

SERVICE MANUAL

F6BFL413A F6BFL413A*V002
F6BFL413A F6BFL413A*V003

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Contents

INTRODUCTION

ENGINE	54
[54.01] ENGINE ASSEMBLY	54.1
[54.04] ENGINE MOUNTING.....	54.2
[54.06] CYLINDER HEAD ASSEMBLY.....	54.3
[54.07] EXHAUST AND INTAKE MANIFOLDS.....	54.4
[54.08] ENGINE COMPONENTS	54.5
[54.12] TIMING GEAR.....	54.6
[54.20] FUEL FEED	54.7
[54.24] SUPERCHARGING	54.8
[54.30] LUBRICATION.....	54.9
[54.31] LUBRICANT COOLING	54.10
[54.32] WATER COOLING	54.11
[54.34] FAN AND COOLING CONTROL	54.12
INJECTION.....	77
[77.10] INJECTION PUMP	77.1
[77.26] ELECTRONIC GOVERNOR	77.2
[77.31] ADDITIONAL FUEL FILTERS	77.3
[77.45] HYDRAULIC ACCUMULATOR.....	77.4
[77.50] INJECTORS	77.5
CHASSIS	50
[50.51] AIR FILTERS AND PIPES.....	50.1
[50.60] RADIATOR AND PIPES.....	50.2
[50.71] EXHAUST PIPES AND SILENCER	50.3
ELECTRICAL COMPONENTS	76
[76.03] ALTERNATOR.....	76.1
[76.19] ENGINE PREHEATING DEVICE.....	76.2

[76.20] BATTERIES	76.3
[76.42] PRESSURE GAUGES, INDICATORS, SENDERS	76.4
[76.91] CABLES AND CONNECTIONS.....	76.5

Contents

INTRODUCTION

Foreword	6
International symbols	8
Grouped Safety Message - General instructions	9
Grouped Safety Message	11
Safety rules	14
5401 ENGINE ASSEMBLY - Basic instructions	16
Conversion factors	19
5430 LUBRICATION - General specification	20
Product identification - Correspondence between technical codes and commercial codes ..	21
Product identification - Technical coding	22
Product identification Commercial coding	23
Product identification	24

Foreword

This publication provides the data, characteristics, instructions and procedures for carrying out repairs on the vehicle and its components. This publication is intended for qualified and specialized personnel. The personnel of the FPT sales and assistance network as well as all FPT authorized service points are specifically qualified and equipped to carry out the repair operations indicated in this publication. Before carrying out any intervention, make sure you have the publication for the vehicle model on which you are about to operate and also make sure that all the accident prevention devices, including but not limited to, glasses, helmet, gloves, shoes, etc. as well as the work, lifting and transport equipment, etc., are available and efficient. Ensure that the vehicle is in such a condition that the work can be carried out safely. The execution of the interventions in strict observance of the indications provided here, as well as the use of the specific equipment indicated, guarantees the correct repair intervention, observance of the execution times and the safety of the operators. Any repair intervention carried out must serve to restore the conditions of functionality, efficiency and safety required by FPT. Any intervention on the vehicle to modify, alter or any other intervention not authorized by FPT will relieve FPT of all and any liability and, in particular, if the vehicle is covered by warranty, implies the immediate forfeiture of the warranty. FPT is not responsible for carrying out repairs. FPT is available to provide all the clarifications necessary for the execution of the interventions as well as to provide indications in cases and situations not provided for in this publication.

The data and information contained in this publication might not be updated as a result of changes made by FPT, at any time, for technical or commercial reasons or due to the need to adapt the vehicle to the legal requirements of the different countries. In case of discrepancy between the indications provided in this publication and what is actually found on the vehicle, please contact the FPT network before proceeding with any intervention.

The complete or partial reproduction of the text or illustrations herein is forbidden.

The service manual is divided into the following sections:

- INTRODUCTION
- ENGINE
- INJECTION
- CHASSIS
- ELECTRICAL COMPONENTS

The "INTRODUCTION" chapter contains the Safety Regulations, the description of the symbols used in the document, the engine identification dataplate and the scheduled maintenance plan.

Each section is divided into chapters; each chapter can be identified by a unique four-digit numerical code and is related to a sub-assembly of the engine.

Chapter 54.01 "COMPLETE ENGINE" provides the general descriptions of the engine, the technical data, the location of the components and the complete engine overhaul procedure. The overhaul procedure is structured as follows:

- Removal
- Checks on individual components
- Installation containing the timely adjustments to be made.

The chapters following the ENGINE section show, for each engine sub-assembly, the descriptions of the sub-assemblies, the descriptions of the individual components within the sub-assemblies, the relative technical data and the specific replacement procedures. When the replacement of the individual component requires the disconnection of other components to gain access, it may be necessary to refer to the complete engine overhaul procedure.

The INJECTION, ELECTRICAL COMPONENTS and CHASSIS sections are structured according to the logic described for the ENGINE section. The CHASSIS section describes all the systems and components that are not physically fitted on the engine. Typically, these are the systems that FPT supplies with the engine, as individual parts.

The wiring diagrams are also provided in the ELECTRICAL COMPONENTS section.

The sections that follow (77 "INJECTION", 50 "CHASSIS", 76 "ELECTRICAL COMPONENTS") with the relative chapters, contain the descriptions and maintenance procedures (disconnection / reconnection) of the different components that make up the engine.

The manual uses proper symbols in its descriptions; the purpose of these symbols is to classify information. In particular, a set of symbols has been defined to classify warnings, while another set has been specified for service operations.

International symbols

SYMBOLS - WARNINGS

	Danger for persons Failure to comply with these prescriptions can result in the risk of serious injury.
	Risk of serious damage to the vehicle Partial or complete non observance of these prescriptions can lead to serious damages to the vehicle and can sometimes result in the guarantee being voided.
	General danger Includes the dangers of both above described signals.
	Environmental protection Indicates correct behaviour in order that vehicle use is as environmentally friendly as possible.
NOTE	Indicates an additional explanation for a piece of information.

Grouped Safety Message - General instructions

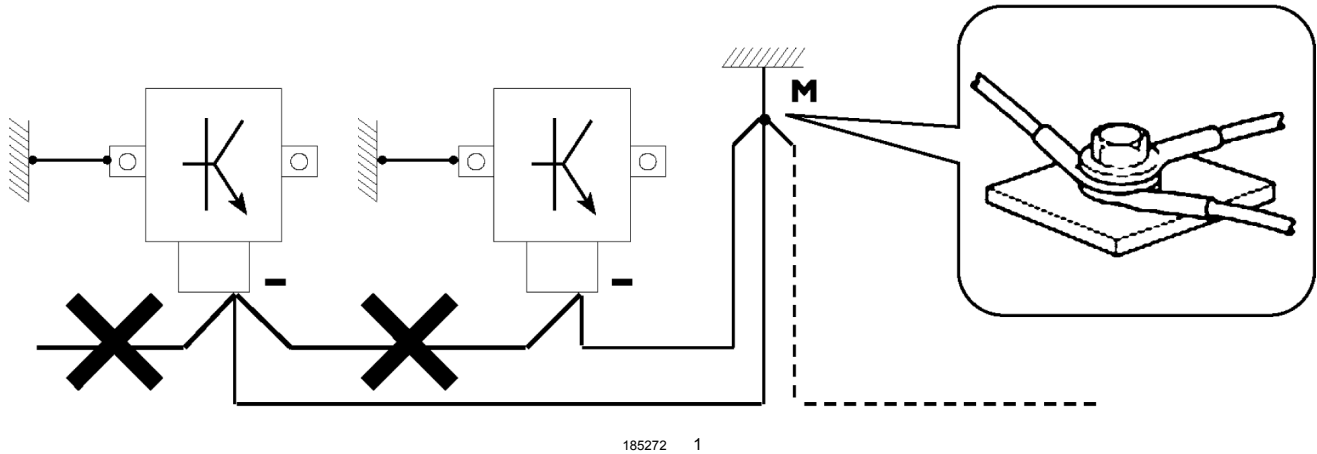
	The warnings shown may not be representative of all the dangerous situations that may occur. Therefore, supervisors should be contacted whenever a dangerous situation that has not been described occurs. Use the specific and general equipment according to that prescribed in the respective use and maintenance handbooks. Check the working condition and suitability of tools not subject to periodic review. Manual handling of loads must be previously appraised regarding the weight, size and path. Handling with mechanical equipment must be done using appropriate lifts and hoists, in terms of weight, shape and volume. Hoisters, ropes and hooks used must show clear indications regarding maximum acceptable carrying capacity. The use of such tools is strictly permitted by authorised personnel only. Stay at a safe distance from the load and never below it. In disassembly operations, always observe the provided prescriptions and prevent any mechanical parts being taken out from accidentally striking workshop personnel. Shop activities performed by two technicians must always been executed with caution; avoid operations that may be dangerous for any collaborators due to lack of field of vision or incorrect position. Keep any personnel not assigned to the operations clear of working area. Learn the necessary concepts of operation and safety relating to the vehicle prior to working on it. Scrupulously observe all safety warnings on the vehicle. Apply suitable signals for the vehicles being repaired. Upon completing repair work, before starting the vehicle, perform all checks indicated in the "Checks by the user" paragraph of the Use and Maintenance handbook. In case of poor visibility when manoeuvring the vehicle, assign a person at ground level to assist. Do not leave the vehicle in motion unattended during repair work. Keep the vehicle stationary using appropriate chocks. When working on a vehicle off the ground, make sure that it is resting firmly on the appropriate supports and that the manual/automatic safety devices are activated in the event of lifting with a hydraulic ramp. When working on vehicles fuelled with natural gas, in addition to the instructions given in the document, also observe all the specific safety regulations provided. Remove the expansion tank cap only when the engine is cold, unscrewing it carefully to allow the residual pressure in the system to escape. Flammable fuels and all fluids and liquids must be handled with care, according to the indications provided in the 16 point cards of harmful materials. Refuelling must be performed outdoors with the engine off, avoiding lit cigarettes, free flames or sparks, in order to prevent sudden fires/explosions. Suitably store flammable, corrosive and pollutant fluids and liquids in accordance with current regulations. Strictly avoid using containers for food to store harmful liquids. Avoid drilling or burning pressurised containers and discard cloths impregnated with inflammable substances into suitable containers. Worn out, damaged or consumable parts must be replaced with original spare parts FPT. During workshop activities, always keep the workplace clean; promptly free or clean floors of any accidental spills and stains of liquids and oils. Electric sockets and electrical equipment necessary to perform repair operations must meet safety rules. For operations on the vehicle's hydraulic, pneumatic, air conditioning and airbag systems (if so equipped), carefully comply with the indications provided in the relevant sections of the manual.
	Wear all required P.P.E and garments when called for by the operation at issue Contact with moving parts may cause serious injuries. Use suitable, preferably tight-fitting garments and avoid wearing jewellery, scarves, etc. Do not leave the engine running in workshops not equipped with a pipe to extract exhaust fumes outside. Do not breathe fumes from heating or welding of paint, as they are harmful; operate outdoors or in well-ventilated areas. Wear an appropriate respirator in the presence of paint dust. Avoid contact with hot water or steam from the engine, radiator and hoses as they could cause serious burns. Avoid direct contact with liquids and fluids inside vehicle systems; consult the 16 remedy points sheet if accidental contact occurs.

	Clean the units or assemblies removed from the vehicle and carefully check their integrity before overhauling. Place in an orderly fashion and in appropriate containers the parts removed or disassembled with their respective fixing elements (screws, nuts, etc.). Check the integrity of the parts that prevent the loosening of screws: split washers, split pins, clips, etc. Self-locking nuts with nylon inserts must always be replaced. Avoid contact of rubber with diesel fuel, petrol or other incompatible substances. Before pressure washing mechanical parts, protect electrical connectors and any control units. The tightening of screws and nuts should always be carried out according to directions; the sales and assistance network FPT is available to provide any clarifications necessary to carry out any repair work not covered by this document. Before welding: • Disconnect all electronic control units and unplug the power cable from the battery's positive terminal (connecting it to the chassis ground) and connectors. • Remove paint by using proper solvents or paint removers and clean relevant surfaces with soap and water. • Wait about 15 min before welding. • Use suitable fire-resistant protections to protect hoses or other components in which fluids or other flammable materials flow when welding. If the vehicle is subject to temperatures higher than 80 °C (drying furnaces), remove the electronic control units.
	The disposal of all liquids and fluids should be carried out in strict compliance with specific regulations in force.

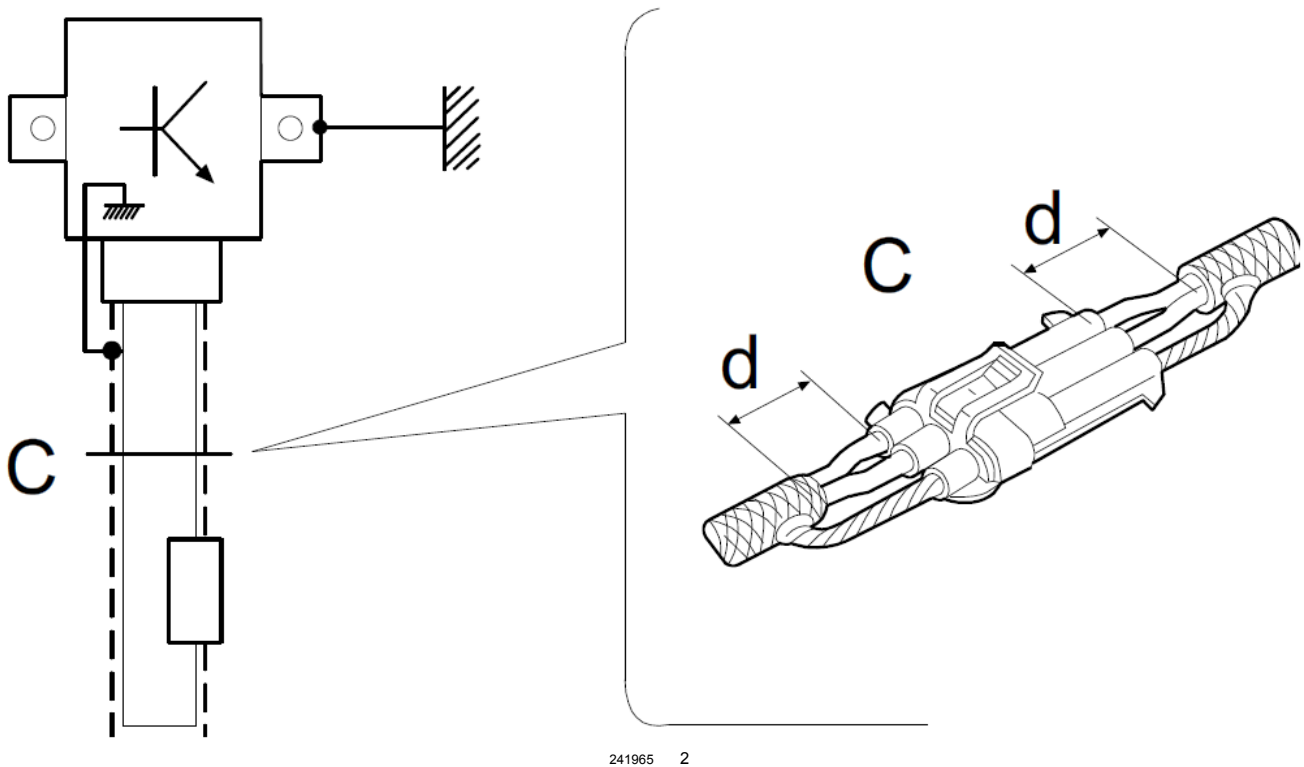
Grouped Safety Message

Grounding and screening

	When having to operate on the electrical/electronic circuit, disconnect the batteries from the circuit, disconnecting the chassis earth cable first of all from the negative terminal of the battery. Before connecting the batteries to the system make sure the latter is well insulated. Disconnect the external recharging apparatus from the public utility network before removing the apparatus pins from the battery terminals. Do not cause sparks to verify the presence of voltage in a circuit. Do not use a test bulb to check the continuity of a circuit. Only use the appropriate testing devices. Make sure that the wirings of electronic devices (length, type of cable, location, strapping, connection of screen braiding, grounding, etc.) conform with the FPT system and that they are carefully restored after repair or maintenance work. Measurements on ECUs, on plug-connectors as well as on electrical connections can be made only on suitable testing lines, by means of special plugs and plug-type bushes. never use improvised equipment like metal wires, screwdrivers, pins or similar. in addition to the risk of causing a short circuit, this might damage plug-type connections and this would then give rise to contact problems. Before replacing an electronic control unit, check the wiring, if necessary contact the T.H.D. (Technical Help Desk) of the market for an authorisation or a recommendation on possible interventions before replacement. For drawing current, carefully follow the indications given in the section Electrical/Electronic system of this manual. It is strictly prohibited to draw current on points that are unauthorised.
	Do not use fast chargers to start up the engine. start up must only be performed with either separate batteries or special truck. Incorrect supply voltage polarisation of the ECUs (such as incorrect polarisation of the batteries) may lead to their destruction. Disconnect the batteries from the system before recharging them by means of an external unit. During connection tighten the union nuts of the connectors (temperature sensors, pressure etc.) only with the specified torque. Isolate the system before disconnecting the junction connector of a main unit. Do not directly supply current to components served by electronic control units with rated vehicle voltage. The cables must be routed so as to be parallel to the reference surface, meaning the nearest possible to the chassis/bodywork structure. Upon completing work on the electrical circuit, restore the electrical connectors and wiring as originally provided. Key programming procedures can be affected by electromagnetic disturbances (mobile phones, etc.). therefore when key programming: 1. Pay attention that there are no noise sources in the cab or near keys. 2. The keys that are not inserted in the dashboard, must be at least 1 m of distance. NOTE: The connectors are viewed from the cable side. connector views contained in the manual are representative of cable side. For fuse identification and rating, comply with the indications present in the vehicle, since their identification or rating may be subject to changes.



The negative conductors connected to a system grounding point must be as short as possible and connected in a "star pattern", as well as being tightened down correctly and as specified ref. **(M)**.



Moreover, the following precautions must always be observed for electronic components:

- The ECUs must be connected to the system ground when they are encased in metal housings.
- Electronic control unit negative cables must be connected to a system ground point, such as the dashboard compartment ground (avoiding "serial" or "chain" connections), as well as to the negative terminal of the battery/ies.
- Even if not connected to the circuit ground/battery negative terminal, analogue ground (sensors) should have optimal isolation. Consequently, particular care should be given to terminal parasitic resistances: oxidation, clinching defects, etc.
- The metal braid of the shielded circuits must be in contact only at the control unit side to which the signal is to be sent.
- In the case of junction connectors the unshielded section **(d)**, near to the latter, must be as short as possible.
- The cables must be routed in such a way as to be parallel to the reference plane, as close as possible to the chassis/body.

Optional electrical and mechanical parts installations



Risk of damage

It is forbidden to make changes or connections to the ECU wiring, especially the data interconnection line between ECUs (CAN line) must never be tampered with.

Partial or complete non observance of these prescriptions can lead to serious damages to the vehicle

Assembly of accessories, additions and modifications on the vehicle are performed complying with the assembly directives FPT (the specific publication "Directive for the transformation and the versions" is available at the Service Network).

It is reminded that, especially with regard to the electric system, several electric sockets are provided for as standard (or optional) sockets in order to simplify and normalise the electrical intervention by bodybuilders.

Any exception to the assembly directives must be authorised by FPT.

Lack of observance of above described prescriptions involves guarantee lapse.

Safety rules

Standard safety precautions

We direct your attention on some precautions that must be necessarily followed in a regular work environment and, in case of non-compliance, any other precaution will not be sufficient to protect the safety of the staff in charge of maintenance.

- Make sure you and all staff are fully aware of current legal safety regulations and ensure that all information is readily available to refer to.
- Please keep the rooms as clean as possible and properly ventilated.
- Equip the rooms with specific, well-visible first-aid boxes, always stocked up with suitable medical aids.
- Be equipped with suitable fire extinguishing devices, properly signalled and never obstructed. Check their operation on a regular basis and train the staff on the intervention priorities and methods.
- Arrange gathering points for the evacuation of the rooms, properly signalling the exit routes.
- Absolutely prohibit smoking in the areas where the works subject to fire hazard are carried out.
- Draw the attention on prohibitions and indications with suitable signs, which are immediately comprehensible always in case of emergency.

Accident prevention

- Do not wear cloths with loose edges, rings and chains, while working near engines and moving organs.
- Use protective gloves and glasses when: filling up inhibitors or anti-freeze; replacing or filling up lubricating oil; using air or liquids under pressure (permitted pressure ≤ 2 bar).
- Wear a protective helmet if working in an area with suspended loads or overhead systems.
- Always wear safety shoes and cloths fitted to the body, better if equipped with rubber bands at the edges.
- Use protective creams for hands.
- Change wet clothes as soon as possible.
- In the presence of a voltage greater than **48 – 60 V**, check the effectiveness of the electrical connections and ground. Make sure your hands and feet are dry and perform the work standing on insulating platforms. Do not proceed if not qualified!
- Do not smoke or spark free flames near batteries and any combustible material.
- Return oily rags or solvents to fire-proof containers.
- Do not perform operations without the necessary instructions.
- Do not use equipment to perform works other than those for which they have been designed, you may sustain accidents, even of serious type.
- In case of checks or calibrations that require the engine to be on, make sure that the room is properly ventilated and use proper fans to remove exhaust gases: intoxication and death hazard.

During maintenance

- Never open the filling cap for the cooling circuit when the engine is hot. The operating pressure will cause the high temperature liquid to leak, resulting in a serious risk of burns. Wait until the temperature drops below **50 °C**.
- Never add coolant to an overheated engine and use exclusively appropriate fluids.
- Always operate with engine off: in case particular circumstances require maintenance with the engine on, consider all the risks involved in these operations.
- Use adequate and safe containers for draining the engine fluids and exhaust oil.
- Preserve the engine clean from oil, gas oil stains and/or chemical solvents.
- The use of solvents or detergents during maintenance may develop toxic vapours. Always ventilate the work rooms. Use safety masks when required.
- Do not leave cloths soaked with flammable substances near the engine.

- When starting up the engine after a repair operation, foresee suitable measures to stop air suction in case of over-speed.
- Do not use quick screwdrivers.
- Do not disconnect the batteries whilst the engine is running.
- Before any interventions involving the electrical circuits, disconnect the batteries.
- Disconnect the batteries from the on-board network while charging.
- After each intervention, make sure the polarity of the battery's terminals is respected and the latter are well tightened and protected against accidental short circuits and oxidation phenomena.
- Do not disconnect and connect the electric connections when power is on.
- Before carrying out removal operations on pipes (pneumatic, hydraulic or fuel pipes), check the possible presence of fluid or air under pressure. Adopt the necessary precautions, exhausting the residual pressures or closing the shut-off valves. Always wear suitable masks or protective glasses. Failure to follow these rules may cause serious accidents and intoxication.
- Avoid improper tightening operations or out of torque. The engine's components may be damaged also seriously, thus prejudicing their life cycle.
- Avoid draughts from fuel tanks in copper alloy and/or pipes without filters.
- Do not apply changes to the cabling, their length must not be modified.
- Do not connect any utility to the engine's electric equipment, unless specifically approved.
- Do not modify the fuel or hydraulic systems without authorization. Any unforeseen change will void the warranty and may prejudice the engine's duration and life cycle.

For engines equipped with electronic units:

- Do not carry out any arc welding without previously removing the electronic units.
- Remove the electronic control units in case of interventions in which temperatures will exceed **80 °C**.
- Do not paint the electronic components and connections.
- Do not modify or alter the data contained in the engine management electronic control unit. Any manipulation or alteration of the electronic components will invalidate the service warranty of the engine and may also affect its operation and duration.

Protection of the environment

- Allows prioritise protection of the environment implementing all necessary precautions to protect the safety and health of staff.
- Make sure you and all staff are fully aware of current standards for the treatment and disposal of fluids and engine oils. Set up adequate signage and specific courses to ensure a full understanding of the rules and the basic prevention measures.
- Collect used oil in suitable containers with water tight seals also providing storage in areas which are adequately marked, ventilated, away from sources of heat and present no fire hazard.
- Handle batteries with care in well ventilated areas and in antacid containers. Beware of fumes coming from the batteries: they may pose a serious risk of poisoning and contamination of the environment.

5401 ENGINE ASSEMBLY - Basic instructions

The intervals indicated below take into account the factors of use, typical of the various types of engine. Always strictly observe the specifications to best maintain engine efficiency.

Checks	Frequency
Engine lubricant oil level check	Daily
Engine coolant level check	Daily
Integrity air filter and housing cleanness check	Daily
Check starter motor (*)	Daily
Visual inspection of the battery integrity	Daily
Inspection for presence of water in fuel filter and/or fuel pre-filter	Daily

Periodic maintenance	Frequency
Check ancillary belt conditions and tension	600 h
Engine lubricant oil replacement	600 h (2) (3)
Replacement of lubricant oil filter	600 h (2) (3) (4)
Heat exchanger (radiator) and radiator grille cleaning	600 h
Replacement of the air filter and cleaning of the housing (1)	1200 h (7)
Fuel filter replacement	600 h (1) (2) (5)
Change fuel pre-filter	600 h (1) (2)
Engine crankcase ventilation filter replacement (CCV filter)	No intervention necessary
Visual inspection of water pump integrity	1200 h

Extraordinary maintenance	Frequency
Adjust rocker arm / valve play	No intervention necessary
Replace ancillary belt	3000 h
Visual inspection of the condition of the turbocharger	1200 h
Visual inspection of the alternator	3000 h
change engine coolant (with 50% anti-freeze)	3000 h (6)
Clean the turbocharger compressor housing	3000 h

ATTENTION: Checks, inspections and replacements are by way of example only and must be in addition to the specifications for vehicles equipped with Stage V engines. The data is only valid if the fitter has observed all the installation instructions provided by FPT.

(*) Not supplied by FPT.

(1) Maximum period relating to the use of high quality fuel (specification ASTM D975 or EN 590); this is reduced in the event of fuel contamination and alarm signals caused by 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 warning light of water present in the pre-filter does not go off after drainage, then the pre-filter must be replaced.

(2) To be carried out every year even if the expected operating hours are not reached. To be carried out each time the dedicated vehicle warning light (if provided) activates. After each oil change carry out the reset using the panel or the diagnostic tool.

For the oil specifications, refer to the table of the oils (**LUBRICATION - General specification (54.30)**).

(4) Only use filters with the following characteristics:

- Degree of filtering **10 µm** - filtering efficiency **40%**.
- Degree of filtering **30 µm** - filtering efficiency **97%**.

(5) Only use filters with the following characteristics:

- Degree of filtering **4 µm** - filtering efficiency **> 95%**.

(6) To be performed every two years even if the specified operating hours interval has not been reached.

(7) The frequency is a function of the environmental conditions and product wear/efficiency. After long periods of inactivity of the engine, carry out the checks before starting the engine. If the warning signal is given indicating that the filter is clogged, the filter must be replaced.



Risk of damage

Extraordinary maintenance operations are the exclusive responsibility of the manufacturer's personnel or specialised personnel using suitable tools and PPE

Failure to comply completely or partially with these requirements may result in the risk of serious damage to the engine and may even, on occasion, invalidate the warranty



Risk of damage

The procedures and methods for carrying out these operations are described in the FPT Technical and Repair Manual.

Failure to comply completely or partially with these requirements may result in the risk of serious damage to the engine and may even, on occasion, invalidate the warranty

Scheduled maintenance for the ATS system

 Scheduled maintenance for the ATS system	Frequency
ATS system forced regeneration via the diagnostic instrument	600 h (*)
Replace ATS system	4000 h

(*) To be carried out by the Service Network. Carry out the forced regeneration before changing the oil.

Conversion factors

Conversions between the main units of measurements of the international system and the most commonly used derived units

Power

$$1 \text{ kW} = 1,36 \text{ CV}$$

$$1 \text{ kW} = 1,34 \text{ Hp}$$

$$1 \text{ CV} = 0,736 \text{ kW}$$

$$1 \text{ CV} = 0,986 \text{ Hp}$$

$$1 \text{ Hp} = 0,746 \text{ kW}$$

$$1 \text{ Hp} = 1,014 \text{ CV}$$

Torque

$$1 \text{ N}\cdot\text{m} = 0,102 \text{ kgm}$$

$$1 \text{ kgm} = 9,81 \text{ N}\cdot\text{m}$$

Rpm

$$1 \text{ rad/s} = 1 \text{ RPM} \times 0.1047$$

$$1 \text{ RPM} = 1 \text{ rad/s} \times 9.5493$$

Pressure

$$1 \text{ bar} = 1,02 \text{ Kg/cm}^2$$

$$1 \text{ Kg/cm}^2 = 0,981 \text{ bar}$$

$$1 \text{ bar} = 100 \text{ kPa}$$

Unless there is a specific need for accuracy:

- The unit Nm is converted into kgm for simplicity according to a ratio of 10:1
 $1 \text{ kgm} = 10 \text{ N}\cdot\text{m}$
- The unit bar is converted into kg/cm² for simplicity according to a ratio of 1:1
 $1 \text{ Kg/cm}^2 = 1 \text{ bar}$

Temperature

$$0 \text{ }^{\circ}\text{C} = 32 \text{ }^{\circ}\text{F}$$

$$1 \text{ }^{\circ}\text{C} = (1 \times 1,8 + 32) \text{ }^{\circ}\text{F}$$

5430 LUBRICATION - General specification

FPT recommended product (*)	International specifications
322 (**)	15W-40 API CK-4 /ACEA E9 (FPI9.LUBR001-TLS OFV) (STD.) 10W-40 API CK-4 /ACEA E9 (FPI9.LUBR001-TLS CK4) (PREM.) 10W-40 API CJ-4 / API CK-4 ACEA E9 (FPI9.LUBR001-TLS CK4) (PREM.) 0W-40 API CK-4 (FPI9.LUBR001-TLS CC) (COLD CLIM. PREM.)

(*) For the FPT recommended product, please refer to <https://www.fptindustrial.com/global/en/service/fluids/oils-and-coolants>

(**) Reference number only valid for eTIM content



288935 1

Product identification - Correspondence between technical codes and commercial codes

Technical coding	Commercial coding
F6BFL413A*V002	F28ERTV
F6BFL413A*V003	

Product identification - Technical coding

The technical code is assigned during production; It is used to identify the main characteristics, characterise the application and the corresponding level of power output.

F6BFL413A*V002 F6BFL413A*V003

- **(F6)** BFL413A*V002 - ENGINE FAMILY IDENTIFICATION
- F6B **(B)** FL413A*V002 - CYLINDER BLOCK: B = structural OFF ROAD
- F6B **(F)** L413A*V002 - MANAGEMENT: F = engine with HW designed for engines Stage V with SCRoF
- F6BF **(L)** 413A*V002 - CYLINDER CONFIGURATION: L = 4 stroke vertical with EGR and after-treatment device
- F6BFL4 **(4)** 13A*V002 - NUMBER OF CYLINDERS
- F6BFL41 **(1)** 3A*V002- MAIN ENGINE CHARACTERISTICS: 1 = Direct injection turbodiesel with aftercooler
- F6BFL41 **(3)** A*V002 - APPLICATION: 3 = Industrial / agricultural
- F6BFL413 **(A)** *V002- TORQUE LEVEL OR ENGINE POWER
- F6BFL413A* **(V)** 002 - EMISSIONS LEVEL: V = Stage V
- F6BFL413A*V **(002)** - VARIANT TO THE BASIC ENGINE WITHIN BILL OF MATERIALS

Product identification Commercial coding

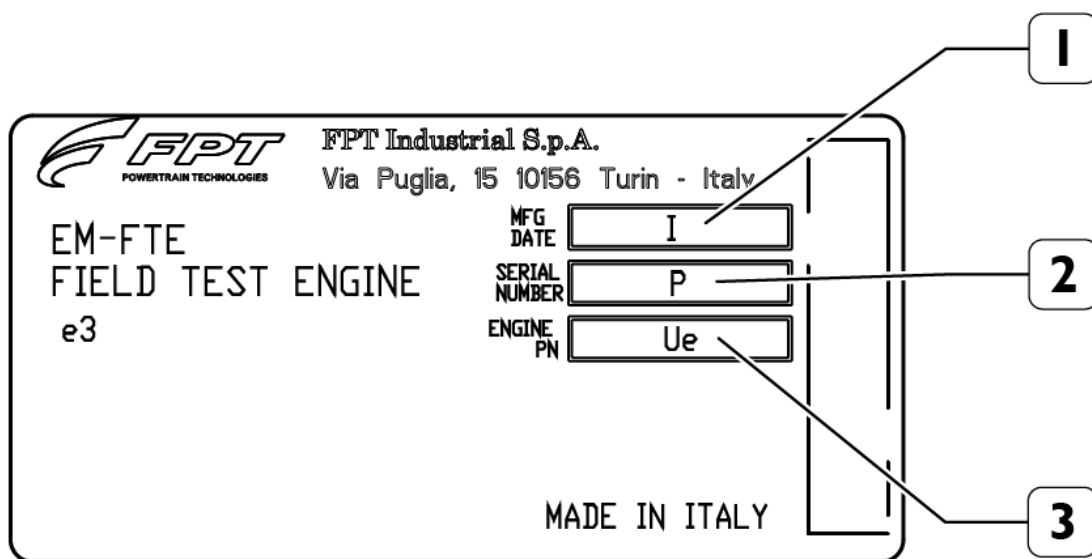
The commercial name is intended to make the information on the characteristics of the engine easy to interpret, bringing together engines of different families, origins and applications for which they are intended. The commercial code cannot be used for technical purposes for the complete recognition of the parts that make up the engine. For this purpose, please refer to the "serial number" otherwise indicated as "ENGINE S/N".

F28ERTV

- **(F)** 28ERTV - ENGINE FAMILY IDENTIFICATION: F = F28
- F **(28)** ERTV - DISPLACEMENT: 36 = 3600 c.c. nominal
- F28 **(E)** RTV - FUEL SUPPLY: E = Electronically controlled injection
- F28E **(R)** TV - CRANKCASE: R = Structural (normal timing gear)
- F28ER **(T)** TV - AIR INTAKE: T = turbocharged intercooled
- F28ERT **(V)** - EMISSIONS LEVEL: V = Stage V

Product identification

APPROVAL PLATE



288803 1

1. Month and year of manufacture
2. Engine serial number
3. Cable FPT

Contents

ENGINE - 54

[54.01] ENGINE ASSEMBLY	54.1
-------------------------------	------

TECHNICAL DATA

ENGINE

Engine horse power POWER - TORQUE CURVES	8
Technical Data	8
Technical Data and assembly clearances	10
Torque	15

FUNCTIONAL DATA

ENGINE

External view	19
External view	21
Component localisation	26

SERVICE

ENGINE

Disassemble	27
Assemble	46
Visual inspection	75

[54.04] ENGINE MOUNTING	54.2
-------------------------------	------

FUNCTIONAL DATA

OIL SUMP

Overview	76
----------------	----

ENGINE BREATHER

Overview - Oil vapour recirculation system	77
--	----

SERVICE

ENGINE BLOCK

Check	78
-------------	----

CYLINDER BARRELS

Check	79
-------------	----

OIL SUMP	
Remove	81
Install	82
CRANKSHAFT FRONT GASKET	
Remove	84
Install	85
CRANKSHAFT REAR GASKET	
Remove	86
Install	87
ENGINE BREATHER	
Remove	88
Install	89

[54.06] CYLINDER HEAD ASSEMBLY 54.3

SERVICE

CYLINDER HEAD	
Remove	90
Check	91
Install	93
ROCKER COVER	
Remove	95
Install	96
VALVE SEAT	
Check	97
Replace	98
VALVES	
Cleaning	100
Disassemble	101
Measure	102
Assemble	103
VALVE SPRING	
Check	104
VALVE GUIDE	
Check	105

[54.07] EXHAUST AND INTAKE MANIFOLDS 54.4

FUNCTIONAL DATA

EGR ASSEMBLY	
Overview (*)	106
EGR MODULATING SOLENOID VALVE	
Overview (*)	108
ABSOLUTE PRESSURE SENSOR	

(*) See content for specific models

Overview (*)	109
THROTTLE POSITION SENSOR	
Overview (*)	110

SERVICE

INTAKE MANIFOLDS	
Remove	111
Install	112
EXHAUST MANIFOLD	
Remove	113
Install	114
EGR ASSEMBLY	
Remove (*)	116
Install (*)	117

[54.08] ENGINE COMPONENTS..... 54.5

SERVICE

ENGINE COMPONENTS	
Overhaul	118
CRANKSHAFT	
Disassemble	120
Measure	121
Assemble	123
Check	125
CRANKPINS	
Measure	126
WEIGHT FASTENING SCREWS	
Remove	128
Install	129
OIL PUMP CONTROL PINION GEAR	
Replace	131
MAIN BEARINGS	
Assemble	132
DRIVE PULLEY ON CRANKSHAFT	
Remove	133
Install	134
CONNECTING ROD	
Check	135
CONNECTING ROD BEARING	
CONNECTING ROD BEARING - Assemble	139
PISTON	
Disassemble	140
Measure	141

(*) See content for specific models

Pre-assemble	143
Assemble	145
Check	146
COMPRESSION RINGS	
Disassemble	147
Check	148
Assemble	150

[54.12] TIMING GEAR..... 54.6

SERVICE

CAMSHAFT	
Check	151
Assemble	152
BUSHES	
Check	153
Replace	154
TAPPETS	
Check	155
ROCKER ARM ASSY	
Remove	156
Install	157

[54.20] FUEL FEED 54.7

FUNCTIONAL DATA

FUEL FEED	
Overview	158
Overview - Electric system	160
Overview - Hydraulic system	163
FILTER ASSEMBLY	
Overview	165

SERVICE

FILTER ASSEMBLY	
Replace	167
Remove	168
Install	169
FILTER SUPPORT	
Remove	170
Install	172
PIPES	
Remove	174
Install	176

[54.24] SUPERCHARGING..... 54.8

FUNCTIONAL DATA

SUPERCHARGING	
Overview	178
TURBO CHARGER	
Overview	179
WASTE GATE VALVE	
Overview	181

SERVICE

TURBO CHARGER	
Remove	182
Check	183
Check	184
Install	185

[54.30] LUBRICATION..... 54.9

FUNCTIONAL DATA

LUBRICATION	
Overview	186
OIL PUMP	
Overview	189
ENGINE OIL FILTER CARTRIDGE	
Overview	190
OIL PRESSURE ADJUSTMENT VALVE	
Overview	191

SERVICE

ENGINE OIL FILTER CARTRIDGE	
Check	192
Change fluid	193
Replace	194
Remove	195
Install	196
FILTER SUPPORT	
Remove	197
Install	198

[54.31] LUBRICANT COOLING 54.10

FUNCTIONAL DATA

HEAT EXCHANGER

Overview	199
----------------	-----

SERVICE

HEAT EXCHANGER

Remove	200
Install	201

[54.32] WATER COOLING 54.11

FUNCTIONAL DATA

WATER COOLING

Overview - Cooling circuit	202
----------------------------------	-----

WATER PUMP ASSEMBLY

Overview	204
----------------	-----

THERMOSTAT

Overview	205
----------------	-----

SERVICE

WATER PUMP ASSEMBLY

Remove	207
Install	208
Check	209

THERMOSTAT

Remove	210
Install	211

[54.34] FAN AND COOLING CONTROL 54.12

SERVICE

WATER PUMP DRIVE BELT

- Check	212
Replace	214
Remove	216
Install	217

FAN CONTROL PULLEY

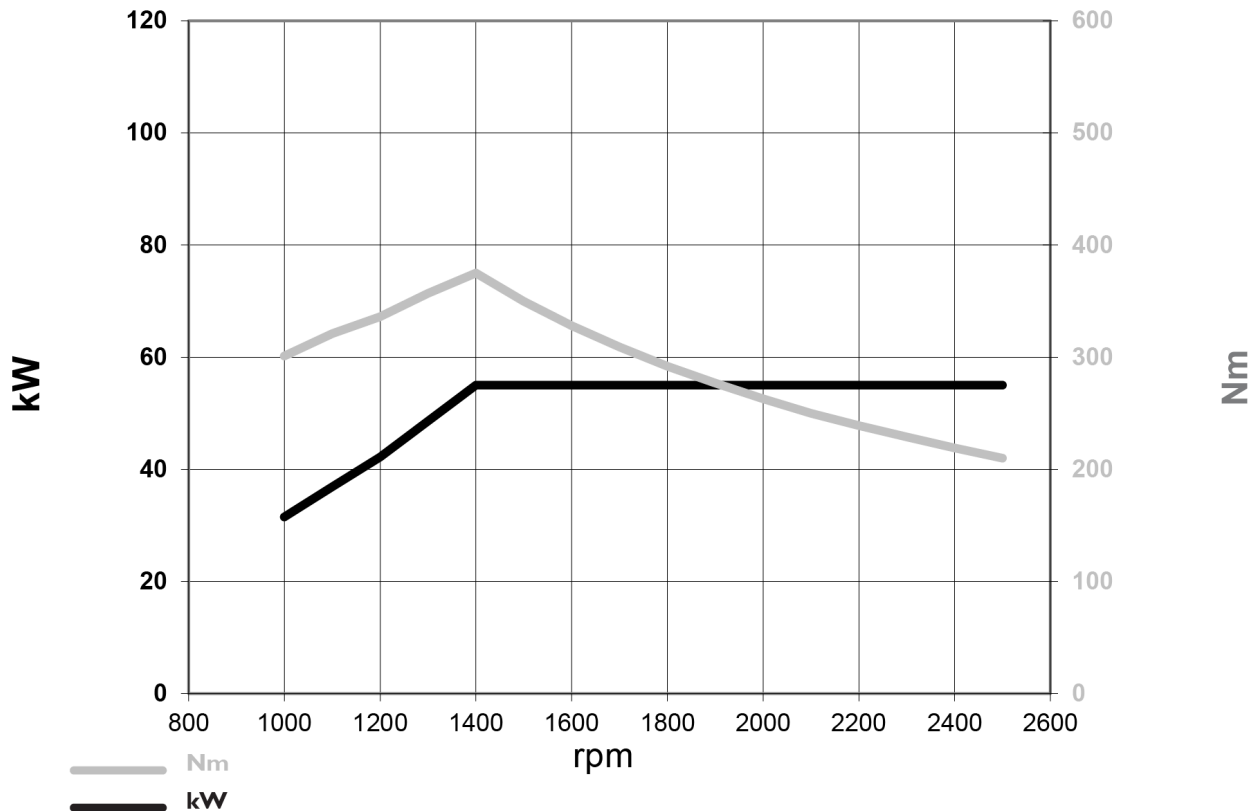
Remove	219
Install	220

FAN HUB MOUNT

FAN HUB MOUNT - Remove	221
FAN HUB MOUNT - Install	222

540110 ENGINE - Engine horse power POWER - TORQUE CURVES

Maximum power 55 kW

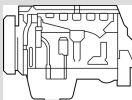


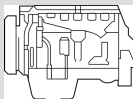
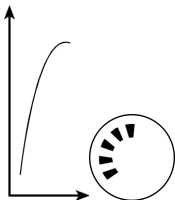
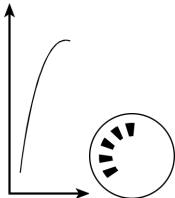
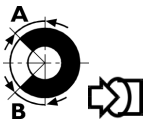
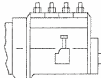
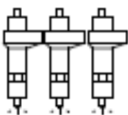
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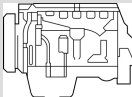
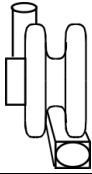
- Maximum POWER **55 kW (75 CV)** at **2300 RPM**
- Maximum TORQUE. **375 N·m (37.5 kgm)** at **1400 RPM**

540110 ENGINE - Technical Data

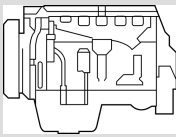
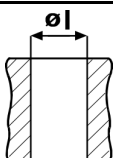
GENERAL CHARACTERISTICS

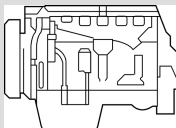
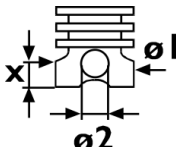
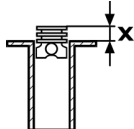
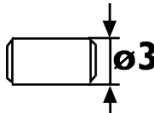
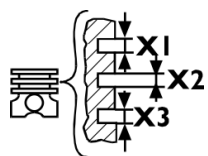
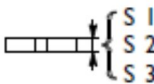
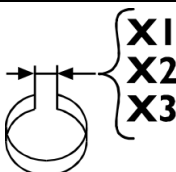
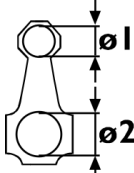
	Type	F6BFL413A*V
	Cycle	4-stroke diesel
	Power Supply	Turbocharged with intercooler
	Injection	Direct
	Number of cylinders	4 in-line
	Bore	90.8 mm
	Stroke	108 mm
	Total displacement	2797 cm³
	compression ratio	17 : 1

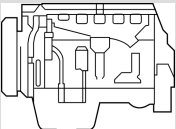
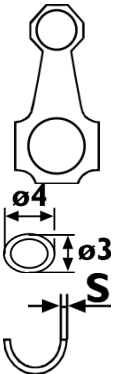
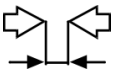
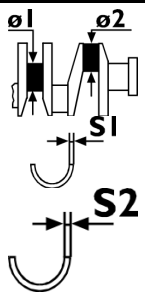
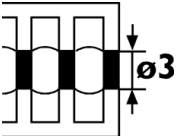
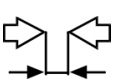
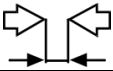
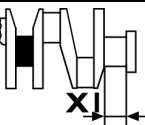
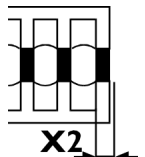
	Type	F6BFL413A*V
	Maximum power	55 kW (75 CV) 2300 RPM
	Max. torque	375 N·m (37.5 kgm) 1400 RPM
	Engine low idle speed	2750 +/- 100 RPM
	Maximum engine idle speed	800 +/- 100 RPM
	TIMING GEAR	
	start before TDC	A = 21°
	end after BDC	B = 37°
	start before BDC	D = 67°
	End after TDC	C = 28°
	FEEDING	The high-pressure supply system is controlled by the BOSCH MD1CS069-7.22. It consists of the BOSCH CP4.1 high-pressure pump, electro-injectors, BOSCH hydraulic accumulator (common rail) HFR-16 OHW, pressure and temperature sensors
	Injection system	BOSCH common rail system
	Electro-injectors type Nozzle type	CRI2.16 OHW PVDLLA 147 PV3
	Firing order	1 - 3- 4- 2
	Injection pressure	1600 bar

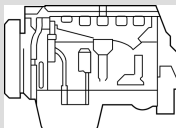
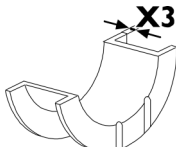
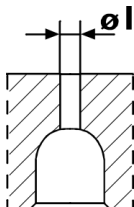
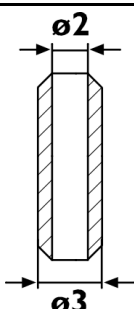
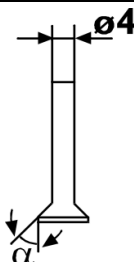
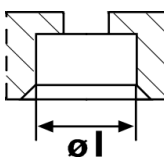
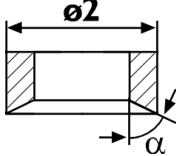
	Type	F6BFL413A*V
	SUPERCHARGING	Turbocharger with intercooler
	Turbocharger type:	Wastegate (WGT) BORG WANNER
	EGR	Outer
	LUBRICATION	Forced by gear pump, pressure relief valve, oil filter, heat exchanger with 5 elements
	Oil pressure with engine warmed up (100 °C):	
	at idle speed	1 bar
	at maximum speed	3.5 bar
-	COOLING	By centrifugal pump, thermostat, radiator, heat exchanger, intercooler
	Water pump drive	Belt driven
	Thermostat	
	start of opening:	79 +/- 2 °C
	Maximum opening	94 °C
	REFILLING	
	Cooling circuit (1)	5 L
	Lubrication system (2):	
	total capacity (first filling) (3)	8.5 L (7.65 kg)
	PERIODIC REPLACEMENT	
	Oil sump at minimum level	5.5 L (4.95 kg)
	Oil sump at maximum level	8 L (7.2 kg)
	Fuel tank (4)	-
(1) Use a 50% solution of purified water and FULL-OAT organic coolant (Organic Acid Technology). NOTE: Observe the correct concentration to ensure a freezing temperature of as low as -35 °C (2) For the oil specifications refer to the oil table (General specification). The oil consumption is considered acceptable up to 0,5% of the fuel consumption. (3) The quantities indicated refer to the first refilling only and are relative to the engine, oil sump and filter refilling. (4) Use STANDARD fuel compliant to standards ASTM D975 or EN 590. The use of additive is not recommended. The fuel known as BIODIESEL is permitted only if compliant to standards EN 14214 - ASTM D6751, mixed with standard fuel in a maximum percentage of 7% or 5% (standard ASTM D6751). The indications regarding the fuel tank capacity are the responsibility of the manufacturer of the vehicle/equipment, since they are subject to variations according to the various configurations of the vehicle/equipment. The fuel can be accepted with the following restrictions: sulphur in fuel < 15 ppm.		

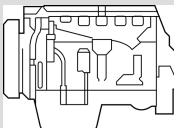
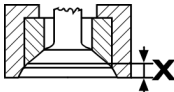
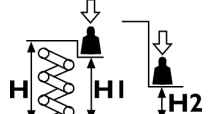
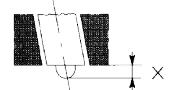
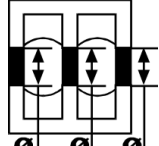
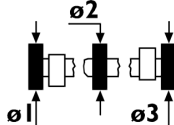
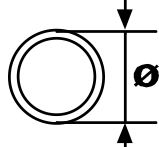
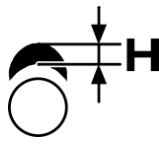
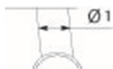
540110 ENGINE - Technical Data and assembly clearances

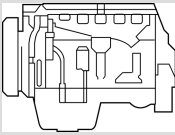
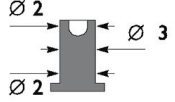
	Type	F6BFL413A*V
CRANK GEAR ELEMENTS AND CYLINDER ASSEMBLY		
	Cylinder liners:	Ø 1 90.800 – 90.820 mm
	>	Ø 1 0.4 mm

	Type		F6BFL413A*V
	Pistons:		
	measuring dimension	X	16 mm
	outer diameter	Ø 1	90.706 – 90.720 mm
	pin seat	Ø 2	33.994 – 34.000 mm
	Piston - cylinder liners		0.080 – 0.114 mm
	Piston diameter	Ø 1	0.4 mm
	Protrusion of the pistons from the crankcase (value on the basis of the head gasket thickness)		
	Head gasket thickness 0.85 mm	X	-0.2 – -0.05 mm
	Head seal thickness 0.95 mm		-0.06 – 1 mm
	Piston pin	Ø 3	33.979 – 33.985 mm
	Piston type:		
	Piston pin - pin seat		0.009 – 0.021 mm
	Piston ring slots	Piston type:	
		X1 (*)	2.39 mm
		X2	2.06 – 2.08 mm
		X3	2.54 – 2.56 mm
	(*) measured on Ø of 87.8 mm		
	Circlips	S1 (**)	2.281 – 2.306 mm
		S2	1.970 – 1.990 mm
		S3	2.470 – 2.490 mm
	(**) measured at 1.5 mm from outer Ø		
	Piston rings - slots	Piston type:	
		1	0.084 – 0.109 mm
		2	0.070 – 0.110 mm
		3	0.050 – 0.090 mm
	Circlips		0.4 mm
	Circlip end opening in cylinder liner:		
		X1	0.25 – 0.40 mm
		X 2	0.60 – 0.80 mm
		X 3	0.25 – 0.45 mm
	Connecting rod small end bush seat	Ø 1	37.010 – 37.030 mm
	Big-end bearing seat	Ø2	59.000 – 59.016 mm

	Type	F6BFL413A*V
	Diameter of connecting rod small end bush	
	Inner	Ø 3 34.010 – 34.020 mm
	Big end half-bearings	S 1.974 – 1.984 mm
	Piston pin - bush	
	Big end half-bearings	
	5 main journals	Ø 1 74.190 – 74.210 mm
	Main journals 1 - 2 - 3 - 4	Ø 1 68.190 – 68.210 mm
	Crankpins	Ø 2 54.990 – 55.010 mm
	Main half-bearings	S1 2.166 – 2.176 mm
	Big end half-bearings	S2 1.974 – 1.984 mm
	Main bearings	
	no. 5	Ø 3 78.575 – 78.601 mm
	n° 1 - 2 - 3 - 4	Ø 3 72.588 – 72.610 mm
	Half bearings main journals	
	n° 5	0.013 – 0.079 mm
	n° 1 - 2 - 3 - 4	0.026 – 0.088 mm
	Half-bearings - crankpins	
	Main half-bearings Big end half-bearings	
	Main journal for shoulder	X1 29.60 – 29.65 mm
	Main bearings for shoulder	X2 24.50 – 24.55 mm

	Type		F6BFL413A*V
	Shoulder half-rings	X3	2.40 – 2.45 mm
	Crankshaft shoulder		0.150 – 0.350 mm
CYLINDER HEAD - TIMING GEAR			
	Valve guide seats on the cylinder head	Ø 1	12.960 – 12.995 mm
	Valve guides	Ø 2	8.023 – 8.038 mm
		Ø 3	13.012 – 13.025 mm
	Valves:		
		Ø 4 α	7.980 – 8.000 mm 60°
		Ø 4 α	7.970 – 7.990 mm 60°
	Valve stem and relative guide		0.023 – 0.058 mm
			0.033 – 0.068 mm
	Seat on the head for valve seat:		
		Ø 1	38.915 – 38.945 mm
		Ø 1	35.415 – 35.445 mm
	Valve housing outer diameter; valve housing inclination on cylinder head:		
		Ø 2 α	38.990 – 39.010 mm 60°
		Ø 2 α	35.490 – 35.510 mm 60°

	Type		F6BFL413A*V
	X Recessing		0.353 – 0.653 mm
			0.358 – 0.658 mm
	Between valve seat and head		0.045 – 0.095 mm
			0.045 – 0.095 mm
	Valve seats		—
	Valve spring height:		
	Free spring	H	46.5 mm
	Under a load of:		
	320 +/- 16 N	H1	32 mm
	560 +/- 25 N	H2	22.5 mm
	Injector protrusion	X	2.48 mm
	Seat for camshaft bush no. 1 (flywheel side)		40.069 – 40.119 mm
	Camshaft seats no. 2 - 3 - 4		50.975 – 51.025 mm
	Camshaft seats no. 5		59.222 – 59.248 mm
	Camshaft supporting pins		
	1	Ø 1	39.975 – 40.025 mm
	2 → 4	Ø 2–3–4	50.881 – 50.926 mm
	5	Ø 5	53.995 – 54.045 mm
	Bushing inside diameter after drive-in		54.094 – 54.149 mm
	Outer bushing diameter		59.335 – 59.393 mm
	Bushing and seat in the crankcase		0.049 – 0.154 mm
	Bushing and supporting pin		0.049 – 0.154 mm
	Maximum lift:		
		H	6.02 mm
		H	5.79 mm
	Tappet washer seat in crankcase	Ø1	18.000 – 18.018 mm

	Type	F6BFL413A*V
	Tappet washer outer diameter:	
	Ø2	17.966 – 17.984 mm
	Ø3	16 mm
	Between tappets and seats	0.016 – 0.052 mm
	Tappets	-

540110 ENGINE - Torque

Description	Quantity	Step	Value
Crankshaft main bearing caps	10 screws M12 x 1.5 x 120	Step 1 — Pre-tightening	50 +/- 6 N·m
		Step 2 — Tighten	80 +/- 6 N·m
		Step 3 — Angle tightening	90°
Motor shaft connecting rod caps	8 screws M8 x 1	Step 1 — Tighten	20 +/- 1 N·m
		Step 2 — Angle tightening	60°
Camshaft longitudinal retaining plate	2 screws M8 x 1.25 x 18		23 +/- 2.3 N·m
Timing gear	6 screws M8 x 1.25 x 20		34 +/- 3.4 N·m
Timing gearbox		13 screws M8 x 1.25 x 25	23 +/- 2.3 N·m
		13 screws M8 x 1.25 x 35	23 +/- 2.3 N·m
Engine flywheel housing		2 screws M12 x 1.75 x 90	117 +/- 11.7 N·m
		10 screws M12 x 1.75 x 40	117 +/- 11.7 N·m
		2 screws M8 x 1.25 x 35	34 +/- 3.4 N·m
Lifting eyelets	2 screws M12 x 1.75 x 25		118 +/- 11.8 N·m
Lifting eyelets	2 screws M10 x 1.5 x 125		67 +/- 6.7 N·m
Oil pressure regulator valve	1 screw M8 x 1.25 x 36		33 +/- 3.3 N·m
Oil pump	3 screws M8 x 1.25 x 36		33 +/- 3.3 N·m
Engine oil sump	8 screws M10 x 1.5 x 230	Step 1 —	40 +/- 2 N·m
		Step 2 — Angle tightening	90°
		Step 3 — Angle tightening	90°
Engine oil sump	4 screws M10 x 1.5 x 160	Step 1 —	40 +/- 2 N·m
		Step 2 — Angle tightening	60°
		Step 3 — Angle tightening	60°
Engine oil sump	4 screws M12 x 1.75 x 160	Step 1 —	85 +/- 4.25 N·m
		Step 2 — Angle tightening	60°
Lubricant oil drain plug in the sump	2 caps M22 x 1.5 x 12		50 +/- 5 N·m
Cylinder head	4 screws M12 x 1.5 x 165	Step 1 —	65 +/- 3,25 N·m

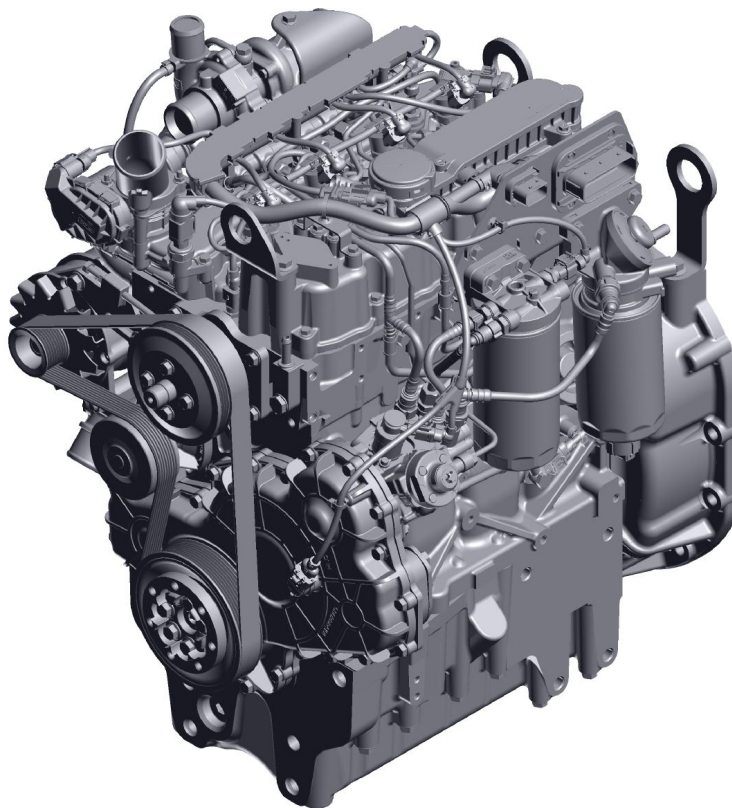
Description	Quantity	Step	Value
Cylinder head	6 screws M15 x 1.5 x 193	Step 2 — Angle tightening	90°
		Step 3 — Angle tightening	60°
		Step 1 —	130 +/- 6.5 N·m
		Step 2 — Angle tightening	90°
Cylinder head	6 screws M8 x 1.25 x 117	Step 3 — Angle tightening	90°
Cylinder head	6 screws M8 x 1.25 x 117		34 +/- 3.4 N·m
Cylinder head plugs	1 plug —		75 +/- 7.5 N·m
Electro-injector brackets	4 nuts M8 x1.25		18 +/- 1.8 N·m
Electro-injector brackets	4 studs M8 x 1.25 x 65		28 +/- 1.4 N·m
Rocker arm unit	12 screws M6 x 1 x 75		10 +/- 1 N·m
Head cover	10 screws M6 x1 x 40		10 +/- 1 N·m
Overhead		8 screws M6 x 1 x 20	10 +/- 1 N·m
Intake manifold		14 screws M6 x 1 x 20	10 +/- 1 N·m
Engine air vent		4 caps M12 x 1.5	20 +/- 2 N·m
		3 studs M6 x 1 x 80	10 +/- 1 N·m
		3 nuts M6 x1	10 +/- 1 N·m
		1 screw M6 x 1 x 80	10 +/- 1 N·m
Common Rail	2 screws M8 x 1.25 x 55		23 +/- 2.3 N·m
Fuel delivery pipes to the electro-injectors	4 rail-side couplings M14 x1.5		35 +/- 1.75 N·m
Fuel delivery pipes to the electro-injectors	4 injector-side couplings M12 x 1.5		25 +/- 1.25 N·m
Delivery fuel pipe from the pump to the rail		1 high pressure fuel pump-side coupling M16 x 1	45 +/- 2.25 N·m
		1 rail-side coupling M14 x 1.5	35 +/- 1.75 N·m
Bracket retaining the delivery fuel pipe from the pump to the rail	3 screws M6 x 1 x 10		10 +/- 1 N·m
Bracket retaining the fuel return pump from the rail and from the high pressure pump		1 screw M6 x 1 x 14	10 +/- 1 N·m
		1 screw M8 x 1.25 x 18	23 +/- 2.31 N·m
Injector fuel return pipe brackets		1 screw M6 x 1 x 14	10 +/- 1 N·m
		1 screw M8 x 1.25 x 18	23 +/- 2.3 N·m
Control socket coupling	1 G 1/4" coupling?		45 +/- 4.5 N·m
Control socket lubrication pipe		1 screw M12 x 1.5	40 +/- 4 N·m
		1 fitting M14 x 1.5	40 +/- 4 N·m
Socket for the service air compressor control	2 screws M10 x 1.5 x 50		46 +/- 4.6 N·m
High pressure fuel pump	3 nuts M8 x1.25		23 +/- 2.3 N·m
High pressure fuel pump	3 studs M8x1.25x12		11 +/- 1.1 N·m
High-pressure pump gear	1 nut M18 x 1.5		80 +/- 4 N·m
High pressure fuel pump spacer	4 screws M6 x 1 x 16		10 +/- 1 N·m
Blow-by filter		7 screws M6 x 1 x 13	10 +/- 2 N·m
Exhaust manifold	9 studs M8 x 1.25 x 52		11 +/- 3 N·m
Exhaust manifold	9 nuts M8 x 1.25	Pre-tightening	10 +/- 0.5 N·m
		Tighten	28 +/- 1.4 N·m
Water pump	2 screws M8 x 1.25 x 25		23 +/- 2.3 N·m
Thermostat cover	3 screws M6 x 1 x 12		10 +/- 1 N·m
Crankshaft pulley	7 screws M10 x 1.5 x 30		70 +/- 7 N·m
Fan pulley control mount	4 screws M8 x 1.25 x 25		23 +/- 2.3 N·m
Fan control pulley	4 screws M8 x 1.25 x 18		23 +/- 2.3 N·m

Description	Quantity	Step	Value
Engine coolant input pipe		3 screws M8 x 1.25 x 65	23 +/- 2.3 N·m
		1 screw M8 x 1.25 x 14	25 +/- 2.5 N·m
Alternator		1 screw M10x1.5x130 + 1 nut M10 x 1.5	45 +/- 4.5 N·m
		1 screw M10 x 1.5 x 35 + 1 nut M10 x 1.5	45 +/- 4.5 N·m
Belt adjusting screw		1 screw M8 x 1.25	20.5 +/- 2.5 N·m
		1 nut M8 x 1.25	20.5 +/- 2.5 N·m
Alternator tensioning bracket		1 screw M10 x 1.5 x 20	45 +/- 4.5 N·m
Oil filter bracket		1 fitting M20 x 1.5 x 18	35 +/- 5 N·m
Oil filter	1 cartridge M27 x 2		30 +/- 3 N·m
Lubricant return pipe from turbocharger	2 screws M6 x 1 x 20		10 +/- 1 N·m
Lubricant oil return pipe from turbocharger bracket	1 screw M6 x 1 x 10		10 +/- 1 N·m
Lubricant delivery pipe to turbocharger		1 screw M10 x 1 x 19	25 +/- 2.5 N·m
		1 nut M14 x 1.5	35 +/- 3.5 N·m
Turbocharger heat shield		2 screws M6 x 1 x 10	10 +/- 1 N·m
		1 screw M8x1.25x12	23 +/- 2.3 N·m
Fuel filter bracket	2 screws M8 x 1.25 x 40		23 +/- 2.3 N·m
Filter bracket/fuel pre-filter bracket	3 screws M8 x 1.25 x 20		23 +/- 2.3 N·m
Fuel pre-filter bracket	3 screws M8 x 1.25 x 25		23 +/- 2.3 N·m
Air bleeding on the fuel filter bracket	1 screw M10		4 +/- 0.5 N·m
Fuel Pre-filter	1 cartridge —		20 +/- 3 N·m
Fuel filter	1 cartridge M20 x 1.5		22 +/- 3 N·m
Pre-heating glow plugs	4 glow plugs M8 x 1		9 +/- 1 N·m
Glow plug harness mount	3 screws M6 x 1 x 14		10 +/- 1 N·m
Crankshaft rpm sensor	1 screw M6 x 1 x 16		9 +/- 0.9 N·m
Camshaft timing sensor	1 screw M6 x 1 x 16		9 +/- 0.9 N·m
Air temperature and pressure sensor	1 screw M6 x 1 x 16		9 +/- 0.9 N·m
Low engine oil pressure sensor	1 sensor M14 x 1.5		35 +/- 3.5 N·m
Coolant temperature sensor	1 sensor M12 x 1.5		20 +/- 5 N·m
Fuel temperature sensor	1 sensor —		30 +/- 5 N·m
Exhaust gas linkage pipe	2 screws M12 x 1.5 x 24		25 +/- 2.5 N·m
Exhaust gas absolute pressure sensor	1 sensor M14 x 1.5		15 +/- 1.5 N·m
Pressure sensor on rail RDS4.2	1 sensor M18 x 1.5		70 +/- 5 N·m
Engine cable fixing bracket	3 screws M8 x 1.25 x 20		23 +/- 2.3 N·m
EGR valve	2 screws M6 x 1 x 20		10 +/- 1 N·m
EGR heat exchanger		5 nuts M8 x1.25	23 +/- 2.3 N·m
		1 screw M6 x 1 x 14	10 +/- 1 N·m
EGR heat exchanger	5 studs M8 x 1.25 x 80		23 +/- 2.3 N·m
Pressure relief valve on rail	1 coupling —		100 +/- 5 N·m
DOC catalyst right bracket		4 screws M8 x 1.25 x 25	25 +/- 2.5 N·m
		3 screws M8 x 1.25 x 30	25 +/- 2.5 N·m
DOC catalyst left bracket		2 screws M8 x 1.25 x 50	25 +/- 2.5 N·m
		2 screws M10 x 1.5 x 35	45 +/- 4.5 N·m
		1 screw M8 x 1.25 x 25	25 +/- 2.5 N·m
DOC catalyst upper bracket		2 nuts M10 x 1.5	45 +/- 4.5 N·m
		2 screws M10 x 1.5 x 20	45.5 +/- 4.5 N·m
Mixer exhaust gas pipe		1 V clamp M10	25 +/- 2.5 N·m
		1 V clamp M6	7 +/- 0.7 N·m
DOC catalytic converter	6 screws M8 x 1.25 x 20		25 +/- 2.5 N·m
Balancing weights	4 screws M8 x 1.25 x 90	Step 1 — Pre-tightening	20 +/- 6 N·m

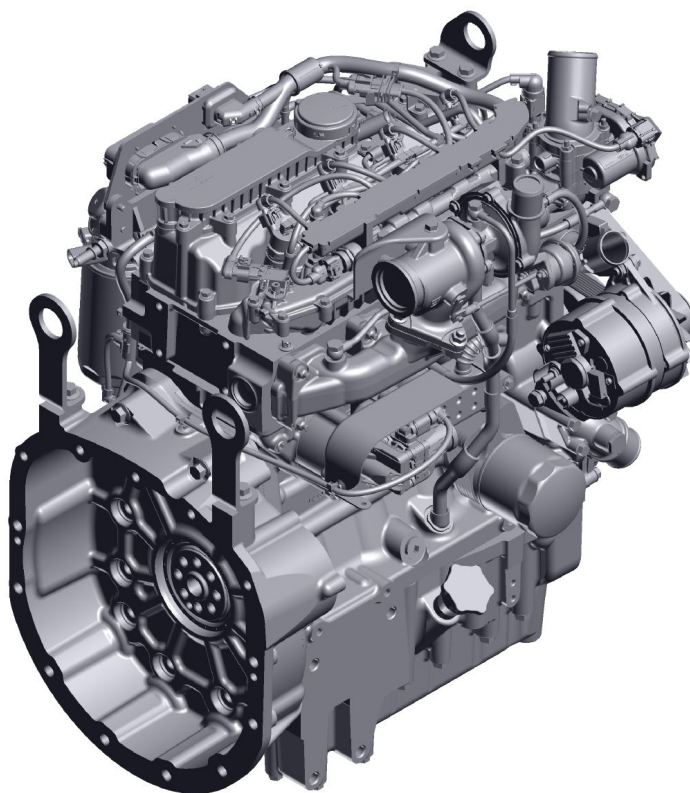
Description	Quantity	Step	Value
		Step 2 — Tighten	60°
Water in fuel pre-filter presence sensor	1 sensor M10 x 1.5		1.85 +/- 0.65 N·m
Exhaust gas temperature sensor		1 fitting M14 x 1.5 x 12	45 +/- 4.5 N·m
		1 screw M6 x 1.5 x 12	10 +/- 1 N·m
Turbocharger		3 nuts M10 x 1.5 x 10	28 +/- 1.5 N·m
		3 studs M10 x 1.5 x 40	25 +/- 1.25 N·m

540110 ENGINE - External view

ISOMETRIC VIEW



298021 1



298020 2

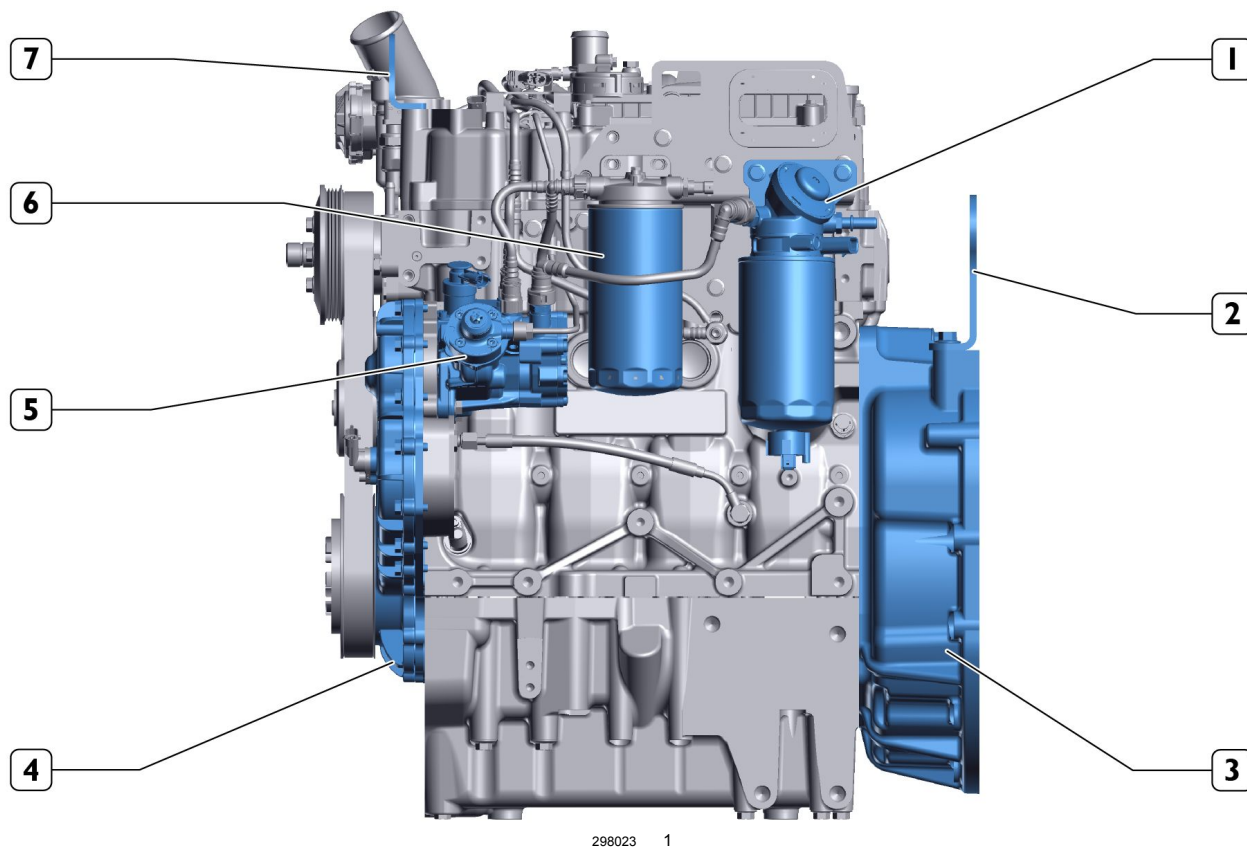
The F6BFL413A is a 4-cylinder in-line turbocharged engine with intercooler with 2 valves per cylinder; It belongs to the F28 series and operates according to a 4-stroke diesel cycle.

The engine fuel system is electronically controlled and based on the direct injection of the fuel in the combustion chamber by means of a high-pressure pump and the common rail.

The intake and exhaust valves are timed with the camshaft tappets, the push rods and the rocker arm assembly.

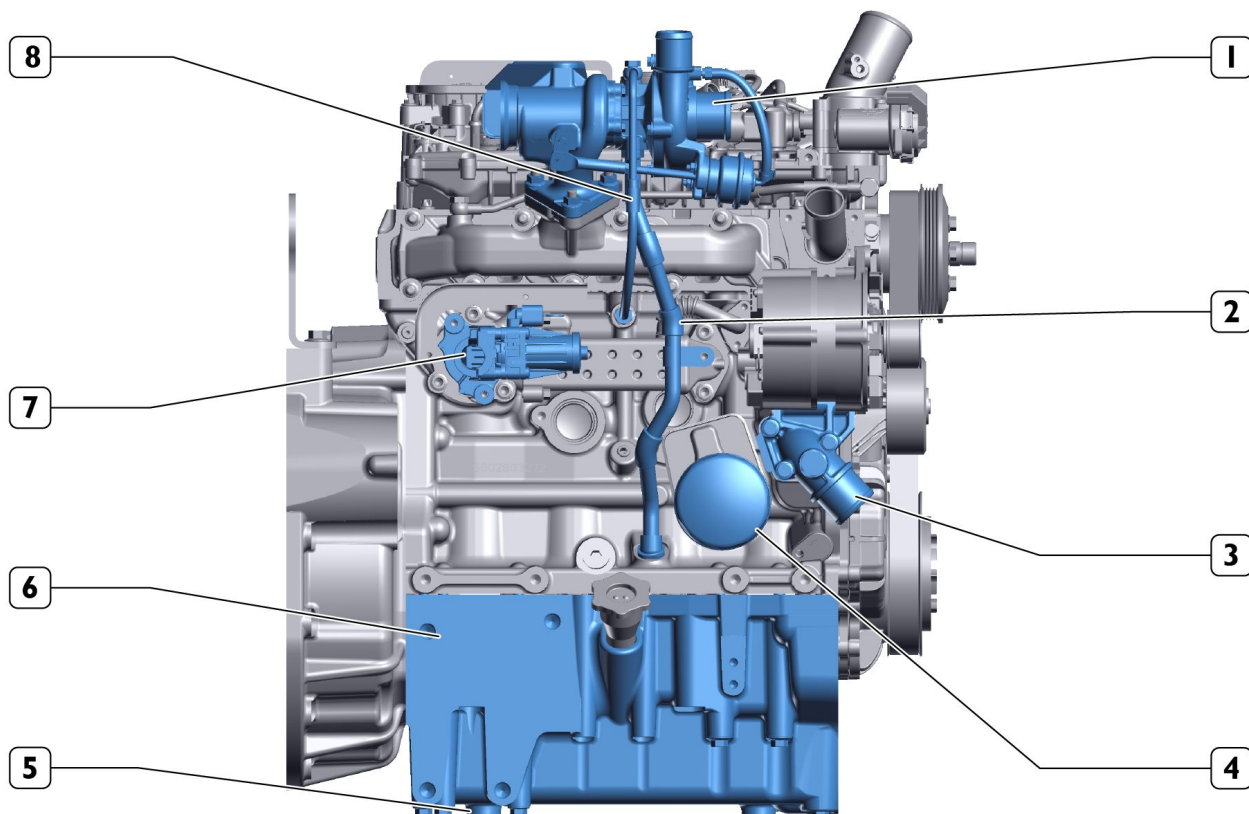
540110 ENGINE - External view

LEFT SIDE VIEW



1. Fuel pre-filter
2. Lifting hook
3. Engine flywheel housing
4. Timing gear cover
5. Fuel high pressure pump
6. Fuel filter
7. Lifting hook

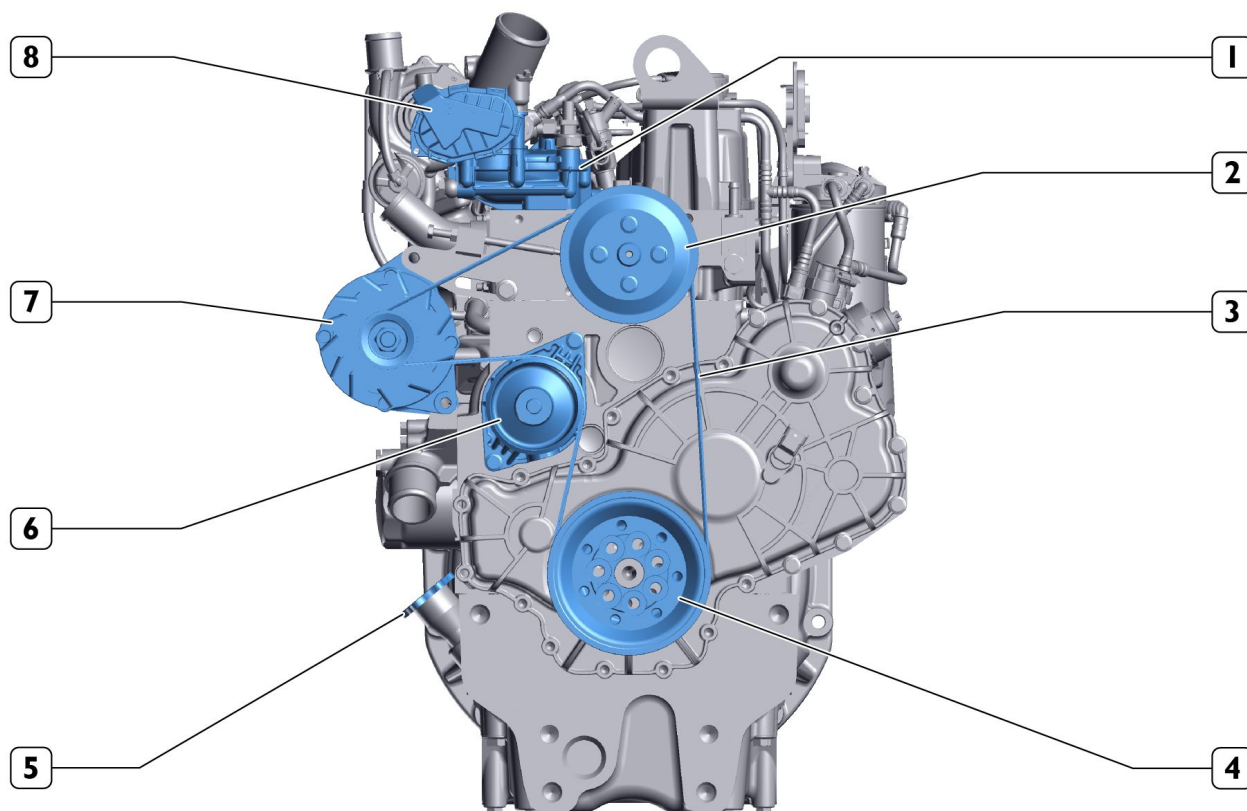
RIGHT SIDE VIEW



298022 2

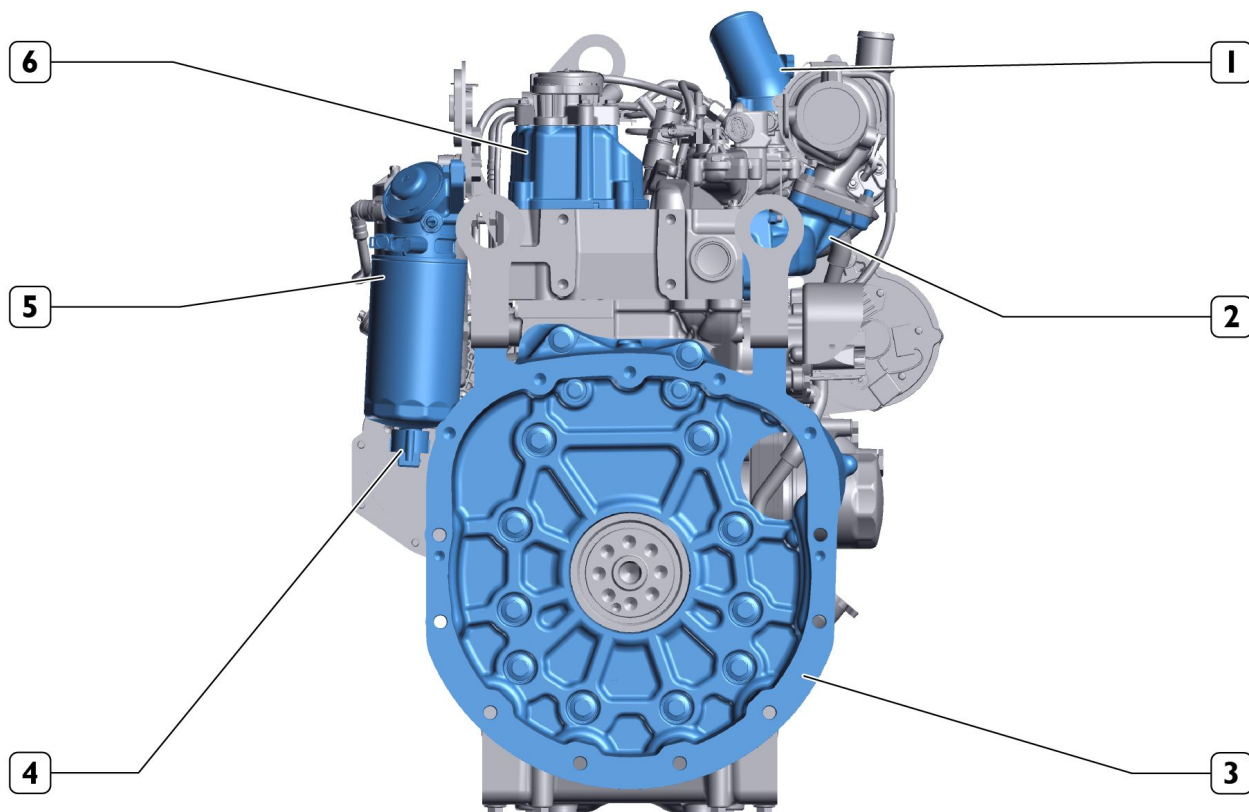
1. Turbocharger
2. Lubricant oil return pipe from turbocharger
3. Engine coolant inlet pipe
4. Engine oil filter
5. Engine lubricant oil drain plug
6. Oil sump
7. EGRvlv
8. Lubricant oil delivery pipe to turbocharger

FRONT SIDE VIEW



298025 3

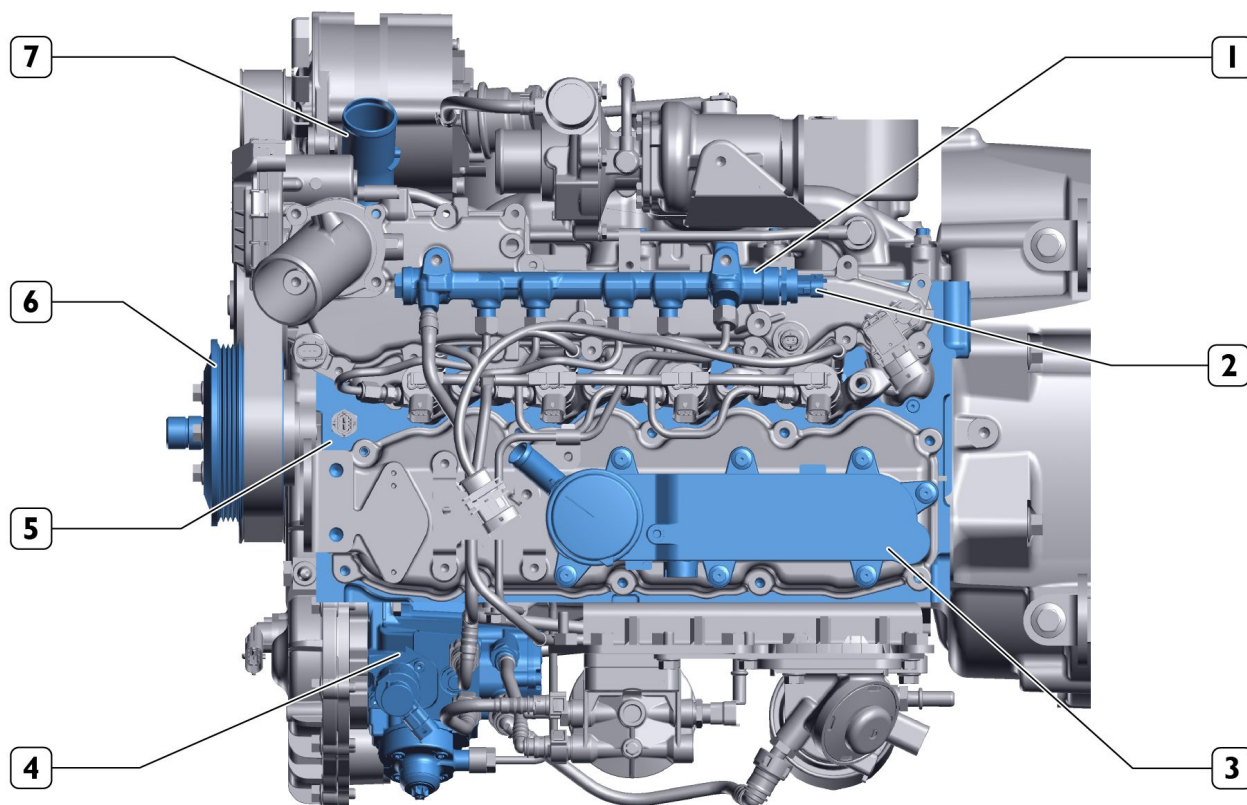
1. Intake manifold
2. Fan control pulley
3. Auxiliary members' belt
4. Crankshaft pulley
5. Engine oil dipstick/Engine oil filler plug
6. Water pump
7. Alternator
8. Throttle body (TVA)

REAR VIEW

298024 4

1. Air inlet pipe
2. Exhaust manifold
3. Engine flywheel housing
4. Sensor detecting water in fuel pre-filter
5. Fuel filter
6. Tappet cover

TOP VIEW

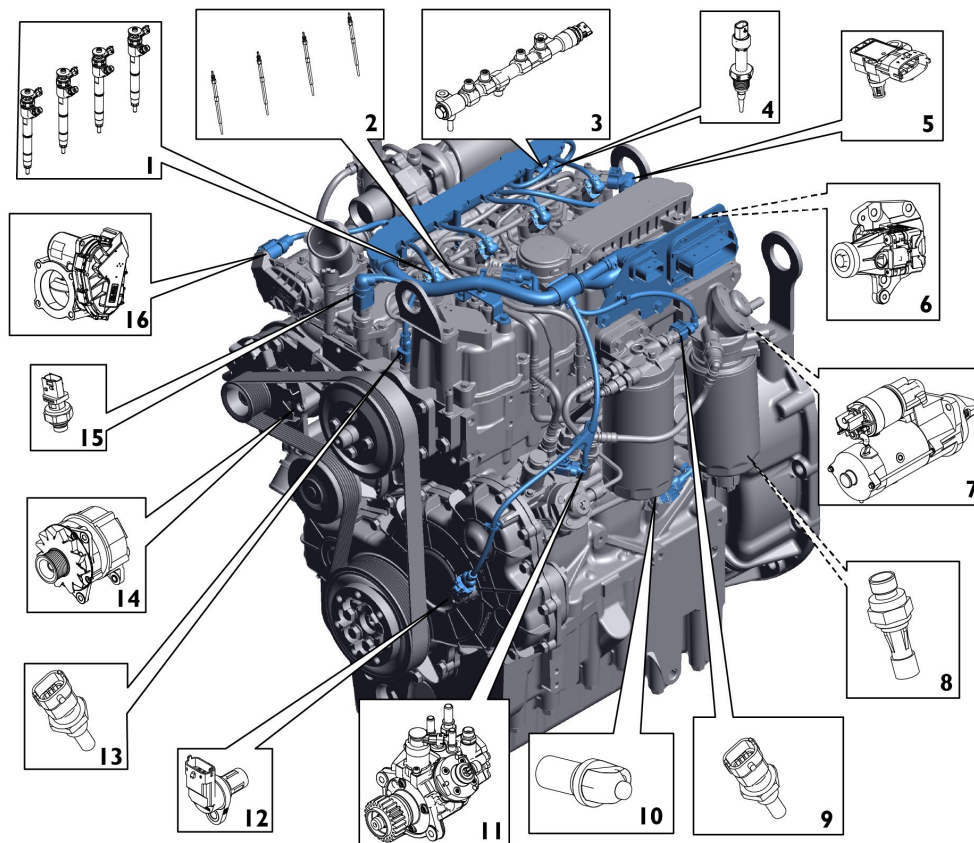


298071 5

1. Common rail
2. Pressure sensor
3. Blow-by filter unit
4. Fuel high pressure pump
5. Cylinder Head
6. Fan control pulley
7. Thermostat cover

540110 ENGINE - Component localisation

Location of engine electrical components



298307 1

1. Electro-injectors
2. Preheating glow plugs
3. Rail pressure sensor
4. Temperature sensor for exhaust gas
5. Supercharging pressure and air temperature sensor
6. Valve EGR
7. Electric starter motor (component not supplied by FPT)
8. Low oil pressure valve
9. Fuel temperature sensor
10. Crankshaft speed sensor (incremental speed)
11. High pressure fuel pump dosing unit
12. Camshaft timing sensor (segmental speed)
13. Coolant temperature sensor
14. Alternator
15. Exhaust gas absolute pressure sensor
16. Throttle body

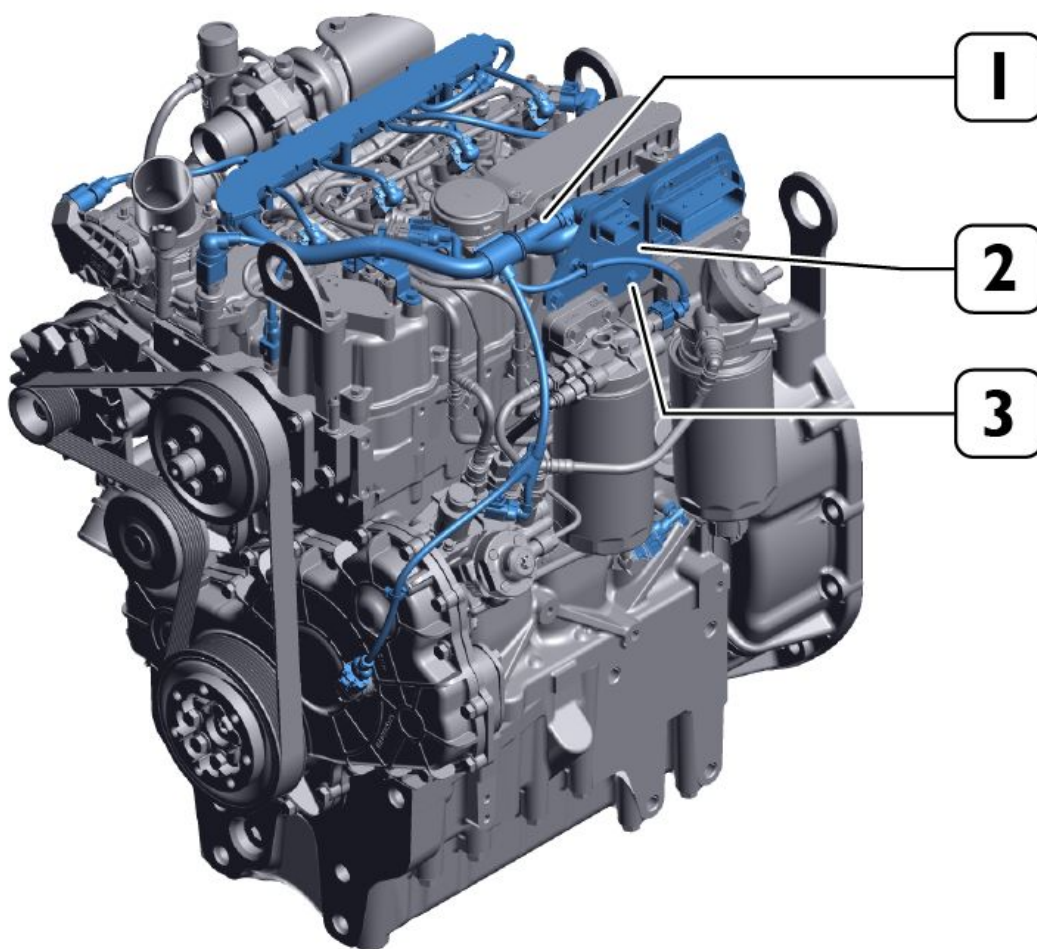
540110 ENGINE - Disassemble

Tool / Material	
Assemblies overhaul revolving stand (bearing capacity 1000 daN, torque 120 daNm)	99322205
Brackets fixing engine to revolving stand 99322205	99361026
Crankshaft lifting tackle	99360500
Remover, cartridge filter	99360076
Socket wrench (8 mm) for removing and refitting glow plugs	SP2275
Tool for removing gaskets	99363204
Tool to remove crankshaft front gasket	99340055

DISASSEMBLING THE ENGINE

1. Disconnect the engine cable **(1)** from the control unit, from the injectors, and from all sensors and senders to which it is connected.

