Housing in head for valve seat:</p>	 Ø 1  Ø 1	41.985 to 42.020 40.985 to 41.020	
 <p>Outside diameter of valve seat; angle of valve seat in cylinder head:</p>	 Ø 2 α  Ø 2 α	42.060 to 42.075 60° - 30' 41.060 to 41.075 45° - 30'	
 <p>Recessing of valve</p>	 X  X	0.5 to 0.8 1.6 to 1.9	
 <p>Between valve seat and head</p>	 	0.040 to 0.090	

Engine	C78 ENS M20 C78 ENT M30	C78 ENT M50	C78 ENT M55
 <p>Valve outside spring height:</p> <p>free height H</p> <p>under a load of: N 454 ± 22 H1 N 840 ± 42 H2</p>		mm	
 <p>Injector protrusion X</p>		0.7	
 <p>Camshaft bush housing fitted in the cylinder head:</p> <p>1 → 7 Ø</p>		80.000 to 80.030	
 <p>Camshaft journal diameter:</p> <p>1 → 7 Ø</p>		75.924 to 75.940	
 <p>Camshaft bushing outer diameter Ø</p>		80.090 to 80.115	
 <p>Camshaft bushing inner diameter Ø</p>		75.990 to 76.045	
 <p>Bushings and housings in engine block</p>		0.060 to 0.115	
 <p>Bushings and journals</p>		0.050 to 0.121	
 <p>Cam lift:</p>		8.07 7.63 8.80 to 8.82	
 <p>Rocker shaft Ø 1</p>		37.984 to 38.000	

Engine	C78 ENS M20 C78 ENT M30	C78 ENT M50	C78 ENT M55
mm			
<p data-bbox="453 380 624 436">Bushing housing in rocker arms:</p>  		<p data-bbox="1015 470 1203 499">41.000 to 41.016</p> <p data-bbox="1015 527 1203 556">41.000 to 41.016</p> <p data-bbox="1015 611 1203 640">42.000 to 42.016</p>	
<p data-bbox="453 709 703 766">Bushing outer diameter for rocker arms:</p>  		<p data-bbox="1015 793 1203 823">41.097 to 41.135</p> <p data-bbox="1015 850 1203 879">41.097 to 41.135</p> <p data-bbox="1015 934 1203 963">42.066 to 42.091</p>	
<p data-bbox="453 1045 703 1102">Bushing inner diameter for rocker arms:</p>  		<p data-bbox="1015 1121 1203 1150">38.025 to 38.041</p> <p data-bbox="1015 1178 1203 1207">38.025 to 38.041</p> <p data-bbox="1015 1262 1203 1291">38.015 to 38.071</p>	
<p data-bbox="453 1381 651 1438">Between bushings and housings:</p>  		<p data-bbox="1027 1451 1187 1480">0.081 to 0.135</p> <p data-bbox="1027 1507 1187 1537">0.081 to 0.135</p> <p data-bbox="1027 1591 1187 1621">0.050 to 0.091</p>	
<p data-bbox="453 1717 687 1774">Between rocker arms and shaft:</p>  		<p data-bbox="1027 1774 1187 1803">0.025 to 0.057</p> <p data-bbox="1027 1831 1187 1860">0.025 to 0.057</p> <p data-bbox="1027 1915 1187 1944">0.015 to 0.087</p>	

**TIGHTENING TORQUES**

Part	Torque	
	Nm	kgm
Capscrews, undercrankcase to crankcase (see fig. 1): ◆		
Outside screws M10x1.25	25	2.5
Inner screws M 16x2	140	14
Inner screws		60°
Inner screws		60°
Outer screws		90°
Piston cooling nozzle union ◆	35 ± 2	3.5 ± 0.2
Heat exchanger fixing screws to the block: (see fig. 7) ◆		
	11.5 ± 3.5	1.15 ± 0.35
	19 ± 3	1.9 ± 0.3
Spacer and oil sump fixing screws (see fig. 8) ◆	50	5
Gearbox fixing screws to the block:		
M 10x1.5	41.5 ± 3.5	4.15 ± 0.35
M 12x1.75	63 ± 7	6.3 ± 0.7
Cylinder head fixing screws (see fig. 2): ◆		
First phase	50	5
Second phase	100	10
Third phase		90°
Fourth phase		60°
Rocker shaft fixing screws (see fig. 3): ◆		
First phase	40	4
Second phase		60°
Lock nut for rocker adjustment screw ◆	39 ± 5	3.9 ± 0.5
Injector blocking brackets screws ◆	36.5	3.65
Shoulder plate fixing bolts to head ◆	23.5	2.35
Engine support bracket fastening screws to cylinder head	74 ± 8	7.4 ± 0.8
Camshaft gear fixing screws: ◆		
First phase	50	5
Second phase		50°
Phonic wheel fastening screws to distribution gear	8.5 ± 1.5	0.85 ± 0.15
Exhaust manifold fixing screws (see fig. 4): ▲		
	40	4
	55	5.5
Connecting rod cap fixing screws: ◆		
First phase	50	5
Second phase		40°

◆ Lubricate with Molykote oil before installation

▲ Lubricate with graphitized oil before installation

**TIGHTENING TORQUES**

Part	Torque	
	Nm	kgm
Engine flywheel fixing screws M16x1.5x58: ◆		
First phase	100	10
Second phase		60°
Engine flywheel fixing screws M16x1.5x110: ◆		
First phase	100	10
Second phase		120°
Damping flywheel fixing screws: ◆	115 ± 15	11.5 ± 1.5
Intermediate gear pin fixing screws: Intermediate ◆		
First phase	30	3
Second phase		90°
Idle gear link rod fastening screw	24.5 ± 2.5	2.4 ± 0.2
Oil pump fastening screw	24.5 ± 2.5	2.4 ± 0.2
Oil pump suction rose fastening screw	24.5 ± 2.5	2.4 ± 0.2
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	24.5 ± 2.5	2.4 ± 0.2
Pulley fastening screw to hub		
First phase	70	7
Second phase		50°
Rocker cap fixing screws (see fig. 9)	9	0.9
Thermostat box fastening screws to cylinder head	24.5 ± 2.5	2.4 ± 0.2
Automatic tightener fastening screws to cylinder block	45 ± 5	4.5 ± 0.5
Fixed tightener fastening screws to cylinder block	105 ± 5	10.5 ± 0.5
Fan support fastening screws to cylinder block	24.5 ± 2.5	2.4 ± 0.2
Starter fastening screws	44 ± 4	4 ± 0.4
Alternator support fastening screw to cylinder block	44 ± 4	4.4 ± 0.4
Alternator bracket fastening screw to cylinder block	24.5 ± 2.5	2.4 ± 0.2
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 Molykote oil before installation

▲ Lubricate with graphitized oil before installation



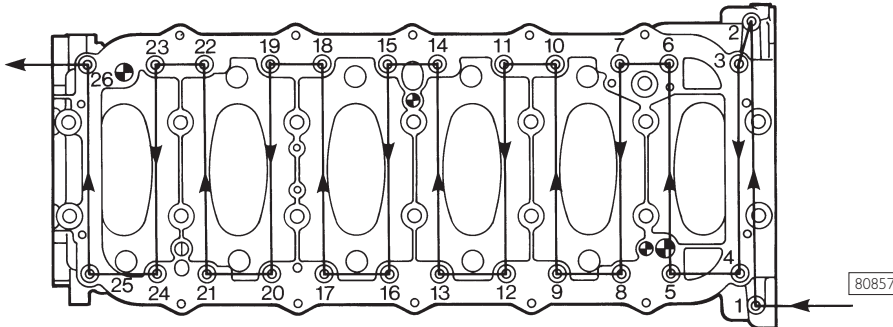
**TIGHTENING TORQUES**

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

**Underblock fixing screws tightening order**

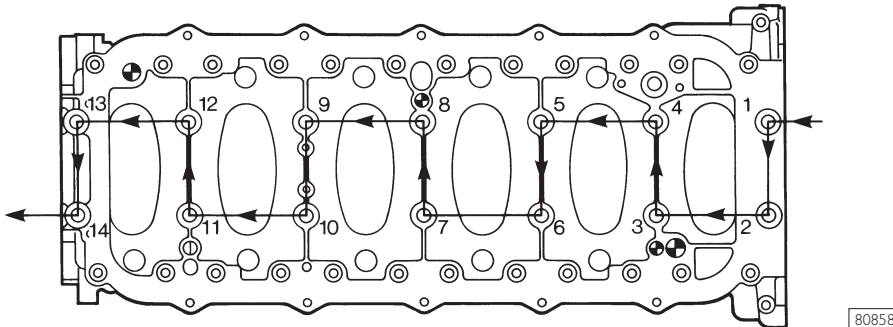
Figure 1

FRONT SIDE



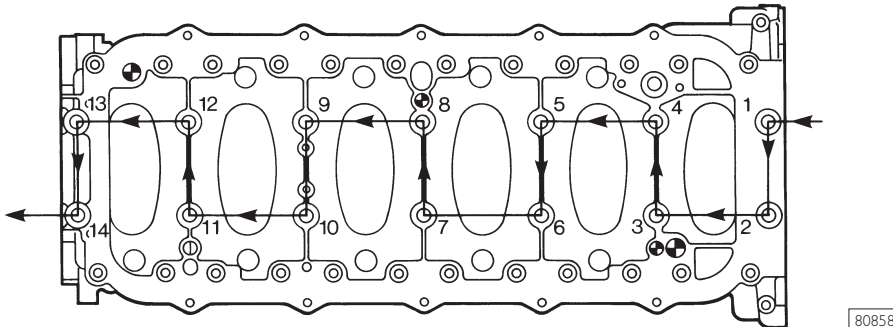
First phase:  
preliminary tightening  
of outer screws  
(25 Nm)

FRONT SIDE



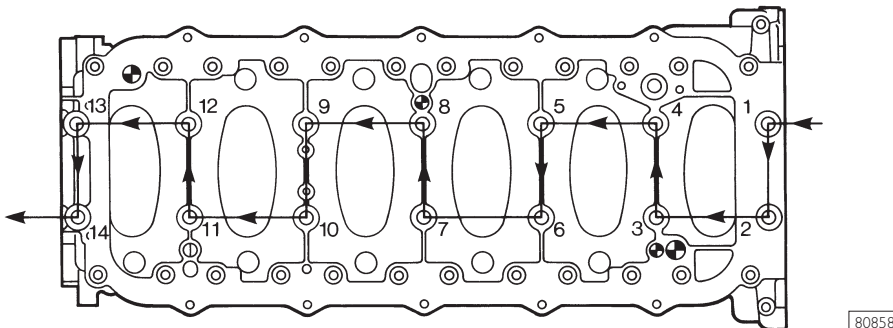
Second phase:  
preliminary tightening  
of inner screws  
(140 Nm)

FRONT SIDE



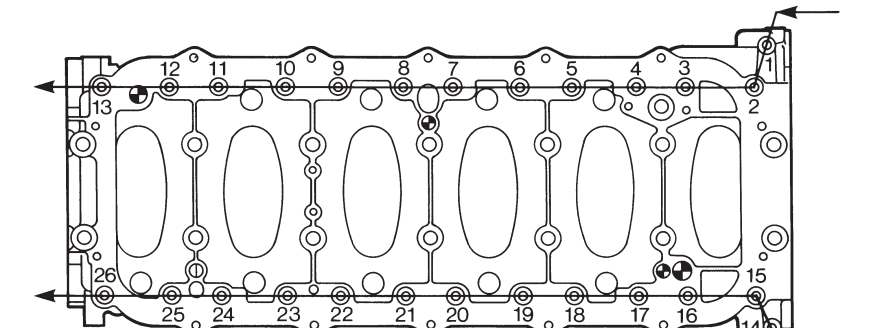
Third phase:  
angle tightening of  
inner screws  
60°

FRONT SIDE



Fourth phase:  
angle tightening of  
inner screws  
60°

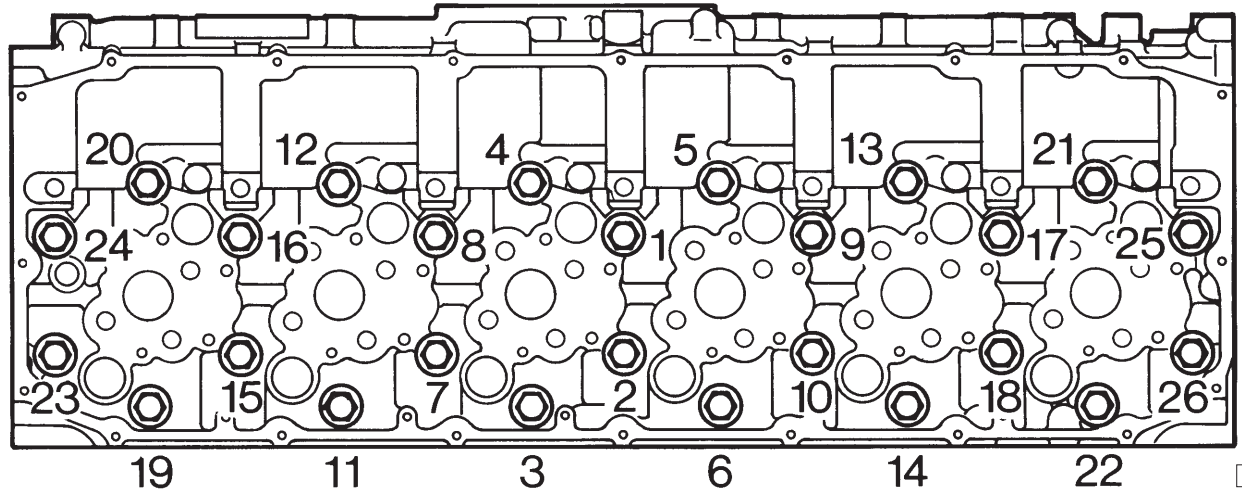
FRONT SIDE



Fifth phase:  
angle tightening of  
outer screws  
90°

**Diagram of cylinder head fixing screws tightening order**

Figure 2

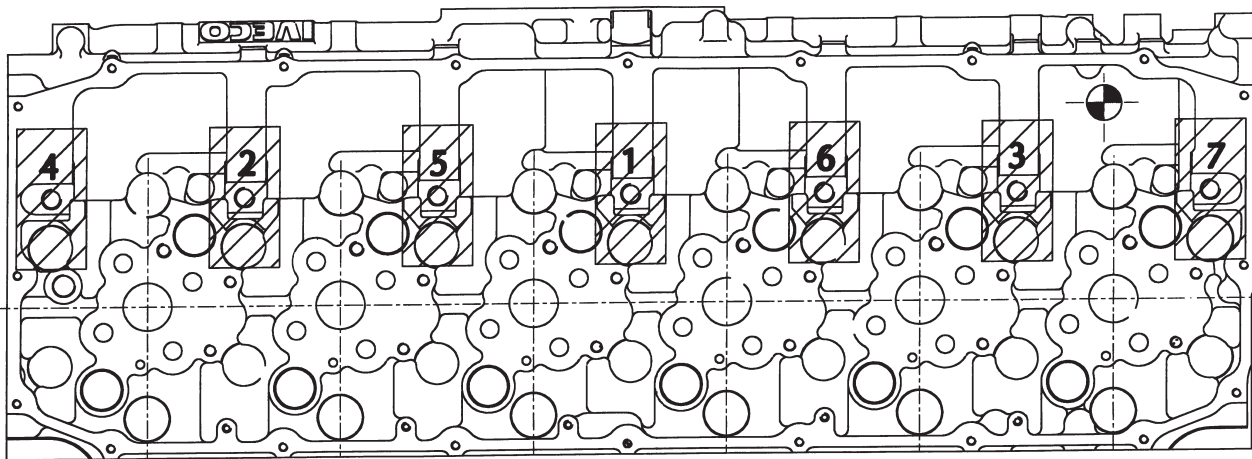


**Sequence**

- |                          |              |                        |        |                              |
|--------------------------|--------------|------------------------|--------|------------------------------|
| <input type="checkbox"/> | First phase  | preliminary tightening | 50 Nm  | Sequence as shown in figure; |
| <input type="checkbox"/> | Second phase | preliminary tightening | 100 Nm | Sequence as shown in figure; |
| <input type="checkbox"/> | Third phase  | angle locking          | 90°    | Sequence as shown in figure; |
| <input type="checkbox"/> | Fourth phase | angle locking          | 75°    | Sequence as shown in figure. |

**Diagram of rocker arm shaft fixing screws tightening order**

Figure 3

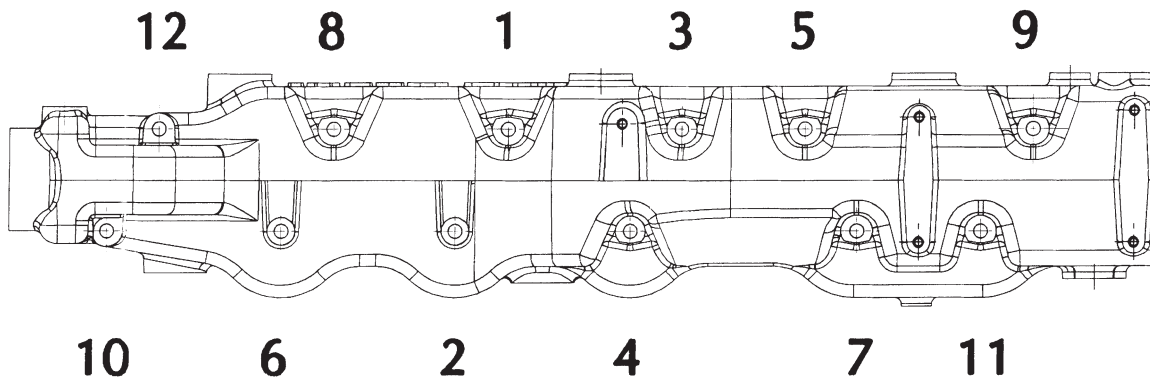


**Sequence**

- |                          |              |  |       |                              |
|--------------------------|--------------|--|-------|------------------------------|
| <input type="checkbox"/> | First phase  | tighten the screws 1-2-3 until they bear down on the rocker arm shaft; |       |                              |
| <input type="checkbox"/> | Second phase | preliminary tightening   | 40 Nm | Sequence as shown in figure; |
| <input type="checkbox"/> | Third phase  | angle locking  | 60°   | Sequence as shown in figure. |

**Diagram of exhaust manifold fixing screws tightening order**

Figure 4



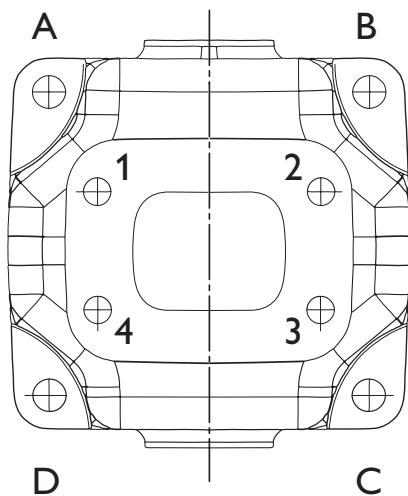
80862

**Sequence**

- |                                       |                        |       |                              |
|---------------------------------------|------------------------|-------|------------------------------|
| <input type="checkbox"/> First phase  | preliminary tightening | 40 Nm | Sequence as shown in figure; |
| <input type="checkbox"/> Second phase | preliminary tightening | 55 Nm | Sequence as shown in figure. |

**Diagram of feeder-line between exhaust manifold and turbocompressor fixing screws and nuts tightening order**

Figure 5



05\_137\_C

**Exhaust manifold side screws**

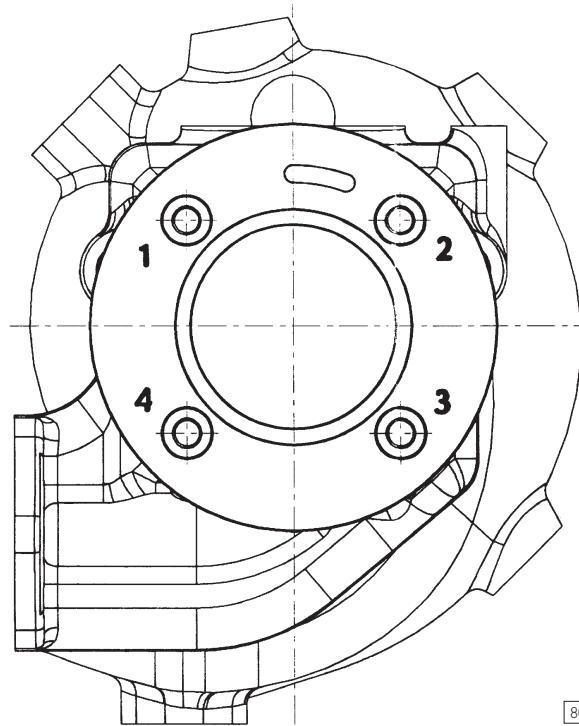
- |   |        |                   |
|---|--------|-------------------|
| <input type="checkbox"/> Tightening torque: | 107 Nm | Sequence B-D-A-C. |
|---|--------|-------------------|

**Turbocompressor side nuts**

- |   |       |                   |
|---|-------|-------------------|
| <input type="checkbox"/> Tightening torque: | 55 Nm | Sequence 4-2-1-3. |
|---|-------|-------------------|

**Diagram of exhaust flange fixing screws tightening order**

Figure 6

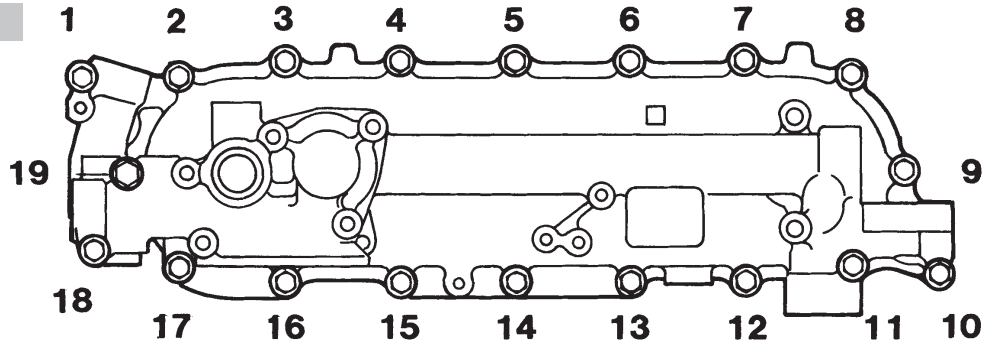


80864

- |   |       |                   |
|---|-------|-------------------|
| <input type="checkbox"/> Tightening torque: | 50 Nm | Sequence 2-4-1-3. |
|---|-------|-------------------|

**Diagram of heat exchanger fixing screws tightening order**

Figure 7



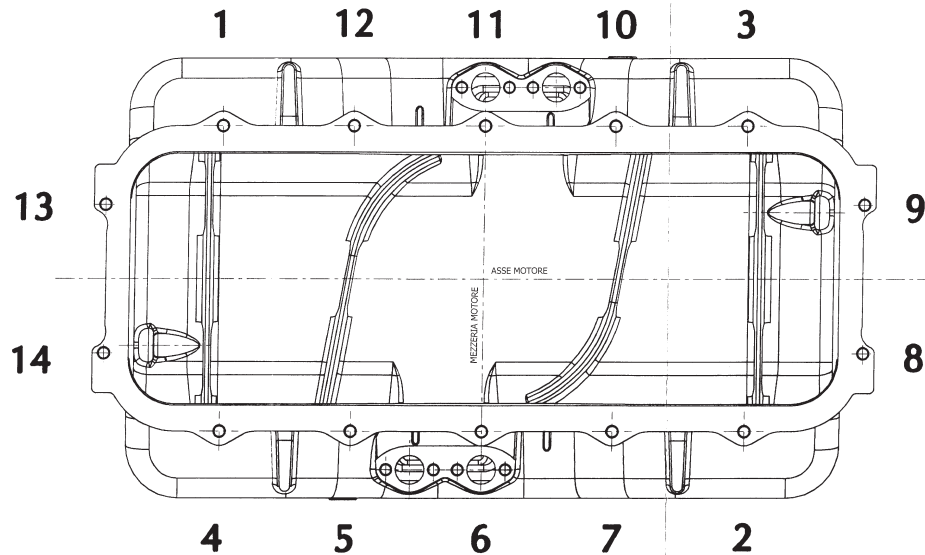
80865

**Sequence**

- ☐ First phase preliminary tightening 15 Nm Sequence as shown in figure;
- ☐ Second phase preliminary tightening 22 Nm Sequence as shown in figure.

**Diagram of engine oil sump fixing screws tightening order**

Figure 8

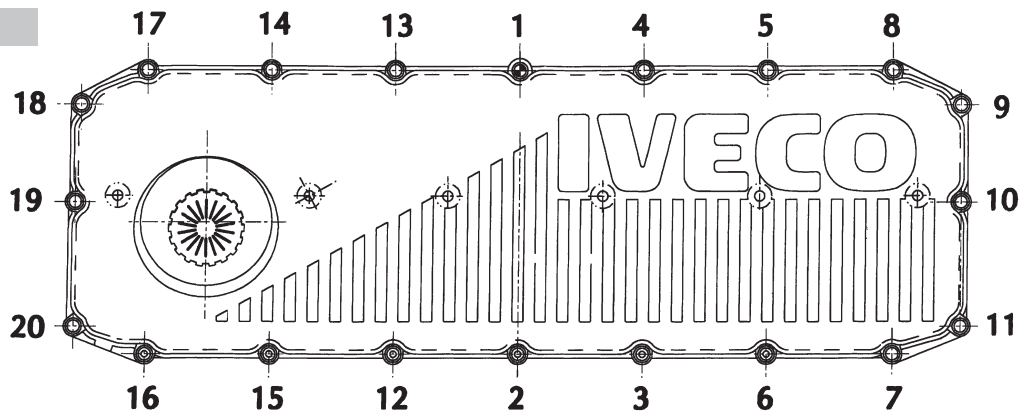


80866

- ☐ Tightening 50 Nm Sequence as shown in figure.

**Diagram of rocker arm cap fixing screws tightening order**

Figure 9



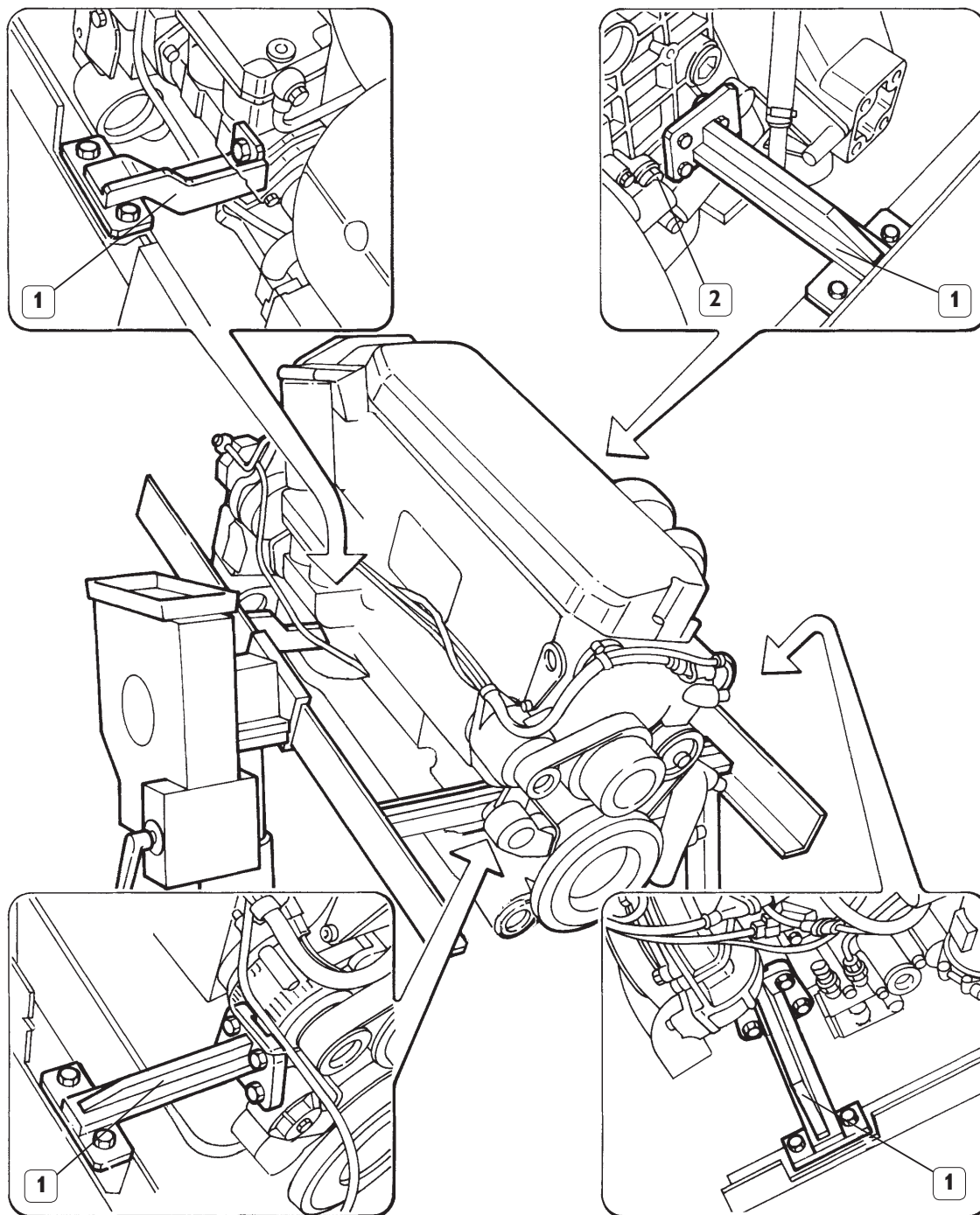
80867

- ☐ 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



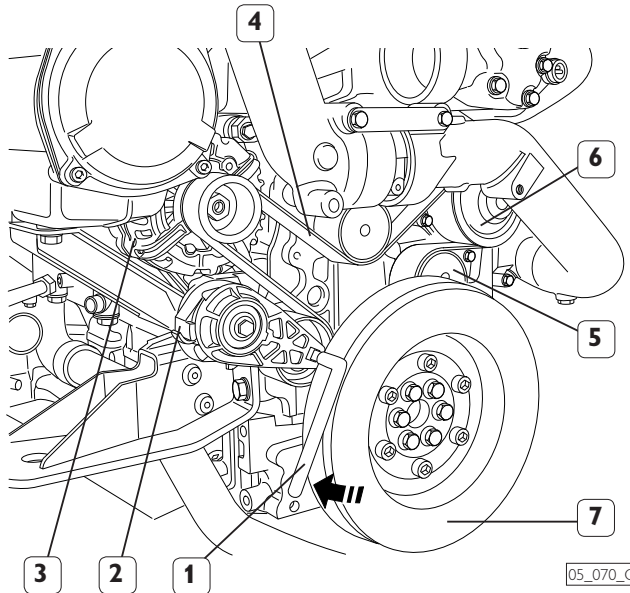
80869

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

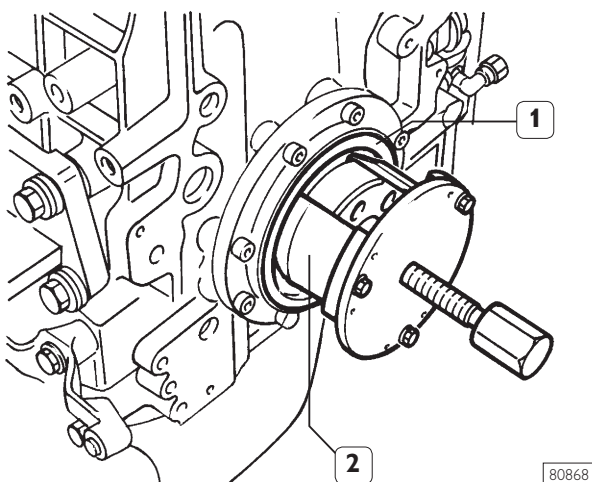


Using an appropriate tool (1), operate in the direction of the arrow, and remove the belt (4) driving the water pump and alternator.

Remove the following components:

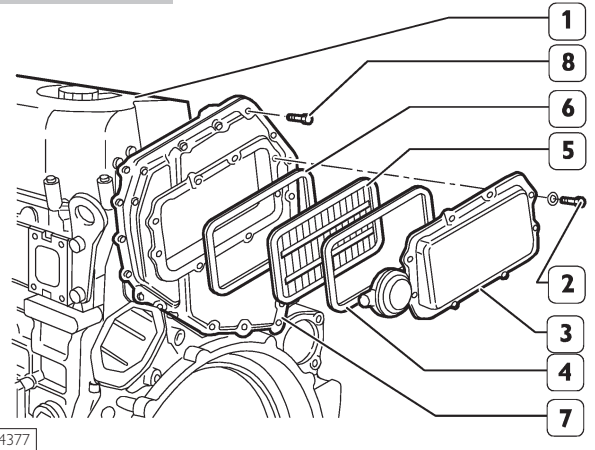
- Automatic belt tightener support (2);
- Alternator (3);
- Fixed tightener (5);
- Water pump (6) and piping;
- Damping flywheel (7);
- Disconnect all electric connections and the sensors;
- Remove fuel pump and piping and oil heat exchanger.

Figure 12



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

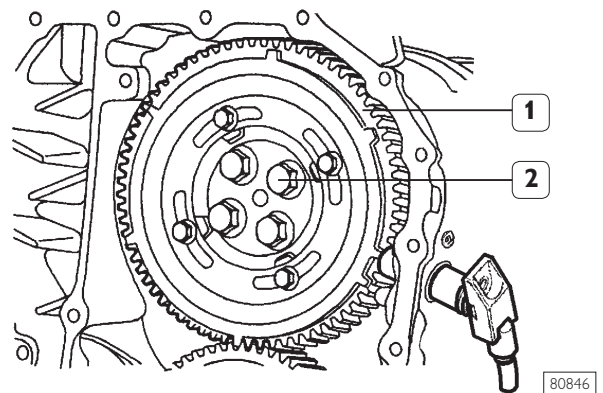
Figure 13



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).

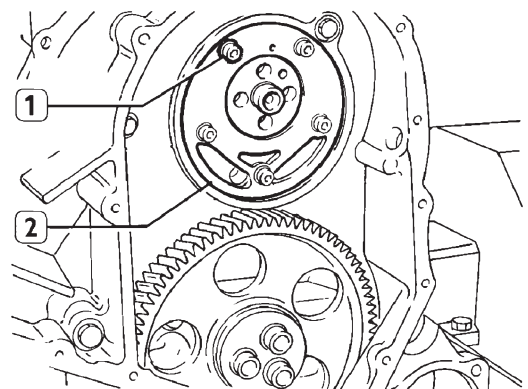
Take off the screws (8) and remove the blow-by case (7).

Figure 14



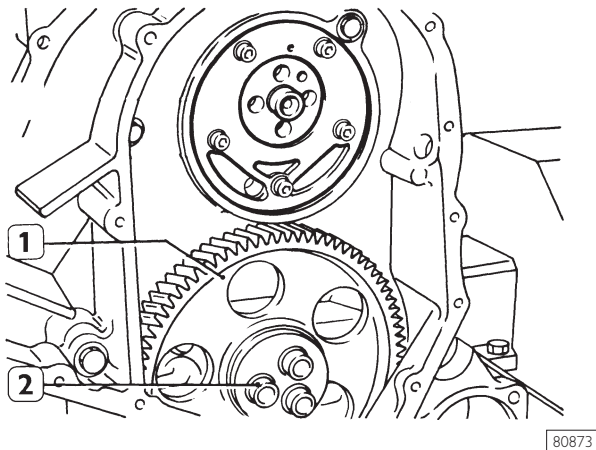
Unscrew the screws (2) and remove the gear (1) with the phonic wheel.

Figure 15



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

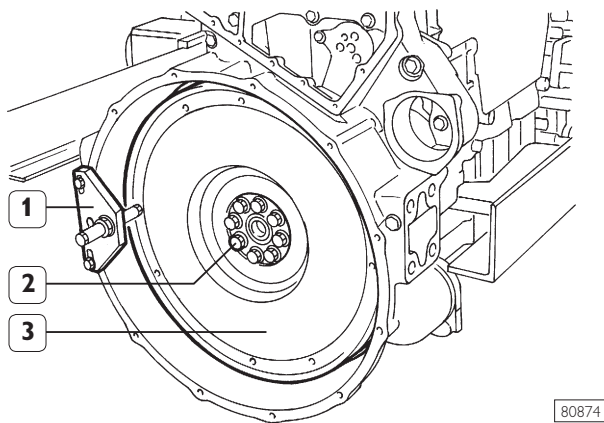
Figure 16



80873

By means of a properly splined wrench, untighten screws (2) and remove the transmission gear (1).

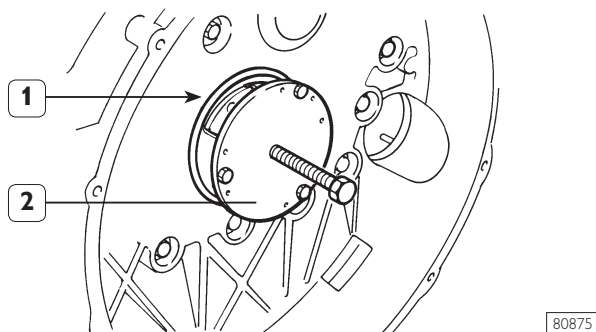
Figure 17



80874

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

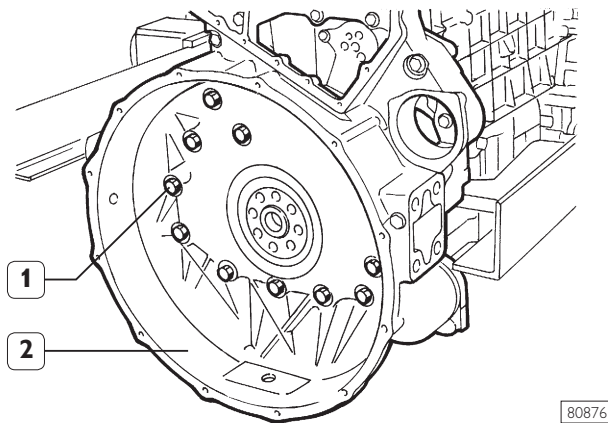
Figure 18



80875

Apply extractor 99340052 (2) and pull out the seal gasket (1).

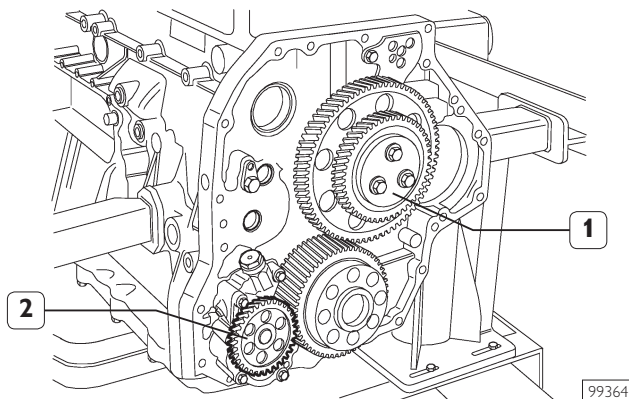
Figure 19



80876

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

Figure 20

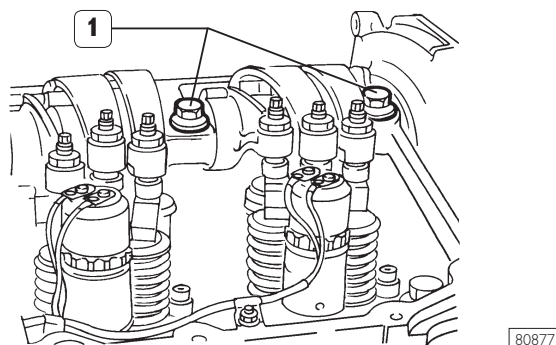


99364

In sequence, take out the following:

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

Figure 21

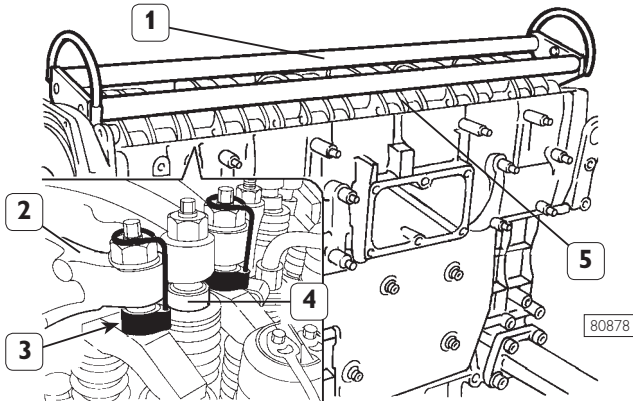


80877

Untighten the fixing screws (1) of rocker arm shaft.

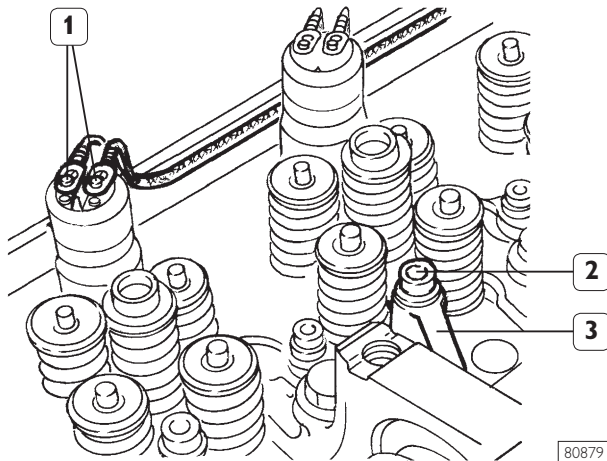


Figure 22



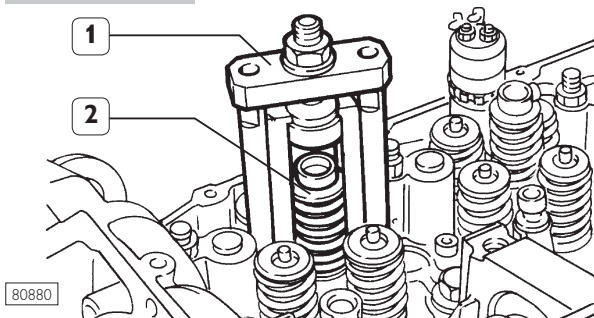
- ❑ Using tool 99360144 (3), secure the blocks (4) to the rocker arms (2);
- ❑ Apply tool 99360553 (1) to the rocker arm shaft (5) and remove the shaft (5) from the cylinder head.

