TECHNOLOGICAL EXCELLENCE

NEF ENGINE

N45 MNA M10
N67 MNA M15

TECHNICAL AND REPAIR MANUAL

MARCH 2006 EDITION

IVECO MOTORS

FPT POWERTRAIN TECHNOLOGIES

FOREWORD

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

The indications contained in this document pertain to the N45 MNA M10.00, N45 MNA M10.01, N67 MNA M15.00, N67 MNA M15.01 marine engine and complement the IVECO MOTORS 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 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 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 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 versions of the motors are generally hown using the same pictures and descriptions, however important differences are shown 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.

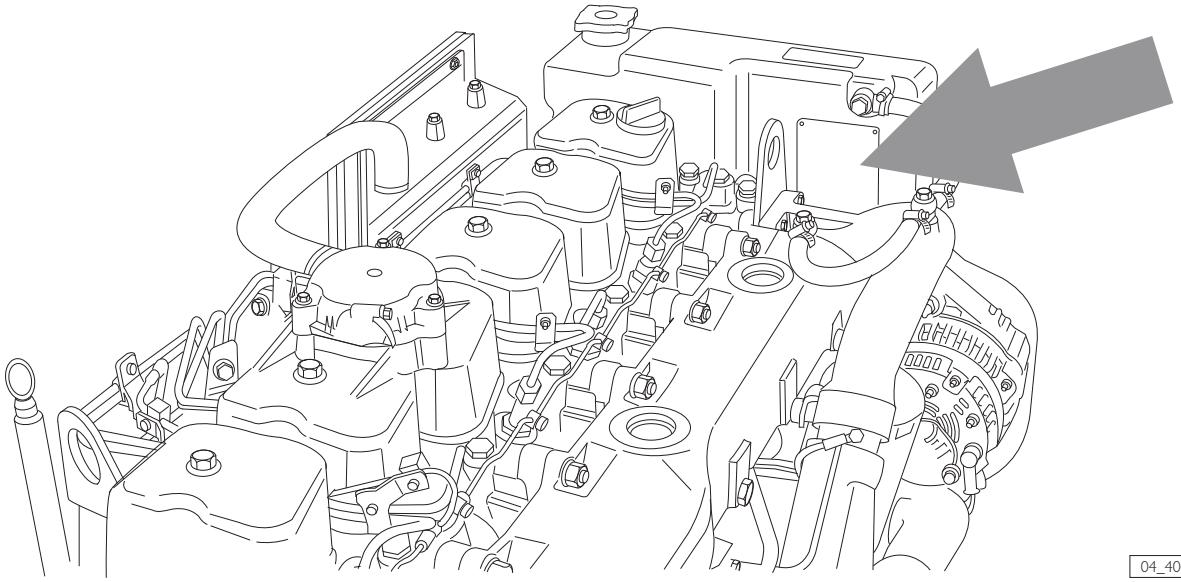
SECTION 1

OVERVIEW

(continues on next page)

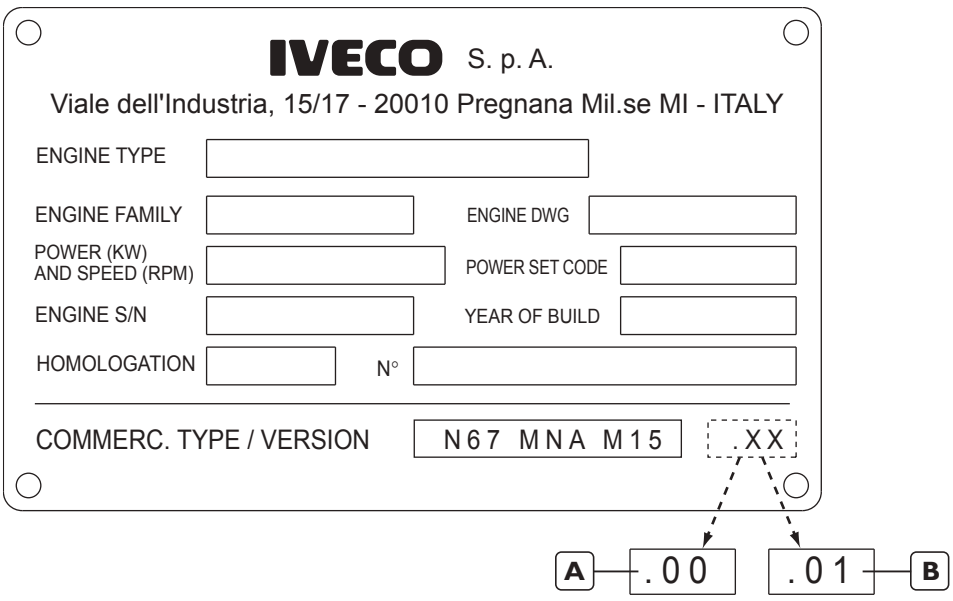
IDENTIFYING DATA

Figure 1



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

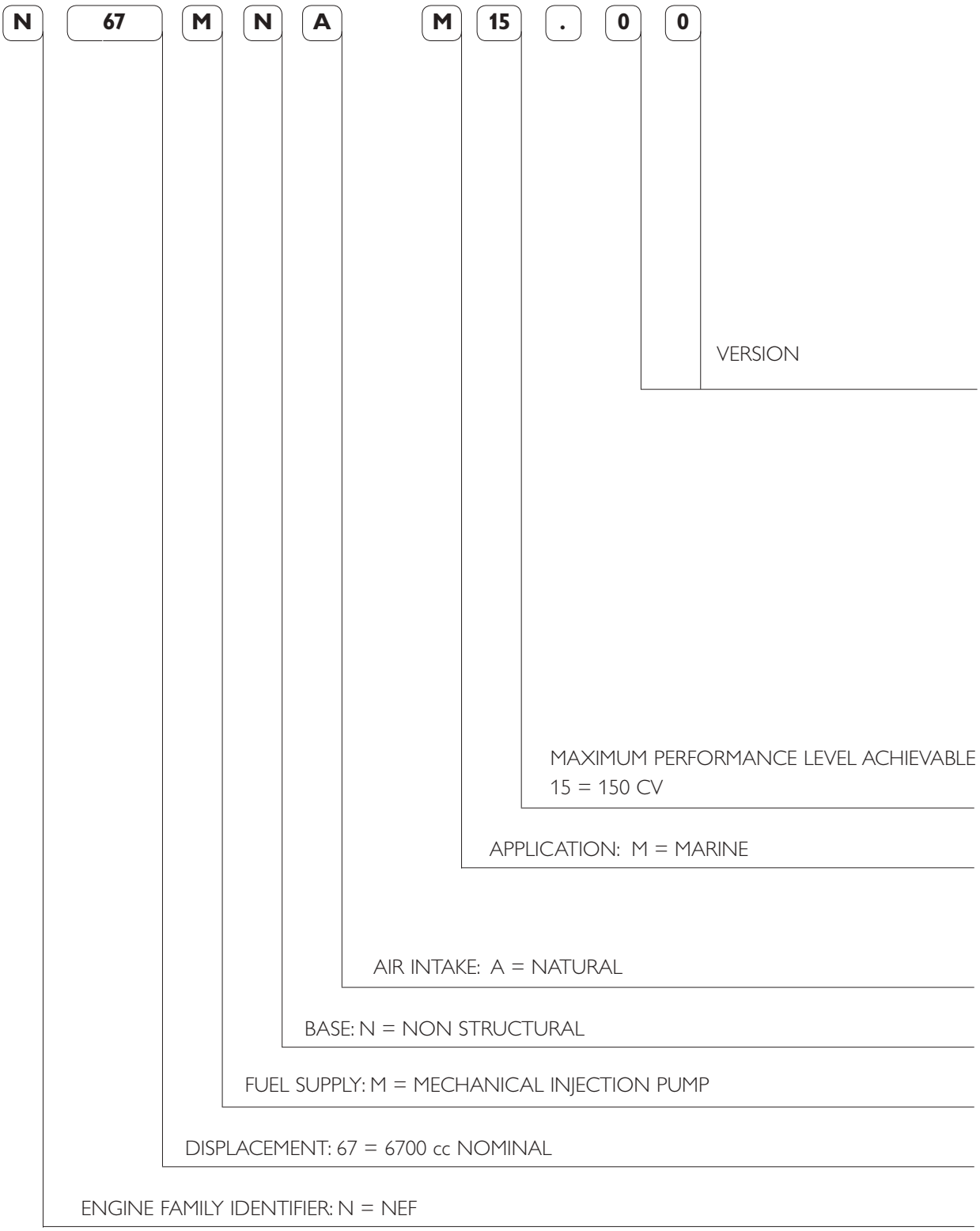
Figure 2



The last two figures of the commercial code refer to the engine model (detail A or B in figure n. 2).
Until the beginning of the year 2006 the engines produced had the code N45 MNA M10.00 or N67 MNA M15.00 (detail A in figure n. 2).
During the year 2006 relevant modifications have been made to the electric system and to the fuel supply circuit and a new model identified with the code N45 MNA M10.01 or N67 MNA M15.01 was created (detail B in figure 2).
This document concerns both the models. The relating contents are developed in different chapters which can be identified thanks to the presence in each title of the extension M10.00/M15.00 or M10.01/M15.01.

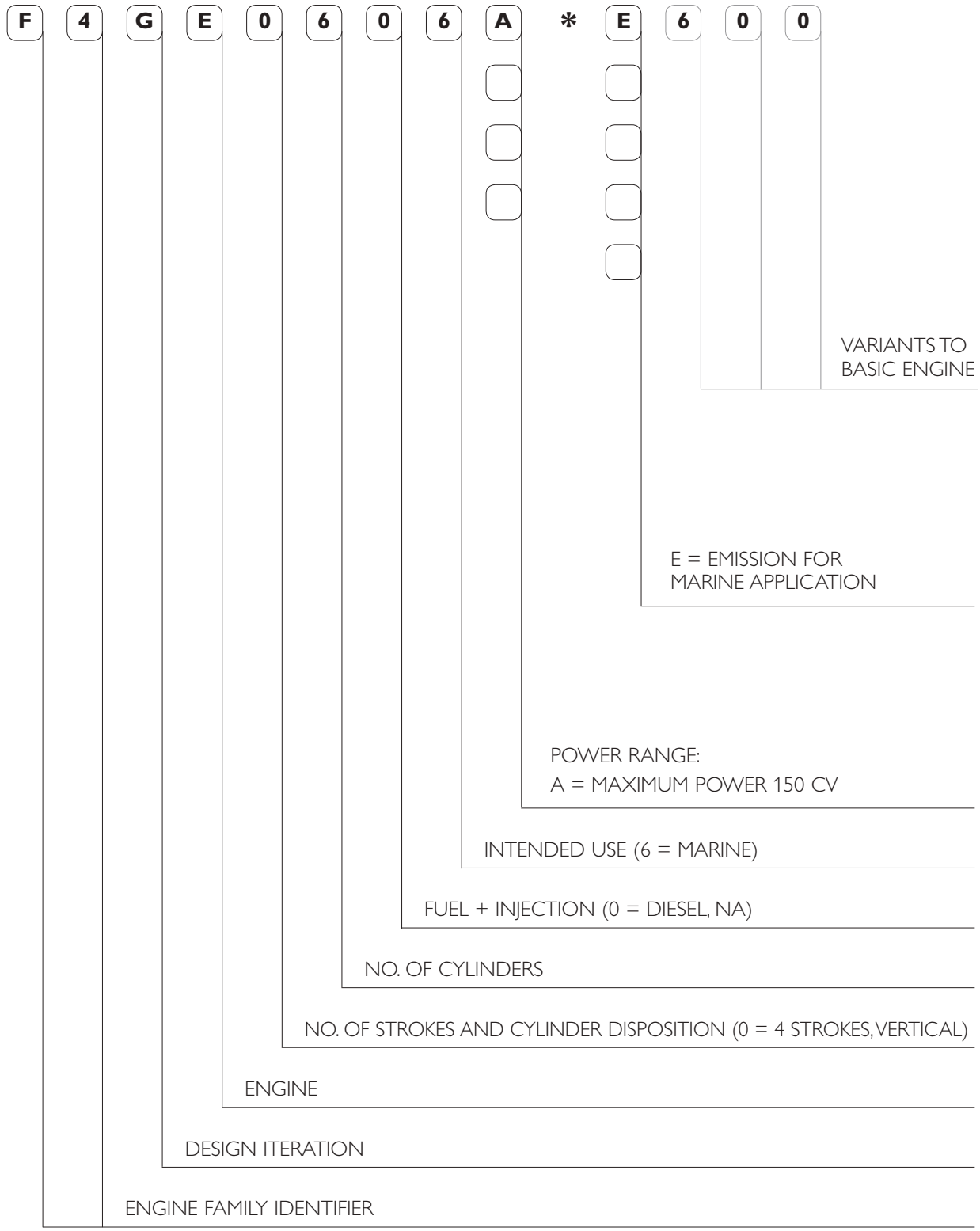
COMMERCIAL CODE

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



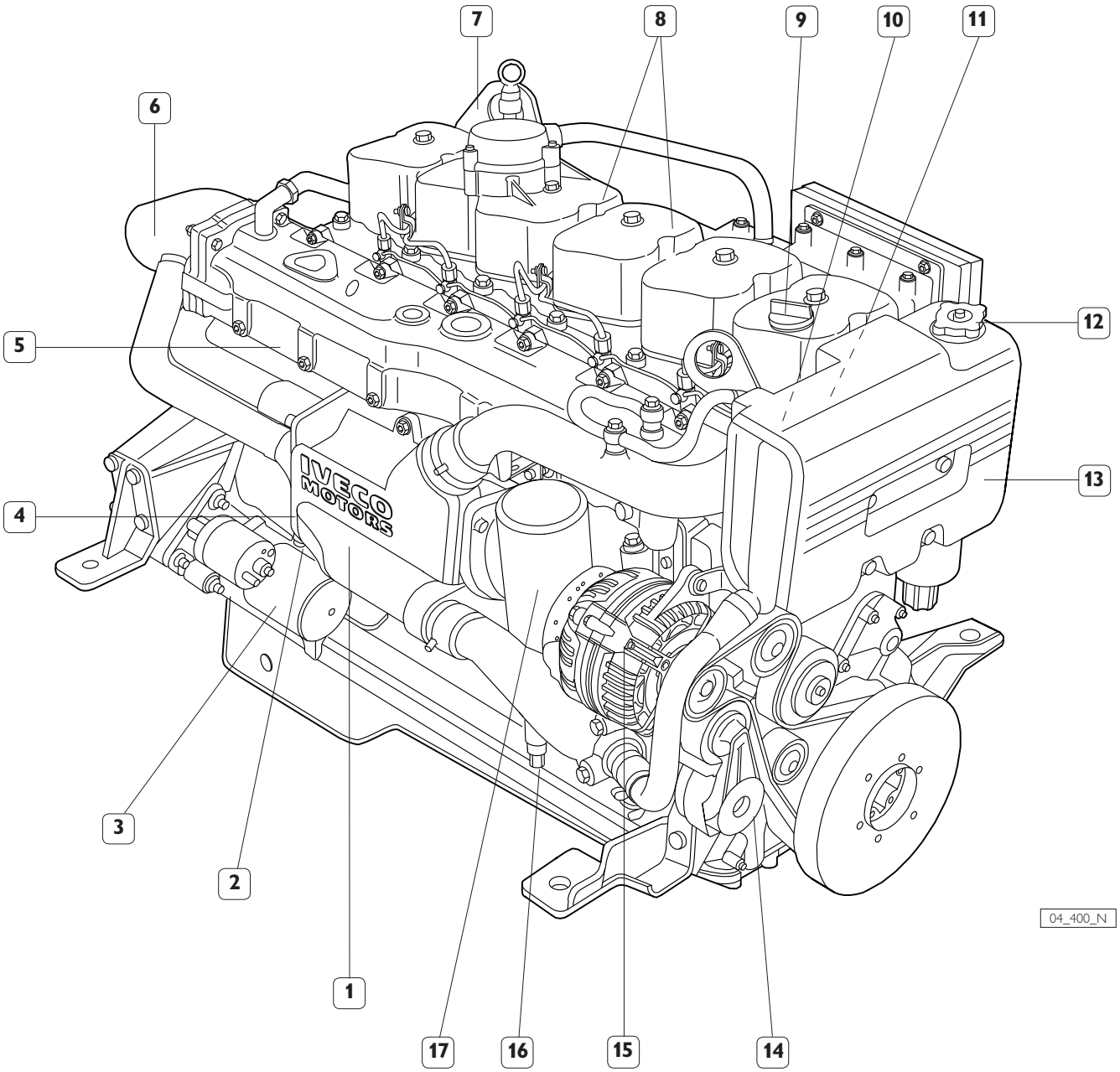
PRODUCT MODEL NUMBER

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



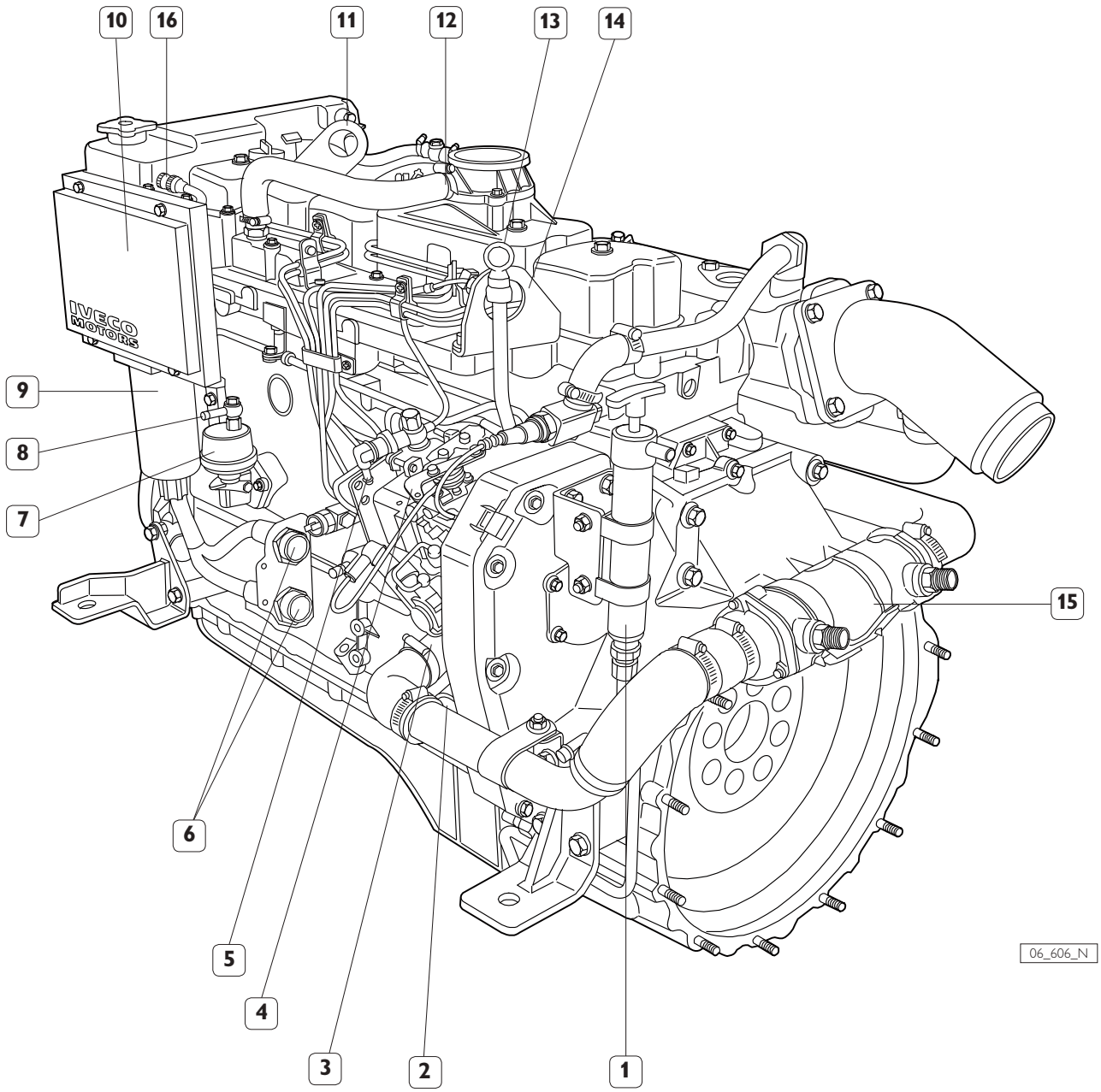
ENGINE PARTS AND COMPONENTS

Figure 3



1. Tube bundle engine coolant / sea-water heat exchanger - 2. Engine coolant discharge cap - 3. Electric starter motor - 4. Location of sacrificial anode - 5. Cooled exhaust manifold - 6. Exhaust gas and sea-water discharge pipeline - 7. Lifting eyebolt - 8. Rocker arm covers - 9. Oil refill cap - 10. Location of thermostatic valve - 11. Cap for engine coolant outlet to sanitary water heating system - 12. Coolant refill cap - 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 4



1. Manual lubricating oil extraction pump - 2. Sea-water inlet - 3. Sea-water pump - 4. Throttle lever lever on injection pump - 5. Rubber holder junction for fuel outflow to the tank - 6. Wiring connectors N45 MNA M10.00 and N67 MNA M15.00 - 7. Low pressure mechanical feed pump - 8. Fuel intake fitting - 9. Fuel filter - 10. Combustion air filter - 11. Lifting eyebolt - 12. Oil vapours vent - 13. Oil dipstick - 14. Lifting eyebolt - 15. Sea-water junction pipe from after-cooler to engine coolant/sea-water heat exchanger (Oil gearbox heat exchanger, on request) - 16. Connector for instrument panel connection wire harness N45 MNA M10.01 and N67 MNA M15.01.

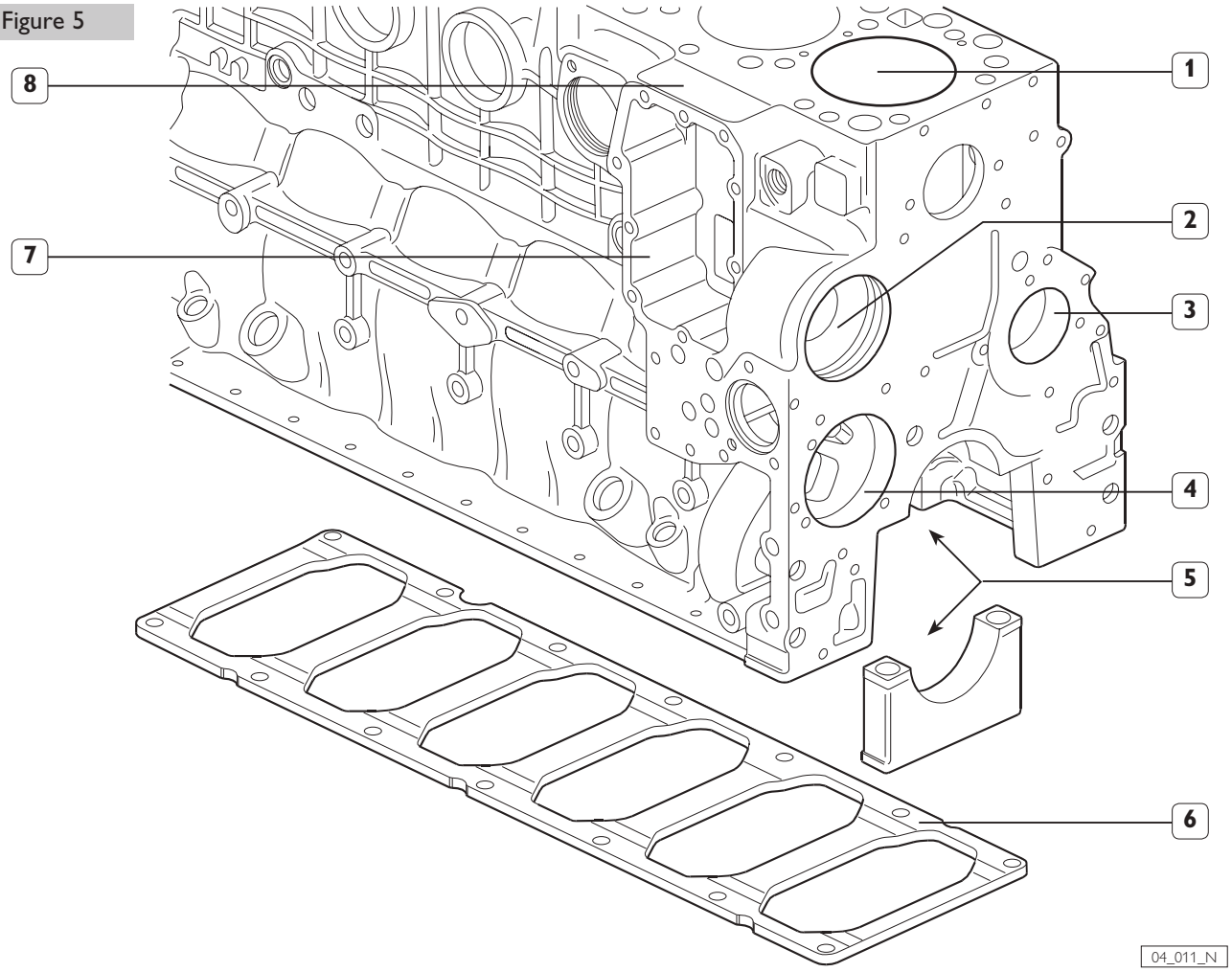
ENGINE ARCHITECTURE

NEF engines are the highest expression of design and engineering efficiency that IVECO MOTORS 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, enable to obtain 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 two 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 5

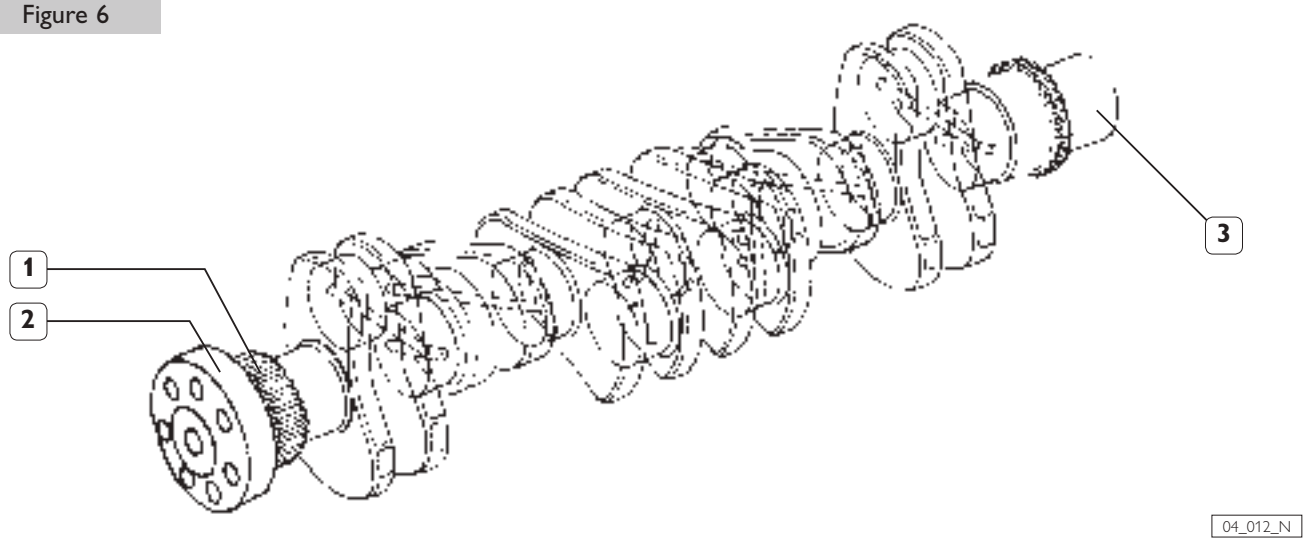


1. Reconditionable integral cylinder barrels - 2. Water pump seat - 3. Camshaft bushing seat - 4. Oil pump seat - 5. Main bearings - 6. Crankcase backing plate - 7. Oil cooler (water/oil) seat - 8. Product model number location.

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 6

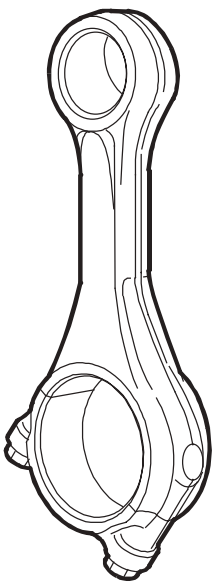


1. Timing system driving gear - 2. Flywheel connecting hub - 3. Oil pump driving gear.

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.
Details 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 disassembled.

Connecting Rods

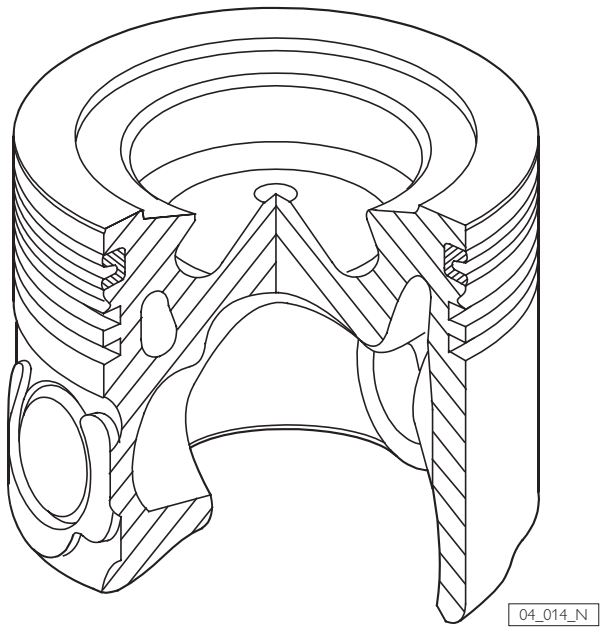
Figure 7



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 8

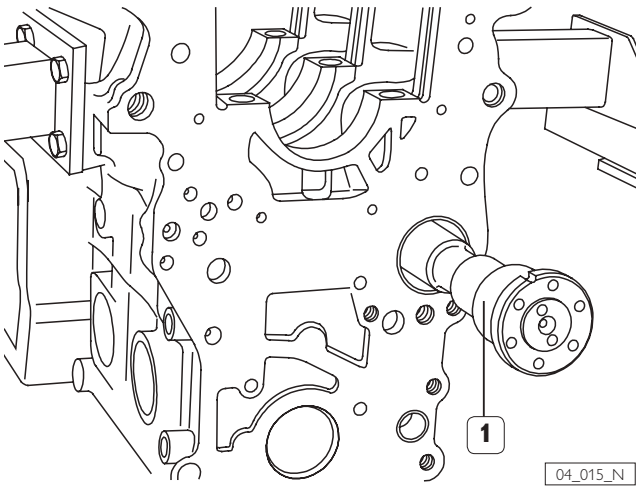


The pistons integrate the high swirl combustion chamber; the annular chambers inside the junk ring enable an effective heat elimination obtained by circulating the lubrication oil delivered by the spray nozzles mounted on the crankcase. On the piston skirt the are three seats for the retaining rings; 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.

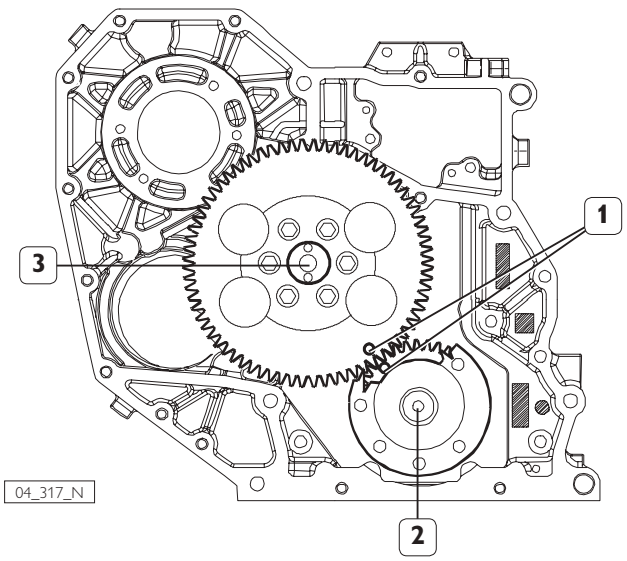
Timing system driving gear

Figure 9



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.

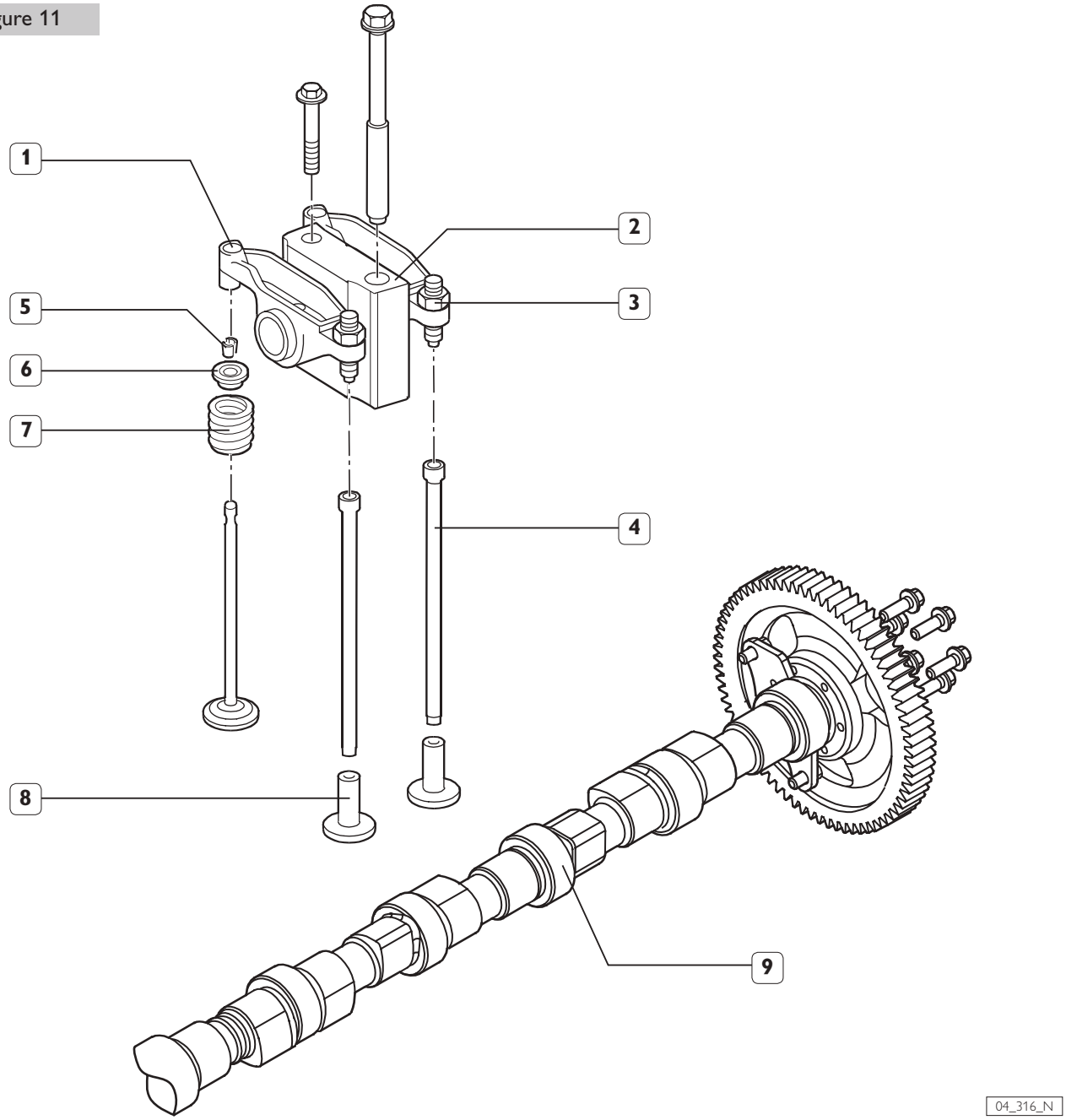
Figure 10



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 11

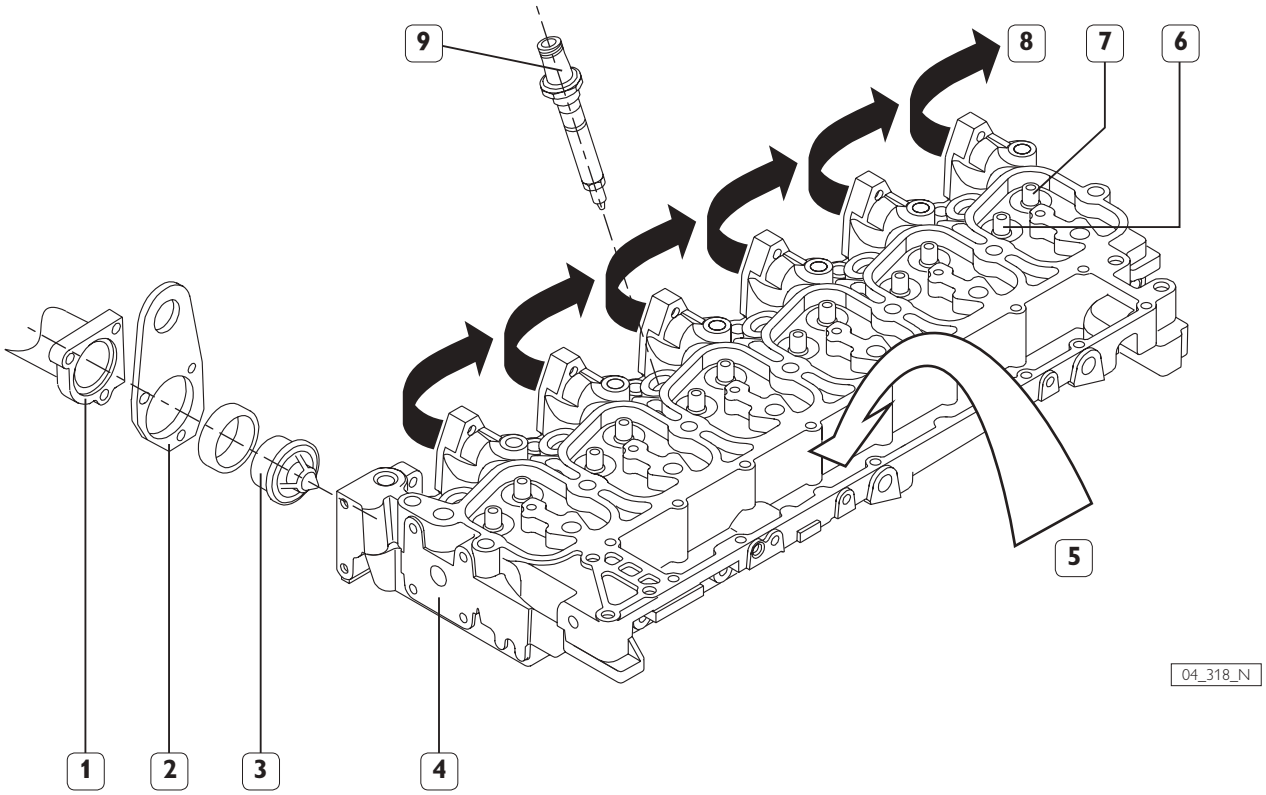


1. Rocker - 2. Rocker support - 3. Adjuster screw - 4. Rod - 5. Cotters - 6. Cup - 7. Spring - 8. Tappet - 9. Camshaft.

The timing camshaft rests on seven mountings; the mounting points at 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.

Cylinder head

Figure 12



1. Engine coolant outlet to sea-water heat exchanger - 2. Lifting eyebolt - 3. Thermostat valve - 4. Cylinder head - 5. Combustion air inlet - 6. Exhaust valve - 7. Induction valve - 8. Exhaust gas outlet - 9. Injector.

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

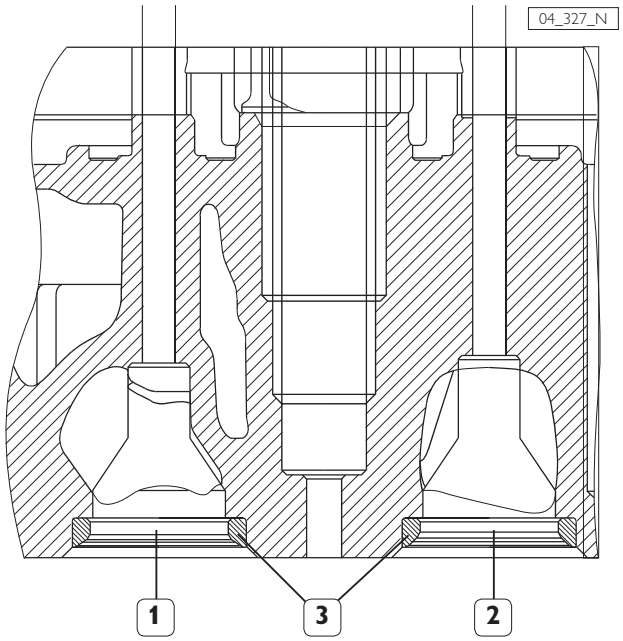
- Valves, with seats and elements inserted;
- Thermostatic valve;
- Injectors.

To the cylinder head are coupled:

- Exhaust manifold;
- Induction manifold.

Valves and valve seats

Figure 13

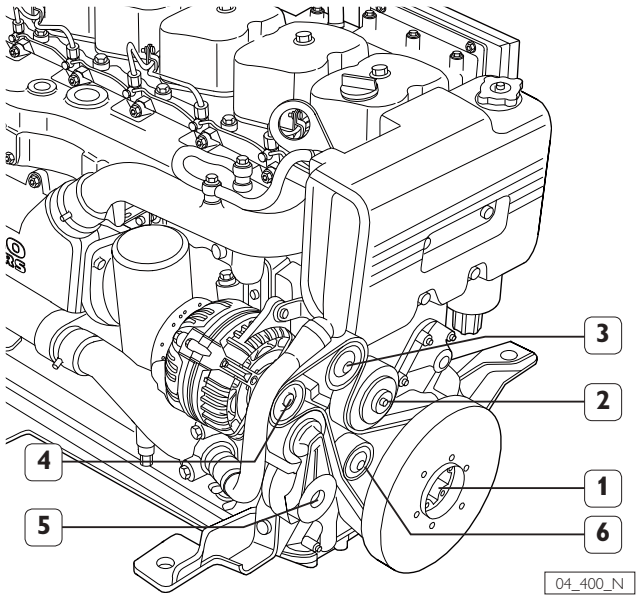


1. Induction valve - 2. Exhaust valve - 3. Inserted elements.

Valves seat, obtained in the cylinder head, have elements inserted with 45° taper ratio for the exhaust valve and 60° taper ratio for the induction valves.

Ancillary machine parts drive

Figure 14

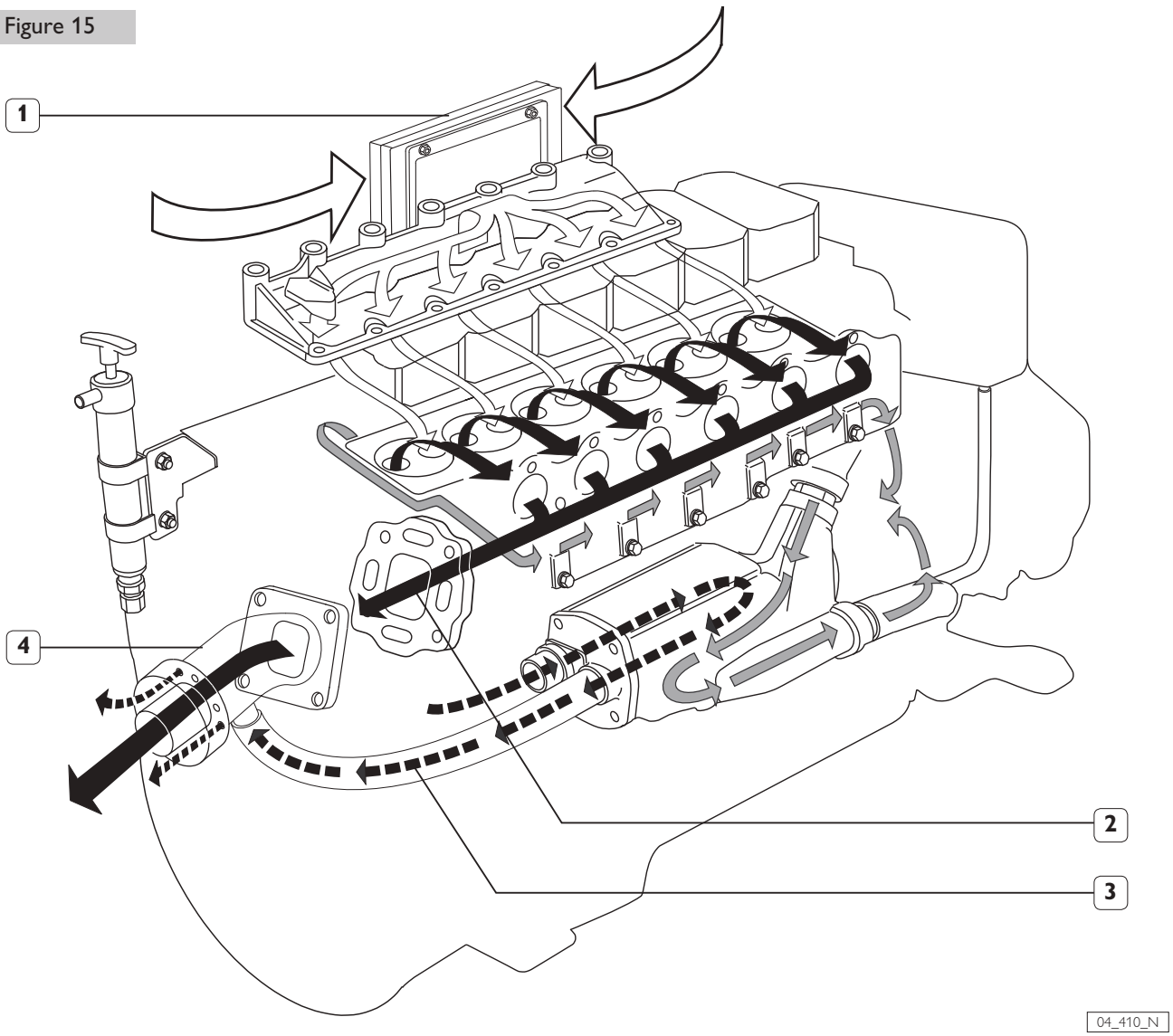


1. Crankshaft - 2. Engine coolant pump pulley - 3. Stationary guide pulley - 4. Alternator pulley - 5. Tightener spring - 6. Stationary guide pulley.

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 15



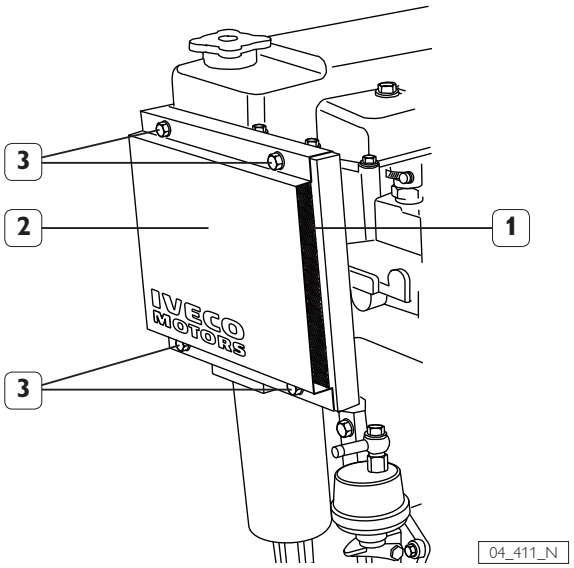
Engine coolant Air inlet Exhaust gas Sea-water

1. Air filter - 2. Exit of the exhaust from the induction - 3. Pipe for exit of sea water from the heat exchanger with motor refrigerating liquid - 4. Exhaust terminal (riser).

The supply air, which is drawn in through the filter, arrives at the cylinders through the induction.
The exhaust gas flows into the exhaust terminal and, where applicable (riser), mixed with sea-water to be expelled.

Comburent air filter

Figure 16

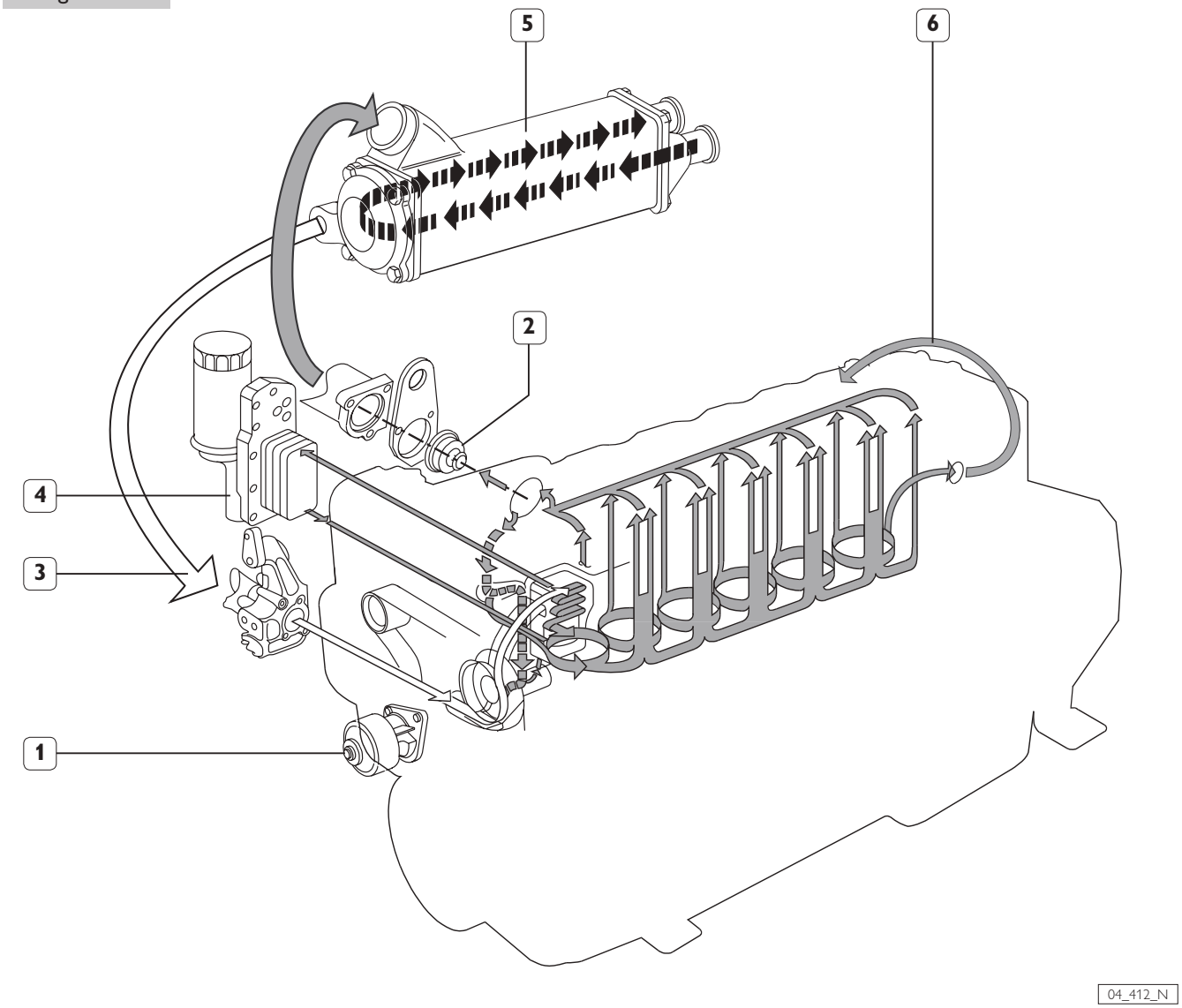


1. Filtering element - 2. Cover - 3. Nuts.

The air is sucked in by the motor through the filter (I) which is made of a synthetic material (Bulpren). To clean it, it is necessary to unscrew the nuts (3), remove the cover (2), remove from its location the filtering element and clean it with compressed air.