NOTE: Suitably cover all connectors to prevent any oxidation and damages.

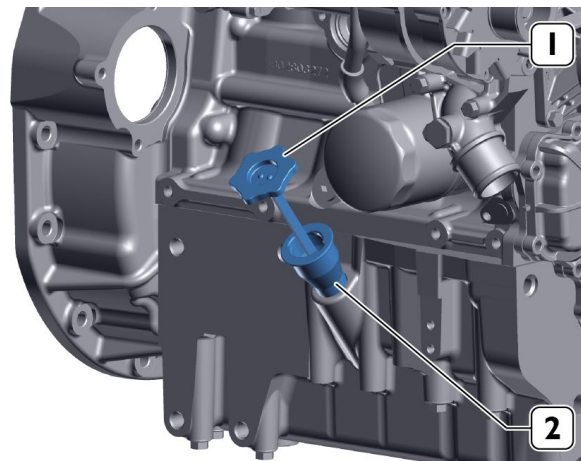


298665 1

2. To ease the removal, loosen the screws **(2)** from the mounting bracket **(3)** of the engine wiring.
3. Remove the retainers of the engine cable **(1)** and remove the cable.

Removing the oil level dipstick and its housing

4. Remove the dipstick (1) and remove its housing (2).



298674 2

Installation on stand and engine lubricant oil draining

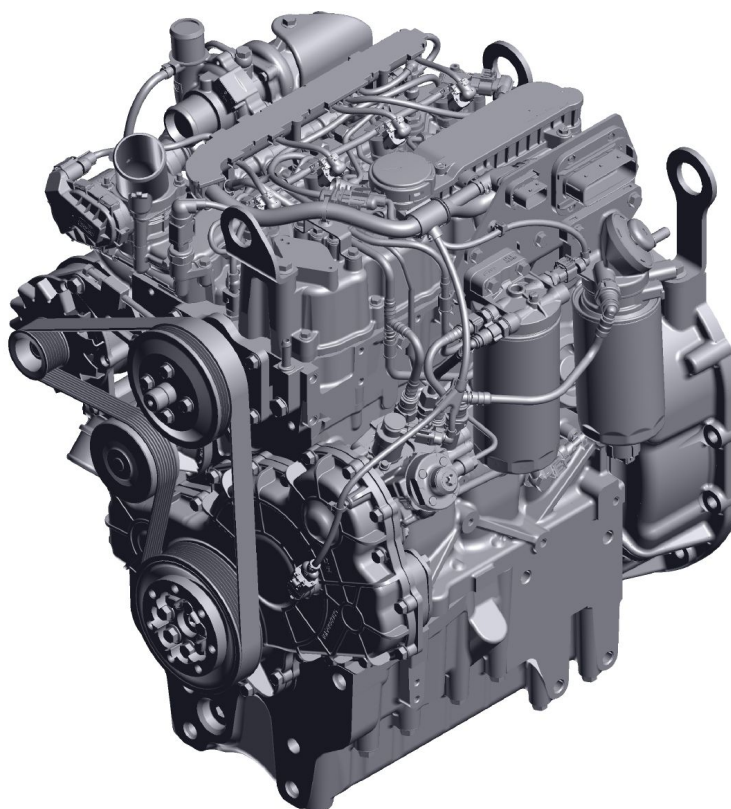


General prescriptions

Before any intervention, always ensure that operators are familiar with the safety and functional requirements of the engine and the vehicle indicated in the document. Strictly observe the safety warnings.

Before moving an assembly, make sure that all the parts are well secured.

Failure to comply with these prescriptions can result in the risk of serious injury and serious damages to the vehicle



298021 3

5. Mount the brackets on the crankcase and tighten the fixing screws to the specified torque.

Tool / Material	
Brackets fixing engine to revolving stand 99322205	99361026

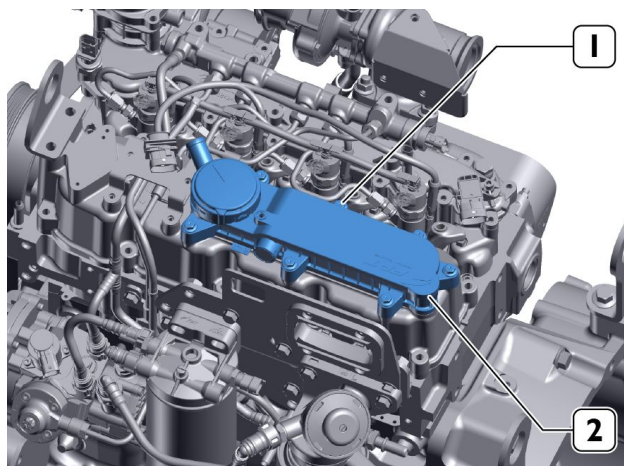
6. Lift the engine and place it on the rotating stand through the special lifting hooks using a sling bar and a hoist.

Tool / Material	
Assemblies overhaul revolving stand (bearing capacity 1000 daN, torque 120 daNm)	99322205

7. Screw the fastening screws of the brackets on the rotating stand.
8. Drain the engine lubricant oil by unscrewing the lubricant oil drain plug located in the lower part of the oil sump.

Blow-by filter unit removal

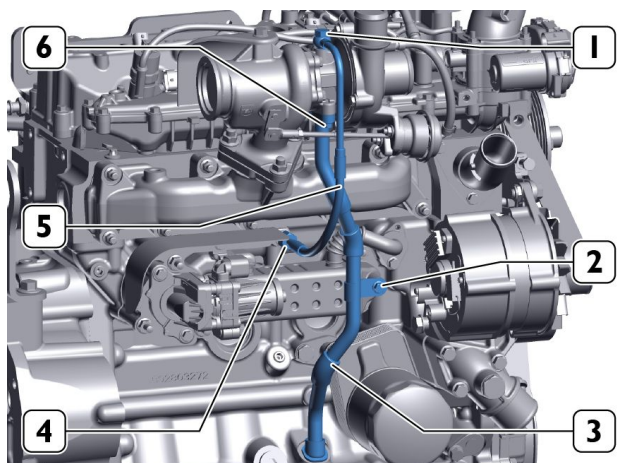
9. Prepare a suitable container for collecting the oil. Unscrew the fastening screws (1) and remove the blow-by filter assembly (2).



298031 4

Removing the lubricant oil delivery and return pipes from the turbocharger

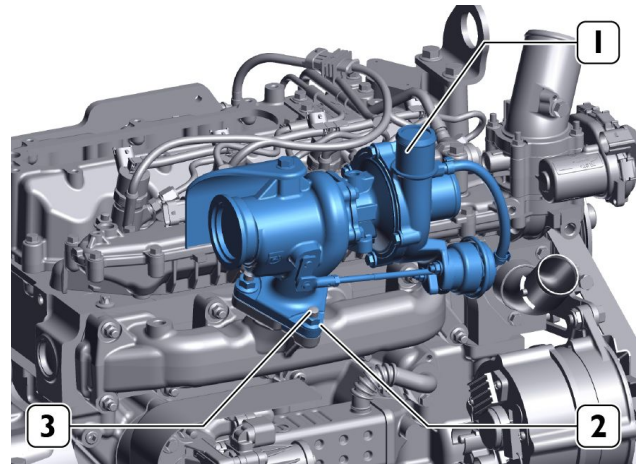
10. Unscrew the screw (1) and the fitting (4) and remove the lubricant oil delivery pipe (5) that connect the crankcase to the turbocharger.
11. Unscrew the fastening screws (6) on the lower part of the turbocharger, recovering the relevant gasket.
12. Unscrew the screw (2) of the mounting bracket of the lubricant oil drain pipe (3) from the turbocharger.
13. Remove the lubricant oil drain pipe (3) from the turbocharger.



298675 5

Turbocharger disassembly

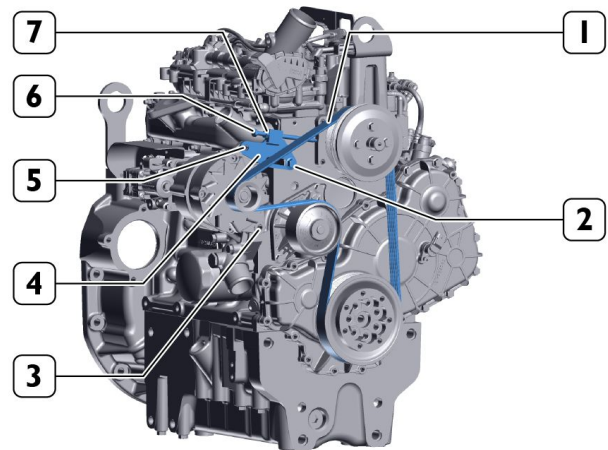
14. Unscrew the nuts **(2)** and remove the turbocharger **(1)**, together with the wastegate valve, recovering the relevant gasket.
15. Unscrew the studs **(3)** from the exhaust manifold.



298676 6

Removal of the auxiliary unit drive belt

16. Loosen, without removing, the bolt **(3)** anchoring the alternator to its lower mount.
17. Unscrew the fastening screw **(2)** of the tensioning bracket **(4)** to the crankcase.
18. Loosen the belt tension of the auxiliary unit **(1)** by unscrewing the adjustment screw **(6)** on the relevant lock nut **(7)**.



298677 7

Risk of damage

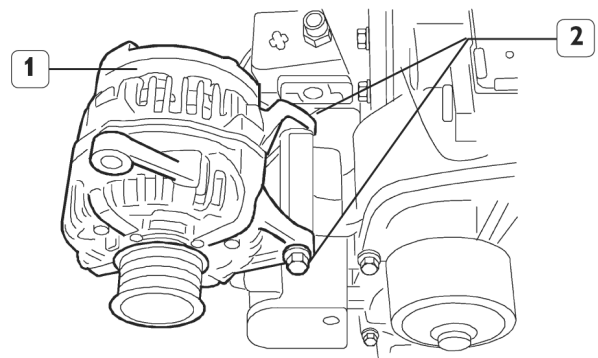
The flexible belt must be replaced with a new one every time it is removed from the vehicle. Partial or complete non observance of these prescriptions can lead to serious damages to the vehicle



19. Remove the auxiliary unit belt **(1)** from all the pulleys: crankshaft pulley, water pump, alternator, fan drive pulley.
20. Unscrew the fastening screw **(5)** of the alternator and remove the tensioning bracket **(4)**.

Alternator removal

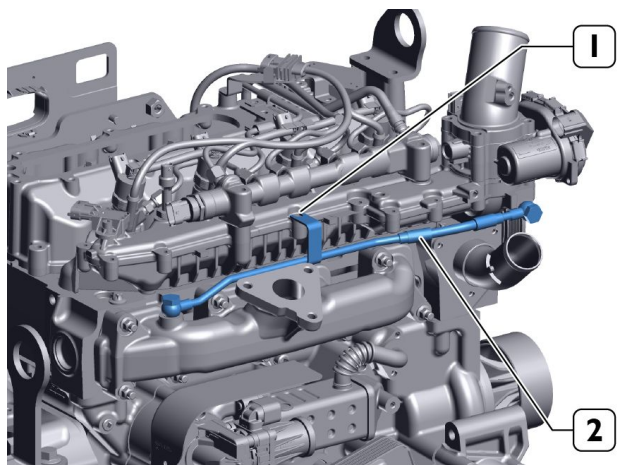
21. Hold the alternator firmly **(1)** and remove it from its mount loosening the screw **(2)**. Recover the nut and washer.



75686 8

Exhaust manifold removal

22. Unscrew the screw (1) of the exhaust gas pipe support yoke, which is the same of the intake manifold.
23. Unscrew the fittings and remove the exhaust gas pipe (2).

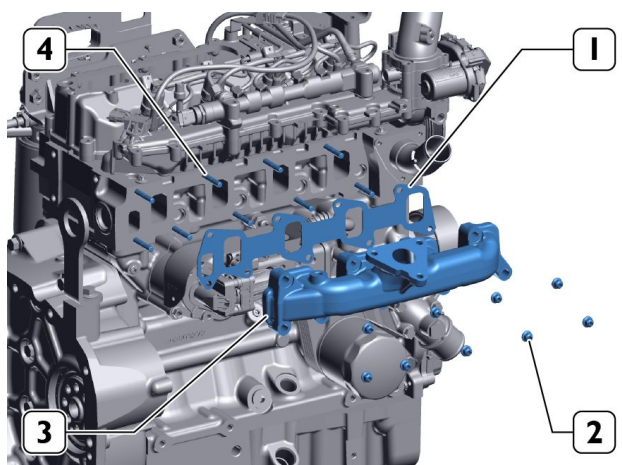


298678 9

24. Unscrew the fastening screws (2) and remove the exhaust manifold (3) from the cylinder head, recovering the gasket (1).

NOTE: Always replace the gasket (1) with a new one at any disassembly.
check the thread of the nuts and studs: it must not show signs of wear or deposits of dirt.

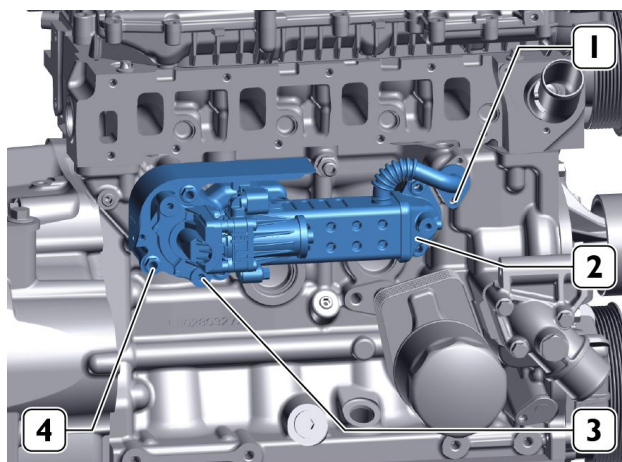
25. Unscrew the studs (4).



298679 10

EGR heat exchanger removal

26. Unscrew the fastening screws (3) and remove the EGR valve.
27. Unscrew the fastening screws (1) and the nuts (4) and remove the EGR heat exchanger (2), together with the relevant gaskets.
28. Remove the studs from the crankcase.

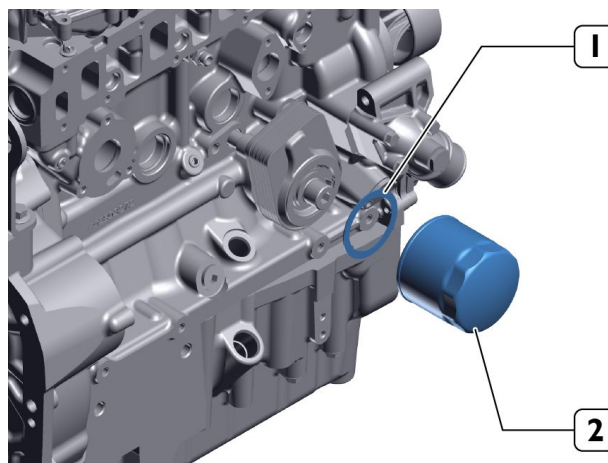


298941 11

Oil filter removal

29. Position a suitable container to collect the exhaust oil under the filter bracket.
30. Use the special tool to unscrew and remove the oil filter (2) from the filter bracket and recover the gasket (1).

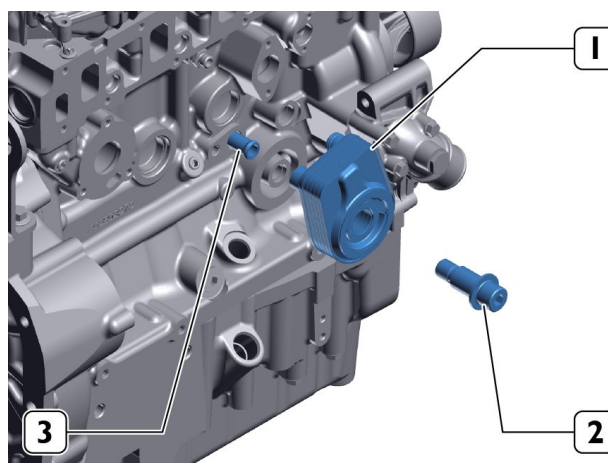
Tool / Material	
Remover, cartridge filter	99360076



298680 12

Removing the oil filter mount

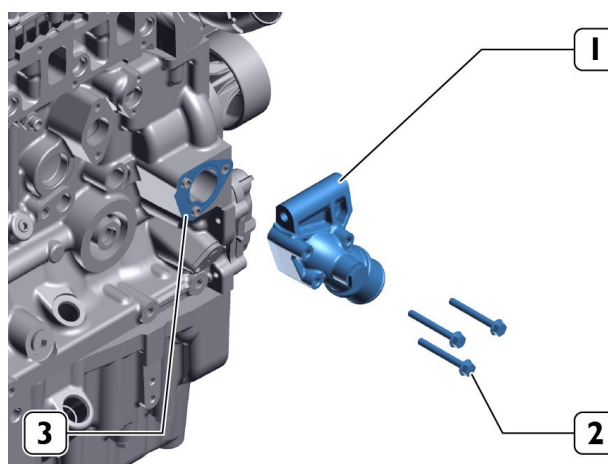
31. Unscrew the fastening screw (2) and remove the oil filter bracket (1) recovering the gasket and the connection pipe (3).



298681 13

Coolant intake pipe removal

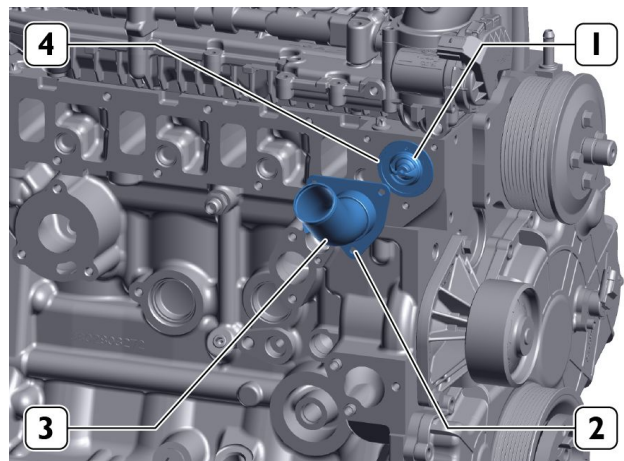
32. Unscrew the screws (2) and remove the coolant intake pipe (1), together with the gasket (3).



298682 14

Thermostat removal

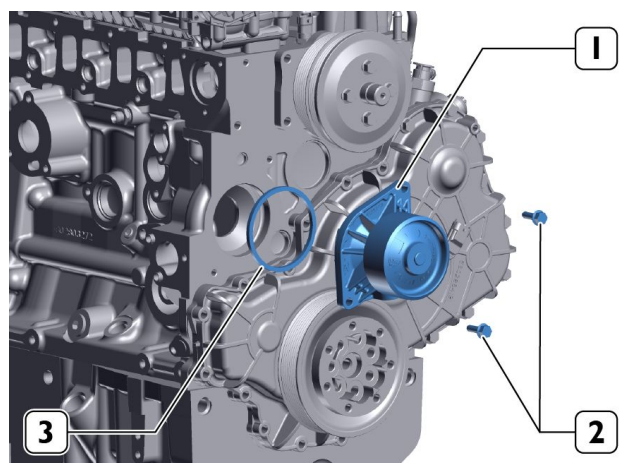
33. Unscrew the fastening screws (2) and disconnect the thermostat unit (3) complete with the gasket (4) from the seat on the cylinder head.
34. Remove the thermostat (1) from its housing.



298683 15

Water pump removal

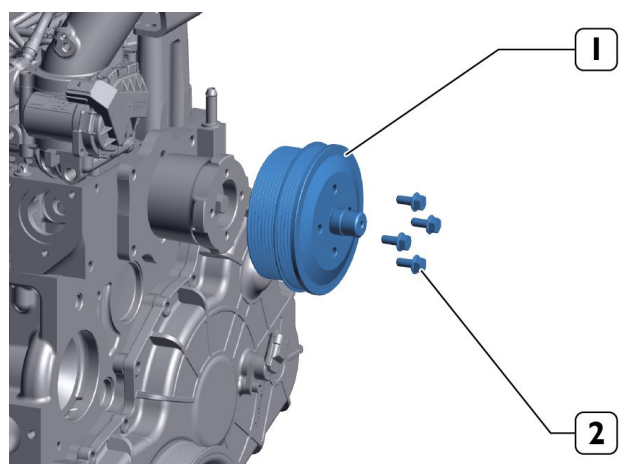
35. Position a suitable container to collect any coolant which may leak out.
36. Unscrew the fastening screws (2) and remove the water pump (1), recovering the gasket (3).



298684 16

Fan control pulley removal

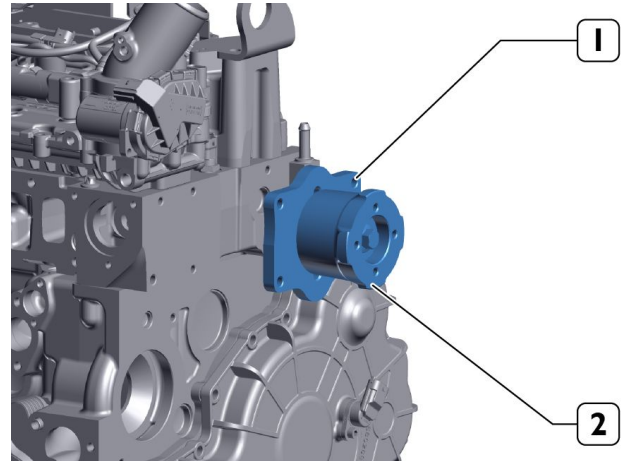
37. Unscrew the screws (2) and remove the fan drive pulley (1).



298685 17

Fan drive pulley mount removal

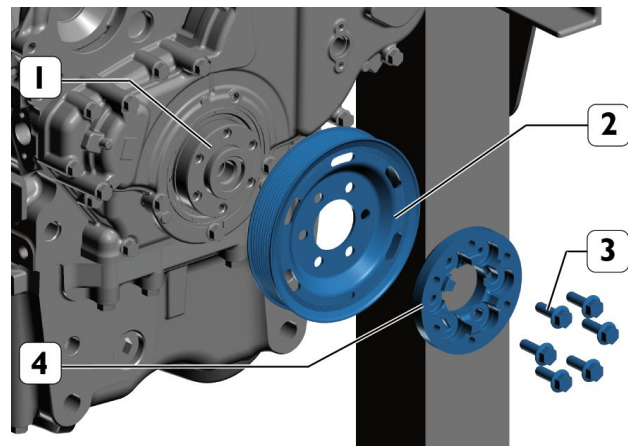
38. Unscrew the screws (1) and remove the fan drive pulley mount (2).



298686 18

Removing the crankshaft pulley

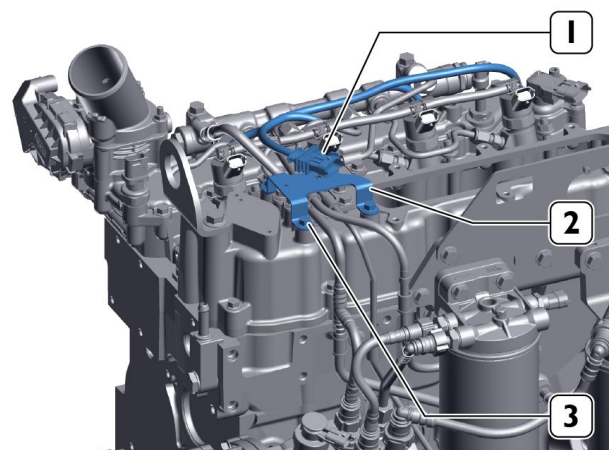
39. Unscrew the fastening screws (3), recover the spacer (4) and remove the crankshaft pulley (2) from the crankshaft (1).



231909 19

Glow plug wiring removal

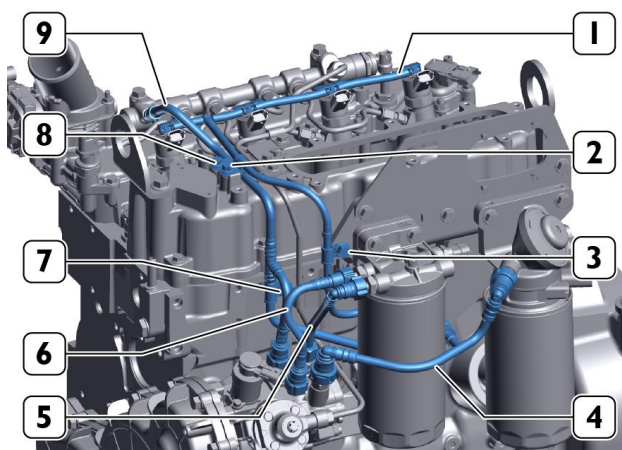
40. Disconnect the glow plug wiring (1), paying attention to the special stop.
41. Unscrew the screws (3) and remove the glow plug wiring retain bracket (2).



298687 20

Low pressure fuel pipes removal

42. Disconnect the low pressure fittings and remove the fuel pipes (4), (5) and (6) on the fuel filter / pre-filter bracket.
43. Unscrew the fastening screws (2) and (3) and remove the retainer brackets of the fuel return pipe (1) from the injectors.
44. Disconnect the low pressure fittings and remove the fuel return pipe (1) from the injectors.
45. Unscrew the fastening screws (7) and (8) and remove the retainer brackets of the fuel return pipe (9) from the rail and from the high pressure pump.
46. Disconnect the low pressure fittings and remove the fuel return pipe (9) from the rail and from the high pressure pump.



298688 21

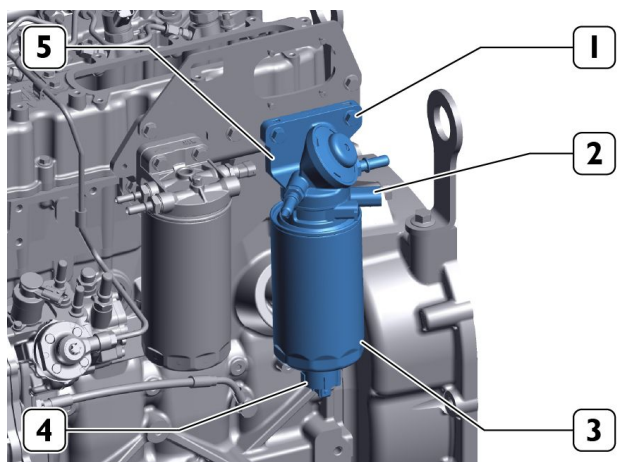
Fuel pre-filter removal

47. Position a container to collect the diesel oil under the fuel pre-filter (3).
48. Use the specific tool to unscrew and remove the pre-fuel filter (3) from the relative pre-fuel mount (5) and recover the gasket.

NOTE: Pay attention to the sensor (4) detecting water in the fuel pre-filter, the electric fuel heater (2) and the relevant connection.

Tool / Material	
Remover, cartridge filter	99360076

49. Unscrew the fastening screws (1) and remove the fuel pre-filter mount (15) from the support yoke.



298689 22

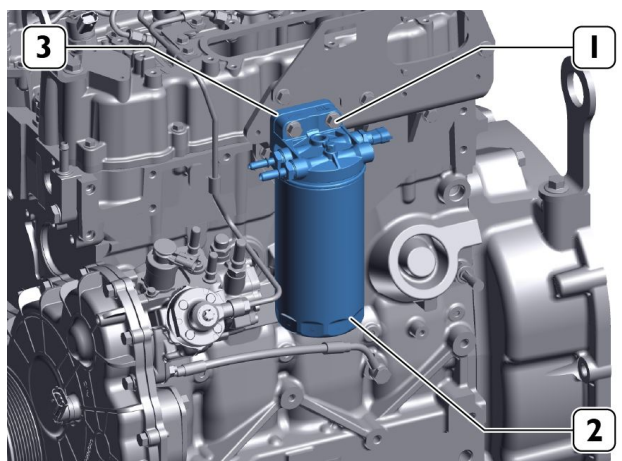
Fuel filter removal

50. Position a container to collect the diesel oil under the fuel filter (2).
51. Use the special tool to unscrew and remove the fuel filter (2) from the relevant filter bracket (3) and recover the gasket.

NOTE: Pay attention to the fuel temperature sensor and to the electric connections of the engine cable.

Tool / Material	
Remover, cartridge filter	99360076

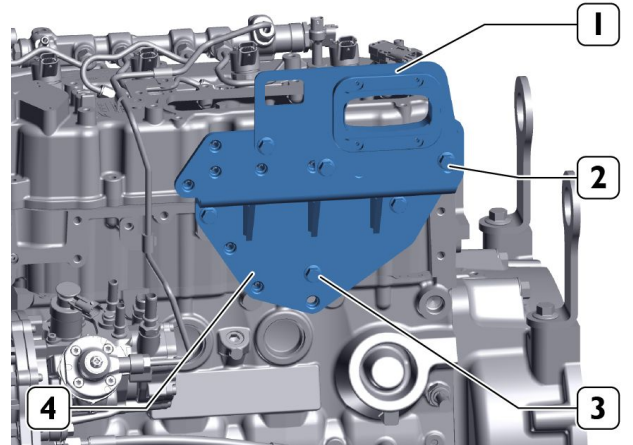
52. Unscrew the fastening screws (1) and remove the fuel filter mount (3) from the support yoke.



298690 23

Fuel filter and pre-filter support yoke removal

53. Unscrew the screws (2) and remove the engine wiring connectors support yoke (1).
54. Unscrew the screws (3) and remove the fuel filter and pre-filter support yoke (4).

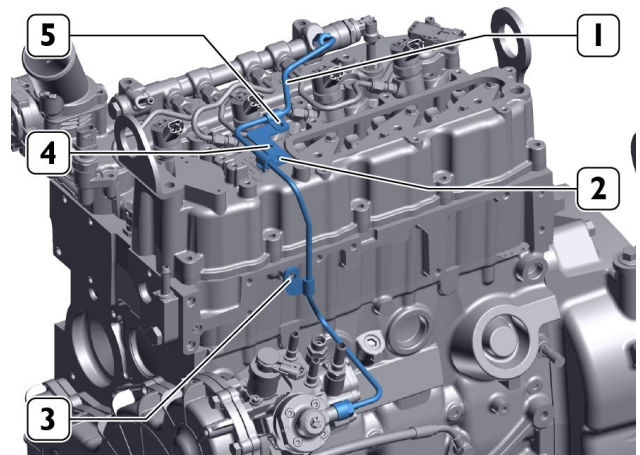


298691 24

Removal of delivery fuel pipe to

55. Unscrew the fastening screws (2), (3), (4) and (5) and remove the retainer brackets of the fuel delivery pipe (1).
56. Unscrew the fittings and remove the fuel delivery pipe (1) from the high pressure pump to the rail.

NOTE: The high pressure fuel delivery pipe must always be replaced with a new one whenever it is removed.

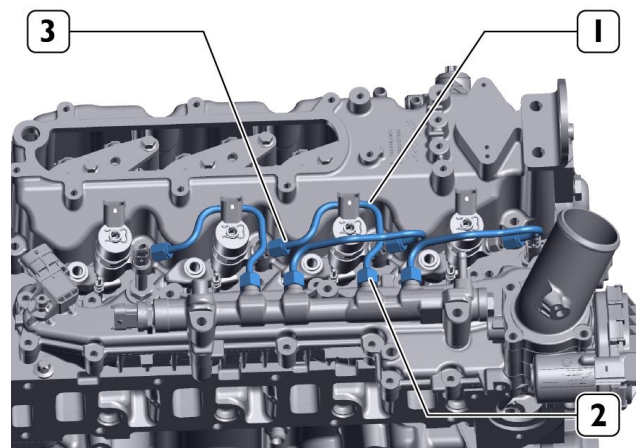


298692 25

Removing the fuel delivery pipe from rail to injectors

57. Remove the high pressure fuel delivery pipes (1) by loosening first the nuts on injector side (3) and then the nuts on Common Rail side (2).

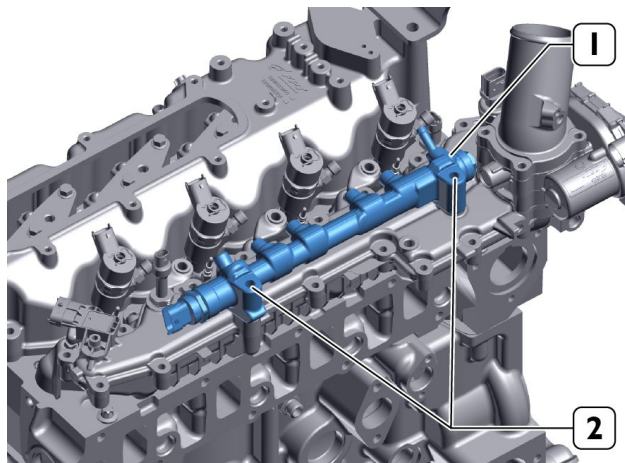
NOTE: The high pressure fuel delivery pipes must be replaced with new ones whenever they are removed.



298693 26

Rail removal

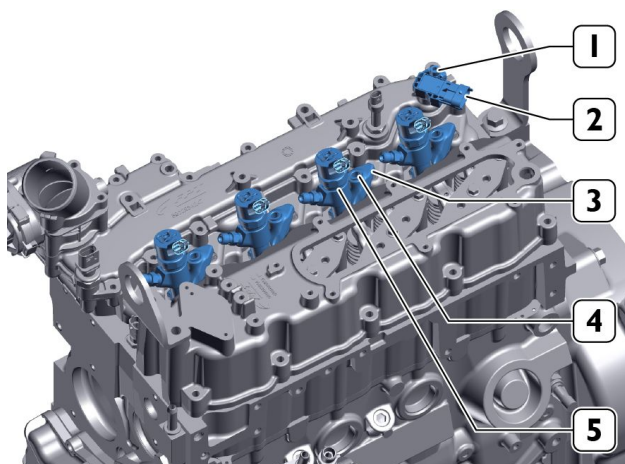
58. Unscrew the fastening screws (2) of the common rail (1).
59. Remove the common rail (1), with the rail pressure sensor and pressure limiting valve, from the intake manifold.



298694 27

Injector removal

60. Unscrew the screw (1) and remove the air temperature and supercharging pressure sensor (2).
61. Unscrew the nuts (4), recovering the washers, and remove the injector (5), together with the fastening bracket (3), from the head and mark it with the cylinders to which it belongs.
62. Unscrew the studs housed on the head.

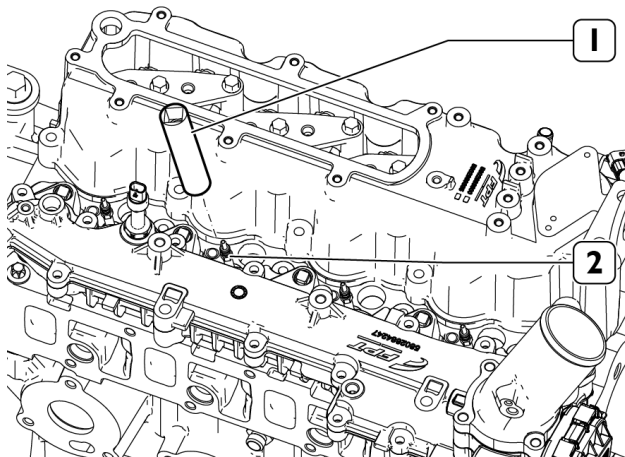


298695 28

Pre-heating plugs removal

63. Unscrew the glow plug (2) using the tool (1).

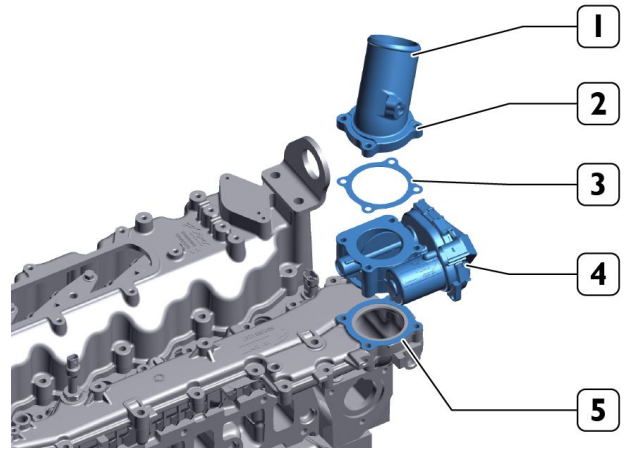
Tool / Material	
Socket wrench (8 mm) for removing and refitting glow plugs	SP2275



298696 29

Throttle valve removal

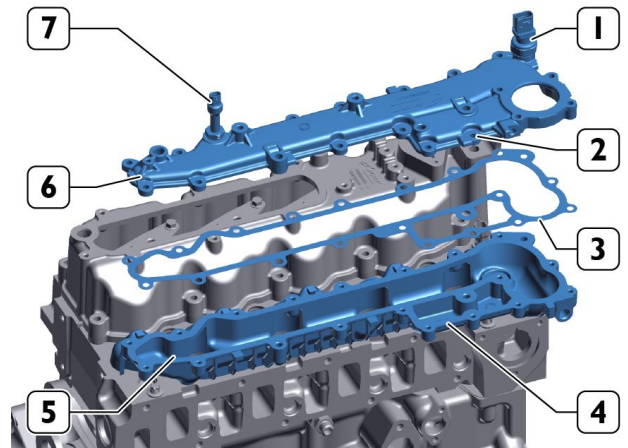
64. Unscrew the nuts **(2)** and the fastening screws and remove the engine air intake **(1)** recovering the gaskets **(3)**.
65. Remove the throttle valve **(4)**, recovering the gasket **(5)**, and remove the studs.



298697 30

Intake manifold removal

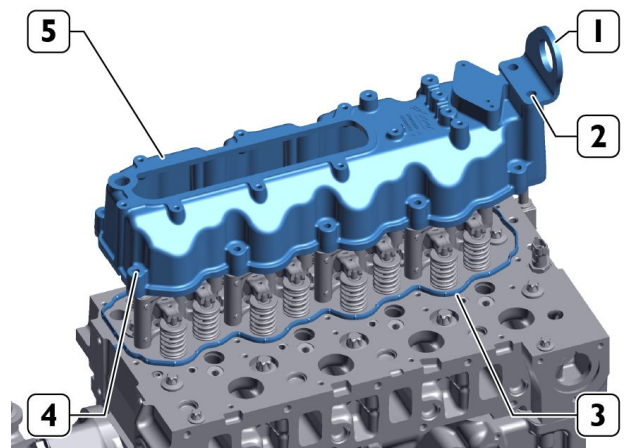
66. Unscrew the temperature sensor **(7)** and the exhaust gas absolute pressure sensor **(1)**.
67. Unscrew the fastening screws **(2)** and remove the intake manifold **(6)**, recovering the gasket from the overhead **(4)**.
68. Unscrew the fastening screws **(5)** and remove the overhead **(4)**, recovering the relevant gaskets.



298698 31

Tappet cover removal

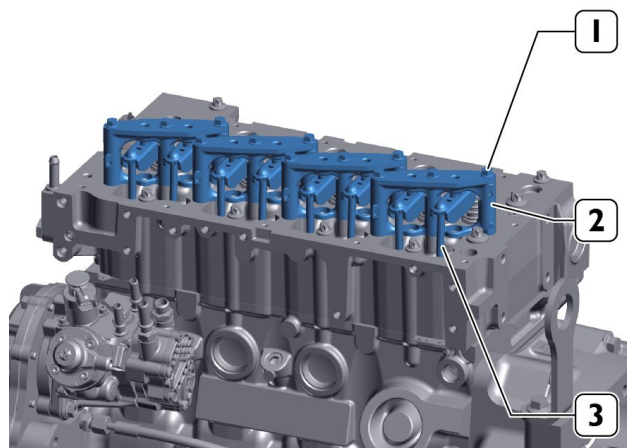
69. Unscrew the fastening screws **(2)** and remove the lifting eyelet **(1)**.
70. Unscrew the screws **(4)** and remove the tappet cover **(5)**, recovering the gasket **(3)**.



298699 32

Rocker arms assembly removal

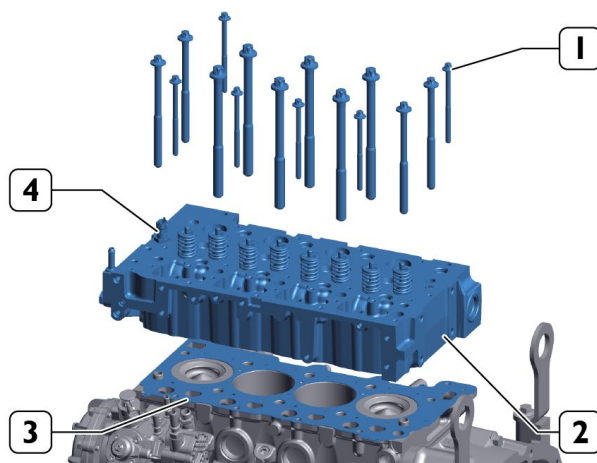
71. Unscrew the screws (1) and remove the intake and exhaust rocker arms assembly (2).
72. Remove the rocker arm control rods (3).



298700 33

Cylinder head removal

73. Unscrew the coolant temperature sensor (4) from the cylinder head (2).
74. Unscrew and remove the screws (1) securing the cylinder head.
75. Position eyebolts on the cylinder head (2), connect them using wire cables or a specific tool and use the lifter to detach the cylinder head (2) from the crankcase.
76. Recover the cylinder head gasket (3) from the crankcase 4.



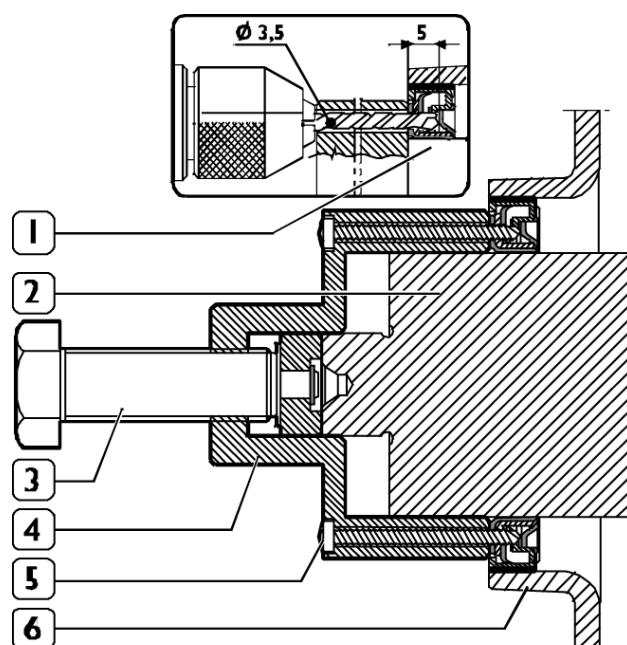
298701 34

Crankshaft front sealing ring removal

77. To remove the seal ring (1) of the crankcase (2) from the front cover (6) apply the specific tool (4) to the front crankshaft tang (2) and, through the tool guide holes, drill the internal seal ring (1) with a drill bit ($\varnothing 3.5$ mm) to a depth of 5 mm.

Tool / Material	
Tool to remove crankshaft front gasket	99340055

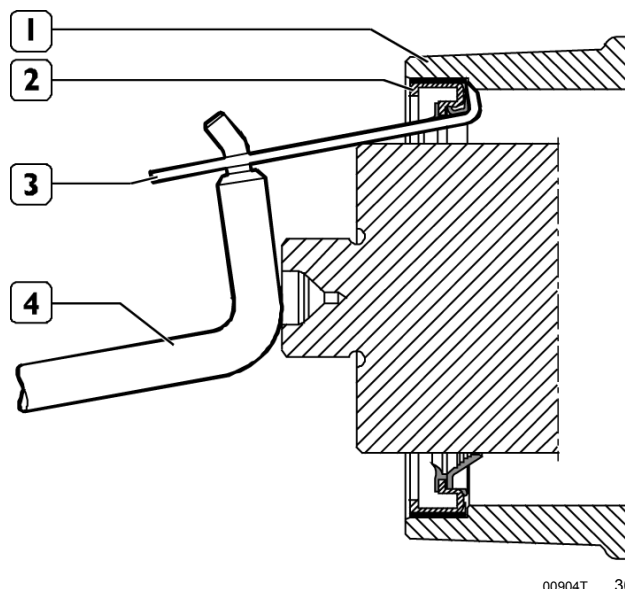
78. Secure the tool (4) to the internal seal ring (1) screwing the 6 screws (5) provided and extract the internal seal ring (1) by screwing the screw (3).



00900T 35

79. Use the special tie rod (3) of the specific tool and the lever (4) to remove the external seal ring (2) from the front cover (1).

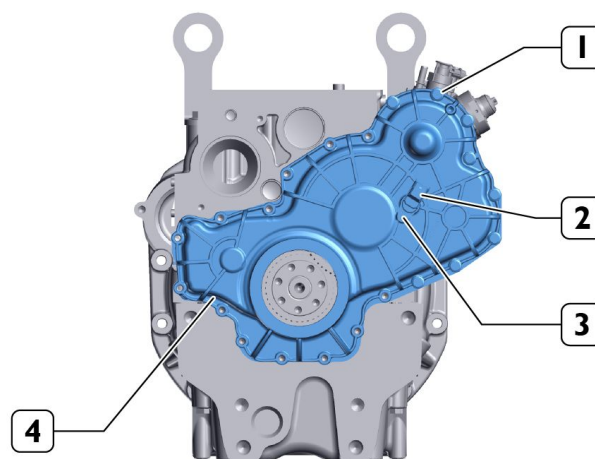
Tool / Material	
Tool for removing gaskets	99363204



00904T 36

Timing gear cover disassembly

80. Unscrew the screw (3) and remove the camshaft timing sensor (2).
81. Unscrew the screws (1) and remove the timing gear case (4), recovering the relevant gasket.



298702 37

High pressure pump removal

82. Unscrew the nut (5) from the high pressure pump shaft and remove the gear (6).

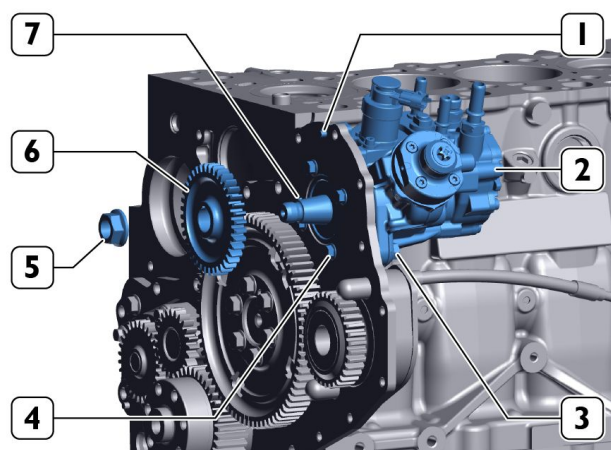
NOTE: Pay attention to the reference dowel pin (7).

83. Unscrew the nuts (3) from the studs and remove the high pressure pump (2).

NOTE: Pay attention to the reference dowel pin (1).

84. Unscrew the screws (4) and remove the spacer and the relevant gasket.

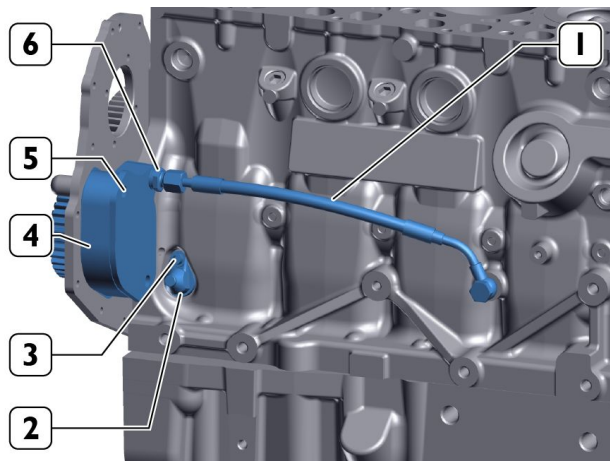
85. Unscrew the studs securing the high pressure pump (2) from the gear case.



298703 38

Control socket removal

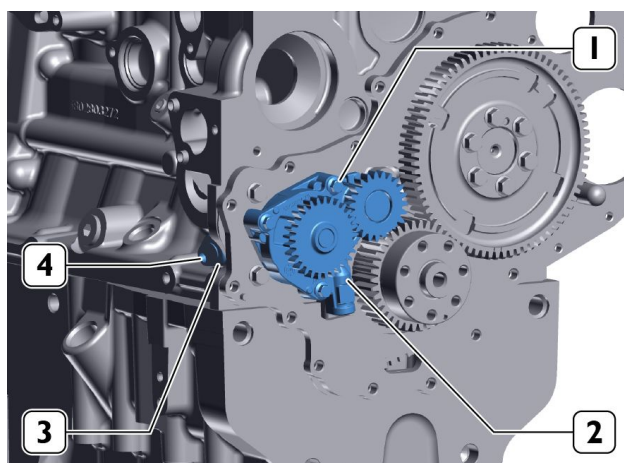
86. Unscrew the fitting and the screw and remove the lubrication pipe (1) of the control socket (4).
87. Unscrew the fitting (6) on the control socket.
88. Unscrew the screws (5) and remove the control socket (4) together with the gasket.
89. Unscrew the screw (3) and remove the engine speed sensor (2).



298704 39

Removing the oil pump

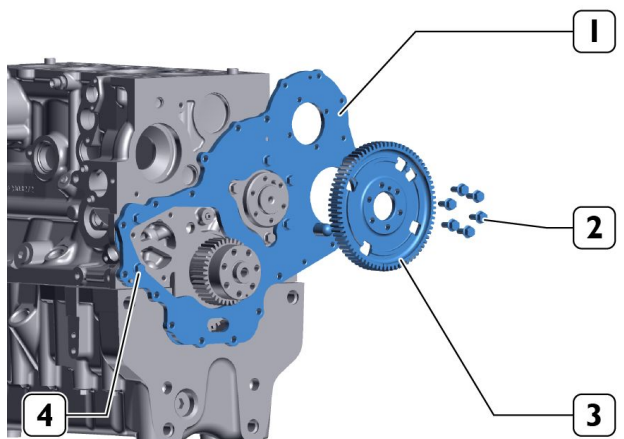
90. Unscrew the screw (4) and remove the oil pressure adjustment valve (3).
91. Unscrew the screws (1) and remove the oil pump (2).



298705 40

Timing gear removal

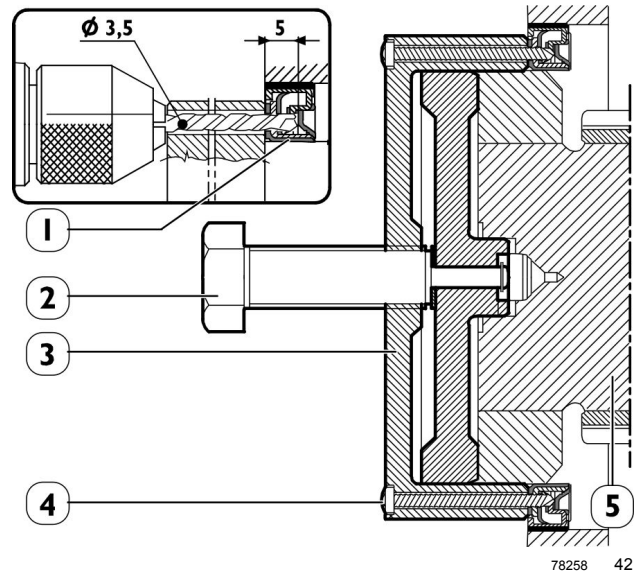
92. Unscrew the screws (2) and remove the timing gear (3).
93. Unscrew the screws (4) and remove the spacer (1) recovering the relevant gasket.



298932 41

Crankshaft rear seal ring removal

94. To extract the crankshaft seal ring from the flywheel housing apply a suitable puller (3) on the rear tang (5).
95. Through the tool guide holes, drill the internal seal ring with a drill bit ($\varnothing 3.5$ mm) to a depth of 5 mm.
96. Extract the ring (1) by screwing the screw (2).
97. Use the special tie rod of the tool and a lever to extract the external seal ring from the flywheel housing.

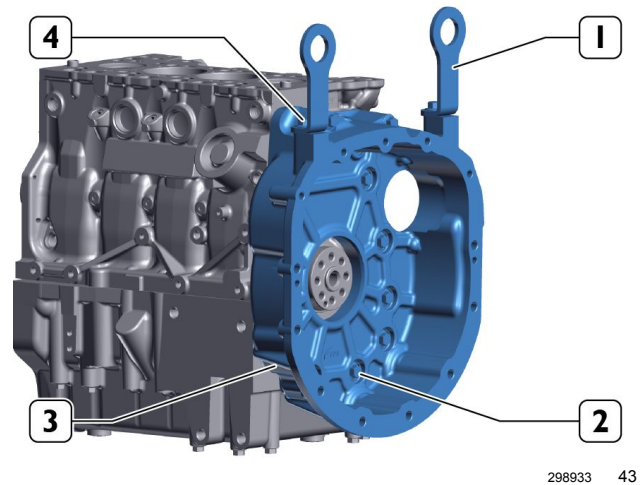


Flywheel housing removal

98. Unscrew the screws (2) and, using the lifting eyebolts (1), remove the flywheel cover (3).

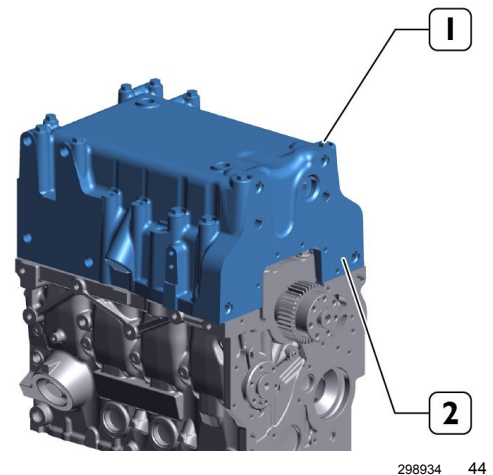
NOTE: During removal, mark the position of the screws, since they have different size.

99. Then unscrew the screws (4) and remove the lifting eyelets (1).



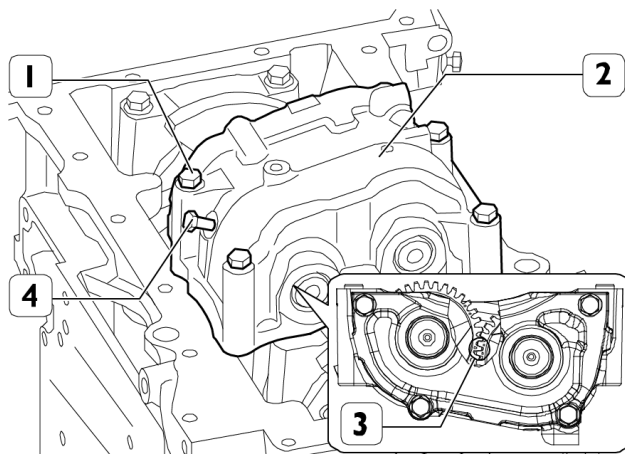
Oil sump removal

100. Rotate the engine of 180° .
101. Unscrew the fastening screws (1) and remove the oil sump (2) recovering the gasket.



Balancing weights removal

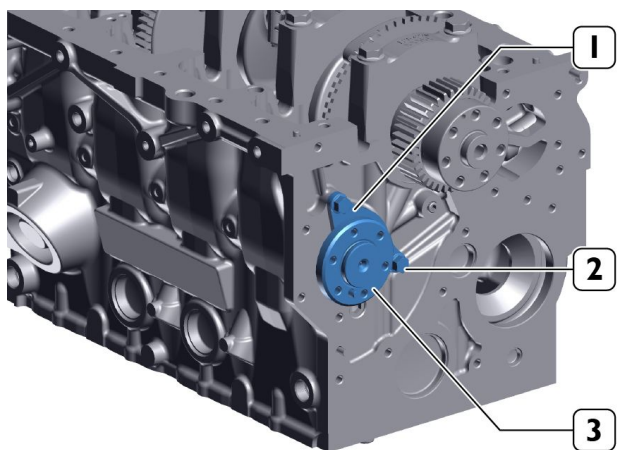
102. Bring cylinder 1 to 118° before the TDC and check that the timing marks stamped (3) on the gears of the balancing weights (2) match, as shown in the figure 45.
103. Use the pin (4) to temporarily lock the rotation of the balancing weights (2).
104. After having locked the additional balancing weights (2) through the pin (3) unscrew the fastening screws (1) and remove them from the crankcase.



242639 45

Camshaft removal

105. Unscrew the screws (2) and remove the retaining plate (1) of the camshaft (3).
106. Carefully withdraw the camshaft (3) from the crankcase.

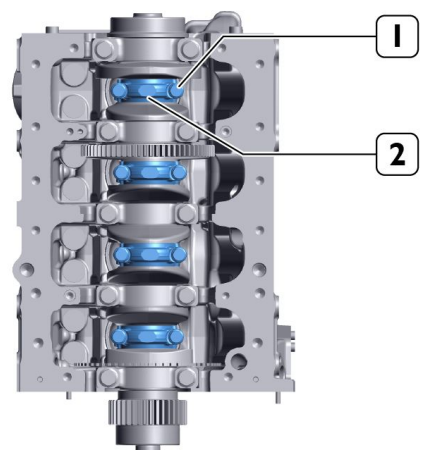


298935 46

Piston removal

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

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

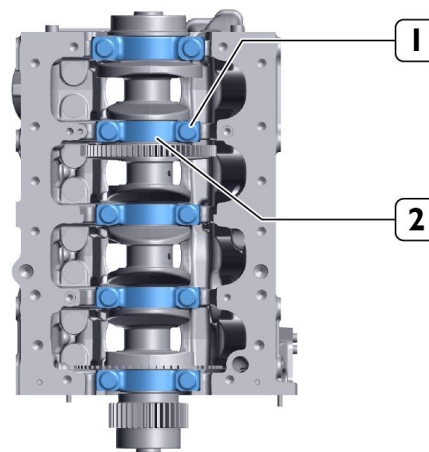


298936 47

Crankshaft removal

109. Remove the screws (1) and disassemble the main bearing caps (2).
110. The last mount of the main bearing cap has the half-bearing provided with shoulder.

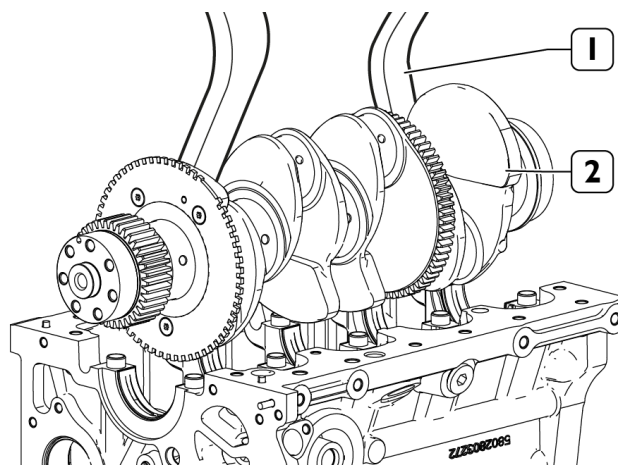
NOTE: Take note of lower and upper half bearing assembling positions since in case of reuse they shall be fitted in the same position found at removal.



298937 48

111. Use the specific tool (1) to lift and remove the crankshaft (2) from the crankcase.

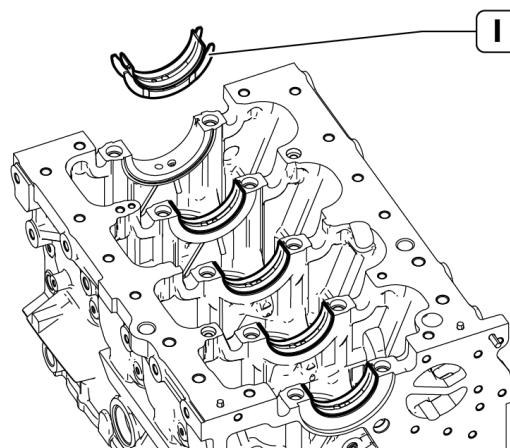
Tool / Material	
Crankshaft lifting tackle	99360500



298938 49

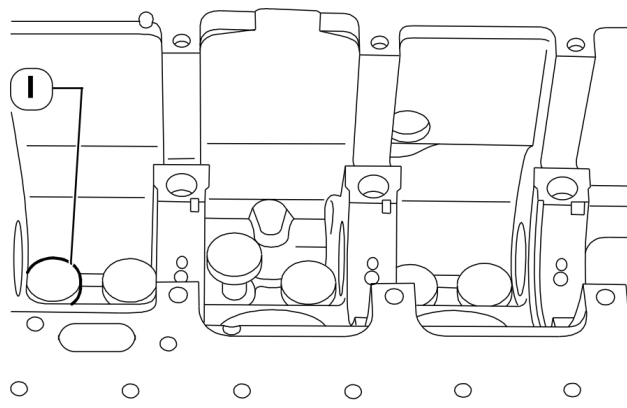
Main bearings removal

112. Remove the main half-bearings (1).



298939 50

113. Remove the tappets **(1)** from the crankcase.



70165 51

540110 ENGINE - Assemble

Description	Quantity	Step	Value
Air bleeding on the fuel filter bracket	1 screw M10		4 +/- 0.5 N·m
Air temperature and pressure sensor	1 screw M6 x 1 x 16		9 +/- 0.9 N·m
Alternator		1 screw M10x1.5x130 + 1 nut M10 x 1.5	45 +/- 4.5 N·m
		1 screw M10 x 1.5 x 35 + 1 nut M10 x 1.5	45 +/- 4.5 N·m
Alternator tensioning bracket		1 screw M10 x 1.5 x 20	45 +/- 4.5 N·m
Balancing weights	4 screws M8 x 1.25 x 90	Step 1 — Pre-tightening	20 +/- 6 N·m
		Step 2 — Tighten	60°
Blow-by filter		7 screws M6 x 1 x 13	10 +/- 2 N·m
Bracket retaining the delivery fuel pipe from the pump to the rail	3 screws M6 x 1 x 10		10 +/- 1 N·m
Bracket retaining the fuel return pump from the rail and from the high pressure pump		1 screw M6 x 1 x 14	10 +/- 1 N·m
		1 screw M8 x 1.25 x 18	23 +/- 2.31 N·m
Camshaft timing sensor	1 screw M6 x 1 x 16		9 +/- 0.9 N·m
Common Rail	2 screws M8 x 1.25 x 55		23 +/- 2.3 N·m
Control socket coupling	1 G 1/4" coupling?		45 +/- 4.5 N·m
Control socket lubrication pipe		1 screw M12 x 1.5	40 +/- 4 N·m
		1 fitting M14 x 1.5	40 +/- 4 N·m
Coolant temperature sensor	1 sensor M12 x 15		20 +/- 5 N·m
Crankshaft pulley	7 screws M10 x 1.5 x 30		70 +/- 7 N·m
Crankshaft rpm sensor	1 screw M6 x 1 x 16		9 +/- 0.9 N·m
Cylinder head	4 screws M12 x 1.5 x 165	Step 1 —	65 +/- 3,25 N·m
		Step 2 — Angle tightening	90°
		Step 3 — Angle tightening	60°
Delivery fuel pipe from the pump to the rail		1 high pressure fuel pump-side coupling M16 x 1	45 +/- 2.25 N·m
		1 rail-side coupling M14 x 1.5	35 +/- 1.75 N·m
EGR heat exchanger	5 studs M8 x 1.25 x 80		23 +/- 2.3 N·m
EGR valve	2 screws M6 x 1 x 20		10 +/- 1 N·m
Electro-injector brackets	4 studs M8 x 1.25 x 65		28 +/- 1.4 N·m
Engine air vent		3 studs M6 x 1 x 80	10 +/- 1 N·m
		3 nuts M6 x 1	10 +/- 1 N·m
		1 screw M6 x 1 x 80	10 +/- 1 N·m
Engine cable fixing bracket	3 screws M8 x 1.25 x 20		23 +/- 2.3 N·m
Engine coolant input pipe		3 screws M8 x 1.25 x 65	23 +/- 2.3 N·m
		1 screw M8 x 1,25 x 14	25 +/- 2,5 N·m
Engine flywheel housing		2 screws M12 x 1.75 x 90	117 +/- 11.7 N·m
		10 screws M12 x 1.75 x 40	117 +/- 11.7 N·m
		2 screws M8 x 1.25 x 35	34 +/- 3.4 N·m
Engine oil sump	4 screws M12 x 1.75 x 160	Step 1 —	85 +/- 4.25 N·m
		Step 2 — Angle tightening	60°
Exhaust gas absolute pressure sensor	1 sensor M14 x 1.5		15 +/- 1.5 N·m
Exhaust gas linkage pipe	2 screws M12 x 1.5 x 24		25 +/- 2.5 N·m
Exhaust gas temperature sensor		1 fitting M14 x 1.5 x 12	45 +/- 4.5 N·m
		1 screw M6 x 1.5 x 12	10 +/- 1 N·m
Exhaust manifold	9 nuts M8 x 1.25	Pre-tightening	10 +/- 0,5 N·m

Description	Quantity	Step	Value
		Tighten	28 +/- 1.4 N·m
Fan control pulley	4 screws M8 x 1.25 x 18		23 +/- 2.3 N·m
Fan pulley control mount	4 screws M8 x 1.25 x 25		23 +/- 2.3 N·m
Fuel Pre-filter	1 cartridge —		20 +/- 3 N·m
Fuel delivery pipes to the electro-injectors	4 rail-side couplings M14 x 1.5		35 +/- 1.75 N·m
Fuel filter	1 cartridge M20 x 1.5		22 +/- 3 N·m
Glow plug harness mount	3 screws M6 x 1 x 14		10 +/- 1 N·m
Head cover	10 screws M6 x 1 x 40		10 +/- 1 N·m
High pressure fuel pump	3 nuts M8 x 1.25		23 +/- 2.3 N·m
High pressure fuel pump spacer	4 screws M6 x 1 x 16		10 +/- 1 N·m
High-pressure pump gear	1 nut M18 x 1.5		80 +/- 4 N·m
Injector fuel return pipe brackets		1 screw M6 x 1 x 14	10 +/- 1 N·m
		1 screw M8 x 1.25 x 18	23 +/- 2.3 N·m
Intake manifold		14 screws M6 x 1 x 20	10 +/- 1 N·m
		4 caps M12 x 1.5	20 +/- 2 N·m
Lifting eyelets	2 screws M12 x 1.75 x 25		118 +/- 11.8 N·m
Lubricant delivery pipe to turbocharger		1 screw M10 x 1 x 19	25 +/- 2.5 N·m
		1 nut M14 x 1.5	35 +/- 3.5 N·m
Lubricant oil drain plug in the sump	2 caps M22 x 1.5 x 12		50 +/- 5 N·m
Lubricant oil return pipe from turbocharger bracket	1 screw M6 x 1 x 10		10 +/- 1 N·m
Lubricant return pipe from turbocharger	2 screws M6 x 1 x 20		10 +/- 1 N·m
Oil filter	1 cartridge M27 x 2		30 +/- 3 N·m
Oil filter bracket		1 fitting M20 x 1.5 x 18	35 +/- 5 N·m
Oil pressure regulator valve	1 screw M8 x 1.25 x 36		33 +/- 3.3 N·m
Oil pump	3 screws M8 x 1.25 x 36		33 +/- 3.3 N·m
Overhead		8 screws M6 x 1 x 20	10 +/- 1 N·m
Pre-heating glow plugs	4 glow plugs M8 x 1		9 +/- 1 N·m
Rocker arm unit	12 screws M6 x 1 x 75		10 +/- 1 N·m
Socket for the service air compressor control	2 screws M10 x 1.5 x 50		46 +/- 4.6 N·m
Thermostat cover	3 screws M6 x 1 x 12		10 +/- 1 N·m
Timing gear	6 screws M8 x 1.25 x 20		34 +/- 3.4 N·m
Timing gearbox		13 screws M8 x 1.25 x 25	23 +/- 2.3 N·m
		13 screws M8 x 1.25 x 35	23 +/- 2.3 N·m
Turbocharger		3 nuts M10 x 1.5 x 10	28 +/- 1.5 N·m
		3 studs M10 x 1.5 x 40	25 +/- 1.25 N·m

Tool / Material	
Assemblies overhaul revolving stand (bearing capacity 1000 daN, torque 120 daNm)	99322205
Brackets fixing engine to revolving stand 99322205	99361044
Crankshaft rear seal installer	99346259
Engine TDC positioning tool	99360612
Key for crankshaft front gasket installation and and timing cover centering	99346270
Remover, cartridge filter	99360076
Socket wrench (8 mm) for removing and refitting glow plugs	SP2275

Check and fit tappets and camshaft

1. Check the bushes as described in **BUSHES - Check (54.12)**.

2. Check the tappet sleeves as described in **TAPPETS - Check (54.12)**.
3. Check the camshaft as described in **CAMSHAFT - Check (54.12)**.
4. Fit the tappets and camshaft as described in **CAMSHAFT - Assemble (54.12)**

Fitting main half-bearings and crankshaft

5. Check the crankshaft as described in **CRANKSHAFT - Measure (54.08)**.
6. Install the main bearings as described in **MAIN BEARINGS - Assemble (54.08)**.
7. Install the crankshaft as described in **CRANKSHAFT - Assemble (54.08)**.
8. Check the crankshaft thrust clearance as described in **CRANKSHAFT - Check (54.08)**.

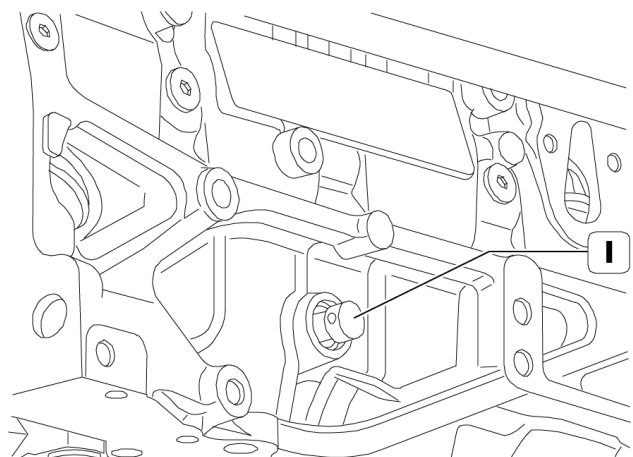
Installation of connecting rod-piston assembly

9. Check the piston components as described in **PISTON - Measure (54.08)**.
10. Check the connecting rod as described in **CONNECTING ROD - Check (54.08)**.
11. Check the circlips as described in **COMPRESSION RINGS - Check (54.08)**.
12. Install the circlips as described in **COMPRESSION RINGS - Assemble (54.08)**.
13. Assemble the piston-connecting rod assembly as described in **PISTON - Pre-assemble (54.08)**.
14. Assemble the big-end bearings as described in **CONNECTING ROD BEARING - Assemble (54.08)**.
15. Install the piston as described in **PISTON - Assemble (54.08)**.
16. Check the protrusion of the pistons as described in **PISTON - Check (54.08)**.

Counter-rotating balance shafts installation

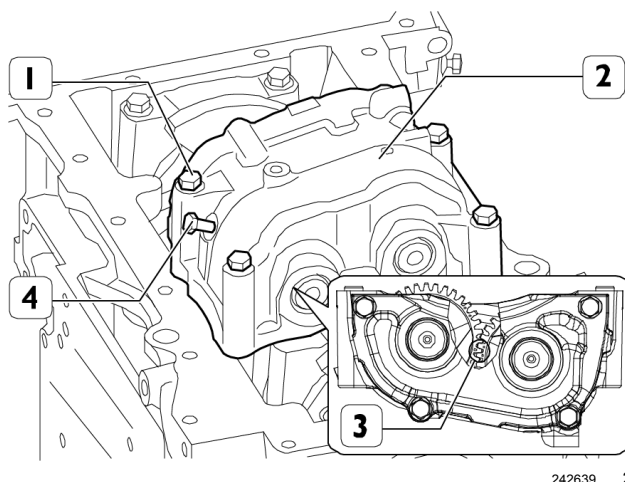
17. Bring the 1st cylinder to **118°** before the TDC. In this condition, the engine is timed, insert the specific tool **(1)** into the crankcase that will align with the hole in the crankshaft.

Tool / Material	
Engine TDC positioning tool	99360612



244555 1

18. Rotate the engine of **180°**.
19. Fit the housing containing the balancing weights **(2)** that were already timed during disassembling using the fastening pin **(4)**.
20. If the pin **(4)** was not engaged during the disassembly phase, and as a result the balancing weights **(2)** are not timed, proceed as follows.
21. Align the marks **(3)** stamped on the gears of the balancing weights **(2)** for timing, as indicated in the figure 2.
22. Use the pin **(4)** to temporarily block the rotation of the balancing weights **(2)**.
23. Fit the housing containing the balancing weights **(2)** and tighten the fastening screws **(1)** on the crankcase to the prescribed torque.



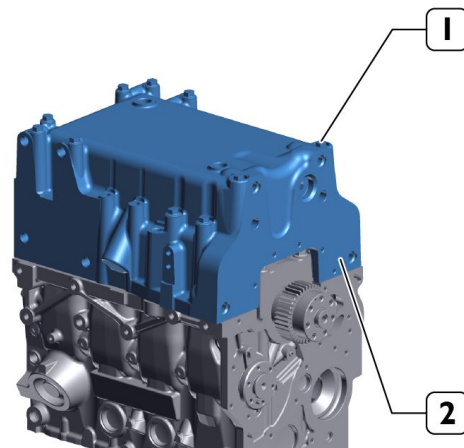
242639 2

Description	Quantity	Step	Value
Balancing weights	4 screws M8 x 1.25 x 90	Step 1 — Pre-tightening	20 +/- 6 N·m
		Step 2 — Tighten	60°

24. Remove the locking pin **(4)** from the balancing weights **(2)**.

Oil sump assembly

25. Correctly position the new gasket on the crankcase.
26. Correctly position the oil sump **(2)** on the crankcase, paying attention to the gasket and tighten the fastening screws **(1)** to the specified torque and according to the sequence shown in the figure 4.



298934 3

Description	Quantity	Step	Value
Engine oil sump	8 screws M10 x 1.5 x 230	Step 1 —	40 +/- 2 N·m
		Step 2 — Angle tightening	90°
		Step 3 — Angle tightening	90°
Engine oil sump	4 screws M10 x 1.5 x 160	Step 1 —	40 +/- 2 N·m
		Step 2 — Angle tightening	60°
		Step 3 — Angle tightening	60°
Engine oil sump	4 screws M12 x 1.75 x 160	Step 1 —	85 +/- 4.25 N·m
		Step 2 — Angle tightening	60°

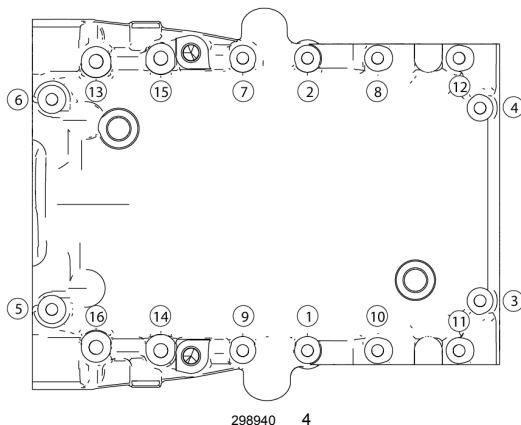


Diagram showing the oil sump fastening screws tightening order.

Flywheel housing assembly

27. Thoroughly clean the timing gear case (1) and the crankcase.

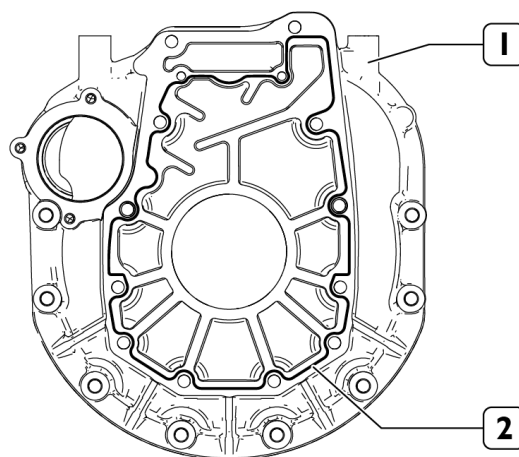
NOTICE: The surface to be sealed **MUST** be clean in order to obtain perfect tightness.

Apply Loctite 5970 (2) to the gear case in order to form a sealing bead of a few mm. See figure 5.

The sealant bead must be even (no lumps), with no air bubbles, and with no areas of a smaller diameter or even empty.

Correct any imperfections immediately. Avoid applying too much sealant as any excess could be dispersed and come out on both sides of the joint thereby obstructing the passage of the lubricant.

After applying the sealant, couple the parts within **10 min**.

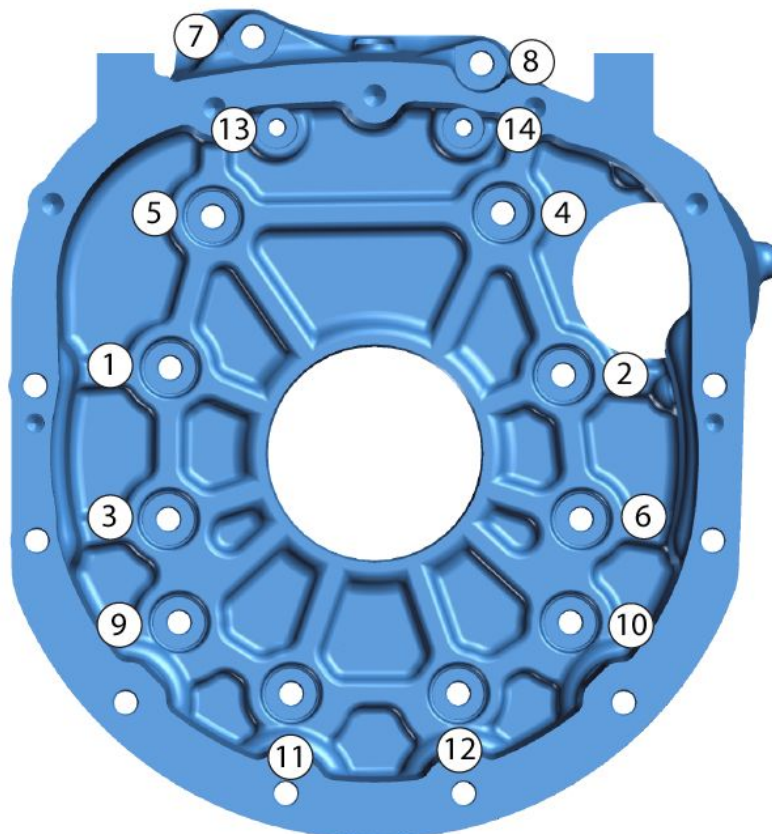


298944 5

28. Refit the flywheel housing to the crankcase and fit the fastening screws in the same position found at removal. Tighten them to the specified torque values in the sequence shown in the figure 6.

NOTE: Always check, before each installation, that the threads of holes and screws do not show any signs of wear or dirt.

Description	Step	Value
Engine flywheel housing	2 screws M12 x 1.75 x 90	117 +/- 11.7 N·m
	10 screws M12 x 1.75 x 40	117 +/- 11.7 N·m
	2 screws M8 x 1.25 x 35	34 +/- 3.4 N·m



298945 6

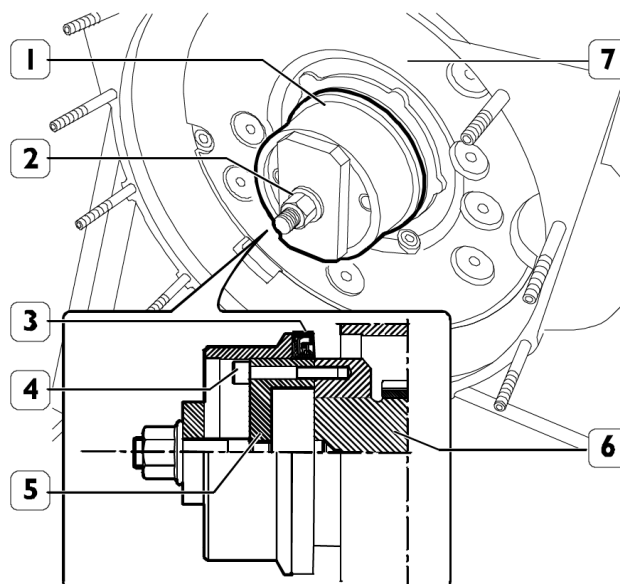
Diagram of the tightening sequence for the fastening screws of the flywheel housing.

Crankshaft rear gasket assembly

29. Apply the part (5) of the special tool to the rear crankshaft tang (6) securing it with the screws (4) and fit the new sealing ring (3).

Tool / Material	
Crankshaft rear seal installer	99346259

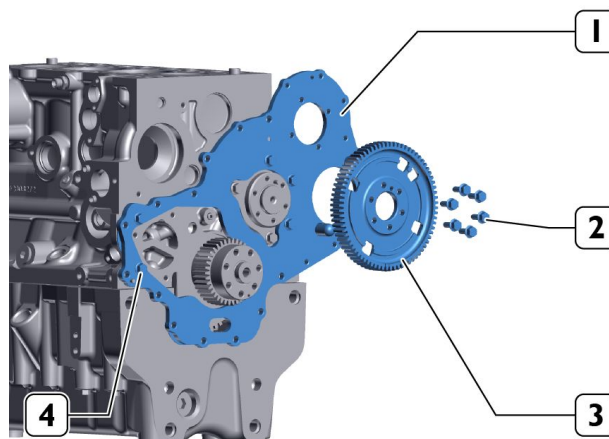
30. Position part (1) on part (5), tighten the nut (2) until the sealing ring (3) is completely installed in the flywheel housing (7).



000901T 7

Timing gear assembly

31. Fit the spacer (1) on the crankcase, inserting a new gasket and tightening the fastening screws (4) to the specified torque.

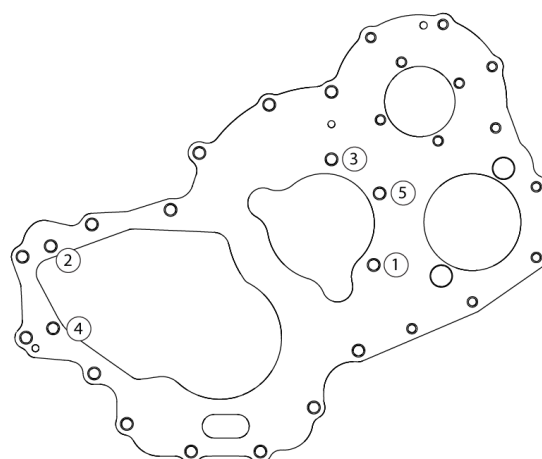


298932 8

32. Tighten the fastening screws (4) in the sequence shown in the figure 9.

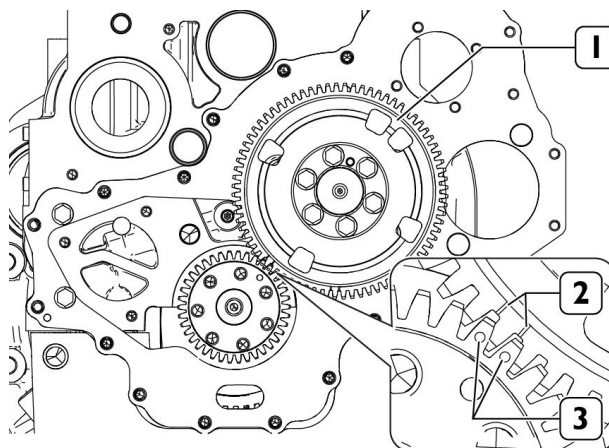
33. Install the timing gear (3) tighten the fastening screws (2) to the specified torque.

Description	Quantity	Step	Value
Timing gear	6 screws M8 x 1.25 x 20		34 +/- 3.4 N·m



298943 9

34. In order for the engine to be timed, you must position the camshaft gear (1) so that its notches (2) correspond with the notches (3) on the crankshaft.



298946 10

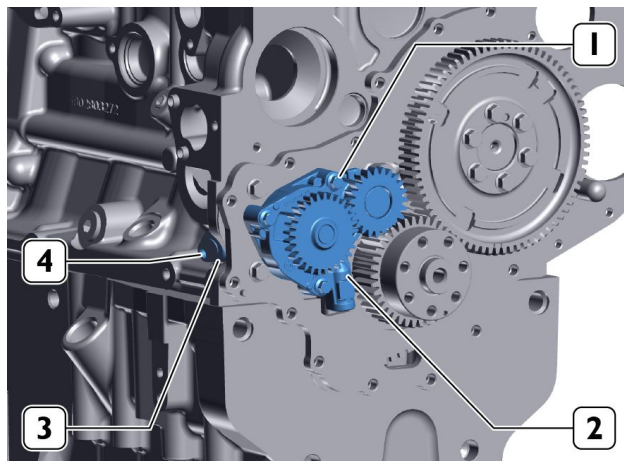
Installing the oil pump

35. Fit the oil pump (2) and tighten the fastening (1) screws to the specified torque.

Description	Quantity	Value
Oil pump	3 screws M8 x 1.25 x 36	33 +/- 3.3 N·m

36. Fit the oil pressure control valve (3) and tighten the fastening screw (4) to the specified torque.

Description	Quantity	Value
Oil pressure regulator valve	1 screw M8 x 1.25 x 36	33 +/- 3.3 N·m



298705 11

Control socket installation

37. Install the engine speed sensor (2) and tighten the fastening screw (3) to the specified torque.

Description	Quantity	Value
Crankshaft rpm sensor	1 screw M6 x 1 x 16	9 +/- 0.9 N·m

38. Install the control socket (4) in its seat, inserting a new gasket and making sure that the gear couples correctly with the timing gear, and tighten the fastening screws (5) to the specified torque.

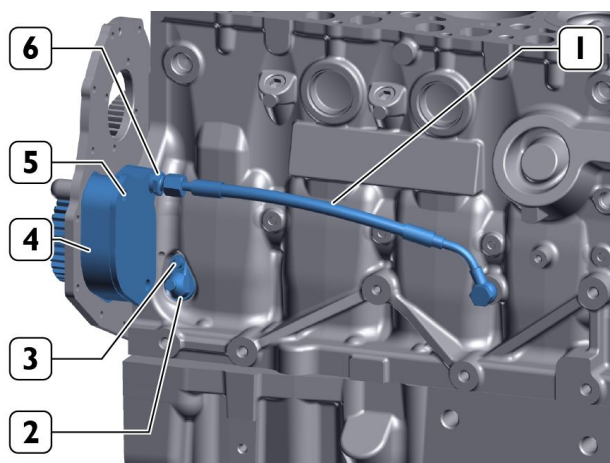
Description	Quantity	Value
Socket for the service air compressor control	2 screws M10 x 1.5 x 50	46 +/- 4.6 N·m

39. Screw the fitting (6) onto the control socket.

Description	Quantity	Value
Control socket coupling	1 G 1/4" coupling?	45 +/- 4.5 N·m

40. Install the lubricant pipe (1) of the control socket (4) and tighten the fitting and the fastening screw to the specified torque.

Description	Step	Value
Control socket lubrication pipe	1 screw M12 x 1.5	40 +/- 4 N·m
	1 fitting M14 x 1.5	40 +/- 4 N·m



298704 12

High-pressure pump assembly

41. Screw in the studs for fastening the high-pressure pump **(2)** to the gear case.

Description	Quantity	Step	Value
High pressure fuel pump	3 studs M8x1.2 5x12		11 +/- 1.1 N·m

42. Correctly insert a new gasket and install the spacer by tightening the fastening screws **(4)** to the specified torque.

Description	Quantity	Step	Value
High pressure fuel pump spacer	4 screwsM6 x 1 x 16		10 +/- 1 N·m

43. Fit the high-pressure pump **(2)** and tighten the nuts **(3)** to the specified torque.

NOTE: Pay attention to the reference dowel pin (1).

