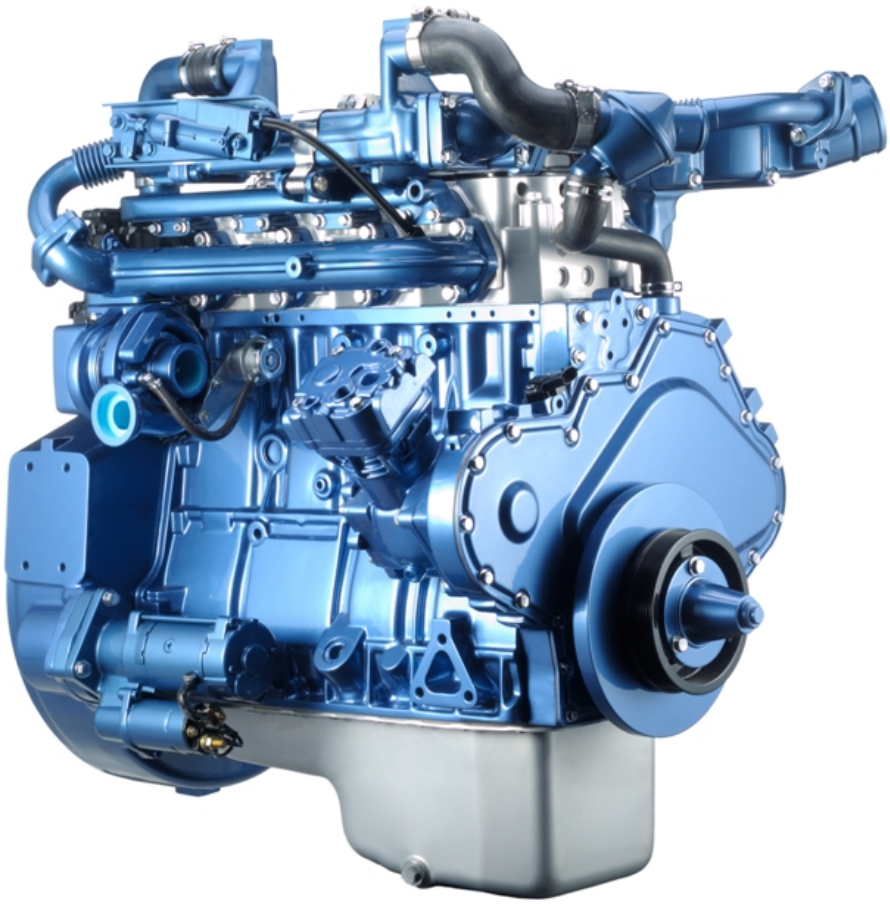
MWM INTERNATIONAL®
A NAVISTAR COMPANY

Workshop Manual



MAXXFORCE 4.8
INTERNATIONAL DIESEL POWER™

MAXXFORCE 7.2
INTERNATIONAL DIESEL POWER™

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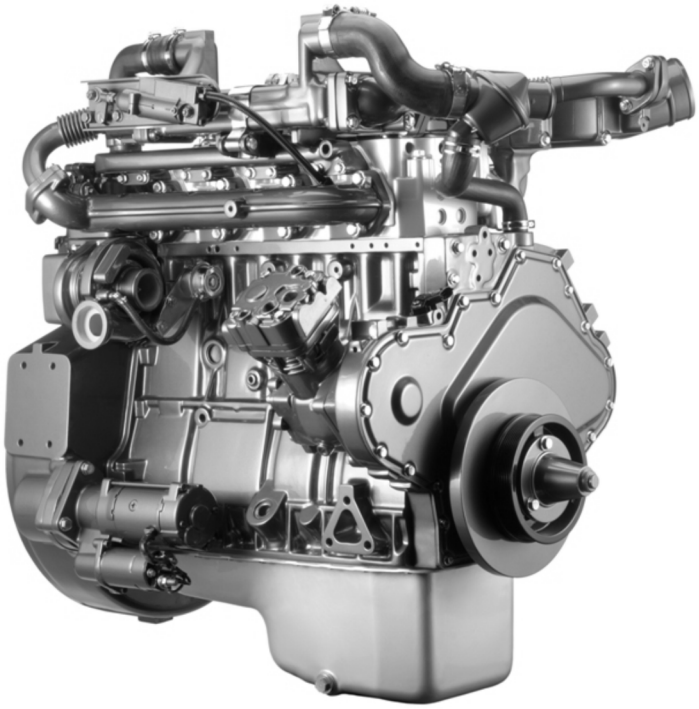

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Presentation

Introduction

This manual contains complete information and specification to assembly and disassembly MAXXFORCE 4.8/7.2 engines and all components manufactured by **MWM INTERNATIONAL Motores Diesel Ltda**.

Read and follow all safety instructions. Consult the item ATTENTION in the Safety General Instructions, in the next section.

The repairing procedures, described in this manual, consider that the engine is positioned on an appropriate stand.

Some of the assembly and disassembly procedures require special tools.

Make sure that the correct tools are used according indicated in the procedures.

The assembly and disassembly specifications and information presented in this manual are the ones which is effective in the moment of its print. **MWM INTERNATIONAL Motores Diesel Ltda**. reserves the right of making any change, at any moment. **MWM INTERNATIONAL Motores Diesel Ltda**. reserves the right of doing changes in the product at any moment without this to incur in any further obligation. In case of any difference in the engine or information of this manual, contact an MIM Authorized Distributor or the factory.

The components used in MIM engines production are produced with last generation technology components and with high level quality standards. When parts changes are necessary, it is recommended to use only MIM genuine spare parts. These parts can be identified by the following marks.

How to Use this Manual

To create this Manual it has been taken as base a generic MAXXFORCE 4.8/7.2 engine, which operations and maintenance procedures are the same for all models of this series. The illustrations therefore, could differ from application to application.

In this Manual, all references to the components of the engine are divided in 17 specific sections. For your convenience, the organization of the Manual is consistent with MIM Service Bulletins.

Content of the Manual

The Manual contains an index that can be used as a quick reference to access each section.

Content of the Sections

Each section contains the following information:

- Page of index in the beginning of each section to help for the fast location of the desired information.
- General information about the operation of the component and the explanation of their main changes.
- Component disassembly, cleaning, inspection and dimension instructions.

Remissive Index

In the end of the manual there is a remissive index to help the location of specific information.

Information on Metric System

All dimensions are expressed in the International Metric System (I.S.).

Important Safety Remarks

Attention: Incorrect procedures and lack of care can cause burns, cuts, mutilation, asphyxia or otherin-juries and even death.

Carefully read all safety procedures and remarks before performing any repair in the engine. The following list presents the general cautions that must be followed to guarantee your personal safety. Special safety measures can be presented with the procedures, if necessary.

- Make sure that the work area around the engine is dry, well lightened, ventilated, organized; without tools and loosened parts, ignition sources and dangerous substances. Check for dangerous conditions can happen and avoid them.
- Always use individual protection equipments (safety eyeglasses, gloves, shoes, etc.) while you are working.
- Remember that parts in movement can cause cuts, mutilation and strangling.
- Do not use loosen or ripped clothes. Remove jewellery and watches before working.
- Disconnect the battery (negative cable first) and discharge the capacitors before beginning the repairs.
- In case the repair is being made in the vehicle, disconnect the starter motor to avoid an accidental start of the engine. In case of industrial engines, place a “Do Not Operate” warning in the operator compartment or on the controls.
- To manually rotate the engine, use ONLY the recommended procedures. Never try to rotate the crankshaft with the fan. This practice can cause serious personal injuries or damages to the fan blades, causing the premature failure of the component.
- If the engine was in operation and the cooling fluid is hot, leave the engine to cold down before slowly open the cover of the reservoir to relief the pressure of the cooling system.
- Do not work with materials that are lifted by jacks or cranes.

  Always use correct blocks, stands or brackets to position the engine before performing any repair.

  Relief the pressure of the pneumatic (brakes), lubrication and cooling systems before removing or disconnect any piping, connections or other elements. Pay attention to the pressure existence before to disconnect any item of a pressurized system. Do not check pressure leakages with the hand. Oil or fuel at high pressure can cause injuries.
- To avoid injuries, use a crane, or ask for help to lift components which weight more than 20 kg. Make sure that all lift equipments as chains, hooks or belts are in good conditions and have the correct load capacity. Make sure that hooks are correctly positioned. Always use an extension when necessary. The lift hooks must not receive side loads.
- Never leave the engine operating in a closed and non ventilated area. The engine exhaust gases are harmful to health.
- The MWM coolant has alkaline substances. Avoid the contact with the eyes. Avoid the prolonged or repetitive contact with the skin. Do not ingest. In case of contact with the skin, wash immediately with water and soap. In case of contact with the eyes, abundantly wash with water for, at least 15 minutes. CALL MEDICAL HELP IMMEDIATELY. KEEP AWAY FROM THE REACH OF THE CHILDREN AND ANIMALS.

- Cleaning solutions and solvents are inflammable materials that **must** be handled with a lot of care. Follow the manufacturer instructions to use these products. KEEP AWAY FROM THE REACH OF CHILDREN AND ANIMALS.
- To avoid burns, pay attention to hot spots on engines that have just been stopped and to hot piping and compartments.
- **Always** use tools in good conditions. Make sure that you know how to handle the tools before beginning any repair. Use ONLY genuine MIM spare parts.
- Some international public health institutions prove that used lubricant oil can be cancerous and contaminates the human reproducer system. Avoid inhaling vapours, ingesting or keeping prolonged contact with these substances.
- People with pacemaker must avoid standing close to the engine electronic injection system.

General Instructions

This engine has been manufactured with the most advanced technology; nevertheless, it was designed to be repaired using regular techniques complemented by quality standards.

- Use good quality fuel, free of water and impurities.
- Use only recommended lubricant oil.
- In case of any irregularity seek for a dealer or authorized service of the vehicle / equipment manufacturer or MWM. Avoid that outsiders make any service in the engine, because this cancels the warranty.
- To use a parallel battery to start de engine, the amperages of both batteries must be the same to avoid tension peaks.The standard procedure is always first to connect the cable on the negative pole and later on the positive pole. Take care to do not invert the poles.
- The inadequate removal of the battery cables may cause the loss of data from ECM, erasing the saved errors from the last start of the engine. It can also cause tension peak, provoking ECM to break down.

Cleaning General Instructions

Cleaning with Acids and Solvents

Several solvents and acid substances can be used to clean the parts of the engine.

MWM INTERNATIONAL Motores Diesel Ltda. does not recommend any specific substance. Always follow the instructions of the manufacturer of the product.

Remove all gaskets, sealing rings, and with a brush of steel or rasper, the sludge deposits, carbon, etc., before placing the parts in the cleaning tank. Be careful to do not damage the surfaces of the sealing elements seats.

Flush all parts with hot water after cleaning. Completely dry them with compressed air. Remove water from screw holes and from lubrication inner grooves.

In case the parts are not to be used soon after the cleaning, dip them in an appropriate anti-oxidation compound. That compound must be removed of the parts before installation in the engine.

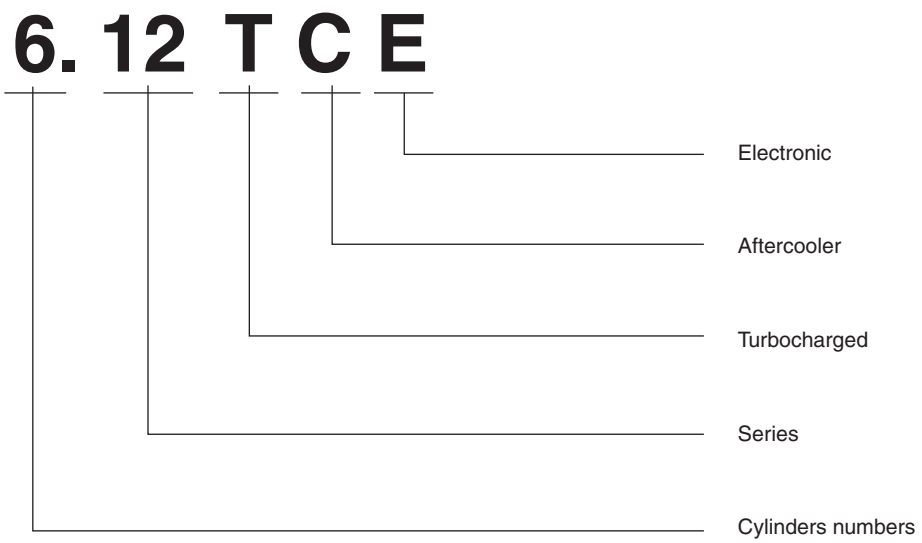
The following parts cannot be cleaned with vapour:

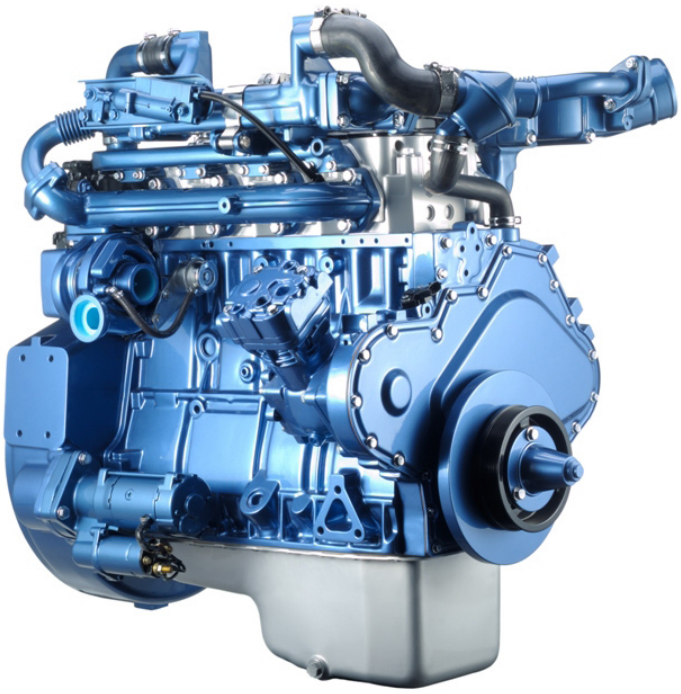
1. Electric and electronics components;
2. Electric harness;
3. Fuel injectors;
4. High pressure pump;
5. Belts, pipes and hoses;
6. Bearings.

Identification and Location of the Serial Number

The engine identification and serial number can be found in the following places:

1. Identification plate on the water pipe.
2. Engraving on the right side of the engine block, close to the cylinder head of the cylinder #3.

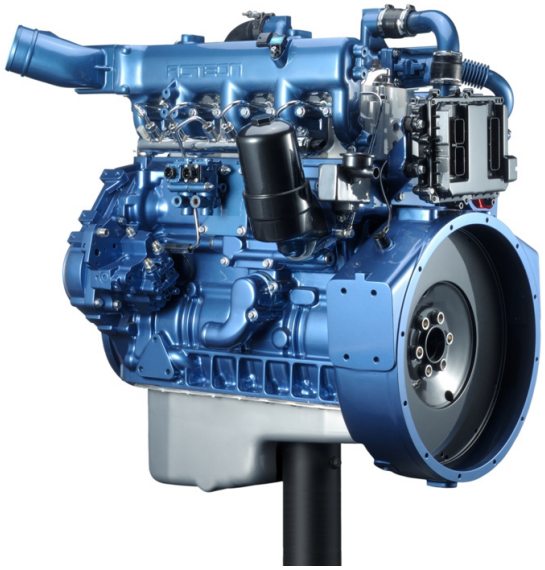




BIC 3387

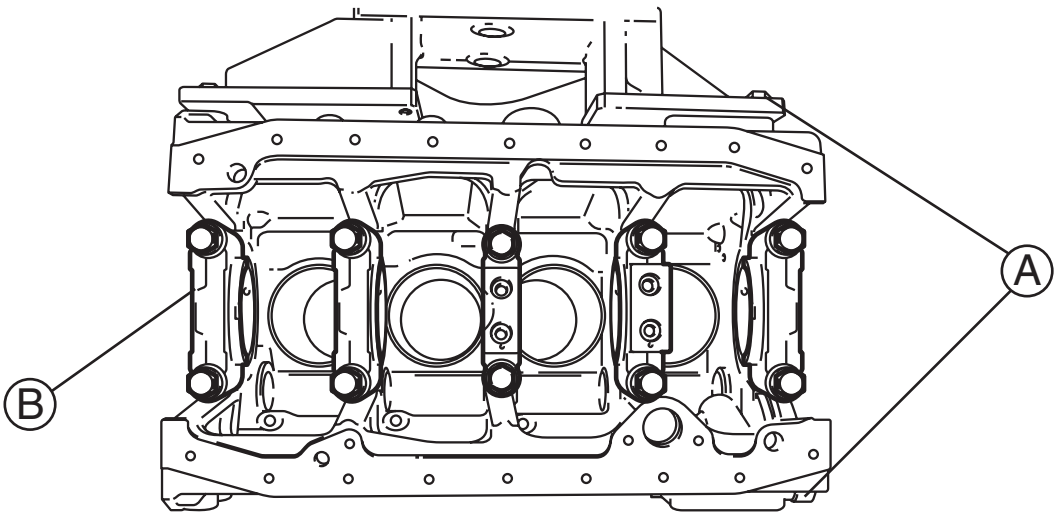
Cylinders Numeration

The cylinders order starts from the flywheel, according to the illustration below.



BIC 3399

During the assembly, check the numbers on the block (A) and on the bearings (B), which indicates the right assembly position.



Engine Identification

Engine serial number

The engine serial number is stamped in the right and rear side of the engine block. In the upper side, close to the cylinder head gasket.

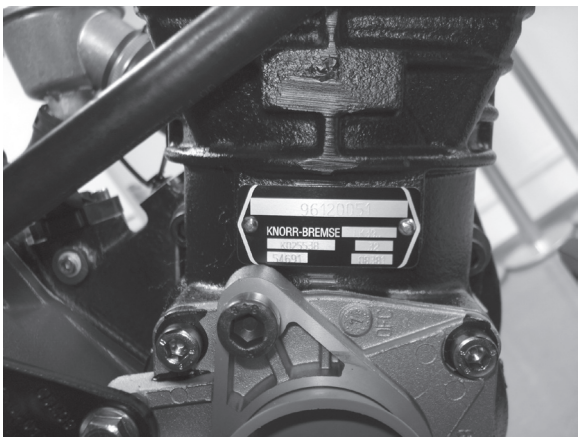
Engine Accessories

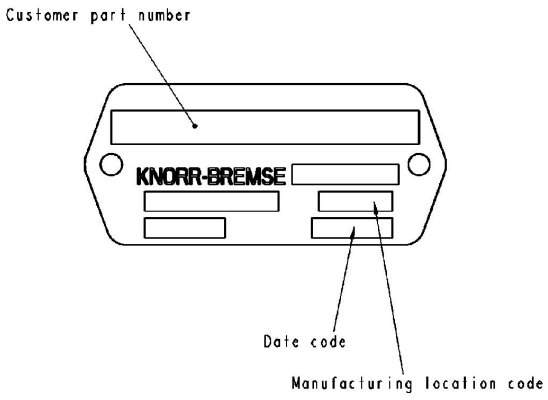
The following engine accessories have manufacturer's labels or identification plates:

- Air compressor (for brake or suspension system)
- Alternator
- Turbocharger
- Power steering pump
- Starter motor
- High Pressure Pump

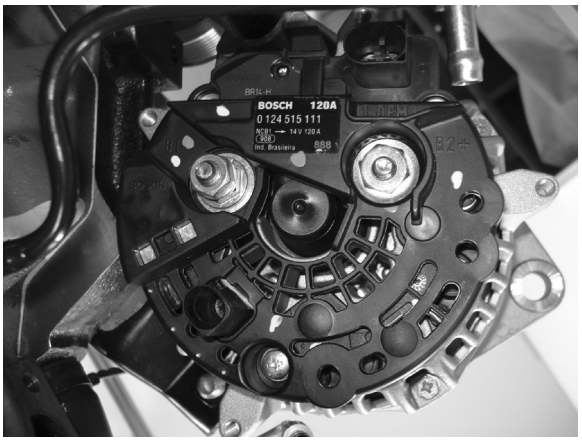
Labels or identification plates include information and specifications helpful to vehicle operators and technicians.

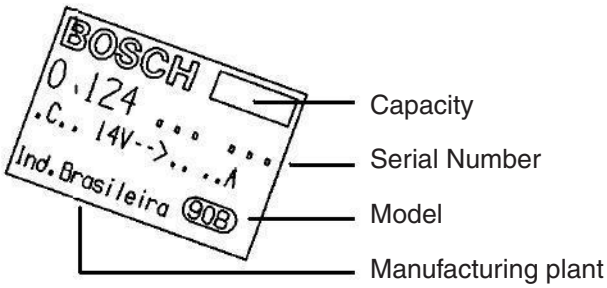
Air compressor



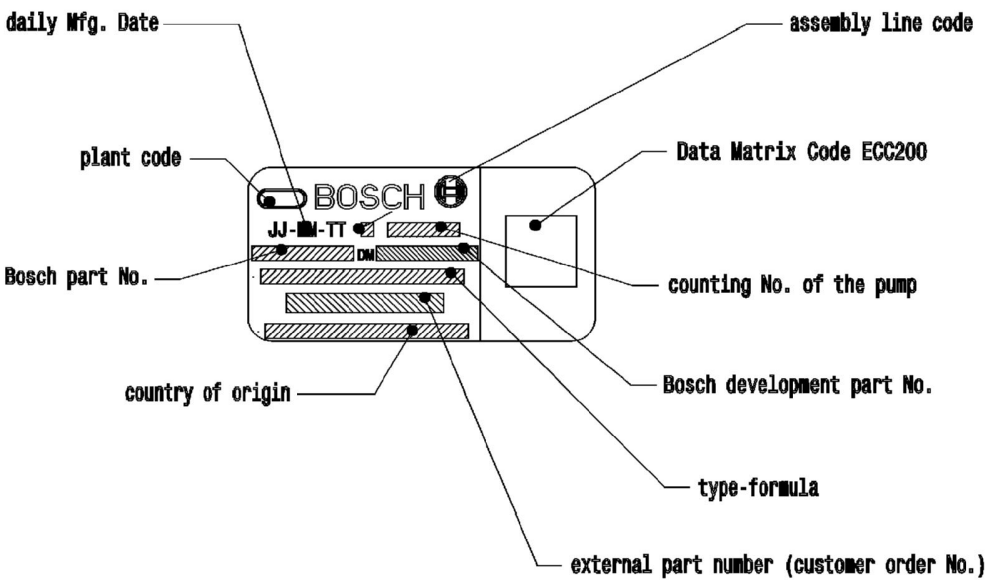


Alternator

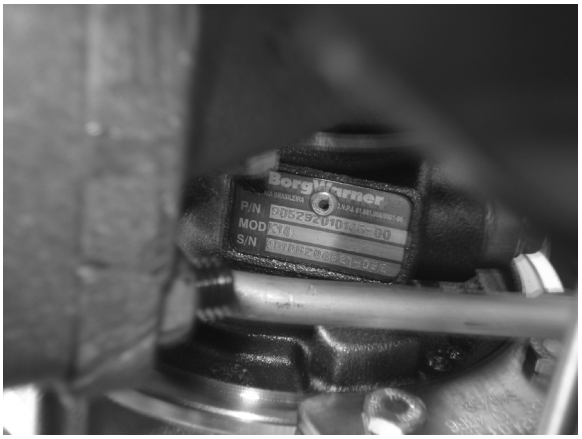




High pressure pump



Turbocharger



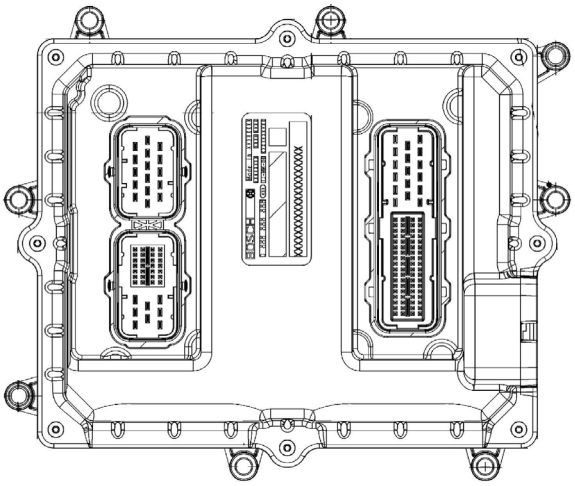
NAMEPLATE

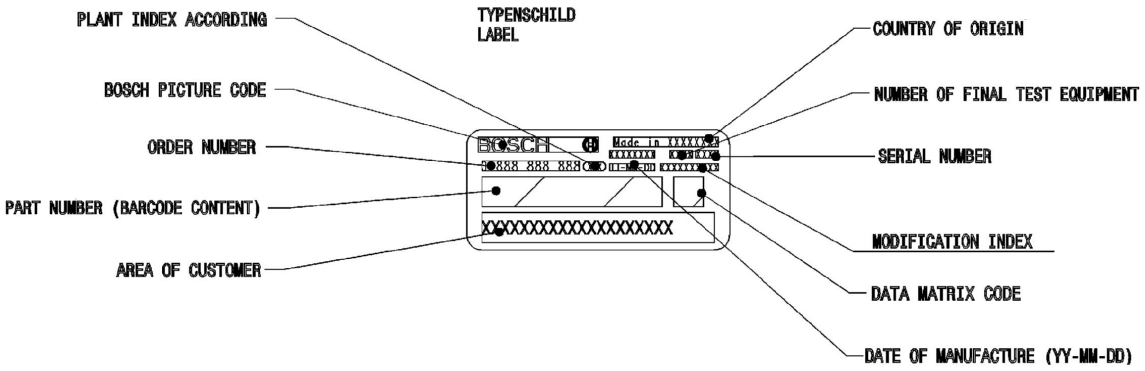
P/N	9.0529.20.1.0146-00
MOD	K14
S/N	53149700003

SERIAL No. CONSISTS OF:

0	01	M	00000	000
YEAR	MONTH	OEM	PRODUCTION ORDER	SEQUENTIAL No.

ECM – Electronic Control Module





Technical Data

Technical Data

Engine Data	4.8	7.2
Engine type	Vertical cylinders in line, 4 strokes	
Injection type	Direct with electronic management – Common Rail	
Cylinder bore	105 mm	
Cylinder stroke	137 mm	
Unit displacement	1,2 l	
Total displacement	4,745 litres	7,118 litres
Quantity of cylinders	4	6
Compression rate	16,8:1	
Firing order	1 - 3 - 4 - 2	1 - 5 - 3 - 6 - 2 - 4
Rotation sense	Counter clockwise (seen by flywheel side)	
Dry engine weight	441 kg (EGR)	551Kg (EGR)
Power @ 2200 rpm	185 CV 138 KW (EGR)	225 CV 165 KW (EGR)
Torque @ 1200 ~ 1500 rpm	680 N.m (69,3 (kgf.m)	861 N.m (87,7 (kgf.m)
Valves clearance (cold)	0,2 to 0,4 mm	
Emission	EURO IV / PROCONVE P6	
Admission system	Waster Gate Intercooler Cooled EGR	Waste Gate Intercooler Cooled EGR
Cylinder Head	Individual cylinder head with 4 valves per cylinder and “cross flow”	

Fuel System

Description	4 Cylinders	6 Cylinders
Maximum fuel inlet restriction (for gears pump)	0.6 to 1.2 bar	
Rail pressure	350 to 1800 bar	
Fuel pressure strip in the fuel filter outlet (at crank speed)	9.7 to 12.8 bar	
Strip of fuel pressure in fuel filter fuel inlet (at operation speed)	10,5 to 13 bar	
Maximum pressure reduction in fuel filter	≤0,8 bar	

Lubrication System

Description	4.8		7.2	
Oil pressure • Nominal speed • Idling speed	4.5 bar (hot engine) 1.0 bar (hot engine)			
Oil temperature • Nominal • Maximum	90 - 110 °C 120 °C			
Oil capacity • Minimum • Maximum (without filter) • Maximum (with filter)	5 ℓ 8 ℓ 9,2 ℓ	13 ℓ 17 ℓ 18,2 ℓ	17 ℓ 29 ℓ 30,2 ℓ	13 ℓ 17 ℓ 18,7 ℓ	23 ℓ 32 ℓ 33,7 ℓ
• Variation pressure of the filter to open by-pass	2,5 + 1,2 bar - 0,3 bar				

Cooling System

Description	4.8	7.2
Volume of water in the engine, without radiator	7 ℓ	9 ℓ
Water temperature • Nominal • Maximum	80 - 90 °C 100 °C	

Thermostat

17.210E OD Thermostat	Opening beginning	Total opening	Maximum opening course
9.229.0757.0046	75 ± 2°C	90°C	10.0 mm

Engine Description

Features

MAXXFORCE is in-line four or six cylinder engine (medium range). The engine displacements are 4.8 liters to MAXXFORCE 4.8 and 7.2 liters to MAXXFORCE 7.2.

The firing order of the cylinders is 1-4-3-2 to four cylinders and 1–5–3–6–2–4 for six cylinders.

The cylinder head has four valves per cylinder with cross flow for improved air flow. The head gasket is mated in metal-rubber and is individual for each cylinder head. The fuel Injector is centrally located between the four valves and directs fuel over the piston bowl for improved performance and reduced emissions. The overhead valve train includes mechanical roller lifters, push rods, rocker arms, and dual valves that open using a valve bridge.

To improve the components durabvility and engine performance this engine uses the hot and cold side concept for components location.

Hot side (right engine side)

- fuel system
- intake air manifold

Cold side (left engine side)

- Turbocharger system
- EGR system
- Air compressor
- Exhaust manifold

A one piece oil pan withstands high-pressure loads during diesel operation.

Manufactured in stamped steel, the oil pan has a compact size and light weight.

Five and seven main bearings support the crankshaft for MAXXFORCE 4.8 and MAXXFORCE 7.2 engines respectively. One insert bushing support the camshaft for each engine, the others supports it's already in the engine block. The rear oil seal carrier is part of the flywheel housing. The open oil pan breather assembly uses a road draft tube to vent oil pan pressure and an oil separator that returns oil to the oil pan.

The rotation sensor (crankshaft position sensor - CKP) and phase sensor (camshaft position sensor - CMP) are used by the ECM to calculate rpm, fuel timing, fuel quantity, and duration of fuel injection.

Manufactured with forged steel and new shape to improve its strength, the pistons are mated to fractured cap joint connecting rods. Replaceable rolled radius wet cylinder liners are used with the pistons.

The new model of the Flywheel viscous damper for the MAXXFORCE 7.2 engine has fins to assist in the refrigeration.

A lube oil pump, mounted on to the front of the engine block, is driven directly by the crankshaft. All engines use an enlarged oil cooler and ecological filter.

A low-pressure fuel supply pump draws fuel from the fuel tank through a fuel filter assembly that includes a strainer, filter element, primer pump, drain valves, and Water In Fuel (WIF) sensor. After filtering, fuel is pumped to the high pressure, then to the fuel rail and finally to the injectors.

The MWM INTERNATIONAL common rail high-pressure injection system includes a cast iron oil manifold, fuel injectors, and a high-pressure pump

The ECM sends pulse PWM signal to control an EGR valve that controls pneumatically an EGR flap from EGR cooler assembly regulating the cooled exhaust gases that ingress the inlet air stream. Cool exhaust gas increases engine tolerance for EGR, while reducing smoke formed by gas dilution in the mixture.

The new water pump was designed with seven vanes to increase the water flow.

The ECM is responsible to monitor and control the electronic engine systems:

The Water In Fuel (WIF) separation occurs when the filter element repels water molecules and water collects at the bottom of the element cavity in the fuel filter housing.

A Water In Fuel (WIF) sensor in the element cavity of the fuel filter housing detects water. When enough water accumulates in the element cavity, the WIF sensor sends a signal to the Electronic Control Module (ECM). A fuel drain valve handle onto the housing can be opened to drain water from the fuel filter housing.

Accessories Features

The air compressor is commonly used for air brakes, doors control or air suspension. A hydraulic power steering pump is assembled with the air compressor. In the MAXXFORCE 4.8L and 7.2L engines the both components are located in the hot side next to the powertrain.

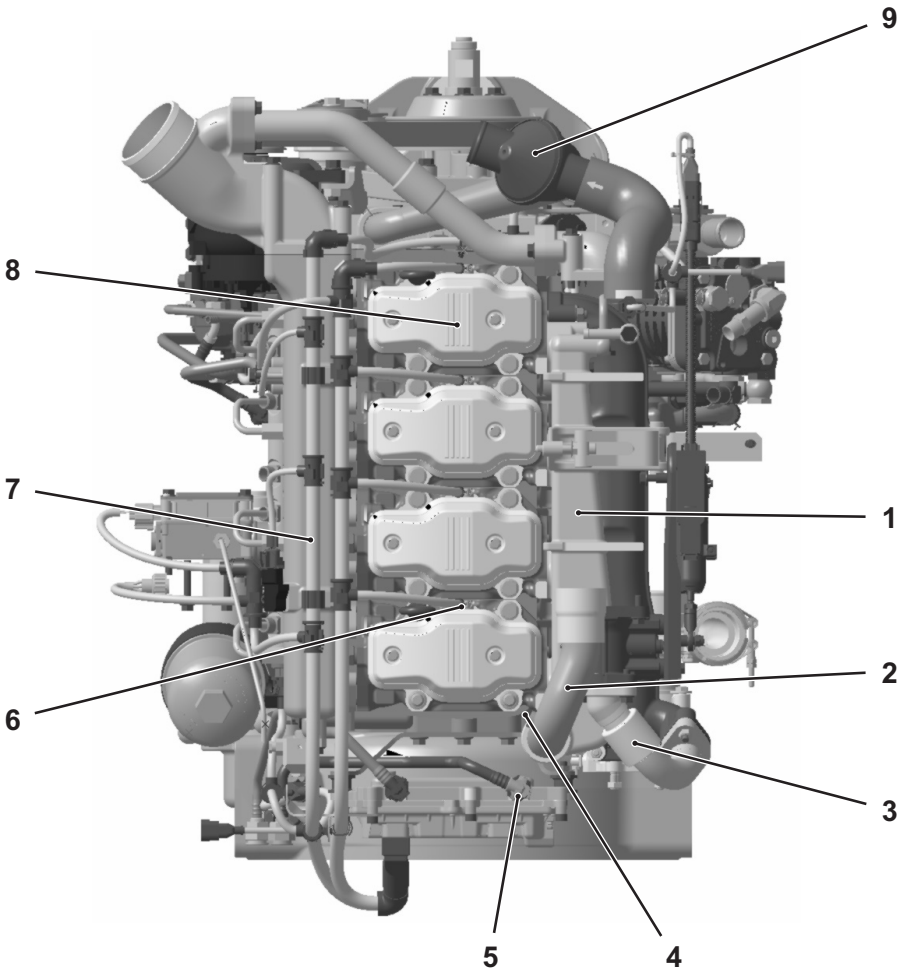
The alternator is used to charge the battery and to power a vehicle system when its engine is running, driven by the pulley system and the belt accessories. It's located in the cold side in the front of the block on the upper position.

The starter motor is an electric motor that initiates rotational motion in an internal combustion engine before it can power itself. On the MAXXFORCE engines it's located in the cold side, next to the Flywheel.

The high pressure pump from 3rd generation supplies the injectors with fuel in high pressure. The maximum pressure rate is 1800 bar. It's located on the cold side next to the powertrain

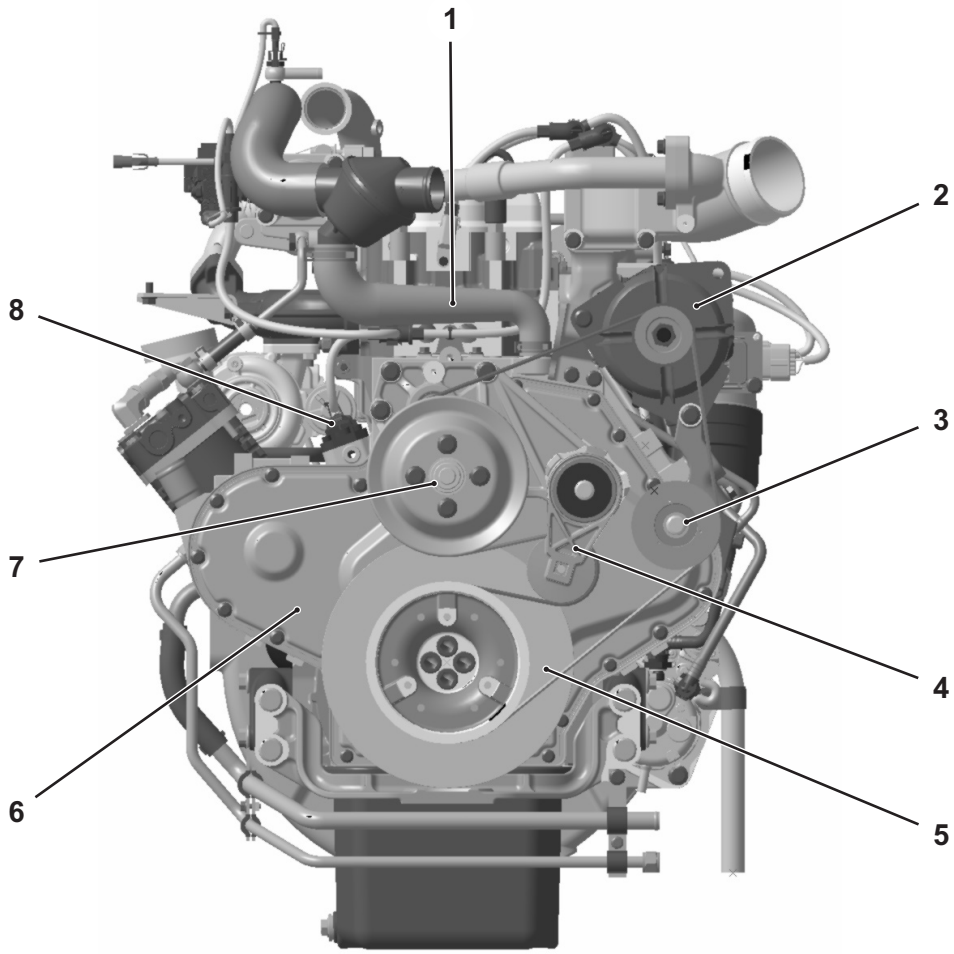
The Wastegate Turbocharger Borg Warner K14 Series is an air compressor used for forced-induction of an internal combustion engine. The purpose of a turbocharger is to increase the air mass entering the engine to create more power. In the MAXXFORCE engines it's located on the hot side, next to the Flywheel in the upper position.

Engine Component Locations



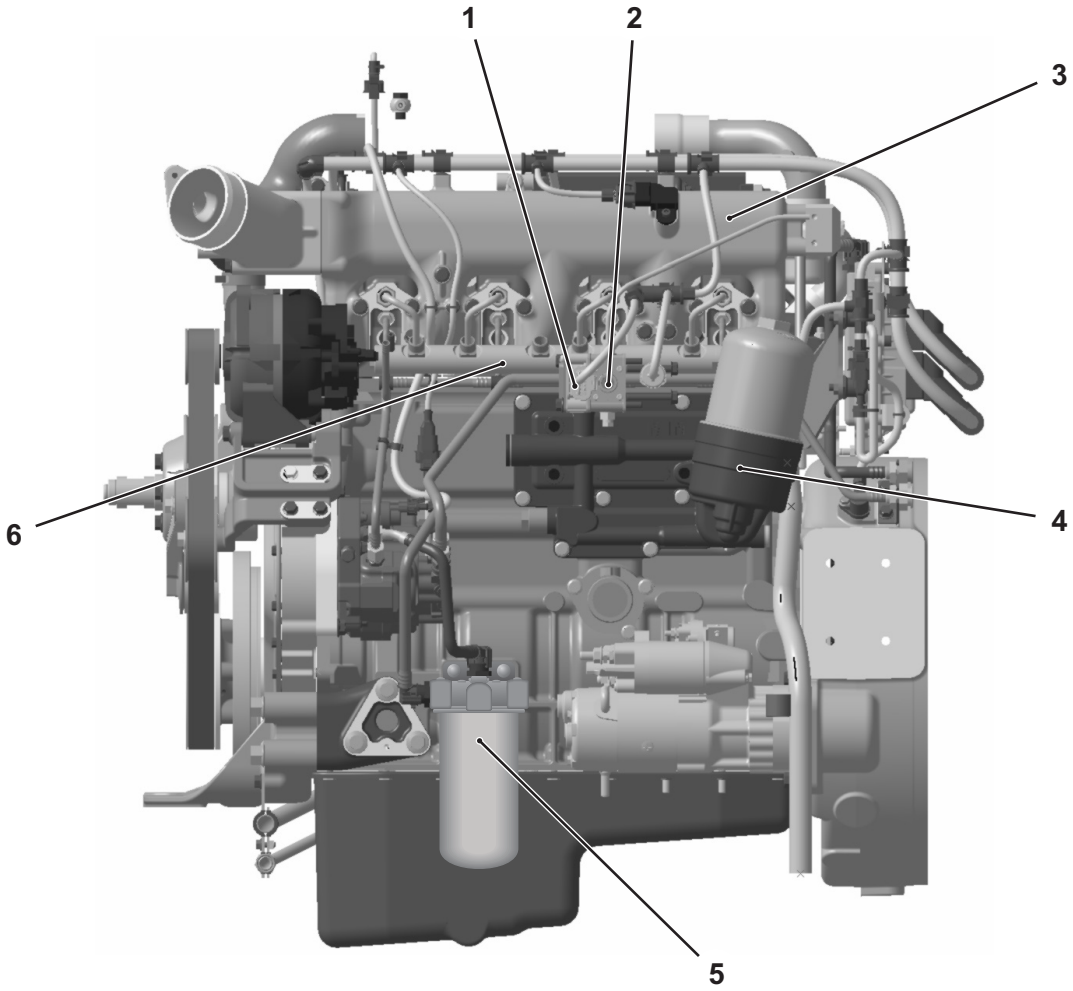
TOP VIEW

1. EGR cooler
2. EGR cooler water pipe
3. EGR air mixer duct
4. Coolant temperature sensor (ECT)
5. ECM cooler inlet pipe
6. Fuel injector connector
7. Main wiring harness
8. Valve cover
9. Thermostatic valve housing



FRONT VIEW

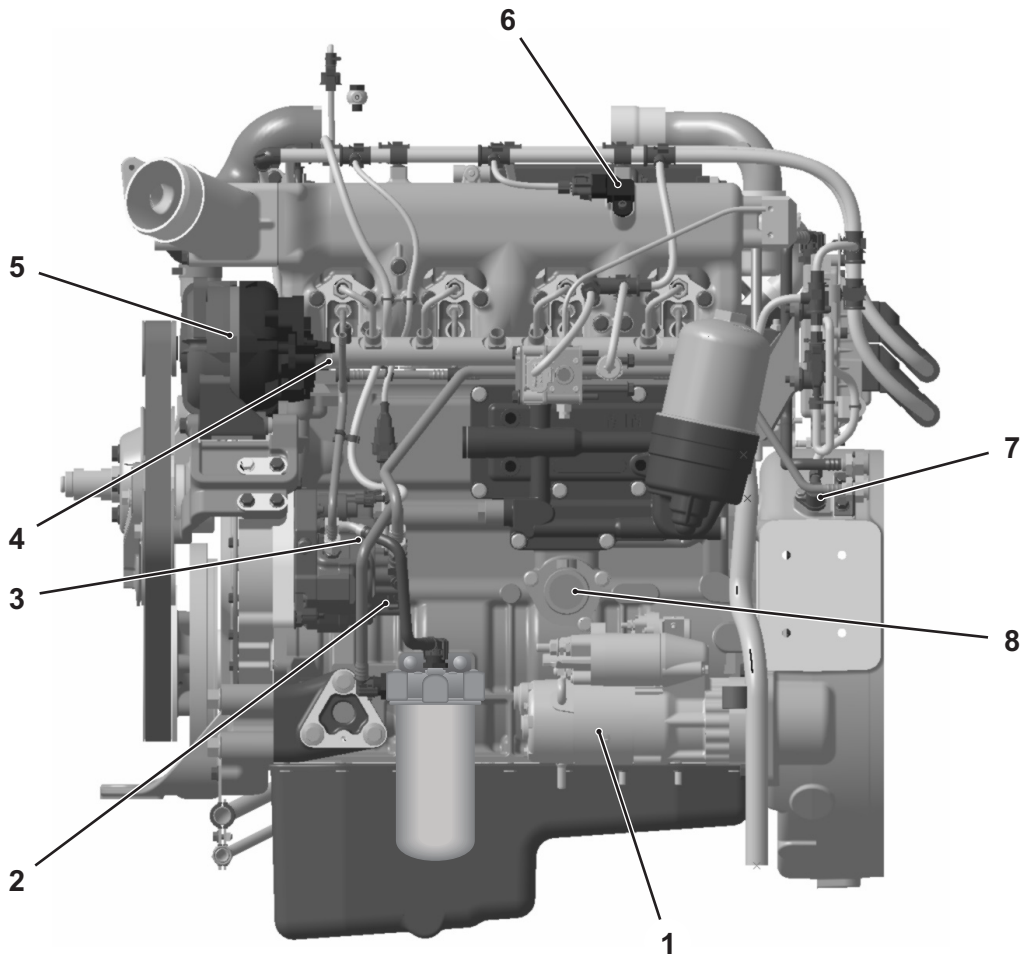
1. Water inlet tube assembly thermostat outlet
2. Alternator
3. Pulley
4. Tightener
5. Vibration damper
6. Front cover
7. Fan drive pulley
8. Pressure and temperature oil sensor (EOPT)



LEFT VIEW (COLD SIDE)

MECHANICAL COMPONENTS

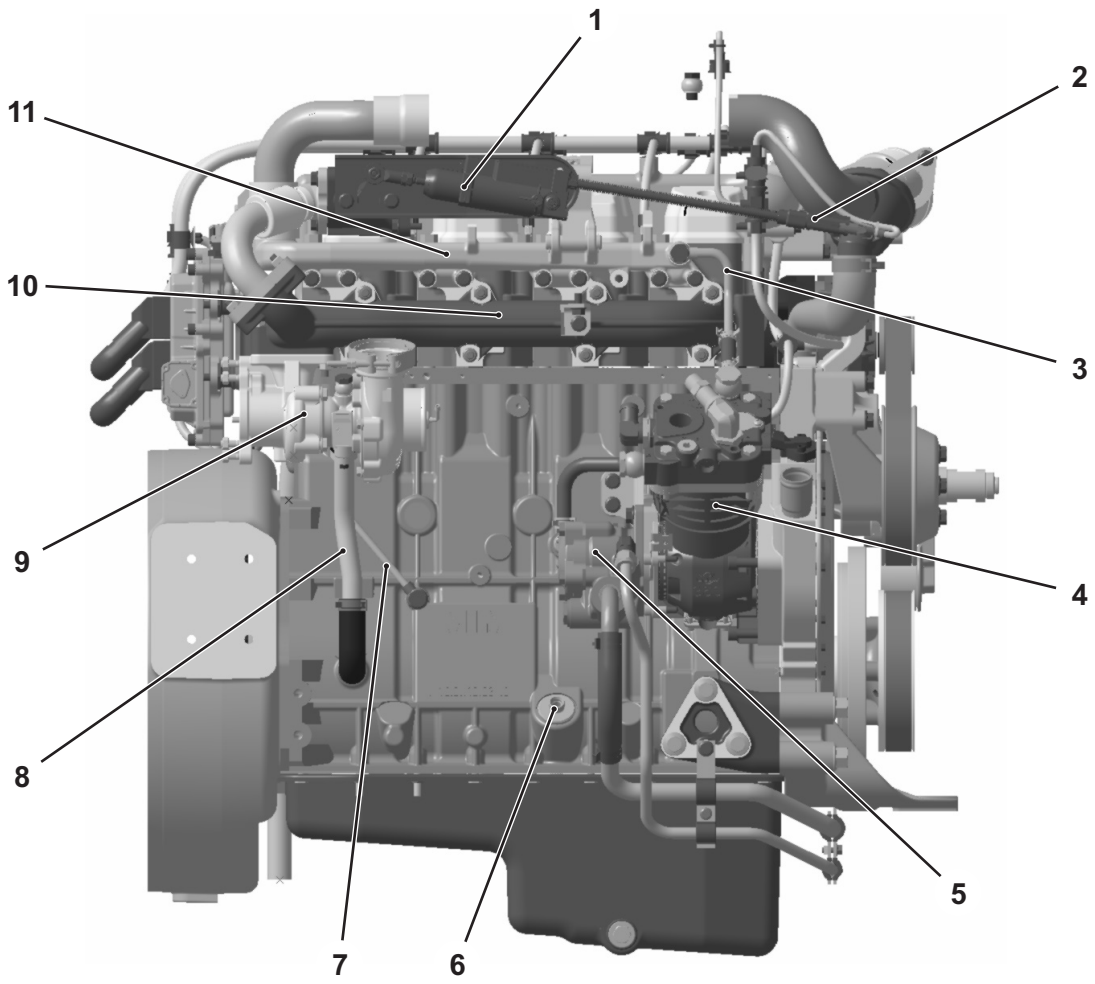
1. Turbo control valve
2. EGR control valve
3. Intake manifold
4. Oil cooler assembly
5. Oil filter
6. Fuel rail



LEFT VIEW (COLD SIDE)

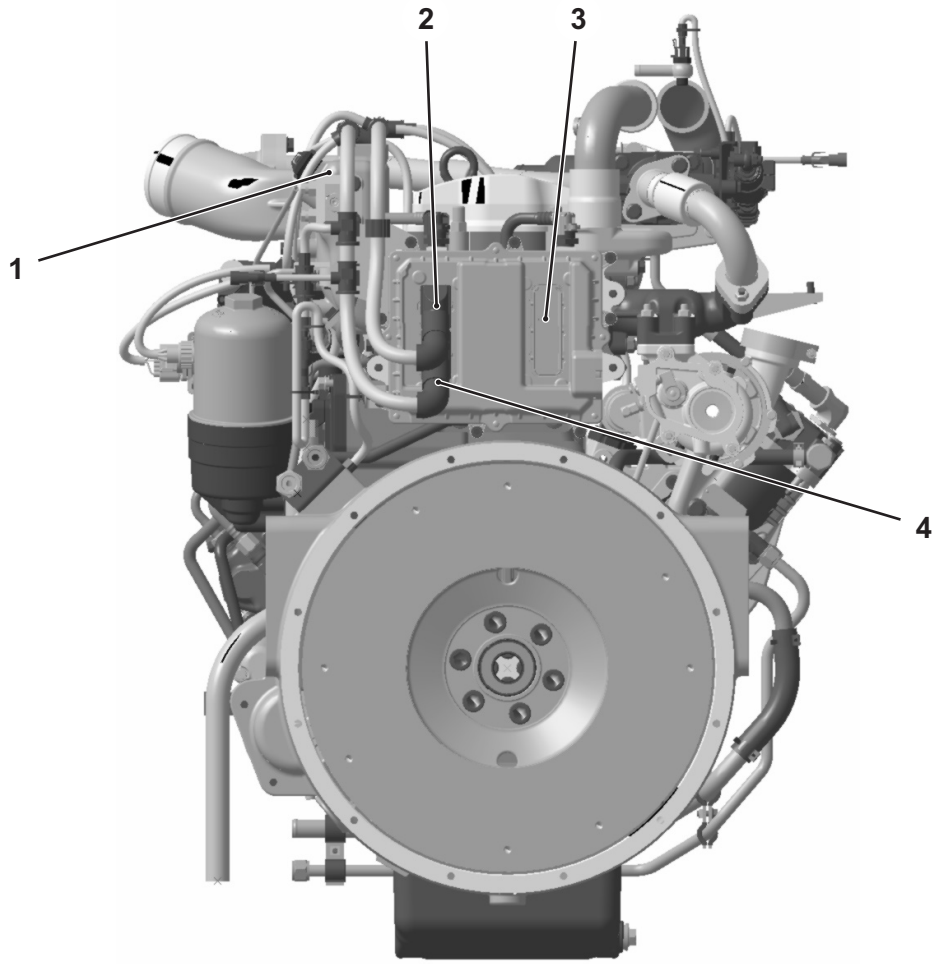
ELETRICAL COMPONENTS

1. Starter motor
2. Valve regulator pressure
3. Phase sensor or Camshaft Position Sensor (CMP) – mounted close to the high pressure fuel pump
4. Fuel pressure sensor (EFP) - Rail
5. Alternator
6. Intake air pressure and temperature sensor (TMAP)
7. Rotation sensor or Crankshaft Position Sensor (CKP)
8. Filler



RIGHT VIEW (HOT SIDE)

1. EGR actuator
2. EGR actuator connector
3. Cooling water pipe (for air compressor)
4. Air compressor
5. Oil pump
6. Oil dipstick
7. Turbo inlet pipe
8. Turbo outlet pipe
9. Turbo wastegate
10. Exhaust manifold

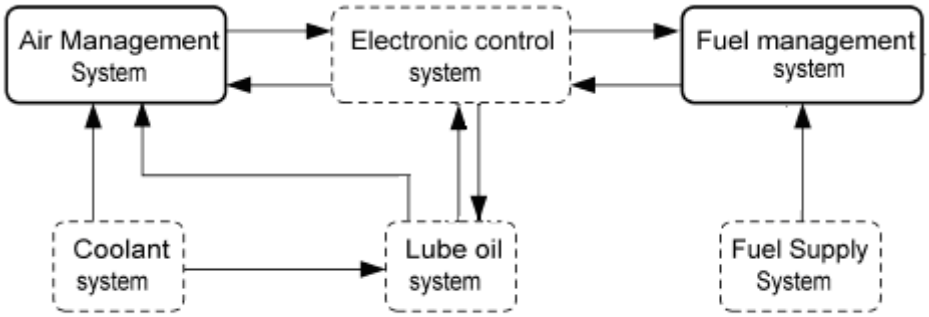


REAR VIEW

1. EGR and turbo air distributor
2. ECM Cylinder Connector “C” of 16 pins
3. ECM Vehicle Connector “A” of 89 pins
4. ECM Engine Connector “B” of 36 pins

Engine Systems

Engine System Diagram



Engine systems

The primary engine systems are Air Management and Fuel Management which share some subsystems or have a subsystem that contributes to their operation.

- The Electronic Control system controls the Air Management System and Fuel Management System.
- The Coolant System provides heat transfer for EGR gases and lubrication oil.
- The Lube Oil System provides lubrication and heat transfer to Electronic Control Module.
- The Fuel Supply System pressurizes fuel, then passes to a heat exchange and sends to the fuel injectors.

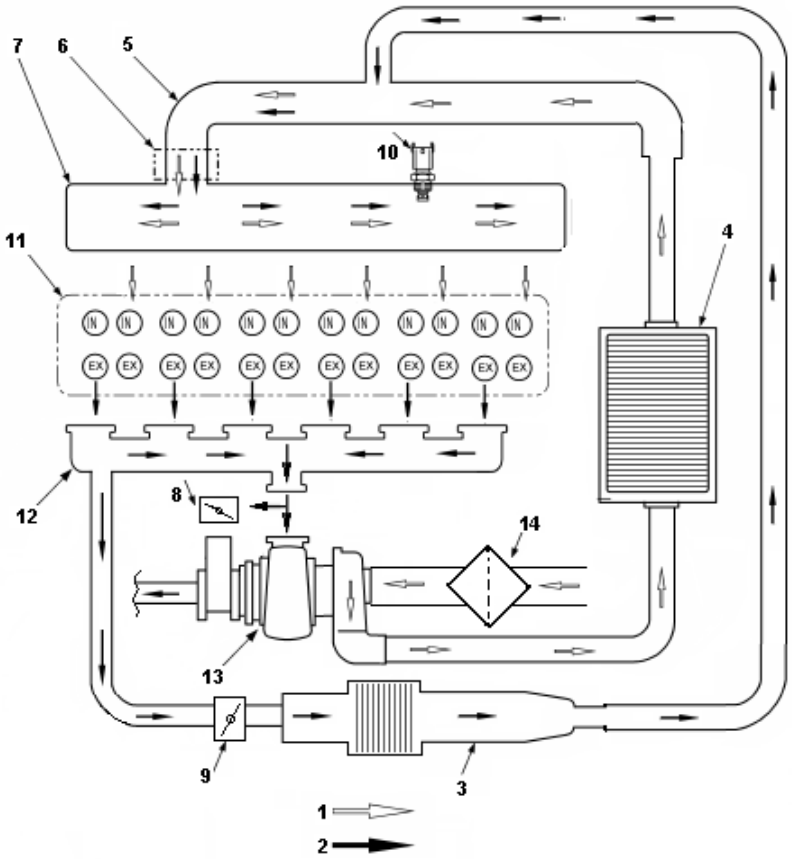
Air Management System

EGR System View

1. TURBO
2. EGR
3. EGR COOLER

Air Management Components and Air Flow

Air Management System (AMS)



1. Intake air
2. Exhaust gas
3. EGR cooler
4. Charge Air Cooler (CAC)
5. Intake air duct
6. Crossover
7. Intake manifold
8. Wastegate valve
9. EGR mixer valve
10. TMAP – Air pressure and temperature sensor
11. Cylinder head 4V per cylinder
12. Exhaust manifold
13. Turbocharger
14. Air filter

The Air Management system includes the following:

- Air filter assembly
- Chassis mounted Charged Air Cooler (CAC)
- Intake manifold
- Cooled Exhaust Gas Recirculation (EGR) system
- Exhaust system
- Intake and EGR mixer duct

Air Flow

Air flows through the air filter assembly and enters in the Turbocharger. The compressor increases the pressure, temperature, and density of the intake air before it enters the Charge Air Cooler (CAC). Cooled compressed air flows from the CAC into the EGR mixer duct.

- If the EGR control valve is open, exhaust gas will flow through the exhaust manifold to the EGR cooler and turbocharger mixing with filtered intake air and flow into the intake manifold.
- If the EGR control valve is closed, only filtered air will flow into the intake manifold.

After combustion, exhaust gas is forced through the exhaust manifold to the EGR cooler (with opened EGR valve) and turbocharger.

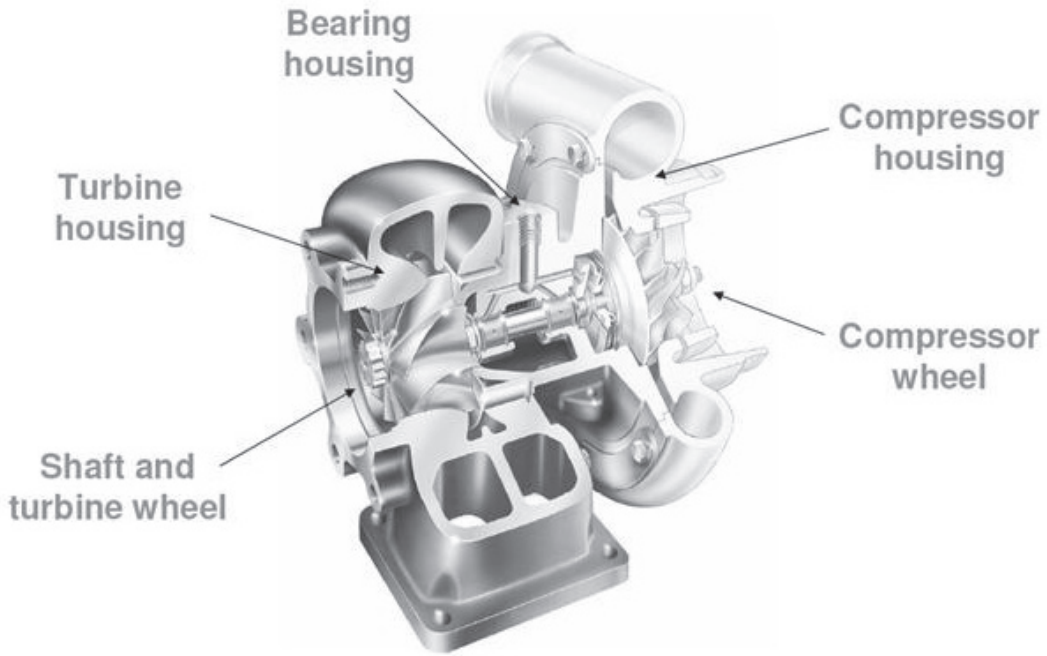
- Some exhaust gas is cooled in the EGR cooler and flows through the EGR control valve to the EGR mixer duct. When exhaust gas mixes with filtered air, nitrogen oxide (NOx) emissions and noise are reduced.
- The exhaust gas remaining flows to the Turbocharger spins and expands through the turbine wheel, varying boost pressure.
- The Turbocharger compressor wheel compresses the mixture of filtered air.

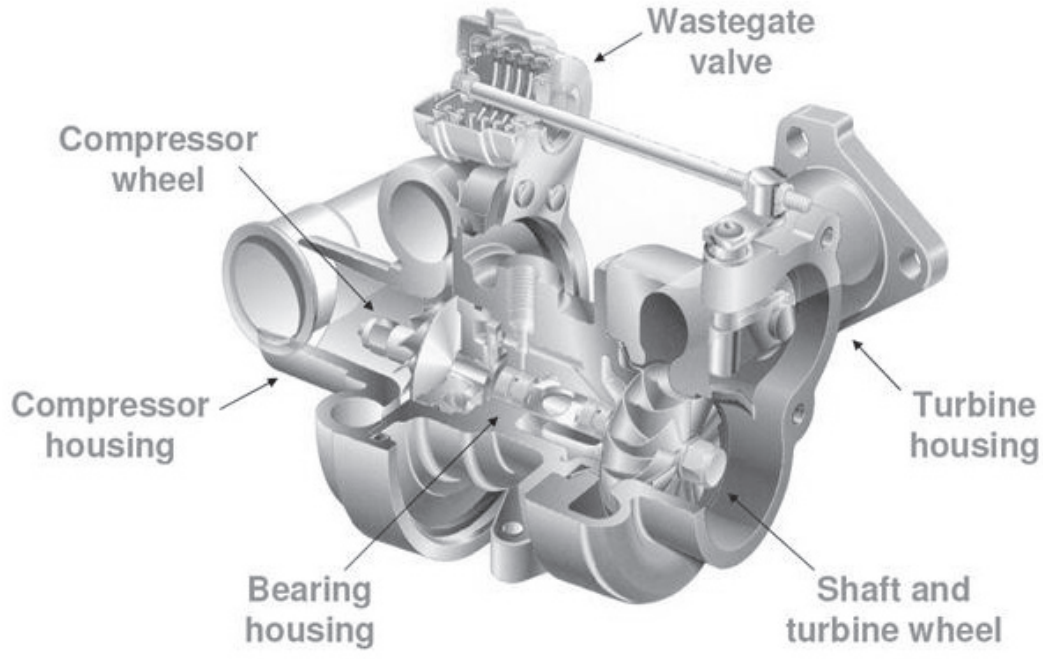
Charge Air Cooler (CAC)

Air from turbocharger passes through a heat network and exchanger tubes before entering the EGR mixer duct. Outside air flowing over the tubes and fins cools the charged air. Charged air is cooler and denser than not cooled air; cooler and denser air improves the fuel-to-air ratio during combustion, resulting in improved emission control and power output.

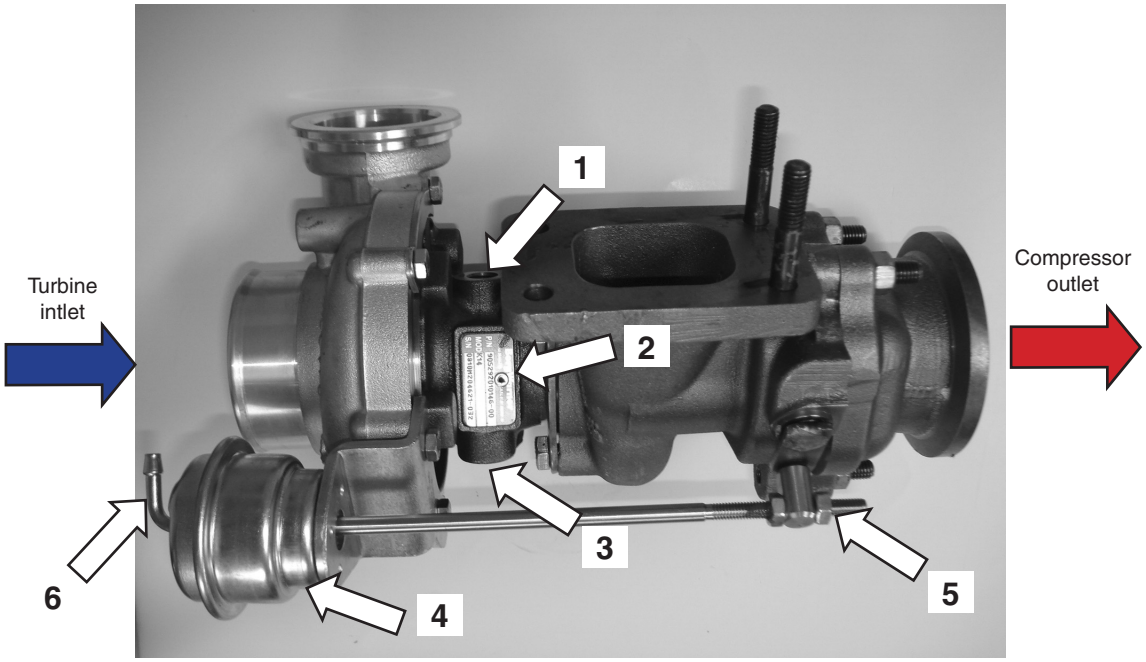
Turbocharger System

Internal Components





External Components



TURBO VIEW

1. Oil inlet
2. Identification label
3. Oil outlet
4. Wastegate air actuator
5. Wastegate valve
6. Turbo control air nipple

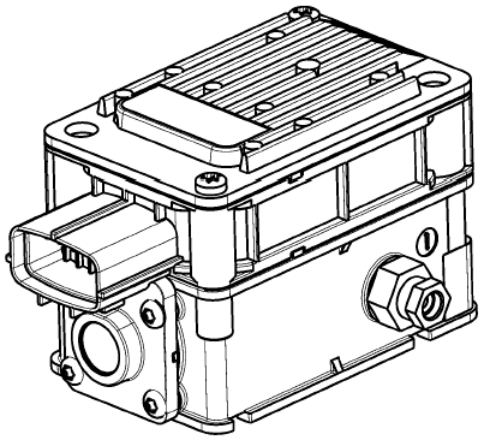
Turbo Wastegate (by BORG WARNER)

The MAXXFORCE engines are equipped with Turbocharger Borg Warner K14 Series. The K14 series offers a housing with single flow and the max flow rate is 0, 16 kg/s. The K14 series also is equipped with an external wastegate valve.

The wastegate valve conduce exhaust gases away from the turbine wheel, when the valve it's activated the exhaust gases are release to the exhaust manifold. That causes the turbine to lose speed, which in turn reduces the rotating speed of the compressor. The primary function of the wastegate is to stabilize boost pressure in turbocharger systems, to protect the engine and the turbocharger.

A wastegate is a separate self-contained mechanism typically used with turbochargers. This valve requires a specially constructed turbo manifold with a dedicated runner going to the wastegate. They are commonly used for regulating boost levels in high power applications, where high boost levels can be achieved.

Wastegate control – pneumatic with electronic boost controller



PWM Valve – Turbo Control

The wastegate control is a fully integral control system, combining in one piece a proportional valve and a pressure sensor in a closed loop pressure control system.

This device communicates with the ECU (Engine Control Unit) as well as provides diagnostic features to support OBD (On-Board Diagnostics). It is available with pressure and with PWM (Pulse Width Modulation) control interface.

Simple modification of exhaust or turbocharger controls is possible, along with optimization of engine performance/ efficiency and gas recirculation rate.

The Valves is housed in a IP6K9K rated enclosure with a 12 pin connector as the standard interface. Current solutions are in compliance with Euro IV and V as well as EPA 07 and 10 legislations. High accuracy and control dynamics are possible via high sample rate frequency. Variants and customization to application at hand is possible with software modification.

The wastegate have one port for attaching the boost control line from the charge air supply line coming from boost control solenoid.

The valve works for both 12 and 24V systems.

Electronic Turbo Boost control (by NORGREN)

Boost control is the principle of controlling the boost level produced in the intake manifold of a turbocharged engine by adjusting the air pressure delivered to the pneumatic wastegate actuator.

Electronic boost control adds an air control solenoid controlled by the ECM (Electronic Control Module). The same general principle of a manual controller is present, which is to control the air pressure presented to the wastegate actuator. This electronic system has a refining control since its work with intelligent algorithms supply by the ECM.

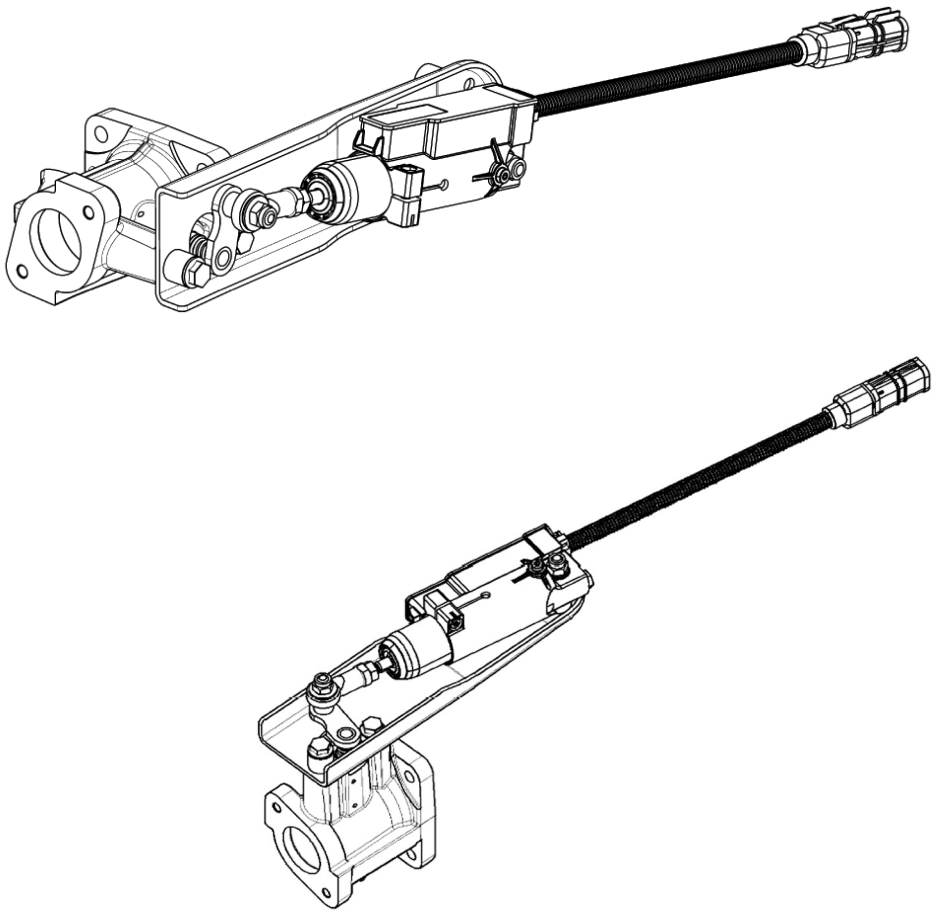
At the component level, boost pressure can either be bled out of the control lines or blocked outright. Either can achieve the goal of reducing pressure pushing against the wastegate. In a bleed-type system air is allowed to pass out of the control lines, reducing the load on the wastegate actuator. On a blocking configuration, air traveling from the charge air supply to the wastegate actuator is blocked while simultaneously bleeding any pressure that has previously built up at the wastegate actuator.

The control for the solenoids in EGR control valve is a closed loop system. Closed loop systems rely on feedback from the intake manifold pressure sensor to meet a predetermined boost pressure.

Solenoids are driven by pulse-width modulation (PWM) as they are binary state devices. By modifying the pulse width at a sufficiently high frequency, average air pressure over time can be controlled.

This electronic boost control offers 3-port solenoids and stepper motors in series or parallel controlled by a single PWM controller.

Exhaust Gas Recirculation (EGR) System



EGR Control Valve

The EGR system includes the following:

- EGR control valve
- EGR cooler
- Air intake manifold
- Inlet and EGR mixer duct
- Exhaust manifold
- Exhaust gas crossover

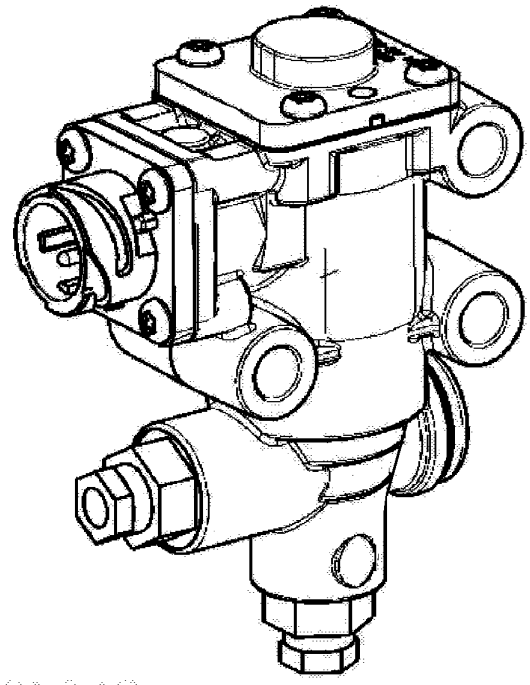
The Exhaust Gas Recirculation (EGR) system reduces Nitrogen Oxide (NOx) emissions. NOX forms during a reaction between nitrogen and oxygen at high temperature during combustion.

EGR works by recirculating a portion of an engine's exhaust gas back to the engine cylinders. Intermixing the incoming air with recirculated exhaust gas dilutes the mix with inert gas, lowering the adiabatic flame temperature, reduces the amount of excess oxygen. The exhaust gas also increases the specific heat capacity of the mix, lowering the peak combustion temperature. Because NOx formation progresses much faster at high temperatures, EGR serves to limit the generation of NOx.

EGR Flow

Some exhaust from the exhaust manifold flows into the EGR cooler. Exhaust from the EGR cooler flows through the exhaust gas crossover to the EGR valve.

When EGR is actuated, the EGR control valve opens allowing cooled exhaust gases to enter the EGR mixer duct to be mixed with filtered intake air.



Egr Control Valve

Proportional valve for Exhaust Gas Recirculation

EGR control device which provides precise pneumatic proportional control for the hot side EGR control valves. A uni-directional cylinder which actuates an exhaust flap is controlled by a proportional valve in order to recirculate exhaust gases for combustion.

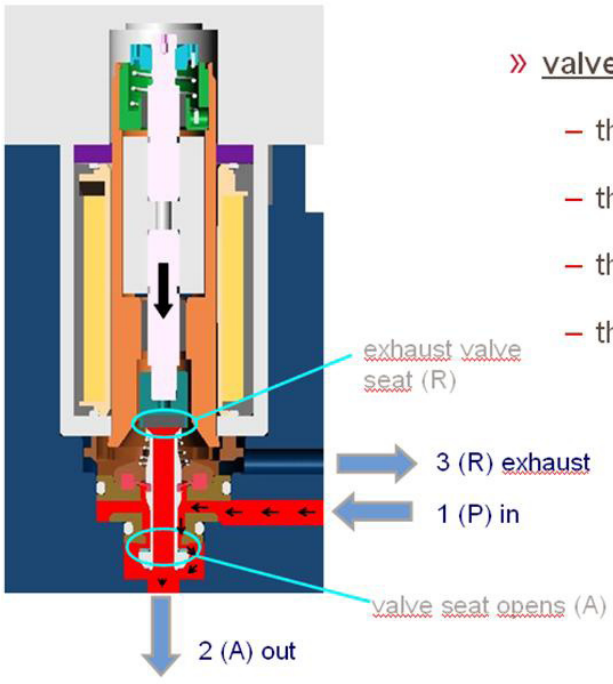
Functional description of EGR Valve Control

The function can be divided into three main steps:

- open, filling
- regulating pressure

  (pressure at P, the solenoid is on, A and R are alternating open and closed)
- off, closed

  (pressure at P, no current through solenoid and the valve is closed)



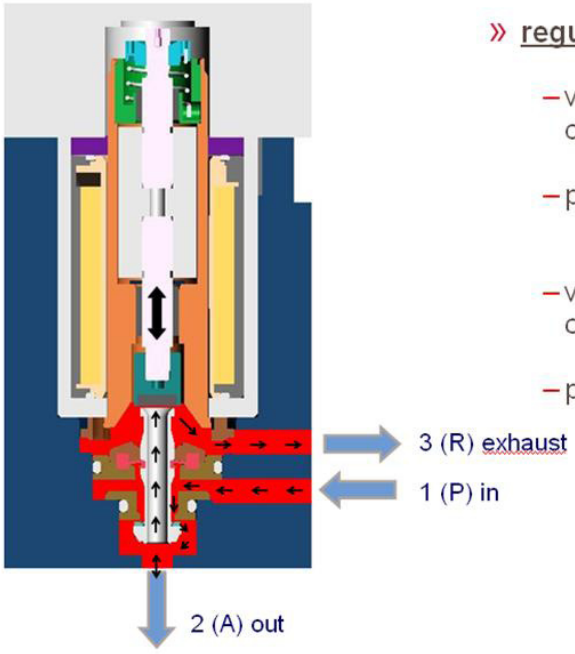
» valve open / filling:

– the solenoid is switched on

– the R - seat is closed

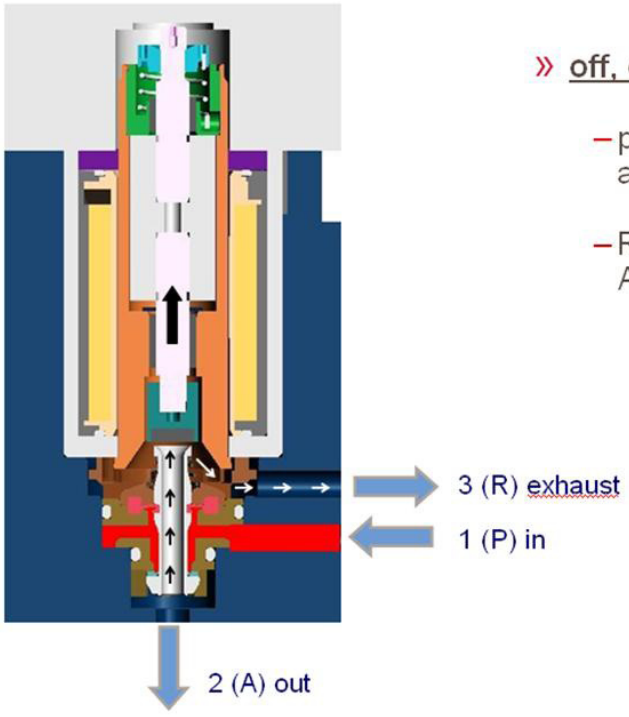
– the valve seat (A) opens

– the air flows from P to A



» regulating output pressure:

- valve seat A opens; valve seat R closes
- pressure increases
- valve seat A closes; valve seat R opens
- pressure decreases

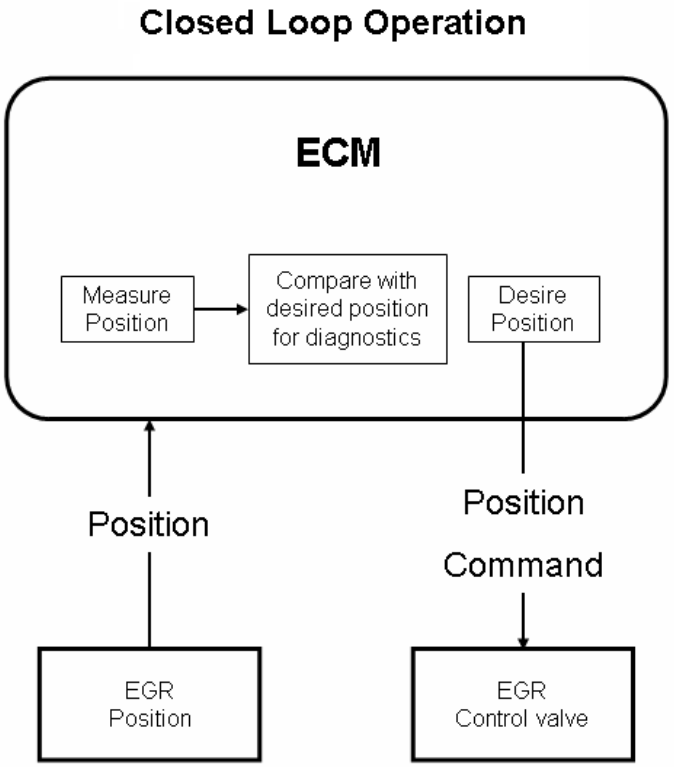


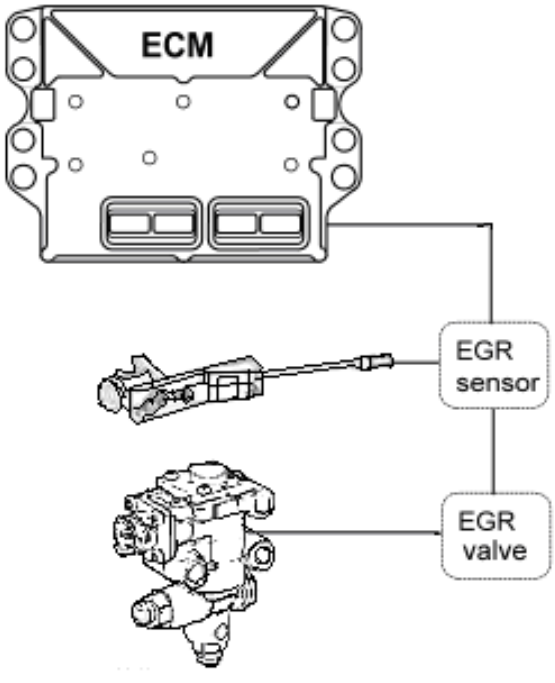
» off, closed:

- pressure at P, the solenoid is off and the valve is closed
- R-seat opens, air flows from A to R

EGR closed loop operation with fault management

The EGR is a closed loop system that uses exhaust gas recirculation position to provide feedback to the ECM.





