NEF ENGINE

N40 ENT M25
N60 ENT M37
N60 ENT M40

TECHNICAL AND REPAIR MANUAL

MARCH 2007 EDITION

TECHNOLOGICAL EXCELLENCE

IVECO MOTORS

FPT POWERTRAIN TECHNOLOGIES

FOREWORD

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

The indications contained in this document pertain to the N40 ENT M25, N60 ENT M37 e N60 ENT M40 marine engine and complement the IVECO MOTORS-FPT publication of "Marine Diesel Engines Installation Handbook" that the reader should refer to for anything that is not explained herein.

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

Safety rules are reported in Section 9 of this publication.

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

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

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

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

In particular

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

To obtain spare parts, you must indicate:

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

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

We refuse all liability
for any errors and omissions.

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

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SECTION CONTENTS

Indications for consultation

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

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

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

CAUTION

During the year 2005, some modifications were made to the internal circuits of the relay box and to the wiring. These modifications make incompatible and harmful the use of the components supplied now together with the components supplied before. Please refer to the instruction shown in Chapter 8.

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SECTION 1

OVERVIEW

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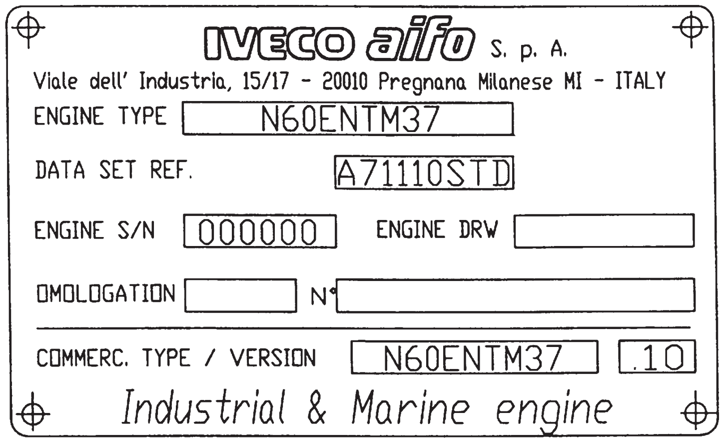
IDENTIFYING DATA (up to December 2003)

Figure 1



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IDENTIFYING DATA (from January 2004)

Figure 2

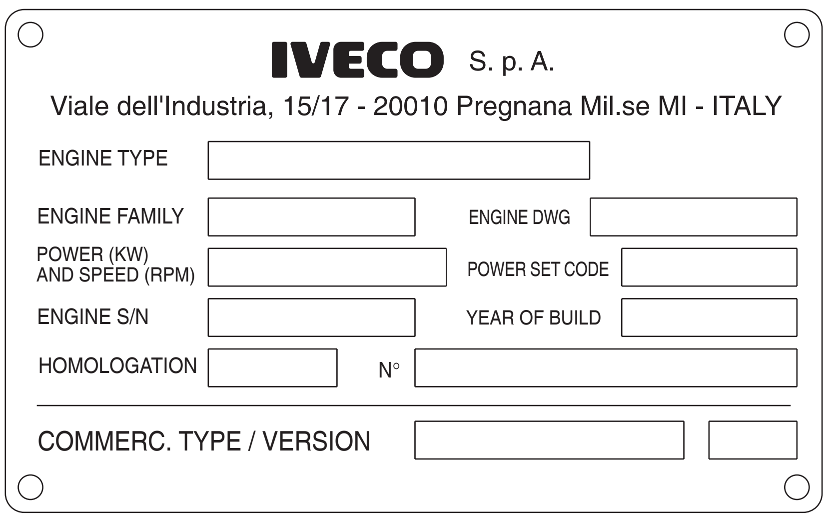

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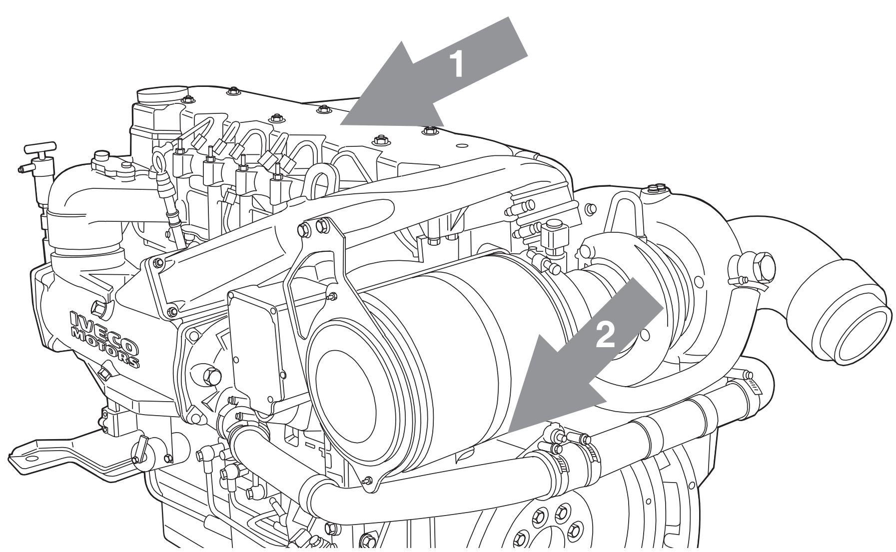
Figure 3



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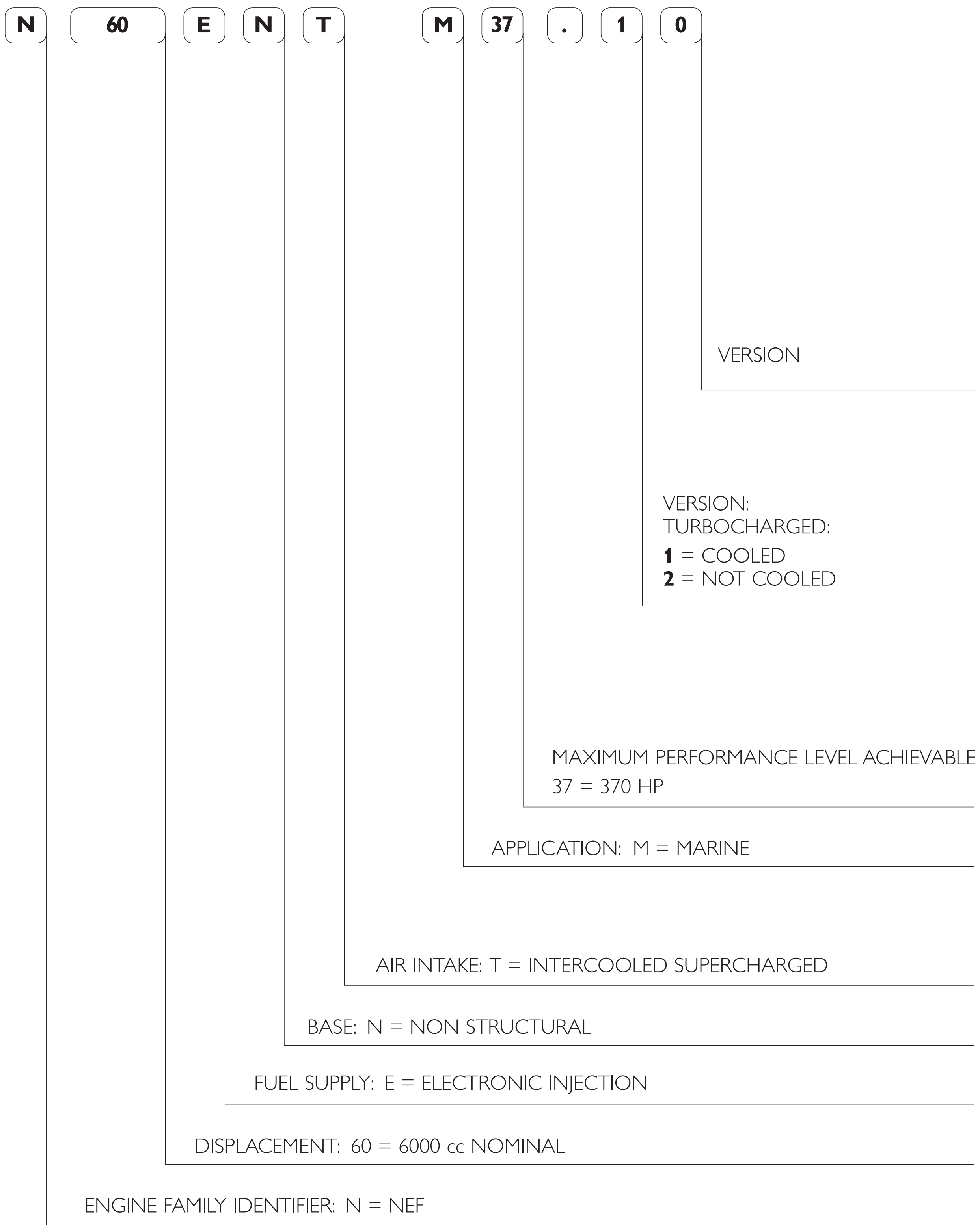
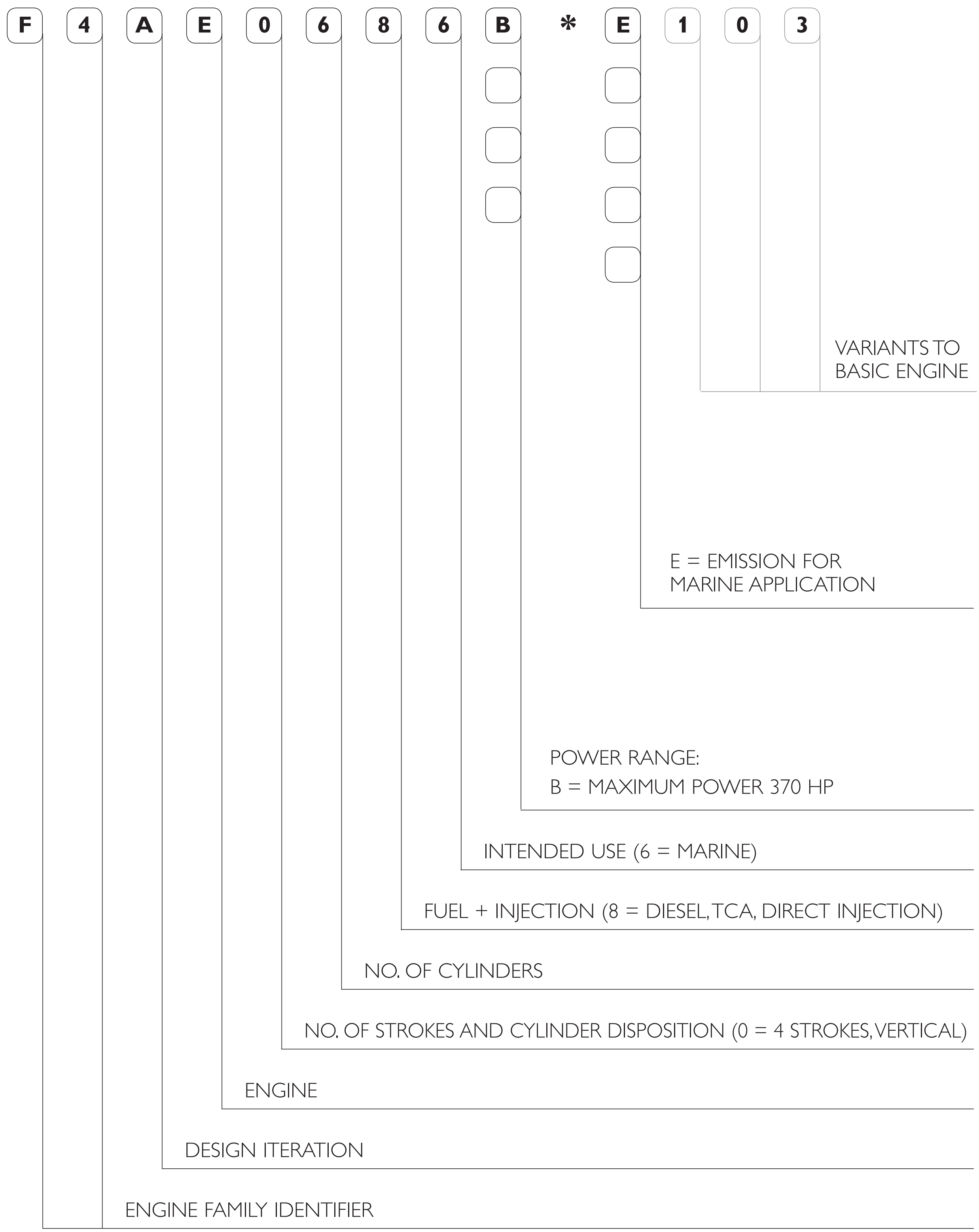
COMMERCIAL CODE

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



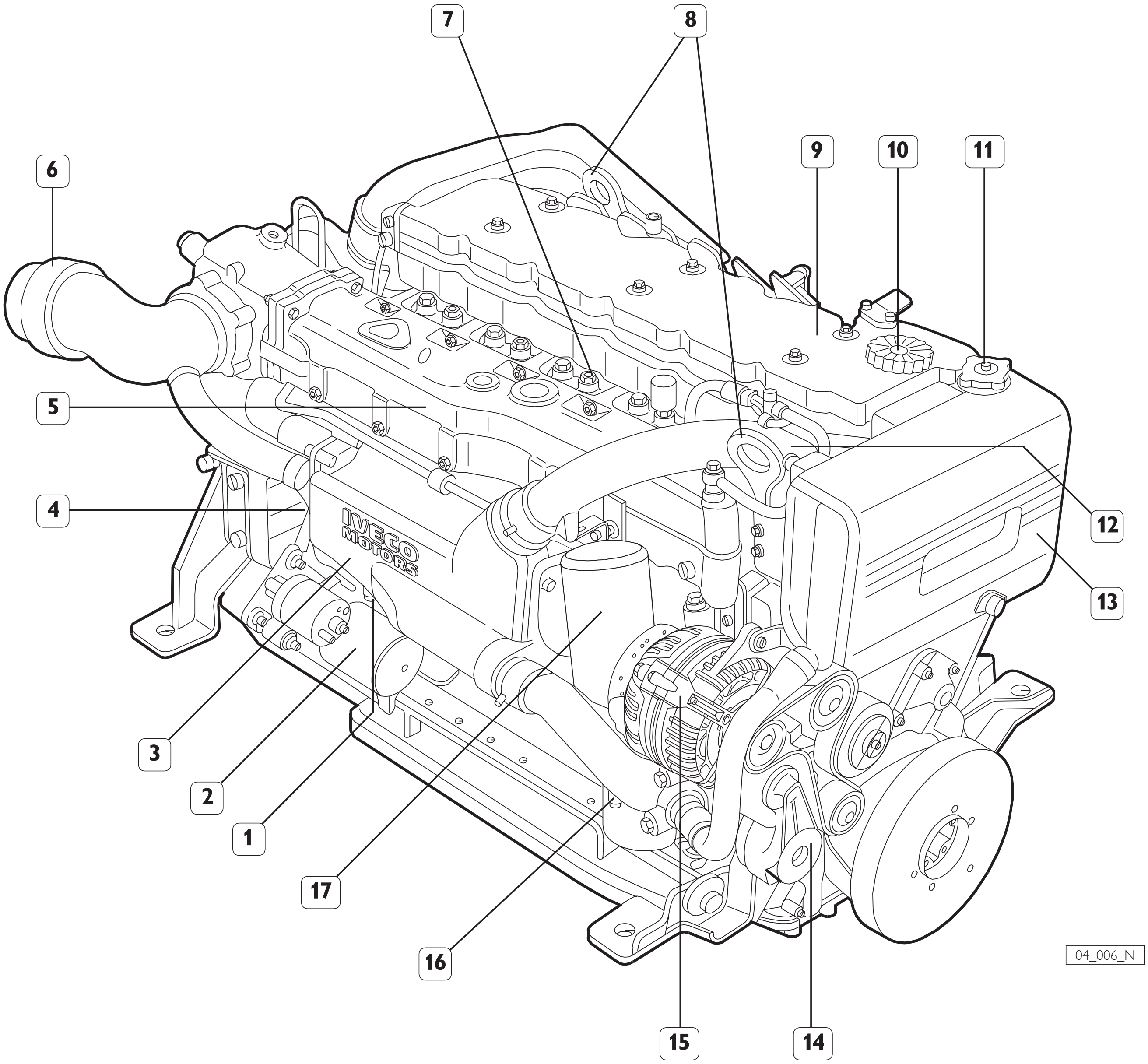
PRODUCT MODEL NUMBER

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



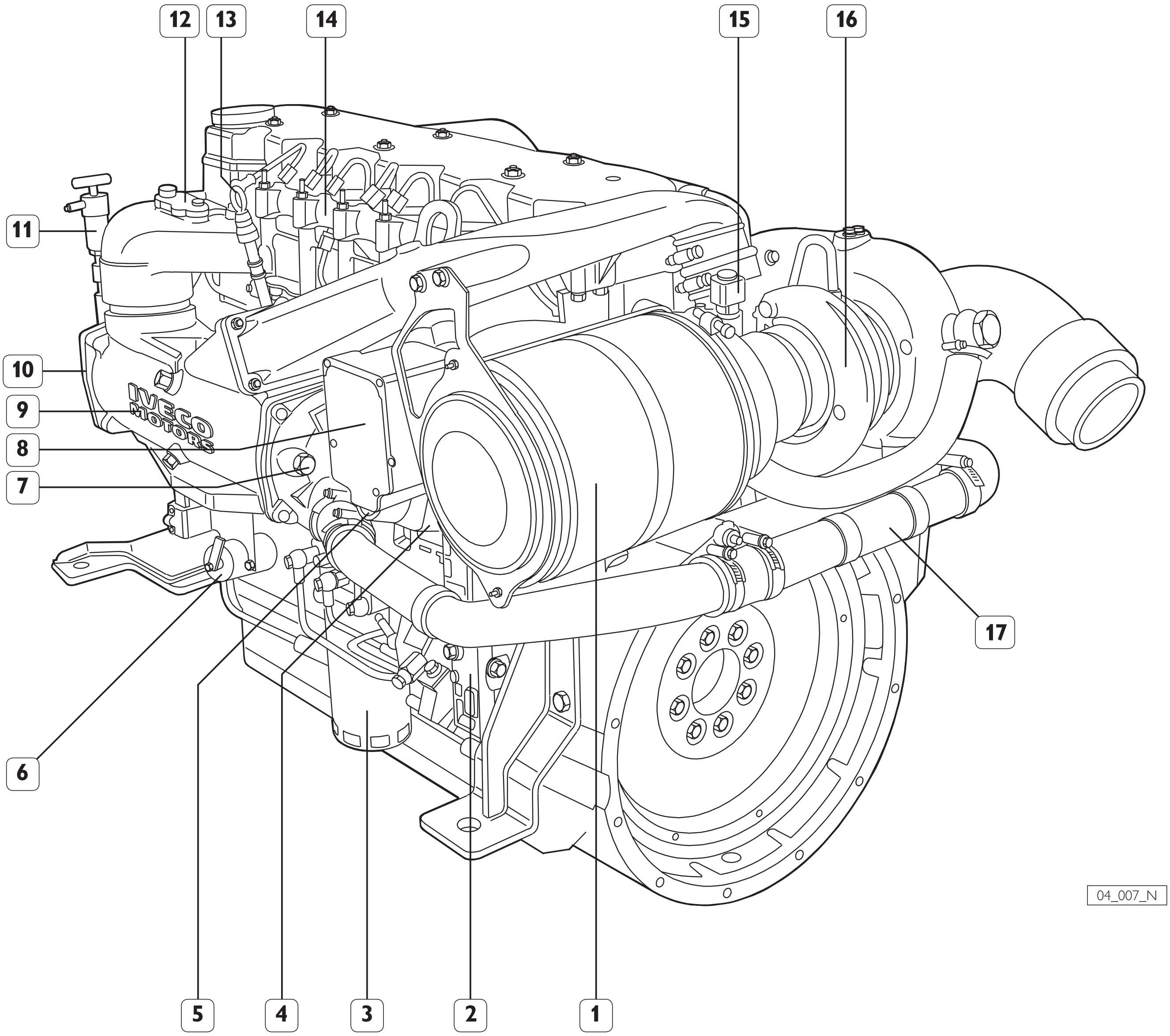
ENGINE PARTS AND COMPONENTS

Figure 4



1. Engine coolant discharge cap - 2. Electric starter motor - 3. Tube bundle engine coolant/sea-water heat exchanger - 4. Location of sacrificial anode - 5. Cooled exhaust manifold - 6. Exhaust gas and sea-water discharge pipeline - 7. Cap for engine coolant outlet to sanitary water heating system - 8. Lifting eyebolts - 9. Rocker arm cover - 10. Oil refill cap - 11. Coolant refill cap - 12. Location of thermostatic valve - 13. Engine coolant tank - 14. Auxiliary belt automatic tensioner - 15. Alternator - 16. Cap for engine coolant discharge and recirculation from sanitary water heating system - 17. Oil filter.

Figure 5



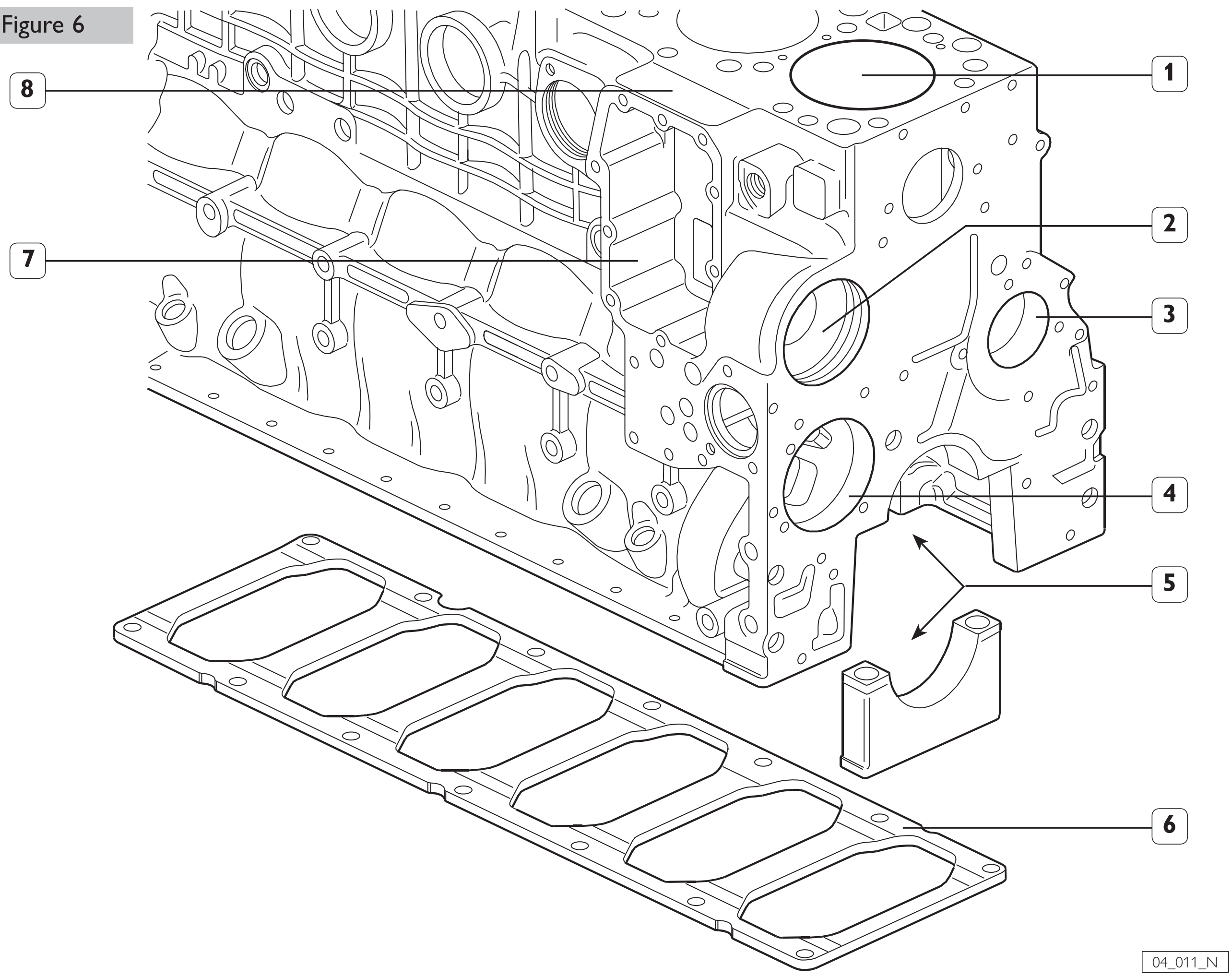
1. Combustion air filter - 2. Common rail high pressure injection pump -3. Fuel filter - 4. Sea-water pump - 5. Sea-water inlet - 6. Throttle potentiometer - 7. Sacrificial anode - 8. Oil vapor separator - 9. Combustion air/sea-water heat exchanger - 10. Location of sea-water discharge cap - 11. Manual lubricating oil extraction pump - 12. Combustion air pressure and temperature sensor - 13. Oil dipstick - 14. Common rail distributor - 15. Air filter clogging sensor - 16. Cooled turbocompressor - 17. Sea-water junction pipe from after-cooler to engine coolant/sea-water heat exchanger.

ENGINE ARCHITECTURE

NEF engines are the highest expression of design and engineering efficiency that IVECO MOTORS-FPT makes available on the market place. They are highly innovative engines designed to be able to comply now with the regulations on fumes and acoustic emissions that will be enforced in the near future.
Designed with innovative techniques and manufactured with advanced working processes, they are the result of hundreds of years of design and engineering tradition as well as of an important international cooperation.
The excellent performance of NEF engines originates from induction and exhaust ducts of new design where, by improving the gas exchange phases, the intaken air turbolence is improved, thus enabling the complete exploitation of the new injection system capacity.
The new criteria chosen in defining the parameters setting the combustion conditions, metering and injection, optimized instant by instant, enable to obtain a new balance between high performance and consumption reduction. NEF engines can be fitted with a mechanical pump or a total electronic controlled "Common Rail" fuel supply system.
Every technical solution has been accurately devised so as to assure qualitative product perfection. The configuration of the engine itself has been designed in such a way as to facilitate access to each individual part thus reducing maintenance time.
Cylinder head fitted with four valves per cylinder, rear timing control, new design connecting rods and aluminum-nickel pistons are components of an engine fitted with 40% less elements than an engine of equivalent performance.

Crankcase

Figure 6

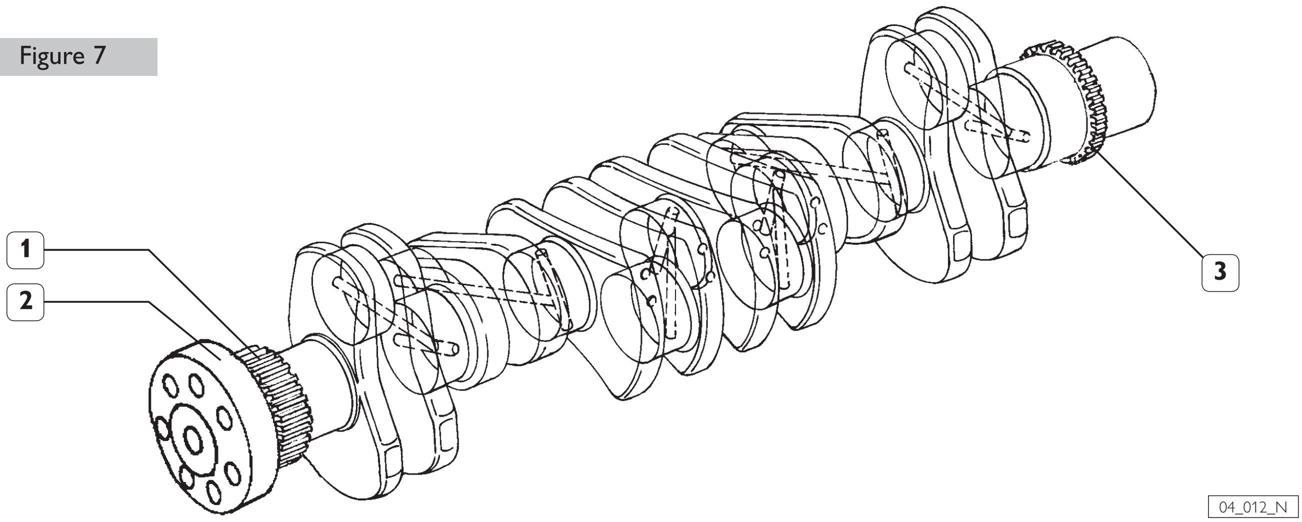


1. Reconditionable integral cylinder barrels - 2. Water pump seat - 3. Camshaft bushing seat - 4. Oil pump seat - 5. Main bearings - 6. Crankcase backing plate - 7. Oil cooler (water/oil) seat - 8. Product model number location.

Moreover, within the cast iron crankcase, coolant circulation grooves, ducts for lubrication loops for the various machine parts and the seat for push rod bushings have been grooved in. The backing plate (6) applied to the lower part makes the crankcase tougher and improves resistance to stress.

Crankshaft

Figure 7

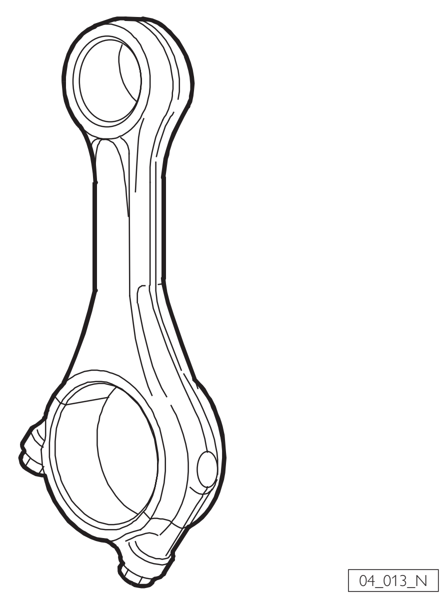


1. Timing system driving gear - 2. Flywheel connecting hub - 3. Oil pump driving gear.

The crankshaft is made in steel hardened by induction and rests on seven mountings; inside the hollow shaft are the ducts for the lubrication oil circulation.
On the front tang, the oil pump driving gear, the phonic wheel, the flywheel connecting hub and the driving pulley of the ancillary components are keyed on.
On the rear tang the camshaft driving gear and the coupling flange to the engine flywheel are keyed on.
The bench half bearings are in cast babbitt lining steel and the 6th is fitted with a shoulder ring to contain the end play of the driving shaft.
Components 1 and 2 in the figure, assembled by negative allowance on the rear tang, are not replaceable. The front and rear retaining rings are of the slide type with radial seal and require special fixtures to be assembled and dis-assembled.

Connecting Rods

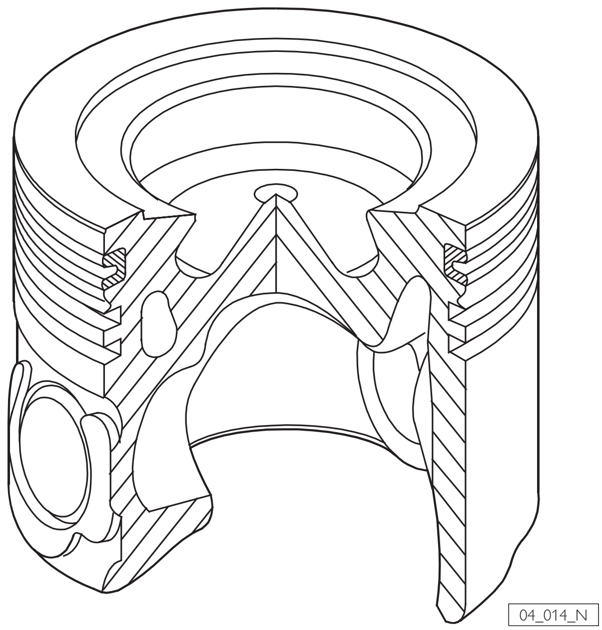
Figure 8



They are made in steel, manufactured by pressing, with small end oblique edged and cap separation obtained by fracture splitting technique.
The connecting rod half bearings are cast babbitt lining steel.
Every connecting rod is marked on the body and on the cap by a number that identifies their coupling and the cylinder into which it is to be assembled; moreover, a letter is impressed on the body stating its weight class.
In case a replacement were necessary, only one type of connecting rod is available as spare part of an intermediate class weight that can be used to replace any other. Therefore, connecting rods that are still efficient, do not need to be replaced even if they are of a different class weight.

Pistons

Figure 9

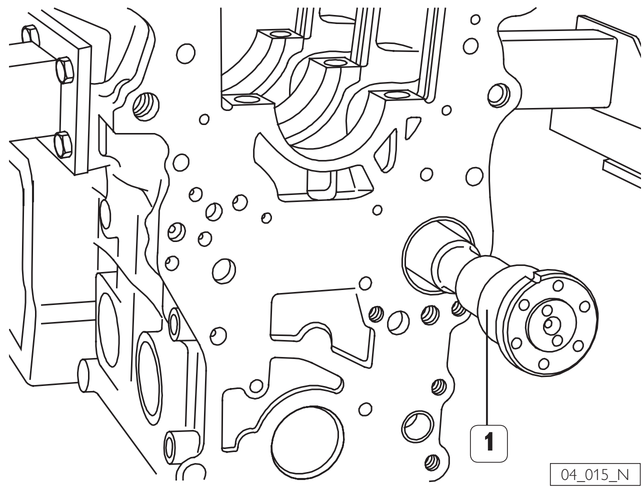


The pistons integrate the high swirl combustion chamber; the annular chambers inside the junk ring enable an effective heat elimination obtained by circulating the lubrication oil delivered by the spray nozzles mounted on the crankcase. On the piston skirt the are three seats for the retaining rings; the first one of these is obtained by a special trapezoidal section cast iron insert.
The piston rings have different functions and different geometry.

- The 1st piston ring has a trapezoidal section and ceramic chrome plating;
- The 2nd piston ring has a a torsional conical rectangular seal;
- The 3rd piston ring has a double oil scraper with internal spring.

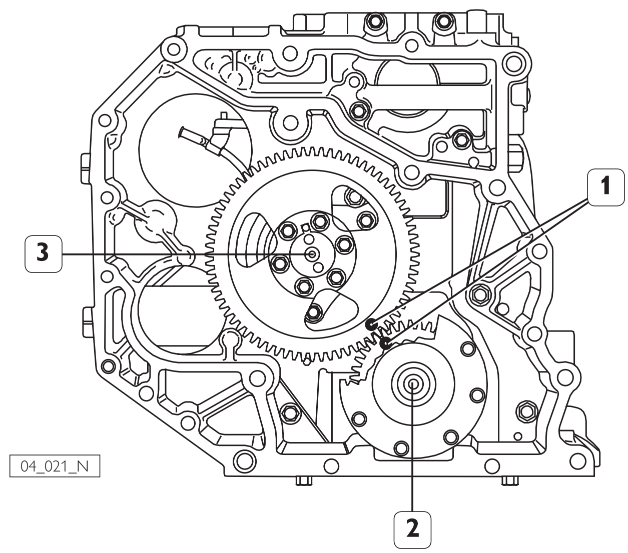
Timing system driving gear

Figure 10



The timing system driving gear machine is a push rods and rockers type, with a camshaft (1) that is located in the crankcase and set into rotation directly by the crankshaft.

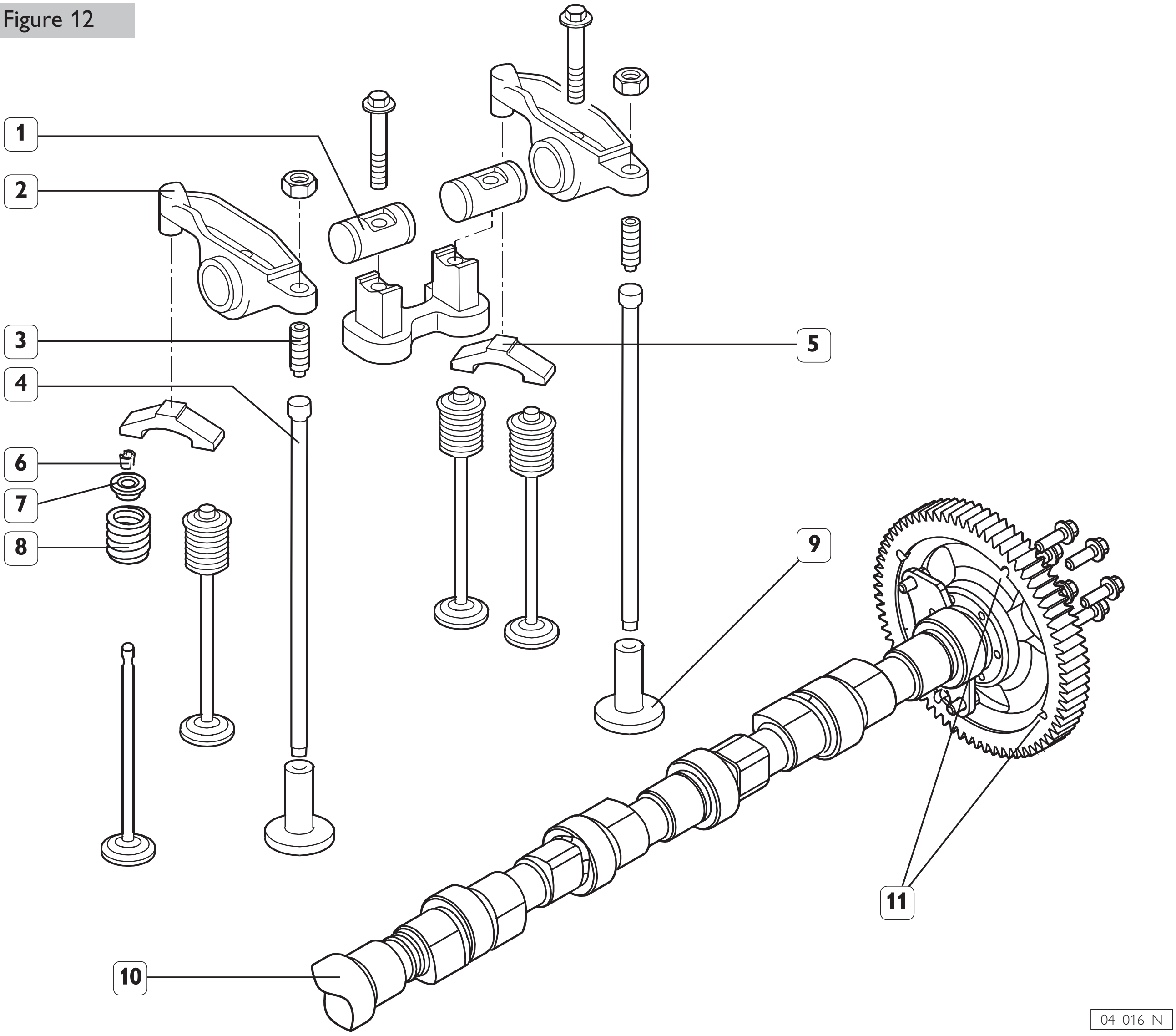
Figure 11



1. Positioning reference - 2. Crankshaft - 3. Camshaft.

The figure illustrates the position that the toothed wheel has to have to set the correct timing strokes.

Figure 12

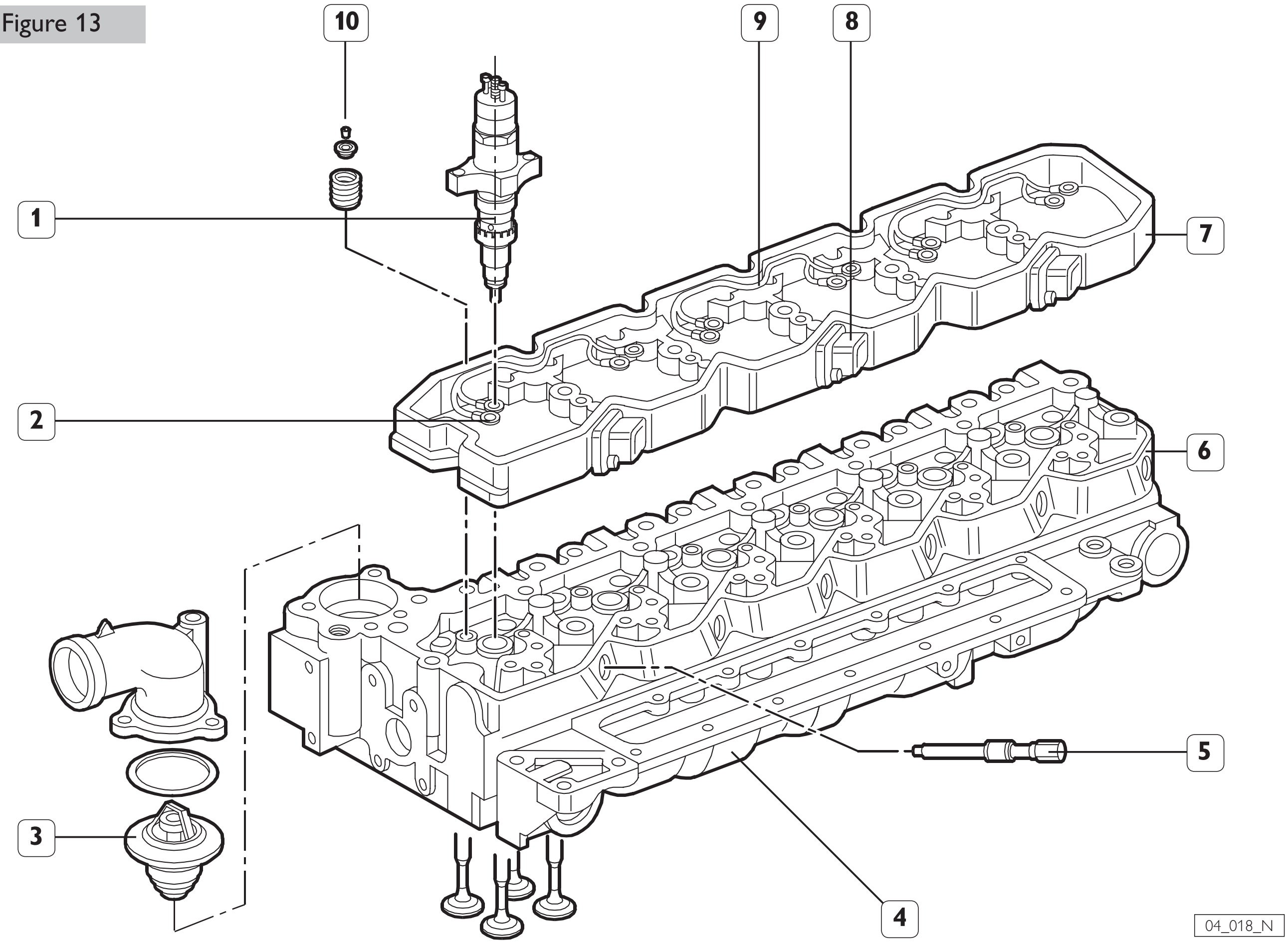


1. Spindle - 2. Rocker - 3. Adjuster screw - 4. Rod - 5. Bridge - 6. Cotters - 7. Cup - 8. Spring - 9. Tappet - 10. Camshaft - 11. Holes for camshaft sensor.

The timing camshaft rests on seven mountings; the mounting points at the front and rear end are fitted with cast babbitt lining steel bushings, assembled by negative allowance.
The timing camshaft is set into rotation by the crankshaft with direct coupling to a straight toothed wheel.The toothed wheel keyed on the timing camshaft has 6+1 slots for camshaft sensors (11) enabling the generation of the electric signals needed for the engine control system.

Cylinder head

Figure 13



1. Electro-injector - 2. Electro-injector electric connection terminal - 3. Thermostat valve - 4. Induction manifold - 5. Fuel filling pipe to the injector - 6. Cylinder head - 7. Chassis bracket for injectors electric outfit - 8. Electric connector - 9. Electro-injector wiring harness - 10. Cotters, cup and spring.

The cylinder head is monolithic and is made in cast iron; it houses slots for the following:

- ❑ Valves, with seats and elements inserted;
- ❑ Thermostatic valve;
- ❑ Electro-injectors;
- ❑ Fuel delivery filling pipes conections to the electro-injectors.

Inside the cylinder head the duct for the recovery of the fuel not used by electro-injectors has been fitted.

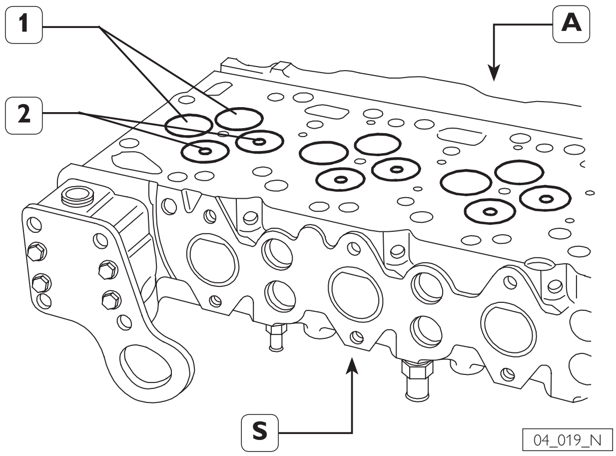
- ❑ Exhaust manifold;
- ❑ Induction manifold

are coupled to the cylinder head.

On the top part of the head the chassis is secured, to which the connectors of the wiring harness for the control of electro-injectors, are fastened.

Valves and valve seats

Figure 14

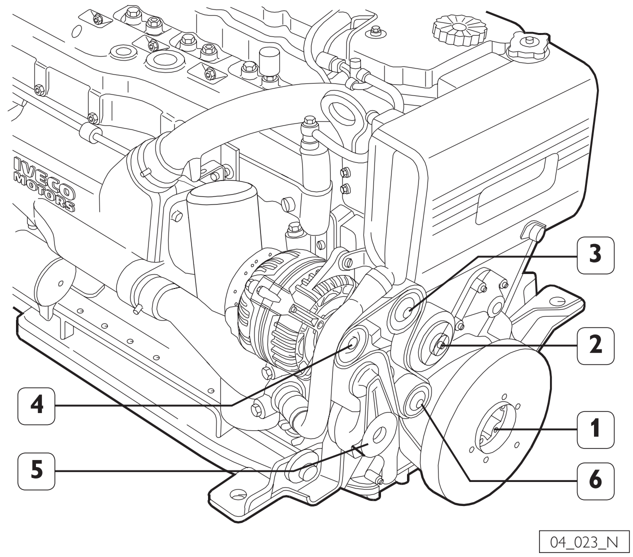


1. Induction valves - 2. Exhaust valves - 3. Inserted element - A. Induction side - S. Exhaust side.

Valves seat are obtained by casting in the cylinder head, and machined to 45° taper ratio for exhaust valves and 60° taper ratio for induction valves.

Ancillary machine members drive

Figure 15

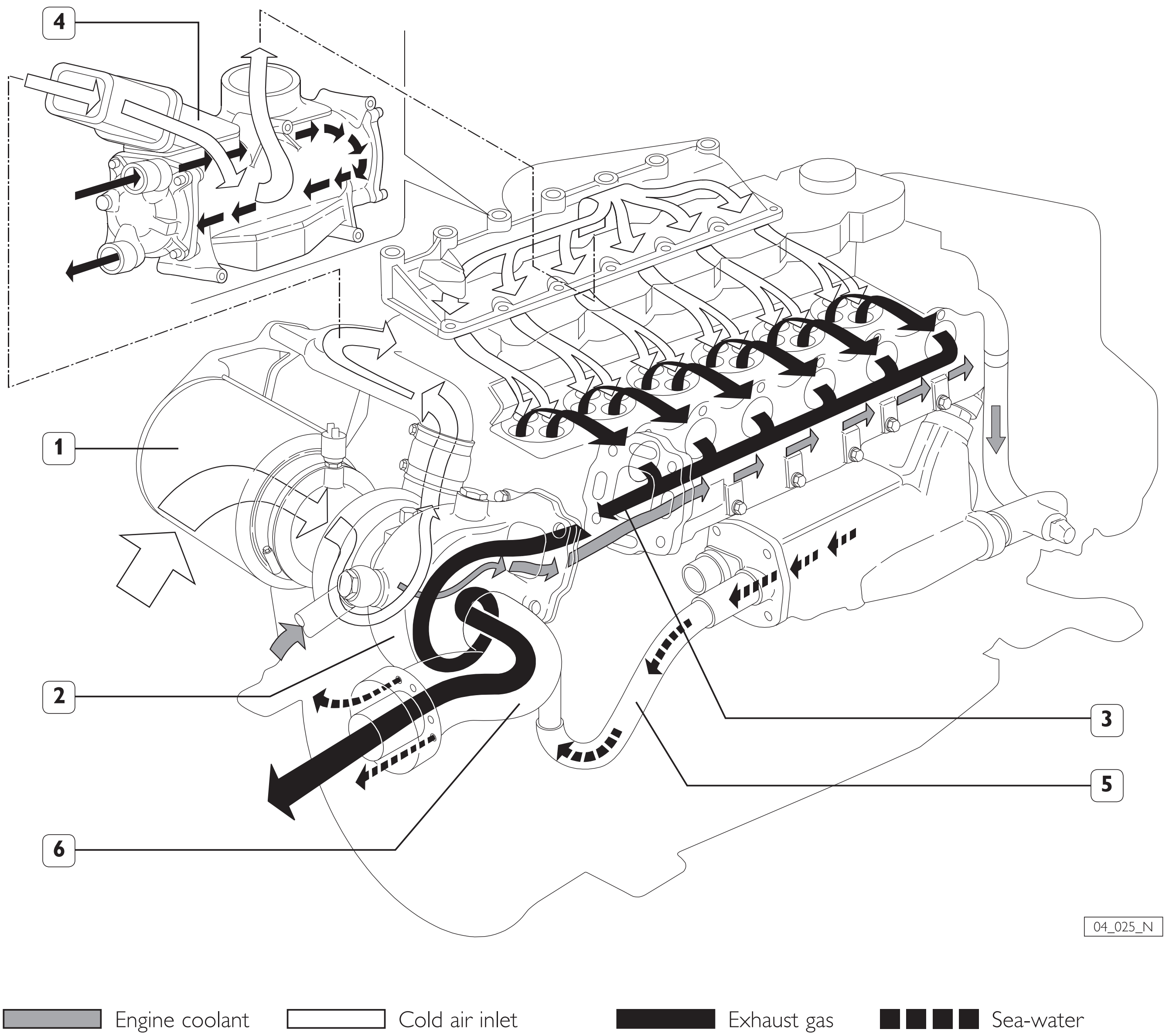


1. Crankshaft - 2. Engine coolant pump pulley - 3. Stationary guide pulley - 4. Alternator pulley - 5. Spring tightner - 6. Stationary guide pulley.

Motion to ancillary machine parts is transmitted by a Poly -V belt put under tension by a gauged spring (5).
Stationary guide pulley (3) is located between the alternator pulley and the engine coolant pump pulley in order to provide an adequate contact surface on the latter.

COMBUSTION AIR INTAKE AND EXHAUST SYSTEM

Figure 16



1. Air filter - 2. Turbocompressor - 3. Exhaust gas inlet in turbine - 4. Heat exchanger air/sea-water - 5. Sea-water outlet pipe from the exchangers - 6. Exhaust terminal (riser).

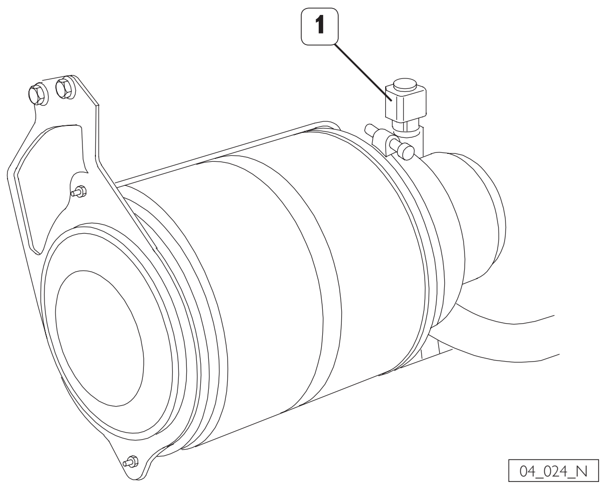
Before reaching the cylinders, supercharging feeding air, intaken through the filter, runs through the heat/sea-water exchanger, thus reducing its temperature, in order to favour a higher engine volumetric efficiency.

The pressure and air temperature sensor located on the induction manifold, provides the ECU of the EDC system with the information enabling a fuel metering adequate to the density of the intaken comburent air and an optimum treatment of the injection advance.

The turbocompressor casing and exhaust manifold are cooled down by engine coolant.
The exhaust gas flows into the exhaust terminal and, where applicable (riser), mixed with sea-water to be expelled.

Comburent air filter

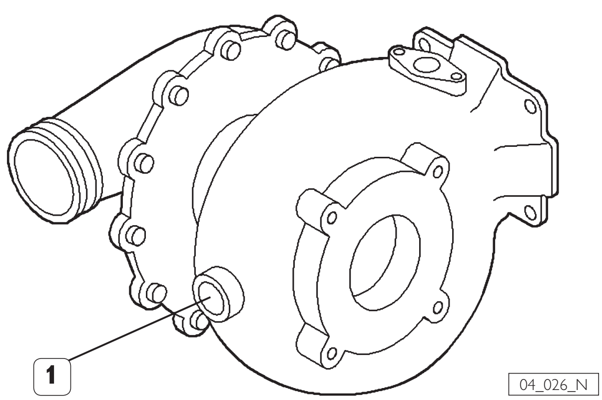
Figure 17



1. Filter clogging sensor.

Turbocompressor

Figure 18

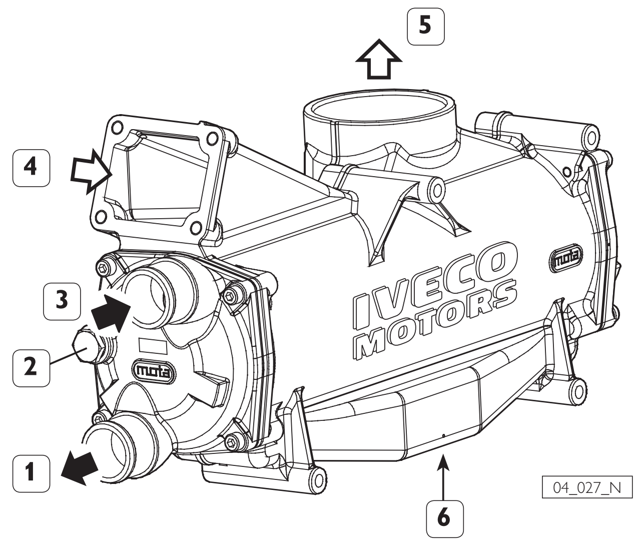


1. Coolant inlet.

The engine is turbosupercharged by a fixed geometry turbine with no waste-gate control.
The turbine is cooled by the coolant circulation from the crankcase.
The compressor-turbine spindle rotates on brass bearings lubricated by pressure lubrication, directly from the oil filter.

Air/sea-water heat exchanger

Figure 19

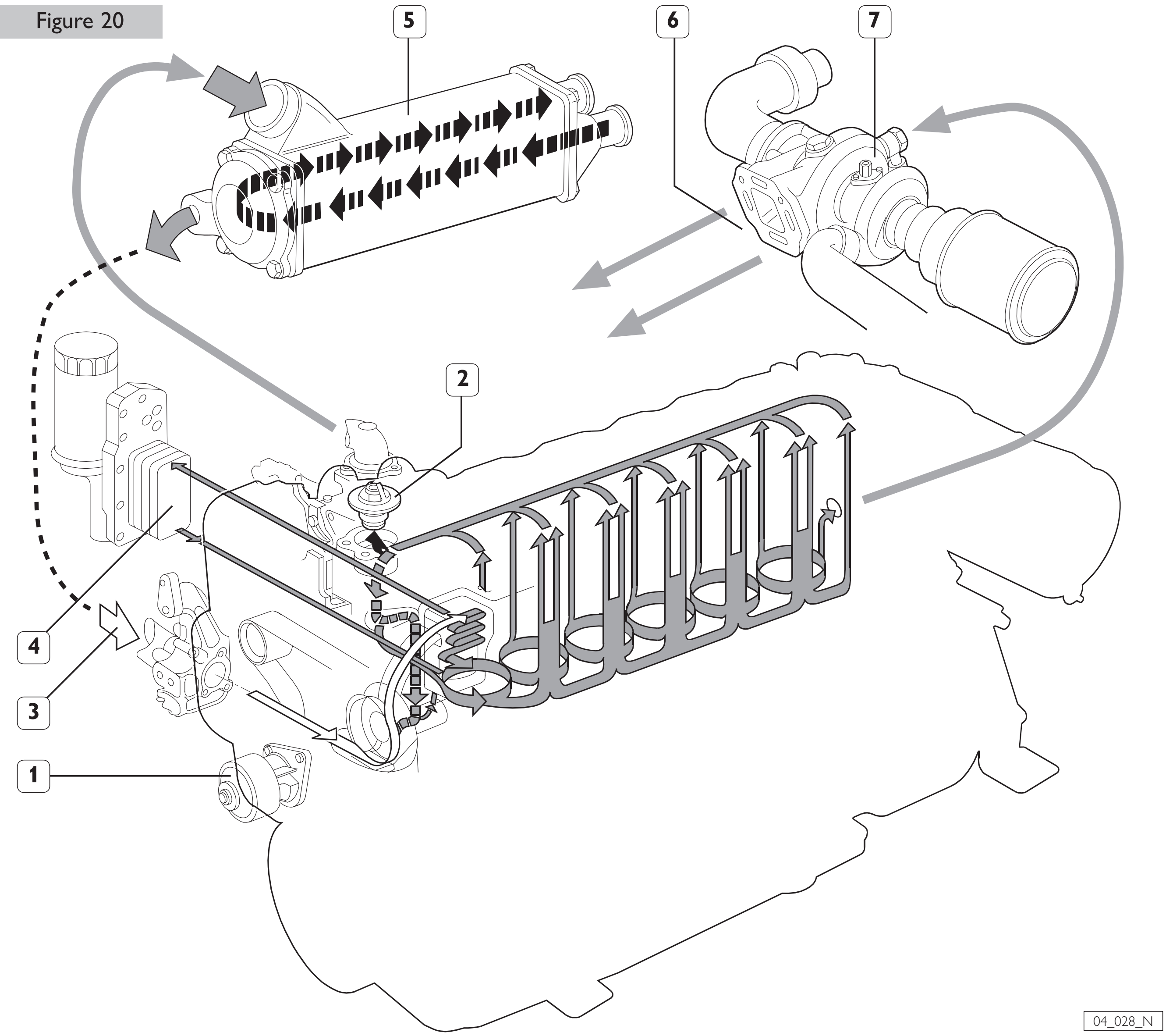


1. Sea-water outlet - 2. Sacrificial anode (Zinc) - 3. Sea-water inlet - 4. comburent air inlet - 5. Comburent air outlet - 6. Condensate drainage hole.

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

COOLING FRESH WATER CLOSED-LOOP

Figure 20



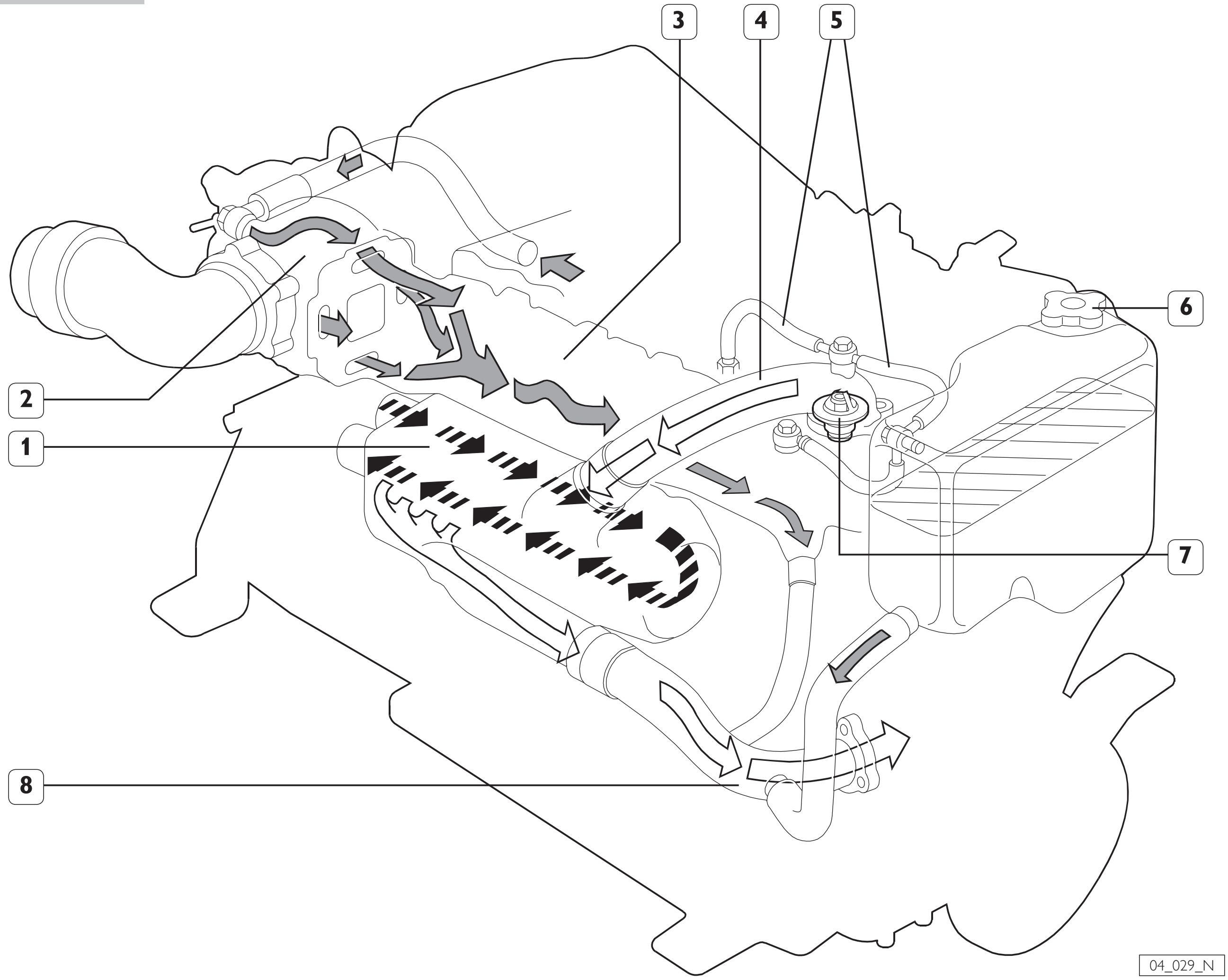
Hot engine coolant — Cold engine coolant — Sea-water

1. Coolant pump - 2. Thermostatic valve - 3. Pump intake flow - 4. Oil/coolant heat exchanger - 5. Coolant/sea-water heat exchanger - 6. To exhaust manifold cooling - 7. Turbocompressor.

The centrifugal pump (1) set into rotation by the crankshaft by means of the poli-V belt, intakes the coolant and sends it to the crankcase to touch the areas of the thermic exchange of the cylinders and afterwards to the engine head put of which it comes through the thermostatic valve (2).
The liquid is made to return to the pump until it reaches the setting temperature of the valve; once this temperature has been reached it is deviated proportionally to the temperature reached, towards the coolant/sea-water heat exchanger (5). A part of it goes back to the pump, another reaches the heat exchanger where it heats the sea-water up to re-enter then into the inlet of the pump. The coolant, before going through the crankcase, cools down the engine oil that goes through its own heat exchanger (4). Some of this oil comes out from the rear branchpipe to touch the turbocompressor and cools down the case (7) and goes through the exhaust manifold cavity, in order to reduce its temperature as it is prescribed by nautical regulations; this part of the liquid flows then into the branch pipe intake of the centrifugal pump.

Exhaust manifold cooling

Figure 21

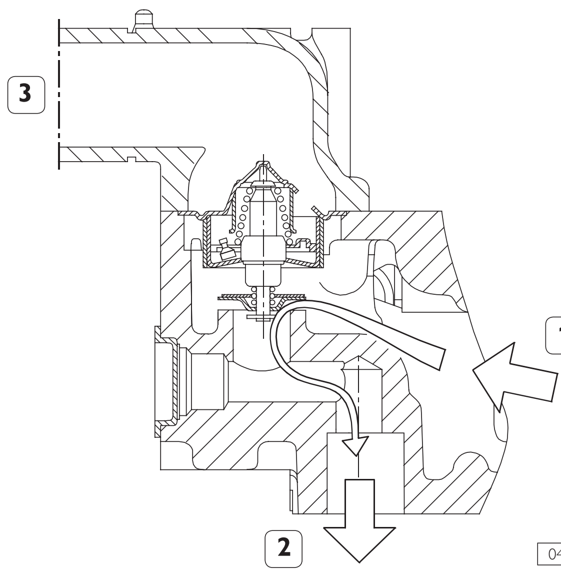


Engine coolant going through exhaust manifold
Hot engine coolant going through coolant exchanger
Sea-water

1. Sea-water/coolant exchanger - 2. Turbocompressor - 3. Exhaust manifold - 4. Thermostatic valve-water/water exchanger connector - 5. Degassing piping - 6. Plug with pressure valve - 7. Thermostatic valve - 8. Water pump manifold inlet.

Thermostatic valve

Figure 22



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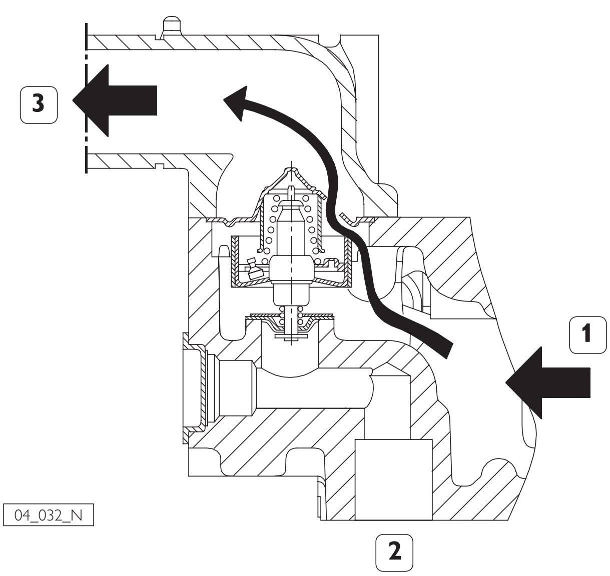
Low temperature operation

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

Figure 23



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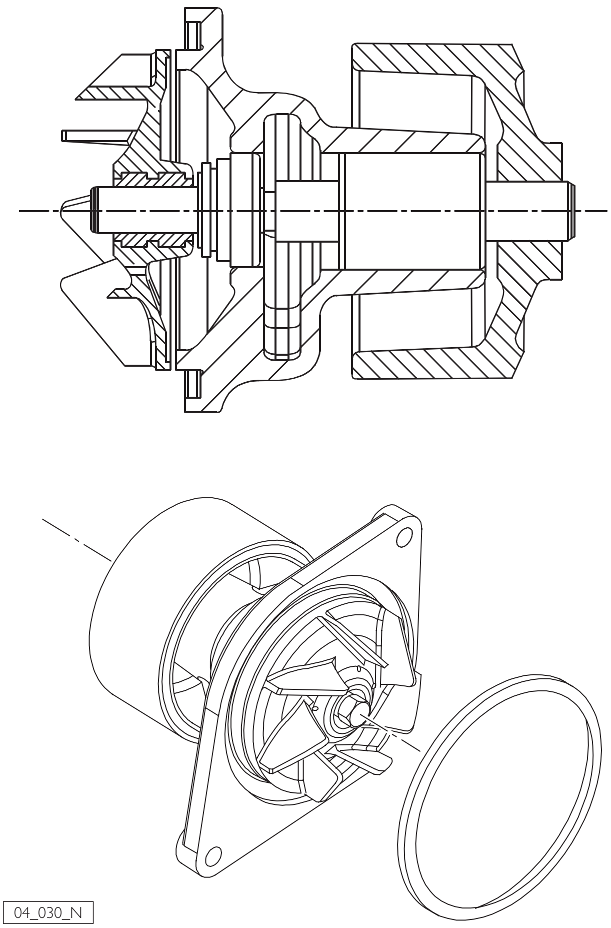
High temperature operation

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

Water pump

Figure 24



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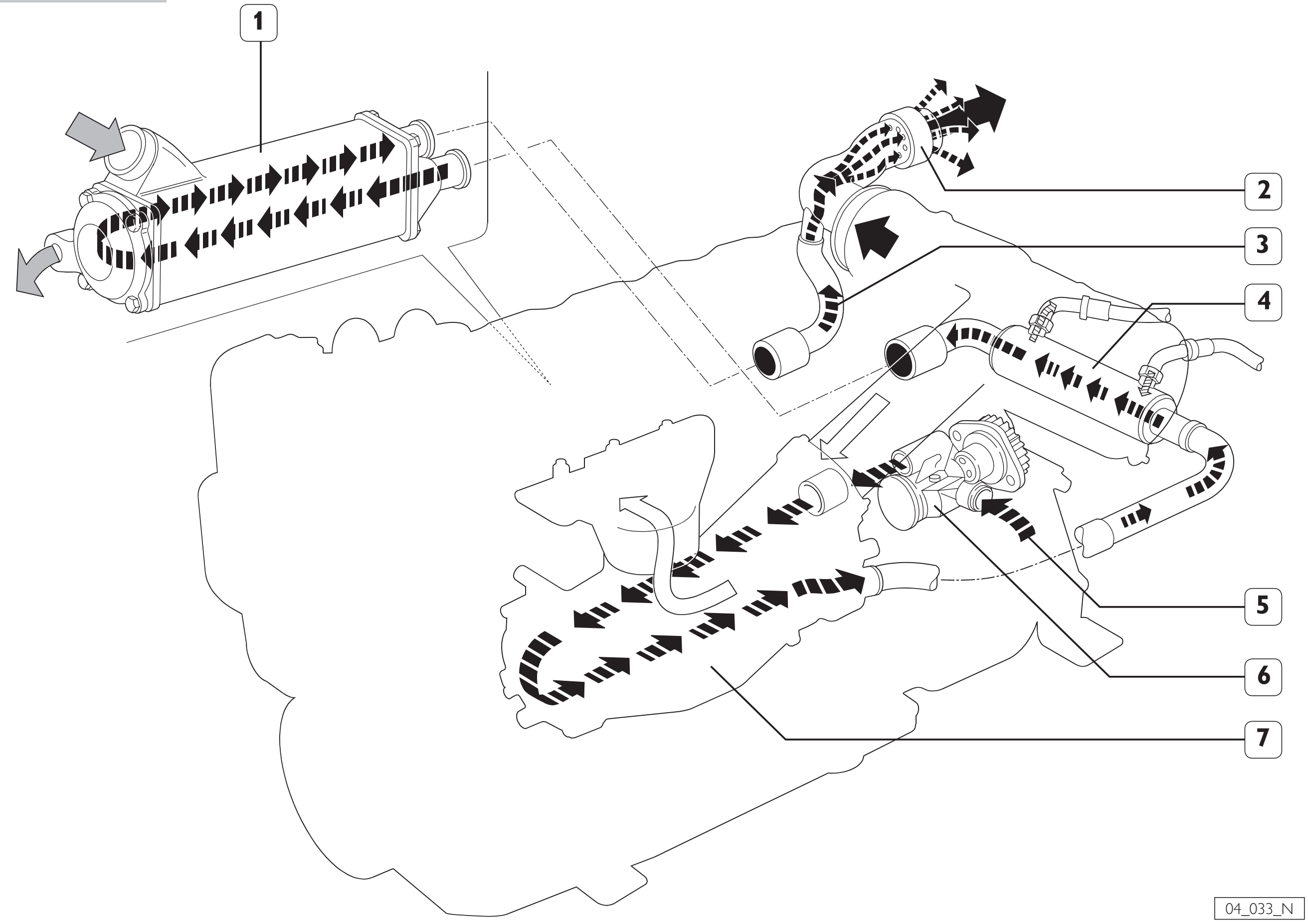
The water pump has its own seat within the crankcase and is set into rotation by the poli-V belt.

Additional expansion tank

In some cases an additional tank may be fitted with the purpose of increasing the available expansion volume; the connection to the main tank will be made through a pipe fitted on the hose holder of the union pipe "overflow". The plug of this tank has to be equipped with a pressure relief valve to enable liquid downflow while the engine is cooling.
This second tank, usually made in transparent material and not pressurized, can be installed in order to have a better access to check its level, that anyway has to be periodically checked also in the main tank.

SEA-WATER OPEN COOLING LOOP

Figure 25



Engine coolant   Cold air   Sea-water

1. Sea-water/coolant exchanger - 2. Outlet (riser) - 3. Sea-water outlet piping from exchanger - 4. Sea-water/oil gear exchanger (optional) - 5. Sea-water inlet - 6. Sea-water pump - 7. Air/sea-water exchanger (intercooler).

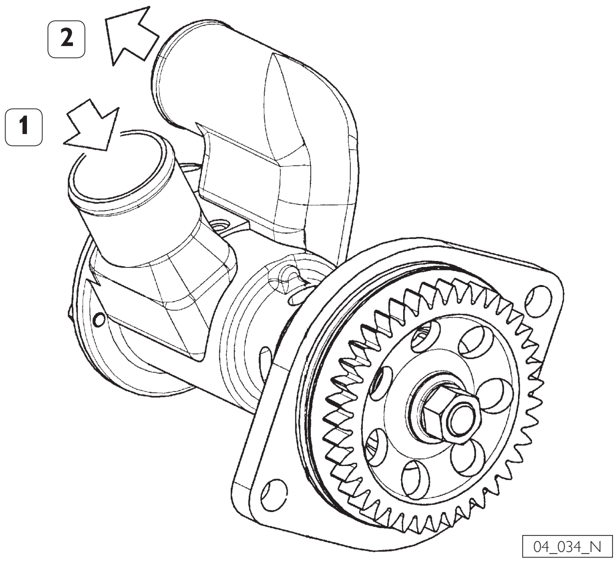
Sea-water drawn from under the bottom of the boat is the means by which the engine heat that has not been transformed into mechanical work is eliminated.

The water, intaken by the pump set into rotation by the cranckshaft by means of a toothed wheel transmission, is directly sent to the supercharging heat exchanger (after-cooler), where the water temperature is reduced to improve engine volumetric efficiency and thus its performance; the water from the after-cooler, going through the gearbox oil heat exchanger (if fitted), reaches the "sea-water/fresh water" heat exchanger removing the heat yielded by the engine and conveyed by the coolant; temperature control is carried out by the thermostatic valve.

The water, before being let into the sea drainage duct, touches and cools down the "riser" - the exhaust gas outlet - leaving the boat with the latter.

Sea-water pump

Figure 26

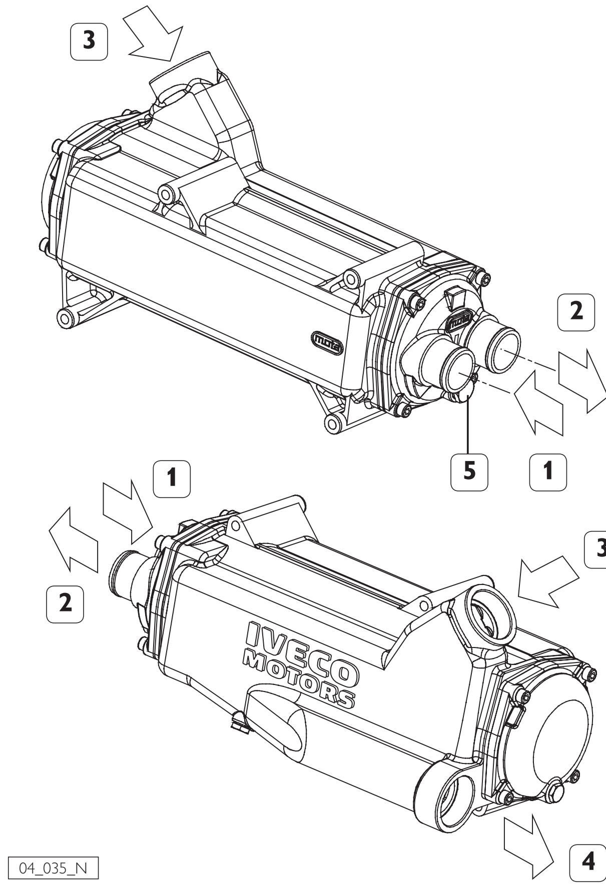


1. Inlet - 2. Outlet.

The sea-water pump, with a neoprene rotor, is geared up by crankshaft.