COOLING FRESH WATER CLOSED-LOOP

Figure 19



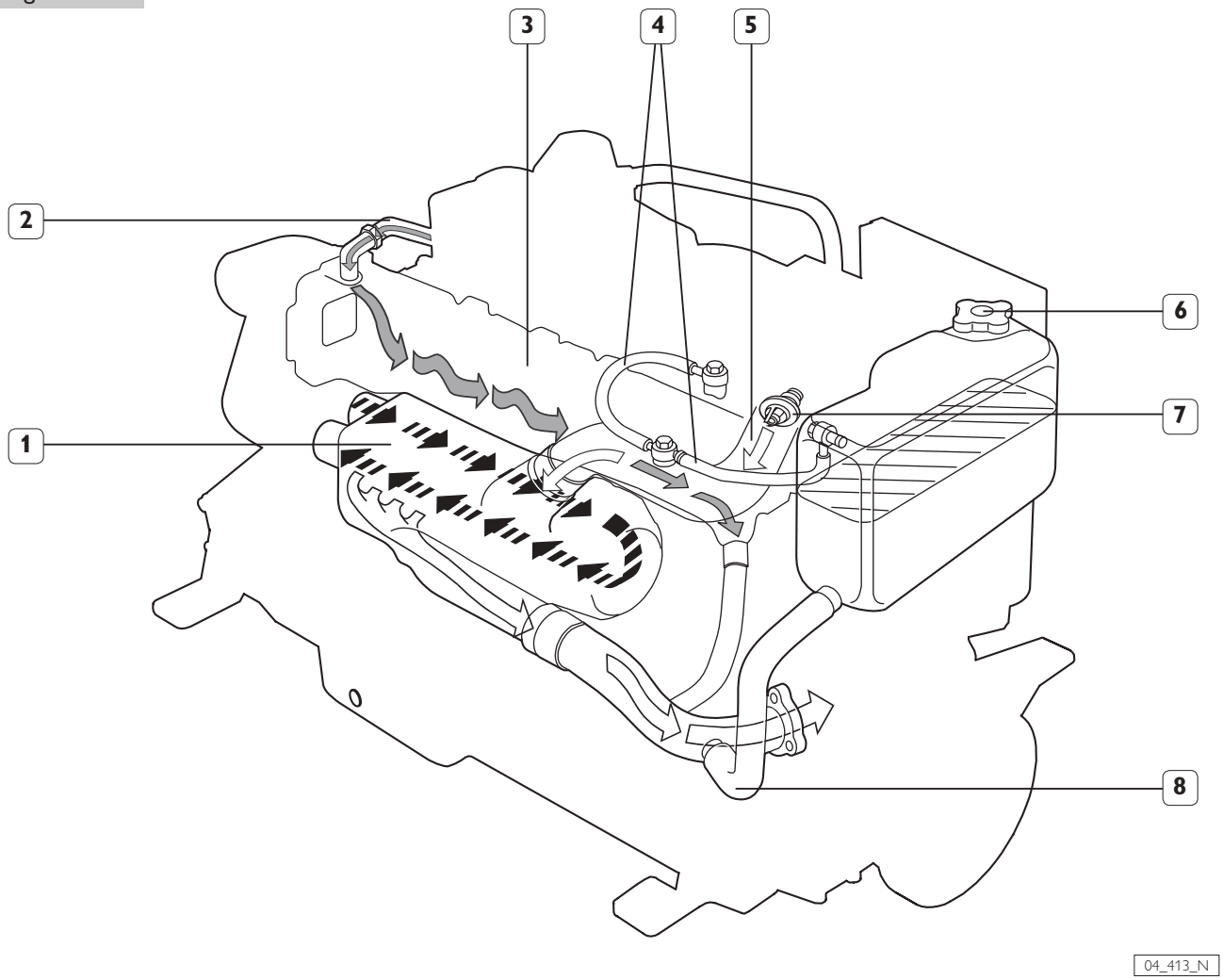
Hot engine coolant
Cold engine coolant
Sea-water

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 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 20

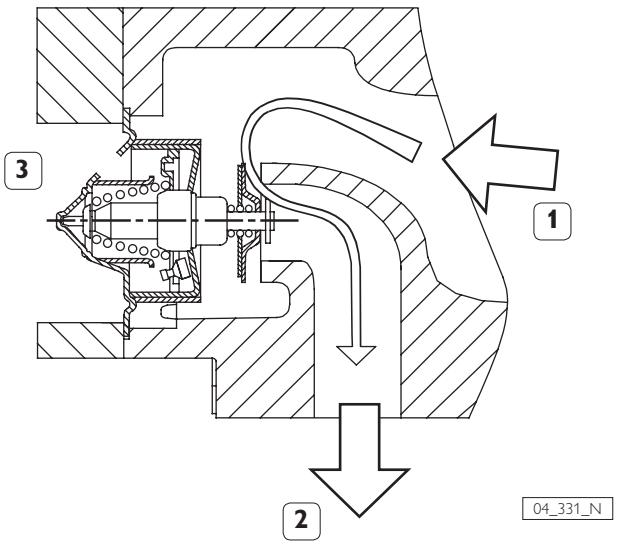


Engine coolant going through exhaust manifold
Hot engine coolant going through coolant exchanger
Sea-water

1. Sea-water/coolant exchanger - 2. Pipe for the entrance of the refrigerating liquid into the exhaust induction - 3. Exhaust manifold - 4. Degassing piping - 5. Thermostatic valve water / water exchanger connector - 6. Plug with pressure valve - 7. Thermostatic valve - 8. Water pump manifold inlet.

Thermostatic valve

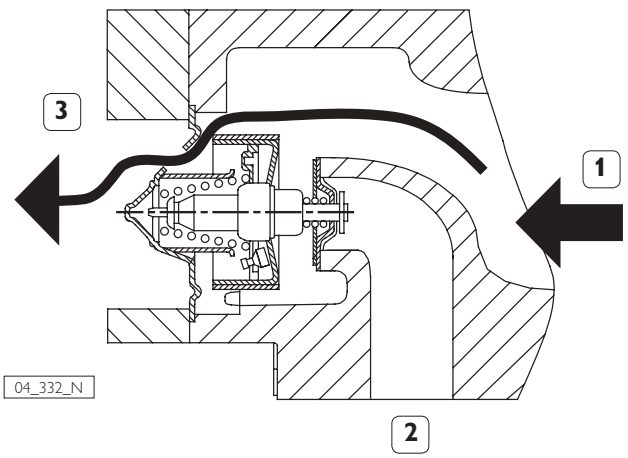
Figure 21



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 22

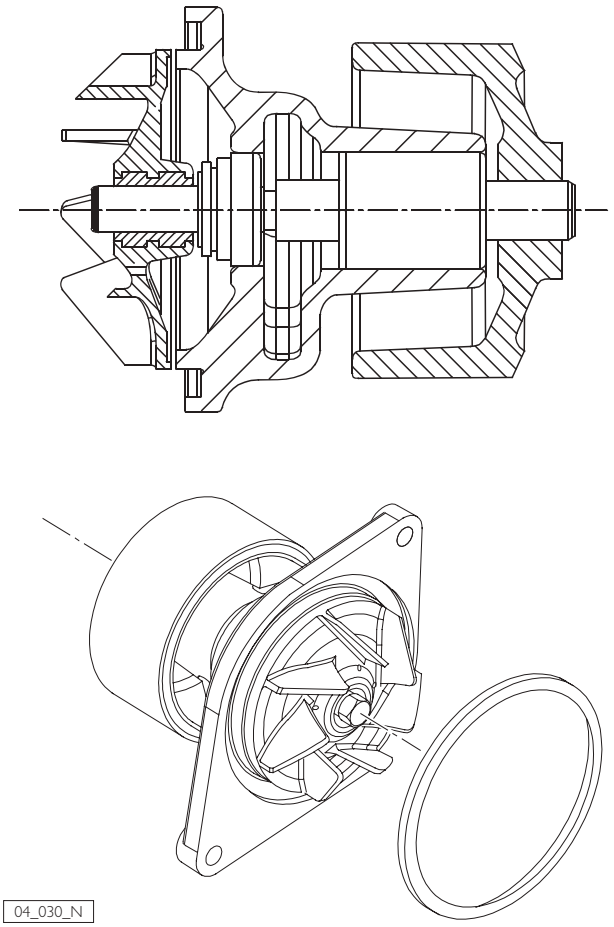


High temperature operation

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 23



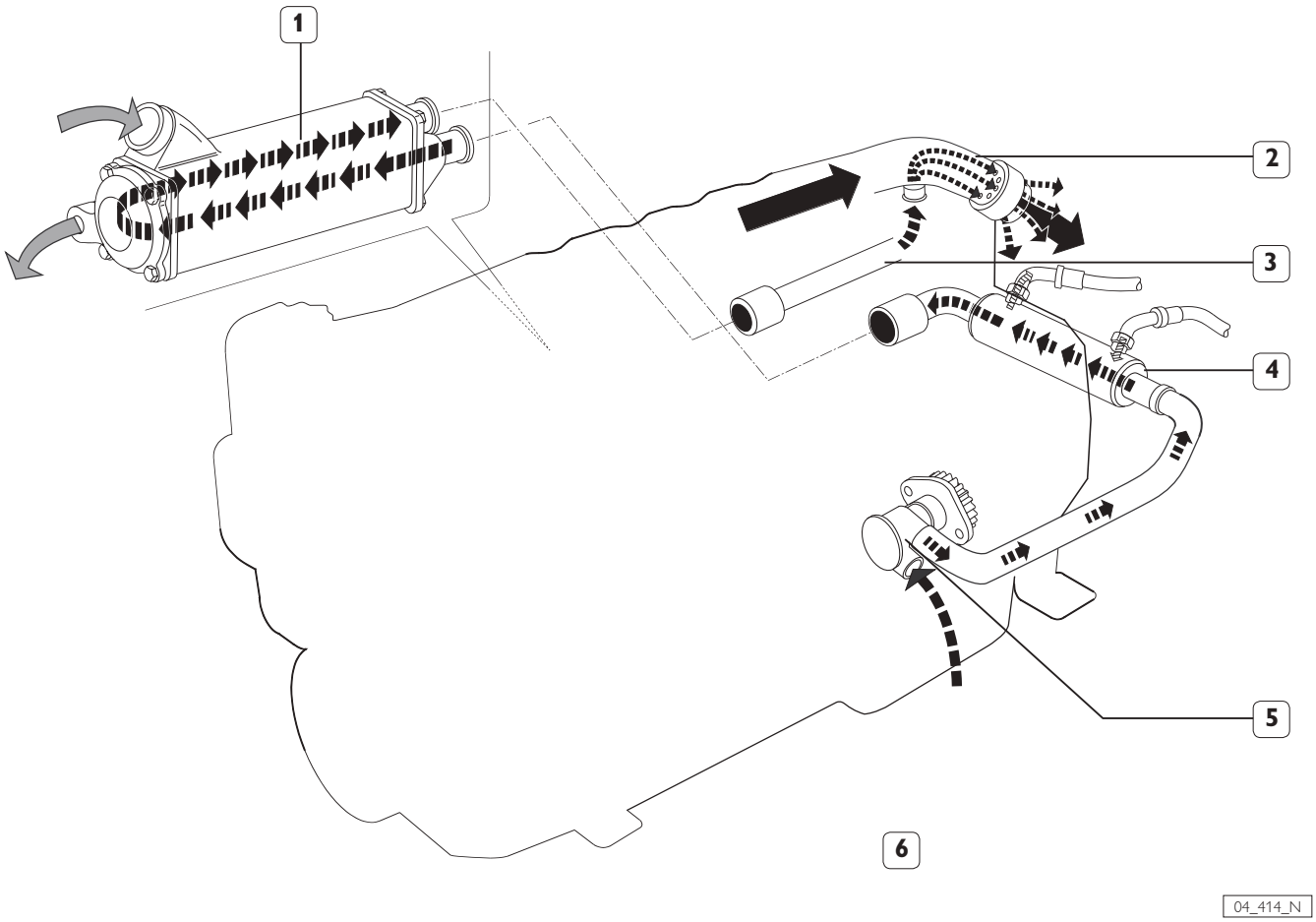
The water pump has its own seat within the crankcase and is set into rotation by the poli-V belt.

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 24



Engine coolant ■■■■ 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 pump - 6. Sea-water inlet.

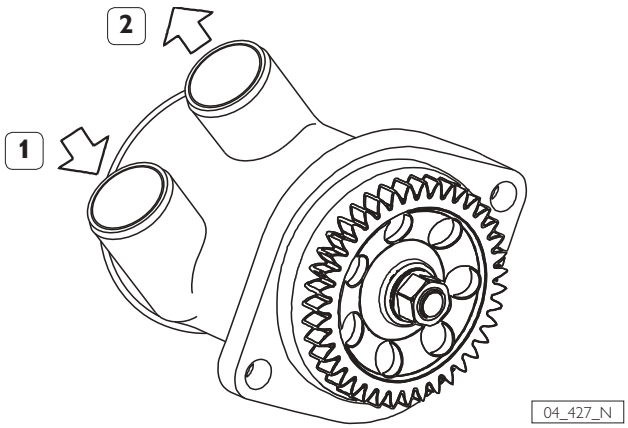
Sea-water drawn from under the bottom of the boat is the means by which the engine heat that has not been transformed into mechanical work is eliminated.

The water is sucked in by the pump which is rotated by the shaft thorough a cogwheel gear, it then goes through the oil inverter heat exchanger – if present – and it reaches the "seawater / fresh water" heat exchanger, where it removes the heat produced by the motor and transmitted by the cooling liquid. The temperature is controlled through a 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 25

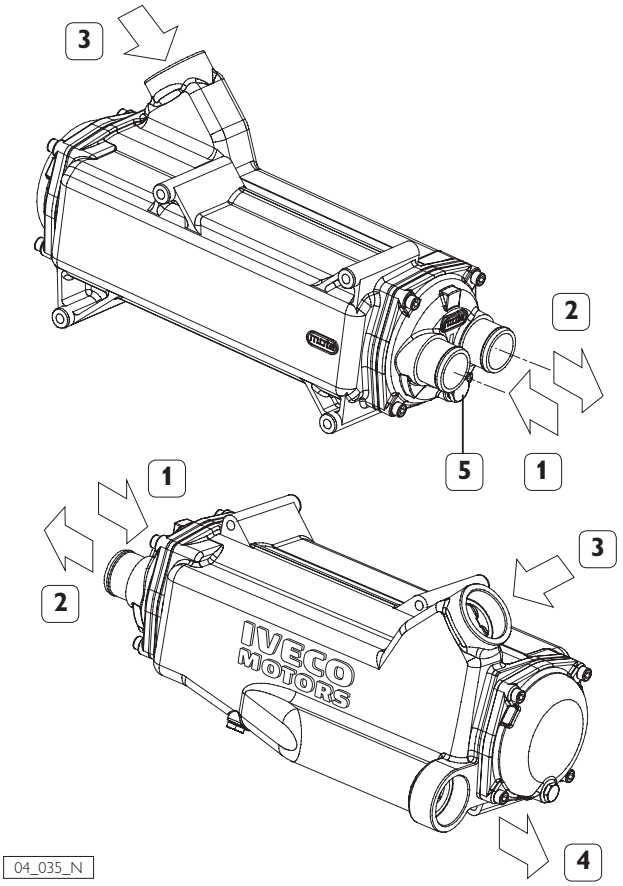


1. Inlet - 2. Outlet..

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

Sea-water / coolant heat exchanger

Figure 26

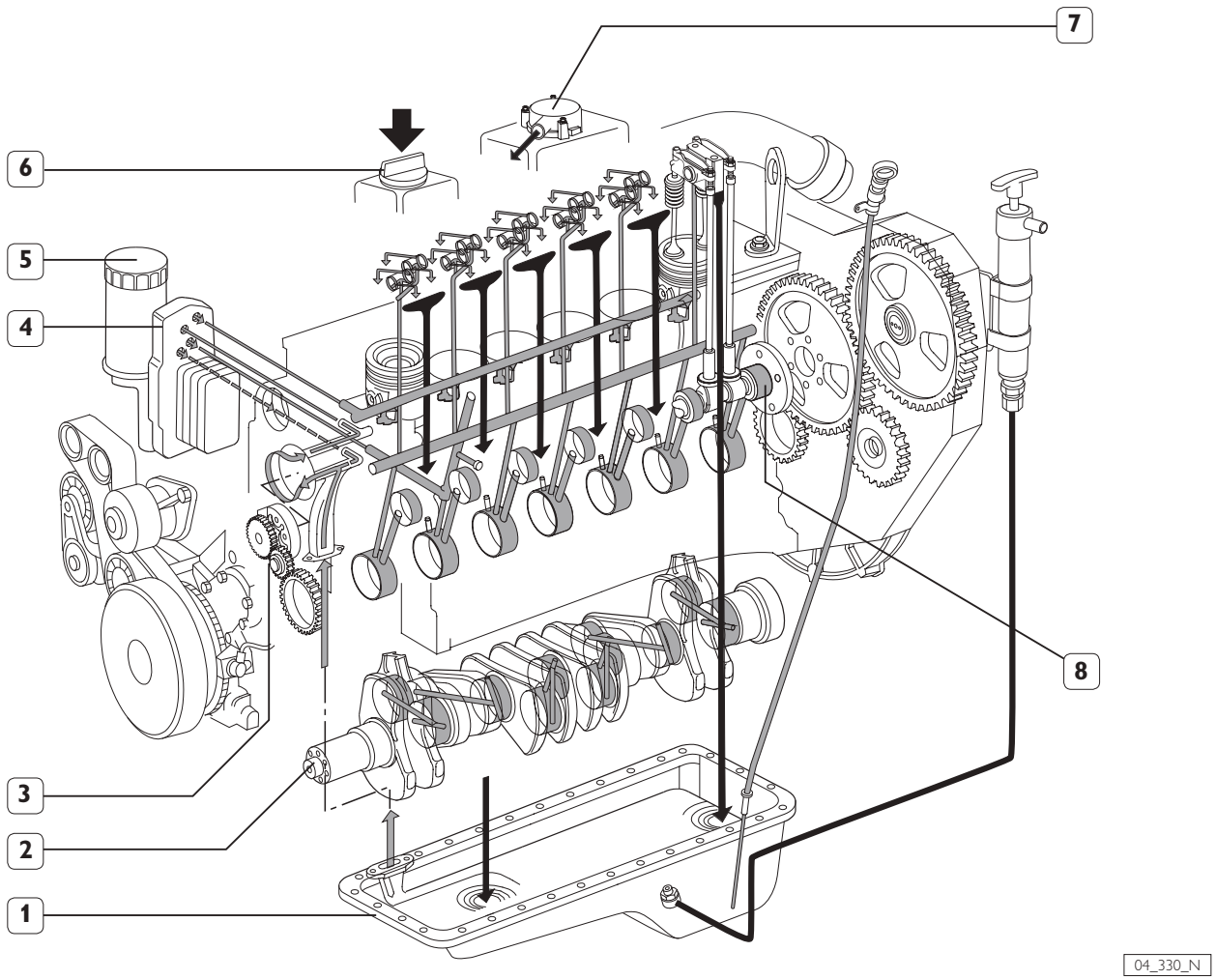


1. Sea-water inlet - 2. Sea-water outlet - 3. Engine coolant inlet - 4. Engine coolant outlet - 5. Sacrificial anode.

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 27



Oil delivery

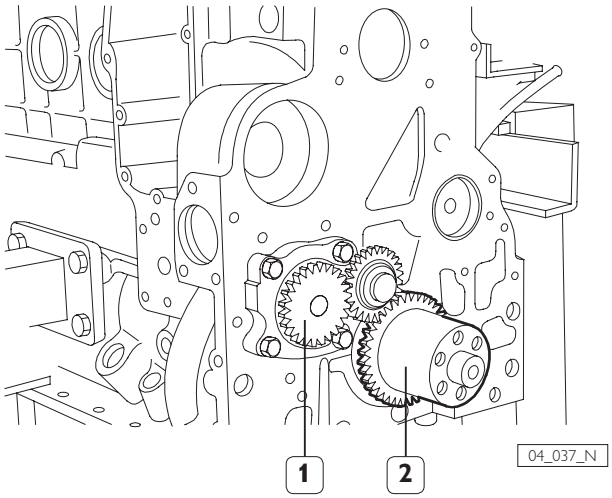
Return to sump

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 vapours vent - 8. 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 fumes exit from the vent and reach the engine intake.

Gear pump

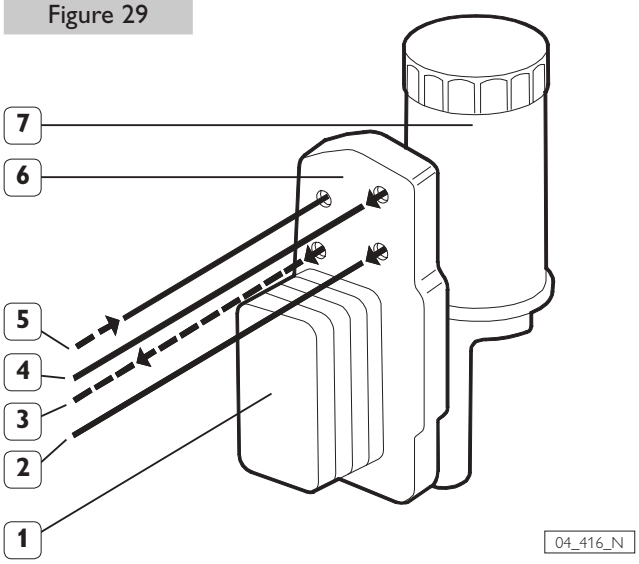
Figure 28



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

Filter bracket

Figure 29

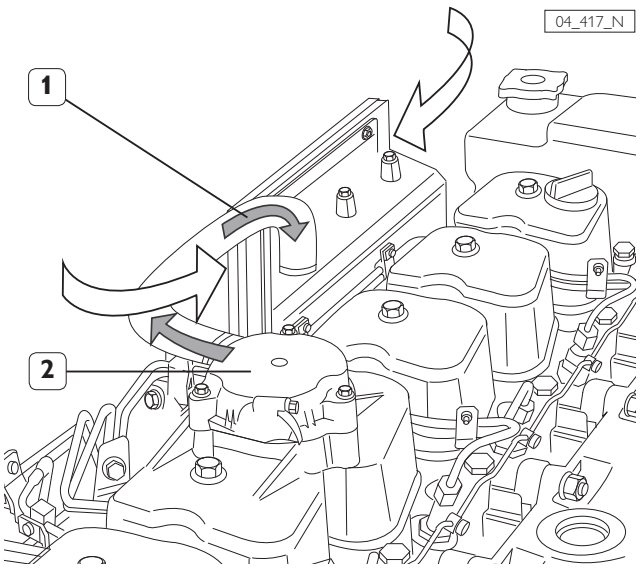


1. Heat exchanger with engine coolant - 2. Oil delivery to internal engine machine parts - 3. Flow recirculated by pressure regulator valve. - 4. Delivery to nozzles piston cooling - 5. Flow inlet from the pump. - 6. Flange coupling onto crankcase - 7. Oil filter.

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 30



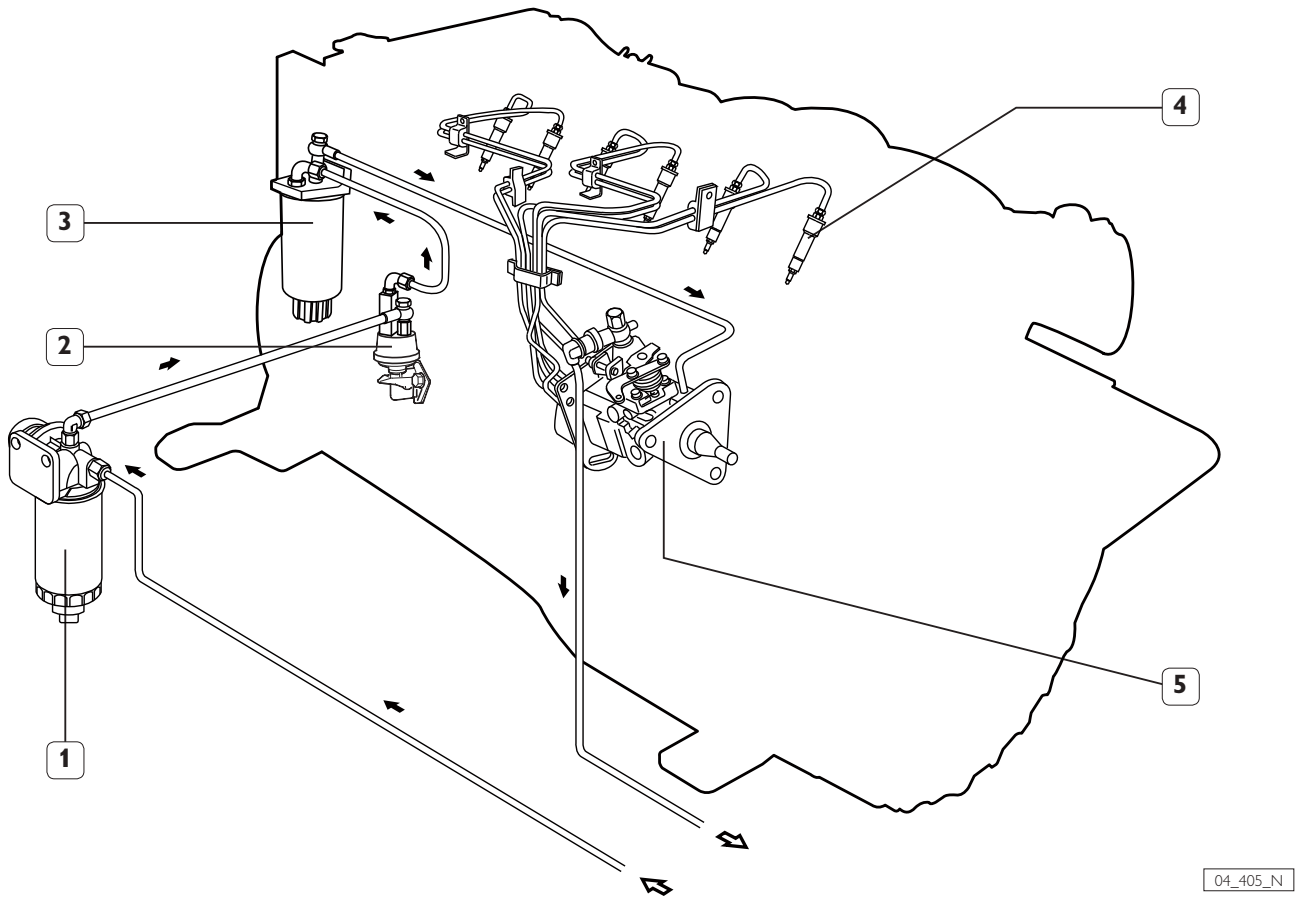
1. Condensate oil to the sump - 2. Flow limiter valve - 3. Residual vapours to engine intake - 4. Oil vapour filter unit - 5. Centrifugal separator.

Oil vapours Inlet air

The oil vapours which generate inside the engine, flow out from the vent located on the 4th and 5th cylinder rocker arm lid, going through the centrifugal gas separator, where some of them condensate and return to the oil sump through the dedicated ducts.
The part which is not condensated is sent to the engine intake by a gauged hole after the air filter.

FUEL LINE

Figure 31

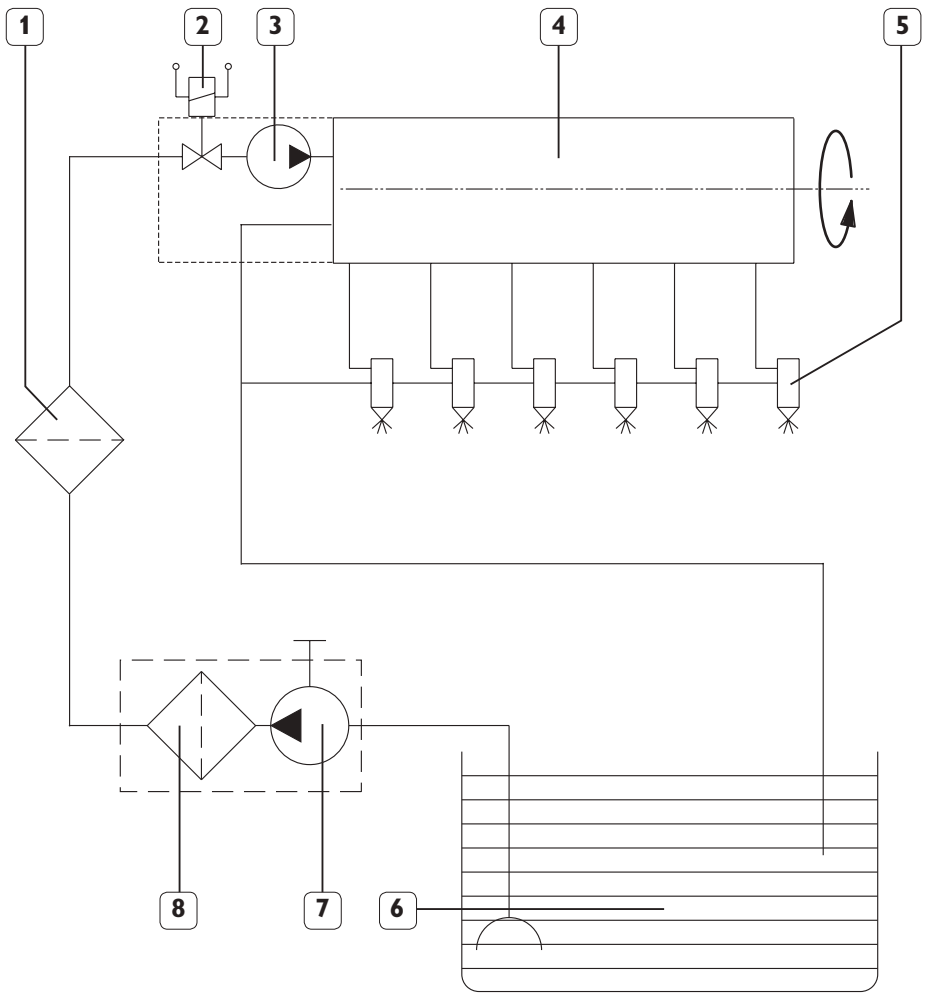


1. Settling prefilter - 2. Low pressure mechanical feed pump - 3. Fuel filter - 4. Injector - 5. Injection pump.

Injection system is made up of mechanical rotary pump. Main components are set on board of the engine except the prefilter.

Fuel supply system scheme

Figure 32



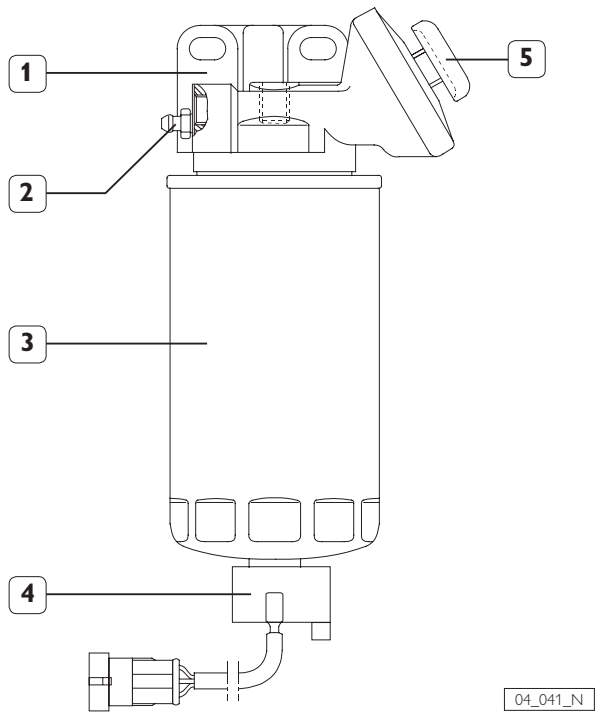
1. Fuel filter - 2. Engine stop solenoid valve - 3. Low pressure mechanical feed pump - 4. Injection pump - 5. Injector - 6. Fuel tank - 7. Manual priming pump - 8. Pre-filter.

During engine rotation, the low pressure pump (3) draws fuel from the tank (6) through the prefilter (8), the main filter (1) and the solenoid valve (2) to supply the injection pump (4).
The injection pump supply injectors (5) with adequate timing and pressure parameters to obtain the performance and, at the same time, complying with anti-pollution regulations.
Fuel not injected by the pump flows with the injectors leakage to recirculate to the tank.
Manual priming pump (7) allows to fill up the fuel system.
The solenoid valve (2) cut off the fuel to the injection pump inlet to obtain the engine stop.

The standard set-up includes a normally open solenoid valve; it requires electric supply to stop the engine (excitation engine stop).
On request, it is possible to insert a normally closed solenoid valve, viceversa requesting electric supply to keep the engine running (non-excitation engine stop).

Fuel pre-filter

Figure 33



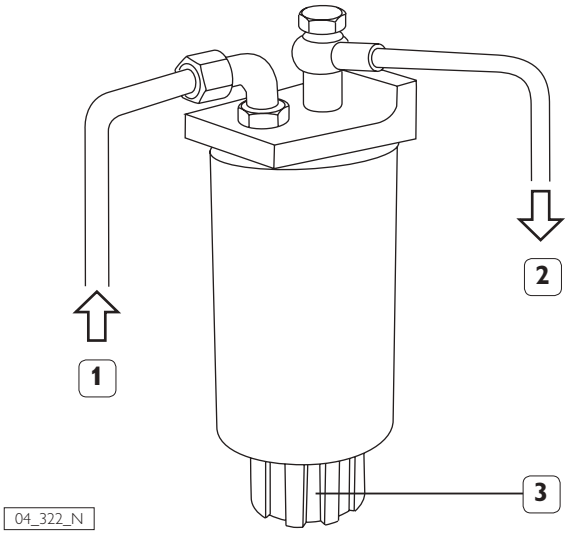
1. Fastener bracket - 2. System bleeding screw - 3. Cartridge - 4. Sensor for detecting the presence of water in the fuel - 5. Manual priming pump.

In the fuel circuit, it is placed before the fuel filter to protect it. Holds impurity larger than 300 µm and assures an high separation from water which may be present in fuel.
On request can be equipped with the sensor for detecting the presence of water in fuel (4).

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

Fuel filter

Figure 34



1. Inlet pipe from prefilter - 2. Injection pump supply pipe - 3. Screw cap to drain water.

In the lower part there is a screw cap (3) to drain the water which may be present in fuel.

SECTION 2

TECHNICAL DATA

GENERAL SPECIFICATIONS

		N45 MNA M10	N67 MNA M15
Cycle		4 Stroke Diesel	
Air supply		naturally aspirated	
Injection		direct	
Number of cylinders		4 in line	6 in line
Bore	mm	104	
Stroke	mm	132	
Total displacement	cm^3	4485	6725
Compression ratio		17,5 ± 0,8 : 1	
Direction of rotation, brake side	rpm	counterclockwise	
Minimum idling rpm	rpm	650 ± 25	
Maximum engine rpm, no load	rpm	3100 ± 25	

Allowed engine inclination angles

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

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)	11,5 (10,5)	16,5 (15)
Total oil capacity with sump at minimum level	liters (kg)	7 (6,3)	8 (7,3)
Total oil capacity with sump at top level	liters (kg)	9 (8,2)	13 (11,8)
Oil pressure, warm engine, minimum idling rpm	bar	≥ 0,7	
Oil pressure, warm engine, maximum rpm	bar	≥ 3,8	
Maximum allowed temperature	°C	120	
Oil dipstick valid for static inclination	degrees/360	0 to +6	

Fuel Supply

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

Injection System

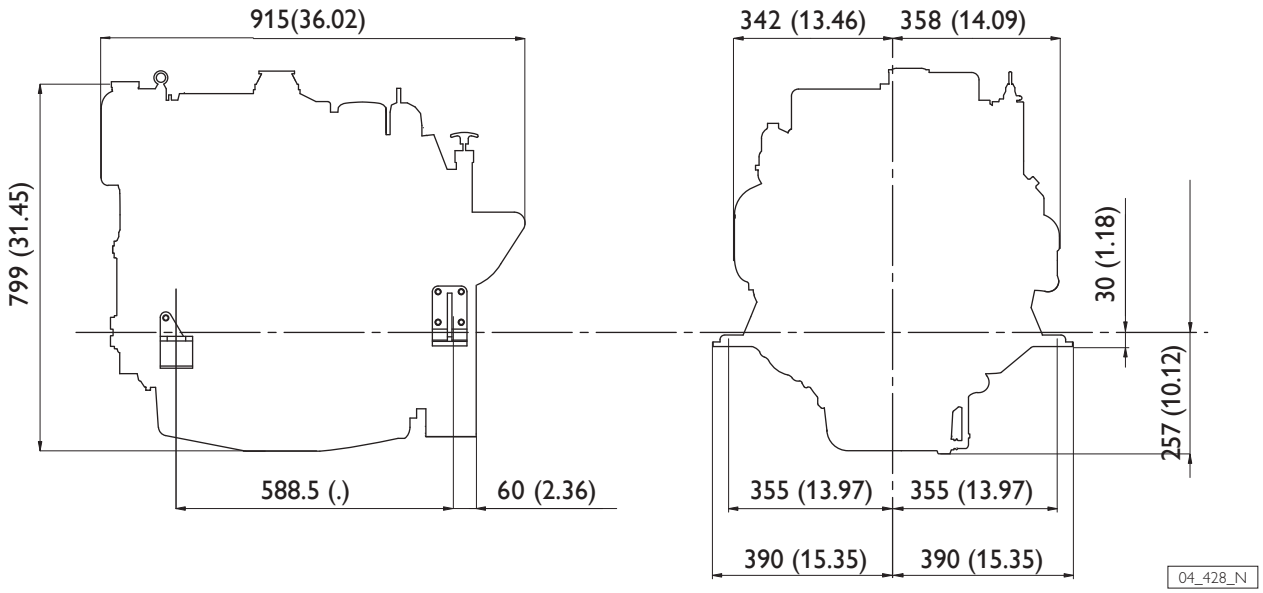
Type		mechanical rotary pump

		N45 MNA M10	N67 MNA M15
Low Temperature Starting			
Allowed, without external aids, down to	°C	-10	
Cooling			
Cooling fresh water closed loop		50% mixture of water/antifreeze Compliant with SAE J 1034 specification	
Total coolant quantity	liters	21	22,5
Expansion tank		standard	
Forced circulation		centrifugal pump	
Flow rate at maximum rpm	liters/h	-	
Temperature regulation		with thermostatic valve	
initial opening	°C	72° ± 2	
maximum opening	°C	82° ± 2	
Sea-water line		forced circulation	
Water pump		self-priming with neoprene impeller	
Sea-water pump height above sea level	m	≤ 2	
Max. pump capacity	liters/h	1200	
Exhaust gas expulsion			
Optional		mixed with sea water	
Electrical system			
Nominal voltage	V dc	12	
Self-regulated alternator:			
Voltage	V dc	14	
Maximum current intensity	A	90	
Electrical starter motor:			
Nominal voltage	V dc	12	
Absorbed electrical power	W	4000	
Recommended battery capacity	Ah	≥ 180	
Current discharge at -18 °C (SAE J 537)	A	≥ 800	
Drive train coupling			
Flywheel diameter	mm (inches)	- (11,5)	
Flywheel case	type	SAE 3	
Weights			
Without liquids and without marine gear	kg	-	605

Dimensions

N45 MNA M10

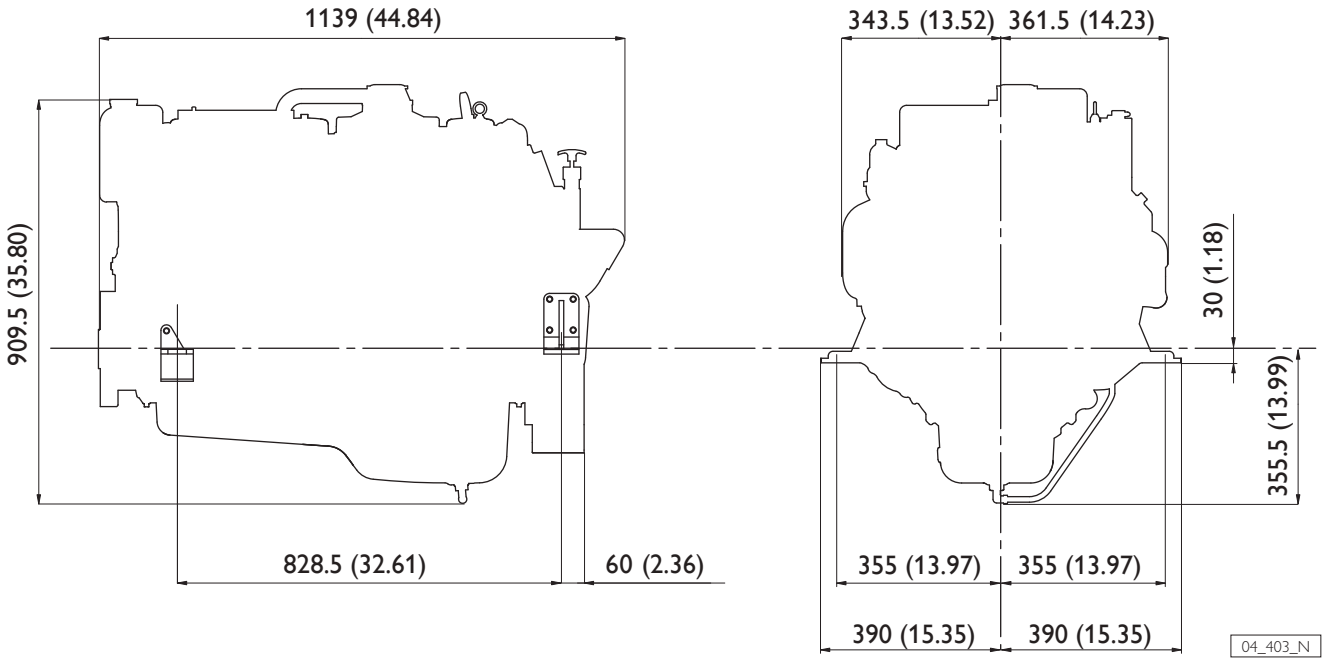
Figure 1



Measurements in: millimeters (inches).

N67 MNA M15

Figure 2



Measurements in: millimeters (inches).

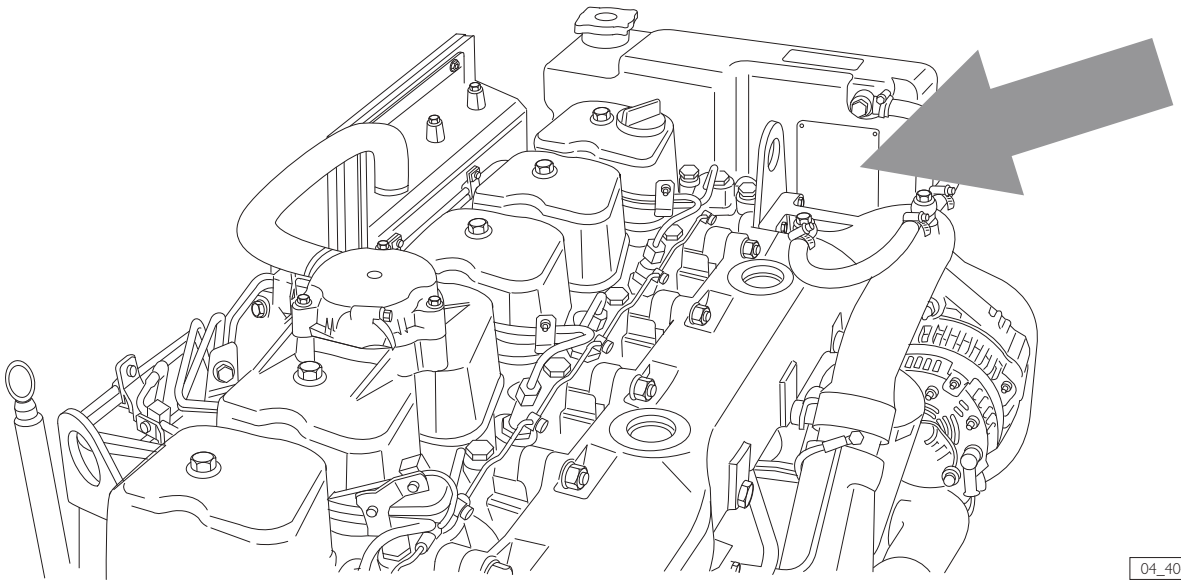
SECTION 3

ELECTRICAL EQUIPMENT

(continues on next page)

FOREWORD

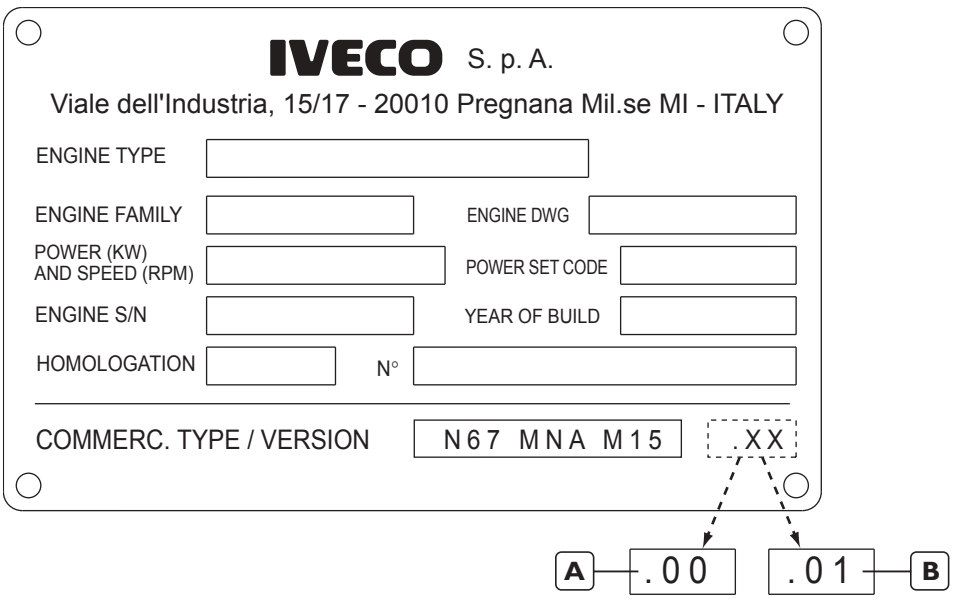
Figure 1



04_404_N

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

Figure 2

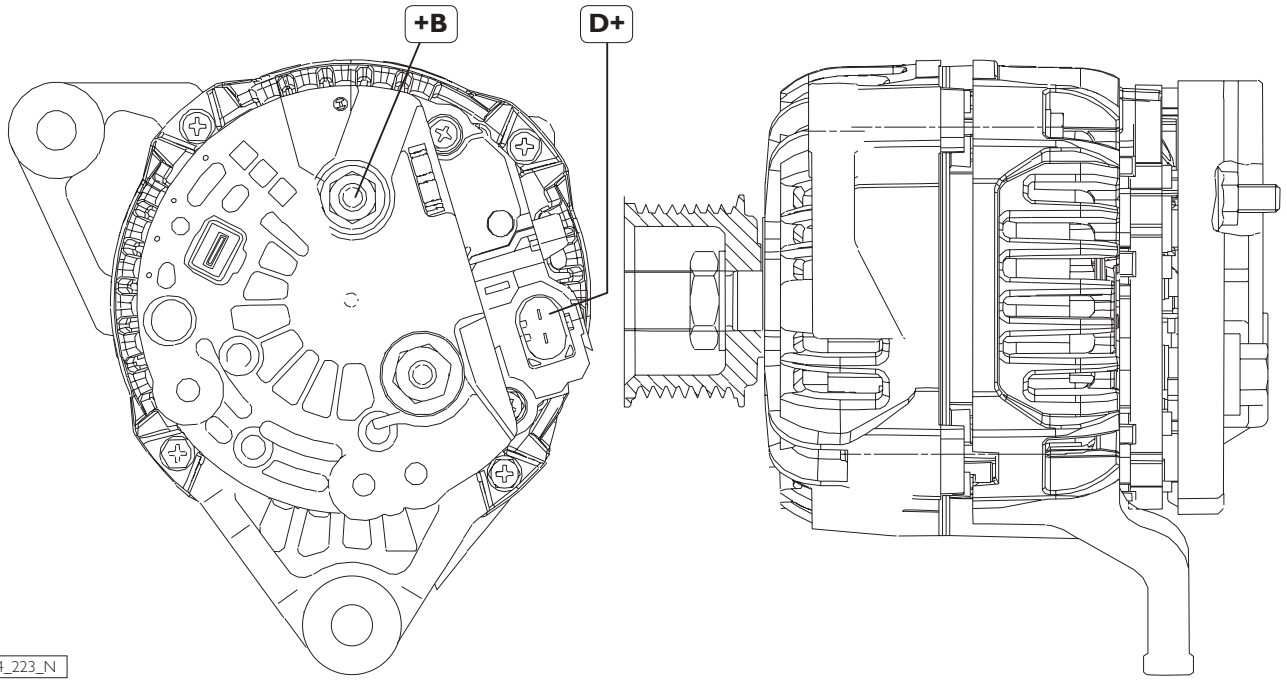


06_016_N

The last two figures of the commercial code refer to the engine model (detail A or B in figure n. 2).
Until the beginning of the year 2006 the engines produced had the code N45 MNA M10.00 or N67 MNA M15.00 (detail A in figure n. 2).
During the year 2006 relevant modifications have been made to the electric system and to the fuel supply circuit and a new model identified with the code N45 MNA M10.01 or N67 MNA M15.01 was created (detail B in figure 2).
This document concerns both the models. The relating contents are developed in different chapters which can be identified thanks to the presence in each title of the extension M10.00/M15.00 or M10.01/M15.01.

