NEF SERIES TIER 4B/STAGE IV

Industrial application

TIER 4B

F4HFE6131*B003
F4HFE613K*B004
F4HFE613N*B002

STAGE IV

F4HFE6131*B005
F4HFE613K*B005
F4HFE613N*B003

Technical and Repair manual

This publication provides unit and relevant component repair data, specifications, instructions and methodologies.

This publication has been drawn up for qualified and specialised personnel.

Before performing any operation check that the part relevant to the unit on which you must work is available along with all safety devices for accident-prevention, such as, goggles, helmet, gloves, shoes, etc. and hoisting and transporting equipment.

Operations are to be performed by following the indications included here, using the special equipment indicated and assuring proper repair, compliance with schedule and operator's safety requirements.

Each repair must aim to restore operating efficiency and safety in compliance with the FPT provisions.

FPT cannot be held liable for modifications, alterations or other interventions non authorised by FPT on the vehicle and if the unit is warranted the above mentioned interventions will cause its expiration.

FPT is not liable for repairing interventions.

FPT will provide further details required to carry out the interventions and all the instructions that are not included on this publication.

Data included in this publication may not be up-to-date therefore subject to Manufacturer's modifications that can be added at any time for technical or commercial purposes and also to meet new law regulations in other Countries.

If issues on this publication differ from what is actually noticed on the unit, please get in touch with the FPT network before starting any intervention".

It is forbidden to copy this text or any of its parts and all illustrations included.

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Introduction

PREFACE

Manuals for repairs are split into Parts and Sections, each one of which is marked by a numeral; the contents of these sections are indicated in the general table of contents.
The sections dealing with things mechanic introduce the specifications, tightening torque values, tool lists, assembly detaching/reattaching operations, bench overhauling operations, diagnosis procedures and maintenance schedules.
The sections (or parts) of the electric/electronic system include the descriptions of the electric network and the assembly's electronic systems, wiring diagrams, electric features of components, component coding and the diagnosis procedures for the control units peculiar to the electric system.
Section 1 describes the engines illustrating its features and working in general.
Section 2 describes the fuel supply type and engine operation.
Section 3 is about the electrical equipment, dealing with wiring, electrical and electronic devices which are distinguished on the basis of their specific use.
Section 4 describes scheduled maintenance and specific overhauling.
Section 5 deals with removal and refitting of the main engine components.
Section 6 describes general mechanical servicing of the engine on the revolving stand.
Section 7 gives engine technical characteristics such as data, installation clearances and tightening torques.
Section 8 is about the tools necessary for performing these operations.
The appendix contains a list of the general safety regulations to be respected by all installation and maintenance engineers in order to prevent serious accidents taking place.
The manual uses proper symbols in its descriptions; the purpose of these symbols is to classify contained information. In particular, there have been defined a set of symbols to classify warnings and a set for assistance operations.

SYMBOLS - Warnings

Danger for persons

Missing or incomplete observance of these prescriptions can cause serious danger for persons' safety.

Danger of serious damage for the assembly

Failure to comply, both fully or in part, with such prescriptions will involve serious damage to the assembly and may sometimes cause the warranty to become null and void.

General danger

It includes the dangers of above described signals.

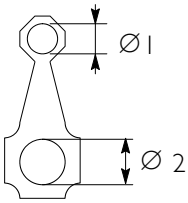
Environment protection

Moreover, it describes the correct actions to be taken to ensure that the assembly is used in such a way so as to protect the environment as much as possible.

NOTE It indicates an additional explanation for a piece of information.

Service operations

Example



Ø 1 = Seat of small end bush

Ø 2 = Seat of connecting rod bearings.

Close applying the required torque + angular value

	Removal Disconnection
	Refitting Connection
	Removal Disassembly
	Fitting in place Assembly
	Tighten to torque
	Tighten to torque + angle value
	Press or caulk
	Regulation Adjustment
	Visual inspection Fitting position check
	Measurement Value to find Check
	Equipment
	Surface for machining Machine finish
	Interference Strained assembly
	Thickness Clearance
	Lubrication Damp Grease
	Sealant Adhesive
	Air bleeding

	Intake
	Exhaust
	Operation
ϱ	Compression ratio
	Tolerance Weight difference
	Rolling torque
	Rotation
	Angle Angular value
	Number of revolutions
	Temperature
	Pressure
>	Oversized Higher than…. Maximum, peak
<	Undersized Less than…. Minimum
	Selection Classes Oversizing
	Temperature < 0 °C Cold Winter
	Temperature > 0 °C Hot Summer
	Preload

GENERAL WARNINGS

Warnings shown cannot be representative of all danger situations possibly occurring. Therefore, it is suggested to contact immediate superiors where a danger situation occurs which is not described.

Use both specific and general-purpose toolings according to the prescriptions contained in respective use and maintenance handbooks. Check use state and suitability of tools not subjected to regular check.

The manual handling of loads must be assessed in advance because it also depends, besides weight, on its size and on the path.

Handling by mechanical means must be with hoisters proper as for weight as well as for shape and volume. Hoisters, ropes and hooks used must contain clear indications on maximum carrying capacity acceptable. The use of said means is compulsorily permitted to authorised personnel only. Stay duly clear of the load, and, anyhow, never under it.

In disassembling operations, always observe provided prescriptions; prevent mechanical parts being taken out from accidentally striking workshop personnel.

Workshop jobs performed in pairs must always be performed in maximum safety; avoid operations which could be dangerous for the co-operator because of lack of visibility or of his/her not correct position.

Keep personnel not authorised to operations clear of working area.

You shall get familiar with the operating and safety instructions for the assembly prior to operating on the latter. Strictly follow all the safety indications found on the assembly.

Do not leave the running assembly unattended when making repairs.

When carrying out work on the assembly lifted off the ground, verify that the assembly is firmly placed on its supporting stands, and that the manual/automatic safety devices have been actuated in the event that the assembly is to be lifted by means of a hoist.

When you have to operate on assemblies powered by natural gas, follow the instructions contained in the document, as well as all the specific safety standards provided for.

Only remove radiator cap when the engine is cold by cautiously unscrewing it in order to let system residual pressure out.

Inflammable fuel and all inflammable fluids and liquids must be handled with care, according to what contained on harmful materials 16-point cards. Refilling must be performed outdoors with the engine off, avoiding lit cigarettes, free flames or sparks in order to prevent sudden fires/bursts. Adequately store inflammable, corrosive and polluting fluids and liquids according to what provided by regulations in force. Compulsorily avoid to use food containers to store harmful liquids. Avoid to drill or bore pressurised containers, and throw cloths impregnated with inflammable substances into suitable containers.

Worn out, damaged or consumable parts must be replaced by original spares.

During workshop activity, always keep the work place clean; timely clear or clean floors from accidental liquid or oil spots. Electric sockets and electric equipment necessary to perform repair interventions must meet safety rules.

Put on, where required by the intervention, garments and protections provided in accident prevention rules; contact with moving parts can cause serious injuries. Use suitable, preferably tight-fitted garments, and avoid to use jewels, scarves, etc.

Do not leave the engine in motion at workshop locations not provided with a pipe to scavenge exhaust gas outside.

Avoid to breathe fumes coming from heating or from paint welding because they can cause damages to health; operate outdoors or in suitably ventilated areas. Put on proper inspirator if paint powder is present.

Avoid contact with hot water or steam coming from the engine, radiator and pipings because they could cause serious burns. Avoid direct contact with liquids and fluids present in vehicle systems; where an accidental contact has occurred, refer to 12-point cards for provisions to make.

Clean the assemblies and carefully verify that they are intact prior to overhauling.
Tidy up detached or disassembled parts with their securing elements (screws, nuts, etc.) into special containers.

Check for the integrity of the parts which prevent screws from being unscrewed: broken washers, dowels, clips, etc. Self-locking nuts with an insert made of nylon must always be replaced.

Avoid contact of rubber parts with diesel oil, petrol or other not compatible substances.

Before washing under pressure mechanical parts, protect electric connectors, and central units, if present.

Tightening screws and nuts must always be according to prescriptions; FPT commercial and assistance network is available to give all clarifications necessary to perform repair interventions not provided in this document.

Before welding:

- ❑ Disconnect all electronic central units, take power cable off battery positive terminal (connect it to chassis bonding) and detach connectors.
- ❑ Remove paint by using proper solvents or paint removers and clean relevant surfaces with soap and water.
- ❑ Await about 15 minutes before welding.
- ❑ Equip with suitable fire resistant protections to protect hoses or other components where fluids or other materials flow which may catch fire easily on welding.

Should the vehicle be subjected to temperatures exceeding 80 °C (dryer ovens), disassemble drive electronic central units.

The disposal of all liquids and fluids must be performed with full observance of specific rules in force.

GENERAL WARNINGS ON THE ELECTRIC SYSTEM

If an intervention has to be made on the electric/electronic system, disconnect batteries from the system; in this case, always disconnect, as a first one, the chassis bonding cable from batteries negative terminal.

Before connecting the batteries to the system, make sure that the system is well isolated.

Disconnect the external recharging apparatus from the public utility network before taking apparatus pins off battery terminals.

Do not cause sparks to be generated in checking if the circuit is energized.

Do not use a test lamp in checking circuit continuity, but only use proper control apparatuses.

Make sure that the electronic devices wiring harnesses (length, lead type, location, strapping, connection to screening braiding, bonding, etc.) comply with FPT system and are carefully recovered after repair or maintenance interventions.

Measurements in drive electronic central units, plugged connections and electric connections to components can only be made on proper testing lines with special plugs and plug bushes. Never use improper means like wires, screwdrivers, clips and the like in order to avoid the danger of causing a short circuit, as well as of damaging plugged connections, which would later cause contact problems.

To start up the engine, do not use fast chargers. Start up must only be performed with either separate batteries or special truck.

A wrong polarization of supply voltage in drive electronic central units (for instance, a wrong polarization of batteries) can cause them to be destroyed.

Disconnect the batteries from the system during their recharging with an external apparatus.

On connecting, only screw up connector (temperature sensors, pressure sensors etc.) nuts at prescribed tightening torque.

Before disconnecting the junction connector from an electronic central unit, isolate the system.

Do not directly supply electronic central units servo components at nominal vehicle voltage.

Cables must be arranged such as to result to be parallel to reference plane, i.e. as close as possible to chassis/body structure.

Once the intervention on the electric system has been completed, recover connectors and wiring harnesses according to original arrangement.

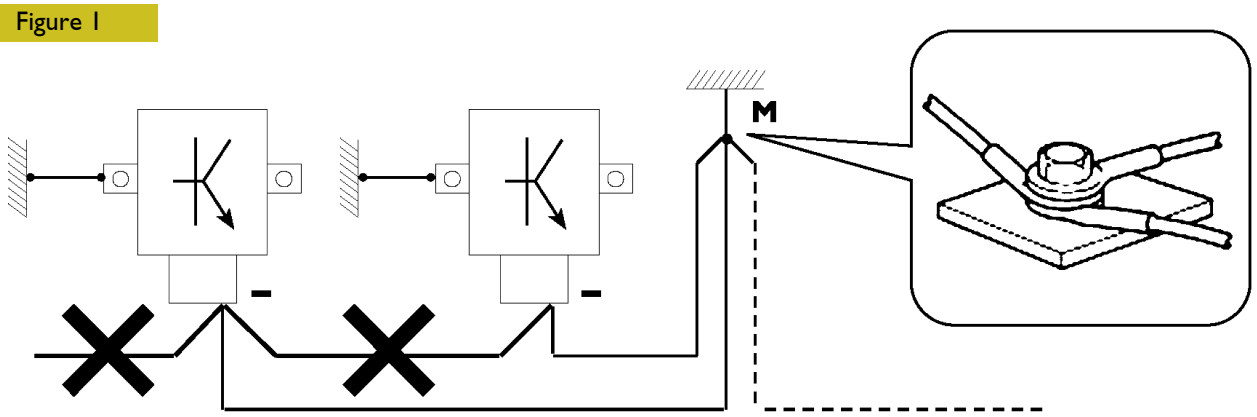
Bonding and screening

Negative leads connected to a system bonded point must be both as short and possible and "star"-connected to each other, trying then to have their centering tidily and properly made (Figure 1, re. M).

Further, following warnings are to be compulsorily observed for electronic components:

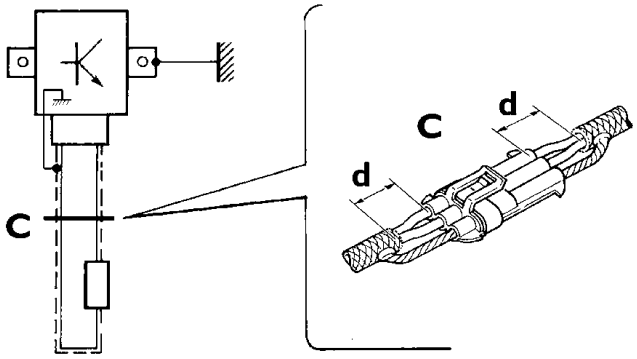
- Electronic central units must be connected to system bonding when they are provided with a metallic shell.
- Electronic central units negative cables must be connected both to a system bonding point such as the dashboard opening bonding (avoiding "serial" or "chain" connections), and to battery negative terminal.
- Analog bonding (sensors), although not connected to battery negative system/terminal bonding, must have optimal isolation. Consequently, particularly considered must be parasitic resistances in lugs: oxidations, clinching defects, etc.
- Screened circuits braiding must only electrically contact the end towards the central unit entered by the signal (Figure 2).
- If junction connectors are present, unscreened section **d**, near them, must be as short as possible (Figure 2).
- Cables must be arranged such as to result to be parallel to reference plane, i.e. as close as possible to chassis/body structure.

Figure 1



1. NEGATIVE CABLES "STAR" CONNECTION TO SYSTEM BONDING **M**

Figure 2



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2. SCREENING THROUGH METALLIC BRAIDING OF A CABLE TO AN ELECTRONIC COMPONENT – **C.** CONNECTOR **d.** DISTANCE → 0

OPTIONAL ELECTRICAL AND MECHANICAL PARTS INSTALLATIONS

Assemblies shall be modified and equipped with additions - and their accessories shall be fitted - in accordance with the assembling directives issued by FPT.
It is reminded that, especially about the electric system, several electric sockets are provided for as series (or optional) sockets in order to simplify and normalise the electrical intervention that is care of preparation personnel.

It is absolutely forbidden to make modifications or connections to electric central units wiring harnesses; in particular, the data interconnection line between central units (CAN line) is to be considered inviolable.

CONVERSIONS BETWEEN THE MAIN UNITS OF MEASUREMENT OF THE INTERNATIONAL SYSTEM AND MOST USED DERIVED QUANTITIES

Power

1 kW = 1.36 CV
1 kW = 1.34 hp
1 CV = 0.735 kW
1 CV = 0.986 hp
1 hp = 0.746 kW
1 hp = 1.014 CV

NOTE The unit CV is converted into hp for simplicity according to a 1:1 ratio
1 hp = 1 CV.

Torque

1 Nm = 0.1019 kgm
1 kgm = 9.81 Nm

Revolutions per time unit

1 rpm = 0.1047 rad/s
1 rad/s = 9.55 rpm

Pressure

1 bar = 1.02 kg/cm^2
1 kg/cm^2 = 0.981 bar
1 bar = 10^5 Pa

NOTE Where accuracy is not particularly needed:

- Nm unit is for the sake of simplicity converted into kgm according to ratio 10:1

1 kgm = 10 Nm;

- bar unit is for the sake of simplicity converted into kg/cm^2 according to ratio 1:1

1 kg/cm^2 = 1 bar.

Temperature

0 °C = 273.15 K
0 °F = 255.37 K
0 °C = 32 °F (the conversion factor between Celsius and Fahrenheit is 1:1.8)

KEY OF LECTURE OF THE HEADINGS AND FOOTNOTES

Type of vehicle

Section title

Page number

MOTORI NEF F4HE

SEZIONE 4 - REVISIONE MECCANICA GENERALE 11

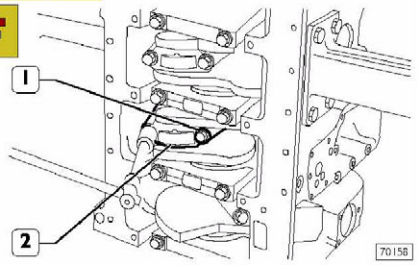
REVISIONE MOTORE 4 E 6 CIL. SMONTAGGIO DEL MOTORE AL BANCO

La trattazione seguente prevede che il motore sia stato montato sul cavalletto rotativo e si sia proceduto alla rimozione di tutti i componenti specifici dell'applicazione Iveco Motors (vedere la Sezione 3 del presente manuale).

La sezione riguarda quindi tutte le più importanti procedure di revisione del basamento motore.

Le operazioni seguenti riguardano il motore 4 cilindri, ma risultano analoghe per il 6 cilindri.

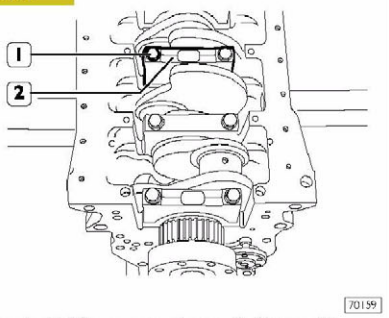
Figura 1



Svitare le viti di fissaggio (1) e rimuovere i cappelli di biella (2). Sfilare gli stantuffi completi di bielle dalla parte superiore del basamento.

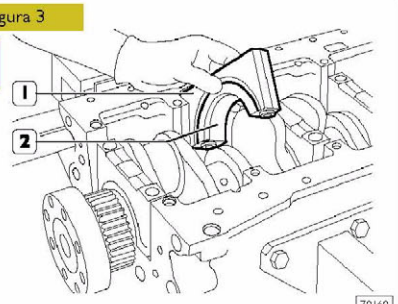
NOTA Mantenere i semicuscinetti nei rispettivi alloggiamenti, poiché, in caso di un loro utilizzo, dovranno essere montati nella posizione riscontrata allo smontaggio.

Figura 2



Rimuovere le viti (1) e smontare i cappelli di banco (2).

Figura 3

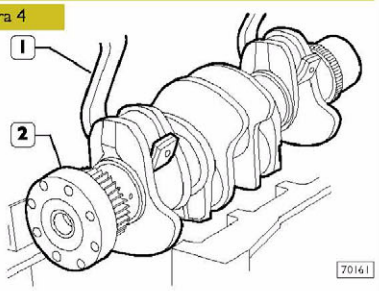


Il penultimo cappello di banco (1) e il relativo supporto hanno il semicuscinetto (2) dotato di spallamento.

NOTA Le viti M12 dei cappelli di banco, devono essere sostituite se il diametro nominale della parte filettata che non lavora, presenta un diametro < 0,1 mm rispetto al valore nominale.

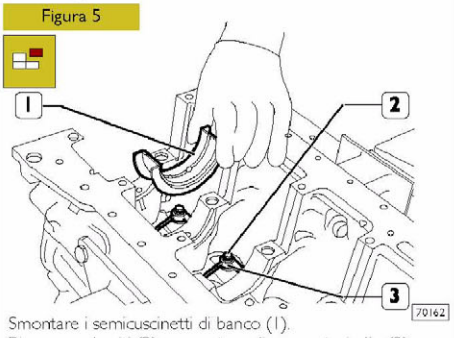
NOTA Annotare la posizione di montaggio dei semicuscinetti inferiori e superiori, poiché in caso di un loro riutilizzo, dovranno essere montati nella posizione riscontrata allo smontaggio.

Figura 4



Con l'attrezzo 99360500 (1) e sollevatore rimuovere l'albero motore (2) dal basamento.

Figura 5



Smontare i semicuscinetti di banco (1).
Rimuovere le viti (2) e smontare gli spruzzatori olio (3).

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When month - year update is present (revi) to the basic edition

F4HFE613 ENGINE

UPDATING

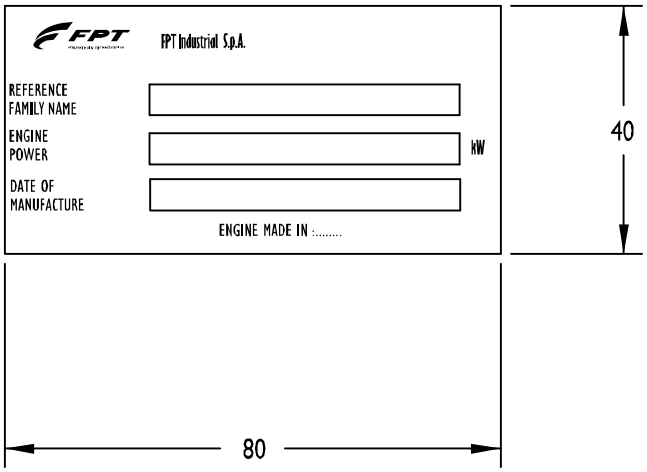
Section	Section name	Description of change	Page	Date of revision

SECTION 1

General specifications

IDENTIFICATION PLATE

Figure 1



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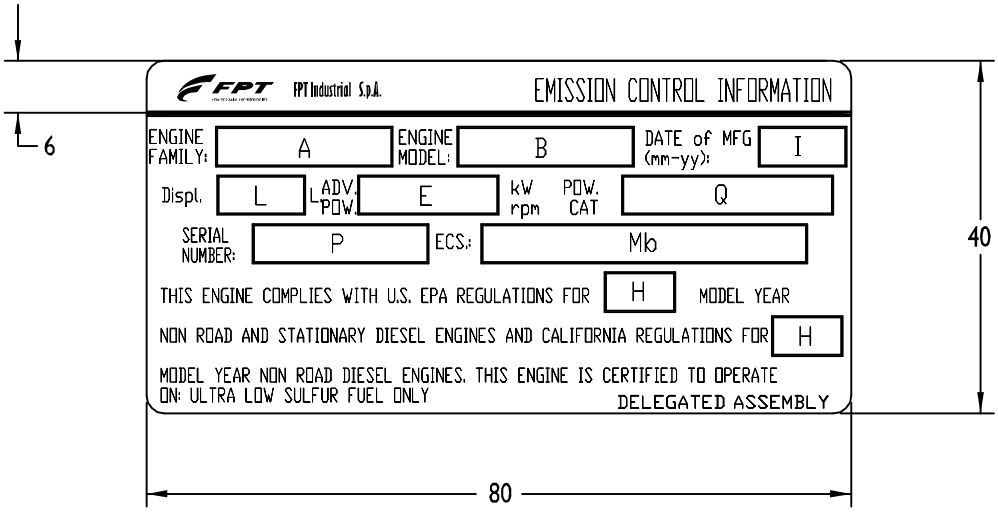
HOMOLOGATION PLATE

Figure 2



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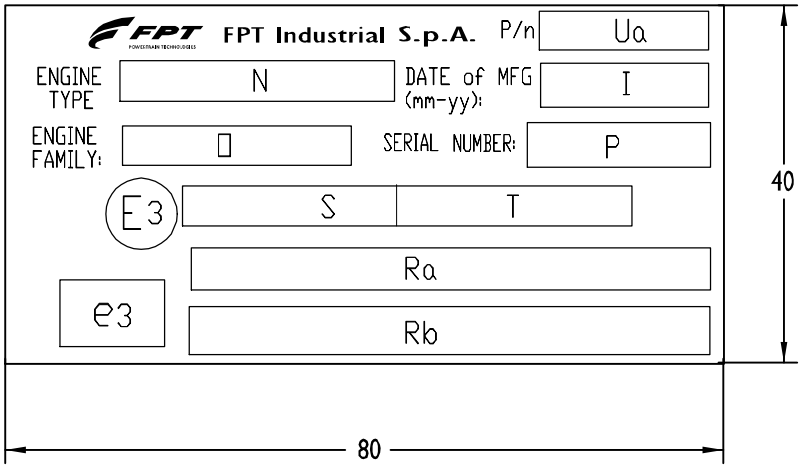
TIER 4B (F4HFE6131*B003 - F4HFE613K*B004 - F4HFE613N*B002)

Figure 3



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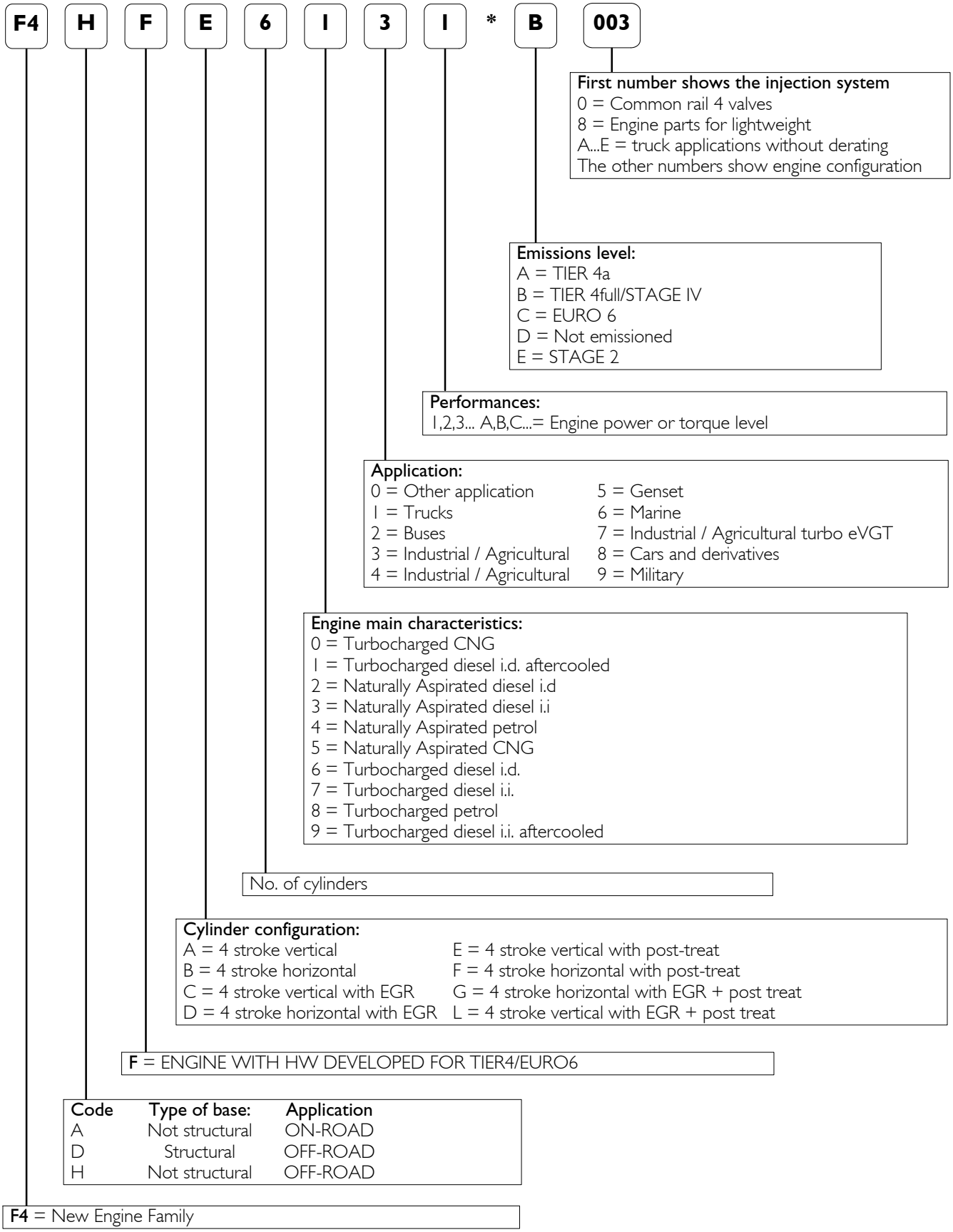
STAGE IV (F4HFE6131*B005 - F4HFE613K*B005 - F4HFE613N*B003)

CORRESPONDENCE BETWEEN TECHNICAL CODE AND COMMERCIAL CODE

Technical Code	Commercial Code
F4HFE6131*B003 **F4HFE613K*B004** **F4HFE613N*B002**	**N67 ENT Z W**
F4HFE6131*B005 **F4HFE613K*B005** **F4HFE613N*B003**	**N67 ENT L W**

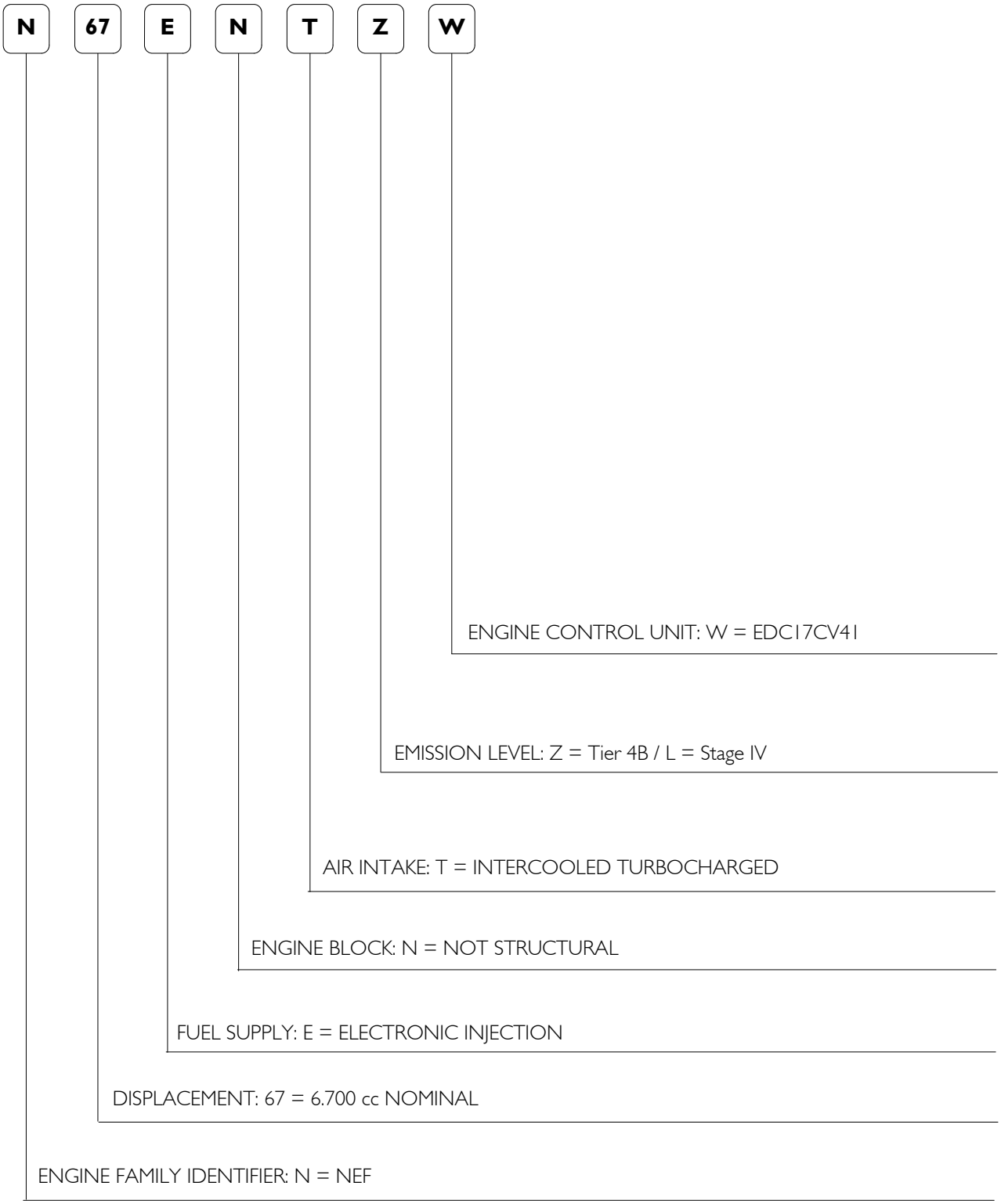
TECHNICAL CODE

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.



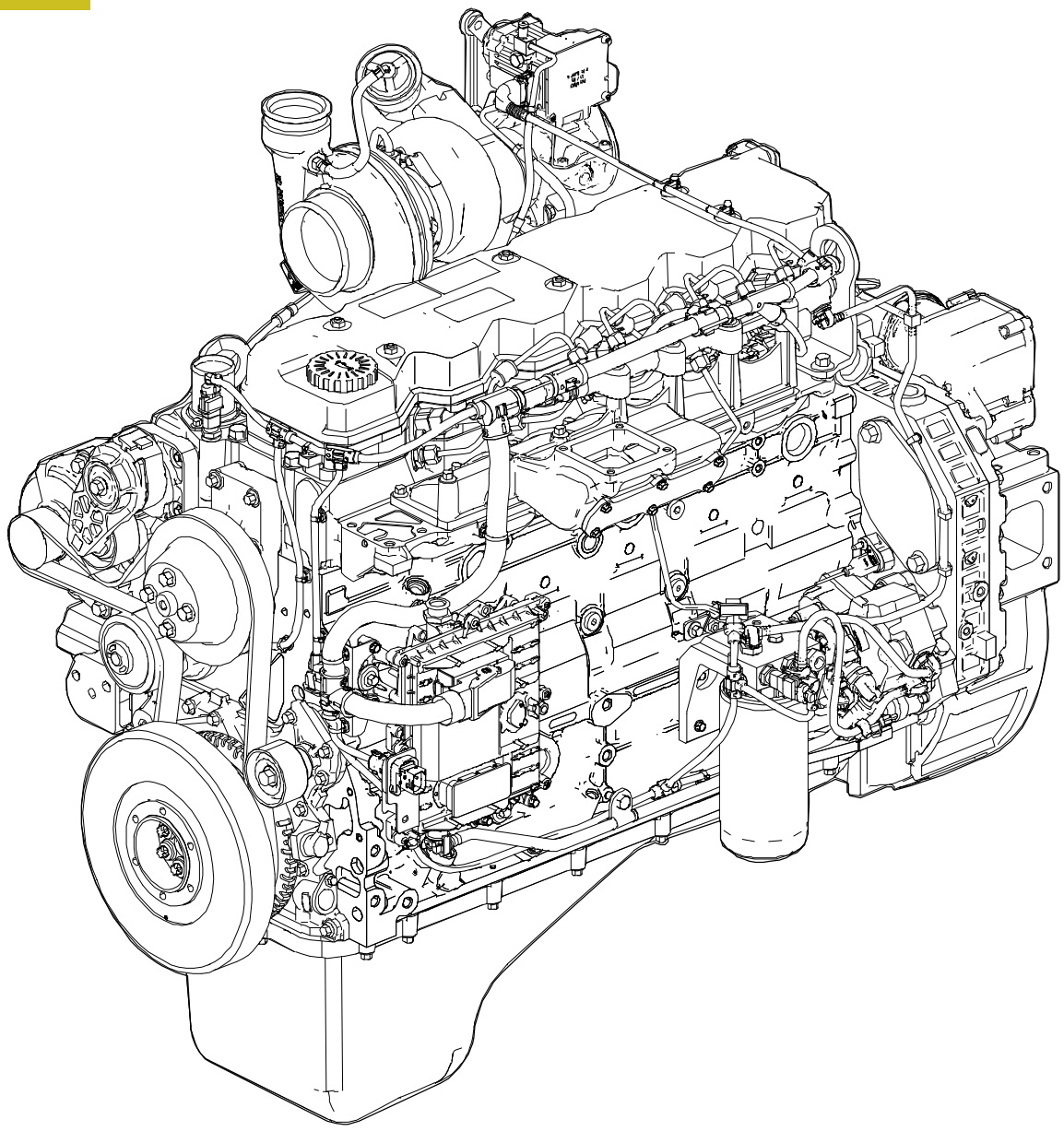
COMMERCIAL CODE

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".



ISO VIEW

Figure 4

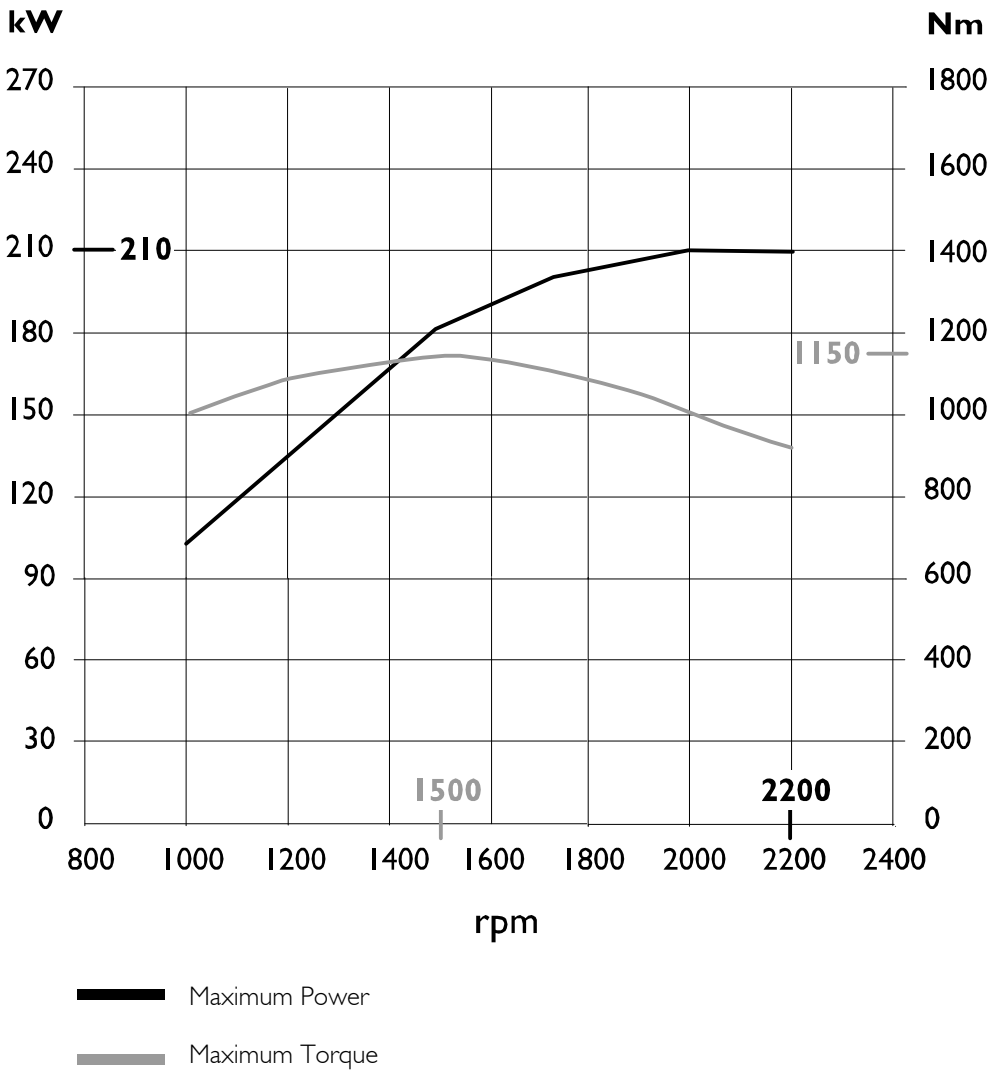


F4HFE613 engine

The engine F4HFE613 is a 6-cylinder in-line turbocharged with intercooler with 4 valves per cylinder; it belongs to the NEF series and operates according to a four-stroke diesel cycle.
The engine supply system is electronically-controlled and it's based on the direct injection of the fuel in the combustion chamber by means of high pressure pump and common rail.
The intake and exhaust valves are timed with the camshaft tappets, the push rods and the rocker arm assembly.

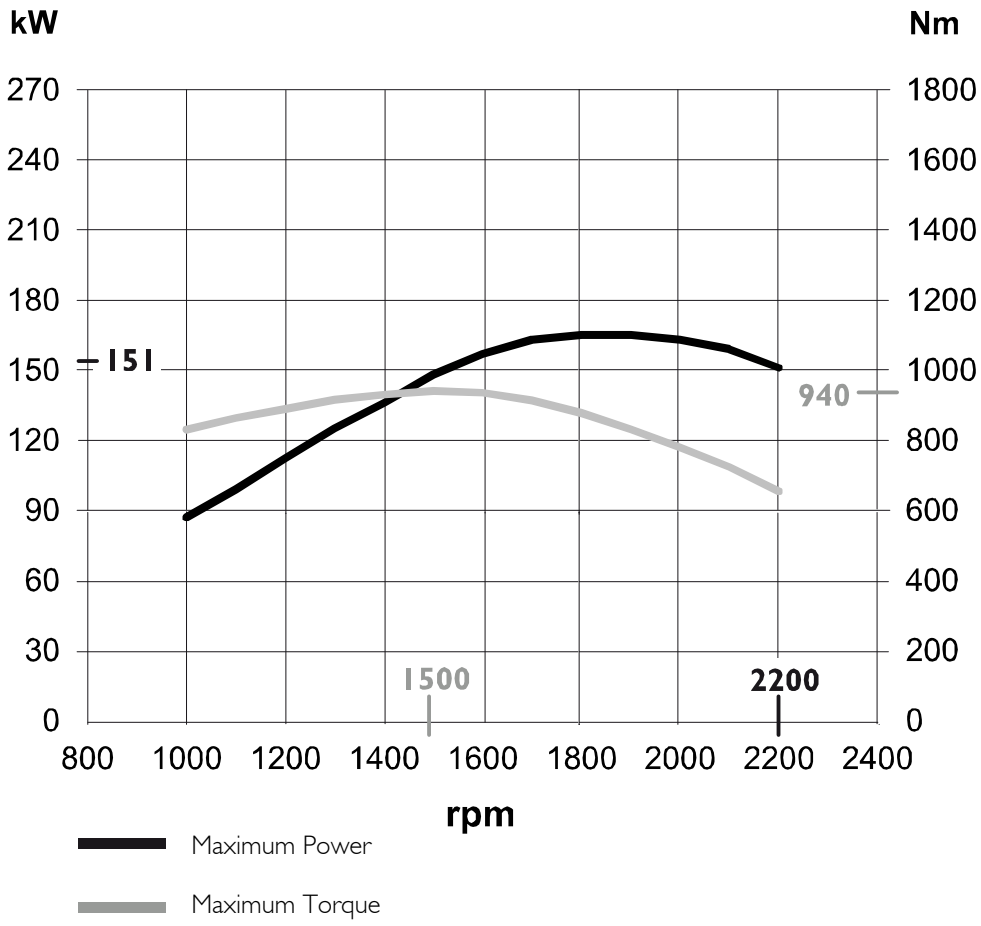
TORQUE AND POWER TYPICAL CURVES (F4HFE6131*B003 - F4HFE6131*B005)

Figure 5



(F4HFE613K*B004 - F4HFE613K*B005)

Figure 6



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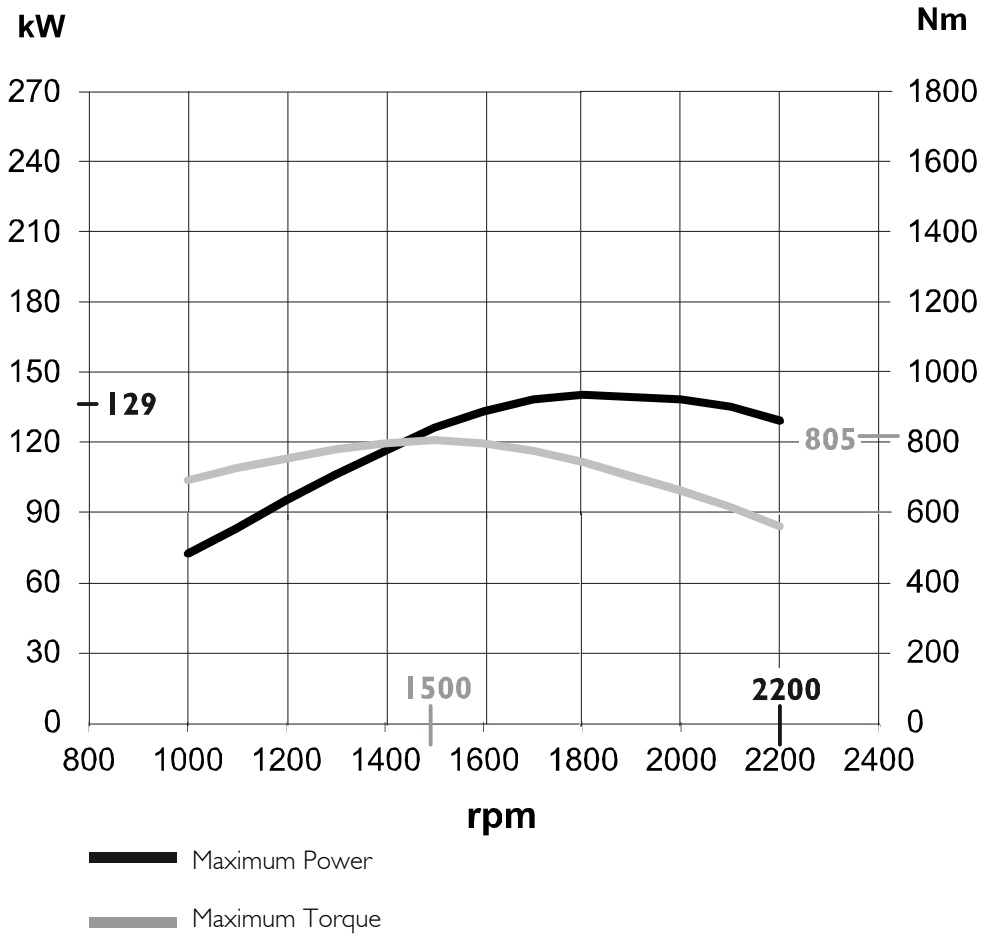
(F4HFE613N*B002 - F4HFE613N*B003)

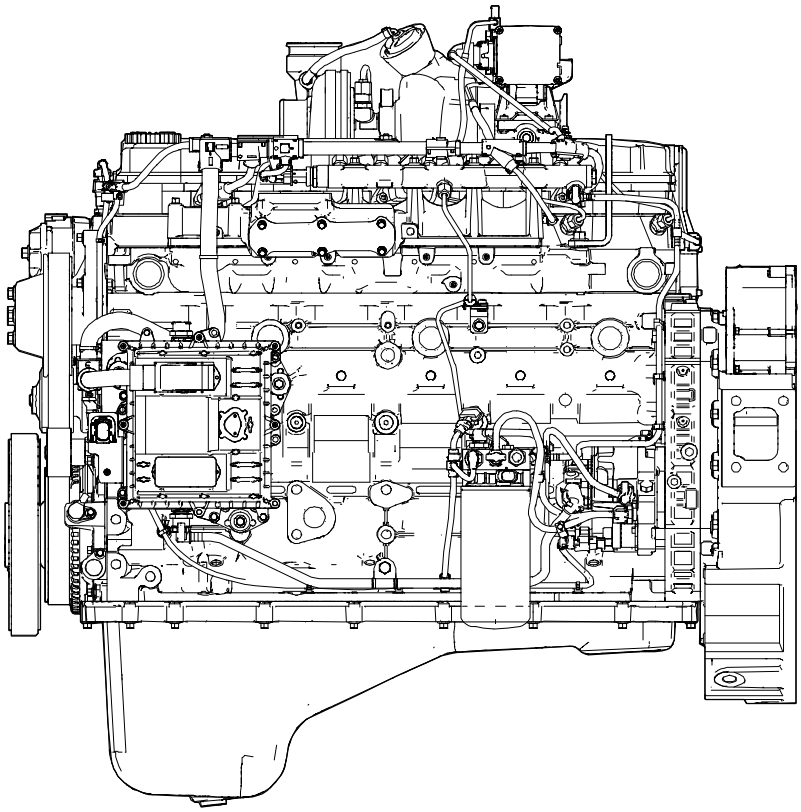
Figure 7



ENGINE VIEWS

(F4HFE6131*B003 - F4HFE6131*B005)

Figure 8



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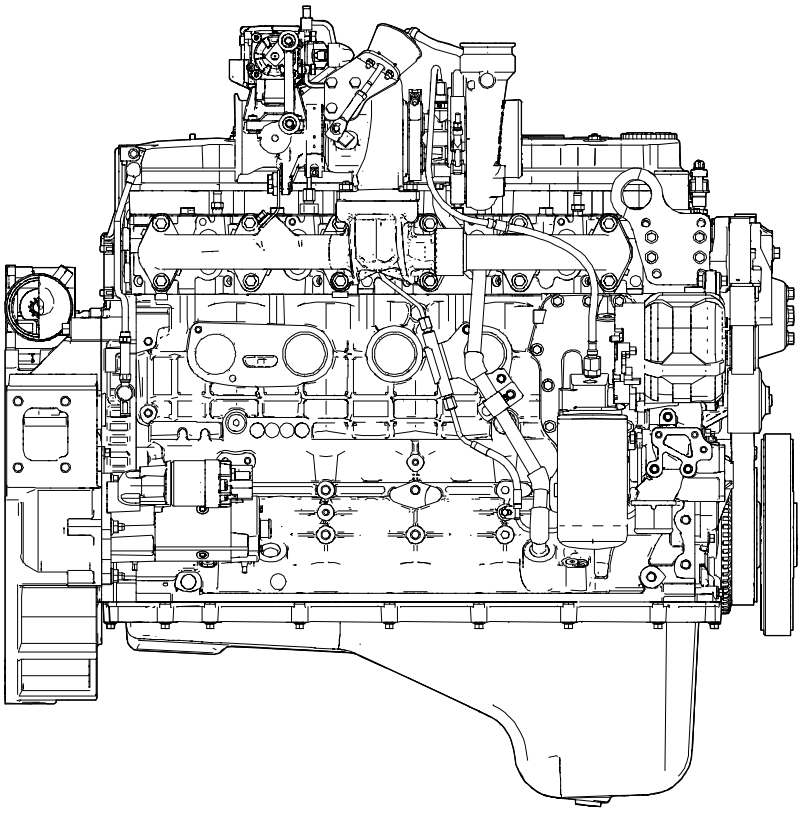
LEFT-HAND SIDE VIEW

Figure 9



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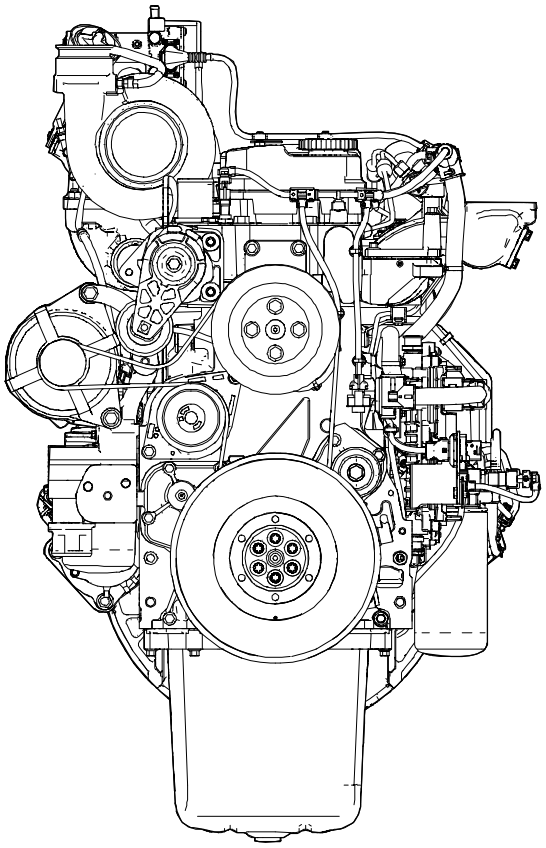
RIGHT-HAND SIDE VIEW

Figure 10



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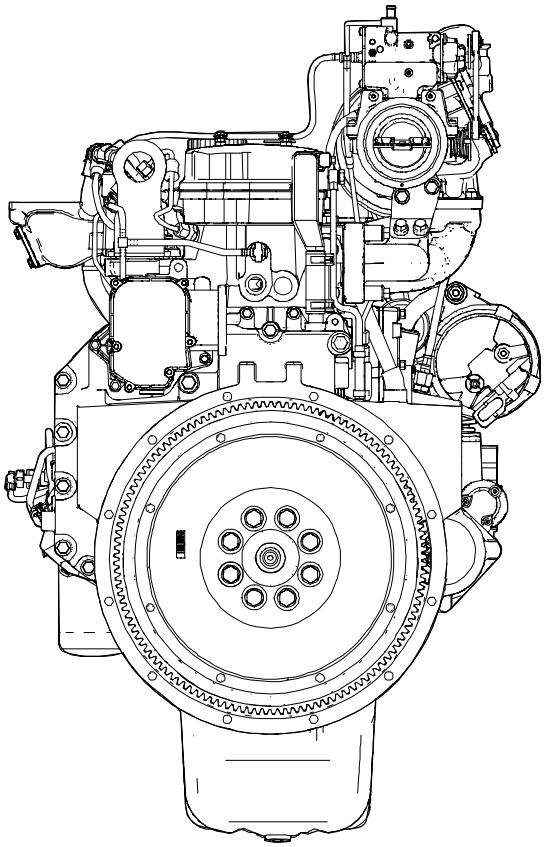
FRONT VIEW

Figure 11



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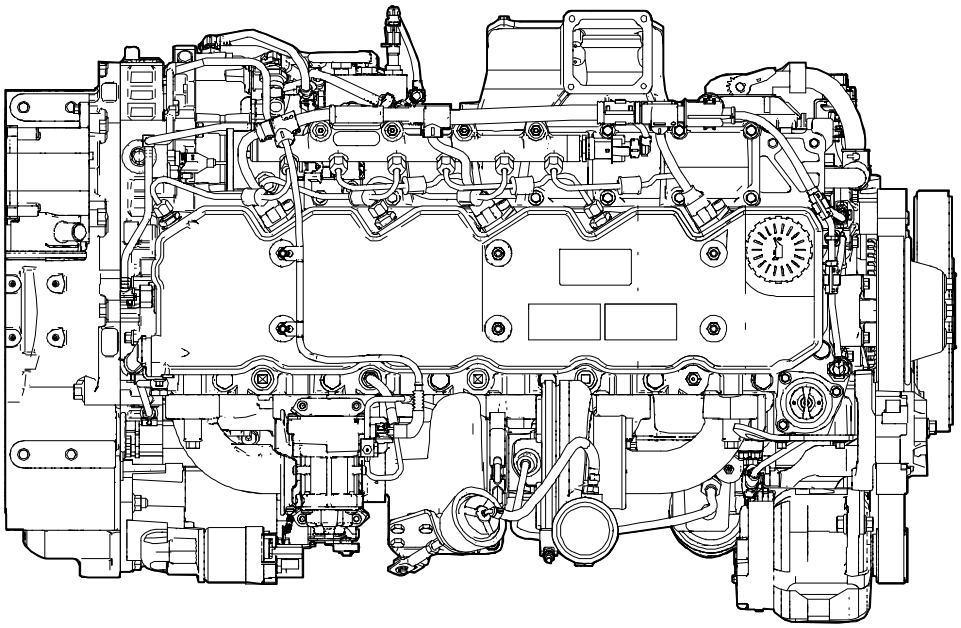
REAR VIEW

Figure 12



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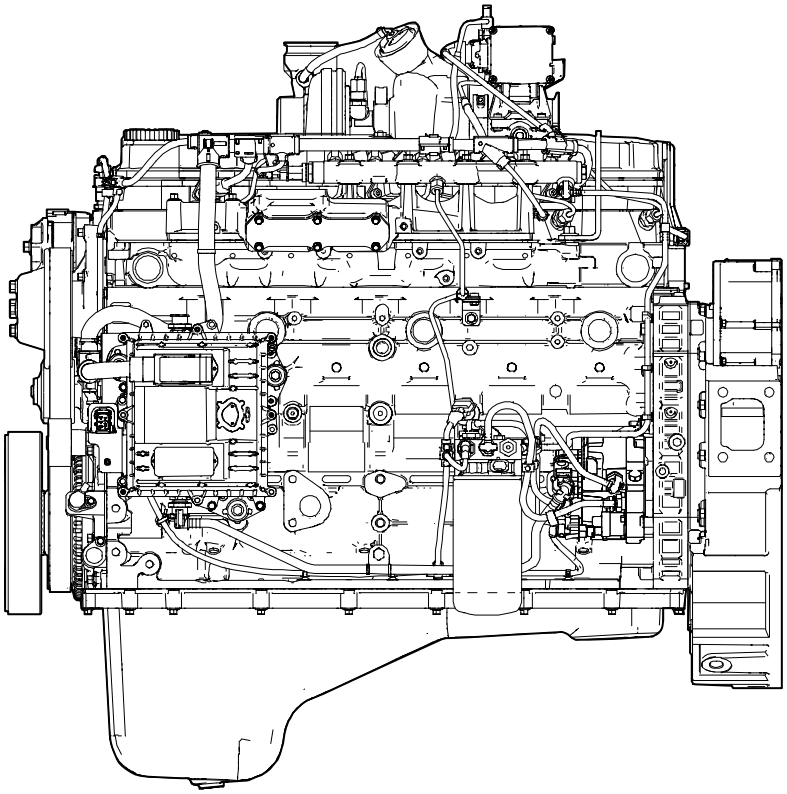
TOP VIEW

(F4HFE613K*B004 - F4HFE613K*B005)

Figure 13



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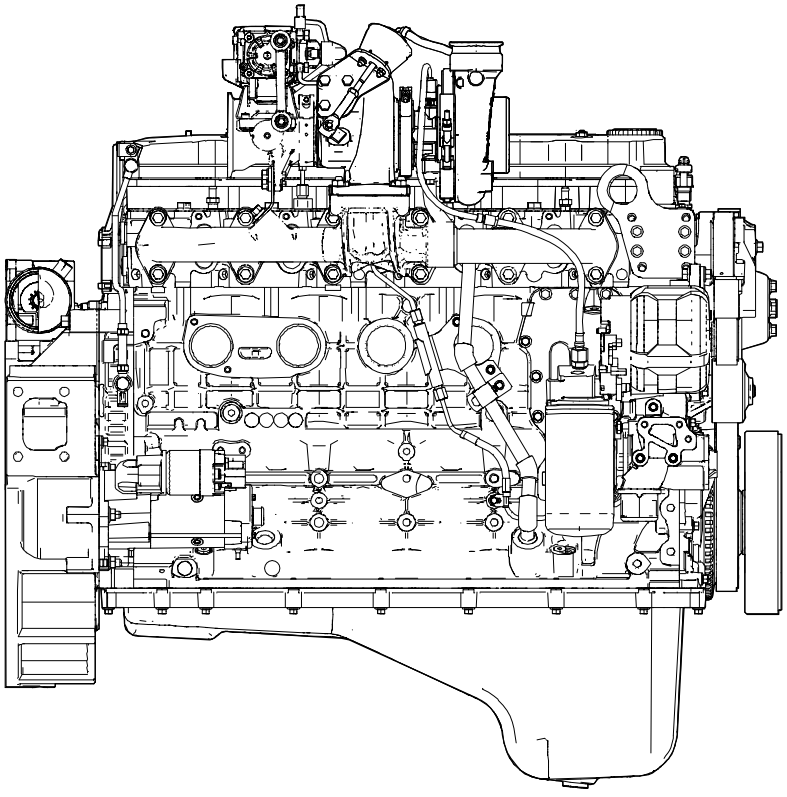
LEFT-HAND SIDE VIEW

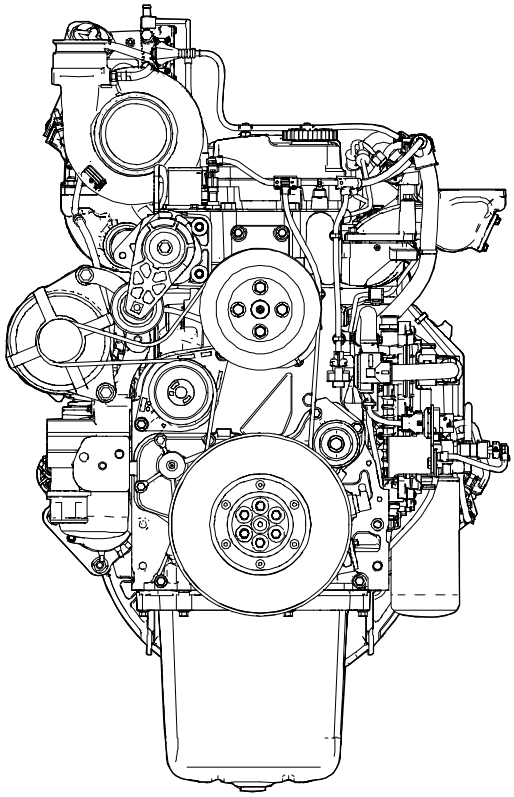
Figure 14



214993

RIGHT-HAND SIDE VIEW

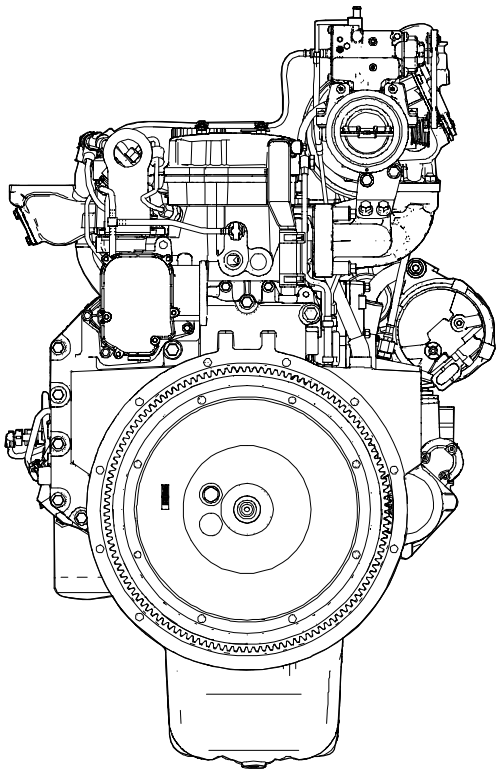
Figure 15



214994

FRONT VIEW

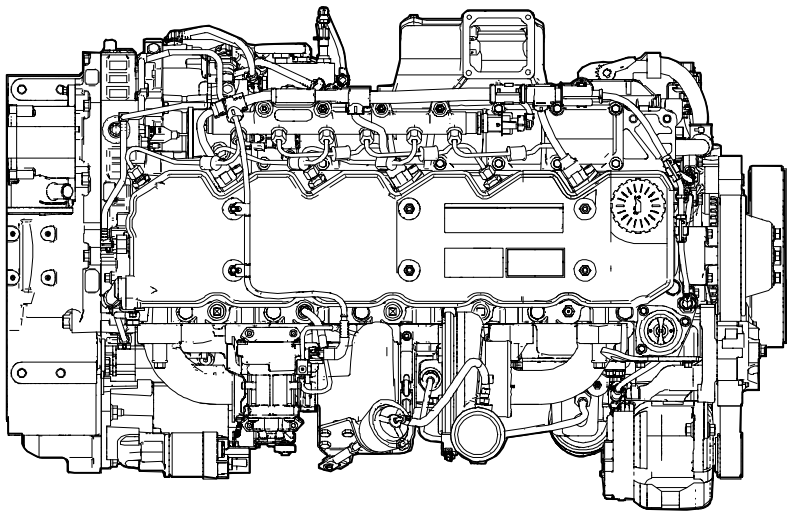
Figure 16



214500

REAR VIEW

Figure 17

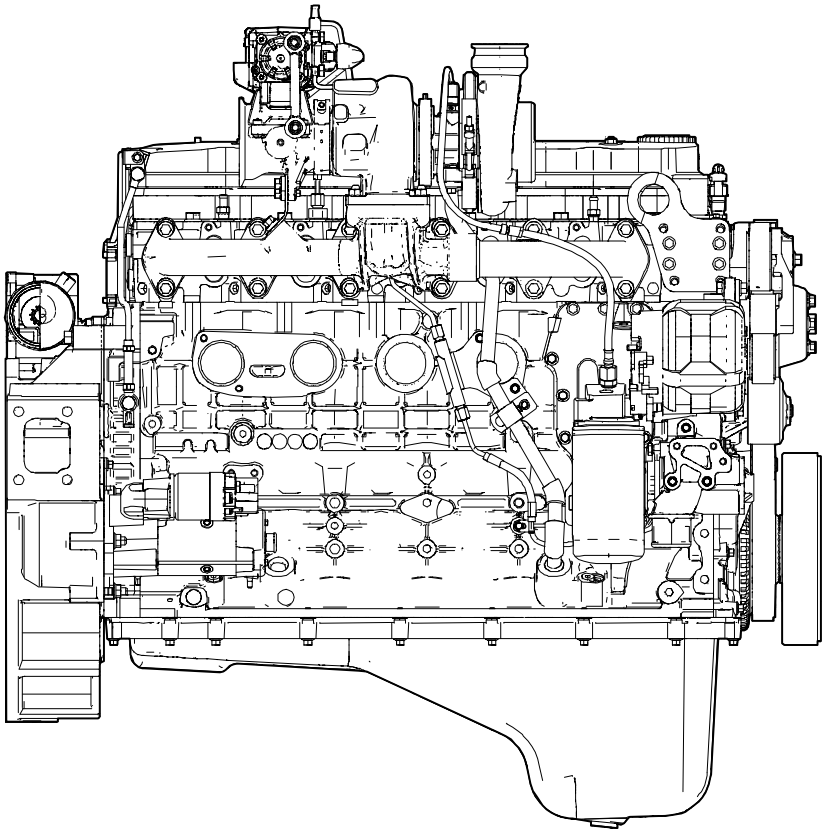


214996

TOP VIEW

(F4HFE613N*B002 - F4HFE613N*B003)

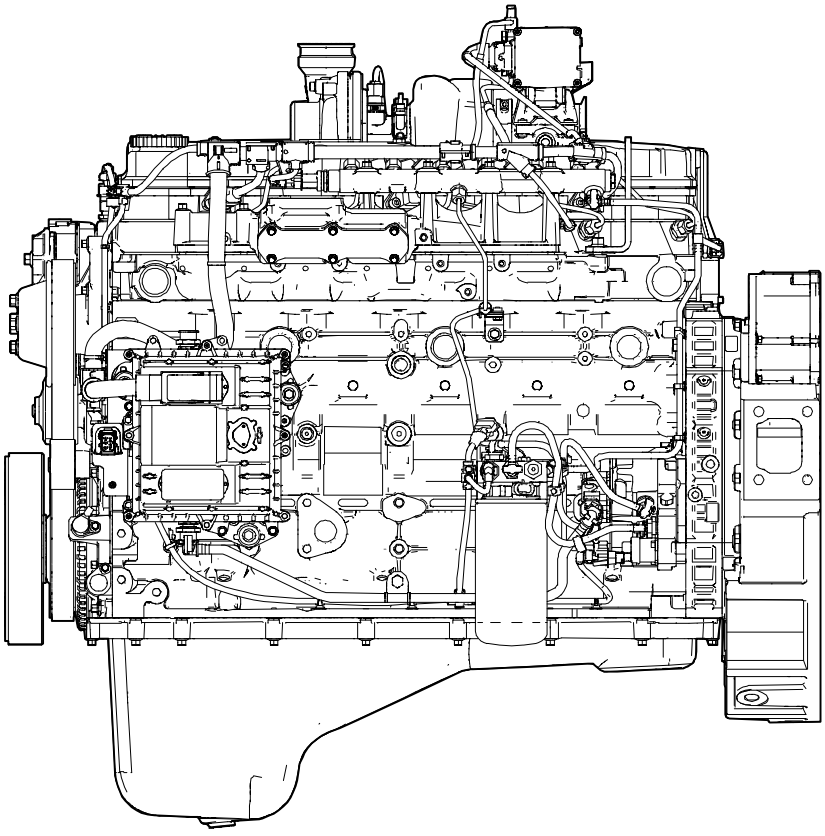
Figure 18



214997

LEFT-HAND SIDE VIEW

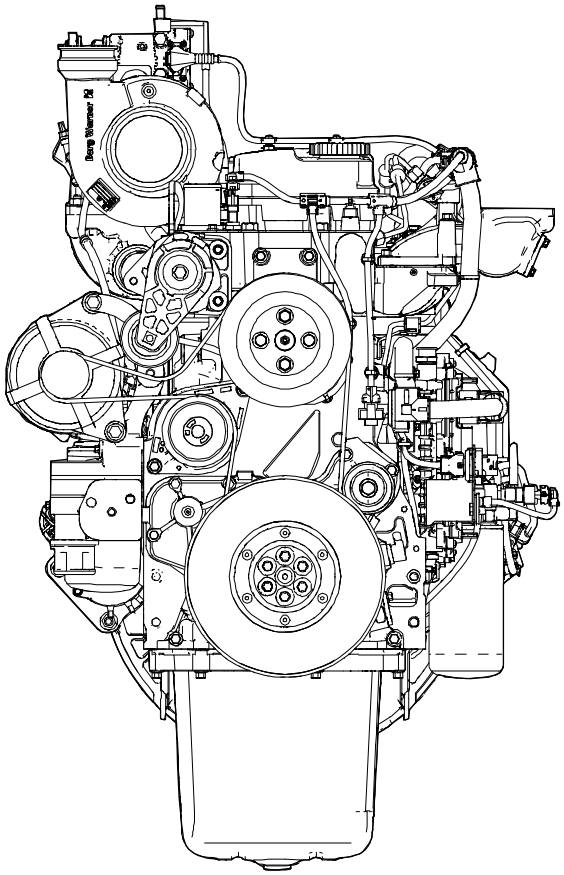
Figure 19



214998

RIGHT-HAND SIDE VIEW

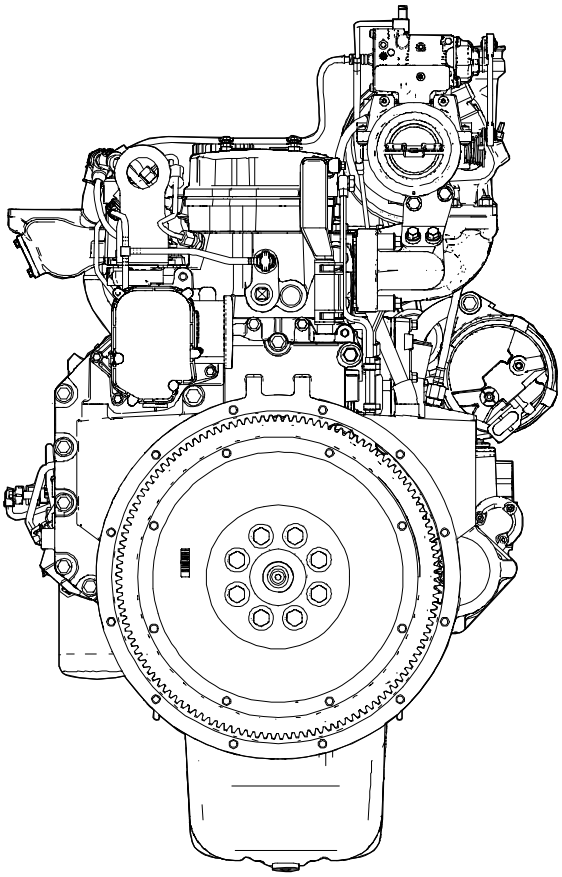
Figure 20



214999

FRONT VIEW

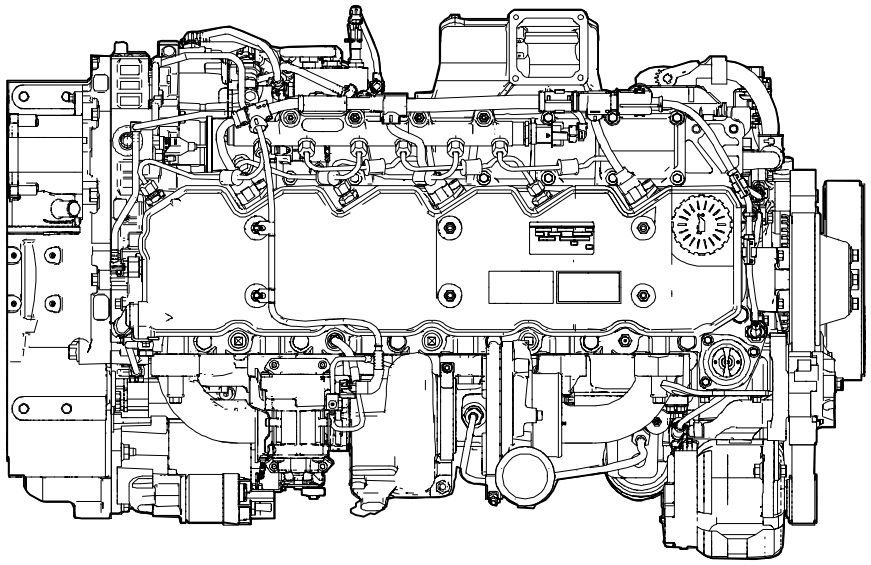
Figure 21



21500

REAR VIEW

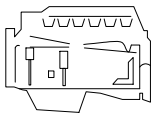
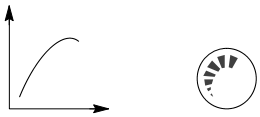
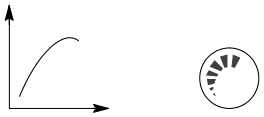
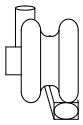
Figure 22



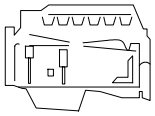
214501

TOP VIEW

GENERAL CHARACTERISTICS

			F4HFE613		
	Type		1*B003 1*B005	K*B004 K*B005	N*B002 N*B003
	Compression ratio		17 : 1	18 : 1	
	Maximum power	kW (hp) rpm	210 (286) 2,200	151 (205) 2,200	129 (175) 2,200
	Maximum torque	Nm (kgm) rpm	1,150 (117.23) 1,500	940 (95.82) 1,500	805 (82.06) 1,500
	Idle speed	rpm	750 ± 50		
	Maximum engine speed	rpm	2375 ± 50		
	Bore x stroke		104 x 132		
	Total displacement	cm^3	6728		
	**TURBOCHARGING**		Turbocharged - with intercooler		Turbocharged - with intercooler
	Turbocharger	type	BorgWarner Waste-gate turbocharger (WGT)		BorgWarner Fixed geometry turbocharger (FGT)
	**LUBRICATION**		Forced by gear pump, pressure relief valve, oil filter		
	Oil pressure with engine hot:				
	- at idle speed	bar	0.6		
	- at maximum speed	bar	3.5		

NOTE These data, characteristics and performance figures are only valid if the fitter respects all FPT installation requirements. Anything fitted by the bodybuilder must always respect the engine design torque, power and speed.

 Type		F4HFE613		
		1*B003 1*B005	K*B004 K*B005	N*B002 N*B003
	COOLING	Liquid cooled		
	Coolant pump control	Belt driven		
	Thermostat:			
	- start of opening °C	79 ± 2		
	- max. opening °C	96		
	REFILLING			
	Cooling circuit (1) litres	11		
	Lubrication circuit (2) total capacity (3) litres (kg)	18 (16.2)		
 ACEA E9 SAE10W-40 / API CJ-4	**Periodic replacement:**			
	- oil sump at min level litres (kg)	8 (7.2)		
	- oil sump at max level litres (kg)	14 (12.6)		
	Fuel tank (4) litres	-		
	Urea tank (5) litres	43 / 65 / 80		

(1) The quantities indicated only relate to the engine in its standard configuration. Use a 50% mixture of water and Actifull OT even during the summer months. As an alternative to Actifull OT, use another product that complies with FPT norm FPI9.COOL002 and / or ASTM D-6210 standard.

(2) Only use lubricants which meet the international standards API CJ-4 / ACEA E9. Recommended oil is SAE 10W-40 that complies with FPT norm FPI9.LUBR001. FPT suggest to use original AkcelA or AmbrA lubricants compliant with SAE 10W40 standard. The oil consumption is considered to be acceptable until a quantity equaling 0.5% of fuel consumption is reached.

(3) The quantities indicated relate to the first refill only and are relative to the engine, oil sump and filter filling.

(4) Use STANDARD fuel compliant to the ASTM D975 or EN 590. Instructions connected to the fuel tank capacity are the responsibility of the vehicle/equipment manufacturer since these are subject to changes depending on the various vehicle/equipment configurations.

(5) Only use AdBlue□/DEF in accordance with ISO 22241 specification.

NOTE These data, characteristics and performance figures are only valid if the fitter respects all FPT installation requirements. Anything fitted by the bodybuilder must always respect the engine design torque, power and speed.

SECTION 2

Operational diagrams

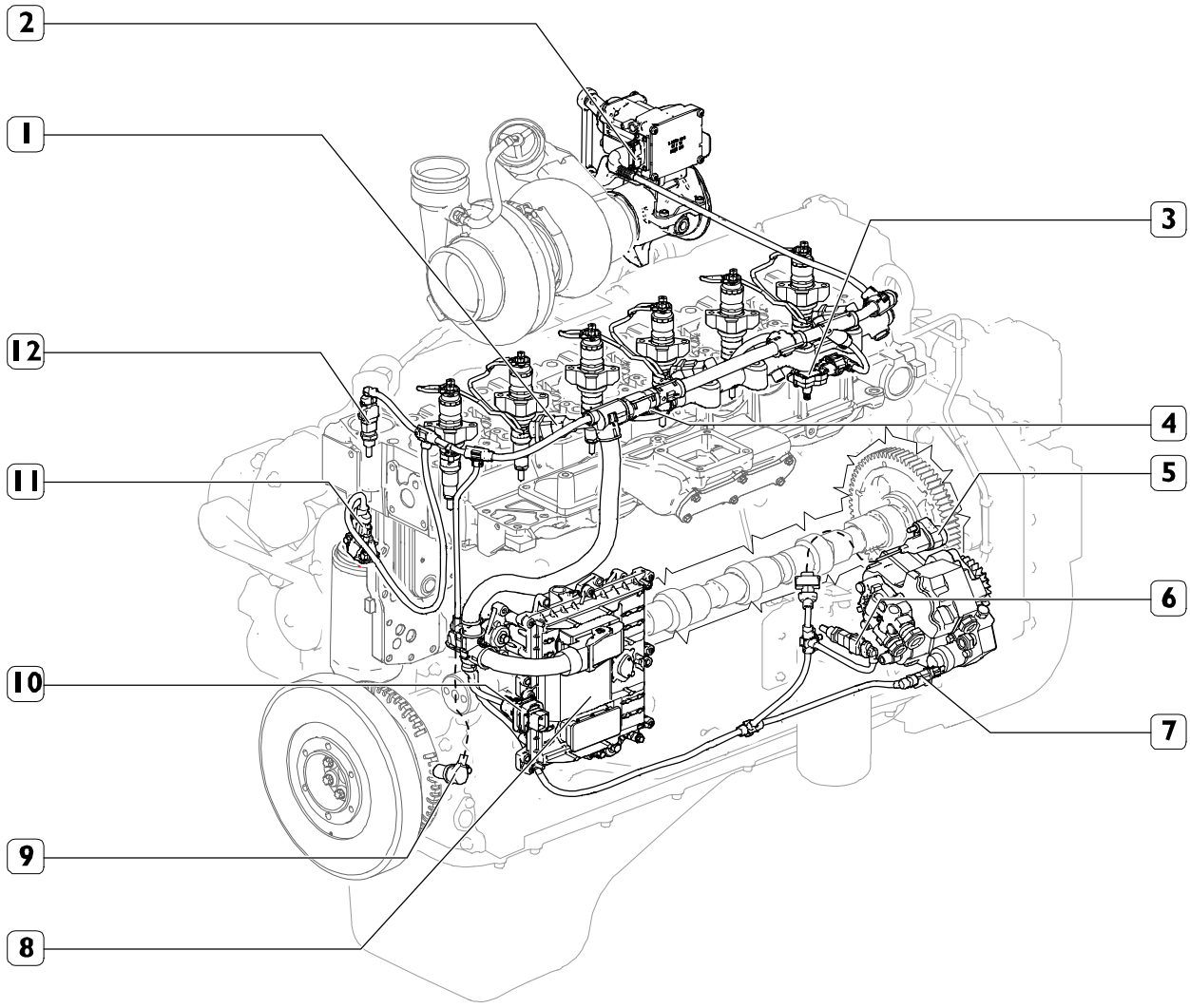
FUEL SUPPLY SYSTEM

General Specifications

In order to reduce PARTICULATES emissions, very high injection pressures are required.
The Common Rail system allows injecting the fuel up to pressures reaching **1600 bar,** at the same time, the injection precision, obtained by the electronic system control, optimizes the engine performance, reducing emissions and consumption.

ELECTRIC SYSTEM

Figure 1



1. Electro-injectors connections - 2. Motorized throttle valve actuator connector (Exhaust flap) - 3. Boost pressure and air temperature sensor - 4. Rail pressure sensor - 5. Camshaft timing segment speed sensor - 6. Fuel temperature sensor - 7. Fuel high pressure pump metering unit - 8. Engine Control Unit ECU17CV41 - 9. Crankshaft rpm increment speed sensor - 10. In line connector - 11. Engine oil pressure and temperature sensor - 12. Coolant temperature sensor

Sensors

Through the sensors, present on the engine, the ECU controls the engine operation.

Air pressure/temperature sensor

It is a component integrating a temperature sensor and a pressure sensor.

Fitted on the intake manifold, it measures the max. inlet air capacity to calculate precisely the fuel quantity to inject at every cycle.

The outlet tension is proportional to the pressure or temperature obtained by the sensor.

Engine oil temperature and pressure sensor

Same as air pressure/temperature sensor, it is fitted on the engine oil filter, in a horizontal position.

It measures engine oil temperature and pressure.

Fuel pressure sensor

Assembled on a rail end, it measures the fuel pressure in the rail in order to determine the injection pressure.

The injection pressure value is used to control the pressure and to determine the electric injection control length.

Fuel temperature sensor

It is a sensor that is equal to the previous one.

It measures fuel temperature to provide the control unit with an index of the diesel fuel thermal state.

Coolant temperature sensor

It is a variable-resistance sensor suitable to measure the coolant temperature to provide the control unit with an index of the engine thermal state.

Crankshaft sensor

It is an inductive sensor placed on the front engine part. Signals generated through the magnetic flow that is closed on the phonic wheel, change their frequencies depending on output shaft rotation speed.

Timing sensor

It is an inductive sensor placed on the engine rear left part. It generates signals obtained from magnetic flow lines that are closed through holes obtained on the keyed gear on the camshaft. The signal generated by this sensor is used by the ECU as injection phase signal.

Though being equal to the flywheel sensor, it is NOT interchangeable since it has a different outside shape.

System functionality

Self-diagnosis

The ECU self-diagnostic system checks signals coming from sensors by comparing them with threshold data.

Engine pre-heating resistance check

The pre-post heating is activated when even only one of the water, air or fuel temperature sensors signals a temperature that is less than 5 °C.

Timing recognition

By means of signals coming from camshaft sensor and flywheel sensor, the cylinder on which fuel must be injected is recognised upon startup.

Injection control

The control unit, depending on information coming from sensors, controls the flow rate regulator, and changes pre--injection and main injection modes.

Closed-loop control for injection pressure

Depending on engine load, measured by processing signals coming from various sensors, the control unit controls the regulator in order to always have the optimum pressure.

Pilot and main injection spark advance control

The control unit, depending on signals coming from various sensors, computes the optimum injection point according to an internal mapping.

Idle speed control

The control unit processes signals coming from various sensors and adjusts the amount of injected fuel.
It controls the pressure regulator and changes the injection time of injectors.
Within certain thresholds, it also takes into account the battery voltage.

Maximum speed limiting

Approaching the peak rpm, the ECU limits the fuel flow by reducing the opening time of the electro-injectors.
The peak rpm of the engines is 2375 ± 50 revs/min. Above this rate the ECU deactivates the electro-injectors.

Cut Off

Fuel cut off upon release is controlled by the control unit performing the following logics:

- ❑ it cuts off injectors supply;
- ❑ it re-activates the injectors shortly before idle speed is reached;
- ❑ it controls fuel flow rate regulator.

Smoke control upon acceleration

With strong load requests, the control unit, depending on signals received by air inlet meter and engine speed sensor, controls the flow rate regulator and changes the injectors actuation time, in order to avoid exhaust smokes.

Fuel temperature control

When the fuel temperature exceeds 78 °C (measured by the sensor placed on fuel filter) the control unit intervenes by reducing injection pressure.
If the temperature exceeds 90 °C, the power is reduced to 60%.

After Run

The control unit microprocessor allows storing certain EPROM data, among which failure memory and Immobilizer information, in order to make them available upon the following startup.

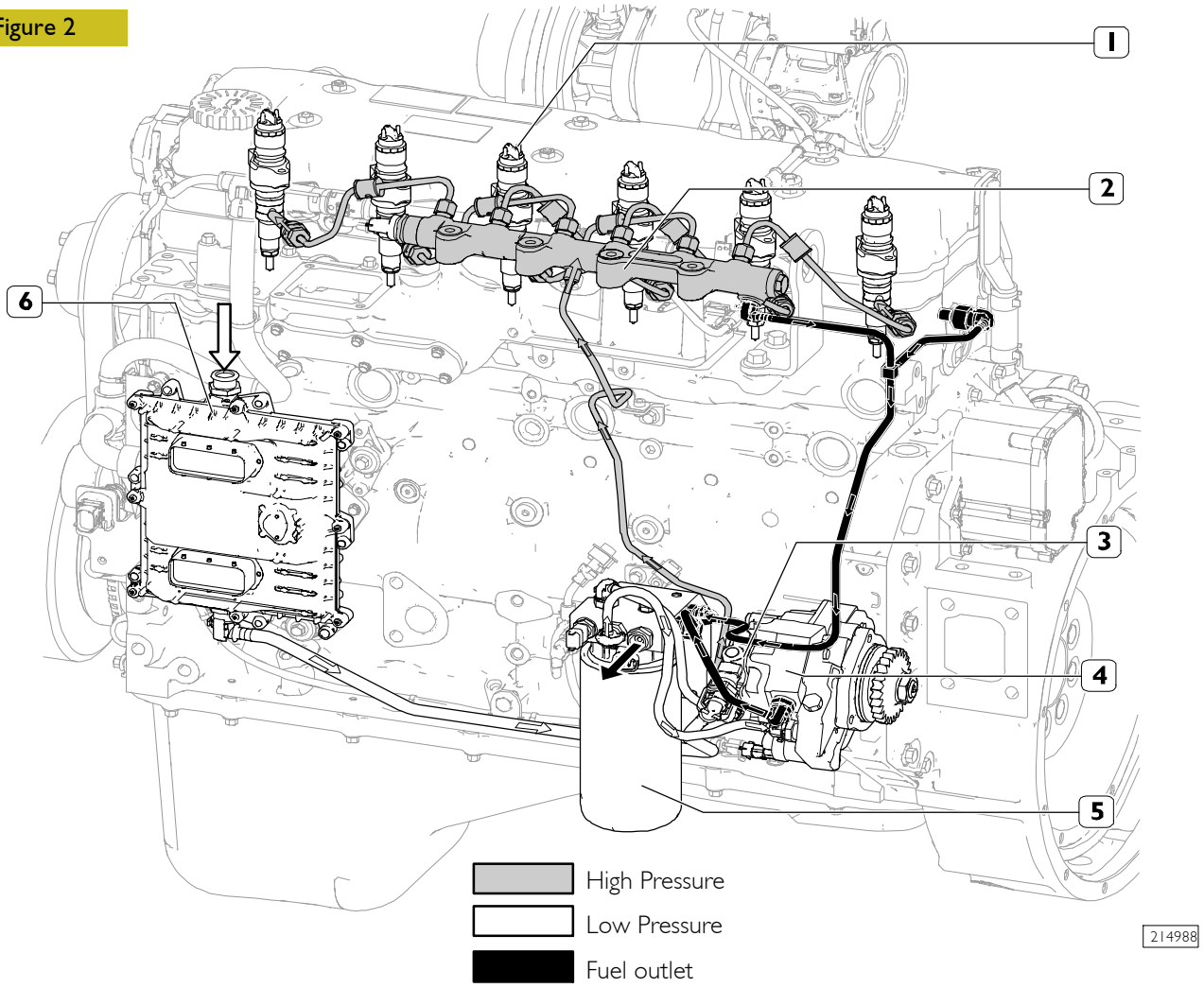
HYDRAULIC SYSTEM

The Common Rail system has a special pump that continuously keeps fuel at high pressure, independently from stroke and cylinder that has to receive the injection and accumulates fuel in a common duct for all injectors.

Therefore, fuel at the injection pressure computed by the ECU is always available at the injectors inlet.

When an injector solenoid valve is energized by the electronic control unit, the injection of fuel directly taken from rail takes place in the related cylinder.

Figure 2



1. Electro-injector - 2. Common Rail - 3. Fuel mechanical pump - 4. Fuel high pressure pump - 5. Fuel filter - 6. Engine Control Unit ECU17CV41

The hydraulic system is implemented by a low pressure circuit and a high pressure circuit.

The high pressure circuit is composed of the following pipings:

- ❑ piping connecting high pressure pump outlet to common rail;
- ❑ common rail;
- ❑ pipings supplying injectors from common rail.

The low pressure circuit is composed of the following pipings:

- ❑ fuel suction piping from tank to pre-filter with manual priming pump;
- ❑ pipings supplying the mechanical pump through the engine control unit heat exchanger;
- ❑ pipings supplying the high pressure pump through the fuel filter.

The fuel draining circuit from common rail, injectors and high pressure pump backflow complete the system.

Fuel system layout

The flow rate regulator (6), placed upstream of the high-pressure pump, adjusts the fuel flow that is necessary on the low--pressure system. Afterwards, the high-pressure pump takes care of supplying the rail properly. This arrangement, by pressurising the necessary fuel only, improves the energetic efficiency and limits fuel heating in the system.

Function of the pressure relief valve (8), assembled on the high-pressure pump, is keeping the pressure, at the flow rate regulator inlet, constant at 5 bars, independently from the efficiency of the fuel filter and of the system set upstream.

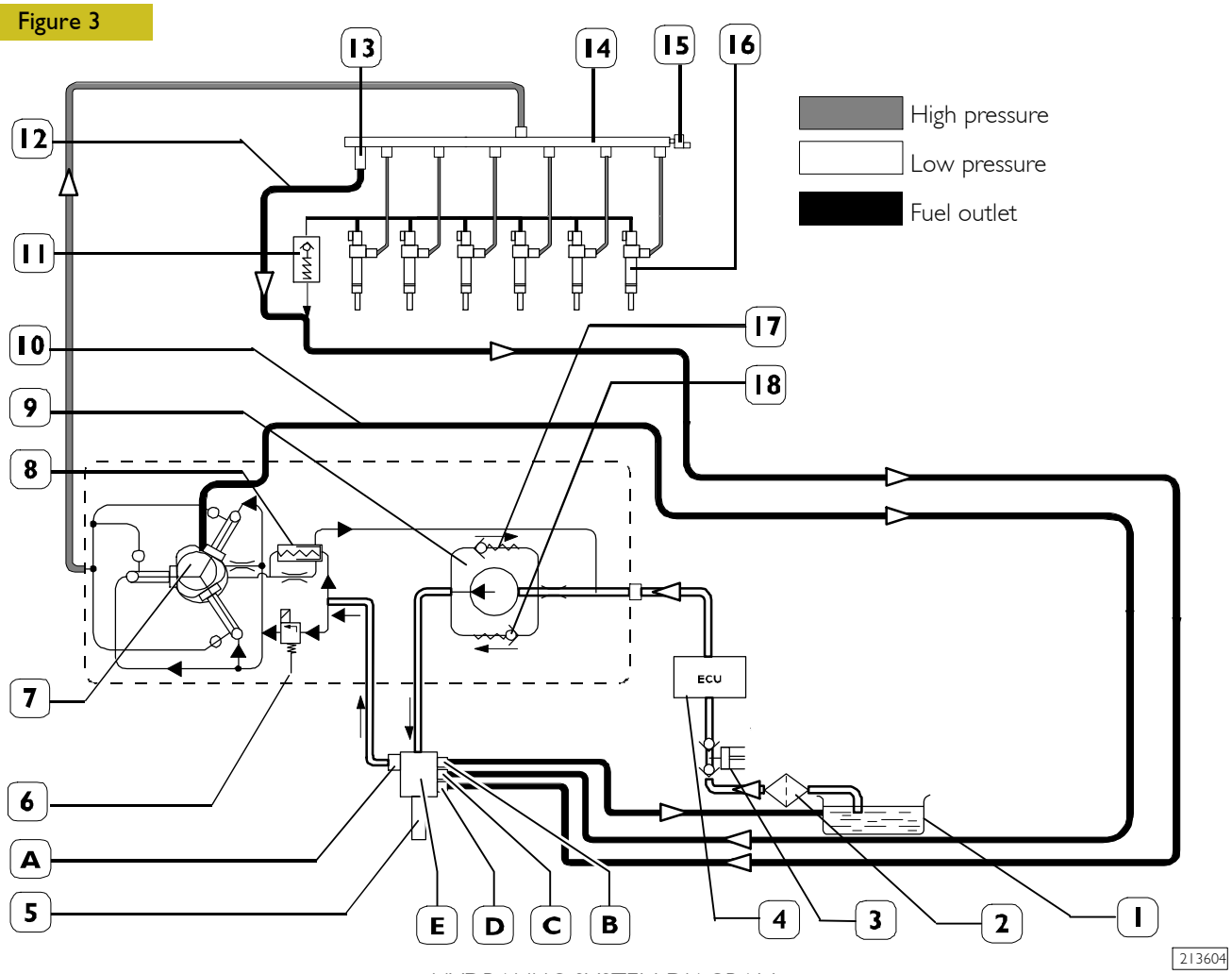
The quick coupler for fuel return (11) housed on the cylinder head, assembled on injector return, limits the fuel return flow from injectors.

Two by-pass valves are placed in parallel with the mechanical supply pump.

The by-pass valve (17) allows fuel to flow from mechanical pump outlet to its inlet, when the fuel filter inlet pressure exceeds the allowed threshold value.

The by-pass valve (18) allows filling the supply system through the manual priming pump (3).

Figure 3



HYDRAULIC SYSTEM DIAGRAM

1. Fuel tank - 2. Prefilter - 3. Manual pump - 4. Control unit - 5. Fuel filter - 6. Flow rate modulator - 7. High pressure pump - 8. Limiting valve on high pressure pump, 5 bar - 9. Mechanical supply pump - 10. High pressure pump reflux pipe - 11. Quick coupler for fuel return from the injectors - 12. Return pipe - 13. Common rail excess pressure valve - 14. Common rail - 15. Pressure sensor - 16. Injector - 17. By-pass valve - 18. By-pass valve

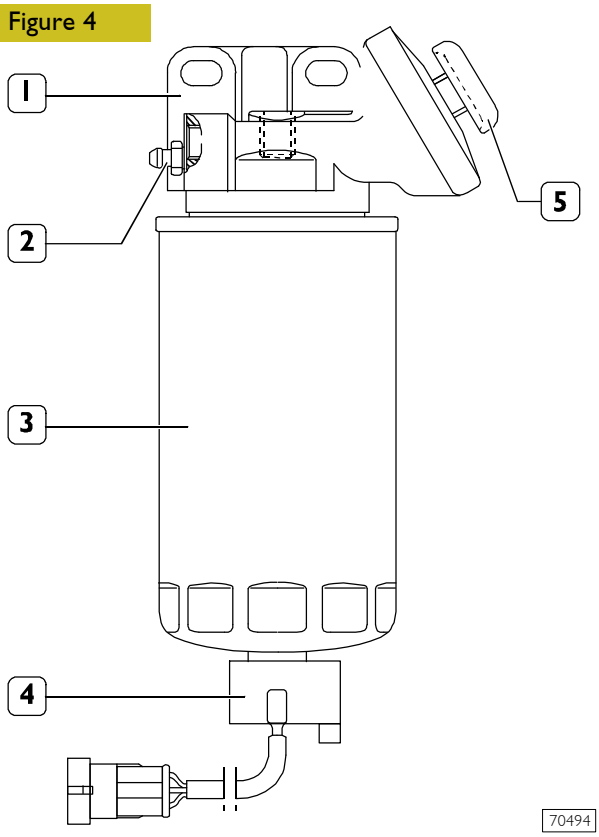
Fuel filter connections:

- **A.** Outlet connection to high-pressure pump
- **B.** Outlet connection for fuel discharge to the tank
- **C.** Inlet connection for fuel discharge from high pressure pump
- **D.** Inlet connection for fuel discharge from common rail and injectors
- **E.** Inlet connection from mechanical supply pump

FUEL SUPPLY SYSTEM COMPONENTS

Fuel prefilter

Figure 4



The fuel filter is of the high water separation type, is assembled on the vehicle chassis, and has the sensor (4) for detecting water in fuel placed on the cartridge (3) base.

Manual priming pump (5) and air bleeding screw (2) from system are located on filter support.

The presence of condensate into filter is signalled by sensor (4) when a warning light on the instrument panel is lit.

If the warning light is on, it is necessary to immediately operate to remove its cause; the common rail system components are quickly damaged by the presence of water or impurities in the fuel.