Sea-water/coolant heat exchanger

Figure 27

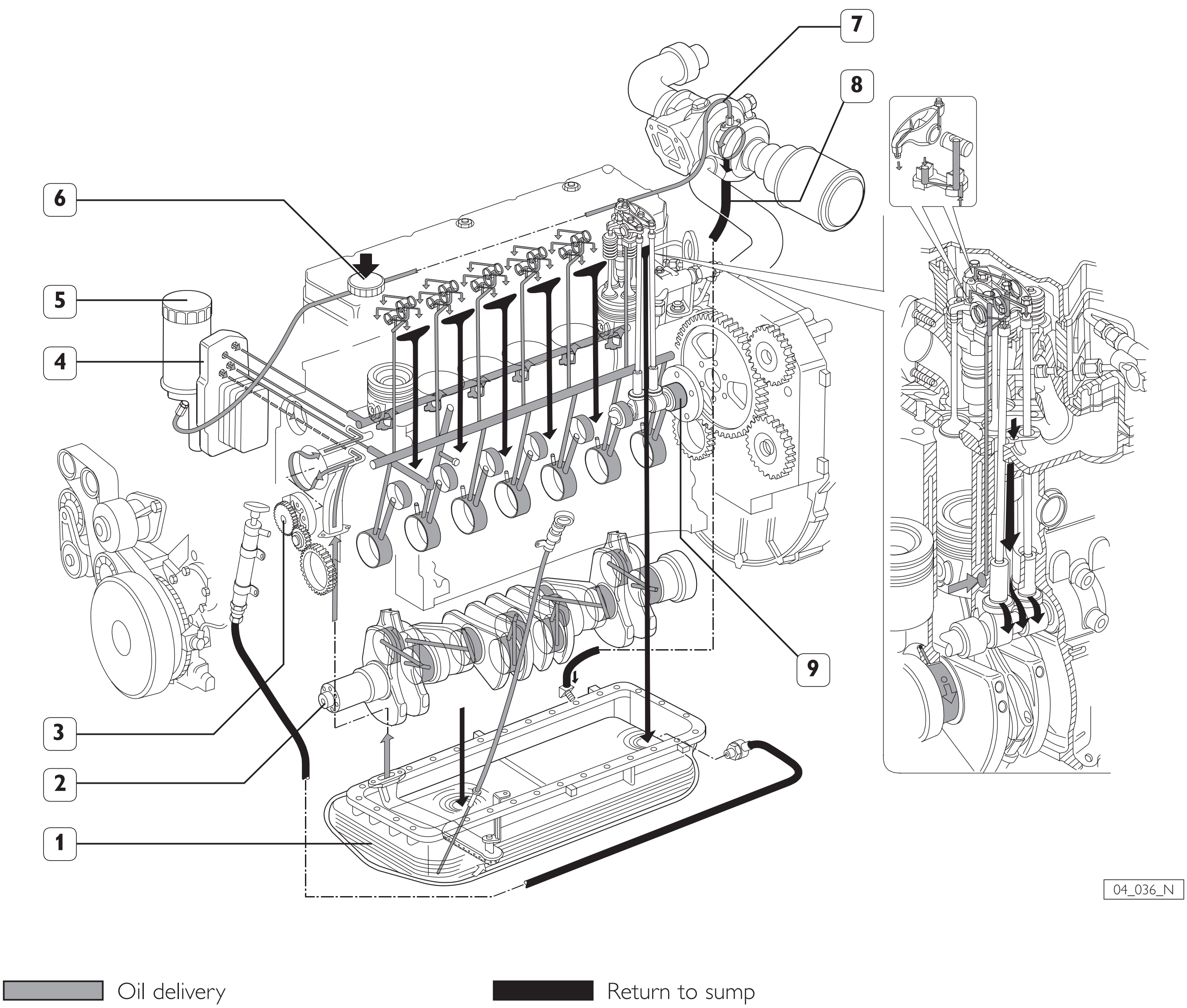


1. Sea-water inlet - 2. Sea-water outlet - 3. Engine coolant inlet - 4. Engine coolant outlet - 5. Sacrificial anode.

The engine coolant, coming from thermostatic valve, goes into the exchanger (3) and touches the tube bundle that is run through the sea-water flow coming from the supercharging air heat exchanger (1); the cooled down engine coolant, goes through the manifold leading to the induction of the centrifugal pump (4).
The sea-water coming out of the exchanger (2) is sent to the outlet.

ENGINE OIL LUBRICATION LOOP

Figure 28



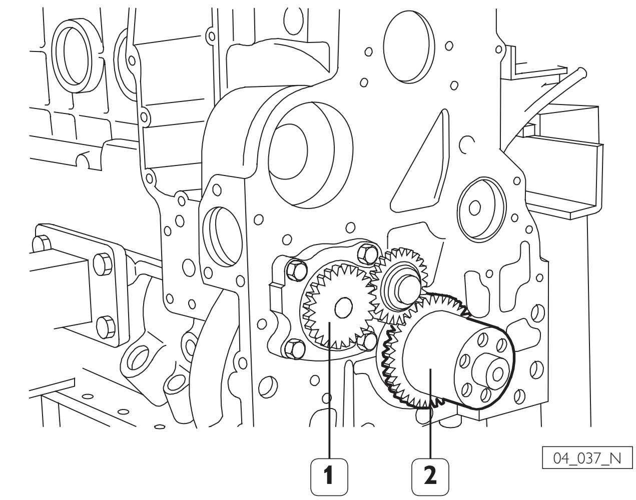
1. Oil sump - 2. Crankshaft - 3. Oil pump - 4. Oil filter bracket with engine coolant/oil heat exchanger - 5. Oil filter - 6. Oil filler cap - 7. Oil delivery to turbocompressor - 8. Oil return from turbocompressor - 9. Timing camshaft.

Lubrication of the engine machine parts is oil forced circulation obtained by a gear pump located in the crankcase. The pump is set into rotation by the crankshaft by means of a toothed wheel and an intermediate gear.
The oil pressurized by the pump, is sent to a filter and then to the engine ducts after going through the heat exchanger located on the flange coupling onto the crankcase also integrating the oil filter bracket; the exchanger is inserted on a seat in the engine crankcase and is touched by the engine coolant.

A duct is specifically assigned to supply the nozzles that deliver the coolant to the pistons, the other one is assigned to the lubrication of the machine internal parts: bench bearings, connecting rods and timing, push rods and rockers; the lubrication of spindles and toothed wheels to actuate ancillary machine parts is obtained by dedicated ducts.
The flows afterwards converge by gravity into the oil sump.
The oil for the lubrication of the spindle of the turbocompressor rotors is drawn immediately after the oil filter, and reaches it by means of a piping external to the crankcase coupled to the rest by a special fitting.

Gear pump

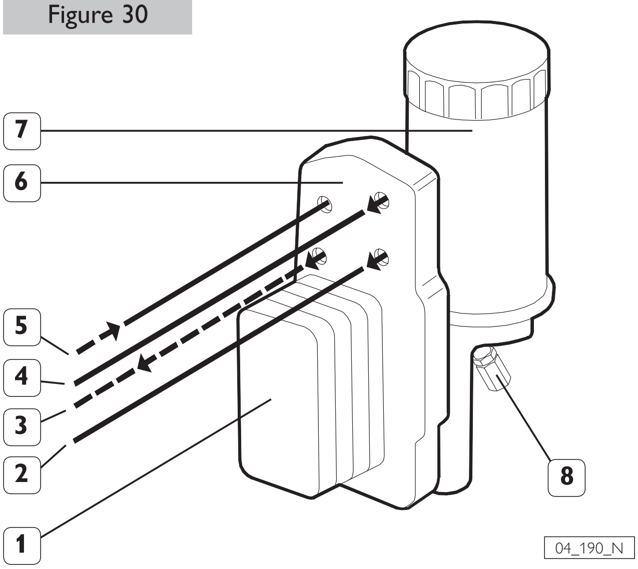
Figure 29



1. Gear oil pump - 2. Crankshaft with driving gear oil pump.

Filter bracket

Figure 30

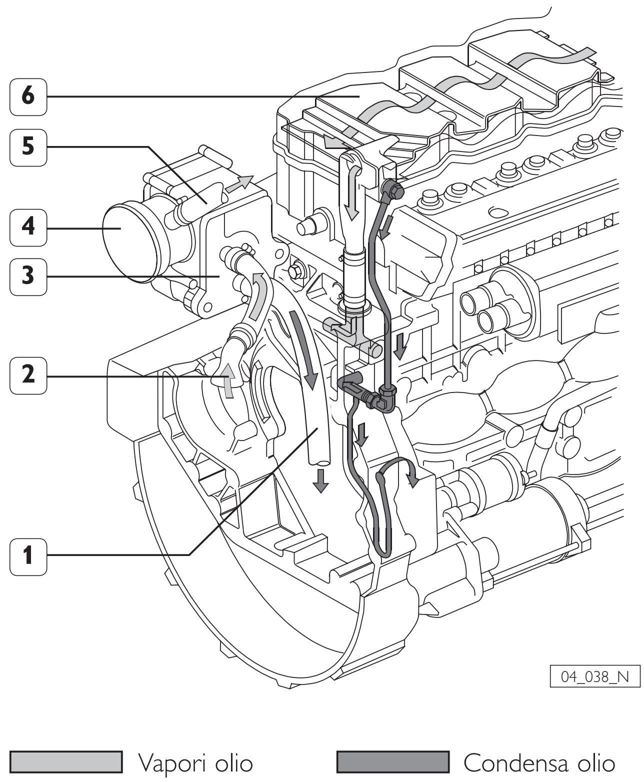


1. Heat exchanger with engine coolant - 2. Oil delivery to internal engine machine parts - 3. Flow recirculated by pressure regulator valve. - 4. Delivery to nozzles piston cooling - 5. Flow inlet from the pump. - 6. Flange coupling onto crankcase - 7. Oil filter - 8. Oil for turbocompressor lubrication connector outlet.

Seats for the pressure and the by-pass valve are fitted on the support. The ducts fitted inside enable to divert the oil inside the engine crankcase to the different lubrication functions. The filter, single cartridge, is two-stage with 5 μm parallel filtering.

Oil vapour recirculation

Figure 31

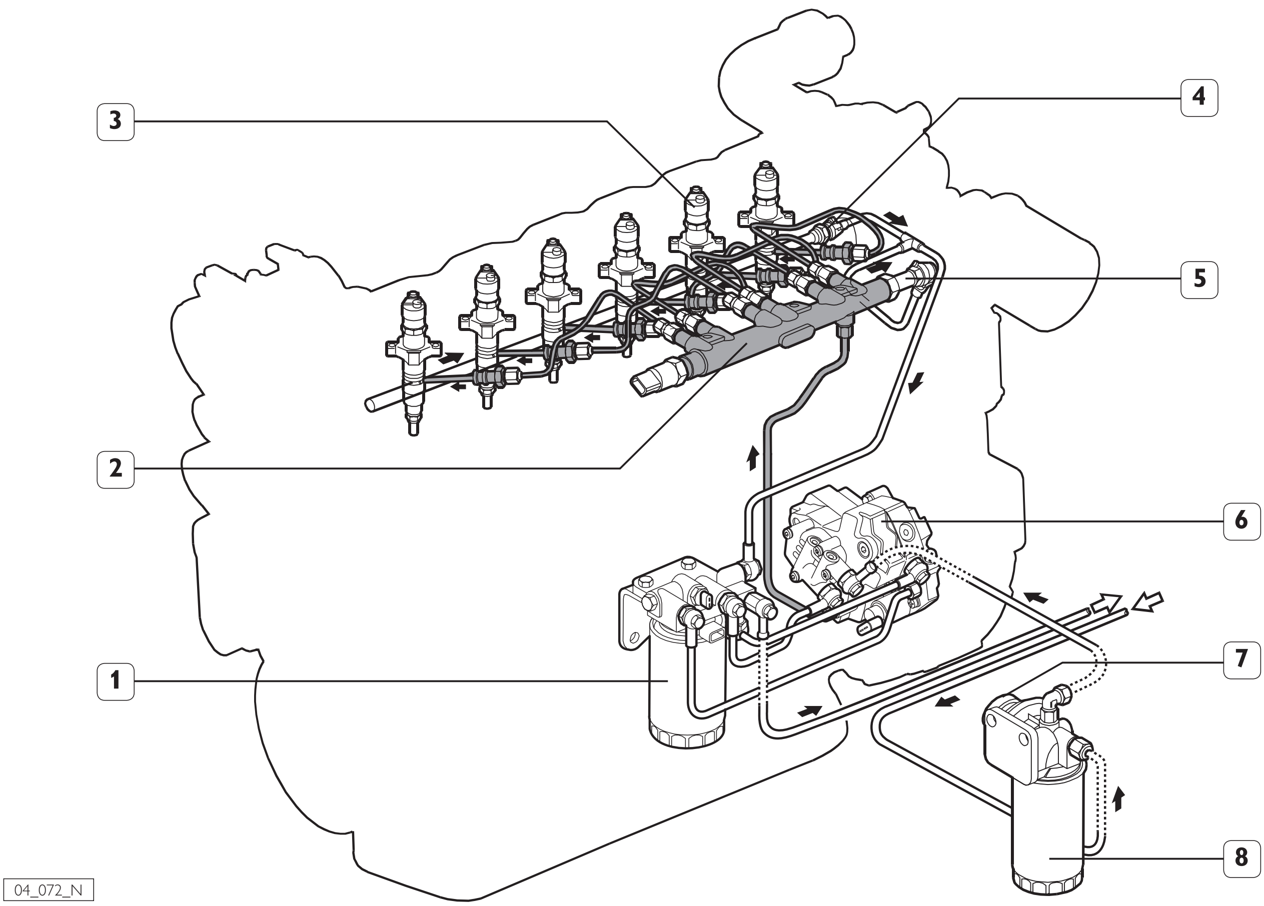


1. Condensate oil to the sump. - 2. Vapours coming from the timing gearbox - 3. Oil vapour filter unit - 4. Flow limiter valve - 5. Residual vapours to engine intake - 6. Centrifugal separator.

The oil vapours which generate inside the engine, go through the centrifugal gas separator located in the upper part of the rocker lid, where some of them condensate and return to the oil sump through the dedicated ducts.
Due to higher pressure, residual vapours are pushed to the timing gearbox and from there to the filter unit. In the unit there are two filtering cartridges operating in parallel condensating a further vapour part that returns in liquid form to the oil sump.
The part which is not condensated is sent to the engine intake by a gauged hole after the air filter.
The vapour maximum load intaken by the engine is adjusted by the action of a membrane valve located in the filter unit.

FUEL LINE

Figure 32



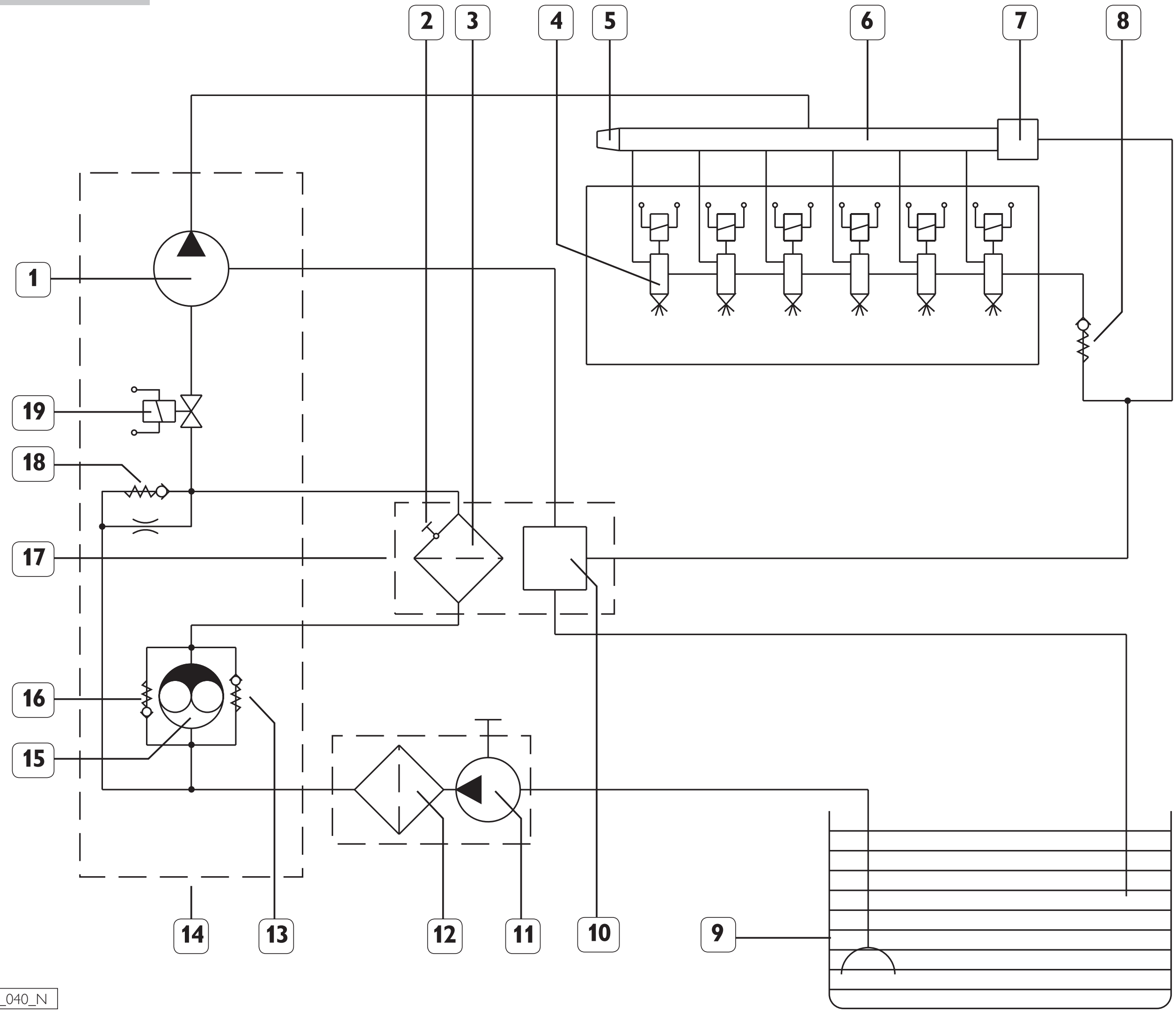
High pressure   Low pressure

1. Fuel filter - 2. Common rail - 3. Electro-injector - 4. Electro-injector return loop pressurization valve - 5. Rail overpressure valve - 6. High and low pressure pump - 7. Priming pump - 8. Settling pre-filter.

N 60 ENT M engine fuel line is integrated in the innovative EDC 7 injection system. Main components are set on board of the engine except the pre-filter.

Fuel supply system scheme

Figure 33



04_040_N

1. High pressure radial pump - 2. Fuel temperature sensor - 3. Fuel filter - 4. Electro-injector - 5. Pressure sensor - 6. Common rail - 7. Common rail overpressure valve - 8. Electro-injector return loop pressurization valve, 1.3 to 2 bar - 9. Fuel tank - 10. Recirculation manifold - 11. Manual priming pump - 12. Pre-filter - 13. Low pressure pump recirculation valve - 14. High and low pressure pump - 15. Low pressure mechanical feed pump - 16. Low pressure pump by-pass valve - 17. Fuel filter support - 18. Low pressure limiter valve - 19. Pressure regulating electrical valve.

The heart of the system is made up of the solenoid valve control (19) and by the high pressure radial pump (1). Low pressure fuel supply takes place by means of a gear pump (15). While the engine rotates, the pump draws fuel from the tank (9) through the pre-filter (12) and sends it through the main filter (3) to the limiting valve (18) that sets up the pressure at 5 bar, recirculating the excess delivery to the inlet of the supply pump (15). The fuel at constant pressure supplies the internal duct for the lubrication of the radial pump (1) and the inlet of the control solenoid valve. The electrovalve actuated by the EDC central unit by means of a fast sequence of pulses, modulates the fuel flow going into the radial pump and as a consequence the flow and the value of the high pressure at the outlet of the pump and supplied to the rail (6). The rail has both the function of storing pressure, timing fuel to the electro-injectors (4) and of supporting and connecting both to the overpressure valve (7) and the sensor of the internal pressure (5). The rail internal pressure sensor (5), enables the EDC central unit to measure its value and to control in loop the control solenoid valve in order to always obtain the high pressure value required by the injection mapping, while the overpressure valve, in the event

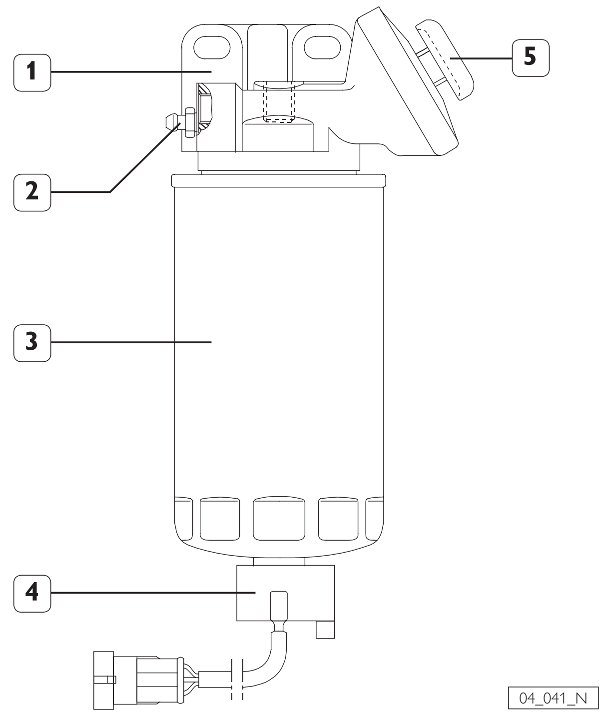
of an anomaly on the control system, protects the hydraulic system components limiting the pressure in the rail to the value of 1750 bar.
The electroinjectors supplied by the exact injection pressure only inject, by means of an electric control on behalf of the central unit, when an electromagnetic actuator present in them gives cause to an hydraulic overpressure, that acting on the spear valve, lifts it up and opens the nozzles. The span of time, the moment, and the optimal pressure for the injection are set out experimentally at the test stand and their values are stored in the central unit in a mapping function of the automotive parameters characterized instant by instant. The hydraulic line closes towards the tank starting from exhaust collection unit to which the one of the fuel filter, high pressure radial pump and the injectors converge.
The pressure valve, located on the cylinder head (8), is connected in series to the reflux from the electroinjectors setting the pressure of the collection duct from 1.3 to 2 bar. Two pipes intercept the fuel used to lubricate and cool the machine parts of the radial pump and in reflux from the electroinjectors to flow into the manifold (10) located on the filter bracket, from which a pipe leads to the fuel tank (9).
Two unidirectional valves are positioned in parallel to the feed mechanical pump. Valve (13), when the pressure at the fuel inlet overcomes the limit value allowed, recirculates the fuel excess to the inlet of the pump itself. When the engine is not rotating, a by-pass valve (16) enables to fill up the feed system by means of the manual pump (11).

CAUTION

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

Fuel pre-filter

Figure 34



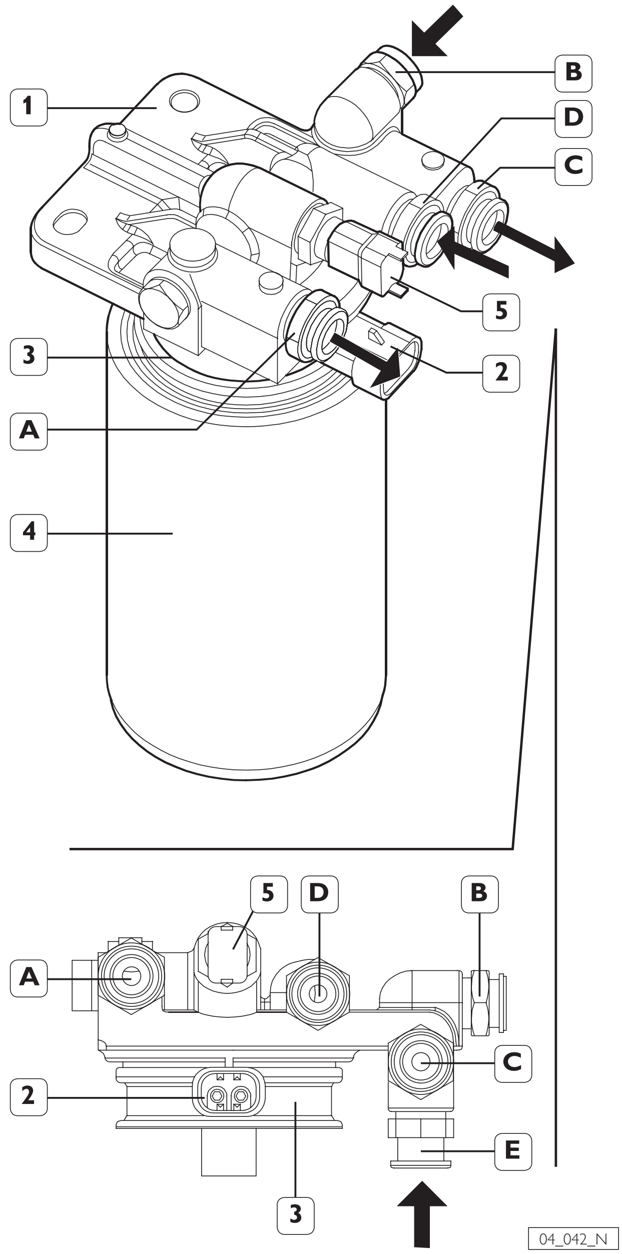
1. Fastener bracket - 2. System bleeding screw - 3. Cartridge - 4. Sensor for detecting the presence of water in the fuel - 5. Manual priming pump.

In the hydraulic line, it is placed before the fuel pump to withhold those particles which might damage it.

- Filtering rating: 300 μm;
- Operating max pressure: 3 bar;
- Operating temperature: from -40 to +70 °C.

Fuel filter

Figure 35

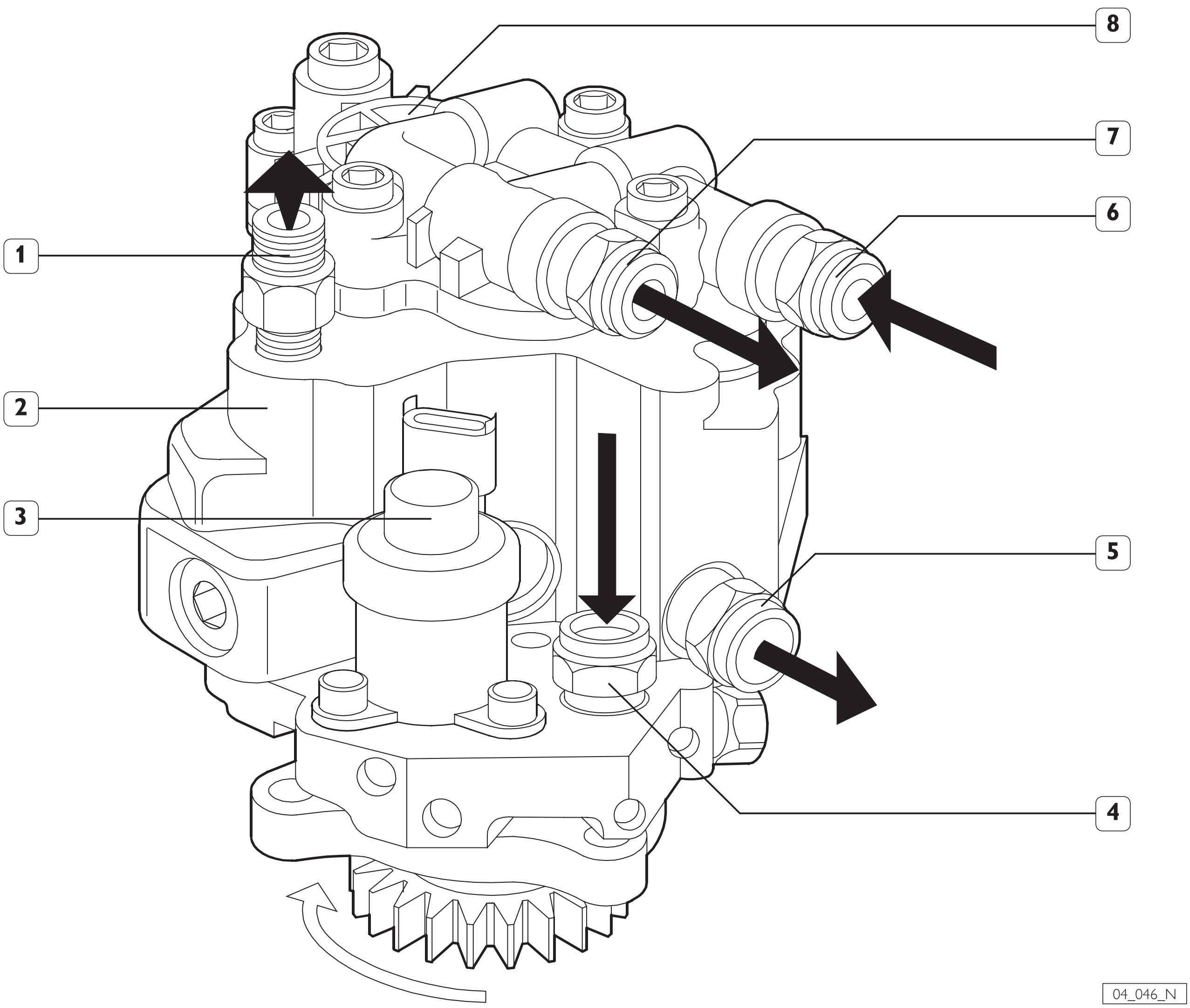


1. Fuel filter support - 2. Heater connector - 3. Fuel electric heater - 4. Fuel filter - 5. Fuel temperature sensor - A. Outlet connector to the high pressure pump - B. Inlet connector to discharge fuel from common rail and from cylinder head (electroinjectors) - C. Outlet connector to discharge fuel to the tank - D. Inlet connector of the feed pump - E. Inlet connector of the high pressure pump discharge.

It preserves the efficiency of high pressure line withholding particles above 5 μm.
It has a high filtering capacity as well as a good separation of water from fuel.
The fuel filter is located on the crankcase in the line between feed pump and high pressure pump. Connectors B - C - E join into one duct which works as a manifold of the fuel recirculating towards the tank. The manifold is entirely separated from the hydraulic line of the filter. On the support the fuel temperature sensor and the heater resistor are positioned.
The heating element activates if the fuel temperature is ≤ 0 °C and heats up to + 5 °C.
The fuel temperature, detected by the EDC 7 sensor, enables to entirely compensate the fuel volumetric mass in relation to its temperature.

Pump assembly

Figure 36

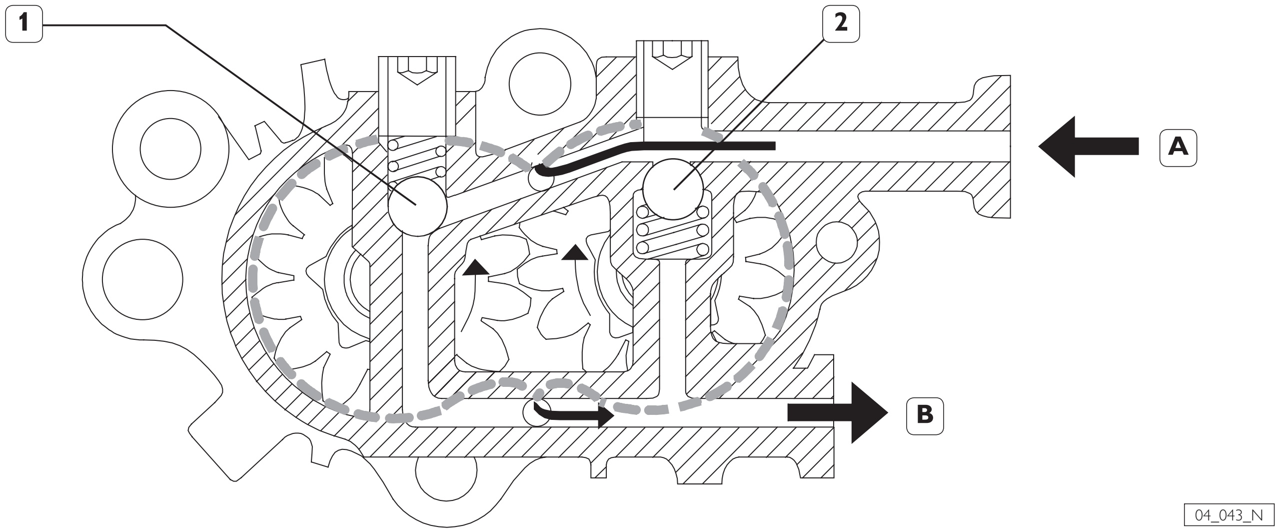


1. Connector fuel outlet to rail - 2. High pressure pump - 3. Pressure control solenoid - 4. Fuel inlet connector from filter - 5. Fuel outlet connector to recirculation manifold - 6. Fuel inlet from tank - 7. Fuel outlet connector from low pressure pump to filter - 8. Low pressure pump.

The high pressure pump is made up of three radial pumping elements driven by a tappet set into rotation by a gear of the timing shaft. In the rear part the feed mechanical pump, driven by the radial pump, is fitted.
The pressure control solenoid valve is located on its side.
The positioning of the pump does not require timing as the injections management is entirely electronically controlled.

Low pressure feed pump

Figure 37

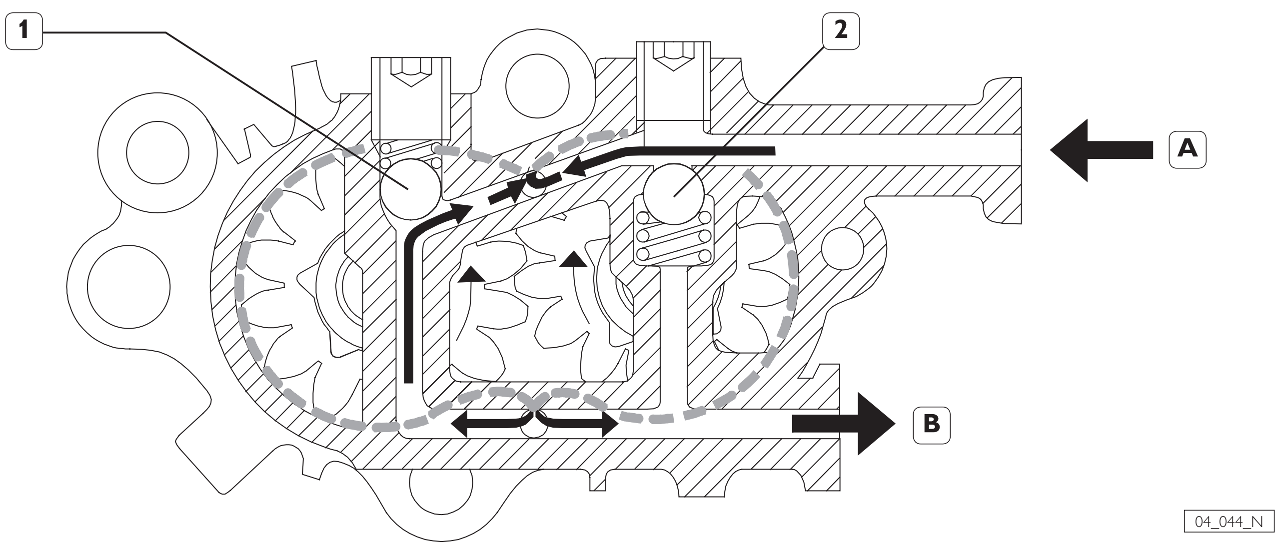


A. Fuel inlet from tank - B. Fuel outlet to filter - 1. Recirculation valve - 2. By-pass valve.

The gear wheel pump is assembled on the rear part of the high pressure pump. It transfers the fuel from the tank to the high pressure pump.

It is set into rotation by the high pressure pump shaft. Under normal operation conditions, the fuel flow inside the mechanical pump is illustrated in figure 37.

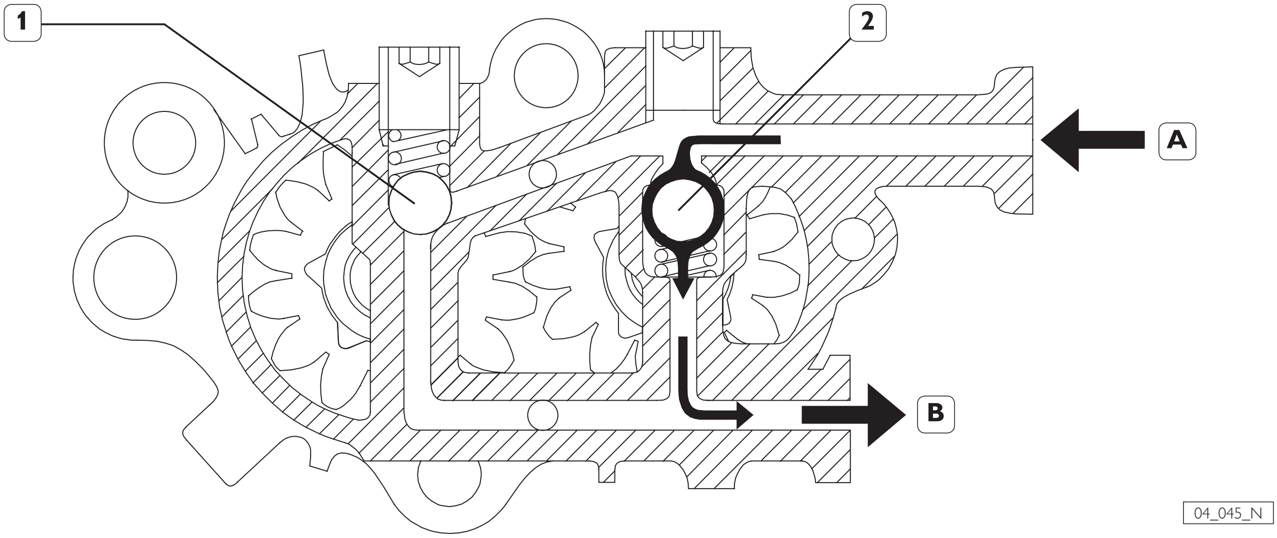
Figure 38



A. Fuel inlet from tank - B. Fuel outlet to filter - 1. Recirculation valve - 2. By-pass valve.

In the case of overpressure at the outlet, figure 38, the recirculation valve comes into action.
The existing pressure, overcoming the spring valve elastic strength (1), connects the outlet with the inlet through a duct (2), recirculating the fuel in excess inside the pump and keeping a pressure rating equal to that of the setting of the valve.

Figure 39

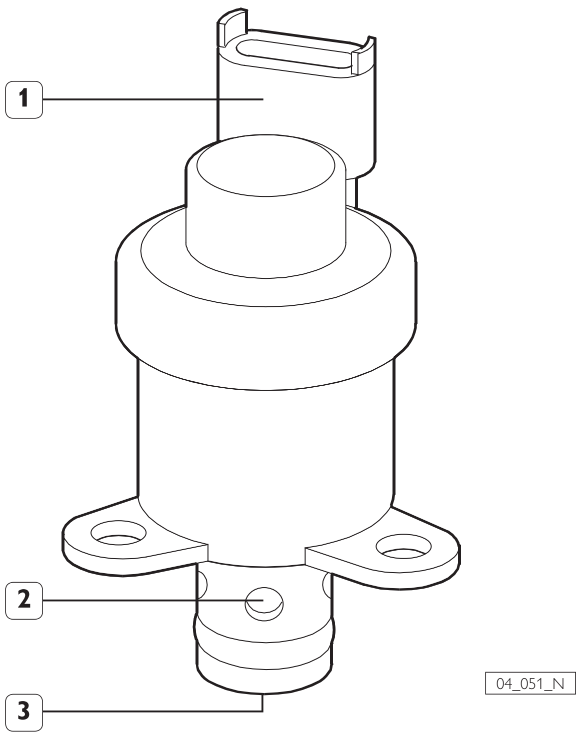


A. Fuel inlet from tank - B. Fuel oulet to filter - 1. Recirculation valve - 2. By-pass valve.

Figure 39 represents the section of the pump during the stage of filling up the line, as an example by means of the manual pump located on the pre-filter. With the engine not in rotation, due to the pressure in the inlet, the by-pass valve (2) opens up enabling the fuel to flow towards the filter.

Pressure control solenoid valve

Figure 40



1. Electric connector - 2. Fuel outlet - 3. Fuel inlet.

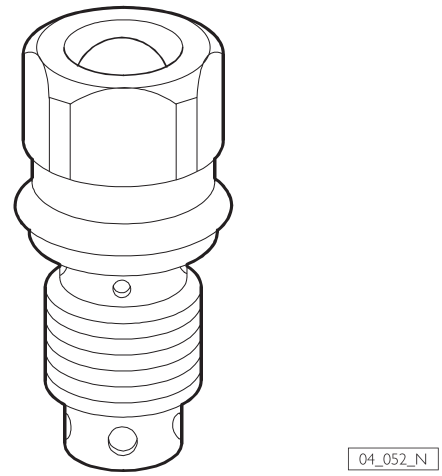
Positioned at the inlet of the high pressure pump, it enables to control the quantity of fuel feeding the pump according to the controls received by the electronic Central Unit. In the absence of control signal, the valve is normally open, therefore the high pressure pump is in maximum delivery condition.

The Central Unit sends a PWM control signal to the controller, in order to choke in a greater or lesser way the inlet section of the fuel to the high pressure pump.

This component cannot be replaced individually and therefore must not be disassembled.

Low pressure limiter valve

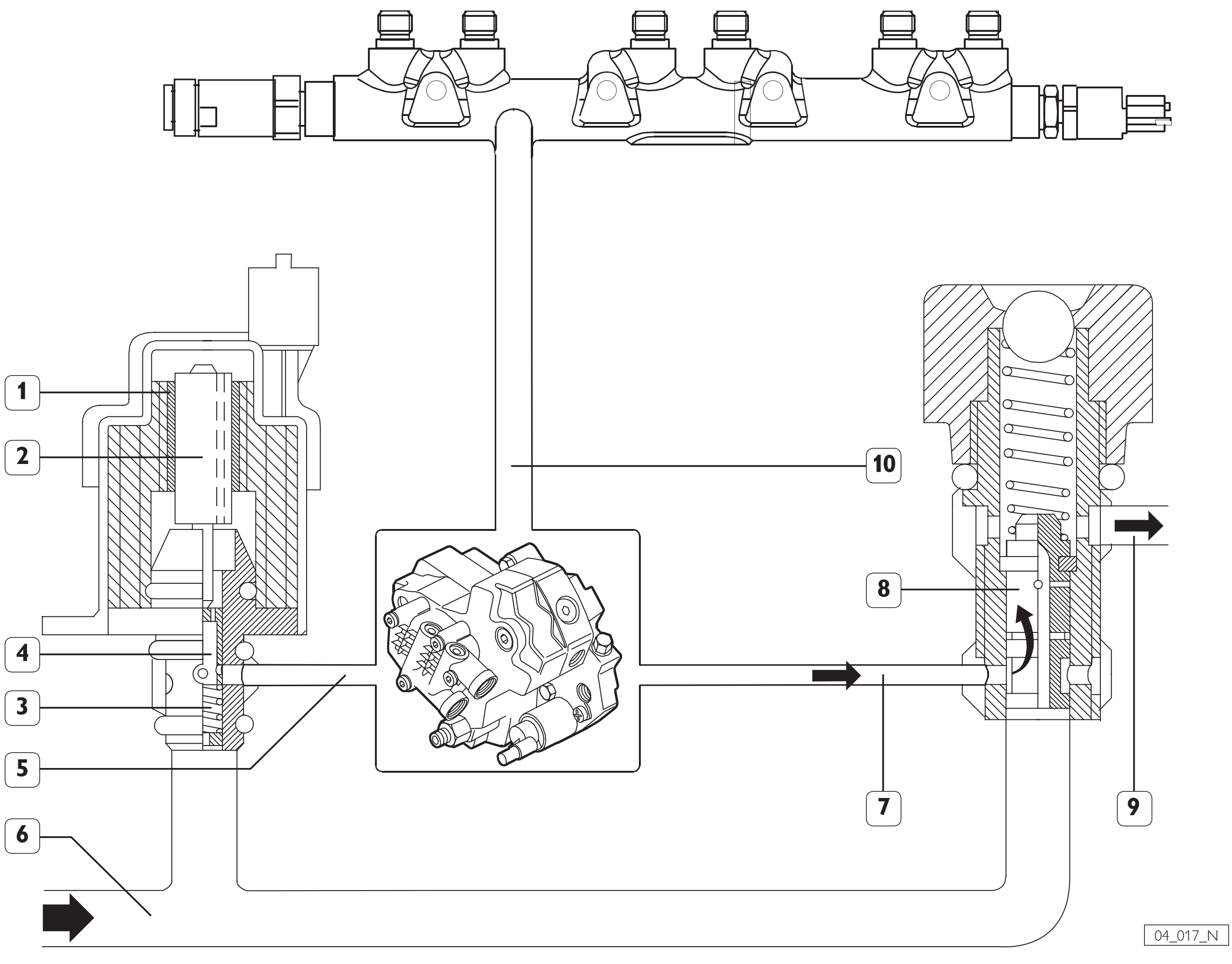
Figure 41



Assembled in parallel to the pressure control solenoid valve, has the function of keeping the inlet pressure constant to the value of 5 bar, that is a necessary condition for a correct operation of the control system.

Pressure control with engine at maximum rating

Figure 42

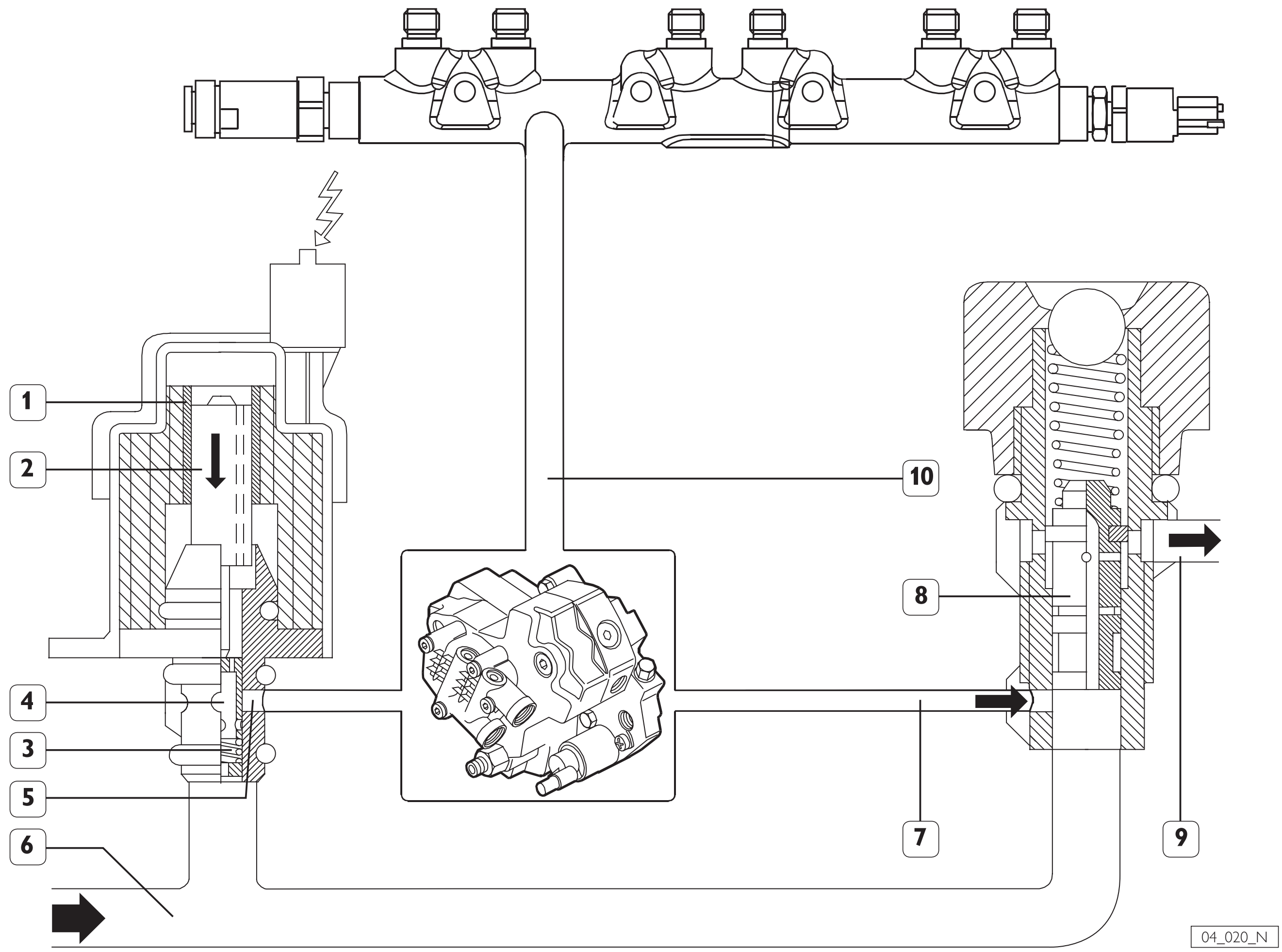


1. Coil - 2. Nucleus - 3. Preloading spring - 4. Spear valve - 5. High pressure pump feed - 6. Fuel inlet (from filter) - 7. Fuel backflow from the high pressure pump - 8. Cylinder for exhaust duct opening - 9. Fuel discharge - 10. Fuel delivery to rail.

When the coil (1) of the solenoid is not energized, the nucleus (2) is in idle position due to the pre-loading spring (3). The spear valve (4) is in the position of maximum delivery.
The valve feeds the high pressure pump with the maximum fuel delivery possible.
The cylinder for exhaust duct opening (8) of the low pressure limiter valve is in closed position. The clearance among the internal parts enables the blow-by of the fuel used to lubricate the pump towards the exhaust (7).

Pressure control with engine at minimum rating

Figure 43



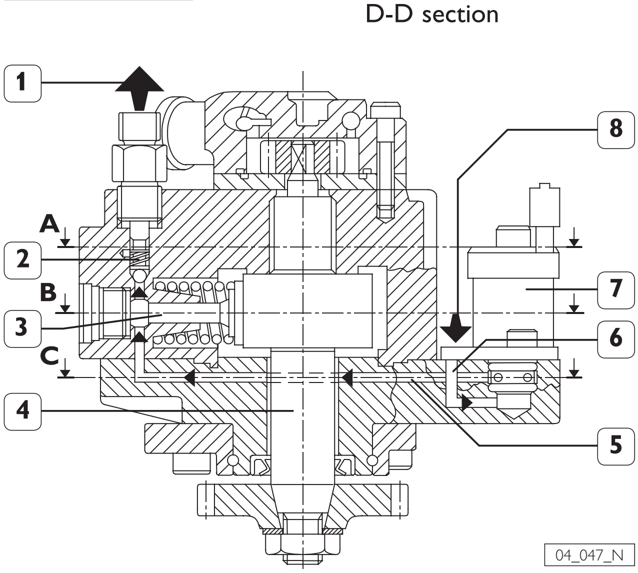
1. Coil - 2. Nucleus - 3. Preloading spring - 4. Spear valve - 5. High pressure pump feed - 6. Fuel inlet (from filter) - 7. Fuel backflow form the high pressure pump - 8. Cylinder for exhaust duct opening - 9. Fuel discharge - 10. Fuel delivery.

When the engine is in the condition of minimum rpm, the EDC Central Unit controls the solenoid by a PWM (Pulse Width Modulation) timely signal to energize the coil and cause the shifting of the nucleus (2).
The nucleus, while shifting, moves the spear valve (4) into the minimum opening position allowing the minimum flow of fuel to the high pressure pump.

The control solenoid is in maximum choking as the common rail has to be kept at relatively low pressure (from 350 to 400 bar). The cylinder (8) of the low pressure limiter valve, which controls the opening of the exhaust duct, is in the maximum opening position in order to allow the fuel in excess to backflow to the exhaust (9).

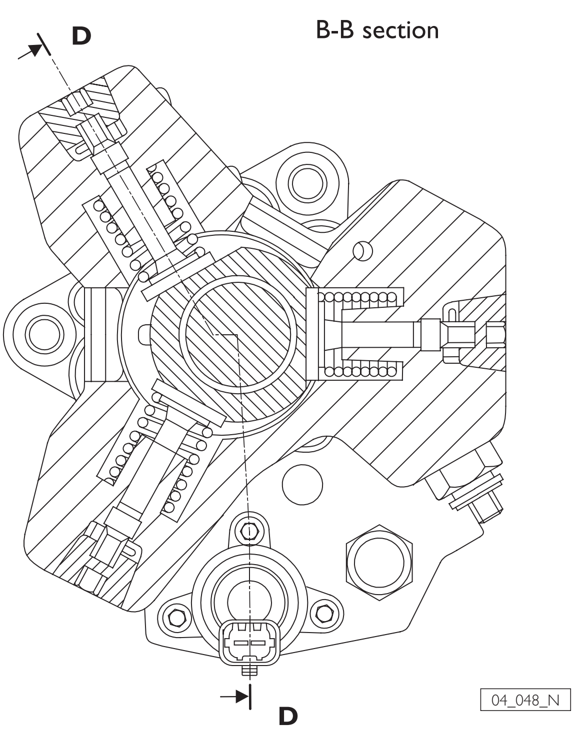
High pressure pump

Figure 44



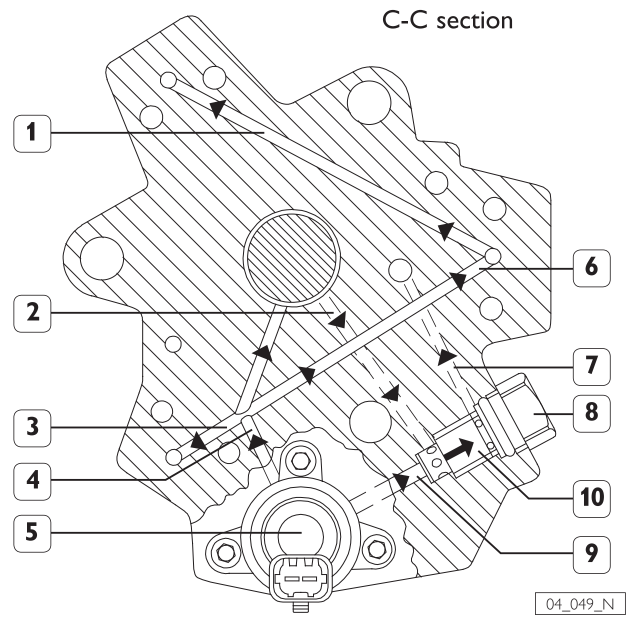
1. Outlet for delivery to rail - 2. Delivery valve to rail - 3. Pumping - 4. Pump shaft - 5. Pumping feed duct - 6. Pressure control feed duct - 7. Pressure control solenoid - 8. Fuel inlet from filter.

Figure 45



During the induction stroke, the pumping, driven by the cam located on the pump shaft, is fed through the pumping feeding duct. The amount of fuel to send to the pumping is set by the pressure control solenoid according to the PWM control received by the electronic Central Unit. During the compression stage of the pumping, the fuel reaches such a pressure to open the delivery valve to common rail and supply it through the outlet.

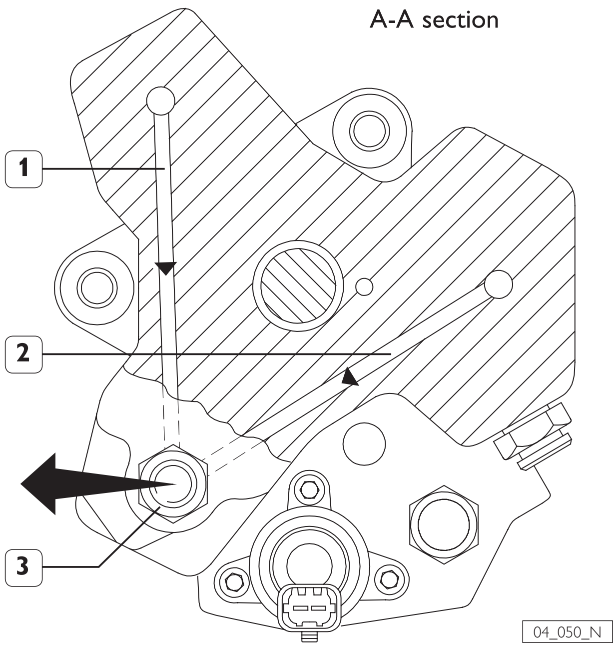
Figure 46



1, 3, 6. Pumping feed ducts - 2. Pump lubrication ducts - 4. Pumping feed main duct - 5. Pressure control solenoid - 7. Control exhaust duct - 8. Low pressure limiter valve - 9. Fuel feed duct from filter - 10. Fuel outlet.

In the section of figure 46 the low pressure fuel paths inside the pump are represented. The pumping feed main duct (4), pumping feed ducts (1, 3, 6), ducts used for pump lubrication (2), the pressure control valve (5), the low pressure limiter valve (8) and the fuel exhaust (10), are outlined. The pump shaft is lubricated by the fuel through the delivery and backflow (2) ducts. The control valve enables to define the fuel amount by which feeding pumpings; the excess fuel backflow through duct (9).
The lower pressure limiter valve in addition to operate as manifold of the high pressure pump fuel drainage, also keeps pressure constant at the regulator inlet.

Figure 47

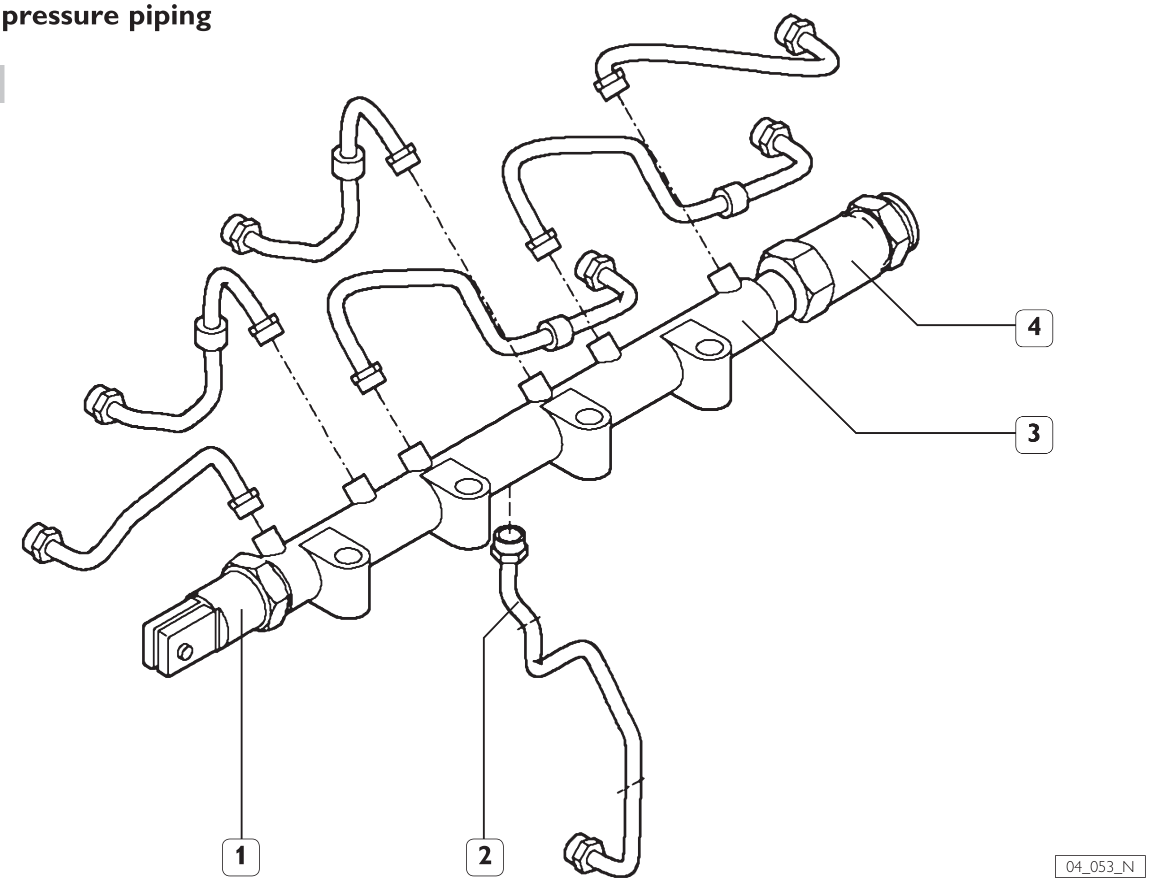


1, 2. Fuel outlet ducts -
3. Fuel outlet from the pump with connector for high pressure piping for common rail

In the section of figure 47 the fuel flow through the pumping outlet ducts is represented.

Rail and high pressure piping

Figure 48

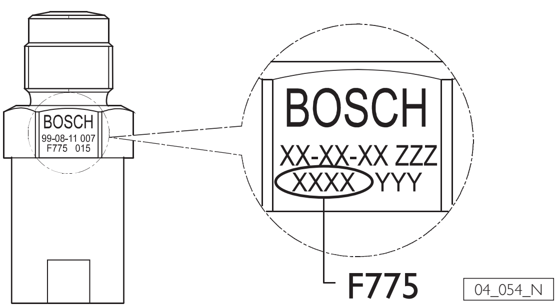


1. Pressure sensor - 2. Fuel inlet from the high pressure pump - 3. Common Rail - 4. Overpressure valve.

The internal volume of the rail is sized in such a way as to allow a fast pressurization during transient states and at the same time to level pressure surging caused by the openings and the closures of the injectors and by the cyclic operation of the high pressure pump. This function is facilitated by the gauge hole located after the high pressure pump. At the ends of the rail the internal pressure sensor and overpressure valve are located. Every piping connected to the rail undergo pressure above 1600 bar, and for this reason the piping disassembled have to be replaced. In the case of maintenance actions on the high pressure line, special care is to be given to avoid the introduction of dirt.

Two-stage overpressure valve

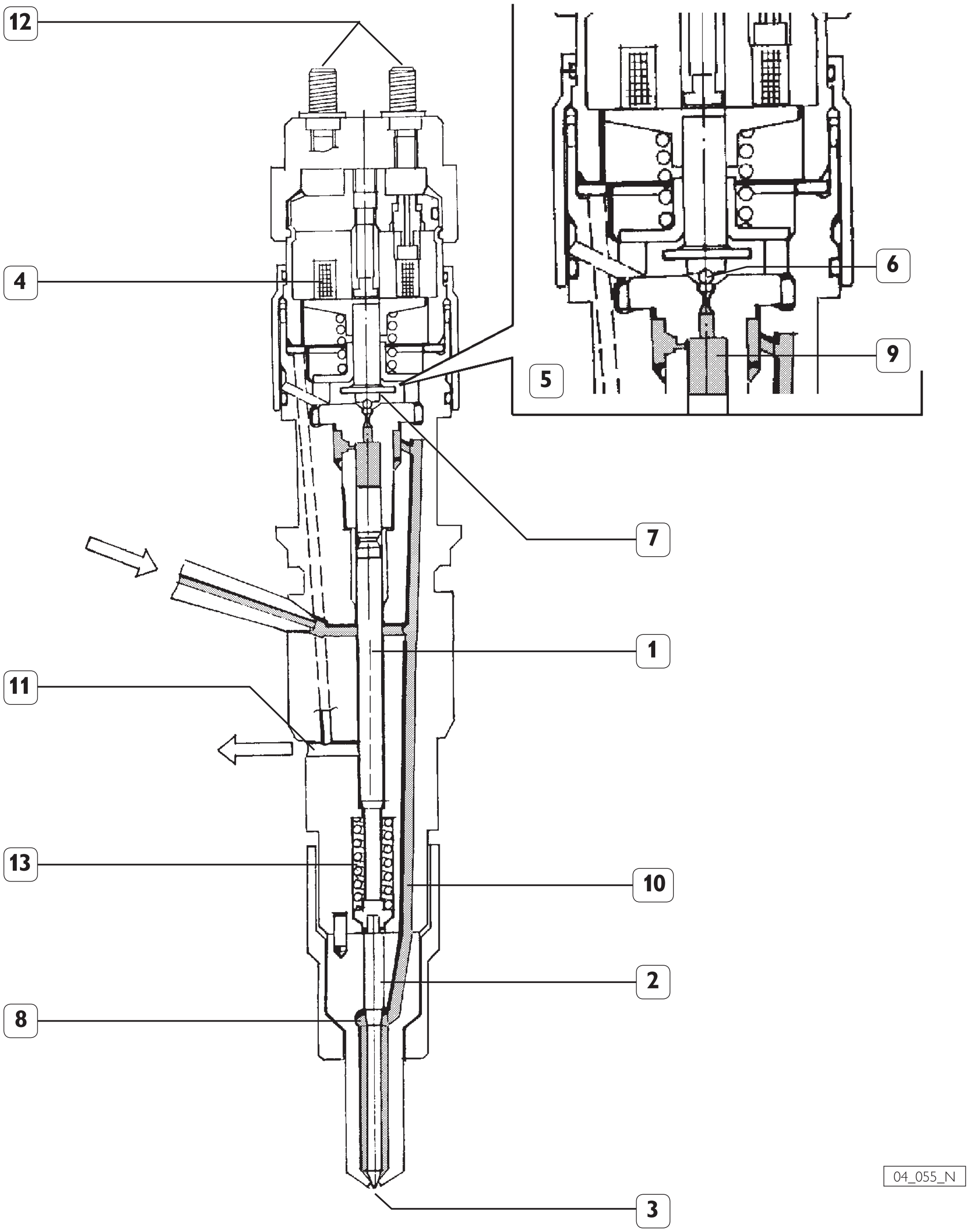
Figure 49



Fitted on one end of the rail, it protects the system components in case of malfunction of the rail pressure sensor or of the pump pressure control causes and excessive pressure increase in the high pressure system.
It is of a mechanical type and it has a double operating threshold: 1750 bar and 800 bar.
In case 1750 bar is reached, in the high pressure system the valve comes into action initially as a normal one stage to let the fuel backflow and thus consequently reducing pressure to safety values and afterwards mechanically controls the pressure in the rail up to about 800. The two stage valve can be recognized by the acronym F775 inside the encoding.
This valve allows to operate the engine for prolonged times under limited performance and avoids the excessive overheating of the fuel preserving the system components.

Electro-injectors

Figure 50



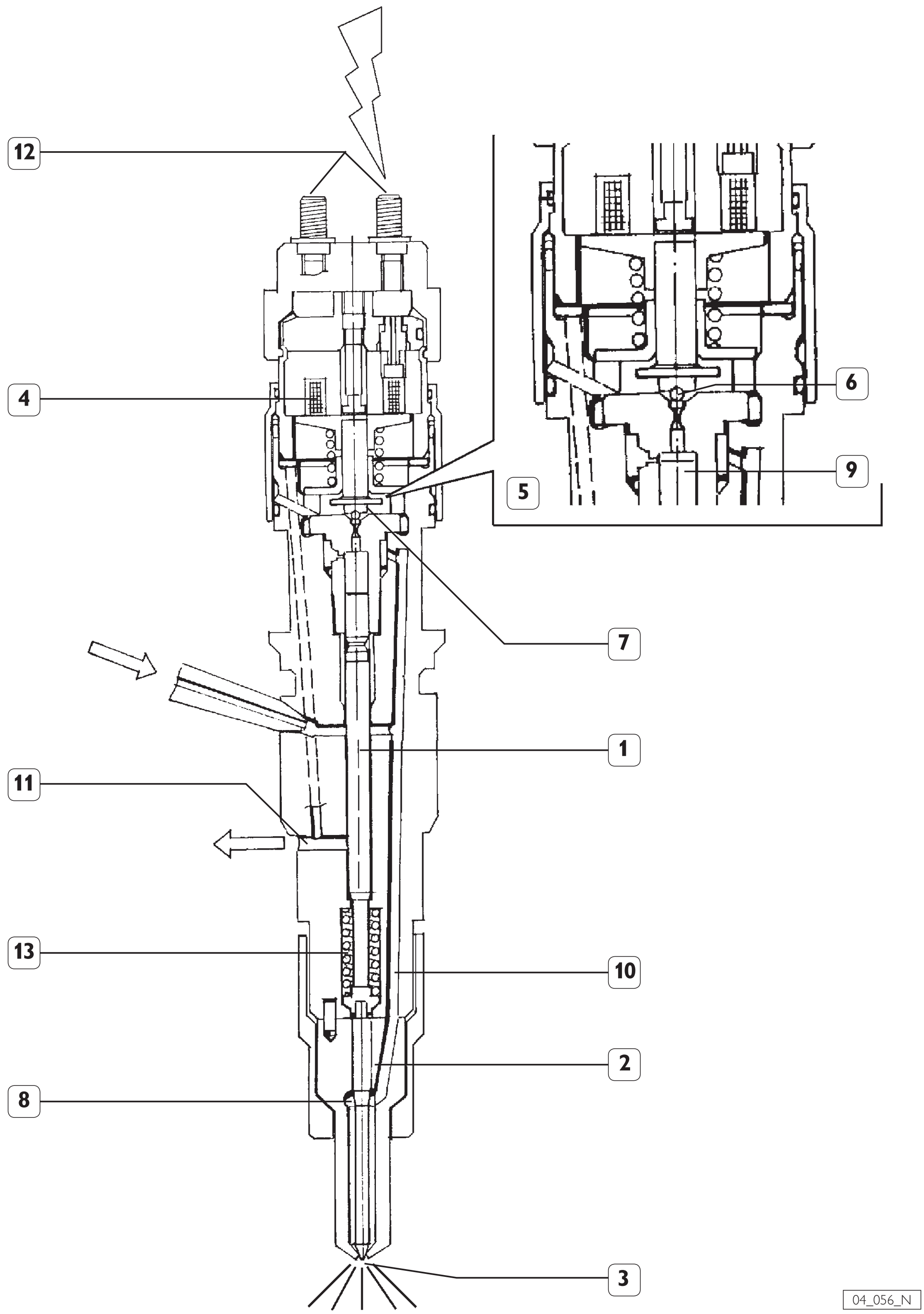
1. Pressure rod - 2. Metering rod - 3. Nozzle - 4. Coil - 5. Pilot Valve - 6. Ball valve - 7. Control area - 8. Pressure chamber - 9. Control volume - 10. Feed/control duct - 11. Control fuel outlet - 12. Electric connection - 13. Spring.

From the construction point of view, the injector is similar to traditional ones, except for the absence of the metering rod spring return.

The electro-injector may be considered made up in two parts; the actuator-spray-nozzle, made up of a pressure rod, metering rod and nozzle; and by the control solenoid made up of the coil and the pilot valve.

The solenoid controls the rise of the metering rod of the spray-nozzle.

Figure 51



1. Pressure rod - 2. Metering rod - 3. Nozzle - 4. Coil - 5. Pilot Valve - 6. Ball valve - 7. Control area - 8. Pressure chamber - 9. Control volume - 10. Feed control duct - 11. Control fuel outlet - 12. Electric connection - 13. Spring.

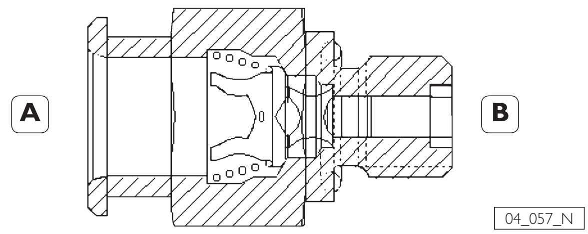
The fuel that is in the control volume, backflows towards the reflux duct causing a pressure decrease in the control volume itself.

At the same time, the fuel pressure in the pressurized chamber causes the rise of the metering rod and consequently the injection of the fuel into the cylinder. The injection ceases by disenergizing the coil. The ball valve goes back into idle posi-

tion, to recreate an equilibrium of forces such as to make the metering rod go back to the close position and stop the injection.
The ratio between the pilot system time and the amount of fuel delivered is a non linear characteristic and with a narrow limit of tolerance typical of every family of electro-injectors; it is the basis of the injection data stored in the ECU.
The use of certified injectors is mandatory for the best efficiency of the engine performance and the accuracy required by the common rail system management. They must have the characteristics prescribed, i.e. analogue to those used to make up the mapping of the injection timing.
Injectors do not need calibration and, due to the high accuracy degree of their components and the complexity of their assembly, replacement of any spare part is not allowed.

Pressurization valve of the electro-injector backflow

Figure 52

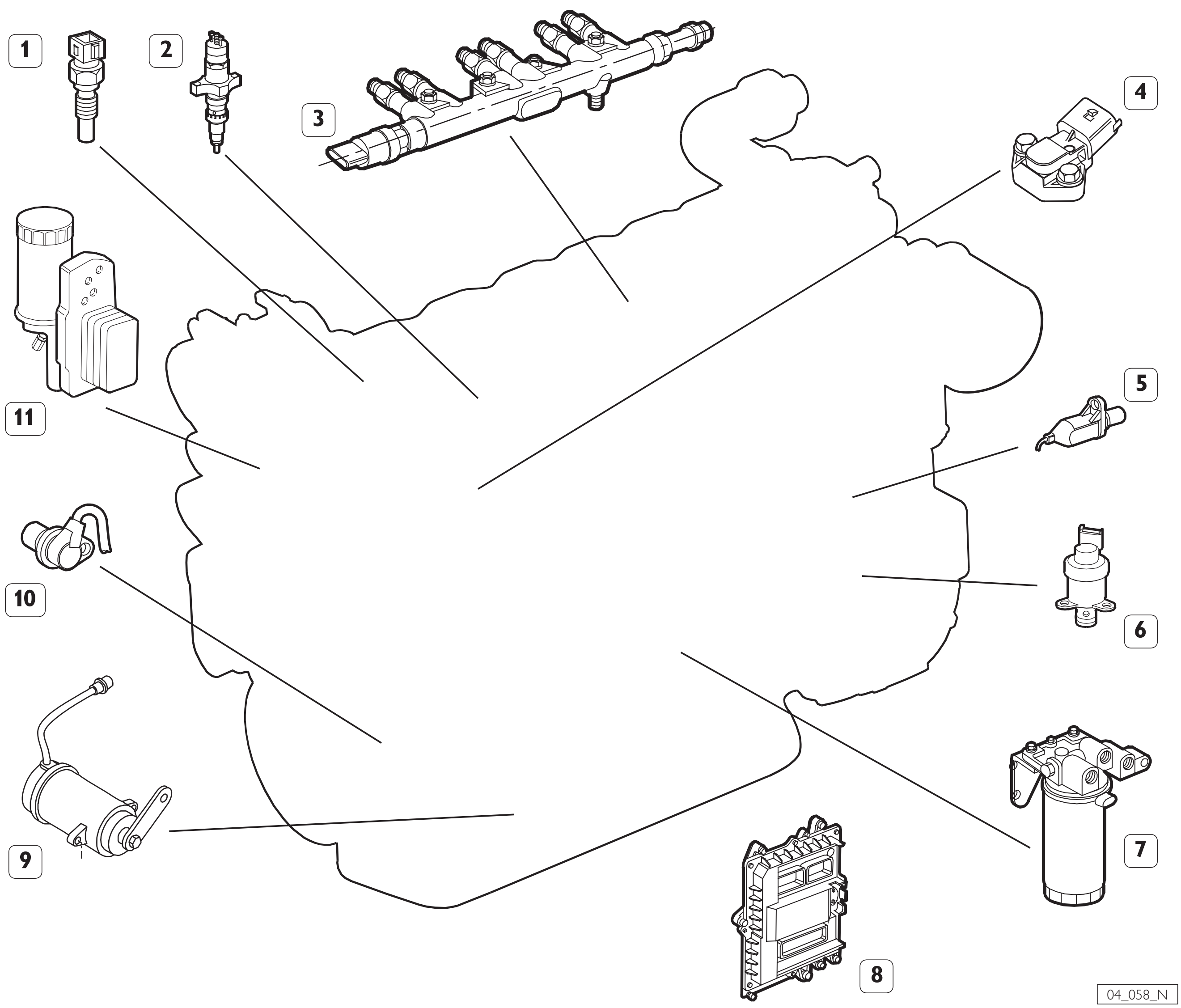


A. To the tank - B. From the electro-injector.

Located in the rear part of the cylinder head, adjusts the pressure in the backflow duct from the electro-injectors at a pressure p = 1.3 to 2 bar.