Figure 23



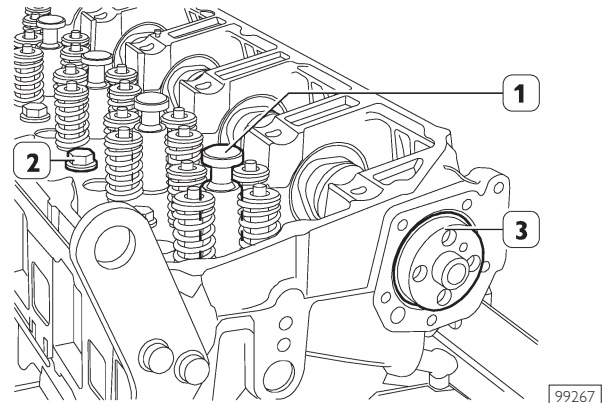
- ❑ Untighten screws and remove electric connections (1) from solenoid valves;
- ❑ Untighten fixing screws (2) of injector brackets (3).

Figure 24



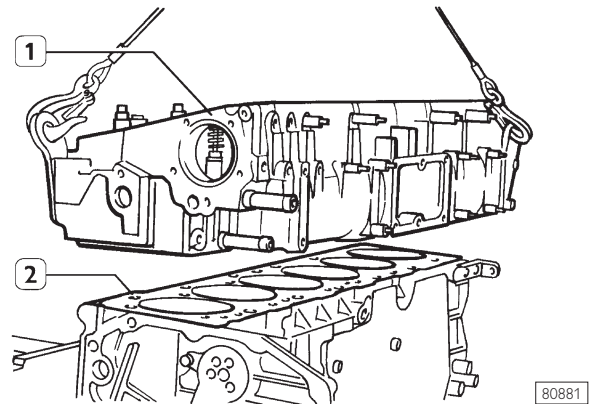
- ❑ Remove injectors (2).
- If this operations is difficult, use extractor 99342148 (1).

Figure 25



- ❑ Fit the plugs 99360177 (1) in place of the injectors;
- ❑ Take out the camshaft (3);
- ❑ Take out the screws (2) fixing the cylinder head.

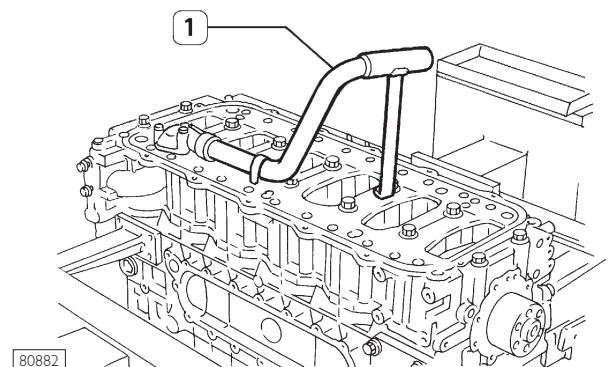
Figure 26



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

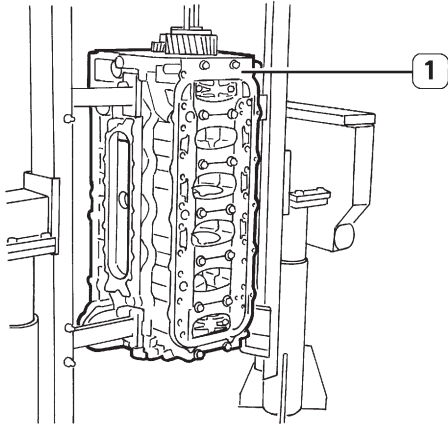
Untighten screws and remove the engine oil sump.

Figure 27



Untighten screws and remove suction rose (1).

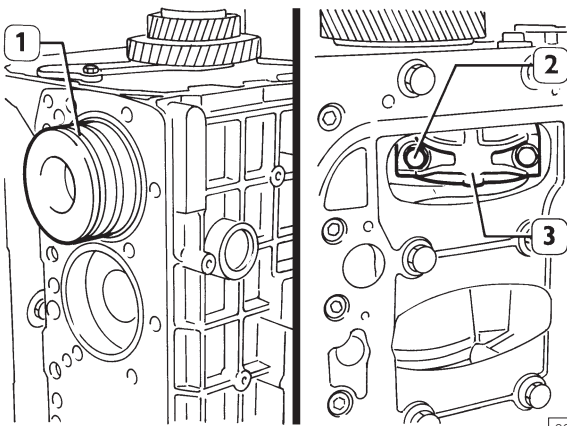
Figure 28



80883

Rotate the block (1) to the vertical position.

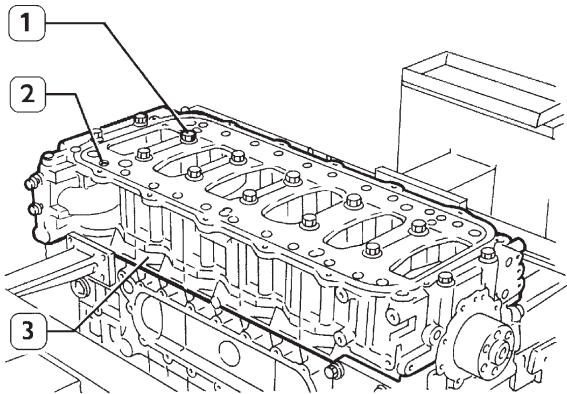
Figure 29



80884

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.

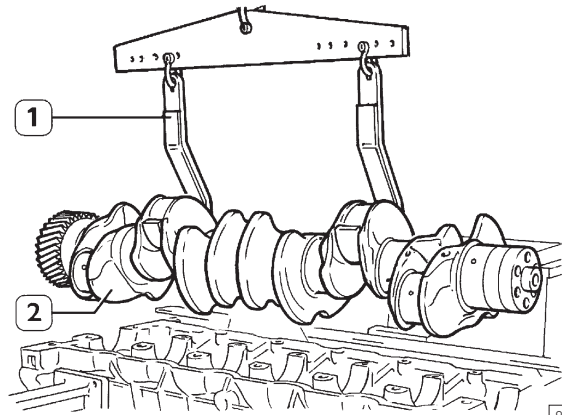
Figure 30



80885

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

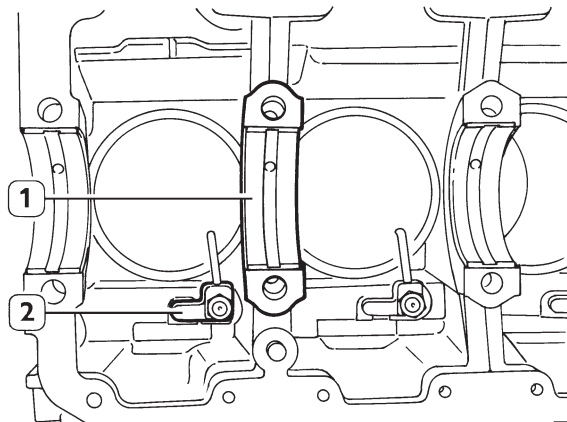
Figure 311



80886

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

Figure 32



80887

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.

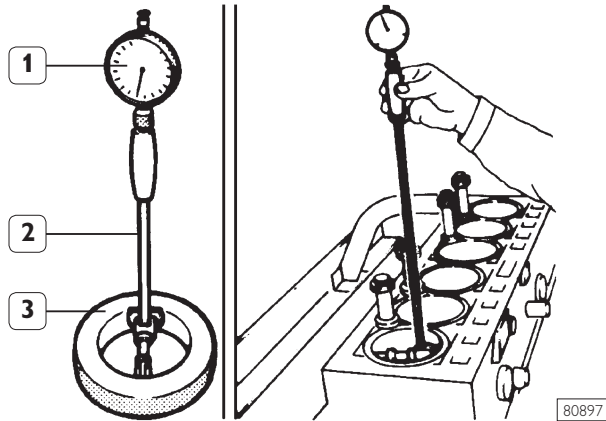
### CAUTION

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 33

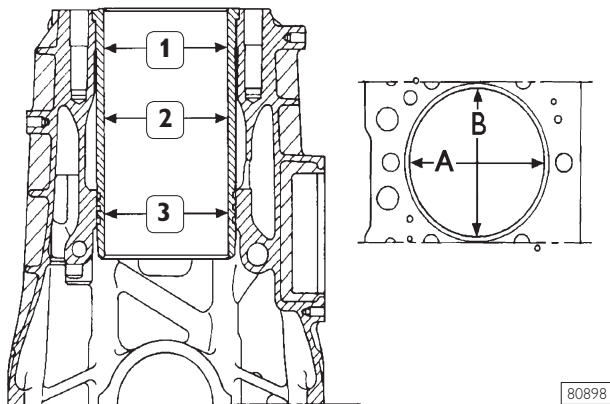


Internal diameter of the cylinder liners is checked for ovalization, taper and wear, using a bore dial (1) centesimal gauge 99395687 (2) previously reset to ring gauge (3), diameter 115 mm.

#### CAUTION

If a 115 ring gauge is not available use a micrometer caliper.

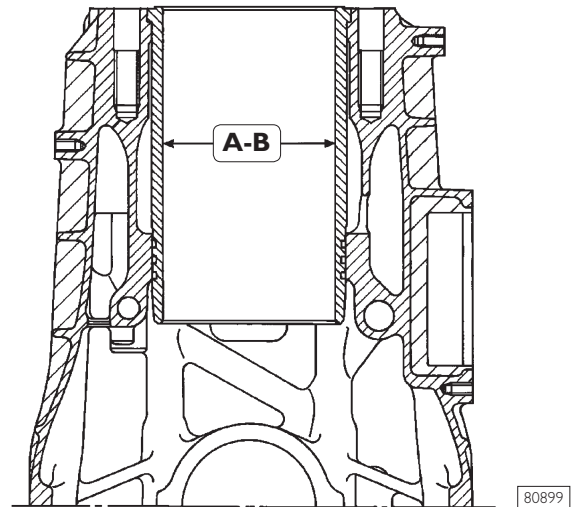
Figure 34



- 1 = 1<sup>st</sup> measuring;
- 2 = 2<sup>nd</sup> measuring;
- 3 = 3<sup>rd</sup> measuring.

Carry out measurements 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 35



- A = Selection class  $\varnothing$  115 to 115.012 mm;
- B = Selection class  $\varnothing$  115.010 to 115.022 mm.

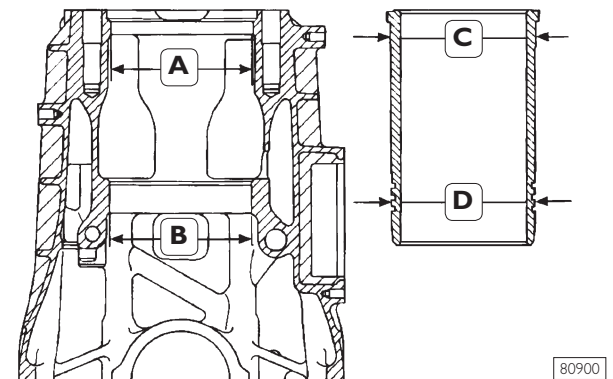
In case of maximum wear exceeding 0.150 mm or maximum ovalization exceeding 0.100 mm compared to the values indicated in the figure, the liners must be replaced as they cannot be ground, lapped or trued.

#### CAUTION



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

Figure 36

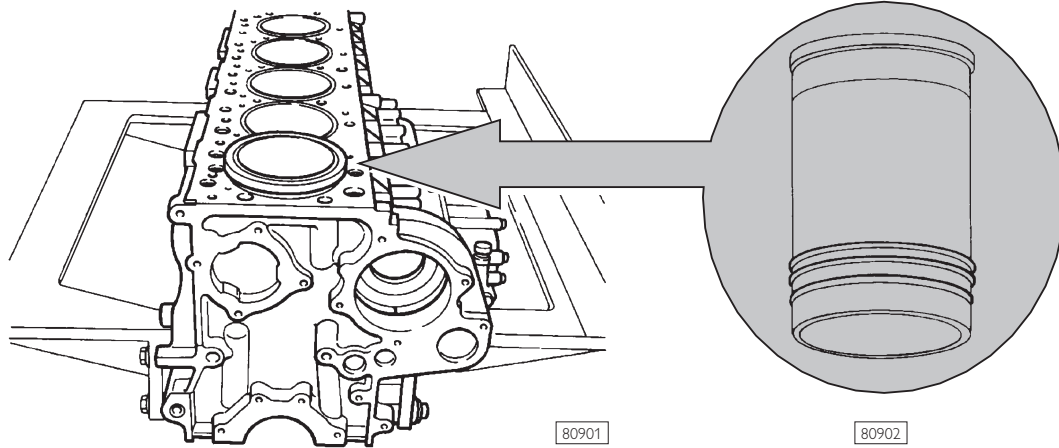


- A =  $\varnothing$  130.200 to 130.225 mm;
- B =  $\varnothing$  128.510 to 128.535 mm;
- C =  $\varnothing$  130.161 to 130.186 mm;
- D =  $\varnothing$  128.475 to 128.500 mm.

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.

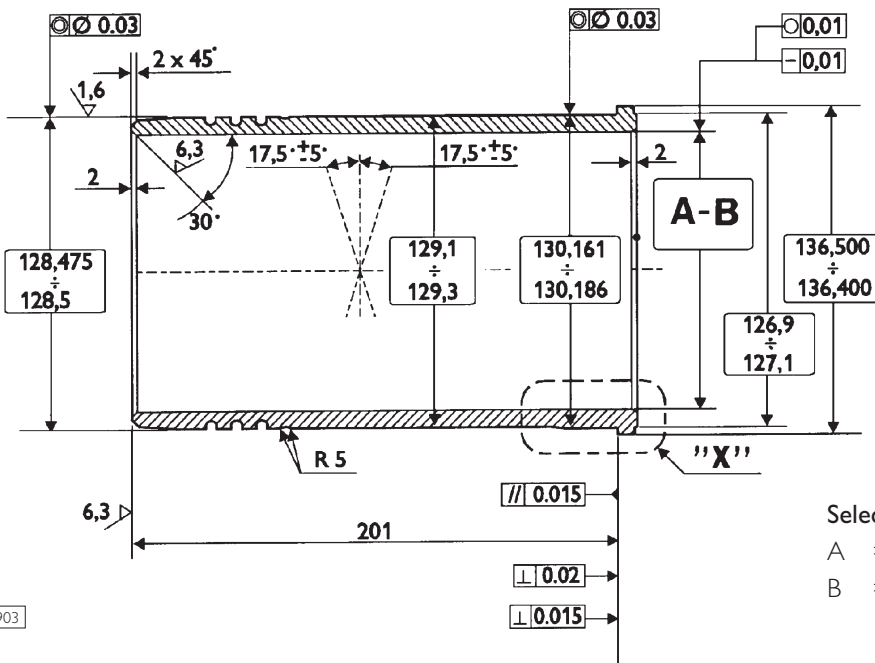
CYLINDER LINERS

Figure 37



BLOCK WITH CYLINDER LINERS

Figure 38



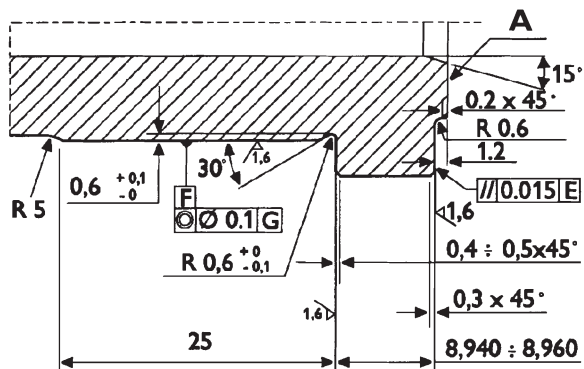
Selection class

A = mm 115.000 to 115.012;

B = mm 115.010 to 115.022.

CYLINDER LINERS MAIN DATA

Figure 39

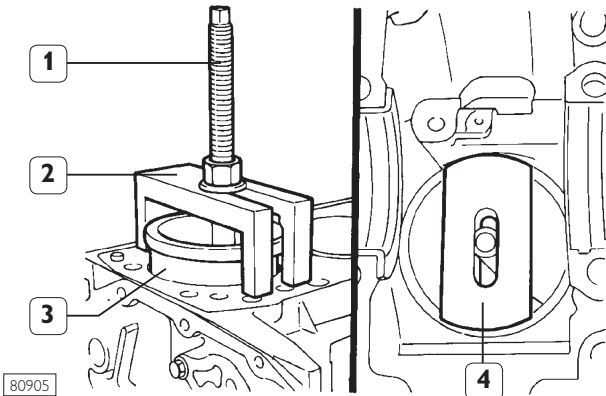


"X" DETAIL

"A" = Selection class marking area.

### Replacing cylinder liners - Removal

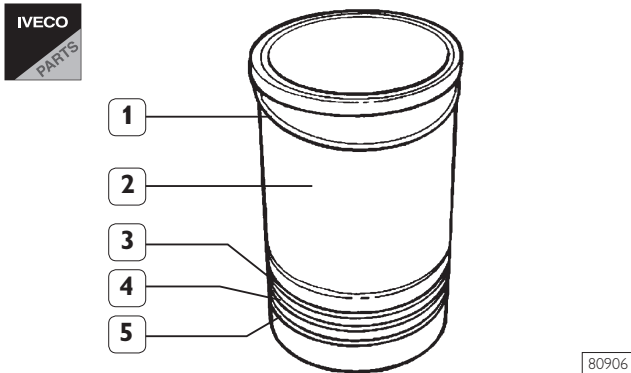
Figure 40



Place components 99360706 (1 and 2) and plate 99360724 (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

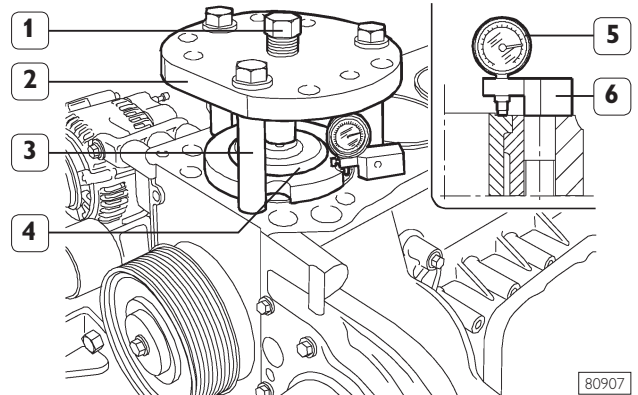


Always replace water sealing rings (3, 4 and 5). Install the adjustment ring (1) on the cylinder liner (2); lubricate lower part of liner and install it in the cylinder unit using the proper tool.

#### CAUTION

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

Figure 42



Check cylinder barrel protrusion with tool 99360334 (1-2-3-4) and tighten screw (1) to 170 Nm. With dial gauge 99395603 (5) placed on base 99370415 (6), measure the cylinder barrel protrusion compared to the cylinder head supporting plane, it must be 0.035 to 0.065 mm (Figure 43); otherwise replace the adjusting ring (1, Figure 41) fitted with spare parts having different thickness.

Figure 43

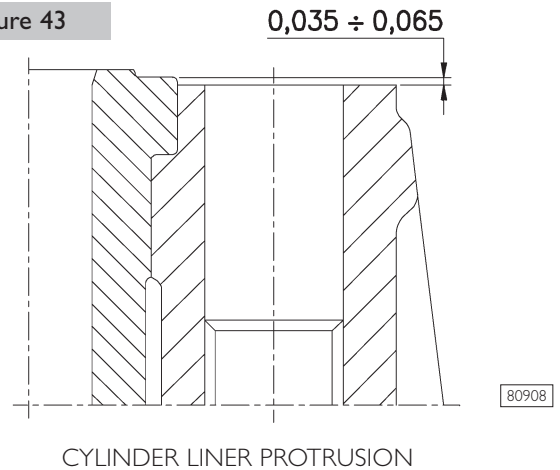
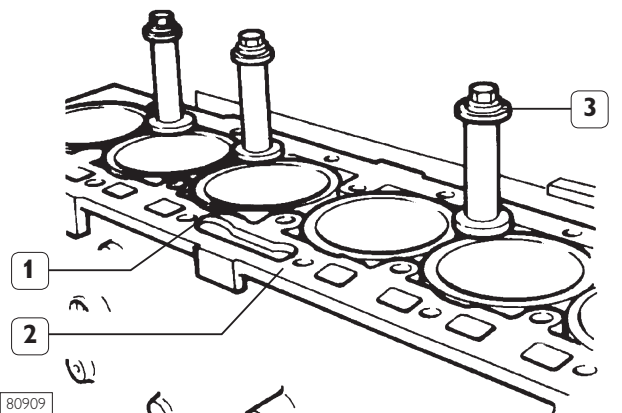


Figure 44



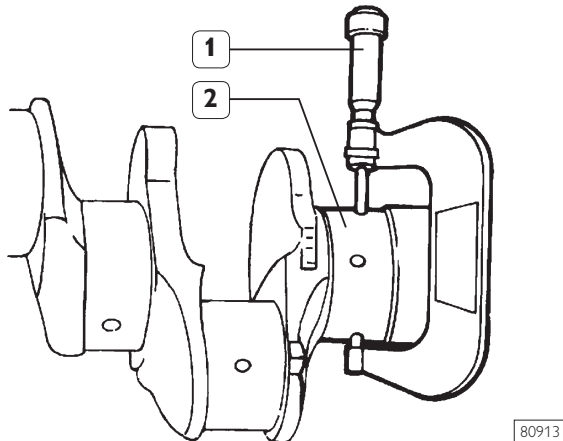
When the installation is completed, block the cylinder liners (1) to the block (2) with studs 99360703 (3).



**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

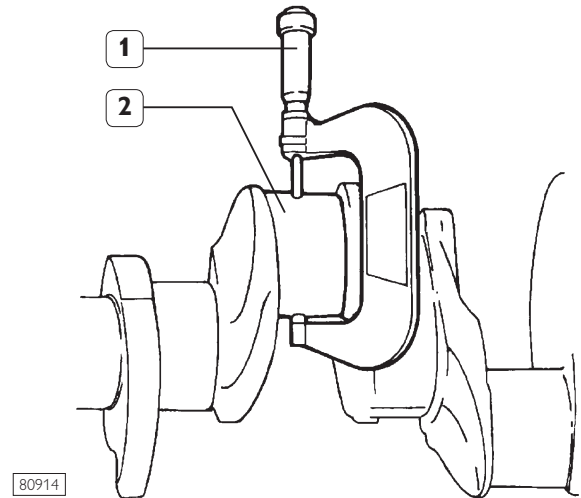


MEASURING THE MAIN JOURNALS

**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**

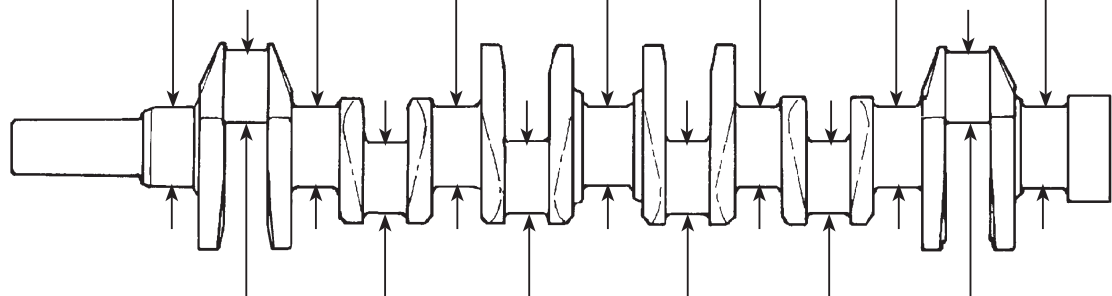
All journals and crank pins must also be ground to the same undersizing class, in order to avoid any alteration to shaft balance.

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

Figure 50

**Main journals**

	1	2	3	4	5	6	7
∅ Min.							
∅ Max.							



∅ Min.						
∅ Max.						

**Crank pins**

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

80915

## 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

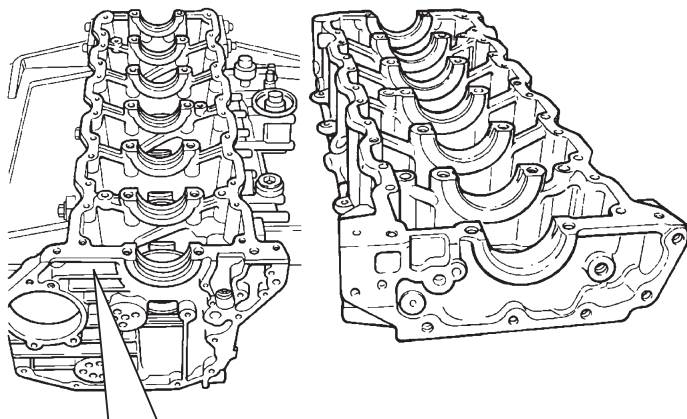
- Determine the diameter class of the connecting rod;
- Determine the diameter class of the big end pin;
- Select half-bearing class to be installed.

### 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).

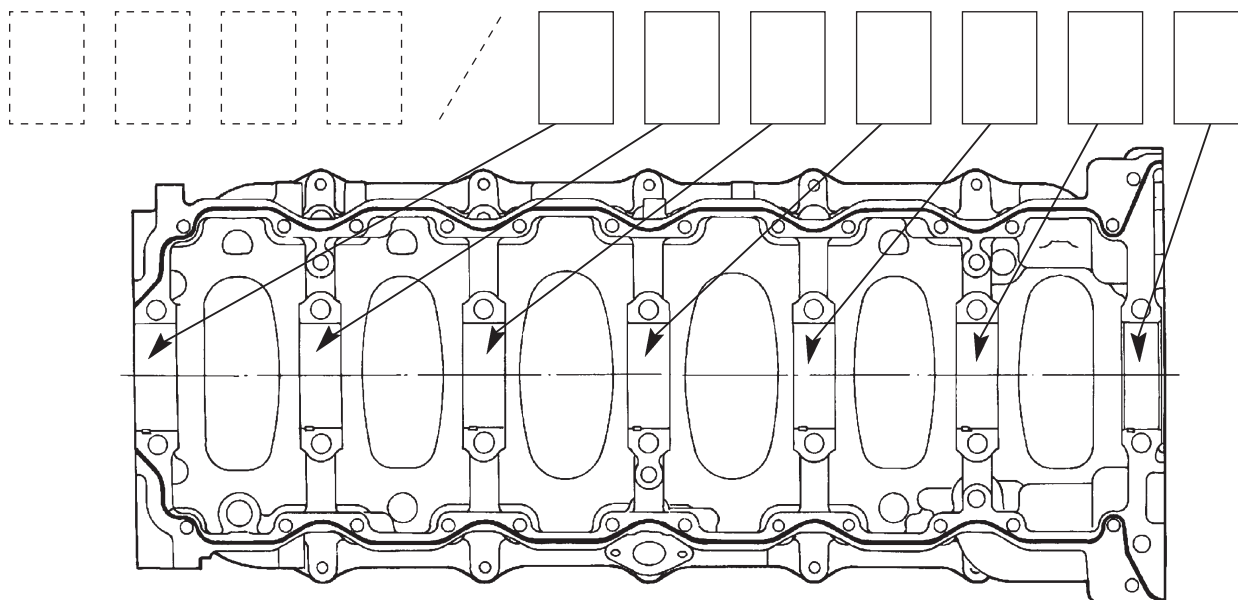
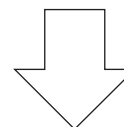
- A four-digit number representing the coupling number of block to the relevant underblock;
- Each of the following seven digits represents the diameter class of the housing they refer to (Figure 51, bottom);
- Each of these digits may be **1, 2** or **3**.

Figure 51



Class	Main bearing housing nominal diameter (mm)
1	89.000 to 89.009
2	89.010 to 89.019
3	89.020 to 89.030

1	=	89.000 to 89.009
2	=	89.010 to 89.019
3	=	89.020 to 89.030





**Selecting the main and big end bearing shells**

**CAUTION**

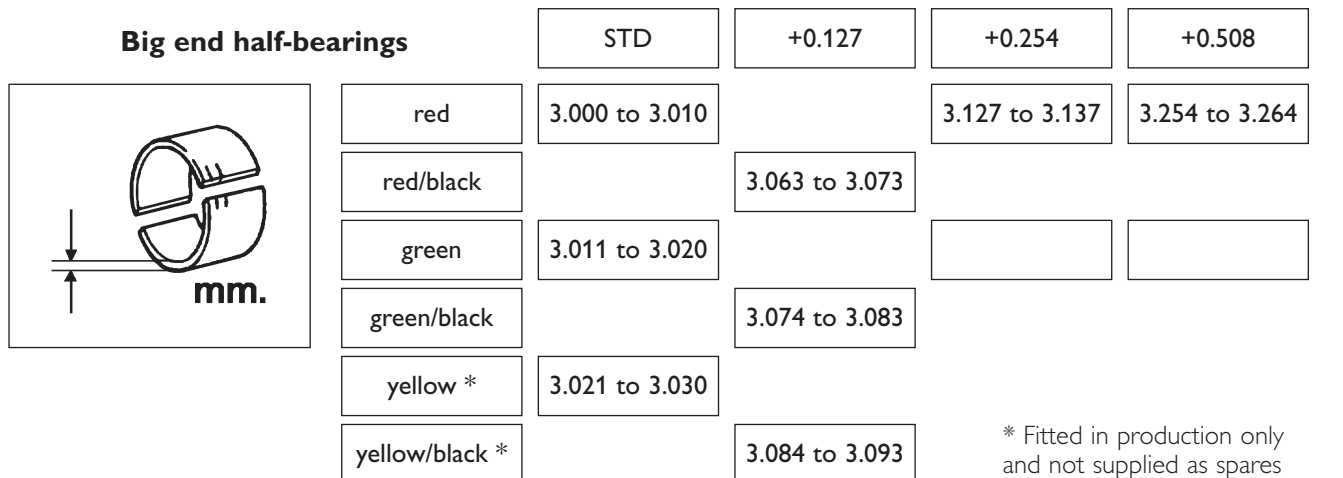
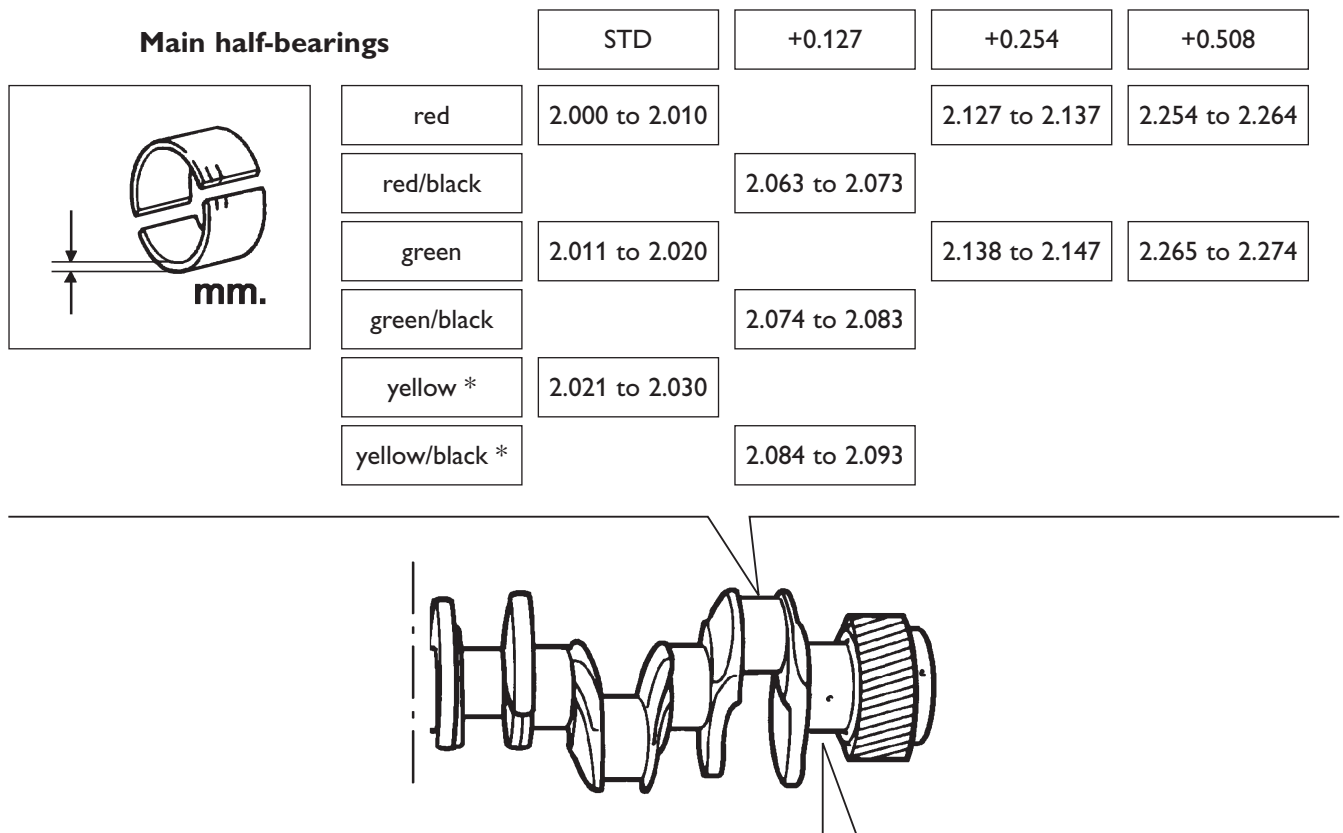
In order obtain the required assembly clearances, main half-bearings and big end half-bearings must be selected as specified below.

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



**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):

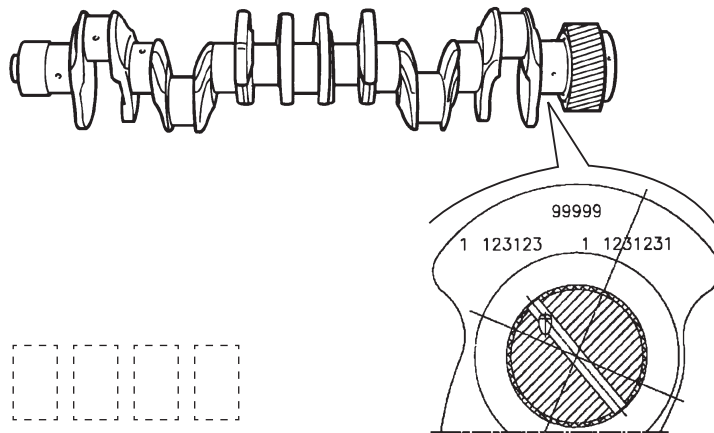
- ❑ A five-digit number representing the shaft serial number;

- ❑ 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);

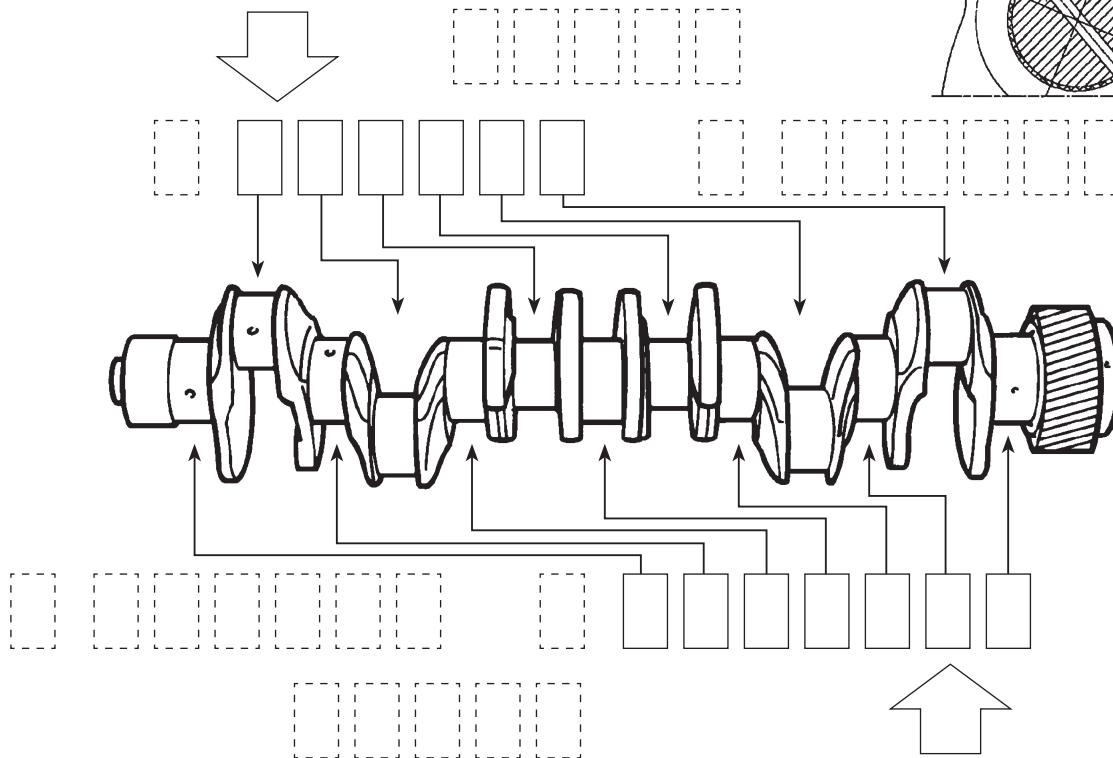
- ❑ The seven-digit series, on the right, refers to the journals and is preceded by a single digit, which indicates journal status (1 = STD, 2 = -0.127); each of the following seven digits represents the diameter class of the journal it refers to (Figure 53, bottom).

Figure 53

Class	Big end pins nominal diameter (mm)
1	72.915 to 72.924
2	72.925 to 72.934
3	72.935 to 72.945



81030



1	=	82.910 to 82.919
2	=	82.920 to 82.929
3	=	82.930 to 82.940

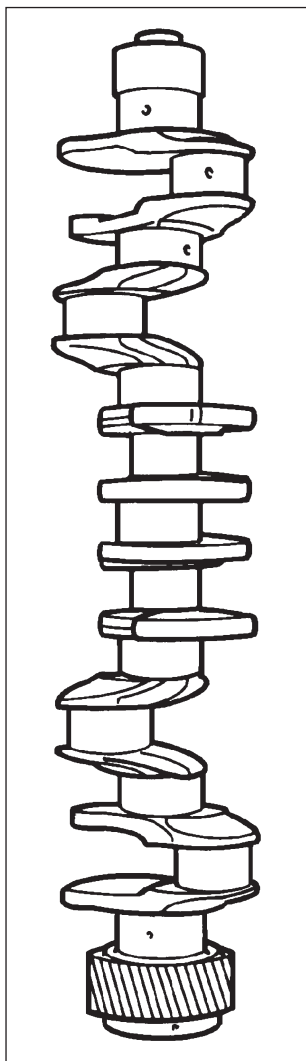
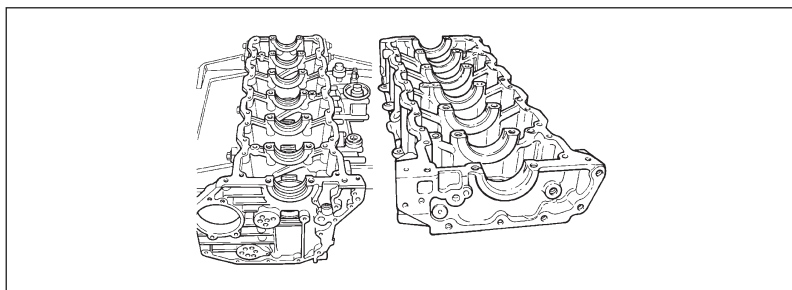
Class Journals nominal diameter (mm)

**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
		red		green
3		red	red	red
		red	red	red

**Selection of main half-bearings (rectified pins)**

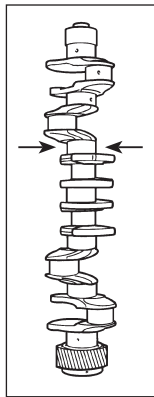
If the journals have been rectified, the procedure described cannot be applied.

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.