Fuel filter

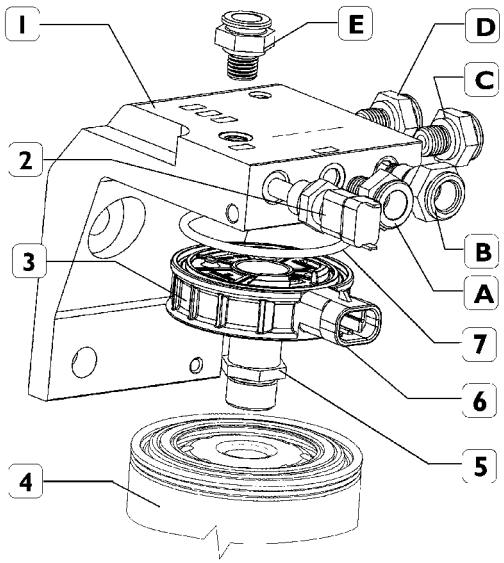
It is located on engine block in the circuit between feed pump and high pressure pump (CP3).

On the support there are located: fuel temperature sensor and heater resistances.

Fuel temperature, signalled by relating sensor to EDC17CV41 central unit, enables a very accurate calculation of the flow rate of fuel to be injected into the cylinders.

The electric heater is activated when the fuel temperature is less than 0 °C and deactivated when the fuel temperature exceeds 5 °C.

Figure 5



1. Fuel filter support - 2. Fuel temperature sensor - 3. Electric fuel heater - 4. Fuel filter - 5. Adapter - 6. Heater connector - 7. Gasket

Fuel filter connections:

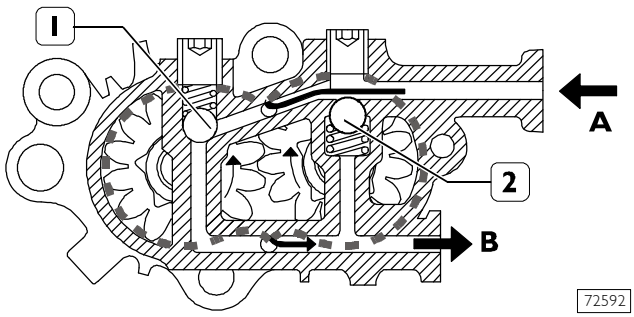
- **A.** Outlet connection to high-pressure pump
- **B.** Outlet connection for fuel discharge to the tank
- **C.** Inlet connection for fuel discharge from high pressure pump
- **D.** Inlet connection for fuel discharge from common rail and injectors
- **E.** Inlet connection from mechanical supply pump

Mechanical supply pump

Feed mechanical pump is a gear pump, mounted on high pressure pump rear side, having the task of feeding high pressure pump. It is driven by high pressure pump shaft.

Normal operating conditions

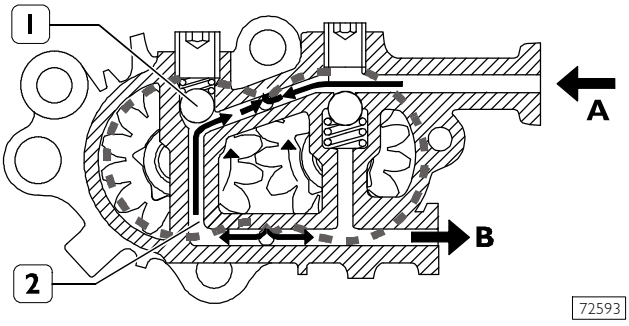
Figure 6



A. Fuel inlet from tank, B. fuel outlet to filter, 1-2 by-pass valves in close position

Overpressure condition at outlet

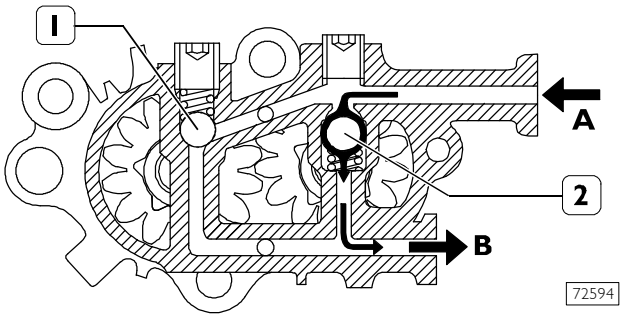
Figure 7



The by-pass valve (1) cuts in when overpressure is generated at outlet B. The existing pressure, overcoming valve spring (1) elastic strength, makes inlet and outlet communicating through duct (2).

Bleeding conditions

Figure 8



The by-pass valve (2) cuts in when, with engine off, the fuel system shall be filled through the priming pump. In this situation the by-pass valve (1) stays closed whereas by-pass valve (2) opens due to inlet pressure, and fuel is drained out through **B**.

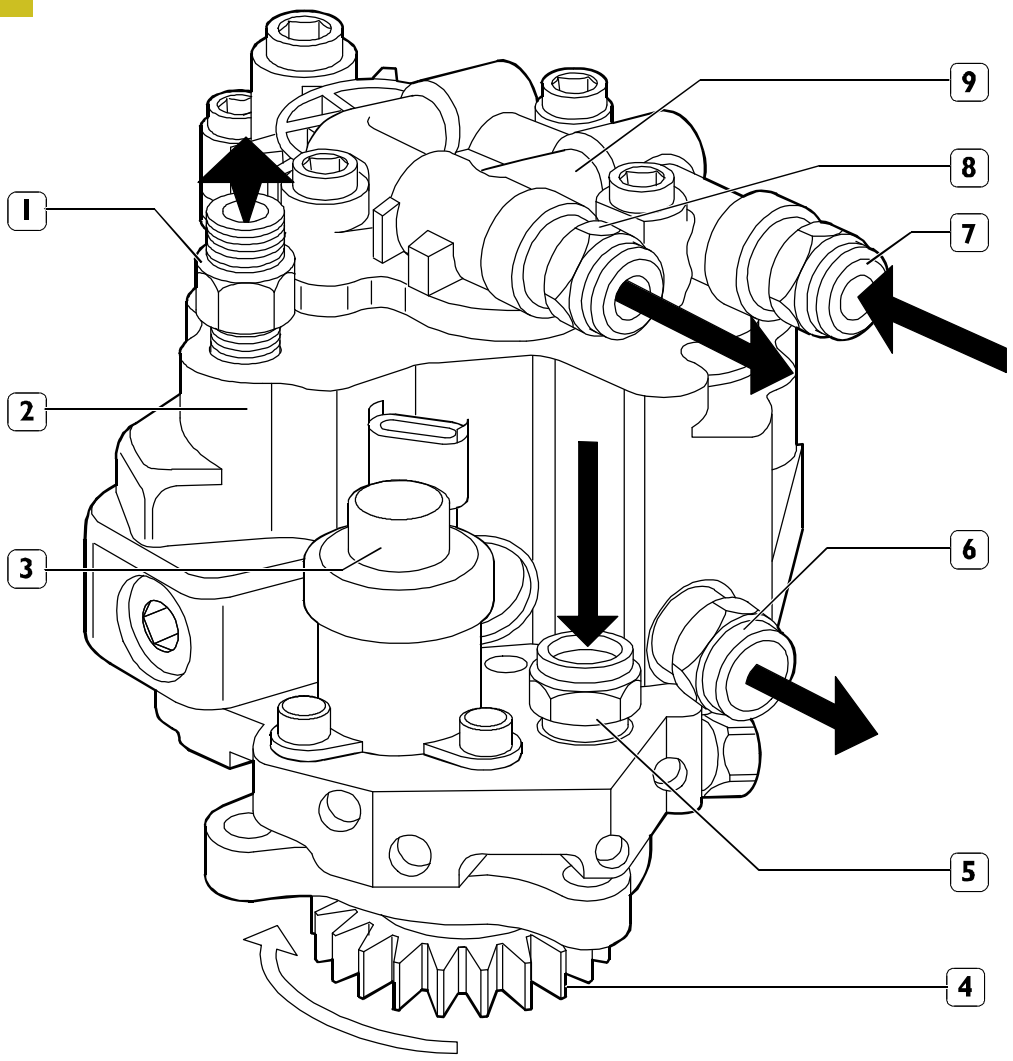
NOTE The mechanical supply pump cannot be replaced individually, therefore it cannot be removed from the high pressure pump.

CP3 high-pressure pump

CP3 high pressure pump is a pump with 3 radial plungers which is driven through a timing system gear. High pressure pump does not require timing. On high pressure pump rear side, feed mechanical pump is mounted, driven by high pressure pump shaft.

NOTE The high pressure pump cannot be serviced and should not therefore be removed and the fastening bolts should not be tampered with.The only possible service operation is the replacement of the drive gear.

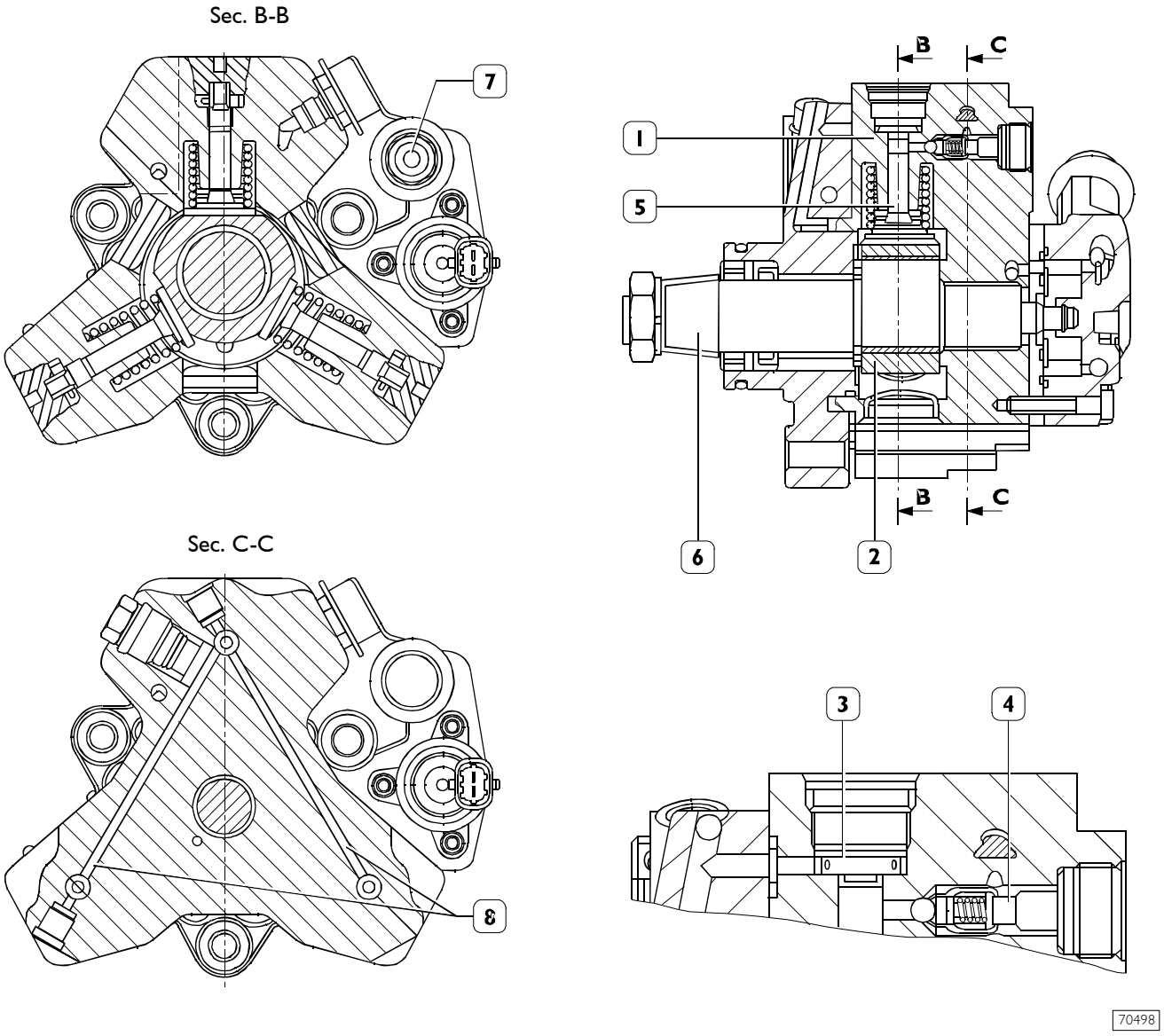
Figure 9



1. Fuel outlet fitting to rail - 2. High-pressure pump - 3. Fuel flow rate regulator - 4. Control gear - 5. Fuel inlet fitting from filter - 6. Fuel outlet fitting to filter support - 7. Fuel inlet fitting from control unit heat exchanger - 8. Fuel outlet fitting from supply pump to filter - 9. Mechanical supply pump

High-pressure pump - inside structure

Figure 10



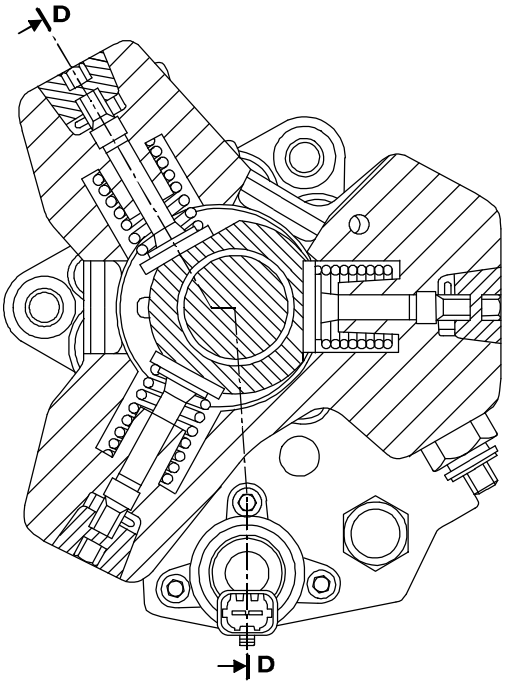
1. Cylinder - 2. Three-lobe element - 3. Cap intake valve - 4. Ball delivery valve - 5. Piston - 6. Pump shaft - 7. Low-pressure fuel inlet - 8. Plungers supplying fuel ducts.

Each plunger is made up of:

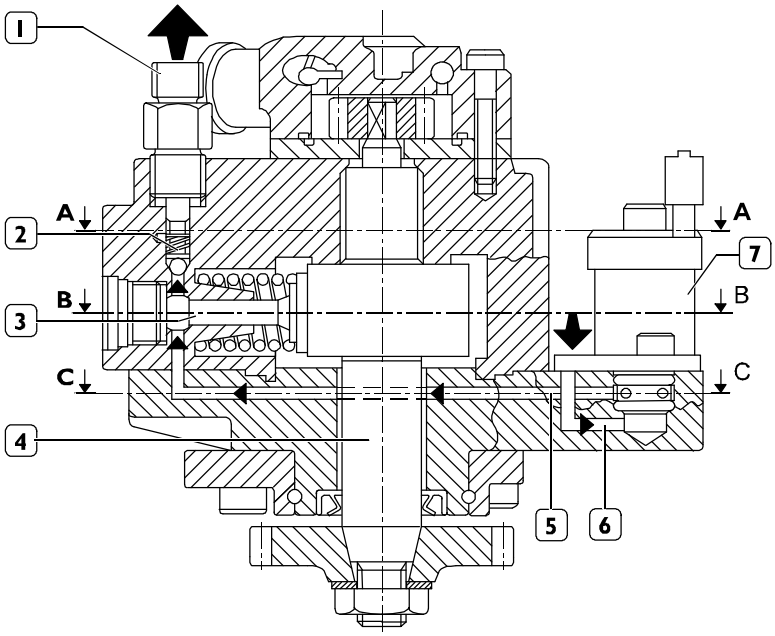
- ❑ one piston (5) driven by a three-lobe element (2) floating on pump shaft (6). Element (2) is floating on a misaligned side of shaft (6). Therefore, during shaft rotation, the element is not turning together with the shaft, but is just translated, according to a circular movement, to a wider radius. It results that the three pumping assemblies are driven alternatively;
- ❑ one cap intake valve (3);
- ❑ one delivery ball valve (4).

Operating principle

Figure 11



Sec. B – B



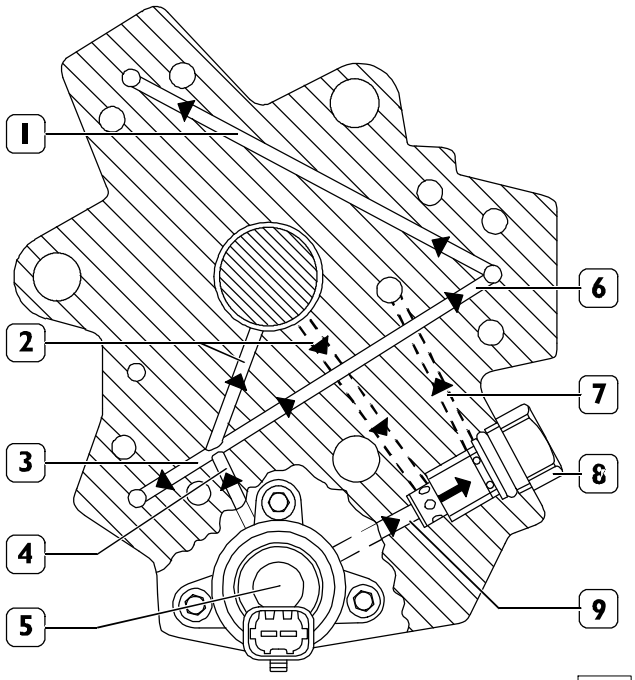
Sec. D – D

72597

1. Fuel outlet fitting to rail - 2. Delivery valve to rail - 3. Plunger - 4. Pump shaft - 5. Plunger supply duct - 6. Pressure regulator supply duct - 7. Flow rate regulator.

Plunger (3) is oriented towards the cam that is present on pump shaft (4). During suction stroke, the plunger is fed through feed duct (5). The quantity of fuel to be sent to the plunger is set by flow rate regulator (7). Flow rate regulator, on the basis of PWM command received by control unit, partialises fuel inflow to the plunger. During plunger compression stroke, fuel reaches such a pressure that valve delivering the fuel to common rail (2) is opened and common rail is fed by the plunger through outlet (1).

Figure 12



Sec. C – C

1. Plunger inlet - 2. Pump lubrication ducts - 3. Plunger inlet - 4. Main plunger supply duct - 5. Flow rate regulator - 6. Plunger inlet - 7. Regulator exhaust duct - 8. 5 bar pressure relief valve - 9. Fuel drain from regulator inlet.

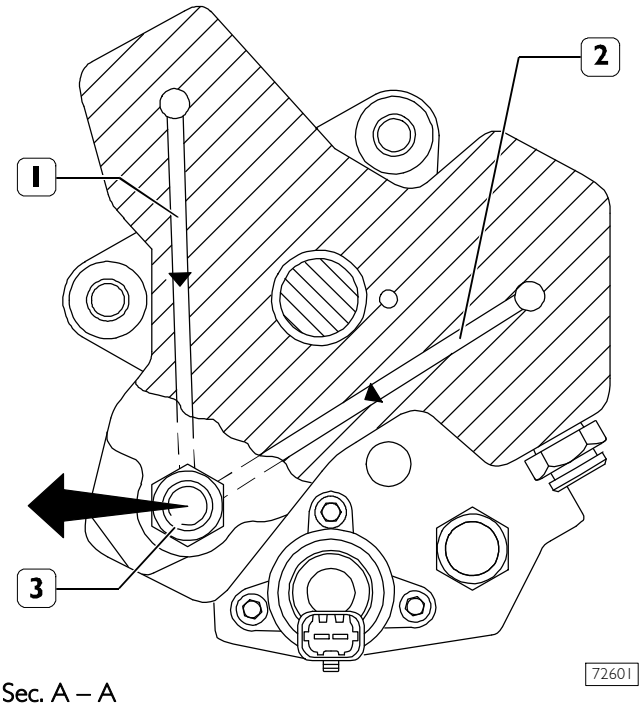
Figure 12 shows low pressure fuel paths inside the path and highlights: main plunger supply duct (4), plunger supply ducts (1 – 3 – 6), pump lubrication ducts (2), flow rate regulator (5), 5 bar pressure relief valve (8) and fuel drain duct (7).

Pump shaft is lubricated by fuel through delivery and return ducts (2).

Flow rate regulator (5) establishes the fuel amount to send to plungers; excess fuel is drained out through duct (9).

5 bar pressure relief valve acts as fuel return regulator and keeps 5 bar constant pressure at regulator inlet.

Figure 13



Sec. A – A

1. Fuel outlet duct - 2. Fuel outlet duct - 3. Fuel outlet from pump with high pressure pipe fitting for common rail.

Figure 13 shows high pressure fuel flow through plunger outlet ducts.

Pressure regulator description

The fuel pressure regulator is fitted on the low pressure circuit of pump CP.3. The pressure regulator modulates the amount of fuel sent to the high-pressure circuit according to the commands received directly from the engine control unit. The pressure regulator is mainly composed of the following components:

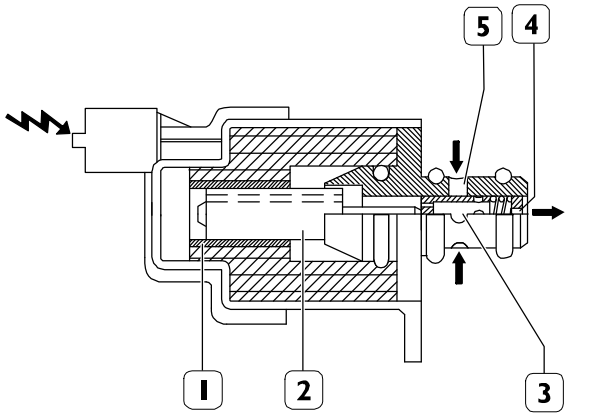
- connector,
- casing,
- solenoid,
- pre-load spring,
- shutter cylinder.

When there is no signal, the pressure regulator is normally open, therefore with the pump providing maximum delivery.

The engine control unit, via the PWM (Pulse Width Modulation) signal, modulates the change in fuel flow rate in the high-pressure circuit by partially closing or opening the sections of passage of the fuel in the low-pressure circuit.

Operation

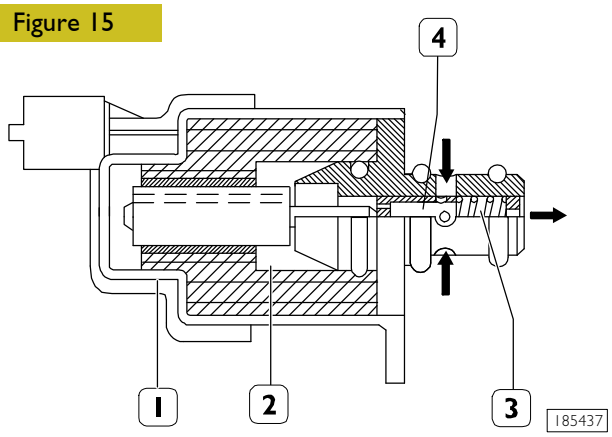
Figure 14



1. Solenoid - 2. Magnetic core - 3. Shutter cylinder - 4. Fuel inlet - 5. Fuel outlet.

When the engine control unit operates the pressure regulator (via PWM signal), the solenoid (1) is energized, which in turn generates the movement of the magnetic core (2). The shift of the core causes the shutter cylinder (3) to move axially, choking the flow of fuel.

Figure 15



1. Solenoid - 2. Magnetic core - 3. Preload spring - 4. Shutter cylinder.

When the solenoid (1) is not energized, the magnetic core is pushed into the rest position by the pre-load spring (3). In this position the shutter cylinder (4) allows the greatest section of passage for the fuel flow.

Operation

The cylinder is filled through the cap intake valve only if the supply pressure is suitable to open the delivery valves set on the plungers (about 2 bars).

The amount of fuel supplying the high-pressure pump is metered by the flow rate regulator, placed on the low-pressure system; the flow rate regulator is controlled by the EDC17CV41 control unit through a PWM signal.

When fuel is sent to a plunger, the related piston is moving downwards (suction stroke). When the piston stroke is reversed, the intake valve closes and the remaining fuel in the plunger chamber, not being able to come out, is compressed above the supply pressure value existing in the rail.

The thereby-generated pressure makes the exhaust valve open and the compressed fuel reaches the high-pressure circuit.

The plunger compresses the fuel till the top dead center (delivery stroke) is reached. Afterwards, the pressure decreases till the exhaust valve is closed.

The plunger piston goes back towards the bottom dead center and the remaining fuel is decompressed.

When the plunger chamber pressure becomes less than the supply pressure, the intake valve is again opened and the cycle is repeated.

The delivery valves must always be free in their movements, free from impurities and oxidation.

The pressure of fuel delivered to rail is modulated by electronic control unit through flow rate regulator solenoid valve.

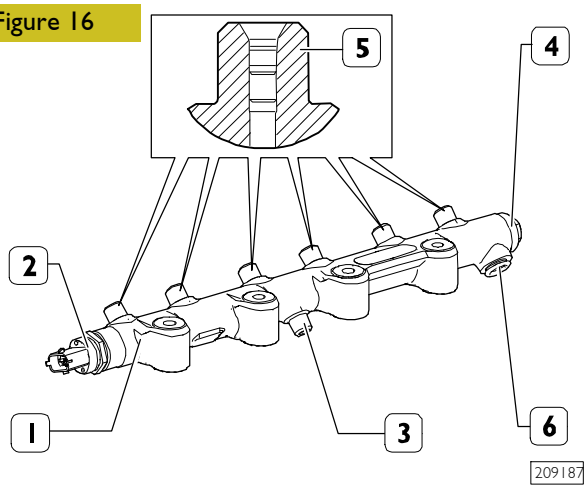
The pump is lubricated and cooled by the fuel.

The radialjet pump removal – refitting time on the engine is highly reduced in comparison with traditional injection pumps, because it does not require setting.

If the pipe between fuel filter and high-pressure pump is to be removed-refitted, be sure that hands and components are absolutely clean.

Rail

Figure 16



1. Rail - 2. Pressure sensor - 3. Fuel inlet from high pressure pump - 4. Overpressure valve - 5. Adjustment valves - 6. Fuel outlet

The rail volume is of reduced sizes to allow a quick pressurisation at startup, at idle and in case of high flow-rates. It anyway has enough volume as to minimise use of plenum chambers caused by injectors openings and closings and by the high--pressure pump operation. This function is further enabled by a calibrated hole being set downstream of the high-pressure pump.

The throttle valves or control bushes (5) have been fitted to the fuel delivery couplings, which control the fuel pressure waves generated by the high pressure pump.

A fuel pressure sensor (2) is screwed to the rail. The signal sent by this sensor to the electronic control unit is a feed--back information, depending on which the rail pressure value is checked and, if necessary, corrected.

Overpressure valve

Overpressure valve is mounted at one rail end. Overpressure valve task is to protect system components should rail pressure sensor or CP3 pump pressure regulator malfunctioning cause a pressure excessive increase in high pressure system. When pressure in rail is reaching 1750 bar, the valve at start operates in order to make fuel flow and consequently decrease pressure to safety values, then mechanically regulates pressure in rail. The valve enables to operate engine for long times with limited performance and prevents fuel excessive overheating, so preserving pipes for fuel return to tank..

Rail nominal pressure	1600 bar
Overpressure valve opening start	1750 bar
Overpressure valve full opening	1950 - 100 bar

Electro-injector

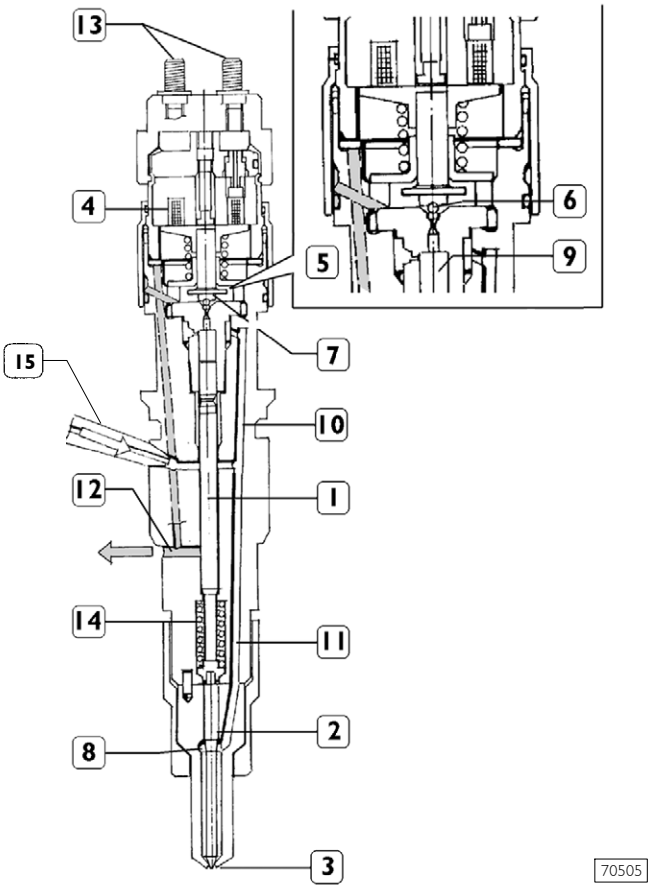
The injector is similar as construction to the traditional ones, apart from the absence of plunger return springs.
The injector can be deemed as composed of two parts:

- actuator – spray nozzle composed of pressure rod (1), plunger (2) and nozzle (3);
- control solenoid valve composed of coil (4) and pilot valve (5).

The solenoid valve controls spray nozzle plunger lift.

Injector in rest position

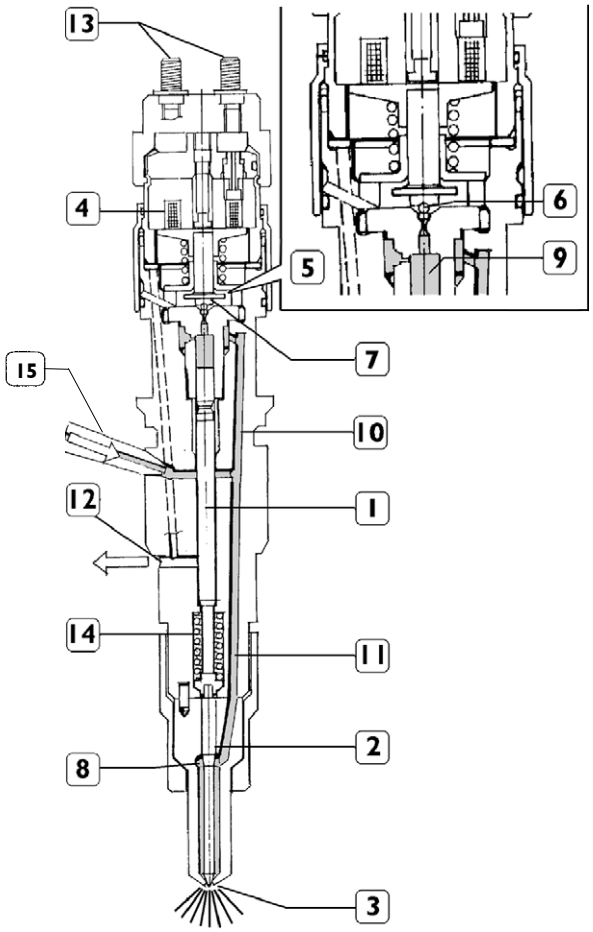
Figure 17



1. Pressure rod - 2. Plunger - 3. Nozzle - 4. Coil - 5. Pilot valve - 6. Ball shutter - 7. Control area - 8. Pressure chamber - 9. Control volume - 10. Control duct - 11. Supply duct - 12. Control fuel outlet - 13. Electric connection - 14. Spring - 15. High-pressure fuel inlet.

Injection start

Figure 18



1. Pressure rod - 2. Plunger - 3. Nozzle - 4. Coil - 5. Pilot valve - 6. Ball shutter - 7. Control area - 8. Pressure chamber - 9. Control volume - 10. Control duct - 11. Supply duct - 12. Control fuel outlet - 13. Electric connection - 14. Spring - 15. High-pressure fuel inlet.

When coil (4) is energised, it makes shutter (6) move upwards. The control volume (9) fuel flows towards flow duct (12) making a pressure drop occur in control volume (9). Simultaneously the fuel pressure into pressure chamber (8) makes plunger (2) lift, with following fuel injection into the cylinder.

Injection end

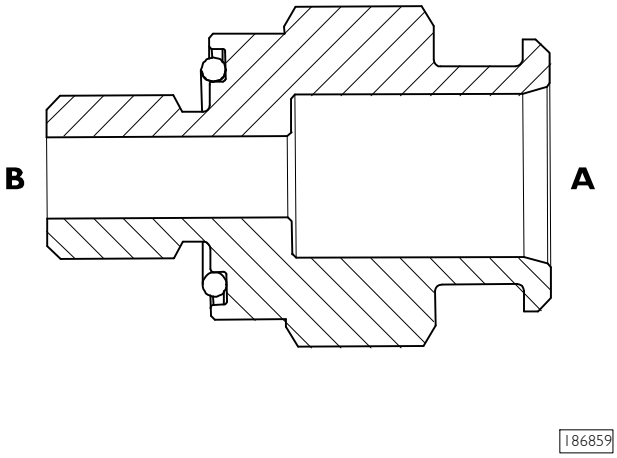
When coil (4) is de-energised, shutter (6) goes back to its closing position, in order to re-create such a force balance as to make plunger (2) go back to its closing position and end the injection.

NOTE The injector cannot be overhauled and therefore it must not be disassembled.

Quick coupler for fuel return

It is housed on the rear of the cylinder head, and adjusts the pressure of fuel returning from injectors.

Figure 19



A. To tank –
B. From injectors

LUBRICATION

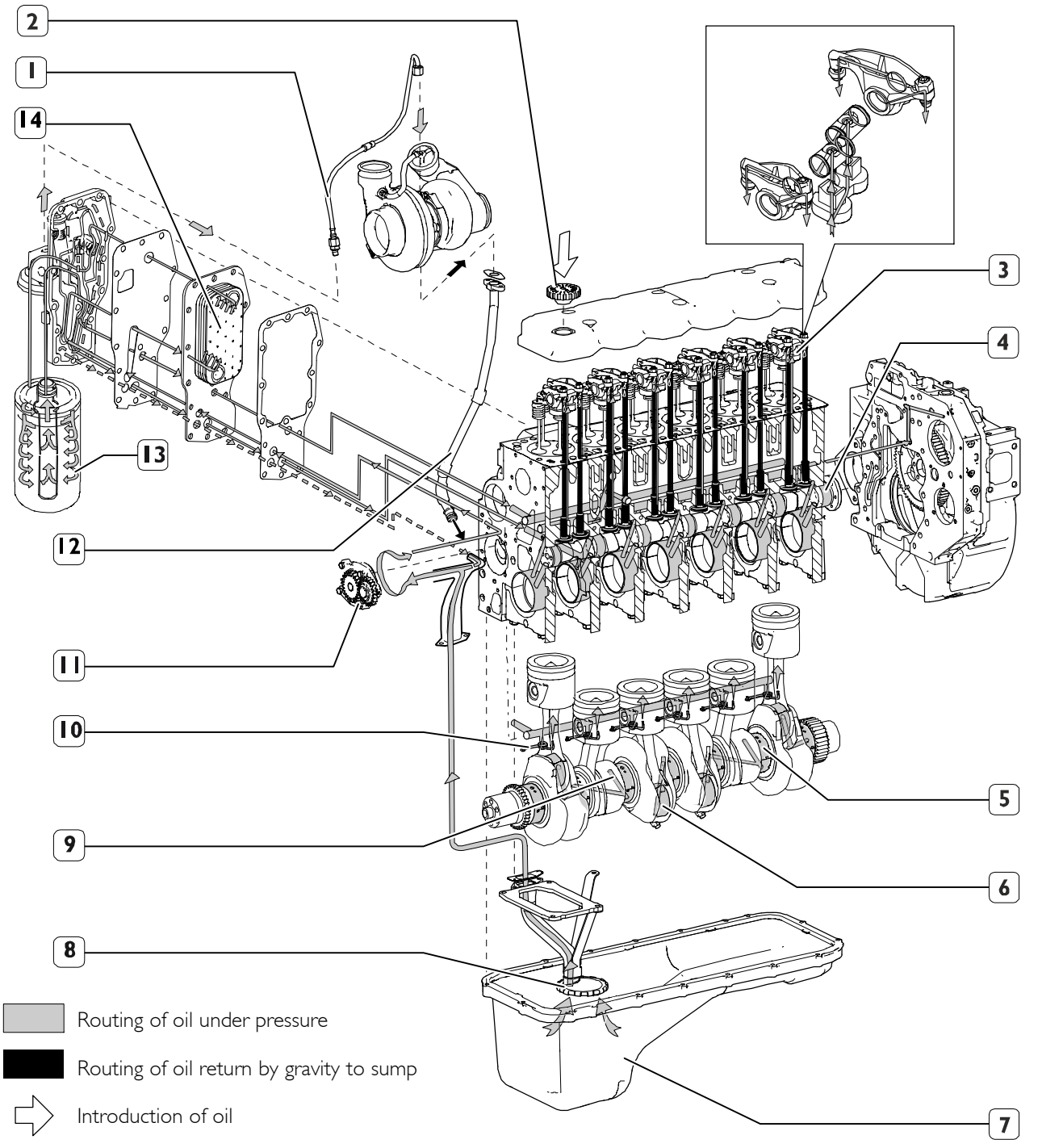
Lubrication by forced circulation is achieved through oil rotary expansion pump, placed in the front part of the basement, driven by the straight-tooth gear splined to the shaft's bar hold.

From the pan, the lubrication oil flows to the driving shaft, to the camshaft and to the valve drive.

Lubrication involves the heat exchanger as well, the turbo--blower and the eventual compressor for any eventual compressed air system.

All these components may often vary according to the specific duty and will therefore be examined in the specific section.

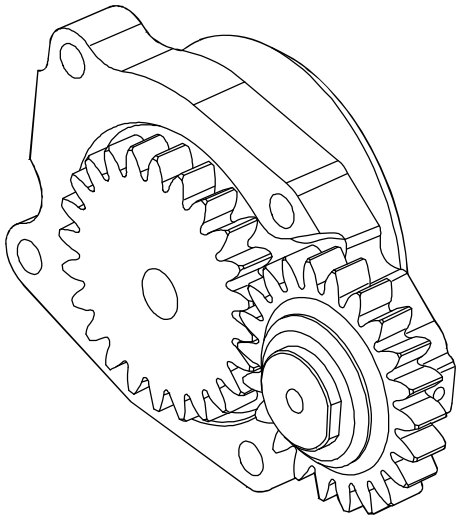
Figure 20



1. Turbocharger lubrication oil delivery pipe - 2. Lubricant oil filler cap - 3. Rocker arm shaft hole - 4. Camshaft bush - 5. Main half-bearings - 6. Connecting rod half-bearings - 7. Oil sump - 8. Oil suction - 9. Crankshaft transverse channels - 10. Piston cooling nozzles - 11. Rotary oil pump - 12. Turbocharger lubrication oil discharge pipe - 13. Oil filter - 14. Heat exchanger lubricant oil / coolant

Oil pump

Figure 21



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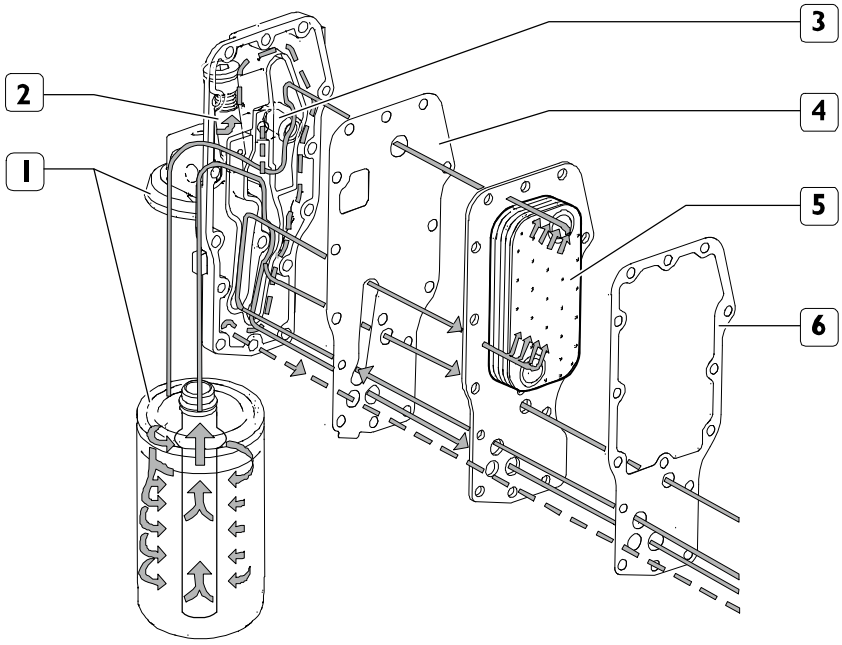
Housed in the front of the crankcase, the oil pump is a rotary pump commanded by a spur gear fitted to the stub of the crankshaft.

NOTE Since the oil pump cannot be overhauled. It shall be replaced when damaged.

Heat exchanger

Figure 22



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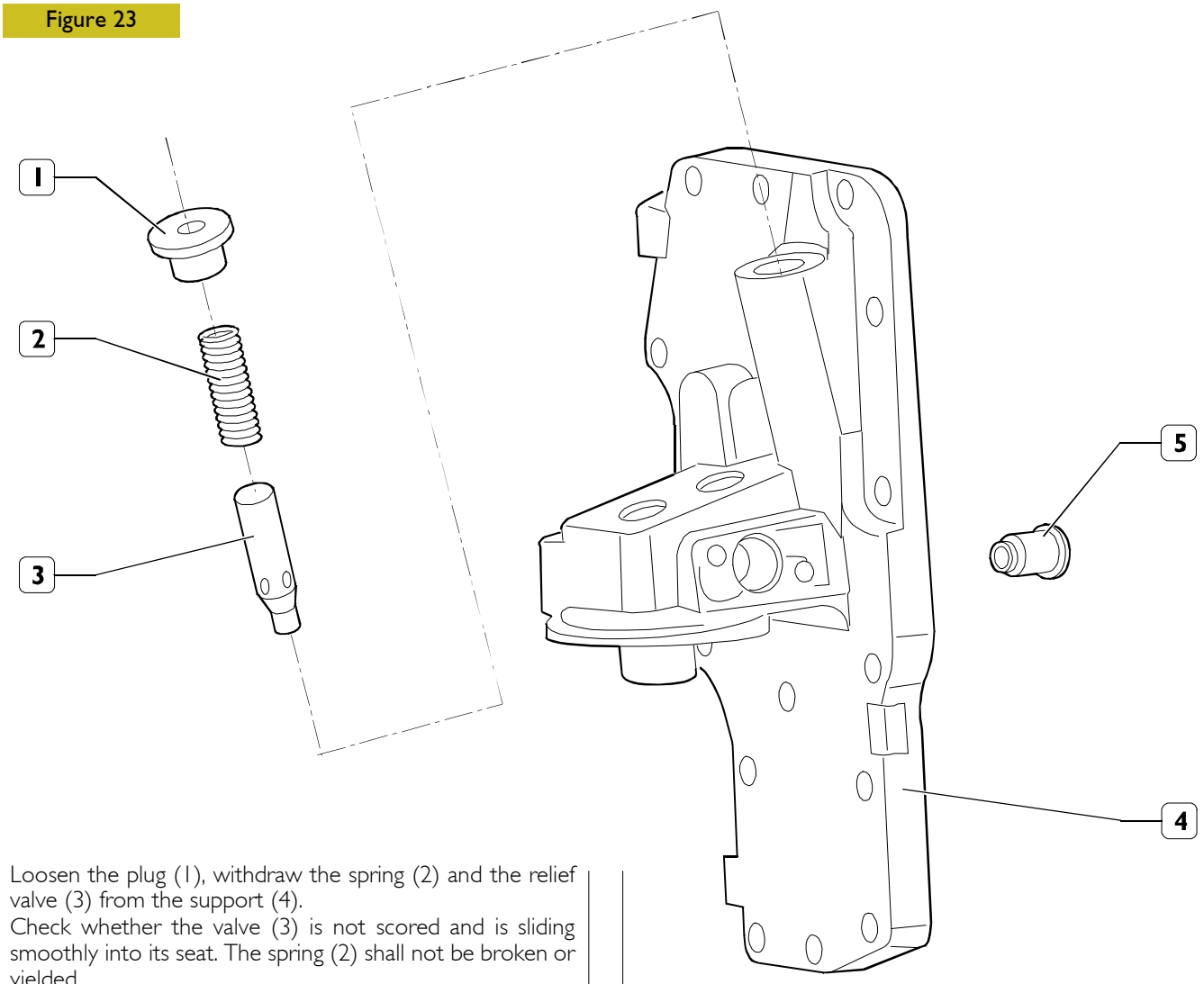
1. Oil filter support - 2. Lubricant pressure control valve - 3. By-pass valve to cut off clogged oil filter - 4. Internal heat exchanger gasket - 5. Heat exchanger lubricant oil / coolant - 6. Gasket between heat exchanger and crankcase

Oil pressure relief valve

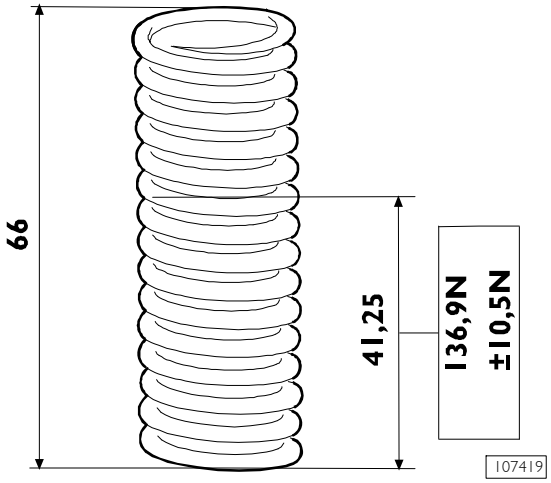
Figure 23



Loosen the plug (1), withdraw the spring (2) and the relief valve (3) from the support (4).
Check whether the valve (3) is not scored and is sliding smoothly into its seat. The spring (2) shall not be broken or yielded.
Pressure regulation at 100 °C oil temperature:
- 1.2 bar min pressure;
- 3.8 bar max. pressure

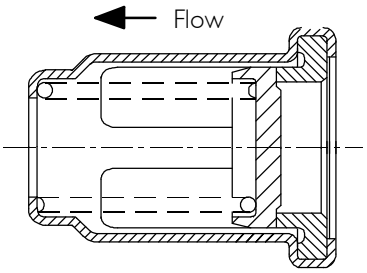
By-pass valve (5) to cut out clogged oil filter.

Figure 24



MAIN DATA TO CHECK OIL PRESSURE RELIEF VALVE SPRING

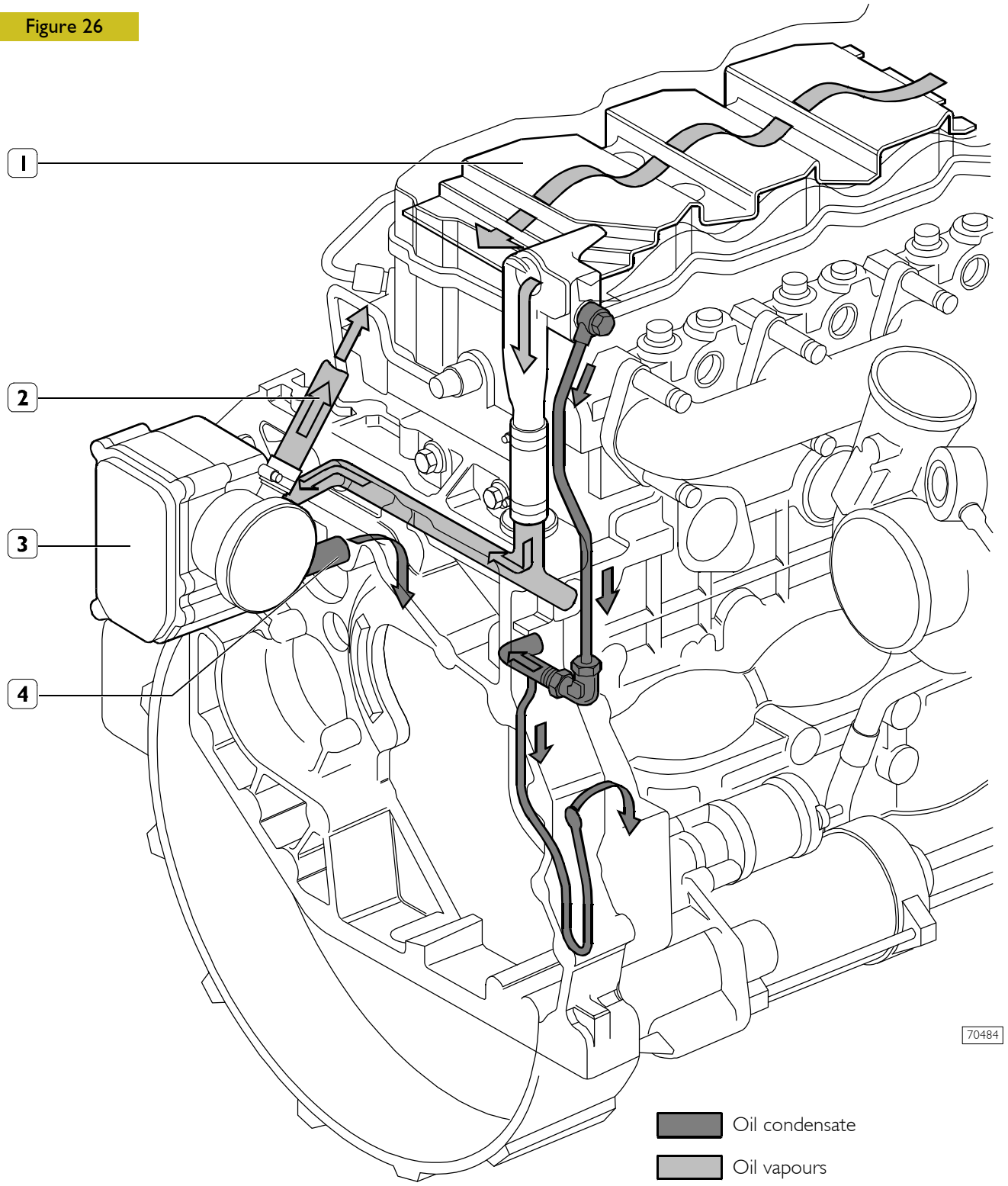
Figure 25



Max blow-by:
20 cm^3/1' at 0.83 bar pressure and at 26.7 °C oil temperature.

OIL VAPOUR RECYCLING

Figure 26



1. Pre-separator - 2. Exhaust to the outside (temporary) - 3. Filter - 4. Return to engine.

The tappet cover houses the pre-separator (1), whose shape and position determines an increase in oil vapour outlet speed and condenses a part of vapours at the same time.

Condensate oil returns to the oil sump whereas the residual vapours are ducted, collected and filtered in the blow-by (3).

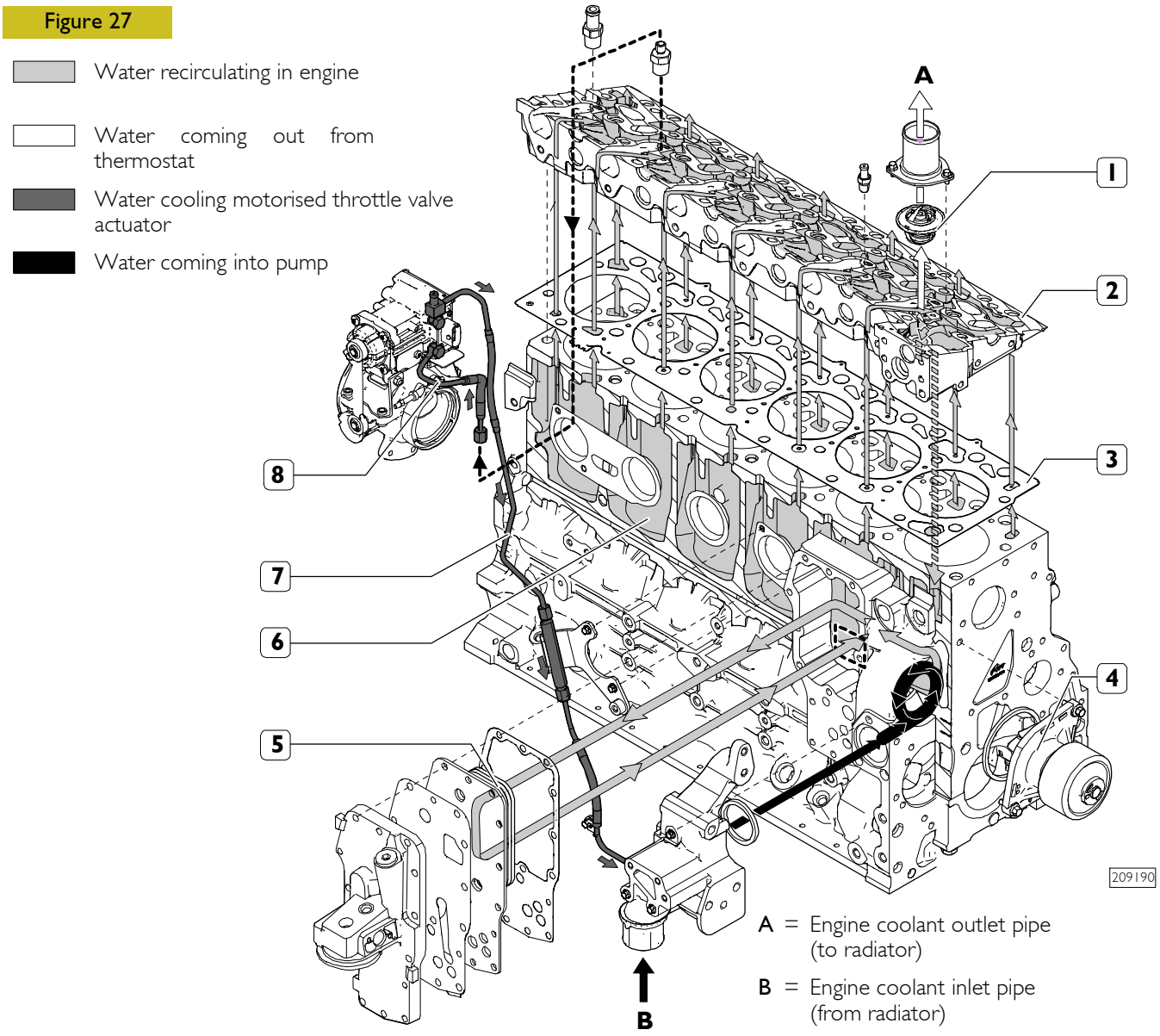
In the blow-by (3), part of the vapours condense and return to the oil sump whereas the remaining part is put into cycle again through pipe (2).

COOLING SYSTEM

The engine cooling system, closed circuit forced circulation type, generally incorporates the following components:

- ❑ Expansion tank; placement, shape and dimensions are subject to change according to the engine's equipment.
- ❑ Radiator, which has the duty to dissipate the heat subtracted to the engine by the cooling liquid. Also this component will have specific peculiarities based on the equipment developed, both for what concerns the placement and the dimensions.
- ❑ Viscous pusher fan, having the duty to increase the heat dissipating power of the radiator. This component as well will be specifically equipped based on the engine's development.
- ❑ Heat exchanger to cool the lubrication oil: even this component is part of the engine's specific equipment.
- ❑ Centrifugal water pump, placed in the front part of the engine block.
- ❑ Thermostat regulating the circulation of the cooling liquid.
- ❑ The circuit may eventually be extended to the compressor, if this is included in the equipment.

Figure 27

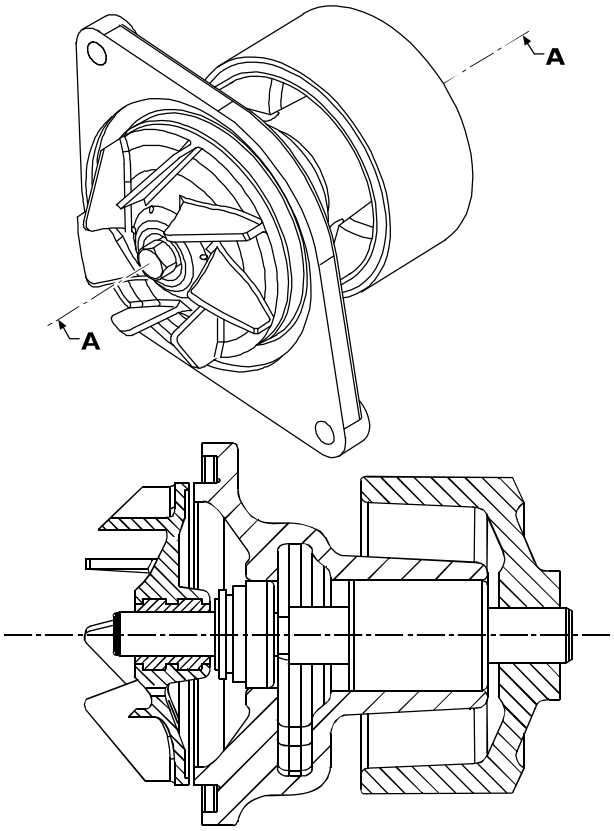


COOLING SYSTEM LAYOUT

1. Thermostat to regulate temperature - 2. Cylinder head cooling channels - 3. Cylinder head gasket - 4. Water pump - 5. Heat exchanger lubricant oil / coolant - 6. Coolant chamber around the cylinder liners - 7. Motorised throttle valve actuator water return pipe - 8. Motorised throttle valve actuator water delivery pipe

Water Pump

Figure 28



Sec. A-A

The water pump is located in a hollow obtained in the cylinder block and is driven by and a poly-V belt.
An automatic tensioner keeps the belt tension.

Pump performances

Coolant fluid temperature: 100 ± 5 °C
Anti-freeze concentration: 50%

Pump speed [rpm]	Flow [L/min]	Pressure [bar]
5,000	210	2.00 : 2.45
2,500	110	0.50 : 0.65

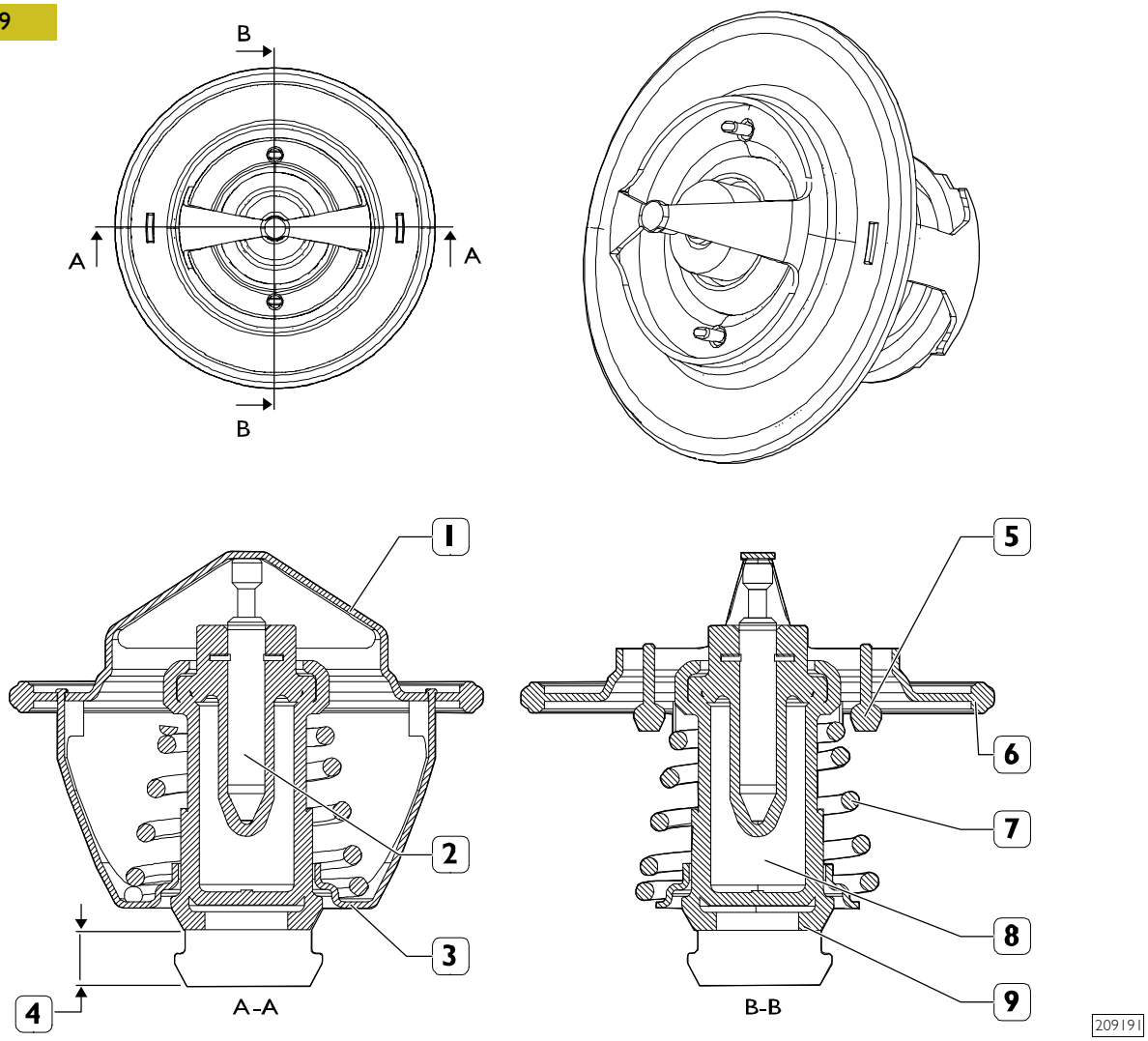
Thermostat

The thermostat, located in the cylinder head, is of the by-pass type and doesn't need regulations.
If there are doubts as to its proper functioning, replace it.
The basic parts of a thermostat are: heat motor, which includes a valve attached to a piston that is embedded in a special wax, flange, spring and frame.
The thermostat has a jiggle pin that allows trapped air in the cooling system to pass through the thermostat and be released from the system.

The thermostat has two important jobs:

- ❑ Accelerate engine warm-up by blocking the circulation of coolant between the engine and radiator until the engine has reached its predetermined temperature.
- ❑ Regulate the engine's operating temperature by opening and closing in response to specific changes in coolant temperature to keep the engine's temperature within the desired operating range.

Figure 29



1. Flange - 2. Stem (piston) - 3. Frame - 4. Min. stroke at full opening temperature - 5. Jiggle pin - 6. Flange seal - 7. Main spring - 8. Wax slug - 9. By-pass valve

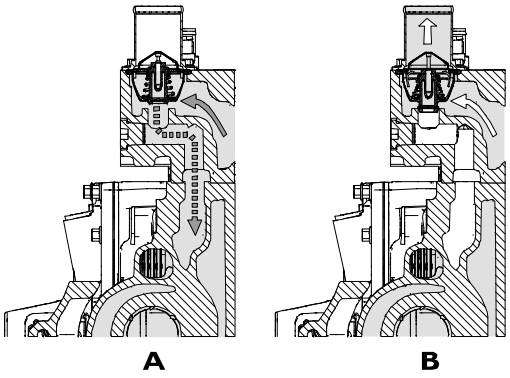
Thermostat performances

Min. allowed working temperature:	-40 °C
Max. allowed working temperature:	135 °C
Max. allowed peak temperature (5 minutes):	150 °C
Max. working differential pressure:	3 bar
Opening start:	79 ± 2 °C
Full opening temperature:	96 °C
Min. stroke at full opening temperature:	7.5 mm

Operation description

- ❑ When the engine is cold, the thermostat is normally closed; restricting flow to the radiator allowing the engine to warm-up;
- ❑ As the engine warms, the increase in heat causes the wax to melt and expand, pushing against a piston inside a rubber boot;
- ❑ This forces the piston outward, opening the thermostat so coolant can start to circulate between the engine and radiator;
- ❑ As heat increases, the thermostat continues to open until engine cooling requirements are satisfied;
- ❑ If the temperature of the circulating coolant begins to drop, the wax element contracts; allowing spring tension to close the thermostat, which decreases coolant flow through the radiator.

Figure 30



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A. Thermostat closed (coolant to water pump through by-pass port)

B. Thermostat open (coolant to radiator)

TURBOCHARGING

The adoption of turbocharging makes it possible to increase the power developed by the engine by emitting, at each cycle, a quantity of combustive air greater than what the engine would have been able to intake naturally through the alternatingmotion of the pistons.

A greater quantity of air emitted into the combustion chamber makes it possible to completely burn a higher quantity of fuel, so as to respect the optimal stoichiometric ratio.

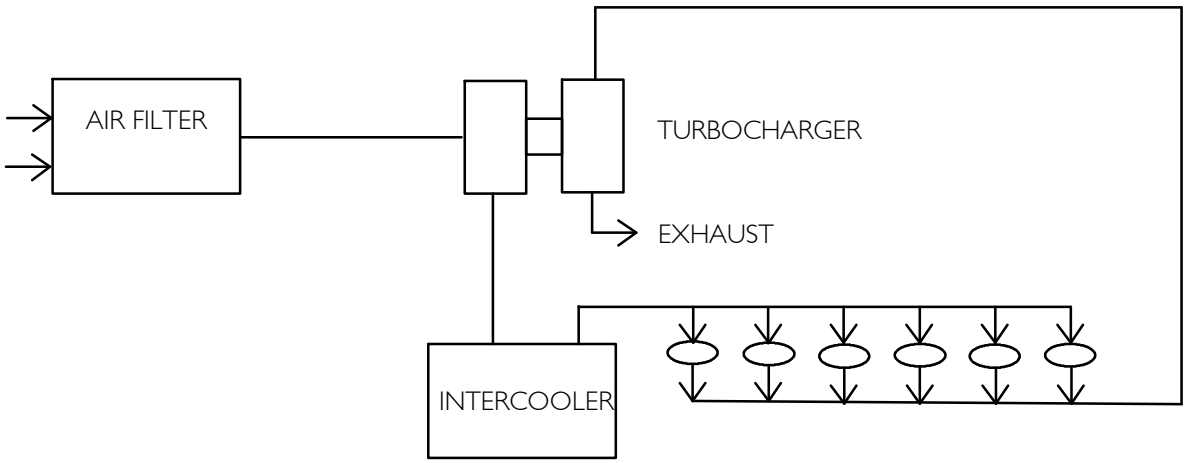
The turbocharging system is composed of: air filter, turbocharger and intercooler.

The air cleaner is a dry type composed of a filtering cartridge that is periodically changeable.

The function of the turbocharger is to use the energy of the engine's exhaust gas to deliver pressurized air to the cylinders.

The intercooler is composed of a radiator applied to the engine coolant radiator, with the function of lowering the turbocharger output air temperature before it is sent to the cylinders.

Figure 31



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The turbocharger consists of a rotating turbine, set in rotation by the exhaust gases during operation of the engine, and a rotating compressor keyed by a shaft connecting the turbine. The compressor, driven by the turbine, compresses the air sucked through the filter.

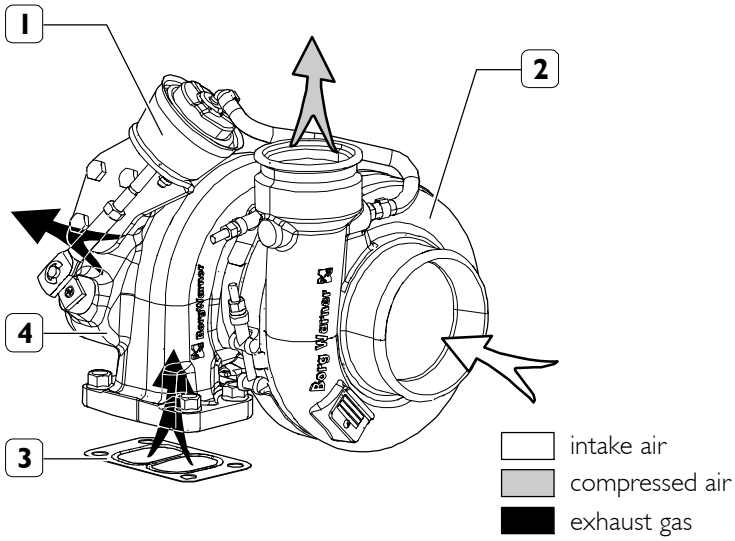
The air is then cooled by the intercooler and sent to the cylinders via the intake manifold.

BorgWarner waste-gate turbocharger (WGT)

(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

The turbocharger is fitted onto the exhaust manifold.

Figure 32

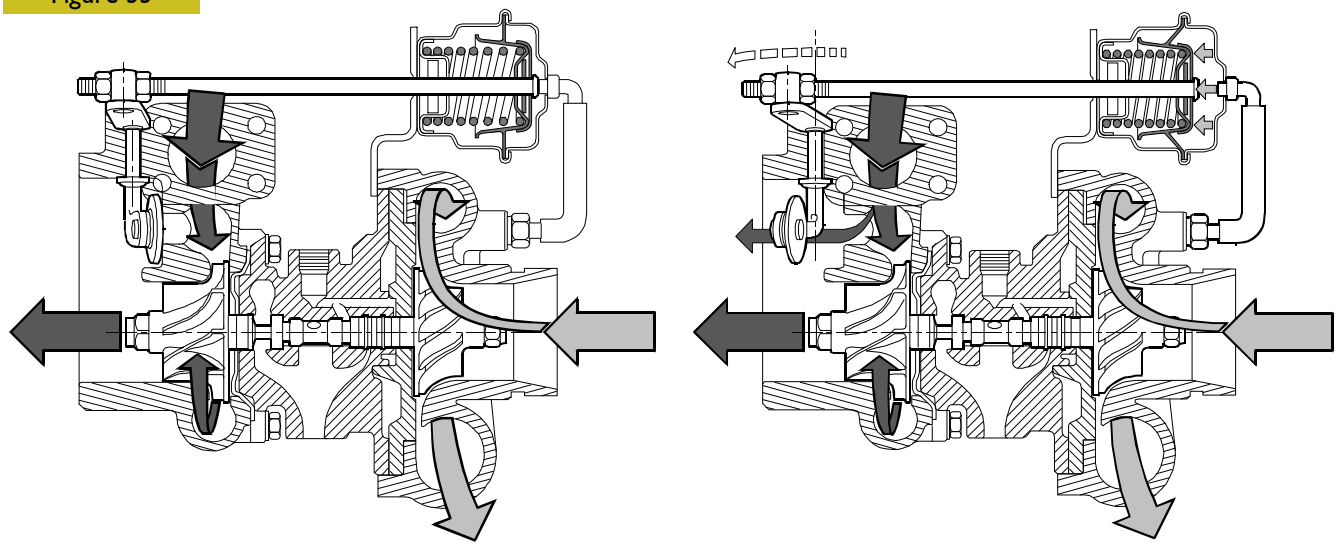


1. Waste-gate valve - 2. Air compressor - 3. Gasket on exhaust manifold - 4. Exhaust gas turbine

The turbocharger mainly consists of:

- a central casing housing a shaft supported by bushings at whose opposite ends are fitted the turbine and the compressor impellers;
- a turbine casing and a compressor casing mounted on the end of the central body;
- an overpressure relief valve (waste-gate) fitted to the turbine body. The function of this valve is to choke the exhaust gas outlet, by conveying part of the gas directly into the exhaust pipe, when the boosting pressure downstream the turbocharger reaches the calibration value.

Figure 33



DEMONSTRATIVE CROSS-SECTION OF A TURBOCHARGER WITH WASTE-GATE VALVE

NOTE Verifying an anomalous operation of the engine, due to the booster system, it is recommended, before performing controls on the turbocharger, to check the efficiency of the sealing gaskets and the fixing of the connection sleeves, making sure of clogging absence inside intake sleeves, air cleaner or inside radiators.
If the turbocharger damage is due to a lack of lubrication, check that the oil circulation pipes are not broken or obstructed, in such case replace them or eliminate the trouble.

Bearing end play check

Position the tracer point of the magnetic-base dial gauge on the turbocharger shaft end and set to zero the dial gauge.

Move the turbocharger shaft axially and check that the clearance is not higher than the prescribed value.

Replace the turbocharger if a different value is found.

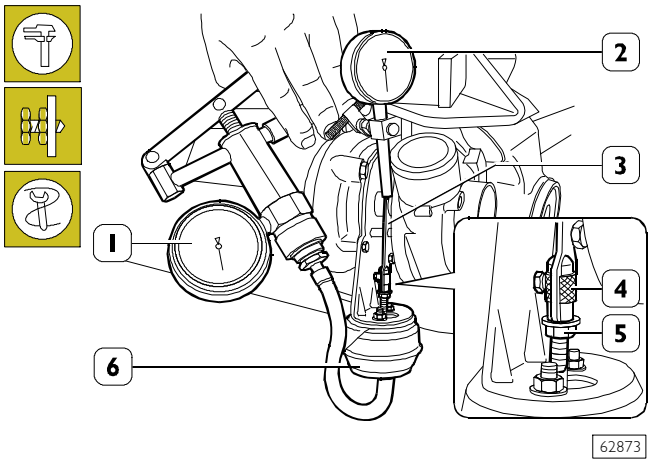
Waste gate

The turbocharger is fitted with a pressure regulation valve, mounted on the exhaust manifold before the turbine and controlled by a pneumatic actuator, connected via a pipe to the intake manifold.

Its job is to limit the quantity of exhaust gas acting on the turbine by sending part of it directly into the exhaust pipe when the boost pressure downstream of the compressor reaches the maximum value set.

Check and adjustment

Figure 34



Cover the air, exhaust gas and lubrication oil inlets and outlets.

Carry out an accurate external cleaning of the turbocharger, using the anticorrosive and antioxidant solution and perform the check on the actuator (6).

Clamp the turbocharger in a vice.

Disconnect the pipe of the actuator (6) and apply to the actuator union, the pipe of pump 99367121 (1).

Apply the magnetic-base dial gauge (2) on the exhaust gas inlet flange in the turbine.

Position the tracer point of the gauge (2) on the tie rod (3) end and set to zero the gauge (2).

Through the pump (1) let in compressed air, in the actuator (6), at the prescribed pressure and make sure that such value is kept constant for the whole check time, otherwise replace the actuator (6).

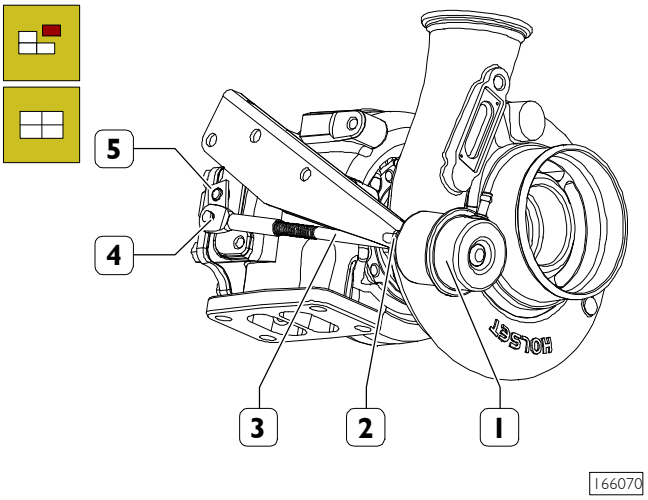
In the above-mentioned conditions, the tie rod must have carried out the prescribe stroke.

NOTE During the operation, beat slightly the actuator (6) in order to eliminate possible sticking of the actuator internal spring.

If a different value is found, loosen the nut (5) and operate properly the knurled ring nut (4).

Actuator replacement

Figure 35



Remove the elastic clip (4) and withdraw the tie rod (3) from the lever (5).

Remove the nuts (2) and remove the actuator (1) from the supporting bracket. Fit the new actuator following the removal operations in reverse order and fitting a new clip (4), tighten the nuts (2) to 5.6 – 6.8 Nm torque.

Check and adjust the actuator (1), if required, as described in the relevant chapter.

Then, paint the nut (6) with safety paint.

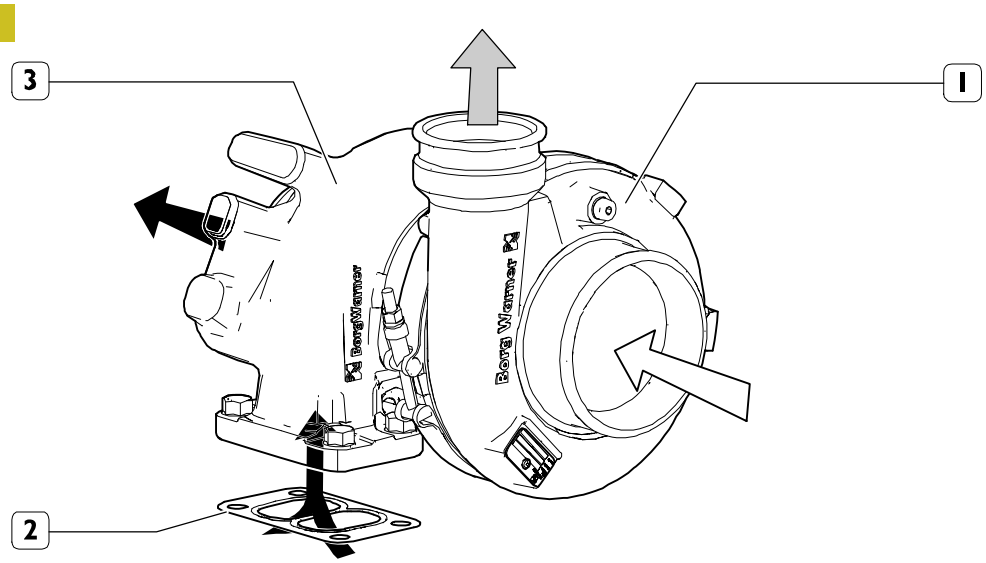
Before refitting the turbocharger on engine, fill the central body with engine oil.

BorgWarner fixed geometry turbocharger (FGT)

(F4HFE613N*B002 - F4HFE613N*B003)

The turbocharger is fitted onto the exhaust manifold.

Figure 36



intake air
compressed air
exhaust gas

1. Air compressor - 2. Gasket on exhaust manifold - 3. Exhaust gas turbine

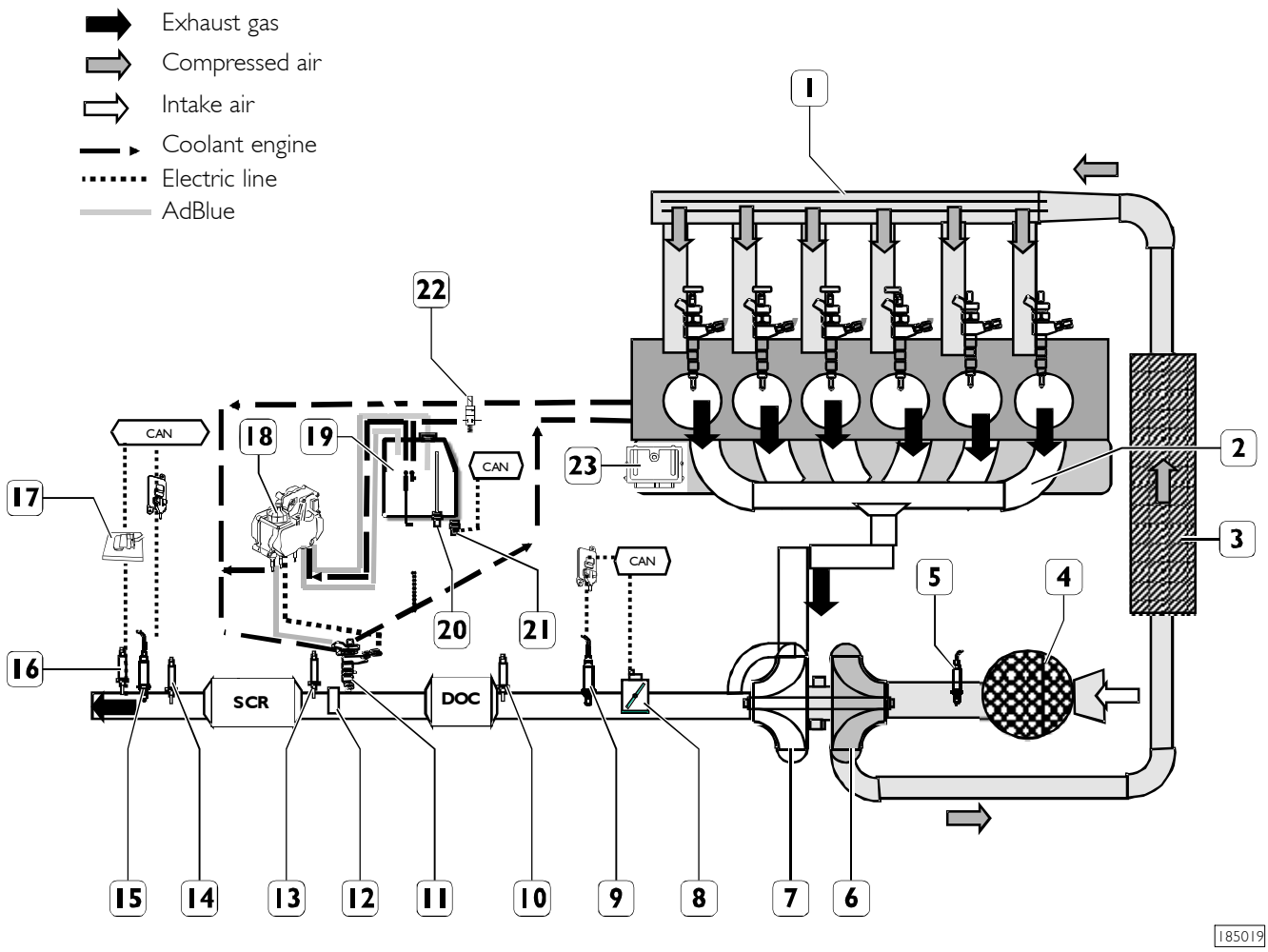
The turbocharger mainly consists of:

- ❑ a central casing housing a shaft supported by bushings at whose opposite ends are fitted the turbine and the compressor impellers;
- ❑ a turbine casing and a compressor casing mounted on the end of the central body;

EXHAUST GAS AFTER-TREATMENT SYSTEM (ATS)

Schematic diagram

Figure 37



1. Intake manifold - 2. Exhaust manifold - 3. Air Intercooler - 4. Air Filter - 5. Intake air humidity & temperature sensor - 6. T/C compressor - 7. T/C turbine - 8. Exhaust flap module - 9. NOx sensor - 10. Exhaust gas temperature sensor - 11. Dosing module - 12. Temperature sensor - 13. Exhaust gas temperature sensor - 14. Exhaust gas temperature sensor - 15. NOx sensor - 16. NH_3 sensor - 17. NH_3 sensor ECU - 18. Supply module Denox 2.2 - 19. AdBlue tank - 20. AdBlue tank level sensor - 21. Urea Quality sensor - 22. Engine coolant 3 way valve - 23. Engine Control Module (EDC17CV41).

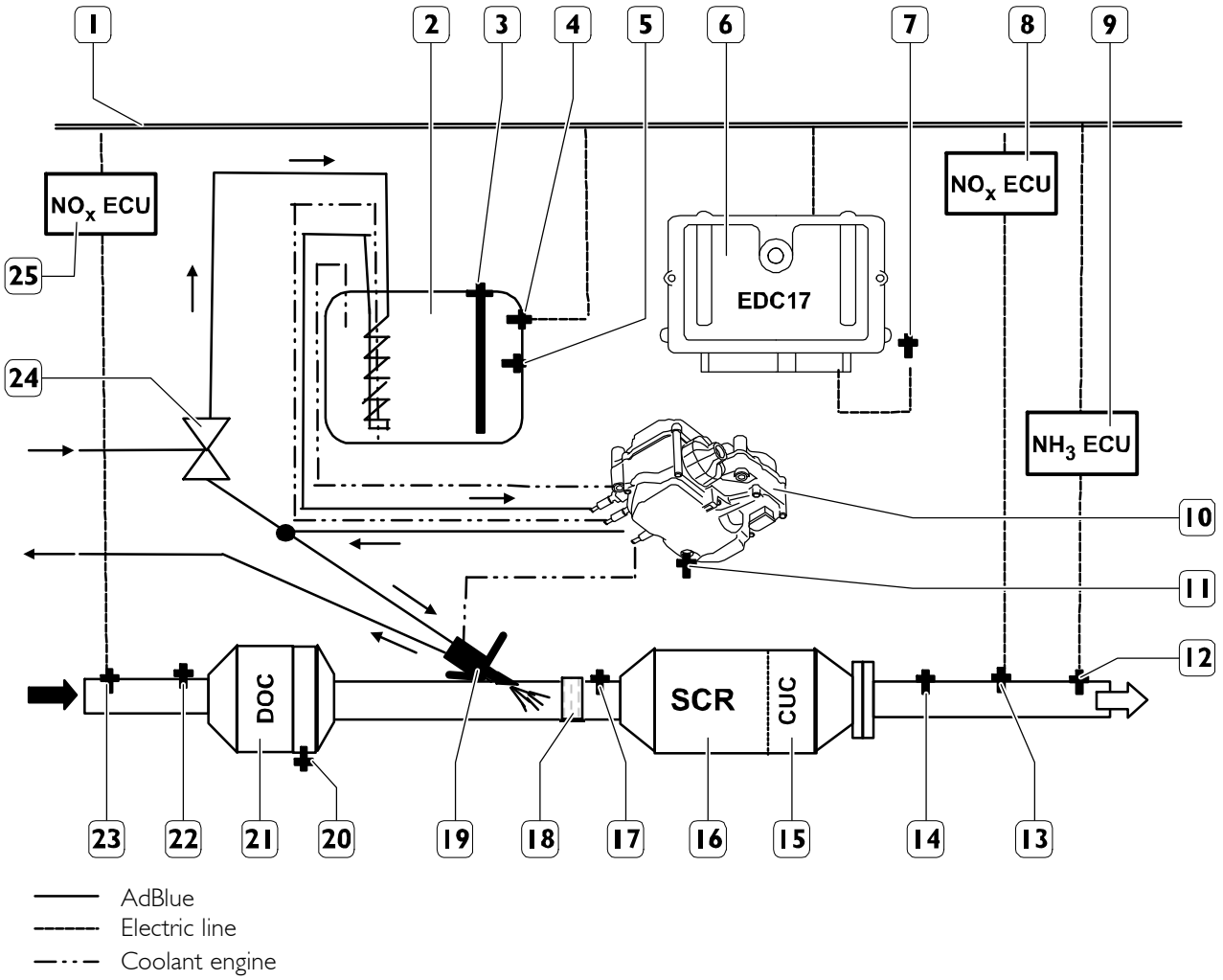
In order to reduce exhaust gas emissions to within the limits required by current standards, it has proved necessary to adopt the exhaust gas after-treatment system (ATS) which combines two devices:

- ❑ two catalytic converters for the treatment of HC (unburned hydrocarbons) and CO (carbon monoxide);
- ❑ the device DeNOx 2.2 for the treatment of NOx (nitrogen oxides).

The ATS system is electronically managed by the ECU EDC17CV41 which, based on the number of engine revs, delivered torque, exhaust gas temperature, amount of nitrogen oxides and air humidity intake, regulates the flow rate of the AdBlue solution to be introduced into the system.

The pump module draws the reagent solution from the tank and sends it under pressure to the mixing and injection module to be injected into the exhaust pipe.

Figure 38

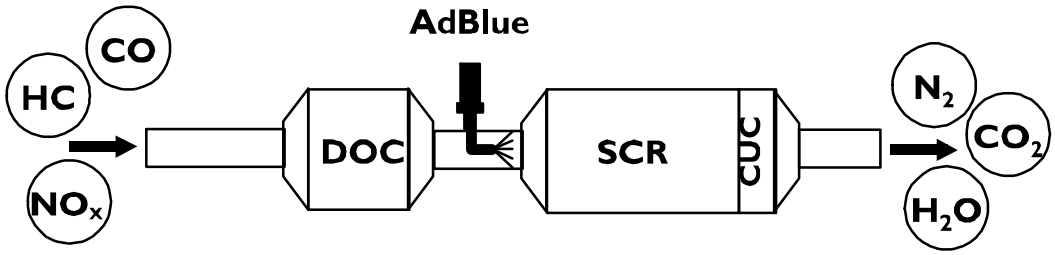


1. Can line - 2. AdBlue tank - 3. AdBlue tank level sensor - 4. Urea quality sensor - 5. AdBlue temperature sensor - 6. Engine Control Module (EDC17CV41) - 7. Umidity and temperature sensor - 8. NOx sensor ECU - 9. NH_3 sensor ECU - 10. Supply module Denox 2.2 - 12. NH_3 sensor - 13. NOx sensor - 14. Temperature sensor - 15. Clean Up Catalyst (CUC) - 16. Selective catalyst reduction (SCR) - 17. Temperature sensor - 18. Mixer - 19. Dosing module - 20. Exhaust gas temperature sensor - 21. Diesel Oxidation Catalyst (DOC) - 22. Exhaust gas temperature sensor - 23. NOx sensor - 24. Engine coolant 3 way valve - 25. NOx sensor ECU.

The ATS system is essentially composed of:

- ❑ a DOC catalytic converter (Diesel Oxidation Catalyst);
- ❑ an SCR catalytic converter (Selective Catalyst Reduction);
- ❑ a CUC filter (Clean Up Catalyst)
- ❑ a tank of the reagent solution (water + urea: AdBlue) with level indicator, temperature sensor and Urea quality sensor;
- ❑ a H_2O switch valve;
- ❑ a supply module;
- ❑ a dosing module;
- ❑ four exhaust gas temperature sensors;
- ❑ a humidity sensor mounted on the engine air suction pipe downstream of the air filter.
- ❑ two sensors to detect the amount of nitrogen oxides (NOx);
- ❑ a sensor to detect the presence of NH_3 (ammonia) upon exit of exhaust gases.

Figure 39



185021

The catalytic converters perform two functions:

- the first is composed of a DOC (Diesel Oxidation Catalyst) which removes HC (unburned hydrocarbons) and CO (carbon monoxide) from the exhaust gases;
- the second is composed of the SCR (Selective Catalyst Reduction) and the CUC (Clean Up Catalyst) upstream of which are located the AdBlue dosing module and the mixer; this is where the reduction reactions of the NOx (nitrogen oxides) take place.

In the first phase the exhaust gases exiting the turbine are conveyed into the DOC catalytic converter in which the hydrocarbons (HC) and carbon monoxide (CO) added to oxygen O_2 are converted into carbon dioxide (CO_2) and water (H_2O) through oxidation reactions.

In the second phase the dosing module, located in the exhaust pipe upstream of the SCR catalytic converter, introduces a water and urea solution (AdBlue) into the exhaust gases by means of a dosing injector.

The final phase of the process is realised in the SCR catalytic converter: the reagent solution, due to the temperature of the exhaust gases, instantly evaporates and, by hydrolysis, is converted into ammonia (NH_3) and carbon dioxide (CO_2), at the same time; the evaporation of the solution causes the lowering of the exhaust gas temperature, bringing it close to the optimum temperature required for the process.

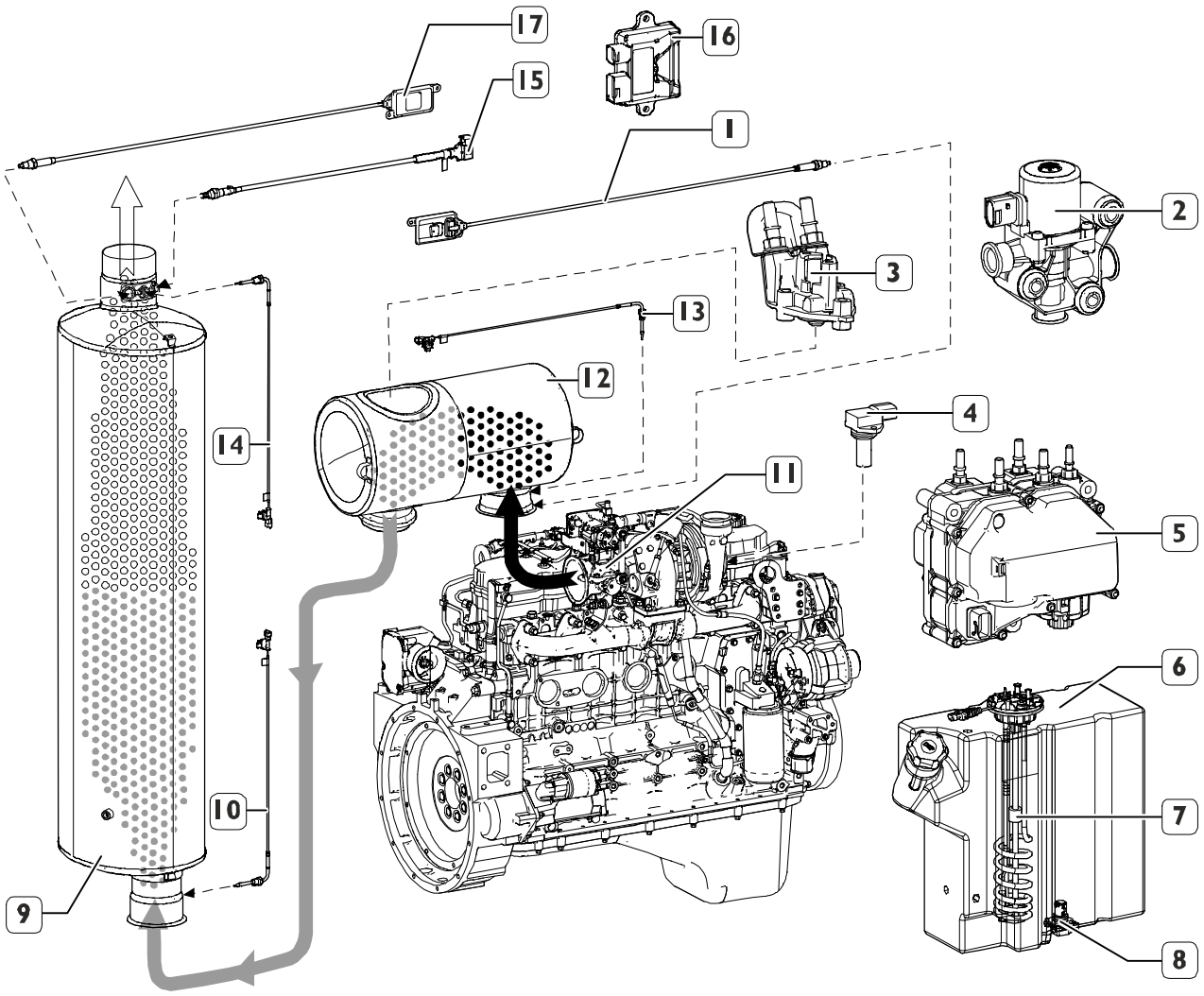
By reacting with the oxygen in the exhaust gases the ammonia is converted into free nitrogen (N_2) and water vapour (H_2O).

The engine control unit, based on the number of engine revs, delivered torque, exhaust gas temperature, air humidity intake, the amount of nitrogen oxides and urea present in the exhaust gases (detected by the respective sensors), regulates the flow rate of the AdBlue solution to be introduced into the system.

The amount of AdBlue injected is controlled by the NH_3 sensor located downstream of the SCR.

It detects the presence of ammonia in the exhaust gases and transmits a signal to the engine control unit, thus supplying a feedback signal.