EDC 7 SYSTEM ELECTRONIC AND ELECTRIC MAIN COMPONENTS

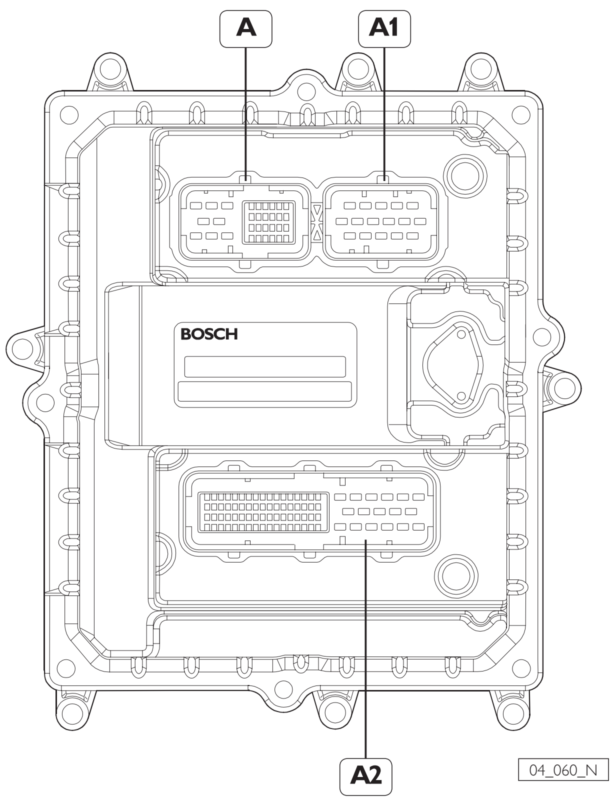
Figure 53



1. Coolant temperature sensor - 2. Electro-injector - 3. Fuel pressure sensor on rail - 4. Combustion air pressure/temperature sensor - 5.Timing sensor - 6. Pressure control solenoid valve - 7. Fuel filter with temperature sensor and electric heater - 8. ECU EDC - 9.Throttle control position sensor - 10. Crankshaft sensor - 11. Oil temperature-pressure sensor.

EDC 7 Electronic Central Unit

Figure 54

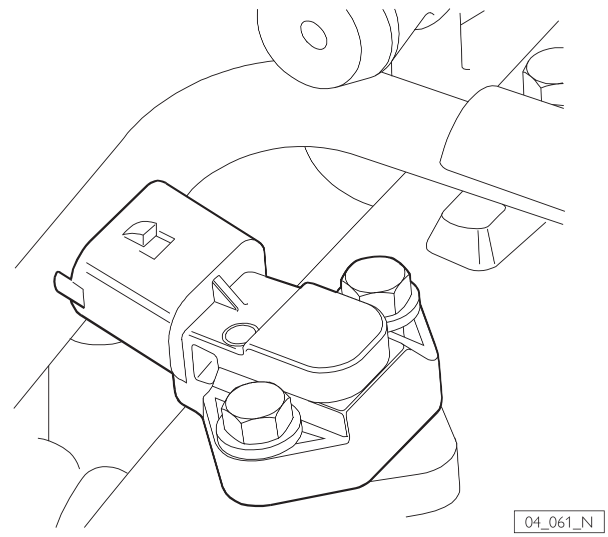


A. Connector for components assembled on engine -
A1. Electro-injector connector -
A2. Connector for connections on the boat side.

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

Air pressure/temperature sensor

Figure 55



It integrates a temperature sensor and a pressure one. Positioned at the entrance of the intake manifold, it produces a signal that is proportional to the absolute pressure value of the intaken and supercharged air. This information, together with the temperature, enables to adequate time and advance to the density of the comburent air, in order to reach the maximum thermodynamic efficiency avoiding harmful emissions and smoke. The pressure sensor is a solid state type with an amplifier electronic circuit adjusted for thermic drift, while the comburent air temperature sensor is a resistor with negative temperature coefficient.

It is connected to the ECU EDC by pins A10, A21, A28 e A29.

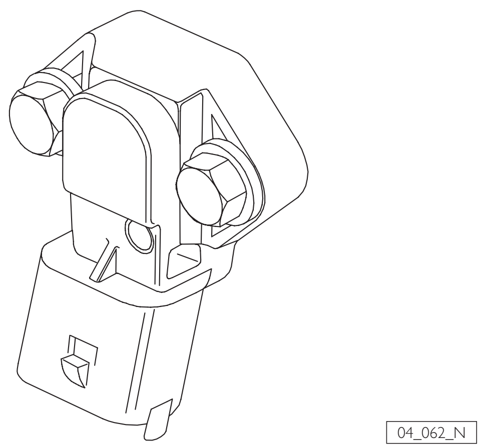
The pressure sensor is powered by a 5 V voltage and the output voltage is proportional to the pressure detected. The temperature sensor has a resistance of about 2.5 kΩ at 20 °C temperature.

Atmospheric pressure sensor

Located inside the ECU, it produces a useful datum to adequate injection procedures to the different positive displacement of the engine caused by the changes of the environmental pressure conditions.

Oil pressure/temperature sensor

Figure 56



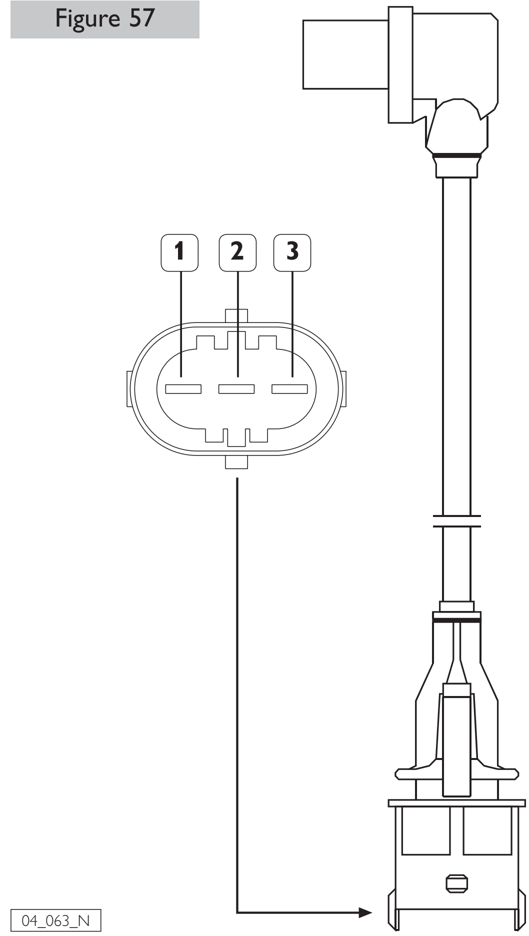
The body of the sensor is similar to that of the air pressure/temperature sensor and the functions carried out are analogous. It is assembled onto the engine oil filter support, to measure the engine oil temperature and pressure. The signal detected is sent to the ECU EDC that manages the low pressure indicator light. In this appliance, pressure and oil temperature values are not shown by instruments but the data are used by the ECU to carry out the monitoring functions. In order to control the oil pressure gauge on the instrument panel, a specific sensor is used.

It is connected to the ECU EDC by pins A9, A19, A33 e A35.

The pressure sensor is powered by a 5 V voltage and the output voltage is proportional to the pressure detected. The temperature sensor has a resistance of about 2.5 kΩ at 20 °C temperature.

Crankshaft sensor

Figure 57



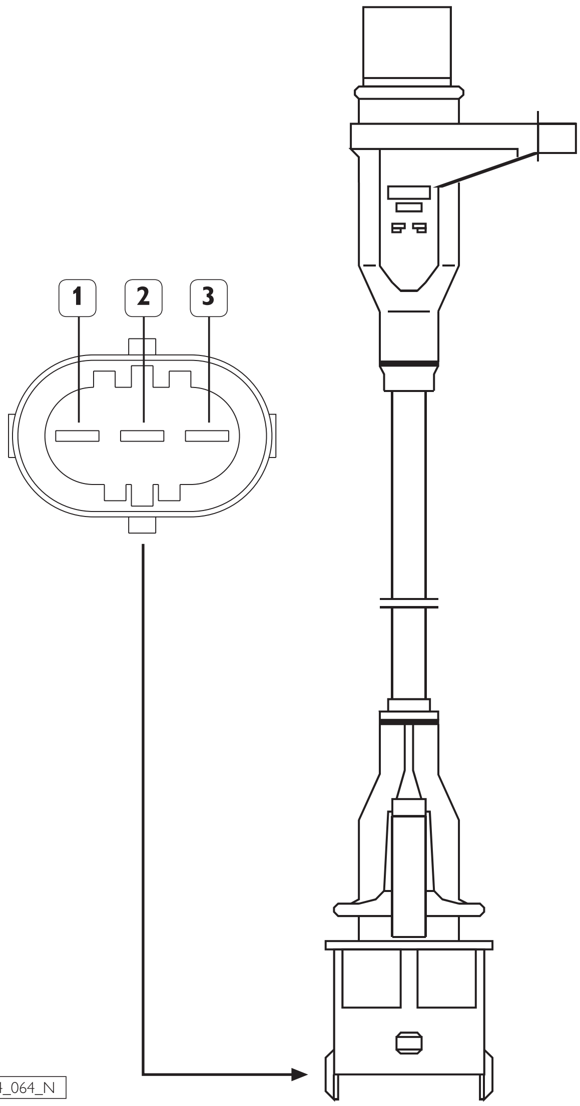
It is a variable reluctance inductive type, which generates periodical alternate signals due to flow variation in the magnetic circuit produced inside the cranckshaft by the presence of a permanent magnet. It faces the pulley keyed on the crankshaft to detect the passage of 58 tooths for every revolution. The number of 58 tooths has been derived by a constant pitch of 6° which would lead to a total of 60 tooths, 2 of which have been eliminated to generate an asimmetry of the signal that the ECU EDC uses as crankshaft positioning reference.
The signal of this sensor is processed in the ECU to assess:

- Engine rotation speed;
- Engine crankshaft acceleration;
- Angular position of the engine in respect to the TDC (top dead center) of the pair of pistons.

It originates the information of the engine RPM on the instrument and control panel.
The interruption of the signal of this sensor during engine operation is provided by a “recovery” of ECU actuated using the signal of the camshaft sensor, thus enabling the engine to carry on operating.
The solenoid is connected to terminals 1 and 2 and has a resistance of about 900 Ω. It is connected to the ECU EDC by pins A24 e A25. Terminal 3 is connected to the electric shielding and is insulated from the sensor.

Camshaft sensor

Figure 58

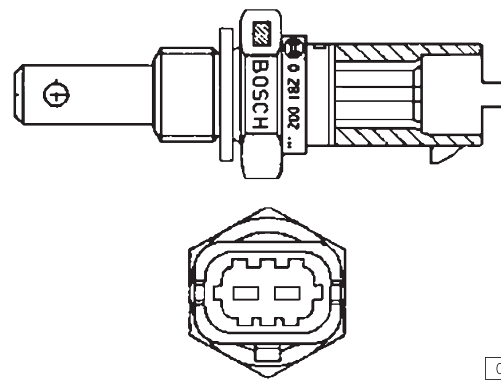


04_064_N

It is an inductive type like the previous one, and generates a signal at the passage of 6 + 1 slots located on the toothed wheel set into rotation by the camshaft.
Six reliefs equidistant among themselves provide the signal of the following one another of the strokes in the 6 cylinders; the seventh relief provides the synchronism signal enabling to recognize the typical injection sequence: 1 - 5 - 3 - 6 - 2 - 4.
The interruption of this signal during the operation of the engine is overcomed by having stored in ECU the injection sequence; if it is occurred before the starting it requires that a specific stroke recognition strategy is actuated.
The solenoid is connected to terminal 1 and 2 and has a resistance of about 900 Ω. It is connected to ECU EDC by pins A24 e A25. Terminal 3 is connected to electric shielding and is insulated from sensor.

Coolant temperature sensor

Figure 59



04_065_N

It is a resistor with negative temperature coefficient and is positioned on the cylinder head at a short distance from the thermostatic valve. It provides the indication of the metering and the advance during the various engine strokes:

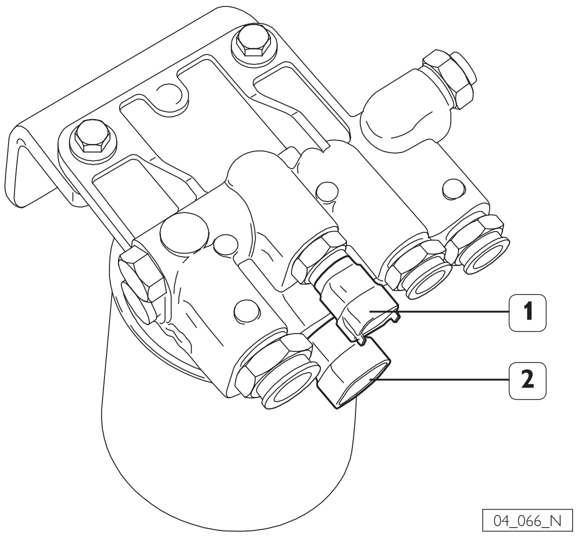
- Cold starting;
- Putting in a steady state;
- Steady state;
- Overtemperature.

The recognition of the overtemperature condition leads ECU to activate derating strategies in order to reduce heat intake and protect engine efficiency.

The sensor has a resistance of about 2.5 kΩ at the temperature of 20 °C. It is connected to ECU EDC by pins A18 and A36.

Fuel temperature sensor

Figure 60

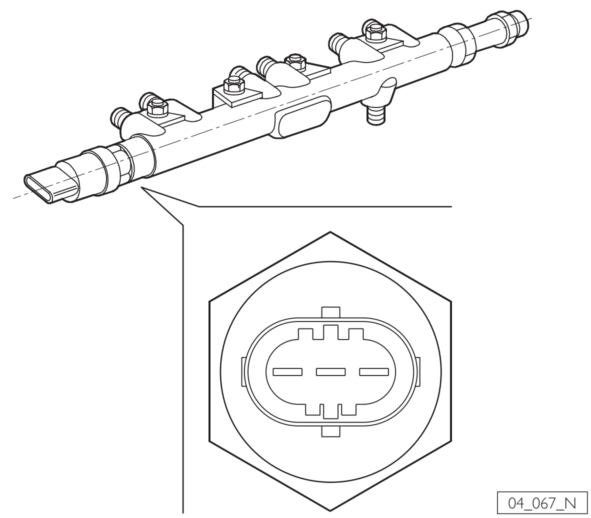


1. Fuel temperature sensor -
2. Filter heating element.

It is identical to the coolant temperature sensor and it is positioned on the fuel filter bracket.
It provides a useful datum to recognize the fuel density that feeds the electro-injectors in order to adequate the injection time to the real quantity to be injected. The derating strategies, used when the fuel critical temperature is overcome, are due to the sensitive reduction of its lubricating action caused by the temperature increase. Sometimes these strategies become evident by the limitation of the maximum performance of the engine.
The ECU activates the relay for the filter heating element with a fuel temperature ≤ 0 °C and heats up + 5 °C.
Temperature sensor has a resistance of about 2.5 kΩ at 20 °C. It is connected to ECU EDC by pins A18 and A36.

Fuel pressure sensor

Figure 61



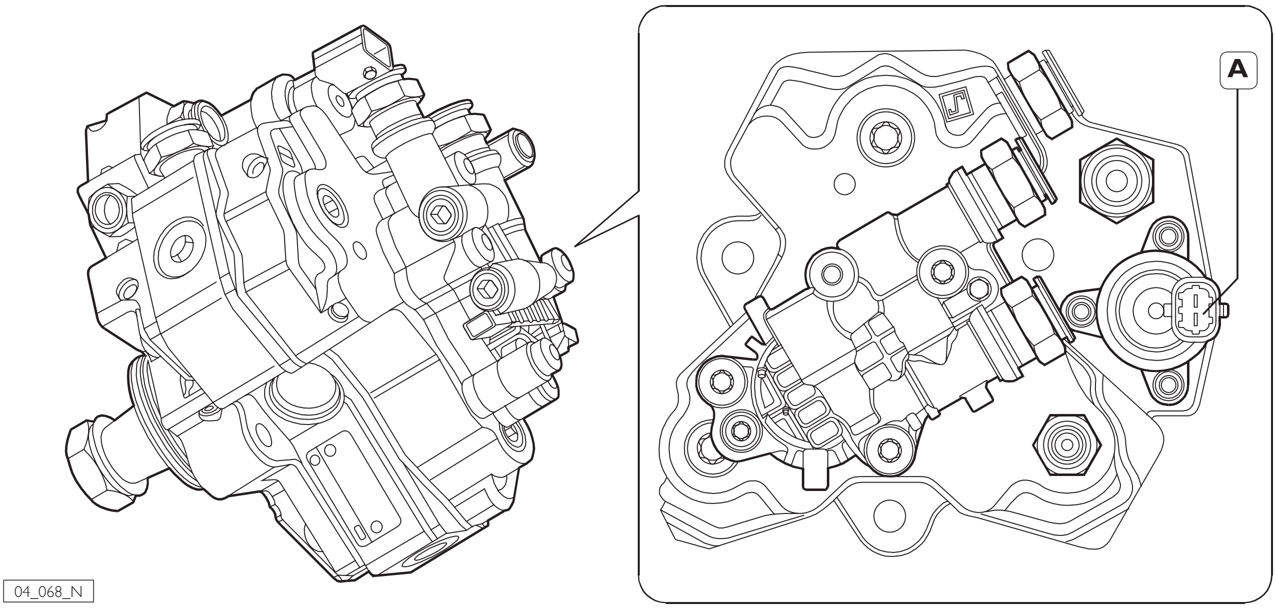
It is assembled on one end of the rail and provides the fuel instantaneous pressure value necessary to assess the injection time span applied to the electro-injectors.
If the measured value differs from the objective value, the ECU corrects the PWM control signal applied by the pressure control solenoid valve.

It is connected to the ECU EDC by pins A12, A20, and A27.

The pressure sensor is powered by 5 V voltage and the output voltage is proportional to the pressure detected.

Pressure control solenoid

Figure 62



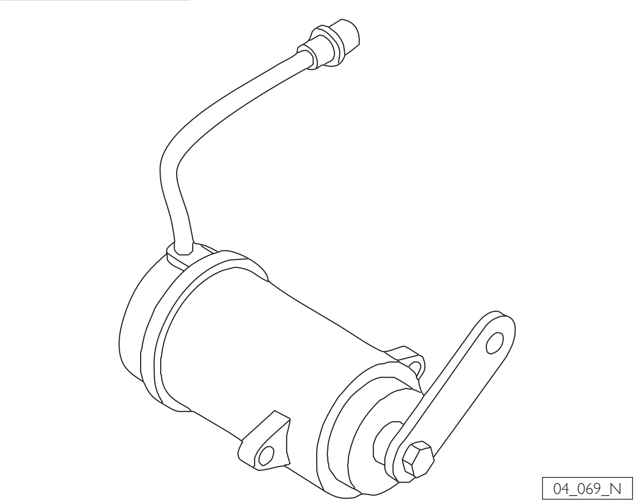
A. Solenoid connector.

The amount of fuel that feeds the high pressure pump is metered by the solenoid valve connected to the low pressure system. The solenoid is normally open and controlled by an ECU EDC PWM signal to obtain a high pressure value ranging between 250 and 1600 bar. The choice to use a normally open valve enables to maintain a good engine functionality even in the case of an interruption of the control circuit.

The component has a resistance of about 2.8 Ω and is connected to the ECU EDC by pins A5 and A7.

Throttle lever position

Figure 63



It provides the primary indication for the reckoning of the fuel amount to be injected.
It is operated by the linkage of the controls on bridge or assisted, produces in output a potentiometric variation of the voltage which supplies it, in relation to the position where the throttle lever is set.
A simultaneous safety indication is provided by the internal switch to confirm the acceleration position: minimum - out of minimum.
Such an indication in addition to the self-adative strategies of the potentiometric signal, is used in the case of anomalies to manage "limp-home" strategies, that enables to get back to harbour notwithstanding the potentiometer being faulty.

SYSTEM FUNCTIONS

By means of the computer electronic management it is possible to actuate in fast sequence both primary functions such as metering computation and injection advance and secondary ones, only necessary in special conditions.
Metering and advance, actuated three times per every crankshaft revolution, are selectively calculated cylinder by cylinder at every injection, while secondary functions as the acceleration management or heating element on fuel filter activation are controlled only when necessary.
Moreover the electronic unit is programmed to carry out continuous checks on presence and consistency of the signals originated from the system sensors, to timely notify the onset of faults or actuate the exclusion of a datum whenever its content is in contrast with the logic sequence of the events occurred up to that moment.

Run up

Immediately after having electrically powered up the system (key is in the ON position), the central unit before setting on the cranking motor, transfers into the main working memory data which have characterised the best engine operation during the previous operation period; they represent the progressive engine ageing and they progressively evolve with usage.
By using this function, engine management is always optimized even from the first operation stages, indipendently from the usage conditions of the engine.
The data transferred after the run-up are those stored after the last engine stop during the "after run" function.

Starting

It is the management stage of the engine functions characterised by the adotpion of useful strategies to a fast reaching of the endothermic engine functions.
Among the restrained signals the most evident is the recognition of the throttle position that does not require to be operated until the starting procedure is concluded.

Metering and fuel injection

It is carried out by the span of time of the injectors electric control fed by the pressurized fuel in the common rail distributor.
Fuel pressure in the common rail distributor is made to change according to the performance goals required from the engine.
The primary datum of the amount of fuel to be injected is calculated according to the information of:

- Throttle position;
- Engine number of RPM.

This datum is further adjusted according to the data of:

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

It may be modified by linearization for acceleration gradient, the minimum RPM, to avoid overspeed or to control limit condition of engine operation.
The span of time of the electro-injector control which sets the real quantity injected is, moreover, related to the fuel pressure datum detected on the common rail distributor and the battery voltage.
Only in case of anomalies which entail serious damages for the engine, injection time zeroing is reached.

Injection advance management

It is obtained by changing in the span of time of one revolution of the crankshaft the instant of the electric control beginning of the electro-injectors.
The values actuated may vary from one injection to the next and in the same way as for the metering varied among the cylinders.
The parameters affecting the injection advance are:

- Throttle position;
- Engine RPM;
- Comburent air temperature and pressure;
- Fuel temperature;
- Coolant temperature.

The values are determined experimentally in order to obtain the best performance and at the same time complying with containment goals on acoustic and fumes emissions.
A further dynamic adjustment during the acceleration phase gives the engine a greater static torque.
The information to check the actuated value obtained in "loop" is provided by the electro-injector solenoid impedance change.

Pre-injection

This term indicates the delivery of a limited amount of fuel that is obtained in the short interval of opening and closing of the spray-nozzle metering rod, before the main injection.

Pre-injection is programmed in the ECU and it is possible up to 2,000 RPM. Its purpose is to limit the pressure increase gradient within the combustion chamber to reduce its peaks and contain typical noise of the direct injection engines.
The amount of fuel injected is an integral part of the main metered injection.

Injection pressure modulation

The best and more reliable torque and power delivery, complying with fumes and acoustic emission containment, is made possible by having a high pressure fuel delivery and by using injectors having a high atomization. In order to conform fuel metering with the high dynamics required by the engine control, apart from managining the injection time, managing the pressure of the fuel injected is also necessary.
This goal is obtained in loop by using the datum supplied by the pressure sensor located on the common rail distributor.

Idling adjusting

This function enables to obtain a constant and repeatable RPM notwithstanding the changing of the operational environmental conditions. The adjustment is obtained by managing metering and the injection beginning instant according to the processing of the information produced by the sensors.
If battery voltage is below efficiency rating, ECU increases rotation to improve alternator recharging.

Self-diagnosis

It is the constant check of the presence of the electrical signals sent by the sensors or delivered to actuators. In the case of anomalies being detected, it enables the electronic unit to process data according to a "recovery" programme.

The central unit not only checks the efficiency of the sensors, actuators and wiring connected to them, but also checks a consistency evaluation of the signals and the information deducted from them.
It is possible to recognise an inconsistency and not use an invalidated datum replacing it with that one predefined by means of comparison with pre-programmed limit parameters or by assessing their increasing or decreasing gradient.
The "recovery" procedure is integrated by the storing of the codes identifying the errors detected. These codes can be decoded by using diagnostic computerized appliances or by means of a blinking light named "blink code".

EDC indicator light

It is located on the instrument and control panel, is directly controlled by the EDC system from the central unit. It is normally off, it will come on for an instant immediately after having supplied the system by means of an efficiency test.
If lit, the EDC indicator shows a likely anomaly of the injection system or an irregular engine operation or of one of its machine parts.

Fuel heating

It assures a correct density of the fuel even at low temperatures, improving atomization in order to obtain a better gradient smoke and emissions.
The heating element is activated on the filter according to the temperature detected.

Linearization of the acceleration gradient

The exhaust and acoustic noxious emissions containment has been obtained by implementing strategies especially to control the injection required for accelerations. Management of the fuel metering and advance, during transient states, has been obtained by devising experimental progression modes stored in the central unit.

Balance of the cylinder torque delivery

It contributes to reduce vibrations and equilibrates its operation.
It is obtained by controlling delivery and injection advance "cylinder by cylinder"; in such a way it is possible to adequate crankshaft angular acceleration produced by each combustion to equal ratings.
Cylinders balance can be carried out only at idle speed, due to software structure complexity, but data thus gathered with a wise adaptation, can be used for higher speed too.

Rotation speed control

It represents the electronic equivalent of the speed controls of the traditional injection pumps.
Like the latter it has the following adjustment characteristics:

- Minum and maximum;
- Every speed.

Top speed limitation

It preserves the efficiency of the engine operation by not allowing overspeed even if accidental.
Limitation strategies are actuated in the following ways:

- When the first threshold is overcome, fuel delivery reduces progressively;
- When the expected top speed has been reached, fuel delivery is zeroed.

Cut off

It consists of non injecting fuel during the engine deceleration phase. The function is operating until the idle speed is reached below which it would be impossible to restore engine thermic operation.

Derating

It can be considered as a recovery programme. It does not produce a storage of an anomaly record. It is caused by the recognition of fuel high temperature, coolant, or combu-rent air. Derating consists of reducing the torque delivered by the engine to preserve it from operation inefficiency. It takes place when overcoming preset thresholds, in a way proportional and gradual to the amount of the overcom-ing of parameter; it does not entail fault signalling on the instrument panel.

Recovery

It is a special way of control and management characterised by the adoption of a number of strategies which enable the system to operate even in the case selfdiagnosis has recog-nized the presence of anomalies. In the majority of cases seafaring can be continued regularly or with reduced per-formance. Adopting a recovery strategy entails the storing of an anomaly code and the corresponding limitation of the maximum power rating delivered by the engine.

The power rating limitation due to recovery strategy is active up to the stopping of the engine even if the anomaly detected is not there anymore. The blink code light on the instrument and control panel will turn on only for the most serious events.

After run

The stage following after every engine stop. It is character-ised by the delay in deenergizing the main supply solenoid contained inside the ECU EDC. During this phase the central unit is still powered for some seconds, during which the data that have characterised the optimized management of the engine up to that moment, are transferred from the main volatile memory to the EEPROM non volatile memory; these data will then be available for the next starting.

These data can be summarised into:

- Management modes (idle speed, torque delivery bal-ance, smoke limit…);
- Threshold setting min/max of signal recognition;
- Fault memory.

At every start up it is important to have available the data that optimize the management and the engine behaviour in terms of TORQUE AND POWER DELIVERY. It is therefore mandatory to use engine stopping strategies (e.g. battery disconnection) not different from those prescribed by the manufacturer (key in OFF position) or which may prevent the correct execution of the after run function.

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SECTION 2

TECHNICAL DATA

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GENERAL SPECIFICATIONS

Engine		N40 ENT M25	N60 ENT M37	N60 ENT M40
Cycle Charge Injection			4-Stroke Diesel Supercharged and intercooled Direct	
Number of cylinders		4 in line	6 in line	6 in line
Bore	mm	102	102	102
Stroke	mm	120	120	120
Total displacement	cm^3	3920	5880	5880
Compression ratio		17 ± 0.8 : 1	17 ± 0.8 : 1	17 ± 0.8 : 1
Direction of rotation, brake side			counterclockwise	
Minimum idling rpm	rpm	650 ± 25	650 ± 25	650 ± 25
Maximum engine rpm, no load	rpm	3050 ± 25	3050 ± 25	3050 ± 25

Allowed engine inclination angles

Maximum longitudinal in continuous operation (static + dynamic)	degrees/360	+ 20	+ 18	+ 18
Maximum transverse in continuous operation (static + dynamic)	degrees/360	± 22° 30'	± 22° 30'	± 22° 30'
Longitudinal for oil level check with standard dipstick	degrees/360	0 to +6	0 to +6	0 to +6

Supercharge
For engines designed for PLEASURE use

Turbo-charger with water-cooled body		HOLSET -	HOLSET HX40M	HOLSET HX40M
Maximum pressure	bar	2.1	2.1	2.1

Supercharge
For engines designed for SPORTING use (N60 ENT M40.10)

Turbo-charger with water-cooled body and waste-gate				HOLSET HX40M
Maximum pressure	bar			2.32

Lubrication

Oil	type		SAE 15 W40/E 3 /	
Oil compliant with specifications			ACEA E3 / API CF4 / MIL L2104E/F	
Total oil capacity on first filling	liters (kg)	12,5 (11,5)	16,5 (14,8)	16,5 (14,8)
Total oil capacity with sump at minimum level	liters (kg)	9 (8,1)	9 (8,1)	9 (8,1)
Total oil capacity with sump at top level	liters (kg)	11 (10)	14,5 (13)	14,5 (13)
Oil pressure, warm engine, minimum idling rpm	bar	≥ 1.2	≥ 1.2	≥ 1.2
Oil pressure, warm engine, maximum rpm	bar	≥ 3.8	≥ 3.8	≥ 3.8
Maximum allowed temperature	°C	120	120	120
Oil dipstick valid for static inclination	degrees/360	0 to +6	0 to +6	0 to +6

Engine		N40 ENT M25	N60 ENT M37	N60 ENT M40

Fuel Supply

Fuel oil compliant with standard		EN 590	EN 590	EN 590
Low pressure transfer pump		gear pump	gear pump	gear pump
Flow rate at maximum rpm	liters/h	250	250	250
Fuel return flow rate to tank	liters/h	240	240	240
Filtering: pre-filter filter	μm μm	300 4	300 4	300 4

Injection System

Type		Common rail	Common rail	Common rail
System		Bosch EDC 7	Bosch EDC 7	Bosch EDC 7
Maximum injection pressure	bar	1450	1450	1450

Low Temperature Starting

Allowed, without external aids, down to	°C	- 15	- 15	- 15

Cooling

Closed coolant loop with sea-water heat exchanger		50% mixture of water/antifreeze Compliant with SAE J 1034 specification		
Total coolant quantity	liters	21,5	24,5	24,5
Expansion tank		standard	standard	standard
Forced circulation		centrifugal pump	centrifugal pump	centrifugal pump
Flow rate at maximum rpm	liters/h	-	-	-
Temperature regulation		with thermostatic valve		
initial opening	°C	72° ± 2	72° ± 2	72° ± 2
maximum opening	°C	82° ± 2	82° ± 2	82° ± 2
Sea-water line		forced circulation		
Water pump		self-priming with neoprene impeller		
Sea-water pump height above sea level	m	≤ 2	≤ 2	≤ 2
Max. pump capacity	liters/h	12000	12000	12000

Exhaust gas expulsion

Standard		mixed with sea-water		

Engine		N40 ENT M25	N60 ENT M37	N60 ENT M40

Electrical system

Nominal voltage	V dc	12	12	12
Self-regulated alternator: Voltage Maximum current intensity	 V dc A	 14 90	 14 90	 14 90
Electrical starter motor: Nominal voltage Absorbed electrical power	 V dc W	 12 4000	 12 4000	 12 4000
Recommended battery capacity	Ah	≥ 180	≥ 180	≥ 180
Current discharge at - 18 °C (SAE J 537)	A	≥ 900	≥ 900	≥ 900

Drive train coupling

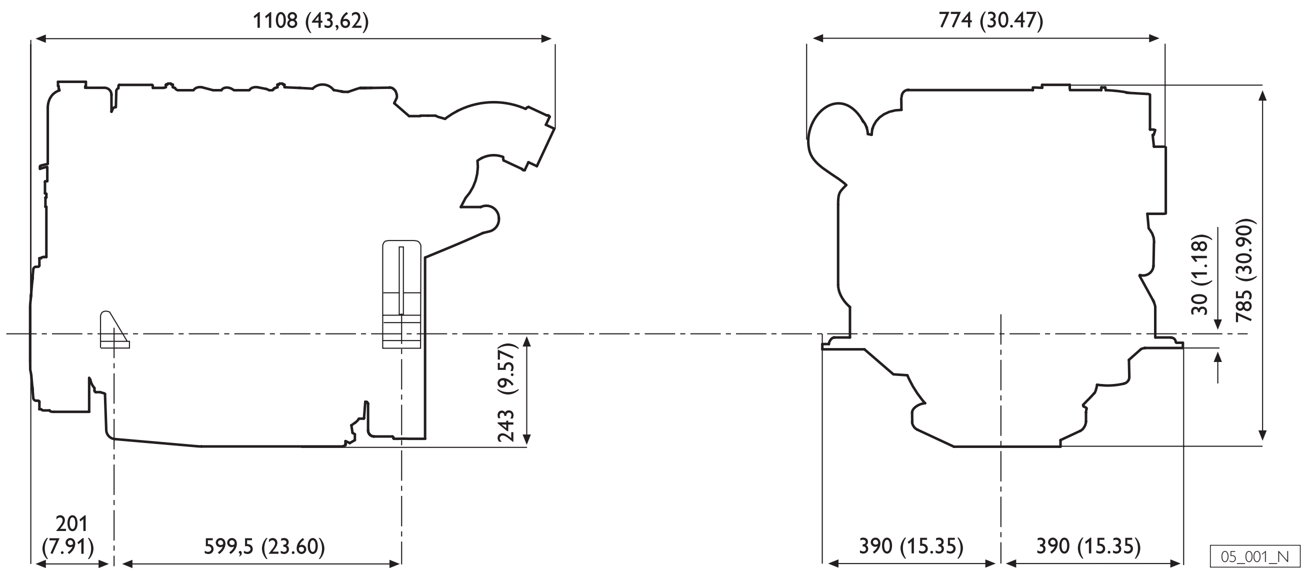
Flywheel diameter	mm (inches)	- (11.5)	- (11.5)	- (11.5)
Flywheel case	type	SAE 3	SAE 3	SAE 3

Weights

Without liquids and without marine gear	kg	-	605	605

Dimensions (4 cylinders)

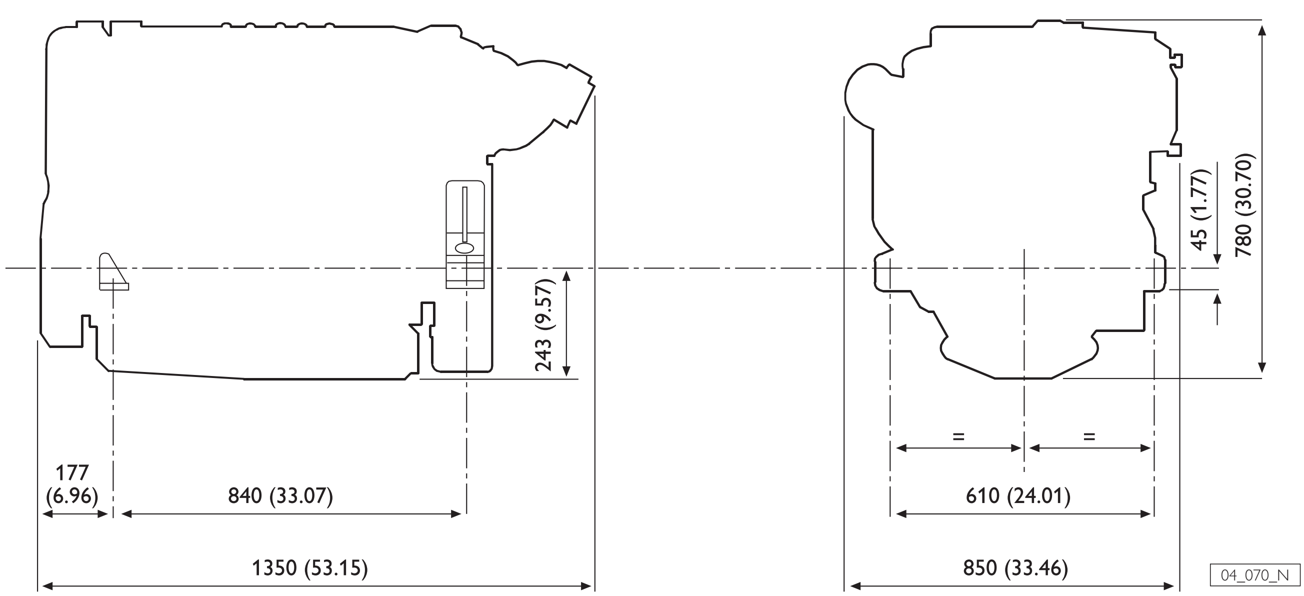
Figure 1 A



Measurements in: millimeters (inches).

DIMENSIONS (6 CYLINDERS)

Figure 1 B



Measurements in: millimeters (inches).

SECTION 3

ELECTRICAL EQUIPMENT

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FOREWORD

During the period of production, the electrical equipment of the motors were updated twice compared with the first series:

- ❏ During 2003, the position of the component and its related connectors inside the relay box has been modified, consequently modifying its wiring as well.
- ❏ During the year 2005, some modifications were made to the internal circuits of the relay box and to the wiring. These modifications make incompatible and harmful the use of the components supplied now together with the components supplied before.

Chapter One of this Section indicates the codes of the components to make the correct couples.

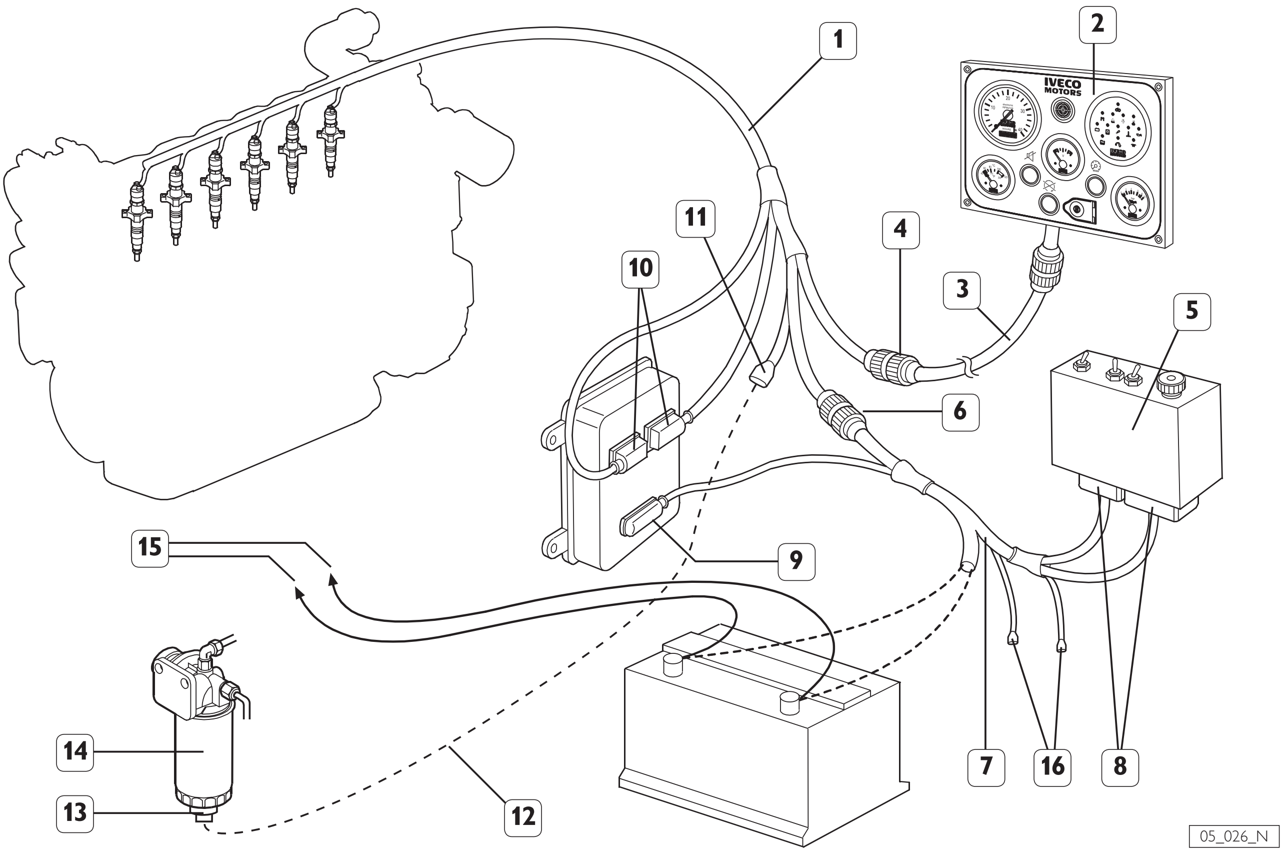
The electrical diagrams relate to the three version indicated in sequence below are printed at the end of this Section:

- ❏ Original series system with title
  VERSION UP TO 10/2003
- ❏ ISecond series system with title
  VERSION FROM 11/2003 TO 2005
- ❏ Third series system with title
  CURRENT VERSION

These are followed by the electrical diagrams common to all three versions.

OVERALL

Figure 1



1. Engine wiring - 2. Indicator and control panel - 3. Provided wire harness - 4. JB Connection - 5. Relay box - 6. JA Connection - 7. Power supply and interface wire harness - 8. JF1 and JF2 connectors - 9. A2 connector of the ECU - 10. A and A1 connectors of the ECU - 11. M Connector - 12. Wiring harness to be manufactured by the yard - 13. Sensor for the presence of water in the fuel - 14. Sedimenting pre-filter - 15. Power line for electric starter motor and alternator - 16. ECF and ECM connectors (Present on the wiring of the new model).

The electric equipment of the system carries out the main connections by means of the wiring provided with the engine, to which the power supply, the electronic components assembled on the engine, the electronic central unit of the injection system, the relay box, and the instrument and control panel are connected.
The product overall is apt for the needs of an adequate installation and complies with electromagnetic compatibility limits legislation on electric installations (EMC). Wiring cannot be modified in any way and any possibility of using its wiring lines for different components is absolutely excluded.
Wiring harness for power supply has to be manufactured by the shipyard following the indications contained in the "N40 ENT M25, N60 ENT M37-M40 Installation Directive" document.

CAUTION

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

Information related to analogue and digital instrument and control panel and the related sensors are present in the "N40 ENT M25, N60 ENT M37-M40 Installation Directive" document.

N40 ENT M25

OLD MODEL

Component	IVECO Code
Engine wiring with clamp	8039604
Engine wiring	8036966
Interface wiring	8035938
12V relay box (brass colour box)	8035890
24V relay box (brass colour box)	8035891

EXISTING MODEL

Component	IVECO Code
Engine wiring with clamp	8041500
Engine wiring	8041167
Interface wiring	8041169
12V relay box (brass colour box) ▲	8041257
12V relay box (black colour box) ▲	8042960
24V relay box (brass colour box) *	8041353
24V relay box (black colour box) *	8042040

▲ Interexchangeable
* Interexchangeable

Chapter 24 shows the electric schemes of the tow models which in the table titles are shown as "OLD MODEL" and "EXISTING MODEL".

N60 ENT M37-M40

OLD MODEL

Component	IVECO Code
Engine wiring with clamp	8035822
Engine wiring	8035817
Interface wiring	8035938
12V relay box (brass colour box)	8035890
24V relay box (brass colour box)	8035891

EXISTING MODEL

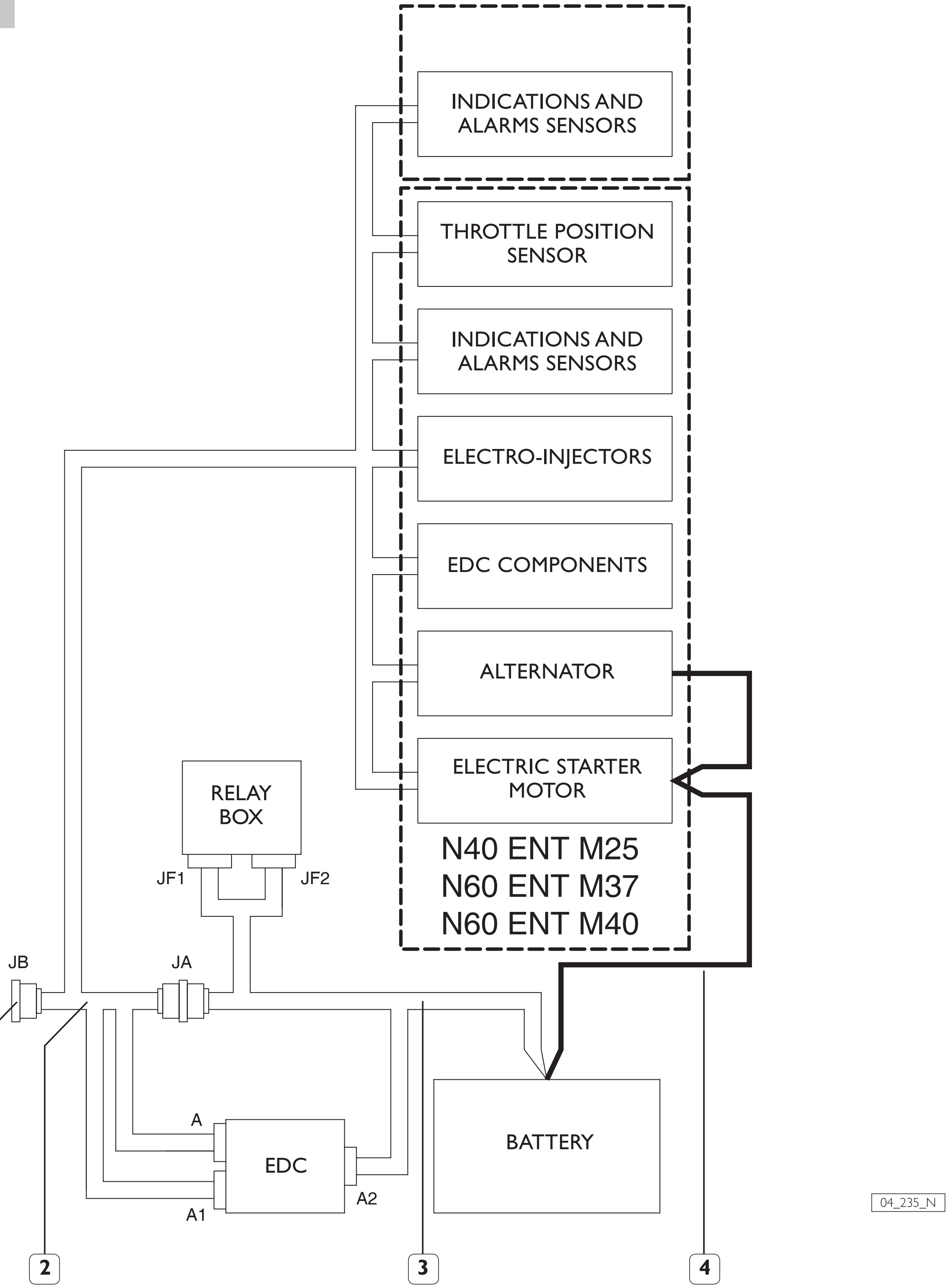
Component	IVECO Code
Engine wiring with clamp	8041170
Engine wiring	8041168
Interface wiring	8041169
12V relay box (brass colour box) ▲	8041257
12V relay box (black colour box) ▲	8042960
24V relay box (brass colour box) *	8041353
24V relay box (black colour box) *	8042040

▲ Interexchangeable
* Interexchangeable

Chapter 24 shows the electric schemes of the tow models which in the table titles are shown as "OLD MODEL" and "EXISTING MODEL".

SYNOPTIC

Figure 2

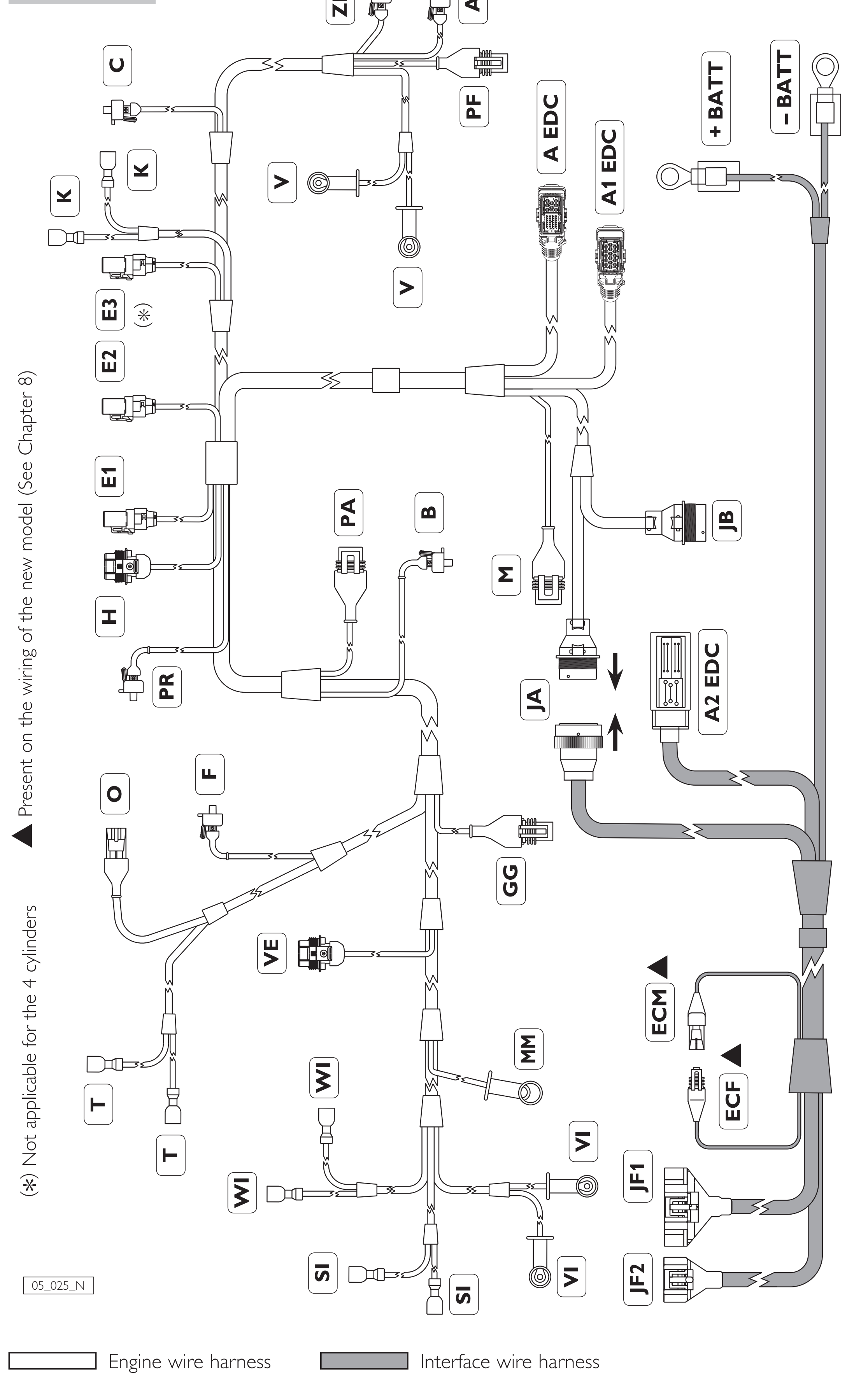


1. Connector for instrument panel connection wire harness - 2. Engine wire harness - 3. Interface wire harness - 4. Power line.

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

WIRE HARNESS

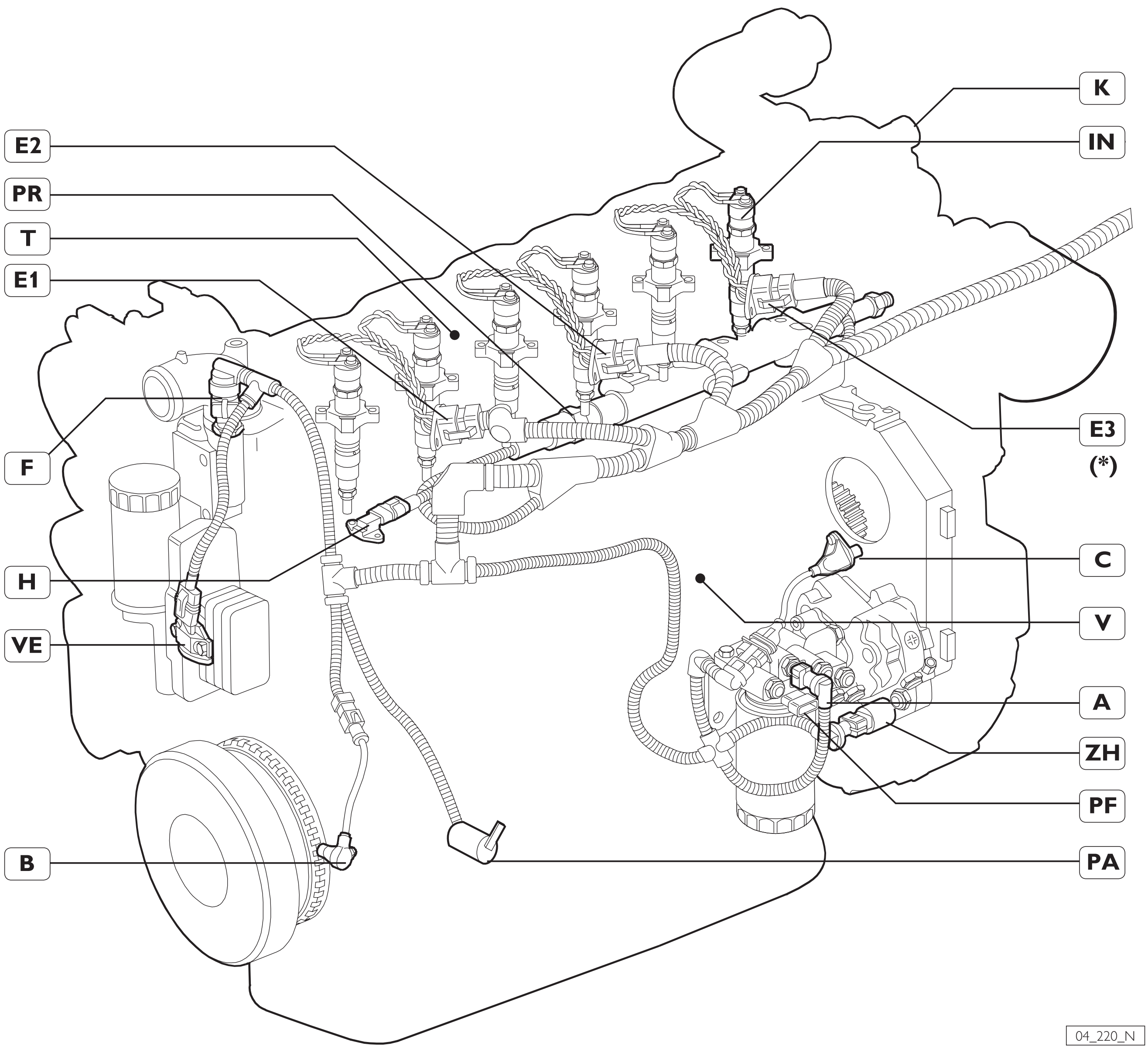
Figure 3



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

LOCATION OF ELECTRICAL COMPONENTS IN THE ENGINE

Figure 4

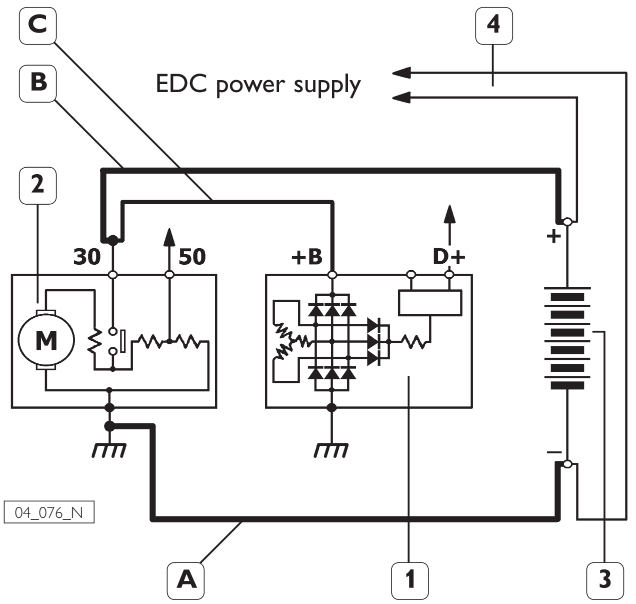


A. Fuel temperature sensor for EDC - B. Drive shaft sensor - C. Camshaft sensor - F. Engine coolant temperature sensor for EDC - H. Combustion air pressure/temperature sensor for EDC - K. Air filter clogging sensor (for alarm) - T. Coolant temperature sensor (for gauge) - V. Oil pressure sensor (for gauge) - E1. Electro-injectors cylinders 1 and 2 connector - E2. Electro-injectors cylinders 3 and 4 connector - E3. Electro-injectors cylinders 5 and 6 connector (*) - IN. Electro-injectors - PA. Throttle position sensor - PF. Heating element on fuel filter - PR. Rail pressure sensor - VE. Engine oil pressure/temperature sensor for EDC - ZH. Pressure control solenoid valve.

(*) Not applicable for the 4 cylinders.

POWER SUPPLY LINE

Figure 5



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

The power supply line, to be implemented by the shipyard, comprises:

- ❑ A. A connection between the negative pole of the battery and engine ground with a conductor having a cross section of at least 70 mm^2;
- ❑ B. A 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^2;
- ❑ C. A connection between the +B terminal of the alternator to the positive +30 terminal of the electric starter motor, to complete the recharge circuit, is reached with a conductor having a cross section of at least 10 mm^2.

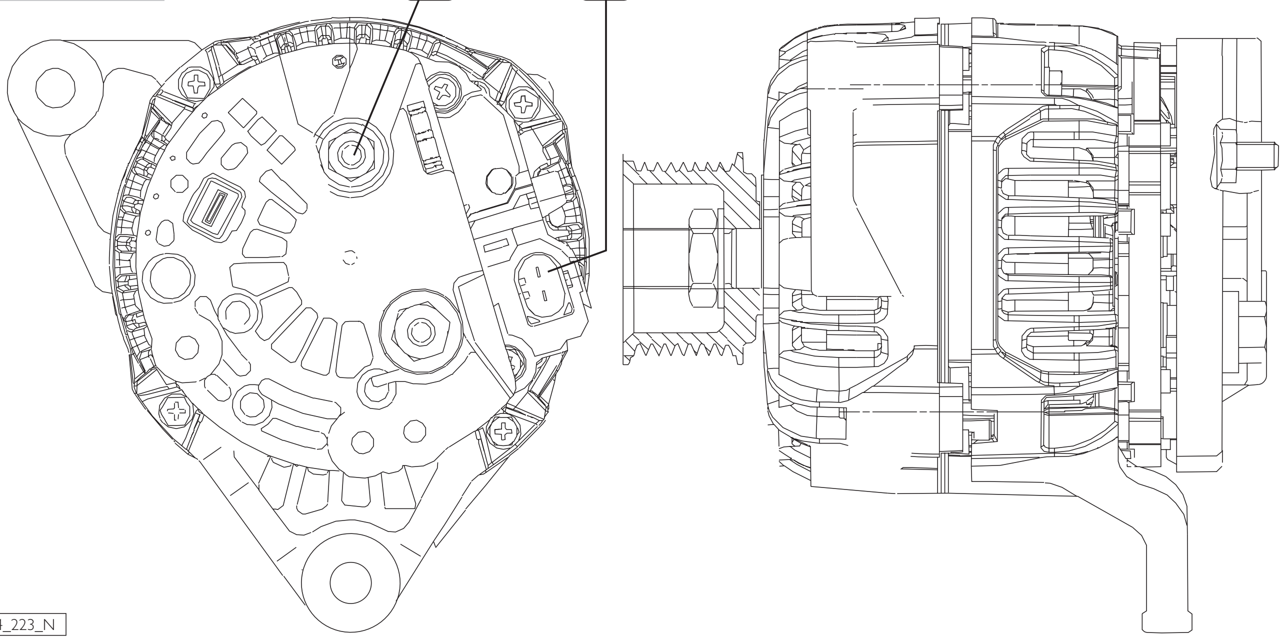
The connection of the electric equipment of the engine to the battery has to be carried out by the two-eyed terminals, +B and -B present on the wiring harness.

CAUTION

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

ALTERNATOR

Figure 6



04_223_N

"Bosch" Model 14 V - 90 A

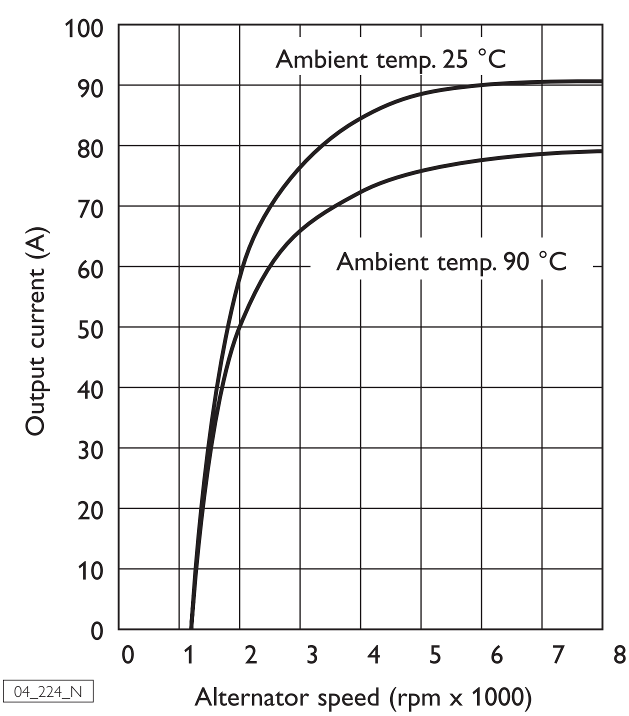
+B. (12 V)	Power supply output terminal
D+. (Lamp)	Power supply voltage of recharge/alarm indicator light located on the panel.

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

Specifications

Nominal voltage	14 V
Nominal current max	90 A
Rpm max	6000 rpm
Current max at 1800 rpm	50 A
Polarity	Negative ground
Rotation	Clockwise viewed from pulley
Belt	Poli-V
Poles	12
Weight	5.7 kg

Figure 7

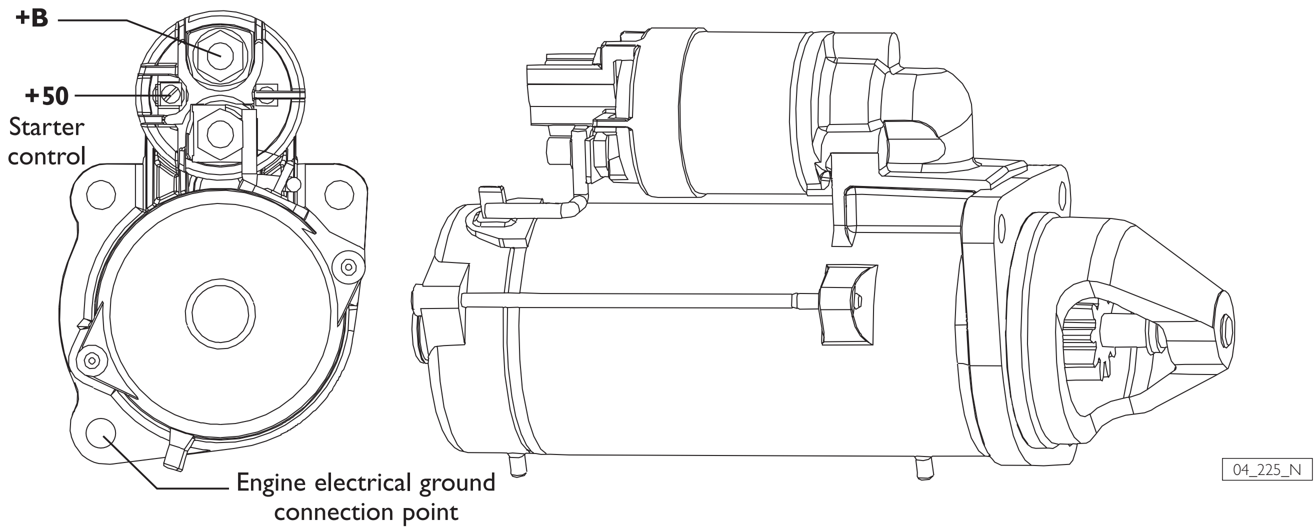


04_224_N

CHARACTERISTIC CURVES

ELECTRICAL STARTER MOTOR

Figure 8

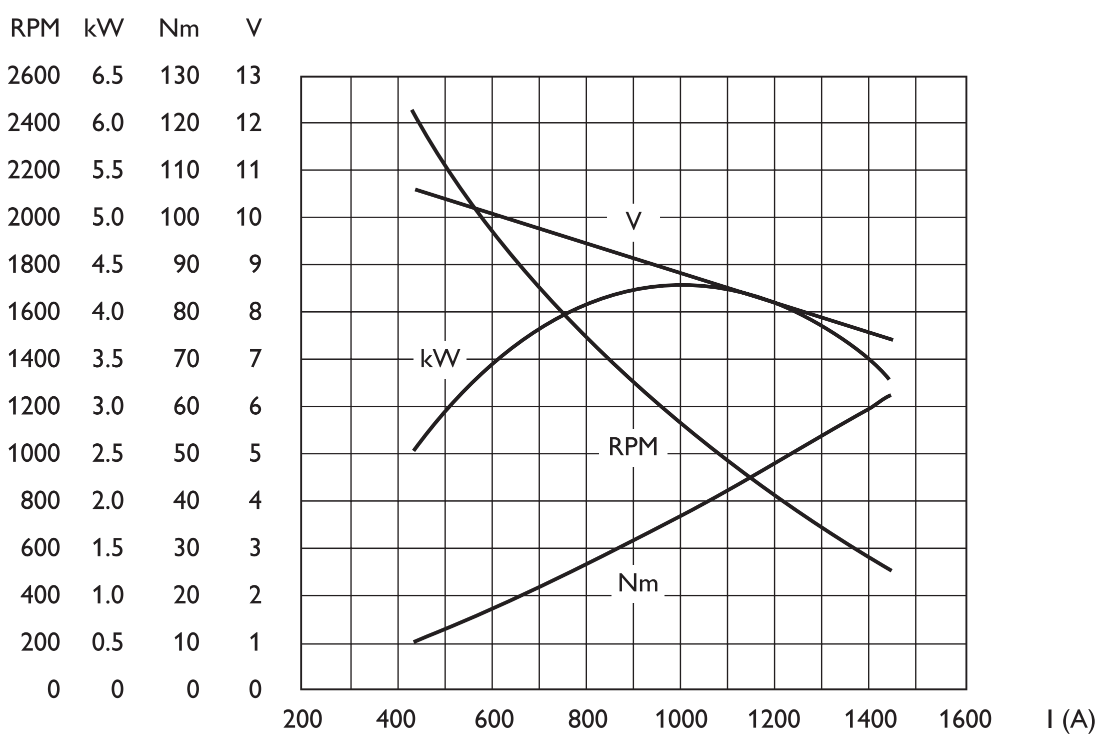


"Bosch" Model - Specifications

Nominal power	4.3 kW
Nominal voltage	12 V
Polarity	Negative ground
Engagement circuit	Positive command

Rotation	Clockwise viewed from pinion end
Operating voltage	13 V max (20 °C)
Water resistance	Water spray test based on JIS D0203 SI

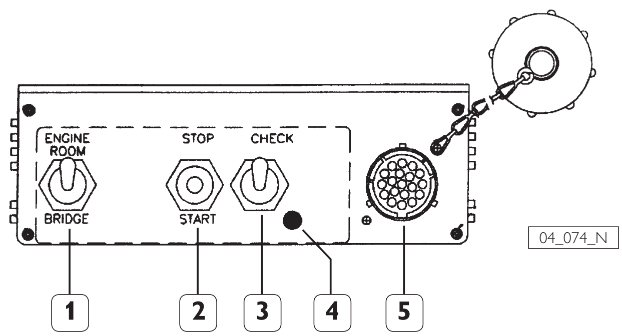
Figure 9



CHARACTERISTIC CURVES

RELAY BOX

Figure 10



1. Engine control selector on bridge or engine room (SW1) - 2. Manual throttle control in engine room (SW2) - 3. Pushbutton for blink code query (SW3) - 4. LED signalling anomalies EDC and blink code (DL1) - 5. Connector for external diagnosis instrument (J1)

It is the main point of interconnection and carries out many interfacing functions among the various components of the system. The electrical commands positioned on the panel allow to control engine starting and stopping (2) directly from the engine room, while excluding any possibility that anyone may involuntarily start the engine from the bridge (1), during servicing operations.
Among the controls present on the panel are the push-button (3) and the "blink code" light indicator (4), useful to obtain, also while underway, indications that will lead to identify 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 totally avoiding the need to restore the electrical continuity of circuits subjected to an anomaly condition. These components are able to 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 the multipolar connector is located, protected by a screw-on lid (5), for connection with the computerized diagnostic tools prescribed by IVECO MOTORS-FPT (see Section 4).
This is to be installed and anchored in such a way as to dampen the vibrations and stresses occurring when underway, and will be accessible during servicing operations and when underway.

Relays contained in the relay box

K1. Fuel filter heater element power supply;
K2. Power supply to terminal 50 of the electric starter motor;
K3. Key switch electric discharge;
K4. Emergency engine shut-down provision;
K5. Start request signal, from key switch to EDC electronic unit.

RPM control

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

Acceleration (SET +)

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

Deceleration (SET –)

Moving the "start - stop" push-button back to the "start" position, after releasing it during the rpm increase phase, a progressive reduction in rpm is obtained; when the push-button is released, the function is inhibited and the rpm reached at that point is maintained.

NOTE

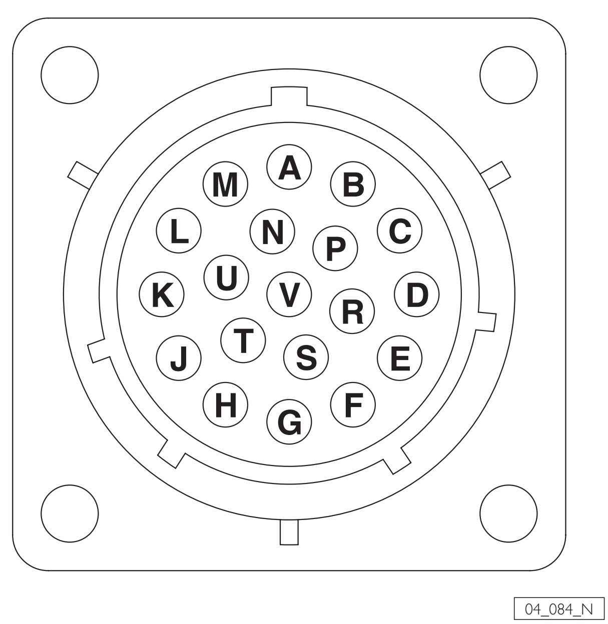
Further action on the push-button will alternatively increase - decrease engine rpm.
The "stop" function takes priority and always stops the engine.

CAUTION

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

Diagnosis connector J1

Figure 11



Relay box connectors

(1st version prior to 10/2003)

Figure 12

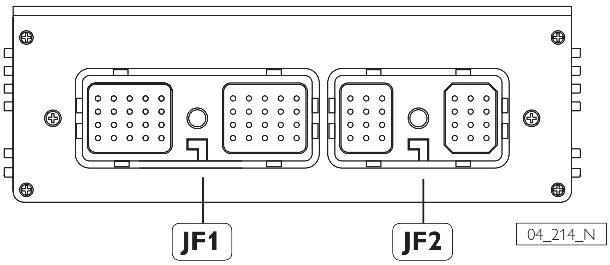
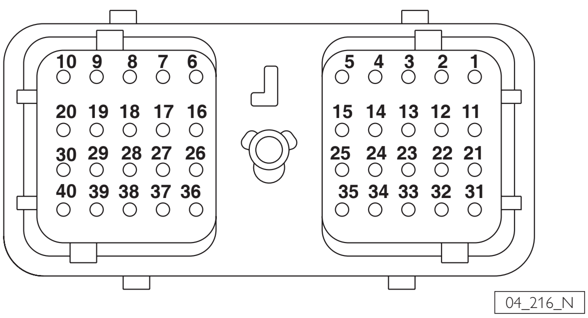
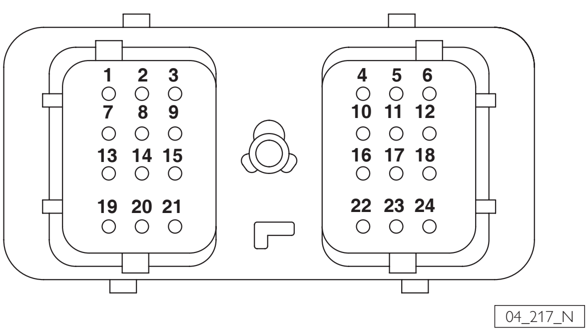


Figure 13



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

Figure 14



JF2 CONNECTOR
(view of the wire harness terminal, coupling side)

(2st version from 11/2003 and existing model)

Figure 15

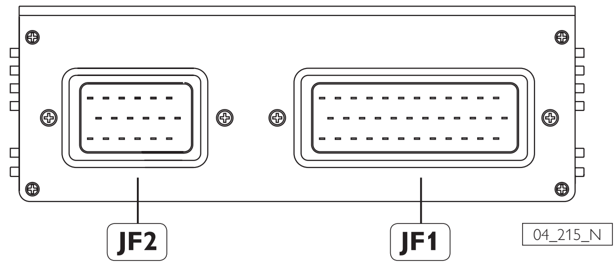
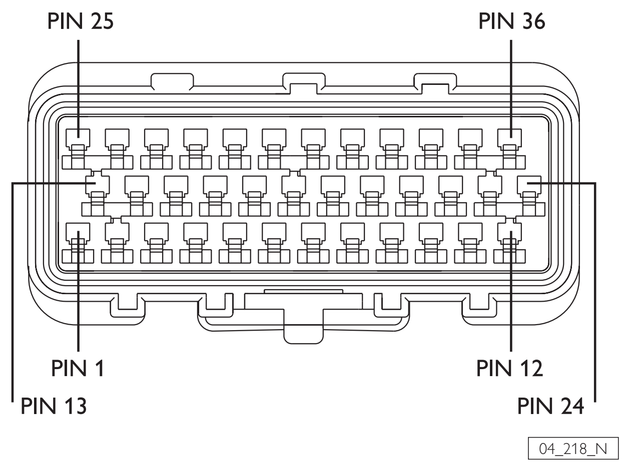
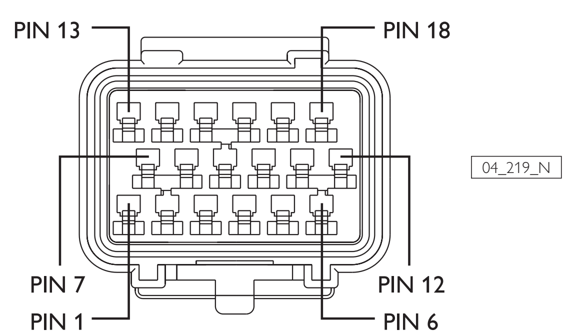


Figure 16



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

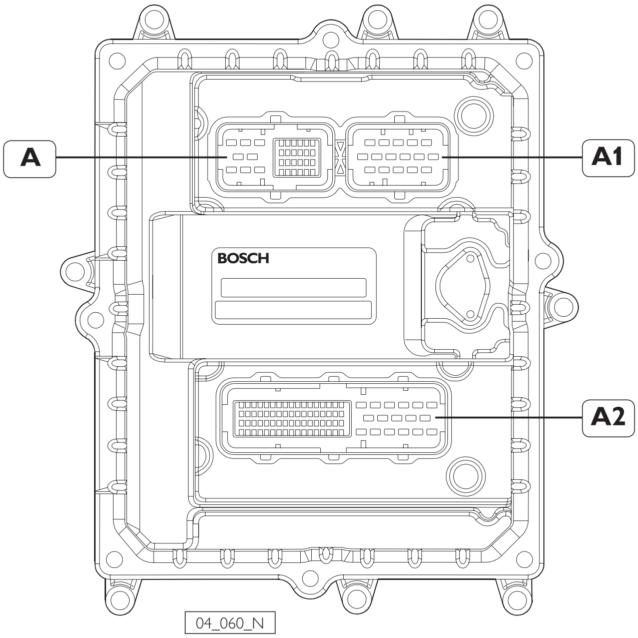
Figure 17



JF2 CONNECTOR
(view of the wire harness terminal, coupling side)

CONNECTIONS OF THE CENTRAL ELECTRONIC UNIT (ECU) EDC 7

Figure 18



A. 36 poles connector - A1. 16 poles connector - A2. 89 poles connector.

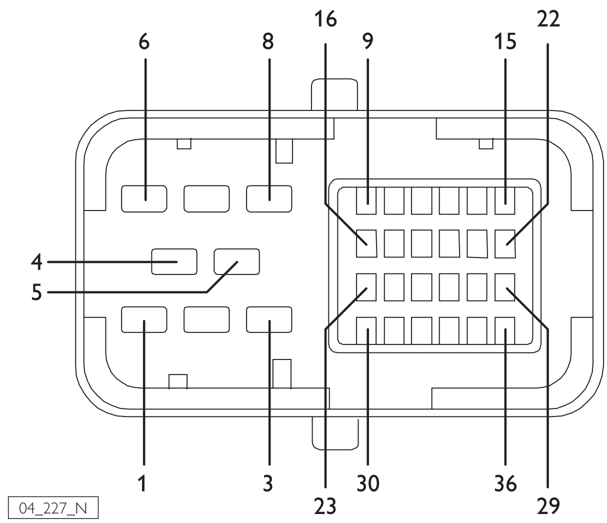
The connection of the central electronic unit, the ECU, to the components of the EDC system is achieved by means of three connectors so as to subdivide the wiring harnesses, thereby favoring a quicker identification of the lines during testing operations.
The different connectors are polarized and provided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

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

Identification of terminal function

EDC A Connector

Figure 19



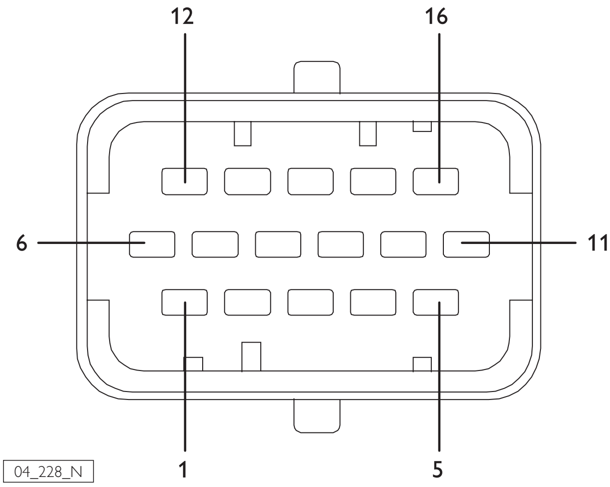
PIN ECU	FUNCTION
1	Not used
2	Not used
3	Not used
4	Not used
5	Negative drive pressure control solenoid valve on the high pressure pump
6	Not used
7	Positive drive pressure control solenoid valve on the high pressure pump
8	Not used
9	Positive supply oil pressure/temperature sensor
10	Positive supply combustion air pressure/temperature sensor
11	Not used
12	Positive supply rail pressure sensor
13	Not used
14	Not used
15	Not used
16	Not used
17	Ground fuel temperature sensor
18	Ground engine coolant temperature sensor
19	Ground oil pressure/temperature sensor

PIN ECU	FUNCTION
20	Ground supply rail pressure sensor
21	Ground combustion air pressure/temperature sensor
22	Not used
23	Camshaft sensor
24	Drive shaft sensor
25	Drive shaft sensor
26	Not used
27	Signal from rail pressure sensor
28	Signal from combustion air pressure sensor
29	Signal from combustion air temperature sensor
30	Camshaft sensor
31	Not used
32	Not used
33	Signal from engine oil pressure
34	Signal from fuel temperature sensor
35	Signal from engine oil temperature sensor
36	Signal from coolant temperature sensor

Identification of terminal function

EDC A1 Connector

Figure 20



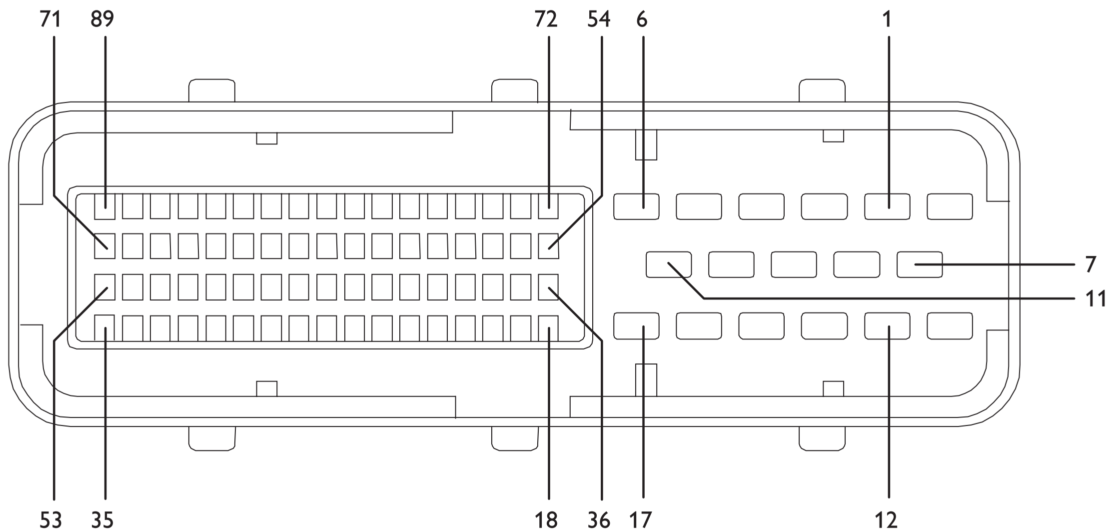
PIN ECU	CABLE COLOUR	FUNCTION
1	-	Not used
2	-	Not used
3	red - blue	Injector cylinder 2
4	white - purple	Injector cylinder 3
5	white - violet	Injector cylinder 4
6	red - white	Injector cylinder 2
7	-	Not used
8	-	Not used
9	red - green	Injector cylinder 1
10	blue - brown	Injector cylinder 6 (*)
11	blue - green	Injector cylinder 5 (*)
12	white - red	Injector cylinder 3
13	red - yellow	Injector cylinder 1
14	white	Injector cylinder 4
15	blue - orange	Injector cylinder 6 (*)
16	blue - yellow	Injector cylinder 5 (*)

(*) Not applicable for the 4 cylinders.