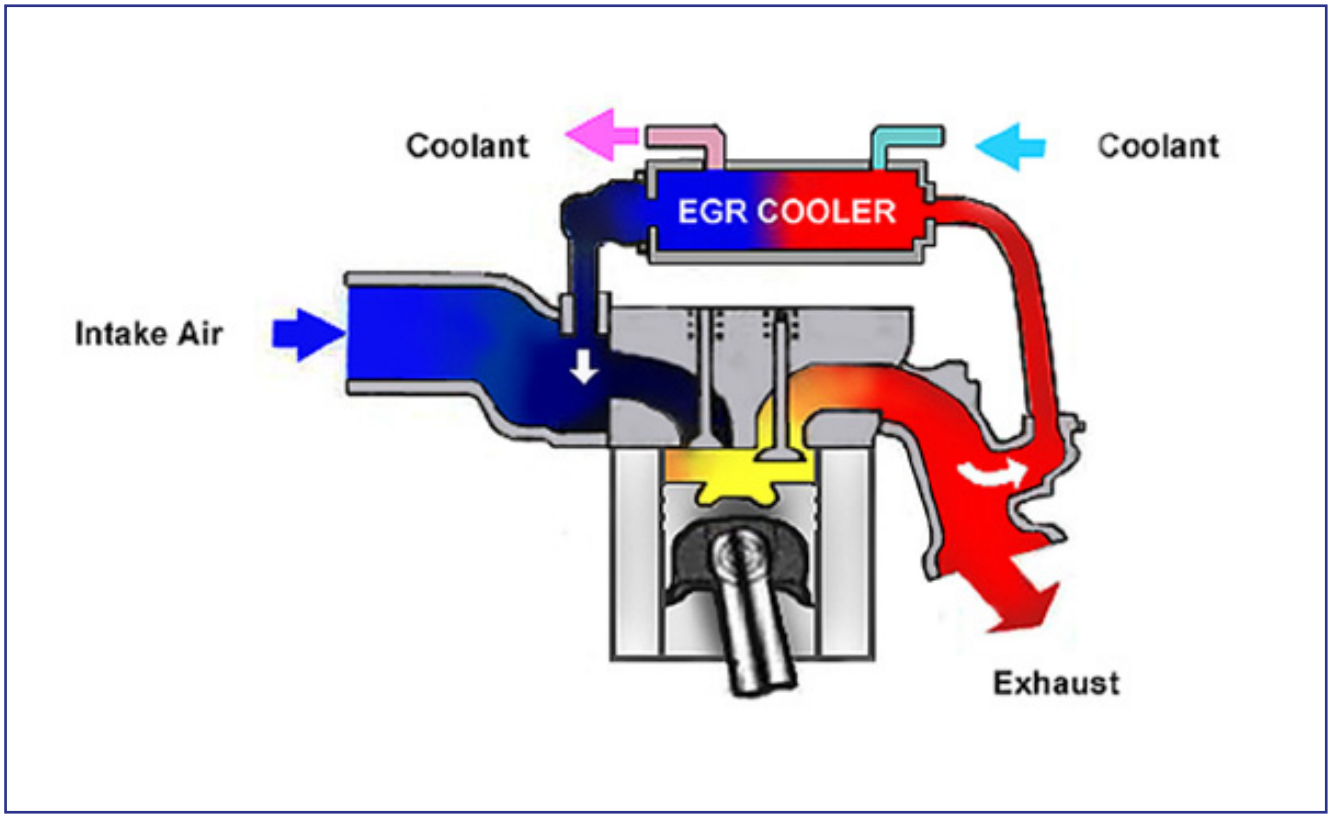
EGR control valve

Exhaust System

The exhaust system includes the following:

- Exhaust valves
- Exhaust manifold
- Turbocharger
- Exhaust piping
- Muffler

The exhaust system removes exhaust gases from the engine. Exhaust gases exit from exhaust valves, through exhaust ports, and flow into the exhaust manifold. Expanding exhaust gases are directed through the exhaust manifold. The exhaust manifold directs some exhaust gases into the Exhaust Gas Recirculation (EGR) cooler. Exhaust gases flowing into the turbocharger drive the turbine wheel. Exhaust gases exit the turbocharger and flow into the exhaust piping, through the muffler, and out the discharge pipe to the atmosphere.

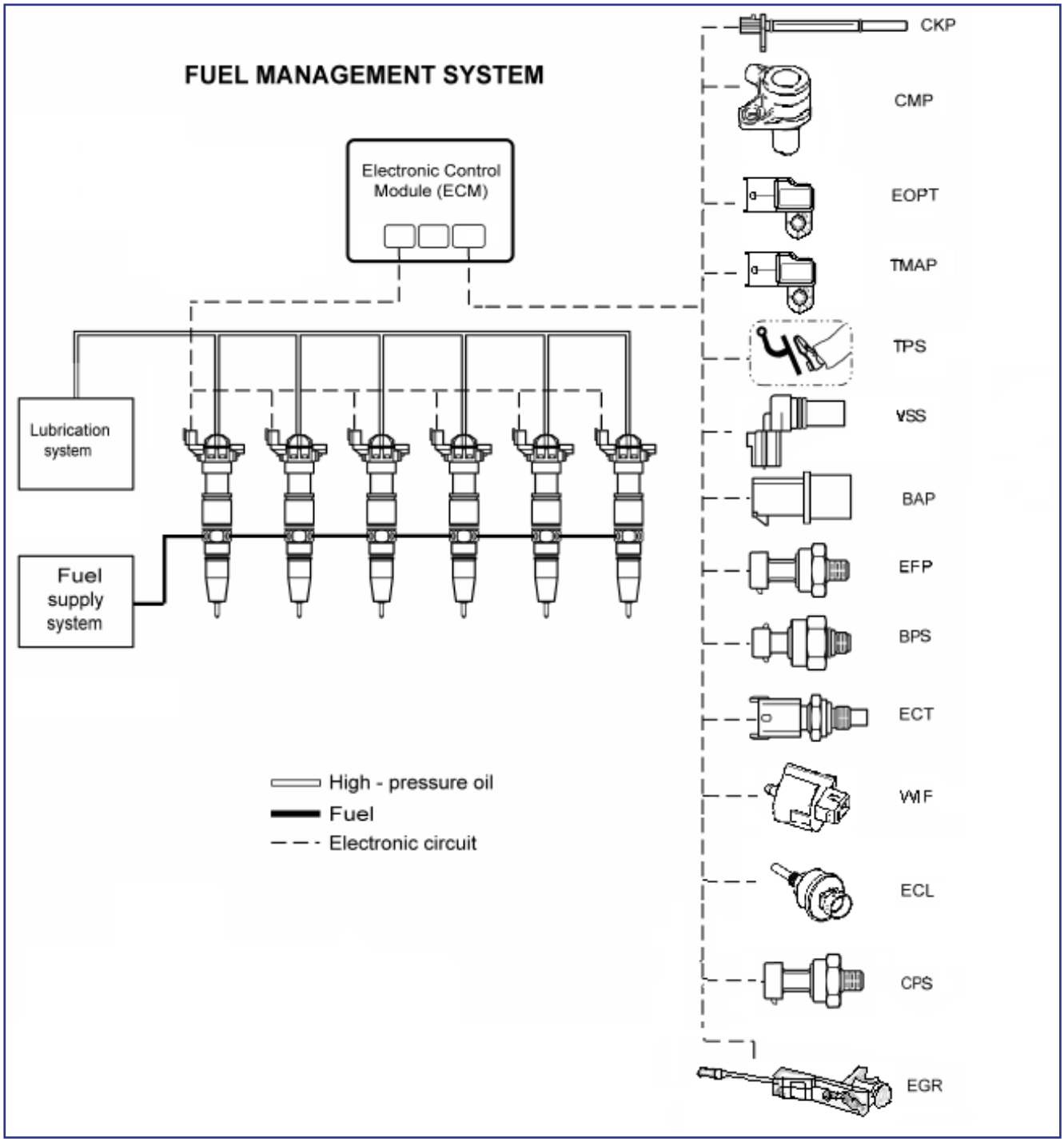


Fuel Management System

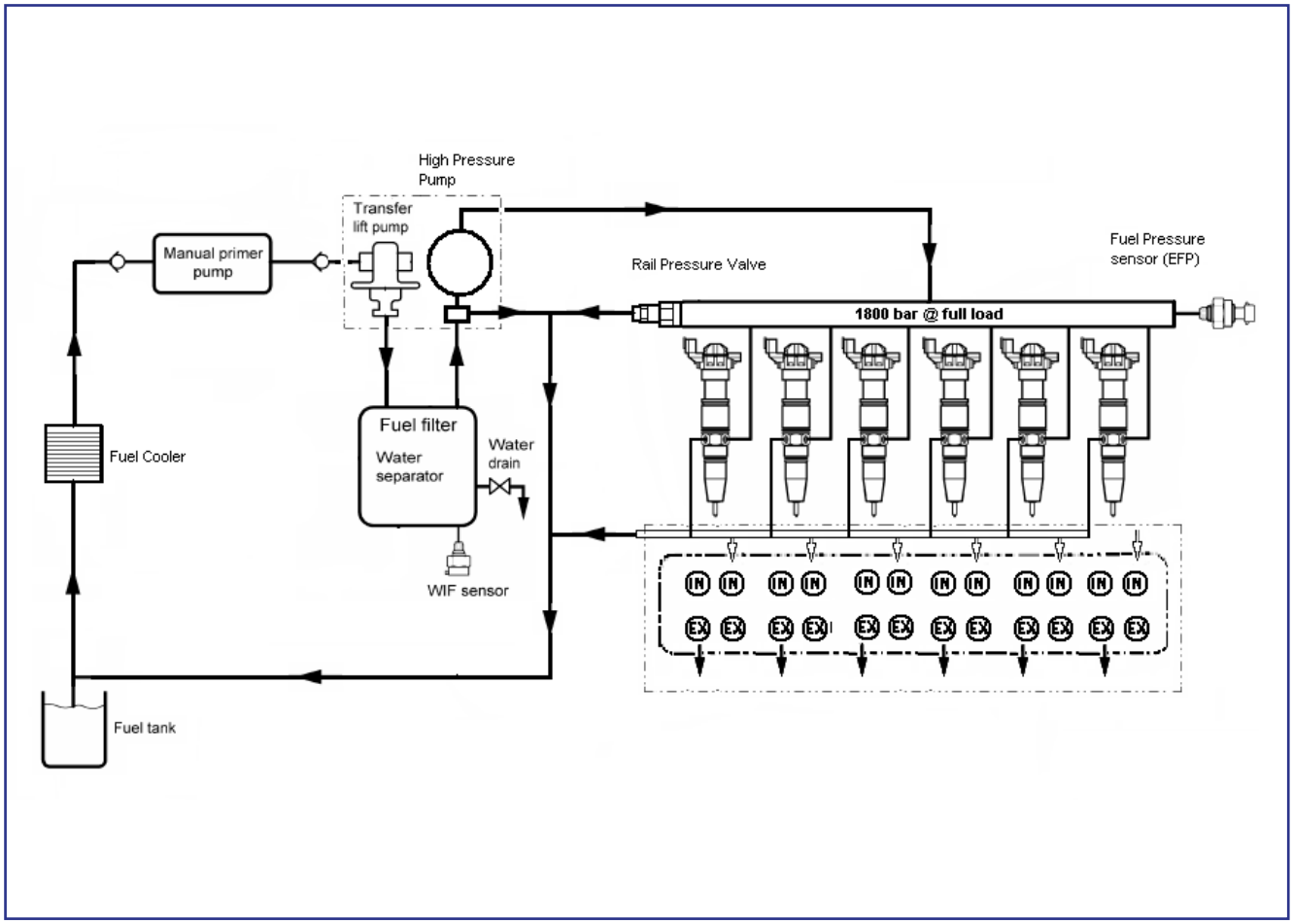
Fuel Management Components

The fuel management system includes the following:

- Fuel supply system
- Fuel injectors
- Lubrication system
- Electronic control system



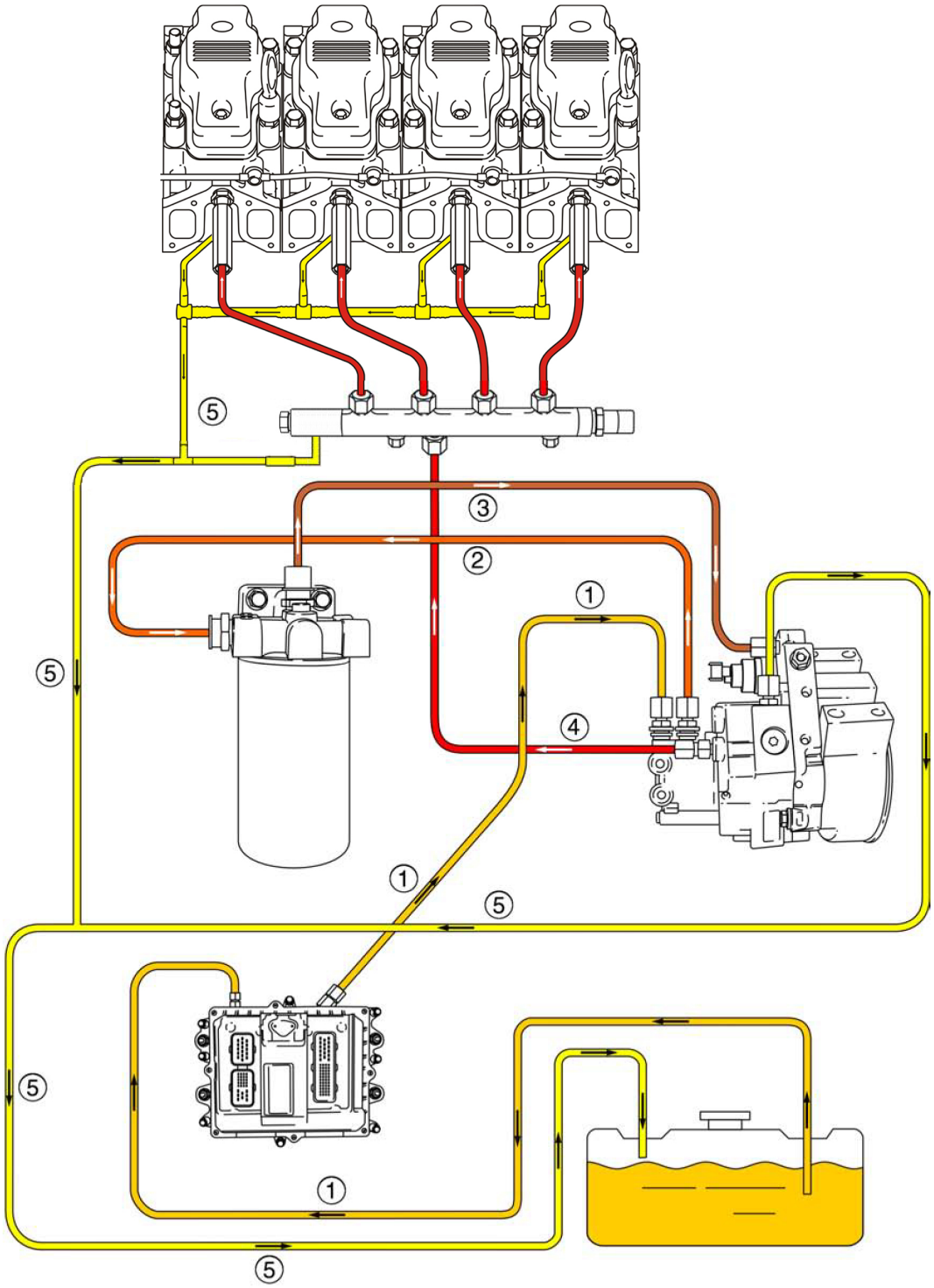
Fuel Flow Schematic



Fuel flow

The fuel filter housing includes the following components:

- fuel strainer
- Fuel filtering element
- Water separator
- Water In Fuel (WIF) sensor
- Water drain valve


5
3
2
1
5
4
1
5
5
1
5
1 Fuel from Tank
2 Fuel from Gearing Pump
3 Filtred Fuel
4 Fuel Under High Pressure
5 Return Fuel

Electronic Control System

Electronic Control System Components

Operation and Function

The Electronic Control Module (ECM) monitors and controls engine performance to ensure maximum performance and adherence to emissions standards.

The ECM has four primary functions:

- Provides Reference Voltage (VREF)
- Conditions input signals
- Processes and stores control strategies
- Control actuators (output signals)

1. Reference voltage (VREF)

The ECM supplies a 5 volt VREF signal to input sensors in the electronic control system. By comparing the 5 volt VREF signal sent to the sensors with their respective returned signals, the ECM determines pressures, positions, and other variables important to engine and vehicle functions.

The ECM supplies two independent circuits for VREF:

- VREF A supplies 5 volts to engine sensors
- VREF B supplies 5 volts to vehicle sensors

2. Signal conditioner

The signal conditioner in the internal microprocessor converts analog signals to digital signals, squares up sine wave signals, or amplifies low intensity signals to a level that the ECM microprocessor can process.

3. Microprocessor

The ECM microprocessor stores operating instructions (control strategies) and value tables calibration parameters). The ECM compares stored instructions and values with conditioned input values to determine the correct operating strategy for all engine operations.

Continuous calculations in the ECM occur at two different levels or speeds: Foreground and Background.

- Foreground calculations are much faster than background calculations and are normally more critical for engine operation. Engine speed control is an example.
- Background calculations are normally variables that change at slower rates. Engine temperature is an example.

Diagnostic Trouble Codes (DTC´s) are generated by the microprocessor, if inputs or conditions do not comply with expected values.

Diagnostic strategies are also programmed into the ECM. Some strategies monitor inputs continuously and command the necessary outputs to achieve the correct performance of the engine.

Microprocessor memory

The ECM microprocessor includes Read Only Memory (ROM) and Random Access Memory (RAM).

ROM

ROM stores permanent information for calibration tables and operating strategies. Permanently stored information cannot be changed or lost by turning the ignition key OFF or when ECM power is interrupted. ROM includes the following:

- Vehicle configuration, modes of operation, and options
- Engine Family Rating Code (EFRC)
- Engine warning and protection modes

RAM

RAM stores temporary information for current engine conditions. Temporary information in RAM is lost when the ignition key is turned to OFF or when ECM power is interrupted. RAM information includes the following:

- Engine temperature
- Engine rpm
- Accelerator pedal position

4.Actuator control

The ECM controls the actuators by applying a low level signal (low side driver) or a high level signal (high side driver). When switched on, both drivers complete a ground or power circuit to an actuator.

Actuators are controlled in three ways, determined by the kind of actuator.

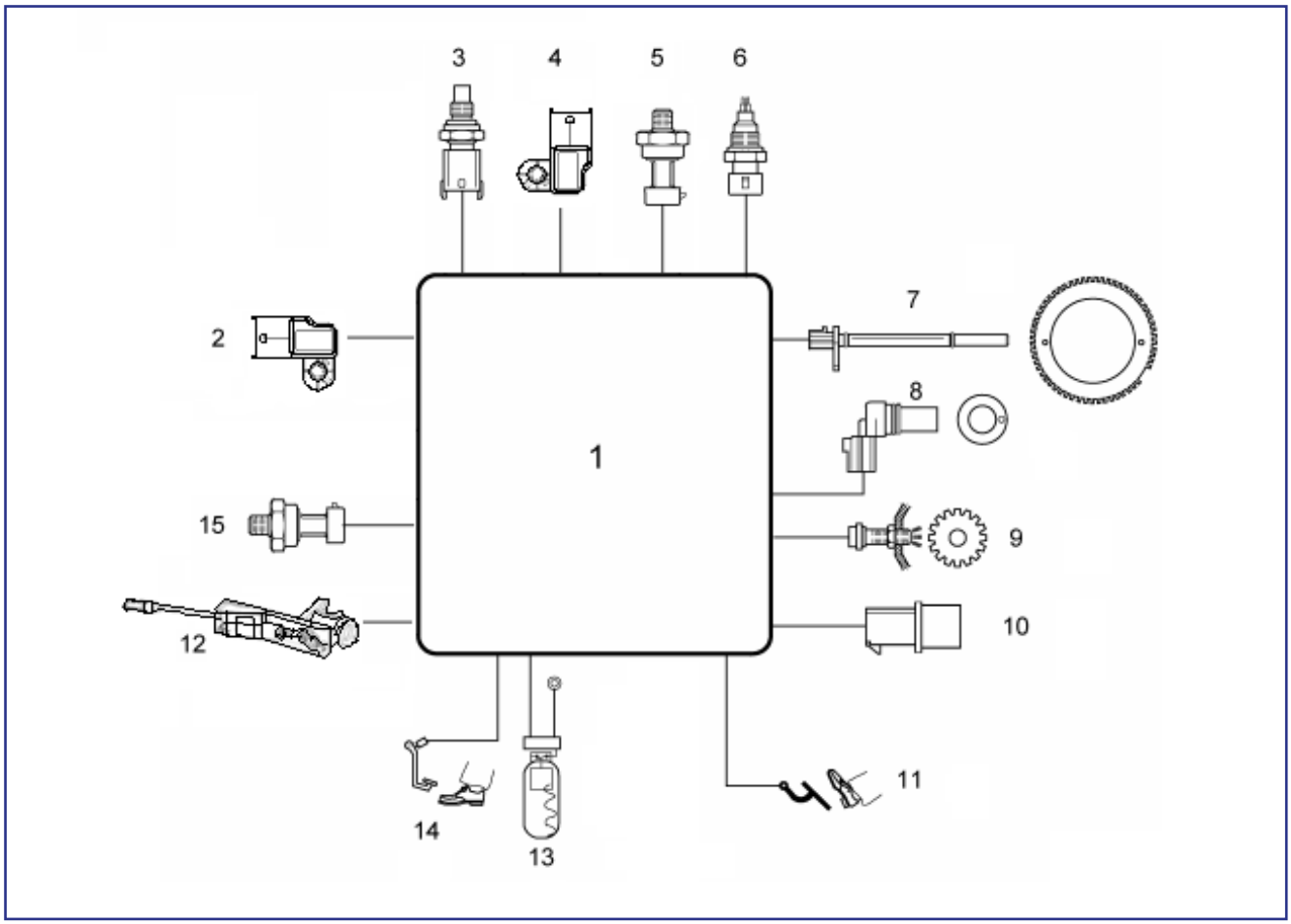
- A duty cycle (percent time on/off)
- A controlled pulse width
- Switched on or off

ECM Control of Engine Operation

The ECM controls engine operation with the following:

- Turbocharger wastegate control module
- EGR control module and control valve
- Fuel Pressure valve
- Injectors

Engine and Vehicle Sensors



1. Electronic Control Module (ECM)
2. Engine Oil pressure and Temperature (EOPT)
3. Engine Coolant Temperature (ECT)
4. Manifold Air Pressure and Temperature (TMAP)
5. Engine Fuel Pressure (EFP)
6. Water In Fuel (WIF) sensor
7. Rotation sensor or Crankshaft Position sensor (CKP)
8. Phase sensor or Camshaft Position sensor (CMP)
9. Vehicle Speed Sensor (VSS)
10. Barometric Absolute Pressure (BAP)
11. Accelerator Position Sensor (APS)
12. Exhaust Gas Recirculation valve Position (EGRP)
13. Engine Coolant Level (ECL)
14. Clutch Position Switch (CPS)
15. Brake Pedal Sensor (BPS)

Thermistor

- ECT
- TMAP
- EOPT

A thermistor sensor changes its electrical resistance with changes in temperature. Resistance in the thermistor decreases as temperature increases, and increases as temperature decreases. Thermistors work with a resistor that limits current in the ECM to form a voltage signal matched with a temperature value.

The top half of the voltage divider is the current limiting resistor inside the ECM. A thermistor sensor has two electrical connectors, signal return and ground. The output of a thermistor sensor is a nonlinear analog signal.

Engine Coolant Temperature (ECT)

The ECM monitors the ECT signal and uses this information for the instrument panel temperature gauge, coolant compensation, Engine Warning Protection System (EWPS), and intake heater operation. The ECT sensor is installed in the water pipe, close to the EGR cooler assembly.

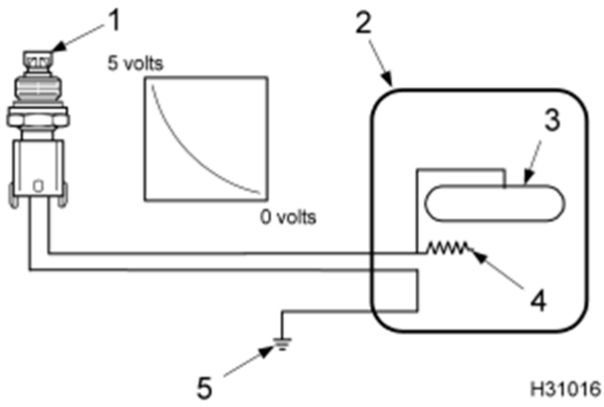
Engine Oil Pressure and Temperature (EOPT)

The ECM monitors the EOPT signal to control fuel quantity and timing when operating the engine. The EOPT signal allows the ECM to compensate for differences in oil viscosity during temperature changes. This ensures that power and torque are available for all operating conditions. The EOPT sensor is installed in the right upper side of the timing gear housing.

Manifold Air Pressure and Temperature (TMAP)

The ECM monitors the TMAP signal for EGR operation and determines intake manifold pressure (boost). This information is used to control fuel rate and injection timing.

The TMAP sensor is in the upper side of intake manifold.



1. Temperature sensor
2. Electronic Control Module (ECM)
3. Microprocessor
4. Voltage Reference (VREF)
5. Ground

Variable capacitance sensor

- BAP
- EFP
- EOPT

Variable capacitance sensors measure pressure. The pressure measured is applied to a ceramic material. The pressure forces the ceramic material closer to a thin metal disk. This action changes the capacitance of the sensor.

The sensor is connected to the ECM by three wires:

- VREF
- Signal return
- Signal ground

The sensor receives the VREF and returns an analog signal voltage to the ECM. The ECM compares the voltage with preprogrammed values to determine pressure.

The operational range of a variable capacitance sensor is linked to the thickness of the ceramic disk.

The thicker the ceramic disk the more pressure the sensor can measure.

Barometric Absolute Pressure (BAP)

The ECM monitors the BAP signal to determine altitude, adjust timing and the fuel quantity. The BAP sensor is installed in the ECM module.

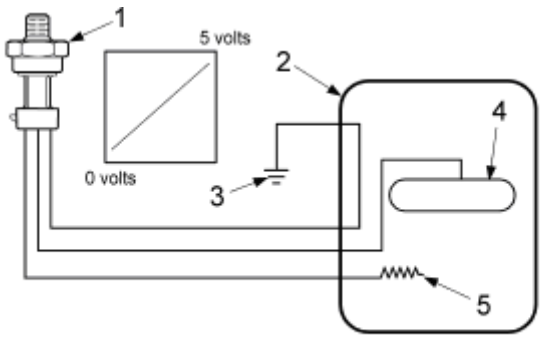
Engine Oil Pressure (EOPT)

The ECM monitors the EOPT signal and uses this information for the instrument panel pressure gauge. The EOPT sensor is installed in the upper right side of timing gear housing.

Engine Fuel Pressure (EFP)

The ECM monitors the EFP signal to determine correct fuel pressure for efficient engine operation.

The EFP sensor is installed in the fuel rail.



1. Pressure sensor
2. Electronic Control Module (ECM)
3. Ground
4. Microprocessor
5. Voltage reference (VREF)

Magnetic sensors

- CKP
- CMP
- VSS

A magnetic sensor generates an alternating frequency that indicates speed. Magnetic sensors have a two wire connection for signal and ground. This sensor has a permanent magnetic core surrounded by a wire coil. The signal frequency is generated by the rotation of gear teeth that disturb the magnetic field.

Crankshaft Position (CKP) sensor

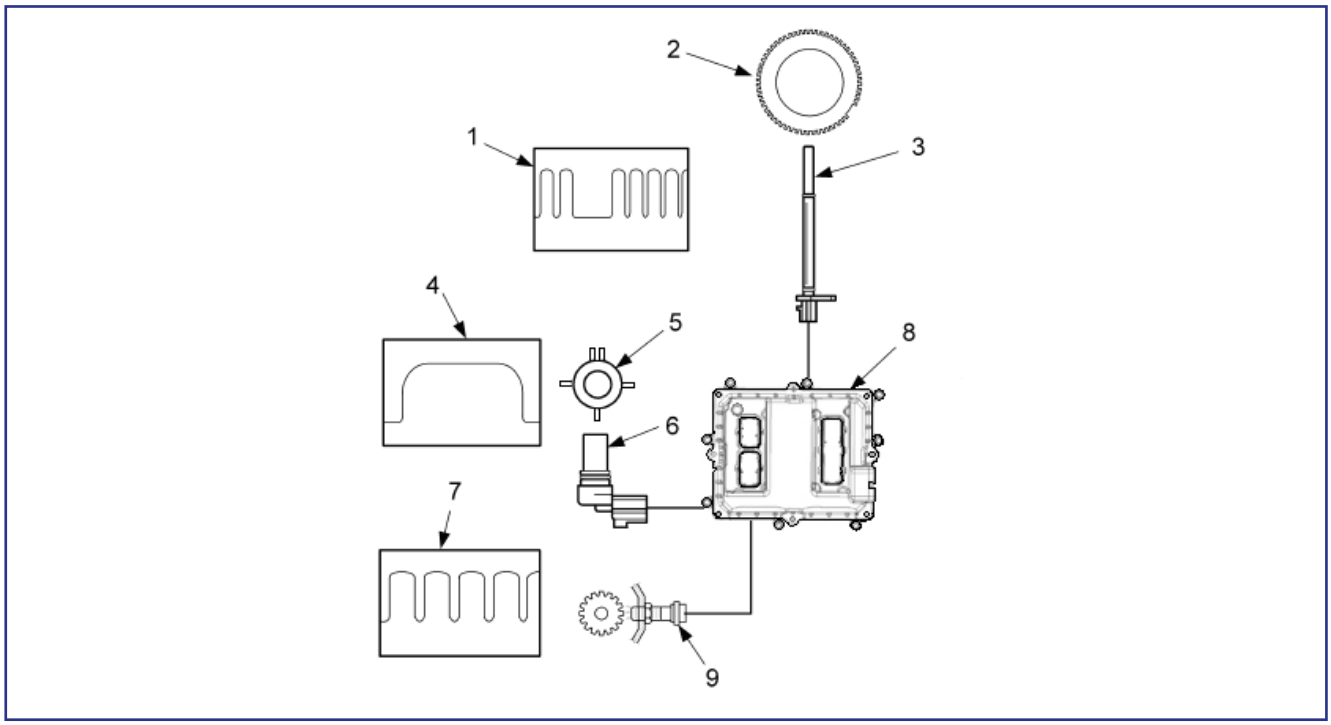
The CKP sensor provides the ECM with a signal that indicates crankshaft speed and position. As the flywheel turns the CKP sensor detects several holes made in the outside of the flywheel. All holes are symmetric between themselves except for an interval between the holes 58 and 60. By comparing the CKP signal with the CMP signal, the ECM calculates engine rpm and timing requirements. The CKP is installed in the top left side of the flywheel housing.

Camshaft Position (CMP)

The CMP sensor provides the ECM with a signal that indicates camshaft position. As the cam rotates, the sensor identifies the position of the cam by locating a peg on the cam. The CMP is installed in the timing gear housing, close to the high pressure fuel pump.

Vehicle Speed Sensor (VSS)

The VSS is commonly installed onto transmission tail shaft speed and provides signal to ECM by sensing the rotation from tooth gear. The detected sine wave signals (AC), received by the ECM, is combined with tire size and axle ratio to calculate the correct vehicle speed. See vehicle workshop manual for VSS location.



1. Crankshaft Position (CKP) signal
2. Crankshaft position sensor timing disk
3. Crankshaft Position (CKP) sensor
4. Camshaft position (CMP) signal
5. Camshaft timing disk
6. Camshaft position (CMP) sensor
7. Vehicle speed signal
8. Electronic Control Module (ECM)
9. Vehicle Speed Sensor (VSS)

Potentiometer

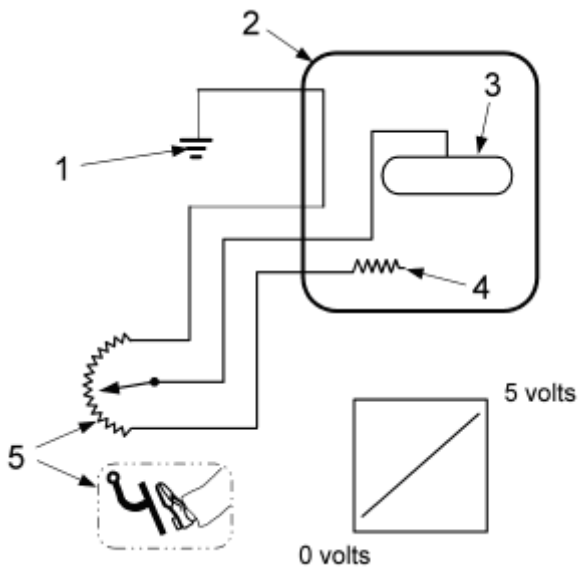
- APS

A potentiometer is a variable voltage divider that senses the position of a mechanical component.

A reference voltage is applied to one end of the potentiometer. Mechanical rotary or linear motion moves the wiper along the resistance material, changing voltage at each point along the resistive material. Voltage is proportional to the amount of mechanical movement.

Accelerator Position Sensor (APS)

The APS provides the ECM with a feedback signal (linear analog voltage) that indicates the operator's demand for power. The APS is mounted in the accelerator pedal.



1. Ground
2. Electronic Control Module (ECM)
3. Microprocessor
4. Voltage reference (VREF)
5. Accelerator Position Sensor (APS)

Switches

- CPS (Clutch Pedal Switch)
- ECL (Engine Coolant Low Level Switch)
- LIS (Low Idle Switch)
- WIF
- BPS (Brake Pedal Switch)
- Parking Brake Switch

Switch sensors indicate position. They operate open or closed, allowing or preventing the flow of current. A switch sensor can be a voltage input switch or a grounding switch. A voltage input switch supplies the ECM with a voltage when it is closed. A grounding switch grounds the circuit when closed, causing a zero voltage signal. Grounding switches are usually installed in series with a current limiting resistor.

Clutch Switch

The CPS determines if a vehicle is in gear. For manual transmissions, the clutch switch serves as

the CPS. For automatic transmissions, the neutral indicator switch functions as the CPS.

Engine Coolant Level (ECL)

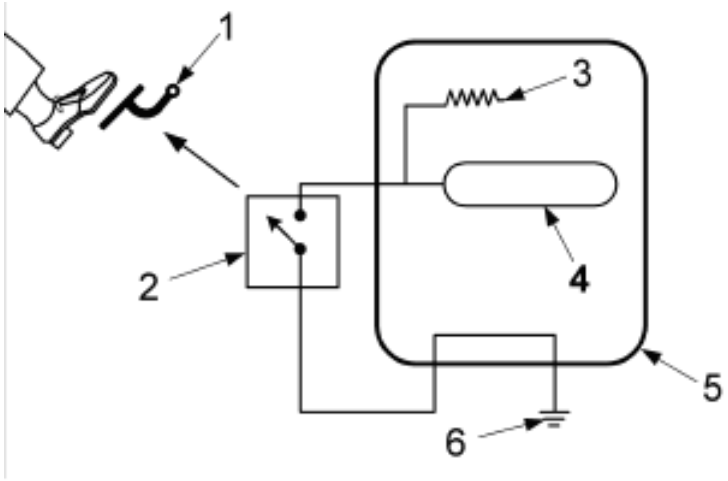
ECL is part of the Engine Warning Protection System. The ECL switch is used in plastic deaeration tank. When a magnetic switch is open, the tank is full. If engine coolant is low, the red ENGINE lamp on the instrument panel is illuminated.

Low Idle Switch (LIS)

The LIS is a redundant switch that provides the ECM with a signal that verifies when the APS is in the idle position.

Water In Fuel (WIF)

A Water In Fuel (WIF) sensor detects water in the fuel. When enough water accumulates at the bottom of the housing, the WIF sensor sends a signal to the Electronic Control Module (ECM); the ECM sets a Diagnostic Trouble Code (DTC) and illuminates the amber WATER IN FUEL lamp on the instrument panel. The WIF is installed in the base of the fuel filter housing.



1. Accelerator pedal
2. Low Idle Switch (LIS)
3. Voltage source with current limiting resistor
4. Microprocessor
5. ECM
6. Ground

NOTES

Operation and Maintenance

Engine operation

Start

- Before operating the MAXXFORCE 4.8/7.2 engine check:
- Water level.
- Fuel level.
- Lubricant level.
- Soon after to start the engine, heat it up at medium speed, without load.Watch lubricant oil pressure and water temperature.
- It is recommended to start the engine without accelerating, keeping the engine at idling speed for 30 seconds in order to pre-lubricate the turbocharger.
- Before stopping the engine, run about 30 seconds at idling speed so that the turbo decrease its speed.

Cold Start

The difficulty of start at very low temperatures can happen due to the collapse of the filter because paraffin formation or lack of ignition of the fuel.

The following actions can be observed:

- Use winter fuel, which does not form paraffinic flakes at low temperatures, or;
- Case the winter fuel is not available, it is necessary that the filter has a heater on the cylinder head to allow fuel flow before the start.

Turbocharger Cares

- Almost all failures in turbochargers are caused by lubrication deficiency (delay in lubrication, restriction or lack of oil, intake of impurities in the oil, etc.) and objects or impurities entrance through intake.
- To maximize the turbo lifetime follow these cautions:
- Do not accelerate the engine immediately after the start.
- Wait 30 seconds with the engine at idling speed before stop it.
- Pre-lubricate the turbocharger after oil change or other service that evolves oil drain. Crank the engine a few times before start the engine. Then run the engine and allow it to run at idling speed for a period of time to establish a complete circulation and oil pressure before to perform high speeds and load.
- In low temperatures or when the engine is being reactivated after a long period without operation, start the engine and let it running at idling speed before operating in high speeds.
- Avoid operating the engine at idling speed for long periods of time.

Running-in

All MIM engines are assembled and tested in the factory, making sure its immediate operation.

However, it needs to be correctly ran-in, regarding that its performance and durability depend, largely, on the cares taken during first operation phase.

As general rule, it is considered as running-in period the first 2,000 km for vehicular engines or the first 50 service hours for stationary, industrial and agriculture engines. The vehicle or equipment under moderate operation has decisive importance to its durability, service safety and economy.

During this period it is very important to follow these recommendations:

- Carefully check if engine oil level is correct;
- Carefully check if water level of the engine cooling system is correct;
- Avoid operate the engine at high speeds, that means do not apply extreme conditions of load or, considering vehicle application, to “stretch out” the speeds;
- Avoid forcing the engine at low speeds;
- Avoid forcing the engine while it has not reached the normal operation temperature yet;
- Avoid operating over the limit of 3/4 (75%) of the maximum load of the vehicle or equipment;
- Avoid operating the engine at constant speeds for long periods of time;
- Avoid leaving the engine running at idling speed for a long period of time;

Strictly follow the maintenance instructions.

Following these recommendations the useful life of the engine will be prolonged.

Fuel Specifications

Diesel

The oil diesel used at MWM INTERNATIONAL Engines must meet Brazilian Standard ANP nº 32, issued in 16.10.2007 – DOU 17.10.2007.

Biodiesel

The use of B5 (fuel composed by mixing diesel oil and biodiesel* and defined as proportion of no more than 5% of biodiesel) is allowed in MAXXFORCE 4.8/7.2 engines, according to Brazilian Standard ANP Nº 07 issued in 03.19.2008 – DOU in 03.20.2008.

The use of B5 that does not meet the specifications recommended by manufacturer, can cause serious damage to internal components of the engine, resulting in the **cancellation** of the warranty.

* Its is understood by biodiesel, a fuel to be used in internal combustion engines with compression ignition, renewable and biodegradable, derived from vegetable oils and/or animal fats.

Lubricant oil

Oil Level Check

- Stop the engine and wait 30 minutes so that the oil can flow back to the carter.
- Make sure that the vehicle is levelled.
- Before pulling oil dipstick, clean the surroundings.
- If necessary complete up to the upper mark (MAXIMUM), without exceeding it. Use the same oil mark and type to complete the level.
- Do not operate the engine with the level below the lower mark (MINIMUM).
- Use only recommended lubricant oil.
- Do not mix different oil brands.
- Chosen an oil type and brand, always use the same.

Oil Change

- The oil must be hot to facilitate the drainage.
- Drain the oil removing the carter plug.
- Wait until not leaving oil anymore.
- Install the plug with a new washer and tighten according to the specification.
- Fill with recommended lubricant oil up to upper level mark (MAXIMUM) of the dipstick.

Oil Filter Change

- Clean the sealing area of the filter with a clean and without threads cloth.
- Lubricate the filter gasket and manually screw until touch.
- Manually tighten.
- Fill up with new oil. In a levelled vehicle, the oil level must reach the upper mark of the dipstick.
- Run the engine checking the sealing of the filter and carter plug.
- Stop the engine and, after 30 minutes, check oil level again, filling up if necessary.

Attention: Always use genuine MIM filter.

Lubricant Oil

The lubricant oil is very important for a good conservation of the inner engine components. Lubricant oil contaminated with sand, soil, dust, water or fuel cause problems to the engine.

Check the appearance of the engine lubricant oil. A dark coloration and low viscosity could mean presence of fuel in the lubricant oil.The presence of bubbles or a milky coloration could indicate presence of water in the oil.

Lubricant Oil Specifications

It must be used multiviscous type lubricant oil that accomplish, at least, to the SAE 15W40 API CI4 (or upper) specifications and to the recommended viscosities.

Attention: Do not mix different oil brands. Chosen one oil type, always use the same in the filling.

Check Lubricant oil Condition

The condition of the lubricant oil is very important for a good conservation of the inner components of the engine.

Cooling Fluid and Coolant

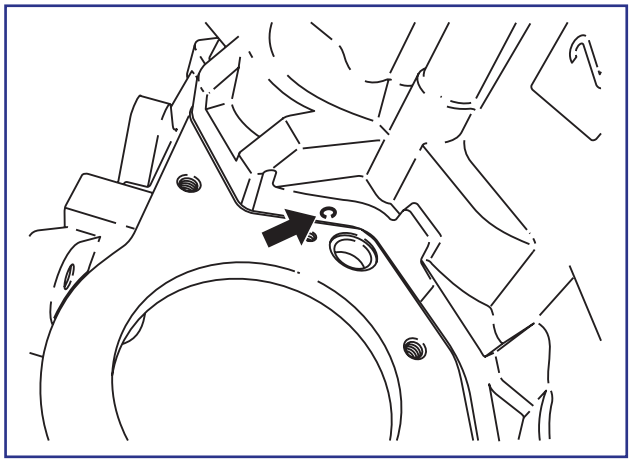
Oil Level Check

Attention:

- Do not open the expansion reservoir cap while the engine is hot.
- Check the level when the engine is cold.
- Check the level of the cooling system daily. If the level is not correct, add clean water + MWM coolant according to the proportion recommended on the bottle.
- Carefully open the first stage of the cap relieving the vapour pressure.
- Check for leaks through cooling piping.
- Check the nominal pressure of the cap in case of change.

Water Pump Check

Check for leaks through the pump drain hole.



Cooling Fluid Filling Procedure

System Fill

Fill the cooling system with the additive quantity indicated in the table and complete with clean water.

System total capacity

MAXXFORCE 4.8/7.2

Turn on the engine and wait until it reaches the normal temperature. Complete the level only with clean water and MWM INTERNATIONAL additive in the correct proportion. After filled the system, run the engine to verify possible leaks.

MWM INTERNATIONAL additive

MIM Number	9.0193.05.6.0011	9.0193.05.6.0012
Name	Anticorrosion additive	Concentrated additive
Properties	Anticorrosion only	Anti-corrosion / Anti-boiling / Anti-freezing
Application	Diesel engines	Diesel engines
Color	Yellow	Red
Ratio	3%	50% ± 10%
Change interval	50.000 km or 3 months	50.000 km or 6 months
Composition	Anticorrosive ethlenoglycol, borates, silicates and colouring	Anticorrosive ethlenoglycol, borates, silicates and colouring
Validity	2 years	5 years
Volume	1L	1L

Maintenance Table

MAINTENANCE PLAN A) Up to 50,000 km/year conditions B) Over than 50,000 km/year conditions	Daily	Initial		A				B			
		2.500 Km	5.000 Km	10.000 Km	20.000 Km	40.000 Km	80.000 Km	15.000 Km	30.000 Km	60.000 Km	120.000 Km
DRAIN FUEL FILTER	•										
CHECK LUBRICANT OIL LEVEL	•										
COLLECT SAMPLE OF LUBRICANT OIL TO ANALYSIS		•		•				•			
CHECK COOLANT LEVEL	•										
CHECK FOR LEAKS IN THE ENGINE	•										
CHECK CONNECTIONS						•				•	
CHANGE LUBRICANT OIL (SAE 15W40 - API CI-4)					•				•		
CHANGE LUBRICANT OIL FILTER					•				•		
CHANGE FUEL FILTER					•				•		
CHANGE AIR FILTER	•										
CLEAN AIR FILTER (if necessary)	•										
ADJUST VALVES CLEARANCE		•				•				•	
CHECK DAMPER CONDITIONS						•				•	
CHECK BELT		•		•				•			
CHANGE BELT						•				•	
CHANGE COOLANT							•				•
CHECK FUEL PIPING CONDITIONS						•				•	
NOZZLES	FREE OF MAINTENANCE										
HIGH-PRESSURE FUEL PUMP	FREE OF MAINTENANCE										
CHECK ELECTRIC CONNECTIONS (Starter Motor and Alternator)				•				•			
CLEAN AND RETIGHTEN BATTERY TERMINALS		•		•				•			
RETIGHTEN ENGINE FIXATION CUSHIONS		•			•				•		
CHECK THE TIGHTENING OF THE SCREWS AND NUTS: EXHAUST MANIFOLD AND ELBOW, TURBOCHARGER FLANGE AND CARTER		•		•				•			
CHECK FAN					•				•		
CHECK TURBOCHARGER (shaft clearance and body condition)			•				•				•

Remark: [1] This table is only for guidance. The Maintenance Table of the vehicle prevails over this table.

[2] For heavy-duty and off-road services perform maintenance in the half of the indicated periods in the table above.

[3] If the engine stays inactive for a long time, it must perform an idling speed test fortnightly, until to reach the operation temperature.

[4] Independent of the intervals indicated for engine lubricant oil changes, it must be changed at each 6 months.

[5] Electronic parts of BOSCH (phase, speed, air pressure, temperature, oil pressure and water temperature sensors) are free of maintenance and checked by recommended diagnose scanner with errors stored in failure memory.

Conservation for Inactive Engines for Long Period

MWM INTERNATIONAL engines are produced protected for, at the most, 3 inactivity months under shut shelter. When the engine is to stay inactive for a long period, it is necessary to follow these cares:

1. Clean the outer parts of the engine.
2. Operate the engine until to reach the operation normal temperature.
3. Drain cooling system and lubricant oil.
4. Fill the radiator with clean water + MWM coolant according to the recommended proportion.
5. Fill up the carter with protective oil SAE 20 W 20.
6. Drain fuel system (reservoir, low pressure system).
7. Operate the engine for 15 minutes at 2/3 of the nominal speed, without load, using a mixture of fuel with 15% of the protective oil SAE 20 W 20.
8. Drain fluid from cooling system and oil from carter. The fuel mixture can stay in the system.
9. Remove valves cover from cylinder heads and spray protective oil on the springs and rocker arms. Reinstall covers.
10. Remove fuel injectors and spray 10 to 15 cm^3 of protective oil in each cylinder with the respective piston at bottom-dead-centre position. Turn crankshaft a complete turn and reinstall fuel injectors.
11. Apply protective grease on articulations.
12. Apply protective oil on machined surfaces.
13. Remove belt(s).
14. Seal all the holes of the engine, to avoid dust and water penetration.

Remarks:

- Renew the engine conservation procedure after each 8 months of inactivity.
- In case of new brand engines, do not consider items 1, 2 and 3.

Preparation of the Engine to Return to Service

1. Before operating an engine which stayed inactive for a long period, follow these procedures:
2. Clean the outer parts of the engine.
3. Fill cooling system with clean water and MWM coolant in the recommended proportion.
4. Change engine lubricant oil filter.
5. Fill the carter with new lubricant oil according recommendation.
6. Install belt(s) and adjust tension.
7. Remove valves cover and lubricate rocker arms with engine oil. Reinstall covers.
8. Drain the fuel mixture from the reservoir and fill with new fuel.
9. Change fuel filter.

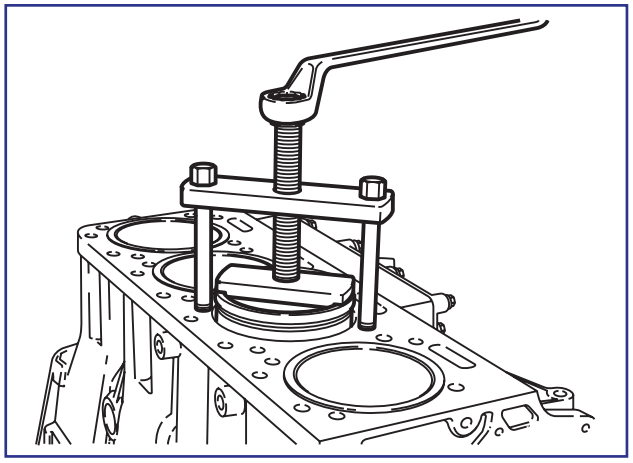
Engine Block

Disassembly Notes

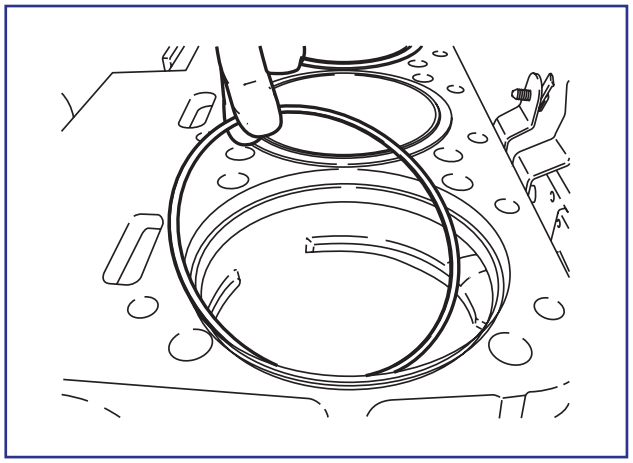
The cylinder liners removal must be made with the special tool MIM nr. 9.610.0.690.017.6 in order to do not damage the engine block or the liners.

The lower part of the tool must be fitted on the lower edge of the liner.

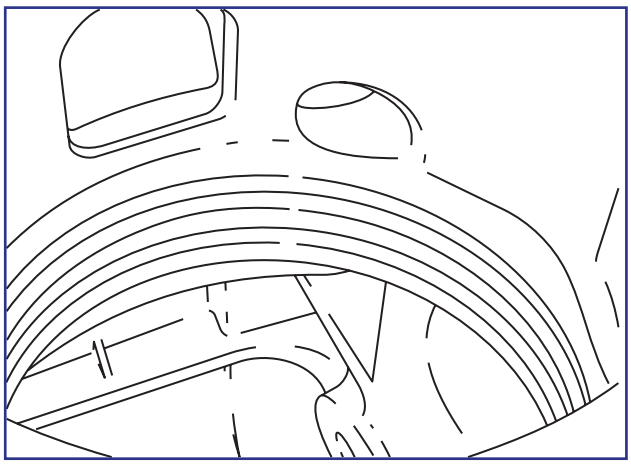
The liner can be removed screwing the nut of the puller.



Clean the block surface cylinder head that must be free of dust or wear.

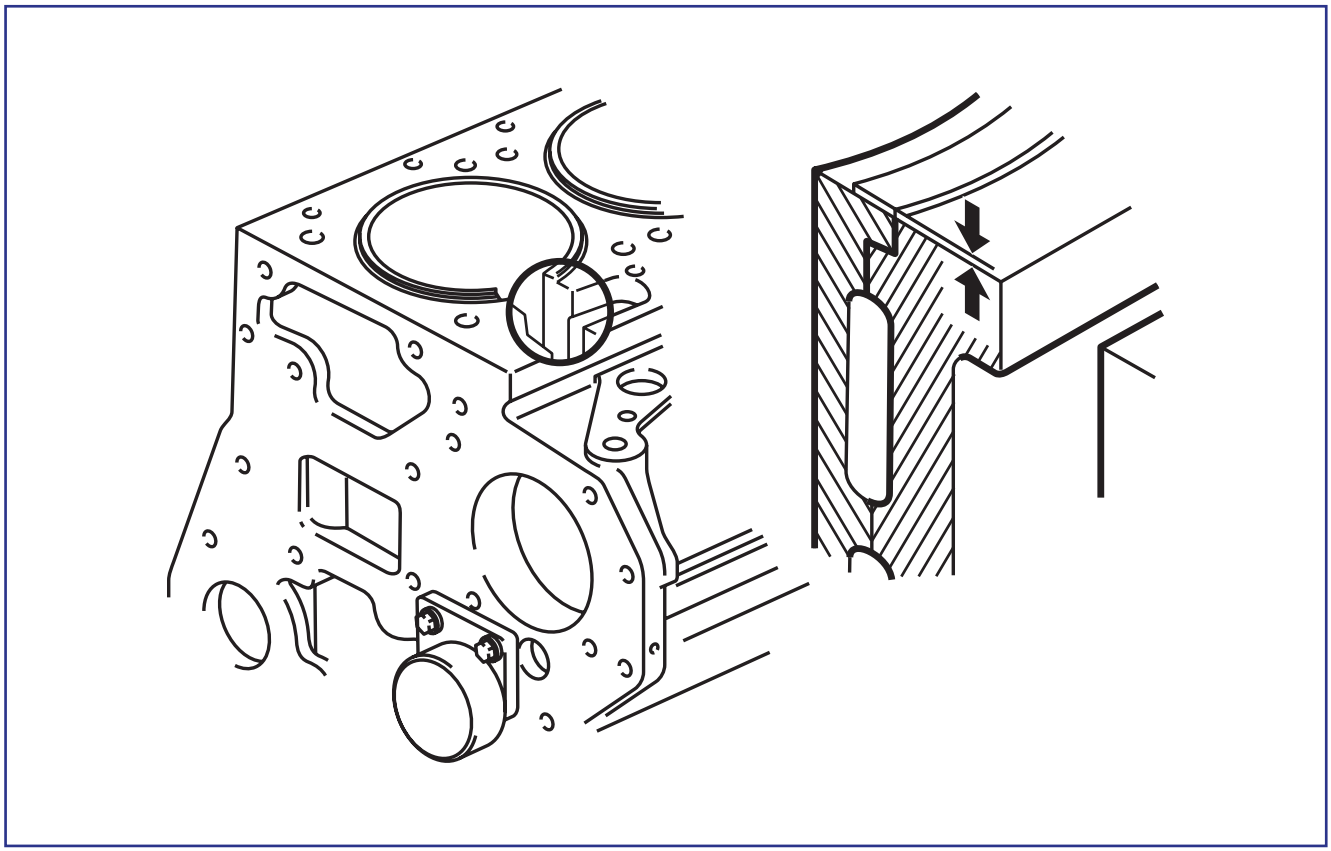


Remove linears sealing rings and replace for new points.



Pre-Assembly Inspections and Measurements

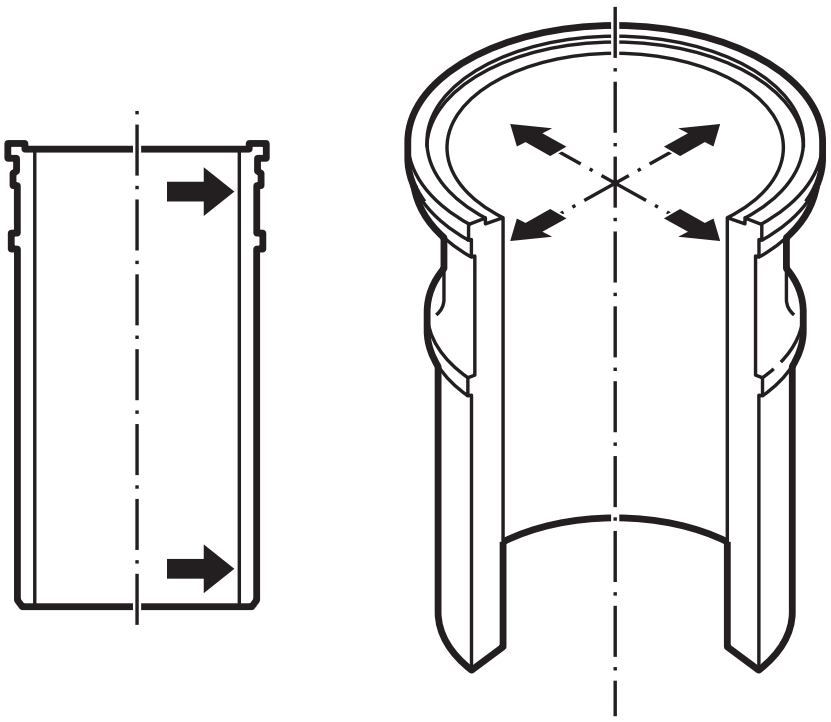
Liner Protrusion Specification



Liner over Engine Block Surface	
Measure	**mm**
Protrusion	*0.03 - 0.10

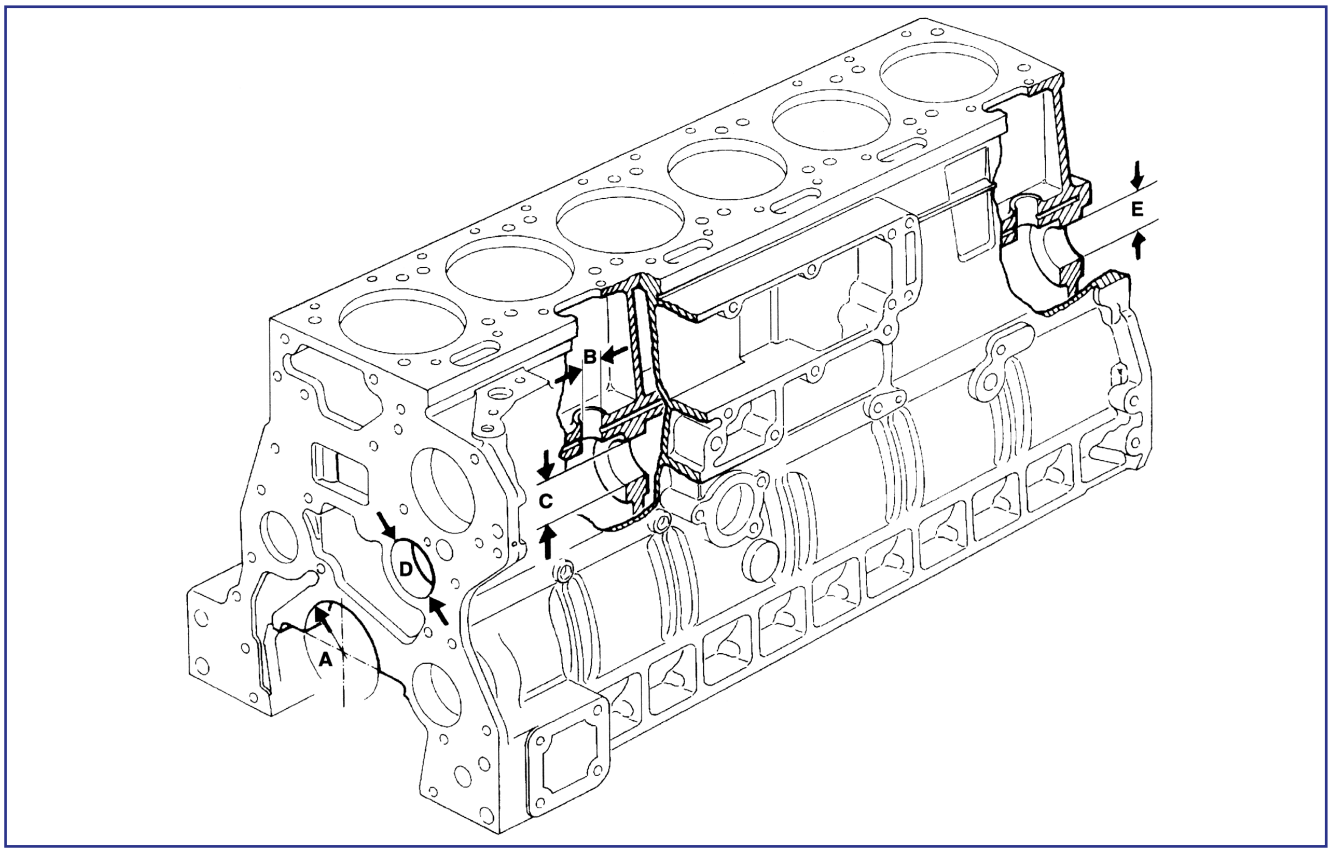
*Affect emissions level

Liners Specification



Liners	
Measure	**mm**
Maximum waste	0.06
Out-of-roundness	0.02
Ø Inner	105.000 - 105.022

Engine Block Specifications

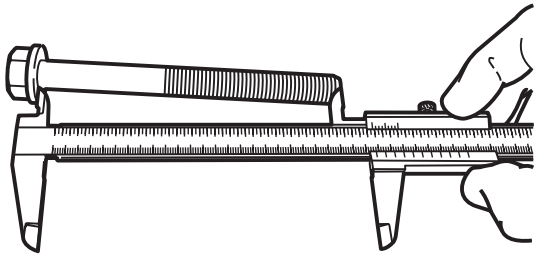


Main Bearings (A)	
Diameter	**mm**
Inner	92.000 - 92.022

Tappets Housing (B)	
Ø Inner	**mm**
standard, nominal	18.000 - 18.018
standard, maximum	18.020
1st repair	18.500 - 18.518

Measure main bearings bolt lengths.

Discard bolts longer than 133.5 mm.



Camshaft Bearing (C) and (E)	
Ø inner	**mm**
without bushing	
standard nominal	50.000 - 50.025
maximum	50.045
1st repair	
without bushing	54.000 - 54.030
with bushing	49.990 - 50.050

Camshaft Bearing (D)	
Ø inner	**mm**
without bushing	54.000 - 54.030
with bushing	49.990 - 50.050

***Remark.:** Camshaft bearing (D) has originally bushing and the others do not. When it is necessary the other bearings can receive bushing as repair.

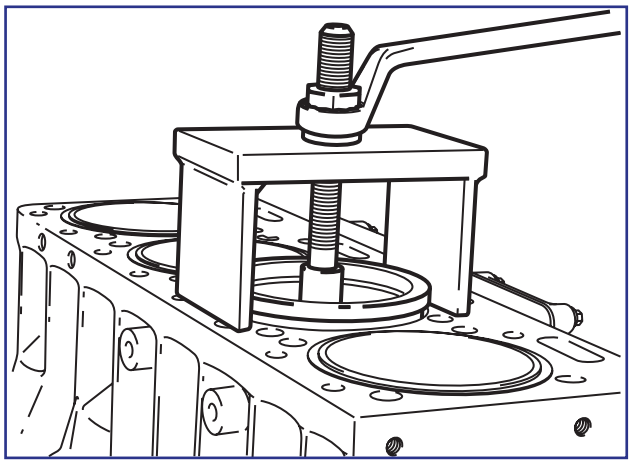
Inspections and Measurements

Liners removal

Using the special tool MIM Nº 9.610.0.690.017.6, remove the liners carefully in order to avoid damages to the block and/or liners.

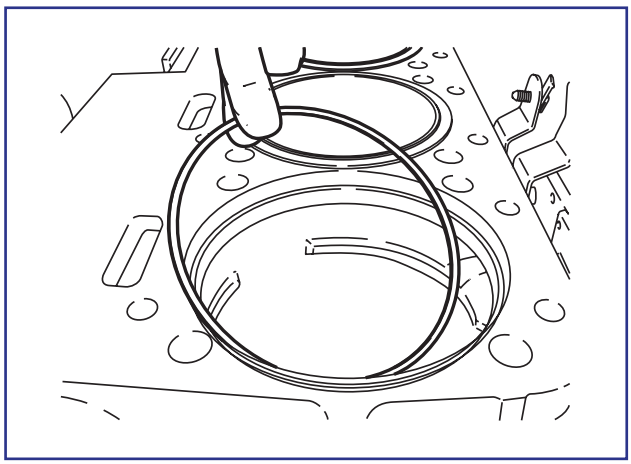
Fit the lower part of the tool to the liner lower border.

The liner must be removed by rotating the nut from the screw extractor to the clockwise.

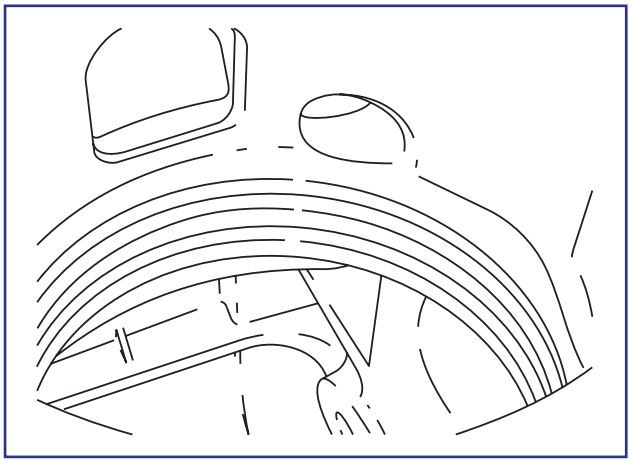


Remove the Inox liners rings.

Clean the block and cylinder head surface that must be free of wear, dirty and impurities.



Remove and install new sealing O-Rings.



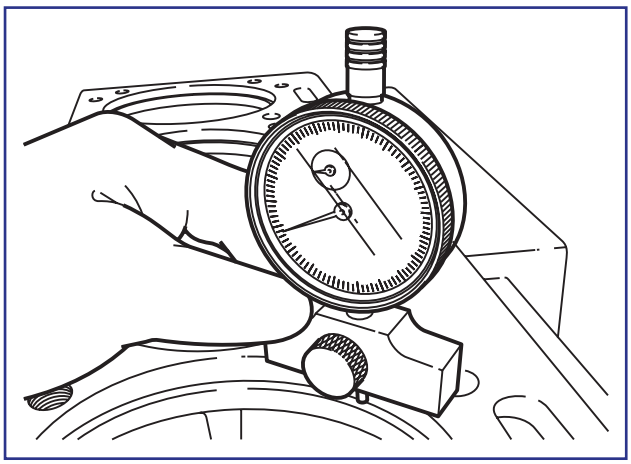
Cylinder liner instalation

Cylinder liners and Inox Ring

Proceed 4 measures distant 90 degrees each in the first step of the liner. Prefer to adopt points close to the cylinder head assembling holes.

Important:

- Considering the same cylinder, the difference between the four points can't be higher than 0,02 mm;
- Always use calibrated instruments.



To obtain the correct protrusion measurement, use the Inox rings with different thickness values.

Install new inox rings (only one for each cylinder)

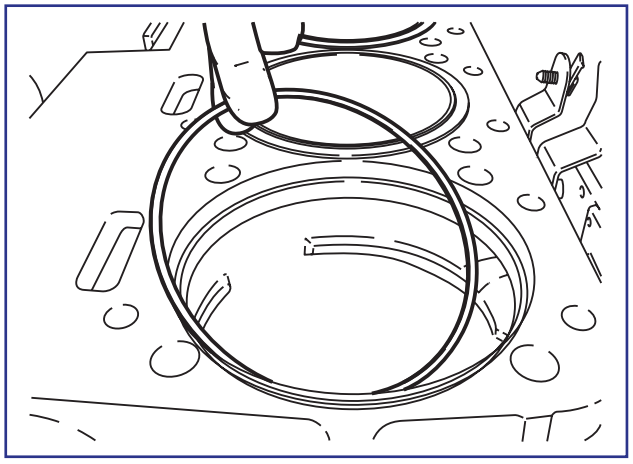
Inox ring thickness available:

9.610.8.340.038.4 = 0,10 mm

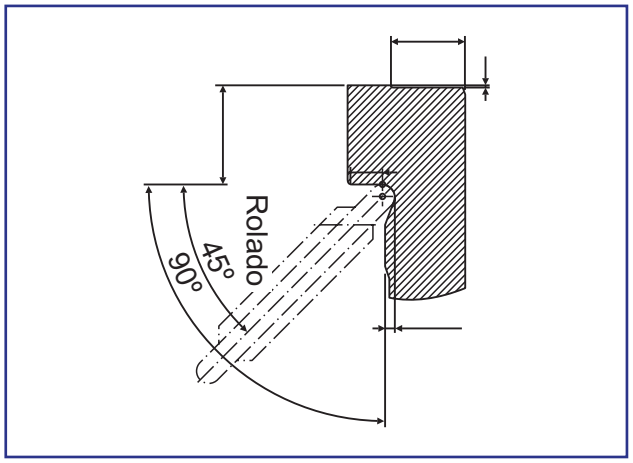
9.610.8.340.039.4 = 0,15 mm

9.610.8.340.040.4 = 0,25 mm

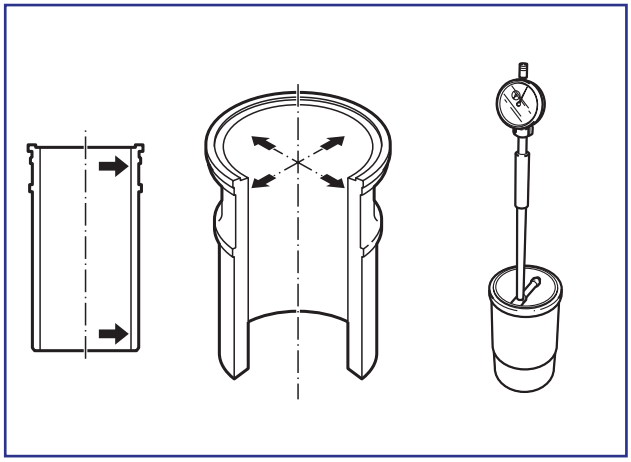
9.610.8.340.041.4 = 0,40 mm



The cylinder liner owns rolled ratio to minimize residual tension load and specific shape to provide contact with cylinder gasket.

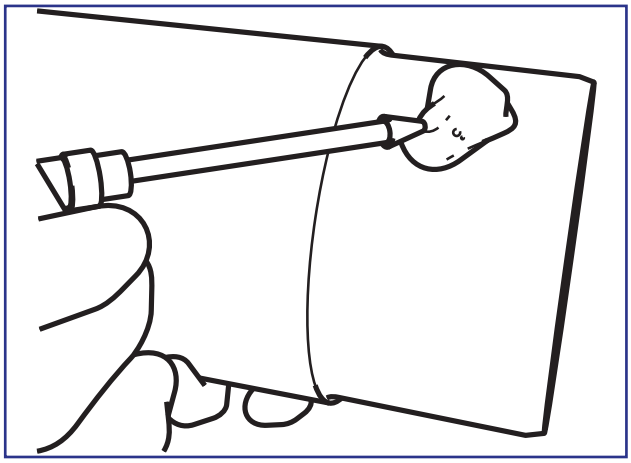


Liners Inspection	
Measure	**mm**
Maximum waste	0.06
Out-of-roundness	0.02
Ø Inner	105.000 - 105.022



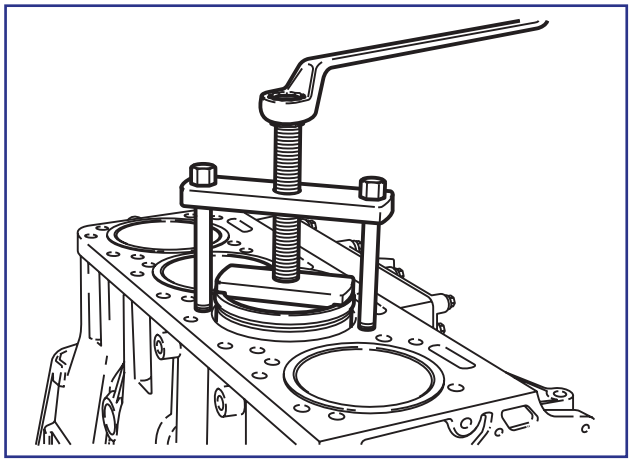
Lubricate the liners with engine oil applying the oil to the sealing rings contact area.

Install manually the liners to the cylinder housing.

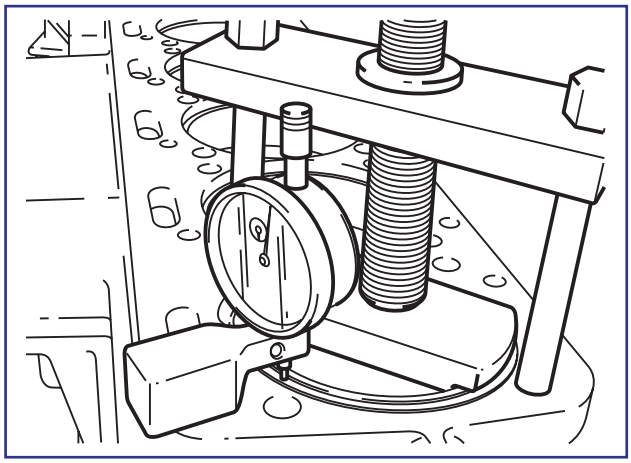


Note: The O-ring must be completely clean to avoid possibility of torsion, cut or damages during assembly procedure that may cause oil with water moisture.

Compress the liner to the housing with the special tool MIM No. 9.610.0.690.025.4 and apply a torque of 25 N.m.

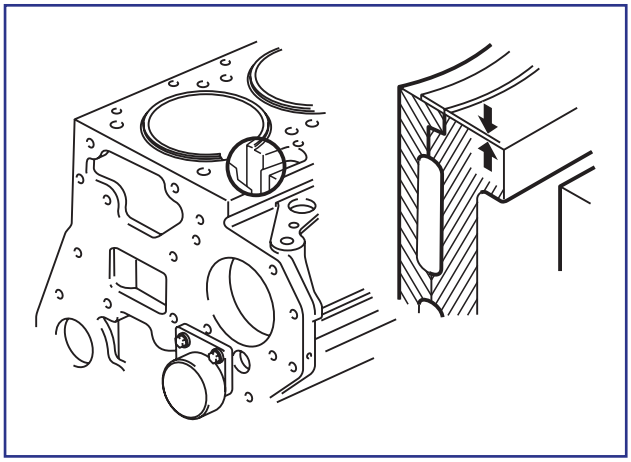


Using a dial indicator gauge, measure the liner protrusion to the block surface.

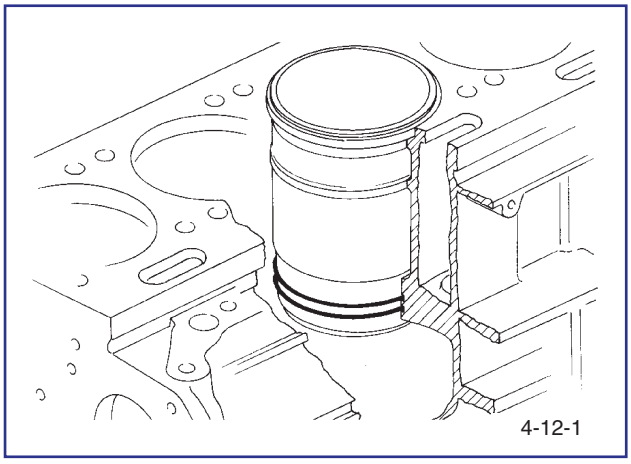


The protrusion must be measured considering for 4 points equal distant each other.

The protrusion must be **0,03 mm to 0,10 mm**, otherwise the liner must be removed and select a new inox ring.



Rings correct position with the assembled liner.