Figure 40



1. DOC upstream NOx sensor - 2. Engine coolant 3 way valve - 3. Dosing module DeNOx 2.2 - 4. Intake air humidity and temperature sensor - 5. Supply module DeNOx 2.2 - 6. AdBlue tank - 7. AdBlue tank level sensor - 8. Urea quality sensor (UQS) - 9. Selective catalyst reduction (SCR) - 10. SCR upstream exhaust gas temperature sensor - 11. Exhaust flap module - 12. Diesel Oxidation Catalyst (DOC) - 13. DOC upstream exhaust gas temperature sensor - 14. SCR downstream exhaust gas temperature sensor - 15. NH_3 sensor - 16. NH_3 sensor ECU - 17. SCR downstream NOx sensor

AdBlue specification
ISO 22241 / AUS32 / DIN V 70070

Urea 32.5% - solution in water

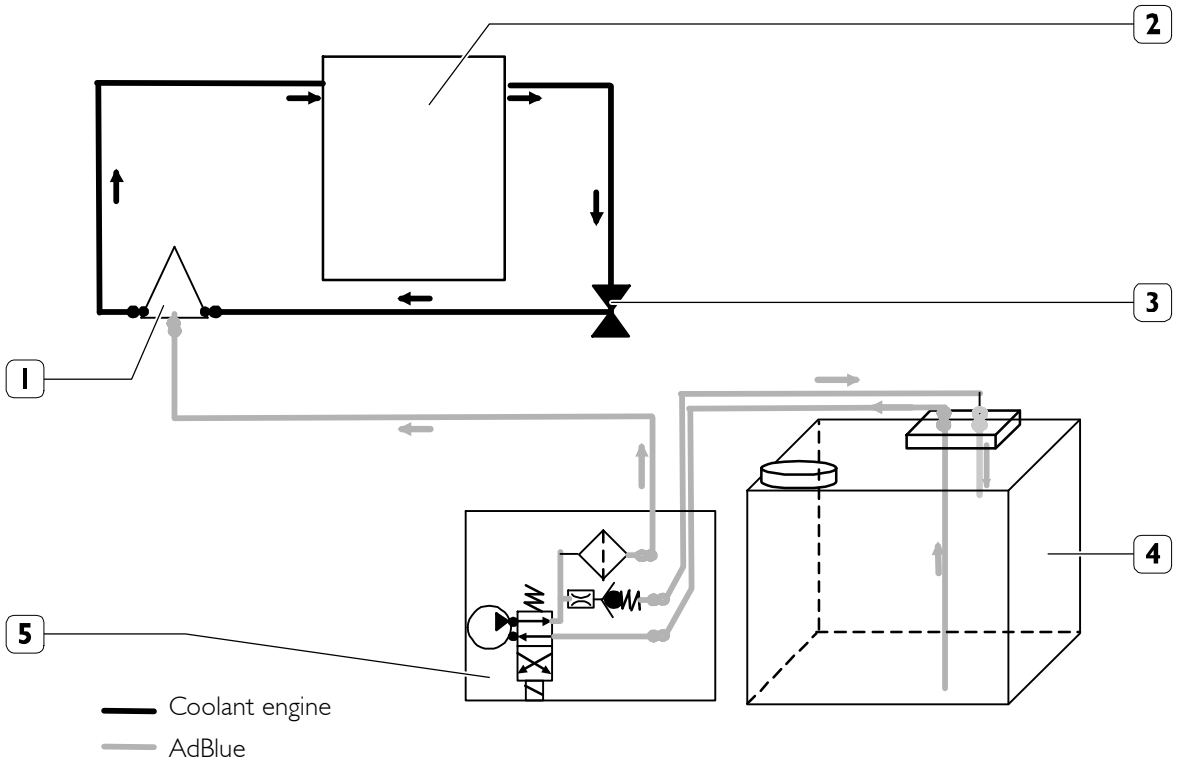
	Min.	Max.	
Urea content	31.8	33.2	% by weight
Density at 20°C	1.087	1.093	g/cm^3
Refracting index at 20°C	1.3814	1.3843	
Alkalinity as NH_3		0.2	%
Biuret		0.3	%
Aldehyde		5	mg/kg
Insolubles		20	mg/kg
Phosphate (PO4)		0.5	mg/kg
Calcium		0.5	mg/kg
Iron		0.5	mg/kg
Copper		0.2	mg/kg
Zinc		0.2	mg/kg
Chromium		0.2	mg/kg
Nickel		0.2	mg/kg
Aluminium		0.5	mg/kg
Magnesium		0.5	mg/kg
Sodium		0.5	mg/kg
Potassium		0.5	mg/kg

System of cooling/heating ATS system

The system performs two functions:

- ❑ continuous cooling of the dosing module;
- ❑ heating of the AdBlue tank, the supply module and AdBlue pipes and, at the same time, cooling of the dosing module.

Figure 41

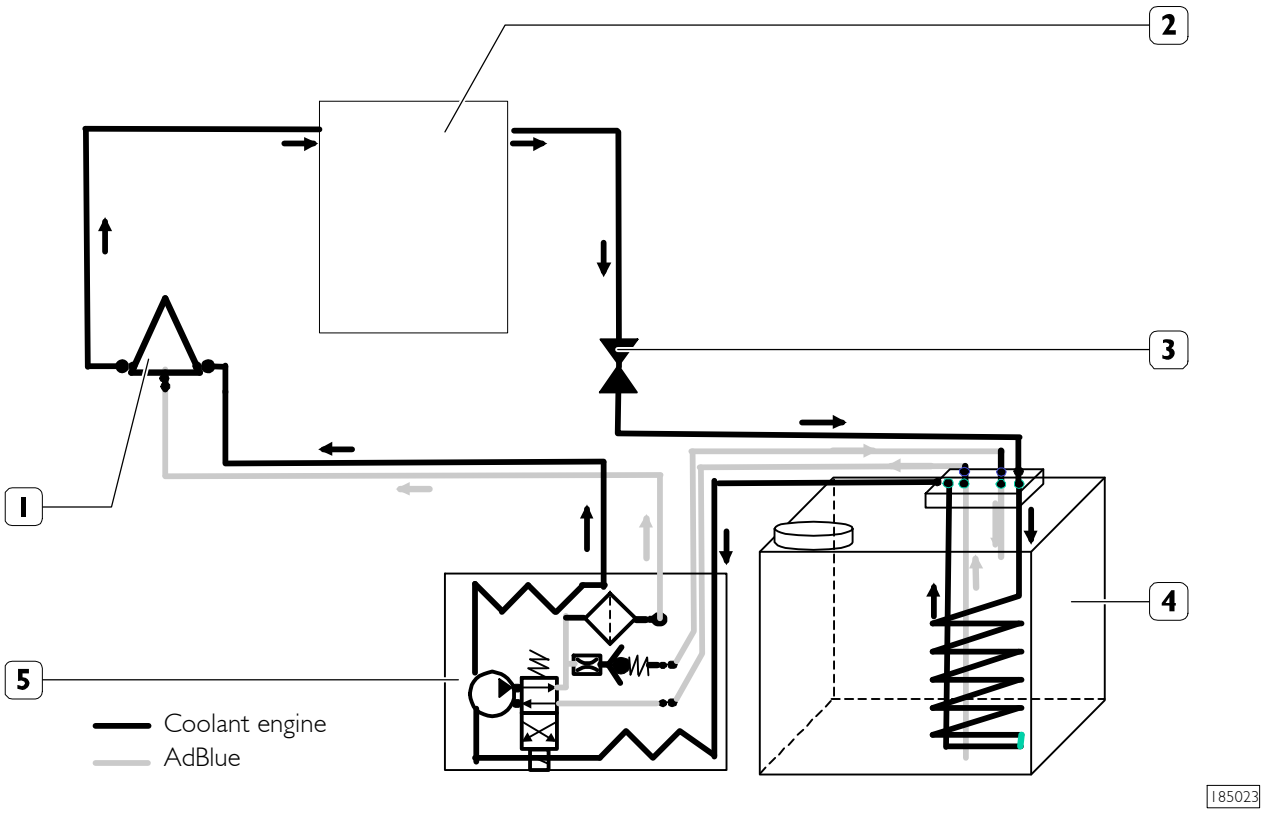


COOLING CONDITION

1. Dosing module - 2. Engine - 3. Engine coolant 3 way valve - 4. AdBlue tank - 5. Supply module.

The dosing module, given its unfavourable assembly position from a cooling point of view and given the high temperatures reached by the exhaust gases downstream of the catalytic converter, is connected to the engine cooling circuit and continuously cooled.

Figure 42



CONDITION OF SIMULTANEOUS HEATING AND COOLING

1. Dosing module - 2. Engine - 3. Engine coolant 3 way valve - 4. AdBlue tank - 5. Supply module.

Please note that AdBlue may freeze below temperatures of -11°C.

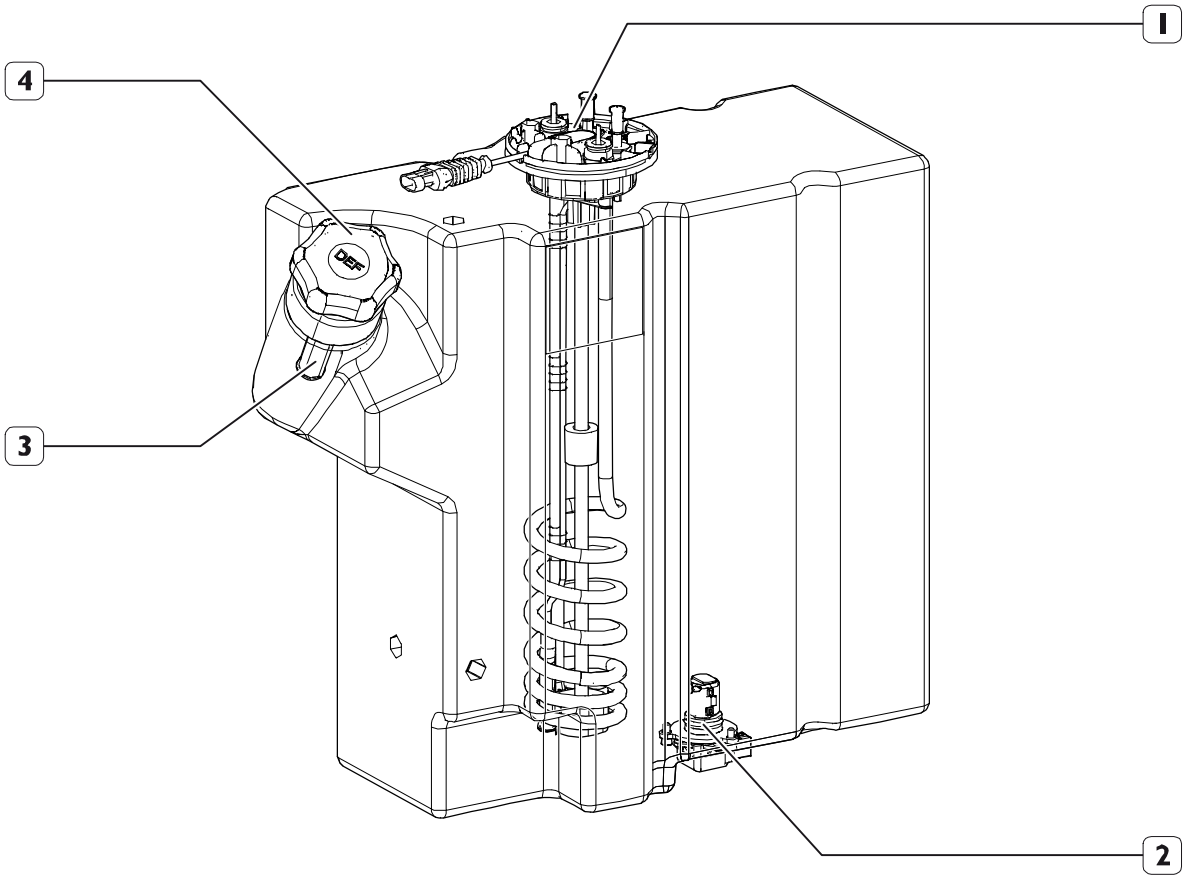
When the temperature of AdBlue in the tank falls below the acceptable limit, the switch valve (3) is activated which enables the flow of the engine coolant into the heating coil inside the tank (4) and hence into the supply module (5).

In this phase, the engine cooling temperature is such as to carry out the function of heating the components as described above.

Afterwards the engine coolant is conveyed towards the dosing module in order to cool its temperature.

MAIN COMPONENTS OF THE ATS SYSTEM
Tank

Figure 43

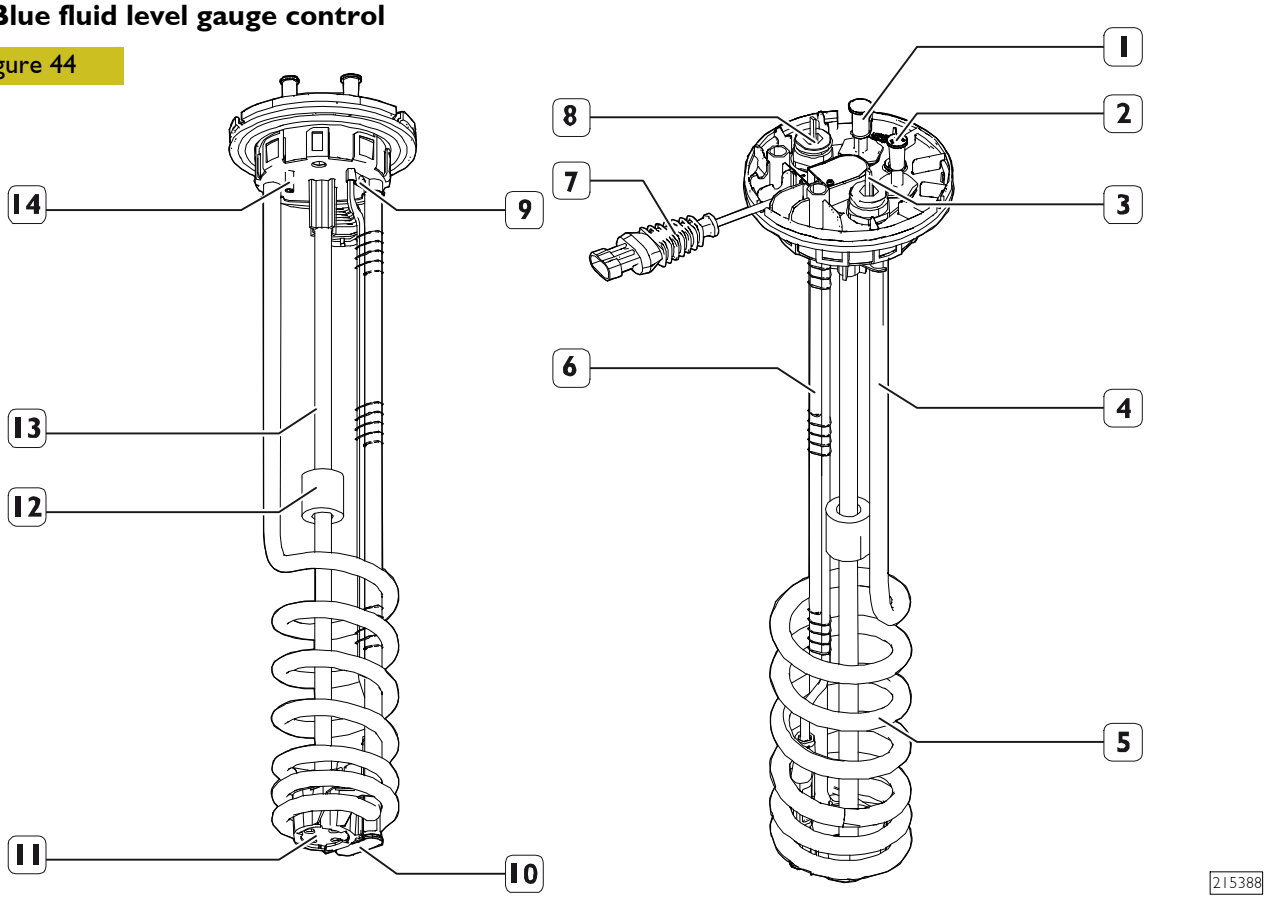


The tank has a level indicator command (1) and contains the reducing substance, consisting of a 33% urea and water solution called AdBlue. The inlet (4) is equipped with a mesh filter (3). A urea quality sensor (2) and a temperature sensor are incorporated in the tank.

NOTE FPT recommends maintaining AdBlue temperature below 50 °C in the tank during operating conditions.
Tank ventilation: the circuit must be protected from dust.

Ad Blue fluid level gauge control

Figure 44



1. AdBlue suction - 2. AdBlue return - 3. Engine coolant outlet - 4. Engine coolant outlet pipe - 5. AdBlue heating coil - 6. Engine coolant inlet pipe - 7. Connector - 8. Engine coolant inlet - 9. Ad Blue suction pipe - 10. Filter - 11. Bottom plate (AdBlue NTC temperature sensor) - 12. Float (AdBlue level sensor) - 13. Reed pipe - 14. AdBlue return pipe

The AdBlue fluid level gauge control consists of

- a float (level sensor);
- an NTC temperature sensor;
- a liquid heating coil in case of low temperatures.

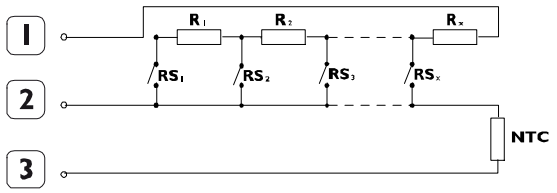
It informs the control unit of changes in the current due to the resistance, caused by the position of the float in relation to the level of the AdBlue liquid.
Frozen AdBlue can be melted by means of a coolant heater coil (5).
A solenoid which is actuated by the ECU controls the engine coolant flow through the AdBlue circuit / tank heater.
Urea quality sensor is integrated in the tank unit to fulfil rapid anti-tampering.

NOTE Ensure connectors are properly sealed with a moisture proof plug prior to AdBlue tank leak testing.

Temperature sensor:	NTC type; 1kΩ +/-5% @ 25°C
Level sensor recommended characteristic:	70 Ω at low level; 20kΩ at high level

Electrical connections:

Figure 45

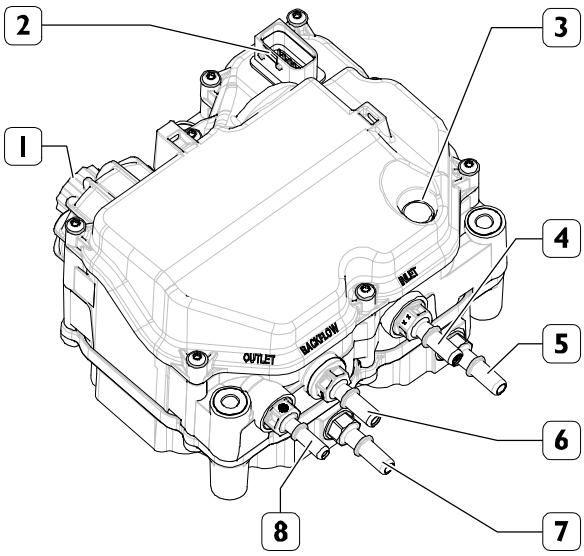


215389

Ref.	Description
1	Level
2	Common ground
3	NTC signal (temperature)

DeNOx 2.2 Supply Module (SM)

Figure 46



185025

1. Main filter - 2. Electrical connector - 3. Pressure compensation membrane - 4. Supply pipe from tank - 5. Fluid input pipe of pump module heating - 6. AdBlue return pipe to tank - 7. Fluid output pipe of pump module heating - 8. Delivery pipe to dosing module

The AdBlue supply module is essentially composed of a diaphragm pump which draws the AdBlue from the tank and conveys it to the dosing module.

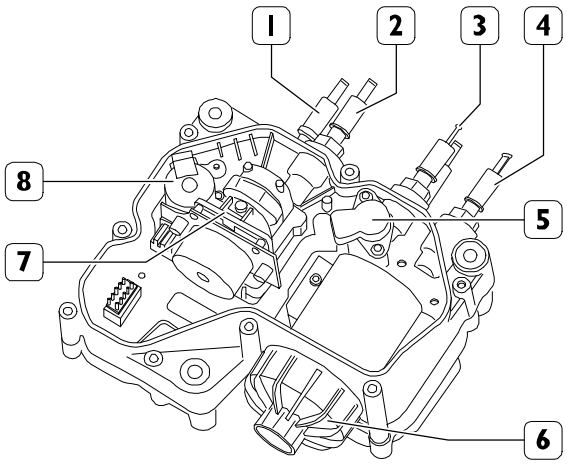
It is equipped with a circuit connected to the engine cooling system which, in the event of low temperatures, prevents the AdBlue from freezing. A pressure sensor is located inside it.

The amount of AdBlue sent to the dosing module and the injection pressure are controlled by the engine control unit and depend on the operating conditions of the engine and the signals sent from the sensors.

Electric power requirements of DeNOx 2.2 Supply Module (SM) for 7.2 kg/h:

24 Volt systems: max 2750 mA @ 28 Volt battery voltage

Figure 47



185029

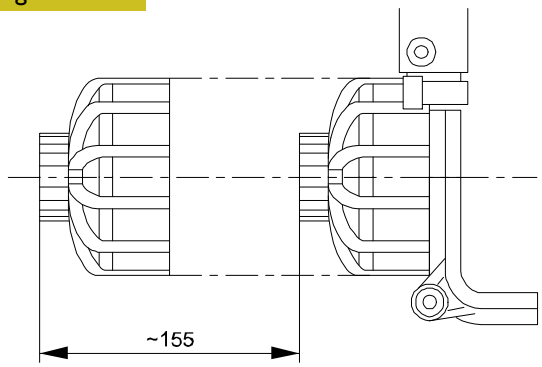
1. Coolant connector - 2. AdBlue inlet from tank - 3. AdBlue back-flow to tank - 4. AdBlue outlet to DM - 5. Pressure sensor - 6. Main filter - 7. Membrane pump - 8. 4/2 Way valve.

To prevent damage to the pump and dosing module, the supply module contains a filter which removes any impurities from the AdBlue.

Please refer to the following procedure for replacement of the filter.

Filter disassembly

Figure 48

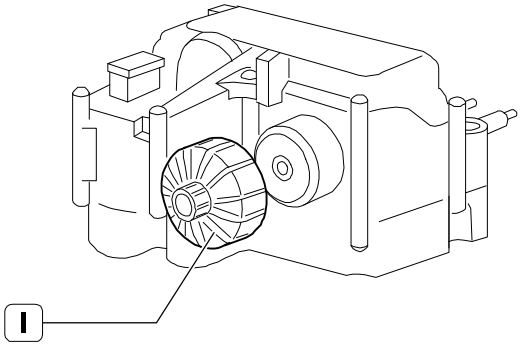


185435

NOTE During installation of the supply module on the vehicle, take into account the minimum aperture for filter replacement.

The minimum value is approx. 155 mm.

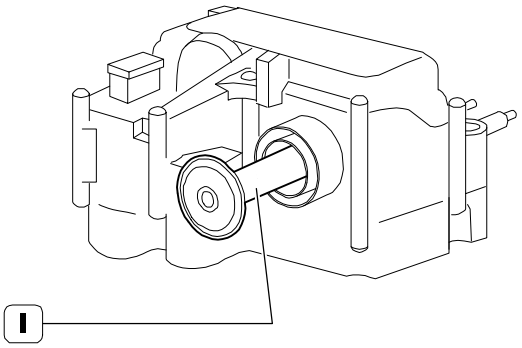
Figure 49



185428

❑ Unscrew and remove the filter cover (1).

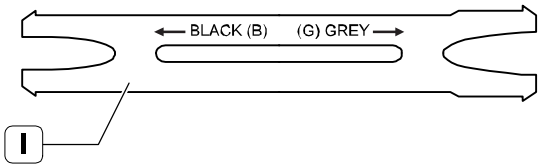
Figure 50



185429

❑ Remove the equalizing element (1).

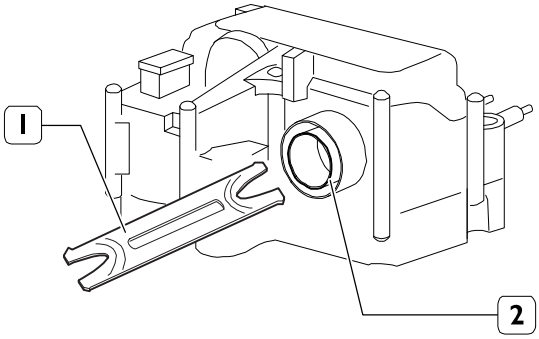
Figure 51



185430

❑ Insert the tool (1) in the correct direction in the filter, based on the colour of the filter supplied

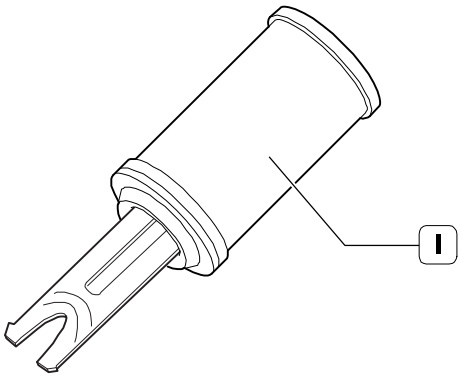
Figure 52



185431

❑ Insert the appropriate tool (1) until a click is felt which indicates the complete engagement of the filter (2).

Figure 53

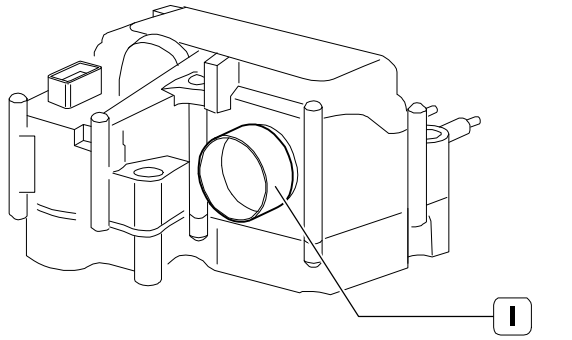


185432

❑ Remove the filter (1).

Filter assembly

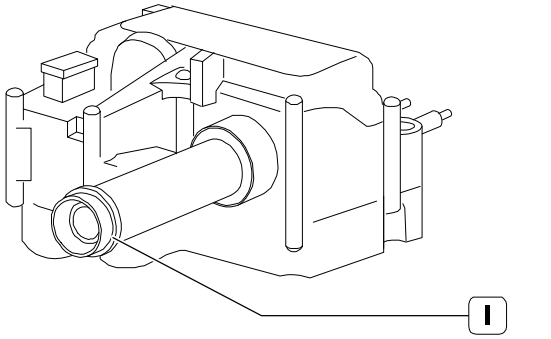
Figure 54



185433

❑ Carefully clean the contact surface with water (1).

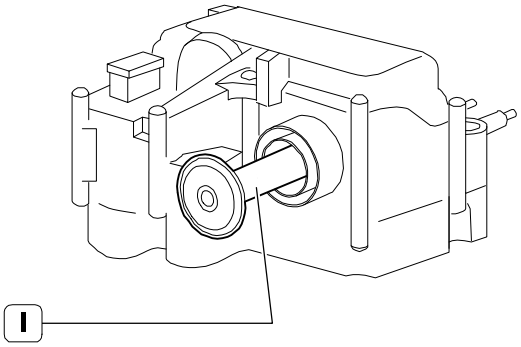
Figure 55



185434

❑ Oil gaskets and assembly new filter (1).

Figure 56

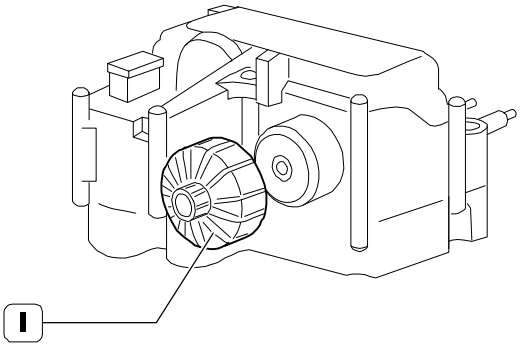


185429

❑ Assembly a new equalizing element (1).

NOTE Check that the filter cover and the contact surface of the supply module are not cracked or damaged. If necessary, replace any damaged components.

Figure 57

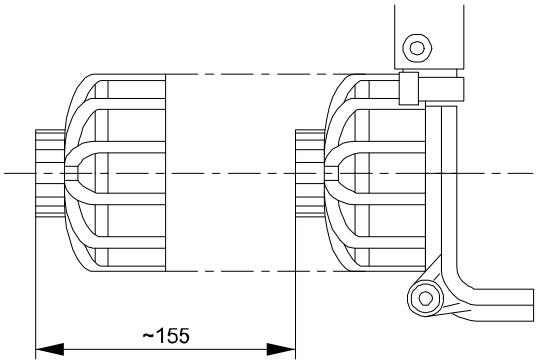


185428

❑ Carefully clean the filter cover (1).

❑ Tighten the filter cover to a torque of 20 ± 5 Nm.

Figure 58



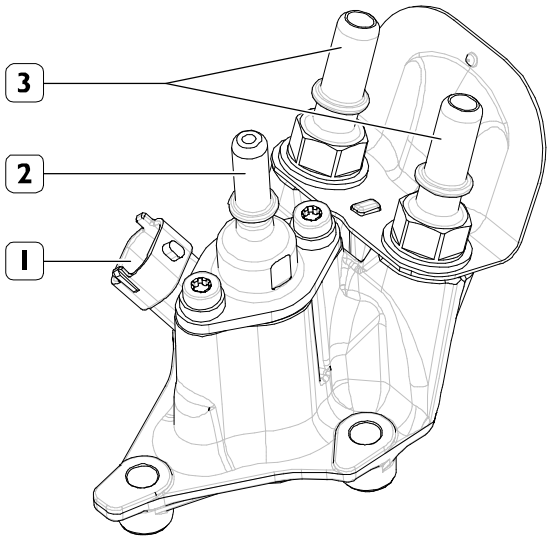
185435

NOTE During installation of the supply module on the vehicle, take into account the minimum aperture for filter replacement.

The minimum value is approx. 155 mm.

DeNOx 2.2 Dosing module (DM)

Figure 59



1. Electrical connector - 2. AdBlue inlet - 3. Coolant engine inlet/outlet

The dosing module is controlled by the engine control unit. Its function is to measure the AdBlue solution to be injected into the exhaust pipe upstream of the SCR catalytic converter.

It is mounted on the catalytic converter and whilst operating is constantly subjected to high temperatures, hence it is connected to the engine cooling circuit by means of the pipes (3).

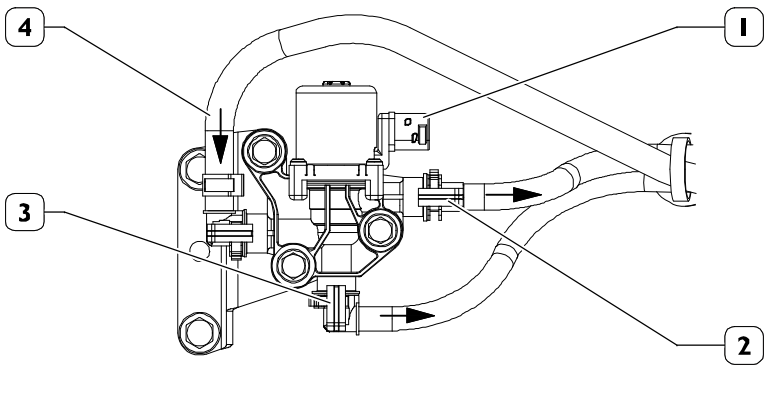
Maximum AdBlue injection pressure: 9 bar.

Hydraulic Capability of DeNOx 2.2 Dosing module (DM):

Normal circulation and no injection:	~ 8 kg/h
Maximum with the small urea injector:	~ 15 kg/h (8 kg/h + 7 kg/h)
Maximum with the large urea injector:	~ 20 kg/h (8 kg/h + 12 kg/h)

Engine coolant 3 way valve

Figure 60



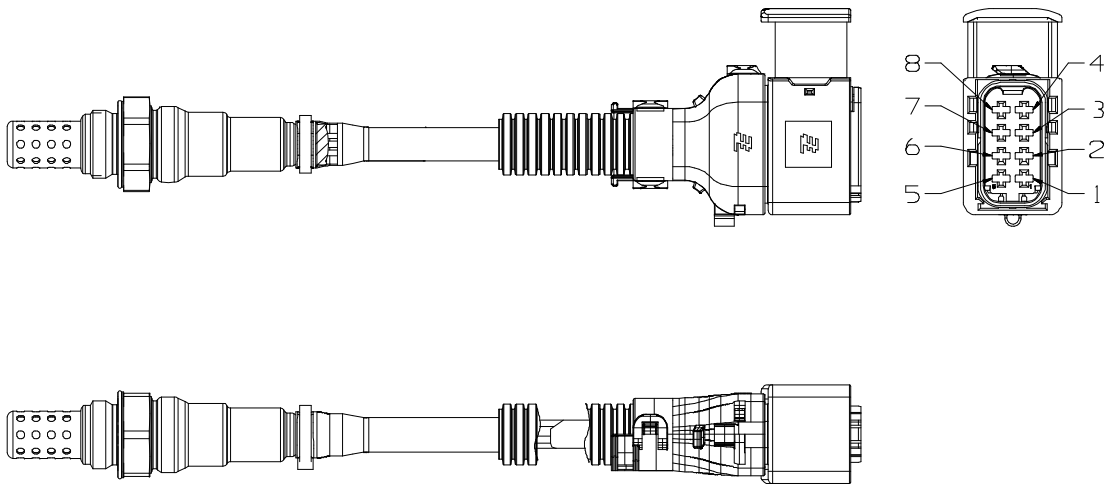
1. Electrical connector - 2. AdBlue tank heating fluid pipe - 3. Dosing module coolant pipe - 4. Engine coolant pipe.

The switch valve is of solenoid valve 2 position/3-way type. Depending on the temperatures detected by the NTC sensor, the switch valve closes or opens the passage of the engine coolant into the AdBlue tank heating coil. The cooling circuit of the dosing module instead always stays open.

The first position, in fact, allows the cooling of the dosing module (DM - Dosing Module) whereas the second position allows the cooling of the AdBlue tank, the supply module (SM - Supply Module) and the relevant pipes, besides heating the DM.

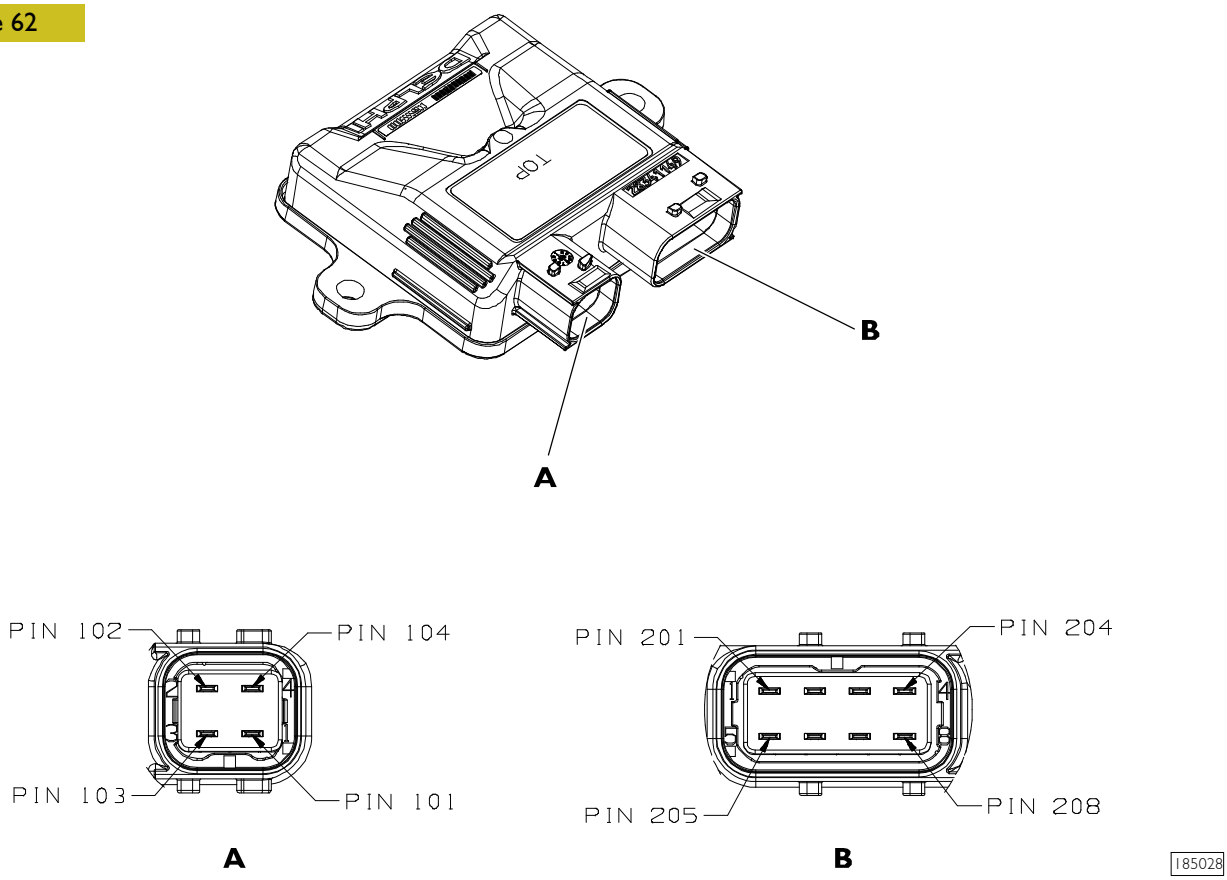
NH_3 sensor

Figure 61



The NH_3 sensor is connected to the engine control unit and, by detecting the presence of ammonia (NH_3) in the exhaust gases exiting the catalytic converter, enables a more accurate regulation of the amount of AdBlue to be injected.

Figure 62

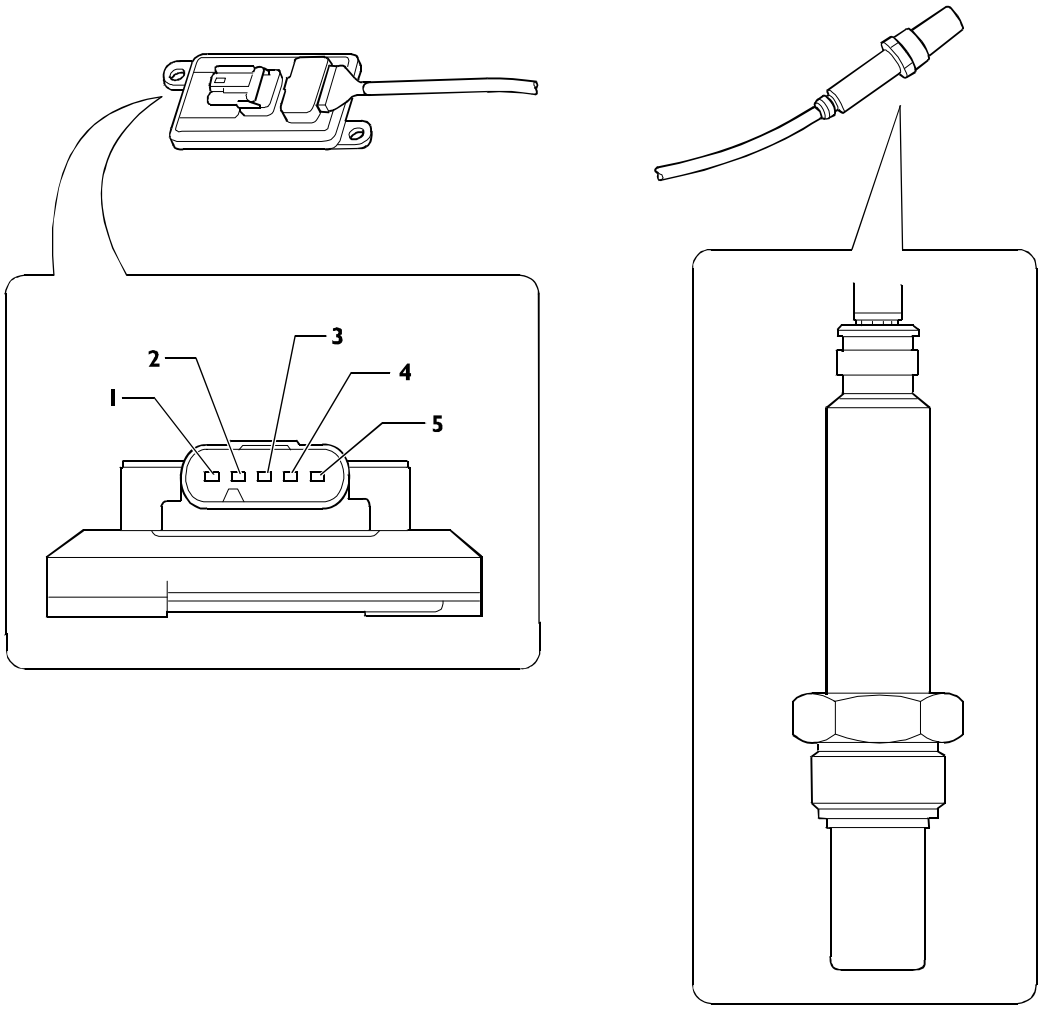


A. Vehicle connector - B. Sensor connector.
101. Supply - 102. Can H - 103. Can L - 104. Ground.

NH_3 SENSOR CHARACTERISTICS	NOMINAL
Normal operating voltage	10 to 32 V
Average current	1.2 A
Max current	4.0 A
Temperature / humidity rating	-40 to 105 °C

Nitric oxide sensor

Figure 63



1. Positive - 2. Mass - 3. CAN L line - 4. CAN H line - 5. Spare

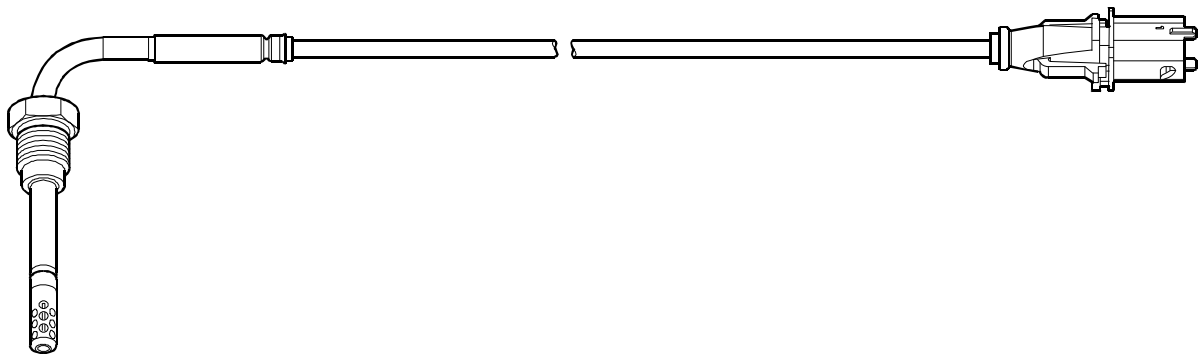
The NOx sensor detects the amount of nitrogen oxides in the exhaust gases entering and exiting the catalytic converters.

Based on this information the engine control unit regulates the amount of AdBlue to be injected and also measures the efficiency of the catalytic converters.

CHARACTERISTICS OF NOx SENSOR	VALUE
Ambient temperature electronics:	- 40 to +105 °C (+105 to +115 °C allowed for up to 10 min)
Wire temperature:	230 °C allowed for up to 100 h

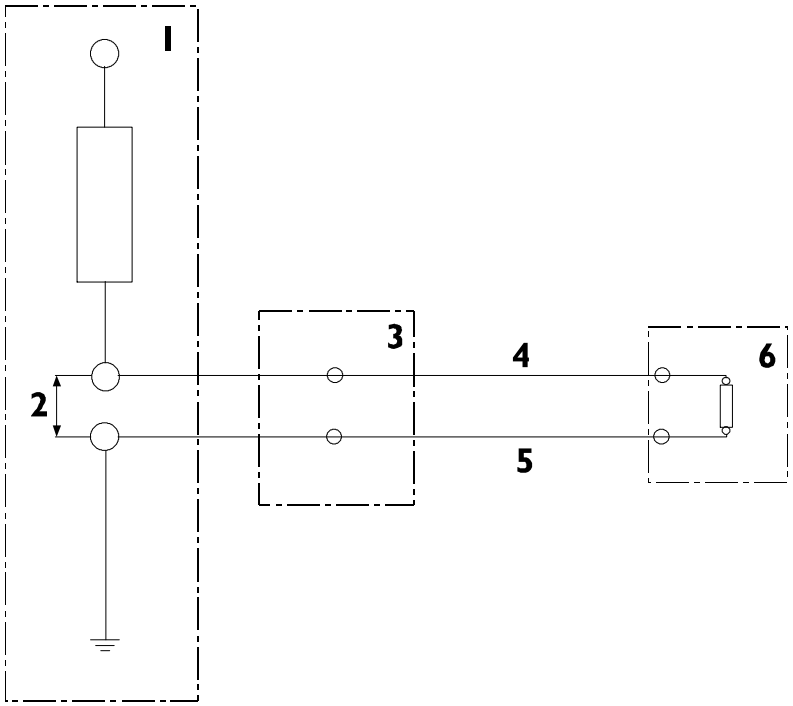
Exhaust gas temperature sensor

Figure 64



102303

Figure 65



102304

FUNCTIONAL WIRING DIAGRAM

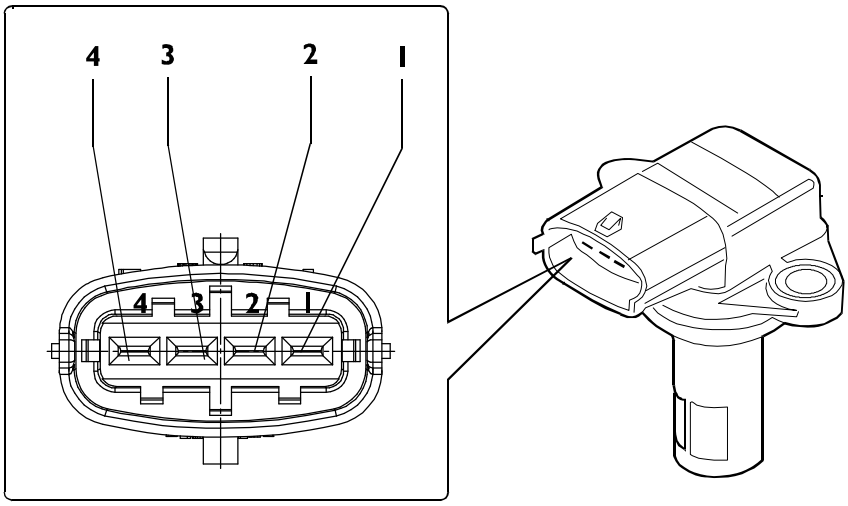
1. Supply voltage - 2. Variable output voltage - 3. Connector - 4. Signal cable (grey) - 5. Ground cable (white) - 6. Sensor.

The function of this sensor is to send the control unit the catalyst inlet and outlet exhaust gas temperature values required to calculate the amount of urea to be injected into the system.

CHARACTERISTICS OF EXHAUST GAS TEMPERATURE SENSOR	VALUE
Power supply	5.00 V ± 0.1%
Output voltage @ Temperature -40 to 1000 °C	0.727 to 2.297 V
Pull up resistance	1000 Ω ± 0.1%
Lead resistance	1 Ω

Humidity and temperature detecting sensor

Figure 66

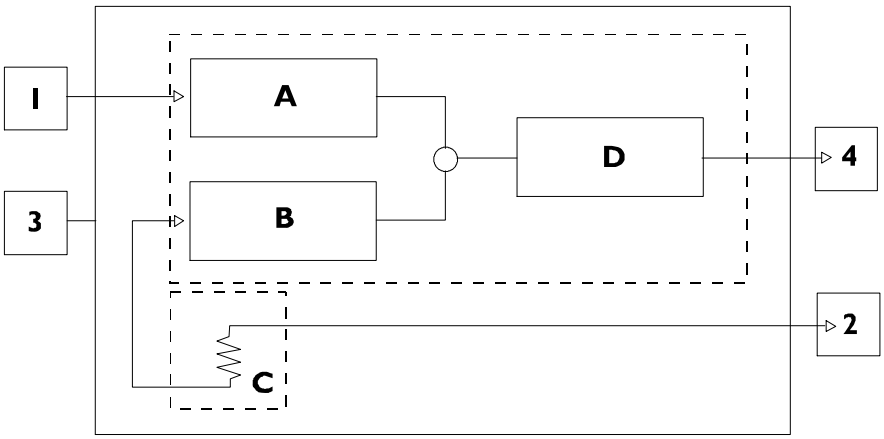


125531

1. Supply - 2. Moisture indicator - 3. Ground connection - 4. Temperature

This sensor, which is mounted to the air filter outlet duct, sends the humidity percentage and temperature of the intake air to the control unit. These data are used by the ECU to determine the level of nitrogen oxide emissions.

Figure 67



102312

ELECTRIC BLOCK DIAGRAM

1. Power supply - 2. Moisture percentage - 3. Ground - 4. Temperature - A. Sample frequency generator - B. Base oscillator - C. NTC temperature sensor - D. Amplifier low pass filter

CHARACTERISTICS OF HUMIDITY SENSOR	VALUE
Voltage supply	5.00 ± 0.25 VDC
Current consumption	10 mA
Humidity operating range	0% RH ÷ 100% RH
Output impedance	70 Ω
Isolation resistance	1 MΩ @ 500 V

CHARACTERISTICS OF TEMPERATURE SENSOR	VALUE
Temperature operating range	-40 ÷ 125 °C
Resistance at 25 °C	NTC 2.186 kΩ ± 1%
Max power at 25 °C	100 mW

ATS SYSTEM MAINTENANCE PLANNING

The general checking/inspection intervals which must be carried out on the ATS system components are as follows.

The frequency of the maintenance operations is just an indication since the use of the engine is the main characteristic to determine and evaluate replacements and checks.

It is not only allowed but recommended that the staff in charge of the maintenance should also carry out the necessary maintenance and controlling operations even if not being included in the ones listed here below but that may be suggested by common sense and by the specific conditions in which the engine is run.

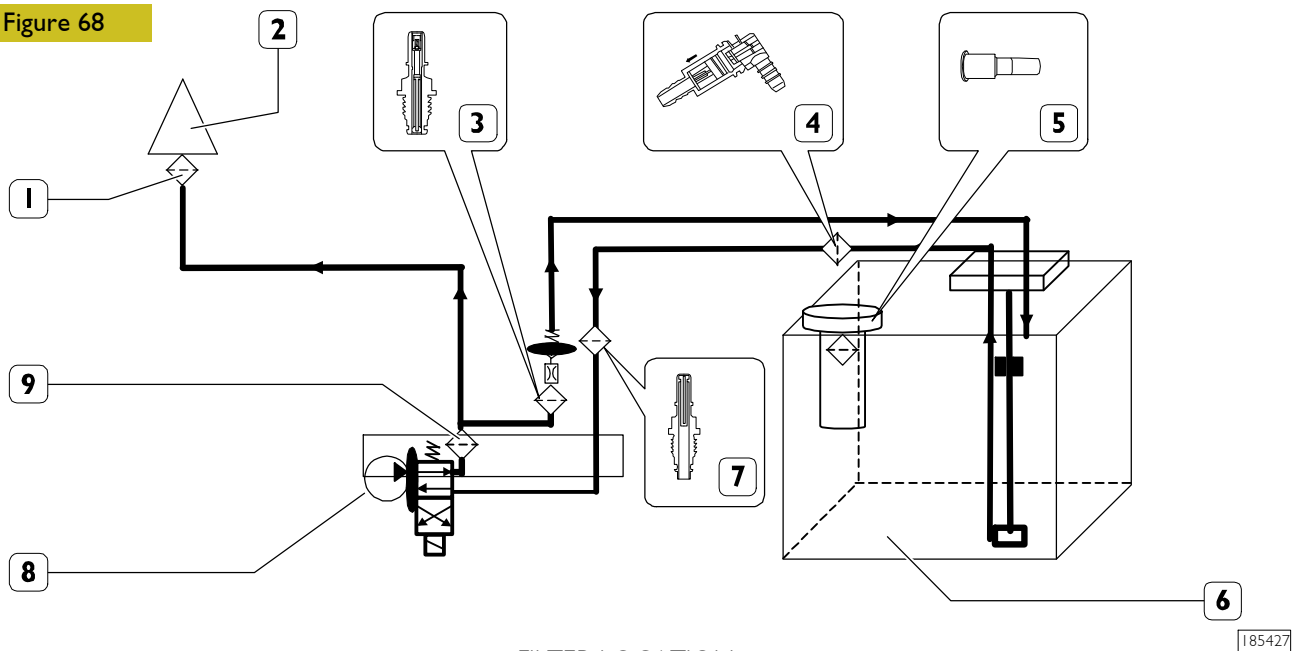
In case of evident system malfunction immediately intervene in order to find the causes.

We wish to remind that each maintenance operation, even the most simple must be performed in compliance with the accident prevention standards for the safety of maintenance personnel in charge.

Component	Function	Service-Requirement
Tank Neck Filter (300 or 100* µm)	Protect tank during filling	No regular service planned (Cleaning, if required)
SM Pre-Filter (100 or 70* µm)	Protect SM from dirt coming from tank	Cleaning @ every oil change interval
SM Inlet-Filter (100 µm)	Protect SM during 1st start-up	No regular service planned (Replacement, if required)
SM Main-Filter	Protect DM	Change every 3,600 hours or 2 years (whichever occurs first)
SM Backflow-Filter (100 µm)	Protect throttle in backflow connector from dirt coming from pressure line or dirt introduced during change of SM Main-Filter	No regular service planned (Replacement, if required)
Dosing Valve Filter (36 µm)	Protect DM during 1st start-up	Cannot be serviced

* for application working in dusty environment only.

Figure 68



FILTER LOCATION

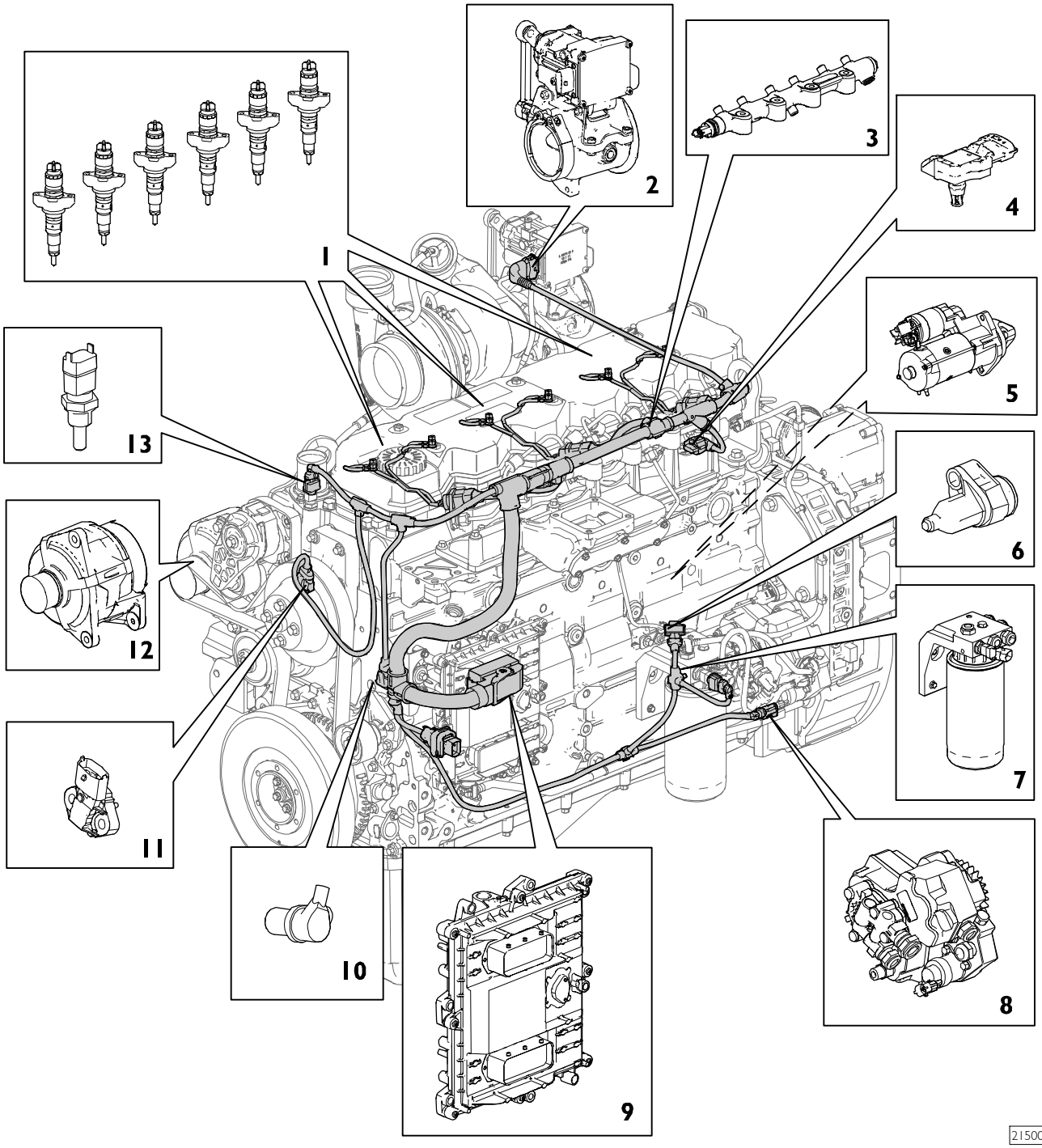
1. Dosing valve filter - 2. Dosing module - 3. SM Backflow-Filter - 4. SM Pre-Filter - 5. Tank pre-filter - 6. AdBlue tank - 7. SM Inlet-Filter - 8. Supply module - 9. SM main filter.

SECTION 3

Electrical equipment

ELECTRICAL COMPONET LAYOUT

Figure 1



The electrical components available on the 6-cylinder NEF engines are listed here following.

1. Electro-injectors - 2. Motorized throttle valve actuator connector (Exhaust flap) - 3. Rail pressure sensor - 4. Boost pressure and air temperature sensor - 5. Electric starter motor - 6. Camshaft timing segment speed sensor - 7. Fuel temperature sensor - 8. Fuel high pressure pump metering unit - 9. Engine Control Unit ECU17CV41 - 10. Crankshaft rpm increment speed sensor - 11. Engine oil pressure and temperature sensor - 12. Alternator - 13. Coolant temperature sensor

EDC17CV41 electronic control unit

The ECU processes the signals from the sensors by applying software algorithms and controls the actuators (especially the electro--injectors and pressure regulator).It records, in the non-volatile memory area, the information on the engine parameters originally set or acquired during engine operation.

The control unit is mounted on the left-hand side of the engine and two connectors are fitted, of which:

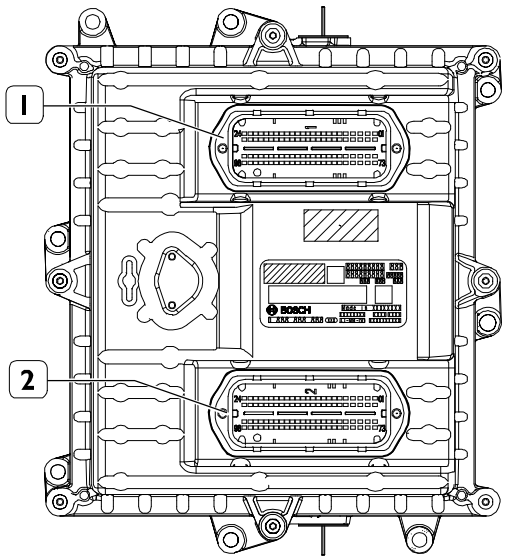
- a connector for the engine cable (injector and sensor connector);
- a connector for the chassis cable.

To reduce the number of connections, the length of the connection cables with the injectors and, as a result, disturbances in the transmitted signal, the control unit is mounted directly on the engine by means of a heat exchanger that cools it, using elastic dowels which reduce the vibrations transmitted by the engine.

Internally, there is an ambient pressure sensor that is used to further improve injection system management.

It is also equipped with a very advanced self-diagnosis system and it is capable of recognizing and memorizing, in function of the environmental conditions, the possible anomalies, even of an intermittent type, that occurred on the system during operation, ensuring a more correct and reliable repair action with the help of the FPT diagnostic instruments.

Figure 2



189003

1. Vehicle connector "1" - 2. Engine connector "2"

EDC SYSTEM FUNCTIONS

The EDC 17CV41 electronic center manages the following main functions:
Fuel injection
Engine brake engagement
Self-diagnosis
Recovery
It also enables:
Interfacing with other electronic systems (if any) available on the vehicle
Diagnosis

Fuel dosing

Fuel dosing is calculated based on:
- accelerator position
- engine rpm
- quantity of air admitted.

The result can be corrected based on:
- fuel temperature (DIESEL DENSITY)
- water temperature

or to prevent:
- noise
- fumes
- overloads
- overheating

Pressure can be adjusted in case of:
- engine brake actuation
- serious defects involving load reduction or engine stop.
- ANTI-POLLUTION devices cutting in: Δp sensor, NOx sensor, NH_3 sensor

Once the control unit has determined the mass of the introduced air and measured its pressure and temperature, it calculates the corresponding fuel load needed to inject into the cylinder (mg. per delivery). It also takes diesel temperature into account (density). The fuel load calculated in this way is converted into crank degrees i.e. injection advance and duration.

Delivery correction based on water temperature

When cold, the engine encounters greater operating resistance, mechanical friction is high, oil is till very viscous and operating plays are not optimized yet.
Fuel injected also tends to condense on cold metal surfaces.
Fuel dosing with a cold engine is therefore greater than when hot.

Delivery correction to prevent noise, fumes or overloads

Behaviors that could lead to the defects under review are well known, so the designer has added specific instructions to the center to prevent them.

De-rating

In the event of engine overheating, decreasing delivery proportionally to the temperature reached by the coolant changes injection.
The control unit uses the oil temperature reading in the event of a coolant temperature sensor failure.

Injection lead electronic control

Injection lead, or the start of fuel delivery expressed in degrees, can differ from one injection to the next, even from one cylinder to another and is calculated similarly to delivery according to engine load, namely, accelerator position, engine rpm and air admitted.
Lead is corrected as required:
- during acceleration
- according to water temperature

and to obtain:
- reduced emissions, noise abatement and no overload
- better vehicle acceleration

High injection lead is set at start, based on water temperature.
Delivery start feedback is given by injection electro valve impedance variation.

Engine speed limiter

The control unit controls the engine speed at all rev ranges and in particular:
- at idle;
- at top speed.

Engine start
Cylinder 1 step and recognition signal synchronization (flywheel and drive shaft sensors) takes place at first engine turns. Accelerator pedal signal is ignored at start. Star delivery is set exclusively based on water temperature, via a specific map. The center enables the accelerator pedal, when it detects flywheel acceleration and rpm such as to consider the engine as started and no longer drawn by the starter motor.

Cold starting
Pre-post heating is activated when just one of the three sensors (water, air or fuel) registers a temperature lower than 10 °C.
Upon activation of the key contact, the pre-heating warning light turns on the electronic dashboard (cluster display) and remains on for a variable amount of time depending on the temperature (while the heating element at the intake manifold heats the air), then it flashes. It is now possible to start up the engine.
When the engine is running, the warning lamp goes out but the heater element continues working for a certain (variable) period of time for post-heating.
If, with the warning lamp blinking, the engine is not started within 20÷25 seconds (absence time) the operation is cancelled in order not to discharge the batteries.
The pre-heating curve is also variable in relation to the battery voltage.

Warm starting
When the ignition key is inserted and the reference temperature exceeds 10 °C, a warning light turns on for approximately 2 seconds as a short test, then goes out. It is now possible to start up the engine.

Run Up
When the ignition key is inserted, the center transfers data stored at previous engine stop to the main memory (Cf. After run), and diagnoses the system.

After Run
At each engine stop with the ignition key, the center still remains fed by the main relay for a few seconds, to enable the microprocessor to transfer some data from the main volatile memory to an non-volatile, cancelable and rewritable (Eeprom) memory to make tem available for the next start (Cf. Run Up).
These data essentially consists of:
- miscellaneous settings, such as engine idling and the like
- settings of some components
- breakdown memory

The process lasts for some seconds, typically from 2 to 60 according to the amount of data to be stored, after which the ECU sends a command to the main relay and makes it disconnect from the battery.

NOTE This procedure must never be interrupted, by cutting the engine off from the battery cutout or disconnecting the latter before 60 seconds at least after engine cutout.

In this case, system operation is guaranteed until the fifth improper engine cutout, after which an error is stored in the breakdown memory and the engine operates at lower performance at next start while the EDC warning light stays on.
Repeated procedure interruptions could in fact lead to center damage.

Cut-off
It refers to the supply cut-off function during deceleration.

Cylinder Balancing
Individual cylinder balancing contributes to increasing comfort and operability.
This function enables individual personalized fuel delivery control and delivery start for each cylinder, even differently between each cylinder, to compensate for injector hydraulic tolerances.
The flow (rating feature) differences between the various injectors cannot be evaluated directly by the control unit. This information is provided by the entry of the codes for every single injector, by means of the diagnosis instrument.

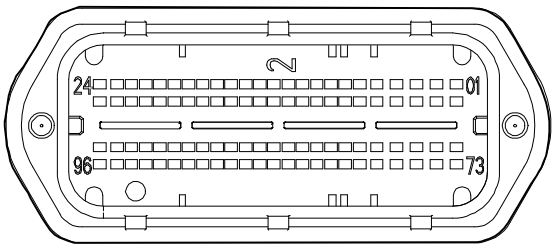
Synchronisation Search
If the camshaft sensor signal fails, the control unit can still recognise the cylinders into which fuel is to be injected.
If this takes place when the engine is already running, the fuel flow is already acquired as a result of which the ECU continues with the sequence already synchronized.
If this occurs when the engine is off, the control unit energises a single solenoid valve. At the latest by the 2nd engine shaft revolution, an injection will occur in that cylinder, for which the central unit only has to synchronise itself on the combustion sequence and start the engine.

Pin out EDC 17CV41 control unit - Engine side connector "2"

Figure 3

Colour legend

C	ORANGE
A	SKY BLUE
B	WHITE
L	BLUE
G	YELLOW
H	GREY
M	BROWN
N	BLACK
W	LIGHT BROWN
S	PINK
R	RED
V	GREEN
Z	PURPLE



189005

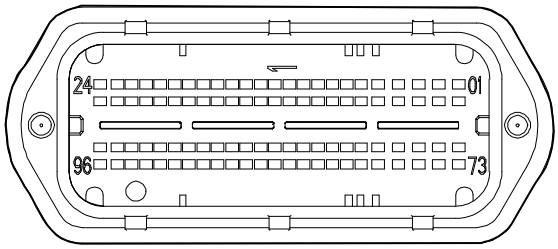
Pin	Cable colour	Signal	Component
01	C	O_P_SVL21	Injector 1 "low", Bank 2, Cylinder 5
02	GN	O_P_SVL22	Injector 2 "low", Bank 2, Cylinder 6
03	N	O_P_SVL23	Injector 3 "low", Bank 2, Cylinder 4
04	-	-	Free
05	-	-	Free
06	Z	G_R_DF03	Engine oil pressure and temperature sensor: ground for frequency input 3
07	BN	V_V_5VSS1A	Boost pressure and air temperature sensor: supply +5V
08	-	-	Free
09	-	-	Free
10	-	-	Free
11	HB	V_V_5VSS3B	Rail pressure sensor: supply +5V
12	C	I_A_AN18	Fuel temperature sensor: NTC temperature signal
13	BC	I_A_AN15	Engine oil pressure and temperature sensor: NTC temperature signal
14	-	-	Free
15	-	-	Free
16	-	-	Free
17	LV	B_D_CANH2	Motorised throttle valve actuator connector (Exhaust flap): Controller Area Network 2 high (CAN H)
18	BV	B_D_CANL2	Motorised throttle valve actuator connector (Exhaust flap): Controller Area Network 2 low (CAN L)
19	-	-	Free
20	-	-	Free
21	-	-	Free
22	-	-	Free
23	-	-	Free
24	-	-	Free
25	Z	O_P_SVH21	Injector 1 "high", Bank 2, Cylinder 5
26	GR	O_P_SVH22	Injector 2 "high", Bank 2, Cylinder 6
27	M	O_P_SVH23	Injector 3 "high", Bank 2, Cylinder 4
28	-	-	Free
29	-	-	Free
30	-	-	Free

Pin	Cable colour	Signal	Component
31	R	V_V_5VSS1F	Engine oil pressure and temperature sensor: supply +5V
32	-	-	Free
33	-	-	Free
34	-	-	Free
35	V	I_A_AN01	Engine oil pressure and temperature sensor: pressure signal
36	HR	I_A_RAILPS	Rail pressure sensor: pressure signal
37	LG	I_A_AN16	Boost pressure and air temperature sensor: NTC temperature signal
38	-	-	Free
39	G	I_A_AN17	Coolant temperature sensor: NTC temperature signal
40	-	-	Free
41	-	-	Free
42	-	-	Free
43	-	-	Free
44	-	-	Free
45	-	-	Free
46	-	-	Free
47	-	-	Free
48	-	-	Free
49	L	O_P_SVH11	Injector 1 "high", Bank 1, Cylinder 1
50	V	O_P_SVH12	Injector 2 "high", Bank 1, Cylinder 3
51	H	O_P_SVH13	Injector 3 "high", Bank 1, Cylinder 2
52	-	-	Free
53	-	-	Free
54	-	-	Free
55	-	-	Free
56	-	-	Free
57	-	-	Free
58	GV	O_V_MEU	Fuel high pressure pump metering unit: supply
59	H - B	G_R_AN18	Fuel/coolant temperature sensor: common ground analog input 18
60	HV	G_R_RAILPS	Rail pressure sensor: ground
61	-	-	Free
62	-	-	Free
63	-	-	Free
64	-	-	Free
65	N	G_R_CRS	Crankshaft rpm increment speed sensor: signal negative
66	B	I_F_CRS	Crankshaft rpm increment speed sensor: signal positive
67	N	G_R_CAS	Camshaft timing segment speed sensor: signal negative
68	B	I_F_CAS	Camshaft timing segment speed sensor: signal positive
69	H	G_R_GN--	-
70	-	-	Free
71	-	-	Free
72	-	-	Free
73	B	O_P_SVL11	Injector 1 "low", Bank 1, Cylinder 1
74	R	O_P_SVL12	Injector 2 "low", Bank 1, Cylinder 3
75	G	O_P_SVL13	Injector 3 "low", Bank 1, Cylinder 2
76	-	-	Free
77	-	-	Free
78	-	-	Free
79	-	-	Free
80	-	-	Free

Pin	Cable colour	Signal	Component
81	-	-	Free
82	-	-	Free
83	GN	O_T_MEU	Fuel high pressure pump metering unit:
84	-	-	Free
85	-	-	Free
86	RG	I_A_AN05	Boost pressure and air temperature sensor: pressure signal
87	-	-	Free
88	-	-	Free
89	-	-	Free
90	BV	G_R_AN05	Boost pressure and air temperature sensor: ground analog input 5
91	-	-	Free
92	-	-	Free
93	-	-	Free
94	-	-	Free
95	-	-	Free
96	-	-	Free

Pin out EDC 17CV41 control unit - Vehicle side connector "1" (TwoBox layout)

Figure 4



189004

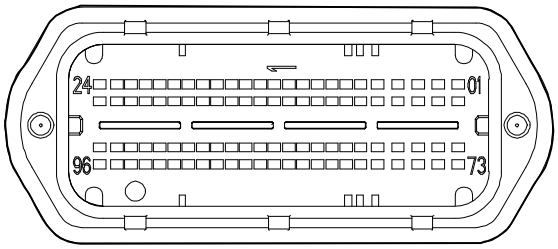
Pin	Signal	Component
01	V_V_BAT +4	Battery plus 4
02	O_T_RL 11	SCR heater
03	G_G_BAT -1	Battery minus 1
04	O_T_RL 14	SCR hose suction line heater
05	G_G_BAT -4	Battery minus 4
06	-	Free
07	I_A_AN 23	SCR pressure sensor
08	I_A_AN 25	SCR temperature sensor
09	I_A_AN 22	Catalyst downstream temperature sensor
10	G_R_AN 10	Common ground
11	-	Free
12	-	Free
13	I_S_DIG 01	Water in fuel switch
14	-	Free
15	I_A_AN 04	Humidity sensor
16	I_A_AN 13	Exhaust gas temperature upstream sensor
17	-	Free
18	-	Free
19	O_S_RH 04	Starter relay
20	O_T_RH 03	ATS intelligent sensors Auxiliary Relay (H)
21	-	Free
22	-	Free
23	O_T_RH 01	DEF Dosing Module
24	-	Free
25	V_V_BAT +3	Battery plus 3
26	V_V_BAT +5	Battery plus 5
27	O_V_RH 31	Common battery plus
28	G_G_BAT -2	Battery minus 2
29	G_G_RL 11	Ground for low side power stage 11
30	-	Free
31	I_A_AN 12	SCR level sensor
32	I_A_AN 24	Catalyst upstream temperature sensor
33	-	Free
34	O_F_ENGN	Engine speed output
35	-	Free
36	-	Free

Pin	Signal	Component
37	-	Free
38	-	Free
39	G_R_AN 12	Common ground
40	I_A_AN 14	Air temperature sensor
41	-	Free
42	-	Free
43	G_R_AN 14	Common ground
44	O_S_RL 24	OBD led
45	O_T_RL 18	ATS intelligent sensors Auxiliary Relay (L)
46	B_D_CANH0	CAN high
47	B_D_CANL0	CAN low
48	-	Free
49	V_V_BAT +2	Battery plus 2
50	O_V_RH 11	Common battery plus
51	G_G_RL 07	Diagnostic LED ground
52	G_G_BAT -5	Battery minus 5
53	-	Free
54	-	Free
55	-	Free
56	-	Free
57	-	Free
58	-	Free
59	-	Free
60	-	Free
61	O_S_RL 20	Fuel filter / pre-filter heating relay
62	-	Free
63	I_S_T 50	Start switch term. 50 input signal
64	-	Free
65	-	Free
66	-	Free
67	-	Free
68	V_V_5VSS1D	Common supply
69	I_S_T 15	KL15
70	B_D_ISOK	ISO-K interface
71	B_D_CANH1	Controller area network 1 (high)
72	O_S_RL 12	SCR Tank Heating Valve
73	V_V_BAT +1	Battery plus 1
74	O_V_RH 21	Common battery plus
75	G_G_BAT -3	Battery minus 3
76	G_G_RL 14	Ground for low side power stage 14
77	O_S_RH 07	Diagnostic LED plus
78	-	Free
79	-	Free
80	-	Free
81	-	Free
82	-	Free
83	O_S_RL 22	Grid heater relay
84	O_T_RL 13	SCR pump motor

Pin	Signal	Component
85	O_T_RL 16	SCR reverting valve
86	-	Free
87	-	Free
88	O_S_RL 21	Low side source driver 21
89	G_G_RL 13	SCR pump motor
90	V_V_5VSS3A	Common supply
91	-	Free
92	-	Free
93	O_S_RL 27	Auxiliary relay / SCR heater relay
94	-	Free
95	B_D_CANL1	Controller area network 1 (low)
96	0_T_RL 10	DEF Dosing Module

Pin out EDC 17CV41 control unit - Vehicle side connector "1" (OneBox layout)

Figure 5



189004

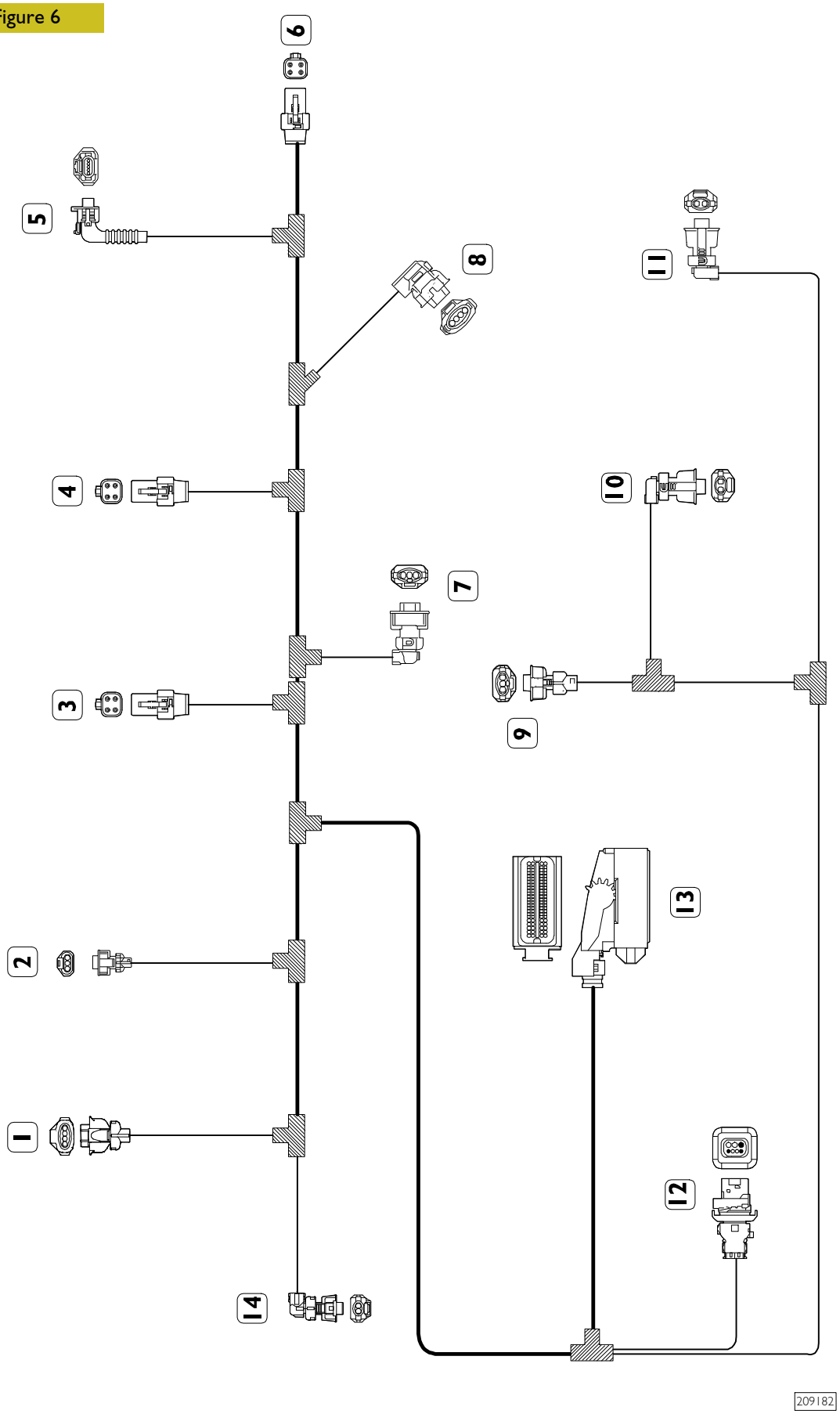
Pin	Signal	Component
01	V_V_BAT +4	Battery plus 4
02	O_T_RL 11	SCR heater
03	G_G_BAT -1	Battery minus 1
04	O_T_RL 14	SCR hose suction line heater
05	G_G_BAT -4	Battery minus 4
06	-	Free
07	I_A_AN 23	SCR pressure sensor
08	I_A_AN 25	SCR temperature sensor
09	I_A_AN 22	Catalyst downstream temperature sensor
10	G_R_AN 10	Common ground
11	-	Free
12	I_S_DIG 05	Redundant brake switch
13	I_S_DIG 01	Water in fuel switch
14	I_S_CRCNEG	Cruise Control/PTO Control (Set -)
15	I_A_AN 04	Humidity sensor
16	I_A_AN 13	Exhaust gas temperature upstream sensor
17	-	Free
18	-	Free
19	O_S_RH 04	Starter relay
20	O_T_RH 03	ATS intelligent sensors Auxiliary Relay (H)
21	-	Free
22	-	Free
23	O_T_RH 01	DEF Dosing Module
24	-	Free
25	V_V_BAT +3	Battery plus 3
26	V_V_BAT +5	Battery plus 5
27	O_V_RH 31	Common battery plus
28	G_G_BAT -2	Battery minus 2
29	G_G_RL 11	Ground for low side power stage 11
30	-	Free
31	I_A_AN 12	SCR level sensor
32	I_A_AN 24	Catalyst upstream temperature sensor
33	-	Free
34	O_F_ENGN	Engine speed output
35	I_S_CRCRES	Cruise Control/PTO Control (Resume)
36	I_S_CRCOFF	Cruise Control/PTO Control (Off)

Pin	Signal	Component
37	I_S_DIG 04	2nd speed limiter switch
38	-	Free
39	G_R_AN 12	Common ground
40	I_A_AN 14	Air temperature sensor
41	I_A_AN 26	Multiple state switch
42	-	Free
43	G_R_AN 14	Common ground
44	O_S_RL 24	OBD led
45	O_T_RL 18	ATS intelligent sensors Auxiliary Relay (L)
46	B_D_CANH0	CAN high
47	B_D_CANL0	CAN low
48	-	Free
49	V_V_BAT +2	Battery plus 2
50	O_V_RH 11	Common battery plus
51	G_G_RL 07	Diagnostic LED ground
52	G_G_BAT -5	Battery minus 5
53	I_F_VSS	Vehicle speed sensor signal
54	G_R_VSS	Vehicle speed sensor ground
55	-	Free
56	-	Free
57	-	Free
58	-	Free
59	-	Free
60	I_S_DIG02	Low idle position switch
61	O_S_RL 20	Fuel filter / pre-filter heating relay
62	-	Free
63	I_S_T 50	Start switch term. 50 input signal
64	-	Free
65	-	Free
66	V_V_5VSS2D	5V sensor supply 2D
67	-	Free
68	V_V_5VSS1D	Common supply
69	I_S_T 15	KL15
70	B_D_ISOK	ISO-K interface
71	B_D_CANH1	Controller area network 1 (high)
72	O_S_RL 12	SCR Tank Heating Valve
73	V_V_BAT +1	Battery plus 1
74	O_V_RH 21	Common battery plus
75	G_G_BAT -3	Battery minus 3
76	G_G_RL 14	Ground for low side power stage 14
77	O_S_RH 07	Diagnostic LED plus
78	-	Free
79	I_A_APP1	Accelerator pedal position sensor 1 signal
80	G_R_APP1	Accelerator pedal position sensor 1 ground
81	I_S_DIG04	Cruise Control/PTO Control (Set +)
82	I_S_DIG012	Brake main switch
83	O_S_RL 22	Grid heater relay
84	O_T_RL 13	SCR pump motor

Pin	Signal	Component
85	O_T_RL 16	SCR reverting valve
86	-	Free
87	-	Free
88	O_S_RL 21	Low side source driver 21
89	G_G_RL 13	SCR pump motor
90	V_V_5VSS3A	Common supply
91	-	Free
92	-	Free
93	O_S_RL 27	Auxiliary relay / SCR heater relay
94	-	Free
95	B_D_CANL1	Controller area network 1 (low)
96	0_T_RL 10	DEF Dosing Module

Engine cable

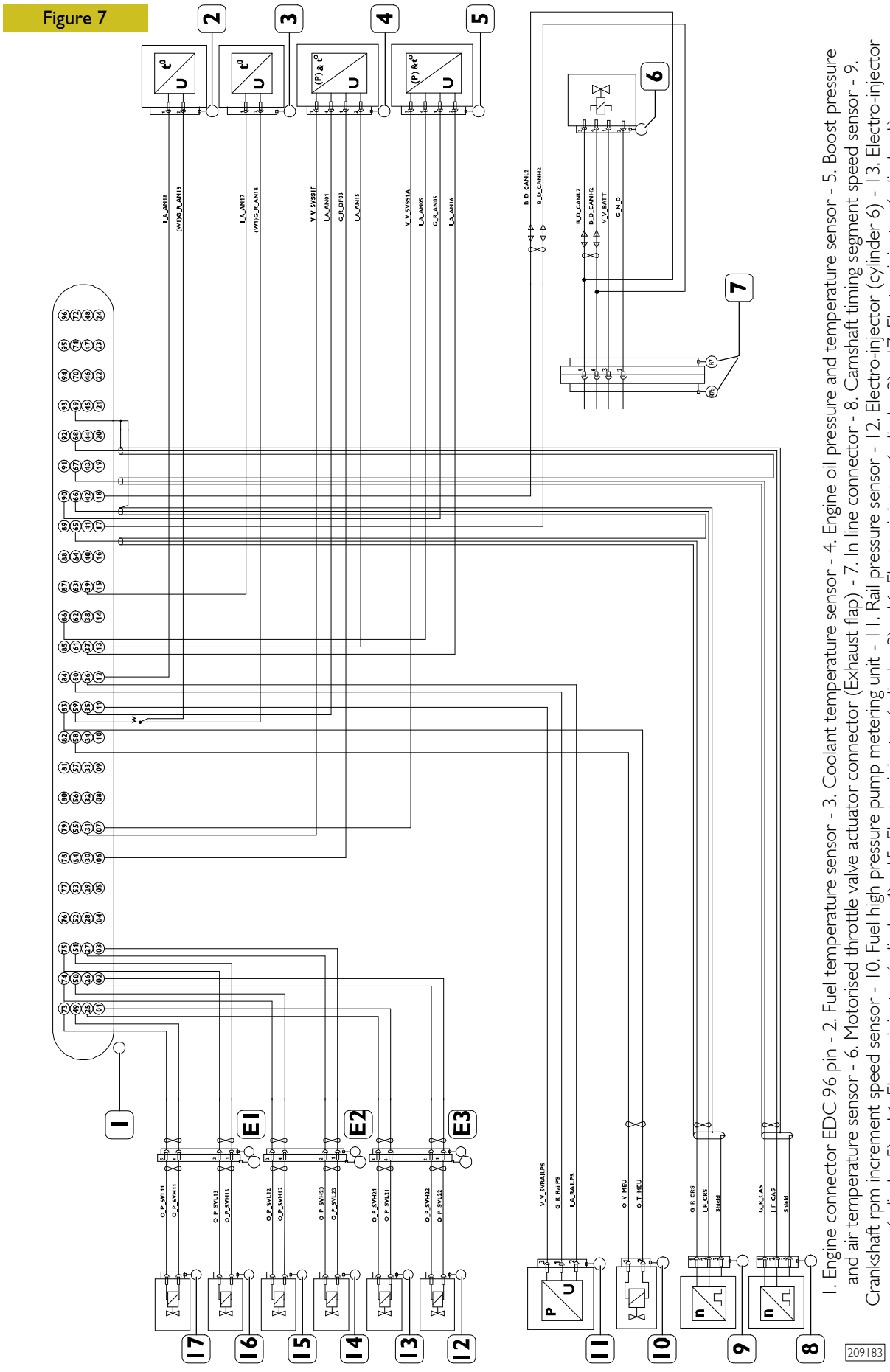
Figure 6



1. Engine oil pressure and temperature sensor - 2. Crankshaft rpm increment speed sensor - 3. Electro-injectors connections (cylinders 1-2) - 4. Electro-injectors connections (cylinders 3-4) - 5. Motorised throttle valve actuator connector (Exhaust flap) - 6. Electro-injectors connections (cylinders 5-6) - 7. Rail pressure sensor - 8. Boost pressure and air temperature sensor - 9. Camshaft timing segment speed sensor - 10. Fuel temperature sensor - 11. Fuel high pressure pump metering unit - 12. In line connector - 13. Engine Control Unit ECU17CV41 - 14. Coolant temperature sensor

Topographical wiring diagram - Engine side

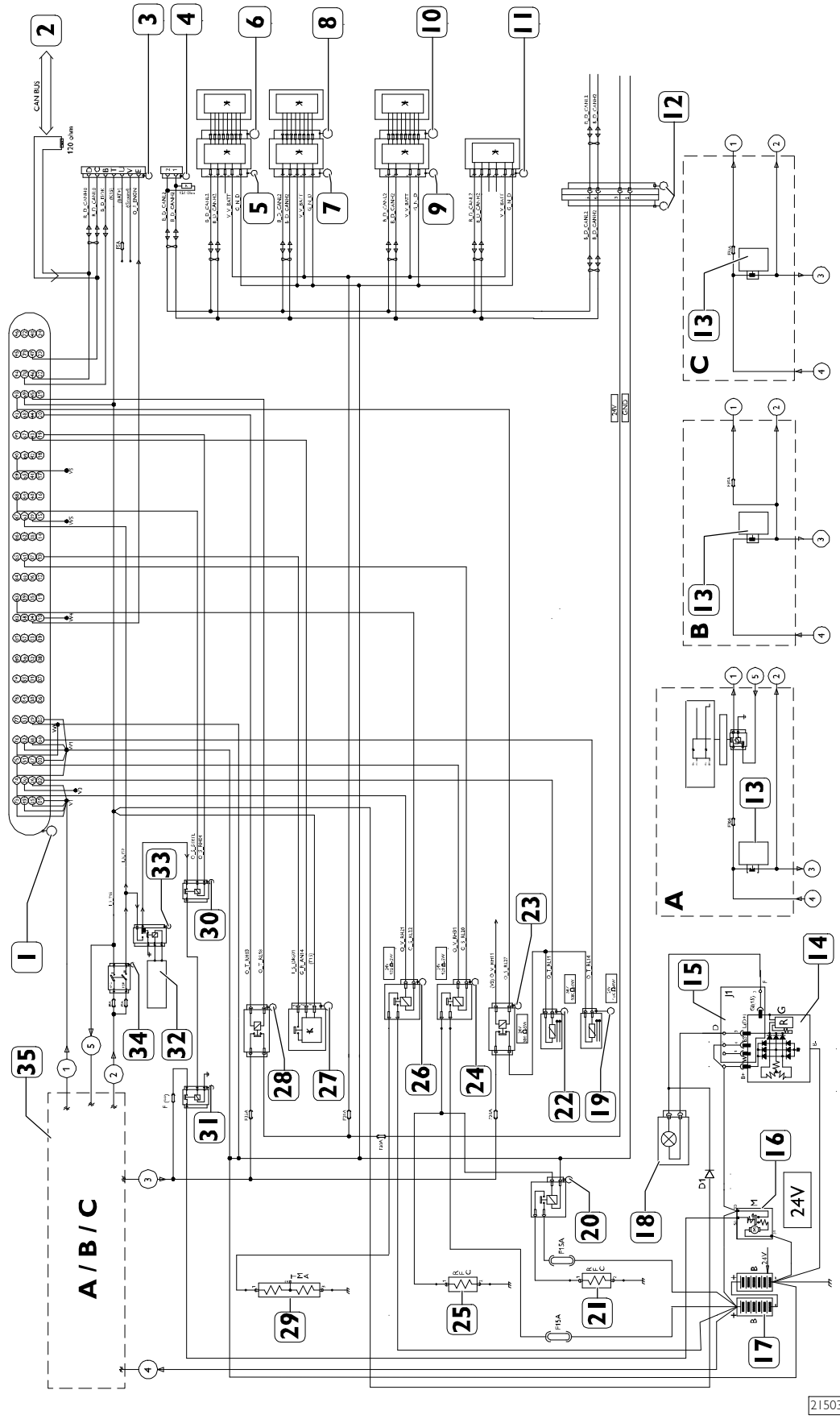
Figure 7



1. Engine connector EDC 96 pin - 2. Fuel temperature sensor - 3. Coolant temperature sensor - 4. Engine oil pressure and temperature sensor - 5. Boost pressure and air temperature sensor - 6. Motorised throttle valve actuator connector (Exhaust flap) - 7. In line connector - 8. Camshaft timing segment speed sensor - 9. Crankshaft rpm increment speed sensor - 10. Fuel high pressure pump metering unit - 11. Rail pressure sensor - 12. Electro-injector (cylinder 6) - 13. Electro-injector (cylinder 5) - 14. Electro-injector (cylinder 4) - 15. Electro-injector (cylinder 3) - 16. Electro-injector (cylinder 2) - 17. Electro-injector (cylinder 1)
E1. Electro-injector connector (cylinder 1-2) - E2. Electro-injector connector (cylinder 3-4) - E3. Electro-injector connector (cylinder 5-6)

EDC 17CV41 control unit wiring diagram - Vehicle side (part 1/2)

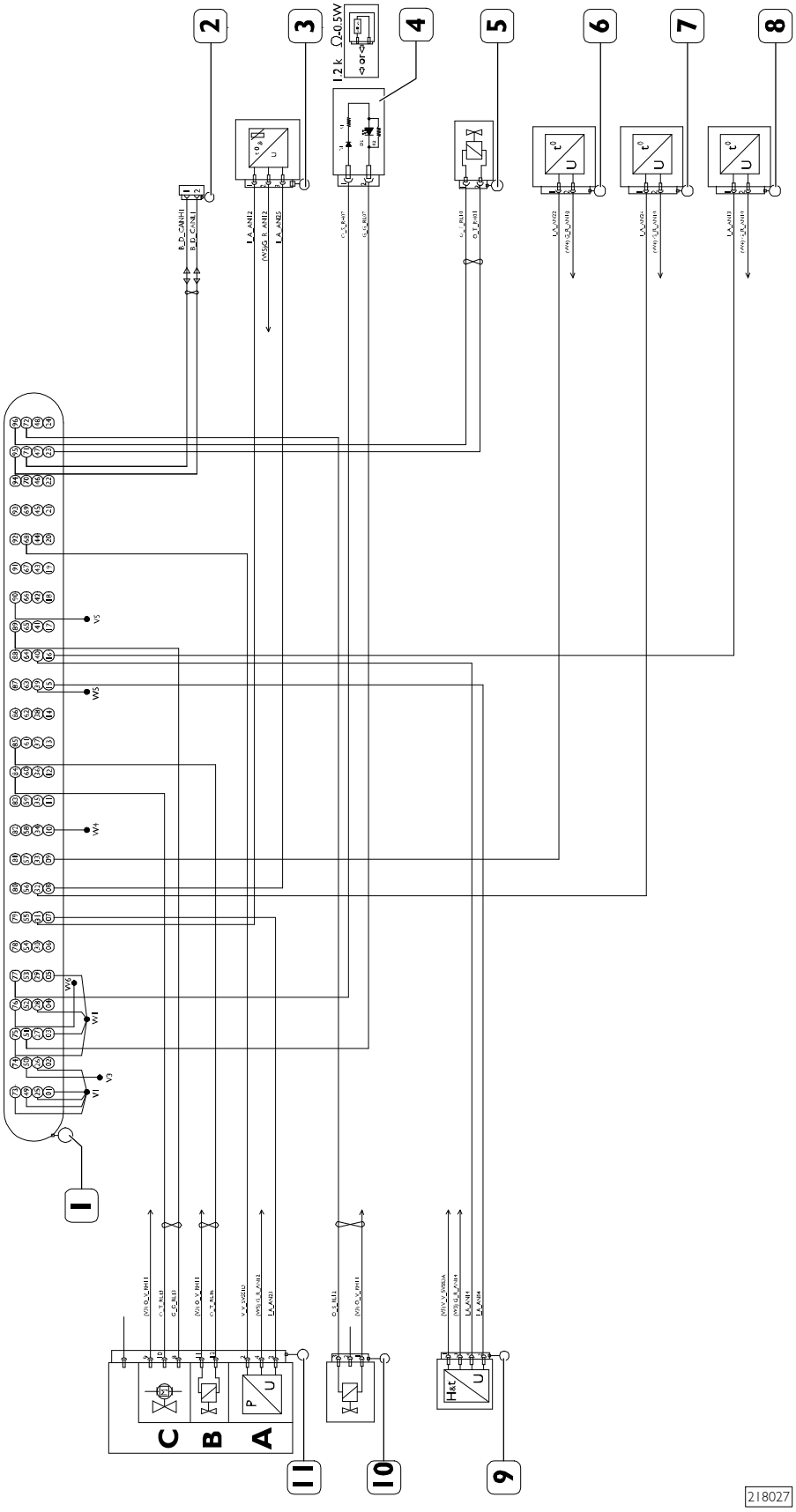
Figure 8



1. Vehicle connector EDC 96 pin - 2. CAN BUS to Customer's application computer - 3. Diagnostic connector - 4. Controller Area Network C - 5. SCR downstream NOx ECU - 6. SCR downstream NOx sensor - 7. DOC upstream NOx ECU - 8. DOC upstream NOx sensor - 9. NH_3 ECU - 10. NH_3 sensor - 11. Urea Quality sensor - 12. In line connector - 13. Battery Disconnection Switch (BDS) - 14. Alternator - 15. Alternator connector kit (J1) - 16. Starter electric motor - 17. Battery - 18. Battery charge warning lamp - 19. SCR hose suction line heater - 20. Fuel pre-filter heater relay - 21. Fuel pre-filter heater - 22. SCR electrical heater - 23. SCR heater relay - 24. Fuel filter/pre-filter heater relay - 25. Fuel filter heater - 26. Grid-heater relay - 27. Water in fuel switch - 28. ATS intelligent sensors auxiliary relay - 29. Grid-heater - 30. Starter control relay - 31. Starter relay - 32. Body controller starter interlock (Vehicle safety) - 33. Body controller starter interlock relay - 34. Key switch - 35. Alternative connections (A. ECU under time relay - B. ECU under BDS - C. ECU not under BDS)

EDC 17CV41 control unit wiring diagram - Vehicle side (part 2/2) - TwoBox layout

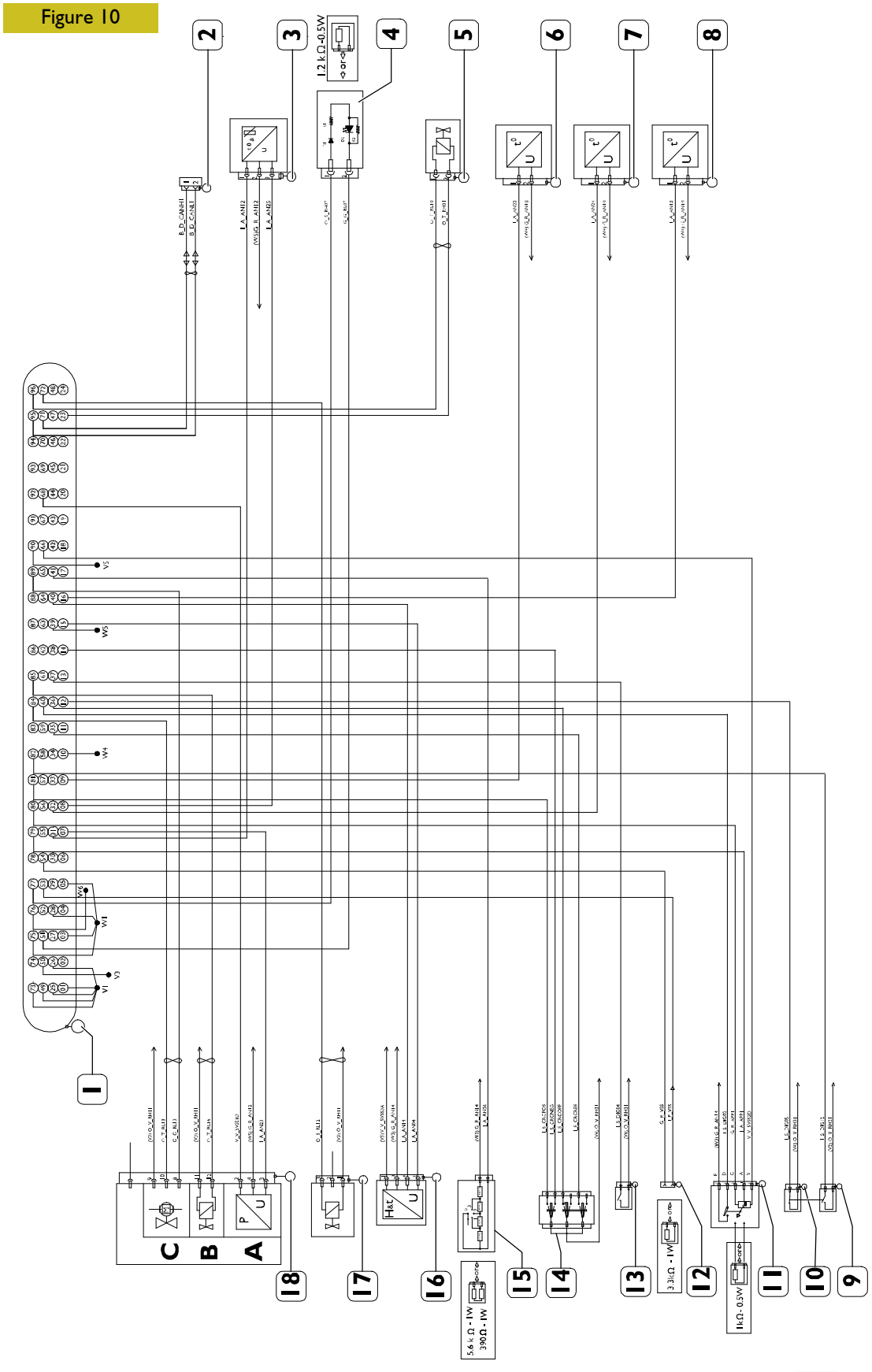
Figure 9



1. Vehicle connector EDC 96 pin - 2. Controller Area Network B - 3. SCR tank level and temperature sensor - 4. Diagnostic LED - 5. DEF dosing module - 6. SCR downstream exhaust gas temperature sensor - 7. SCR upstream exhaust gas temperature sensor - 8. DOC upstream exhaust gas temperature sensor - 9. Humidity and ambient temperature sensor - 10. SCR tank heating valve - 11. SCR Pump module (A. SCR pressure sensor - B. SCR reverting valve - C. SCR pump motor)

EDC 17CV41 control unit wiring diagram - Vehicle side (part 2/2) - OneBox layout

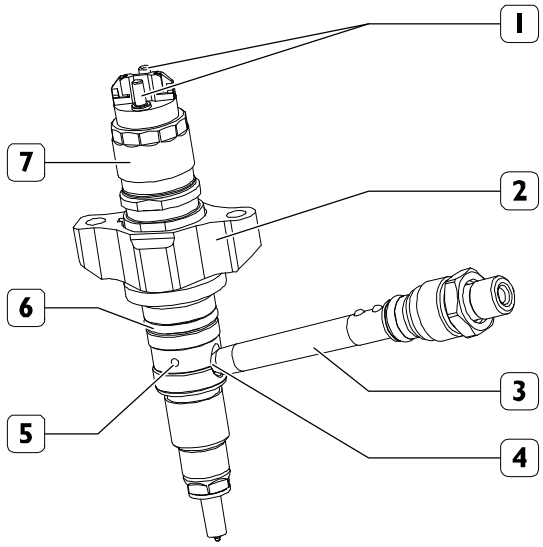
Figure 10



1. Vehicle connector EDC 96 pin - 2. Controller Area Network B - 3. SCR tank level and temperature sensor - 4. Diagnostic LED - 5. DEF dosing module - 6. SCR downstream exhaust gas temperature sensor - 7. SCR upstream exhaust gas temperature sensor - 8. DOC upstream exhaust gas temperature sensor - 9. Brake main switch - 10. Redundant brake switch - 11. Accelerator pedal position sensor - 12. Vehicle speed signal - 13. 2nd speed limiter switch - 14. Cruise Control / PTO Control - 15. Multiple state switch (Resistor module) - 16. Humidity and ambient temperature sensor - 17. SCR tank heating valve - 18. SCR Pump module (A. SCR pressure sensor - B. SCR reverting valve - C. SCR pump motor)

Electroinjectors

Figure 11



182250

1. Coils for connection to engine cable - 2. Head anchorage bracket - 3. Fuel intake manifold - 4. High pressure fuel input - 5. Low pressure residual fuel output - 6. Gasket - 7. Injector.