Identification of terminal function

EDC A2 Connector

Figure 21



PIN ECU	FUNCTION
1	Positive supply (+B)
2	Ground for K1 and K2 relays
3	Negative supply (-B)
4	Connected to JA-25
5	Not used
6	Not used
7	Positive supply (+B)
8	Positive for blink code button and K5 relay power supply
9	Negative supply (-B)
10	Not used
11	Not used
12	Positive supply (+B)
13	Positive supply (+B)
14	Negative supply (-B)
15	Negative supply (-B)
16	Connected to JA-28
17	Not used
18	Not used

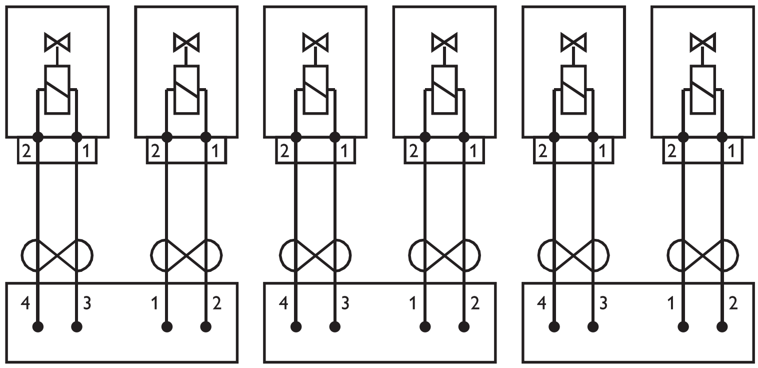
PIN ECU	FUNCTION
19	Power supply for idling switch sensor located in throttle position sensor SW 1 and SW 2 switches located on relay box
20	Positive from K5 relay during cranking
21	Not used
22	Not used
23	Not used
24	Not used
25	Not used
26	Not used
27	Positive from blink-code button
28	Positive for EDC faults indicator light
29	Not used
30	"L" diagnosis line
31	"K" diagnosis line
32	Not used
33	Not used
34	Not used
35	Not used
36	Positive for K1 relay control

PIN ECU	FUNCTION
37	Positivo for K2 relay control
38	Not used
39	Positive connected to + 15 (key switch in ON position)
40	Not used
41	Control from SW 1 to enable engine controls from ENGINE ROOM
42	Control from SW 1 to enable engine controls from ENGINE ROOM
43	Not used
44	Engine start control from SW 2 (located on relay box)
45	Engine stop control from SW 2 (located on relay box)
46	Not used
47	Not used
48	Engine phase output signal
49	Engine speed output signal
50	Not used
51	Not used
52	CAN line
53	CAN line
54	Not used
55	Power supply for throttle position sensor
56	Resistor 3.3 kΩ (balancing load)
57	Not used
58	Not used
59	Not used
60	Not used
61	Not used

PIN ECU	FUNCTION
62	Not used
63	Low oil pressure indicator control
64	EDC fault indicator control
65	High coolant temperature indicator control
66	Not used
67	Not used
68	Not used
69	Not used
70	Not used
71	Not used
72	Signal from idling switch sensor located in throttle position sensor
73	Not used
74	Resistor 3.3 kΩ (balancing load)
75	Not used
76	Not used
77	Not used
78	Not used
79	Not used
80	Not used
81	Negative supply for throttle position sensor
82	Not used
83	Signal from throttle position sensor
84	Not used
85	Not used
86	Not used
87	Not used
88	Not used
89	Not used

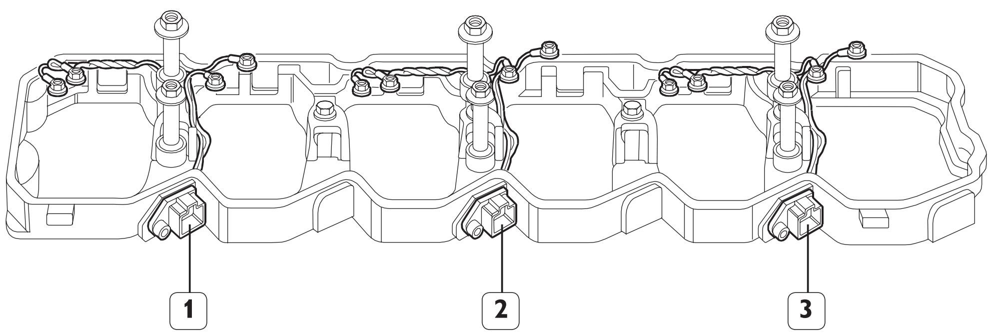
Electro-injectors connectors

Figure 22



04_230_N

Figure 23



04_231_N

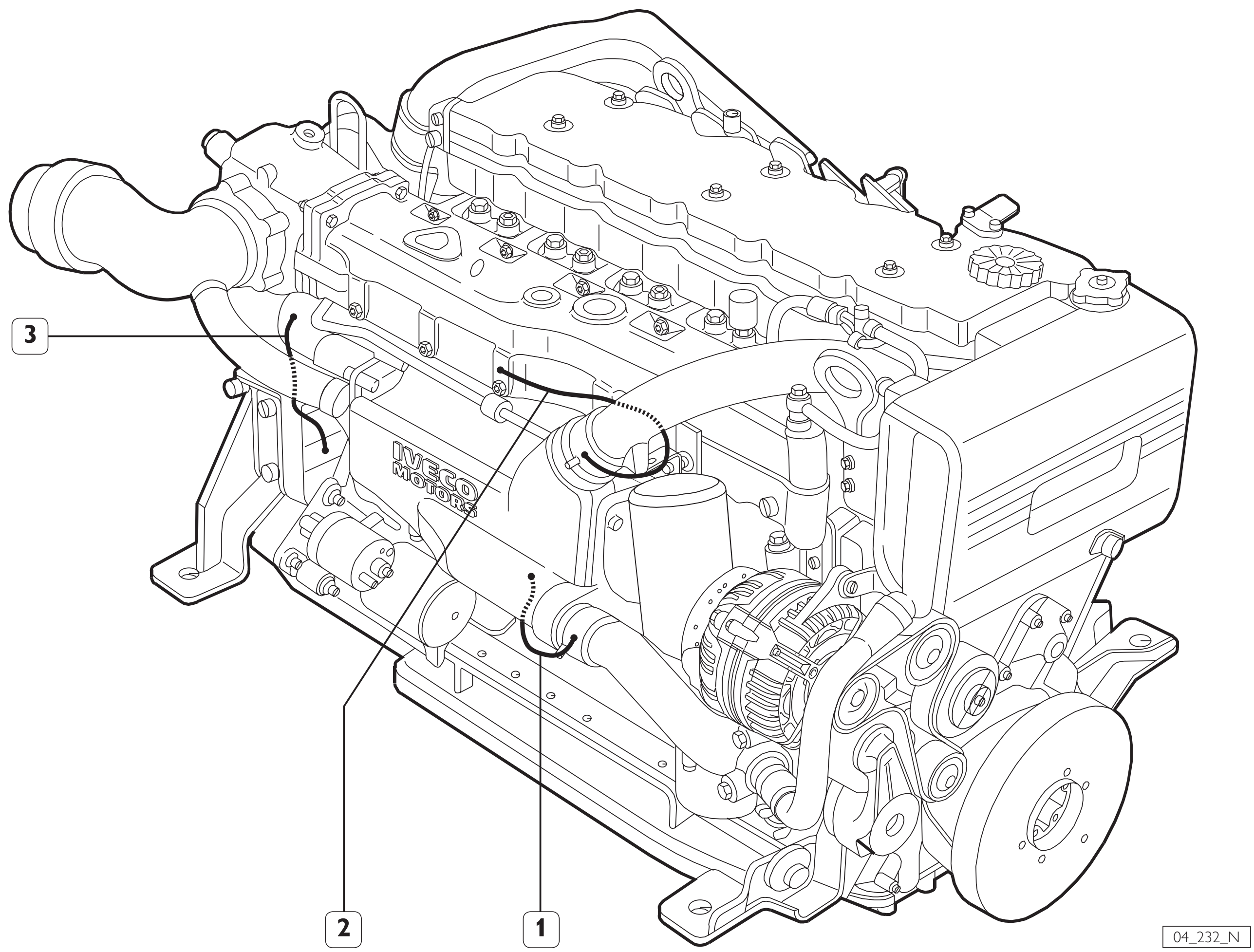
1. Electro-injectors cylinders 1 and 2 connector - 2. Electro-injectors cylinders 3 and 4 connector - 3. Electro-injectors cylinders 5 and 6 connector (not applicable for the 4 cylinders).

The wiring connecting the electro-injectors to the ECU is made up of two branches: the first one is located in the bay that houses the timing elements, the second one is integrated in the engine wiring and ends with 3 four-way connectors.

The 3 wiring inside the timing bay have been made with pairs of conductors whose insulation is apt to withstand the hard conditions of that environment; every couple of conductor is braided to avoid the generation of electromagnetic interferences. Pay special attention to the phases of connection of the terminals of the wiring of the electro-injectors which have to take place with spotless clean conductors and applying the correct tightening torque.

EQUIPOTENTIAL CONNECTIONS TO ENGINE GROUND

Figure 24



To prevent electrochemical corrosion phenomena, some elements included in the cooling circuits were electrically grounded with copper braids with eyelet terminations.
Elements connected to the engine ground with metallic braid conductors:

1. Junction of the fresh water outlet pipe from the water/water heat exchanger;
2. Fresh water supply pipe to water/water exchanger;
3. Sea-water supply pipe to water/water exchanger.

CAUTION

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

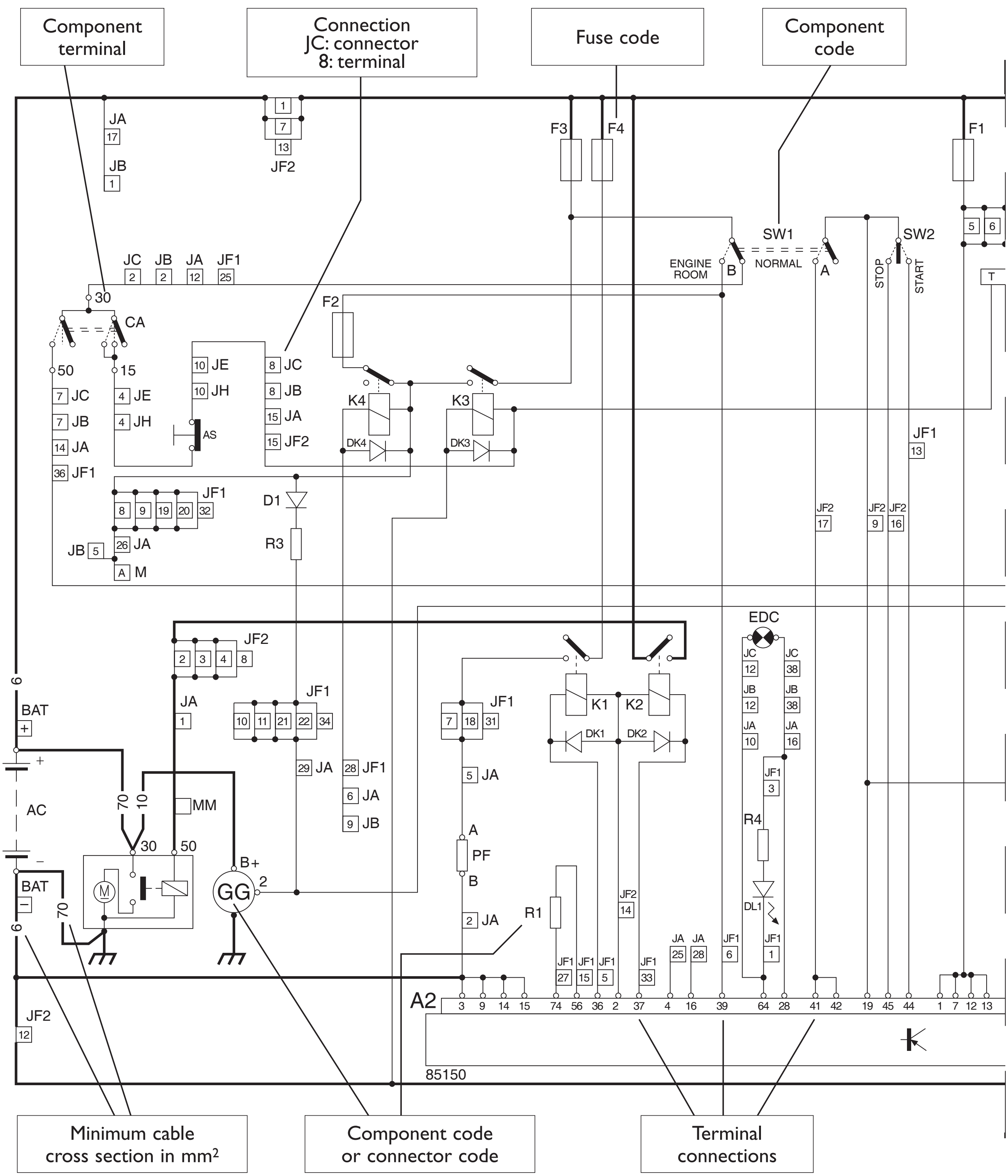
ELECTRICAL DIAGRAMS

Wiring diagram key

General conditions for the preparation and interpretation of wiring diagrams

- ❏ Key switch open;
- ❏ Engine not running;
- ❏ Liquids at efficient levels and pressures.

Figure 25



Electrical equipment component code

A	fuel temperature sensor for EDC
B	drive shaft sensor
C	camshaft sensor
F	engine coolant temperature sensor for EDC
H	combustion air pressure/temperature sensor for EDC
K	air filter clogging sensor (for alarm)
L	instrument panel light switch
M	sensor for detecting the presence of water in the fuel pre-filter (for alarm)
O	exhaust gas temperature sensor
T	coolant temperature sensor (for gauge)
V	oil pressure sensor (for gauge)
P1	sound alarm inhibition push-button
R1	3.3 kΩ resistor to inhibit speed input
R2	120 Ω resistor for CAN line balancing
R3	alternator pre-excitation resistor
R4	DL1 resistor
AC	battery
AQ	engine shut-off push-button on main panel
AS	engine shut-off push-button on secondary panel
CA	key switch
CS	engine start push-button on secondary panel
GG	alternator
IN	electro-injector
MC	converter module for digital panel
MM	electric starter motor
MS	IVECO MOTORS-FPT indications and alarms module
PA	throttle position sensor
PE	emergency shut-down push-button (optional, installer's responsibility)
PF	heating element on fuel filter
PR	rail pressure sensor
QP	main analog instrument panel
QS	secondary analog instrument panel
SA	buzzer
SI	gearbox oil temperature sensor
VE	engine oil pressure/temperature sensor for EDC
VI	high gearbox oil pressure sensor (25 bar)
WI	low gearbox oil pressure sensor (7 bar)
ZH	pressure control solenoid valve
DL1	EDC fault indicator and blink code LED (on relay box panel)
SW1	bridge or engine room engine control selector (on relay box panel)
SW2	manual throttle control in engine room (on relay box panel)
SW3	blink code emission request push-button (on relay box panel)
85150	ECU of the EDC system

(continues on next page)

Electrical equipment component code (cont.)

Connectors

A	36 pole EDC engine components
A1	16 pole EDC electro-injectors
A2	89 poles EDC boat side
E1	cylinders 1 and 2 electro-injectors
E2	cylinders 3 and 4 electro-injectors
E3 (✻)	cylinders 5 and 6 electro-injectors
ECF (▲)	for the engine stopping function if stressed
ECM (▲)	for the engine stopping function if stressed
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
JE1 ON INTERFACE WIRE HARNESS FOR CONVERTER MODULE	set for connection to the 2nd main digital instrument panel
JF1	relay box
JF2	relay box
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	high coolant temperature
SBLA	low coolant level
SBPO	low oil pressure
SCP	pre-post heating
SIFA	clogged air filter
SIFB	clogged oil vapor filter
SIFC	clogged fuel filter
SIFO	clogged oil filter
SP	pre-lubrication
SS	alternator fault
SSV	runaway engine

Gauges

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

Relays contained in the relay box

K1	fuel filter heater element power supply
K2	power supply to terminal 50 of the electric starter motor
K3	key switch electric discharge
K4	emergency engine shut-down provision
K5	start request signal, from key switch to EDC electronic unit

Fuses contained in the relay box

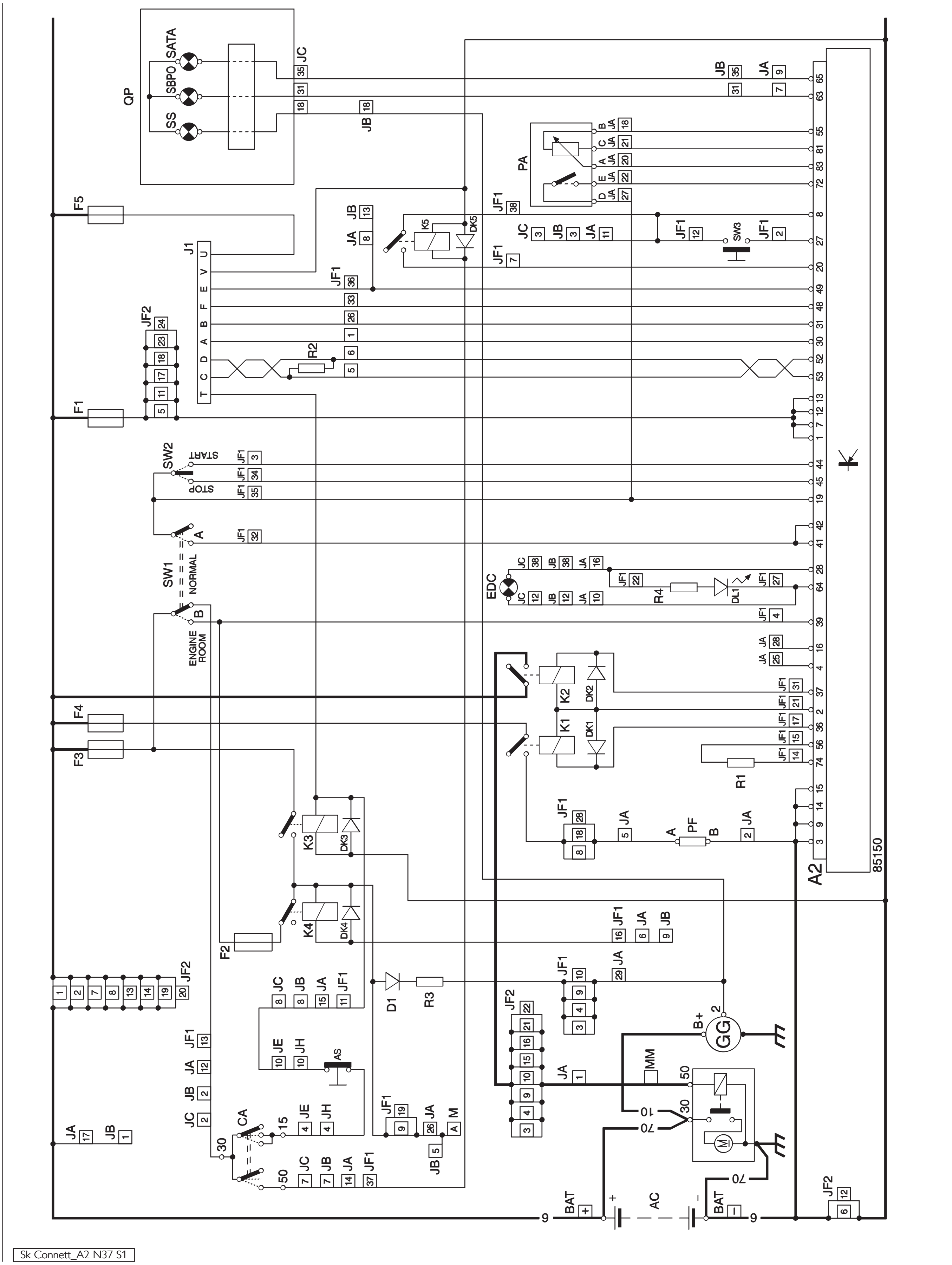
F1, F2, F3, F4, F5	self restoring (not replaceables)

(✻) Not applicable for the 4 cylinders

(▲) Present on the wiring of the new model

EDC connector A2

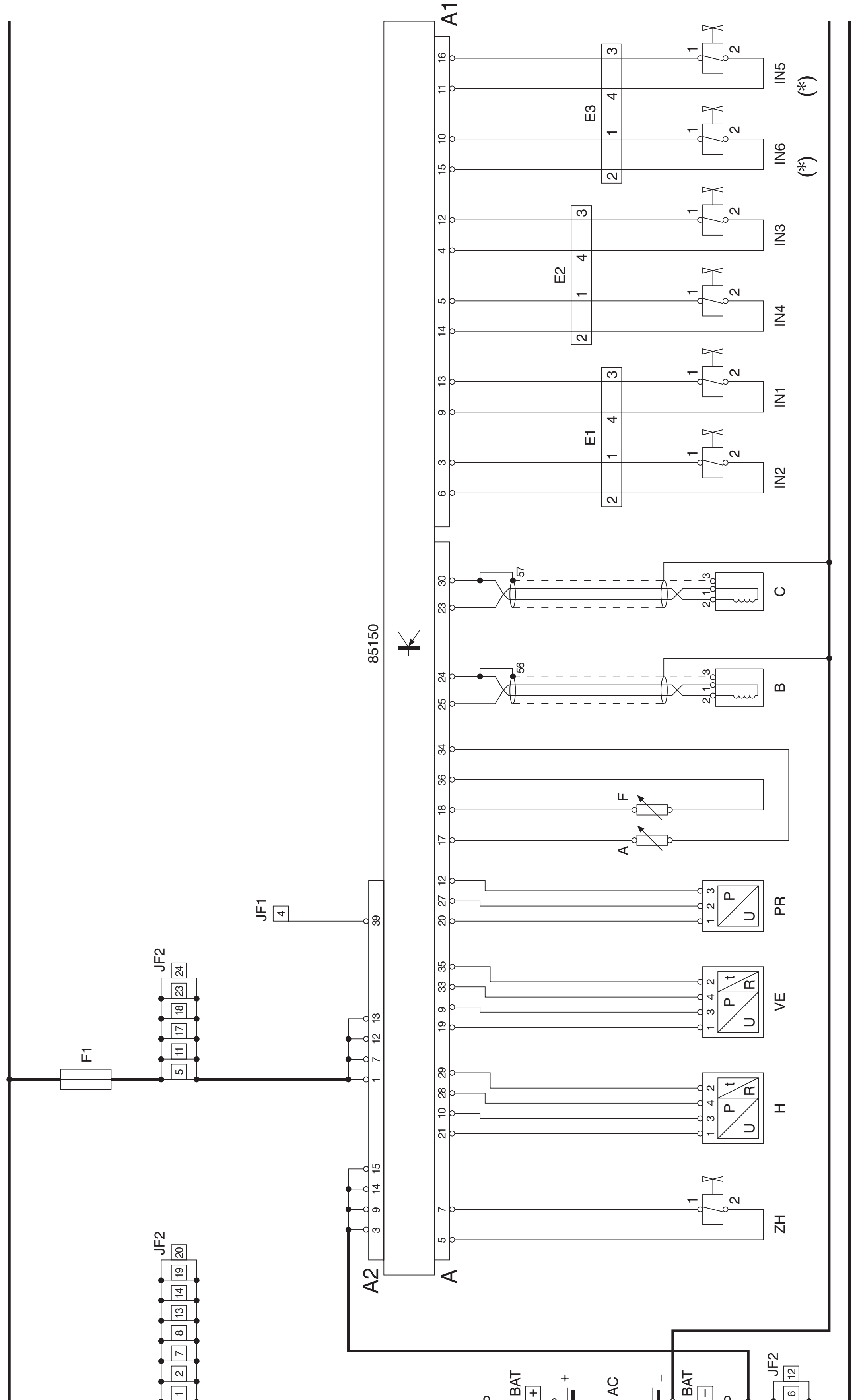
VERSION PRIOR TO 10/2003



Sk Connett_A2 N37 S1

EDC connectors A - A1

VERSION PRIOR TO 10/2003

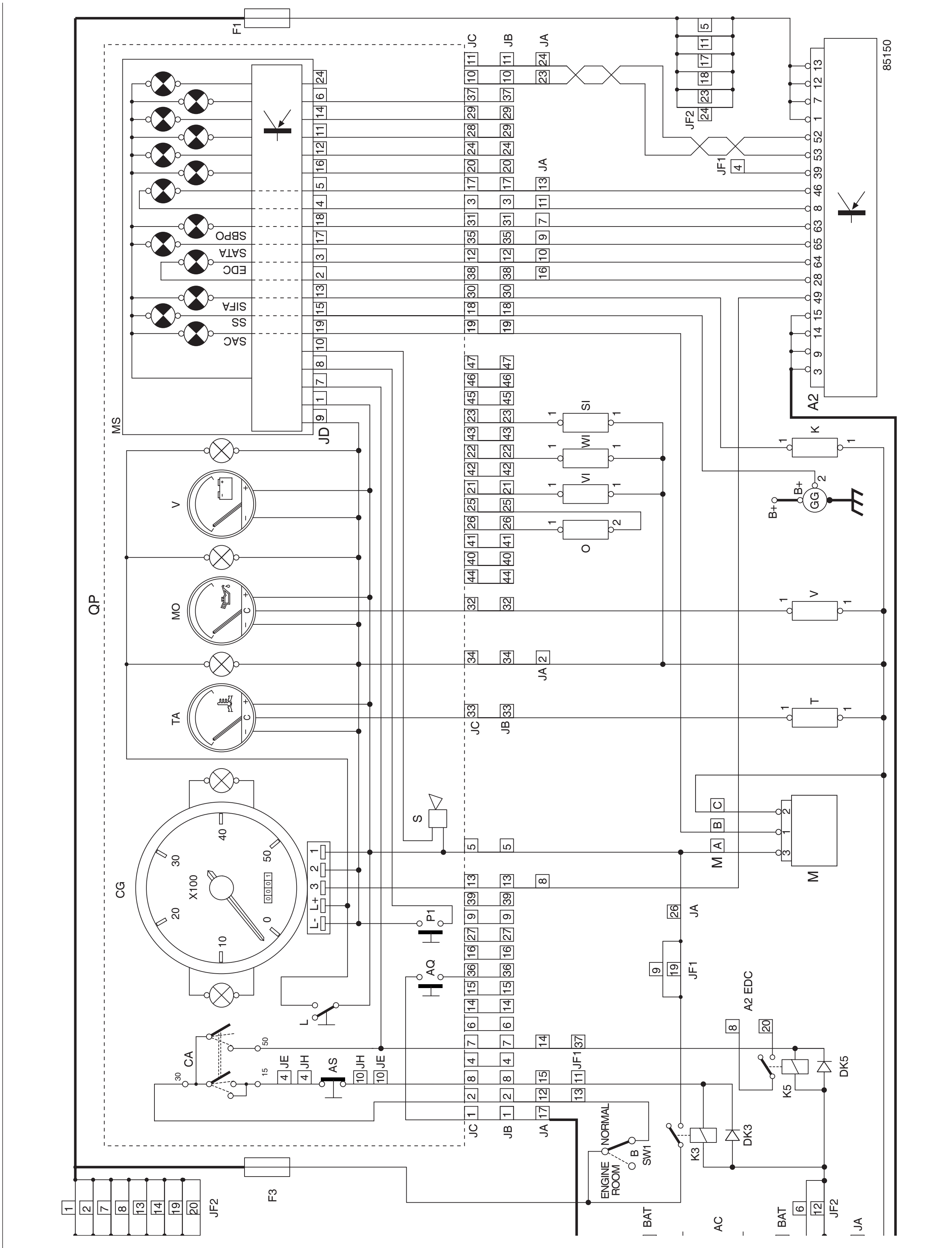


(*) Not applicable for the 4 cylinders.

Sk Connett_A2 N37 S1

Main analog instrument panel

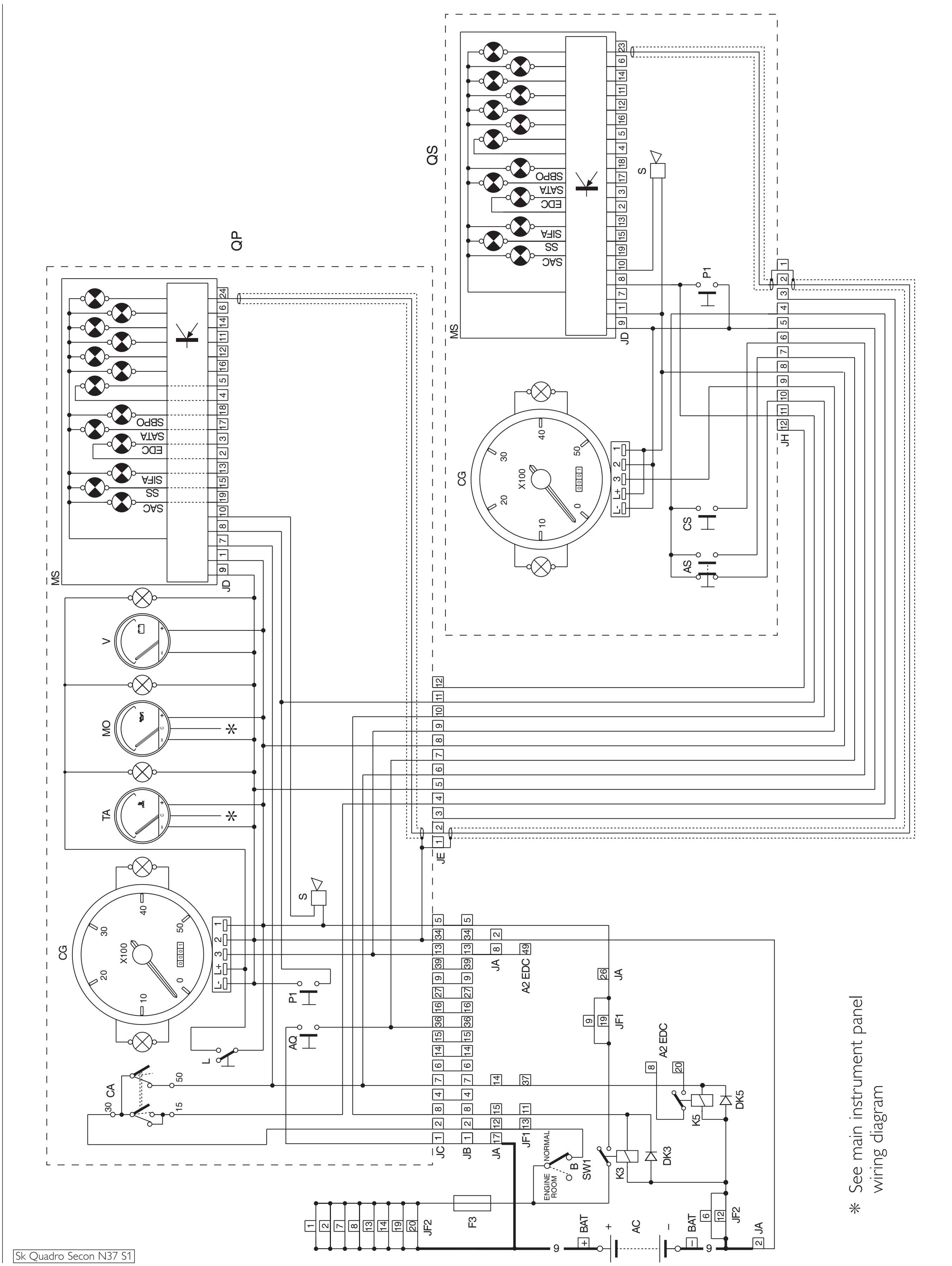
VERSION PRIOR TO 10/2003



Sk Quadro Princ N37 S1

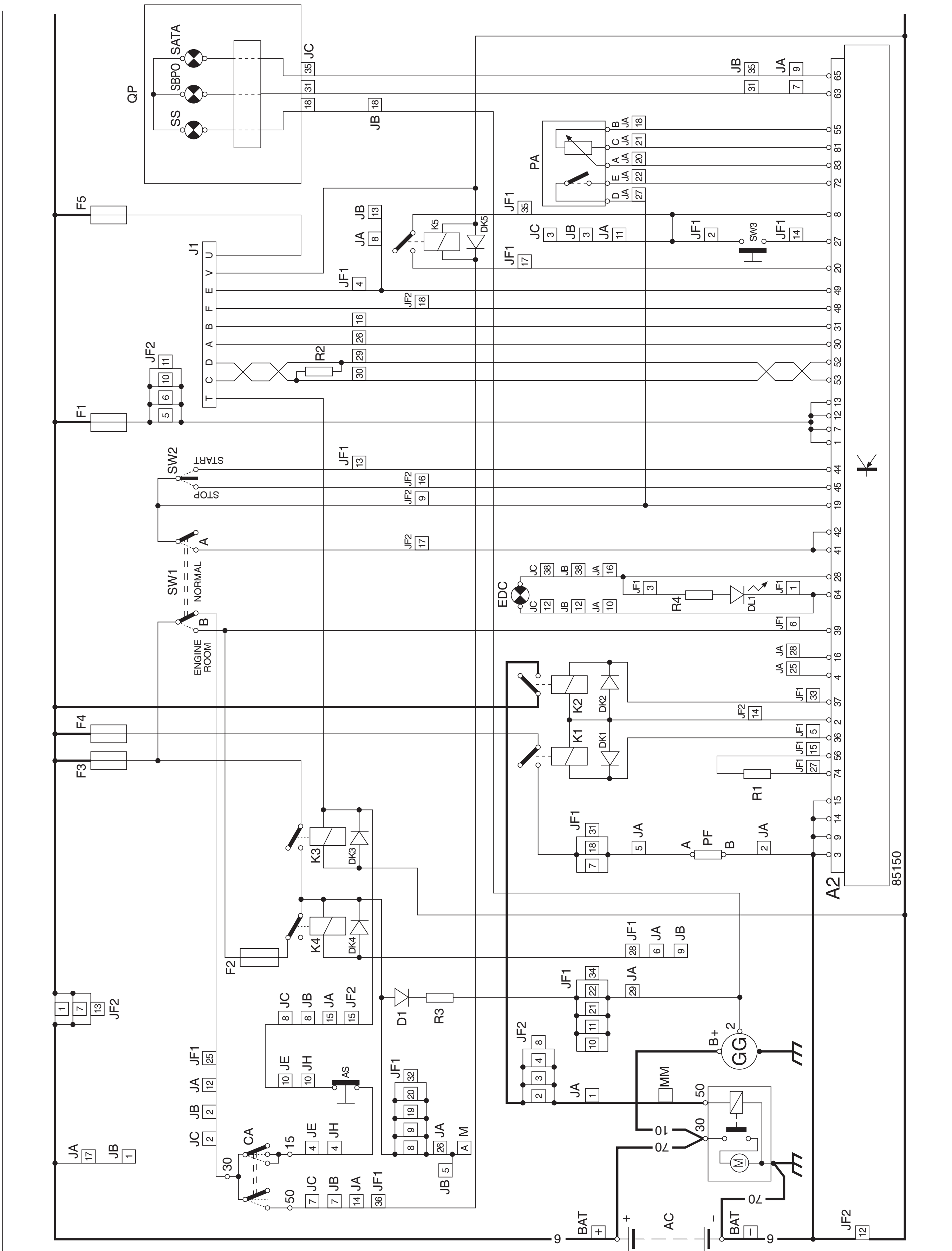
Secondary analog instrument panel

VERSION PRIOR TO 10/2003



EDC connector A2

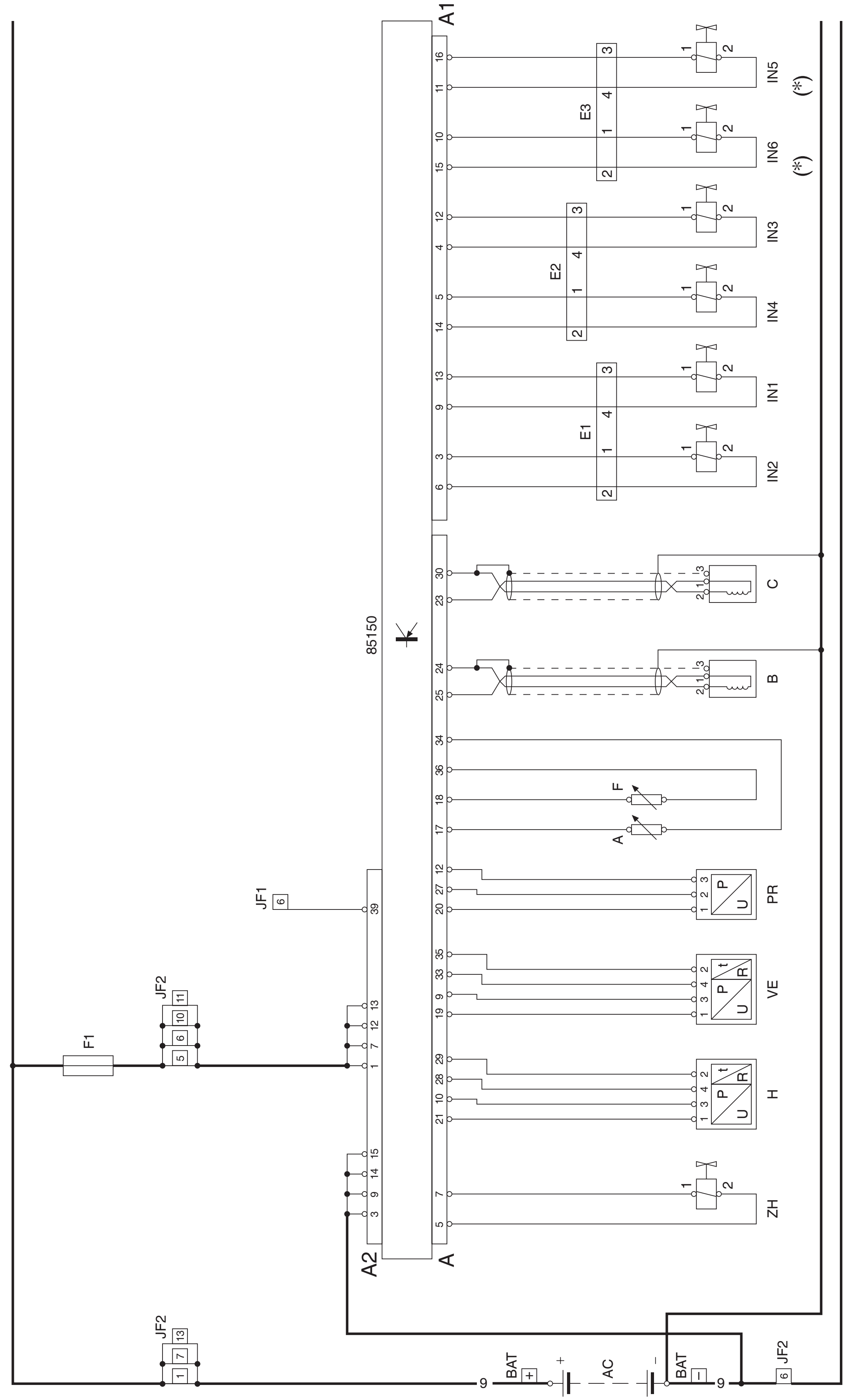
VERSION FROM 11/2003 TO 2005



Sk Connett_A2 N37 S2

EDC connectors A - A1

VERSION FROM 11/2003 TO 2005

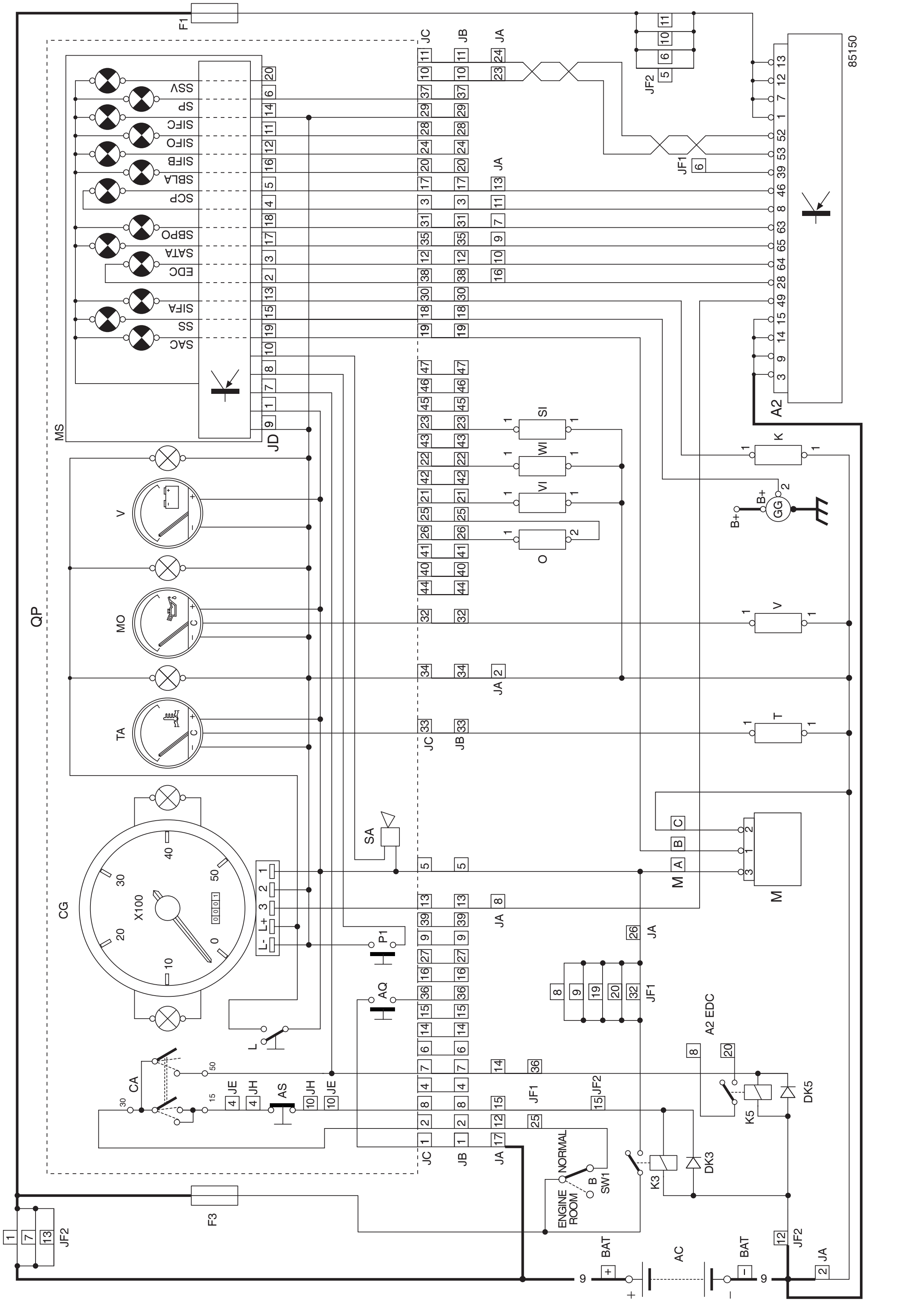


(*) Not applicable for the 4 cylinders.

Sk Connett_A-A1 N37 S2

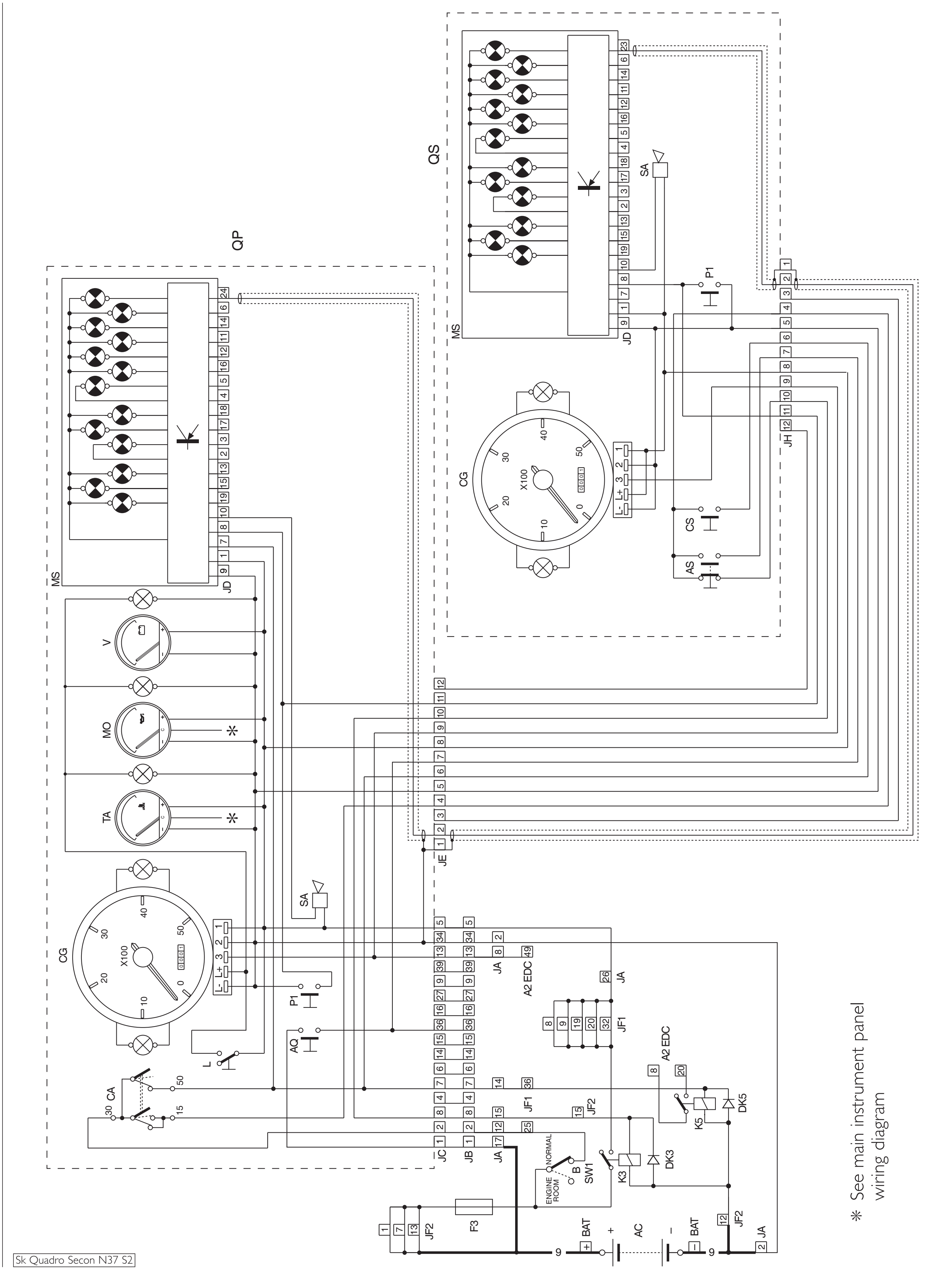
Main analog instrument panel

VERSION FROM 11/2003 TO 2005



Secondary analog instrument panel

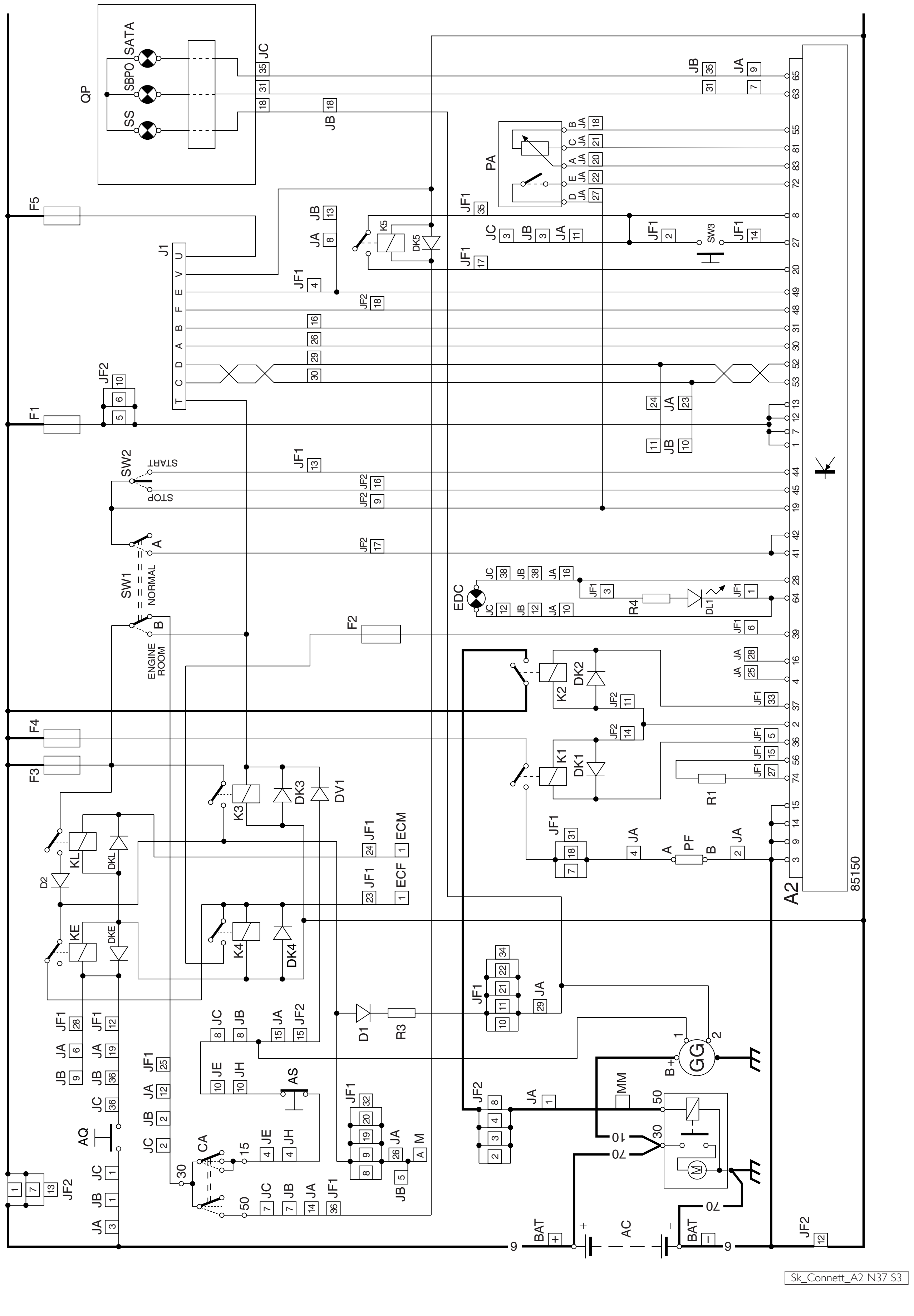
VERSION FROM 11/2003 TO 2005



Sk Quadro Secon N37 S2

EDC connector A2

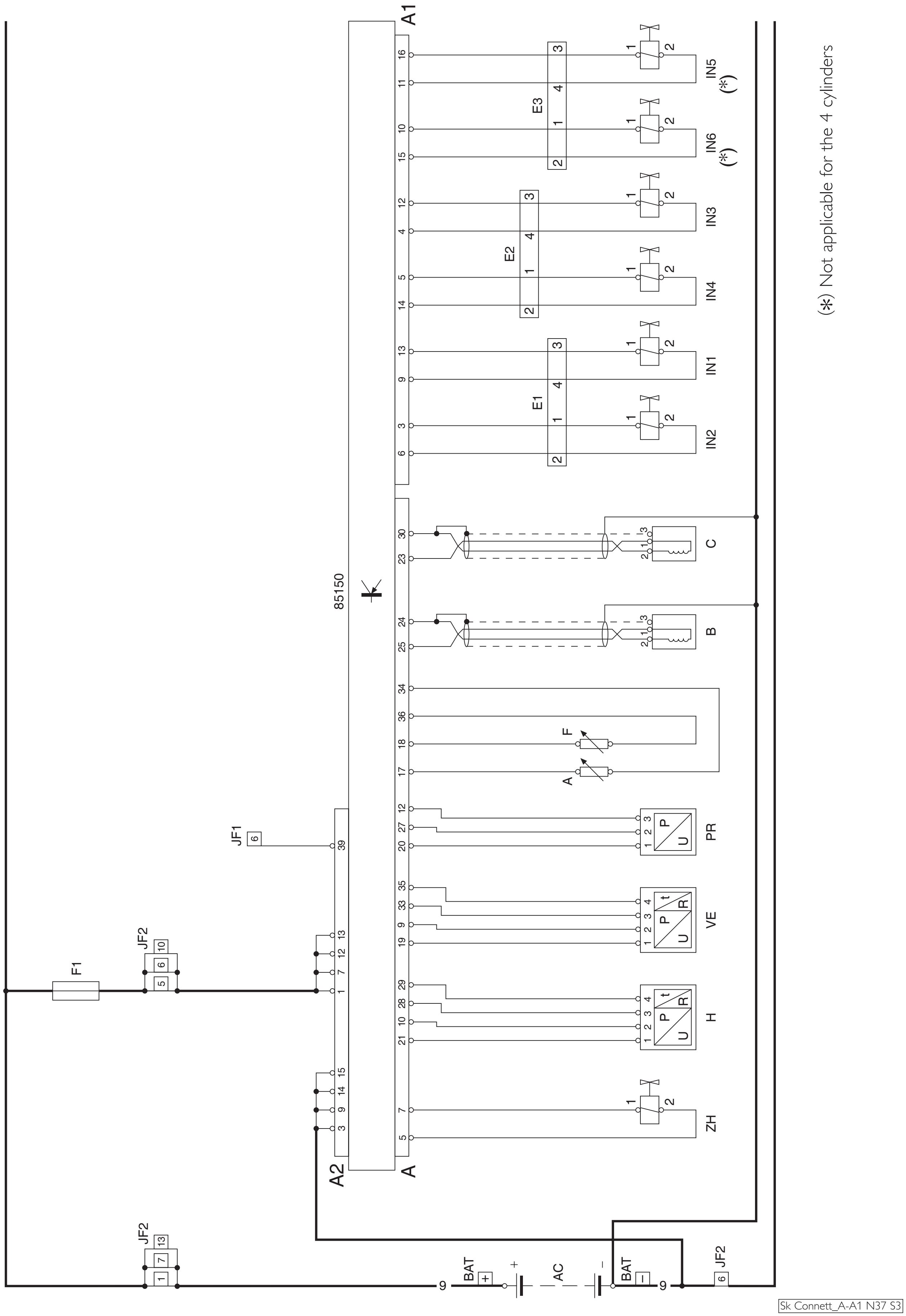
EXISTING MODEL



Sk_Connett_A2 N37 S3

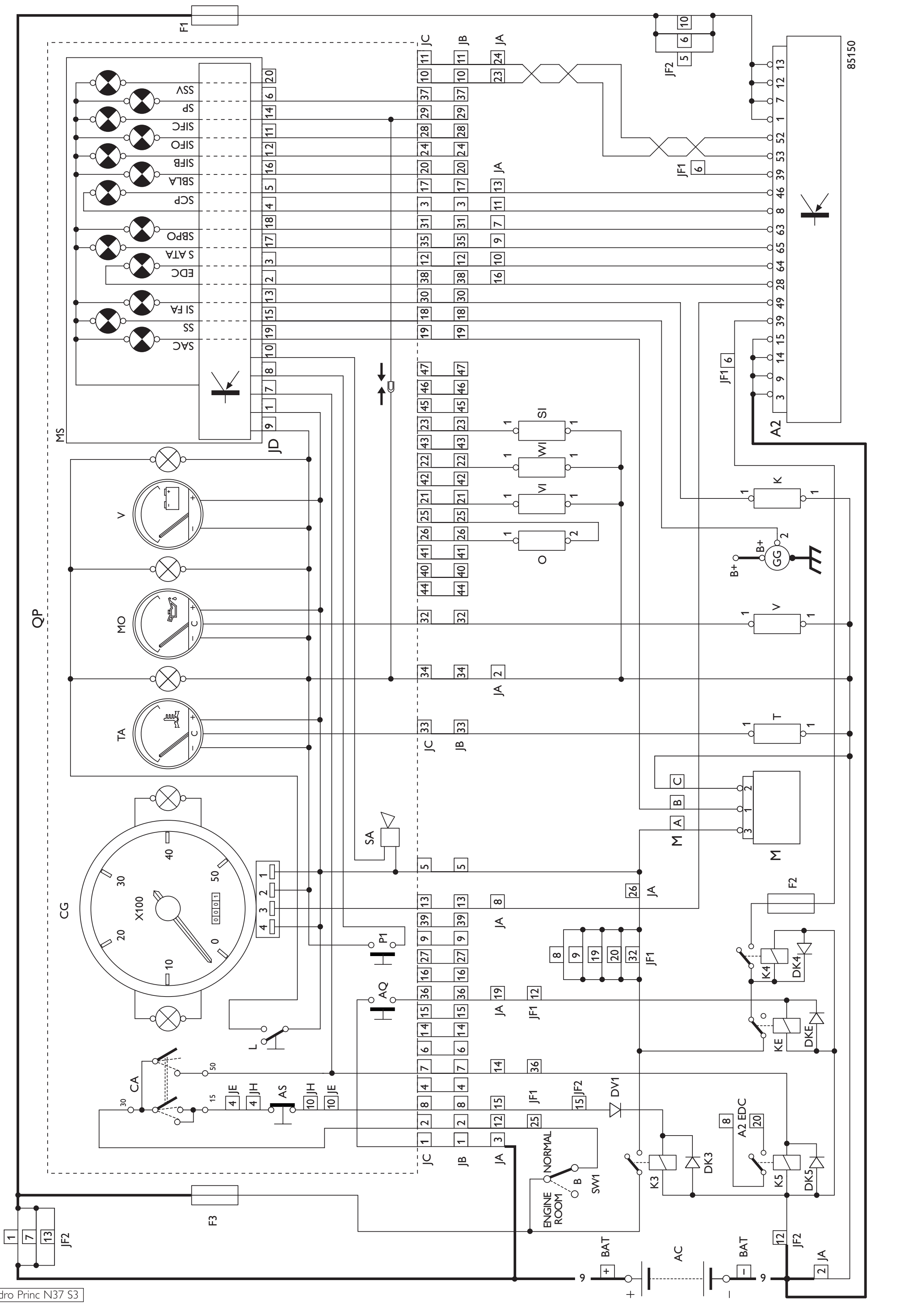
EDC connectors A - A1

EXISTING MODEL



Main analog instrument panel

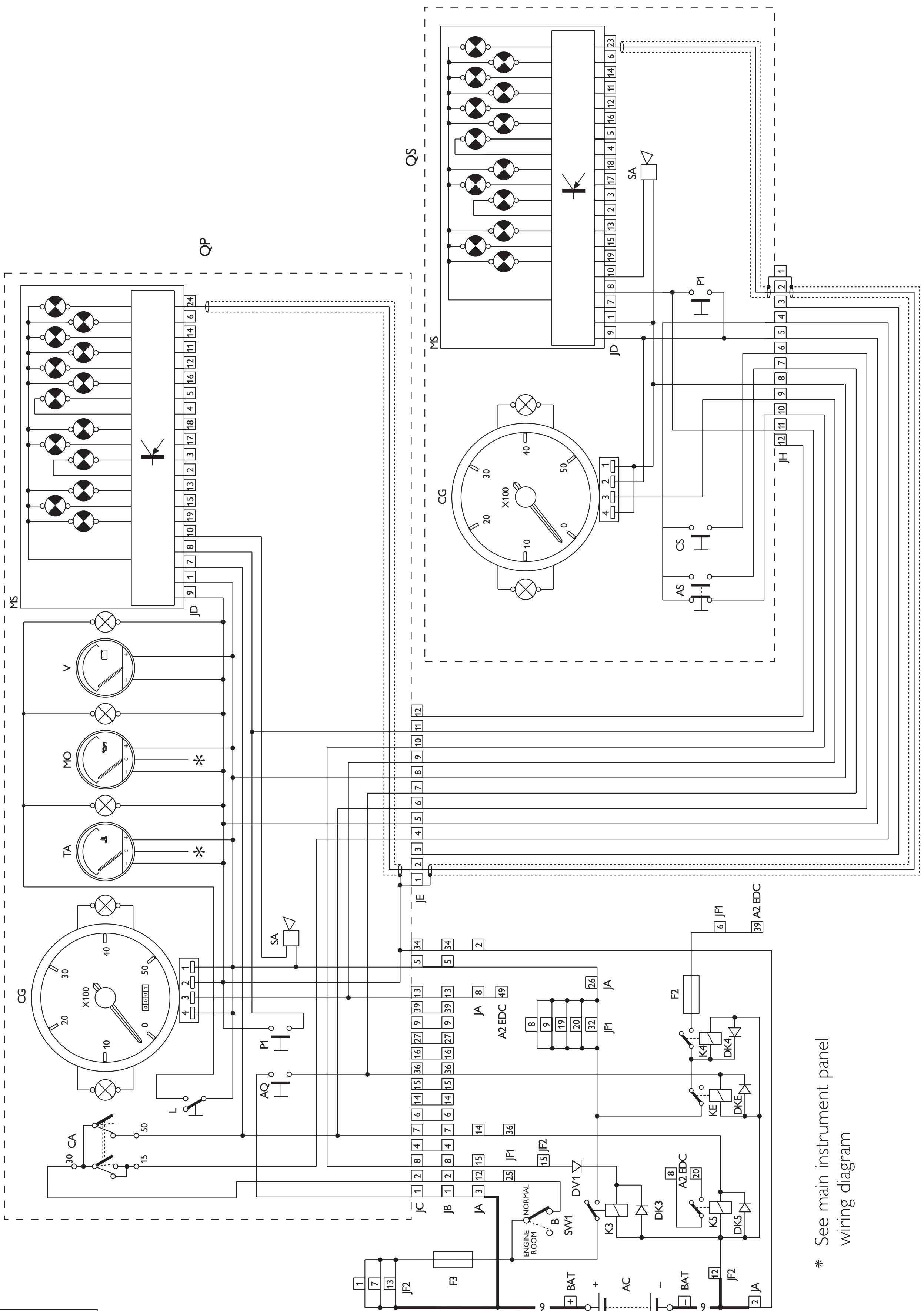
EXISTING MODEL



Sk Quadro Princ N37 S3

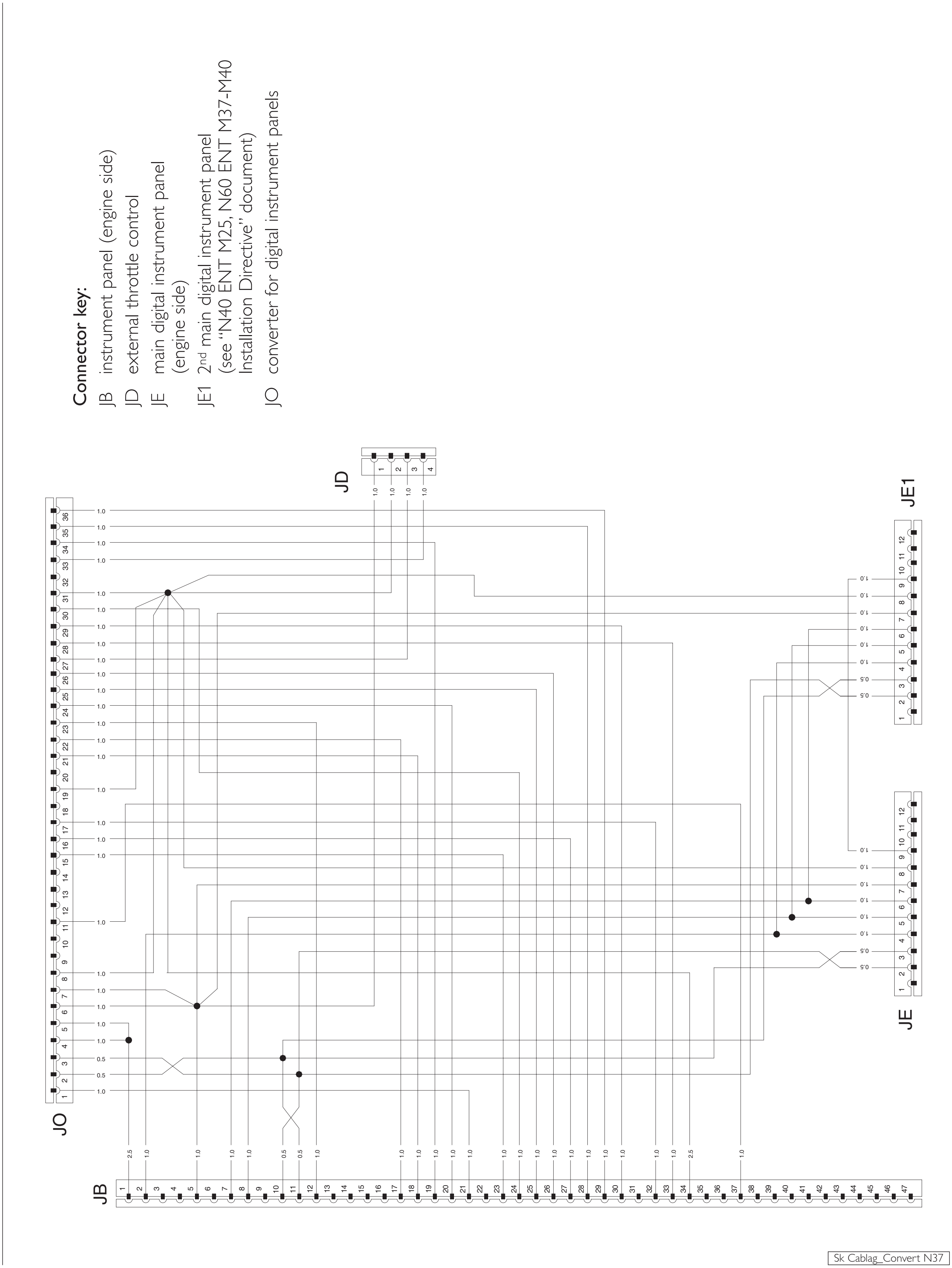
Secondary analog instrument panel

EXISTING MODEL



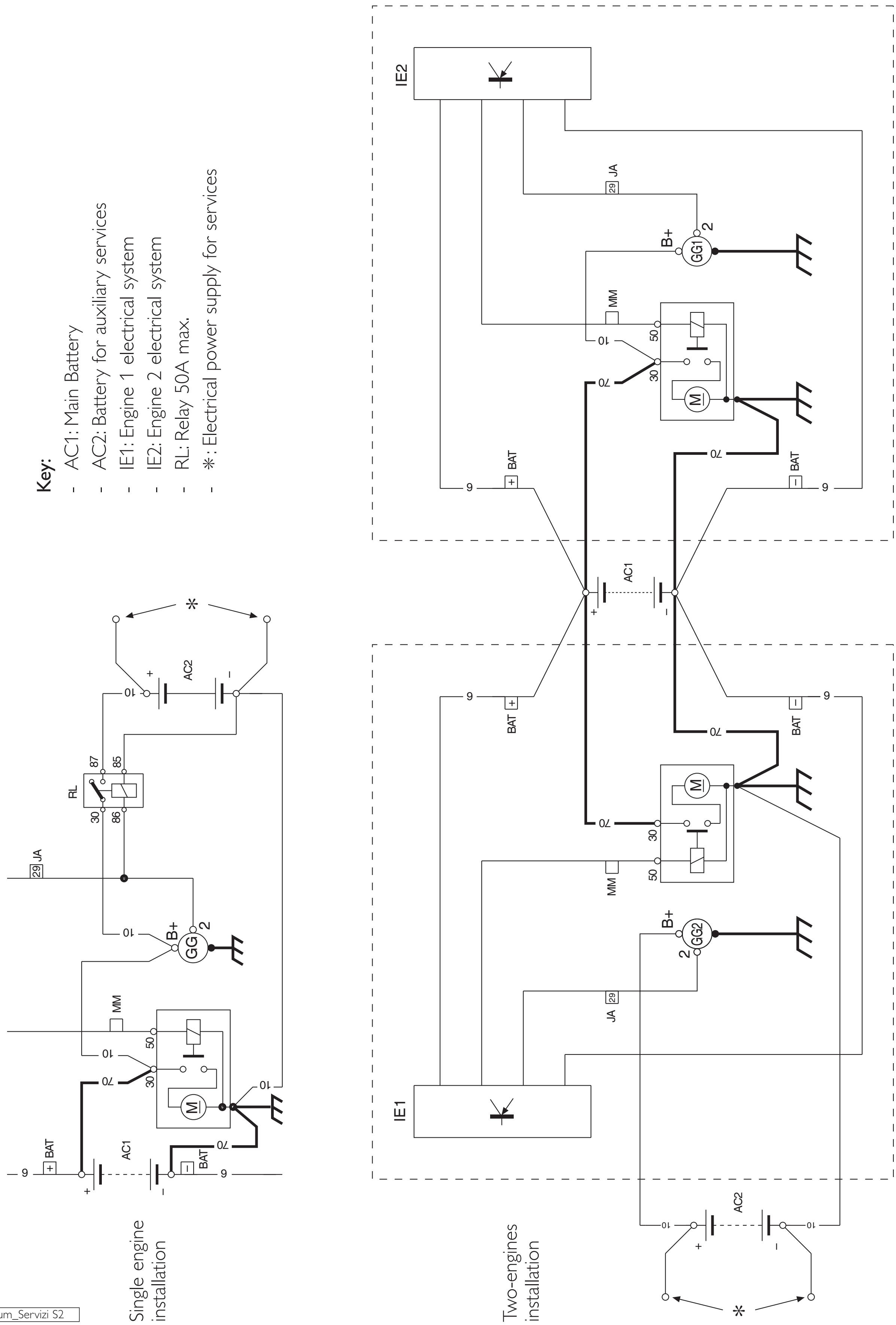
Sk Quadro Secon N37 S3

CAN - BUS converter module interface wiring



Supplementary services battery recharge

Key:
- AC1: Main Battery
- AC2: Battery for auxiliary services
- IE1: Engine 1 electrical system
- IE2: Engine 2 electrical system
- RL: Relay 50A max.
- *: Electrical power supply for services



SECTION 4

DIAGNOSTICS

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FOREWORD

A proper diagnosis is reached through the competence acquired with years of experience and attending training courses.
When the user complains of poor performance or operating anomalies, due consideration must be given to his/her indications, in order to derive useful information that will orient our actions.
After ascertaining the existence of the anomaly, we recommend starting troubleshooting operations by decoding the self-diagnosing data of the Central Electronic Unit of the EDC system.
The continuous operating tests on the components connected to it and the test of the operation of the entire system periodically carried out while in operation, provide an important diagnostic indication, made available by decoding the "error/anomaly" codes issued by the blinking of the fault indicator light: the "blink-code".
Using computerized IVECO MOTORS-FPT instruments, IT 2000 and PT 01, two-way communications can be established with the central unit, enabling not only to decode the error codes but also to route the investigation in its memory to retrieve the additional information required to determine the origin of the fault.
Every time a problem is notified and its existence is ascertained, you must query the electronic unit in one of the ways indicated and then proceed with troubleshooting with tests and measurements, to obtain a picture of the overall operating conditions and identify the real causes of the fault.
If the electronic unit provides no indications, proceed through experience, adopting traditional diagnostic modes.
Technicians and maintenance personnel are advised, in these cases, to check ratings and technical data prescribed in the "N40 ENT M25, N60 ENT M37-M40 Installation Directive" document.
In order to partly overcome service personnel's lack of experience with this new system, we have provided, in the pages that follow, a TROUBLESHOOTING GUIDE.

The guide comprises two distinct sections:

- The first one, organized by Blink Code, involves the anomalies identified by the EDC 7 unit, mainly electrical or electronic in nature;
- The second one, organized by symptoms, describes the possible anomalies not recognized by the electronic unit, frequently mechanical or hydraulic in nature.