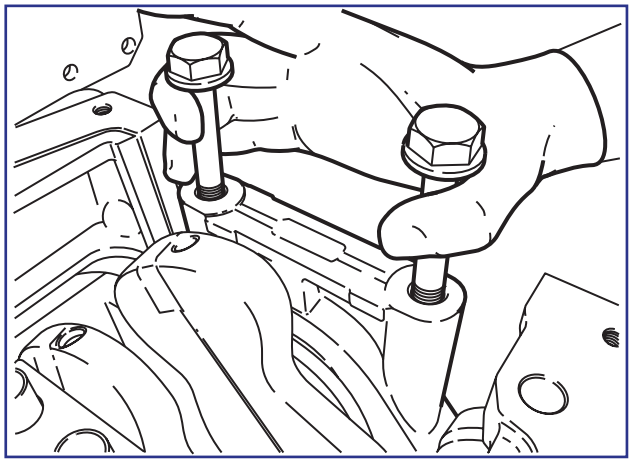


NOTES

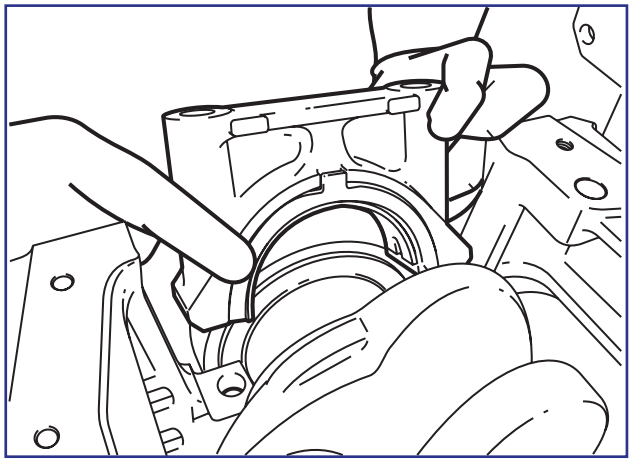
Crankshaft

Disassembly Notes

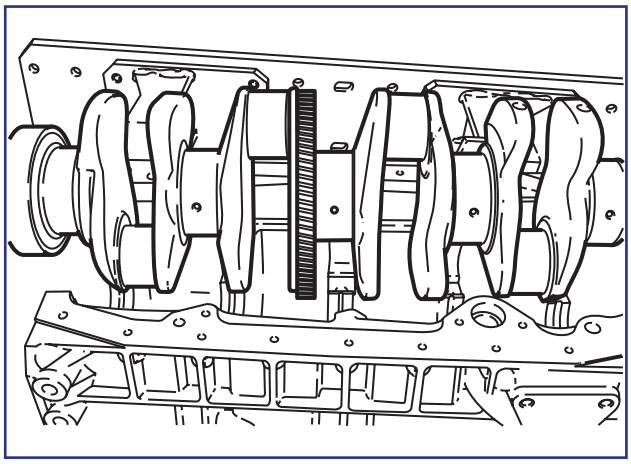
After removing the carter, pistons and connecting rods, flywheel and pulley, position the engine on the stand in upright position and loosen the main bearing caps. To remove the bearing caps use the fixation bolts.



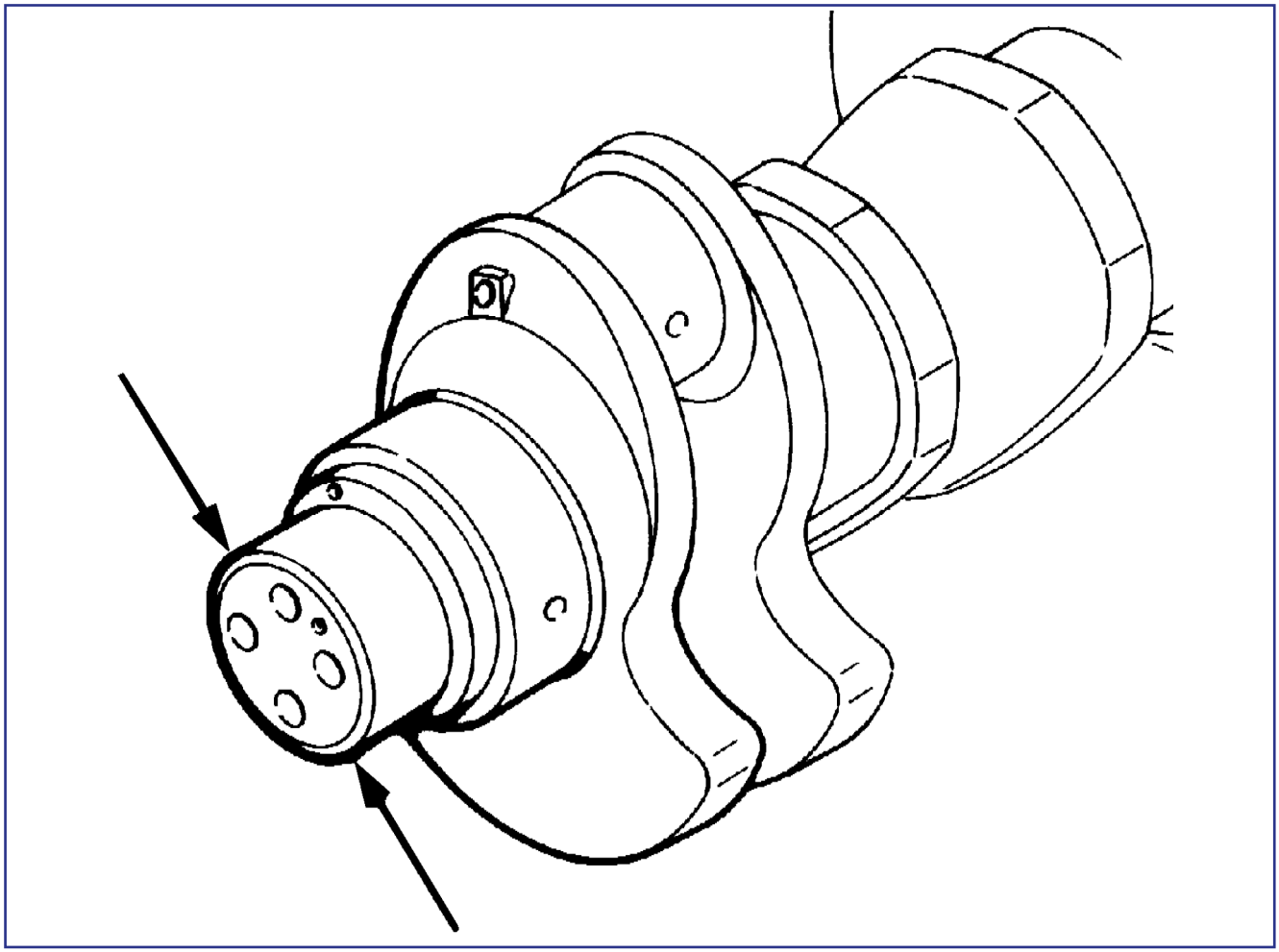
Remove the axial thrust ring from bearing #1 (flywheel side).



Carefully remove crankshaft in order to do not hit on any part of the engine block, avoiding damaging it. The storage of the crankshaft must always be done in upright position, avoiding any warping possibility.

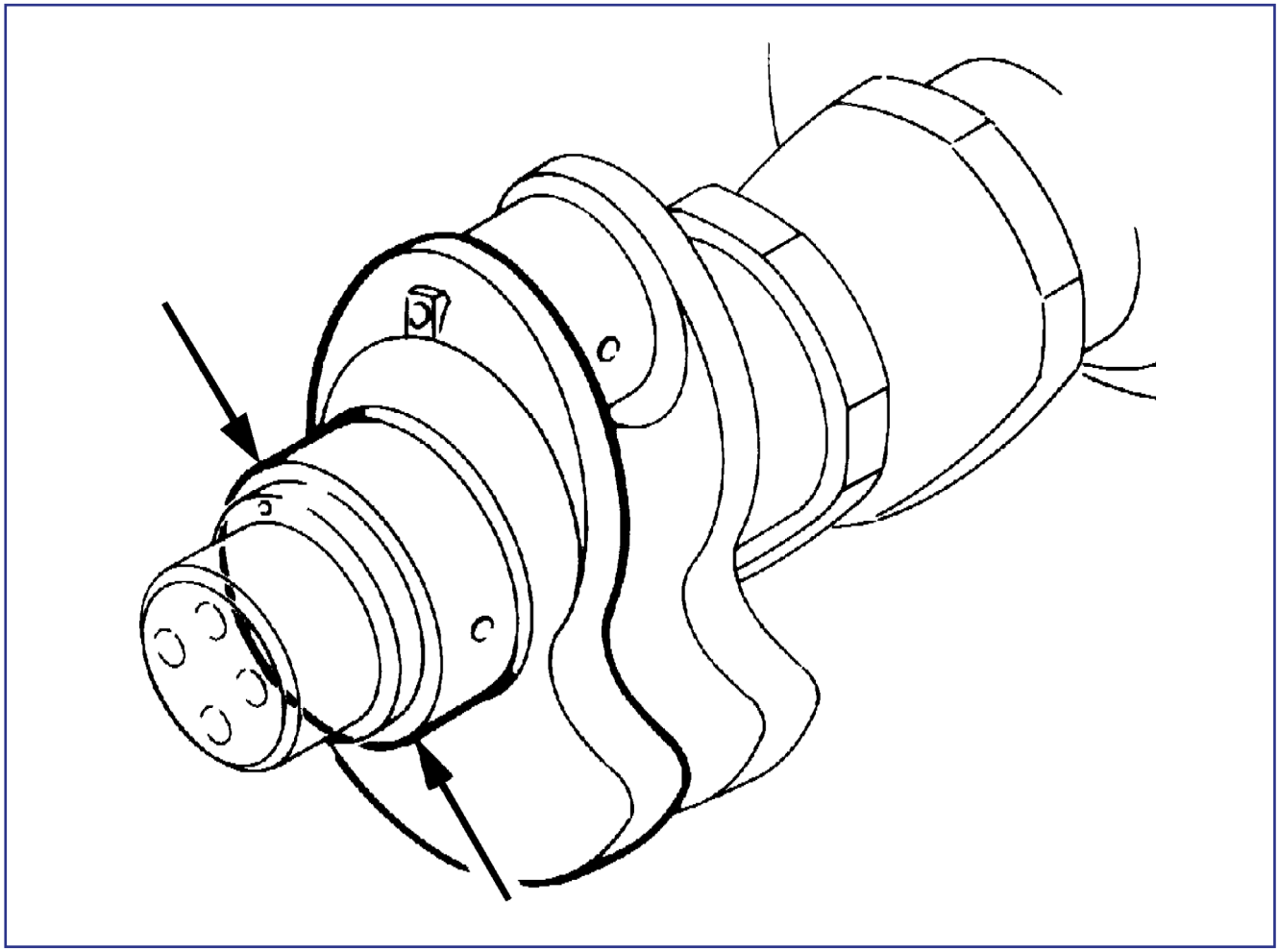


Crankshaft Specification



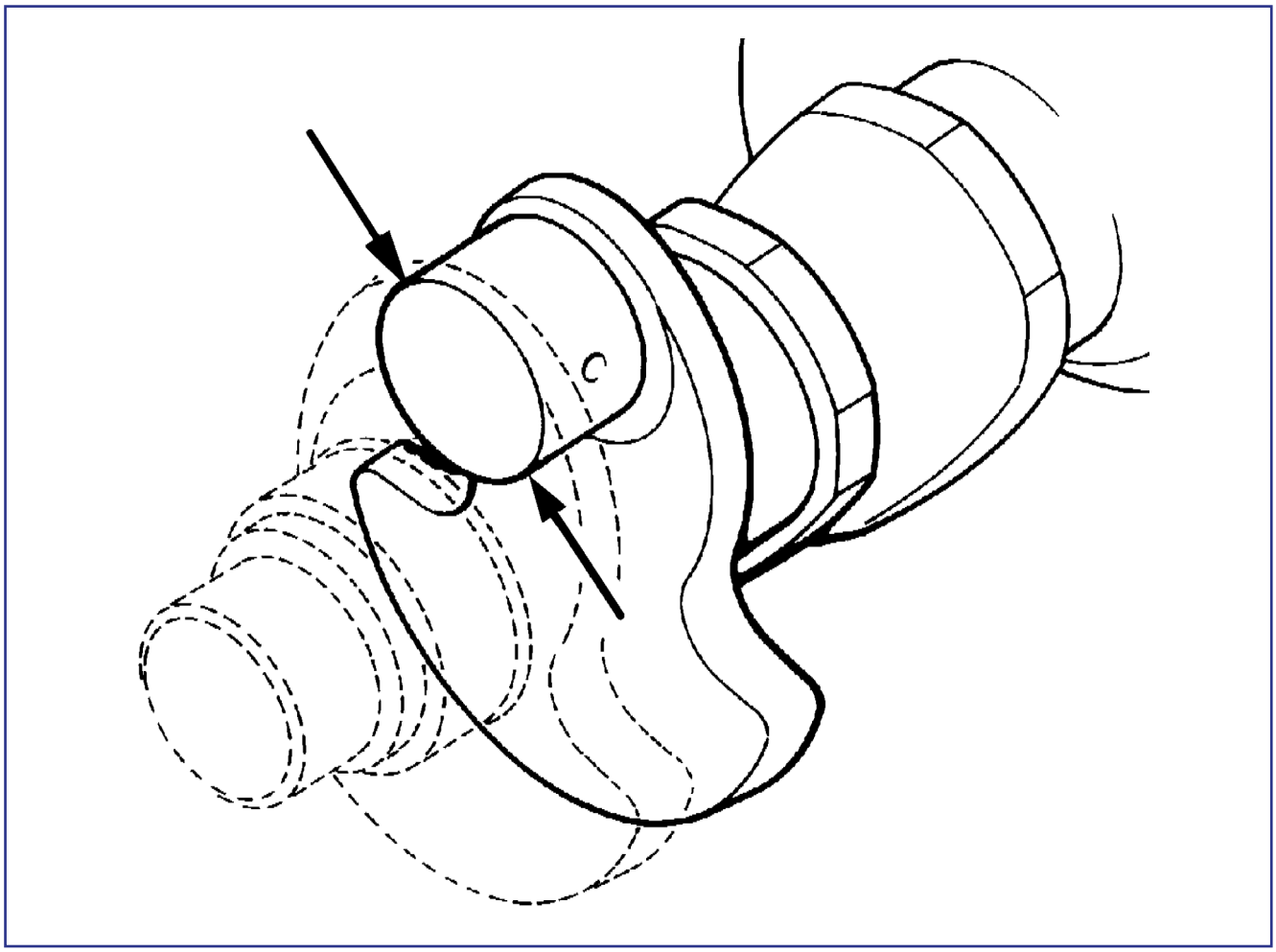
Gear	
Diameter	**mm**
Seat	60.020 - 60.039

Main Journals Specification



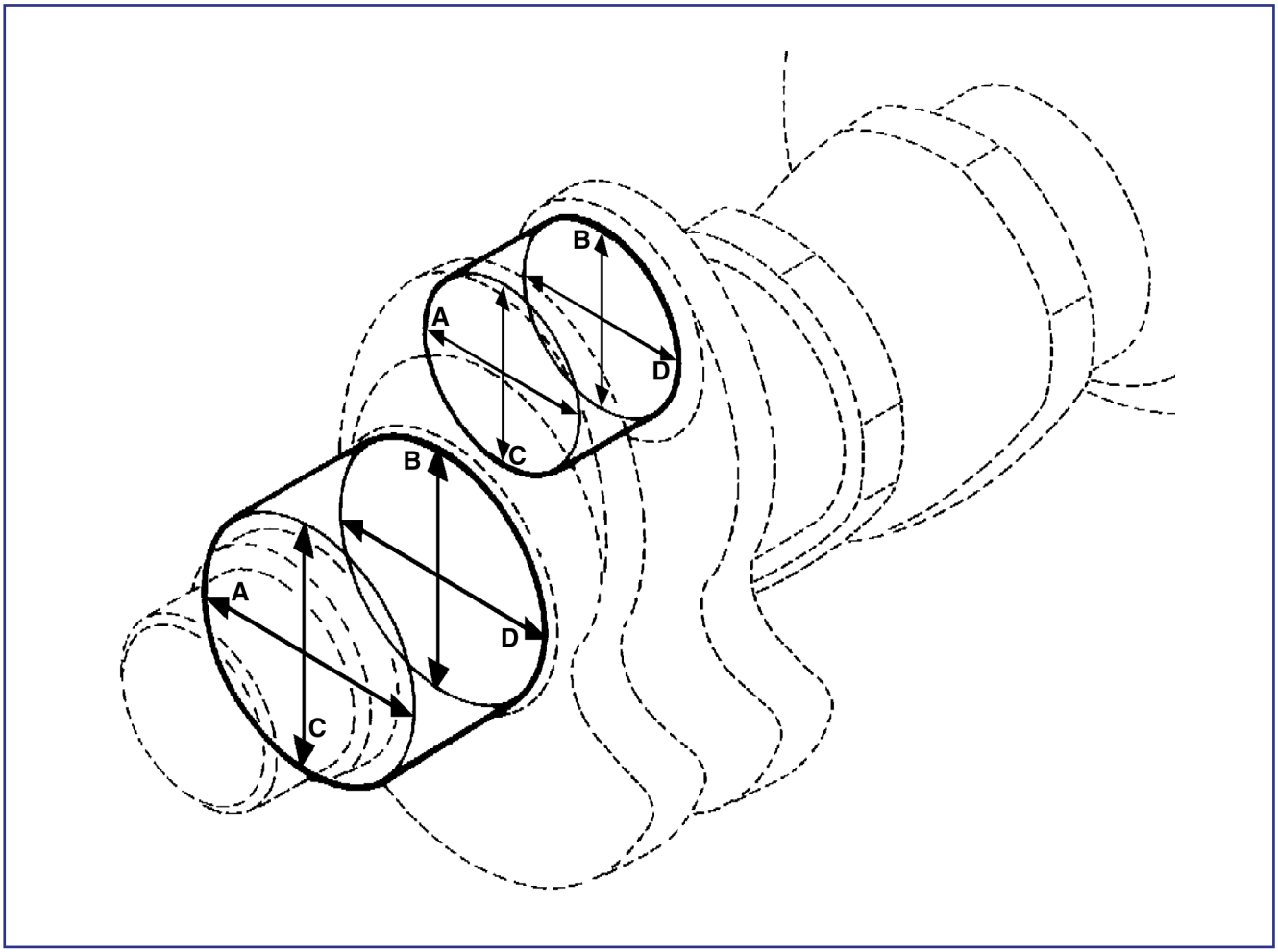
Main Journal	
Diameter	**mm**
Standard	85.942 - 85.964
1st repair	85.692 - 85.714
2nd repair	85.442 - 85.464
3rd repair	85.192 - 85.214
4th repair	84.942 - 84.964

Crankpins Specification



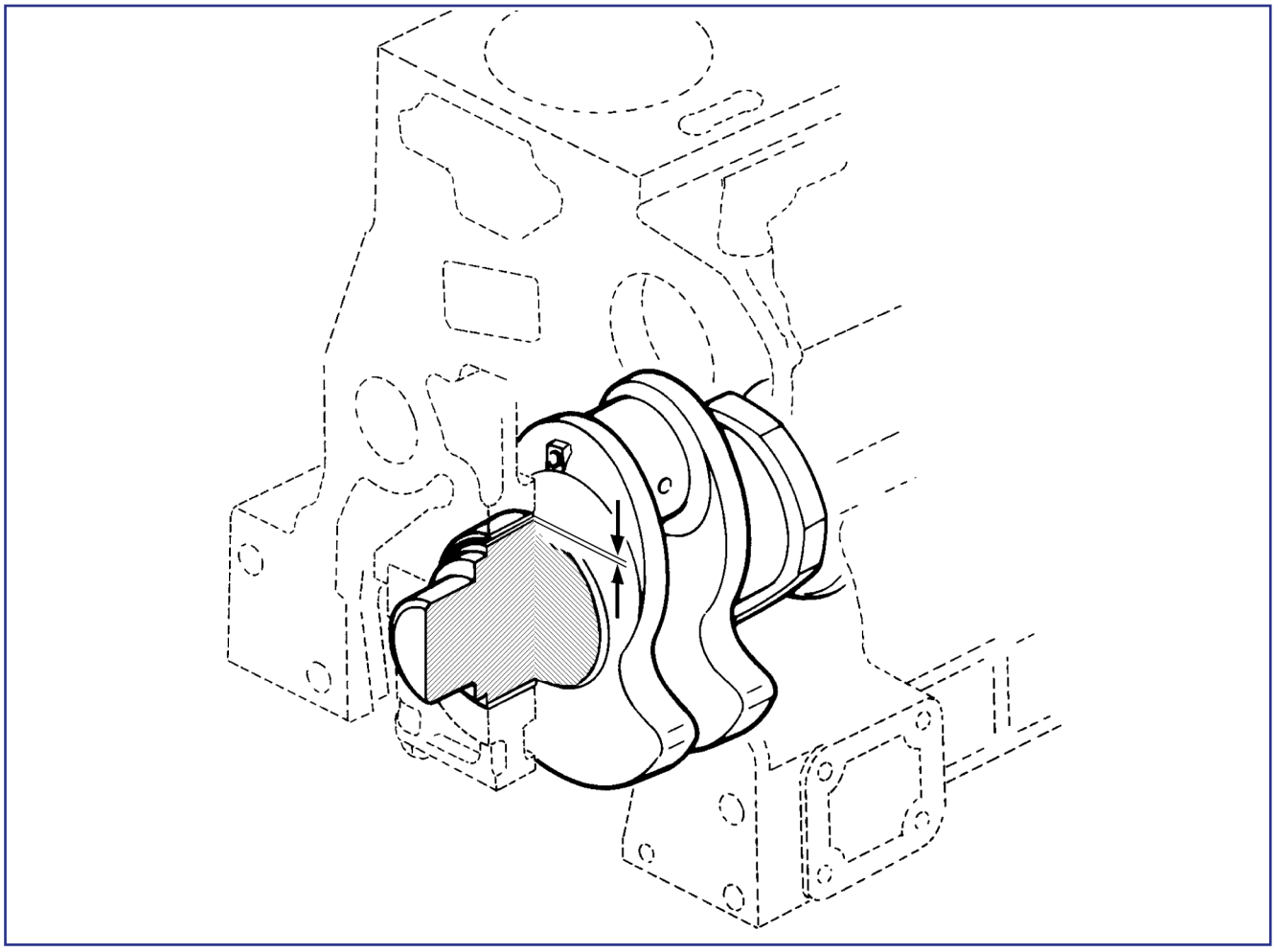
Main Journal	
Diameter	**mm**
Standard	62.951 - 62.970
1st repair	62.701 - 62.720
2nd repair	62.451 - 62.470
3rd repair	62.201 - 62.220
4th repair	61.951 - 61.970

Out-of-roundness and Taper Specification



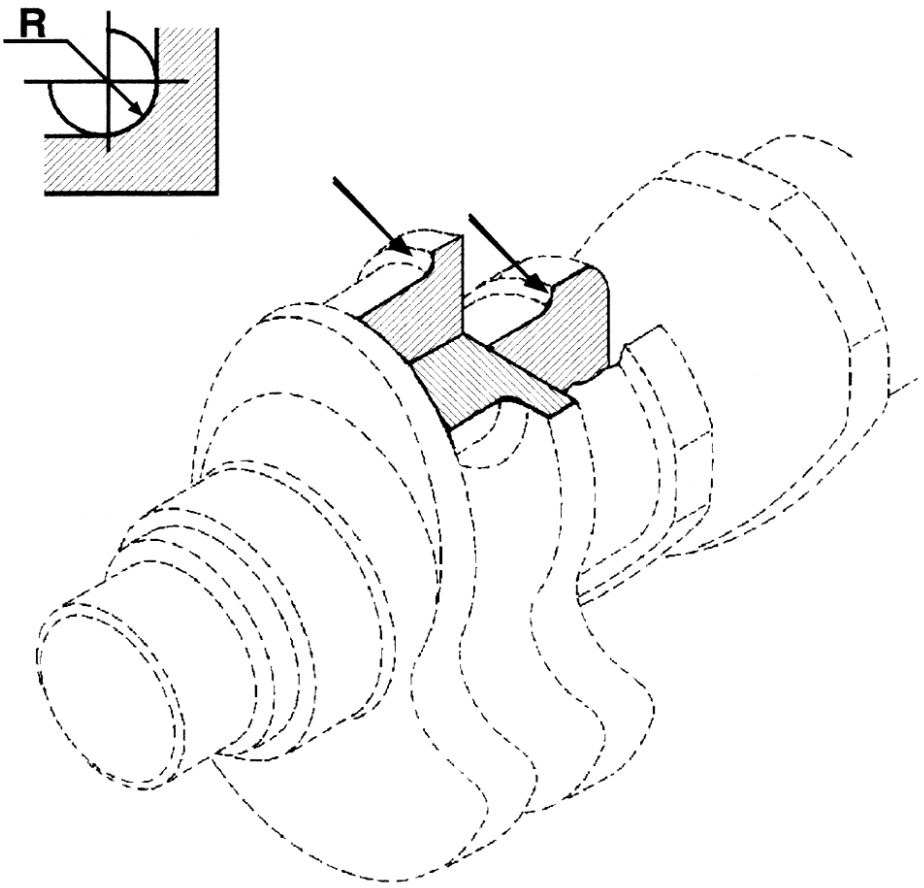
Maximum Out-of-roundness	mm
A x C and B x D	0.01
Maximum Taper	**mm**
A x B and C x D	0.01

Radial Clearance



Radial Clearance (except central main journal)	mm
nominal	0.036 - 0.096
maximum	0.245

Fillets



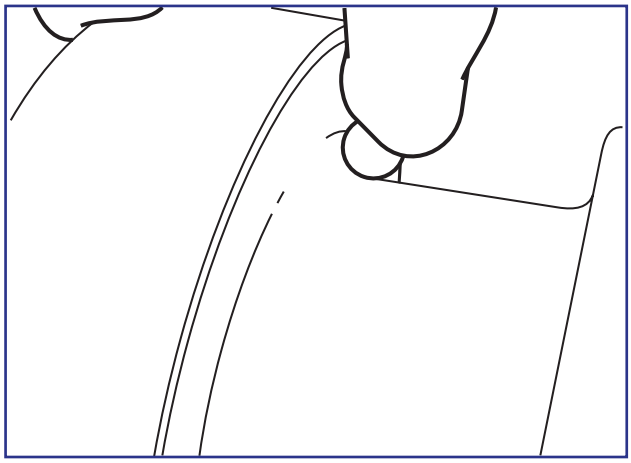
Fillet	mm
Nominal	3.8 - 4.0

Pre-Assembly Inspections and Measurements

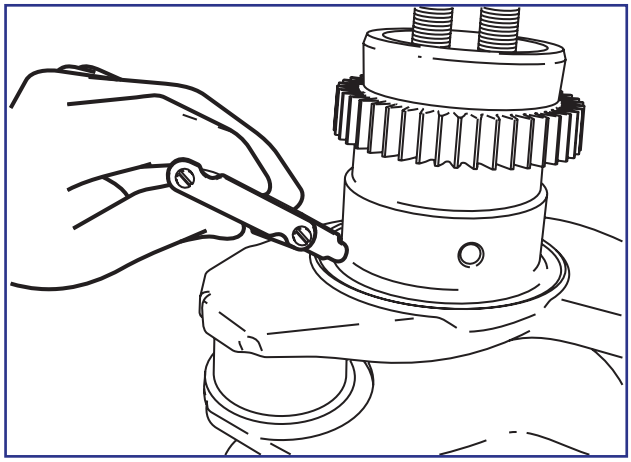
Crankshaft

Crankshaft, as well as the bearings, can be visually checked. It is necessary to check for overheating signs, deep scratches, cracks or other types of damage. Presenting anyone of these damages it is necessary to check the possibility of machining and to use oversized bearing shells.

Measure the fillets with a calibrated sphere.



The measurement of the fillets can also be performed with a radius shim.

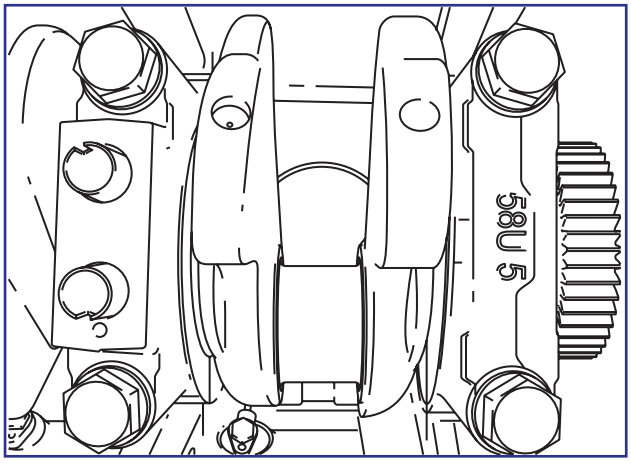


Engine Block Bearings

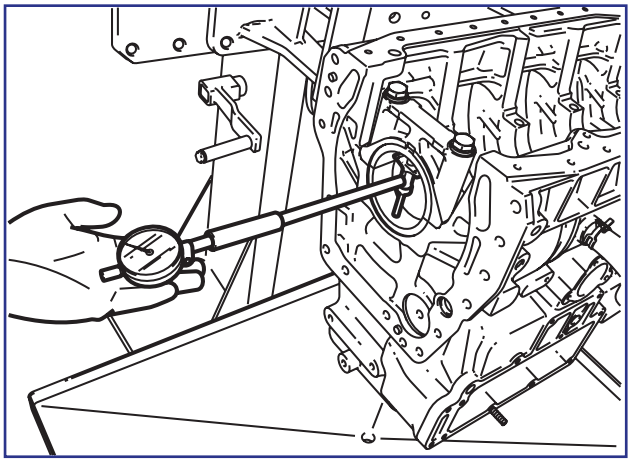
Before doing any check on the caps and main bearings, make sure that the numeration engraved on the engine block corresponds to the bearing cap.

Install bearing caps and tighten according to the specification.

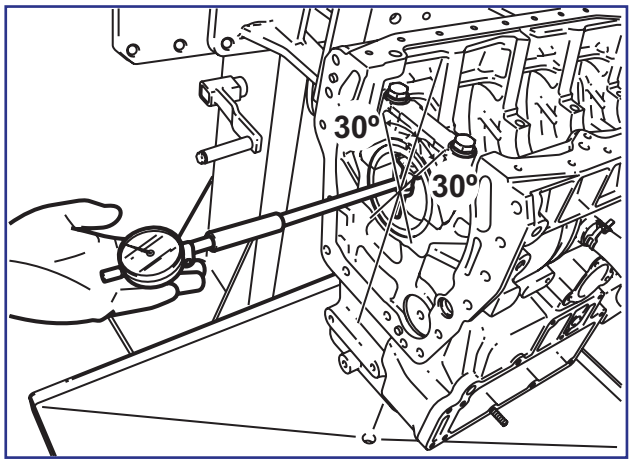
1st	50-5 N.m
2nd	150° ± 5°
Torque Range	170 to 282 N.m



Measure bearings diameter, out-of-roundness and taper without bearing shells.

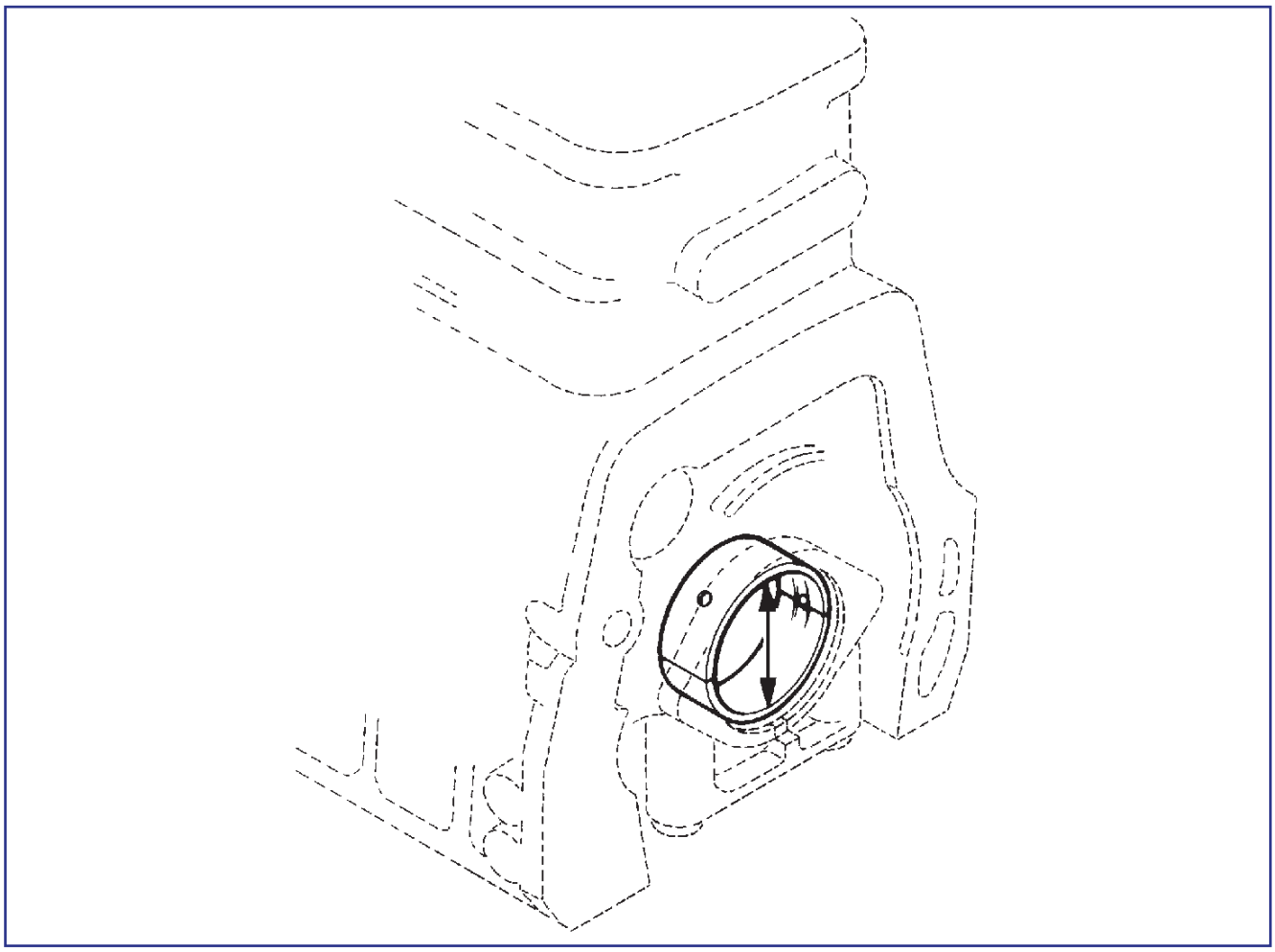


Measure bearing with the bore gauge at 30° to the left and 30° to the right from the central position.



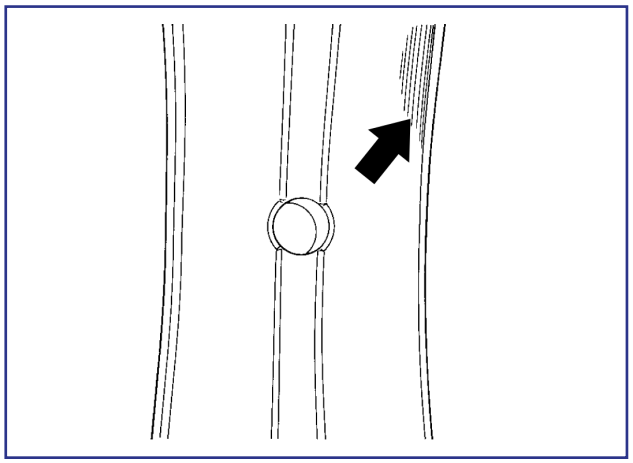
Bearing shells

Main Bearings Specifications

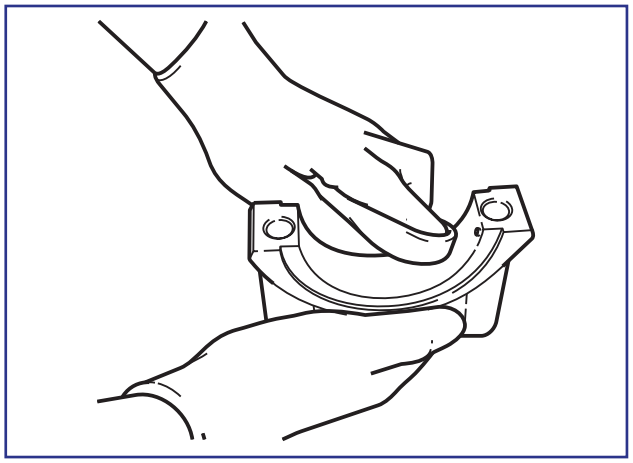


Engine Block	
Diameter	**mm**
Without bearing shell	92.000 - 92.022
Engine Block	
Diameter	**mm**
Standard	86.000 - 86.038
1st repair	85.750 - 85.788
2nd repair	85.500 - 85.538
3rd repair	85.250 - 85.288
4th repair	85.000 - 85.038
Pre-tension	0.025 - 0.060

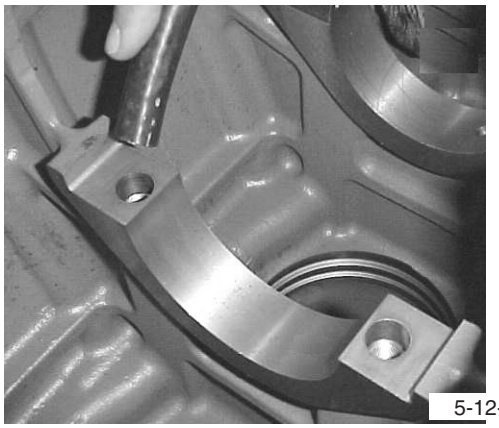
Depending on the presented defect on the bearing shells it is possible to identify what is the problem of the engine: excessive clearance, out-of-roundness or taper. A failure or excessive clearance also can be detected by the reduction of the lubricant oil pressure. The prolonged operation with low oil pressure can cause beats and vibrations in crankshaft and consequently early deterioration of the bearing shells.



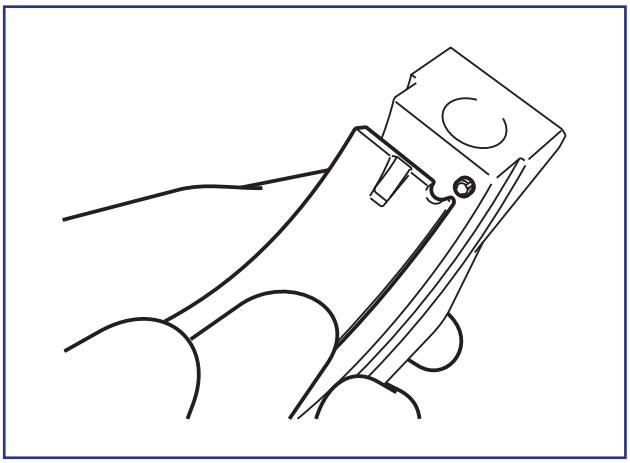
To perform the measurement of the bearings with the bearing shells installed, well clean the bearing cap, avoiding distortion due to oil or dirt presence.



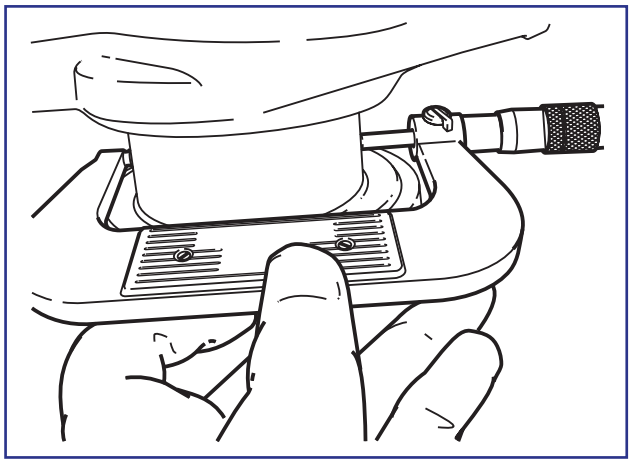
Also clean bearing bolt holes. The holes must be completely free of oil residues, splinters and impurities.


5-12-3

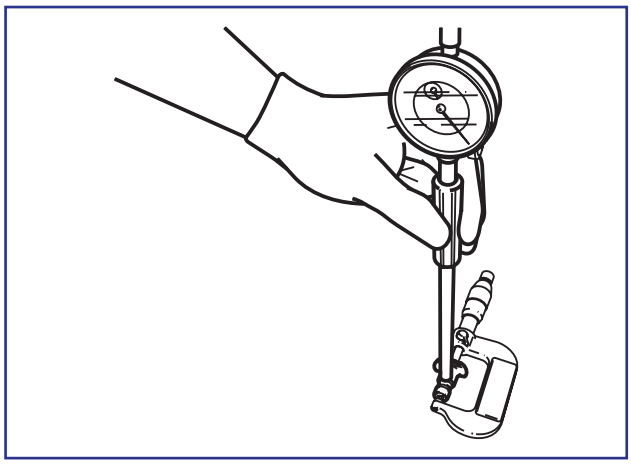
Position the bearing shells with the aid of the expansion pin.



Measure the crankshaft.The measurements must be taken twice at 90° and in the two edges of the bearing, checking crankpins and main journals out-of-roundness and taper.

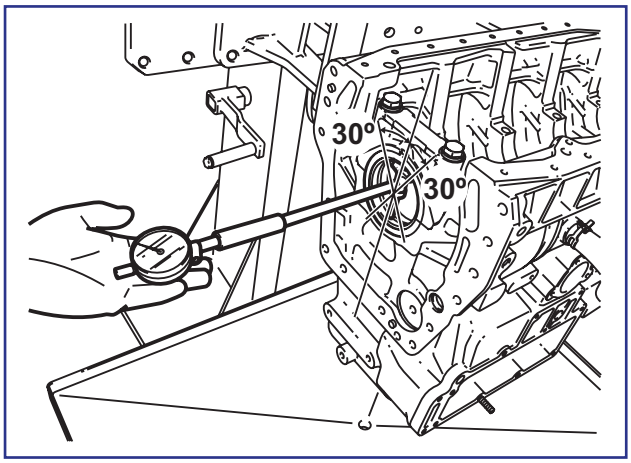


Compare the clearances obtained on the crankshaft through the bore gauge.



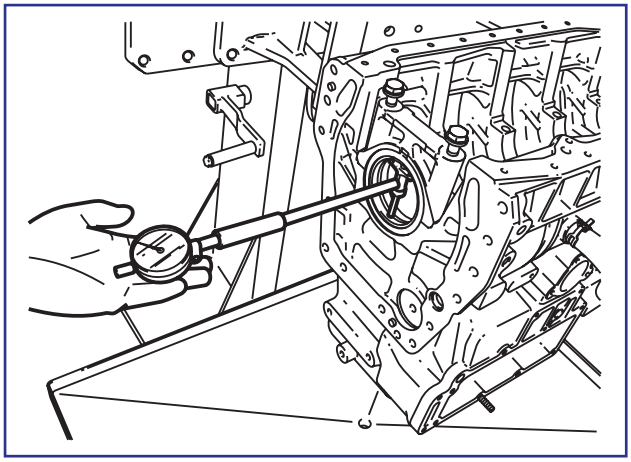
Assembly bearing caps and tighten according specification. Perform the measurements in the same way that they were performed for the bearings without bearing shells to obtain the radial force.

The 1st measurement is made in the centre of the bearing.



Remove one of the bolts of the bearing and measure bearing pre-tension.

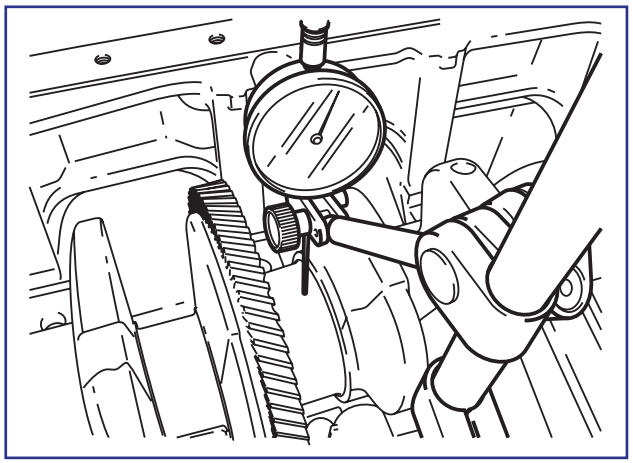
Pre-tension: 0.025 - 0.060 mm.



Crankshaft

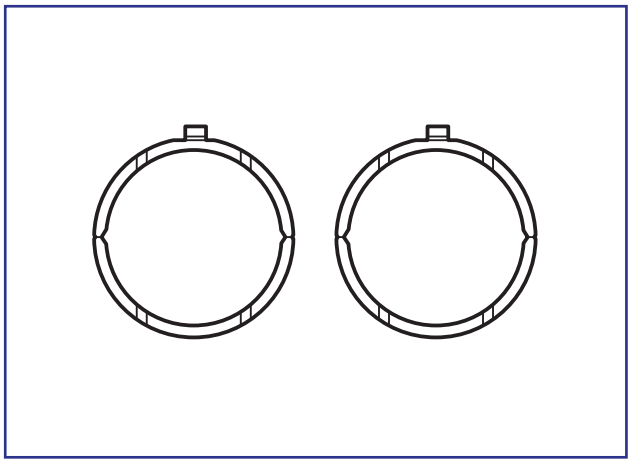
With the bearing shells of the first and last bearings only installed and oiled, place crankshaft. With a dial indicator gauge on the central main journal, turn crankshaft and measure warping.

	4 cyl.	6 cyl.
Maximum Warping (mm)	0.11	0.15



Check crankshaft thrust rings. Check for damages existence or excessive waste. In the assembly, the side with two grooves must be toward the shaft.

When necessary it can be used over-sized thrust ring, which must have its flat surface adjusted, in order to get the necessary axial clearance.

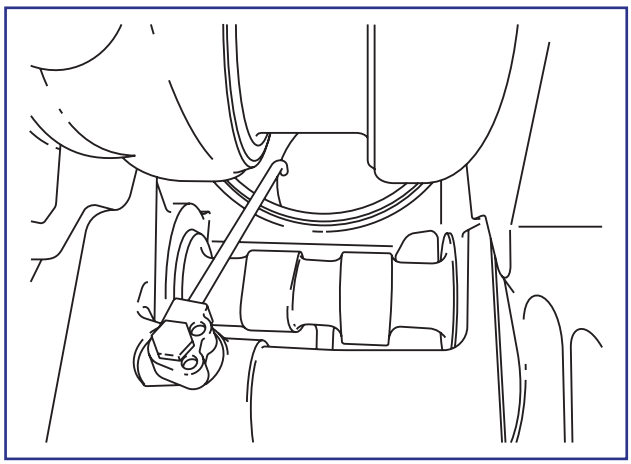


Crankshaft Thrust Ring	
Thickness	mm
Standard	3.42 - 3.47
Over-size	3.67 - 3.72

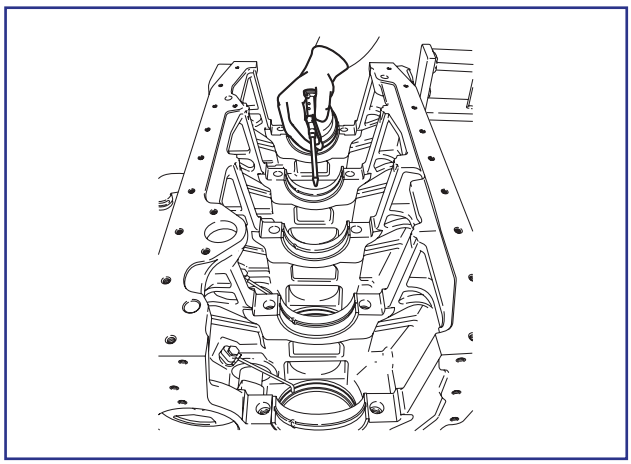
Assembly

Install piston cooling oil injectors. Observe if the two guided pin are correct fitted to the block holes.

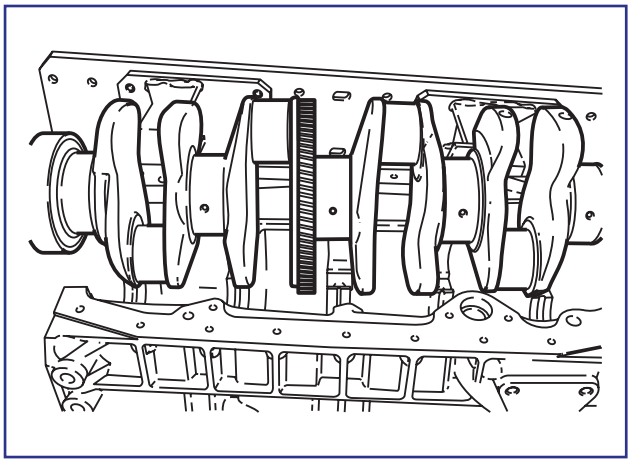
Apply torque of 10 ± 1.5 Nm.



Install and oil all bearing shells.

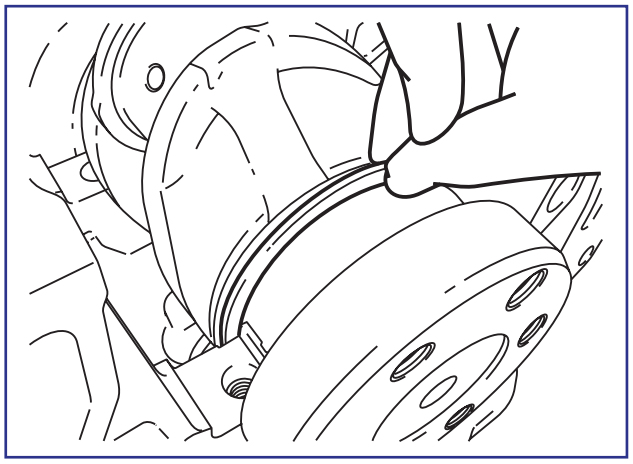


Install crankshaft.



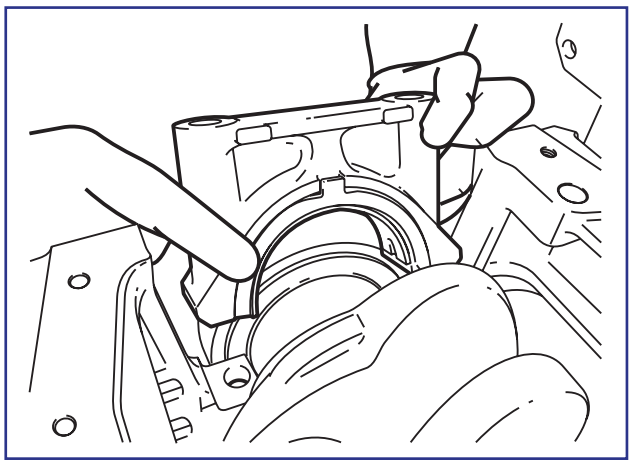
Bolts Tighten Torque Specification	
Step	
1st:	50 - 5 Nm
2nd:	155° ± 5°
Lmax	133.50 mm

Install first bearing lower thrust ring.



Attention: Thrust rings grooves must stay towards the crankshaft (mobile side).

Assembly bearing caps with the upper thrust ring.

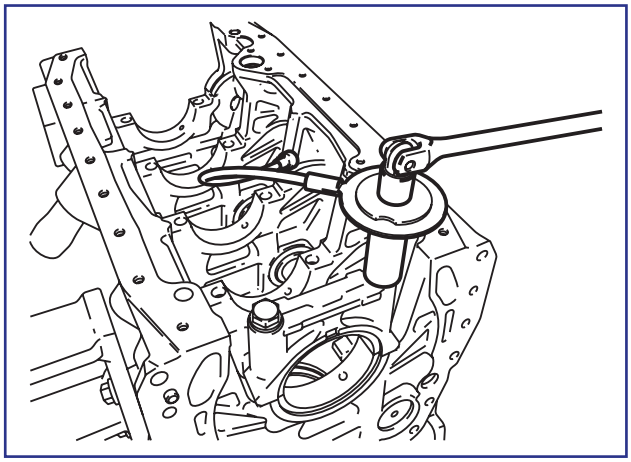


Thrust Ring	
Thickness	mm
Standard	3,42 – 3,47
Oversize	3,67 – 3,92

Tighten bolts in two steps and tighten according the specification.

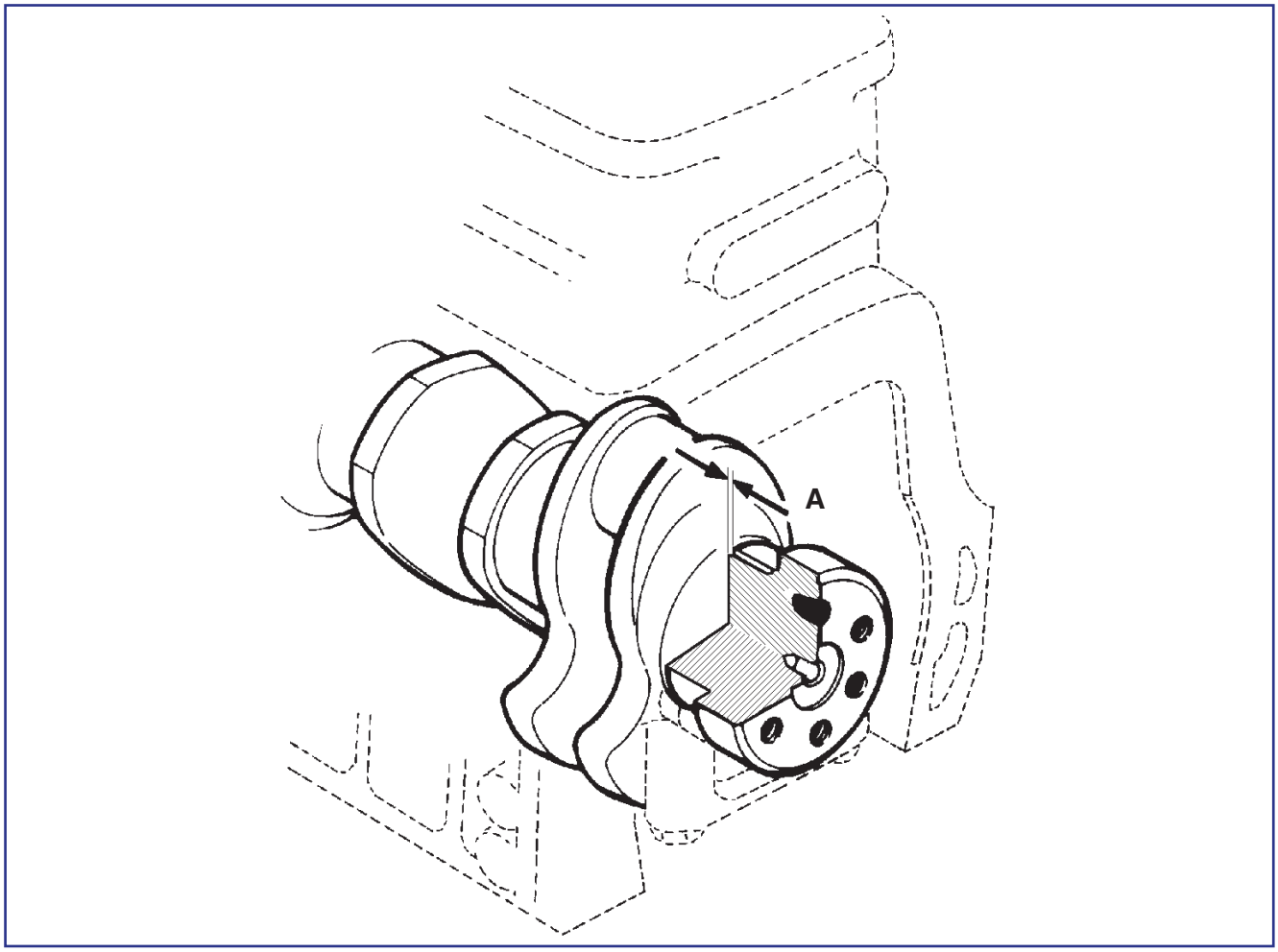
The torque must be applied from the center to the extremities.

1st	50-5 N.m
2nd	155° ± 5°
Torque Range	170 to 282 N.m

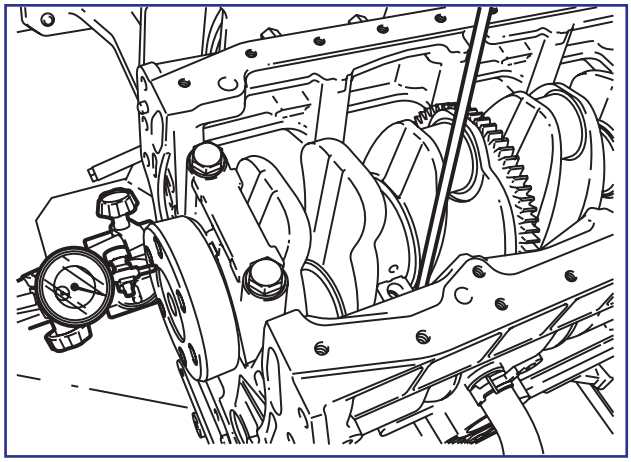


Measurements After Assembly

Axial Clearance Specification



Axial clearance (A)	mm
Nominal	0.08 - 0.25
Maximum	0.4



Measure the crankshaft axial clearance.

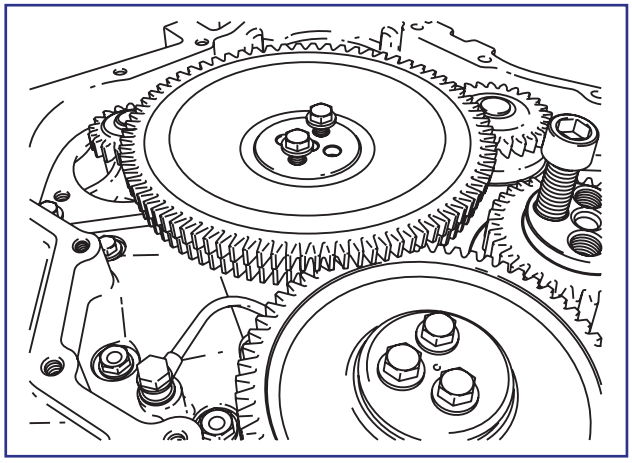
a. Set the dial indicator to zero.
b. Release the cap mouting bolt from one side of the cap.
c. Using a screwdriver push the cranckshaft to the crankshaft gear side.
d. Measure the dial indicator value.

NOTES

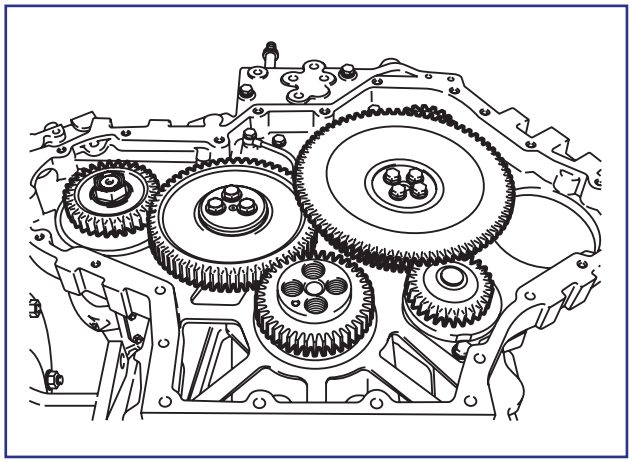
Camshaft

Disassembly Notes

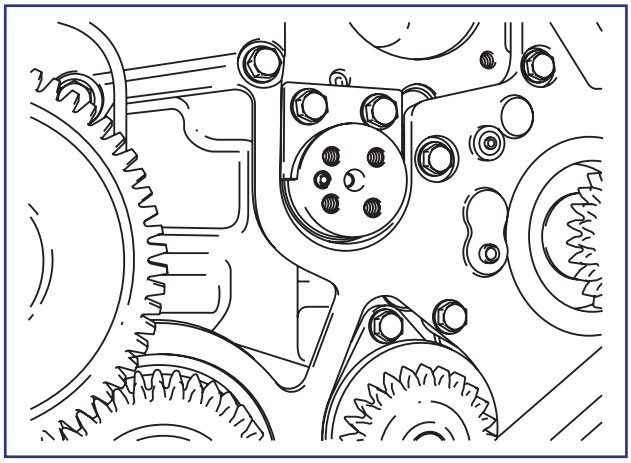
Remove high pressure fuel pump gear.



Remove camshaft gear.

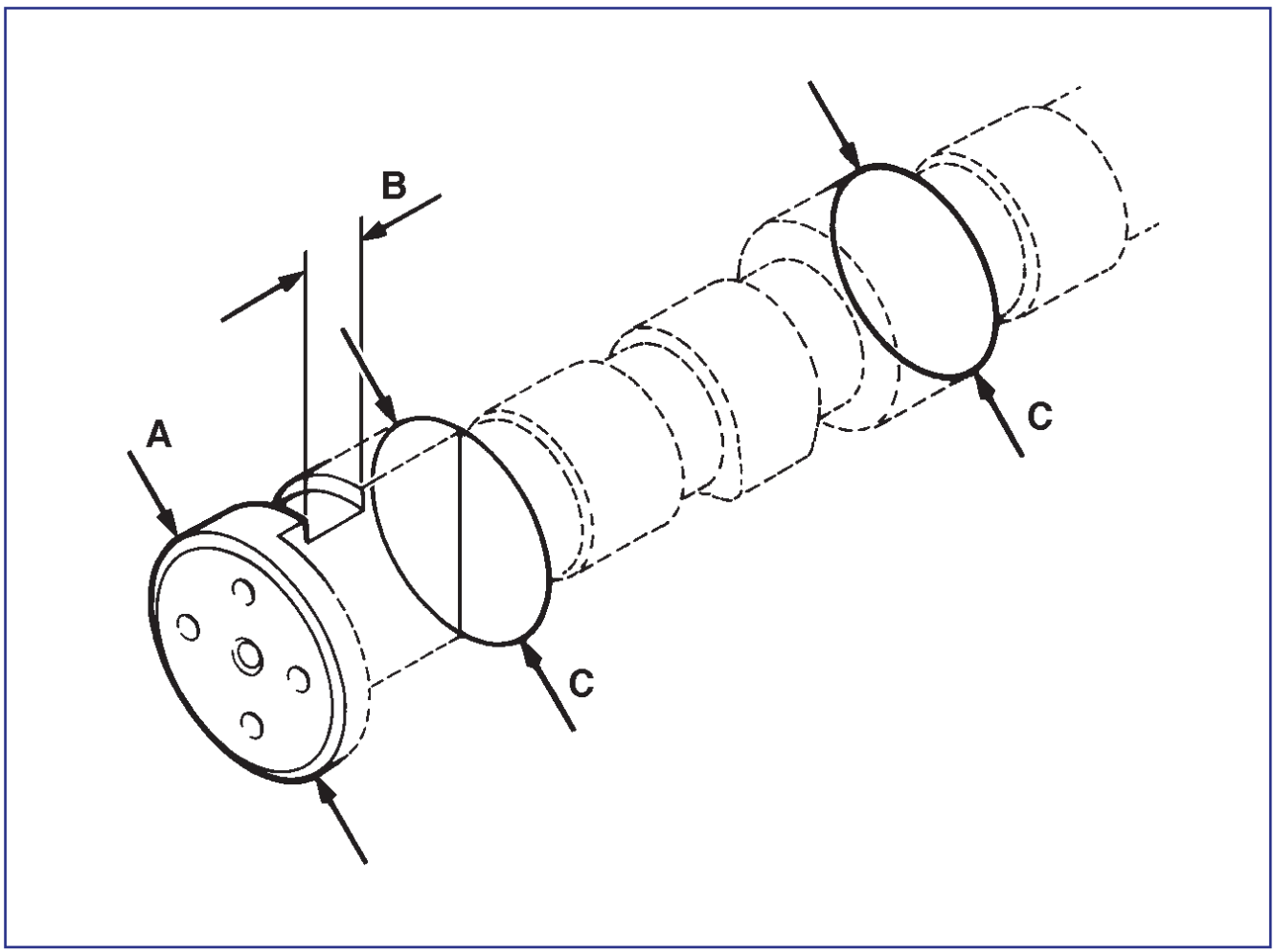


Remove camshaft lock.



Turn the engine, keeping the carter side upwards. Remove camshaft with the hands and through the front of the engine, making a movement of rotation. Take care to do not damage the bearings of the shaft and engine block. If necessary, remove the camshaft bushing from the engine block.

Camshaft Specifications



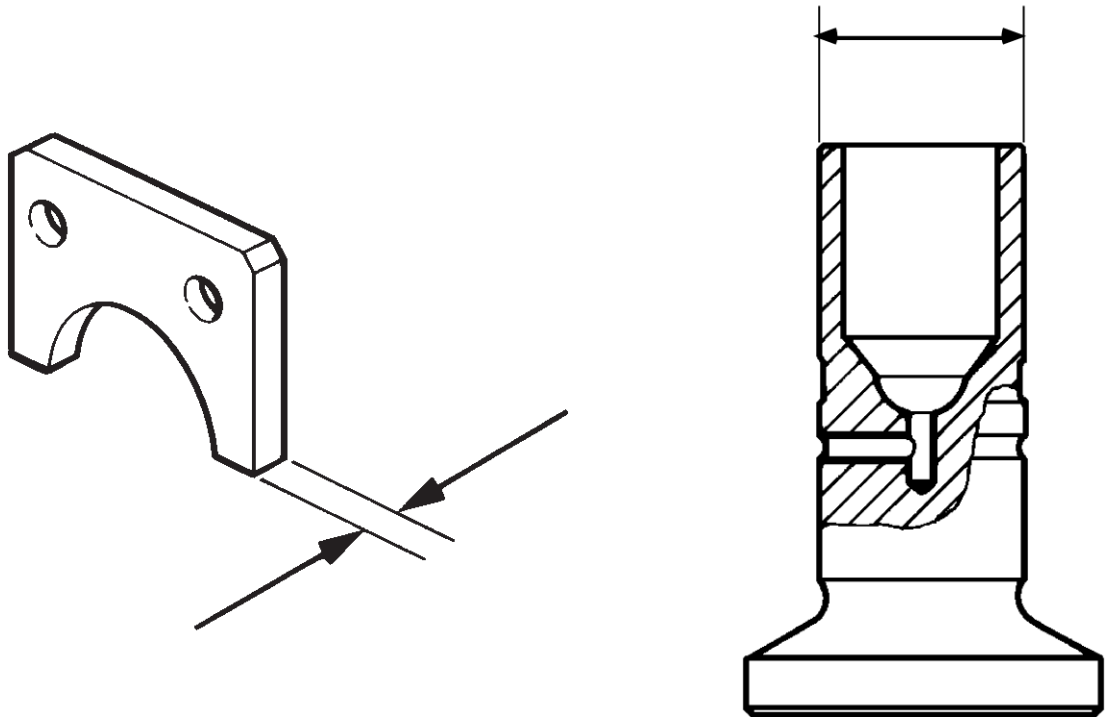
Gear seat	
Diameter (A)	**mm**
Nominal	51.971 - 51.990

Axial Clearance Limitation Groove	
Width (B)	**mm**
Nominal Maximum	7.100 - 7.190 7.275

Main journals	
Diameter (C)	**mm**
Standard	49.873 - 49.897

Main Journal	
Bearing Clearance	**mm**
Axial Radial Maximum warping	0.05 - 0.19 0.05 - 0.13 0,04

Tappets and Lock Plate Specification

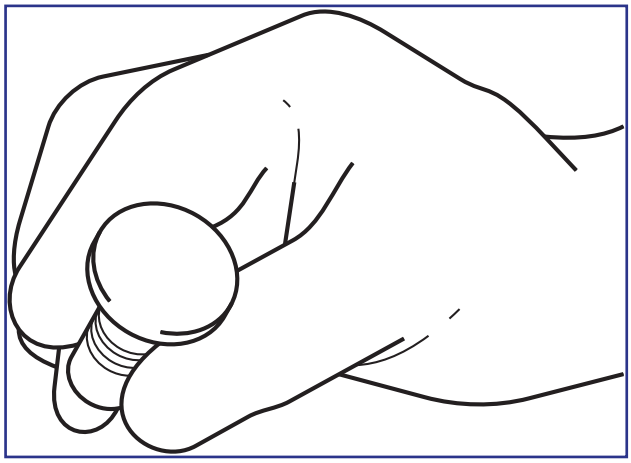


Lock Plate	
Thickness	**mm**
Nominal	7.00 - 7.05

Tappets	
Diameter (C)	**mm**
Standard Nominal Minimum	 17.983 - 17.994 17.975
1st repair Nominal	 18.483 - 18.494

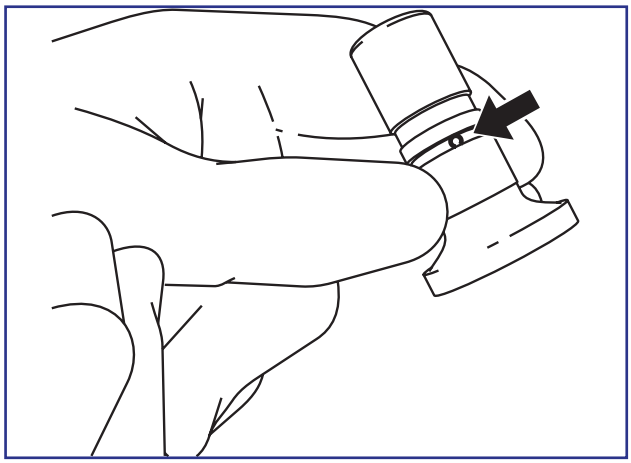
Pre-Assembly Inspections and Measurements

Visually check the tappets. Check if there are marks of excessive waste on the contact area with the cams of the camshaft.



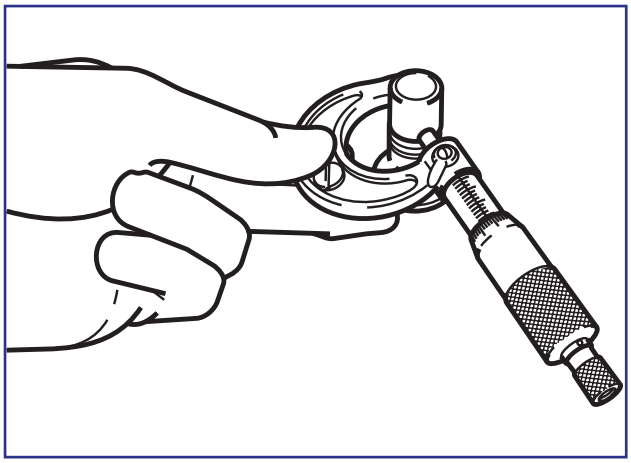
Attention: During its operation the tappets perform a rotating movement, responsible for a uniform distribution of the force, uniforming the waste. It must not have waste on only one area.

Visually check tappet lubrication holes.

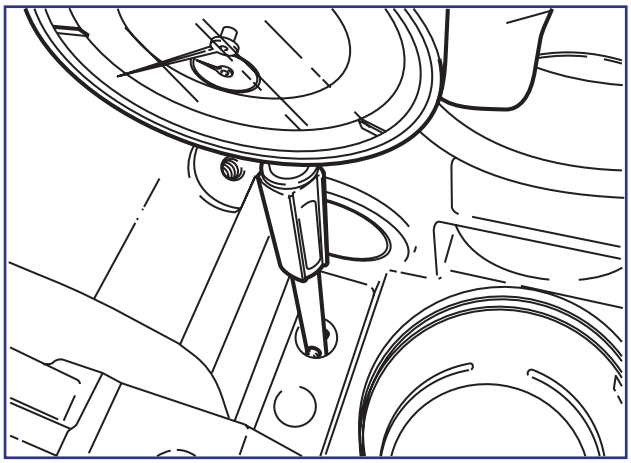


Attention: The lubrication holes of the tappets cannot be obstructed.

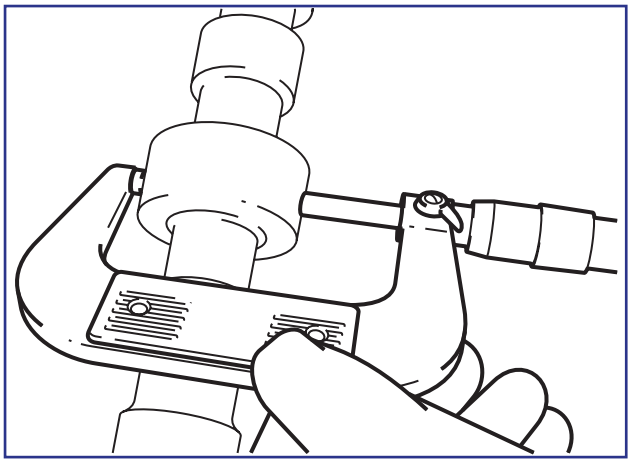
Measure the diameter and out-of-roundness of the tappets housing.



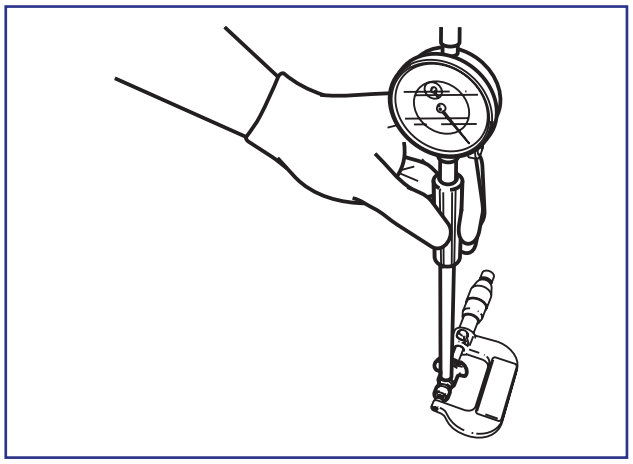
Measure the tappets diameter.



Measure the camshaft bearing diameters.



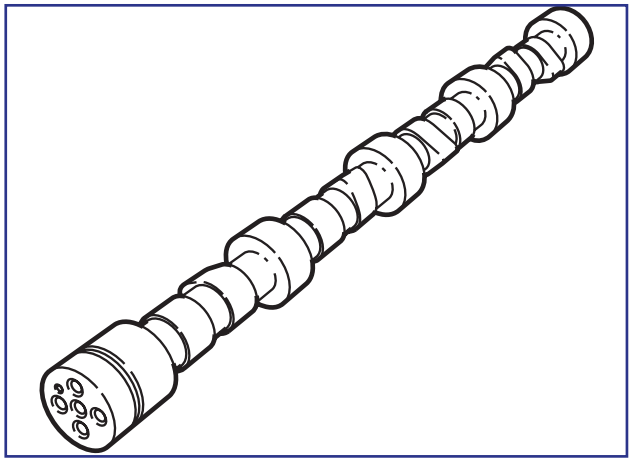
Comparing the performed measurements, obtain the clearance between the bearing and the housing.



Measure the camshaft bearing housing bores.

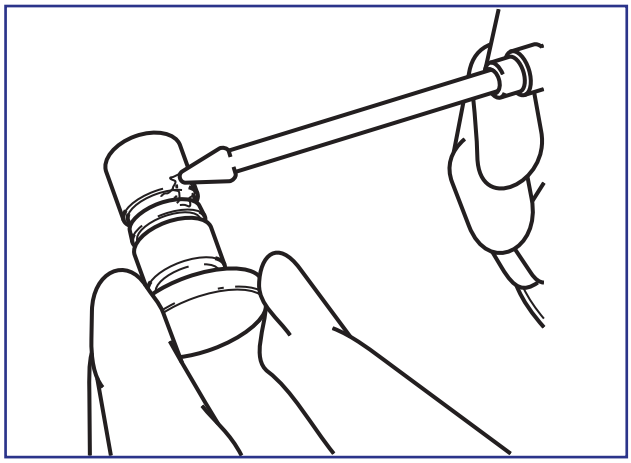
Measure the camshaft warping.

	4 cyl.	6 cyl.
Maximum warping (mm)	0,04	0,04

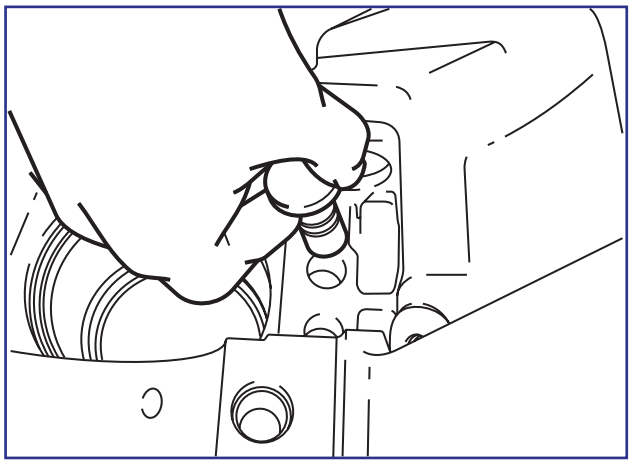


Assembly

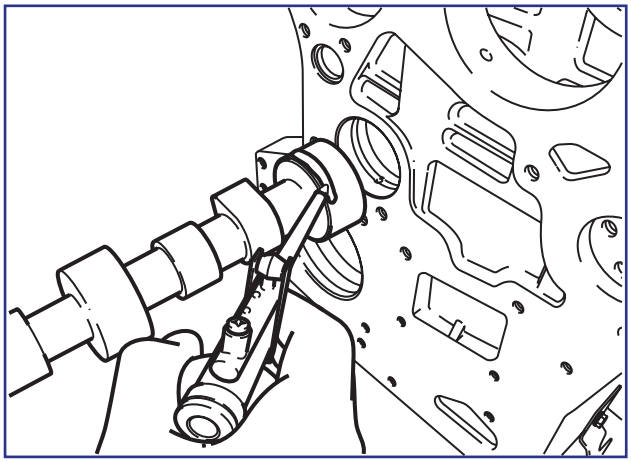
Clean and lubricate the tappets and the tappets housing.



Install them with the hands. If it is not necessary to change the tappets check the original position in that they were installed and reinstall them in the same positions.



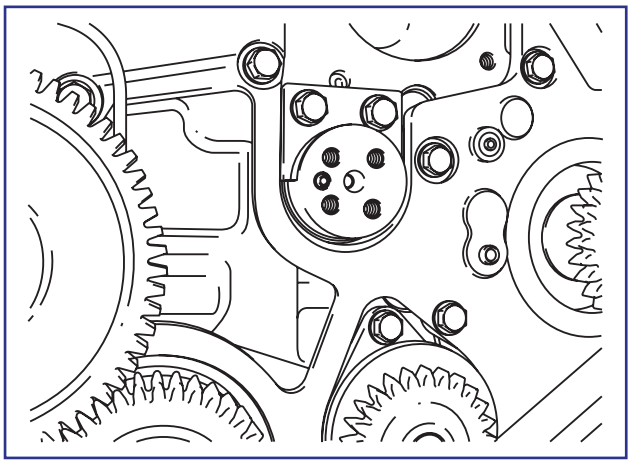
Clean and lubricate camshaft bearings.



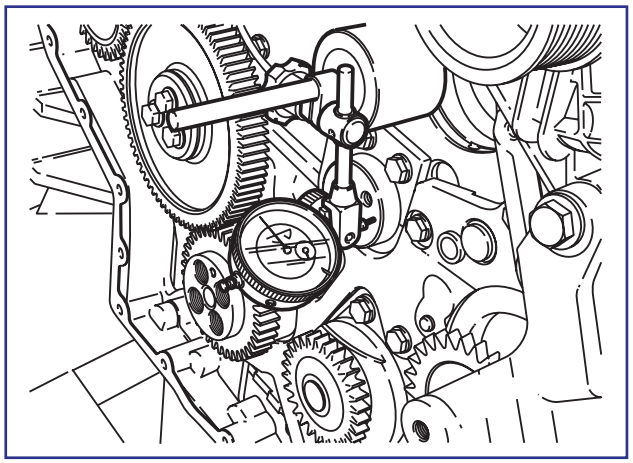
Install it with the hands making rotating movements. Take care to do not damage the bushings in the engine block.

After camshaft installation, install the axial lock and tighten fixation bolts according to the specification.