ALTERNATOR

Figure 3



"Bosch" Model 14 V - 90 A

+B. (12 V) Power supply output terminal

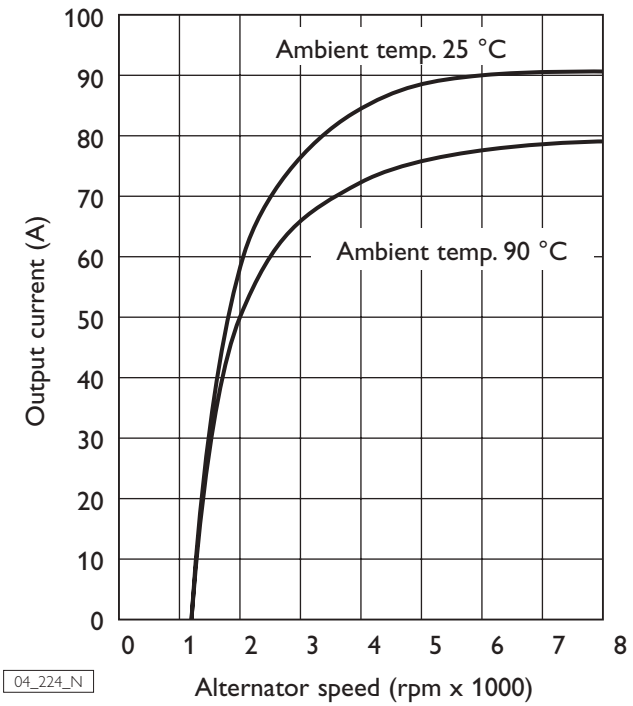
D+. (Lamp) Power supply voltage of recharge/alarm indicator light located on the panel.

Tightening torque for wire terminal nut B+ from 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

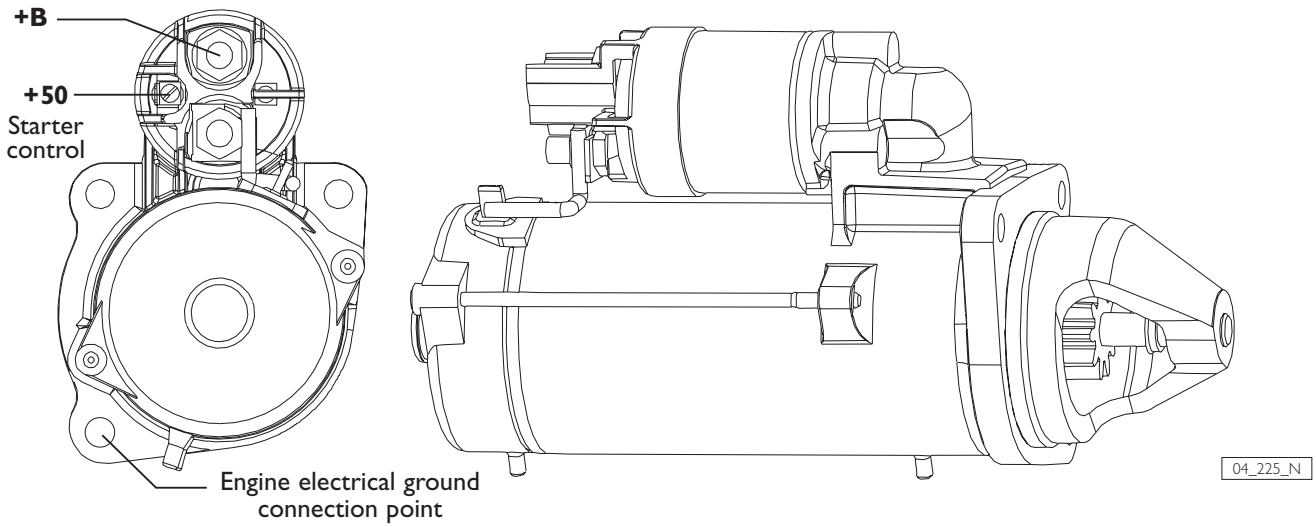
Figure 4



CHARACTERISTIC CURVES

ELECTRICAL STARTER MOTOR

Figure 5

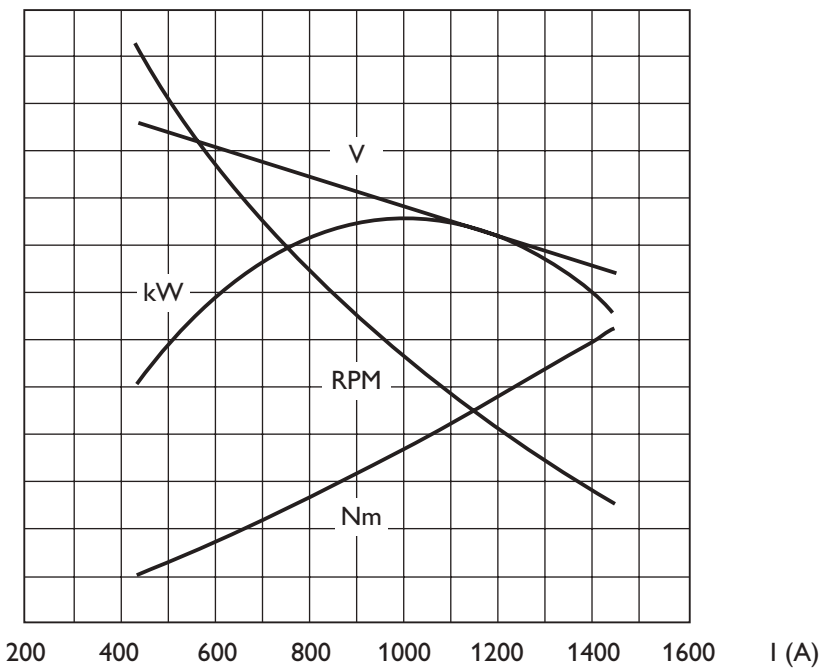


"Bosch" Model - Specifications

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 6

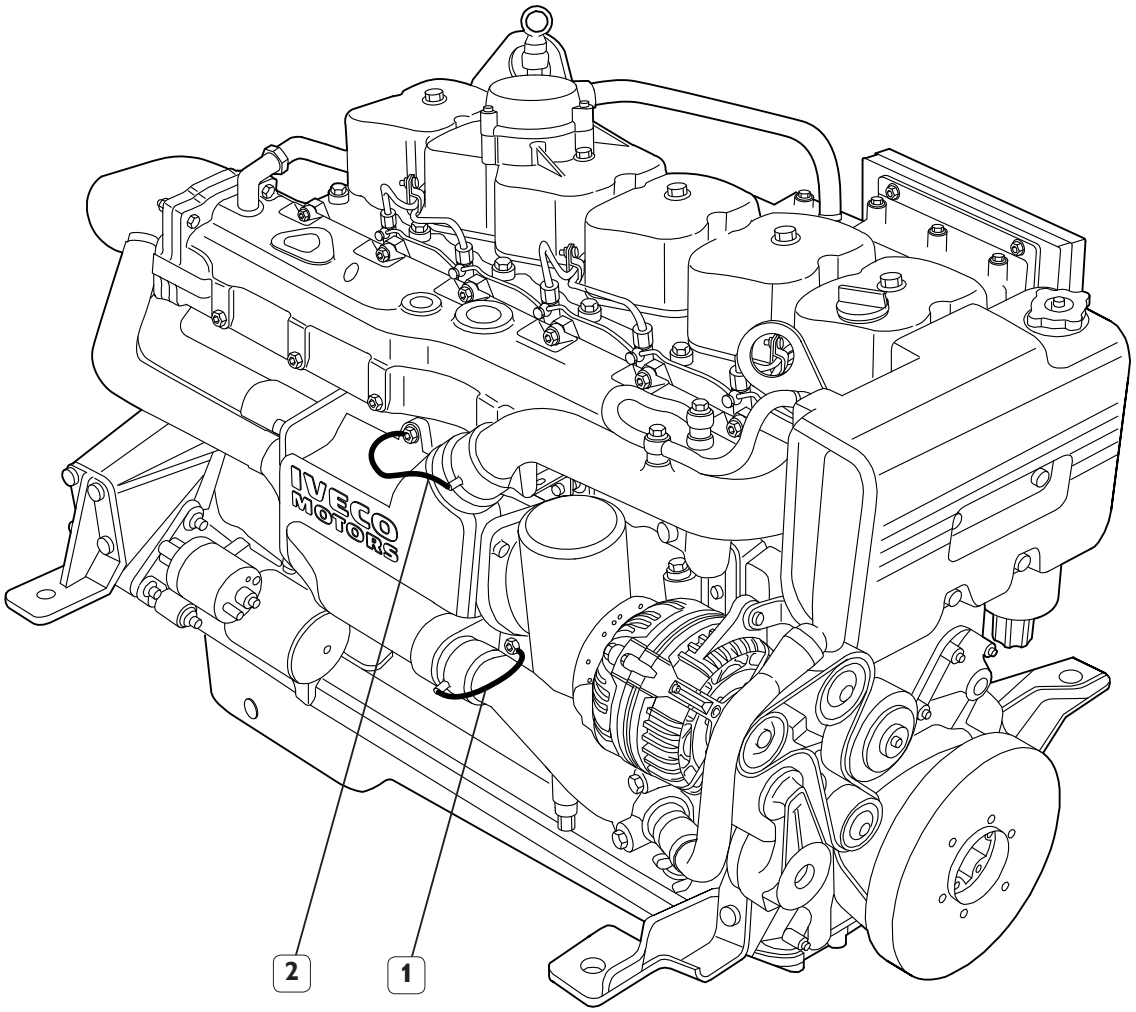
RPM	kW	Nm	V
2600	65	130	13
2400	60	120	12
2200	55	110	11
2000	50	100	10
1800	45	90	9
1600	40	80	8
1400	35	70	7
1200	30	60	6
1000	25	50	5
800	20	40	4
600	15	30	3
400	10	20	2
200	5	10	1
0	0	0	0



CHARACTERISTIC CURVES

EQUIPOTENTIAL CONNECTIONS TO ENGINE GROUND

Figure 7



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.

CAUTION

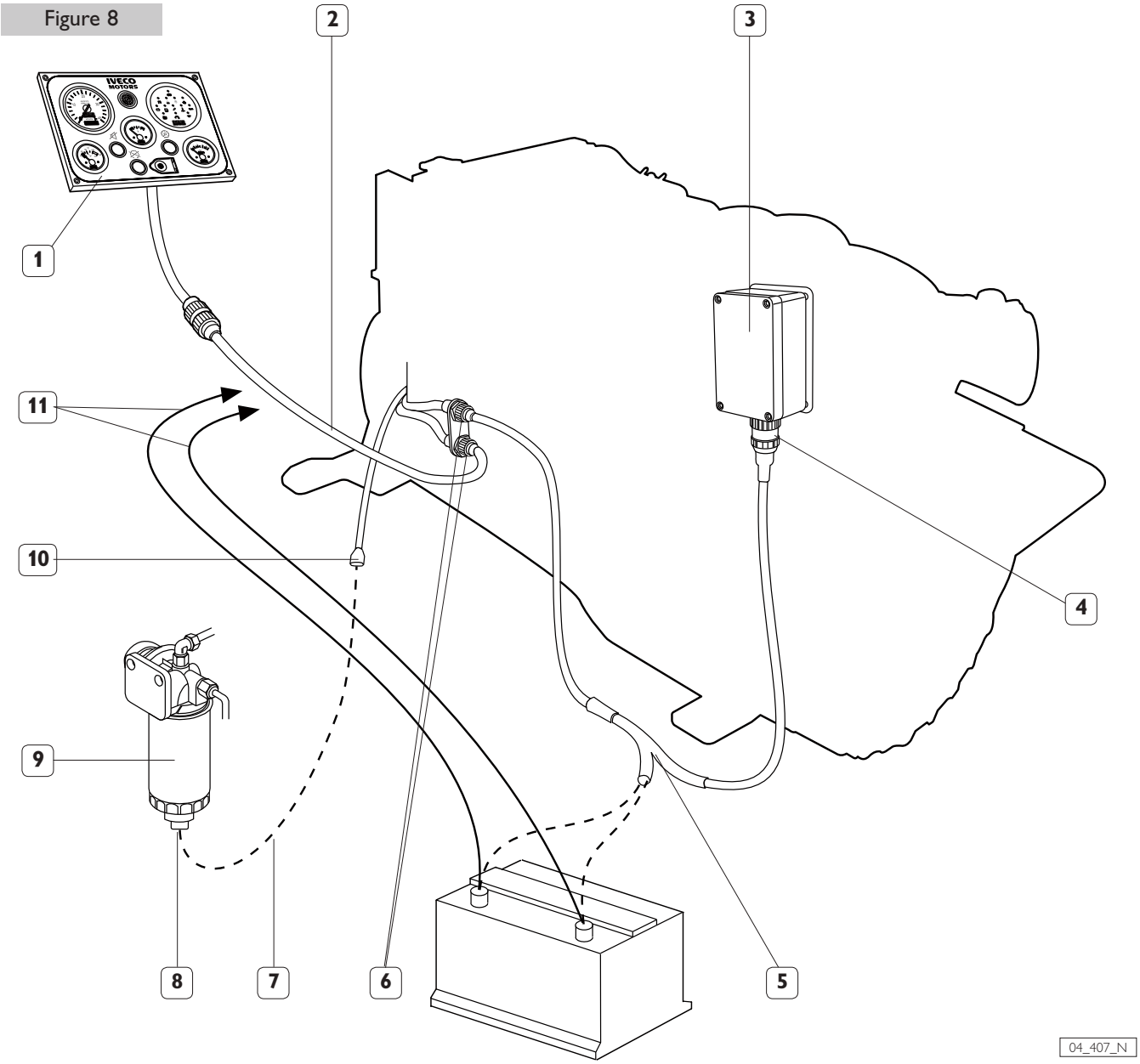
To enhance connection efficiency, the screw threads and the surfaces in contact with the electrical terminals must be clean and not oxidized, so thoroughly inspect and remove any impurities before each reinstallation procedure.

N45 MNA M10.00
N67 MNA M15.00

MODEL PRODUCED UNTIL THE BEGINNING OF THE YEAR 2006

M10.00/M15.00 OVERALL

Figure 8



1. Indicator and control panel - 2. Provided wire harness - 3. Relay box - 4. JF Connection - 5. Power supply and interface wire harness - 6. JA and JB connectors - 7. Wiring harness to be manufactured by the shipyard - 8. Sensor for the presence of water in fuel - 9. Sedimenting pre-filter - 10. M Connector - 11. Power line for electric starter motor and alternator.

The electric equipment of the system carries out the main connections by means of the wiring provided with the engine, to which the power supply, the electronic components assembled on the engine, the electronic central unit of the injection system, relay box and the instrument and control panel are connected.
The entire product 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 "N45 MNA M10 - N67 MNA M15 Installation Directive" document.

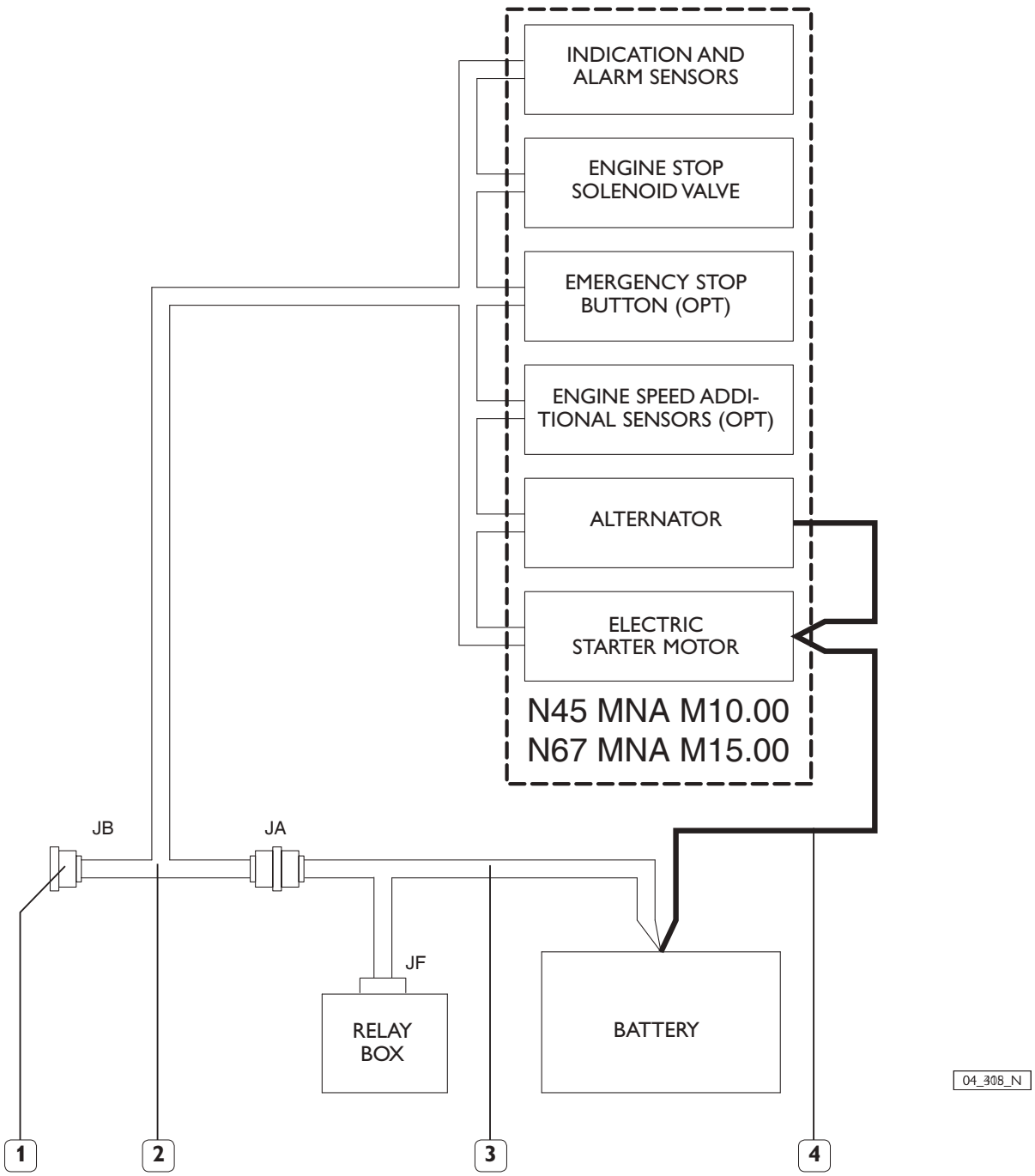
CAUTION

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 "N45 MNA M10 - N67 MNA M15 Installation Directive" document.

M10.00/M15.00 SYNOPTIC

Figure 9

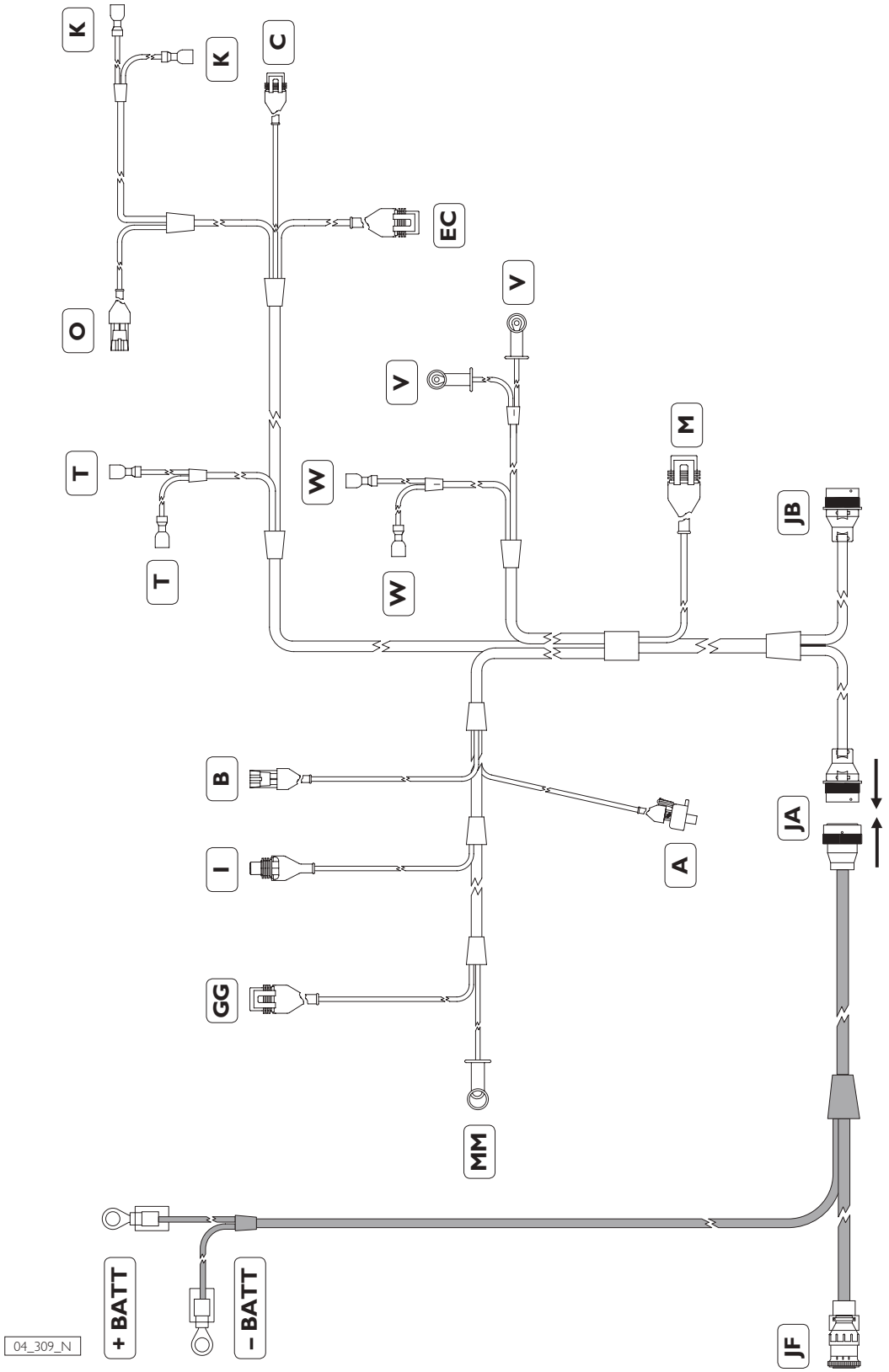


1. Connector for instrument panel connection wire harness - 2. Engine wire harness - 3. Interface wire harness - 4. Power line.

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.

M10.00/M15.00 WIRE HARNESS

Figure 10



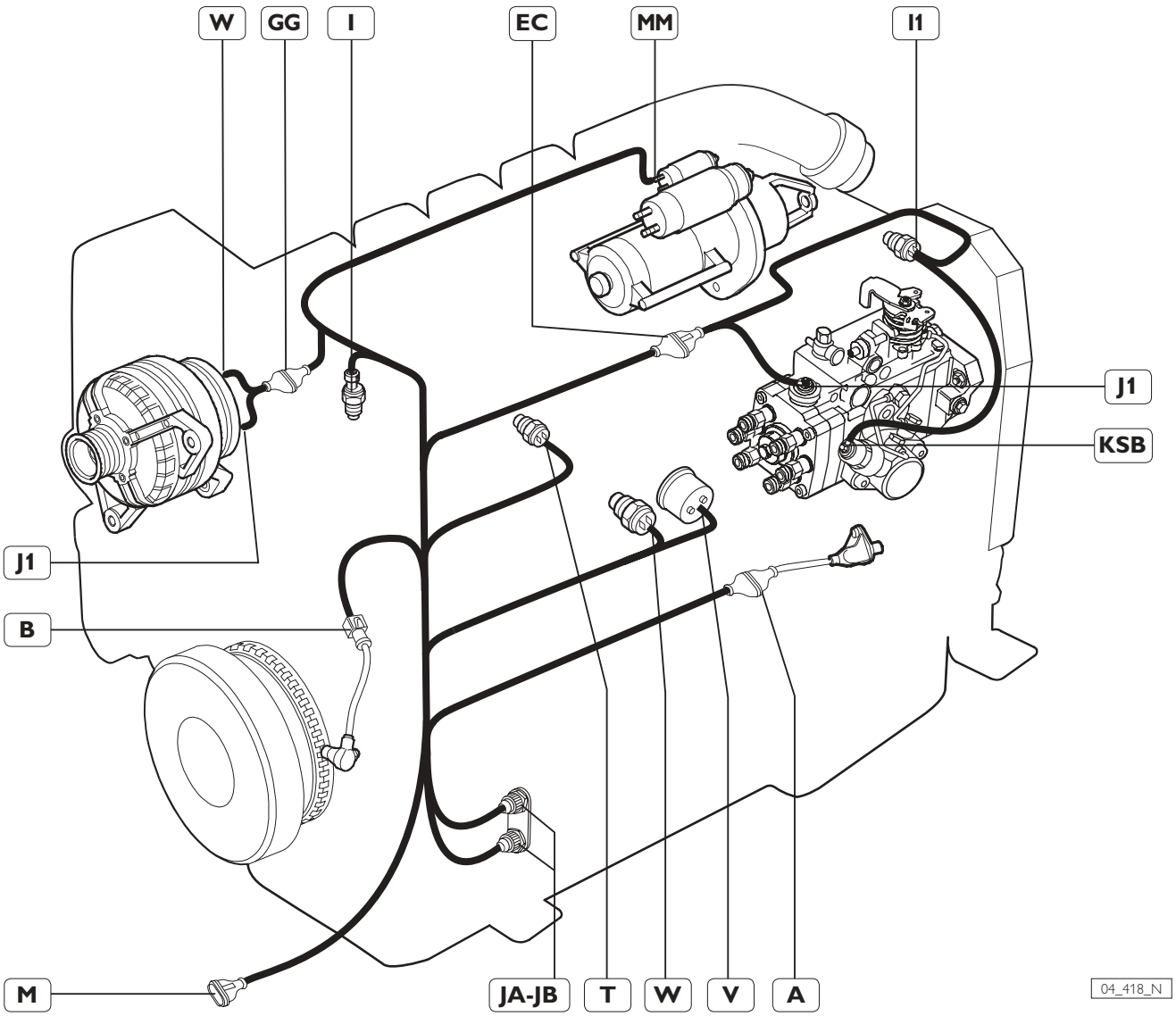
A. Drive shaft sensor (on request) - B. Drive shaft sensor (on request) - C. Emergency shut-down push-button (on request, installer's responsibility) - I. High coolant temperature sensor (for alarm) - K. Air filter clogging sensor (for alarm) - M. Sensor for detecting the presence of water in the fuel pre-filter (for alarm) - O. Exhaust gas temperature sensor (on request) - T. Coolant temperature sensor (for gauge) - V. Oil pressure sensor (for gauge) - W. Low oil pressure sensor (for alarm) - EC. Injection pump connector - I1. KSB Refrigerating liquid temperature sensor - J1. Engine stop solenoid valve - KSB. Cold injection advance adjustment device - GG. Connector for alternator - J1. Alternator excitation - W. Signal for revolution counter - JB. Instrument panel connection wire harness - JF. Relay box - MM. Electric starter motor.

Engine wire harness

Interface wire harness

M10.00/M15.00 LOCATION OF ELECTRICAL COMPONENTS IN THE ENGINE

Figure 11

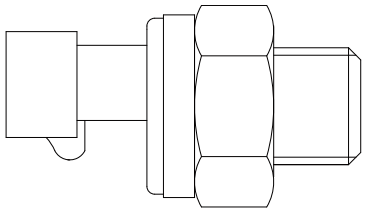


A. Drive shaft sensor (on request) - B. Drive shaft sensor (on request) - I. High coolant temperature sensor (for alarm) - K. Air filter clogging sensor (for alarm) - M. Sensor for detecting the presence of water in the fuel pre-filter (for alarm) - T. Coolant temperature sensor (for gauge) - V. Oil pressure sensor (for gauge) - W. Low oil pressure sensor (for alarm) - EC. Injection pump connector - I1. KSB Refrigerating liquid temperature sensor - J1. Engine stop solenoid valve - KSB. Cold injection advance adjustment device - GG. Connector for alternator - J1. Alternator excitation - W. Signal for revolution counter - JA. Interface connection wire harness - JB. Instrument panel connection wire harness - MM. Electric starter motor.

M10.00/M15.00 ELECTRICAL COMPONENTS

KSB Refrigerating liquid temperature sensor

Figure 12



Thermometrical switch which manages the activation of the cold injection advance adjustment device.

Operating voltage	from 6 V to 24 V
Condition at ambient temperature	normally closed
Closing temperature	≥ 63 ± 3 °C
Opening temperature	≤ 53 ± 3 °C
Maximum current	15A (inductive)
Poles	isolated

KSB solenoid valve

Operating voltage	12 V
Resistance value	7 ± 1,4 Ω

Operating voltage	24 V
Resistance value	28 ± 5,6 Ω

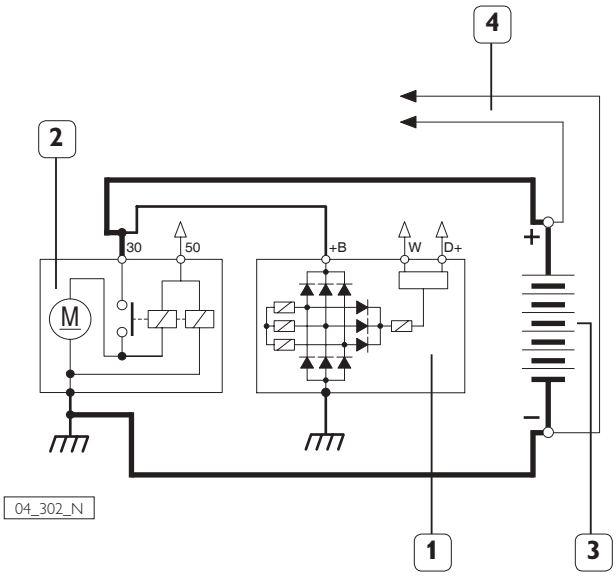
Engine stop solenoid valve

Operating voltage	12 V
Resistance value	5 ± 1 Ω

Operating voltage	24 V
Resistance value	20 ± 4 Ω

M10.00/M15.00 POWER SUPPLY LINE

Figure 13



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.

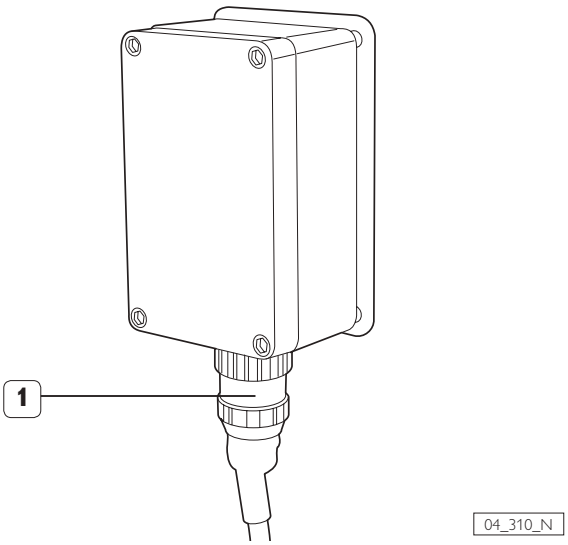
The connection of the electric equipment of the engine to the battery has to be carried out by the two-eyed terminals, +B and -B present on the wiring harness.

CAUTION

In presence of equipments with excitation engine stop, if magneto-thermal protecting breakers or battery-switch are installed on system electrical supply lines, eventual interruption of electrical supply will not allow to stop the engine.

M10.00/M15.00 RELAY BOX

Figure 14

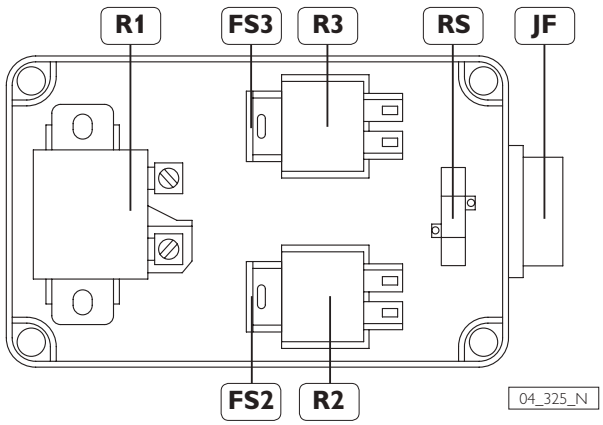


1. JF connection.

It is the main point of interconnection and carries out many interfacing functions among the various components of the system.
Inside the box, are present the power management relays of some components and two fuses that protect the electrical lines against short circuits or excessive current absorption.
Connect it to wiring using the 16 pole JF connector.
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.

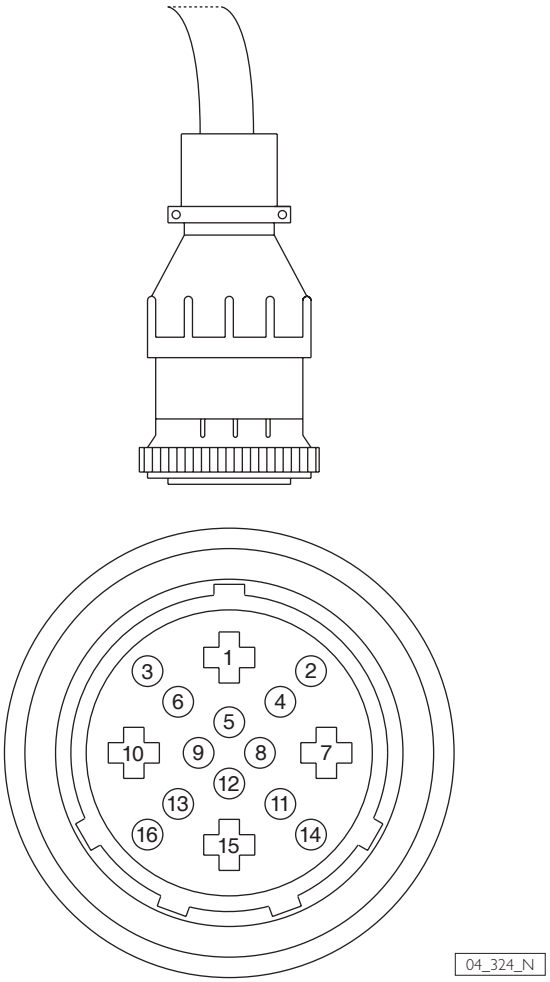
Internal components position

Figure 15



R1. Power supply to terminal 50 of the electric starter motor - R2. Emergency engine shut-down provision - R3.-Key switch electric discharge - FS 2. Fuse on solenoid valve supply line for engine stop - FS 3. Fuse on main supply line - RS. Alternator pre-excitation resistor - JF.-Interface connector wire harness.

Figure 16



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

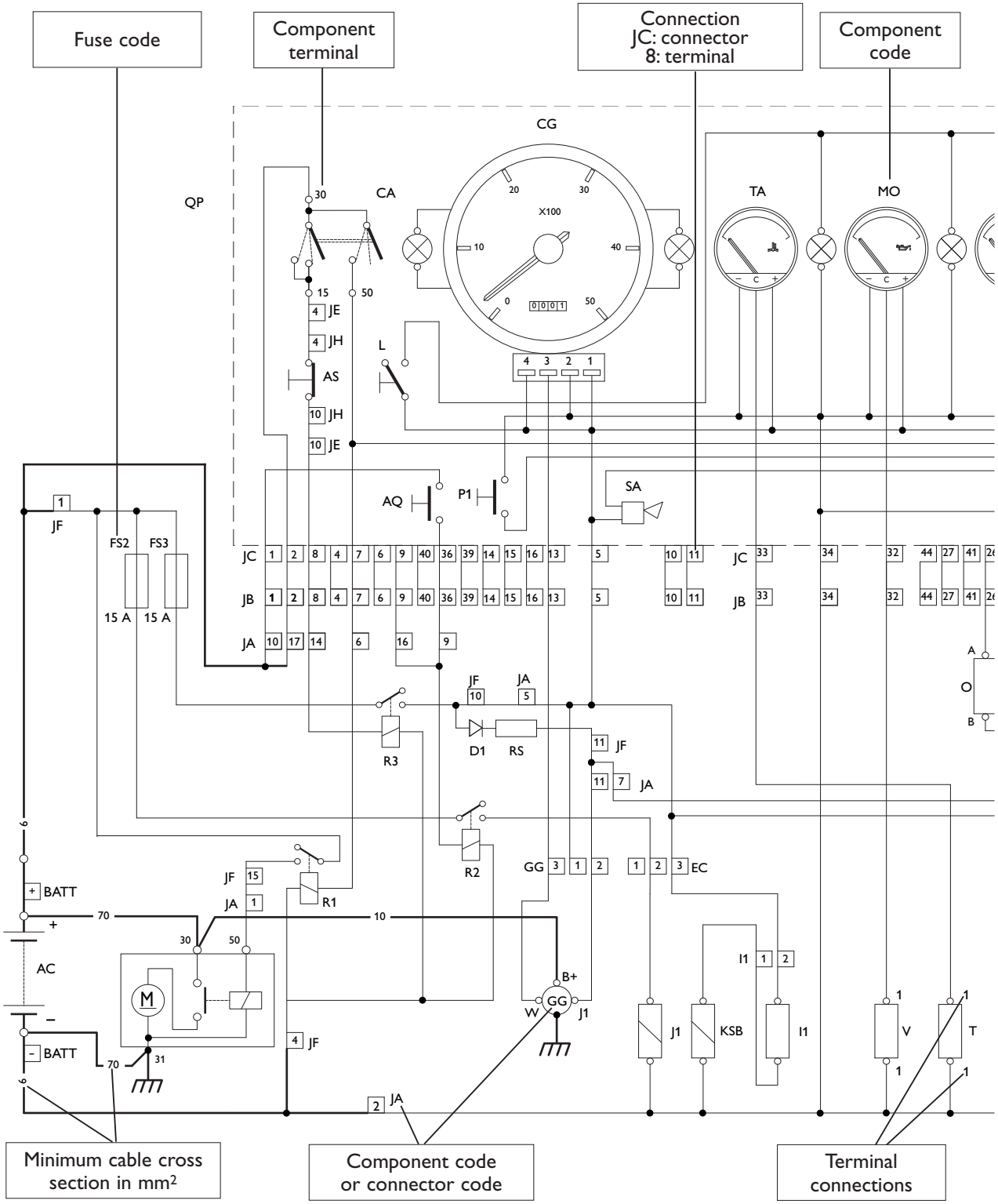
M10.00/M15.00 ELECTRICAL DIAGRAMS

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 17



Electrical equipment component code

A	drive shaft sensor (on request)
AC	battery
AQ	engine shut-off push-button on main panel
AS	engine shut-off push-button on secondary panel
B	drive shaft sensor (on request)
C	emergency shut-down push-button (optional, installer's responsibility)
CA	key switch
CS	engine start push-button on secondary panel
EC	injection pump connector
GG	connector for alternator
I	high coolant temperature sensor (for alarm)
I1	KSB refrigerating liquid temperature sensor
J1	engine stop solenoid valve
J1	alternator excitation
K	air filter clogging sensor (for alarm)
KSB	cold injection advance adjustment device
L	instrument panel light switch
M	sensor for detecting the presence of water in the fuel pre-filter (for alarm)
MM	electric starter motor
MS	IVECO MOTORS indications and alarms module
O	exhaust gas temperature sensor (on request)
P1	sound alarm inhibition push-button
QP	main analog instrument panel
QS	secondary analog instrument panel
SA	buzzer
T	coolant temperature sensor (for gauge)
V	oil pressure sensor (for gauge)
W	low oil pressure sensor (for alarm)
W	signal for revolution counter

Connectors

JA	connection between engine wiring and interface wire harness
JB ON ENGINE WIRE HARNESS	set for connection to the main analog instrument panel
JC ON MAIN ANALOG INSTRUMENT PANEL	set for connection to the engine wire harness
JD	IVECO MOTORS indications and alarms module
JE ON MAIN ANALOG INSTRUMENT PANEL	set for connection to the secondary analog instrument panel
JF	relay box
JH ON SECONDARY ANALOG INSTRUMENT PANEL	set for connection to the main analog instrument panel

Indicator lights

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

Gauges

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

Relays contained in the relay box

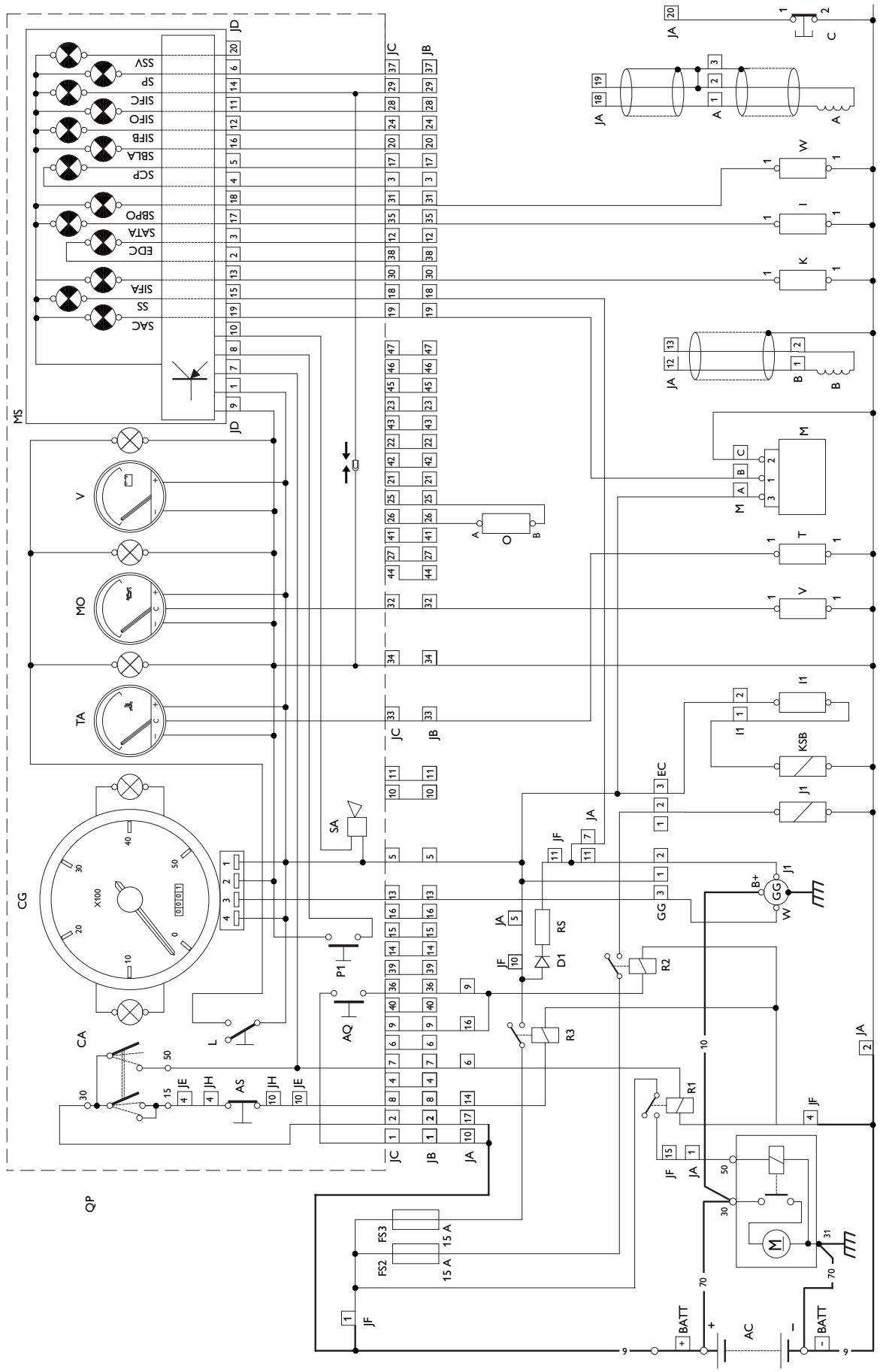
R1	power supply to terminal 50 of the electric starter motor
R2	emergency engine shut-down provision
R3	key switch electric discharge

Fuses contained in the relay box

FS 2	on solenoid valve supply line for engine stop
FS 3	on main supply line

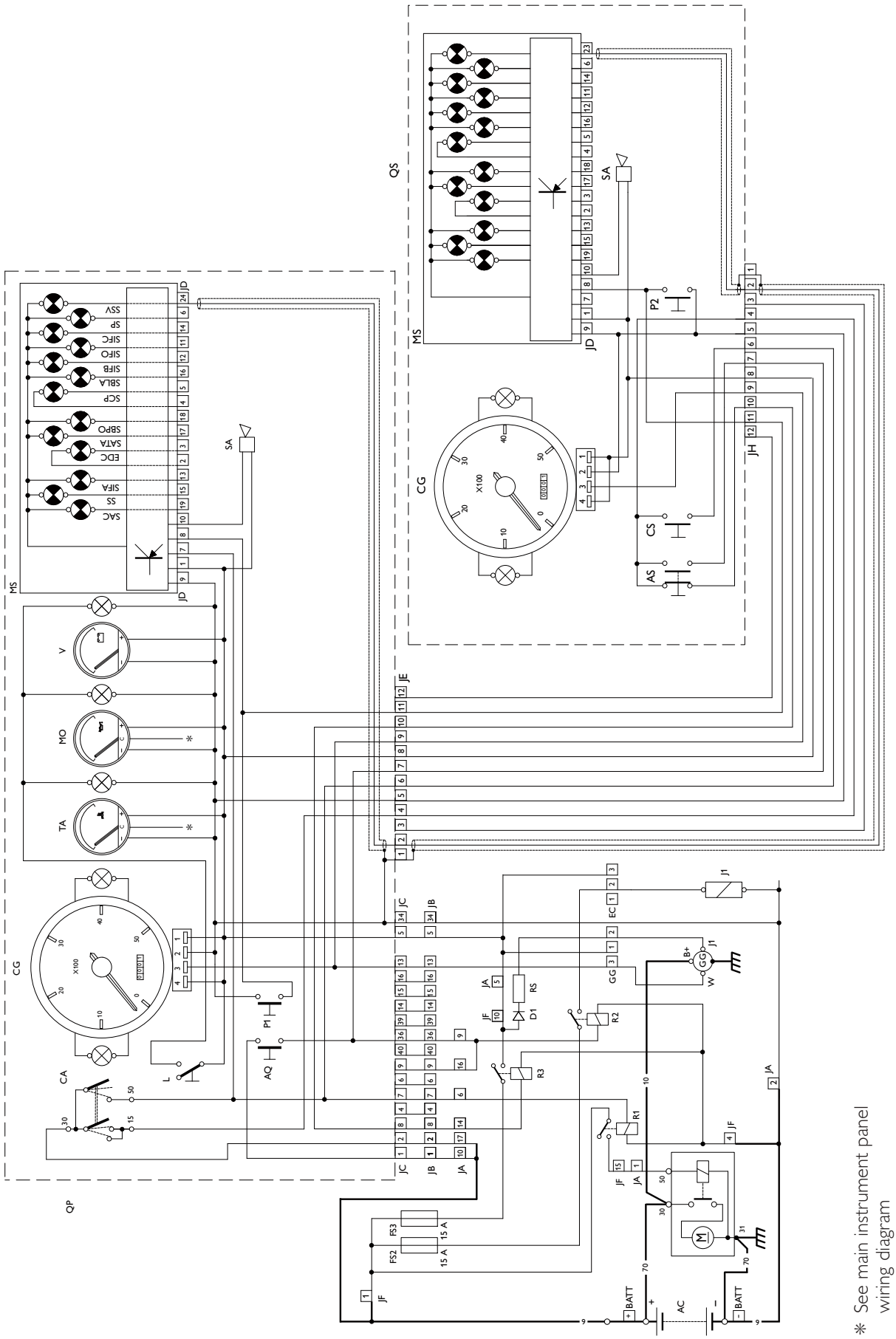
Main analog instrument panel

M10.00/M15.00



Secondary analog instrument panel

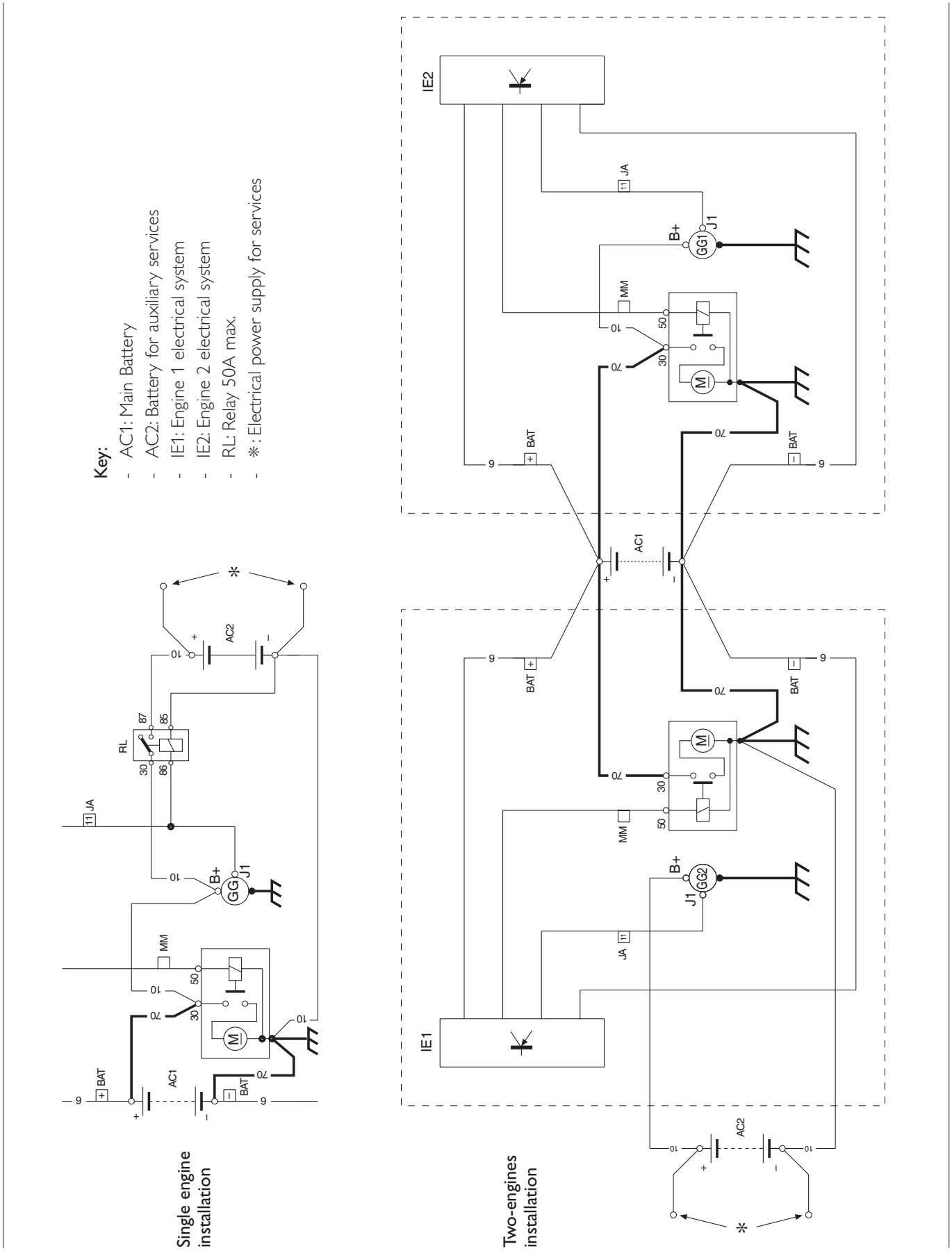
M10.00/M15.00



* See main instrument panel wiring diagram

Supplementary services battery recharge

M10.00/M15.00

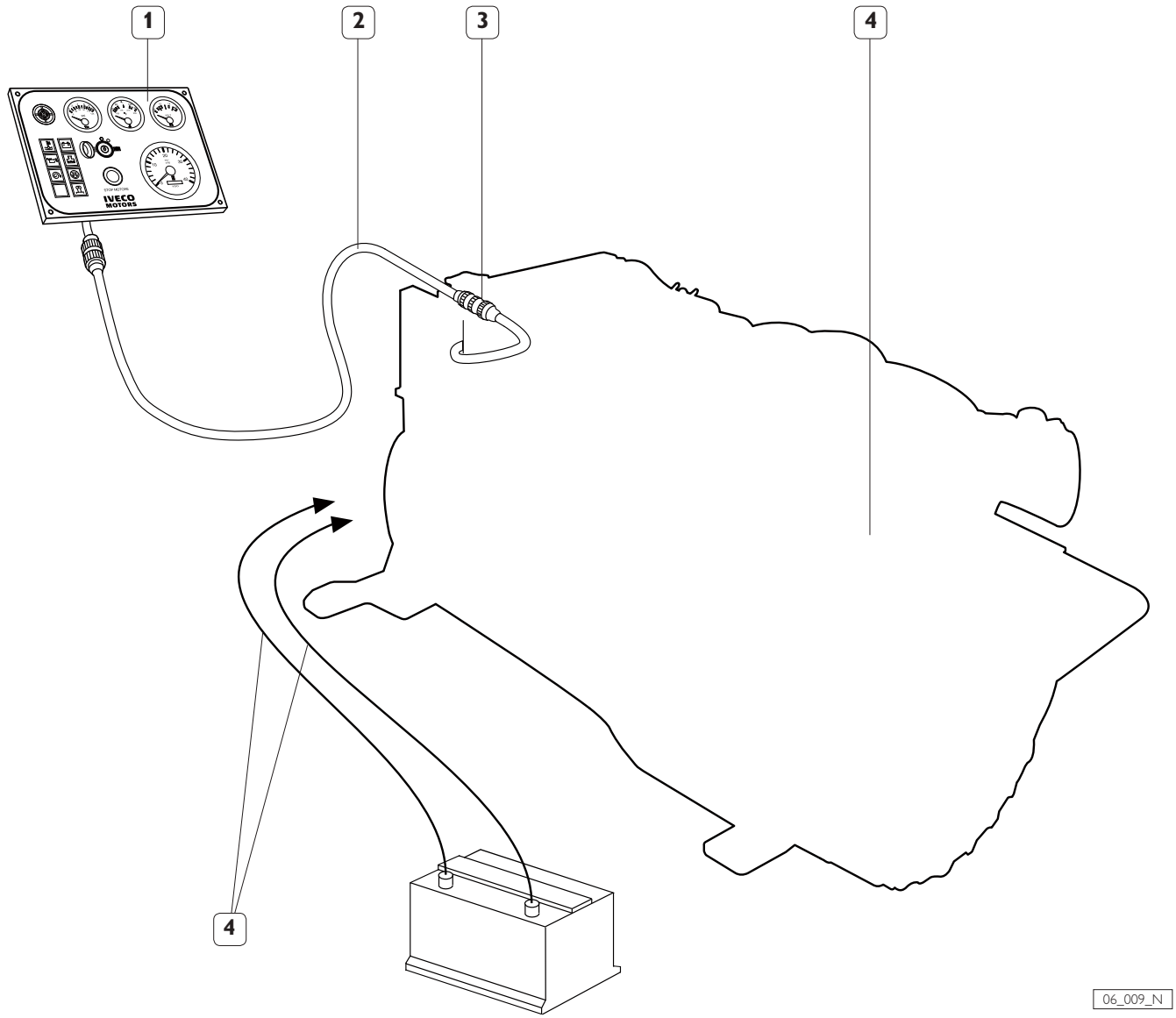


N45 MNA M10.01
N67 MNA M15.01

MODEL PRODUCED FROM THE YEAR 2006

M10.01/M15.01 OVERALL

Figure 18



1. Indicator and control panel - 2. Provided wire harness - 3. JB Connection - 4. Power line for electric starter motor and alternator.