It is a N.O. solenoid valve.

They are connected to the EDC ECU on connector A.

The electroinjector can be considered as consisting of 2 parts:

- ❑ actuator - atomizer including pressure rod, needle and nozzle;
- ❑ control solenoid valve including coil and pilot valve.

The solenoid valve controls atomizer needle lift.

INJECTION START

When coil is energized, lock pin moves upward.

The control volume fuel flows to return duct causing control volume pressure drop.

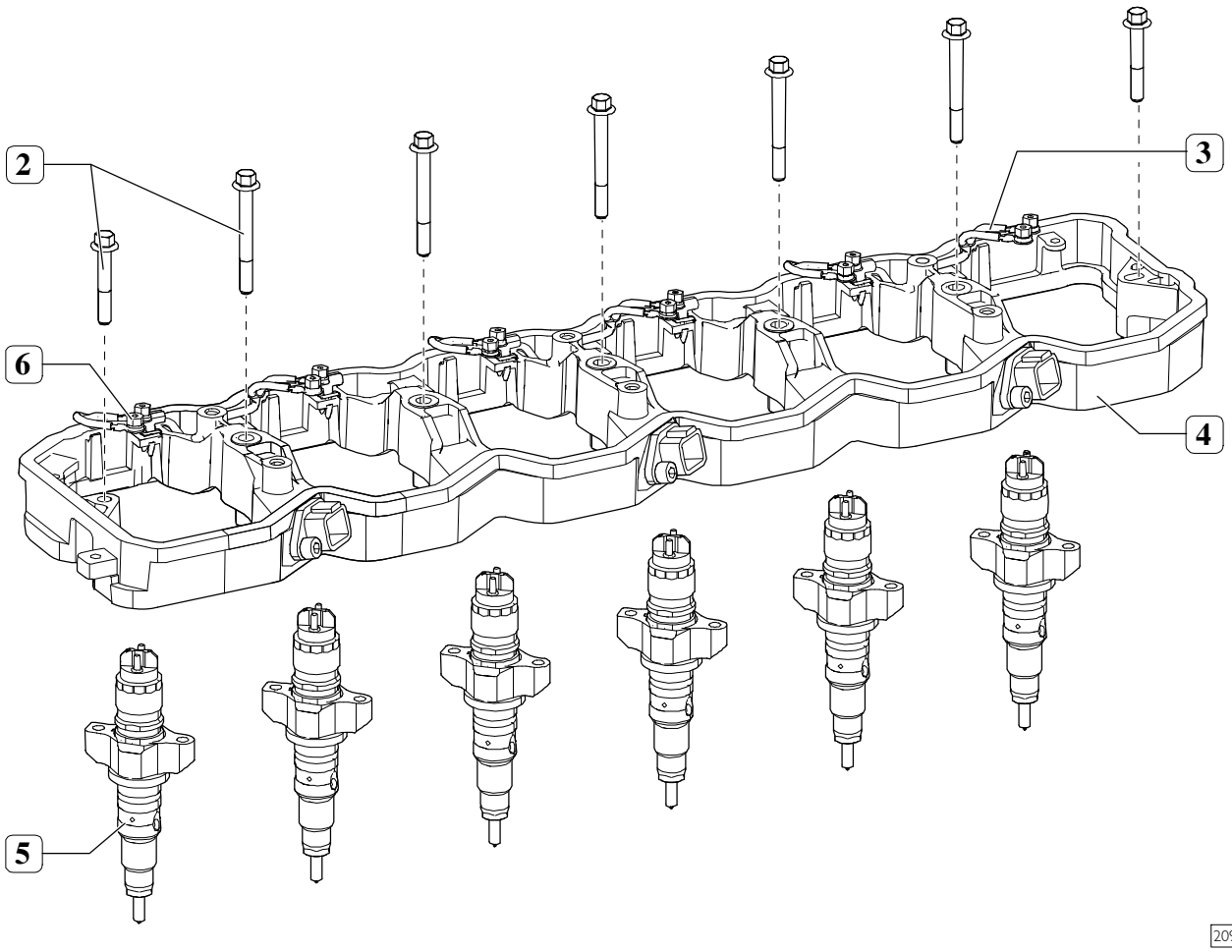
At the same time, fuel pressure in pressure chamber causes needle uplift and therefore fuel injection in cylinder.

END OF INJECTION

When coil is de-energized, lock pin returns to lock position to look for a force balance such to return to needle close position and stop injection.

Ref.		Description	ECU pin
CONNECTOR E1	1	Injector 3 "high", Bank 1, Cylinder 2	51A
	2	Injector 3 "low", Bank 1, Cylinder 2	75A
	3	Injector 1 "low", Bank 1, Cylinder 1	73A
	4	Injector 1 "high", Bank 1, Cylinder 1	49A
CONNECTOR E2	1	Injector 3 "low", Bank 2, Cylinder 4	03A
	2	Injector 3 "high", Bank 2, Cylinder 4	27A
	3	Injector 2 "low", Bank 1, Cylinder 3	74A
	4	Injector 2 "high", Bank 1, Cylinder 3	50A
CONNECTOR E3	1	Injector 2 "low", Bank 2, Cylinder 6	02A
	2	Injector 2 "high", Bank 2, Cylinder 6	26A
	3	Injector 1 "high", Bank 2, Cylinder 5	25A
	4	Injector 1 "low", Bank 2, Cylinder 5	01A

Figure 12

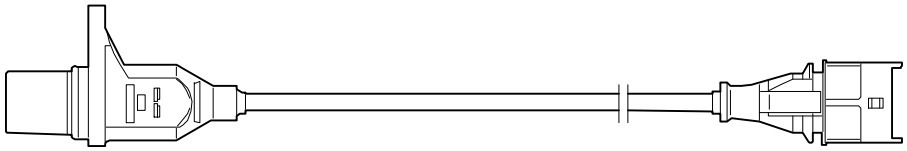


1. Screws fastening wiring support - 2. Electro-injector wiring - 3. Wiring support - 4. Electro-injectors - 5. Nuts fastening wiring on each electro-injector

Camshaft timing segment speed sensor

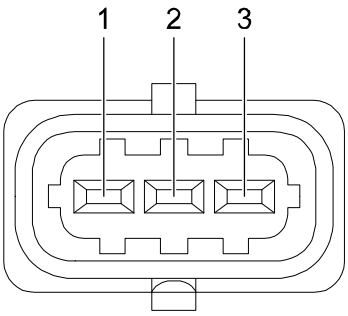
The timing sensor generates signals obtained from a magnetic flux field closing through the holes in the timing gear on the camshaft.
The signal generated by this sensor is utilized by the electronic control unit as an injection phase signal.
Although it is similar to the flywheel sensor, these two devices are NOT interchangeable because of the different external shape.
The timing sensor is connected to the control unit on pins 67A - 68A. The sensor impedance is ~900 Ω.

Figure 13



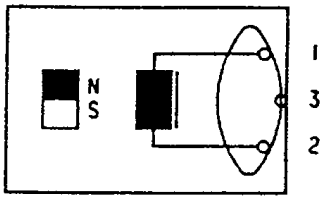
209186

Figure 14



183652

Connector



50288

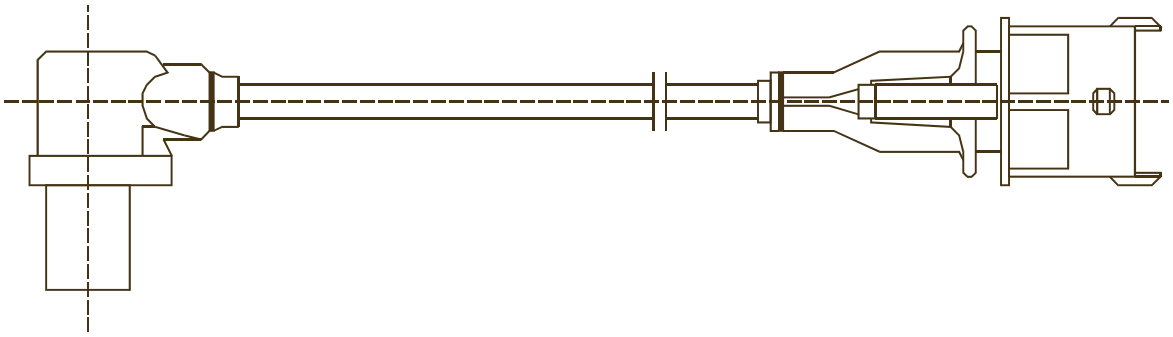
Wiring diagram

Ref.	Description	ECU Pin
1	Ground	67A
2	NTC	68A
3	Shield	69A

Crankshaft rpm increment speed sensor

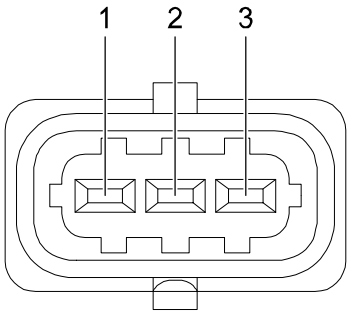
The crankshaft sensor produces signals obtained from a magnetic flux field closing through the openings in a phonic wheel fitted on the crankshaft.
The crankshaft sensor is connected to the control unit on pins 65A - 66A. The sensor impedance is ~900 Ω.

Figure 15



50319

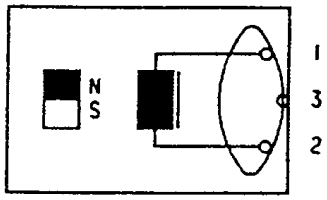
Figure 16



183652

Connector

Figure 17



50288

Wiring diagram

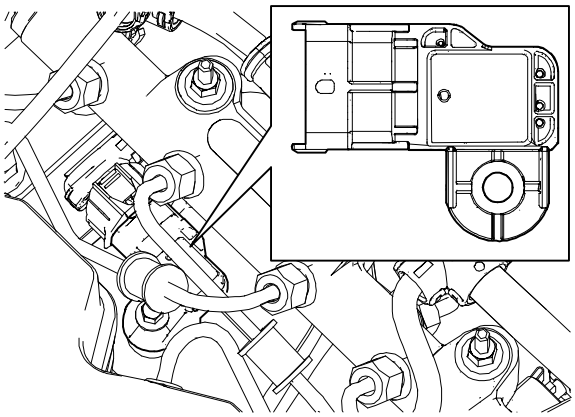
Ref.	Description	ECU Pin
1	Ground	65A
2	NTC	66A
3	Shield	69A

Boost pressure and air temperature sensor

This component incorporates a temperature sensor and a pressure sensor.
Mounted on the intake manifold, the sensor measures the maximum flow rate of air supplied, which serves to make an accurate calculation of the quantity of fuel to be injected in each cycle.
The sensor is connected to the control unit on pins 90A - 37A - 07A - 86A.
The power supply is 5 Volt
Voltage at the sensor output is proportional to the detected pressure or temperature.

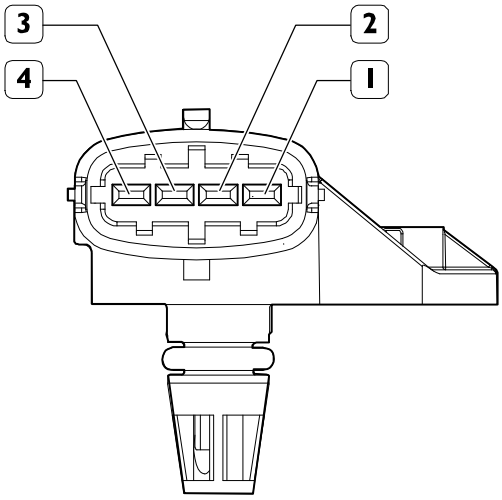
Pin 37A Temperature signal
Pin 86A Pressure signal

Figure 18



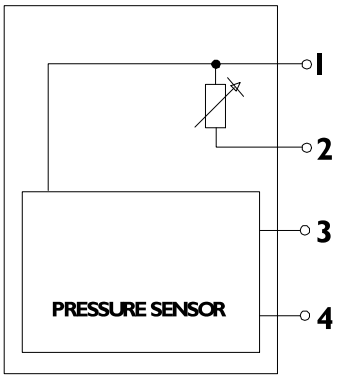
209195

Figure 19



213601

Figure 20



190518

Wiring diagram

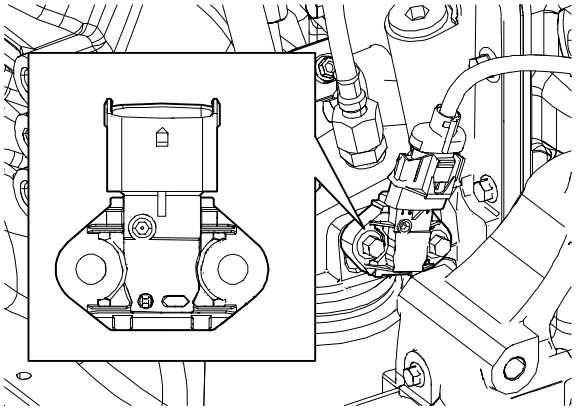
Ref.	Description	ECU Pin
1	Ground	90A
2	NTC signal (temperature)	37A
3	+5 V power input	07A
4	Signal (pressure)	86A

Engine oil pressure and temperature sensor

The engine oil temperature-pressure sensor is installed on the engine oil filter support in a vertical position.
This sensor measures the engine oil temperature and pressure.
The sensor is connected to the control unit on pins 06A - 13A - 31A - 35A.
The sensor is supplied with 5 Volts. The signal detected is transmitted to the EDC control unit which, in turn, controls the relative device on the instrument panel (gauge + low pressure warning light).
The oil temperature is not displayed on any gauges - this value is used exclusively by the control unit.

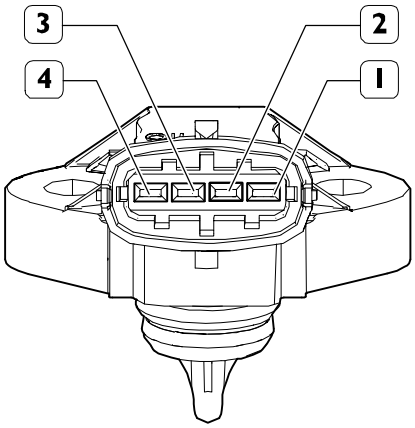
Pin 13A Temperature signal
Pin 35A Pressure signal

Figure 21



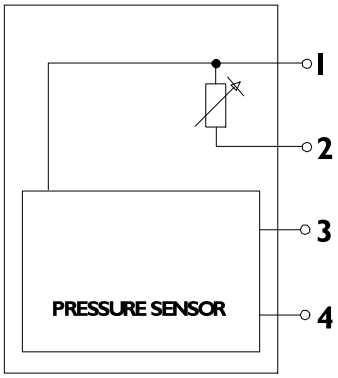
209196

Figure 22



213602

Figure 23



190518

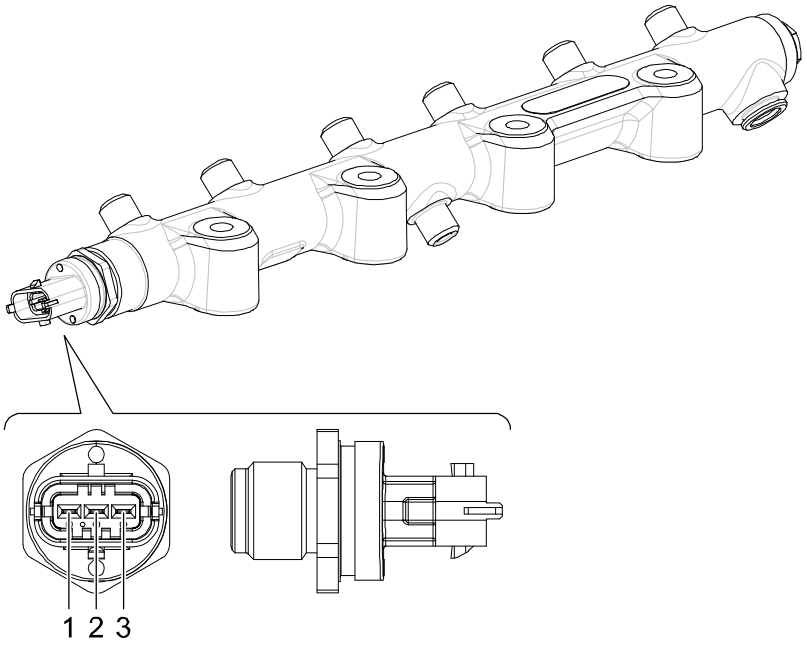
Wiring diagram

Ref.	Description	ECU Pin
1	Ground	06A
2	NTC signal (temperature)	13A
3	+5 V power input	31A
4	Signal (pressure)	35A

Rail pressure sensor

Mounted on one end of the rail, this sensor measures the internal fuel pressure and informs the control unit of the value (feedback). The injection pressure value is used as a pressure control feedback signal and to determine the duration of the electrical injection command.
This sensor is connected to the control unit on pins 60A - 36A - 11A.
The power supply is 5 Volt.

Figure 24



183654

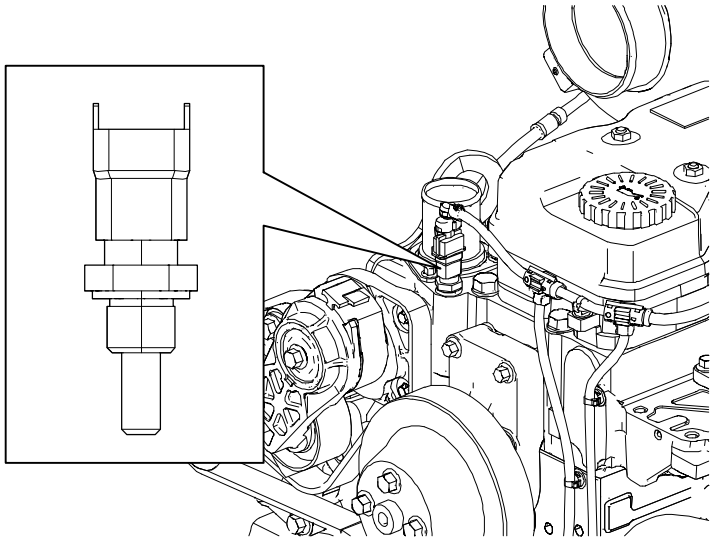
Fuel pressure sensor connector

Ref.	Description	ECU pin
1	Ground	60A
2	Signal	36A
3	Power supply	11A

Coolant temperature sensor

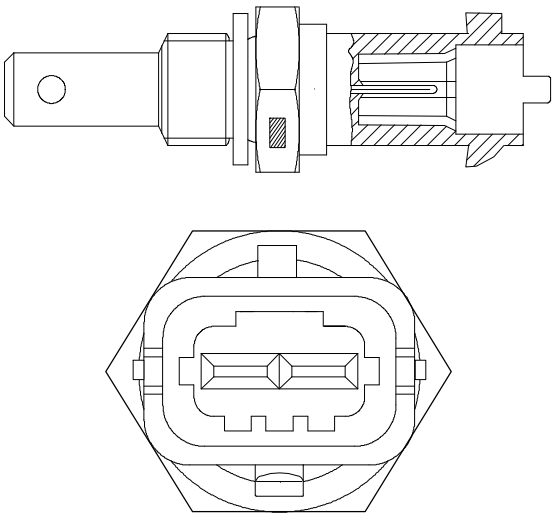
It is a N.T.C. sensor located on the head water output manifold on the engine left side.
It determines the coolant temperature for the various control logics of operation of the engine when hot or cold and identifies the need to enrich the mixture when the engine is cold or reduce fuel injection when it is hot.
This sensor is connected to the control unit on pins 39A - 59A.
The impedance of the coolant temperature sensor at 20 °C is approximately 2.50 **Ω**.

Figure 25



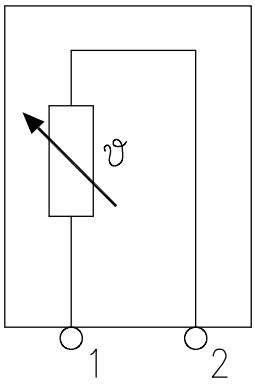
215014

Figure 26



213603

Figure 27



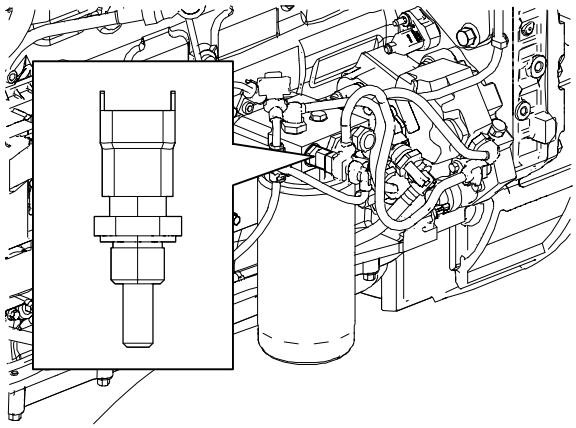
107798

Ref.	Description	ECU Pin
1	Ground	39A
2	NTC signal (temperature)	59A

Fuel temperature sensor

This sensor is identical to the coolant temperature sensor.
It detects the fuel temperature thus enabling the ECU to determine the fuel density and volume and adjust the delivery.
The fuel temperature sensor is connected to the control unit on pins 12A - 59A.
The sensor impedance at 20 °C is approximately 2.50 Ω.

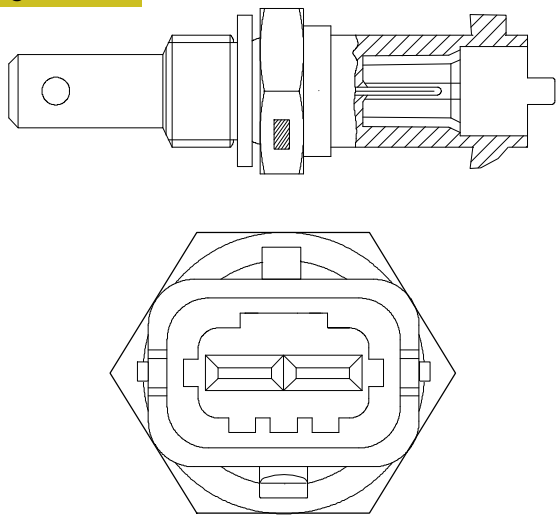
Figure 28



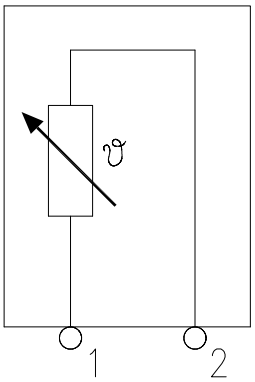
209197

The ECU drives the filter heater contactor at fuel temperature ≤ 5 °C.

Figure 29



213603



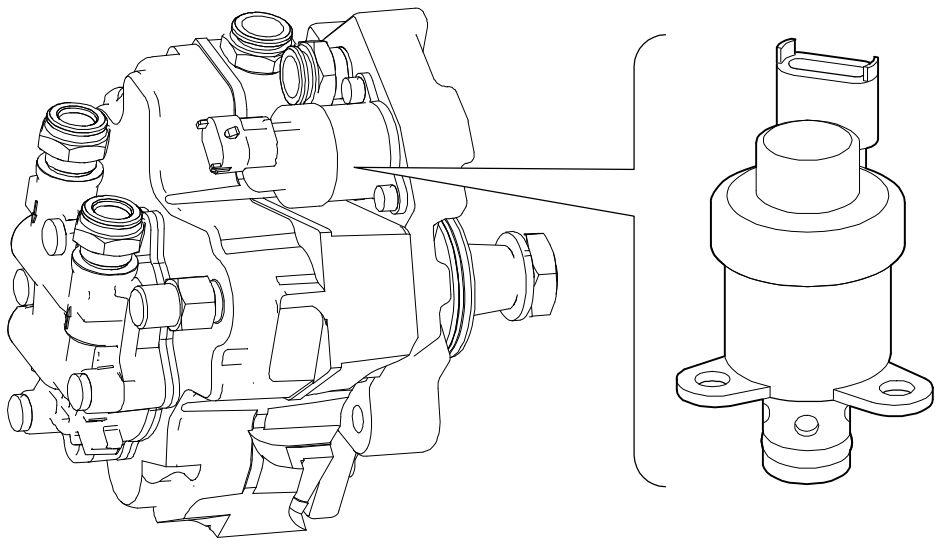
107798

Connector

Ref.	Description	ECU Pin
1	Ground	12A
2	NTC signal (temperature)	59A

Fuel high pressure pump metering unit

Figure 30



183657

The flow rate regulator is located at the inlet of the high-pressure pump on the low-pressure circuit; its function is to modulate the quantity of fuel to feed to the high-pressure pump on the basis of commands received from the electronic control unit.

It basically consists of the following parts:

- ❑ trapezoidal section shutter;
- ❑ valve control pin;
- ❑ pre-charging spring;
- ❑ coils.

In the absence of the control signal, the flow rate regulator is normally open, and hence the high pressure pump is in its maximum delivery conditions.

The control unit modulates a PWM control signal which reduces, to a greater or lesser extent, the section carrying the fuel to the high pressure pump.

This component cannot be replaced individually and hence it cannot be taken down.

The quantity of fuel supplied to the high pressure pump is metered by the flow rate regulator on the low pressure system; the flow rate regulator is managed by the control unit.

Delivery pressure to the rail is modulated between 250 and 1600 bar by the electronic control unit by controlling the flow rate regulator solenoid valve.

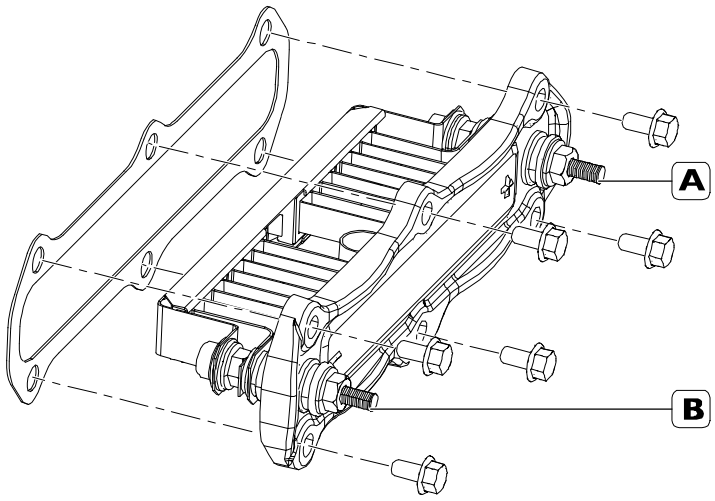
- ❑ This component is a N.O. solenoid valve.
- ❑ The solenoid is connected to the control unit on pin 58A - 83A.
- ❑ The solenoid valve impedance is approximately 3.2 Ω.

Ref.	Description	ECU Pin
1	Ground	58A
2	Signal	83A

Pre-heating resistor (Grid-heater)

The pre-post heating resistance is located on the intake manifold.
The resistance serves to heat the air in pre / post heating operations. This resistance is powered by a contactor.
The resistance impedance is approximately 0.5 Ω.

Figure 31



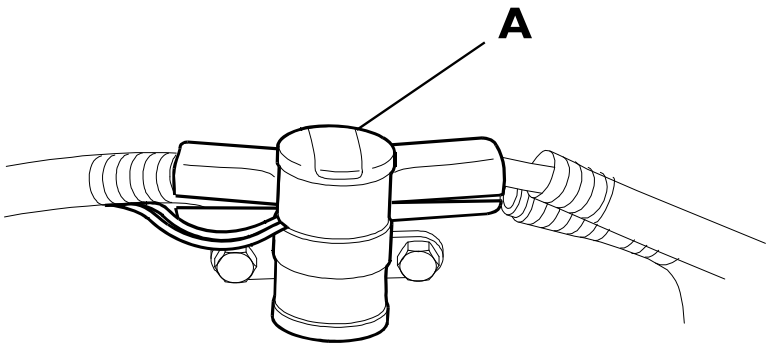
201031

A. - B. Connection terminals

Grid-heater performances

2,4 kW @ 24 V
isolated ground
controlled by the Engine Control Unit ECU17CV41
installed into the intake manifold

Figure 32



002371t

A. Control contactor

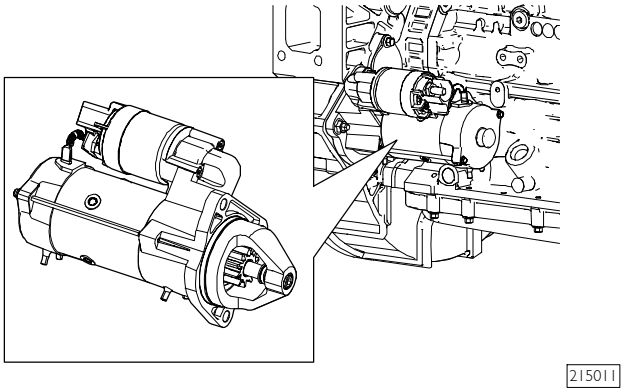
The control contactor is connected to the control unit B connector.
The contactor is tripped with water and/or fuel temperature below 5 °C.
The contactor impedance is approximately 15 Ω.

Do not use flammable gases or liquids to provoke the engine ignition.

These substances in contact with the resistance could easily become inflamed creating situations of serious danger.

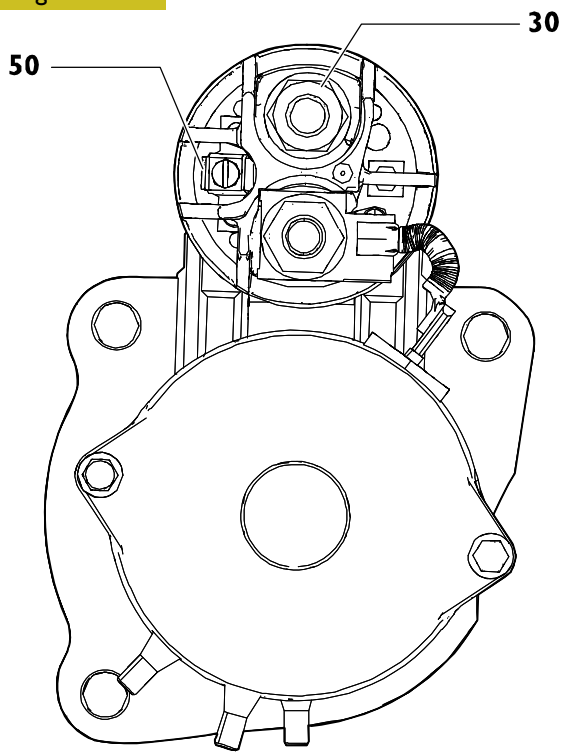
Electric starter motor

Figure 33



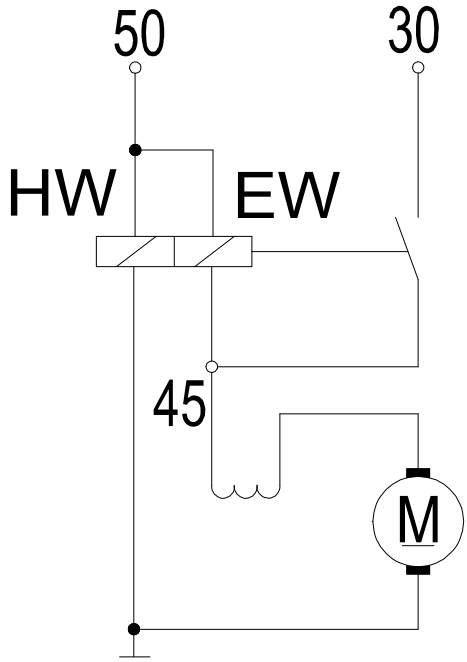
215011

Figure 34



215012

Figure 35



165899

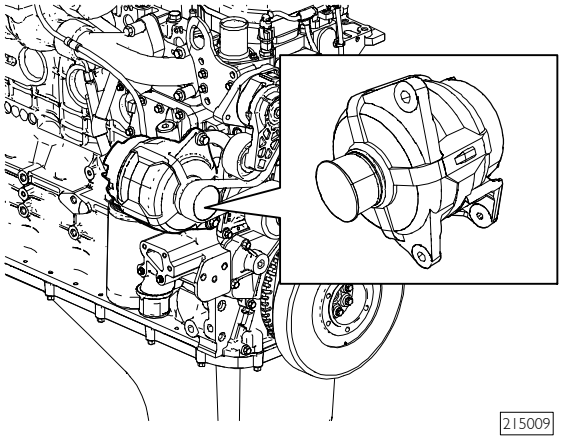
The starter motor runs the engine, gaining its inertia and friction, and bringing it to a certain number of revolutions such as to initiate the formation of the mixture required for combustion and then the autonomous movement of the engine.
The movement is transmitted by a DC electric motor, powered by the battery, via an engagement pinion which rotates the sprocket formed on the engine flywheel.
Due to a free wheel engagement, the pinion turns off when the main engine rotates faster than the starter motor.
A relay energized by the current of the starter motor engages the pinion by means of a fork.
The starter motor included is a translation type and starts by means of the pinion, with relay housed directly above the starter motor.
Ignition is usually controlled via the ignition switch on the control panel and provides a positive voltage to the relay located on the starter motor.

Specifications:

Type:	BOSCH HX87-M
Nominal voltage:	24 V
Nominal rated power:	4 kW
Number of poles:	4
Direction of rotation:	clockwise (seen from flywheel side)
Battery capacity:	min. 44 Ah - Max. 110 Ah
Discharge current (EN 50342):	min. 357 A - Max. 765 A

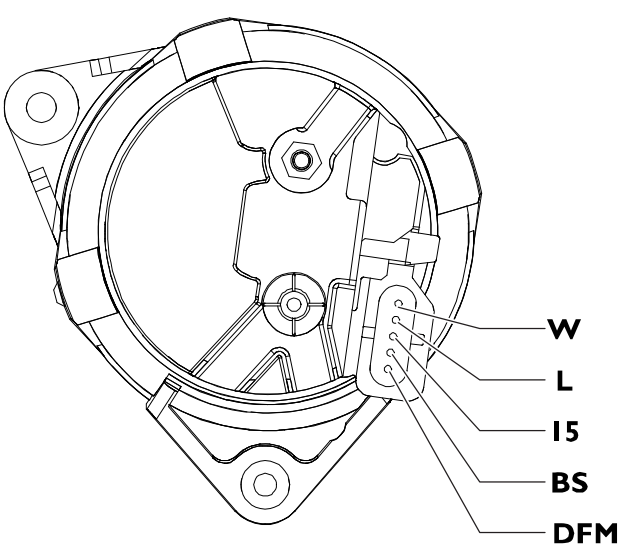
Alternator

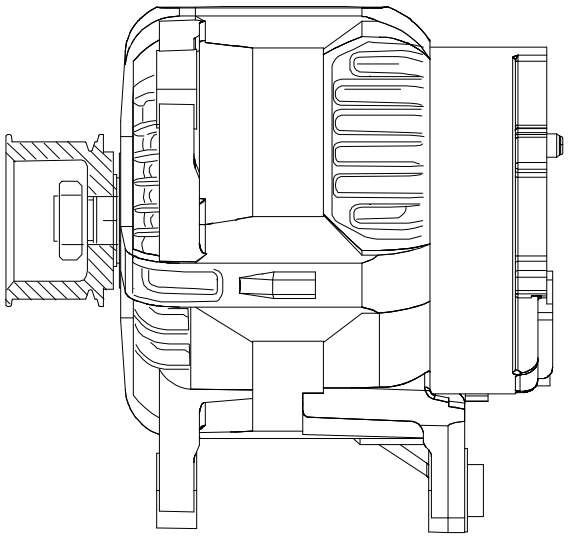
Figure 36



215009

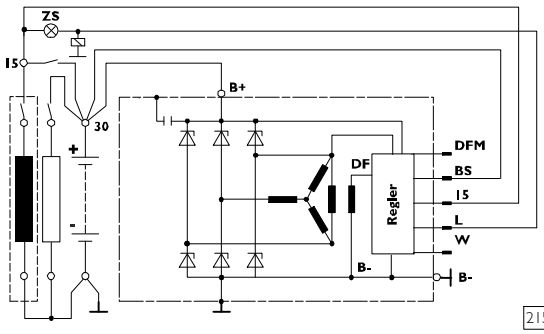
Figure 37





215010

Figure 38



215008

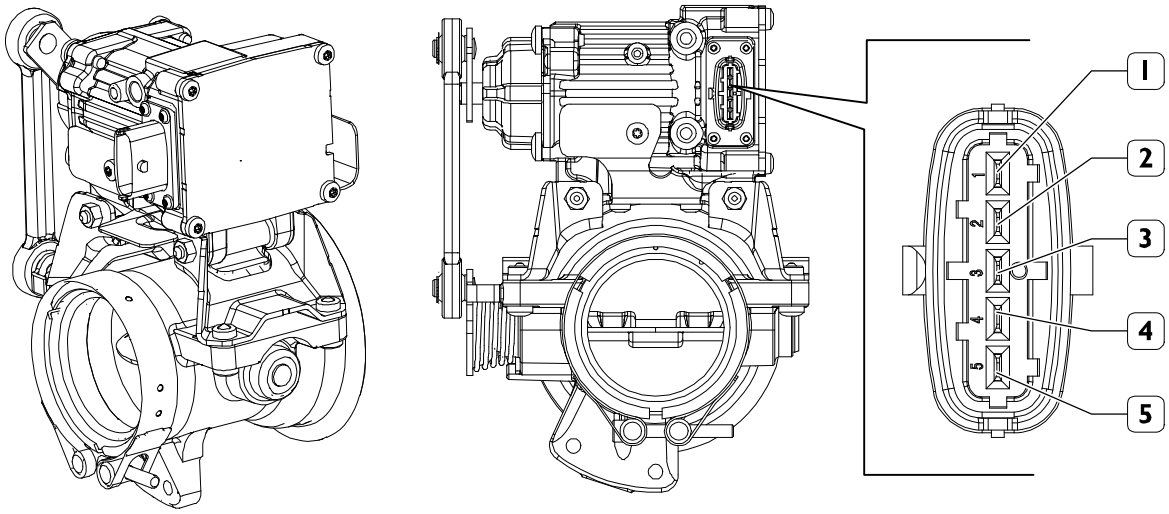
It is frontally located on the right-hand side of the engine and is controlled by the auxiliary assembly belt.

Specifications:

Type:	BOSCH NCB1
Nominal voltage:	28 V
Nominal rated current:	70 A @ 6,000 rpm 35 A @ 1,800 rpm
Stand-by current consumption:	≤ 1mA
Maximum continuous rotation velocity:	≤ 12,000 min-1
Operating temperature range:	-40 °C ÷ +110 °C
Weight:	6.5 kg
Direction of rotation:	clockwise

Motorized throttle valve actuator connector (Exhaust flap)

Figure 39



Ref.	Description	ECU Pin
1	V Bat	-
2	Ground	-
3	-	-
4	Can L	18A
5	Can H	17A

SECTION 4

Scheduled maintenance

Page

SCHEDULED MAINTENANCE
Recovery

To ensure optimised working conditions, in the following pages we are providing instructions for the overhaul control interventions, checks and setting operations that must be performed on the engine at due planned dates.

The frequency of the maintenance operations is just an indication since the use of the engine is the main characteristic to determine and evaluate replacements and checks.

It is not only allowed but recommended that the staff in charge of the maintenance should also carry out the necessary maintenance and controlling operations even if not being included in the ones listed here below but that may be suggested by common sense and by the specific conditions in which the engine is run.

In case of evident engine malfunction, such as excessive smoke of exhaust gas, high coolant temperature or low oil pressure, immediately intervene in order to find the causes.
We wish to remind that each maintenance operation, even the most simple must be performed in compliance with the accident prevention standards for the safety of maintenance personnel in charge.

Regular maintenance and inspection planning

Checks (in periods of use)	Frequency
Check the engine lubricant oil level	Daily
Check the engine coolant level	Daily
Engine visual inspection	50 hours
Drain the water from the fuel pre-filter	150 hours (1)
Check tension and condition of ancillary belt	300 hours
Check the condition of the exhaust duct(s)	Six-months
Check using ECU	In the case of a fault
Planned maintenance	**Frequency**
Change engine lubricant oil (*)	600 hours (2) (3)
Change oil filter (*)	600 hours (2) (3) (4)
Change fuel pre-filter	600 hours (5) (1)
Change fuel filter	600 hours (2) (1) (4)
Change ancillary belt	1,200 hours
Turbocharger visual inspection	1,200 hours
Change blow-by filter	1,500 hours (2)
Special maintenance	**Frequency**
Adjust valves/rocker arms clearance	2,400 hours
Replacement of the coolant	3,000 hours (5)

*) Frequency for construction equipment application: -100 hours versus standard application.

1) Maximum period relative to the use of high quality fuel, (specification ASTM D975 or EN 590); this is reduced based on fuel contamination and the alarm signals due to filter clogging and/or the presence of water in the pre-filter. The filter clogging signal indicates that the filter must be replaced. If the signal of water present in the pre-filter does not turn off after drainage, the filter must be replaced.
2) To be performed every year even if the specified operating hours interval has not been reached.
3) The frequencies are applicable for lubricants which meet the international standards API CJ-4 / ACEA E9 as specified in the REFILLING table.
4) Only use filters with the following specifications:
   - degree of filtering < 12 µm
   - filtering efficiency 99.5% (ß > 200).
5) To be performed every two years even if the specified operating hours interval has not been reached.

NOTE The frequency of the maintenance operations is just an indication since the use of the engine is the main characteristic to determine and evaluate replacements and checks.

The maintenance operations are valid only if the setter fully complies with all the installation prescriptions provided by FPT.

Furthermore, the users assembled by the setter shall always be in conformance to couple, power and number of turns based on which the engine has been designed.

Checks not included in maintenance planning-daily checks

It is a good habit to execute, before engine start, a series of simple checks that might represent a valid warranty to avoid inconveniences, even serious, during engine running. Such checks are usually up to the operators and to the vehicle's drivers.
- Level controls and checks of any eventual leakage from the fuel, cooling and lubricating circuits.
- Notify the maintenance if any inconvenience is detected of if any filling is necessary.

After engine start and while engine is running, proceed with the following checks and controls:
- check presence of any eventual leakage from the fuel, cooling and lubricating circuits.
- Verify absence of noise or unusual rattle during engine working.
- Verify, using the vehicle devices, the prescribed pressure temperature and other parameters.
- Visual check of fumes (colour of exhaust emissions)
- Visual check of cooling liquid level, in the expansion tank.

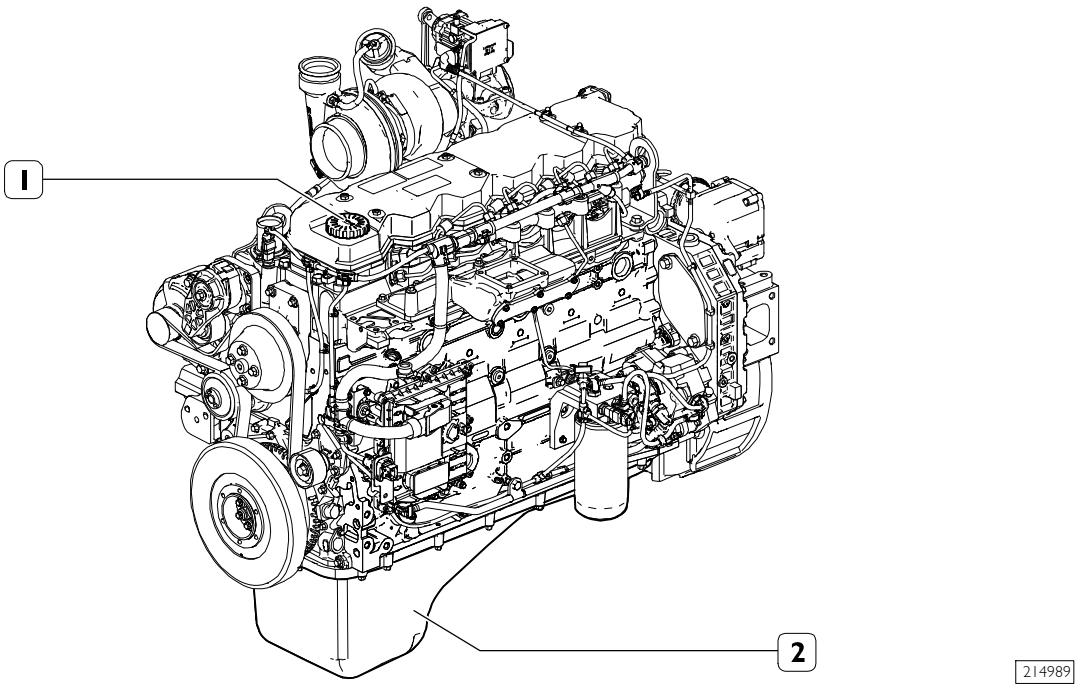
MAINTENANCE PROCEDURES

Checks and inspections

Engine oil level check

The check must be executed when the engine is disconnected and possibly cool.
The check can be made using the specially provided flexible rod.
Draw off the rod from its slot and check that the level is within the etched tags of minimum and maximum level.
Whether it should be difficult to make the evaluation, proceed cleaning the rod using a clean cloth with no rag grinding and put it back in its slot. Draw it off again and check the level.
In case the level results being close to the tag showing minimum level, provide filling lubrication of the engine's components.
Always ensure the oil added has the same characteristics of the oil contained in the sump.
Mixing is not allowed as this would not guarantee correct lubrication of the internal parts of the engine.

Figure 1



If the level is insufficient, it is necessary to top up with lubricant oil which meets the international specifications ACEA E9, as indicated in the REFILLING table.
Remove the lubricant oil cap (1) and pour engine lubricant oil through the hole.
Use the oil dipstick to check that the lubricant oil level does not exceed the "Max" limit.
Make sure that the oil dipstick is fully inserted and that the oil filler cap is fully tightened in a clockwise direction.

The engine oil is highly polluting and harmful.

In case of contact with the skin, rinse well with water and detergent.

Adequately protect the skin and the eyes, operate in full compliance with safety regulations.

Disposal must be carried out properly, and in full compliance with the law and regulations in force.

Combustion system inspection

The check must be executed both when the engine disconnected and when it is running.
The check operation consists in examining the fuel pipelines running from the tank to the pre-filter (if provided in the specific equipment), to the filter, to the high pressure pump and to the rail diffuser and from this last one to the head.

Special attention must be paid to the connections on the high pressure pipelines.

Due to the high pressure within the pipelines running from the high-pressure pump to the rail diffuser and from this last one to the electro-injectors, special attention must be aid also in checking presence of any leakage or blow-by.

Protect the eyes and the skin from any eventual high pressure jet: these may deeply penetrate under the skin surface provoking serious poisoning.

Cooling system inspection

The check must be executed both when the engine disconnected and when it is running.

Check the pipelines from the engine to the radiator, from the expansion tank and vice-versa. Find out any blow-by, verify the status of the pipes specially close to the holding strips.

Verify that the radiator is clean, the correct working of the fan flywheels, the presence of any leakage from the connectors, from the manifold and from the radiating unit.

Due to the high temperatures achieved by the system, do not operate immediately after the engine's disconnection, but wait for the time deemed necessary for the cooling.
Protect the eyes and the skin from any eventual high pressure jet of cooling liquid.

The density of the cooling liquid must be checked any how every year before winter season and be replaced in any case every two year.

NOTE In case of new filling, proceed bleeding system, through the bleeds on the engine.

If bleeding of the system is not carried out, serious inconvenience might be caused to the engine due to the presence of air pockets in the engine's head.

Lubricating system inspection

The check must be executed both when the engine disconnected and when it is running.

Verify the presence of any oil leakage or blow-by from the head, from the engine pan of from the heat exchanger.

The engine oil is highly polluting and harmful.
In case of contact with the skin, rinse well with water and detergent.

Adequately protect the skin and the eyes, operate in full compliance with safety regulations.

Disposal must be carried out properly, and in full compliance with the law and regulations in force.

Inspection of water presence within fuel filter or pre-filter

NOTE The components of the common rail system can be damaged very quickly in presence of water or impurity within the fuel.

Timely proceed operating on the pre-filter (not available on the engine block) to carry out the drainage of the water within the feed circuit.

Inspection of drive belt tensioning

The drive belt tensioning control is made using an automatic tensioning device therefore no intervention is required apart from checking the wear status of the belt itself.

Check of belt's tear and wear status

Carefully verify the belt's surface in order to detect any sign of incision, crack, excessive wear in correspondence of toothing; check end and surface grinding.

Danger: if the engine is switched off but is still hot, unexpected motion of the belt may occur.

Wait for engine temperature cooling as a precaution in order to avoid serious danger injury.

Planned maintenance

Oil motor and oil filter replacement

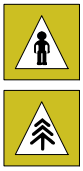
Warning: We recommend to wear proper protections because of high motor service temperature.

The motor oil reaches very high temperature: you must always wear protection gloves.

Due to the several applications, the pan shape and the oil quantity can change slightly. However, the following operations are valid for all applications.

We recommend to carry out the oil drainage when the motor is hot.

- ❑ Place a proper container for the oil collecting under the pan connected with the drain plug.
- ❑ Unscrew the plug and then take out the control dipstick and the inserting plug to ease the downflow of the lubrication oil.



The oil motor is very pollutant and harmful.

In case of contact with the skin, wash with much water and detergent.

Protect properly skin and eyes: operate according to safety rules.

Dispose of the residual properly following the rules.

- ❑ After the complete drainage, screw the plug and carry out the clean oil filling.

Use only the recommended oil or oil having the requested features for the correct motor functioning.

In case of topping up, don't mix oils having different features.

If you don't comply with theses rules, the service warranty is no more valid.

- ❑ Check the level through the dipstick until when the filling is next to the maximum level notch indicated on the dipsick.

Whereas you replace the lubrication oil, it is necessary to replace the filter.

According to the application the filter can be located in different positions: the following procedure is a valid guide for all applications.

- ❑ The filter is composed by a support and a filtering cartridge. For the cartridge replacement use the 9936076-tool.

Warning: the oil filter contains inside a quantity of oil of about 1 kg.

Place properly a container for the liquid.

Warning: avoid the contact of skin with the motor oil: in case of contact wash the skin with running water.

The motor oil is very pollutant: it must be disposed of according to the rules.

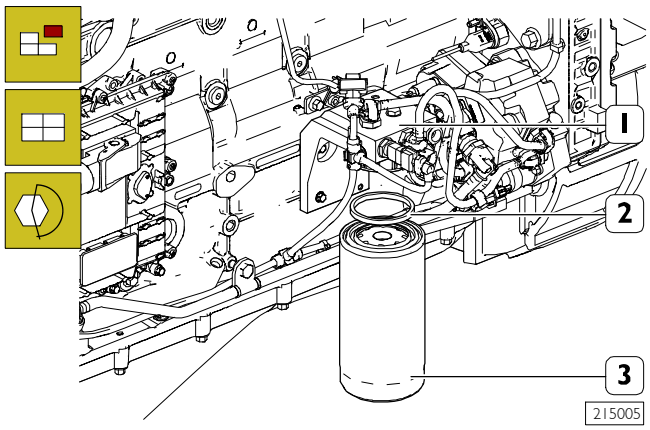
- ❑ Replace the filtering cartridge with a new one and screw manually until when the gasket is in contact with the support.
- ❑ Tighten further using tool 99360076 to a torque of 20 ± 2 Nm.
- ❑ Operate the motor for some minutes and check the level through the dipstick again. If it is necessary, carry out a topping up to compensate the quantity of oil used for the filling of the filtering cartridge.

Fuel filter replacement

During this operation don't smoke and don't use free flames.

Avoid to breathe the vapors coming from filter.

Figure 2



- ❑ Place a container for collecting the diesel under the filter support (1).
- ❑ Remove the filter (3) by unscrewing it from its relative support by using the 99360076-tool.
- ❑ Replace the filter element and the O-ring seal (2) contained inside the filter (3).
- ❑ Carefully clean the surfaces of the support (1) in contact with the O-ring seal (2).
- ❑ Moisten the sealing gasket (2) of the fuel filter (3) with a thin layer of oil.
- ❑ Manually tighten the fuel filter (3) on the support (1) until it comes into contact with the gasket (2).
  Additionally tighten the fuel filter (3) to the prescribed torque using a specific tool.

Ref	No.	Description	Tightening torques
(3)	1	M20x1.5	20 ± 2 Nm

Do not smoke or use open flames during this operation. Do not inhale the vapours that exit the filter.

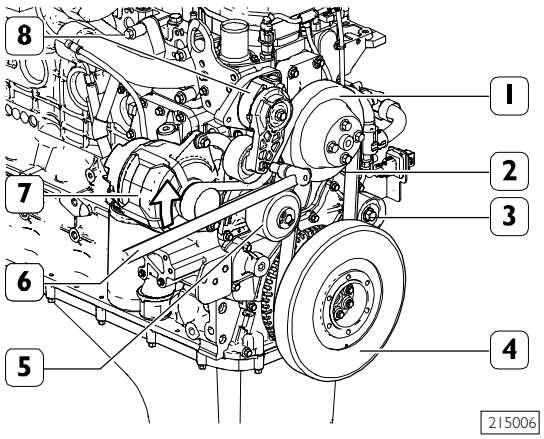
Pay attention to the electric fuel pre-heater (if installed) and the relative electrical connection.

Do not fill the new fuel filter before placing it on the support in order to prevent harmful impurities from entering the fuel circuit and the injection system.

Eliminate the consumables and any materials in contact with them (for example, filters) in accordance with current regulations.
The FPT Technical Service Network workshops are equipped for this purpose.

Change ancillary belt

Figure 3



- ❑ Remove the belt (2) by acting on the automatic belt tensioner (8) with the appropriate tool (6) from the alternator (7), water pump (5), fan control pulley (1), crankshaft pulley with damper (4) and fixed guide roller (3).
- ❑ Replace the worn belt (2) with new one.
- ❑ Fit the Poly V belt (2) on the pulleys and guide roller.
- ❑ Use the appropriate tool (6) on the automatic belt tensioner (8) in order to fit the new belt (2) in the operating position.
- ❑ Additional adjustments are not required. The belt (2) tension is adjusted automatically by the calibrated spring in the automatic belt tensioner (8).
- ❑ Operate the engine for a few hours and check that the belt (2) is properly fit.

Warning: with switched off motor (but still hot) the belt can operate without advance notice.

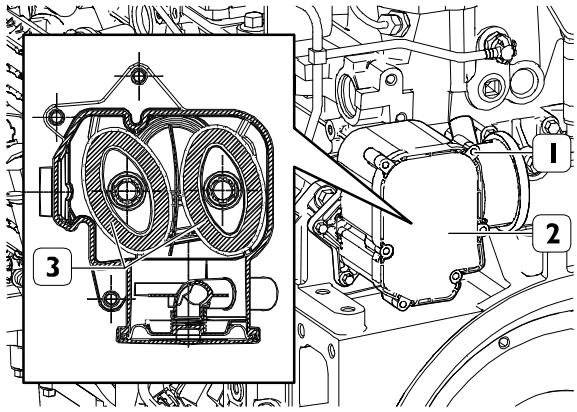
Wait for the motor temperature lowering to avoid very serious accidents.

Inspection/replacement of blow-by filter

The filter in subject has been developed and equipped for the collection, filtering and condense of the lubricating oil vapours.

Within the filter unit (2) two cartridge filters are included (3).

Figure 4



The check of the filtering element is carried out by removing the cover and drawing off the cartridges (3).

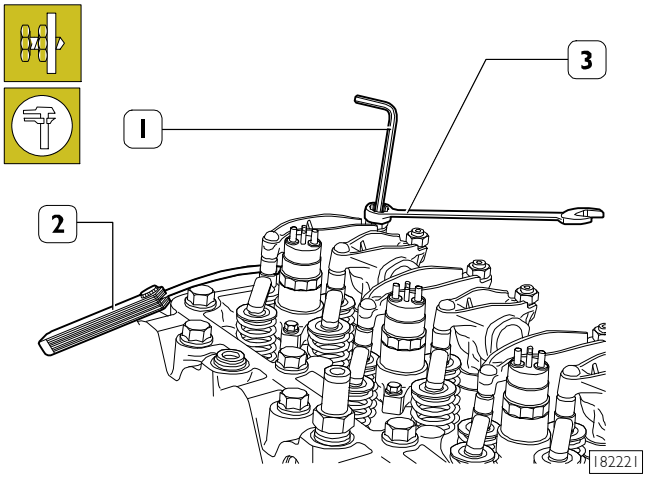
Turbocharger visual inspection

Only proceed when the engine is not turning over. Visually check that the turbine and compressor impellers and the relative inlet and outlet ducts are not obstructed or damaged, otherwise replace them.

Unscheduled maintenance

Adjustment of valve/rocker arm clearance

Figure 5



The adjustment of the clearance between the rocker arms and the intake and exhaust valve control rods must be strictly carried out using an Allen wrench (1), box-end wrench (3) and a feeler gauge (2).

Clearance shall be as follows:
- intake valves 0.25 ± 0.05 mm
- exhaust valves 0.50 ± 0.05 mm.

NOTE In order to perform the rocker arm - valve clearance adjustment more quickly, proceed as follows:

❑ Rotate the crankshaft, balance the valves of cylinder no. 1 and adjust the valves marked by the asterisk as shown in the tables below:

cylinder no.	1	2	3	4	5	6
intake	-	-	*	-	*	*
exhaust	-	*	-	*	-	*

❑ Rotate the crankshaft, balance the valves of cylinder no. 6 and adjust the valves marked by the asterisk as shown in the tables below:

cylinder no.	1	2	3	4	5	6
intake	*	*	-	*	-	-
exhaust	*	-	*	-	*	-

Change engine coolant

- ❑ Only proceed when the engine is not turning, and is at low temperature, so as not to run the risk of burns.
- ❑ Place a container for collecting coolant under the heat exchanger (radiator).
- ❑ Remove the pressurization cap from the expansion tank.
- ❑ Loosen the retaining elements and remove the sleeves connecting the engine cooling circuit to the heat exchanger.
- ❑ Drain the coolant from the heat exchanger (radiator) and wait until it is completely empty.
- ❑ Once emptied, refit the cooling circuit making sure the sleeves are perfectly sealed.
- ❑ Refill the engine and the heat exchanger until the cooling circuit has been completely refilled using a mixture of 50% water and Actifull OT, as contained in the section FLUIDS. Do not fill the expansion tank to the brim.
- ❑ With the coolant cap open, start the engine and let it idle for approx. one minute. This helps to completely bleed the air contained in the cooling circuit.
- ❑ Stop the engine and top up with more coolant, if necessary.
- ❑ When the engine is cold, make sure that the coolant in the expansion tank is a few centimetres below the filling hole.
- ❑ In the event of an externally located level indicator as regards the heat exchangers, proceed with the top up operation by making sure that the coolant does not overfill the internal volume of the exchanger in order to allow the expansion of coolant volume during increases in temperature.

The failure to observe the aforesaid procedure does not guarantee the presence of the correct quantity of coolant in the engine.

When the engine is hot, pressure builds up in the cooling circuits which may eject hot liquid violently, resulting in a risk of burns. Open the filler cap of the coolant tank only if necessary and only when the engine is cold.

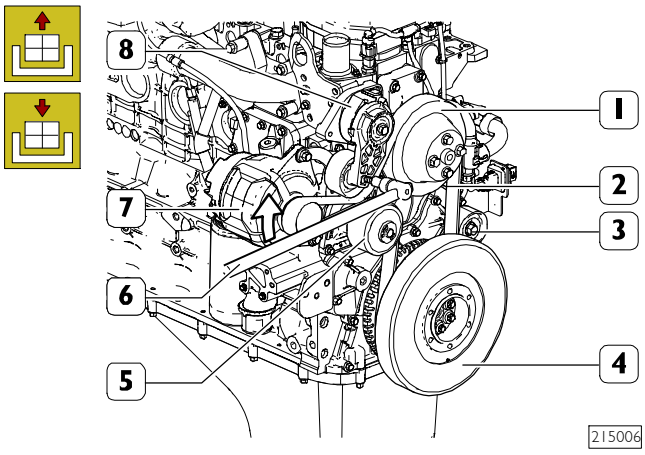
SECTION 5

Removal and installation of main components

REMOVAL AND INSTALLATION AUXILIARY DRIVE BELT

Removal

Figure 1



- ❑ Remove the belt (2) by acting on the automatic belt tensioner (8) with the appropriate tool (6) from the alternator (7), water pump (5), fan control pulley (1), crankshaft pulley with damper (4) and fixed guide roller (3).

Installation

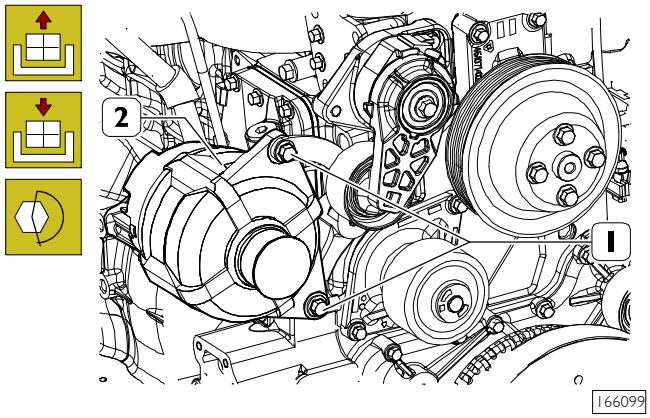
- ❑ Fit the Poly V belt (2) on the pulleys and guide roller.
- ❑ Use the appropriate tool (6) on the automatic belt tensioner (8) in order to fit the new belt (2) in the operating position.
- ❑ Additional adjustments are not required. The belt (2) tension is adjusted automatically by the calibrated spring in the automatic belt tensioner (8).
- ❑ Operate the engine for a few hours and check that the belt (2) is properly fit.

ALTERNATOR REMOVAL AND INSTALLATION

Removal

Disconnect the electrical connections of the alternator.
Remove the auxiliary components drive belt as described in the relative procedure.

Figure 2



Undo the screws (1) and disconnect the alternator (2).

Ref	No.	Description
(1)	1	M10x1.5x110
(1)	1	M10x1.5x30

Installation

Place the alternator (2) in position, fasten the screws (1) and tighten them to the specified torque.

Ref	No.	Description	Tightening torques
(1)	1	M10x1.5x110	43 ± 6 Nm
(1)	1	M10x1.5x30	43 ± 6 Nm

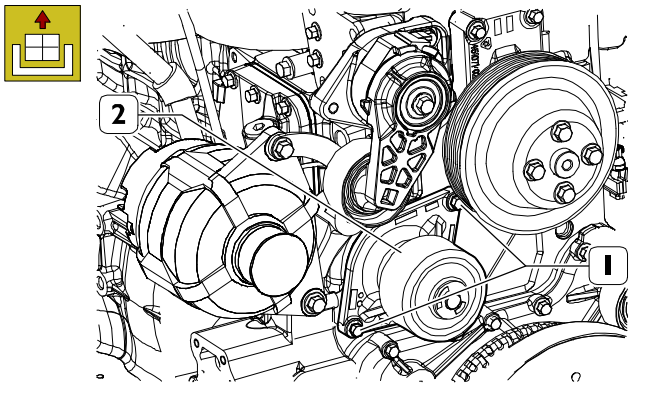
Install the auxiliary components drive belt as described in the relative procedure.
Connect the alternator electrical connections.

COOLANT PUMP REMOVAL AND INSTALLATION

Removal

Remove the auxiliary components drive belt as described in the relative procedure.
Position a suitable container to catch any coolant.

Figure 3

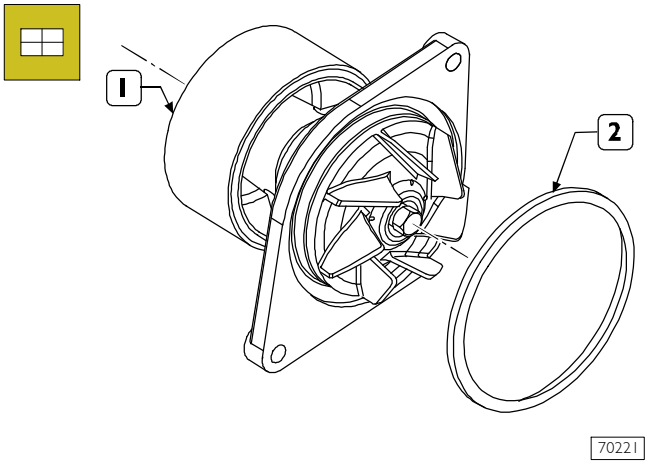


Undo the screws (1) and remove the water pump (2).

Ref	No.	Description
(1)	2	M8x1.25x35

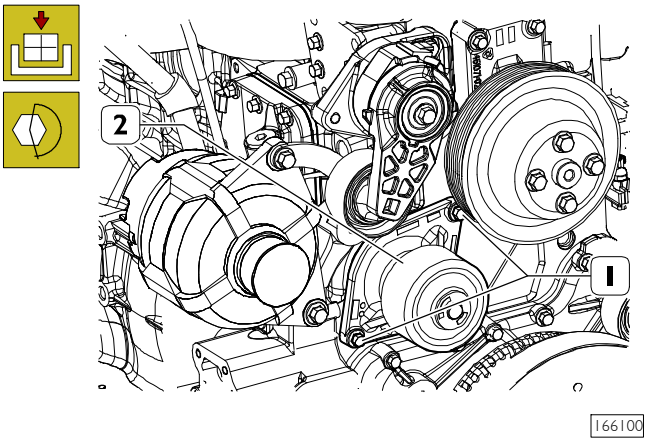
Installation

Figure 4



Apply a new seal ring (2) to the coolant pump (1).

Figure 5



Place the coolant pump (2) in position, fasten the screws (1) and tighten them to the specified torque.

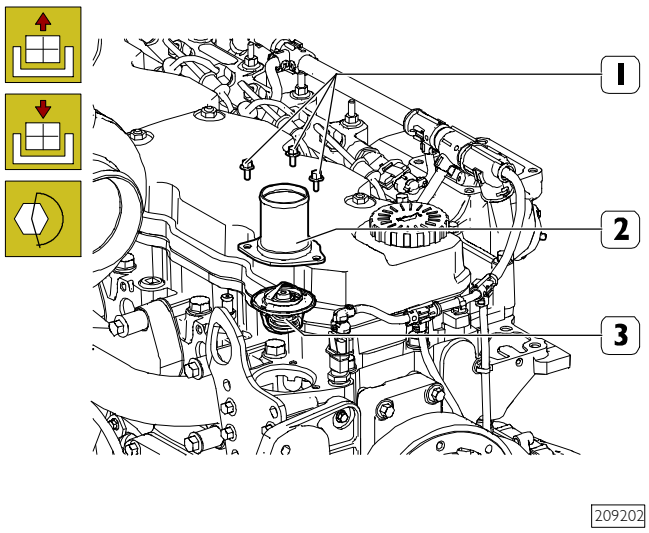
Ref	No.	Description	Tightening torques
(1)	2	M8x1.25x35	24 ± 4 Nm

Install the auxiliary components drive belt as described in the relative procedure.

THERMOSTAT REMOVAL AND INSTALLATION

Removal

Figure 6



Unscrew the fastening screws (1) and disassemble the thermostat unit: remove the engine coolant outlet pipe (2) and the thermostat (3) complete with its gasket.

Ref	No.	Description
(1)	3	M6x1x12

Installation

Assemble the thermostat unit: fit the thermostat (3) complete with its gasket and the engine coolant outlet pipe (2); tighten the fastening screws (1) to the prescribed torque.

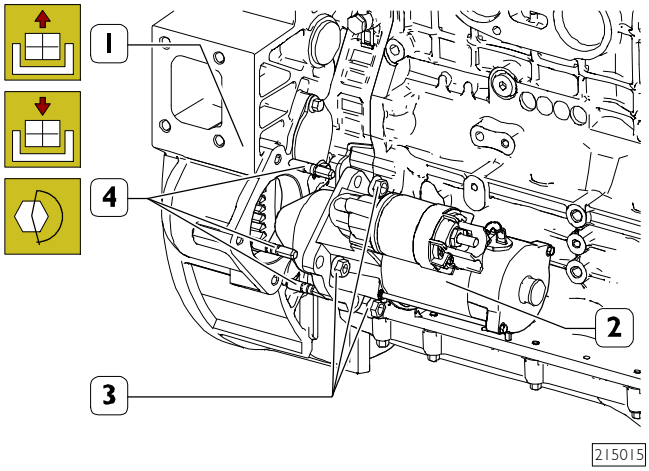
Ref	No.	Description	Tightening torques
(1)	3	M6x1x12	13.5 ± 1.5 Nm

REMOVAL AND INSTALLATION STARTER MOTOR

Removal

Disconnect the starter motor electrical connections.

Figure 7



Ensure that the the electric starter motor (2) is suitably supported.
Unscrew the fastening nuts (3) and remove the electric starter motor (2).
Unscrew the studs (4) from the flywheel housing (1).

Ref	No.	Description
(3)	3	M10x1.5
(4)	3	M10x1.5x50

Installation

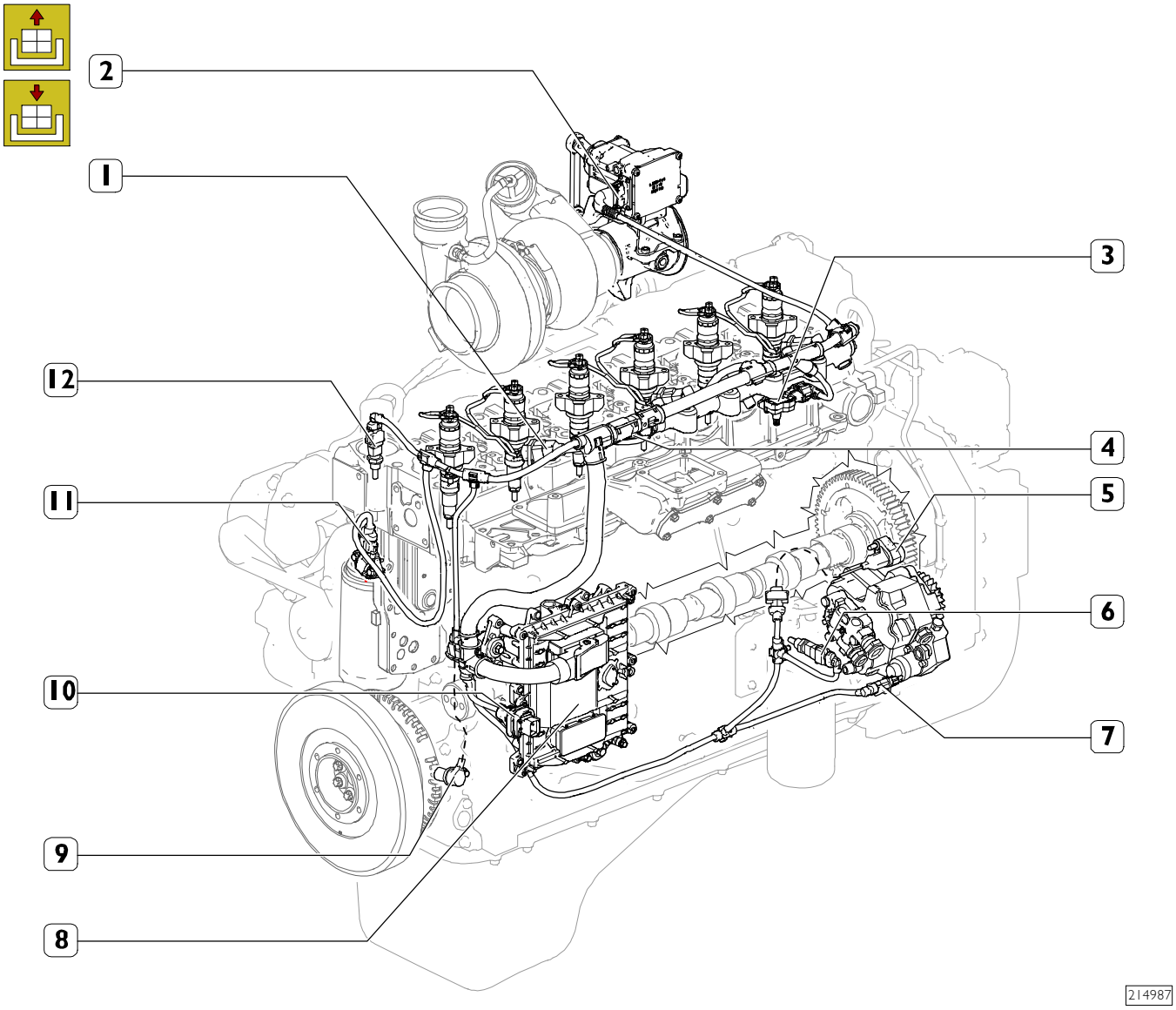
Screw the studs (4) and fit the electric starter motor (2) into the internal part of the flywheel housing (1). Tighten the fastening nuts (3) to the prescribed torque.
Connect the starter motor electrical connections.

Ref	No.	Description	Tightening torques
(3)	3	M10x1.5	43 ± 6 Nm
(4)	3	M10x1.5x50	-

ENGINE CABLE REMOVAL AND INSTALLATION

Removal

Figure 8



1. Electro-injectors connections - 2. Motorized throttle valve actuator connector (Exhaust flap) - 3. Boost pressure and air temperature sensor - 4. Rail pressure sensor - 5. Camshaft timing segment speed sensor - 6. Fuel temperature sensor - 7. Fuel high pressure pump metering unit - 8. Engine Control Unit ECU17CV41 - 9. Crankshaft rpm increment speed sensor - 10. In line connector - 11. Engine oil pressure and temperature sensor - 12. Coolant temperature sensor

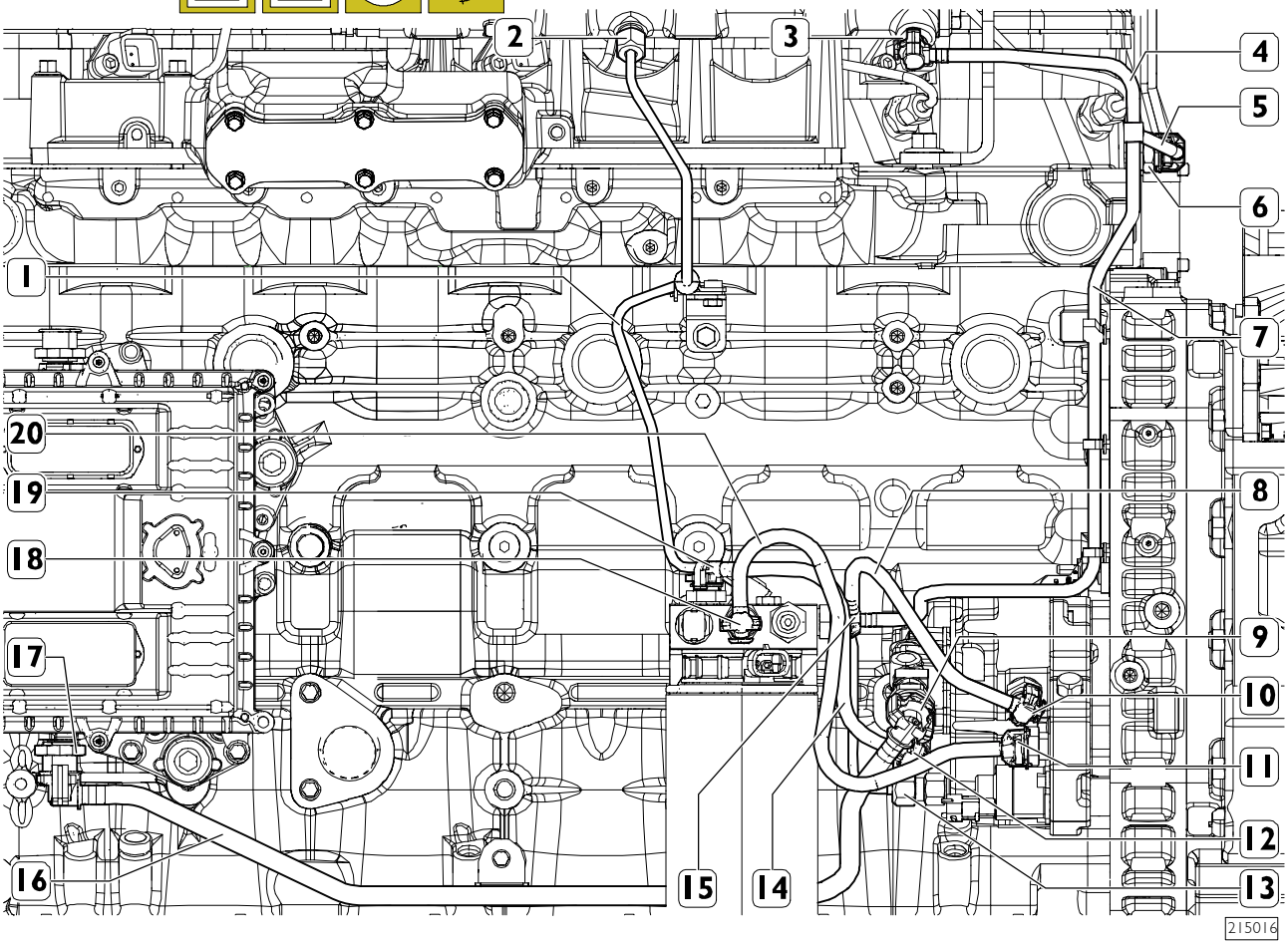
Remove the engine cable by unplugging it from the ECU (8), from the motorized throttle valve actuator connector (2) and from all the sensors and transmitters to which it is connected. Open the straps holding the engine cable to the engine block and remove it completely.

Installation

Place the engine cable in position and close the straps retaining the engine cable to the engine block. Connect the engine cable to the ECU (8), to the motorized throttle valve actuator connector (2) and to all the sensors and transmitters indicated in the electrical equipment section.

FUEL PIPES REMOVAL AND INSTALLATION

Figure 9

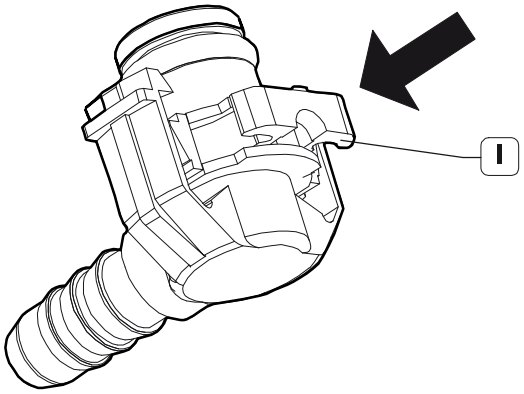


Removal

Remove the engine cable as described in the relative procedure.
Position a suitable container to catch any fuel.
Disconnect the retainers (11 and 18) and remove low pressure fuel pipe (20) from fuel filter to high pressure pump;
Disconnect the retainers (9 and 17) and remove low pressure fuel pipe (16) from engine control unit heat exchanger to mechanical pump;
Disconnect the retainers (12 and 19) and remove low pressure fuel pipe (14) from mechanical pump to fuel filter.
Disconnect the retainers (10 and 15) and remove backflow fuel pipe (8) from high pressure pump to fuel filter support;
Disconnect the retainers (3 and 6) and remove backflow fuel pipes (4, 5 and 7) from common rail and electro-injectors to the fuel filter support.
Unscrew the hose couplings (2 and 13) of the high pressure fuel pipe (1) from high pressure pump to common rail;
Unscrew the screw fastening the pipe (1) to the engine block and remove it.

Ref	No.	Description
(2,13)	3	M14x1.5

Figure 10



To disconnect low pressure/backflow fuel pipes from relevant quick connecting joints, it is necessary to keep pressed locking retainer (1) as shown in the picture.

Installation

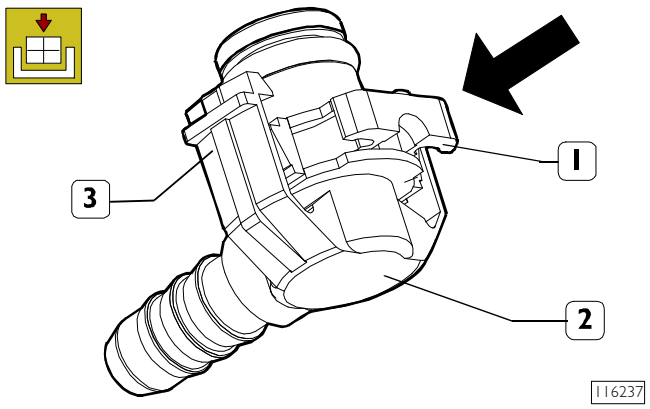
Fit the pipe (1) to the engine block and tighten the fastening screw to the prescribed torque.
Connect the high pressure fuel pipe pipe (1) both to the high pressure pump and to the common rail and tighten the hose couplings (2 and 13) to the prescribed torque.

Ref	No.	Description	Tightening torques
(2,13)	2	M14x1.5	24 ± 4 Nm

NOTE The high pressure fuel hose must always be replaced with a new one whenever it is removed. The hose couplings must be tightened to torque using spanner 99317915 and torque wrench 99389829.

Fit backflow fuel pipes (4, 5 and 7) from common rail and electro-injectors to the fuel filter support and connect the retainers (3 and 6).
Fit backflow fuel pipe (8) from high pressure pump to fuel filter support and connect the retainers (10 and 15).
Fit low pressure fuel pipe (14) from mechanical pump to fuel filter and connect the retainers (12 and 19).
Fit low pressure fuel pipe (16) from engine control unit heat exchanger to mechanical pump and connect the retainers (9 and 17).
Fit low pressure fuel pipe (20) from fuel filter to high pressure pump and connect the retainers (11 and 18).
Install the engine cable as described in the relative procedure.

Figure 11

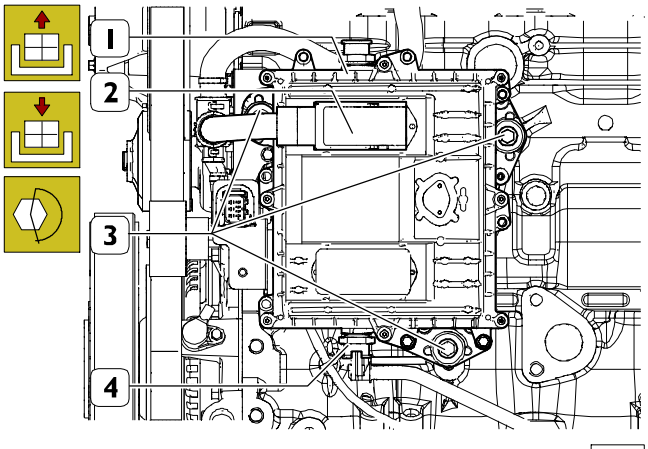


To connect the low pressure fuel hose to the connection fitting, insert the quick-fit coupling (2) in the connection fitting and push it in until the catch (3) engages.

ENGINE CONTROL UNIT REMOVAL AND INSTALLATION

Removal

Figure 12



Disconnect the engine cable (2) from the ECU (1), as described in the relative section.
Position a suitable container to catch any fuel.
Disconnect the retainer and remove the low pressure fuel pipe from fuel pre-filter to the engine control unit heat exchanger.
Disconnect the retainer (4) and remove the low pressure fuel pipe from the engine control unit heat exchanger to to mechanical pump, as described in the relative section.
Unscrew the supporting screws (3), and remove the ECU (1), including the heat exchanger.

Ref	No.	Description
(3)	3	M8x1.25

Installation

Fit the ECU (1) including the heat exchanger on the crankcase and tighten the supporting screws (3) to the prescribed torque.
Connect the low pressure fuel pipe from the mechanical pump to the engine control unit heat exchanger by means of the retainer (4), as described in the relative procedure.
Connect the low pressure fuel pipe from fuel pre-filter to the engine control unit heat exchanger by means of the retainer.
Connect the engine cable (2) to the ECU (1), as described in the relative section.

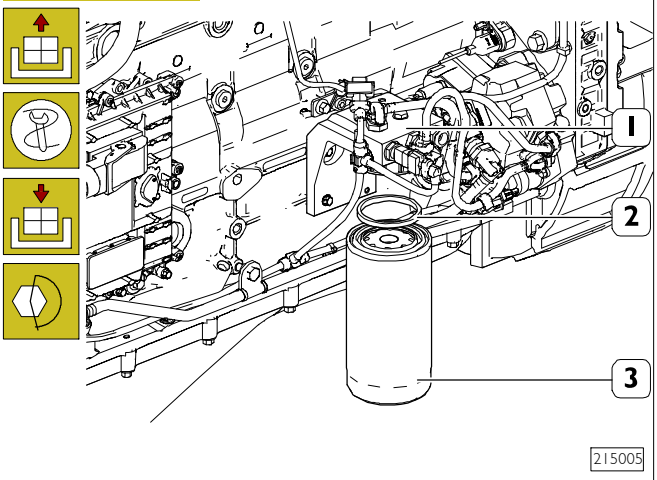
Ref	No.	Description	Tightening torques
(3)	3	M8x1.25	24 ± 4 Nm

NOTE Replacing the elastic support elements is recommended.

FUEL FILTER REMOVAL AND INSTALLATION

Removal

Figure 13



Place a container for collecting the diesel under the filter support (1).
Unscrew and remove the filter (3) from its relative support (1) by tool 99360076.

Ref	No.	Description
(3)	1	M20x1.5

Installation

Moisten the sealing gasket (2) of the fuel filter (3) with a thin layer of oil.
Manually tighten the fuel filter (3) on the support (1) until it comes into contact with the gasket (2).
Additionally tighten the fuel filter (3) to the prescribed torque using a specific tool.

Ref	No.	Description	Tightening torques
(3)	1	M20x1.5	20 ± 2 Nm

NOTE Pay attention to the electric fuel pre-heater (if installed) and the relative electrical connection.

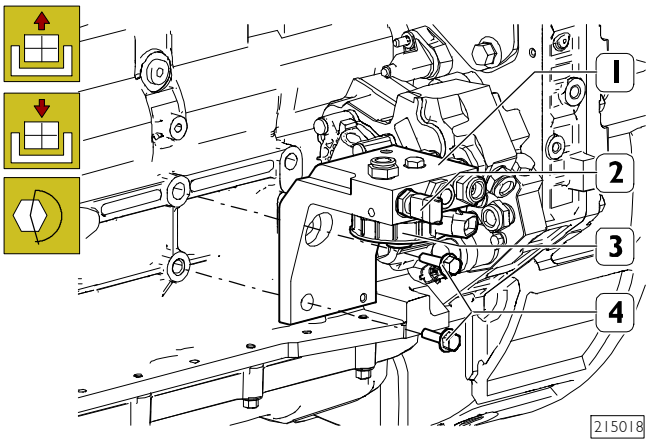
FUEL FILTER SUPPORT REMOVAL AND INSTALLATION

Removal

Remove the engine cable as described in the relative procedure.
Remove the fuel pipes as described in the relative procedure.

Remove the fuel filter as described in the relative procedure.

Figure 14



Place a container for collecting diesel under the fuel filter support (1).
Unscrew the fastening screws (4) and remove the fuel filter support (1) together with the electric fuel pre-heater (3) and the fuel temperature sensor (2).

Ref	No.	Description
(4)	2	M12x1.75x30

NOTE Pay attention to the electric fuel pre-heater (if installed) and the relative electrical connection.

Installation

Place a container for collecting diesel under the fuel filter support (1).
Fit the fuel filter support (1) together with the electric fuel pre-heater (3) and the fuel temperature sensor (2) on the crankcase and tighten the fastening screws (4).

Ref	No.	Description	Tightening torques
(4)	2	M12x1.75x30	80 ± 8 Nm

Install the fuel filter as described in the relative procedure.
Install the fuel pipes as described in the relative procedure.
Install the engine cable as described in the relative procedure.

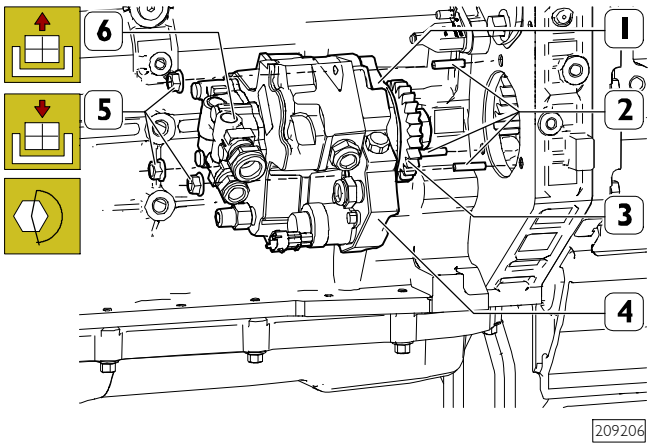
INJECTION PUMP REMOVAL AND INSTALLATION

Removal

Remove the engine cable as described in the relative procedure.
Remove the fuel pipes as described in the relative procedure.

Remove the fuel filter as described in the relative procedure.
Remove the fuel filter support as described in the relative procedure.
Position a suitable container to catch any fuel.

Figure 15



Ensure that the fuel high pressure pump (4) is suitably supported.
Unscrew the fastening nuts (5) and remove the fuel high pressure pump (4) complete with the mechanical pump (6), the flange (1) and the gear (3).
Unscrew the studs (2).

Ref	No.	Description
(2)	3	M8x1.25x50
(5)	3	M8-8

Installation

Screw the studs (2) and fit the fuel high pressure pump (4) complete with the mechanical pump (6), the flange (1) and the gear (3).
Tighten the fastening nuts (5) to the prescribed torque.

Ref	No.	Description	Tightening torques
(2)	3	M8x1.25x50	11 ± 3 Nm
(5)	3	M8-8	24 ± 4 Nm

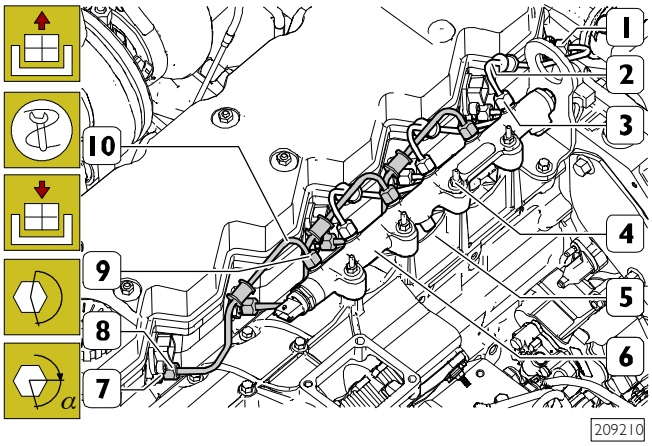
Install the fuel filter support as described in the relative procedure.
Install the fuel filter as described in the relative procedure.
Install the fuel pipes as described in the relative procedure.
Install the engine cable as described in the relative procedure.

REMOVAL AND INSTALLATION COMMON RAIL

Removal

Position a suitable container to catch any fuel.
Disconnect the fuel pressure sensor connector as described in the procedure regarding the engine cable.
Disconnect the low pressure fuel return hose from the common rail, as described in the relative procedure.
Remove the fuel hose from the high pressure pump to the common rail as described in the relative procedure.

Figure 16



Unscrew the hose couplings (1, 3, 8 and 9) from the common rail (6) and injector manifolds (7) and remove the high pressure fuel delivery pipes (2 and 10).
Unscrew the threaded double-shank shoulder screws (4) and remove the common rail (6) from the intake manifold (5).

Ref	No.	Description
(1,8)	6	M14x1.5
(3,9)	6	M14x1.5
(4)	4	M8x1.25x125

Installation

Install the common rail and high pressure fuel delivery pipes by proceeding as follows:

- ❑ fit the common rail (6) on the intake manifold (5) and manually tighten the threaded double-shank shoulder screws (4);
- ❑ tighten two central screws (4) to a torque of 0.1 Nm;
- ❑ fit the high pressure fuel delivery pipes (2 and 10) and manually tighten the hose couplings (1, 3, 8 and 9) fist of all from common rail side and then from cylinder head side;
- ❑ tighten the hose couplings (1, 3, 8 and 9) to a torque of 5 Nm, fist of all from cylinder head side and then from common rail side;
- ❑ tighten the threaded double-shank shoulder screws (4) fixing the common rail (6) on the intake manifold (5) to the prescribed torque;
- ❑ tighten the hose couplings (1, 3, 8 and 9) to the prescribed torque, fist of all from common rail side and then from cylinder head side.