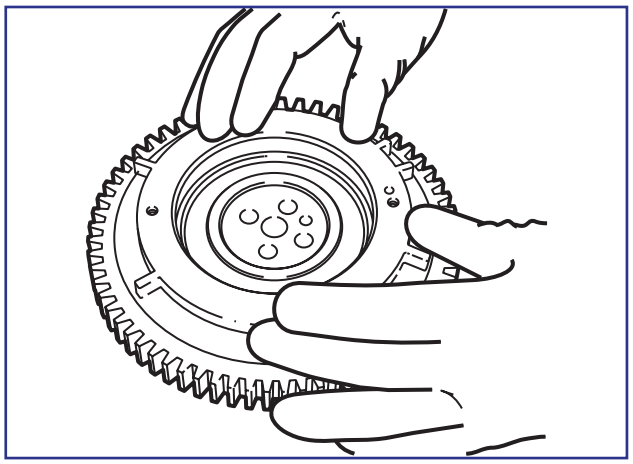
Apply torque: 30 ± 5 N.m



Measure the camshaft axial clearance. Repeat the operation sometimes to make sure of the measurement.

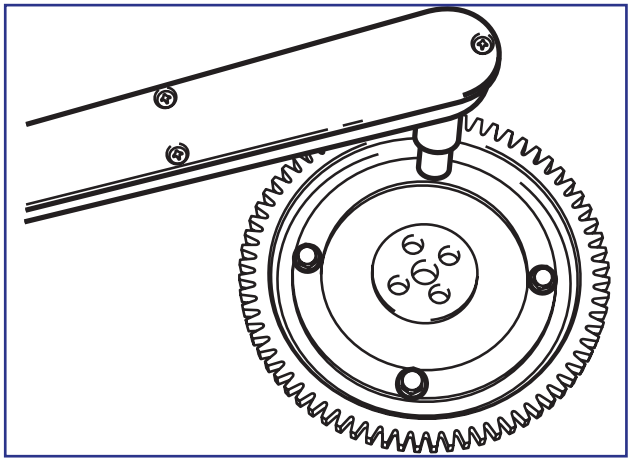


Assembly the pulse-wheel. Attention to the expansion bushing, which guides the correct positioning.



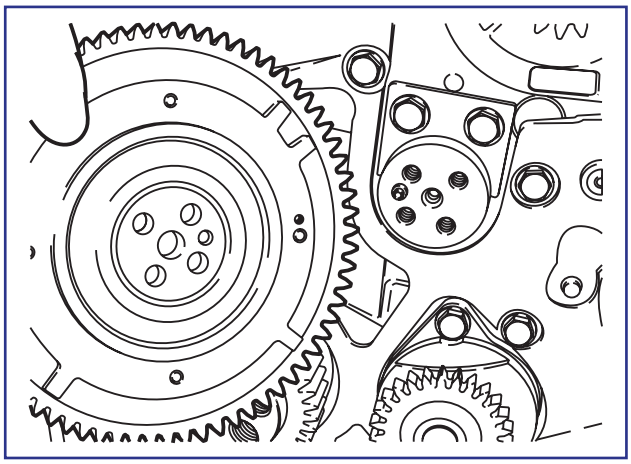
Assembly pulse wheel fixation bolts and tighten according the specification.

Apply torque: 8,5 ± 1 N.m

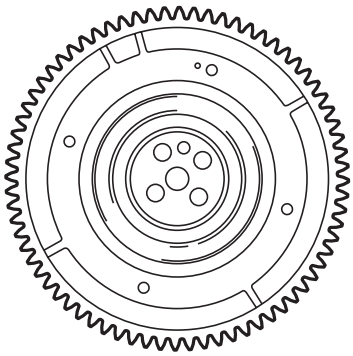


Install camshaft gear.

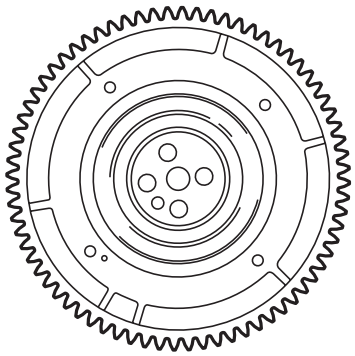
(shown 6 cylinders camshaft gear)



Pay attention to the difference between the pulse wheels of the 4 and 6 cylinders engines.



Four Cylinder



Six Cylinder

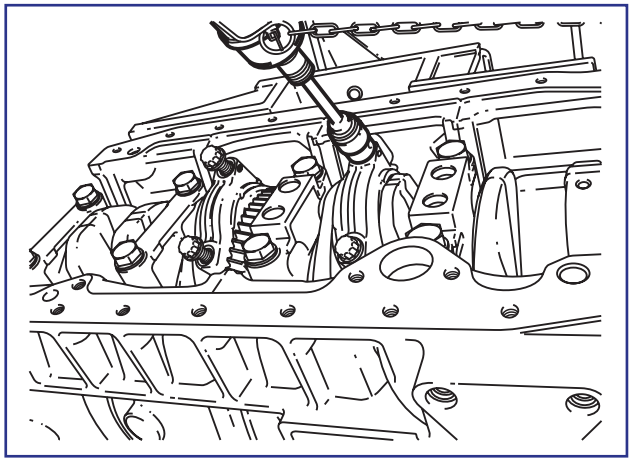
NOTES

Pistons and Connecting Rods

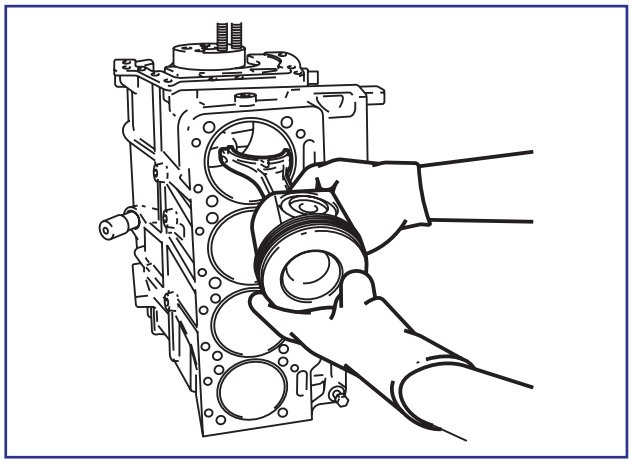
Disassembly Notes

After the removal of the carter and cylinder heads, position the engine in upright position to remove the connecting rods.

Remove connecting rod caps. The bolts must be loosened alternately and in steps. Do not complete loosen the screw of one side and later loosen other.



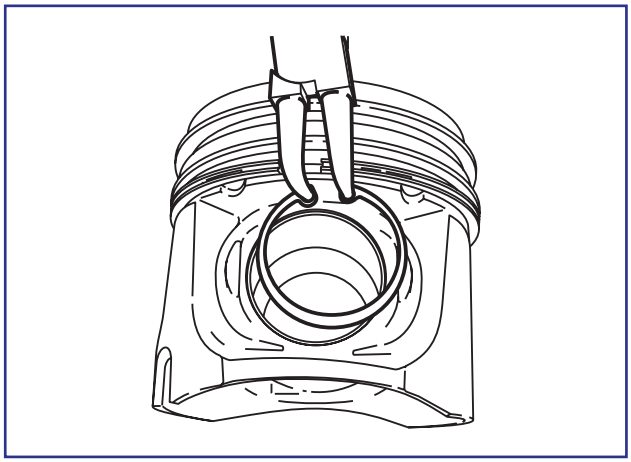
Before removing the piston, clean the inner part of the liner to remove residues of coal and impurities. With the connecting rod caps out, carefully remove the piston / connecting rod set through the upper side of the engine.



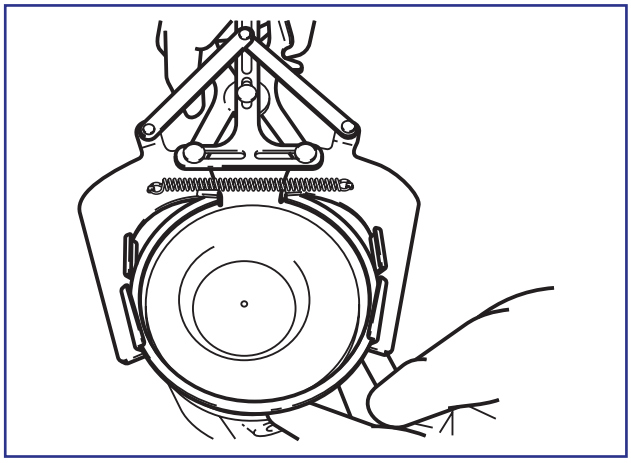
Remove piston pin snap rings. The piston pins must move freely.

It is not necessary to hit or to heat up the piston pins.

To remove connecting rod bushings send the connecting rods to a specialized authorized workshop.



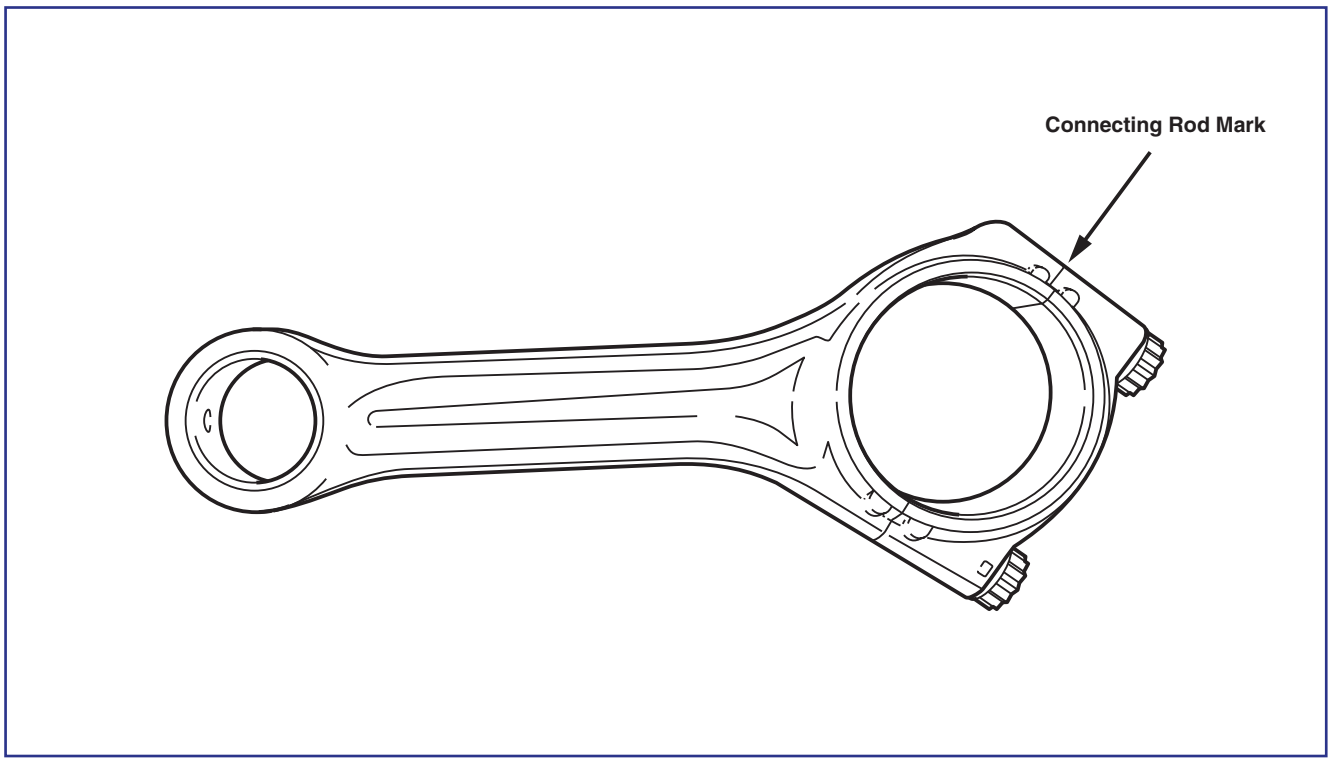
Remove piston rings with an appropriate device.



Attention: When removing the piston and connecting rod, observe the position of jet oil to avoid cranks and damages.

Pre-Assembly Inspections and Measurements

The weight of the connecting rod is identified by a sequence of letters and numbers between the stem and the cap. According to the letter (X, Y and Z) it is possible to identify the weight strip.



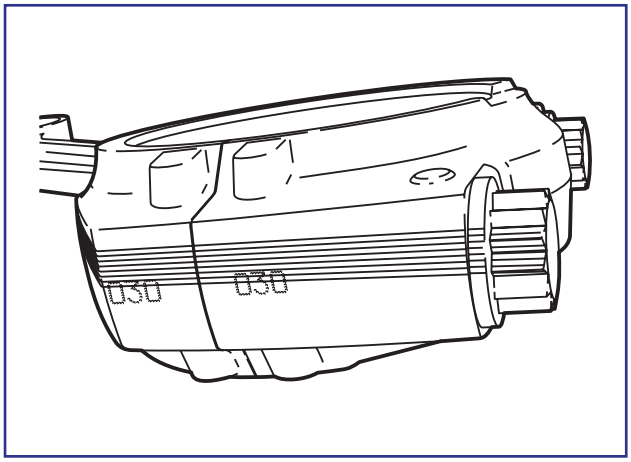
Weight Class

Letter	Weight Strip	Application
X	1855g - 1876g	Production
Y	1877g - 1898g	Spare Part
Z	1899g - 1920g	Production

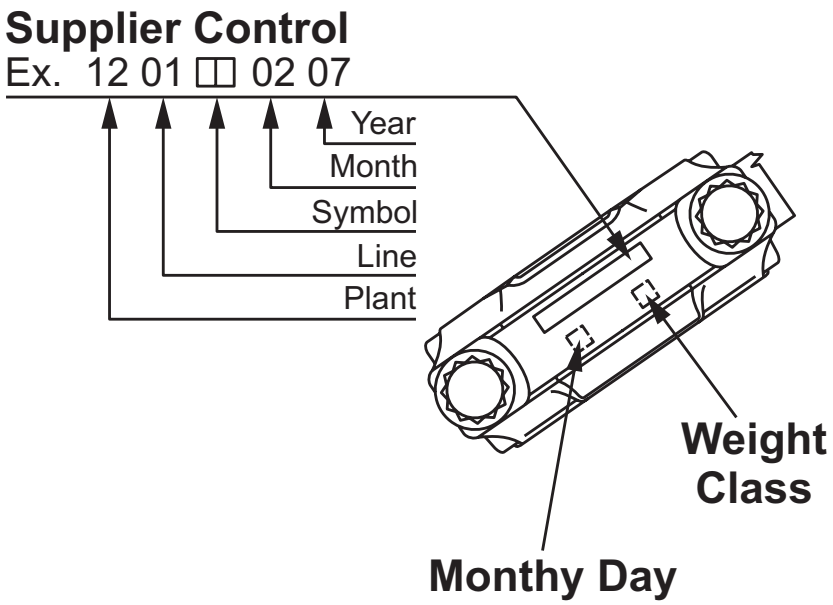
The difference of weight between all pistons / connecting rods sets, in the same engine, must be of, at the most, 41g. So, as spare part it is only available the connecting rod of the letter Y.

Connecting Rod Mark

The connecting rod stem / cap pair is cracked made by the coincidence of the digits engraved on the connecting rod stem with the first 4 digits engraved on the connecting rod cap.



Identification code:

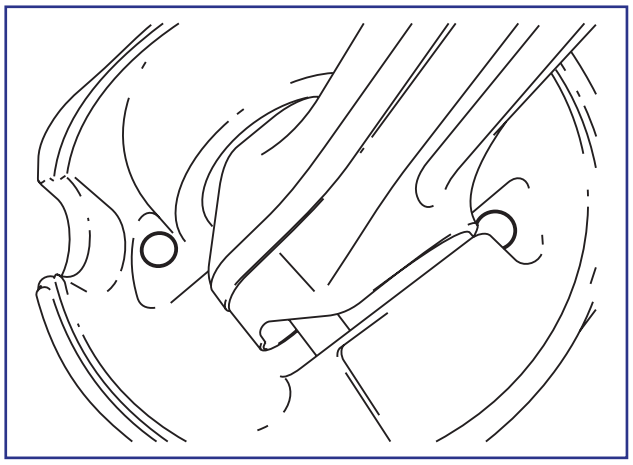


(*) As spare part it is only available connecting rods of the “Y” strip mass that is used to replace connecting rods of any other strips.

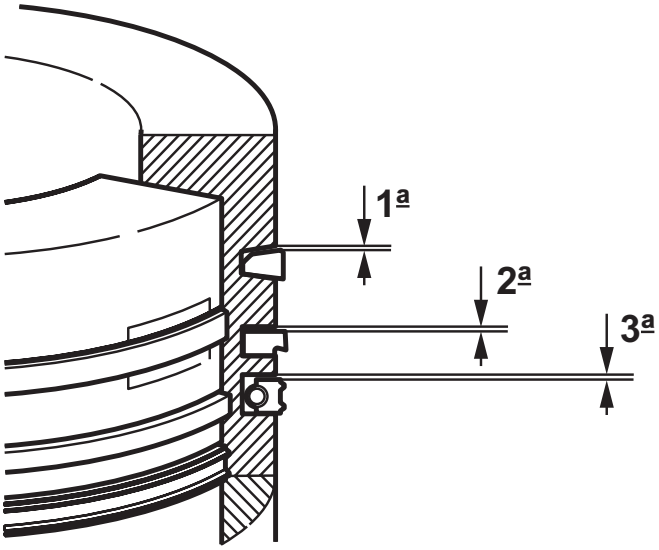
Important: Do not assembly connecting rods of “X” and “Z” mass strip in the same engine, because these connecting rods exceed the maximum limit of mass difference.

Piston

Observe the two holes for cooling the piston head.



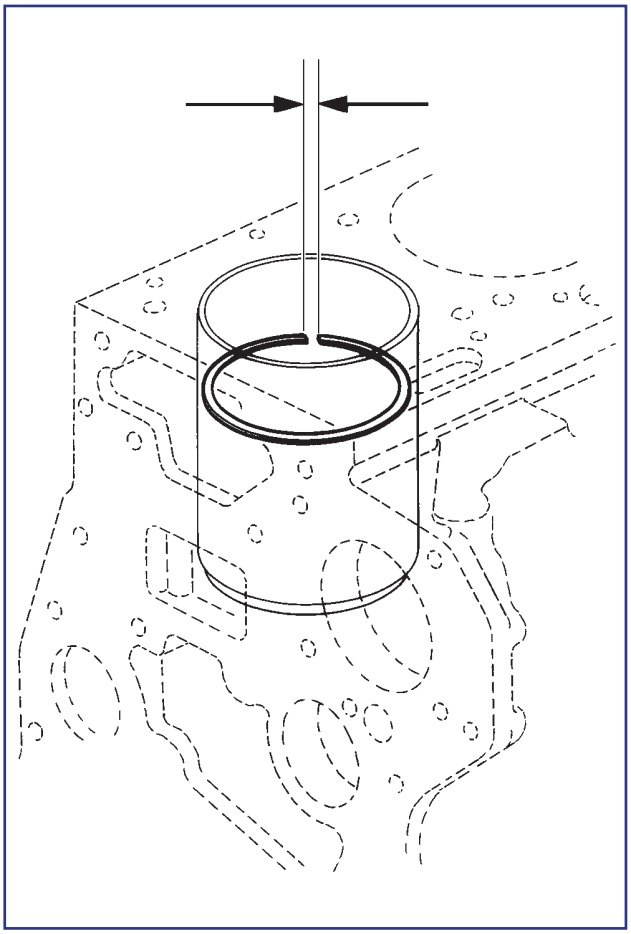
Piston Grooves Specifications



Remark: The rings of the MAXXFORCE engines are identified by a strip on the outer diameter.

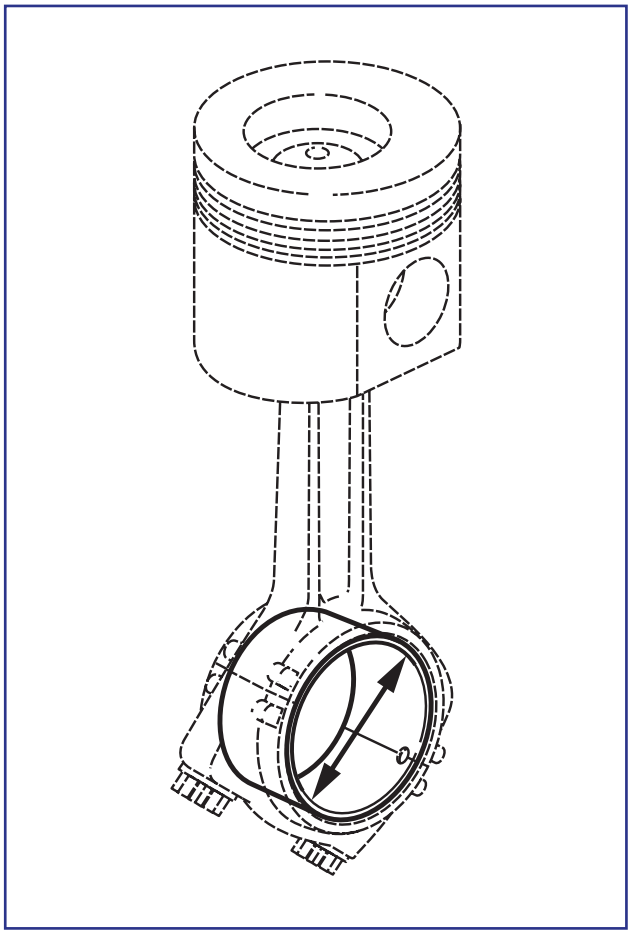
Rings Dimensions and Clearances in the Grooves (Standard)			
Groove	Dimensions (mm)	Clearance (mm)	Strip Code
1st	105.0 x 3.0 x 4.55	0.25	Orange
2nd	105.0 x 2.5 x 4.55	0.20	Yellow
3rd	105.0 x 3,5 x 3.70	0.15	Green

Ring Ends Gaps Specification



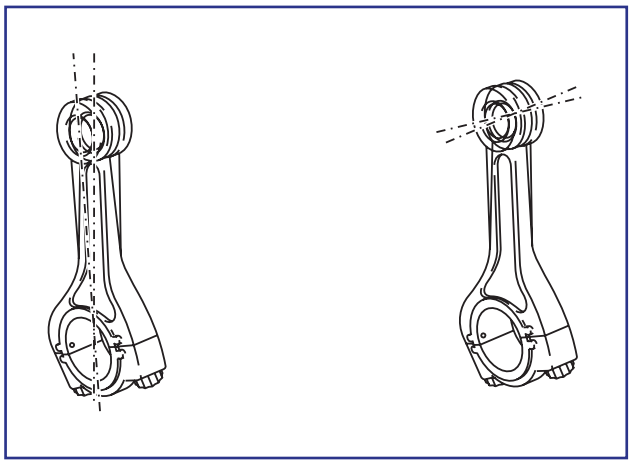
Ends Gap	(mm)
1st and 2nd groove	
Nominal	0.30 - 0.55
Maximum	2.0
3rd groove	
Nominal	0.25 - 0.55
Maximum	2.0

Connecting Rod Bearings Specification



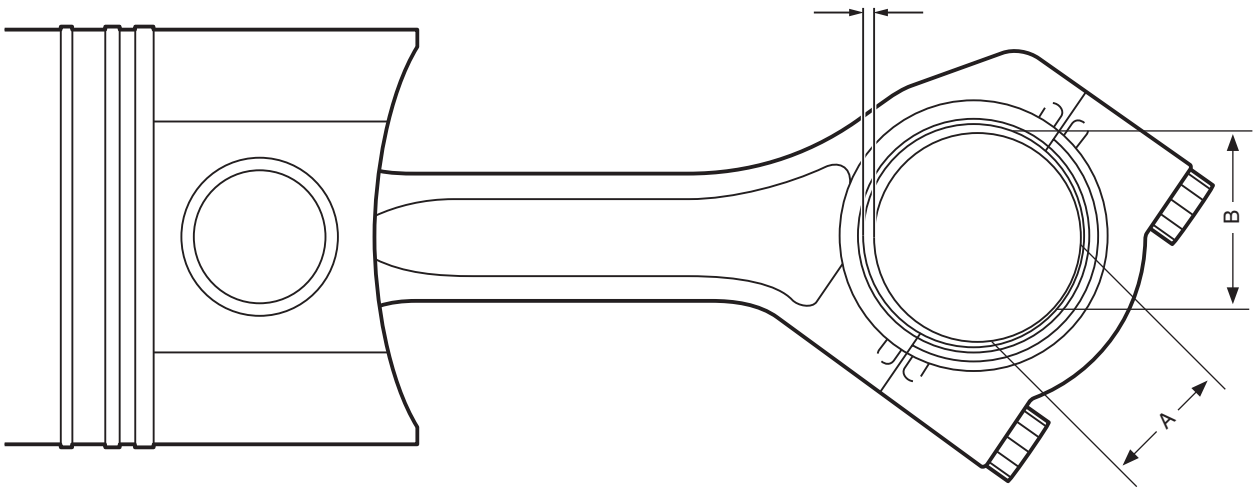
Connecting Rod Bearing, Ø (bore)	
Diameter	**(mm)**
Standard	62.992 to 63.037
Repair 1	62.746 to 62.791
Repair 2	62.496 to 62.541
Repair 3	62.246 to 62.291
Repair 4	61.996 to 62.041
Pre tension	0.025 to 0.060

Connecting Rod Warping



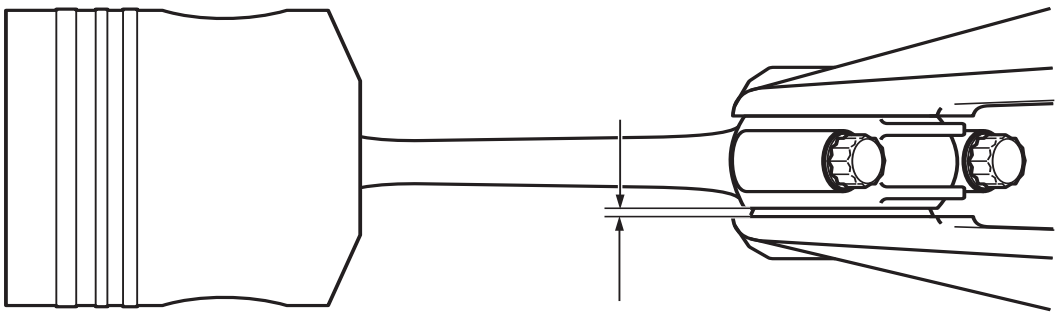
Maximum Torsion	Maximum Warping
0.10	0.03

Connecting Rods Specifications



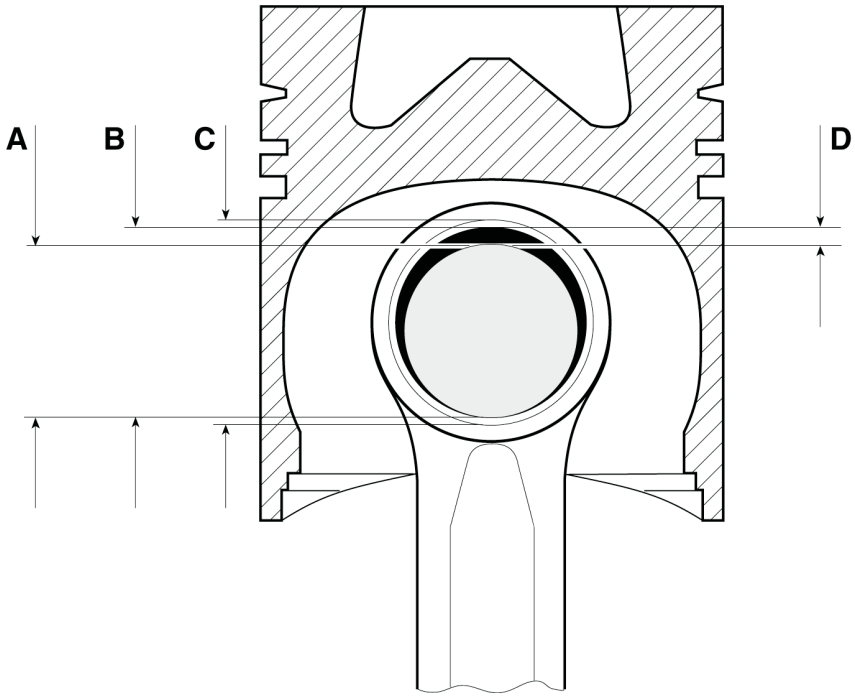
Radial Clearance	(mm)
Nominal	0.026 - 0.081
Maximum	0.178

Diameter Ø	(mm)
A (With Connection Rod)	
B (Without Connection Rod)	



Side Clearance	(mm)
Nominal	0.30 - 0.50
Maximum	0.90

Piston and Pin



ØA Piston Pin	
Diameter	**(mm)**
Nominal	37.994 to 38.000
Maximum	37.900

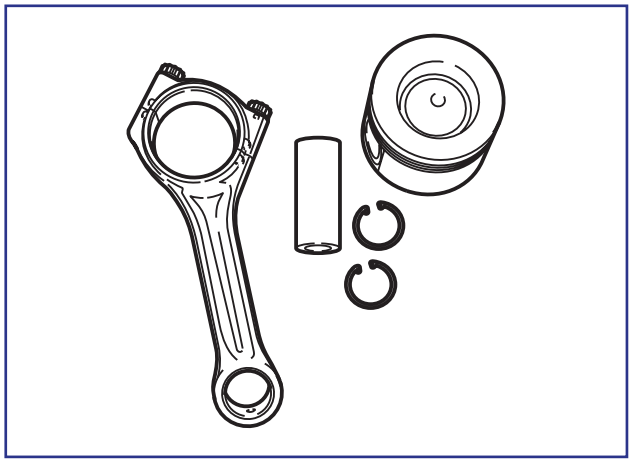
ØB Connecting Rod Bushing (assembled)	
Diameter	**(mm)**
Nominal	38.037 to 38.095
Maximum	38.140

ØC Connecting Rod Bushing (housing)	
Diameter	**(mm)**
Nominal	41.000 to 41.016

ØD Piston Pin	
Diameter	**(mm)**
Nominal	0.030 to 0.086
Maximum	0.150

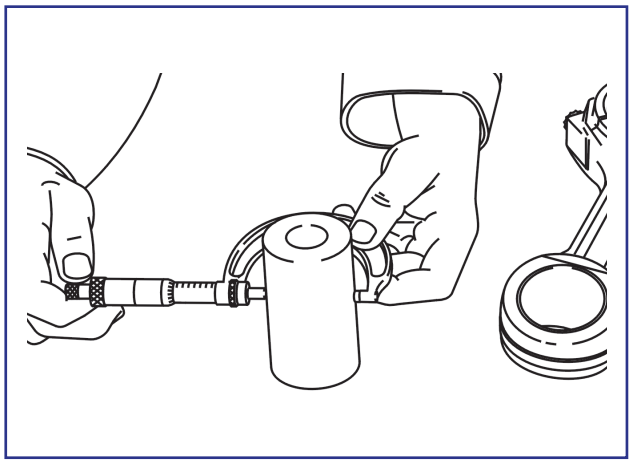
Pre-Assembly Inspections and Measurements

Visually check pistons, pins and connecting rods.

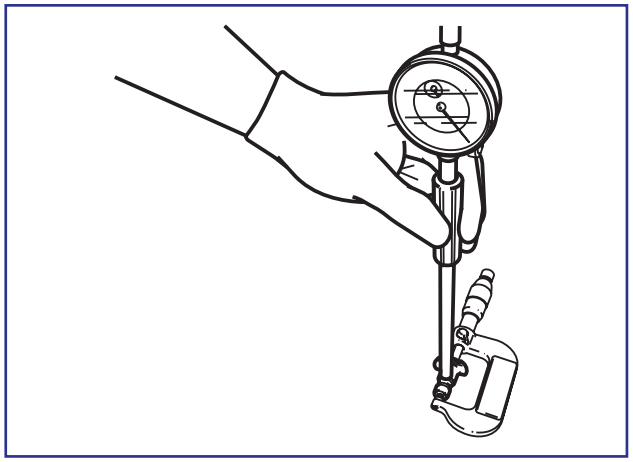


Check piston pin for marks, scratches or excessive waste.

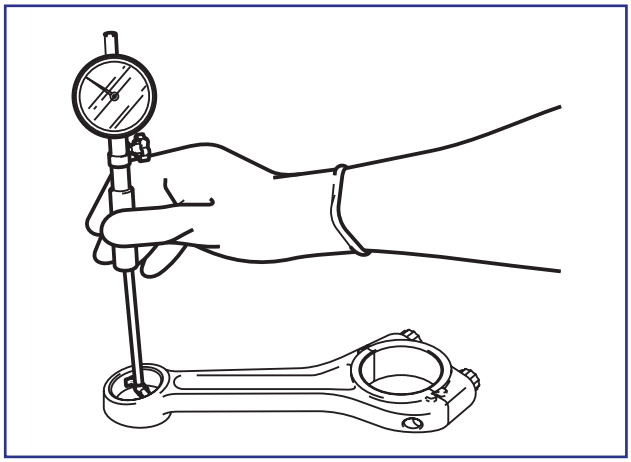
Measure the diameter of the pin. Check pins taper and out-of-roundness.



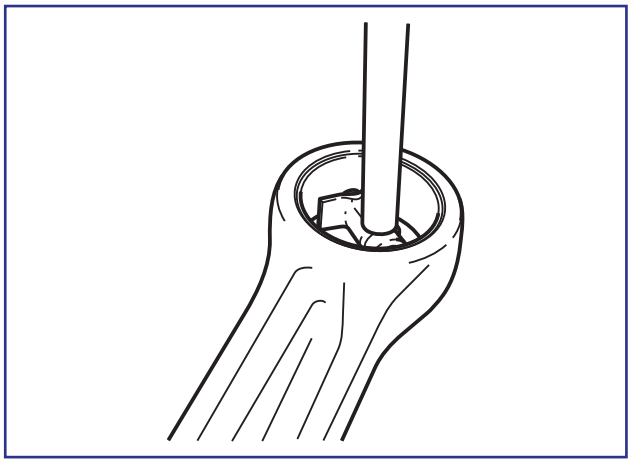
Transfer the piston pin measured to the telescope gauge.



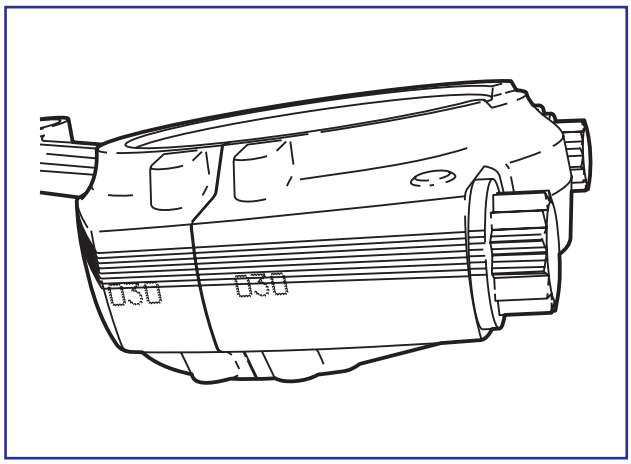
Measure the clearance of the connecting rod bushing housing to the piston pin. Check connecting rod, possible damages, marks or waste. Damages on the connecting rod stem (profile “I”) could case cracks and ruptures of the connecting rod.



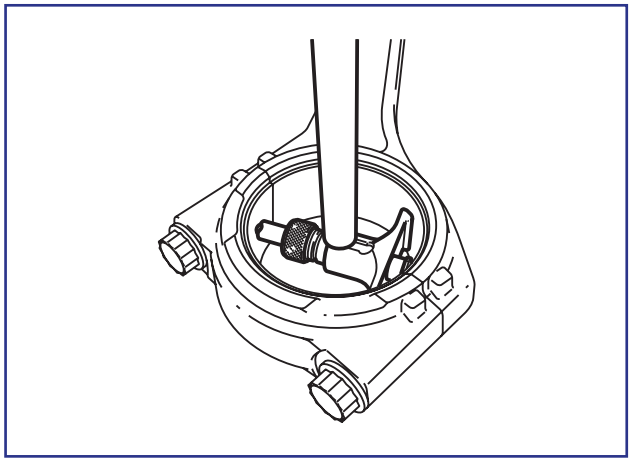
With the bushing assembled, measure the diameter of the housing of the piston pin.



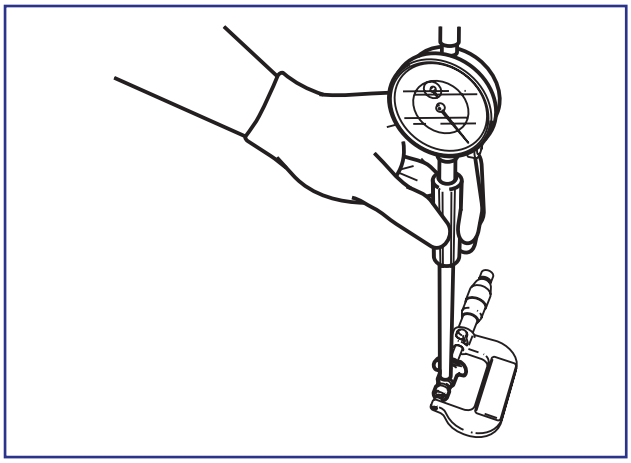
Before performing the measurement of the bearings, check the mark codes on the cap and on the connecting rod. These codes indicate the parity between connecting rod and cap, guaranteeing the perfect seating of the bearing shells in the assembly. Loosen the bolts of the connecting rod, disassembling the connecting rod bearing and cap.



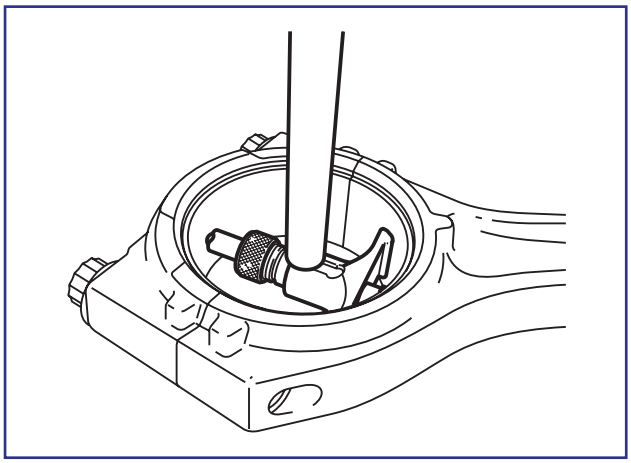
Assembly the connecting rod cap tightening according to the specification (without the bearing shells) and checking whit 2 points 90° distant each other starting from 30° of the partition of the connecting rod, checking out-of-roundness.



Checking crankshaft to connecting rod clearance by measuring the crankshaft diameter with micrometer and transfer this measure to the telescope gauge.

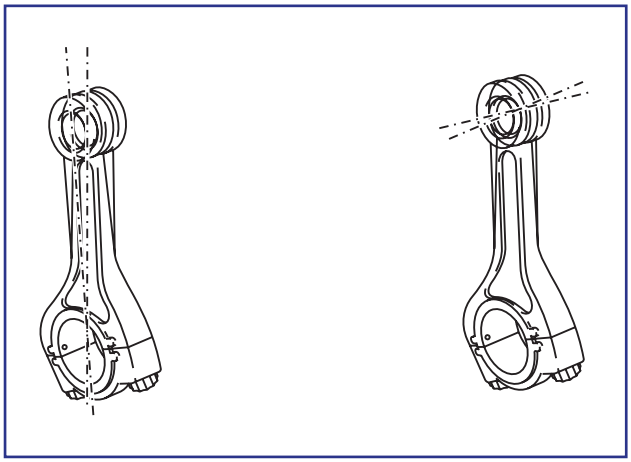


With bearing shells assembled measure the clearance with the telescop gauge.



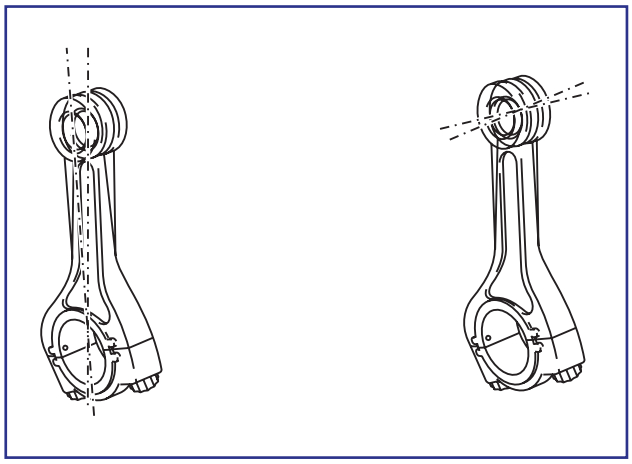
Check connecting rod torsion.

Maximum Torsion = 0.10 mm

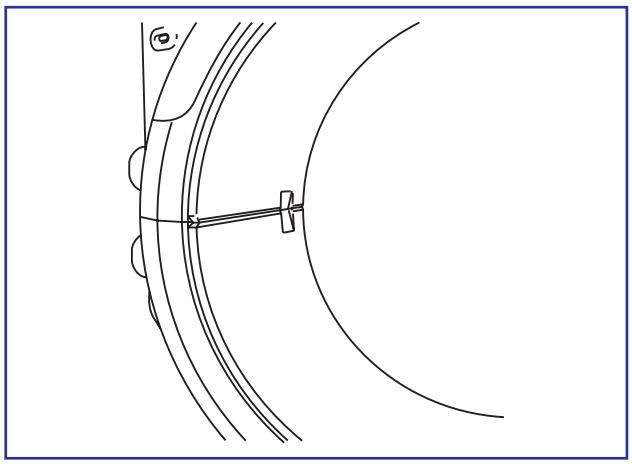


Check connecting rod warping.

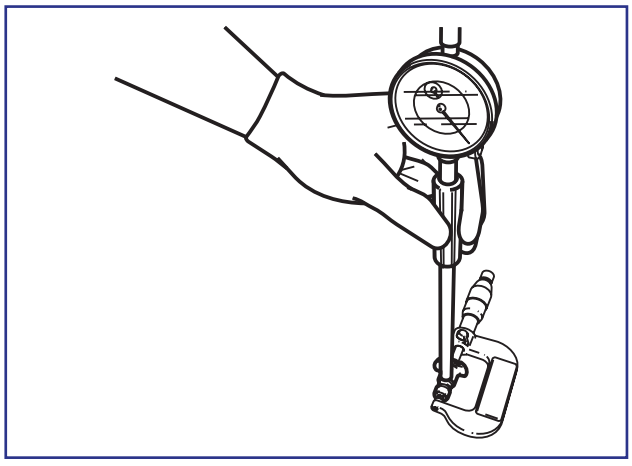
Maximum Warping = 0.03 mm



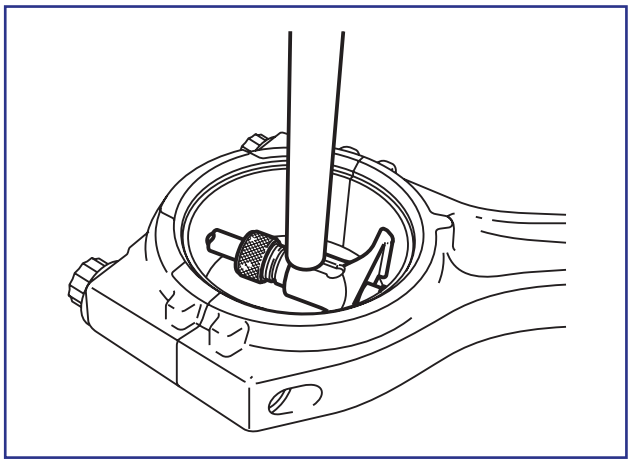
Loosen connecting rod cap, assembly the bearing shells with the aid of the expansion pin, assembly again the connecting rod cap and tighten according to



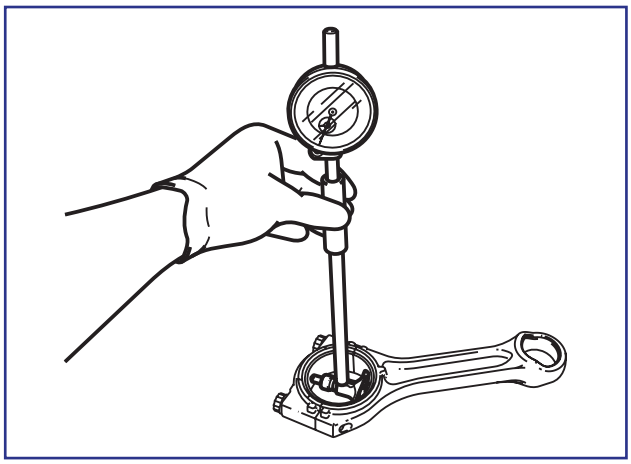
Compare the clearances obtained from the crankpins with the bore gauge.



Measure the clearance with the bore gauge turned 90° from the partition of the bearing shells.

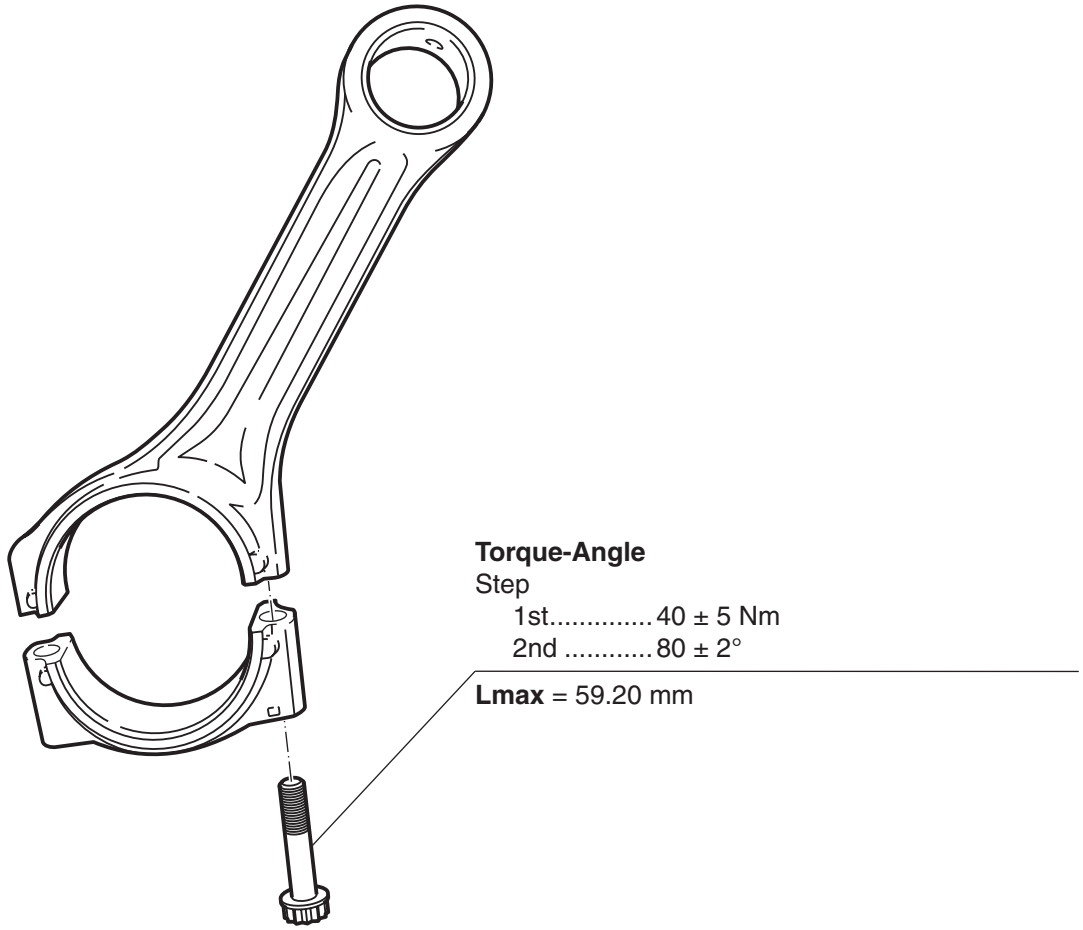


With the telescope gauge at 90° from the partition of the connecting rod, reset the dial indicator gauge, remove one of the connecting rod bolts and measure its pre-tension.



Connecting Rod Bolts Tightening Specification

One void at joint face per side is allowed. The void can not exceed 2 mm x 5 mm on the outer surface of the connecting rod.

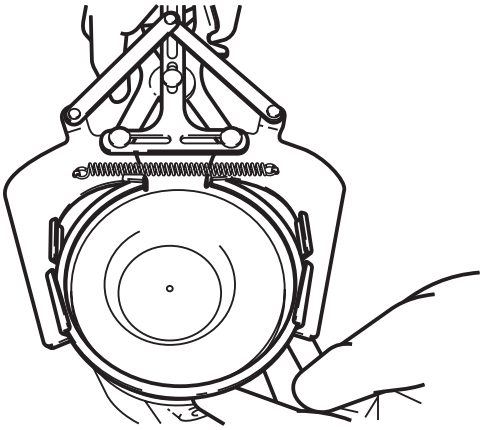


Assembly

The “CTOPW”, “CTOPK” and “CTOP” marks must be upward.

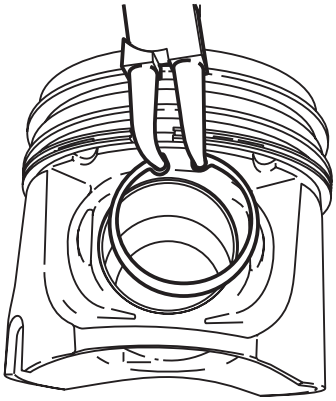
7-17-1

Assembly the piston rings.

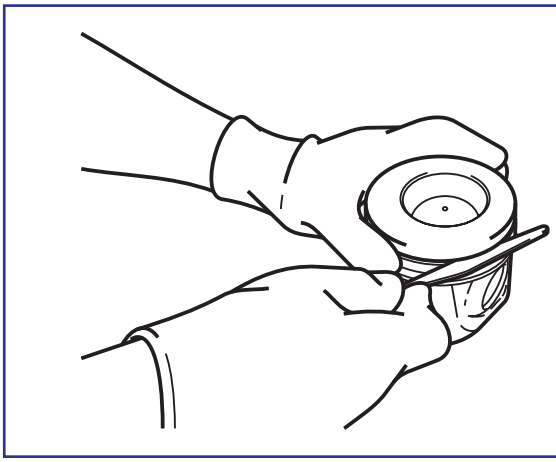


Lubricate piston pin, assembly the piston in the connecting rod, observing the correct positioning between them.The arrow on the top of the piston must be toward the side of the 3 holes of the connecting rod.

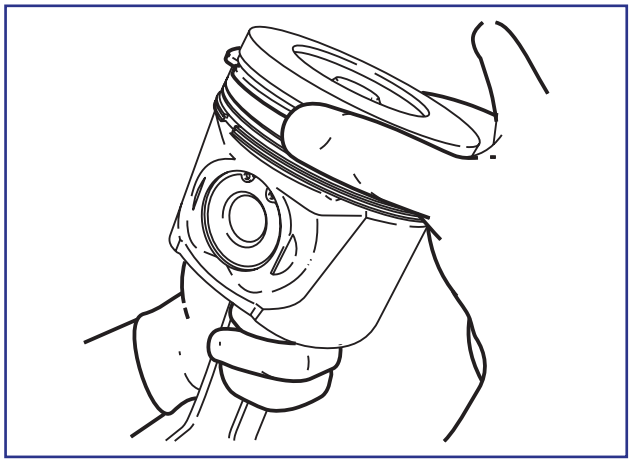
Clean the backs of the bearing shells and assembly on the stem and on the connecting rod cap that also must be clean.



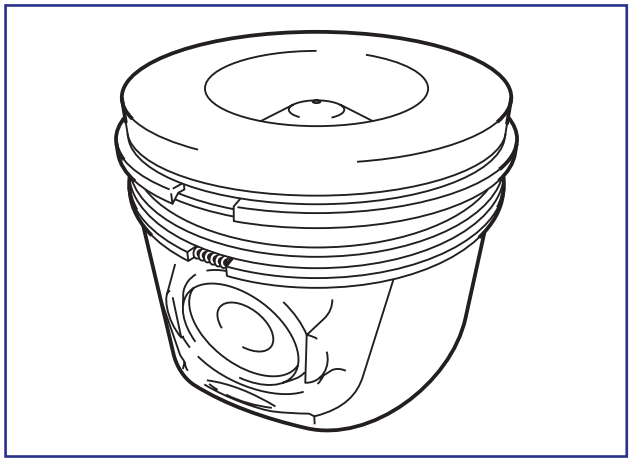
Check the ring grooves, pin housing and the skirt of the piston. Check the clearance of the rings in the piston grooves.



Lubricate the liners and piston rings. When installing the piston / connecting rod set in the cylinder, mind the correct assembly position.The arrow on to top of the piston must point toward the flywheel side.

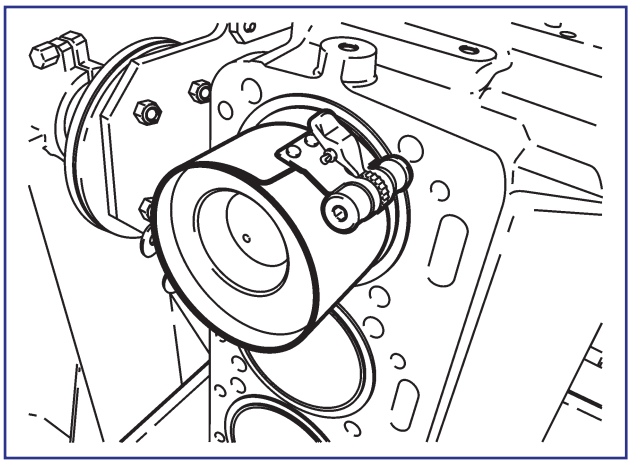


Before installing the pistons in the cylinders, position the ends of the rings in the direction of the pin, displaced 180° to each other.

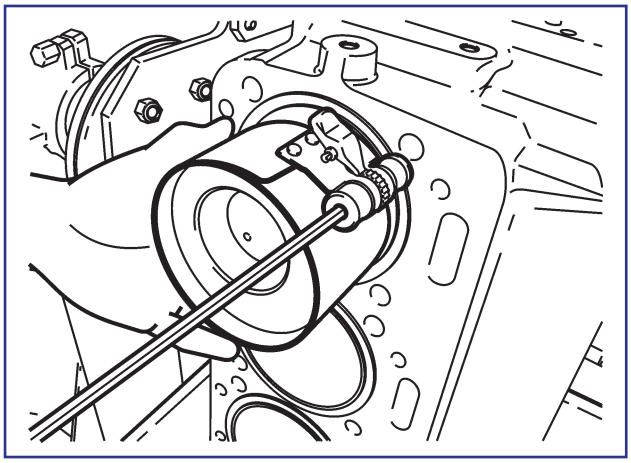


Install the device for piston assembly to close the rings.

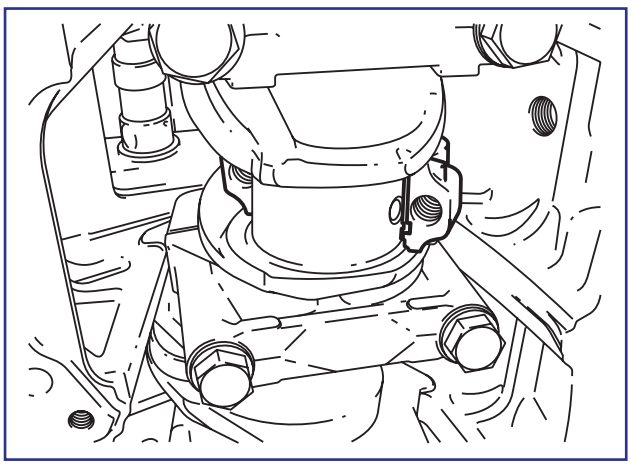
Note: **Position the engine flywheel upward. This avoids the contact of the connecting rod with the oil injectors.**



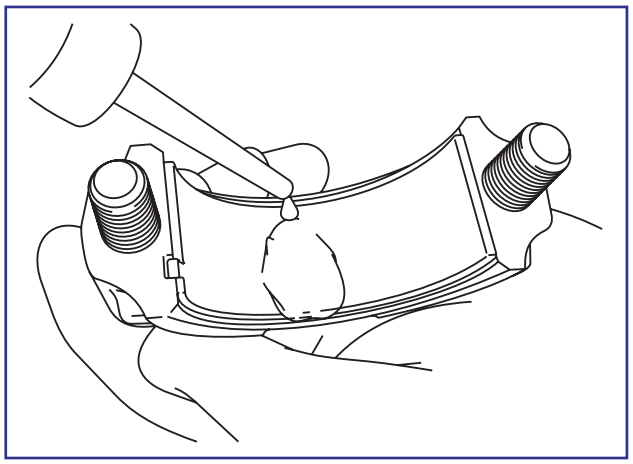
Carefully push the piston inside the cylinder. Never hit directly on the top of the piston.



Observe the correct position to the crankshaft.



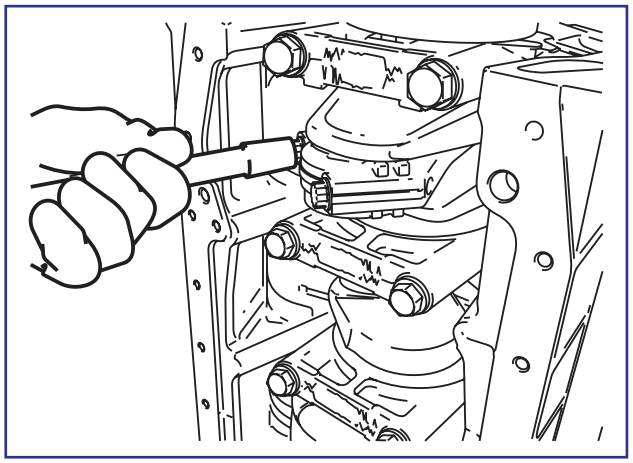
Lubricate the two inner halves of the bearing shells.



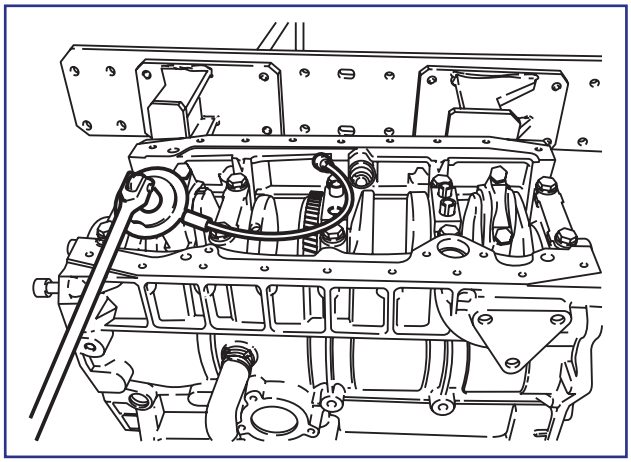
Position the connecting rod stem in the crankshaft crankpin and install the connecting rod cap. Tighten the bolts according to specification.

1st 40 ± 5 N.m

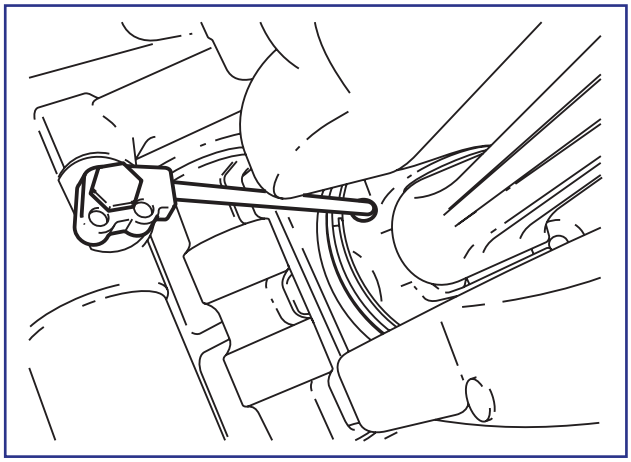
2nd 80° ± 2°



Check if the connecting rod has free side movement. Measure the side clearance.



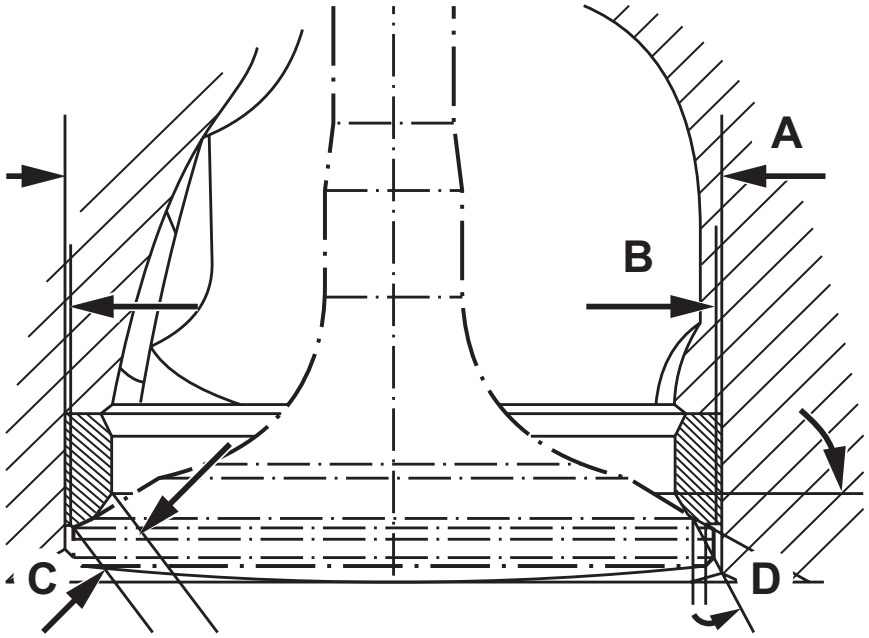
Check if the oil injector is aimed direct to the piston hole otherwise it may cause excessive piston heat and damage the engine.



Cylinder Heads

Disassembly Notes

Valve Seats Specification



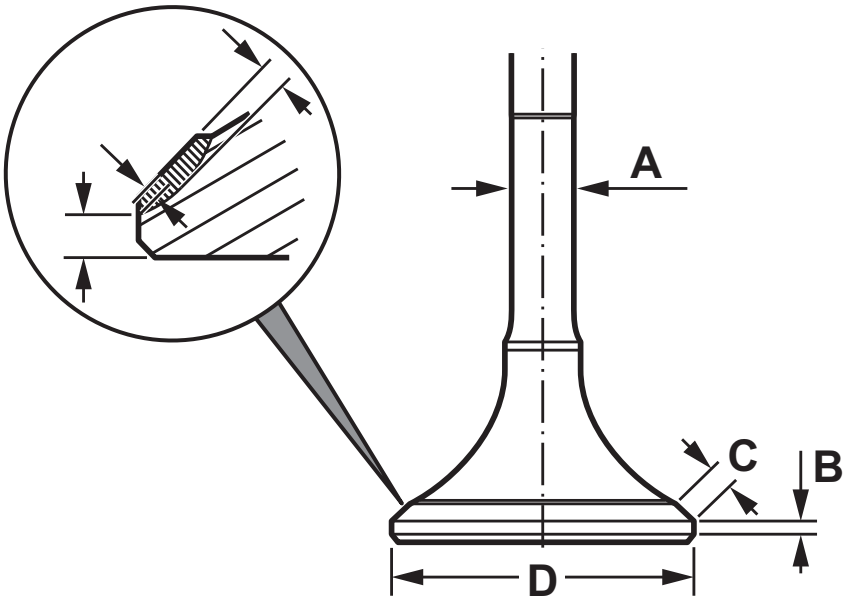
ØA	
Housing	**(mm)**
Standard Intake Exhaust	 37,600 - 37,625 33,500 - 33,525

Ø (B)	
Outer	**(mm)**
Standard Intake Exhaust	 37,660 - 37,671 33,580 - 33,596

(C)	
Seat Width	**(mm)**
Standard Intake Exhaust Maximum	 1.80 2.10 2.80

Ø (D)	
Seat Angle	**(mm)**
Intake	60°
Escape	45°

Valves Specification



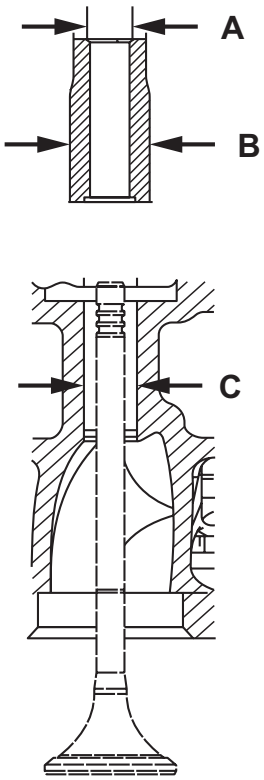
ØA	
Stem	**(mm)**
Nominal	6,956 - 6,970

(B)	
Head height	**(mm)**
Intake Exhaust	2.2 2.1

(C)	
Surface width	**(mm)**
Intake Exhaust	5.7 2.9

Ø (D)	
Seat Angle	**(mm)**
Intake Escape	36.5 - 36,7 32.4 - 32.6

Valve Guides Specification



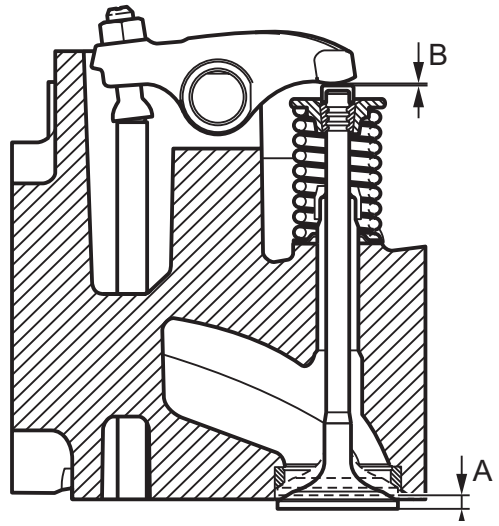
ØA	
After assembly	**(mm)**
Nominal Repair Maximum	6.65 - 6.80

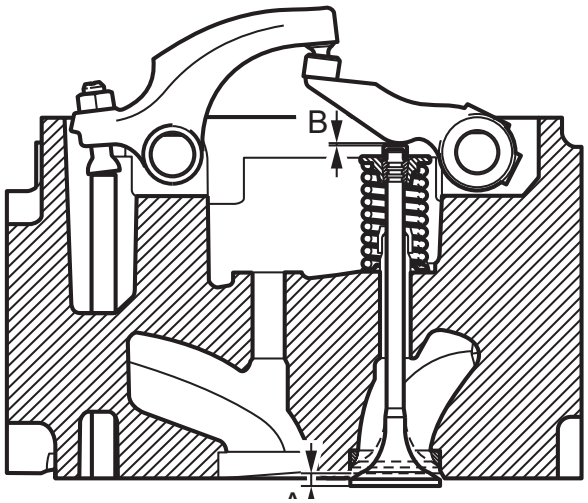
Ø (B)	
Outer	**(mm)**
Nominal	12,028 - 12,039

Ø (C)	
Housing	**(mm)**
Nominal	12.5

Ø (D)	
Clearance at the Stem	**(mm)**
Nominal Maximum	0.030 - 0.070 0.111

Specification of Guide Height and Distance to Cylinder Head Surface



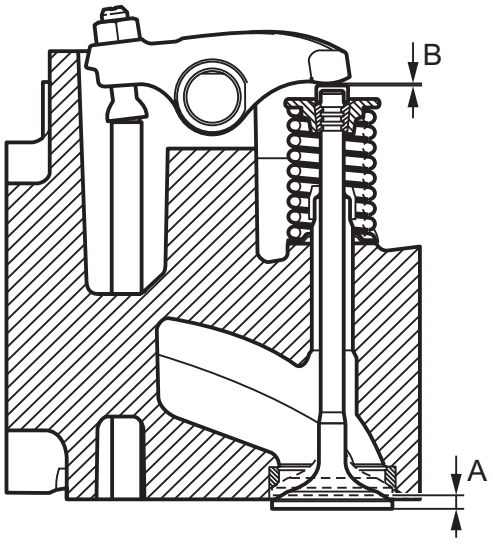


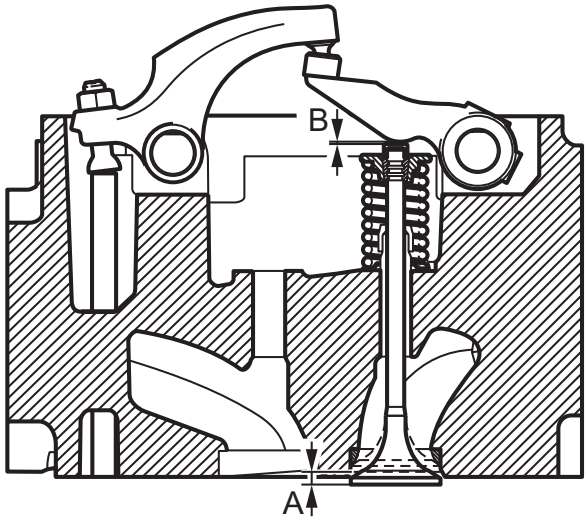
Guide Height (A)	(mm)
Intake and Exhaust	11.3 – 12.6

Distance to cylinder head surface (B)	(mm)
Nominal	
Intake	0.8 - 1.1
Exhaust	1.30 - 1.60
Maximum	
Intake	1.35
Exhaust	1.85

Guide height to cylinder head face (C)	(mm)
Intake and Exhaust	45.0

Valves Course and Clearance

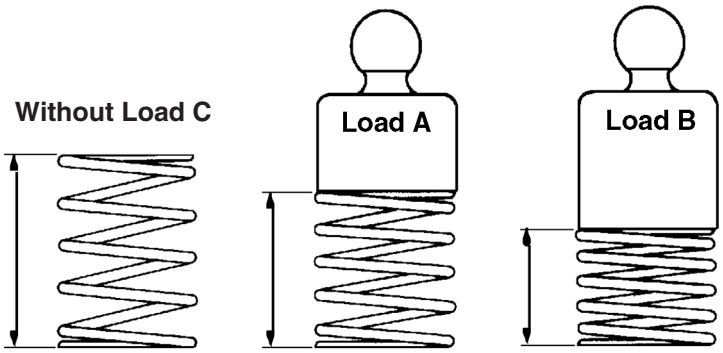




ØA	
Course	**(mm)**
Intake Exhaust	11.10 - 11.34 11.22 - 11.46

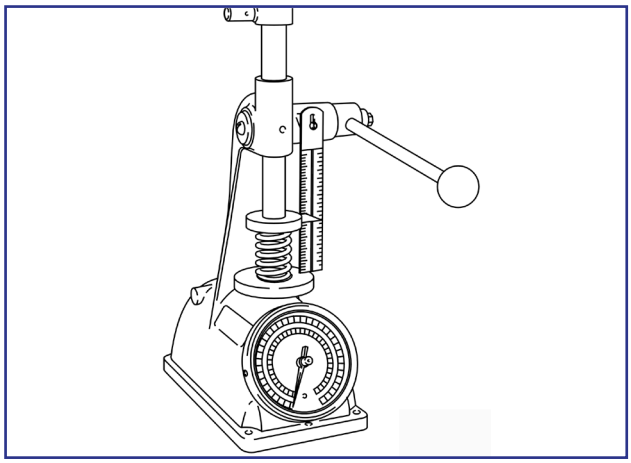
Ø (B)	
Clearance	**(mm)**
Intake Exhaust	0.40

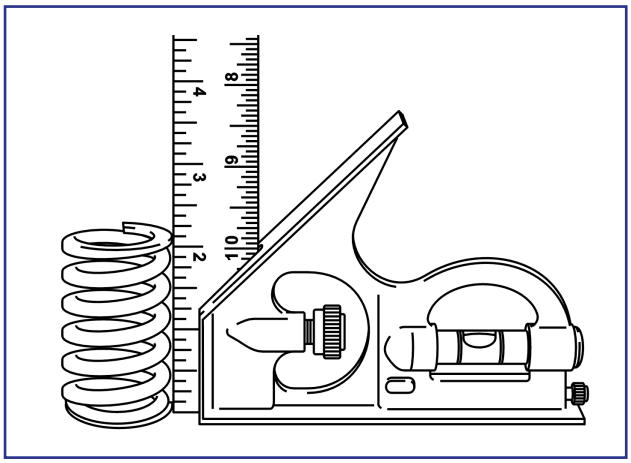
The test is performed placing the springs on a special device and reading the closing force for two different deflections according to the following table.The intake valves springs are single (only one spring) and exhaust valves springs are double.



Intake and exhaust valve spring			
Ø wire		3,50 mm	
Load	**(kgf)**	**Length**	**(mm)**
C A B	0.0 35.0 ± 2.9 52.00 ± 3.2	C A B	60.6 40.0 30.0

Special device for spring measurement.

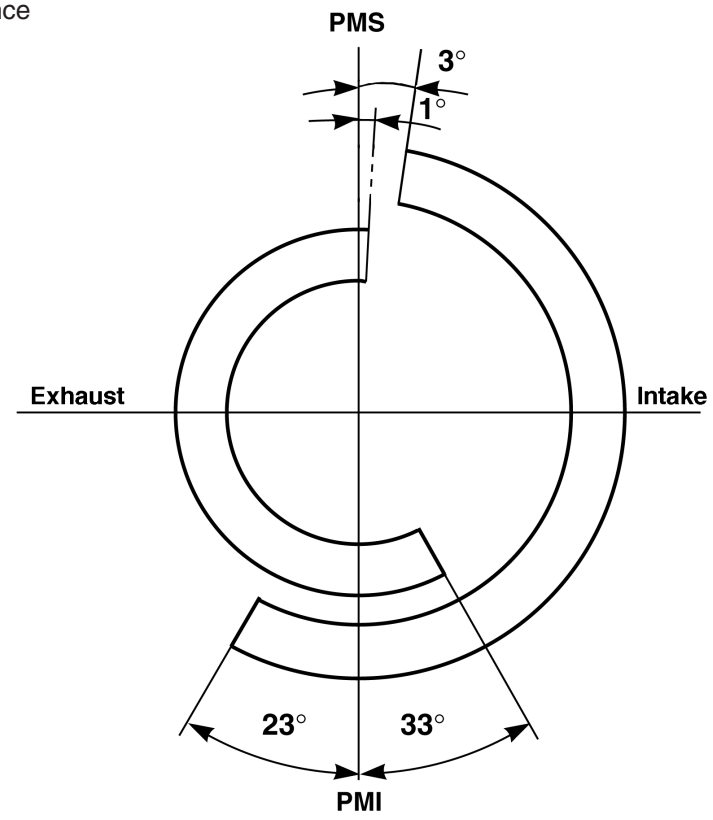




Valves Diagram

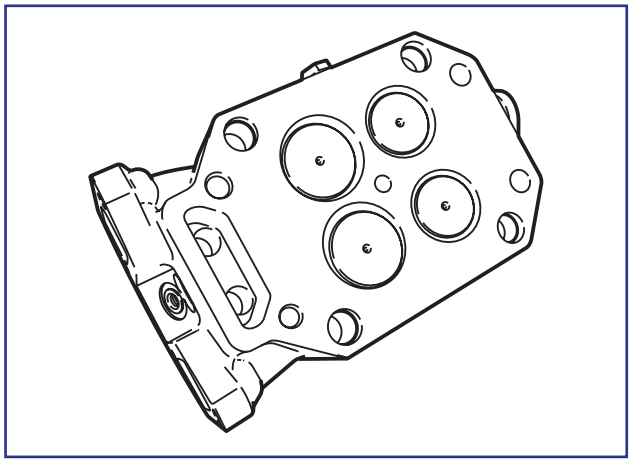
Valves clearance: 1 mm
(After the check, readjust the valve clearance to 0.40 mm)

Intake:	Open 3° after TDC
	Close 23° after PMI
Exhaust:	Open 33° before PMI
	Close 1° after TDC
Tolerance:	± 3°

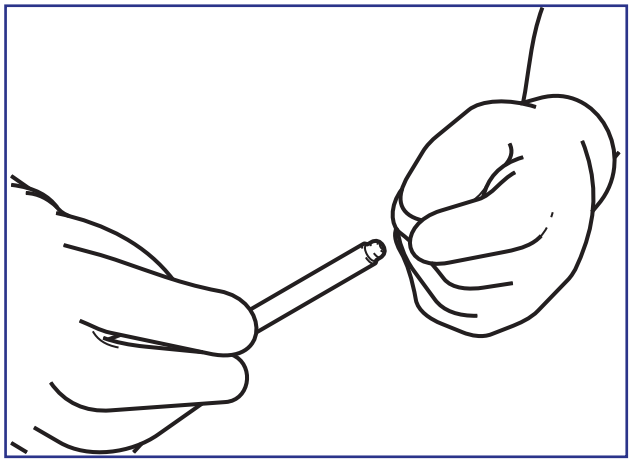


Pre-Assembly Inspections and Measurements

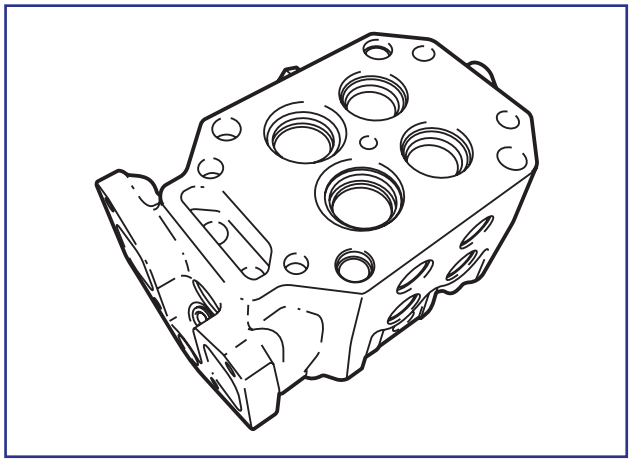
Visually check cylinder heads for leaks.



Check push rods. The push rods ends must not be loosen or cracked. Check for excessive waste and if the lubrication hole is not obstructed. Check if the push rods are not warped.

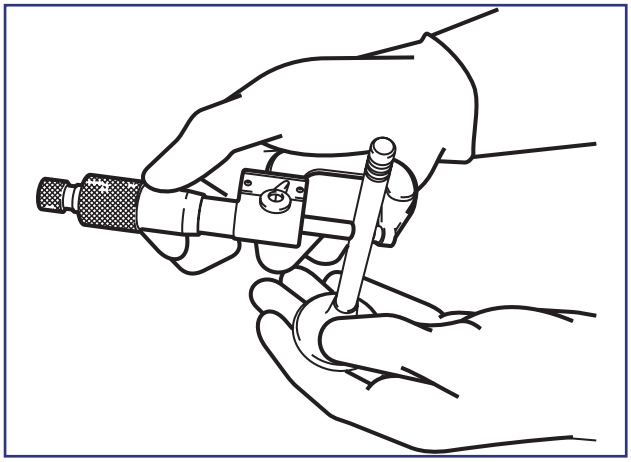


Cylinder heads surfaces must never be machined.