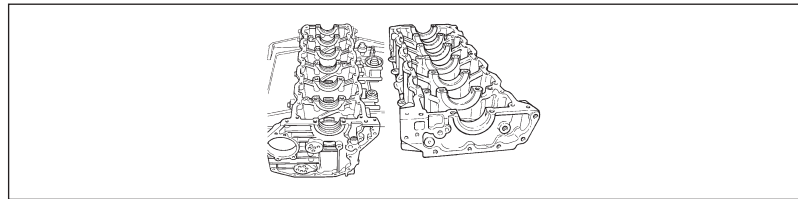
red/black =  
mm 3.063 to 3.073

**-0.127**

green/black =  
mm 3.063 to 3.073



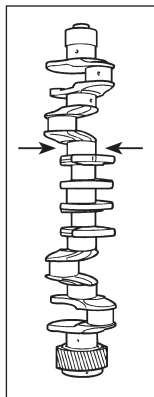
82.784	1
82.793	
82.794	2
82.803	
82.804	3
82.814	



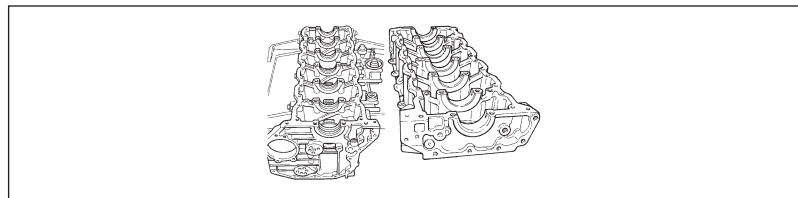
1	2	3
green/black	green/black	green/black
green/black	green/black	green/black
red/black	green/black	green/black
red/black	green/black	green/black
red/black	red/black	green/black
red/black	red/black	green/black

**-0.254**

red =  
mm 3.127 to 3.137



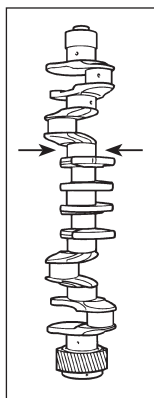
82.666
82.686



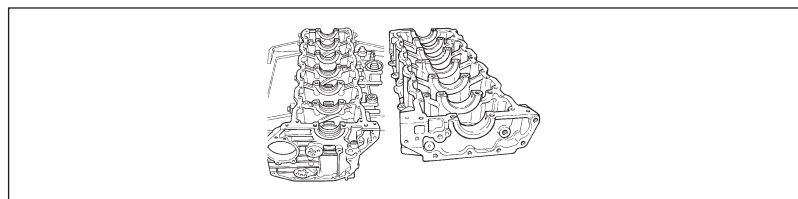
1	2	3
red	red	red
red	red	red

**-0.508**

red =  
mm 3.254 to 3.264



82.412
82.432



1	2	3
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 = 2890 to 2920 g.  
B = 2921 to 2950 g.  
C = 2951 to 2980 g.
- 2 Number indicating the diameter selected for the housing of the big end bearing:  
1 = 77.000 to 77.010 mm  
2 = 77.011 to 77.020 mm  
3 = 77.021 to 77.030 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

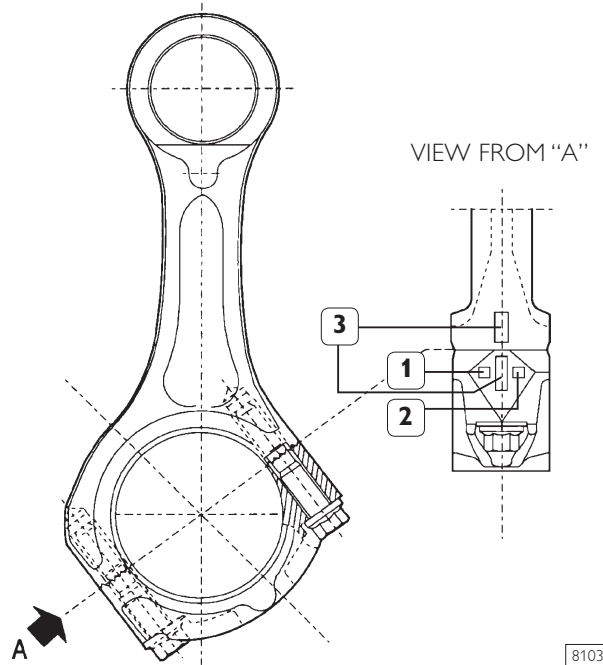
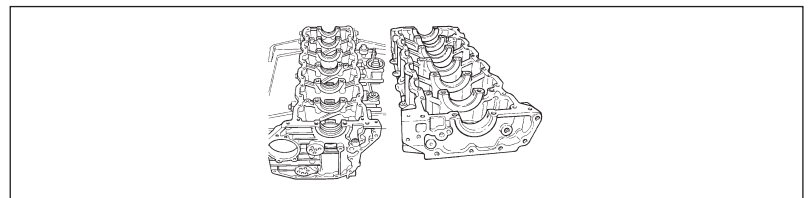
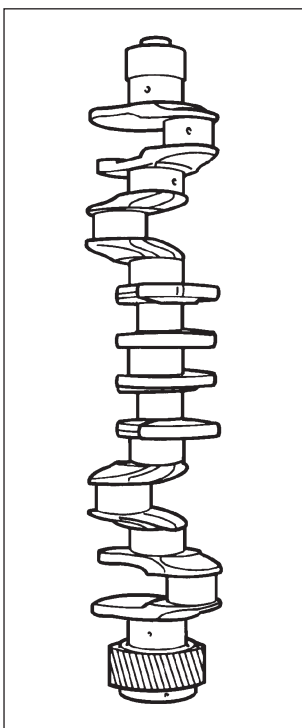


Figure 56

STD.



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

81032

**Selection of connecting rod half-bearings (rectified pins)**

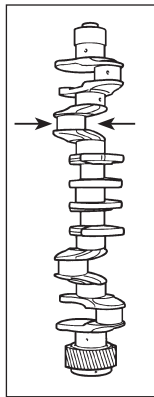
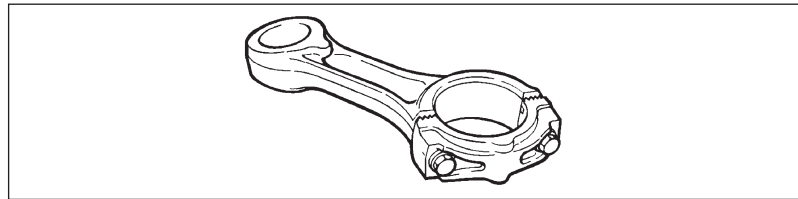
If pins have been rectified, the procedure described must be applied.

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 2.074 to 2.083

**-0.127**

green/black =  
mm 2.063 to 2.073

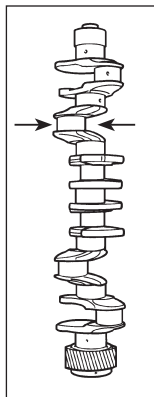


72.789	<b>1</b>
72.798	
72.799	<b>2</b>
72.808	
72.809	<b>3</b>
72.818	

1	2	3
green/black	green/black	green/black
green/black	green/black	green/black
red/black	green/black	green/black
red/black	green/black	green/black
red/black	red/black	green/black
red/black	red/black	green/black

**-0.254**

red = mm 2.127 to 2.137  
green = mm 2.138 to 2.147

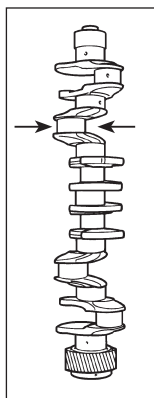


72.671	<b>1</b>
72.680	
72.681	<b>2</b>
72.691	

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

**-0.508**

red = mm 2.254 to 2.264  
green = mm 2.265 to 2.274



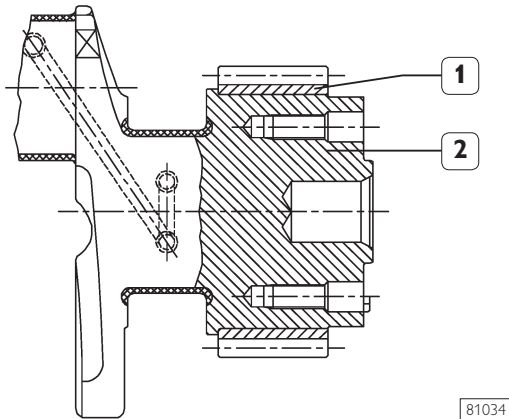
72.417	<b>1</b>
72.426	
72.427	<b>2</b>
72.437	

1	2	3
red	green	green
red	green	green
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

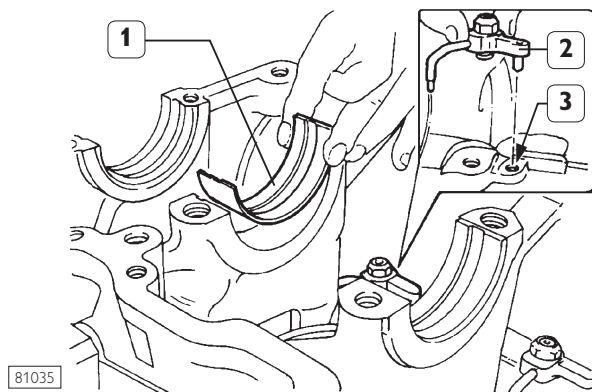


When fitting the new gears (1) on the crankshaft (2), heat them for about 15 minutes in an oven at no more than 180 °C.

Let them cool down after the installation.

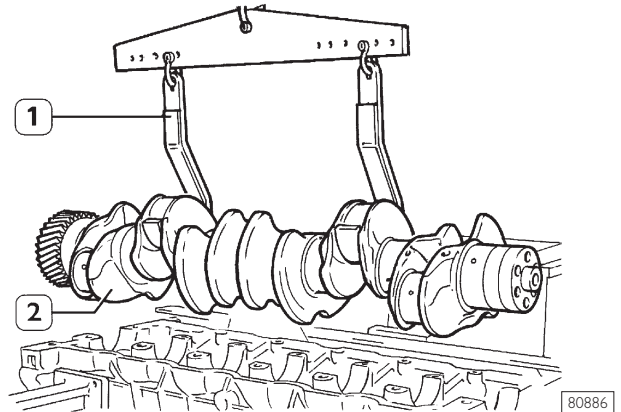
### Checking main journal installation clearance

Figure 58



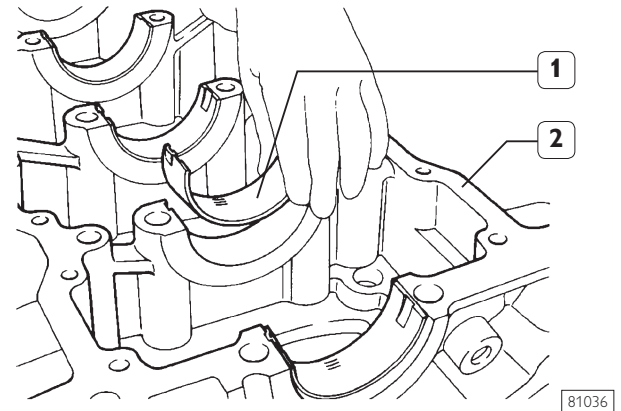
Install the oil spray nozzles (2) and have the dowel coincide with the block hole (3).  
Install the half-bearings (1) on the main bearings.

Figure 59



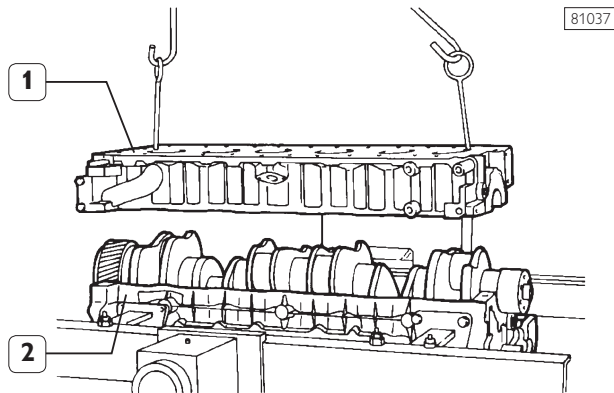
Using the hoist and hook 99360500 (1) mount the driving shaft (2).

Figure 60



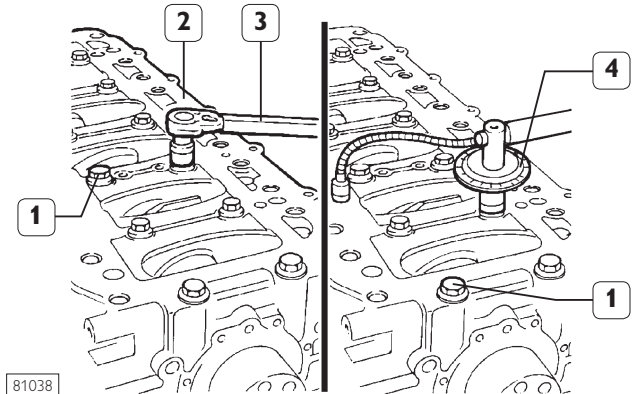
Install the half-bearings (1) on the main bearings in the underblock (2).  
Check the installation clearance between the main journals and the relative bearings as follows:

Figure 61



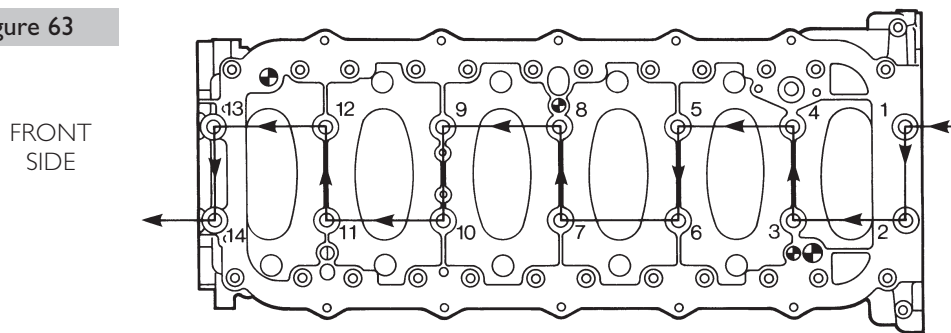
- Place a piece of calibrated wire on the journal of the crankshaft (2), parallel to the longitudinal axis; install the underblock (1), by hoist and appropriate hooks.

Figure 62



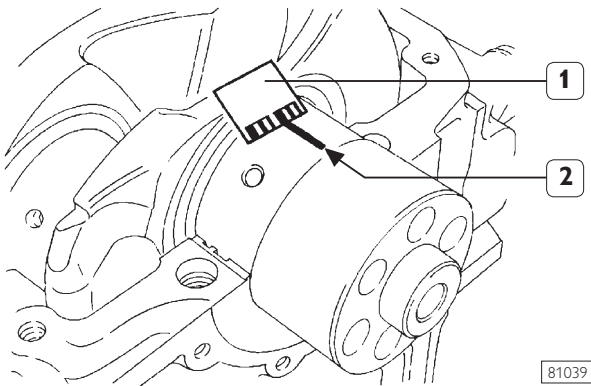
- Lubricate inside screws (1) with UTM oil, and tighten them by dynamometric wrench to 140 Nm torque, thus with 60° angle closing, following the diagram in figure below.

Figure 63



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

Figure 64



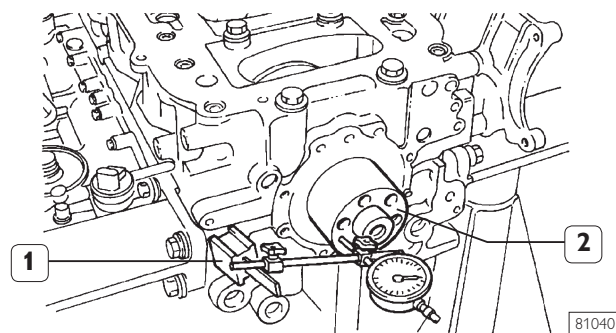
- Remove the under-block.

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

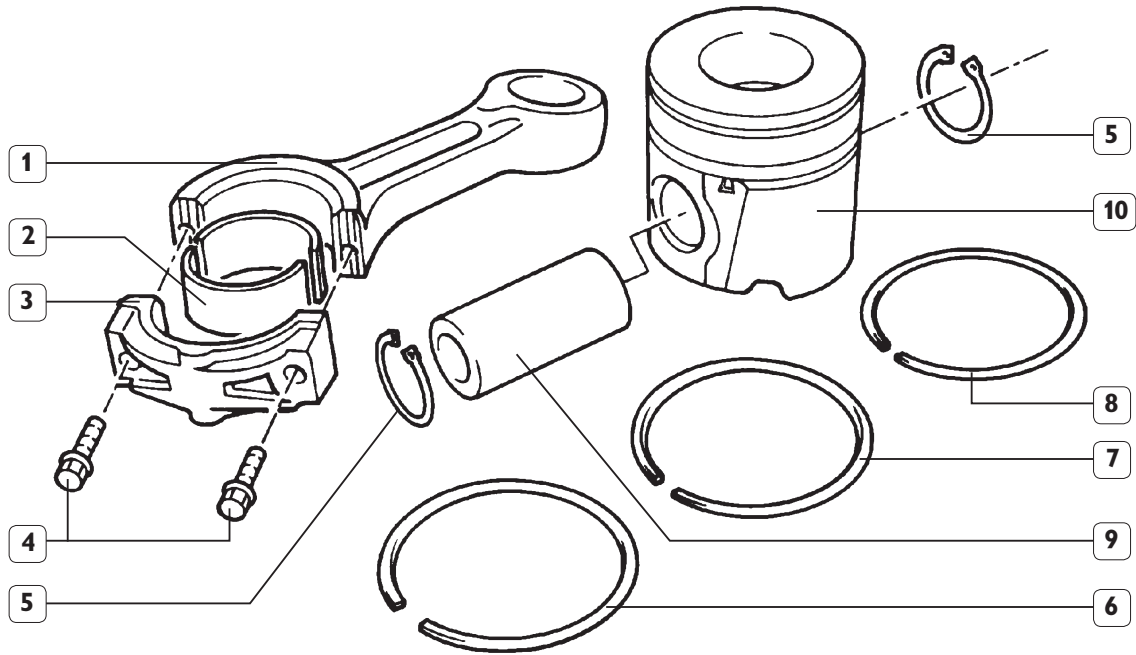


End float is checked by placing a magnetic dial gauge (1) on the crankshaft (2), as shown in the figure. If the value obtained is higher than specified, replace the rear thrust half-bearings and repeat this check.



**PISTON CONNECTING ROD ASSEMBLY**

Figure 66



81041

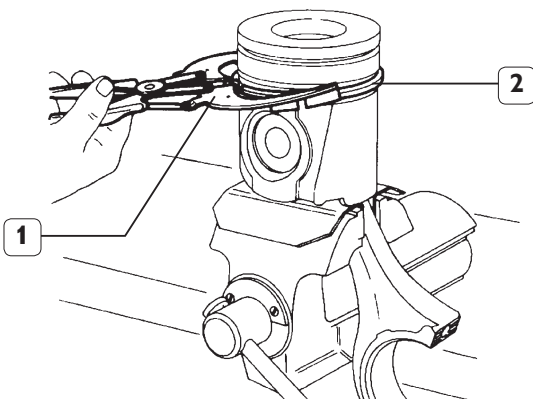
PISTON CONNECTING ROD ASSEMBLY

- 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 not show any trace of seizing, scoring, cracking; replace as necessary.

**Removal**

Figure 67

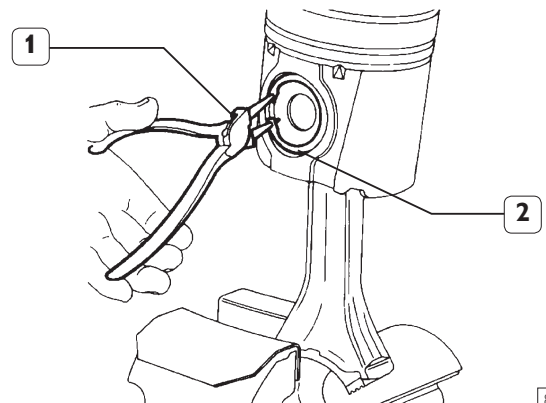


81042

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.

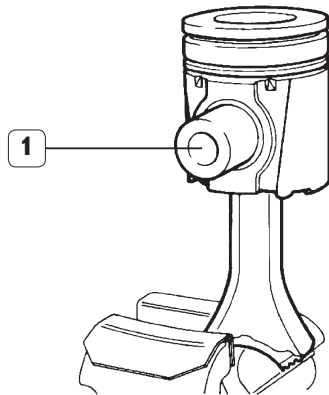
Figure 68



81043

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

Figure 69

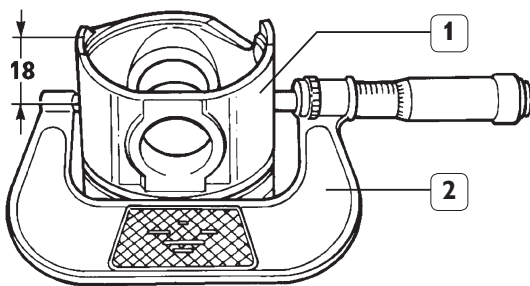


81044

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

### Measuring the diameter of the pistons

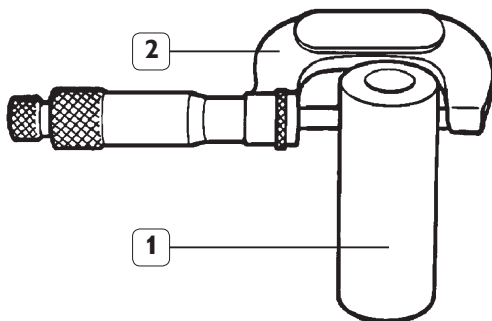
Figure 70



81045

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

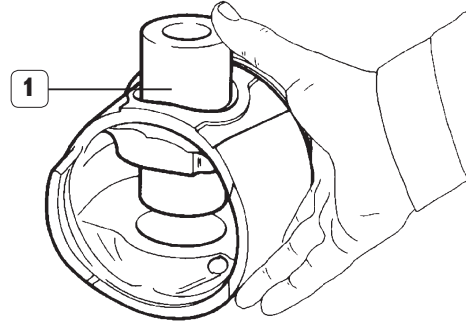


81046

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

### Conditions for correct gudgeon pin-piston coupling

Figure 72

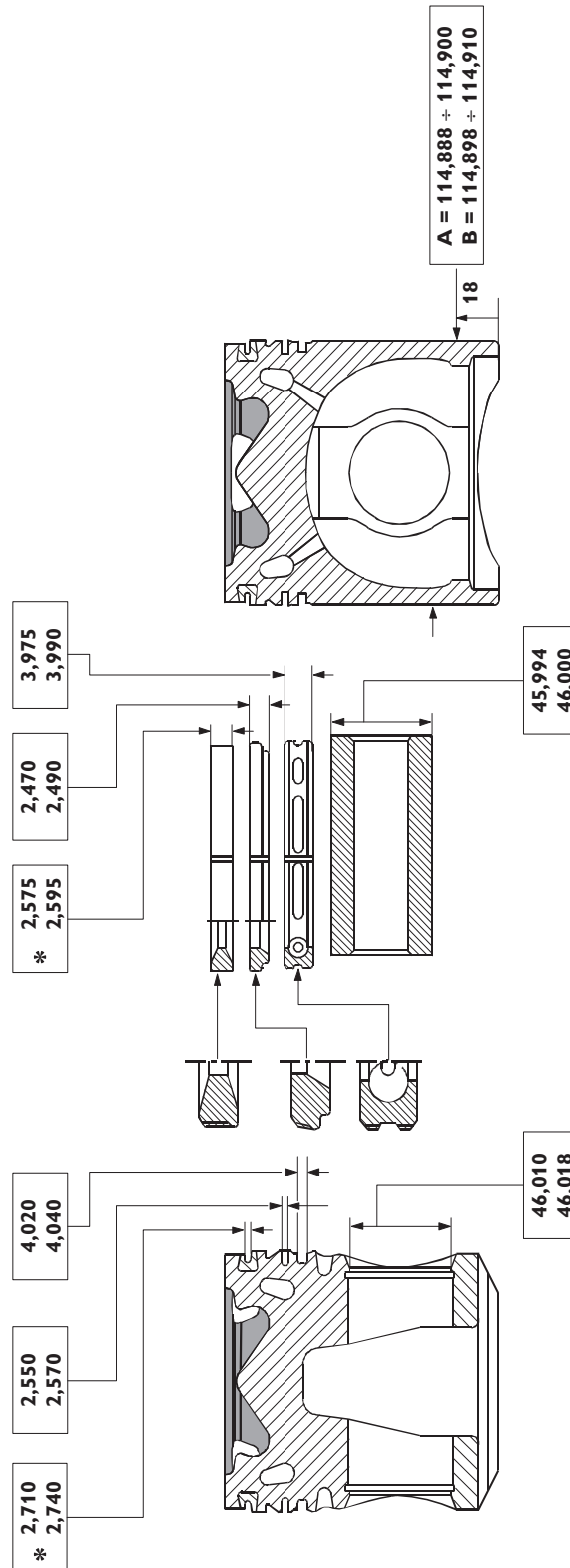


81047

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.

**Piston C78 ENS M20 - C78 ENT M30**

Figure 73A

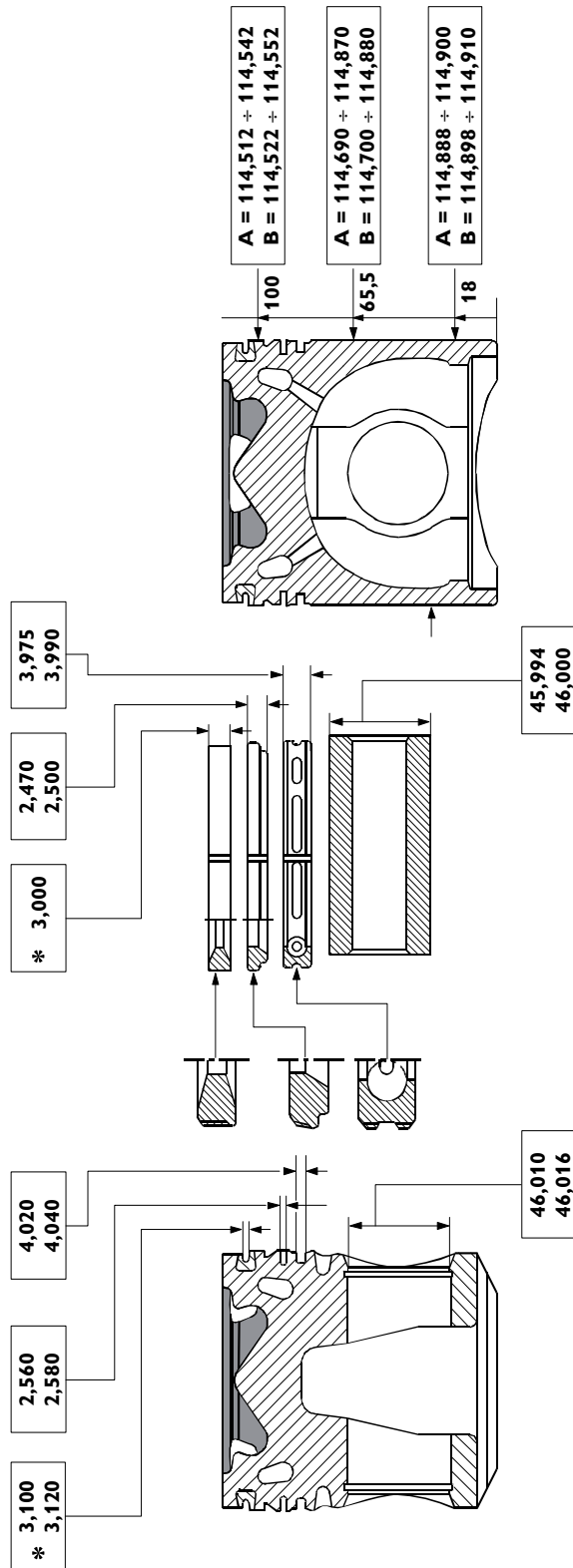


MAIN DATA ON PISTONS, AND PISTONS RINGS

\* Values are determined on Ø of 112 mm.

**Piston C78 ENT M50-M55**

Figure 73B

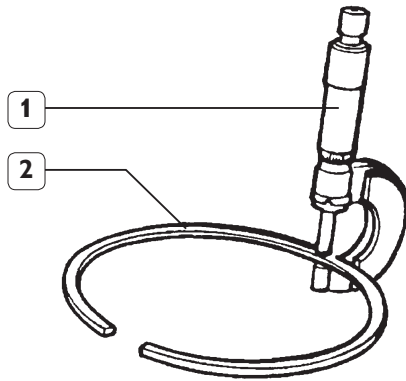


MAIN DATA ON PISTONS, AND PISTONS RINGS

\* Values are determined on  $\varnothing$  of 112 mm.

**Piston rings**

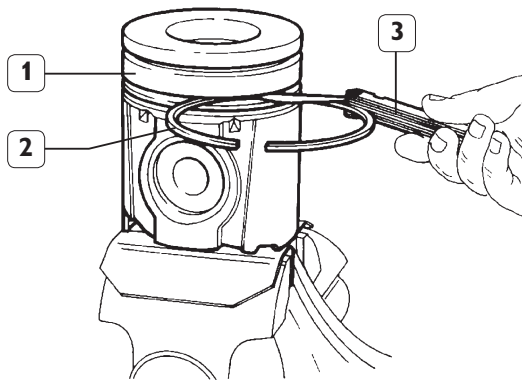
Figure 74



81049

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

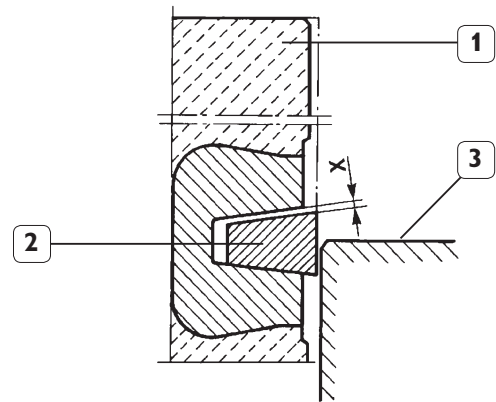
Figure 75



81050

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

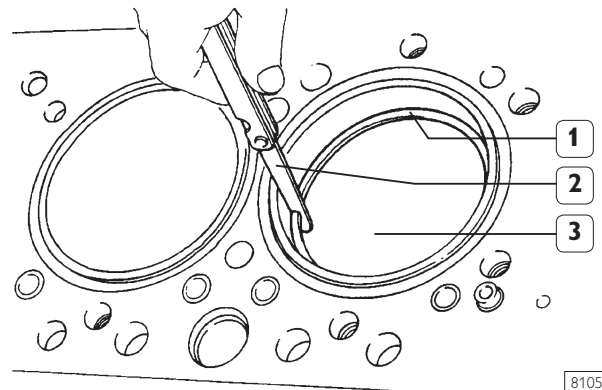
Figure 76



81051

The sealing ring (2) of the 1<sup>st</sup> 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



81052

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**

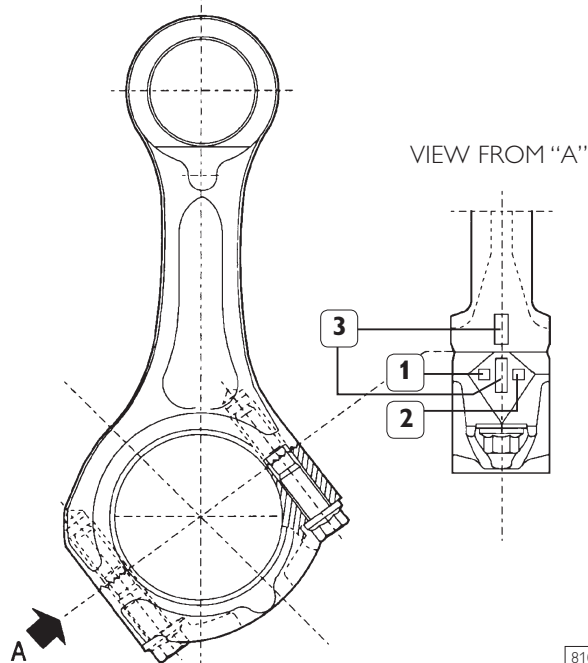
Data concerning the class section of connecting rod housing and weight are stamped on the big end.

**CAUTION**

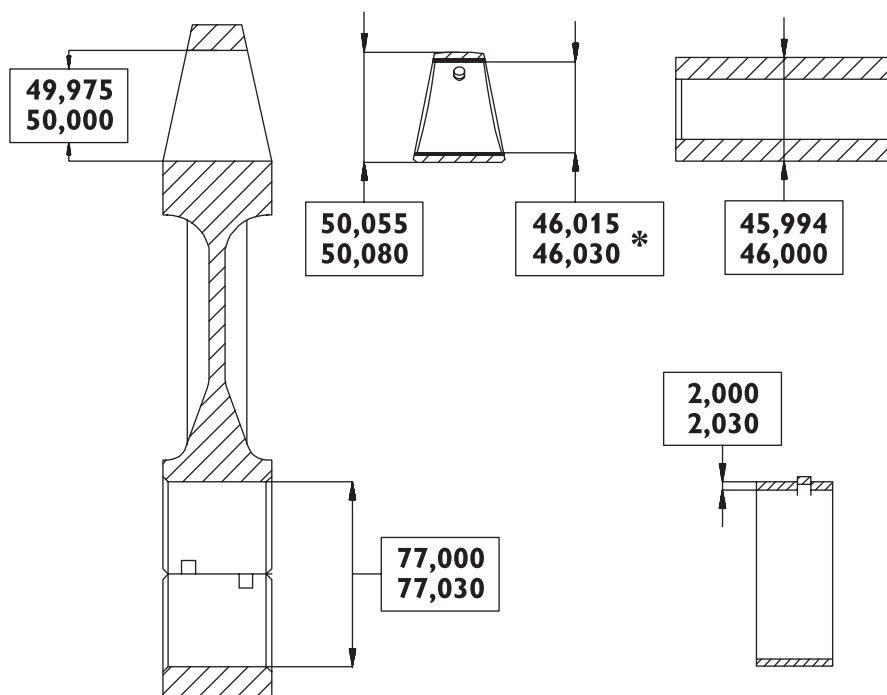
When installing connecting rods, make sure they all belong to the same weight class.

**Diagram connecting rod marks**

- 1** Letter indicating the weight class:  
A = 2890 to 2920 g.  
B = 2921 to 2950 g.  
C = 2951 to 2980 g.
- 2** Number indicating the selection of diameter for the big end bearing housing:  
1 = 77.000 to 77.010 mm  
2 = 77.011 to 77.020 mm  
3 = 77.021 to 77.030 mm
- 3** Numbers identifying cap-connecting rod coupling.

**Figure 78**

81032

**Figure 79**

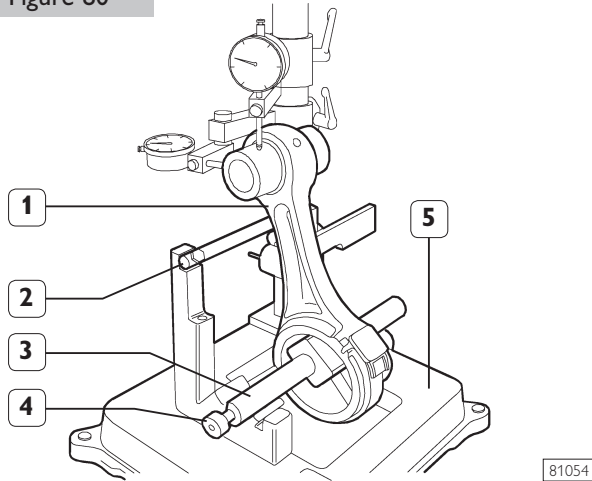
81053

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

\* Values to be obtained after installing the bush.

### Checking connecting rod alignment

Figure 80



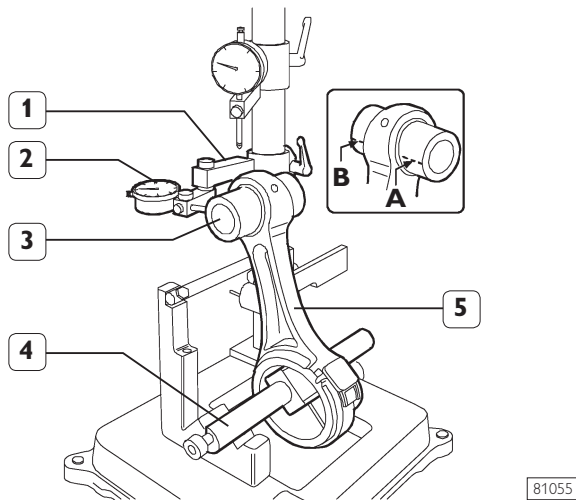
#### Checking axis alignment

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

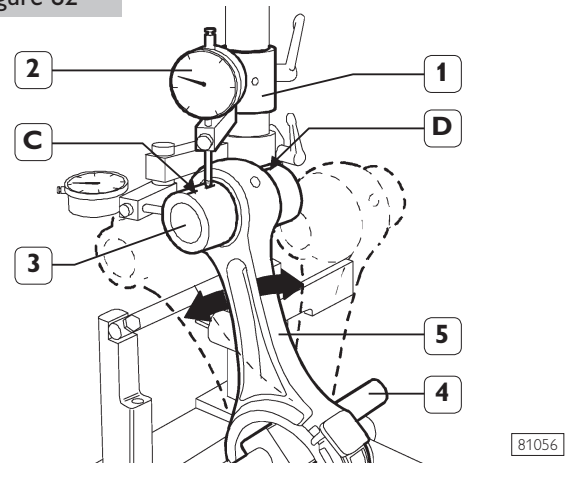


Check the torsion of the connecting rod (5) by comparing two points (**A** and **B**) of the pin (3) on the horizontal plane of the axis of the connecting rod.

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

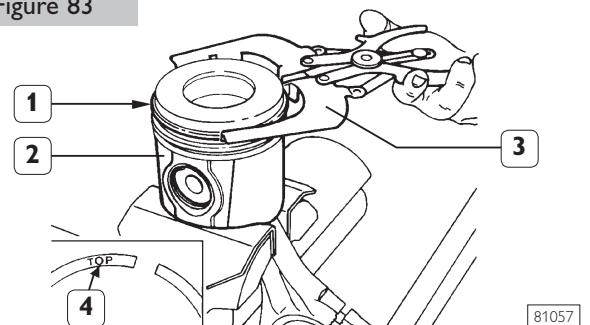
Carry out the steps for removal described on page 161 in reverse order.

#### 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

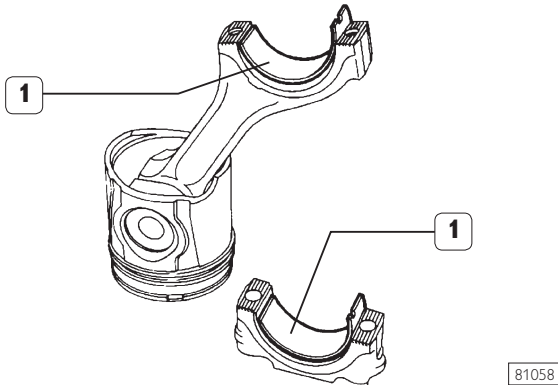


To fit the piston rings (1) on the piston (2) use the pliers 99360184 (3).

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

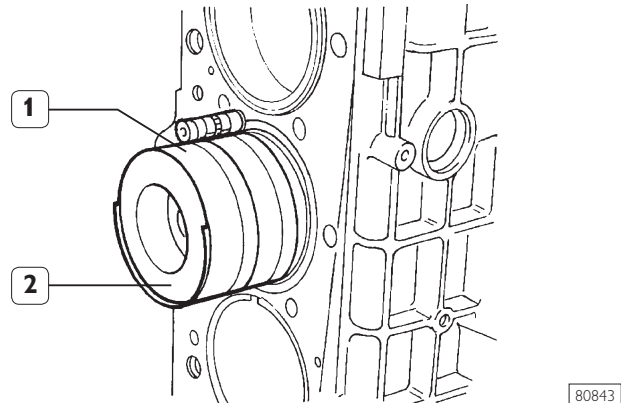


Install half-bearings (1), selected as specified from page 152, on both the connecting rod and the cap.

### CAUTION

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

Figure 85



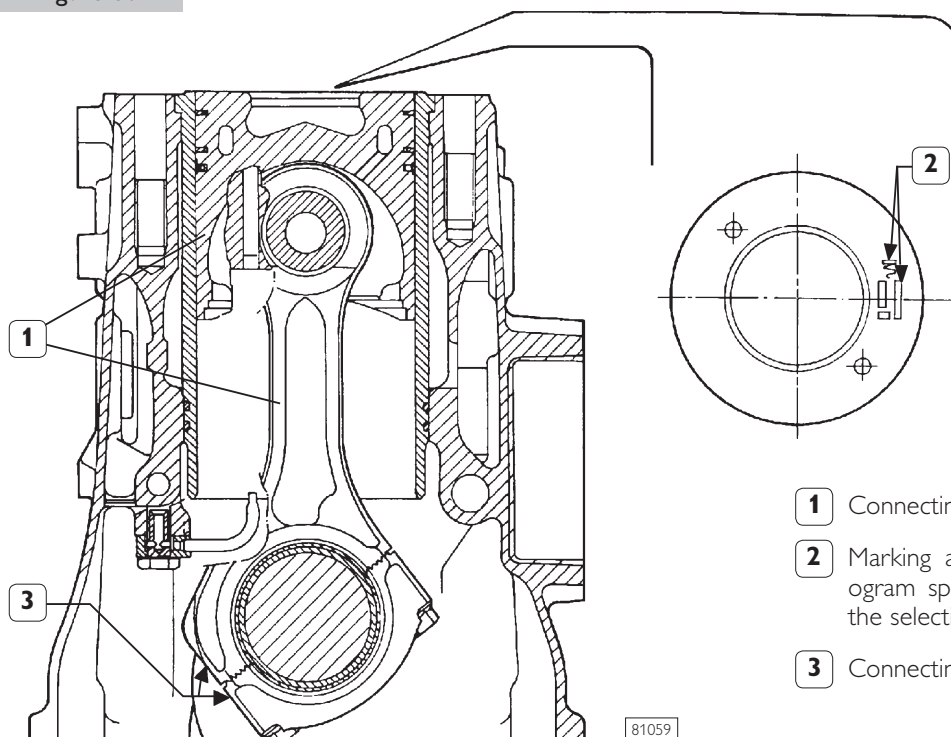
Fit the connecting rod-piston assemblies (1) into the piston liners (2) using band 99360605 (1, Figure 85). Check the following:

- 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 0.32 to 0.69 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).