Description	Quantity	Step	Value
High pressure fuel pump	3 nuts M8 x1.25		23 +/- 2.3 N·m

44. Turn the spindle until the reference dowel (**7**) is in the position shown in the figure.

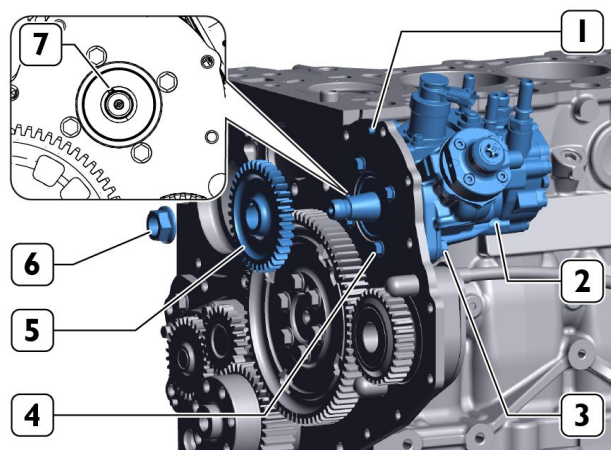
45. Insert the gear and tighten the nut **(5)** on the high-pressure pump shaft to the specified torque.

NOTE: Pay attention to the reference dowel pin (7).

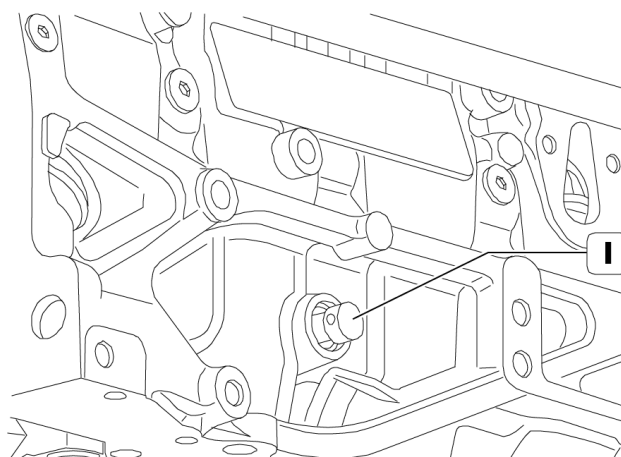
Description	Quantity	Step	Value
High-pressure pump gear	1 nut M18 x 1.5		80 +/- 4 N·m

46. Remove the special tool **(1)** in the crankcase in order to release the rotation of the crankshaft.

Tool / Material	
Engine TDC positioning tool	99360612



298947 13



244555 14

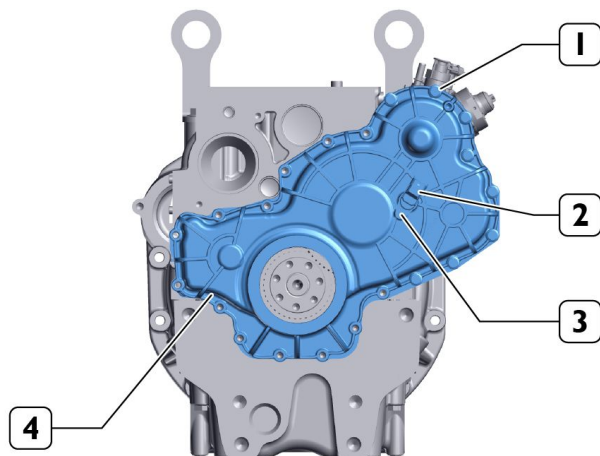
Timing gear assembly cover mounting

47. Correctly position a new gasket and install the timing gear case (4) tightening the fastening screws (1) to the specified torque and according to the sequence shown in the figure 16.

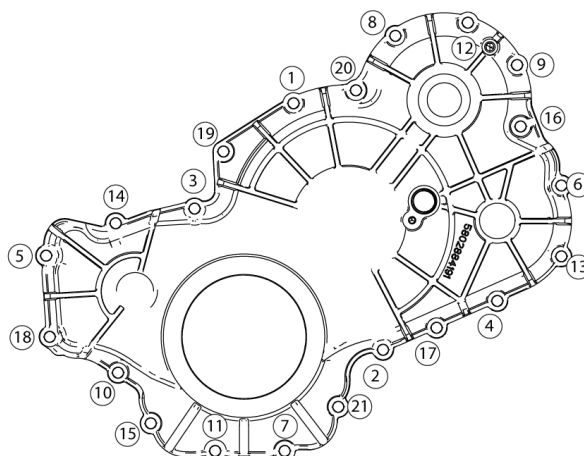
Description	Step	Value
Timing gearbox	13 screws M8 x1.25 x 25	23 +/- 2.3 N·m
	13 screws M8 x 1.25 x 35	23 +/- 2.3 N·m

48. Install the camshaft timing sensor (2) and tighten the fastening screw (3) to the specified torque.

Description	Quantity	Value
Camshaft timing sensor	1 screw M6 x 1 x 16	9 +/- 0.9 N·m



298702 15



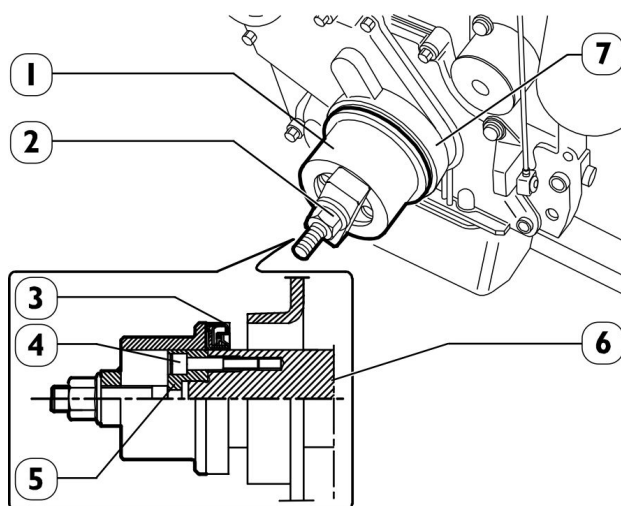
298942 16

Crankshaft front sealing ring refitting

49. Apply the part (5) of the special tool to the front crankshaft tang (6) securing it with the screws (4) and keying it onto the new sealing ring (3).

Tool / Material	
Key for crankshaft front gasket installation and and timing cover centering	99346270

50. Position part (1) on part (5), tighten the nut (2) until the crankshaft sealing ring (3) is completely installed in the front cover (7).



70225 17

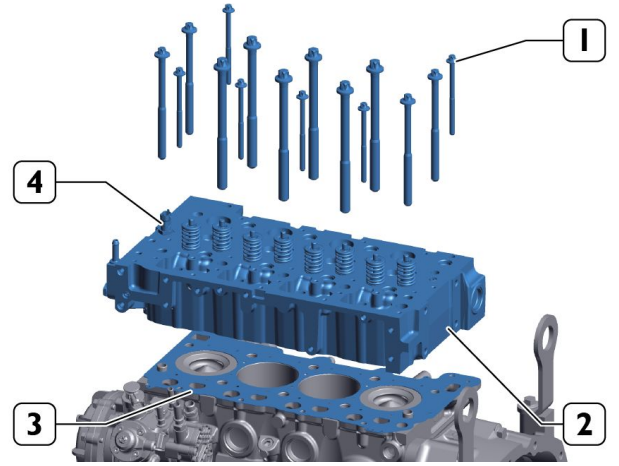
Cylinder head installation

51. Check that the mating surfaces of the head seal and crankcase are clean.
52. There are two types of cylinder head gaskets (3):
 1. Type A, thk. **0.85 mm**
 2. Type B, thk. **0.95 mm**
53. Check the protrusion S of the pistons as indicated in the table **ENGINE - Technical Data (54.01)**.
If S is between **-0.2 – -0.05 mm**, use a type A gasket.
If S is between **-0.06 – 1 mm**, use a type B gasket.
54. Keep the cylinder head (2) gasket (3) clean.
55. Pay attention to the cable reference dowels present on the surface of the crankcase and fit the cylinder head (2) gasket (3).
56. Connect metal ropes or the specific tool to the eye-bolts and use the lifting device to place the cylinder head (2) on the crankcase.

NOTE: If the valves have not been removed from the cylinder head, they must be reinstalled before installing the cylinder head on the crankcase.

57. After fitting the cylinder head (2), screw in the new fastening screws (1) and tighten them in three stages, following the order and methods shown in the figure 38.

NOTE: Always check, before each installation, that the threads of holes and screws do not show any signs of wear or dirt.

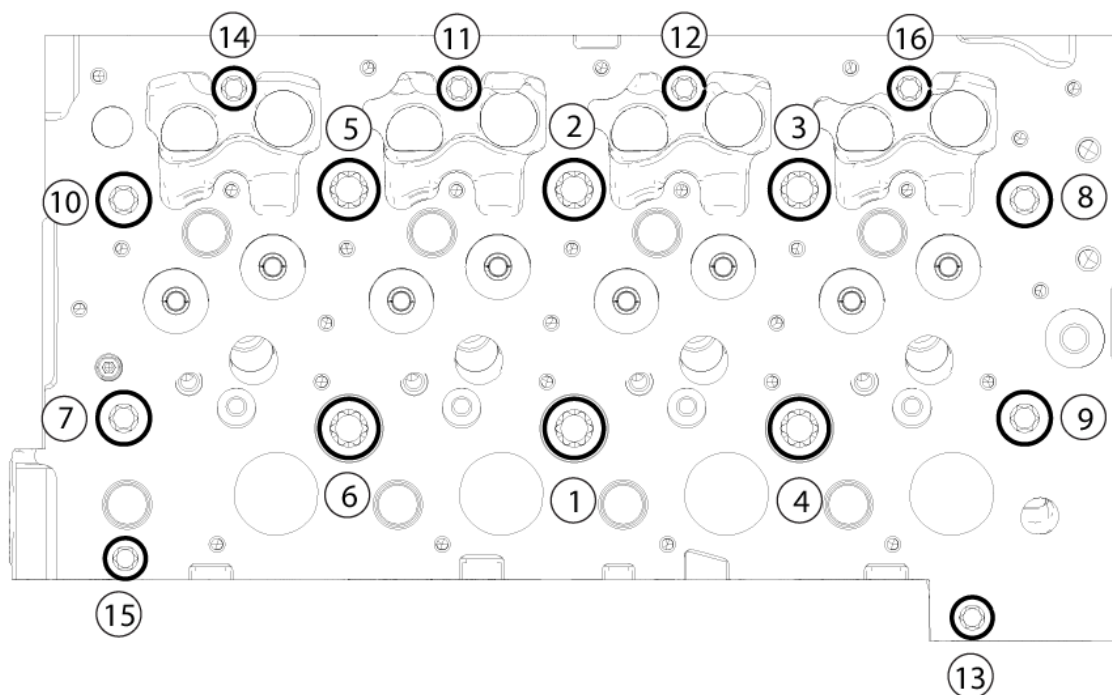


298701 18

Description	Quantity	Step	Value
Cylinder head	6 screws M15 x 1.5 x 193	Step 1 —	130 +/- 6.5 N·m
		Step 2 — Angle tightening	90°
		Step 3 — Angle tightening	90°
Cylinder head	6 screws M8 x 1.25 x 117		34 +/- 3.4 N·m
Cylinder head	4 screws M12 x 1.5 x 165	Step 1 —	65 +/- 3,25 N·m
		Step 2 — Angle tightening	90°
		Step 3 — Angle tightening	60°

58. Install the coolant temperature sensor on the cylinder head (4).

Description	Quantity	Value
Coolant temperature sensor	1 sensor M12 x 15	20 +/- 5 N·m



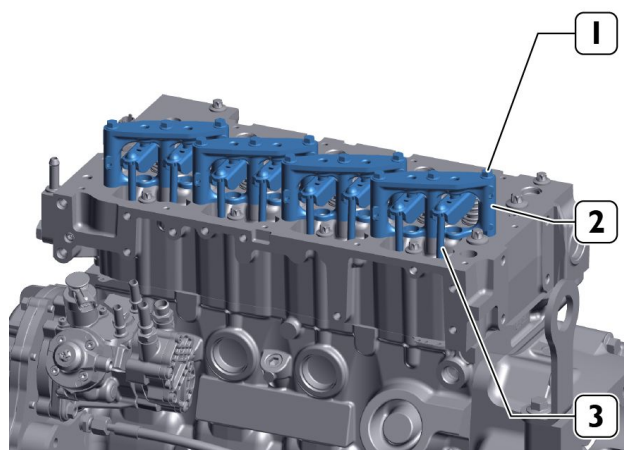
298073 19

Diagram of the tightening sequence of the cylinder head fastening screws.

Rocker arms assembly installation

59. The control rods **(3)** of the rocker arms must not have any deformations; tappets must not show signs of seizure or wear; if there is any sign of seizure or wear, replace them.
60. Intake and exhaust valve pushrods **(3)** are identical and are therefore interchangeable.
61. Insert the rocker arm control rods. **(3)**
62. Reassemble the intake and exhaust rocker arm assembly **(2)** and tighten the fastening screws **(1)** to the specified torque.

Description	Quantity	Step	Value
Rocker arm unit	12 screws M6 x 1 x 75		10 +/- 1 N·m



298700 20

Tappet cover assembly

63. Place a new gasket (3) on the tappet cover (5).
64. Install the tappet cover (5) with a new gasket (3) and tighten the fastening screws (4) to the specified torque following the sequence and methods shown in the figure 22.

Description	Quantity	Step	Value
Head cover	10 screws M6 x1 x 40		10 +/- 1 N·m

65. Correctly position the lifting eyelets (1) and tighten the fastening screws (2) to the specified torque.

Description	Quantity	Value
Lifting eyelets	2 screws M12 x 1.75 x 25	118 +/- 11.8 N·m

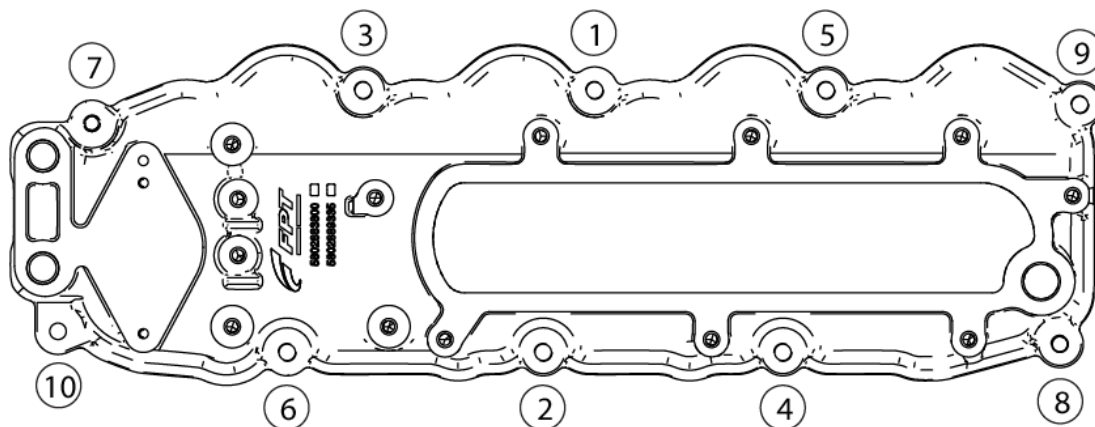
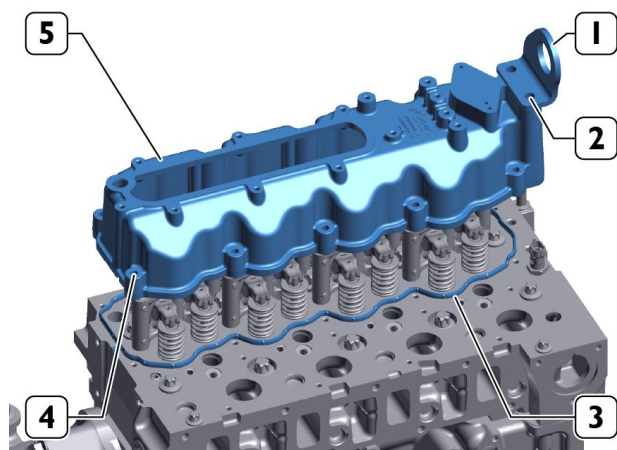


Diagram of tightening sequence for tappet cover fastening screws.

Inlet manifold assembly

66. Install the overhead (4) and tighten the fastening screws (5) to the specified torque and following the sequence and methods shown in the figure 24.

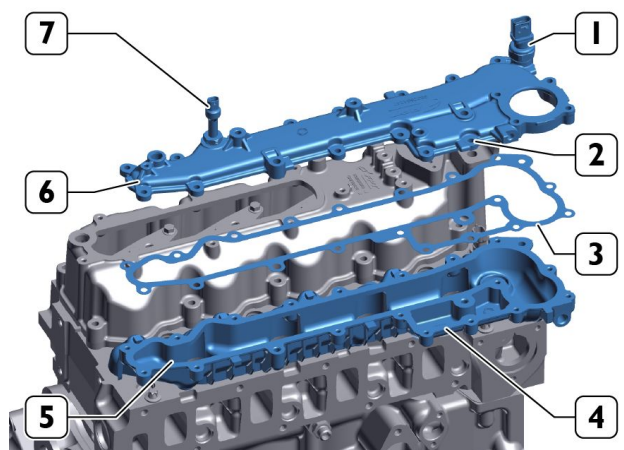
Description	Step	Value
Overhead	8 screws M6 x 1 x 20	10 +/- 1 N·m

67. Fit the intake manifold (6), correctly positioning a new gasket and tighten the fastening screws (2) to the specified torque and following the sequence and methods shown in the figure 25.

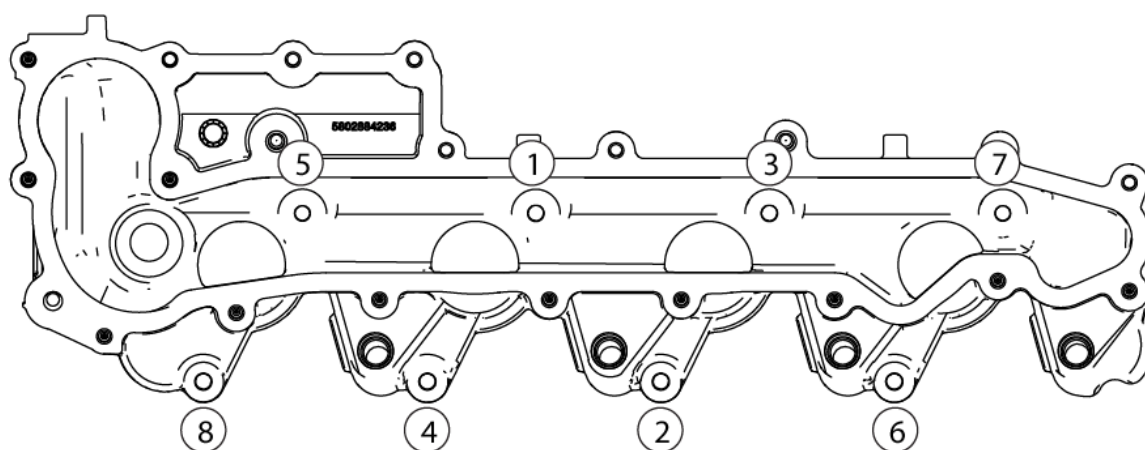
Description	Step	Value
Intake manifold	14 screws M6 x 1 x 20	10 +/- 1 N·m
	4 caps M12 x 1.5	20 +/- 2 N·m

68. Fit the temperature sensor (7) and the exhaust gas absolute pressure sensor (1).

Description	Quantity	Step	Value
Exhaust gas absolute pressure sensor	1 sensor M14 x 1.5		15 +/- 1.5 N·m
Exhaust gas temperature sensor		1 fitting M14 x 1.5 x 12	45 +/- 4.5 N·m
		1 screw M6 x 1.5 x 12	10 +/- 1 N·m

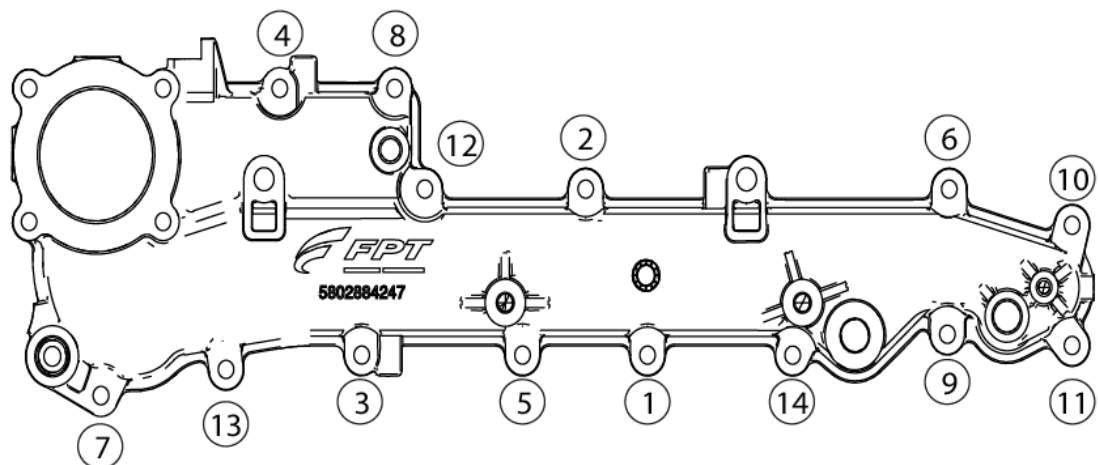


298698 23



298950 24

Diagram of tightening sequence for overhead fastening screws.



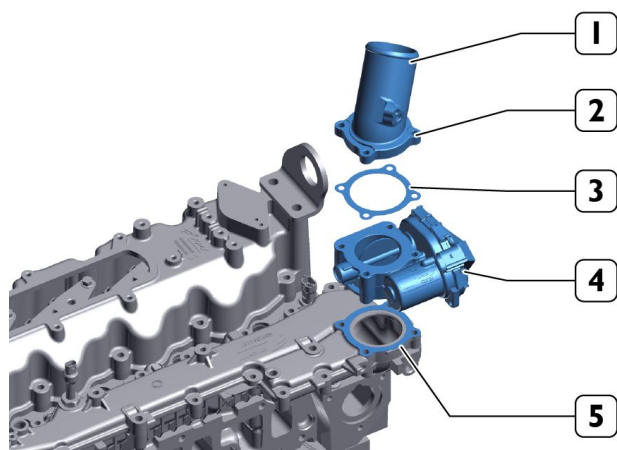
298948 25

Diagram of tightening sequence for intake manifold fastening screws.

Throttle valve assembly

69. Tighten the studs to the prescribed torque and install the throttle valve (4), with a new gasket (5).
70. Install the engine air intake (1) with a new gasket (3) and tighten the nuts (2) and the fastening screw to the specified torque.

Description	Step	Value
Engine air vent	3 studs M6 x 1 x 80	10 +/- 1 N·m
	3 nuts M6 x1	10 +/- 1 N·m
	1 screw M6 x 1 x 80	10 +/- 1 N·m



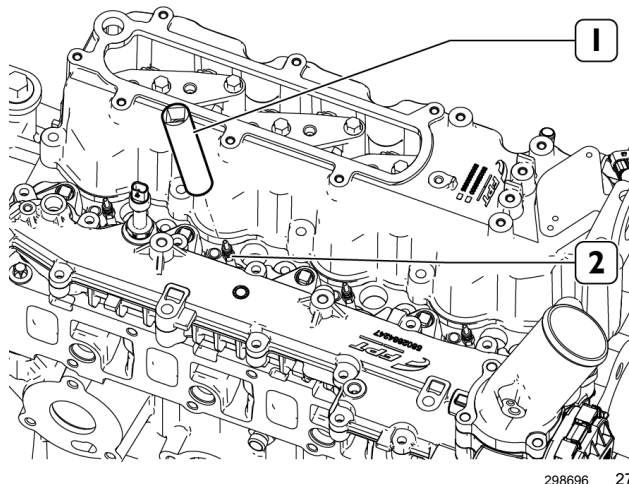
298697 26

Pre-heating glow plug assembly

71. Tighten the glow plug (2) using the tool (1), to the specified torque.

Tool / Material	
Socket wrench (8 mm) for removing and refitting glow plugs	SP2275

Description	Quantity	Value
Pre-heating glow plugs	4 glow plugs M8 x 1	9 +/- 1 N·m



298696 27

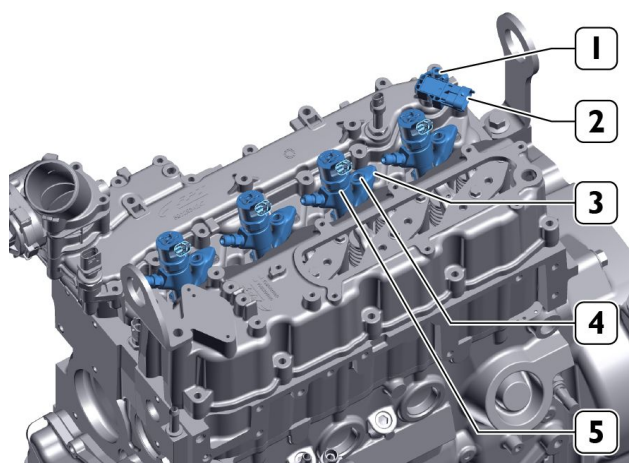
Injector assembly

72. Fit the studs and tighten them to the specified torque.

Description	Quantity	Step	Value
Electro-injector brackets	4 nuts M8 x 1.25		18 +/- 1.8 N·m

73. Fit the electro-injector (5) on the head together with the fixing bracket (3) and tighten the nuts (4), together with their washers, to the prescribed torque.

Description	Quantity	Step	Value
Electro-injector brackets	4 studs M8 x 1.25 x 65		28 +/- 1.4 N·m



298695 28

74. Fit the air temperature and boost pressure sensor (2) and tighten the fastening screw (1) to the specified torque.

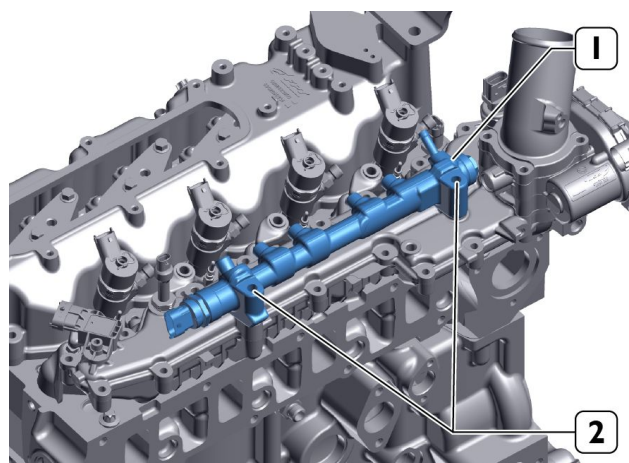
Description	Quantity	Value
Air temperature and pressure sensor	1 screw M6 x 1 x 16	9 +/- 0.9 N·m

Rail installation

75. Fit the common rail (1) together with the rail pressure sensor and the pressure relief valve, on the intake manifold.

76. Tighten the fastening screws (2) to the specified torque.

Description	Quantity	Step	Value
Common Rail	2 screws M8 x 1.25 x 55		23 +/- 2.3 N·m



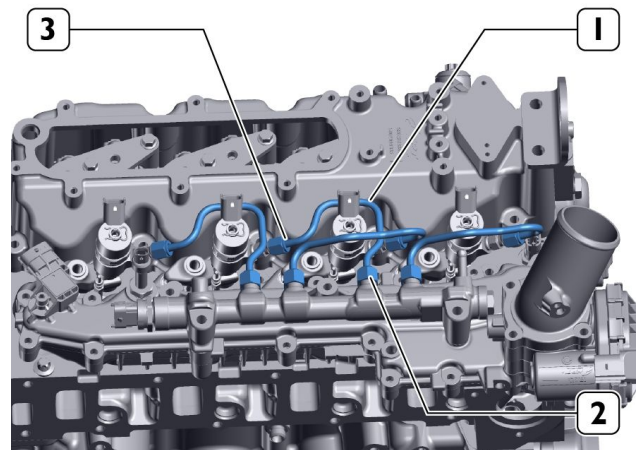
298694 29

Fuel delivery pipe assembly rail to the injectors

77. Fit the high pressure fuel delivery pipes (1) and manually position first the common rail side nuts (2) and then the injector side nuts (3) up near then.
78. First tighten the common rail side nuts (2) and then the injector side nuts (3) in two steps to the prescribed torque.

NOTE: The high pressure fuel delivery pipes must be replaced each time they are disconnected.

Description	Quantity	Step	Value
Fuel delivery pipes to the electro-injectors	4 rail-side couplings M14 x1.5		35 +/- 1.75 N·m



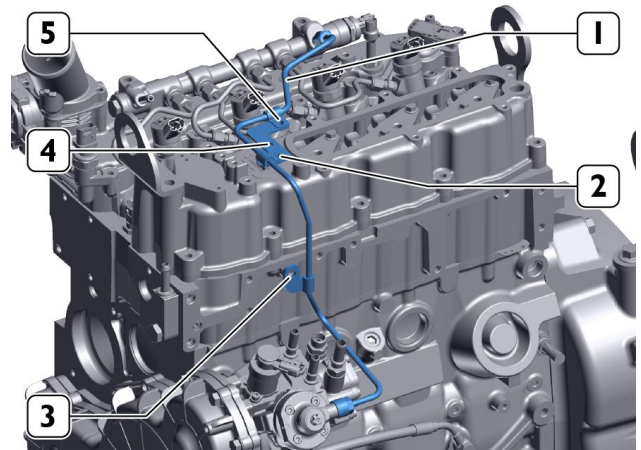
298693 30

Fuel delivery pipe assembly

79. Fit the fuel delivery pipe (1) from the high pressure pump to the rail and tighten the couplings to the prescribed torque.

NOTE: The high pressure fuel delivery pipe must always be replaced with a new one whenever it is removed.

Description	Step	Value
Delivery fuel pipe from the pump to the rail	1 high pressure fuel pump-side coupling M16 x 1	45 +/- 2.25 N·m
	1 rail-side coupling M14 x 1.5	35 +/- 1.75 N·m



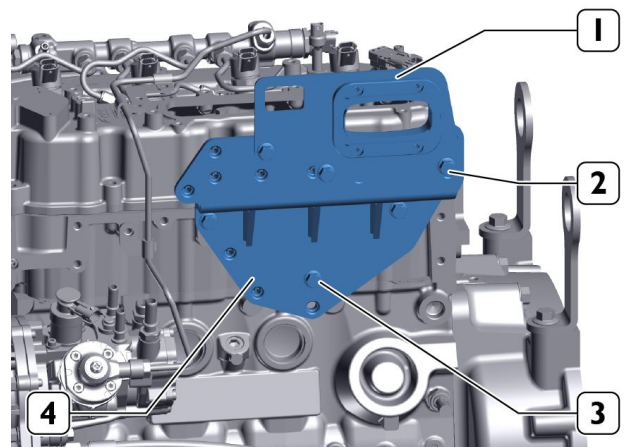
298692 31

80. Install the fuel delivery pipe retaining brackets (1) and tighten the fastening screws (2), (3), (4) and (5) to the specified torque.

Description	Quantity	Value
Bracket retaining the delivery fuel pipe from the pump to the rail	3 screws M6 x 1 x 10	10 +/- 1 N·m

Filter and pre-fuel filter supporting bracket assembly

81. Install the bracket (4) supporting the filter and pre-fuel filter and tighten the fastening screws (3) to the specified torque.
82. Fit the supporting bracket (1) of the engine wiring connectors and tighten the fastening screws (2) to the specified torque.



298691 32

Fuel filter assembly

83. Fit the fuel filter support (3) on the supporting bracket and tighten the fastening screws (1) to the specified torque.

Description	Quantity	Value
Fuel filter	1 cartridge M20 x 1.5	22 +/- 3 N·m

84. Moisten the sealing gasket of the fuel filter (2) with a thin layer of engine oil.

85. Manually screw the fuel filter (2) onto the support until it comes into contact with the gasket.

NOTE: Pay attention to the fuel temperature sensor and to the electric connections of the engine cable.

86. With the specific tool, tighten the fuel filter (2) further to a torque of:

Tool / Material	
Remover, cartridge filter	99360076

Description	Quantity	Value
Fuel filter	1 cartridge M20 x 1.5	22 +/- 3 N·m

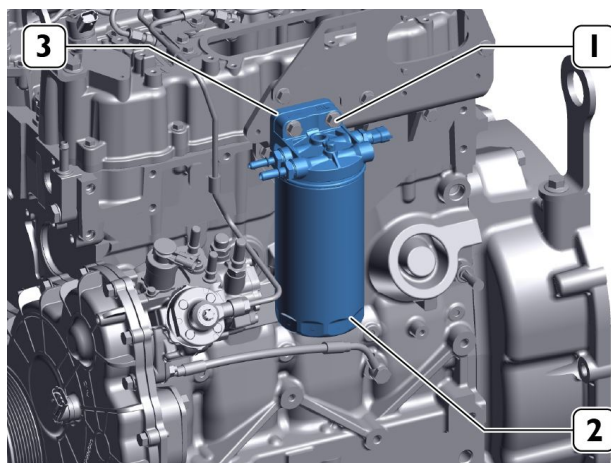
87. After the fuel filter (2) has been replaced it is possible that air bubbles may become trapped inside the fuel supply circuit.

88. Bleed residual air from the fuel filter (1) by loosening the breather plug connecting it to a suitable container using a transparent flexible hose.

89. Operate the fuel pre-filter hand pump until the fuel coming out through the breather plug is completely free of air bubbles.

90. Tighten the bleeder plug to the specified torque.

Description	Quantity	Value
Air bleeding on the fuel filter bracket	1 screw M10	4 +/- 0.5 N·m



298690 33

Fuel pre-filter assembly

91. Fit the fuel pre-filter bracket (5) on the support yoke and tighten the fastening screws (1).
92. Moisten the fuel pre-filter sealing gasket (3) with a film of engine oil.
93. Manually screw the fuel filter (3) onto the support (5) until it comes into contact with the gasket.

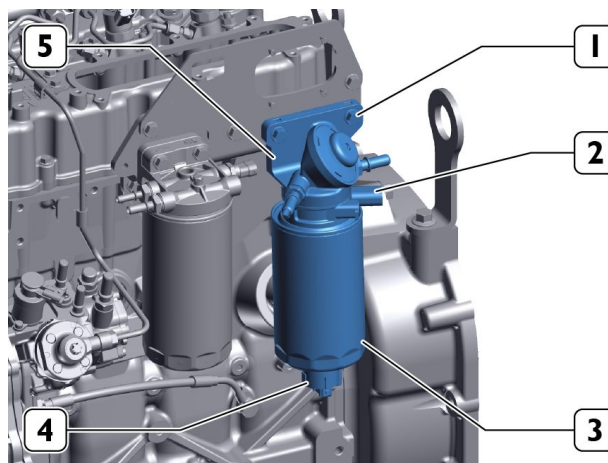
NOTE: Pay attention to the sensor (4) detecting water in the fuel pre-filter, the electric fuel heater (2) and the relevant connection.

94. Use the special tool to further tighten the fuel pre-filter (3) to a torque of:

Tool / Material	
Remover, cartridge filter	99360076

Description	Quantity	Value
Fuel Pre-filter	1 cartridge —	20 +/- 3 N·m

95. Then connect the electrical connection of the sensor (4) detecting water in the fuel pre-filter and the electrical connection of the electric fuel heater (2).



298689 34

Assembly of the low-pressure fuel pipes

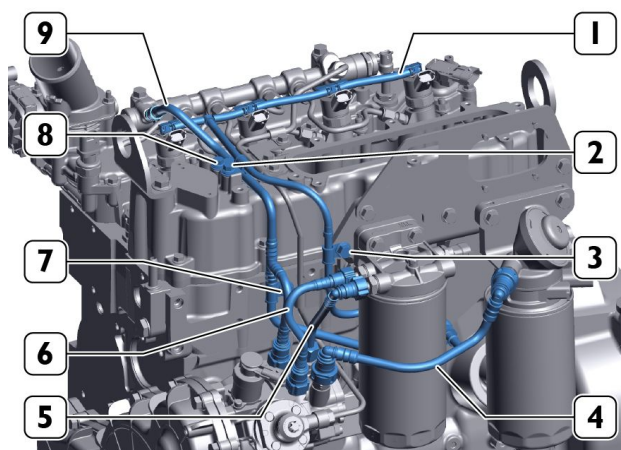
96. Fit the fuel return pipe (9) from the rail and from the high pressure pump, connecting the couplings.
97. Install the brackets retaining the fuel return pipe (9) from the rail and from the high-pressure pump and tighten the fastening screws (7) and (8) to the specified torque.

Description	Step	Value
Bracket retaining the fuel return pump from the rail and from the high pressure pump	1 screw M6 x 1 x 14	10 +/- 1 N·m
	1 screw M8 x 1.25 x 18	23 +/- 2.31 N·m

98. Fit the fuel return pipe (1) from the injectors and connect the low pressure couplings.
99. Install the brackets retaining the fuel return pipe (1) from the injectors and tighten the fastening screws (2) and (3) to the prescribed torque.

Description	Step	Value
Injector fuel return pipe brackets	1 screw M6 x 1 x 14	10 +/- 1 N·m
	1 screw M8 x 1.25 x 18	23 +/- 2.3 N·m

100. Fit the fuel pipes (4), (5) and (6) on the fuel filter / pre-filter support and connect the low-pressure fittings.



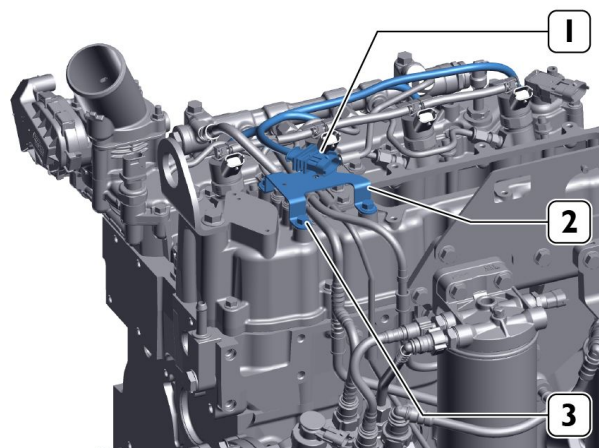
298688 35

Glow plug wiring assembly

101. Fit the bracket (2) retaining the glow plug wiring and tighten the screws (3) to the prescribed torque.

Description	Quantity	Value
Glow plug harness mount	3 screws M6 x 1 x 14	10 +/- 1 N·m

102. Install the glow plug wiring (1) and fix it using the retaining clip.



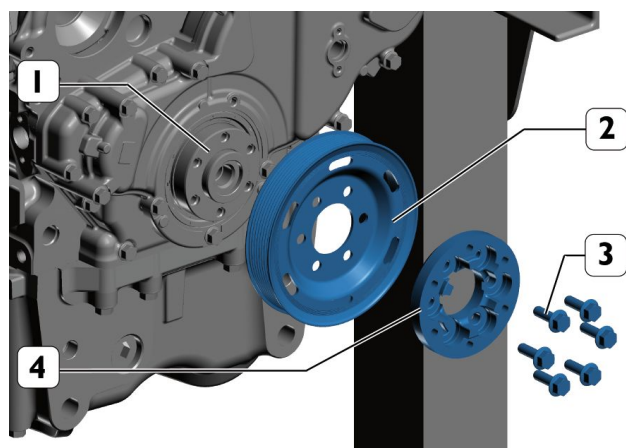
298687 36

Fitting the crankshaft pulley

103. Key the crankshaft pulley (2) and spacer (4) onto the crankshaft (1) and tighten the fastening screws (3) to the specified torque.

NOTE: The crankshaft rotation locking tool can facilitate the installation of the crankshaft pulley.

Description	Quantity	Value
Crankshaft pulley	7 screws M10 x 1.5 x 30	70 +/- 7 N·m

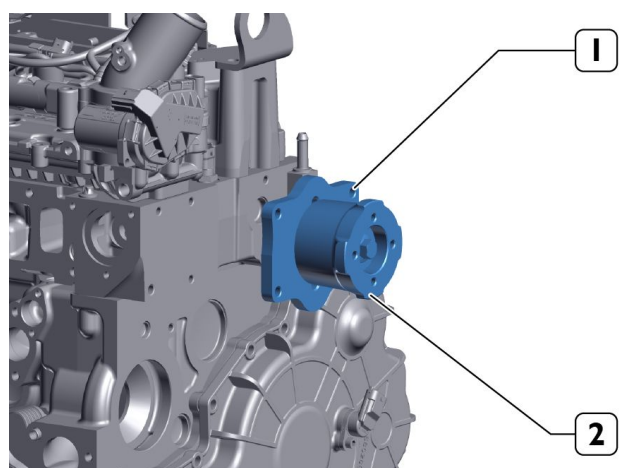


231909 37

Fan drive pulley mount assembly

104. Correctly position the fan drive pulley mount (2) on the crankcase and tighten the screws (1) to the specified torque.

Description	Quantity	Value
Fan pulley control mount	4 screws M8 x 1.25 x 25	23 +/- 2.3 N·m

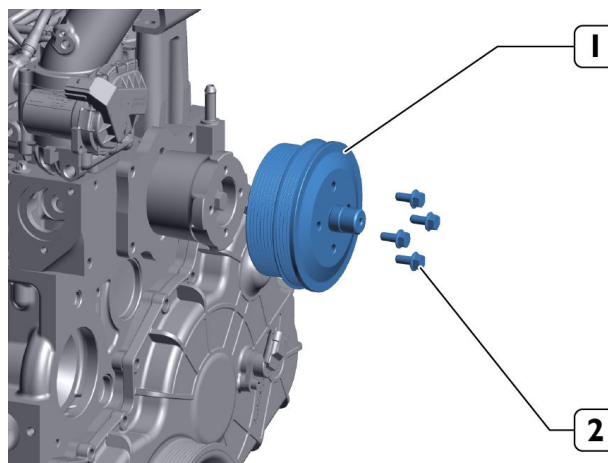


298686 38

Fan drive pulley assembly

105. Correctly position the fan drive pulley (1) on its mount and tighten the fastening screws (2) to the specified torque.

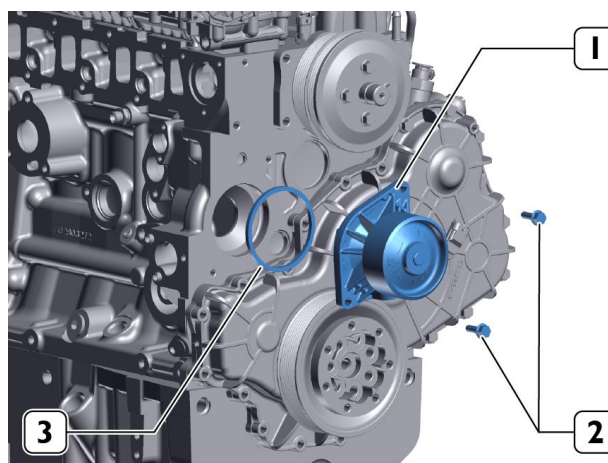
Description	Quantity	Value
Fan control pulley	4 screws M8 x 1.25 x 18	23 +/- 2.3 N·m



298685 39

Water pump assembly

106. Apply a new sealing ring (3) to the water pump (1).
107. Position the water pump (1) in its seat and tighten the fastening screws (2) to the prescribed torque.

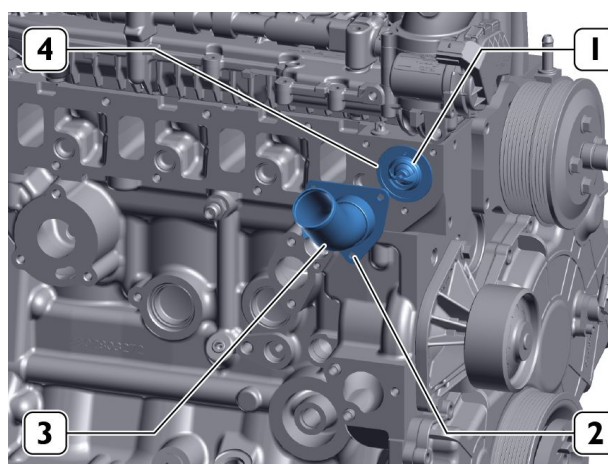


298684 40

Thermostat assembly

108. Install the thermostat (1) in its housing.
109. Fit the thermostat body (3), complete with the gasket (4) in the seat of the cylinder head, and tighten the fastening screws (2) to the specified torque.

Description	Quantity	Step	Value
Thermostat cover	3 screws M6 x 1 x 12		10 +/- 1 N·m

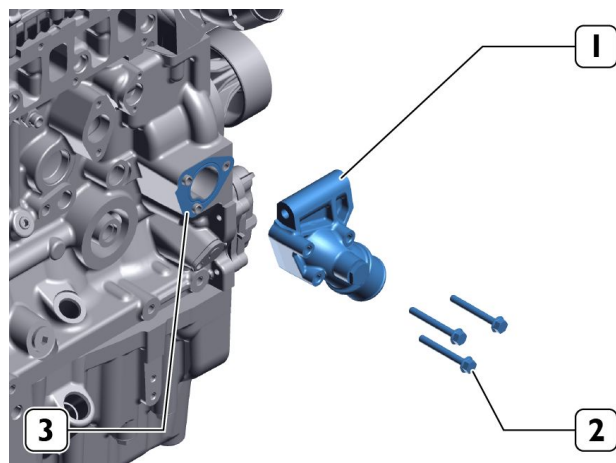


298683 41

Coolant filler pipe assembly

110. Fit the coolant filler pipe (1) together with the gasket (3) and tighten the fastening screws (2).

Description	Step	Value
Engine coolant input pipe	3 screws M8 x 1.25 x 65	23 +/- 2.3 N·m
	1 screw M8 x 1.25 x 14	25 +/- 2.5 N·m

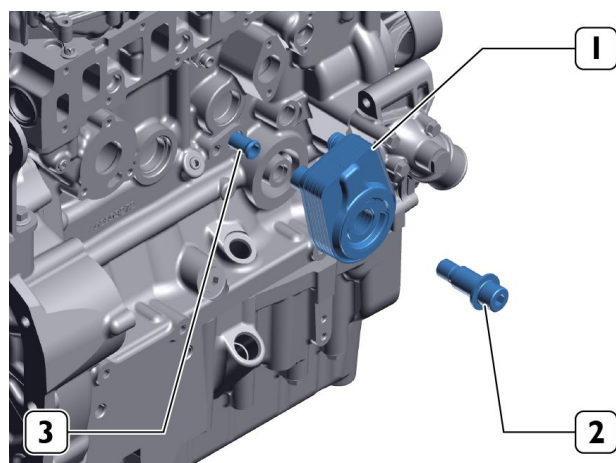


298682 42

Oil filter mount assembly

111. Install the pipe connection (3) and the oil filter support (1), inserting a new gasket and tightening the fastening screw (2) to the specified torque.

Description	Step	Value
Oil filter bracket	1 fitting M20 x 1.5 x 18	35 +/- 5 N·m



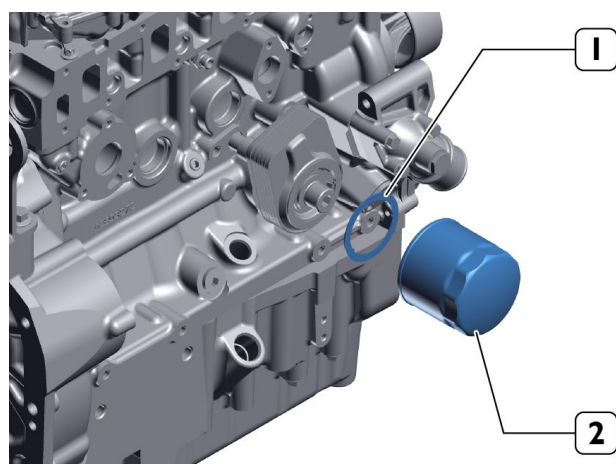
298681 43

Oil filter assembly

112. Moisten the sealing gasket (1) with a thin layer of oil and place it in its seat on the oil filter (2).
113. Tighten the oil filter (2) manually on the bracket until the sealing gasket (1) adheres.
114. Use the special tool to further tighten the oil filter (2) to torque:

Description	Quantity	Value
Oil filter	1 cartridge M27 x 2	30 +/- 3 N·m

Tool / Material	
Remover, cartridge filter	99360076



298680 44

EGR heat exchanger assembly

115. Install the studs on the crankcase and tighten them to the specified torque.

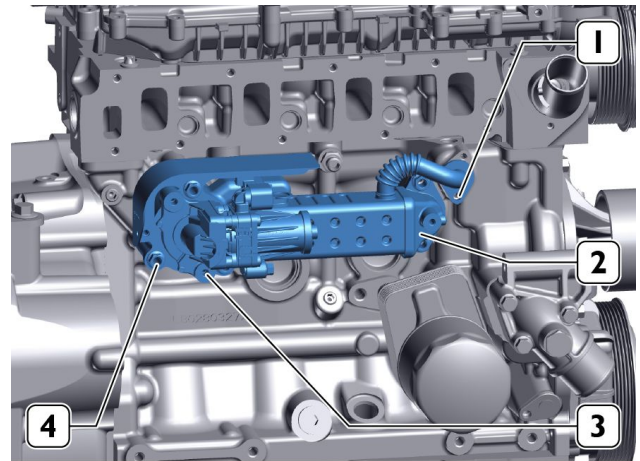
Description	Step	Value
EGR heat exchanger	5 nuts M8 x1.25	23 +/- 2.3 N·m
	1 screw M6 x 1 x 14	10 +/- 1 N·m

116. Install the EGR heat exchanger (2), inserting the gaskets, and tighten the fastening screws (1) and the nuts (4) to the prescribed torque.

Description	Quantity	Step	Value
EGR heat exchanger	5 studs M8 x 1.25 x 80		23 +/- 2.3 N·m

117. Fit the EGR valve and tighten the fastening screws (3) to the prescribed torque.

Description	Quantity	Value
EGR valve	2 screws M6 x 1 x 20	10 +/- 1 N·m



298941 45

Exhaust manifold assembly

118. Tighten the studs (4) to the specified torque:

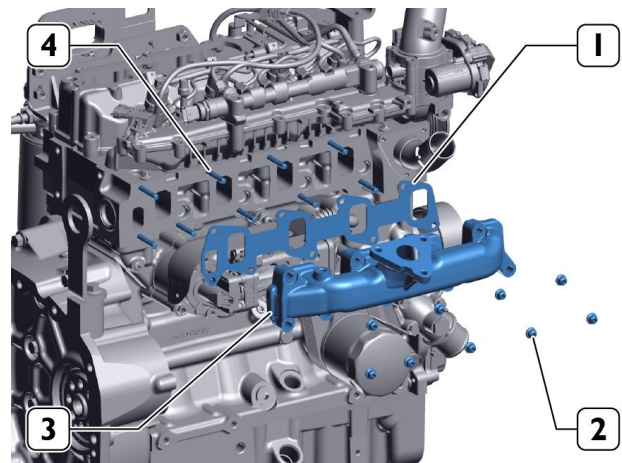
Description	Quantity	Step	Value
Exhaust manifold	9 studs M8 x 1.25 x 52		11 +/- 3 N·m

119. Position a new gasket (1) on the cylinder head studs (4).

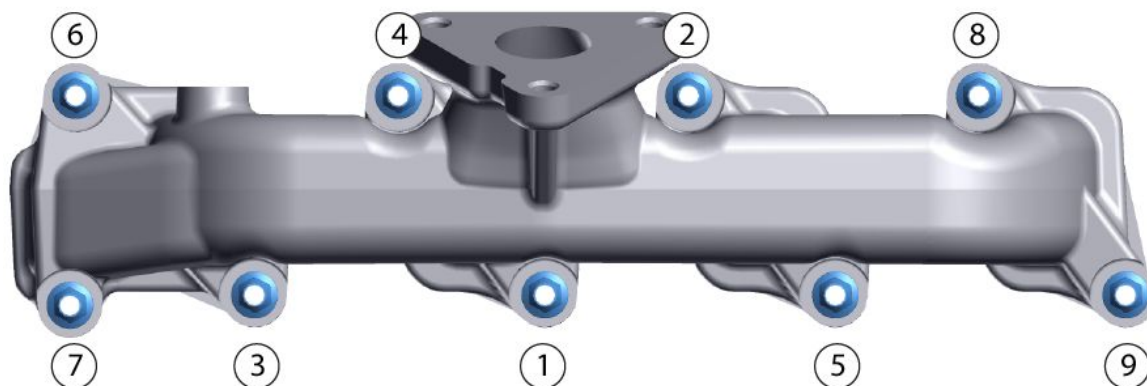
120. Fit the exhaust manifold (3) on the cylinder head studs (4) and tighten, following the tightening order indicated below in the figure, the retaining nuts (2) to the prescribed torque

NOTE: Always replace the gasket (1) with a new one at any disassembly.
check the thread of the nuts and studs: it must not show signs of wear or deposits of dirt.

Description	Quantity	Step	Value
Exhaust manifold	9 nuts M8 x 1.25	Pre-tightening	10 +/- 0,5 N·m
		Tighten	28 +/- 1.4 N·m



298679 46



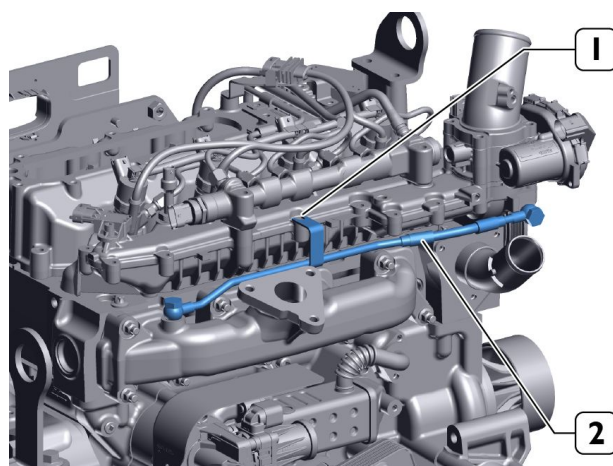
298075 47

Diagram of tightening sequence for exhaust manifold fastening screws.

121. Position the exhaust gas pipe (2) and tighten the couplings to the prescribed torque.

Description	Quantity	Value
Exhaust gas linkage pipe	2 screws M12 x 1.5 x 24	25 +/- 2.5 N·m

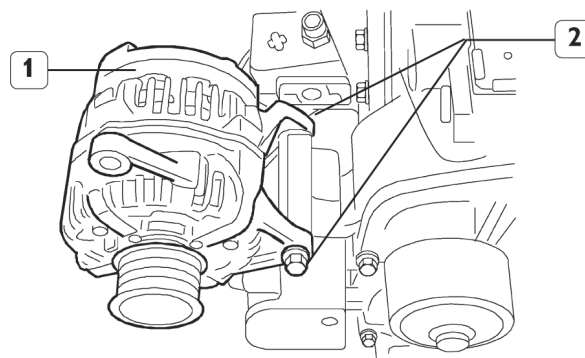
122. Tighten the screw (1) securing the bracket supporting the exhaust gas pipe which is the same the intake manifold.



298678 48

Alternator assembly

123. Put the alternator (1) back into its original position.
124. Screw in but do not tighten (2).



75686 49

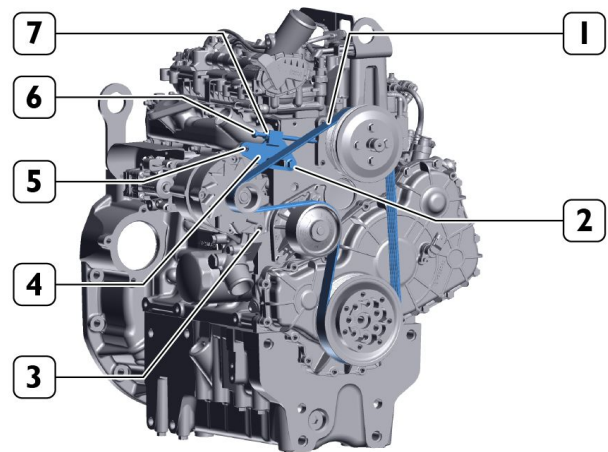
Auxiliary drive belt assembly

125. Install the tensioning bracket **(4)** and tighten the fastening **(5)** screw to the specified torque.
126. Correctly position the drive belt **(1)** on all pulleys: crankshaft pulley, water pump, alternator, fan drive pulley.
127. Tension the drive belt **(1)** and tighten the fastening screw **(6)** until the fastening screw **(2)** reaches the end of the duct that houses the bracket **(4)**.
128. Tighten the nut **(7)** and the fastening screw **(1)** to the specified torque.

Description	Step	Value
Alternator tensioning bracket	1 screw M10 x 1.5 x 20	45 +/- 4.5 N·m

129. Tighten the fastening screw **(4)** and the nut **(1)** securing the alternator to the support.

Description	Step	Value
Alternator	1 screw M10x1.5x130 + 1 nut M10 x 1.5	45 +/- 4.5 N·m
	1 screw M10 x 1.5 x 35 + 1 nut M10 x 1.5	45 +/- 4.5 N·m

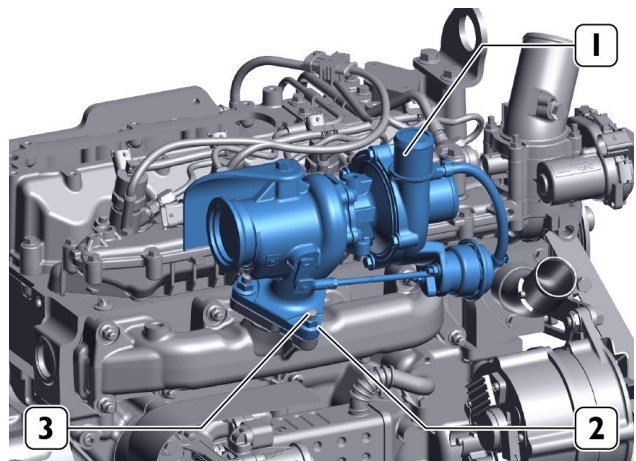


298677 50

Turbocharger assembly

130. Screw the studs **(3)** onto the exhaust manifold.
131. Fit the turbocharger **(1)** together with the wastegate valve onto the exhaust manifold and correctly position a new gasket.
132. Tighten the fastening nuts **(1)** to the prescribed torque.

Description	Step	Value
Turbocharger	3 nuts M10 x 1.5 x 10	28 +/- 1.5 N·m
	3 studs M10 x 1.5 x 40	25 +/- 1.25 N·m



298676 51

Installation of lubricant oil delivery and return pipe from turbocharger

133. Fit a new gasket and tighten the screws (6) securing the lubricant oil return pipe (3) to the turbocharger.

Description	Quantity	Step	Value
Lubricant return pipe from turbocharger	2 screws M6 x 1 x 20		10 +/- 1 N·m

134. Introduce the lubricant oil return pipe (3) from the turbocharger into the engine crankcase with a new sealing ring.

135. Install the fixing bracket of the pipe (3) to the crankcase and tighten the fastening screw (2) to the specified torque.

Description	Quantity	Step	Value
Lubricant oil return pipe from turbocharger bracket	1 screw M6 x 1 x 10		10 +/- 1 N·m

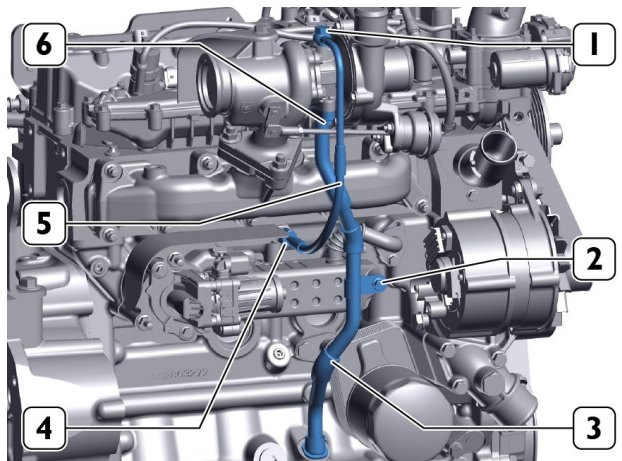
136. Install the lubricant oil delivery pipe (5) connecting the crankcase to the turbocharger and tighten the fittings (1) and (3) to the specified torque.

Description	Step	Value
Lubricant delivery pipe to turbocharger	1 screw M10 x 1 x 19	25 +/- 2,5 N·m
	1 nut M14 x 1.5	35 +/- 3.5 N·m

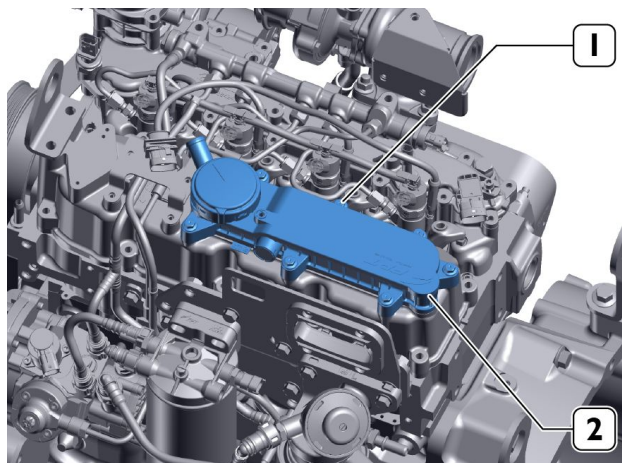
Blow-by filter unit assembly

137. Fit the blow-by filter unit (2) and tighten the fastening screws (1) to the prescribed torque.

Description	Step	Value
Blow-by filter	7 screws M6 x 1 x 13	10 +/- 2 N·m

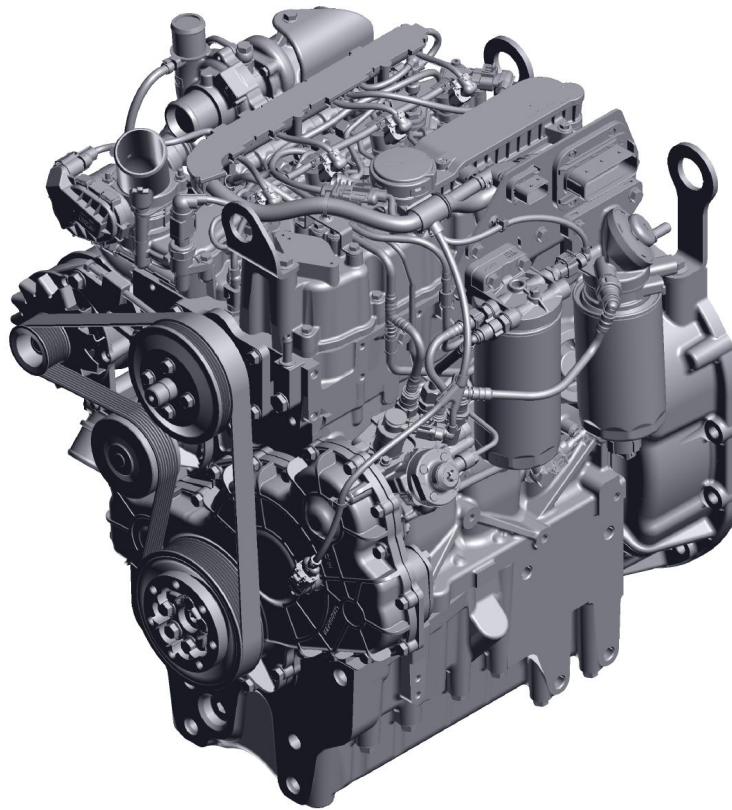


298675 52



298031 53

Removing the rotating stand



298021 54

138. Unscrew the fastening screws from the brackets on the rotating stand.
139. Lift the engine from the rotating stand using the lifting hooks, beam and hoist.
140. Unscrew the fastening screws and remove the brackets from the engine crankcase.

Tool / Material	
Assemblies overhaul revolving stand (bearing capacity 1000 daN, torque 120 daNm)	99322205

Tool / Material	
Brackets fixing engine to revolving stand 99322205	99361044

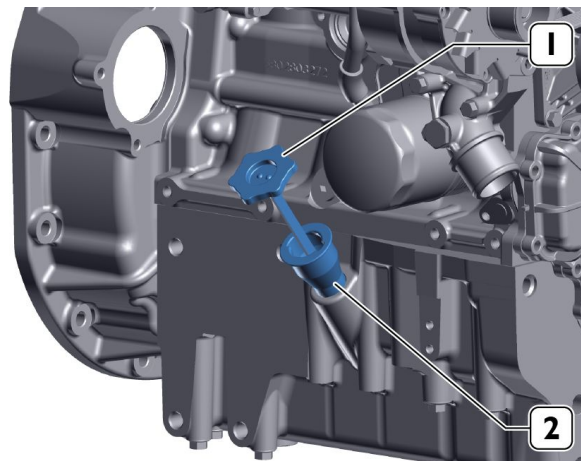
141. Tighten the oil drain plug housed in the lower part of the sump and tighten to the specified torque.

Description	Quantity	Step	Value
Lubricant oil drain plug in the sump	2 caps M22 x 1.5 x 12		50 +/- 5 N·m

142. Top up with lubricant oil through the designated oil filler hole on the oil sump observing the quantities and quality as indicated in the section **ENGINE - Technical Data (54.01)**..

Removing the oil level dipstick and its housing

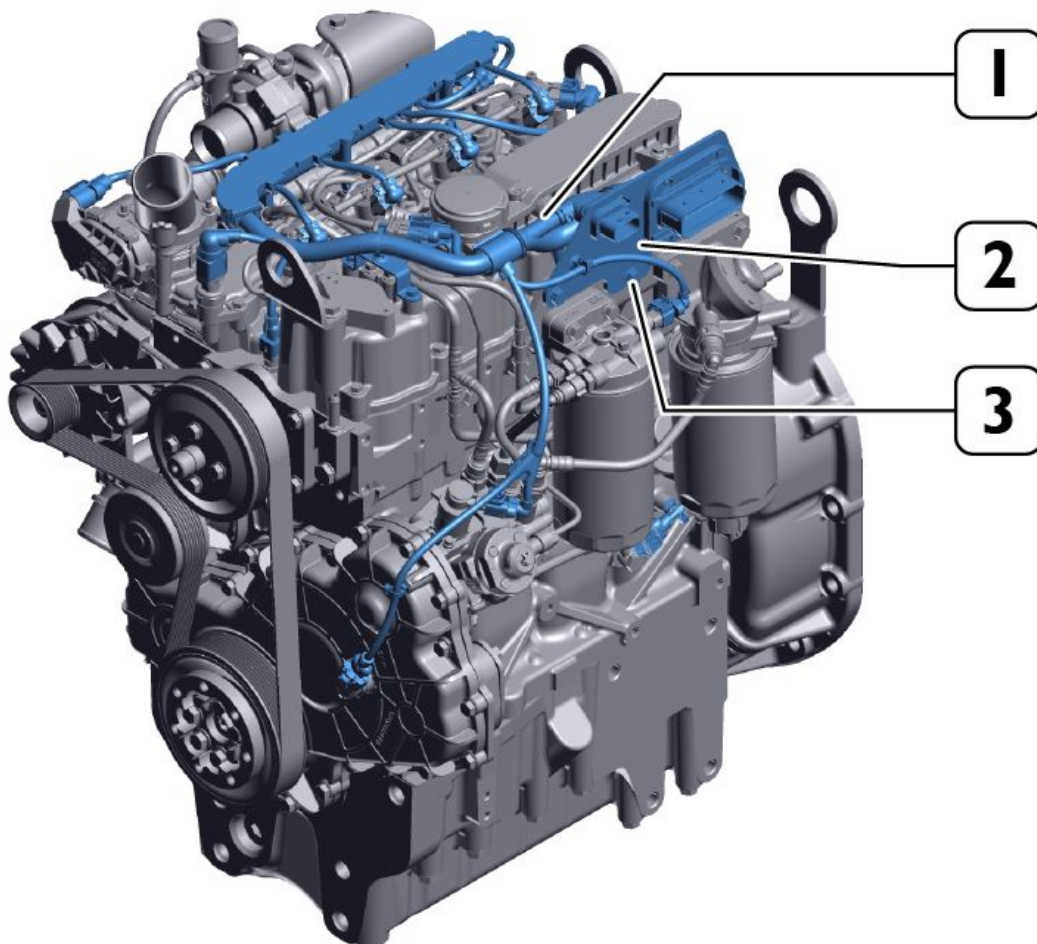
143. Install the housing (2) and insert the oil dipstick (1).



298674 55

Fitting the engine cable

144. Arrange the engine cable (1) correctly and fasten all engine cable fastening clips. Connect the engine cable to the control unit and all sensors and transmitters shown in the figure



298665 56

145. Tighten the fastening screws **(2)** of the bracket **(3)** securing the engine wiring to the specified torque.

Description	Quantity	Value
Engine cable fixing bracket	3 screws M8 x 1.25 x 20	23 +/- 2.3 N·m

Checks and inspections

NOTICE: The following checks must be executed after the engine has been installed on the vehicle. Check that the fluid top-ups and refilling operations have been completed to the specified levels.

146. Start the engine and keep it running at slightly above idle speed and wait for the coolant temperature to reach the specified value for the thermostat valve to open and then check the following.
147. Check for water leakage from the connecting manifolds of the engine cooling circuit pipes and cab interior heating pipes, if necessary tighten the O-rings further.
148. Carefully check the fuel filter pipe fittings.
149. Check that there are no oil leaks from the cylinder head and cover, the oil sump and crankcase, heat exchanger oil filter and relative housings between the various pipes of the lubrication circuit.
150. Check that there are no fuel leaks from the fuel pipes.
151. Check that there are no air leaks from the pneumatic pipes (if fitted).
152. Check the correct operation of the warning lights on the instrument panel and equipment disconnected when the engine was disconnected.
153. Check and carefully bleed the engine cooling system by repeatedly draining it.

540110 ENGINE - Visual inspection

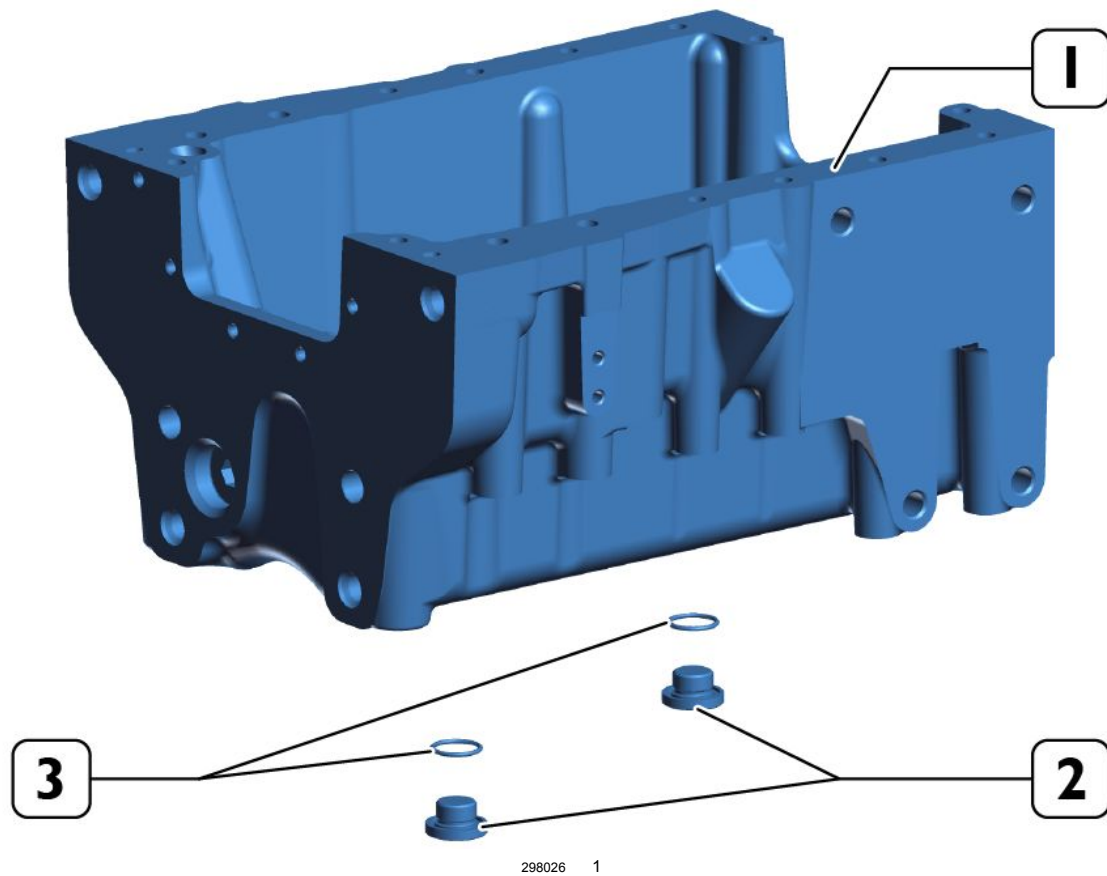
Before starting the engine, carry out the following checks:

- Checking the levels and checking for any leaks from the fuel, cooling and lubrication circuits.

After starting the engine and with the engine running, perform the following checks and inspections:

- check for any leaks from the fuel, coolant and lubricant circuits.
- Make sure that there are no unusual noises or clinks while the engine is running.
- Visually check the exhaust smoke (colour of the exhaust emissions).
- Visually check the coolant level in the expansion tank.

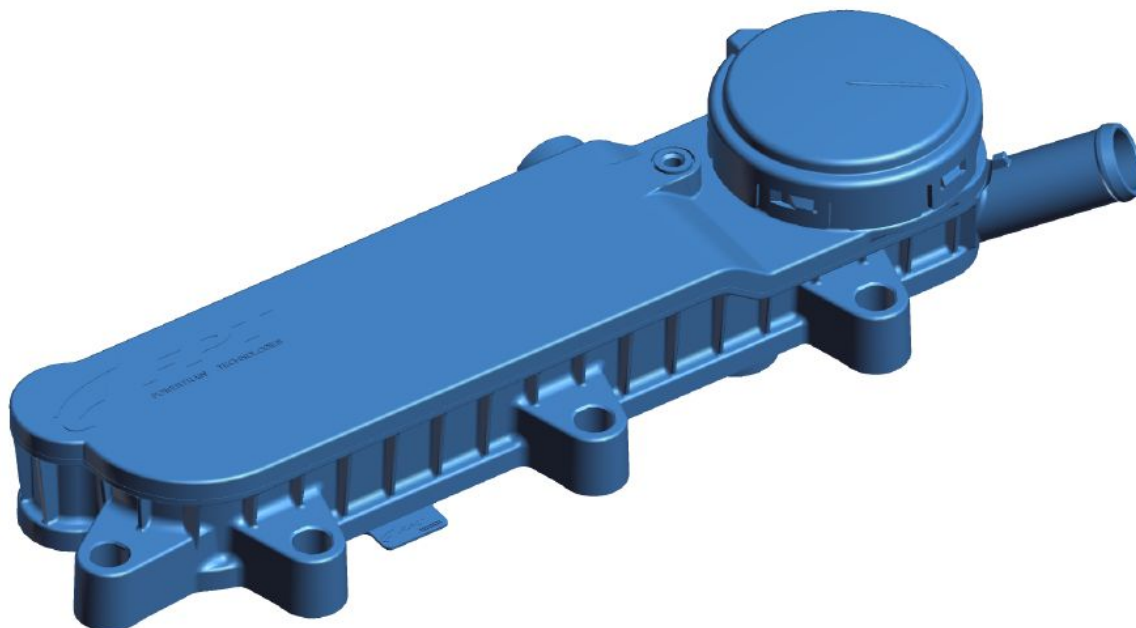
540430 OIL SUMP - Overview



298026 1

1. Oil sump gasket
2. Oil drain plugs on sump
3. Oil drain plug gaskets on sump

540480 ENGINE BREATHER - Overview - Oil vapour recirculation system



298027 1

The oil vapour recirculation circuit permits the separation and the condensation of the oil vapours contained in the gas originating from the crankcase for recovery in the sump. The remaining gas is then introduced in the intake circuit to be again burnt in the combustion chamber.

This gas consists of a mixture of air, combustion vapours and lubricant.

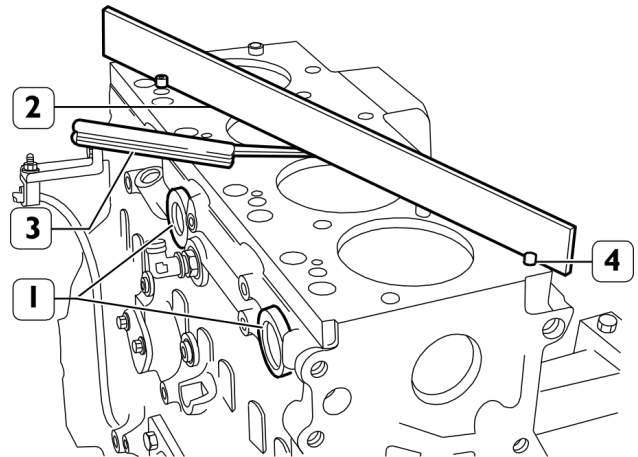
The gas originating from the crankcase rises up to the cylinder head, and is sent to the blow-by filter blow-by by the separator located inside the tappet cover, whose form and position determines an increase in the release speed of the oil vapours and at the same time condensates a part of them.

The condensed oil returns to the sump while the residual steam is directed, collected and filtered in the blow-by filter .

An additional part of the vapours condense in the blow-by filter and return to the oil sump via the channel whereas the remaining part is not released into the atmosphere but is recirculated in the intake through the breather pipe .

540410 ENGINE BLOCK - Check

1. Check that the cylinder head face, on the crankcase, does not present deformations.
2. This check can be carried out, after having removed the dowel pins (4) with a calibrated rule (2) and feeler gauge (3).
3. After ascertaining the areas of deformation, correct the contact surface with a grinding machine.
4. Planarity error shall not exceed:



70170 1

Technical data

Planarity error	0.075 mm
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NOTE: Crankcase levelling shall be performed only after checking that piston protrusion from the cylinder is not exceeding the specified value.

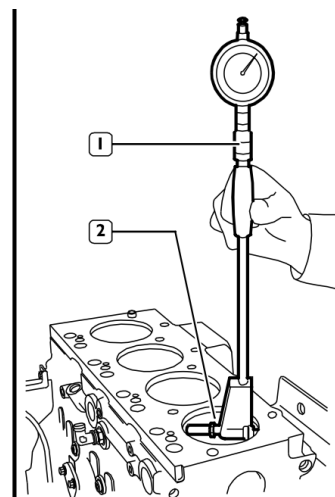
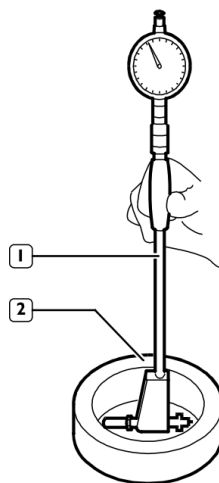
5. Check the state of the cylinder assembly (1) machining plugs; if they are rusty or there is any doubt at all about their seal, change them.
6. When levelling is completed, reset cylinders liner chamfer as shown in the figure.

540420 CYLINDER BARRELS - Check

Description	Quantity	Step	Value
Crankshaft main bearing caps	10 screws M12 x 1.5 x 120	Step 1 — Pre-tightening	50 +/- 6 N·m
		Step 2 — Tighten	80 +/- 6 N·m
		Step 3 — Angle tightening	90°

Cylinder liner checks and measurements

- Once the engine is disassembled, thoroughly clean the cylinder-crankcase assembly.
- Use the proper rings to handle the cylinder block.
- Check thoroughly that no cracks are to be noticed on the crankcase.
- Check the condition of casting hole plugs. If the caps are rusted or there is any doubt over the efficiency of the seal the produce, replace the caps with new ones.
- Inspect the surfaces of the cylinder sleeves; they should not be scored, seized, ovalised, conical or worn to excess.



70166 1

General prescriptions

If a ring gauge is not available, zero using a micrometer.

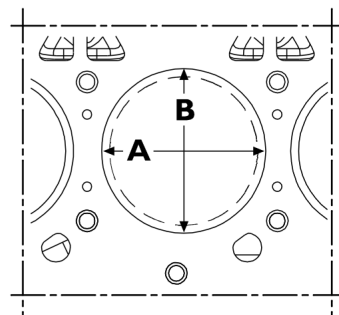
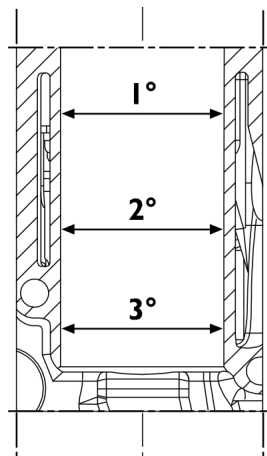


Partial or complete non observance of these prescriptions can lead to serious damages to the vehicle

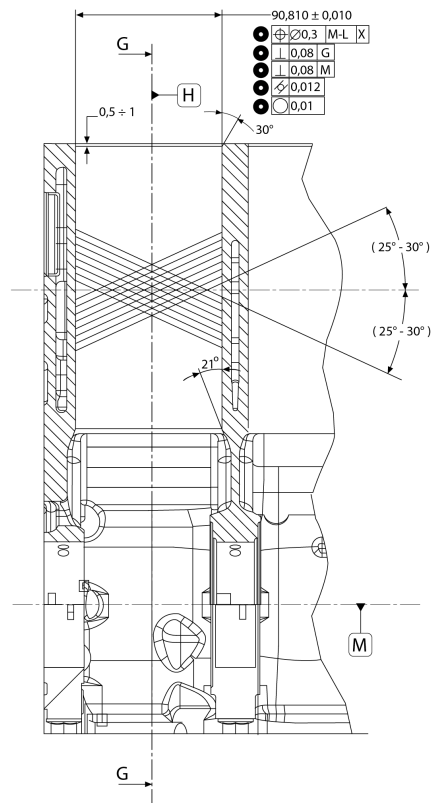
The internal diameter of the cylinder liners is checked to ascertain the extent of ovalisation, taper and wear, using the bore meter (1) fitted with a dial gauge previously reset on the ring gauge (2) of the diameter of the cylinder liner.

- Measurements shall be performed on each cylinder, at three different heights in the bore and on two planes perpendicular with each other: one parallel to the longitudinal axis of the engine (A) and the other perpendicular to it (B); the greatest wear is usually found to be on this surface and during the first measurement.
- Should ovalization, taper or wear be found, bore and grind the cylinder liners. The refacing of the cylinder liners should be made in relation to the diameter of the pistons supplied as spare parts oversized by 0.4 mm and to the prescribed assembly clearance.

NOTE: When refacing, all pipes must have the same increase (0.4 – 0.8 mm).



70167 2



298059 3

8. Check main bearing housings as follows:
9. Fit the main bearings caps on the supports without bearings.
10. Tighten the fastening screws to the required torque value.

Description	Quantity	Step	Value
Crankshaft main bearing caps	10 screws M12 x 1.5 x 120	Step 1 — Pre-tightening	50 +/- 6 N·m
		Step 2 — Tighten	80 +/- 6 N·m
		Step 3 — Angle tightening	90°

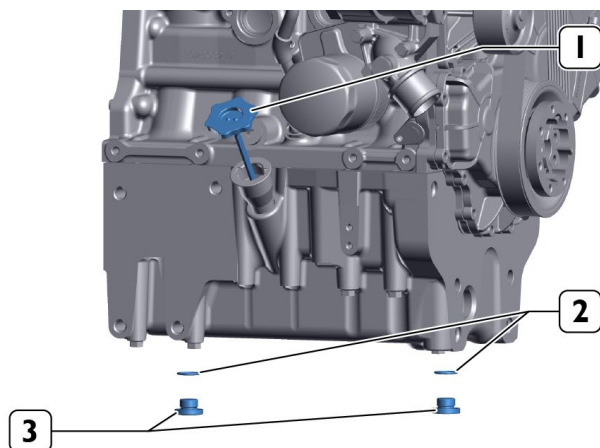
11. Use the proper internal gauge to check whether the seat diameter is falling within the specified value.
12. Replace crankcase if higher value is found.

540430 OIL SUMP - Remove

1. Position an appropriate container for the oil collection below the sump in line with the drain plugs (3).

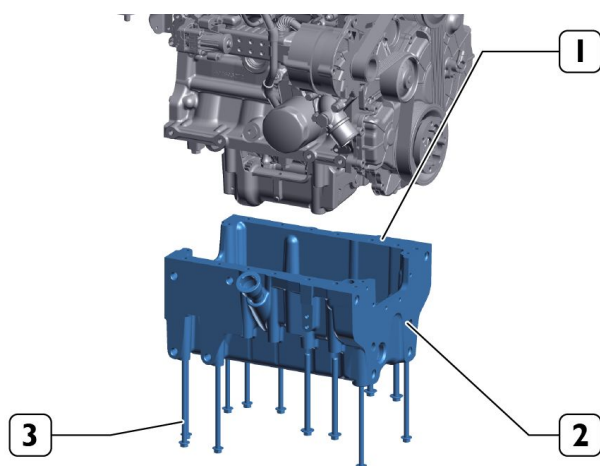
NOTE: It is recommended that the oil is drained while hot.

2. To make the oil flow easier, unscrew the filler plug (1) and remove the oil dipstick .
3. Unscrew the drain plugs (3), recovering the gaskets (2) and let the lubricant contained in the oil sump flow out completely.



298028 1

4. Unscrew the fastening screws (3) and remove the oil sump (2) recovering the gasket (1).



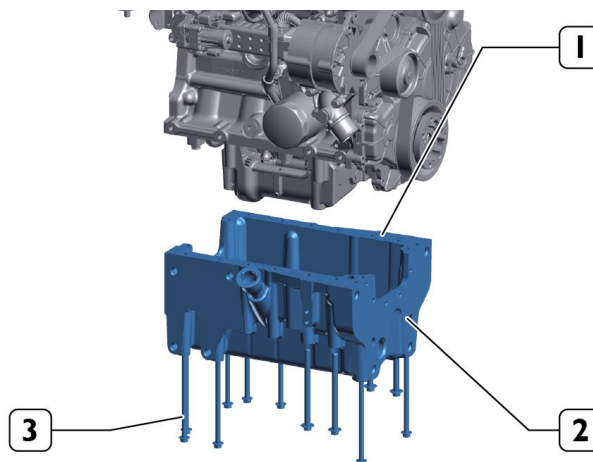
298029 2

540430 OIL SUMP - Install

Description	Quantity	Step	Value
Engine oil sump	4 screws M12 x 1.75 x 160	Step 1 —	85 +/- 4.25 N·m
		Step 2 — Angle tightening	60°
Lubricant oil drain plug in the sump	2 caps M22 x 1.5 x 12		50 +/- 5 N·m

- Position the gasket (1) on the oil sump (2).
- Fit the oil sump (2) in position on the crankcase and tighten the fastening screws (3) to the torque specified and in the order shown in the figure 2.

Description	Quantity	Step	Value
Engine oil sump	8 screws M10 x 1.5 x 230	Step 1 —	40 +/- 2 N·m
		Step 2 — Angle tightening	90°
		Step 3 — Angle tightening	90°
Engine oil sump	4 screws M10 x 1.5 x 160	Step 1 —	40 +/- 2 N·m
		Step 2 — Angle tightening	60°
		Step 3 — Angle tightening	60°
Engine oil sump	4 screws M12 x 1.75 x 160	Step 1 —	85 +/- 4.25 N·m
		Step 2 — Angle tightening	60°



298029 1

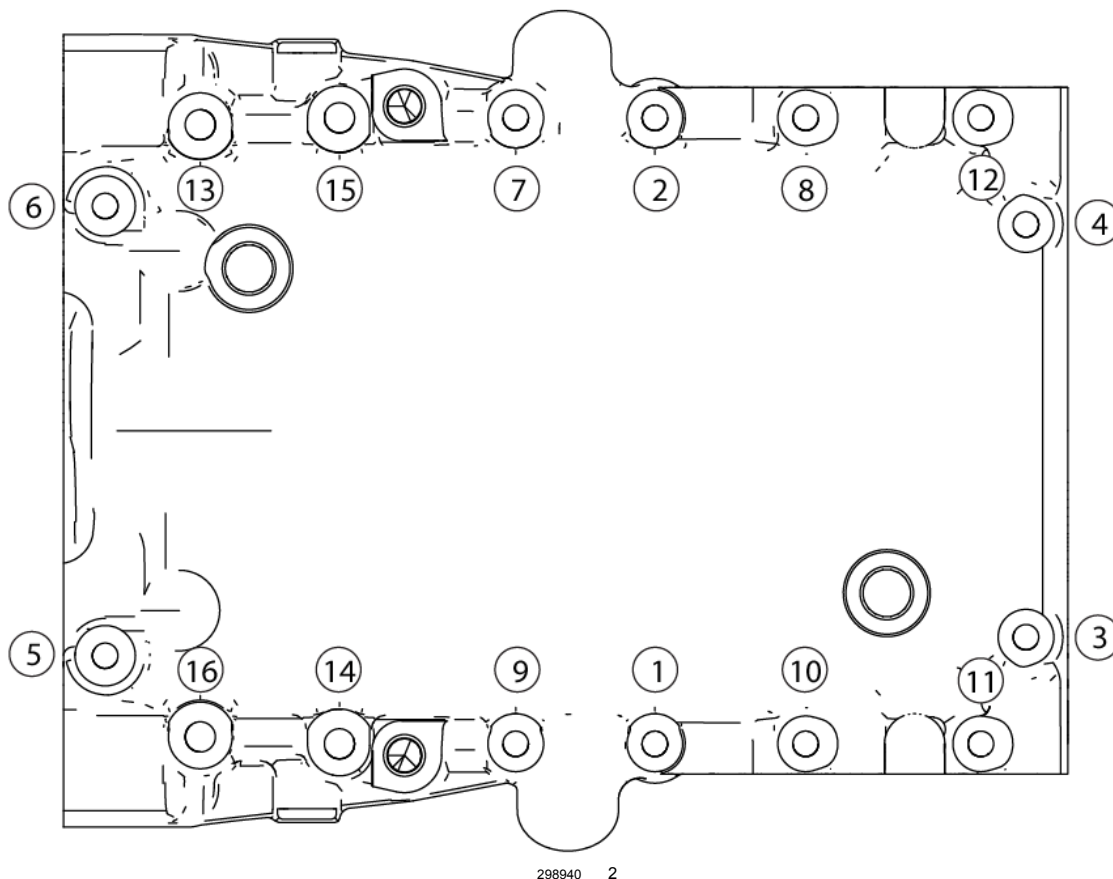


Diagram of the tightening sequence for oil sump fastening screws.

General prescriptions



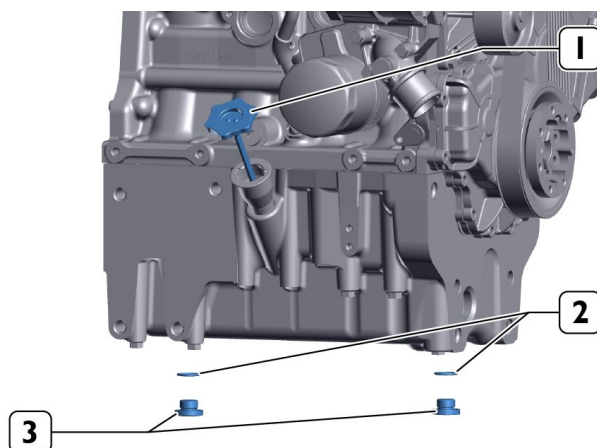
For correct engine operation, only use recommended oils or oils with the required characteristics. In the case of refilling, do not mix oils with different characteristics. Failure to observe these indications will void the guarantee.

Failure to comply completely or partially with these requirements may result in the risk of serious damage to the engine and may even, on occasion, invalidate the warranty

3. Using new gaskets (2), screw down the drain plugs (3) into the oil sump and tighten to the specified torque.

Description	Quantity	Step	Value
Lubricant oil drain plug in the sump	2 caps M22 x 1.5 x 12		50 +/- 5 N·m

4. Fill with clean oil through the filler pipe and check the oil level using the dipstick (1): the level must come close to the MAX notch which can be seen on the dipstick. Otherwise top-up with the necessary quantity through the filler pipe, then tighten the filler plug (1).