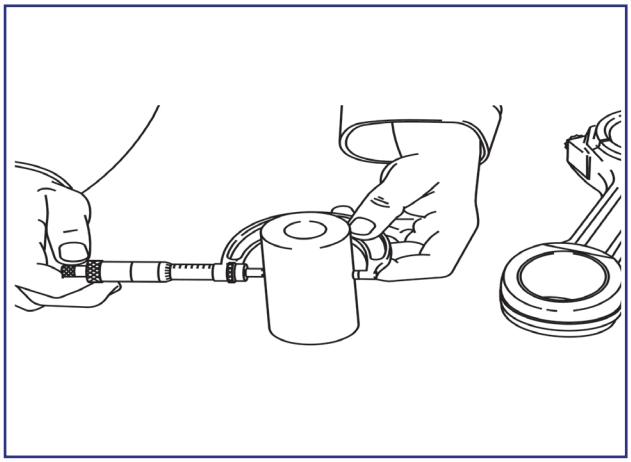


Measure the outer diameter of the valve stem in 3 different points:

- Upper part
- Central part
- Lower part



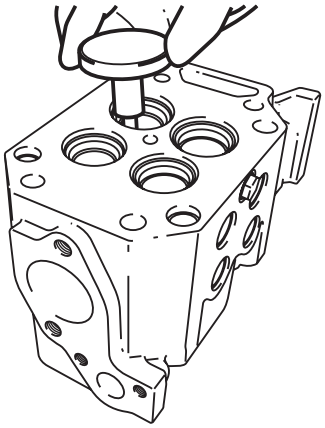
Measure the outer diameter of the valve guide.



Attention: Do not measure the diameter on the lowered part of the guide.

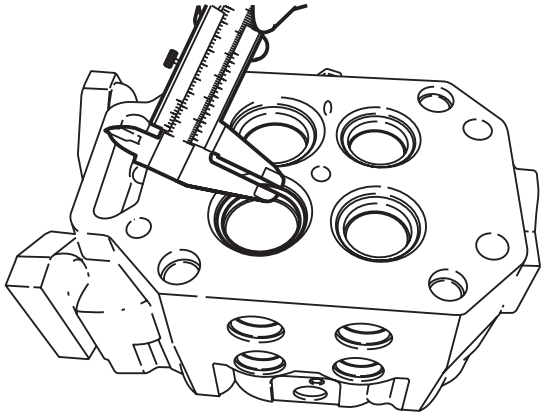
Measure valve guide housing bore.

After the measurements, install valve guides with the special tool MWM nr. 9.610.0.690.014.6.

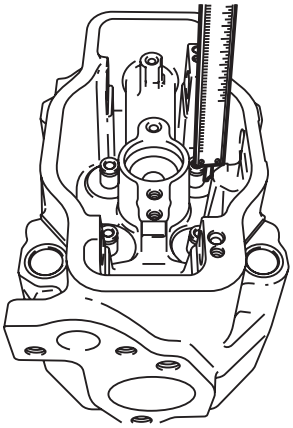


Measure the bore of the assembled valve guide.

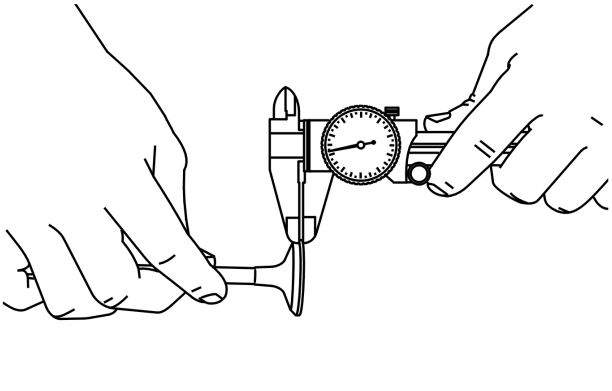
Measure the width of the valve contact surface.



Measure the valve guide height in relation to the cylinder head.



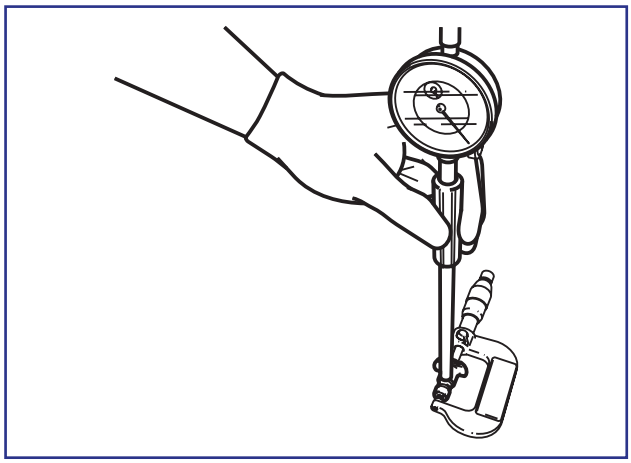
Measure the width of the valves seat.



Check if the rocker arm ends do not present excessive waste or cracks in the shaft housing or on the contact area with the valve stem. After removing the rocker arms, check for grip signs.

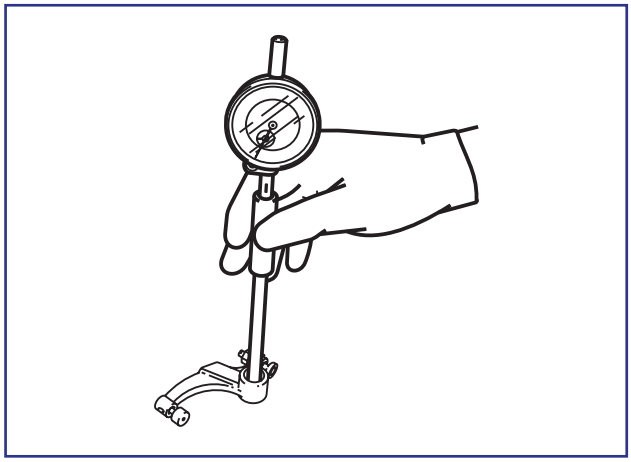
Measure the rocker arm shaft and out of roundness.

Check with the micrometer.



Measure the shaft housing bore.

Check rocker arms ends axial clearance in the shafts and deformities like roundness and taper.



Remark: Before beginning the assembly of the cylinder head set, all parts must be well clean.

Cylinder head assembly

Cylinder head

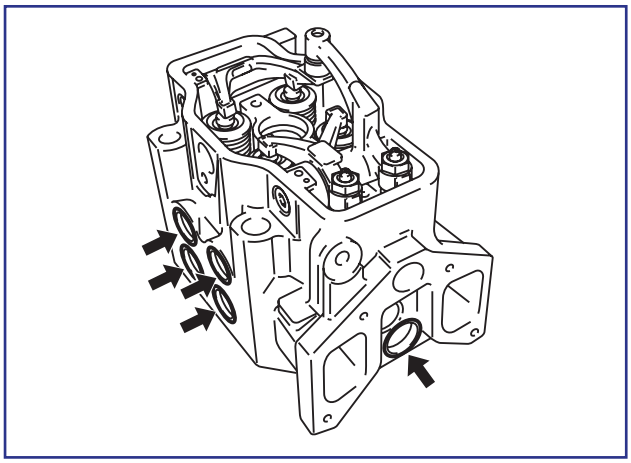
Before release the cylinder head bolts, remove the valve cover and balancer.

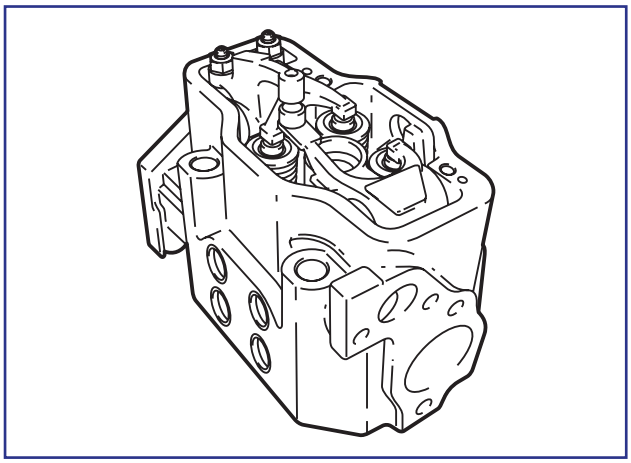
Utilize the cylinder head bolts for cylinder head and gaskets removal procedure.

Remove carefully the cylinder heads.

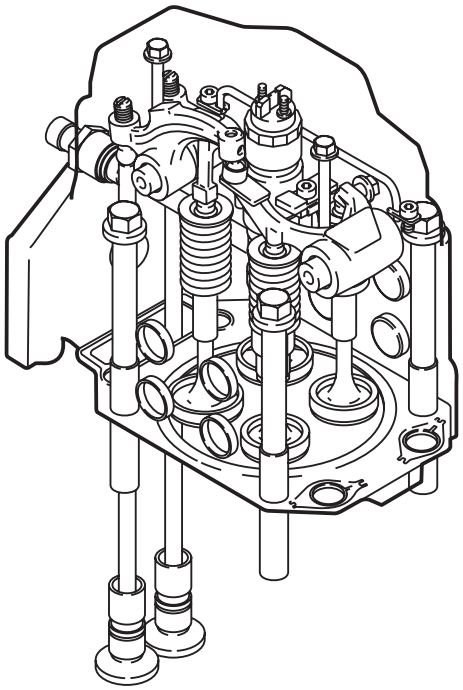
Verify the sealing cover conditions, as shown.

Note: If there are leakage signals, replace the components, as necessary.



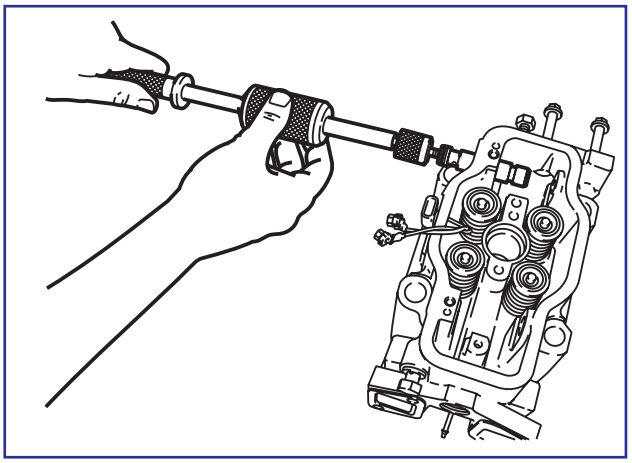


Cylinder head – general view

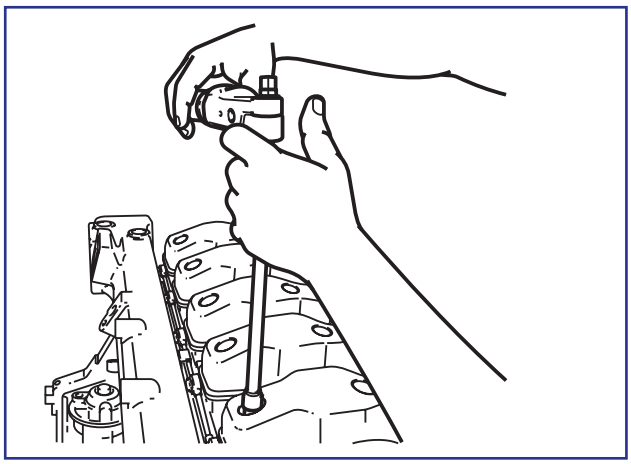


Cylinder Head - Disassembly Procedure

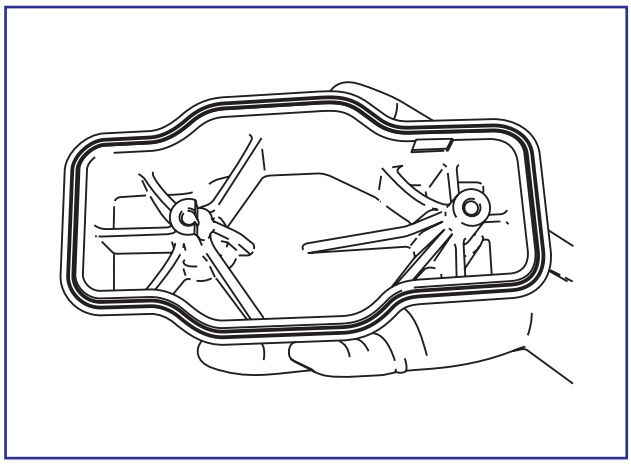
To remove the balancer rocker arm shaft, utilize the special tools MIM No. D700596C1 and 9.407.0.690.040.6.



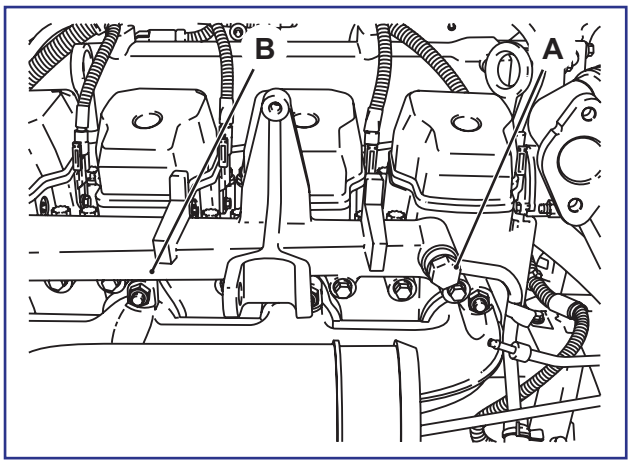
Remove the valve cover.



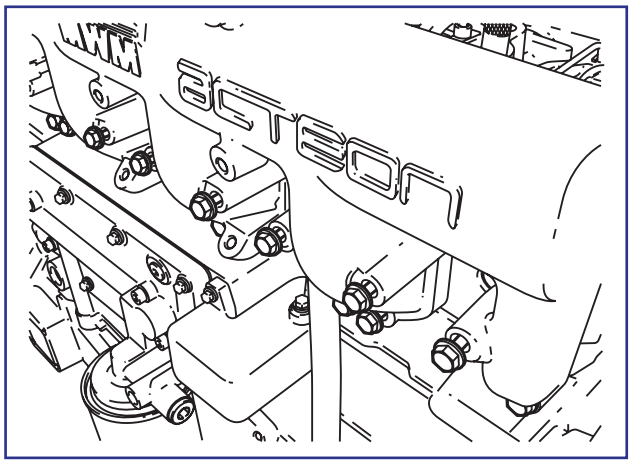
Remove valve cover sealing ring.



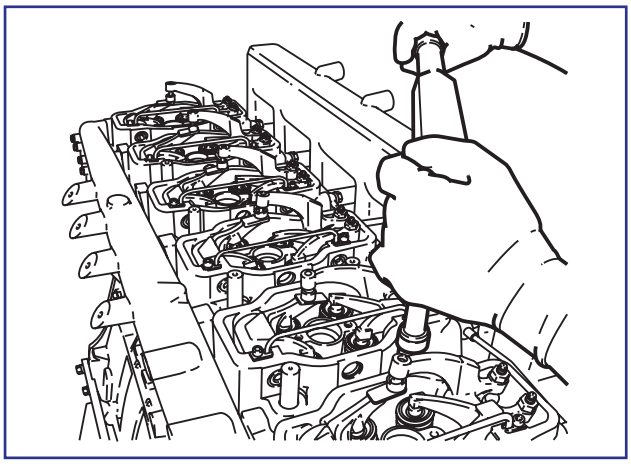
Remove the water outlet pipe.



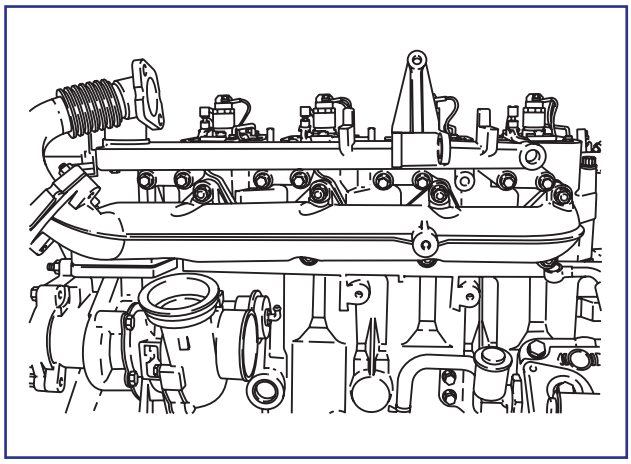
Remove the intake manifold.



Remove the cylinder head mounting bolts.

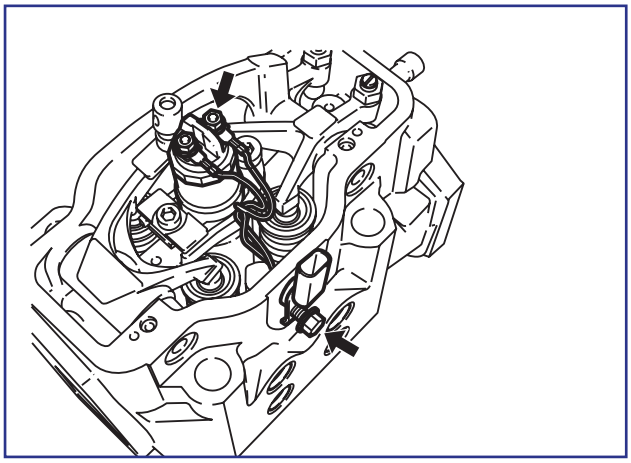


Remove water pipe mounting bolts.



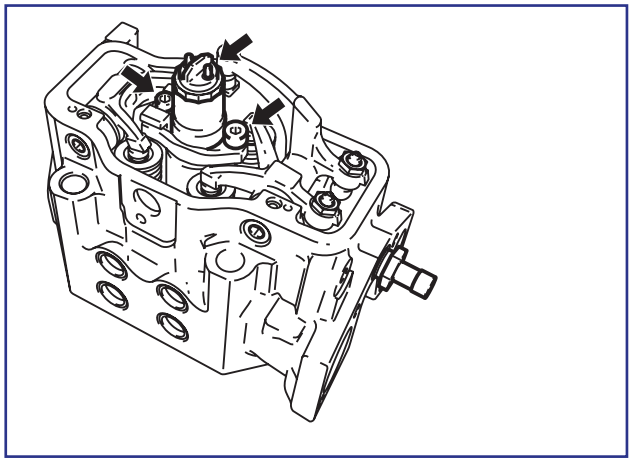
Remove the nuts and disconnect the electrical wrip from the cylinder head to the injector connectors.

Remove the bolt and disconnect external injection nozzle connector.

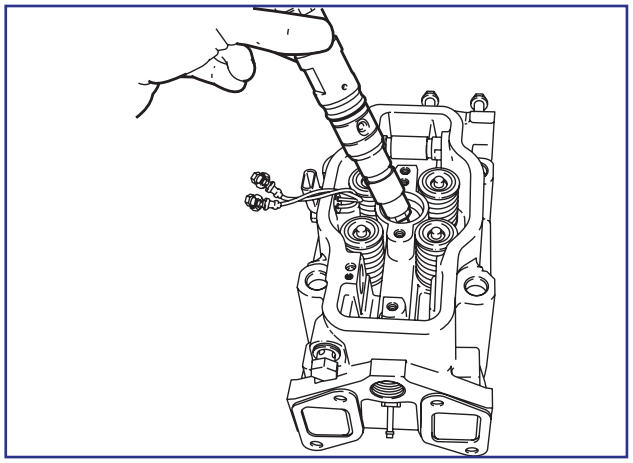


Procedure to remove the injection nozzle

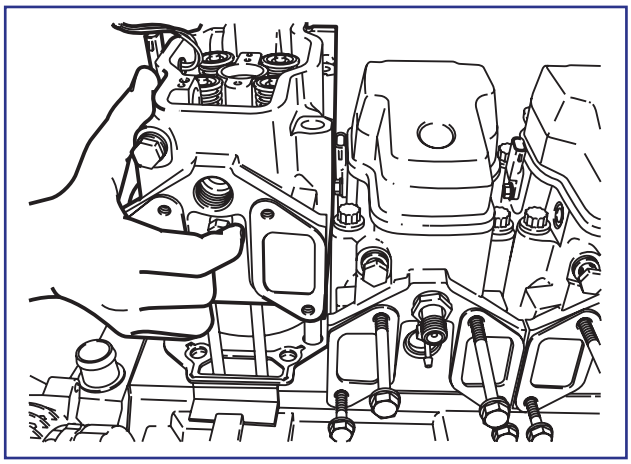
1. Remove the clip, bridge and the two bolts.
2. Remove special step bolt.
3. Remove the holder clip bolt.
4. Remove the holder clip.
5. Remove the Holder Bridge.
6. Remove the high pressure connector.



Remove the fuel injector to the cylinder head.

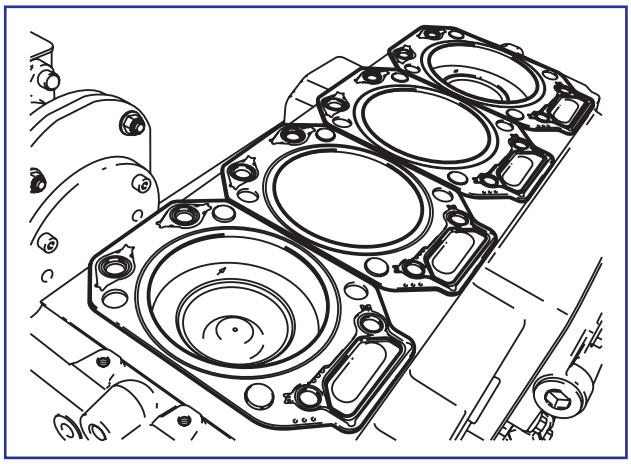


Remove the cylinder head.

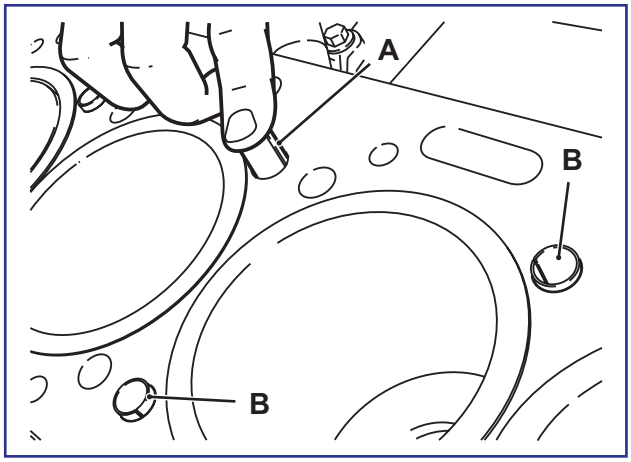


Remove the push rods.

Remove the gaskets.

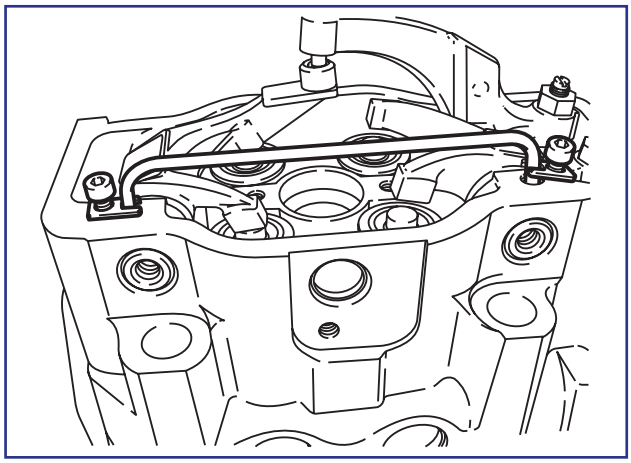


Remove the guide bushing.

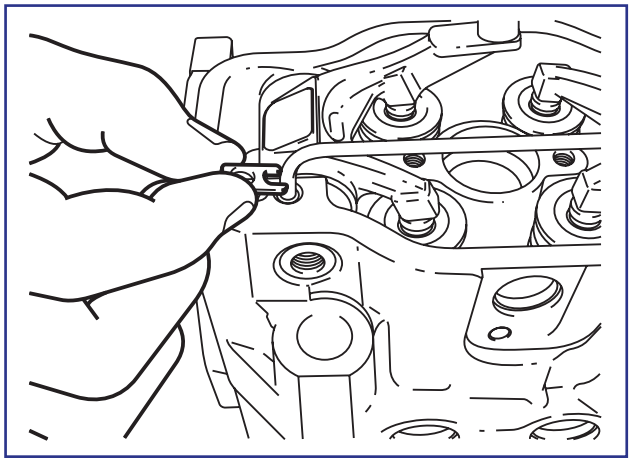


Cylinder head – disassembly procedure

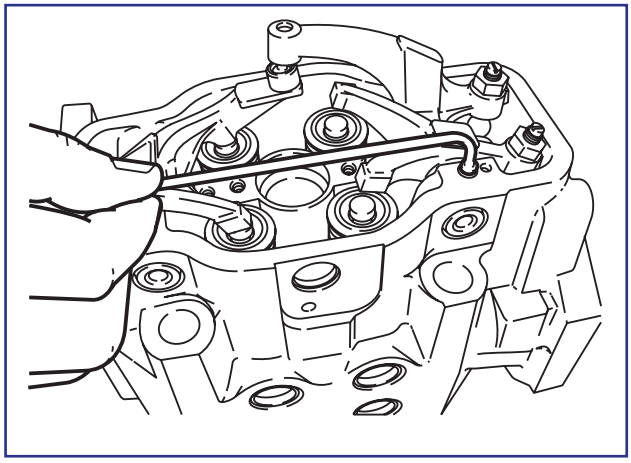
Remove the M5X10 bolts.



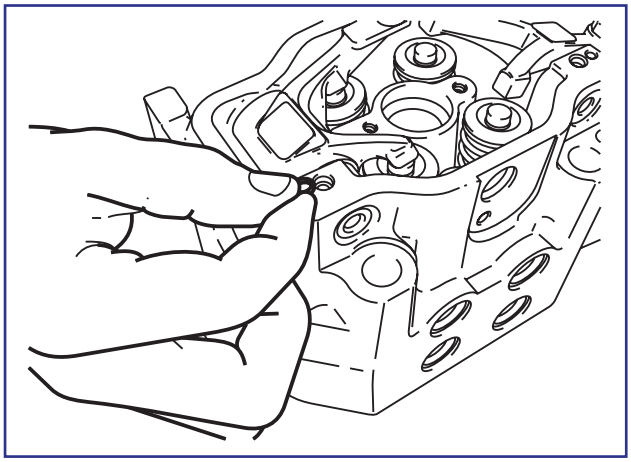
Remove the lubrication pipe locker.



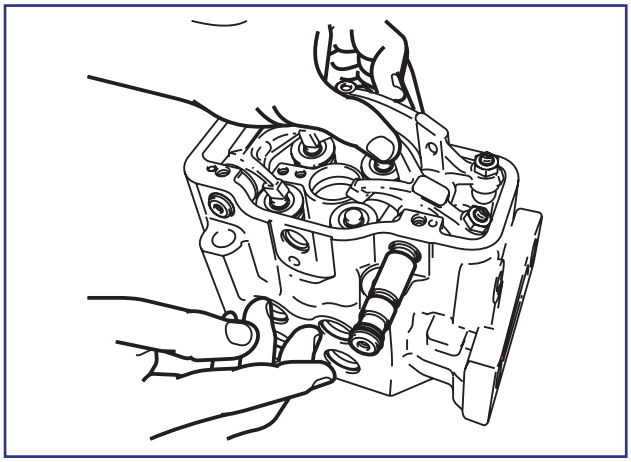
Remove the balancer shaft lubrication pipe locker.



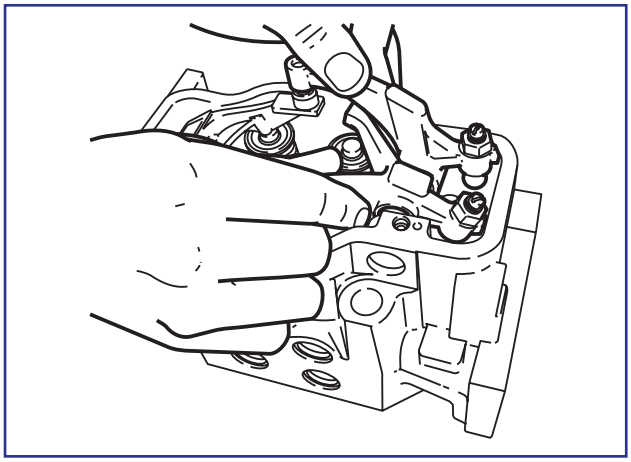
Remove the O-Ring.



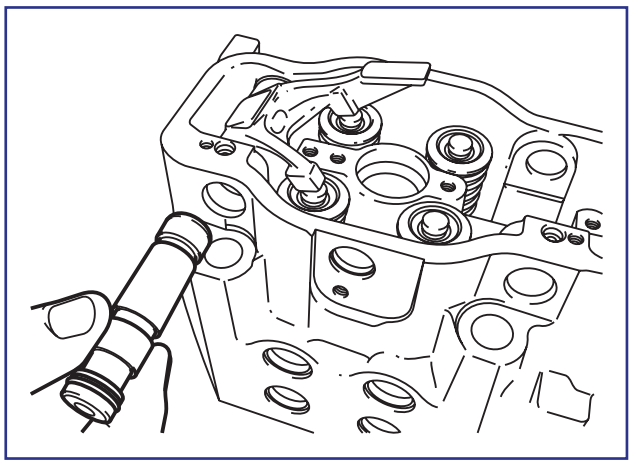
Remove the balancer shaft with the O-Ring.



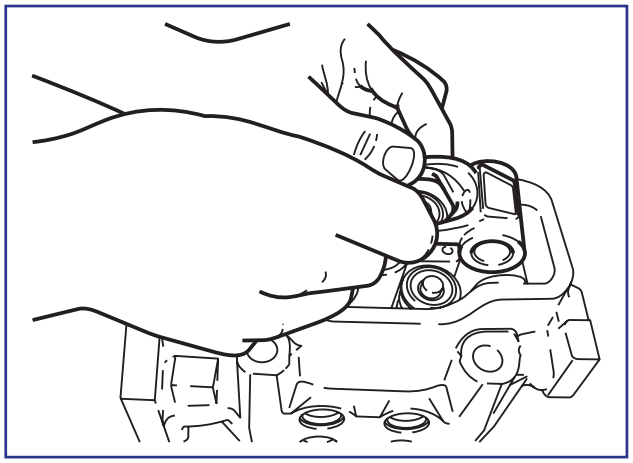
Remove the intake rocker arms.



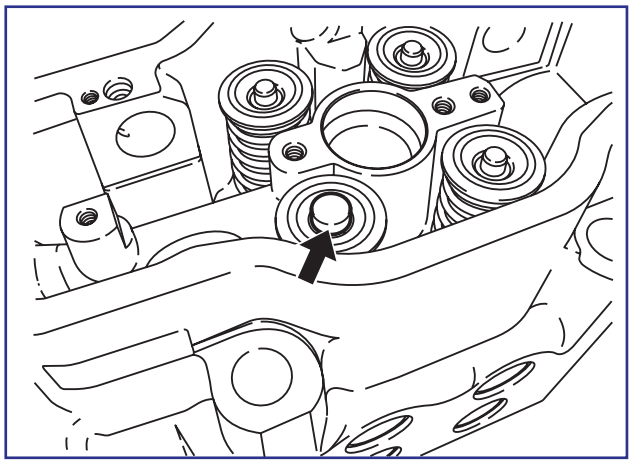
Remove the balancer shaft with the O-Ring.



Remove the exhaust rocker arm.

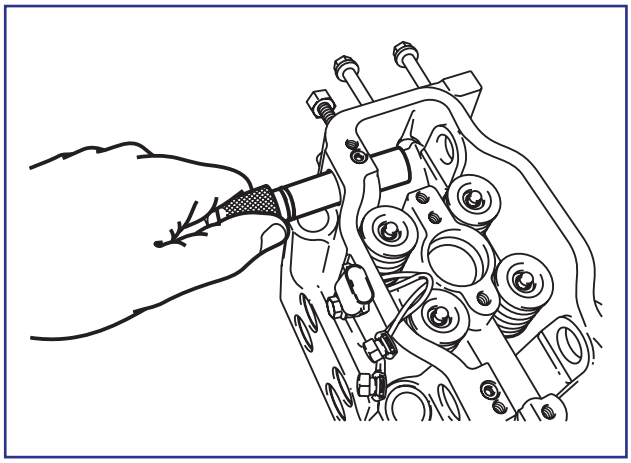


Remove the valve to balancer spacers.

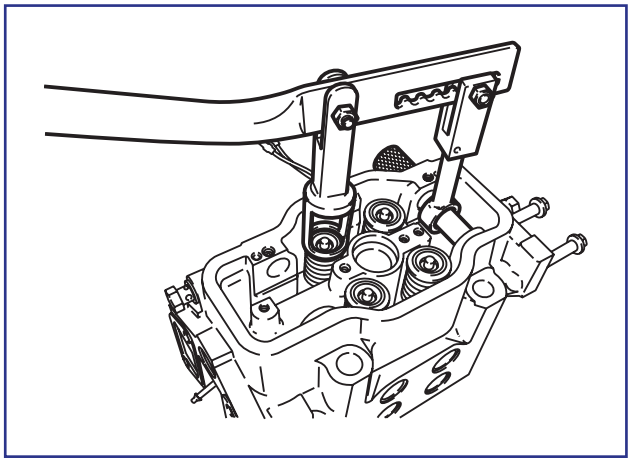


To compress and remove the valve spring locks, use the special tool No. D7000598C1.

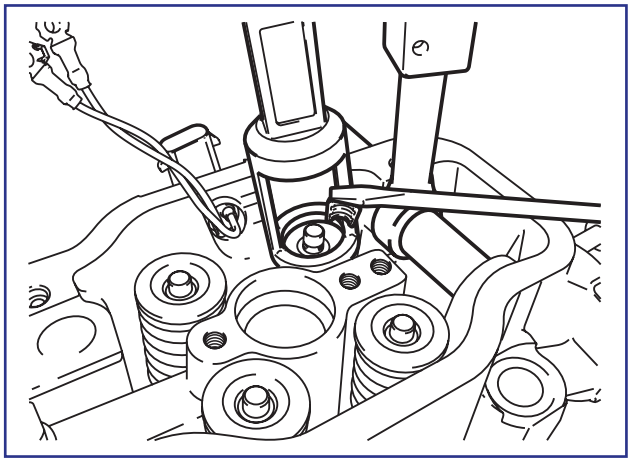
Install the special tool guide, as shown.



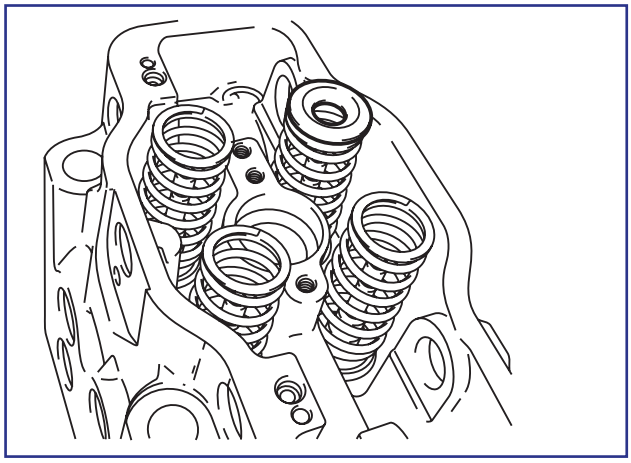
Install the special tool lever to the guide, as shown.



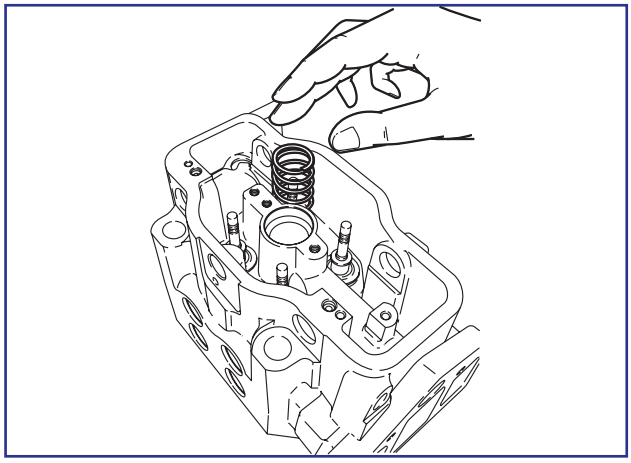
Compress the spring and remove the spring locks, as shown.



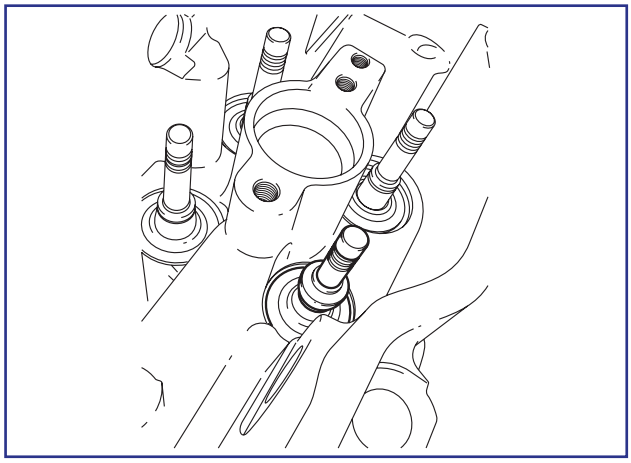
Remove the spring upper discs.



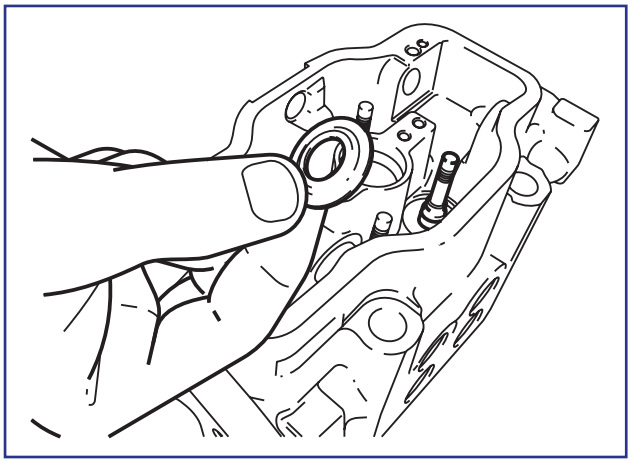
Remove the spring valves.



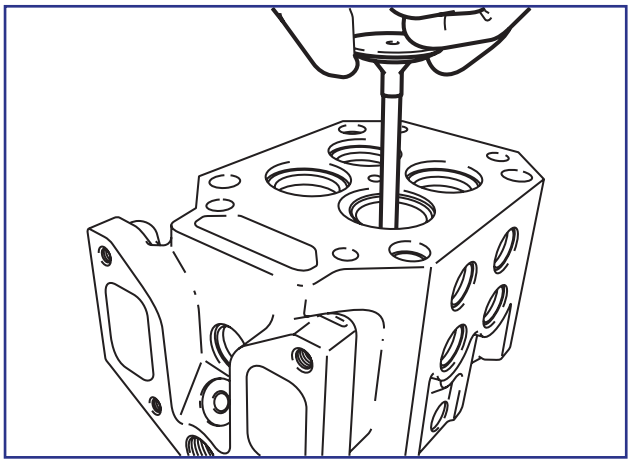
Remove the valve retainers off its housing.



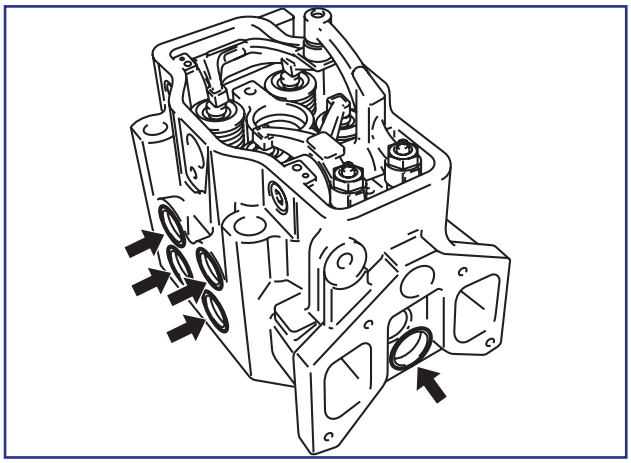
Remove the lower spring discs.

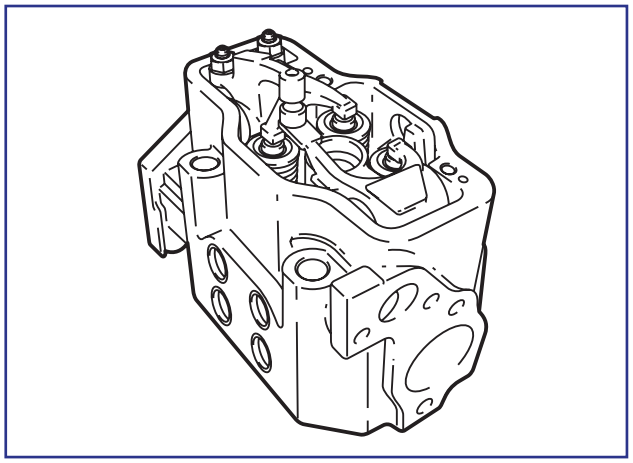


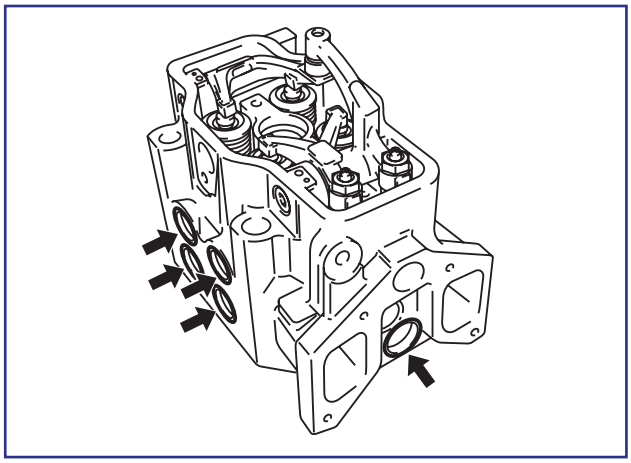
Remove the 4 valves.



Check the 9 sealing covers illustrated regarding to leakage, corrosion or damages. Replace if is necessary.

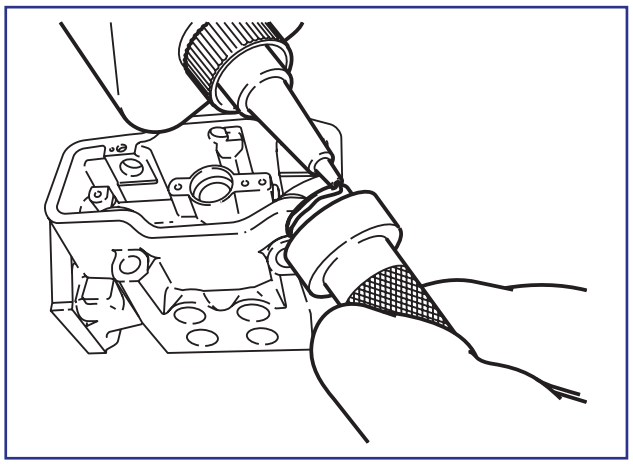




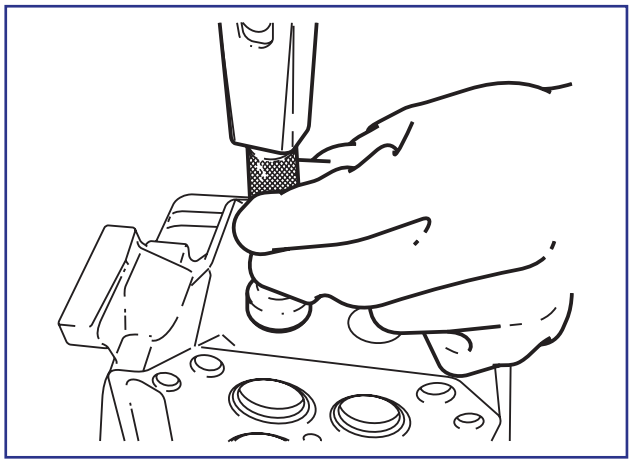


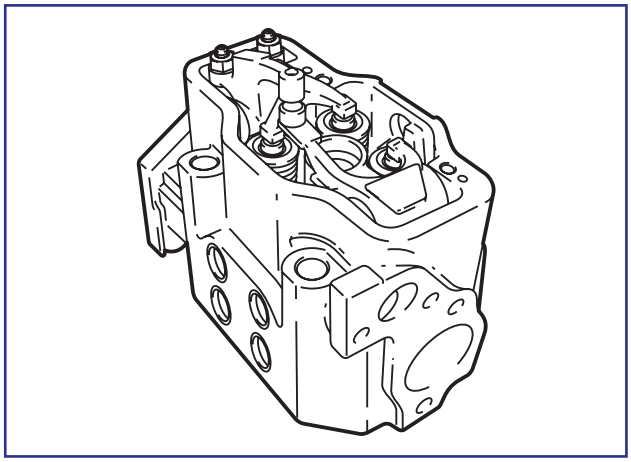
Cylinder head – assembly procedure

Apply loctite 648 or equivalent to the sealing.

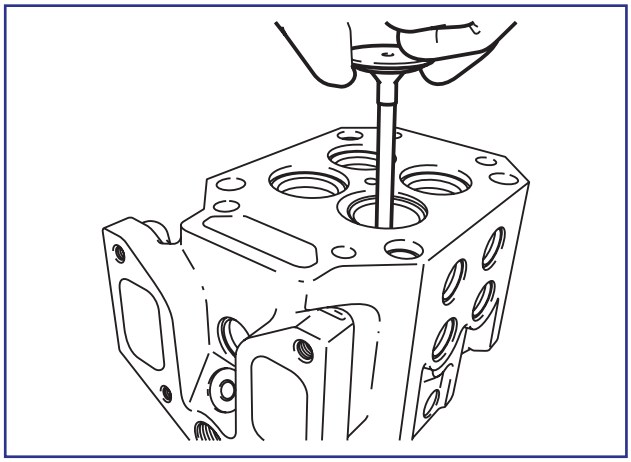


Install the 9 sealing covers. See the following illustration for sealing cover locations.

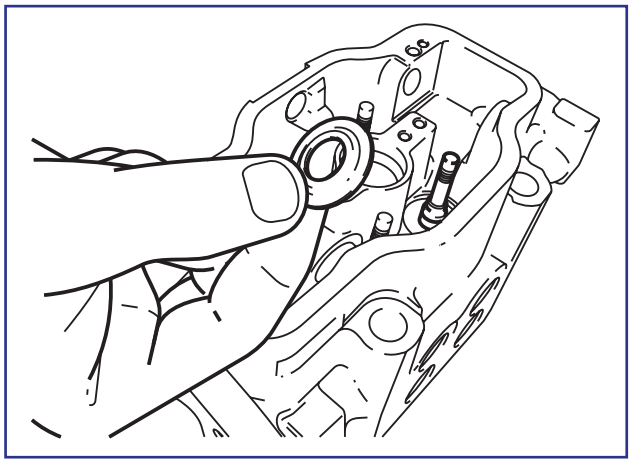




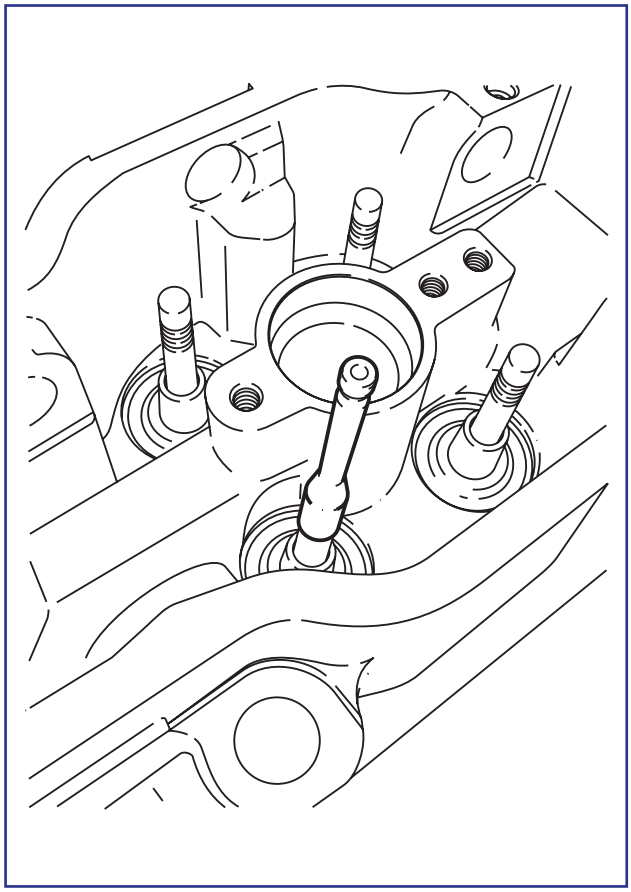
Install the 4 valves.



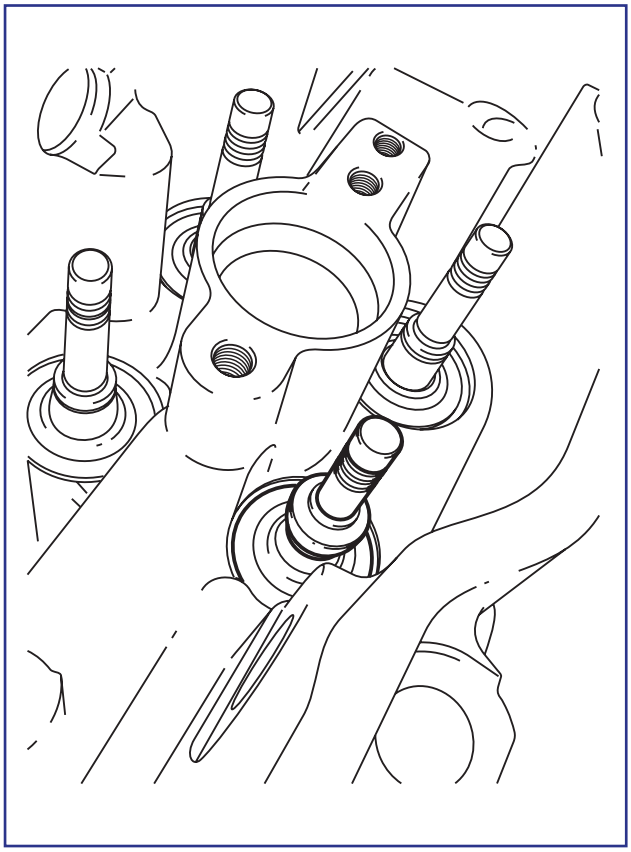
Install the lower spring discs.



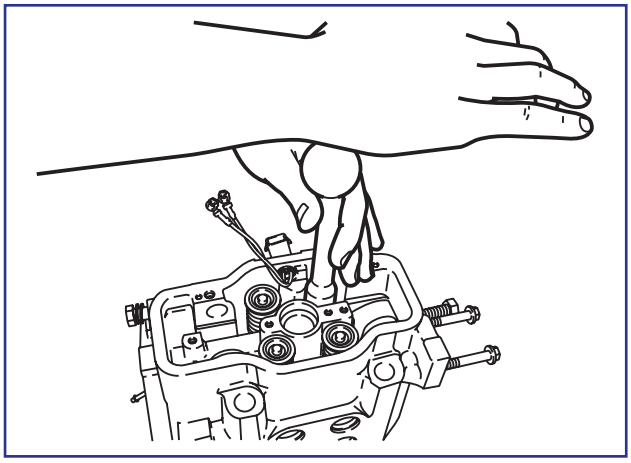
Install the special tool No. D70000597C1 to slide the valve retainer.



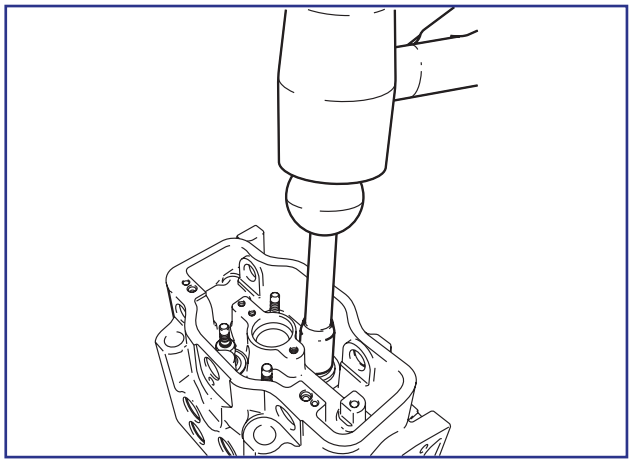
Put the valve retainers in the shown position.



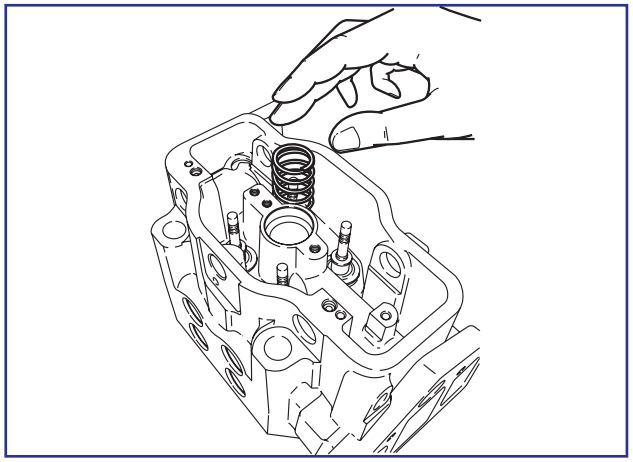
Using the special tool No. D70000597C1 and its spacer, install the valve retainer in its housing.



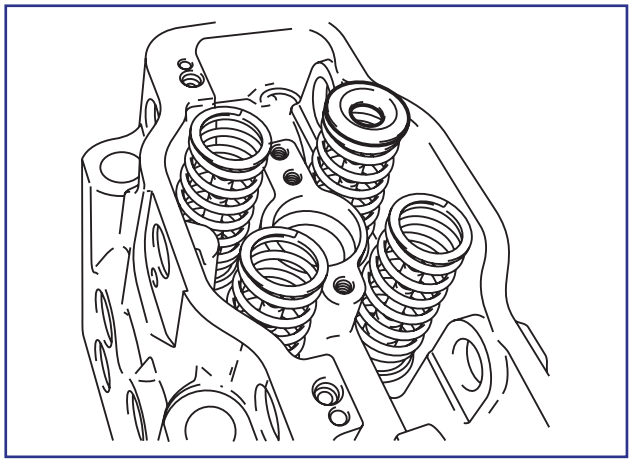
To assure the valve retainer is fully fitted onto the stem of cylinder head valve guide, the special tool spacer must reachs the cylinder head surface. Use a rubber hammer and apply light blows over the special tool observing the spacer reachs such position.



Install the spring valves.

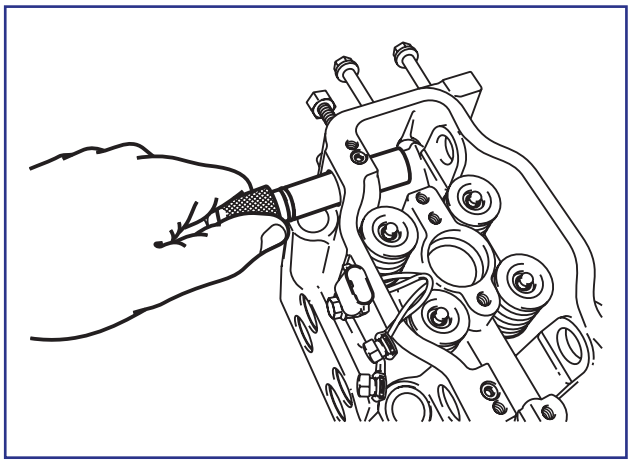


Install the spring upper discs.

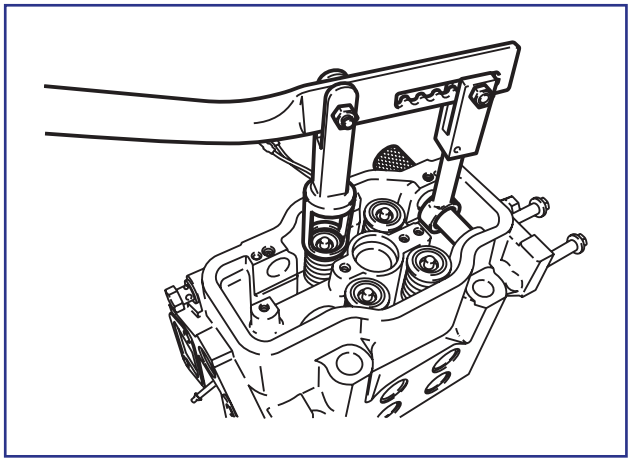


To compress and install the valve spring locks, use the special tool No. D7000598C1.

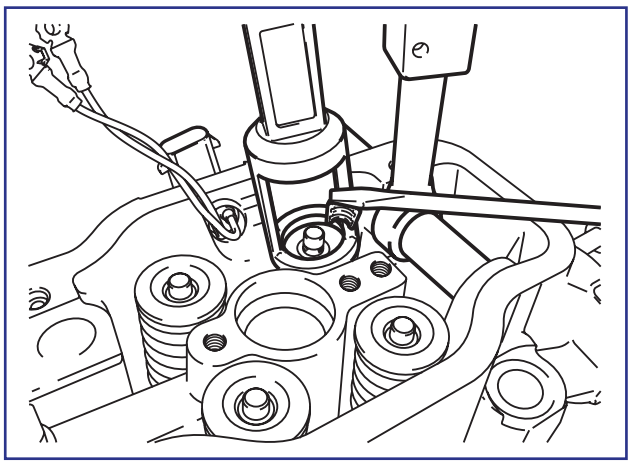
Install the special tool guide, as shown.



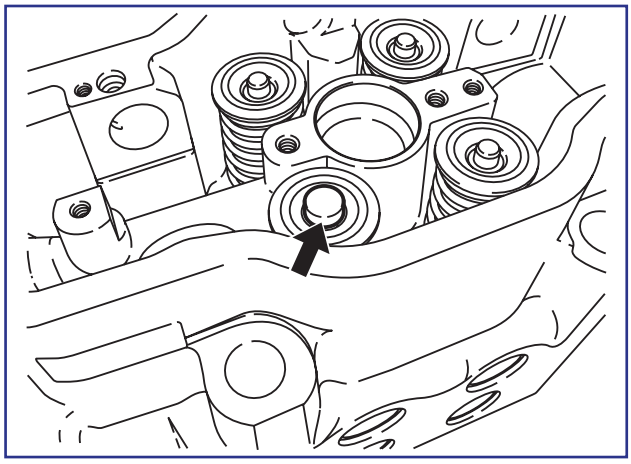
Install the special tool lever to the guide, as shown.



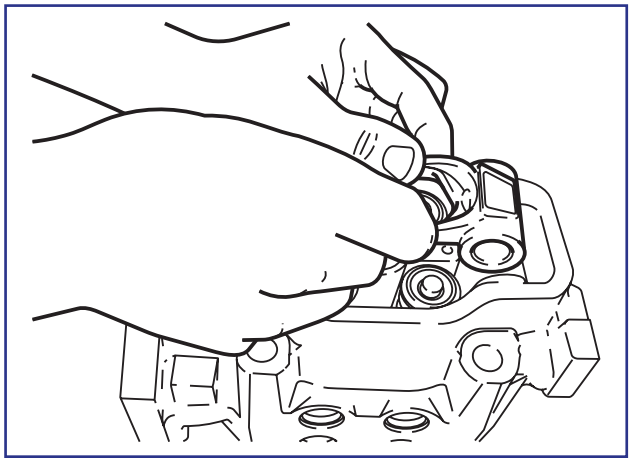
Compress the spring and install the spring locks, as shown.



Install the valve to balancer spacers.

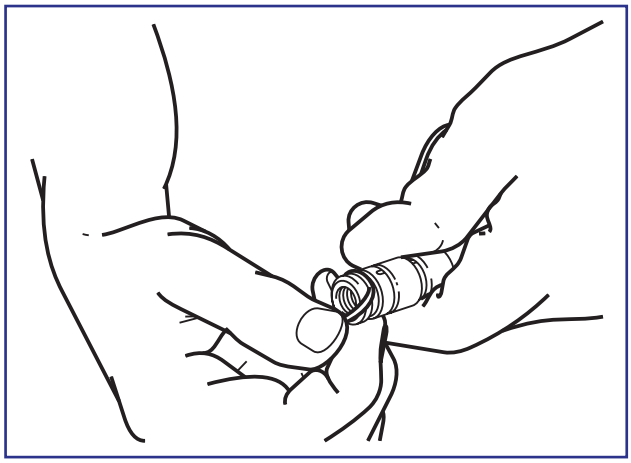


Install the exhaust rocker arm.

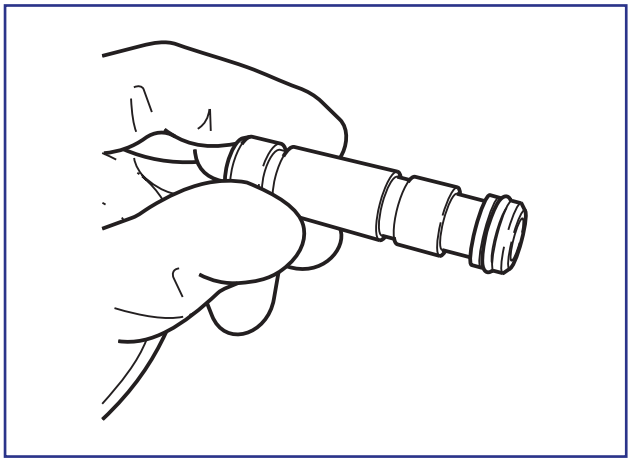


Apply vaseline or clean oil engine to the O-Ring previously.

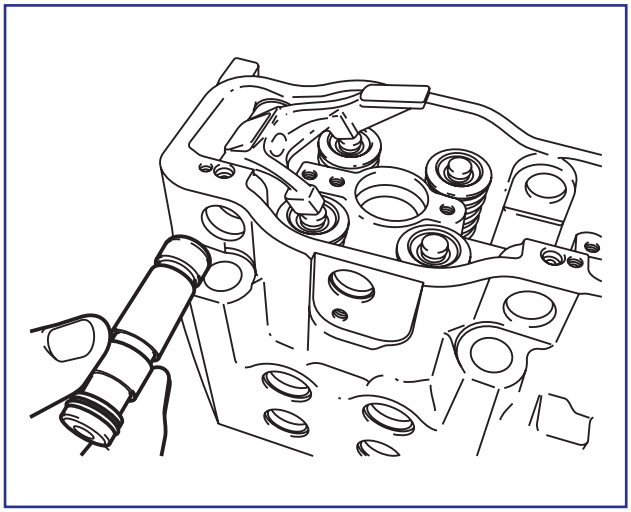
Install the O-Ring on its balancer shaft housing.



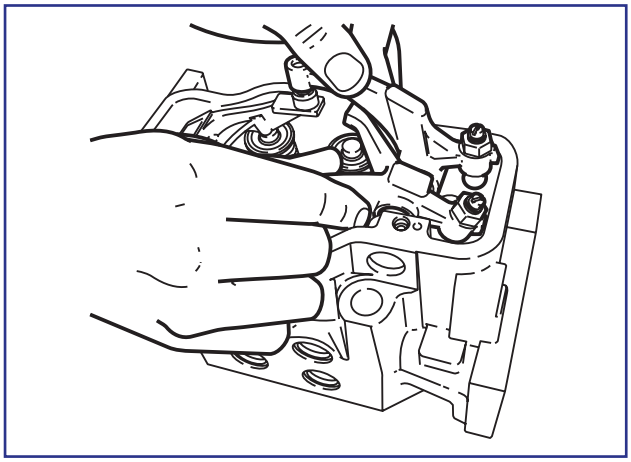
Note: when mounting the balancer shaft, make sure that the O-Ring fits correctly, to avoid any damage.



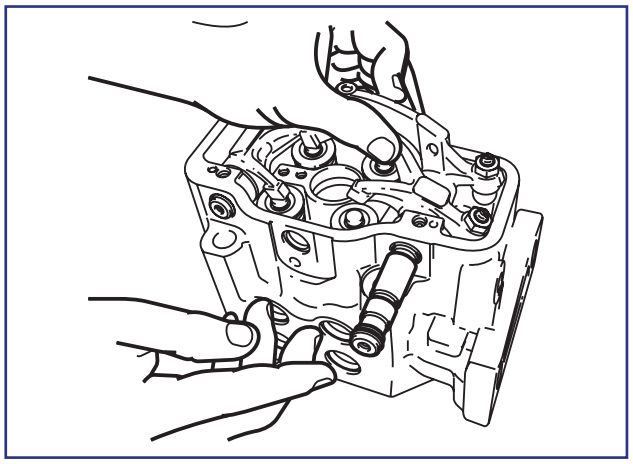
Install the balancer shaft with the O-Ring to the outer side.



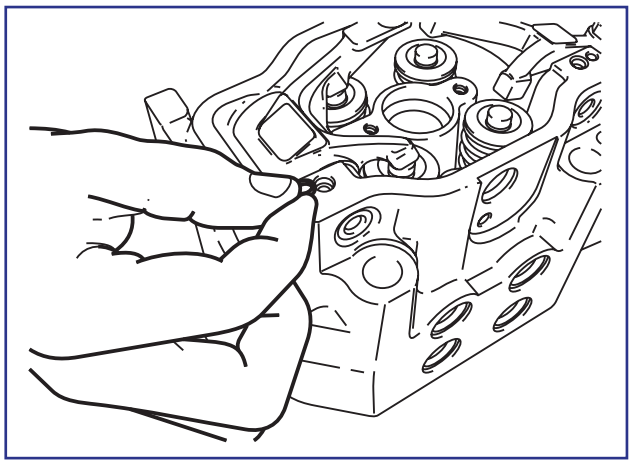
Install the intake rocker arms.



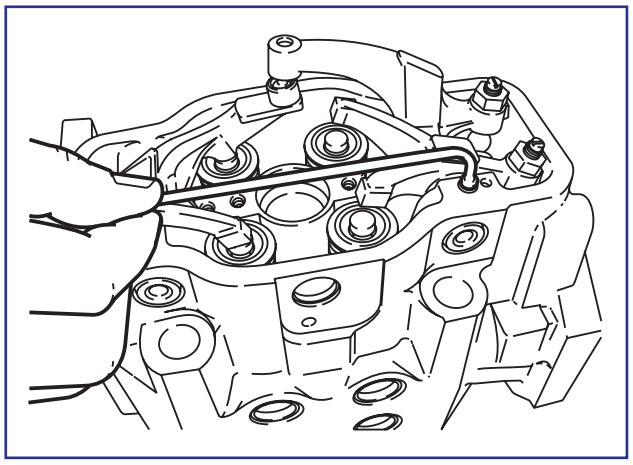
With the O-Ring previously installed, mount the balancer shaft with the O-Ring to the outer side.



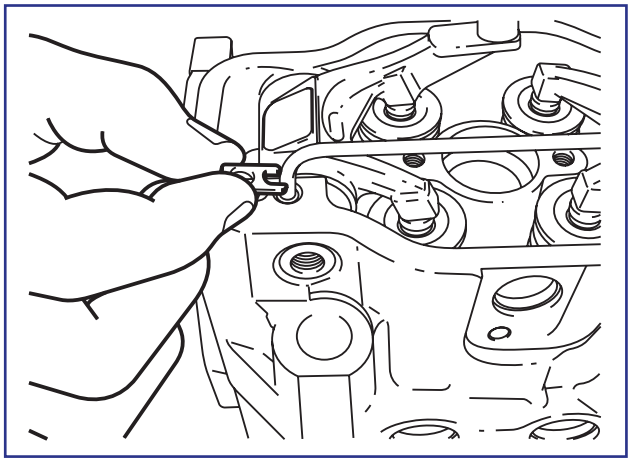
Install the O-Ring.



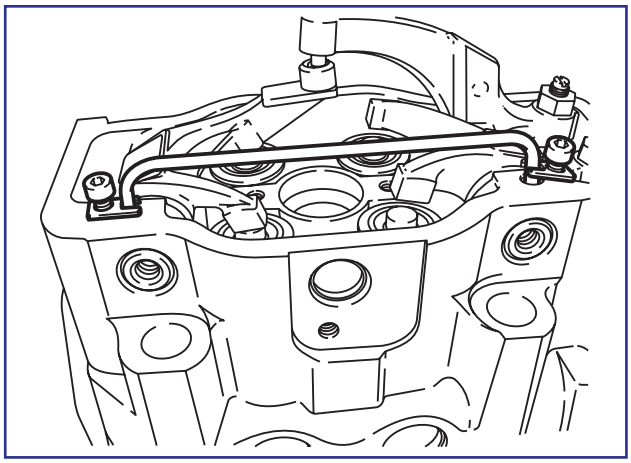
Install the balancer shaft lubrication pipe locker.



Install the lubrication pipe locker.

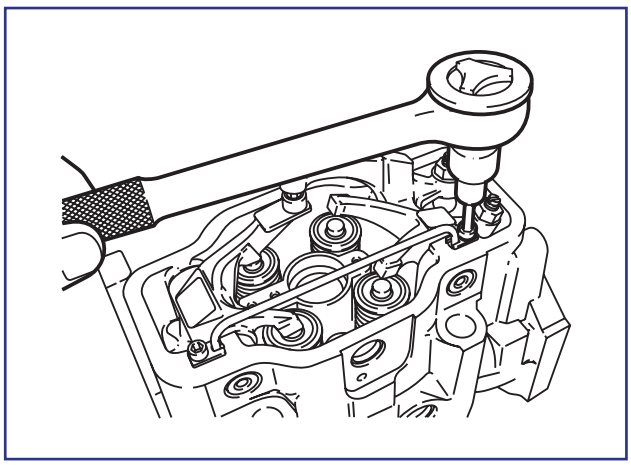


Install the M5X10 bolts.



Tighteen the bolt.

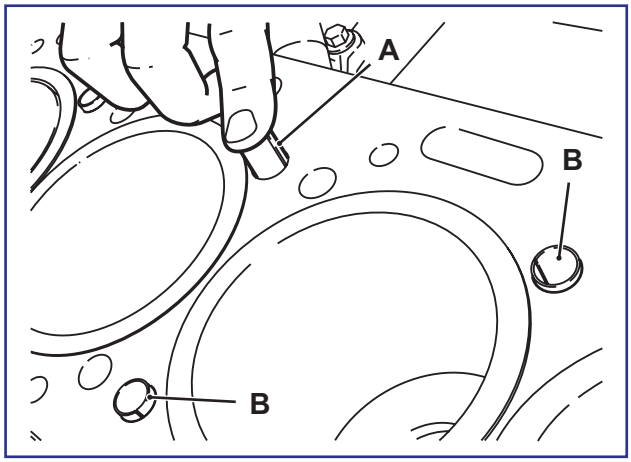
Torque: 4 to 6 N.m



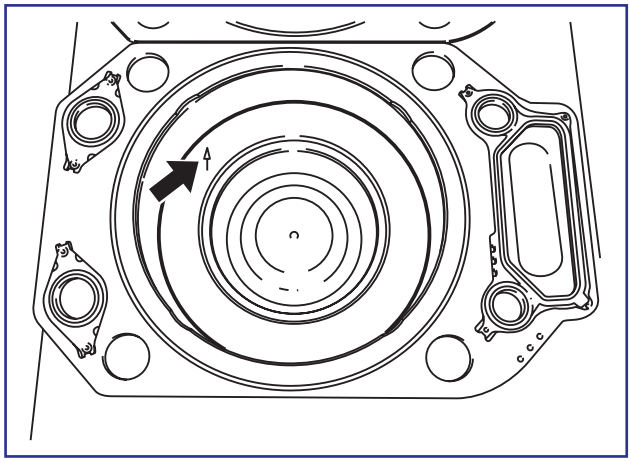
Cylinder head to the engine block instalation

a. Install the guide bushing.

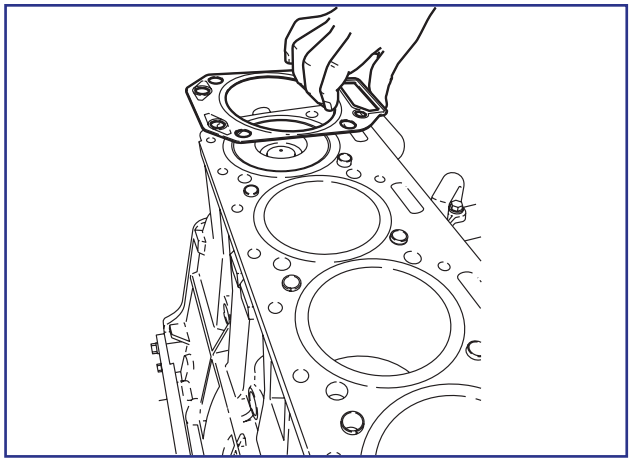
b. Two guides for each cylinder at opposite sides, as shown.



For the cylinder gasket instalation, observe the TOP position market on the gasket that must face to the upper side.

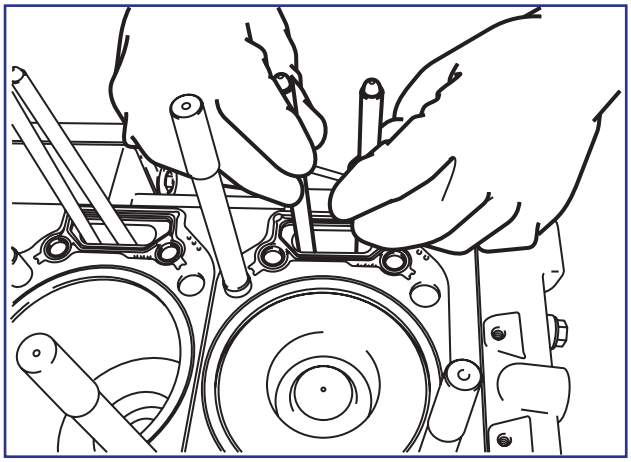


Install the gasket that must fits to guide bushing.

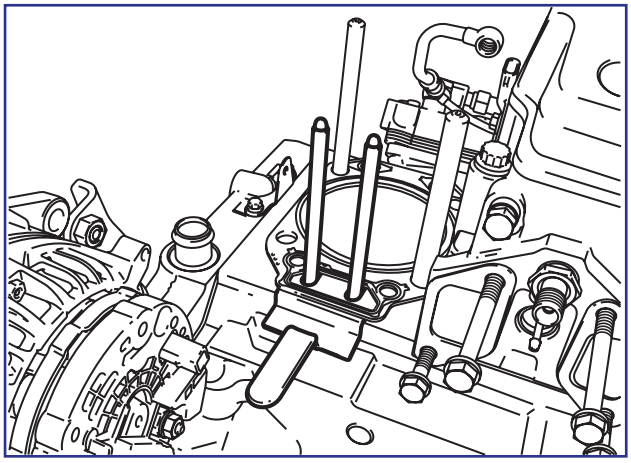


Install the guide pin special tool No. 9.407.8.690.030.4 to align the cylinder heads

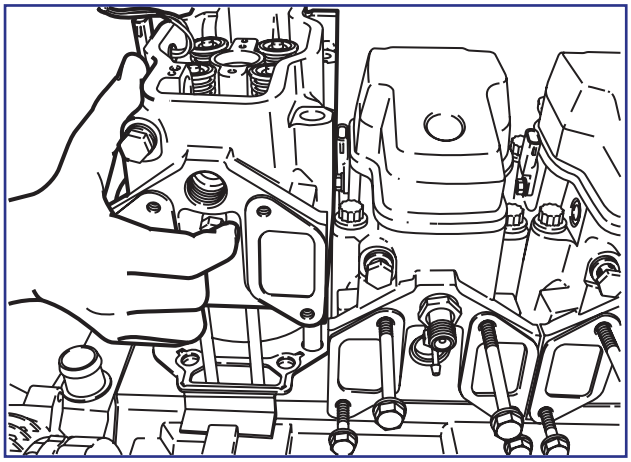
Install the push rods.



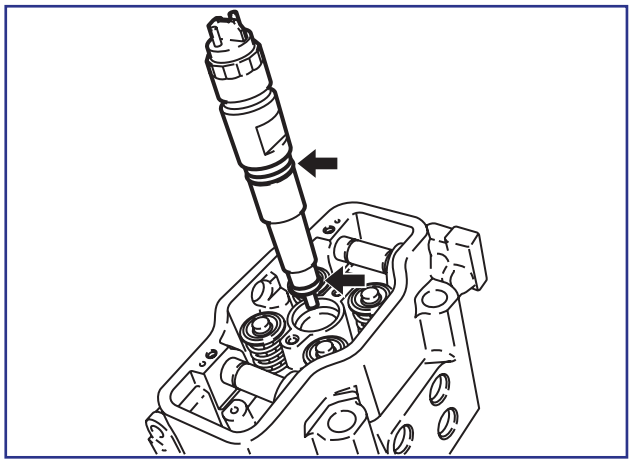
Install the special tool No. D7000595C1 to align the push rods.



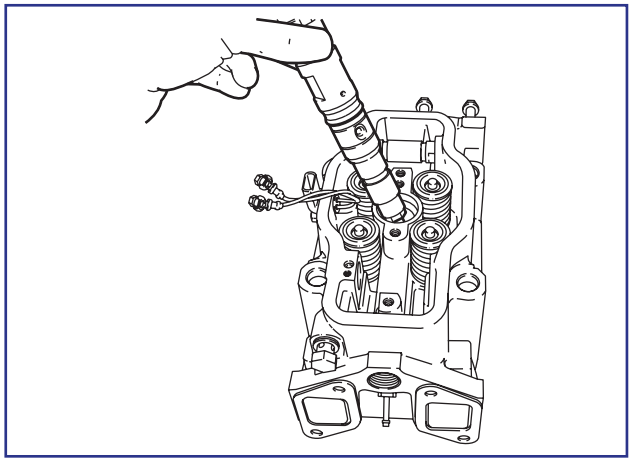
Install the cylinder head.



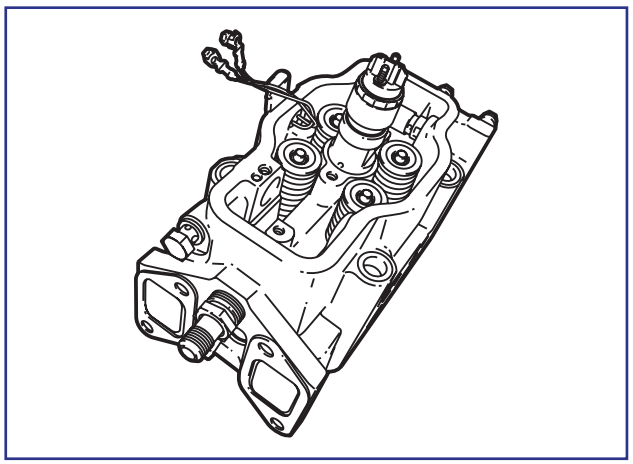
Install new O-Ring and sealing washer to the injector and observe its correct position.



Install the fuel injector to the cylinder head.

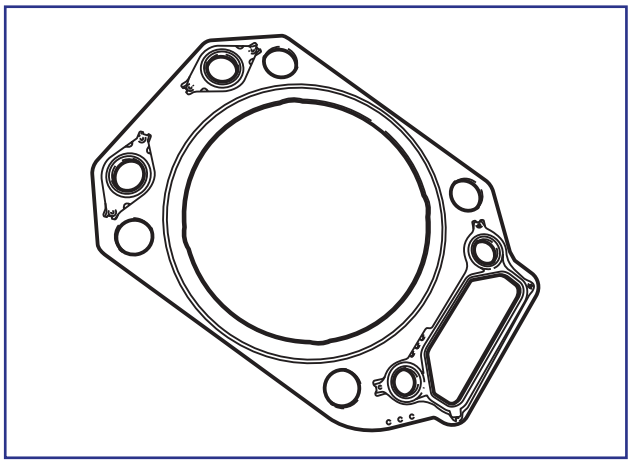


Install the High pressure connector on its correct position.