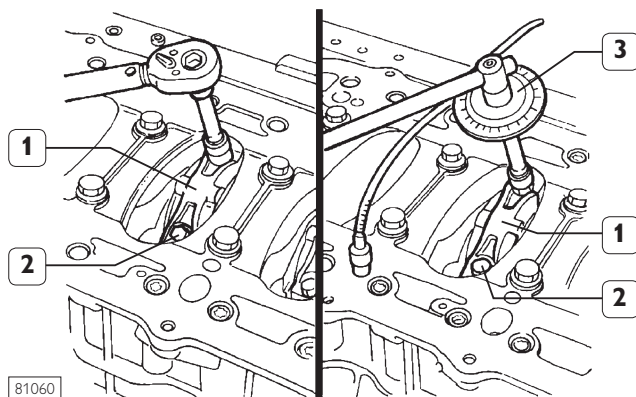


### Checking assembly clearance of big end pins

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



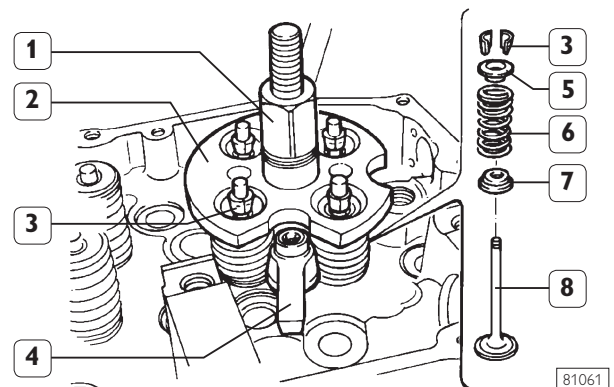
- ❑ Install the connecting rod caps (1) with half-bearings; tighten the connecting rod cap fixing screws (2) to 50 Nm (5 Kgm) torque. By tool 99395216 (3), tighten the screws further at 40° angle;
- ❑ Remove the caps and check the clearance by comparing the width of the calibrated wire with the scale 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

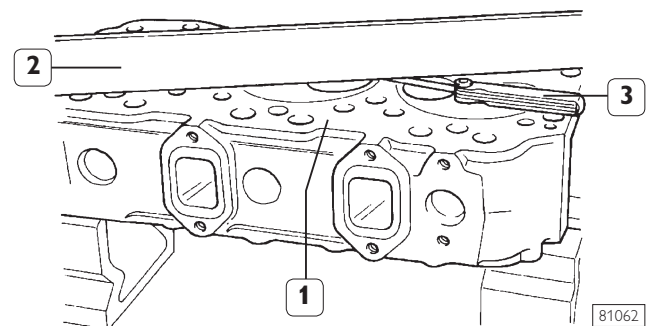
Figure 88



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.

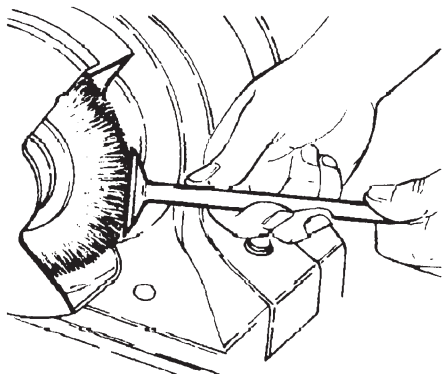
### CAUTION

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

**VALVES**

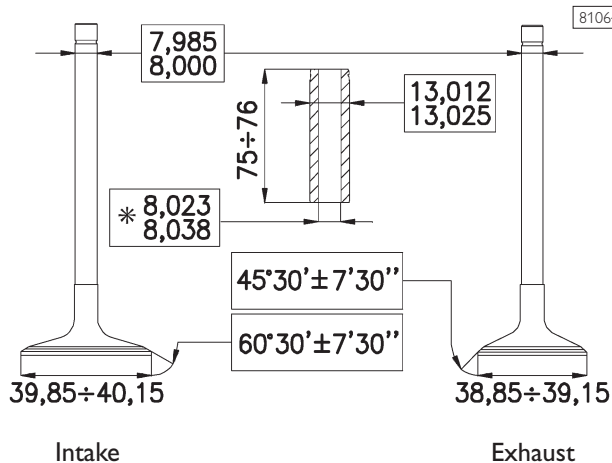
**Removing deposits and checking the valves**

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



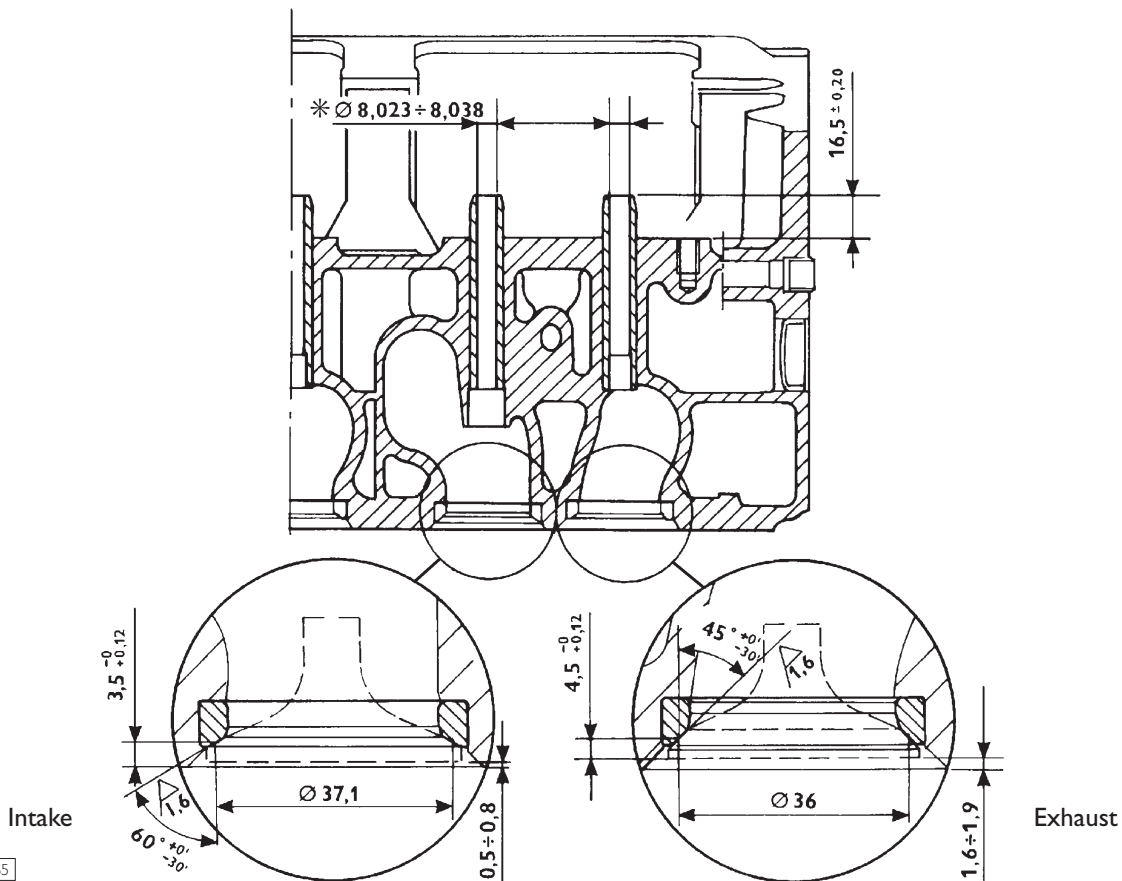
MAIN DATA - VALVES AND VALVE GUIDES

\* 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



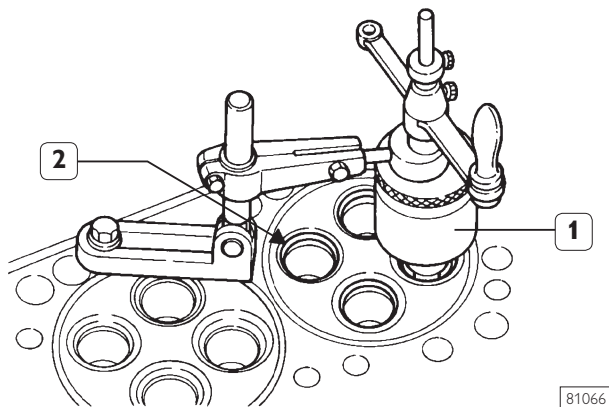
### Replacing of valve guides

Remove valve guides by means of tool 99360288. Install by means of tool 99360288 equipped with part 99360294, 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 16.3 to 16.7 (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.

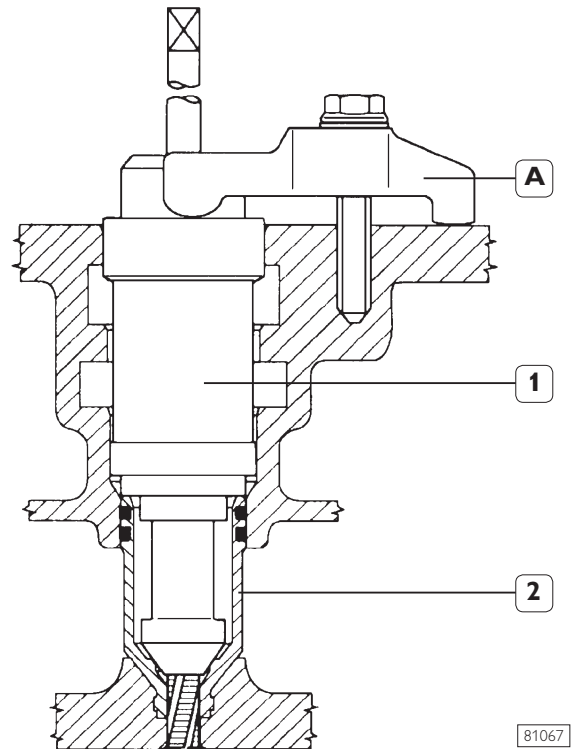
After reaming the valve seats, use tool 99370415, to make sure that the valve position, with respect to the cylinder head surface, is the following:

- ❑ -0.5 to -0.8 mm (recessing) of intake valves;
- ❑ -1.6 to -1.9 mm (recessing) of exhaust valves.

### REPLACING INJECTOR HOLDER CASES

#### Removal

Figure 94

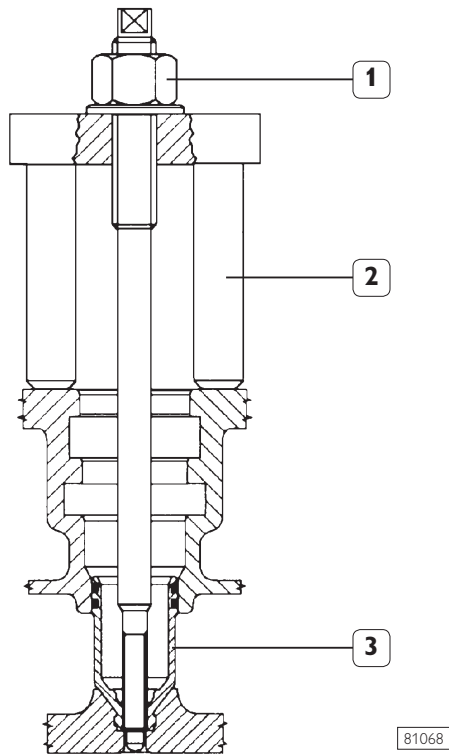


To replace the injector case (2), act as follows:

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

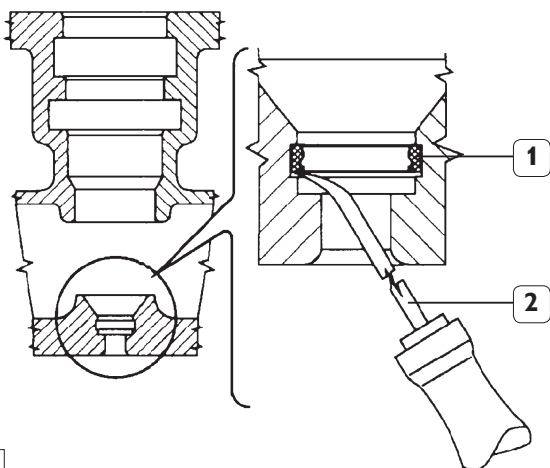
Carry out operations described in figs. 94-97-98-99 by fixing tools to the cylinder head by means of bracket A.

Figure 95



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

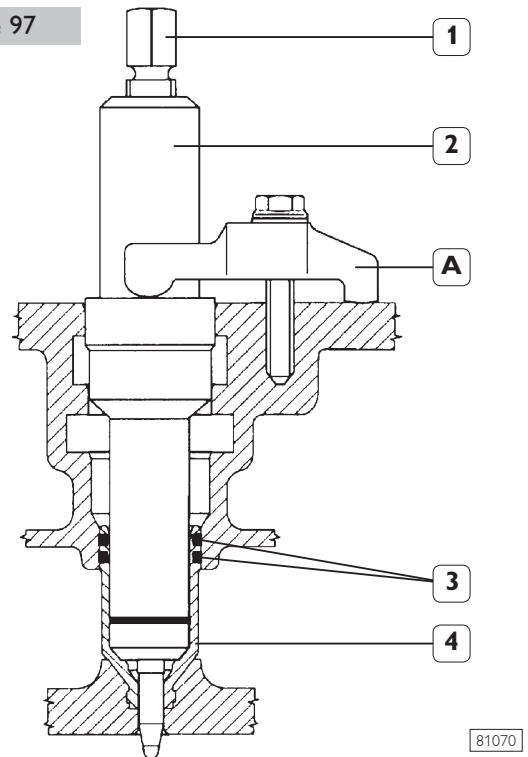
Figure 96



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

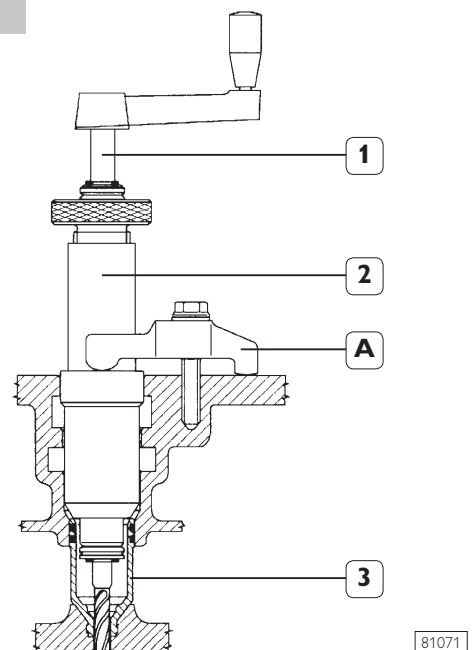
## Mounting

Figure 97



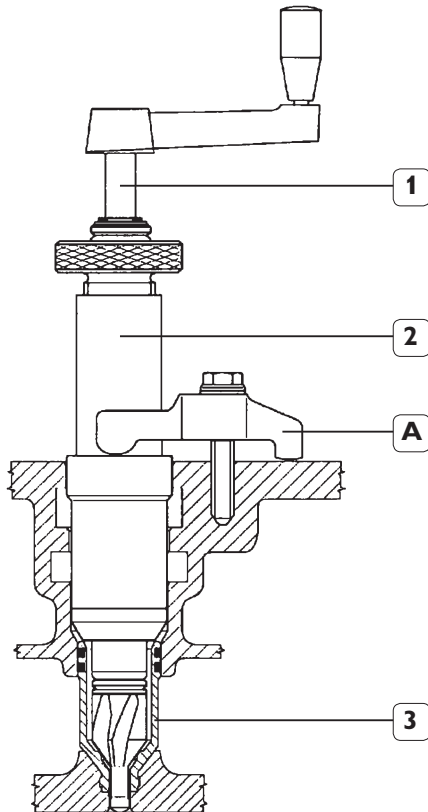
- Lubricate sealing rings (3) and fit them to the case (4); fix tool 99360554 (2) to the cylinder head by means of bracket A, install the new case, tighten the screw (1), upsetting the case lower part.

Figure 98



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

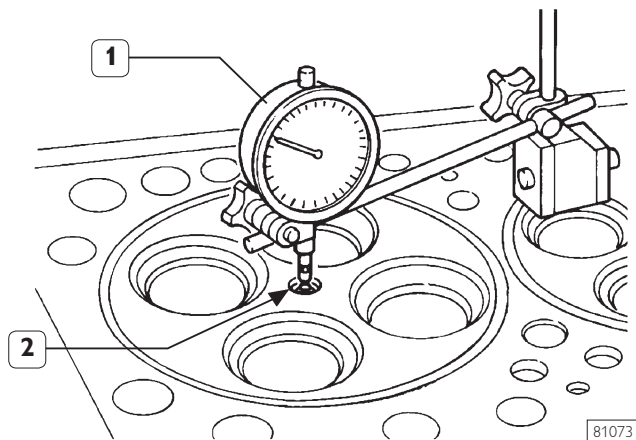
Figure 99



- Through miller 99394041 (1) and bushing 99394014 (2), ream the injector seat in the case (3), check the injector protrusion from the cylinder head plane which must be 0.7 mm.

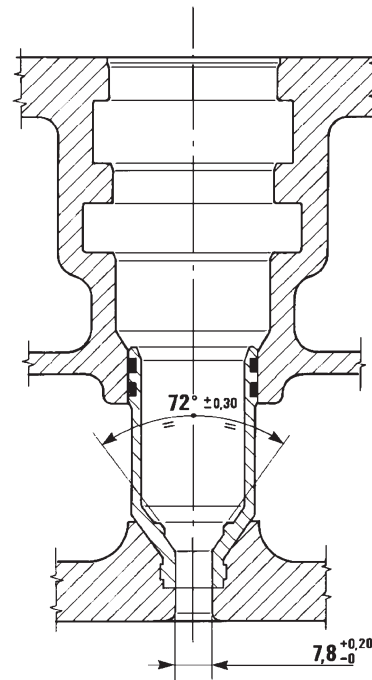
**Checking protrusion of injectors**

Figure 100



Using dial gauge (1), check the protrusion of the injector (2) which must be 0.7 mm.

Figure 101

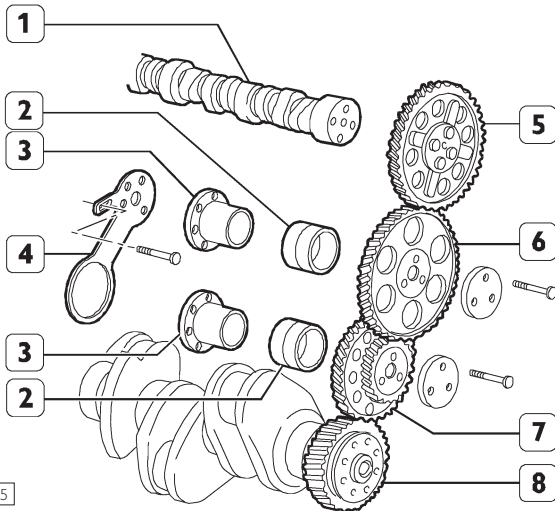


INSTALLATION DIAGRAM FOR INJECTOR CASE

## TIMING GEAR

## Camshaft drive

Figure 102



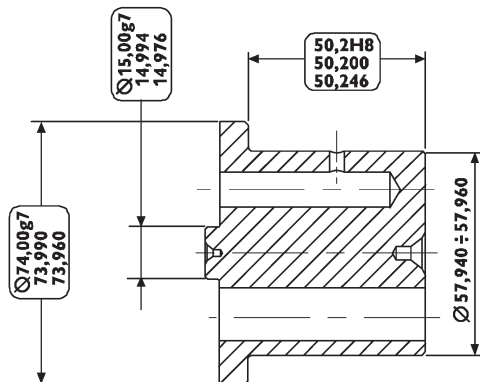
86925

## 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.

## Intermediate gear pin

Figure 103

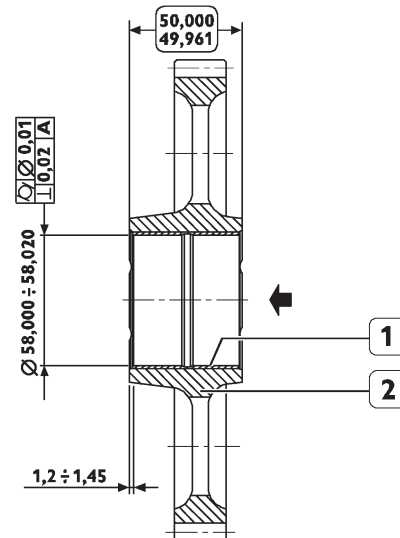


86926

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

## Idler gear

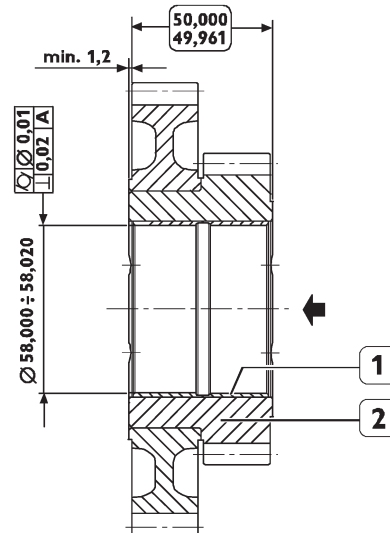
Figure 104



86927

## Twin idler gear

Figure 105



99283

## Replacing the bushings

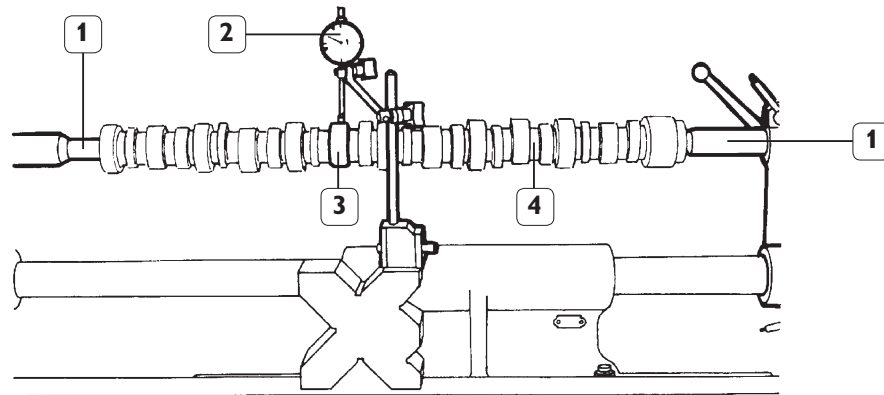
Bushings (1, Figures 104-105) can be replaced when they are worn. Put up the bushing, then grind it so as to bring it to a dimension of  $\text{Ø } 58,010 \pm 0,10 \text{ mm}$ .

## CAUTION

Bushings must be forced into gears (2, Figures 98 - 99) by following the direction of the arrow: they must be positioned at the level shown in the figures.

## Checking cam lift and pin alignment

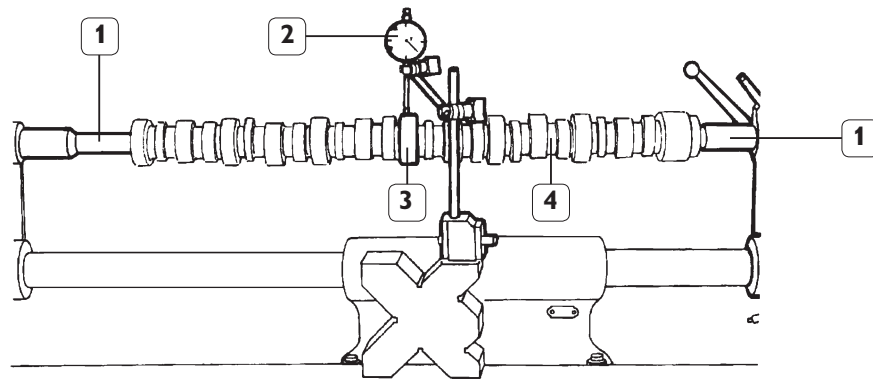
Figure 106



81088

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.

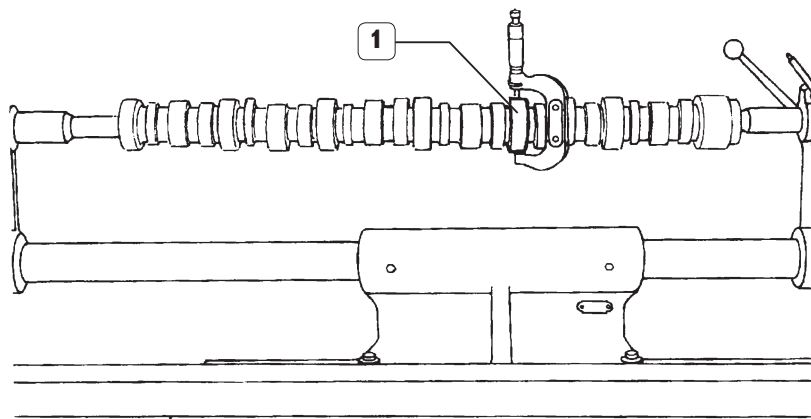
Figure 107



81075

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

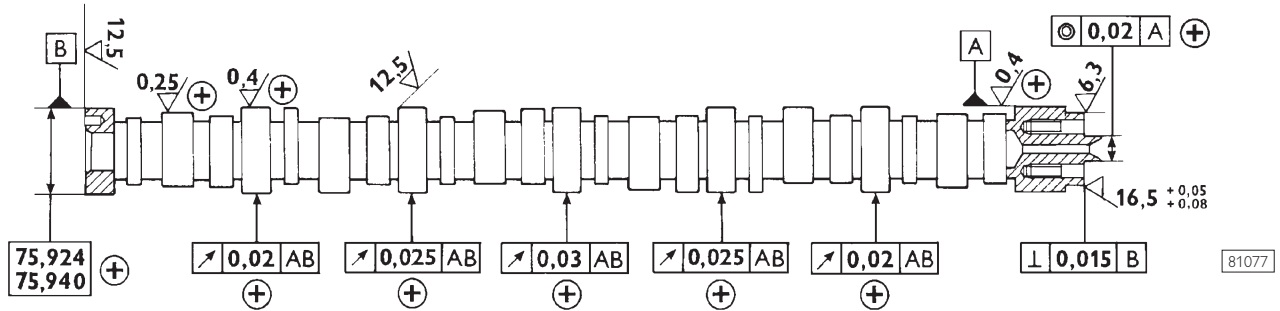


81076

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

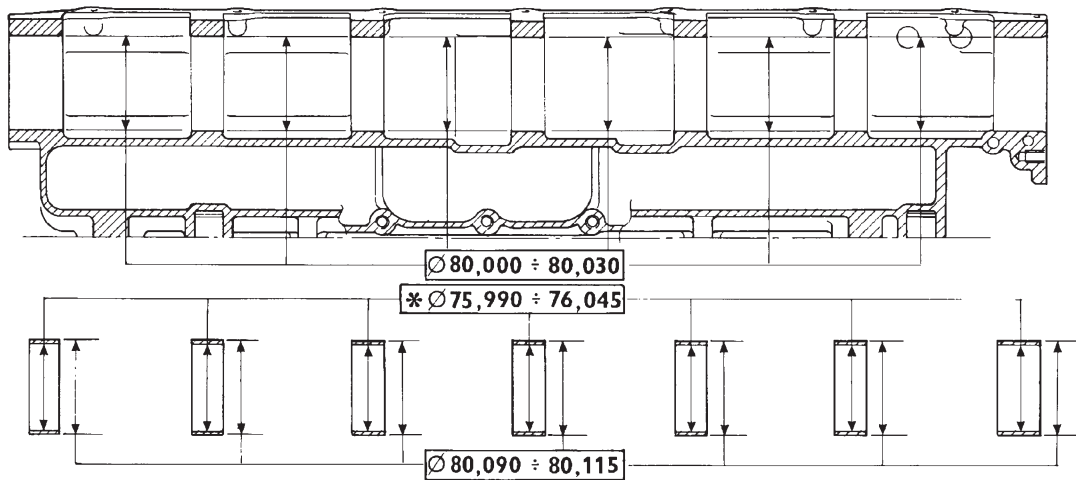
The surfaces of shaft supporting pin and cams must be extremely smooth; if you see any sign of seizing or scoring, replace the shaft and the relative bushes.

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

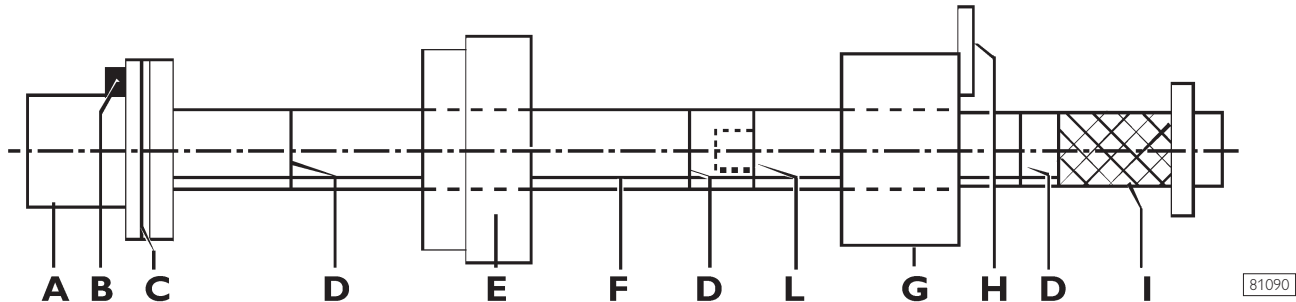
\* Bush inner diameter after installation.

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 99360487.

## Replacing camshaft bushes using beater 99360487

Figure 111

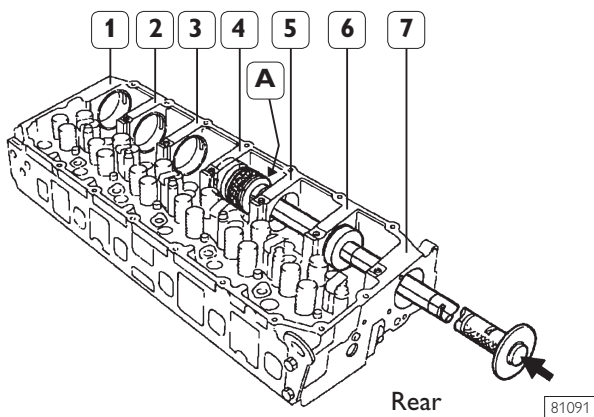


81090

- 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



81091

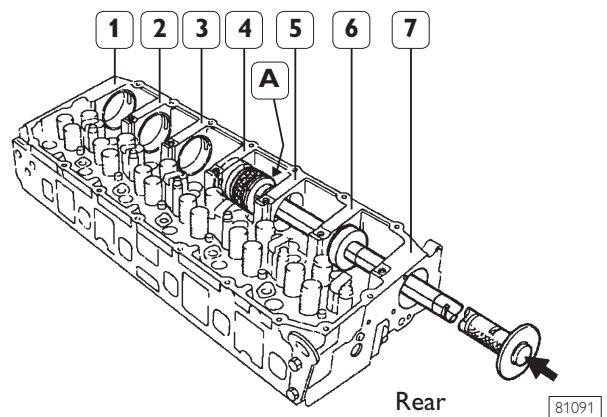
The sequence for removing the bushes is 7, 6, 5, 4, 3, 2, 1. The bushes are extracted from the front of the single seats.

Removal does not require the drift extension for bushes 5, 6 and 7 and it is not necessary to use the guide bushing. For bushes 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



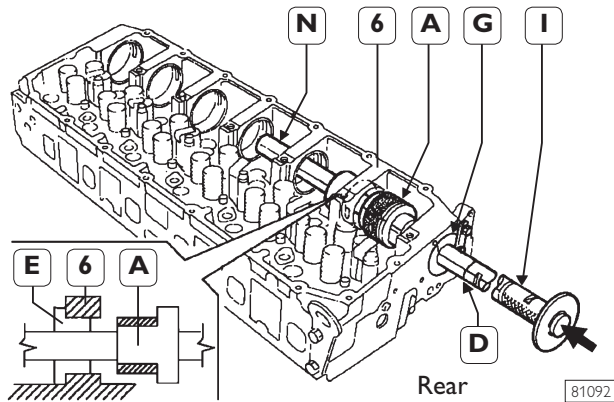
81091

Assemble the drift together with the extension.

To insert bushes 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 7<sup>th</sup> 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 1<sup>st</sup> red reference mark (D) is flush with the guide bushing (G).

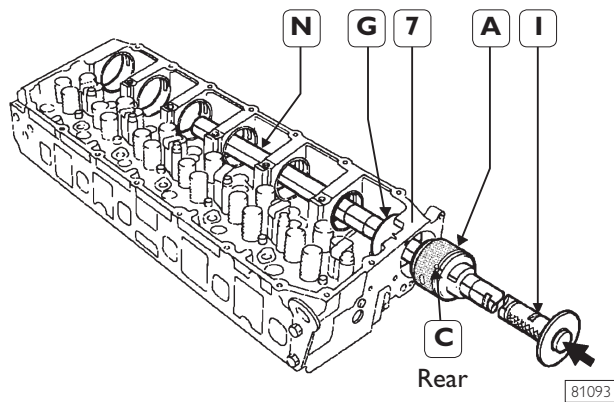
Figure 114



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

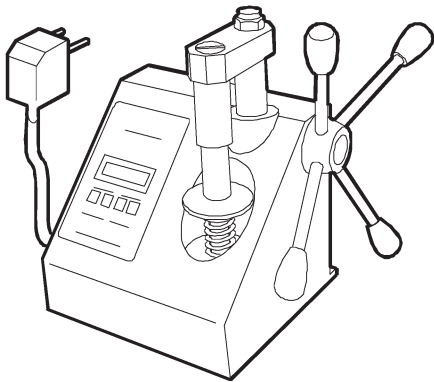


To insert bushing (7), proceed as follows:

- 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 7<sup>th</sup> bushing is driven in when the reference mark (C) is flush with the bushing seat.

## VALVE SPRINGS

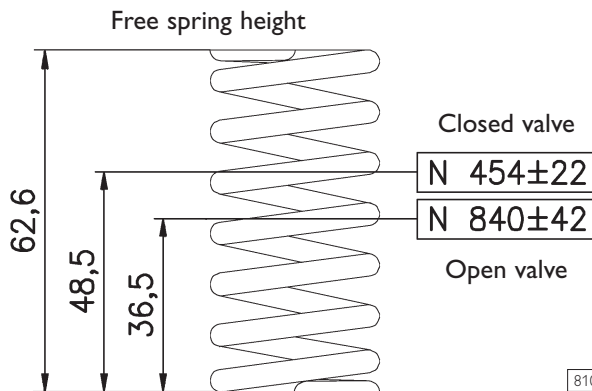
Figure 116



99305047

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

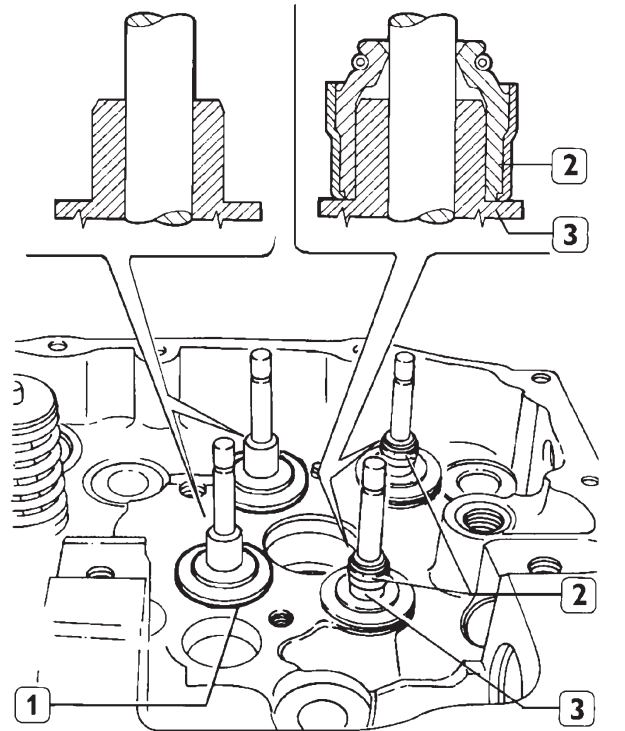


81094

MAIN DATA TO CONTROL INTAKE  
AND EXHAUST VALVE SPRING

## Fitting the valves and oil seal ring

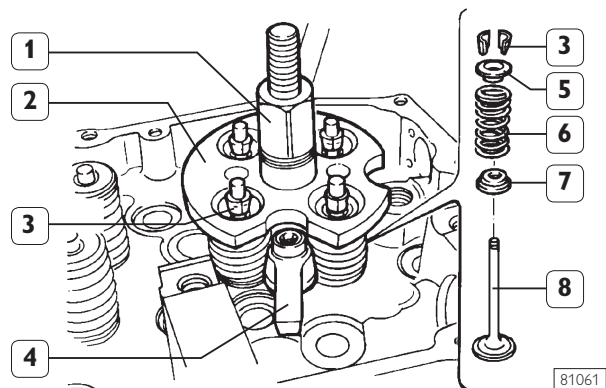
Figure 118



87051

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

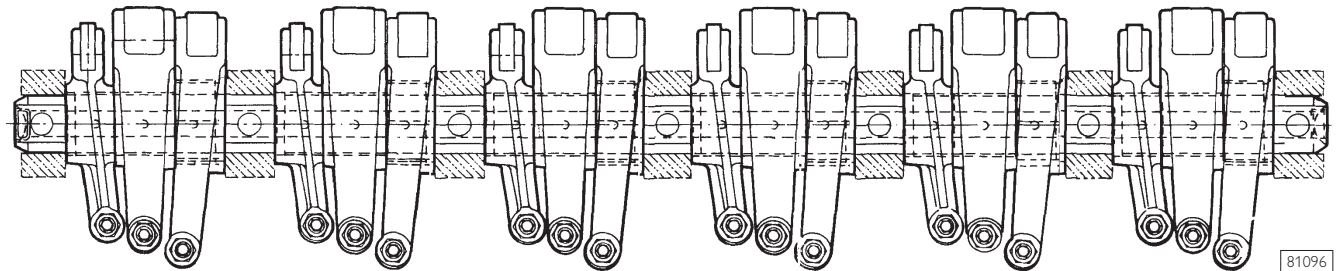


81061

- ❑ Fit springs (6) and the upper plate (5);
- ❑ Apply tool 99360264 (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.  
Rocker slides directly on the cam profiles via rollers.

The other end acts on a bar directly supported by the two valves stems.

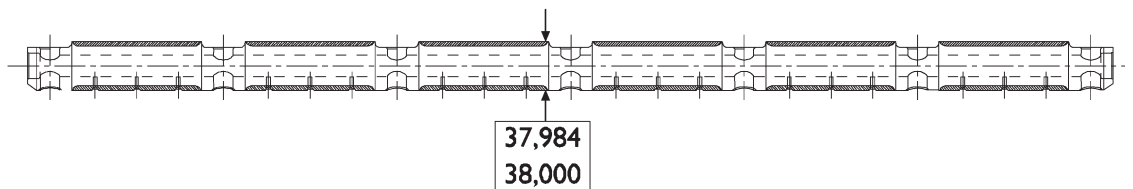
A pad is placed between the rocker adjusting screw and the bar.

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

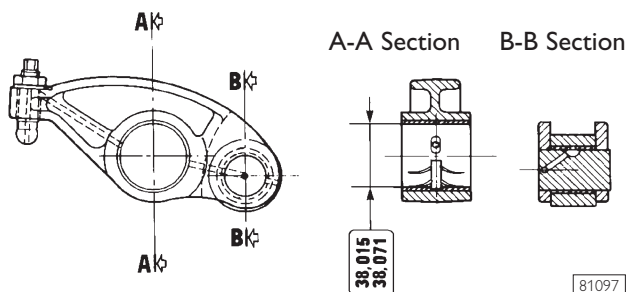


MAIN DATA OF THE ROCKER ARM SHAFT

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

### Rockers

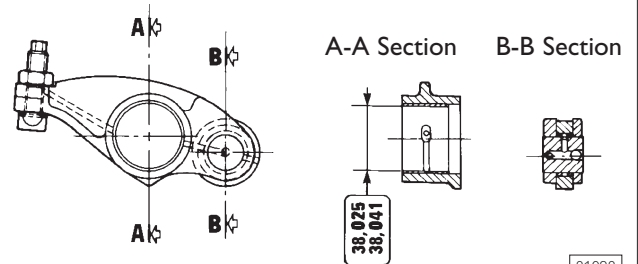
Figure 122



PUMP INJECTOR ROCKER

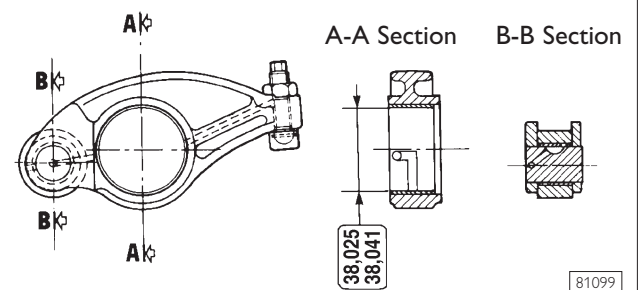
The bush surfaces must not show any trace of scoring or excessive wear; otherwise, replace bushes or the whole rocker.

Figure 123



INTAKE VALVES ROCKER

Figure 124



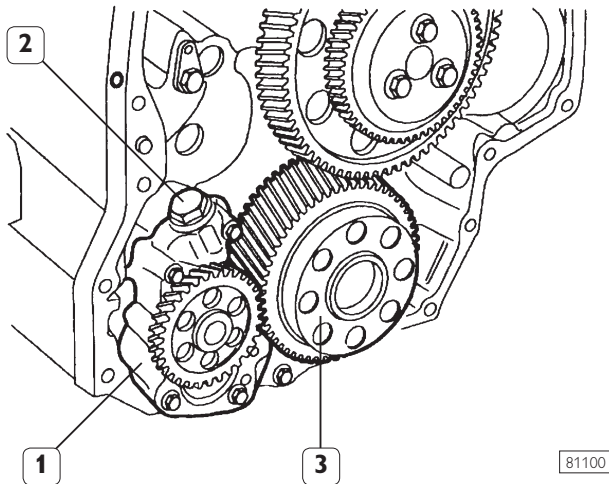
EXHAUST VALVES ROCKER

## LUBRICATION SYSTEM COMPONENTS

Description and operation on Section 1.