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

ECU BEHAVIOUR

Anomalies indicator light

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

Light off: no anomaly detected or slight anomaly that does not compromise operating safety

Light on: significant anomaly, allowing to proceed to a service center

Blinking light: severe anomaly requiring immediate repairs. If possible, shut the engine down.

Blink code

The emission of the anomaly codes detected during self-testing and stored in the ECU starts after pressing and releasing the "CHECK" push-button on the relay box panel, 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 indicator and control 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.

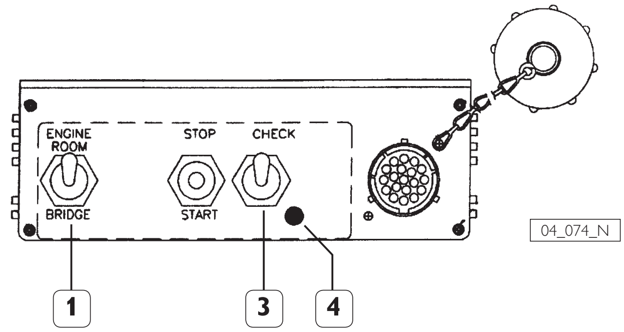
If no anomalies are stored, the light comes on when the push-button is pressed and comes off about 1 second after its release, without any subsequent blinking.

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 anomalies whose cause has already been removed from being signaled in the future.

Error deletion procedure

Figure 1



A. Shut the engine down and keep the key switch in the "OFF" position;

B. Go to the relay box. Keeping the "CHECK" diagnostic push-button (3) pressed, move the adjacent "BRIDGE - ENGINE ROOM" switch (1) to the "ENGINE ROOM" position, while keeping the diagnostic push-button pressed for 8 more seconds;

C. Release the push-button and move the "ENGINE ROOM" switch to the "BRIDGE" position.

The confirmation of the cancellation carried out will be provided by a following query of the blink code; the blink code light (4) 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 preset thresholds according to the severity of the case.

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

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

BLINK CODE TABLE (software version 4.1_2 V5.3)

Blinking Code	EDC indicator light	Indicated fault	Max power reduction
		Control area	
1.1	(on)	not significant in marine applications	-
1.3	(on)	not significant in marine applications	-
1.4	on	throttle position sensor	**x**
1.5	(off)	not significant in marine applications	-
1.6	(on)	not significant in marine applications	-
1.7	(off)	not significant in marine applications	-
1.8	on	EDC lamp indicator	-
		Engine Area 1	
2.1	on	water temperature sensor	-
2.2	off	air temperature sensor	-
2.3	off	fuel temperature sensor	-
2.4	on	supercharge air pressure sensor	**x**
2.5	off	ambient pressure sensor (inside the unit)	-
2.6	on	lubrication oil pressure sensor	-
2.7	on	lubrication oil temperature sensor	-
2.8	off	coil relay fuel heater	-
2.9	(on)	not significant in marine applications	-
		Engine Area 2	
3.1	off	cylinder balancing 1	-
3.2	off	cylinder balancing 5 (*)	-
3.3	off	cylinder balancing 3	-
3.4	off	cylinder balancing 6 (*)	-
3.5	off	cylinder balancing 2	-
3.6	off	cylinder balancing 4	-
3.7	on	battery voltage	-
3.8	(off)	not significant in marine applications	-
3.9	(on)	not significant in marine applications	-
4.6	(on)	not significant in marine applications	-

(*) Not applicable for the 4 cylinders.

(continue to next page)

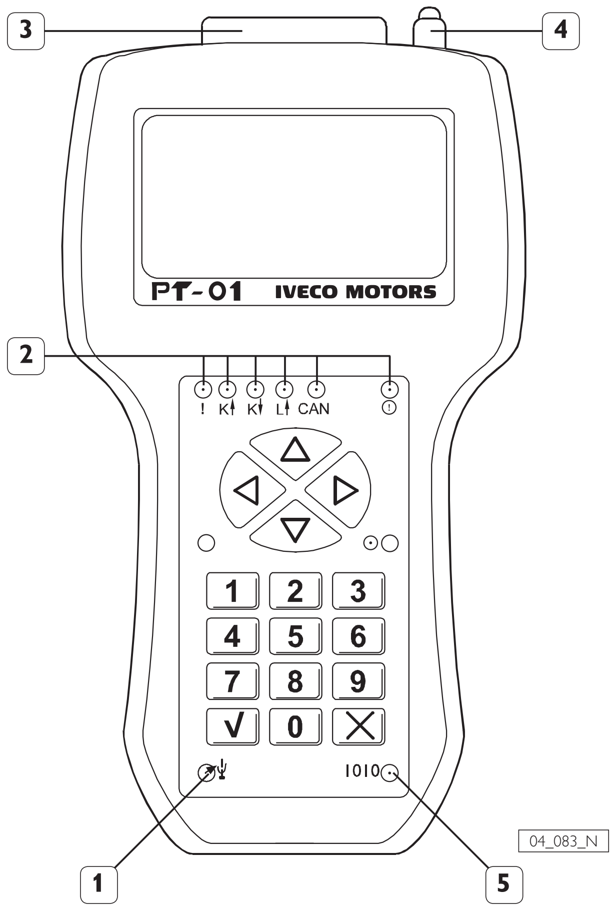
Blinking Code	EDC indicator light	Indicated fault	Max power reduction
		Injectors	
5.1	on	cylinder 1 electro-injector fault	**x**
5.2	on	cylinder 5 electro-injector fault (*)	**x**
5.3	on	cylinder 3 electro-injector fault	**x**
5.4	on	cylinder 6 electro-injector fault (*)	**x**
5.5	on	cylinder 2 electro-injector fault	**x**
5.6	on	cylinder 4 electro-injector fault	**x**
5.7	on	electro-injector cylinder 1-2-3 power driver (1-4 for the 4 cylinders)	**x**
5.8	on	electro-injector cylinder 4-5-6 power driver (2-3 for the 4 cylinders)	**x**
		Engine RPM sensor	
6.1	on	flywheel sensor	**x**
6.2	on	timing system sensor	**x**
6.3	off	engine speed signal plausibility	-
6.4	blinking	engine overspeed	-
6.5	on	coil relay electric starter motor	-
6.6	off	revolution counter signal	-
6.8	off	synchronism trouble with diagnosis tool	-
		Fuel pressure	
8.1	blinking	fuel pressure control	**x**
8.2	blinking	fuel pressure signal	**x**
8.3	blinking	pressure regulator solenoid valve	**x**
8.4	blinking	twin stage valve tripping	**x**
8.5	blinking	MIN/MAX rail pressure error	ENGINE STOP
		Electronic unit	
9.3	(blinking)	not significant in marine applications	**x**
9.4	on	main relay	-
9.6	blinking	after-run procedure not completed	**x**
9.7	on	sensor/ECU supply	**x**

(*) Not applicable for the 4 cylinders.

DIAGNOSING WITH PT-01 INSTRUMENT

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

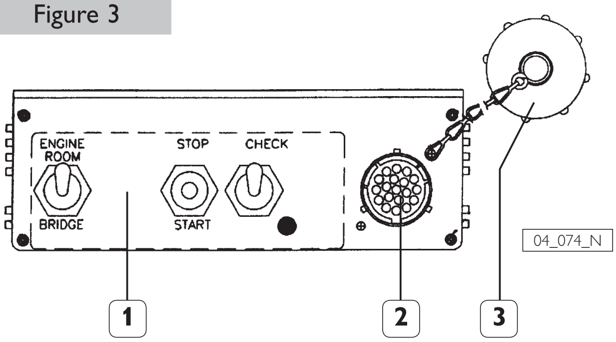
Figure 2



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

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

Figure 3



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

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

Functions of the Instrument

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

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

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

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

CAUTION

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

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

The instrument displays the following options:

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

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

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

Identifier

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

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

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

Fault Memory

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

- Intermittent;
- Present.

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

First screen

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

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

Second screen

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

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

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

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

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

Relays
- Main;
- Fuel filter heater.

Power supply voltage

Indicator lights
- EDC.

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

Parameter reading

Parameters available for display are grouped into two categories:

- Measurable;
- State.

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

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

Active diagnostics

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

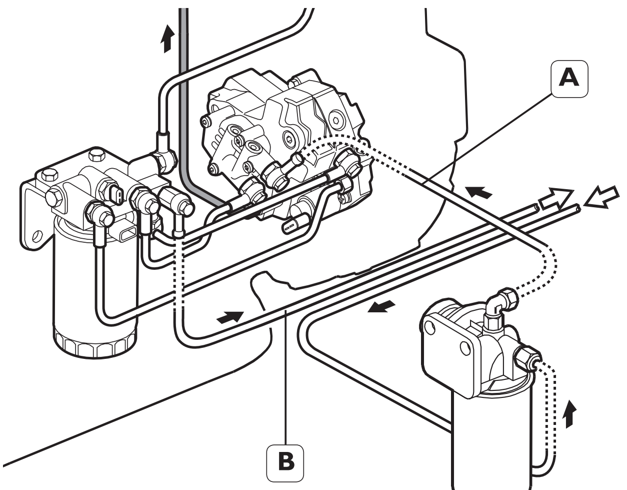
The components driven by the instrument are:
- Fuel filter heater relay;
- EDC indicator light.

MAJOR DIAGNOSTIC ACTIONS

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

Checking pressure in fuel supply line

Figure 4



04_072_N

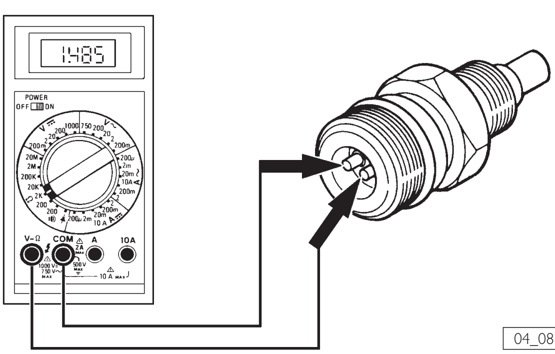
Gauges will be interposed in A and B by "T" unions. Measurements have to be carried out at various engine speeds from minimum to maximum at intervals of 200 RPM.

Acceptable limit ratings

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

Checking component resistance value

Figure 5

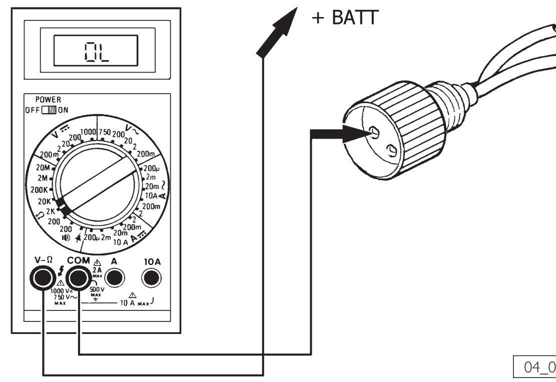


04_086_N

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

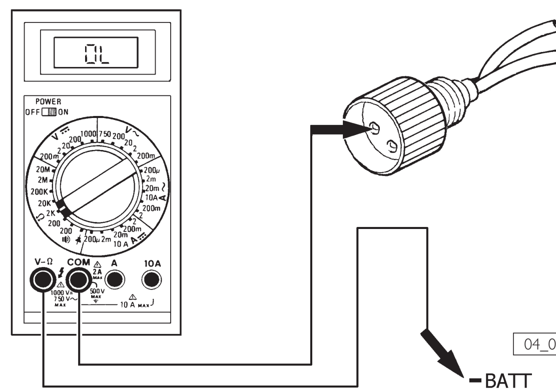
Checking line insulation

Figure 6



04_087_N

Figure 7



04_088_N

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

REFERENCE VALUES

For non hardwired sensors

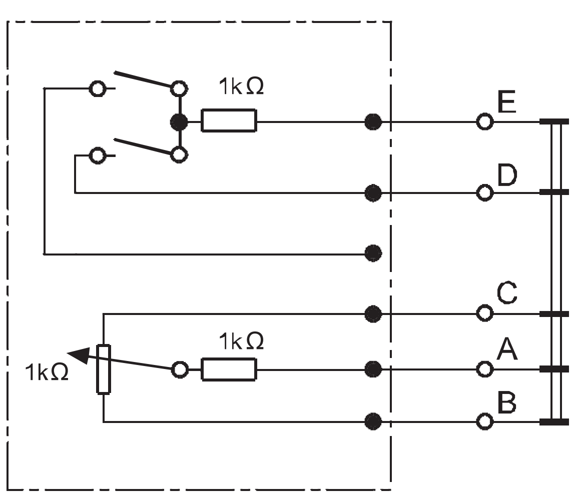
Component	Test conditions	Minimum Ω value	Maximum Ω value
Intake air temperature sensor Coolant temperature sensor Fuel temperature sensor Lubrication oil temperature sensor	-10 °C	8100	10800
	0 °C	5200	6750
	20 °C	2300	2700
	50 °C	730	950
	80 °C	300	360
Flywheel position and rotation sensor	20 °C	800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

CAUTION

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

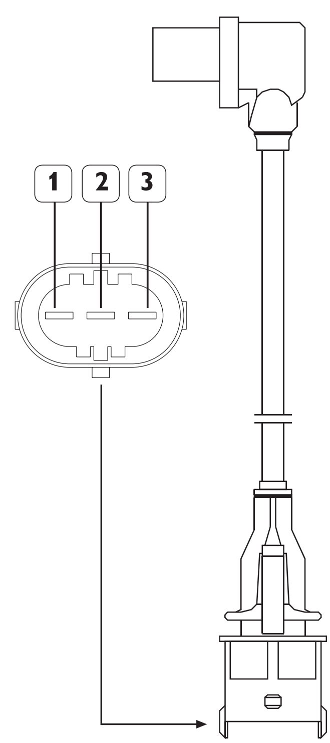
Throttle position sensor

Figure 8



04_089_N

Sensors wired with shielded wires



04_063_N

REFERENCE VALUES

For wired sensors powered by the ECU

Component	ECU connection	Test conditions	Minimum - maximum value
Combustion air temperature sensor signal	A21 A29	Panel key ON	0.5 to 4.5 Vcc
Coolant temperature sensor signal	A18 A36	Panel key ON	0.5 to 4.5 Vcc
Fuel oil temperature sensor signal	A17 A34	Panel key ON	0.5 to 4.5 Vcc
Flywheel position and rotation sensor signal	A24 A25	Engine running 650 rpm	> 0.8 Vac
Camshaft position and rotation sensor signal	A23 A30	Engine running 650 rpm	> 0.2 Vac
Combustion air absolute pressure sensor signal	A21 A28	Engine running 650 rpm	0.9 to 1.1 Vcc
Combustion air absolute pressure sensor power supply	A10 A21	Panel key ON	4.5 to 5.5 Vcc
Fuel pressure sensor power supply	A12 A20	Panel key ON	4.5 to 5.5 Vcc
Lubrication oil pressure sensor power supply	A9 A19	Panel key ON	4.5 to 5.5 Vcc
Safety signal from throttle position sensor	A2-19 A2-72	Lever in position 0	> 4 Vcc
		Lever in position ≠ 0	< 1 Vcc
Throttle lever position sensor power supply	A2-55 A2-81	Panel key ON	4.5 to 5.5 Vcc
Position signal from throttle position sensor	A2-83 A2-81	Lever in position 0	0.3 to 0.5 Vcc
		Lever in position ≠ 0	> 3 Vcc

GUIDE TO BLINK CODE DIAGNOSING

Blink Code	EDC light	System reactions	Possible cause	Recommended tests or actions	Notes
1.1 Unbalanced speed-ometer input anomaly	On	EDC indicator light on for no reason	The resistive load simulator is not detected	Check the integrity of the 3.3 kΩ resistance between pins A2-56 and A2-74 of the EDC connector and the associated wiring.	A resistive load replaces a signal that is not used in this application
		Maximum power reduction. Fast idling at 750 RPM with the throttle lever in any position	Idling switch (in throttle sensor) signal shorted to ground or shorted positive or faulty switch	Read measurable parameters with the diagnosis instrument: by moving the throttle lever the idling switch should switch between ON and OFF. If not, disconnect the throttle lever from the wiring, then 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 A2-19 e A2-72.	
1.4 Throttle position sensor anomaly	On	Maximum power reduction. With the throttle lever at rest, the engine runs at fast idling speed (750 RPM). On moving the lever, the engine speed increases progressively to > 2000 RPM and viceversa	Shorted ground or shorted to positive or out of range power supply or defective throttle lever potentiometer	Read measurable parameters with the diagnosis instrument to verify the potentiometer works properly: by moving the throttle lever the potentiometer signal should vary from 0% to 100%. If not, disconnect the throttle lever from the wiring, then use a multimeter to check the integrity of the potentiometer (R. total = approx. 1 kΩ). Check the linear change in resistance of the potentiometer between the minimum and maximum. If the potentiometer is integral, check the wiring between potentiometer connector (wiring side) and EDC connector A2-55, A2-81 and A2-83.	
		Maximum power reduction. Fast idling at 750 RPM with the throttle lever in any position	No throttle lever signals or implausible signal between the idling switch (safety contact) and the potentiometer.	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 A2-19 e A2-72. 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 pin A2-55, A2-81 and A2-83.	

GUIDE TO BLINK CODE DIAGNOSING

Blink Code	EDC light	System reactions	Possible cause	Recommended tests or actions	Notes
1.8 EDC Light fault	Off or On	EDC indicator light does not come on turning the key in ON position, or it is on with the key in OFF position	EDC light wiring in open circuit or power supply short circuit	Diagnosis active with the diagnosis instrument.If result is negative check bulb. If bulb is integral check wiring between the component and EDC central unit on pins A2-28 and A2-64.	When the key is turned to the position ON EDC light comes on for about 2 seconds.
2.1 Water temperature sensor anomaly	On	Slight power reduction	Engine coolant temperature sensor shorted to ground or shorted to positive or open circuit or defective sensor	Read measurable parameters. If the engine temperature read in the control unit is the same as the oil temperature or is inconsistent, disconnect the sensor from the wiring. Then, using a multimeter, check the integrity of the sensor (R = approx. 2.5 kΩ at 20 °C). If the sensor is integral, check the wiring between the sensor connector and EDC connector pin A-18 and A-36.	
2.2 Combustion air temperature sensor anomaly	Off	Slight power reduction	Intake air temperature sensor shorted to ground or shorted to positive or open circuit or defective sensor	Read measurable parameters with the diagnosis instrument. If the turbocharging air temperature is fixed at 30 °C or is inconsistent, disconnect the sensor from the wiring. Check the integrity of the sensor as regards temperature (R = approx. 2.5 kΩ at 20 °C) and ground insulation. If the sensor is integral, check the wiring between the sensor connector and EDC connector A-21 and A-29.	Temperature sensor is integrated with the pressure sensor.
2.3 Fuel temperature sensor anomaly	Off	Slight power reduction	Fuel temperature sensor shorted to ground or shorted to positive or open circuit or defective sensor	Read measurable parameters with the diagnosis instrument. If the fuel temperature is fixed at 20° or is not consistent, disconnect sensor from the wiring, check by multimeter the value related to temperature (resistance about 2.5 kΩ at 20 °C) and insulation from ground. If sensor is efficient check wiring between component and EDC Central Unit on pins A-17 and A-34.	If K1 relay is always closed, the heater on the fuel filter is always powered on.
2.4 Combustion air pressure sensor anomaly	On	Maximum power reduction	Engine absolute pressure feeding air shorted to ground or shorted to positive or open circuit or defective sensor	Read measurable parameters with the diagnosis instrument. If the absolute pressure is fixed at 1600 mbar or is not consistent, check by using a multimeter, with the sensor connected, the supply voltage (U = 5V ± 10%) and the output voltage ≈1V at idling. Check the wiring between the sensor connector (wiring side) and EDC connector pins A-10, A-21 and A-28.	If the electrics are in order, verify the turbo-compressor. Pressure sensor is integrated with the temperature sensor.

GUIDE TO BLINK CODE DIAGNOSING

Blink Code	EDC light	System reactions	Possible cause	Recommended tests or actions	Notes
2.5 Atmospheric air pressure sensor anomaly (inside unit)	Off	No perceivable reaction	Atmospheric air pressure sensor shorted to ground or shorted to positive or open circuit.	Read measurable parameters with the diagnosis instrument. If the absolute pressure is fixed at 970 mbar or is not consistent, the anomaly cannot be removed. The sensor is integrated in the EDC control unit and cannot be replaced separately. Call IVECO MOTORS-FPT and follow their instructions.	Any paintwork or dirt on the engine/control unit may jeopardize correct ambient pressure measurement.
2.6 Lubrication oil pressure sensor anomaly	On	No perceivable reaction	Lubrication oil pressure sensor shorted to ground or shorted to positive or open circuit.	Read measurable parameters with diagnosis instrument. If the absolute pressure is fixed at 60 mbar or it is not consistent, measure by multimeter, on a powered on sensor, the supply voltage value (U = 5 V ± 10%). If the value is consistent check wiring between the component and EDC Central Unit on pins A-10, A-21 and A-28.	Pressure sensor integrates temperature sensor. If the oil pressure value is very low, a maximum power limitation strategy is activated.
2.7 Lubrication oil temperature anomaly	On	No perceivable reaction	Lubrication oil temperature sensor shorted to ground or shorted to positive or open circuit.	Read measurable parameters with diagnosis instrument. If the fuel temperature is fixed at 120° or it is not consistent, disconnect sensor from wiring, check by multimeter value related to temperature (resistance about 2.5 kΩ at 20 °C and insulation from ground. If sensor is efficient, check wiring between component and Central Unit on pins A-19 and A-33.	If the oil pressure value is very low a maximum power limitation strategy is activated.
2.8 Coil relay fuel heater anomaly	On	Possible maximum power limitation due to paraffin condensation in fuel filter when ambient temperature is very harsh (T < -15 °C)	Coil relay K1 shorted or open circuit.	Diagnosis active with the diagnosis instrument. If the result is negative check wiring between pins JF1-17 and A2-36 and between pins JF1-21 and A2-2.	

GUIDE TO BLINK CODE DIAGNOSING

Blink Code	EDC light	System reactions	Possible cause	Recommended tests or actions	Notes
3.1 Cylinder 1 balancing	Off	No perceivable reaction.	Electroinjector delivery drifting from characteristics or pressure decay in cylinder.	Call IVECO MOTORS-FPT and follow their instructions.	
3.2 Cylinder 5 balancing (not present on the 4 cylinders)	Off	No perceivable reaction.	Electroinjector delivery drifting from characteristics or pressure decay in cylinder.	Call IVECO MOTORS-FPT and follow their instructions.	
3.3 Cylinder 3 balancing	Off	No perceivable reaction.	Electroinjector delivery drifting from characteristics or pressure decay in cylinder.	Call IVECO MOTORS-FPT and follow their instructions.	
3.4 Cylinder 6 balancing (not present on the 4 cylinders)	Off	No perceivable reaction.	Electroinjector delivery drifting from characteristics or pressure decay in cylinder.	Call IVECO MOTORS-FPT and follow their instructions.	
3.5 Cylinder 2 balancing	Off	No perceivable reaction.	Electroinjector delivery drifting from characteristics or pressure decay in cylinder.	Call IVECO MOTORS-FPT and follow their instructions.	
3.6 Cylinder 4 balancing	Off	No perceivable reaction.	Electroinjector delivery drifting from characteristics or pressure decay in cylinder.	Call IVECO MOTORS-FPT and follow their instructions.	

GUIDE TO BLINK CODE DIAGNOSING

Blink Code	EDC light	System reactions	Possible cause	Recommended tests or actions	Notes
3.7 Battery voltage anomaly	Off	Fast idling.	EDC power supply voltage too low or too high.	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 Injector failure cylinder 1	On	The engine runs on 5 cylinders.	Electroinjector cylinder 1 shorted to positive or to ground or open circuit.	Check the integrity of the injector coil cylinder 1 (R = 0.3 Ω ± 10%), and ground insulation. If the coil is integral, check the wiring between the solenoid valve and EDC connector on pin A2-9 and A2-13. Check correct tightness to torque of the connectors on the injector solenoid valve (1.5 Nm).	Immediately afterwards the engine might keep on turning on 3 cylinders (4-5-6) as the injectors are controlled by two power stages.
5.2 Injector failure cylinder 5 (not present on the 4 cylinders)	On	The engine runs on 5 cylinders.	Electroinjector cylinder 5 shorted to positive or to ground or open circuit.	Check the integrity of the injector coil cylinder 5 (R = 0.3 Ω ± 10%), and ground insulation. If the coil is integral, check the wiring between the solenoid valve and EDC connector on pin A2-3 and A2-6. Check correct tightness to torque of the connectors on the injector solenoid valve (1.5 Nm).	Immediately afterwards the engine might keep on turning on 3 cylinders (1-2-3) as the injectors are controlled by two power stages.
5.3 Injector failure cylinder 3	On	The engine runs on 5 cylinders.	Electroinjector cylinder 3 shorted to positive or to ground or open circuit.	Check the integrity of the injector coil cylinder 3 (R = 0.3 Ω ± 10%), and ground insulation. If the coil is integral, check the wiring between the solenoid valve and EDC connector on pin A2-4 and A2-12 Check correct tightness to torque of the connectors on the injector solenoid valve (1.5 Nm).	Immediately afterwards the engine might keep on turning on 3 cylinders (4-5-6) as the injectors are controlled by two power stages.

GUIDE TO BLINK CODE DIAGNOSING

Blink Code	EDC light	System reactions	Possible cause	Recommended tests or actions	Notes
5.4 Injector failure cylinder 6 (not present on the 4 cylinders)	On	The engine runs on 5 cylinders.	Electroinjector cylinder 6 shorted to positive or to ground or open circuit.	Check the integrity of the injector coil cylinder 6 (R = 0.3 Ω ± 10%), and ground insulation. If the coil is integral, check the wiring between the solenoid valve and EDC connector on pin A2-5 and A2-14. Check correct tightness to torque of the connectors on the injector solenoid valve (1.5 Nm).	Immediately afterwards the engine might keep on turning on 3 cylinders (1-2-3) as the injectors are controlled by two power stages.
5.5 Injector failure cylinder 2	On	The engine runs on 5 cylinders.	Electroinjector cylinder 2 shorted to positive or to ground or open circuit.	Check the integrity of the injector coil cylinder 2 (R = 0.3 Ω ± 10%), and ground insulation. If the coil is integral, check the wiring between the solenoid valve and EDC connector on pin A2-11 and A2-16. Check correct tightness to torque of the connectors on the injector solenoid valve (1.5 Nm).	Immediately afterwards the engine might keep on turning on 3 cylinders (4-5-6) as the injectors are controlled by two power stages.
5.6 Injector failure cylinder 4	On	The engine runs on 5 cylinders.	Electroinjector cylinder 4shorted to positive or to ground or open circuit.	Check the integrity of the injector coil cylinder 4 (R = 0.3 Ω ± 10%), and ground insulation. If the coil is integral, check the wiring between the solenoid valve and EDC connector on pin A2-10 and A2-15. Check correct tightness to torque of the connectors on the injector solenoid valve (1.5 Nm).	Immediately afterwards the engine might keep on turning on 3 cylinders (1-2-3) as the injectors are controlled by two power stages.

GUIDE TO BLINK CODE DIAGNOSING

Blink Code	EDC light	System reactions	Possible cause	Recommended tests or actions	Notes
5.7 Anomaly control stage cylinder injectors 1-2-3	On	The engine runs on 3 cylinders.	An electroinjector (cylinders 1, 2 or 3) or their wiring shorted. Fault inside EDC unit.	If it is associated with codes 5.1 or 5.3 or 5.5, proceed with the cheks advised, reset memory and start the engine again. If the anomaly persists call IVECO MOTORS-FPT and follow their instructions.	
5.8 Anomaly control stage cylinder injectors 4-5-6	On	The engine runs on 3 cylinders.	An electroinjector (cylinders 4, 5 or 6) or their wiring shorted. Fault inside EDC unit.	If it is associated with codes 5.2 or 5.4 or 5.6, proceed with the cheks advised, reset memory and start the engine again. If the anomaly persists call IVECO MOTORS-FPT and follow their instructions.	
6.1 Flywheel sensor anomaly	On	Starting the engine takes longer than normal. Maximum power reduction.	Wire connections shorted to ground or shorted to positive or open circuit.	Check the sensor is clean and correctly positioned and secured. Check the integrity of the sensor (R = 900 Ω ± 10% at 20 °C) and ground insulation. If the sensor is integral, check the wiring between the sensor andEDC connector on pin A-24 and A-25.	The defect is not detected with the engine stationary. It is frequently associated with error 6.3. Engine does not start because EDC Central Unit interrupts the control to the electric starter.
6.2 Camshaft sensor anomaly	On	Starting the engine takes longer than normal. Maximum power reduction, increased noise.	Wire connections shorted to ground or shorted to positive or open circuit.	Check the sensor is clean and correctly positioned and secured. Check the integrity of the sensor (R = 900 Ω ± 10%) and ground insulation; replace it if defective. If the sensor is integral, check the wiring between the sensor andEDC connector on pin A-23 and A-30.	The defect is not detected with the engine stationary. It is frequently associated with error 6.3.
6.3 Implausible flywheel and camshaft signals	On	The engine stops and/or doesn't start.	Flywheel and camshaft signals electrically correct but implausible in timing.	Proceed with checks related to codes 6.1 and 6.2. Check damper flywheel integrity. Reset error memory , start the engine again.	The defect is not detected with the engine stationary. If the engine fails to start (or switches off when running), the phonic wheel of the camshaft might be out of step: disconnect the sensor connector to allow engine starting.

GUIDE TO BLINK CODE DIAGNOSING

Blink Code	EDC light	System reactions	Possible cause	Recommended tests or actions	Notes
6.4 Engine overspeed anomaly	Blinking	No reaction perceivable, other than the light blinking.	Engine overspeed observed.	Delete the fault memory and restart the engine.	
6.5 Coil relay electric starter motor anomaly	On	The electric motor is not powered on when so required by the key control.	Coil relay K2 shorted or open circuit.	Diagnosis active with the diagnosis instrument. If the result is negative check wiring between pins JF1-31 and A2-37 and between pins JF1-21 and A2-2.	
6.6 Revolution counter signal anomaly	Off	Revolution-counter malfunction.	Revolution-counter or wire connections shorted to ground or shorted to positive or open circuit.	Check the wiring connected to pin JB-13 and A2-49.	Probably no diagnosis possible.
6.8 Synchronism trouble with diagnosis tool	Off	Possible difficulty in communication between diagnosis tool and EDC control unit.	Diagnosis line shorted to ground or shorted to positive or open circuit.	Check the wiring between pin J1-A and A2-30 and between pin J1-B and A2-31.	
8.1 Fuel pressure control anomaly	Blinking	Great maximum power reduction. Starting may be difficult or impossible.	Pressure measured on rail is very different from that calculated by EDC unit. Possible air blow-by or loss in the fuel line.	Check fuel level and the float condition. Check sealing on the fuel line.	
8.2 Fuel pressure signal anomaly	Blinking	Great maximum power reduction. Starting may be difficult or impossible.	Rail pressure sensor or wire connections shorted to ground or shorted to positive or open circuit.	Read measurable parameters with diagnosis instrument. If the pressure is not consistent measure the voltage power value ($U = 5\ V \pm 10\%$) by multimeter, with the sensor connected. If the value is consistent check wiring between component and EDC unit on pins A2-12, A2-20 and A2-27.	

GUIDE TO BLINK CODE DIAGNOSING

Blink Code	EDC light	System reactions	Possible cause	Recommended tests or actions	Notes
8.3 Fuel pressure regulator solenoid valve anomaly	Blinking	Great maximum power reduction. Starting may be difficult or impossible.	Pressure regulator valve or wire connections shorted to ground or shorted to positive or open circuit.	Measure by multimeter the solenoid resistance value (R = 2.8 Ω ± 10%) and insulation from ground. If component is efficient check wiring between component and EDC unit on pins A2-5 and A2-7. Check connector efficiency.	
8.4 Twin stage valve tripping activation	Blinking	Great maximum power reduction.	Probable operation of the two-stage overpressure valve due to an excessive pressure value.	If associated with code 8.1, check 8.1, 8.2 and 8.3.	
8.5 Rail pressure too high	Blinking	The engine stops.	Probable lack of operation of the two-stage overpressure valve due to an excessive pressure value.	Replace the two-stage overpressure valve. After its replacement carry out checks 8.2 and 8.3.	
9.4 Main relay anomaly	On	EDC anomaly signal bulb always ON (even with key in OFF position). Batteries will run down in a short while.	EDC unit power supply always on even with key in OFF position.	With key in OFF position check the absence of positive voltage on EDC pin A2-39. With key in OFF position disconnect +B from the battery for at least one minute, reconnect, reset fault memory. If the defect persists call IVECO MOTORS-FPT and follow their instructions.	Main relay is incorporated in EDC central unit and it is not replaceable.
9.6 After-run procedure not completed	On	Great maximum power reduction.	Failure of the EDC internal test procedure that takes place in the control unit every time the engine stops.	Delete the fault memory and try again: if the error remains, call IVECO MOTORS-FPT and follow their instructions.	Possible stop of the engine for longer times when the key is turned to OFF position. Possible association with fault storage of stage of actuators pilot systems.

GUIDE TO BLINK CODE DIAGNOSING

Blink Code	EDC light	System reactions	Possible cause	Recommended tests or actions	Notes
9.7 Sensor supply anomaly	On	Engine malfunction. Possible maximum power reduction.	Electronic control unit fault.	Delete the fault memory and try again: if the error remains, call IVECO MOTORS-FPT and follow their instructions	Possible association with error codes of sensor powered by EDC central unit.

GUIDE TO SYMPTOM DIAGNOSING

Blink Code	Symptom	Part	Possible cause	Recommended tests or action
NO	Engine does not start	Batteries	- Low charge - Faulty terminal connections	- Recharge (disconnecting battery from system wiring) - Clean, check insulation, tighten terminals
NO	Engine does not start	Electrical starter motor	- Malfunction - Faulty terminal connections	- Check efficiency. - Check connections to positive (+ 30) and engine ground
NO	Engine does not start	EDC power supply anomaly	- Supply fuse (inside box relay) - Batteries malfunction - +B and –B electrical connections - Wiring	- Check +B and –B electrical connections - Check voltage to A2 connector
NO	Engine does not start	"15" control from key switch	- Malfunction - Faulty terminal connections	- Check wiring and key switch
NO	Engine does not start	Fuel feed pump	- Incorrect priming	- Check seal or air intake on induction side
NO	Engine does not start	Fuel circuit	- Incorrect filling (air in fuel circuit)	- Check seal and air with a clear tube, arranged as an inverted U, inserted before the inlet junction.
NO	Engine does not start	Fuel filter and pre-filter	- Clogged	- Bleed - Check tank - Replace
NO	Engine does not start	High pressure pump	- Malfunction	- Carry out every check on hydraulic lines and electric system. - Call IVECO MOTORS-FPT and follow their instructions

GUIDE TO SYMPTOM DIAGNOSING

Blink Code	Symptom	Part	Possible cause	Recommended tests or action
NO	Engine frequently overheats	Coolant level	- Below MIN level	- Check for leaks - Top up correct level
NO	Engine frequently overheats	Water pump drive belt	- Poor tension - Wear	- Check tension - Replace - Check for liquid leakage on drive belt
NO	Engine frequently overheats	Water pump	- Malfunction	- Replace - Check belt tension - Check for liquid leakage on drive belt
NO	Engine frequently overheats	Thermostatic valve	- Locked, closed or only partially open	- Replace - Check for impurities in coolant
NO	Engine frequently overheats	Coolant/sea-water heat exchanger	- Clogged	- Clean or replace
NO	Engine frequently overheats	Air filter	- Clogged	- Clean or replace - Check filter clogging sensor
NO	Engine frequently overheats	Cylinder head gaskets	- Compression leaking from cylinder head gaskets	- Check cooling water circuit pressure - Replace head gaskets

GUIDE TO SYMPTOM DIAGNOSING

Blink Code	Symptom	Part	Possible cause	Recommended tests or action
NO	Poor performance	Fuel circuit	- Tank net filter clogged - Fuel prefilter clogged - Fuel filter clogged - Air in fuel circuit - Fuel pressure too low - Heavy fuel leakage	- Clean or replace clogged filters - Check intake seals - Check pressure relief valve on the fuel gear pump - Check the integrity of the fuel gear pump
NO	Poor performance	Injectors	- Malfunction - Locked, closed - Locked, open	- The non operating electro-injector can be detected feeling by touching the total lack of pulsing on the related high pressure piping. - Call IVECO MOTORS-FPT and follow their instructions
NO	Poor performance	Engine air feed	- Air filter clogged	- Check filter clogged sensor - Clean of replace filter
NO	Poor performance	Gas exhaust system	- Leakage along the cooled manifold before the turbine.	- Check and remove cause of leak
NO	Poor performance	Gas exhaust system	- Clogged	- Check exhaust back-pressure
NO	Poor performance	Turbocompressor	- Inefficient - Inefficient bearings	- Check - Check parts and lubrication circuit - Replace
NO	Poor performance	Camshaft	- Wear - Incorrect timing	- Check - Replace - Check, restore correct timing
NO	Poor performance	Engine valves	- Excessive or nil clearance	- Check, restore correct clearance
NO	Poor performance	Intake air pressure sensor	- Output signal too low (below the pressure value)	- Using a multimeter on the component, check the output voltage according to a manometer
NO	Poor performance	- Intake air temperature sensor - Water temperature sensor - Fuel temperature sensor - Oil temperature sensor	- Output signal too high	- Using a multimeter on the component, check the resistance according to a thermometer

GUIDE TO SYMPTOM DIAGNOSING

Blink Code	Symptom	Part	Possible cause	Recommended tests or action
NO	Poor performance	Fuel filter heater powered even in presence of high external temperature	- K1 relay contatct closed or shorted on the filter heater wiring.	- Check voltage on the fuel filter heater connector.
NO	The engine emits grey-white smoke	Water in cylinders	- Leakages from cylinder gasket - Water in intake system from air/sea-water heat exchanger - Water in fuel	- Check coolant level - Check fresh water circuit pressurization - Check heat exchanger - Check efficiency of sensor to detect the presence of water in fuel
NO	The engine emits blue smoke	Oil in cylinders	- Excessive oil consumption - Oil leaking in turbocompressor - Oil leaking from valve guides	- Check lubrication oil consumption - Overhaul
NO	Engine stops	Fuel tank	- Not enough fuel in tank - Float in incorrect position	- Refill and bleed fuel circuit - Modify float or tank tilt
NO	Engine stops	Net filter Prefilter Fuel filter	- Clogged	- Replace - Check efficiency of fuel filter clogging sensor
NO	Engine stops	Fuel circuit	- See "Poor performance"	- See "Poor performance"
NO	Engine stops	EDC power supply anomaly	- Faulty terminal connections - Wiring - Key switch	- Check +B and –B electrical connections - Check wiring and key switch

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SECTION 5

MAINTENANCE

PERIODICITY OF CHECKS AND MAINTENANCE OPERATIONS

Execution of the operations indicated below requires competence and compliance with the safety regulations enforced in each Country. Checks can be performed by the user of the vessel and/or by the workshop personnel. Periodic maintenance operations must be performed by qualified personnel and require the use of tools, work instruments, and suitable protection means. Extraordinary maintenance operations is to be performed by IVECO MOTORS-FPT authorized workshop personnel with adequate training and sufficient technical information.

Frequencies applicable to engines designed for PLEASURE use

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				■				

Periodic maintenance operations		Periodicity						
		Every start	150 hours	300 hours	600 hours	900 hours	1200 hours	Annual (2)
Clean air filter(s)	(1) (8)			■				■
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 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)					■			■
Inspect sea-water intake	(1)					■		■
Check wear of sea-water pump impeller						■		■
Replace engine lubricating oil								2 years
Adjust valve-rocker arm clearance	every 3000 hours							

Extraordinary maintenance operations (5)		Periodicity						
		Every start	150 hours	300 hours	600 hours	900 hours	1200 hours	Every 3 years (7)
Clean turbocompressor						■		■
Clean heat exchangers	(6)					■		■
Replace water pump and alternator drive belt							■	■
Inspect damper in drive shaft front pulley								■

Frequencies applicable to engines designed for SPORTING use
N60 ENT M40.10 - 353 kW (480 CV) @ 3000 rpm

Checks		**Periodicity**						
		Every start	100 hours	300 hours	600 hours	900 hours	1200 hours	Annual
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								■

Periodic maintenance operations		**Periodicity**						
		Every start	100 hours	300 hours	600 hours	900 hours	1200 hours	Annual
Clean air filter(s)	(1) (8)							■
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 fuel pre-filter(s)	(1) (3)							■
Replace fuel filter(s)	(1) (3)							■
Replace oil filter(s)								■
Replace gearbox(es) oil (see data provided by the manufacturer)								■
Inspect sea-water intake	(1)							■
Check wear of sea-water pump impeller			■					
Replace engine lubricating oil								■
Adjust valve-rocker arm clearance				■				

Extraordinary maintenance operations (5)		**Periodicity**						
		Every start	100 hours	300 hours	600 hours	900 hours	1200 hours	Annual
Clean turbocompressor								■
Clean heat exchangers	(6)							■
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 carried out annually even if the specified number of operating hours is not reached.

(3) Maximum time interval for high quality fuel; it may be reduced depending on their contamination. The filter is provided with clogging sensor; if a clogging indication is provided, 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 8.

(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 heat 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) Replace air filter(s): every 2 years.

PREPARING THE ENGINE FOR LONG IDLE PERIODS

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

1. Drain the lubricating oil from the sump, after heating the engine;
2. Pour 30/M-type protective oil (alternatively, oil conforming with MIL 2160B Type 2 specifications) into the engine to the "minimum" level marked on the dipstick.
   Start the engine and let it run for about 5 minutes;
3. Drain the fuel from the injection line and from the filter, taking care to avoid letting the fuel come in contact with the auxiliaries belt;
4. Connect the fuel line to a tank containing CFB protective liquid (ISO 4113) and assist the inflow of the liquid by pressurizing the line and turning the engine over for about 2 minutes, after excluding the operation of the injection system. The required operation may be carried out by directly polarizing the terminal 50 of the electric starter motor with positive voltage 12 V, using a conductor prepared for the occasion;
5. Nebulize 30/M-type protective oil at the rate of about 10 g per liter of displacement:
   N40 ENT M25 = 40g
   N60 ENT M37 = 60g
   N60 ENT M40 = 60g
   into the turbocompressor intake, while the engine is turning over as described above;
6. Close with suitable stoppers or seal with adhesive tape all engine intake, exhaust, aeration and venting ports;
7. Drain the residual 30/M-type protective oil from the sump; it may be re-used for 2 more engine preparation operations;
8. Apply tags with the inscription "ENGINE WITHOUT OIL" on the engine and onboard panel;
9. Drain the coolant, if it has not been mixed with antifreeze and corrosion inhibiting agents, affixing tags to indicate that the operation has been carried out.

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

ENGINE'S FIRST START/RESTORING NORMAL OPERATING CONDITIONS

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

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SECTION 6

SERVICING OPERATIONS ON INSTALLED ENGINE

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FOREWORD

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

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

The checks necessary at the completion of an installation or re-embarkation are described in the "N40 ENT M25, N60 ENT M37-M40 Installation Directive" document.

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

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

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

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

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

PRESCRIPTIONS FOR WORK ON THE INJECTION SYSTEM

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

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

❏ Replacement of the ECU EDC 7 must be authorized by IVECO MOTORS-FPT after specific agreements with the Technical Assistance Service;

❏ The electro-injectors cannot be overhaul; their replacement must be authorized by IVECO MOTORS-FPT with the specific agreement of the Technical Assistance Service; for disassembly, follow the indications provided in the specific paragraph of this Section;

❏ Keep parts and components clean, making sure that during handling and assembly (starting with the simple replacement of filter and pre-filter) no sludge or foreign matter is allowed to enter the lines, with particular attention to the fuel supply line in the segment downstream the filter;

❏ Maintain the proper polarization of all electrical connections;

❏ Tighten the threaded connections to the prescribed torque;

❏ Make sure that the flywheel and camshaft sensors are positioned so they abut, ensuring they are as close to perpendicular (with respect to the bearing surface) as possible.

CAUTION

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

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

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

❏ Set the key switch to the STOP position;

❏ Wait 10 sec. and disconnect the battery terminals;

❏ Disconnect the connections according to the prescriptions set out in Section 3;

❏ Remove, if necessary, the entire wiring harness from the retaining bracket;

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

REPLACING THE ELECTRO-INJECTORS

Removal

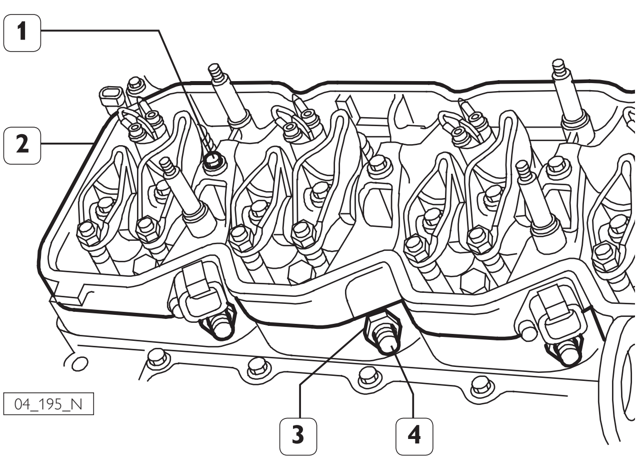
Make sure the conditions you work in are safe (they may differ depending on the application).

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

CAUTION

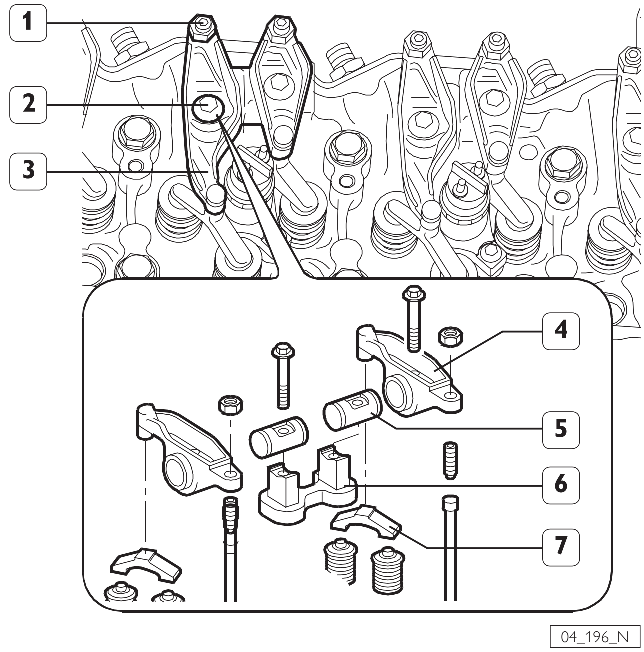
When unlocking the fitting fastening the pipe to the hydraulic accumulator, it is necessary to prevent the flow limiters from turning, by using a special wrench.

Figure 1



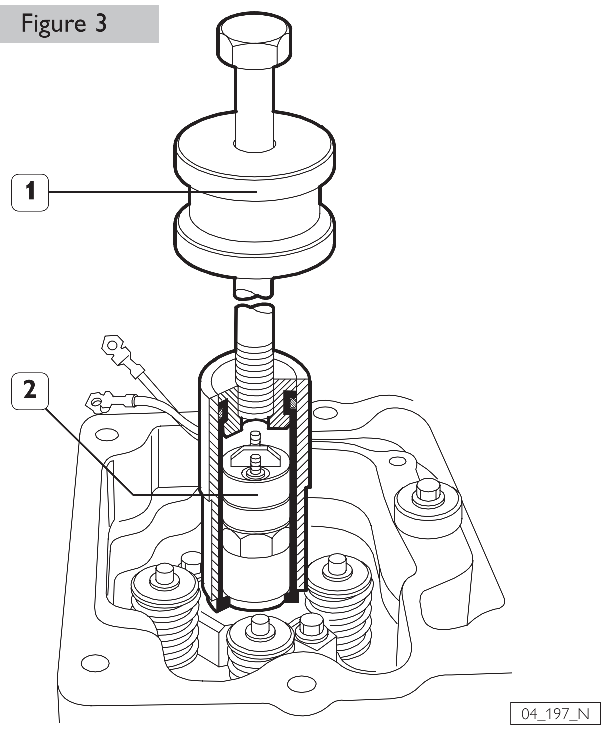
Remove the screws (1) and disconnect the electro-injector wiring mount (2) together with the gasket.
Remove the nuts (3) and take the fuel manifolds (4) out.

Figure 2



Loosen tappet adjustment fastening nuts (1) and unscrew the adjusters.
Remove the screws (2), remove the rocker assembly (3), consisting of: bracket (6), rockers (4), shafts (5) and remove jumpers (7) from valves.

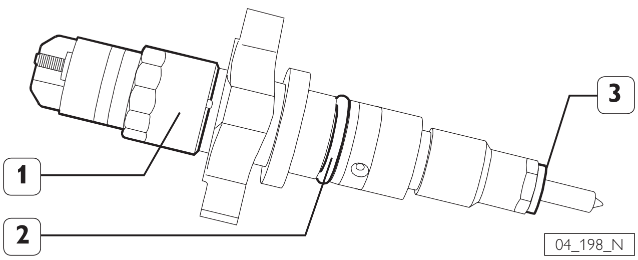
Figure 3



Remove injector fastening screws. Use tool 99342101 (1) to remove injectors (2) from the cylinder head.

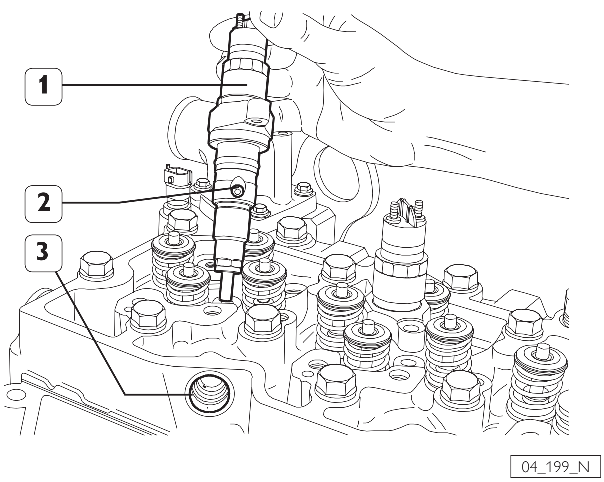
Fitting

Figure 4



Fit a new sealing ring (2) lubricated with petroleum jelly and a new sealing washer (3) on the injector (1).

Figure 5



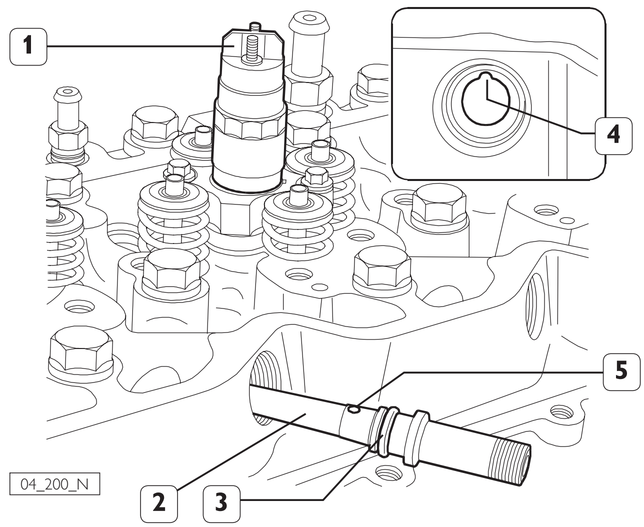
Fit injectors (1) on the cylinder head seats, directed so that the fuel inlet hole (2) is facing the fuel manifold seat (3) side.

CAUTION

Use tool 99342101 to fit the injector into its seat.

Screw injector fastening screws without tightening them.

Figure 6



Fit a new sealing ring (3) lubricated with petroleum jelly on the fuel manifold (2) and fit it into the cylinder head seat so that the positioning ball (5) fits the relevant housing (4).

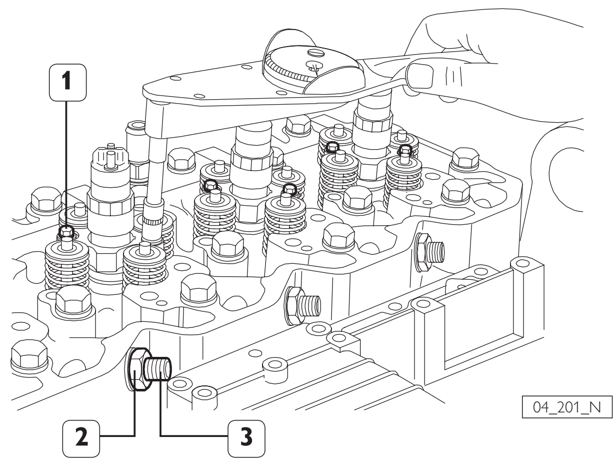
CAUTION

Disassembled fuel manifolds (2) must not be used again. Replace them with new ones.

CAUTION

During this operation (figure 6), the injector (1) is to be moved so that the manifold (2) is properly inserted into the fuel inlet hole.

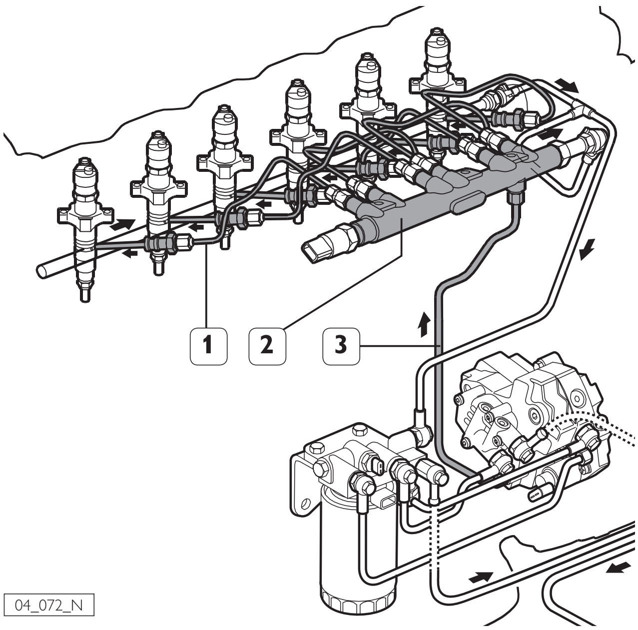
Figure 7



Use the torque wrench to tighten gradually and alternately the injector fastening screws (1) to 8.5 ± 0.8 Nm torque. Tighten the fuel manifold (3) fastening nuts (2) to 50 Nm torque.

FUEL SYSTEM PIPING

Figure 8



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

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

CAUTION

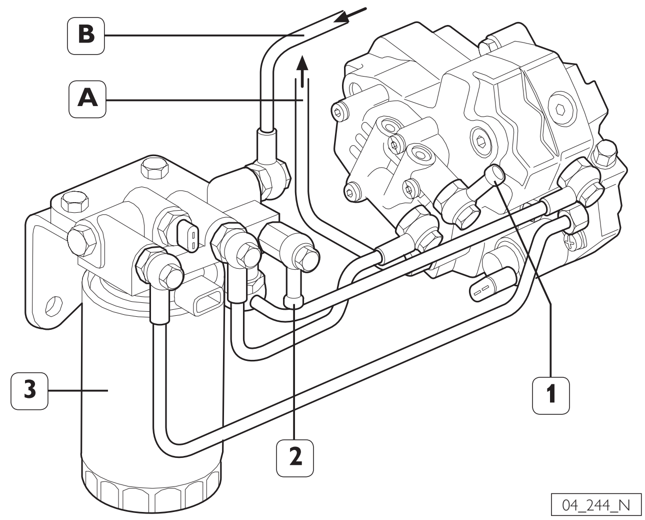
The high-pressure system may reach very high pressure levels:
DO NOT ATTEMPT TO LOOSEN HYDRAULIC CONNECTIONS TIGHTENING ITEMS WITH THE ENGINE RUNNING.

Tighten axial junction nuts with a torque of 20 Nm.

CAUTION

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

Figure 9

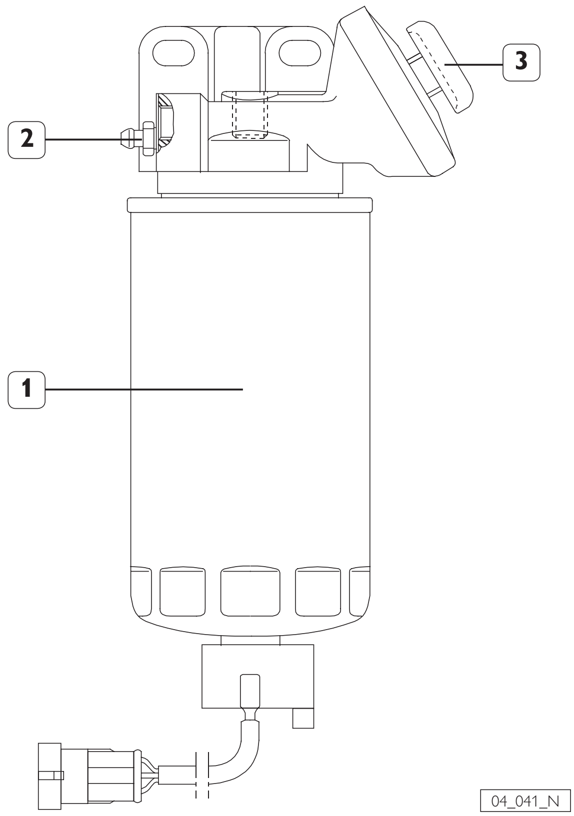


A. To rail supply - B. Return flow from rail
1. Rubber holder junction for fuel inflow from pre-filter -
2. Rubber holder junction for fuel outflow to the tank -
3. Fuel filter.

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

VENTING THE AIR FROM THE FUEL FEED LOOP

Figure 10



1. Fuel prefilter - 2. System bleeding screw - 3. Manual priming pump.

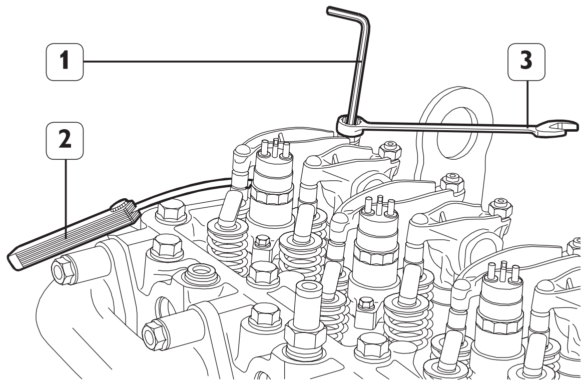
To exhaust air from fuel system, operate the pre-filter (1) manual pump (3) or use a specific electric pump. Loosen the vent fitting (2) on the pre-filter and operate the pump until only fuel without air flows out. Tighten the vent fitting and continue pumping during the initial start-up phases.
Make sure that the fuel that flows out of the fitting is not dispersed in the environment.

CAUTION

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

VALVES CLEARANCE ADJUSTMENT

Figure 11



04_203_N

Adjust clearance between rockers and valves using setscrew wrench (1), box wrench (3) and feeler gauge (2).

Working clearance should be as follows:

- Intake valves 0.25 ± 0.05 mm;
- Exhaust valves 0.50 ± 0.05 mm.

CAUTION

In order to adjust faster the operating clearance for rocker arms - valves, proceed as follows:

For the 4 cylinders engine

Rotate the drive shaft, balance cylinder 1 valves and adjust the valves marked by the ■ symbol as shown in the table:

Cylinder n.	1	2	3	4
intake	-	-	■	■
exhaust	-	■	-	■

Rotate the drive shaft, balance cylinder 4 valves and adjust the valves marked by the ■ symbol as shown in the table:

Cylinder n.	1	2	3	4
intake	■	■	-	-
exhaust	■	-	■	-

For the 6 cylinders engine

Rotate the drive shaft, balance cylinder 1 valves and adjust the valves marked by the ■ symbol as shown in the table:

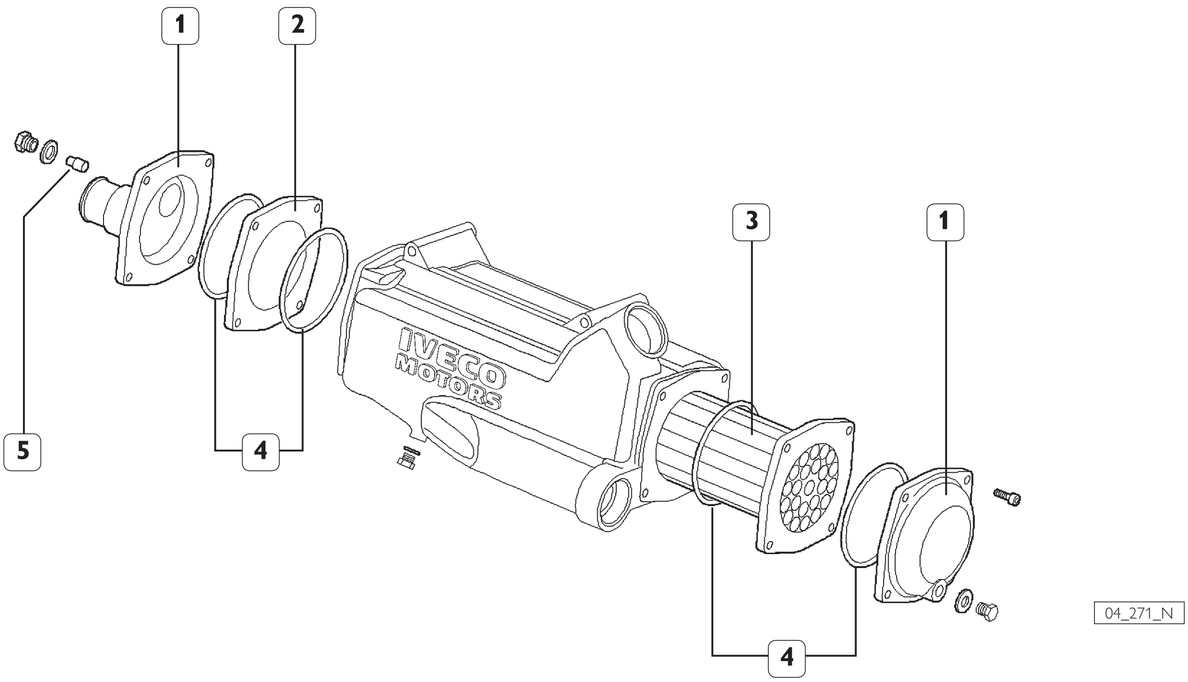
Cylinder n.	1	2	3	4	5	6
intake	-	-	■	-	■	■
exhaust	-	■	-	■	-	■

Rotate the drive shaft, balance cylinder 6 valves and adjust the valves marked by the ■ symbol as shown in the table:

Cylinder n.	1	2	3	4	5	6
intake	■	■	-	■	-	-
exhaust	■	-	■	-	■	-

CLEANING THE ENGINE COOLANT/SEA-WATER HEAT EXCHANGER

Figure 12



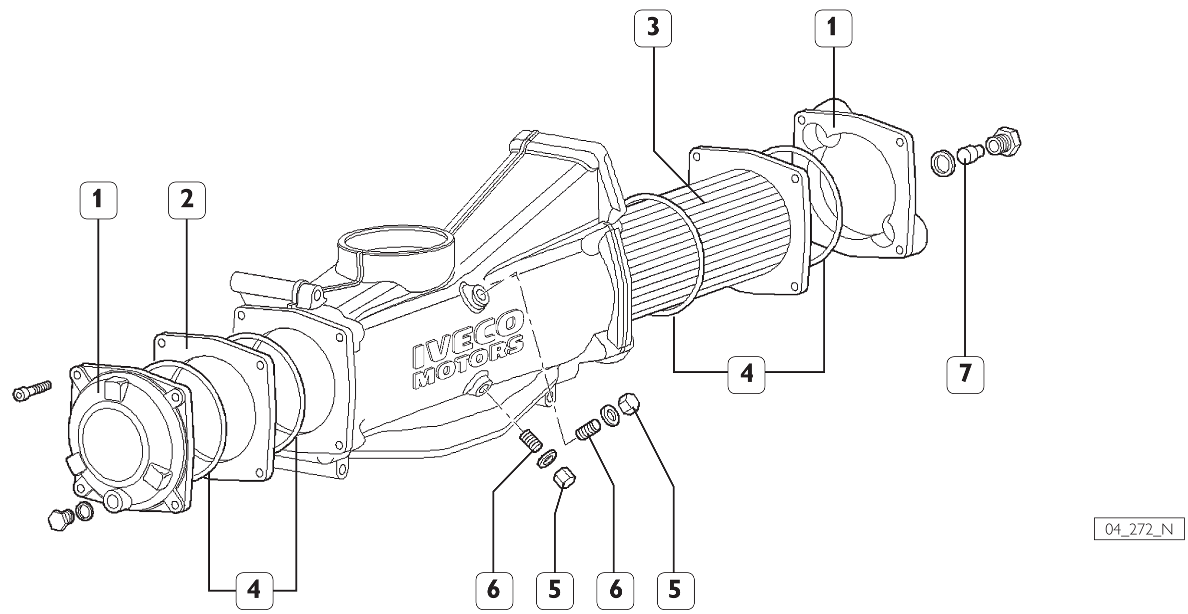
1. Cover - 2. Spacer - 3. Tube bundle - 4. Sealing rings - 5. Zinc sacrificial anode.

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

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

CLEANING THE AIR/SEA-WATER HEAT EXCHANGER

Figure 13



1. Cover - 2. Spacer - 3. Tube bundle - 4. Sealing rings - 5. Plug - 6. Tube bundle fixing screw - 7. Zinc sacrificial anode.

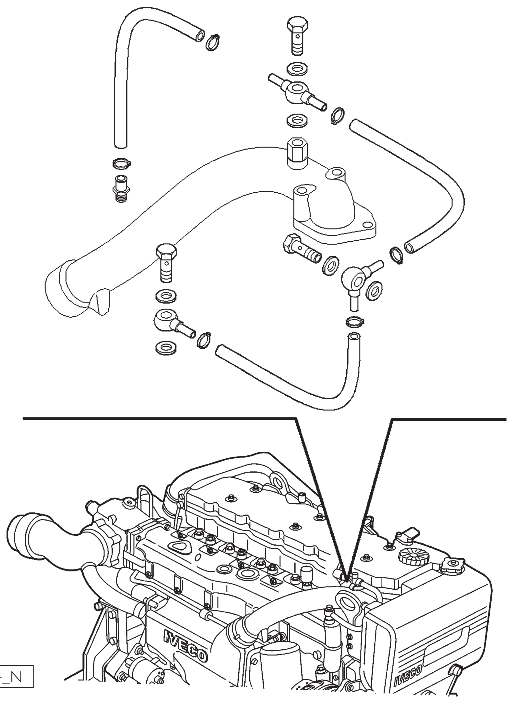
In order to guarantee a perfect operation of the heat exchanger, regularly clean the tube bundle. If the surfaces of the heat exchanger come into contact with salted water, they may be subjected to biological fouling and to hydrocarbon deposit which may be present in harbors' waters; surfaces coming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

- ❏ Remove 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 residues 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.

MARINE PARTS DECOUPLING

Some periodical maintenance and overhaul interventions require full access to engine parts and removal of marine parts. The following sequence is suggested to simplify the necessary operations.

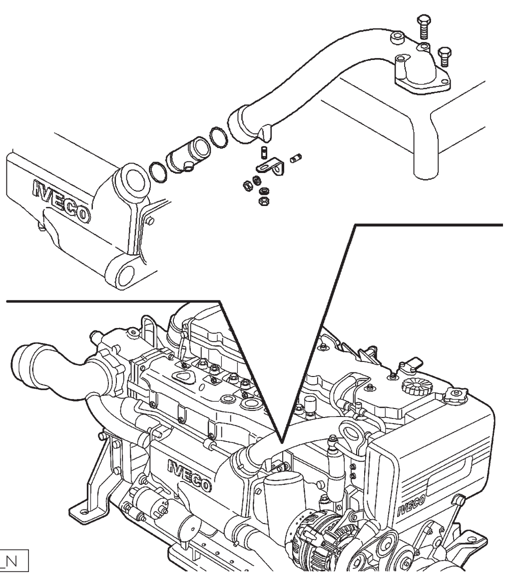
Figure 14



04_274_N

Remove cooling circuit exhaust pipes, located on engine head.

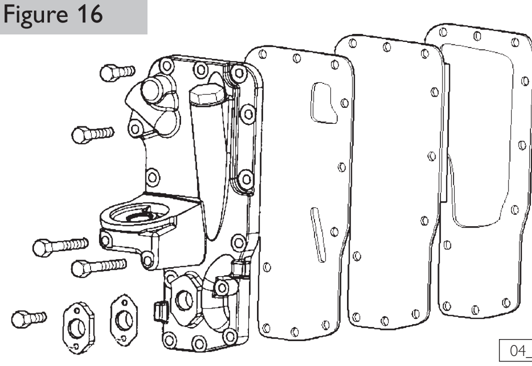
Figure 15



04_275_N

Remove coolant inlet pipe which joints the engine to the water/water heat exchanger.

Figure 16

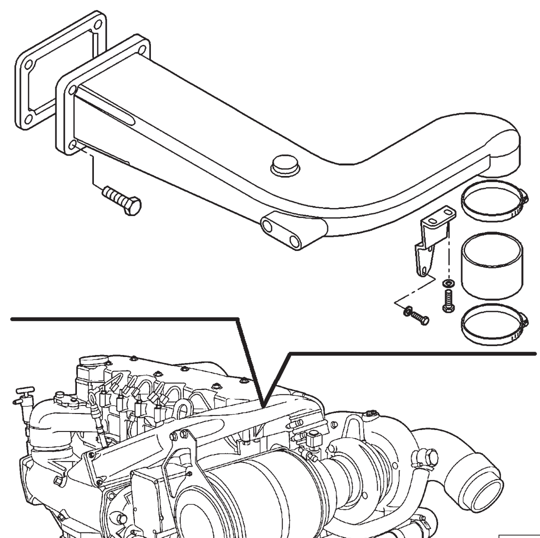


04_273_N

Remove the support and the oil filter from their housing located on engine base.

Decouple the air filter and the turbocompressor exhaust riser.

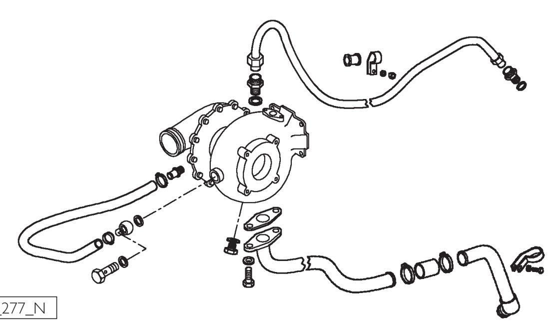
Figure 17



04_276_N

Remove the booster air pipe, joining the turbocompressor to the air/water exchanger (aftercooler).

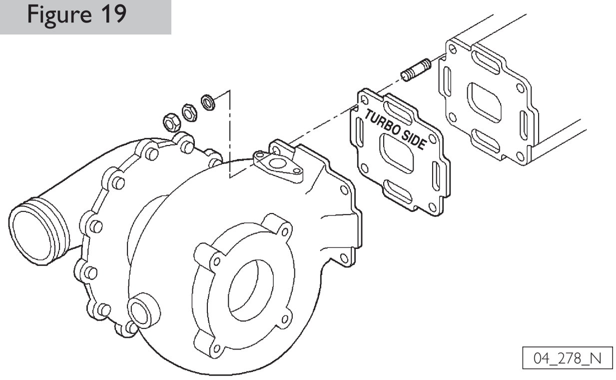
Figure 18



04_277_N

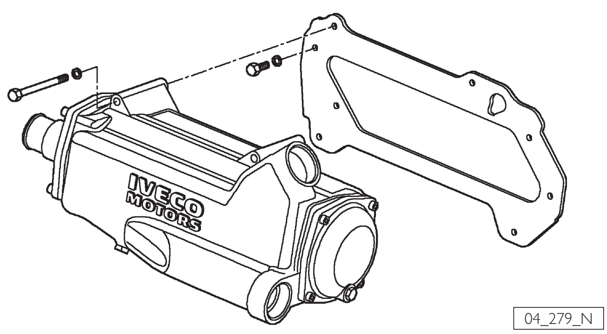
Prepare turbocompressor removal by disassembling coolant and lubricant inlet pipes.

Figure 19



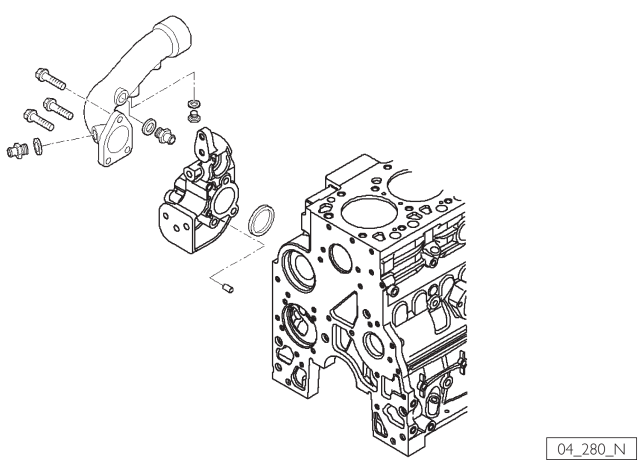
Decouple the turbocompressor from the exhaust manifold and remove it; please note that, when reassembling it, it will be necessary to observe the assembling direction of the gasket placed between the two components and marked with the caption "TURBO SIDE".

Figure 20



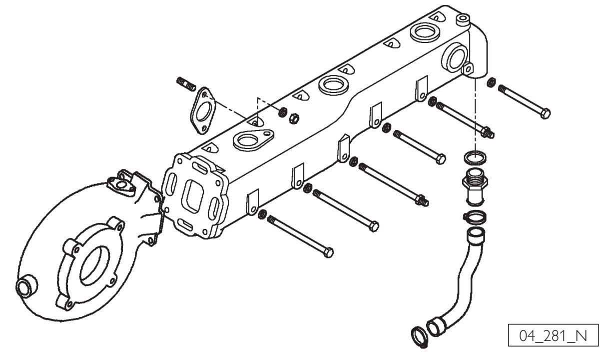
Remove the tube bundle heat exchanger and the circulating pump outlet/inlet coolant pipe after having loosened the threaded collar of the coolant outlet pipe.

Figure 21



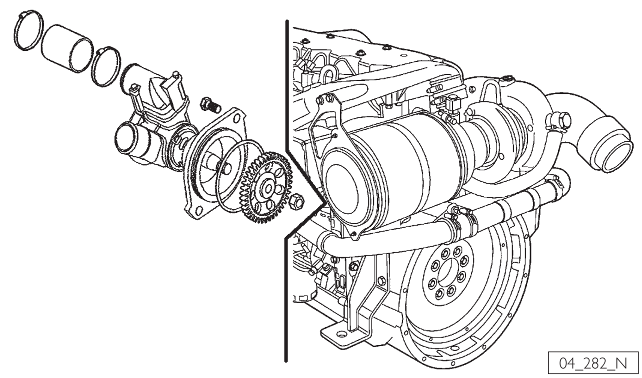
The alternator and the belt tensioner are simultaneously anchored to the exchanger support. Remove them if necessary.

Figure 22



Remove the exhaust manifold to complete engine preparation for overhauling.

Figure 23



Marine parts include the open cooling circuit sea-water pump which may be removed from its housing if necessary.