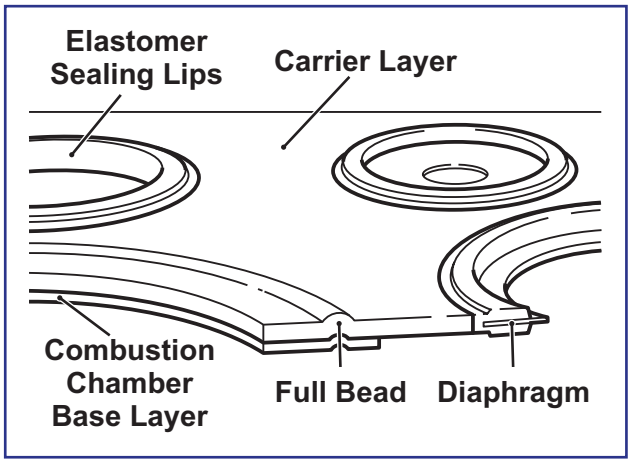


Cylinder Head Gasket

The cylinder head gasket is made of steel and its main characteristic is its double assembly, that is to say, for two cylinder heads.



Metal-elastomer cylinder-head gaskets, strong and durable sealing system consisting of metal carriers with vulcanized elastomer profiles. The basics for outstanding performace of the metal-elastomer cylinder-head gasket is the distribution of compressive strenght in the engine block/cylinder head region specific compressive strength in the combustion chamber area and a low compressive strenght in the liquid area. The metal-elastomer cylinder-head gasket is the leading sealing techinique for heavyduty engines with innovative drive concepts with four-valve technology, new injection systems, lightweight construction, higher ignition pressures and optimized engine performance.



Elastomer sealing lips

Elastomer sealing lips provide the seal for coolant and oil. Their material and geometry are specially adapted to the engine.

Carrier layer

Together with the combustion chamber bead, this layer determines the compressed thickness and the gas seal.

Combustion-chamber base layer

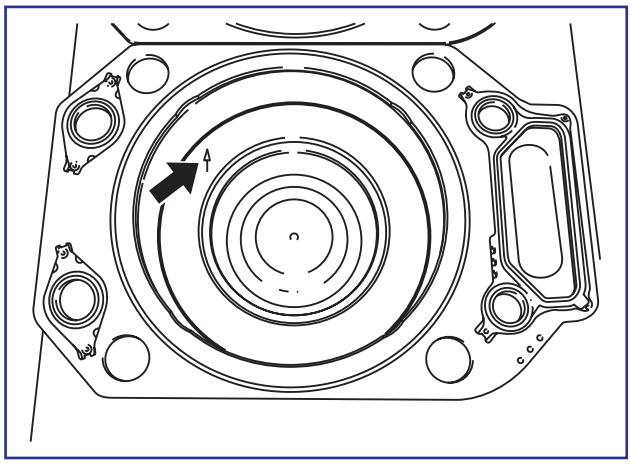
The combustion-chamber base layer is a design element that serves to increase the compressive strenght at the combustion chamber. The bolt forces are thus transferred to the combustion chamber area in a controlled manner.

Full bead

This generates a balanced compressive strenght along the edge of the combustion chamber.

Diaphragm

The flow of coolant can be controlled by guiding the flow cross-sections over vulcanized diaphragms.



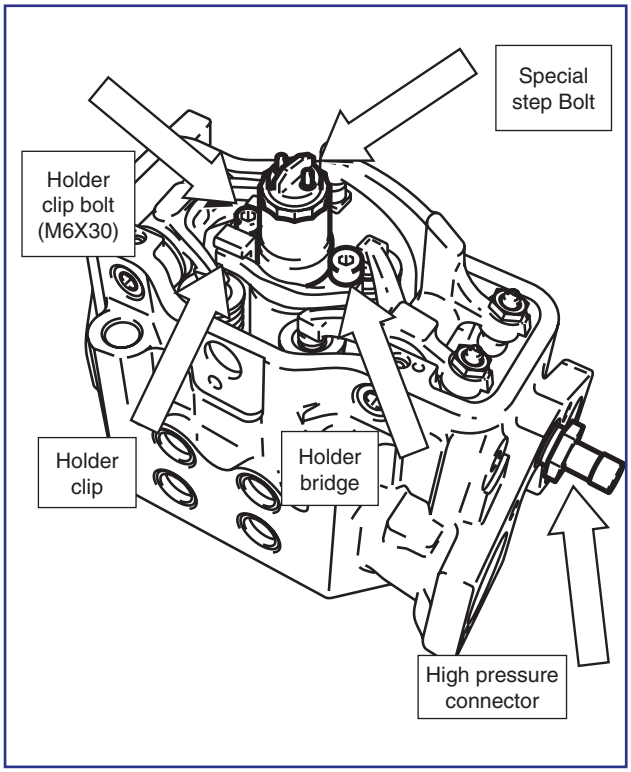
Complex Geometric

The gasket presents complex geometry and radius along ist circumference for this application.

Procedure to install the injection nozzle

1. Manually mount the clip, bridge and the two bolts.
2. Apply a torque of 3 to 5 N.m to the special step bolt.
3. Apply a torque of 1 to 1.5 N.m to the holder clip bolt.
4. Relieve the torque from holder clip bolt to 0 N.m.
5. Apply a torque of 15 to 20 N.m to the High pressure connector.
6. Apply a torque of 3 to 5 N.m to the holder clip bolt (1St Stage).
7. Apply a torque of 7 to 13 N.m to the holder clip bolt (2nd Stage).
8. Apply a torque of 50 to 55 N.m to the High pressure connector.

Note: This procedure is necessary to assure the correct seating and aligning from injector and high pressure connector.

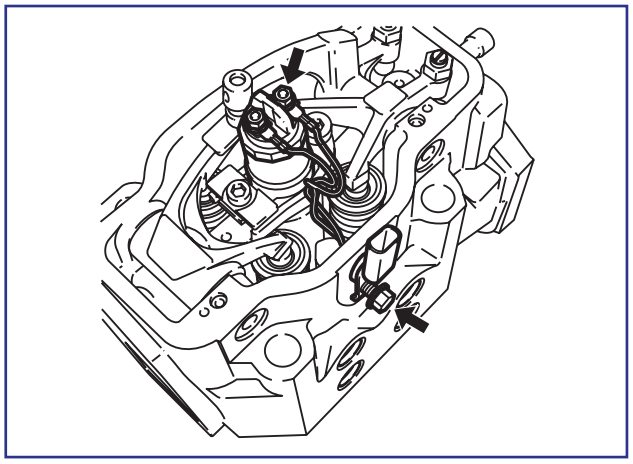


Using a M4 nut, connect the electrical wrip from the cylinder head to the injector connectors. Apply the torque to the nut.

Torque: 1.25 to 1.75 N.m

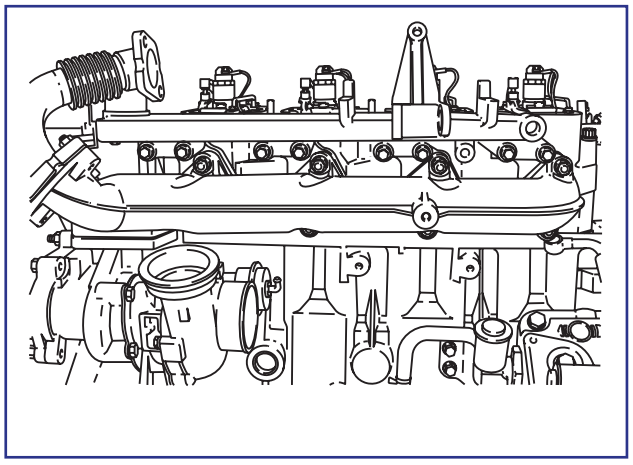
With a M6X12 bolt, tighten the external injection nozzle connector, applying the correct torque.

Torque: 7.5 to 9.5 N.m



Install the water outlet pipe.

Torque: 10N.m (apply torque crossed from center to the outside)

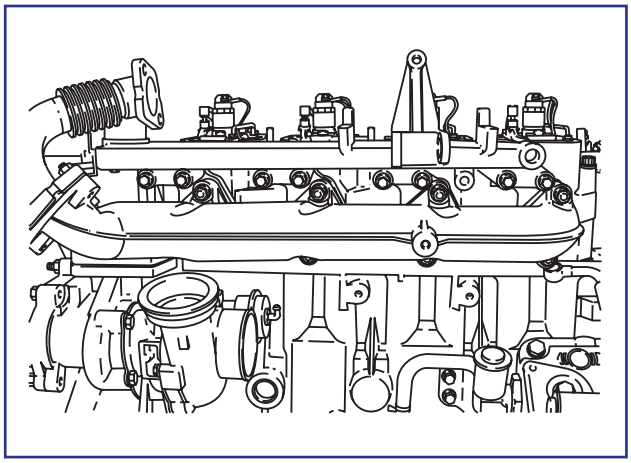


Install the water outlet pipe and exhaust manifold.

Torque:

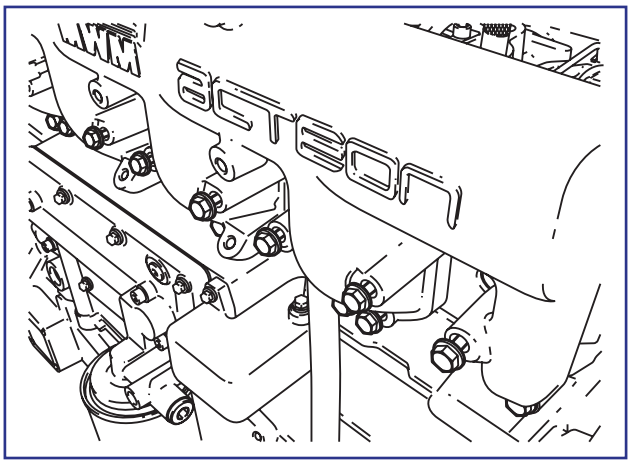
Water outlet pipe - 10N.m (apply torque crossed from center to the outside)

Exhaust Manifold - 10N.m (apply torque crossed from center to the outside)



Install the intake manifold.

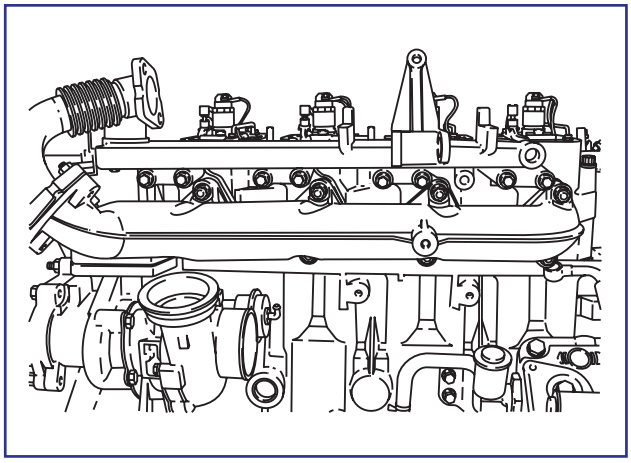
Torque: 10N.m (apply torque crossed from center to the outside)

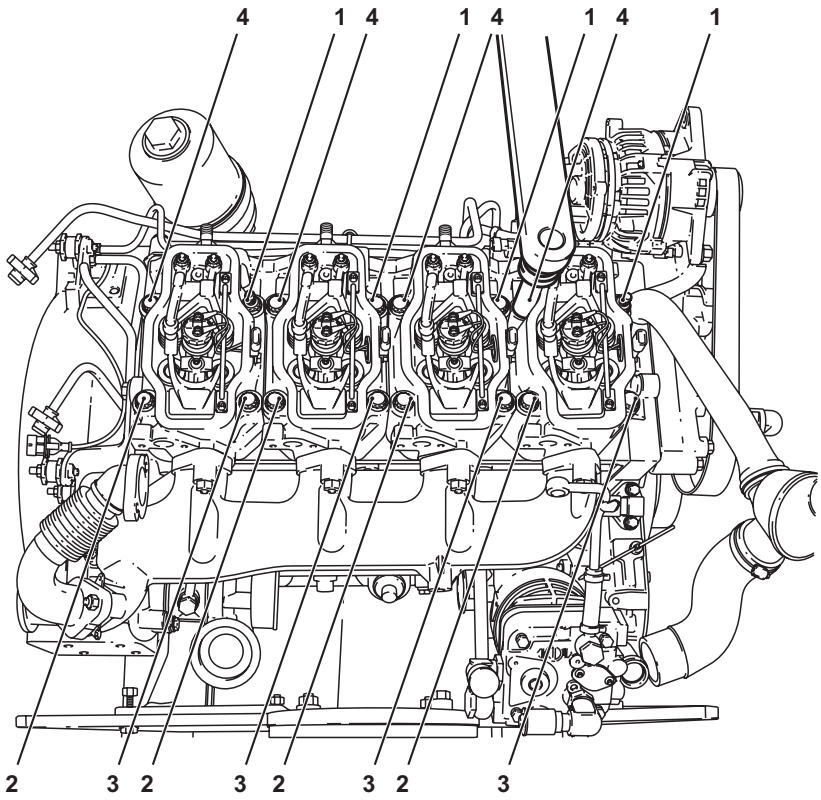


Apply a torque 21 to 29 N.m to the water outlet pipe crossing from center to the external side.

Apply a torque 60 to 80 N.m to the exhaust manifold crossing from center to the external side.

Remove the guide pin special tool.





Tighten the bolts following the sequence above in three steps, for each cylinder, according to the especifications below:

Torque conventional and angular:

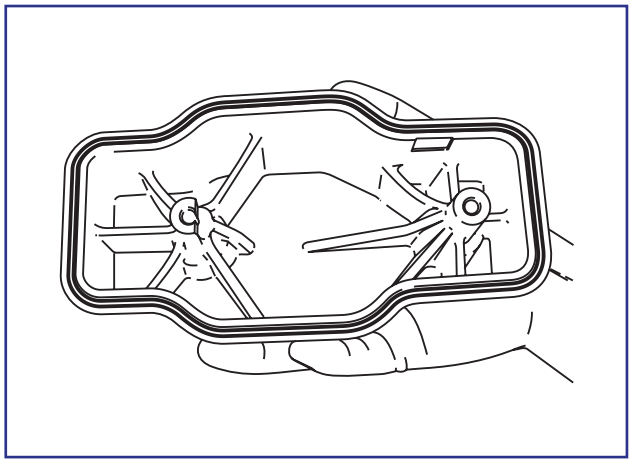
1st) 60 a 70 N.m

2nd) 60° ± 3°

3rd) 60° ± 3°

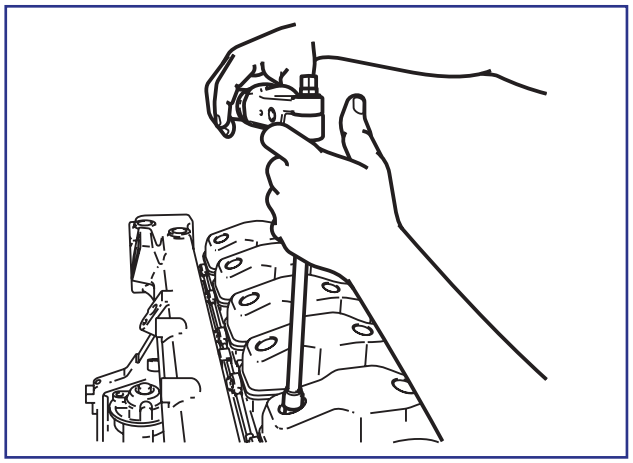
To adjust the valves, see the specific procedure in this section.

Utilize a new valve cover sealing ring, observe its correct position.



Using a M6x60 bolt, install the valve cover applying the correct torque.

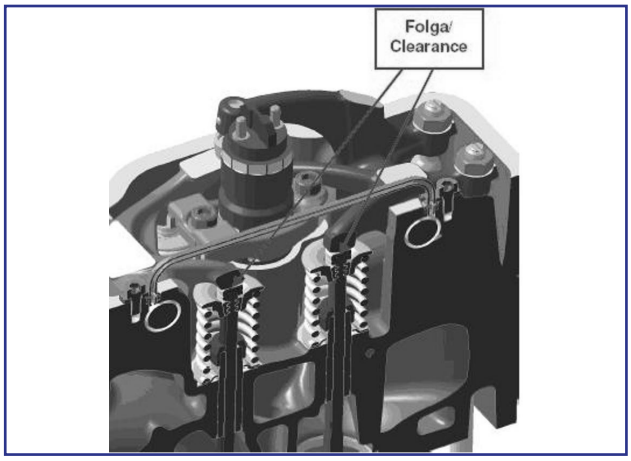
Torque: 7.5 to 9.5 N.m

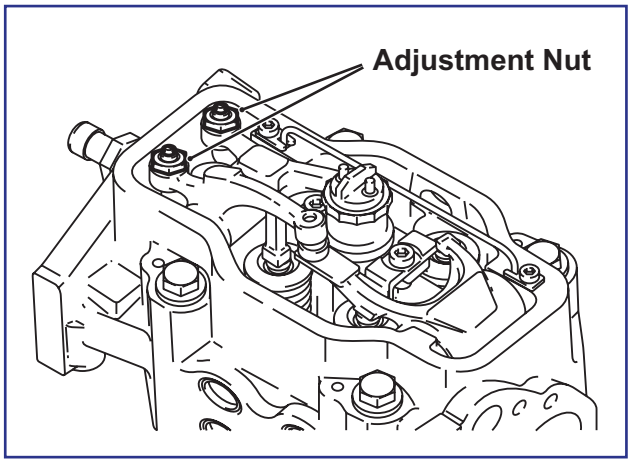


Cylinder head – admission and exhaust valves adjustment

Follow this procedure to assure the correct valve clearance adjustment.

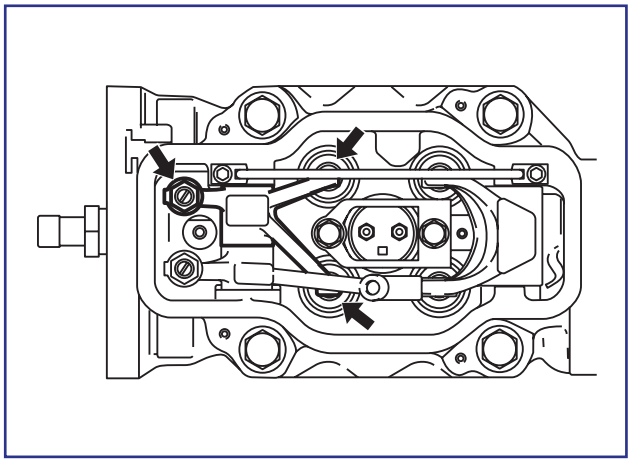
With the engine in cold condition, turn the crankshaft until the cylinder 4 intake and exhaust valves are closed, ensuring that camshaft is not acting the rocker arm that will be adjusted.





Intake valve adjustment

Adjustment clearance for admission and exhaust = 0.40 mm



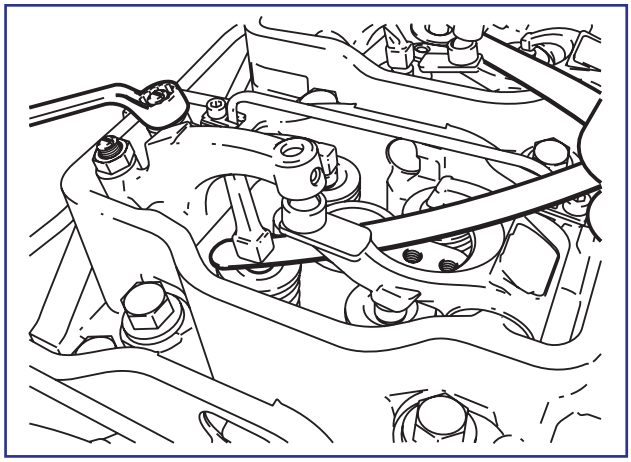
Start the adjustment through the intake rocker arm inserting the feeler gauge between the rocker arm and valve cap, as shown.

Use the feeler gauge with 0.40 mm

Using a screwdriver and a star key, tighten the adjustment bolt until remove the clearance between feeler gauge, rocker arm and valve cap, certifying that is still possible to remove the feeler gauge under such condition.

Apply a torque to the adjustment bolt.

Torque of adjustment bolt: 20 to 26 N.m



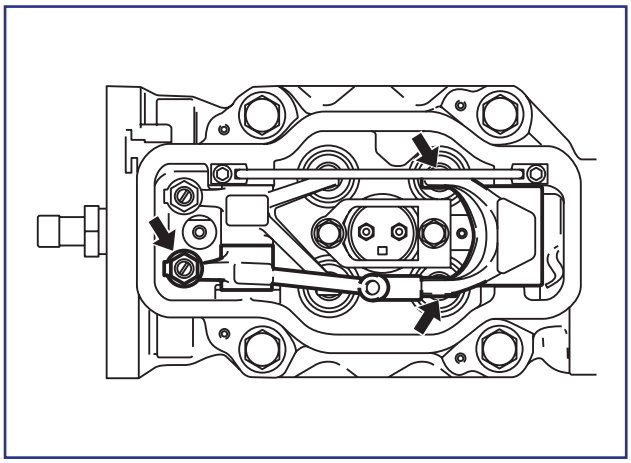
NOTES:

1. Once concluded the adjustment nut for the first valve, it´s necessary to check the second valve clearance. If the clearance is correct follow the exhaust valve adjustment.

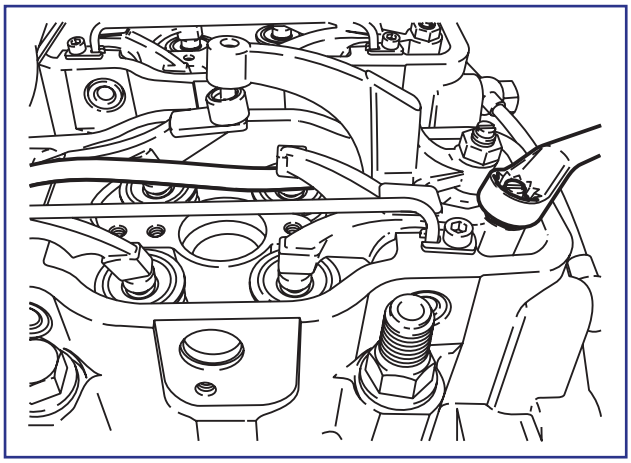
2. If the second valve clearance found is higher than the specification, lower the first valve in steps of 0.10 mm until the second valve reachs the 0.40mm specified.

Exhaust valve adjustment

Adjustment clearance for admission and exhaust = 0.40 mm



Proceed with the same procedure from intake valves and using the images shown for exhaust valves as reference.

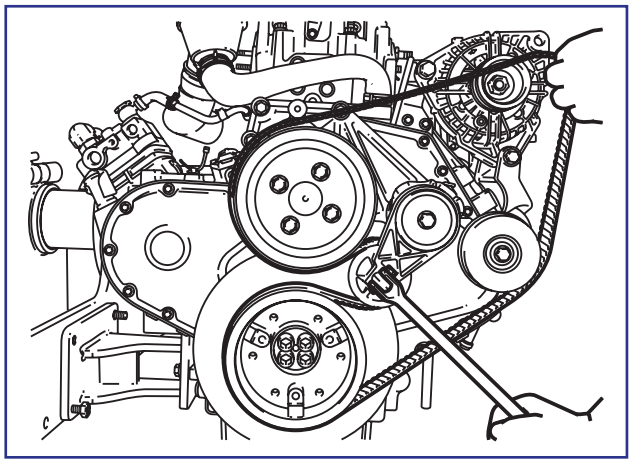


NOTES

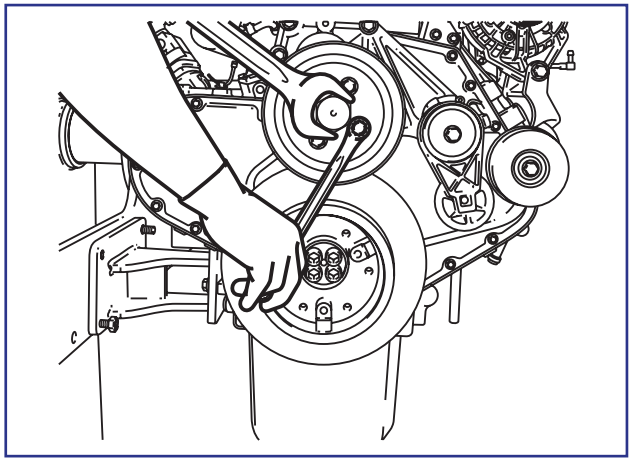
Housing Gear

Disassembly Notes

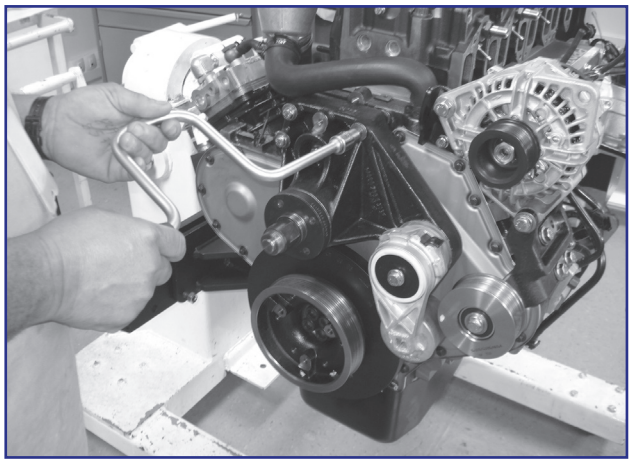
1. Remove bolt acessories.



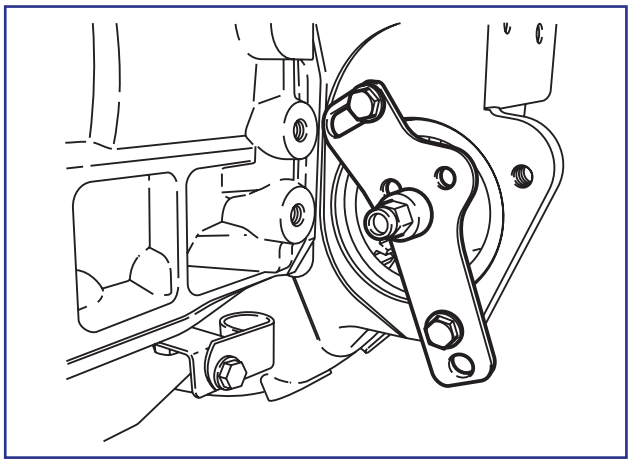
2. Remove the pulley bolts and then remove the pulley.



3. Remove the pulley support.

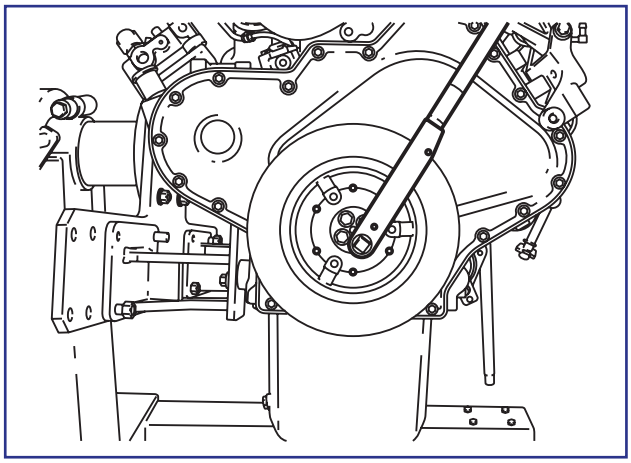


Before disassembling the pulley, lock the flywheel with the special tool MIM nr. 9.610.0.690.026.4.

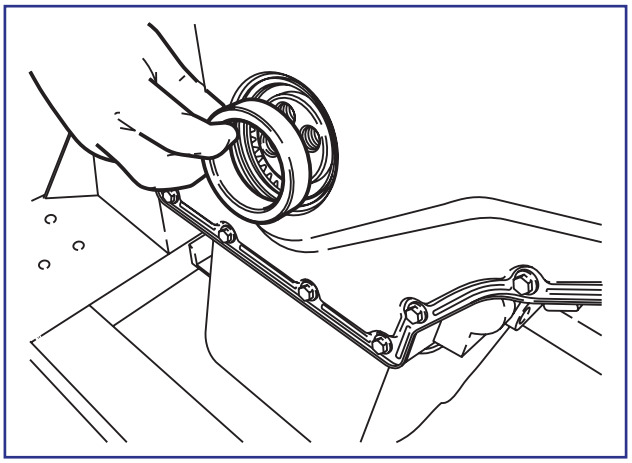


Loosen the bolts of the crankshaft pulley.

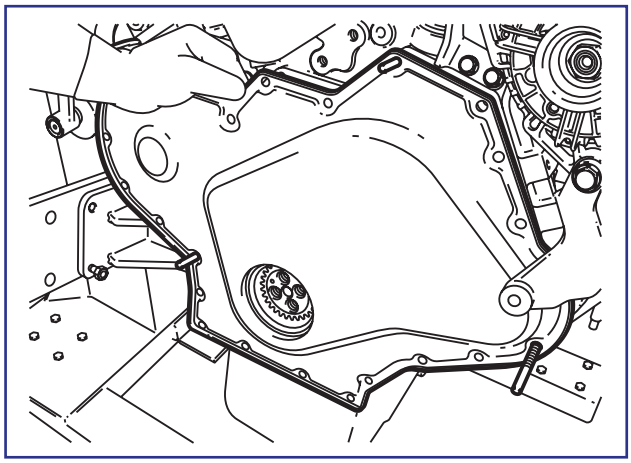
Remove the pulley and damper set.



Remove the front seat.



Remove the front cover mounting bolts and then remove the cover.



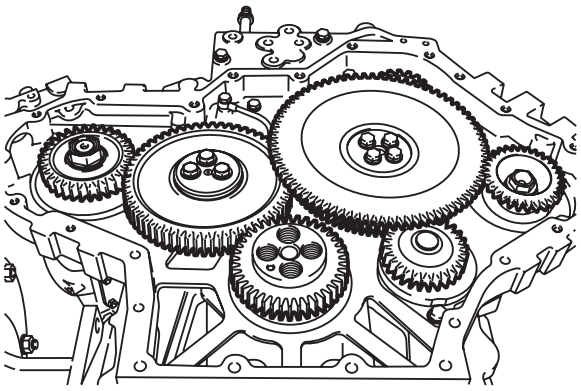
Inspections and Measurements

Visually check damper and pulley(s).

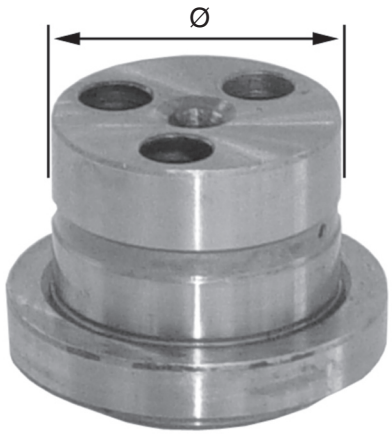
Visually check gears. Check for waste signs or cracks on the base of the teeth.

Presenting such as those defects, the gears must be replaced.

Measure the components of the housing gear according to the following illustration:



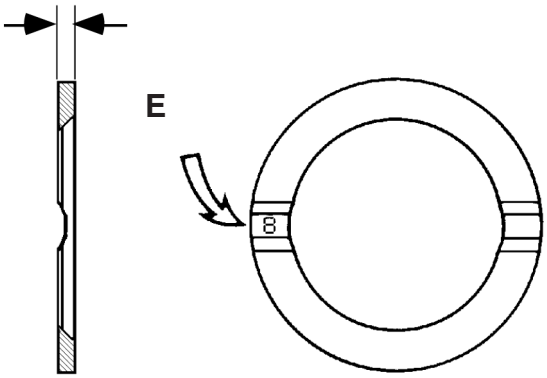
Specifications



9-3-2

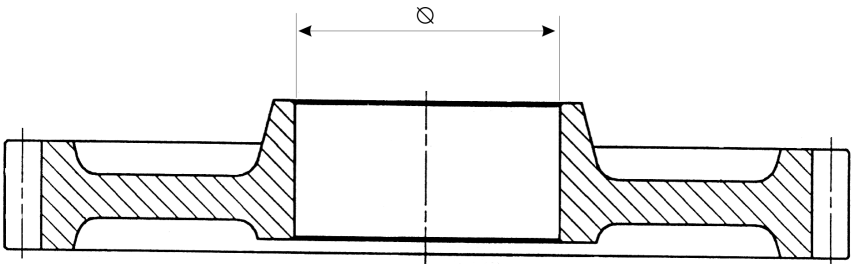
Idle gear bearing	
Measurements	**mm**
Ø nominal	44.995 -45.011
Gear clearances	**mm**
Radial Axial	0.013 - 0.075 0.06 - 0.14

Specifications

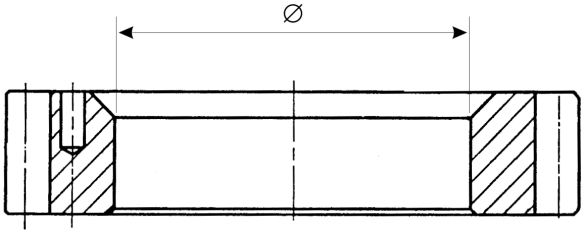


Thrust ring (for intermediate ring)	
E (mm)	**MIM nr.**
3.46 - 3.48	9.610.0.433.004.4
3.51 - 3.53	9.610.0.433.005.4
3.57 - 3.59	9.610.0.433.006.4

Idle gear	
Ø furo	**mm**
Without bushing	50.000 - 50.015
With bushing	45.024 - 45.070
Quantity of teeth	61

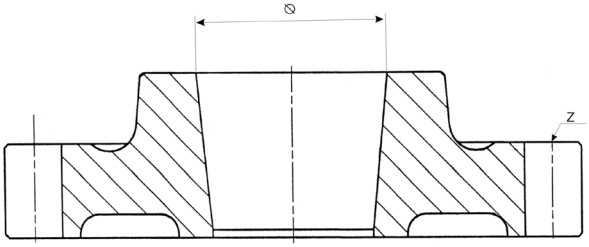


Crankshaft front gear	
Ø hole mm	60.000 - 60.025
Quantity of teeth	36

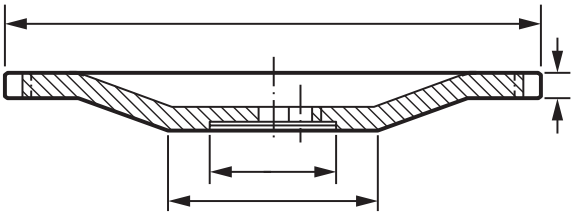


Specifications

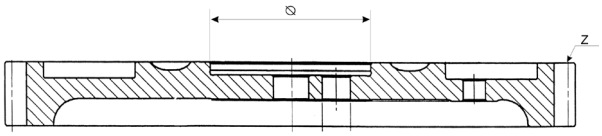
High pressure pump gear	
Ø hole mm	20.000 - 20.033
Quantity of teeth	27



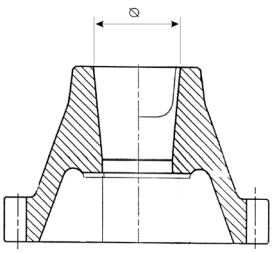
Camshaft front gear (Camshaft to fuel pump driving gear)	
Ø hole mm	50 - 50.032
Quantity of teeth	80



Camshaft back gear (Camshaft timing gear)	
Ø hole mm	52.00 - 52.03
Quantity of teeth	72



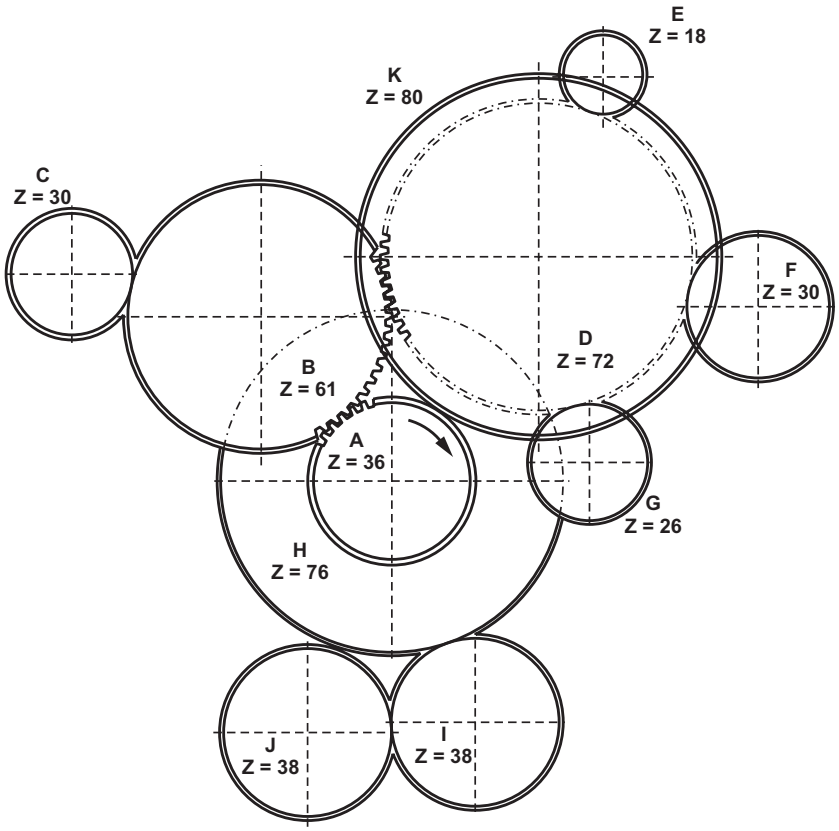
Air compressor gear	
Ø hole mm	30.00 - 30.033
Quantity of teeth	32



Gears clearances specification

ID	DENOMINATION
A	Crankshaft gear
B	Idle gear
C	High pressure fuel pump gear
D	Camshaft back gear
E	Water pump gear
F	Air compressor gear
G	Oil pump gear
H	Balancer unit driving gear (*)
I/J	Balancer unit gears (*)
K	Camshaft front gear

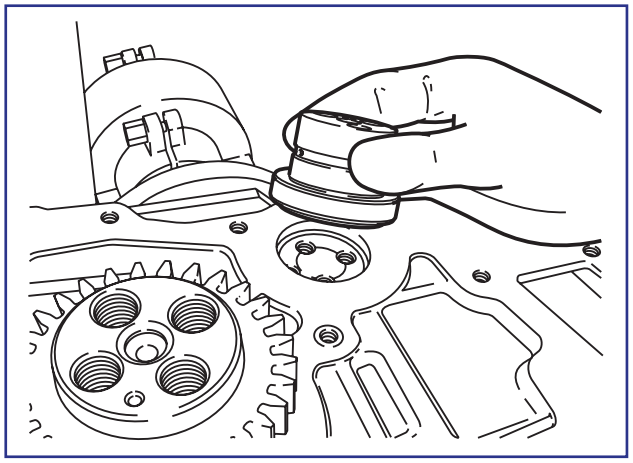
* For 4.12 engines



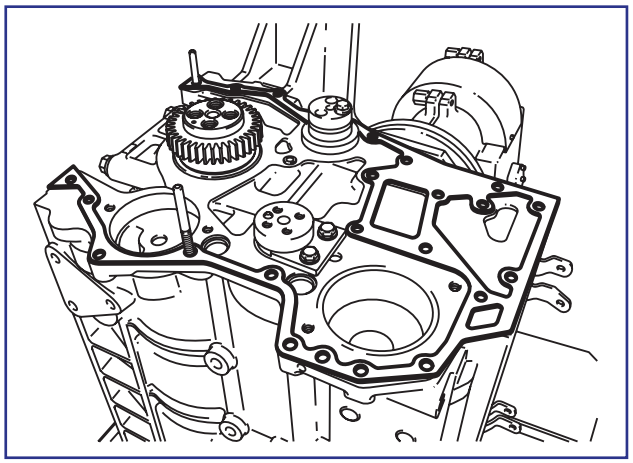
Gears backlash	0.05-0.18 mm

Assembly

Install the idle bearing without the disk and the thrust ring for a perfect centralization of the intermediary piece.

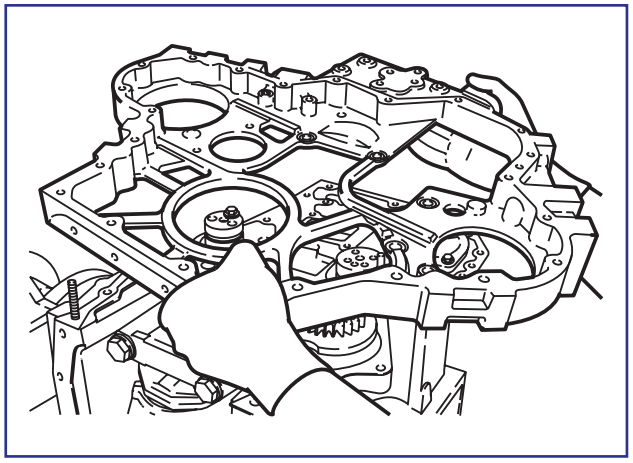


Assembly the gasket.



Install the housing gear tightening the fixation bolts crosswise according to the specification.

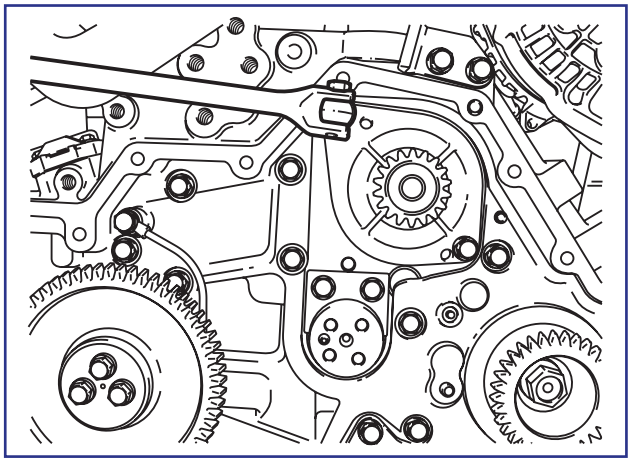
Apply torque: 15 ± 5 Nm



Attention: The centralization of the housing gear is important to guarantee the specified clearances of the distribution gears.

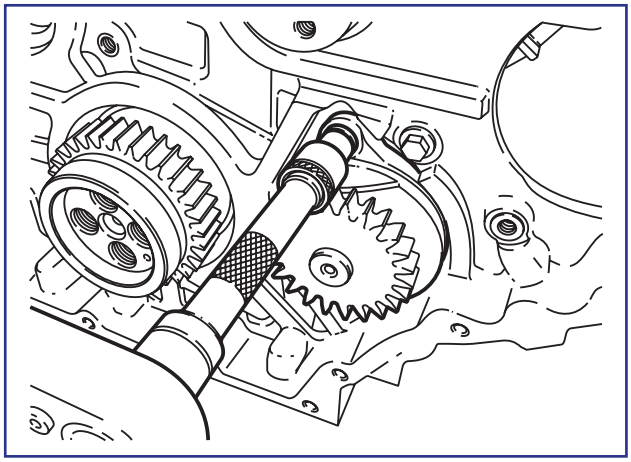
Install water pump, tightening according to the specification.Take care to do not damage the sealing ring.

Apply torque: 20 ± 5 Nm



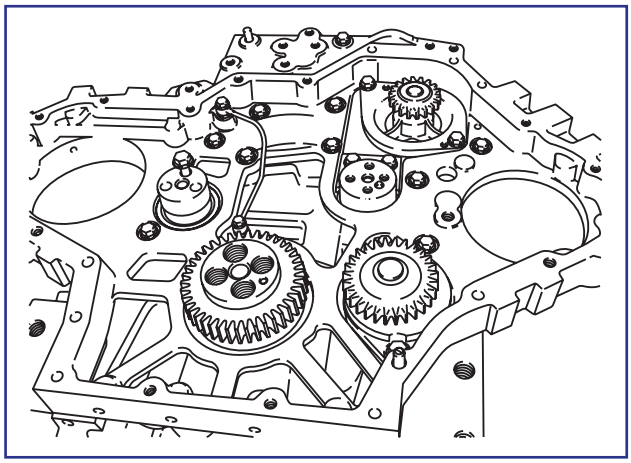
Install lubricant oil pump tightening according to the specification.Take care to do not damage the sealing ring.

Apply torque: 20 ± 5 Nm

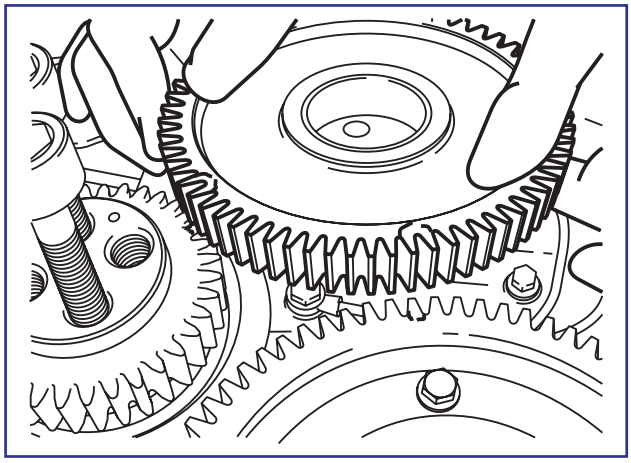


Install lubrication pipes tightening according to the specification (electronic engine shown).

Apply torque: 5 ± 5 Nm

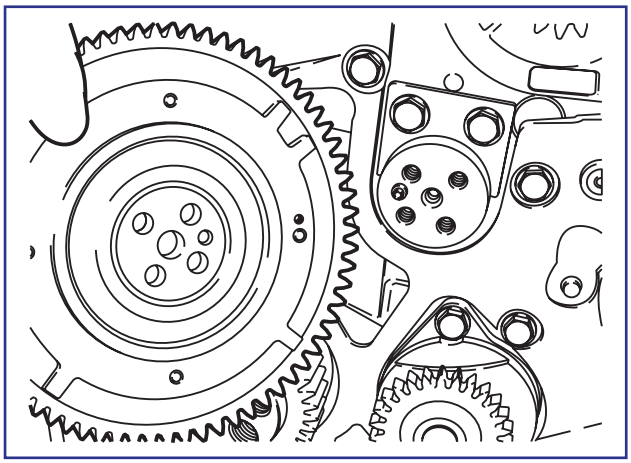


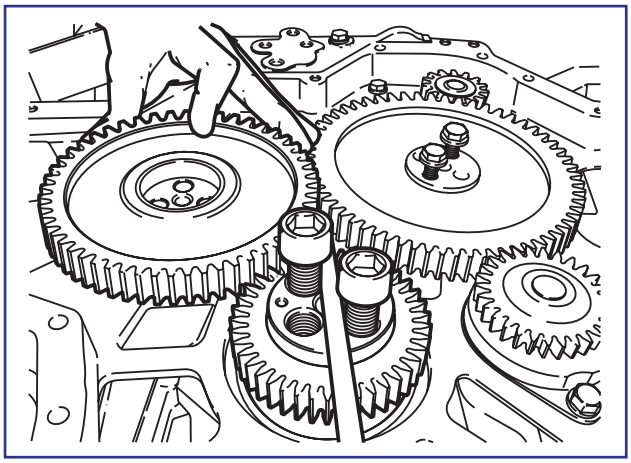
Assembly the idle gear.

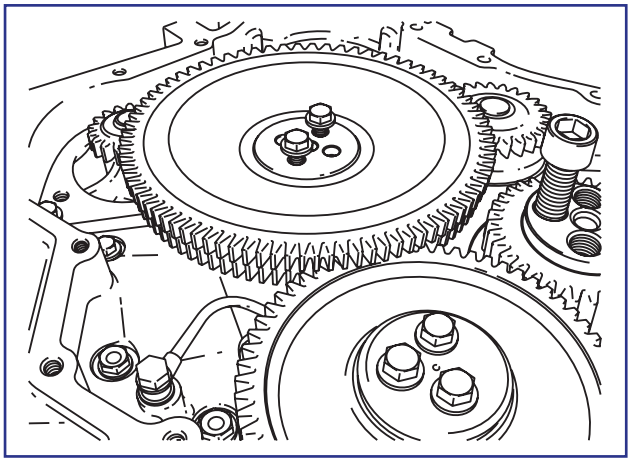


Assembly camshaft gear and tighten the bolts according to the specification.

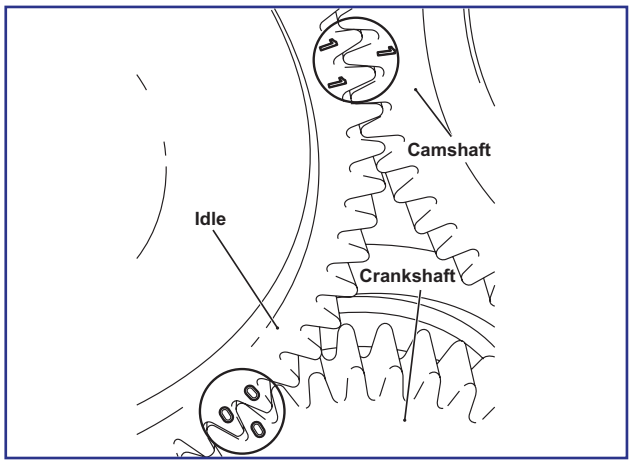
Apply torque: 1st: 20 ± 5 Nm
2nd: 30° ± 2°
Torque Range: 35 to 65 Nm



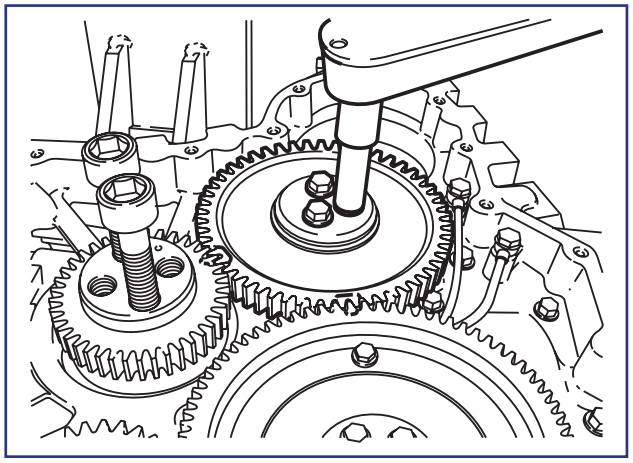




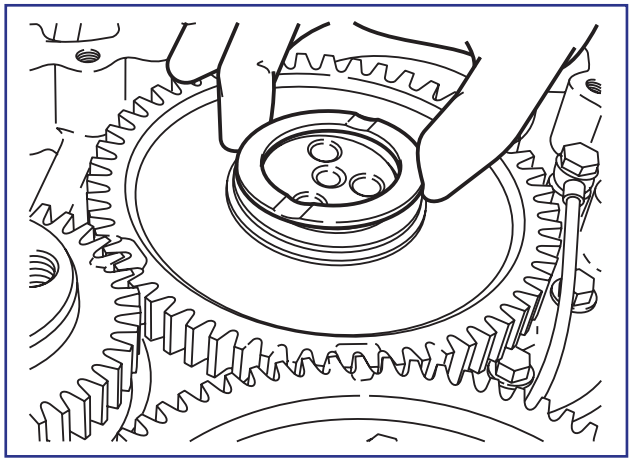
Detail of the timing gear marks.



Remove the bolts of the idle bearing.



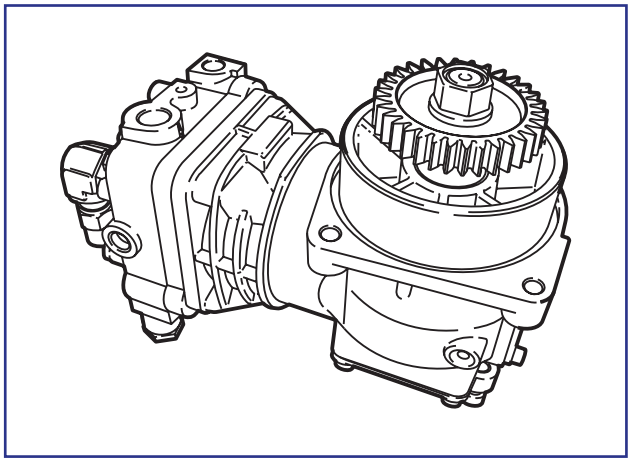
Install the thrust ring of the idle gear.The two grooves must stay towards the side of the shaft. There are 3 different thickness of thrust ring in order to guarantee the axial clearance of the idle gear.



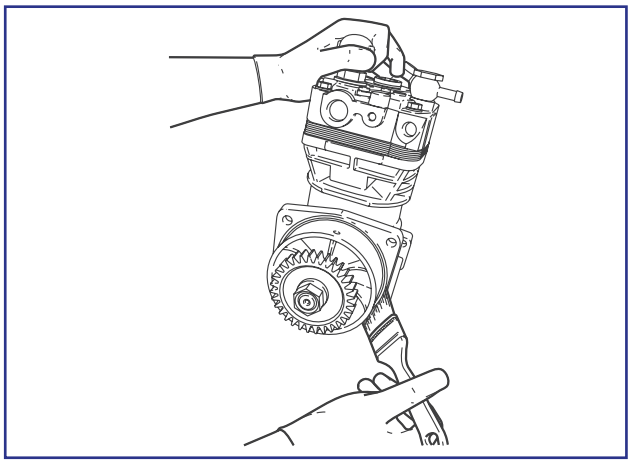
Air Compressor Replacement

Remove the nut and its protector and install the gear and its nut applying the torque.

Apply torque: 230 ± 20 Nm

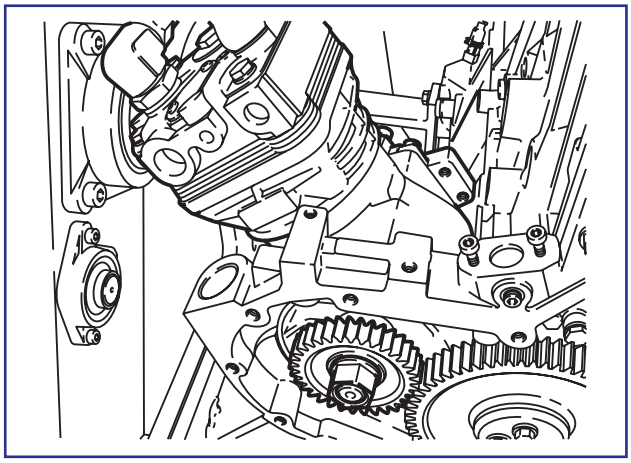


Install a new O-ring to the air compressor and apply vaseline to avoid damages during installation.



Install the bolts to the air compressor and tighten to the specified torque.

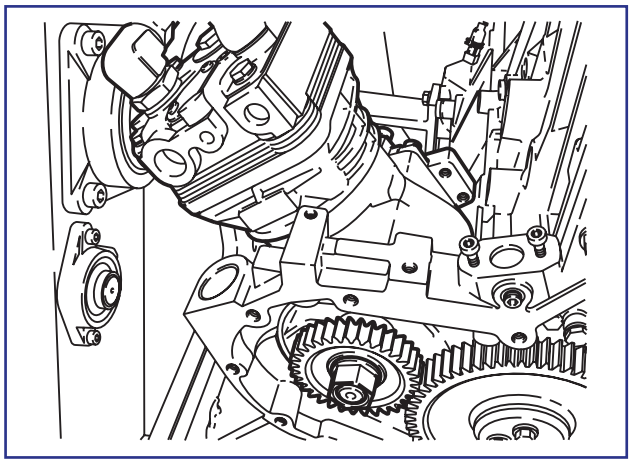
Apply torque: 230 ± 20 Nm



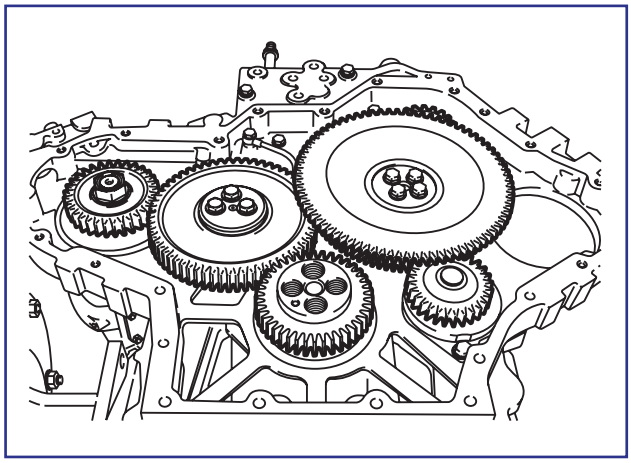
Install dhe bolts to the air compressor bracket to the engine block.

Apply torque: 20 ± 6 Nm

Install the air compressor and gear assembly.

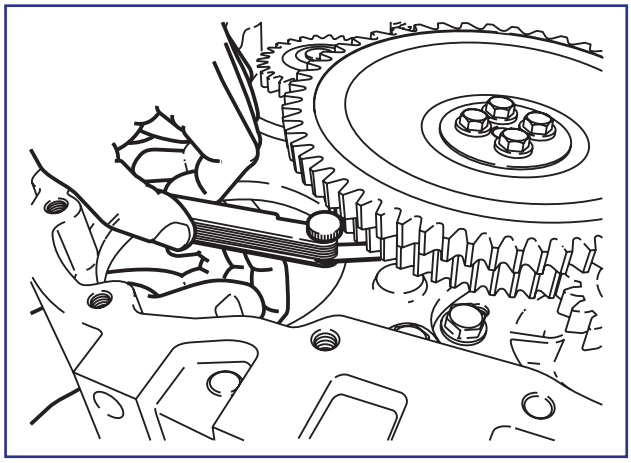


Tighten all fixation bolts of sinchronization gears with the specified torques. See special torques table in Appendix A.



Measure the clearance between high pressure pump timing gear and camshaft gear.

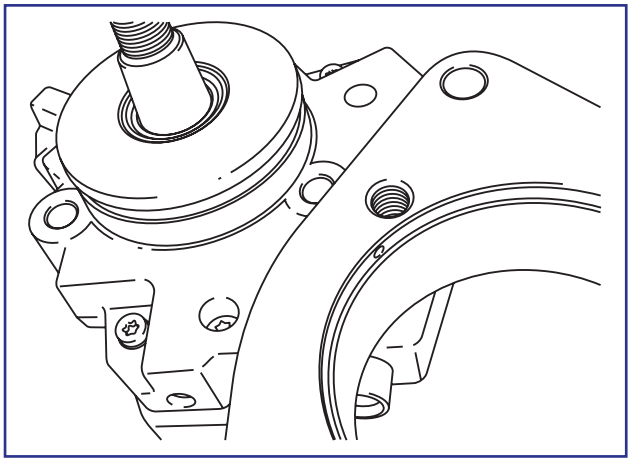
Clearance specification _____ to _____ mm.



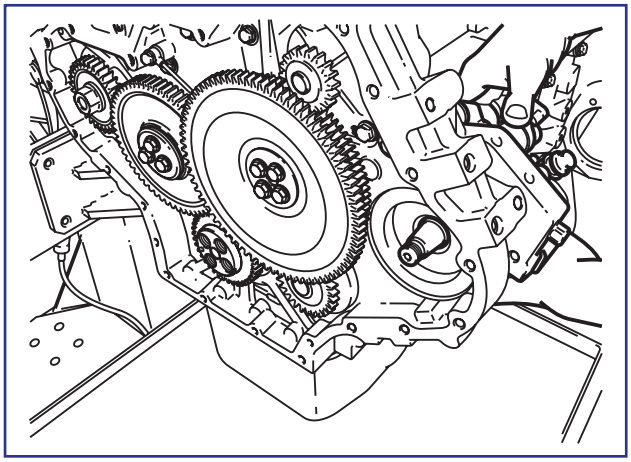
High pressure fuel pump – Pre Assembly

Check and replace the O-ring from fuel pump checking that its in the correct position to avoid damage during flange adapter assembly.

Install the flange adapter to the fuel pump housing.

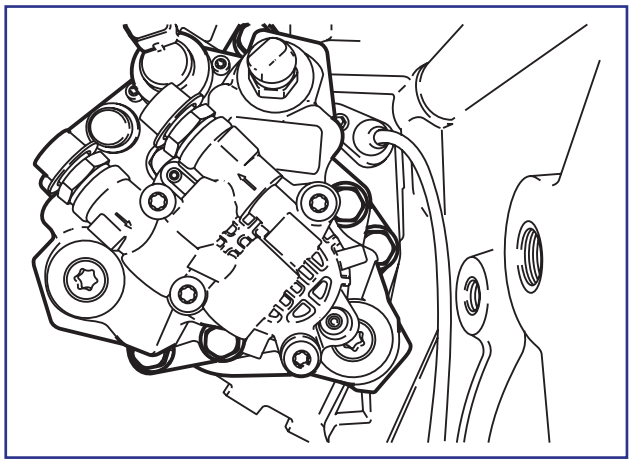


Install high pressure pump to the gear housing.



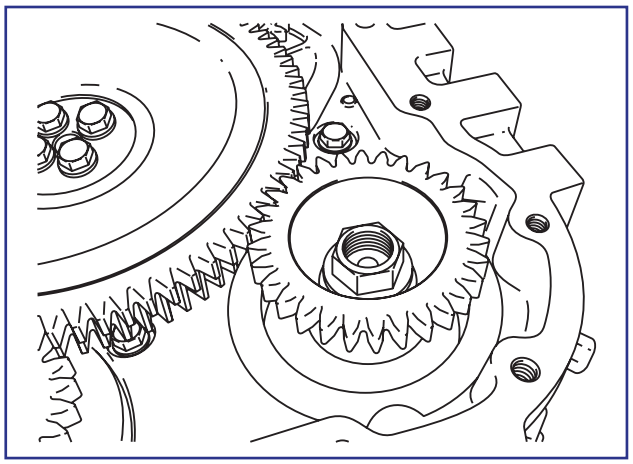
Tighten the bolts.

Apply torque: 50 ± 5 Nm

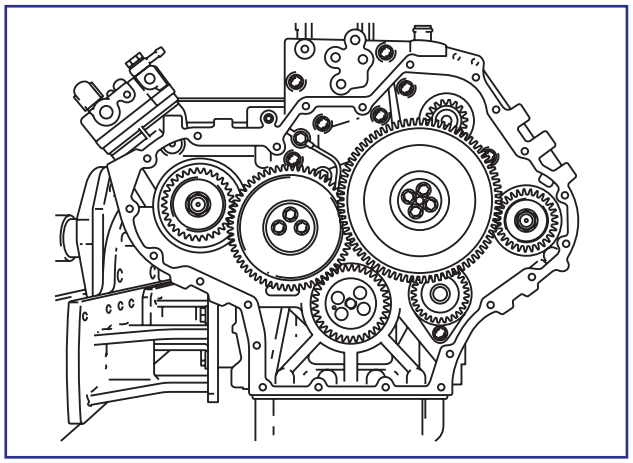


Install the fuel pump gear and nut applying the torque.

Apply torque: 105 ± 5 Nm



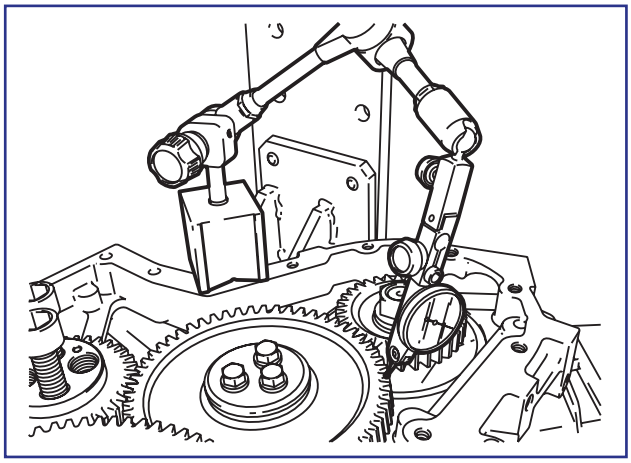
View of the assembled gears set.

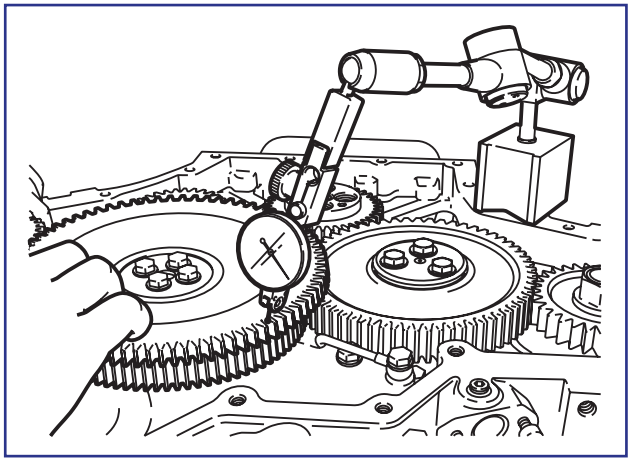


Attention:

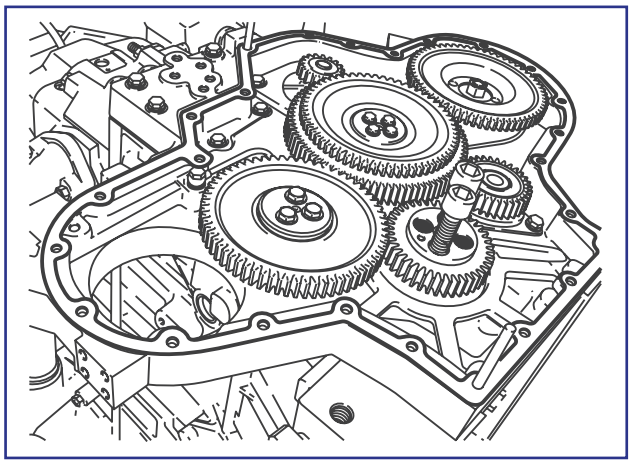
- During the engine operation there must not be gearing noise.
- A noisy operation indicates too much clearance between gears or teeth excessive waste.

Measure the clearance between both timing gear.





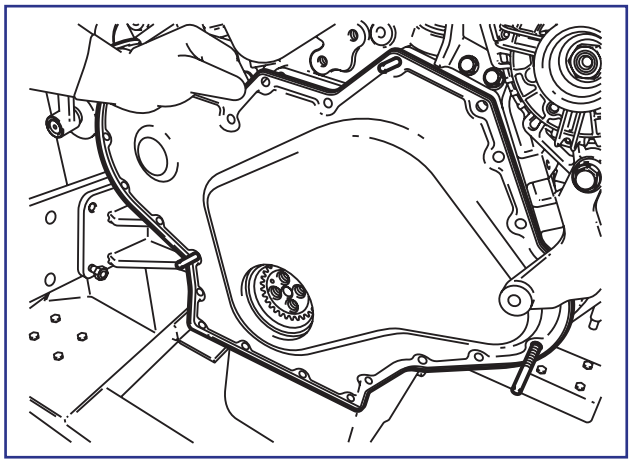
Assembly the front cover gear housing a new gasket.



Centre the front cover with the special tool MWM nr.

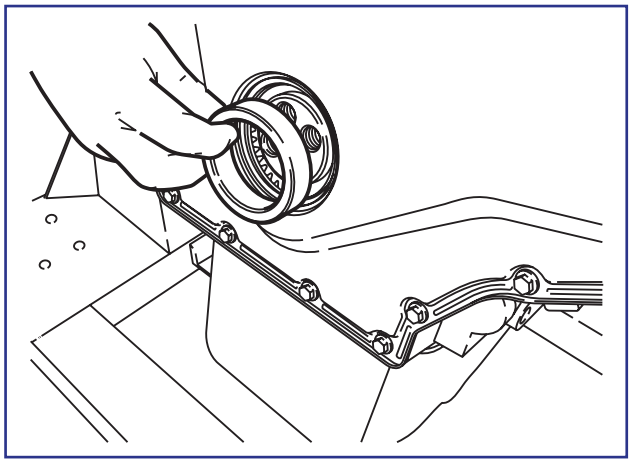
9.610.0.690.019.6.

Place the bolts without tightening to allow the movement of the cover.

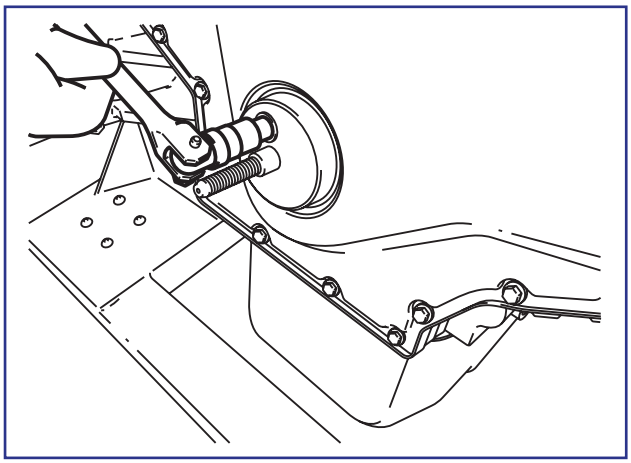


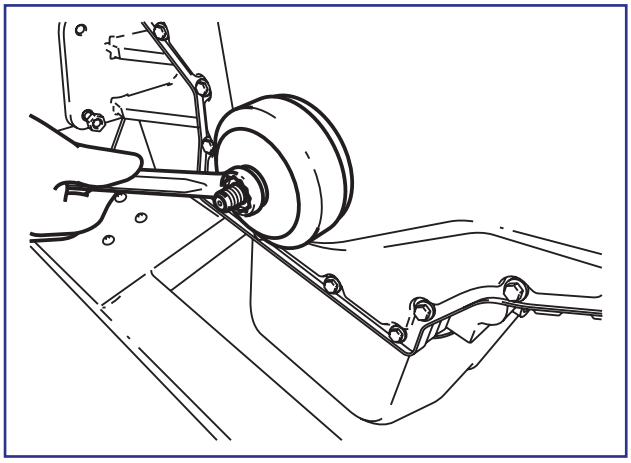
Tighten the fixation bolts of the front cover.

Apply torque: 25 ± 3 Nm



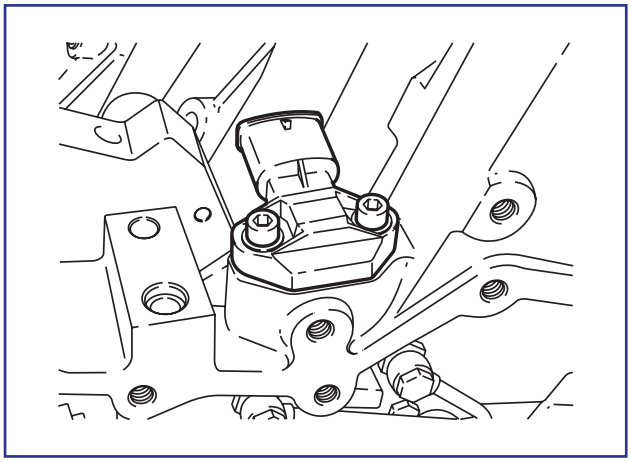
Install the crankshaft seal with the special tool MWM nr. 9.610.0.690.019.6.



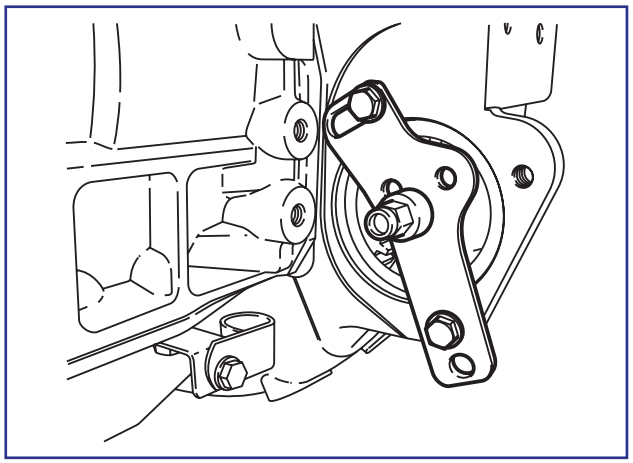


Assembly the temperature and oil pressure sensor.

Apply torque: 8,5 ± 1 Nm



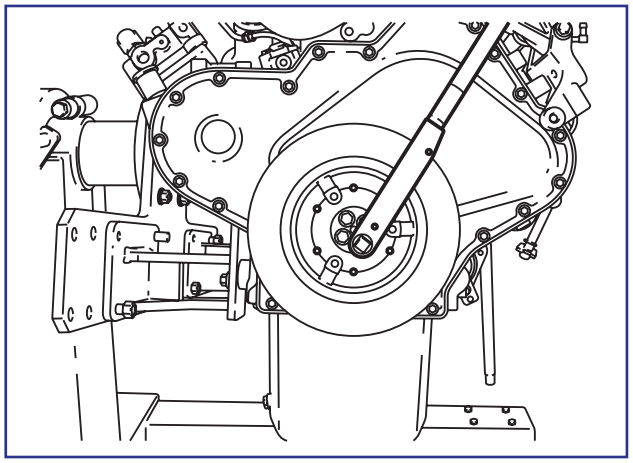
Lock the engine with the special tool on the flywheel.



Assembly the front pulley with the damper. Tighten the bolts crosswise with the specified torque.

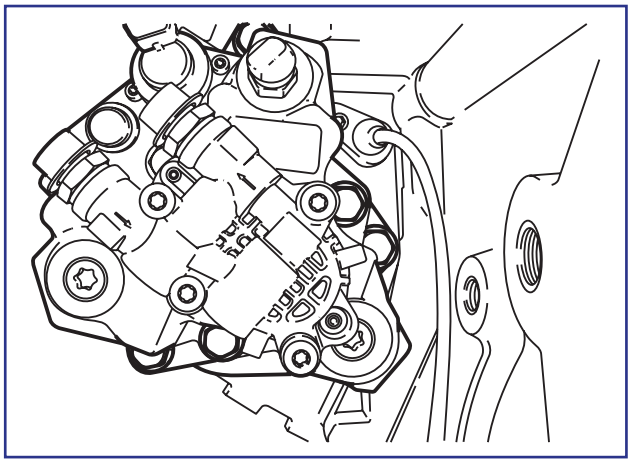
Apply torque: 1st: 100 ± 10 Nm

2nd: 275 ± 15 Nm



Assembly the adapter, then the camshaft sensor and apply the specified torque.

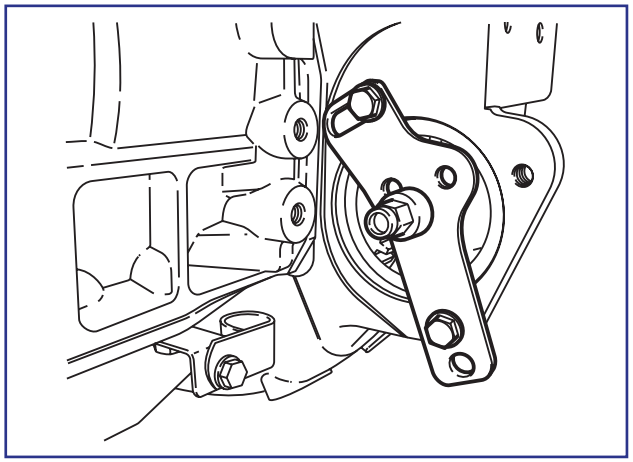
Apply torque: 8,5 ± 1 Nm



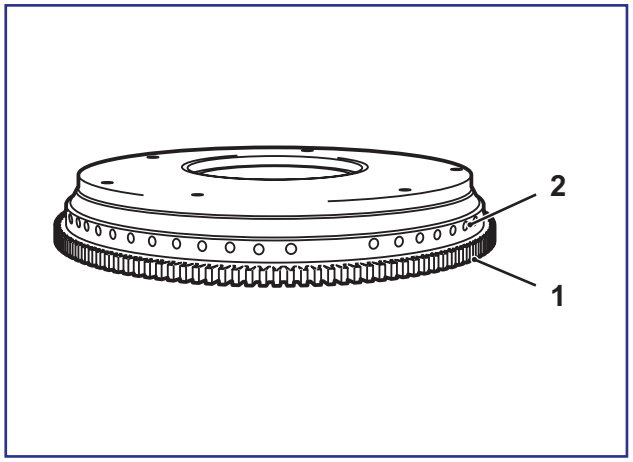
Flywheel and Flywheel Housing

Disassembly Notes

Before removing flywheel, lock the engine crankshaft with the special tool MWM nr. 9.610.0.690.026.4.

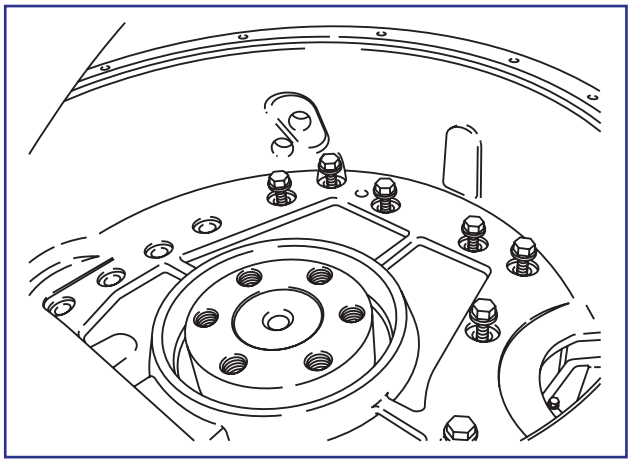


To remove the gear ring (1) from the flywheel (2), heat the gear form 100 to 180° C and hit it.



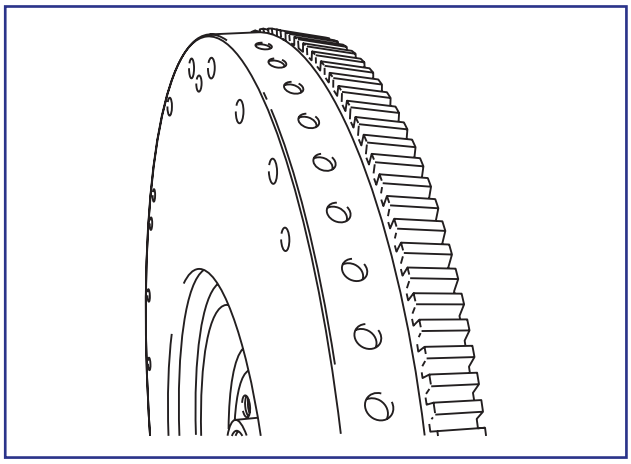
Pre-assembly inspections

Visually check flywheel housing for cracks or any damage.



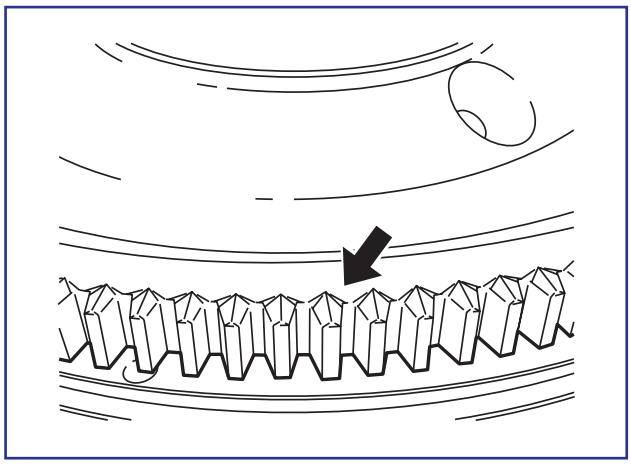
Visually check flywheel and gear ring. Failures in the starter motor gearing can be caused by broken gear ring or damage teeth.

Check if the sensor holes are clean and in good conditions.