The electric equipment of the system carries out the main connections by means of the wiring provided with the engine, to which the power supply, the electronic components assembled on the engine, the electronic central unit of the injection system, relay box and the instrument and control panel are connected.
The entire product 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 "N45 MNA M10 - N67 MNA M15 Installation Directive" document.

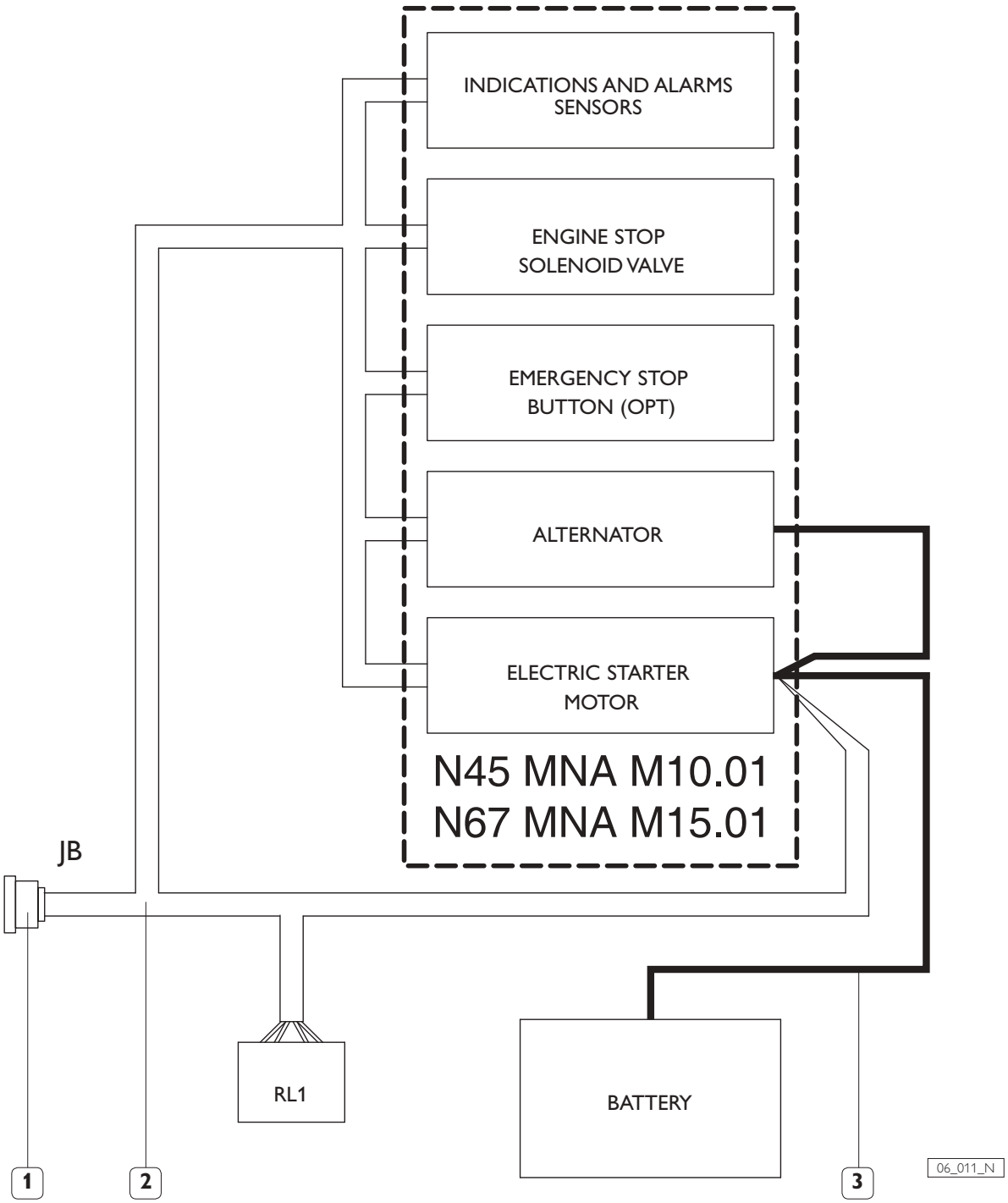
CAUTION

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 "N45 MNA M10 - N67 MNA M15 Installation Directive" document.

M10.01/M15.01 SYNOPTIC

Figure 19

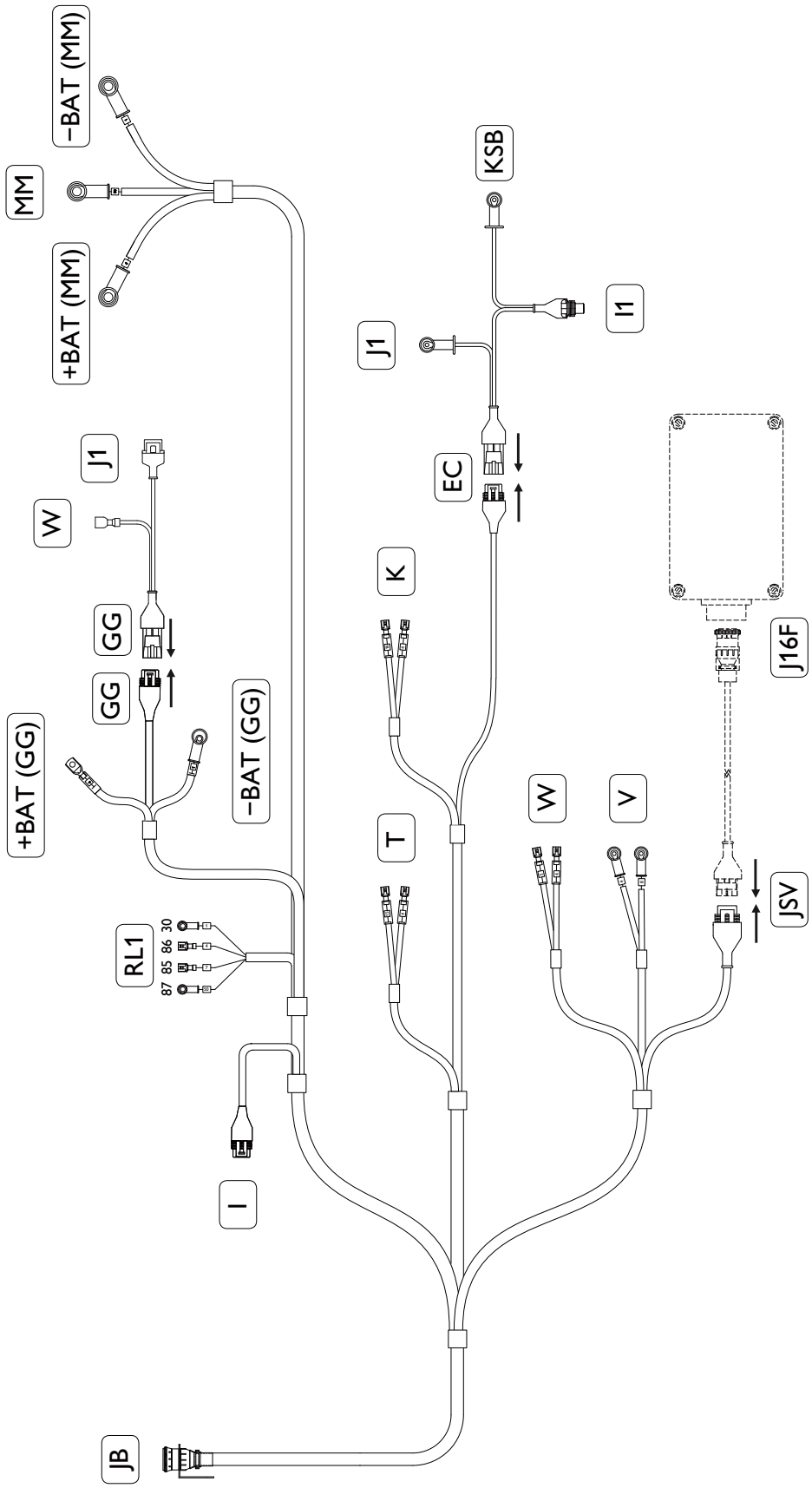


1. Connector for instrument panel connection wire harness - 2. Engine wire harness - 3. Power line.

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.

M10.01/M15.01 WIRE HARNESS

Figure 20

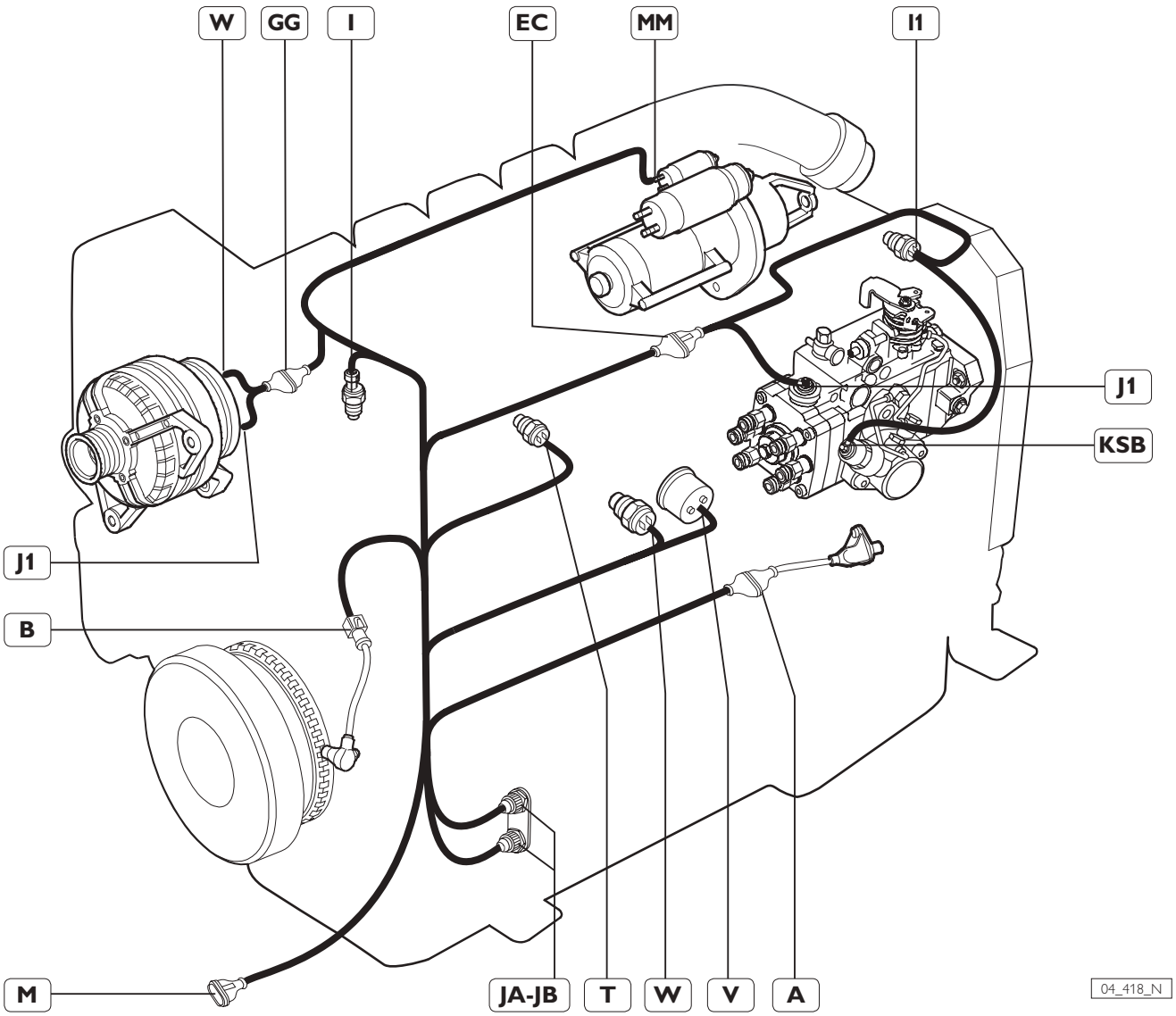


06_012_N

I. High coolant temperature sensor (for alarm) - K. Air filter clogging sensor (for alarm) - T. Coolant temperature sensor (for gauge) - V. Oil pressure sensor (for gauge) - W. Low oil pressure sensor (for alarm) - VV. Signal for revolution counter - EC. Injection pump connector - I1. KSB Refrigerating liquid temperature sensor - J1. Engine stop solenoid valve - KSB. Cold injection advance adjustment device - GG. Connector for alternator - JB. Instrument panel connection wire harness - J1. Alternator excitation - JSV. Over speed module connector - J16F. Engine rotation over speed control module (on request) - RL1. Starter relay motor - MM. Electric starter motor.

M10.01/M15.01 LOCATION OF ELECTRICAL COMPONENTS IN THE ENGINE

Figure 21

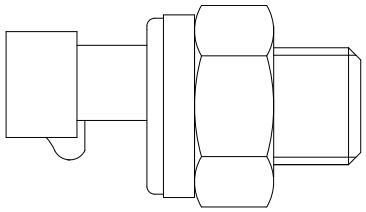


I. High coolant temperature sensor (for alarm) - K. Air filter clogging sensor (for alarm) - T. Coolant temperature sensor (for gauge) - V. Oil pressure sensor (for gauge) - W. Low oil pressure sensor (for alarm) - EC. Injection pump connector - I1. KSB Refrigerating liquid temperature sensor - J1. Engine stop solenoid valve - KSB. Cold injection advance adjustment device - GG. Connector for alternator - J1. Alternator excitation - W. Signal for revolution counter - JB. Instrument panel connection wire harness - MM. Electric starter motor - JSV. Over speed module connector - RL1. Starter relay motor.

M10.01/M15.01 ELECTRICAL COMPONENTS

KSB Refrigerating liquid temperature sensor

Figure 22



Thermometrical switch which manages the activation of the cold injection advance adjustment device.

Operating voltage	from 6 V to 24 V
Condition at ambient temperature	normally closed
Closing temperature	≥ 63 ± 3 °C
Opening temperature	≤ 53 ± 3 °C
Maximum current	15A (inductive)
Poles	isolated

KSB solenoid valve

Operating voltage	12 V
Resistance value	7 ± 1,4 Ω

Operating voltage	24 V
Resistance value	28 ± 5,6 Ω

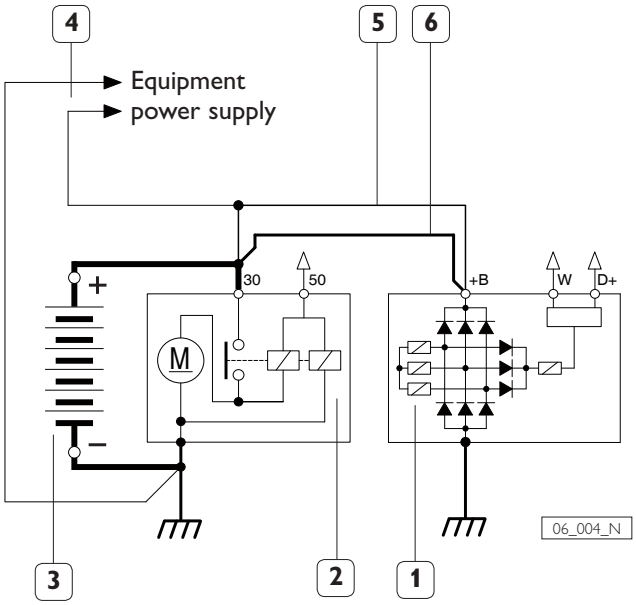
Engine stop solenoid valve

Operating voltage	12 V
Resistance value	5 ± 1 Ω

Operating voltage	24 V
Resistance value	20 ± 4 Ω

M10.01/M15.01 POWER SUPPLY LINE

Figure 23



1.Alternator - 2. Electric starter motor - 3. Battery - 4. Engine wire harness - 5.This conductor is present on the engine wiring - 6.This conductor must be parallel connected to the existing one.

The connection of the +B terminal of the alternator to the positive +30 terminal of the electric starter motor must be achieved with a conductor having a cross section of at least 20 mm^2. On the engine wiring there is a 6 mm2 section conductor: a 16 mm2 section or – or higher – conductor must be connected to it.The connection of the positive +30 terminal of the electric starter motor to the positive pole of the battery, achieved with a conductor having a cross section of at least 70 mm^2, allows to obtain, as shown in the figure, the simultaneous connection of the alternator to the battery. On the same +30 terminal of the start-up electric engine it is necessary to connect the eye battery lead connection marked with "+ BAT (MM)". The connection between the engine ground and the negative pole of the battery must be achieved according to the guidelines provided in the Engine electrical ground paragraph.

CAUTION

Do not use any magneto-thermal activation protection items to stop engine. Using off-the-shelf equipment, you stop the engine energizing the proper solenoid valve. In lack of power supply you could not stop the engine.

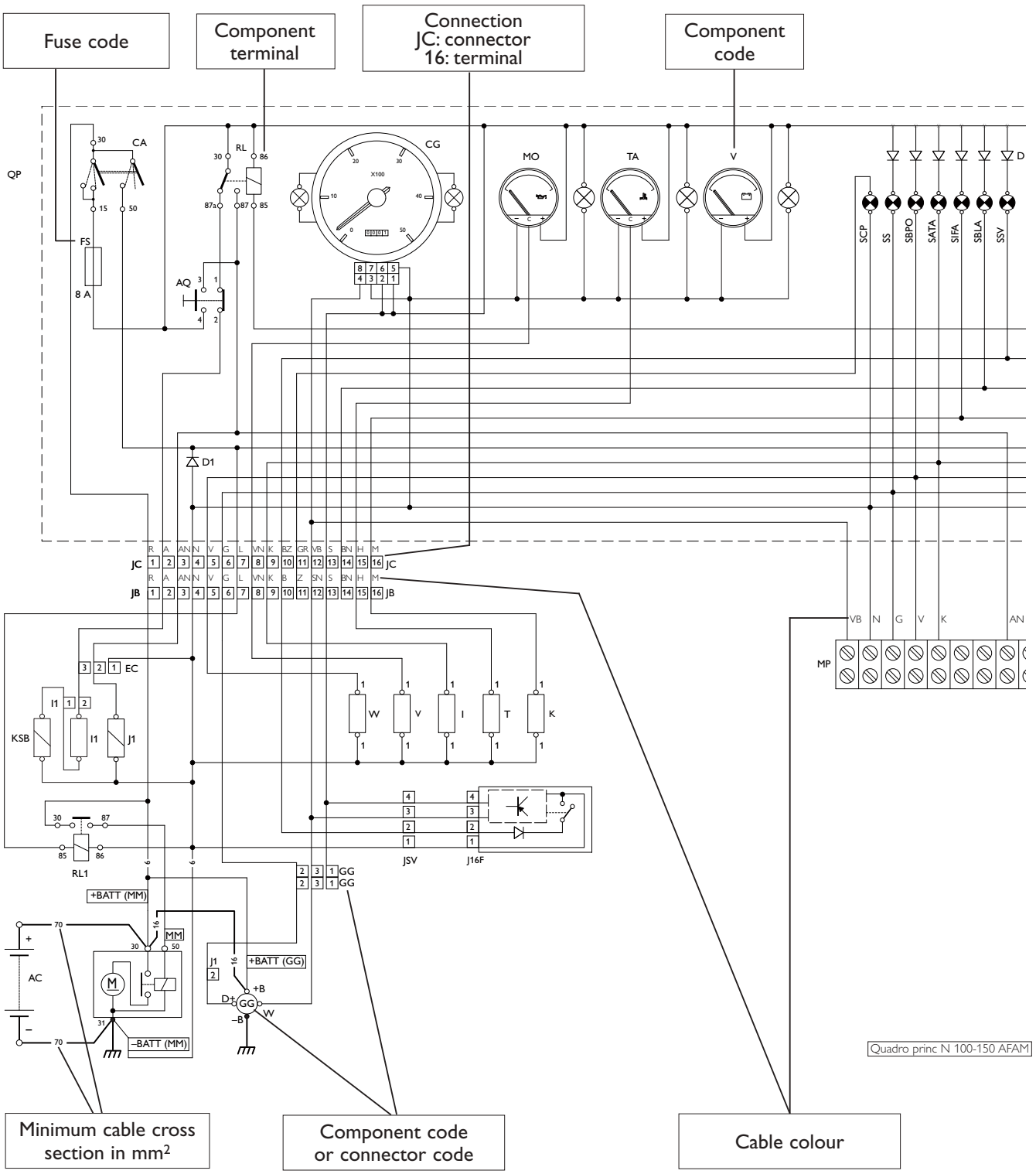
M10.01/M15.01 ELECTRICAL DIAGRAMS

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 24



Electrical equipment component code

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
D	6 diodes block
D1	Protection diode (on the main board)
GG	alternator
I	high coolant temperature sensor (for alarm)
I1	KSB refrigerating liquid temperature sensor
J1	engine stop solenoid valve
J1	alternator excitation
K	air filter clogging sensor (for alarm)
KSB	cold injection advance adjustment device
MA	alarms management module
MM	electric starter motor
QP	main analog instrument panel
QS	secondary analog instrument panel
SA	buzzer
T	coolant temperature sensor (for gauge)
V	oil pressure sensor (for gauge)
W	low oil pressure sensor (for alarm)
J16F	Engine rotation over speed control module (on request)

Connecteurs

JA	IVECO MOTORS indications and alarms module
JB ON ENGINE WIRE HARNESS	set for connection to the main analog instrument panel
JC ON MAIN ANALOG INSTRUMENT PANEL	set for connection to the engine wire harness
JSV	Over speed module connector
MF ON SECONDARY ANALOG INSTRUMENT PANEL	pre-set clamp for connection to the main analog instrument panel
MP ON MAIN ANALOG INSTRUMENT PANEL	pre-set clamp for connection to the secondary analog instrument panel

Lampes de signalisation

SAC	Presence of an alarm on the personalized board (if the IVECO MOTORS alarm and signalling module is not present)
SATA	coolant high temperature
SBLA	low coolant level
SBPO	low oil pressure
SCP	pre-post heating
SIFA	clogged air filter
SS	alternator fault
SSV	runaway engine

Gauges

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

Relays

RL1	power supply to terminal 50 of the electric starter motor
RL	For engine stop from alarm module

Fusibles

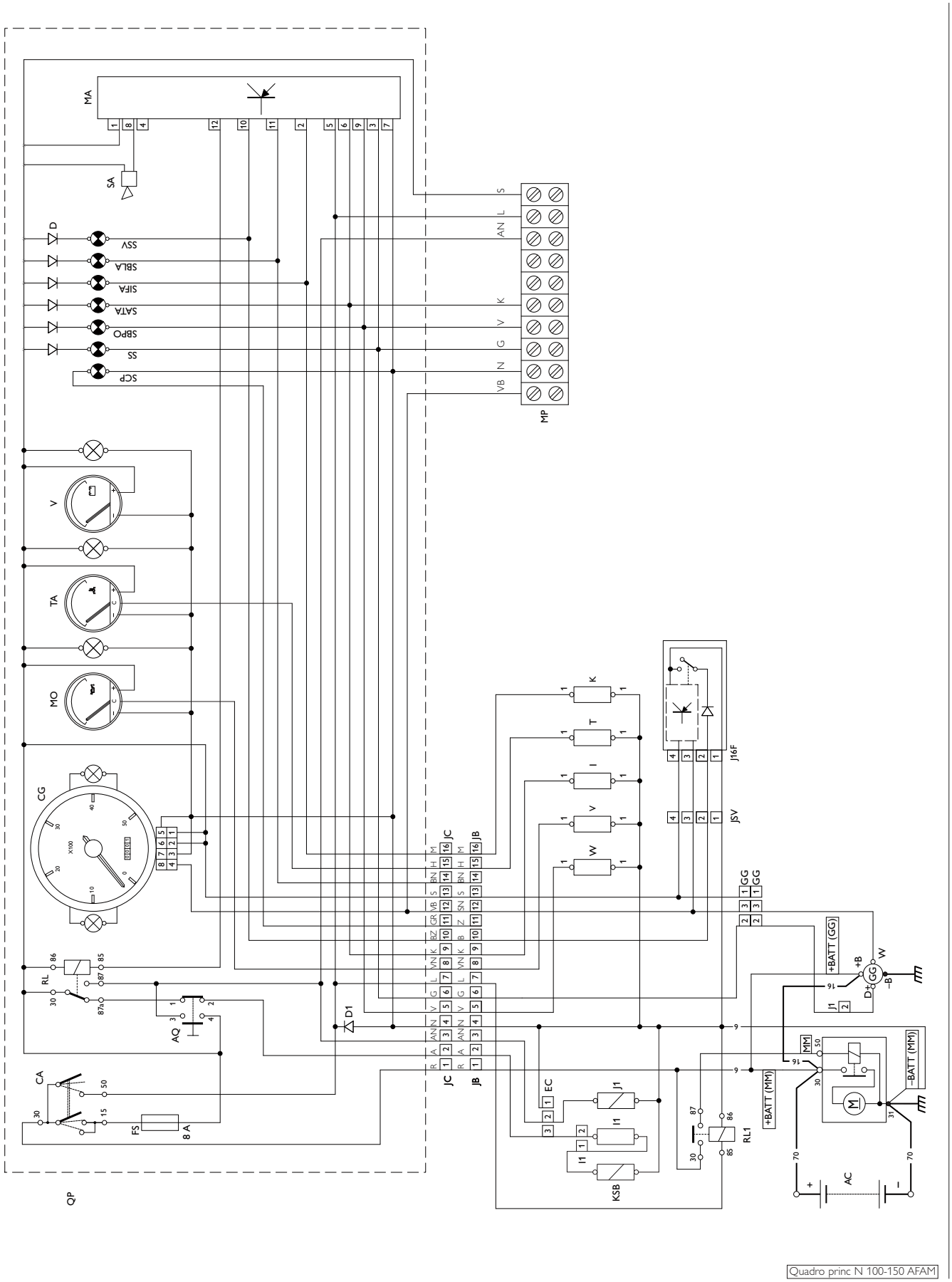
FS	on "15" supply line

Board electric cables colour index

K	orange
A	sky blue
B	white
L	blue
G	yellow
H	grey
M	brown
N	black
S	pink
R	red
V	green
Z	purple

Main analog instrument panel

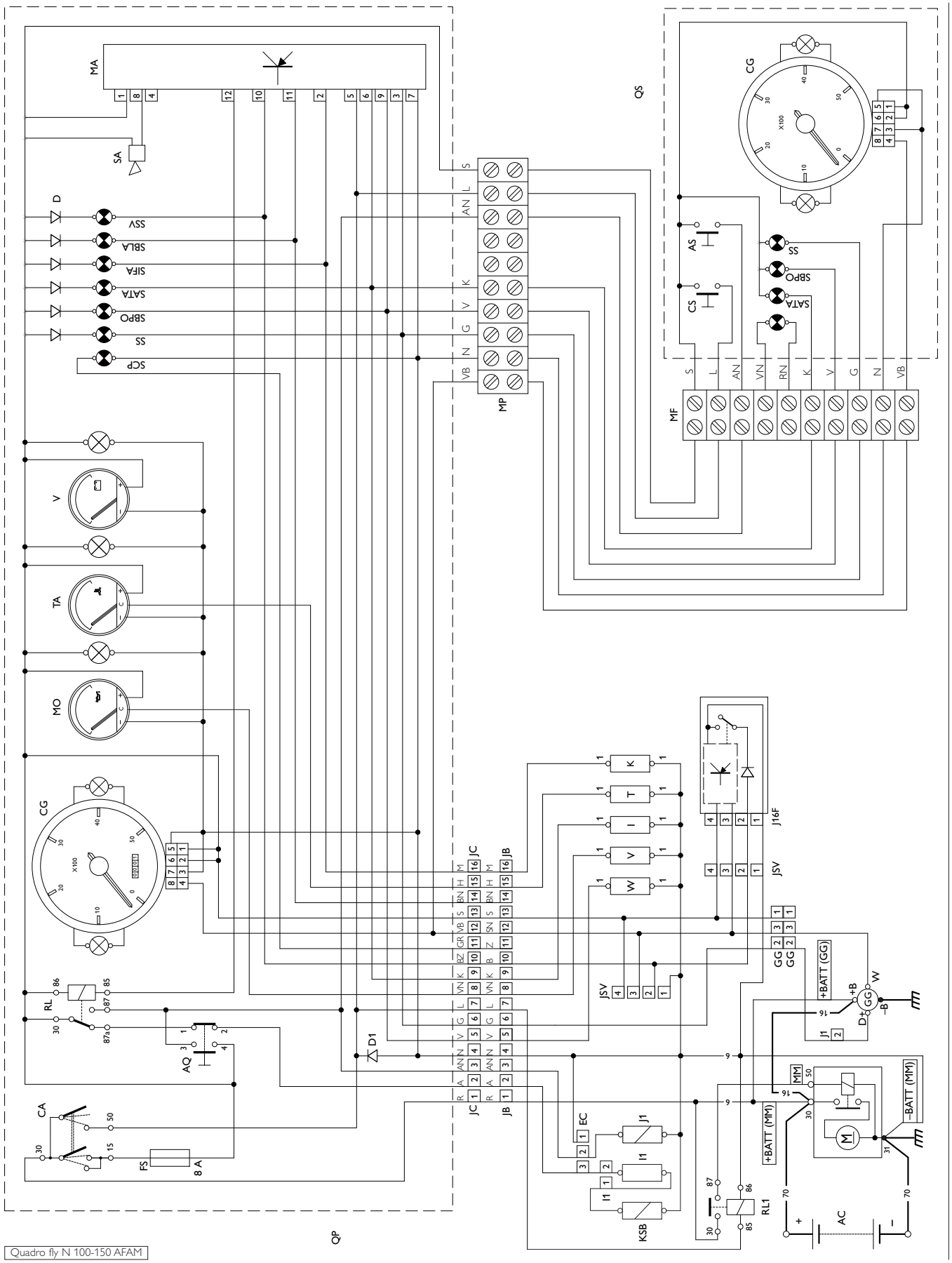
M10.01/M15.01



Quadro princ N 100-150 AFAM

Secondary analog instrument panel

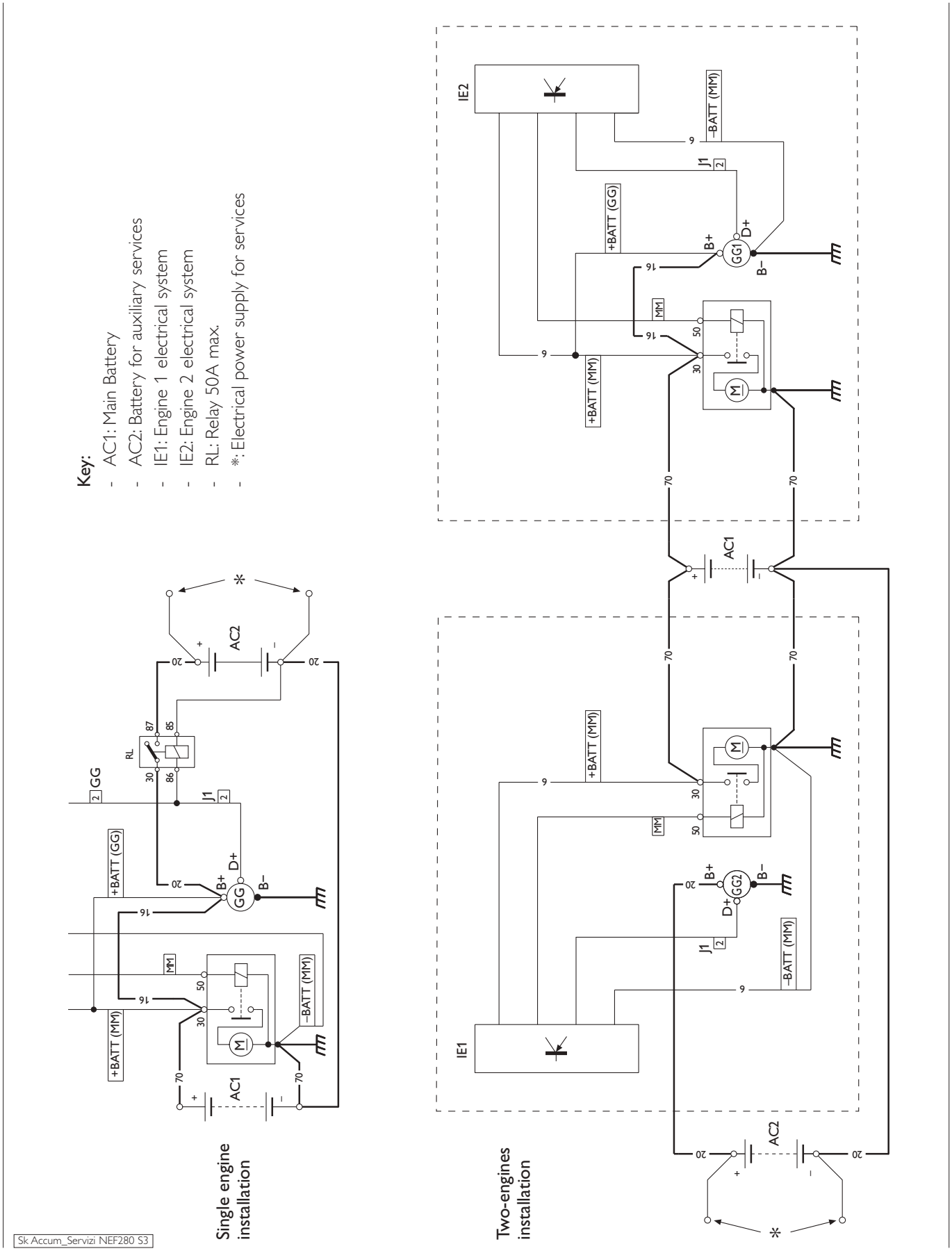
M10.01/M15.01



Quadro fly N 100-150 AFAM

Supplementary services battery recharge

M10.01/M15.01



SECTION 4

DIAGNOSTICS

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.

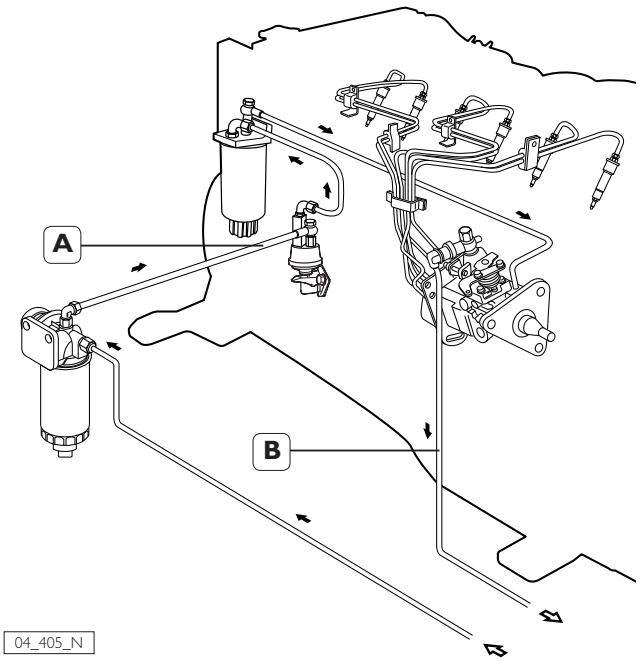
After ascertaining the existence of the anomaly, we recommend starting troubleshooting operations with tests and measurements, to obtain a picture of the overall operating conditions and identify the real fault causes.
If adopted diagnostic modes provide no indications, proceed to check ratings and technical data provided in the "N45 MNA M10 - N67 MNA M15 Installation Directive" document.

We have provided, in the following pages, a TROUBLESHOOTING GUIDE organized by symptoms, describing 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.

MAJOR DIAGNOSTIC ACTIONS

Checking pressure in fuel supply line

Figure 1



04_405_N

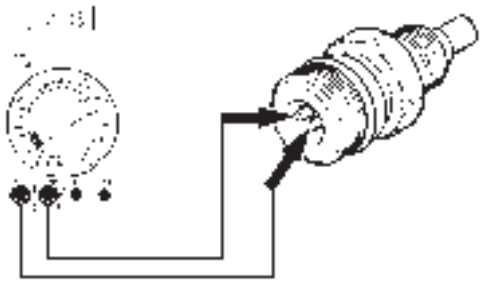
Gauges will be interposed in A and B by "T" unions. Measurements have to be carried out at various engine speeds from minimum to maximum at intervals of 200 RPM.

Acceptable limit ratings

Point	Minimum	Maximum
A	- 20 kPa	0 kPa
B	0 kPa	10 kPa

Checking component resistance value

Figure 2

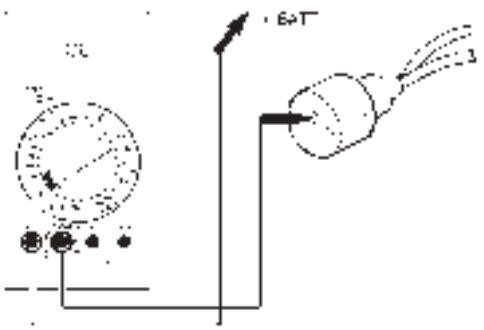


04_086_N

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.

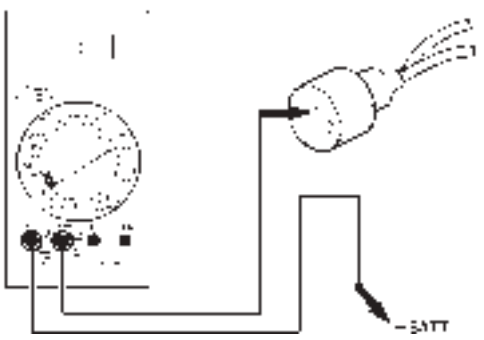
Checking line insulation

Figure 3



04_087_N

Figure 4



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

REFERENCE VALUES

For non hardwired sensors

Component	Test conditions	Minimum Ω value	Maximum Ω value
Coolant temperature sensor	90 °C	51.2	± 4.3
Lubrication oil pressure sensor	0 bar 2 bar 4 bar 6 bar maximum	10 52 88 124 -	+ 3 / - 5 ± 4 ± 4 ± 5 184
Drive shaft sensor	20 °C	800	1000
Camshaft sensor	20 °C	800	1000
Engine stop solenoid valve (12V)	20 °C	4	6
Engine stop solenoid valve (24V)	20 °C	16	24
KSB solenoid valve (12V)	20 °C	5,6	8,4
KSB solenoid valve (24V)	20 °C	22,4	33,6

CAUTION

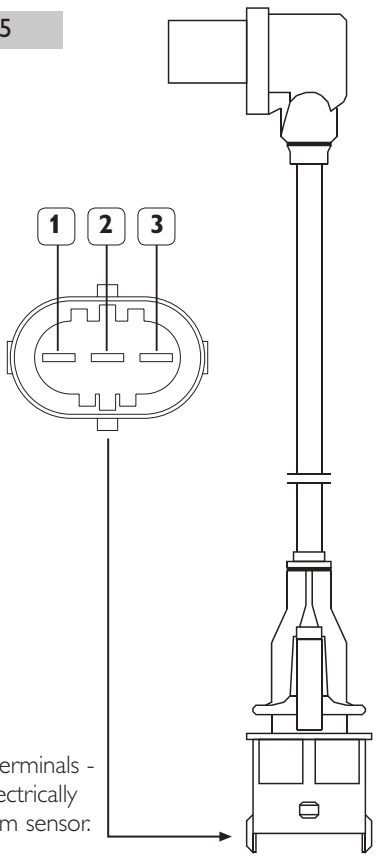
Measurements refer only to the reference component.
Measurements closest to reality are taken including the relevant wiring.
Always check the continuity of the SHIELD conductor from the sensor to the electronic unit and the latter's good insulation from the other signal conductors.

For inductive sensors

Component	Test conditions	Value
Drive shaft sensor	Engine running 650 rpm	> 0.8 Vac
Camshaft sensor	Engine running 650 rpm	> 0.8 Vac

Sensors wired with shielded wires

Figure 5



GUIDE TO SYMPTOM DIAGNOSING

Symptom	Part	Possible cause	Recommended tests or action
Engine does not start	Battery	- Low charge - Faulty terminal connections	- Recharge (disconnecting battery from system wiring) - Clean, check insulation, tighten terminals
Engine does not start	Electrical starter motor	- Malfunction - Faulty terminal connections	- Check efficiency - Check connections to positive (+ 30) and engine ground
Engine does not start	Injection pump	- Incorrect timing - Wear or defective	- Check, restore correct timing - Injection pump overhaul
Engine does not start	"15" control from key switch	- Malfunction - Faulty terminal connections	- Check wiring, key switch and relay R1 contained in relay box
Engine does not start	Fuel feed pump	- Incorrect priming	- Check seal or air intake on induction side
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.
Engine does not start	Fuel circuit	- Presence of water	- Drain water from fuel filter and prefilter. Clean fuel tank and piping. Remove and clean injection pump. Restore fuel loop, fill the tank and vent the air.
Engine does not start	Fuel filter and pre-filter	- Clogged	- Bleed - Check tank - Replace

GUIDE TO SYMPTOM DIAGNOSING

Symptom	Part	Possible cause	Recommended tests or action
Engine frequently overheats	Coolant level	- Below MIN level	- Check for leaks - Top up correct level
Engine frequently overheats	Water pump drive belt	- Poor tension - Wear	- Check tension - Replace - Check for liquid leakage on drive belt
Engine frequently overheats	Water pump	- Malfunction	- Replace - Check belt tension - Check for liquid leakage on drive belt
Engine frequently overheats	Thermostatic valve	- Locked, closed or only partially open	- Replace - Check for impurities in coolant
Engine frequently overheats	Coolant / sea-water heat exchanger	- Clogged	- Clean or replace
Engine frequently overheats	Air filter	- Clogged	- Clean or replace
Engine frequently overheats	Cylinder head gaskets	- Compression leaking from cylinder head gaskets	- Check cooling water circuit pressure - Replace head gaskets
Engine frequently overheats	Injection pump	- Incorrect timing - Incorrect calibration	- Check, restore correct timing - Injection pump calibration/overhaul

GUIDE TO SYMPTOM DIAGNOSING

Symptom	Part	Possible cause	Recommended tests or action
Poor performance	Fuel circuit	- Tank net filter clogged - Fuel prefilter clogged - Fuel filter clogged - Air in fuel circuit - Heavy fuel leakage	- Clean or replace clogged filters - Check intake seals - Check the integrity of the fuel gear pump
Poor performance	Injectors	- Malfunction - Locked, closed - Locked, open	- Loosening the connector on the pipe connecting the injector, it excludes the injection, enabling to locate the cylinder where the anomaly is present. Proceed with caution in order to avoid dangerous fuel sprays and dispersions in the environment.
Poor performance	Engine air feed	- Air filter clogged	- Clean or replace filter
Poor performance	Gas exhaust system	- Clogged	- Check exhaust back-pressure
Poor performance	Camshaft	- Wear - Incorrect timing	- Check - Replace - Check, restore correct timing
Poor performance	Engine valves	- Excessive or nil clearance	- Check, restore correct clearance
Poor performance	Injection pump	- Incorrect timing - Incorrect calibration	- Check, restore correct timing - Injection pump overhaul
Poor performance	Automatic injection advance device	- Malfunction	- Injection pump calibration/overhaul

GUIDE TO SYMPTOM DIAGNOSING

Symptom	Part	Possible cause	Recommended tests or action
Poor performance	Speed regulator on injection pump	- Malfunction	- Injection pump calibration/overhaul
Poor performance	Tie rods between command lever and regulation lever on injection pump	- Incorrectly adjusted	- Check, adjust the tie-rods so that command lever can be moved to the full delivery position.
Poor performance	Cylinders, pistons	- Excessive wear	- Engine overhaul
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
The engine emits blue smoke	Oil in cylinders	- Oil leaking in turbocompressor - Oil leaking from valve guides	- Check lubrication oil consumption - Overhaul
Engine stops	Fuel tank	- Not enough fuel in tank - Float in incorrect position	- Refill and bleed fuel circuit - Modify float or tank tilt
Engine stops	Net filter Prefilter Fuel filter	- Clogged	- Replace - Check efficiency of fuel filter clogging sensor
Engine stops	Fuel circuit	- See "Poor performance"	- See "Poor performance"
Engine stops	Engine stop solenoid valve power supply only (on versions with de-energizing engine stop)	- Connections - Wiring - Key switch - Relay R1	- Check +B and –B electrical connections - Check wiring, key switch and relay R1

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 authorized workshop personnel with adequate training and sufficient technical information.

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

Periodic maintenance operations		**Periodicity**						
		Every start	150 hours	300 hours	600 hours	900 hours	1200 hours	Annual (2)
Clean air filter(s)	(1)			■				■
Check belt tension and conditions				■				■
Check zinc anode corrosion condition	(4)			■				■
Restore battery electrolyte level				■				■
Drain/draw water and condensations from tank(s)	(1)			■				■
Replace engine lubricating oil (after first 50 hours)					■			■
Replace fuel pre-filter(s)	(1) (3)				Max			■
Replace fuel filter(s)	(1) (3)				Max			■
Replace oil filter(s) (after first 50 hours)					■			■
Replace gearbox(es) oil (see data provided by the manufacturer)					■			■
Inspect sea-water intake	(1)					■		■
Check wear of sea-water pump impeller						■		■
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 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) 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.

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:
   N45 MNA M10 = 45g
   N67 MNA M15 = 70g
   into the engine 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;
9. Remove the tags with the inscription "ENGINE WITHOUT OIL" from the engine and from the panel.

SECTION 6

SERVICING OPERATIONS ON INSTALLED ENGINE

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 "N45 MNA M10 - N67 MNA M15 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 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.