540442 CRANKSHAFT FRONT GASKET - Remove

Tool / Material	
Tool for removing gaskets	99363204
Tool to remove crankshaft front gasket	99340055

Prior operation:

DRIVE PULLEY ON CRANKSHAFT - Remove (54.08)

Crankshaft front seal ring removal

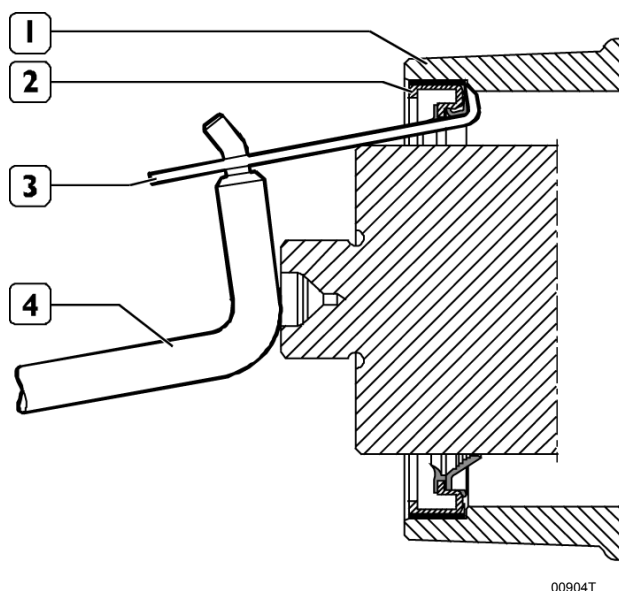
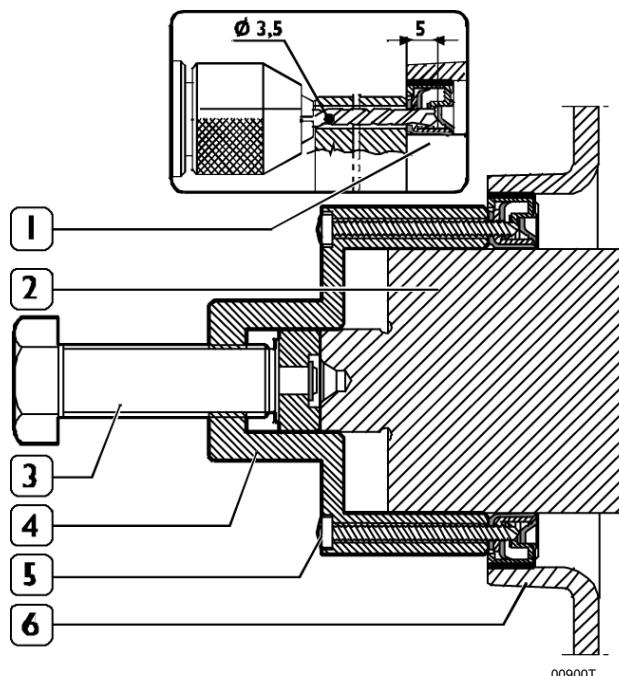
- To remove the seal ring (1) of the crankshaft (2) from the front cover (6) apply the specific tool (4) on the front tang of the crankshaft (2) and, through the guide holes of the tool, drill the internal seal ring (1) with a drill bit ($\varnothing 3.5$ mm) at a depth of 5 mm.

Tool / Material	
Tool to remove crankshaft front gasket	99340055

- Fasten the tool (4) to the inner seal ring (1) by screwing the 6 provided screws (5). Proceed with the removal of the inner seal ring (1) by tightening the screw (3).

- Use a tie rod (3) for the specific tool and a lever (4) to remove the external seal ring (2) from the front cover (1).

Tool / Material	
Tool for removing gaskets	99363204



540442 CRANKSHAFT FRONT GASKET - Install

Tool / Material

Key for crankshaft front gasket installation and and timing cover centering

99346270

Crankshaft front seal ring refitting

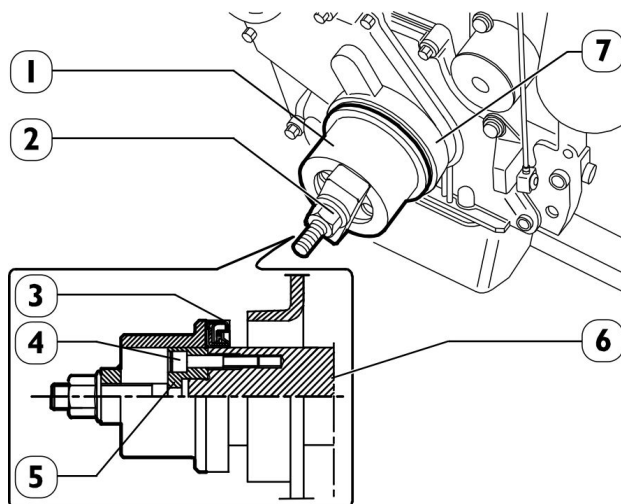
1. Apply the part (5) of the special tool to the front crankshaft tang (6) securing it with the screws (4) and keying it onto the new sealing ring (3).

Tool / Material

Key for crankshaft front gasket installation and and timing cover centering

99346270

2. Position part (1) on part (5), tighten the nut (2) until the crankshaft seal ring (3) is fully installed on the front cover (7).



70225 1

Next operation:

DRIVE PULLEY ON CRANKSHAFT - Install (54.08)

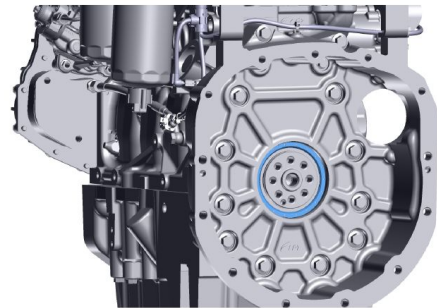
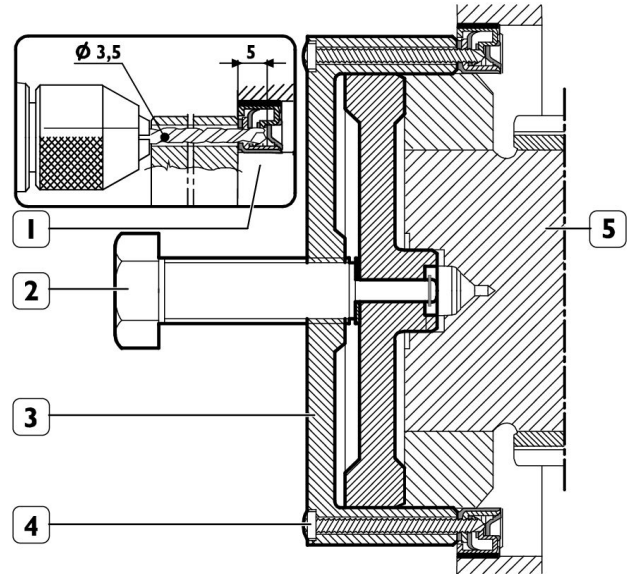
540462 CRANKSHAFT REAR GASKET - Remove

Prior operation:

Remove the flywheel

Crankshaft rear seal ring removal

1. To extract the crankshaft seal ring from the flywheel housing apply a suitable puller (3) on the rear tang (5).
2. Through the tool guide holes, drill the internal seal ring with a drill bit ($\varnothing 3.5$ mm) to a depth of 5 mm.
3. Extract the ring (1) by screwing the screw (2).
4. Use the special tie rod of the tool and a lever to extract the external seal ring from the flywheel housing.



298030 1

540462 CRANKSHAFT REAR GASKET - Install

Tool / Material

Crankshaft rear seal installer

99346259

Crankshaft rear seal ring refitting

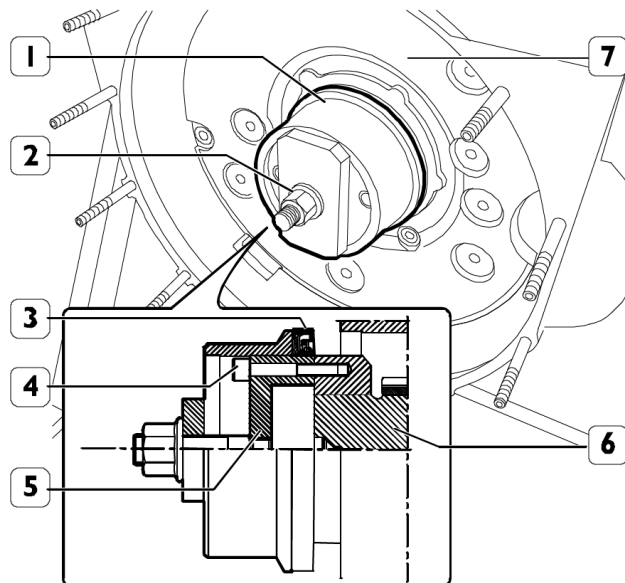
1. Apply the part (5) of the special tool to the rear crankshaft tang (6) securing it with the screws (4) and fit the new seal ring (3).

Tool / Material

Crankshaft rear seal installer

99346259

2. Position part (1) on part (5) and screw down the nut (2) to fit the seal fully (3) in the flywheel housing (7).



000901T 1

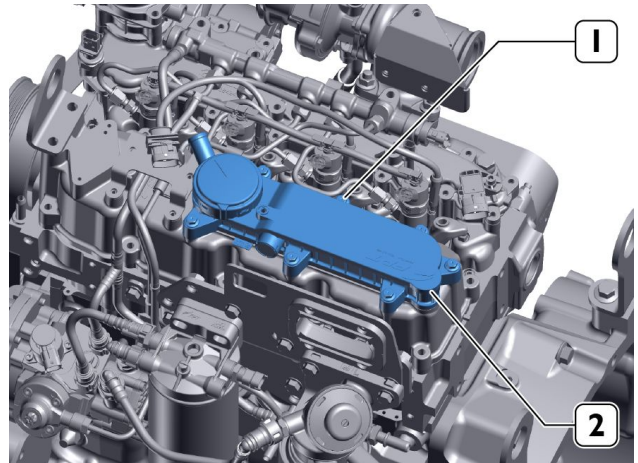
Next operation:

Fit the flywheel

540480 ENGINE BREATHER - Remove

Blow-by filter removal

1. Position a suitable container to collect the oil. Unscrew the fastening screws (1) and remove the blow-by filter unit (2).



298031 1

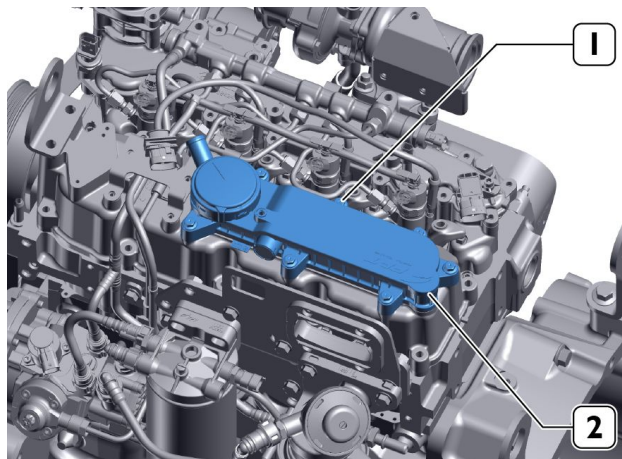
540480 ENGINE BREATHER - Install

Description	Step	Value
Blow-by filter	7 screws M6 x 1 x 13	10 +/- 2 N·m

Blow-by filter installation

1. Install the blow-by filter unit **(2)** and tighten the fastening screws **(1)** to the specified torque.

Description	Step	Value
Blow-by filter	7 screws M6 x 1 x 13	10 +/- 2 N·m



298031 1

540610 CYLINDER HEAD - Remove

Prior operation:

Position a suitable container to catch any fuel.

Prior operation:

Remove the engine cable as described in the procedure **ENGINE CABLES - Remove (76.91)** .

Prior operation:

Remove the exhaust manifold as described in the procedure **EXHAUST MANIFOLD - Remove (54.07)**.

Prior operation:

Remove the supply system as described in the procedure **HIGH PRESSURE ACCUMULATOR - Remove (77.45)** .

Prior operation:

Remove the intake manifold as described in the procedure **INTAKE MANIFOLDS - Remove (54.07)**.

Prior operation:

Remove the fuel filter bracket as described in the procedure **FILTER SUPPORT - Remove (54.20)** .

Prior operation:

Remove the injectors as described in the procedure **INJECTOR - Remove (77.50)**.

Prior operation:

Remove the glow plugs as described in the procedure **PREHEATER PLUGS - Remove (76.19)**.

Prior operation:

Remove the valves and rocker arm assembly as described in the procedure **ROCKER ARM ASSY - Remove (54.12)**.

Prior operation:

Remove the drive belt as described in the procedure **WATER PUMP DRIVE BELT - Remove (54.34)**.

Prior operation:

Remove the alternator as described in the procedure **ALTERNATOR ASSEMBLY - Remove (76.03)**.

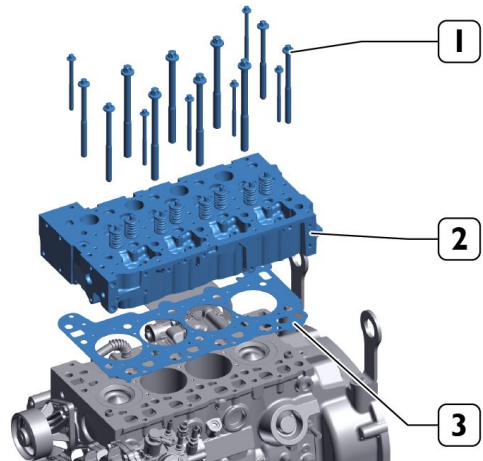
Prior operation:

Remove the fan drive pulley bracket as described in the procedure **FAN HUB MOUNT - Remove (54.34)**.

Prior operation:

Remove the thermostat unit as described in the procedure **THERMOSTAT - Remove (54.32)** .

1. Unscrew the screws **(1)** and remove the cylinder head **(2)**, recovering the gasket **(3)**.



298032 1

540610 CYLINDER HEAD - Check

Prior operation:

VALVES - Disassemble (54.06)

Checking cylinder block head contact surface

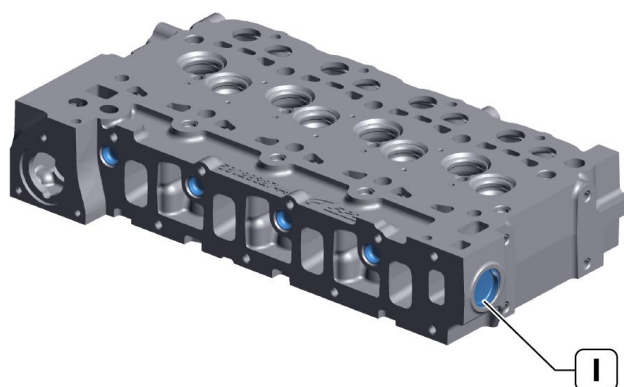
1. After having identified any deformed areas, regrind the head mating surface using a grinder.
2. Planarity error must not exceed **0.075 mm**.
3. Check the condition of the cylinder assembly caps: replace them if they are oxidised or if there is any doubt regarding their seal.

Checking moistened cylinder head gasket

4. This check must be carried out with the designated tools.
5. Use a pump to fill with water heated to approx. **90 °C** and at a pressure of **2 – 3 bar**.
6. Replace the spring seat plugs (1) if they are found to leak, using a suitable drift for their removal/installation.

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

7. Replace if there are any leaks from the cylinder head.



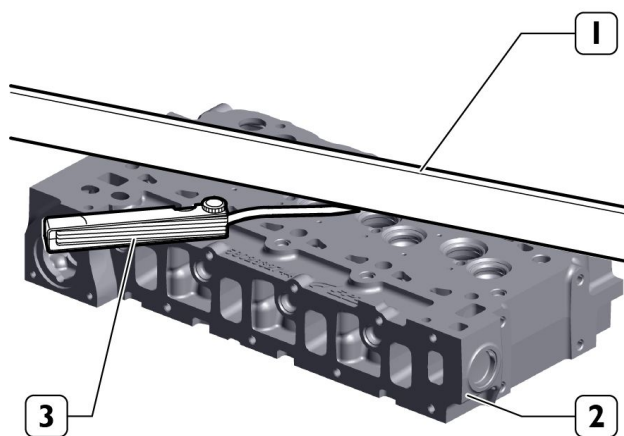
298308 1

Cylinder head contact surface check

8. Check the supporting surface of the head (2) on the cylinder block with a rule (1) and a feeler gauge (3).

NOTE: Distortion found along the whole cylinder head shall not exceed **0.20 mm**.

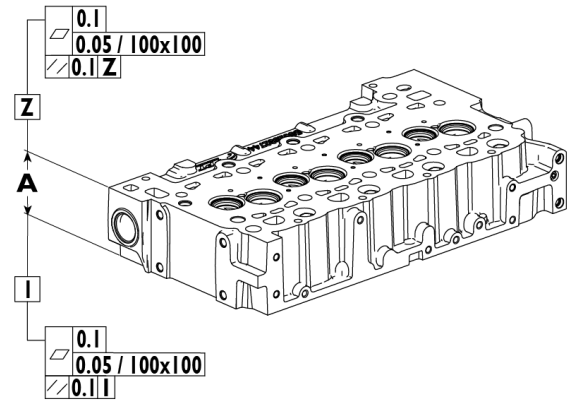
9. If higher values are found grind the cylinder head according to values and indications shown in the following figure.



298310 2

10. Check that the nominal thickness (**A**) of the cylinder head is **90 +/- 0.1 mm**.
11. If removing material from the contact surface of the cylinder head do not exceed the maximum allowed value (**B**) **0.13 mm**.

NOTE: After regrinding, check the valve recessing and if necessary regrind the valve seats to meet the prescribed valve recess.



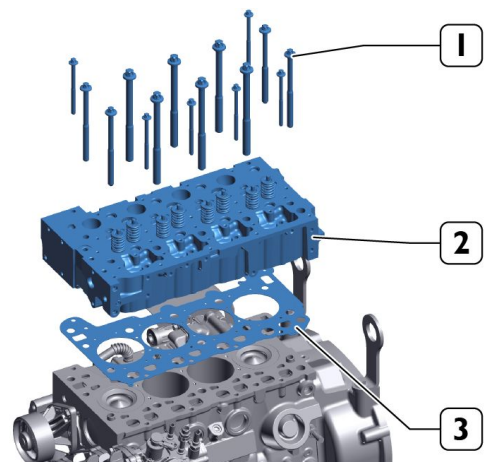
298309 3

540610 CYLINDER HEAD - Install

Description	Quantity	Step	Value
Cylinder head	4 screws M12 x 1.5 x 165	Step 1 —	65 +/- 3,25 N·m
		Step 2 — Angle tightening	90°
		Step 3 — Angle tightening	60°

1. Check that the mating surfaces of the head seal and crankcase are clean.
2. Keep the cylinder head gasket clean.
3. Correctly position the gasket (3) of the cylinder head with the shim shown in the section **ENGINE - Technical Data (54.01)**, with the word "TOP" facing the head.

NOTE: It is essential to keep the gasket sealed in its package until just before assembly.



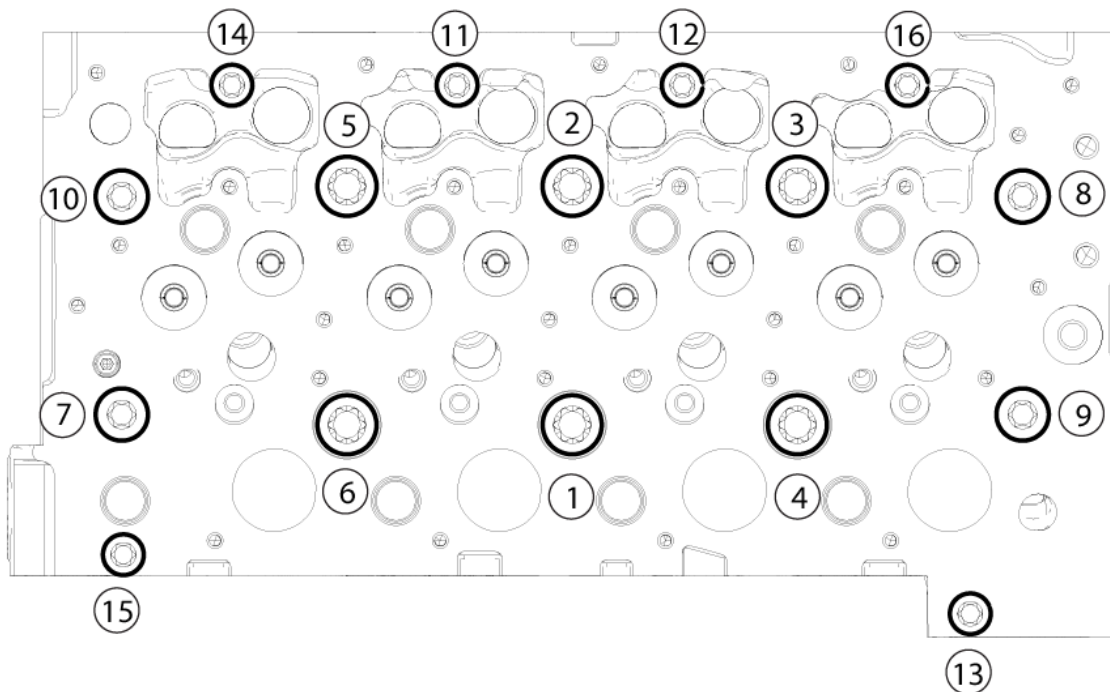
298032 1

NOTE: Always check that the screw threads and holes show no sign of wear or dirt prior to assembly.

4. Fit the cylinder head and tighten the new fastening screws (1) to the specified torque.

Description	Quantity	Step	Value
Cylinder head	6 screws M15 x 1.5 x 193	Step 1 —	130 +/- 6.5 N·m
		Step 2 — Angle tightening	90°
		Step 3 — Angle tightening	90°
Cylinder head	6 screws M8 x 1.25 x 117		34 +/- 3.4 N·m
Cylinder head	4 screws M12 x 1.5 x 165	Step 1 —	65 +/- 3,25 N·m
		Step 2 — Angle tightening	90°
		Step 3 — Angle tightening	60°

HEAD SCREWS TIGHTENING SEQUENCE



298073 2

Diagram of the tightening sequence of the cylinder head fastening screws.

Next operation:

Remove the thermostat assembly as described in the procedure **THERMOSTAT - Install (54.32)**.

Next operation:

Remove the fan drive pulley mount described in the procedure **FAN HUB MOUNT - Install (54.34)**.

Next operation:

Fit the alternator as described in the procedure **ALTERNATOR ASSEMBLY - Install (76.03)**

Next operation:

Fit the drive belt as described in the procedure **WATER PUMP DRIVE BELT - Install (54.34)**

Next operation:

Fit the valves and rocker arm assembly as described in the procedure **ROCKER ARM ASSY - Install (54.12)**.

Next operation:

Fit the glow plugs as described in the procedure **PREHEATER PLUGS - Install (76.19)**

Next operation:

Fit the injectors as described in the procedure **INJECTOR - Install (77.50)**

Next operation:

Fit the fuel filter bracket as described in the procedure **FILTER SUPPORT - Install (54.20)**

Next operation:

Install the intake manifold as described in the procedure **INTAKE MANIFOLDS - Install (54.07)**.

Next operation:

Fit the fuel supply system as described in the procedure **HIGH PRESSURE ACCUMULATOR - Remove (77.45)**.

Next operation:

Fit the exhaust manifold as described in the procedure **EXHAUST MANIFOLD - Install (54.07)**

Next operation:

Fit the engine breather assembly **ENGINE BREATHER - Install (54.04)** .

Next operation:

Fit the engine cable as described in the procedure **ENGINE CABLES - Install (76.91)**.

540630 ROCKER COVER - Remove

Prior operation:

Remove the engine cable as described in the procedure **ENGINE CABLES - Remove (76.91)**.

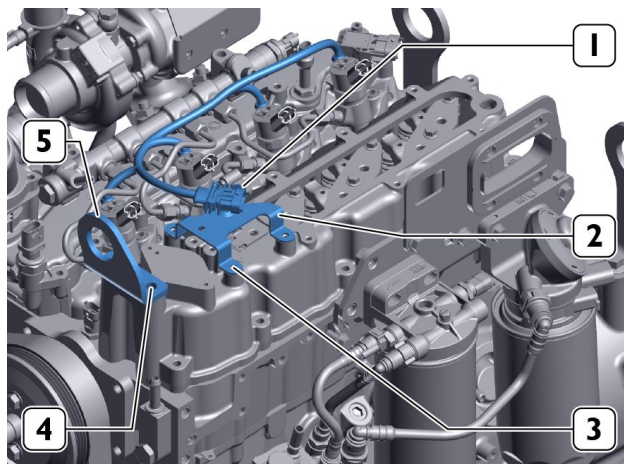
Prior operation:

Disconnect the fuel pipes as described in the procedure **PIPES - Remove (54.20)**.

Prior operation:

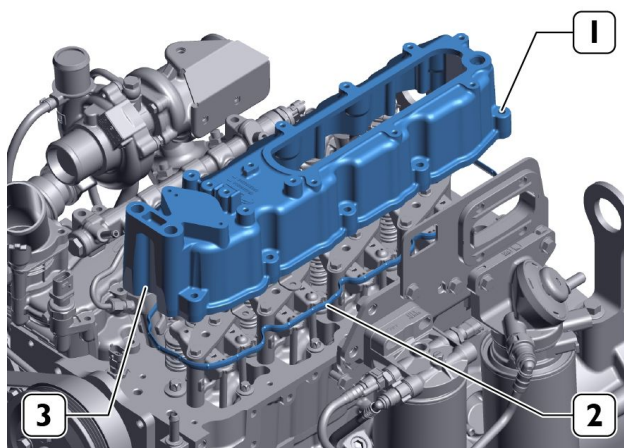
Remove the engine breather filter unit as described in the procedure **ENGINE BREATHER - Remove (54.04)**.

1. Disconnect the wiring of the glow plugs (1).
2. Unscrew the screws (3) and remove the glow plug wiring retainer bracket (2).
3. Unscrew the screws (4) and remove the lifting eyelet (5).



298033 1

4. Unscrew the screws (1) and remove the tappet cover (3) recovering the gasket (2).



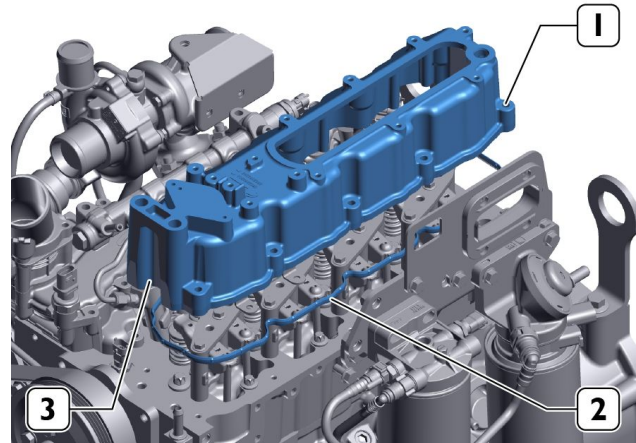
298034 2

540630 ROCKER COVER - Install

Description	Quantity	Step	Value
Glow plug harness mount	3 screws M6 x 1 x 14		10 +/- 1 N·m
Head cover	10 screws M6 x1 x 40		10 +/- 1 N·m
Lifting eyelets	2 screws M12 x 1.75 x 25		118 +/- 11.8 N·m

- Fit a new gasket (3) on the tappet cover (2).
- Install the tappet cover (3) with a new gasket (2) and tighten the screws (1) to the specified torque.

Description	Quantity	Step	Value
Head cover	10 screws M6 x1 x 40		10 +/- 1 N·m



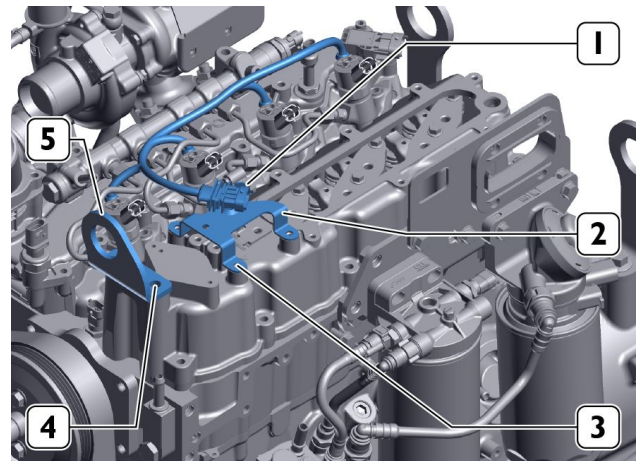
298034 1

- Position the lifting eyelet (5) and tighten the screws (4) to the specified torque.

Description	Quantity	Value
Lifting eyelets	2 screws M12 x 1.75 x 25	118 +/- 11.8 N·m

- Position the glow plug wiring retainer bracket (2) and tighten the screws (3) to the prescribed torque.

Description	Quantity	Value
Glow plug harness mount	3 screws M6 x 1 x 14	10 +/- 1 N·m



298033 2

Next operation:

Fit the engine breather filter unit as described in the procedure **ENGINE BREATHER - Install (54.04)**.

Next operation:

Connect the fuel pipes as described in the procedure **PIPES - Install (54.20)**.

Next operation:

Fit the engine cable **ENGINE CABLES - Install (76.91)**.

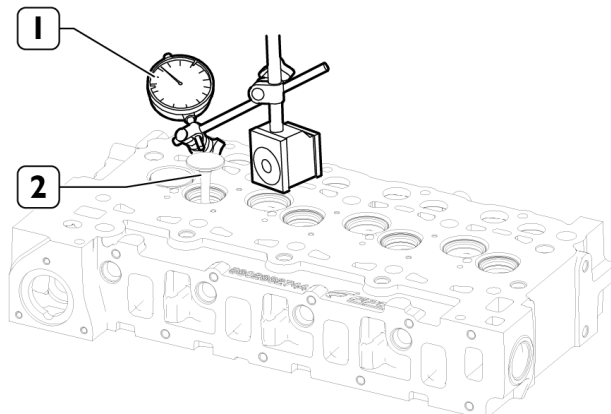
540661 VALVE SEAT - Check

Prior operation:

VALVES - Disassemble (54.06)

Checking clearance between valve stem and valve guide and centring valves

1. Insert the valve **(2)** in its seat and let the head protrude about ten millimetres.
2. The checks are made using a magnetic comparator **(1)** positioned as shown, the assembly clearance is:



298035 1

Valve	Assembly clearance
Intake	0.016 – 0.031 mm
Draining	0.026 – 0.041 mm

3. Making the valve **(2)** turn, check that the run out error is no greater than **0.007 mm**.
4. If there is an excessive radial clearance or centring error, recheck the valve dimensions and replace the worn parts.

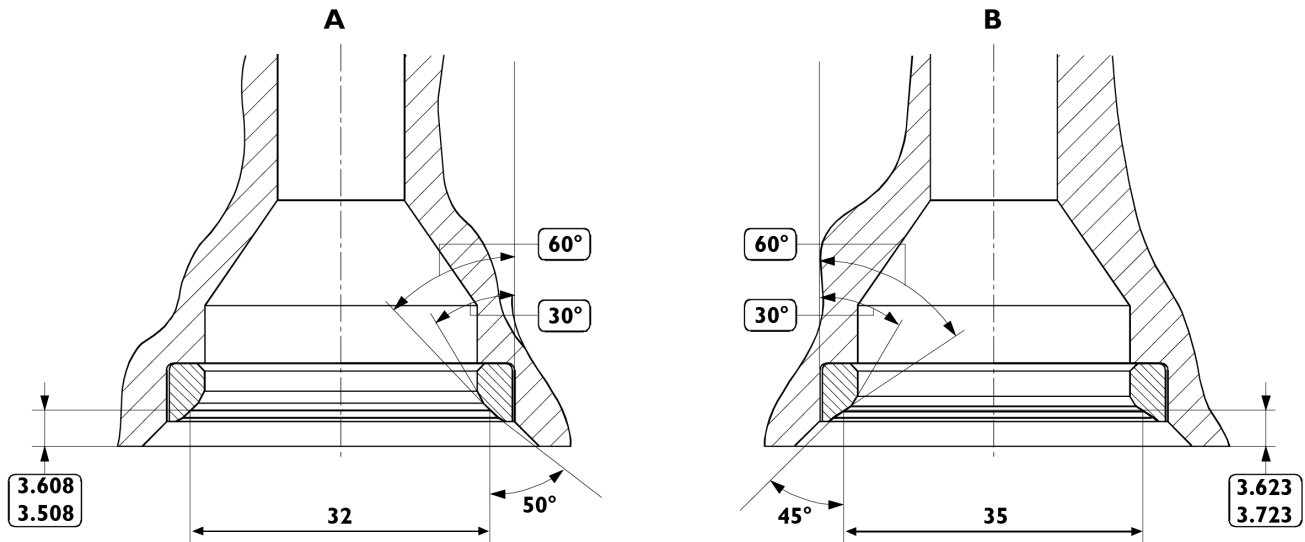
540661 VALVE SEAT - Replace

Tool / Material	
Base, dial gauge, countershaft bearing adjustment (use with 99395604)	99370415
Dial gauge (0-5mm)	99395603

Prior operation:

VALVES - Disassemble (54.06)

Regrinding - replacing valve seats



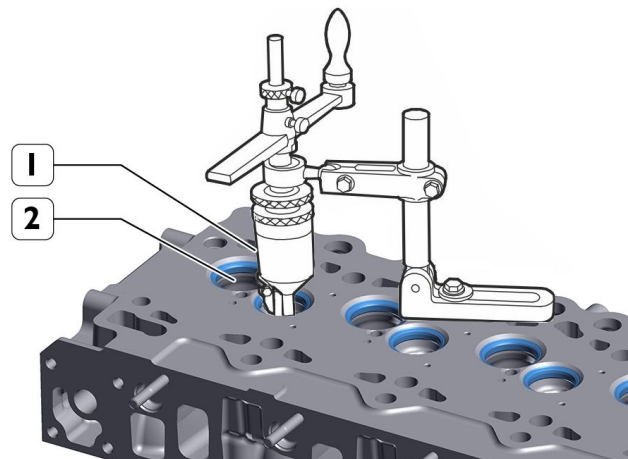
298221 1

MAIN DATA OF ENGINE VALVE SEATS

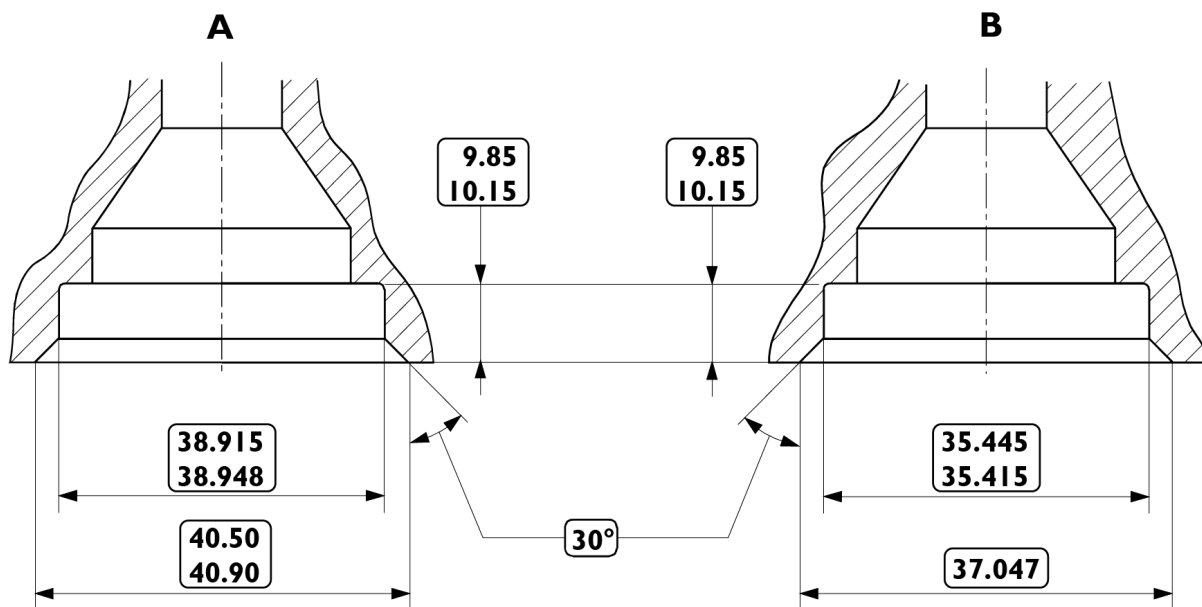
A. Exhaust

B. Intake

1. Check that main data of the valves seats are coherent with those in the figure.
2. If slight scoring or burnout is found, regrind using the tool (1) according to the angle values shown in the following figure.



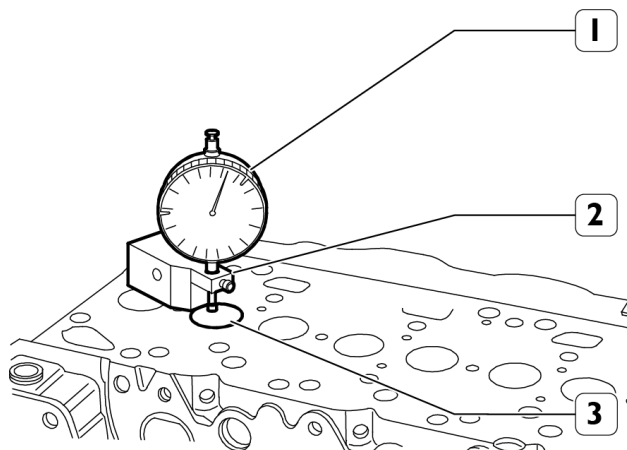
267871 2



298305 3

- A. Exhaust
- B. Intake
3. If the valve seats cannot be restored by only regrinding, it is possible to mount the inserts supplied as spares.
4. In this case regrind the seats on the cylinder head and fit the valve seats.
5. To fit the valve seats in the cylinder head, heat the cylinder head to **80 – 100 °C** and, using a suitable drift, fit it in the new previously cooled valve seats **(2)**.
6. Then use the specific tool to regrind the valve seats to the values indicated in the following figure.
7. After regrinding, use the base **(2)** and the dial gauge **(1)** to check that the recess value of the valves **(3)** is as specified.

Tool / Material	
Base, dial gauge, countershaft bearing adjustment (use with 99395604)	99370415
Dial gauge (0-5mm)	99395603



263269 4

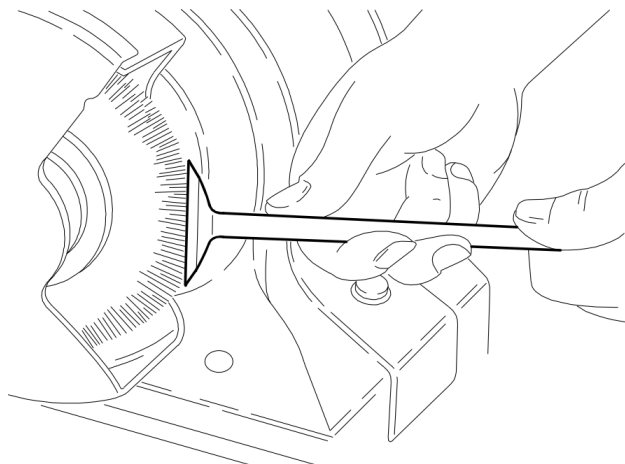
540662 VALVES - Cleaning

Prior operation:

VALVES - Disassemble (54.06)

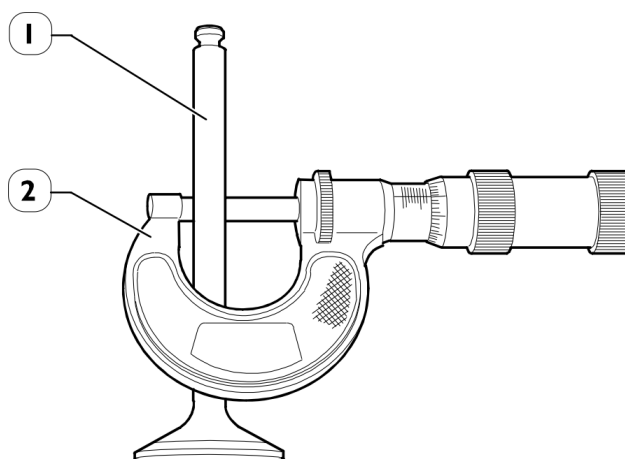
Removing carbon deposits, checking and grinding valves

1. Remove all carbon deposits from the valves using a wire brush.
2. Check that the valves show no signs of seizing, scoring or cracking.
3. Regrind the valve seats, if required, removing as little material as possible.



18625 1

4. Check the valve stem (1) using a micrometer (2): it must be between:



18882 2

Valve	Diameter
Intake	7.980 – 8.000 mm
Exhaust	7.970 – 7.990 mm

540662 VALVES - Disassemble

Tool / Material

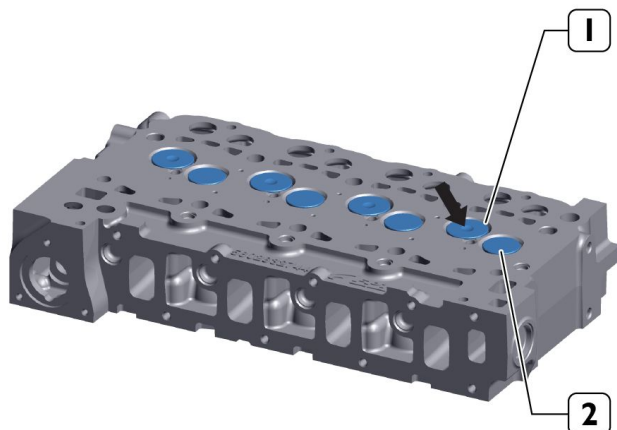
Engine valves remover/installer

99360268

Valve removal

- Before removing the valves from the cylinder head, number them so that they can be re-installed in the same positions they were removed from if they are to be re-used.

NOTE: The intake valves (1) have a greater diameter than the exhaust valves (2). The central cavity (→) of the intake valve mushroom (2) distinguishes it from that of the exhaust valve (1).



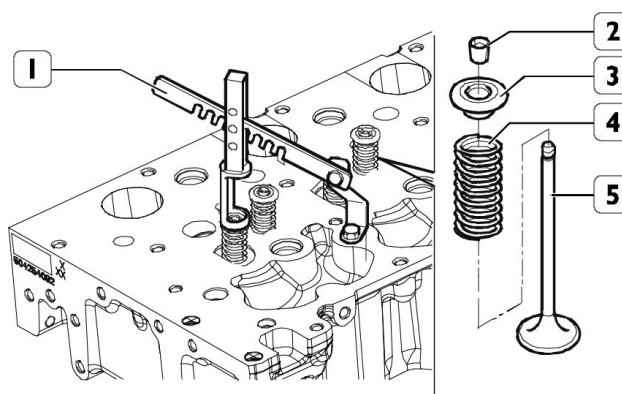
298074 1

- Valve removal shall be performed using tool (1) and pressing the cap (3) so that when compressing the springs (4), the cotters (2) can be removed. Then remove: The plate (3) and the springs (4).

Tool / Material

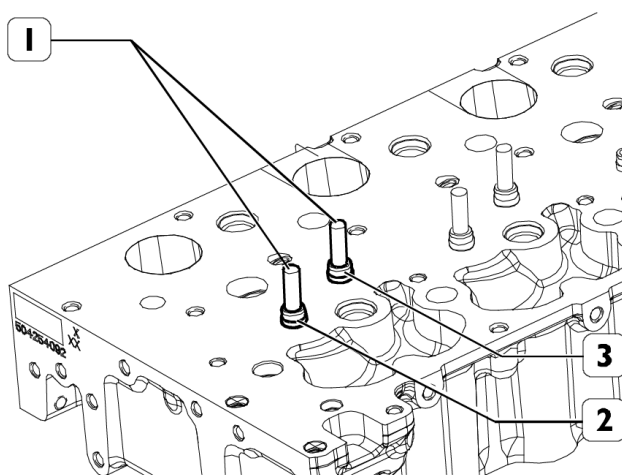
Engine valves remover/installer

99360268



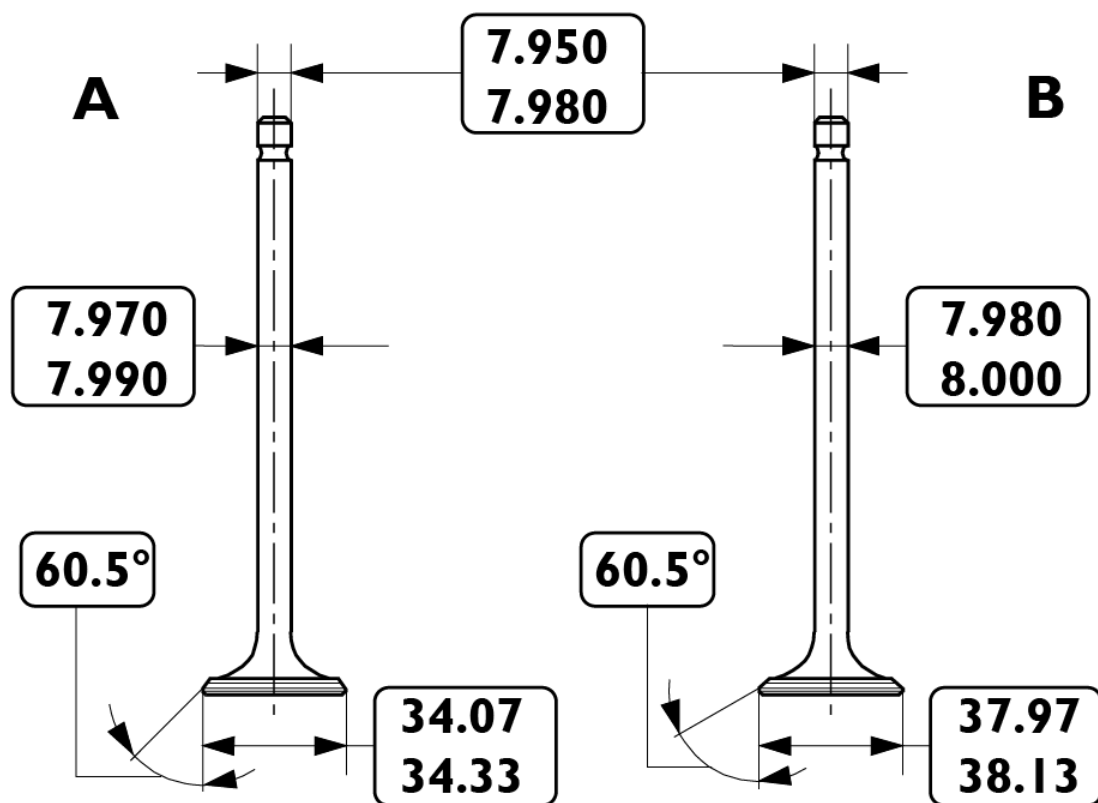
119567 2

- Turn the cylinder head upside down and remove the valves (1).
- Remove the sealing rings (2), (3) from the relative valve guides.



119572 3

540662 VALVES - Measure



298222 1

INTAKE AND EXHAUST VALVE MAIN DATA

- A. Discharge valve
- B. Intake valve

540662 VALVES - Assemble

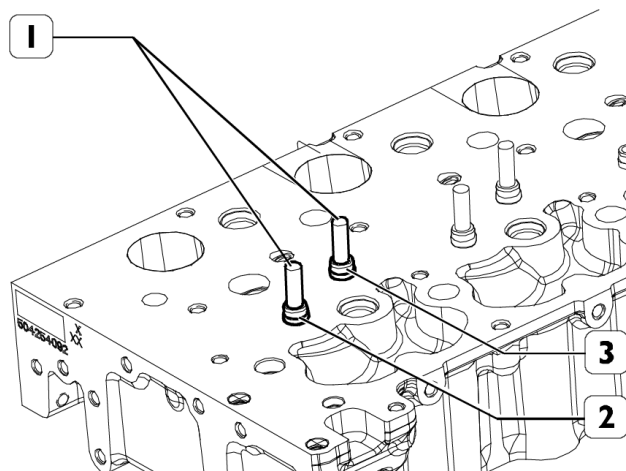
Tool / Material

Engine valves remover/installer

99360268

Valve fitting

1. Lubricate the stem of the valves **(1)** and insert them into the relevant valve guides according to the position marked during removal.
2. Fit the seal rings **(2)** and **(3)** onto the valve guide.



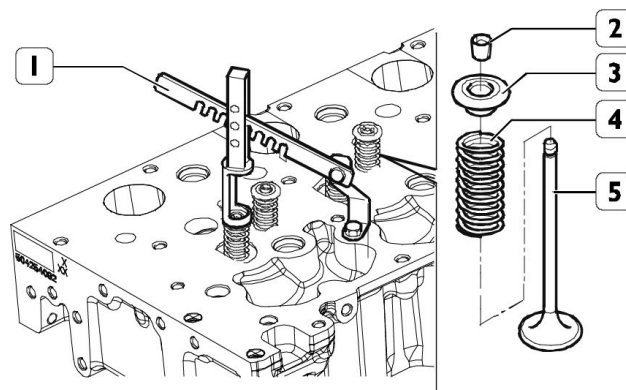
119572 1

3. Position on the cylinder head: the spring **(4)** and upper plate **(3)**: Using tool **(1)** compress the spring **(4)** and fasten the plate **(3)** to the valve **(5)** with the cotters **(2)**.

Tool / Material

Engine valves remover/installer

99360268



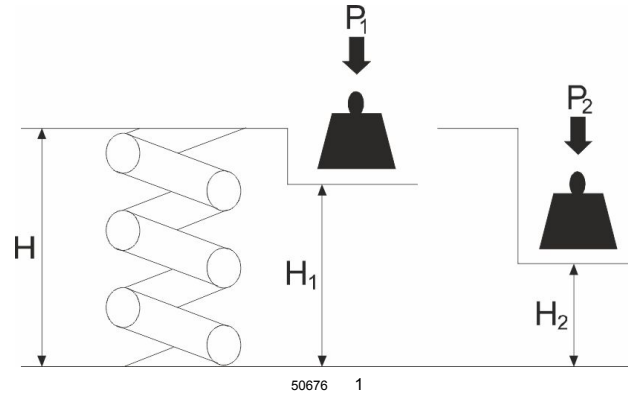
119567 2

540665 VALVE SPRING - Check

Prior operation:

VALVES - Disassemble (54.06)

Valve spring check



KEY DATA FOR CHECKING INTAKE AND EXHAUST VALVE SPRINGS

1. Prior to assembling, check the valve spring flexibility using a suitable tool. Compare the elastic deformation and load data with those of the new springs shown in the following table.

Height		Under a load of:	
H	46.5 mm	Free	
H1	32 mm	P1	320 +/- 16 mm
H2	22.5 mm	P2	560 +/- 25 mm

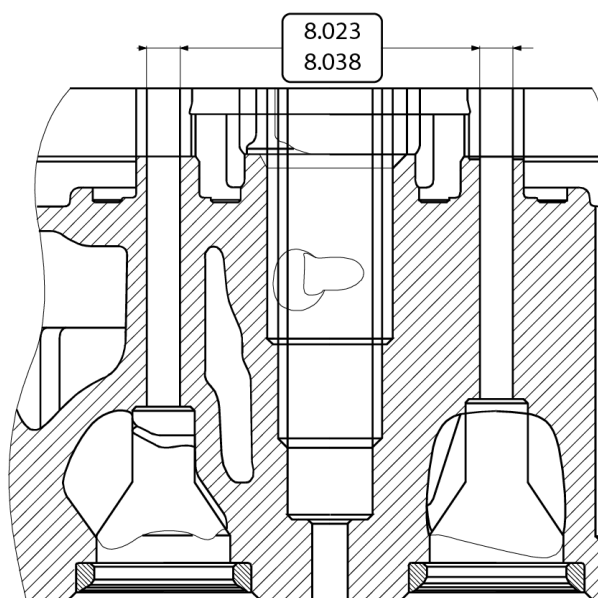
540667 VALVE GUIDE - Check

Prior operation:

VALVES - Disassemble (54.06)

Valve guide check

1. Use a bore gauge, measure the internal diameter of the valve guides; it must be equal to the value shown in the figure.



298209 1

540740 EGR ASSEMBLY - Overview

Product	Configuration
F6BFL413A F6BFL413A*V002	ALL

The EGR exhaust gas recirculation system comprises a heat exchanger and a flow regulating valve.

The heat exchanger lowers the temperature of the exhaust gas which is partially sent to the combustion chamber. This operation lowers the combustion temperature of the mixture. This is done because the exhaust gas, which is completely inert, mixes with the mixture and slows down the rate of combustion.

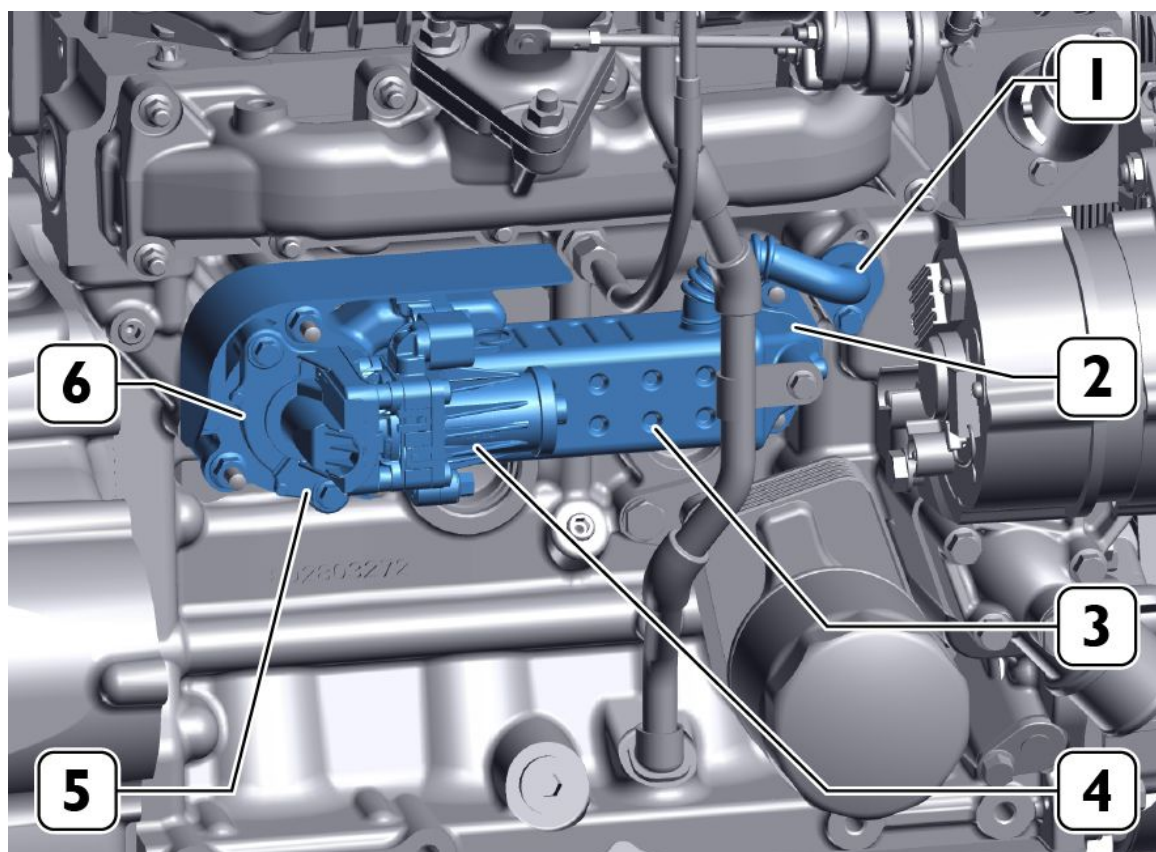
Lowering this temperature considerably reduces NOx (Nitrogen Oxide) emissions which are harmful to the environment.

The body of the heat exchanger is composed of a bundle of tubes cooled externally by the engine coolant. The part of the exhaust gas intended for recirculation, is sent to the shell and tube exchanger and is cooled.

The EGR flow regulating valve is mounted on the end of the heat exchanger.

The recirculation exhaust gas flow is controlled by an electrically controlled plate valve.

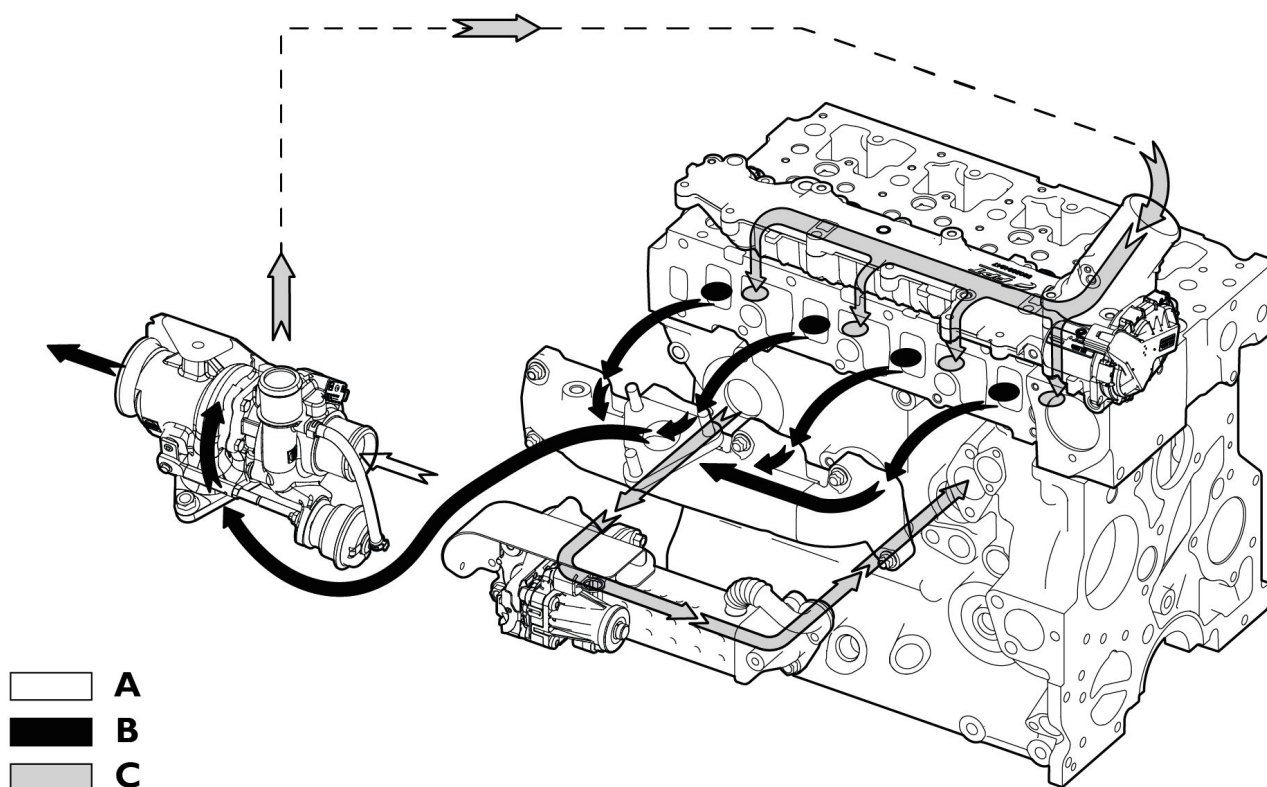
To ensure higher efficiency and longer durability to the valve, the valve is cooled by engine coolant from heat exchanger.



298666 1

1. Coolant pipe from EGR heat exchanger to crankcase
2. Exhaust gas outlet from EGR to crankcase
3. EGR heat exchanger exhaust gas/coolant
4. EGR valve
5. Coolant pipe inlet from crankcase to EGR valve
6. EGR exhaust gas inlet from crankcase to EGR valve

Operation diagram



298672 2

- A. Intake air entering the turbocharger from the air filter
- B. Exhaust gas
- C. Compressed air from turbocharger to engine air intake / EGR exhaust gas recirculation

540746 EGR MODULATING SOLENOID VALVE - Overview

Product	Configuration
F6BFL413A F6BFL413A*V002	ALL

Exhaust gas valve (EGR)

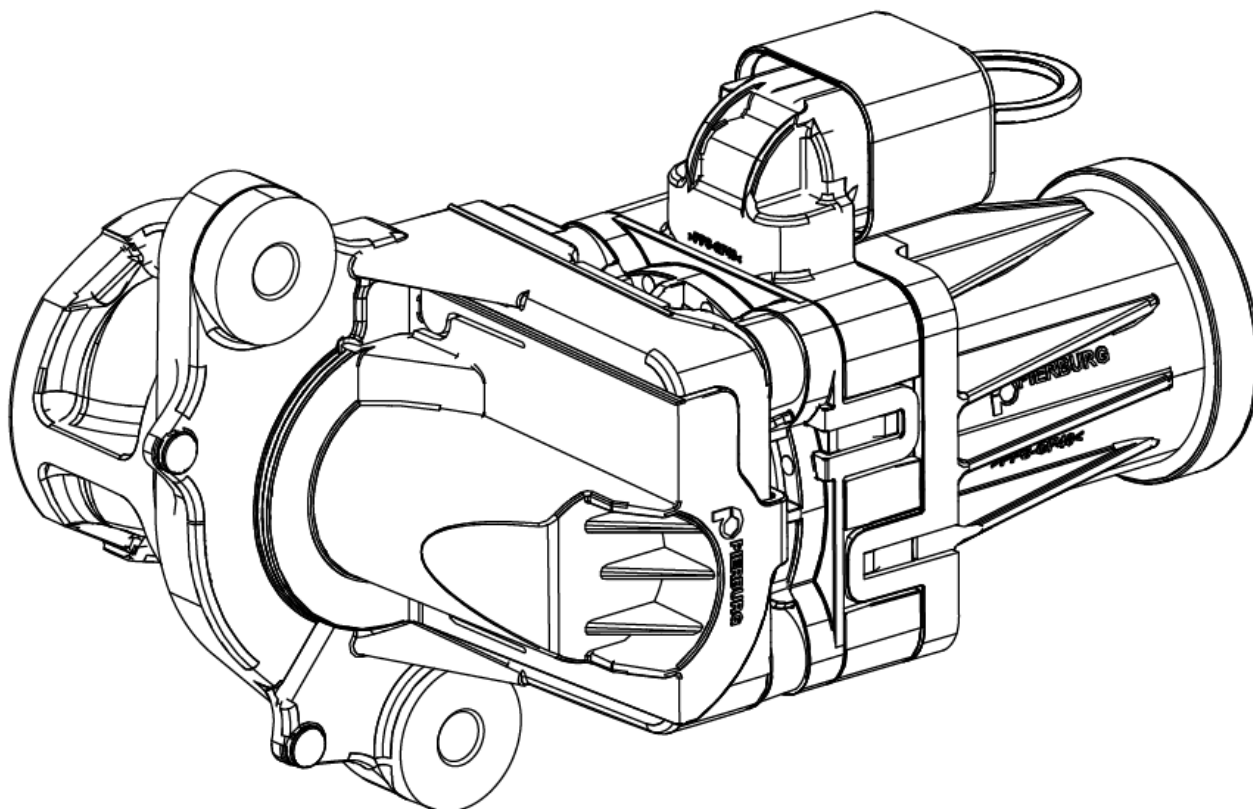
Fit between the EGR system and the exhaust manifold, this is a motorised valve that regulates the quantity of exhaust gas to recirculate in the cylinders at each cycle.

Contains a position sensor and an actuator for the electric valve motor.

The sensor is powered at **5 V**.

Sensor-actuator pin-out

Pin	Description
1	EGR valve DC motor actuator positive
2	EGR valve position sensor signal output
3	Not connected
4	EGR valve position sensor ground
5	EGR valve DC motor actuator negative
6	EGR valve position sensor power supply



298673 1

540751 ABSOLUTE PRESSURE SENSOR - Overview

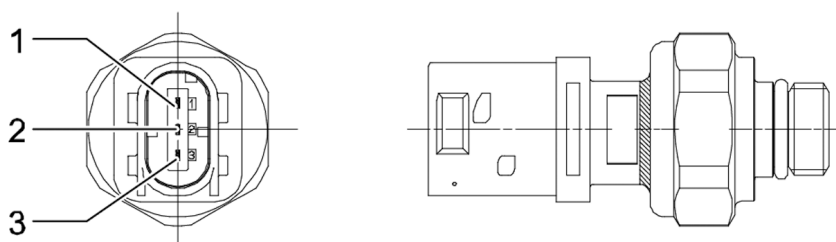
Product	Configuration
F6BFL413A F6BFL413A*V002	ALL

Absolute exhaust gas pressure sensor

Fit on a return pipe from the exhaust manifold, it is a sensor that measures the pressure of the exhaust gas, which the engine control unit uses to accurately calculate the quantity of exhaust gas to recirculate in the intake and therefore to control the EGR system throttle valve.

It is fed at 5 volt tension.

Voltage at the output is proportional to the pressure detected by the sensor.



261759 1

Sensor pin-out

Pin	Description
1	Feeding
2	Ground
3	Signal

540762 THROTTLE POSITION SENSOR - Overview

Product	Configuration
F6BFL413A F6BFL413A*V002	ALL

Throttle body (TVA)

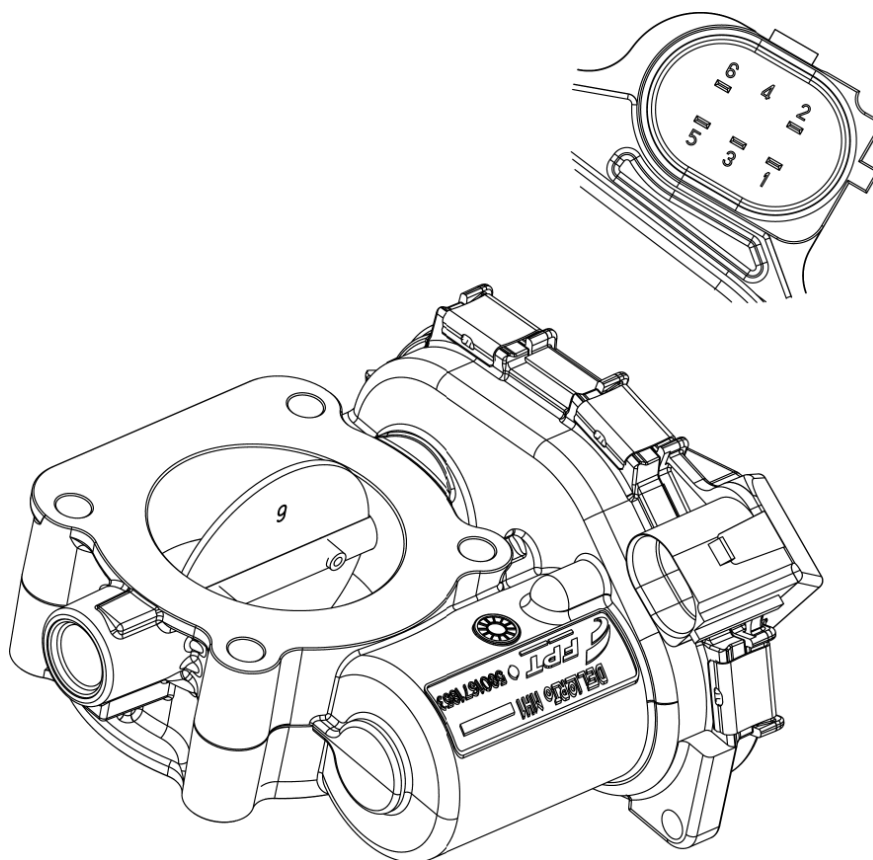
A motorised valve is fit between the engine air intake and the intake manifold that regulates the quantity of air to be sent to the cylinders at each cycle.

Contains a position sensor and an actuator for the electric valve motor.

The sensor is powered at **5 V**.

Sensor-actuator pin-out

Pin	DeFromCablescription
1	TVA valve position sensor power supply
2	TVA valve DC motor actuator negative
3	TVA valve position sensor ground
4	Not connected
5	TVA valve position sensor signal output
6	TVA valve DC motor actuator positive



232628 1

540710 INTAKE MANIFOLDS - Remove

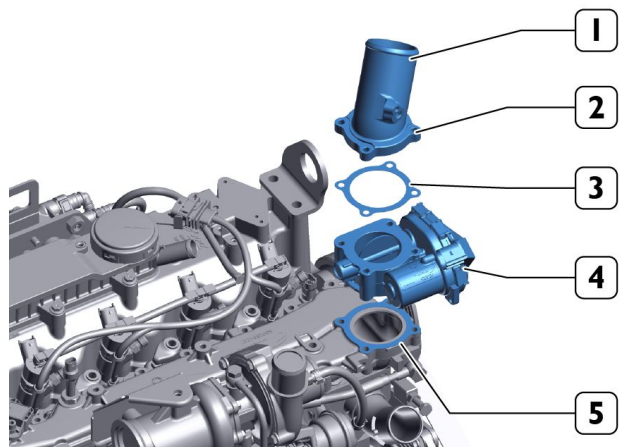
Prior operation:

Disconnect the engine cable as described in the procedure **ENGINE CABLES - Remove (76.91)**

Prior operation:

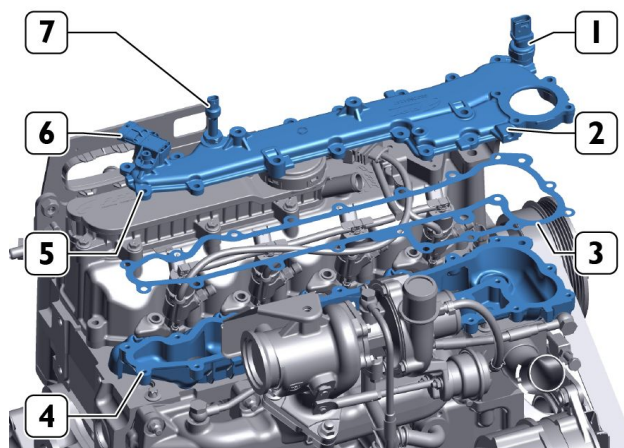
Remove the common rail assembly as described in the procedure **HIGH PRESSURE ACCUMULATOR - Remove (77.45)**

1. Unscrew the nuts and the fastening screw (2) and remove the engine air intake (1) recovering the gasket (3).
2. Remove the throttle valve (4) recovering the gasket (5) and unscrew the studs.



298038 1

3. Unscrew the fastening screws (5) and remove the intake manifold (2), the temperature sensor assembly (7), supercharging pressure sensor (6) and air temperature and exhaust gas absolute pressure sensor (1), from the overhead (4).
4. Recover the gasket (3) from the overhead (6).
5. Unscrew the fastening screws and remove the overhead (4).



298039 2

540710 INTAKE MANIFOLDS - Install

Description	Step	Value
Engine air vent	3 studs M6 x 1 x 80	10 +/- 1 N·m
	3 nuts M6 x1	10 +/- 1 N·m
	1 screw M6 x 1 x 80	10 +/- 1 N·m
Intake manifold	14 screws M6 x 1 x 20	10 +/- 1 N·m
	4 caps M12 x 1.5	20 +/- 2 N·m
Overhead	8 screws M6 x 1 x 20	10 +/- 1 N·m

1. Install the overhead (4) and tighten the fastening screws to the prescribed torque.

Description	Step	Value
Overhead	8 screws M6 x 1 x 20	10 +/- 1 N·m

2. Position the gasket (3) on the overhead (4).
3. Fit the intake manifold (2), with the temperature sensor assembly (7), supercharging pressure sensor (6) and air temperature and exhaust gas absolute pressure sensor (1), and tighten the fastening screws (5) to the prescribed torque.

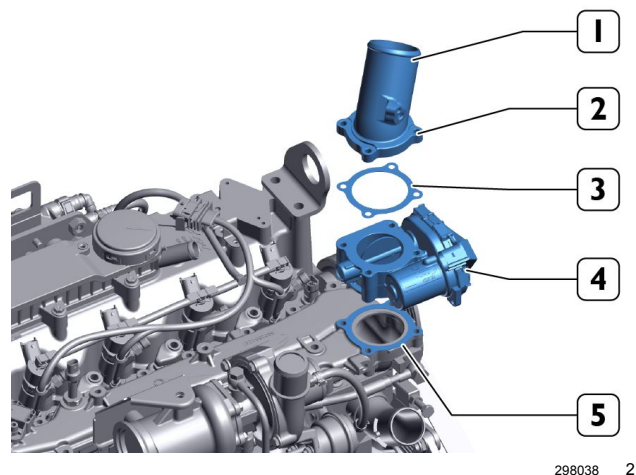
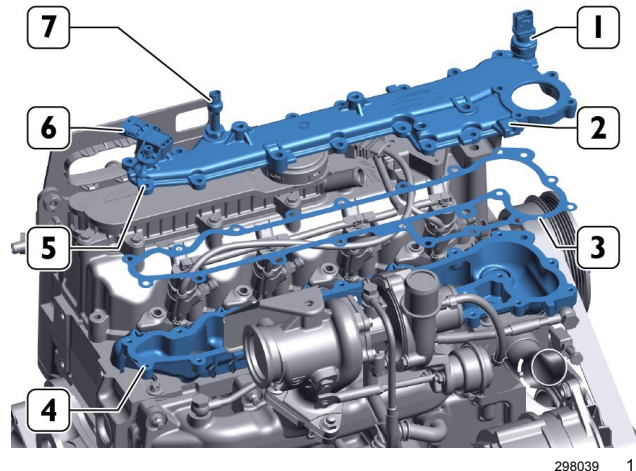
Description	Step	Value
Intake manifold	14 screws M6 x 1 x 20	10 +/- 1 N·m
	4 caps M12 x 1.5	20 +/- 2 N·m

4. Tighten the studs to the prescribed torque and install the throttle valve (4), with a new gasket (5).

Description	Step	Value
Engine air vent	3 studs M6 x 1 x 80	10 +/- 1 N·m
	3 nuts M6 x1	10 +/- 1 N·m
	1 screw M6 x 1 x 80	10 +/- 1 N·m

5. Fit the engine air intake (1) together with a new gasket (3) and tighten the nuts and the fastening screw (2) to the specified torque.

Description	Step	Value
Engine air vent	3 studs M6 x 1 x 80	10 +/- 1 N·m
	3 nuts M6 x1	10 +/- 1 N·m
	1 screw M6 x 1 x 80	10 +/- 1 N·m



Next operation:

Install the common rail assembly as described in the procedure **HIGH PRESSURE ACCUMULATOR - Install (77.45)**

Next operation:

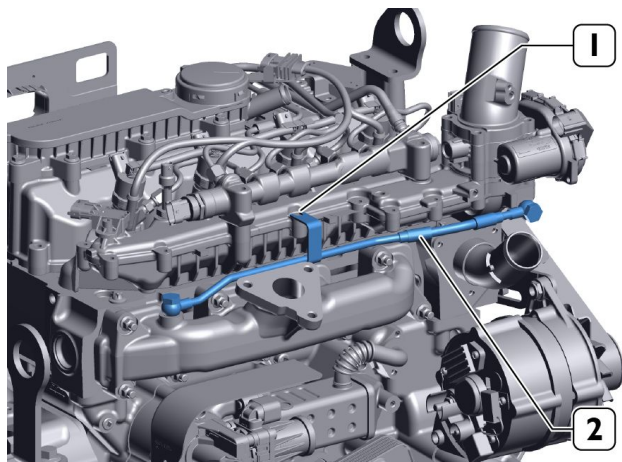
Connect the engine cable as described in the procedure **ENGINE CABLES - Install (76.91)**

540720 EXHAUST MANIFOLD - Remove

Prior operation:

Remove the turbocharger as described in the procedure **TURBO CHARGER - Remove (54.24)**

1. Unscrew the fastening screw **(1)** of the exhaust gas pipe supporting bracket, which is the same one of the intake manifold.
2. Unscrew the fittings and remove the exhaust gas pipe **(2)**.

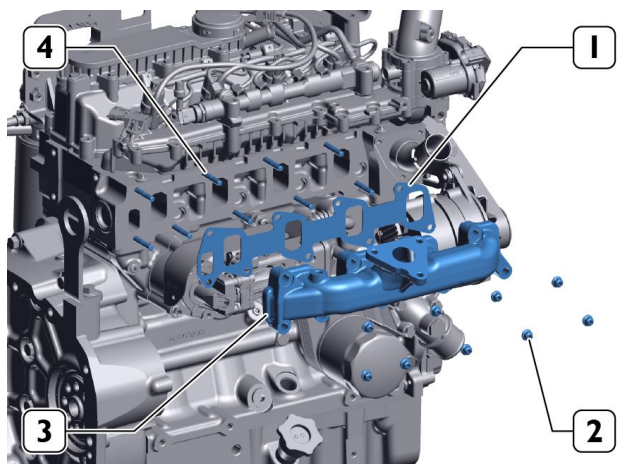


298072 1

3. Unscrew the fastening nuts **(2)** and disconnect the exhaust manifold **(3)** from the studs **(4)** of the cylinder head , recovering the gasket **(1)**.

NOTE: always replace the gasket **(1)** with a new one at any disassembly. Check the thread of the nuts and studs: there must be no sign of wear or deposit of dirt.

4. Unscrew the studs **(4)**.



298040 2

540720 EXHAUST MANIFOLD - Install

Description	Quantity	Step	Value
Exhaust gas linkage pipe	2 screws M12 x 1.5 x 24		25 +/- 2.5 N·m
Exhaust manifold	9 nuts M8 x 1.25	Pre-tightening	10 +/- 0.5 N·m
		Tighten	28 +/- 1.4 N·m

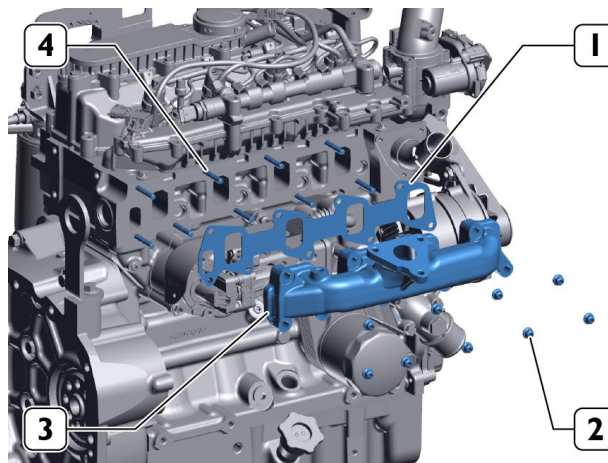
1. Tighten the studs (4) to the specified torque:

Description	Quantity	Step	Value
Exhaust manifold	9 studs M8 x 1.25 x 52		11 +/- 3 N·m

2. Place a new gasket (1) on the cylinder head studs (4).

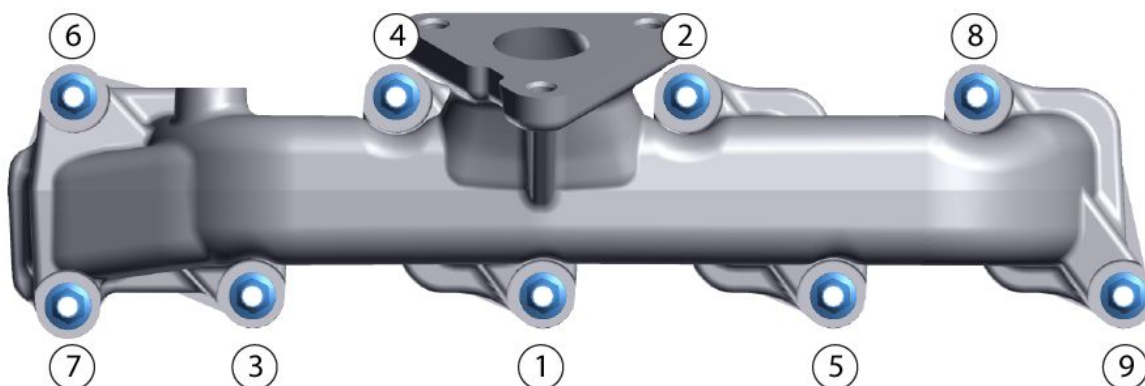
3. Fit the exhaust manifold (3) on the studs (4) of the cylinder head and tighten the fastening nuts (2) observing the tightening order indicated in the following figure, to the specified torque

NOTE: always replace the gasket (1) with a new one at any disassembly. Check the thread of the nuts and studs: there must be no sign of wear or deposit of dirt.



298040 1

Description	Quantity	Step	Value
Exhaust manifold	9 nuts M8 x 1.25	Pre-tightening	10 +/- 0.5 N·m
		Tighten	28 +/- 1.4 N·m



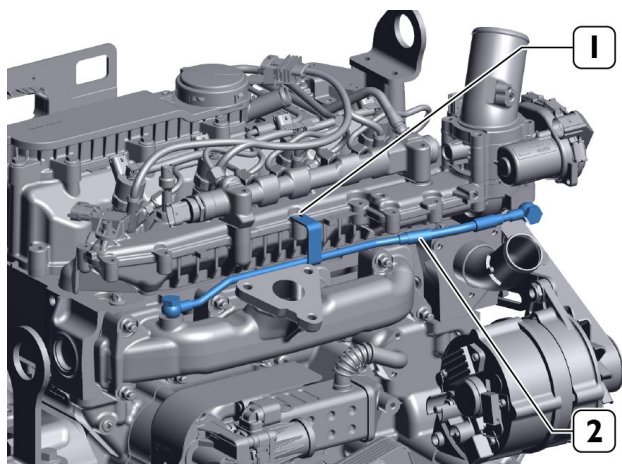
298075 2

diagram of tightening sequence for exhaust manifold fastening screws.

4. Correctly position the exhaust gas pipe (2) and tighten the fittings to the specified torque.

Description	Quantity	Value
Exhaust gas linkage pipe	2 screws M12 x 1.5 x 24	25 +/- 2.5 N·m

5. Tighten the fastening screw (1) of the exhaust gas pipe supporting bracket. This is the same as one for the intake manifold.



298072 3

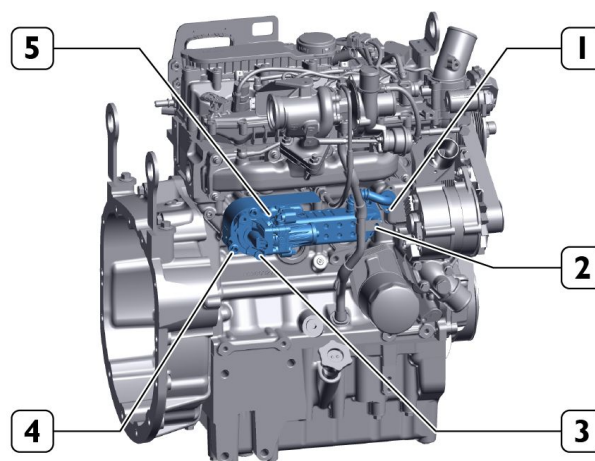
Next operation:

Install the turbocharger as described in the procedure **TURBO CHARGER - Install (54.24)**

540740 EGR ASSEMBLY - Remove

Product	Configuration
F6BFL413A F6BFL413A*V002	ALL

1. Unscrew the fastening screw **(2)** and move the oil return pipe from the turbocharger in order to ease the removal of the EGR.
2. Unscrew the fastening screws **(3)** and remove the EGR valve .
3. Unscrew the fastening screws **(1)** and nuts **(4)** and remove the EGR heat exchanger **(5)** together with the relevant gaskets.



298036 1

4. Remove the studs from the cylinder block.

540740 EGR ASSEMBLY - Install

Product	Configuration
F6BFL413A F6BFL413A*V002	ALL

Description	Quantity	Step	Value
EGR heat exchanger		5 nuts M8 x1.25	23 +/- 2.3 N·m
		1 screw M6 x 1 x 14	10 +/- 1 N·m
EGR valve	2 screws M6 x 1 x 20		10 +/- 1 N·m
Lubricant oil return pipe from turbocharger bracket	1 screw M6 x 1 x 10		10 +/- 1 N·m

- Fit the studs on the crankcase and tighten them to the specified torque.

Description	Quantity	Step	Value
EGR heat exchanger	5 studs M8 x 1.25 x 80		23 +/- 2.3 N·m

- Install the EGR heat exchanger (5), interposing the gaskets, and tighten the fastening screw (1) and the nuts (4) to the specified torque.

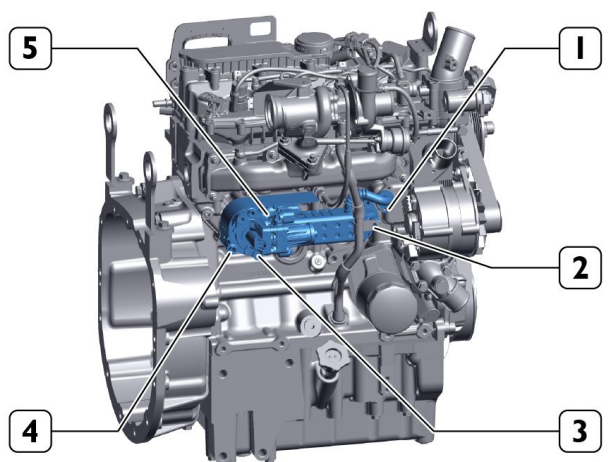
Description	Step	Value
EGR heat exchanger	5 nuts M8 x1.25	23 +/- 2.3 N·m
	1 screw M6 x 1 x 14	10 +/- 1 N·m

- Fit the EGR valve and tighten the fastening screws (3) to the specified torque.

Description	Quantity	Value
EGR valve	2 screws M6 x 1 x 20	10 +/- 1 N·m

- Correctly position the oil return pipe from the turbocharger and tighten the fastening screw (2).

Description	Quantity	Step	Value
Lubricant oil return pipe from turbocharger bracket	1 screw M6 x 1 x 10		10 +/- 1 N·m

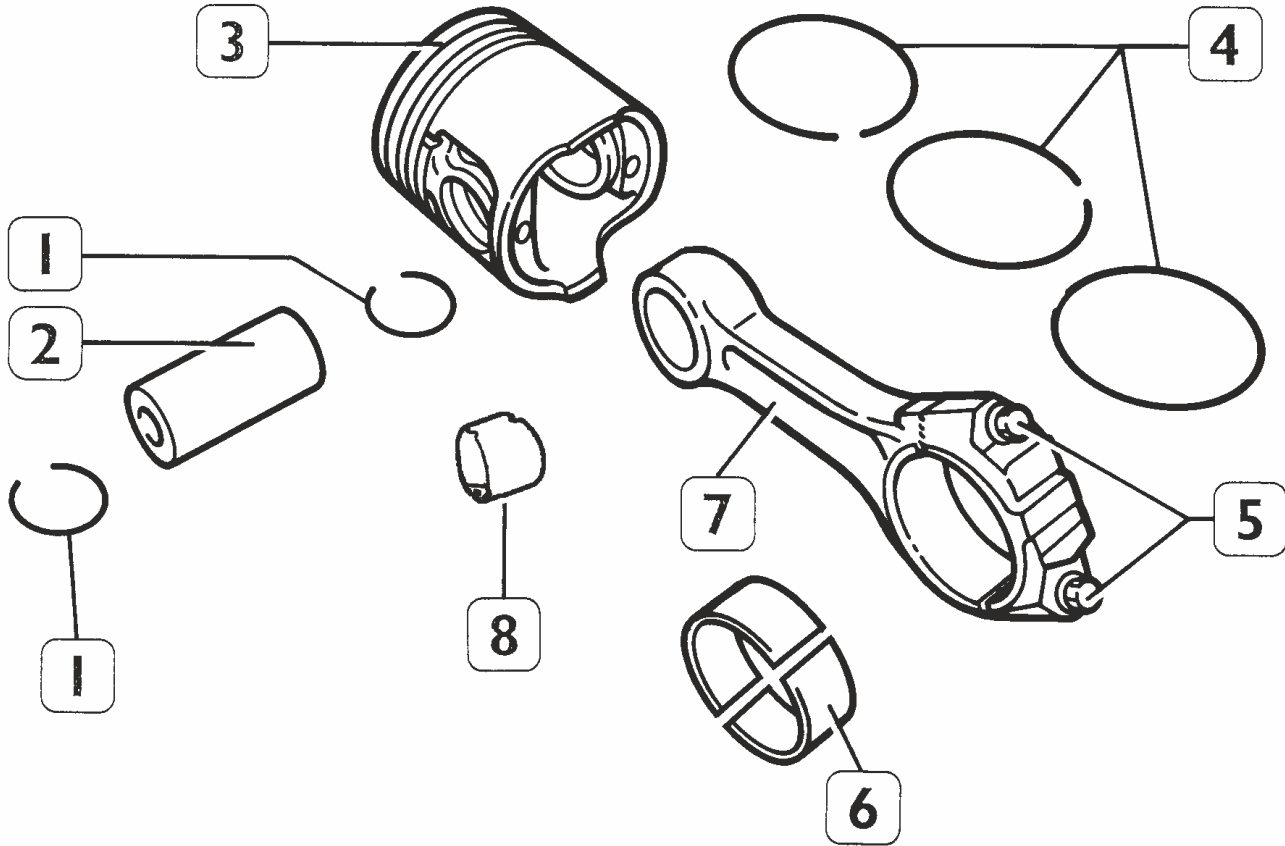


298036 1

5408 ENGINE COMPONENTS - Overhaul

OVERHAULING THE CONNECTING ROD-PISTON ASSEMBLY

- Overhaul the piston connecting rod assembly components as described hereafter.



70191 1

- Retaining rings
 - Pin
 - Piston
 - Piston rings
 - Screws
 - Half bearings
 - Connecting rod
 - Bushing
- Make sure the pistons do not show any sign of seizing, scoring, cracking or excessive wear; otherwise, replace as necessary.
 - For the overhaul of the piston-connecting rod assembly perform the procedures indicated below in the following order:

NOTE: The pistons are supplied with spare parts increased by **0.4 mm**.

- COMPRESSION RINGS - Disassemble (54.08)**
- PISTON - Disassemble (54.08)**
- PISTON - Measure (54.08)**
- COMPRESSION RINGS - Check (54.08)**

- 8. **CONNECTING ROD - Check (54.08)**
- 9. **PISTON - Pre-assemble (54.08)**
- 10. **COMPRESSION RINGS - Assemble (54.08)**
- 11. **PISTON - Assemble (54.08)**
- 12. **CRANKPINS - Measure (54.08)**
- 13. **PISTON - Check (54.08)**

540810 CRANKSHAFT - Disassemble

Tool / Material

Crankshaft lifting tackle

99360500

Prior operation:

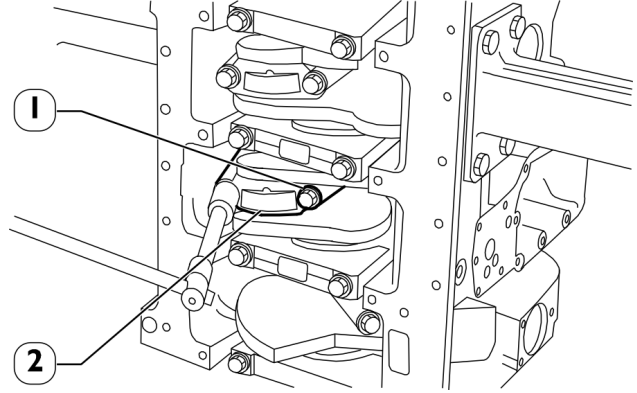
Remove the oil sump as described in the procedure **OIL SUMP - Remove (54.04)**.

Prior operation:

Remove the balancing weights as described in the procedure **WEIGHT FASTENING SCREWS - Remove (54.08)**.