INSTRUCTIONS FOR DISEMBARKING THE ENGINE

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

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

Handling

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

SECTION 7

TOOLS

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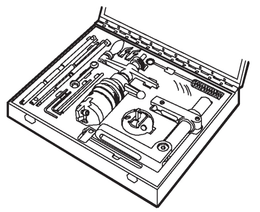
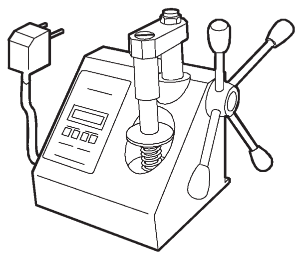
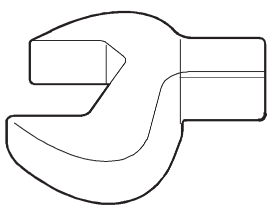
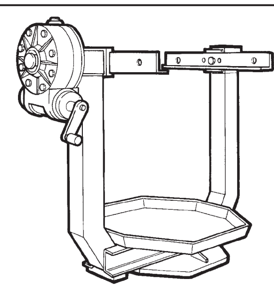
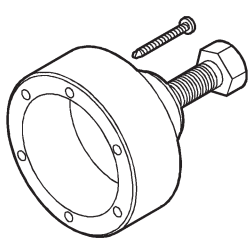
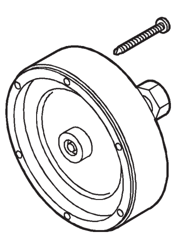
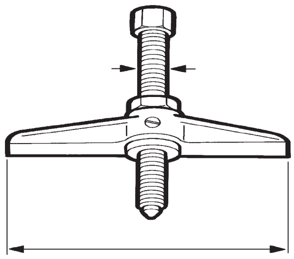
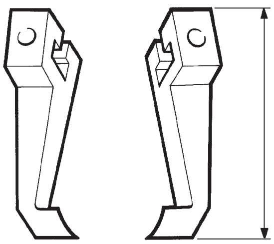
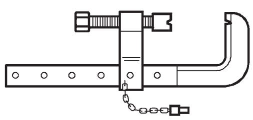
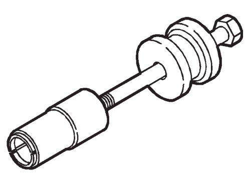
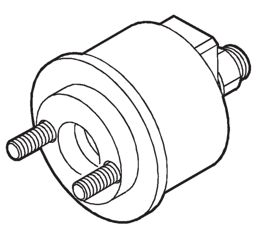
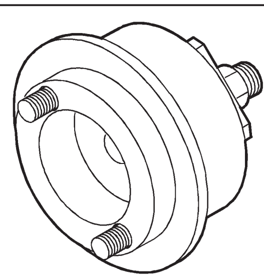
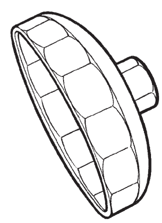
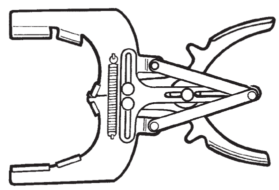
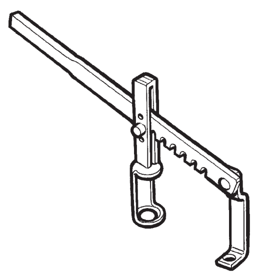
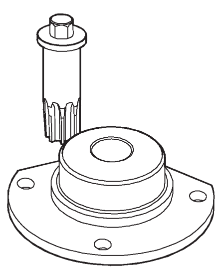
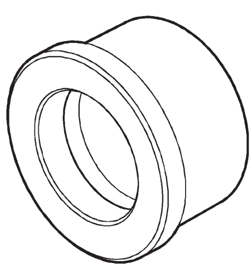
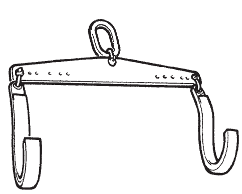
TOOLS

Tool No.		Definition
99305018		Kit for valve seat regrinding
99305047		Spring load tester
99317915		Set of 3 pin wrenches (14 - 17 - 19 mm)
99322205		Revolving stand for overhauling units (700 daN/m capacity, 120 daN/m torque)
99340055		Tool to remove output shaft front gasket
99340056		Tool to remove output shaft rear gasket

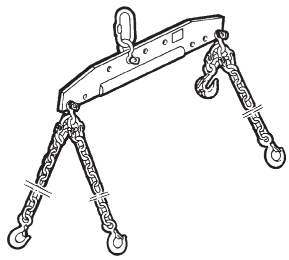
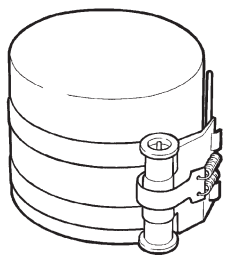
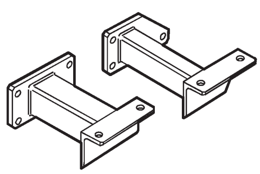
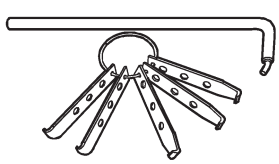
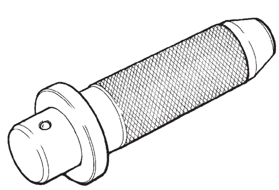
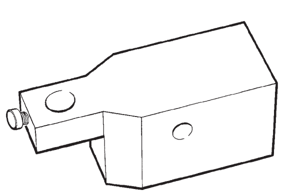
TOOLS

Tool No.		Definition
99341001		Double acting puller
99341009		Pair of brackets
99341015		Press
99342101		Tool to remove injectors
99346252		Tool for fitting output shaft rear gasket
99346253		Tool for fitting output shaft rear gasket

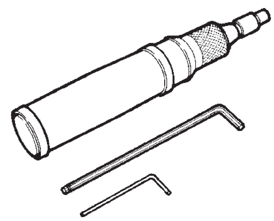
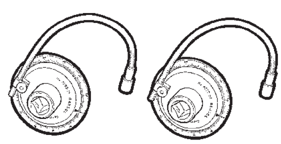
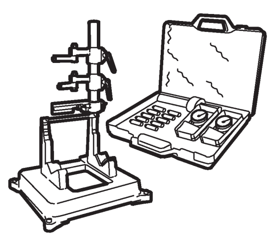
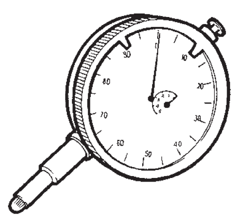
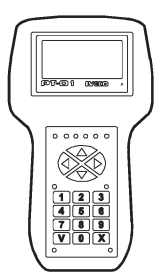
TOOLS

Tool No.		Definition
99360076		Tool to remove oil filter (engine)
99360183		Pliers for removing/refitting piston rings (65 - 110 mm)
99360268		Tool for removing/refitting engine valves
99360339		Tool for rotating/stopping the engine flywheel
99360362		Beater for removing/refitting camshaft bushes (to be used with 993700069)
99360500		Tool for lifting the output shaft

TOOLS

Tool No.		Definition
99360595		Lifting rig for engine removal/refitting
99360605		Band for fitting piston into cylinder barrel (60 - 125 mm)
99361037		Brackets for fastening engine to revolving stand 99322205
99363204		Tool to remove gaskets
99370006		Handgrip for interchangeable beaters
99370415		Gauge base for different measurements (to be used with 99395603)

TOOLS

Tool No.		Definition
99389834		Torque screwdriver for injector solenoid valve connector stop nut setting
99395216		Pair of gauges with 1/2" and 3/4" square head for angle tightening
99395363		Complete bush testing square
99395603		Dial gauge (0 - 5 mm)
8093731		Tester PT1

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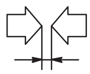
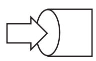
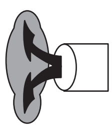
SECTION 8

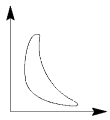
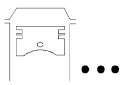
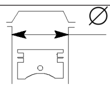
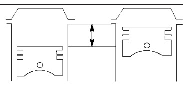
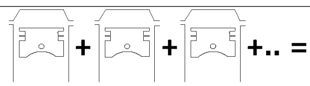
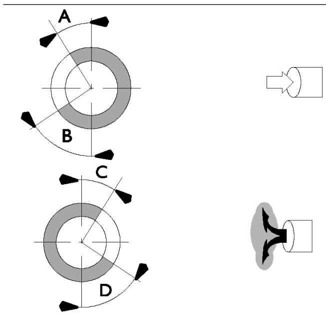
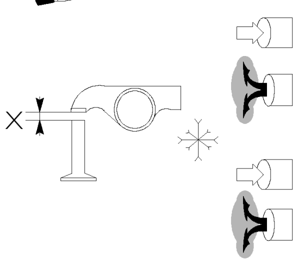
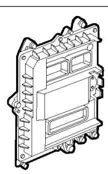
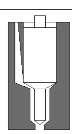
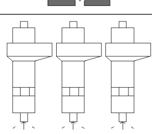
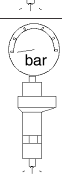
OVERHAUL

(continues on next page)

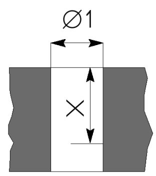
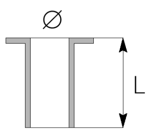
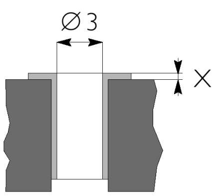
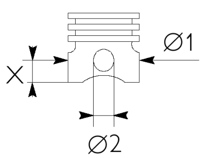
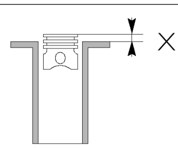
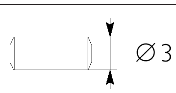
Graph and symbols

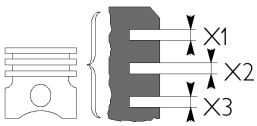
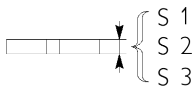
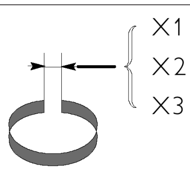
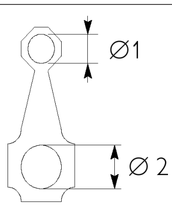
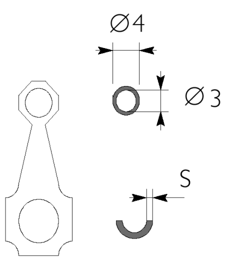
	Surface for machining Machine finish
	Interference Strained assembly
	Thickness Clearance
	Intake
	Exhaust
	Operation
ϱ	Compression ratio
	Preload
$>$	Oversized Higher than … Maximum, peak
$<$	Undersized Less than … Minimum
	Selection Classes Oversizing
IVECO PARTS	Replacement Original spare parts

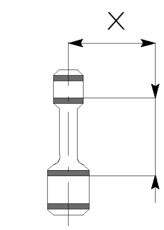
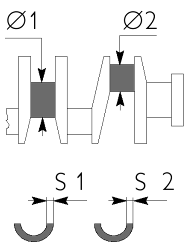
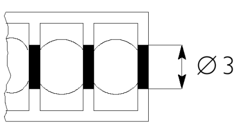
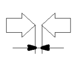
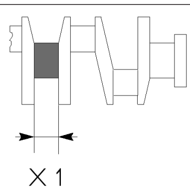
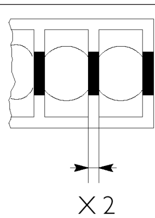
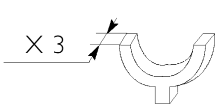
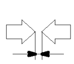
GENERAL SPECIFICATIONS

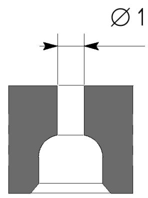
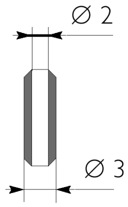
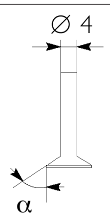
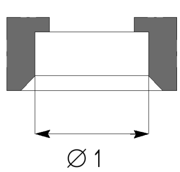
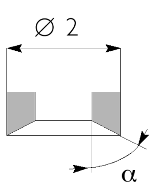
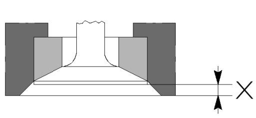
	Engine		4 Cylinders	6 Cylinders
	Cycle		Four-stroke diesel engine	
	Air feeding		Turbocharged with aftercooler	
	Injection		Direct	
	Number of cylinders		4 in-line	6 in-line
	Bore	mm	102	
	Stroke	mm	120	
	Total displacement	cm³	3920	5880
	**Timing**			
	start before T.D.C.	A	18.5°	
	end after B.D.C.	B	29.5°	
	start before B.D.C.	D	67°	
	end after T.D.C.	C	35°	
	Checking timing			
	X	mm	-	
		mm	-	
	Checking operation			
	X	mm	0.20 to 0.30	
		mm	0.45 to 0.55	
	**Fuel feed**			
	Injection		High pressure common rail	
	Type:	Bosch	EDC7 ECU	
	Nozzle type		Injectors	
	Injection sequence		1 - 3 - 4 - 2	1 - 5 - 3 - 6 - 2 - 4
	Injection pressure	bar	250 - 1450	

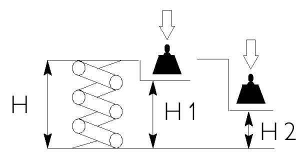
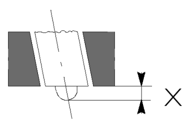
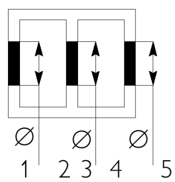
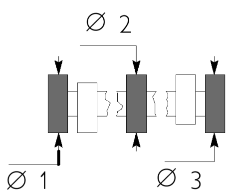
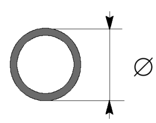
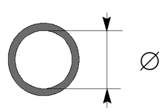
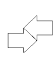
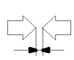
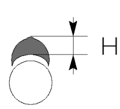
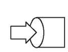
CLEARANCE DATA

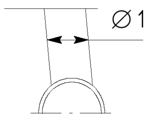
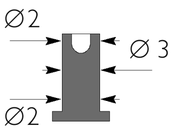
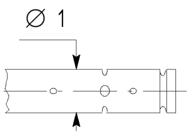
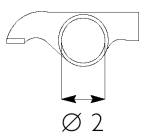
	Engine		4 Cylinders	6 Cylinders
Cylinder unit and crankshaft components			mm	
	Cylinder barrels	Ø 1	102,01 to 102,03	
	Cylinder barrels: outside diameter length	 Ø 2 L	 - -	
	Cylinder barrels - housings on engine block (interference)		-	
	Outside diameter	Ø 2	-	
	Cylinder barrels: inside diameter	 Ø 2	 -	
	Spare pistons type: Size Outside diameter Pin housing	 X Ø 1 Ø 2	 12 101.883 to 101.897 40.008 to 40.014	
	Piston - cylinder barrels		0.113 to 0.147	
	Piston diameter	Ø 1	0.5	
	Piston protrusion	X	0.28 to 0.52	
	Piston pin	Ø 3	39.9968 to 40.0032	
	Piston pin - pin housing		0.0048 to 0.0172	

	Engine		4 Cylinders 6 Cylinders
	Cylinder unit and crankshaft components		mm
	Split ring slots	X 1* X 2 X 3	2.705 to 2.735 2.420 to 2.440 4.020 to 4.040
	Split rings * measured on 98 mm Ø, 4 cyl. * measured on 99 mm Ø, 6 cyl.	S 1* S 2 S 3	2.560 to 2.605 2.350 to 2.380 3.975 to 4.000
	Split rings - slots	1 2 3	0.100 to 0.175 0.040 to 0.090 0.020 to 0.065
IVECO PARTS	Split rings		0.5
	Split ring end opening in cylinder barrel:	X 1 X 2 X 3	0.22 to 0.32 0.60 to 0.85 0.25 to 0.55
	Small end bush housing Big end bearing housing	Ø 1 Ø 2	42.987 to 43.013 72.987 to 73.013
	Small end bush diameter Outside Inside Spare big end half bearings	Ø 4 Ø 3 S	43.279 to 43.553 40.019 to 40.033 1.955 to 1.968
	Small end bush - housing		0.266 to 0.566
	Piston pin - bush		0.0362 to 0.0158
IVECO PARTS	Big end half bearings		0.250 to 0.500

	Engine		4 Cylinders	6 Cylinders
Cylinder unit and crankshaft components			mm	
	Size	X	-	
	Max. tolerance on connecting rod axis alignment	=	-	
	Journals Crankpins	Ø 1 Ø 2	82.99 to 83.01 68.987 to 69.013	
	Main half bearings Big end half bearings	S 1 S 2	2.456 to 2.464 1.955 to 1.968	
	* provided as spare part			
	Main bearings n° 1-5 / 1-7 n° 2-3-4 / 2-3-4-5-6	 Ø 3 Ø 3	 87.982 to 88.008 87.977 to 88.013	
	Half bearings - Journals n° 1-5 / 1-7 n° 2-3-4 / 2-3-4-5-6		 0.041 to 0.119 0.041 to 0.103	
	Half bearings - Crankpins		0.033 to 0.041	
IVECO PARTS	Main half bearings Big end half bearings		+ 0.250 ; + 0.500	
	Shoulder journal	X 1	37.475 to 37.545	
	Shoulder main bearing	X 2	25.98 to 26.48	
	Shoulder half-rings	X 3	37.28 to 37.38	
	Output shaft shoulder		0.068 to 0.410	

	Engine		4 Cylinders / 6 Cylinders
Cylinder head - timing system			mm
	Valve guide seats on cylinder head	Ø 1	7.042 to 7.062
	Valve guides:	Ø 2	-
		Ø 3	-
	Valve guides and seats on head		-
	Valve guides		-
	Valves:		
		Ø 4 α	6.970 to 6.999 60° ± 0.25°
		Ø 4 α	6.970 to 6.999 45° ± 0.25°
	Valve stem and guide		0,043 to 0,092
	Housing on head for valve seat:	Ø 1	34.837 to 34.863
		Ø 1	34.837 to 34.863
	Valve seat outside diameter; valve seat angle on cylinder head:	Ø 2 α	34.917 to 34.931 60°
		Ø 2 α	34.917 to 34.931 45°
	Sinking	X	0.59 to 1.11
		X	0.96 to 1.48
	Between valve seat and head		0.054 to 0.094
			0.054 to 0.094
	Valve seats		-

	Engine		4 Cylinders / 6 Cylinders
Cylinder head - timing system			mm
	Valve spring height: free spring under a load equal to: 339.8 ± 9 N 741 ± 39 N	 H H 1 H 2	 47.75 35.33 25.2
	Injector protrusion	X	-
	Camshaft bush housings n° 1-5 / 1-7 Camshaft housings n° 2-3-4 / 2-3-4-5-6		59.222 to 59.248 54.089 to 54.139
	Camshaft journals: 1 ➔ 5 1 ➔ 7	 ∅ ∅	 53,995 ÷ 54,045 54,005 ÷ 54,035
	Camshaft bush outside diameter:	∅	-
	Bush inside diameter	∅	54.083 to 54.147
	Bushes and housings on block		-
	Bushes and journals		0.038 to 0.162
	Cam lift:  	 H H	 6.045 7.582

Engine		4 Cylinders	6 Cylinders
Cylinder head - timing system		mm	
	Tappet cap housing on block Ø 1	16.000 to 16.030	
	Tappet cap outside diameter: Ø 2 Ø 3	15.924 to 15.954 15.960 to 15.975	
	Between tappets and housings	0.025 to 0.070	
	Tappets	-	
	Rocker shaft Ø 1	21.965 to 21.977	
	Rockers Ø 2	22.001 to 22.027	
	Between rockers and shaft	0.024 to 0.062	

ENGINE OVERHAUL - ENGINE DISASSEMBLY AT THE BENCH

Foreword

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

CAUTION

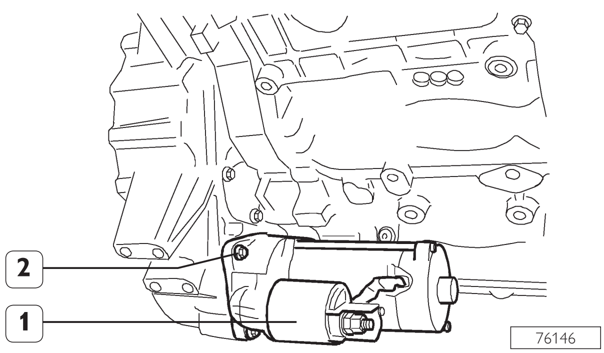
All operations of engine disassembly operations as well as overhaul operations must be executed by qualified engineers provided with the specific tooling and equipment required.

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

The following operations are relating to the 4 cylinder engine but are similar and applicable for the 6 cylinder.

Engine setting operations for the assembly on turning stand

Figure 1



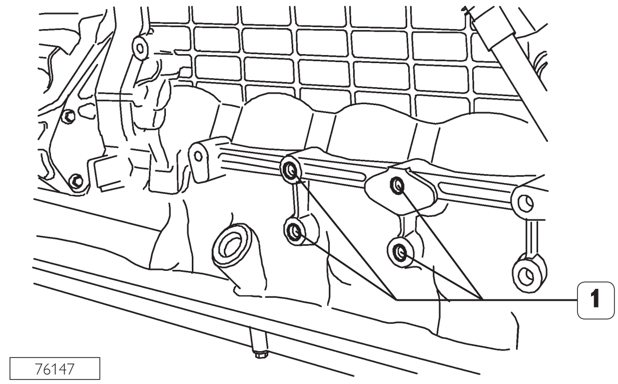
On the right hand side:

- ❏ Disassemble the starter; properly hold the starter (1) and loosen the fixing screws (2);
- ❏ Disassemble oil filter.

CAUTION

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

Figure 2

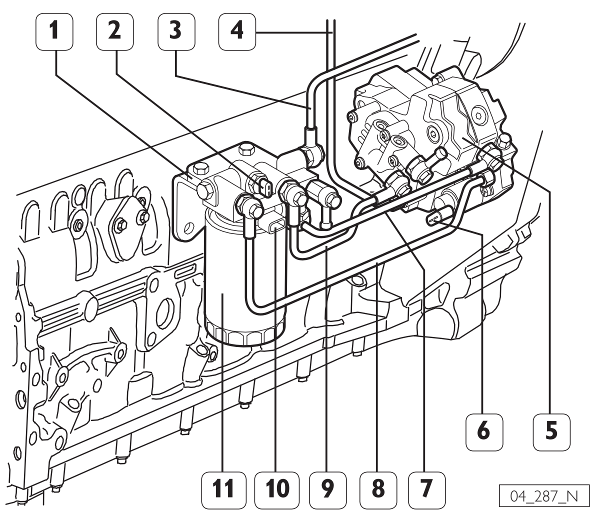


- ❏ Assemble the bracket bearing 99361037 using the four screw threaded ports (1).

On the left hand side:

- ❏ Remove the oil dipstick together with guide pipe (2); (loosen the guide pipe disassembling from the block); properly pipe the screw-threaded port to avoid inlet of foreign matters.

Figure 3



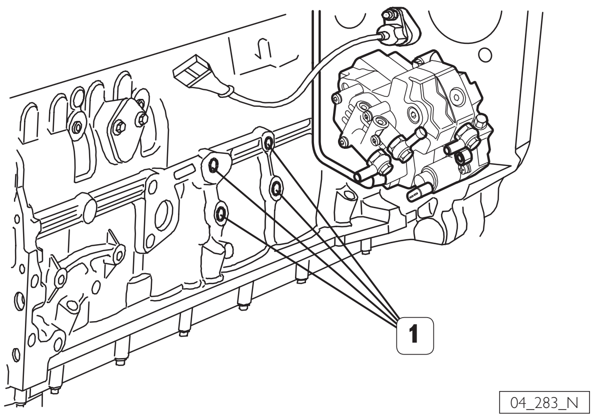
- ❏ Disconnect the connectors (2, 6 and 10) from wiring harness;
- ❏ Remove low pressure fuel pipes (3, 7, 8 and 9);
- ❏ With the 99360076 tool remove the fuel filter (11) from bearing (1);
- ❏ Disconnect the high pressure fuel pipe (4) from rail and from high pressure pump (5), and remove it from engine block loosening the fixing clamps.

CAUTION

Because of the high pressure in the pipelines connecting the high pressure pump to the rail, and this one to the electro-injectors, it is absolutely forbidden to:

- ❏ Disconnect the pipelines when the engine is running;
- ❏ Re-use the disassembled pipelines.

Figure 4



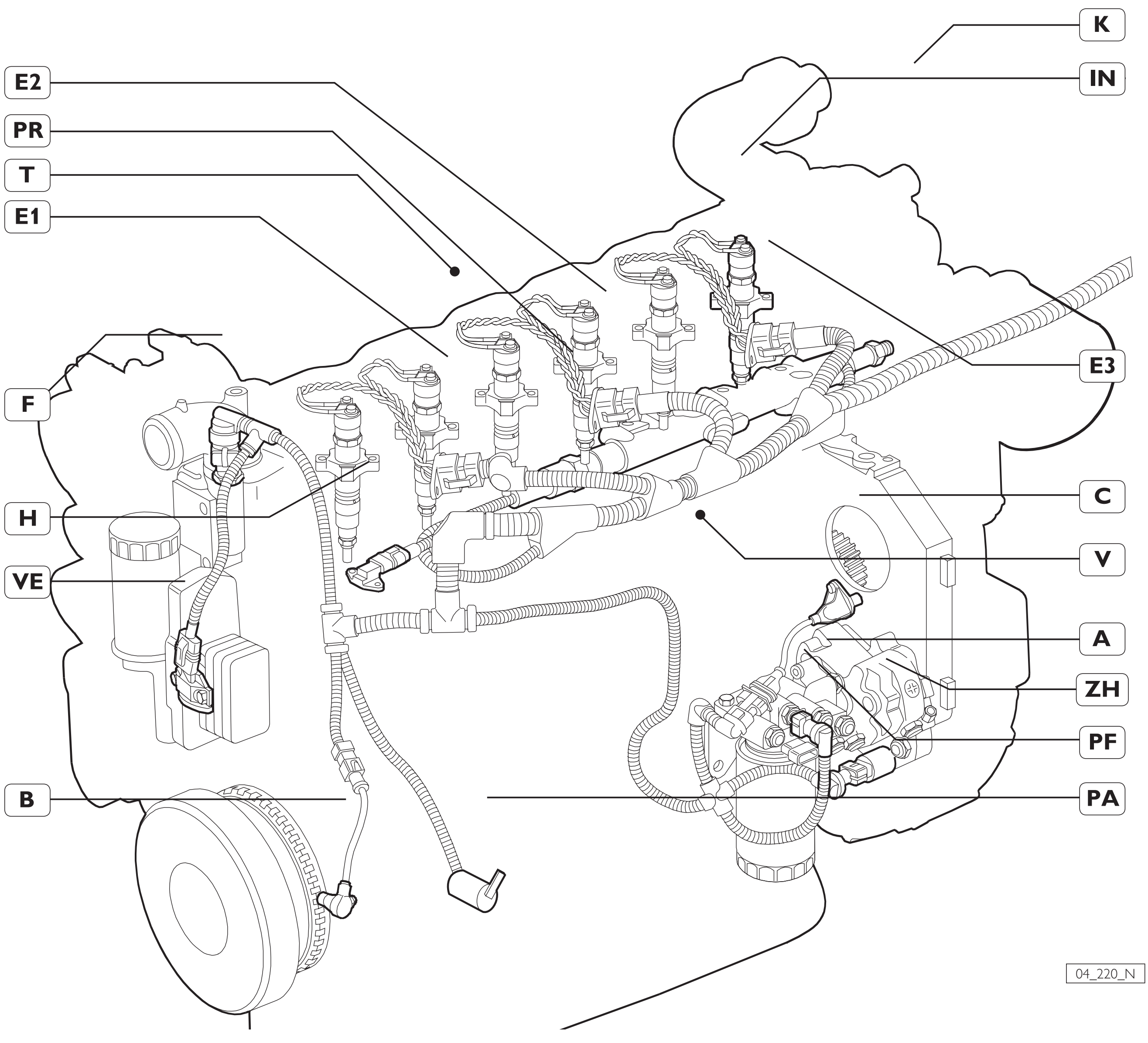
- ❏ Assemble the 99361037 second bracket by means of the screw-threaded ports (1);
- ❏ Lift the engine using the 99360595 rocker arm and put it on the 99322205 turning stand;
- ❏ Drain the oil through the cap on the side of the sump.

CAUTION

Avoid contact of engine oil with the skin: in case of skin contamination rinse in running water.
Engine oil is highly pollutant: provide for disposal in compliance with the law and regulations in force.

Components removal

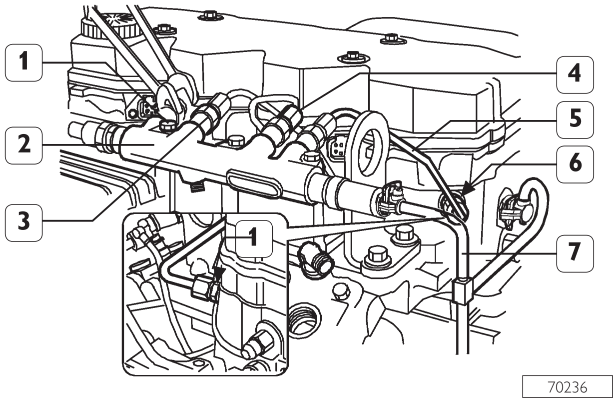
Figure 5



A. Fuel temperature sensor for EDC - B. Drive shaft sensor - C. Camshaft sensor - F. Engine coolant temperature sensor for EDC - H. Combustion air pressure/temperature sensor for EDC - K. Air filter clogging sensor (for alarm) - T. Coolant temperature sensor (for gauge) - V. Oil pressure sensor (for gauge) - E1. Electro-injectors cylinders 1 and 2 connector - E2. Electro-injectors cylinders 3 and 4 connector - E3. Electro-injectors cylinders 5 and 6 connector - IN. Electro-injectors - PA. Throttle position sensor - PF. Heating element on fuel filter - PR. Rail pressure sensor - VE. Engine oil pressure/temperature sensor for EDC - ZH. Pressure control solenoid valve.

- ❏ Disconnect all the connectors from wiring harness;
- ❏ Loosen the fixing clamps retaining the wiring to the engine block and remove it.

Figure 6



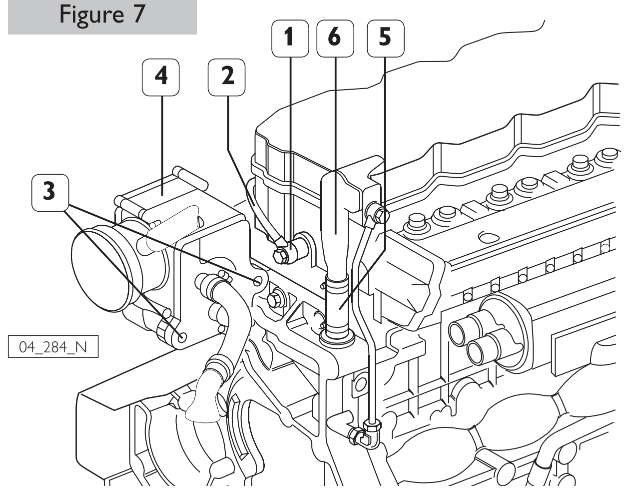
❑ Disconnect from the rail (2): the fuel pipe (7) according to procedures described in figure 3. Disconnect fuel pipes (5) from rail (2) and injector manifolds (6).

CAUTION

When releasing pipe (6) connections (4) to rail (2), use the proper wrench to avoid rotation of flow limiters (3).

❑ Remove the screws (1) and disconnect the rail (2).

Figure 7



❑ Disconnect the pipeline (2) from the fuel recover pressure-limiter (2), working on the connections as described in Figure 3;

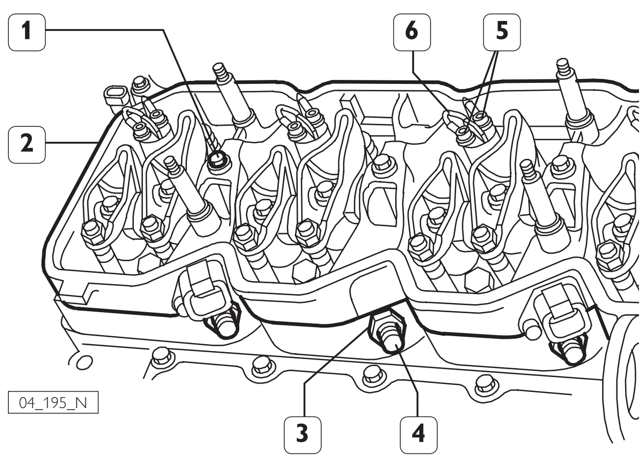
❑ Unscrew the nut and loosen the clamp tightening the oil vapour pipe (5);

❑ Remove the pipe (6);

❑ Loosen the screws (3) and disassemble the blow-by filter (4);

❑ Remove on the nuts and tappet cover.

Figure 8



❑ Remove nuts (5) and disconnect the electrical cables from injectors (6);

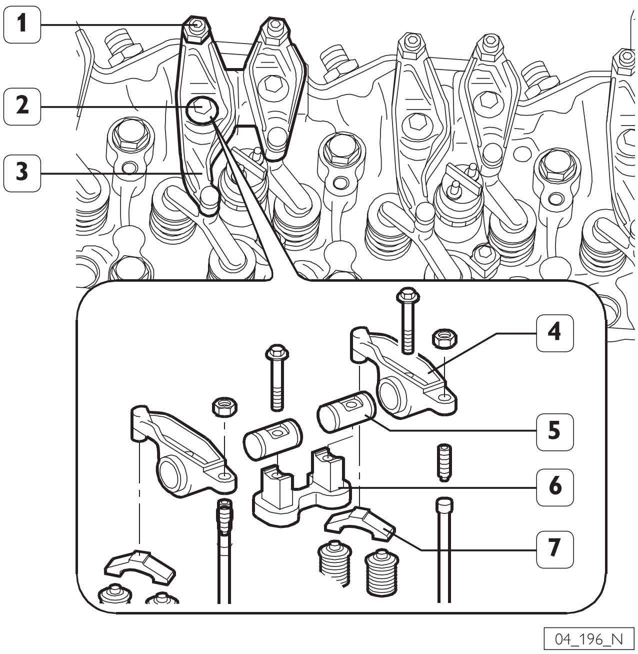
❑ Remove screws (1) and disconnect injector wiring support (2) including the gasket;

❑ Remove nuts (3) and remove fuel manifolds (4).

CAUTION

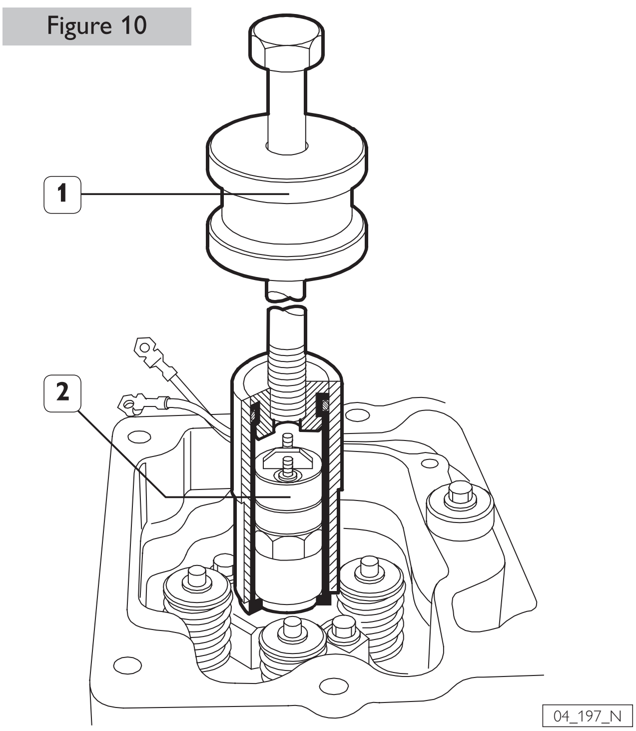
Disassembled fuel manifolds (4) must not be used again, replace with new ones during reassembly.

Figure 9



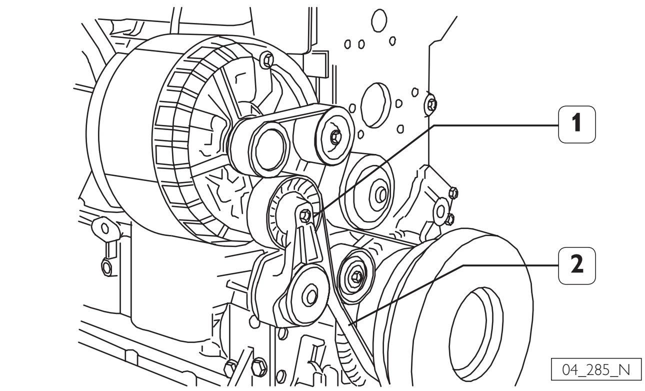
Loosen tappet adjustment fastening nuts (1) and unscrew the adjusters.
Remove the screws (2), remove the rocker assembly (3), consisting of: bracket (6), rockers (4), shafts (5) and remove jumpers (7) from valves.

Figure 10



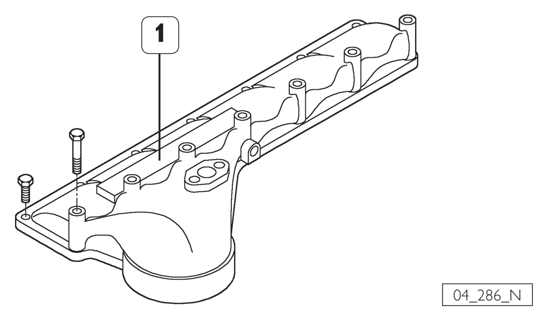
Remove injector fastening screws. Use tool 99342101 (1) to remove injectors (2) from the cylinder head.

Figure 11



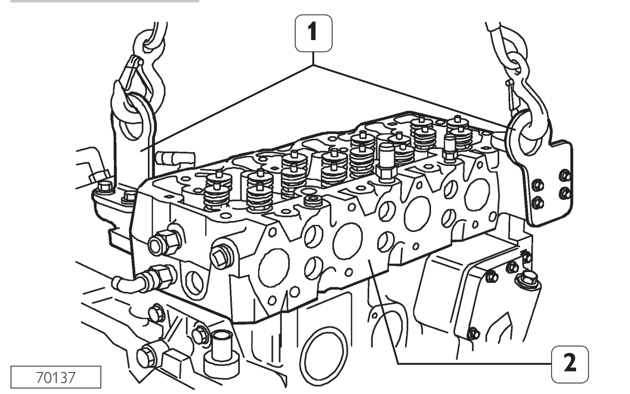
- ❏ Release on the drive belt tensioner (1) and extract the belt (2) from the alternator, water pump and belt rebound pulleys;
- ❏ Disassemble the belt tensioner;
- ❏ Loosen the screws fixing the alternator to the support and remove it.

Figure 12



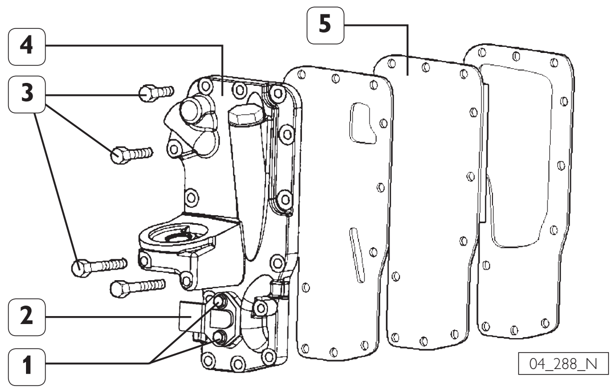
- ❏ Loosen the fixing screws and remove the inlet manifold (1);
- ❏ Remove the cylinder head fixing screws.

Figure 13



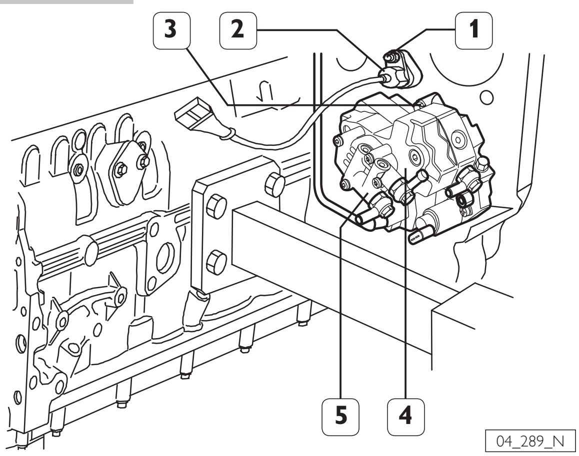
Hook brackets (1) with suitable lifting chains and remove cylinder head (2) from block using hoist.

Figure 14



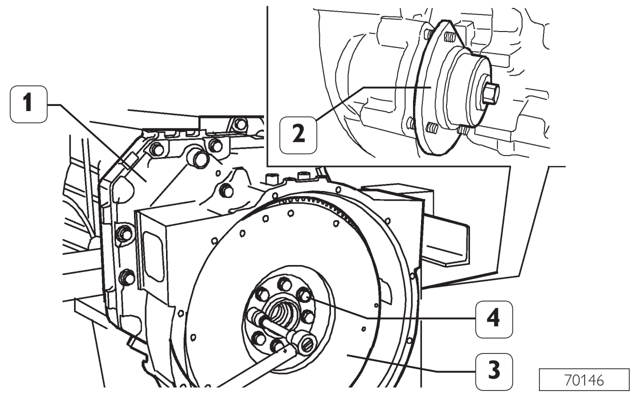
- Remove the screws (1) and disconnect the oil temperature/pressure sensor (2);
- Remove the screws (3) and then remove: heat exchanger/oil filter support (4), intermediate plate (5) and relevant gaskets.

Figure 15



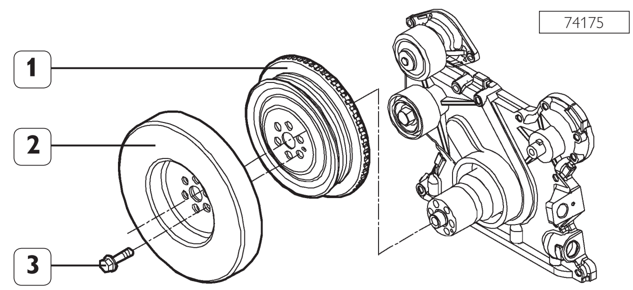
- Remove the nut (1) and disconnect the timing sensor (2);
- Remove the nuts (3) and disconnect the high pressure pump (4) including the feed pump (5).

Figure 16



- Fit tool 99360339 (2) to the flywheel housing (1) to stop flywheel (3) rotation;
- Loosen the screws (4).

Figure 17

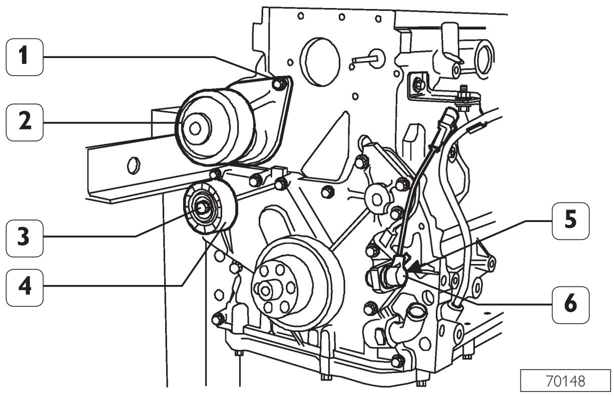


- Unloose the screws (3) and disassemble the damping flywheel (2) and the pulley (1);
- The tool for flywheel holding can help removal of damping flywheel (2) mounted on the pulley (1).

CAUTION

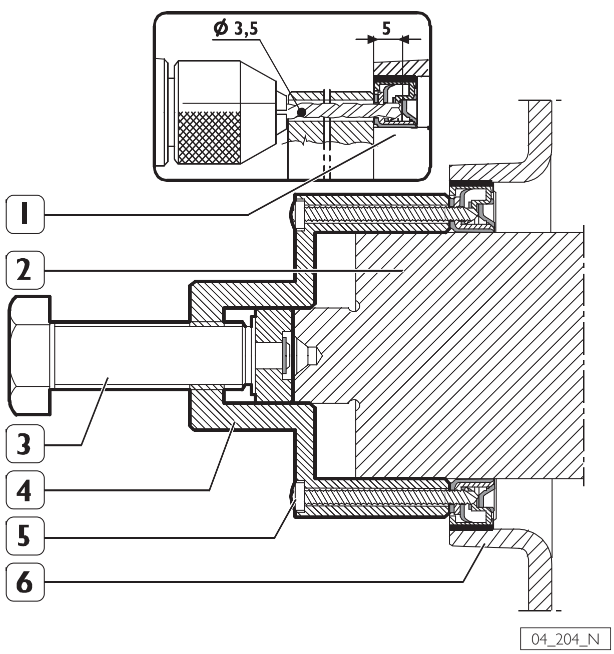
In some versions, the phonic wheel mounted on pulley (1) may be not present and pulley (1) can be different from the pulley shown in Figure 17.

Figure 18



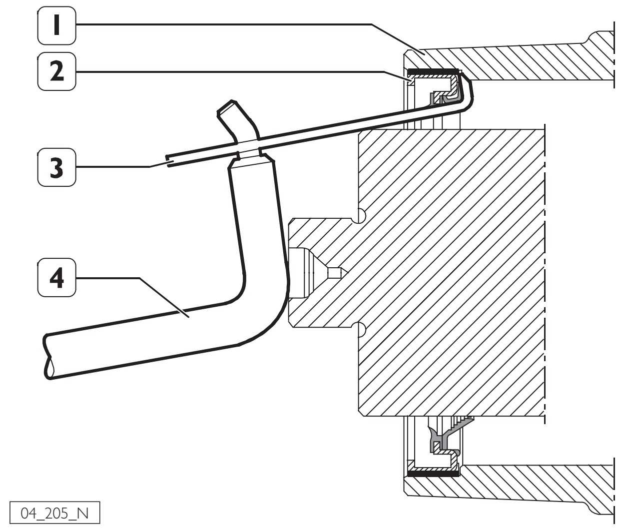
- Remove the screws (1) and disconnect the water pump (2);
- Remove the screw (3) and the roller (4);
- Remove the screw (5) and disconnect the engine speed sensor (6).

Figure 19



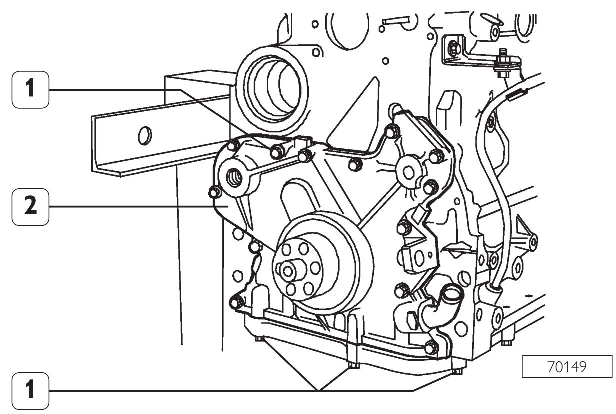
- Remove the engine drive shaft fixing ring from the front cover. Use the tool 99340055 (4) to operate on the front tang (2) of the engine drive shaft. Through the tool guide ports, drill the internal holding ring (1) using ∅ 3.5 mm drill for a 5 mm depth;
- Fix the tool to the ring tightening the 6 screws specially provided. Proceed to remove the ring (1) by tightening the screw (3).

Figure 20



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

Figure 21

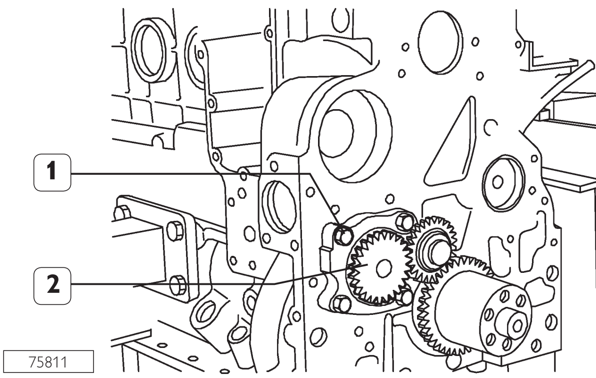


- Loosen the screws (1) and remove the front cover (2).

CAUTION

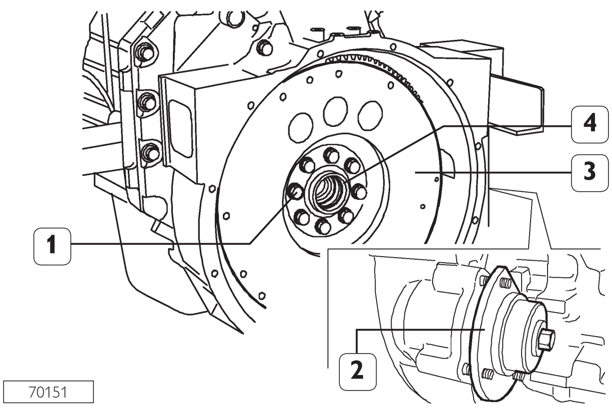
Take note of the screw (1) assembly position, since the screws have different length.

Figure 22



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

Figure 23

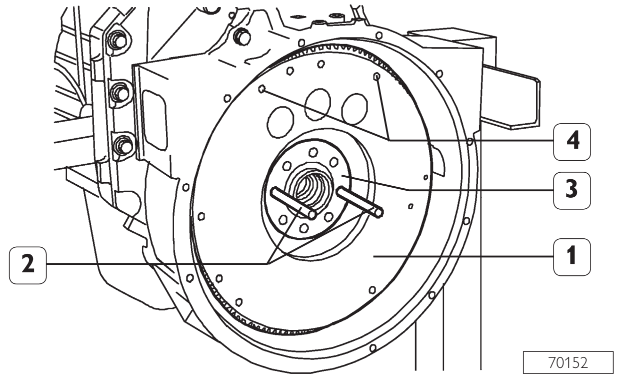


❏ Screw out the opposite screws (1) from the ports where the withdrawal pins are to be introduced (see following picture);

❏ Loosen remaining flywheel fixing screws (3) to the engine drive shaft (4);

❏ Remove the flywheel block tool 99360351 (2).

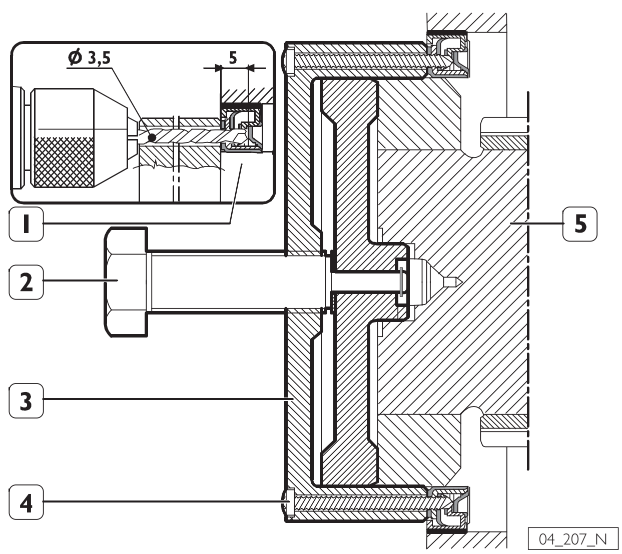
Figure 24



❏ Screw down two medium length screws in the ports (4) to sling the flywheel with a hoist;

❏ By means of two guide pins (2) previously screwed into the engine drive shaft ports (3) control the engine flywheel (1) removal by means of a hoist.

Figure 25



❏ Remove the flywheel cover box fixing ring using the tool 99340056 (3) to operate on the back tang (5) of the engine drive shaft;

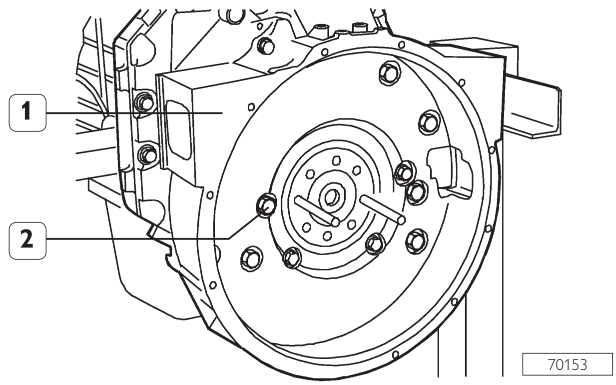
❏ Through the tool guide ports, drill the internal holding ring using ∅ 3.5 mm drill for a 5mm depth;

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

❏ Proceed with drawing the ring (1) tightening the screw (2);

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

Figure 26

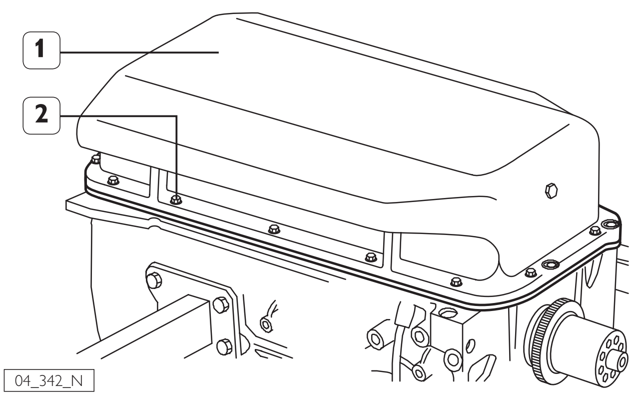


❏ Loosen the screws (2) and remove the flywheel cover box (1).

CAUTION

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

Figure 27



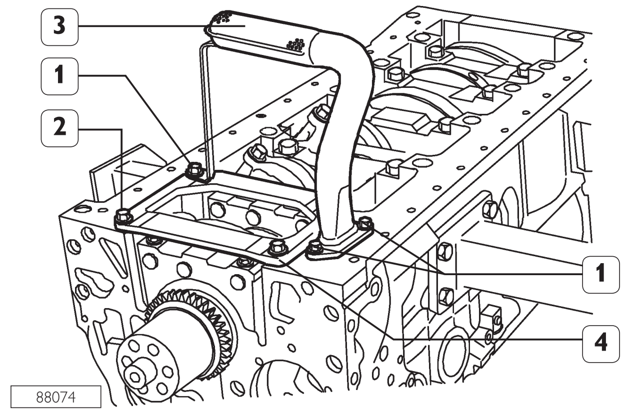
❏ Turn the engine upside-down;

❏ Loosen the screws (2) and remove the oil sump (1).

CAUTION

The shape and dimensions of the sump and of the rose pipe may vary according to the engine application.
The relating illustrations provide general guidelines of the operation to be performed.
The procedures described are applicable anyway.

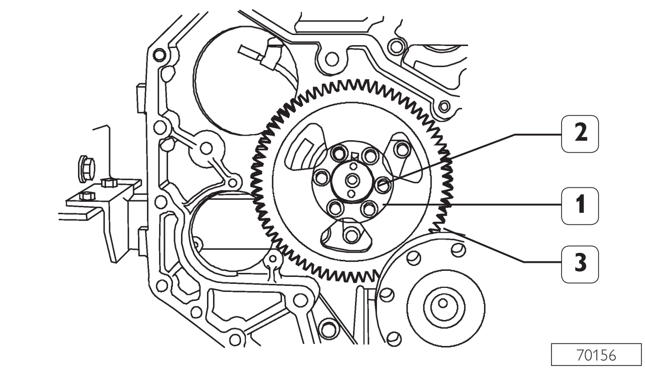
Figure 28



❏ Loosen the screws (1) and disassemble the oil suction rose pipe (3);

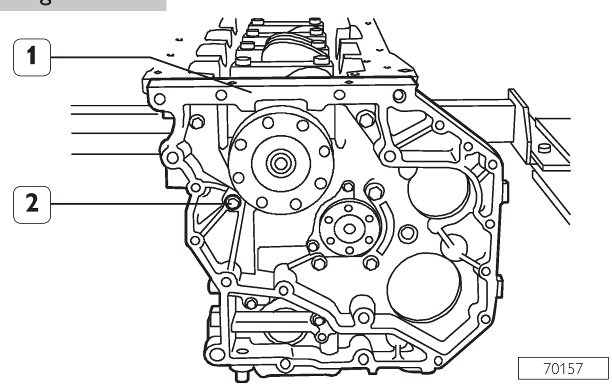
❏ Loosen the screws (2) and remove the stiffening plate (4).

Figure 29



❏ Loosen the screws (1) and disassemble the gear from the camshaft (2).

Figure 30



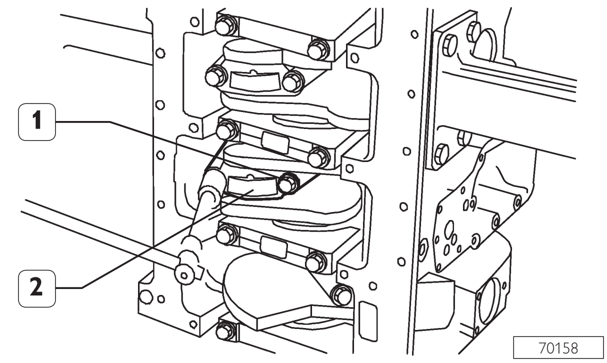
❏ Loosen the screws (2) and disassemble the timing gearbox (1).

CAUTION

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

CYLINDER UNIT

Figure 31

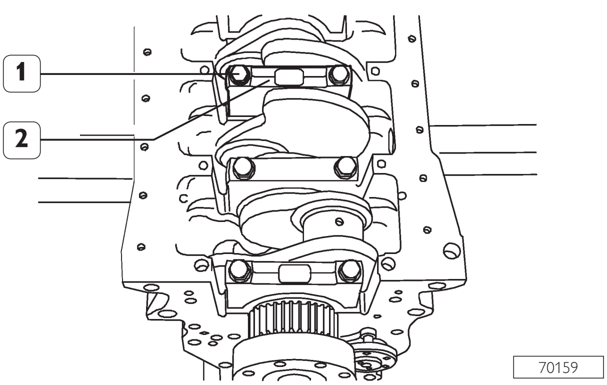


- ❑ Remove the screws (1) fastening the connecting rod caps (2) and remove them;
- ❑ Remove the pistons including the connecting rods from the top of the engine block.

CAUTION

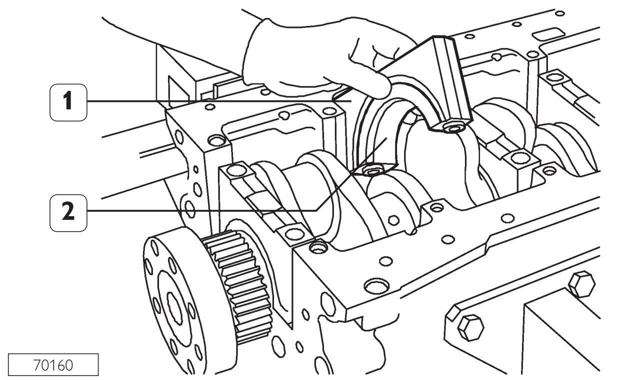
Keep the half-bearings into their housings since in case of use they must be fitted in the same position found at removal.

Figure 32



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

Figure 33

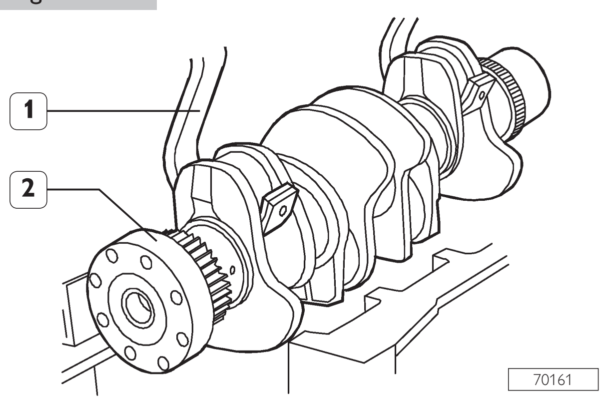


- ❑ The last main bearing cap but one (1) and the relevant support are fitted with shoulder half-bearing (2).

CAUTION

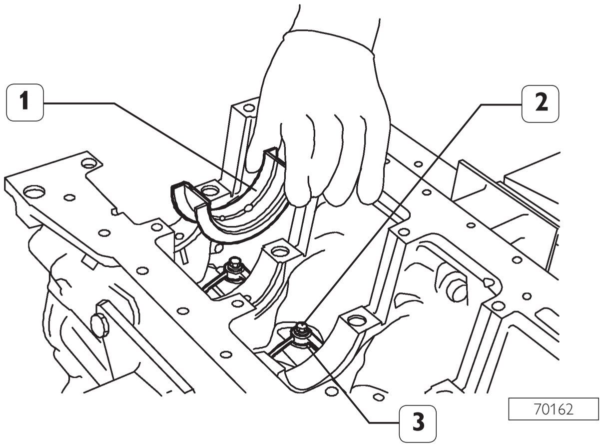
Take note of lower and upper half-bearing assembling positions since in case of reuse they must be fitted in the same position found at removal.

Figure 34



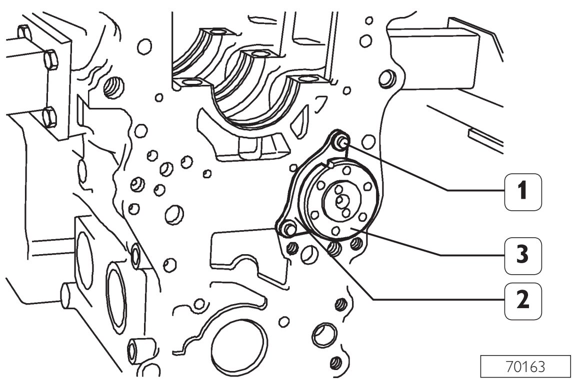
- ❑ Use tool 99360500 (1) and hoist to remove the crankshaft (2) from the block.

Figure 35



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

Figure 36

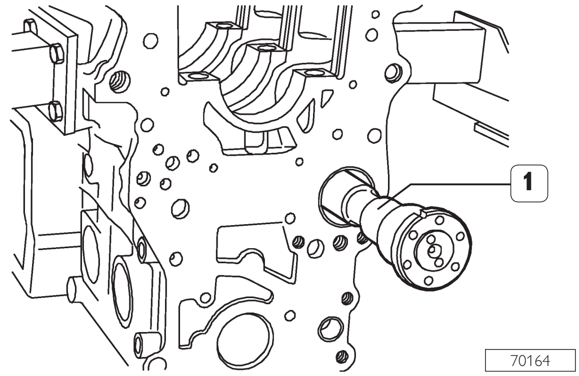


- Remove the screws (1) and disconnect camshaft (3) retaining -plate (2).

CAUTION

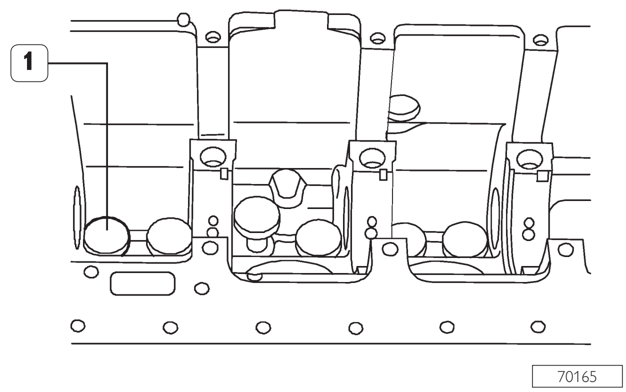
Take note of plate (2) assembling position.

Figure 37



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

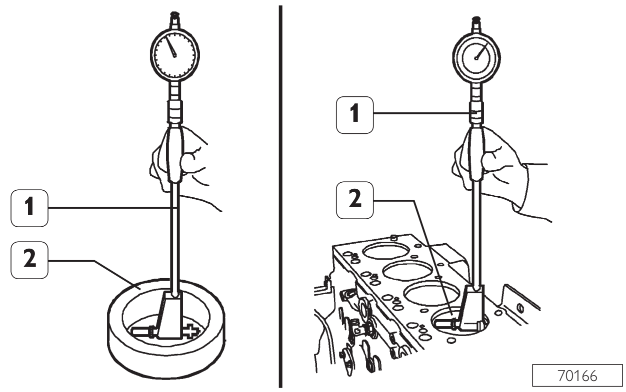
Figure 38



- Remove the tappets (1) from the engine block.

Checks and measurements

Figure 39

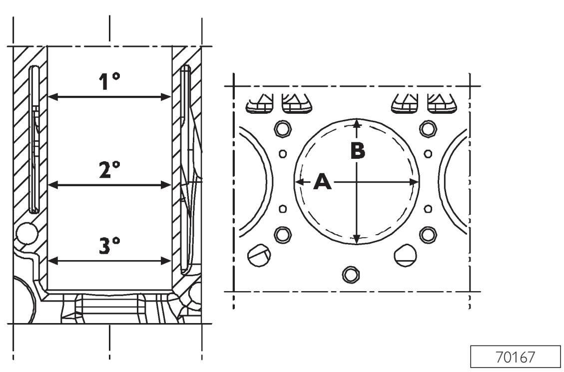


Once engine is disassembled, clean accurately the cylinder-block assembly.
Use the proper rings to handle the cylinder unit.
Inspect the engine block to verify the absence of any crack.
Check operating plug conditions and replace them in case of uncertain seal or if rusted.
Inspect cylinder barrel surfaces; they must be free from seizing, scores, ovalisation, taper or excessive wear.
Inspection of cylinder barrel bore to check ovalisation, taper and wear will be performed using the bore dial gauge (1) fitted with the dial gauge previously set to zero on the ring gauge (2) of the cylinder barrel diameter.

CAUTION

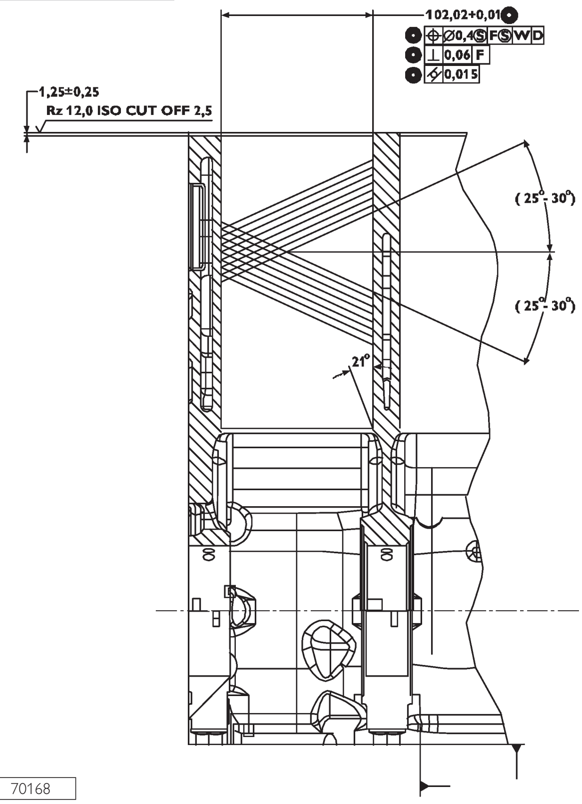
Should the ring gauge be not available, use a micrometer for zero-setting.

Figure 40



Measurements must be performed on each cylinder, at three different heights in the barrel and on two planes perpendicular with each other: one parallel to the longitudinal axis of the engine (A), and the other perpendicular (B). Maximum wear is usually found on plane (B) in correspondence with the first measurement.
Should ovalisation, taper or wear be found, bore and grind the cylinder barrels. Cylinder barrel regrinding must be performed according to the spare piston diameter oversized by 0.5 mm and to the specified assembling clearance.

Figure 41



CAUTION

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

Check main bearing housings as follows:

- ❑ Fit the main bearings caps on the supports without bearings;
- ❑ Tighten the fastening screws to the prescribed torque;
- ❑ Use the proper internal gauge to check whether the housing diameter is falling within the specified value.

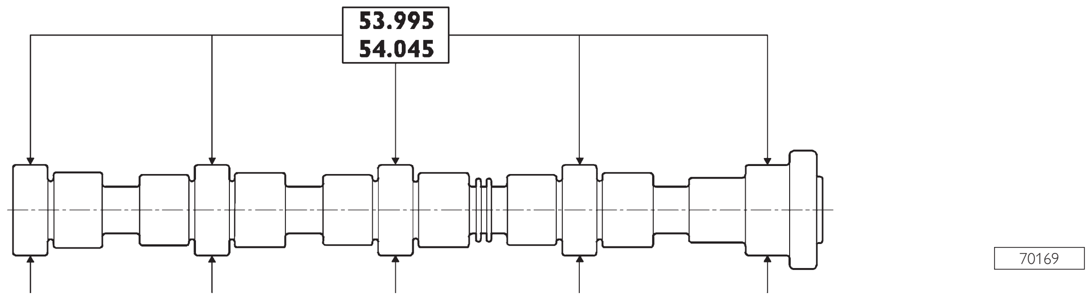
Replace if higher value is found.

Checking head supporting surface on cylinder unit

When finding the distortion areas, replace the cylinder unit.
Planarity error cannot exceed 0.075 mm.
Check cylinder unit operating plug (1) conditions, replace them in case of uncertain seal or if rusted.

TIMING SYSTEM

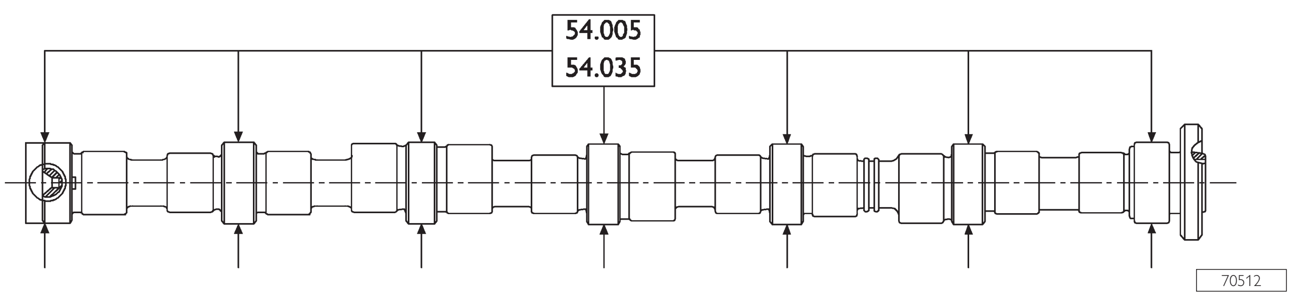
Figura 42 A



CAMSHAFT MAIN DATA (4 cylinders)
Specified data refer to pin standard diameter.

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

Figura 42 B



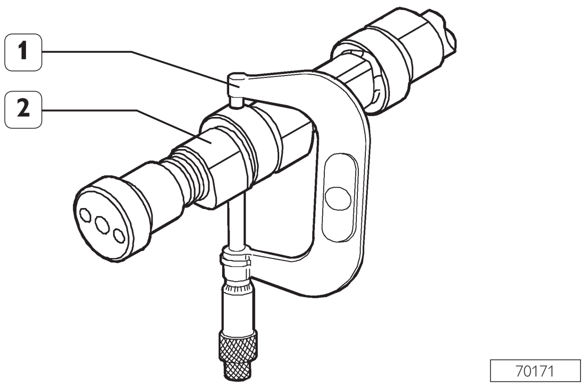
MAIN DATA ABOUT CAMSHAFT PINS (6 cylinders)
Specified data refer to pin standard diameter.

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

Checking cam lift and pin alignment

Set the camshaft on the tailstock and using a 1/100 gauge set on the central support, check whether the alignment error is not exceeding 0.04 mm, otherwise replace the camshaft.
Check cam lift; found values must be: 6.045 mm for exhaust cams and 7.582 mm for intake cams, in case of different values replace the camshaft.

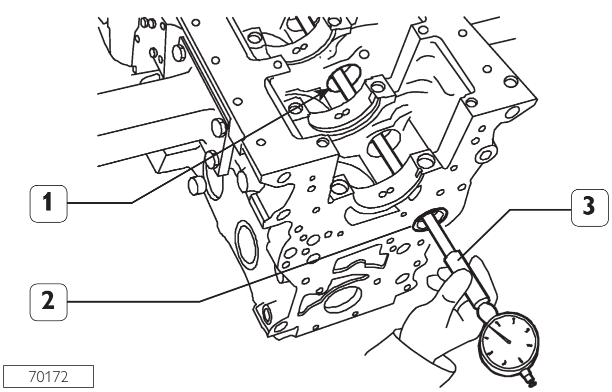
Figure 43



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

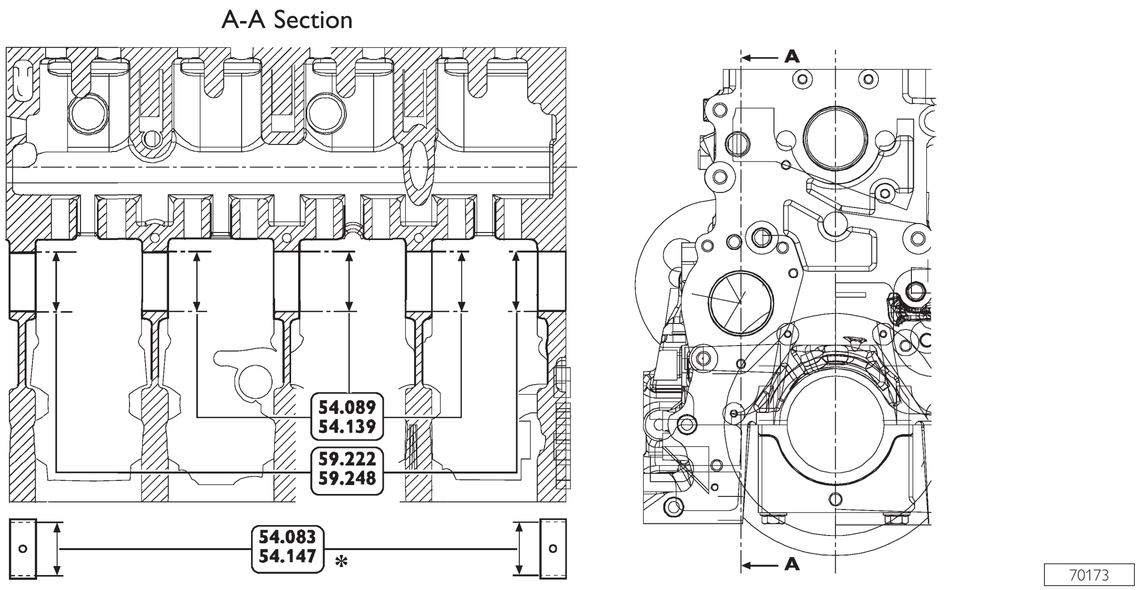
Bushes

Figure 44



Camshaft bushes (2) must be pressed into their housings.
Internal surfaces must not show seizing or wear.
Use bore dial gauge (3) to measure camshaft front and rear bush (2) and intermediate housing (1) diameter.
Measurements must be performed on two perpendicular axes.

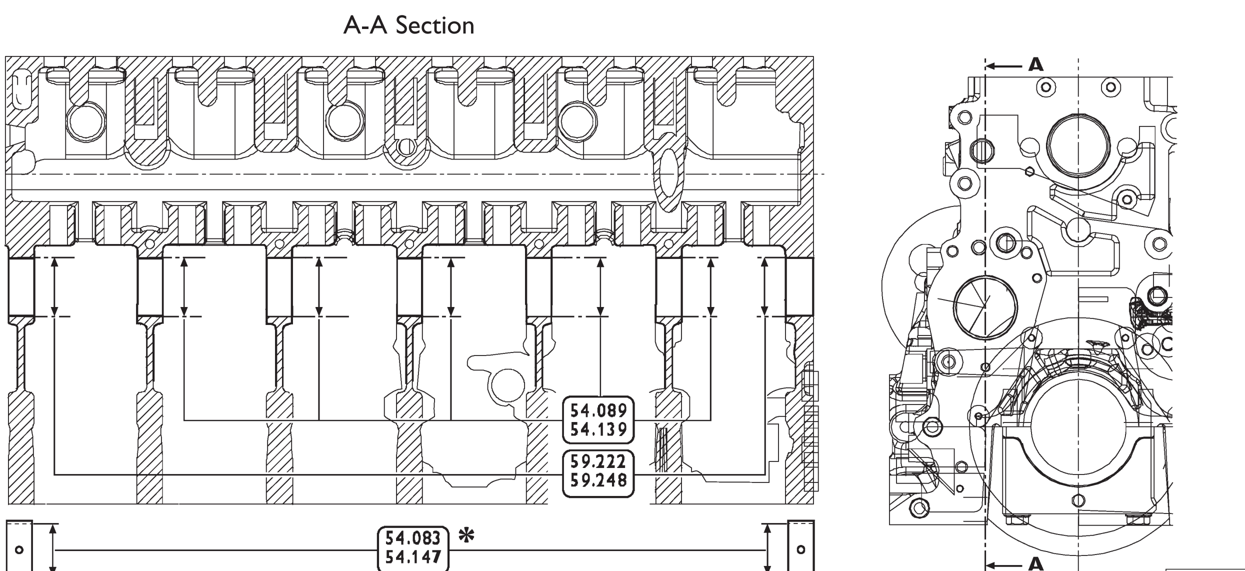
Figura 45 A



CAMSHAFT BUSH AND HOUSING MAIN DATA (4 cylinders)

* Value to be obtained after driving the bushes.

Figura 45 B

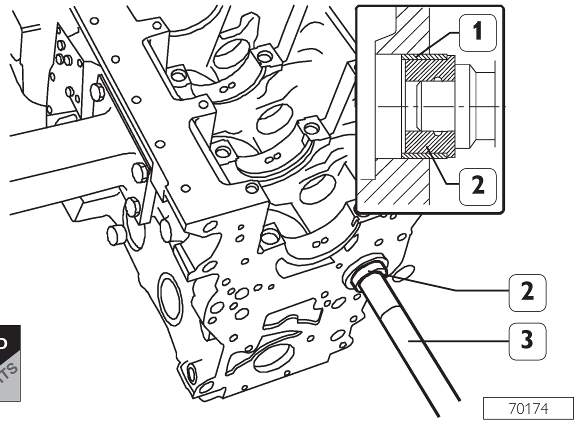


CAMSHAFT BUSH AND HOUSING MAIN DATA (6 cylinders)

* Value to be obtained after driving the bushes.