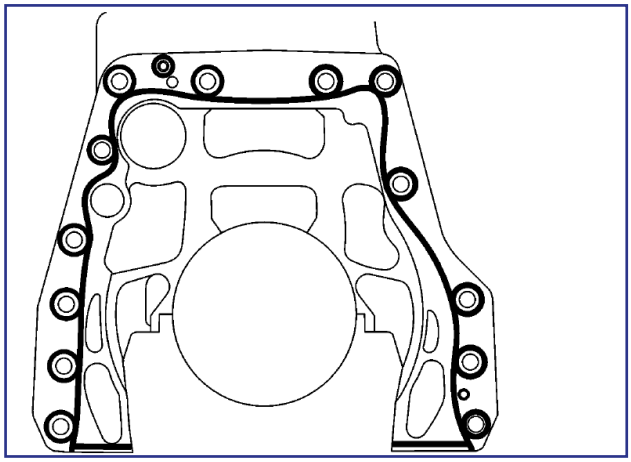


Assembly

To install the gear ring on the flywheel, first heat it up to a temperature around 250°C and assembly it paying attention to the assembly position indicated by a mark (see indication).

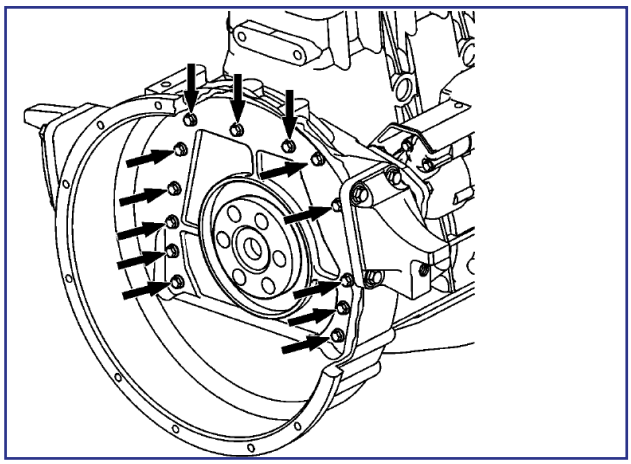


Clean the housing and the engine block. Apply Loctite 515 on the contact surface between the engine block and the housing, surrounding the bolt holes.



Assembly the housing on the engine block and tighten the bolts according to the specification.

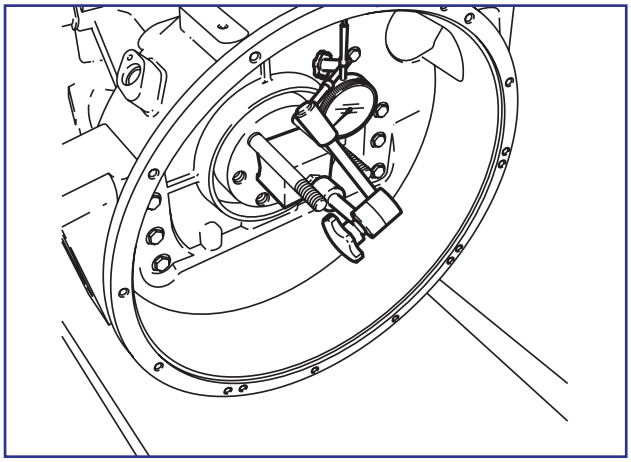
Torque: 85 to 115 N.m



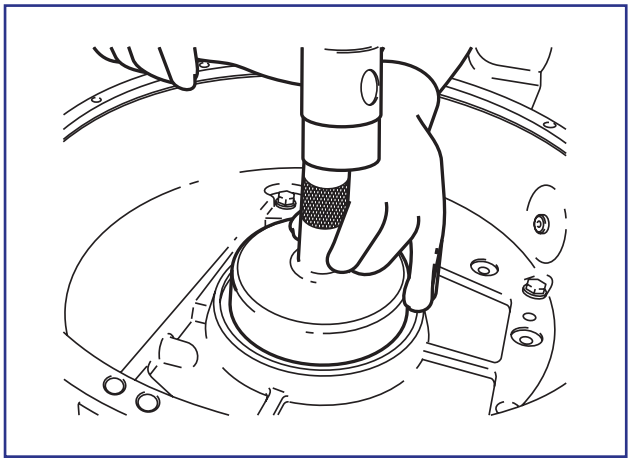
Inspections After Assembly

After the flywheel installation, measure the concentricity of the fitting of the shaft pilot in relation to the housing.

Maximum concentricity = 0.2 mm

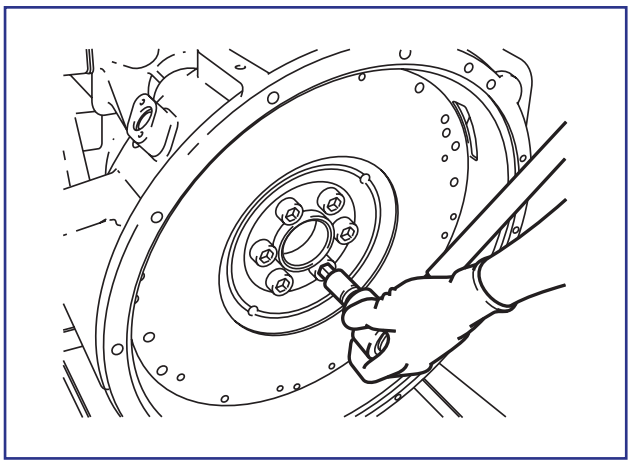


Install the rear seal with the special tool MIM nr. 9.610.0.690.020.6.



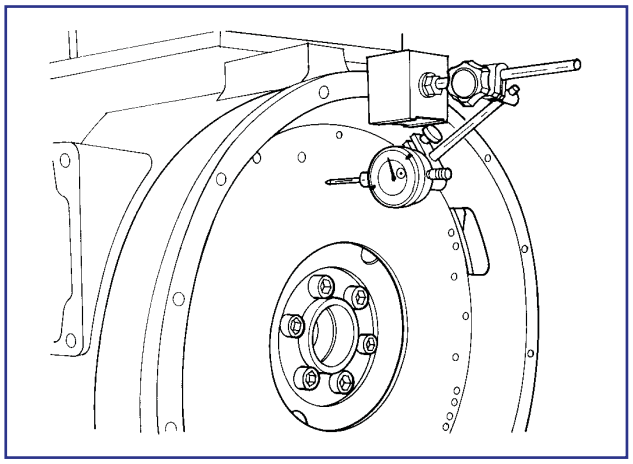
With the engine locked assembly the flywheel. Tighten the crankshaft fixation bolts according to the specification.

Apply torque: 1st: 100 ± 10 Nm
2nd:275 ± 15 Nm



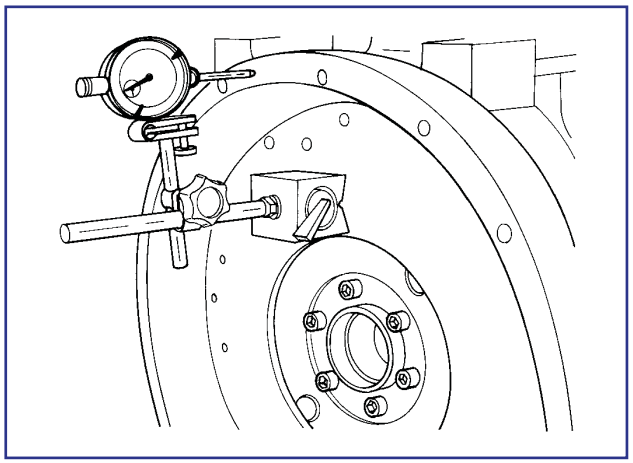
Check the side oscillation of the flywheel.

Maximum side oscillation = 0.30 mm



Check the parallelism of the flywheel in relation to the housing.

Maximum parallelism = 0.20 mm

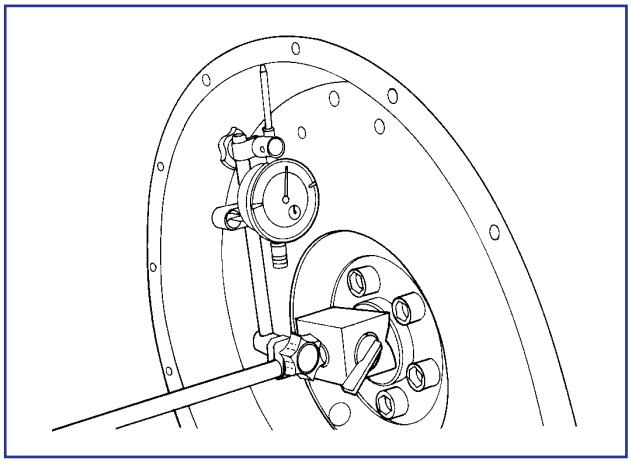


Check the concentricity of flywheel to the housing.

Maximum concentricity = 0.20 mm

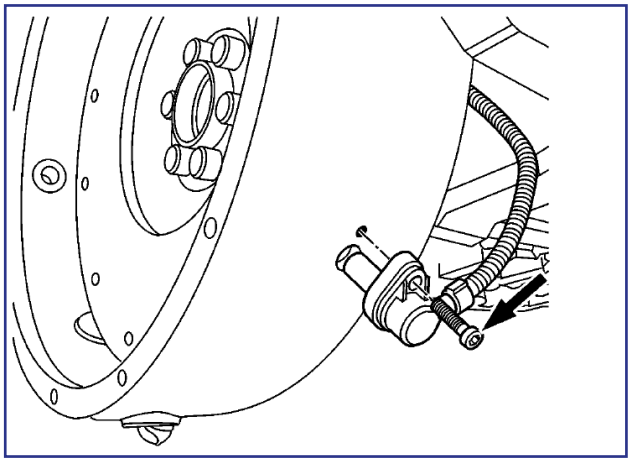
Dynamic Balancing = Holes ø10 x 12 mm maximum, in a ray of 197 mm.

Acceptable unbalancing = 425 g.mm.



Assembly the speed sensor and apply the specified torque.

Apply torque: 8,5 ± 1 Nm

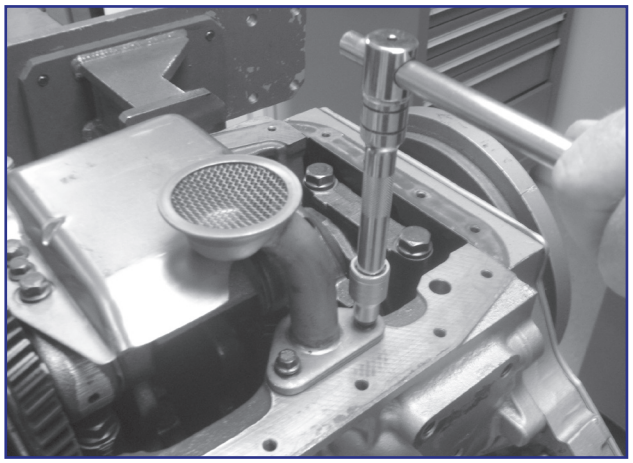


Balancer Unit

Remark

The balancer unit is an exclusive item of the 4 cylinders engines, especially for vehicular applications.

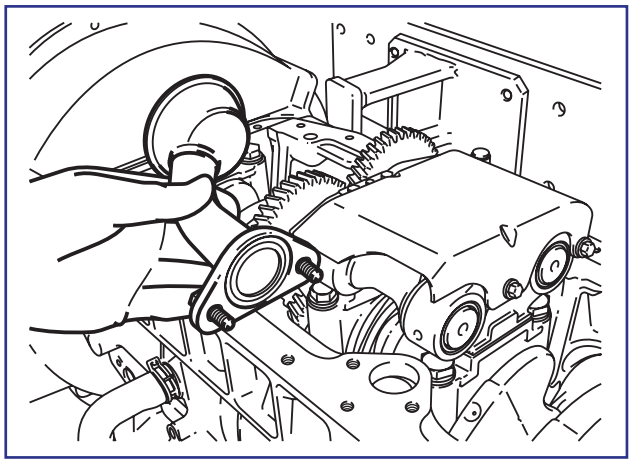
It is not recommended its removal because, despite does not affect the engine life, may cause excessive vibration to the chassis, cabin, accessories, etc.



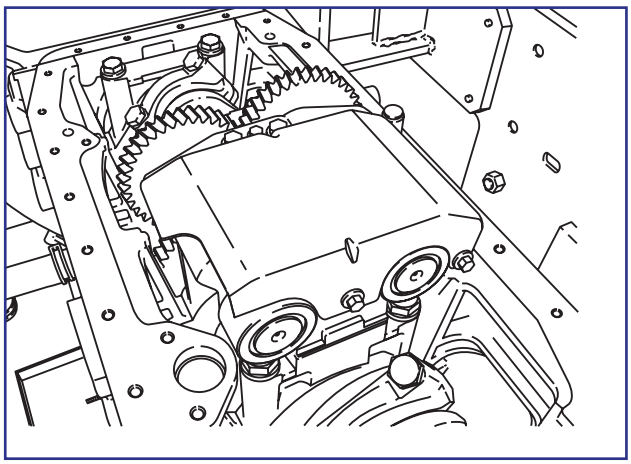
Disassembly Notes

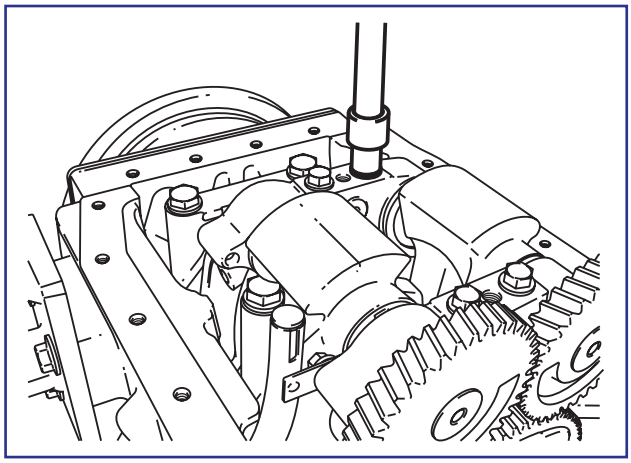
After removing the carter, carefully remove the oil suction pipe in order to do not let the sealing ring to fall inside the suction gallery.

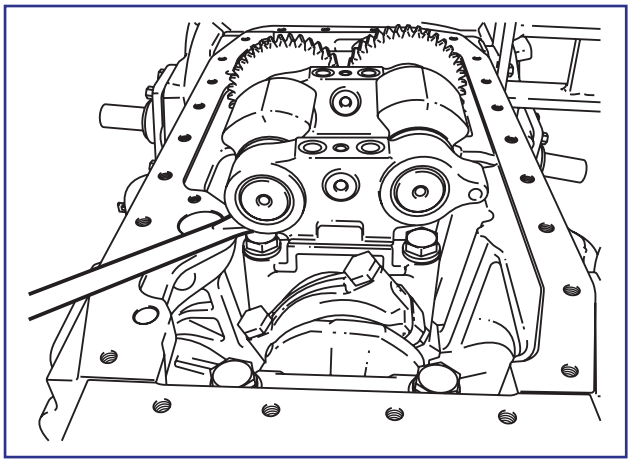
Note: Check and replace the O-ring if necessary.

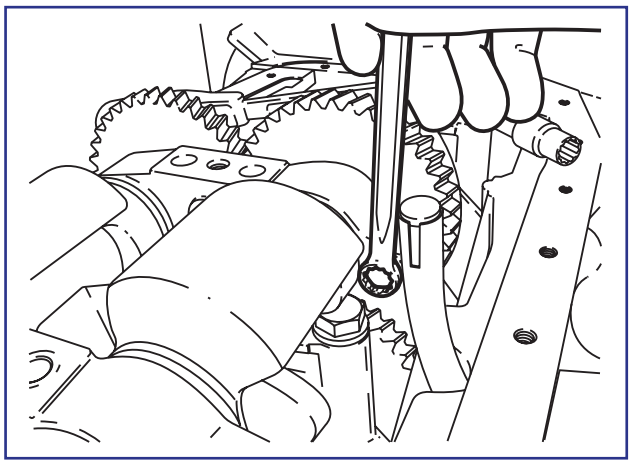


Remove the deflector of the balancer unit. Loosen the balancer bolts and carefully remove it to do not loosen the bearing. Keep the guide-pins on their positions.



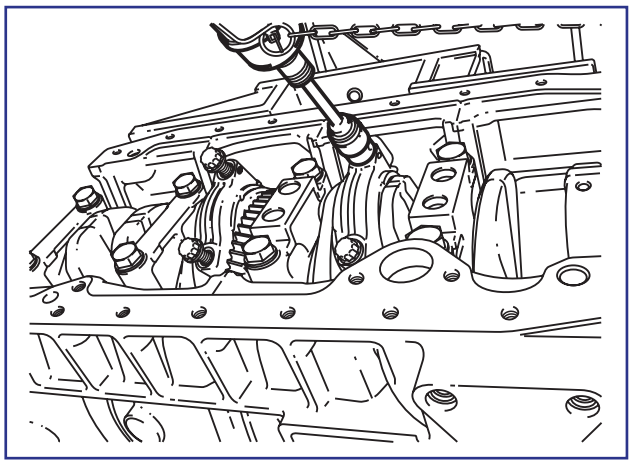






Assembly

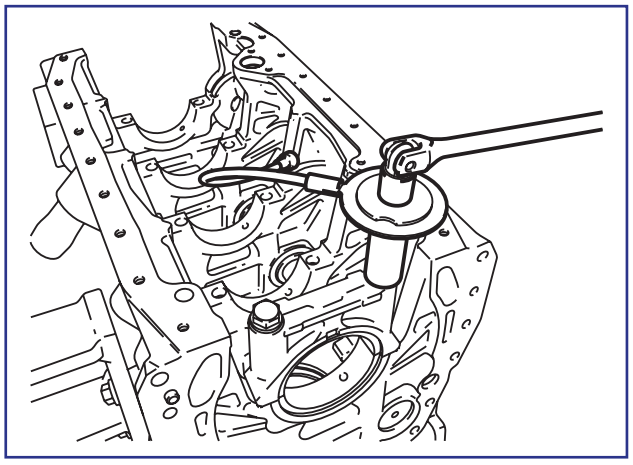
Loosen the bolts of the bearing caps correspondent to the balancer unit and, with a rubber hammer, move them away to the maximum.



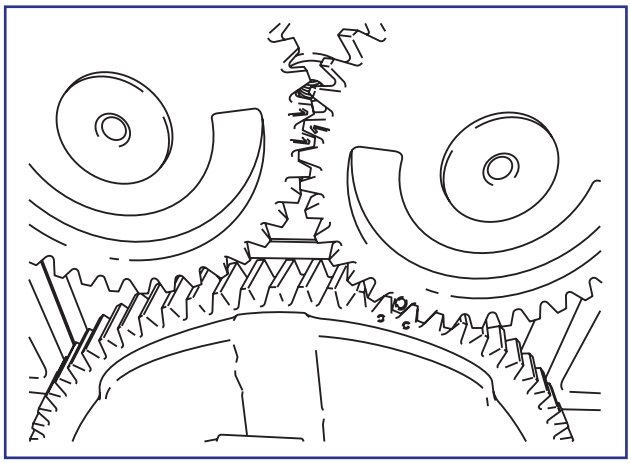
Tighten only one of the bearings with the specified torque leaving the other bearing free for the balancer adjustment.

Apply torque: 1st: 50 ± 5 Nm

2nd: 155° ± 5°



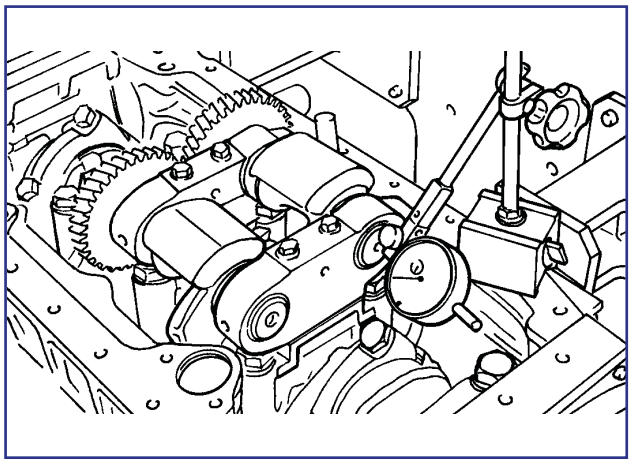
Observe the marks “00” and “0” on the balancer gear and on the crankshaft gear ring to guarantee the timing of assembly.



Bolts Tightening Torques Specification

Measurements After Assembly

Perform a pre-adjustment with a shim of 0.20 mm. Lean the bearing to eliminate the clearance and slightly move the bearing that is free.

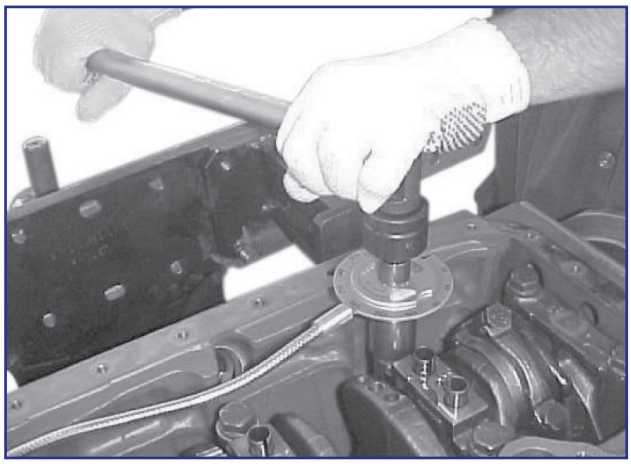


Remove the balancer unit to apply the specified torque in the bearing which the adjustment was done.

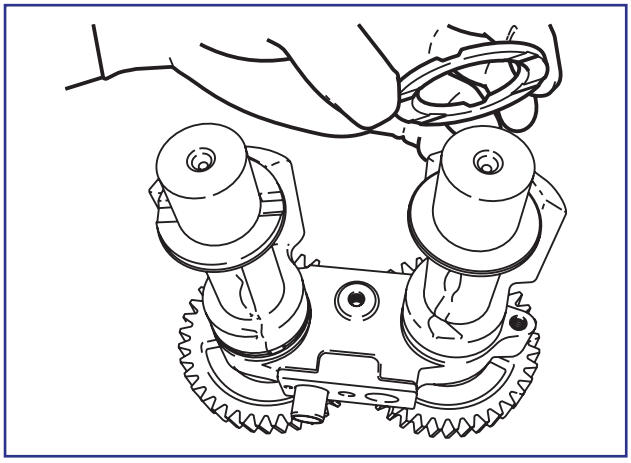
Apply torque: 1st: 50 ± 5 Nm

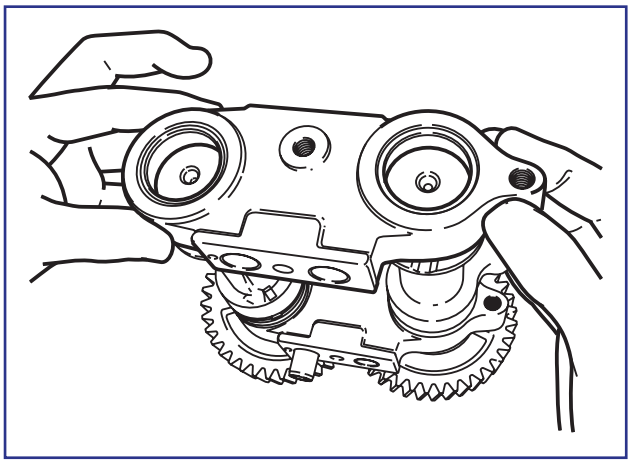
2nd: 155° ± 5°

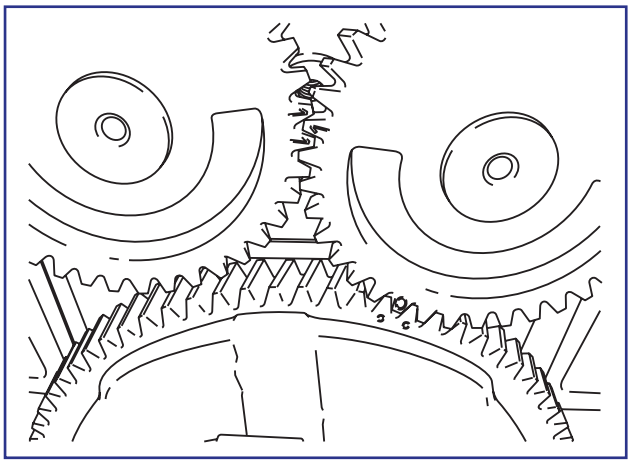
Torque ranger: 170 to 282 Nm

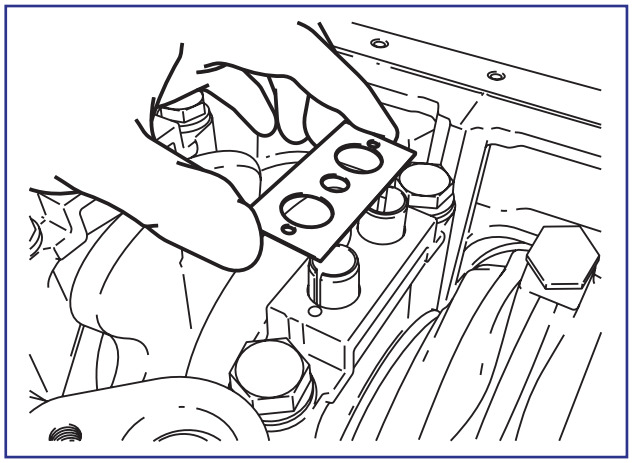


Install the bearing ring observing the assembly side.



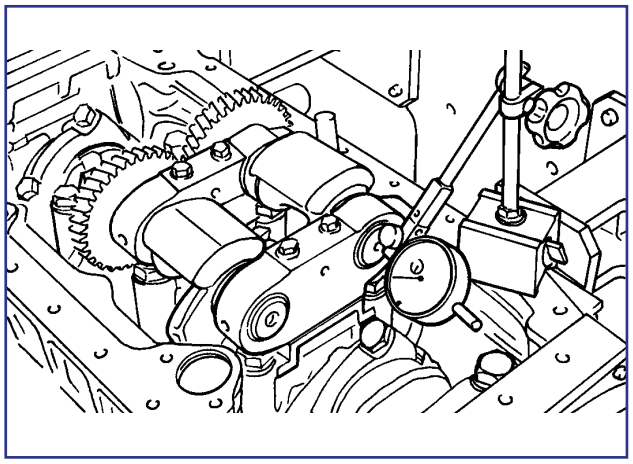






After installed, measure the axial clearance in the balancer unit shafts, observing the clearance specification from 0.10 to 0.30 mm.

There are three thicknesses of bearing ring:
9.226.0.433.001.4 3.45 to 3.50 mm (3.5)
6.208.0.433.003.4 3.55 to 3.60 mm (3.6)
6.208.0.433.002.4 3.35 to 3.40 mm (3.4)



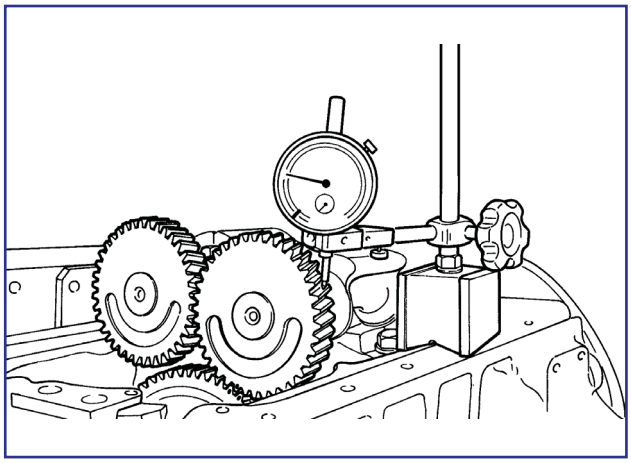
Measure the backlash between the balancer gear and crankshaft gear ring.

Determine the necessary amount of shims between the balancer and the bearing caps for a clearance from 0.05 to 0.18 mm.

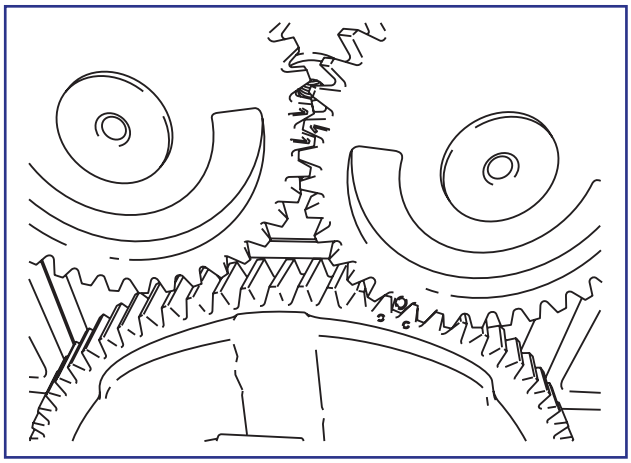
The shims are available with 0.1 mm of thickness.

Use the same amount of shims on the two bearings to keep the balancer alignment.

Remove the balancer and, with the choosen bearing thrust rings, install the correct shims on the bearing caps guide-pins.

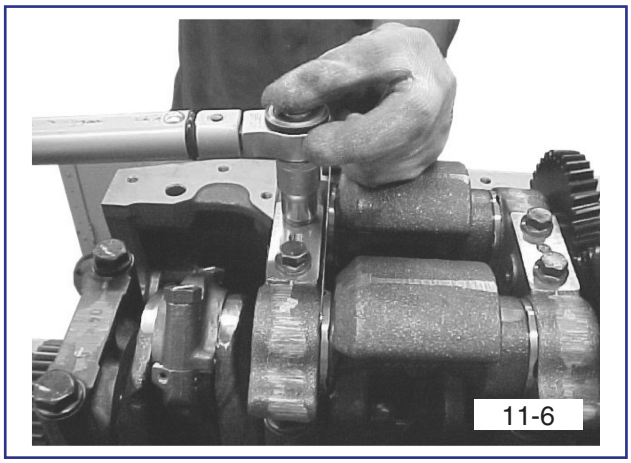


Reinstall the balancer with the timing of the marks “00” and “0”.



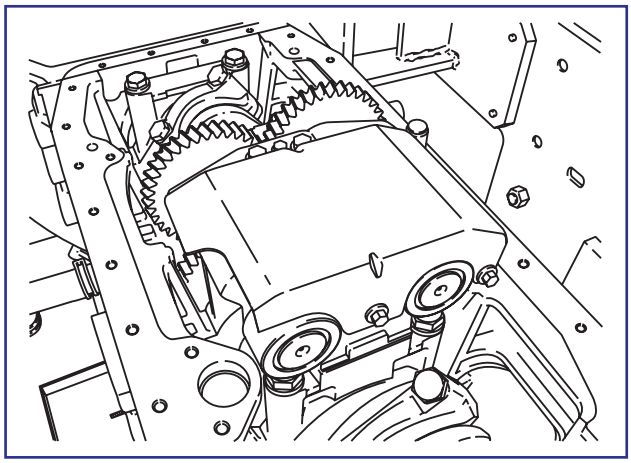
Tighten the balancer bolts with 60 ± 5 Nm.

Repeat the measurements of the axial clearance of the balancer shaft and backlash to confirm they are according to the specification.



Reinstall balancer deflector, oil suction pipe and carter, tightening the bolts according to the specification.

See special torques table in Appendix A.



NOTES

Lubrication System

Lubrication System

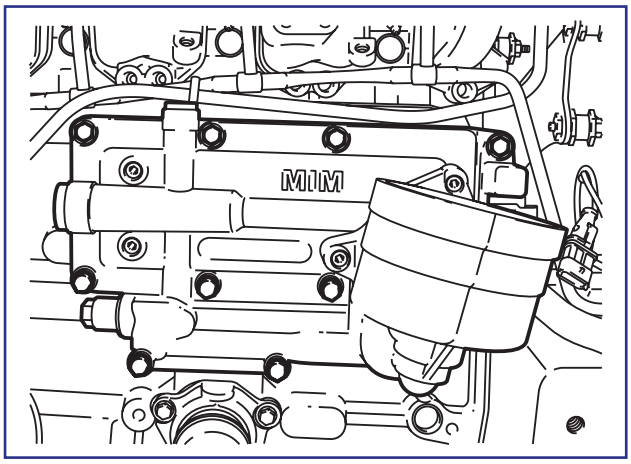
Oil Lubrication Circuit

Disassembly Notes

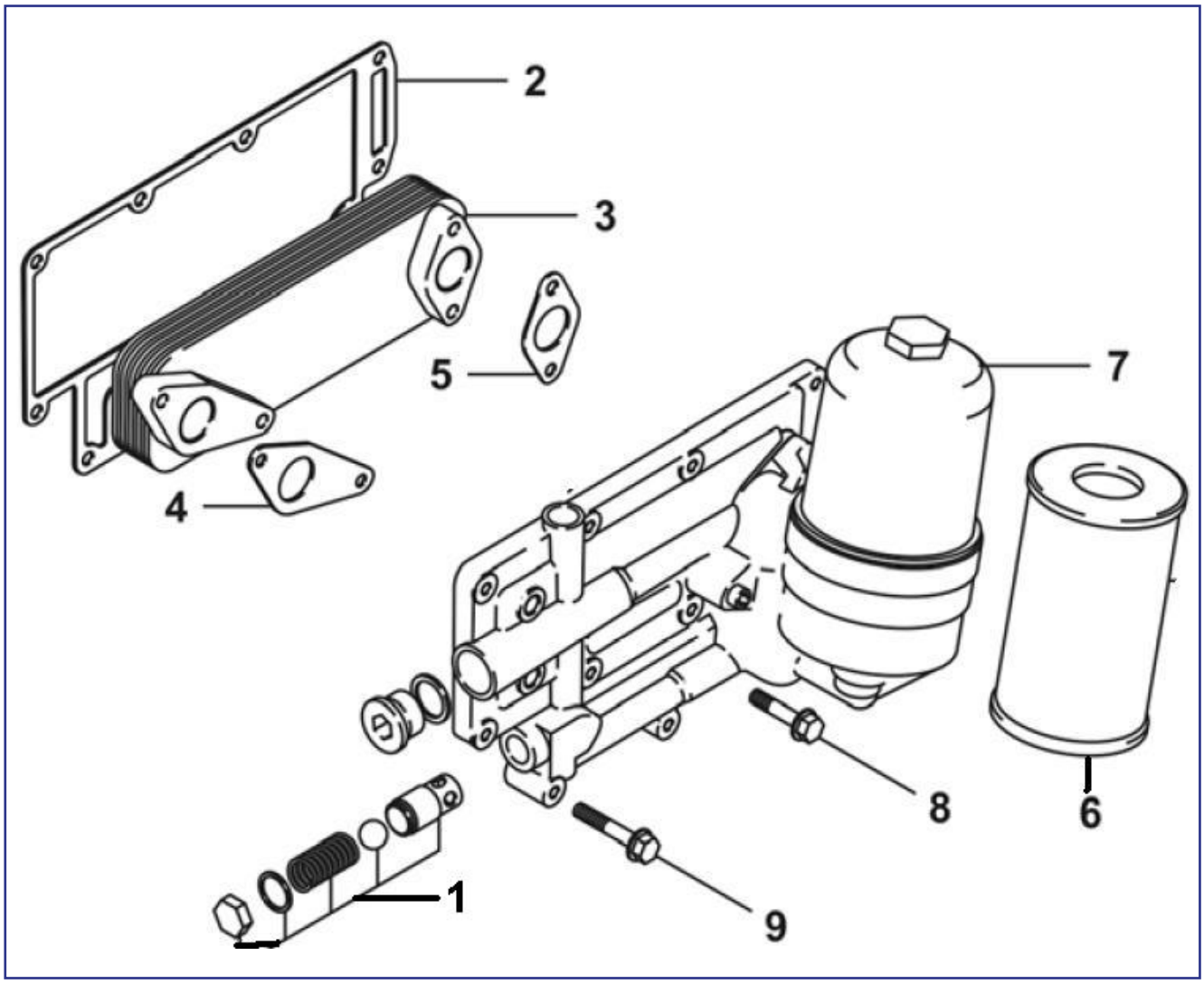
Remove lubricant oil cooler removing only the hexagonal bolts.

During the removal of oil cooler, do not remove the “Torx” bolts, avoiding the mixture of lubricant oil in the cooling system.

The bolts “Torx” types require a special driver for their removal and, if necessary, only can be removed when the oil cooler is removed from the engine block.



OIL SYSTEM MODULE (Ecological filter)



Oil system module (Ecological filter module)

1. Oil pressure valve regulator
2. Oil cooler gasket
3. Oil cooler
4. Oil cooler gasket
5. Oil cooler gasket
6. Filter element
7. Cover
8. Mounting bolt
9. Mounting bolt

Removal

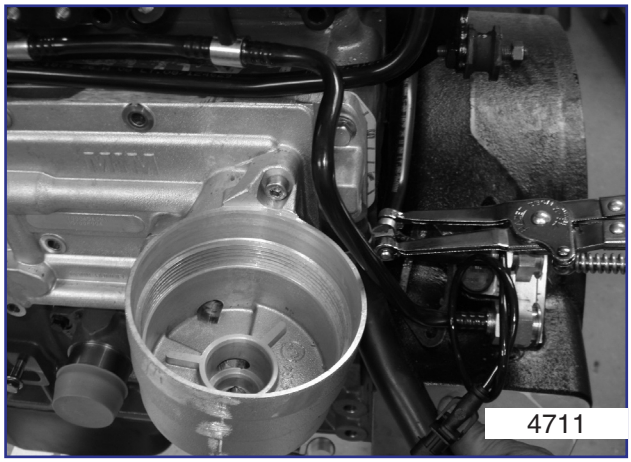
Oil System Module

Warning: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the “Safety Information” section of this manual.

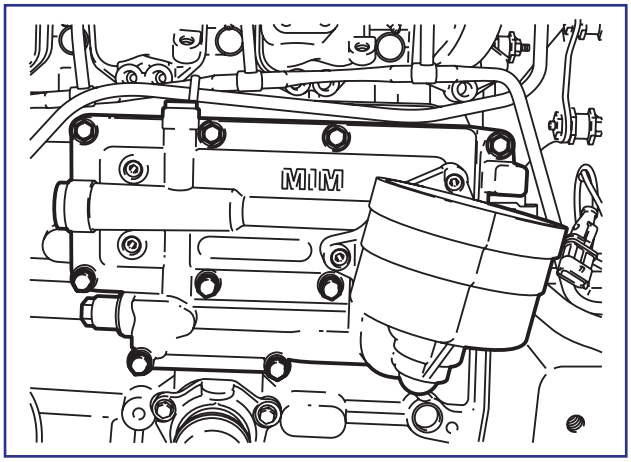
Warning: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle.

Warning: To avoid serious personal injury or possibly death, do not remove the oil system module from a hot engine. Wait until engine cools down before removing.

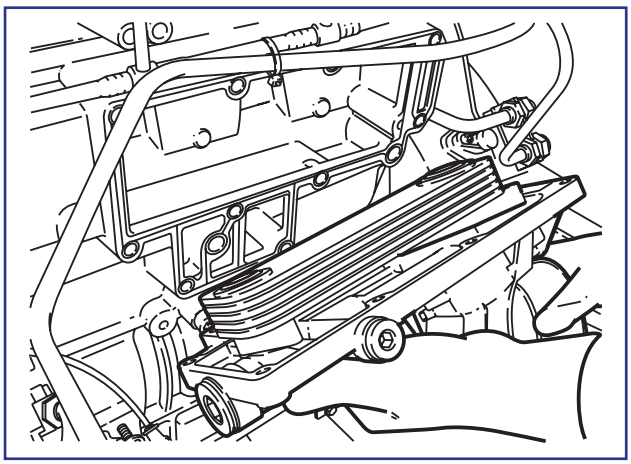
1. Remove the drain plug, the washer and drain the oil engine. Discard the washer.
2. Remove the oil element and cover. See specific procedure in Engine Preparation section.
3. Using the tool indicated, remove the clamp and the hose.



4. Remove all oil cooler to block mounting bolts.

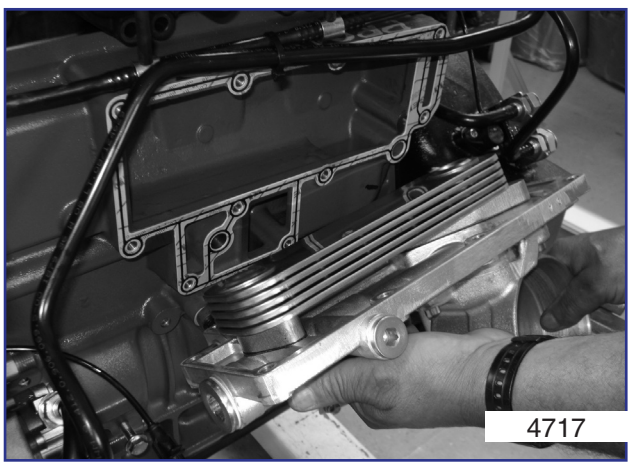


5. Remove the oil module and gasket. Discard the gasket.



Separating the oil cooler from oil cooler housing

1. Remove the four allen mounting bolts.



Caution: To avoid engine damage, when removing the oil cooler from its base housing, do not use excessive force against the aluminum cooler plate to separate from base. Do not apply any force to the oil cooler fins.

2. Using a small rubber hammer, apply just enough force to break the coolant and oil gasket bonds.

3. Separate the oil cooler from the oil cooler housing. Remove and discard the two gaskets.

Removing the oil pressure regulator valve (Only remove in case of failure)

1. Using a wrench, remove the oil pressure valve from the oil system module.

   Replace the valve regulator assembly.

Cleaning and Inspection

Cleaning the Oil System Module

Caution: To avoid engine damage, the oil cooler must be replaced if there was a bearing failure. Debris from a bearing failure cannot be removed from the oil cooler.

Caution: To avoid engine damage, do not attempt to clean the assembled oil system module in solvent. Solvent will be trapped in the oil cooler, regulator valve assembly, and oil thermal valve assembly. Failure to follow this caution could result in engine damage.

The following items should be removed:

- Oil cooler

The following items should NOT be removed:

- Oil pressure regulator valve assembly
- Remaining oil housing plugs

The oil system module housing can be cleaned in solvent and blown dry with clean filtered compressed air.

1. Remove any gaskets remaining onto the oil housing, cooler and engine block to cooler housing.

2. Immerse the disassembled oil cooler housing into a suitable solvent.

3. Flush and drain the oil cooler housing to remove any residue. Dry all components with filtered compressed air.

4. Check the oil cooler housing for blocked orifices and damaged threads. Replace oil cooler housing if required.

5. Remove any debris that may be blocking the filter bypass valve.

Installation

Oil System Module and Oil cooler

1. Place two new gaskets onto the oil cooler. Install the four allen mounting bolts and tighten to the torque of XX N.m.

2. Place a new oil module gasket and mount the the oil module onto the engine block.

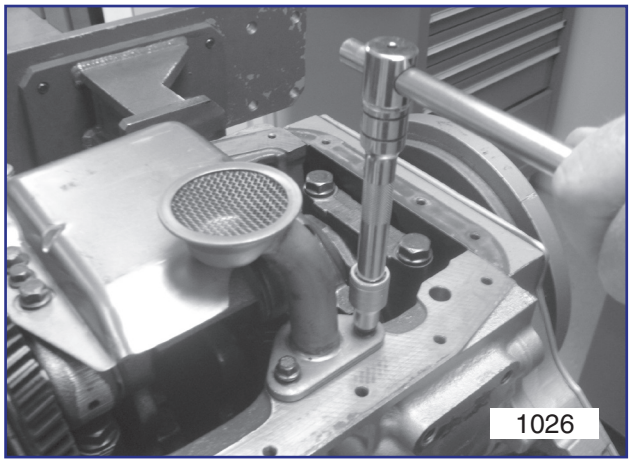
3. Install the oil cooler bolts applying the torque of XX N.m.

4. Install the clamp and the hose to the oil module.

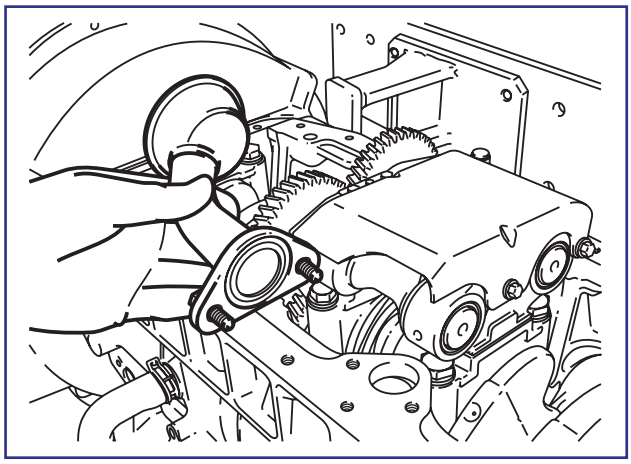
5. Install the oil element and cover. See specific procedure in Engine Preparation section.

Inspections and Measurements

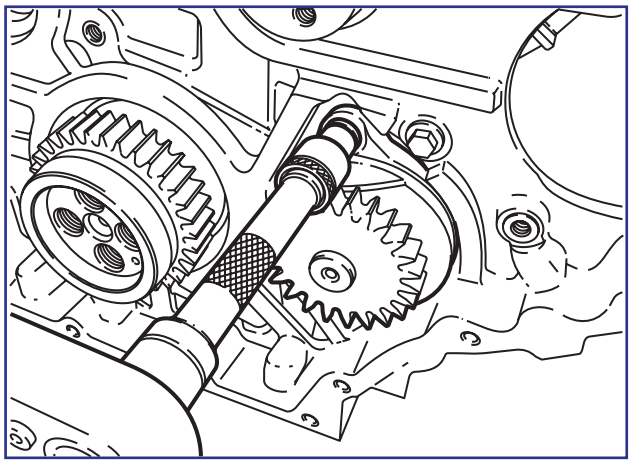
Clean and check the oil suction pipe in the engine for cracks or blockings.



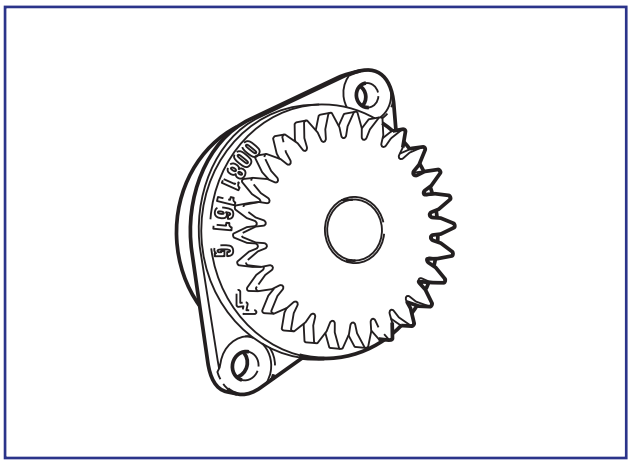
Change the sealing ring of the oil suction pipe.



Remove the oil pump.



Visually check the drive gear of the oil pump, the inner part of the carcass and the rotor, for damages or excessive waste.



Check the clearance between oil pump rotors.

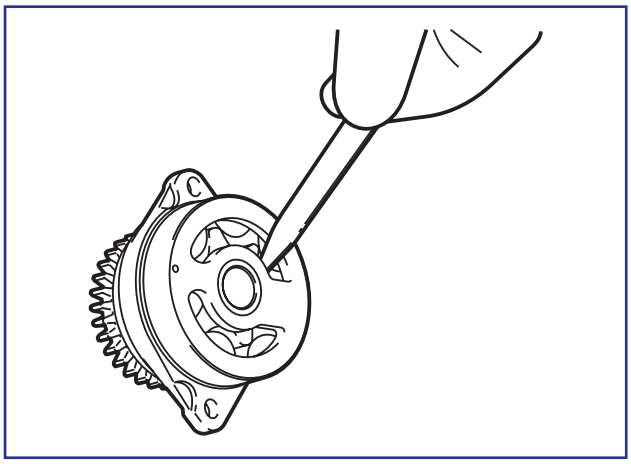
Clearance between rotors: 0.05 - 0.10 mm

Check the radial clearance between the outer rotor and the pump carcass.

Radial clearance: 0.06 - 0.10 mm

Check rotors axial clearance.

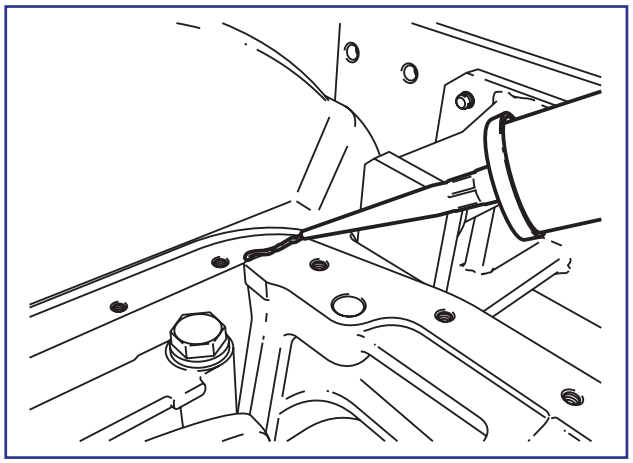
Axial clearance: 0.025 - 0.075 mm

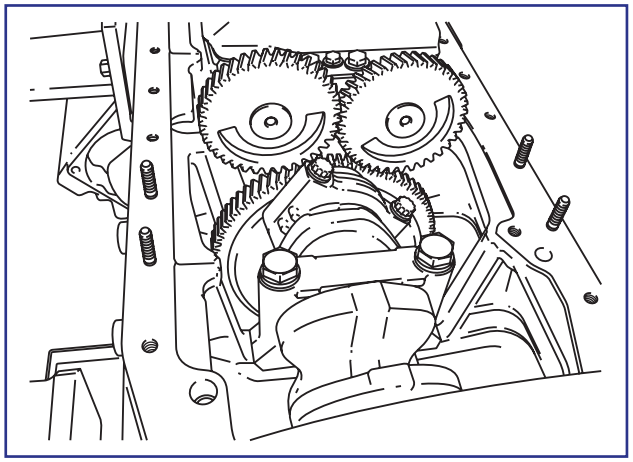


Assembly

Carefully install the oil suction pipe in order to do not let the sealing ring to fall inside the suction gallery.

Install a new carter gasket. The gasket must be assembled without glues or adhesives.

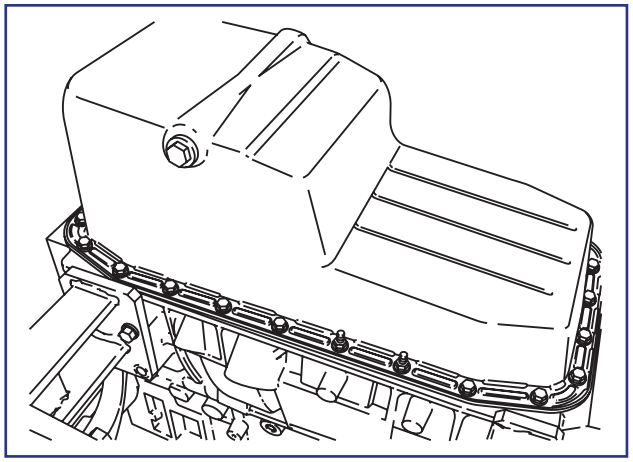




Assembly the carter tightening the bolts from the edges, crosswise and apply the specified torque.

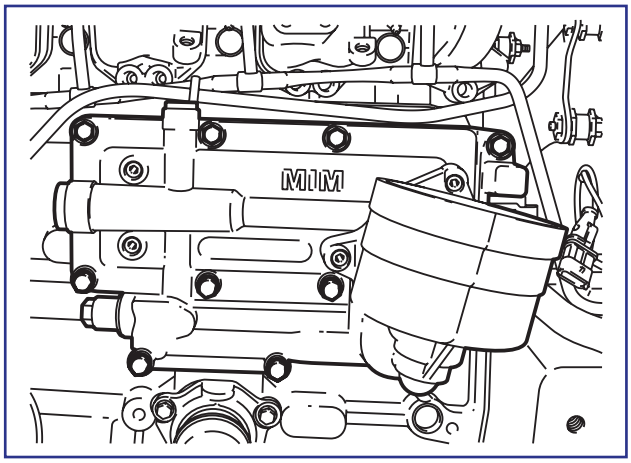
Apply torque: 25 ± 5 Nm (for bolts and nuts)

10 ± 2 Nm (for studs)



Clean the sealing surfaces and carefully assembly, reinstalling the oil cooler.Tighten the hexagonal bolts crosswise applying the specified torque.

Apply torque: 25 ± 3 Nm



Engine Electrical

Sensor Identification

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the “Safety Information” section of this manual.

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle.

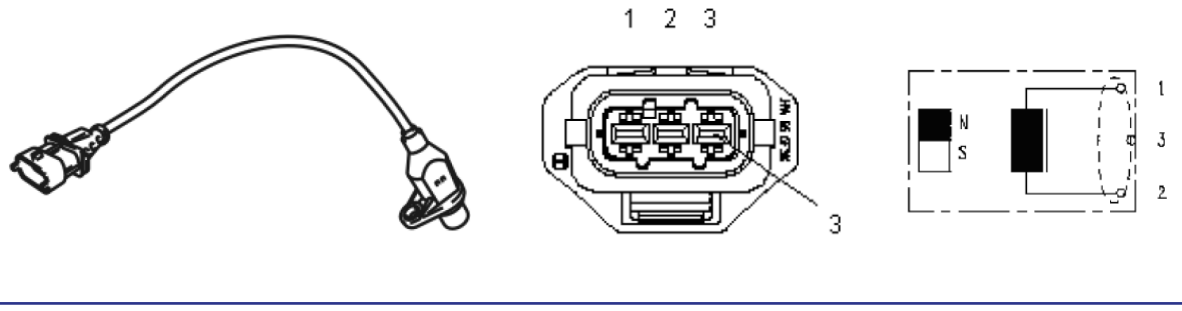
NOTE: For information regarding the removal or installation of adjacent components, refer to the following service procedures located in other sections of this manual:

- Valve cover

This section should be used for sensors identification and location. For a more detailed description of electrical sensors, see the Engine and Vehicle Sensors in the “Introduction” in this manual, or the diagnostic manual.

Engine Sensors

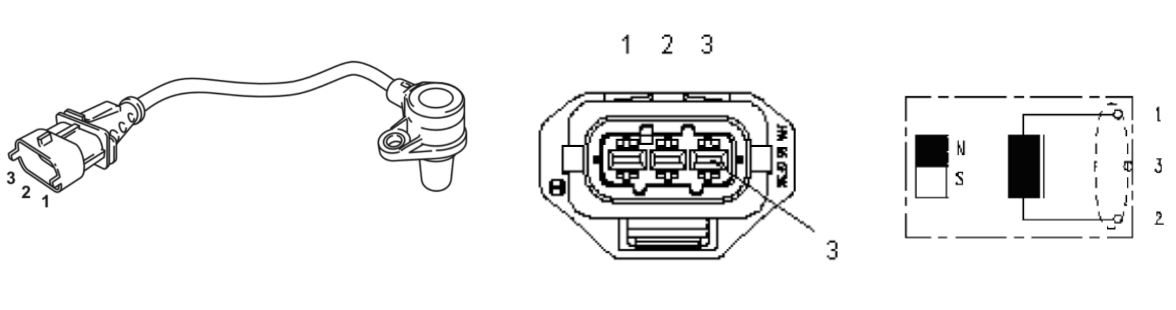
Phase sensor or Camshaft Position (CMP) sensor



The phase sensor is a magnetic type sensor used to sense crankshaft position. It responds to a rotating plate actuator mounted onto the back of the camshaft gear. The CMP sensor is installed in the front cover, close to the high pressure fuel pump.

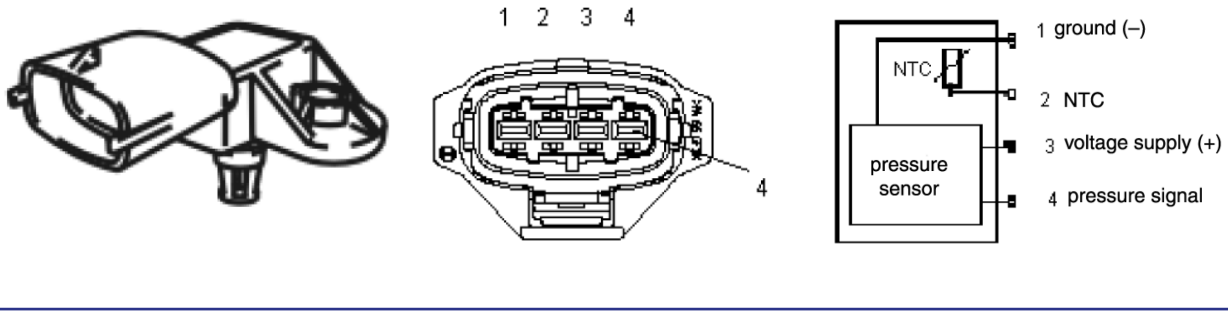
When ordering this sensor for replacement, make sure that the sensor you receive is the same one pictured.

Rotational sensor or Crankshaft Position sensor (CKP)



The CKP sensor is a magnetic pickup sensor used to sense camshaft position. The CKP sensor is installed on the top left of the flywheel housing.

Engine Oil Pressure and Temperature (EOPT) sensor



The EOPT sensor consists of a piezo-resistive pressure sensor element and the temperature sensor element is an NTC-resistor in a suitable circuitry for signal amplification and temperature compensation integrated on a silicon chip.

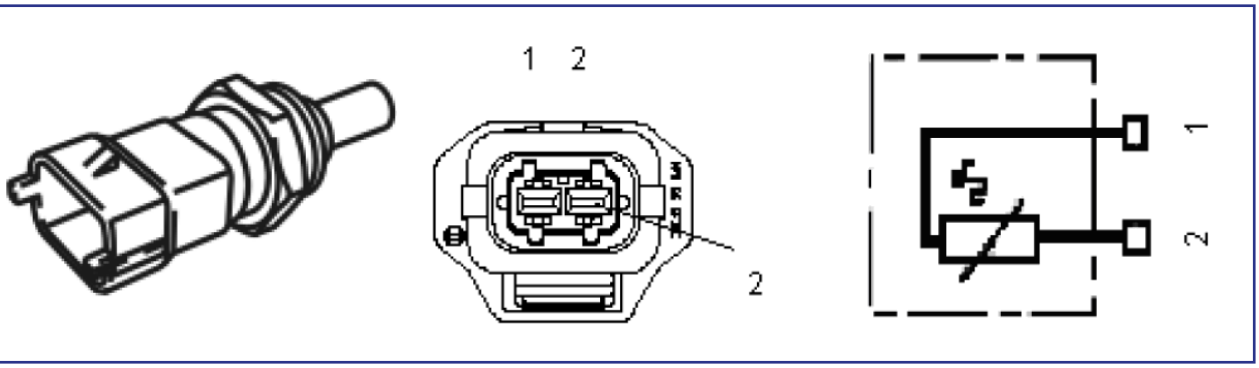
This component has the same functionality as TMAP sensor and it is designed to operate with engine oil.

This sensor measures the absolute pressure and temperature.

The EOPT sensor is installed onto the front cover to the right engine side, close to the air compressor.

Installation: The O´Ring will seal the sensor from atmosphere and only a thin film of light engine oil (5W20) may be applied as lubricant. Don't use silicone based lubricants.

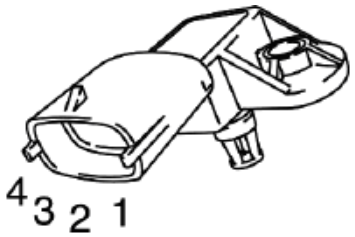
Engine Coolant Temperature (ECT) sensor

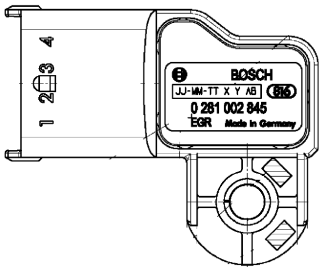


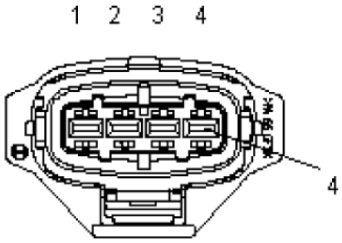
The ECT sensor is a thermistor type sensor.

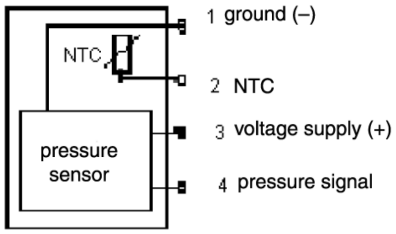
The ECT sensor is installed in the EGR cooler inlet water pipe located on the right rear side of the engine.

Manifold Air Pressure and Temperature (TMAP) sensor









The TMAP sensor measures the absolute air pressure and temperature.

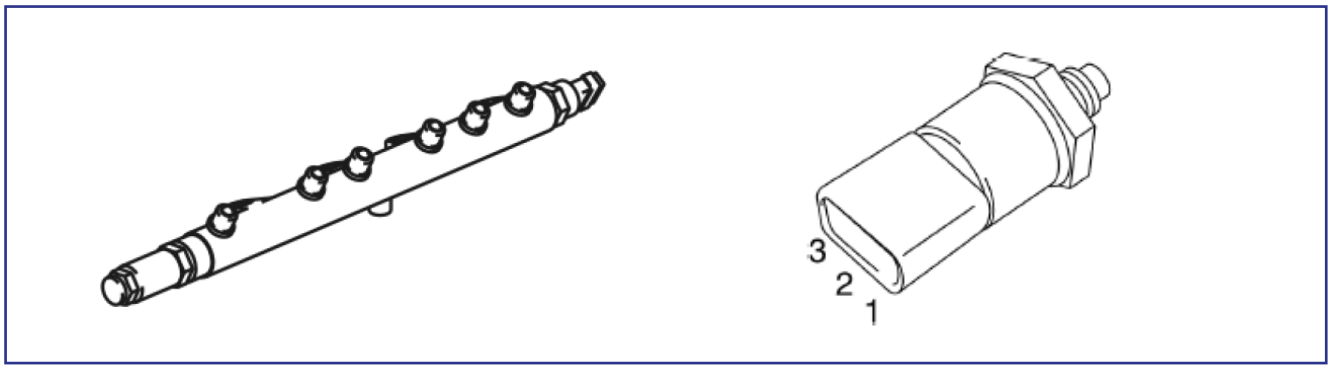
This sensor consists of a piezo-resistive pressure sensor element and the temperature sensor element is an NTC-resistor in a suitable circuitry for signal amplification and temperature compensation integrated on a silicon chip.

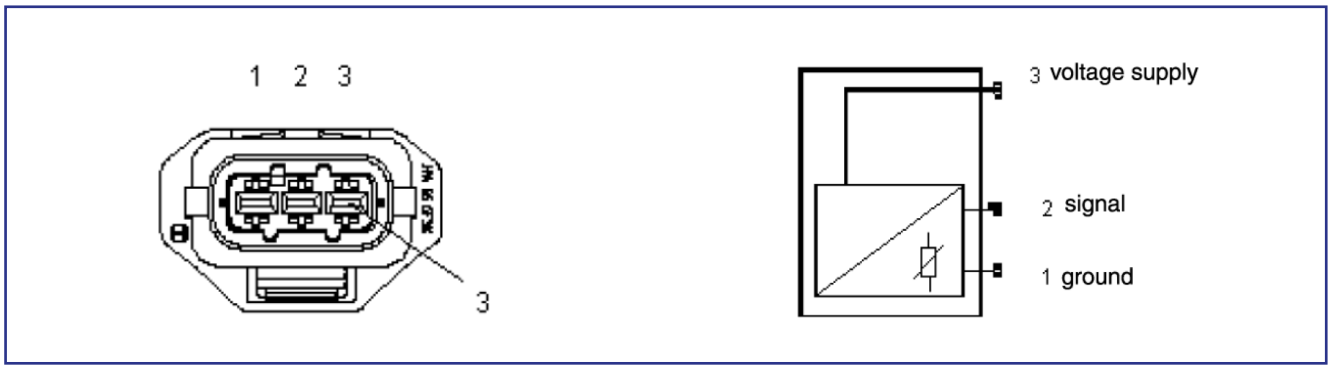
This component is marked as “EGR” that means it is specially developed to operate under air stream after inlet of exhaust gas recirculation.

The TMAP sensor is installed onto the air intake manifold, located in the left engine side.

Installation: The O´Ring will seal the sensor from atmosphere and only a thin film of light engine oil (5W20) may be applied as lubricant. Don’t use silicone based lubricants.

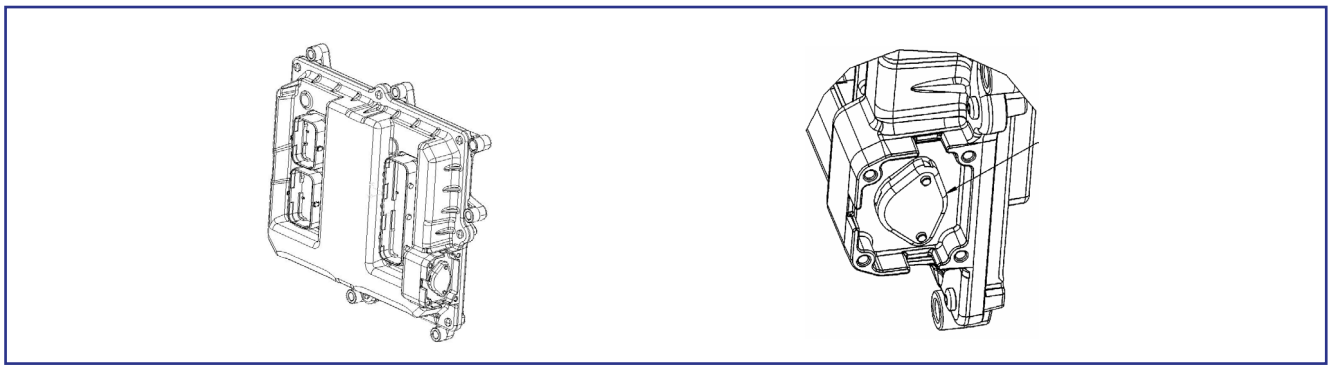
Fuel Pressure (EFP) sensor - Rail





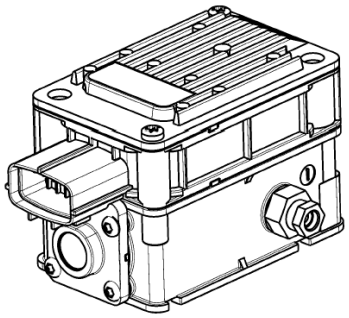
The EFP sensor is a variable capacitance sensor. The EFP sensor is installed in the fuel rail.

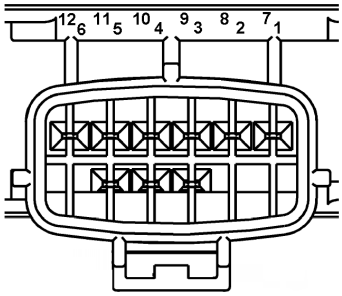
Barometric Absolute Pressure (BAP) sensor



The BAP sensor is a variable capacitance sensor. The BAP sensor is located in the ECM.

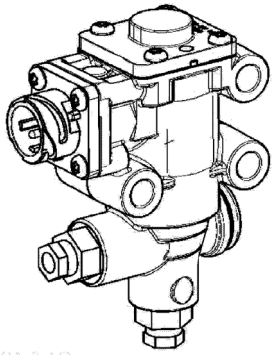
Turbo Control – PWM valve





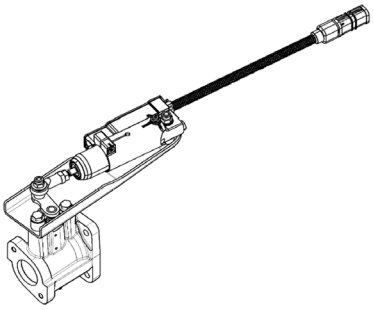
The Turbo control receives PWM pulses from ECM and actuates via pneumatic system a wastegate valve to control turbo pressure.

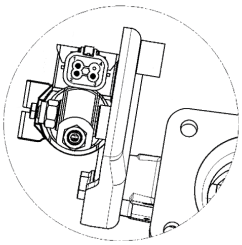
EGR Control Valve



The EGR valve receives PWM pulses from ECM and actuates via pneumatic system a uni-directional cylinder which actuates an exhaust flap to control the recirculation exhaust gases.

Proportional valve for Exhaust Gas Recirculation



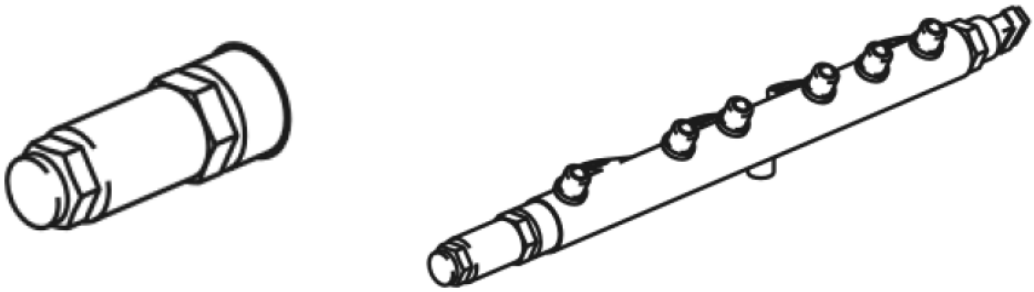


A uni-directional cylinder which actuates an exhaust flap is activated by the proportional valve in order to recirculate exhaust gases for combustion.

Rail Pressure Valve

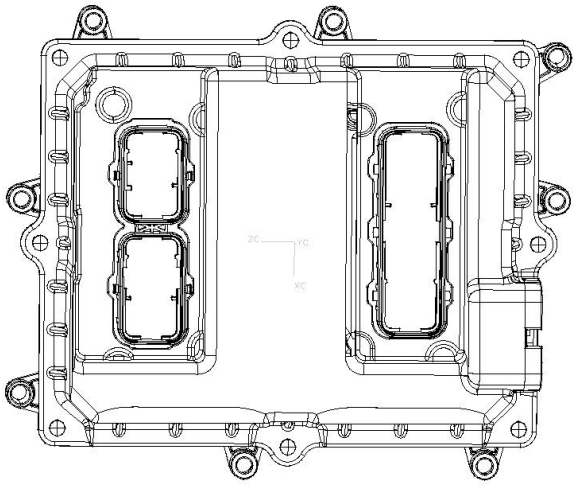
The Fuel pressure valve actuator is mounted in the High Pressure Fuel Pump.

Rail Pressure Limiter Valve

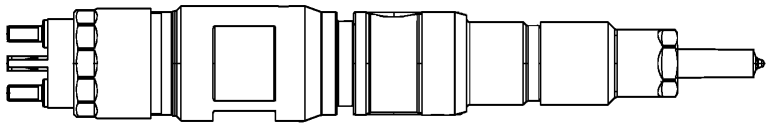


The Rail Pressure limiter valve is installed in the Fuel Rail.

Rail Pressure Limiter Valve

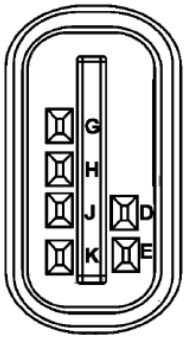


Fuel Injectors

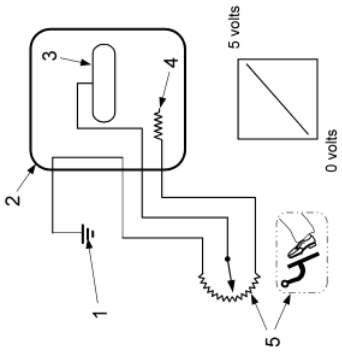


Vehicle Sensors

Throttle Position Sensor (TPS)

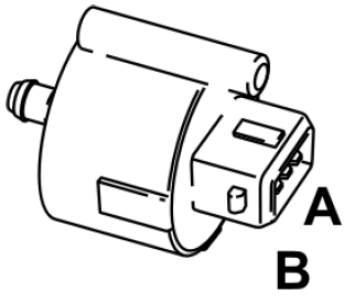


Vehicle Speed Sensor (VSS)



The VSS sensor is designed to measure the vehicle speed. It is located in the vehicle, see vehicle workshop manual for further information.

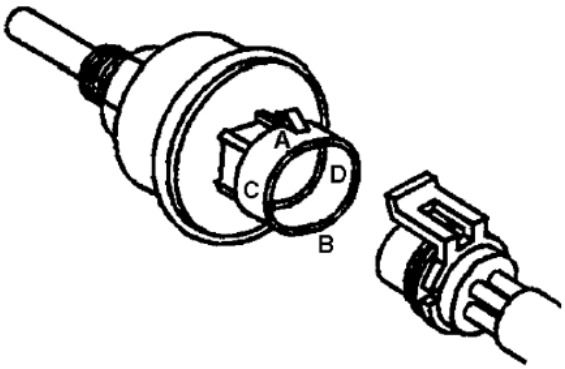
Water In Fuel (WIF) sensor



The Water in Fuel sensor detects water in the fuel.

The WIF sensor is installed at the base of the fuel filter housing.

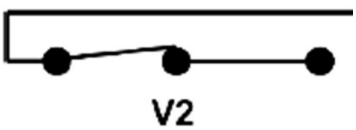
Engine Coolant Level (ECL) sensor



The ECL sensor is a variable capacitance sensor.

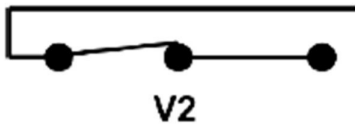
The ECL sensor is located in the vehicle. See vehicle workshop manual for further information.

Clutch Pedal Sensor (CPS)

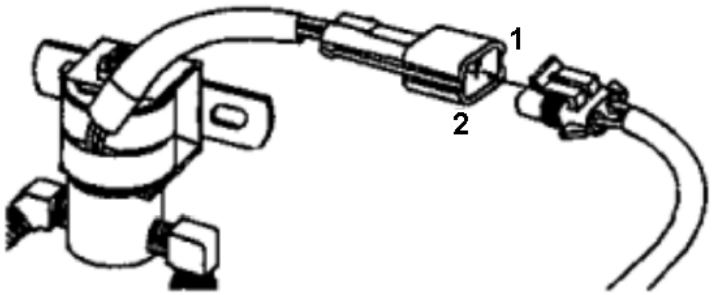


The CPS sensor is a switch normally open type. The CPS sensor is located in the clutch pedal assembly. See vehicle workshop manual for further information.

Brake Pedal Sensor (BPS)



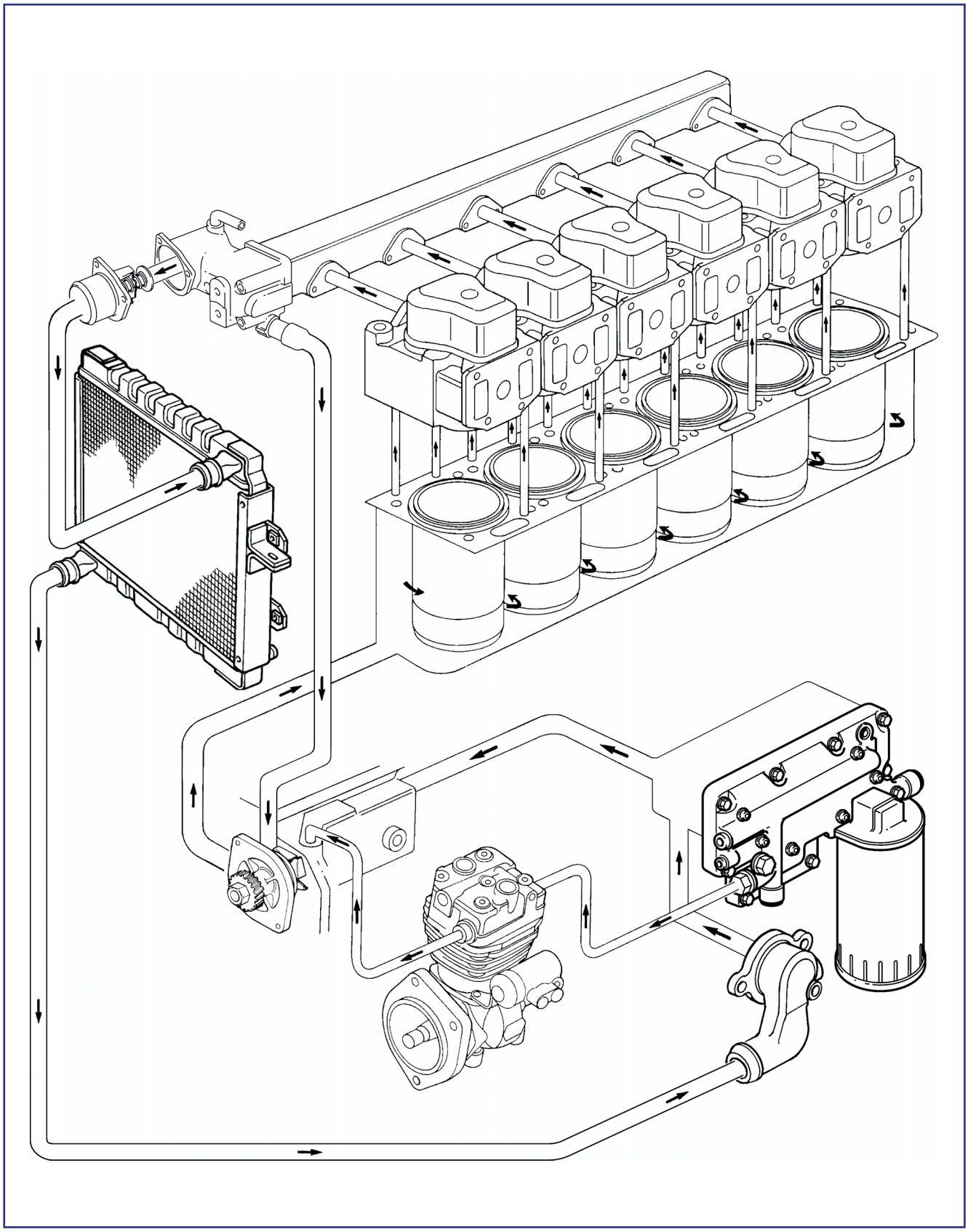
Engine Brake Solenoid



Cooling System

Cooling System

Cooling Circuit



Disassembly Notes

Attention: Never perform a service in any component of the cooling system while the engine is running.

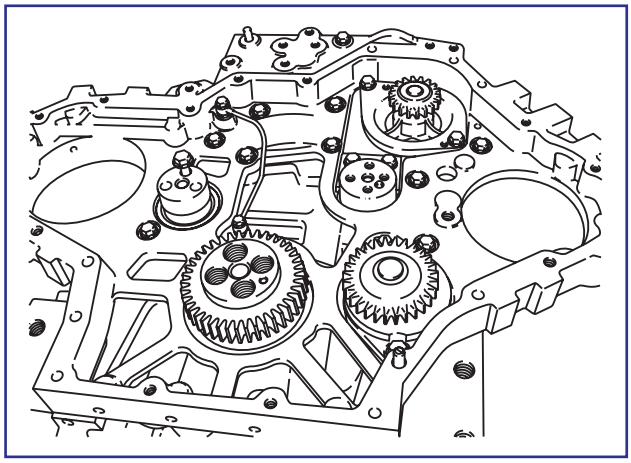
Avoid touching the components of the cooling system soon after the operation of the engine, this can cause burns.

The cooling fluid can spill and cause burns if the radiator cap is removed while the system is still hot. Remove the radiator cap, let the system to cool down, turn the cap until the first stage and wait all the pressure to be relieved.