Ref	No.	Description	Tightening torques
(1,8)	6	M14x1,5 1st phase 2nd phase	10 Nm 55°
(3,9)	6	M14x1.5 1st phase 2nd phase	10 Nm 55°
(4)	4	M8x1.25x125	36 ± 5 Nm

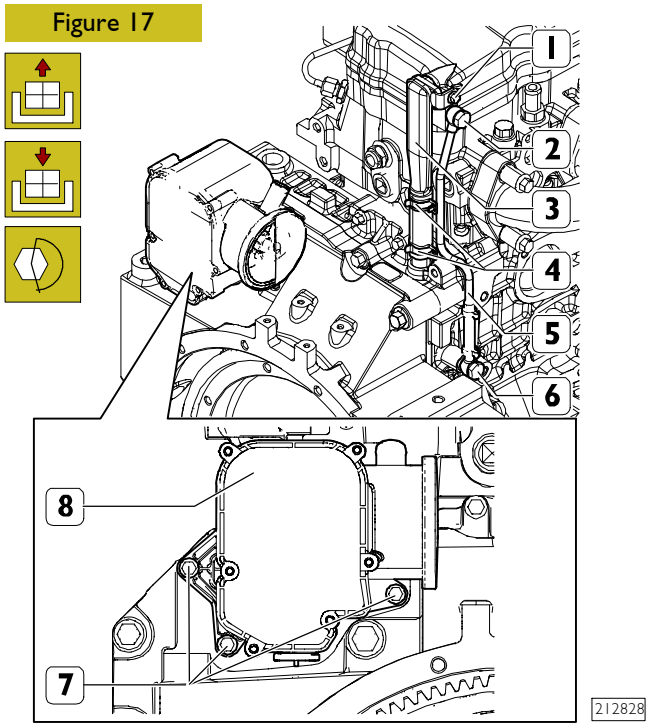
NOTE The high pressure fuel delivery pipes must be replaced every time they are removed. The hose couplings must be tightened to torque using spanner 99317915 and torque wrench 99389829.

Install the fuel hose from the high pressure pump to the common rail as described in the relative procedure.
Connect the low pressure fuel return hose to the common rail, as described in the relative procedure.
Connect the fuel pressure sensor connector as described in the procedure regarding the engine cable.

OIL VAPOUR RECIRCULATION (BLOW-BY) SYSTEM REMOVAL AND INSTALLATION

Removal

Figure 17



Position a suitable container to catch any oil.
Unscrew the fastening screw (1), loosen the retaining clamps (4) and remove the blow-by breather pipe (3).
Unscrew the hose connectors (2 and 6) and remove the oil return pipe (5).
Unscrew the fastening screws (7) and remove the blow-by filter (8).

Ref	No.	Description
(1)	1	M6x1
(2,6)	2	M12x1.5
(7)	3	M6x1

Installation

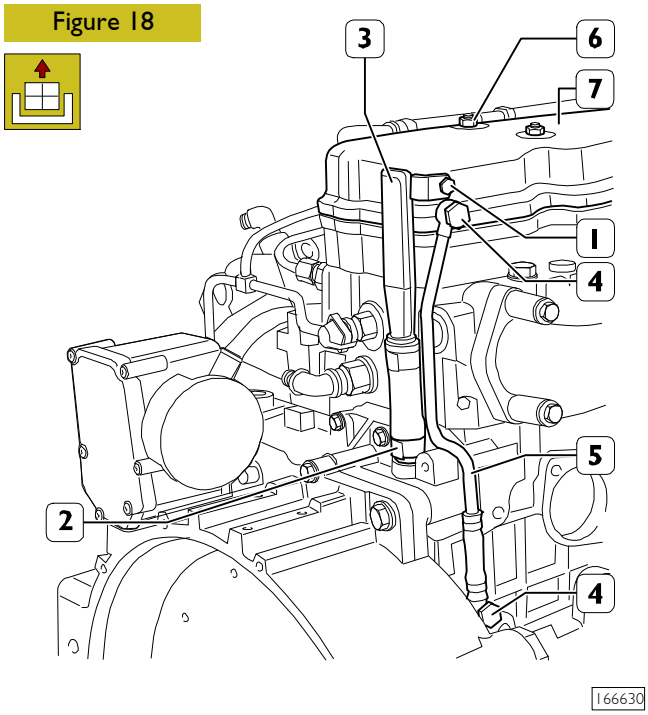
Fit the blow-by filter (8) in position on the on the flywheel housing and tighten the fastening screws (7) to the prescribed torque.
Install the oil return pipe (5) with new copper washers and tighten the hose connectors (2 and 6) to the prescribed torque.
Fit the blow-by breather pipe (3) into the coupling located on the timing gear case and secure it with the retaining clamps (4). Tighten the screw (1) fastening to the tappet cover to the prescribed torque.

Ref	No.	Description	Tightening torques
(1)	1	M6x1	10 ± 2 Nm
(2,6)	2	M12x1.5	20 ± 4 Nm
(7)	3	M6x1	10 ± 2 Nm

TAPPET COVER REMOVAL AND INSTALLATION

Removal

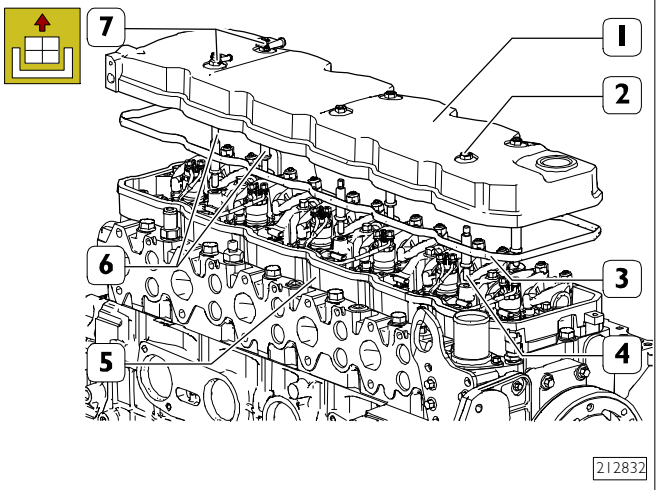
Figure 18



166630

Undo the screw (1). Loosen the elastic strap (2) and remove the blow-by pipe (3).
Unscrew the couplings (4) and remove the pipe (5).

Figure 19



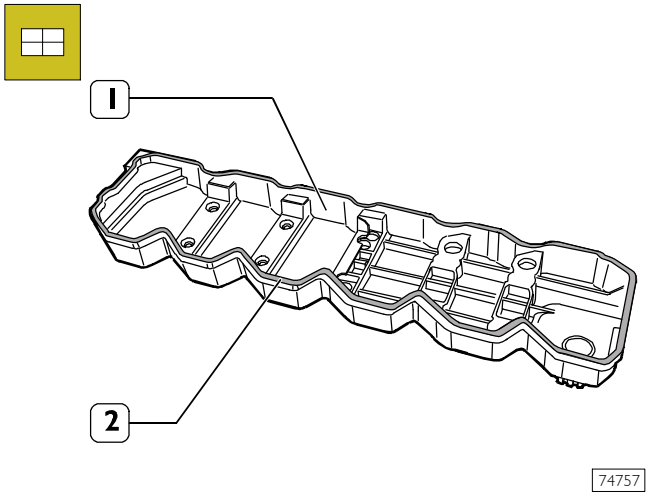
212832

Unscrew the fastening nuts (2 and 7) and remove the tappet cover (1) from the wiring support (5) retrieving relative gasket (3).
Unscrew the threaded double-shank shoulder screws (4 and 6) from the wiring support (5).

Ref	No.	Description
(2,7)	6	M8x1.25

Installation

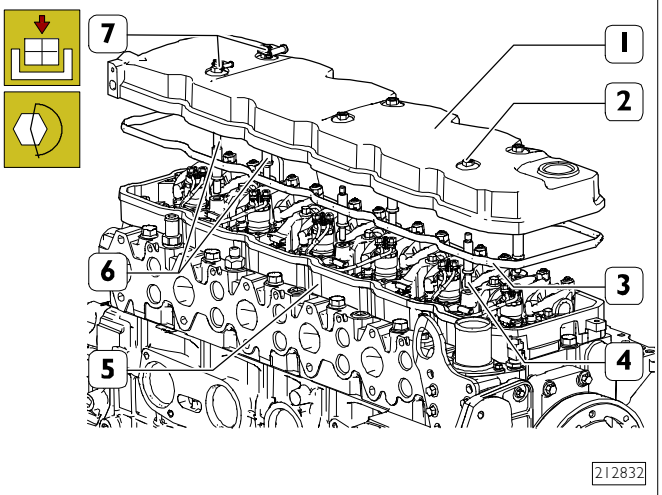
Figure 20



74757

Fit a new gasket (2) on the tappet cover (1).

Figure 21

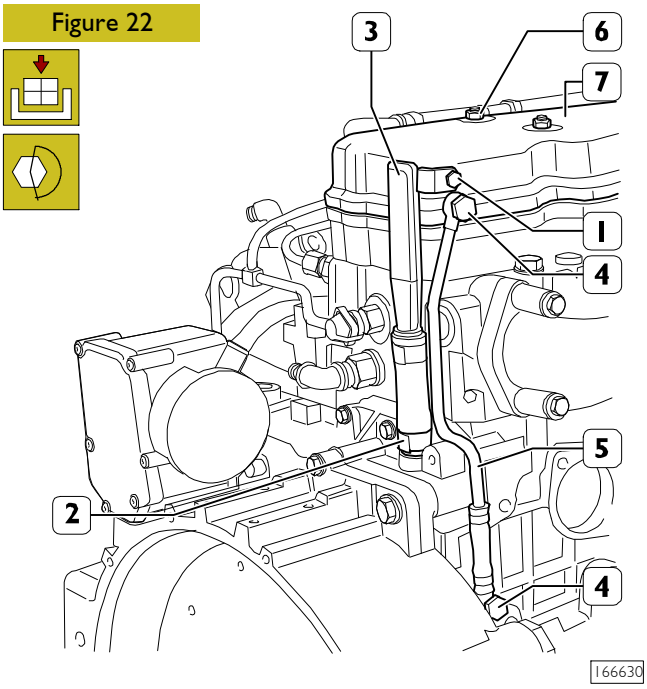


212832

Screw the threaded double-shank shoulder screws (4 and 6) in the wiring support (5).
Install the tappet cover (1) on the wiring support (5) after having interposed a new gasket (3).
Tighten the fastening nuts (2 and 7) to the prescribed torque.

Ref	No.	Description	Tightening torques
(2,7)	6	M8x1.25	24 ± 4 Nm

Figure 22



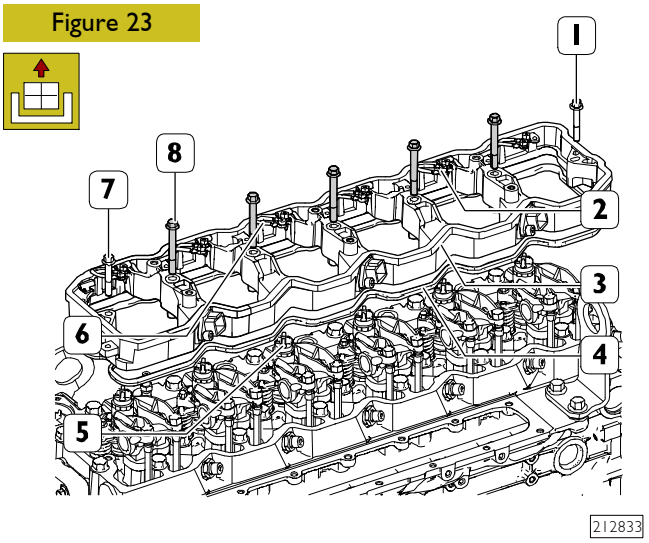
Place the pipe (5) in position with new copper washers in the tappet cover and timing case couplings (4). Then tighten the couplings (4) to the specified torque.
Place the blow-by pipe (3) into the coupling located on the timing case and secure it with the elastic strap (2).
Insert the upper coupling of the new blow-by pipe (5), with a new seal ring, into the tappet cover and tighten the screw (1).

INJECTOR WIRING SUPPORT REMOVAL AND INSTALLATION

Removal

Remove the tappet cover as described in the relative section.
Disconnect the engine cable from the injector wiring connections, as described in the relative section.

Figure 23

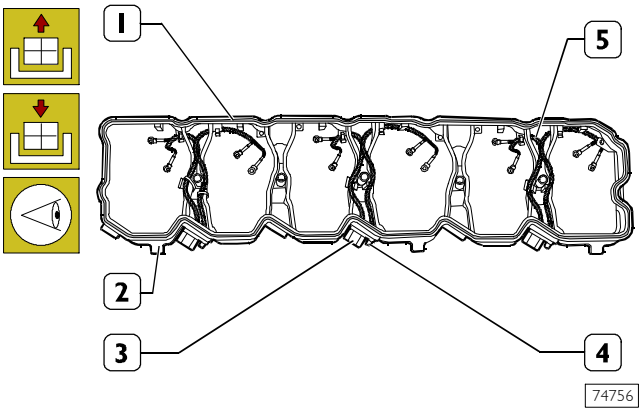


Remove the nuts (2) and disconnect the electrical cables (6) from the electro-injectors (5).
Unscrew the screws (1, 7 and 8) and remove the electro-injector wiring support (3) complete with gasket (4).

Ref	No.	Description
(1,7)	2	M8x1.25
(2)	12	M4
(8)	5	M8x1.25

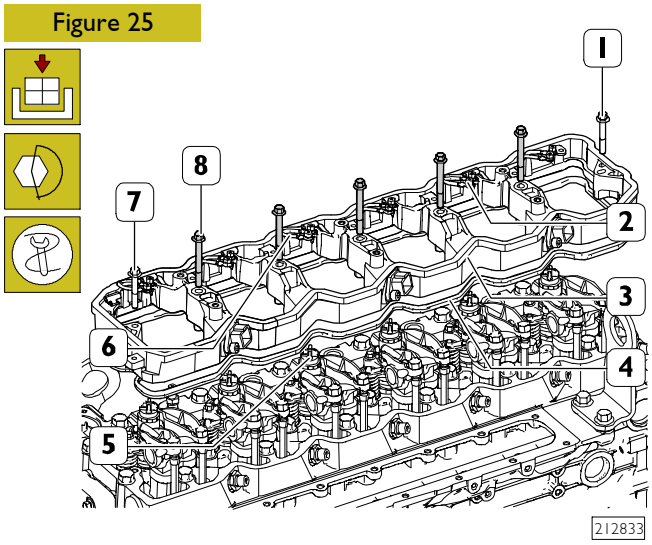
Installation

Figure 24



Check the condition of the electrical cables (5), if they are damaged replace them by cutting the straps (2) securing them to the bracket and removing the screws (4) securing the connectors to this (3).
Fit a new gasket (1) on the bracket (2).

Figure 25



Fit the electro-injector wiring support (3) complete with a new gasket (4) and tighten the screws (1, 7 and 8) to the prescribed torque.
Connect the electrical cables (6) to the electro-injectors (5) and use the torque wrench 99389834 to tighten the fastening nuts (2) to the prescribed torque.

Ref	No.	Description	Tightening torques
(1,7)	2	M8x1.25	24 ± 4 Nm
(2)	12	M4	1.5 ± 0.25 Nm
(8)	5	M8x1.25	24 ± 4 Nm

NOTE Always check that the threads on the screws and their holes do not show any signs of wear or traces of dirt before fitting.

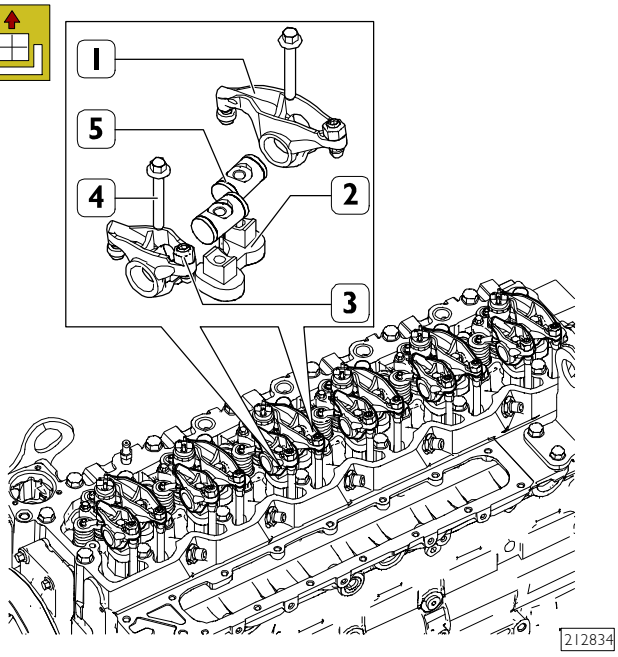
Connect the engine cable to the injector wiring connections, as described in the relative procedure.
Install the tappet cover as described in the relative section.

REMOVAL AND INSTALLATION ROCKER ARM ASSEMBLY

Removal

Remove the tappet cover as described in the relative section.
Remove the injector wiring support as described in the relative section.

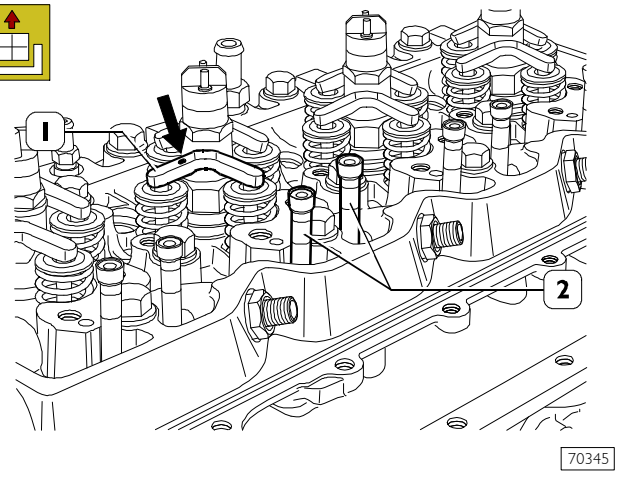
Figure 26



Loosen the tappet adjuster retaining nuts (3) and unscrew the tappet adjuster screws;
Unscrew the fastening screws (4) and disassemble the rocker unit from the cylinder head, including support (2), rockers (1) and shafts (5).

Ref	No.	Description
(4)	12	M8x1.25

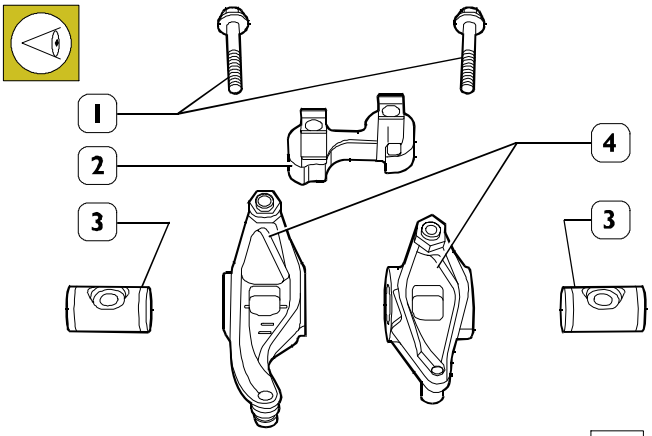
Figure 27



Remove the bridges (1) from valves and the pushrods (2) from the cylinder head and crankcase.

Installation

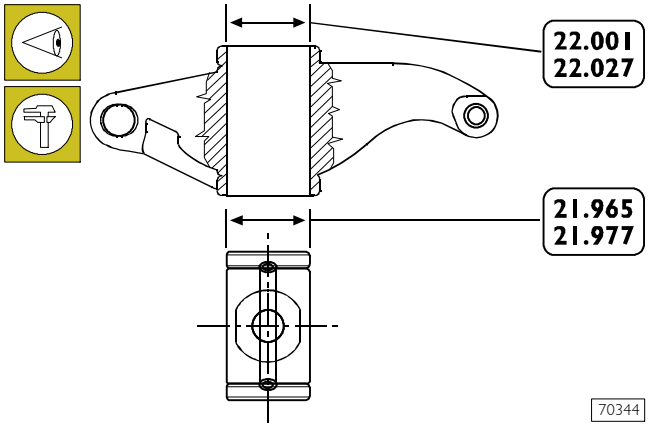
Figure 28



ROCKER ARM ASSEMBLY COMPONENTS:

1. Screws - 2. Bracket - 3. Shafts - 4. Rocker arms

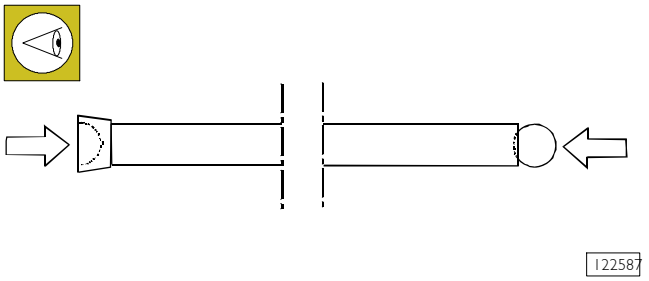
Figure 29



SHAFT-ROCKER MAIN DATA

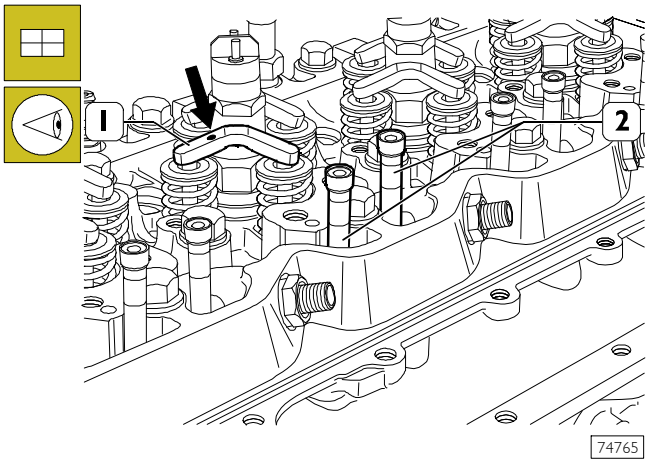
Check that shaft/rocker arm coupling surfaces are not excessively worn or damaged.

Figure 30



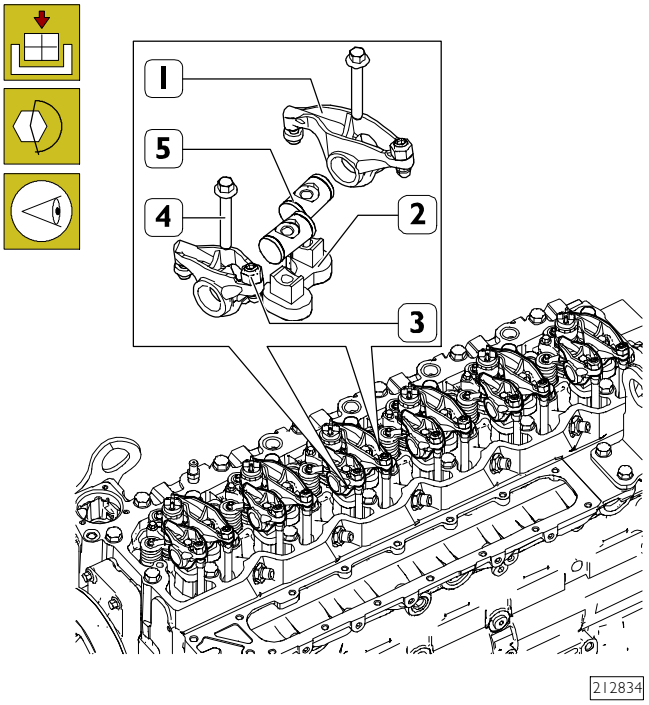
The control rods of the rocker arms must have no deformations; the spherical seats for contact with the rocker arm adjustment screw and with the tappets (arrows) must show no trace of seizure or wear; if they do, replace them. The intake and exhaust valve control rods are identical and are therefore interchangeable.

Figure 31



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

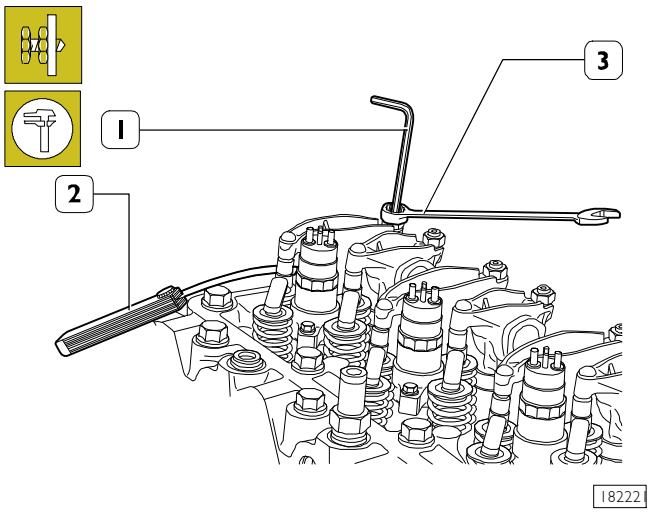
Figure 32



Check that tappet adjusters screws and retaining nuts (3) are loose to prevent their balking on the rods when refitting the rocker assembly.
Install the rocker unit consisting of bracket (2), rockers (1), shafts (5) and secure them to the cylinder head by tightening the fastening screws (4) to the prescribed torque.

Ref	No.	Description	Tightening torques
(4)	12	M8x1.25	36 ± 5 Nm

Figure 33



The adjustment of the clearance between the rocker arms and the intake and exhaust valves must be strictly carried out using an Allen wrench (1), box-end wrench (3) and a feeler gauge (2).
Clearance shall be as follows:

- ❑ intake valves 0.25 ± 0.05 mm
- ❑ exhaust valves 0.50 ± 0.05 mm.

NOTE In order to perform the rocker arm - valve clearance adjustment more quickly, proceed as follows:

- ❑ Rotate the crankshaft, balance the valves of cylinder no. 1 and adjust the valves marked by the asterisk as shown in the tables below:

cylinder no.	1	2	3	4	5	6
intake	-	-	*	-	*	*
exhaust	-	*	-	*	-	*

- ❑ Rotate the crankshaft, balance the valves of cylinder no. 6 and adjust the valves marked by the asterisk as shown in the tables below:

cylinder no.	1	2	3	4	5	6
intake	*	*	-	*	-	-
exhaust	*	-	*	-	*	-

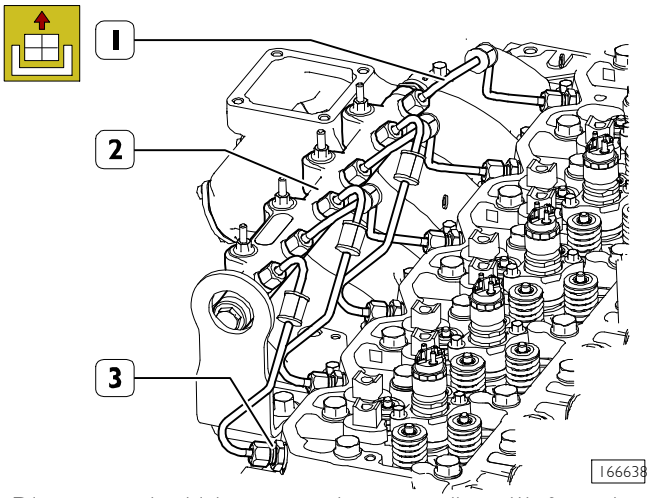
Install the injector wiring support as described in the relative section.
Install the tappet cover as described in the relative section.

INJECTOR REMOVAL AND INSTALLATION

Removal

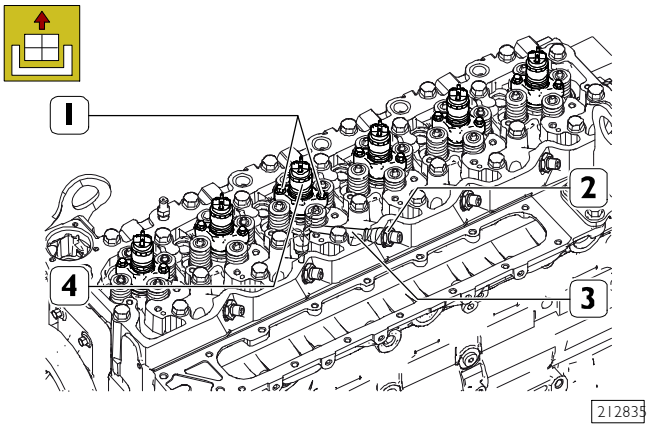
Remove the tappet cover as described in the relative section.
Remove the injector wiring support as described in the relative section.
Remove the rocker arm assembly as described in the relative section.
Position a suitable container to catch any fuel.

Figure 34



Disconnect the high pressure hose couplings (1) from the common rail (2) and injector manifolds (3), then remove them.

Figure 35

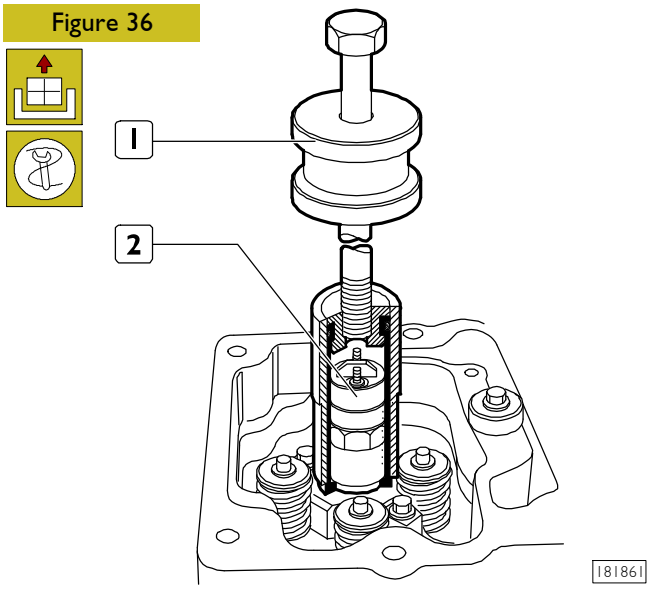


Undo the fastening nuts (2) and remove the fuel manifolds (3).
Unscrew the electro-injector (4) fastening screws (1).

Ref	No.	Description
(1)	12	M6x1x35
(2)	6	M22x1.5x9.5

NOTE Disassembled fuel manifolds (2) must not be used again, but replaced with new ones.

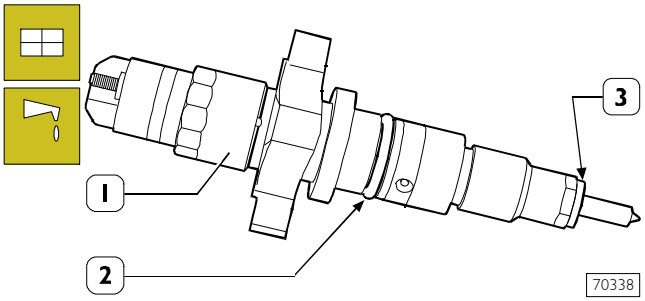
Figure 36



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

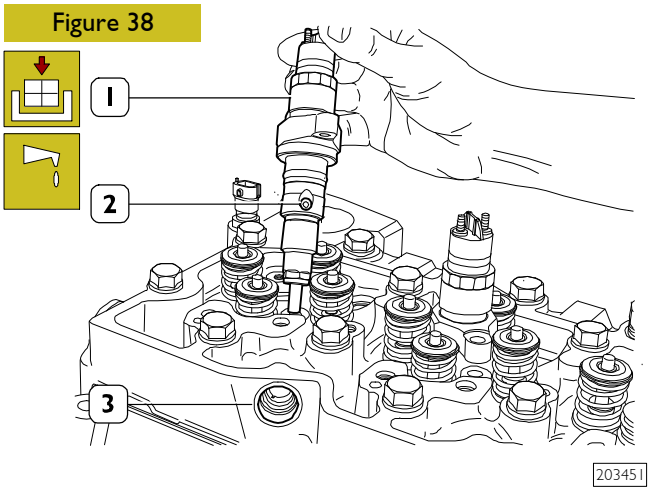
Installation

Figure 37



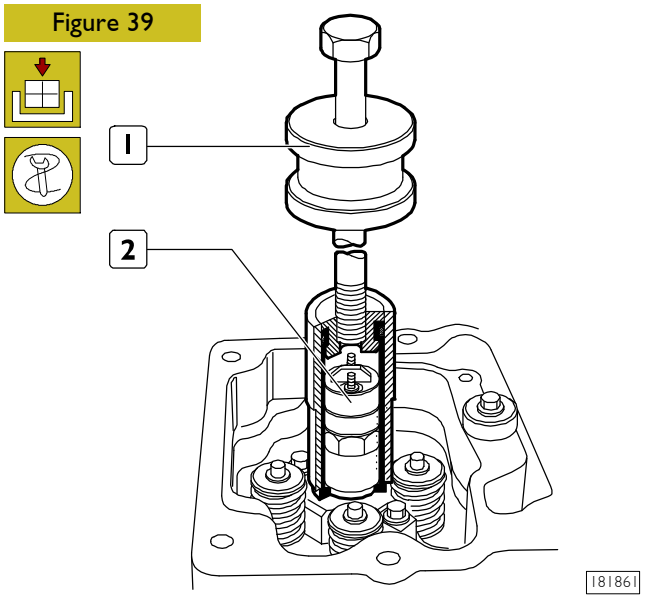
Fit a new seal ring (2) lubricated with vaseline and a new washer (3) on the injector (1).

Figure 38



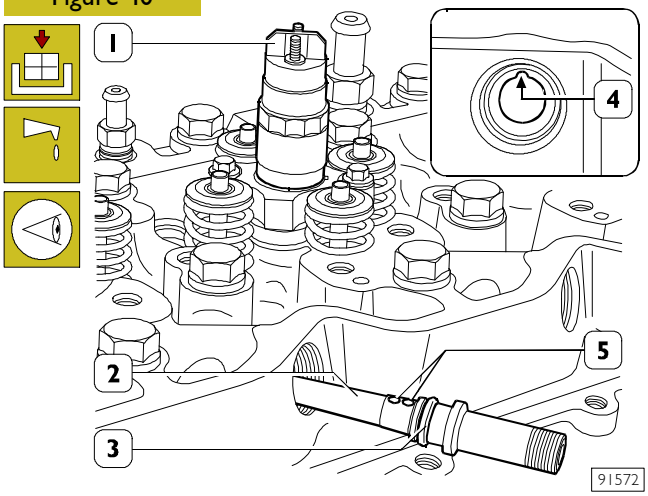
Place the injectors (1) in position on the cylinder head seats so that the fuel inlet hole (2) is facing the fuel manifold seat (3) side.

Figure 39



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

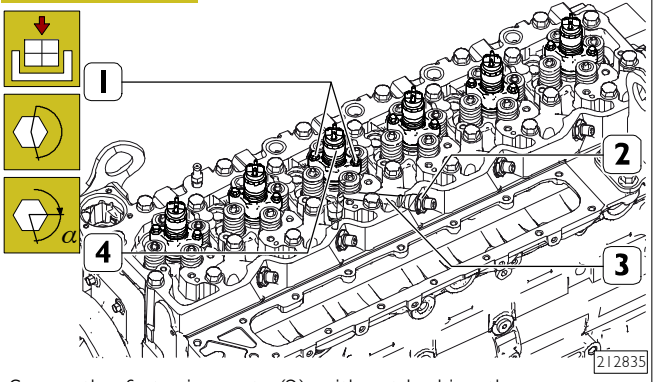
Figure 40



Fit a new seal ring (3), lubricated with Vaseline, onto a new fuel manifold (2).
Position the fuel manifold in place on the cylinder head seat so that the positioning balls (5) coincide with the relevant housing (4).

NOTE Fuel manifolds (2) must not be reused after removal but rather replaced with new ones.

Figure 41

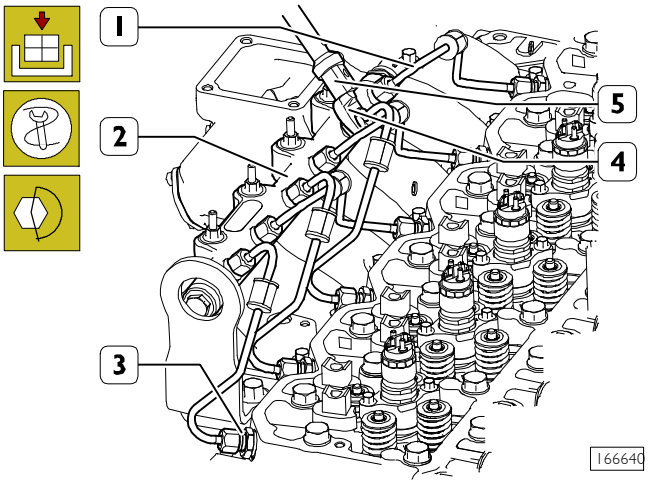


Screw the fastening nuts (2) without locking them;
Tighten gradually and alternately the electro-injector (4) fastening screws (1) to the prescribed torque in four stages;
Tighten the fuel manifold (3) fastening nuts (2) to the prescribed torque.

Ref	No.	Description	Tightening torques
(1)	12	M6x1x35 1st phase 2nd phase 3rd phase 4th phase	3.5 ± 0.35 Nm 25° 25° 25°
(2)	6	M22x1.5x9.5	55 ± 5 Nm

NOTE During this operation, manoeuvre the injector (4) so that the manifold (3) is properly inserted into the injector fuel inlet hole.
Tightening to angle is performed using tool 99395216.

Figure 42



Place the new high pressure fuel hoses (1) in position and tighten the couplings to the electro-injector collectors (3) and the common rail (2) to the specified torque.

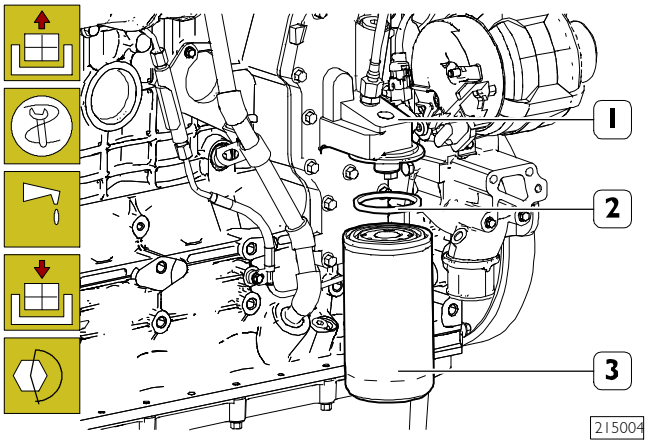
NOTE The hoses (1), as they are subject to high pressure, must be replaced every time they are removed. The hose couplings must be tightened to a torque of 24 ± 4 Nm, using spanner 99317915 (4) and torque wrench 99389829 (5).

Install the rocker arm assemblies, the injector wiring support and the tappet cover as described in the relative sections.

ENGINE OIL FILTER REMOVAL AND INSTALLATION

Removal

Figure 43



Place a container for collecting the spent oil under the filter support (1).
Unscrew and remove the oil filter (3) from its relative support (1) by tool 99360076.

Ref	No.	Description
(3)	1	M27x2

Installation

Moisten the sealing gasket (2) of the oil filter (3) with a thin layer of oil.
Manually tighten the oill filter (3) on the support (1) until it comes into contact with the gasket (2).
Additionally tighten the oil filter (3) to the prescribed torque using a specific tool.
Operate the engine for a few minutes and then check the level using the dipstick. If necessary, top up to compensate for the quantity of oil used to fill up the filtering cartridge.

Ref	No.	Description	Tightening torques
(3)	1	M27x2	18 ± 2 Nm

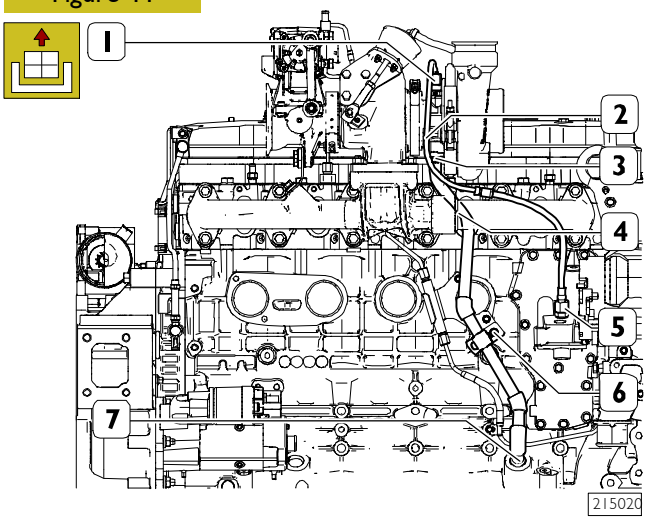
TURBOCHARGER REMOVAL AND INSTALLATION

Removal

Remove the engine oil filter as described in the relative procedure. Disconnect the engine cable from the motorized throttle valve, as described in the relative procedure.

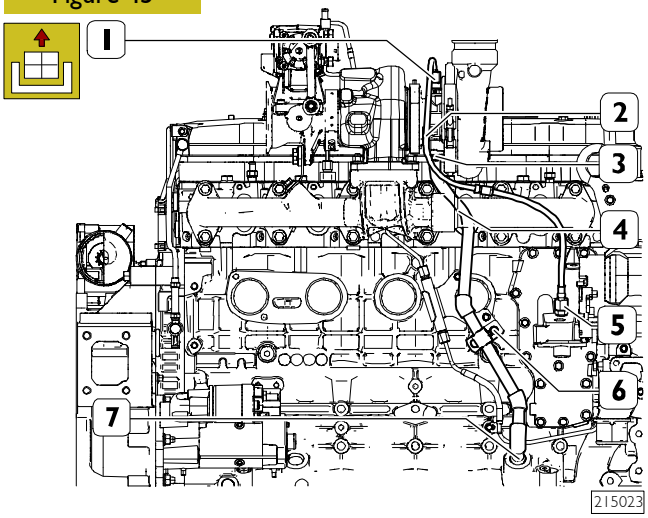
(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

Figure 44



(F4HFE613N*B002 - F4HFE613N*B003)

Figure 45



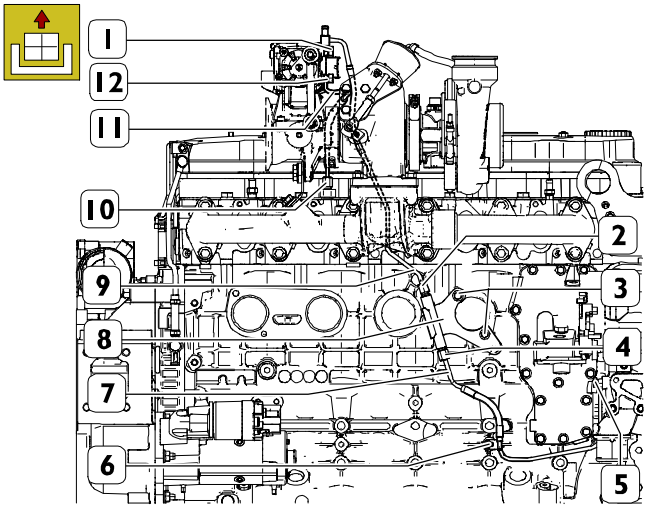
Position a suitable container to catch any oil.
Unscrew the hose couplings (1 and 5) and remove the lubrication oil delivery pipe (2) from the upper part of the heat exchanger to the turbocharger.
Remove the lubrication oil discharge pipe (4) from the turbocharger by proceeding as follows:

- ❑ unscrew the fastening screws (3) in the lower part of the turbocharger, recovering the relevant gasket;
- ❑ unscrew the screw (6) that retain the piping (4) to the block by means of the fastening collar;
- ❑ unscrew the coupling (7) from the crankcase.

Ref	No.	Description
(1,5)	2	11/16-16 (M16)
(3)	2	M8x1.25x25
(6)	1	M8x1.25x16

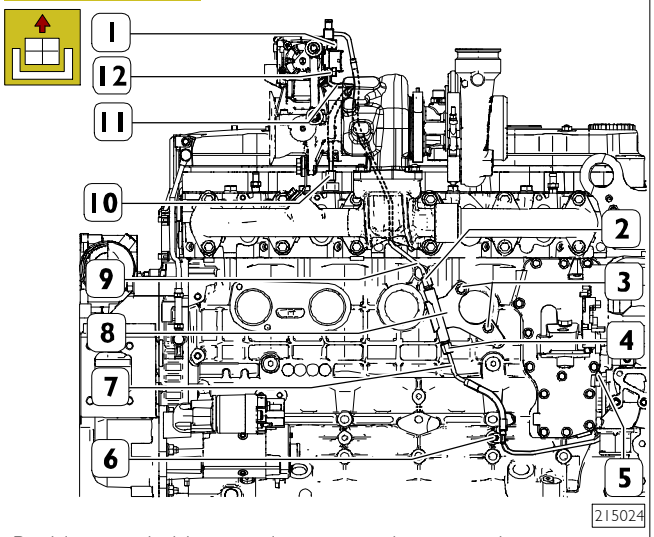
(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

Figure 46



(F4HFE613N*B002 - F4HFE613N*B003)

Figure 47



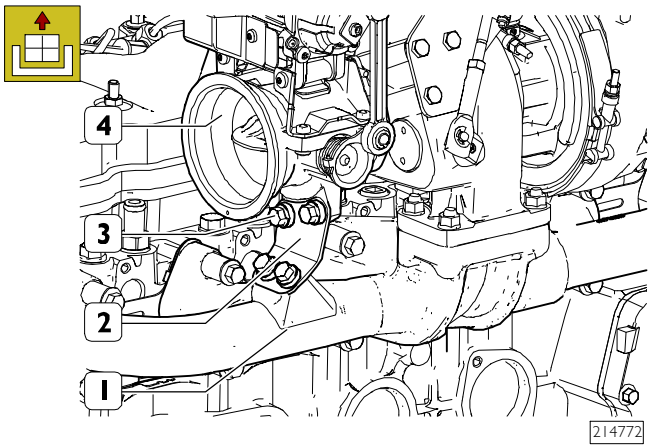
Position a suitable container to catch any coolant.
Remove the motorized throttle valve water inlet and outlet pipes by proceeding as follows:

- ❑ unscrew the fastening nut (2) and connector (1) and remove the upper-part water return pipe (9);
- ❑ unscrew the fastening nut (4), connector (5) and screw (6) and remove the lower-part water return pipe (7);
- ❑ unscrew the fastening screws (3) and remove the water return pipe union (8);
- ❑ unscrew the fastening nut (10) and connector (12) and remove the water delivery pipe (11).

Ref	No.	Description
(1,12)	2	M10x1
(2,4,10)	3	M12x1.5
(3)	2	M8x20
(5)	1	M10x1
(6)	1	M8x16

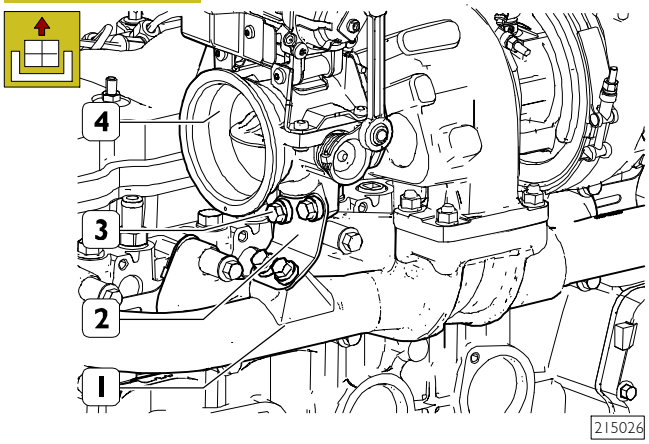
(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

Figure 48



(F4HFE613N*B002 - F4HFE613N*B003)

Figure 49

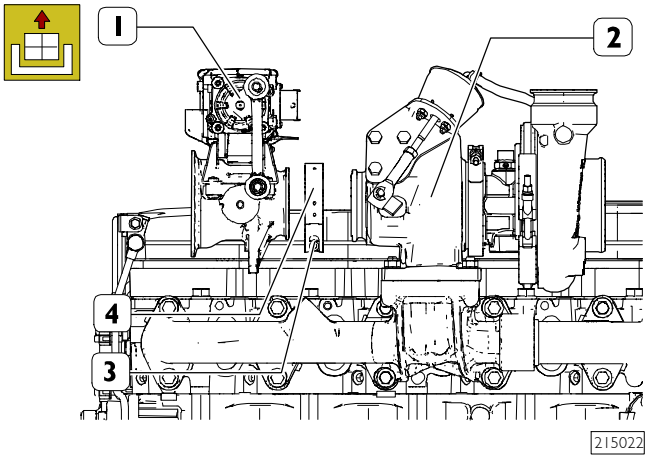


Unscrew the fastening screws (3) and remove the bracket (2) fixing the motorized throttle valve (4) to the exhaust manifold (1).

Ref	No.	Description
(3)	4	M8x1.25x25

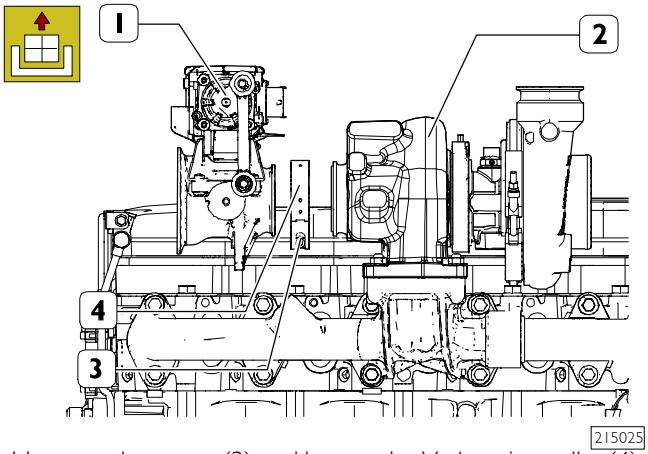
(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

Figure 50



(F4HFE613N*B002 - F4HFE613N*B003)

Figure 51

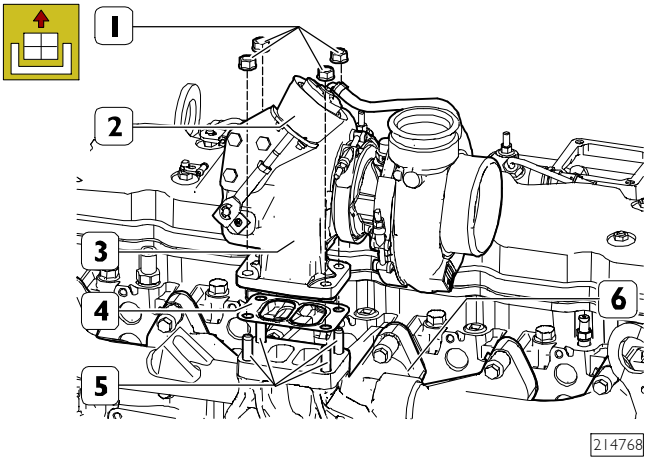


Unscrew the screw (3) and loosen the V-clamping collar (4) to remove the motorized throttle valve (1) from the turbocharger (2).

Ref	No.	Description
(3)	1	M6x1x50

(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

Figure 52

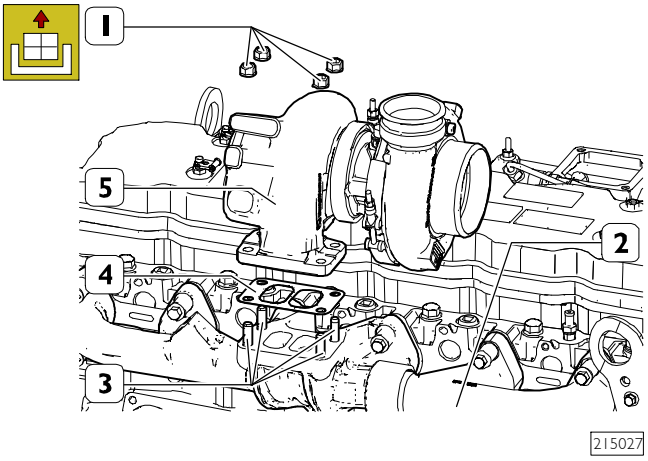


Unscrew the fastening nuts (1) and remove the turbocharger (3) together with the waste-gate valve (2), recovering the relevant gasket (4).
Unscrew the studs (5) from the exhaust manifold (6).

Ref	No.	Description
(1)	4	M10
(5)	4	M10x1.5x42

(F4HFE613N*B002 - F4HFE613N*B003)

Figure 53



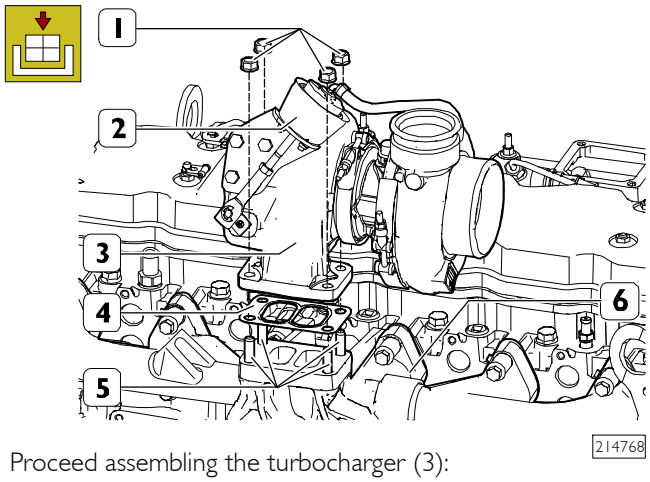
Unscrew the fastening nuts (1) and remove the turbocharger (5), recovering the relevant gasket (4).
Unscrew the studs (3) from the exhaust manifold (2).

Ref	No.	Description
(1)	4	M10
(3)	4	M10x1.5x42

Installation

(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

Figure 54



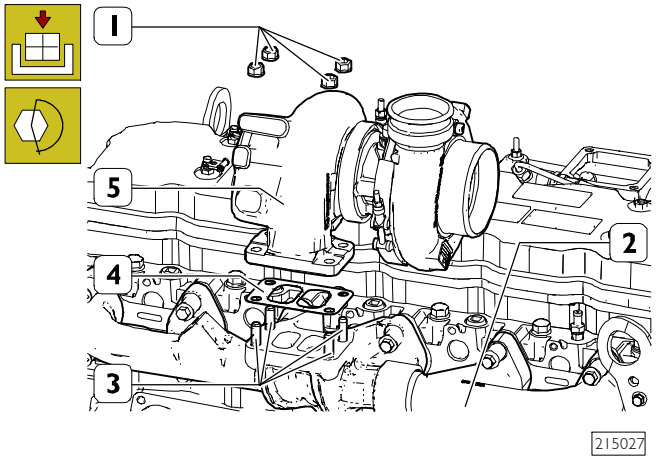
Proceed assembling the turbocharger (3):

- ❑ screw the studs (5) on the exhaust manifold (6);
- ❑ hold the turbocharger (3) together with the waste-gate valve (2) and place it on the exhaust manifold (6) after having interposed a new gasket (4);
- ❑ tighten the fastening nuts (1) to the prescribed torque.

Ref	No.	Description	Tightening torques
(1)	4	M10	43 ± 6 Nm
(5)	4	M10x1.5x42	25 ± 5 Nm

(F4HFE613N*B002 - F4HFE613N*B003)

Figure 55



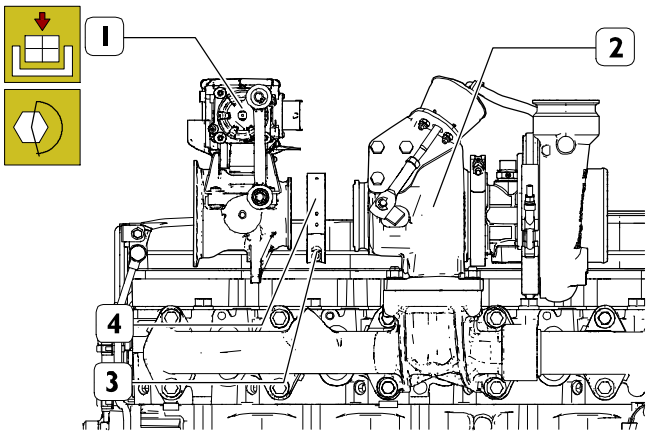
Proceed assembling the turbocharger (5):

- ❑ screw the studs (3) on the exhaust manifold (2);
- ❑ hold the turbocharger (5) and place it on the exhaust manifold (2) after having interposed a new gasket (4);
- ❑ tighten the fastening nuts (1) to the prescribed torque.

Ref	No.	Description	Tightening torques
(1)	4	M10	43 ± 6 Nm
(3)	4	M10x1.5x42	25 ± 5 Nm

(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

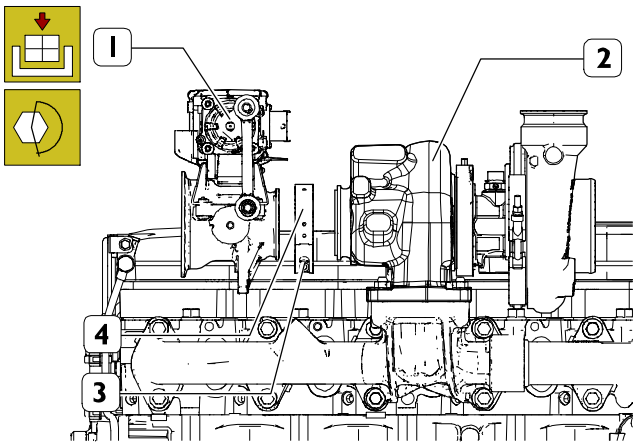
Figure 56



215022

(F4HFE613N*B002 - F4HFE613N*B003)

Figure 57



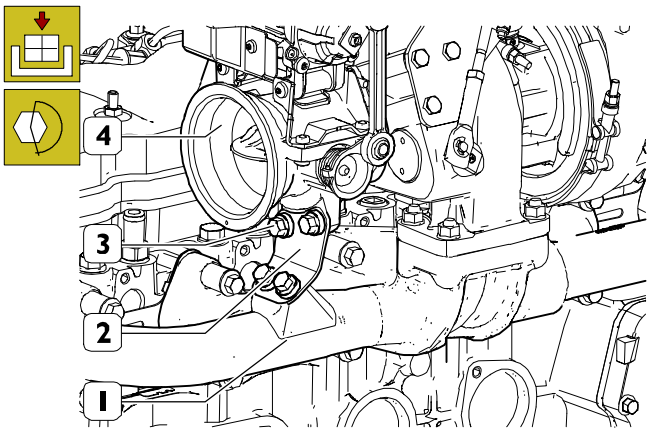
215025

Install the motorized throttle valve (1) onto the turbocharger (2).
Screw the screw (3) and tighten the V-clamping collar (4) to the prescribed torque.

Ref	No.	Description	Tightening torques
(3)	1	M6x1x50	10 ± 2 Nm

(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

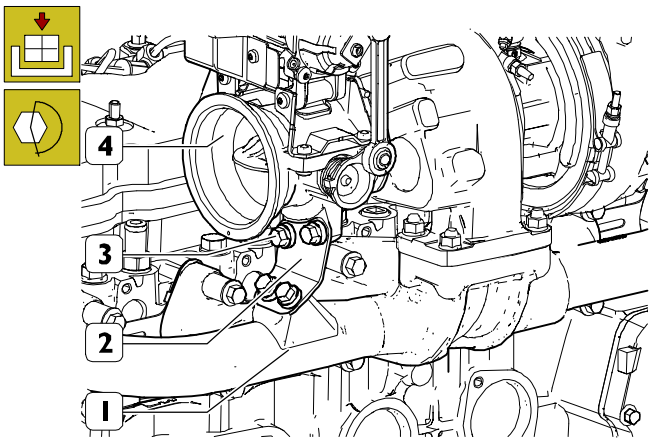
Figure 58



214772

(F4HFE613N*B002 - F4HFE613N*B003)

Figure 59



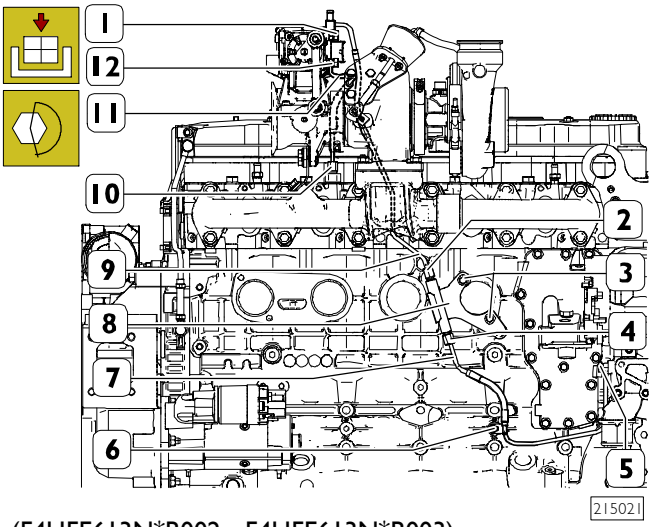
215026

Assemble the bracket (2) fixing the motorized throttle valve (4) to the exhaust manifold (1) and tighten the fastening screws (3) to the prescribed torque.

Ref	No.	Description	Tightening torques
(3)	4	M8x1.25x25	25 Nm

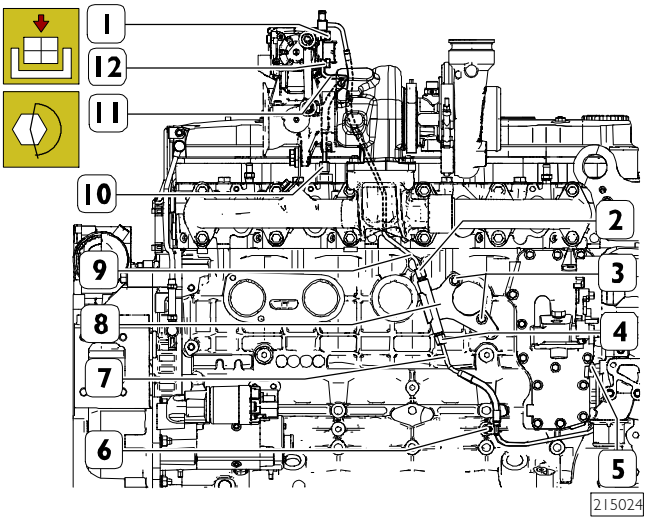
(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

Figure 60



(F4HFE613N*B002 - F4HFE613N*B003)

Figure 61



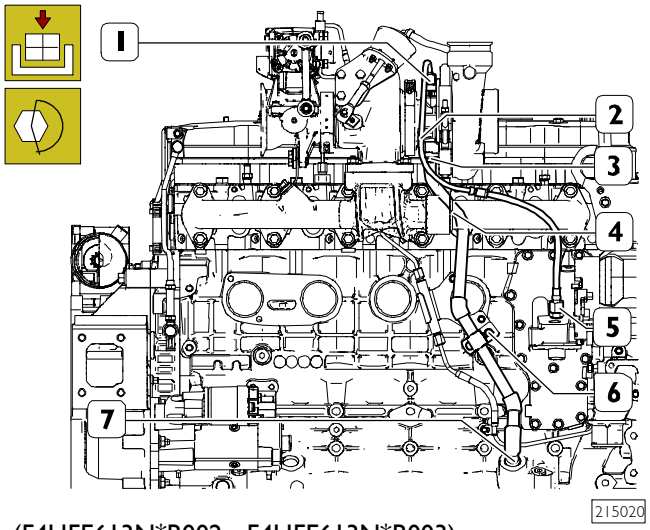
Install the motorized throttle valve water inlet and outlet pipes by proceeding as follows:

- ❑ fit the water delivery pipe (11) and tighten the fastening nut (10) and connector (12) to the prescribed torque;
- ❑ fit the water return pipe union (8) and tighten the fastening screws (3) to the prescribed torque;
- ❑ fit the lower-part water return pipe (7) and tighten the fastening nut (4), connector (5) and screw (6) to the prescribed torque;
- ❑ fit the upper-part water return pipe (9) and tighten the fastening nut (2) and connector (1) to the prescribed torque.

Ref	No.	Description	Tightening torques
(1,12)	2	M10x1	20 Nm
(2,4,10)	3	M12x1.5	45 Nm
(3)	2	M8x20	23 ± 2.3 Nm
(5)	1	M10x1	25 Nm
(6)	1	M8x16	23 ± 2.3 Nm

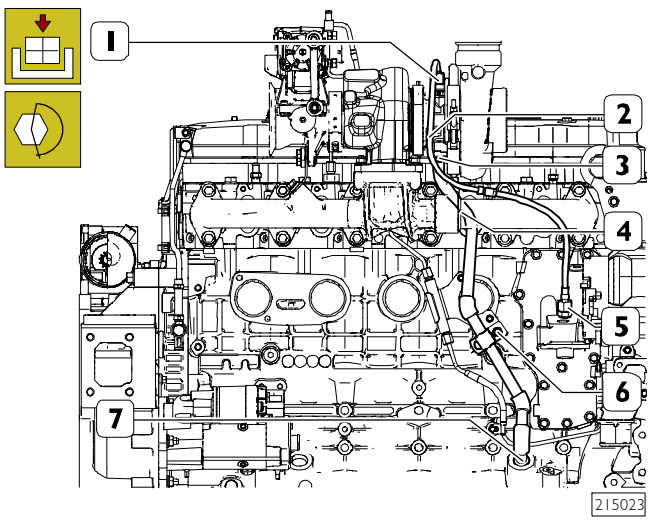
(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

Figure 62



(F4HFE613N*B002 - F4HFE613N*B003)

Figure 63



Install the lubrication oil discharge pipe (4) onto the turbocharger by proceeding as follows:

- ❑ screw the coupling (7) on the crankcase;
- ❑ screw the fastening screws (3) in the lower part of the turbocharger, after fitting a new gasket;
- ❑ screw the screw (6) that retain the piping (4) to the block by means of the fastening collar.

Fit the lubrication oil delivery pipe (2) from the upper part of the heat exchanger to the turbocharger and tighten the hose couplings (1 and 5) to the prescribed torque.

Ref	No.	Description	Tightening torques
(1,5)	2	11/16-16 (M16)	36 ± 5 Nm
(3)	2	M8x1.25x25	23 ± 2 Nm
(6)	1	M8x1.25x16	23 ± 2 Nm

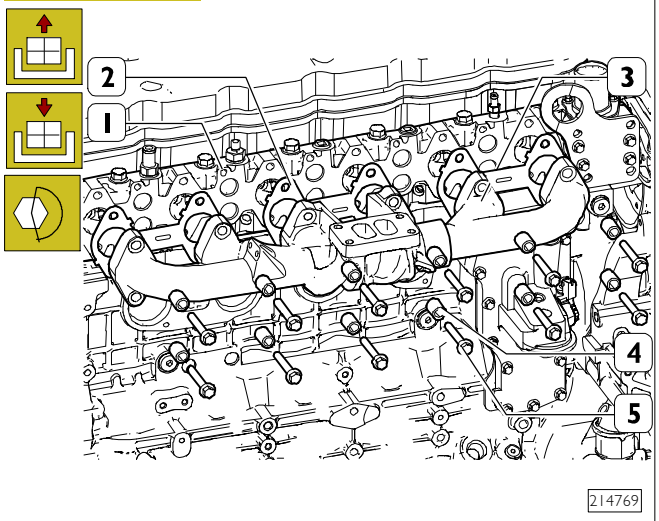
Connect the engine cable to the motorized throttle valve, as described in the relative procedure.
Install the engine oil filter as described in the relative procedure.

EXHAUST MANIFOLD REMOVAL AND INSTALLATION

Removal

Remove the turbocharger as described in the relative section.

Figure 64



Unscrew the screws (5) together with spacers (4) and remove the exhaust manifold (3) complete with relevant gaskets (2) from the cylinder head (1).

Ref	No.	Description
(5)	12	M10x1.5x65

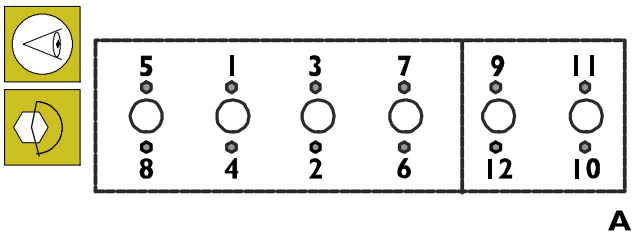
Installation

- ❑ Fit new gaskets (2) on the exhaust manifold (3);
- ❑ Assemble the exhaust manifold (3) on the cylinder head (1) and tighten the fastening screws (5) together with spacers (4) to the prescribed torque following order and mode shown in the figure below.

Ref	No.	Description	Tightening torques
(5)	12	M10x1.5x65	55 ± 3 Nm

Install the turbocharger as described in the relative section.

Figure 65



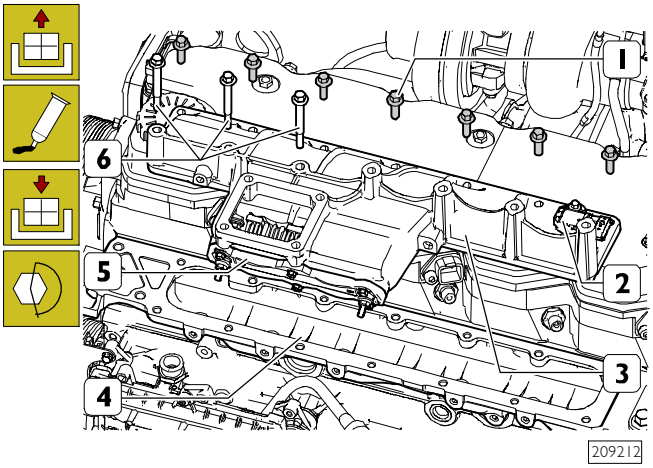
Tightening order layout for exhaust manifold fastening screws.
A = Front side

INTAKE MANIFOLD REMOVAL AND INSTALLATION

Removal

Remove the common rail as described in the relative section. Disconnect the cold-start heater electrical connections (if fitted).

Figure 66



Unscrew the fastening screws (1 and 6) and remove the intake manifold (3) together with the boost pressure and air temperature sensor (2) from the cylinder head (4).

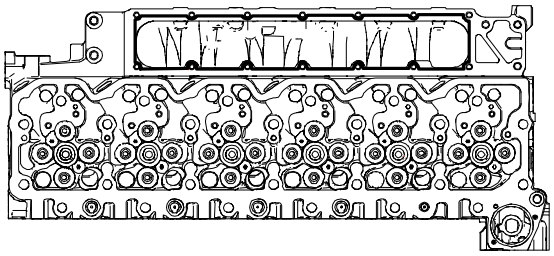
Ref	No.	Description
(1)	7	M8x1.25x25
(6)	3	M8x1.25x70

Installation

Fit the intake manifold (3) together with the boost pressure and air temperature sensor (2) on the cylinder head (4) and tighten the fastening screws (1 and 6) to the prescribed torque.

Ref	No.	Description	Tightening torques
(1)	7	M8x1.25x25	24 ± 4 Nm
(6)	3	M8x1.25x70	24 ± 4 Nm

Figure 67



209211

Carefully clean the contact surfaces and apply a continuous sealant bead of LOCTITE 5970 to the surface of the cylinder head as shown in the figure below.

NOTE Perfect seal is only obtained by cleaning accurately the surface to seal. Smear with LOCTITE 5970 to obtain a bead of few mm diameter. It shall be uniform (no clots), without air bubbles, thin areas or discontinuities. Any imperfection shall be corrected as soon as possible. Avoid to use excess material to seal the joint. Excessive sealant could come out from joint sidesand cause lubricant passage clogging. After applying the sealant, the joint shall be assembled immediately (10 - 20 minutes).

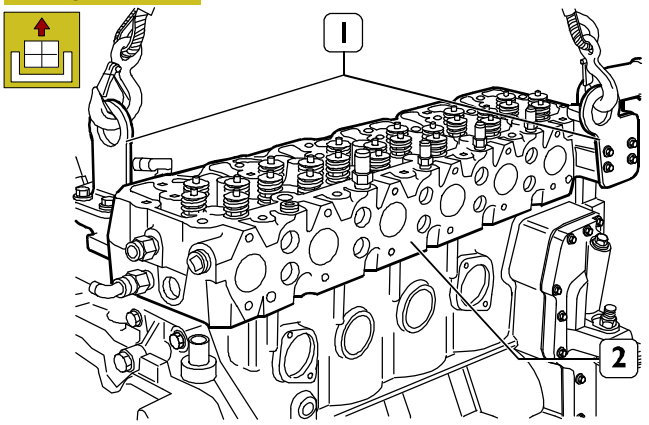
Install the common rail as described in the relative section.
Connect the cold-start heater electrical connections (if fitted).

CYLINDER HEAD REMOVAL AND INSTALLATION

Removal

Remove the engine cable as described in the relative section.
Remove the thermostat as described in the relative section.
Remove the common rail as described in the relative section.
Remove the rocker arm assembly as described in the relative section.
Remove the injectors as described in the relative section.
Remove the turbocharger as described in the relative section.
Remove the exhaust manifold as described in the relative section.
Remove the intake manifold as described in the relative section.

Figure 68

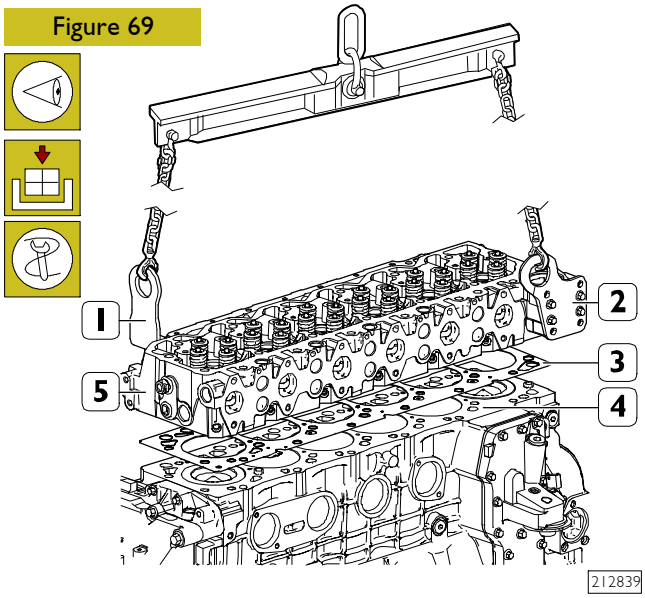


74779

Undo the retaining screws, hook metal cables onto the brackets (1) and remove the cylinder head (2) from the engine block using a hoist.
Remove the head gasket.

Installation

Figure 69



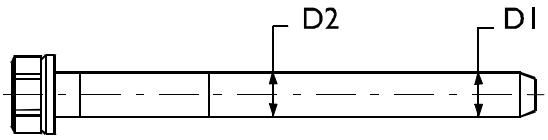
Use suitable lifting hooks (1 and 2) in order to lift and fit the cylinder head (5) on the engine block (4) after having interposed a new gasket (3) by using a hoist with tool 99360595.

NOTE Clean the cylinder head (5) and engine block (4) contact surfaces.
There are two types of head gasket:
- Type A 1.25 mm thick
- Type B 1.15 mm thick

Check the average projection S of the pistons:
If S > 0.40 mm use gasket type A.
If S ≤ 0.40 mm use gasket type B.
Take care not to get the cylinder head gasket dirty.
Arrange a new cylinder head gasket (3) on the engine block with the marking "TOP" facing the head.
The arrow shows the point where the gasket thickness is marked.

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

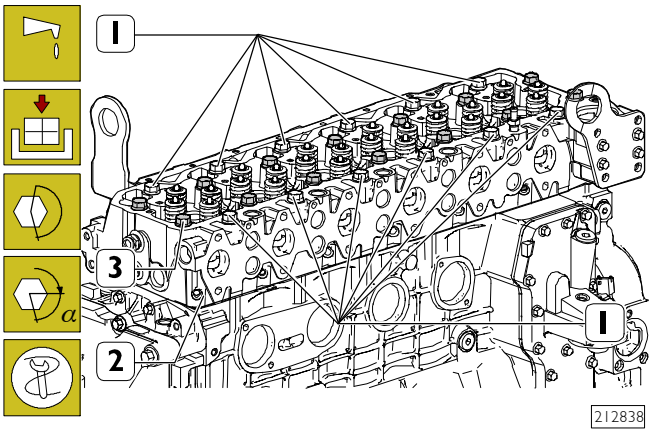
Figure 70



NOTE Before re-using retaining screws (1) measure diameters D1 and D2 as shown in the figure:
- ❑ if D1-D2 < 0.1 mm the screw can be reused
- ❑ if D1-D2 > 0.1 mm the screw must be replaced

Always check that the threads on the screws and their holes do not show any signs of wear or traces of dirt before fitting.

Figure 71



After having correctly positioned the gasket on the crankcase, assemble the cylinder head (2) and tighten the fastening screws (1 and 3) in three phases, following order and mode shown in the figure below.

Ref	No.	Description	Tightening torques
(1)	12	M12x1.75x130 1st phase 2nd phase 3rd phase	 35 ± 5 Nm 90° 90°
(3)	14	M12x1.75x150 1st phase 2nd phase 3rd phase	 55 ± 5 Nm 90° 90°

NOTE The screws (1 and 3) must be lubricated before being mounted on the cylinder head (2).
The screws (1 and 3) must be tightened following a "spiral" pattern starting in the middle and going outwards.
Use tool 99395216 for angle tightening.

Figure 72

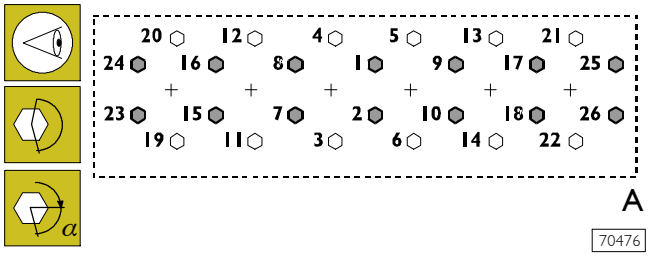


Diagram of the tightening sequence for the cylinder head fixing screws.
A = Front side

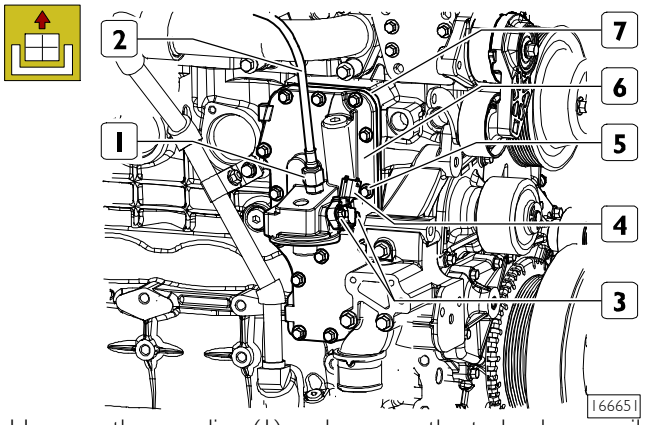
Install the intake manifold as described in the relative section.
Install the exhaust manifold as described in the relative section.
Install the turbocharger as described in the relative section.
Install the injectors as described in the relative section.
Install the rocker arm assemblies as described in the relative chapter.
Install the common rail as described in the relative section.
Install the thermostat as described in the relative section.
Install the engine cable as described in the relative section.

REMOVAL AND INSTALLATION ENGINE OIL HEAT EXCHANGER

Removal

Remove the auxiliary components drive belt as described in the relative procedure.
Remove the alternator as described in the relative section.
Position a suitable container to catch any engine oil.
Remove the engine oil filter as described in the relative section.

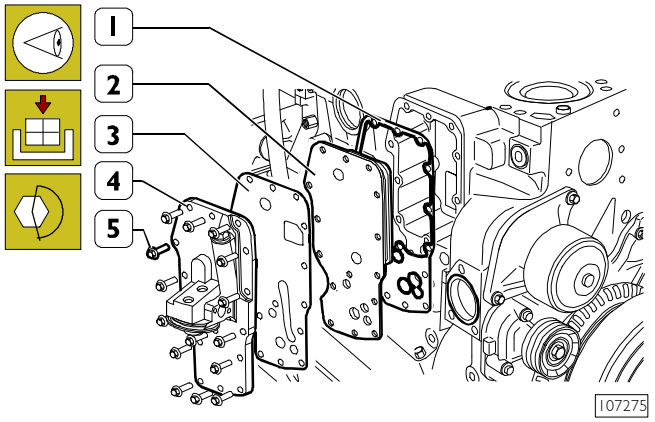
Figure 73



Unscrew the coupling (1) and remove the turbocharger oil delivery pipe (2).
Remove the screws (3) and the oil pressure / temperature sensor (4).
Remove the screws (5) and disassemble the oil filter / heat exchanger bracket (6), intermediate plate (6) and relative gaskets.

Installation

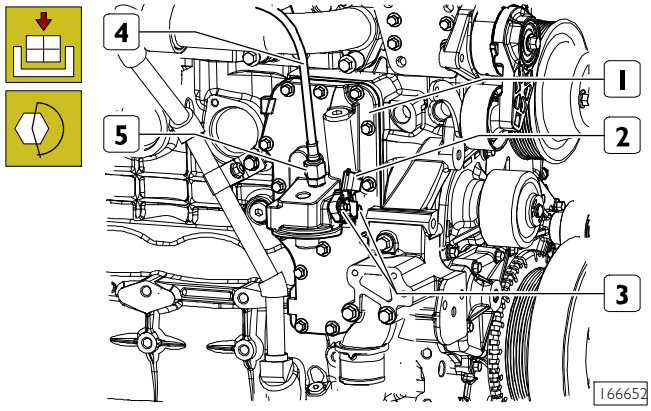
Figure 74



Fit the following on the engine block: a new gasket (1), the heat exchanger (2) a new gasket (3) and the oil filter bracket (4).
Tighten the screws (5) to the specified torque.

NOTE Always check that the threads on the screws and their holes do not show any signs of wear or traces of dirt before fitting.

Figure 75



Place the oil temperature/pressure sensor (2) in position on the bracket (1) with a new seal ring then screw in the retaining screws (3) and tighten them to the specified torque.
Install the oil delivery pipe (1), screwing on the coupling (2).
Install the engine oil filter as described in the relative section.
Install the alternator as described in the relative section.
Install the auxiliary components drive belt as described in the relative procedure.
Check the oil level with the dipstick: the level must be near the MAX mark on the dipstick.
If it is much below this level, top up with the necessary quantity.

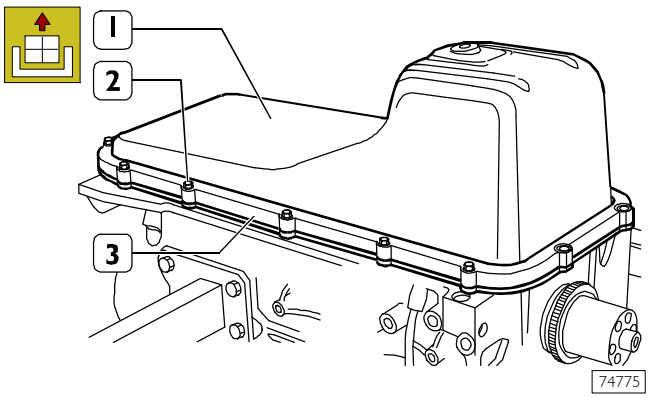
OIL SUMP REMOVAL AND INSTALLATION

Removal

Place a suitable container under the oil sump drain plug to catch the oil.
Open the oil filler on the cylinder head and remove the dipstick to aid the flow of oil.
Unscrew the drain plug and let the oil in the sump drain completely.

NOTE It is recommended to drain the oil when the engine is hot.

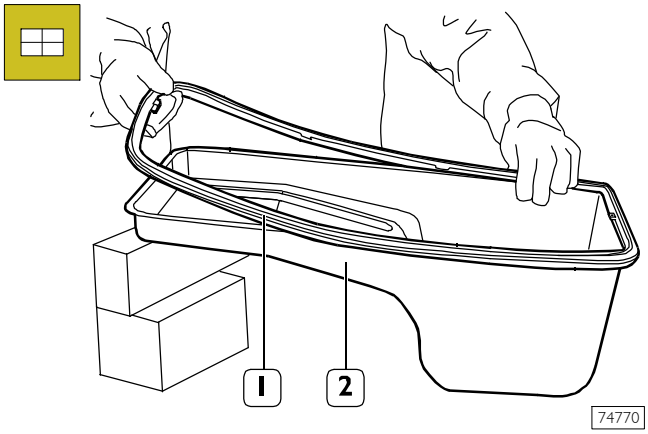
Figure 76



Undo the screws (2) then remove the plate (3) and oil sump (1), retaining the gasket.

Installation

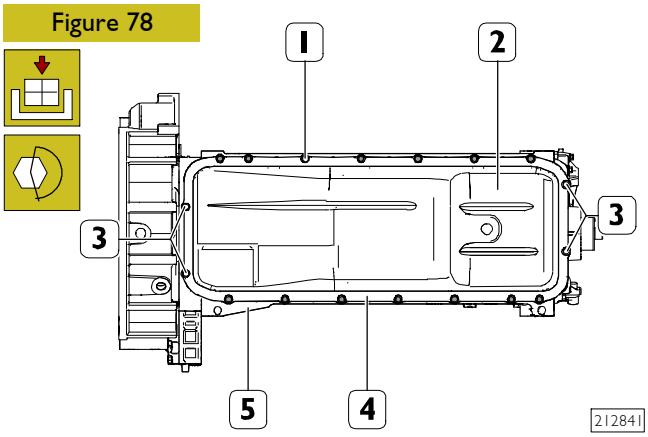
Figure 77



Set the gasket (1) on the oil sump (2).

NOTE If it does not show any signs of damage the gasket can be reused.

Figure 78



Fit the oil sump (2) in position on the crankcase (5) and apply the relevant plate (4) to it.
Tighten the fastening screws (1 and 3) to the prescribed torque.
Screw on the drain plug with a new washer and proceed to fill with clean oil.

Ref	No.	Description	Tightening torques
(1)	14	M8x1.25x40	25 Nm
(3)	4	M8x1.25x45	25 Nm

Use only recommended oils or those with the required characteristics to ensure correct operation of the engine.
Failure to observer these requirements shall void the guarantees.

Check the oil level with the dipstick: the level must be near the MAX mark on the dipstick.
If it is much below this level, top up with the necessary quantity.

SECTION 6

General mechanical overhauling

INTRODUCTION

The following description covers general mechanical overhaul starting from the engine which has been removed from the vehicle.

NOTE Refer to the specific publication for removing the engine from the vehicle.
Engine removal operations, as with overhauling, must be carried out by specialised personnel with specific equipment.

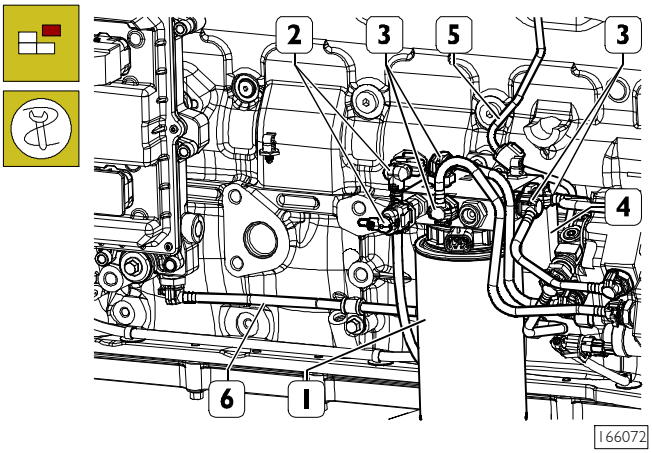
This section contains:

- ❑ the operations to perform for mounting the engine on the rotating stand,
- ❑ the sequence of removal operations for the main components,
- ❑ overhaul of the engine block and the cylinder head,
- ❑ the sequence of refitting operations for the main components,
- ❑ operations required for completing engine assembly after removal from the rotating stand,
- ❑ final checks and tests.

Part of the operations covered in this section can be performed directly on the engine still fitted in the vehicle, in relation to their accessibility in the engine compartment and on the vehicle version; these are listed in Section 5 - Removal-refitting of main engine components.

FITTING THE ENGINE TO THE ROTATING STAND

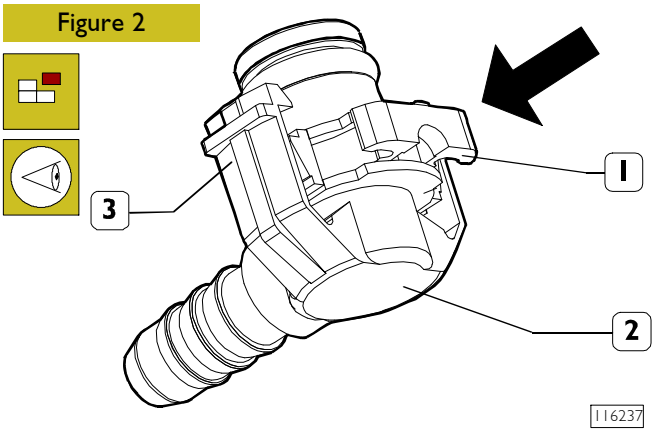
Figure 1



To apply the brackets 99361037 to the engine block for fastening the engine to the overhaul stand, proceed as follows, working from the left side of the engine:

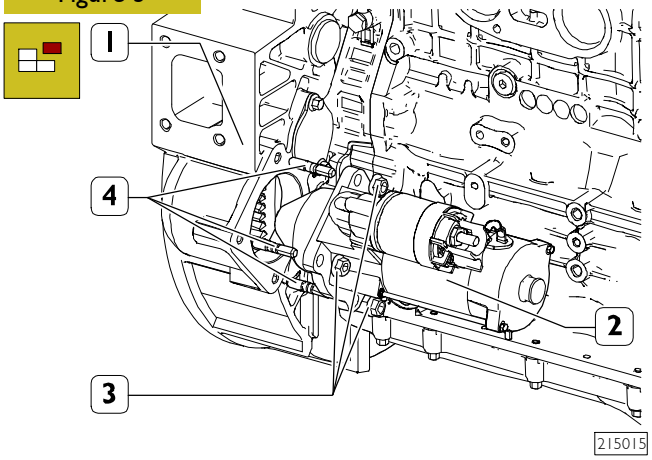
- ❑ Position a suitable container to catch any fuel.
- ❑ Using tool 99360076, remove the fuel filter (1) from its support.
- ❑ Unplug the fuel temperature sensor and the camshaft timing sensor electrical connections (2).
- ❑ Disconnect the low-pressure fuel hoses (3) from the filter support.
- ❑ Unscrew the fastening screws and remove the fuel filter support (4) complete with the bracket, if fitted, from the engine block.

Figure 2



To disconnect the low pressure fuel hose from the relevant connecting joint, you need to keep the clasp (1) pressed, and release the quick fitting joint (2).

Figure 3



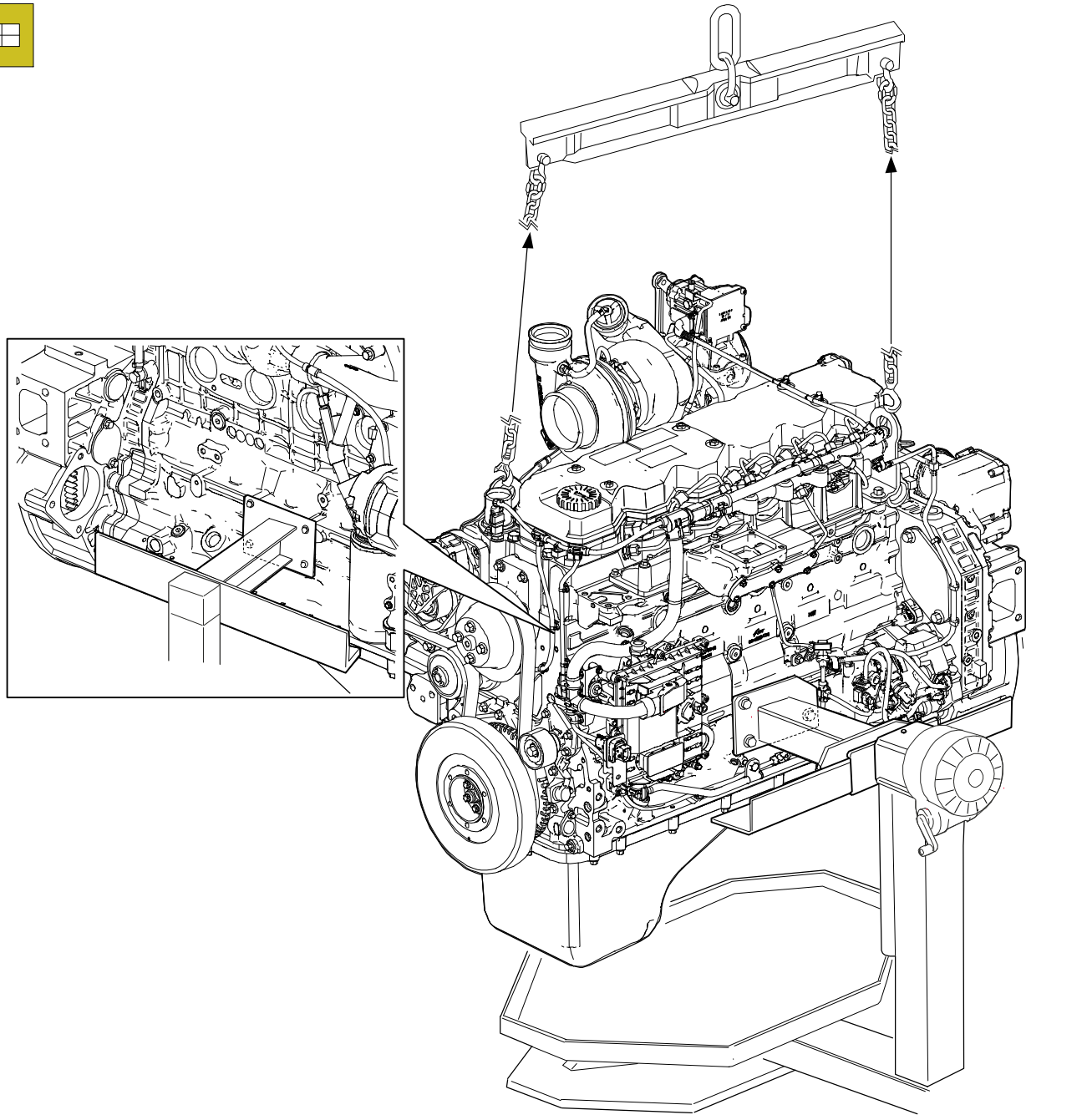
Ensure that the electric starter motor (2) is suitably supported.
Unscrew the fastening nuts (3) and remove the electric starter motor (2).
Unscrew the studs (4) from the flywheel housing (1).

Ref	No.	Description
(3)	3	M10x1.5
(4)	3	M10x1.5x50

Fit brackets 99361037 to the engine block and use these to secure the engine to the rotating stand 99322205.
Drain the oil from the engine by removing the plug from the oil sump.

Dispose of the oil according to applicable laws.