Bush replacement

Figure 46



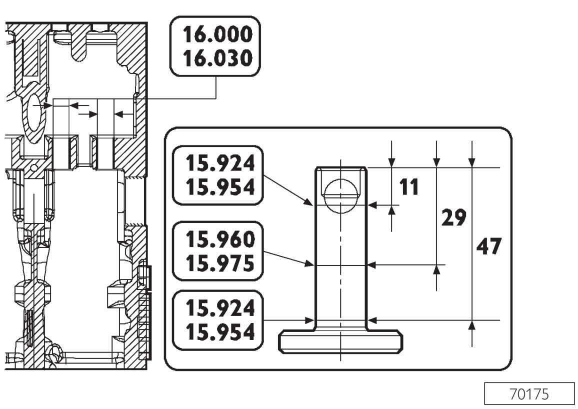
To replace front and rear bushes (1), remove and refit them using the beater 99360362 (2) and the handgrip 99370006 (3).

CAUTION

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

Tappets

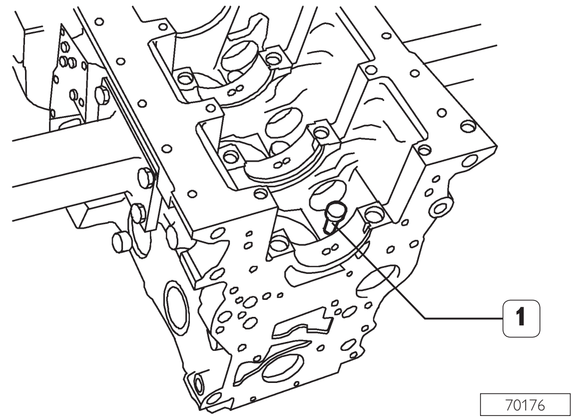
Figure 47



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

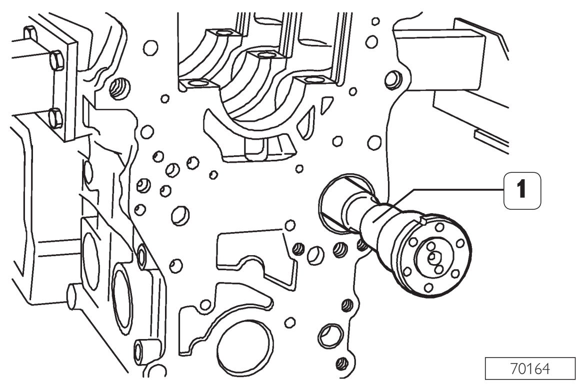
Fitting tappets - Camshaft

Figure 48



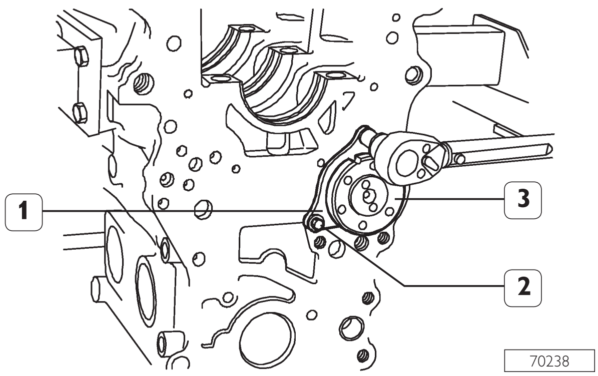
- ❑ Lubricate the tappets (1) and fit them into the relevant housings on the engine block.

Figure 49



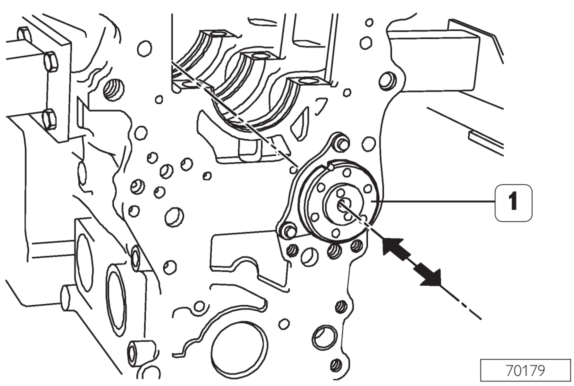
- ❑ Lubricate the camshaft bushes and fit the camshaft (1) taking care not to damage the bushes or the housings.

Figure 50



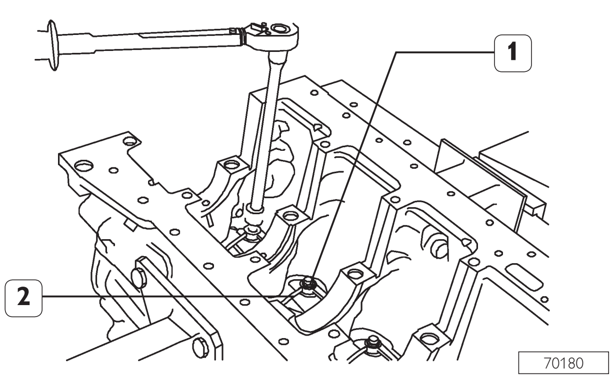
❑ Set camshaft (3) retaining plate (1) with the slot facing the top of the engine block and the marking facing the operator, then tighten the screws (2) to the prescribed torque.

Figure 51



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

Figure 52

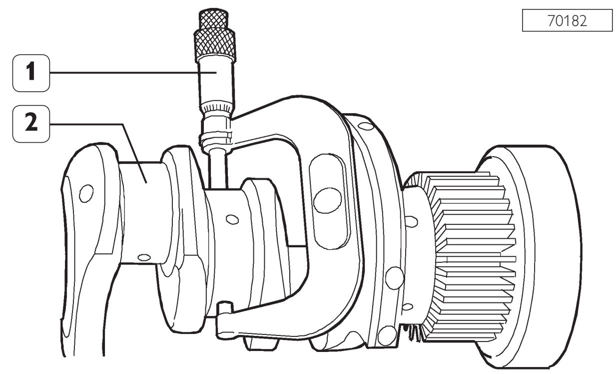


❑ Fit nozzles (2) and tighten the fastening screws (1) to the prescribed torque.

OUTPUT SHAFT

Measuring journals and crankpins

Figure 53



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

CAUTION

It is recommended to insert the found values in the proper table.
See Figure 26.

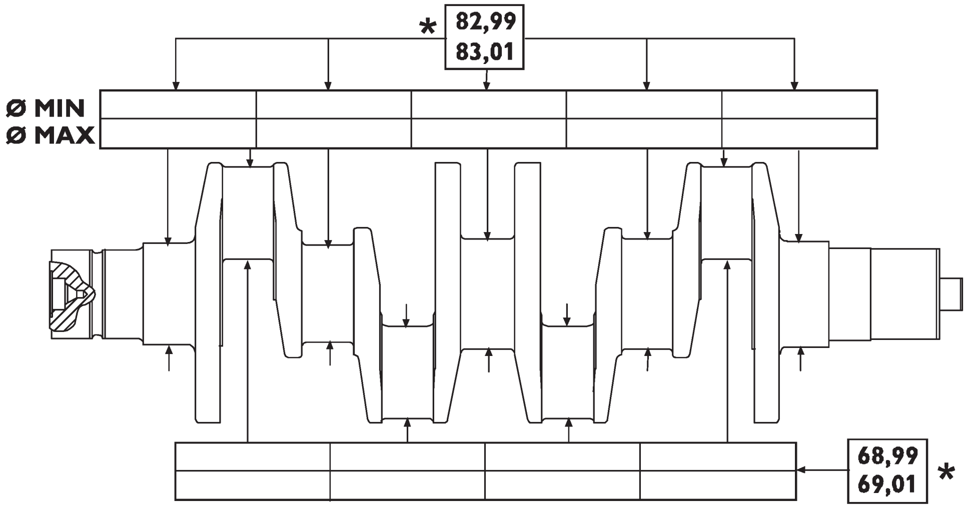
Undersize classes are: 0.250 - 0.500 mm.

CAUTION

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

Measuring journals and crankpins (4 cylinders)

Figura 54 A

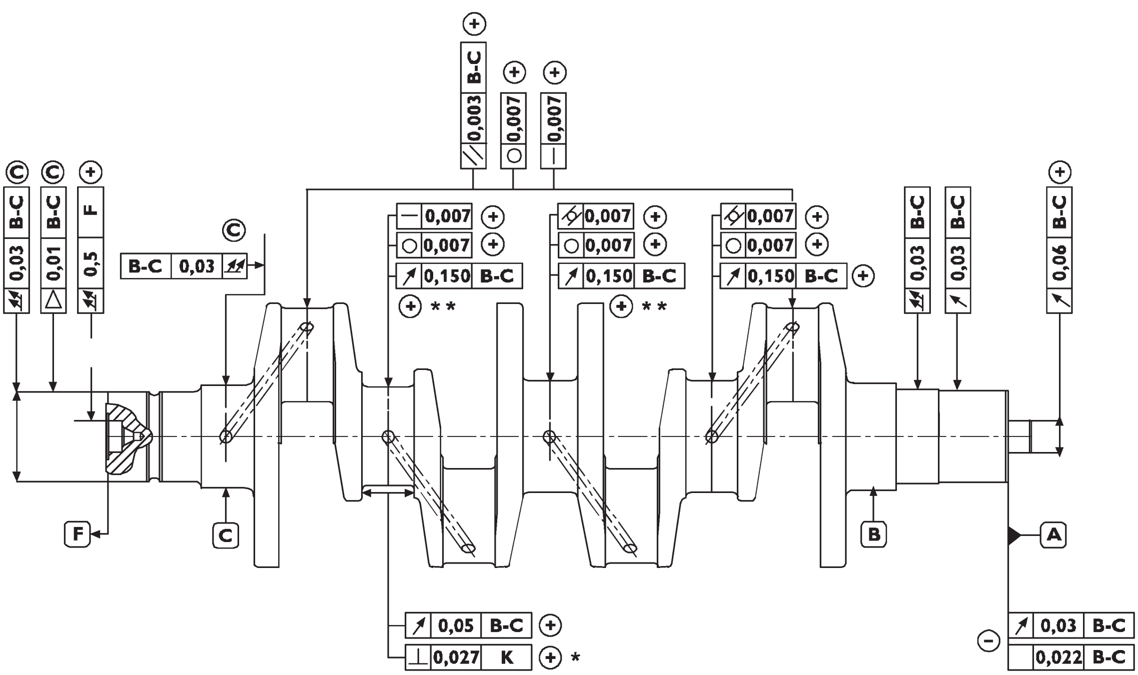


70181

FILL THIS TABLE WITH OUTPUT SHAFT JOURNAL AND CRANKPIN MEASURED VALUES

* Rated value.

Figura 55 A



70183

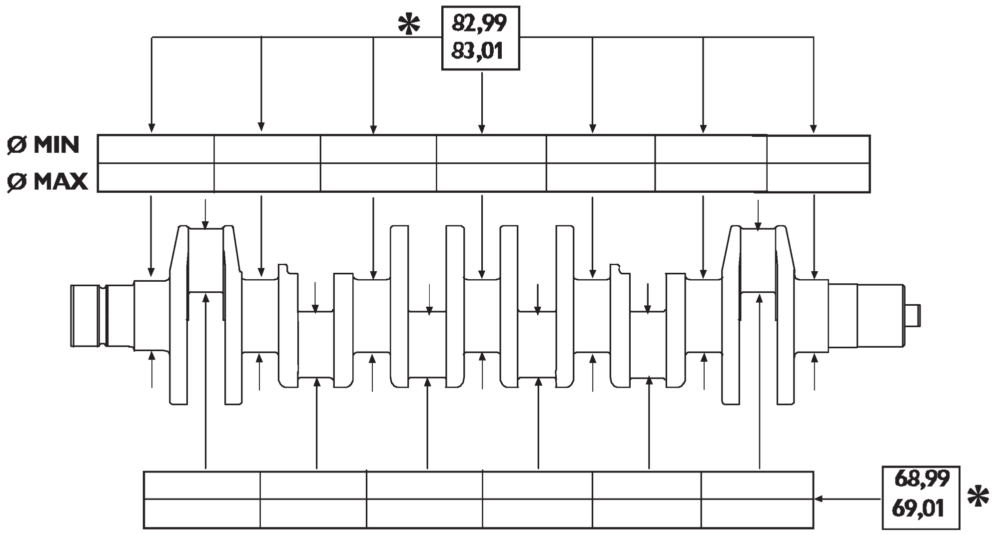
MAIN OUTPUT SHAFT TOLERANCES

* Measured on a radius greater than 45.5 mm

** ↗ 0.500 between adjacent main journals

Measuring journals and crankpins (6 cylinders)

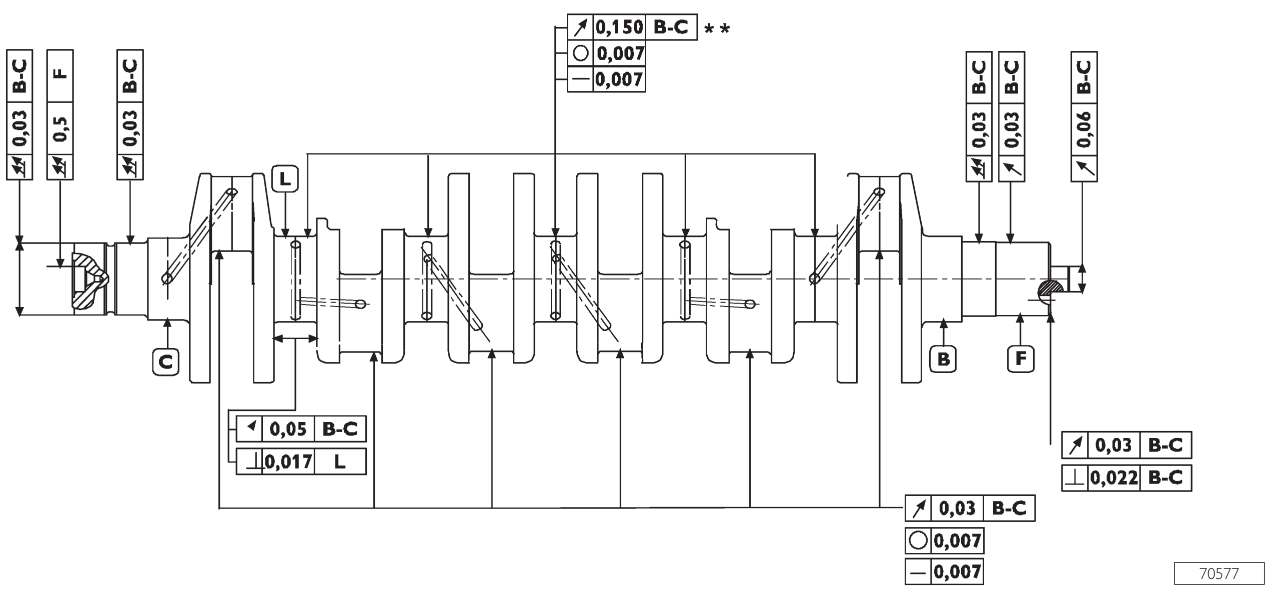
Figure 54 B



FILL THIS TABLE WITH OUTPUT SHAFT JOURNAL AND CRANKPIN MEASURED VALUES

* Rated value.

Figure 55 B

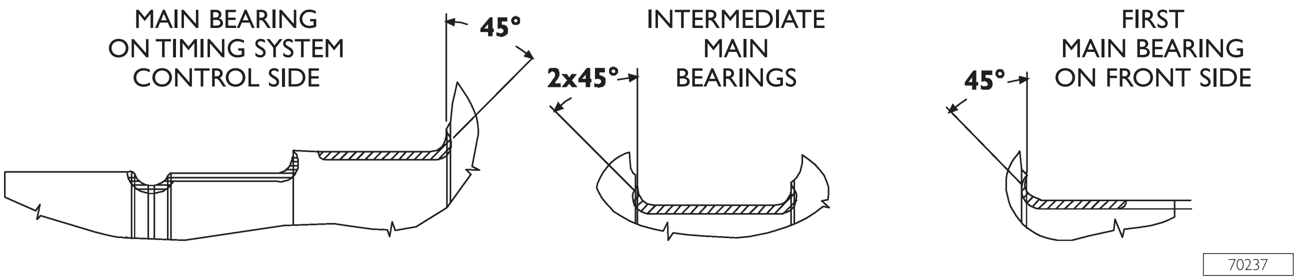


MAIN OUTPUT SHAFT TOLERANCES

* Measured on a radius greater than 45.5 mm

** ↗ 0.500 between adjacent main journals

Figure 56

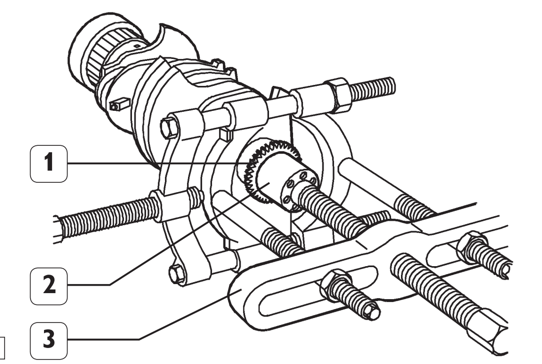


Tolerances	Tolerance characteristic	Graphic symbol
Shape	Roundness	○
	Cilindricity	/○/
	Parallelism	//
Direction	Verticality	⊥
	Straightness	—
Position	Concentricity or coaxiality	◎
	Circular oscillation	↗
Oscillation	Total oscillation	⇗
	Taper	—▷—

Levels of importance for product characteristics	Graphic symbol
Critical	©
Important	⊕
Secondary	⊖

Replacing oil pump control gear

Figure 57

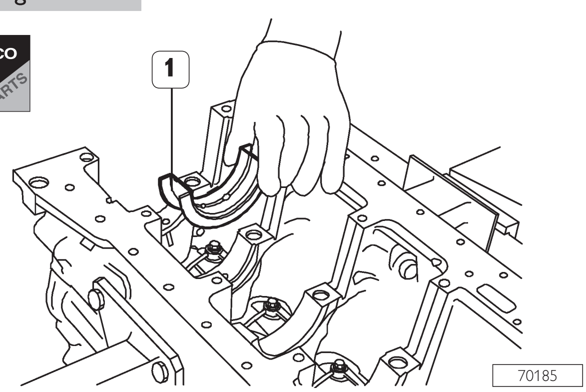


Check that gear toothing (1) is not damaged or worn, otherwise remove it using the proper puller (3).

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

Fitting main bearings

Figure 58



CAUTION

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

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

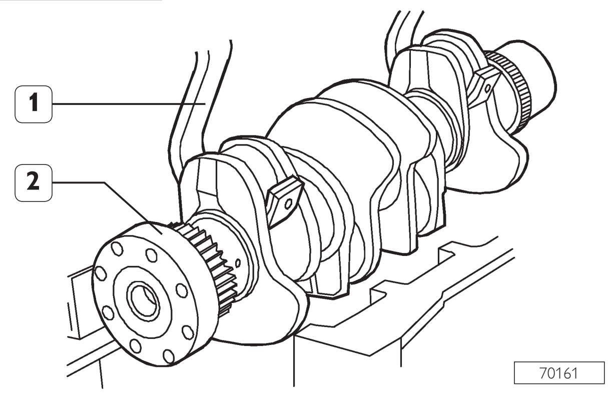
CAUTION

Do not try to adapt the bearings.

Clean accurately the main half bearings (1) having the lubricating hole and fit them into their housings.
The last main half bearing but one (1) is fitted with shoulder half rings.

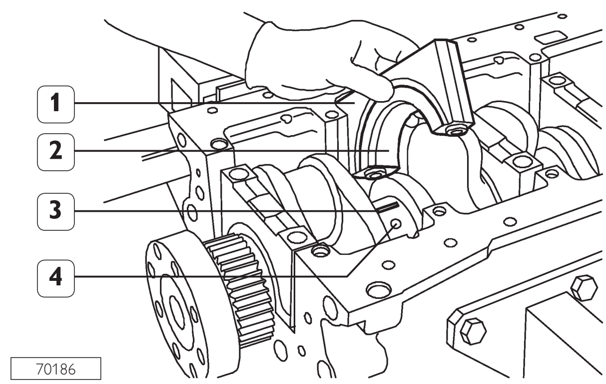
Finding journal clearance

Figure 59



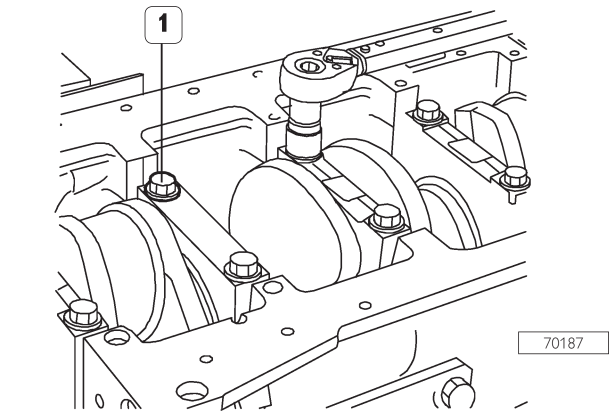
Refit the crankshaft (2).
Check the backlash between crankshaft main journals and the relevant bearings as follows:

Figure 60



- ❏ Clean accurately the parts and remove any trace of oil;
- ❏ Position a piece of calibrated wire (3) on the crankshaft pins (4) so that it is parallel to the longitudinal axis;
- ❏ Fit caps (1), including the half bearings (2) on the relevant supports.

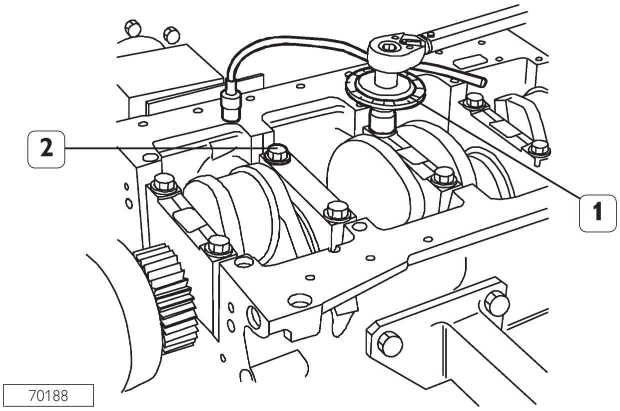
Figure 61



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

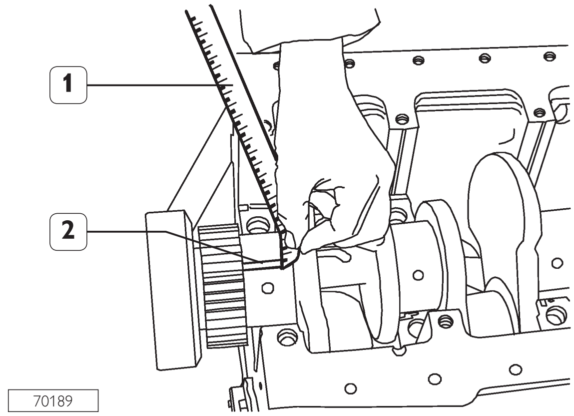
- 1st stage, with torque wrench to 50 ± 6 Nm;
- 2nd stage, with torque wrench to 80 ± 6 Nm.

Figure 62



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

Figure 63

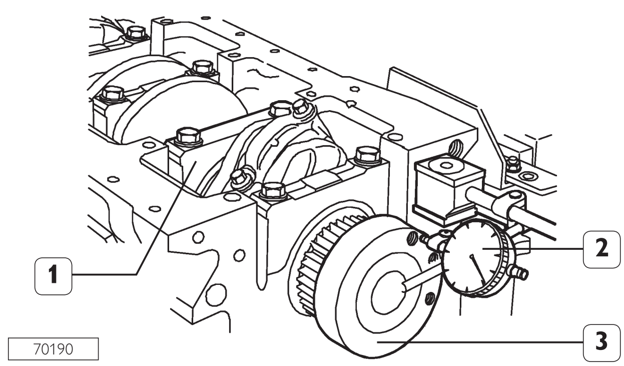


- Remove caps from supports.

The backlash between the main bearings and the pins is found by comparing the width of the calibrated wire (2) at the narrowest point with the scale on the envelope (1) containing the calibrated wire.
The numbers on the scale indicate the backlash in mm.
Replace the half bearings and repeat the check if a different backlash value is found. Once the specified backlash is obtained, lubricate the main bearings and fit the supports by tightening the fastening screws as previously described.

Checking crankshaft shoulder clearance

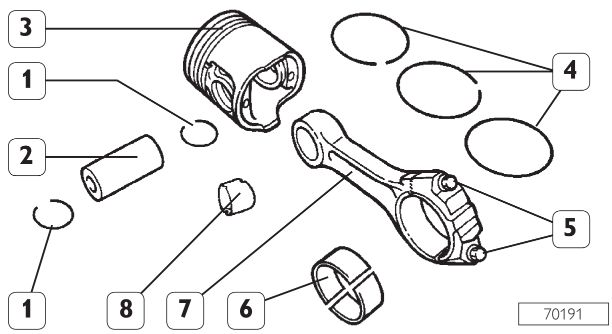
Figure 64



This check is performed by setting a magnetic-base dial gauge (2) on the crankshaft (3) as shown in the figure, standard value is 0.068 to 0.41.
If higher value is found, replace main thrust half bearings of the second rear support but one (1) and repeat the clearance check between crankshaft pins and main half bearings.

CONNECTING ROD - PISTON ASSEMBLY

Figure 65

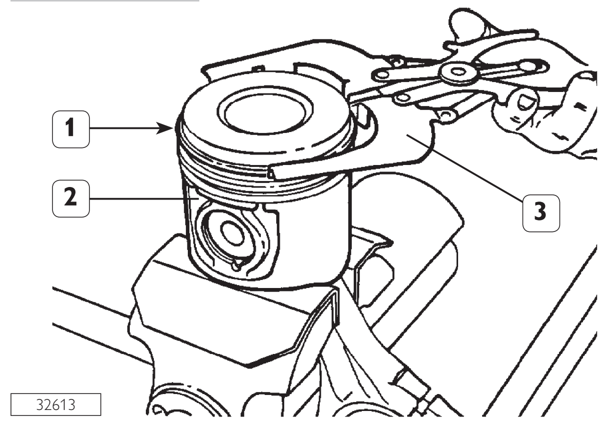


CONNECTING ROD - PISTON ASSEMBLY COMPONENTS
1. Stop rings - 2. Pin - 3. Piston - 4. Split rings - 5. Screws - 6. Half bearings - 7. Connecting rod - 8. Bush.

CAUTION

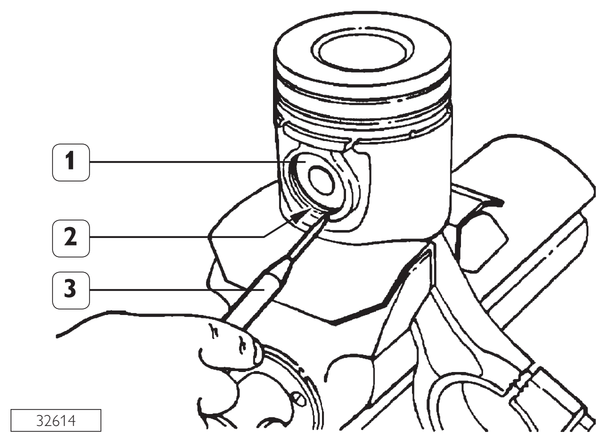
Pistons are supplied from parts with 0.5 mm oversize.

Figure 66



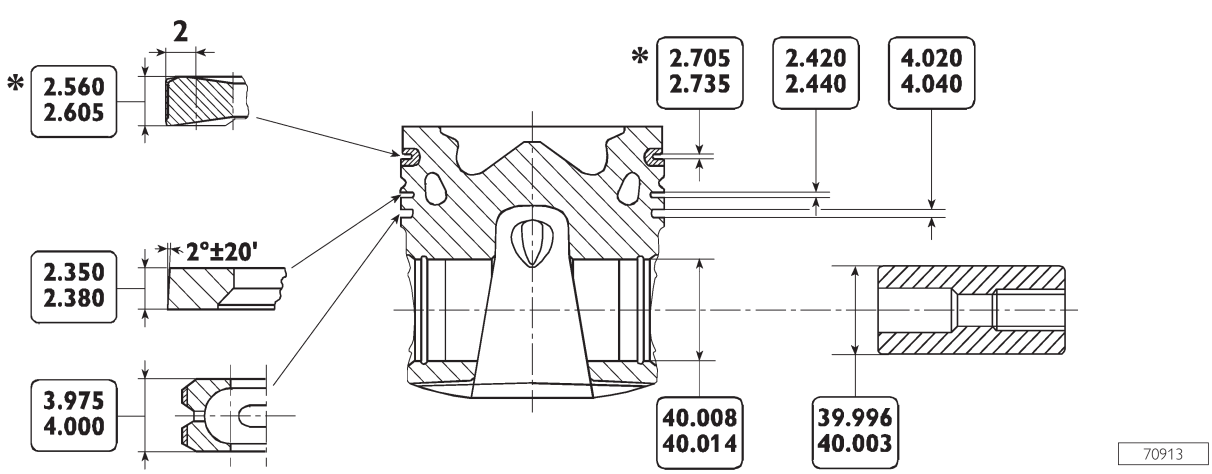
❏ Remove split rings (1) from piston (2) using pliers 99360183 (3).

Figure 67



❏ Piston pin (1) split rings (2) are removed using a scriber (3).

Figure 68

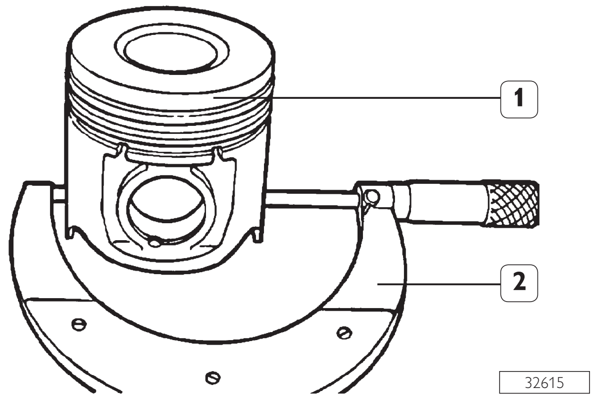


MAIN DATA CONCERNING KS. PISTON, PINS AND SPLIT RINGS

* Value measured on 99 mm diameter.

Measuring piston diameter

Figure 69

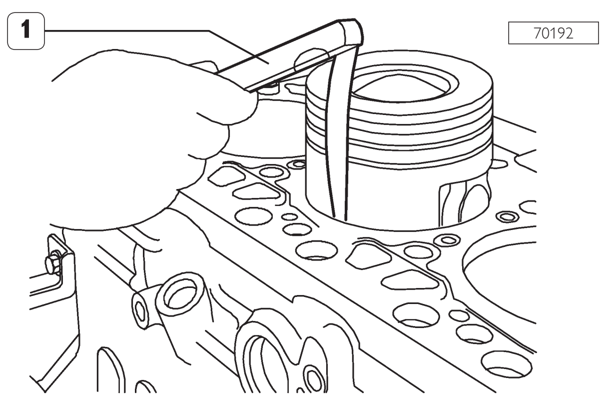


❑ Using a micrometer (2), measure the diameter of the piston (1) to determine the assembly clearance.

CAUTION

The diameter must be measured at 12 mm from the piston skirt.

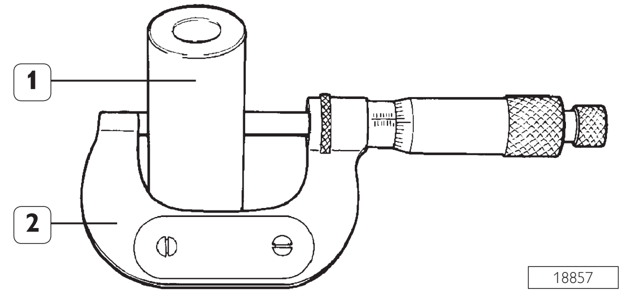
Figure 70



❑ The clearance between the piston and the cylinder barrel can be checked also with a feeler gauge (1) as shown in the figure.

Piston pins

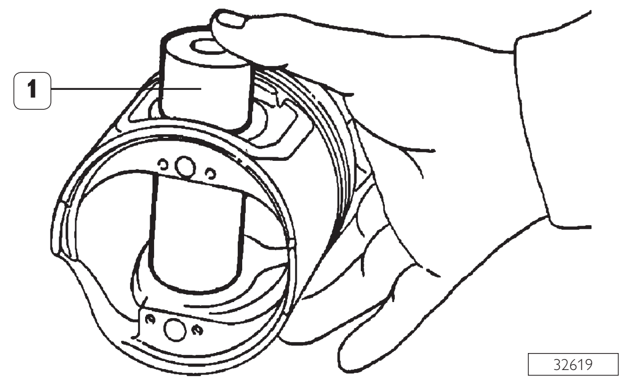
Figure 71



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

Conditions for proper pin-piston coupling

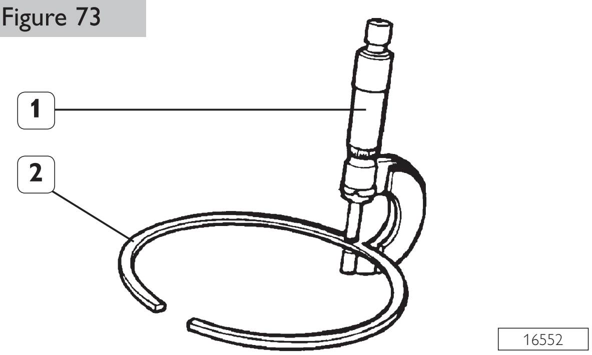
Figure 72



❑ Lubricate the pin (1) and its seat on piston hubs with engine oil; the pin have to be fitted into the piston with a slight finger pressure and must not fall down because of its own weight.

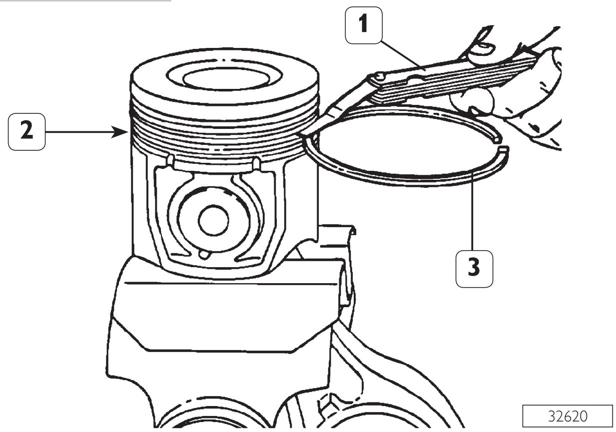
Split rings

Figure 73



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

Figure 74



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

Figure 75

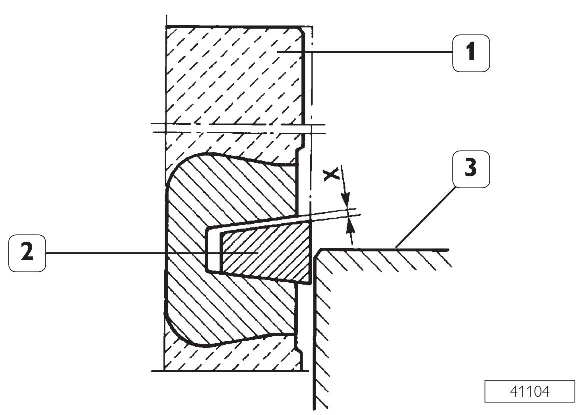
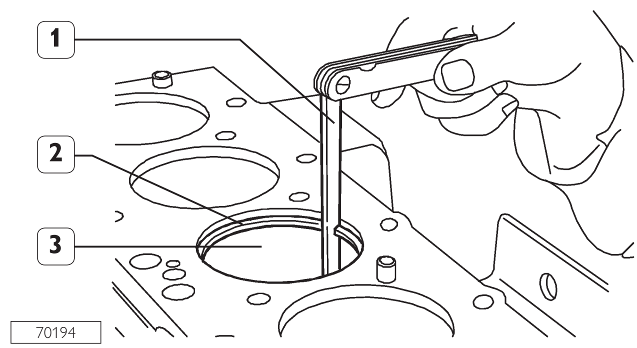


DIAGRAM FOR MEASURING THE CLEARANCE X BETWEEN THE FIRST PISTON SLOT AND THE TRAPEZOIDAL RING

Since the first sealing ring section is trapezoidal, the clearance between the slot and the ring have to be measured as follows: make the piston (1) protrude from the engine block so that the ring (2) protrudes half-way from the cylinder barrel (3).
In this position, use a feeler gauge to check the clearance (X) between ring and slot: found value must be the specified one.

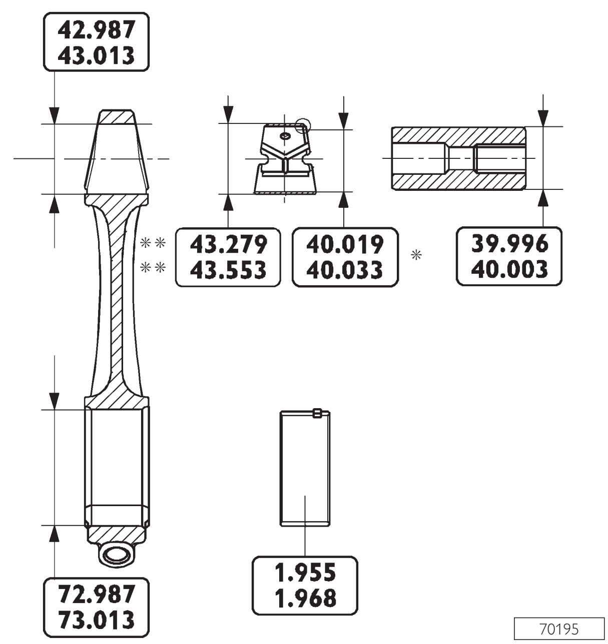
Figure 76



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

Connecting rods

Figure 77



MAIN DATA FOR CONNECTING ROD, BUSH, PISTON PIN AND HALF BEARINGS

* Value for inside diameter to be obtained after driving in connecting rod small end and grinding.

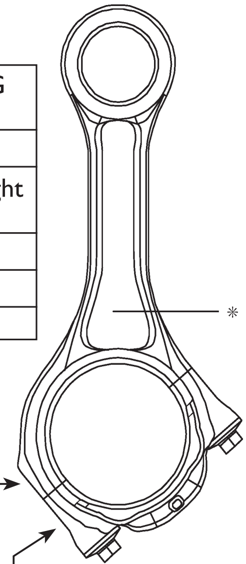
** Value not measurable in released condition.

CAUTION

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

Figure 78

CONNECTING ROD BODY	
1234	W
Connecting rod No.	Weight
0001	V
↓	W
9999	X



70196

CONNECTING ROD CAP		
1234	A	123
Connecting rod No.	Year	Day
0001	A 1998	001
↓	B 1999	↓
9999	C 2000	366
	D 2001	

CAUTION

Every connecting rod is marked as follows:

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

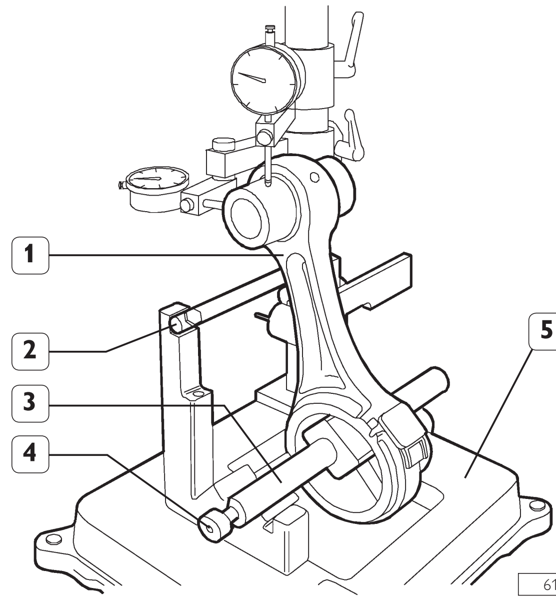
Spare connecting rods are of the W class with green marking (see * position in Figure 78).
Material removal is not allowed.

Bushes

Check that the bush in the connecting rod small end is free from scoring or seizing and that it is not loosen. Otherwise replace.
Removal and refitting will be performed using the proper beater.
When refitting take care to make coincide the oil holes set on the bush with those set on the connecting rod small end.
Grind the bush to obtain the specified diameter.

Checking connecting rods

Figure 79



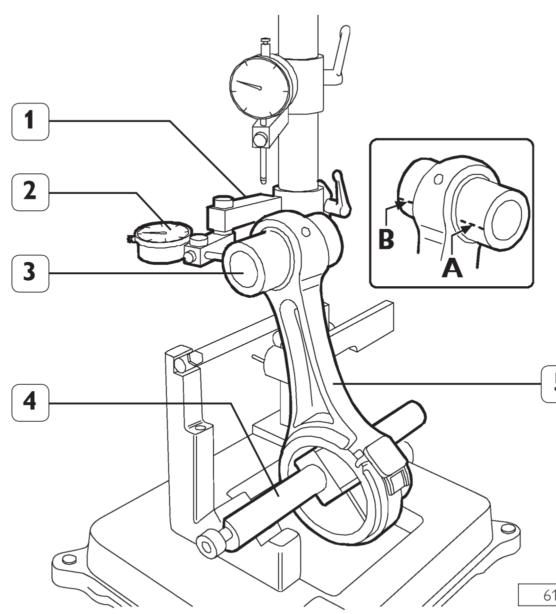
61696

Check that the axis of the connecting rods (1) are parallel using tool 99395363 (5) as follows:

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

Checking torsion

Figure 80

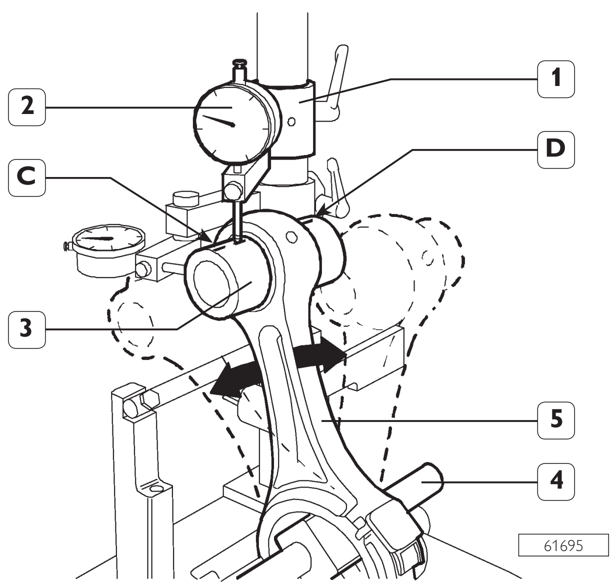


61694

Check connecting rod (5) torsion by comparing two points (A and B) of pin (3) on the horizontal plane of the connecting rod axis.
Position the dial gauge (2) support (1) to obtain a preload of approx. 0.5 mm on the pin (3) in point A and then set the dial gauge (2) to zero. Move 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 not exceed 0.08 mm.

Checking bending

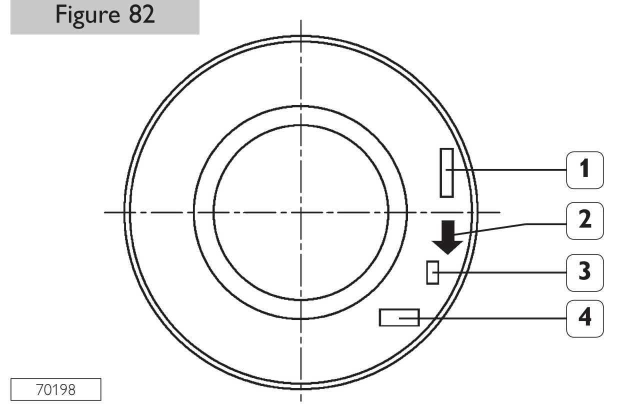
Figure 81



Check connecting rod (5) bending by comparing two points C and D of the pin (3) on the vertical plane of the connecting rod axis.
Position the vertical support (1) of the dial gauge (2) to rest the latter on pin (3), point C.
Move the connecting rod forwards and backwards to find pin top position, then in this condition reset the dial gauge (2).
Move the spindle with the connecting rod (5) and repeat the check of the top point on the opposite side D of the pin (3). The difference between point C and point D must not exceed 0.08 mm.

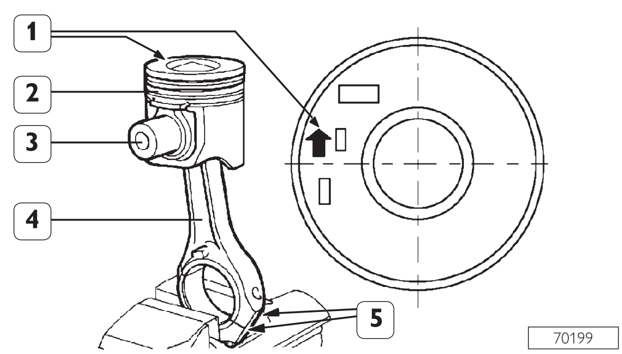
Fitting connecting rod-piston assembly - Connecting rod-piston coupling

Figure 82



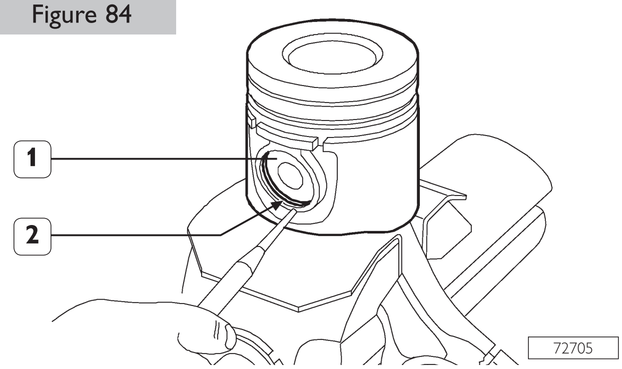
The piston crown is marked as follows:
1. Part number and design modification number;
2. Arrow showing piston assembling direction into cylinder barrel, this arrow must face the front key of the engine block;
3. Marking showing 1st slot insert testing;
4. Manufacturing date.

Figure 83



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

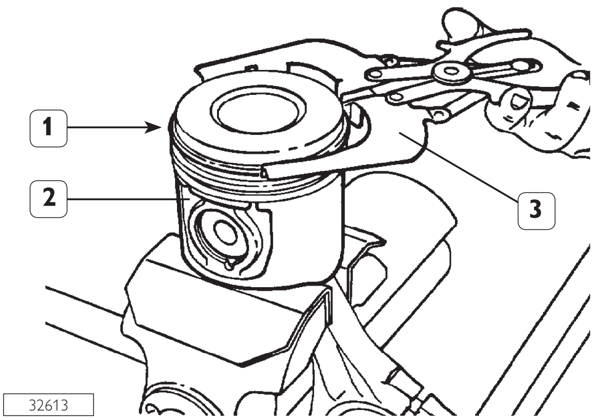
Figure 84



Insert the split rings (2) to lock the pin (1).

Fitting split rings

Figure 85



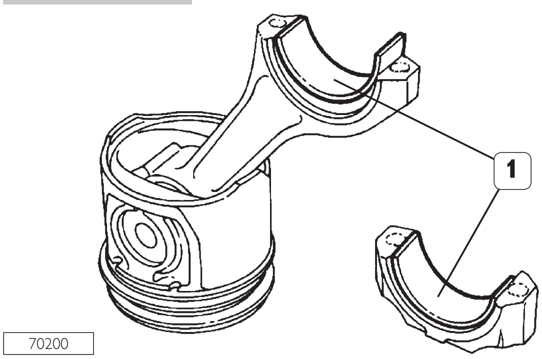
Use pliers 99360183 (3) to fit the split rings (1) on the piston (2).
Split rings must be fitted with the marking "TOP" facing upwards and their openings displaced with each other by 120°.

CAUTION

Split rings are supplied spare with the following sizes:

- **Standard, yellow marking;**
- **0.5 mm oversize, yellow/green marking.**

Figure 86



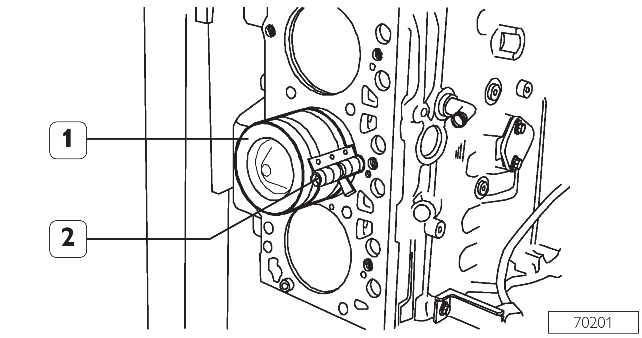
Fit half bearings (1) on connecting rod and cap.

CAUTION

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

Fitting connecting rod-piston assembly into cylinder barrels

Figure 87



Lubricate accurately the pistons, including the split rings and the cylinder barrel inside.
Use band 99360605 (2) to fit the connecting rod-piston assembly (1) into the cylinder barrels and check the following:

- The number of each connecting rod must correspond to the cap coupling number.

Figure 88

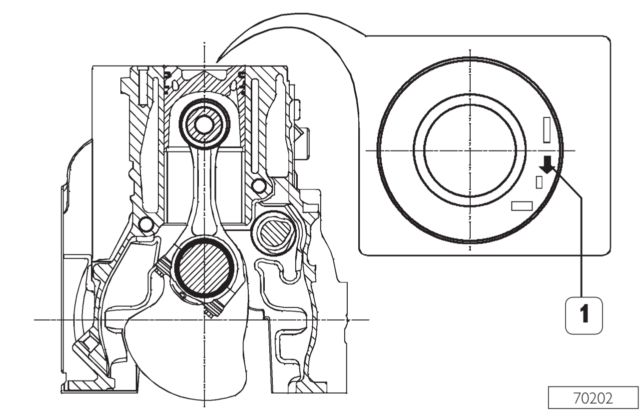
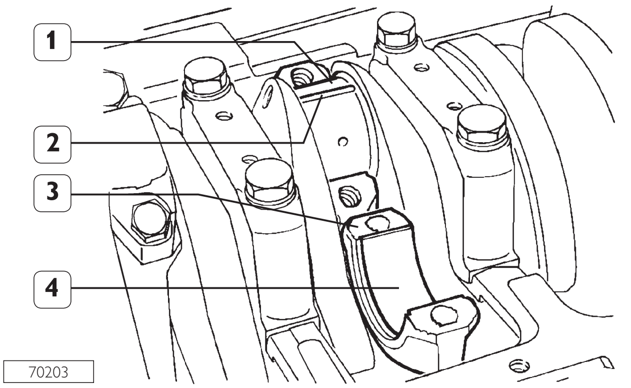


DIAGRAM FOR CONNECTING ROD-PISTON ASSEMBLY FITTING INTO BARREL

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

Finding crankpin clearance

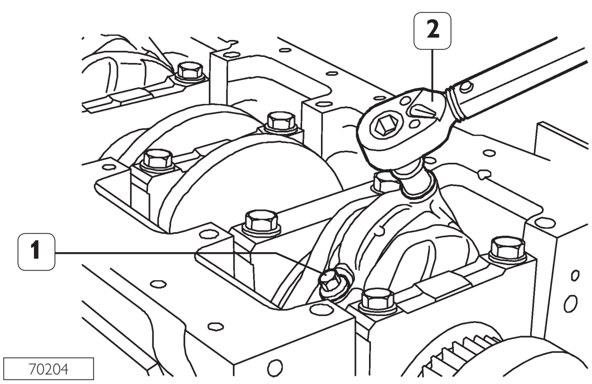
Figure 89



To measure the clearance proceed as follows:

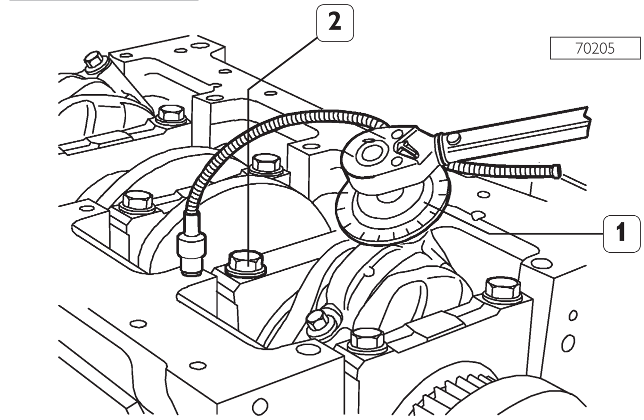
- ❑ Clean the parts accurately and remove any trace of oil;
- ❑ Set a piece of calibrated wire (2) on the output shaft pins (1);
- ❑ Fit the connecting rod caps (3) with the relevant half bearings (4).

Figure 90



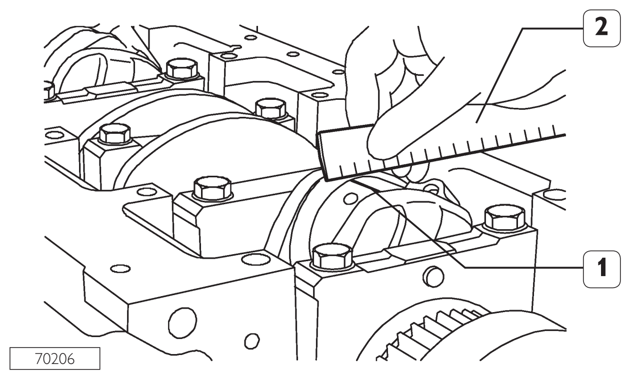
- ❑ Lubricate the screws (1) with engine oil and then tighten them to the prescribed torque using the torque wrench (2).

Figure 91



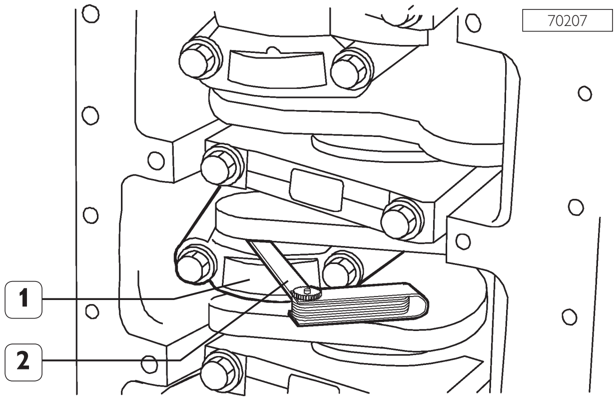
- ❑ Apply tool 99395216 (1) to the socket wrench and tighten screws (2) of 60°.

Figure 92



- ❑ Remove the cap and find the existing clearance by comparing the calibrated wire width (1) with the scale on the wire envelope (2).

Figure 93



If a different clearance value is found, replace the half bearings and repeat the check.
Once the specified clearance has been obtained, lubricate the main half bearings and fit them by tightening the connecting rod cap fastening screws to the prescribed torque.

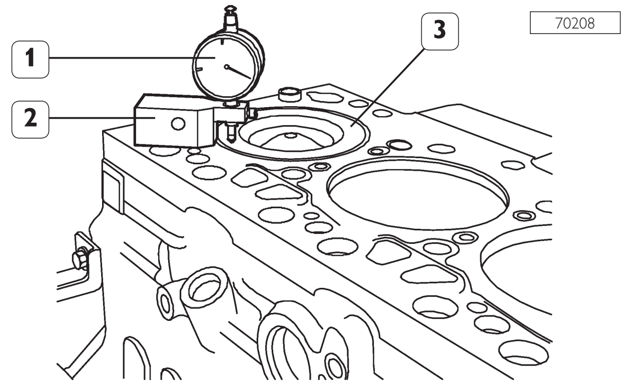
CAUTION

Before the final fitting of the connecting rod cap fastening screws, check that their diameter measured at the centre of the thread length is not < 0.1 mm than the diameter measured at approx. 10 mm from screw end.

Check manually that the connecting rods (1) are sliding axially on the output shaft pins and that their end float, measured with feeler gauge (2) is 0.10 to 0.33 mm.

Checking piston protrusion

Figure 94

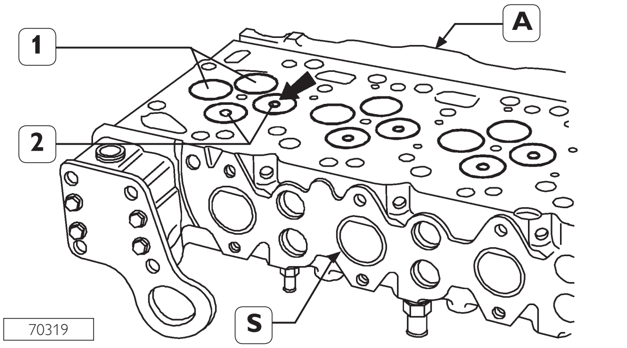


Once connecting rod-piston assemblies refitting is over, use dial gauge 39395603 (1) fitted with base 99370415 (2) to check piston (3) protrusion at T.D.C. with respect to the top of the engine block.
Protrusion must be 0.28 to 0.52 mm.

CYLINDER HEAD

Removing the valves

Figure 95



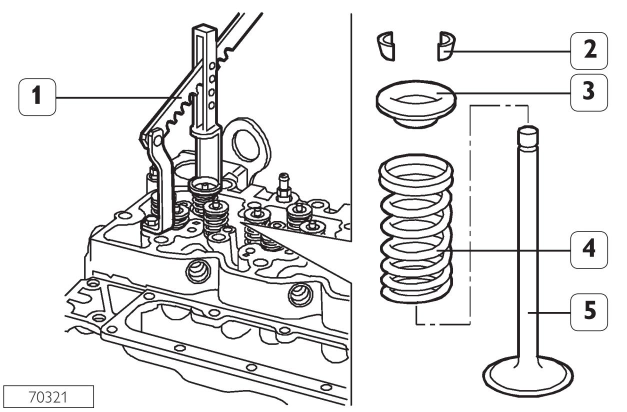
Intake (1) and exhaust (2) valves have heads with the same diameter.

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

CAUTION

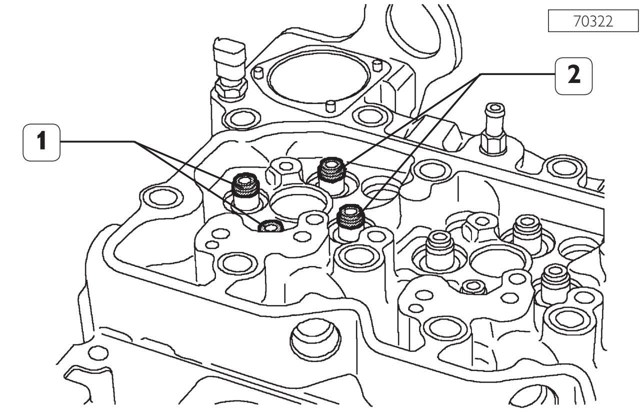
Should cylinder head valves be not replaced, number them before removing in order to refit them in the same position.
A = Intake side - S = Exhaust side

Figure 96



Valve removal will be performed using tool 99360268 (1) and pressing the cap (3) so that when compressing the springs (4) the cotters (2) can be removed.Then remove the cap (3) and the springs (4).
Repeat this operation for all the valves.
Overturn the cylinder head and remove the valves (5).

Figure 97



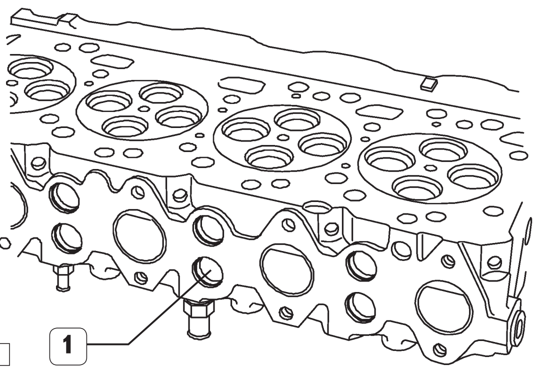
Remove sealing rings (1 and 2) from the valve guide.

CAUTION

Sealing rings (1) for intake valves are yellow.
Sealing rings (2) for exhaust valves are green.

Checking cylinder head wet seal

Figure 98



70323

This check should be performed using the proper tools.
Use a pump to fill with water heated to approx. 90 °C and 2 to 3 bar pressure.
Replace the core plugs (1) if leaks are found, use the proper punch for their removal/refitting.

CAUTION

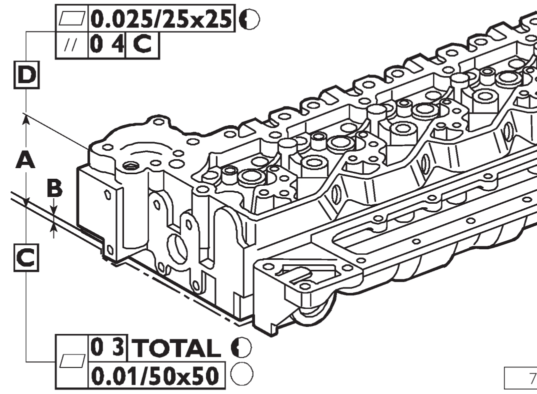
Before refitting, smear the plug surfaces with water-repellent sealant.

Replace the cylinder head if leaks are found.

Checking cylinder head supporting surface

Distortion found along the whole cylinder head cannot exceed 0.20 mm.
If higher values are found grind the cylinder head according to values and indications shown in the following figure.

Figure 99



70325

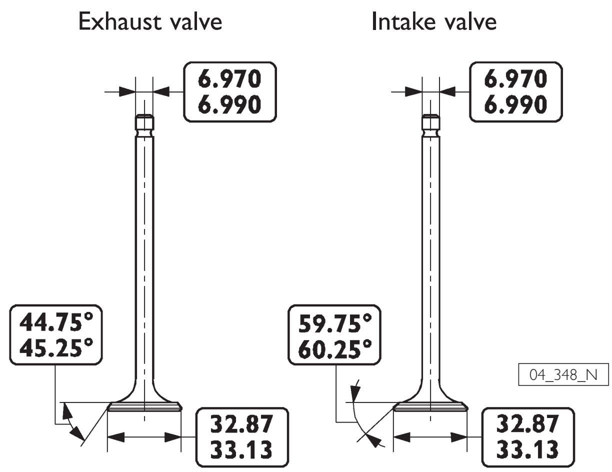
The rated thickness A for the cylinder head is 105 ± 0.25mm, max. metal removal cannot exceed thickness B by 0.13 mm.

CAUTION

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

VALVES

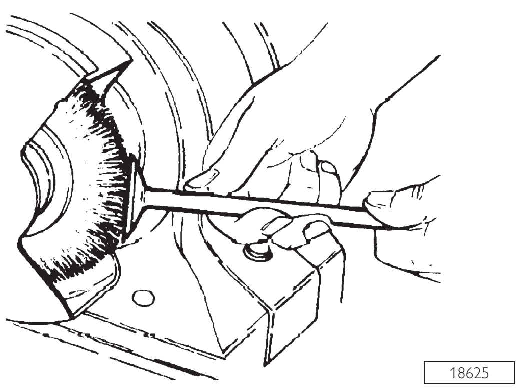
Figure 100



INTAKE AND EXHAUST VALVE MAIN DATA

Removing carbon deposits, checking and grinding valves

Figure 101

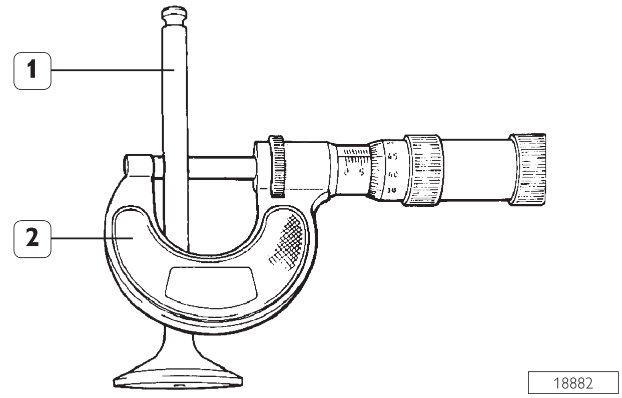


Remove carbon deposits from valves using the proper metal brush.

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

Regrind the valve seats, if required, using tool 99305018 and removing as less material as possible.

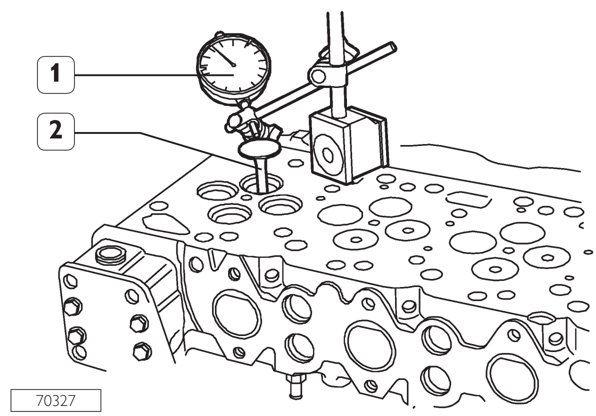
Figure 102



Check the valve stem (1) using a micrometer (2), it must be 6.970 ± 6.999.

Checking clearance between valve stem and valve guide and valve centering

Figure 103

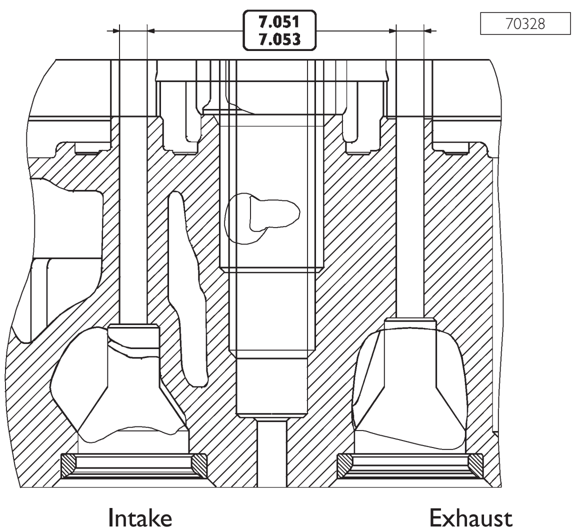


Use a magnetic base dial gauge (1) set as shown in the figure, the assembling clearance must be 0.052 ± 0.092 mm.

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

Valve guide

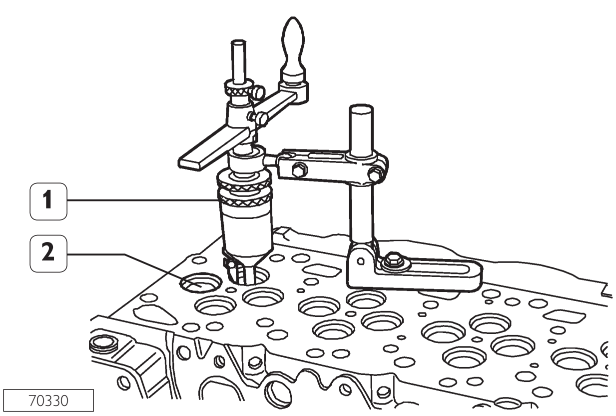
Figure 104



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

Regrinding - Replacing the valve seats

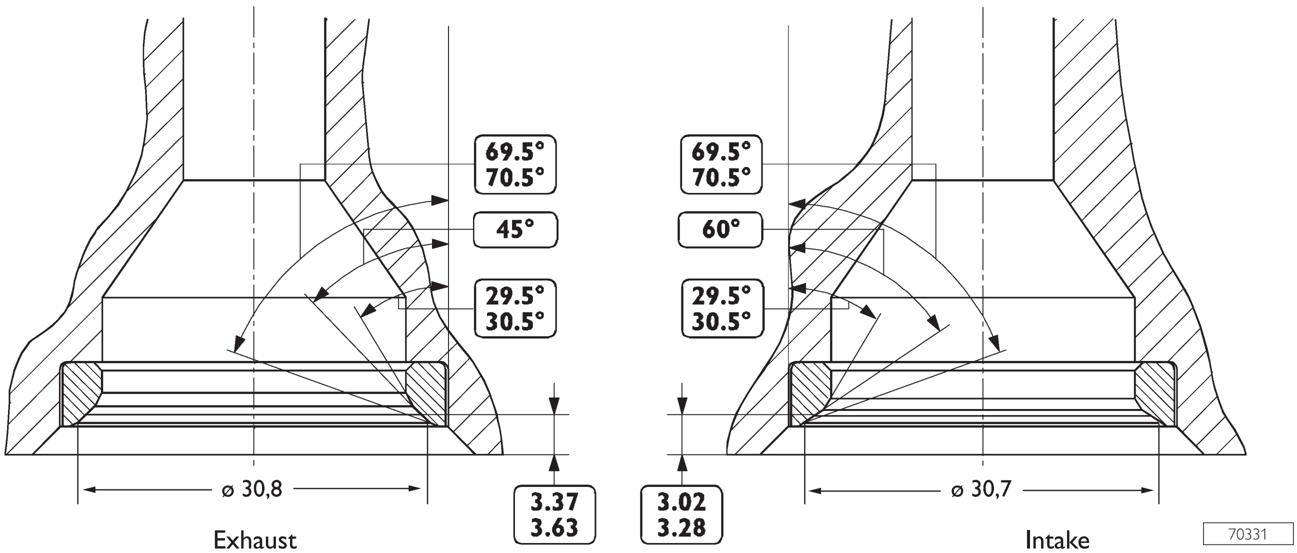
Figure 105



Check the valve seats (2). If slight scoring or burnout is found, regrind seats using tool 99305018 (1) according to the angle values shown in Figure 106 (4 cylinders engines) or 108 (6 cylinders engines).

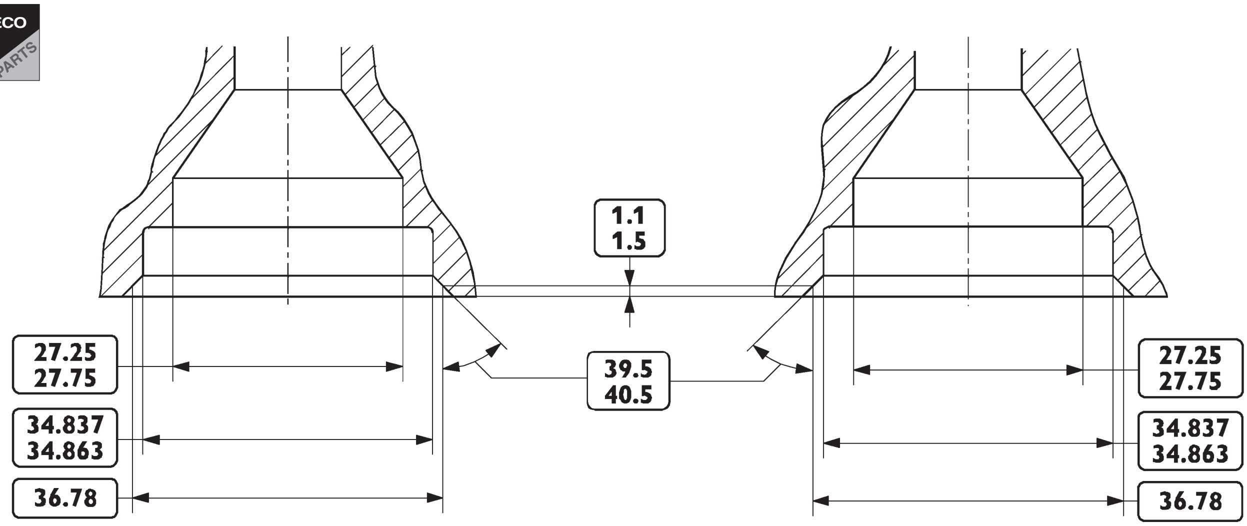
Valve seats (4 cylinders engines)

Figura 106



VALVE SEAT MAIN DATA

Figura 107



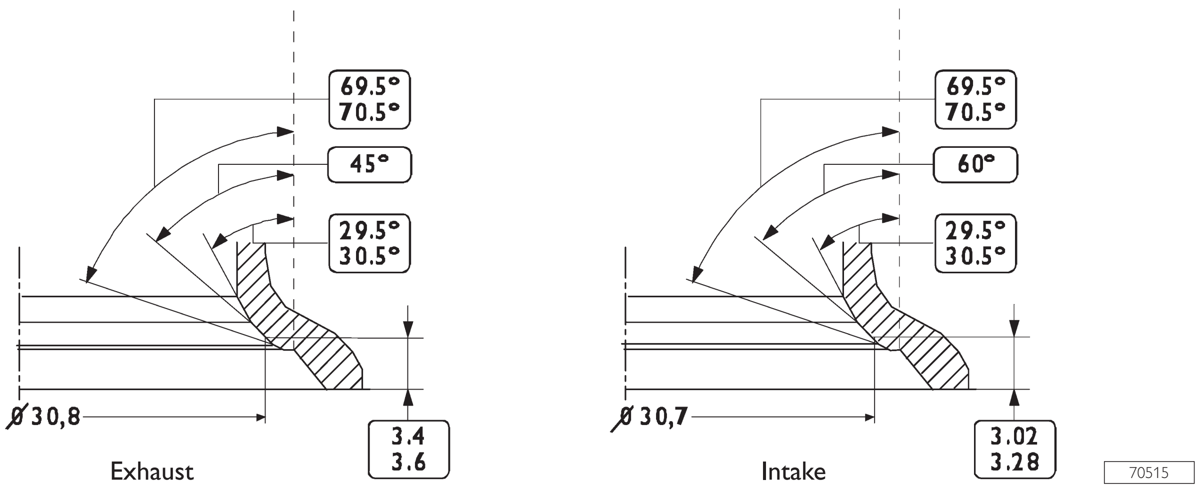
MAIN DATA CONCERNING THE SEATS ON THE CYLINDER HEAD

Should valve seats be not reset just by regrinding, replace them with the spare ones. Use tool 99305018 (1, Figure 105) to remove as much material as possible from the valve seats (take care not to damage the cylinder head) until they can be extracted from the cylinder head using a punch.

Heat the cylinder head to 80° - 100°C and using the proper punch, fit the new valve seats, previously cooled, into the cylinder head.
Use tool 99305018 to regrind the valve seats according to the values shown in Figure 106.

Valve seats (6 cylinders engines)

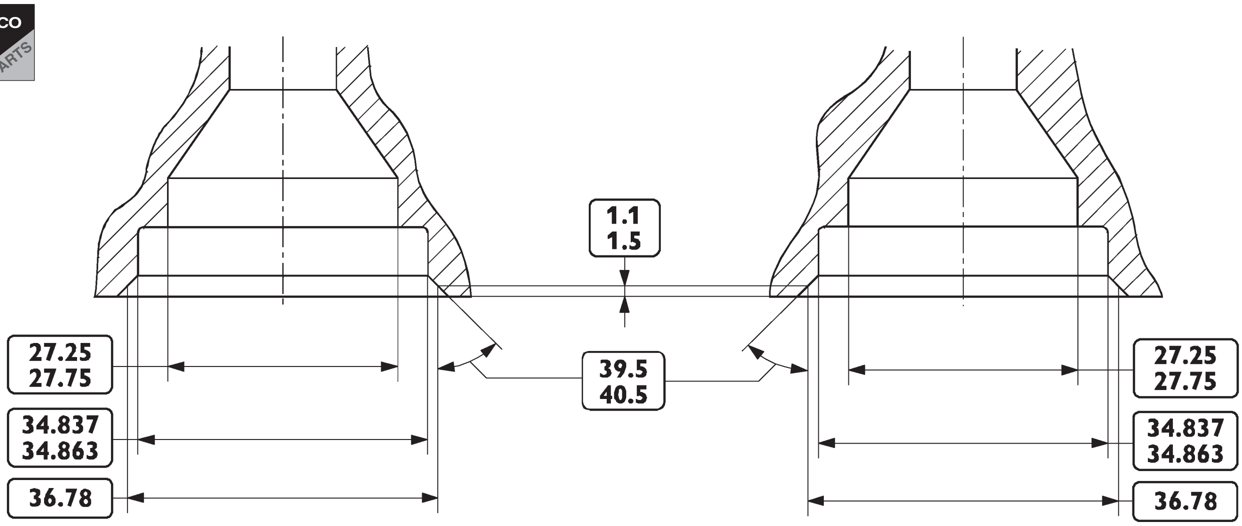
Figure 108



VALVE SEATS MAIN DATA

Valve seats are installed by casting onto the cylinder head and machined to the correct dimension.