1. Loosen the screws (1) securing the connecting rod caps (2) and remove the relative retainers.

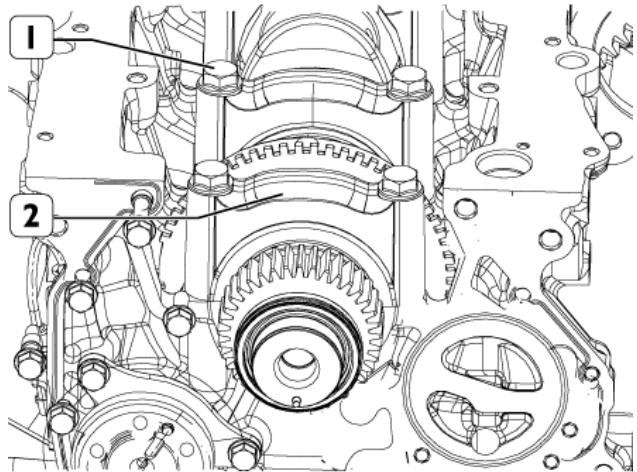
NOTE: Keep the half bearings in the respective seats since after the overhaul, they will have to be refitted in the same position.



70158 1

2. Unscrew the screws (1) and disassemble the main bearing caps (2).
3. The last main bearing cap (2) and the relevant mount are fitted with shoulder half-bearing.

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



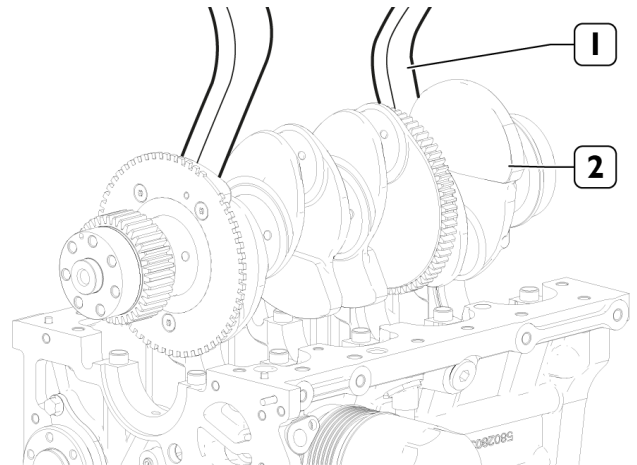
119545 2

4. Remove the crankshaft (2) from the block by means of the tool (1).

Tool / Material

Crankshaft lifting tackle

99360500



298202 3

540810 CRANKSHAFT - Measure

Measuring main journals and crank pins

1. Grind journals and crankpins if seizure, 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.

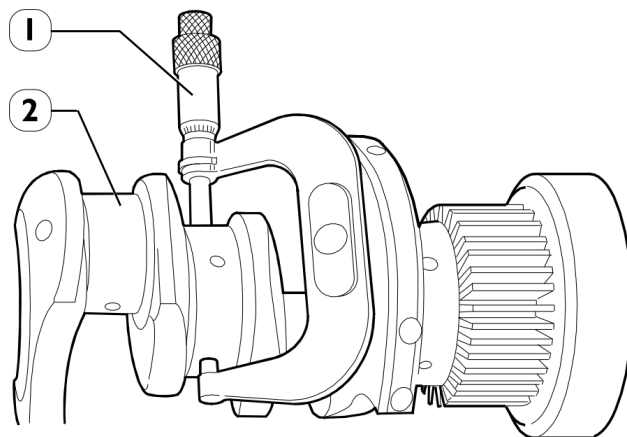
NOTE: The main journals and crankpins must always be ground to the same undersize class.

Main journals and crankpins undersize shall be marked on the side of the crank arm no. 1.

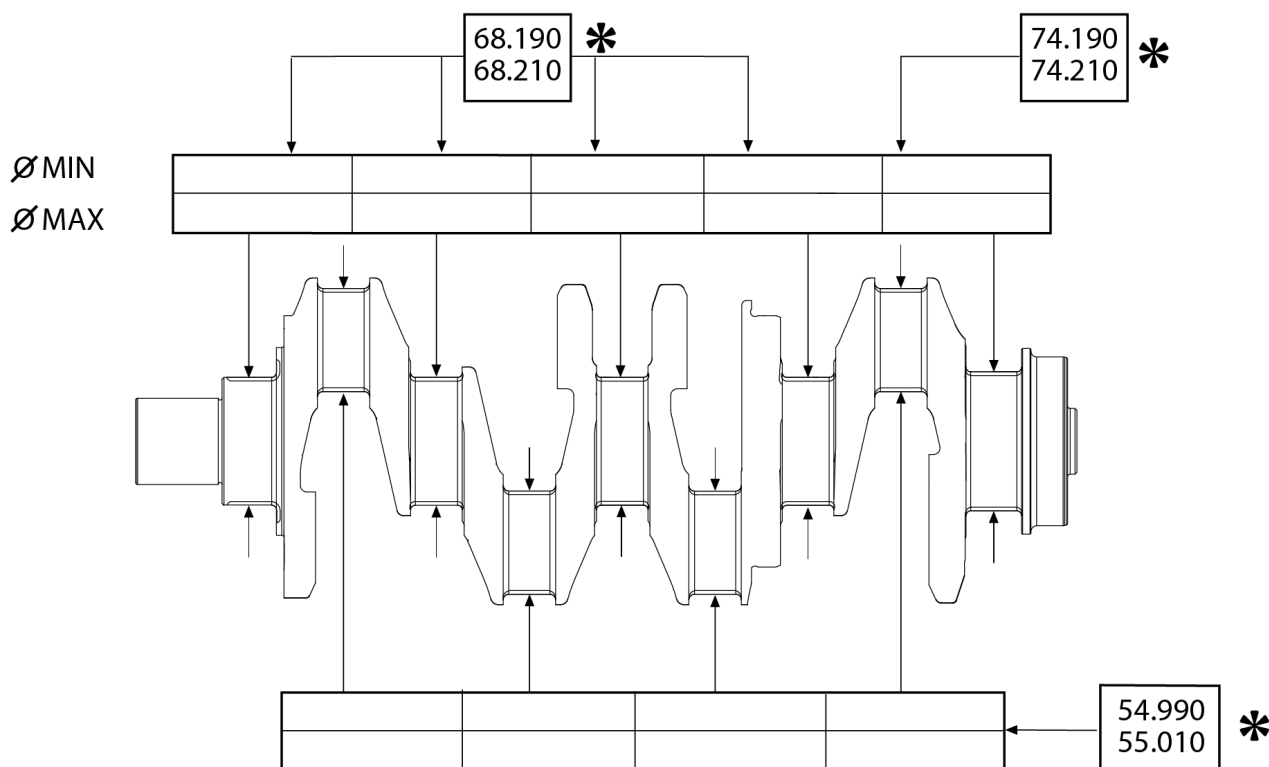
For undersized crankpins: letter M.

For undersized journals: letter B.

For undersized crankpins and journals: letters MB.

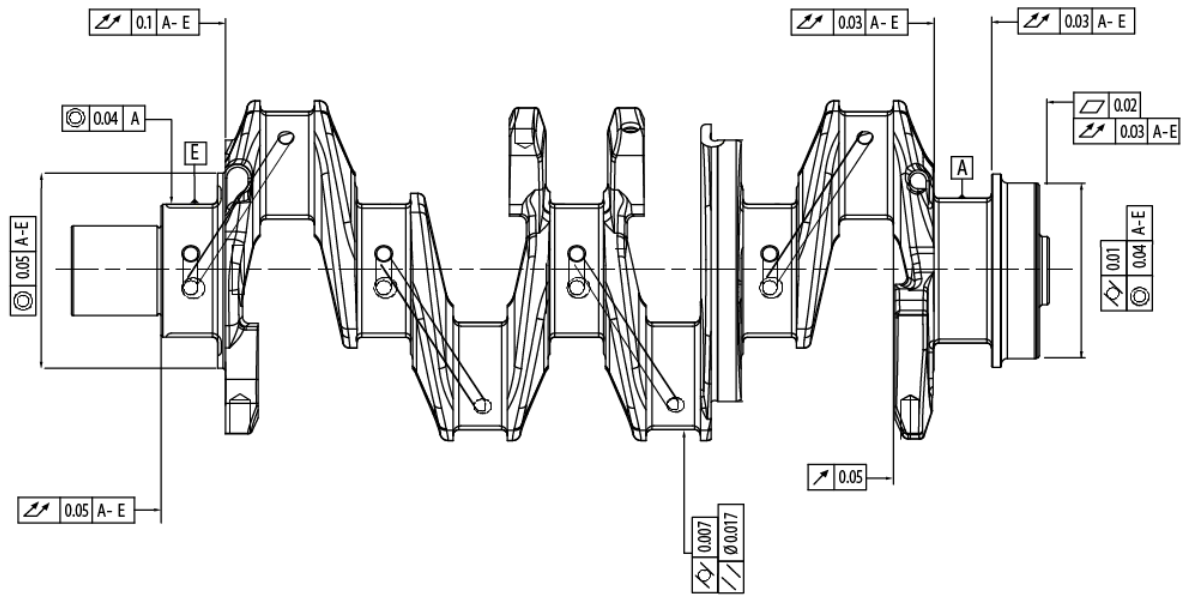


70182 1



298219 2

FILL THIS TABLE WITH THE VALUES MEASURED ON THE OUTPUT SHAFT SUPPORTS AND CRANKPINS
- (*) Rated value (dimensions in mm)

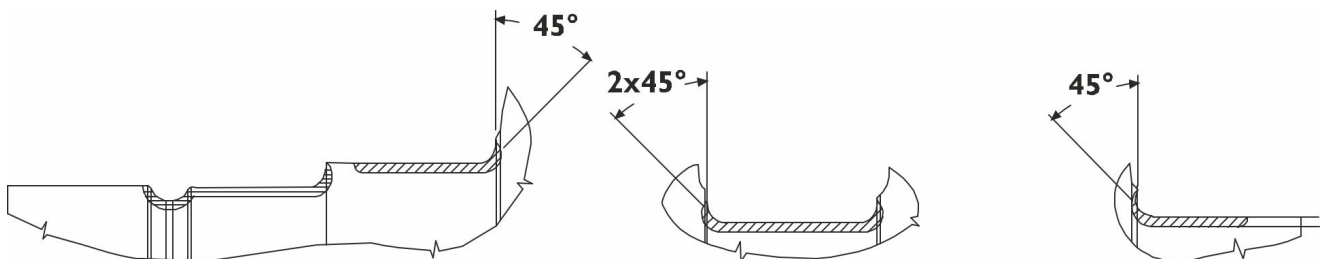


298220 3

MAIN OUTPUT SHAFT TOLERANCES

TOLERANCES	TOLERANCE CHARACTERISTICS	GRAPHIC SYMBOL
SHAPE	Circularity	$\bigcirc$
	Cylindricity	$\bigcirc/\bigcirc/$
ORIENTATION	Alignment	$//$
	Verticality	$\perp$
	Straightness	$-$
POSITION	Concentrically or coaxially	$\bigcirc$
OSCILLATION	Circular oscillation	$\nearrow$
	Total oscillation	$\nearrow \nearrow$

LEVEL OF SIGNIFICANCE BY PRODUCT FEATURES	GRAPHIC SYMBOL
CRITICAL	$\bigcirc$
IMPORTANT	$\oplus$
SECONDARY	$\ominus$



70237 4

MAIN BEARING ON TIMING SYSTEM CONTROL SIDE – INTERMEDIATE MAIN BEARINGS – FIRST MAIN BEARING ON FRONT SIDE

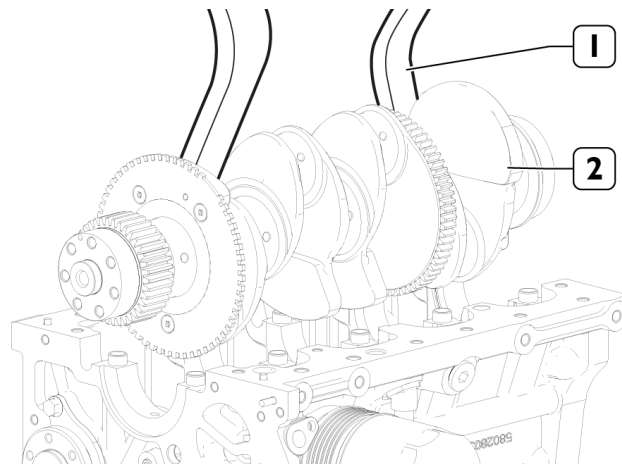
540810 CRANKSHAFT - Assemble

Description	Quantity	Step	Value
Crankshaft main bearing caps	10 screws M12 x 1.5 x 120	Step 1 — Pre-tightening	50 +/- 6 N·m
		Step 2 — Tighten	80 +/- 6 N·m
		Step 3 — Angle tightening	90°

Tool / Material	
Crankshaft lifting tackle	99360500

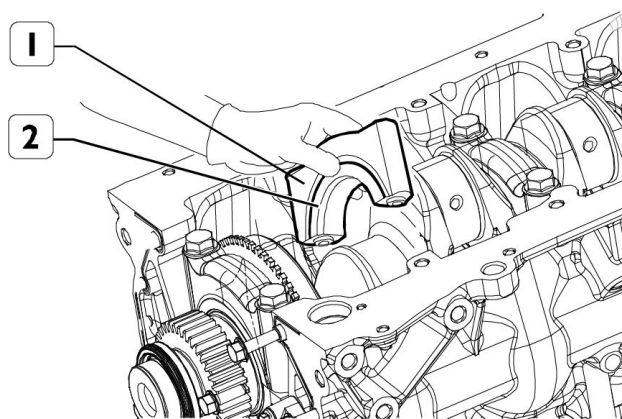
- Using the tool (1), fit the crankshaft (2).

Tool / Material	
Crankshaft lifting tackle	99360500



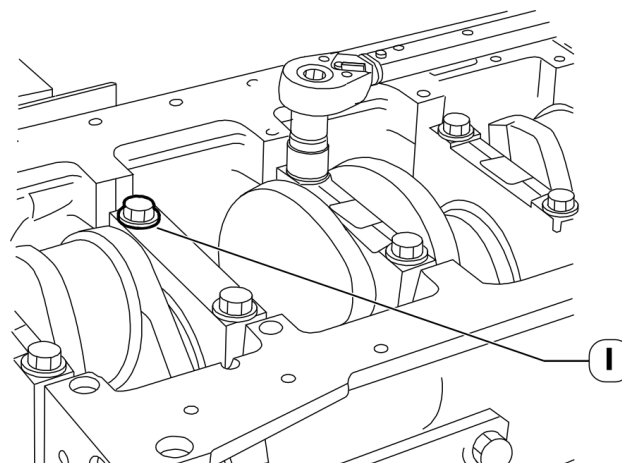
298202 1

- Thoroughly clean the parts and remove any trace of oil.
- Fit caps (1), including the half bearings (2) on the relevant supports.



128169 2

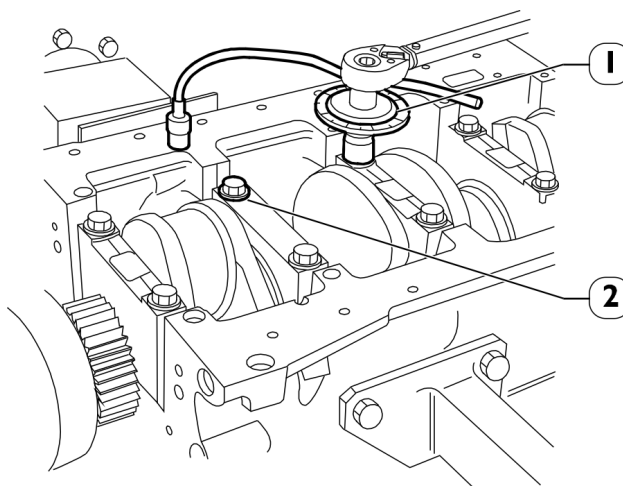
- Screw the new pre-lubricated screws (1) and tighten them in two successive stages. 1st stage with torque wrench to 80 +/- 6 N·m.



70187 3

5. 2nd step with tool (1) positioned as shown in the figure, tighten the screws (2) further to with an angle of $90 \pm 2^\circ$.

Description	Quantity	Step	Value
Crankshaft main bearing caps	10 screws M12 x 1.5 x 120	Step 1 — Pre-tightening	$50 \pm 6 \text{ N}\cdot\text{m}$
		Step 2 — Tighten	$80 \pm 6 \text{ N}\cdot\text{m}$
		Step 3 — Angle tightening	90°



70188 4

Next operation:

Fit the oil sump as described in the procedure **OIL SUMP - Install (54.04)**

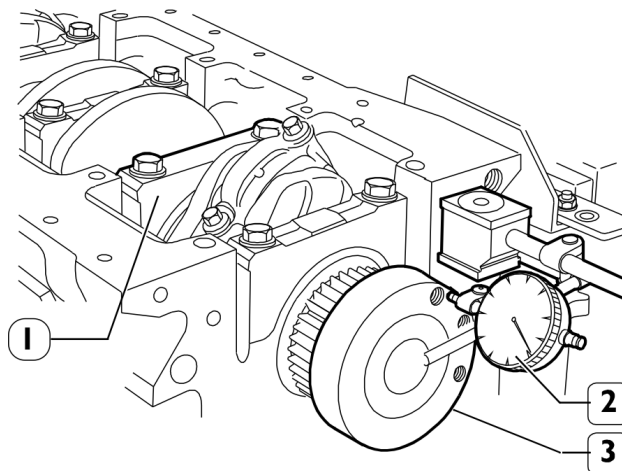
Next operation:

Fit the balancing weights as described in the procedure **WEIGHT FASTENING SCREWS - Install (54.08)**

540810 CRANKSHAFT - Check

Check crankshaft axial clearance

1. This check is carried out by placing a magnetic based dial gauge (2) on the output shaft (3) as indicated in the figure. The normal value is **0.150 – 0.350 mm**.
2. If a higher value is detected, replace the main half-bearings of the next to last rear support (1) carrying the thrust bearing and repeat the clearance check between the output shaft pins and the main half-bearings.



70190 1

540812 CRANKPINS - Measure

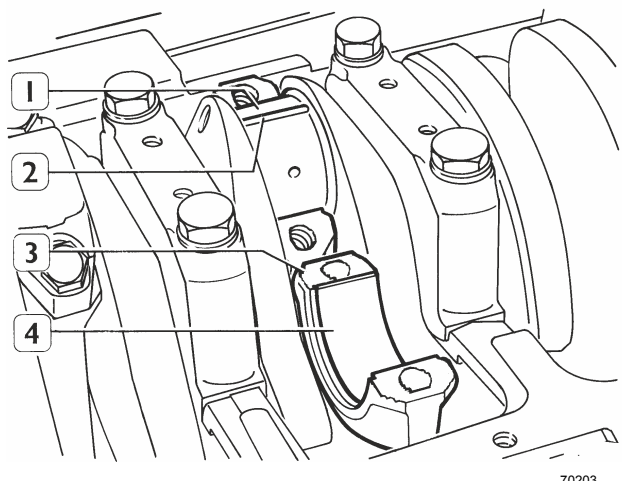
Description	Quantity	Step	Value
Motor shaft connecting rod caps	8 screws M8 x 1	Step 1 — Tighten	20 +/- 1 N·m
		Step 2 — Angle tightening	60°

Prior operation:

PISTON - Assemble (54.08)

Crankpin assembly clearance measurement

1. Carry out the following operations to measure the clearance:
2. Carefully clean the parts and remove any trace of oil.
3. Set a piece of calibrated wire (2) on the crankshaft pins (1).
4. Fit the connecting rod caps (3) with the relative half-bearings (4).



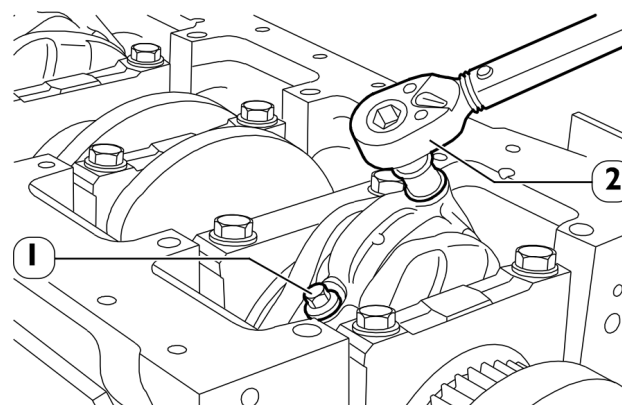
70203 1

General risk, general prescriptions

- When assembling, always replace with new parts: gaskets and sealing rings, split pins, safety plates and springs.

- The nuts and screws must be tightened to the specified torque with the thread dry and de-greased.

Failure to comply with these prescriptions can result in the risk of serious injury and serious damages to the vehicle

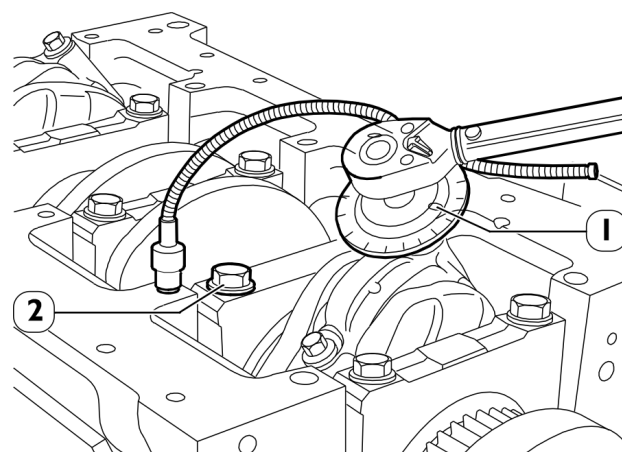


70204 2

Tighten the screws (1), pre-lubricated with the prescribed oil, with a torque wrench (2).

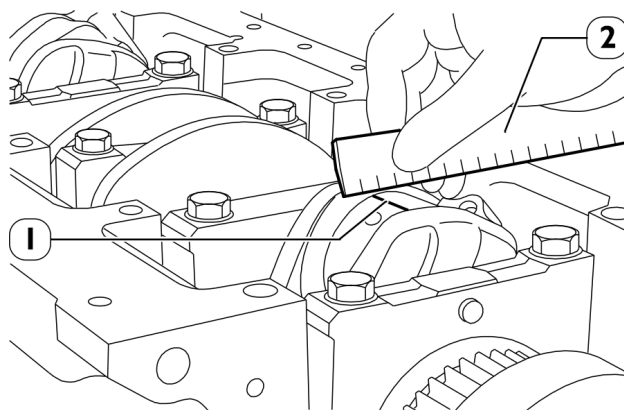
5. Apply the specific tool (1) to the socket wrench and tighten the screws (2) to the specified angle.

Description	Quantity	Step	Value
Motor shaft connecting rod caps	8 screws M8 x 1	Step 1 — Tighten	20 +/- 1 N·m
		Step 2 — Angle tightening	60°



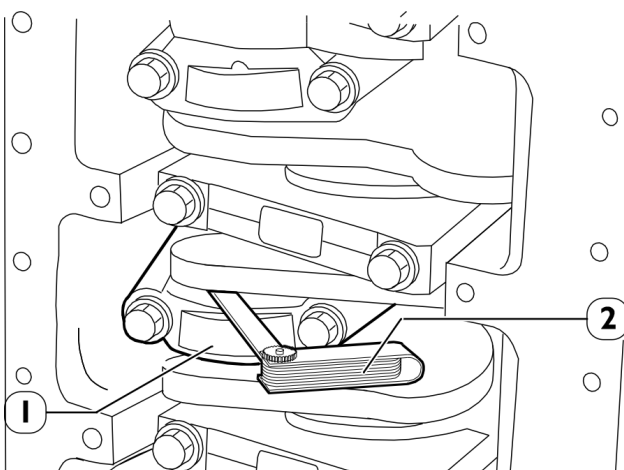
70205 3

6. Remove the cap and find the existing clearance by comparing the calibrated wire width (1) with the scale indicated on the envelope (2) which contained the wire.



70206 4

7. If the clearance is not as prescribed, change the half bearings and repeat the check.
8. On obtaining the prescribed clearance, lubricate the connecting rod half bearings and fit them permanently by tightening the screws securing the connecting rod caps as described.
9. Check manually that the connecting rods (1) are sliding axially on the crankshaft pins and that their axial clearance, measured with feeler gauge (2) is: **0.10 – 0.33 mm**.



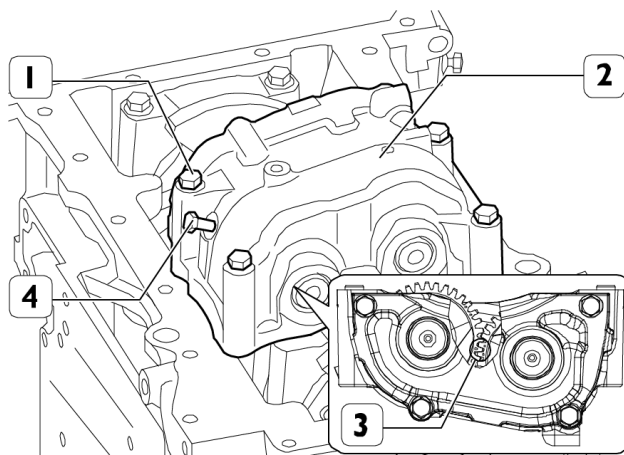
70207 5

540813 WEIGHT FASTENING SCREWS - Remove

Prior operation:

OIL SUMP - Remove (54.04)

1. Bring cylinder 1 to **118°** before the TDC and check that the marks **(3)** stamped on the gears of the balancing weights **(2)** for timing are aligned as shown in figure 1.
2. Use the pin **(4)** to temporarily block the rotation of the balancing weights **(2)**.
3. After having blocked the additional balancing masses **(2)** through the pin **(3)** unscrew the fastening screws **(1)** and remove it from the crankcase.



242639 1

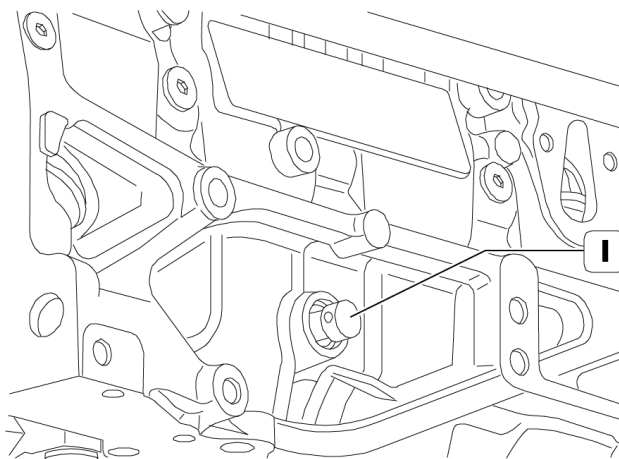
540813 WEIGHT FASTENING SCREWS - Install

Description	Quantity	Step	Value
Balancing weights	4 screws M8 x 1.25 x 90	Step 1 — Pre-tightening	20 +/- 6 N·m
		Step 2 — Tighten	60°

Tool / Material	
Engine TDC positioning tool	99360612

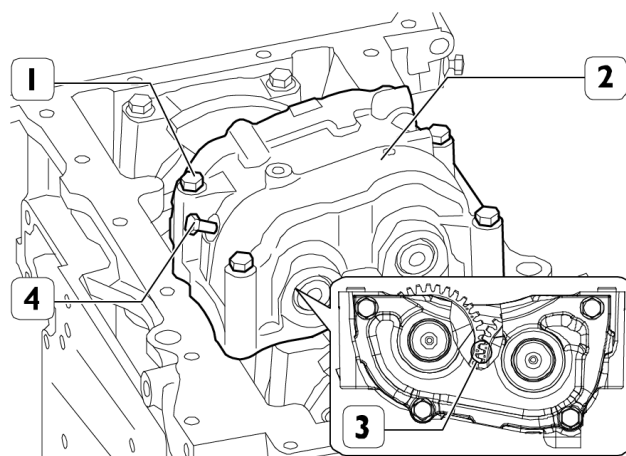
1. Bring cylinder 1 to **118°** before the TDC. In this condition, the engine is timed, insert the specific tool **(1)** into the crankcase so that it engages with the hole in the crankshaft.

Tool / Material	
Engine TDC positioning tool	99360612



244555 1

2. Rotate the engine of **180°**.
3. Fit the case with the balancing weights **(2)** already timed during the removal operation, using the fastening pin. **(4)**
4. If during removal the pin **(4)** was not inserted and therefore the balancing weights **(2)** have not been timed, proceed as follows.
5. Align the stamped marks **(3)** on the gears of the balancing weights **(2)** for timing, as shown in the figure 2.
6. Use the pin **(4)** to temporarily block the rotation of the balancing weights **(2)**.
7. Fit the case containing the balancing weights **(2)** and tighten the fastening screws **(1)** on the crankcase to the specified torque.



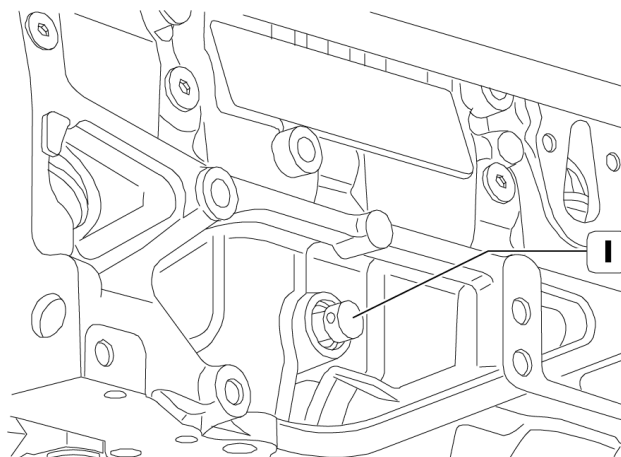
242639 2

Description	Quantity	Step	Value
Balancing weights	4 screws M8 x 1.25 x 90	Step 1 — Pre-tightening	20 +/- 6 N·m
		Step 2 — Tighten	60°

8. Remove the locking pin **(4)** from the balancing weights **(2)**.

9. Remove the specific tool **(1)** from the crankcase to release rotation of the crankshaft.

Tool / Material	
Engine TDC positioning tool	99360612



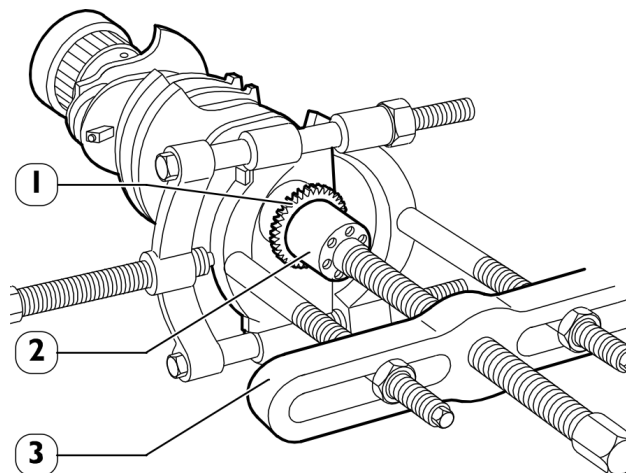
244555 3

Next operation:
OIL SUMP - Install (54.04)

540815 OIL PUMP CONTROL PINION GEAR - Replace

Oil pump drive gear replacement

1. Check that gear tothing **(1)** is not damaged or worn, otherwise remove using the proper puller **(3)**.
2. After fitting the new gear, it must be heated for **10 min** in an oven at a temperature of **180 °C** and keyed to the engine by interposing the key.



70184 1

540816 MAIN BEARINGS - Assemble

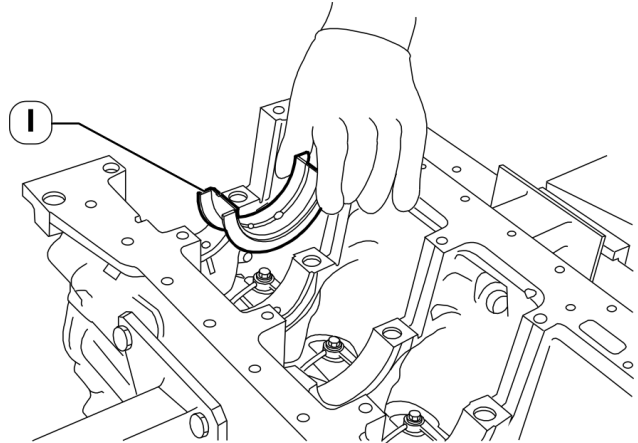
Main bearings assembly

1. Clean accurately the main half-bearing **(1)** having the lubricating hole and fit them into their housings.

NOTE: *Not finding it necessary to replace the main bearings, refit them in exactly the same sequence and position as in removal.*

NOTE: *Do not attempt to adapt the bearings.*

2. The second last main half-bearing **(1)** is fitted with shoulder half rings.



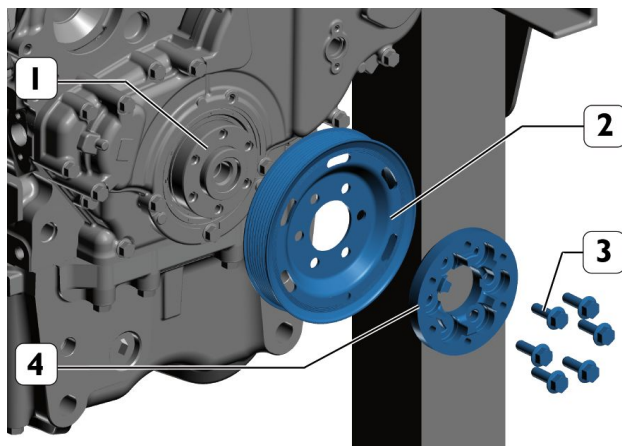
70185 1

540821 DRIVE PULLEY ON CRANKSHAFT - Remove

Prior operation:

Remove the belt as described in the procedure **WATER PUMP DRIVE BELT - Remove (54.34)**

1. Unscrew the fastening screws (3), recover the spacer (4) and remove the crankshaft pulley (2) from the crankshaft (1).



231909 1

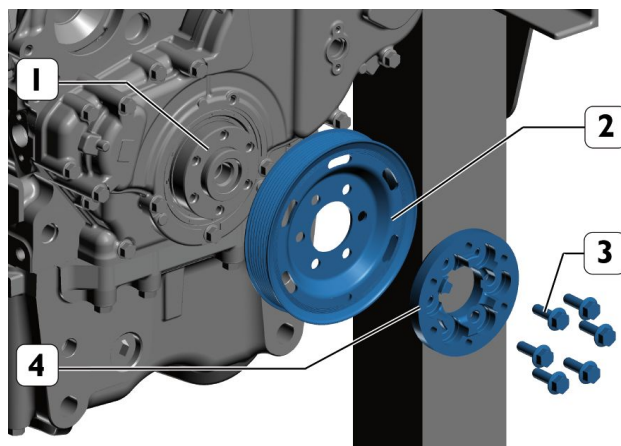
540821 DRIVE PULLEY ON CRANKSHAFT - Install

Description	Quantity	Value
Crankshaft pulley	7 screws M10 x 1.5 x 30	70 +/- 7 N·m

- Fit (1) the crankshaft pulley (2) and the spacer (4) on the crankshaft and tighten the fastening screws (3) to the specified torque.

NOTE: The flywheel rotation blocking tool can make it easier to install the crankshaft pulley.

Description	Quantity	Value
Crankshaft pulley	7 screws M10 x 1.5 x 30	70 +/- 7 N·m



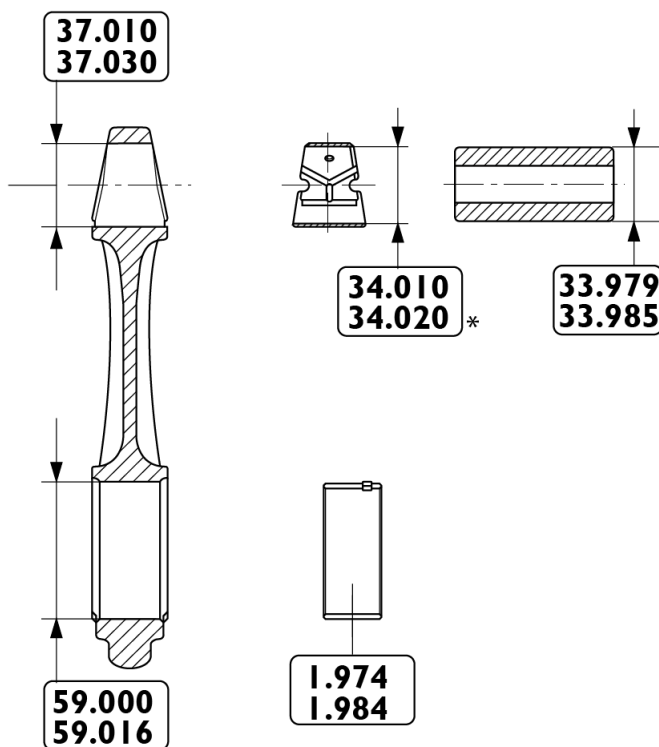
231909 1

Next operation:

Fit the belt as described in procedure **WATER PUMP DRIVE BELT - Install (54.34)**

540830 CONNECTING ROD - Check

Connecting rods



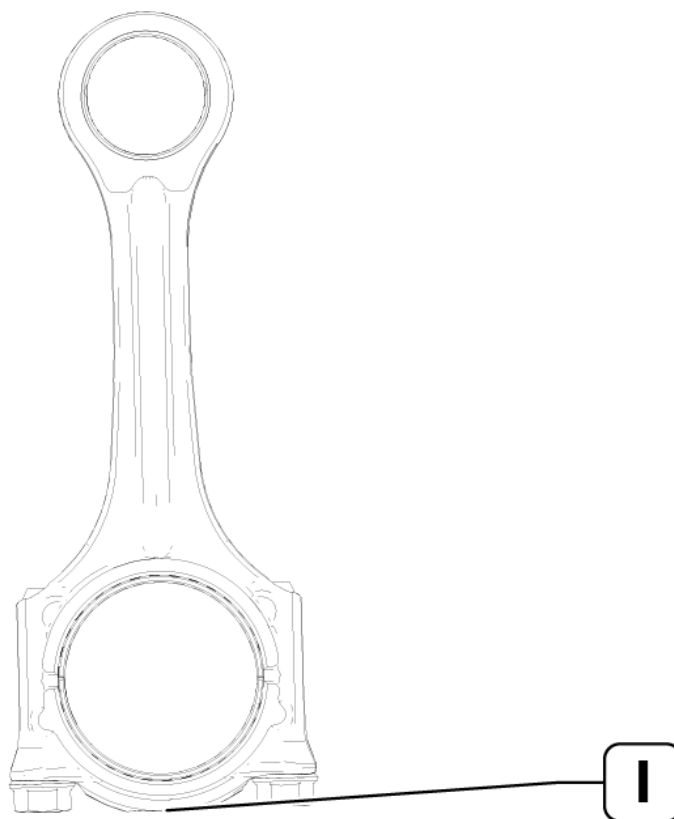
298210 1

MAIN DATA OF THE CONNECTING ROD, BUSHING, PISTON PIN AND HALF-BEARINGS (*) Inner diameter to be obtained after driving in the small end and reboring with borer.

1. During checks make sure that the main data of the connecting rod, bushing, piston pin and half-bearings is that shown in the figure.

NOTE: To obtain better coupling, the connecting rod-cap coupling surfaces are knurled. Do not remove the knurling.

2. Check the identification data of each connecting rod noting the code stamped in areas **(A)** and **(B)**.



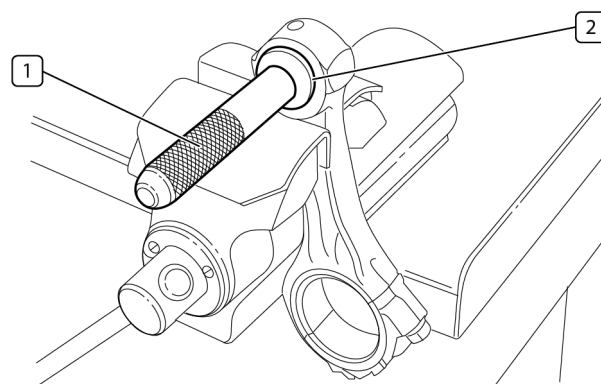
298211 2

1. Identification codes

Connecting rod identification code

Connecting rod small end bush check

1. Check that the bushing in the small end has not come loose and shows no sign of seizure or scoring. Otherwise replace it.
2. Removal and refitting shall be performed using the proper drift.
3. When refitting make sure that the holes for the oil on the bushing coincide with those on the connecting rod small end.

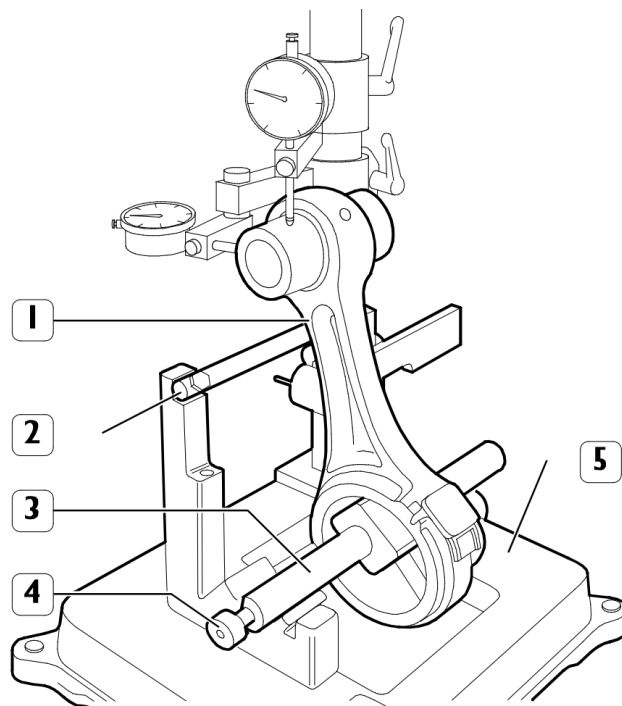


32625 3

4. Ream the bushing to obtain the specified diameter.

Alignment check

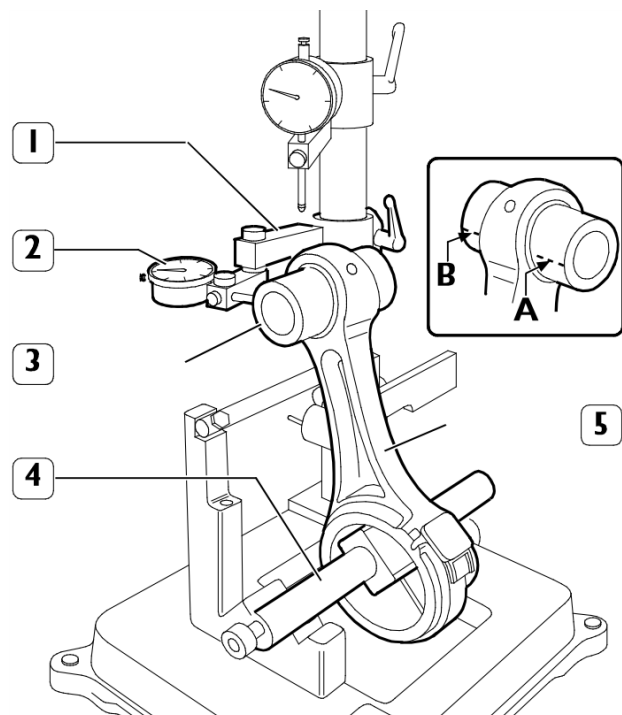
1. Check the alignment of the connecting rod axis (1) using a suitable device (5) proceed as follows:
2. Fit the connecting rod (1) on the spindle of the tool (5) and lock it with the screw (4).
3. Set the spindle (3) on the V prisms resting the connecting rod (1) on the stop bar (2).



61696 4

Torsion check

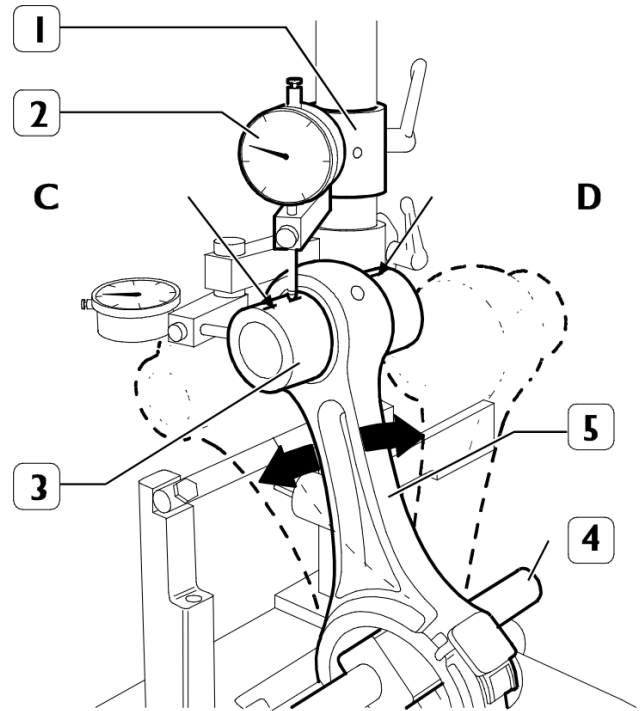
1. Check the bend of the connecting rod (5) by comparing two points (A) and (B) of the pin (3) on the horizontal plane of the connecting rod axis.
2. Position the mount (1) of the dial gauge (2) so that this pre-loads by approx. **0.05 mm** on the pin (3) at point A and reset the dial gauge (2). Shift the spindle (4) with the connecting rod (5) and compare any deviation on the opposite side (B) of the pin (3): the difference between A and B must not exceed **0.08 mm**.



61694 5

Bending check

1. Check the bend of the connecting rod (5) by comparing two points (C) and (D) of the pin (3) on the vertical plane of the connecting rod axis.
2. Position the vertical support (1) of the dial gauge (2) so that this rests on the pin (3) at point (C).
3. Swing the connecting rod to and fro, establishing the highest position of the pin and reset the dial gauge in this condition (2).
4. Move spindle with connecting rod (5) and repeat the highest point check on opposite side (D) of pin (3). The difference between points (C) and (D) must not exceed **0.08 mm**.



61695 6

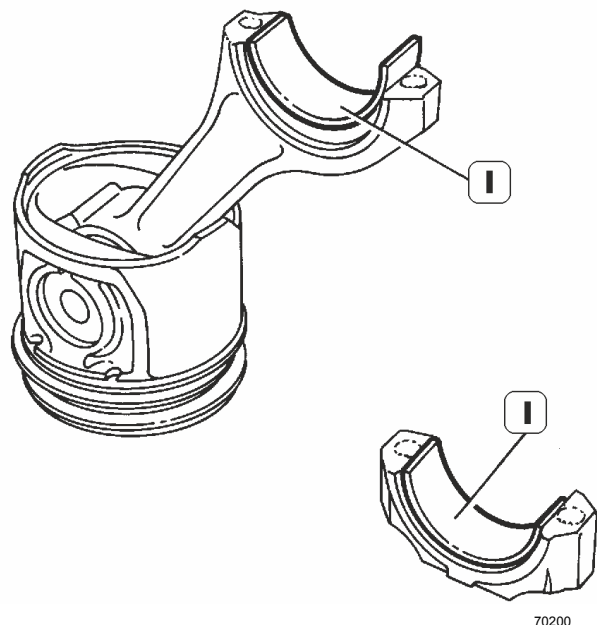
540831 CONNECTING ROD BEARING - Assemble

Big end half-bearing fitting

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

NOTE: Not finding it necessary to replace the connecting rod bearings, refit them in exactly the same sequence and position as in removal.

Do not make any adjustment on the half bearings.



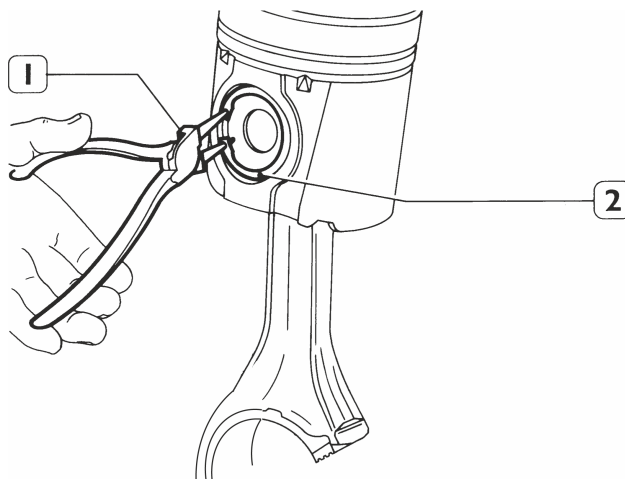
70200 1

540840 PISTON - Disassemble

Prior operation:

COMPRESSION RINGS - Disassemble (54.08)

1. The circlips (2) of the piston pin are removed using tipped pliers (1).



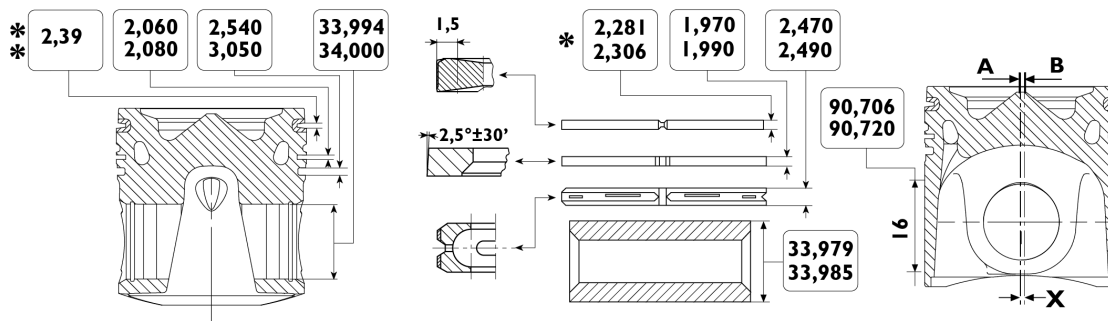
126312 1

540840 PISTON - Measure

Prior operation:

COMPRESSION RINGS - Disassemble (54.08)

Measuring the piston diameter



298212 1

MAIN DATA OF THE PISTON WITH CIRCLIPS AND PIN SEATS - (*)

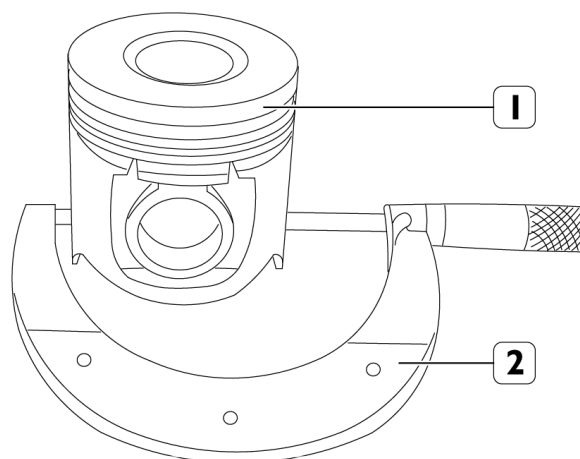
(*) The dimensions must be calculated at 1.5 mm from the outer diameter.

- A. Piston axle
- B. Piston axle
- X. 0.6 +/- 0.15 mm

Pistons

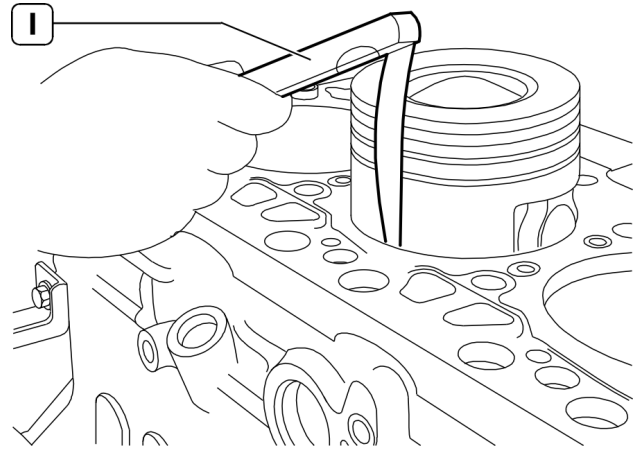
1. Using a micrometer (2) measure the piston diameter (1) to determine the assembly clearance.

NOTE: The diameter is to be measured at 49.5 mm from the piston skirt end.



272821 2

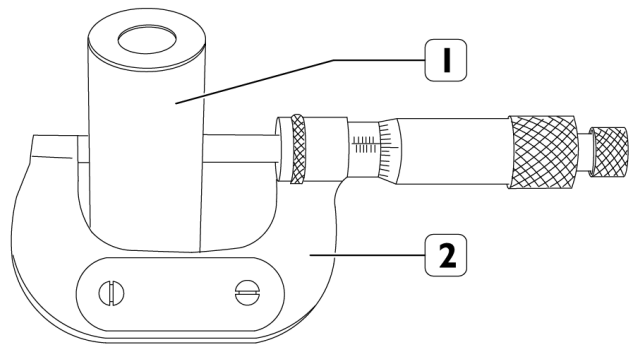
2. The clearance between the piston and the cylinder liner can also be checked with a feeler gauge (1) as shown in the figure.



70192 3

Piston pins

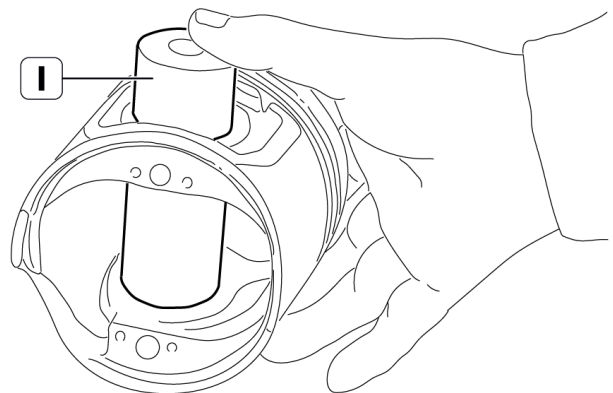
3. Measuring the diameter of the piston pin (1) using a micrometer (2).



272819 4

Conditions for correct pin/piston coupling

4. Lubricate the pin (1) and the relevant housing on the piston hubs with engine oil; Pin must be inserted in the piston with a light finger pressure and it should not come out by gravity.

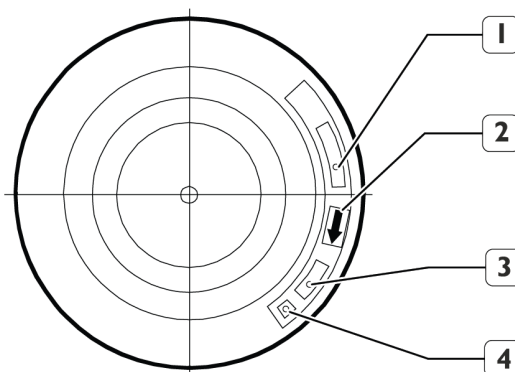


272824 5

540840 PISTON - Pre-assemble

Connecting rod-piston coupling - FAN SPEED

1. Before assembling the piston with the connecting rod, identify arrow **(2)** on the piston crown.

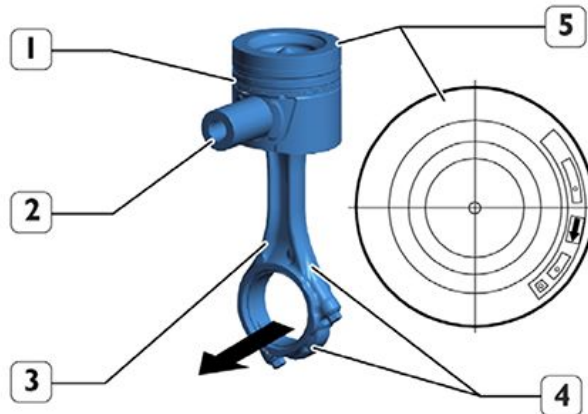


255572 1

(1) Part code – (2) Arrow indication positioning of connecting rod - piston assembly (facing the front side of the crankcase) – (3) Date of production – (4) Marking indicating testing of the 1st slot insert

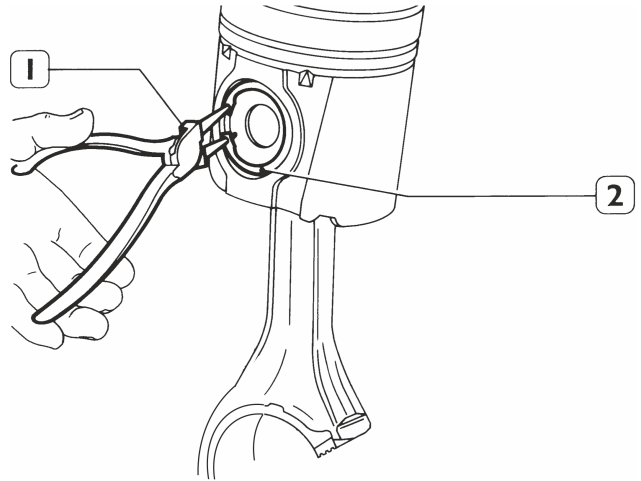
The piston crown is marked as follows:

1. Part number and design modification number;
 2. Arrow showing piston assembling direction into cylinder liner, this arrow shall face the front key of the crankcase;
 3. Marking showing 1st slot insert testing;
 4. Manufacturing date.
2. With the pin **(2)**, connect the piston **(1)** to the connecting rod **(3)** so that the piston **(1)** assembly reference arrow **(5)** in the cylinder liners and the numbers **(5)** printed on the connecting rod **(3)** appear as shown in the figure.



255235 2

3. Insert the piston rings **(2)** securing the pin.

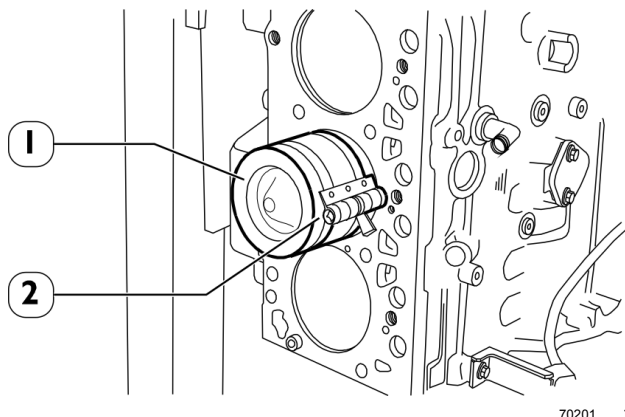


126312 3

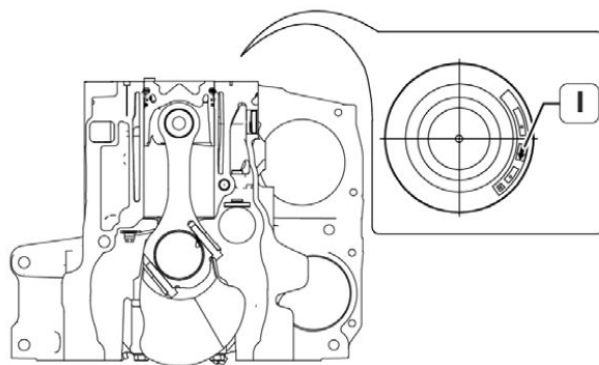
540840 PISTON - Assemble

Fitting the connecting rod-piston assembly into the cylinder liners

1. Lubricate the pistons well, including the circlips and the inside of the cylinder liners.
2. Using the clamp **(2)**, install the connecting rod-piston assemblies **(1)** in the cylinder linings checking that:
 3. The number of each connecting rod corresponds to the cap coupling number.
 4. The openings of the elastic rings must be out of phase with each other by: **120 °C**.
 5. Connecting rod-piston assemblies shall have the same weight.
6. the arrow **(1)** marked on the piston crown should face the front side of the crankcase or the slot obtained on the piston skirt should correspond to the oil nozzle position.



70201 1



255578 2

540840 PISTON - Check

Tool / Material	
Base,dial gauge,countershaft bearing adjustment(use with 99395604)	99370415
Dial gauge(0-5mm)	99395603

Prior operation:

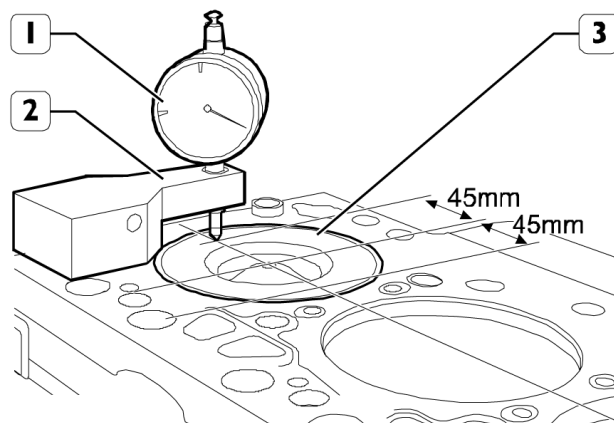
PISTON - Assemble (54.08)

Piston protrusion check

- Once refitting of the connecting rod-piston assemblies is complete, use a dial gauge (1) together with a base (2) to check the protrusion of the pistons (3) at T.D.C. in relation to the top of the engine block, carrying out the following operations:

Tool / Material	
Dial gauge(0-5mm)	99395603
Base,dial gauge,countershaft bearing adjustment(use with 99395604)	99370415

- On piston 1, as indicated in the Figure and measuring at a distance of **45 mm** from the centre, measure protrusions S1 and S2 of the piston in relation to the top surface of the crankcase and then calculate the average: $Scyl1 = (S1 + S2) / 2$.
- repeat the operation to calculate the average protrusion of pistons 2, 3, 4, 5 and 6 and calculate the average: $S = (Scyl1 + Scyl2 + Scyl3 + Scyl4 + Scyl5 + Scyl6) / 6$.

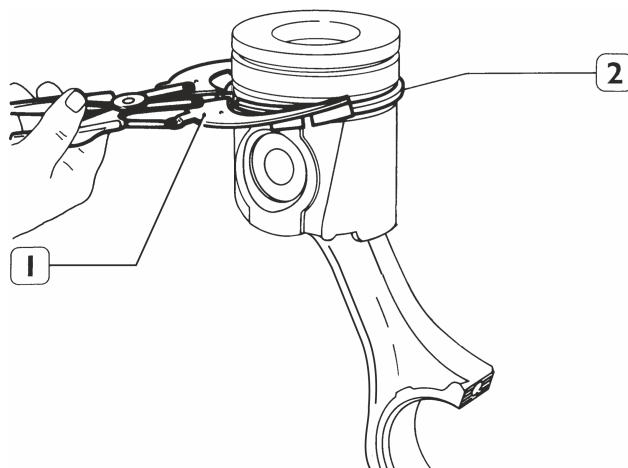


166655 1

540842 COMPRESSION RINGS - Disassemble

Piston rings removal

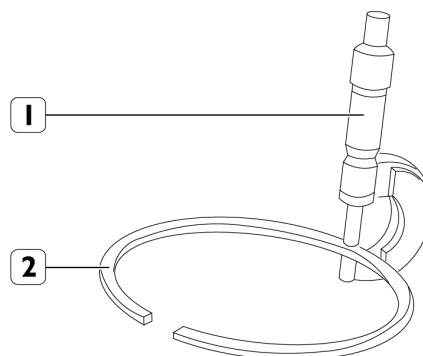
1. Removal of piston rings (1) from the pin (2) using pliers (3).



126311 1

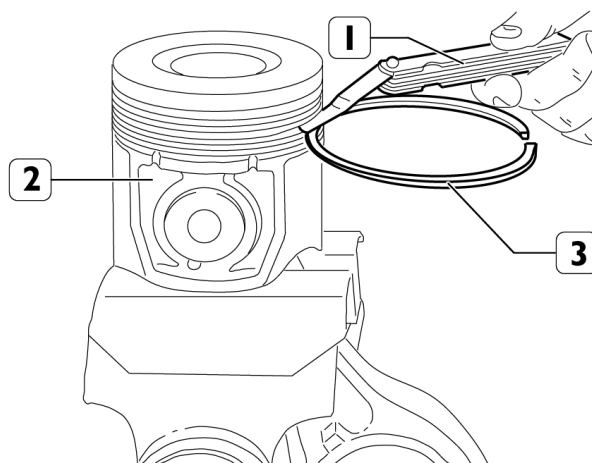
540842 COMPRESSION RINGS - Check

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



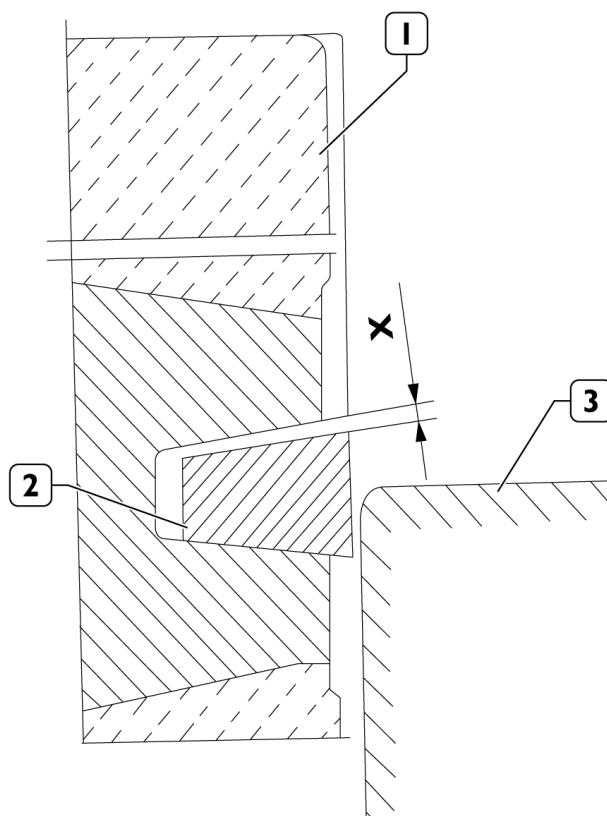
272820 1

2. Check the axial clearance between the seal rings (3) of the 2nd and 3rd slot and the relative seats on the piston (2) with a feeler gauge (1).



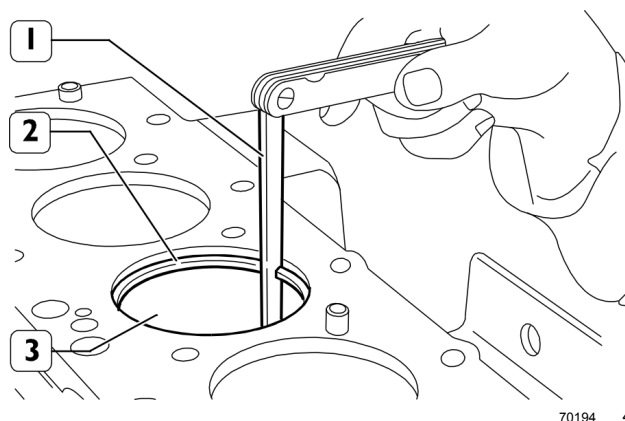
272825 2

3. Since the section of the first piston ring section is trapezoidal, the clearance between the slot and the ring is to be measured as follows; make the piston (1) protrude from the crankcase so the ring (2) in question comes out halfway from the cylinder liner (3).
4. In this position and using a feeler gauge, check that the clearance (X) between the ring and the slot falls within the prescribed values.



3513 3

5. Use a feeler gauge (1) to measure the opening end clearance of the piston ring (2) fitted into the cylinder liner (3).



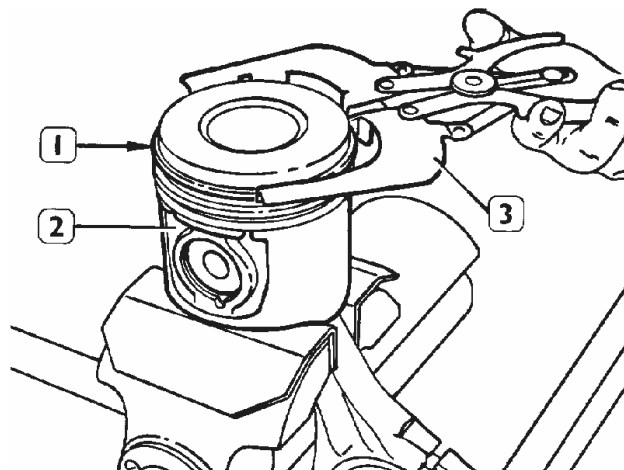
70194 4

540842 COMPRESSION RINGS - Assemble

Fitting piston rings

1. Use pliers (3) to fit the piston rings (1) on the piston (2).
2. The rings are to be fitted with the word TOP facing upwards and their openings are to be displaced in relation to the others by: **120 °C**.

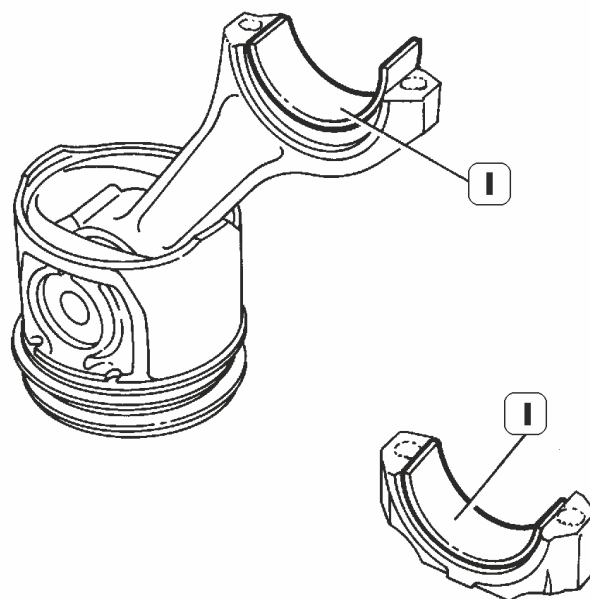
NOTE: Spare piston rings are supplied in the sizes below:
 standard, marked with yellow paint;
 - oversized by **0.4 mm** and marked with green/yellow paint.



32613 1

3. Support the half bearings (1) both on the connector rod and the cap.

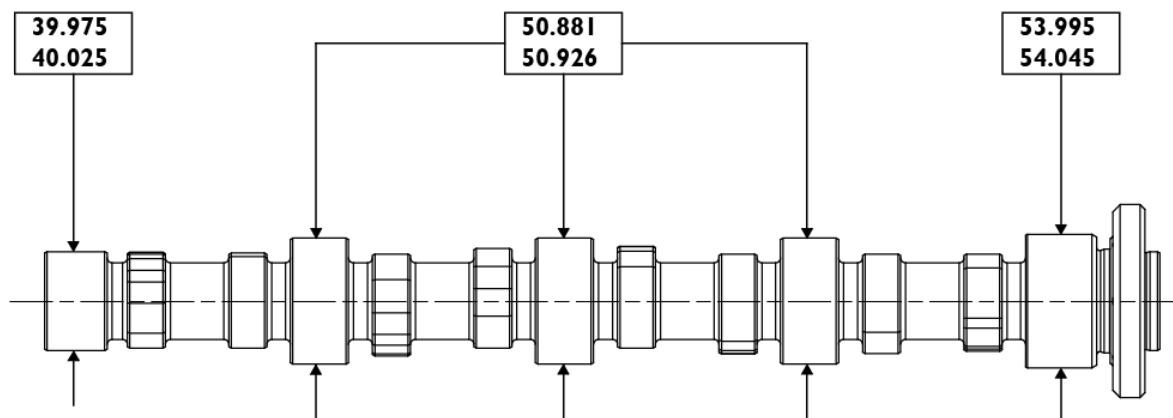
NOTE: Not finding it necessary to replace the connecting rod bearings, you need to fit them back in exactly the same sequence and position as in removal.
 Do not make any adjustment on the half bearings.



70200 2

541210 CAMSHAFT - Check

Camshaft

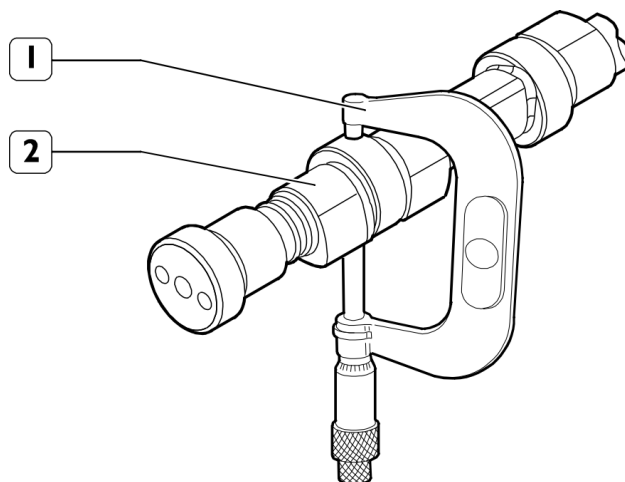


298218 1

CAMSHAFT MAIN DATA - The data provided refers to the standard diameter (dimensions in mm) of the pins

Checking cam lift and pin alignment

1. Position the camshaft on the tailstocks and using a centesimal gauge on the central support, check that the alignment error does not exceed **0.04 mm**, otherwise replace the camshaft.
2. Then, check the cam lifting: It must be **6.02 mm** for the exhaust cams and **5.79 mm** for the intake cams; in case of different values, replace the shaft.
3. Check camshaft **(2)** pin diameter using a micrometer **(1)** on two perpendicular axes.



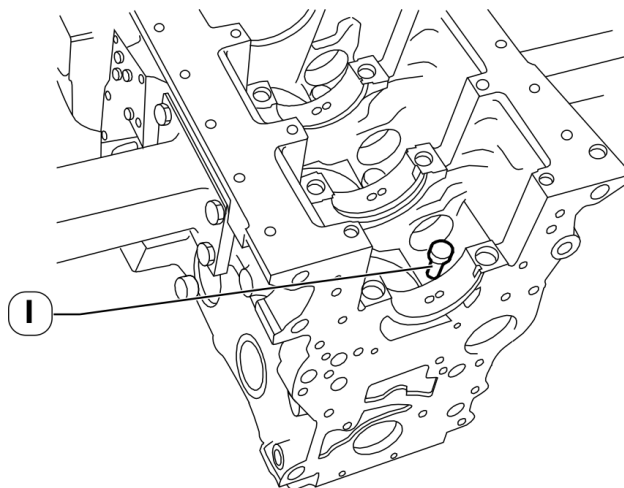
70171 2

541210 CAMSHAFT - Assemble

Description	Quantity	Step	Value
Camshaft longitudinal retaining plate	2 screws M8 x 1.25 x 18		23 +/- 2.3 N·m

Fitting tappets - Camshaft

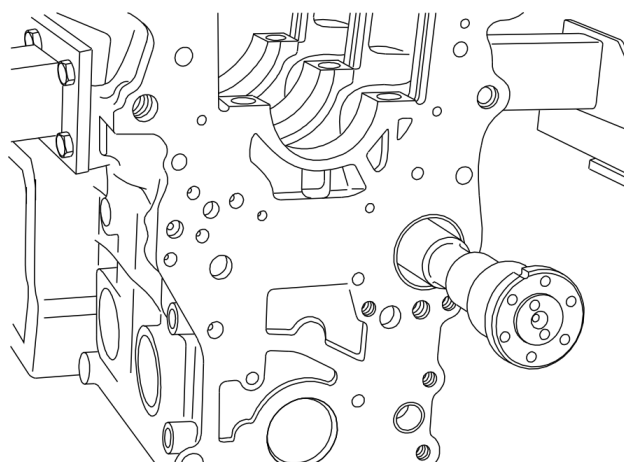
1. Lubricate the tappets (1) and fit them into the relevant seats on the crankcase.



70176 1

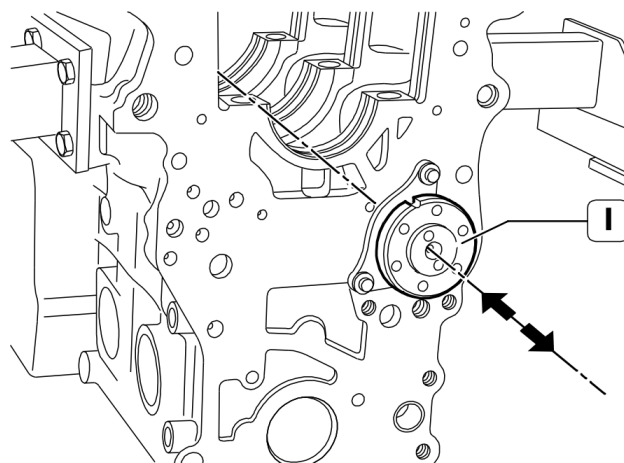
2. Lubricate the bushing and the other camshaft support seats and assemble the camshaft (1) taking care that, during the operation, the bushing or support seats are not damaged.
3. Set the camshaft (3) retaining plate (1) with the slot facing the top of the engine block and the marking facing the operator, then tighten the screws (2) to the specified torque.

Description	Quantity	Step	Value
Camshaft longitudinal retaining plate	2 screws M8 x 1.25 x 18		23 +/- 2.3 N·m



70164 2

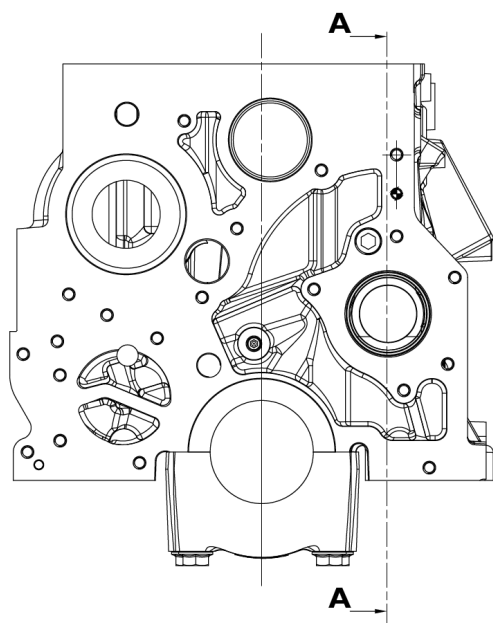
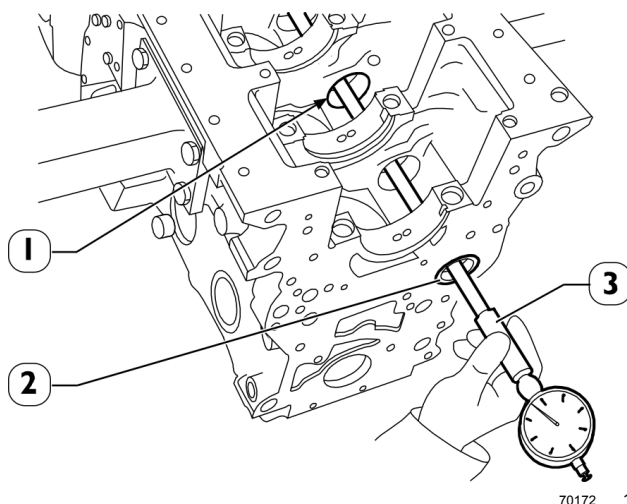
4. Check the camshaft end float (1). It must be 0.23 +/- 0.13 mm.



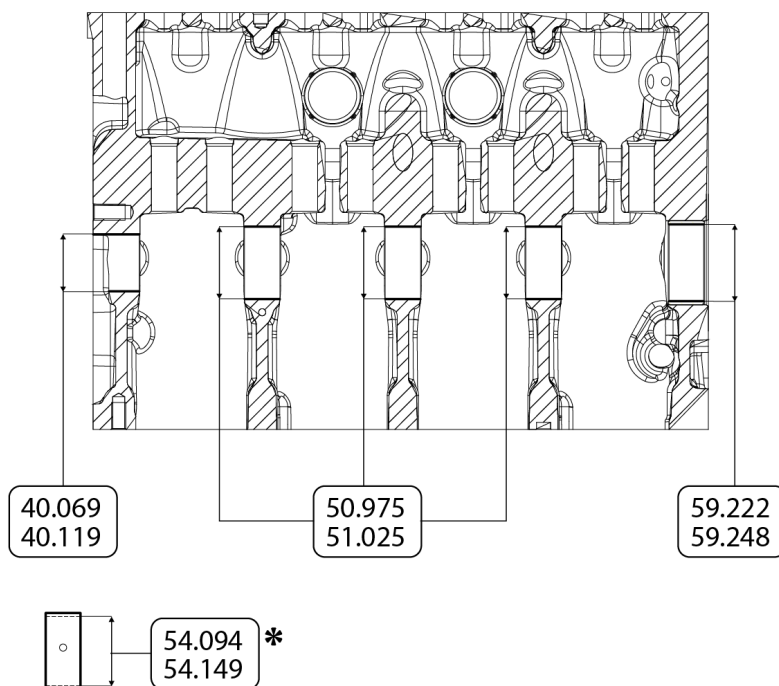
70179 3

541213 BUSHES - Check

1. The bushing (2) for the camshaft must be forced into its seat.
2. The internal surfaces must show no signs of seizure or worn.
3. Use a bore meter (3) to measure the diameter of the bushing (2) and the intermediate seats (1) of the camshaft.
4. Measurements should be performed on two perpendicular axes.



SEZ.A-A



298217 2

CAMSHAFT BUSH AND HOUSING MAIN DATA - (*)Value to be obtained after the installation of the bush (dimensions in mm).

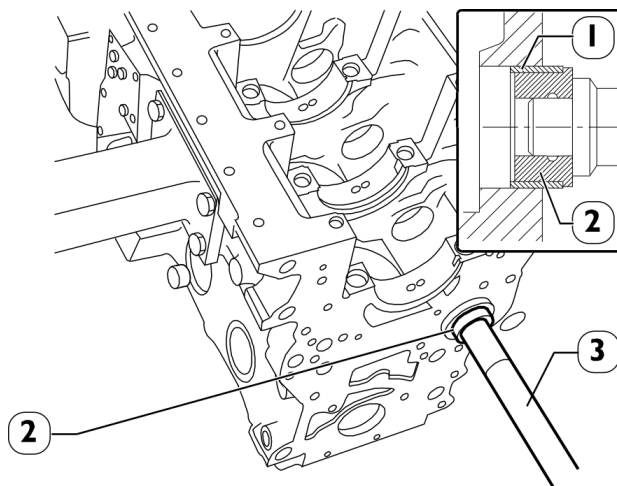
541213 BUSHES - Replace

Tool / Material	
Camshaft bush assembly and disassembly punch (use with 99370006)	99360362
Handle, interchangeable driver	99370006

Camshaft bushes replacement

- To replace the rear bushing (1) use the same drift (2) and grip (3) as for the disassembly and assembly.

Tool / Material	
Camshaft bush assembly and disassembly punch (use with 99370006)	99360362
Handle, interchangeable driver	99370006

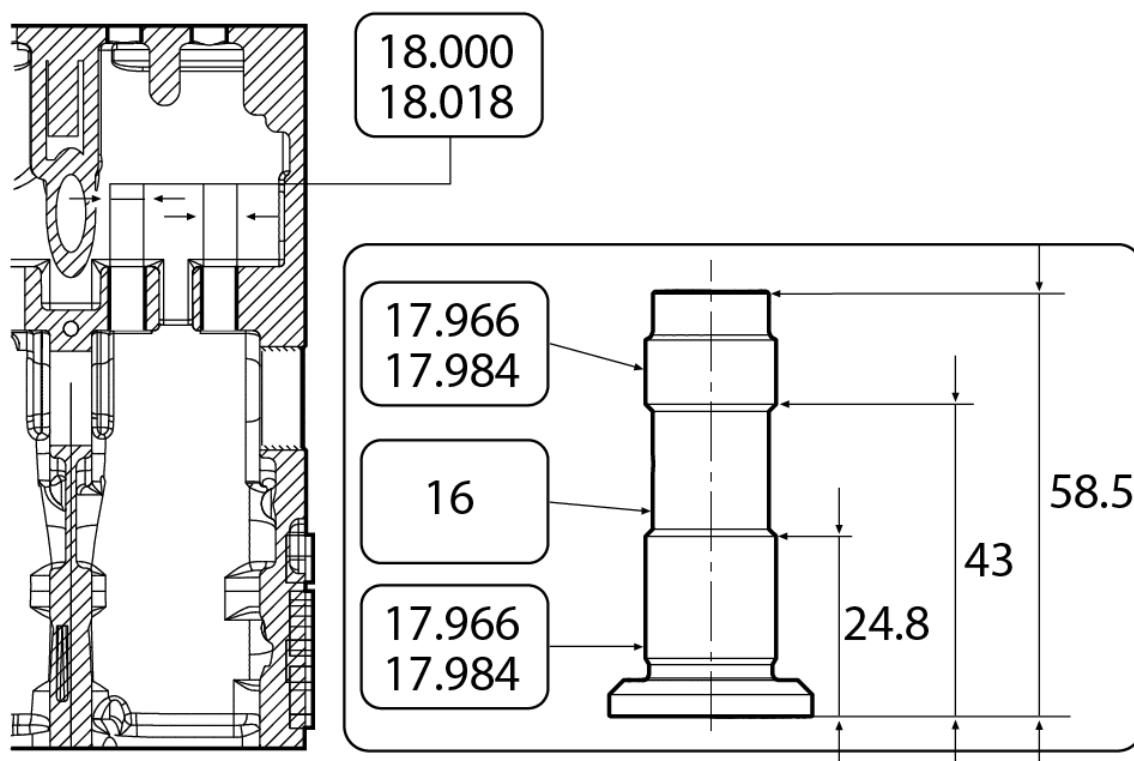


70174 1

NOTE: Bushing (1) for assembly must be oriented so that the lubrication holes match with those on the seat of the crankcase.

541224 TAPPETS - Check

1. Perform tappet measurements and make sure these correspond with their main data and with the data of the crankcase seats as in the figure.



298216 1

541230 ROCKER ARM ASSY - Remove

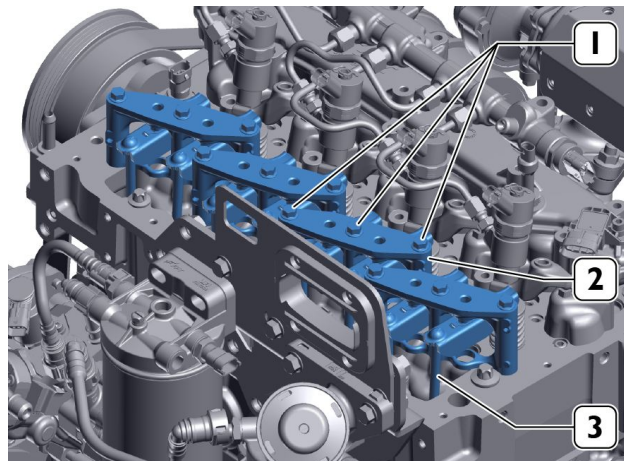
Prior operation:

Remove the engine cable as described in the procedure **ENGINE CABLES - Remove (76.91)**.

Prior operation:

Remove the tappet cover as described in the procedure **ROCKER COVER - Remove (54.06)**.

1. Unscrew the screws (1) and remove the suction and exhaust rocker arms assembly (2).
2. Remove the rocker arm control rods (3).



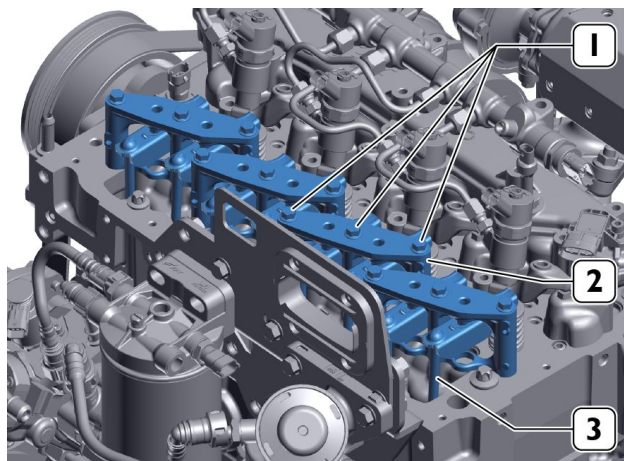
298311 1

541230 ROCKER ARM ASSY - Install

Description	Quantity	Step	Value
Rocker arm unit	12 screws M6 x 1 x 75		10 +/- 1 N·m

1. The control rods of the rocker arms must have no deformations; the tappets must not show any signs of seizure or wear; otherwise replace them.
2. Intake and exhaust valve control rods are identical and are therefore interchangeable.
3. Insert the rocker arm control rods (3).
4. Install the suction and exhaust rocker arms assembly (2) and tighten the screws (1) to the specified torque.

Description	Quantity	Step	Value
Rocker arm unit	12 screws M6 x 1 x 75		10 +/- 1 N·m



298311 1

Next operation:

Fit the tappet cover as described in the procedure **ROCKER COVER - Remove (54.06) ROCKER COVER - Install (54.06)**.

Next operation:

Install the engine cable as described in the procedure **ENGINE CABLES - Remove (76.91)**.

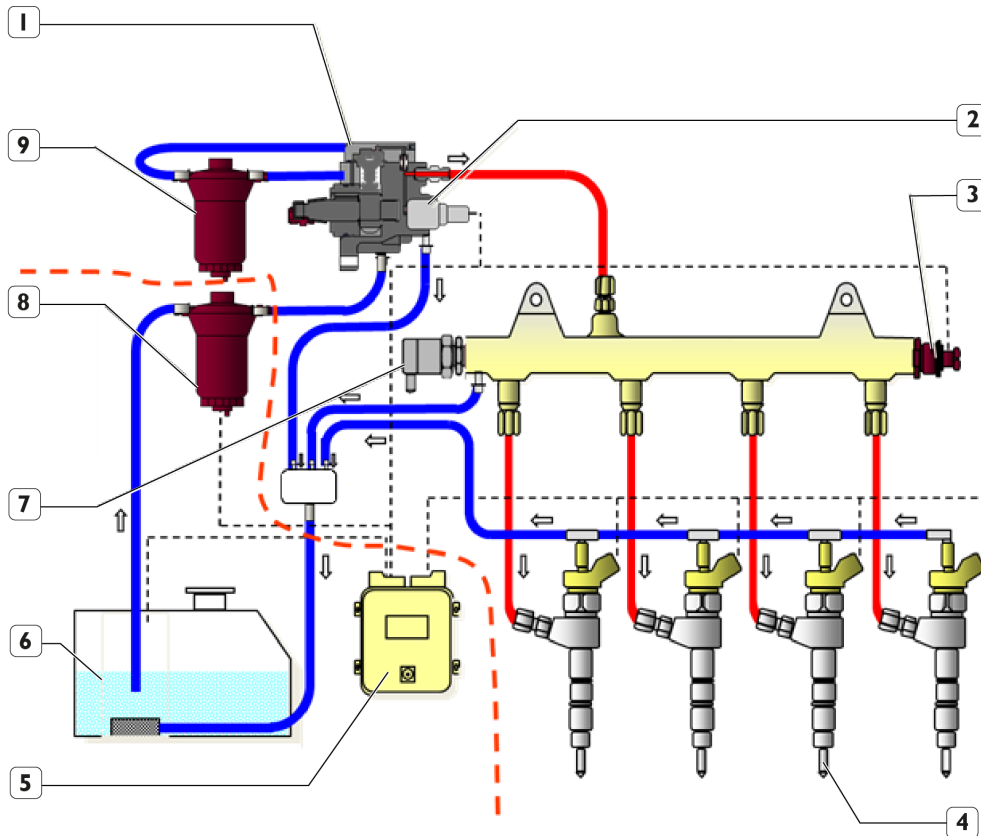
5420 FUEL FEED - Overview

SUPPLY SYSTEM

In order to reduce PARTICULATES emissions, very high injection pressures are required.