- ❑ Keep parts and components clean, making sure that during handling and assembly (starting with the simple replacement of filter and pre-filter) no sludge or foreign matter is allowed to enter the lines, with particular attention to the fuel supply line in the segment downstream of the filter;
- ❑ Maintain the proper polarization of all electrical connections;
- ❑ Tighten the threaded connections to the prescribed torque;
- ❑ 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.**

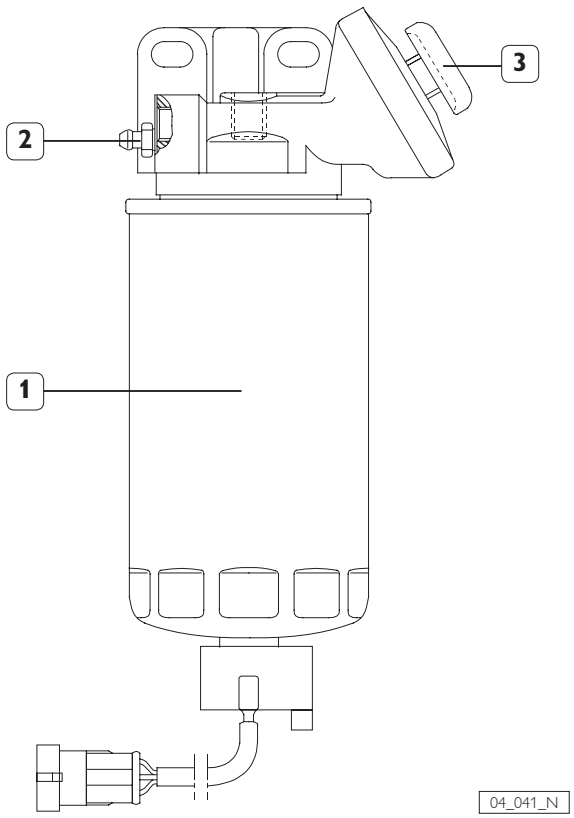
To proceed with the overhaul of the engine or its parts, you must disconnect the electrical connections of the system's components and of the sensors providing indications on the control panel.

To proceed as indicated, we provide below the procedure to avoid the risk to damage the electrical components.

- ❑ Set the key switch to the STOP position and shut the engine down;
- ❑ Wait 10 sec. and disconnect the battery terminals;
- ❑ Disconnect the connectors releasing the restrain system, than split the parts avoiding sudden motions;
- ❑ Remove, if necessary, the entire wiring harness from the engine.

VENTING THE AIR FROM THE FUEL FEED LOOP

Figure 1



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

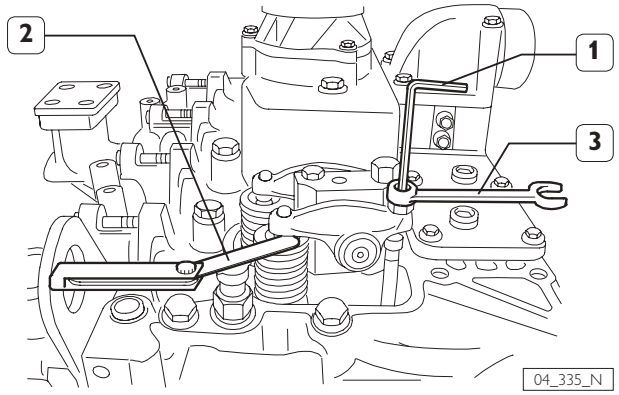
To exhaust air from fuel system, operate the pre-filter (1) manual pump (3) or use a specific electric pump.
Loosen the vent fitting (2) on the pre-filter and operate the pump until only fuel without air flows out. Tighten the vent fitting and continue pumping during the initial start-up phases.
Make 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 2



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

N45 MNA M10

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	■	-	■	-

N67 MNA M15

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

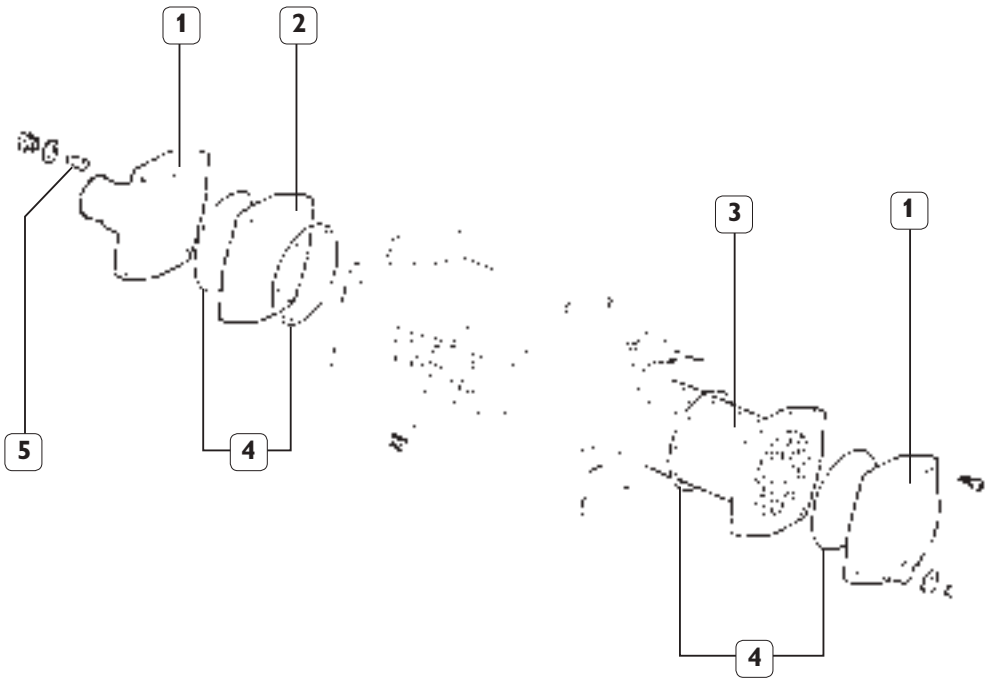
Cylinder n.	1	2	3	4	5	6
intake	-	-	■	-	■	■
exhaust	-	■	-	■	-	■

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 3



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

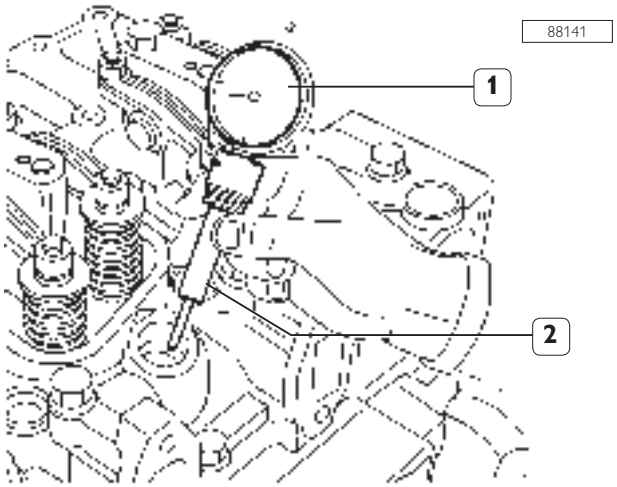
In order to guarantee a perfect operation of the heat exchanger, regularly clean the tube bundle. If the surfaces of the heat exchanger come into contact with salted water, they may be subjected to biological fouling and to hydrocarbon deposit which may be present in harbors' waters.

- ❏ 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.

ADJUSTING INJECTION PUMP TIMING

It requires to ensure the exact pumper position of injection pump compared to an exact angular position of crankshaft.

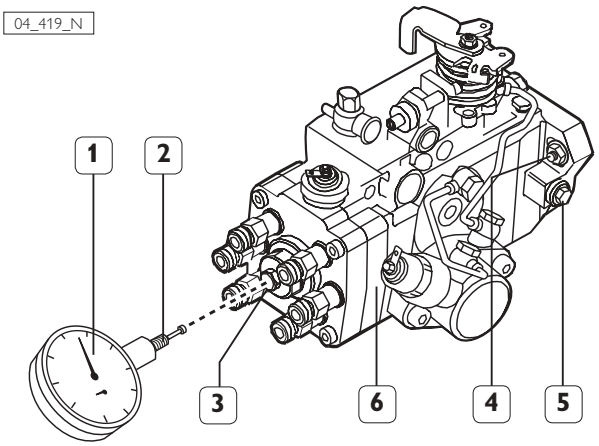
Figure 4



Bring the cylinder 1 piston to T.D.C., compression end, proceeding as follows:

- ❏ Rotate crankshaft in a position where both intake and exhaust valves are closed;
- ❏ Swap the cylinder 1 injector with tool 99395097 (1) inclusive of centesimal dial gauge, and preload the dial gauge;
- ❏ Rotate the crankshaft in the opposite direction to normal rotation, until reaching the lesser value on the dial gauge;
- ❏ Carefully rotate the crankshaft in the normal direction of rotation, until reaching the maximum value on the dial gauge (corresponding to cylinder 1 piston T.D.C. position);
- ❏ Verify that both intake and exhaust valves are closed, then set the dial gauge to zero.

Figure 5



- ❏ Remove the screw (3) and screw the tool 99395100 (2), inclusive of centesimal dial gauge (1), ensuring that the shaft is making contact with the pumper;
- ❏ Preload the dial gauge by 3 mm;
- ❏ Rotate the crankshaft in the opposite direction to normal rotation, until the pumper reaches its own B.D.C., as shown by the dial gauge;
- ❏ Set the dial gauge to zero;
- ❏ Rotate the crankshaft of about 30° in the opposite direction to normal rotation;
- ❏ Carefully rotate the crankshaft in the normal direction of rotation, until reading the 0.00 mm value on the dial gauge (1) of tool 99395097 (Fig. 4), corresponding to cylinder 1 piston T.D.C. position;
- ❏ Partially loosen the lateral screw (5) locking the pump shaft, without removing the slip washer;
- ❏ Loosen the pump fixing nuts (4) without remove them, so as to allow the pump body rotation;
- ❏ Carefully rotate the pump body until reading the prescribed pumper stroke value on the dial gauge (1) of tool 99395100 (Fig. 6) (see following table);
- ❏ Tighten the pump fixing nuts (4) and the lateral screw (5) to prescribed torque values; proceed with timing verification.

Injection pump timing data

With reference to the engine code and that applied to the injection pump (point 6 of Figure 5).

Engine	Injection pump	Pumper stroke with cylinder 1 piston at T.D.C.	
N45 MNA M10 (74 kW)	Bosch VE4/12F 1400 L 1057	1,8 ± 0,05 mm	
N45 MNA M10 (66,5 kW)	Bosch VE4/12F 1400 L 1057A	1,9 ± 0,05 mm	PRELIMINARY
N45 MNA M10 (63 kW)	Bosch VE4/12F 1400 L 1057B	1,9 ± 0,05 mm	PRELIMINARY
N67 MNA M15 (110 kW)	Bosch VE6/12F 1400 L 1055	1,8 ± 0,05 mm	
N67 MNA M15 (99,5 kW)	Bosch VE6/12F 1400 L 1055A	1,8 ± 0,05 mm	PRELIMINARY
N67 MNA M15 (92 kW)	Bosch VE6/12F 1400 L 1055B	1,8 ± 0,05 mm	PRELIMINARY

VERIFY INJECTION PUMP TIMING

Arrange in advance the tools on the engine, as shown in procedures described in Figures 5 and 6.

- ❑ Carefully rotate the crankshaft in the normal direction of rotation, until reading the 0.00 mm value on the dial gauge (1) of tool 99395097 (Fig. 5), corresponding to cylinder 1 piston T.D.C. position;
- ❑ Read the pumper stroke value on the dial gauge (1) of tool 99395100 (Fig. 6);
- ❑ If the measured value is not within the prescribed tolerance, follow operations described in chapter "ADJUSTING INJECTION PUMP TIMING" in the previous page.

CALIBRATING THE INJECTION PUMP

The BOSCH servicing network must carry out the revision and calibration operations.

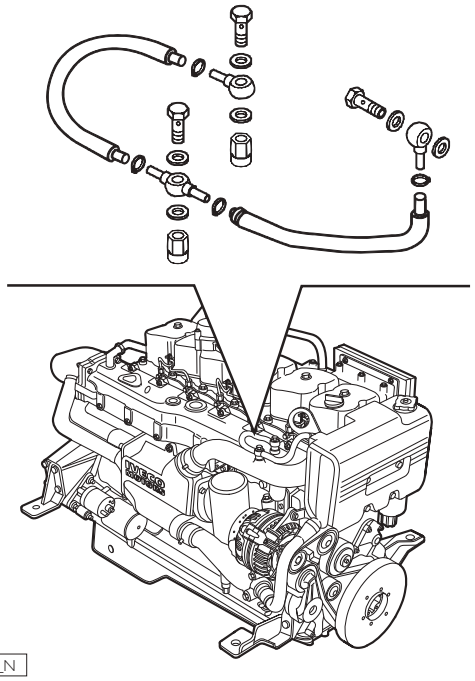
The paper containing the data for calibrating the pump on the bench is identified by the code applied to the body of the injection pump (point 6 of Figure 6) and is available from the BOSCH servicing network.

Otherwise contact the IVECO MOTORS Technical Service Centre.

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.

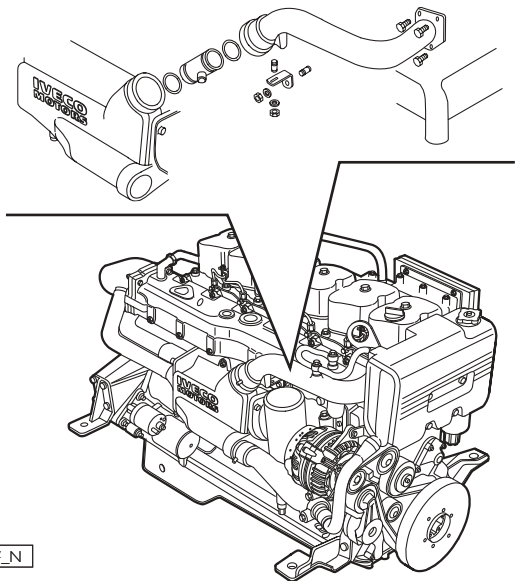
Figure 6



04_423_N

Remove cooling circuit exhaust pipes, located on engine head.

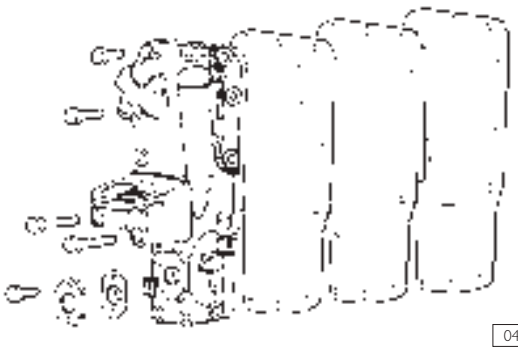
Figure 7



04_327_N

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

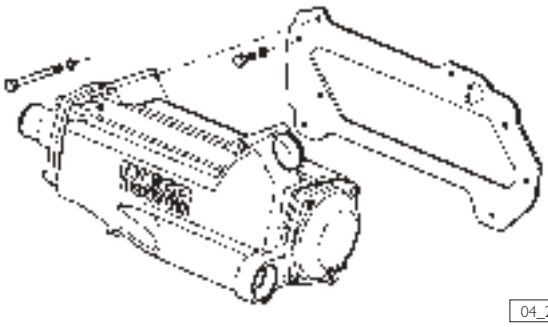
Figure 8



04_273_N

Remove the support and the oil filter from their housing located on engine base.
Decouple the air filter exhaust riser.

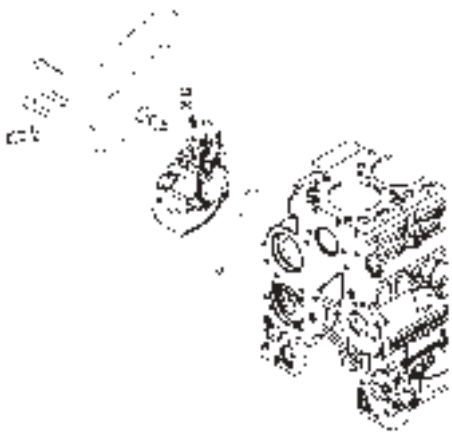
Figure 9



04_279_N

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.

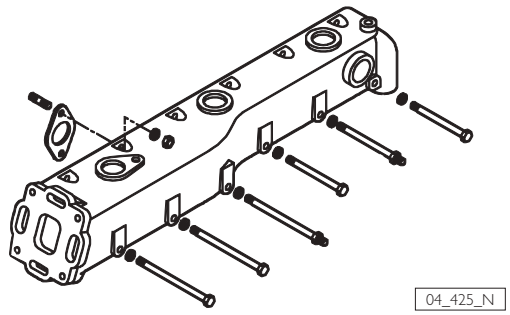
Figure 10



04_280_N

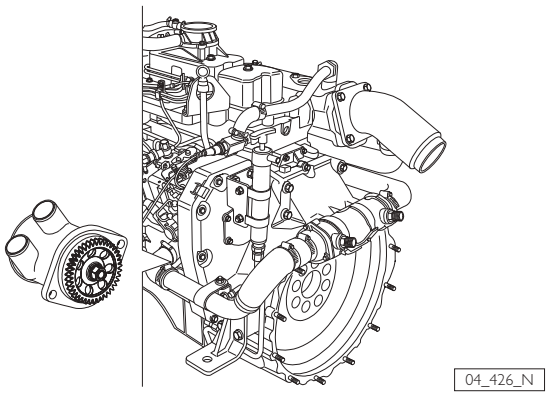
The alternator and the belt tensioner are simultaneously anchored to the exchanger support. Remove them if necessary.

Figure 11



Remove the exhaust manifold to complete engine preparation for overhauling.

Figure 12



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.

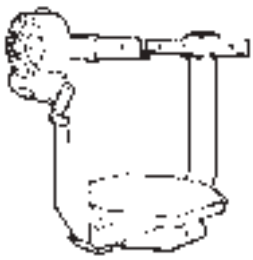
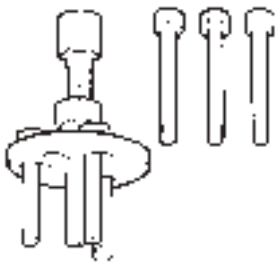
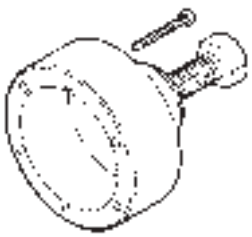
Handling

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.

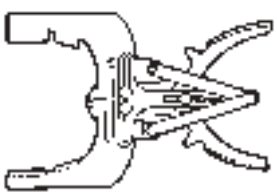
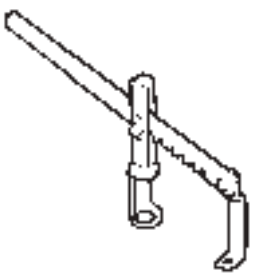
SECTION 7

TOOLS

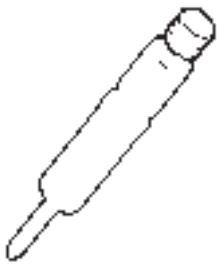
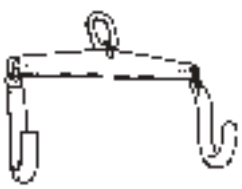
TOOLS

Tool No.		Definition
99305019		Kit for valve seat regrinding
99305047		Spring load tester
99322205		Revolving stand for overhauling units (700 daN/m capacity, 120 daN/m torque)
99340035		Injection pump gear extractor
99340055		Tool to remove output shaft front gasket
99340056		Tool to remove output shaft rear gasket

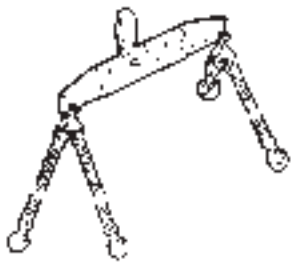
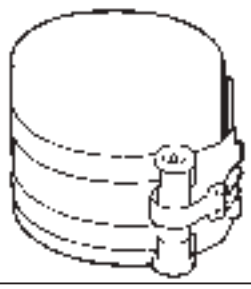
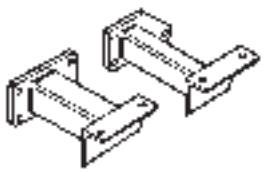
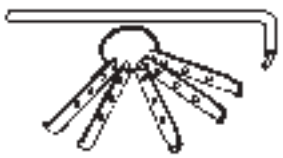
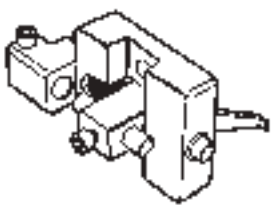
TOOLS

Tool No.		Definition
99340205		Tool to remove injectors
99346252		Tool for fitting output shaft rear gasket
99346253		Tool for fitting output shaft rear gasket
99360076		Tool to remove oil filter (engine)
99360183		Pliers for removing/refitting piston rings (65 - 110 mm)
99360268		Tool for removing/refitting engine valves

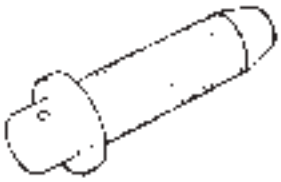
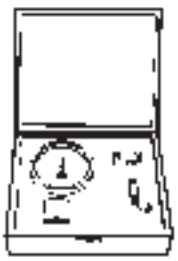
TOOLS

Tool No.		Definition
99360330		Flywheel crank handle
99360339		Tool for stopping the engine flywheel
99360344		Adapter, cylinder compression test (use with 99395682)
99360351		Tool for flywheel holding
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
99365195		Comparator holder tool for injection pump timing (to be used with 99395604)
99367121		Manual pump for pressure and de-pressure measuring

TOOLS

Tool No.		Definition
99370006		Interchangeable willow handgrip
99370415		Gauge base for different measurements (to be used with 99395603)
99395097		Tool to check top dead centre (use with 99395604)
99395100		Dial gauge holder for rotary injection pump timing (use with 99395603)
99395216		Pair of gauges with 1/2" and 3/4" square head for angle tightening
99395220		All-purpose goniometer/Inclinometer

TOOLS

Tool No.		Definition
99395363		Complete bush testing square
99395603		Dial gauge (0 to 5 mm)
99395604		Dial gauge (0 v 10 mm)
99395682		Diesel fuel engine cylinder compression control device

SECTION 8

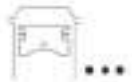
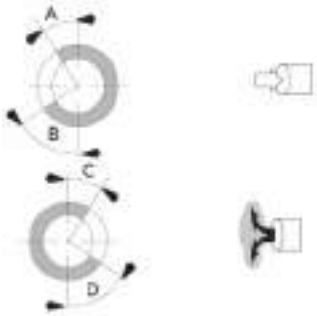
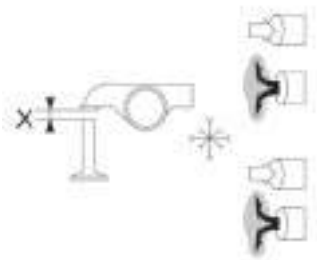
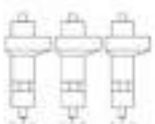
OVERHAUL

(continues on next page)

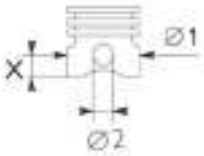
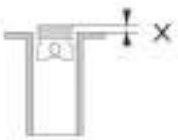
Graph and symbols

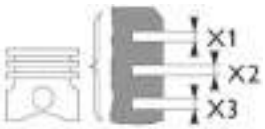
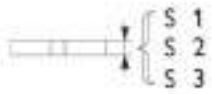
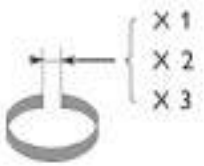
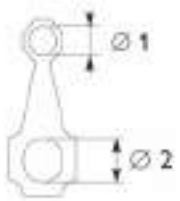
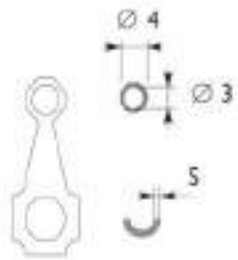
	Surface for machining Machine finish
	Interference Strained assembly
	Thickness Clearance
	Intake
	Exhaust
	Operation
	Compression ratio
	Preload
	Oversized Higher than … Maximum, peak
	Undersized Less than … Minimum
	Selection Classes Oversizing
	Replacement Original spare parts

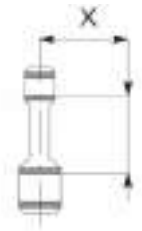
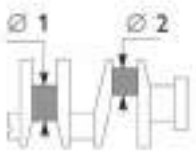
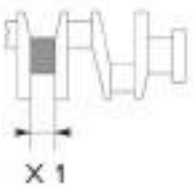
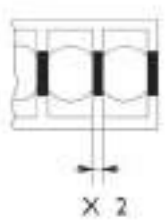
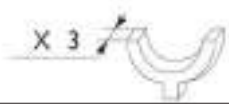
GENERAL SPECIFICATIONS

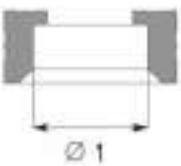
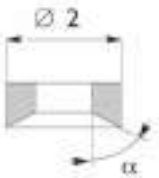
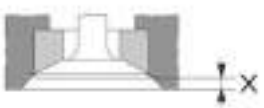
	Type		N45 MNA M10	N67 MNA M15
	Cycle		Four-stroke diesel engine	
	Air feeding		Naturally aspirated	
	Injection		Direct	
	Number of cylinders		4	6
	Bore	mm	104	
	Stroke	mm	132	
	Total displacement	cm^3	4485	6728
	**Timing**			
	start before T.D.C.	A	15°	
	end after B.D.C.	B	35°	
	start before B.D.C.	D	69°	
	end after T.D.C.	C	21°	
	Checking timing			
	X	mm	-	
	X	mm	-	
	Checking operation			
	X	mm	0.25 ± 0.05	
	X	mm	0.50 ± 0.05	
	Fuel feed			
	Injection Type: rotary Bosch		VE 4/12 F 1400 L 1057	VE 6/12 F 1400 L 1055
	Nozzle type Injectors		DSLA 145 P	
	Injection sequence		1 - 3 - 4 - 2	1 - 5 - 3 - 6 - 2 - 4

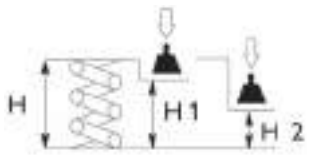
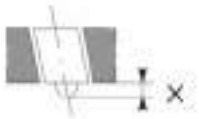
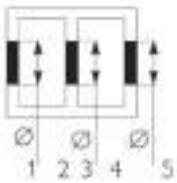
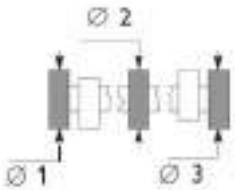
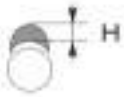
CLEARANCE DATA

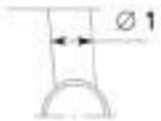
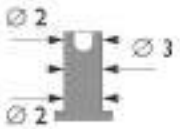
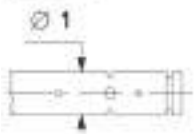
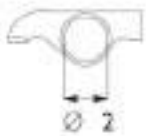
	Type		N45 MNA M10	N67 MNA M15
Cylinder unit and crankshaft components			mm	
	Cylinder barrels	Ø1	104.000 to 104.024	
	Spare pistons type: Size Outside diameter Pin housing	 X Ø 1 Ø 2	 55.9 103.730 to 103.748 38.010 to 38.016	
	Piston - cylinder barrels		0.252 to 0.294	
	Piston diameter	Ø 1	0.4; 0.8	
	Piston protrusion	X	0.28 to 0.52	
	Piston pin	Ø 3	37.994 to 38.000	
	Piston pin - pin housing		0.010 to 0.022	

Type		N45 MNA M10	N67 MNA M15
Cylinder unit and crankshaft components		mm	
	Split ring slots X 1 X 2 X 3	2.705 to 2.735 2.440 to 2.460 4.030 to 4.050	
	Split rings S 1 S 2 S 3	2.560 to 2.605 2.350 to 2.380 3.970 to 3.990	
	Split rings - slots 1 2 3	0.100 to 0.175 0.060 to 0.110 0.040 to 0.080	
	Split rings	0.4; 0.8	
	Split ring end opening in cylinder barrel: X 1 X 2 X 3	 0.30 to 0.40 0.60 to 0.80 0.30 to 0.55	
	Small end bush housing Ø 1 Big end bearing housing Ø 2	40.987 to 41.013 72.987 to 73.013	
	Small end bush diameter Outside Ø 4 Inside Ø 3 Spare big end half bearings S	 40.987 to 41.013 38.019 to 38.033 1.955 to 1.968	
	Small end bush - housing	0.266 to 0.566	
	Piston pin - bush	0.019 to 0.039	
	Big end half bearings	0.250 to 0.500	

Type			N45 MNA M10	N67 MNA M15
Cylinder unit and crankshaft components			mm	
	Size	X	-	
	Max. tolerance on connecting rod axis alignment	=	-	
	Journals	Ø 1	82.99 to 83.01	
	Crankpins	Ø 2	68.987 to 69.013	
	Main half bearings	S 1	2.456 to 2.464	
	Big end half bearings	S 2	1.955 to 1.968	
	Main bearings n° 1-7	Ø 3	87.982 to 88.008	
	n° 2-3-4-5-6	Ø 3	87.977 to 88.013	
	Half bearings - Journals n° 1-7		0.064 to 0.095	
	n° 2-3-4-5-6		0.059 to 0.100	
	Half bearings - Crankpins		0.033 to 0.041	
	Main half bearings Big end half bearings		+ 0.250 ; + 0.500	
	Shoulder journal	X 1	37,350 to 37,650	37,475 to 37,545
	Shoulder main bearing	X 2	31.730 to 32.280	
	Shoulder half-rings	X 3	37.28 to 37.38	
	Output shaft shoulder		0.095 to 0.270	

	Type		N45 MNA M10	N67 MNA M15
Cylinder head - timing system			mm	
	Valve guide seats on cylinder head	Ø 1	8.019 to 8.039	
	Valves:			
		Ø 4	7.943 to 7.963	
		α	60°	
		Ø 4	7.943 to 7.963	
		α	45°	
	Valve stem and guide		0.056 to 0.096	
	Housing on head for valve seat:			
		Ø 1	46.987 to 47.013	
		Ø 1	43.637 to 43.663	
	Valve seat outside diameter; valve seat angle on cylinder head:			
		Ø 2	47.063 to 47.089	
		α	60°	
		Ø 2	43.713 to 43.739	
		α	45°	
		X	0.356 to 1.102	
	Sinking	X	0.104 to 0.840	
	Between valve seat and head		0.050 to 0.102	
			0.050 to 0.102	
	Valve seats		-	

	Type		N45 MNA M10	N67 MNA M15
Cylinder head - timing system			mm	
	Valve spring height: free spring under a load equal to: 329 N 641 N	 H H 1 H 2	 63.50 49.02 38.20	
	Injector protrusion	X	non regolabile	
	Camshaft bush housings n° 1-7 Camshaft housings n° 2-3-4-5-6		59.222 to 59.248 54.089 to 54.139	
	Camshaft journals: 1 ➔ 7	 Ø	 53.995 to 54.045	
	Camshaft bush outside diameter:	Ø	59.222 to 59.248	
	Bush inside diameter	Ø	54.083 to 54.147	
	Bushes and housings on block		-	
	Bushes and journals		0.038 to 0.162	
	Cam lift: 	 H H	 11.02 10.74	

	Type		N45 MNA M10	N67 MNA M15
Cylinder head - timing system			mm	
	Tappet cap housing on block	Ø 1	-	
	Tappet cap outside diameter:	Ø 2 Ø 3	15.929 to 15.959 15.965 to 15.980	
	Between tappets and housings		-	
	Tappets		-	
	Rocker shaft	Ø 1	18.963 to 18.975	
	Rockers	Ø 2	19.000 to 19.026	
	Between rockers and shaft		0.025 to 0.063	

ENGINE OVERHAUL - ENGINE REMOVAL AT THE BENCH

Preface

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

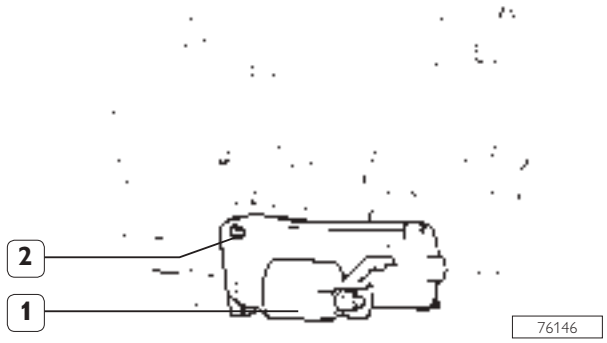
All operations of engine disassembly operations as well as overhaul operations must be executed by qualified engineers provided with the specific tooling and equipment required.

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



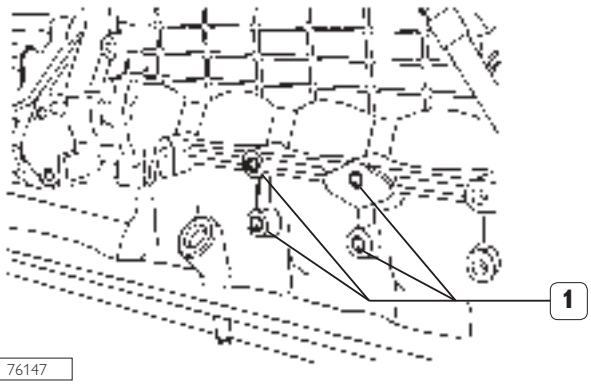
On the right hand side:

- ❏ 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

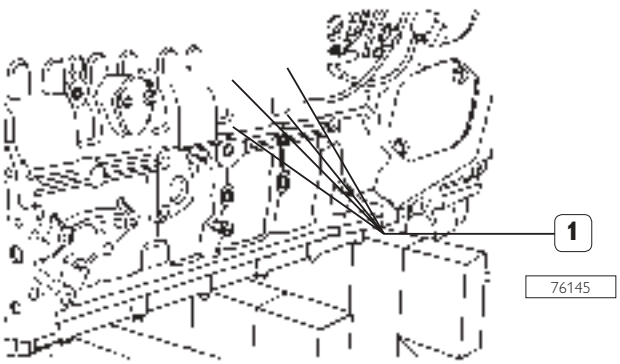


- ❏ Assemble the bracket bearing 99361037 using the four screw threaded ports (1).

On the left hand side:

- ❏ Remove the hose between sea water pump and heat exchanger;
- ❏ 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



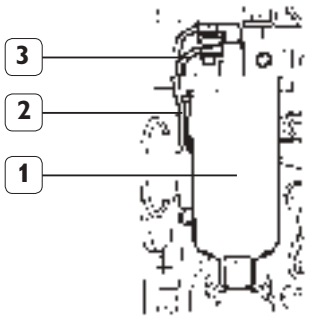
- ❏ Assemble the second bracket 99361037 throughout the screw-threaded ports (1);
- ❏ Lift the engine using the rocker arm 99360595 and put it on the turning stand 99322205;
- ❏ Drain the oil through the cap underneath the plug.

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 4

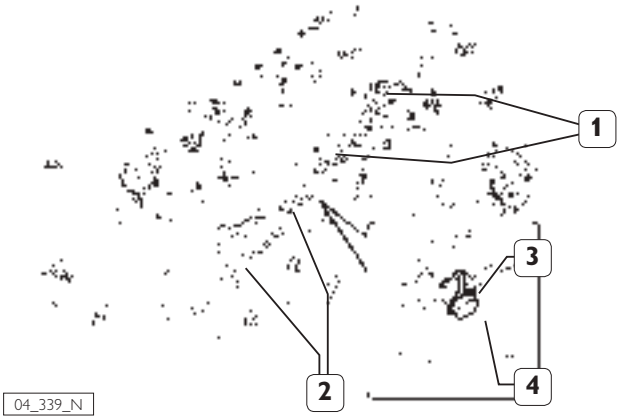


- ❑ Place a container under the fuel filter and screw out the condense drain faucet underneath said filter. Carry out complete drainage of the fuel contained therein;
- ❑ Screw out completely the faucet and, using equipment 99360076 disassemble oil filters (1);
- ❑ Disconnect fuel pipelines (2 and 3)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

Figure 5

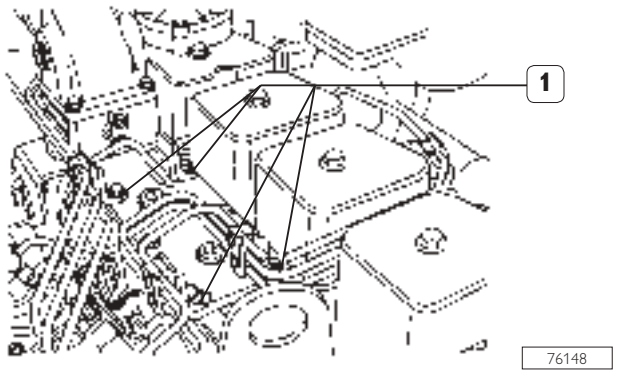
- ❑ Disconnect the LDA pipe (1) from the head and from the feed pump;
- ❑ Cap the ends of the pipelines as well as the feed pump and the engine head;
- ❑ Disassemble the pipes (2) that constitute the fuel recovery and supply between the pump and the injectors.

Figure 6



- ❑ Disconnect the supply pipe unit from the injectors (1);
- ❑ Remove fuel exhaust pipe (2) from the injectors by removing screw (4) and seal (3).

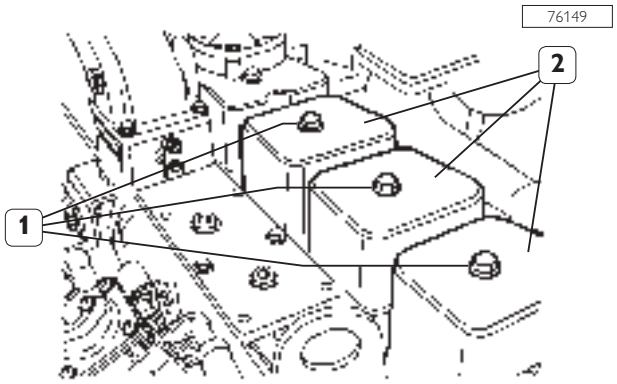
Figure 7



- ❑ Loosen the screws (1) holding the fixing brackets of such pipelines.

Pipe the pipeline ends.

Figure 8

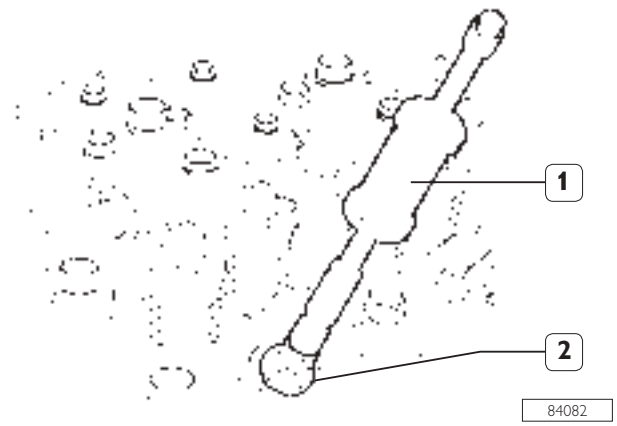


❏ Remove tappet caps: Loosen the fixing screws (1) and lift the caps (2); remove the gaskets.

CAUTION

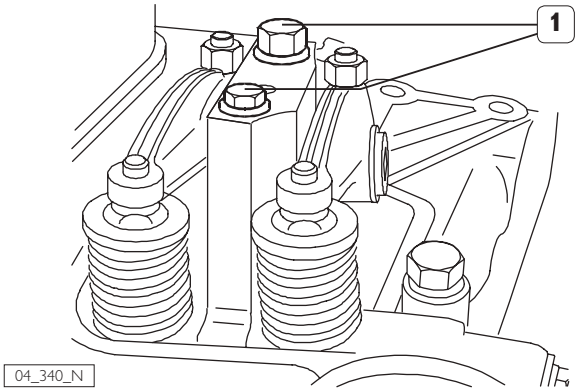
On the tappet cap there is a blow-by valve for the lubrication oil vapours.
All the gaskets shall always be replaced during assembly.

Figure 9



❏ Remove injectors (2) with tool 99340205 (1) and take out the cylinder head.

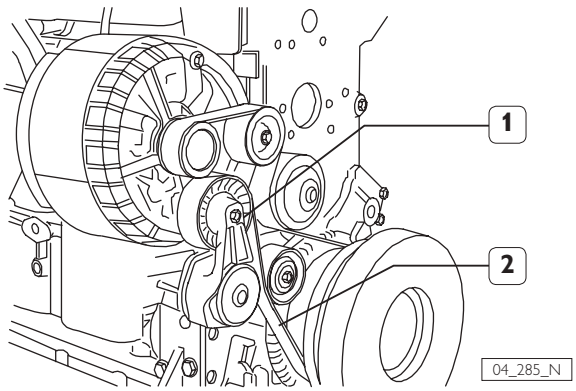
Figure 10



❏ Disassemble rocker arm bearings; loosen the two fixing screws (1) and remove the complete rocker armbearing; withdraw tappet rods;

❏ Repeat the operation for all the remaining rocker arm bearings.

Figure 11

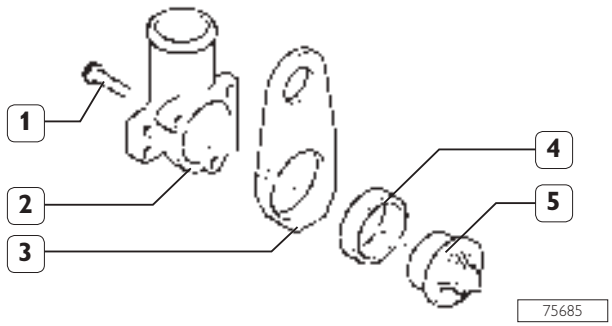


❏ Workon the drive belt tensor (1) and extract the belt (2) from the belt pulleys, from the water pump ones and from the belt rebound pulleys;

❏ Disassemble the belt tensor;

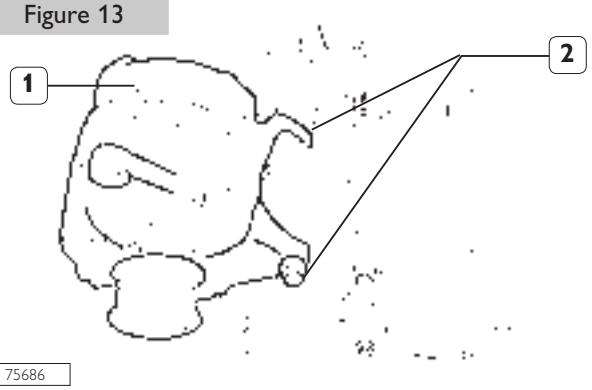
❏ Unloose the screw fixing the alternator to the upper bracket.

Figure 12



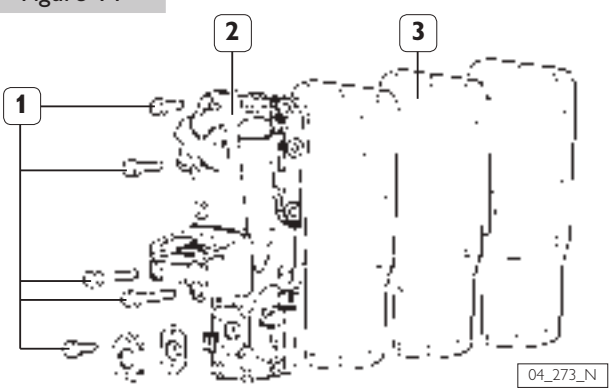
- ❏ Disassemble thermostat unit; loosen the three fixing screws (1) and disassemble the thermostat unit (2) together with the bracket (3); remove the gasket (4) and the thermostat (5);
- ❏ In order to facilitate head overhauling operations at the test bench keep bracket (3) assembled on it by fixing it with the thermostat unit screws.

Figure 13



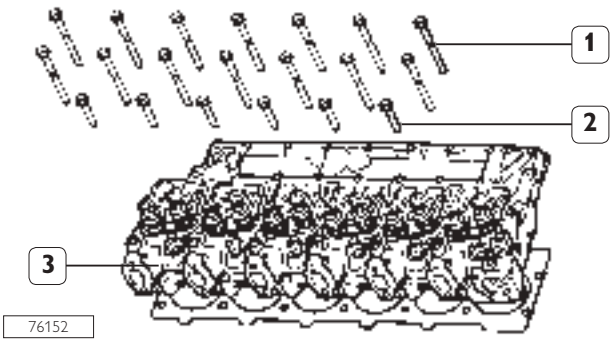
- ❏ Properly hold the alternator (1) separating it from its bearing by loosening the screw (2); remove screw nut and washer.

Figure 14



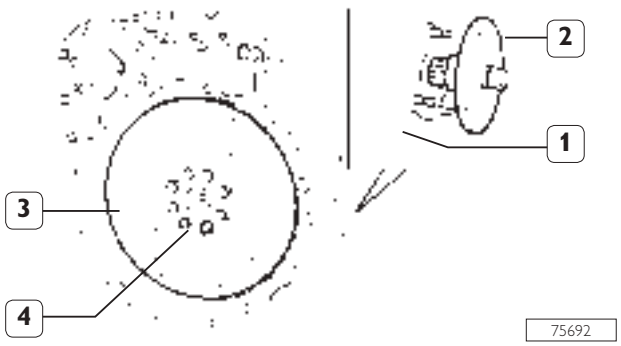
- ❏ Loosen the screws (1) and disassemble the oil filter/heat exchanger bearing (2), interlayer plate (6) and relating gaskets;
- ❏ Disassemble injection pump (see specific procedure).

Figure 15



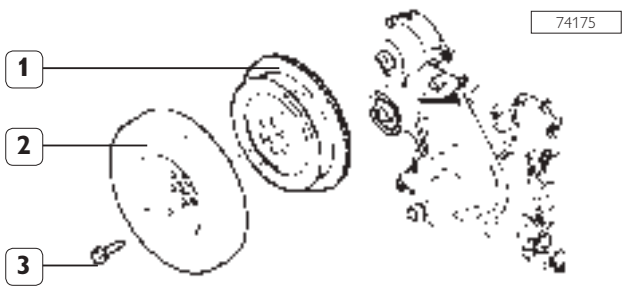
- ❏ Disassemble cylinder head; loosen the screws (1) and (2) fixing the cylinder head (3);
- ❏ Hook the brackets with metal ropes and, throughout a hoist withdraw cylinder head from the block.

Figure 16



- ❏ Apply the suitable tool (2) on the flywheel covering box (1) in order to lock flywheel (3) rotation. (use the starting motor fixing nuts and studs);
- ❏ Loosen the flywheel fixing screws (4) to engine drive shaft.

Figure 17

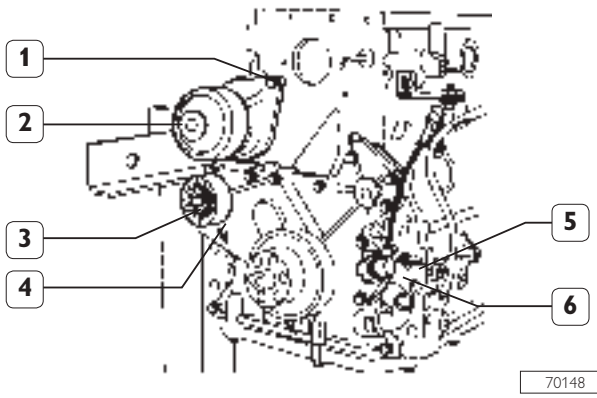


- ❏ Unloose the screws (3) and disassemble the damping flywheel (2) and the pulley (1);
- ❏ The tool for flywheel holding can help removal of damping flywheel (2) mounted on the pulley (1).

CAUTION

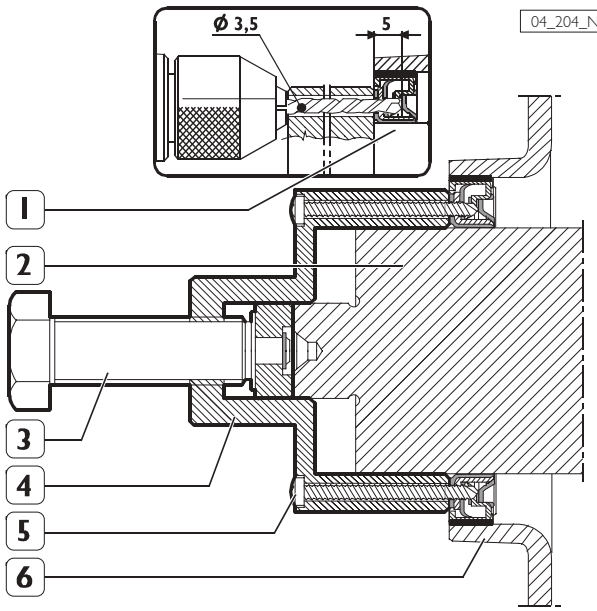
In some versions, the phonic wheel mounted on pulley (1) may be not present and pulley (1) can be different from the pulley shown in Figure 17.

Figure 18



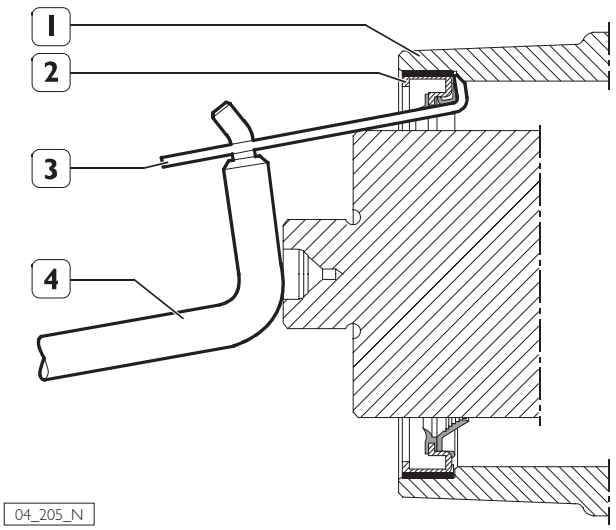
- ❏ Remove the screws (1) and disconnect the water pump (2);
- ❏ Remove the screw (3) and the roller (4);
- ❏ Remove the screw (5) and disconnect the engine speed sensor (6).