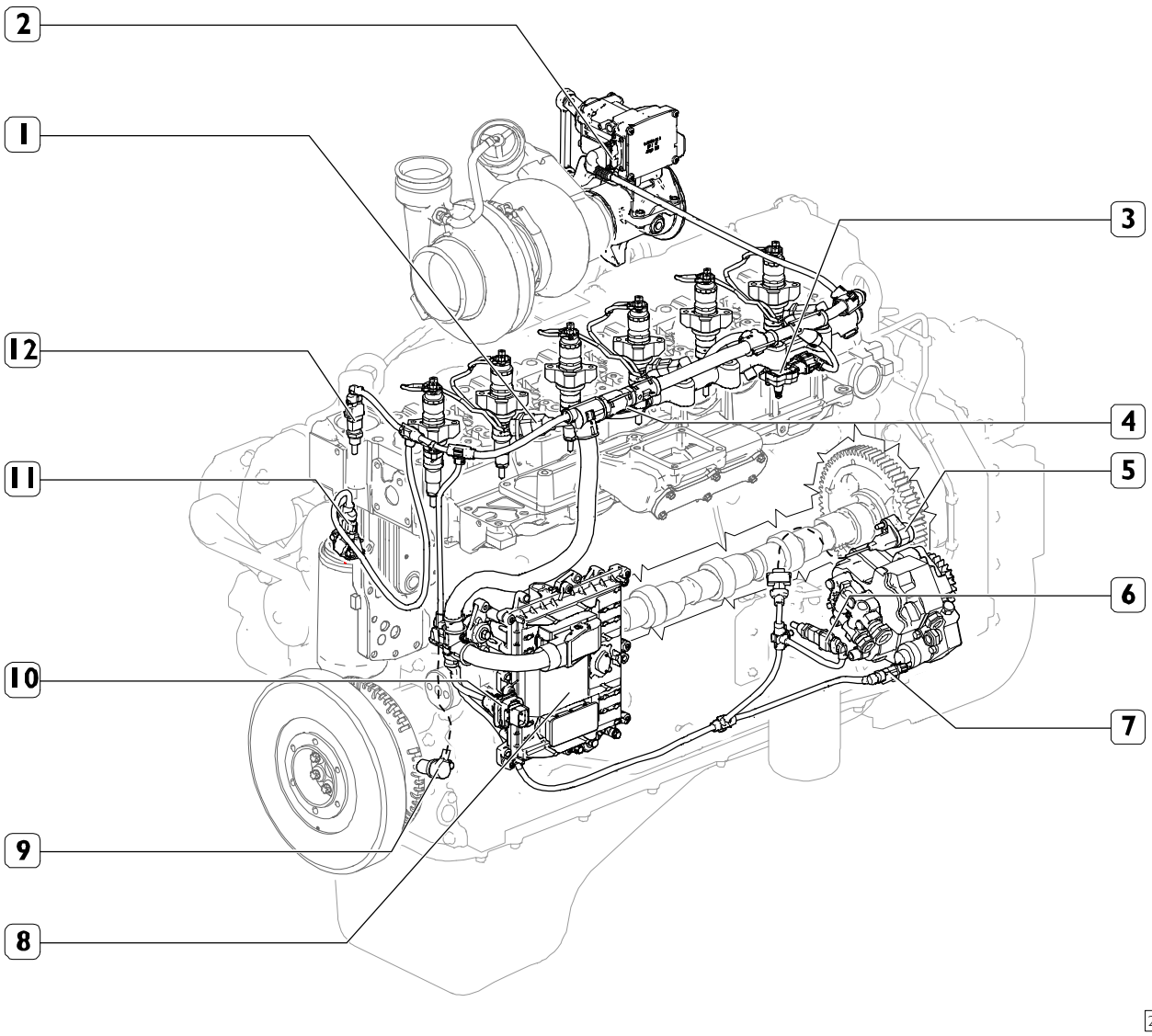
Figure 4



215019

REMOVAL OF MAIN COMPONENTS

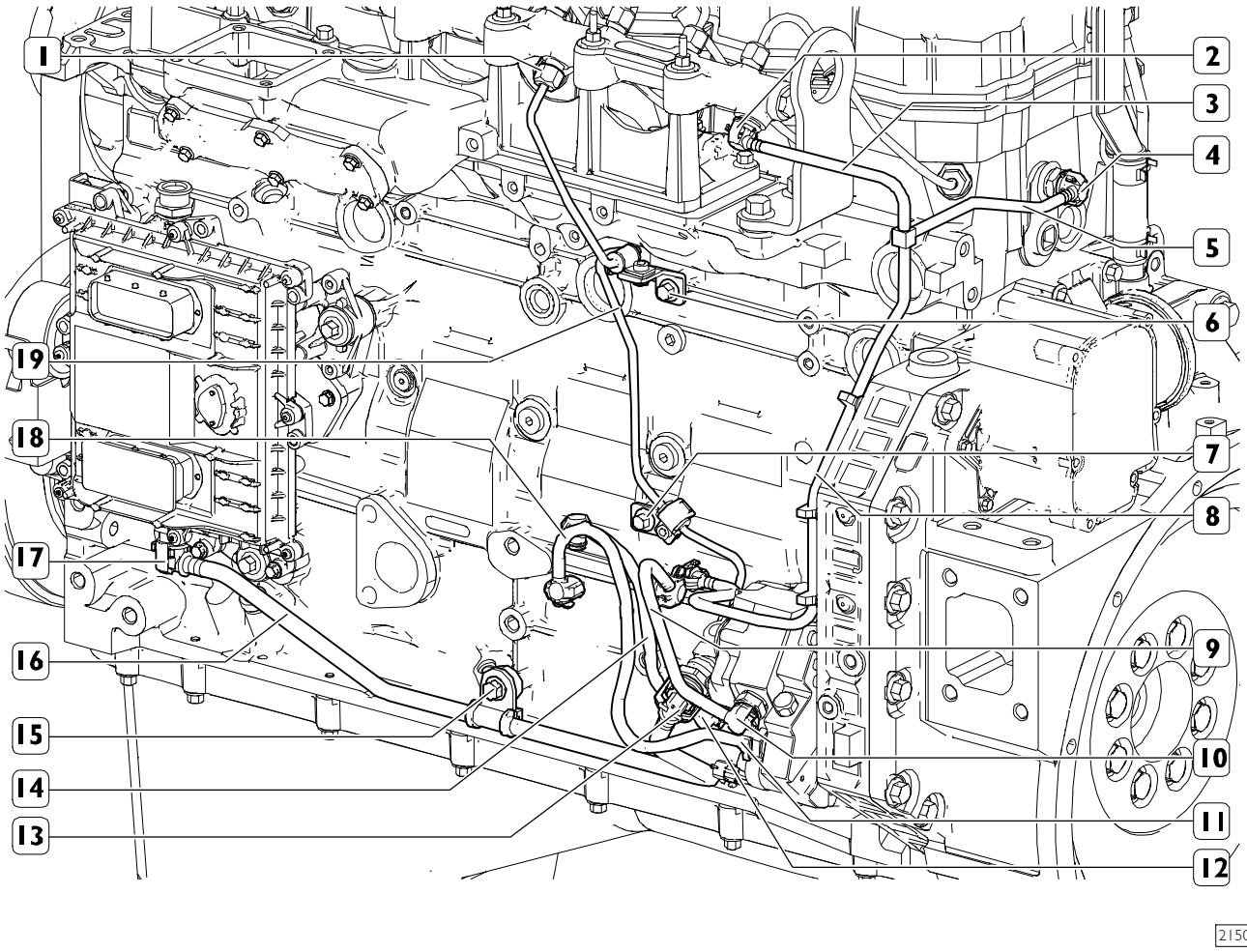
Figure 5



1. Electro-injectors connections - 2. Motorized throttle valve actuator connector (Exhaust flap) - 3. Boost pressure and air temperature sensor - 4. Rail pressure sensor - 5. Camshaft timing segment speed sensor - 6. Fuel temperature sensor - 7. Fuel high pressure pump metering unit - 8. Engine Control Unit ECU17CV41 - 9. Crankshaft rpm increment speed sensor - 10. In line connector - 11. Engine oil pressure and temperature sensor - 12. Coolant temperature sensor

Remove the engine cable by unplugging it from the ECU (8), from the motorized throttle valve actuator connector (2) and from all the sensors and transmitters to which it is connected. Open the straps holding the engine cable to the engine block and remove it completely.

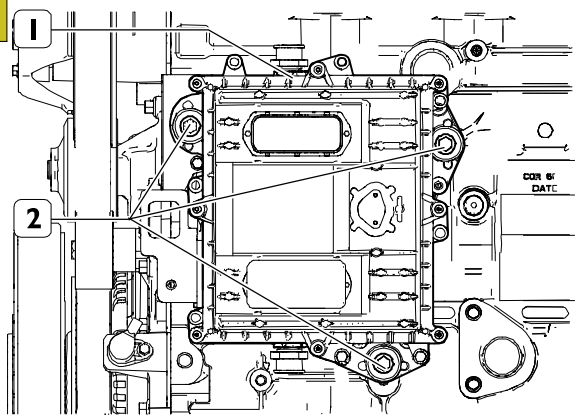
Figure 6



Position a suitable container to catch any fuel.
Disconnect the retainer (11) and remove low pressure fuel pipe (18) from fuel filter to high pressure pump;
Disconnect the retainers (13 and 17), unscrew the screw (15) and remove low pressure fuel pipe (16) from engine control unit heat exchanger to mechanical pump;
Disconnect the retainer (12) and remove low pressure fuel pipe (14) from mechanical pump to fuel filter.
Disconnect the retainer (10) and remove backflow fuel pipe (9) from high pressure pump to fuel filter support;
Disconnect the retainers (2 and 4) and remove backflow fuel pipes (3, 5 and 8) from common rail and electro-injectors to the fuel filter support.
Unscrew the hose couplings (1) of the high pressure fuel pipe (19) from high pressure pump to common rail;
Unscrew the screws (6 and 7) fastening the pipe (19) to the engine block and remove it.

Ref	No.	Description
(1)	2	M14x1.5
(6)	1	M8x1.25x20
(7)	1	M8x1.25x16

Figure 7

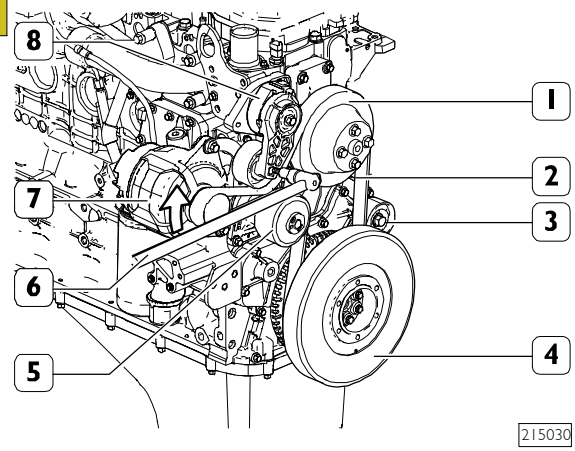


215029

Position a suitable container to catch any fuel.
Disconnect the retainer and remove the low pressure fuel pipe from fuel pre-filter to the engine control unit heat exchanger.
Unscrew the supporting screws (2), and remove the ECU (1), including the heat exchanger.

Ref	No.	Description
(2)	3	M8x1.25

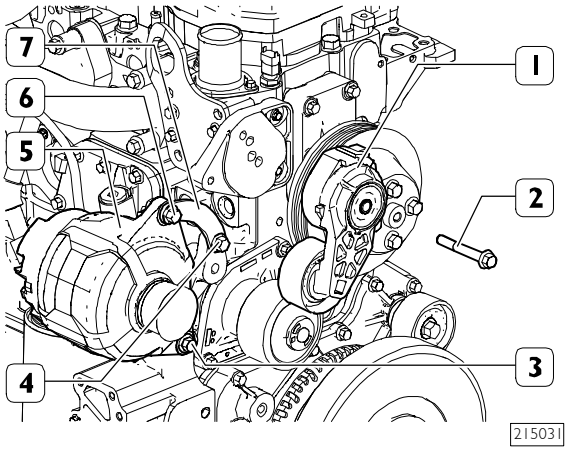
Figure 8



215030

Remove the belt (2) by acting on the automatic belt tensioner (8) with the appropriate tool (6) from the alternator (7), water pump (5), fan control pulley (1), crankshaft pulley with damper (4) and fixed guide roller (3).

Figure 9

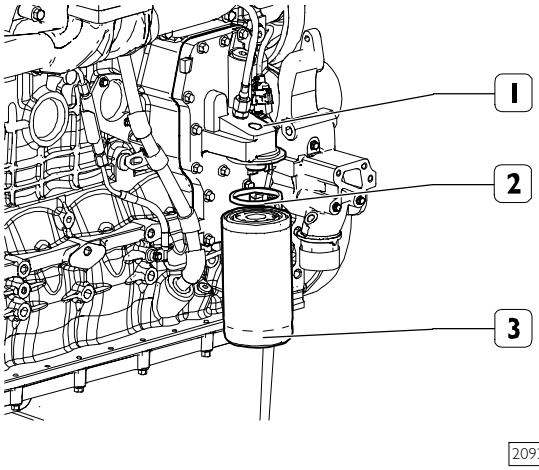


215031

Unscrew the fastening screw (2) and remove the automatic belt tensioner (1).
Unscrew the fastening screws (3, 4 and 6) and remove the alternator (5) and its bracket (7).

Ref	No.	Description
(2)	1	M10x1.5x70
(3)	1	M10x1.5x110
(4)	1	M10x1.5x20
(6)	1	M10x1.5x30

Figure 10



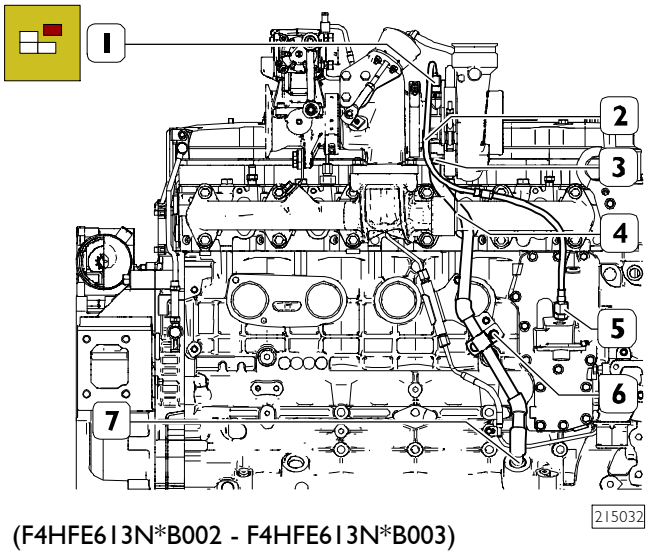
209220

Place a container for collecting the spent oil under the filter support (1).
Unscrew and remove the oil filter (3) from its relative support (1) by tool 99360076.

Ref	No.	Description
(3)	1	M27x2

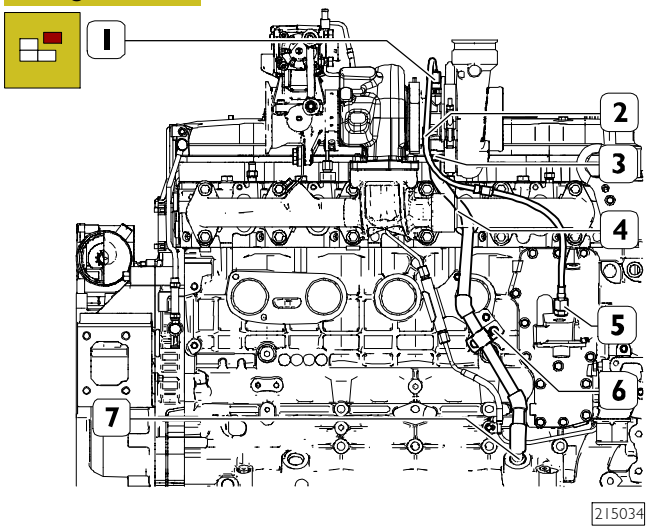
(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

Figure 11



(F4HFE613N*B002 - F4HFE613N*B003)

Figure 12



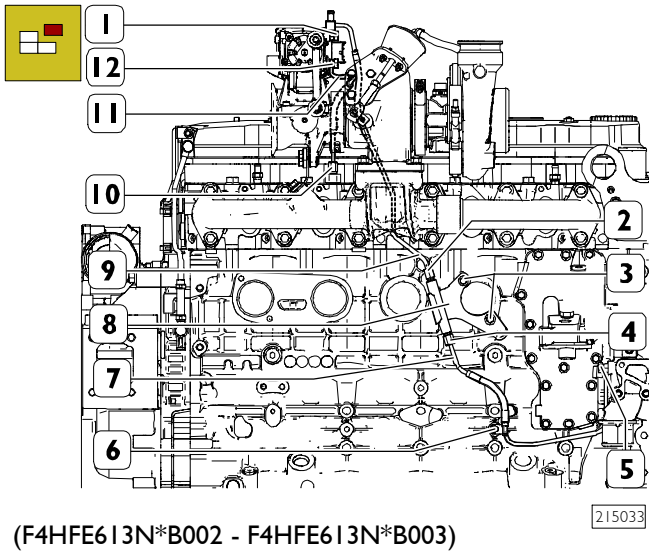
Position a suitable container to catch any oil.
Unscrew the hose couplings (1 and 5) and remove the lubrication oil delivery pipe (2) from the upper part of the heat exchanger to the turbocharger.
Remove the lubrication oil discharge pipe (4) from the turbocharger by proceeding as follows:

- ❑ unscrew the fastening screws (3) in the lower part of the turbocharger, recovering the relevant gasket;
- ❑ unscrew the screw (6) that retain the piping (4) to the block by means of the fastening collar;
- ❑ unscrew the coupling (7) from the crankcase.

Ref	No.	Description
(1,5)	2	11/16-16 (M16)
(3)	2	M8x1.25x25
(6)	1	M8x1.25x16

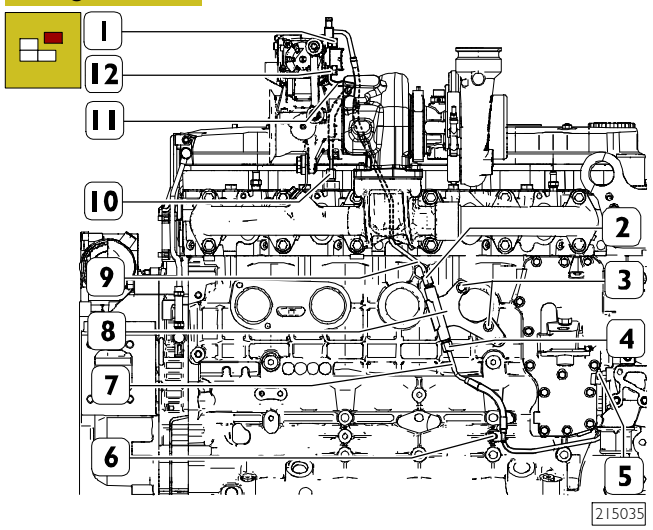
(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

Figure 13



(F4HFE613N*B002 - F4HFE613N*B003)

Figure 14



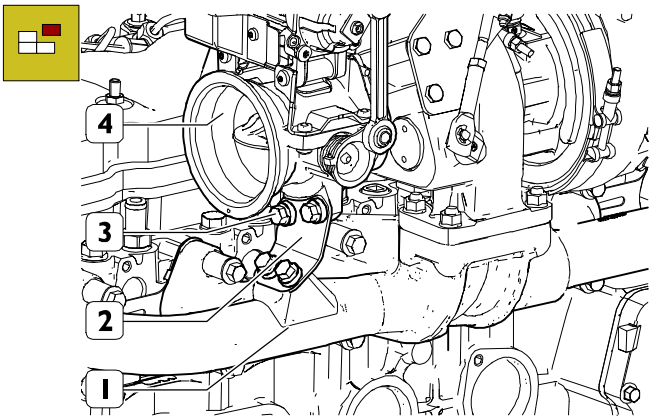
Position a suitable container to catch any coolant.
Remove the motorized throttle valve water inlet and outlet pipes by proceeding as follows:

- ❑ unscrew the fastening nut (2) and connector (1) and remove the upper-part water return pipe (9);
- ❑ unscrew the fastening nut (4), connector (5) and screw (6) and remove the lower-part water return pipe (7);
- ❑ unscrew the fastening screws (3) and remove the water return pipe union (8);
- ❑ unscrew the fastening nut (10) and connector (12) and remove the water delivery pipe (11).

Ref	No.	Description
(1,12)	2	M10x1
(2,4,10)	3	M12x1.5
(3)	2	M8x20
(5)	1	M10x1
(6)	1	M8x16

(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

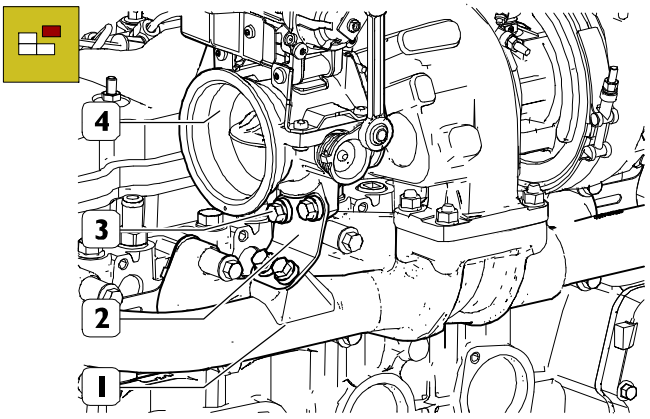
Figure 15



214772

(F4HFE613N*B002 - F4HFE613N*B003)

Figure 16



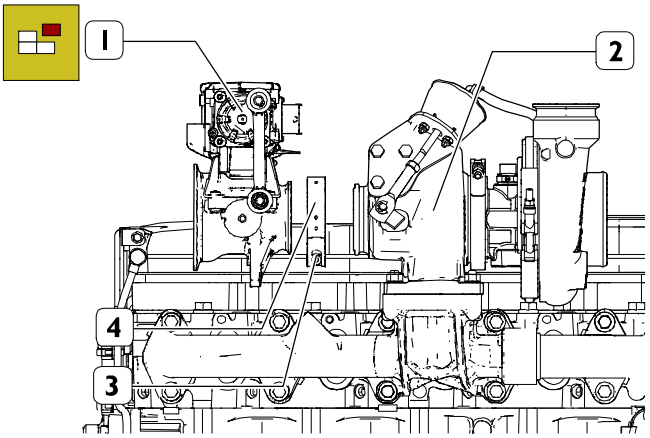
215026

Unscrew the fastening screws (3) and remove the bracket (2) fixing the motorized throttle valve (4) to the exhaust manifold (1).

Ref	No.	Description
(3)	4	M8x1.25x25

(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

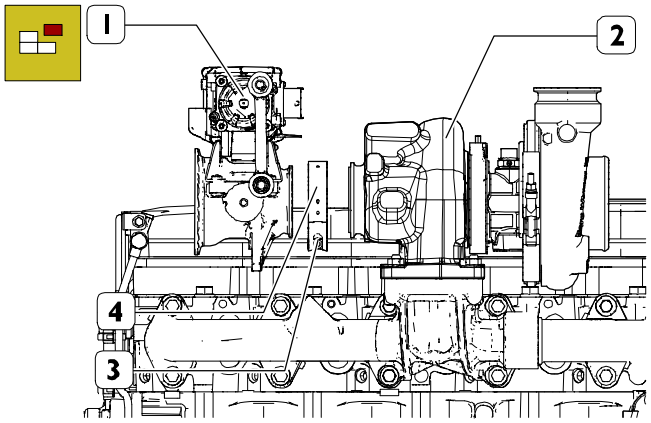
Figure 17



215022

(F4HFE613N*B002 - F4HFE613N*B003)

Figure 18



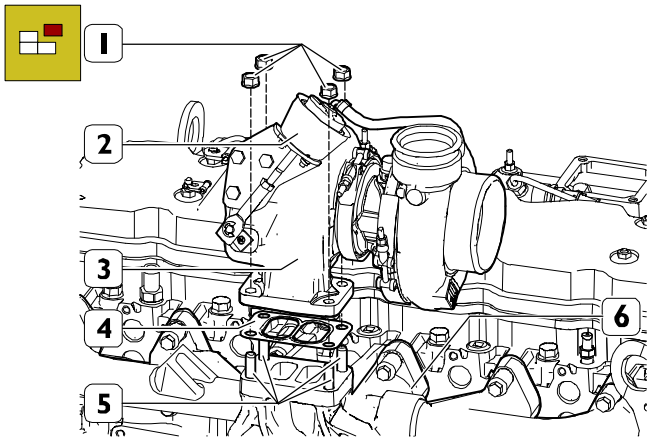
215025

Unscrew the screw (3) and loosen the V-clamping collar (4) to remove the motorized throttle valve (1) from the turbocharger (2).

Ref	No.	Description
(3)	1	M6x1x50

(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

Figure 19



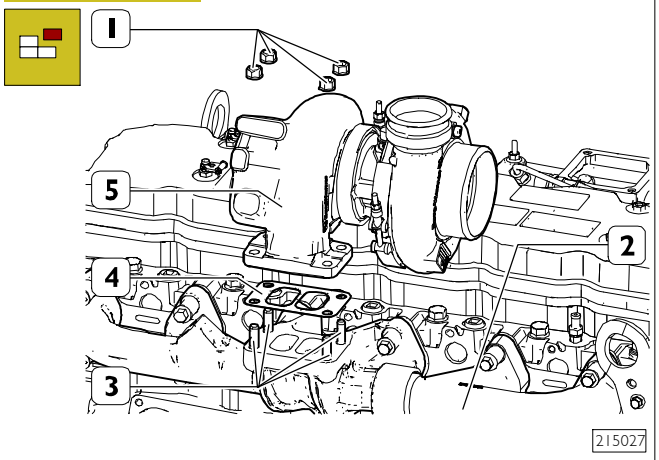
214768

Unscrew the fastening nuts (1) and remove the turbocharger (3) together with the waste-gate valve (2), recovering the relevant gasket (4).
Unscrew the studs (5) from the exhaust manifold (6).

Ref	No.	Description
(1)	4	M10
(5)	4	M10x1.5x42

(F4HFE613N*B002 - F4HFE613N*B003)

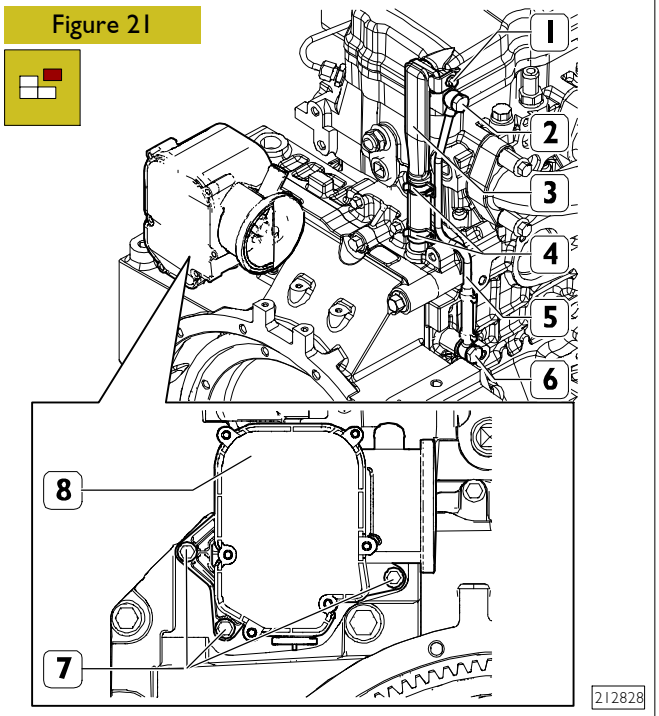
Figure 20



Unscrew the fastening nuts (1) and remove the turbocharger (5), recovering the relevant gasket (4).
Unscrew the studs (3) from the exhaust manifold (2).

Ref	No.	Description
(1)	4	M10
(3)	4	M10x1.5x42

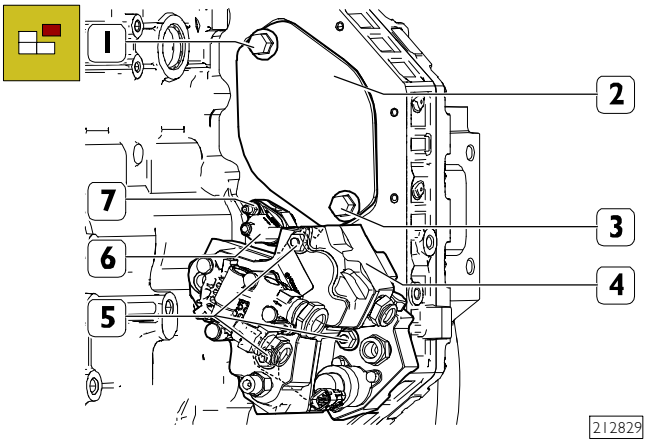
Figure 21



Position a suitable container to catch any oil.
Unscrew the fastening screw (1), loosen the retaining clamps (4) and remove the blow-by breather pipe (3).
Unscrew the hose connectors (2 and 6) and remove the oil return pipe (5).
Unscrew the fastening screws (7) and remove the blow-by filter (8).

Ref	No.	Description
(1)	1	M6x1
(2,6)	2	M12x1.5
(7)	3	M6x1

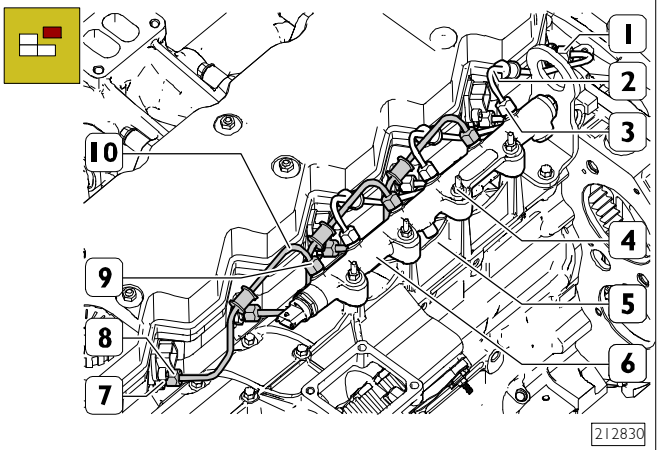
Figure 22



Unscrew the fastening screws (1 and 3) and remove the cover (2), retrieving relative gasket.
If present, remove the flange and the gear of the power take-off (PTO).
Unscrew the fixing nut (7) and remove the camshaft timing segment speed sensor (6).
Ensure that the fuel high pressure pump (4) is suitably supported.
Unscrew the fastening nuts (5) and remove the fuel high pressure pump (4) complete with the mechanical pump, the flange and the gear. Unscrew the studs (5).

Ref	No.	Description
(5)	3	M8x1.25x50
(5)	3	M8-8
(1,3)	2	M12x1.75x25
(7)	1	M6x1x5

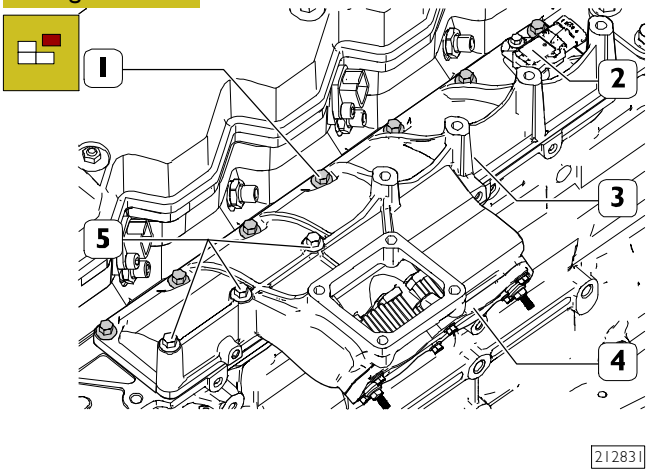
Figure 23



Unscrew the hose couplings (1, 3, 8 and 9) from the common rail (6) and injector manifolds (7) and remove the high pressure fuel delivery pipes (2 and 10).
Unscrew the threaded double-shank shoulder screws (4) and remove the common rail (6) from the intake manifold (5).

Ref	No.	Description
(1,8)	6	M14x1.5
(3,9)	6	M14x1.5
(4)	4	M8x1.25x125

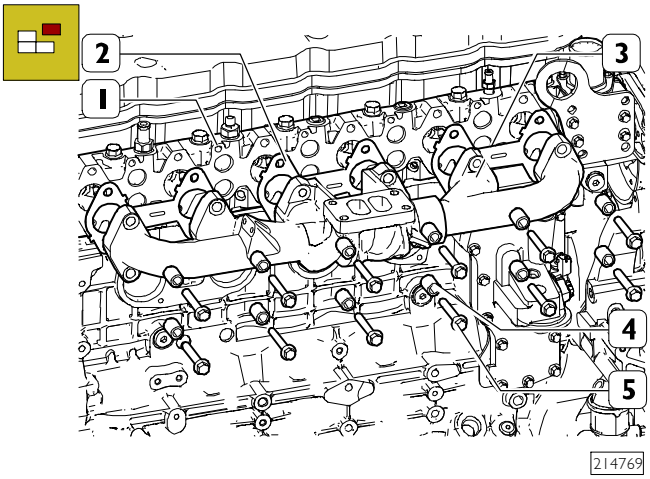
Figure 24



Unscrew the fastening screws (1 and 5) and remove the intake manifold (3) together with the boost pressure and air temperature sensor (2).

Ref	No.	Description
(1)	7	M8x1.25x25
(5)	3	M8x1.25x70

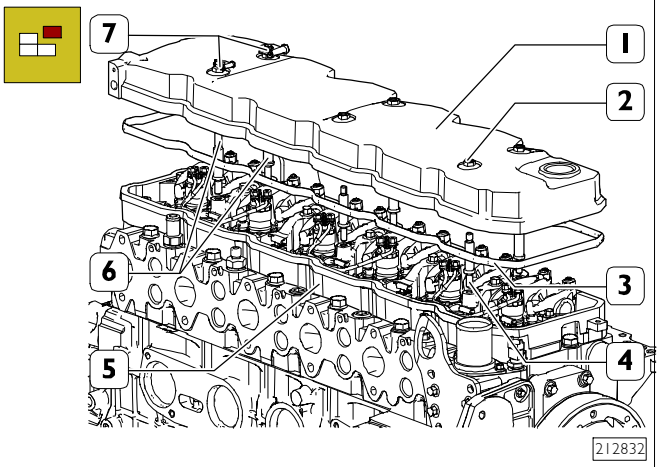
Figure 25



Unscrew the screws (5) together with spacers (4) and remove the exhaust manifold (3) complete with relevant gaskets (2) from the cylinder head (1).

Ref	No.	Description
(5)	12	M10x1.5x65

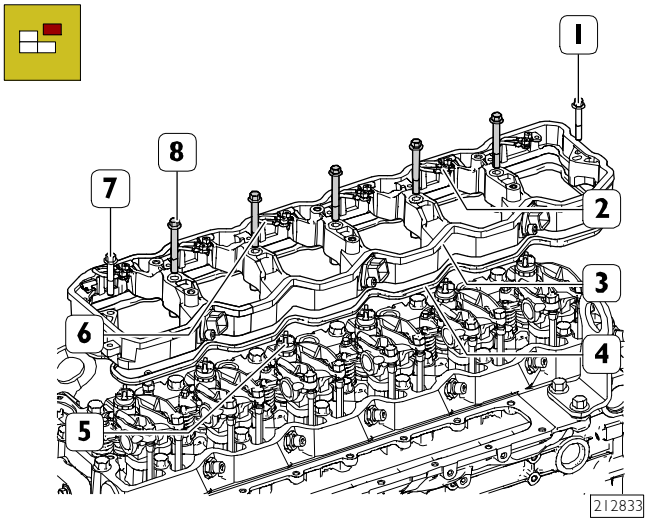
Figure 26



Unscrew the fastening nuts (2 and 7) and remove the tappet cover (1) from the wiring support (5) retrieving relative gasket (3).
Unscrew the threaded double-shank shoulder screws (4 and 6) from the wiring support (5).

Ref	No.	Description
(2,7)	6	M8x1.25

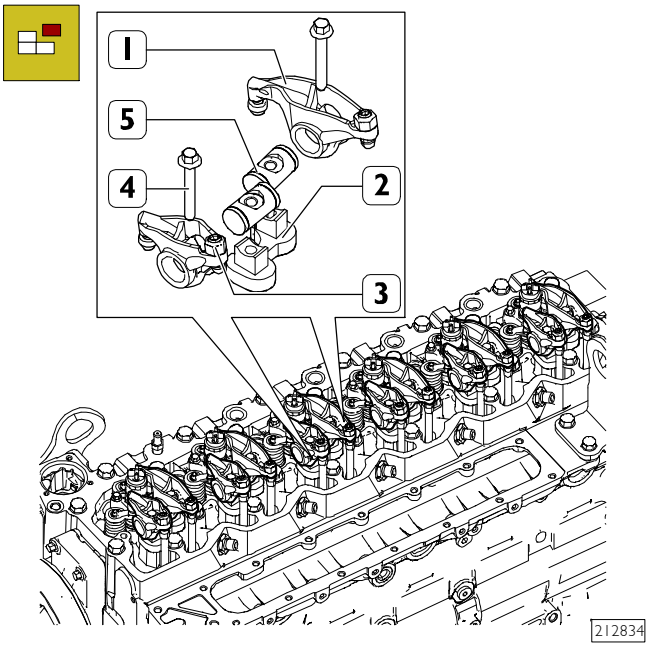
Figure 27



Remove the nuts (2) and disconnect the electrical cables (6) from the electro-injectors (5).
Unscrew the screws (1, 7 and 8) and remove the electro--injector wiring support (3) complete with gasket (4).

Ref	No.	Description
(1,7)	2	M8x1.25
(2)	12	M4
(8)	5	M8x1.25

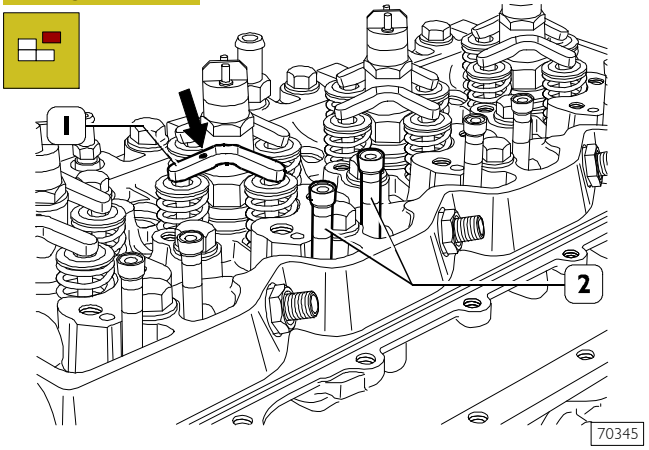
Figure 28



Loosen the tappet adjuster retaining nuts (3) and unscrew the tappet adjuster screws;
Unscrew the fastening screws (4) and disassemble the rocker unit from the cylinder head, including support (2), rockers (1) and shafts (5).

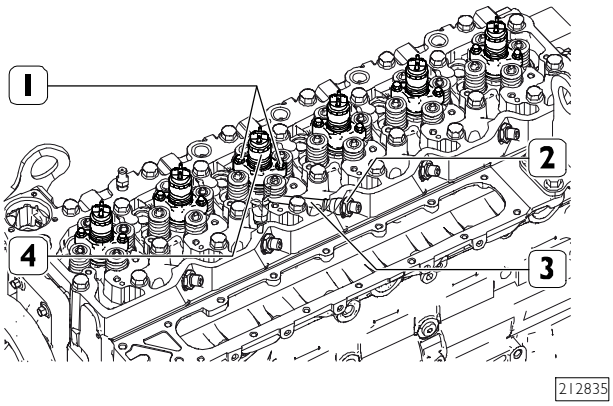
Ref	No.	Description
(4)	12	M8x1.25

Figure 29



Remove the bridges (1) from valves and the pushrods (2) from the cylinder head and crankcase.

Figure 30

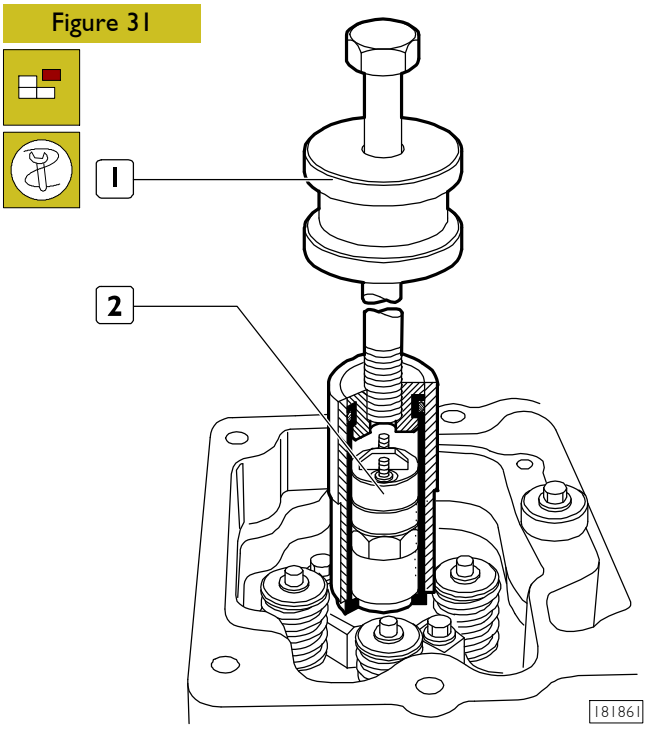


Undo the fastening nuts (2) and remove the fuel manifolds (3).
Unscrew the electro-injector (4) fastening screws (1).

Ref	No.	Description
(1)	12	M6x1x35
(2)	6	M22x1.5x9.5

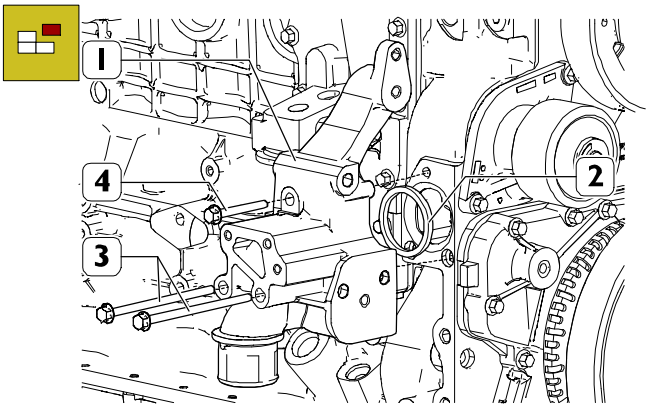
NOTE Disassembled fuel manifolds (2) must not be used again, but replaced with new ones.

Figure 31



Undo the injector fastening screws and use tool 99342101 (1) to remove the injectors (2) from the cylinder head.

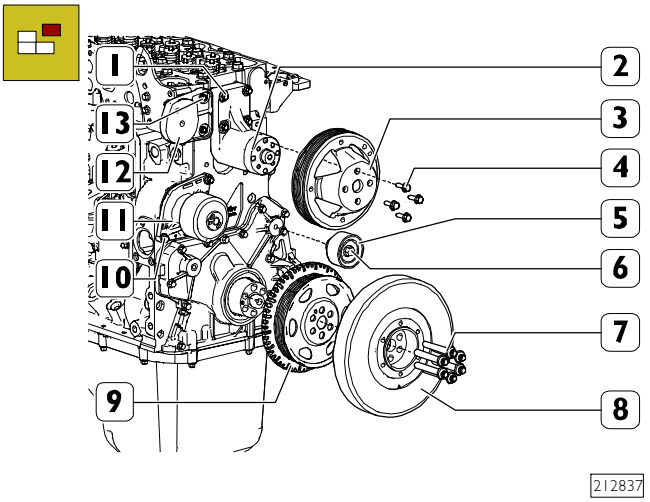
Figure 32



Unscrew the fastening screws (3 and 4) and remove the engine coolant inlet (1), retrieving relative gasket (2).

Ref	No.	Description
(3)	2	M10x1.5x130
(4)	1	M10x1.5x70

Figure 33

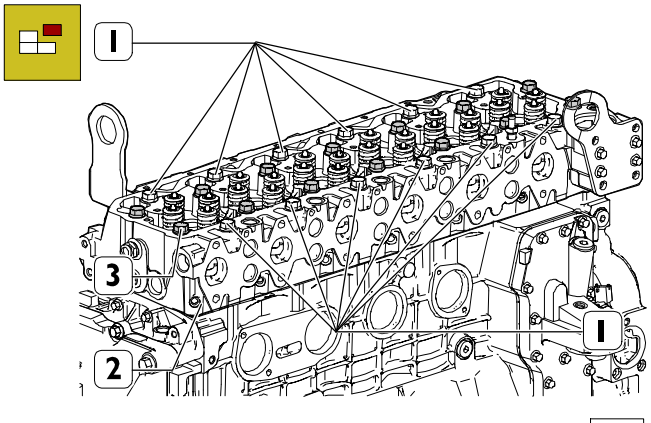


Unscrew the fastening screws (4) and remove the fan control pulley (3).
Unscrew the fastening screws (1) and remove the fan pulley mounting (2).
Unscrew the fastening screws (13) and remove the automatic belt tensioner mounting (12).
Unscrew the fastening screw (6) and remove the idler guide pulley (5).
Unscrew the fastening screws (7) and remove the damper pulley (8) together with the crankshaft pulley (9).
Unscrew the fastening screws (10) and remove the water pump (11).

Ref	No.	Description
(1)	4	M8x1.25x45
(4)	4	M10x25
(6)	1	M10x1.5
(7)	6	M12x1.25
(10)	2	M8x1.25x35
(13)	2	M8x1.25x30

NOTE The flywheel blocking device can aid the removal of the damper pulley (8) fitted onto the crankshaft pulley (9).

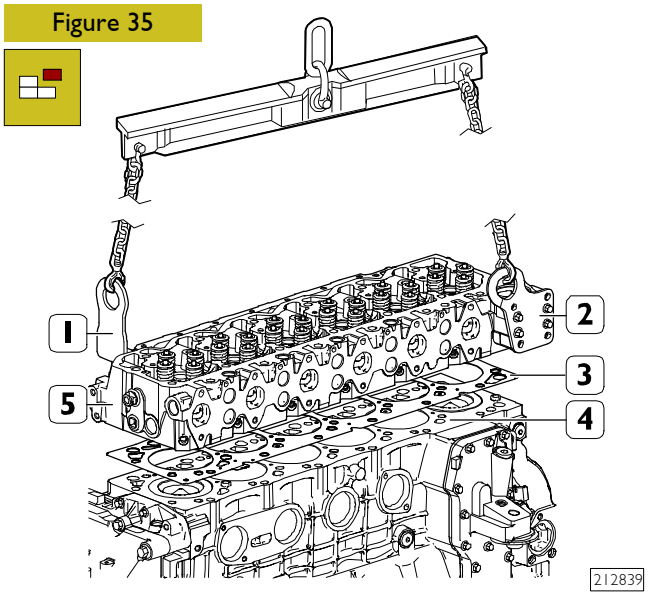
Figure 34



Unscrew the screws (1 and 3) fixing the cylinder head (2) to the crankcase.

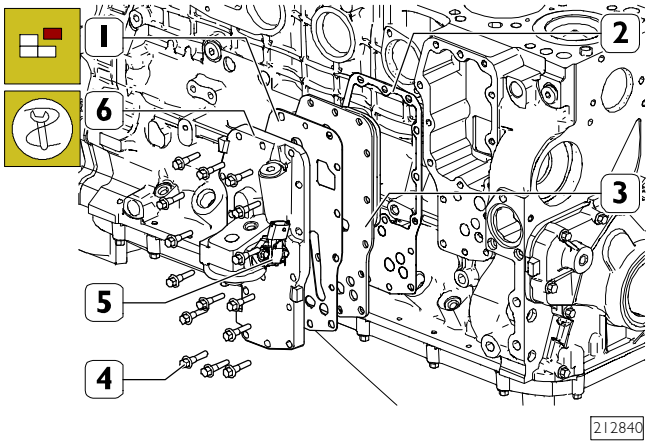
Ref	No.	Description
(1)	12	M12x1.75x130
(3)	14	M12x1.75x150

Figure 35



Use suitable lifting hooks (1 and 2) in order to lift and remove the cylinder head (5) complete with gasket (3) from the engine block (4) by using a hoist with tool 99360595.

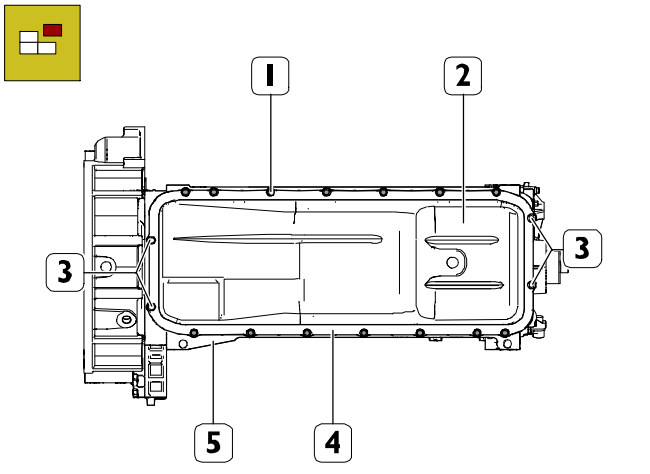
Figure 37



Unscrew the fastening screws (4) and remove the oil filter / heat exchanger together with oil pressure and temperature sensor (5), including oil filter support (6), heat exchanger plate (3) and relative gaskets (1 and 2).

Ref	No.	Description
(4)	15	M8x1.25x35

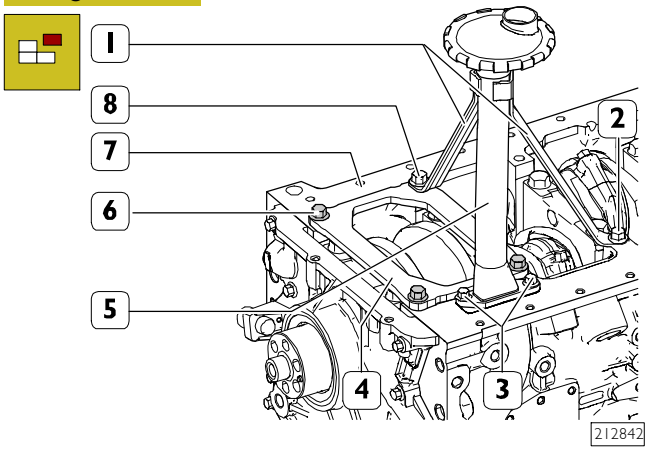
Figure 36



Turn the engine upside-down.
Unscrew the fastening screws (1 and 3) and remove the oil sump (2) from the crankcase (5), recovering relevant gasket (4).

Ref	No.	Description
(1)	14	M8x1.25x40
(3)	4	M8x1.25x45

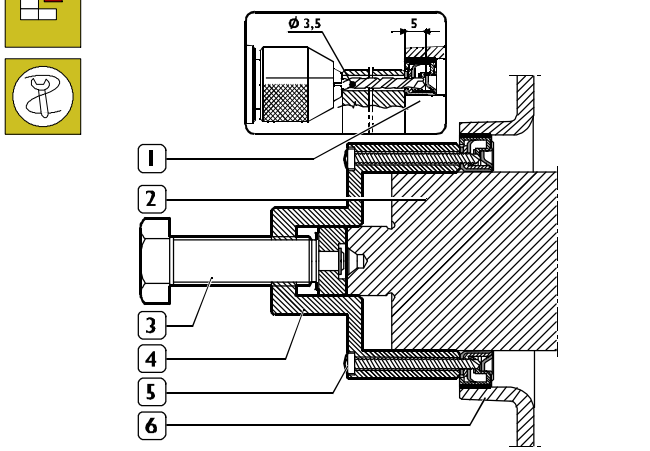
Figure 38



Unscrew the fastening screws (2 and 8) and remove the oil suction strainer pipe brackets (1).
Unscrew the fastening screws (3) and remove the oil suction strainer pipe (5) recovering relevant gasket from the crankcase (7).
Unscrew the fastening screws (6) and remove the stiffening plate (4) from the crankcase (7).

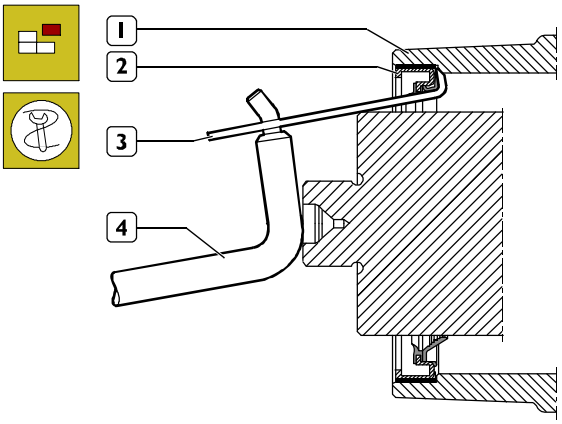
Ref	No.	Description
(2)	1	M10x1.5x20
(3)	2	M8x20
(6)	3	M10x1.5x25
(8)	1	M10x1.5x25

Figure 39



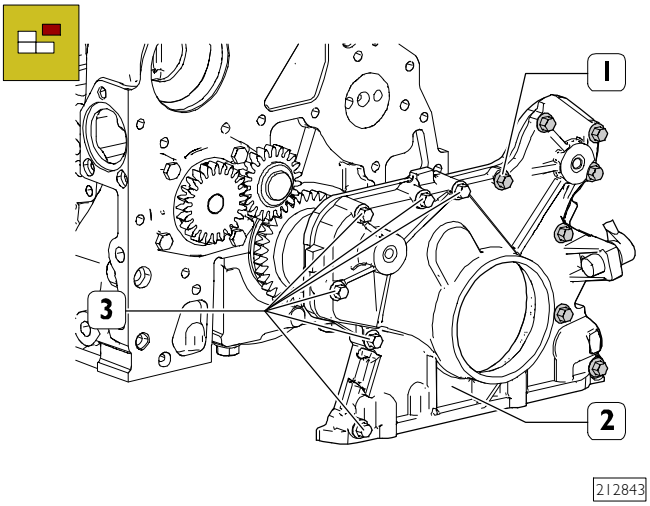
Extract the crankshaft front cover seal. Fit the tool 99340055 (4) onto the front shank (2) of the crankshaft. Through the guide holes in the tool, perforate the internal seal (1) with a drill bit (Ø 3.5 mm) to a depth of 5 mm.
Secure the tool to the ring (1) with the 6 screws provided. Then extract the ring by screwing in the screw (3).

Figure 40



Fit the appropriate tie-rod (3) of tool 99363204 onto the external seal (2) as illustrated in the figure and, using the lever (4), extract it from the front cover (1).

Figure 41

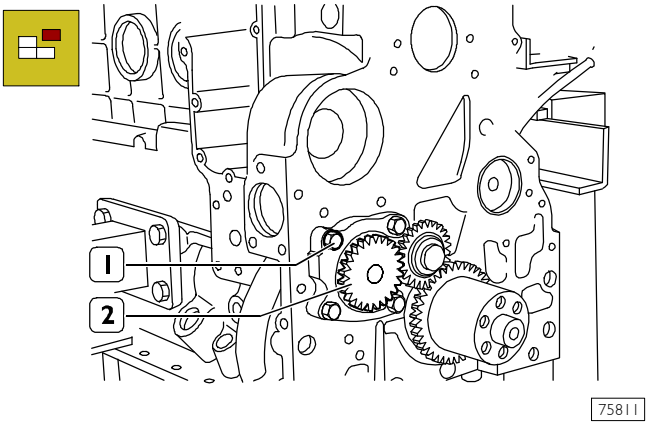


Unscrew the fastening screws (1 and 3) and remove the front cover (2) together with the crankshaft rpm increment speed sensor.

Ref	No.	Description
(1)	7	M8x1.25x30
(3)	6	M8x1.25

NOTE Take note of the screw (1 and 3) assembly position, since the screws have different length.

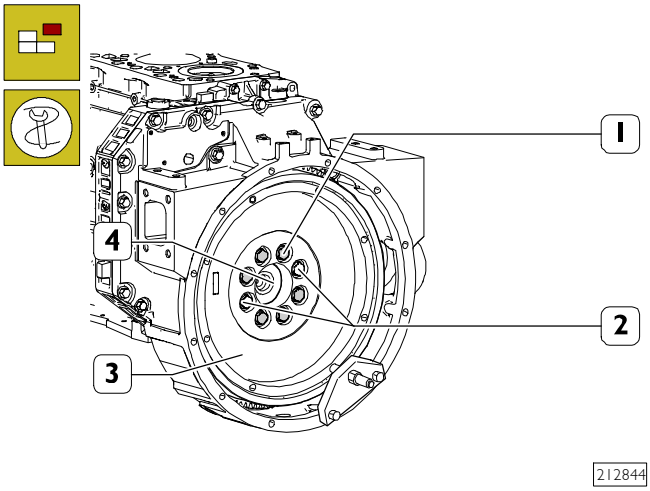
Figure 42



Undo the screws (1) and remove the oil pump (2).

Ref	No.	Description
(1)	4	M8x1.25

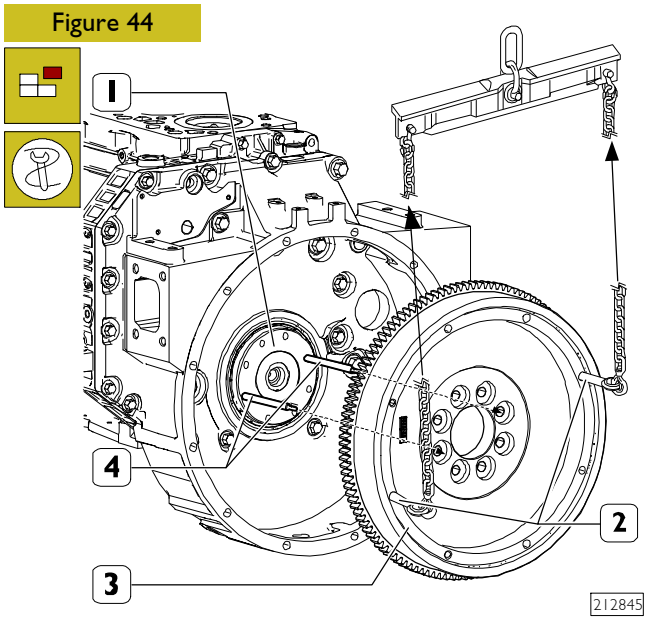
Figure 43



Apply tool 99360351 on the flywheel housing in order to block the engine flywheel (3) rotation.
Screw out two opposite screws (2) fixing the engine flywheel (3) to the crankshaft (4).
Introduce two withdrawal pins in the ports (see the following picture).
Loosen remaining screws (1) fixing the engine flywheel (3) to the crankshaft (4) and remove flywheel blocking tool 99360351.

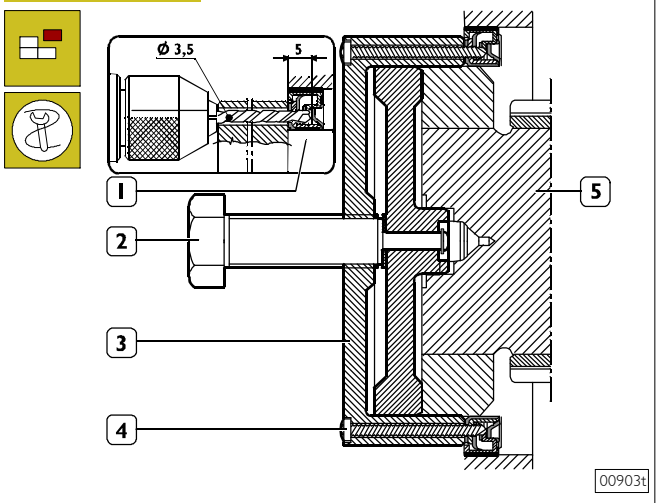
Ref	No.	Description
(1,2)	8	M12x1.25

Figure 44



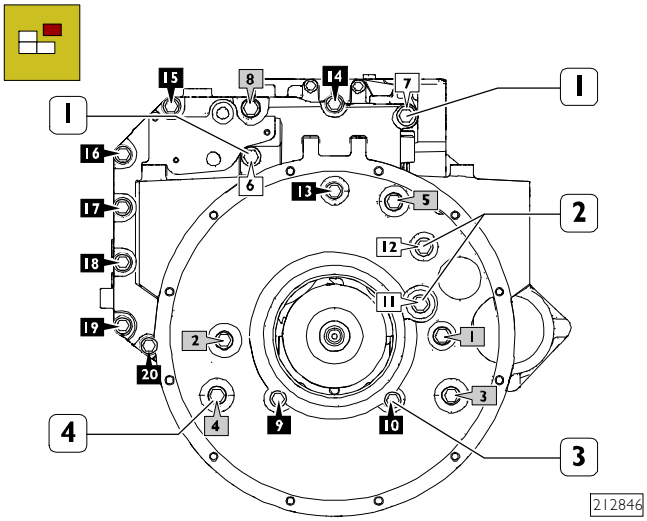
Screw up two medium length screws in the ports (2) to sling the engine flywheel (3).
Throughout the two guide pins (4) previously screwed up into the crankshaft ports (1) control the engine flywheel (3) withdrawal by means of a hoist with tool 99360595.

Figure 45



Extract the flywheel housing seal ring by fitting tool 99340056 (3) on the rear shank (5) of the drive shaft.
Through the guide holes of the tool, perforate the internal seal ring with a drill bit (Ø 3.5 mm) to a depth of 5 mm.
Fix tool 99340056 (3) to the ring (1) by means of the 6 screws (4) provided.
Proceed to remove the ring (1) by screwing in the screw (2).
Fit the appropriate tie-rod of tool 99363204 onto the flywheel housing external seal and extract it using the lever.

Figure 46

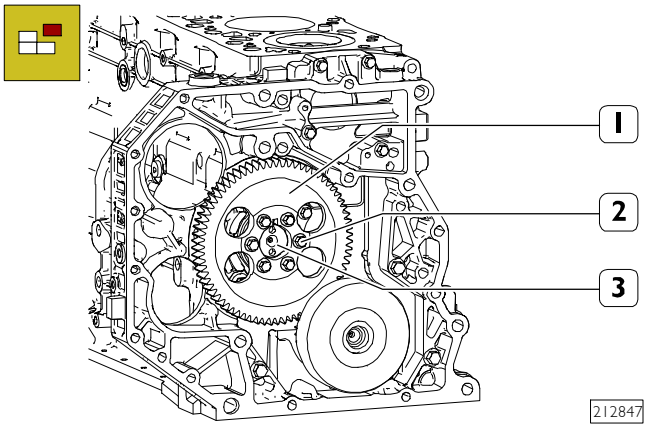


Unscrew the fastening screws (1, 2, 3 and 4) and remove the flywheel housing.

Ref	No.	Description
(1)	2	M12x1.75
(2)	2	M10x1.5
(3)	10	M10x1.5
(4)	6	M12x1.75

NOTE Note down the installation positions of the screws since they are of different sizes.

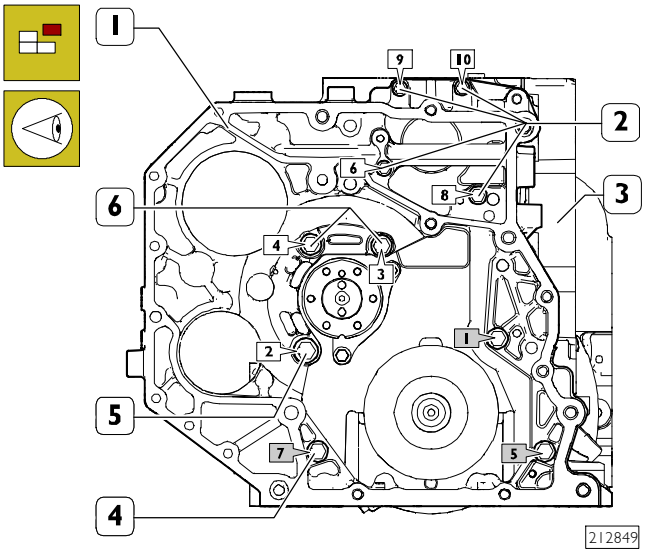
Figure 47



Unscrew the fastening screws (2) and remove the timing gear (1) from the camshaft.

Ref	No.	Description
(2)	6	M8x1.25

Figure 48



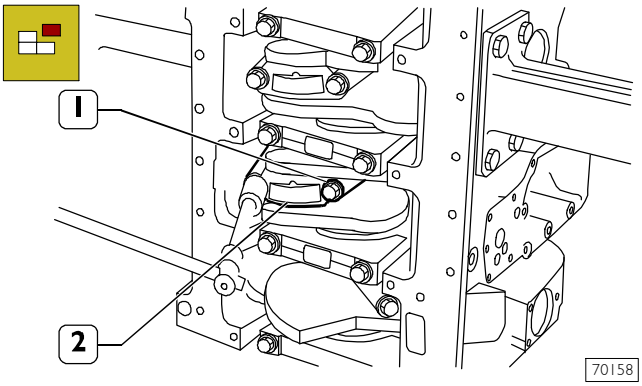
Unscrew the fastening screws (2, 4, 5 and 6) and remove the timing gear case (1) from the crankcase (3).

Ref	No.	Description
(2)	4	M8x1.25
(4)	3	M10x1.5
(5)	1	M12x1.75
(6)	2	M10x1.5

NOTE Note down the installation positions of the screws since they are of different sizes.

BENCH ENGINE BLOCK DISASSEMBLY

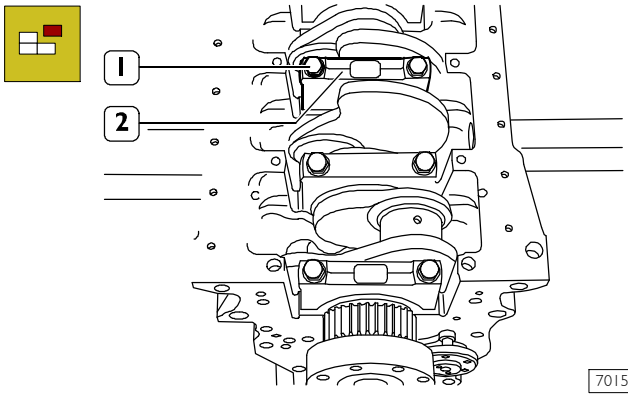
Figure 49



Remove and remove the connecting rod cap (2) fixing screws (1).
Extract the pistons together with the connecting rods from the top of the crankcase.

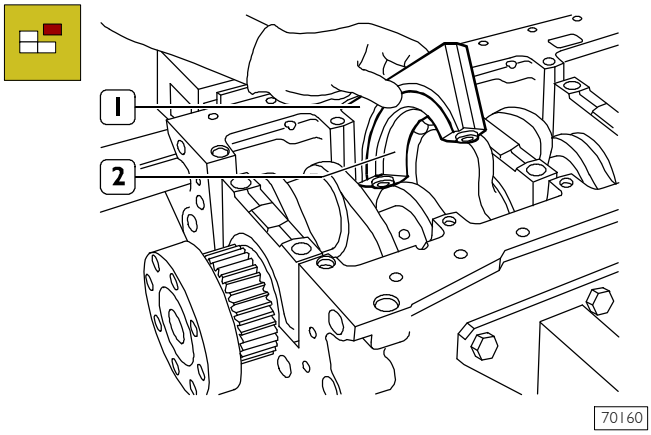
NOTE Maintain the half-bearings in their relevant seats because, in the event of use, they should be mounted in the position detected when disassembling.

Figure 50



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

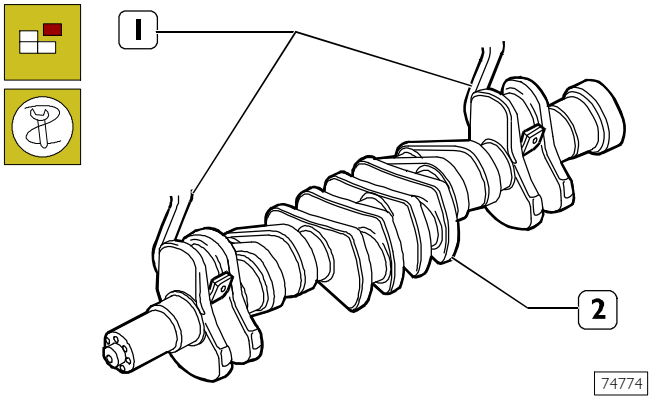
Figure 51



The second-last-main cap (1) and its relevant support have the half-bearing (2) equipped with shoulder.

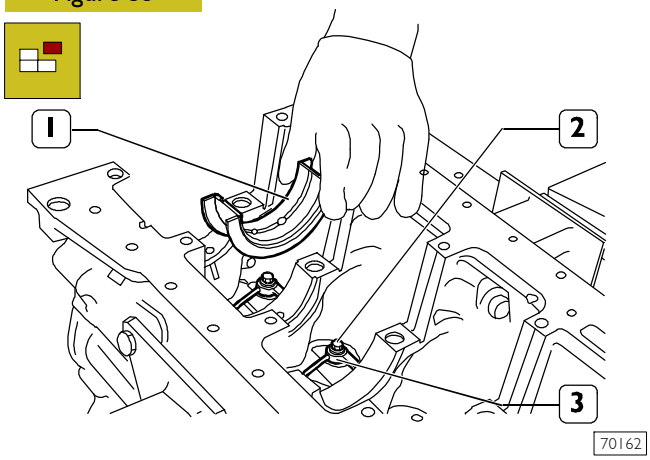
NOTE Write down the upper and lower half-bearing assembling position, in the event of use, they should be mounted in the position detected when disassembling.

Figure 52



Remove the crankshaft (2) from the block by means of tool 99360500 (1) and hoister.

Figure 53

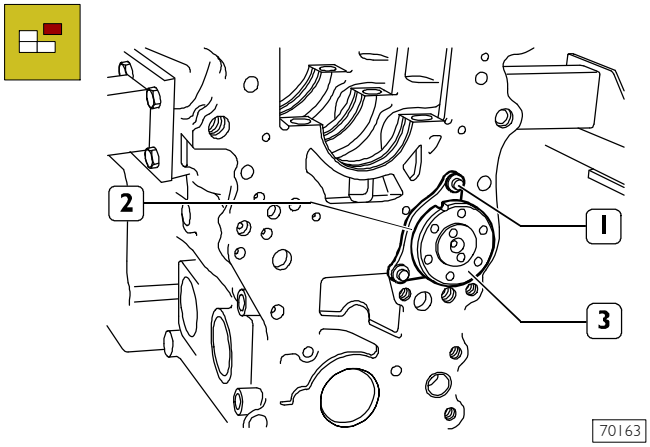


70162

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

Ref	No.	Description
(2)	6	M8x1.25x20

Figure 54

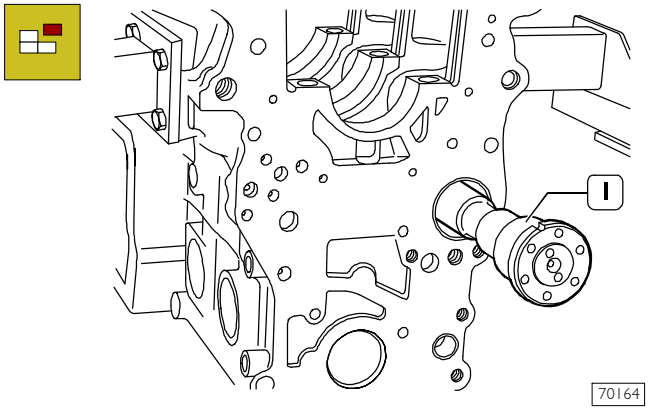


70163

Remove the screws (1) and remove the camshaft (3) check plate (2)

NOTE Write down the plate (2) assembling position.

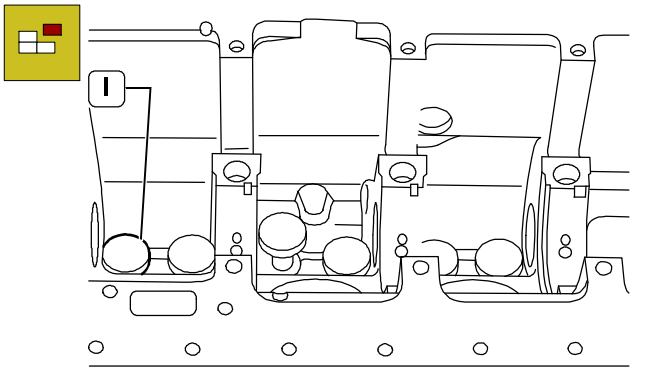
Figure 55



70164

Carefully withdraw the camshaft (1) from the crankcase.

Figure 56

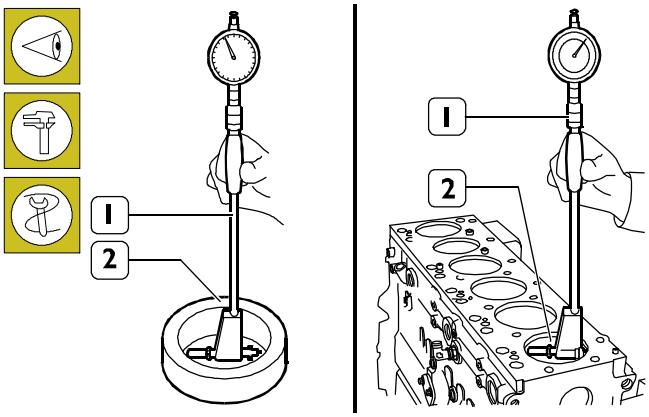


70165

Withdraw the tappets (1) from crankcase.

CRANKCASE
Controls and measurements

Figure 57

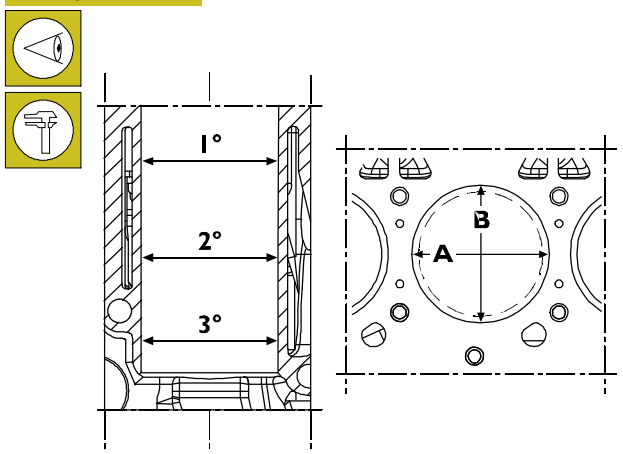


75386

Carefully clean the crankcase, when performed the engine disassembly.
Use the proper rings to transfer the crankcase.
Carefully check that the block does not present any cracks.
Check the plug conditions. Replace them if they are rusty or in case of doubt about their conditions.
Examine the cylinder bore surfaces; they must not present any seizing, scoring, ovalization, taper, and excessive wearing traces.
The internal diameter check of the cylinder bore, to verify the ovalization, taper and wearing entity, is performed by means of bore meter (1) equipped with dial gauge previously set to zero on the ring gauge (2) of the cylinder barrel diameter.

NOTE If you do not have at your disposal the ring gauge, use a micrometer for the zero setting operation.

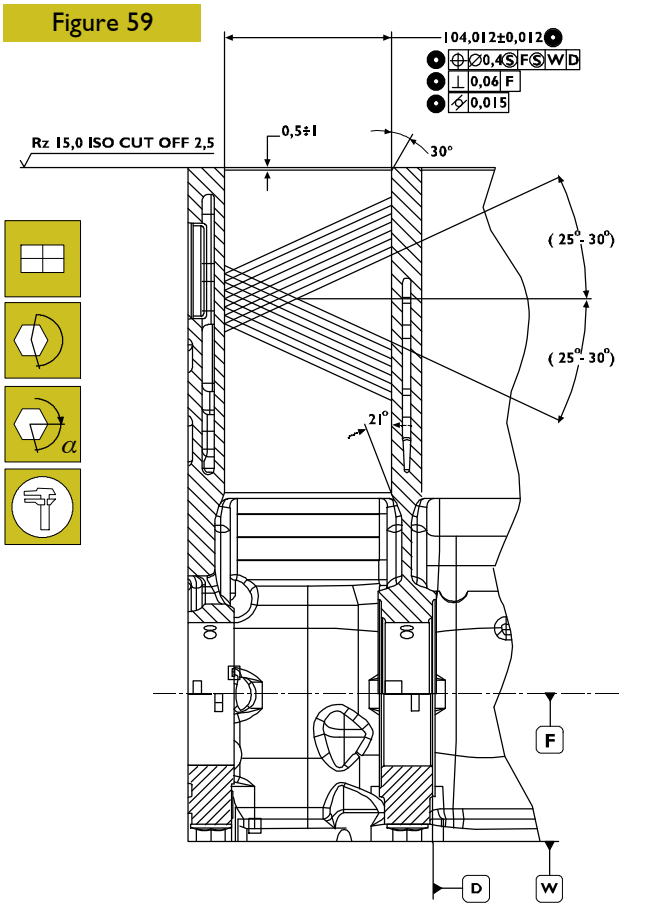
Figure 58



70167

The measurements must be performed for each individual cylinder at three different heights from the barrel and on two perpendicular surfaces: one parallel to the longitudinal engine axis (A) and the other one perpendicular (B); usually the max wear is detected on this latter surface and in correspondence with the first measurement.
If you detect any ovalization, taper or wear, ream and grind the cylinders. The cylinder barrel regrinding must be performed in relation to the diameter of the spare pistons oversized of 0.4 or 0.8 mm in respect of the nominal value and prescribed assembling clearance.

Figure 59



107804

NOTE In the event of grinding operation, all the cylinders must result of the same oversize (0.4 or 0.8 mm)

Check the main bearing seats, proceeding as follows:

- ❑ mount the main caps on the supports without bearings;
- ❑ tighten the fixing screws to the torque prescribed;
- ❑ by means of an adequate gauge, verify that the internal diameter of the seats correspond to the value prescribed.

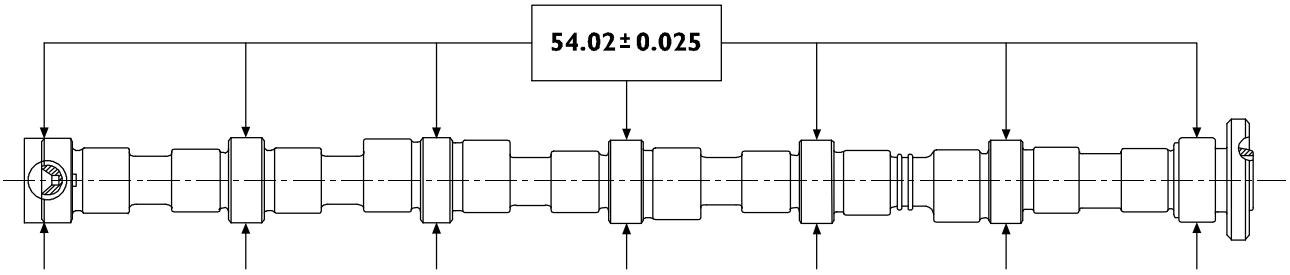
If you detect a higher value, replace the crankcase.

Checking head supporting surface on cylinder unit

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

TIMING SYSTEM
Camshaft

Figure 60



MAIN DATA ABOUT CAMSHAFT PINS
Specified data refer to pin standard diameter

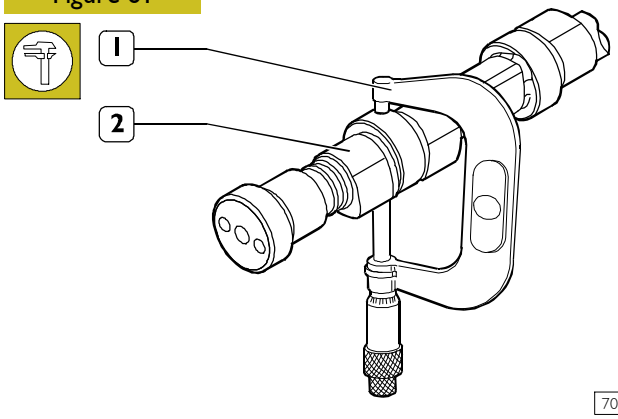
84089

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

Checking cam lift and pin alignment

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

Figure 61

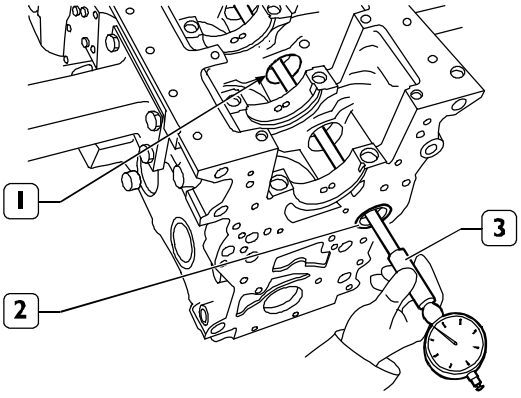


70171

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

BUSH

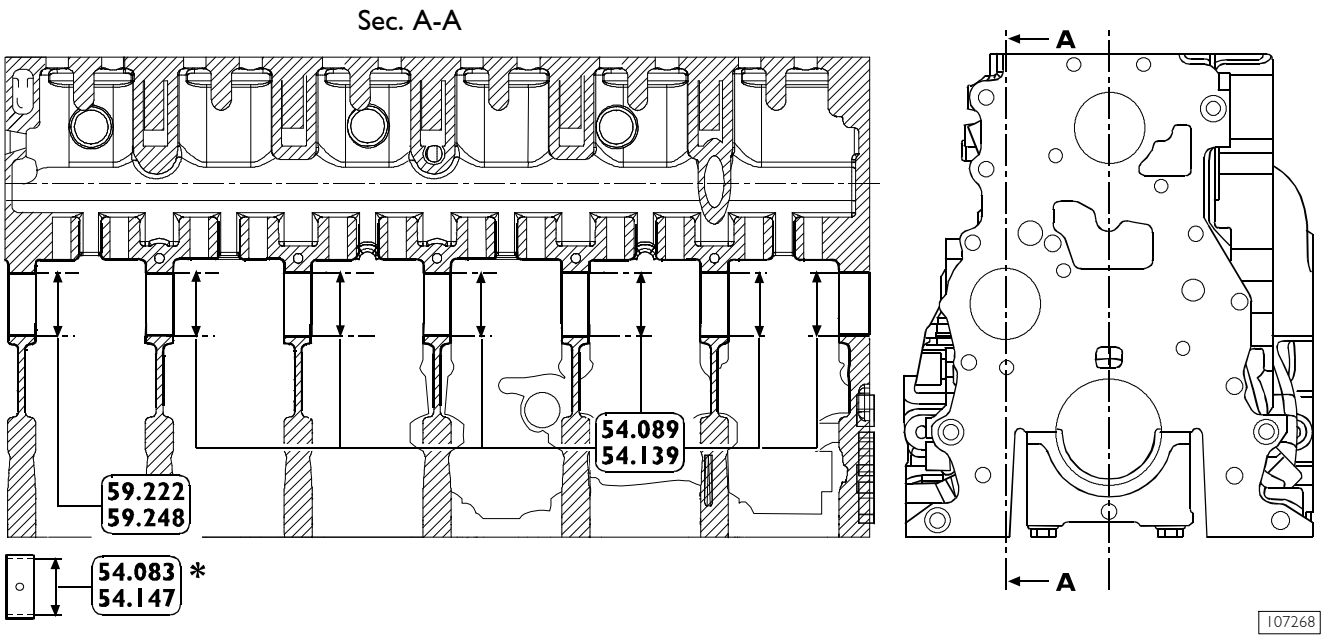
Figure 62



70172

Camshaft bush (2) shall be pressed into its housing.
Internal surface must not show seizing or wear.
Use bore dial gauge (3) to measure camshaft bush (2) and intermediate housing (1) diameter.
Measurements shall be performed on two perpendicular axes.

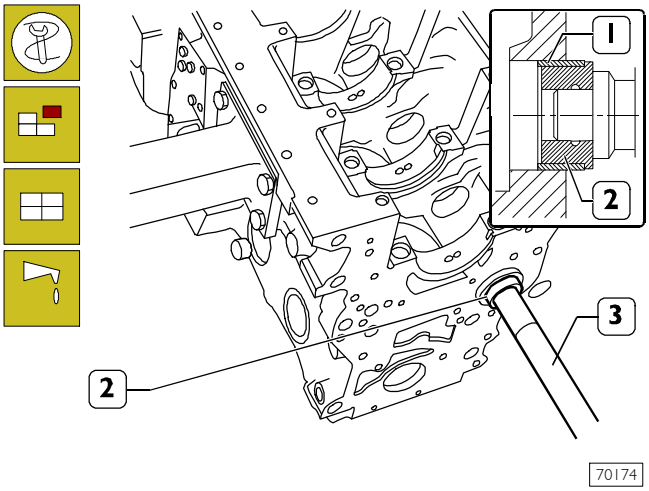
Figure 63



CAMSHAFT BUSH AND HOUSING MAIN DATA
* Value to be obtained after driving the bush.

Bush replacement

Figure 64

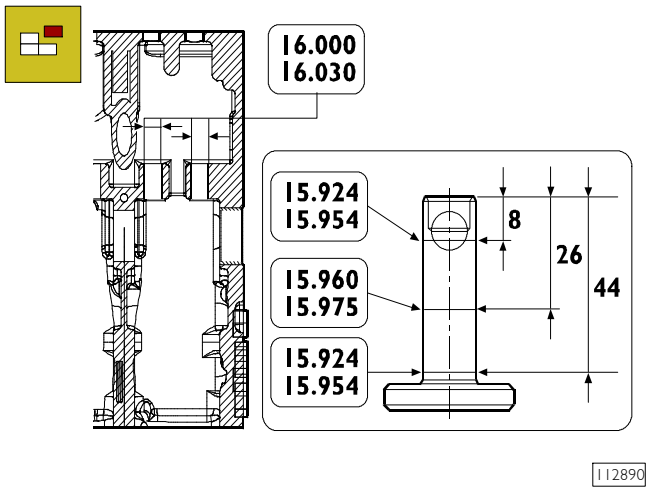


To replace rear bushing (1), use, for dismounting and mounting it, beater 99360362 (2) and handgrip 99370006 (3).

NOTE Bushing (1), on mounting, must be oriented in such a way that lubrication holes match the holes present on block seat.

TAPPETS

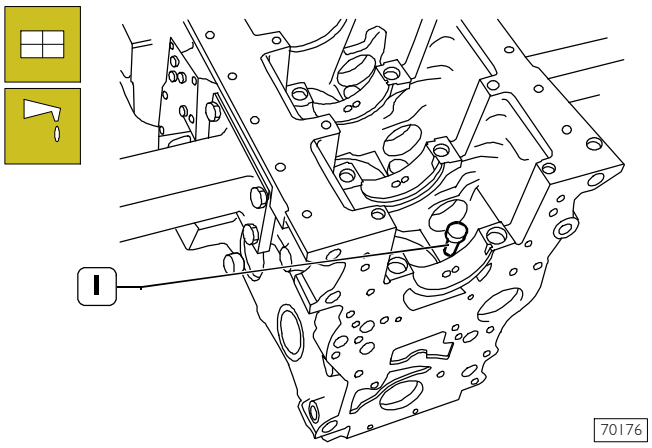
Figure 65



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

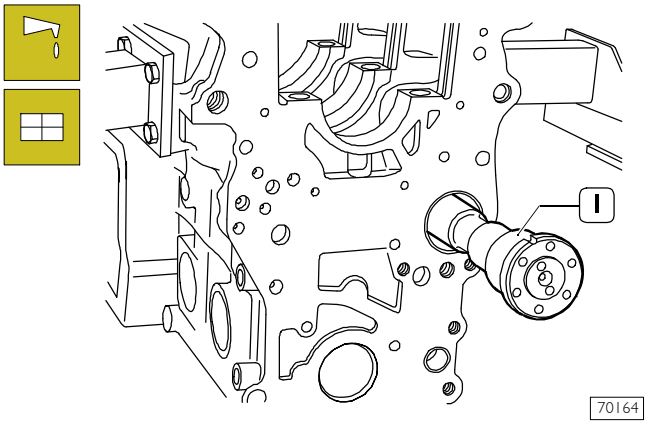
Fitting tappets – camshaft

Figure 66



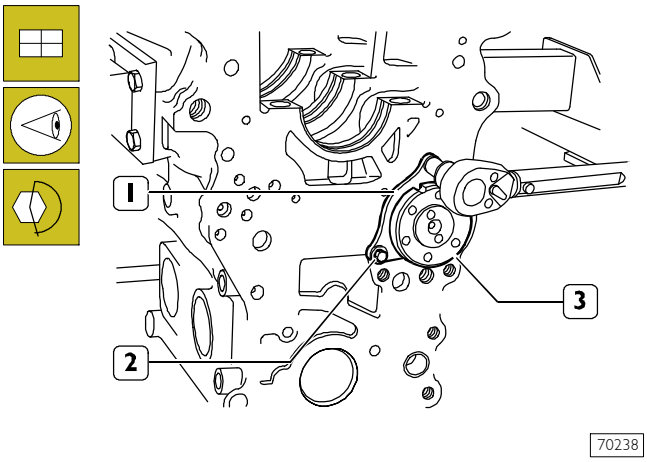
Lubricate the tappets (1) and fit them into the relevant housings on the engine block.

Figure 67



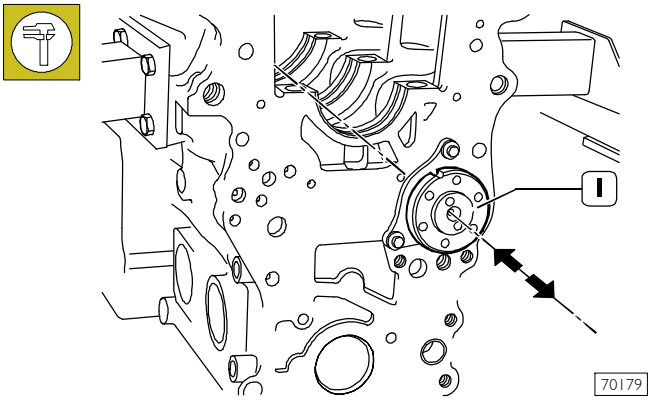
Lubricate the bushing and other timing system shaft support seats and mount camshaft (1) taking care that, during the operation, the bushing or support seats are not being damaged.

Figure 68



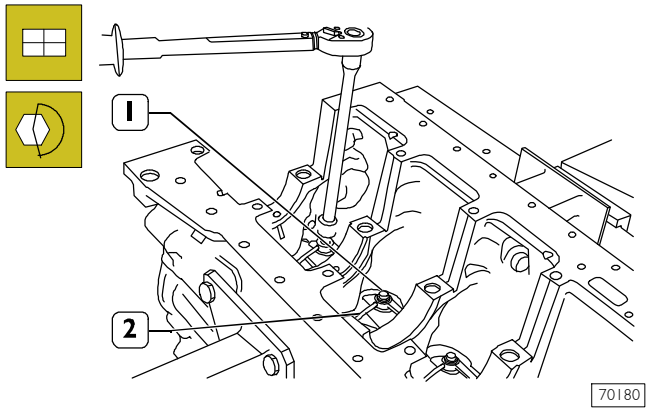
Set camshaft (3) retaining plate (1) with the slot facing the top of the engine block and the marking facing the operator, then tighten the screws (2) to the specified torque.

Figure 69



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

Figure 70

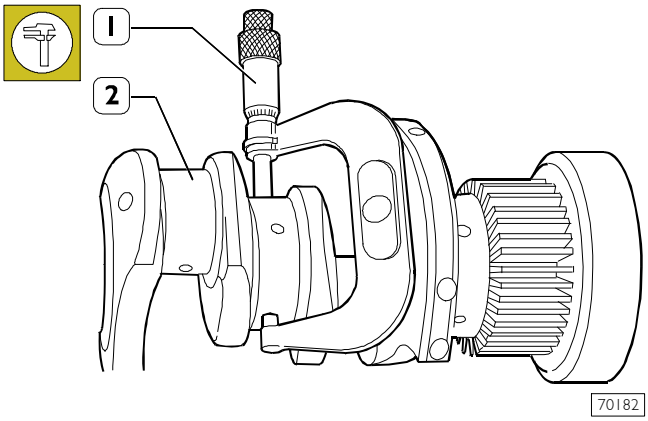


Fit nozzles (2) and tighten the fastening screws (1) to the specified torque.

Ref	No.	Description	Tightening torques
(1)	6	M8x1.25x20	15 ± 3 Nm

CRANKSHAFT
Measuring journals and crankpins

Figure 71



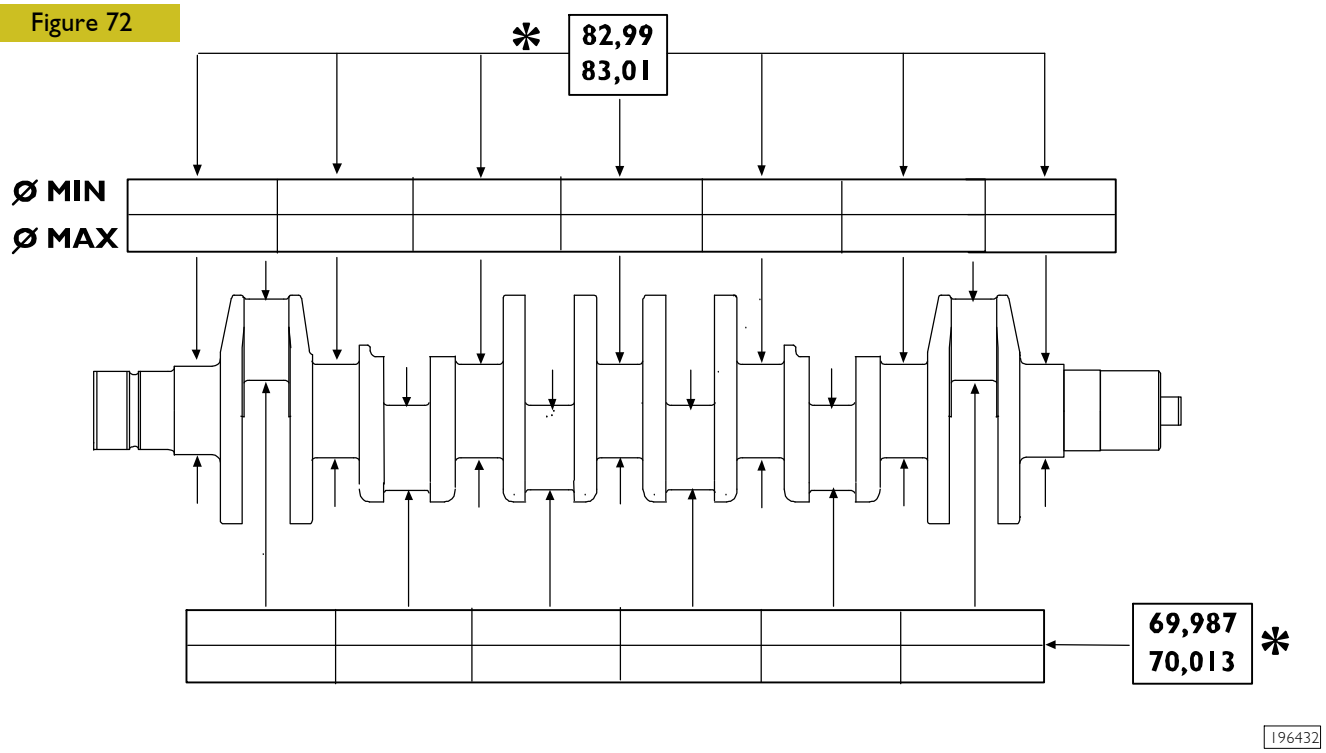
Grind journals and crankpins if seizing, scoring or excessive ovalisation are found. Before grinding the journals (2) measure them with a micrometer (1) to decide the final diameter to which the pins are to be ground.