### Oil pump

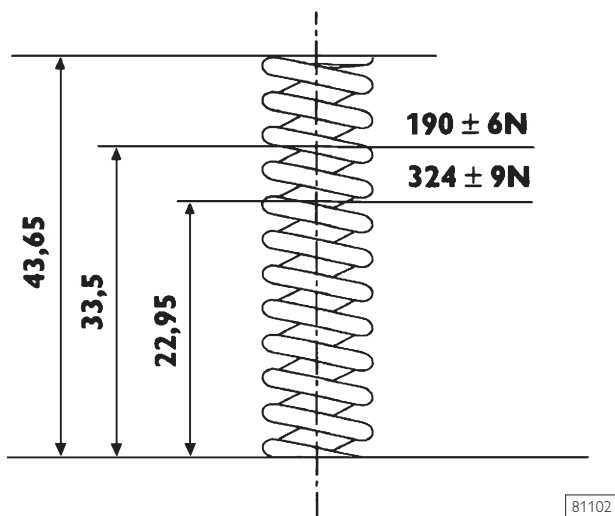
Figure 125



Oil pump (1) contains the overpressure valve (2) adjusted to start of opening pressure  $10.1 \pm 0.7$  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

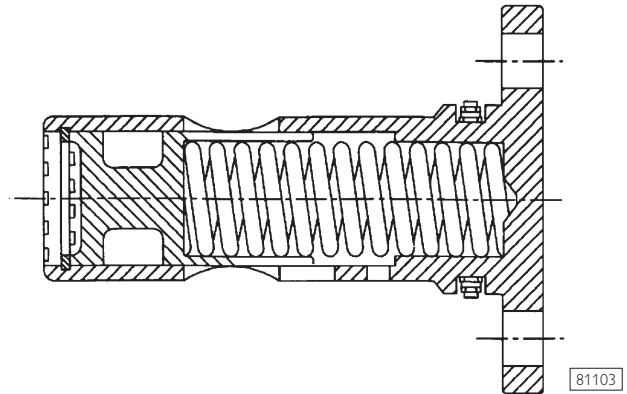
Figure 126



MAIN DATA TO CHECK  
THE OVERPRESSURE VALVE SPRING

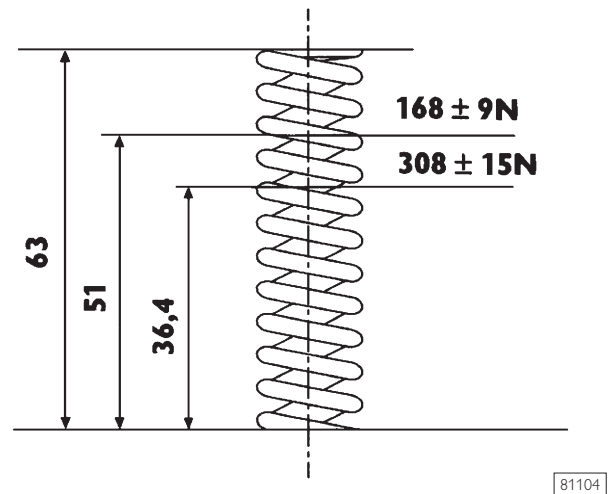
### Oil pressure control valve

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.

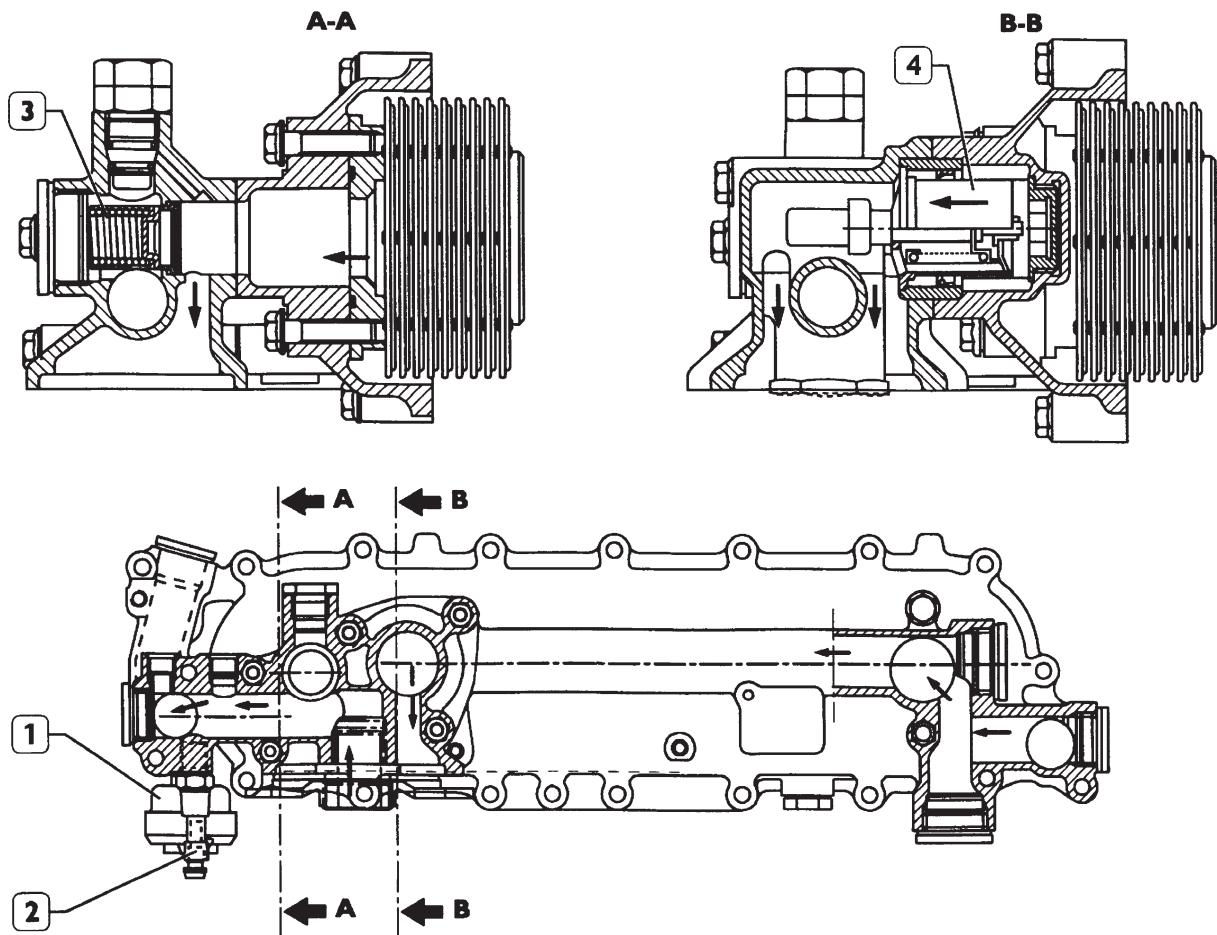
Figure 128



MAIN DATA TO CHECK  
THE OIL PRESSURE CONTROL VALVE SPRING

## Heat exchanger

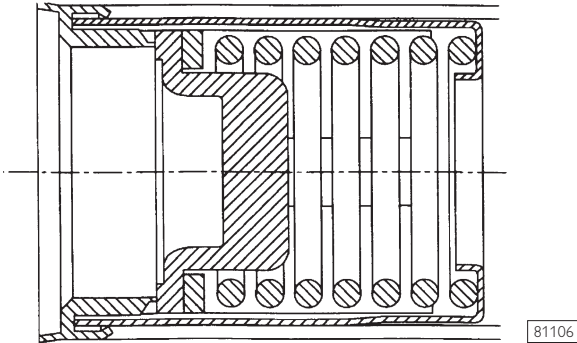
Figure 129



1. Oil pressure sensor - 2. Oil low pressure switch (closed at pressure  $p \leq 0.5$  bar) - 3. Filter by-pass valve - 4. Thermostatic valve.

## Filter by-pass valve

Figure 130

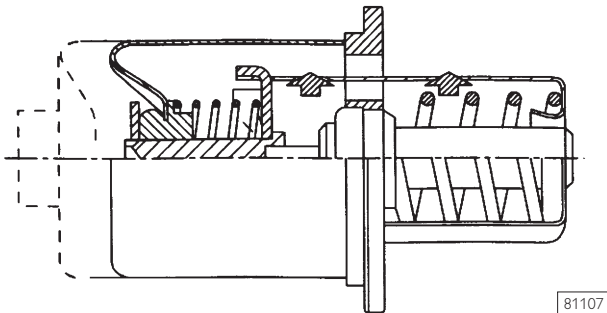


81106

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



81107

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  $82 \pm 2$  °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.



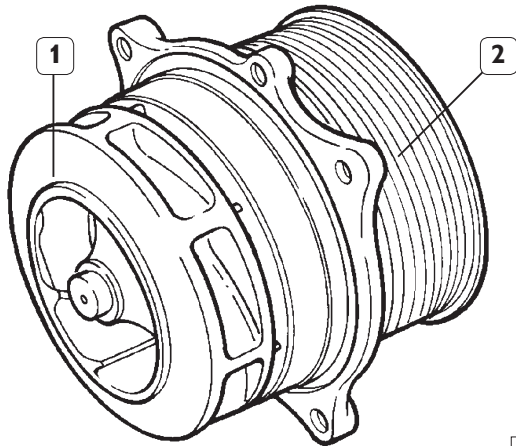
## COOLING SYSTEM COMPONENTS

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



81101

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  $68 \pm 2 \text{ }^\circ\text{C}$  and to shut the channel to the coolant pump completely at the temperature of  $78 \pm 2 \text{ }^\circ\text{C}$ .

Check the valve works properly; replace it if in doubt.

Figure 133

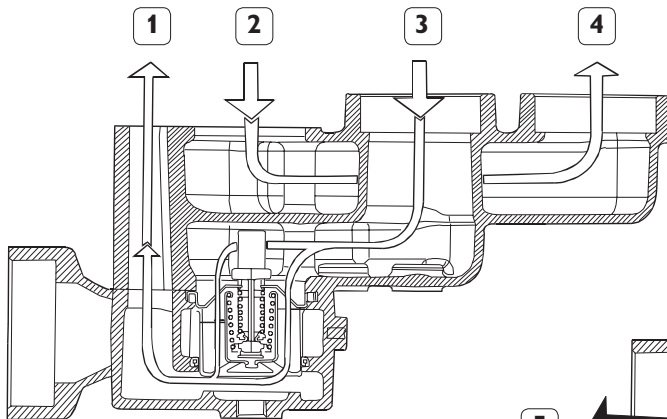
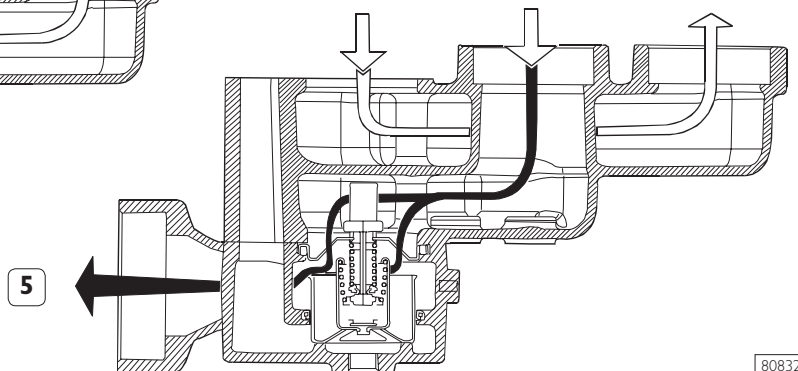


Figure 134



80832

 Low temperature liquid

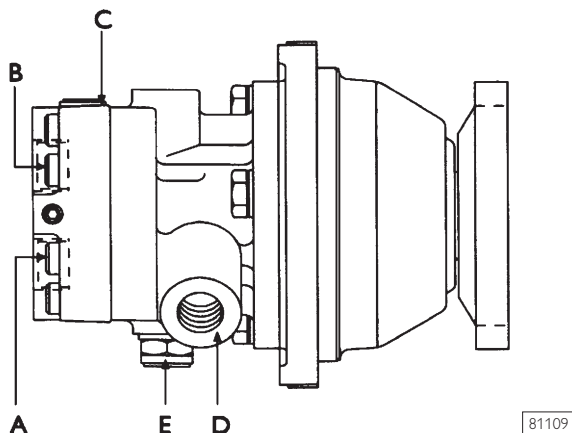
 High temperature liquid

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

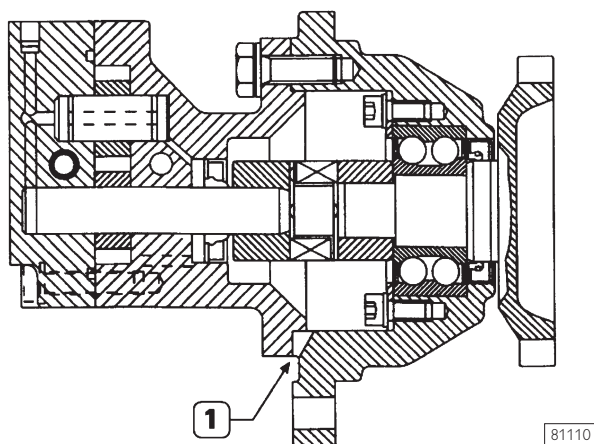
Figure 135



- 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

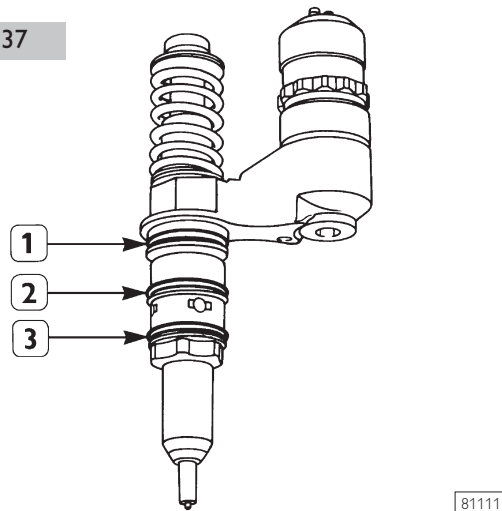


1. Oil and fuel leakage indicator

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

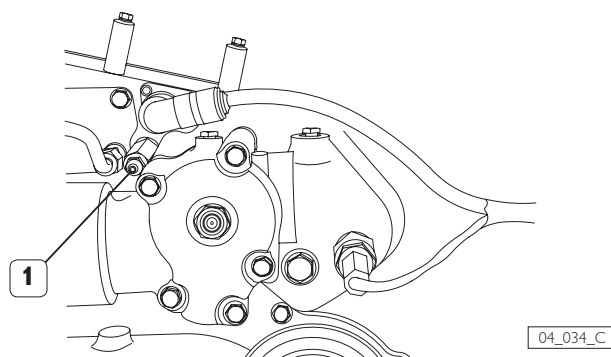


1. Fuel/oil seal - 2. Fuel in/fuel out seal - 3. Fuel seal.

### 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

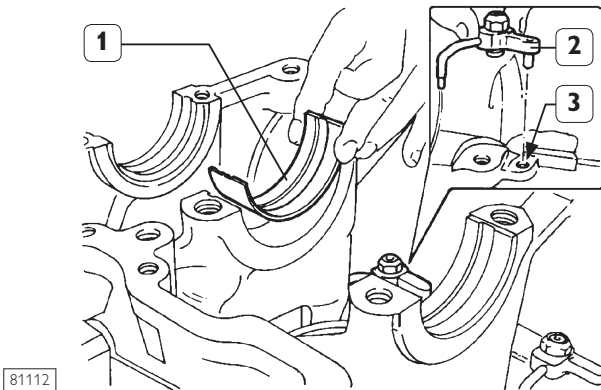
Before extracting the injector-pump, you must empty the fuel inflow and recirculation channels machined in the cylinder head, to prevent the liquid from dripping into the underlying combustion chamber machined in the piston crown. To do so, loosen the fuel inlet junction to the cylinder head and the 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

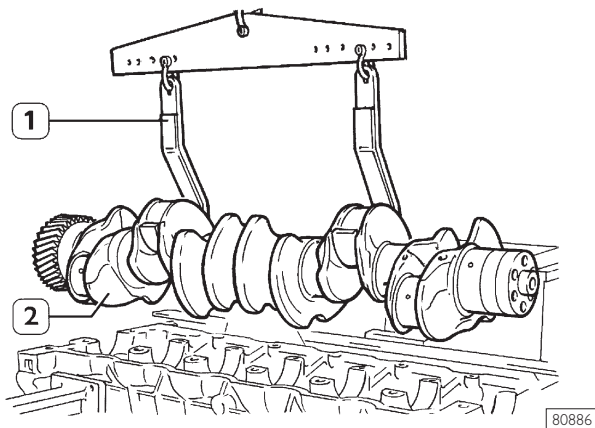
Fix the engine block to the stand 99322230 by means of brackets 99361035.  
Install the cylinder liners as described in page 149.

Figure 139



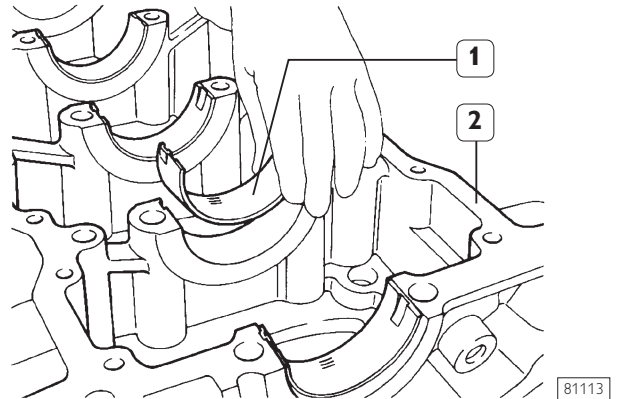
Fit the oil spray nozzles (2), so that the dowel coincides with the block hole (3).  
Place the half bearings (1) on the main bearings.

Figure 140



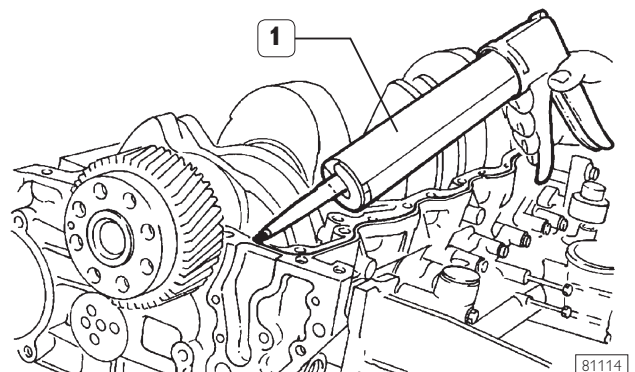
Lubricate the half bearings, then install the crankshaft (2) by means of hoist and hook 99360500 (1).

Figure 141



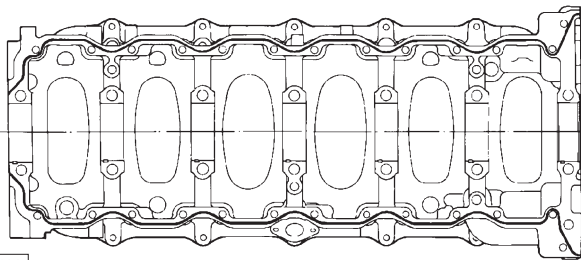
Place the half-bearings (1) on the main bearings in the underblock (2).  
Remove the underblock.

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

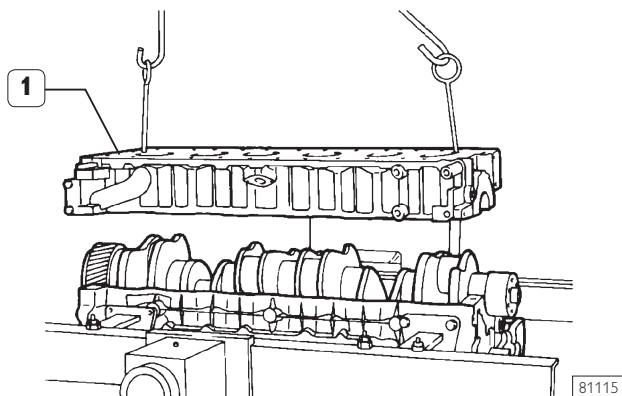


SEALANT APPLICATION DIAGRAM

**CAUTION**

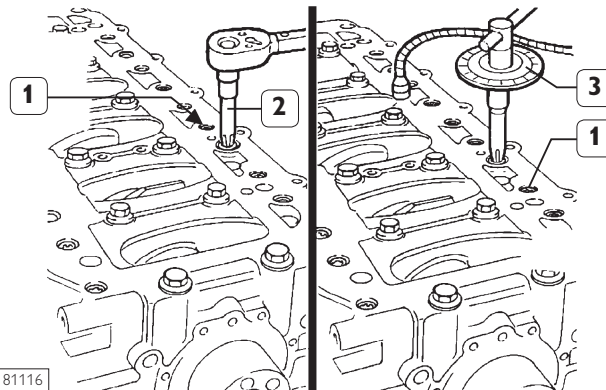
Fit the underblock within 10' since application of the sealant.

Figure 144



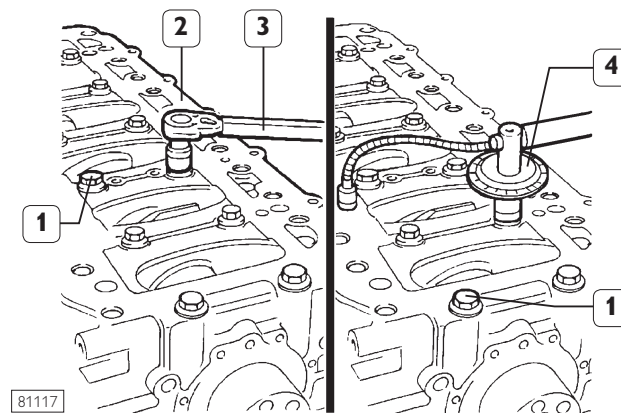
Fit the underblock by means of a suitable hoist and hooks (1).

Figure 145



Fit the underblock and, using a dynamometric wrench (2), close the splined outer (1) screws to 25 Nm torque, according to the diagram shown on next page.

Figure 146

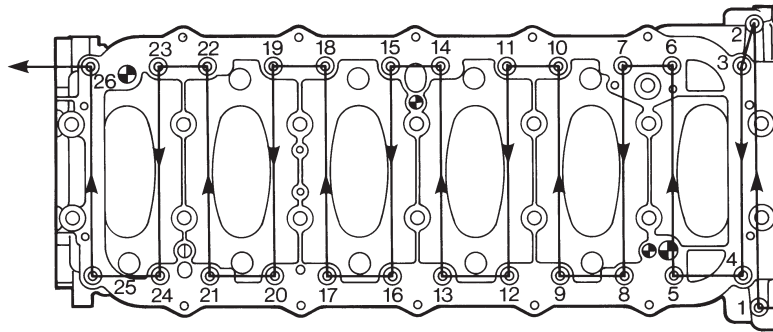


Close the inner screws (1) to 140 Nm torque by means of a dynamometric wrench (3, Figure 146), then with two further angular phases  $60^\circ + 60^\circ$ , using tool 99395216 (4). Tighten again the outer screws (1, Figure 145) with  $90^\circ$  angular closing, using tool 99395215 (3, Figure 145).

**Diagram showing the underblock fixing screws tightening order**

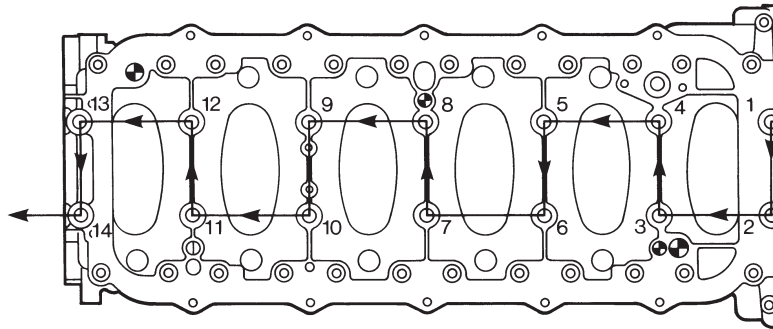
Figure 147

FRONT SIDE



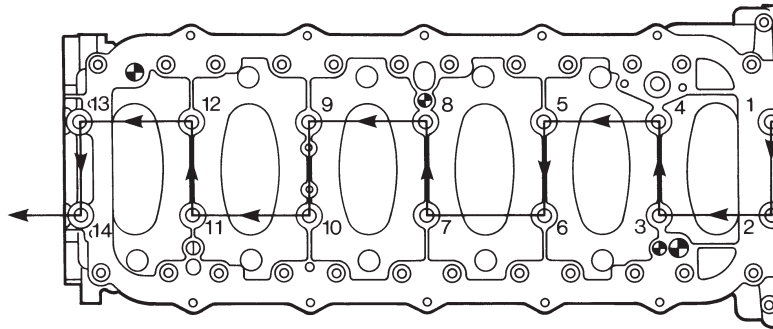
First phase:  
outer screws  
preliminary tightening  
(25 Nm)

FRONT SIDE



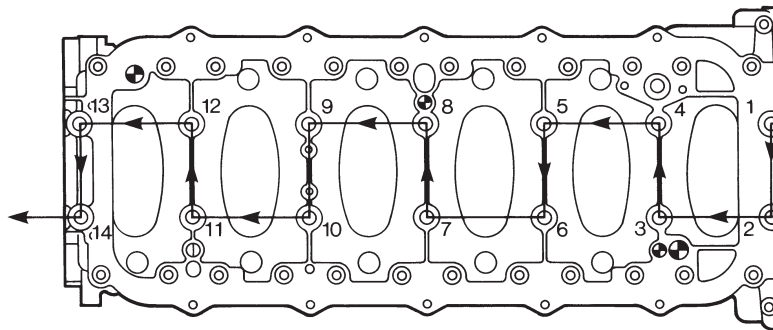
Second phase:  
inner screws  
preliminary tightening  
(140 Nm)

FRONT SIDE



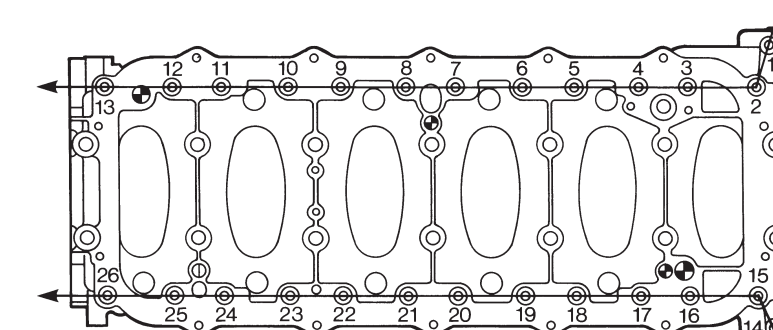
Third phase:  
inner screws  
angle closing  
(60°)

FRONT SIDE



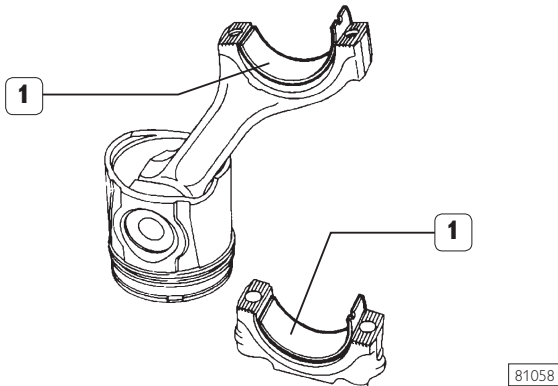
Fourth phase:  
inner screws  
angle closing  
(60°)

FRONT SIDE



Fifth phase:  
outer screws  
angle closing  
(90°)

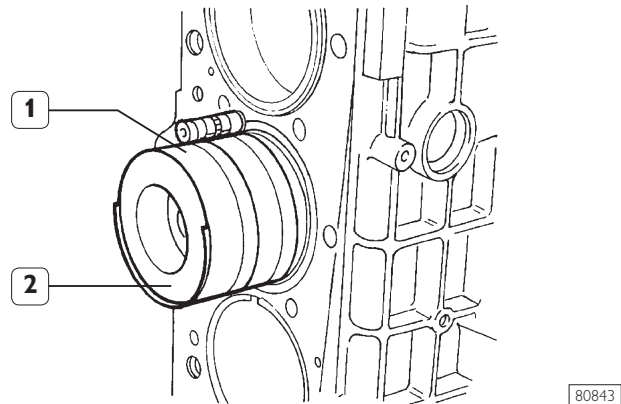
Figure 148



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



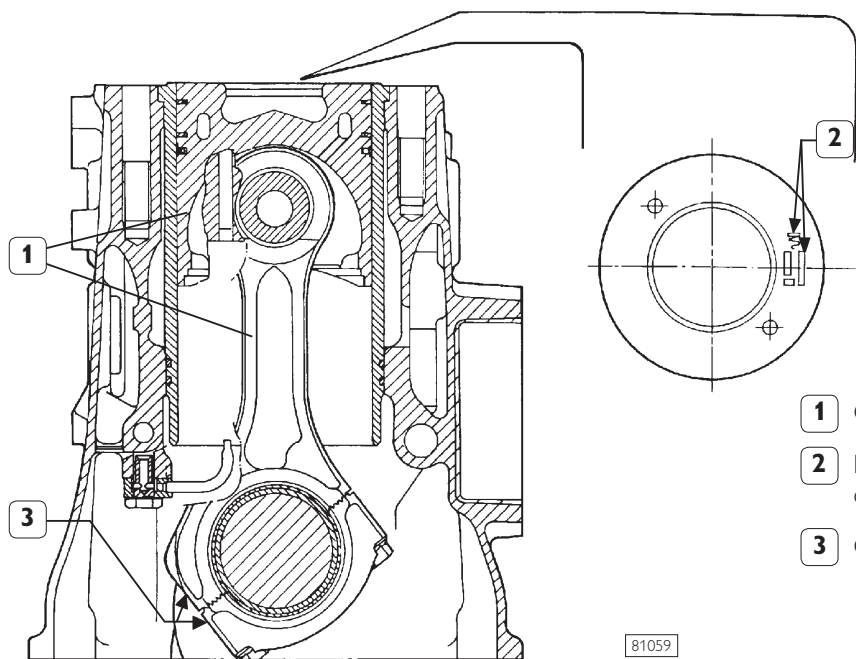
Fit the connecting rod-piston assemblies (2) into the piston liners, using the band 99360605 (1, Figure 149). Check the following:

- ❑ 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

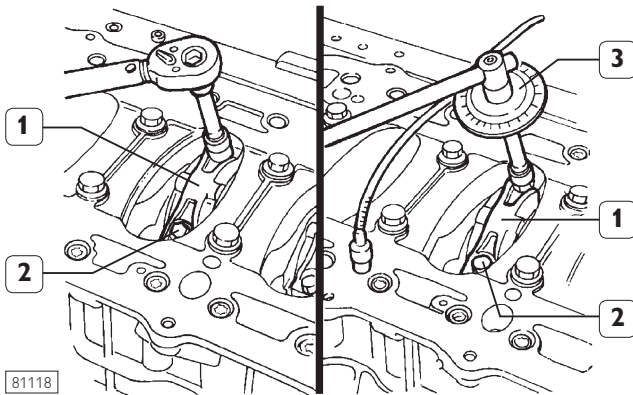
Once assembly is complete, check piston protrusion from cylinder barrels: it must be 0.32 to 0.69 mm.

Figure 150



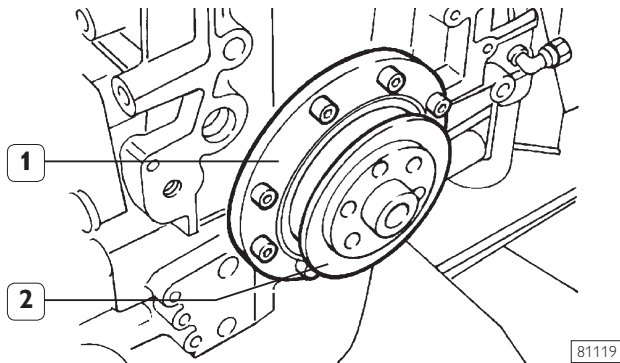
- ❶ Connecting rod-piston assembly;
- ❷ Marking area of ideogram on the piston crown;
- ❸ Connecting rod marking area.

Figure 151



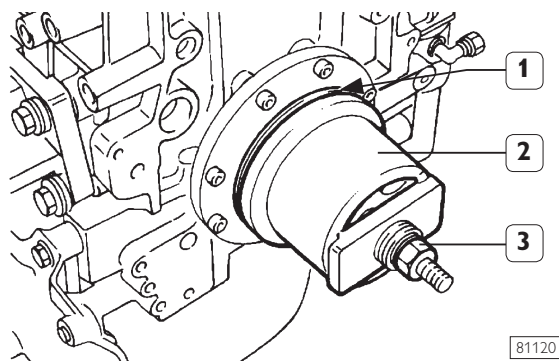
Connect the connecting rods to the relative journals, fit the connection rod caps (1) with half bearings; tighten the fixing screws (2) of the connecting rod caps to 50 Nm torque (5 Kgm). Using tool 99395216 (3), further tighten screws with 40° angle.

Figure 152



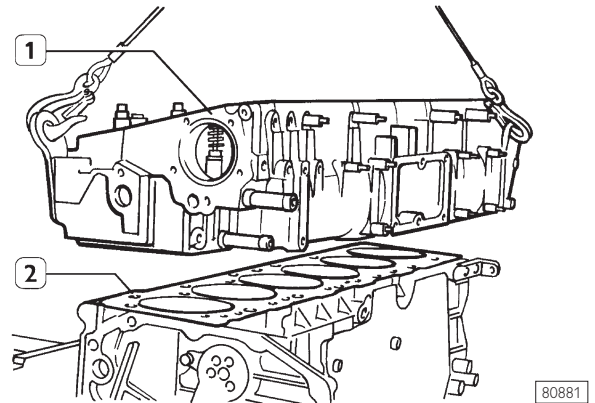
By means of centering ring 99396033 (2), check the exact cover position (1), otherwise act as necessary and tighten the screws.

Figure 153



Fit the sealing gasket (1), install the fitting tool 99346245 (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

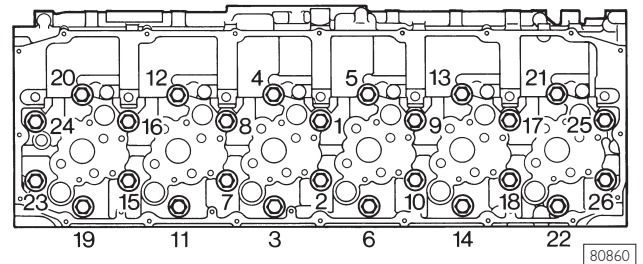
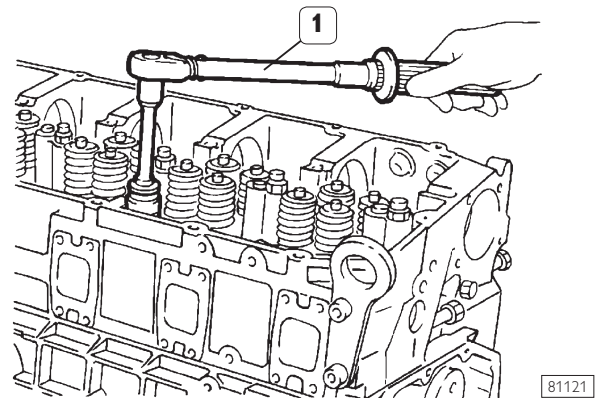


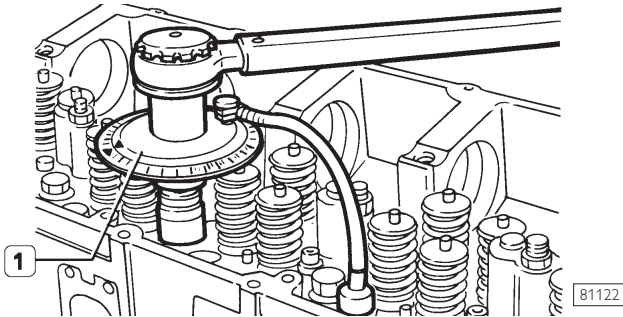
Diagram showing the cylinder head fixing screws tightening order:

Figure 156



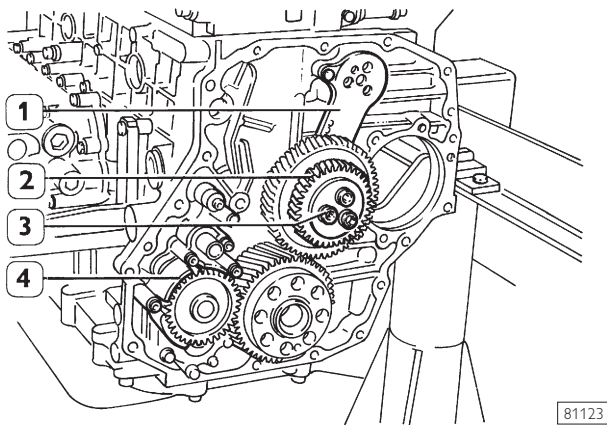
- Preliminary tightening by means of a dynamometric wrench (1):
  - 1<sup>st</sup> phase: 50 Nm (5 Kgm);
  - 2<sup>nd</sup> phase: 100 Nm (10 Kgm).

Figure 157



- Angle closing by means of tool 99395216 (1):
- 3<sup>rd</sup> phase: 90° angle;
  - 4<sup>th</sup> phase: 75° angle.

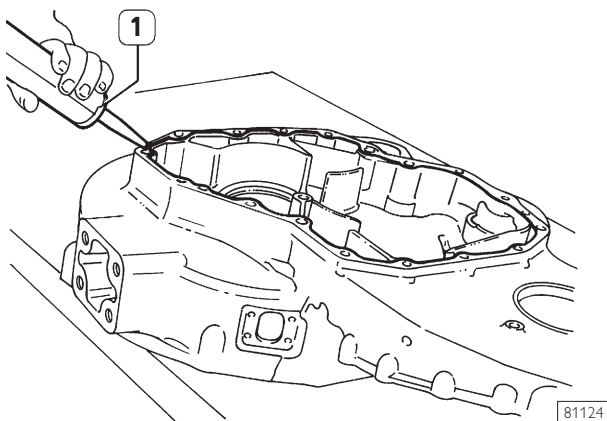
Figure 158



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

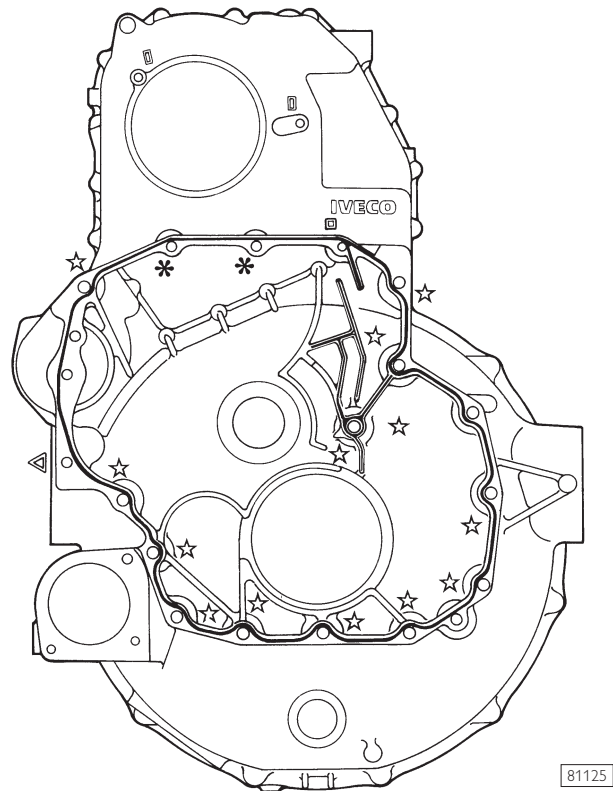


Apply sealant Loctite 5970 IVECO No. 2992644 to the gear box using the proper equipment (1).  
The sealer string (1) diameter should be from 1,3 to 2 mm.