Figure 109

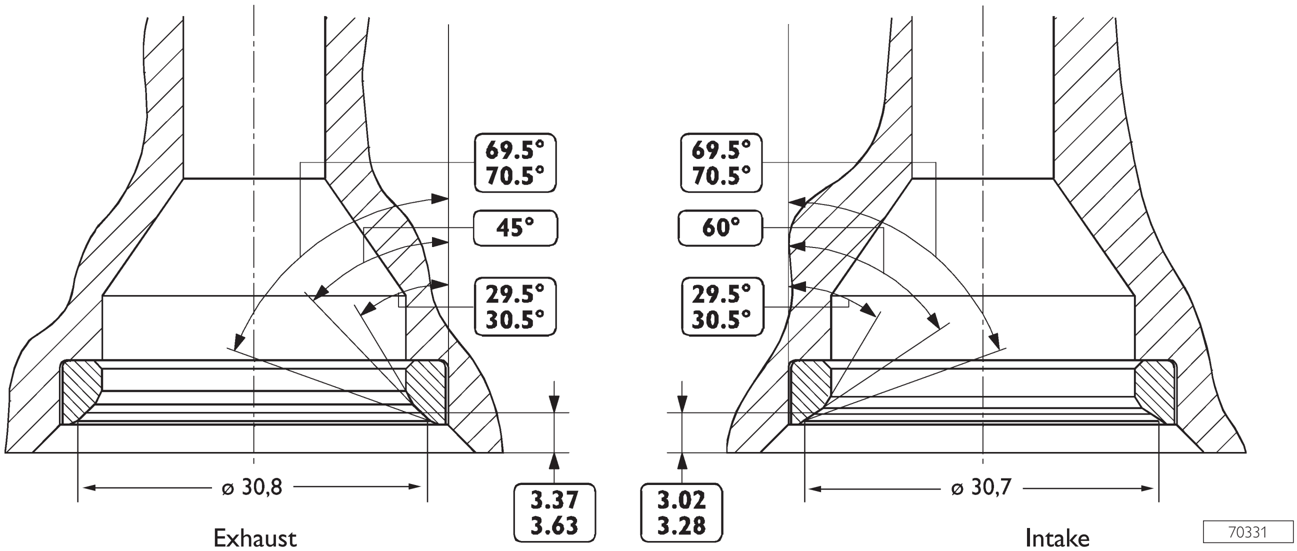


MAIN DATA ABOUT MACHINING SEAT TO INSERT SPARE VALVE SEATS

Should valve seats be not reset just by regrinding, replace them with the spare ones.
In this case, machine the seats on the cylinder head (as indicated above) to insert the spare valve seats.

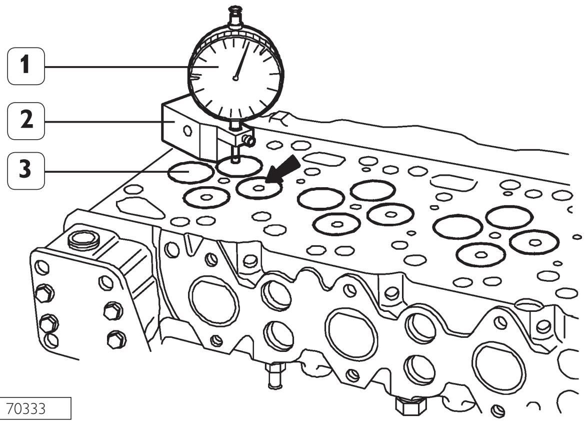
Heat the cylinder head to 80° - 100°C and using the proper punch, fit the new valve seats, previously cooled, into the cylinder head.
Use tool 99305018 to regrind the valve seats according to the values shown in Figure 110.

Figure 110



INSERTED SPARE VALVE SEATS MAIN DATA

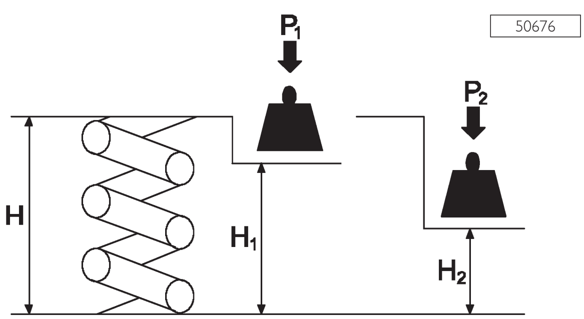
Figure 111



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

Valve springs

Figure 112



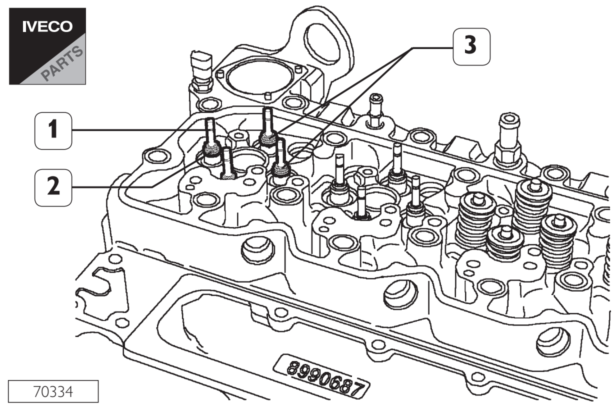
MAIN DATA TO CHECK INTAKE AND EXHAUST VALVE SPRINGS

Before refitting use tool 99305047 to check spring flexibility. Compare load and elastic deformation data with those of the new springs shown in the table above.

	Height (mm)	Under a load of (N)	
H	47.75		Free
H_1	35.33	P_1	339.8 ± 19
H_2	25.20	P_2	741 ± 39

FITTING CYLINDER HEAD

Figure 113

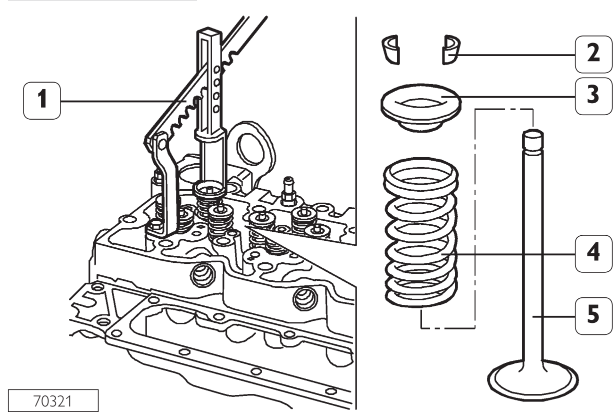


Lubricate the valve stems (1) and fit them into the relevant valve guides according to the position marked at removal.
Fit the sealing rings (2 and 3) on the valve guide.

CAUTION

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

Figure 114



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

INSTALLATION OF COMPONENTS

Figure 115

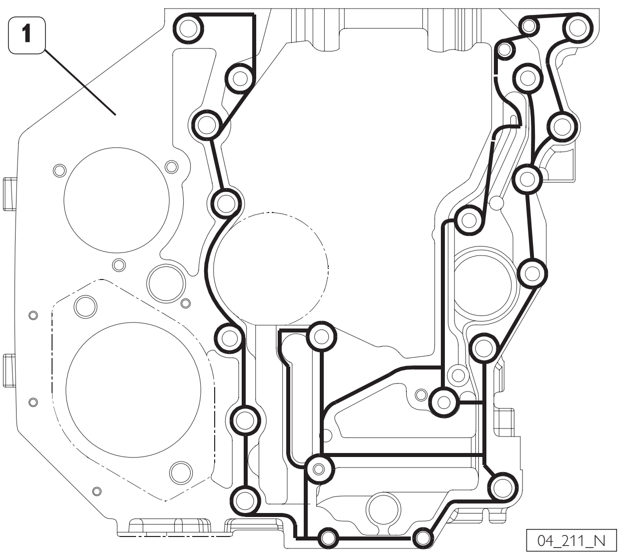


DIAGRAM SHOWING SEALING LOCTITE 5205 APPLICATION WITHIN GEARBOX AREAS

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

CAUTION

It is necessary and essential to clean the surface to be sealed in order to achieve excellent tight seal.
Apply sealing Loctite 5205 on the box in order to form a kerbstone of a few mm. diameter.
It must be uniform (no lumps), with no air blisters, thinner or irregular zones.
Any imperfection must be corrected as soon as possible.
Avoid using material in excess to seal the joint.
Too much sealing material would spill on both sides of the joint and obstruct lubricant passages.
After having completed seal application, the joints must be assembled within 10-20 minutes.

Figure 116

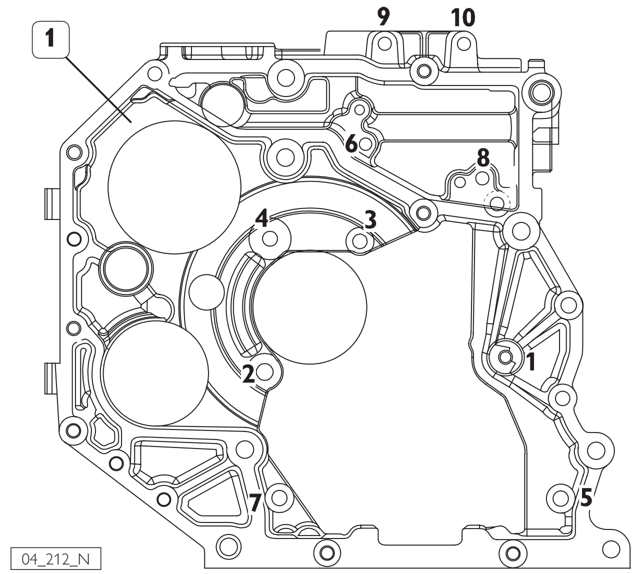


DIAGRAM SHOWING SCREW TIGHTENING TO FIX REAR GEARBOX

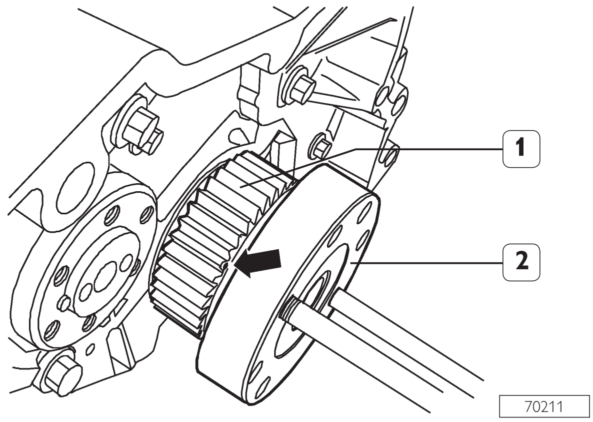
- ❏ Reassemble the box (1) to the engine block;
- ❏ Tighten the fixing screws in the same position as found out during disassembly and fix the screws to the locking torques listed here below, following the order as shown in the picture:

- M12 Screw	65 to 89 Nm;
- M8 Screw	20 to 28 Nm;
- M10 Screw	42 to 52 Nm.

CAUTION

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

Figure 117

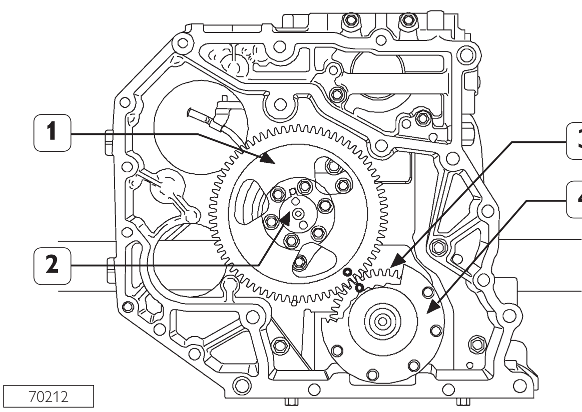


❏ With a penmarker, mark the tooth (1) of the driving gear assembled to the engine drive shaft (2) with (➡) timing notch.

CAUTION

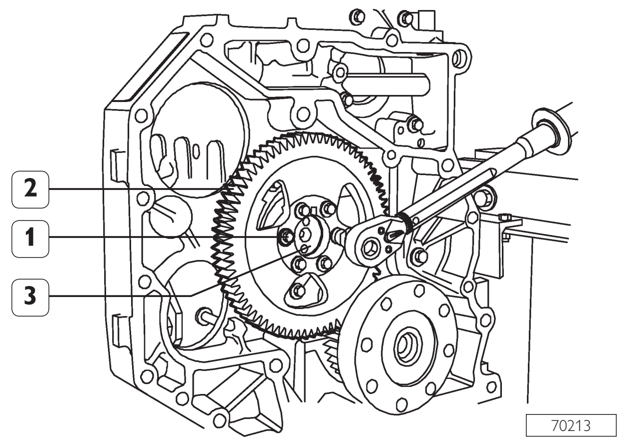
Screw down two pins to make operation of engine drive shaft rotation easier.

Figure 118



❏ Orient engine drive shaft (4) and camshaft (2), taking care that during assembly of the driving gear (1) to the camshaft, the notches marked on the gears (1 and 3) are to match.

Figure 119



❏ Tighten the screws (1) fixing the gear (2) to the camshaft (3) and lock them to the prescribed torque.

Figure 120

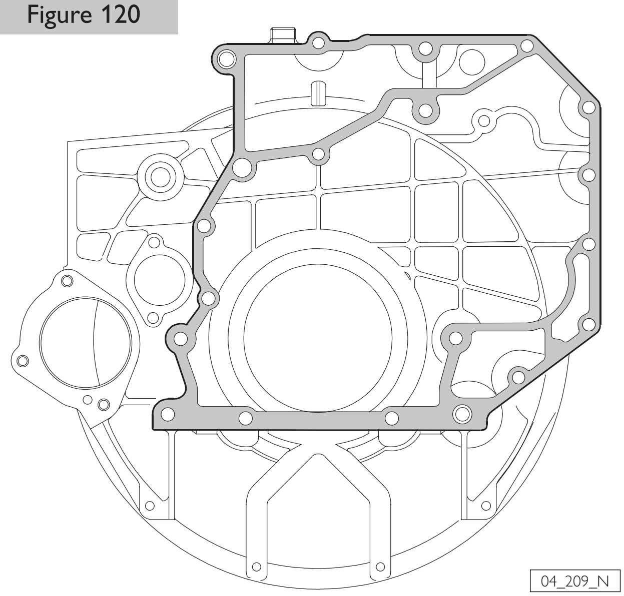


DIAGRAM SHOWING SEALING LOCTITE 5205 APPLICATION

CAUTION

It is necessary and essential to clean the surface to be sealed in order to achieve excellent tight seal.
Apply sealing Loctite 5205 on the box in order to form a kerbstone of a few mm. diameter.
It must be uniform (no lumps), with no air blisters, thinner or irregular zones.
Any imperfection must be corrected as soon as possible.
Avoid using material in excess to seal the joint.
Too much sealing material would spill on both sides of the joint and obstruct lubricant passages.
After having completed seal application, the joints must be assembled within 10-20 minutes.

Figure 121

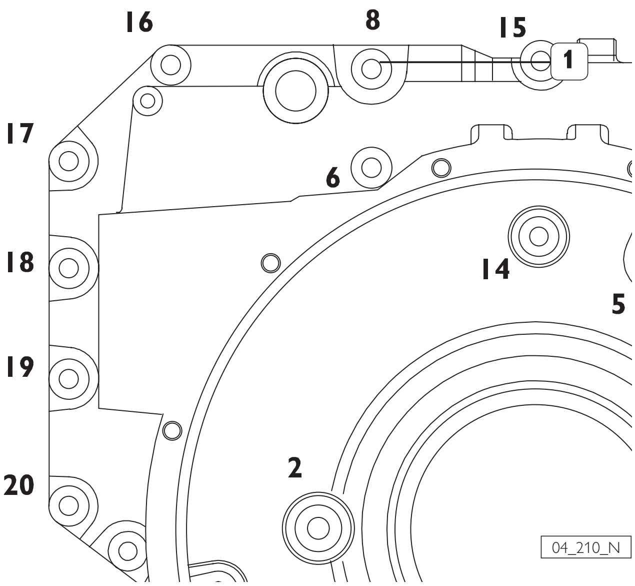


DIAGRAM SHOWING SCREW TIGHTENING TO FIX FLYWHEEL COVER BOX.

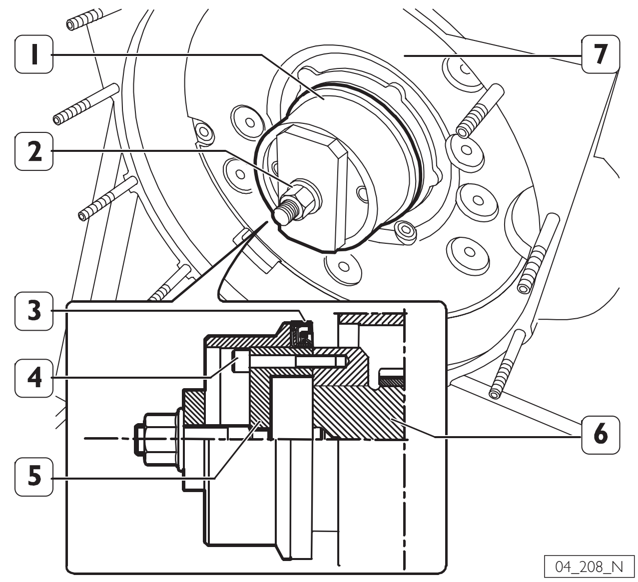
❏ Reassemble the box (1) to the engine block, tighten the fixing screws in the same position as found out during disassembly and fix the screws to the locking torques listed here below, following the order as shown in the picture:

- M12 Screw 75 to 95 Nm;
- M10 Screw 44 to 53 Nm.

CAUTION

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

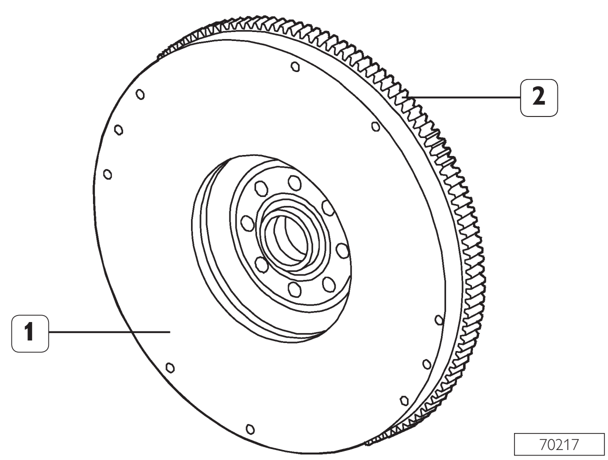
Figure 122



❏ Apply to engine drive shaft rear tang (6), the component (5) of the tool 99346252, fix it tightening the screws (4) and key the new holding ring on it (3);

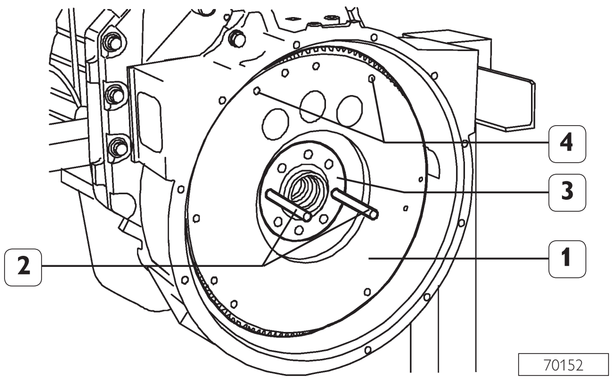
❏ Place component (1) on component (5), tighten the screw nut (2) until complete assembly of the fixing ring (3) into the flywheel cover box (7).

Figure 123



Check the conditions of the rim tooth (2). Whether tooth break or excessive wear is detected, disassemble the rim from the engine flywheel using a common willow and replace with a new one, previously heated to 150 °C for 15-20 minutes; bevelling must be located towards engine flywheel direction.

Figure 124

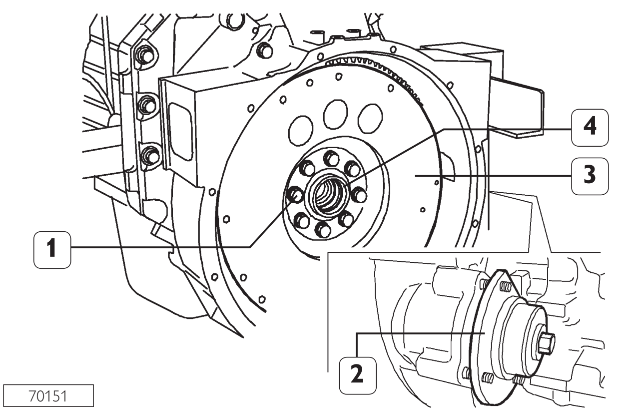


❑ Screw down two hooks or trail rings in the flywheel (1) threaded ports (4) for handling;

❑ Using a hoist, handle the flywheel to place it in its place inside the flywheel housing;

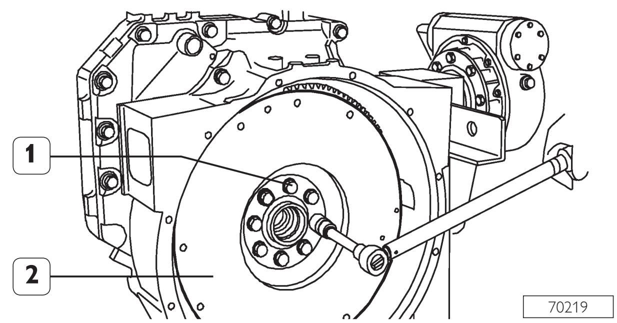
❑ Screw down two pins (2) having appropriate length, in the shaft ports (3) and using them as guide, assemble the engine flywheel (1) properly placing it inside the flywheel housing.

Figure 125



Tighten the screws (1) fixing the engine flywheel (4) to the engine shaft. Put tool 99360339 (2) on the flywheel cover box (1) to block engine flywheel rotation.

Figure 126



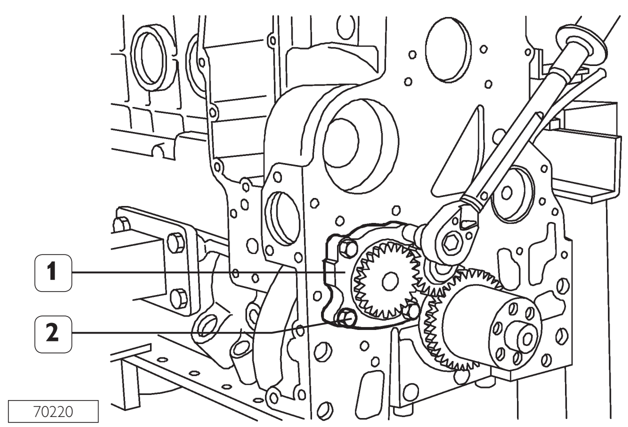
Tighten the engine flywheel (2) fixing screws (1) in two phases:

- 1st phase: tightening by means of dynamometric wrench to torque 30 ± 4 Nm;
- 2nd phase: 60° ± 5° angle dwell.

CAUTION

Angle dwell must always be performed using 99395216 tool.
Before every assembly, always check that threads of holes and screws have no evidence of tear and wear nor dirt.

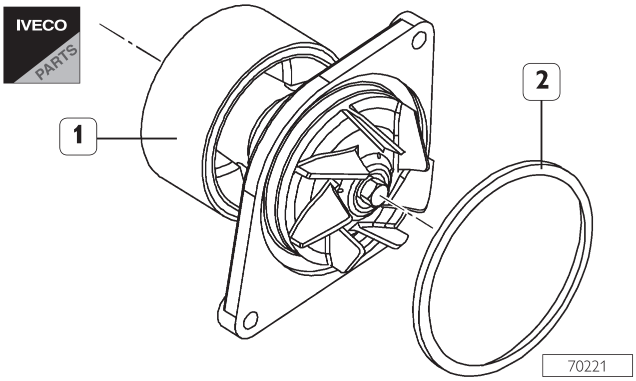
Figure 127



❑ Assemble oil pump (1);

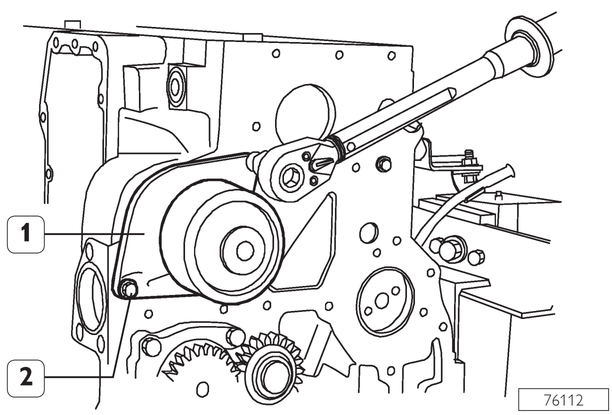
❑ Tighten fixing screws (2) and lock them to the prescribed torque.

Figure 128



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

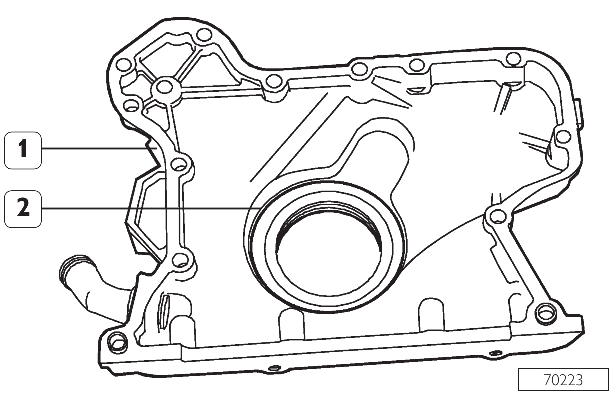
Figure 129



❏ Assemble the water pump (1);

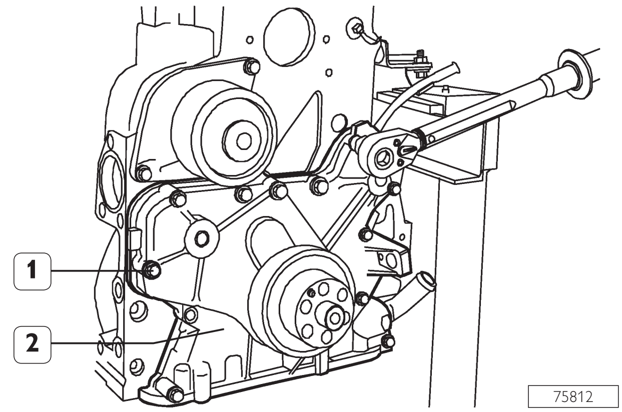
❏ Tighten the screws (2) and lock them to the prescribed torque.

Figure 130



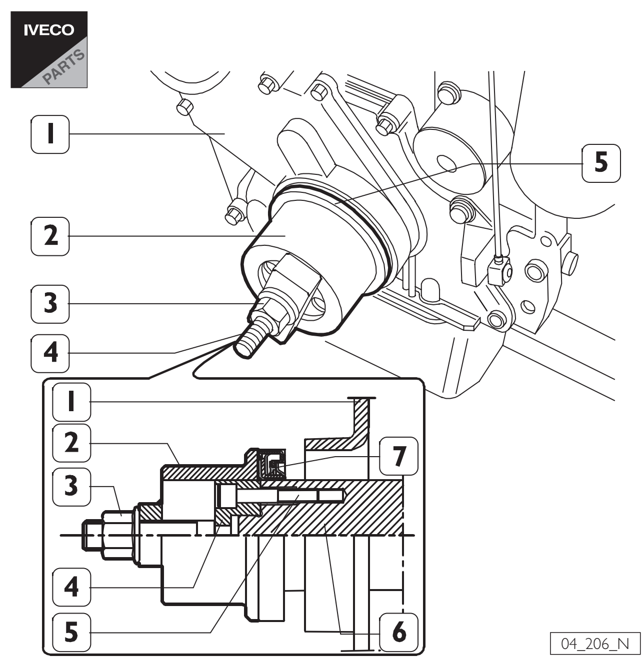
❏ Remove the fixing ring (2) from the front cover (1), accurately clean the contact surface and apply sealing Loctite 5205 on it.

Figure 131



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

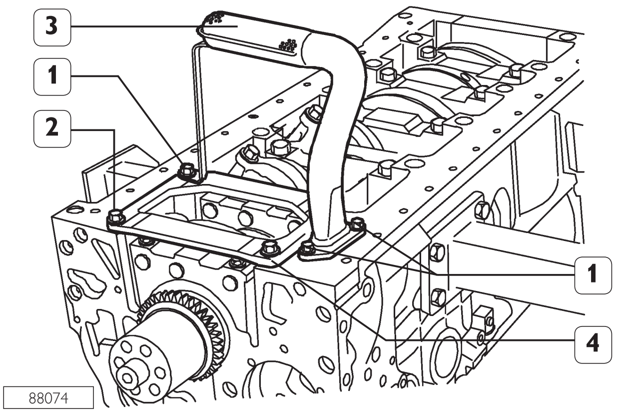
Figure 132



❏ Apply on engine drive shaft front tang (6) the component (4) of the tool 99346252, fix it with the screws (5) and key the new holding ring on it (7);

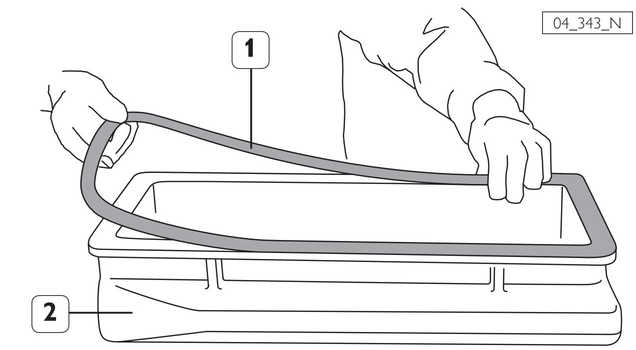
❏ Place the component (2) on the component (4), screw down the threaded nut until carrying out the complete assembly of the holding ring (7) to the front cover.

Figure 133



❑ Assemble plate (4), suction rose (3) and tighten the fixing screws (2 and 1) locking them on the prescribed torque.

Figure 134



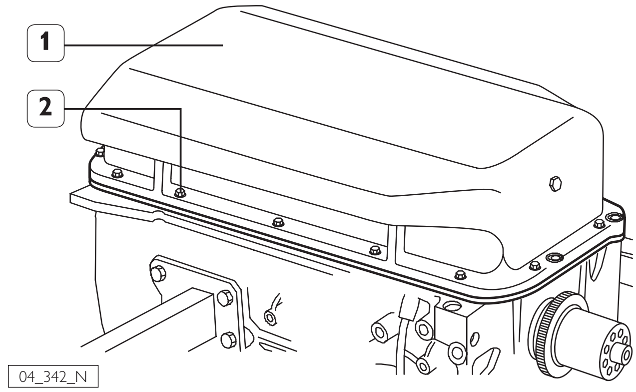
❑ Provide for new gasket replacement (1) of the oil sump (2).

CAUTION

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

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

Figure 135

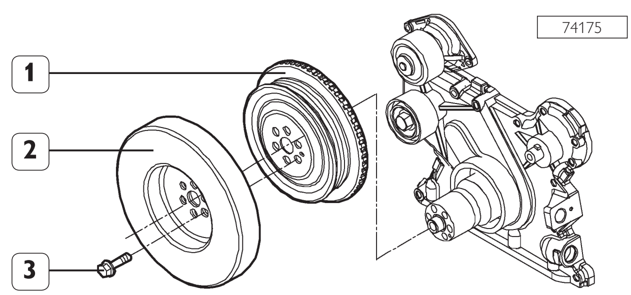


❑ Assemble oil sump (1). Tighten the screws (2) and lock them to the prescribed torque.

CAUTION

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

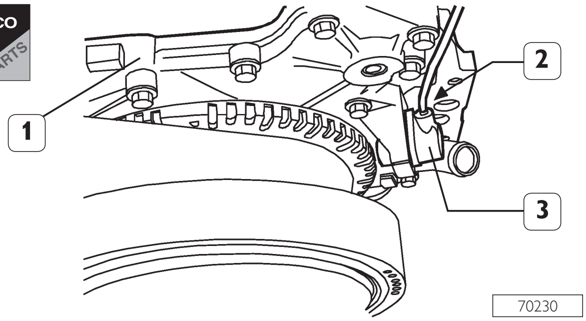
Figure 136



❑ Assemble the pulley (1) and the damping flywheel (2) to the driving shaft;

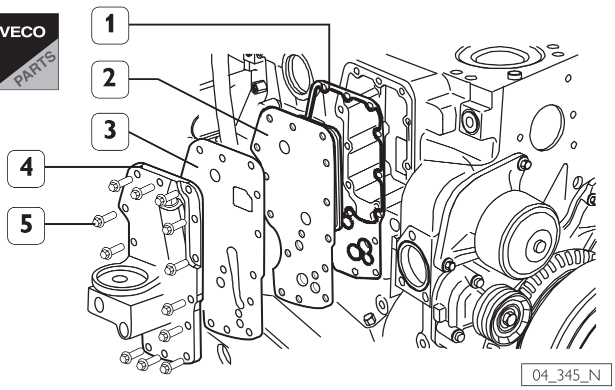
❑ Tighten the fixing screws (3) and clamp them to the torque 68 ± 7 Nm.

Figure 137



- ❑ Fit a new sealing ring on the speed sensor (3) (if fitted);
- ❑ Fit the speed sensor (3) on the front cover (1) and tighten the screw (2) to the prescribed torque (if fitted).

Figure 138

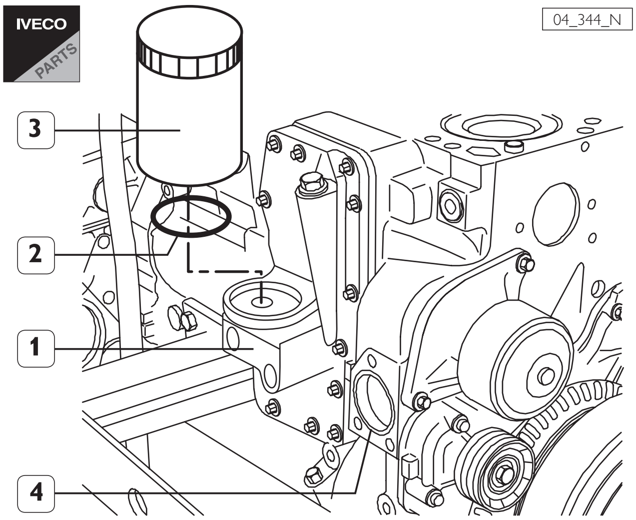


- ❑ Assemble the following elements to the block: new gasket (1), heat exchanger (2), new gasket (3), oil filter bearing (4);
- ❑ Tighten the screws (5) and lock them to the prescribed torque.

CAUTION

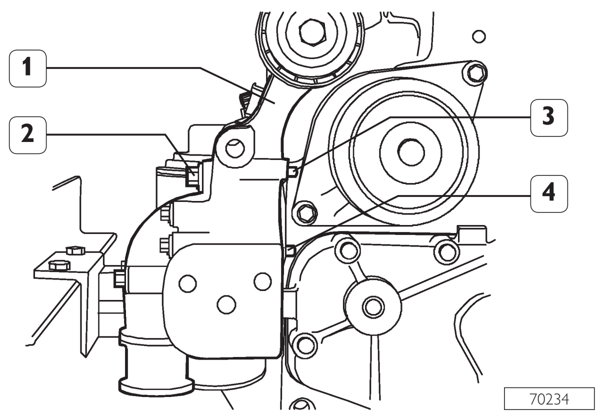
Before every assembly, always check that threads of holes and screws have no evidence of tear and wear nor dirt.

Figure 139



- ❑ Lubricate the fixing ring (2) using engine oil and place it on the oil filter (3);
- ❑ Manually screw the oil filter (3) on the bearing union (1) until counter-boring, further screw down the oil filter (3) by 3/4 turn;
- ❑ Place a new fixing ring on the block housing (4).

Figure 140

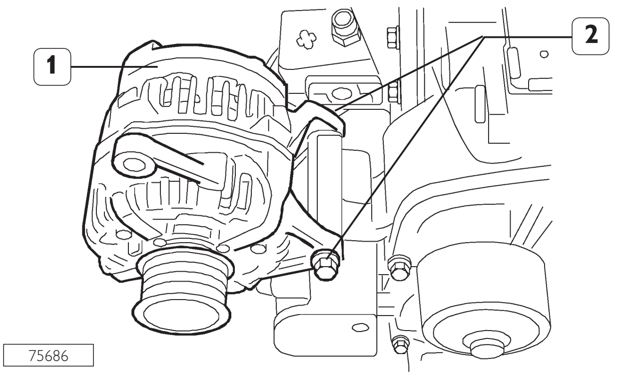


- ❑ Assemble the alternator bearing (1) ensuring that the pins (3 and 4) are against the engine block;
- ❑ Tighten the screws (2) and lock them to the prescribed torque.

CAUTION

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

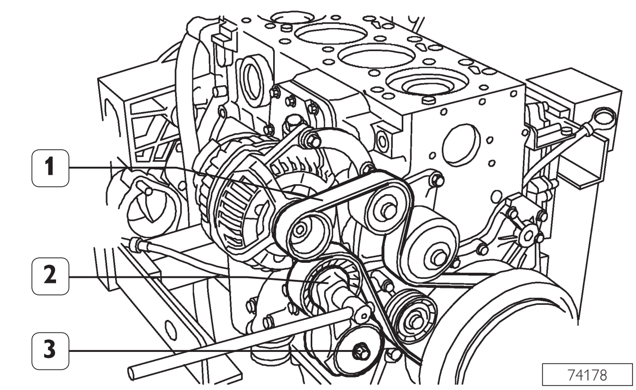
Figure 141



❏ Mount the alternator (1) to the support;

❏ Tighten without locking the screw (2).

Figure 142



❏ Mount the automatic belt tensioner (2);

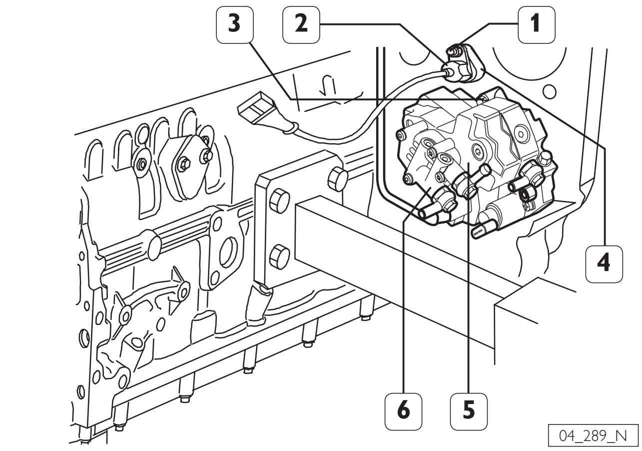
❏ Tighten the screw (3) to the prescribed torque;

❏ Turn the automatic belt tensioner (2) to fit the belt (1) on pulleys and guide rollers.

CAUTION

In case the previously removed belt is assembled again, examine it carefully to check possible cuts or yielding marks.

Figure 143

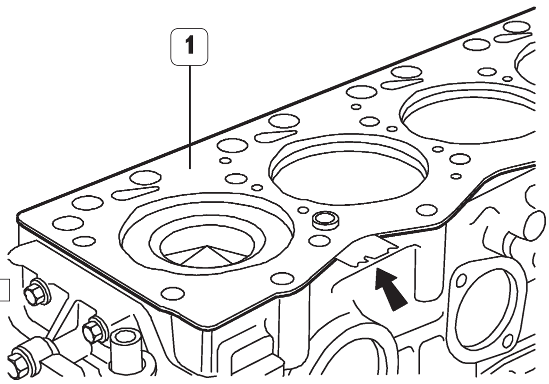


❏ Mount the high pressure pump (5) including the feed pump (6) and tighten the nuts (3) to the prescribed torque;

❏ Fit the support (4) with a new sealing ring, the timing sensor (2) with a new sealing ring and tighten the relevant fastening nut (1) to the prescribed torque.

REFITTING THE CYLINDER HEAD

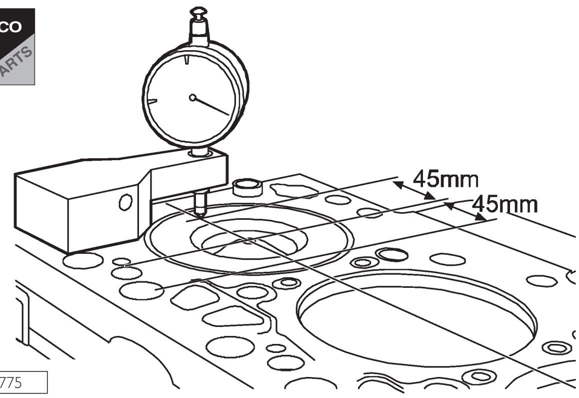
Figure 144



87759

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

Figure 145



88775

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

- For each piston detect, as indicated on Figure 145, at a distance of 45 mm from the centre of the piston overhandings S1 and S2 in relation to the engine base upper plane then calculate the average:

$$Scil1 = \frac{S1 + S2}{2}$$

For 4 cylinder versions
Repeat the operation for pistons 2, 3 and 4 and calculate the average value:

$$S = \frac{Scil1 + Scil2 + Scil3 + Scil4}{4}$$

For 6 cylinder versions
Repeat the operation for pistons 2, 3, 4, 5 and 6 and calculate the average value:

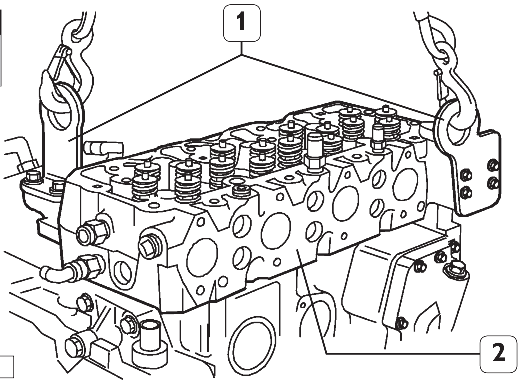
$$S = \frac{Scil1 + Scil2 + Scil3 + Scil4 + Scil5 + Scil6}{6}$$

If S is > 0.40 mm use seal type A.
If S is < 0.40 mm use seal type B.

CAUTION

Before re-utilising the fixing screws for the cylinder head, verify there is no evidence of wear or deformation; in that case replace them.

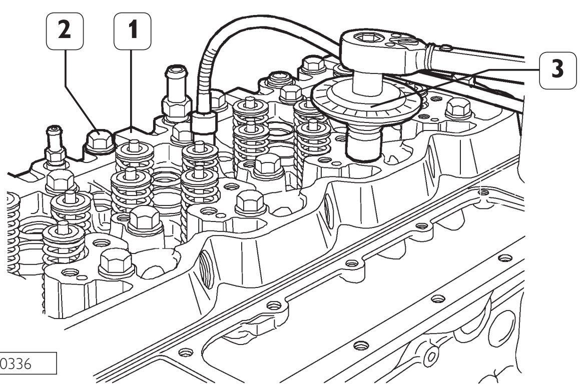
Figure 146



70137

Apply a new gasket to the engine block and then place the cylinder head (2) slung by the hanger brackets (1).

Figure 147



70336

Assemble cylinder head (1), tighten the screws (2) in three following steps, following order and mode shown in the figure below.

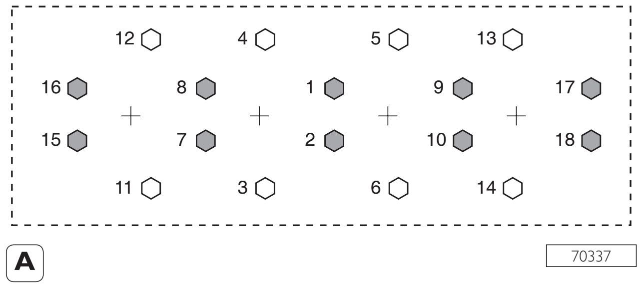
CAUTION

The angle tightening is carried out through tool 99395216 (3).

CAUTION

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

Figura 148 A



70337

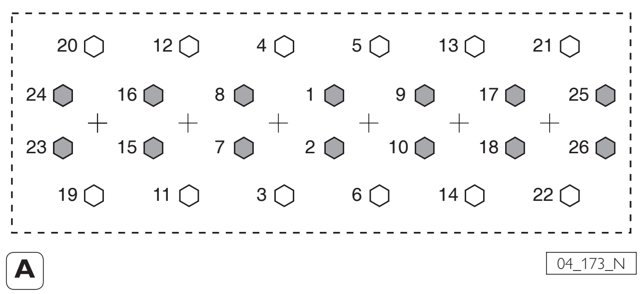
4-CYLINDER ENGINE

Tightening order layout for cylinder head fastening screws:

- 1st step pre-tightening with a torque wrench:
  - 12x1.75x130 Screw (⬢) 35 ± 5 Nm;
  - 12x1.75x150 Screw (⬡) 55 ± 5 Nm.
- 2nd step tightening with a 90° ± 5° angle;
- 3rd step tightening with a 90° ± 5° angle.

A = Engine front side

Figura 148 B



04_173_N

6-CYLINDER ENGINE

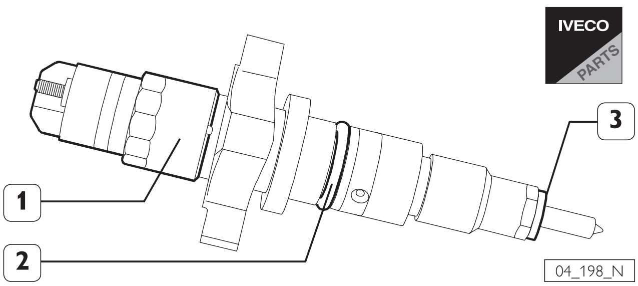
Tightening order layout for cylinder head fastening screws:

- 1st step pre-tightening with a torque wrench:
  - 12x1.75x130 Screw (⬢) 35 ± 5 Nm;
  - 12x1.75x150 Screw (⬡) 55 ± 5 Nm.
- 2nd step tightening with a 90° ± 5° angle;
- 3rd step tightening with a 90° ± 5° angle.

A = Engine front side

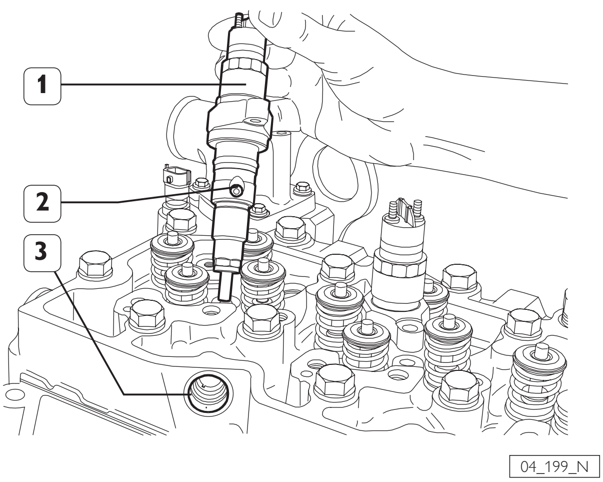
Injectors assembly

Figure 149



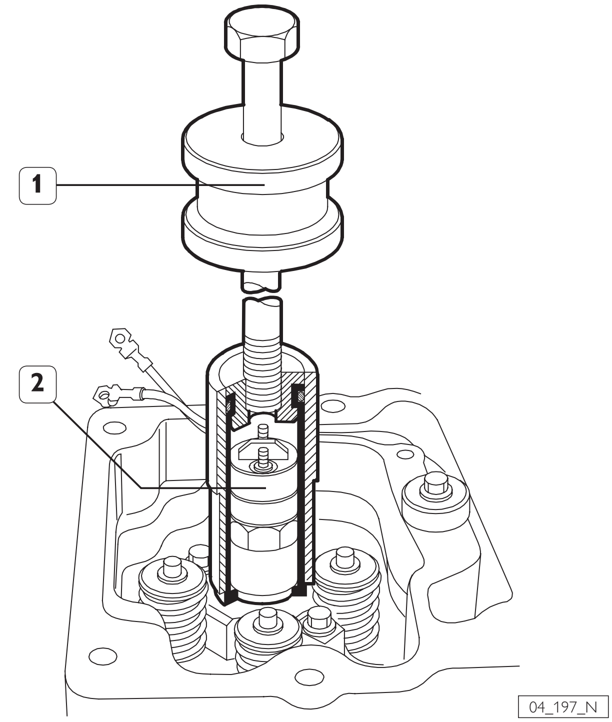
Fit a new sealing ring (2) lubricated with petroleum jelly and a new sealing washer (3) on injector (1).

Figure 150



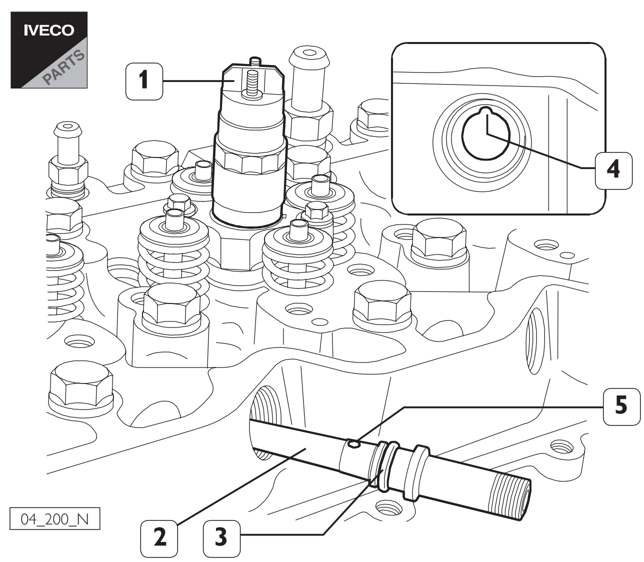
Fit injectors (1) on the cylinder head seats, directed so that the fuel inlet hole (2) is facing the fuel manifold seat (3) side.

Figure 151



Use tool 99342101 (1) to fit the injector (2) into its seat. Screw injector fastening screws without tightening them.

Figure 152



Fit a new sealing ring (3) lubricated with petroleum jelly on the fuel manifold (2), and fit it into the cylinder head seat so that the positioning ball (5) is coinciding with the relevant housing (4).

CAUTION

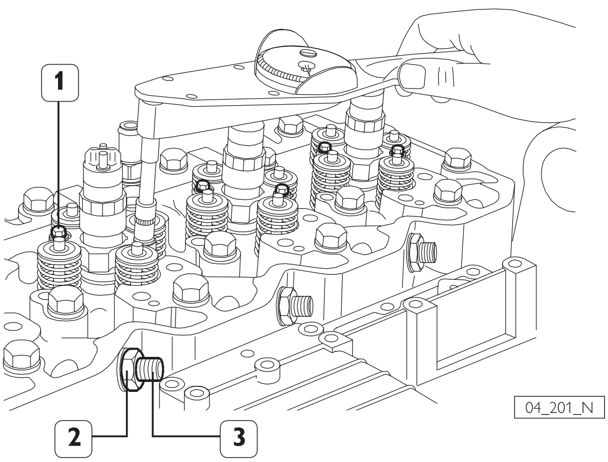
Disassembled fuel manifolds (2) must not be used again. Replace them with new items.

Screw the fastening nuts (2, Figure 153) without locking them.

CAUTION

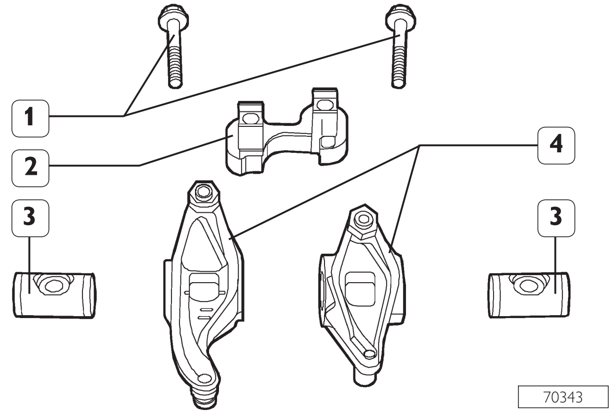
During this operation, handle the injector (1) so that the manifold (2, Figure 150) is properly inserted into the fuel inlet hole (2, Figure 148).

Figure 153



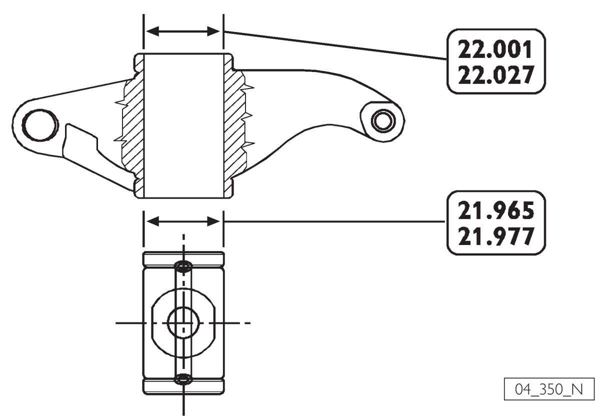
Use the torque wrench to tighten gradually and alternately the injector fastening screws (1) to 8.5 ± 0.8 Nm torque.
Tighten the fuel manifold (3) fastening nuts (2) to 50 Nm torque.
Carry out the assembly of the rocker arms unit, after previous check of the components.

Figure 154



ROCKER ASSEMBLY COMPONENTS:
1. Screws - 2. Bracket - 3. Shafts - 4. Rockers.

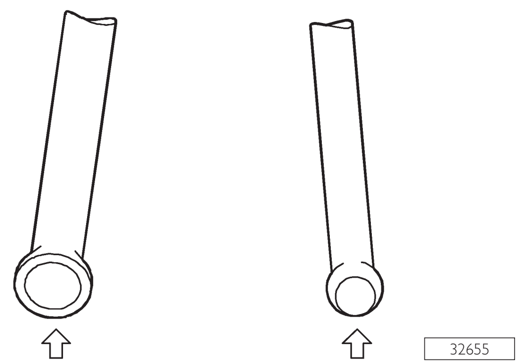
Figure 155



SHAFT-ROCKER MAIN DATA

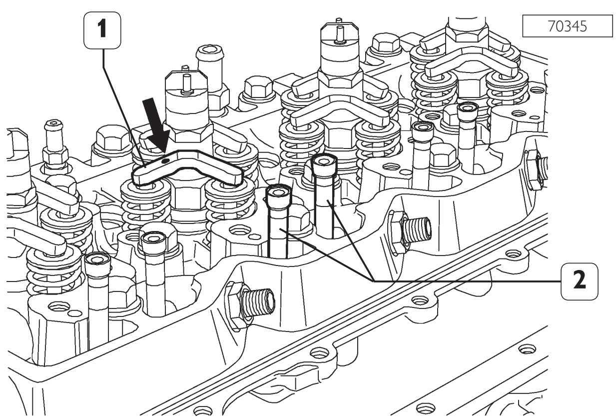
Check that shaft/rocker coupling surfaces are not showing excessive wear or damages.

Figure 156



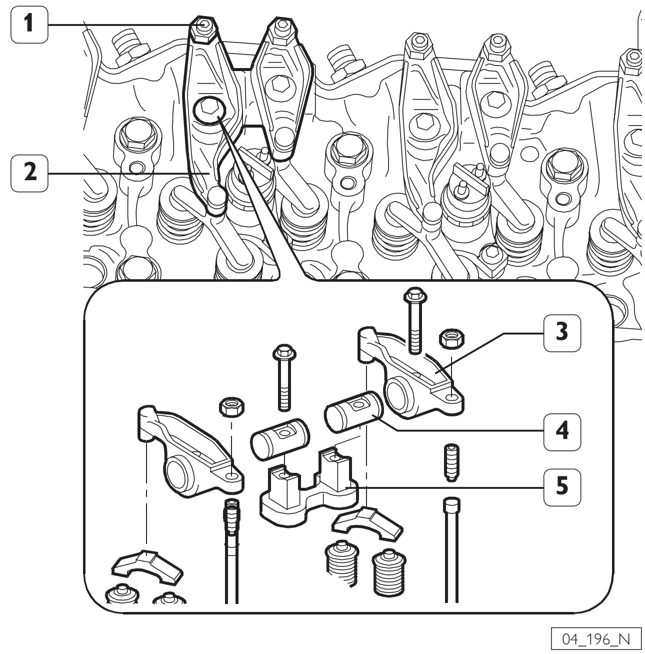
Prior to assembly, check the rocker control rods: they must be free from distortions; the ball seats in touch with the rocker adjusting screw and with tappets (arrows) must not show seizing or wear; otherwise replace them.
Intake and exhaust valve control rods are identical and are therefore interchangeable.

Figure 157



Fit the rods (2).
Position jumpers (1) on valves with marks (➔) facing the exhaust manifold.

Figure 158

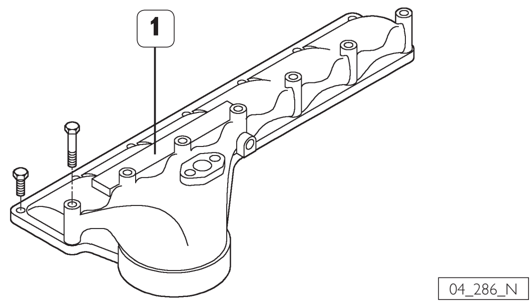


Check that tappet adjusters (1) are loose to prevent their balking on the rods (2, Figure 157) when refitting the rocker assembly.
Then refit the rocker assembly consisting of: bracket (5), rockers (3), shafts (4) and secure them to the cylinder head by tightening the fastening screws (2) to 36 Nm torque.

Adjusting valve clearance

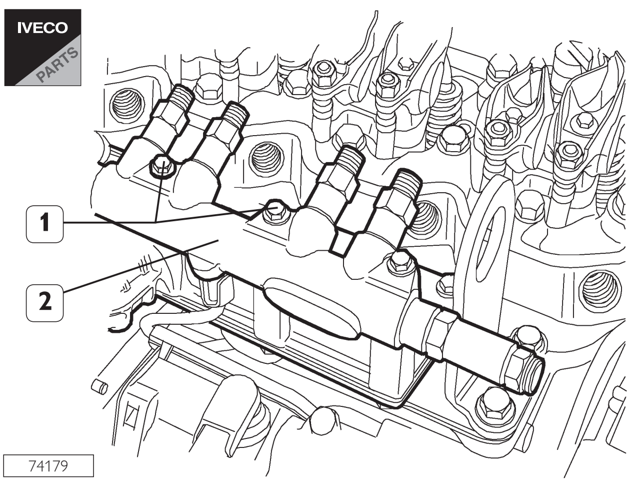
(see Section 6)

Figure 159



Apply to the coupling surface of the intake manifold (1) equipped with heater (2) a sufficient coat of Loctite 5999 and tighten the screws to the prescribed torque.

Figure 160



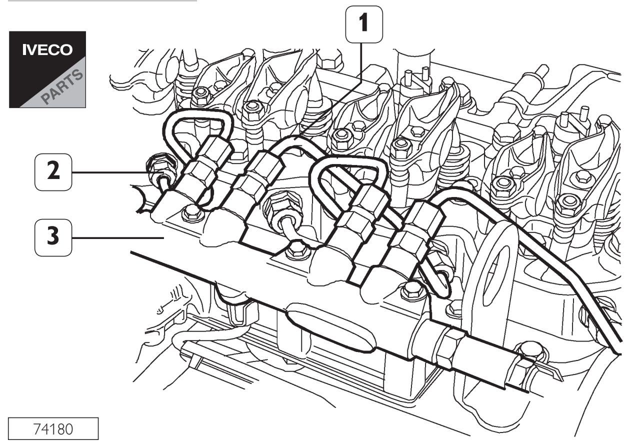
Mount the rail (2) to the intake manifold and tighten the screws (1) to the prescribed torque.

CAUTION

Because of the high pressure in the pipelines connecting the high pressure pump to the rail, and this one to the electro-injectors, it is absolutely forbidden to:

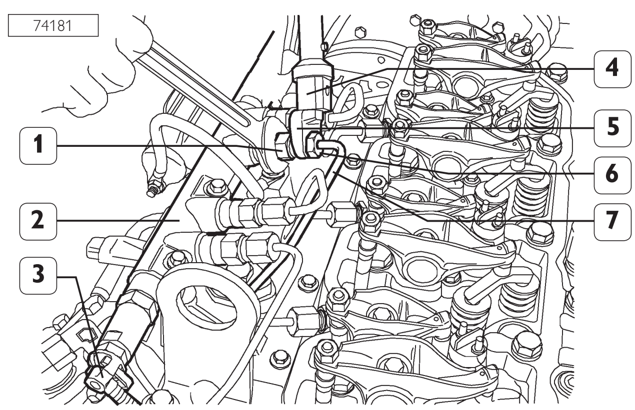
- ❑ **Disconnect the pipelines when the engine is running;**
- ❑ **Re-use the disassembled pipelines.**

Figure 161



Connect new fuel pipes (1) to rail (3) and injector manifolds (2).

Figure 162

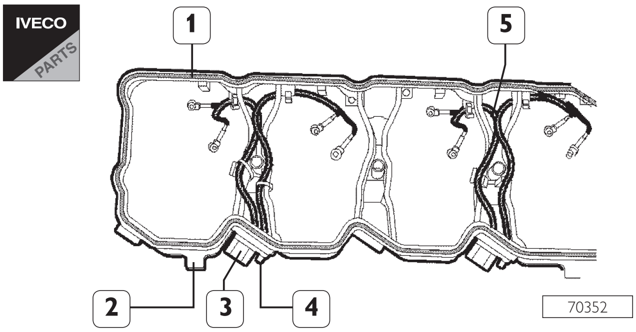


CAUTION

Pipe (7) connections must be tightened to 20 Nm torque, using the proper wrench (5) and the torque wrench 99389833 (4).
Connections (6) must be tightened while holding the flow limiting valve hexagon (1) with the proper wrench.

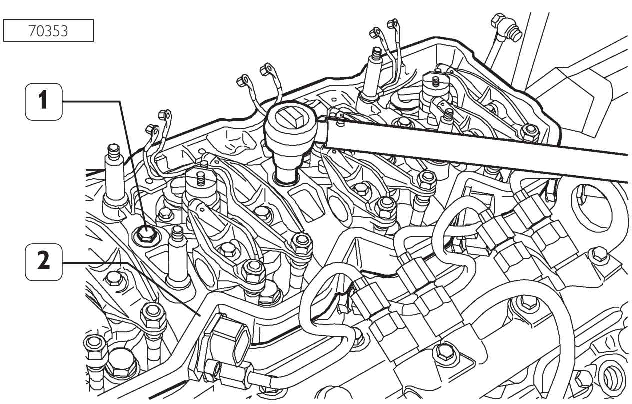
Connect the fuel pipe (3) to the rail (2).

Figure 163



Check electrical cable (5) conditions, if damaged replace them by cutting the support clamps (2) and removing the screws (4) that secure it to connections (3).
Fit a new gasket (1) on the support (2).

Figure 164

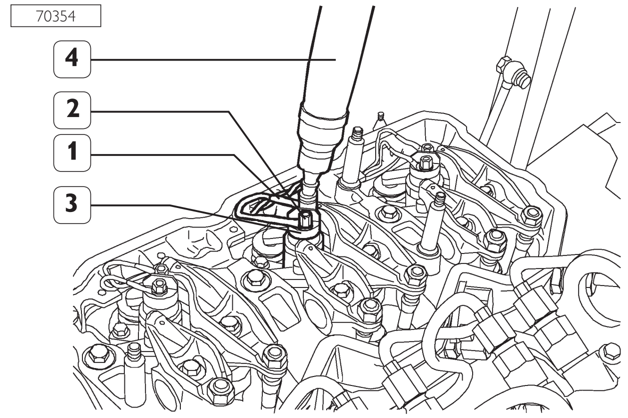


Fit the wiring support (2) and tighten the screws (1) to the prescribed torque.

CAUTION

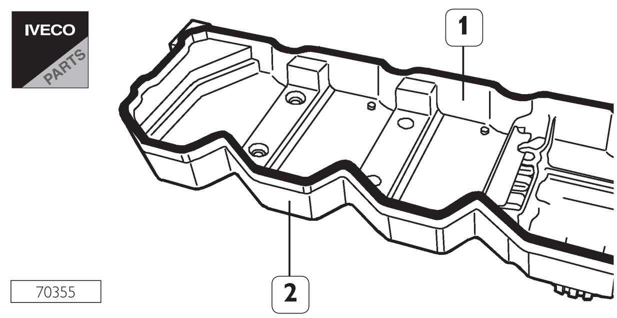
Before every assembly, always check that threads of holes and screws have no evidence of tear and wear nor dirt.

Figure 165



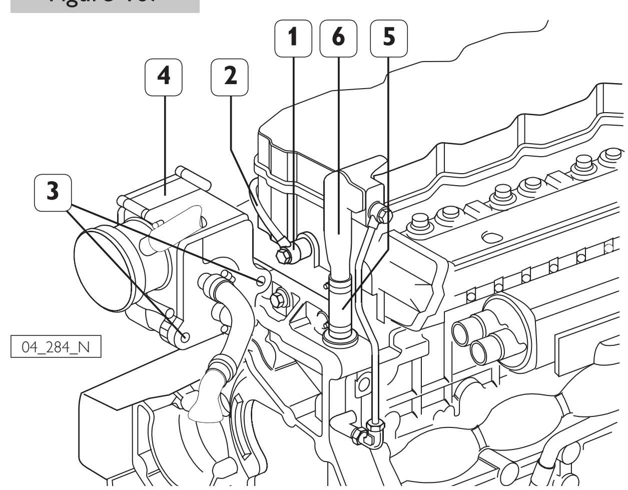
Connect the electrical cables (1) to the injectors (3) and use the torque wrench 99389834 (4) to tighten the fastening nuts (2) to the prescribed torque.

Figure 166



Fit a new gasket (2) on the tappet cover (1).
Place the tappet cover on, insert the bolts and tighten them to the prescribed torque.

Figure 167



Insert the blow-by filter (4) and tighten the screws (3).
Connect the pipeline (6) and fix the oil vapour recover pipe (5) using the clamp; lock up the nut fixing it to the upper edge.
Connect the pipeline (2) to the pressure limiter (1).

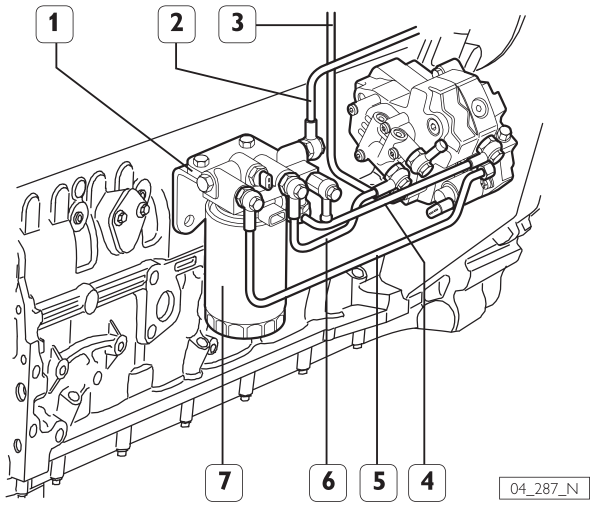
To complete engine assembly it is necessary to remove it from the turning stand.

❑ Using rocker arm 99360595 hold the engine and loosen the screws fixing the brackets to the turning stand 99322205;

❑ Disassemble the brackets from the engine after having properly put it on a wooden bearing.

Engine completion

Figure 168



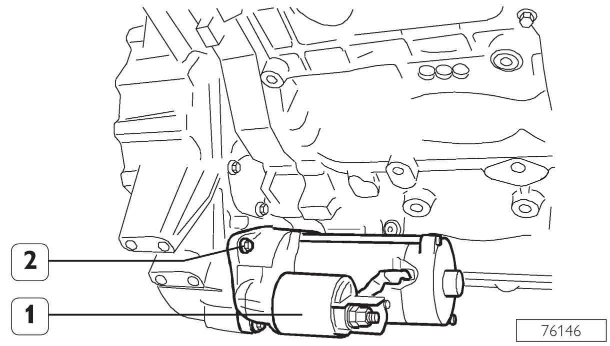
❑ Assemble the bracket and the support (1) of the fuel filter (7);

❑ Proceed connecting in sequence the pipelines (2, 4, 6 and 5);

❑ Connect the fuel pipeline (3) from the high pressure pump to the rail;

❑ Tighten the screws of hydraulic fittings to the prescribed torque values.

Figure 169



❑ Reassemble the starter;

❑ Properly hold the starter (1) and tighten the fixing screws (2) to the prescribed torque;

❑ Assemble oil filter;

❑ Assemble oil level rod together with guide pipe;

❑ Proceed to install marine parts;

❑ Fill the engine with oil and coolant liquid quantity required.

TIGHTENING TORQUES

Marine parts tightening torques

Part	Torque	
	Nm	kgm
M10 Nut turboblowers fixing on exhaust manifold	43 ± 6	4.3 ± 0.6
M10 Lock nut fixing turboblowers on exhaust manifold	26 ± 10	2.6 ± 0.1
M8 x 115 Screw for air / air or water / water exchanger	18 ± 2	1.8 ± 0.2
M8 x 120 Screw for air / water heat exchanger	18 ± 2	1.8 ± 0.2
M12 x 30 Screw for front engine support legs	69 ± 7	6.9 ± 0.7
M12 x 30 Screw for back engine support legs	66 ± 7	6.6 ± 0.7
M6 x 20 Screw for cooled riser stub pipe	8 ± 1	0.8 ± 0.1
M10 Nut anchoring the alternator	43 ± 6	4.3 ± 0.6
M10 x 140 Screw fixing the pump water inlet pipe and support bracket	43 ± 6	4.3 ± 0.6
M10 x 80 Screw fixing pump water inlet pipe and support bracket	43 ± 6	4.3 ± 0.6
M10 x 30 Screw fixing the electric engine starter	43 ± 6	4.3 ± 0.6
M12 x 30 Screw fixing the sea-water pump	85 ± 8	8.5 ± 0.8
M10 x 120 Screw for lower anchoring of the exhaust manifold	53 ± 6	5.3 ± 0.6
M10 x 150 Screw for lower anchoring of the exhaust manifold	53 ± 6	5.3 ± 0.6

Engine parts tightening torques

Part		Torque Nm	kgm
M6 Stud bolts for camshaft sensors		8 ± 2	0.8 ± 0.2
M8 Stud bolts for fuel pump		12 ± 2	1.2 ± 0.2
M12 Screw fixing rear gearbox		77 ± 12	7.7 ± 1.2
M10 Screw fixing rear gearbox		47 ± 5	4.7 ± 0.5
M8 Screw fixing rear gearbox		24 ± 4	2.4 ± 0.4
M6 Nut fixing camshaft sensor		10 ± 2	1 ± 0.2
M8 Screw fixing oil pump	Phase 1	8 ± 1	0.8 ± 0.1
	Phase 2	24 ± 4	2.4 ± 0.4
M8 Screws fixing front cover		24 ± 4	2.4 ± 0.4
M8 Screw to secure camshaft longitudinal retainer plate		24 ± 4	2.4 ± 0.4
M8 Screw fixing camshaft gear		36 ± 4	3.6 ± 0.4
M10 Screw fixing crankcase base plate		43 ± 5	4.3 ± 0.4
M18 Nut to secure high-pressure pump gear		105 ± 5	10.5 ± 0.5
M8 Nuts fixing fuel pump		24 ± 4	2.4 ± 0.4
1/2 inch plug on the cylinder head		24 ± 4	2.4 ± 0.4
1/4 inch plug on the cylinder head		36 ± 5	3.6 ± 0.5
3/4 inch plug on the cylinder head		12 ± 2	1.2 ± 0.2
M6 Screws fixing injectors	Phase 1	8.5 ± 0.35	0.85 ± 0.035
	Phase 2	75° ± 5°	
Nut fixing union to supply injector		50 ± 5	5 ± 0.5
M8 Screw fixing intake manifold		24 ± 4	2.4 ± 0.4
M12 Screw fixing rear brackets for lifting engine		77 ± 12	7.7 ± 1.2
M8 Screw fixing Common Rail		24 ± 4	2.4 ± 0.4
M14 High-pressure fuel pipe unions		20 ± 2	2 ± 0.2
M12 Screw (12x1.75x130) fixing cylinder head	Phase 1	35 ± 5	3.5 ± 0.5
M12 Screw (12x1.75x150) fixing cylinder head	Phase 1	55 ± 5	5.5 ± 0.5
	Phase 2	90°± 5°	
	Phase 3	90°± 5°	
Rocker mount fixing screw		36 ± 5	3.6 ± 0.5
Valve clearance adjustment nuts		24 ± 4	2.4 ± 0.4
M14 Nuts fixing supply pipe from high-pressure pump Common rail		20 ± 2	2 ± 0.2
M8 Screw fixing high-pressure pipe union		24 ± 4	2.4 ± 0.4
M6 Screw fixing bulkhead connector of head for wiring		10 ± 2	1 ± 0.2
M8 Screw fixing wiring mount to supply electro-injectors		24 ± 4	2.4 ± 0.4
Nuts fixing wiring on single electro-injector		1.5 ± 0.25	0.15 ± 0.025
M12 Screw fixing fuel filter bracket		77 ± 8	7.7 ± 0.8
M8 Screw fixing fuel filter holder		24 ± 4	2.4 ± 0.4
Fuel filter		contact + 3/4 turn	

Engine parts tightening torques (cont.)

Part		Torque Nm	Torque kgm
M22 Screw fixing oil press. adj. valve on oil filter mount		80 ± 8	8 ± 0.8
M8 Screw radiator gasket and oil filter mount		24 ± 4	2.4 ± 0.4
Oil filter		contact + 3/4 turn	
11/8 inch connection on filter mount for turbine lubrication		24 ± 4	2.4 ± 0.4
M12 Nut fixing pipe for turbine lubrication		10 ± 2	1 ± 0.2
M10 Screw fixing engine coolant inlet connection		43 ± 6	4.3 ± 0.6
Fixing bend 90° (if necessary) on engine fluid inlet connection		24 ± 4	2.4 ± 0.4
M6 Screw fixing engine coolant outlet union		10 ± 2	1 ± 0.2
Fixing pins on crankcase for exhaust manifold		10 ± 2	1 ± 0.2
M12 Screw fixing damper adapter and damper on crankshaft	Phase 1 Phase 2	50 ± 5 90°	5 ± 0.5
M10 Screw fixing pulley on crankshaft		68 ± 7	6.8 ± 0.7
M8 Screw fixing water pump		24 ± 4	2.4 ± 0.4
M10 Screw fixing auxiliary component drive belt tensioners		43 ± 6	4.3 ± 0.6
M10 Screw fixing auxiliary component drive belt fixed pulleys		43 ± 6	4.3 ± 0.6
M10 Screw fixing flywheel box M12 Screw fixing flywheel box		85 ± 10 50 ± 5	8.5 ± 1 5.0 ± 0.5
M8 Nut fixing valve cover		24 ± 4	2.4 ± 0.4
M6 Screw fixing camshaft sensor		8 ± 2	0.8 ± 0.2
M6 Screw fixing crankshaft sensor		8 ± 2	0.8 ± 0.2
M14 Screw fixing engine coolant temperature sensor		20 ± 3	2 ± 0.3
M5 Screw fixing oil pressure - temperature sensor		6 ± 1	0.6 ± 0.1
Screw fixing fuel pressure sensor		35 ± 5	3.5 ± 0.5
M14 Screw fixing fuel temperature sensor		20 ± 3	2 ± 0.3
Screw fixing air temp./press. sensor on intake manifold		6 ± 1	0.6 ± 0.1
M12 Screw fixing engine oil level sensor		12 ± 2	1.2 ± 0.2
M12 Adapter on turbine for lubricating oil pipes (inlet)		35 ± 5	3.5 ± 0.5
Pipe fixing on M10 adapter for turbine lubrication		35 ± 5	3.5 ± 0.5
Oil pipe fixing on adapter M10 for turbine lubrication to crankcase		43 ± 6	4.3 ± 0.6
M8 oil drain pipe fixing on turbine		24 ± 4	2.4 ± 0.4
M6 Fixing for oil return from the cylinder head to the flywheel box		10 ± 2	1 ± 0.2
M12 Screw fixing engine flywheel	Phase 1 Phase 2	30 ± 4 60° ± 5°	3 ± 0.4
M8 Screw fixing front bracket for lifting engine		24 ± 4	2.4 ± 0.4
Screw fixing engine oil sump		24 ± 4	2.4 ± 0.4
M8 Screw fixing cylinder barrel lubrication nozzles		15 ± 3	1.5 ± 0.3

Engine parts tightening torques (cont.)

Part		Torque Nm	kgm
M12 Screw fixing crankshaft caps	Phase 1	50 ± 6	5 ± 0.6
	Phase 2	80 ± 6	8 ± 0.6
	Phase 3	90° ± 5°	
M11 Screw fixing big end caps	Phase 1	60 ± 5	6 ± 0.5
	Phase 2	60° ± 5°	
Alternator			
M10 Screw, bracket fixing on water feed pipefitting		43 ± 6	4.3 ± 0.6
M10 Screw, alternator locking		43 ± 6	4.3 ± 0.6
Starter			
Starter fixing screw		43 ± 6	4.3 ± 0.6

SECTION 9

SAFETY REGULATIONS

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SAFETY REGULATIONS

Standard safety regulations

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

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

Accident prevention

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

During maintenance

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

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

For engines equipped with an electronic control unit:

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

Respecting the Environment

- ❏ Respecting the Environment is of primary importance: all necessary precautions to ensure the personnel's safety and health are to be adopted;
- ❏ Be informed and inform the personnel as well of laws in force regulating use and exhaust of liquids and engine exhaust oil. Provide for adequate board indications and organize specific training courses to ensure that the personnel is fully aware of such law instructions and of basic preventive safety measures;
- ❏ Collect exhaust oils in adequate containers with air-tight sealing ensuring that storage is made in specific, properly identified, areas that will be ventilated, far from heat sources, and not exposed to fire danger;
- ❏ Handle batteries with care, storing them in ventilated environment and in anti-acid containers. Warning: battery exhalations represent serious danger of intoxication and environment contamination.

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