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

Undersize classes are: 0.250 – 0.500 mm

NOTE 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

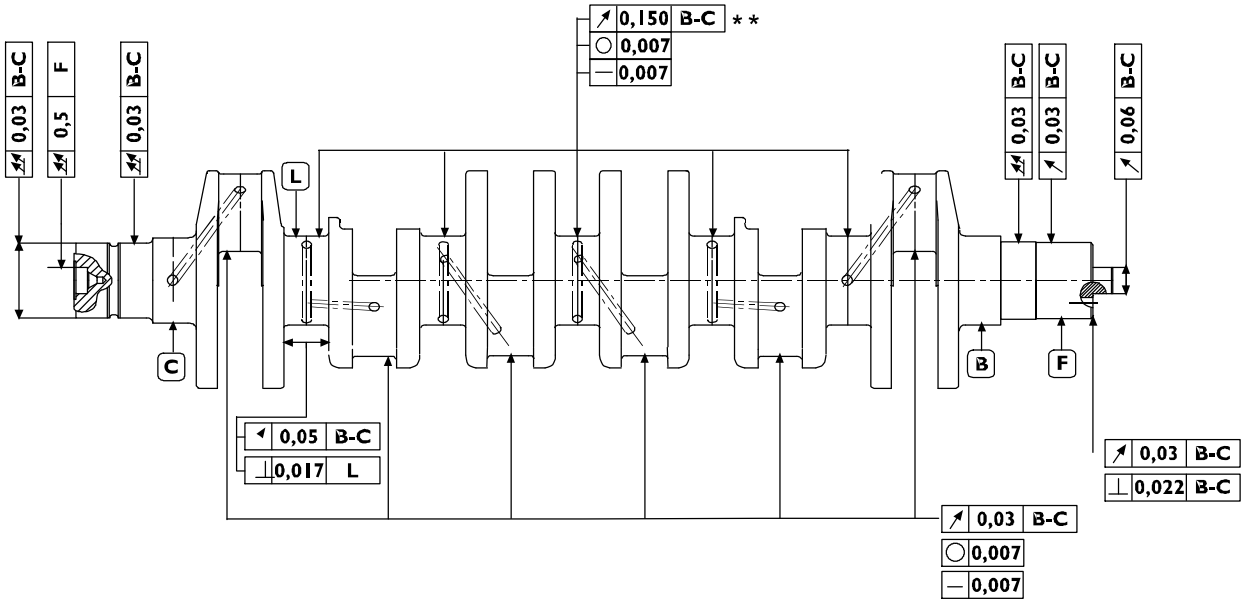
Figure 72



FILL THIS TABLE WITH OUTPUT SHAFT JOURNAL AND CRANKPIN MEASURED VALUES

*Rated value

Figure 73

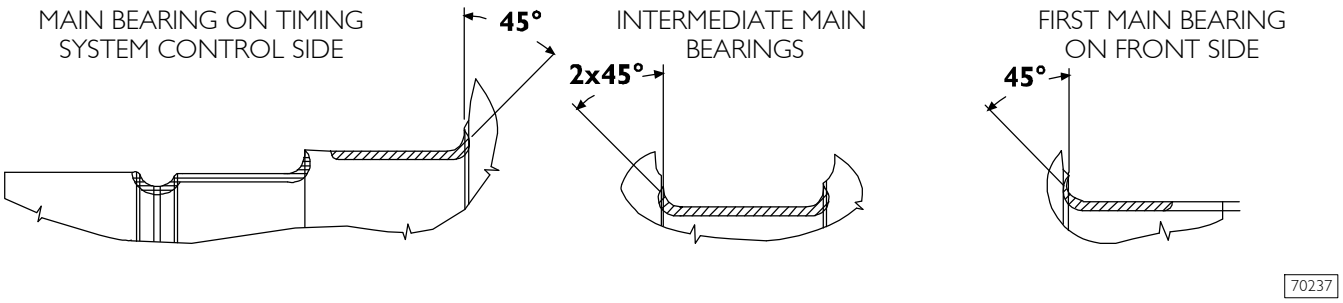


* Measured on a radius greater than 45.5 mm

** ↗ 0.500 between adjacent main journals

MAIN CRANKSHAFT TOLERANCES

Figure 74



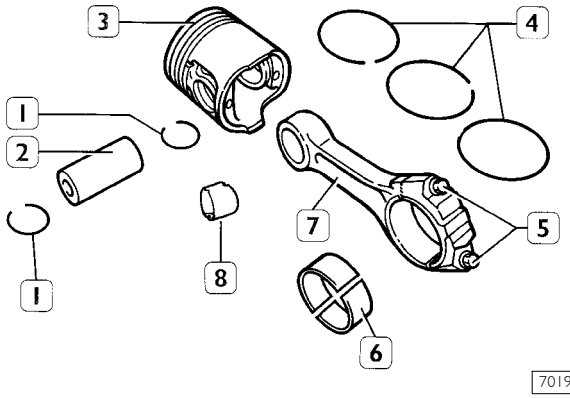
TOLERANCES	TOLERANCE CHARACTERISTIC	GRAPHIC SYMBOL
SHAPE	Roundness	○
	Cilindricity	/○/
DIRECTION	Parallelism	//
	Verticality	⊥
	Straightness	—
POSITION	Concentricity or coaxiality	◎
OSCILLATION	Circular oscillation	↗
	Total oscillation	⌰

LEVELS OF IMPORTANCE FOR PRODUCT CHARACTERISTICS	GRAPHIC SYMBOL
CRITICAL	©
IMPORTANT	⊕
SECONDARY	⊖

CONNECTING ROD – PISTON ASSEMBLY

Connecting rod-piston assembly removal

Figure 75

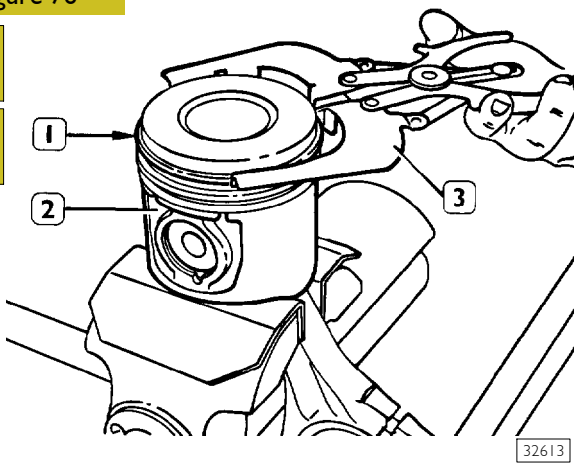


CONNECTING ROD – PISTON ASSEMBLY COMPONENTS

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

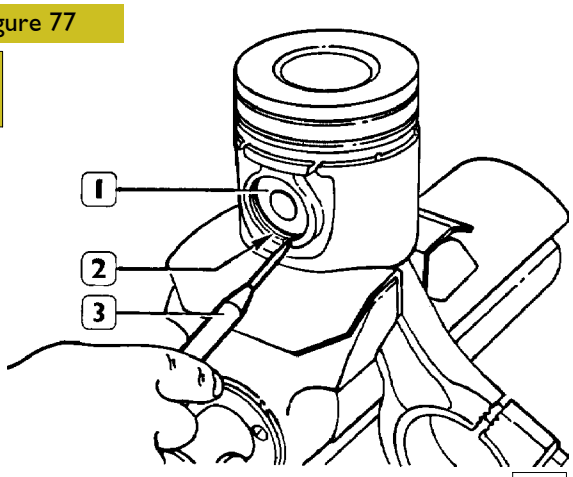
NOTE Pistons are supplied spare with 0.4 or 0.8 mm oversize.

Figure 76



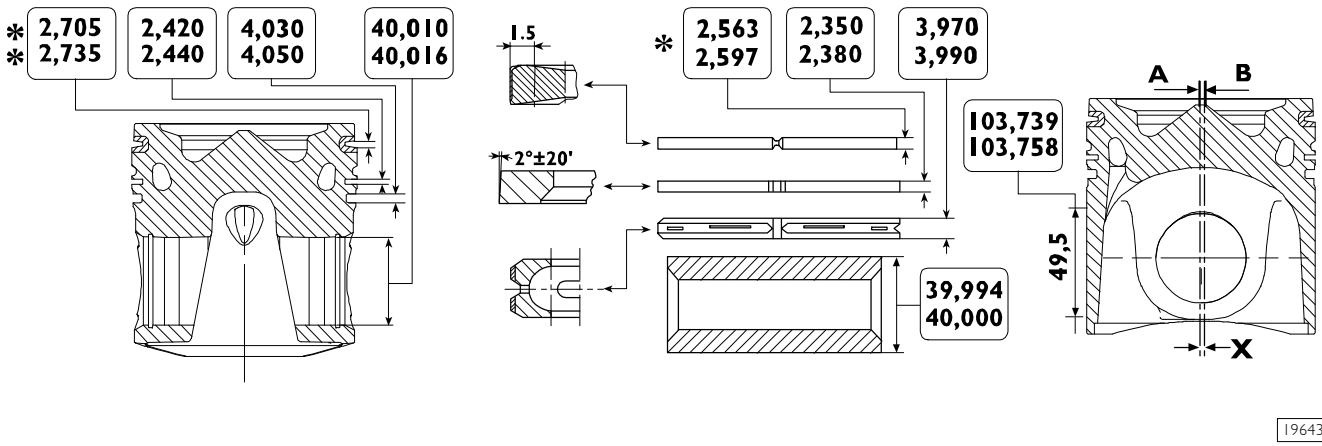
Remove split rings (1) from piston (2) using pliers 99360183 (3).

Figure 77



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

Figure 78



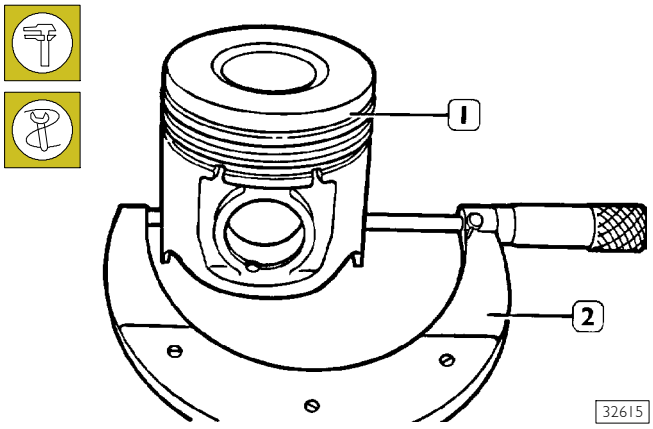
MAIN DATA OF THE PISTON WITH PIN TUNNEL AND PLASTIC RINGS

* Value measured on 101 mm diameter

Pistons

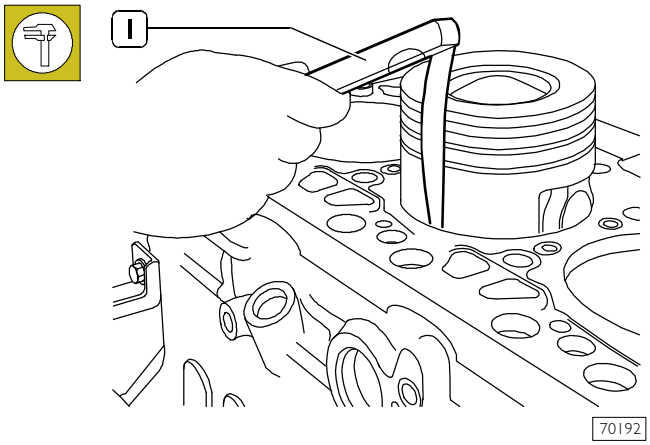
Measuring piston diameter

Figure 79



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

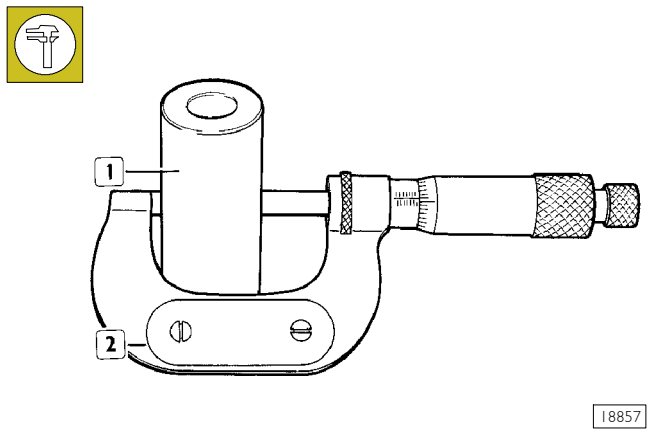
Figure 80



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

Gudgeon pins

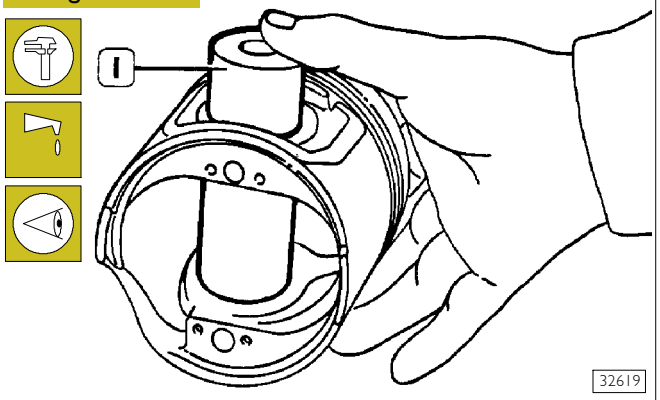
Figure 81



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

Conditions for proper pin-piston coupling

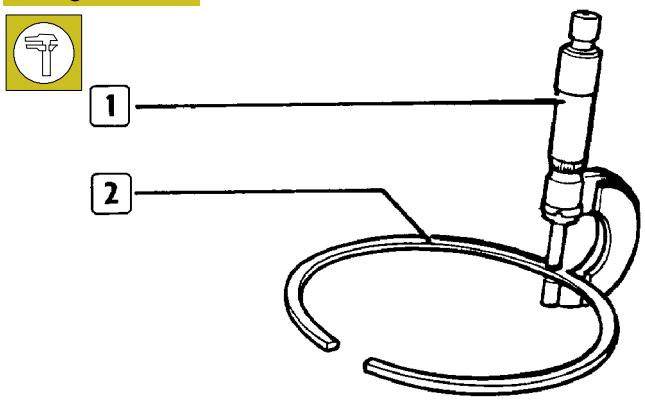
Figure 82



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.

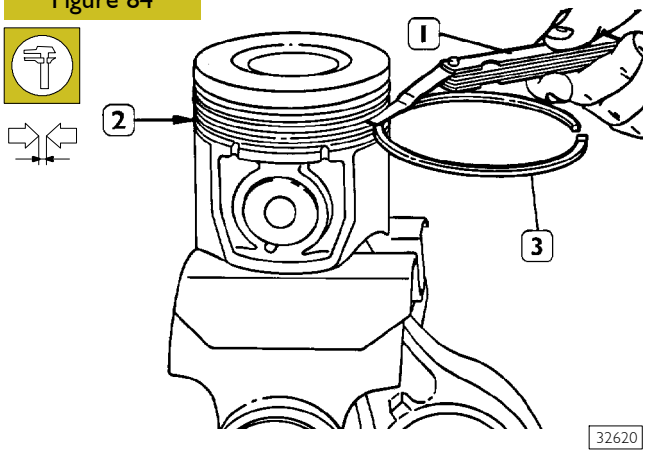
Piston rings

Figure 83



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

Figure 84



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 85

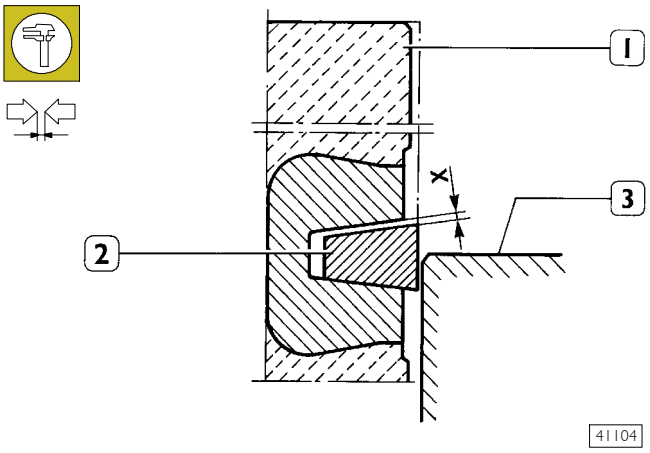
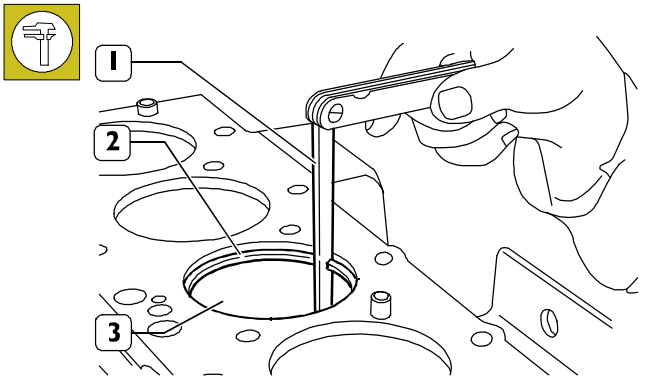


DIAGRAM FOR MEASURING THE CLEARANCE X BETWEEN THE FIRST PISTON SLOT AND THE TRAPEZOIDAL RING

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.

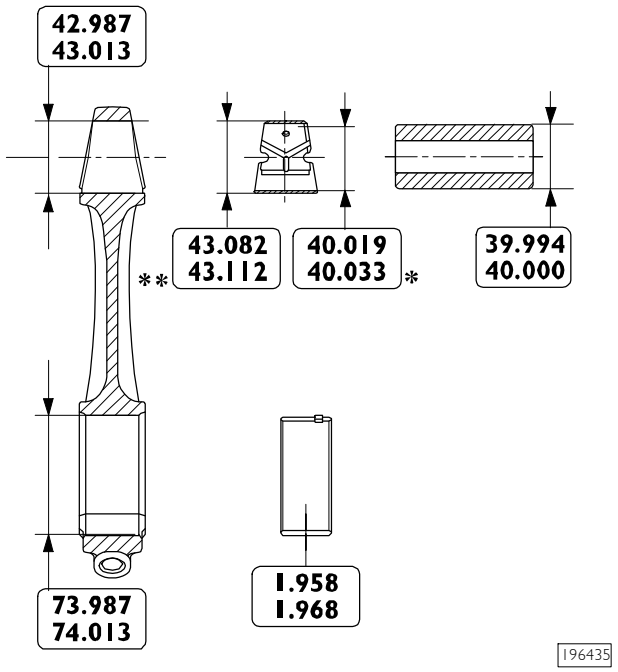
Figure 86



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 87

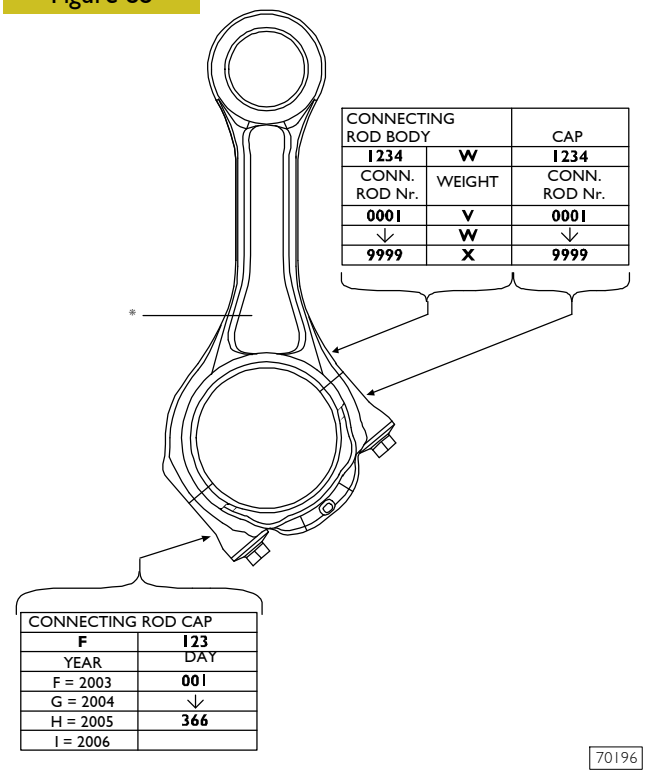


MAIN DATA FOR CONNECTING ROD, BUSH, PISTON PIN AND HALF BEARINGS

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

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

Figure 88



NOTE Every connecting rod is marked as follows:

- On body and cap with a number showing their coupling and the corresponding cylinder. In case of replacement it is therefore necessary to mark the new connecting rod with the same numbers of the replaced one.
- On body with a letter showing the weight of the connecting rod assembled at production:
  - V, 1560 to 1600 g (yellow marking);
  - W, 1601 to 1640 g (green marking);
  - X, 1641 to 1680 g (blue marking);

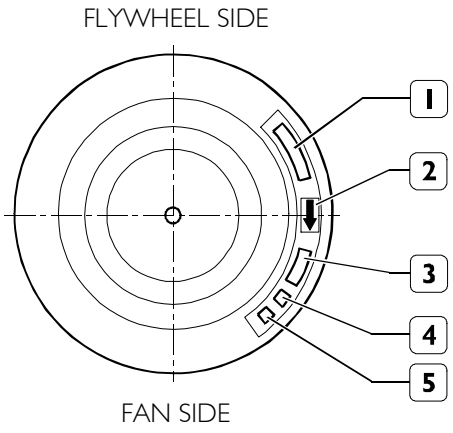
Spare connecting rods are of the W class with green marking *.
Material removal is not allowed.

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.

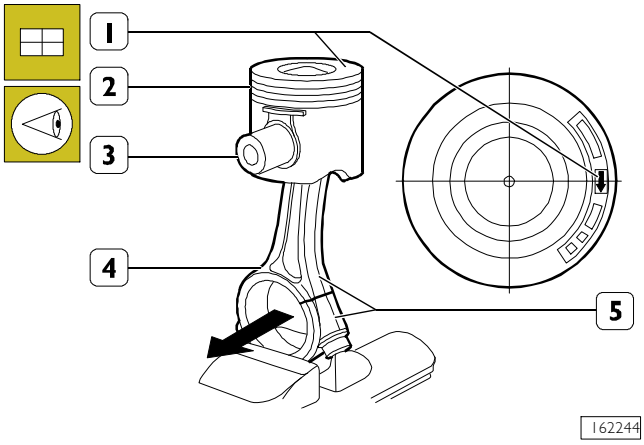
Fitting connecting rod-piston assembly
Connecting rod-piston assembling

Figure 89



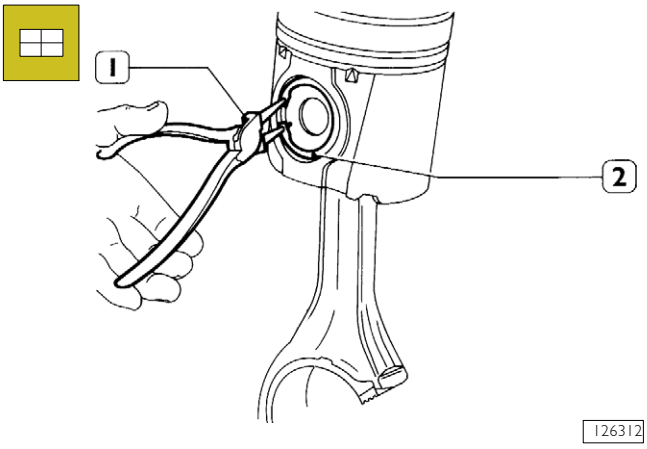
The piston crown is marked as follows:
1. Part number and design modification number;
2. Arrow showing piston assembling direction into cylinder barrel, this arrow shall face the front key of the engine block (fan side);
3. Marking showing 1st slot insert testing;
4. Manufacturing date;
5. Product traceability

Figure 90



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.

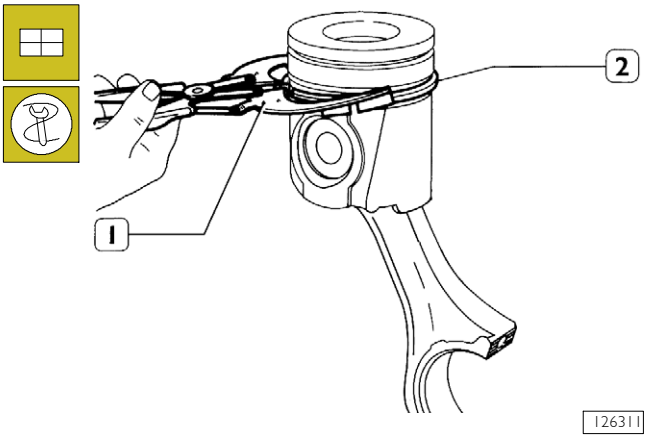
Figure 91



Position the piston on the connecting rod according to the diagram shown in the figure, fit the pin and stop it by the split rings (2).

Fitting split rings

Figure 92



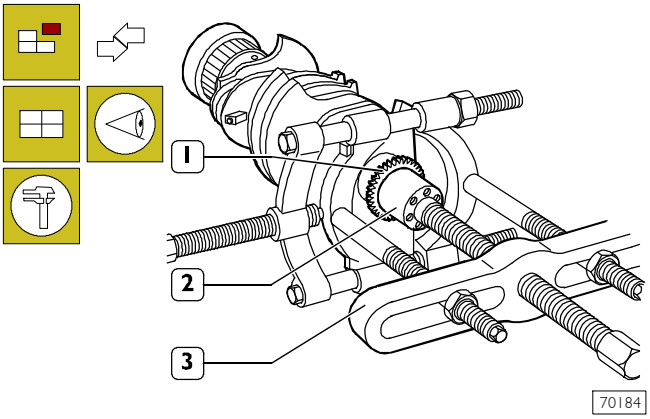
Use pliers 99360183 (1) to fit the split rings on the piston (2). Split rings shall be fitted with the marking "TOP" facing upwards and their openings shall be displaced with each other by 120°.

NOTE Split rings are supplied spare with the following sizes:
- standard;
- 0.4 mm oversize;
- 0.8 mm oversize.

BENCH ENGINE BLOCK ASSEMBLY

Replacing oil pump control gear

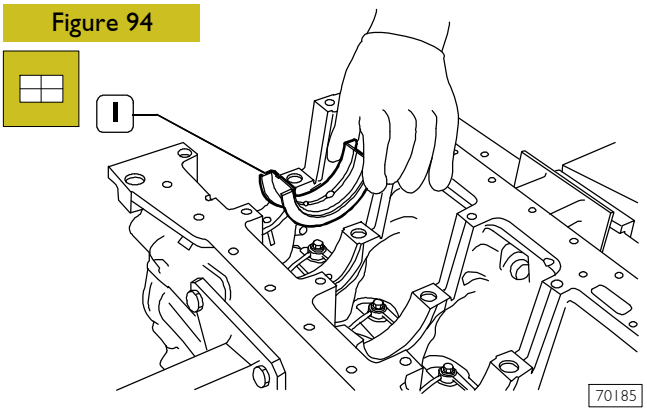
Figure 93



Check that gear toothing (1) is not damaged or worn, otherwise remove it using the proper puller (3).
On mounting the new gear, the gear has to be heated for 10' at 180 °C temperature and keyed on engine shaft by putting the key in between.

Fitting main bearings

Figure 94



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

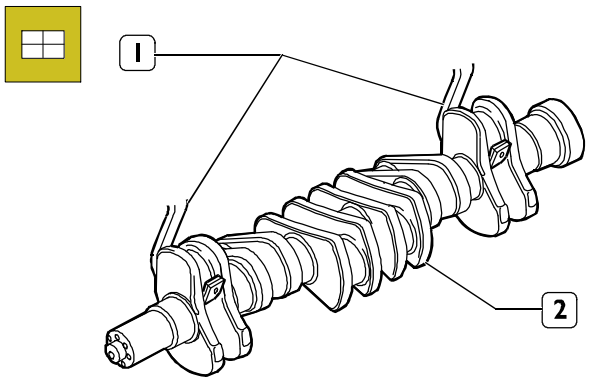
Main bearings (1) are supplied spare with 0.250 – 0.500 mm undersize on the internal diameter.

NOTE 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.

Crankshaft installation

Figure 95



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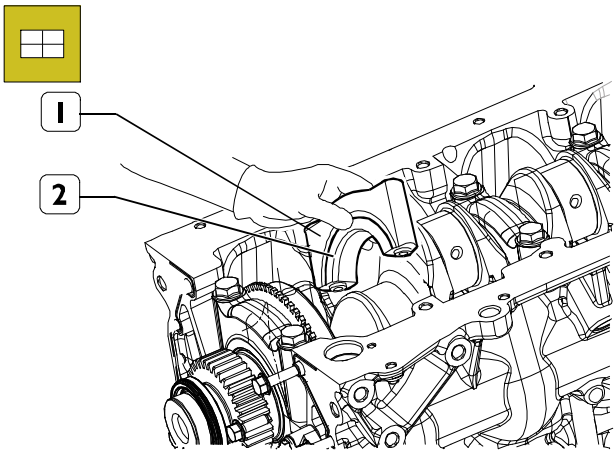
Refit the output shaft (2).

Figure 96



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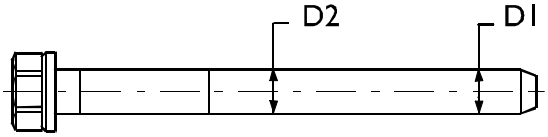
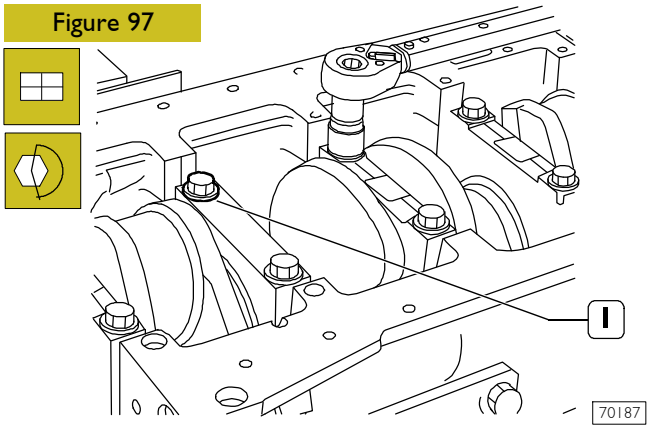
- ❑ Clean accurately the parts and remove any trace of oil;
- ❑ fit caps (1), including the half bearings (2) on the relevant supports.

NOTE Before reusing the fastening screws (1), perform two diameter measurements as shown in figure, registering diameters D1 and D2:
if D1-D2 < 0.1 mm the screw may be reused
if D1-D2 > 0.1 mm the screw must be replaced



75703

Figure 97



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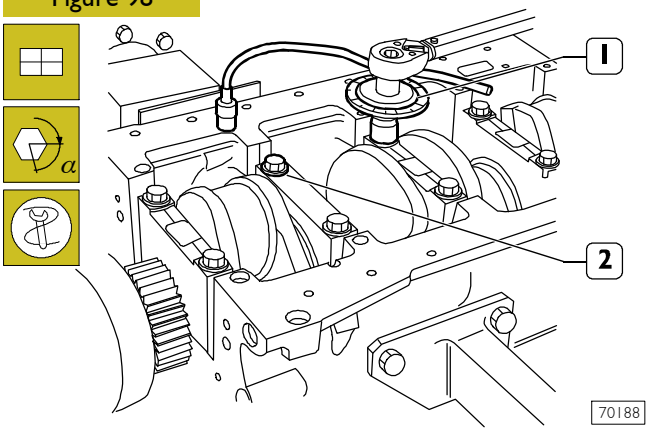
Tighten the pre-lubricated screws (1) in the following two successive stages:

- ❑ 1st stage, with torque wrench to 80 ± 6 Nm.

Figure 98



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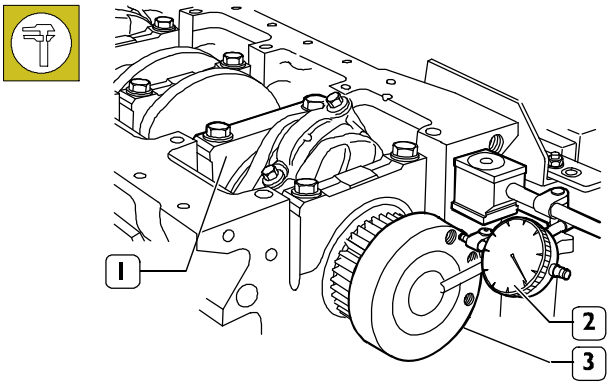
- ❑ 2nd stage, with tool 99395216 (1) set as shown in the figure, tighten the screws (2) with 90° ± 2° angle.

Checking crankshaft end float

Figure 99

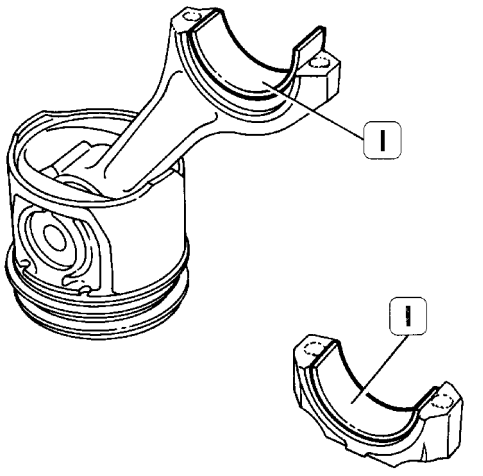


70190

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

Fitting connecting rod half bearings

Figure 100

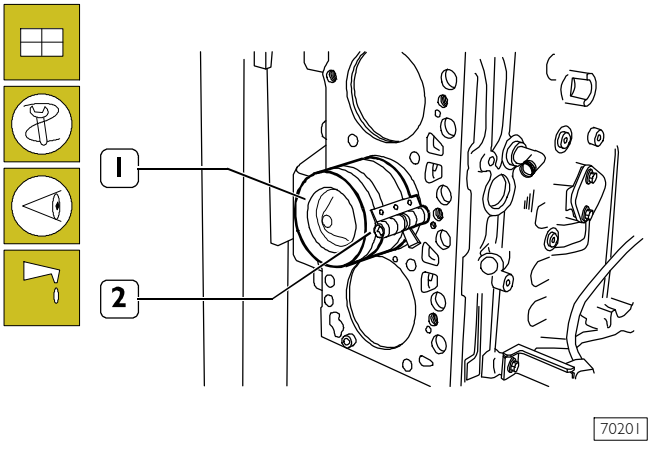


Fit half bearings (1) on connecting rod and cap.

NOTE 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 101



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 102

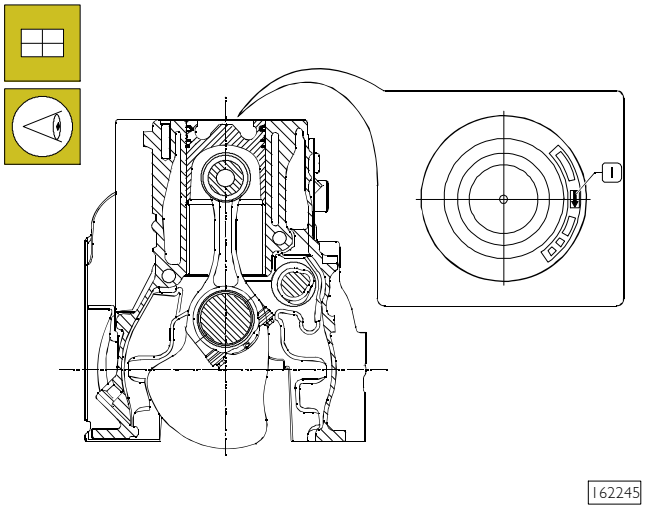
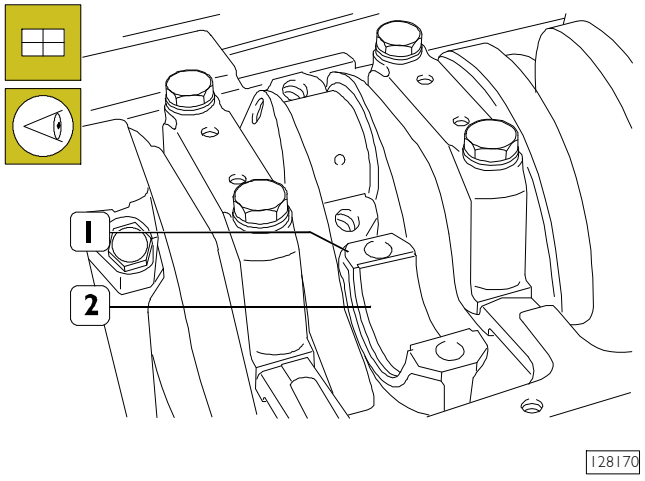


DIAGRAM FOR INSTALLING CONNECTING ROD PISTON ASSEMBLY INTO CYLINDER
(viewed from front)

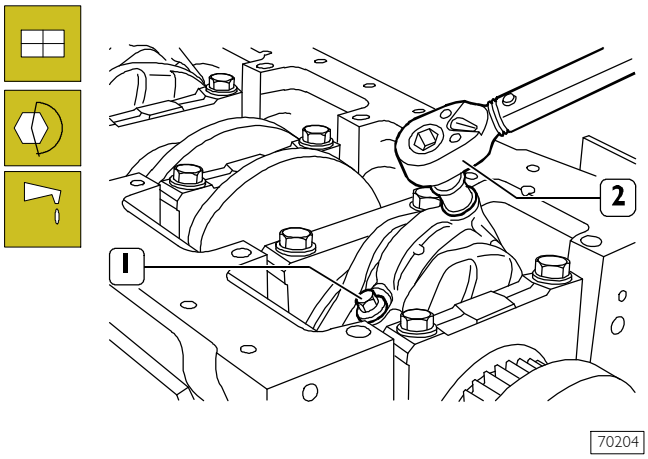
- ❑ split ring openings shall be displaced with each other by 120°;
- ❑ connecting rod-piston assemblies shall have the same weight;
- ❑ the arrow marked on the piston crown shall be facing the front side of the engine block or the slot obtained on the piston skirt shall be corresponding to the oil nozzle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

Figure 103



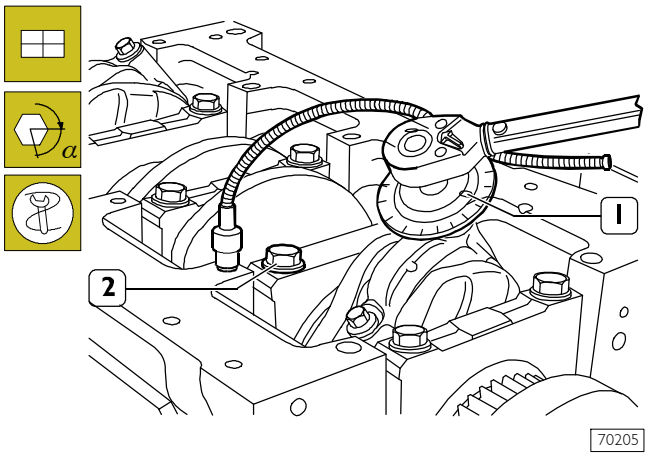
- ❑ Clean the parts accurately and remove any trace of oil;
- ❑ install the big end caps (1) with the relative half-bearings (2).

Figure 104



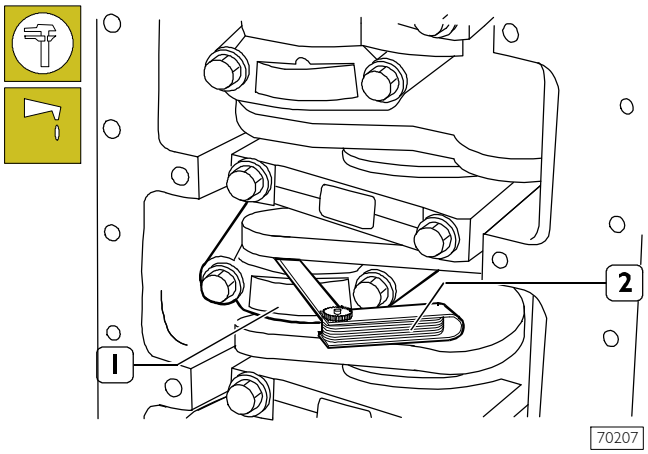
❑ lubricate the screws (1) with engine oil and then tighten them to the specified torque using the torque wrench (2).

Figure 105



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

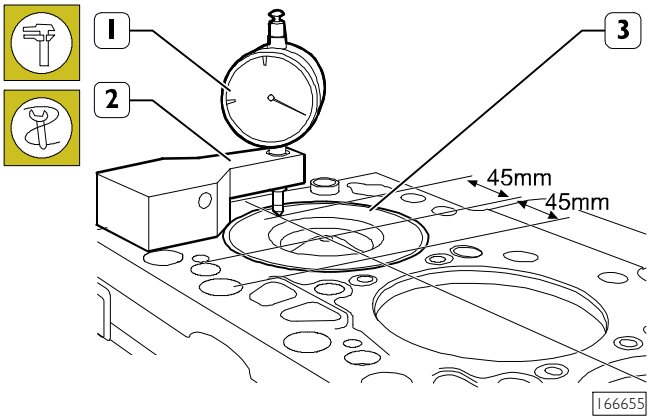
Figure 106



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

Checking piston protrusion

Figure 107



Once connecting rod-piston assemblies refitting is over, use dial gauge 99395603 (1) fitted with base 99370415 (2) to check piston (3) protrusion at T.D.C. with respect to the top of the engine block, carrying out the following operations:

❑ measure the protrusions S1 and S2 of piston no. 1 from the top surface of the engine block at a distance of 45 mm from the centre of the piston and then calculate the average protrusion:

$$S_{cil1} = \frac{S1 + S2}{2}$$

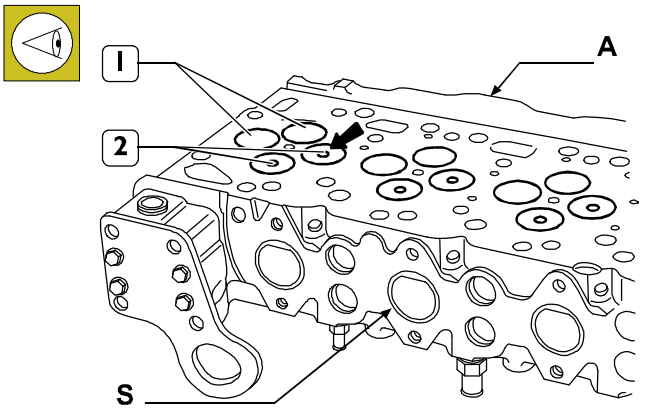
❑ repeat the operation to calculate the average protrusion of pistons 2, 3, 4, 5 and 6, then calculate the average value of the protrusions:

$$S = \frac{S_{cil1} + S_{cil2} + S_{cil3} + S_{cil4} + S_{cil5} + S_{cil6}}{6}$$

CYLINDER HEAD DISMANTLING

Removing the valves

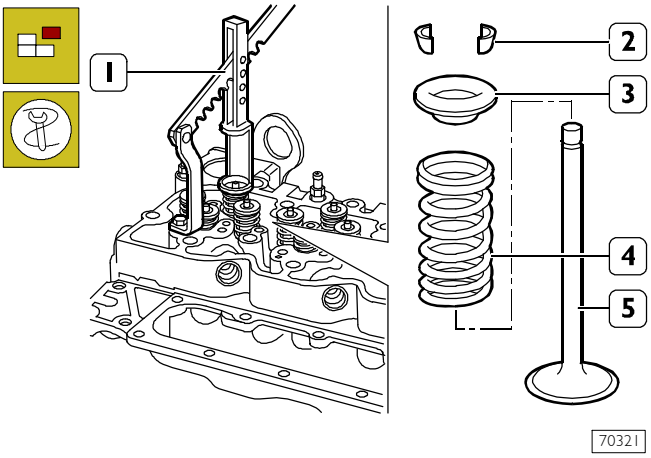
Figure 108



Intake (1) and exhaust (2) valves have heads with the same diameter.
The central notch (→) of the exhaust valve (2) head distinguishes it from the intake valve.

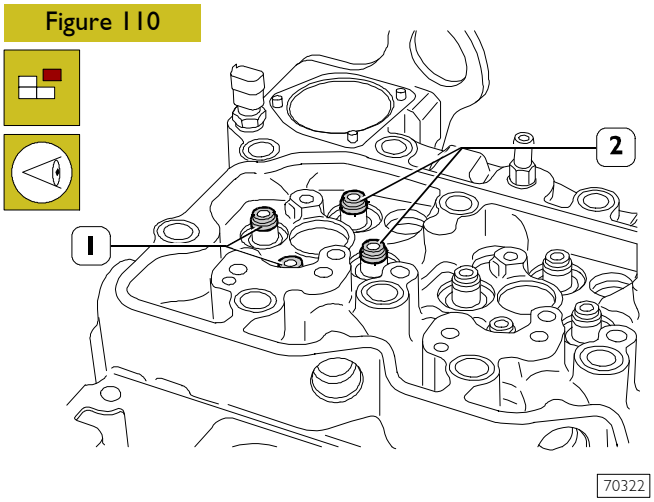
NOTE Should valves be not replaced, number them before removing in order to refit them in the same position.
A = intake side – S = exhaust side

Figure 109



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).
Repeat this operation for all the valves.
Overturn the cylinder head and withdraw the valves (5).

Figure 110

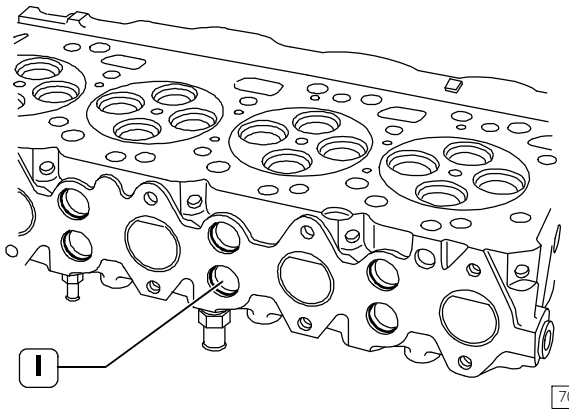


Remove the sealing rings (1 and 2) from the relevant valve guides.

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

Checking cylinder head wet seal

Figure 111



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.

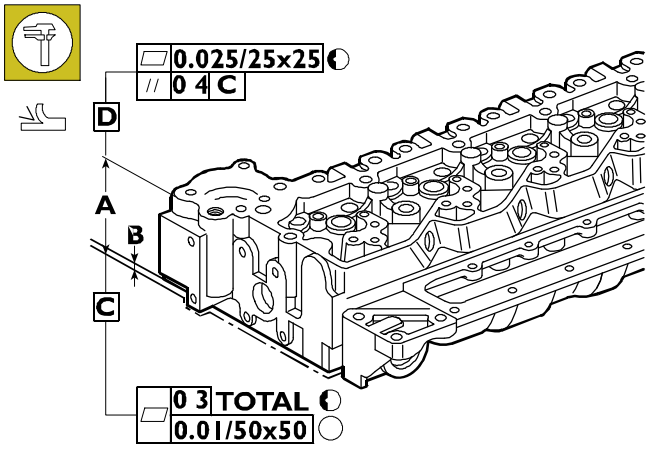
NOTE Before refitting, smear the plug surfaces with water--repellent sealant.

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 112

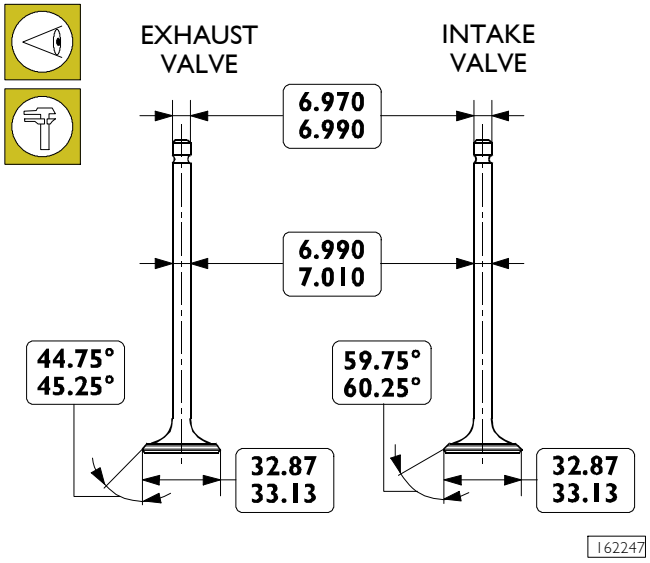


The rated thickness A for the cylinder head is 105 ± 0.25 mm, max. metal removal shall not exceed thickness B by 0.13 mm.

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

VALVES

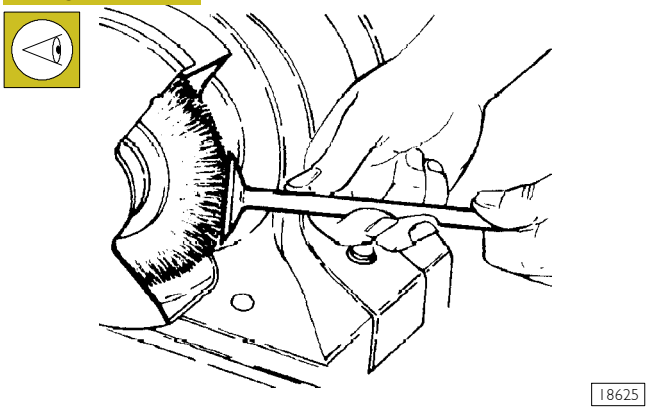
Figure 113



INTAKE AND EXHAUST VALVE MAIN DATA

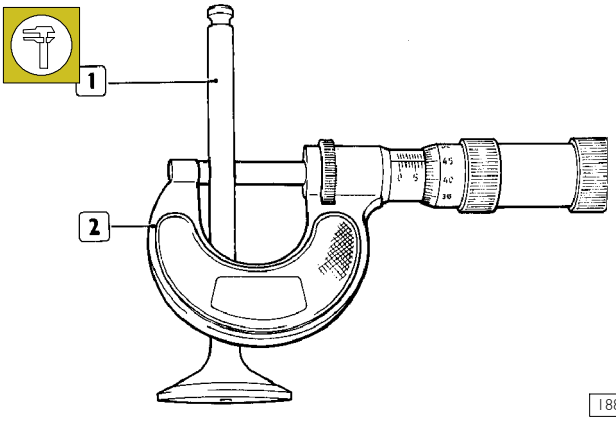
Removing carbon deposits, checking and grinding valves

Figure 114



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, removing as less material as possible.

Figure 115

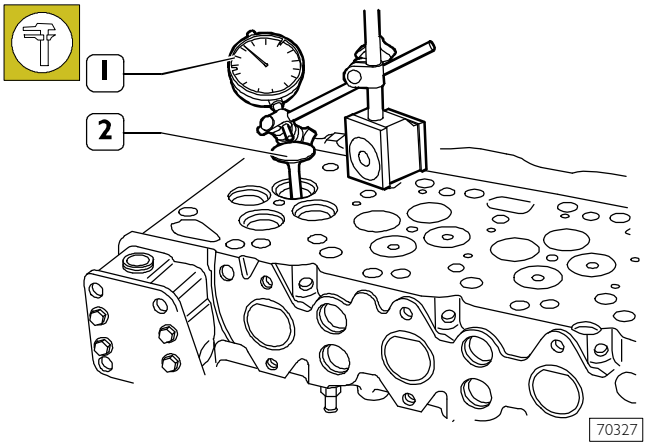


18882

Check the valve stem (1) using a micrometer (2), it shall be 6.990 ± 7.010 mm.

Checking clearance between valve stem and valve guide and valve centering

Figure 116

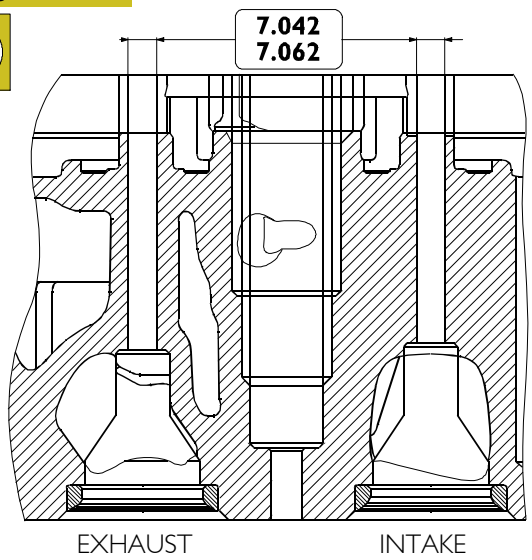


70327

Use a magnetic base dial gauge (1) set as shown in the figure, the assembling clearance shall be 0.032 ± 0.072 mm.
Turn the valve (2) and check that the centering error is not exceeding 0.03 mm.

VALVE GUIDES

Figure 117

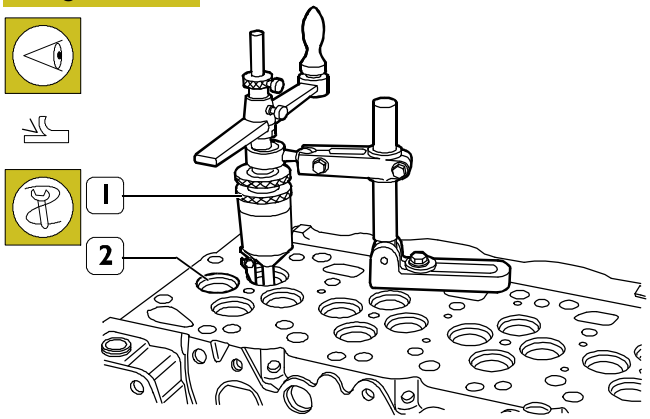


79457

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.

VALVE SEATS
Regrinding – replacing the valve seats

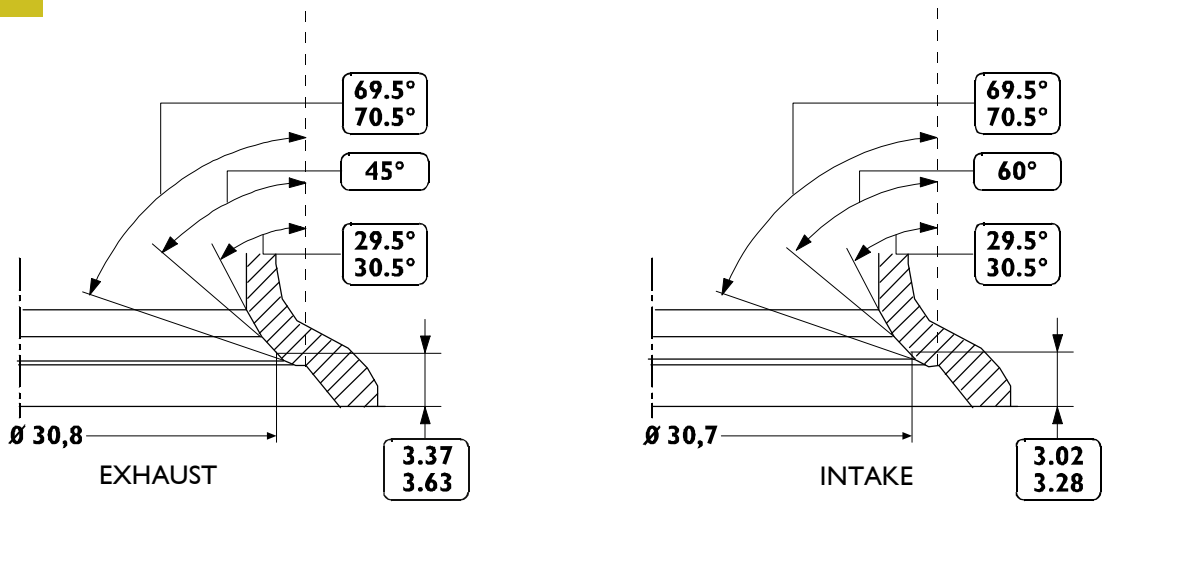
Figure 118



70330

Check the valve seats (2). If slight scoring or burnout is found, regrind seats using tool (1) according to the angle values shown in Figure 119.

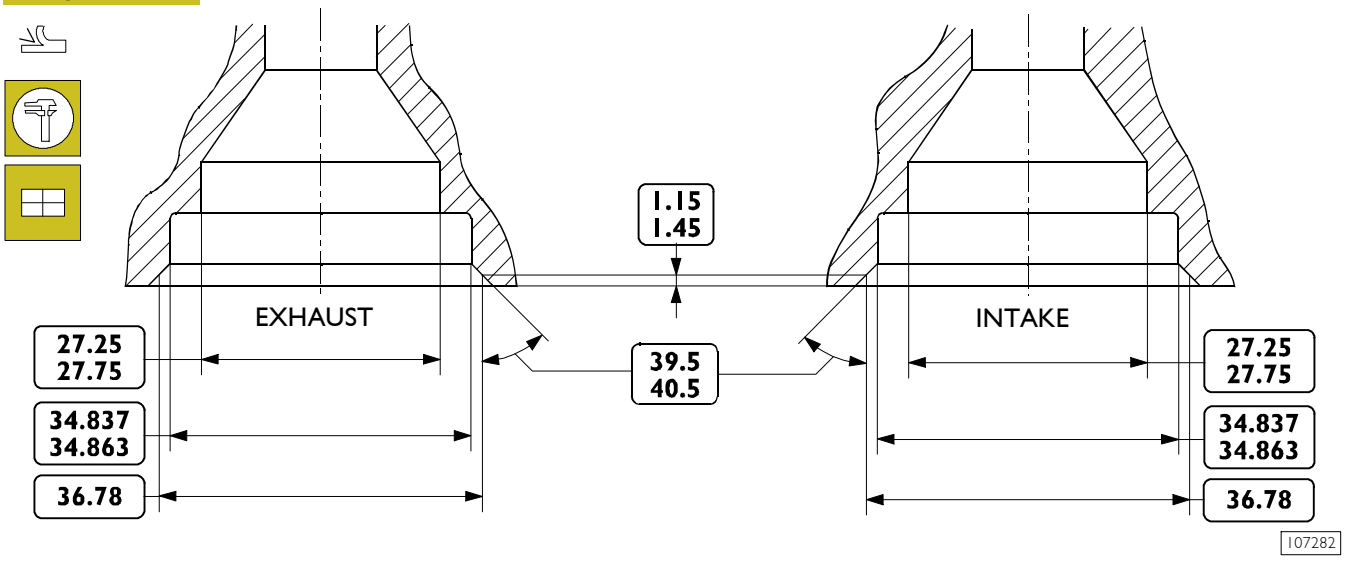
Figure 119



MAIN DATA OF ENGINE VALVE SEATS

The valve seats are cast in the cylinder head and machined.

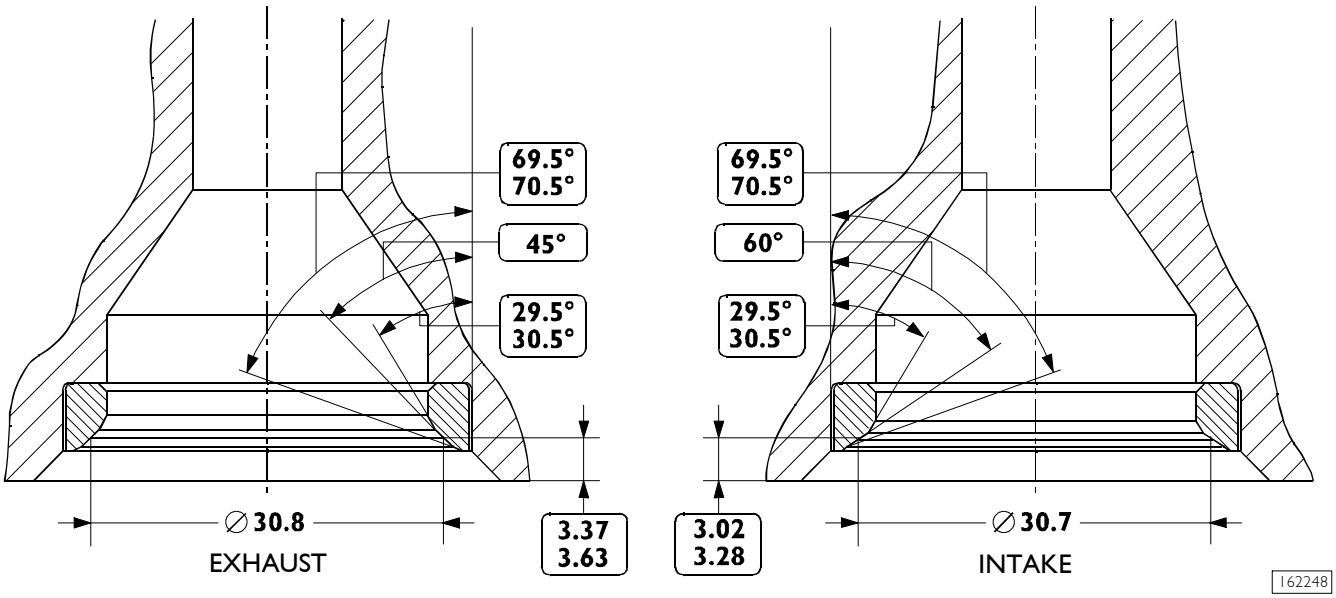
Figure 120



If the valve seats cannot be restored by only regrinding, it is possible to mount the inserts supplied as spares.
In this case, it is necessary to make the seats on the cylinder head with the dimensions shown in the figure and to mount the valve seats.

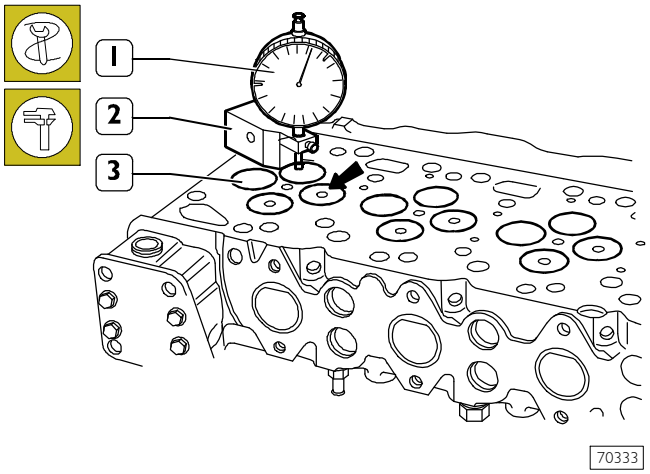
To mount the valve seats in the cylinder head it is necessary to heat the cylinder head to 80 - 100 °C and, using a suitable drift, mount the new valve seats (2) in them after they have been cooled.
Then use the specific tool to grind the valve seats to the values given in Figure 121.

Figure 121



MAIN VALVE SEAT DATA

Figure 122

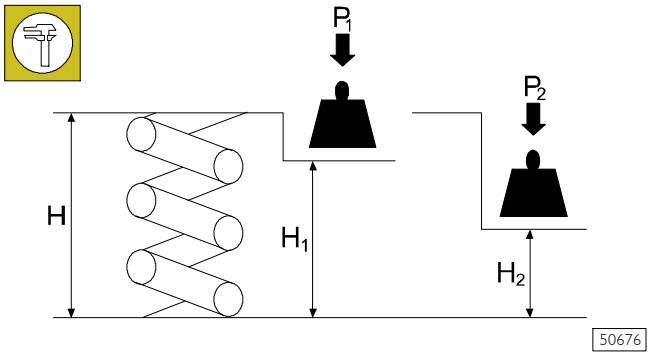


After regrinding, check with the base 99370415 (2) and the dial gauge 99395603 (1) that the valve recessing (3) is as prescribed.

Height		Under a load of	
mm		N	
H	35.33		Free
H1	35.33	P1	339.8 ± 9
H2	25.2	P2	741 ± 39

VALVE SPRINGS

Figure 123

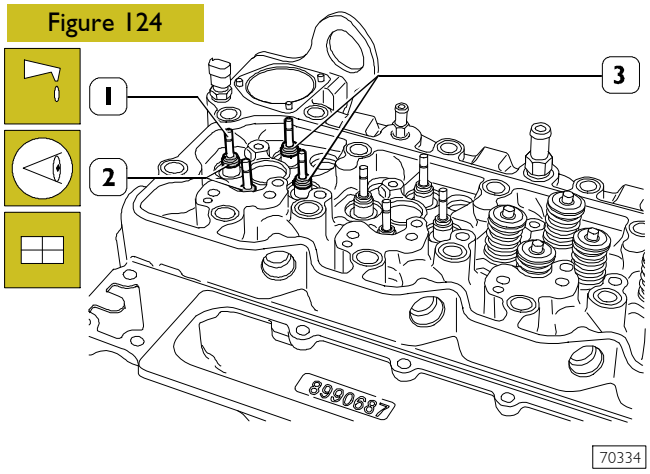


MAIN DATA TO CHECK INTAKE AND EXHAUST VALVE SPRINGS

Prior to assembly, check valve spring flexibility using a suitable tool. Compare the elastic deformation and load data with those for new springs given in the following table.

ASSEMBLING CYLINDER HEAD

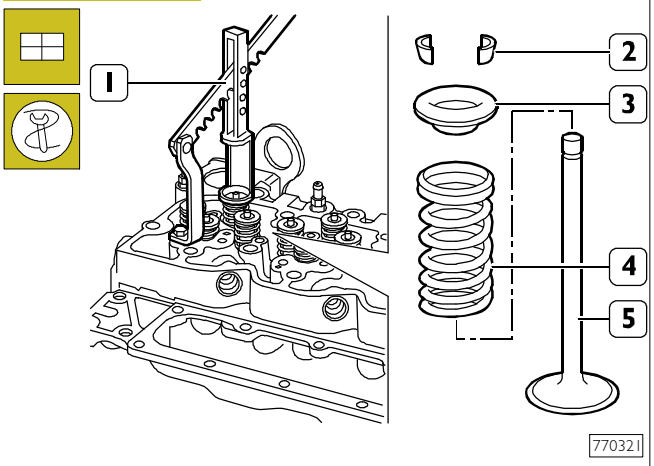
Figure 124



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.

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

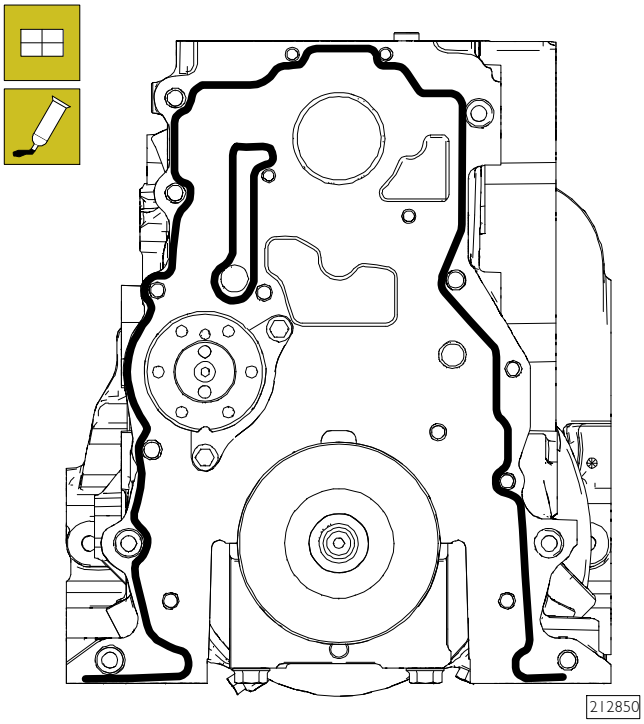
Figure 125



Position on the cylinder head: the spring (4) and upper plate (3): using tool 99360268 (1), compress the spring (4) and fasten the plate (3) to the valve (5) with the cotters (2).

REFITTING MAIN COMPONENTS

Figure 126



LOCTITE 5205 SEALANT APPLICATION AREAS

Clean accurately the timing gear case and the engine block.

NOTE Perfect seal is only obtained by cleaning accurately the surface to seal.
Smear the case with LOCTITE 5205 to obtain a bead of few mm diameter.
It shall be uniform (no clots), without air bubbles, thin areas or discontinuities.
Any imperfection shall be corrected as soon as possible.
Avoid to use excess material to seal the joint.
Excessive sealant could come out from joint sides and cause lubricant passage clogging.
After applying the sealant, the joint shall be assembled immediately (10 – 20 minutes).

Figure 127

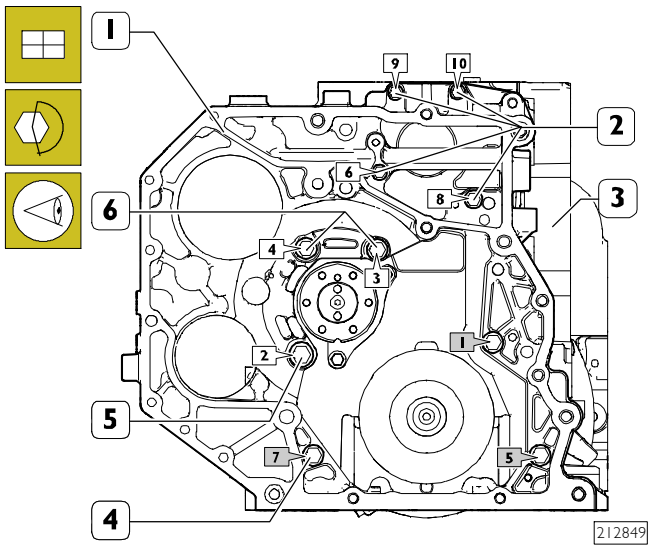


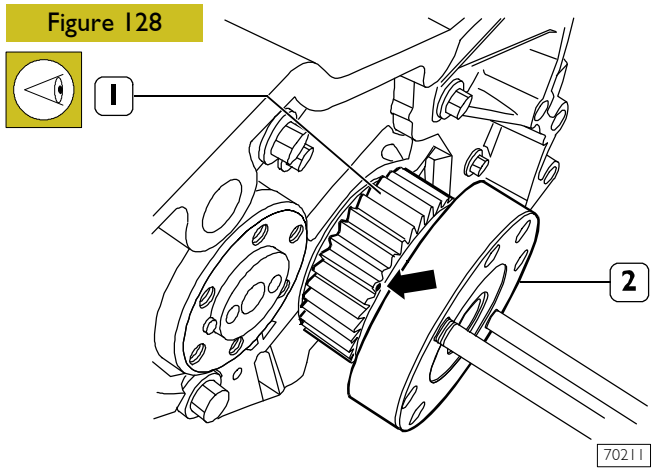
DIAGRAM FOR TIGHTENING THE REAR TIMING GEAR CASE FASTENING SCREWS

Refit the timing gear case (1) to the crankcase (3). Screw the fastening screws (2, 4, 5 and 6) to the same position found at removal and tighten them to the prescribed torque following the sequence shown in the figure.

Ref	No.	Description	Tightening torques
(2)	4	M8x1.25	24 ± 4 Nm
(4)	3	M10x1.5	47 ± 5 Nm
(5)	1	M12x1.75	77 ± 12 Nm
(6)	2	M10x1.5	47 ± 5 Nm

NOTE Before any assembly operation always verify that the hole and screw threads have no evidence of wear or dirt.

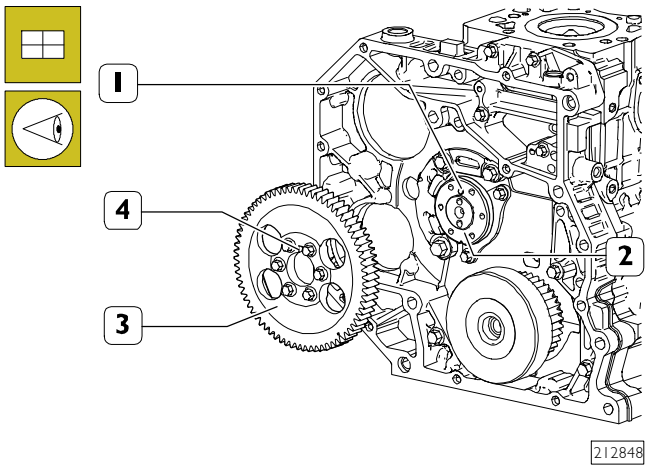
Figure 128



With a felt-tip pen, highlight the conducting gear tooth (1) mounted on the engine shaft (2) upon the side surface of which a groove has been created for the ignition timing.

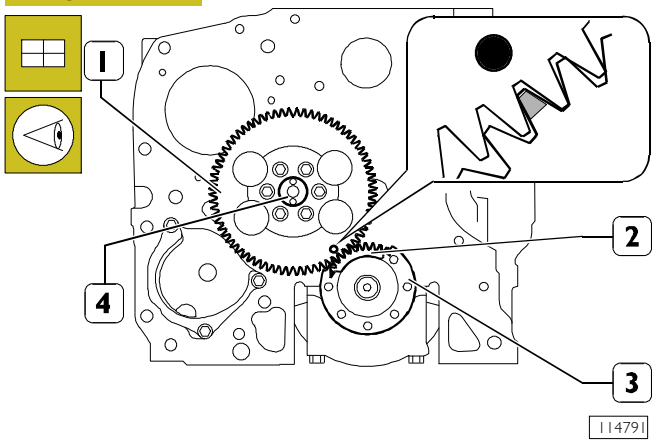
NOTE Fasten screwing of the two pins to facilitate the operation of engine driving shaft rotation.

Figure 129



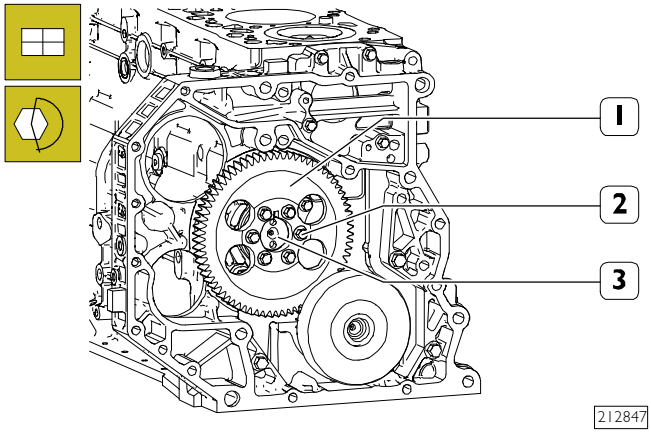
Ensure that, during the assembly of the timing gear (3) on the camshaft (2), the reference pins (1 and 4) match.

Figure 130



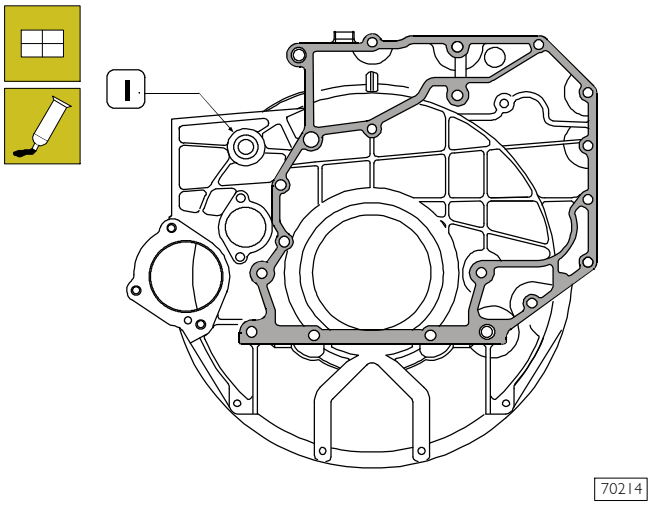
Turn the engine shaft (3) and the distribution shaft (4) so that by mounting the bevel gear on the latter (1) the stencilled mark on the gear (1) coincides with the groove on the gear tooth (2).

Figure 131



Tighten the screws (1) fastening gear (2) to camshaft (3) to the specified torque.

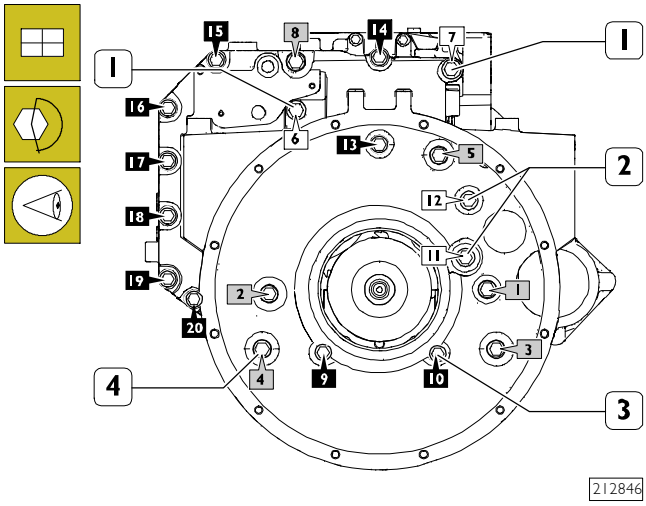
Figure 132



LOCTITE 5205 SEALANT APPLICATION AREAS

NOTE Perfect seal is only obtained by cleaning accurately the surface to seal.
Smear the case with LOCTITE 5205 to obtain a bead of few mm diameter.
It shall be uniform (no clots), without air bubbles, thin areas or discontinuities.
Any imperfection shall be corrected as soon as possible.
Avoid to use excess material to seal the joint.
Excessive sealant could come out from joint sides and cause lubricant passage clogging.
After applying the sealant, the joint shall be assembled immediately (10 – 20 minutes).

Figure 133



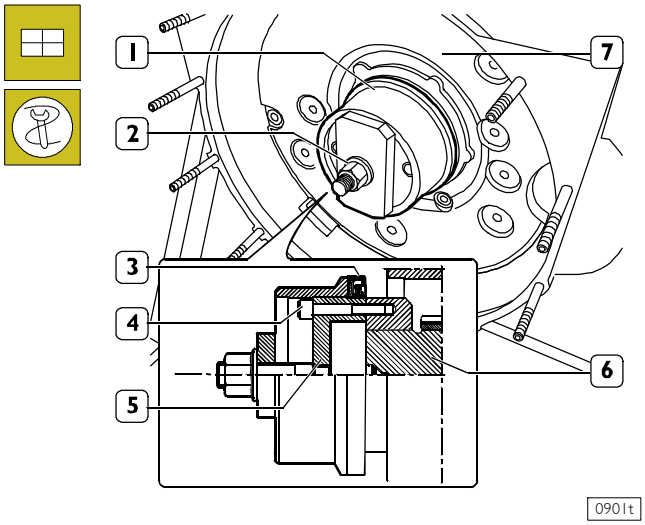
SEQUENCE FOR TIGHTENING THE FLYWHEEL HOUSING FASTENING SCREWS

Refit the flywheel housing to the engine block.
Screw the fastening screws (1, 2, 3 and 4) to the same position found at removal and tighten them to the prescribed torque following the sequence shown in the figure.

Ref	No.	Description	Tightening torques
(1)	2	M12x1.75	85 ± 10 Nm
(2)	2	M10x1.5	49 ± 5 Nm
(3)	10	M10x1.5	49 ± 5 Nm
(4)	6	M12x1.75	85 ± 10 Nm

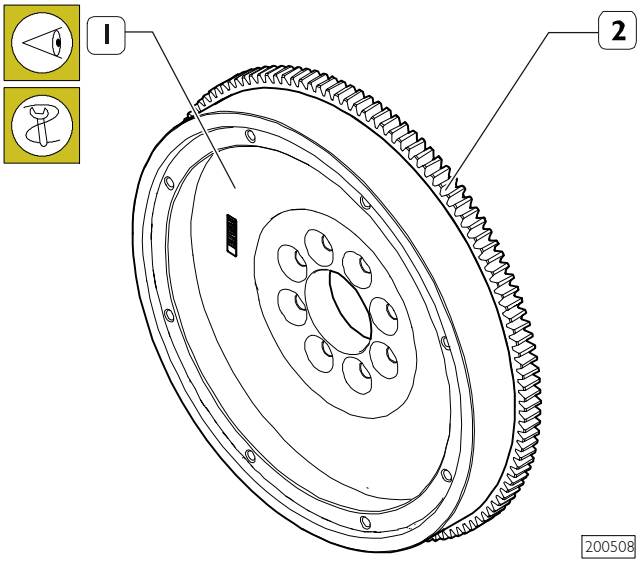
NOTE Before any assembly operation always verify that the hole and screw threads have no evidence of wear or dirt.

Figure 134



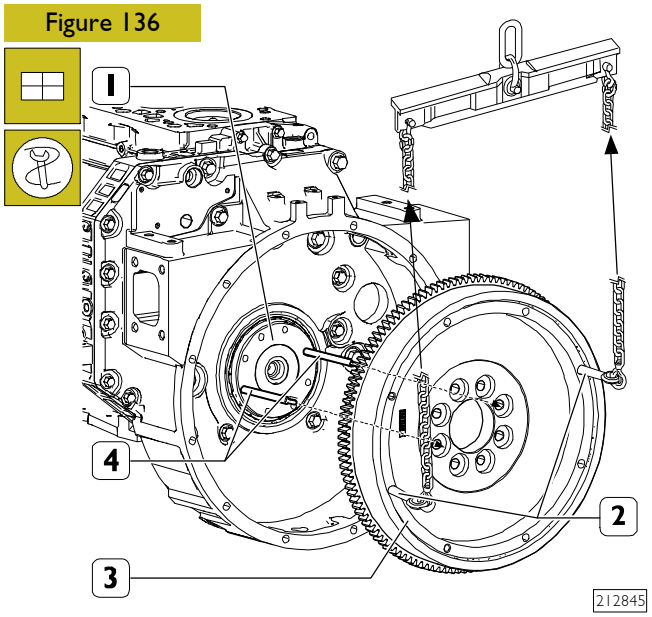
Apply tool 99346253 part (6) to the rear output shaft tang (5), secure it by screws (4) and fit the new sealing ring (3). Position part (1) on part (5), screw nut (2) until completing sealing ring (3) fitting into flywheel housing (7).

Figure 135



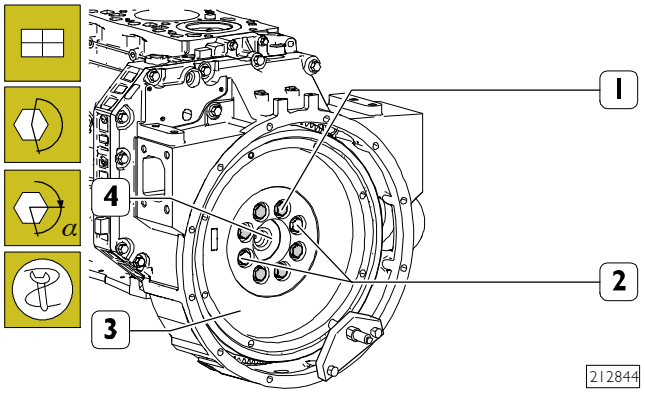
Check the supporting surface (1) of the clutch plate and if it is scratched, it is necessary to carry out turning.
Check ring gear teeth (2), if breakage or excessive wear is found remove the ring gear from the engine flywheel using a suitable hammer and fit the new one, previously heated to 150 °C for 15 to 20 minutes. Chamfering on ring gear inside diameter shall be facing the engine flywheel.

Figure 136



Screw up two medium length screws in the ports (2) to sling the engine flywheel (3).
Screw up two guide pins (4) having suitable length into the crankshaft holes (1) and assemble the engine flywheel (3) by means of a hoist with tool 99360595.

Figure 137

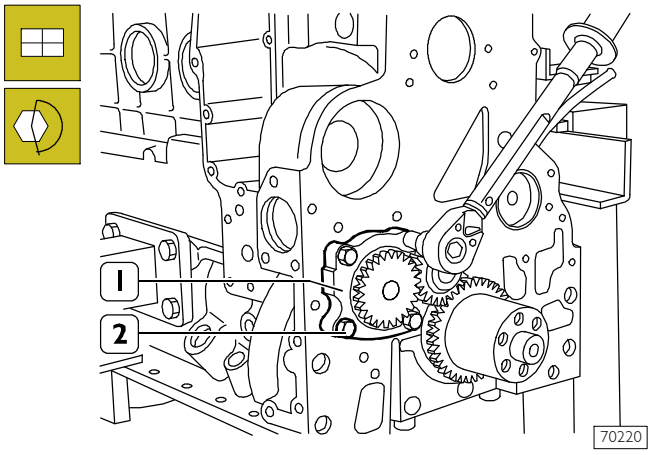


Apply tool 99360351 on the flywheel housing in order to block the engine flywheel (3) rotation.
Remove the two withdrawal pins in the ports (see the previous picture).
Tighten the screws (1 and 2) fixing the engine flywheel (3) to the crankshaft (4) in two phases.

Ref	No.	Description	Tightening torques
(1,2)	8	M12x1.25	30 ± 4 Nm 60°

NOTE Tightening to angle is performed using tool 99395216.
Before any assembly operation always verify that the hole and screw threads have no evidence of wear or dirt.

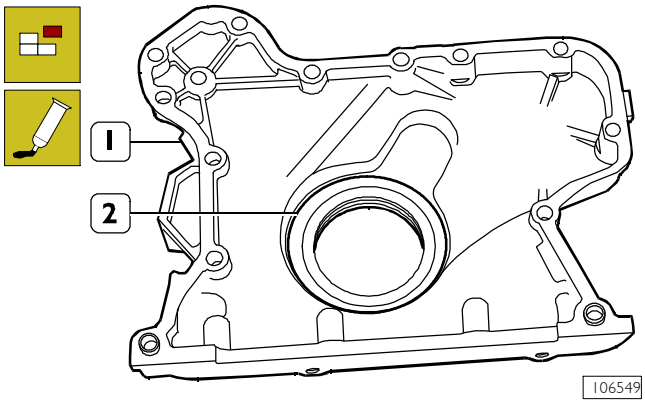
Figure 138



Fit the oil pump (1).
Tighten the fastening screws (2) to the specified torque.

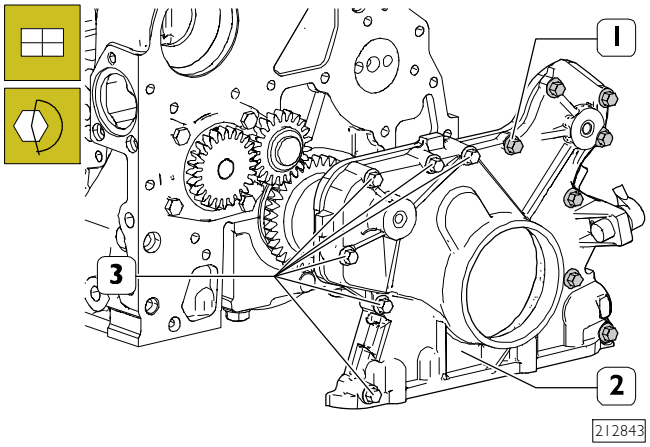
Ref	No.	Description	Tightening torques
(2)	4	M8x1.25 1st phase 2nd phase	8 ± 1 Nm 24 ± 4 Nm

Figure 139



Remove the sealing ring (2) from the front cover (1), clean accurately the coupling surfaces and smear them with LOCTITE 5205.

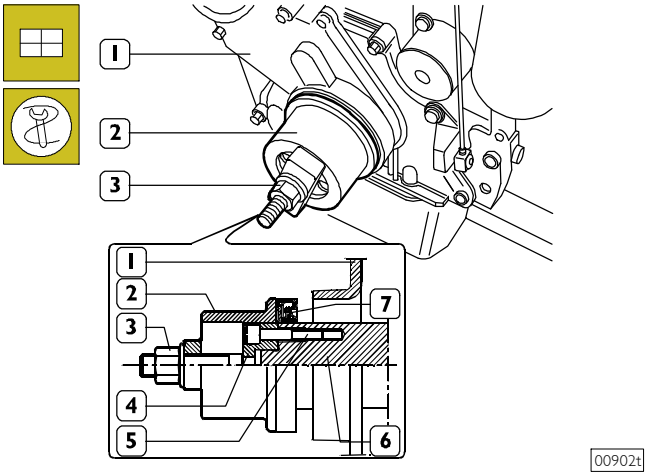
Figure 140



Fit the front cover (2) together with the crankshaft rpm increment speed sensor to the engine block.
Screw the fastening screws (1 and 3) to the same position found at removal and tighten them to the prescribed torque.

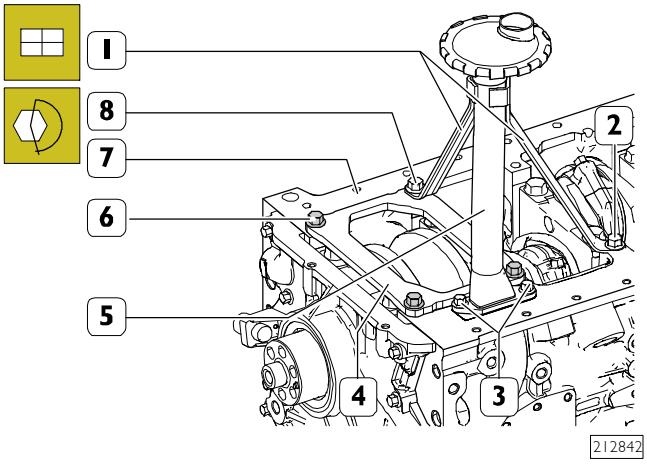
Ref	No.	Description	Tightening torques
(1)	7	M8x1.25x30	24 ± 4 Nm
(3)	6	M8x1.25	24 ± 4 Nm

Figure 141



Apply tool 99346252 part (4) to the front output shaft tang (6), secure it by screws (5) and fit the new sealing ring (7). Position part (2) on part (4), screw nut (3) until completing sealing ring (7) fitting into front cover (1).

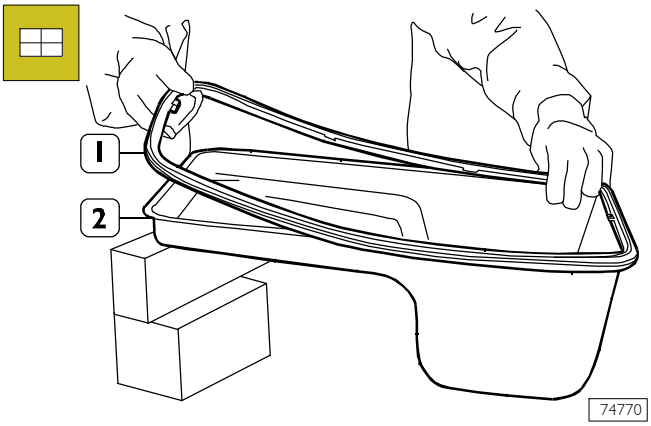
Figure 142



Turn the engine upside-down.
Fit the oil suction strainer pipe (5) on the crankcase (7) after having interposed a new gasket and tighten the fastening screws (3) to the specified torque.
Fit the stiffening plate (4) and the oil suction strainer pipe brackets (1) on the crankcase (7) and tighten the fastening screws (2, 6 and 8) to the specified torque.

Ref	No.	Description	Tightening torques
(2)	1	M10x1.5x20	45 Nm
(3)	2	M8x20	25 Nm
(6)	3	M10x1.5x25	43 ± 5 Nm
(8)	1	M10x1.5x25	43 ± 5 Nm

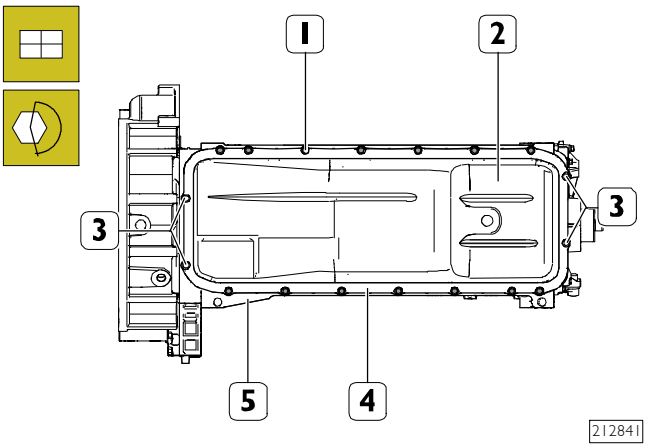
Figure 143



Set the gasket (1) on the oil sump (2).

NOTE If it does not show any signs of damage the gasket can be reused.

Figure 144

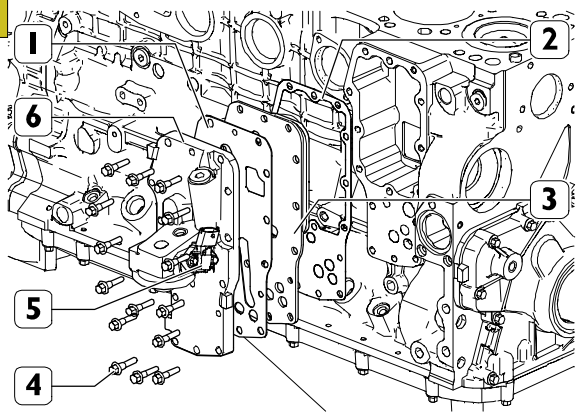


Fit the oil sump (2) in position on the crankcase (5) and apply the relevant plate (4) to it.
Tighten the fastening screws (1 and 3) to the prescribed torque.

Ref	No.	Description	Tightening torques
(1)	14	M8x1.25x40	25 Nm
(3)	4	M8x1.25x45	25 Nm

NOTE Always check that the threads on the screws and their holes do not show any signs of wear or traces of dirt before fitting

Figure 145

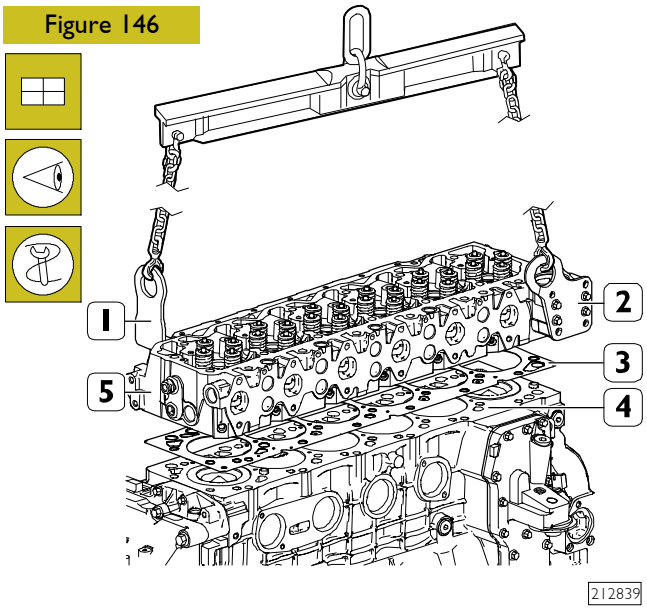


Assemble the oil filter / heat exchanger together with oil pressure and temperature sensor (5) to the block, including the following elements: oil filter support (6), heat exchanger plate (3) and relative gaskets (1 and 2).
Tighten the fastening screws (4) to the prescribed torque.

Ref	No.	Description	Tightening torques
(4)	15	M8x1.25x35	26 ± 4 Nm

NOTE Always check that the threads on the screws and their holes do not show any signs of wear or traces of dirt before fitting.

Figure 146



Use suitable lifting hooks (1 and 2) in order to lift and fit the cylinder head (5) on the engine block (4) after having interposed a new gasket (3) by using a hoist with tool 99360595.

NOTE Check cleanness of cylinder head (5) and engine block (4) coupling surface.
There are two types of head gasket:
- ❑ Type A - 1.25 mm thick
- ❑ Type B - 1.15 mm thick

Check the average protrusion S of the pistons.
If S > 0.40 mm use gasket type A.
If S ≤ 0.40 mm use gasket type B.
Do not get the cylinder head gasket dirty.
Place the gasket (3) in position with the marking "TOP" facing the head.
The arrow shows the point where the gasket thickness is given.

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

NOTE Before reusing the fastening screws (1), perform two diameter measurements as shown in figure, registering diameters D1 and D2:
if D1-D2 < 0.1 mm the screw may be reused
if D1-D2 > 0.1 mm the screw must be replaced

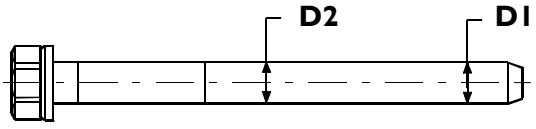
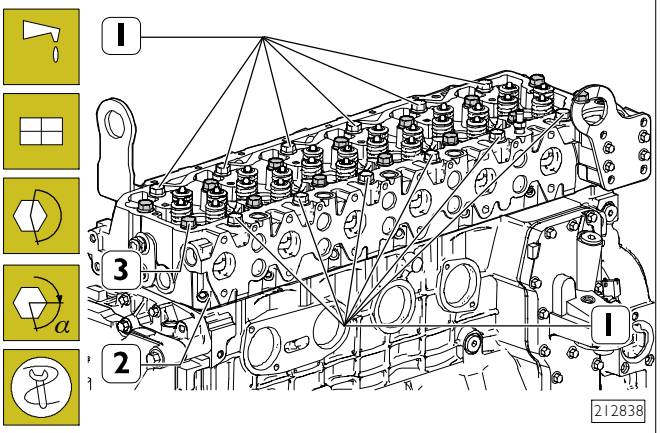


Figure 147



After having correctly positioned the gasket on the crankcase, assemble the cylinder head (2) and tighten the fastening screws (1 and 3) in three phases, following order and mode shown in the figure below.

Ref	No.	Description	Tightening torques
(1)	12	M12x1.75x130	
		1st phase	35 ± 5 Nm
		2nd phase	90°
		3rd phase	90°
(3)	14	M12x1.75x150	
		1st phase	55 ± 5 Nm
		2nd phase	90°
		3rd phase	90°

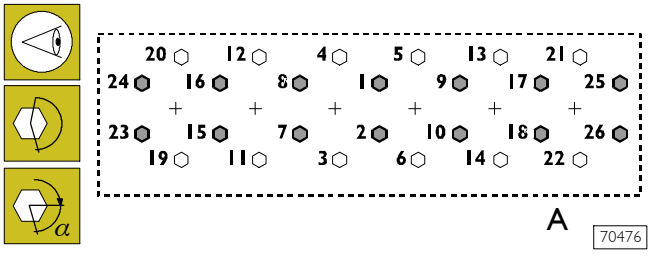
NOTE The screws (1 and 3) must be lubricated before being mounted on the cylinder head (2).

NOTE The screws (1 and 3) must be tightened following a "spiral" pattern starting in the middle and going outwards.

NOTE The angle tightening is carried out through tool 99395216.

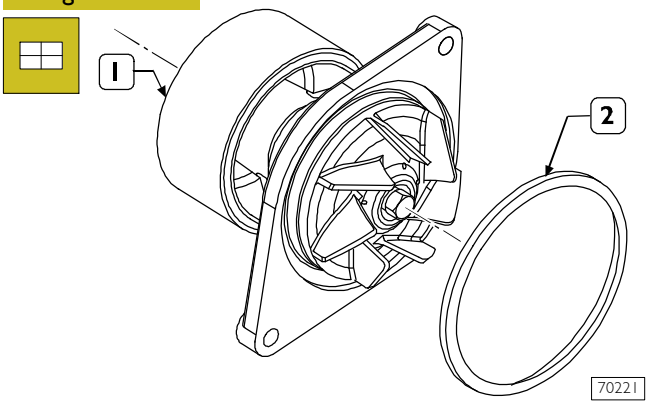
NOTE Before any assembly operation always verify that the hole and screw threads have no evidence of wear or dirt.