**CAUTION**

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

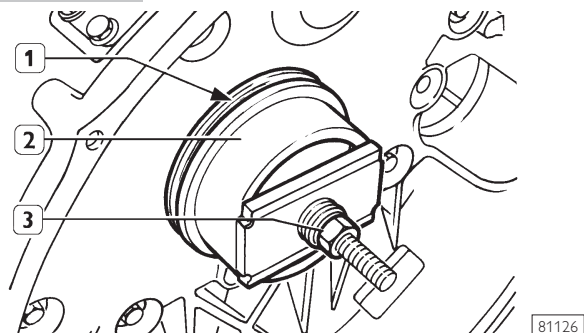
Figure 160



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

- ☆ no. 13 screws M 12 x 1.75 x 80 tightening torque 63 Nm
- \* no. 3 screws M 10 x 1.5 x 35 tightening torque 42 Nm
- no. 1 screw M 10 x 1.5 x 100 tightening torque 42 Nm
- △ no. 1 screw M 10 x 1.5 x 180 tightening torque 42 Nm
- ▭ no. 2 screws M 18 x 1.25 x 125 tightening torque 24 Nm

Figure 161



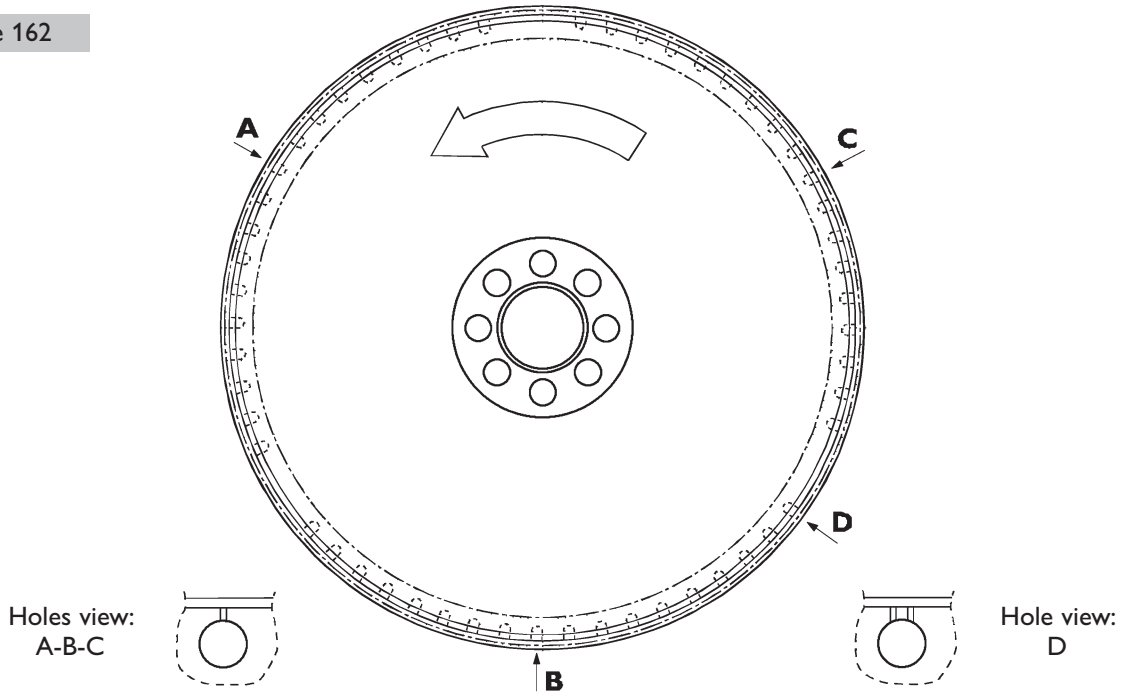
Fit the sealing gasket (1), install the fitting tool 99346246 (2) and drive the sealing gasket by screwing the nut (3).



## ENGINE FLYWHEEL

### Assembly

Figure 162



81108

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.

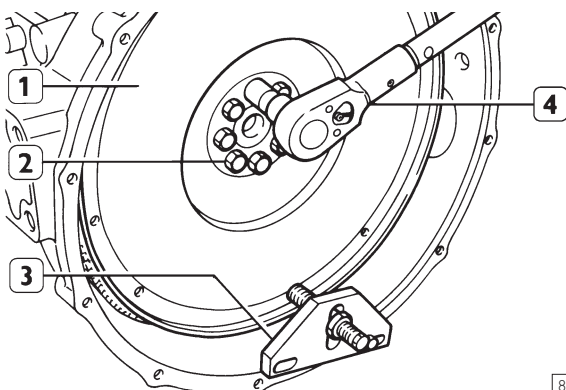
#### CAUTION

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

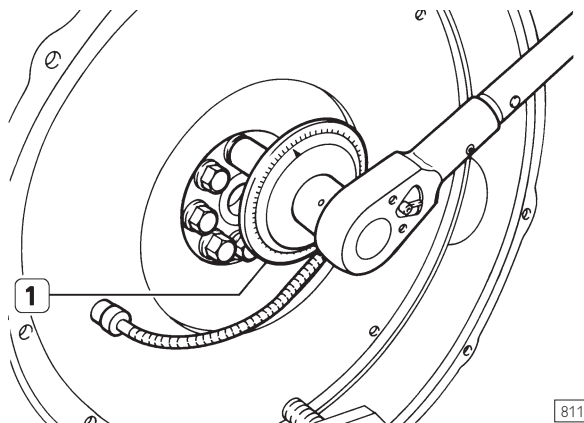


81127

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 100 Nm torque (10 kgm).

Figure 164

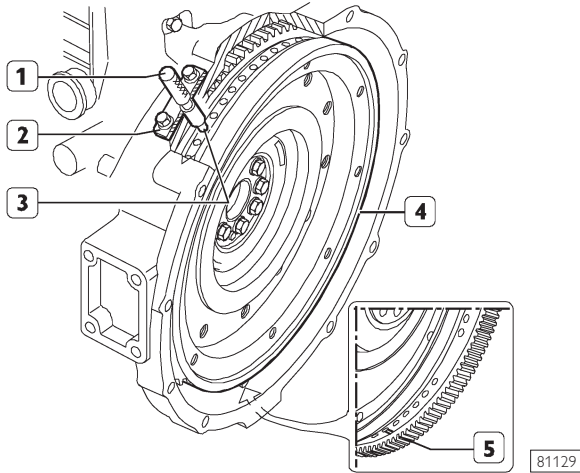


81128

- Second phase: 60° 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).

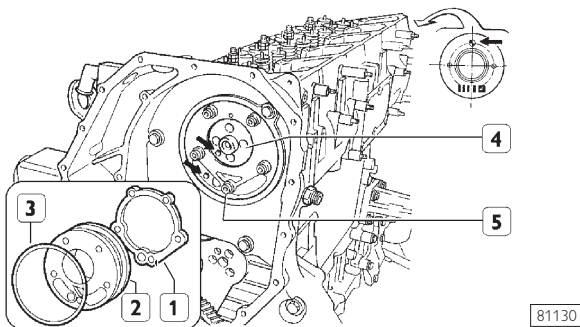
This situation occurs when:

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

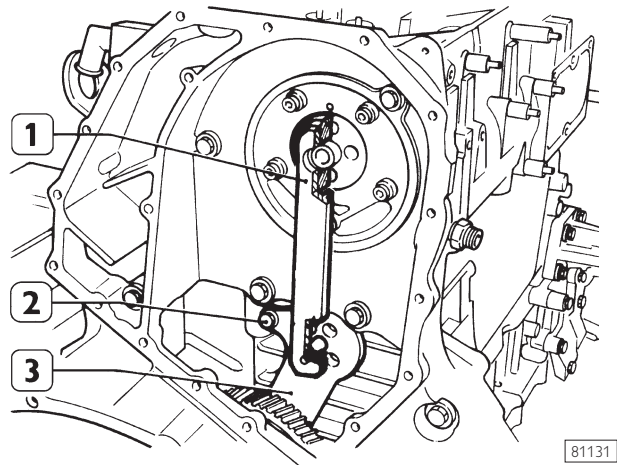


Fit the camshaft (4), positioning it observing the reference marks (→) as shown in the figure.

Lubricate the seal (3) and fit it on the shoulder plate (2).

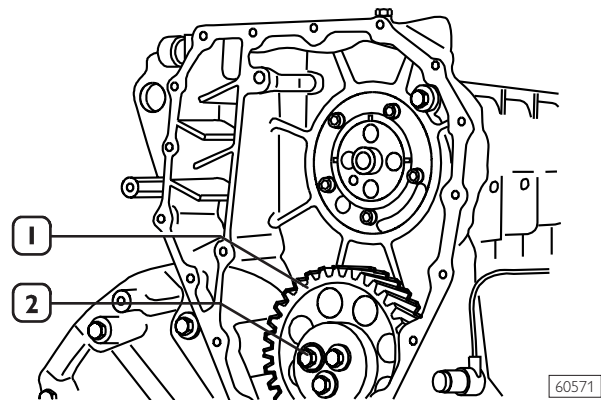
Mount the shoulder plate (2) with the sheet metal gasket (1) and tighten the screws (5) to the required torque.

Figure 167



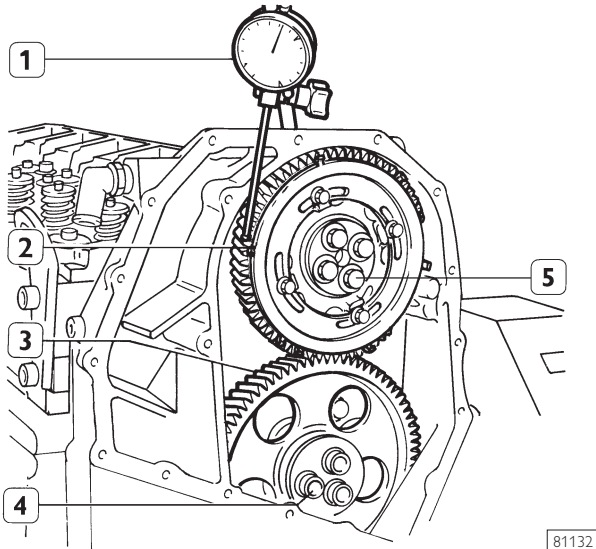
- Apply gauge 99395215 (1), check and record the position of the rod (3) for the transmission gear; tighten the screw (2) to the prescribed torque.

Figure 168



- Fit the idle gear (1) back on and lock the screws (2) to the required torque.

Figure 169



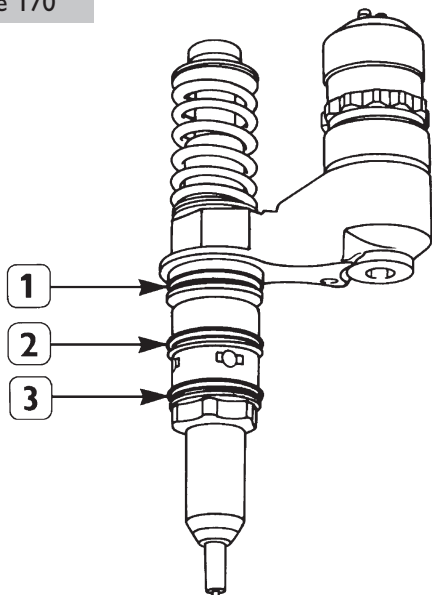
81132

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 required 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

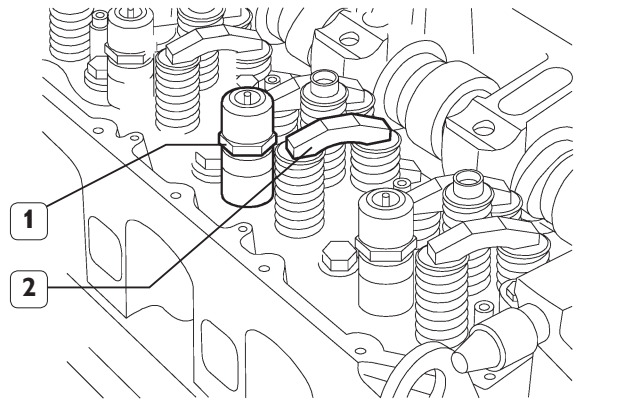
Figure 170



81111

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

Figure 171



99284

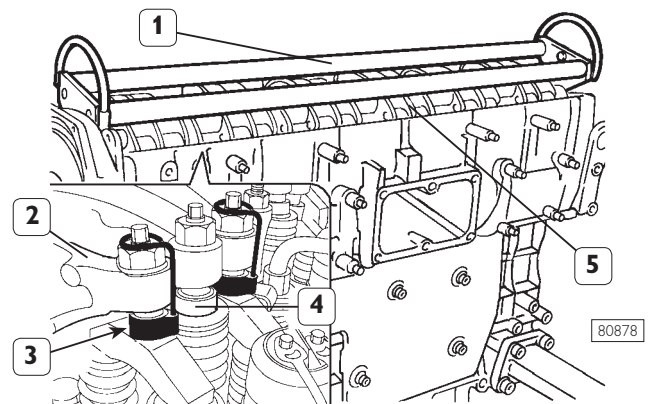
- ❑ Carefully position the injectors (1) into the seats and use a torque wrench to tighten the bracket screws at the torque of 26 Nm;
- ❑ Mount the braces (2) on the valve stems all oriented with the larger hole on the same side.

### CAUTION

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

### Rocker arm shaft assembly

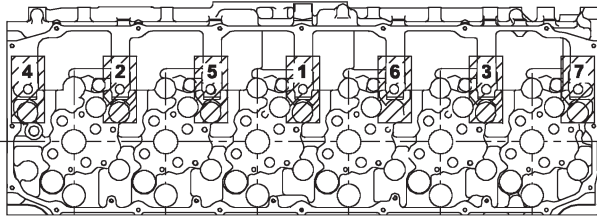
Figure 172



80878

- ❑ 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

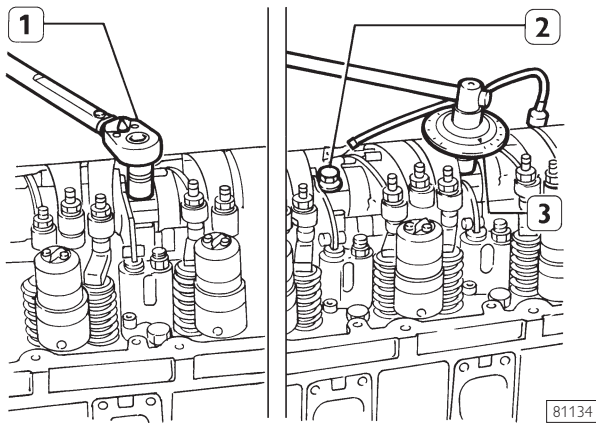


70567A

#### SCHEME OF SCREW TIGHTENING SEQUENCE SECURING ROCKER ARMS

Screw screws (1 - 2 - 3) until rocker arms are brought to contact relating seats on cylinder head, tighten the screws according to sequence indicated in figure operating in two steps as indicated in successive figure.

Figure 174

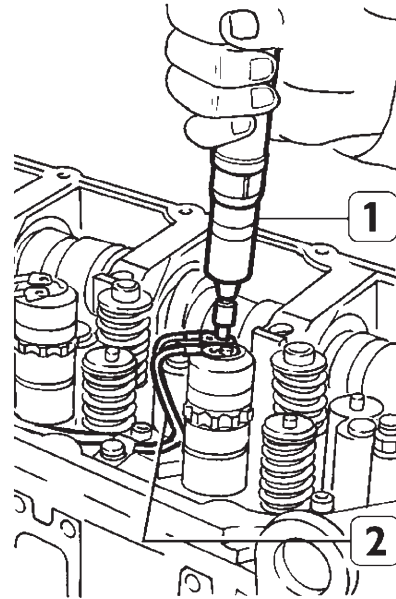


81134

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 40 Nm (4 kgm);
- ❑ Tighten with tool 99395216 (3), at an angle of 60°.

Figure 175



81135

- ❑ Mount the electrical wiring harness (2), fastening its terminals to the injector solenoid valves, by means of torque screwdriver (1), at the torque of 1.36 to 1.92 Nm.

#### Adjusting camshaft phase

(see Section 6)

#### Checking the timing phase

(see Section 6)

#### Timing shaft phonic wheel keying

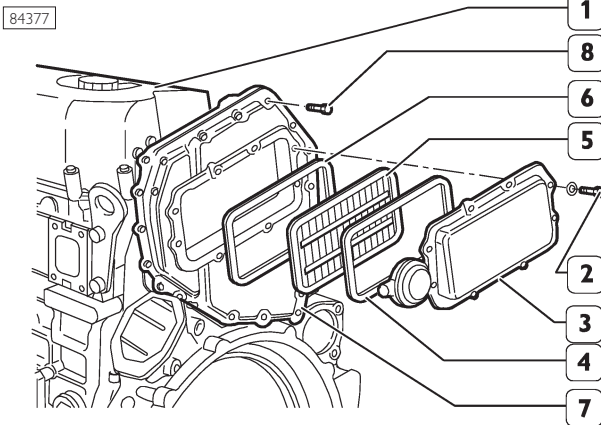
(see Section 6)

#### 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

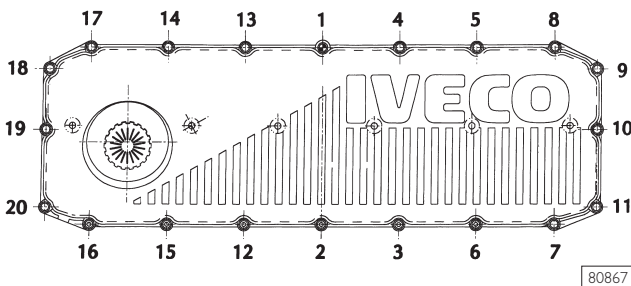
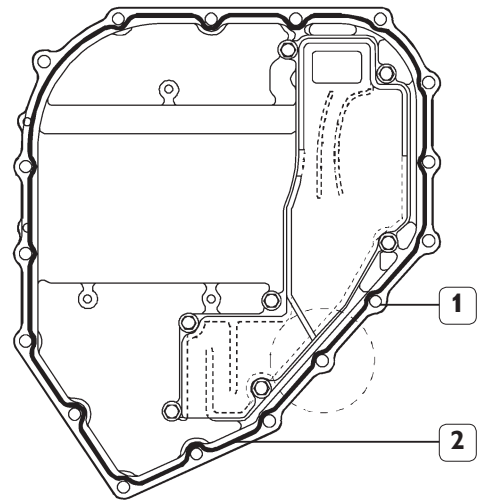


DIAGRAM OF ROCKER ARM CAP FIXING SCREWS TIGHTENING SEQUENCE

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  $\varnothing$  1.3 to 2 mm, as shown in the figure.

**CAUTION**

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

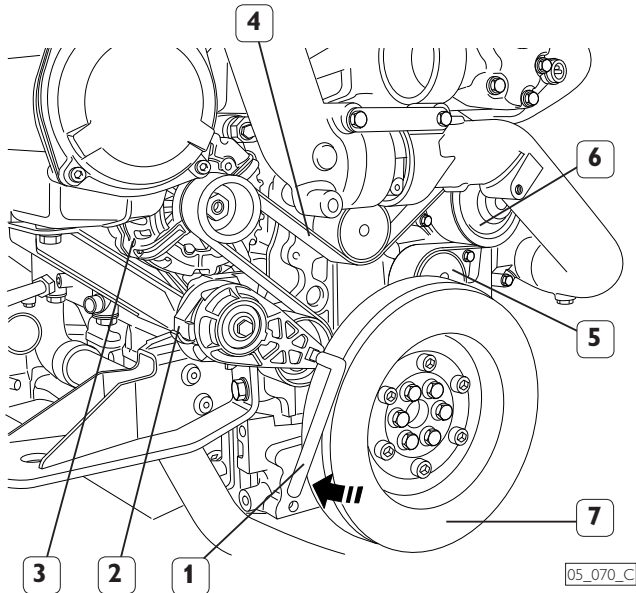
Install the filter (5, Figure 176) and the gaskets (4 and 6, Figure 176).

**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, EDC unit and electrical connections.

Fill the engine with oil and coolant liquid quantity required.

## SECTION 9

## C78 ENS M20 ENGINE

	Page
SPECIFICATIONS	201
Dimensions	203
INJECTION SYSTEM - EDC	204
WIRE HARNESS	205
LOCATION OF ELECTRICAL COMPONENTS ON ENGINE	206
SENSORI EDC	207
Combustion air pressure/temperature sensor	207
Intake air sensor	207
Electrical equipment component code	208
Wiring diagram EDC connector A	210

PAGE LEFT INTENTIONALLY BLANK



**SPECIFICATIONS**

Engine		C78 ENS M20
Cycle		4-Stroke Diesel
Charge		Supercharged
Injection		Direct
Number of cylinders		6 in line
Bore	mm	115
Stroke	mm	125
Total displacement	cm <sup>3</sup>	7790
Compression ratio		16,5 ± 0,8 to 1
Direction of rotation, flywheel side		counterclockwise
Minimum idling rpm	rpm	600 ± 25
Maximum engine rpm, no load	rpm	2190 ± 25
<b>Allowed engine inclination angles</b>		
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°
<b>Supercharge</b>		
Turbocompressor with water-cooled body		KKK K27
Pressure regulation		-
Waste-gate maximum opening pressure	bar	-
<b>Lubrication</b>		
Oil	type	SAE 15 W 40/E 3
Oil compliant with specifications		ACEA E3/API CF4/MIL L2104E/F
Total oil capacity on first filling	liters (kg)	31 (28)
Total oil capacity with sump at minimum level	liters (kg)	18 (16,3)
Total oil capacity with sump at top level	liters (kg)	25 (22,7)
Oil pressure, warm engine, minimum idling rpm	bar	≥ 1,5
Oil pressure, warm engine, maximum rpm	bar	≥ 5
Maximum allowed temperature	°C	105
Oil dipstick valid for static inclination	degrees/360	0 to +10°
<b>Fuel supply</b>		
Fuel oil compliant with standard		EN 590
Low pressure transfer pump		gear pump
Flow rate at maximum rpm	kg/h	68
Fuel return flow rate to tank	kg/h	≤ 12
Filtering: pre filter	µm	36,5
Filtering: filter	µm	5

Engine		C78 ENS M20
<b>Injection system</b>		
Type		pump - injectors (EUI)
System		Bosch EDC MS 6.2
Maximum injection pressure	bar	1600
<b>Low temperature starting</b>		
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
<b>Cooling</b>		
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	~ 40
Engine-only capacity	liters	~ 15,5
Expansion tank		standard
Forced circulation		centrifugal pump
Flow rate at maximum rpm	l/h	18900
Temperature regulation		with thermostatic valve
Initial opening	°C	68 ± 2
Sea water line	°C	78 ± 2
Sea water line		forced circulation
Sea water pump		volumetric self-priming with neoprene impeller      centrifugal self-priming
Max. pump capacity	l/h	15500
<b>Exhaust gas expulsion</b>		
Optional		stack
Optional		riser
<b>Electrical system</b>		
Nominal voltage	Vcc	24
Self-regulated alternator:		
Voltage	Vcc	29
Maximum current intensity	A	90
Electrical starter motor:		
Nominal voltage	V	24
Absorbed electrical power	W	4500
Recommended batteries capacity	Ah	≥ 120
Current discharge at - 18 °C (SAE J 537)	A	≥ 900

Engine

C78 ENS  
M20

**Drive train coupling**

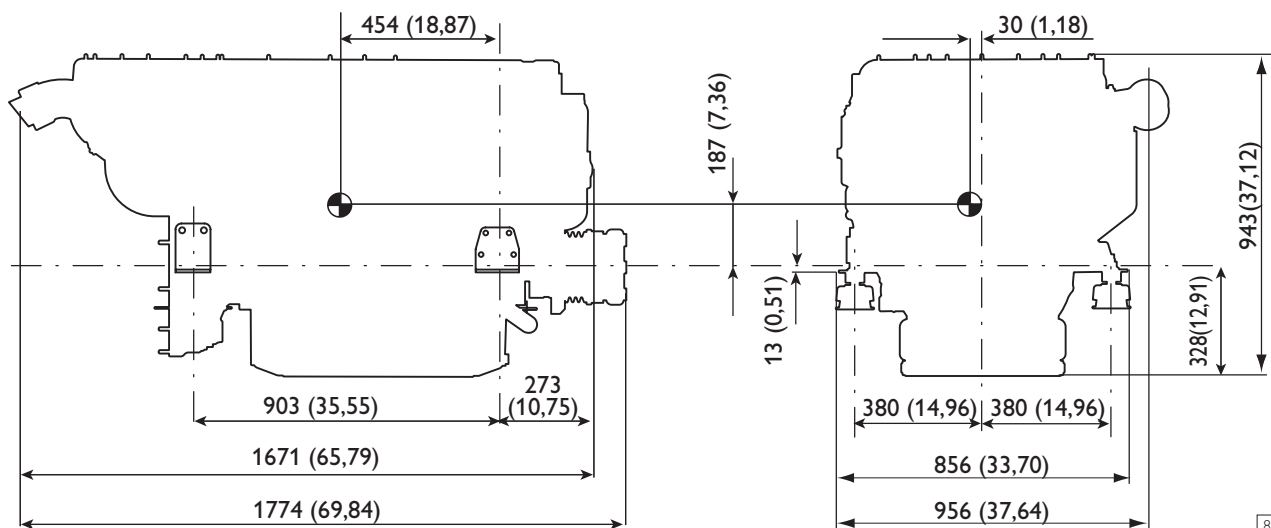
Flywheel diameter	mm (inches)	355 (14)
Flywheel case	type	SAE 1

**Weights**

Without liquids and without gearbox	kg	900
-------------------------------------	----	-----

**Dimensions**

Figure 1



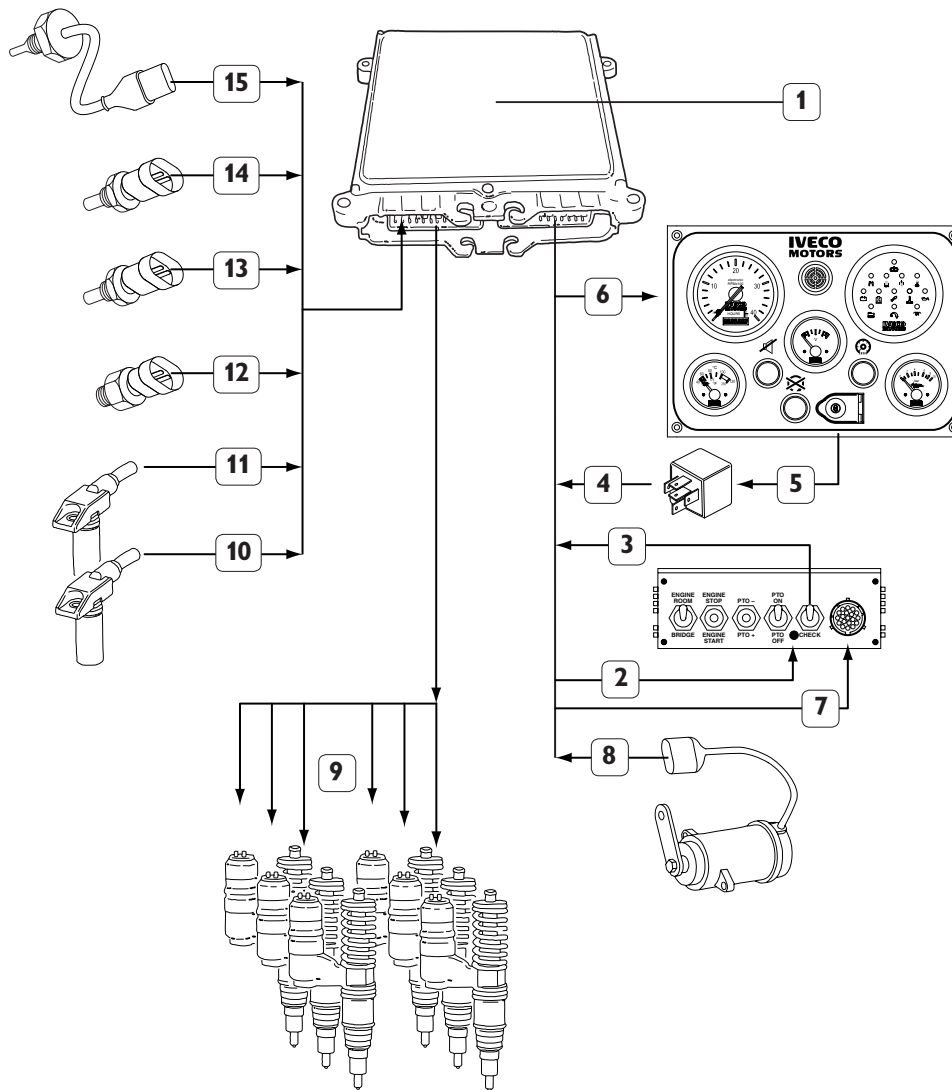
80821

☉ Centre of gravity

Sizes in mm (inches)

**INJECTION SYSTEM - EDC (Electronic Diesel Control)**

Figure 2



06\_001\_C

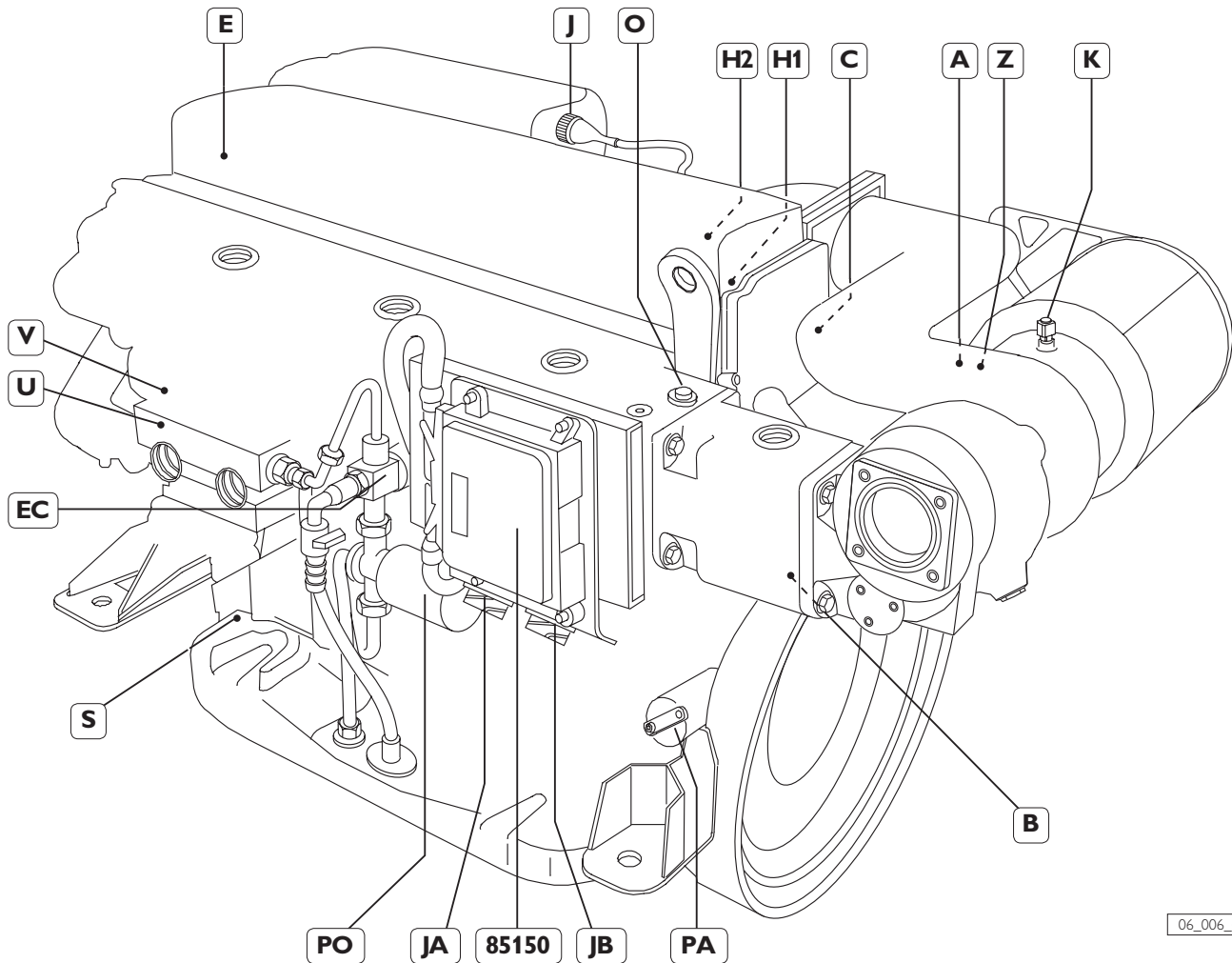
1. Central electronic unit ECU with atmospheric pressure sensor - 2. Fault indicator light - 3. Blink code request push-button - 4. Main relay - 5. Key control - 6. RPM Gauge - 7. Diagnostics connector - 8. Throttle position sensor - 9. Pumper injectors with electrical control, EUI - 10. Timing sensor - 11. Flywheel sensor - 12. Combustion air pressure sensor - 13. Fuel temperature sensor - 14. Engine coolant temperature sensor - 15. Combustion air temperature sensor.

Due to the light supercharge pressure required, the C78 ENS M20 engine does not require the presence of the air/sea water heat exchanger. The electric system is common also to other engines of the same family, but the C78 ENS M20 engine is differentiated by the use of specific sensors for temperature and combusting air pressure. To connect these sensors to the engine wiring system it is necessary to use an extension cable connected to the H connector.



**LOCATION OF ELECTRICAL COMPONENTS ON ENGINE**

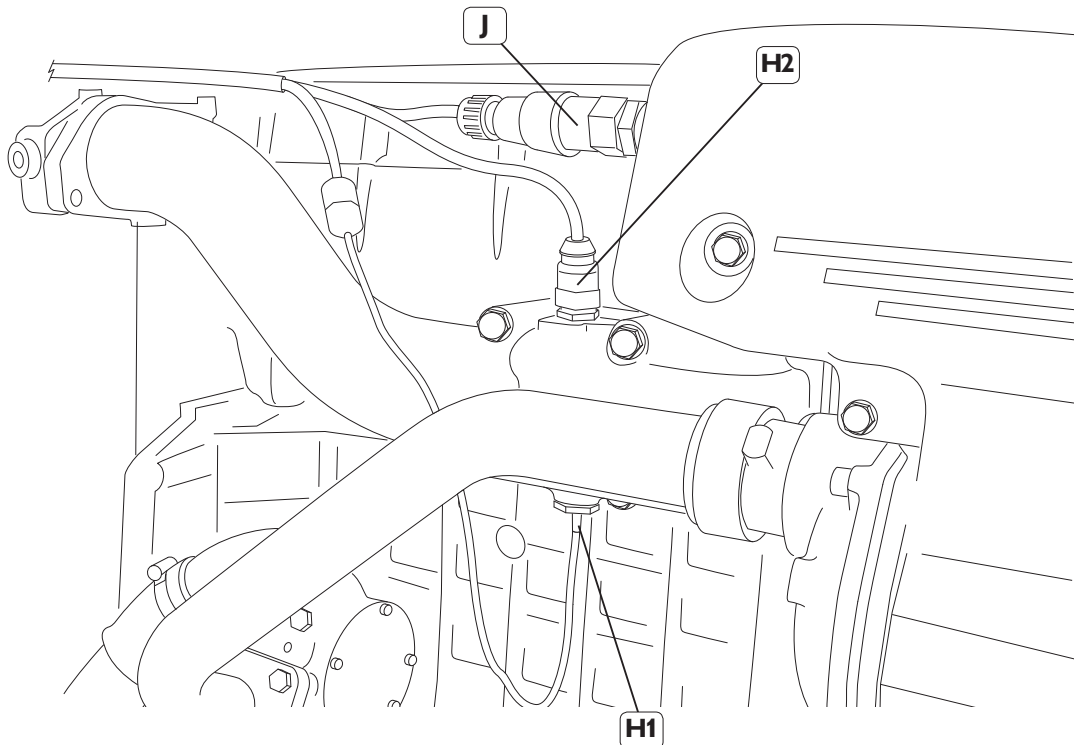
Figure 4



- A. Fuel temperature sensor for EDC - B. Drive shaft sensor for EDC - C. Camshaft sensor - E. EUI solenoid valves - H2. Combustion air pressure sensor for EDC - J. Low coolant level sensor (for alarm) - K. Air filter clogging sensor (for alarm) - O. Exhaust gas temperature sensor (for gauge) - H1. Intake air temperature sensor for EDC - S. Oil temperature sensor (for gauge) - U. Clogged oil filter sensor (for alarm) - V. Oil pressure sensor (for gauge) - Z. Clogged fuel filter sensor (for alarm) - EC. Switching solenoid valve for oil charge/discharge - JA. Connection between engine wiring and interface wire harness - JB. Instrument panel connection wire harness - PA. Throttle position sensor - PO. Pre-lubrication electrical pump - 85150. EDC ECU.

**SENSORI EDC**

Figure 5

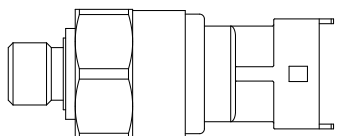


06\_011\_C

H1. Intake air sensor for EDC - H2. Combustion air pressure/temperature for EDC - J. Low coolant level sensor.

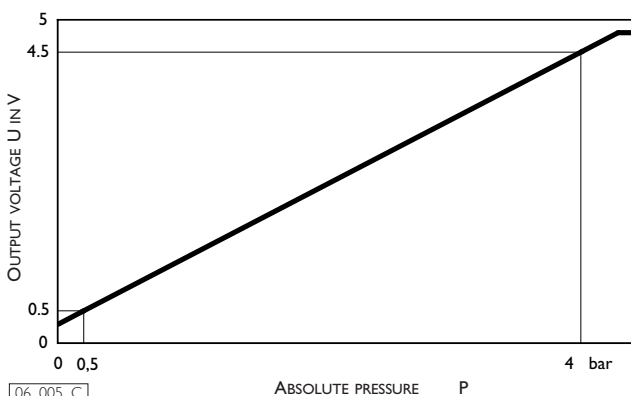
**Combustion air pressure/temperature sensor**

Figure 6



06\_004\_C

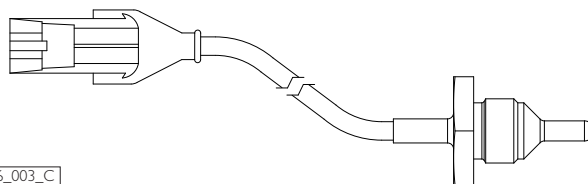
Operating power 5 V



06\_005\_C

**Intake air sensor**

Figure 7



06\_003\_C

Resistance value at 25°C 10 kΩ

Poles Isolated

**Electrical equipment component code**

A	fuel temperature sensor for EDC	QP	main analog instrument panel
AC	battery	QS	secondary analog instrument panel
AQ	engine shut-off push-button on main panel	R1	3.3 k $\Omega$ resistor to inhibit speed input
AS	engine shut-off push-button on secondary panel	R2	DL1 resistor
B	drive shaft sensor for EDC	R3	alternator pre-excitation resistor
C	camshaft sensor	S	oil temperature sensor (for gauge)
CA	key switch	SA	buzzer
CS	engine start push-button on secondary panel	SI	gearbox oil temperature sensor
DL1	EDC fault indicator and blink code LED (on relay box panel)	SW1	bridge or engine room engine control selector (on relay box panel)
EC	switching solenoid valve for oil charge/discharge	SW2	start and stop push button (on relay box panel)
F	engine coolant temperature sensor for EDC	SW3	manual accelerator throttle control in engine room (on relay box panel)
GG	alternator	SW4	PTO ON/PTO OFF selector (on relay box panel)
GH	power relay for starting aid	SW5	blink code emission request push-button (on relay box panel)
H2	combustion air pressure sensor for EDC	T	coolant temperature sensor (for gauge)
I	high coolant temperature sensor (for alarm)	U	Clogged oil filter sensor (for alarm)
IN	injectors solenoid valve	V	oil pressure sensor (for gauge)
J	low coolant level sensor (for alarm)	VI	high gearbox oil pressure sensor (25 bar)
K	air filter clogging sensor (for alarm)	W	low oil pressure sensor (for alarm)
L	instrument panel light switch	WI	low gearbox oil pressure sensor (7 bar)
M	sensor for detecting the presence of water in the fuel pre-filter (for alarm)	X	clogged blow-by filter sensor (for alarm)
MC	CAN - BUS converter module for digital panel	Z	clogged fuel filter sensor (for alarm)
MM	electric starter motor	85150	ECU of the EDC system
MP	pre-lubrication and oil transfer module		
MS	IVECO MOTORS-FPT indications and alarms module		
O	exhaust gas temperature sensor (for gauge)		
H1	intake air temperature sensor for EDC		
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		

*(continues on next page)*



**Electrical equipment component code (cont.)****Connectors**

A	35 pole EDC boat components
B	35 pole EDC engine components
E	EUI injectors solenoid valve
H	sensor H1/H2 wiring harness
J1	external diagnostic tool (on the relay box panel)
JA	connection between engine wiring and interface wire harness
JA ON SECONDARY DIGITAL INSTRUMENT PANEL	set for connection to the main digital instrument panel
JB ON ENGINE WIRE HARNESS	set for connection to the main analog instrument panel or to the interface wire harness for converter module
JC ON MAIN ANALOG INSTRUMENT PANEL	set for connection to the engine wire harness
JD	IVECO MOTORS-FPT indications and alarms module
JD ON INTERFACE WIRE HARNESS FOR CONVERTER MODULE	external throttle control
JE ON MAIN ANALOG INSTRUMENT PANEL	set for connection to the secondary analog instrument panel
JE ON INTERFACE WIRE HARNESS FOR CONVERTER MODULE	set for connection to the main digital instrument panel
JE ON MAIN DIGITAL INSTRUMENT PANEL	set for connection to the secondary digital instrument panel
JE ON MAIN INTERFACE WIRE HARNESS	set for connection to the alarms control unit (for Certification Bodies)
JE1 ON INTERFACE WIRE HARNESS FOR CONVERTER MODULE	set for connection to the 2 <sup>nd</sup> main digital instrument panel
JF	relay box
JF1	relay box
JG	pre-lubrication control unit
JH ON SECONDARY ANALOG INSTRUMENT PANEL	set for connection to the main analog instrument panel
JH ON MAIN DIGITAL INSTRUMENT PANEL	set for connection to the interface wire harness for converter module
JO	converter for digital panels

**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
SIM	expired programmed maintenance interval
SP	pre-lubrication
SS	alternator fault
SSV	overspeed engine