The Common Rail system allows injection of fuel at pressures reaching **1600 bar**, while the precision of the injection, obtained by means of the system's electronic management, optimises engine operation by limiting emissions and consumption.

Fuel system diagram



233177 1

1. High-pressure fuel pump
2. Fuel dosing unit
3. Fuel pressure sensor on rail
4. Injector
5. Engine control unit MD1CS069-7.22
6. Fuel tank
7. Common rail pressure relief valve
8. Fuel pre-filter with manual pump (part not supplied by FPT)
9. Fuel filter

The fuel is drawn in by the fuel tank and passes in the fuel pre-filter, which is equipped with a water detection sensor.

The mechanical fuel pump is of the gear type and is located inside the high-pressure pump.

Two by-pass valves are placed in parallel to the mechanical fuel pump. The first by-pass valve permits the fuel to flow from the exit of the mechanical pump to its inlet when the inlet pressure of the fuel filter exceeds the permitted limit.

The second by-pass valve makes it possible to fill the fuel system via the manual pump fit on the fuel filter/pre-filter mount.

The fuel dosing unit, fit on the high pressure pump, regulates the flow of the fuel necessary in the low pressure system.

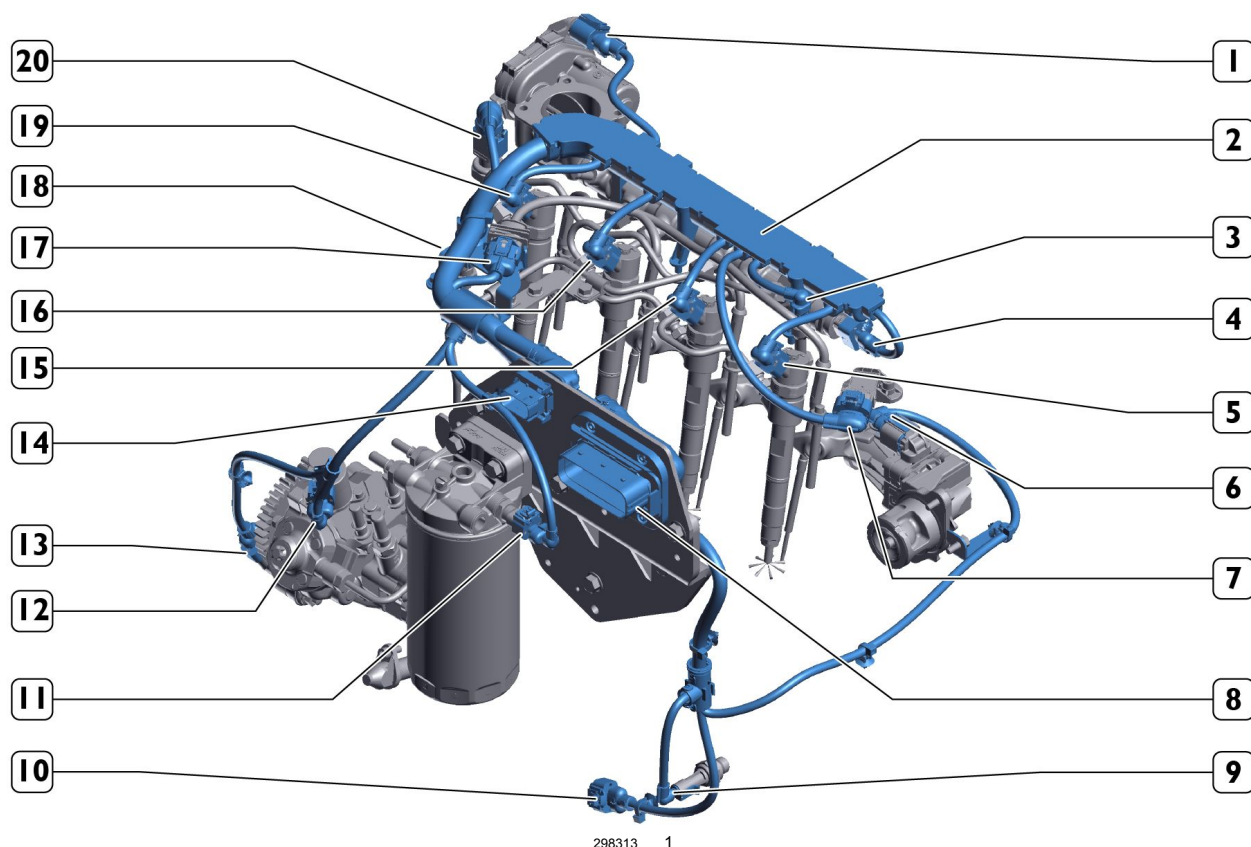
The distributor piston additionally increases the fuel pressure and sends the fuel through the delivery pipe to the Common rail and then to the electro-injectors.

The high pressure pump correctly supplies the Common rail. This solution, only pressurising the necessary fuel, improves energy efficiency and limits heating the fuel in the system.

The function of the relief valve, mounted on the high-pressure pump, is to maintain the flow rate, at the flow regulator inlet, constant, regardless of the efficiency of the fuel filter and of the system situated upstream.

The fuel which leaks from the electro-injectors is recovered and sent to the tank again.

5420 FUEL FEED - Overview - Electric system



1. Throttle body connector
2. Engine cable
3. Air temperature sensor connector
4. Common Rail pressure sensor connector
5. Cylinder 4 injector solenoid valve connector
6. Pierburg EGR valve connector
7. Supercharging pressure and air temperature sensor connector
8. Vehicle connector
9. Low oil pressure valve connector
10. Crankshaft speed sensor (incremental speed) connector
11. Fuel temperature sensor connector
12. High pressure fuel pump dosing unit connector
13. Camshaft timing sensor (segmental speed) connector
14. Cylinder connector
15. Cylinder 3 injector solenoid valve connector
16. Cylinder 2 injector solenoid valve connector
17. Glow plugs connector
18. Coolant temperature sensor connector
19. Cylinder 1 injector solenoid valve connector
20. Exhaust gas absolute pressure sensor connector

Through the sensors, present on the engine, the control unit controls the engine operation.

Air pressure/temperature sensor

This is a component that integrates a temperature sensor and a pressure sensor. Mounted on the intake manifold, it measures the maximum air flow aspirated that serves to provide accurate calculation of the amount of fuel to inject at each cycle. The voltage at the outlet is proportional to the pressure and temperature detected by the sensor.

Engine oil temperature - pressure sensor

Installed on the crankcase, it measures the engine oil 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 value of injection pressure is used to keep the pressure level under control and to determine the time duration of the injection electronic command.

Fuel Temperature Sensor

This sensor is identical to the previous one. It detects the temperature of the fuel to give the control unit information about the fuel oil temperature conditions.

Coolant temperature sensor

This is a variable resistance sensor that is able to measure coolant temperature and transmit a signal to the control unit reflecting the thermal conditions of the engine.

Crankshaft sensor

It is an inductive sensor placed on the engine front side. Signals generated through the magnetic flow that closes on the phonic wheel, change their frequencies depending on crankshaft rotation speed.

Timing sensor

It is an inductive sensor located in the rear left area of the engine. It generates signals obtained from magnetic flux lines which close through the holes situated in gears force fitted to the camshaft.

The signal generated by this sensor is used by the control unit as the injection timing signal. Though being equal to the crankshaft sensor, it is NOT interchangeable since it has a different outside shape.

Self-diagnostics

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

Synchronization search

By means of signals coming from camshaft sensor and crankshaft sensor, the cylinder on which fuel must be injected is recognised upon start-up.

Injection control

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

Closed loop injection pressure check

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

Pilot and main injection 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 electro-injectors. Within certain thresholds, it also takes into account the battery voltage.

Maximum speed limiting

By approximating to the maximum speed, the control unit limits the fuel flow rate by reducing the opening time of the injectors.

The engine maximum speed is **2750 +/- 100 RPM**. Above this speed the ECU deactivates the injectors.

Cut Off

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

- It removes power supply from the injectors;
- it re-activates the injectors shortly before idling speed is reached;
- It controls the fuel flow regulator.

Smokiness on acceleration control

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

Checking fuel temperature

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

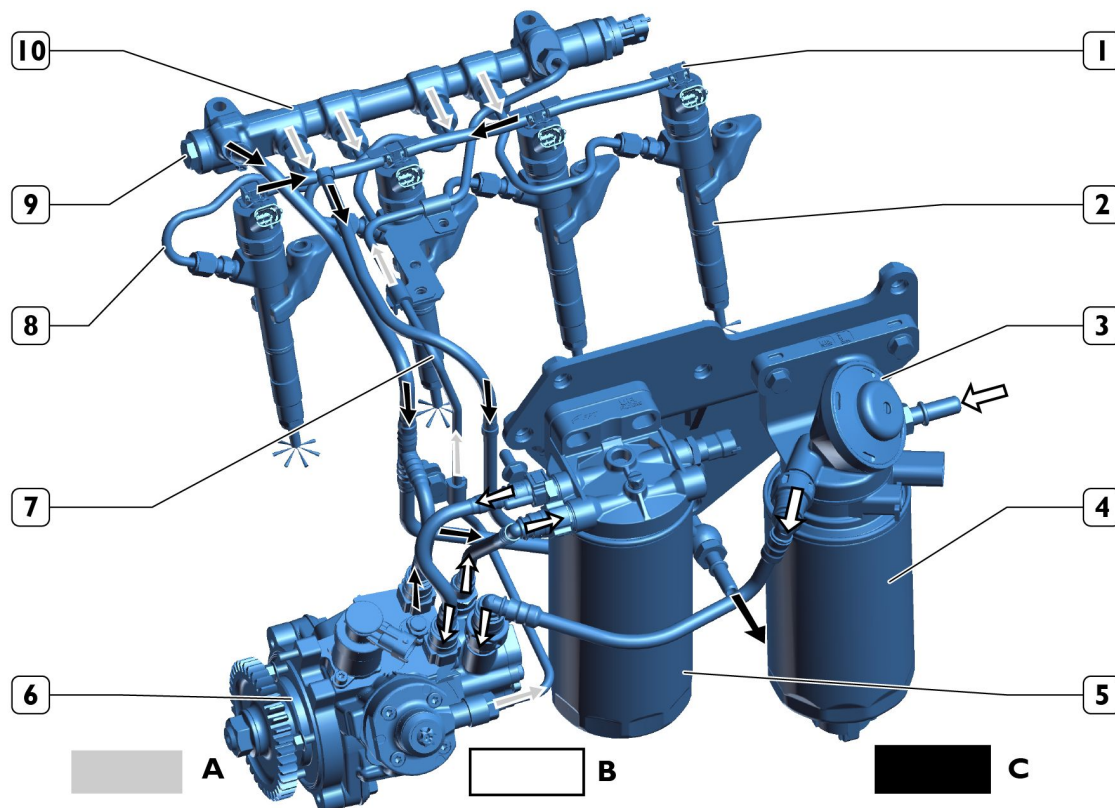
After Run

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 start-up.

5420 FUEL FEED - Overview - Hydraulic system

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 electro-injectors. At the electro-injector inlet therefore, there is always fuel at the injection pressure calculated by the ECU. When an injector solenoid valve is energised by the electronic control unit, the injection of fuel directly taken from rail takes place in the related cylinder.



298041 1

- A. High pressure
- B. Low pressure
- C. Fuel discharge

- 1. Fuel return from the injectors
- 2. Injector
- 3. Manual fuel pump (on the fuel pre-filter mount)
- 4. Fuel pre-filter
- 5. Fuel filter
- 6. Fuel high pressure pump
- 7. Fuel delivery pipe to the Common Rail
- 8. Fuel delivery pipe to the injectors from the high pressure rail
- 9. Pressure relief valve on rail
- 10. Common Rail

The fuel system consists of a low pressure circuit and a high pressure circuit. The high pressure circuit is composed of the following pipes:

- Pipe connecting the high-pressure pump outlet to the common rail;
- Common Rail;
- Pipes supplying injectors from common rail.

The low pressure circuit is composed of the following pipes:

- Pipe from fuel tank to pre-filter (not supplied by FPT);
- Pipe from fuel pre-filter to mechanical pump;
- Pipe from mechanical pump to fuel filter;
- Pipe from fuel filter to high pressure pump.

The pipes of the fuel drain circuit from Common Rail, electro-injectors and the high pressure pump reflux complete the system.

542010 FILTER ASSEMBLY - Overview

Fuel filter/pre-filter

The function of the fuel filter is to retain the impurities contained in the fuel and protect the components in the fuel circuit.

It is located on the fuel filter/pre-filter bracket and from a functional point of view is included in the circuit upstream of the high pressure pump.

The fuel filter/pre-filter mount is fitted with: the fuel temperature sensor and the fuel heater.

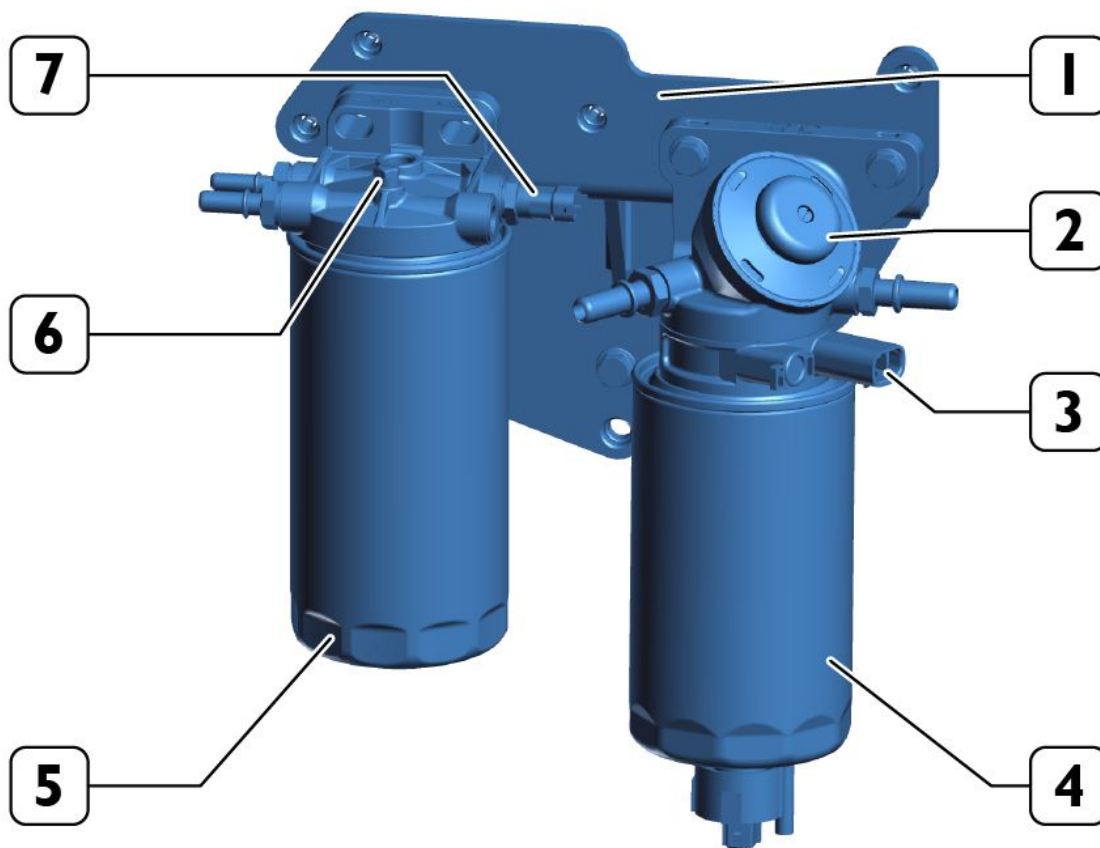
The fuel temperature indicated by the relative sensor at the MD1CS069–7.22 control unit makes it possible to accurately calculate the flow rate of the fuel to be injected in the cylinders.

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

The high water separation type fuel pre-filter is mounted on fuel filter/pre-filter mount and on the cartridge base it has a sensor for detecting water in the fuel circuit.

The presence of condensate in the filter is signalled by sensor when a warning light on the instrument panel comes on.

The fuel filter/pre-filter mount also houses a manual priming pump and a screw for bleeding the air from the system.



298046 1

1. Fuel filter/pre-filter mount
2. Manual fuel pump (on the fuel pre-filter mount)
3. Electric fuel heater
4. Fuel pre-filter
5. Fuel filter

6. System air bleed screw
7. Fuel temperature sensor

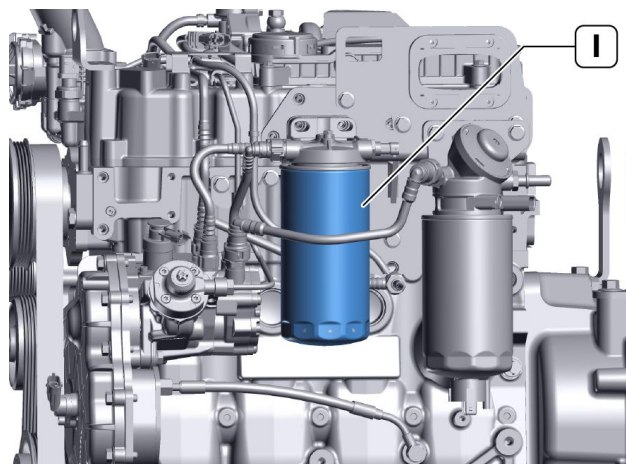
542010 FILTER ASSEMBLY - Replace

Tool / Material	
Remover, cartridge filter	99360076

Replacement of the fuel filter

- Position a container to collect the diesel below the fuel filter **(1)**.
- Use the specific tool to unscrew and remove the fuel filter **(1)** from the relative filter bracket and recover the gasket.

Tool / Material	
Remover, cartridge filter	99360076



298047 1

NOTE: Pay attention to the fuel temperature sensor and the electrical connections of the engine cable.

- Replace the fuel filter.
- Moisten the gasket of the fuel filter **(1)** with a thin layer of engine oil.
- Manually tighten the fuel filter **(1)** on the support until it makes contact with the gasket .

NOTE: Pay attention to the fuel temperature sensor and the electrical connections of the engine cable.

- Using the specific tool, further tighten the fuel filter **(1)** to the torque:

Description	Quantity	Value
Fuel filter	1 cartridge M20 x 1.5	22 +/- 3 N·m

- After replacing the fuel filter **(1)** there may be oil bubbles in the fuel circuit.
- Bleed the residual air from the fuel filter **(1)** by loosening the breather plug and connecting it to a suitable container with a transparent flexible pipe.
- Start the manual fuel pre-filter pump until the fuel exiting the bleeder plug is completely free of air bubbles.
- Tighten the bleeder plug to the specified torque.
- Start the engine and allow it to run at minimum for a few minutes to expel any remaining air.

542010 FILTER ASSEMBLY - Remove

Tool / Material

Remover, cartridge filter

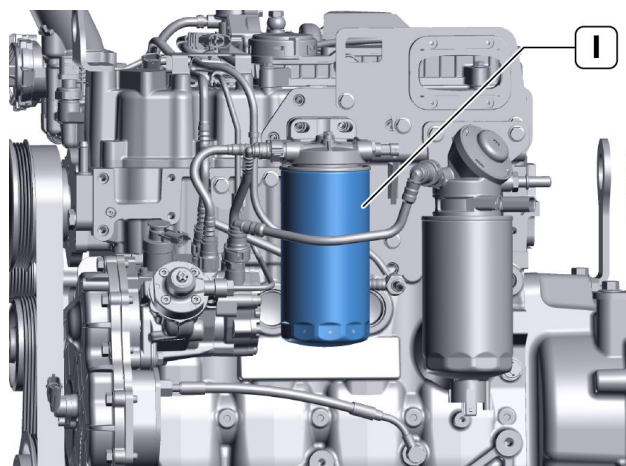
99360076

1. Position a container to collect the diesel below the fuel filter **(1)**.
2. Use the specific tool to unscrew and remove the fuel filter **(1)** from the relative filter bracket and recover the gasket.

Tool / Material

Remover, cartridge filter

99360076



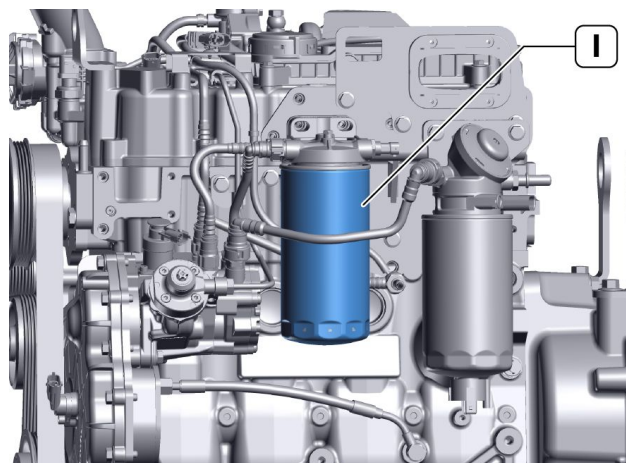
298047 1

NOTE: Pay attention to the fuel temperature sensor and the electrical connections of the engine cable.

542010 FILTER ASSEMBLY - Install

Description	Quantity	Value
Air bleeding on the fuel filter bracket	1 screw M10	4 +/- 0.5 N·m
Fuel filter	1 cartridge M20 x 1.5	22 +/- 3 N·m

1. Moisten the gasket of the fuel filter **(1)** with a thin layer of engine oil.
2. Manually tighten the fuel filter **(1)** on the support until it makes contact with the gasket .



298047 1

NOTE: Pay attention to the fuel temperature sensor and the electrical connections of the engine cable.

3. Using the specific tool, further tighten the fuel filter **(1)** to the torque:

Description	Quantity	Value
Fuel filter	1 cartridge M20 x 1.5	22 +/- 3 N·m

4. After replacing the fuel filter **(1)** there may be oil bubbles in the fuel circuit.
5. Bleed the residual air from the fuel filter **(1)** by loosening the breather plug and connecting it to a suitable container with a transparent flexible pipe.
6. Start the manual fuel pre-filter pump until the fuel exiting the bleeder plug is completely free of air bubbles.
7. Tighten the bleeder plug to the specified torque.

Description	Quantity	Value
Air bleeding on the fuel filter bracket	1 screw M10	4 +/- 0.5 N·m

8. Start the engine and allow it to run at minimum for a few minutes to expel any remaining air.

542014 FILTER SUPPORT - Remove

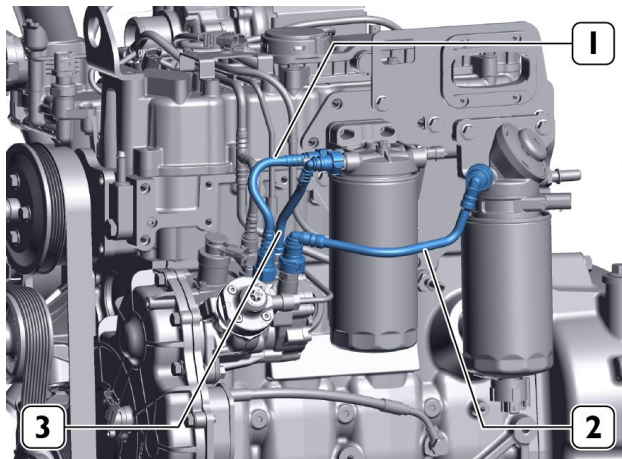
Tool / Material

Remover, cartridge filter

99360076

Removal of fuel filter bracket

1. Disconnect the low-pressure fittings and remove the fuel pipes (1) and (3) from the fuel filter bracket.
2. Disconnect the low pressure unions and remove the fuel pipe (2) on the fuel filter/pre-filter mount.

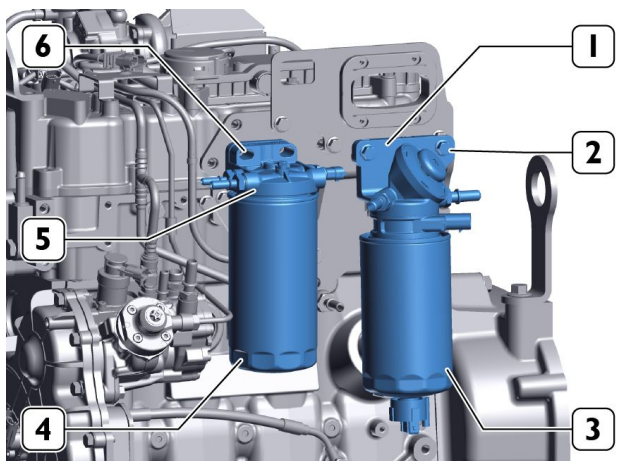


298048 1

3. Disconnect the electrical connections and partially remove the engine cable below the pre-fuel filter (3).

NOTE: Pay attention to the sensor detecting the presence of water in the fuel pre-filter and to the electrical connections of the engine cable.

4. Use the specific tool to unscrew and remove the fuel pre-filter (3) from the relative filter mount (2) and recover the gasket.



298049 2

Tool / Material

Remover, cartridge filter

99360076

5. Unscrew the fastening screws (2) and remove the bracket of the fuel pre-filter (1) from the support yoke.
6. Use the specific tool to unscrew and remove the fuel filter (4) from the relative filter bracket (5) and recover the gasket.

NOTE: Pay attention to the fuel temperature sensor and the electrical connections of the engine cable.

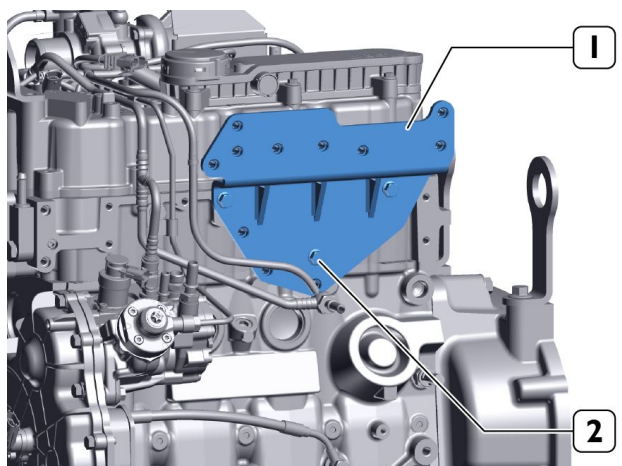
Tool / Material

Remover, cartridge filter

99360076

7. Unscrew the fastening screws (6) and remove the bracket of the fuel filter (5) from the support yoke.

8. Unscrew the fastening screws **(2)** and remove the fuel pre-filter/filter mount **(1)**.



298203 3

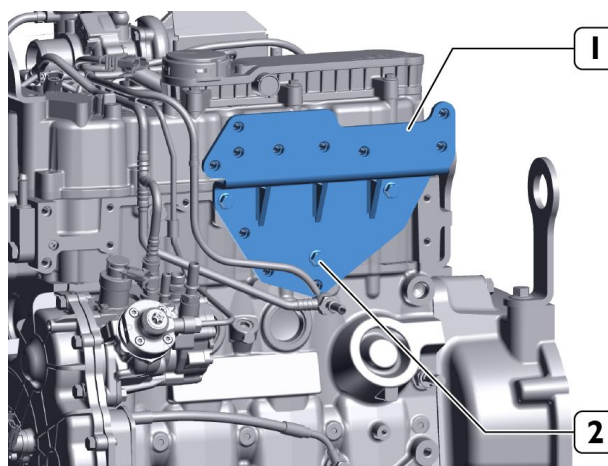
542014 FILTER SUPPORT - Install

Description	Quantity	Value
Air bleeding on the fuel filter bracket	1 screw M10	4 +/- 0.5 N·m
Filter bracket/fuel pre-filter bracket	3 screws M8 x 1.25 x 20	23 +/- 2.3 N·m
Fuel Pre-filter	1 cartridge —	20 +/- 3 N·m
Fuel filter	1 cartridge M20 x 1.5	22 +/- 3 N·m
Fuel filter bracket	2 screws M8 x 1.25 x 40	23 +/- 2.3 N·m

Fuel filter bracket refitting

- Fit the pre-fuel filter mount (1) on the crankcase and tighten the fastening screws (2) to the specified torque:

Description	Quantity	Value
Filter bracket/fuel pre-filter bracket	3 screws M8 x 1.25 x 20	23 +/- 2.3 N·m



298203 1

2. Fit the fuel filter bracket (5) on the support yoke and tighten the fastening screws (6).

Description	Quantity	Value
Fuel filter bracket	2 screws M8 x 1.25 x 40	23 +/- 2.3 N·m

3. Moisten the gasket of the fuel filter with a thin layer of engine oil.
4. Manually tighten the fuel filter (4) on the mount (5) until it makes contact with the gasket.

NOTE: Pay attention to the fuel temperature sensor and the electrical connections of the engine cable.

5. Using the specific tool, further tighten the fuel filter (1) to the torque:

Description	Quantity	Value
Fuel filter	1 cartridge M20 x 1.5	22 +/- 3 N·m

6. Fit the fuel pre-filter bracket (1) on the support yoke and tighten the fastening screws (2).

Description	Quantity	Value
Fuel Pre-filter	1 cartridge —	20 +/- 3 N·m

7. Moisten the gasket of the pre-fuel filter with a thin layer of engine oil.
8. Manually tighten the fuel pre-filter (3) on the mount (1) until it fits against the gasket.

NOTE: Pay attention to the sensor detecting the presence of water in the fuel pre-filter and to the electrical connections of the engine cable.

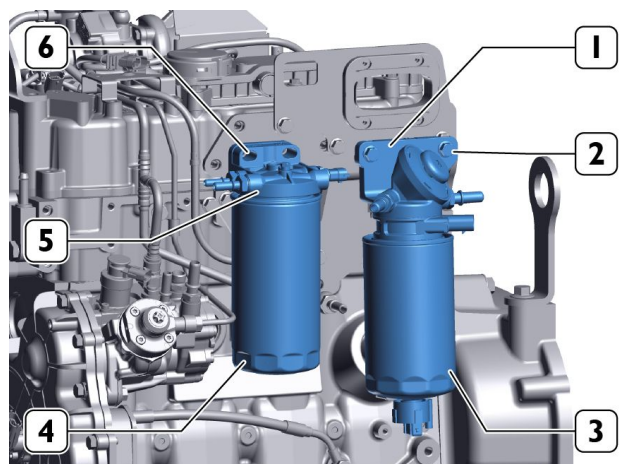
9. Using the specific tool, further tighten the fuel pre-filter (3) to the torque:

Description	Quantity	Value
Fuel Pre-filter	1 cartridge —	20 +/- 3 N·m

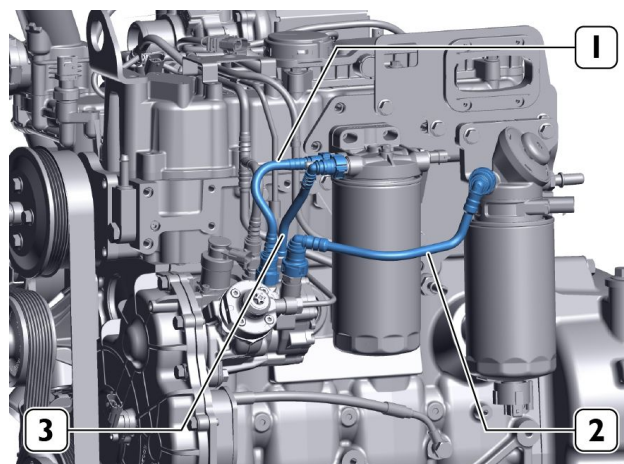
10. Fit the fuel pipe (2) on the fuel filter/pre-filter mount and connect the low pressure fittings.
11. Fit the fuel pipes (1) and (3) from the fuel filter bracket and connect the low pressure fittings.
12. After replacing the fuel filter there may be oil bubbles in the fuel circuit.
13. Bleed the residual air from the fuel filter by loosening the breather plug and connecting it to a suitable container with a transparent flexible pipe.
14. Start the manual fuel pre-filter pump until the fuel exiting the bleeder plug is completely free of air bubbles.
15. Tighten the bleeder plug to the specified torque.

Description	Quantity	Value
Air bleeding on the fuel filter bracket	1 screw M10	4 +/- 0.5 N·m

16. Start the engine and allow it to run at minimum for a few minutes to expel any remaining air.



298049 2



298048 3

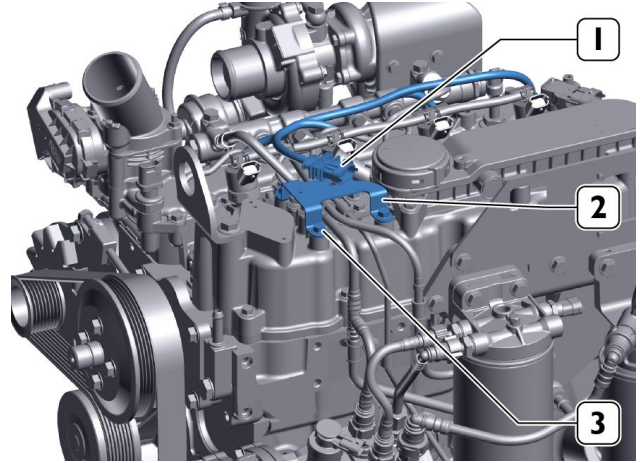
542020 PIPES - Remove

Prior operation:

Disconnect the engine cable as described in the procedure **ENGINE CABLES - Remove (76.91)**

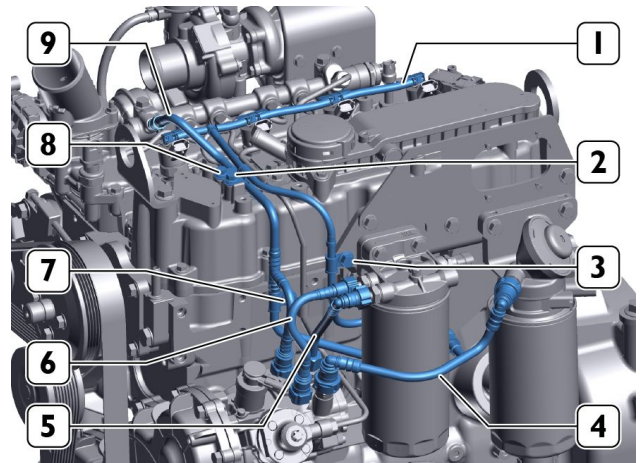
Removal of fuel pipes

1. Remove the wiring of the glow plugs (1), paying attention to the relevant stop.
2. Unscrew the screws (3) and remove the glow plug wiring retainer bracket (2).

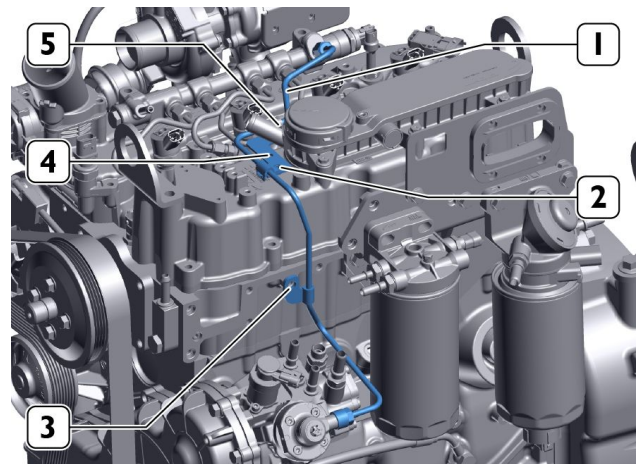


298312 1

3. Disconnect the low pressure fittings and remove the fuel pipes (4), (5) and (6) on the fuel filter/pre-filter bracket.
4. Unscrew the fastening screws (2) and (3) and remove the fuel return pipe (1) retainer brackets from the injectors.
5. Disconnect the low pressure fittings and remove the fuel return pipe (1) from the injectors.
6. Unscrew the fastening screws (7) and (8) and remove the brackets retaining the fuel return pipe (9) from the rail and from the high pressure pump.
7. Disconnect the low pressure fittings and remove the fuel return pipe (9) from the rail and from the high pressure pump.
8. Loosen the fastening screws (3), (4) and (5) and remove the retainer brackets of the fuel delivery pipe (1).
9. Unscrew the fittings and remove the fuel delivery pipe (1) from the high pressure pump to the rail.



298050 2

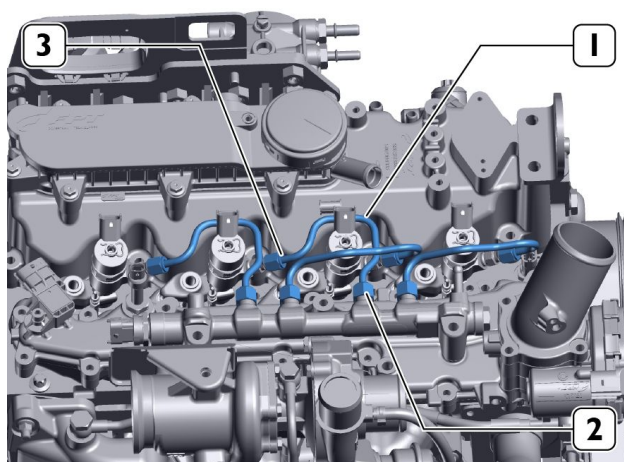


298051 3

NOTE: The high-pressure fuel delivery pipe must always be replaced each time it is removed.

10. Remove the high-pressure fuel delivery pipes (1) by first loosening the injector side nuts (3) and then the Common Rail side nuts (2).

NOTE: The high-pressure fuel delivery pipes must be replaced each time they are disconnected.



298052 4

542020 PIPES - Install

Description	Quantity	Step	Value
Bracket retaining the delivery fuel pipe from the pump to the rail	3 screws M6 x 1 x 10		10 +/- 1 N·m
Bracket retaining the fuel return pump from the rail and from the high pressure pump		1 screw M6 x 1 x 14	10 +/- 1 N·m
		1 screw M8 x 1.25 x 18	23 +/- 2.31 N·m
Delivery fuel pipe from the pump to the rail		1 high pressure fuel pump-side coupling M16 x 1	45 +/- 2.25 N·m
		1 rail-side coupling M14 x 1.5	35 +/- 1.75 N·m
Fuel delivery pipes to the electro-injectors	4 rail-side couplings M14 x1.5		35 +/- 1.75 N·m
Glow plug harness mount	3 screws M6 x 1 x 14		10 +/- 1 N·m
Injector fuel return pipe brackets		1 screw M6 x 1 x 14	10 +/- 1 N·m
		1 screw M8 x 1.25 x 18	23 +/- 2.3 N·m

Refitting fuel pipes

- Fit the high-pressure fuel delivery pipes (1) by first manually positioning the common rail side nuts (2) and then the injector side nuts (1).
- First tighten the nuts (2) on the common rail side and then the nuts (1) on the injector side in two steps, to the specified torque.

NOTE: The high-pressure fuel delivery pipes must be replaced each time they are disconnected.

Description	Quantity	Step	Value
Fuel delivery pipes to the electro-injectors	4 injector-side couplings M12 x 1.5		25 +/- 1.25 N·m
Fuel delivery pipes to the electro-injectors	4 rail-side couplings M14 x1.5		35 +/- 1.75 N·m

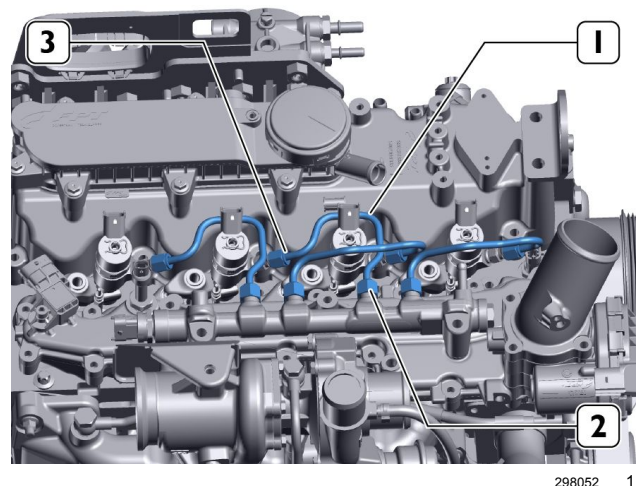
- Fit the fuel delivery pipe (1) from the high pressure pump to the rail and tighten the fittings to the specified torque.

NOTE: The high-pressure fuel delivery pipe must always be replaced each time it is removed.

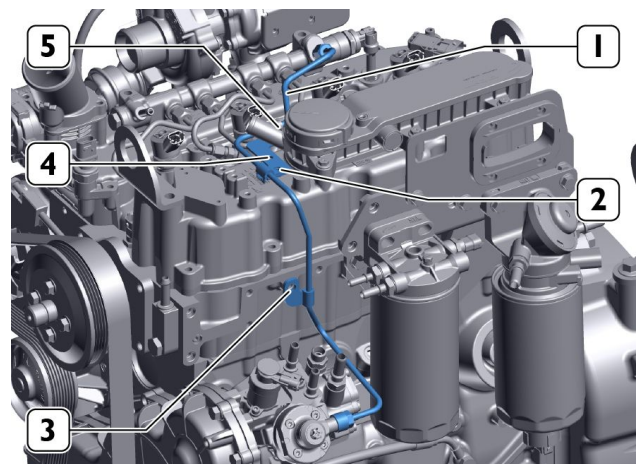
Description	Step	Value
Delivery fuel pipe from the pump to the rail	1 high pressure fuel pump-side coupling M16 x 1	45 +/- 2.25 N·m
	1 rail-side coupling M14 x 1.5	35 +/- 1.75 N·m

- Install the brackets retaining the fuel delivery pipe (1) and tighten the fastening screws (3), (4) and (5) to the specified torque.

Description	Quantity	Value
Bracket retaining the delivery fuel pipe from the pump to the rail	3 screws M6 x 1 x 10	10 +/- 1 N·m



298052 1



298051 2

5. Fit the fuel return pipe (9) from the rail and from the high pressure pump by connecting the fittings.
6. Install the retainer bracket of the fuel return pipe (9) from the rail and from the high pressure pump, and tighten the fastening screws (7) and (8) to the specified torque.

Description	Step	Value
Bracket retaining the fuel return pump from the rail and from the high pressure pump	1 screw M6 x 1 x 14	10 +/- 1 N·m
	1 screw M8 x 1.25 x 18	23 +/- 2.31 N·m

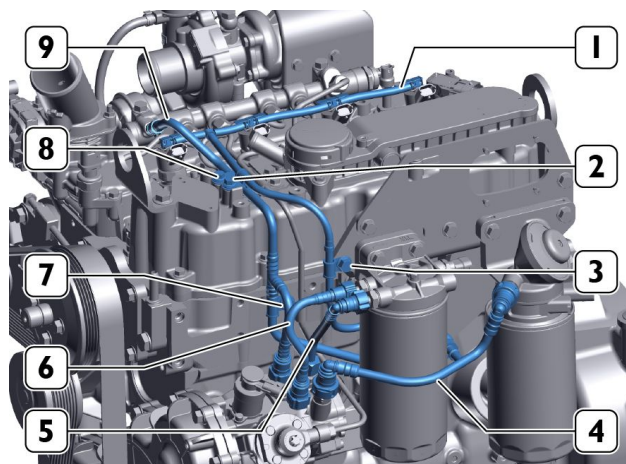
7. Fit the fuel return pipe (1) from the injectors and connect the low pressure fittings.
8. Install the brackets retaining the fuel return pipe (1) from the injectors and tighten the fastening screws (2) and (3) to the specified torque.

Description	Step	Value
Injector fuel return pipe brackets	1 screw M6 x 1 x 14	10 +/- 1 N·m
	1 screw M8 x 1.25 x 18	23 +/- 2.3 N·m

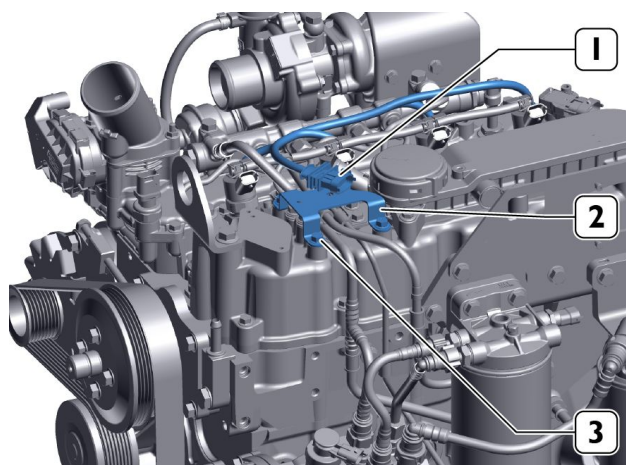
9. Fit the fuel pipes (4), (5) and (6) on the fuel filter/pre-filter bracket and connect the low pressure fittings.
10. Fit the glow plug wiring retainer bracket (2) and tighten the screws (3) to the prescribed torque.

Description	Quantity	Value
Glow plug harness mount	3 screws M6 x 1 x 14	10 +/- 1 N·m

11. Install the glow plug wiring (1) and secure it using the special retainer.



298050 3



298312 4

Next operation:

Connect the engine cable as described in the procedure **ENGINE CABLES - Install (76.91)**

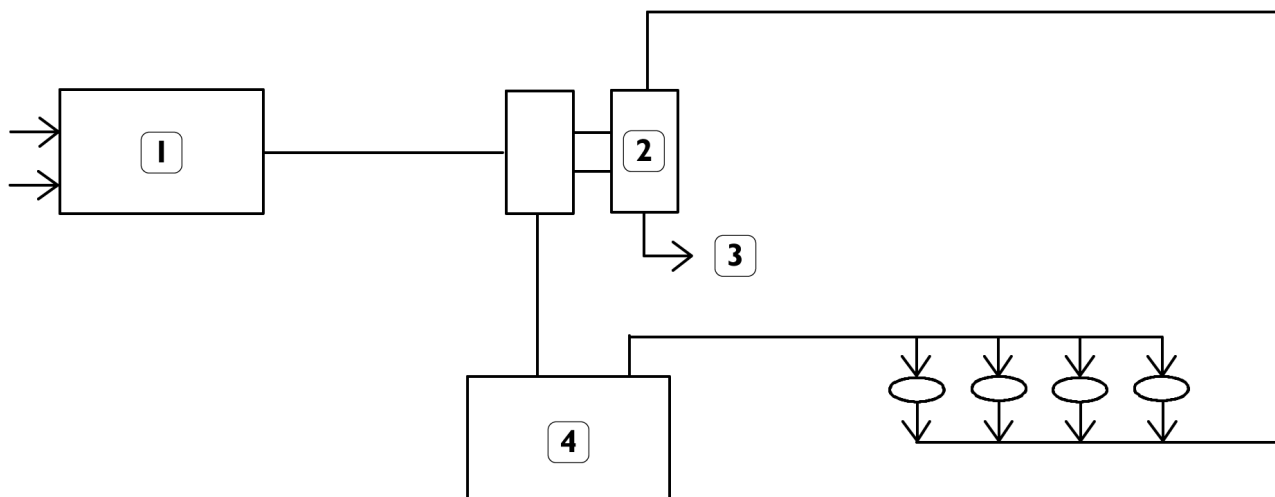
5424 SUPERCHARGING - Overview

The supercharging system consists of: an air filter (1), a turbocharger (2) and the intercooler (3).

The air filter is the dry type comprising a filter cartridge that should be replaced at regular intervals.

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

The intercooler consists of an air/water exchanger mounted on the engine coolant radiator with the function of lowering the temperature of the compressed air exiting the turbocharger.



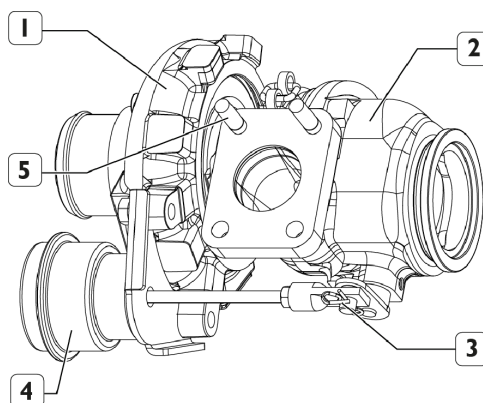
228658 1

1. Air filter
2. Turbocharger
3. To flush
4. Intercooler

542410 TURBO CHARGER - Overview

The turbocharger, installed on the exhaust manifold, mainly comprises:

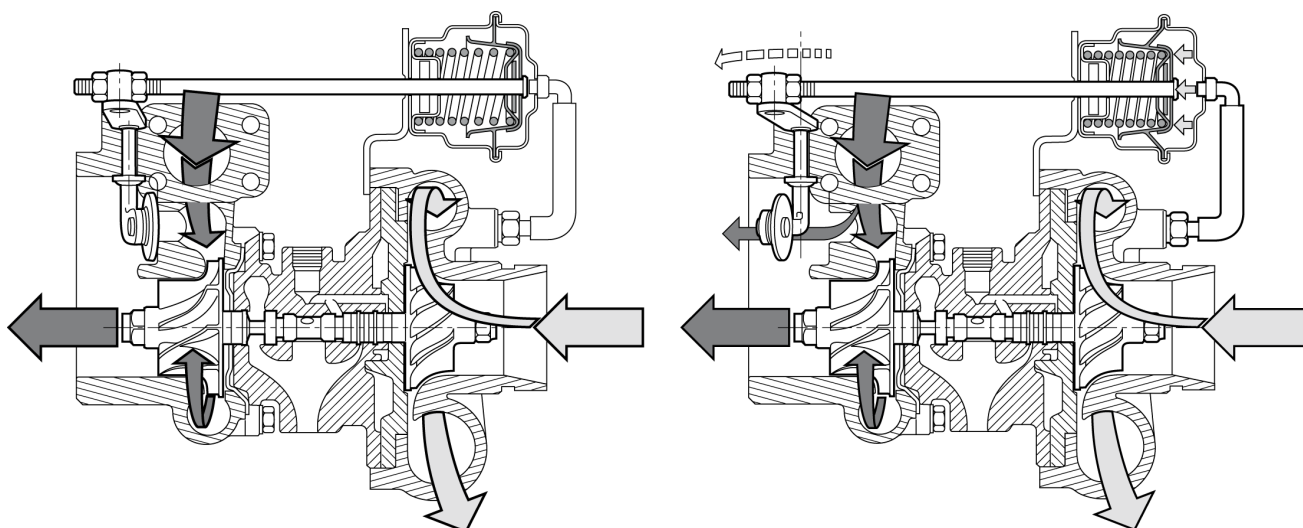
- a central casing housing a shaft supported by bushings at whose opposite ends are fitted the turbine and the compressor wheels;
- a turbine casing and a compressor casing mounted on the end of the central body;
- overpressure relief valve (Wastegate) applied on the turbine casing. Its function is to choke the exhaust gas outlet, sending a portion of the exhaust gas straight into the exhaust pipe when the turbocharging pressure downstream from the turbocharger reaches the calibration value



233184 1

1. Compressor body
2. Turbine body
3. Waste Gate actuator lever
4. Waste-Gate valve pneumatic actuator
5. Stud for fixing the turbocharger to the exhaust manifold

Waste Gate Valve



75532 2

- A. Closed throttle valve
- B. Throttle valve open

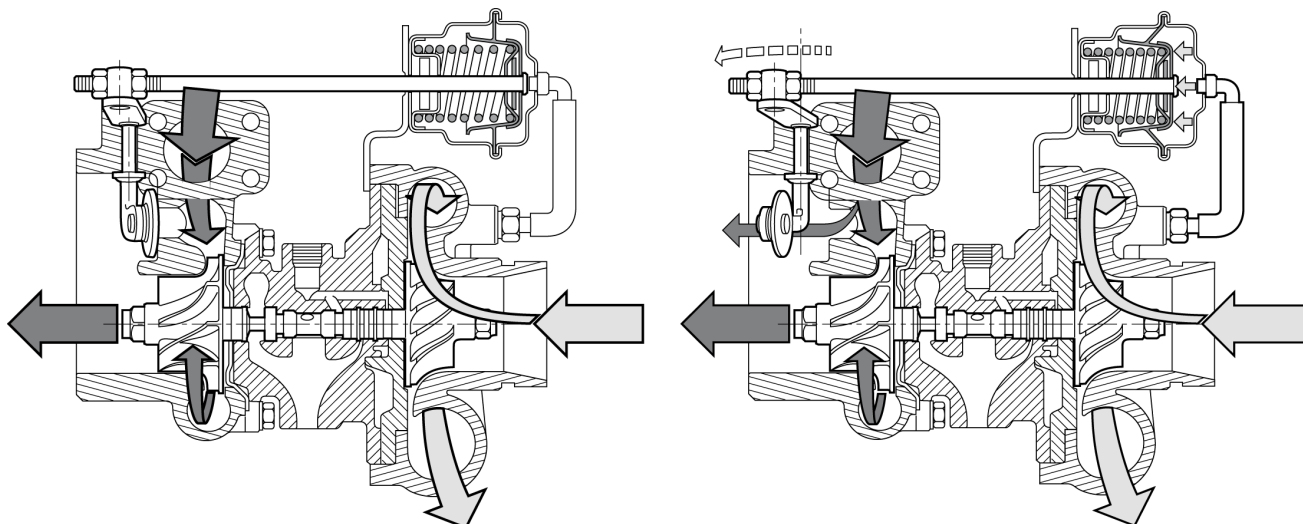
SECTION SHOWING A TURBOCHARGER WITH A WASTE-GATE VALVE

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 filter or inside radiators.

If the turbocharger damage is due to lack of lubrication, check that the oil circulation pipes are not broken or clogged and in that case replace it.

542418 WASTE GATE VALVE - Overview

Waste-Gate valve



75532 1

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

The turbocharger is equipped with a pressure regulator valve fit on the exhaust manifold upstream of the turbine and controlled by a pneumatic actuator, connected by a pipe to the intake manifold.

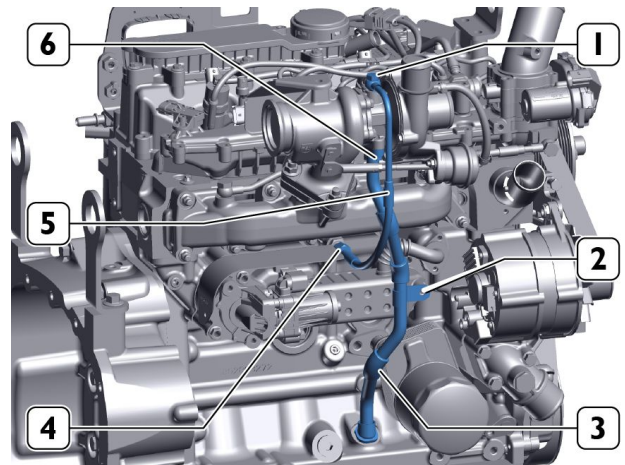
Its purpose is to limit the quantity of the exhaust gas that acts on the turbine, sending a part directly into the exhaust pipe when the boost pressure downstream of the compressor reaches the maximum prescribed value.

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 burst or clogged, in which case replace them or repair the fault.

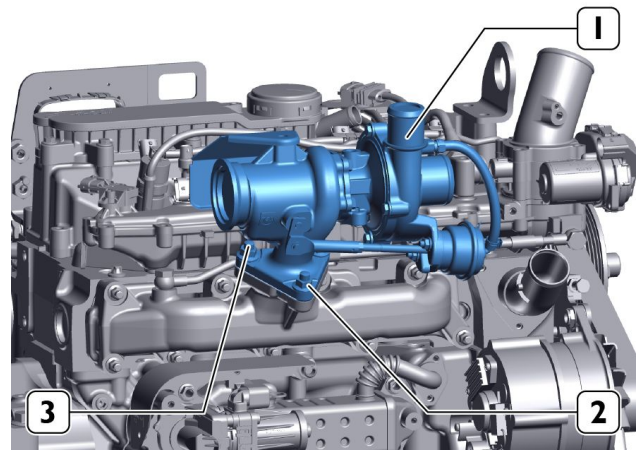
542410 TURBO CHARGER - Remove

1. Unscrew the fittings **(1)** and **(4)** and remove the oil delivery pipe **(5)** to the turbocharger.
2. Unscrew the fastening screw **(2)** of the oil return pipe mounting bracket **(3)** from the turbocharger.
3. Unscrew the fastening screws **(6)** and remove the oil return pipe **(3)** from the turbocharger.



298053 1

4. Unscrew the nuts **(2)** and remove the turbocharger **(1)** from the exhaust manifold, recovering the gasket.
5. If necessary, remove the studs **(3)** from the exhaust manifold and replace them.



298054 2

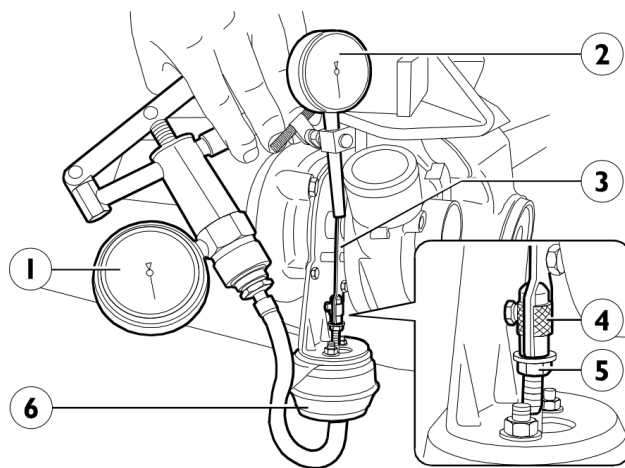
542410 TURBO CHARGER - Check

Check and adjustment

1. Cover air, exhaust gas and lubricant inlets and outlets.
2. Thoroughly clean the outside of the turbocharger using anti-corrosive and antioxidant fluid and check the actuator (6).
3. Clamp the turbocharger in a vice.
4. Disconnect the pipe of the actuator (6) and fit the pump pipe to the actuator pipe (1) filler.
5. Apply the magnetic stand gauge (2) to exhaust gas inlet flange in the turbine.
6. Set gauge feeler pin (2) on the end of the tie rod (3) and set gauge to zero (2).
7. Using the pump (1), deliver compressed air at a pressure of **1.9 +/- 0.002 bar** into the actuator (6). Make sure that this pressure value remains constant for the entire duration of the check. Otherwise, replace the actuator (6).
8. In this set-up, the tie rod must have travelled by the specified distance.

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

9. If a different value is found, loosen the nut (5) and act on the knurled ring nut (4).

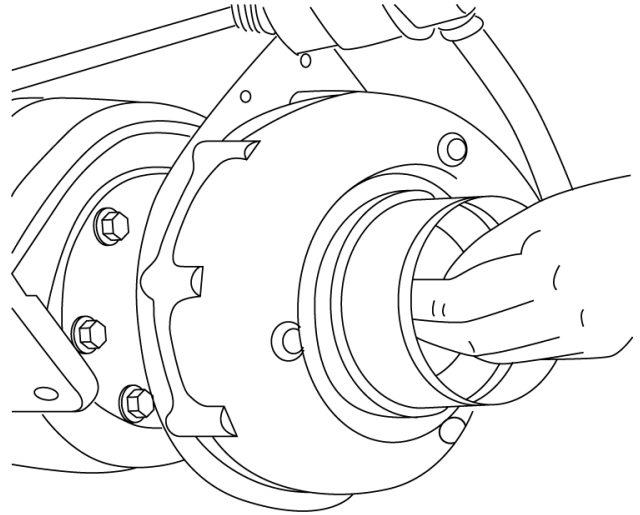


62873 1

542410 TURBO CHARGER - Check

Turbocharger visual inspection

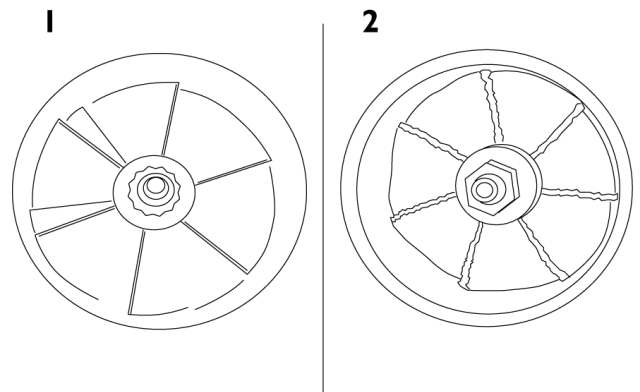
1. Only proceed with the engine stopped.
2. Manually tighten the shaft but allowing it still to rotate, and check for any jams.



254423 1

3. Check for any wear in the housing inside the compressor.

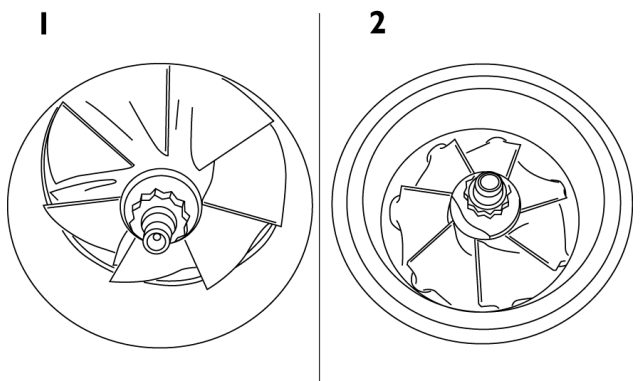
1. There are no signs of wear on the inner diameter of the compressor
2. Signs of contact between the rotor and the inner diameter of the compressor



254424 2

4. Visually check the condition of the compressor, blades and turbine.

1. There are no signs of wear on the inner diameter of the compressor
2. Signs of contact between the rotor and the inner diameter of the compressor



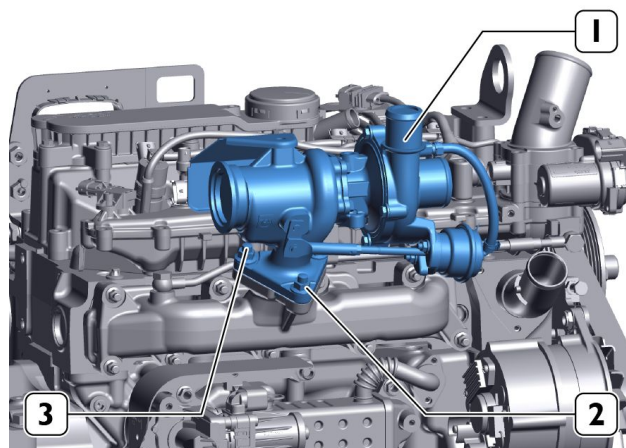
254425 3

542410 TURBO CHARGER - Install

Description	Quantity	Step	Value
Lubricant delivery pipe to turbocharger		1 screw M10 x 1 x 19	25 +/- 2,5 N·m
		1 nut M14 x 1.5	35 +/- 3.5 N·m
Lubricant oil return pipe from turbocharger bracket	1 screw M6 x 1 x 10		10 +/- 1 N·m
Lubricant return pipe from turbocharger	2 screws M6 x 1 x 20		10 +/- 1 N·m
Turbocharger		3 nuts M10 x 1.5 x 10	28 +/- 1,5 N·m
		3 studs M10 x 1.5 x 40	25 +/- 1.25 N·m

- if removed, screw the nuts **(3)** onto the exhaust manifold and tighten them to the specified torque.
- Refit the turbocharger **(1)** to the exhaust manifold with a new gasket and tighten the fastening nuts **(2)** to a torque of:

Description	Step	Value
Turbocharger	3 nuts M10 x 1.5 x 10	28 +/- 1,5 N·m
	3 studs M10 x 1.5 x 40	25 +/- 1.25 N·m



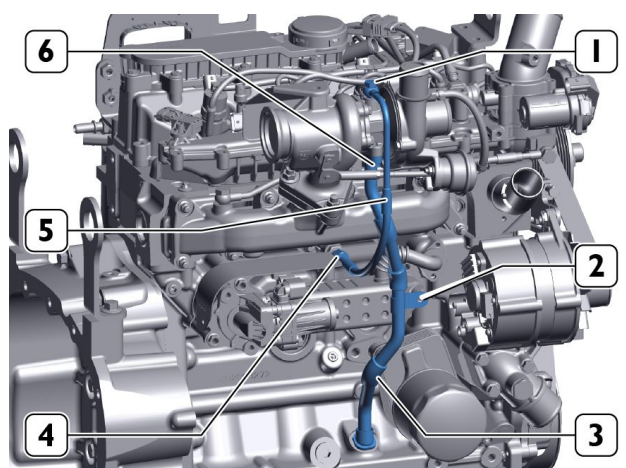
298054 1

- Connect the oil return pipe **(3)** from the turbocharger and tighten the fastening screws **(6)** to the specified torque.

Description	Quantity	Step	Value
Lubricant return pipe from turbocharger	2 screws M6 x 1 x 20		10 +/- 1 N·m

- Tighten the fastening screw **(2)** of the oil return pipe mounting bracket **(3)** from the turbocharger.

Description	Quantity	Step	Value
Lubricant oil return pipe from turbocharger bracket	1 screw M6 x 1 x 10		10 +/- 1 N·m



298053 2

- Connect the oil delivery pipe **(5)** to the turbocharger and tighten the fittings **(1)** and **(4)** to the specified torque.

Description	Step	Value
Lubricant delivery pipe to turbocharger	1 screw M10 x 1 x 19	25 +/- 2,5 N·m
	1 nut M14 x 1.5	35 +/- 3.5 N·m

5430 LUBRICATION - Overview

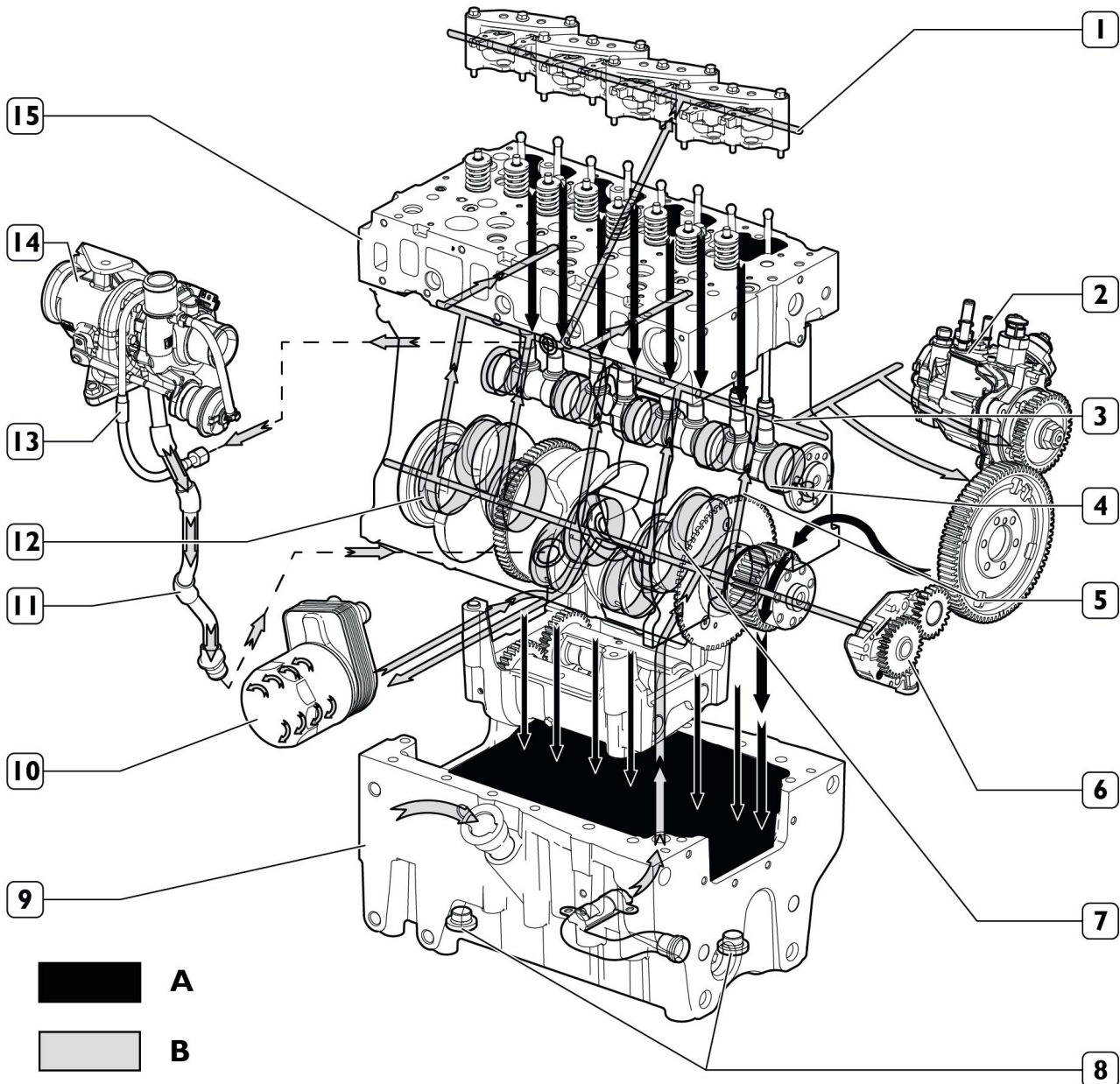
LUBRICATION CIRCUIT

Forced-circulation lubrication is provided by the rotor oil pump, housed in the front part of the crankcase and controlled by the straight-tooth gear splined to the crankshaft tang.

From the sump, the lubrication oil is sent to the crankshaft, the camshaft and the valve control..

Lubrication also includes the heat exchanger and turbocharger.

Lubrication system diagram

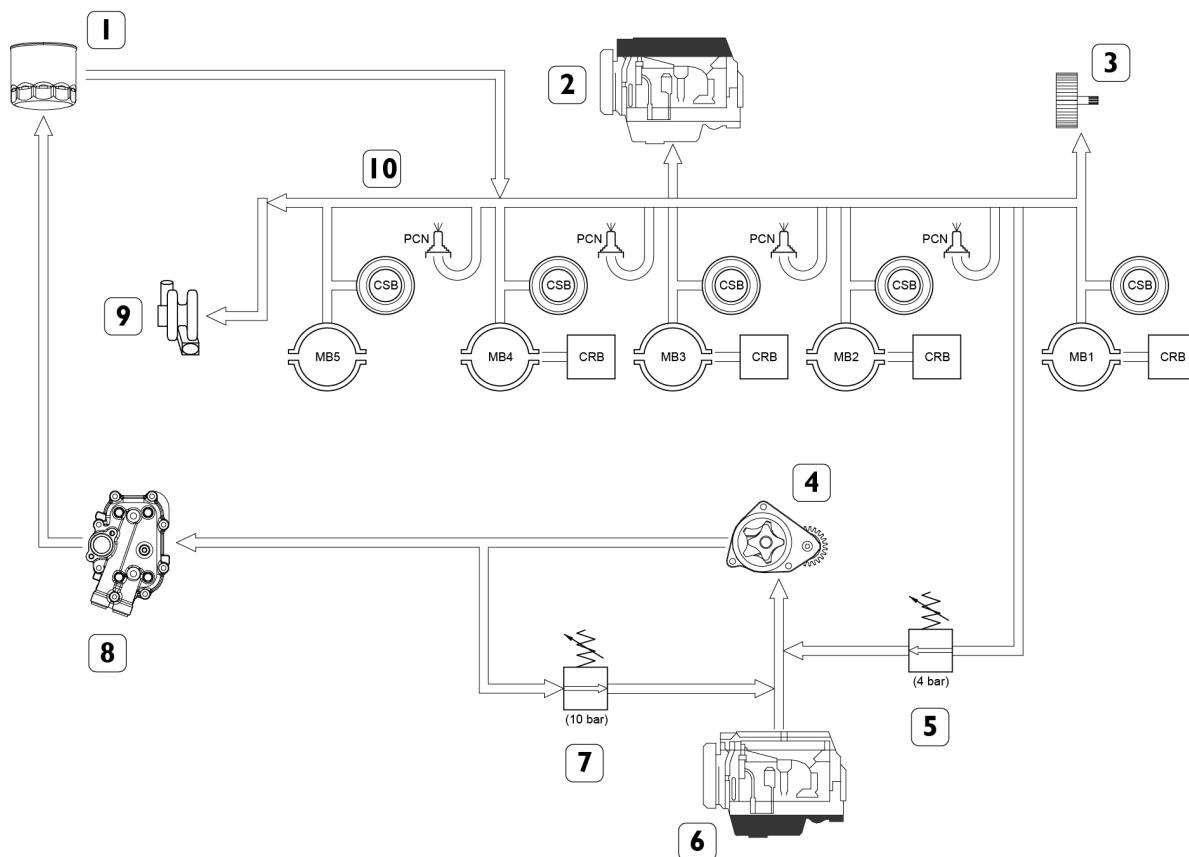


300851 1

1. Rocker arm shaft lubrication
2. High-pressure pump
3. Tappet cover and push rods lubrication

-
4. Camshaft bushing
 5. Piston cooling nozzles
 6. Rotary oil pump
 7. Big end half-bearing lubrication
 8. Lubricant oil drain plug
 9. Oil sump
 10. Engine oil filter
 11. Turbocharger lubricant oil drain pipe
 12. Main half-bearing lubrication
 13. Turbocharger lubricant oil delivery pipe
 14. Turbocharger
 15. Cylinder Head

Lubrication circuit



268615 2

1. Oil filter
2. Cylinder Head
3. Power take-off
4. Oil pump
5. Oil pressure regulating valve (**4 bar**)
6. Oil sump
7. Vent valve (**10 bar**)
8. Heat exchanger
9. Turbochargers
10. Main duct

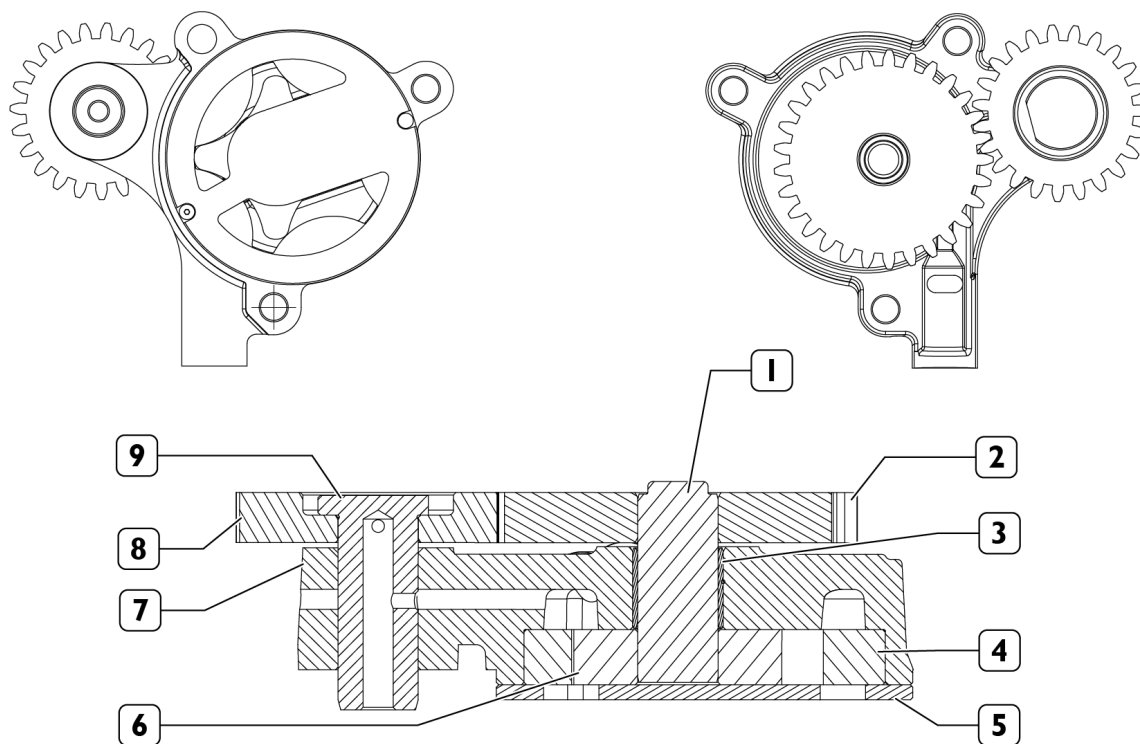
MB	Main bearings
CRB	Big-end bearings
PCN	Jets for cooling the pistons
CSB	Camshaft bearings

543010 OIL PUMP - Overview

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: The oil pump cannot be overhauled. If any faults are detected, it must be replaced.

Oil pump cross-section



298213 1

- | | |
|-------------------|------------------|
| 1. Control rod | 6. Inner rotor |
| 2. Drive gear | 7. Oil pump body |
| 3. Bush | 8. Idle gear |
| 4. External rotor | 9. Guide pin |
| 5. Cover | |

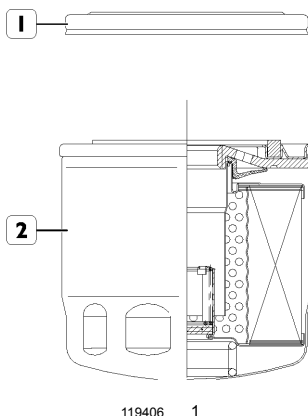
Oil pump performance

Pump performance	
Pump speed	1050 – 3250 RPM
Delivery pressure	2 – 5 bar
Rated flow	10.5 – 35 L/min
oil temperature	120 °C
Oil used	SAE 15W40

543070 ENGINE OIL FILTER CARTRIDGE - Overview

Engine oil filter

Its function is to collect the metal residuals from the engine oil.

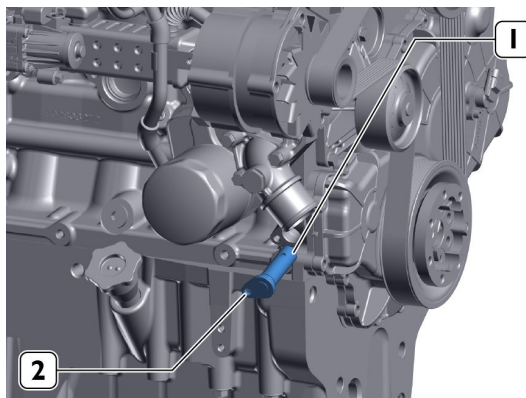


1. Protection cover
2. Cartridge

Technical data	
Filtering surface	1350 +/- 100 cm ²
Filter collapse (ISO 4548/3)	> 10 bar
Burst pressure (ISO 4548/3)	20 bar
Pressure pulses (1 Hz) >50,000 cycles (ISO 4548/5)	0-15 bar
Operating temperature	-40 – +120 °C
Tightening torque	30 N·m + 5
Maximum load	50 L/min
Loss of load (at the end of the life cycle)	2.5 bar
Filtering capacity with loss of load of 2,5 bar (ISO 16889)	> 15 g

543075 OIL PRESSURE ADJUSTMENT VALVE - Overview

Oil pressure regulating valves (4 – 10 bar)



298055 1

1. Control valve
2. Control valve fastening screw

Oil pressure regulating valve (4 bar)

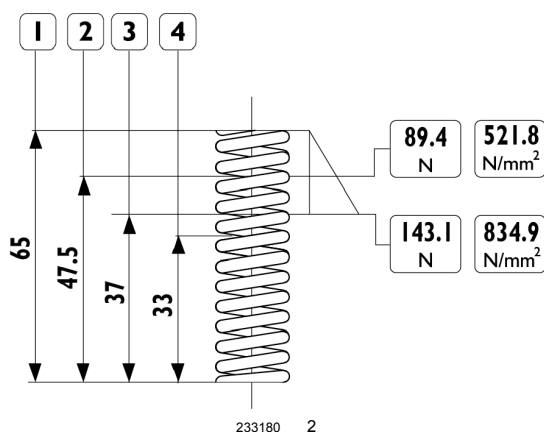
The oil pressure regulating valve is located on the right side of the crankcase near the coolant / lubricant oil heat exchanger and guarantees the correct level of pressure in the main lubrication duct inside the crankcase when the oil is cold.

Unscrew the plug , remove the spring and the control valve from the support .

Check whether the valve is not scored and is sliding smoothly into its seat. The spring shall not be broken or yielded.

Start of opening pressure **4 bar**.

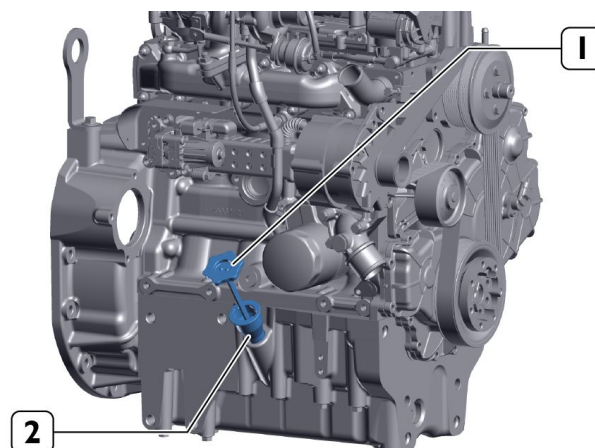
MAIN DATA TO CHECK THE OIL PRESSURE RELIEF VALVE SPRING



543070 ENGINE OIL FILTER CARTRIDGE - Check

Engine lubricant oil level check

1. The check must be performed when the engine is stopped and possibly cold.
2. Make sure that the engine or that the machine in which it is installed is on a flat surface.
3. Use the oil dipstick **(1)** to check that the lubricant oil level falls between the "Min" and "Max" markings.
4. If it is difficult to check the level, clean the oil dipstick **(1)** using a clean cloth without any loose threads, and re-fit the dipstick into its seat **(2)**. Remove it again and check the level.



298056 1

General prescriptions

The engine oil is highly pollutant and harmful. In case of contact with the skin, wash thoroughly with soap and water. Protect skin and eyes appropriately; work in accordance with accident prevention regulations.



Dispose of the residue in full compliance with legal regulations.

Failure to comply completely or partially with these requirements may result in the risk of serious damage to the engine and may even, on occasion, invalidate the warranty

5. If the level is too low, top-off using lubricant oil compliant to the specifications in the table "General specifications - REFILLING".
6. To top-off, remove the lubricant oil filling cap **(1)** and pour engine lubricant oil into the sump through the inlet pipe **(2)**.
7. Always make sure to add oil with the same characteristics as the one contained in the sump. Mixtures which do not ensure the proper lubrication of the internal parts of the engine are not permitted.
8. Make sure that the dipstick **(1)** is inserted completely and that the oil filler cap is completely tightened.

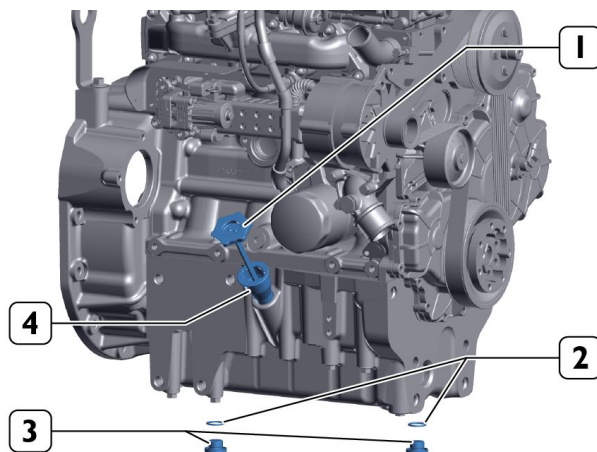
543070 ENGINE OIL FILTER CARTRIDGE - Change fluid

Description	Quantity	Step	Value
Lubricant oil drain plug in the sump	2 caps M22 x 1.5 x 12		50 +/- 5 N·m

Engine lubricant oil replacement

1. Only proceed when the engine is not turning and is at low temperature, so as not to run the risk of burns.
2. Place a suitable container for collecting the oil beneath the engine lubricant oil drain plug **(3)**.
3. To make it easier for the engine lubricant to exit, remove the engine oil dipstick **(1)**.
4. Unscrew the plugs **(3)** from the oil sump and drain the engine lubricant oil.
5. Wait until the oil sump is completely empty then retighten the oil drain plugs **(3)** with new gaskets **(2)**.

Description	Quantity	Step	Value
Lubricant oil drain plug in the sump	2 caps M22 x 1.5 x 12		50 +/- 5 N·m



298057 1

6. Use lubricant oil to refill through the filler pipe. **(4)**
7. Use the dipstick **(1)** to check that the level of engine lubricant oil does not exceed the "Max" limit.
8. If it is difficult to read the level, clean the dipstick **(1)** using a thread-free cloth and replace the dipstick in its seat. Remove it again and check the level.
9. Insert the dipstick **(1)** and close the lubricant filler cap.

General prescriptions



Dispose of consumable materials and the parts in contact with them (for example filters) in accordance with the law. The workshops of the FPT Service Network are equipped for this purpose. Correct behavior will ensure that vehicle is used as environmentally friendly as possible

543070 ENGINE OIL FILTER CARTRIDGE - Replace

Tool / Material	
Remover, cartridge filter	99360076

1. The filter must be replaced when the lubricant oil is changed.
2. Only use filters with a filtering degree that is the same as the previous one.
3. Only proceed when the engine is not turning and is at low temperature, so as not to run the risk of burns.
4. Position a container to collect the used oil below the filter bracket .
5. Use the specific tool to unscrew and remove the oil filter **(2)** from the filter bracket and recover the gasket **(1)**.

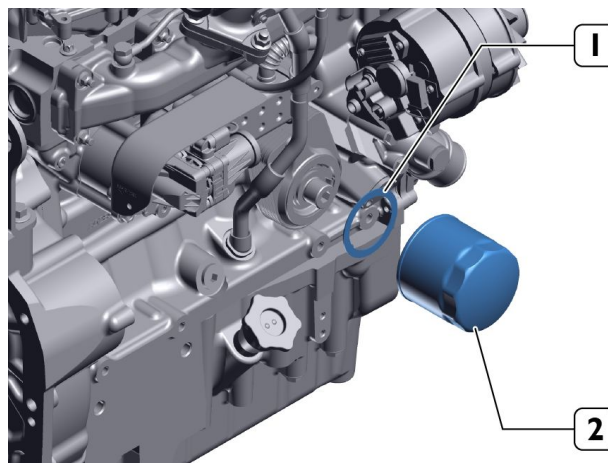
Tool / Material	
Remover, cartridge filter	99360076

6. Replace the oil filter **(2)** and the gasket **(1)**.
7. Moisten the gasket **(1)** with a thin layer of oil and place it in its seat on the oil filter **(2)**.
8. Manually tighten the oil filter **(2)** on the support until it fits up against the gasket **(1)**.
9. Using the designated tool, tighten the oil filter **(2)** further to the specified torque:

Description	Quantity	Value
Oil filter	1 cartridge M27 x 2	30 +/- 3 N·m

Tool / Material	
Remover, cartridge filter	99360076

10. 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.



298058 1

543070 ENGINE OIL FILTER CARTRIDGE - Remove

Tool / Material

Remover, cartridge filter

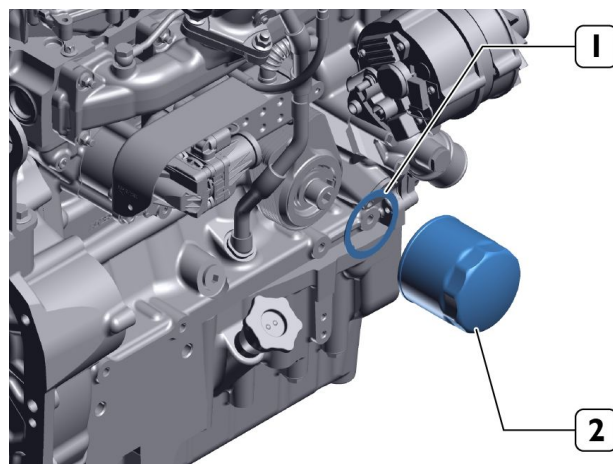
99360076

1. Position a container to collect the used oil below the filter bracket .
2. Only proceed when the engine is not turning and is at low temperature, so as not to run the risk of burns.
3. Use the specific tool to unscrew and remove the oil filter **(2)** from the filter bracket and recover the gasket **(1)**.

Tool / Material

Remover, cartridge filter

99360076



298058 1

543070 ENGINE OIL FILTER CARTRIDGE - Install

Description	Quantity	Value
Oil filter	1 cartridge M27 x 2	30 +/- 3 N·m

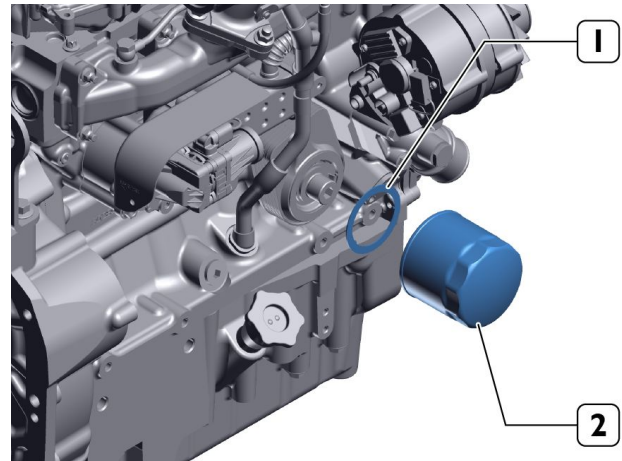
Tool / Material	
Remover, cartridge filter	99360076

1. Moisten the gasket **(1)** with a thin layer of oil and place it in its seat on the oil filter **(2)**.
2. Manually tighten the oil filter **(2)** on the support until it fits up against the gasket **(1)**.
3. Using the designated tool, tighten the oil filter **(2)** further to the specified torque:

Description	Quantity	Value
Oil filter	1 cartridge M27 x 2	30 +/- 3 N·m

Tool / Material	
Remover, cartridge filter	99360076

4. 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.



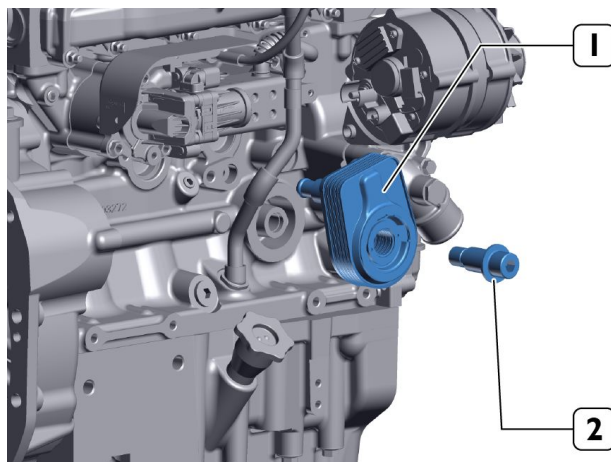
298058 1

543072 FILTER SUPPORT - Remove

Prior operation:

Remove the oil filter as described in procedure **ENGINE OIL FILTER CARTRIDGE - Remove (54.30)**.

1. Position a container to collect the used oil below the oil filter mount **(1)**.
2. Unscrew the fastening screws **(2)** and remove the oil filter mount **(1)** recovering the gasket.



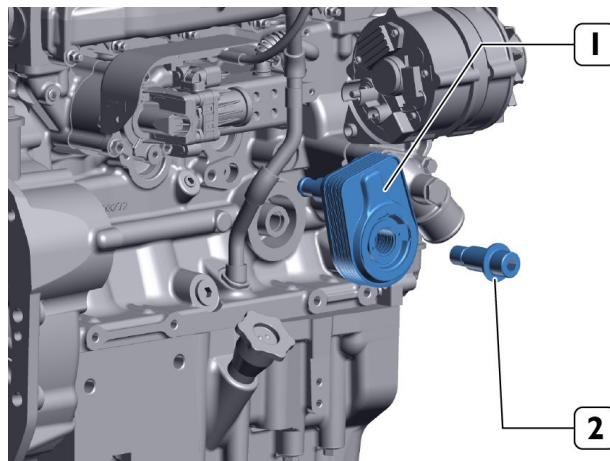
298060 1

543072 FILTER SUPPORT - Install

Description	Step	Value
Oil filter bracket	1 fitting M20 x 1.5 x 18	35 +/- 5 N·m

- Place a gasket on the oil filter mount **(1)**.
- Fit the oil filter bracket **(1)** and tighten the fastening screw **(2)** to the specified torque.