Figure 19



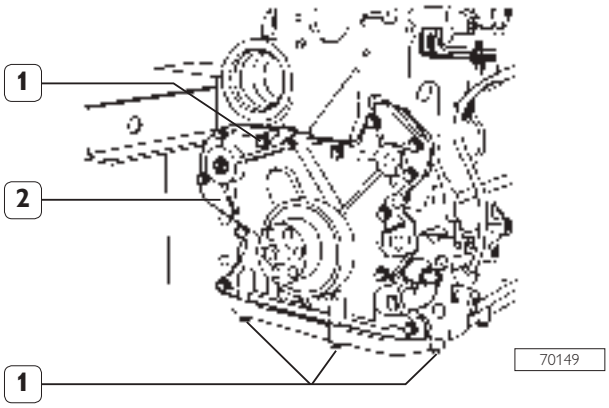
- ❏ Remove the engine drive shaft fixing ring from the front cover. Use the tool 99340055 (4) to operate on the front tang (2) of the engine drive shaft. Throughout the tool guide ports, drill the internal holding ring (1) using Ø 3.5 mm drill for a 5 mm depth;
- ❏ Fix the tool to the ring tightening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

Figure 20



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

Figure 21

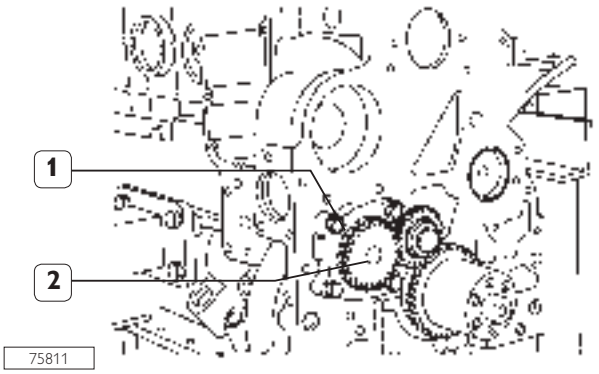


- ❏ Loosen the screws (1) and remove the front cover (2).

CAUTION

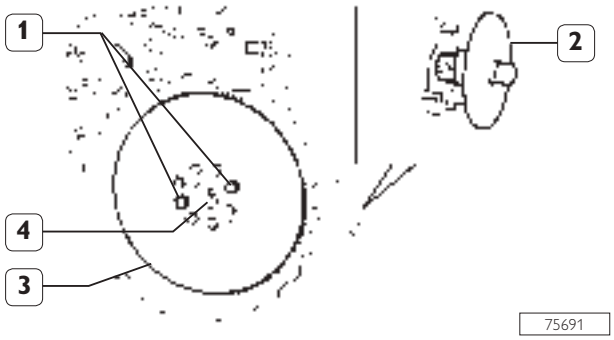
Take note of the screw (1) assembly position, since the screws have different length.

Figure 22



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

Figure 23

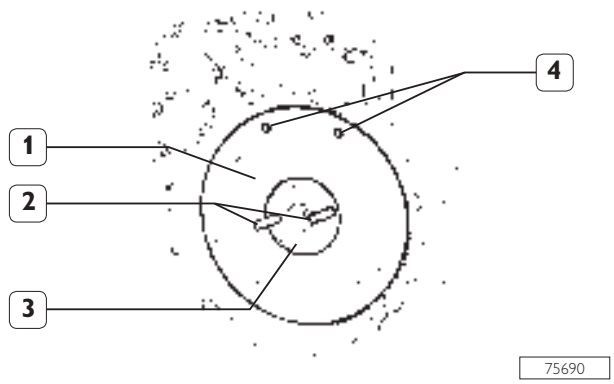


❏ Screw out the opposite screws (1) fromthe portswhere the withdrawal pins shall be introduced (see following picture);

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

❏ Remove the flywheel block tool (2).

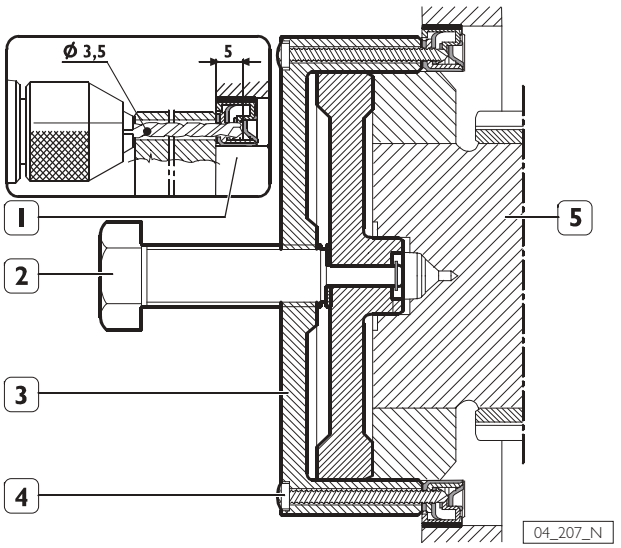
Figure 24



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

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

Figure 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;

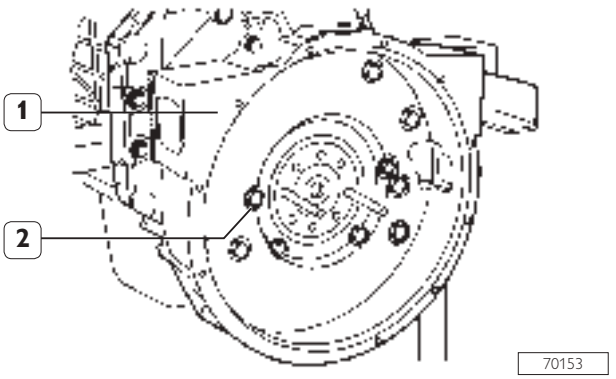
❏ Throughout the tool guide ports, drill the internal holding ring using Ø 3.5 mm drill for a 5mm depth;

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

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

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

Figure 26

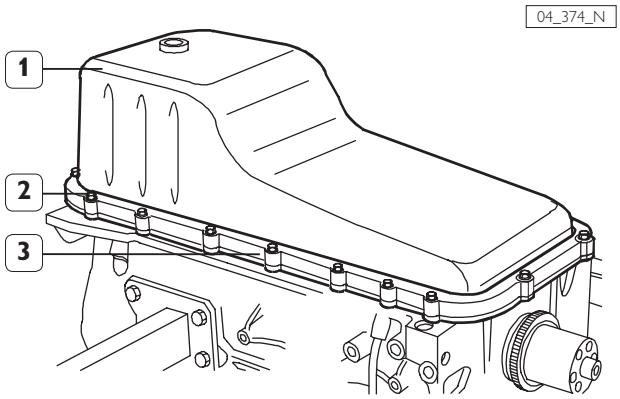


❏ Loosen the screws (2) and remove the flywheel cover box (1).

CAUTION

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

Figure 27



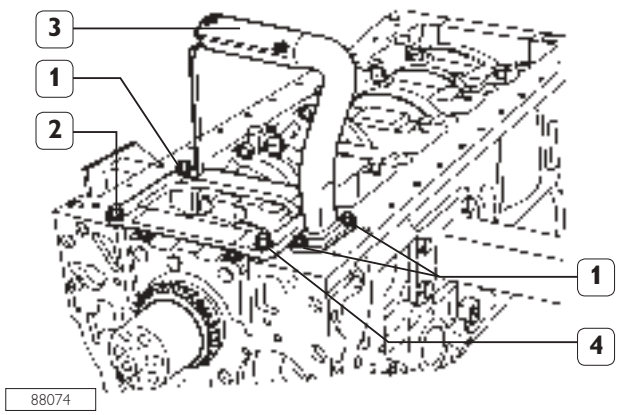
❏ Turn the engine upside-down;

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

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.

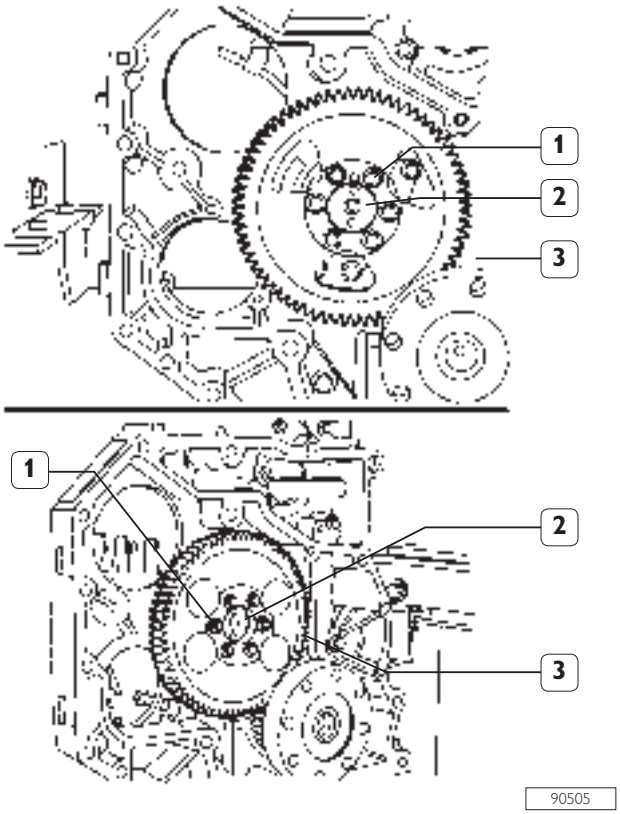
Figure 28



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

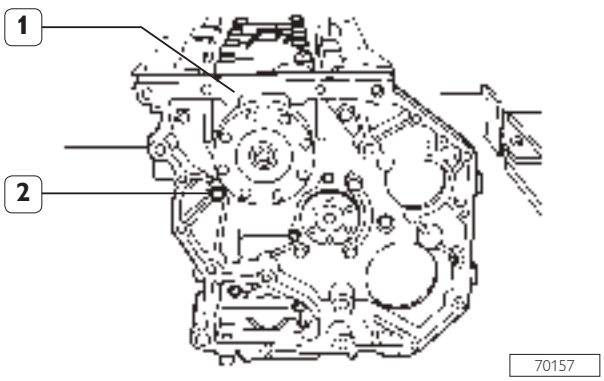
❏ Loosen the screws (2) and remove the stiffening plate (4).

Figure 29



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

Figure 30



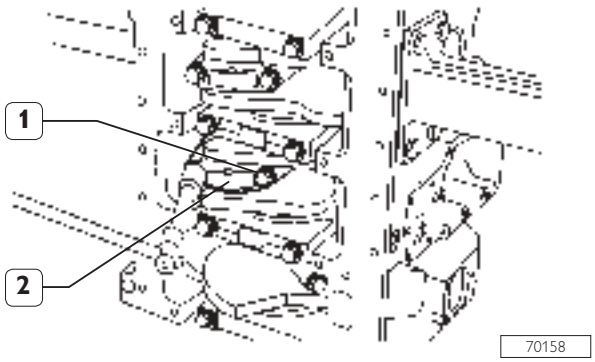
❏ Loosen the screws (2) and disassemble the timing gear-box (1).

CAUTION

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

CYLINDER UNIT

Figure 31

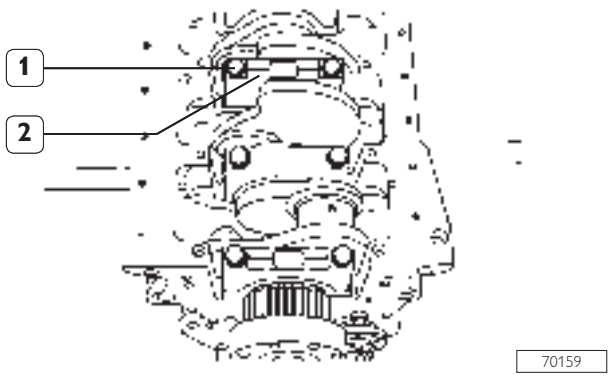


Remove the screws (1) fastening the connecting rod caps (2) and remove them.
Withdraw the pistons including the connecting rods from the top of the engine block.

CAUTION

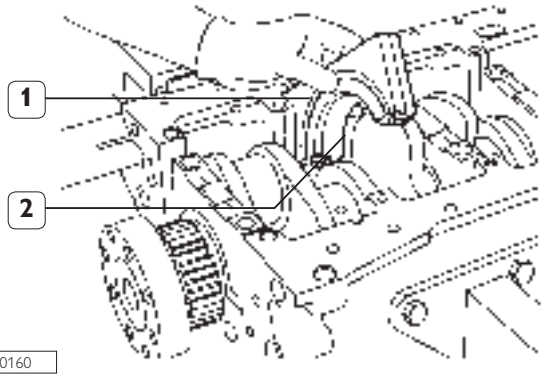
Keep the half-bearings into their housings since, in case of use, they shall be fitted in the same position found at removal.

Figure 32



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

Figure 33

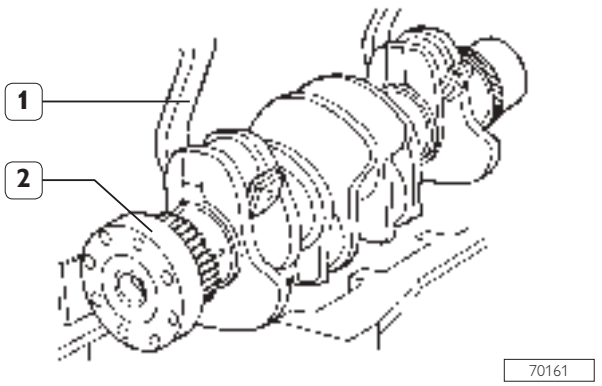


The second last main bearing cap (1) and the relevant support are fitted with shoulder half-bearing (2).

CAUTION

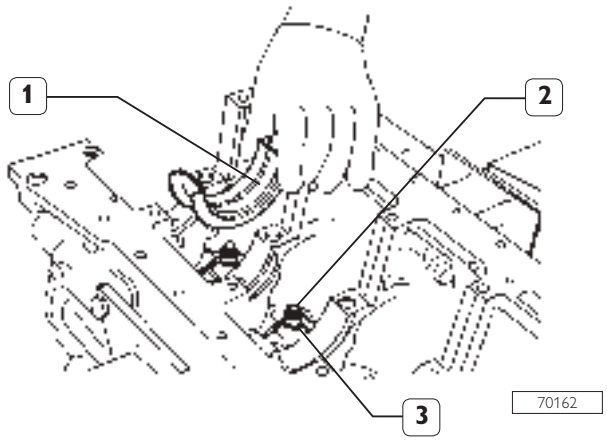
Take note of lower and upper half-bearing assembling positions since in case of reuse they shall be fitted in the same position found at removal.

Figure 34



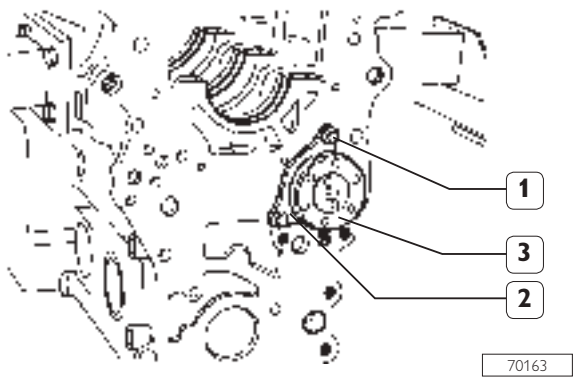
Use tool 99360500 (1) and hoist to remove the crankshaft (2) from the block.

Figure 35



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

Figure 36

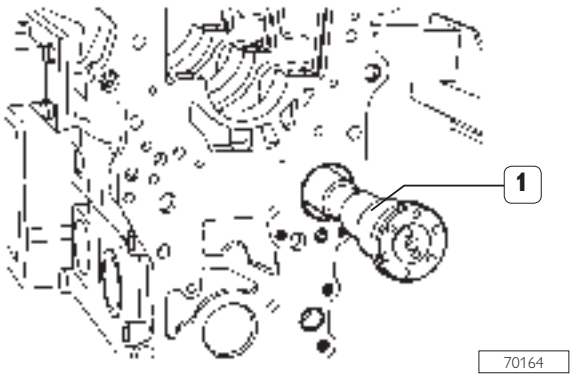


Remove the screws (1) and disconnect camshaft (3) retaining -plate (2).

CAUTION

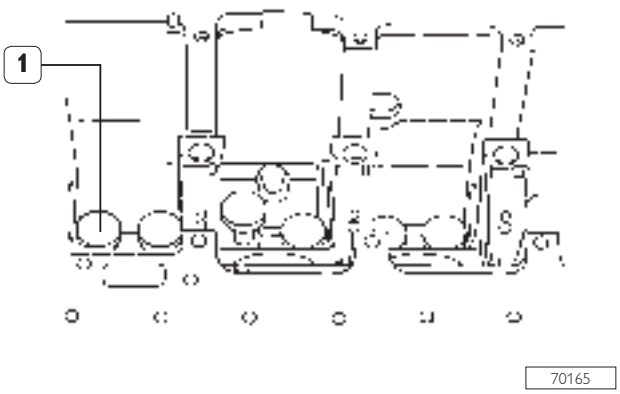
Take note of plate (2) assembling position.

Figure 37



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

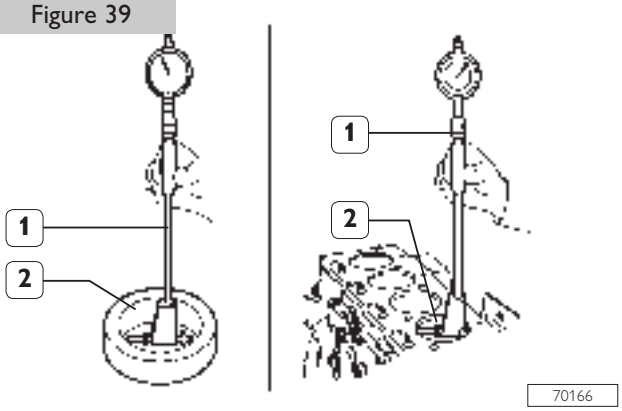
Figure 38



Withdraw the tappets (1) from the engine block.

Checks and measurements

Figure 39

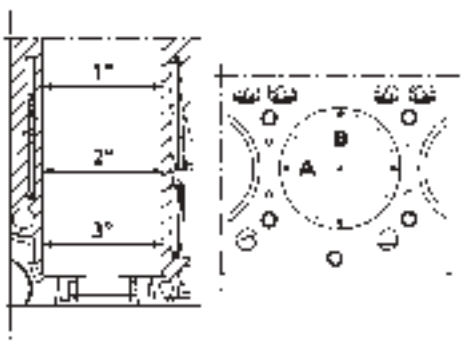


Once engine is disassembled, clean accurately the cylinder-block assembly.
Use the proper rings to handle the cylinder unit.
The engine block shall not show cracks.
Check operating plug conditions and replace them in case of uncertain seal or if rusted.
Inspect cylinder barrel surfaces; they shall be free from seizing, scores, ovalisation, taper or excessive wear.
Inspection of cylinder barrel bore to check ovalisation, taper and wear shall be performed using the bore dial gauge 99395687 (1) fitted with the dial gauge previously set to zero on the ring gauge (2) of the cylinder barrel diameter.

CAUTION

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

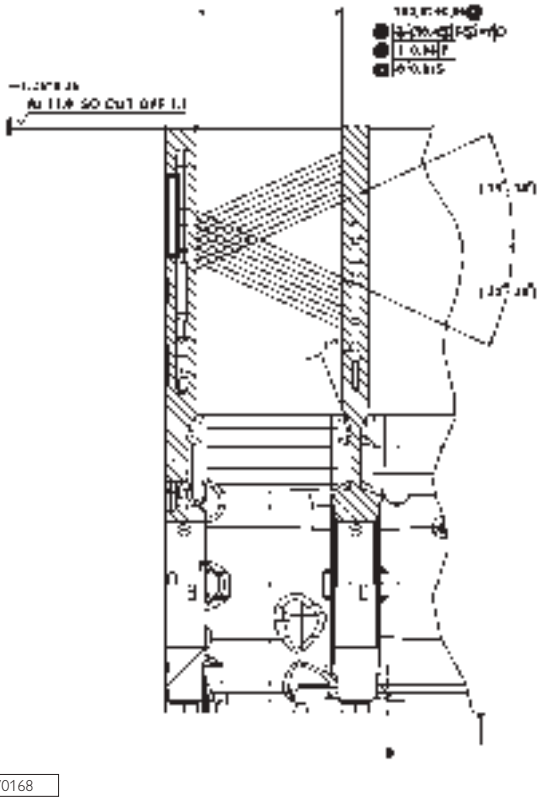
Figure 40



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

Should ovalisation, taper or wear be found, bore and grind the cylinder barrels. Cylinder barrel regrinding shall be performed according to the spare piston diameter oversized by 0.5 mm and to the specified assembling clearance.

Figure 41



CAUTION

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

Check main bearing housings as follows:

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

Replace if higher value is found.

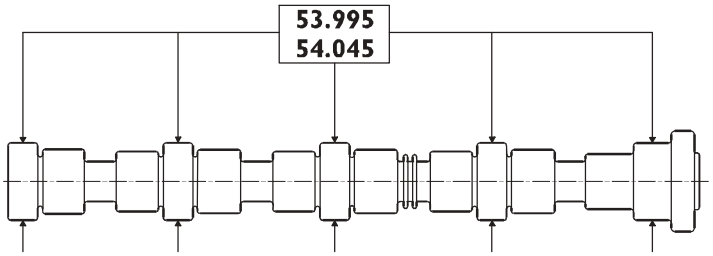
Checking head supporting surface on cylinder unit

After checking for possible deformation zones, perform the smoothing of supporting surface using a grinder.
Planarity error shall not exceed 0.075 mm.
Check cylinder unit operating plug (1) conditions, replace them in case of uncertain seal or if rusted.

TIMING SYSTEM

N45 MNA M10

Figure 42

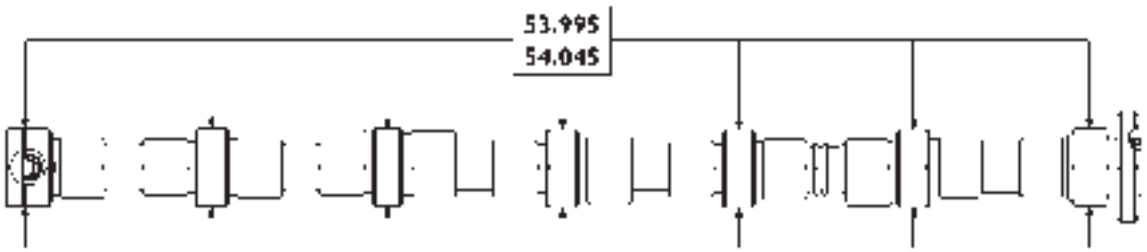


04_429_N

MAIN DATA ABOUT CAMSHAFT PINS (4 cylinders)

N67 MNA M15

Figure 43



04_347_N

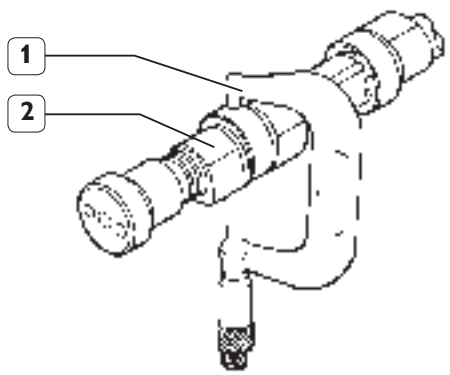
MAIN DATA ABOUT CAMSHAFT PINS (6 cylinders)

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

Checking cam lift and pin alignment

Set the camshaft on the tailstock and using a centesimal dial 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 shall be: 6.045 mm for exhaust cams and 7.582 mm for intake cams, in case of different values replace the camshaft.

Figure 44

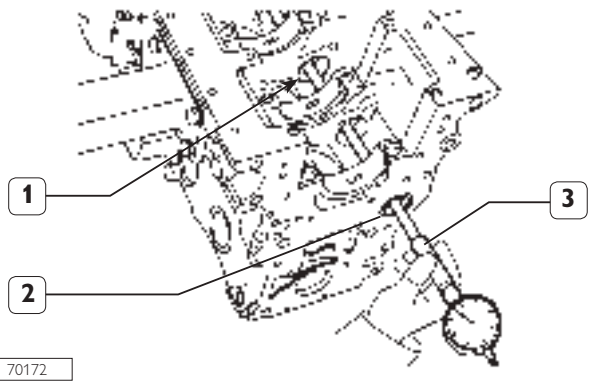


70171

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

Bushes

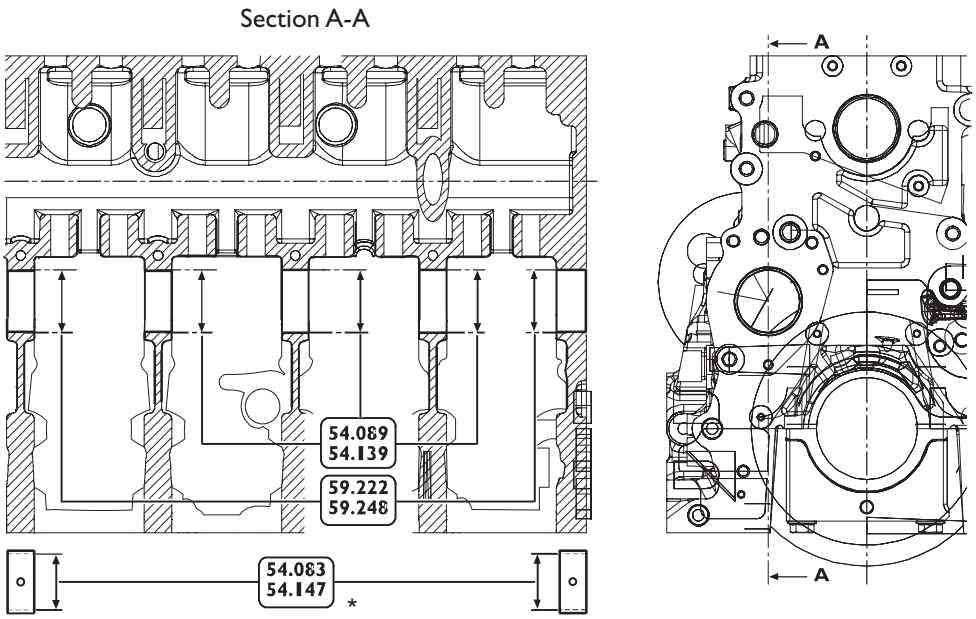
Figure 45



70172

Camshaft bushes (2) shall 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 shall be performed on two perpendicular axes.

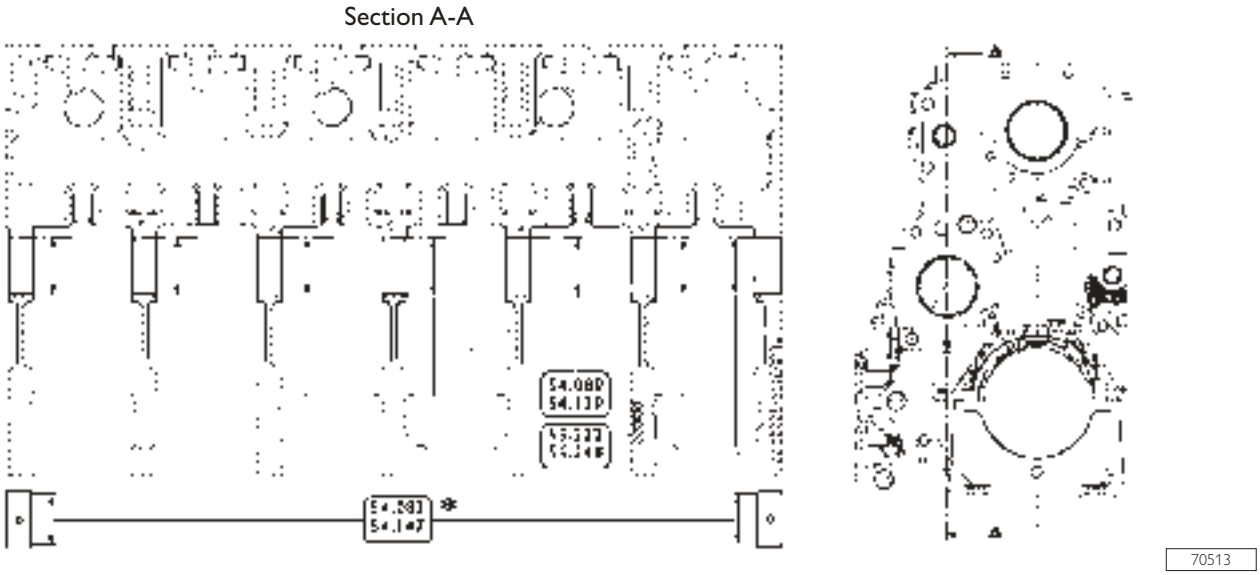
Figure 46



CAMSHAFT BUSH AND HOUSING MAIN DATA

* Value to be obtained after driving the bushes.

Figure 47

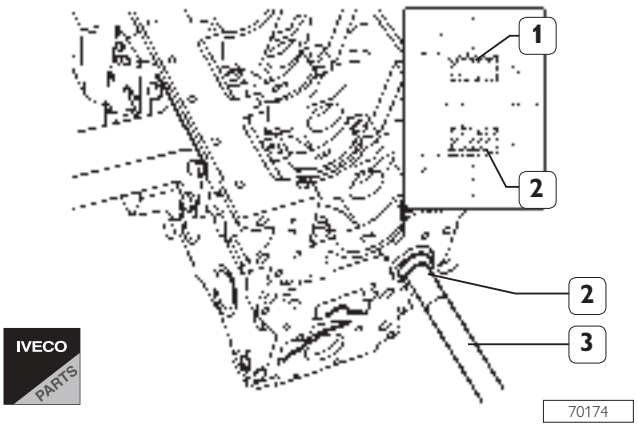


CAMSHAFT BUSH AND HOUSING MAIN DATA

* Value to be obtained after driving the bushes.

Bush replacement

Figure 48



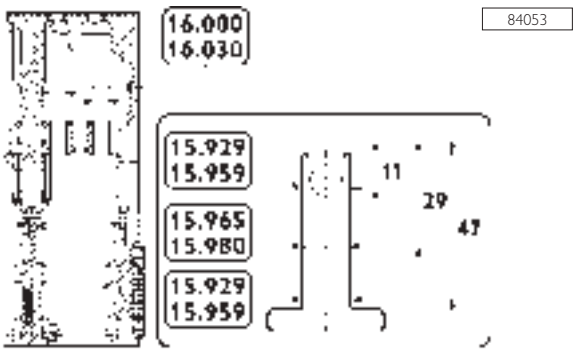
To replace front and rear bushes (1), remove and refit them using the beater 99360362 (2) and the handgrip 99370006 (3).

CAUTION

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

Tappets

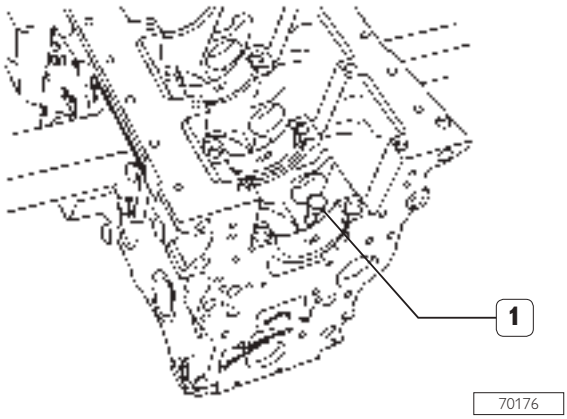
Figure 49



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

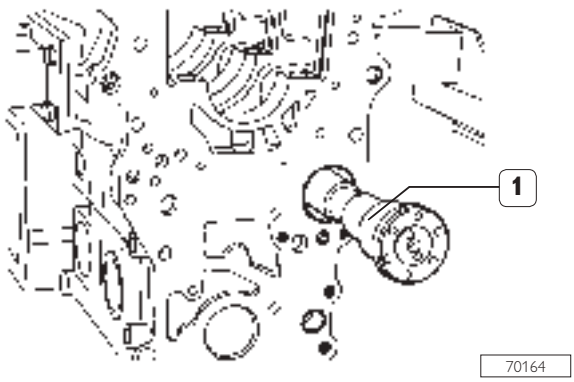
Fitting tappets - camshaft

Figure 50



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

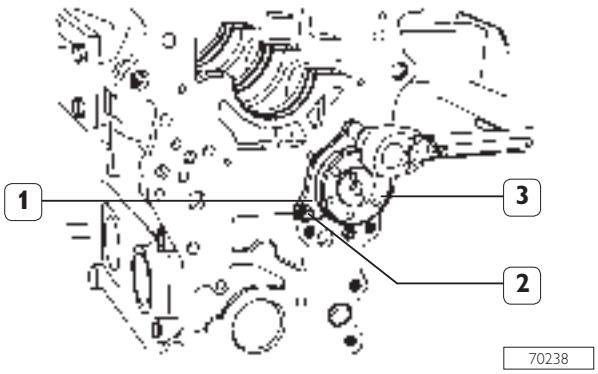
Figure 51



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

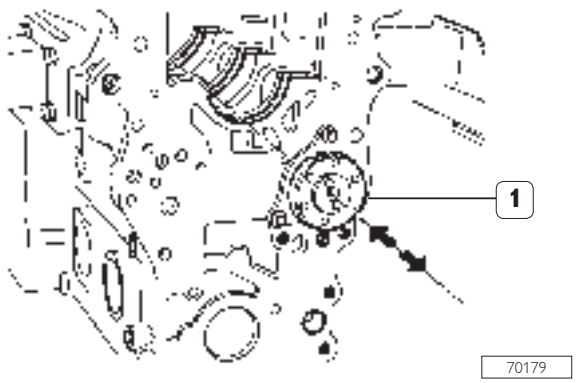
OUTPUT SHAFT

Figure 52



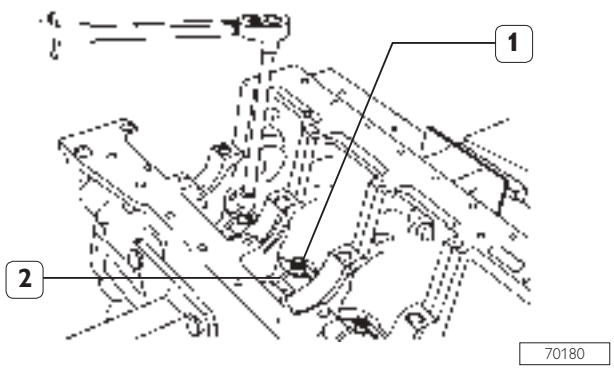
Set camshaft (3) retaining plate (1) with the slot facing the top of the engine block and the marking facing the operator, then tighten the screws (2) to the specified torque.

Figure 53



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

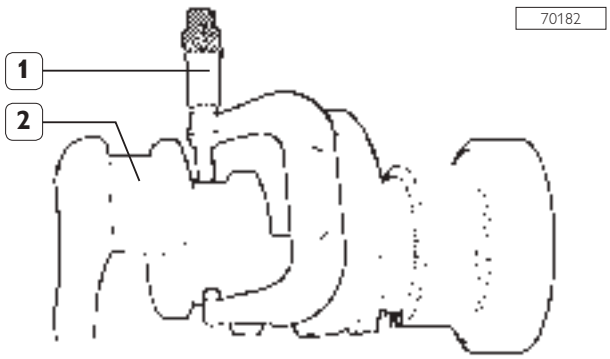
Figure 54



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

Measuring journals and crankpins

Figure 55



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 54.

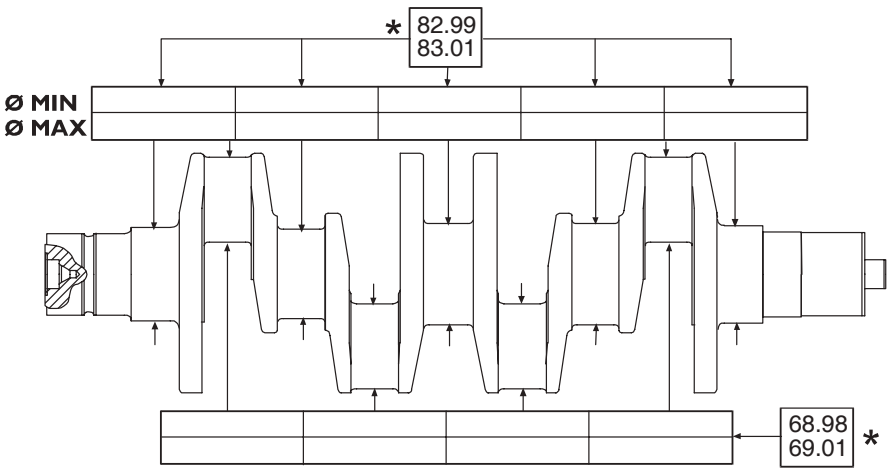
Undersize classes are : 0.250 - 0.500 mm.

CAUTION

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

Measuring journals and crankpins (4 cylinders)

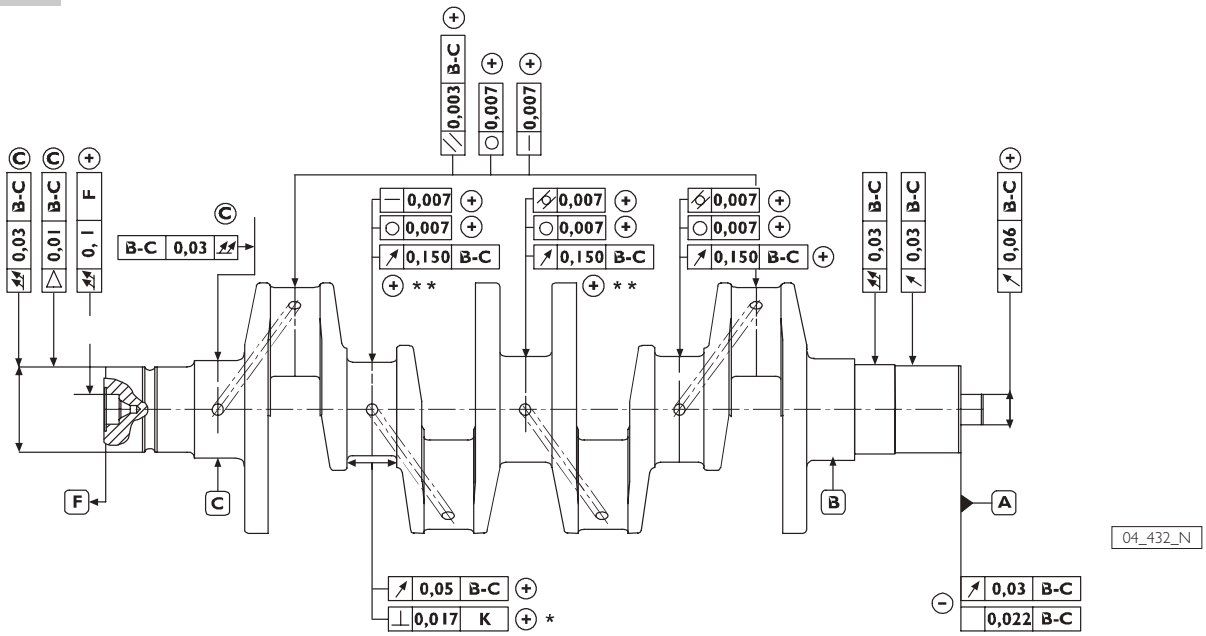
Figure 56



FILL THIS TABLE WITH OUTPUT SHAFT JOURNAL AND CRANKPIN MEASURED VALUES

* Rated value.

Figure 57

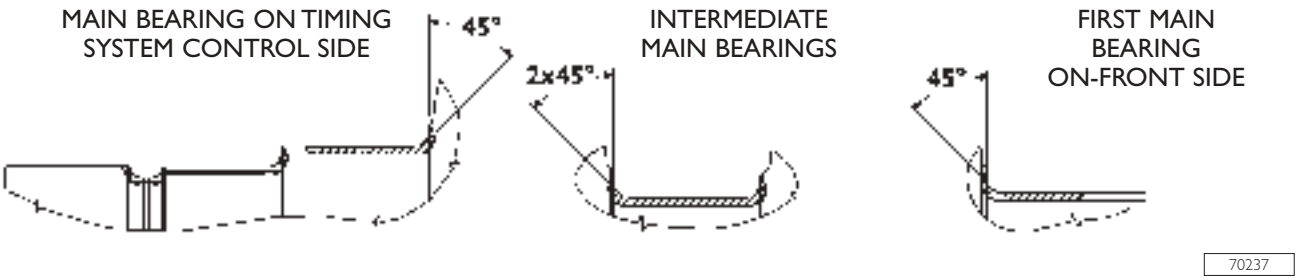


MAIN OUTPUT SHAFT TOLERANCES

* Measured on a radius greater than 45.5 mm.

** ⟋ 0.500 between adjacent main journals.

Figure 58

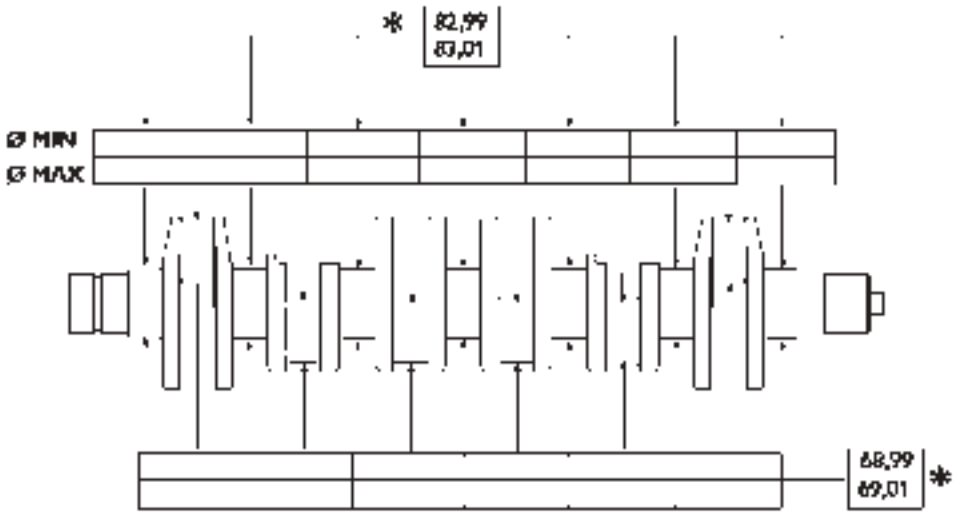


Tolerances	Tolerance characteristic	Graphic symbol
Shape	Roundness	○
	Cilindricity	⌭
	Parallelism	//
Direction	Verticality	⊥
	Straightness	—
Position	Concentricity or coaxiality	◎
	Circular oscillation	↗
Oscillation	Total oscillation	⌰
	Taper	⌲

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

Measuring journals and crankpins (6 cylinders)

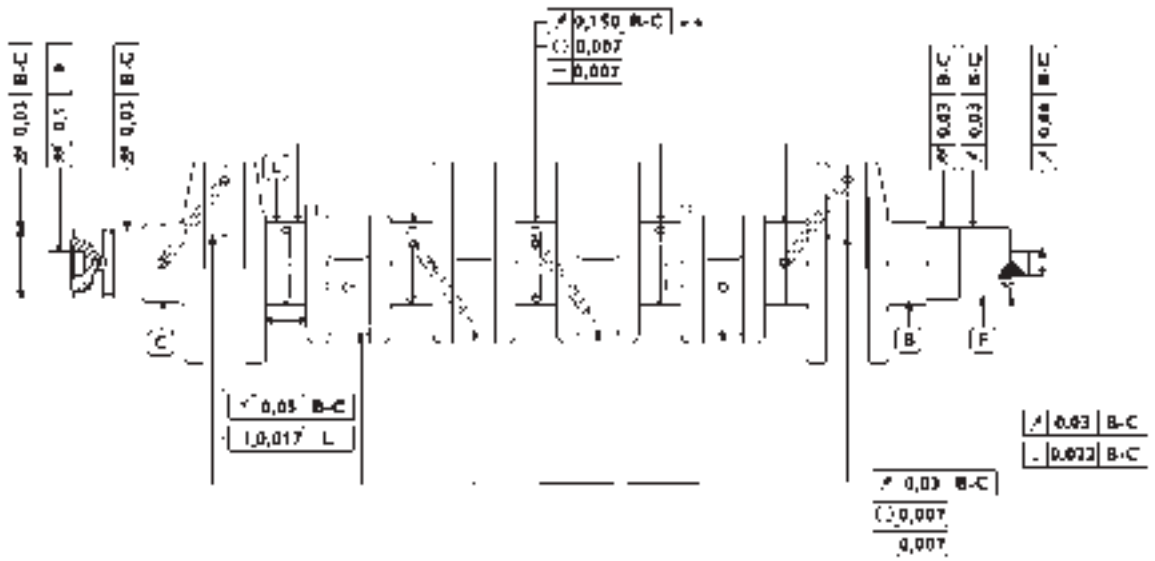
Figure 59



FILL THIS TABLE WITH OUTPUT SHAFT JOURNAL AND CRANKPIN MEASURED VALUES

* Rated value.

Figure 60

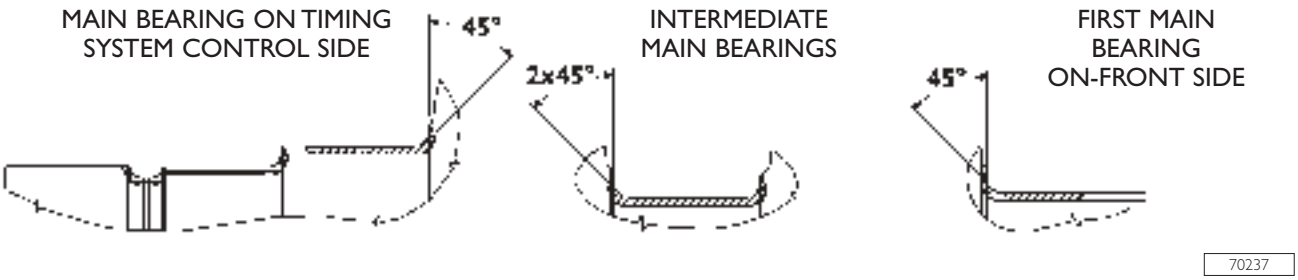


MAIN OUTPUT SHAFT TOLERANCES

* Measured on a radius greater than 45.5 mm.

** ↗ 0.500 between adjacent main journals.

Figure 61

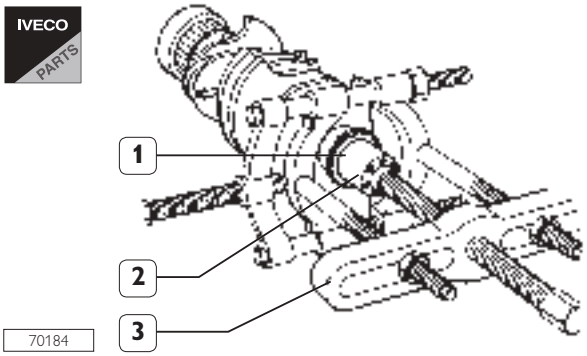


Tolerances	Tolerance characteristic	Graphic symbol
Shape	Roundness	○
	Cilindricity	⌭
	Parallelism	//
Direction	Verticality	⊥
	Straightness	—
Position	Concentricity or coaxiality	◎
	Circular oscillation	↗
Oscillation	Total oscillation	⌰
	Taper	⌲

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

Replacing oil pump control gear

Figure 62

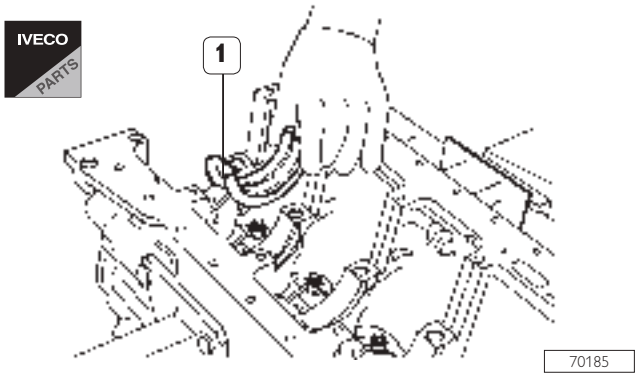


Check that gear toothing (1) is not damaged or worn, otherwise remove it using the proper puller (3).

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 63



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.

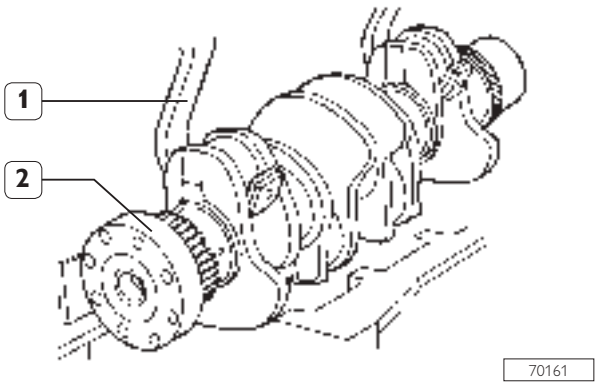
CAUTION

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

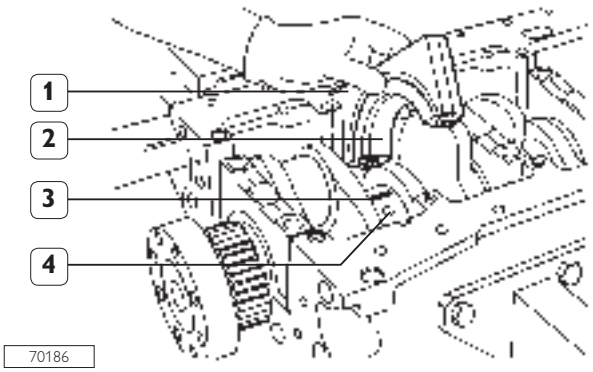
Finding journal clearance

Figure 64



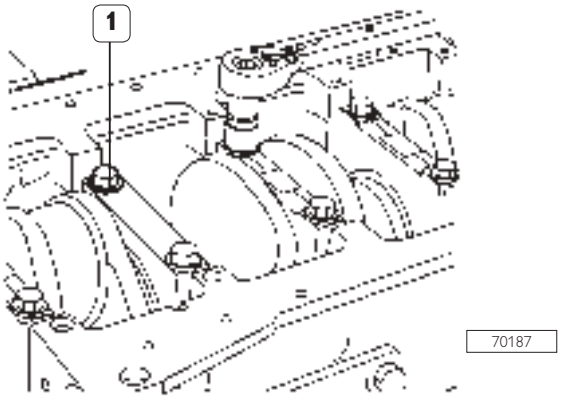
Refit the crankshaft (2).
Check the backlash between crankshaft main journals and the relevant bearings as follows:

Figure 65



- ❏ 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.

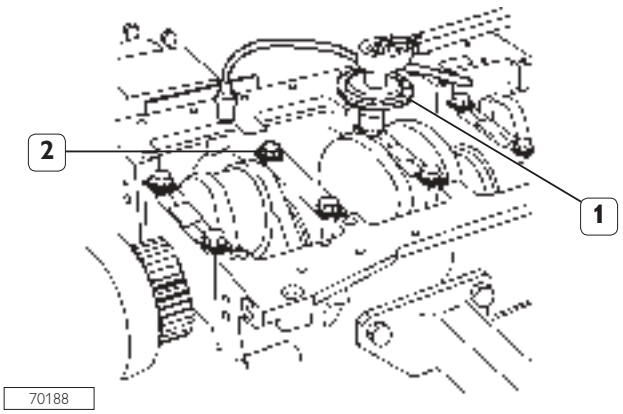
Figure 66



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

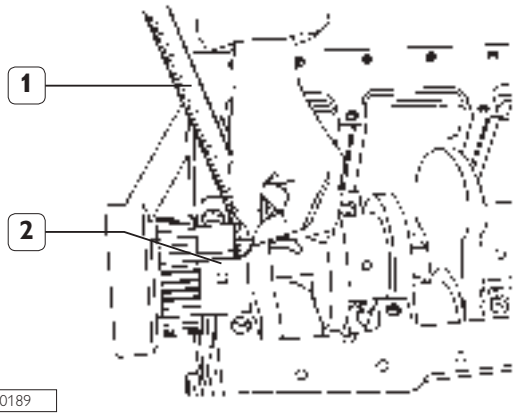
- ❏ 1st stage, with torque wrench to 50 ± 6 Nm;
- ❏ 2nd stage, with torque wrench to 80 ± 6 Nm.