Figure 148



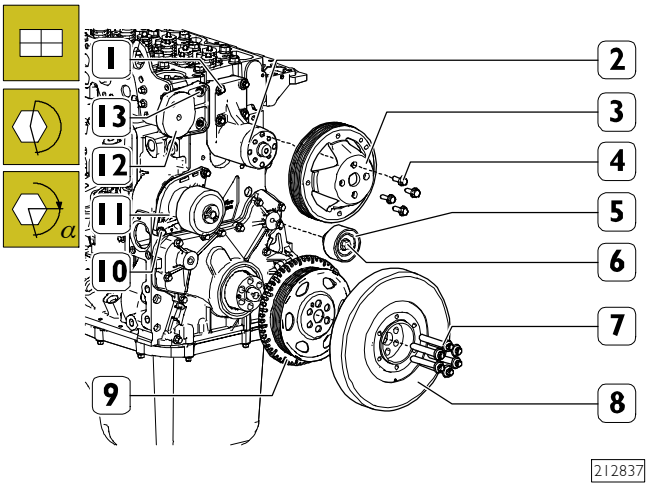
Tightening order layout for cylinder head fastening screws:
A = Front side

Figure 149



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

Figure 150

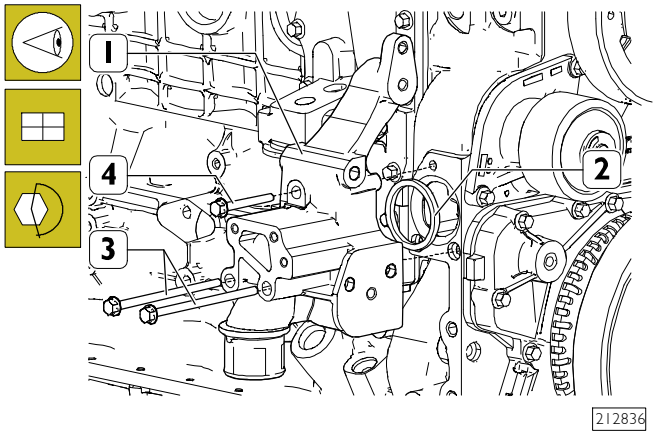


Install the water pump (11) and tighten the fastening screws (10) to the prescribed torque.
Install the crankshaft pulley (9) together with the damper pulley (8) on the crankshaft and tighten the fastening screws (7) to the prescribed torque.
Install the idler guide pulley (5) and tighten the fastening screw (6) to the prescribed torque.
Install the automatic belt tensioner mounting (12) and tighten the fastening screws (13) to the prescribed torque.
Install the fan pulley mounting (2) and tighten the fastening screws (1) to the prescribed torque.
Install the fan control pulley (3) and tighten the fastening screws (4).

Ref	No.	Description	Tightening torques
(1)	4	M8x1.25x45	24 ± 4 Nm
(4)	4	M10x25	68 ± 7 Nm
(6)	1	M10x1.5	43 ± 6 Nm
(7)	6	M12x1.25 1st phase 2nd phase	 50 ± 5 Nm 90°
(10)	2	M8x1.25x35	24 ± 4 Nm
(13)	2	M8x1.25x30	24 ± 4 Nm

NOTE The flywheel blocking device can aid the installation of the damper pulley (8) fitted onto the crankshaft pulley (9).

Figure 151

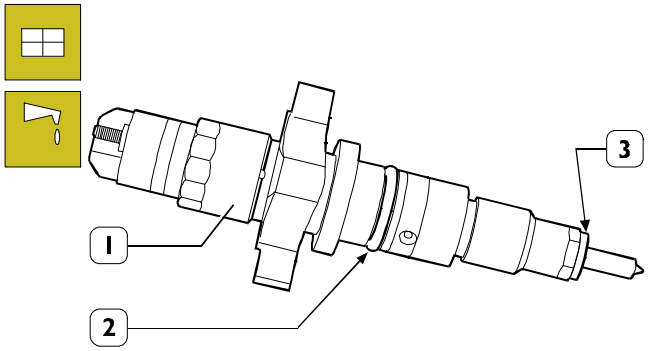


Assemble the engine coolant inlet (1), after having interposed a new gasket (2), so that the two reference hollow pins are set against the crankcase.
Tighten the fastening screws (3 and 4) to the prescribed torque.

Ref	No.	Description	Tightening torques
(3)	2	M10x1.5x130	43 ± 6 Nm
(4)	1	M10x1.5x70	43 ± 6 Nm

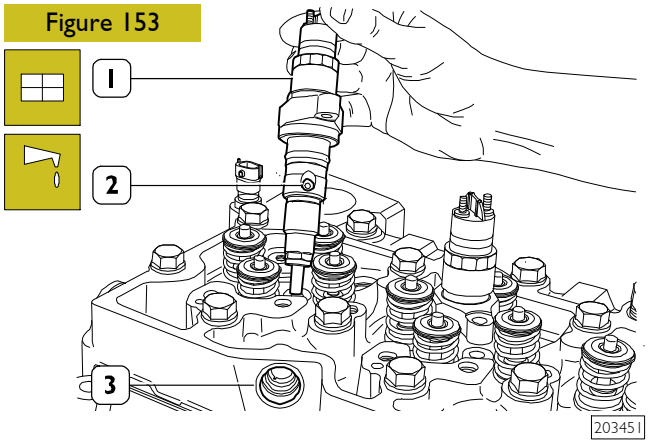
NOTE Before any assembly operation always verify that the hole and screw threads have no evidence of wear or dirt.

Figure 152



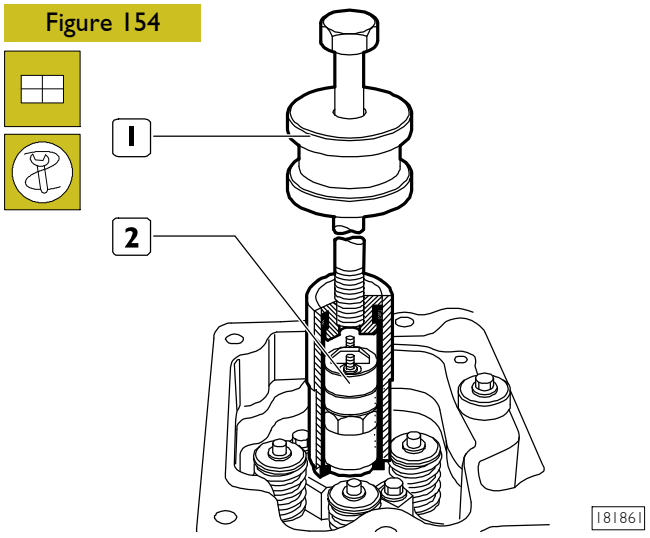
Fit a new sealing ring (2) lubricated with petroleum jelly and a new sealing washer (3) on injector (1).

Figure 153



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

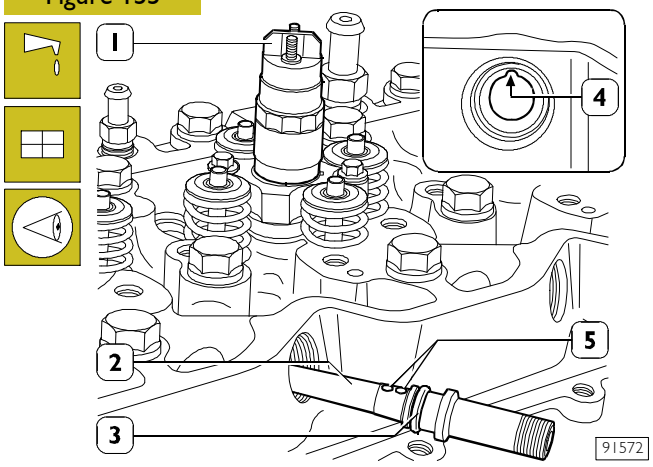
Figure 154



Use tool 99342101 (1) to fit the injector (2) into its seat.

Screw injector fastening screws without tightening them.

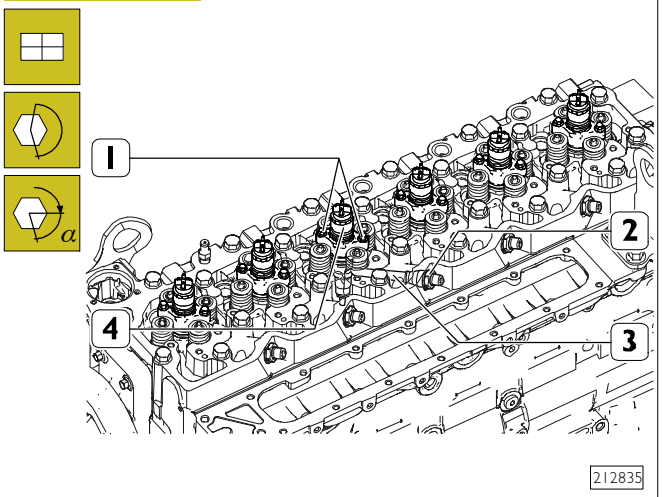
Figure 155



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

NOTE Disassembled fuel manifolds (2) must not be used again. Replace with new items.
The fuel manifolds (2) for engines have 2 positioning spheres.

Figure 156



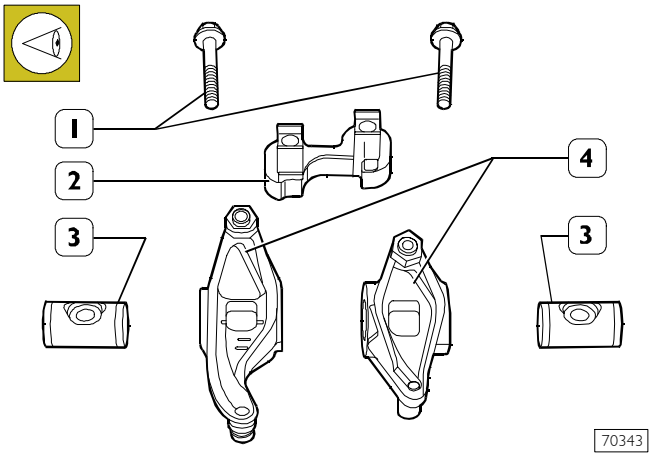
Screw the fastening nuts (2) without locking them;
Tighten gradually and alternately the electro-injector (4) fastening screws (1) to the prescribed torque in four stages;
Tighten the fuel manifold (3) fastening nuts (2) to the prescribed torque.

Ref	No.	Description	Tightening torques
(1)	12	M6x1x35	
		1st phase	3.5 ± 0.35 Nm
		2nd phase	25°
		3rd phase	25°
		4th phase	25°
(2)	6	M22x1.5x9.5	55 ± 5 Nm

NOTE During this operation, the injector (4) shall be moved so that the manifold (3) is properly inserted into the fuel inlet hole.

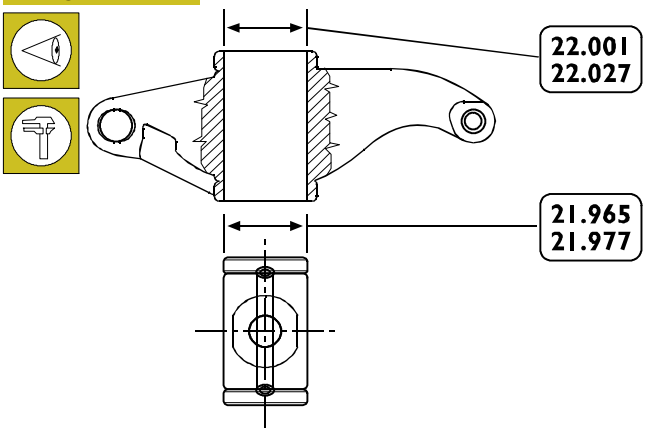
NOTE Tightening to angle is performed using tool 99395216.

Figure 157



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

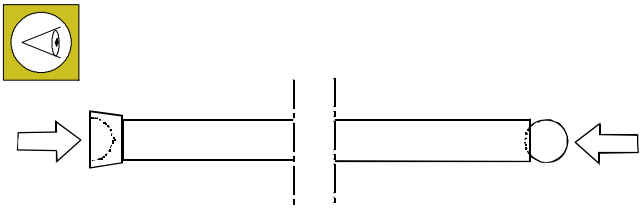
Figure 158



SHAFT-ROCKER MAIN DATA

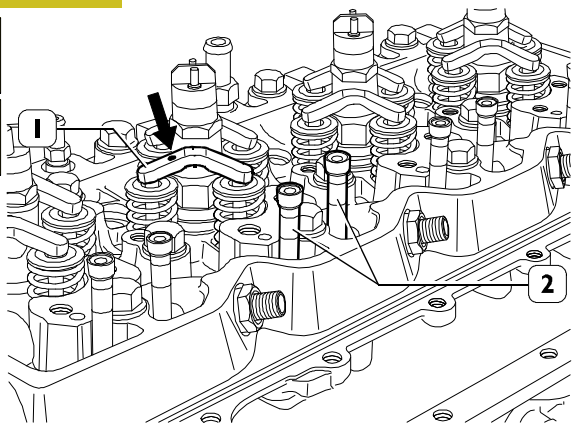
Check that shaft/rocker coupling surfaces are not showing excessive wear or damages.

Figure 159



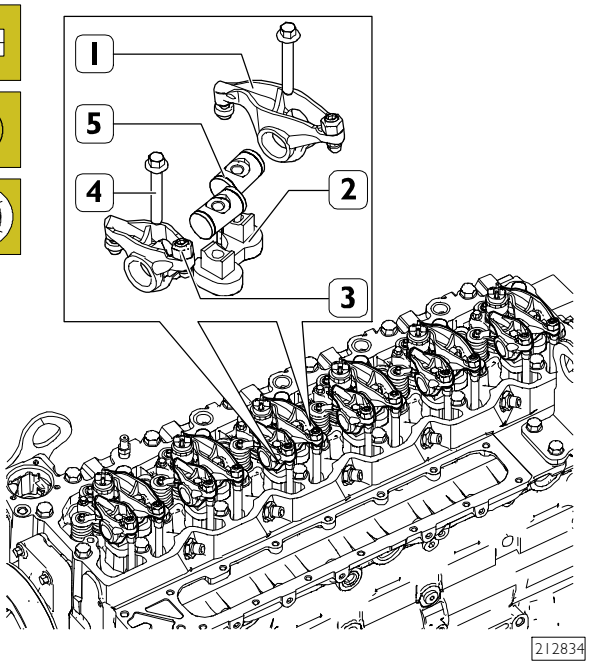
Rocker control rods shall not be distorted; the ball seats in touch with the rocker adjusting screw and with tappets (arrows) shall not show seizing or wear; otherwise replace them. Intake and exhaust valve control rods are identical and are therefore interchangeable.

Figure 160



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

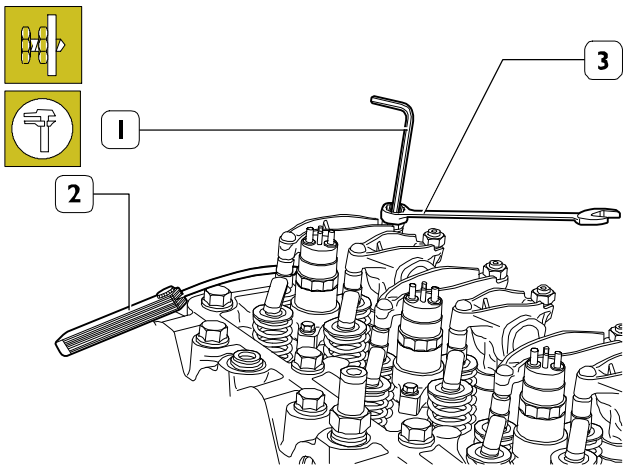
Figure 161



Check that tappet adjusters screws and retaining nuts (3) are loose to prevent their balking on the rods when refitting the rocker assembly.
Install the rocker unit consisting of bracket (2), rockers (1), shafts (5) and secure them to the cylinder head by tightening the fastening screws (4) to the prescribed torque.

Ref	No.	Description	Tightening torques
(4)	12	M8x1.25	36 ± 5 Nm

Figure 162



18222

The adjustment of the clearance between the rocker arms and the intake and exhaust valves must be strictly carried out using an Allen wrench (1), box-end wrench (3) and a feeler gauge (2).
Clearance shall be as follows:

- ❑ intake valves 0.25 ± 0.05 mm
- ❑ exhaust valves 0.50 ± 0.05 mm.

NOTE In order to perform the rocker arm - valve clearance adjustment more quickly, proceed as follows:

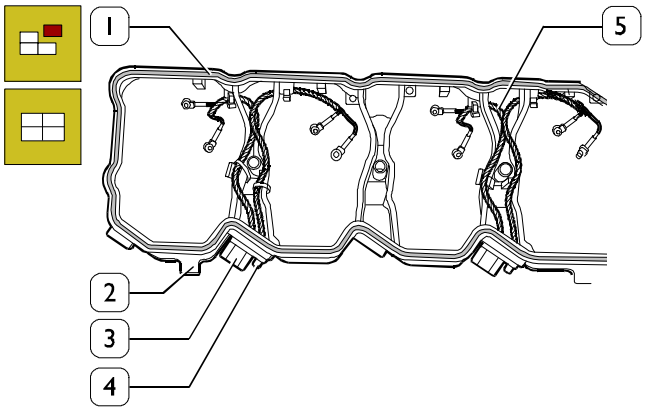
- ❑ Rotate the crankshaft, balance the valves of cylinder no. 1 and adjust the valves marked by the asterisk as shown in the tables below:

cylinder no.	1	2	3	4	5	6
intake	-	-	*	-	*	*
exhaust	-	*	-	*	-	*

- ❑ Rotate the crankshaft, balance the valves of cylinder no. 6 and adjust the valves marked by the asterisk as shown in the tables below:

cylinder no.	1	2	3	4	5	6
intake	*	*	-	*	-	-
exhaust	*	-	*	-	*	-

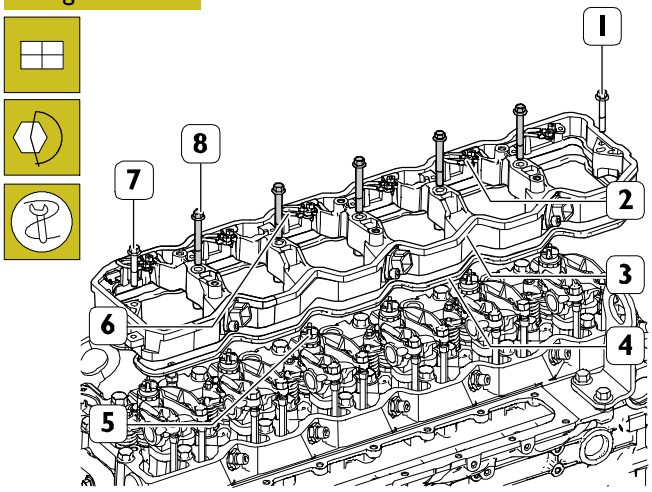
Figure 163



70352

Check the condition of the electrical cables (5), if they are damaged replace them by cutting the straps (2) securing them to the bracket and removing the screws (4) securing the connectors to this (3).
Fit a new gasket (1) on the bracket (2).

Figure 164



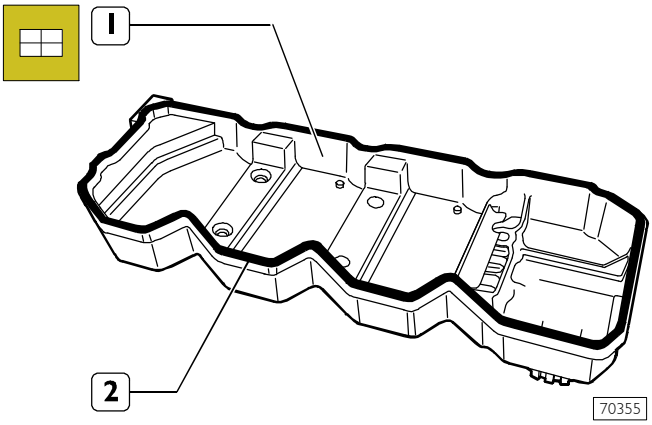
212833

Fit the electro-injector wiring support (3) complete with a new gasket (4) and tighten the screws (1, 7 and 8) to the prescribed torque.
Connect the electrical cables (6) to the electro-injectors (5) and use the torque wrench 99389834 to tighten the fastening nuts (2) to the prescribed torque.

Ref	No.	Description	Tightening torques
(1,7)	2	M8x1.25	24 ± 4 Nm
(2)	12	M4	1.5 ± 0.25 Nm
(8)	5	M8x1.25	24 ± 4 Nm

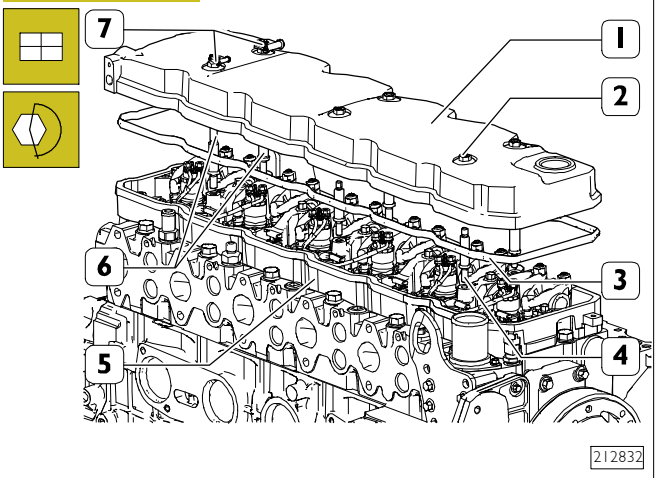
NOTE Before any assembly operation always verify that the hole and screw threads have no evidence of wear or dirt.

Figure 165



Fit a new gasket (2) on the tappet cover (1).

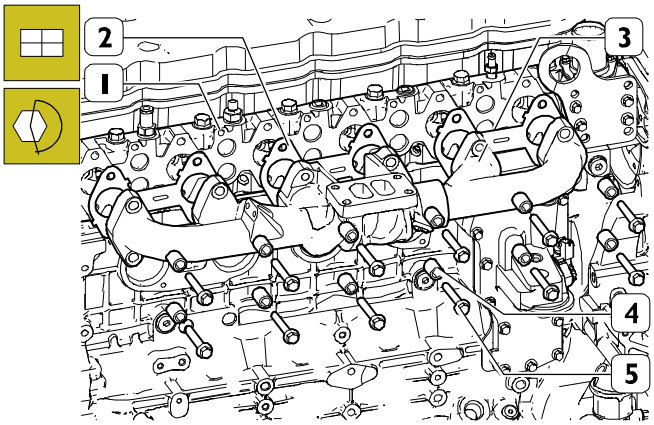
Figure 166



Screw the threaded double-shank shoulder screws (4 and 6) in the wiring support (5).
Install the tappet cover (1) on the wiring support (5) after having interposed a new gasket (3).
Tighten the fastening nuts (2 and 7) to the prescribed torque.

Ref	No.	Description	Tightening torques
(2,7)	6	M8x1.25	24 ± 4 Nm

Figure 167

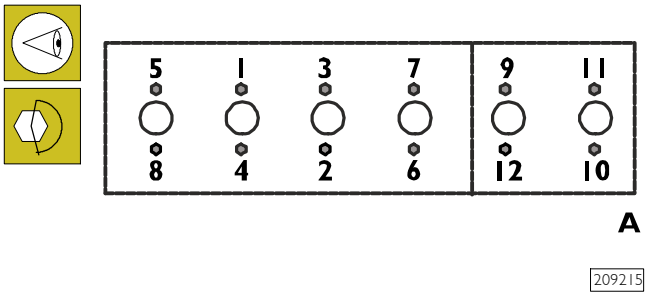


Fit the exhaust manifold (3) in position with new gaskets (2) to the cylinder head (1) and tighten the fastening screws (5) after having interposed spacers (4) to the prescribed torque following order and mode shown in the figure below.

Ref	No.	Description	Tightening torques
(5)	12	M10x1.5x65	55 ± 3 Nm

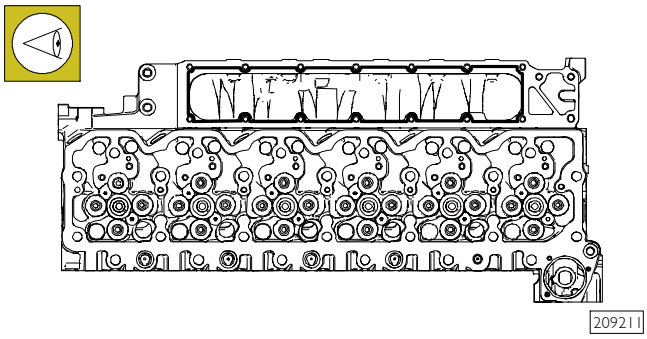
NOTE Always replace the gaskets (2) using new ones. Check the threads of the fixing screws: there shall be no evidence of wear or dirt deposit.

Figure 168



Tightening order layout for exhaust manifold fastening screws
A = Front side

Figure 169



Carefully clean the contact surfaces and apply a continuous sealant bead of LOCTITE 5970 to the surface of the cylinder head as shown in the figure below.

NOTE Perfect seal is only obtained by cleaning accurately the surface to seal. Smear with LOCTITE 5970 to obtain a bead of few mm diameter.

It shall be uniform (no clots), without air bubbles, thin areas or discontinuities.

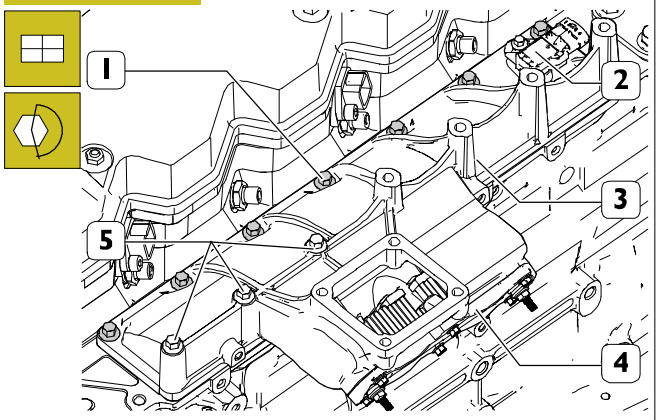
Any imperfection shall be corrected as soon as possible.

Avoid to use excess material to seal the joint.

Excessive sealant could come out from joint sidesand cause lubricant passage clogging.

After applying the sealant, the joint shall be assembled immediately (10 - 20 minutes).

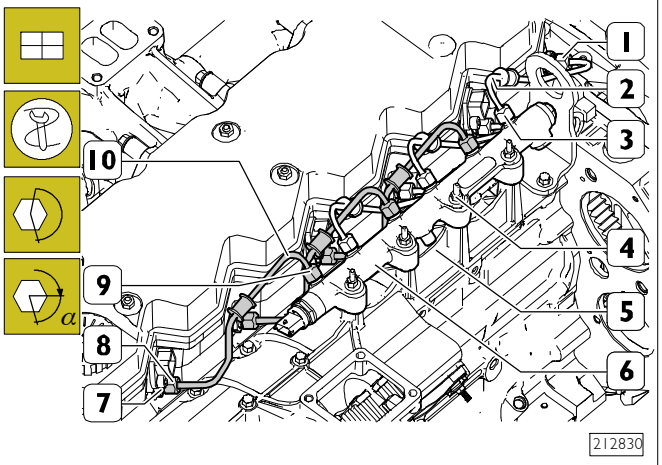
Figure 170



Install the intake manifold (3) together with the boost pressure and air temperature sensor (2) on the cylinder head and tighten the fastening screws (1 and 5) to the prescribed torque.

Ref	No.	Description	Tightening torques
(1)	7	M8x1.25x25	24 ± 4 Nm
(5)	3	M8x1.25x70	24 ± 4 Nm

Figure 171



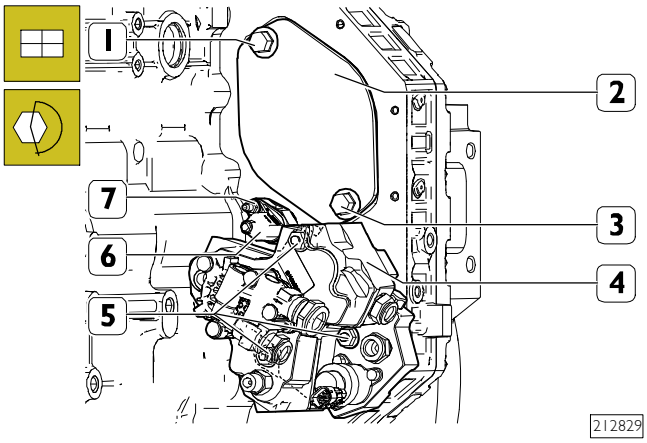
Install the common rail and high pressure fuel delivery pipes by proceeding as follows:

- ❑ fit the common rail (6) on the intake manifold (5) and manually tighten the threaded double-shank shoulder screws (4);
- ❑ tighten two central screws (4) to a torque of 0.1 Nm;
- ❑ fit the high pressure fuel delivery pipes (2 and 10) and manually tighten the hose couplings (1, 3, 8 and 9) fist of all from common rail side and then from cylinder head side;
- ❑ tighten the hose couplings (1, 3, 8 and 9) to a torque of 5 Nm, fist of all from cylinder head side and then from common rail side;
- ❑ tighten the threaded double-shank shoulder screws (4) fixing the common rail (6) on the intake manifold (5) to the prescribed torque;
- ❑ tighten the hose couplings (1, 3, 8 and 9) to the prescribed torque, fist of all from common rail side and then from cylinder head side.

Ref	No.	Description	Tightening torques
(1,8)	6	M14x1.5 1st phase 2nd phase	 10 Nm 55°
(3,9)	6	M14x1.5 1st phase 2nd phase	 10 Nm 55°
(4)	4	M8x1.25x125	36 ± 5 Nm

NOTE The high pressure fuel delivery pipes must be replaced every time they are removed. The hose couplings must be tightened to torque using spanner 99317915 and torque wrench 99389829.

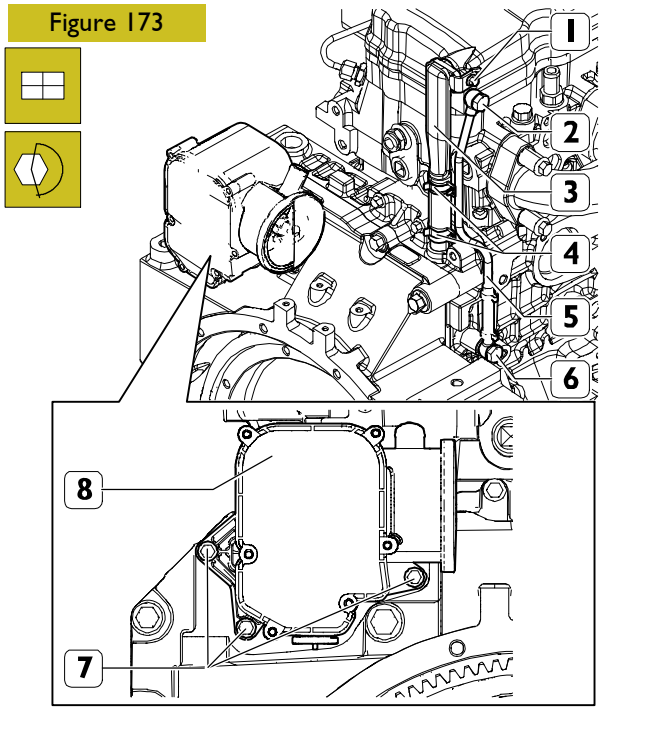
Figure 172



Ensure that the the fuel high pressure pump (4) is suitably supported.
Screw the studs (5). Fit the fuel high pressure pump (4) complete with the mechanical pump, the flange and the gear and tighten the fastening nuts (5) to the prescribed torque.
Install the stud, the support with a new sealing ring and the camshaft timing segment speed sensor (6). Tighten the fixing nut (7) to the prescribed torque.
If present, install the power take-off (PTO) equipped with the flange and the gear.
Fit the cover (2), after having interposed a new gasket and tighten the fastening screws (1 and 3) to the prescribed torque.

Ref	No.	Description	Tightening torques
(5)	3	M8x1.25x50	11 ± 3 Nm
(5)	3	M8-8	24 ± 4 Nm
(1,3)	2	M12x1.75x25	80 ± 5 Nm
(7)	1	M6x1x5	12 Nm

Figure 173

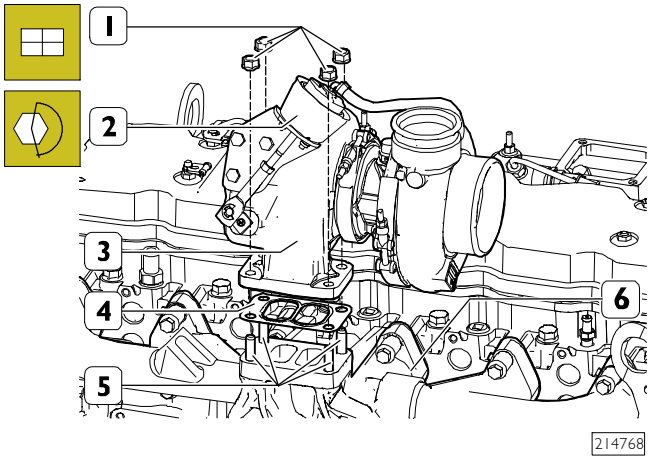


Fit the blow-by filter (8) in position on the on the flywheel housing and tighten the fastening screws (7) to the prescribed torque.
Install the oil return pipe (5) with new copper washers and tighten the hose connectors (2 and 6) to the prescribed torque.
Fit the blow-by breather pipe (3) into the coupling located on the timing gear case and secure it with the retaining clamps (4). Tighten the screw (1) fastening to the tappet cover to the prescribed torque.

Ref	No.	Description	Tightening torques
(1)	1	M6x1	10 ± 2 Nm
(2,6)	2	M12x1.5	20 ± 4 Nm
(7)	3	M6x1	10 ± 2 Nm

(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

Figure 174



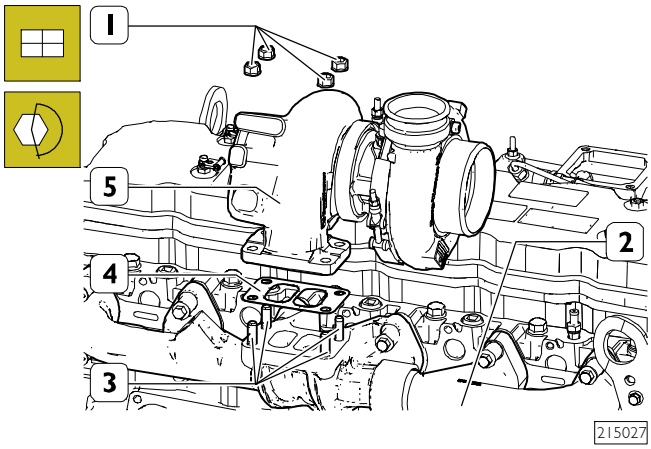
Proceed assembling the turbocharger (3):

- ❑ screw the studs (5) on the exhaust manifold (6);
- ❑ hold the turbocharger (3) together with the waste-gate valve (2) and place it on the exhaust manifold (6) after having interposed a new gasket (4);
- ❑ tighten the fastening nuts (1) to the prescribed torque.

Ref	No.	Description	Tightening torques
(1)	4	M10	43 ± 6 Nm
(5)	4	M10x1.5x42	25 ± 5 Nm

(F4HFE613N*B002 - F4HFE613N*B003)

Figure 175



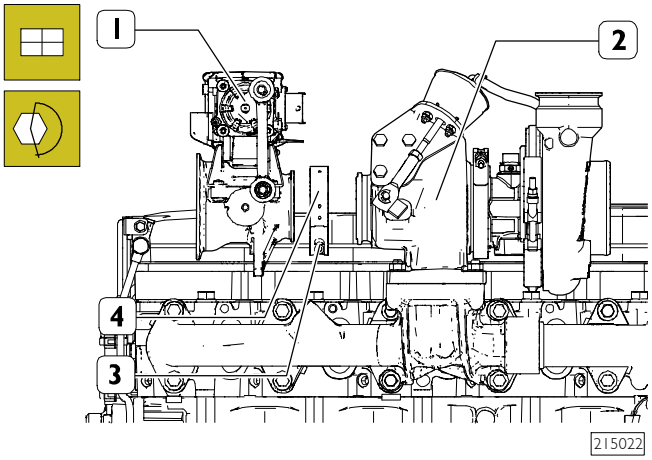
Proceed assembling the turbocharger (5):

- ❑ screw the studs (3) on the exhaust manifold (2);
- ❑ hold the turbocharger (5) and place it on the exhaust manifold (2) after having interposed a new gasket (4);
- ❑ tighten the fastening nuts (1) to the prescribed torque.

Ref	No.	Description	Tightening torques
(1)	4	M10	43 ± 6 Nm
(3)	4	M10x1.5x42	25 ± 5 Nm

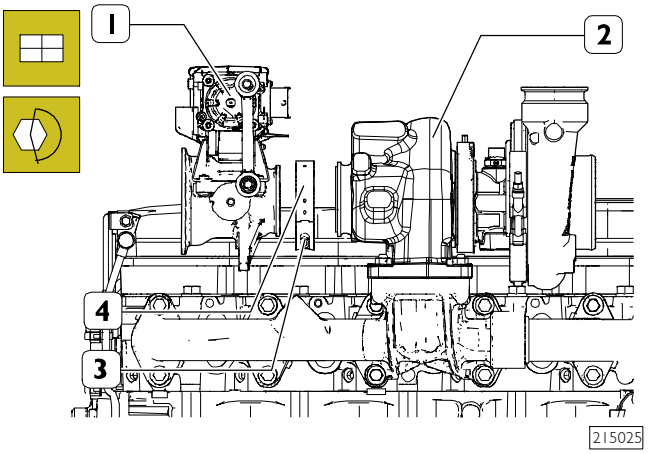
(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

Figure 176



(F4HFE613N*B002 - F4HFE613N*B003)

Figure 177

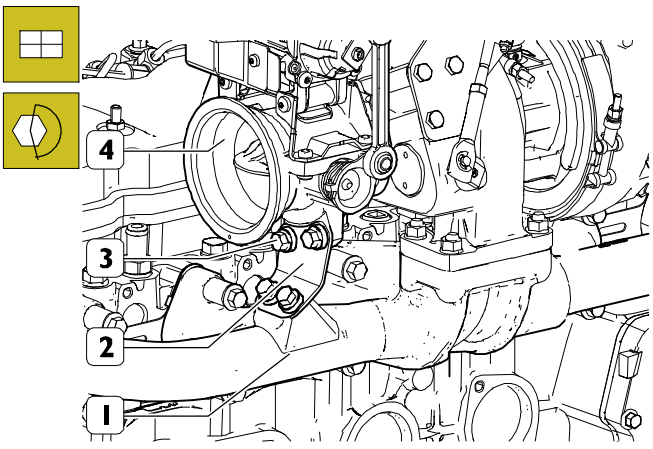


Install the motorized throttle valve (1) onto the turbocharger (2).
Screw the screw (3) and tighten the V-clamping collar (4) to the prescribed torque.

Ref	No.	Description	Tightening torques
(3)	1	M6x1x50	10 ± 2 Nm

(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

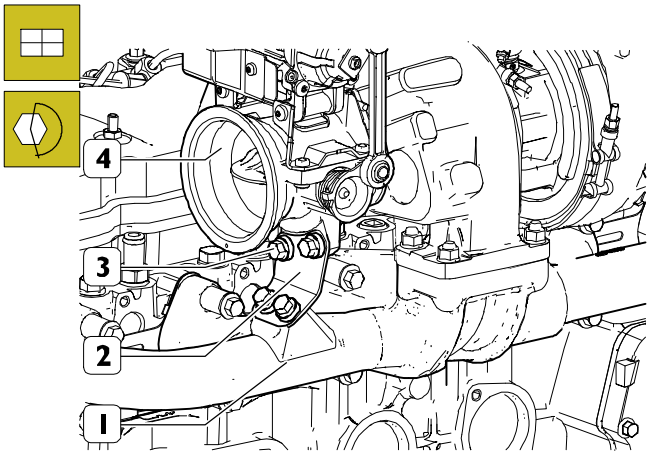
Figure 178



214772

(F4HFE613N*B002 - F4HFE613N*B003)

Figure 179



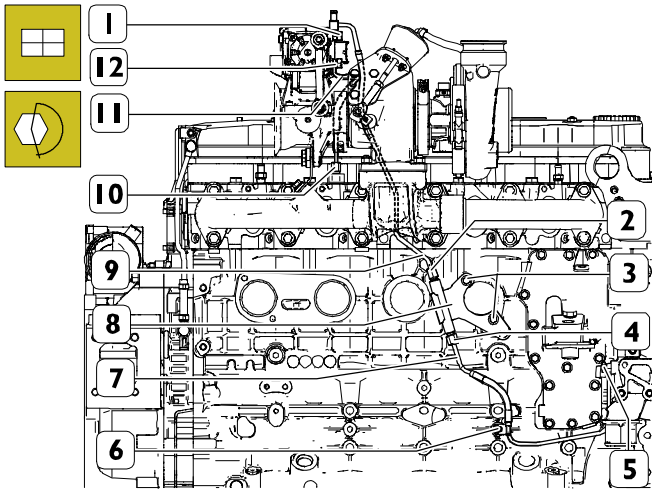
215026

Assemble the bracket (2) fixing the motorized throttle valve (4) to the exhaust manifold (1) and tighten the fastening screws (3) to the prescribed torque.

Ref	No.	Description	Tightening torques
(3)	4	M8x1.25x25	25 Nm

(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

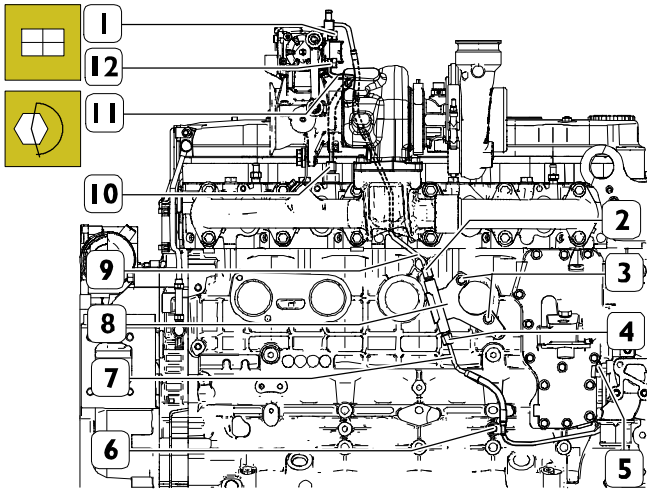
Figure 180



215033

(F4HFE613N*B002 - F4HFE613N*B003)

Figure 181



215035

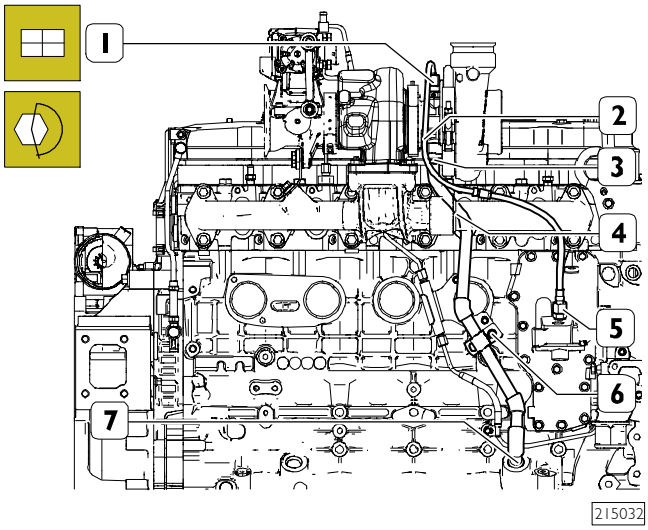
Install the motorized throttle valve water inlet and outlet pipes by proceeding as follows:

- ❑ fit the water delivery pipe (11) and tighten the fastening nut (10) and connector (12) to the prescribed torque;
- ❑ fit the water return pipe union (8) and tighten the fastening screws (3) to the prescribed torque;
- ❑ fit the lower-part water return pipe (7) and tighten the fastening nut (4), connector (5) and screw (6) to the prescribed torque;
- ❑ fit the upper-part water return pipe (9) and tighten the fastening nut (2) and connector (1) to the prescribed torque.

Ref	No.	Description	Tightening torques
(1,12)	2	M10x1	20 Nm
(2,4,10)	3	M12x1.5	45 Nm
(3)	2	M8x20	23 ± 2.3 Nm
(5)	1	M10x1	25 Nm
(6)	1	M8x16	23 ± 2.3 Nm

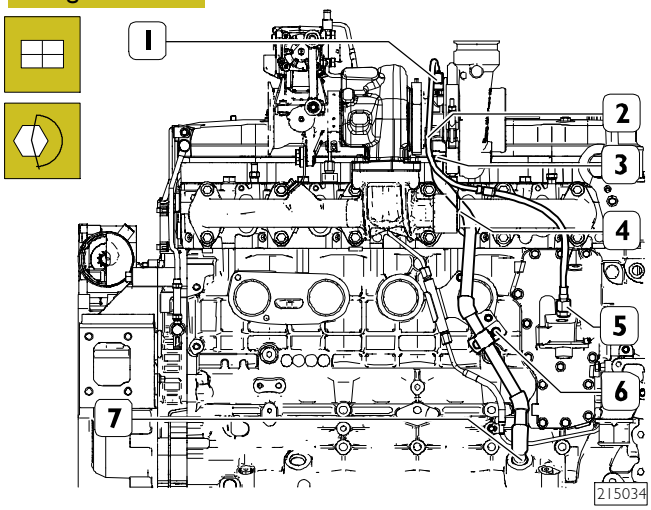
(F4HFE6131*B003 - F4HFE6131*B005 - F4HFE613K*B004 - F4HFE613K*B005)

Figure 182



(F4HFE613N*B002 - F4HFE613N*B003)

Figure 183



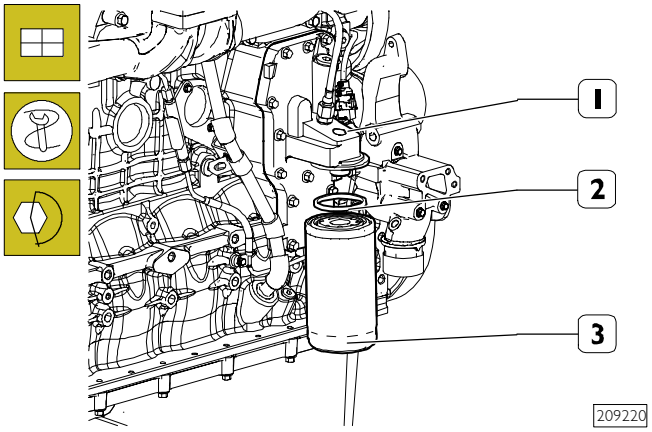
Install the lubrication oil discharge pipe (4) onto the turbocharger by proceeding as follows:

- ❑ screw the coupling (7) on the crankcase;
- ❑ screw the fastening screws (3) in the lower part of the turbocharger, after fitting a new gasket;
- ❑ screw the screw (6) that retain the piping (4) to the block by means of the fastening collar.

Fit the lubrication oil delivery pipe (2) from the upper part of the heat exchanger to the turbocharger and tighten the hose couplings (1 and 5) to the prescribed torque.

Ref	No.	Description	Tightening torques
(1,5)	2	11/16-16 (M16)	36 ± 5 Nm
(3)	2	M8x1.25x25	23 ± 2 Nm
(6)	1	M8x1.25x16	23 ±2 Nm

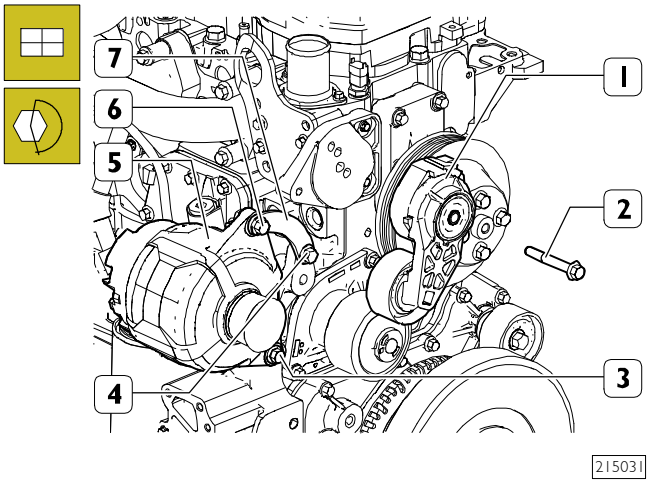
Figure 184



Moisten the sealing gasket (2) of the oil filter (3) with a thin layer of oil.
Manually tighten the oil filter (3) on the support (1) until it comes into contact with the gasket (2).
Additionally tighten the oil filter (3) to the prescribed torque using a specific tool.
Operate the engine for a few minutes and then check the level using the dipstick. If necessary, top up to compensate for the quantity of oil used to fill up the filtering cartridge.

Ref	No.	Description	Tightening torques
(3)	1	M27x2	18 ± 2 Nm

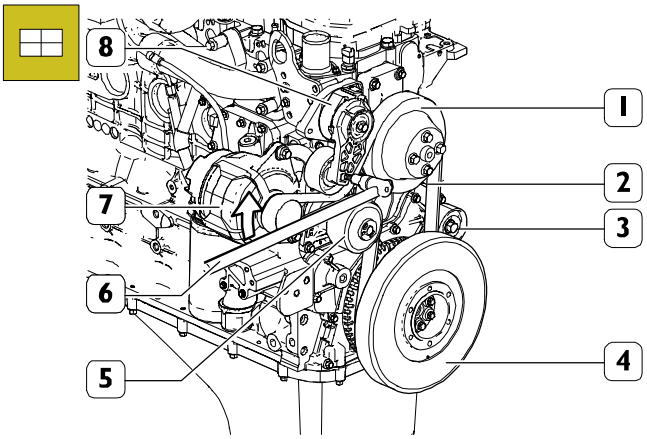
Figure 185



Install the bracket (7) fixing the alternator (5) and tighten the fastening screws (3, 4 and 6) to the prescribed torque.
Fit the automatic belt tensioner (1) and tighten the fastening screw (2) to the prescribed torque.

Ref	No.	Description	Tightening torques
(2)	1	M10x1.5x70	43 ± 6 Nm
(3)	1	M10x1.5x110	43 ± 6 Nm
(4)	1	M10x1.5x20	43 ± 6 Nm
(6)	1	M10x1.5x30	43 ± 6 Nm

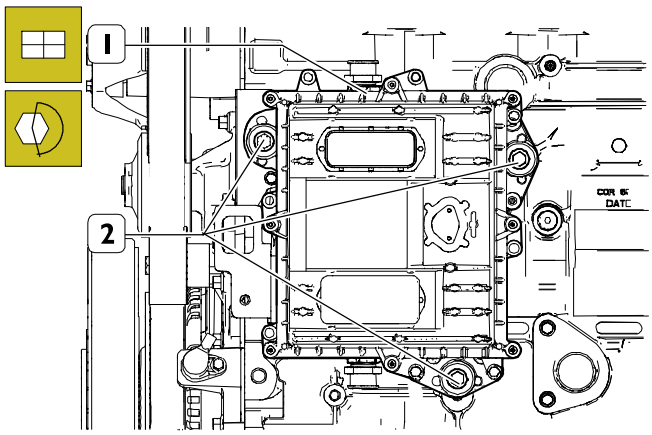
Figure 186



215030

Fit the Poly V belt (2) on the pulleys and guide roller.
Use the appropriate tool (6) on the automatic belt tensioner (8) in order to fit the new belt (2) in the operating position.
Additional adjustments are not required. The belt (2) tension is adjusted automatically by the calibrated spring in the automatic belt tensioner (8).

Figure 187

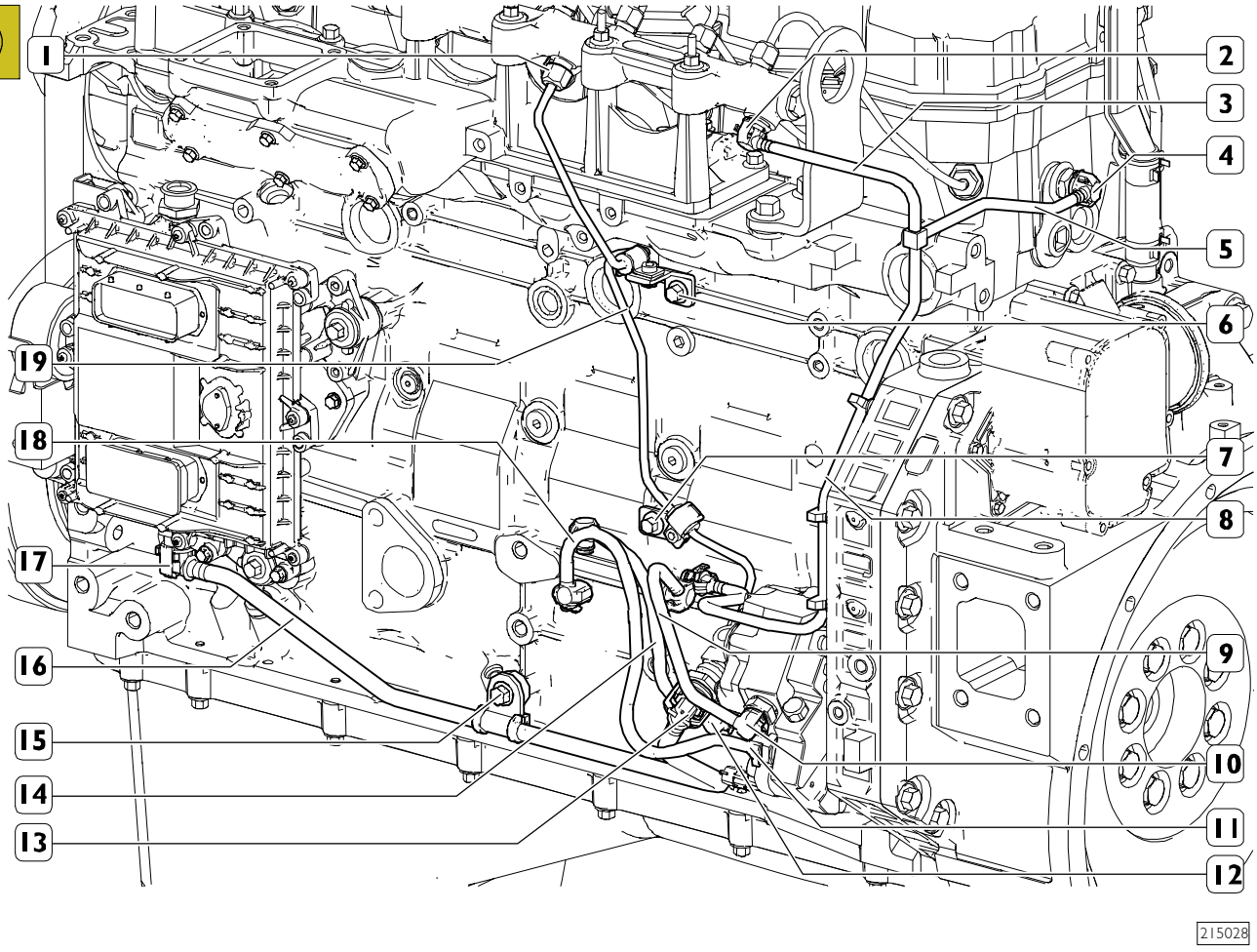


215029

Fit the ECU (1), including the heat exchanger and tighten the supporting screws (2) to the prescribed torque.
In case the rubber buffers are cracked or excessively deformed, provide replacing them.
Install the low pressure fuel pipe from fuel pre-filter to the engine control unit heat exchanger and connect the retainer.

Ref	No.	Description	Tightening torques
(2)	3	M8x1.25x45	14 Nm

Figure 188



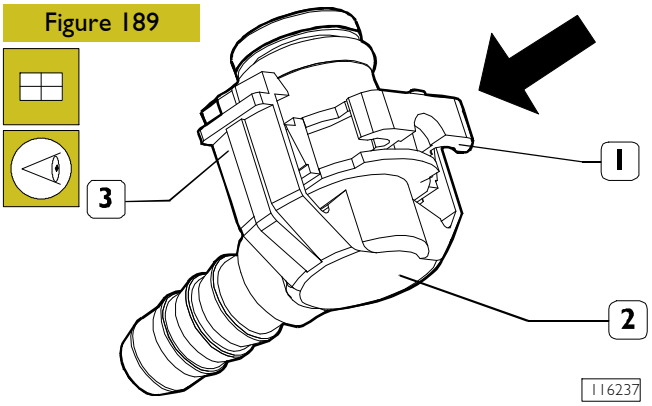
Fit the high pressure fuel pipe (19) to the engine block and tighten the fastening screws (6 and 7) to the prescribed torque.
Connect the pipe (19) both to the high pressure pump and to the common rail and tighten the hose couplings (1) to the prescribed torque.

Ref	No.	Description	Tightening torques
(1)	2	M14x1.5	24 ± 4 Nm
(6)	1	M8x1.25x20	25 Nm
(7)	1	M8x1.25x16	25 Nm

NOTE The high pressure fuel hose must always be replaced with a new one whenever it is removed. The hose couplings must be tightened to torque using spanner 99317915 and torque wrench 99389829.

Fit backflow fuel pipes (3, 5 and 8) from common rail and electro-injectors to the fuel filter support and connect the retainers (2 and 4).
Fit backflow fuel pipe (9) from high pressure pump to fuel filter support and connect the retainer (10).
Fit low pressure fuel pipe (14) from mechanical pump to fuel filter and connect the retainer (12).
Fit low pressure fuel pipe (16) from engine control unit heat exchanger to mechanical pump, tighten the fastening screw (15) to the prescribed torque and connect the retainers (13 and 17).
Fit low pressure fuel pipe (18) from fuel filter to high pressure pump and connect the retainer (11).

Figure 189



To connect the low pressure fuel hose to the connection fitting, insert the quick-fit coupling (2) in the connection fitting and push it in until the catch (3) engages.

NOTE Check proper fuel hose connection.

Place the engine cable in position and close the straps retaining the engine cable to the engine block. Connect the engine cable to the ECU (8), to the motorized throttle valve actuator connector (2) and to all the sensors and transmitters indicated in the electrical equipment section.

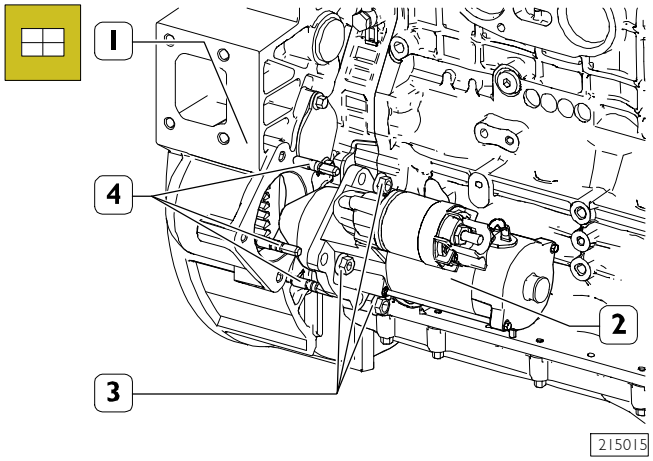
REMOVING THE ENGINE FROM THE ROTATING STAND

To complete engine assembly it is necessary to remove it from the turning stand 99322205.

- ❑ Using a hoist with tool 99360595 hold the engine and loosen the screws fixing the brackets 99361037 to the turning stand 99322205.
- ❑ Disassemble the brackets 99361037 from the engine after having properly put it on a suitable support.

COMPLETING ENGINE ASSEMBLY

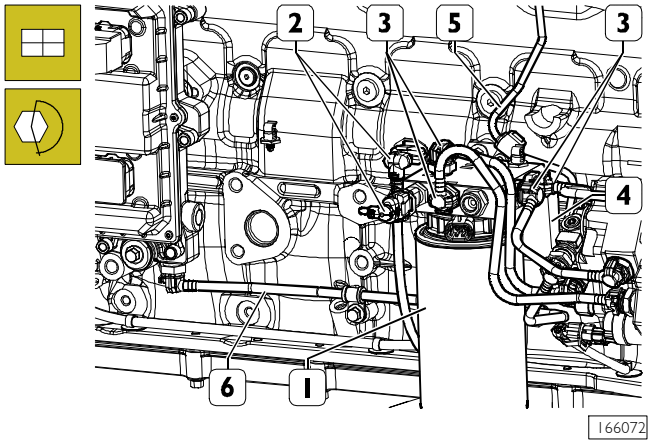
Figure 190



Screw the studs (4) and fit the electric starter motor (2) into the internal part of the flywheel housing (1). Tighten the fastening nuts (3) to the prescribed torque.

Ref	No.	Description	Tightening torques
(3)	3	M10x1.5	43 ± 6 Nm
(4)	3	M10x1.5x50	-

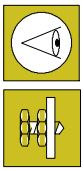
Figure 191



- ❑ Place the fuel filter support (4) in position together with the bracket, if present, and tighten the retaining screws to the specified torque.
- ❑ Connect the low-pressure fuel hoses (3) to the filter support.
- ❑ Connect the fuel temperature sensor and camshaft timing sensor electrical connections (2).
- ❑ Fully screw the fuel filter (1) onto the connection on its support by hand, then further tighten to a torque of 20 ± 2 Nm.

CHECKS AND INSPECTIONS

NOTE The following checking inspections must be carried out after the engine assembly on the vehicle. Preventively check that the liquid levels have been correctly restored.



Start the engine and leave it running just above the idling speed, wait until the coolant reaches the temperature necessary to open the thermostat and then check:

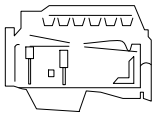
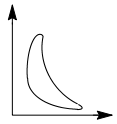
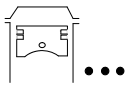
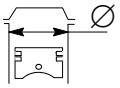
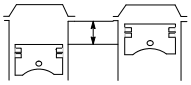
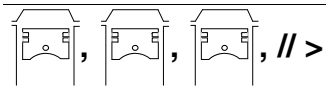
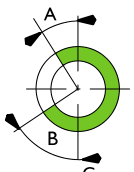
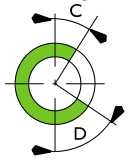
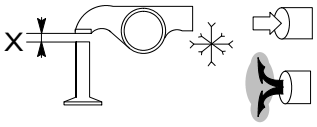
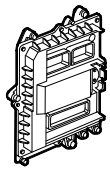
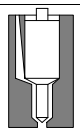
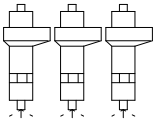
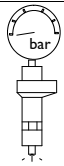
- ❑ that there are no water leaks from the connecting sleeves of engine cooling circuit pipes and cab internal heating pipes, tighten the clamping collars if required;
- ❑ check carefully the connection between the low pressure fuel pipes and the relevant connectors;
- ❑ that there are no oil leaks between the cover and the cylinder head, between oil sump and engine block, between heat exchanger oil filter and the relevant housings and between the different pipes in the lubricating circuit;
- ❑ that there are no fuel leaks from the fuel pipes;
- ❑ that there are no air leaks from pneumatic pipes (if fitted);
- ❑ check also proper operation of the warning lights set on the instrument panel and of the equipment disconnected when engine was removed.
- ❑ Carefully check and bleed the engine cooling equipment by repeated draining operations.

SECTION 7

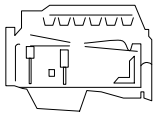
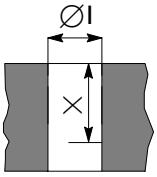
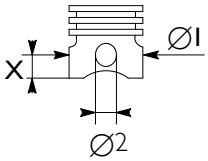
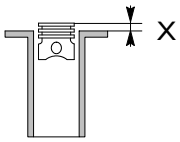
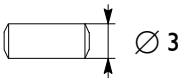
Technical specifications

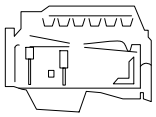
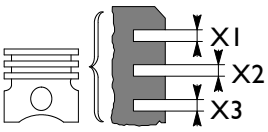
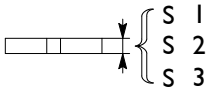
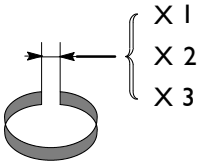
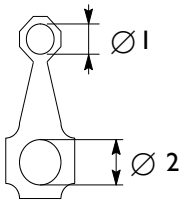
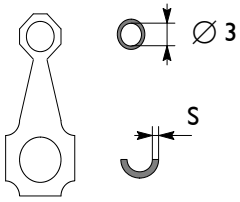
Page

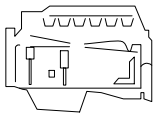
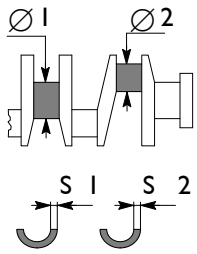
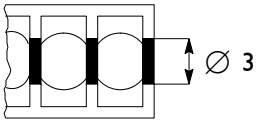
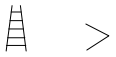
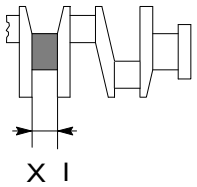
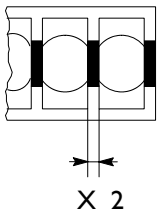
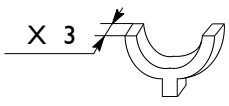
GENERAL SPECIFICATIONS

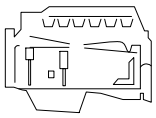
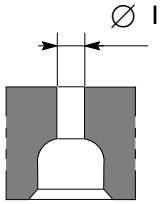
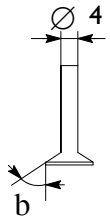
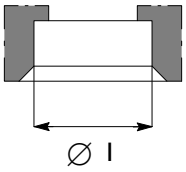
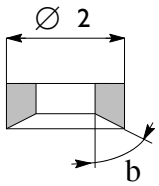
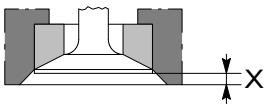
			F4HFE613		
	Type		I*B003 I*B005	K*B004 K*B005	N*B002 N*B003
	Cycle		Four-stroke diesel engine		
	Power		Turbocharged with intercooler		
	Injection		Direct		
	Number of cylinders		6		
	Bore	mm	104		
	Stroke	mm	132		
	Total displacement	cm^3	6728		
	**TIMING**				
	start before T.D.C.. end after B.D.C.	A B	18.5° 29.5°		
 	start before B.D.C. end after T.D.C.	D C	67° 35°		
	Checking operation ×	mm mm	0,20 ÷ 0,30 0,45 ÷ 0,55		
	**FUEL FEED** Injection Type:	Bosch	high pressure common rail EDC17CV41 ECU		
	Injector		CRIN2		
	Nozzle type		DLLA137 PV3 198 878	DLLA 137 PV3 208 244	
	Injection sequence		1 - 5 - 3 - 6 - 2 - 4		
	Injection pressure	bar	250 - 1600		

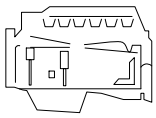
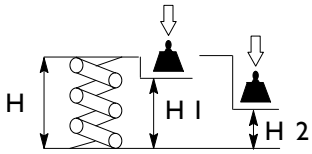
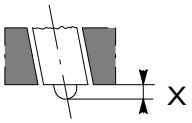
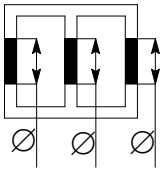
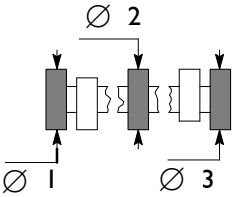
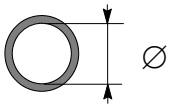
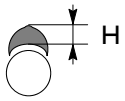
CLEARANCE DATA

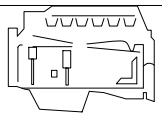
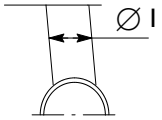
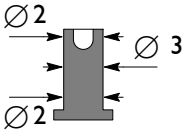
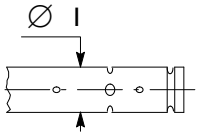
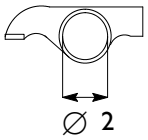
		F4HFE613		
	Type	I*B003 I*B005	K*B004 K*B005	N*B002 N*B003
CYLINDER UNIT AND CRANKSHAFT COMPONENTS		mm		
	Cylinder barrels Ø1	104.000 ÷ 104.024		
	> Ø1	0.4 - 0.8		
	Pistons type: Size X Outside diameter Ø 1 Pin housing Ø 2	49.5 103.739 ÷ 103.757 40.010 ÷ 40.016		
	Piston diameter Ø 1	0.4 - 0.8		
	Piston - cylinder liners	0.243 ÷ 0.285		
	Piston protrusion X	0.28 ÷ 0.52		
	Piston pin Ø 3	39.994 ÷ 40.000		
	Piston pin – pin housing	0.010 ÷ 0.022		

		F4HFE613		
	Type	I*B003 I*B005	K*B004 K*B005	N*B002 N*B003
CYLINDER UNIT AND CRANKSHAFT COMPONENTS		mm		
	Piston ring slots: X1* X 2 X 3 * measured on 101 mm	2.705 ÷ 2.735 2.420 ÷ 2.440 4.030 ÷ 4.050		
	Piston rings: S 1* S 2 S 3	2.563 ÷ 2.597 2.350 ÷ 2.380 3.970 ÷ 3.990		
	Piston rings - slots	0.108 ÷ 0.172 0.040 ÷ 0.090 0.040 ÷ 0.080		
	Piston rings	0.4 - 0.8		
	Piston ring end opening X 1 X 2 X 3	0.30 ÷ 0.40 0.60 ÷ 0.80 0.30 ÷ 0.55		
	Small end bush housing Ø 1 Big end bearing housing Ø 2	42.987 ÷ 43.013 73.987 ÷ 74.013		
	Small end bush diameter Inside Ø 3 Big end half bearings S	40.019 ÷ 40.033 1.958 ÷1.968		
	Piston pin – bush	0.019 ÷ 0.039		
	Big end half bearings	0.250 - 0.500		

		F4HFE613		
	Type	1*B003 1*B005	K*B004 K*B005	N*B002 N*B003
CYLINDER UNIT AND CRANKSHAFT COMPONENTS		mm		
	Journals Ø 1 Crankpins Ø 2 Main half bearings S 1 Big end half bearings S 2	82.990 ÷ 83.010 69.987 ÷ 70.013 2.464 ÷ 2.472 1.958 ÷ 1.968		
	Main bearings No. 1 - 7 Ø 3 No. 2 - 3 - 4 - 5 - 6 Ø 3	87.982 ÷ 88.008 87.977 ÷ 88.013		
	Half bearings – Journals No. 1 - 7 No. 2 - 3 - 4 - 5 - 6	0.028 ÷ 0.090 0.023 ÷ 0.095		
	Half bearings - Crankpins	0.038 ÷ 0.110		
	Main half bearings Big end half bearings	0.250 - 0.500		
	Shoulder journal X 1	37.475 ÷ 37.545		
	Shoulder main bearing X 2	32.180 ÷ 32.280		
	Shoulder half-rings X 3	37.28 ÷ 37.38		
	Output shaft shoulder	0.095 ÷ 0.265		

		F4HFE613		
	Type	1*B003 1*B005	K*B004 K*B005	N*B002 N*B003
CYLINDER HEAD – TIMING SYSTEM		mm		
	Valve guide seats on cylinder head Ø 1	7.042 ÷ 7.062		
	Valves:			
	Ø 4 α	6.990 ÷ 7.010 60° ± 0.25°		
	Ø 4 α	6.990 ÷ 7.010 45° ± 0.25°		
	Valve stem and guide	0.032 ÷ 0.072		
	Housing on head for valve seat:			
	Ø1	34.837 ÷ 34.863		
	Ø1	34.837 ÷ 34.863		
	Valve seat outside diameter; valve seat angle on cylinder head:			
	Ø 2 α	34.917 ÷ 34.931 60°		
	Ø 2 α	34.917 ÷ 34.931 45°		
	hollowing X	0.59 ÷ 1.11		
	X	0.96 ÷ 1.48		
	Between valve seat and head	0.054 ÷ 0.094		
		0.054 ÷ 0.094		
	Valve seats	-		

	Type		F4HFE613		
			I*B003 I*B005	K*B004 K*B005	N*B002 N*B003
CYLINDER HEAD – TIMING SYSTEM			mm		
	Valve spring height: free spring under a load equal to: 339.8 ± 19 N 741 ± 39 N	 H H1 H2	 47.75 35.33 25.2		
	Injector protrusion	X	not adjustable		
	Camshaft bush housings No. 1 (flywheel side) Camshaft pin seats No. 2-3-4-5-6-7	 Ø	59.222 ÷ 59.248 54.089 ÷ 54.139		
	Camshaft journals: I ⇒ 7	Ø	53.995 ÷ 54.045		
	Bush inside diameter	Ø	54.083 ÷ 54.147		
	Bushes and journals		0.038 ÷ 0.152		
	Cam lift:  	 H H	 6.045 7.582		

		F4HFE613		
	Type	1*B003 1*B005	K*B004 K*B005	N*B002 N*B003
CYLINDER HEAD – TIMING SYSTEM		mm		
	Tappet cap housing on block Ø 1	16.000 ÷ 16.030		
	Tappet cap outside diameter: Ø 2 Ø 3	15.924 ÷ 15.954 15.960 ÷ 15.975		
	Between tappets and housings	0.025 ÷ 0.070		
	Tappets	-		
	Rocker shaft Ø 1	21.965 ÷ 21.977		
	Rockers Ø 2	22.001 ÷ 22.027		
	Between rockers and shaft	0.024 ÷ 0.062		

TIGHTENING TORQUE

DESCRIPTION		TORQUE		
		Nm		Kgm
Piston cooling nozzles (6 unions M8x1.25x20)		15 ± 3		1.5 ± 0.3
Crankshaft caps (14 screws M12x1.5)	1st phase	80 ± 6		8.0 ± 0.6
	2nd phase		90°	
Crankshaft caps (14 screws M12x1.5)	1st phase	50 ± 5		5.0 ± 0.5
	2nd phase		60°	
Camshaft longitudinal retaining plate (2 screws M8x1.25)		24 ± 4		2.4 ± 0.4
Rear gear case				
(1 screw M12x1.75)		77 ± 12		7.7 ± 1.2
(4 screws M8x1.25)		24 ± 4		2.4 ± 0.4
(5 screws M10x1.5)		47 ± 5		4.7 ± 0.5
Timing gear (6 screws M8x1.25)		36 ± 2		3.6 ± 0.2
Flywheel housing				
(8 screws M12x1.75)		85 ± 10		8.5 ± 1.0
(12 screws M10x1.5)		49 ± 5		4.9 ± 0.5
Engine flywheel (8 screws M12x1.25)	1st phase	30 ± 4		3.0 ± 0.4
	2nd phase		60°	
Oil pump (4 screws M8x1.25)	1st phase	8 ± 1		0.8 ± 0.1
	2nd phase	24 ± 4		2.4 ± 0.4
Front cover				
(7 screws M8x1.25x30)		24 ± 4		2.4 ± 0.4
(6 screws M8x1.25)		24 ± 4		2.4 ± 0.4
Crankcase stiffening plate (4 screws M10x1.5x25)		43 ± 5		4.3 ± 0.5
Oil suction strainer pipe (2 screws M8x20)		25		2.5
Oil suction strainer pipe bracket (1 screw M10x1.5x20)		45		4.5
Oil sump				
(14 screws M8x1.25x40)		25		2.5
(4 screws M8x1.25x45)		25		2.5
Oil sump plug (M22x1.5)		50 ± 5		5.0 ± 0.5
Heat exchanger and oil filter support (15 screws M8x1.25x35)		26 ± 4		2.6 ± 0.4
Oil pressure relief valve on oil filter support (1 plug M22x1.5)		80 ± 8		8.0 ± 0.8
Oil filter (1 adapter M27x2)		18 ± 2		1.8 ± 0.2
Oil filler pipe (2 screws M12x1.75x25)		80 ± 4		8.0 ± 0.4
Brackets for lifting engine				
(4 screws M8x1.25x25)		36 ± 5		3.6 ± 0.5
(2 screws M12x1.75x25)		77 ± 12		7.7 ± 1.2
Cylinder head				
(12 screws M12x1.75x130)	1st phase	35 ± 5		3.5 ± 0.5
	2nd phase		90°	
	3rd phase		90°	
(14 screws M12x1.75x150)	1st phase	55 ± 5		5.5 ± 0.5
	2nd phase		90°	
	3rd phase		90°	
Electro-injectors	1st phase	3.5 ± 0.35		0.35 ± 0.04
(12 screws M6x1x35)	2nd phase		25°	
	3rd phase		25°	
	4th phase		25°	
Fuel manifolds on cylinder head (6 nuts M22x1.5x9.5)		55 ± 5		5.5 ± 0.5

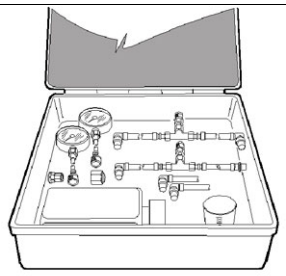
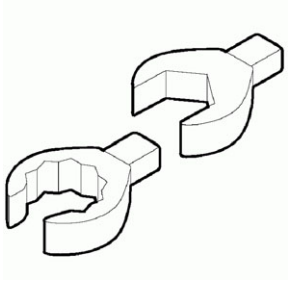
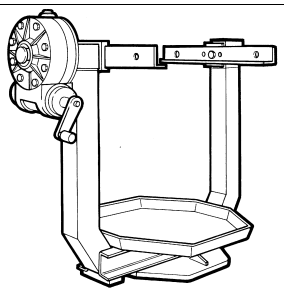
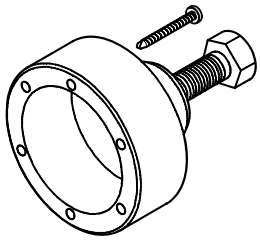
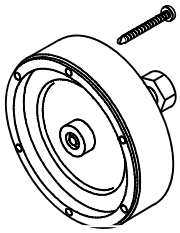
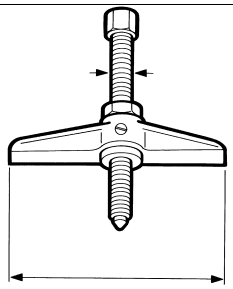
DESCRIPTION		TORQUE	
		Nm	Kgm
Rocker assembly bracket (12 screws M8x1.25)		36 ± 5	3.6 ± 0.5
Valve clearance adjustment (12 nuts M8x1.25)		24 ± 4	2.4 ± 0.4
Electro-injector wiring support (7 screws M8x1.25)		24 ± 4	2.4 ± 0.4
Wiring on each electro-injector (12 nuts M4)		1.5 ± 0.25	0.15 ± 0.025
Tappet cover (6 nuts M8x1.25)		2424 ± 4 ± 4	2.4 ± 0.4
Intake manifold			
(7 screws M8x1.25x25)		24 ± 4	2.4 ± 0.4
(3 screws M8x1.25x70)		24 ± 4	2.4 ± 0.4
Pre-heating grid-heater resistor (6 screws M6x1x16)		10 ± 2	1.0 ± 0.2
Common Rail (4 screws M8x1.25x125)		36 ± 5	3.6 ± 0.5
Overpressure valve DBV4 (M20x1.5)		100 ± 5	10.0 ± 0.5
High pressure fuel delivery pipes	1st phase	10	1.0
(12 hose couplings M14x1.5)	2nd phase	55°	
Power take-off cover (2 screws M12x1.75x25)		80 ± 5	8.0 ± 0.5
High pressure pump gear (1 nut M18x1.5)		105 ± 5	10.5 ± 0.5
High pressure pump			
(3 nuts M8-8)		24 ± 4	2.4 ± 0.4
(3 studs M8x1.25x50)		11 ± 3	1.1 ± 0.3
Fuel supply pipe from high-pressure pump to common rail			
(2 hose couplings M14x1.5)	1st phase	10	1.0
	2nd phase	55°	
(1 screw M8x1.25x20)		25	2.5
(1 screw M8x1.25x16)		25	2.5
Fuel suction pump crankcase cover (2 screws M8x1.25x20)		24 ± 4	2.4 ± 0.4
Blow-by breather plate to tappet cover (1 screw M6x1)		10 ± 2	1.0 ± 0.2
Blow-by breather pipe (2 hose connectors M12x1.5)		20 ± 4	2.0 ± 0.4
Blow-by filter (3 screws M6x1)		10 ± 2	1.0 ± 0.2
Exhaust manifold (12 screws M10x1.5x65)		55 ± 3	5.5 ± 0.3
Turbocharger			
(4 nuts M10x1.5)		45 ± 2	4.5 ± 0.2
(4 studs M10x1.5x42)		25 ± 5	2.5 ± 0.5
Turbocharger air outlet to intercooler (1 screw M6x1x55)		10 ± 2	1.0 ± 0.2
Turbocharger exhaust outlet to throttle valve (1 screw M6x1x50)		6 ± 1	0.6 ± 0.1
Motorized throttle valve water pipes			
(2 connectors M10x1)		20	2.0
(3 nuts M12x1.5)		45	4.5
(2 screws M8x20)		23 ± 2.3	2.3 ± 0.23
(1 connector M10x1)		25	2.5
(1 screw M8x16)		23 ± 2.3	2.3 ± 0.23
Bracket fixing motorized throttle valve to exhaust manifold			
(4 screws M8x1.25x25)		25	2.5
Turbocharger lubrication oil pipes			
(2 nuts M16 11/16-16)		36 ± 5	3.6 ± 0.5
(2 screws M8x1.25x25)		23 ± 2	2.3 ± 0.2
(2 screws M8x1.25x16)		23 ± 2	2.3 ± 0.2
Engine coolant inlet			
(2 screws M10x1.5x130)		43 ± 6	4.3 ± 0.6
(1 screw M10x1.5x70)		43 ± 6	4.3 ± 0.6
Engine coolant outlet / thermostat cover (3 screws M6x1x12)		13.5 ± 1.5	1.35 ± 0.15

DESCRIPTION		TORQUE	
		Nm	Kgm
Water pump (2 screws M8x1.25x35)		24 ± 4	2.4 ± 0.4
Crankshaft pulley with damper pulley	1st phase	50 ± 5	5.0 ± 0.5
(6 screws M12x1.25)	2nd phase	90°	
Fan pulley mounting (4 screws M8x1.25x45)		24 ± 4	2.4 ± 0.4
Fan control pulley (4 screws M10x25)		68 ± 7	6.8 ± 0.7
Idler guide pulley (1 screw M10x1.5)		43 ± 6	4.3 ± 0.6
Automatic belt tensioner mounting (2 screws M8x1.25x30)		24 ± 4	2.4 ± 0.4
Automatic belt tensioner (1 screw M10x1.5x70)		43 ± 6	4.3 ± 0.6
Fuel filter mounting (2 screws M12x1.75x30)		80 ± 8	8.0 ± 0.8
Fuel filter (1 adapter M20x1.5)		20 ± 2	2.0 ± 0.2
Engine control unit (3 screws M8x1.25x45)		14	1.4
Camshaft timing sensor (1 nut with stud M6x1x5)		12	1.2
Crankshaft rpm sensor (1 screw M6x1x20)		10 ± 2	1.0 ± 0.2
Coolant temperature sensor (M14x1.5x12)		24 ± 4	2.4 ± 0.4
Engine oil pressure and temperature sensor (2 screws M6x1x20)		10 ± 2	1.0 ± 0.2
Rail pressure sensor (M18x1.5)		70 ± 5	7.0 ± 0.5
Fuel temperature sensor (M14x1.5)		24 ± 4	2.4 ± 0.4
Boost pressure and air temperature sensor (1 screw M6x1x20)		10 ± 2	1.0 ± 0.2
Alternator			
(1 screw M10x1.5x110)		43 ± 6	4.3 ± 0.6
(1 screw M10x1.5x20)		43 ± 6	4.3 ± 0.6
(1 screw M10x1.5x30)		43 ± 6	4.3 ± 0.6
Electric starter motor (3 nuts M10x1.5)		43 ± 6	4.3 ± 0.6
1/2 inch plug on the cylinder head		24 ± 4	2.4 ± 0.4
3/4 inch plug on the cylinder head		36 ± 5	3.6 ± 0.5
1/4 inch plug on the cylinder head		12 ± 2	1.2 ± 0.2
M18x1.5 plug on engine block		24 ± 4	2.4 ± 0.4
M22x1.5 plug on cylinder head		80 ± 5	8.0 ± 0.5
M6x1.5 plug on engine block		10 ± 2	1.0 ± 0.2
M18x1.5x14.5 plug on engine block		24 ± 4	2.4 ± 0.4
M10x1x9.5 plug on engine block		24 ± 4	2.4 ± 0.4
M14x1.5x11 plug on engine block		24 ± 4	2.4 ± 0.4
M16x1.5 couplings		24 ± 4	2.4 ± 0.4
3/4" coupling		36 ± 4	3.6 ± 0.4
M12x1.5 coupling on cylinder head		22 ± 2	2.2 ± 0.2
M10x1 cap		24 ± 4	2.4 ± 0.4

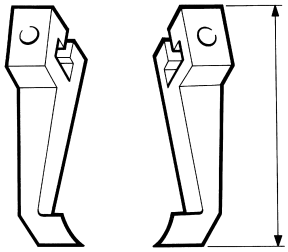
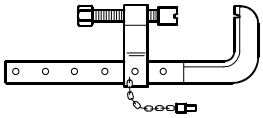
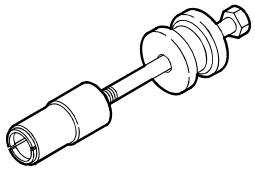
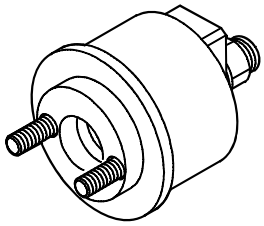
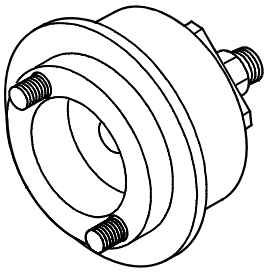
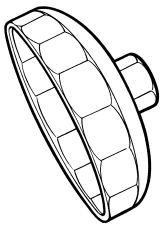
SECTION 8

Tools

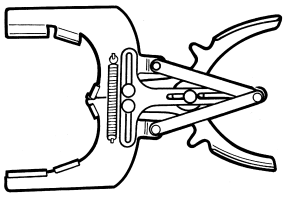
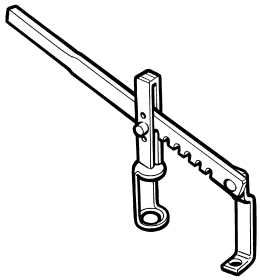
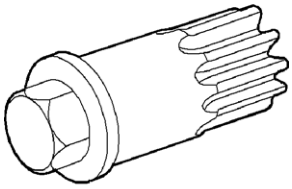
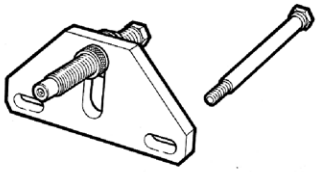
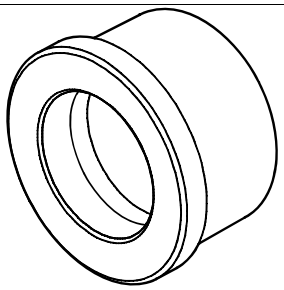
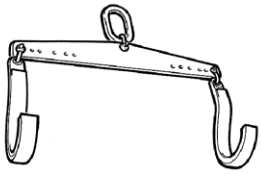
TOOLS

TOOL NO.		DESCRIPTION
99305453		Tool used to check the low-/high-pressure system fuel supply circuit
99317915		Set of five ring spanners with insert 9x12 (14 - 15 - 17 - 18 - 19)
99322205		Revolving stand for overhauling units (1000 daN capacity, 120 daNm torque)
99340055		Tool to remove output shaft front gasket
99340056		Tool to remove output shaft rear gasket
99341001		Double acting puller

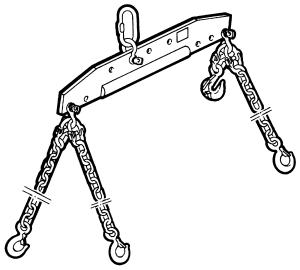
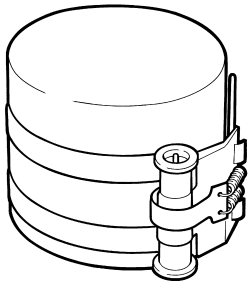
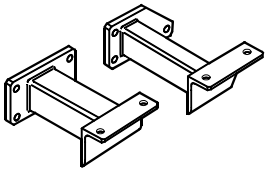
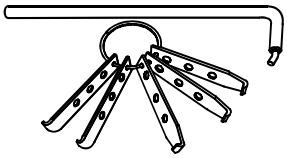
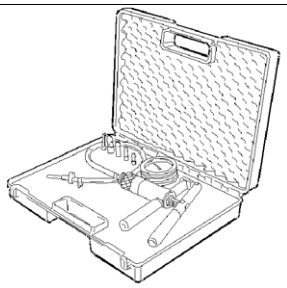
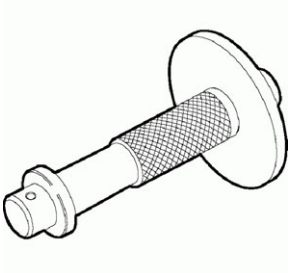
TOOLS

TOOL NO.		DESCRIPTION
99341009		Pair of brackets
99341015		Press
99342101		Tool to remove injectors
99346252		Tool for fitting output shaft front gasket
99346253		Tool for fitting output shaft rear gasket
99360076		Tool to remove oil filter (engine)

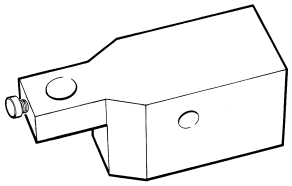
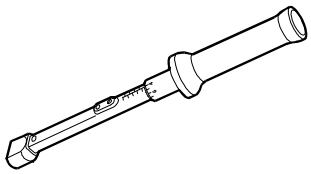
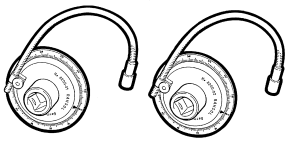
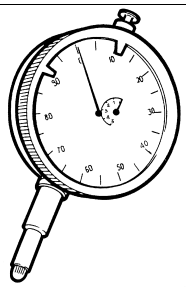
TOOLS

TOOL NO.		DESCRIPTION
99360183		Pliers for removing/refitting piston rings (65 – 110 mm)
99360268		Tool for removing/refitting engine valves
99360330		Tool for rotating engine flywheel
99360351		Equipment for flywheel holding
99360362		Beater for removing/refitting camshaft bushes (to be used with 99370006)
99360500		Tool for lifting the output shaft

TOOLS

TOOL NO.		DESCRIPTION
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
99367121		Manual pump for measuring pressure and vacuum
99370006		Handgrip for interchangeable beaters

TOOLS

TOOL NO.		DESCRIPTION
99370415		Gauge base for different measurements (to be used with 99395603)
99389829		Dog type dynamometric wrench 9x12 (5-60 Nm)
99389834		Torque screwdriver (1-6 Nm) for injector solenoid valve connector stop nut setting
99395216		Pair of gauges with ½" and ¾" square head for angle tightening
99395603		Dial gauge (0 – 5 mm)

Appendix

SAFETY PRESCRIPTIONS
Standard safety prescriptions

Particular attention shall be drawn on some precautions that must be followed absolutely in a standard working area and whose non fulfillment will make any other measure useless or not sufficient to ensure safety to the personnel in-charge of maintenance.

- ❑ Be informed and inform personnel as well of the laws in force regulating safety, providing information documentation available for consultation.
- ❑ Keep working areas as clean as possible, ensuring adequate aeration.
- ❑ Ensure that working areas are provided with emergency boxes, that must be clearly visible and always provided with adequate sanitary equipment.
- ❑ Provide for adequate fire extinguishing means, properly indicated and always having free access. Their efficiency must be checked on regular basis and the personnel must be trained on intervention methods and priorities.
- ❑ Organize and displace specific exit points to evacuate the areas in case of emergency, providing for adequate indications of the emergency exit lines.
- ❑ Smoking in working areas subject to fire danger must be strictly prohibited.
- ❑ Provide Warnings throughout adequate boards signaling danger, prohibitions and indications to ensure easy comprehension of the instructions even in case of emergency.

Prevention of injury

- ❑ Do not wear unsuitable cloths for work, with fluttering ends, nor jewels such as rings and chains when working close to engines and equipment in motion.
- ❑ Wear safety gloves and goggles when performing the following operations:
  - filling inhibitors or anti-frost
  - lubrication oil topping or replacement
  - utilization of compressed air or liquids under pressure (pressure allowed: ≤ 2 bar)
- ❑ Wear safety helmet when working close to hanging loads or equipment working at head height level.
- ❑ Always wear safety shoes when and cloths adhering to the body, better if provided with elastics at the ends.
- ❑ Use protection cream for hands.
- ❑ Change wet cloths as soon as possible
- ❑ In presence of current tension exceeding 48-60 V verify efficiency of earth and mass electrical connections. Ensure that hands and feet are dry and execute working operations utilizing isolating foot-boards. Do not carry out working operations if not trained for.
- ❑ Do not smoke nor light up flames close to batteries and to any fuel material.
- ❑ Put the dirty rags with oil, diesel fuel or solvents in anti-fire specially provided containers.
- ❑ Do not execute any intervention if not provided with necessary instructions.
- ❑ Do not use any tool or equipment for any different operation from the ones they've been designed and provided for: serious injury may occur.
- ❑ In case of test or calibration operations requiring engine running, ensure that the area is sufficiently aerated or utilize specific vacuum equipment to eliminate exhaust gas. Danger: poisoning and death.

During maintenance

- ❑ Never open filler cap of cooling circuit when the engine is hot. Operating pressure would provoke high temperature with serious danger and risk of burn. Wait unit the temperature decreases under 50 °C.
- ❑ Never top up an overheated engine with cooler and utilize only appropriate liquids.
- ❑ Always operate when the engine is turned off: whether particular circumstances require maintenance intervention on running engine, be aware of all risks involved with such operation.
- ❑ Be equipped with adequate and safe containers for drainage operation of engine liquids and exhaust oil.
- ❑ Keep the engine clean from oil tangles, diesel fuel and or chemical solvents.
- ❑ Use of solvents or detergents during maintenance may originate toxic vapors. Always keep working areas aerated. Whenever necessary wear 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 runaway speed rate.
- ❑ Do not utilize fast screw-tightening tools.
- ❑ Never disconnect batteries when the engine is running.
- ❑ Disconnect batteries before any intervention on the electrical system.
- ❑ Disconnect batteries from system aboard to load them with the battery loader.
- ❑ After every intervention, verify that battery clamp polarity is correct and that the clamps are tight and safe from accidental short circuit and oxidation.
- ❑ Do not disconnect and connect electrical connections in presence of electrical feed.
- ❑ Before proceeding with pipelines disassembly (pneumatic, hydraulic, fuel pipes) verify presence of liquid or air under pressure. Take all necessary precautions bleeding and draining residual pressure or closing dump valves. Always wear adequate safety mask or goggles. Non fulfillment of these prescriptions may cause serious injury and poisoning.

- ❑ Avoid incorrect tightening or out of couple. Danger: incorrect tightening may seriously damage engine's components, affecting engine's duration.
- ❑ Avoid priming from fuel tanks made out of copper alloys and/or with ducts not being provided with filters.
- ❑ Do not modify cable wires: their length shall not be changed.
- ❑ Do not connect any user to the engine electrical equipment unless specifically approved.
- ❑ Do not modify fuel systems or hydraulic system unless specific approval has been released. Any unauthorized modification will compromise warranty assistance and furthermore may affect engine correct working and duration.

For engines equipped with electronic gearbox:

- ❑ Do not execute electric arc welding without having priory removed electronic gearbox.
- ❑ Remove electronic gearbox in case of any intervention requiring heating over 80 °C temperature.
- ❑ Do not paint the components and the electronic connections.
- ❑ Do not vary or alter any data filed in the electronic gearbox driving the engine. Any manipulation or alteration of electronic components shall totally compromise engine assistance warranty and furthermore may affect engine correct working and duration.

Respect of the Environment

- ❑ Respect of the Environment shall be of primary importance: all necessary precautions to ensure personnel's safety and health shall 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 personnel is fully aware of such law prescriptions and of basic preventive safety measures.
- ❑ Collect exhaust oils in adequate specially provided containers with hermetic sealing ensuring that storage is made in specific, properly identified areas that shall be aerated, far from heat sources and not exposed to fire danger.
- ❑ Handle the batteries with care, storing them in aerated environment and within anti-acid containers. Warning: battery exhalation represent serious danger of intoxication and environment contamination.