Description	Step	Value
Oil filter bracket	1 fitting M20 x 1.5 x 18	35 +/- 5 N·m



298060 1

Next operation:

Fit the oil filter as described in procedure **ENGINE OIL FILTER CARTRIDGE - Install (54.30)**.

543110 HEAT EXCHANGER - Overview

The heat exchanger inside the engine cooling system serves to reduce the temperature of the engine oil by absorbing heat via the engine coolant.



298061 1

543110 HEAT EXCHANGER - Remove

1. To remove the heat exchanger refer to the following procedure **FILTER SUPPORT - Remove (54.30)**

543110 HEAT EXCHANGER - Install

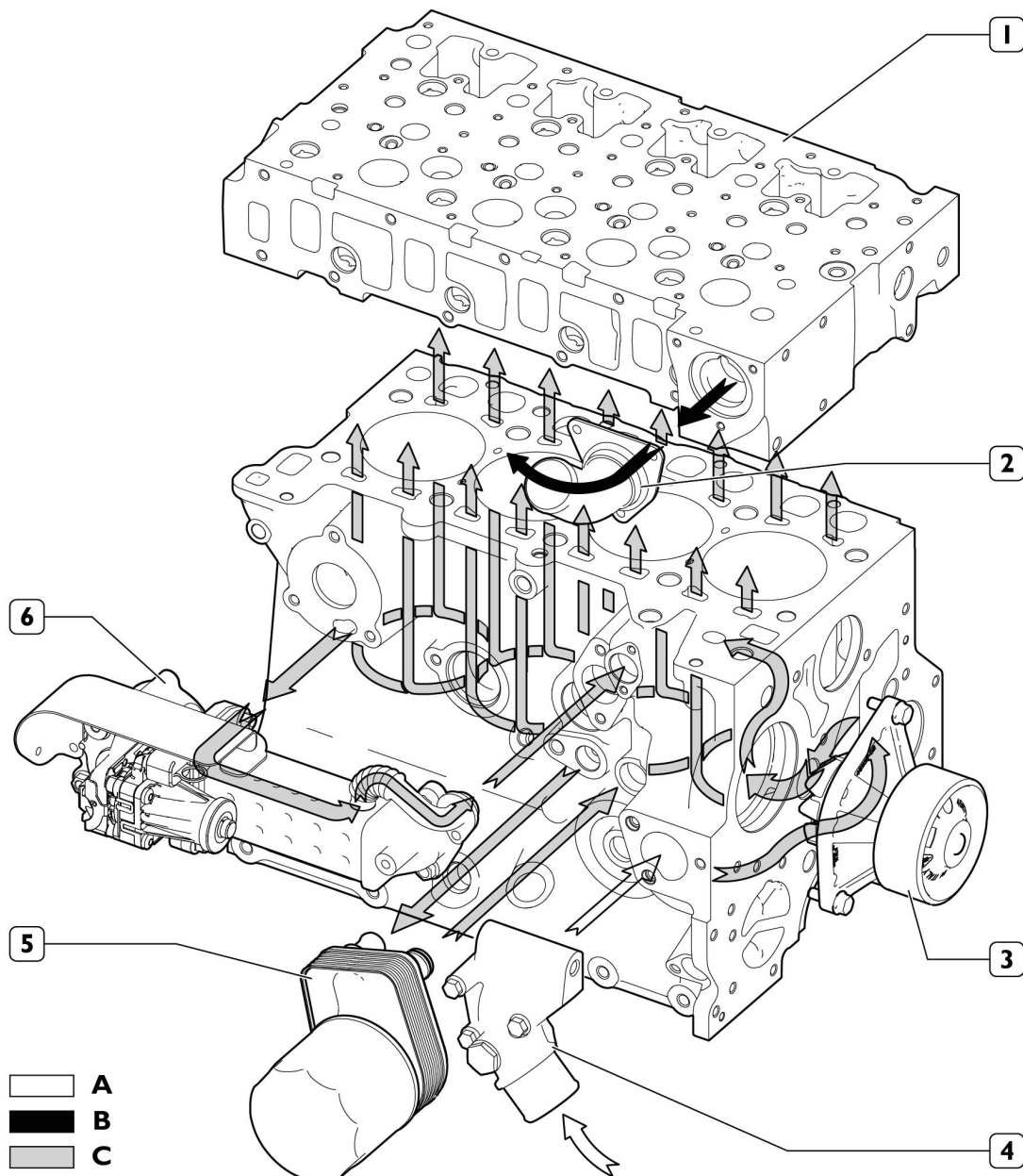
1. To install the heat exchanger refer to the following procedure **FILTER SUPPORT - Install (54.30)**.

5432 WATER COOLING - Overview - Cooling circuit

The engine cooling system, of the closed-loop forced-circulation type, is generally composed of the following components:

- Expansion tank: the position, shape and dimensions can change depending on the engine outfitting;
- Radiator: it dissipates the heat taken from the engine by the coolant. Its position and dimensions can change depending on the version;
- Fan: it increases the dissipating radiator power: also it is part of the specific engine version;
- Heat exchanger: it allows cooling down the lubricant oil and is installed in the cylinder block;
- Water pump: it is a centrifugal pump positioned in the front part of the crankcase;
- Thermostat: it regulates the temperature of the coolant circulating in the engine;
- The circuit can also extend to the compressor if the construction provides for its presence.

Cooling system diagram with



- A. Coolant inlet to the water pump (from the radiator)
 - B. Coolant outlet from the cylinder head (to the radiator)
 - C. Coolant circulating in the engine
-
- 1. Cylinder Head
 - 2. Engine coolant outlet pipe (to the radiator) / Thermostat cover
 - 3. Water pump
 - 4. Engine coolant inlet pipe (from the radiator)
 - 5. EGR heat exchanger exhaust gas/coolant
 - 6. Heat exchanger lubricant oil/coolant

543210 WATER PUMP ASSEMBLY - Overview

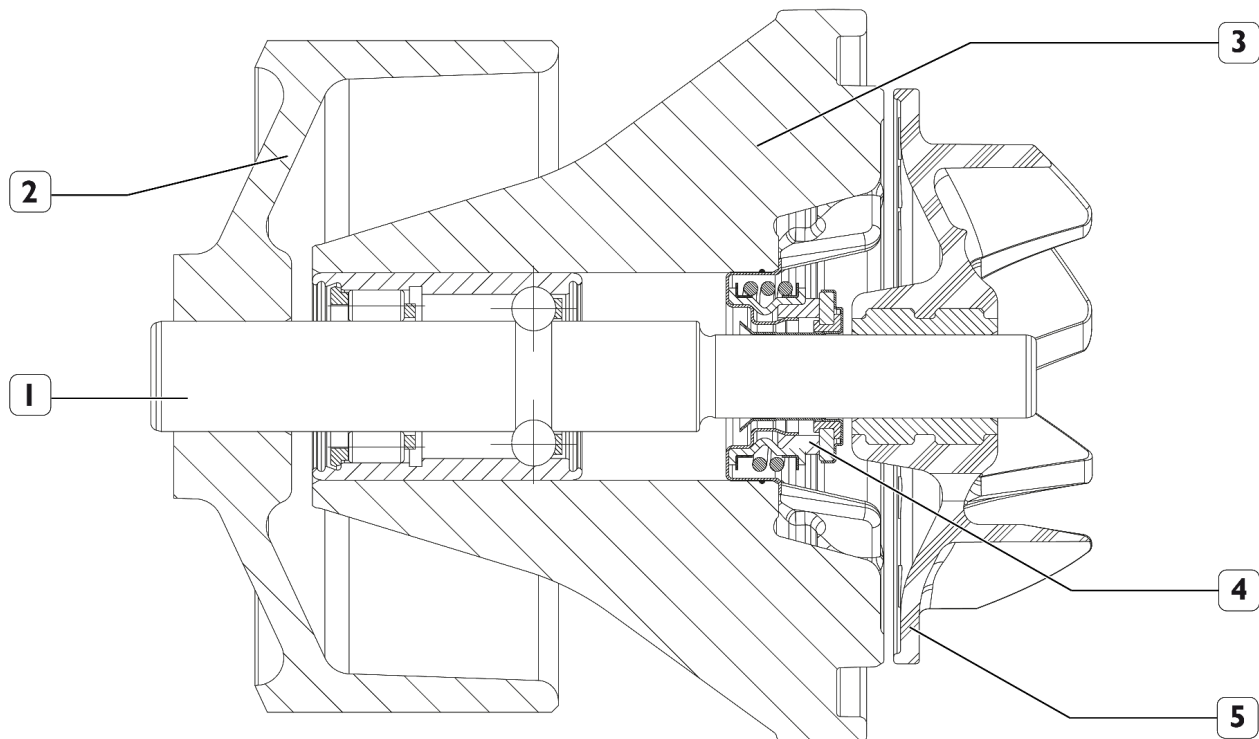
Section on water pump

The water pump, located in a housing obtained in the crankcase, is controlled by a poly-V belt.

A manual tensioner keeps the belt tension.

The water pump is of the vane centrifugal type.

The water tightness between the pump body and the shaft is obtained by means of a gasket.



232617 1

1. Shaft with bearing
2. Control pulley
3. Pump unit
4. sheath
5. Impeller

Water pump technical data		
Coolant temperature	100 +/- 5 °C	
Concentration of antifreeze	50%	
Pump speed	Capacity	Pressure [bar]
5000 RPM	210 L/min	2.00 - 2.45 bar
2500 RPM	110 L/min	0.5 - 0.65 bar

543250 THERMOSTAT - Overview

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.

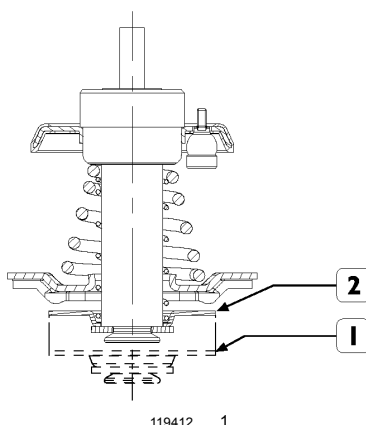
The main components of a thermostat are: thermal motor, including a valve fastened to a piston integrated in a special wax, flange, spring and chassis.

The thermostat has a pin that permits the air trapped in the cooling system to pass in the thermostat and be released from the system.

The thermostat has two important functions:

- It heats the engine faster, blocking the circulation of the coolant between the engine and the radiator until the engine reaches its predefined temperature.
- It controls the operating temperature of the engine by opening and closing in response to specific changes in the coolant temperature in order to maintain the engine temperature within the desired range.

Thermostat operating diagram



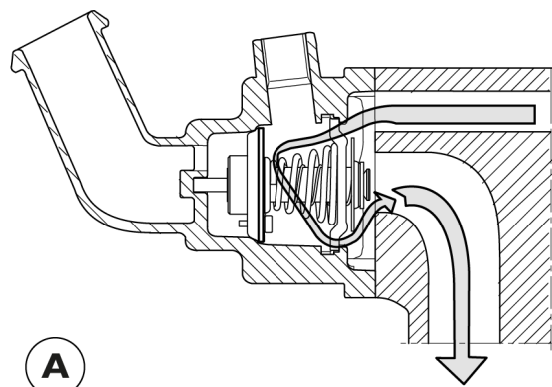
1. Maximum stroke at the temperature of full opening
2. Minimum stroke at the initial opening temperature

Technical data	
Maximum permitted operating temperature	130 +/- 2 °C
Maximum stroke at the maximum permitted operating temperature	11.5 mm
Initial opening temperature	79 +/- 2 °C
Stroke at the initial opening temperature	0.3 mm
Complete opening temperature	94 +/- 2 °C
Minimum stroke at the temperature of full opening	8 mm

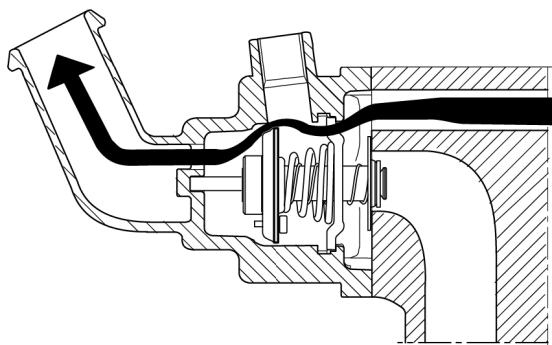
Operation

- With the engine cold, the thermostat is normally closed; the restriction of the flow to the radiator makes it possible to heat the engine;
- When heating the engine, the increase in heat causes the wax to melt, which expands and acts against a piston inside a rubber bellows;
- This lifts the piston, which opens the thermostat so that the coolant can start to circulate between the engine and the radiator;
- With the increase in heat, the thermostat continues to open until the engine is cooled sufficiently;
- If the temperature of the circulating coolant starts to decrease, the wax element will contract, permitting the closure of the thermostat due to the effect of the spring's action and reducing the flow of the coolant towards the radiator.

functional diagram



A



B

233174 2

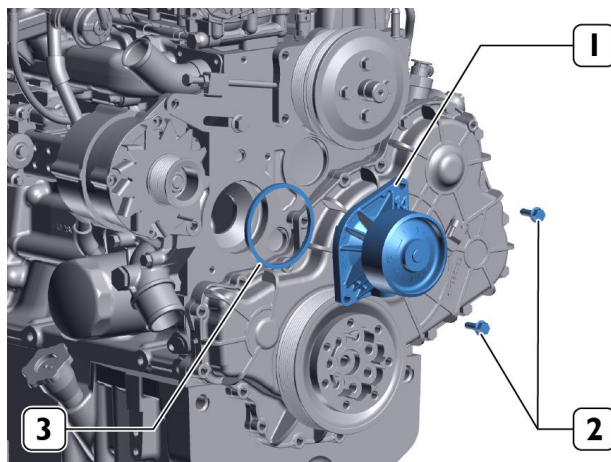
- A. Closed thermostat (coolant recirculation to the water pump via the by-pass duct)
- B. Thermostat open (coolant outlet from the cylinder head to the radiator)

543210 WATER PUMP ASSEMBLY - Remove

Prior operation:

Remove the water pump drive belt as described in the procedure **WATER PUMP DRIVE BELT - Remove (54.34)**.

1. Position a suitable container to collect any coolant which may leak out.
2. Unscrew the fastening screws **(2)** and remove the water pump **(1)** recovering the gasket **(3)**.

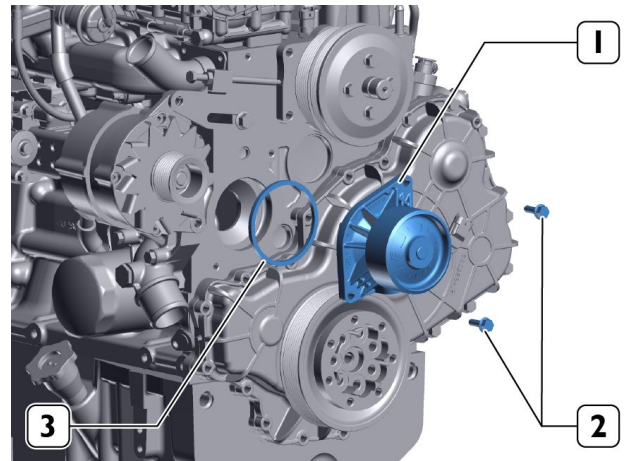


298062 1

543210 WATER PUMP ASSEMBLY - Install

1. Apply a new sealing ring (3) to the water pump (1).
2. Fit the water pump (1) in its housing and tighten the fastening screws (2) to the specified torque.

Description	Quantity	Value
Water pump	2 screws M8 x 1.25 x 25	23 +/- 2.3 N·m



298062 1

Next operation:

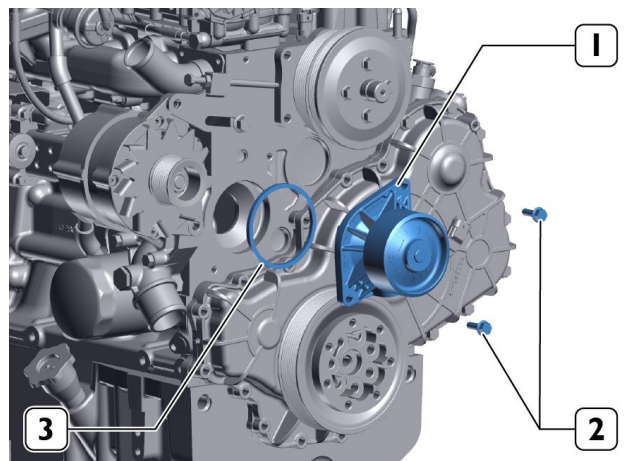
Fit the water pump drive belt as described in procedure **WATER PUMP DRIVE BELT - Install (54.34)**

543210 WATER PUMP ASSEMBLY - Check

Description	Quantity	Value
Water pump	2 screws M8 x 1.25 x 25	23 +/- 2.3 N·m

Water pump

1. Proceed only with engine not running. The water pump is driven by the belt and is housed in the front of the engine. A rotor inside the pump pushes the water through the circuit. The rotor is fitted on a shaft supported by the pump body with bearings and seals
2. Check no coolant leaks out while the engine is running.
3. Check that the rotor inside the pump is not broken or loosened and the blades are not worn.
4. Replace the water pump, acting as follows (if necessary).
5. Drain the engine coolant from the radiator: open the discharge valve on the bottom of the radiator or loosen the lower hose of the radiator.
6. Remove the auxiliary members' belt.
7. Unscrew the fastening screws (2) and remove the water pump (1).
8. Clean and dry the assembly surfaces and remove all traces of the old gaskets.
9. Correctly position a new gasket (3) on the water pump (1), put the pump in its seat and tighten the fastening screws (2) to the specified torque.



298062 1

Description	Quantity	Value
Water pump	2 screws M8 x 1.25 x 25	23 +/- 2.3 N·m

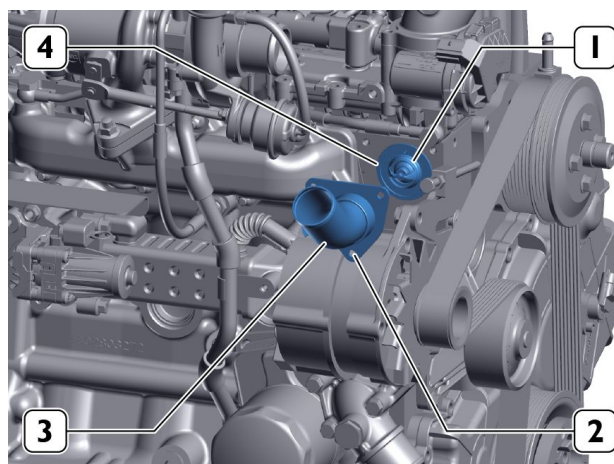
10. Refill the cooling circuit and bleed the air.

ATTENTION: When a water pump begins to leak, the cooling system will lose coolant. If the problem is not identified, the coolant leak will cause the engine to overheat.

ATTENTION: If the engine overheats, the entire cooling system (radiator, flexible pipes, water pump and engine) must be inspected to check for coolant leaks. If the coolant overflows from the shaft and from the water pump hole, the water pump must be replaced.

543250 THERMOSTAT - Remove

1. Unscrew the fastening screws **(2)** and remove the thermostat assembly **(3)**, complete with the gasket **(4)**, from the seat on the cylinder head.
2. Remove the thermostat **(1)** from its housing.



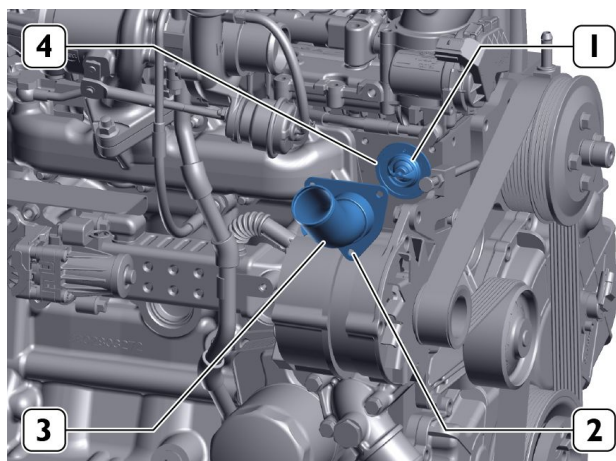
298063 1

543250 THERMOSTAT - Install

Description	Quantity	Step	Value
Thermostat cover	3 screws M6 x 1 x 12		10 +/- 1 N·m

1. Fit the thermostat (1) into its housing.
2. Fit the thermostat assembly (3), complete with gasket (4), in the seat on the cylinder head and tighten the fastening screws (2) to the specified torque.

Description	Quantity	Step	Value
Thermostat cover	3 screws M6 x 1 x 12		10 +/- 1 N·m



298063 1

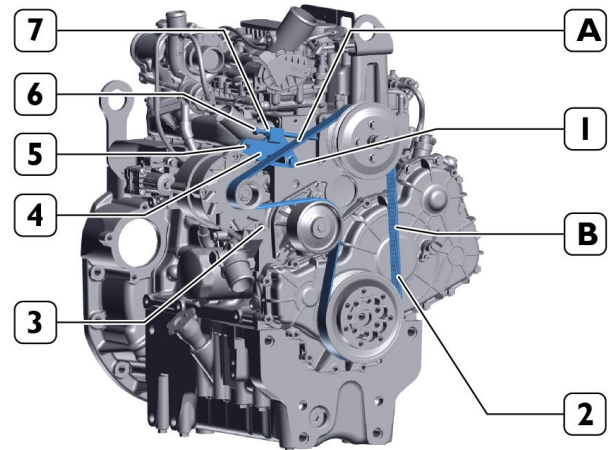
543411 WATER PUMP DRIVE BELT - Check

Prior operation:

WATER PUMP DRIVE BELT - Replace (54.34)

Main activity

1. Visually check that the alternator belt is not worn or damaged; If it is damaged, replace it as described in the procedure **WATER PUMP DRIVE BELT - Replace (54.34)**.
2. Wait for at least **15 min** with the engine running at idle. Then with the engine off and the belt temperature stabilised at **23 +/- 5°**, use a suitable tool to check the tension of the auxiliary unit drive belt. The correct tension of the auxiliary drive belt (**2**) must lie within the range indicated in the table:



298204 1

Auxiliary members' belt tension

Ratio	Control frequency (A) (140 ± 20 N/rib)	Control frequency (B)(140 ± 20 N/rib)
RT 0.96	193 +/- 14 Hz	151 +/- 11 Hz
RT 1.10	191 +/- 14 Hz	151 +/- 11 Hz
RT 1.29	190 +/- 14 Hz	151 +/- 11 Hz
RT 1.40	189 +/- 14 Hz	151 +/- 11 Hz

NOTE: The tension of the belt is measured in the intermediate point (**A**) of the branch between the crankshaft pulley and the fan drive pulley and in the point (**B**) between the alternator pulley and the fan drive pulley.

3. If necessary, regulate the tension of the belt (**2**) as described below.
4. Loosen the bolt (**3**) anchoring the alternator to its lower mount and the screw (**5**) fastening the tensioning bracket to the crankcase.
5. Proceed with tensioning the auxiliary drive belt (**2**) by tightening the adjustment screw (**5**) until the tensioning bracket (**4**) reaches the position of maximum adjustment extension available, as shown in the figure.
6. Fully rotate the crankshaft twice to ensure that the ancillary drive belt (**2**) has settled.
7. tighten the screw (**1**) fastening the tensioning bracket (**4**) to the crankcase to the specified torque.

Description	Step	Value
Alternator tensioning bracket	1 screw M10 x 1.5 x 20	45 +/- 4.5 N·m

8. Tighten the bolt **(3)** anchoring the alternator to its lower mount to the specified torque.

Description	Step	Value
Alternator	1 screw M10x1.5x130 + 1 nut M10 x 1.5	45 +/- 4.5 N·m
	1 screw M10 x 1.5 x 35 + 1 nut M10 x 1.5	45 +/- 4.5 N·m

9. Turn the adjustment screw **(5)** two full turns anti-clockwise, then tighten the relative locking nut **(6)** to the specified torque.

Description	Step	Value
Belt adjusting screw	1 screw M8 x 1.25	20.5 +/- 2.5 N·m
	1 nut M8 x 1.25	20.5 +/- 2.5 N·m

543411 WATER PUMP DRIVE BELT - Replace

Change the ancillary belt

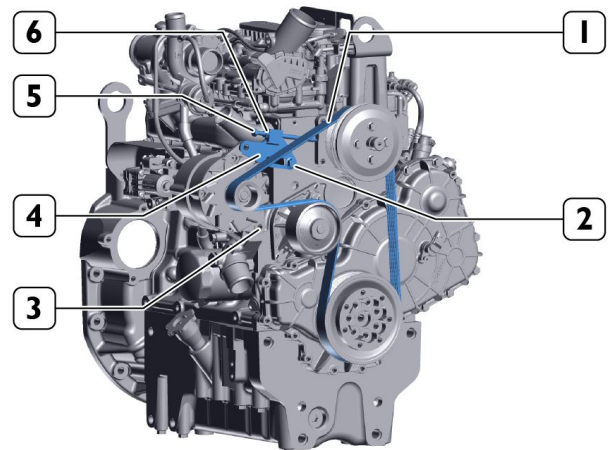
1. Loosen the bolt (3) anchoring the alternator to its lower mount and the screw (2) fastening the tensioning bracket (4) to the crankcase.
2. Loosen the locking nut (6) and unscrew the screw (5) adjusting the tensioning bracket (4) to loosen and remove the auxiliary drive belt (1).
3. Replace the auxiliary drive belt (1) with a new one.
4. Make sure that all the components of the pulleys and the guide rollers are clean and free of wear and damage. If necessary, replace the worn or damaged components.
5. Make sure that the pulleys and guide rollers are free of dirt and accumulations from the old belt.
6. Fit the new auxiliary unit drive belt (1) inside the shoulders of all the pulleys, in the following order: crankshaft pulley, fan drive pulley, alternator, water pump. Make sure the belt is centred on all the pulleys.

NOTE: The ribs on the auxiliary members' belt (1) must be positioned in the grooves of each pulley.

7. Proceed with tensioning the auxiliary drive belt (1) by tightening the adjustment screw (5) until the tensioning bracket (4) reaches the position of maximum adjustment extension available, as shown in the figure.

NOTE: The tension of the belt is measured as described in the procedure **WATER PUMP DRIVE BELT - Check (54.34)**.

8. Fully rotate the crankshaft twice to ensure that the ancillary drive belt (1) has settled.
9. Tighten the screw (2) fastening the tensioning bracket (4) to the crankcase to the specified torque.



298064 1

Description	Step	Value
Alternator	1 screw M10x1.5x130 + 1 nut M10 x 1.5	45 +/- 4.5 N·m
	1 screw M10 x 1.5 x 35 + 1 nut M10 x 1.5	45 +/- 4.5 N·m

10. Tighten the bolt (3) anchoring the alternator to its lower mount to the specified torque.

Description	Step	Value
Alternator	1 screw M10x1.5x130 + 1 nut M10 x 1.5	45 +/- 4.5 N·m
	1 screw M10 x 1.5 x 35 + 1 nut M10 x 1.5	45 +/- 4.5 N·m

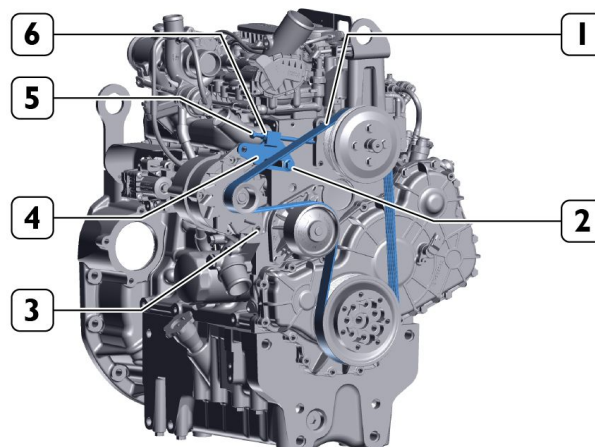
11. Turn the adjustment screw **(5)** two full turns anti-clockwise, then tighten the relative locking nut **(6)** to the specified torque.

Description	Step	Value
Belt adjusting screw	1 screw M8 x 1.25	20.5 +/- 2.5 N·m
	1 nut M8 x 1.25	20.5 +/- 2.5 N·m

543411 WATER PUMP DRIVE BELT - Remove

Removal

1. Loosen the bolt **(3)** anchoring the alternator to its lower mount and the screw **(2)** fastening the tensioning bracket **(4)** to the crankcase.
2. Loosen the locking nut **(6)** and unscrew the screw **(5)** adjusting the tensioning bracket **(4)** to loosen and remove the auxiliary drive belt **(1)**.

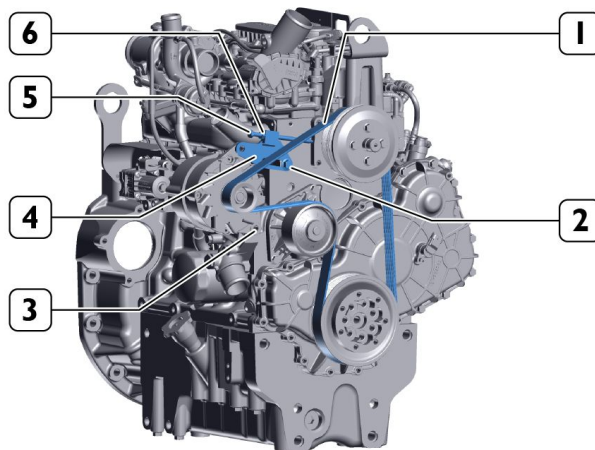


298064 1

543411 WATER PUMP DRIVE BELT - Install

Description	Step	Value
Alternator	1 screw M10x1.5x130 + 1 nut M10 x 1.5	45 +/- 4.5 N·m
	1 screw M10 x 1.5 x 35 + 1 nut M10 x 1.5	45 +/- 4.5 N·m
Alternator tensioning bracket	1 screw M10 x 1.5 x 20	45 +/- 4.5 N·m
Belt adjusting screw	1 screw M8 x 1.25	20.5 +/- 2.5 N·m
	1 nut M8 x 1.25	20.5 +/- 2.5 N·m

1. Make sure that all the components of the pulleys and the guide rollers are clean and free of wear and damage. If necessary, replace the worn or damaged components.



298064 1

2. Make sure that the pulleys and guide rollers are free of dirt and accumulations from the old belt.
3. Fit the new auxiliary unit drive belt (1) inside the shoulders of all the pulleys, in the following order: crankshaft pulley, fan drive pulley, alternator, water pump. Make sure the belt is centred on all the pulleys.

NOTE: The ribs on the auxiliary members' belt (1) must be positioned in the grooves of each pulley.

4. Proceed with tensioning the auxiliary drive belt (1) by tightening the adjustment screw (5) until the tensioning bracket (4) reaches the position of maximum adjustment extension available, as shown in the figure.

NOTE: The tension of the belt is measured as described in the procedure **WATER PUMP DRIVE BELT - Check (54.34)**.

5. Fully rotate the crankshaft twice to ensure that the ancillary drive belt (1) has settled.
6. tighten the screw (2) fastening the tensioning bracket (4) to the crankcase to the specified torque.

Description	Step	Value
Alternator tensioning bracket	1 screw M10 x 1.5 x 20	45 +/- 4.5 N·m

7. Tighten the bolt (3) anchoring the alternator to its lower mount to the specified torque.

Description	Step	Value
Alternator	1 screw M10x1.5x130 + 1 nut M10 x 1.5	45 +/- 4.5 N·m
	1 screw M10 x 1.5 x 35 + 1 nut M10 x 1.5	45 +/- 4.5 N·m

8. Turn the adjustment screw **(5)** two full turns anti-clockwise, then tighten the relative locking nut **(6)** to the specified torque.

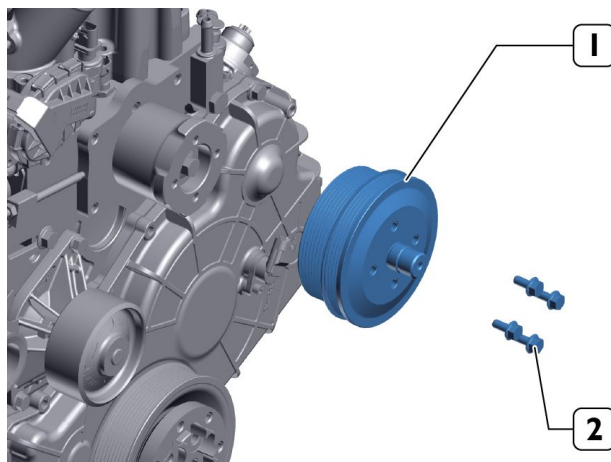
Description	Step	Value
Belt adjusting screw	1 screw M8 x 1.25	20.5 +/- 2.5 N·m
	1 nut M8 x 1.25	20.5 +/- 2.5 N·m

543416 FAN CONTROL PULLEY - Remove

Prior operation:

Remove the auxiliary unit drive belt as described in the procedure **WATER PUMP DRIVE BELT - Remove (54.34)**.

1. Unscrew the screws **(2)** and remove the fan drive pulley **(1)**.



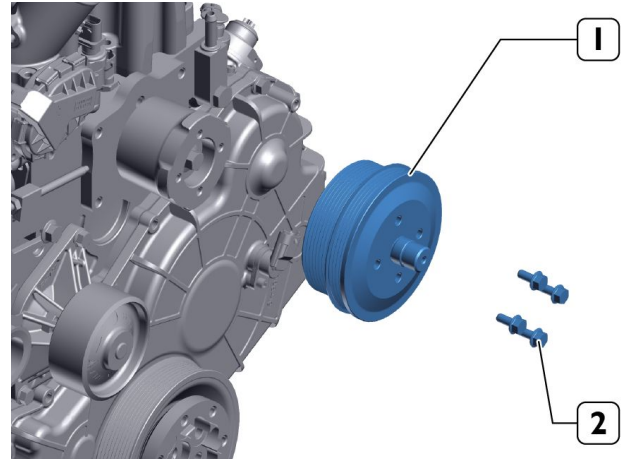
298314 1

543416 FAN CONTROL PULLEY - Install

Description	Quantity	Value
Fan control pulley	4 screwsM8 x 1.25 x 18	23 +/- 2.3 N·m

- Position the fan control pulley (1) onto its mount and tighten the screws (2) to the specified torque.

Description	Quantity	Value
Fan control pulley	4 screwsM8 x 1.25 x 18	23 +/- 2.3 N·m



298314 1

Next operation:

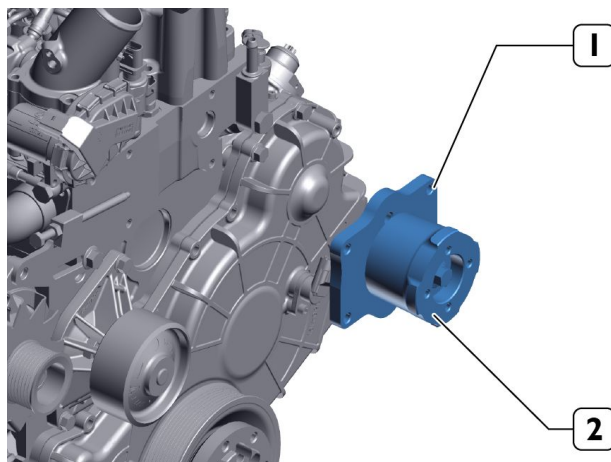
Fit the auxiliary unit drive belt as described in the procedure **FAN CONTROL PULLEY - Install (54.34)**.

543425 FAN HUB MOUNT - Remove

Prior operation:

Remove the fan drive pulley as described in the procedure **FAN CONTROL PULLEY - Remove (54.34)**

1. Unscrew the screws **(1)** and remove the fan drive pulley mount **(2)**.



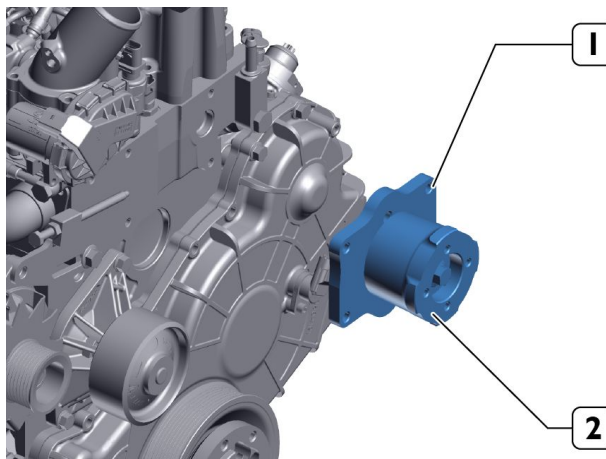
298315 1

543425 FAN HUB MOUNT - Install

Description	Quantity	Value
Fan pulley control mount	4 screwsM8 x 1.25 x 25	23 +/- 2.3 N·m

- Position the fan drive pulley mount (2) on the crankcase and tighten the screws (1) to the specified torque.

Description	Quantity	Value
Fan pulley control mount	4 screwsM8 x 1.25 x 25	23 +/- 2.3 N·m



298315 1

Next operation:

Fit the fan drive pulley as described in the procedure **FAN CONTROL PULLEY - Install (54.34)** .

Index

ENGINE - 54

540751	ABSOLUTE PRESSURE SENSOR - Overview (*)	109
541213	BUSHES - Check	153
541213	BUSHES - Replace	154
541210	CAMSHAFT - Assemble	152
541210	CAMSHAFT - Check	151
540842	COMPRESSION RINGS - Assemble	150
540842	COMPRESSION RINGS - Check	148
540842	COMPRESSION RINGS - Disassemble	147
540830	CONNECTING ROD - Check	135
540831	CONNECTING ROD BEARING - Assemble	139
540812	CRANKPINS - Measure	126
540810	CRANKSHAFT - Assemble	123
540810	CRANKSHAFT - Check	125
540810	CRANKSHAFT - Disassemble	120
540810	CRANKSHAFT - Measure	121
540442	CRANKSHAFT FRONT GASKET - Install	85
540442	CRANKSHAFT FRONT GASKET - Remove	84
540462	CRANKSHAFT REAR GASKET - Install	87
540462	CRANKSHAFT REAR GASKET - Remove	86
540420	CYLINDER BARRELS - Check	79
540610	CYLINDER HEAD - Check	91
540610	CYLINDER HEAD - Install	93
540610	CYLINDER HEAD - Remove	90
540821	DRIVE PULLEY ON CRANKSHAFT - Install	134
540821	DRIVE PULLEY ON CRANKSHAFT - Remove	133
540740	EGR ASSEMBLY - Install (*)	117
540740	EGR ASSEMBLY - Overview (*)	106
540740	EGR ASSEMBLY - Remove (*)	116
540746	EGR MODULATING SOLENOID VALVE - Overview (*)	108
540110	ENGINE - Assemble	46
540110	ENGINE - Component localisation	26
540110	ENGINE - Disassemble	27

540110	ENGINE - Engine horse power POWER - TORQUE CURVES	8
540110	ENGINE - External view	19
540110	ENGINE - External view	21
540110	ENGINE - Technical Data	8
540110	ENGINE - Technical Data and assembly clearances	10
540110	ENGINE - Torque	15
540110	ENGINE - Visual inspection	75
540410	ENGINE BLOCK - Check	78
540480	ENGINE BREATHER - Install	89
540480	ENGINE BREATHER - Overview - Oil vapour recirculation system	77
540480	ENGINE BREATHER - Remove	88
5408	ENGINE COMPONENTS - Overhaul	118
543070	ENGINE OIL FILTER CARTRIDGE - Change fluid	193
543070	ENGINE OIL FILTER CARTRIDGE - Check	192
543070	ENGINE OIL FILTER CARTRIDGE - Install	196
543070	ENGINE OIL FILTER CARTRIDGE - Overview	190
543070	ENGINE OIL FILTER CARTRIDGE - Remove	195
543070	ENGINE OIL FILTER CARTRIDGE - Replace	194
540720	EXHAUST MANIFOLD - Install	114
540720	EXHAUST MANIFOLD - Remove	113
543416	FAN CONTROL PULLEY - Install	220
543416	FAN CONTROL PULLEY - Remove	219
543425	FAN HUB MOUNT - Install	222
543425	FAN HUB MOUNT - Remove	221
542010	FILTER ASSEMBLY - Install	169
542010	FILTER ASSEMBLY - Overview	165
542010	FILTER ASSEMBLY - Remove	168
542010	FILTER ASSEMBLY - Replace	167
542014	FILTER SUPPORT - Install	172
543072	FILTER SUPPORT - Install	198
542014	FILTER SUPPORT - Remove	170
543072	FILTER SUPPORT - Remove	197
5420	FUEL FEED - Overview - Electric system	160
5420	FUEL FEED - Overview	158
5420	FUEL FEED - Overview - Hydraulic system	163
543110	HEAT EXCHANGER - Install	201
543110	HEAT EXCHANGER - Overview	199
543110	HEAT EXCHANGER - Remove	200
540710	INTAKE MANIFOLDS - Install	112

540710	INTAKE MANIFOLDS - Remove	111
5430	LUBRICATION - Overview	186
540816	MAIN BEARINGS - Assemble	132
543075	OIL PRESSURE ADJUSTMENT VALVE - Overview	191
543010	OIL PUMP - Overview	189
540815	OIL PUMP CONTROL PINION GEAR - Replace	131
540430	OIL SUMP - Install	82
540430	OIL SUMP - Overview	76
540430	OIL SUMP - Remove	81
542020	PIPES - Install	176
542020	PIPES - Remove	174
540840	PISTON - Assemble	145
540840	PISTON - Check	146
540840	PISTON - Disassemble	140
540840	PISTON - Measure	141
540840	PISTON - Pre-assemble	143
541230	ROCKER ARM ASSY - Install	157
541230	ROCKER ARM ASSY - Remove	156
540630	ROCKER COVER - Install	96
540630	ROCKER COVER - Remove	95
5424	SUPERCHARGING - Overview	178
541224	TAPPETS - Check	155
543250	THERMOSTAT - Install	211
543250	THERMOSTAT - Overview	205
543250	THERMOSTAT - Remove	210
540762	THROTTLE POSITION SENSOR - Overview (*)	110
542410	TURBO CHARGER - Check	183
542410	TURBO CHARGER - Check	184
542410	TURBO CHARGER - Install	185
542410	TURBO CHARGER - Overview	179
542410	TURBO CHARGER - Remove	182
540667	VALVE GUIDE - Check	105
540661	VALVE SEAT - Check	97
540661	VALVE SEAT - Replace	98
540665	VALVE SPRING - Check	104
540662	VALVES - Assemble	103
540662	VALVES - Cleaning	100

(*) See content for specific models

540662	VALVES - Disassemble	101
540662	VALVES - Measure	102
542418	WASTE GATE VALVE - Overview	181
5432	WATER COOLING - Overview - Cooling circuit	202
543210	WATER PUMP ASSEMBLY - Check	209
543210	WATER PUMP ASSEMBLY - Install	208
543210	WATER PUMP ASSEMBLY - Overview	204
543210	WATER PUMP ASSEMBLY - Remove	207
543411	WATER PUMP DRIVE BELT - Check	212
543411	WATER PUMP DRIVE BELT - Install	217
543411	WATER PUMP DRIVE BELT - Remove	216
543411	WATER PUMP DRIVE BELT - Replace	214
540813	WEIGHT FASTENING SCREWS - Install	129
540813	WEIGHT FASTENING SCREWS - Remove	128

Contents

INJECTION - 77

[77.10] INJECTION PUMP	77.1
------------------------------	------

FUNCTIONAL DATA

INJECTION PUMP ASSY	
Overview - High pressure pump BOSCH CP4.1	3
HIGH PRESSURE ADJ UNIT	
HIGH PRESSURE ADJ UNIT - Overview	7

SERVICE

INJECTION PUMP ASSY	
Remove	9
Install	10

[77.26] ELECTRONIC GOVERNOR.....	77.2
----------------------------------	------

FUNCTIONAL DATA

AIR PRESSURE SENSOR	
Overview	12
FUEL TEMPERATURE SENSOR	
Overview	13

[77.31] ADDITIONAL FUEL FILTERS.....	77.3
--------------------------------------	------

SERVICE

FUEL PRE-FILTER	
Remove	14
Install	15
Check	16
Replace	17

[77.45] HYDRAULIC ACCUMULATOR.....	77.4
------------------------------------	------

FUNCTIONAL DATA

HIGH PRESSURE ACCUMULATOR	
---------------------------	--

Overview	19
PRESSURE SENSOR	
PRESSURE SENSOR - Overview	21

SERVICE

HIGH PRESSURE ACCUMULATOR	
Remove	22
Install	23
PRESSURE SENSOR	
Disassemble	24
Assemble	25
OVER PRESURE VALVE	
Disassemble	26
Assemble	27

[77.50] INJECTORS.....	77.5
-------------------------------	-------------

FUNCTIONAL DATA

INJECTOR	
Overview	28

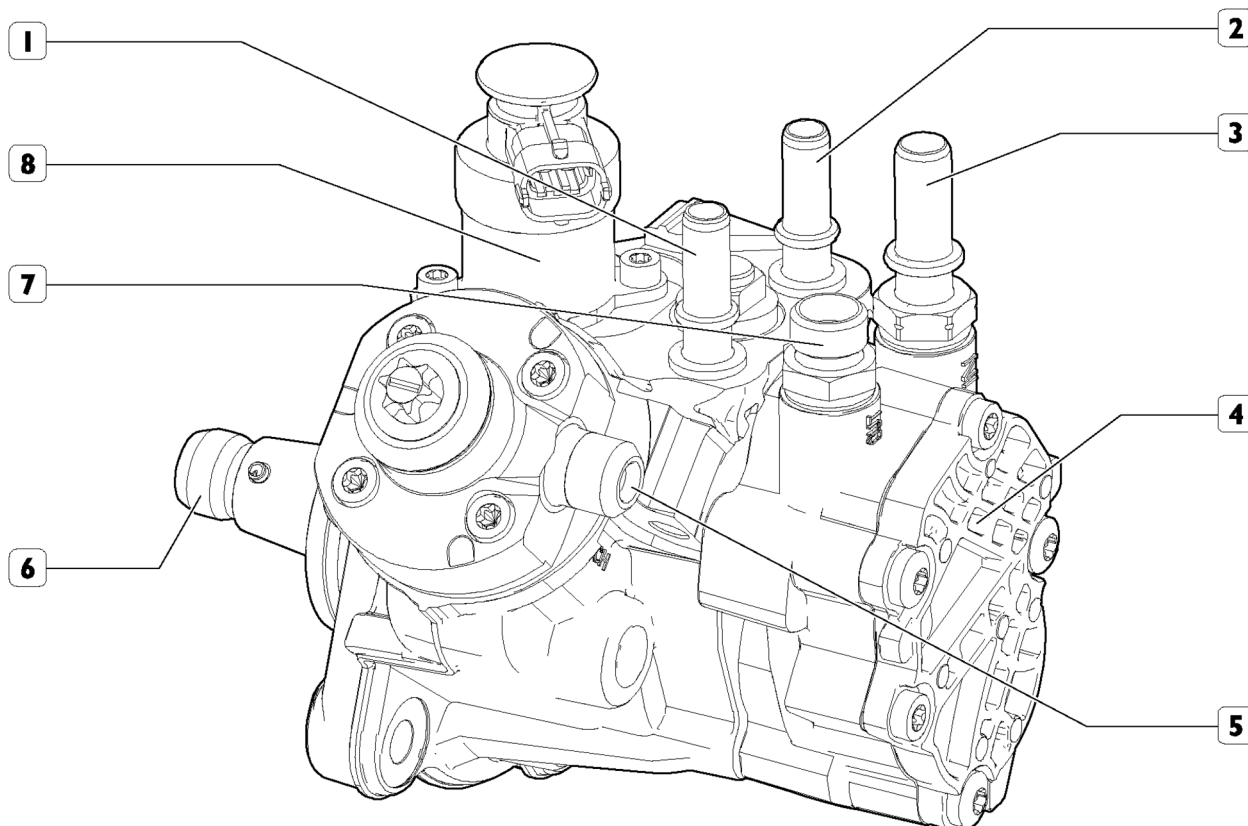
SERVICE

INJECTOR	
Remove	29
Install	30

771010 INJECTION PUMP ASSY - Overview - High pressure pump BOSCH CP4.1

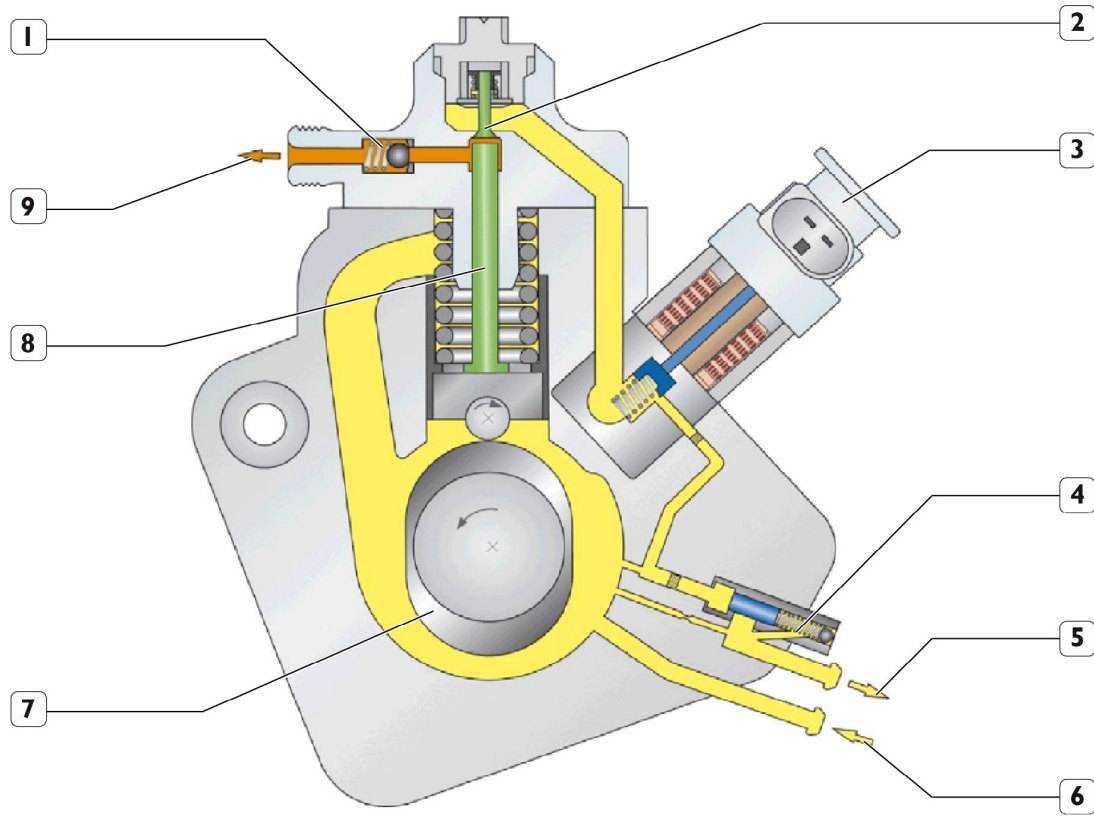
The CP4.1 high pressure pump is a pump with a single piston controlled by the timing gear. The mechanical fuel pump that is controlled by the high pressure pump shaft is fit on the rear side of the high pressure pump.

NOTE: The high pressure pump cannot be overhauled and therefore it must not be removed and the fastening screws must not be tampered with. The only operation that is possible is the replacement of the drive gear.



192043 1

1. Fuel entrance from the fuel filter
2. Fuel discharge (to the tank)
3. Fuel inlet from tank
4. Mechanical supply pump
5. High pressure fuel delivery coupling (to the common rail)
6. Pump drive gear shaft
7. Fuel outlet union (to the fuel filter)
8. Fuel dosing valve



232613 2

1. Ball delivery valve
2. Cap intake valve
3. Fuel dosing valve N290
4. Fuel exhaust valve
5. Low pressure fuel exhaust (to the fuel tank)
6. Low pressure fuel inlet (from the fuel filter)
7. Pump shaft with cam
8. Piston
9. High pressure fuel delivery (to the common rail)

The high pressure fuel pump comprises the following:

- a piston (8) operated by the pump control rod (7) equipped with a cam;
- cap intake valve (2);
- a ball delivery valve (1);
- a fuel discharge valve (4).

232614 3

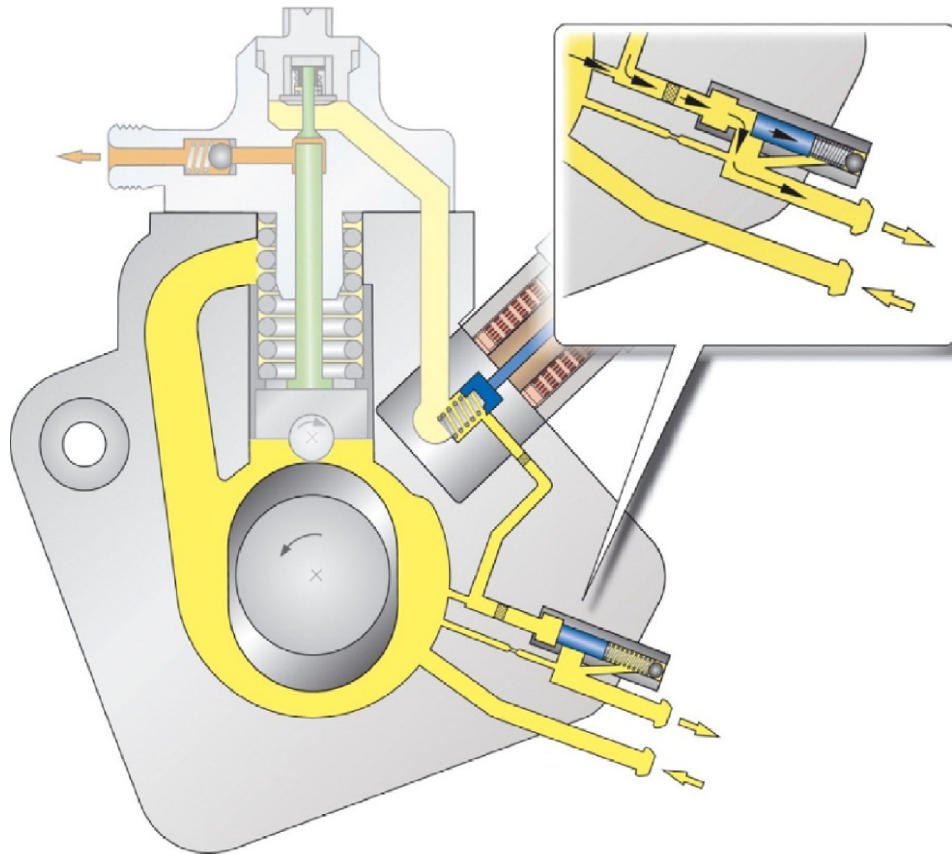
3

A detailed technical cross-section diagram of a mechanical assembly. A central green rod passes through a grey housing. A yellow component, possibly a piston or valve, is positioned around the rod. A callout box in the upper left corner provides a magnified view of the rod's upper end, showing a small orange component and a green tip. The main assembly includes a large yellow circular component at the bottom, a blue and red component on the right, and a yellow rod extending from the bottom right. Arrows indicate the direction of movement or flow.

232615 4

4

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77.1 [77.10] / 5



232616 5
Exhaust step

771034 HIGH PRESSURE ADJ UNIT - Overview

High-pressure fuel pump dosing unit

Situated at the inlet of the high pressure pump on the low pressure system, this flow regulator adjusts the quantity of fuel reaching the high pressure pump on the basis of the commands received from the electronic control unit.

It mainly consists of the following parts:

- tapered shutter;
- valve control pin;
- pre-load spring;
- coils.

In the absence of a control signal, the pressure regulator is normally open, and thus the high-pressure pump is in maximum delivery mode.

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

This component cannot be replaced individually and thus should not be dismantled.

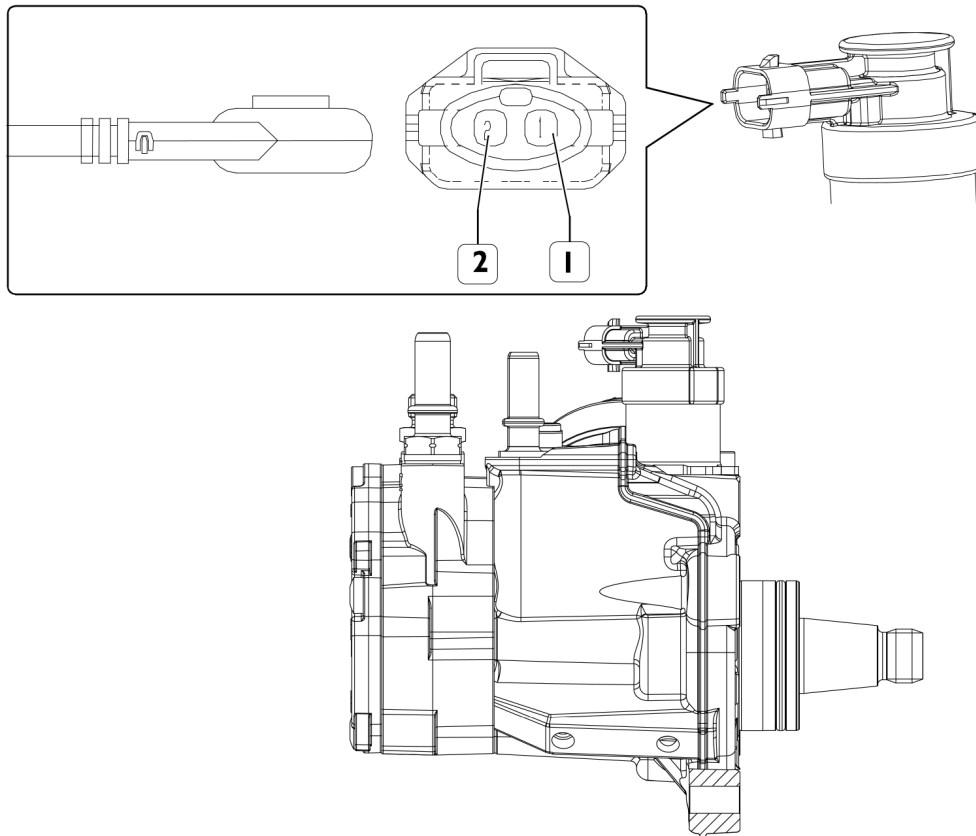
The quantity of fuel that powers the high pressure pump is dosed by the load regulator on the low pressure system; the flow regulator is managed by the control unit.

The delivery pressure to the rail is regulated between 250 and 1,800 bar by the control unit acting on the pressure regulator solenoid valve.

It is a N.O. solenoid valve.

Its resistance is:

Technical data	
Pressure regulator solenoid valve resistance	= 3,2 Ω



232625 1

Valve pin-out

Pin	DeFromCablescription
1	Feeding
2	Signal

771010 INJECTION PUMP ASSY - Remove

Prior operation:

Disconnect the engine cable as described in the procedure **ENGINE CABLES - Remove (76.91)**.

Prior operation:

Remove the low-pressure fuel pipes as described in the procedure **PIPES - Remove (54.20)**.

Prior operation:

Remove the fuel filter as described in the procedure **FILTER ASSEMBLY - Remove (54.20)**.

Prior operation:

Remove the fuel filter bracket as described in the procedure **FILTER SUPPORT - Remove (54.20)**.

Prior operation:

Remove the water pump drive belt as described in the procedure **WATER PUMP DRIVE BELT - Remove (54.34)**.

Prior operation:

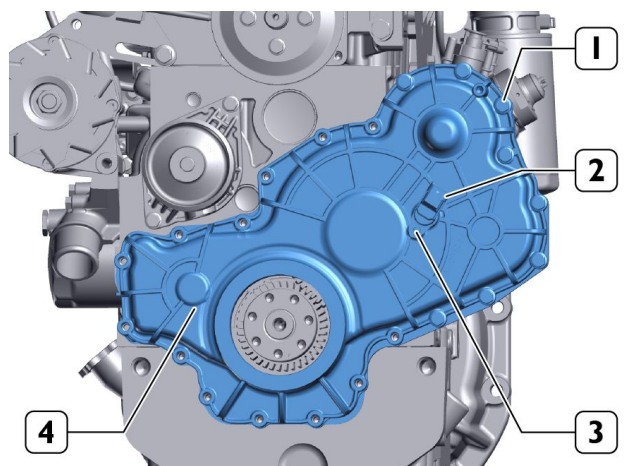
Remove the crankshaft pulley as described in the procedure **DRIVE PULLEY ON CRANKSHAFT - Remove (54.08)**.

Prior operation:

Remove the crankshaft front gasket as described in the procedure **CRANKSHAFT FRONT GASKET - Remove (54.04)**.

High pressure pump removal

1. Unscrew the screw (3) and remove the camshaft timing sensor (2).
2. Unscrew the screws (1) and remove the timing gear case (4).



298205 1

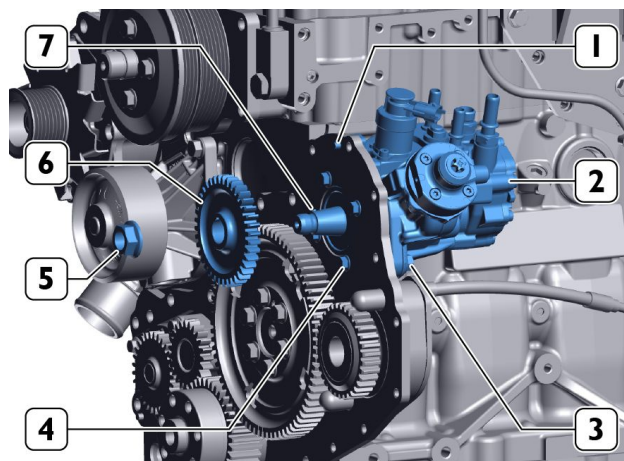
3. Unscrew the nut (5) from the high pressure pump spindle and remove the gear (6).

NOTE: Pay attention to the reference dowel pin (7).

4. Unscrew the nuts (3) from the studs and remove the high pressure pump (2).

NOTE: Pay attention to the reference dowel pin (1).

5. Unscrew the screws (4) and remove the spacer and the relevant gasket.
6. Unscrew the studs securing the high-pressure pump (2) from the gear case.



298065 2

771010 INJECTION PUMP ASSY - Install

Description	Quantity	Step	Value
Camshaft timing sensor	1 screw M6 x 1 x 16		9 +/- 0.9 N·m
High pressure fuel pump	3 nuts M8 x1.25		23 +/- 2.3 N·m
High pressure fuel pump spacer	4 screws M6 x 1 x 16		10 +/- 1 N·m
High-pressure pump gear	1 nut M18 x 1.5		80 +/- 4 N·m
Timing gearbox		13 screws M8 x1.25 x 25	23 +/- 2.3 N·m
		13 screws M8 x 1.25 x 35	23 +/- 2.3 N·m

Refitting high pressure pump

1. Tighten the studs on the gear case for fastening the high-pressure pump (2).

Description	Quantity	Step	Value
High pressure fuel pump	3 studs M8x1.25x12		11 +/- 1.1 N·m

2. Fit the spacer, with a new gasket, and tighten the screws (4) to the specified torque.

Description	Quantity	Step	Value
High pressure fuel pump spacer	4 screws M6 x 1 x 16		10 +/- 1 N·m

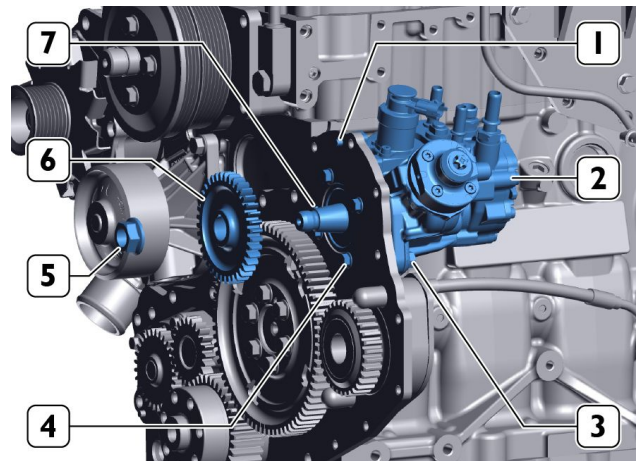
3. Fit the high-pressure pump (2) in the correct position through the reference pin (1) and tighten the nuts (3) to the specified torque.

Description	Quantity	Step	Value
High pressure fuel pump	3 nuts M8 x1.25		23 +/- 2.3 N·m

4. Fit the pump drive gear (6) on the high-pressure pump spindle with the key (7) and tighten the nut (5) to the specified torque.

NOTE: Pay attention to correctly orientate the pump drive gear (6) with respect to the high-pressure pump spindle to avoid sticking with the key (7).

Description	Quantity	Step	Value
High-pressure pump gear	1 nut M18 x 1.5		80 +/- 4 N·m



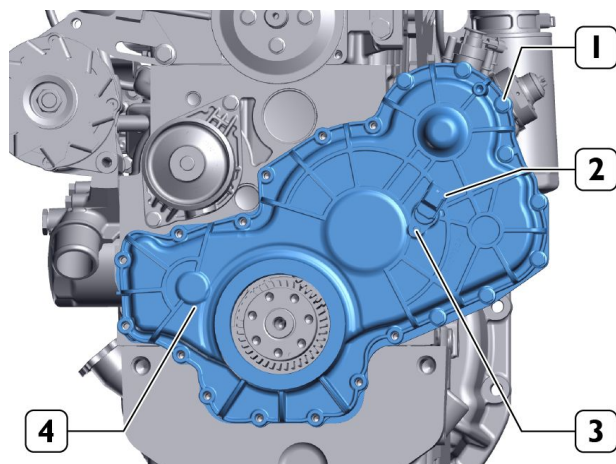
298065 1

5. Fit the timing gear case (4) and tighten the screws (1) to the specified torque.

Description	Step	Value
Timing gearbox	13 screws M8 x1.25 x 25	23 +/- 2.3 N·m
	13 screws M8 x 1.25 x 35	23 +/- 2.3 N·m

6. Fit the timing sensor phase sensor (2) and tighten the screw (3) to the prescribed torque.

Description	Quantity	Value
Camshaft timing sensor	1 screw M6 x 1 x 16	9 +/- 0.9 N·m



298205 2

Next operation:

Fit the crankshaft front gasket as described in the procedure **CRANKSHAFT FRONT GASKET - Install (54.04)**.

Next operation:

Fit the crankshaft pulley as described in the procedure **DRIVE PULLEY ON CRANKSHAFT - Install (54.08)**.

Next operation:

Fit the water pump drive belt as described in the procedure **WATER PUMP DRIVE BELT - Install (54.34)**.

Next operation:

Fit the fuel filter bracket as described in the procedure **FILTER SUPPORT - Install (54.20)**.

Next operation:

Fit the fuel filter as described in the procedure **FILTER ASSEMBLY - Install (54.20)**.

Next operation:

Fit the low-pressure and high-pressure fuel pipes as described in the procedure **PIPES - Install (54.20)**.

Next operation:

Connect the engine cable as described in the procedure **ENGINE CABLES - Install (76.91)**.

772646 AIR PRESSURE SENSOR - Overview

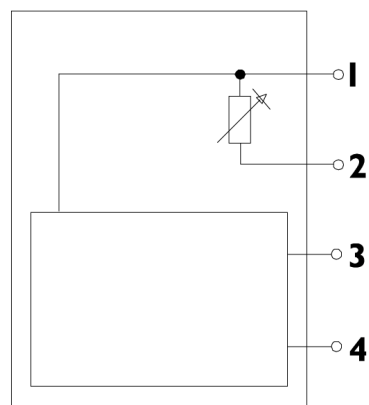
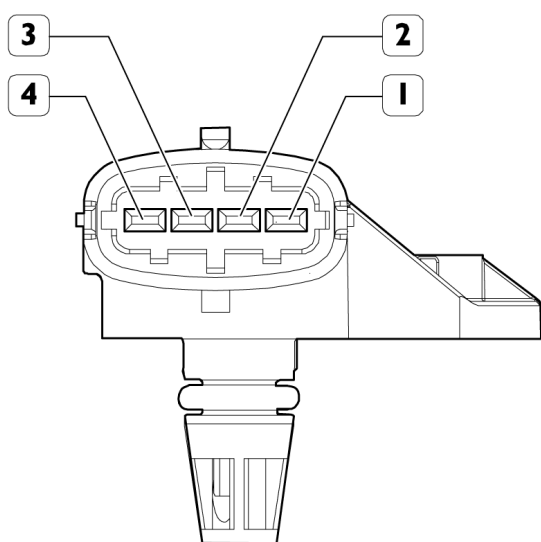
Boost pressure and air temperature sensor

This component incorporates a temperature sensor and a pressure sensor.

It is fitted to the intake manifold so that, by measuring the maximum quantity of air taken in, it makes it possible to determine the exact amount of fuel to be injected at each cycle.

It is powered at **5 V** .

The output voltage is proportional to the pressure (or temperature) measured by the sensor.



227114 1

Sensor pin-out

Ref.	Description
1	Ground
2	Temperature signal
3	Feeding
4	Pressure signal

772656 FUEL TEMPERATURE SENSOR - Overview

Fuel temperature sensor

It is a variable resistance sensor. It detects the fuel temperature thus enabling the ECU to determine the fuel density and volume and adjust the delivery.

Its resistance is:

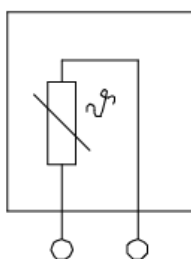
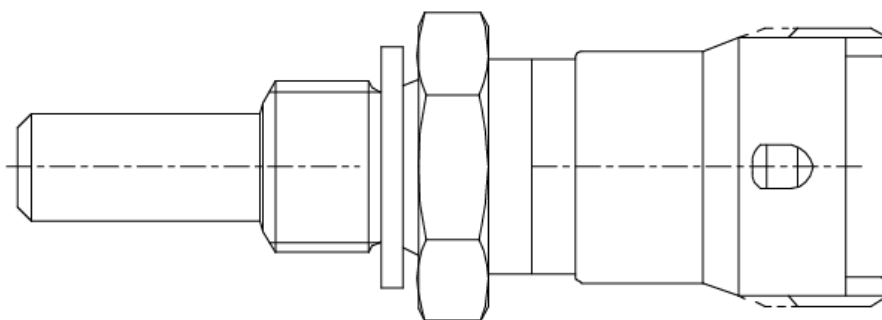
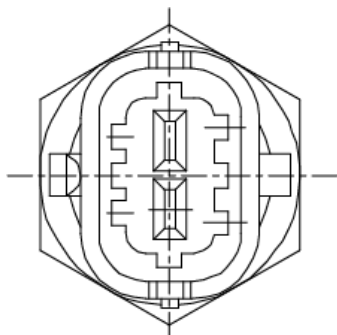
Resistance	
Conditions: Temperature 20 °C	2,5 kΩ

The ECU controls the control contactor to heat the filter to the fuel temperature:

Technical data	
Fuel temperature: ≤	5 °C

Sensor pin-out

Ref.	Description
1	Signal
2	Ground



195652 1

773110 FUEL PRE-FILTER - Remove

Tool / Material

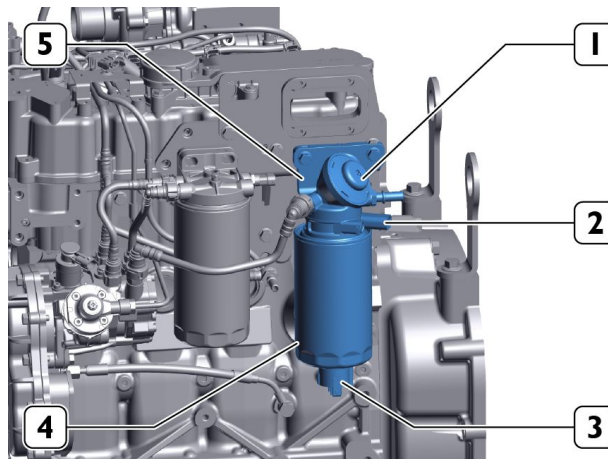
Remover, cartridge filter

99360076

1. Disconnect the electrical connection of the sensor (3) detecting water in the fuel pre-filter and the electrical connection of the fuel electric heater (2).
2. Position a container to collect the diesel oil below the fuel pre-filter (4).
3. Use the specific tool to unscrew and remove the fuel pre-filter (4) from the relative pre-filter mount (5) and recover the gasket .

NOTE: Pay attention to the sensor (3) detecting the presence of water in the fuel pre-filter and to the electrical connections of the engine cable.

NOTE: Pay careful attention to the electric fuel heater (2) and the relative electrical connection.



298066 1

Tool / Material

Remover, cartridge filter

99360076

773110 FUEL PRE-FILTER - Install

1. Moisten the gasket of the pre-fuel filter (4) with a thin layer of engine oil.
2. Manually tighten the fuel pre-filter (4) on the bracket (5) until it fits against the gasket.

NOTE: Pay attention to the sensor (3) detecting the presence of water in the fuel pre-filter and to the electrical connections of the engine cable.

NOTE: Pay careful attention to the electric fuel heater (2) and the relative electrical connection.

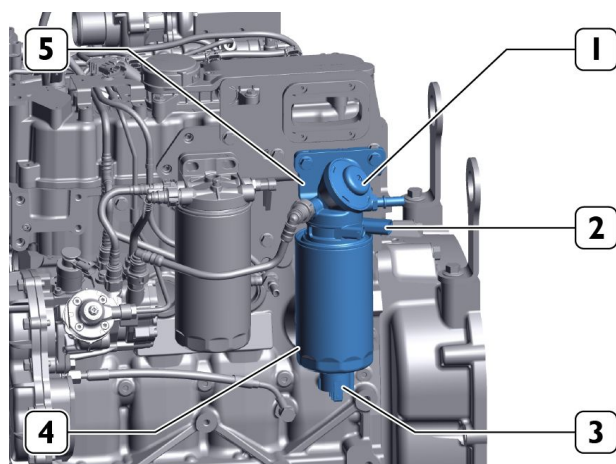
3. Using specific tool, further tighten the pre-fuel filter (4) to the specified torque:

Description	Quantity	Value
Fuel Pre-filter	1 cartridge —	20 +/- 3 N·m

4. Connect the electrical connection of the sensor (3) detecting water in the fuel pre-filter and the electrical connection of the fuel electric heater (2).
5. After replacing the pre-fuel filter (4) there may be oil bubbles in the fuel circuit.
6. Bleed the residual air from the pre-fuel filter (4) by loosening the breather plug and connecting it to a suitable container with a transparent flexible pipe.
7. Actuate the manual pump (1) of the fuel pre-filter (4) until the fuel exiting the breather plug is completely free of air bubbles.
8. Tighten the bleeder plug to the specified torque.

Description	Quantity	Value
Air bleeding on the fuel filter bracket	1 screw M10	4 +/- 0.5 N·m

9. Start the engine and allow it to run at minimum for a few minutes to expel any remaining air.



298066 1

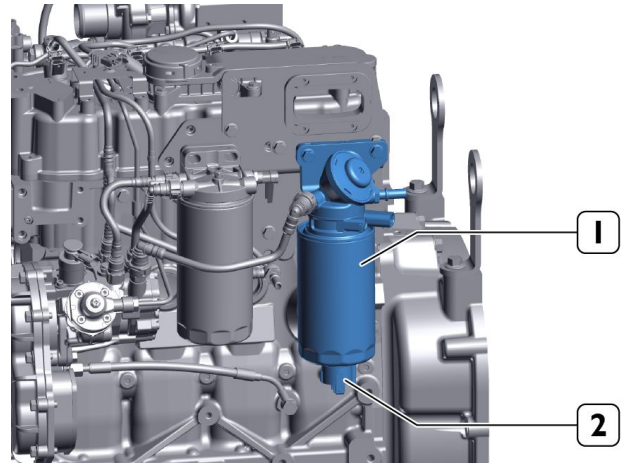
773110 FUEL PRE-FILTER - Check

Check for water in fuel pre-filter/filter

1. Proceed with the engine off and at a low temperature.
2. Place a container below the pre-filter **(1)** to collect the fluid.
3. Visually check for water in fuel pre-filter **(1)**.
4. Disconnect the electrical connection and unscrew the sensor **(2)** to detect the presence of water in the fuel in the lower part of the fuel pre-filter **(1)**.
5. Drain the fluid until only fuel exits.

ATTENTION: The disposal of all liquids and fluids must be in full compliance with current legislation.

6. When draining is completed, retighten the sensor **(2)** at the base of the fuel pre-filter **(1)** and reconnect the electrical connections.
7. Check that the water presence sensor **(2)** is working correctly.



298206 1

773110 FUEL PRE-FILTER - Replace

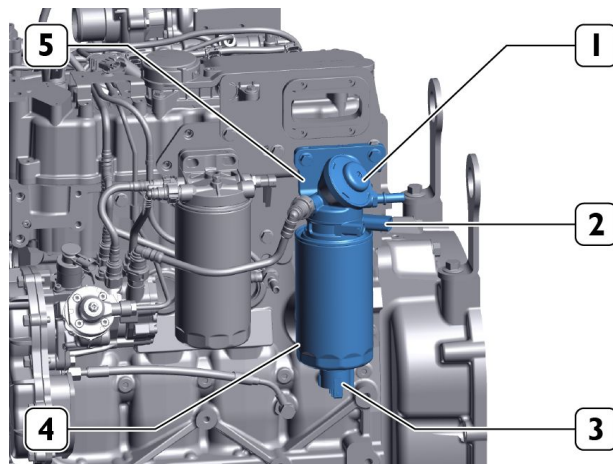
Description	Quantity	Value
Air bleeding on the fuel filter bracket	1 screw M10	4 +/- 0.5 N·m
Fuel Pre-filter	1 cartridge —	20 +/- 3 N·m

Tool / Material		
Remover, cartridge filter		99360076

1. Disconnect the electrical connection of the sensor (3) detecting water in the fuel pre-filter and the electrical connection of the fuel electric heater (2).
2. Position a container to collect the diesel oil below the fuel pre-filter (4).
3. Use the specific tool to unscrew and remove the fuel pre-filter (4) from the relative pre-filter mount (5) and recover the gasket .

NOTE: Pay attention to the sensor (3) detecting the presence of water in the fuel pre-filter and to the electrical connections of the engine cable.

NOTE: Pay careful attention to the electric fuel heater (2) and the relative electrical connection.



298066 1

Tool / Material		
Remover, cartridge filter		99360076

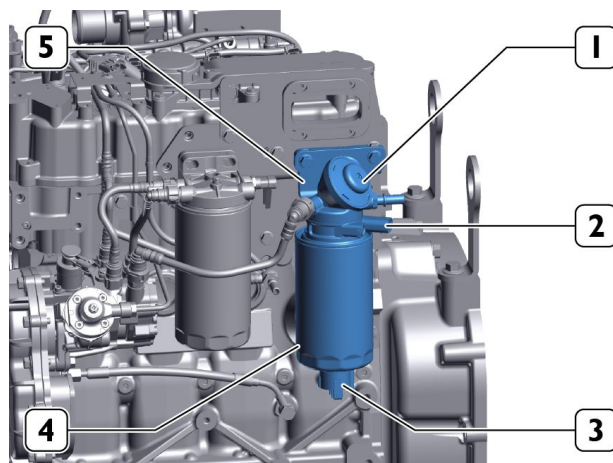
4. Replace the fuel pre-filter.
5. Moisten the gasket of the pre-fuel filter (4) with a thin layer of engine oil.
6. Manually tighten the fuel pre-filter (4) on the bracket (5) until it fits against the gasket.

NOTE: Pay attention to the sensor (3) detecting the presence of water in the fuel pre-filter and to the electrical connections of the engine cable.

NOTE: Pay careful attention to the electric fuel heater (2) and the relative electrical connection.

7. Using specific tool, further tighten the pre-fuel filter (4) to the specified torque:

Description	Quantity	Value
Fuel Pre-filter	1 cartridge —	20 +/- 3 N·m



298066 2

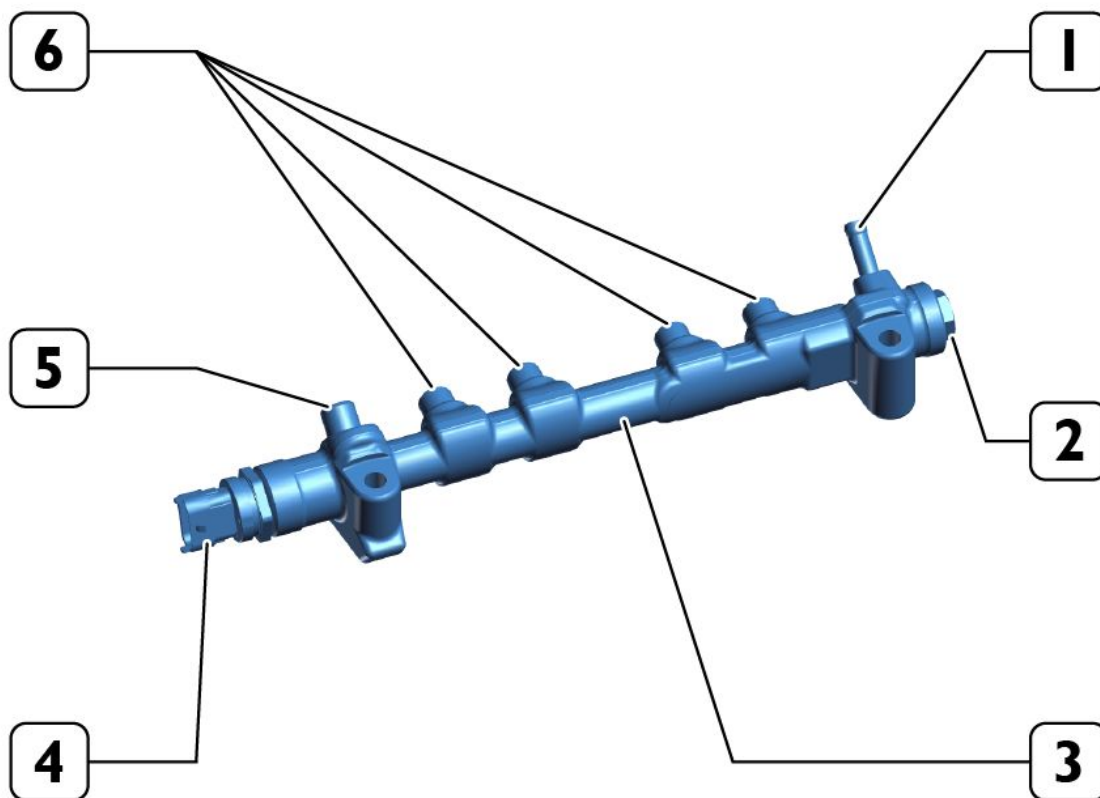
8. Connect the electrical connection of the sensor (3) detecting water in the fuel pre-filter and the electrical connection of the fuel electric heater (2).
9. After replacing the pre-fuel filter (4) there may be oil bubbles in the fuel circuit.
10. Bleed the residual air from the pre-fuel filter (4) by loosening the breather plug and connecting it to a suitable container with a transparent flexible pipe.
11. Actuate the manual pump (1) of the fuel pre-filter (4) until the fuel exiting the breather plug is completely free of air bubbles.
12. Tighten the bleeder plug to the specified torque.

Description	Quantity	Value
Air bleeding on the fuel filter bracket	1 screw M10	4 +/- 0.5 N·m

13. Start the engine and allow it to run at minimum for a few minutes to expel any remaining air.

774510 HIGH PRESSURE ACCUMULATOR - Overview

Rail (pressure accumulator)



298067 1

1. Fuel outlet towards tank
2. Overpressure valve
3. Rail
4. Pressure sensor
5. Fuel inlet from high-pressure pump
6. Fuel outlet towards the injectors

The rail **(3)** volume is of reduced size to allow a quick pressurisation at start-up, at idle and in case of high flow-rates.

It anyway has enough volume as to minimise pulsations 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 have been fitted to the fuel delivery couplings, which control the fuel pressure waves generated by the high pressure pump.

A fuel pressure sensor **(4)** is screwed to the rail.

The signal sent by this sensor to the electronic control unit represents feed-back data, based on which the rail pressure value is checked and corrected if necessary.

Overpressure valve

This is installed at one rail end and it protects system components should a fault in either the rail pressure sensor or the pump pressure regulator causes an excessive increase of pressure in the high pressure system.

When the pressure in the rail reaches **1750 bar**, the valve initially trips to run fuel off and accordingly reduce the pressure to safe levels. It then mechanically regulates the pressure in the rail.

This valve enables to have the engine operated for long time with limited performance and inhibits fuel excessive overheating, so preserving the pipes returning from the tank.

Rated pressure rail	1600 bar
Overpressure valve opening start	1750 bar
Complete opening of overpressure valve	1950 bar

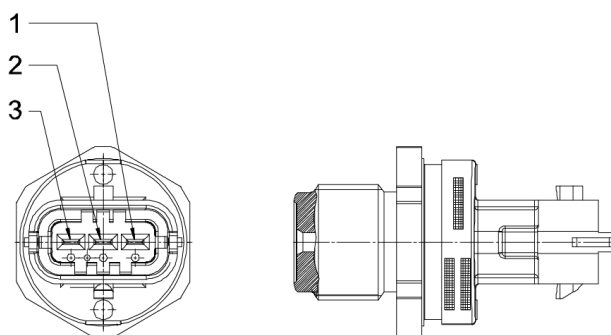
774511 PRESSURE SENSOR - Overview

Fuel pressure sensor on rail

Assembled on one end of the rail, it measures the existing fuel pressure and informs the control unit (feed - back).

The value of injection pressure is used to keep the pressure level under control and to determine the time duration of the injection electronic command.

It is powered at **5 V**.



195675 1

Pin	DeFromCablescription
1	Ground
2	Signal
3	Feeding

774510 HIGH PRESSURE ACCUMULATOR - Remove

Prior operation:

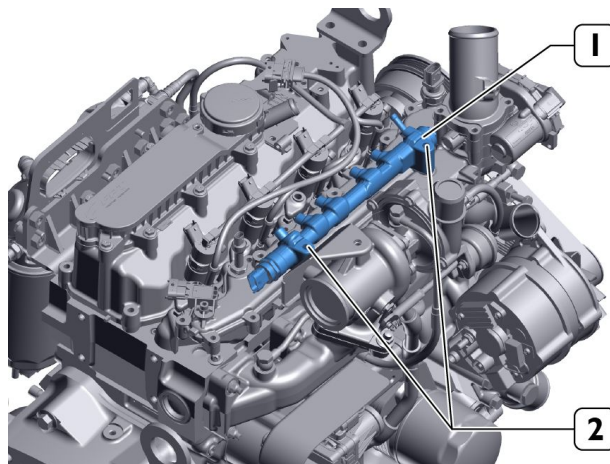
Disconnect the engine cable as described in the procedure **ENGINE CABLES - Remove (76.91)**.

Prior operation:

Remove the fuel delivery and return pipes from the rail and from the high pressure pump, as described in the procedure **PIPES - Remove (54.20)**.

Common Rail removal

1. Loosen the screws **(2)** fastening the common rail **(1)**.
2. Remove the common rail **(1)**, together with the rail pressure sensor and the pressure relief valve, from the intake manifold.



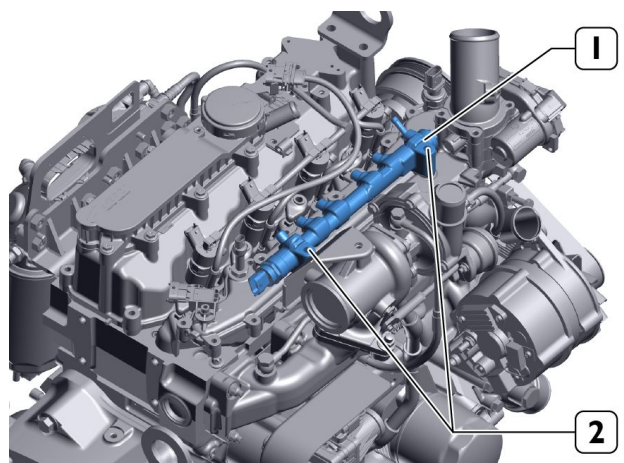
298068 1

774510 HIGH PRESSURE ACCUMULATOR - Install

Description	Quantity	Step	Value
Common Rail	2 screws M8 x 1.25 x 55		23 +/- 2.3 N·m

- Fit the common rail (1), together with the rail pressure sensor and the pressure relief valve, on the intake manifold.
- Tighten the fastening screws (2) to the specified torque.

Description	Quantity	Step	Value
Common Rail	2 screws M8 x 1.25 x 55		23 +/- 2.3 N·m



298068 1

Next operation:

Fit the fuel delivery and return pipes from the rail and from the high pressure pump, as described in the procedure **PIPES - Install (54.20)**.

Next operation:

Connect the engine cable as described in the procedure **ENGINE CABLES - Install (76.91)**.

774511 PRESSURE SENSOR - Disassemble

1. Loosen the pressure sensor using the wrench or unscrew the rail by hand.
2. If present, remove the O-ring gasket.
3. Clean the sensor thread and the contact surface of the rail.
4. Plug the seat of the sensor on the rail using a plastic cap to prevent contamination.

774511 PRESSURE SENSOR - Assemble

Description	Quantity	Value
Pressure sensor on rail RDS4.2	1 sensor M18 x 1.5	70 +/- 5 N·m

1. Remove the plastic cap from the sensor seat on the rail.
2. Inspect the thread and the contact surfaces of the pressure sensor and the rail.
3. If there is any damage or wear, replace the concerned parts.
4. If present, install a new O-ring gasket.
5. Prior to assembly, lubricate the sensor thread and mordant.
6. Manually tighten the pressure sensor on the rail to a torque of:

Description	Quantity	Value
Pressure sensor on rail RDS4.2	1 sensor M18 x 1.5	70 +/- 5 N·m

774513 OVER PRESURE VALVE - Disassemble

1. Use a wrench to loosen the relief valve and unscrew it manually from the rail.
2. If present, remove the O-ring gasket.
3. Clean the thread of the relief valve and the contact surface of the rail.
4. Plug the seat of the relief valve on the rail using a plastic cap to prevent contamination.

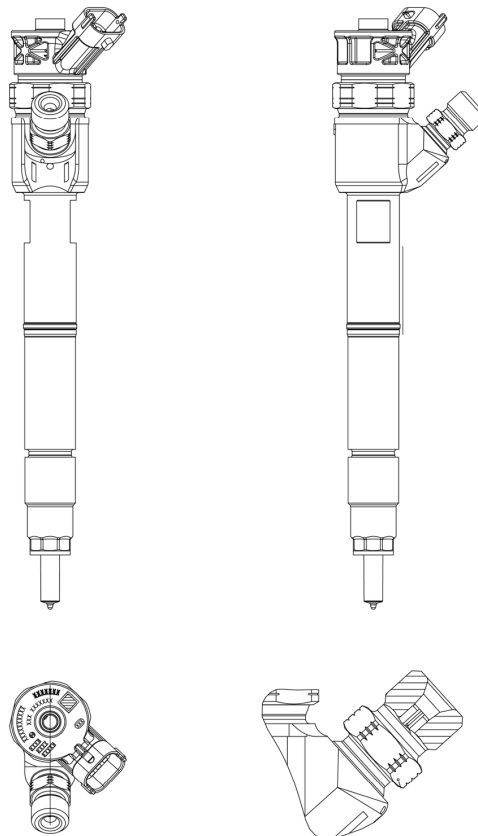
774513 OVER PRESURE VALVE - Assemble

Description	Quantity	Value
Pressure relief valve on rail	1 coupling —	100 +/- 5 N·m

1. Remove the plastic cap from the relief valve seat on the rail.
2. Inspect the thread and the contact surfaces of the relief valve and the rail.
3. If damage or wear is found, replace the concerned parts.
4. If fitted, install a new eyelet gasket.
5. Prior to assembly, lubricate the relief valve thread and clamp.
6. Manually screw the relief valve on the rail and tighten to a torque of:

Description	Quantity	Value
Pressure relief valve on rail	1 coupling —	100 +/- 5 N·m

775010 INJECTOR - Overview



232621 1

Electro Injectors

The electro-injector essentially consists of two parts:

- actuator - spray nozzle consisting of a pressure rod , a needle and a jet ;
- Driving solenoid valve made up of coil and pilot valve.