Figure 67



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

Figure 68

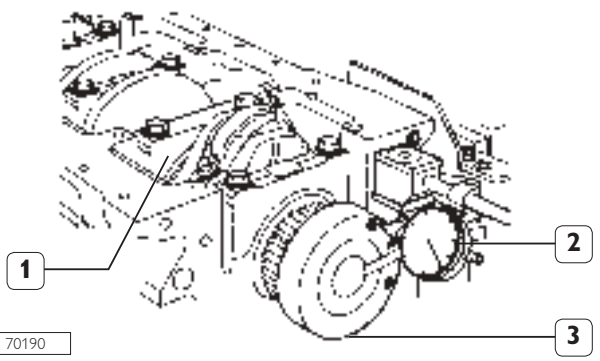


- ❏ Remove caps from supports.

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

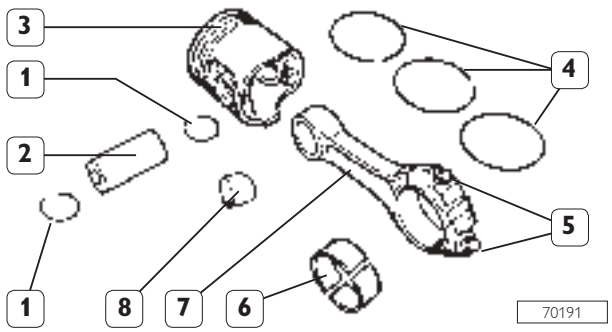
Figure 69



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 last rear support (1) and repeat the clearance check between crankshaft pins and main half bearings.

CONNECTING ROD - PISTON ASSEMBLY

Figure 70



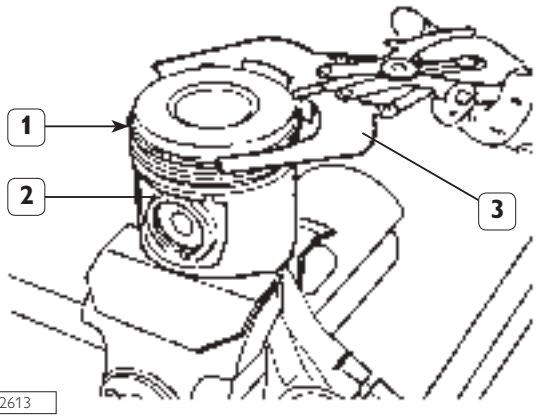
CONNECTING ROD - PISTON ASSEMBLY COMPONENTS

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

CAUTION

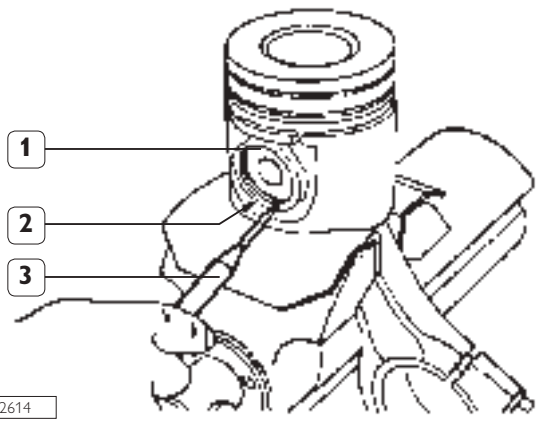
Pistons are supplied from parts with 0.5 mm oversize.

Figure 71



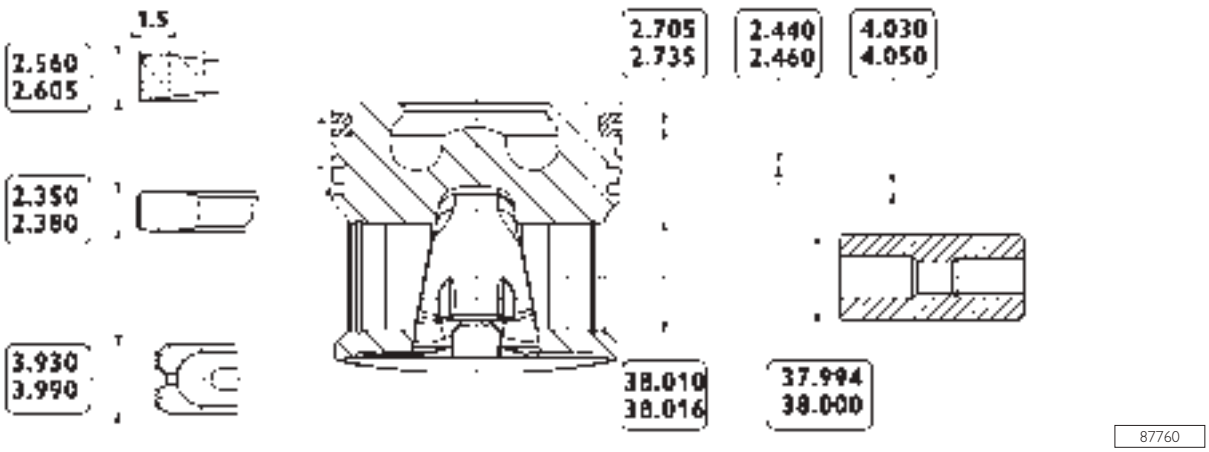
Remove split rings (1) from piston (2) using pliers 99360183 (3).

Figure 72



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

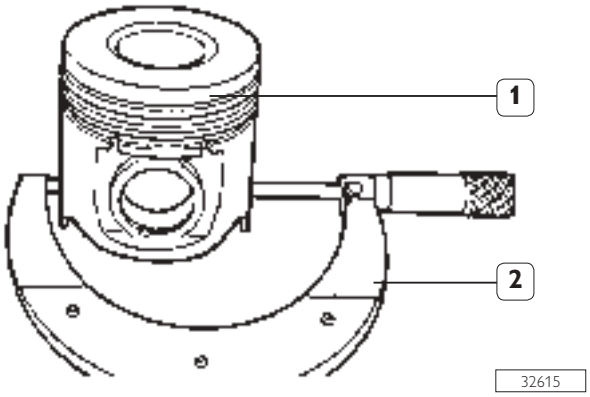
Figure 73



MAIN DATA CONCERNING KS. PISTON, PINS AND SPLIT RINGS

Measuring piston diameter

Figure 74

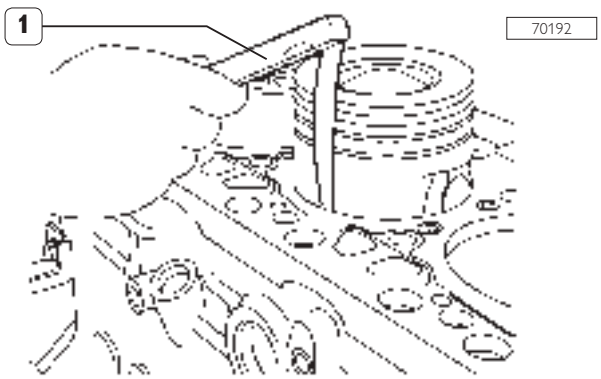


❏ Using a micrometer (2), measure the diameter of the piston (1) to determine the assembly clearance.

CAUTION

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

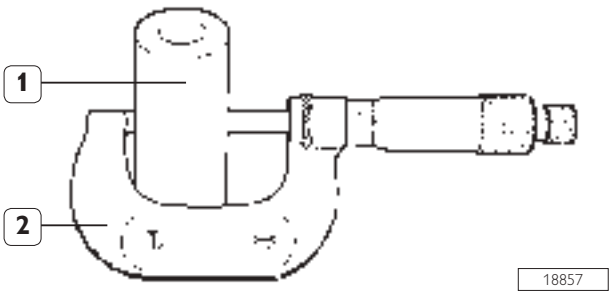
Figure 75



❏ 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

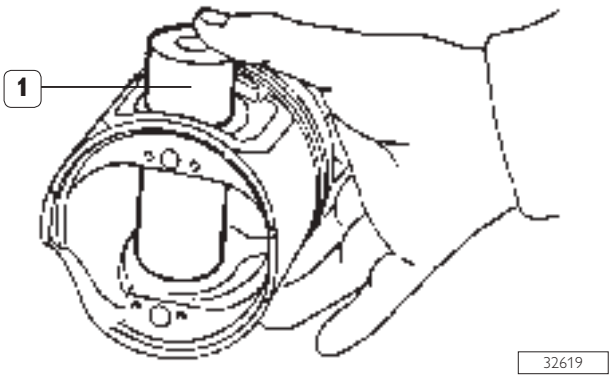
Figure 76



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

Conditions for proper pin-piston coupling

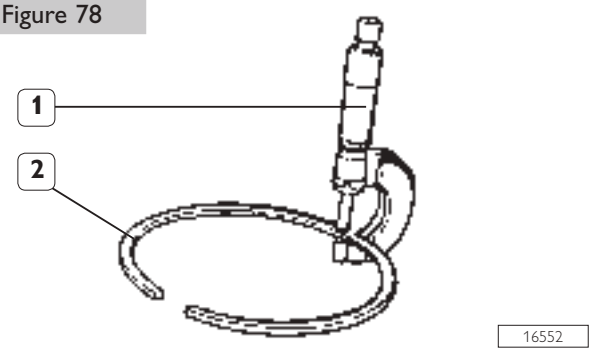
Figure 77



❏ Lubricate the pin (1) and its seat on piston hubs with engine oil; the pin shall be fitted into the piston with a slight finger pressure and shall not be withdrawn by gravity.

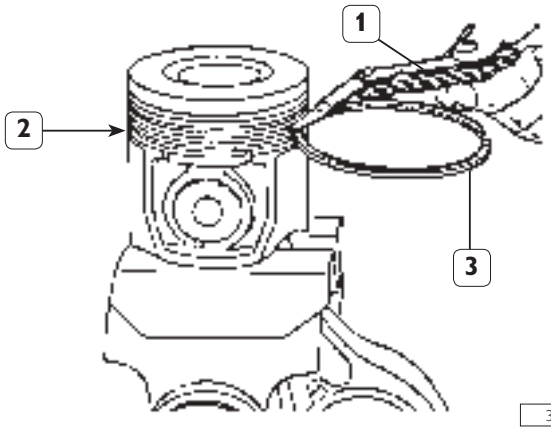
Split rings

Figure 78



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

Figure 79



❏ 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 80

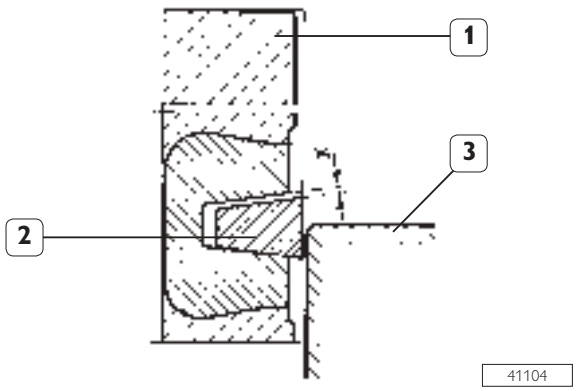
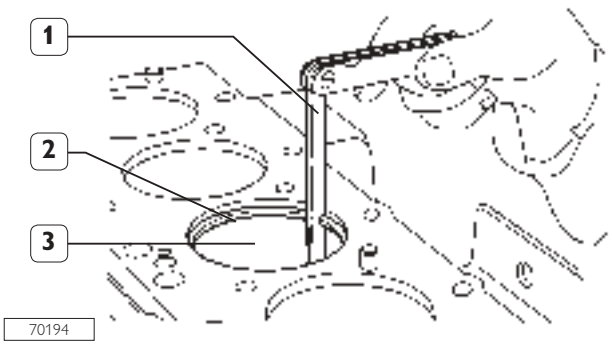


DIAGRAM FOR MEASURING THE CLEARANCE X BETWEEN THE FIRST PISTON SLOT AND THE TRAPEZOIDAL RING

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

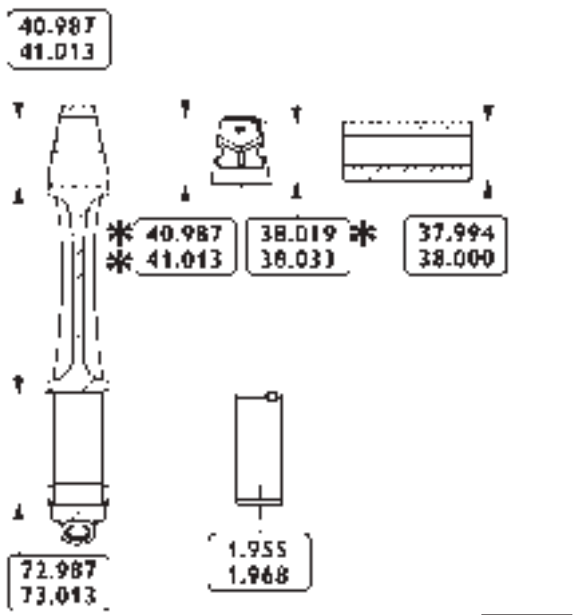
Figure 81



❏ 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 82



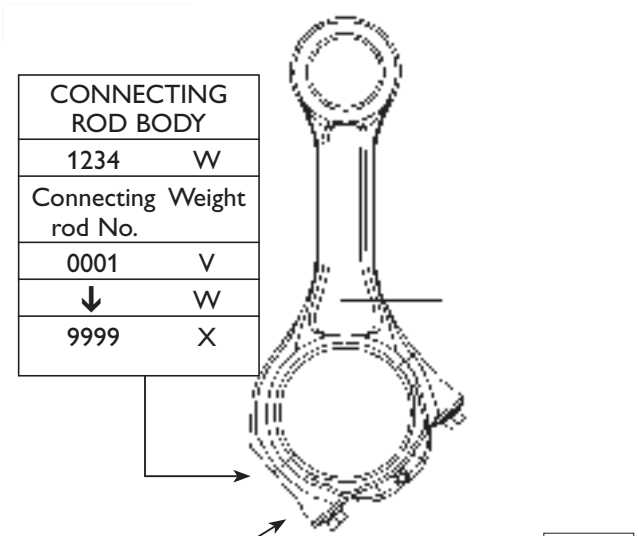
MAIN DATA FOR CONNECTING ROD, BUSH, PISTON PIN AND HALF BEARINGS

* 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.



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:
  - S V, 1820 to 1860 (yellow marking);
  - S W, 1861 to 1900 (green marking);
  - S X, 1901 to 1940 (blue marking).

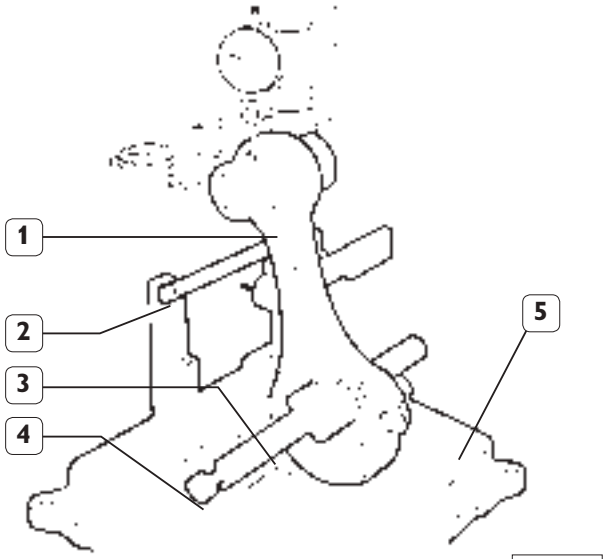
Spare connecting rods are of the W class with green marking (see position of * in Fig. 78).
Material removal is not allowed.

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

Checking connecting rods

Figure 84



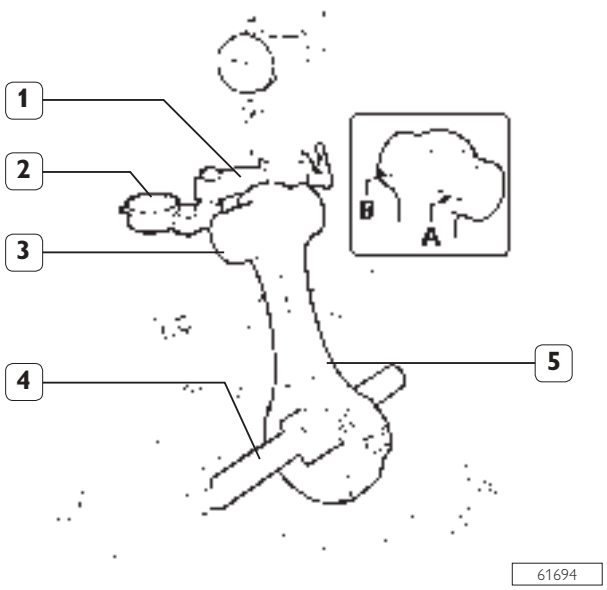
61696

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 85

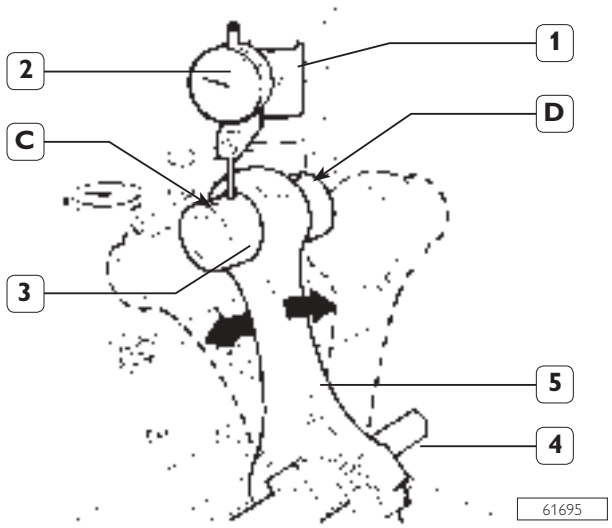


61694

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 shall not exceed 0.08 mm.

Checking bending

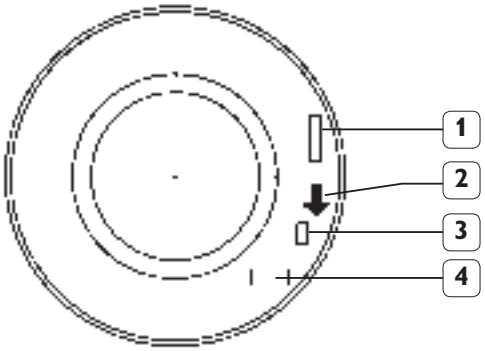
Figure 86



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 shall not exceed 0.08 mm.

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

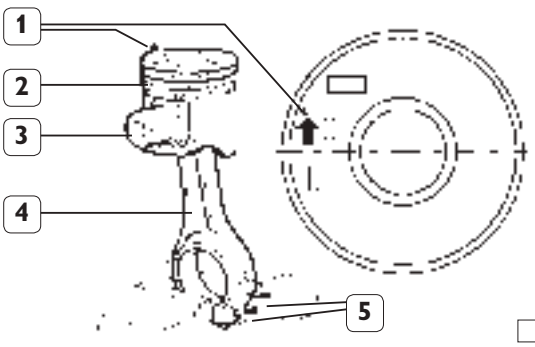
Figure 87



The piston crown is marked as follows:

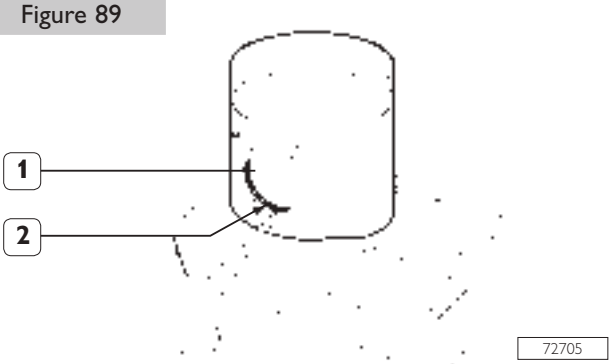
1. Part number and design modification number;
2. Arrow showing piston assembling direction into cylinder barrel, this arrow shall face the front key of the engine block;
3. Marking showing 1st slot insert testing;
4. Manufacturing date.

Figure 88



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.

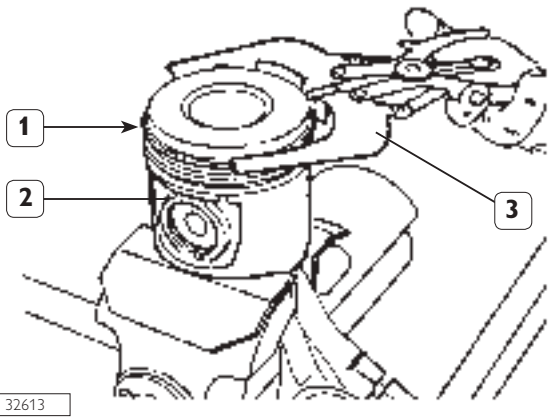
Figure 89



Insert split rings (2) for locking pin (1).

Fitting split rings

Figure 90



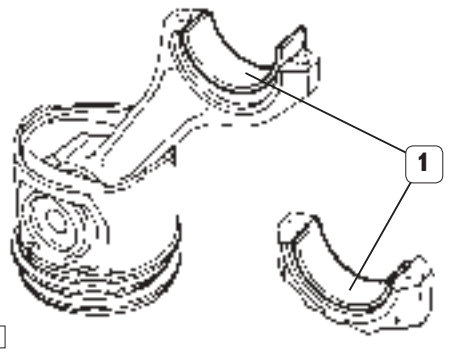
Use pliers 99360183 (3) to fit the split rings (1) on the piston (2).
Split rings shall be fitted with the marking "TOP" facing upwards and their openings shall be displaced with each other by 120°.

CAUTION

Split rings are supplied spare with the following sizes:

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

Figure 91



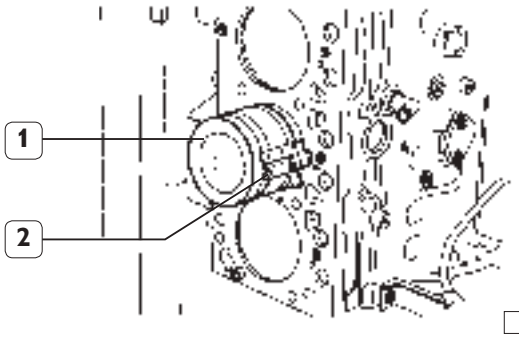
Fit half bearings (1) on connecting rod and cap.

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 92



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

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

Figure 93

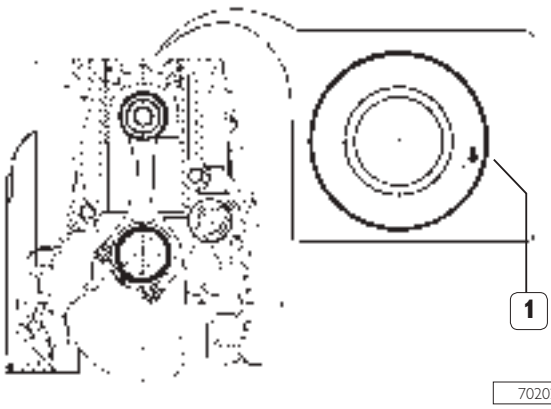
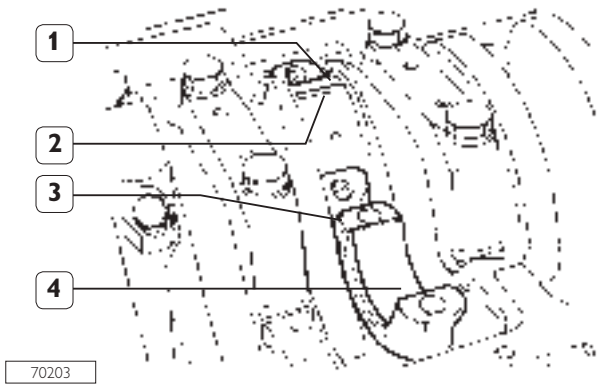


DIAGRAM FOR CONNECTING ROD-PISTON ASSEMBLY FITTING INTO BARREL

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

Finding crankpin clearance

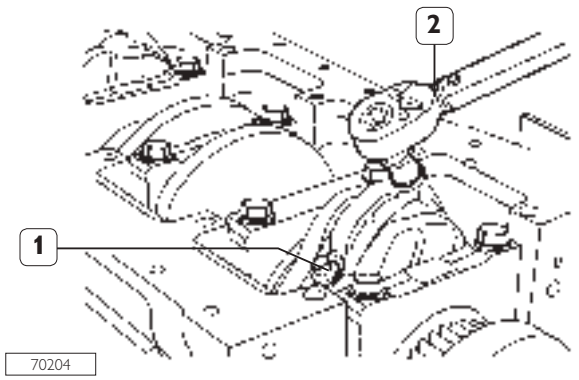
Figure 94



To measure the clearance proceed as follows:

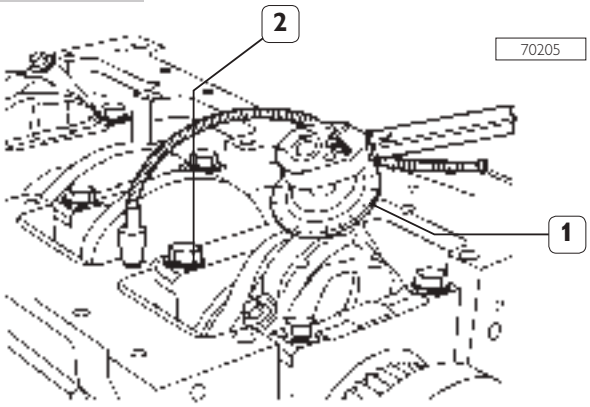
- ❏ Clean the parts accurately and remove any trace of oil;
- ❏ Set a piece of calibrated wire (2) on the output shaft pins (1);
- ❏ Fit the connecting rod caps (3) with the relevant half bearings (4).

Figure 95



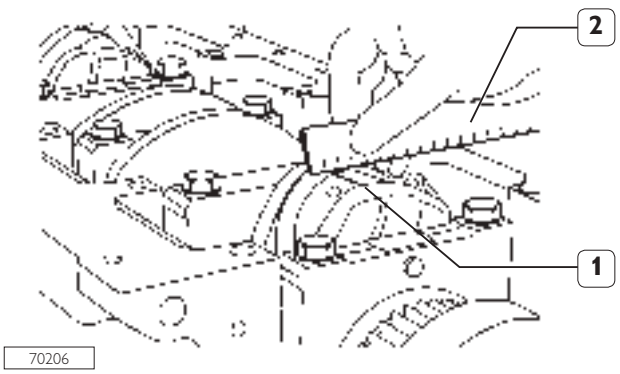
- ❏ Lubricate the screws (1) with engine oil and then tighten them to the specified torque using the torque wrench (2).

Figure 96



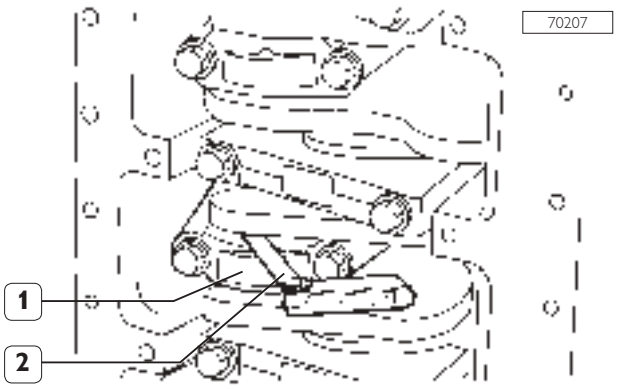
- ❏ Apply tool 99395216 (1) to the socket wrench and tighten screws (2) of 60°.

Figure 97



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

Figure 98



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

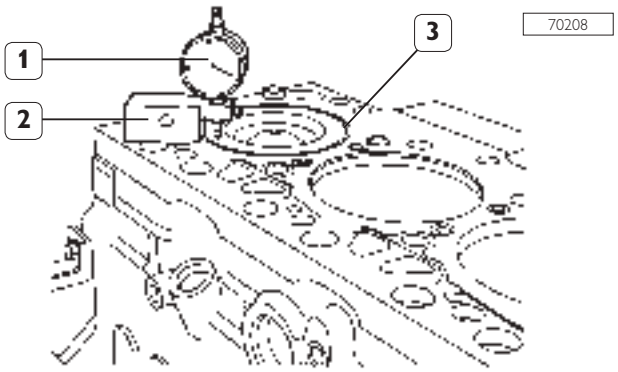
CAUTION

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 0.250 to 0.275 mm.

Checking piston protrusion

Figure 99

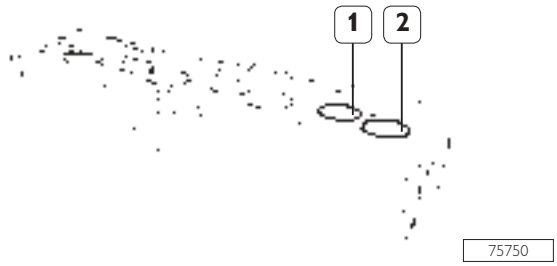


Once connecting rod-piston assemblies refitting is over, use dial gauge 39395603 (1) fitted with base 99370415 (2) to check piston (3) protrusion at T.D.C. with respect to the top of the engine block.
Protrusion shall be 0.28 to 0.52 mm.

CYLINDER HEAD

Removing the valves

Figure 100

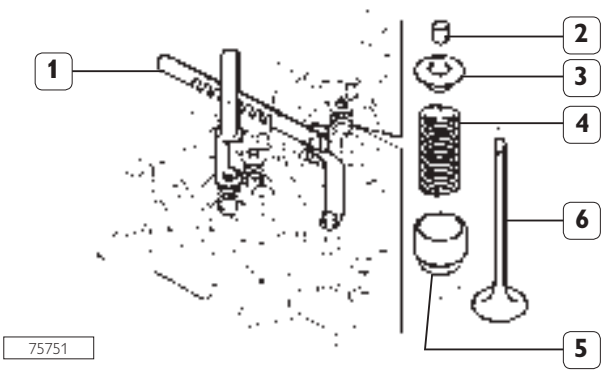


Intake (1) and exhaust (2) valves have heads with different diameter.

CAUTION

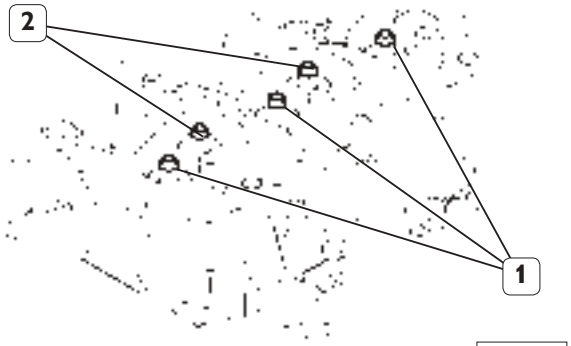
Should cylinder head valves be not replaced, number them before removing in order to refit them in the same position.

Figure 101



Valve removal shall be performed using tool 99360268 (1) and pressing the cap (3) so that when compressing the springs (4) the cotters (2) can be removed. Then remove the cap (3) and the springs (4) and the protective cap (5).
Repeat this operation for all the valves.
Overturn the cylinder head and withdraw the valves (6).

Figure 102



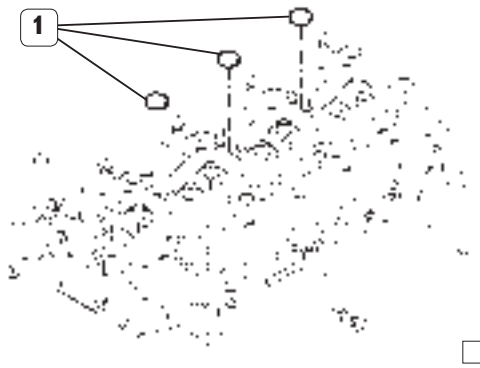
Remove sealing rings (1 and 2) from the valve guide.

CAUTION

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

Checking cylinder head wet seal

Figure 103



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

CAUTION

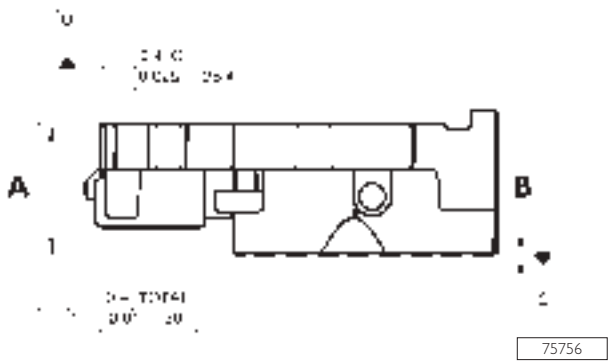
Before refitting, smear the plug surfaces with water-repellent sealant.

Replace the cylinder head if leaks are found.

Checking cylinder head supporting surface

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

Figure 104



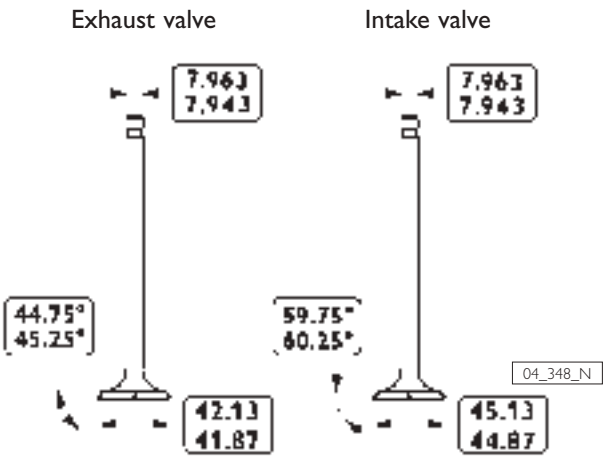
The rated thickness A for the cylinder head is 95 ± 0.25 mm, max. metal removal shall not exceed thickness B by 0.13 mm.

CAUTION

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

VALVES

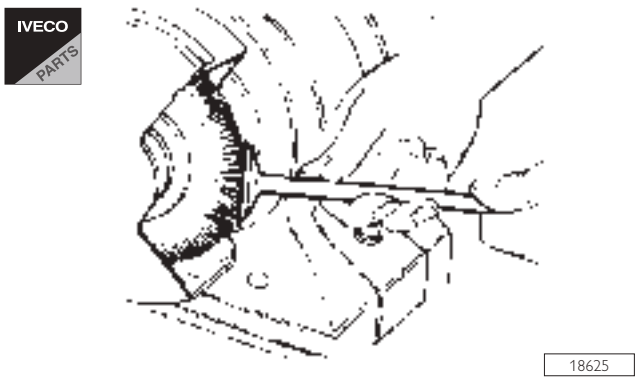
Figure 105



INTAKE AND EXHAUST VALVE MAIN DATA

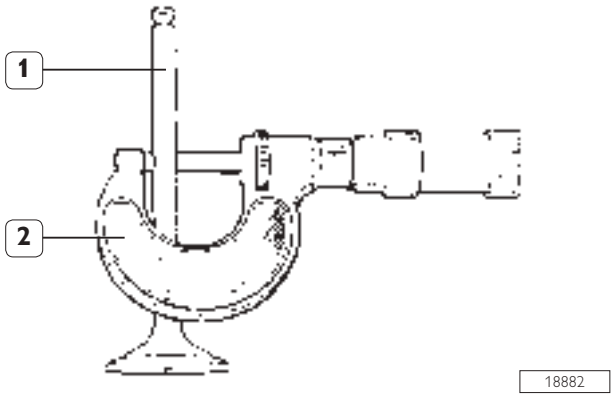
Removing carbon deposits, checking and-grinding valves

Figure 106



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.

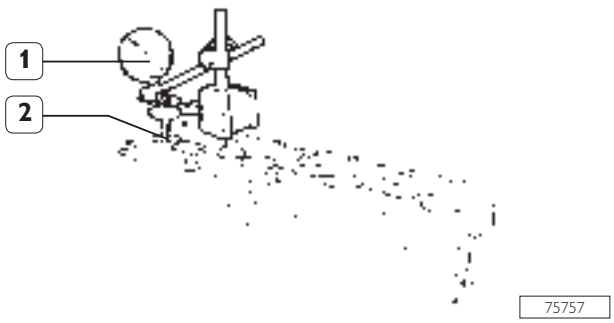
Figure 107



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

Checking clearance between valve stem and-valve guide and valve centering

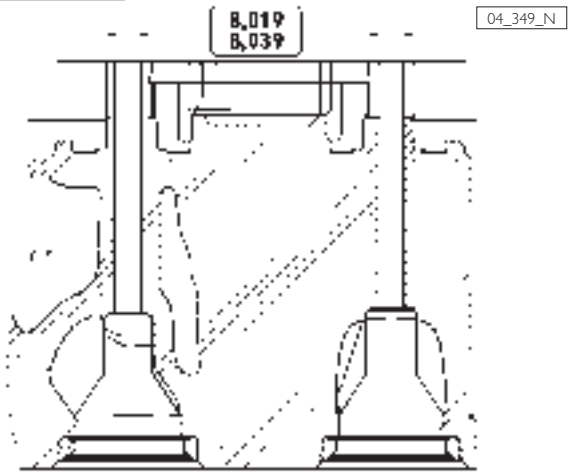
Figure 108



Use a magnetic base dial gauge (1) set as shown in the figure, the assembling clearance shall be 0.056 ± 0.096 mm.
Turn the valve (2) and check that the centering error is not exceeding 0.03 mm.

Valve guide

Figure 109

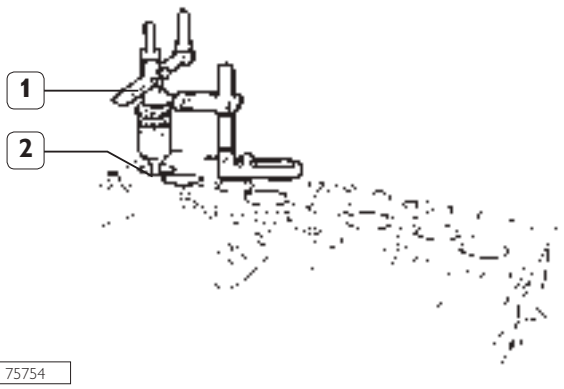


Intake Exhaust

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

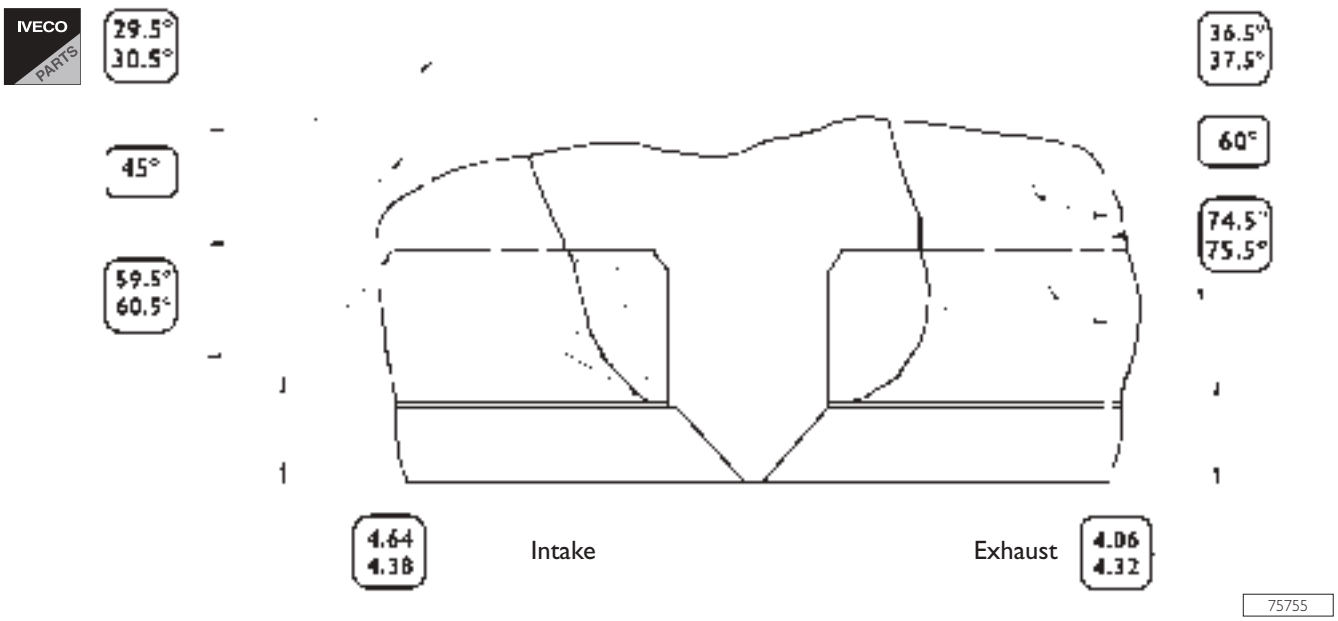
Regrinding - Replacing the valve seats

Figure 110



Check the valve seats (2). If slight scoring or burnout is found, regrind seats using tool 99305014 (1) according to the angle values shown in Figure 111.

Figure 111

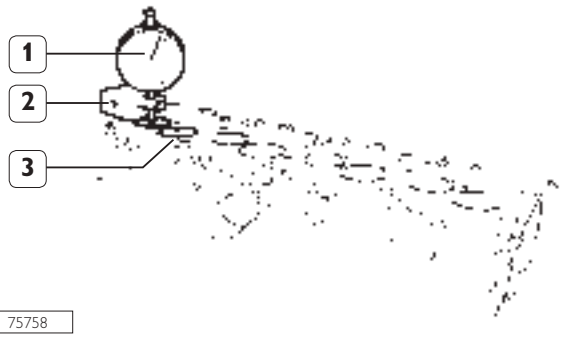


VALVE SEAT MAIN DATA

Should valve seats be not reset just by regrinding, replace them with the spare ones. Use tool 99305019 (Figure 110) to remove as much material as possible from the valve seats (take care not to damage the cylinder head) until they can be extracted from the cylinder head using a punch.

Heat the cylinder head to 80-100 °C and using the proper beater, fit the new valve seats, previously cooled, into the cylinder head.
Use tool 99305019 to regrind the valve seats according to the values shown in Figure 111.

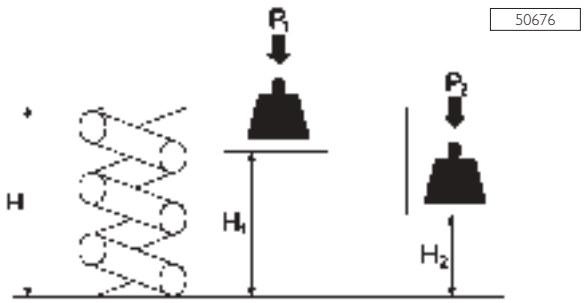
Figure 112



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 113



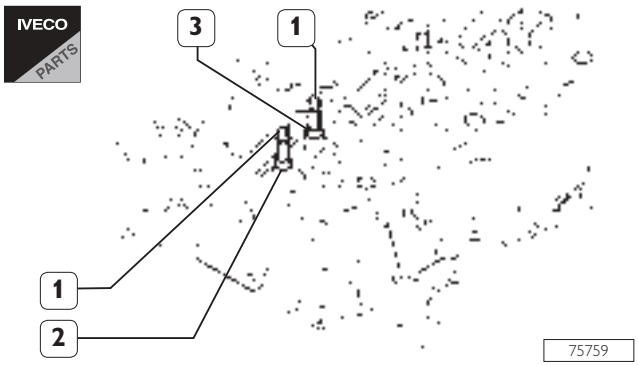
MAIN DATA TO CHECK INTAKE AND EXHAUST VALVE SPRINGS

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

Height		Under a load of
H (free)	63.50	N
H_1	49.02	329
H_2	38.20	641

FITTING CYLINDER HEAD

Figure 114

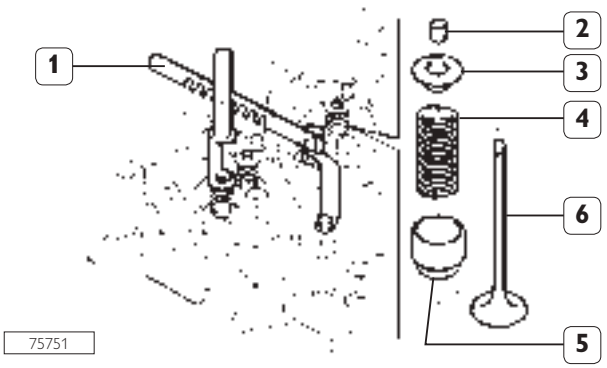


Lubricate the valve stems (1) and fit them into the relevant valve guides according to the position marked at removal. Fit the sealing rings (2 and 3) on the valve guide.

CAUTION

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

Figure 115



Position on the cylinder head: the protective cap (5), 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 116

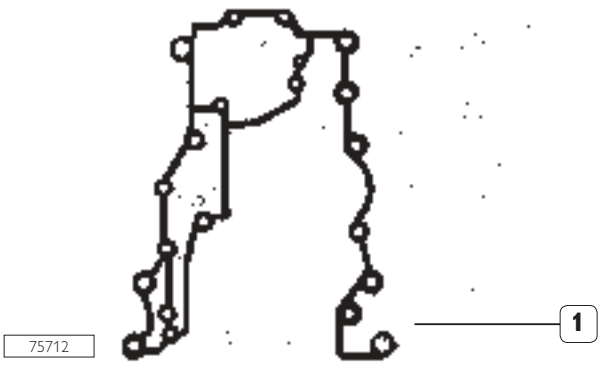


DIAGRAM SHOWING SEALING LOCTITE 5205 APPLICATION WITHIN GEARBOX AREAS

❑ 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 eventual imperfection shall be correct as soon as possible.
Avoid using material in excess to seal the joint.
Too much sealing material would drop out on both sides of the joint and obstruct lubricant passages.
After having completed seal application, the joints must be immediately assembled (10-20 minutes time).

Figure 117

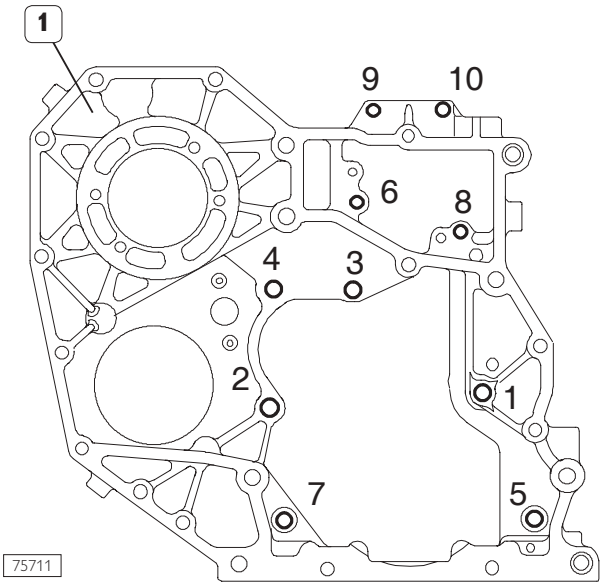


DIAGRAM SHOWING SCREW TIGHTENING TO FIX REAR GEARBOX

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

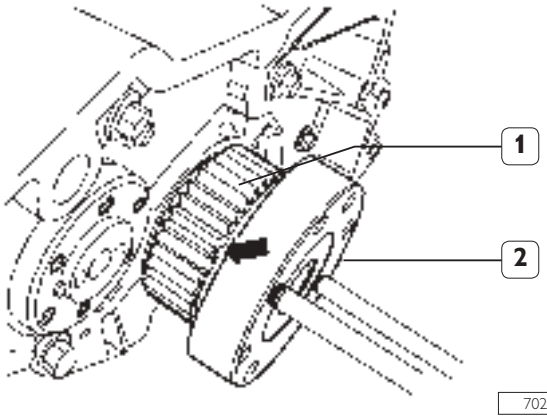
❑ Tighten the fixing screws in the same position as found out during disassembly and fix the screws to the locking torques listed here below, following the order as shown in the picture.

- Screws M12 65 to 89 Nm;
- Screws M8 20 to 28 Nm;
- Screws M10 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 118

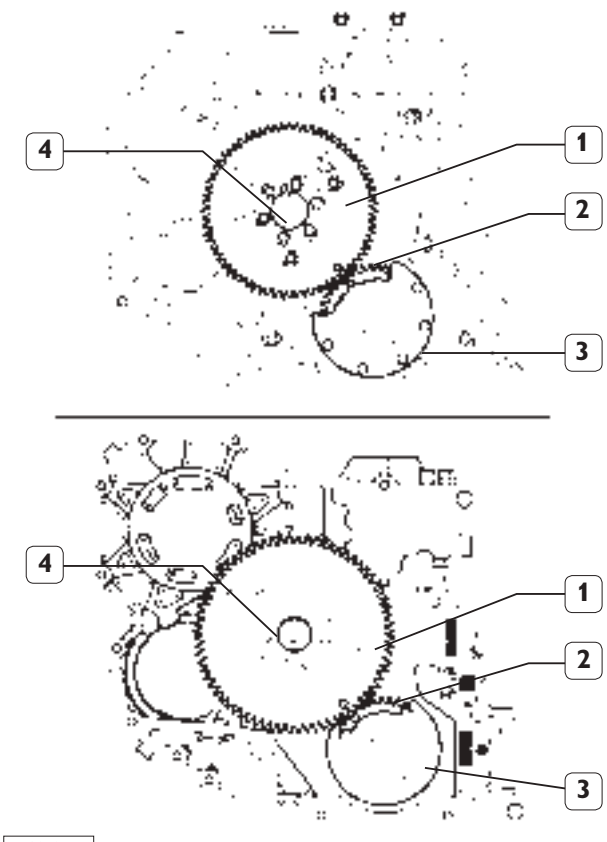


❏ With a penmarker, mark the tooth (1) of the driving gear assembled to the engine drive shaft (2) with (➡) timing notch.