**Gauges**

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

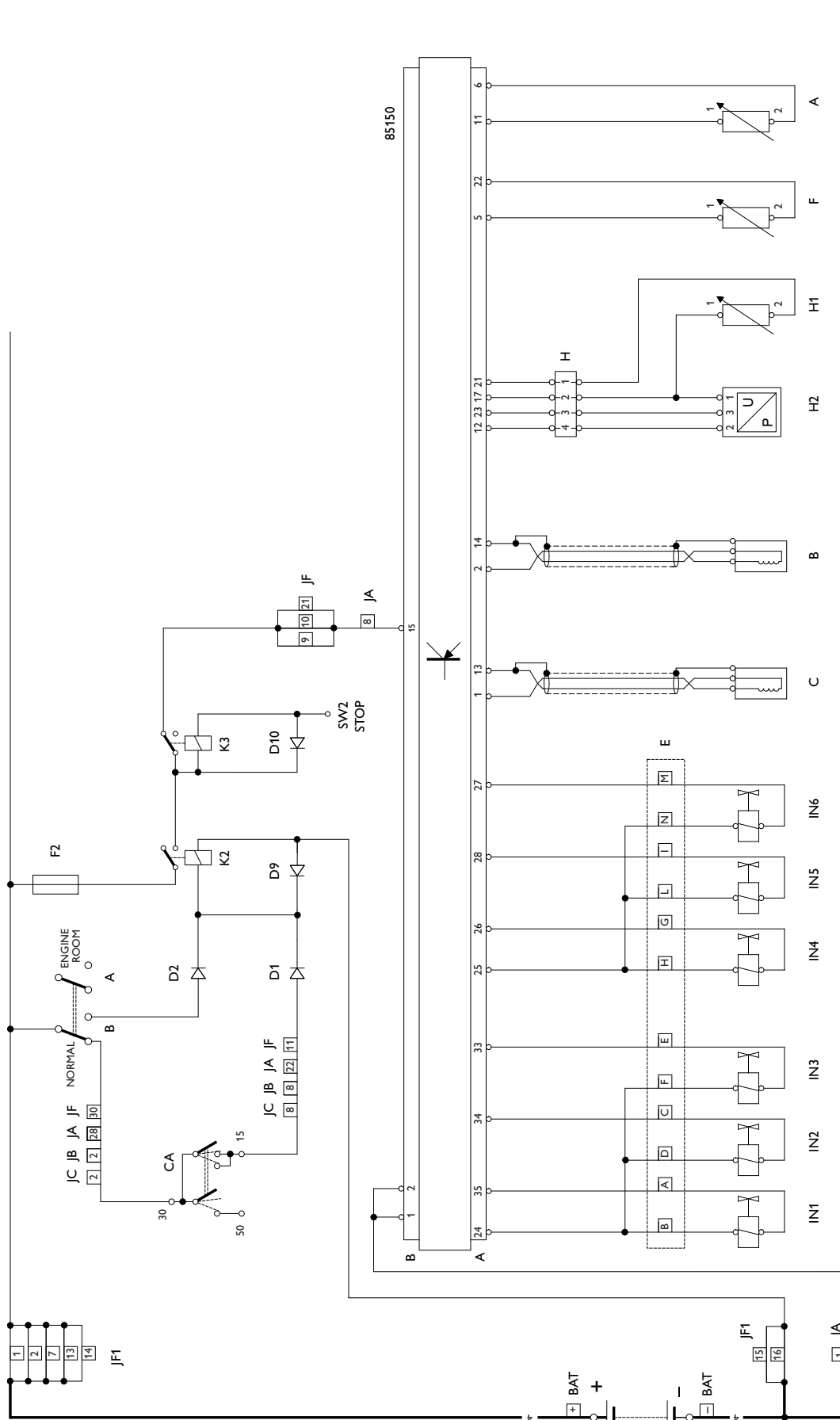
**Relays contained in the relay box**

K1	EDC main (power supply)
K2	key switch electric discharge
K3	emergency engine shut-down provision
K4	enabling start engine from engine room
K5	power supply to terminal 50 of the electric starter motor
K6	cranking exclusion when engine is running

**Fuses contained in the relay box**

F1, F2	self restoring (not replaceables)
--------	-----------------------------------

Wiring diagram EDC connector A



## SECTION 10

SAFETY SYSTEM FOR HOMOLOGATED  
INSTALLATIONS

	Page
SAFETY SYSTEM FOR HOMOLOGATED INSTALLATIONS	213
Unit installed	213
Electronic monitoring unit	214
Sensors	214
Wiring	215
Insulated pole power network (optional)	215
Electrical starting motor	216
Alternator	216
Auxiliary EDC electronic unit	217
Synoptic	218
Wiring	219
Monitoring unit	220
Function of JS connection terminals	221
Position of the safety system sensors	222
Drive shaft rev. speed sensor (BA)	224
Exhaust gas temperature sensor (O)	224
Coolant high temperature sensor (IA)	224
Engine oil low pressure sensor (WA)	225
Engine oil pressure sensor (VA)	225
Coolant oil temperature sensor (S)	225
Refrigerating liquid pressure and low pressure sensor (WVA)	226
Fuel pressure sensor (VCA)	226
Line balancing components	227
Engine cut-out control buttons (JEM)	227

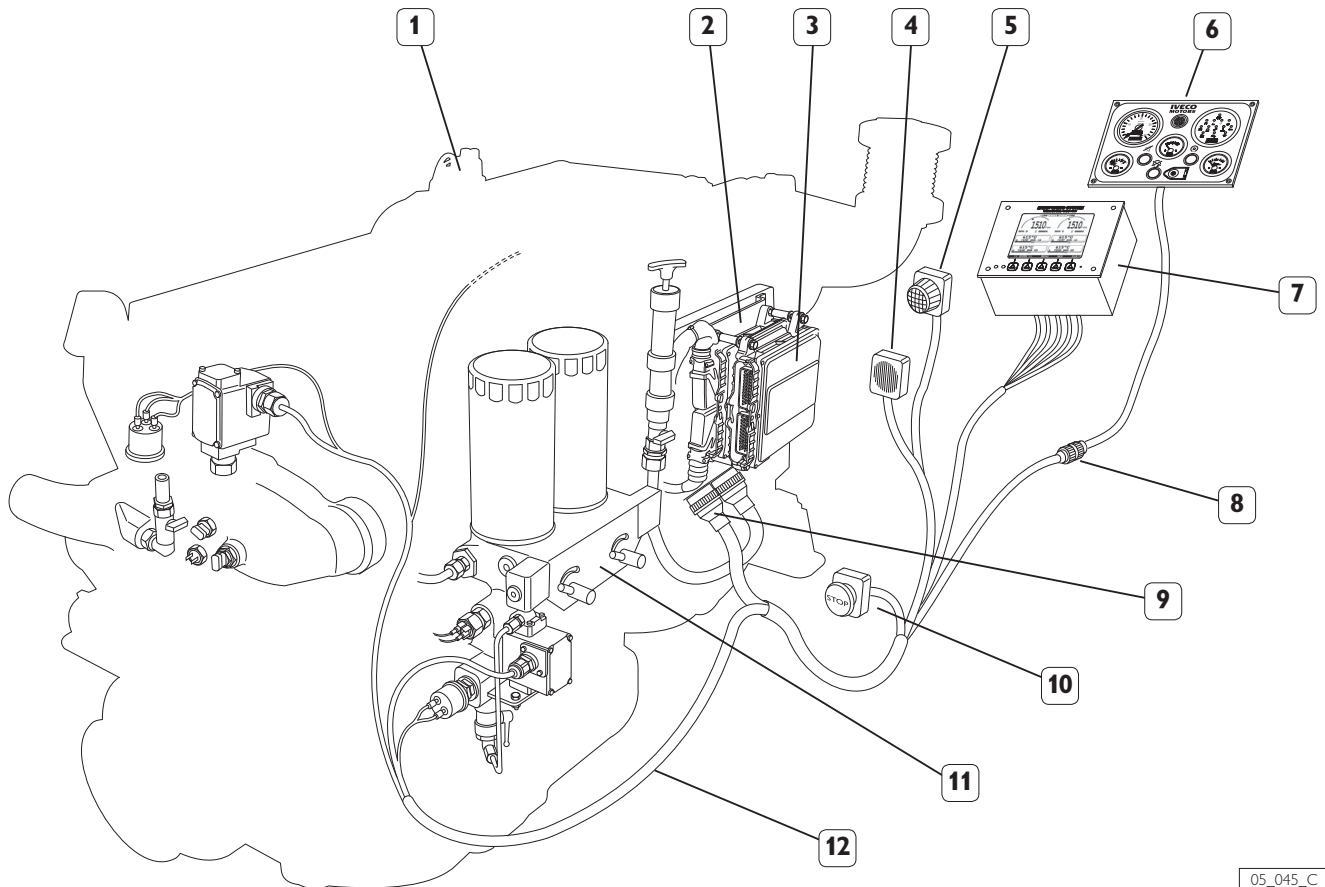
(cont.)

ELECTRICAL DIAGRAMS FROM THE SAFETY SYSTEM	228
Wiring unit JB - JC	229
EDC system – connector B	230
METHOD OF USE OF THE SAFETY SYSTEM INTERFACE	231
Monitoring	231
Basic operations	231
Video mode setting	232
Advanced operations	232
Maintenance rates monitoring	233
Maintenance intervals resetting	233
Alarms management	234
Navigation monitoring	234
Depth monitoring (Echo sounder)	235
Safety behaviour	235

## SAFETY SYSTEM FOR HOMOLOGATED INSTALLATIONS

### Unit installed

Figure 1



05\_045\_C

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. Connector JC -
9. Connector JS -
10. Emergency engine cutout button -
11. Oil filters which can be replaced when the engine is rotating -
12. JB, JC wiring, specific for homologated systems.

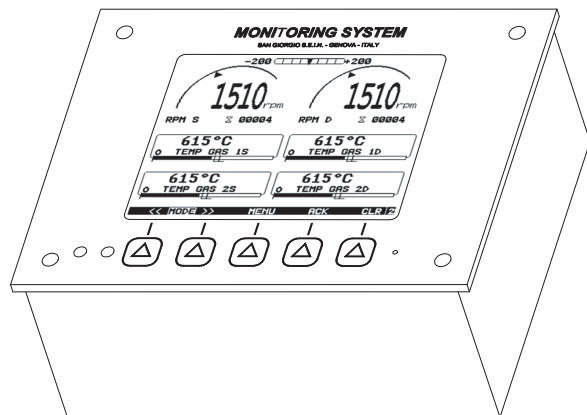
The electric and electronic equipment of engines requiring a conformity declaration issued by the Certifying bodies comprises, in addition to that provided for the standard configuration, a series of components for the measurement, processing and recording of engine operating parameters. The aim of the 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

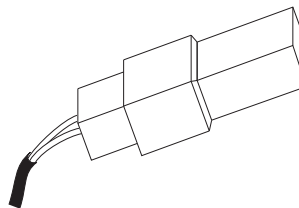
This unit monitors the operation of the specific safety system. With its computerised logic it acquires the electric signals issued by the sensors linked up to it, converting them into physical parameters of temperature, pressures and revs. This data is displayed on the liquid crystal display and processed 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 10).

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.

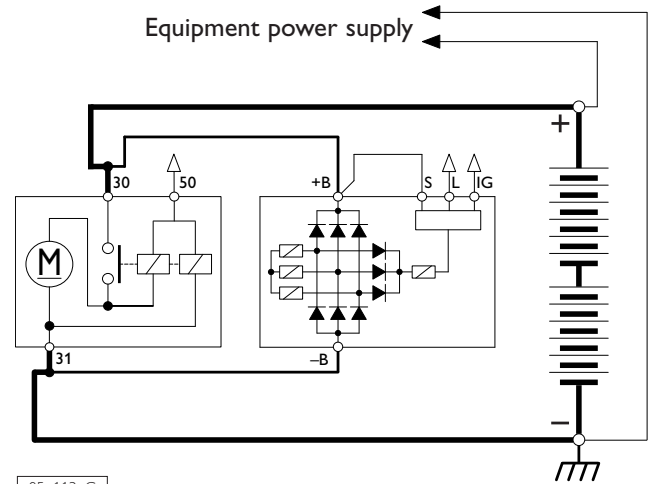
The electric diagrams, referred to the identification of the inputs/outputs of the connectors of the monitoring unit may vary following the programming of particular features of the application.

### CAUTION

To obtain the engine cut-out function by the JS monitoring unit it is necessary to unite the two JE connectors on the JB-JC wiring and the engine wiring.

## Insulated pole power network (optional)

Figure 4

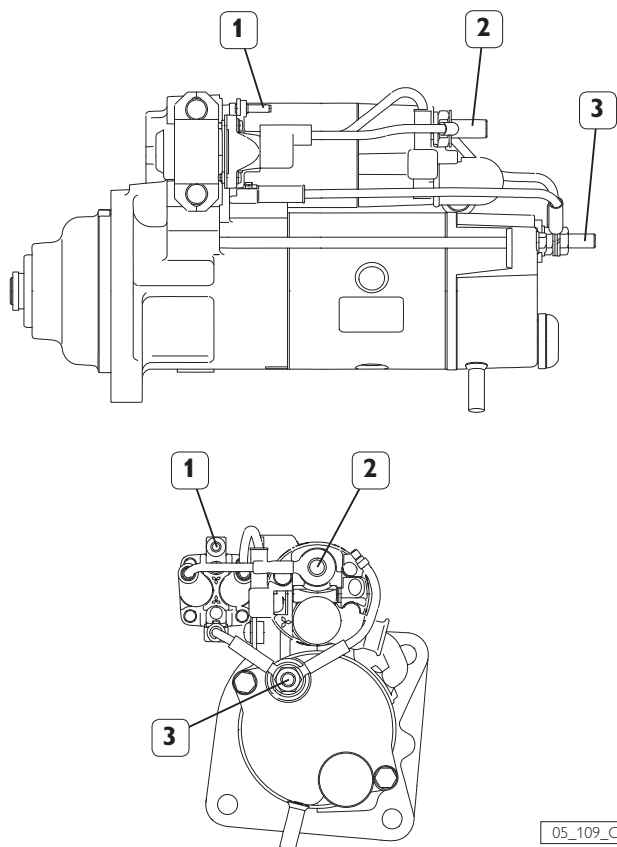


05\_113\_C

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



05\_109\_C

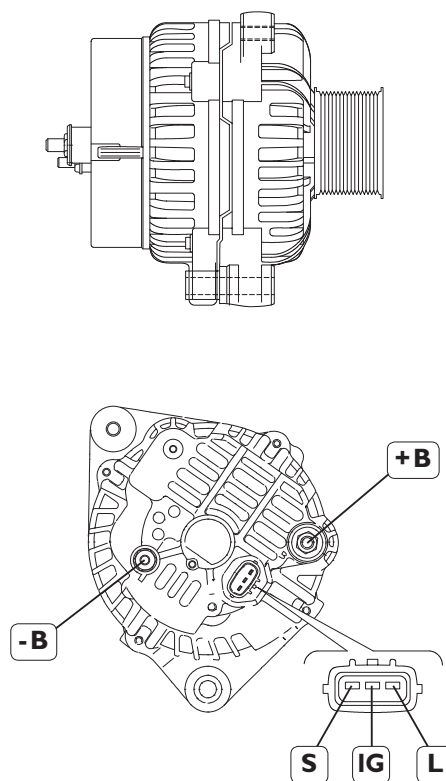
1. Excitation coil command (50) - 2. Positive power pole (+B) - 3. Negative supply pole (-BATT).

## Technical data:

- Nominal supply voltage 24 V
- Absorbed power 5 kW
- Terminal connection "50" M5 x 0.8 tightening torque 2-2.5 Nm
- Terminal connection "+B" M10 x 1.5 tightening torque 14.7-17.7 Nm
- Terminal connection "-BATT" M8 x 125 tightening torque 9.8-11.8 Nm

**Alternator**

Figure 6



05\_112\_C

## Technical data:

- Nominal voltage 24 V
  - Nominal current 90 A
  - Terminal connection "+B" M8 x 1,25 tightening torque 12.5 Nm  $\pm$  20%
  - Terminal connection "-B" M6 x 1 tightening torque 6.0 Nm  $\pm$  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.



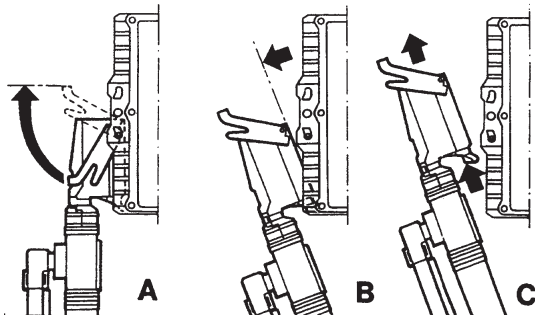
### Auxiliary EDC electronic unit

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:

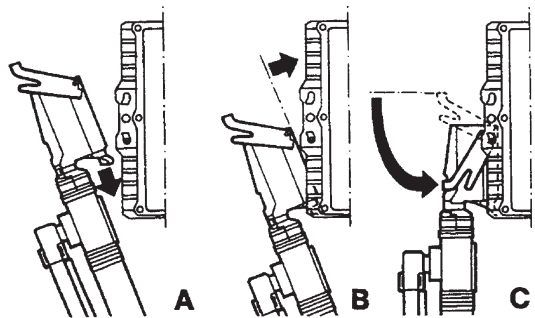
- stop the engine;
- wait 10 seconds, then disconnect the terminal clamps from the battery;
- proceed as follows to extract and reinsert the connectors.

Figure 7



80802A

REMOVING ECU CONNECTORS



80802B

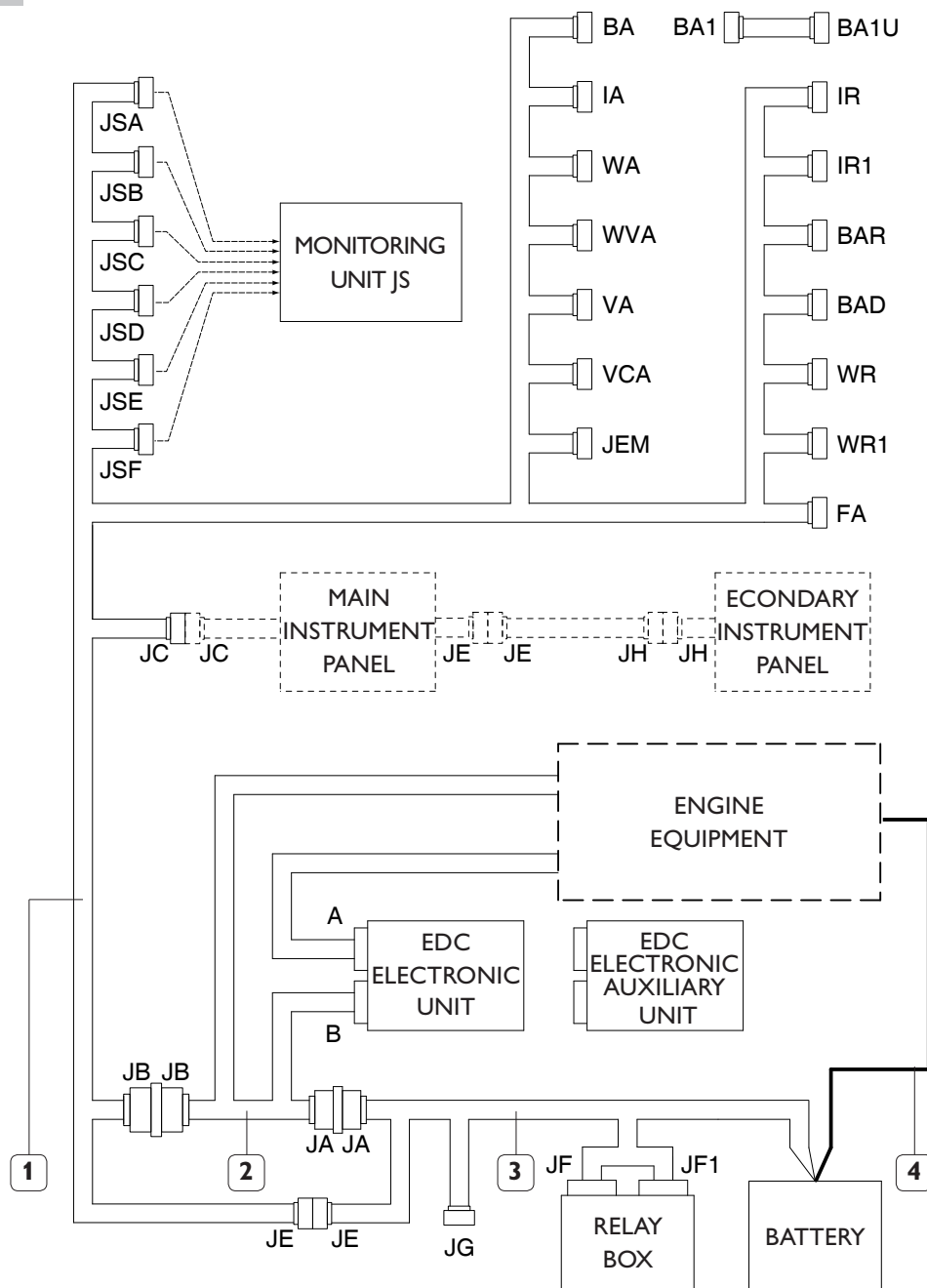
INSERTING ECU CONNECTORS

At the end of the operation:

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

## Synoptic

Figure 8



05\_032\_C

1. Specific wiring unit for installation of instrument panel and monitoring unit - 2. Engine wiring - 3. Interface wiring - 4. Power network.

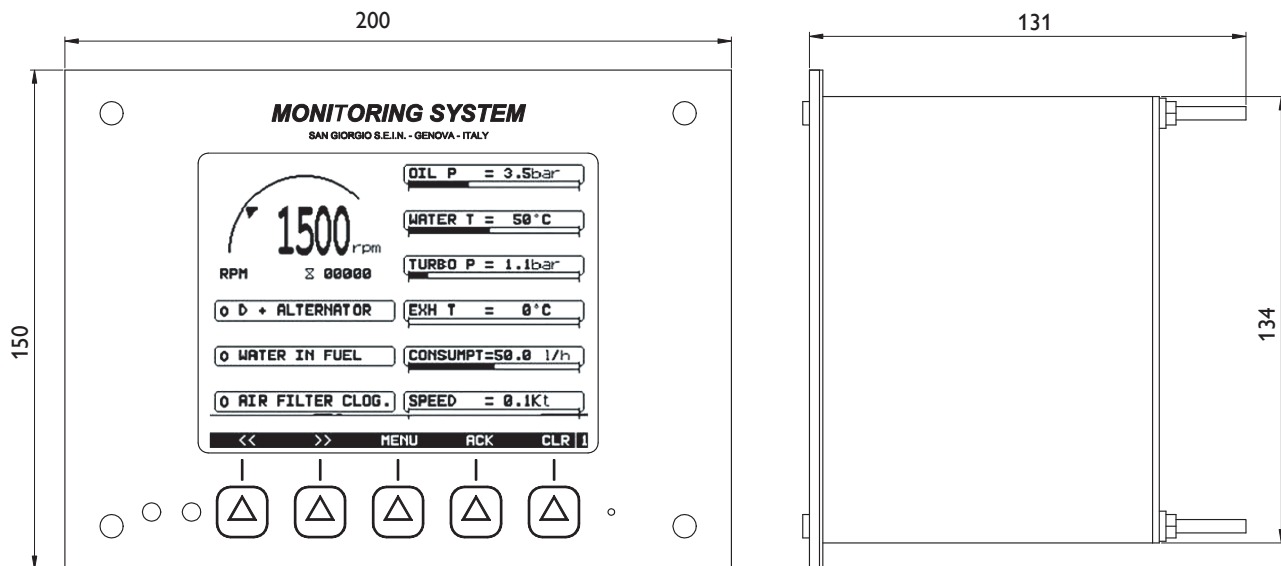
#### DESTINATION OF CONNECTORS OF THE SAFETY SYSTEM (excluding standard supply connectors)

BA. Drive shaft sensor - BAD. Diode for BA - BAR. Resistor for BA - BA1, BA1U. Connectors of the extension cable for engine rev. speed - FA. Acoustic and luminous alarms - IA. Coolant temperature sensor - IR. Parallel resistor for IA - IR1. Series resistor for IA - JE. Connector for cutting out agitated engine - JEM. Connector for cutout switches in the case of an emergency and motor cutout from the engine room - JS. Electronic monitoring unit - JSA, 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:

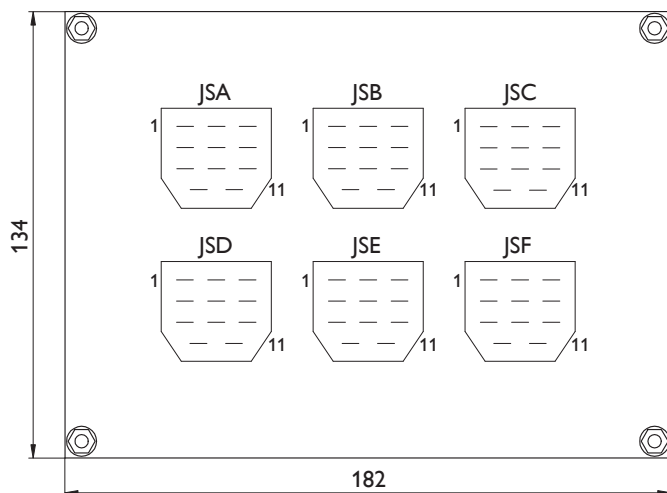


## Monitoring unit

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

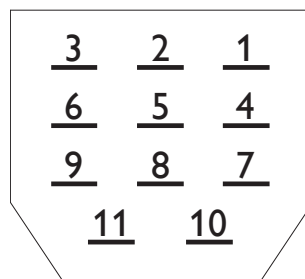
pin	JSA Thermocouples	JSB Supply	JSC CAN network
1	Exhaust fumes temperature	Supply 12/24 V (+)	CAN (H)
2	-	Supply 12/24 V (+)	CAN (L)
3	-	Mass (-)	-
4	-	Mass (-)	-
5	Exhaust fumes temperature	-	GPS - NMEA 0183 <sup>(2)</sup> protocol
6	-	N.C. relay 1 - Acoustic signaling <sup>(2)</sup>	Echo sounder - NMEA 0183 <sup>(2)</sup> protocol
7	-	Mass (-)	-
8	-	N.O. relay 1 - Acoustic signaling	-
9	-	N.C. relay 2 - light signal <sup>(2)</sup>	GPS/Eco sounder <sup>(2)</sup> Mass (-)
10	-	Mass (-)	-
11	-	N.O. relay 2 - light signal	-

**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	Gear box oil pressure <sup>(2)</sup>	Engine revs (EDC) <sup>(1)</sup>	N.C. Cut-out relay 3 <sup>(2)</sup>
2	Coolant pressure (WVAS) <sup>(1)</sup>	Engine revs (BA) <sup>(1)</sup>	-
3	Engine oil pressure (VA) <sup>(1)</sup>	Low coolant level (J) <sup>(1)</sup>	12/24 V (+) common relay 3 stoppage
4	Sea water circuit pressure <sup>(2)</sup>	Low gear box oil pressure <sup>(2)</sup>	N.O. Cut-out relay 3 (JE) <sup>(1)</sup>
5	Engine oil temperature (S) <sup>(1)</sup>	Air filter blockage (K) <sup>(1)</sup>	Alternator recharge (L) <sup>(1)</sup>
6	Low engine oil pressure (WA) <sup>(1)</sup>	Low coolant pressure (WVAA) <sup>(1)</sup>	Pre-lubrication (opt.)
7	Water in the pre-filter (M) <sup>(1)</sup>	Fuel filter blockage (Z) <sup>(1)</sup>	Imp.Voltage signal 12/24 V (+)
8	Fuel pressure (VCA) <sup>(1)</sup>	Engine revs (BAR - BA) <sup>(1)</sup>	Engine stopping circuit damaged (JEM - JE) <sup>(1)</sup>
9	EDC (failure signal) <sup>(1)</sup>	-	-
10	High coolant temperature (IA) <sup>(1)</sup>	Oil filter blockage (U) <sup>(1)</sup>	-
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.

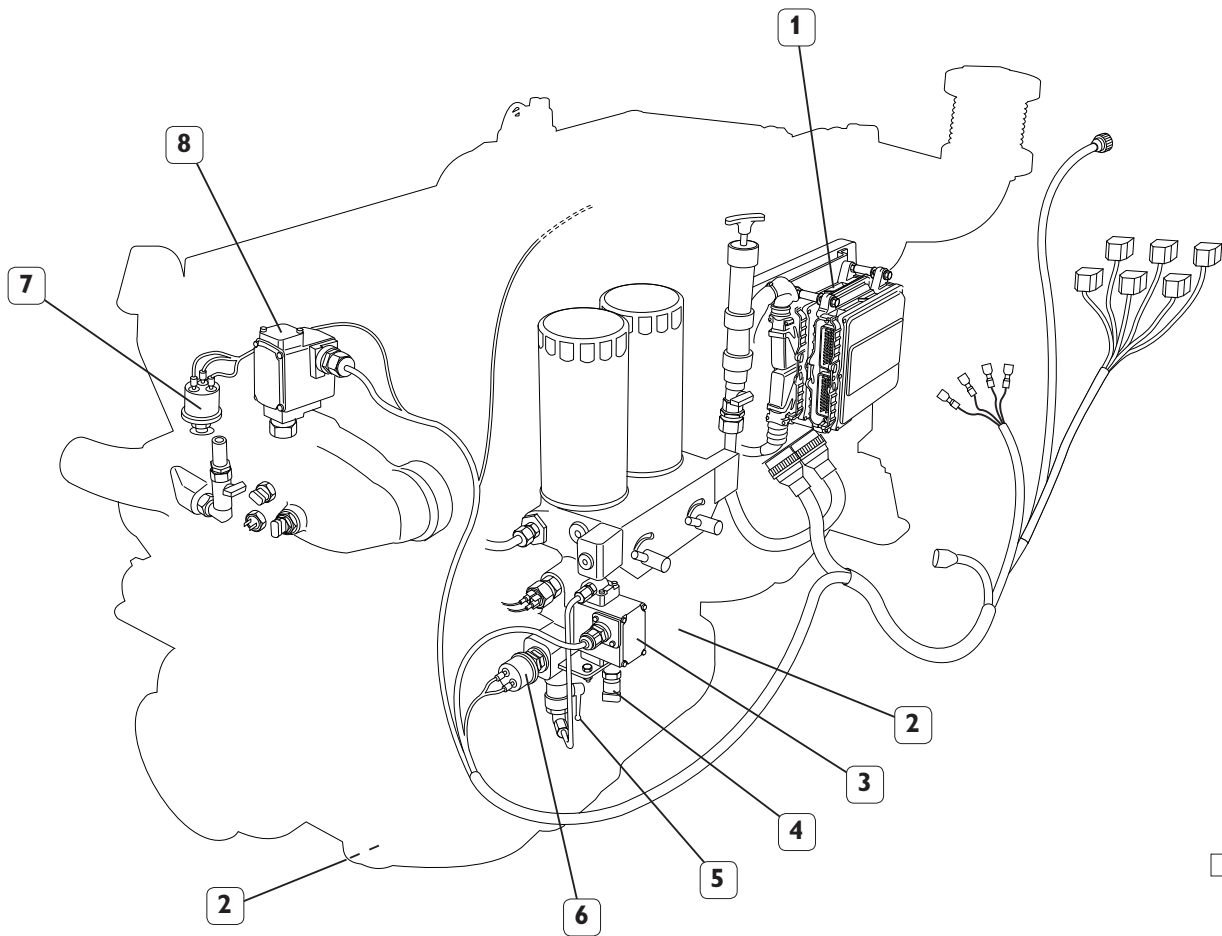


05\_051\_C

CONNECTORS JS SEEN FROM WIRING SIDE

## Position of the safety system sensors

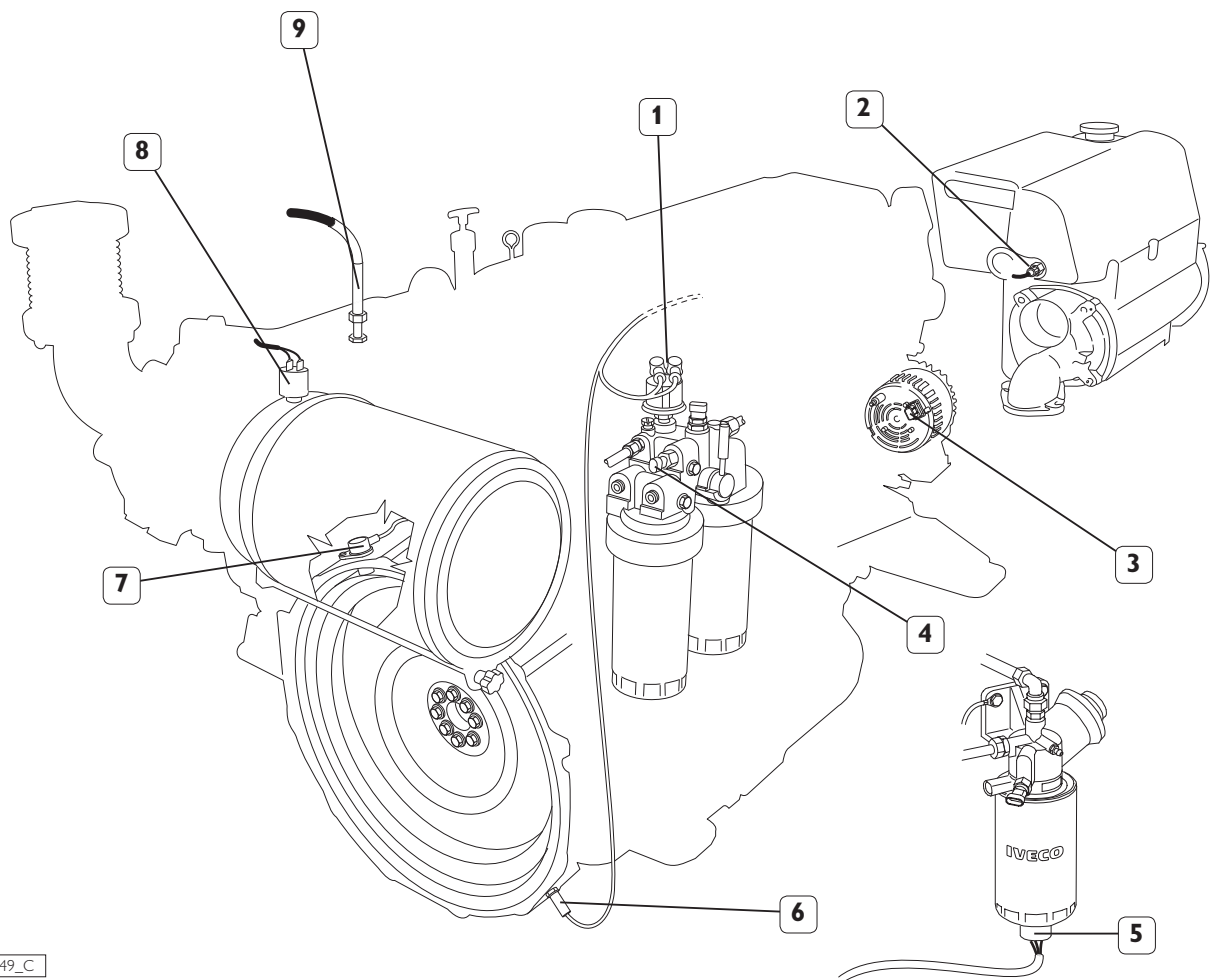
Figure 11



05\_048\_C

1. Engine rotation speed and EDC system damaged signal - 2. Oil temperature analogical sensor - 3. Low oil pressure sensor (WA) - 4. Oil filters congestion sensor - 5. WA efficiency test tap - 6. Oil pressure analogical sensor (VA) - 7. Cooling liquid pressure and low pressure analogical sensor (WVA) - 8. Cooling liquid high temperature sensor (IA).

Figure 12

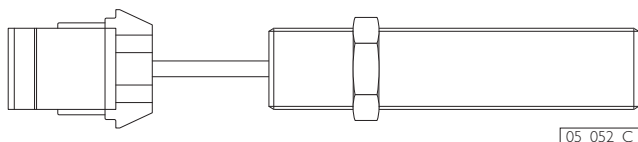


05\_049\_C

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

**Drive shaft rev. speed sensor (BA)**

Figure 13



05\_052\_C

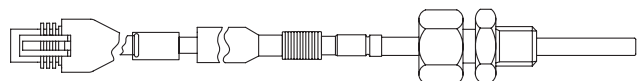
This is of the inductive type and when the engine is running it produces a sinusoidal alternate signal the value of which increases in proportion to the engine rev. speed. The sensor BA enables the measurement of the engine rev- speed using the passage of the holes positioned in a radial arrangement 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



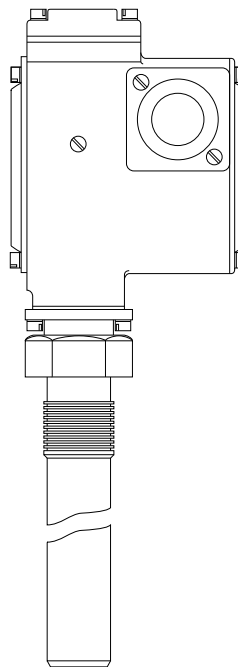
04\_260\_N

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

**Coolant high temperature sensor (IA)**

Figure 15



05\_053\_C

Thermometric switch which supplies the information for the engine high temperature alarm.

Operating power	from 6 V to 24V
-----------------	-----------------

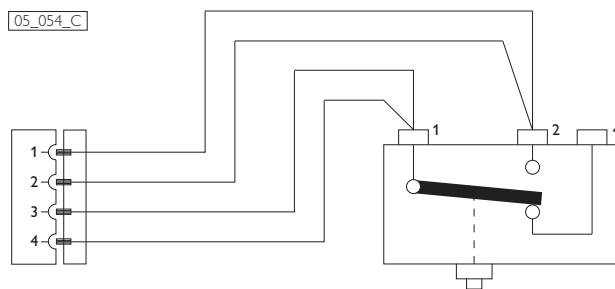
Condition at ambient temperature	normally open
----------------------------------	---------------

Commutation temperature:	°C
--------------------------	----

Poles	Isolated
-------	----------

**Electric diagram:**

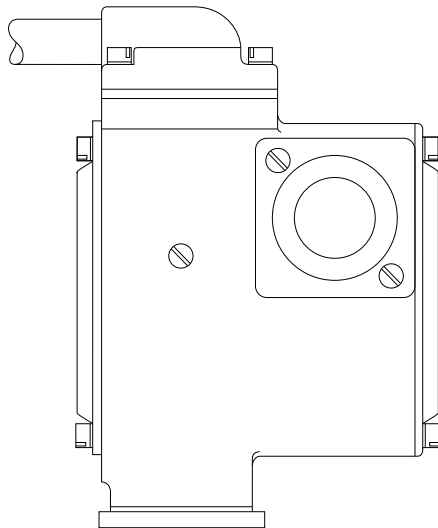
05\_054\_C





**Engine oil low pressure sensor (WA)**

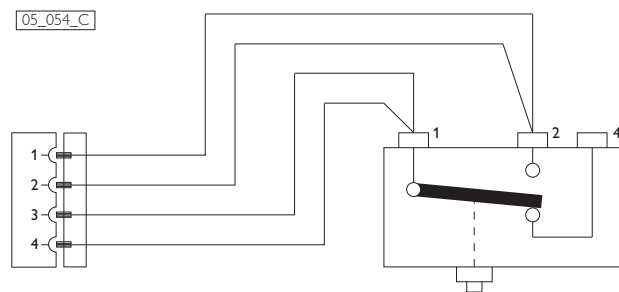
Figure 16



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

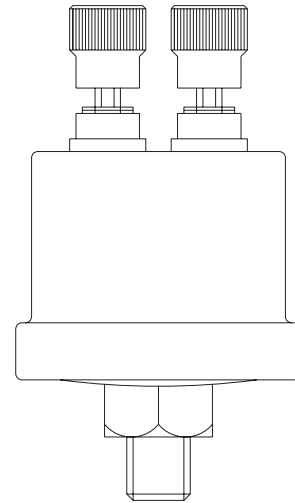
Operating power	from 6 V to 24V
Condition at ambient pressure	normally closed
Commutation pressure:	0,4/0,8/1,2 bar
Poles	Isolated

**Electric diagram:**



**Engine oil pressure sensor (VA)**

Figure 17

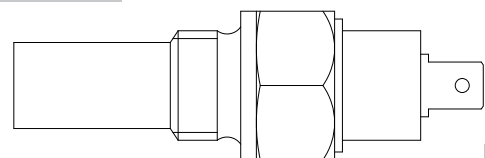


Component which supplies a rheostatic signal for the analogical indication of the fluid pressure.

Operating power	from 6 V to 24V
Setting field from	0 bar to 10 bar
Resistance value at 0 bar	10 Ω +3/-5 Ω
Resistance value at 2 bar	52 ± 4 Ω
Resistance value at 4 bar	88 ± 4 Ω
Resistance value at 6 bar	124 ± 5 Ω
Maximum value of resistance	184 Ω
Operating temperature	from - 25°C to +100°C
Poles	Isolated

**Coolant oil temperature sensor (S)**

Figure 25

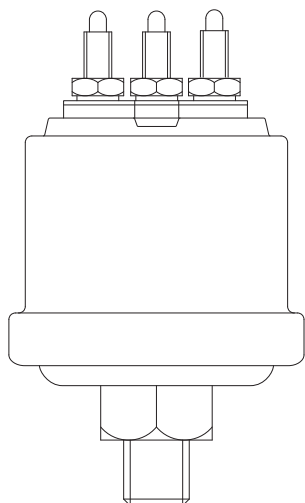


Resistor with negative temperature coefficient, providing the signal for analog temperature indication.