The N.O. type solenoid valve checks the lift of the nozzle needle.

Beginning of injection

Upon being supplied with power, the coil moves up the shutter.

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

At the same time, the fuel pressure in the pressure chamber causes the needle to rise resulting in the fuel being injected into the cylinder.

End of injection

When power to the coil is cut off, the shutter closes again so as to re-create an equilibrium which moves the needle back into its closed position and stops the injection process.

This is an N.C. solenoid valve. They are individually connected to the engine control unit on connector 2.

The resistance of the coil of each individual injector is:

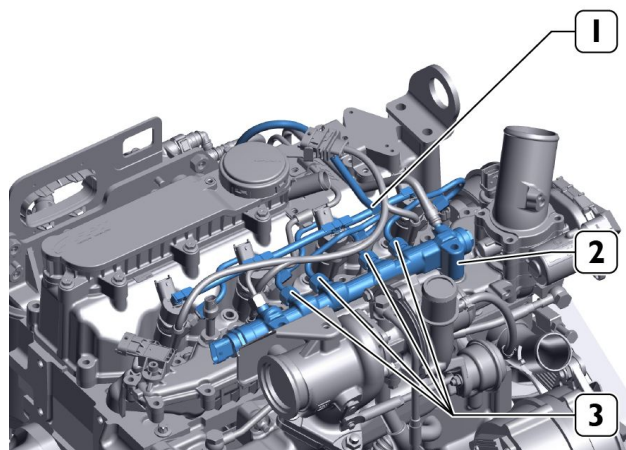
Technical data	
Injector coil resistance	0.56 – 0.57 Ω required.

775010 INJECTOR - Remove

Prior operation:

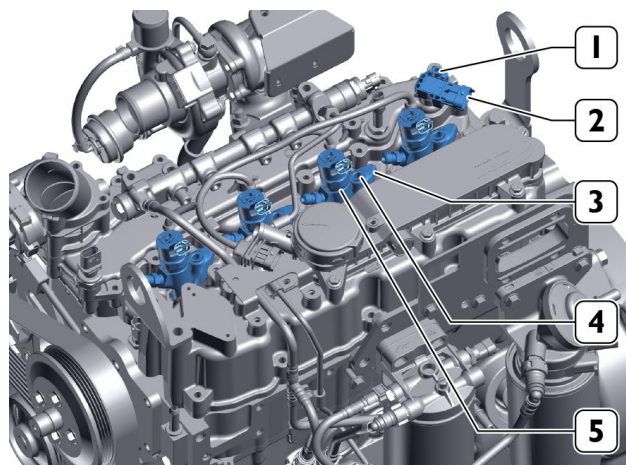
Disconnect the engine cable from the injector cable as described in the procedure **ENGINE CABLES - Remove (76.91)**.

1. Position a suitable container to catch any fuel.
2. Disconnect the fuel return pipe **(1)** from the injectors .
3. Disconnect the high pressure pipe fittings **(3)** from the injectors and from the rail **(2)**.



298069 1

4. Unscrew the screw **(1)** and remove the air temperature and supercharging pressure sensor **(2)**.
5. Unscrew the nuts **(4)** recovering the relevant washers, remove the injector **(5)** together with the fixing bracket **(3)**, from the head and mark it with the cylinder to which it belongs.
6. Unscrew the studs housed on the head.



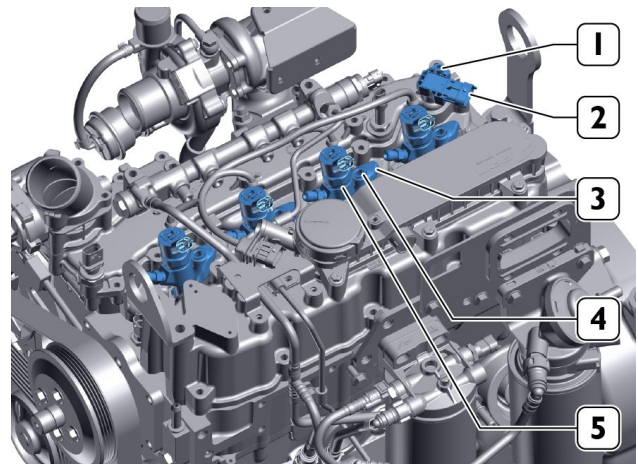
298070 2

775010 INJECTOR - Install

Description	Quantity	Step	Value
Air temperature and pressure sensor	1 screw M6 x 1 x 16		9 +/- 0.9 N·m
Electro-injector brackets	4 nuts M8 x1.25		18 +/- 1.8 N·m
Fuel delivery pipes to the electro-injectors	4 rail-side couplings M14 x1.5		35 +/- 1.75 N·m

- Fit the studs and tighten them to the specified torque.

Description	Quantity	Step	Value
Electro-injector brackets	4 studs M8 x 1.25 x 65		28 +/- 1.4 N·m



298070 1

NOTE: Replace washers before refitting the injector

- Fit the electro-injector (5) on the head together with the fixing bracket (3) and tighten the nuts (4), together with their washers, to the prescribed torque.

Description	Quantity	Step	Value
Electro-injector brackets	4 nuts M8 x1.25		18 +/- 1.8 N·m

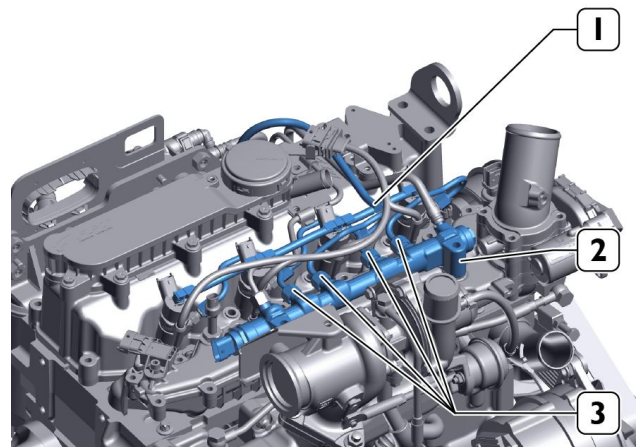
- Fit the air temperature and supercharging pressure sensor (2) and tighten the screw (2) to the prescribed torque.

Description	Quantity	Value
Air temperature and pressure sensor	1 screw M6 x 1 x 16	9 +/- 0.9 N·m

- Connect the high pressure pipe couplings (3) on the injectors and on the rail (2).

NOTE: The pipes (3), as they are subject to high pressure, must be replaced each time they are removed.

Description	Quantity	Step	Value
Fuel delivery pipes to the electro-injectors	4 injector-side couplings M12 x 1.5		25 +/- 1.25 N·m
Fuel delivery pipes to the electro-injectors	4 rail-side couplings M14 x1.5		35 +/- 1.75 N·m



298069 2

- Connect the fuel return pipe (1) from the electro-injectors.

NOTE: *Visually check that the pipes are not blocked or damaged*

Next operation:

Connect the engine cable from the injector wiring, as described in the procedure **ENGINE CABLES - Install (76.91)**.

Index

INJECTION - 77

772646	AIR PRESSURE SENSOR - Overview	12
773110	FUEL PRE-FILTER - Check	16
773110	FUEL PRE-FILTER - Install	15
773110	FUEL PRE-FILTER - Remove	14
773110	FUEL PRE-FILTER - Replace	17
772656	FUEL TEMPERATURE SENSOR - Overview	13
774510	HIGH PRESSURE ACCUMULATOR - Install	23
774510	HIGH PRESSURE ACCUMULATOR - Overview	19
774510	HIGH PRESSURE ACCUMULATOR - Remove	22
771034	HIGH PRESSURE ADJ UNIT - Overview	7
771010	INJECTION PUMP ASSY - Install	10
771010	INJECTION PUMP ASSY - Overview - High pressure pump BOSCH CP4.1	3
771010	INJECTION PUMP ASSY - Remove	9
775010	INJECTOR - Install	30
775010	INJECTOR - Overview	28
775010	INJECTOR - Remove	29
774513	OVER PRESURE VALVE - Assemble	27
774513	OVER PRESURE VALVE - Disassemble	26
774511	PRESSURE SENSOR - Assemble	25
774511	PRESSURE SENSOR - Disassemble	24
774511	PRESSURE SENSOR - Overview	21

Contents

CHASSIS - 50

[50.51] AIR FILTERS AND PIPES.....	50.1
------------------------------------	------

SERVICE

ENGINE SUPPLY AIR FILTER

Cleaning	2
Replace	3

[50.60] RADIATOR AND PIPES.....	50.2
---------------------------------	------

SERVICE

RADIATOR

Check	4
Check - Liquid density	5
Change fluid	6
Cleaning	8

[50.71] EXHAUST PIPES AND SILENCER.....	50.3
---	------

FUNCTIONAL DATA

EXHAUST PIPES AND SILENCER

EXHAUST PIPES AND SILENCER - Overview	9
---	---

TEMPERATURE SENSOR

Overview	12
----------------	----

SERVICE

EXHAUST PIPES AND SILENCER

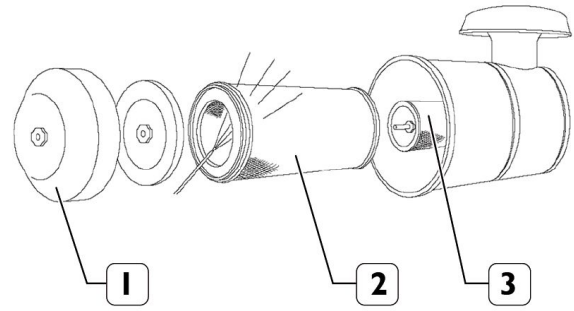
Service instruction - Forced regeneration procedure	14
---	----

EXHAUST PIPES

Visual inspection	20
-------------------------	----

505110 ENGINE SUPPLY AIR FILTER - Cleaning

1. Only proceed with the engine stopped.
2. Remove the cover (1) of the filter after unscrewing the locking handle.
3. Remove the external cartridge (2), after unscrewing the second locking handle; make sure that dust does not enter the sleeve during this operation.
4. Make sure there are no impurities. Otherwise, clean the filter element according to the instructions provided below.
5. Blow dehumidified compressed air onto the filter element, from the inside outwards (maximum pressure **200 kPa**). Do not use detergents; do not use diesel oil.
6. Never strike the filter element with tools and check its condition before refitting it.
7. Replace it if broken or torn.
8. Check the condition of the gasket at its base. Some filtering system are equipped with a second filter element (3) which does not require cleaning; they must be replaced at least every 3 times that the main element is changed
9. Mount following the steps for removal in the reverse order.
10. Prepare the mechanical clog indicator for use by pressing the button on the top part of the indicator. The electric sensor does not require this operation.



265017 1

General prescriptions

The engine oil is highly pollutant and harmful. In case of contact with the skin, wash thoroughly with soap and water. Protect skin and eyes appropriately; work in accordance with accident prevention regulations.



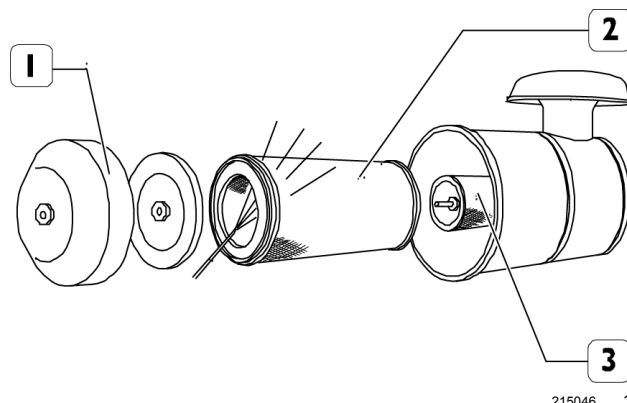
Dispose of the residue in full compliance with legal regulations.

Failure to comply completely or partially with these requirements may result in the risk of serious damage to the engine and may even, on occasion, invalidate the warranty

505110 ENGINE SUPPLY AIR FILTER - Replace

Air filter replacement (component not supplied by FPT)

1. Only proceed with the engine stopped.
2. Remove the filter cover (1) after first unscrewing the locking handle.
3. Remove the external cartridge (2), after having released the second locking handle. During this operation, pay careful attention to ensure there is no contamination inside the sleeve.
4. Check that there is no dirt in the air filter seat. Clean it if necessary.
5. Replace the filter element (2) and the relative gasket at its base.
6. Some filtering systems are equipped with a second filter element (3) which does not require cleaning. It (3) must be changed at least once every three times that the main element is replaced (2).
7. Position the new filter element (2) in its seat.
8. Reassemble by repeating the above operations in reverse order.
9. Restore the clogged indicator by pressing the button on the top part of the indicator. This operation is not necessary if there is an electric sensor.



215046 1

General prescriptions

Make sure that the components are refitted correctly. Incorrect fitting could cause the engine to intake unfiltered air which could lead to serious damage.



Failure to comply completely or partially with these requirements may result in the risk of serious damage to the engine and may even, on occasion, invalidate the warranty

506010 RADIATOR - Check

Engine coolant level check

1. Only proceed when the engine is not turning, and is at low temperature, so as not to run the risk of burns.
2. Remove the pressurisation cap from the expansion tank.
3. Check that the coolant in the expansion tank is above the minimum level.
4. If necessary, top up the expansion tank with a mixture of **50%** water and Actifull OT CONCENTRATE, as indicated in the REFILLING table. Do not fill the expansion tank to the brim.
5. When the engine is cold, check that the level of coolant is a few centimetres below the filling hole.
6. If there is a level indicator outside of 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 due to an increase in temperature.

506010 RADIATOR - Check - Liquid density

1. Remove the expansion tank plug and remove a sample of coolant with a normal densimeter used to check the density of the anti-freeze fluid.



Risk of burns

When the engine is hot, pressure builds up in the cooling circuits which may eject hot liquid violently, resulting in a risk of burns.

Failure to comply with these prescriptions can result in the risk of serious injury and serious damages to the vehicle

2. Depending on the temperature of the fluid, check the percentage of antifreeze in the fluid on the reading scale of the instrument.

The percentage must exceed **40%** but must not exceed **50%**.

3. If necessary, restore the percentage of antifreeze, bearing in mind that the fluid needs to be replaced every 2 to.

The density of the coolant must however be checked every year before the winter and it must be changed every two years.

506010 RADIATOR - Change fluid

Engine coolant replacement

1. Only proceed when the engine is not turning, and is at low temperature, so as not to run the risk of burns.
2. Place a container for collecting coolant under the heat exchanger (radiator).
3. Remove the pressurisation cap from the expansion tank.
4. Loosen the retaining elements and remove the sleeves connecting the engine cooling circuit to the heat exchanger.
5. Drain the coolant from the heat exchanger (radiator) and wait until it is completely empty.
6. Once emptied, refit the cooling circuit making sure the sleeves are perfectly sealed.
7. Refill the engine and the heat exchanger until completely filling the cooling circuit with a mixture of **50%** water and Actifull OT CONCENTRATE, as indicated in the REFILLING table. Do not fill the expansion tank to the brim.
8. With the coolant cap open, start the engine and let it idle for approx. **1 min**. This helps to completely bleed the air contained in the cooling circuit.
9. Stop the engine and if necessary top up with more coolant, if necessary.
10. When the engine is cold, make sure that the coolant in the expansion tank is a few centimetres below the filling hole.
11. If there is a level indicator outside of 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 due to an increase in temperature.

General prescriptions

Failure to observe the procedure described above will not guarantee the presence of the correct quantity of coolant in the engine.



Failure to comply completely or partially with these requirements may result in the risk of serious damage to the engine and may even, on occasion, invalidate the warranty

Risk of burns

When the engine is hot, pressure builds up in the cooling circuits which may eject hot liquid violently, resulting in a risk of burns.



Failure to comply with these prescriptions can result in the risk of serious injury and serious damages to the vehicle



Risk of burns

Open the filler cap of the coolant tank only if necessary and only when the engine is cold.

Failure to comply with these prescriptions can result in the risk of serious injury and serious damages to the vehicle

506010 RADIATOR - Cleaning

Clean the heat exchanger (radiator)

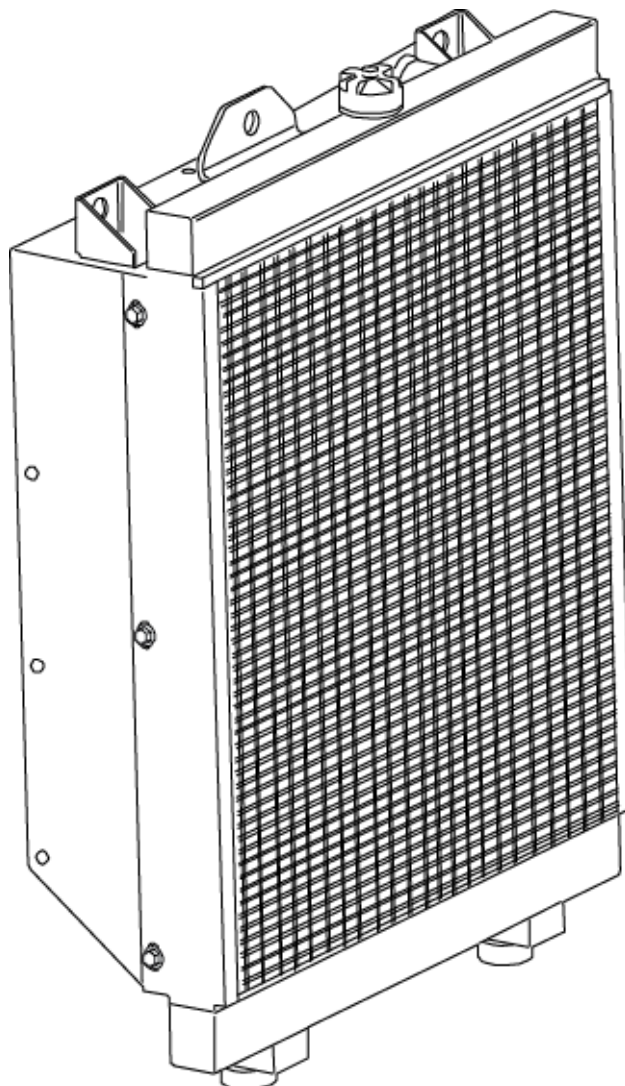
1. Check that the radiator air inlets are free from dirt (dust, mud, straw, etc.).
2. Clean them if necessary using compressed air or steam.



Risk of injury:

Before carrying out the procedure, ensure you are wearing suitable PPE. Proceed in accordance with accident prevention standards.

Failure to comply with these prescriptions can result in the risk of serious injury



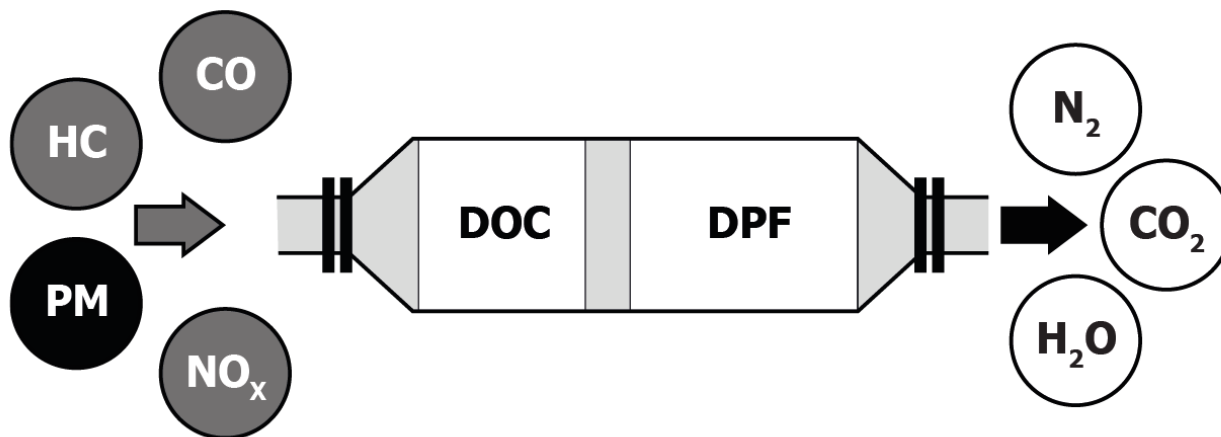
200503 1

5071 EXHAUST PIPES AND SILENCER - Overview

EXHAUST GAS POST-TREATMENT SYSTEM (ATS)

The Stage V regulations, which require a limit on the number of particulate particles (PN) (compared to the previous regulations which set a limit to the mass of particulate), has made mandatory the implementation of DPF filter (Diesel Particulate Filter).

ATS configuration



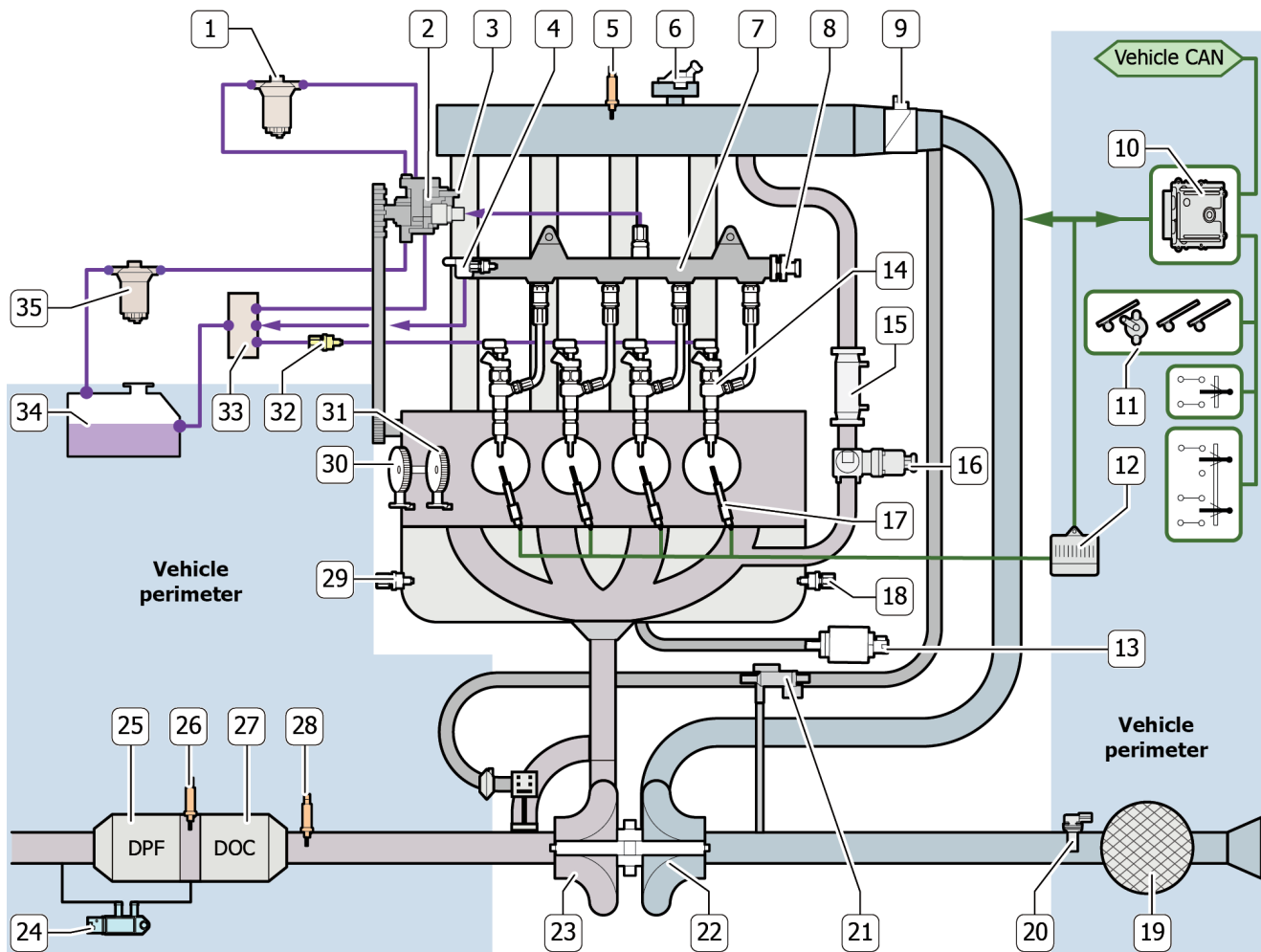
298670 1

- A DOC (Diesel Oxidation Catalyst) catalytic converter;
- A DPF (Diesel Particulate Filter)

To reduce exhaust gas emissions within the limits required by current standards, it is necessary to implement the exhaust gas post-treatment system (ATS) which combines more devices:

- A DOC catalytic converter that, via a series of oxidation reactions allows the treatment of HC (unburned hydrocarbons) and CO (carbon monoxide) using the residual oxygen O_2 at the exhaust by transforming it into carbon dioxide (CO_2) and water (H_2O) through oxidation reactions. The oxidation of CO and HC are obtained through the use of noble metals such as platinum and palladium.
- The EGR system (EGR valve and heat exchanger) reduces NO_x emissions. Once the EGR valve is open, the exhaust gas flows through the EGR heat exchanger where the combustion temperature is reduced in order to reduce the quantity of NO_x , then the exhaust gas enters the intake pipe.
- The diesel particulate filter DPF to remove NO_x and PM from the diesel exhaust, by oxidising simultaneously CO and HC.

SCRoF configuration diagram

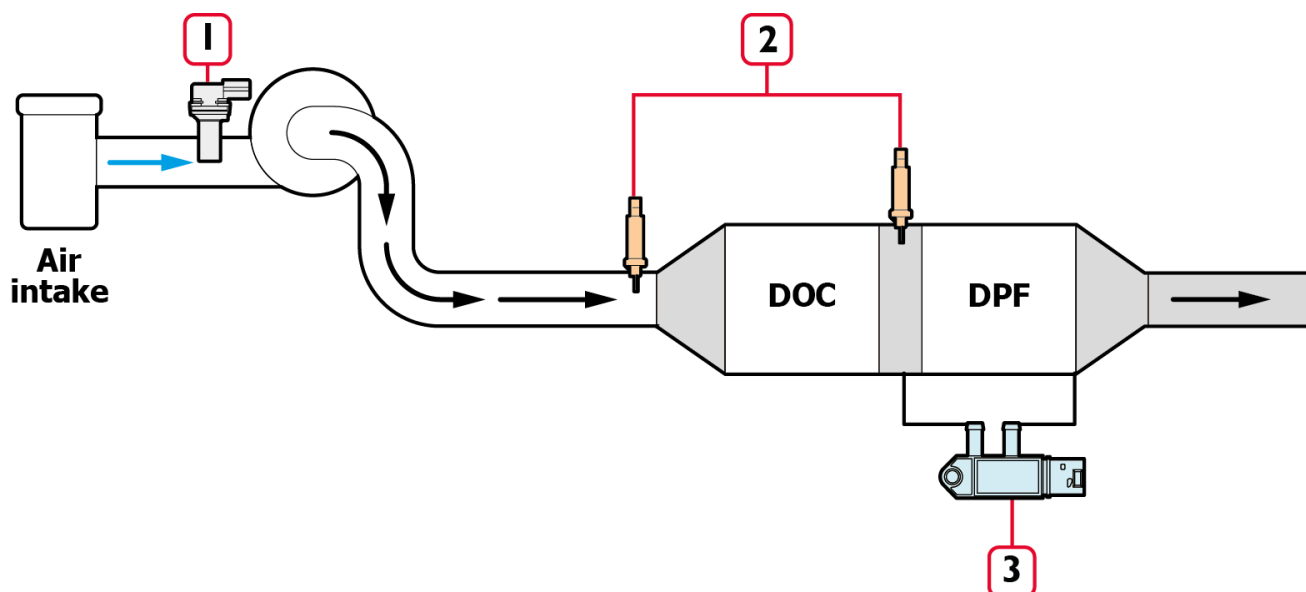


(1) Fuel filter with temperature sensor - (2) High pressure fuel pump - (3) Fuel high pressure pump dosing valve - (4) Rail pressure sensor - (5) Air temperature sensor (intake manifold) - (6) Boost pressure and air temperature sensor (intake manifold) - (7) Rail - (8) Overpressure valve - (9) Throttle valve (TVA) - (10) Engine control unit - (11) Machine interface (pedal, power take-off,...) - (12) Glow plug connector - (13) Exhaust gas absolute pressure sensor - (14) Injectors - (15) EGR heat exchanger - (16) EGR valve - (17) Glow plugs - (18) Oil pressure sensor - (19) Air filter - (20) Intake air temperature and humidity sensor - (21) Waste-gate pressure modulator - (22) Compressor - (23) Turbine - (24) Pressure differential sensor - (25) DPF particulate filter - (26) Temperature sensor downstream of DOC - (27) DOC catalytic converter - (28) Temperature sensor upstream of DOC - (29) Engine coolant temperature sensor - (30) Crankshaft incremental speed sensor - (31) Phasing segmental speed sensor (camshaft) - (32) Check valve (on fuel return line on injector) - (33) - (34) Fuel return damper - (35) Fuel pre-filter with heater and water sensor in the filter.

The ATS system is managed by the engine control unit via a series of sensors:

- Two exhaust gas temperature sensors;
- One humidity sensor fitted on the engine air intake pipe downstream of the air filter;
- One pressure differential sensor;

Electronic management of the ATS

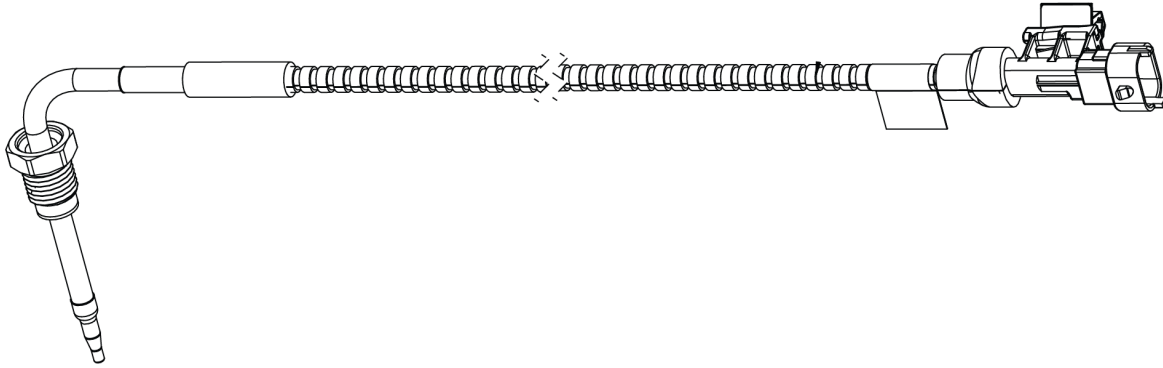


298669 3

(1) Inlet air temperature and humidity sensor - (2) Exhaust gas temperature sensor upstream and downstream of the DOC - (3) Pressure differential sensor.

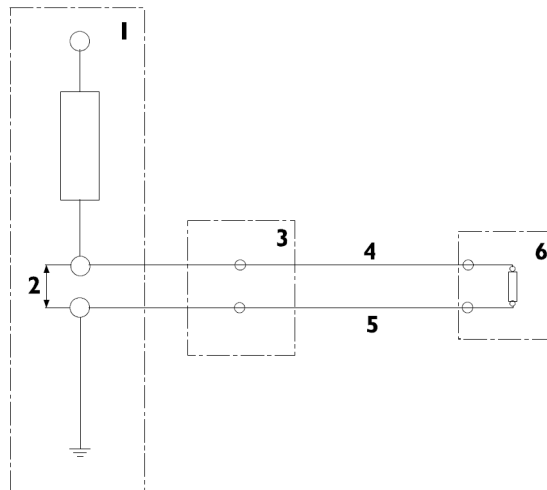
507133 TEMPERATURE SENSOR - Overview

Exhaust gas temperature sensor



267934 1

Functional wiring diagram



102304B 2

1. Power 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 to the control unit the exhaust gas temperature measured in various points of the ATS:

- At the DOC inlet, signal used to protect the DOC against overheating.
- At the DOC outlet, signal used to protect the DOC against overheating.

CHARACTERISTICS OF THE EXHAUST GAS TEMPERATURE SENSOR	NOMINAL
Power supply	+ 5 +/- 0.1% V
Output resistance at temperature of - 40 – 800 °C	170.2 – 738.7 V
Pull-up resistance	1.000 +/- 0.1% Ω
Cable resistance	1 Ω
Tightening torque	45 +/- 4.5 N·m

Sensor characteristics

(T)	(RS)	(V0)
- 40 °C	170.2 Ω	0.727 V
- 20 °C	185.6 Ω	0.783 V
0 °C	201.1 Ω	0.837 V
25 °C	220.1 Ω	0.902 V
50 °C	239.0 Ω	0.964 V
100 °C	276.4 Ω	1.083 V
150 °C	313.2 Ω	1.193 V
200 °C	349.5 Ω	1.295 V
250 °C	385.1 Ω	1.390 V
300 °C	420.2 Ω	1.479 V
350 °C	454.7 Ω	1.563 V
400 °C	488.6 Ω	1.641 V
450 °C	521.9 Ω	1.715 V
500 °C	554.6 Ω	1.784 V
600 °C	618.3 Ω	1.910 V
700 °C	679.7 Ω	2.023 V
800 °C	738.7 Ω	2.124 V

5071 EXHAUST PIPES AND SILENCER - Service instruction - Forced regeneration procedure

Risk of damage

The forced regeneration of the exhaust gas post-treatment device is a procedure which must always be carried out by Service Centres and can only be activated via a diagnostics tool.



Failure to comply completely or partially with these requirements may result in the risk of serious damage to the engine and may even, on occasion, invalidate the warranty

Risk of injury:

Before carrying out the procedure, ensure you are wearing suitable PPE. Proceed in accordance with accident prevention standards.



Failure to comply with these prescriptions can result in the risk of serious injury

Before starting the forced regeneration, follow the indications shown in the warnings.

General warnings

- During forced regeneration the surfaces of the unit components, in particular the components of the ATS system and of the engine, reach extremely high temperatures.
- Check that the unit is in a safe area, that is appropriately isolated from other equipment and vehicles.
- Carry out the forced regeneration only in an open space.
- Make sure that there are no flammable materials in the area.

Risk of burns

The area around the assembly must be cordoned off to prevent any unauthorized persons from coming into contact with the high temperature exhaust gases, which could cause serious personal injury. Failure to comply with these prescriptions can result in the risk of serious injury



- Hang special safety signs on the unit warning that maintenance is being performed, according to the specific national directives.
- Wear PPE required by national regulations.
- The forced regeneration of the exhaust gas post treatment device is a procedure which must always be carried out by the Assistance Network and may be activated through the diagnostics tool (PT-Box/ VCI) or through the dedicated CAN message (CMBC1).
- The regeneration phase includes an automatic warm up phase
- At the end of the regeneration the engine will have a cold down phase at approximately **1500 RPM**.

 Risk of damage
The procedure can last a maximum of 50 minutes including the heating phase.
Partial or complete non observance of these prescriptions can lead to serious damages to the vehicle

- In case of doubts, refer to the parent company before proceeding.

Off-road and on-road warnings



General risk, general prescriptions

The forced regeneration must be carried out with the vehicle parked in a safe position.
Failure to comply with these prescriptions can result in the risk of serious injury and serious damages to the vehicle

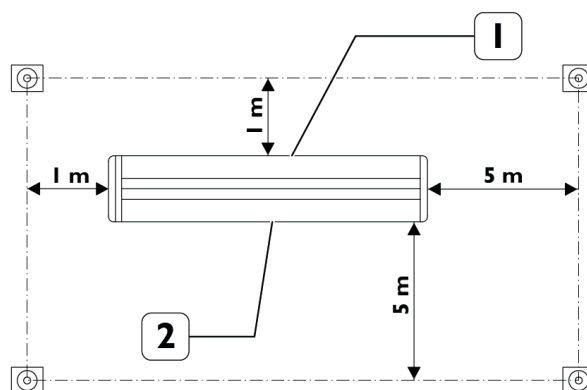


General risk, general prescriptions

No other vehicle must be in the direction of the exhaust pipe at a distance of less than 5 metres. This precaution must be strictly observed, because during the forced regeneration the released heat in the silencer zone is very high.
Failure to comply with these prescriptions can result in the risk of serious injury and serious damages to the vehicle

1. • Park the machine away from flammable elements (hay bales, dry leaves)
- Make sure that the exhaust line is clean and not covered by flammable work residuals
- Before starting the procedure mark the area around the vehicle with barrier signs as indicated in the figure.

NOTE: 1) Vehicle – 2) Exhaust gas terminal side and its position on the vehicle.



Specific warnings for generator units

- Isolate the generator unit from the electric distribution line by acting on the phase disconnecting switches – main current contactors.
- Open the access doors on the soundproof unit to ease the ventilation of the engine compartment.
- Delimit the area around the generator; reserving a space of at least **2 m** around the unit, paying particular attention of the exhaust gas discharge into the atmosphere.

Off-road and on-road connections

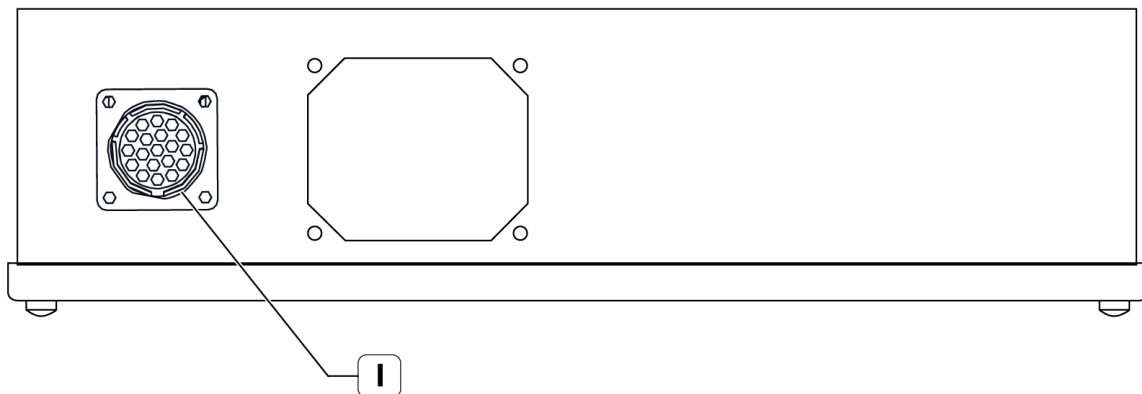
- To carry out the forced regeneration of the ATS system, connect the diagnostic tool (PT-Box o VCI) to the OBD diagnosis socket.
 - PT-Box (**PREPARATIONS - Overview (29.54)**)
 - VCI (**PREPARATION - Overview (29.55)**)

Connections for generators

- Make sure that the unit is switched off from the switchboard. Unit power supply switch set to “OFF” and/or control panel switched OFF.
 - Current generator units: isolate the unit from the three-phase system of the distribution network using the disconnecting switches. Apply special mechanical stops to the disconnecting switches in compliance with applicable national directives.
 - Hang on the switchboard the signs required by applicable national regulations; signs warning that maintenance is being carried out on the unit.

To perform the forced regeneration of the ATS system, connect the PT-Box o VCI diagnostic tool to the interface housing as described below.

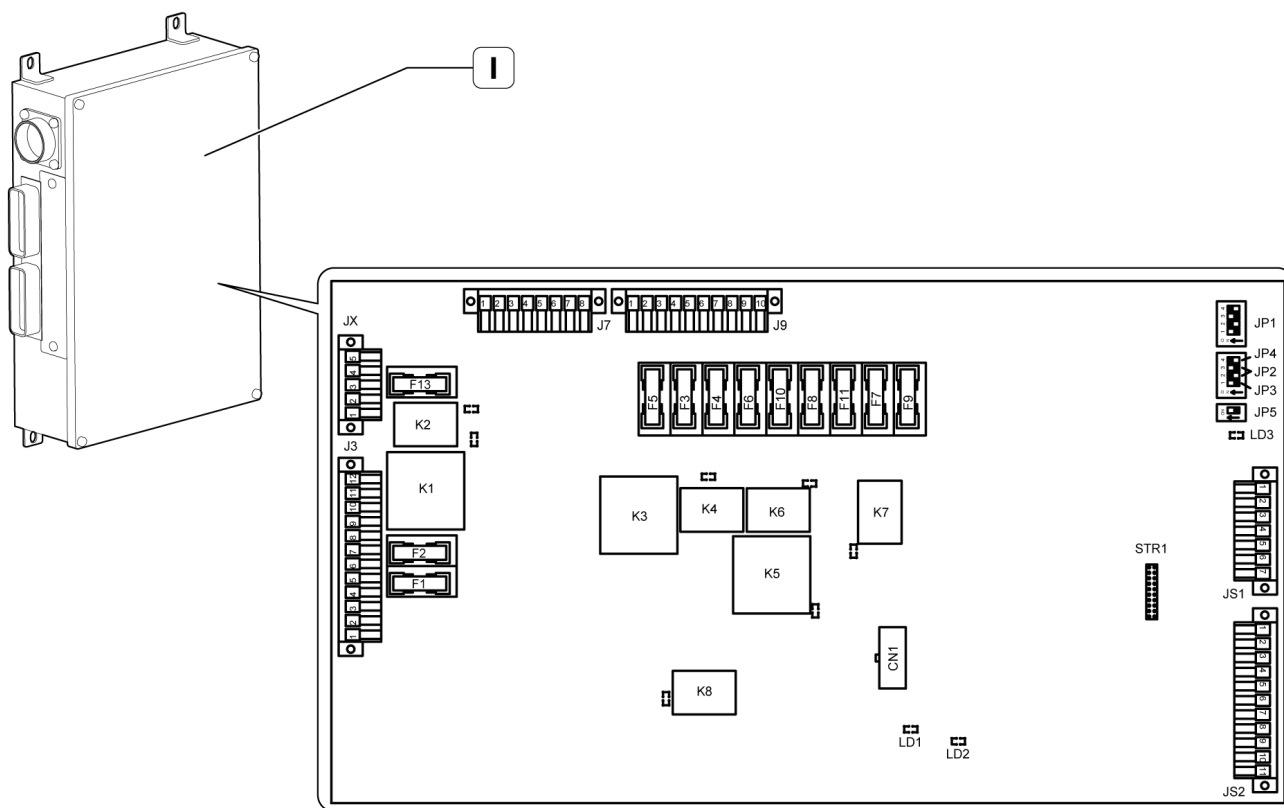
- PT-Box (**PREPARATIONS - Overview (29.54)**)
- VCI (**PREPARATION - Overview (29.55)**)



268543_1 2

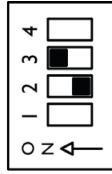
(1) 19 pin engine diagnostics socket

- Remove the front cover **(1)** of the interface housing to access the internal board.



268551 3

Set the unit in diagnostic mode by acting on the micro-switches JP2.

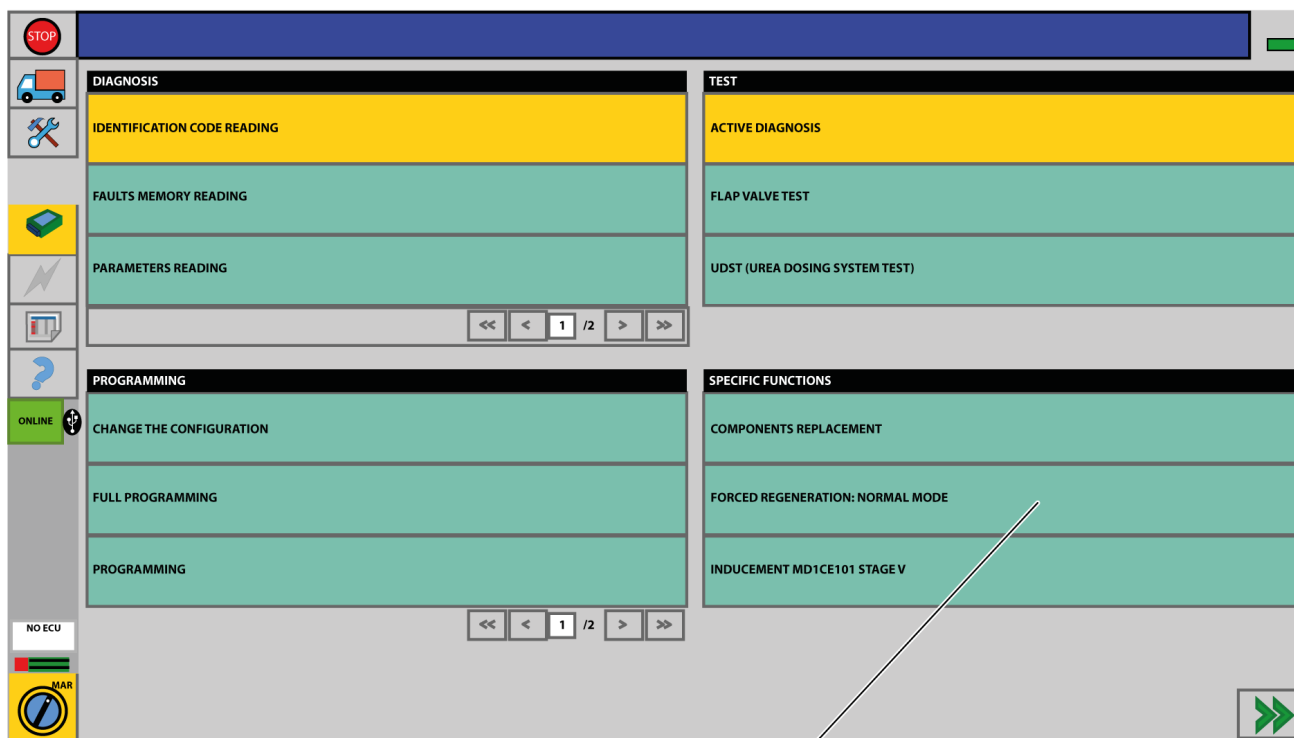
Diagnostics position	JP2  ON
Operational position (default)	JP2  ON

Starting the forced regeneration procedures through the diagnostic tool

- Start the diagnostic tool (PT-Box o VCI) and follow the step-by-step instructions to select the forced regeneration procedure for the ATS system.

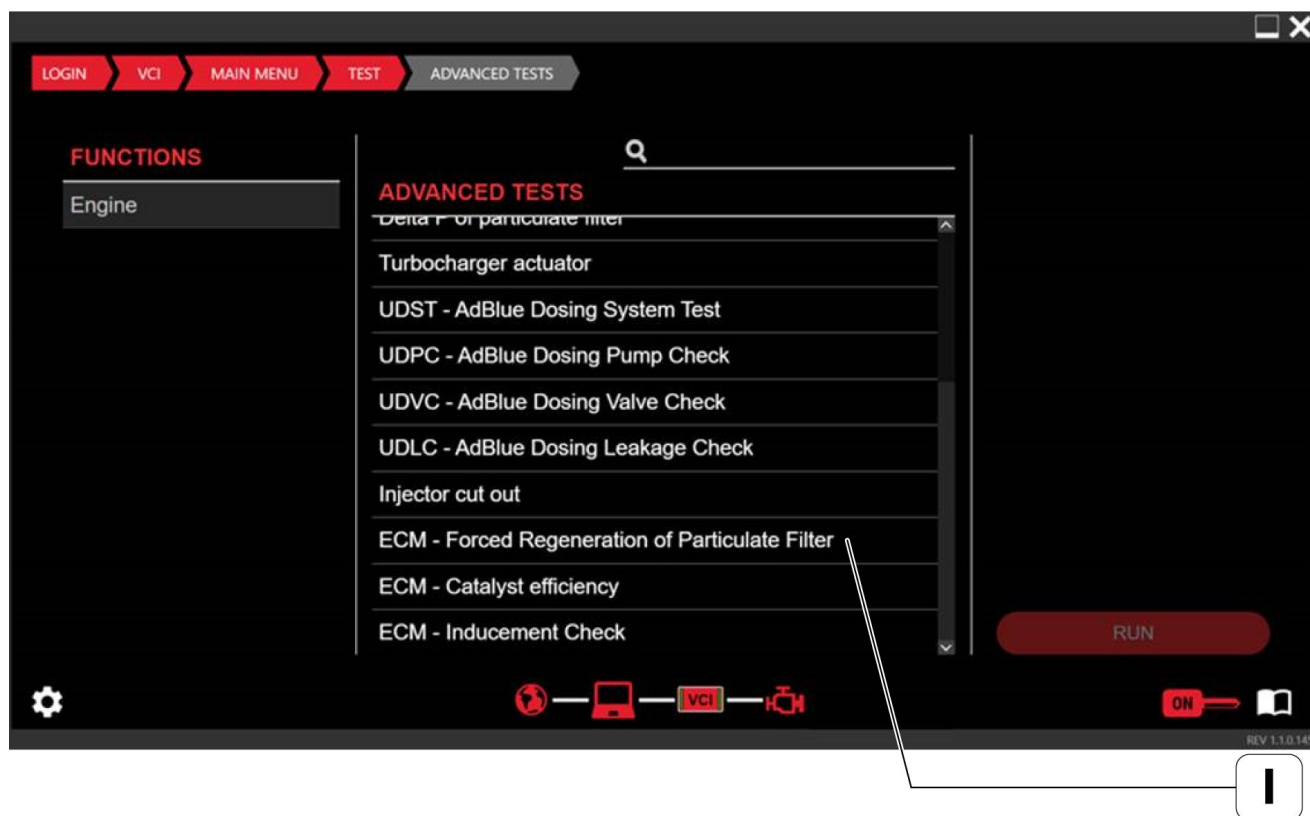
The functions of the diagnostic tool are contained in four sub-menus.

- “Diagnostic” menu
- “Programming” menu
- “Test” menu
- “Specific functions” menu



268552 4

Screen regarding the diagnostic tool with PT-Box



268552_1 5

Screen regarding the diagnostic tool with VCI

To start the forced regeneration select the function (1) highlighted in the figure and follow the step-by-step instructions proposed by the diagnostic tool.

NOTICE: *The procedure is managed by the diagnostic tool: do not carry out any operation until the instrument indicates that the procedure is completed. The procedure is fully automatic and it is not necessary to check the vehicle during the regeneration phase.*

507120 EXHAUST PIPES - Visual inspection

Check the condition of the exhaust duct(s)

1. Visually check the coolant level in the expansion tank.
2. Visually check that the exhaust gas system is not obstructed or damaged.
3. Make sure there are no hazardous fumes in the machine, Contact the Manufacturer if necessary.

Index

CHASSIS - 50

505110	ENGINE SUPPLY AIR FILTER - Cleaning	2
505110	ENGINE SUPPLY AIR FILTER - Replace	3
507120	EXHAUST PIPES - Visual inspection	20
5071	EXHAUST PIPES AND SILENCER - Overview	9
5071	EXHAUST PIPES AND SILENCER - Service instruction - Forced regeneration procedure	14
506010	RADIATOR - Change fluid	6
506010	RADIATOR - Check - Liquid density	5
506010	RADIATOR - Check	4
506010	RADIATOR - Cleaning	8
507133	TEMPERATURE SENSOR - Overview	12

Contents

ELECTRICAL COMPONENTS - 76

[76.03] ALTERNATOR	76.1
--------------------------	------

FUNCTIONAL DATA

ALTERNATOR ASSEMBLY

Overview	3
----------------	---

SERVICE

ALTERNATOR ASSEMBLY

Remove	5
Install	6
Visual inspection	7

[76.19] ENGINE PREHEATING DEVICE	76.2
--	------

FUNCTIONAL DATA

PREHEATER PLUGS

Overview	8
----------------	---

SERVICE

PREHEATER PLUGS

Remove	9
Install	10

[76.20] BATTERIES	76.3
-------------------------	------

SERVICE

BATTERY

Check - Battery check	11
-----------------------------	----

[76.42] PRESSURE GAUGES, INDICATORS, SENDERS	76.4
--	------

FUNCTIONAL DATA

ENGINE OIL PRESSURE GAUGE SENDER

ENGINE OIL PRESSURE GAUGE SENDER - Overview	12
---	----

ENGINE WATER TEMPERATURE SENDER	
ENGINE WATER TEMPERATURE SENDER - Overview	14
REV.COUNTER SENDER	
Overview	15
TIMING GEAR SPEED SENDER	
Overview	16

[76.91] CABLES AND CONNECTIONS 76.5

FUNCTIONAL DATA

ENGINE CABLES	
Overview	17

SERVICE

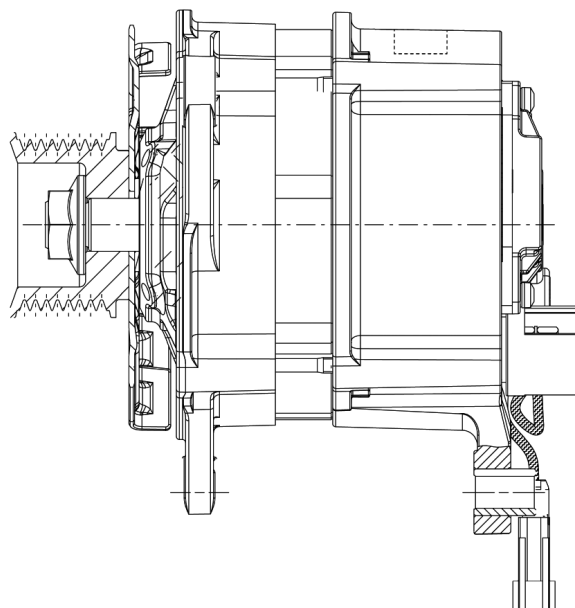
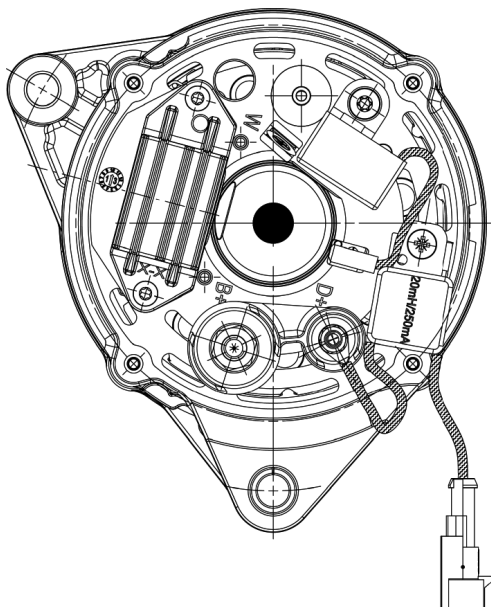
ENGINE CABLES	
Remove	19
Install	20

760310 ALTERNATOR ASSEMBLY - Overview

Alternator

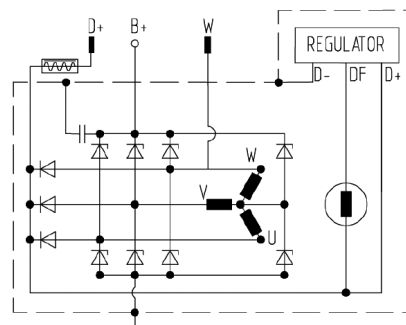
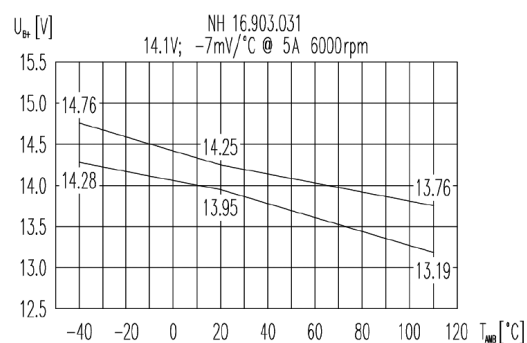
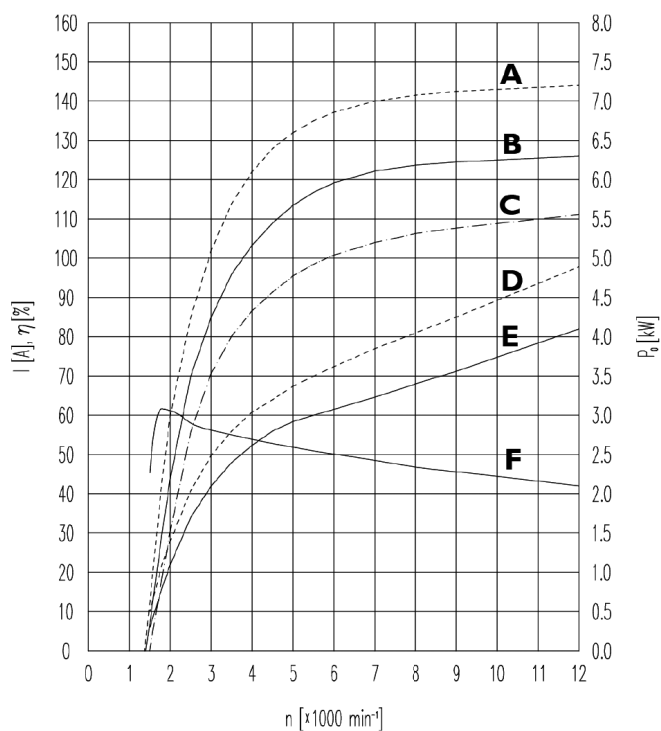
It is frontally located on the right-hand side of the engine and is controlled by the auxiliary assembly belt.

Technical view



231930 1

Characteristic curves



232618 2

- A. Current curve (A) when cold
- B. Current curve (A) when hot
- C. Current curve (A) when hot 110 °C

-
- D. Power curve (**kW**) when cold
- E. Power curve (**kW**) when hot
- F. Efficiency curve (%)

Characteristics

Sense of rotation: clockwise

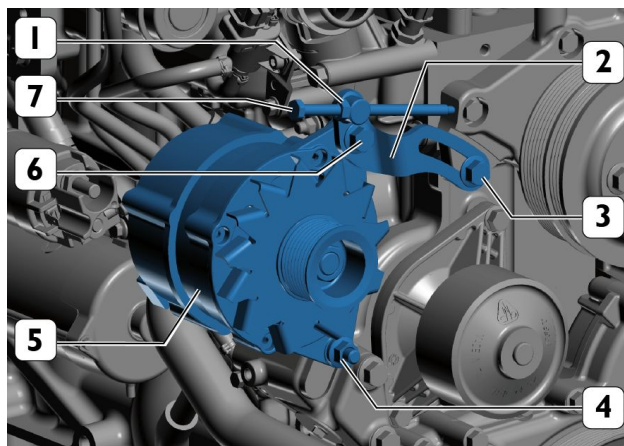
Technical data	
Rated voltage	14 V
Nominal supply current	100 A
Maximum continuous speed	≤ 15.000 RPM
Power absorption (stand-by)	≥ 1 mA
Operating temperature range	-40 – 110 °C

760310 ALTERNATOR ASSEMBLY - Remove

Prior operation:

WATER PUMP DRIVE BELT - Remove (54.34)

1. Unscrew the fastening screws **(3)** and **(6)** and remove the tensioning bracket **(2)** from the crankcase.
2. Unscrew the anchoring bolt **(4)** and remove the alternator **(5)** from its lower support mount.



231005 1

760310 ALTERNATOR ASSEMBLY - Install

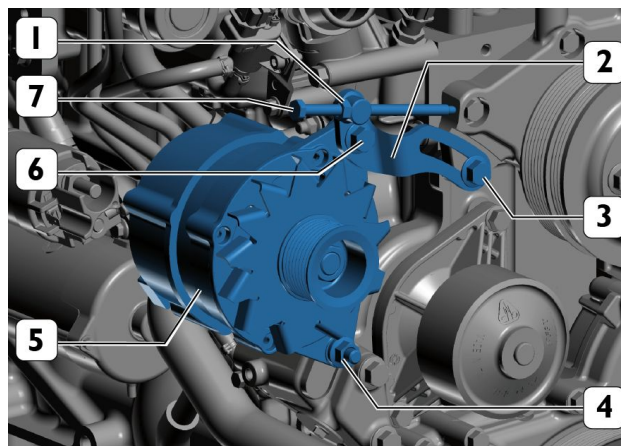
Description	Step	Value
Alternator	1 screw M10x1.5x130 + 1 nut M10 x 1.5	45 +/- 4.5 N·m
	1 screw M10 x 1.5 x 35 + 1 nut M10 x 1.5	45 +/- 4.5 N·m
Alternator tensioning bracket	1 screw M10 x 1.5 x 20	45 +/- 4.5 N·m

- Position the alternator (5) in its seat and anchor it with the bolt (4) to its lower support mount.

Description	Step	Value
Alternator	1 screw M10x1.5x130 + 1 nut M10 x 1.5	45 +/- 4.5 N·m
	1 screw M10 x 1.5 x 35 + 1 nut M10 x 1.5	45 +/- 4.5 N·m

- Secure the tensioning bracket (2) to the crankcase by tightening the fastening screws (3) and (6) to the specified torque.

Description	Step	Value
Alternator tensioning bracket	1 screw M10 x 1.5 x 20	45 +/- 4.5 N·m



231005 1

Next operation:

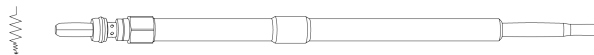
WATER PUMP DRIVE BELT - Install (54.34)

760310 ALTERNATOR ASSEMBLY - Visual inspection

1. Only continue with the engine switched off.
2. Visually check that the alternator is not damaged, in which case it must be replaced.
3. Check there are no unusual noises while the engine is running.
4. Check that the alternator fastening bolts are correctly tightened.
5. Inspect the connection of the battery cable on the rear side of the alternator. Make sure it is clean and correctly tightened.

761915 PREHEATER PLUGS - Overview

Pre-heating glow plugs



298215 1

Incandescent elements used to reach the conditions for triggering combustion when the engine is cold.



298214 2

1. Glow plug 1
2. Glow plug 2
3. Glow plug 3
4. Glow plug 4

The glow plug bridle connects the pre-heating glow plugs to the engine control unit.

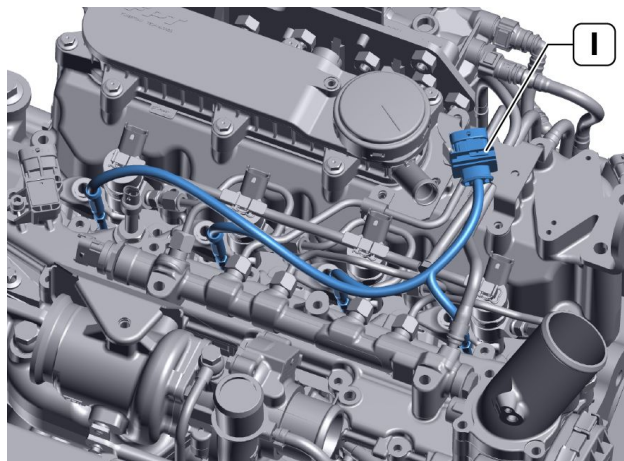
761915 PREHEATER PLUGS - Remove

Tool / Material

Socket wrench (8 mm) for removing and refitting glow plugs

SP2275

1. Remove the glow plug wiring (1).



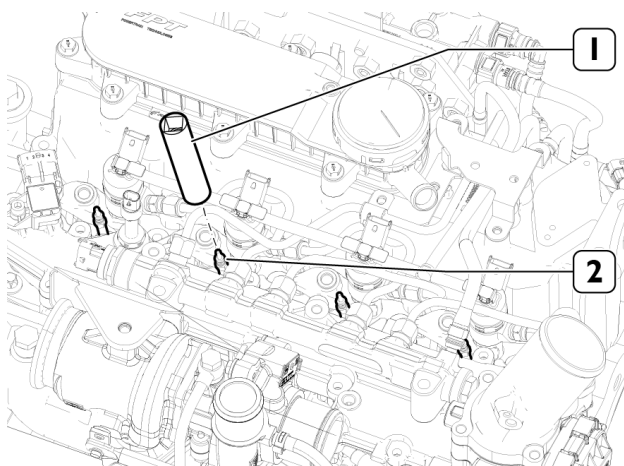
298207 1

2. Unscrew the glow plug (2) using the tool (1).

Tool / Material

Socket wrench (8 mm) for removing and refitting glow plugs

SP2275



298208 2

761915 PREHEATER PLUGS - Install

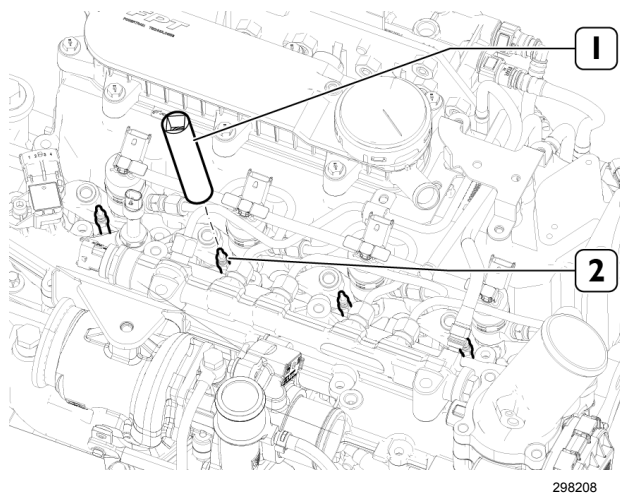
Description	Quantity	Value
Pre-heating glow plugs	4 glow plugs M8 x 1	9 +/- 1 N·m

Tool / Material	
Socket wrench (8 mm) for removing and refitting glow plugs	SP2275

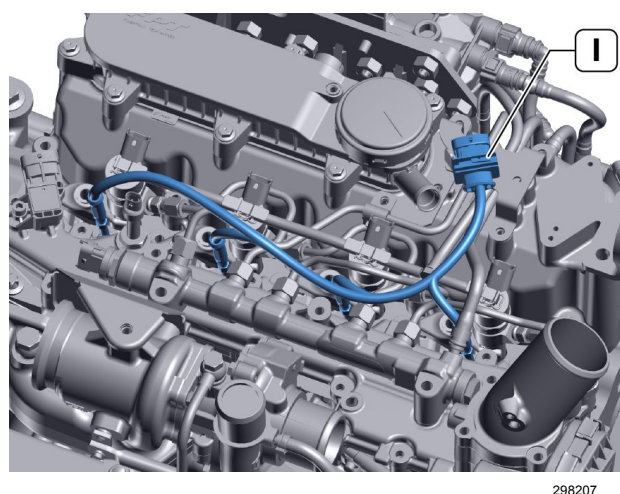
1. Tighten the glow plug (1) with the tool (2) to the specified torque.

Tool / Material	
Socket wrench (8 mm) for removing and refitting glow plugs	SP2275

Description	Quantity	Value
Pre-heating glow plugs	4 glow plugs M8 x 1	9 +/- 1 N·m

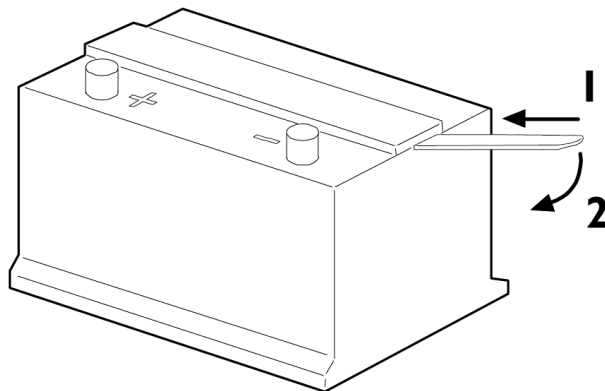


2. Install the glow plug wiring (1).



762010 BATTERY - Check - Battery check

1. Check that the battery terminals and cable clamps are clean, well tightened and protected by Vaseline.
2. In the event of cable terminals and battery terminals are dirty, proceed as indicated below.
3. Loosen the nut and remove the terminal from the negative terminal (marked with a "-").
4. Loosen the nut and remove the terminal from the positive terminal (marked with a "+").
5. Use a metal brush or fine grade sand paper to clean the cable terminals and the battery terminals until they are shiny.
6. Smear the cable terminals with Vaseline and insert them onto the battery terminals making sure that the positive pole is connected first, followed by the negative pole, and then tighten each terminal.
7. Check the level of wear and corrosion of the cables and terminals; if deteriorated, replace them.
8. Visually check the condition of the batteries: the terminals must not be deteriorated and the body must not be damaged, and in that case proceed with replacement.



198322 1

764251 ENGINE OIL PRESSURE GAUGE SENDER - Overview

Engine oil low pressure valve

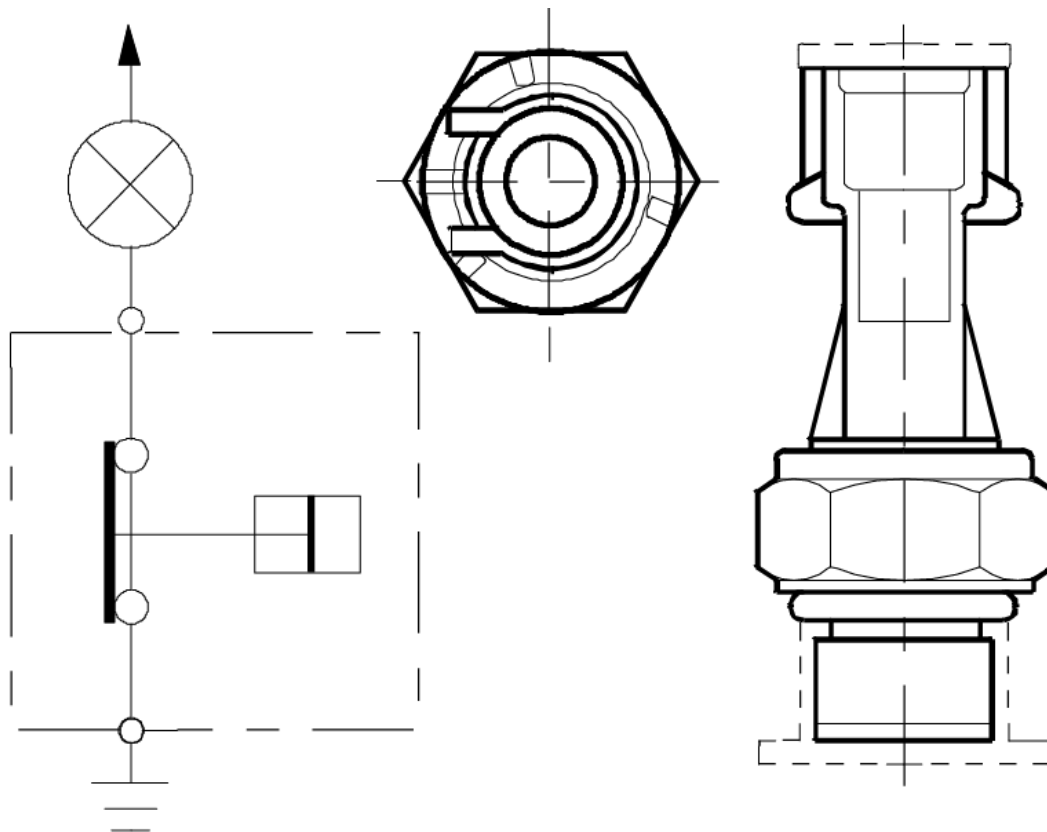
It is fit on the oil filter mount.

It only measures the engine oil pressure.

It is powered at **5 V**.

The signal detected is transmitted to the engine control unit, which in turn controls the indicator on the instrument panel (oil low pressure warning light and indicator).

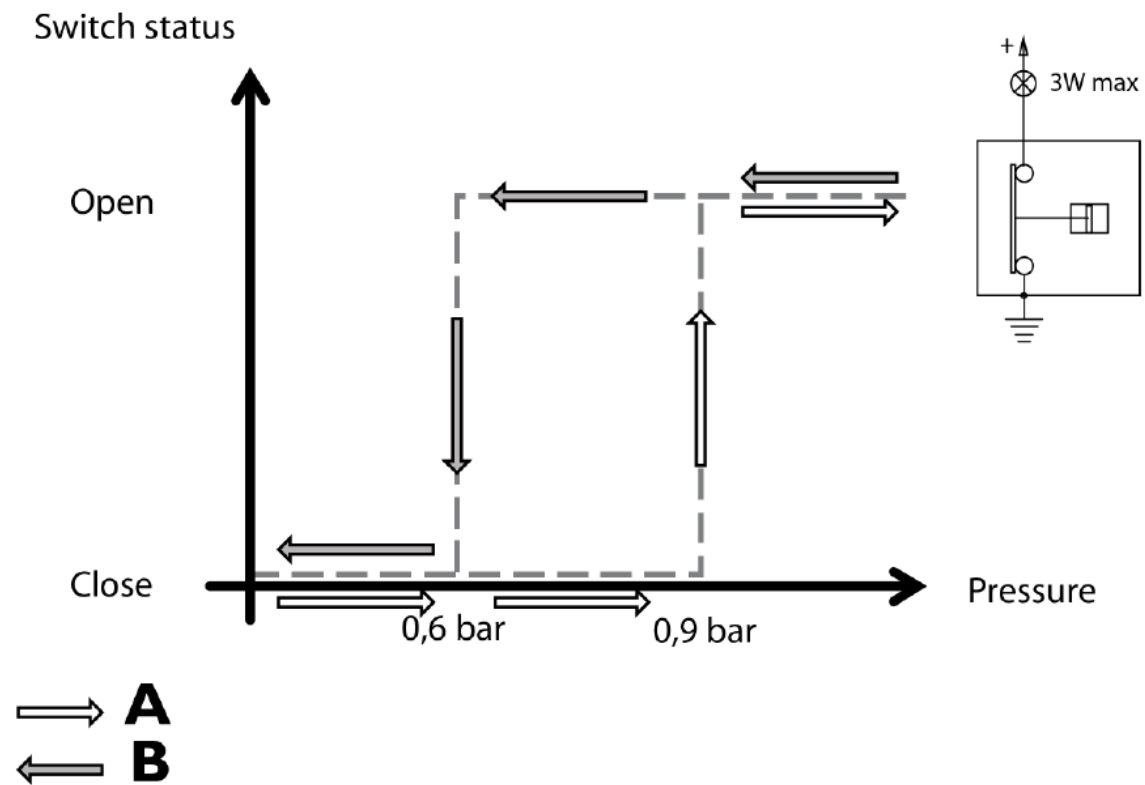
The engine oil temperature is not detected by a sensor and therefore is not used by the Engine Control Unit.



75722 1

Pin - Out

Ref.	Description
1	Pressure signal



250583 2

- A. Path followed by the valve switch when the pressure increases from **0 bar** to $P \geq 1$.
- B. Path followed by the valve switch when the pressure decreases from $P \geq 1$ to **0 bar**.

764254 ENGINE WATER TEMPERATURE SENDER - Overview

Coolant temperature sensor

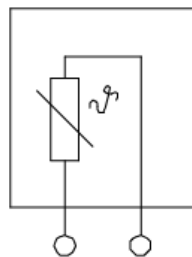
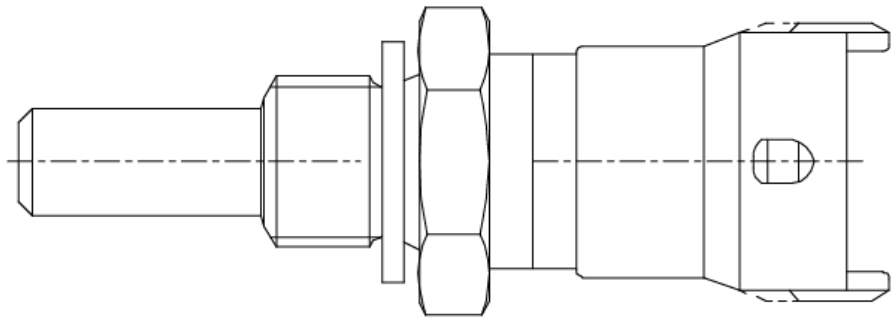
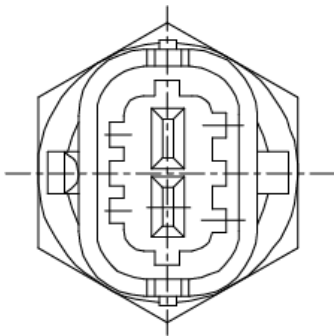
It is an N.T.C. sensor and is positioned near the water outlet manifold from the head on the thermostat casing from the right side of the engine. It determines the coolant temperature for the various control logics of operation of the engine when hot or cold and identifies the need to enrich the mixture when the engine is cold or reduce fuel injection when it is hot.

Its resistance is:

Resistance	
Conditions: Temperature 20 °C	2,50 kΩ

Sensor pin-out

Pin	DeFromCablescription
1	Signal
2	Ground



195652 1

764263 REV.COUNTER SENDER - Overview

Crankshaft speed sensor (incremental speed)

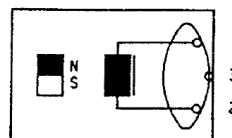
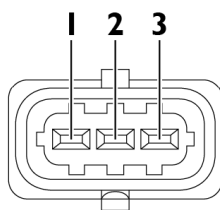
It is an inductive sensor. It generates signals obtained from changes in magnetic flux created by spaces between the teeth on the phonic wheel fitted to the crankshaft.

The sensor resistance value is:

Technical data	
Resistance	= 900 Ω

Sensor pin-out

Ref.	Description
1	Signal
2	Signal
3	Shield



231925 1

764264 TIMING GEAR SPEED SENDER - Overview

Camshaft timing sensor (segmental speed)

It is an inductive sensor. It generates signals obtained from magnetic flux lines which close through the holes situated in gears force fit on the camshaft. The signal this sensor generates is used by the electronic control unit as an injector timing signal.

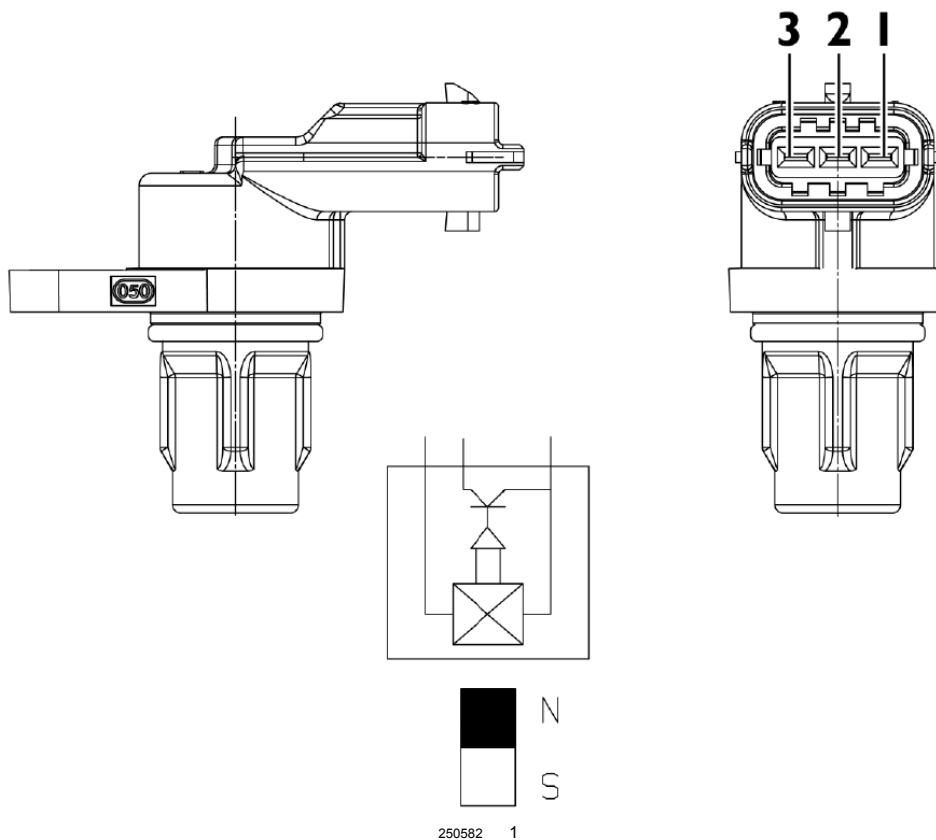
Though it is similar to the engine speed sensor, it is NOT interchangeable as it has a different shape.

The sensor resistance value is:

Technical data	
Resistance	900 Ω

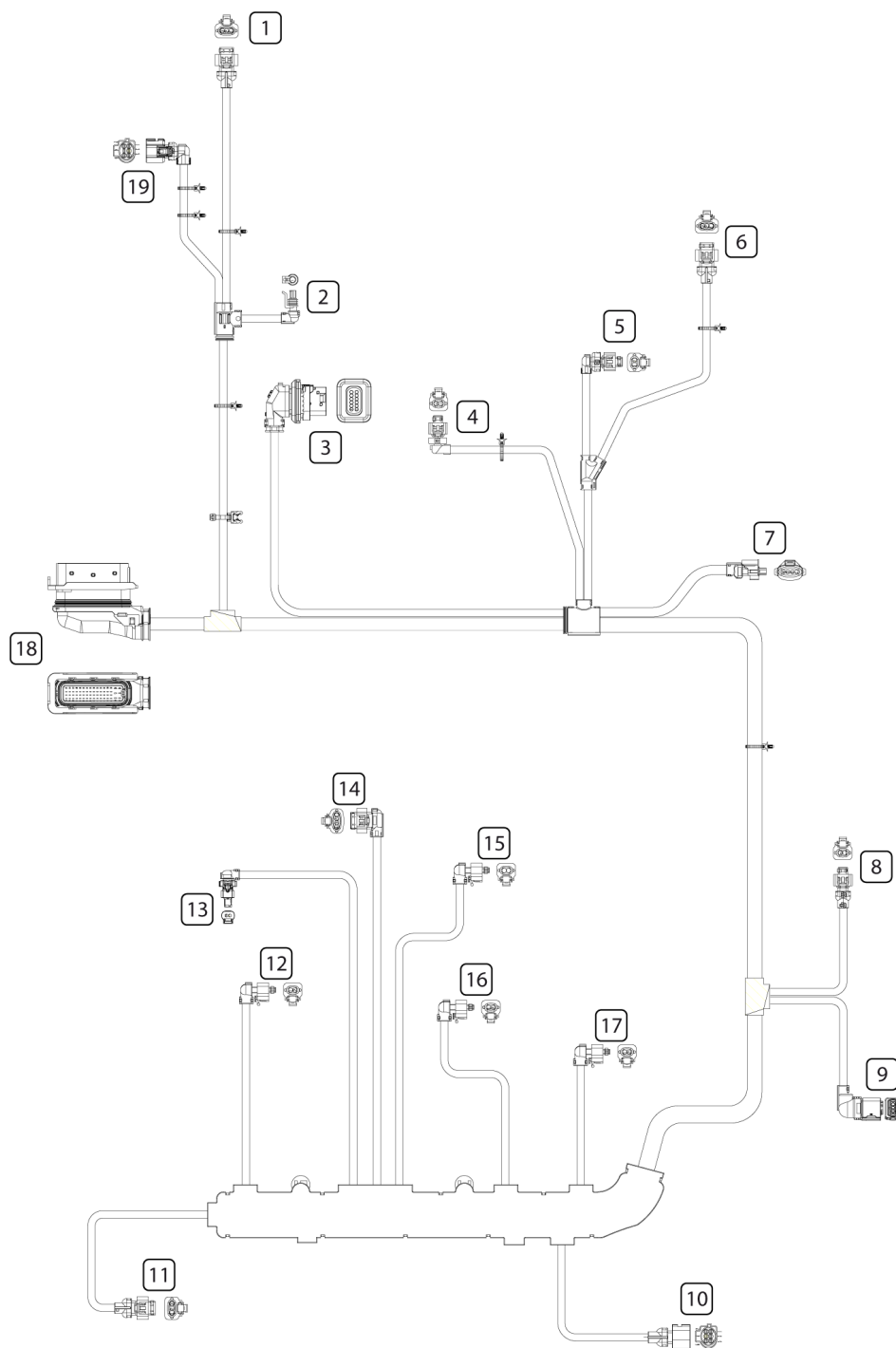
Sensor pin-out

Ref.	Description
1	Ground
2	Signal
3	Feeding



769140 ENGINE CABLES - Overview

Cable on engine



298667 1

1. Crankshaft speed sensor (incremental speed)
2. Low oil pressure valve
3. Cylinder interconnection connector
4. Fuel temperature sensor
5. High pressure fuel pump dosing unit
6. Camshaft timing sensor (segmental speed)

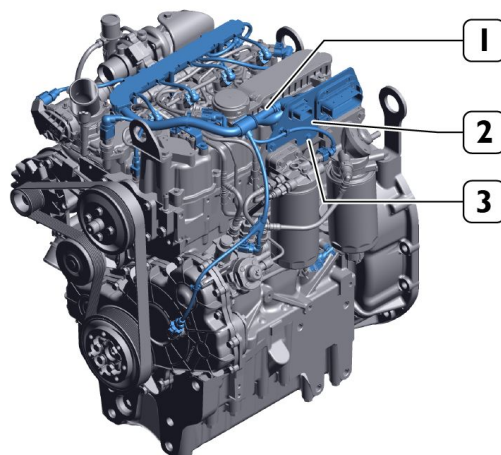
7. Heating glow plugs connector
8. Coolant temperature sensor
9. Exhaust gas absolute pressure sensor
10. Throttle valve sensor
11. Pressure sensor Common Rail
12. Cylinder 4 injector solenoid valve
13. Air temperature sensor
14. Supercharging pressure and air temperature sensor
15. Cylinder 3 injector solenoid valve
16. Cylinder 2 injector solenoid valve
17. Cylinder 1 injector solenoid valve
18. Vehicle wiring connector
19. Valve EGR Pieburg

769140 ENGINE CABLES - Remove

1. Disconnect the engine cable **(1)** from the control unit, from the electro-injectors and from all the sensors and transmitters to which it is connected.

NOTE: Suitably cover all the connectors to prevent oxidation or any damage.

2. To ease the removal, loosen the screws **(2)** from the fixing bracket **(3)** of the engine wiring.
3. Remove the clips fastening the engine cable **(1)** and remove the cable.



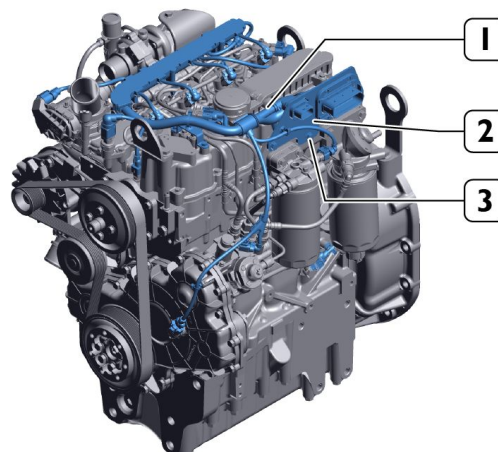
298665 1

769140 ENGINE CABLES - Install

Description	Quantity	Value
Engine cable fixing bracket	3 screws M8 x 1.25 x 20	23 +/- 2.3 N·m

1. Position correctly the engine cable **(1)** and secure all mounts of the engine cable. Connect the engine cable to the control unit and to all sensors and senders shown in the figure
2. Tighten the screws **(2)** of the engine wiring fixing bracket **(3)** to the specified torque.

Description	Quantity	Value
Engine cable fixing bracket	3 screws M8 x 1.25 x 20	23 +/- 2.3 N·m



298665 1

ELECTRICAL COMPONENTS - 76

760310	ALTERNATOR ASSEMBLY - Install	6
760310	ALTERNATOR ASSEMBLY - Overview	3
760310	ALTERNATOR ASSEMBLY - Remove	5
760310	ALTERNATOR ASSEMBLY - Visual inspection	7
762010	BATTERY - Check - Battery check	11
769140	ENGINE CABLES - Install	20
769140	ENGINE CABLES - Overview	17
769140	ENGINE CABLES - Remove	19
764251	ENGINE OIL PRESSURE GAUGE SENDER - Overview	12
764254	ENGINE WATER TEMPERATURE SENDER - Overview	14
761915	PREHEATER PLUGS - Install	10
761915	PREHEATER PLUGS - Overview	8
761915	PREHEATER PLUGS - Remove	9
764263	REV.COUNTER SENDER - Overview	15
764264	TIMING GEAR SPEED SENDER - Overview	16

SPECIAL TOOL INDEX

Genuine	Reference	PAGE
99322205 [Assemblies overhaul revolving stand (bearing capacity 1000 daN, torque 120 daNm)]	ENGINE - Disassemble	54.1 / 29
	ENGINE - Assemble	54.1 / 72
99340055 [Tool to remove crankshaft front gasket]	ENGINE - Disassemble	54.1 / 39
	CRANKSHAFT FRONT GASKET - Remove	54.2 / 84
99346259 [Crankshaft rear seal installer]	ENGINE - Assemble	54.1 / 51
	CRANKSHAFT REAR GASKET - Install	54.2 / 87
99346270 [Key for crankshaft front gasket installation and timing cover centering]	ENGINE - Assemble	54.1 / 55
	CRANKSHAFT FRONT GASKET - Install	54.2 / 85
99360076 [Remover, cartridge filter]	ENGINE - Disassemble	54.1 / 32
	ENGINE - Assemble	54.1 / 63
	FILTER ASSEMBLY - Replace	54.7 / 167
	FILTER ASSEMBLY - Remove	54.7 / 168
	FILTER SUPPORT - Remove	54.7 / 170
	ENGINE OIL FILTER CARTRIDGE - Replace	54.9 / 194
	ENGINE OIL FILTER CARTRIDGE - Remove	54.9 / 195
	ENGINE OIL FILTER CARTRIDGE - Install	54.9 / 196
	FUEL PRE-FILTER - Remove	77.3 / 14
	FUEL PRE-FILTER - Replace	77.3 / 17
99360268 [Engine valves remover/installer]	VALVES - Disassemble	54.3 / 101
	VALVES - Assemble	54.3 / 103
99360362 [Camshaft bush assembly and disassembly punch (use with 99370006)]	BUSHES - Replace	54.6 / 154
99360500 [Crankshaft lifting tackle]	ENGINE - Disassemble	54.1 / 44
	CRANKSHAFT - Disassemble	54.5 / 120
	CRANKSHAFT - Assemble	54.5 / 123
99360612 [Engine TDC positioning tool]	ENGINE - Assemble	54.1 / 48
	WEIGHT FASTENING SCREWS - Install	54.5 / 129
99361026 [Brackets fixing engine to revolving stand 99322205]	ENGINE - Disassemble	54.1 / 28
	ENGINE - Assemble	54.1 / 72
99363204 [Tool for removing gaskets]	ENGINE - Disassemble	54.1 / 40
	CRANKSHAFT FRONT GASKET - Remove	54.2 / 84
99370006 [Handle, interchangeable driver]	BUSHES - Replace	54.6 / 154
99370415 [Base, dial gauge, countershaft bearing adjustment (use with 99395604)]	VALVE SEAT - Replace	54.3 / 99
	PISTON - Check	54.5 / 146
99395603 [Dial gauge (0-5mm)]	VALVE SEAT - Replace	54.3 / 99
	PISTON - Check	54.5 / 146
SP2275 [Socket wrench (8 mm) for removing and refitting glow plugs]	ENGINE - Disassemble	54.1 / 37
	ENGINE - Assemble	54.1 / 61
	PREHEATER PLUGS - Remove	76.2 / 9
	PREHEATER PLUGS - Install	76.2 / 10