CAUTION

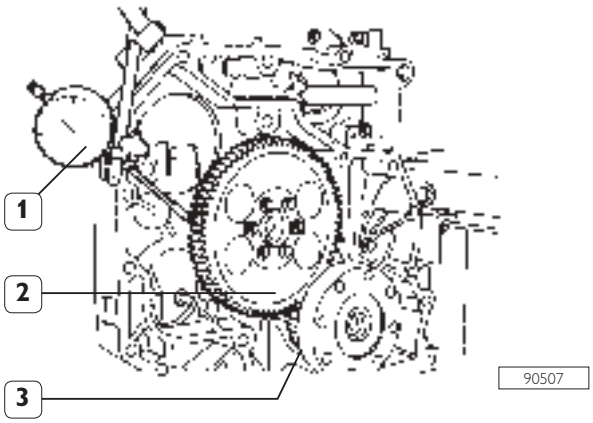
Screw down two pins to facilitate operation of engine drive shaft rotation.

Figure 119



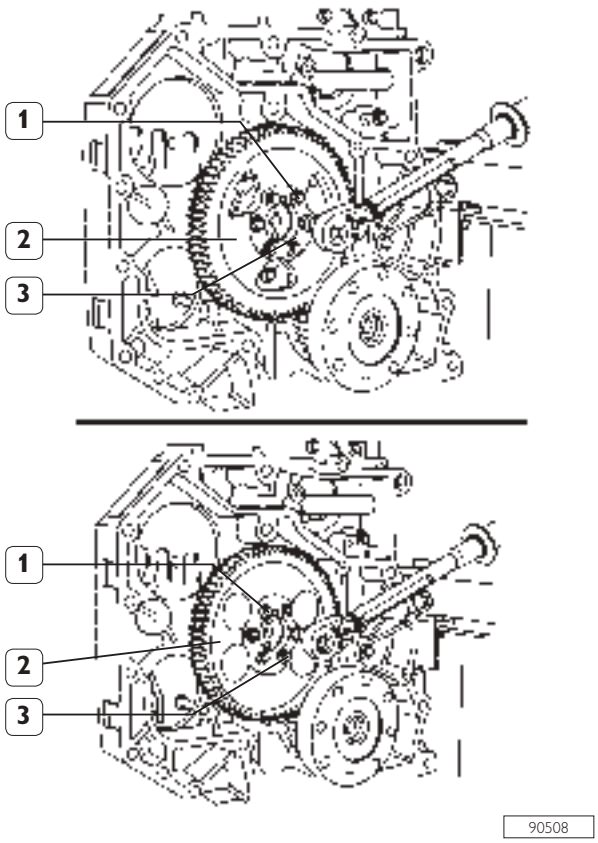
❏ Orient engine drive shaft (3) and camshaft (4) taking care that in phase of assembly of the driving gear (2) to the camshaft, the notches marked on the gears (1 and 2) shall match.

Figure 120



❏ Position comparator (1) on timing system gear (2) and check that the clearance between gears (2) and (3) is within 0.076 to 0.280 mm range.

Figure 121



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

Figure 122

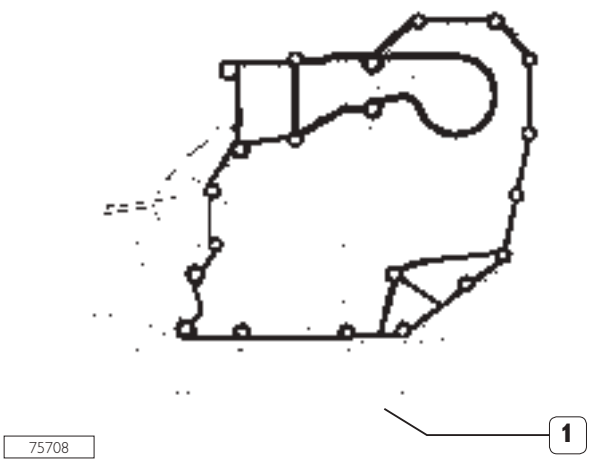


DIAGRAM SHOWING SEALING LOCTITE 5205 APPLICATION

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 eventual imperfection shall be correct as soon as possible.
Avoid using material in excess to seal the joint.
Too much sealing material would drop out on both sides of the joint and obstruct lubricant passages.
After having completed seal application, the joints must be immediately assembled (10-20 minutes time).

Figure 123

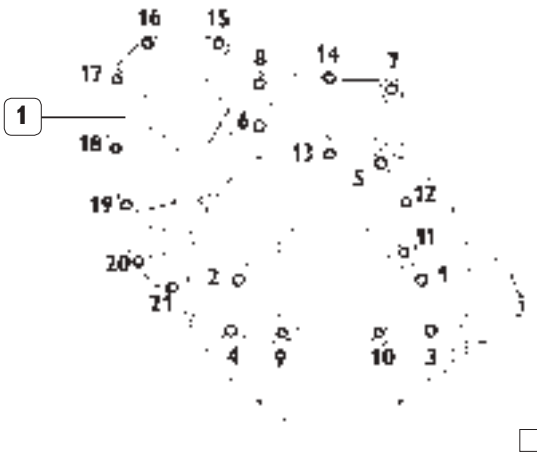


DIAGRAM SHOWING SCREW TIGHTENING TO FIX FLYWHEEL COVER BOX.

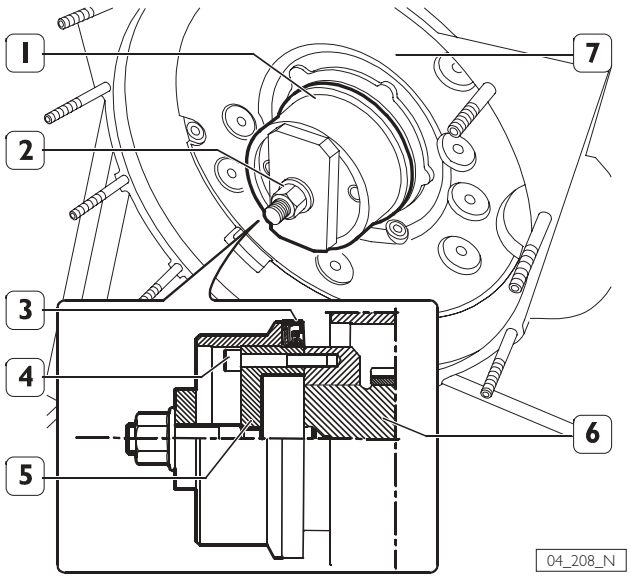
❑ Reassemble the box (1) to the engine block, tighten the fixing screws in the same position as found out during disassembly and fix the screws to the locking torques listed here below, following the order as shown in the picture.

- Screws M12 75 to 95 Nm;
- Screws M10 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.

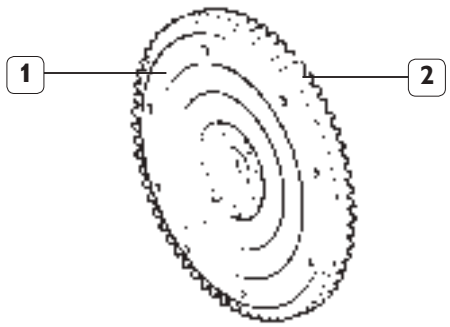
Figure 124



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

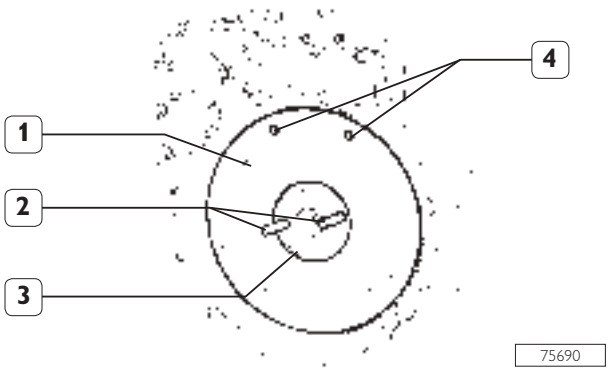
❑ Place detail (1) on detail (5), tighten the screw nut (2) until complete assembly of the fixing ring (3) into the flywheel cover box (7).

Figure 125



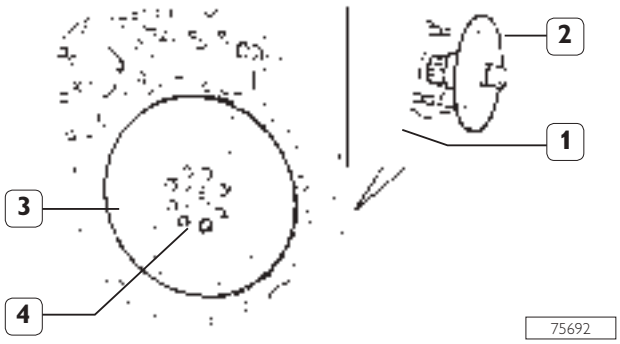
Check the conditions of the rim tooth (2). Whether tooth break or excessive wear is detected, disassemble the rim from the engine flywheel using a common willow and replace with a new one, previously heated to 150 °C degrees for 15-20 seconds; bevelling must be made towards engine flywheel direction.

Figure 126



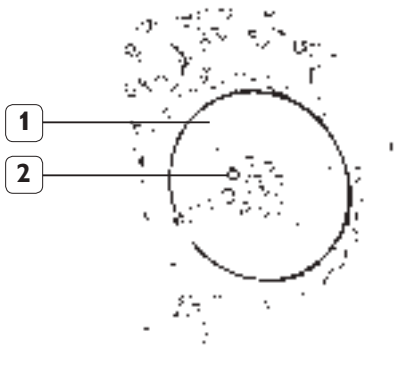
- ❏ Screw down two hooks or trail rings in the flywheel (1) threaded ports (4) for handling;
- ❏ Using a hoist, handle the flywheel to place it in its housing inside the flywheel cover box;
- ❏ Screw down to pins (2) having appropriate length, in the shaft ports (3) and using them as guide, assemble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

Figure 127



- ❏ Tighten the screws (4) fixing the engine flywheel (3) to the engine shaft. Use tool 99360339 (2) to operate on the flywheel cover box (1) to block engine flywheel rotation.

Figure 128



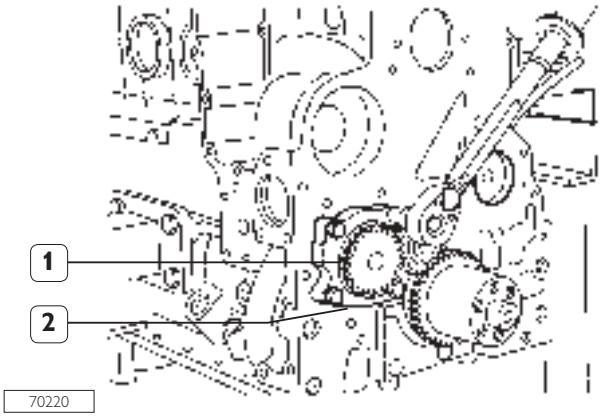
Tighten the engine flywheel (1) fixing screws (2) in two phases:

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

CAUTION

Angle dwell shall 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.

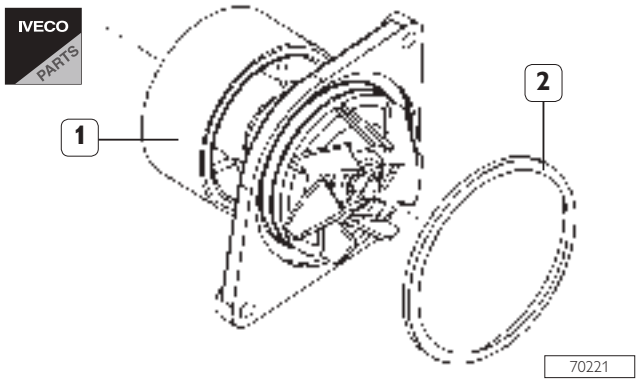
Figure 129



❏ Assemble oil pump (1);

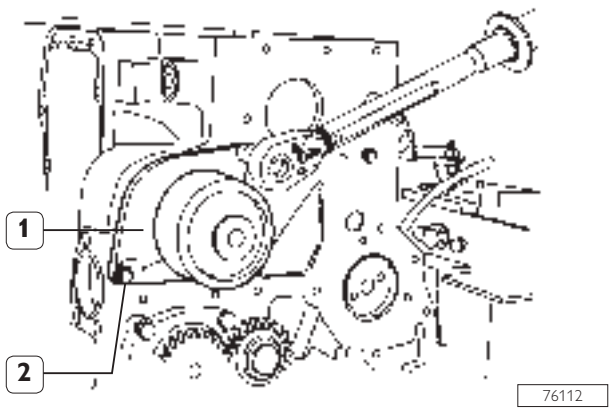
❏ Tighten fixing screws (2) and lock them to the prescribed torque.

Figure 130



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

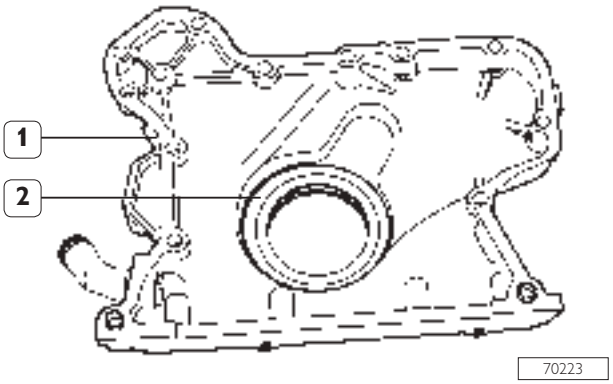
Figure 131



❏ Assemble the water pump (1);

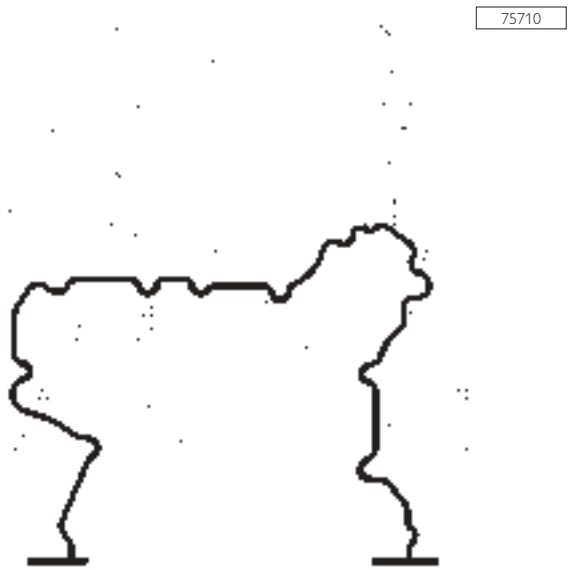
❏ Tighten the screws (2) and lock them to the prescribed torque.

Figure 132



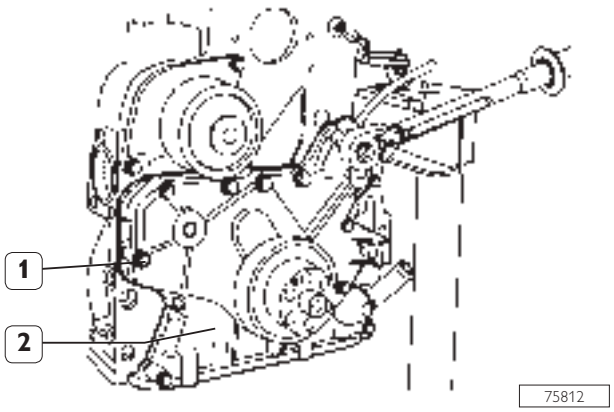
❏ Remove the fixing ring (2) from the front cover (1), accurately clean the plug surface.

Figure 133



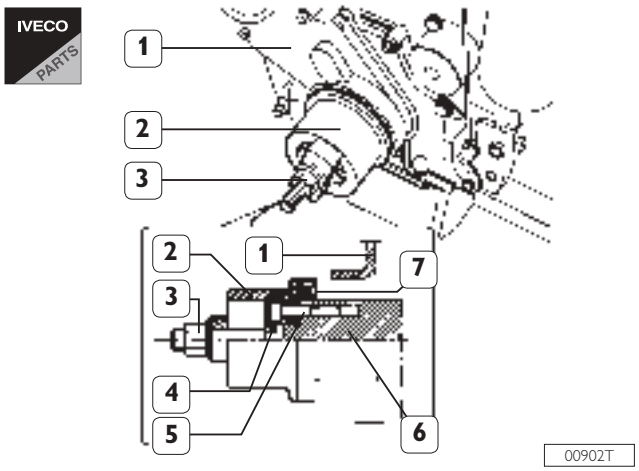
❏ Accurately clean the contact surface of engine block and apply sealing Loctite 5205 on it in order to form a uniform and continuous kerbstone with no lumps.

Figure 134



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

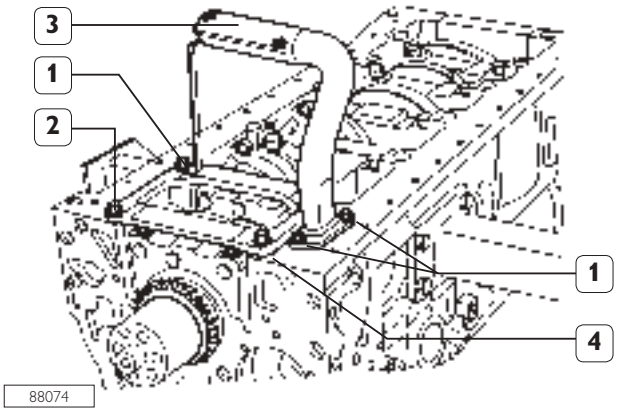
Figure 135



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

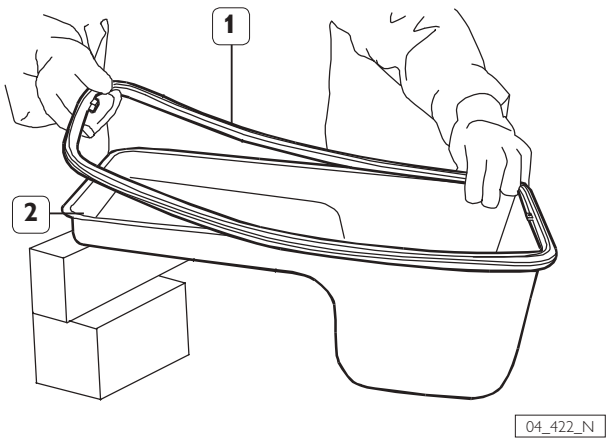
❏ Place the detail (2) on the detail (4), screw-up the threaded nut until carrying out the complete assembly of the holding ring (7) to the front cover.

Figure 136



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

Figure 137

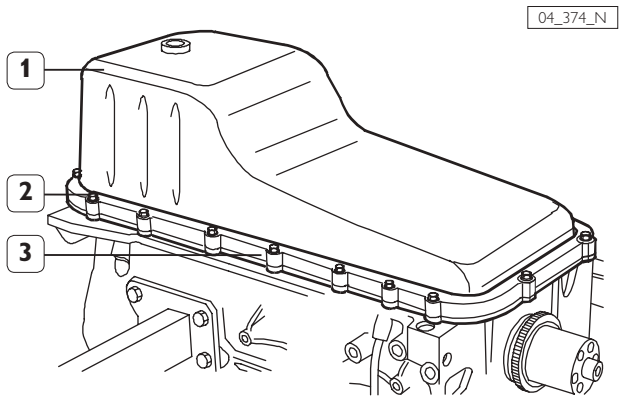


❏ Provide for newgasket replacement (1) of the oil sump (2).

CAUTION

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

Figure 138

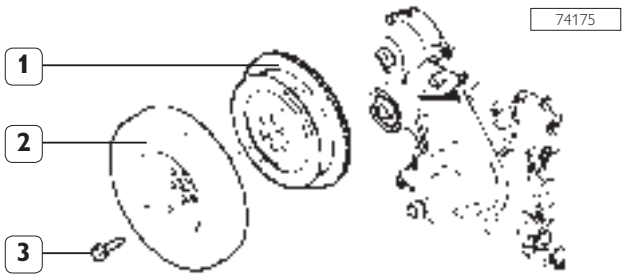


❏ Assemble oil sump (1) , apply the plate over it (3). Tighten the screws (2) and lock them to the prescribed torque.

CAUTION

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

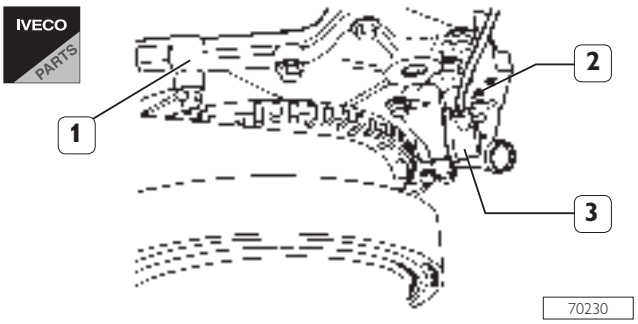
Figure 139



❏ Assemble the pulley (1) and the dumping flywheel (2) to the driving shaft;

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

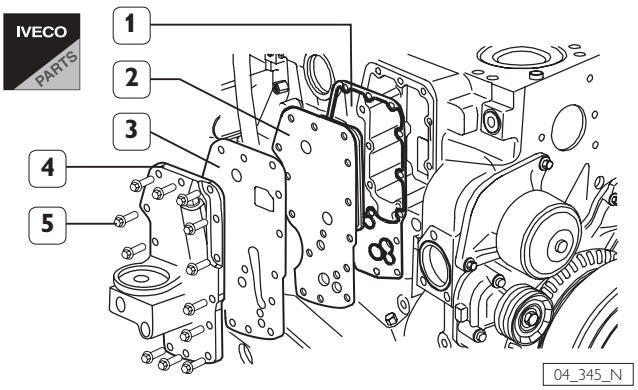
Figure 140



❏ 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 specified torque (if fitted).

Figure 141



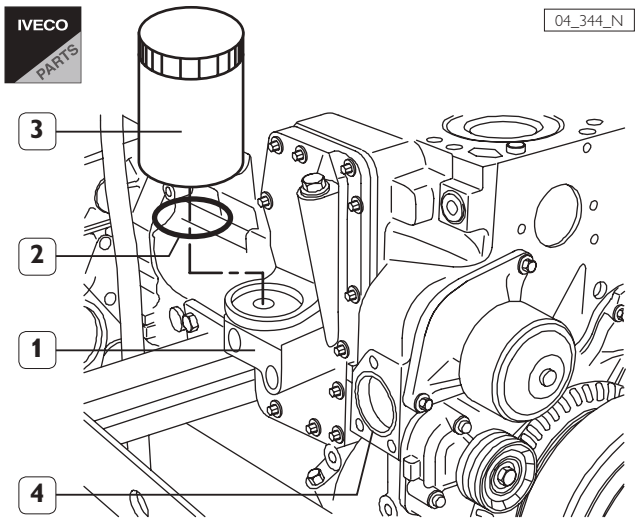
❏ Assemble the following elements to the block: new gasket (1), heat exchanger (2), new gasket (3), oil filter bearing (4);

❏ Tighten the screws (5) and lock them to the prescribed torque.

CAUTION

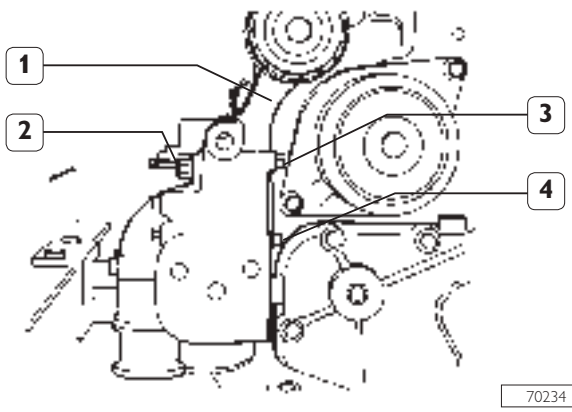
Before every assembly, always check that threads of holes and screws have no evidence of tear and wear nor dirt.

Figure 142



- ❏ Lubricate the fixing ring (2) using engine oil and place it on the oil filter (3);
- ❏ Manually start 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 143

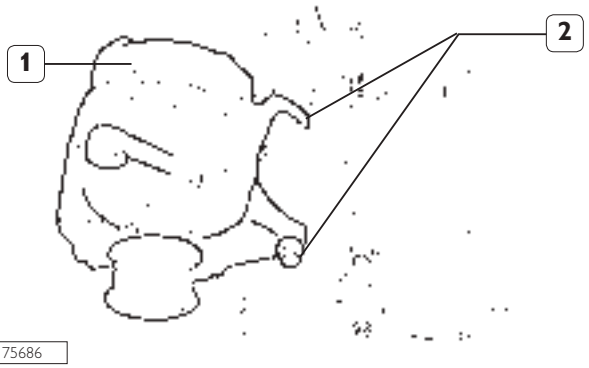


- ❏ Assemble the alternator bearing (1) ensuring that the pins (3 and 4) are against the engine block;
- ❏ Tighten the screws (2) and lock them to the prescribed torque.

CAUTION

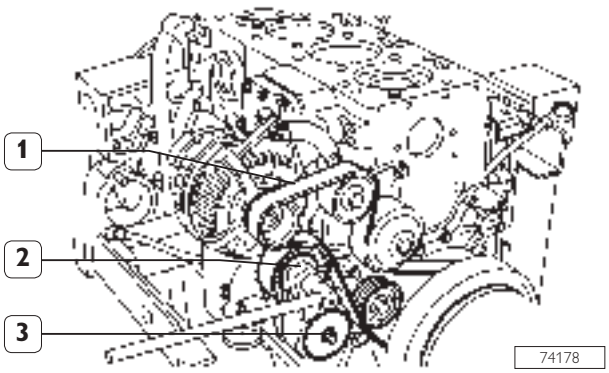
Before every assembly, always check that threads of holes and screws have no evidence of tear and wear nor dirt.

Figure 144



- ❏ Connect the alternator (1) to the support;
- ❏ Tighten without locking the screw (2).

Figure 145



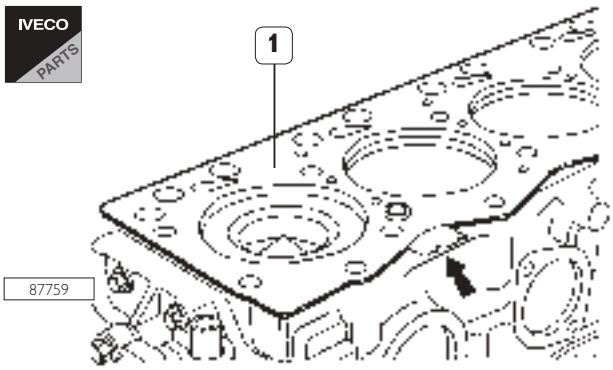
- ❏ Refit the automatic belt tensioner (2);
- ❏ Tighten the screw (3) to the specified torque;
- ❏ Turn the automatic belt tensioner (2) to fit the belt (1) on pulleys and guide rollers.

CAUTION

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

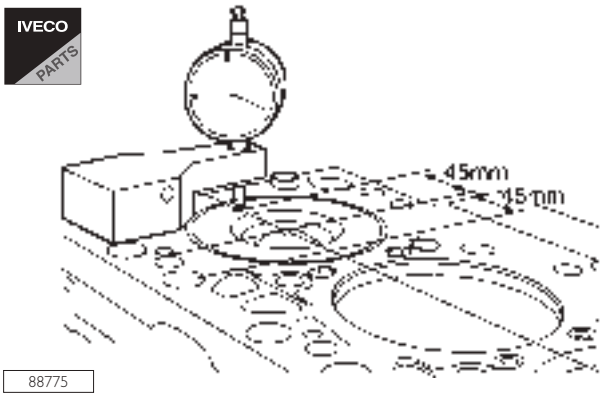
Refitting the cylinder head

Figure 146



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 "N. of component" (1) facing the head.
The arrow shows the point where the gasket thickness is given.

Figure 147



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 142, 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:

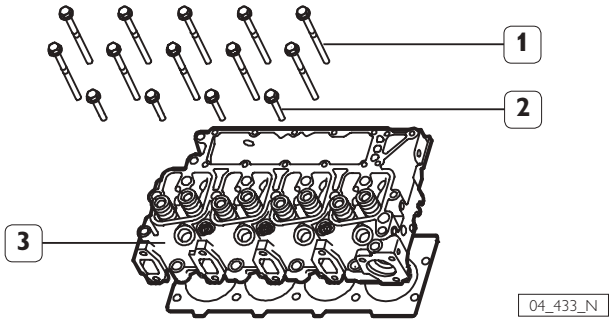
$$S = \frac{Scil1 + Scil2 + Scil3 + Scil4 + Scil5 + Scil6}{6}$$

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 and in that case replace them.

Figure 148

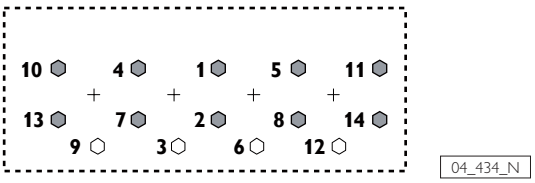


❏ Place the head (3) over the block and insert screws (1) and (2).

CAUTION

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

Figure 149

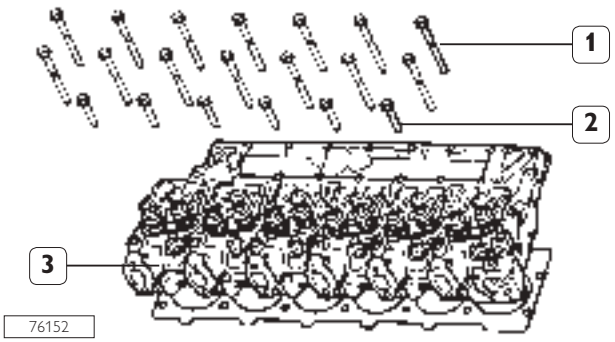


❏ Lubricate cylinder head bolts and install to head;

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

- M12 x 70 50 Nm + 90 degrees;
- M12 x 140 40 Nm + 180 degrees;
- M12 x 180 70 Nm + 180 degrees.

Figure 150

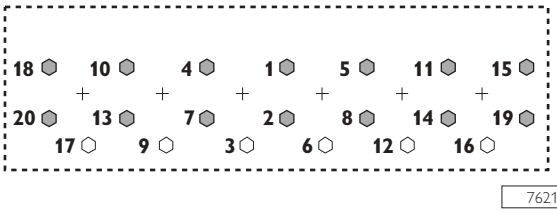


❏ Place the head (3) over the block and insert screws (1) and (2).

CAUTION

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

Figure 151

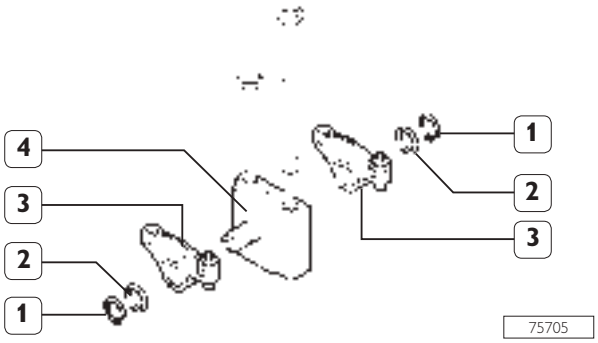


❏ Lubricate cylinder head bolts and install to head;

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

- M12 x 70 50 Nm + 90 degrees;
- M12 x 140 40 Nm + 180 degrees;
- M12 x 180 70 Nm + 180 degrees.

Figure 152

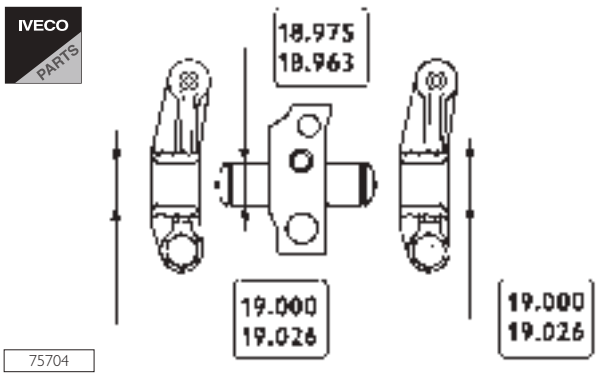


ROCKER ARM UNIT COMPONENTS:

1. Elastic ring - 2. Spacer - 3. Rocker arms - 4. Support.

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

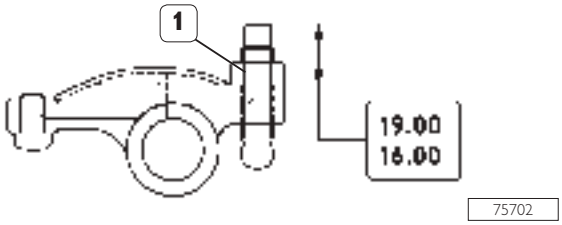
Figure 153



SHAFT AND ROCKER ARM BASIC DATA

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

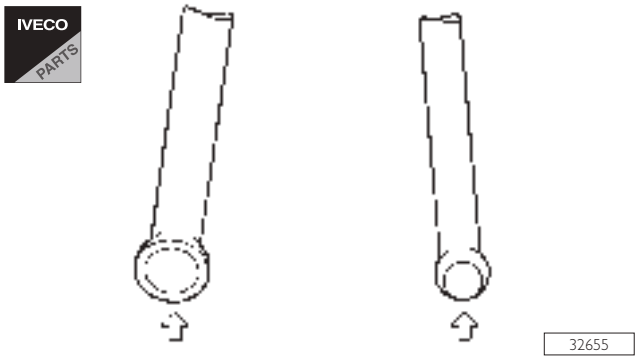
Figure 154



ROCKER ARM ADJUSTMENT SCREW

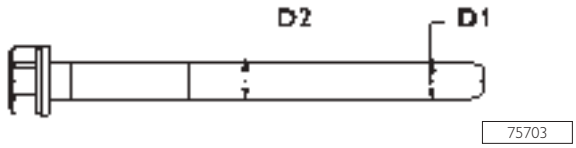
If unscrewed, check adjustment quota.
Tighten the screw-threaded nut (1) to the 0.4-0.6 Nm torque.

Figure 155



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

Figure 156

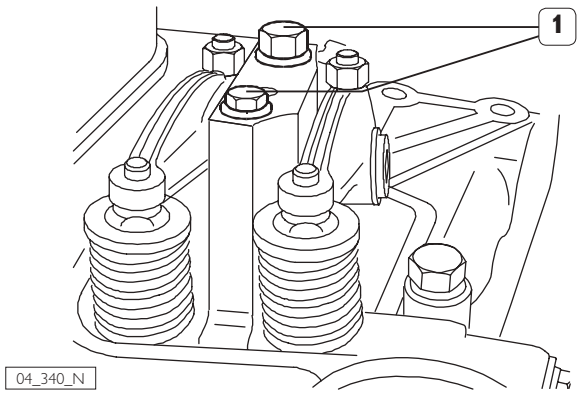


❑ Insert the tappet driving rods and the Rocker Arm unit.

Before using the fixing screws again, measure them twice as indicated in the picture, checking D1 and D2 diameters:

- If D1 - D2 < 0.1 mm the screw can be utilised again;
- If D1 - D2 > 0.1 mm the screw must be replaced.

Figure 157

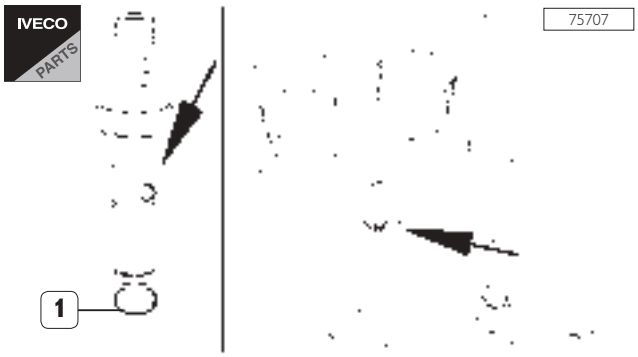


❑ Tighten the screws (1) to the prescribed torque.

Adjusting valve clearance

(see Section 6).

Figure 158

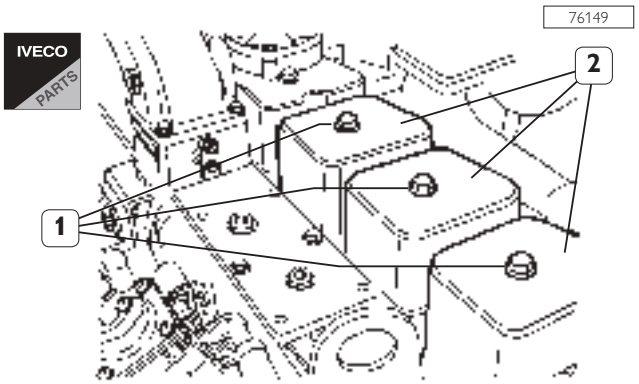


❑ Assemble injectors after having replaced the sealing gasket (1).

CAUTION

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

Figure 159



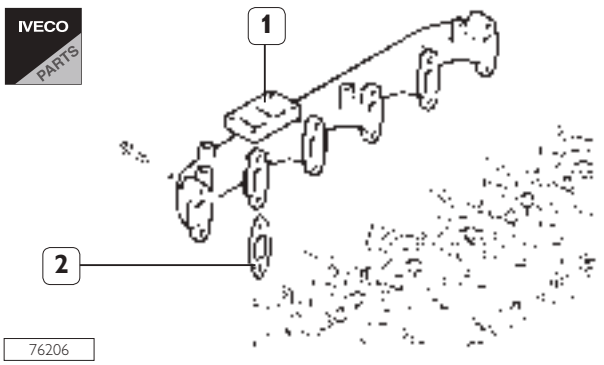
❏ Assemble cylinder covers (2) with the respective gaskets;

❏ Fit the seal nods and tighten the screws (1) fixing them to the prescribed torque.

CAUTION

Always replace the gaskets using new ones.
Check the threads of the fixing screws: there shall be no evidence of wear or dirt deposit.
Seal nods shall have no visible deformation. In such case provide for replacement with new nods.

Figure 160

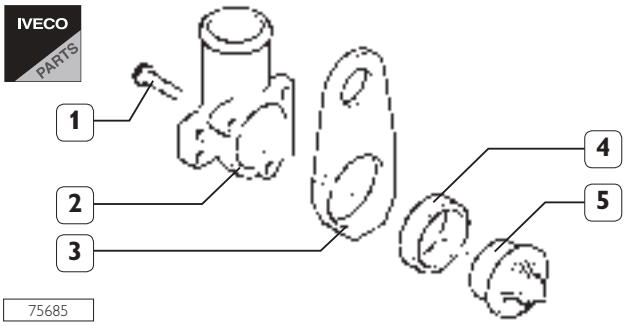


❏ Assemble exhaust manifold (1) providing new gaskets (2).

CAUTION

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

Figure 161



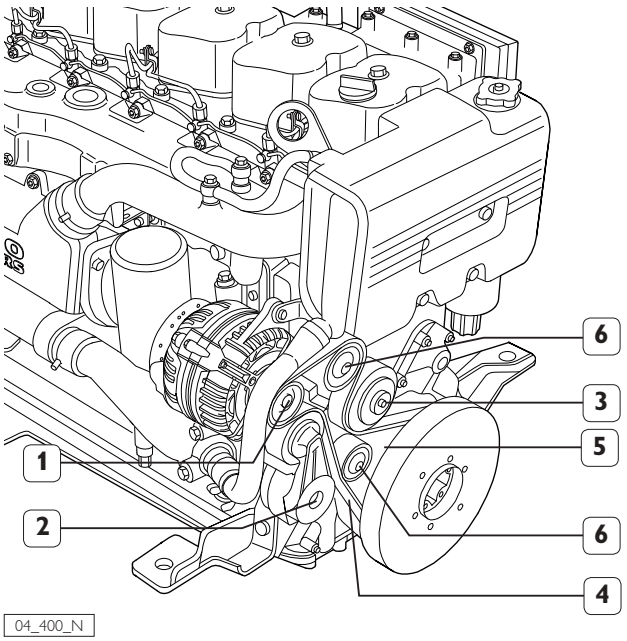
❏ Assemble thermostat unit (2) including thermostat (5) and gasket (4);

❏ Tighten the screws to the prescribed torque.

CAUTION

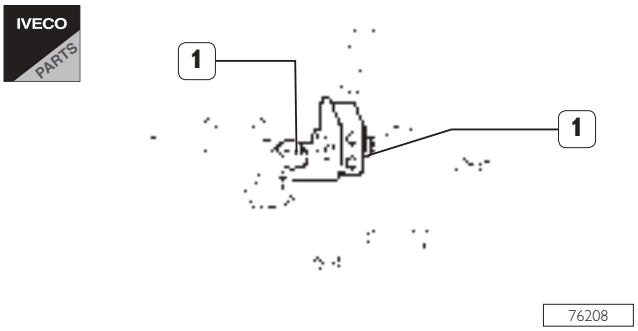
The screws (1) have been have been utilised to fix the bracket (3).
Disassemble the bracket (3) and reassemble components from 1 to 5 as shown in the picture.
The gasket (4) must be new.

Figure 162



❏ Mount Poly-V belt (4) engine shaft pulley (5), guide pulleys (6), water pump (3) and alternator (1); stretch the belt by operating on automatic belt tensioner (2).

Figure 163

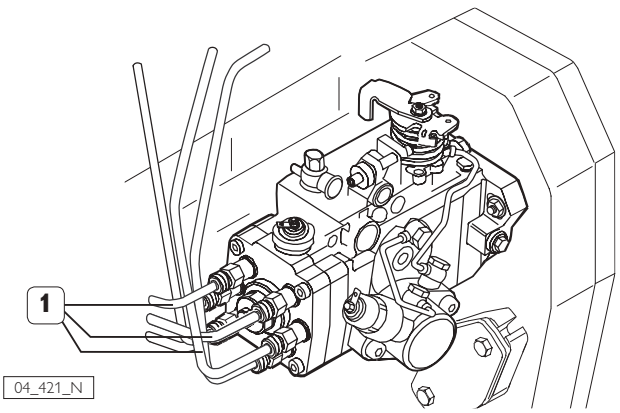


- ❏ Also assemble the brackets (1) fixing the fuel pipelines to the injectors: use the same screws (2) fixing the manifold plate as shown in the picture;
- ❏ Also assemble feed pump (see specific procedure).

CAUTION

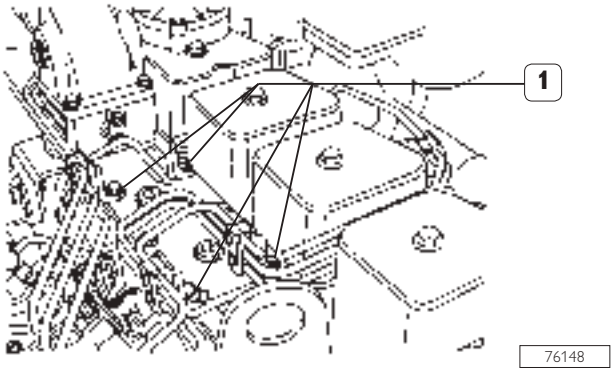
Pump mounting requires specific procedure contained in this section.

Figure 164



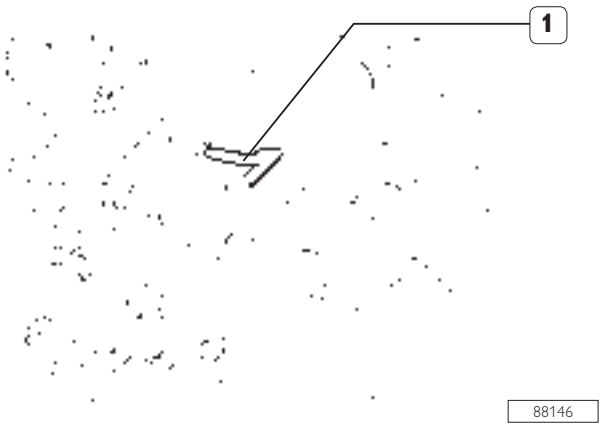
- ❏ Assemble the injection pump supply pipes (1);
- ❏ Screw down the locking nuts fixing the pipes to the injection pump;
- ❏ Tighten the screws fixing the fuel recovery manifold to the injection pump;
- ❏ Tighten the locking nuts on the injectors and tighten the screws to fasten the fuel recovery manifold.

Figure 165



- ❏ Fix the pipes to the injectors throughout the brackets previously assembled.

Figure 166

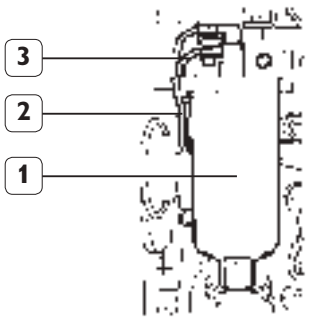


- ❏ Assemble the injection pump pipe (1).

Adjusting injection pump phase

(see Section 6)

Figure 167



- ❑ Assemble the fuel filter bearing (4) to the bracket fixed to the engine head;
- ❑ Connect the fuel pipelines (2 and 3) respectively from priming pump to filter bearing and from this last one to feed pump;
- ❑ Using 99360076 equipment assemble fuel filter (1).

CAUTION

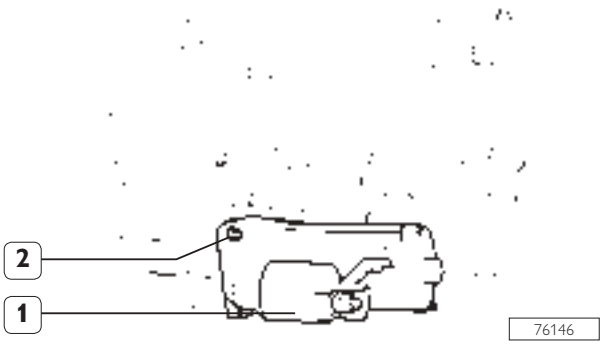
The filter shall be priory filled with fuel to facilitate feed system bleed operations.

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.

Completion of the engine

Figure 168



- ❑ 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	Torque kgm
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 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
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
Cooling Nozzles (M8x1.25x10)		15 ± 3	1.5 ± 0.3
Main bearing cap	1st stage	50 ± 6	5.0 ± 0.6
	2nd stage	80 ± 6	8.0 ± 0.6
	3rd stage	90° ± 5°	
Rear gear housing assembly	(M8x1.25x40)	24 ± 4	2.4 ± 0.4
	(M8x1.25x25)	24 ± 4	2.4 ± 0.4
	(M10x1.5)	49 ± 5	4.9 ± 0.5
Oil pump (M8x1.25x30)	1st stage	8 ± 1	0.8 ± 0.1
	2nd stage	24 ± 4	2.4 ± 0.4
Front cover assembly	(M8x1.25x45)	24 ± 4	2.4 ± 0.4
	(M8x1.25x30)	24 ± 4	2.4 ± 0.4
Connecting rod bolts (M11x1.25)	1st stage	30 ± 3	3.0 ± 0.3
	2nd stage	60 ± 5	6.0 ± 0.5
	3rd stage	60° ± 5°	
Ladder frame assembly (M10x1.25x25)		43 ± 5	4.3 ± 0.5
Oil rifle plugs	(M10x1)	6 ± 1	0.6 ± 0.1
	(M14x1.5)	11 ± 2	1.1 ± 0.2
Assemble oil suction tube (M8x1.25x20)		24 ± 4	2.4 ± 0.4
Oil sump assembly	(M8x1.25x25)	24 ± 4	2.4 ± 0.4
	(M18x1.50)	60 ± 9	6.0 ± 0.9
Set timing pin (Torx screw M5 T25)		5 ± 1	0.5 ± 0.1
Fuel pump assembly	M8 screw	24 ± 4	2.4 ± 0.4
	M6 screw	10 ± 1	1.0 ± 0.1
	M6 nut	10 ± 1	1.0 ± 0.1
M10x1.5 flange head nuts pre-torque	1st stage	10 -15	1.0 -1.5
	2nd stage	50 -55	5.0 -5.5
Fuel pump gear (drive gear nut)	snug torque	15 -20	1.5 -2.0
	final torque	85 -90	8.5 -9.0
Inspection cover on the gearbox		30 -35	3.0 -3.5
Rocker assys (M8)		24 ± 4	2.4 ± 0.4
Cylinder head bolts	(M12x70)	50 + 90°	5.0 + 90°
	(M12x140)	40 + 180°	4.0 + 180°
	(M12x180)	70 + 180°	7.0 + 180°
Assy rocker covers (M8x1.25x25)		24 ± 4	2.4 ± 0.4
Intake manifold (M8x1.25)		24 ± 4	2.4 ± 0.4
Assy air intake connection (M8x1.25)		24 ± 4	2.4 ± 0.4
Oil bypass valve into lube filter head (nut M22x1.5x10)		80 ± 8	8.0 ± 0.8
Plug (M12x1.5x12)		10 ± 1	1.0 ± 0.1
Water pump (M8x1.25x25)		24 ± 4	2.4 ± 0.4
Water inlet connection	(M8x1.25x35)	24 ± 4	2.4 ± 0.4
	(M8x1.25x70)	24 ± 4	2.4 ± 0.4
Rear lifting bracket (M12x1.75x30)		77 ± 12	7.7 ± 1.2

Engine parts tightening torques (cont)

Part		Torque Nm	kgm
Crankshaft pulley (M12x1.75x10.9)		110 ± 5	11.0 ± 0.5
Flywheel housing	(M12x120)	85 ± 10	8.5 ± 1.0
	(M12x80)	85 ± 10	8.5 ± 1.0
	(M10x80)	49 ± 5	4.9 ± 0.5
	(M10x40)	49 ± 5	4.9 ± 0.5
Flywheel housing on crankshaft (M12x1.25)	1st stage	30 ± 4	3.0 ± 0.4
	2nd stage		60° ± 5°
Aspiration pump gear cover (M8x1.25x16)		24 ± 4	2.4 ± 0.4
Fuel injectors		60 ± 5	6.0 ± 0.5
Oil feed to oil filter head		24 ± 4	2.4 ± 0.4
Alternator to alternator support (M8x1.25x30)		24 ± 4	2.4 ± 0.4
Alternator to water inlet conn. assy (M8x1.25x30)		24 ± 4	2.4 ± 0.4
Lower alternator mounting (M10x1.25x25)		24 ± 4	2.4 ± 0.4
Alternator upper pivot to support (M10)		49 ± 5	4.9 ± 0.5
Alternator mounting hardware (M12x1.75x120)		43 ± 6	4.3 ± 0.6
Alternator wiring (M6x1.0 nut)		10 ± 2	1.0 ± 0.2
Starter motor to gear case (M10)		49 ± 5	4.9 ± 0.5
Screw M8 for fastening cylinder barrel lubricating nozzles		15 ± 3	1.5 ± 0.3
Screw M12 for fastening output shaft caps	1st stage	50 ± 6	5 ± 0.6
	2nd stage	80 ± 6	8 ± 0.6
	3rd stage		90° ± 5°
Screw M8 for fastening camshaft longitudinal retaining plate		24 ± 4	2.4 ± 0.4
Screw M8 for fastening camshaft gear		36 ± 4	3.6 ± 0.4
Screw M11 for fastening connecting rod caps	1st stage	60 ± 5	6 ± 0.5
	2nd stage		60° ± 5°

SECTION 9

SAFETY REGULATIONS

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;
- ❏ Do not modify the fuel or hydraulic systems without having received specific approval from IVECO MOTORS. 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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