Operating voltage	6 V to 24V
Calibration range	0°C to 120 °C
Resistance value at 90°C	51,2 ± 4,3 Ω
Poles	isolated

### Refrigerating liquid pressure and low pressure sensor (WVA)

Figure 18



05\_056\_C

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

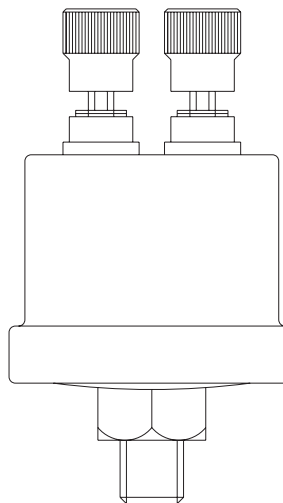
Field of intervention	from 0 to 5 bar
Stamping of the terminals	M - G
Wiring terminals	WVAG - WVAS

#### Switch

Condition at ambient pressure	normally open
Closing pressure	$\geq 0,25$ bar
Stamping of the terminals	M - WK
Wiring terminals	WVAG - WVAA

### Fuel pressure sensor (VCA)

Figure 19



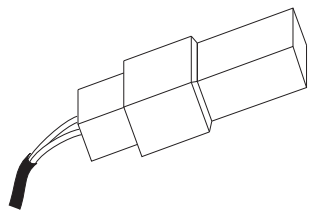
04\_237\_N

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

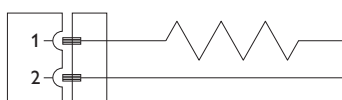
**Line balancing components**

Figure 20



05\_047\_C

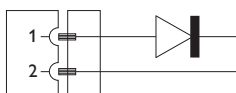
Electric diagram:



05\_058\_C

Code	Resistor features
IR	33 kΩ 1W
IR1	6.8 kΩ 1W
WR	1.5 kΩ 1W
WR1	470 Ω 1W
BAR	4.7 kΩ 1W

Electric diagram:



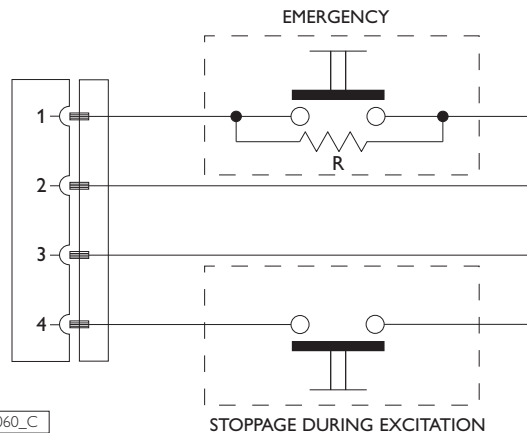
05\_059\_C

Code	Diode code
BAD	1N 4007

**Engine cut-out control buttons (JEM)**

Electric diagram:

Figure 21



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**

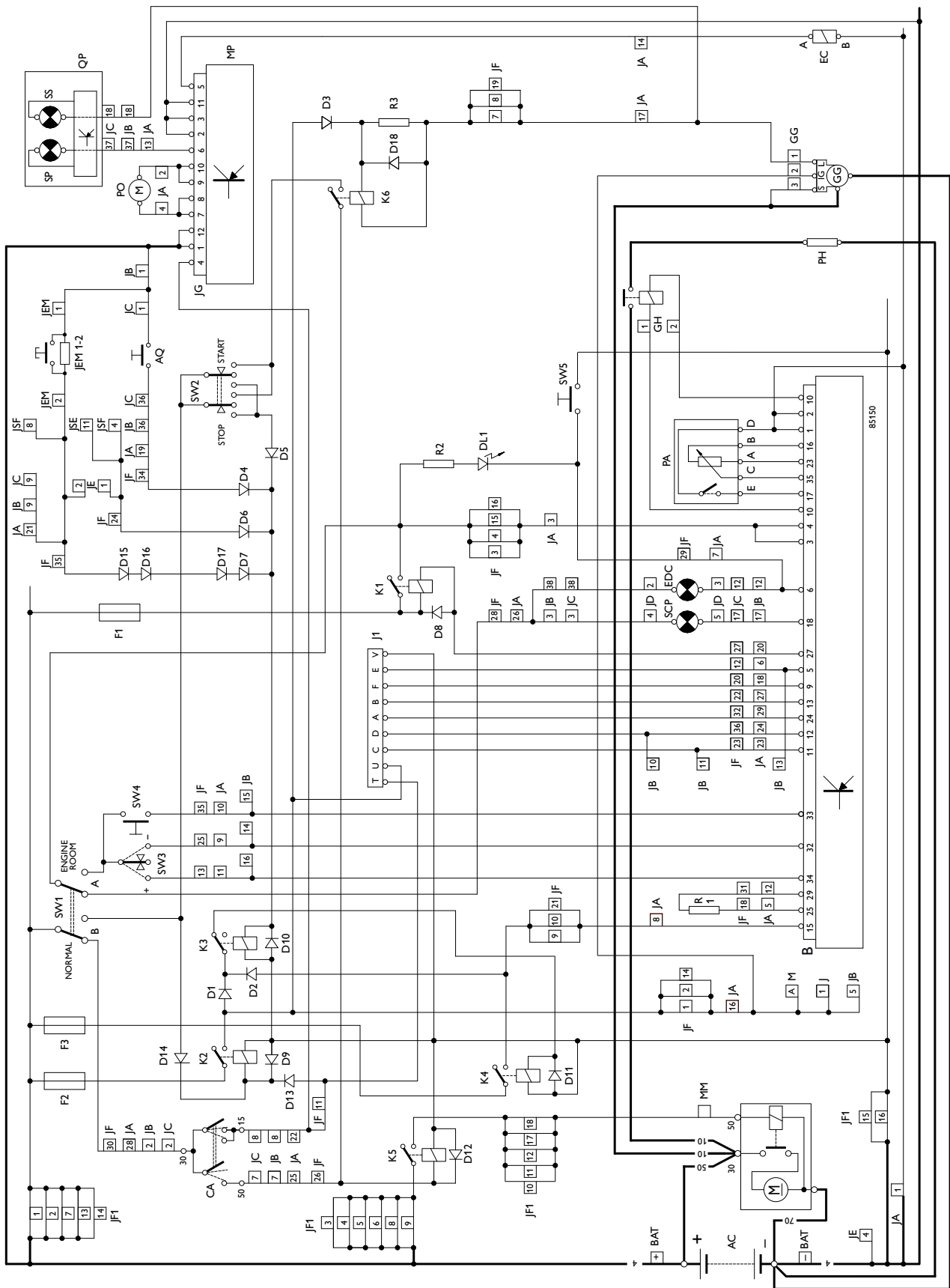
A	Fuel temperature sensor for EDC
B	Drive shaft sensor for EDC
C	Camshaft sensor
E	EUI solenoid valves
F	Engine coolant temperature sensor for EDC
H	Combustion air pressure sensor for EDC
I	High coolant temperature
J	Low coolant level sensor
K	Air filter clogging sensor
M	Sensor for detecting the presence of water in the fuel pre-filter
O	Exhaust gas temperature sensor
P	Intake air temperature sensor for EDC
S	Oil temperature sensor
T	Coolant temperature sensor
U	Clogged oil filter sensor
V	Oil pressure sensor
W	Low oil pressure sensor
X	Clogged blow-by filter sensor
Z	Clogged fuel filter sensor
EC	Switching solenoid valve for oil charge/discharge
GG	Alternator
GH	Pre-heating power relay
JB	Instrument panel connection wire harness
JE	Alarms control unit (for Certification Bodies)
JF, JF1	Relay box
JG	Pre-lubrication control unit
MM	Electric starter motor
PA	Throttle position sensor
PO	Pre-lubrication electrical pump
SI	Gear box oil temperature sensor
VI	High gear box oil pressure sensor (25 bar)
WI	Low gear box oil pressure sensor (7 bar)

**Code of components of the safety system**

BA	Drive shaft sensor
BAD	Diode for BA
BAR	Resistor for BA
BA1, BA1U	Connectors of the extension cable for engine rev. speed
FA	Acoustic and luminous alarms
IA	Coolant temperature sensor
IR	Parallel resistor for IA
IR1	Series resistor for IA
JE	Connector for cutting out agitated engine
JEM	Connector for cutout switches in the case of an emergency and motor cutout from the engine room
JS	Electronic monitoring unit
JSA, 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



### EDC system – connector B



## 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

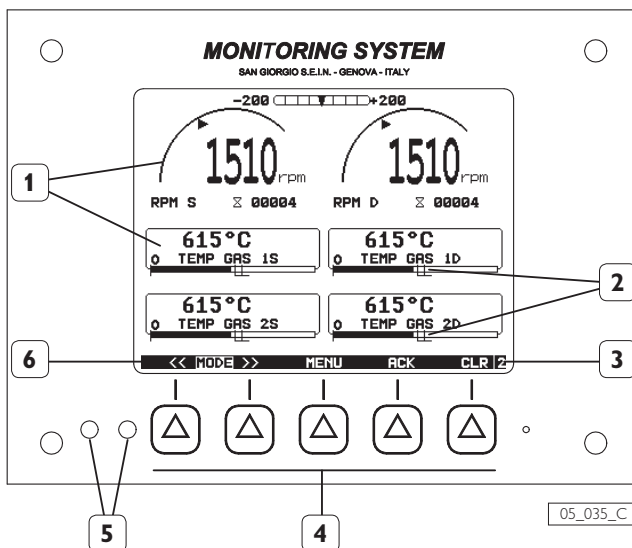
The system is supplied programmed to suit the homologation instructions arranged; every need linked to different programming of the operating characteristics will be met by the information presented by the Constructor with specific documentation. Please remember that the settings, allowed to adapt the 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 22



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 level 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.

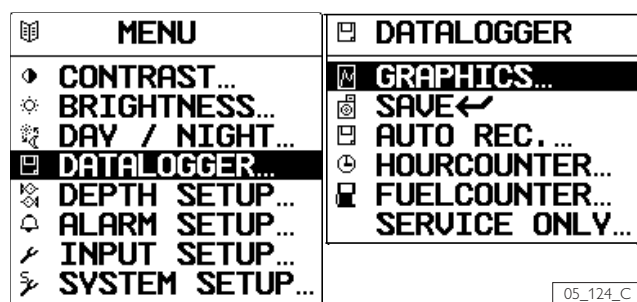
## Video mode setting

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 23



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

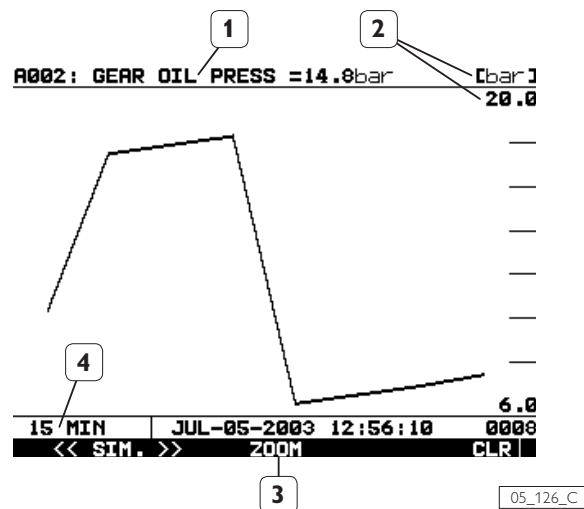
To chose the display mode, do as follows:

- 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 24



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".
- "FUEL COUNTER": (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

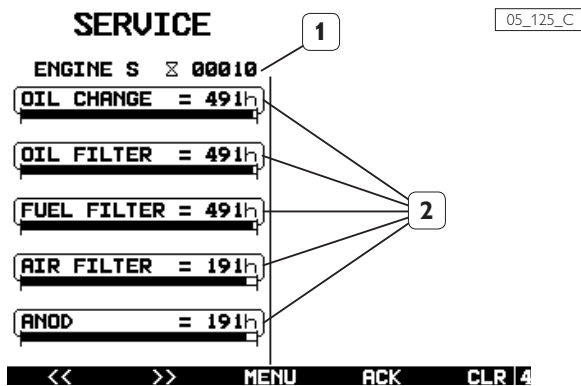
This unit is programmed to enable the monitoring of the hours during which the engine works before set maintenance interventions. Only the Technical Assistance Service Personnel can modify the data relating to the hours of the different intervals.

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 25



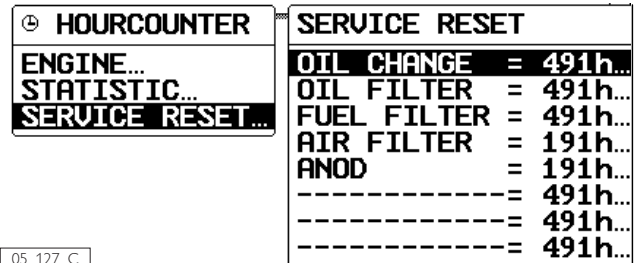
1. Engine working hours indicator - 2. Indicator of the remaining hours before intervention is required.

### 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 26



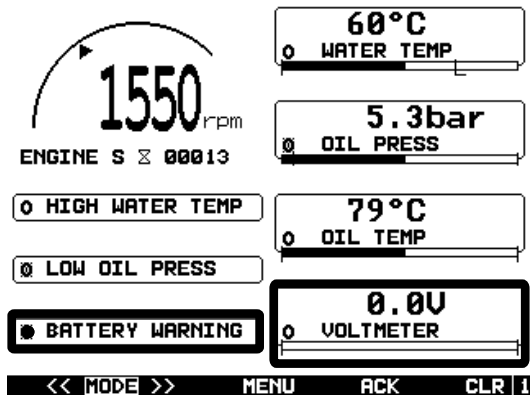
05\_127\_C

- 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 27



05\_128\_C

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

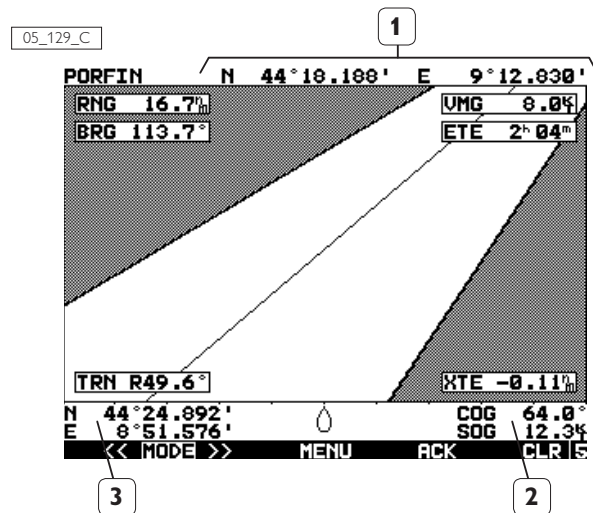
VMG – Real speed at waypoint

ETE – Expected arrival time

TRN – Course direction for waypoint

XTE – Off course mistake

Figure 28

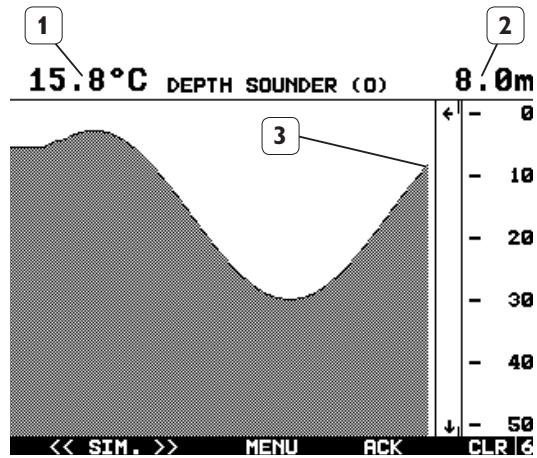


1. Destination (Waypoint) - 2. Course and speed - 3. Position of the moment.

### 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 29



05\_130\_C

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).

PAGE LEFT INTENTIONALLY BLANK

## SECTION 11

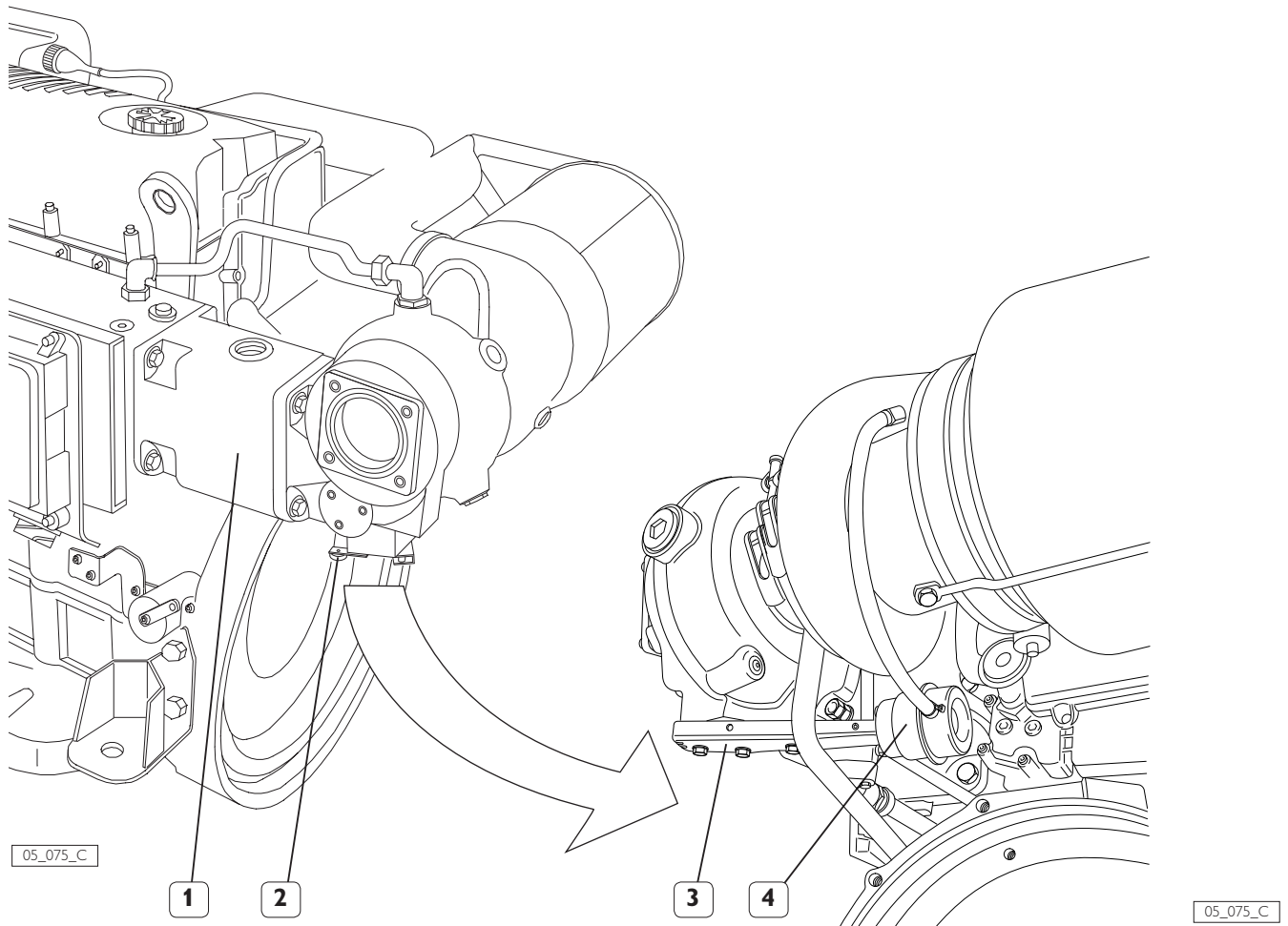
## UPDATING

	Page
TURBOCOMPRESSOR	239
INJECTION SYSTEM - EDC	240
Wire harness	241
Location of electrical components on engine	242
Electrical equipment component code	244
Wiring diagram EDC connector A	246
Guide to blink code diagnosis	247

PAGE LEFT INTENTIONALLY BLANK

# TURBOCOMPRESSOR

Figure 1



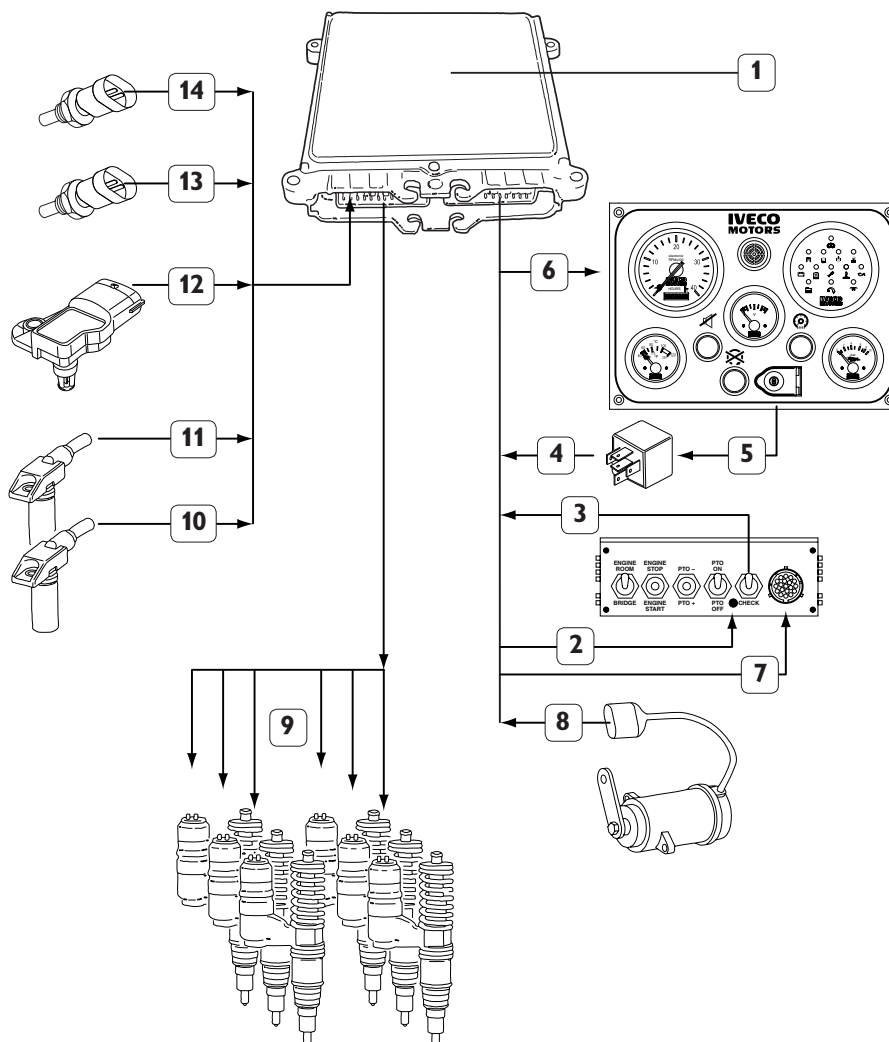
- 1. Turbocompressor supply feeder-line - 2. Waste gate valve command rod. -
- 3. Command rod guard - 4. Waste gate valve pneumatic actuator.

The Turbocompressor assembled on the C78 ENT M50 and C78 ENT M55 motors have been replaced during 2005. The new type of Turbocompressor employs a pneumatic actuator which does not require cooling because it commands the waste gate valve through a rod. This choice enables the use of a Turbocompressor supply connection similar to the connection employed on the C78 ENT M30 engine

Engine	Turbocompressor model
C78 ENT M30	KKK K27 without wastegate
C78 ENT M50	HOLSET HX 55IM with wastegate
C78 ENT M55	HOLSET HX 55WM with wastegate

**INJECTION SYSTEM - EDC (Electronic Diesel Control)**

Figure 2



05\_116\_C

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.

Also some parts of the EDC system have been updated during 2005.

The internal motor cooling liquid temperature sensors and the fuel temperature sensors have been replaced with other parts which are different because of the connection. The air pressure and temperature sensors have been replaced by one sensor which integrates both these functions.

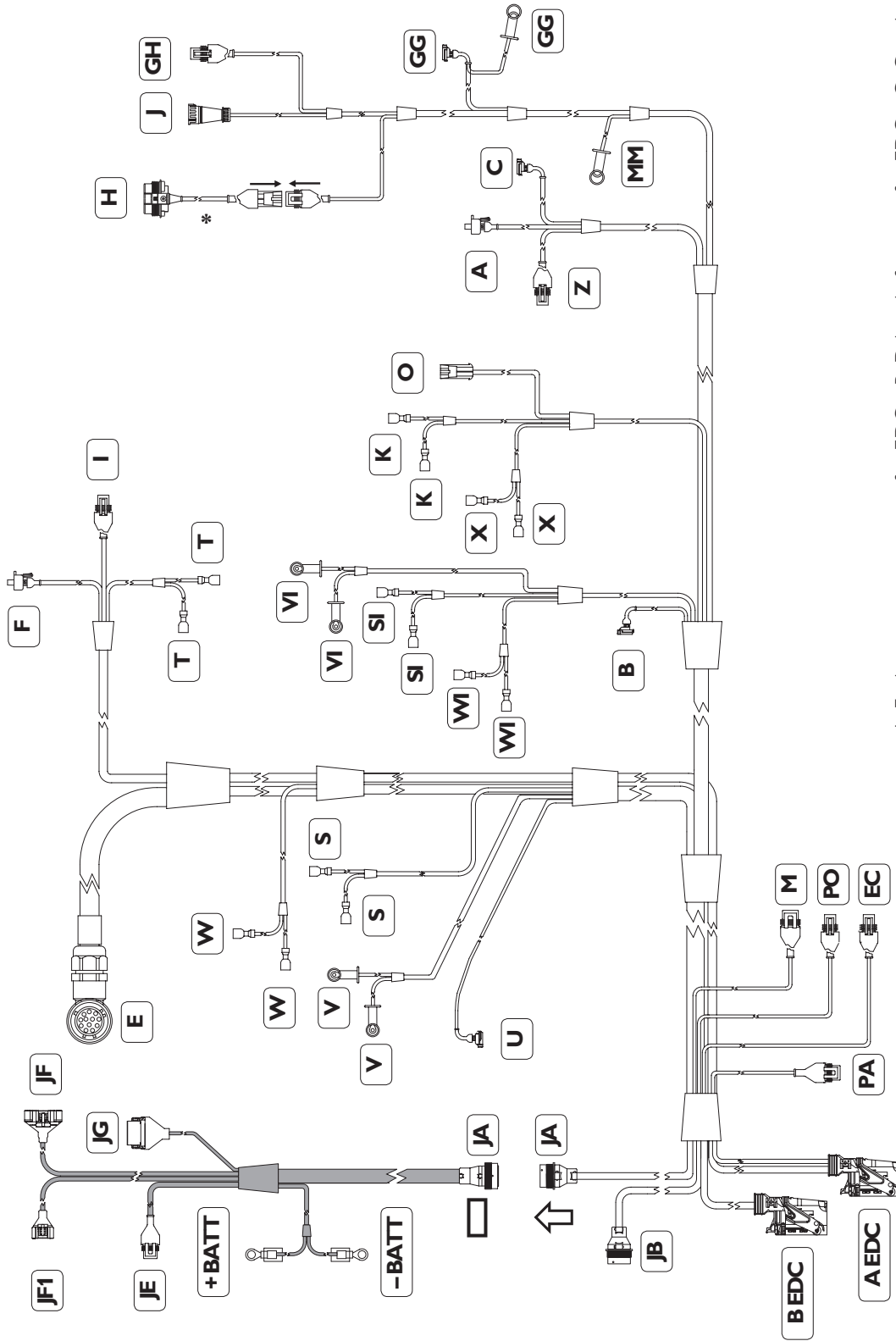
The following pages contain the list of modifications made to the wiring, to the electric schemes and to the position of some parts.

At the end of the Section there is the only modification of the GUIDE TO DIAGNOSIS FROM BLINK CODE, which refers to the connection terminals of the new sensor.



Wire harness

Figure 3



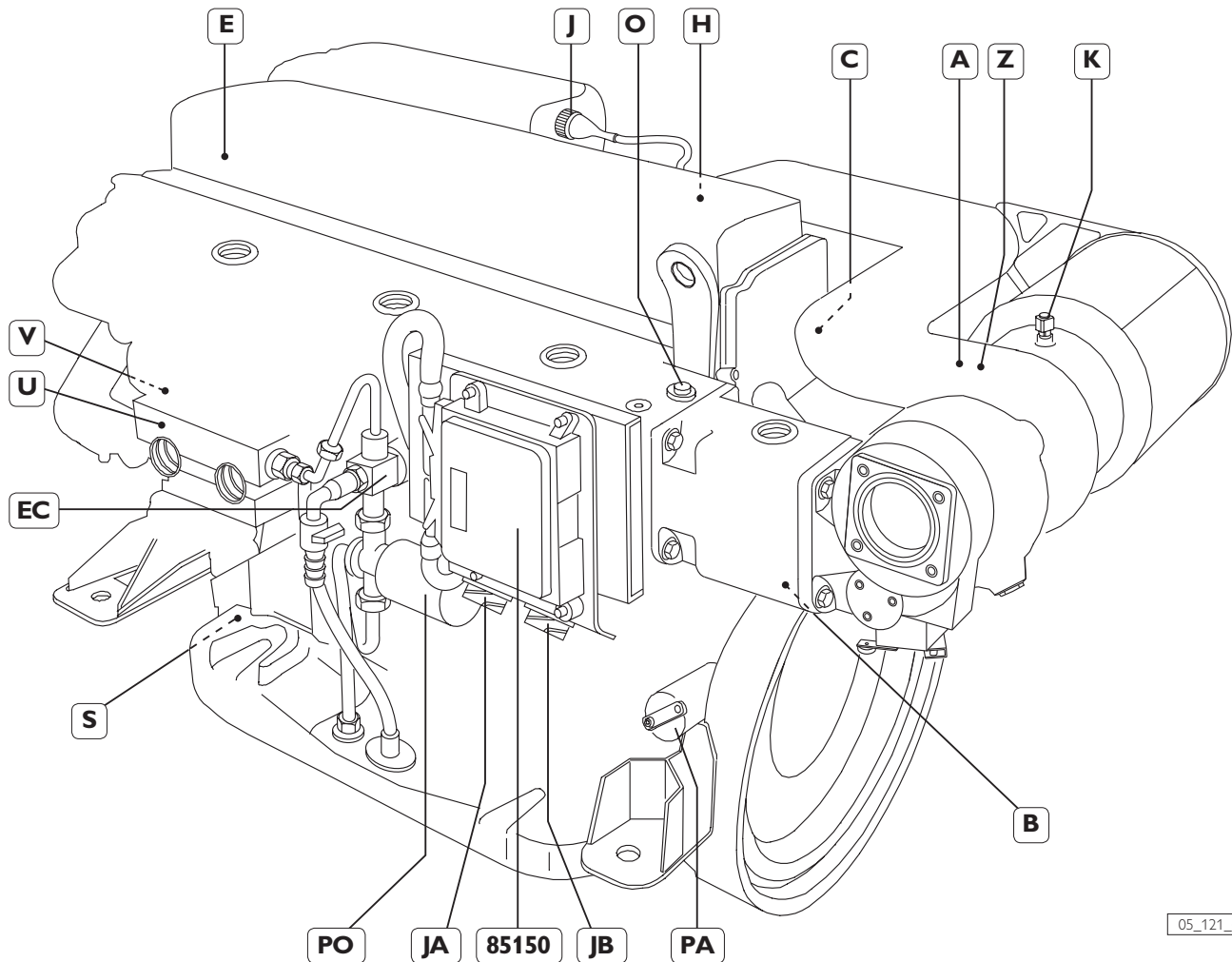
05\_116\_C

Engine wire harness      Interface wire harness

A. Fuel temperature sensor for EDC - B. Drive shaft sensor for EDC - C. Camshaft sensor - E. EU solenoid valves - F. Engine coolant temperature sensor for EDC - H. Combustion air pressure/temperature sensor for EDC - I. High coolant temperature - J. Low coolant level sensor (for alarm) - K. Air filter clogging sensor (for alarm) - M. Sensor for detecting the presence of water in the fuel pre-filter (for alarm) - O. Exhaust gas temperature sensor (for gauge) - S. Oil temperature sensor (for gauge) - T. Coolant temperature sensor (for alarm) - U. Clogged oil filter sensor (for alarm) - V. Oil pressure sensor (for gauge) - W. Low oil pressure sensor (for alarm) - X. Clogged blow-by filter sensor (for alarm) - Z. Clogged fuel filter sensor (for alarm) - EC. Switching solenoid valve for oil charge/discharge - GG. Alternator - JG. Pre-heating power relay - JB. Instrument panel connection wire harness - JE. Alarms control unit (for Certification Bodies) - JF1. Relay box - JG. Pre-lubrication control unit - PA. Throttle position sensor - PO. Pre-lubrication electrical pump - SI. Gear box oil temperature sensor - VI. High gear box oil pressure sensor (25 bar) - WI. Low gear box oil pressure sensor (7 bar) - \* Sensor H wiring harness.

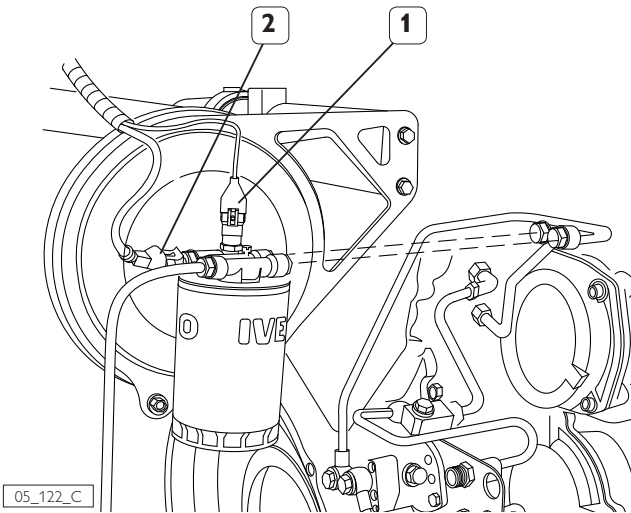
## Location of electrical components on engine

Figure 4



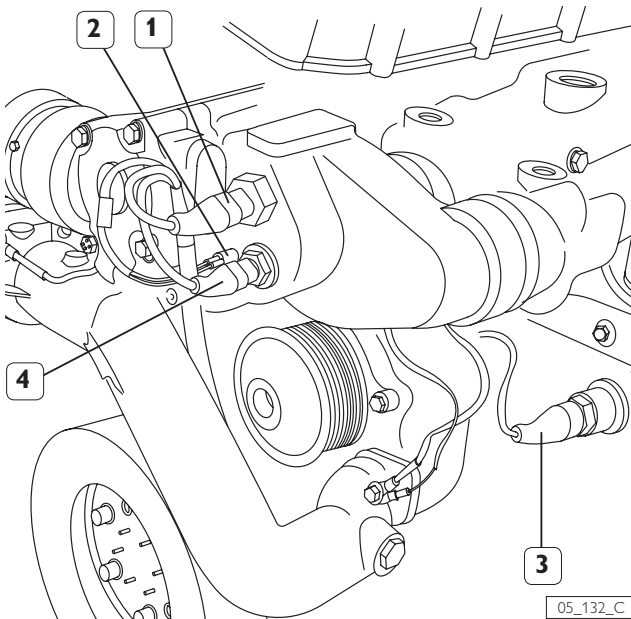
- A. Fuel temperature sensor for EDC - B. Drive shaft sensor for EDC - C. Camshaft sensor - E. EUI solenoid valves - H. Combustion air pressure/temperature sensor for EDC - J. Low coolant level sensor (for alarm) - K. Air filter clogging sensor (for alarm) - O. Exhaust gas temperature sensor (for gauge) - S. Oil temperature sensor (for gauge) - U. Clogged oil filter sensor (for alarm) - V. Oil pressure sensor (for gauge) - Z. Clogged fuel filter sensor (for alarm) - EC. Switching solenoid valve for oil charge/discharge - JA. Connection between engine wiring and interface wire harness - JB. Instrument panel connection wire harness - PA. Throttle position sensor - PO. Pre-lubrication electrical pump - 85150. EDC ECU.

Figure 5



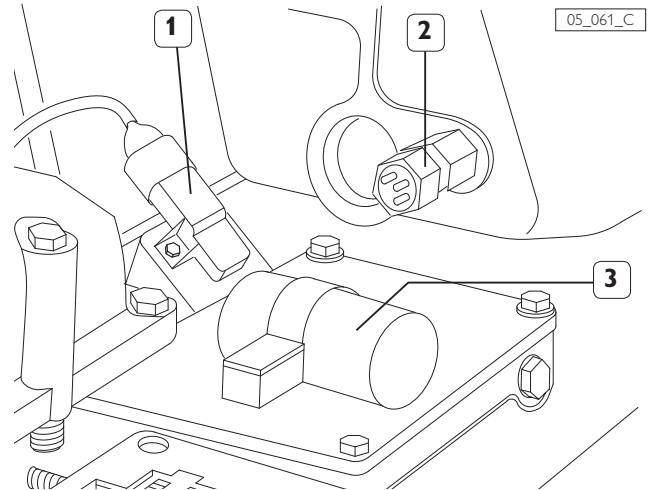
1. Fuel temperature sensor (A) -
2. Clogged fuel filter sensor (Z).

Figure 6



1. Coolant temperature sensor for gauge (T) -
2. High coolant temperature (I) -
3. Low oil pressure sensor (W) -
4. Engine coolant temperature sensor for EDC (F).

Figure 7



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

**Electrical equipment component code**

A	fuel temperature sensor for EDC	QP	main analog instrument panel
AC	battery	QS	secondary analog instrument panel
AQ	engine shut-off push-button on main panel	R1	3.3 k $\Omega$ resistor to inhibit speed input
AS	engine shut-off push-button on secondary panel	R2	DL1 resistor
B	drive shaft sensor for EDC	R3	alternator pre-excitation resistor
C	camshaft sensor	S	oil temperature sensor (for gauge)
CA	key switch	SA	buzzer
CS	engine start push-button on secondary panel	SI	gearbox oil temperature sensor
DL1	EDC fault indicator and blink code LED (on relay box panel)	SW1	bridge or engine room engine control selector (on relay box panel)
EC	switching solenoid valve for oil charge/discharge	SW2	start and stop push button (on relay box panel)
F	engine coolant temperature sensor for EDC	SW3	manual accelerator throttle control in engine room (on relay box panel)
GG	alternator	SW4	PTO ON/PTO OFF selector (on relay box panel)
GH	power relay for starting aid	SW5	blink code emission request push-button (on relay box panel)
H	combustion air pressure/temperature sensor for EDC	T	coolant temperature sensor (for gauge)
I	high coolant temperature sensor (for alarm)	U	Clogged oil filter sensor (for alarm)
IN	injectors solenoid valve	V	oil pressure sensor (for gauge)
J	low coolant level sensor (for alarm)	VI	high gearbox oil pressure sensor (25 bar)
K	air filter clogging sensor (for alarm)	W	low oil pressure sensor (for alarm)
L	instrument panel light switch	WI	low gearbox oil pressure sensor (7 bar)
M	sensor for detecting the presence of water in the fuel pre-filter (for alarm)	X	clogged blow-by filter sensor (for alarm)
MC	CAN - BUS converter module for digital panel	Z	clogged fuel filter sensor (for alarm)
MM	electric starter motor	85150	ECU of the EDC system
MP	pre-lubrication and oil transfer module		
MS	IVECO MOTORS-FPT indications and alarms module		
O	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		

*(continues on next page)*

**Electrical equipment component code (cont.)****Connectors**

A	35 pole EDC boat components
B	35 pole EDC engine components
E	EUI injectors solenoid valve
J1	external diagnostic tool (on the relay box panel)
JA	connection between engine wiring and interface wire harness
JA	ON SECONDARY DIGITAL INSTRUMENT PANEL set for connection to the main digital instrument panel
JB	ON ENGINE WIRE HARNESS set for connection to the main analog instrument panel or to the interface wire harness for converter module
JC	ON MAIN ANALOG INSTRUMENT PANEL set for connection to the engine wire harness
JD	IVECO MOTORS-FPT indications and alarms module
JD	ON INTERFACE WIRE HARNESS FOR CONVERTER MODULE external throttle control
JE	ON MAIN ANALOG INSTRUMENT PANEL set for connection to the secondary analog instrument panel
JE	ON INTERFACE WIRE HARNESS FOR CONVERTER MODULE set for connection to the main digital instrument panel
JE	ON MAIN DIGITAL INSTRUMENT PANEL set for connection to the secondary digital instrument panel
JE	ON MAIN INTERFACE WIRE HARNESS set for connection to the alarms control unit (for Certification Bodies)
JE1	ON INTERFACE WIRE HARNESS FOR CONVERTER MODULE set for connection to the 2 <sup>nd</sup> main digital instrument panel
JF	relay box
JF1	relay box
JG	pre-lubrication control unit
JH	ON SECONDARY ANALOG INSTRUMENT PANEL set for connection to the main analog instrument panel
JH	ON MAIN DIGITAL INSTRUMENT PANEL set for connection to the interface wire harness for converter module
JO	converter for digital panels

**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
SIM	expired programmed maintenance interval
SP	pre-lubrication
SS	alternator fault
SSV	overspeed engine

**Gauges**

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

**Relays contained in the relay box**

K1	EDC main (power supply)
K2	key switch electric discharge
K3	emergency engine shut-down provision
K4	enabling start engine from engine room
K5	power supply to terminal 50 of the electric starter motor
K6	cranking exclusion when engine is running

**Fuses contained in the relay box**

F1, F2	self restoring (not replaceables)
--------	-----------------------------------



**Guide to blink code diagnosis**

Blink Code	EDC light	System reactions	Possible cause	Recommended tests or action
2.2	Off	No perceivable reaction	Air temperature sensor on intake manifold shorted or shorted to ground or shorted to positive or open circuit or defective sensor.	Read measurable parameters with the diagnosis instrument: with this error, the turbocharging air temperature will be fixed at 20 °C. Check the integrity of the sensor (R = approx. 2.5 kOhm at 20 °C) between its pins 1 and 2. If the sensor is integral, check the wiring between the sensor connector and EDC connector pin A17 - A21.

PAGE LEFT INTENTIONALLY BLANK



## SECTION 12

## SAFETY REGULATIONS

	Page
SAFETY REGULATIONS	251
Standard safety regulations	251
Accident prevention	251
During maintenance	251
Respecting the Environment	252

PAGE LEFT INTENTIONALLY BLANK

## SAFETY REGULATIONS

### Standard safety regulations

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

- ❑ Be informed and 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:  $\leq 2$  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 fire-proof 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 over-speed;
- ❑ 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.



**IVECO  
MOTORS**



IVECO S.p.A.  
PowerTrain

Viale Dell'Industria, 15/17  
20010 Pregnana Milanese - MI - (Italy)  
Tel. +39 02 93.51.01 - Fax +39 02 93.59.00.29  
[www.ivecomotors.com](http://www.ivecomotors.com)