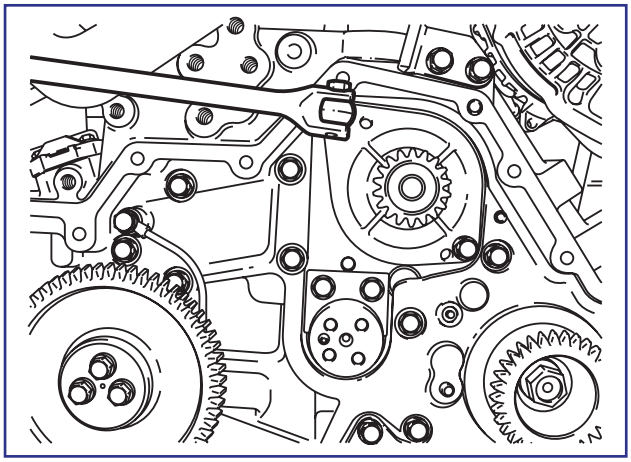
To access the water pump, remove the front cover and camshaft gear.

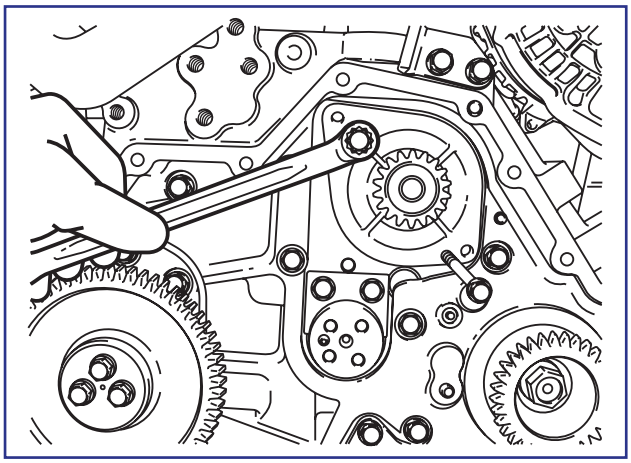
Remove the water pump fixation bolts and screw them in the indicated holes.

Screwing the bolts the water pump will be removed.



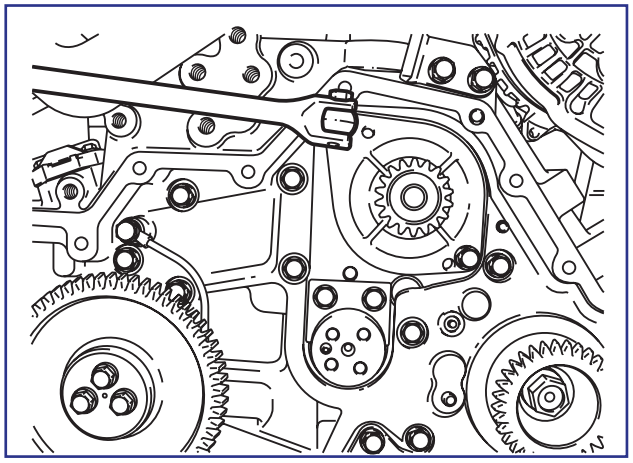
Remove water pump.



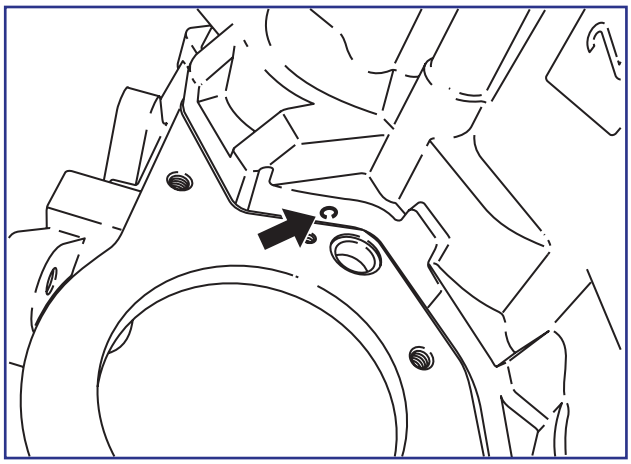


Inspections

Check water pump carcass and rotor.



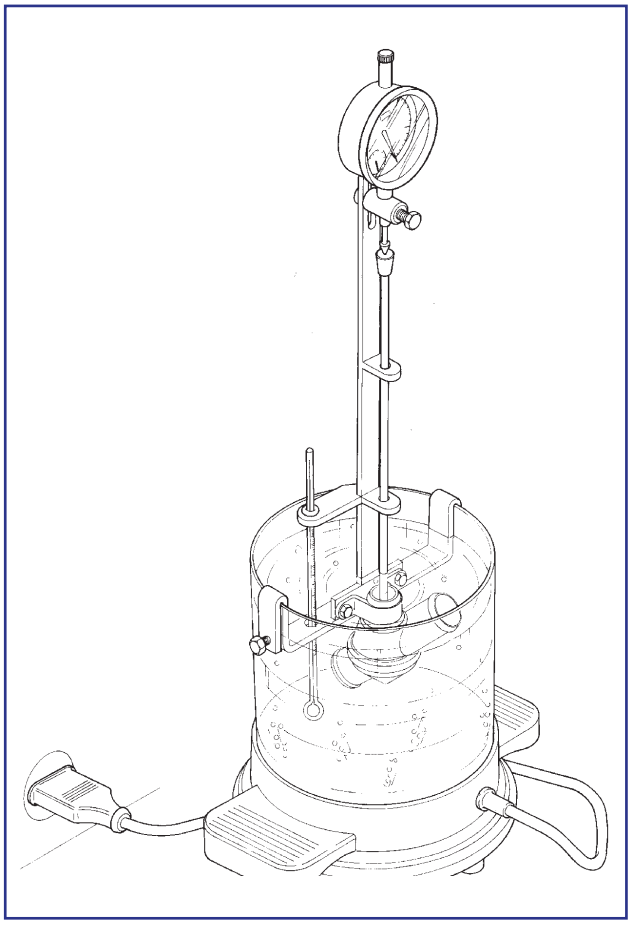
Check the inspection hole located on the left side of the engine block (seen by the flywheel side). If there are signs of water or oil leakage, probably there is leakage through the water pump or through the sealing rings. Check and change, if necessary.



Thermostat Test Procedure

Test the thermostat and check its operation conditions according to the procedure below:

- Place the thermostat in a recipient and fill with water up the valve stays totally immerse.
- Position a dial indicator gauge on the stem of the thermostat and adjust a pre-load of 1 mm.
- Install a thermometer of scale 0-100 °C immerse into the water.
- Gradually heat the water up.
- Take note of the temperatures at the beginning and final of the thermostat opening course (beginning and end of the dial indicator gauge movement), and the final total course of the dial indicator gauge (fully open).
- Compare the values found with the table. Change the thermostat if the temperature of the beginning of opening is out of the specified values and / or the total operation course is below specified.



Assembly

Assembly the thermostat in the carcass with a new sealing ring.

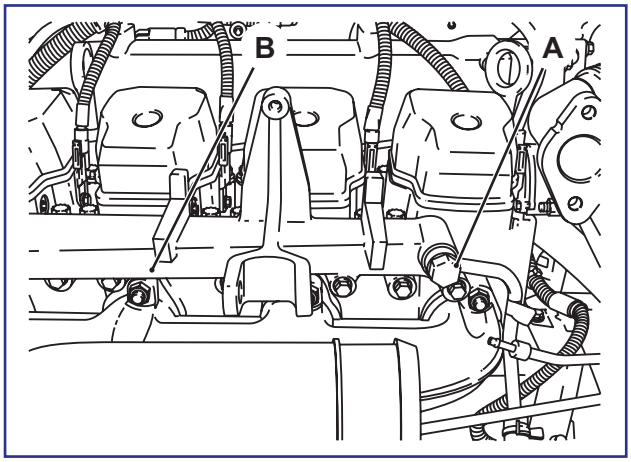
Attention: Never operate the engine without the thermostat, because the engine will not reach the correct operation temperature.

The sealing rings of the component disassembled must be always changed.

Water pipe

Removal

1. Remove cooled EGR assembly. See specific procedure in this service manual for further information.



2. Water pipe removal:
   a. Remove the water tube to air compressor outlet pipe hollow bolt.
   b. Remove the mounting bolts.
3. Remove the water pipe and discard the O-Ring´s.

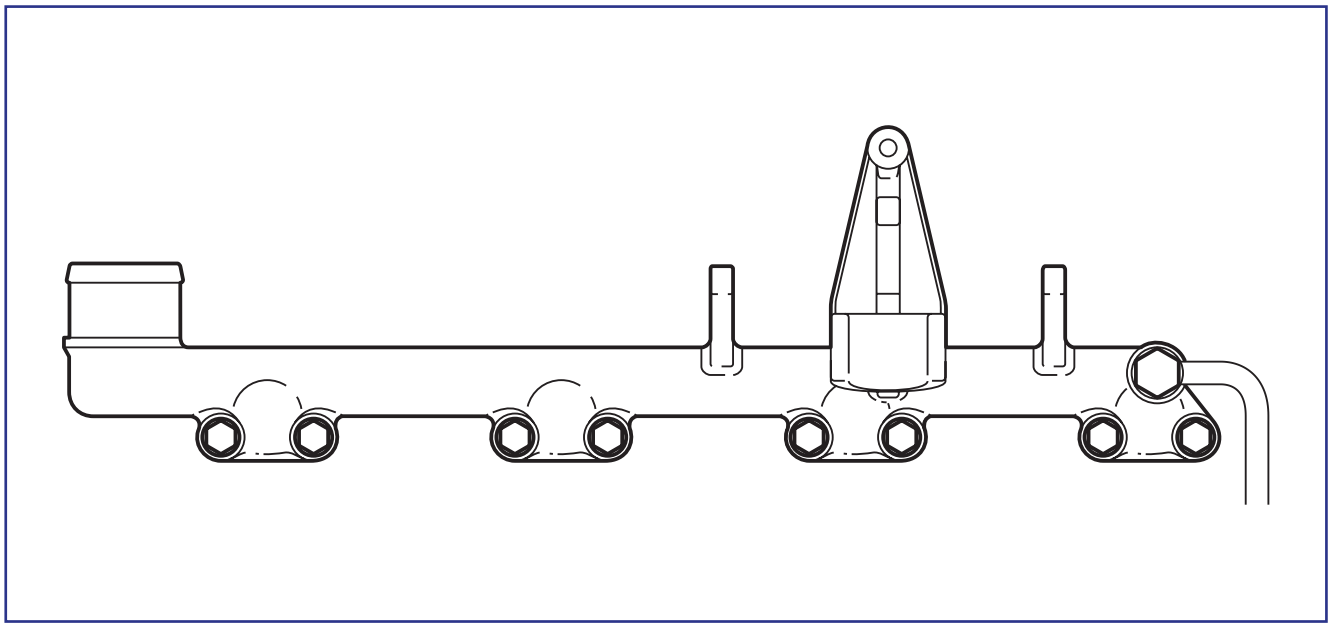
Cleaning

1. Clean mating surfaces between water pipe and cylinder heads.
2. Check water pipe for damages, cracks and wear. Replace the water pipe as necessary.
3. Clean water pipe thoroughly with a suitable non-caustic solvent.
4. After cleaning, blow dry using filtered compressed air.

Installation

Caution: To avoid engine damages, do not attempt to grind or machine the water pipe to compensate for a warped condition.

1. Install new O-Ring´s onto the water pipe hole housing.



2. Mount water pipe and its bolts. Applies the torque and sequence shown.

   Torque: 25 ± 4 Nm

3. Thread the water tube to air compressor outlet pipe hollow bolt applying the torque of 20 ± 6 Nm.

4. Install cooled EGR assembly. See specific procedure in this service manual for further information.

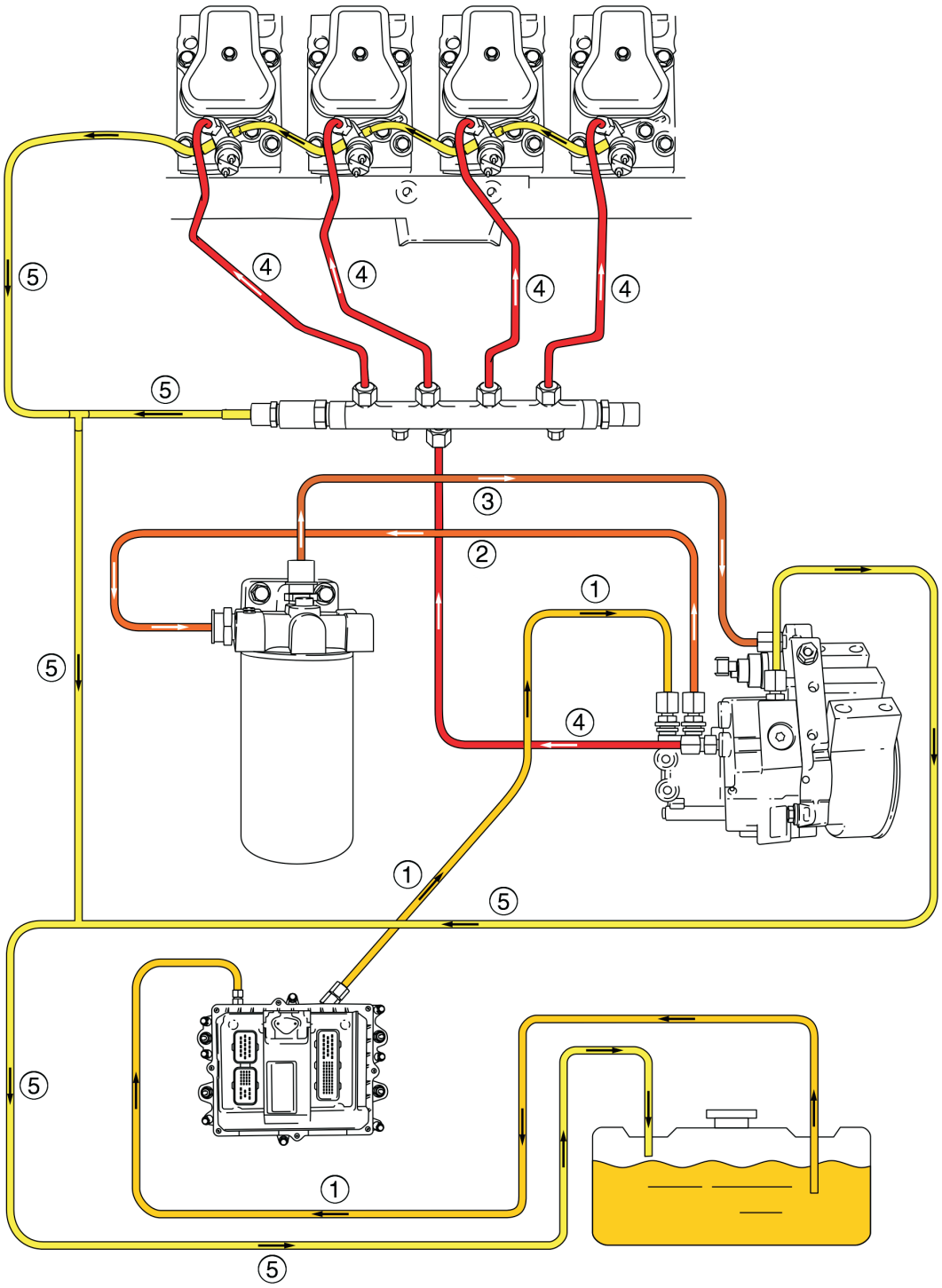
Attention: For the best performance of the cooling system, it is necessary that all the water passages inside the engine are properly filled up. The aeration of the cooling system can cause high temperature spots on the cylinder heads and engine block surfaces, causing cracks in those components and burns on cylinder head gaskets.

Fuel Injection System

Attention:

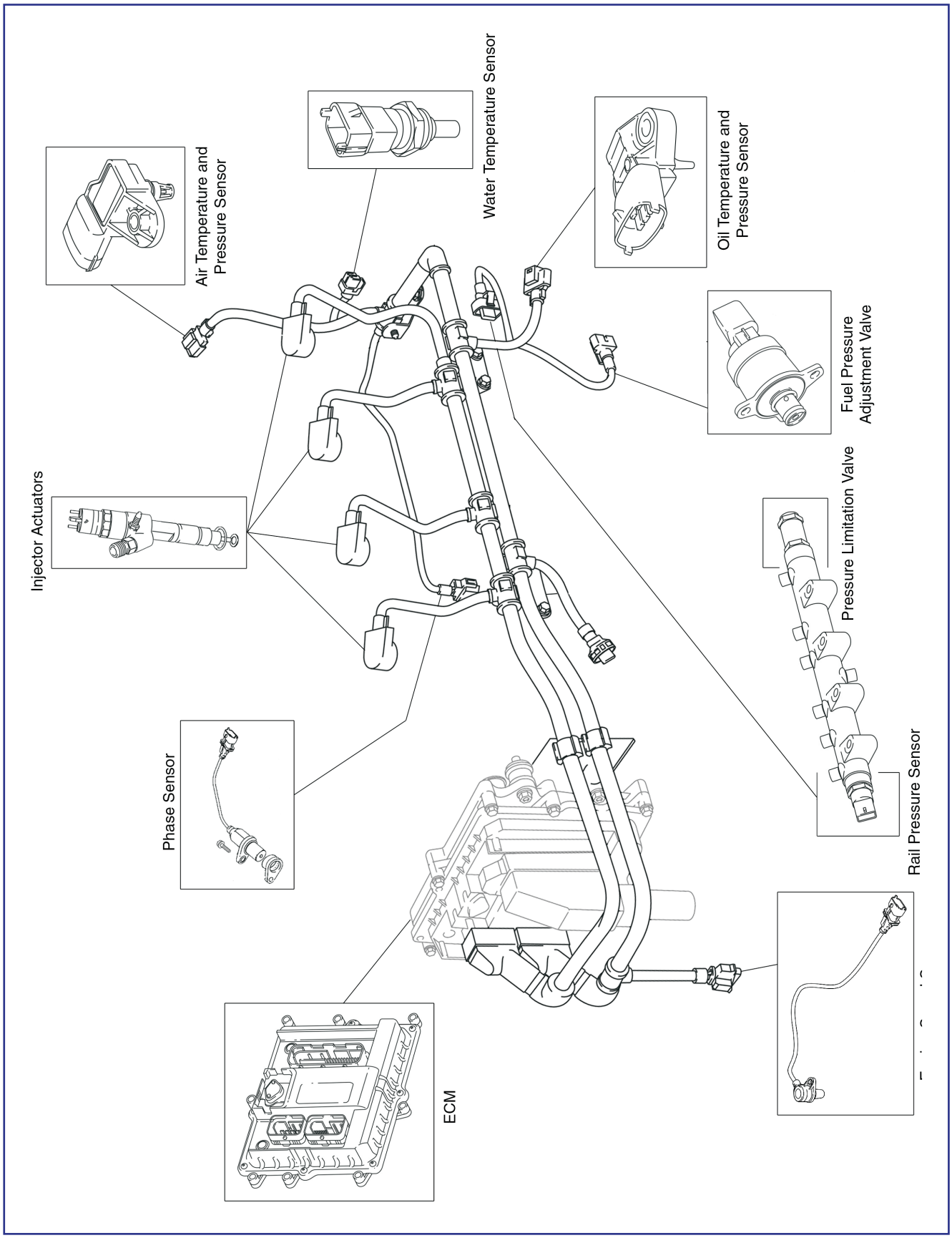
- **Never perform service on any component of the system while the engine is running.**
- **Do not smoke while is servicing on the fuel system or any other system of the engine.**
- **Avoid contact with electric components that may produce sparks.**
- **Always check tanks, piping, hoses and other components of the fuel system for leakages.**
- **When the engine is in operation, do not touch on the injectors connectors. The high tension can cause serious injuries.**
- **Do not bleed the fuel injection system with the engine in operation. The high pressure in the system can cause serious injuries if disassembled.**
- **The ECM, under no circumstances, can be disassembled for any kind of service. Only the Bosch authorized service station can check or repair any problem in this component after analyzed by the scanner. The inappropriate repair causes the cancellation of the component warranty and consequently the cancellation of the total warranty of the engine.**
- **The solenoids installed on the Rail only can be disassembled if problems on its operation are shown up by the scanner. Otherwise it must not be disassembled under any circumstances.**
- **Before beggining to assembly the harness on the ECM, make sure that the battery cables are disconnected.**
- **The repairing on the injection system only can be performed after 30 seconds of the engine stop, necessary time to assure the total reduction of the pressure in the Rail.**

Common Rail Modulated Pressure Fuel Injection System

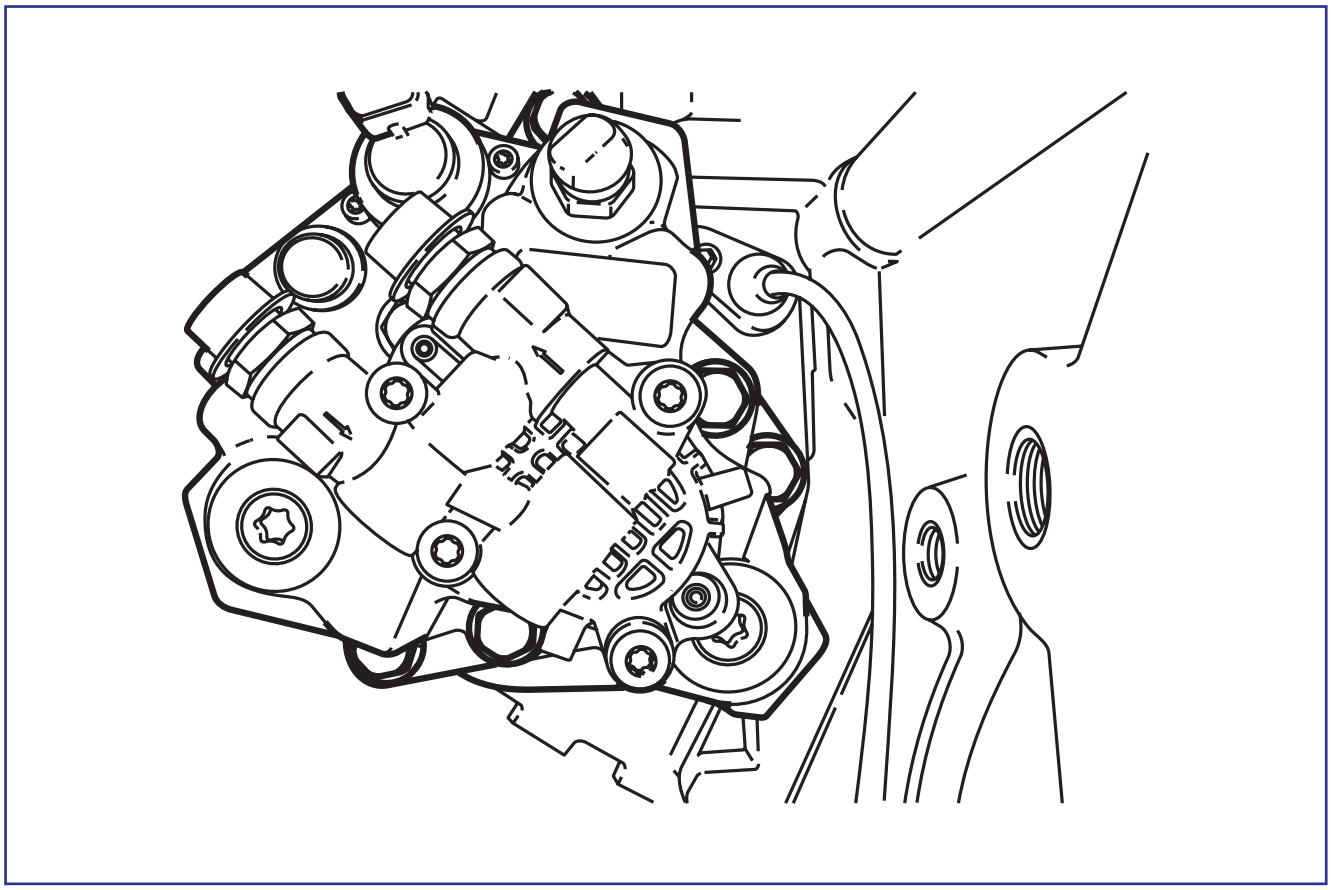


1 Fuel from Tank
2 Fuel from Gearing Pump
3 Filtred Fuel
4 Fuel Under High Pressure
5 Return Fuel

Common Rail Harness “4.12”



CP 3.3 Pump – Rear Part View



A Filter fuel inlet

B Rail pressure control valve (m-prop)

C Fuel return to the tank

D Fuel outlet to filter

E ECM cooler fuel inlet

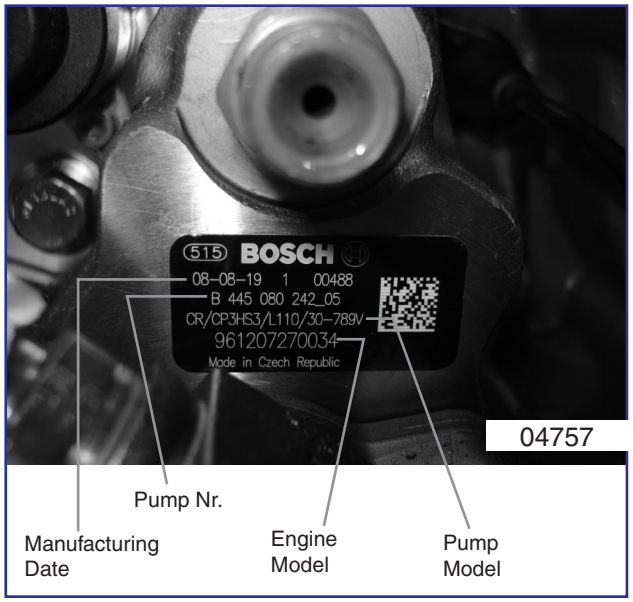
F Fuel outlet to the Rail

G Fuel lift pump

BCP 3.3 – Identification Plate

The identification plate of the high-pressure fuel pump is important to help in the tracking of the component and to indicate its origin.

The loss can delay or even cancel the warranty of the product.



Fuel rail

Warning: **To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.**

Warning: **To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle.**

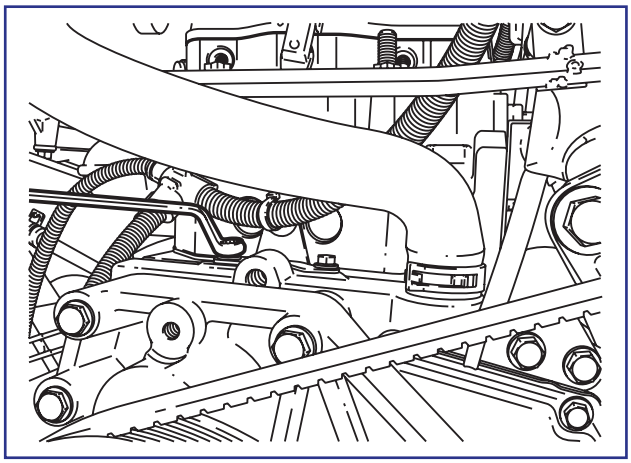
Warning: **To avoid serious personal injury, possible death, or damage to the engine or vehicle, comply with the following when draining fuel:**

- **Do not smoke.**
- **Keep away from open flames and sparks.**

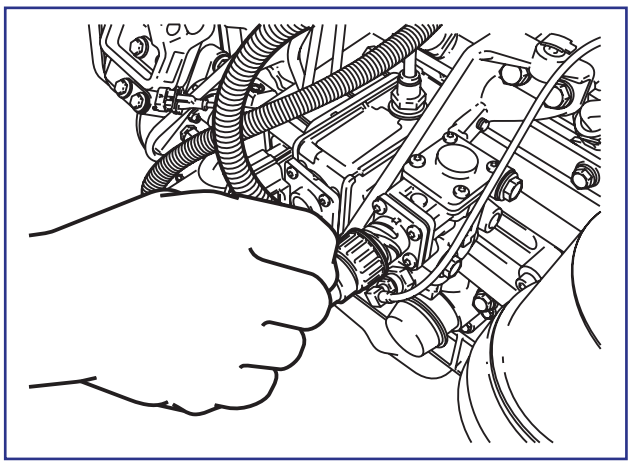
1. Drain the fuel filter assembly of all water and fuel into a suitable container before removing assembly. Dispose of properly.

Removal

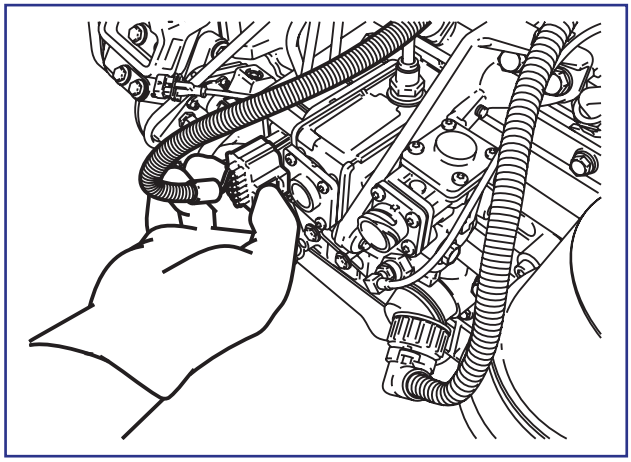
1. Disconnect wire bracket from front side engine.



2. Detach the connector from EGR control valve.

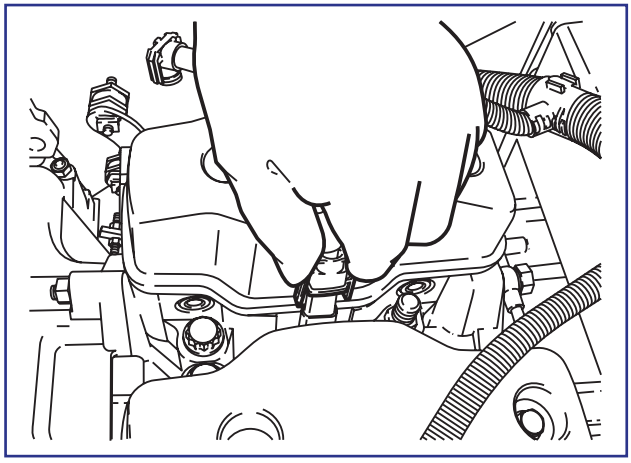


3. Detach the connector from wastegate control valve.

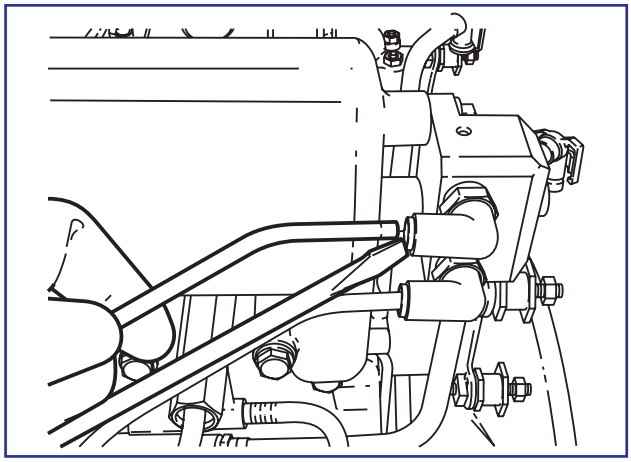


4. Disconnect all fuel injector connectors.

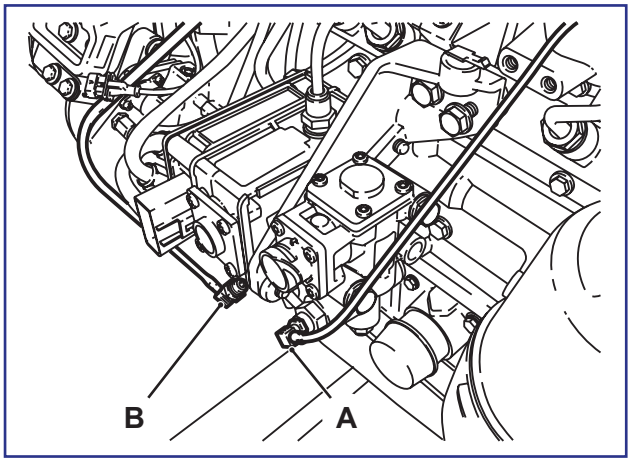
5. Lift and remove the wiring from the engine.



6. Air distributor pipes removal:
   a. To release the pipe, use a screwdriver to push the metallic ring as shown in the figure;
   b. while press the ring, pull the pipe out;
   c. release the two pipes from air distributor.

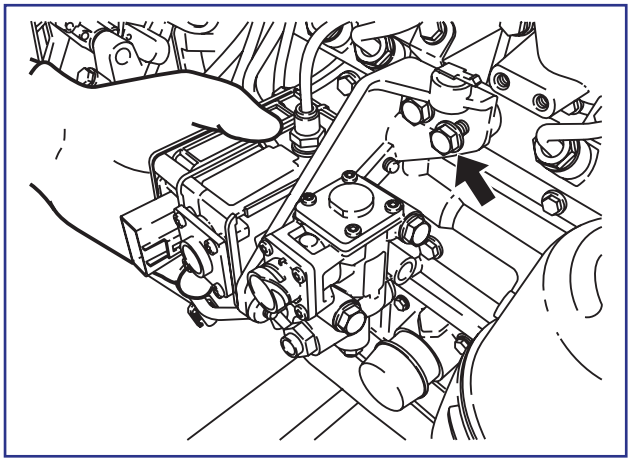


7. For pipe to PWM valves removal, unscrew the nut (shown in a.) and release the two pipe connectors (shown in b.)

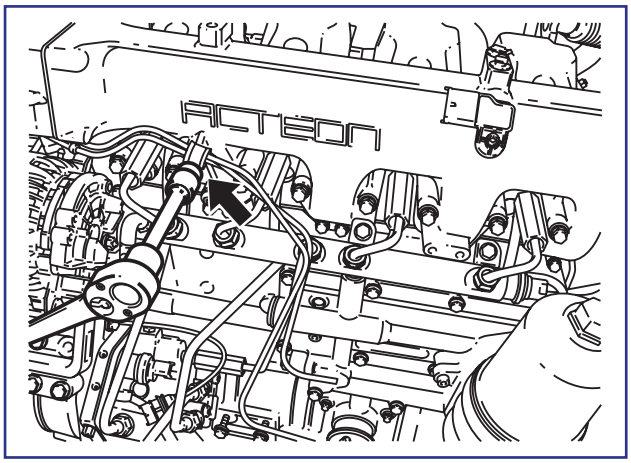


8. Unscrew and remove the two mounting bolts.

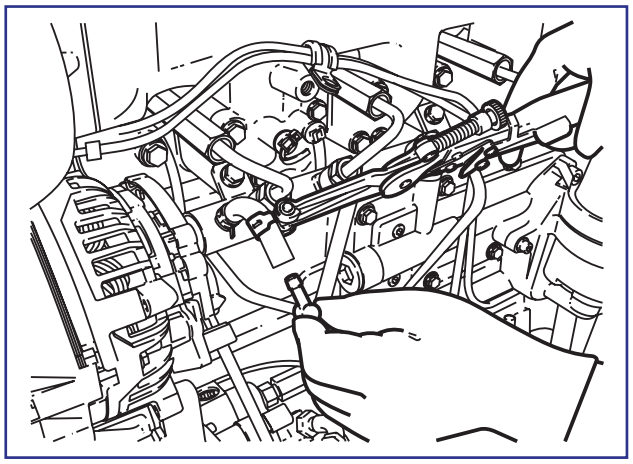
9. Remove the PWM valves assembly.



10. Remove the pipe bracket mounting bolt.



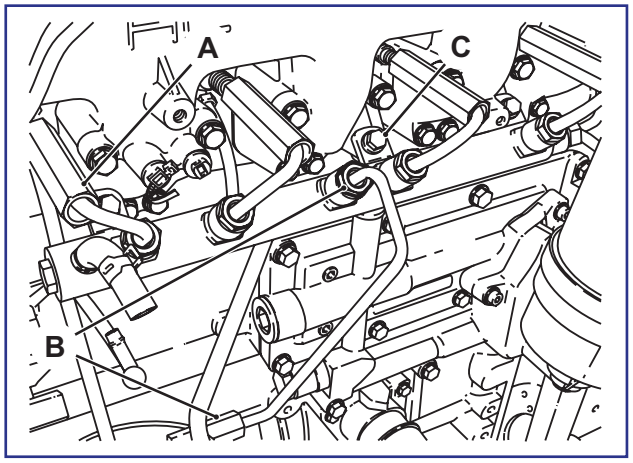
11. Using the tool shown, remove the clamp from fuel return hose.



12. Fuel pipes connectors and bracket removal:
    a. unscrew all fuel rail to injectors connectors;
    b. unscrew the high pressure pump to fuel rail pipe connectors from both sides.
    c. unscrew and remove the fuel rail bracket mounting bolts;

IMPORTANT: Discard all fuel pipes after removal.

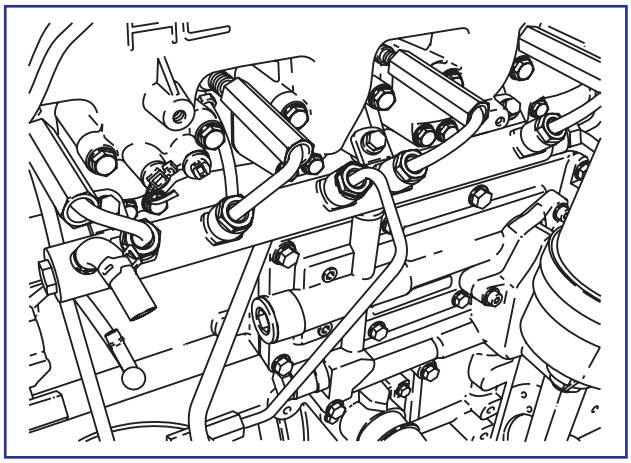
13. Remove the fuel rail assembly.



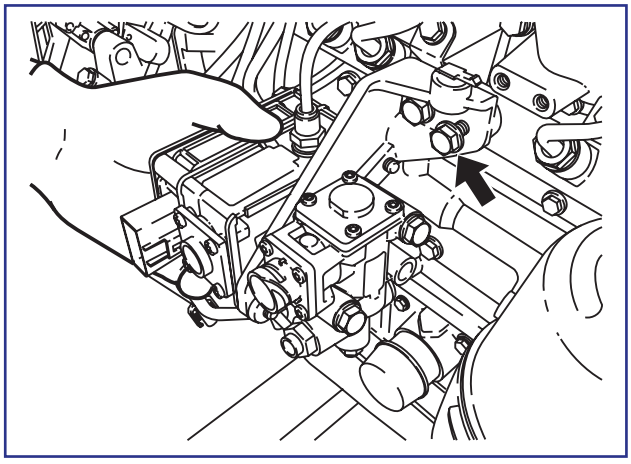
Installation

Caution: Always use new fuel rail pipes. Do not reutilize the fuel rail pipes to avoid serious personal injury, possible death, or damage to the fuel system or engine.

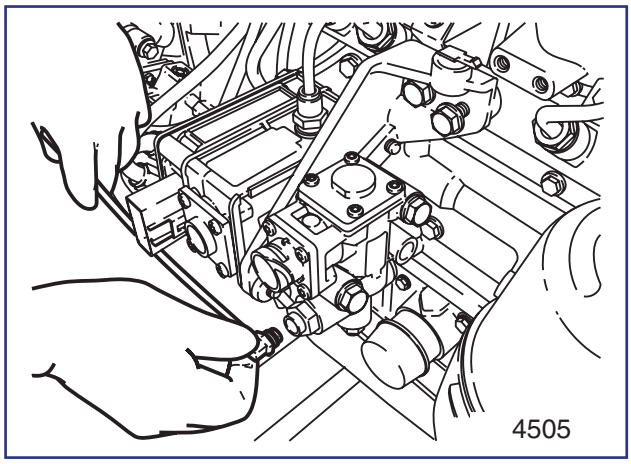
1. Mount the fuel rail bracket onto the engine block.
2. Using new fuel pipes. Install the fuel rail to injectors pipes and applies the torque of 30 ± 3 N.m
3. Using new fuel pipe. Install the high pressure pump to fuel rail pipe and applies the torque of XX N.m



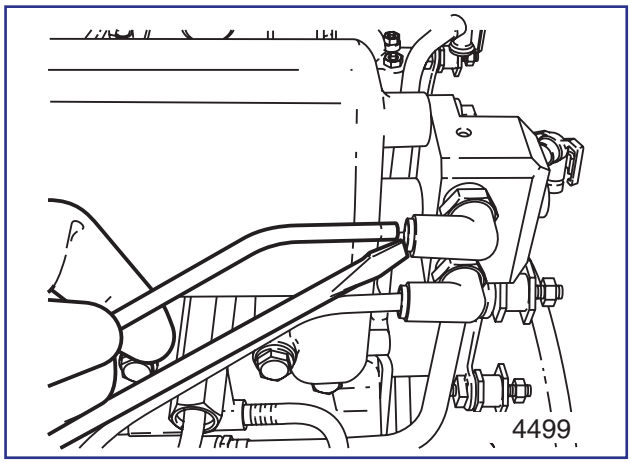
4. Install the clamp from fuel return hose.
5. Thread the pipe bracket mounting bolt. Applies the torque of 25 ± 2 N.m.



6. Install the PWM valves assembly. Mount the two bolts and applies the torque of 20 ± 3 N.m.



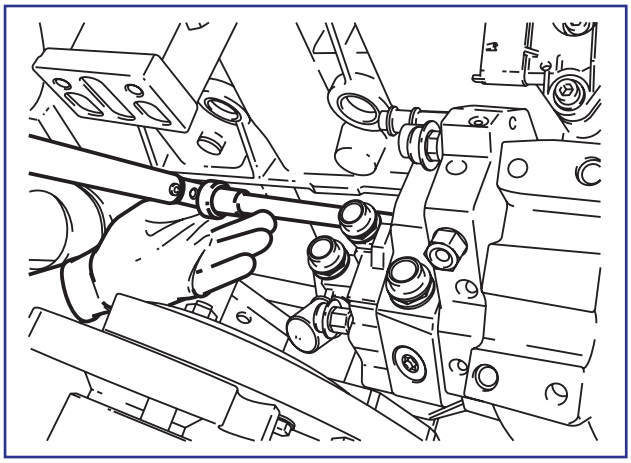
7. Install the pipe to PWM valves connector by pushing the connector until hear the “Click”.



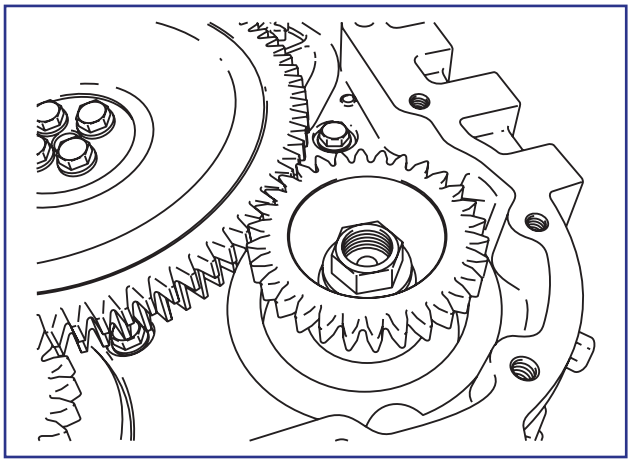
8. Air distributor pipes mounting:
   - To install the pipe, push the metallic ring as shown in the figure;
   - While press the ring, push the pipe in until feel the top or course end;
   - Mount the two pipes from air distributor.
9. Mount the wiring harness and connectors:
   - Connect all fuel injector connectors.
   - Attach the connector from wastegate control valve.
   - Attach the connector from EGR control valve.
   - Connect the wire bracket from the front side engine. Applies the torque of 8 ± 1 N.m

Fuel High-Pressure Pump Removal

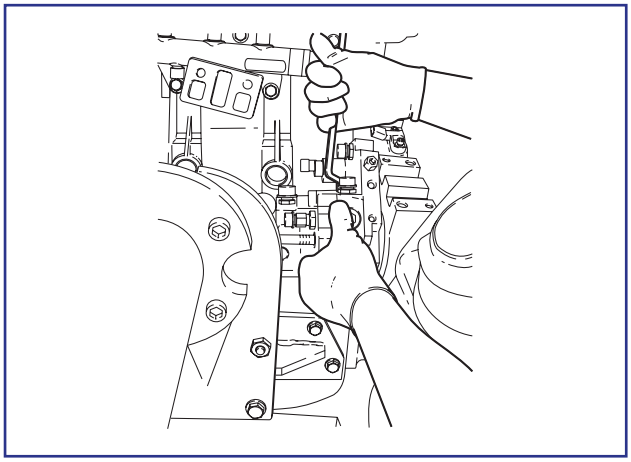
After loosening and removing the pipes, loosen high pressure pump fixation bolts on the intermediary piece.



Loosen and remove the fixation nut of the high pressure pump gear by the side of the gearing cover. Remove the gear.



After removing the gear, totally loosen the bolts and remove the high pressure pump.



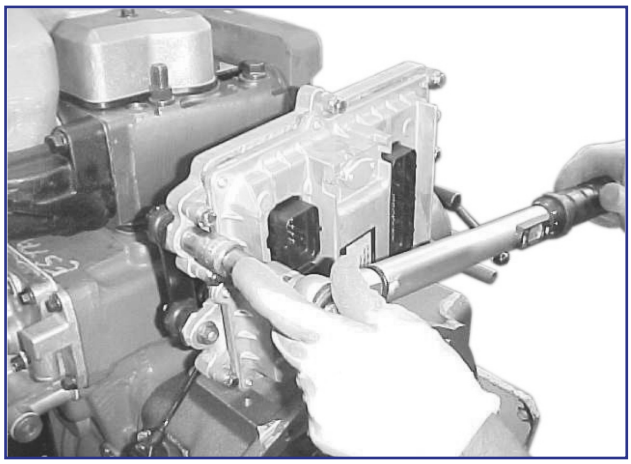
The removal must be done with caution. The friction between the o-ring and the housing of the pump can difficult its removal. As it is a component that requires extreme care, keep it in a reserved place and far from accidents.

Attention:

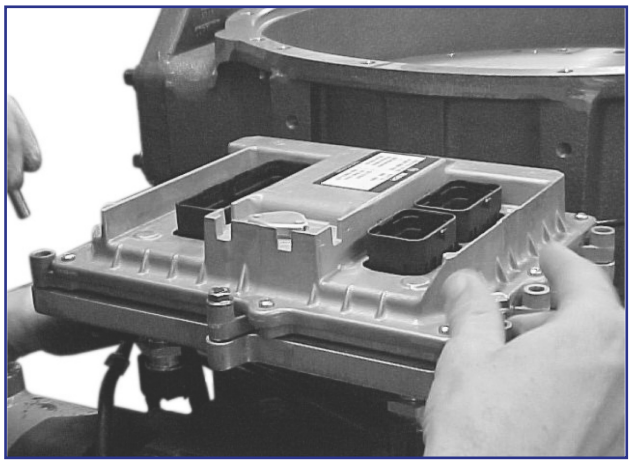
- **The high pressure pump must never be disassembled. Any violation cancels the warranty.**
- **If it is necessary to repair the pump, it must to be sent to the Bosch authorized network.**

Electronic Control Module Disassembly/ Assembly (ECM)

If it is necessary to change the ECM, first loosen the bolts that fix the module to the cooler.



At the module removal, remove the sealing o-ring. Clean the residues from the cooler.



Attention:

- **The ECM is a "Black-Box" and must never be disassembled for any reason;**
- **Previous the replacemente of component, inspect the wiring harness and the pins conectors. Due to corrosion, damage pins or humidity 9water ingress).**
- **Use onlu back probe adequated during the measuring testes.**
- **Check all active DTC's.**

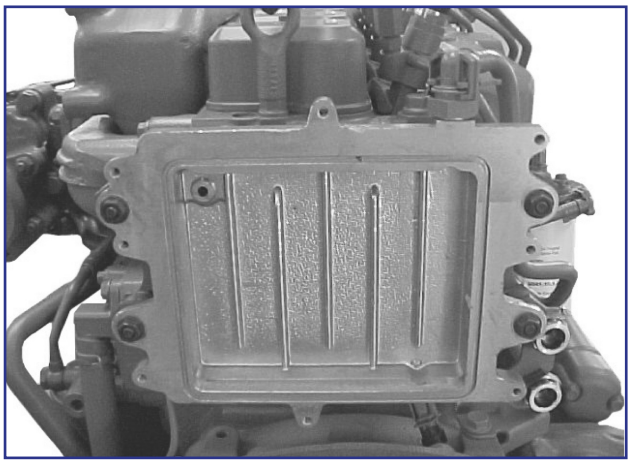
Inspection

Perform a visual analysis on the cooler to check fo any irregularity. Change it if necessary.

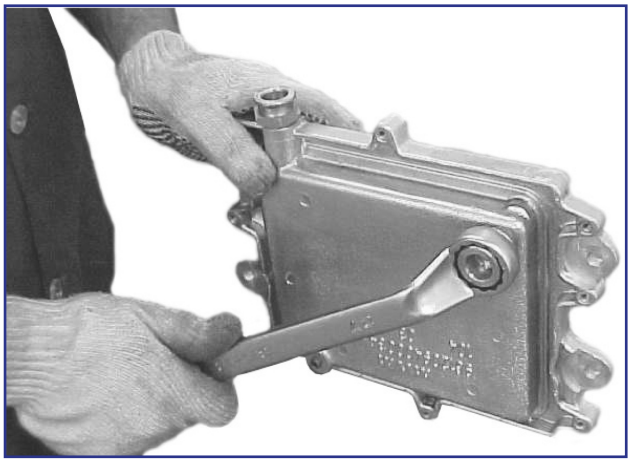
Check cooler drain plug for leakages

Change it if necessary

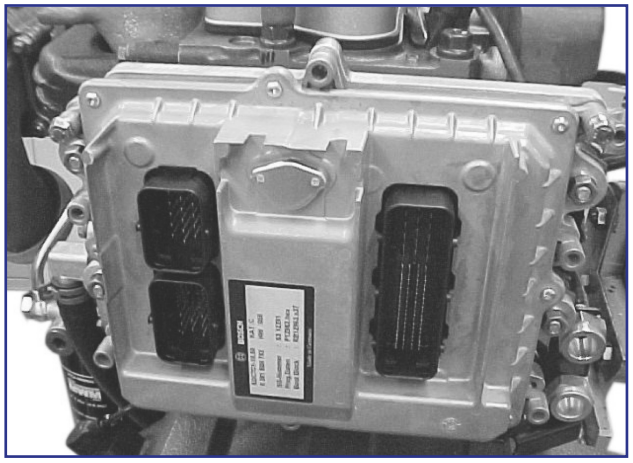
Tighten with 10 ± 1.5 Nm.



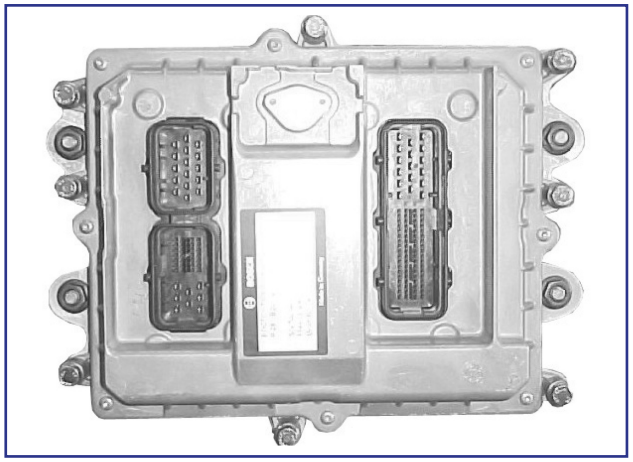
Visually check the condition of the nipples. If necessary, change them. Apply the specified torque. The cooler has a drain plug. If the change is necessary, first apply liquid gasket and then apply the specified torque.



If problems in injection system are caused by the ECM, the component, under no circumstances, must not be open to check or repair. The violation of the module cancels the warranty of the component and, consequently, the total warranty of the engine.

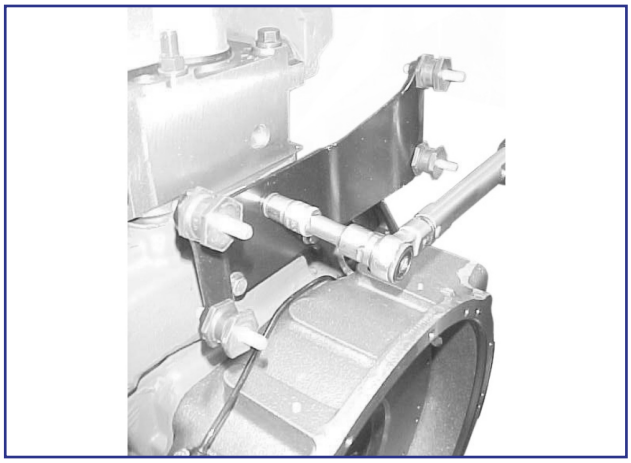


Visually check the ECM pins set. Check for dirt and clean if necessary.

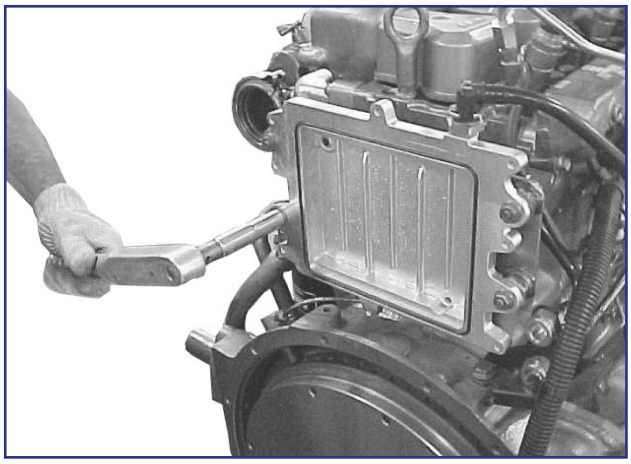


Assembly

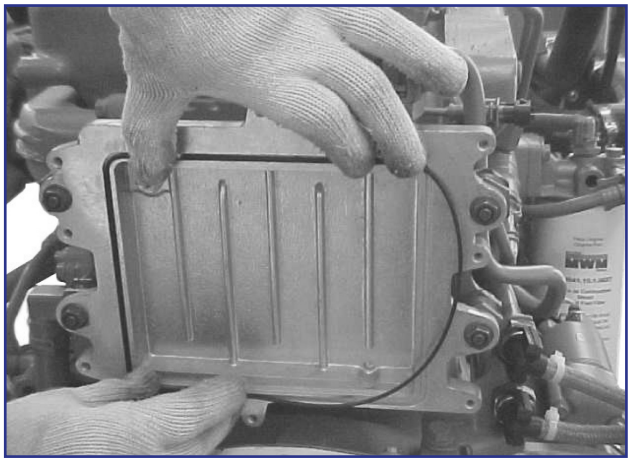
Assembly the cooler bracket. Apply the specified torque. After assembling the bracket, assembly cushions on the bracket and apply the specified torque.



Assembly the cooler with ECM.

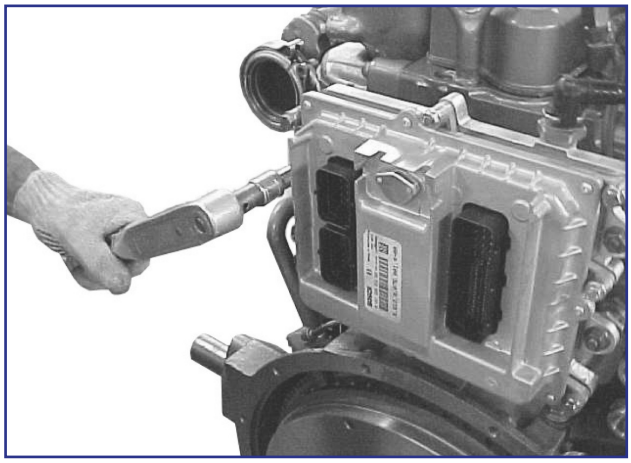


Replace and install the O-ring.

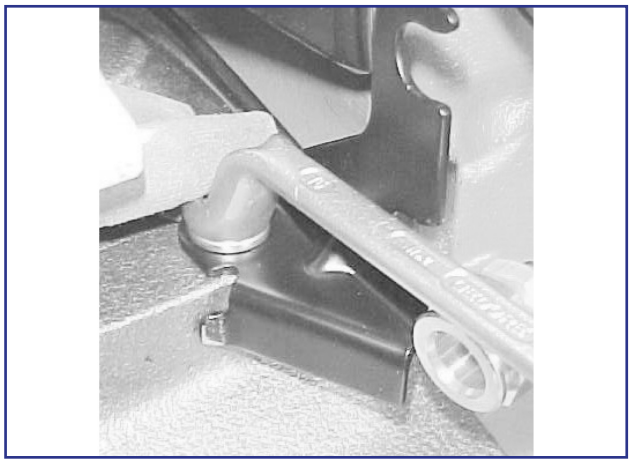


Assembly the ECM. Attention to the centralization of the fixation bolts in the cooler.

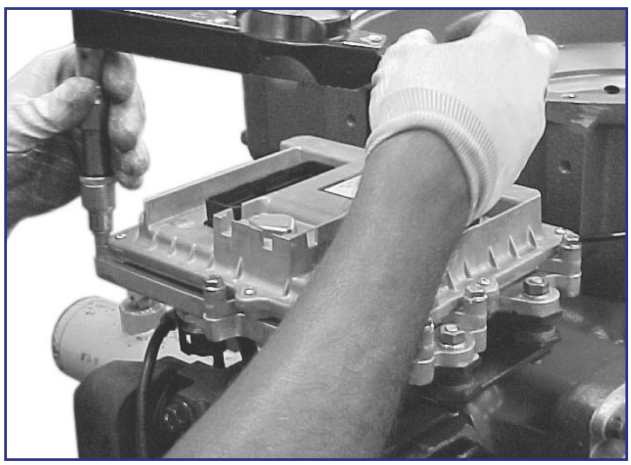
After positioning the ECM, tighten the bolts and apply the specified torque.



Assembly the bracket of the nipples for fast-connector. Apply the specified torque.

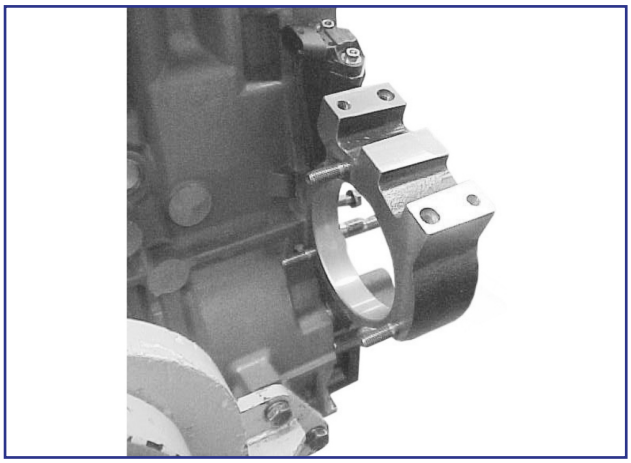


Tighten the nuts. Apply the specified torque.

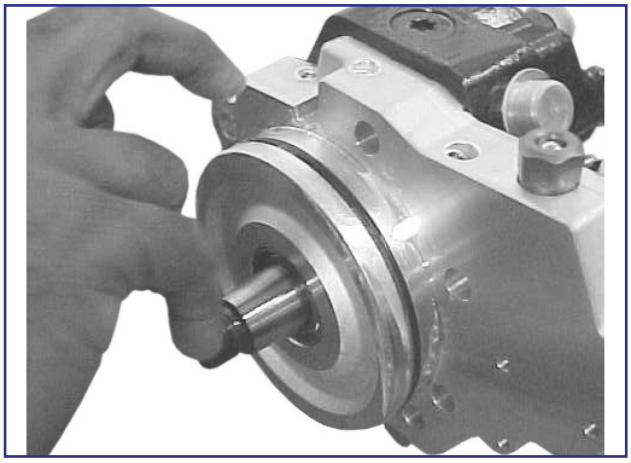


High Pressure Pump Assembly

Clean the housing of the high pressure pump.



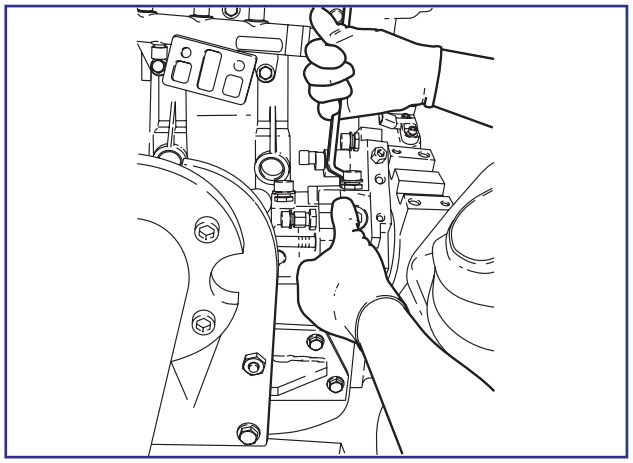
Assembly a new o-ring on the high pressure pump. Clean the area and put on a Vaseline layer on the contact area of the o-ring with the housing on the intermediary piece.



Install high pressure pump. Perform tightening with care in order to the o-ring to do not bite the lateral of the pump. Position the pump with the bolts until touch on the wall of the intermediary piece and apply the specified torque.

Check if there is a perfect seat of the pump on the intermediary piece.

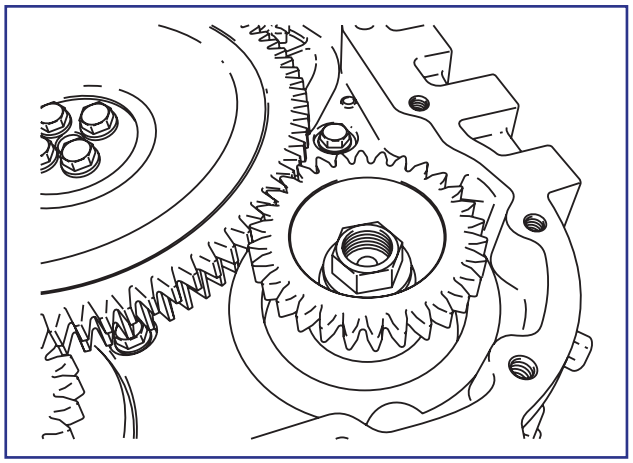
Apply tighten of 40 ± 6 Nm.



After assembling the pump, position the gear on the shaft and assembly. Once there is not timing on this gear the pump shaft does not have cotter for positioning.

Position gear washer and fixation nut and apply the specified torque.

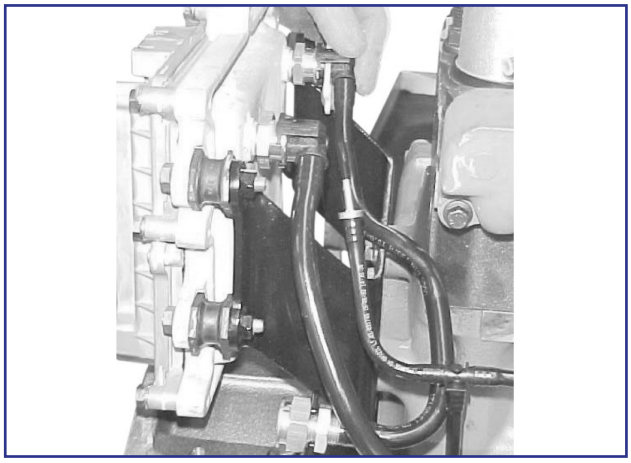
The protective caps must be removed only immediately before the piping assembly, avoiding contaminations.



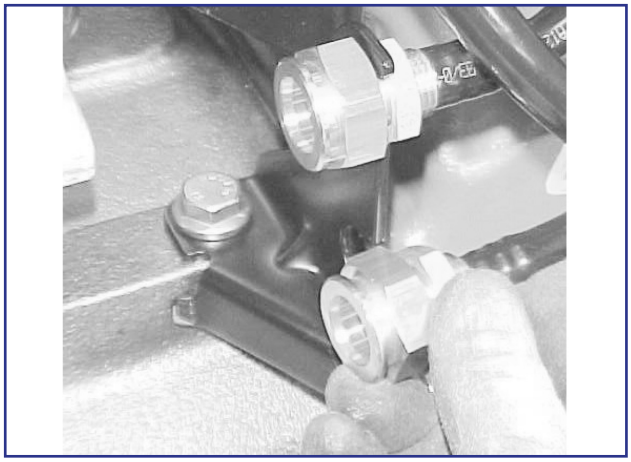
Attention:

- **The cone of the high pressure pump shaft and the gear must be clean and free of oil and grease before the fixation. The materials for cleaning can be: test benzene, ethyl alcohol, glycol or isopropanol.**
- **The high-pressure pump, due to its lubrication by the fuel, in any case may work dry. Before the first start, fill approximately 60 ml of fuel to guarantee the lubrication of the inner parts. For the first filling, a electric fuel pump can be used with minimum pressure of 2 bar and 4 bar maximum.**

After the installation of the high pressure pipes, assembly low pressure piping. First, assembly ECM cooler fuel inlet and outlet pipes.

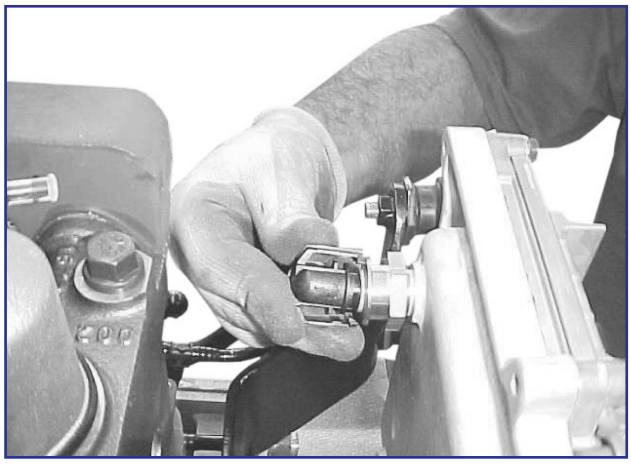


After assembly on the cooler, connect the nipple of fast connection on the bracket.



Assembly return pipe of the high pressure pump to the fuel tank. Apply the specified tightening torque on the nut-cap, assembly the nipple of fast connection on the bracket.

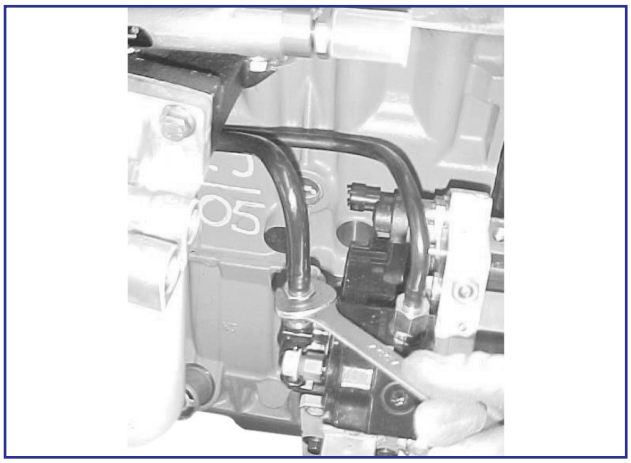
Assembly the cooler fuel outlet pipe to the high pressure pump.



Assembly the cooler pipe nut-cap of the high pressure pump and apply the specified torque.

The assembly of the nut-cap of the pipe must be carefully made, therefore the tightening torque of the nut of the fuel lift pump is lesser.

This way, during the assembly, use a spanner to perform the counter-tightening.



Assembly the fuel outlet pipe. Keep the same procedure used in the fuel inlet pipe assembly. Assembly fuel inlet and outlet pipes of the filter head. First, visually check the condition of the nipples. If necessary, change them. Apply the specified torque.

Assembly the fuel inlet pipe. First, assembly the nut-cap and apply the specified torque and then assembly the fast connector.

Assembly the fuel outlet pipe. Keep the same procedure used in the fuel inlet pipe assembly.

Assembly the fast connector of the return pipe on the pressure limiter valve.

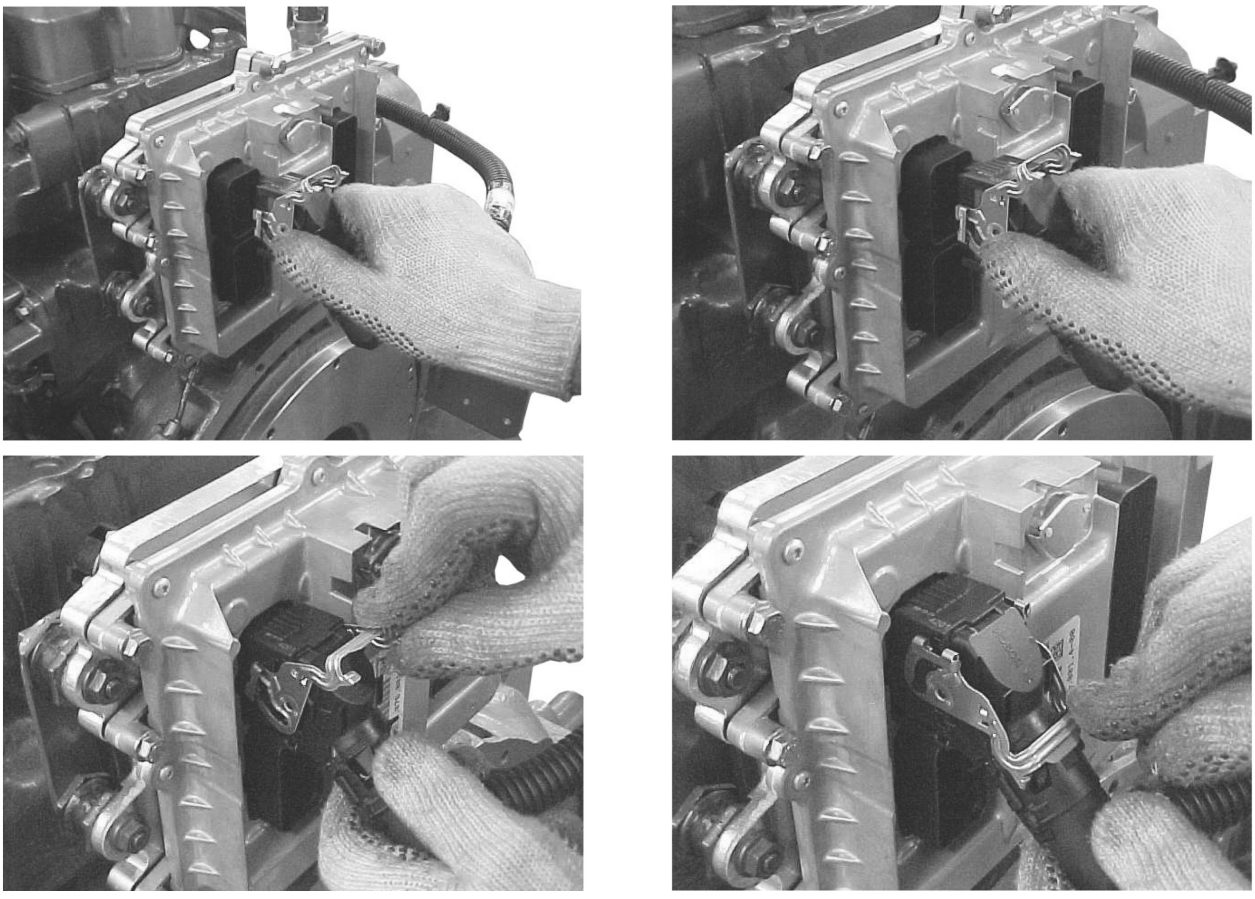
Fit the return pipe on the injector.

Apply the specified tightening torques on the nut-caps of the fuel lift pump and of the high pressure pump.

Assembly the high pressure pipe of the pump to the Rail. Apply the specified torque.

General view of the fuel injection system assembled.

General view of the high-pressure piping assembled.



Assembly the harness on the ECM.

Pam attention of the position of assembly the connecting lock harness.

Deaeration of Low Pressure System

In concluding the maintenance of injection system or in case of lack of fuel, drain the air of the low pressure system with the manual pump (repeat this procedure until the appearing of movement restriction) and start the engine.

In case of engine failure, repeat the procedure and, then, start the engine again.

After the engine start, leave the engine for a few minutes, in idle speed.

Attention:

This procedure must be used on the cases below

- **Lack of fuel;**
- **Maintenance (ex: replacement of filters / pipes).**

Intake, Exhaust and Turbocharger System

Air intake manifold

Warning: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the “Safety Information” section of this manual.

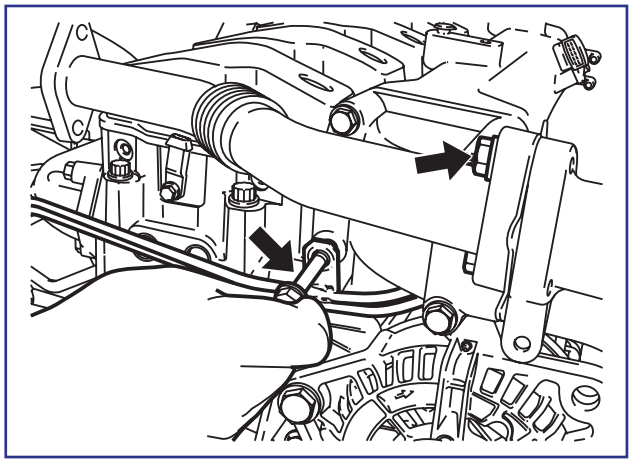
Warning: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle.

Warning: To avoid serious personal injury, possible death, or damage to the engine or vehicle, comply with the following when draining fuel:

- Do not smoke.
- Keep away from open flames and sparks.

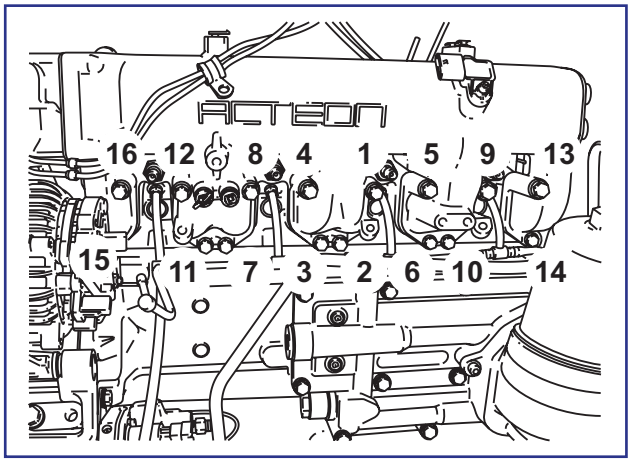
Removal

1. Remove the fuel rail. See specific procedure in this service manual for further information.



2. Remove the EGR and wastegate air pipe bracket mounting bolt.

3. Remove the air mixer mounting bolts.



4. Remove the manifold mounting bolts.

5. Lay down the intake manifold and then remove it, as shown.

6. Discard manifold gaskets and remove all gaskets remaining over the cylinder heads and intake manifolds holes.

Installation

Intake Manifold

Caution: To avoid engine damage, do not attempt to grind or machine the intake manifold to compensate for a warped condition.

1. Clean inlet manifold thoroughly with a suitable non-caustic solvent.

2. After cleaning, blow dry using filtered compressed air.

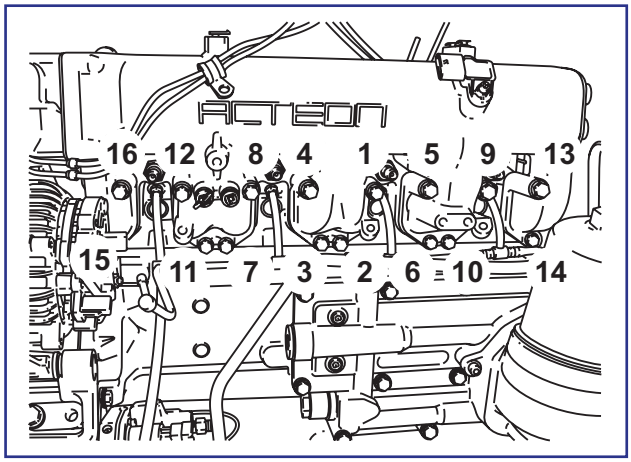
3. Check manifold for cracks and damage. Replace intake manifold as necessary.

Aligning intake gaskets to manifold

1. Insert an intake manifold bolt into each end of the intake manifold (both top holes).

2. Place intake manifold gasket over these two bolts to ensure proper alignment between the manifold and gasket.

3. Place all manifold bolts into bolt hole mounting finger tight, in their correct positions.



4. Thread intake manifold bolts to the torque value and according to the sequence.

   Torque through 20 ± 3 Nm.

5. Assembly the remaining components using the reversal order of removal procedure.

Intake/ exhaust manifold, cooled egr, turbocharger and water pipe

Removal

Warning: **To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.**

Warning: **To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle.**

NOTE: For information regarding the removal or installation of adjacent components, refer to the following service procedures located in other sections of this manual:

- Turbo Wastegate
- Intake Air Elbow
- EGR Valve and Sensor
- EGR Cooler
- Air Compressor
- Hidraulic Pump
- Water Pipe
- Exhaust Manifold

Turbocharger

Removal

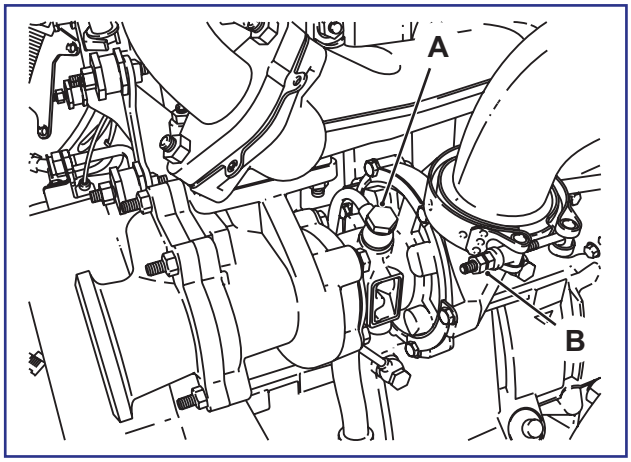
Wastegate Assembly and Components

Warning: **To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.**

Warning: **To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure that the engine has cooled down sufficiently before attempting to remove turbocharger assembly.**

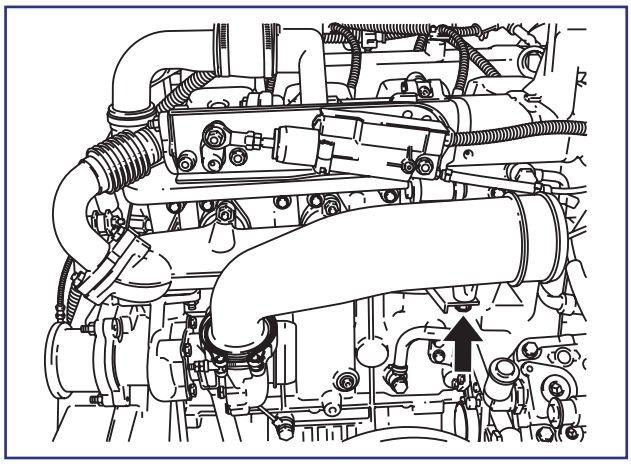
Warning: **To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure to disconnect the battery cable from the battery. Failure to remove the battery ground cable could cause an electrical arc while removing the turbocharger.**

1. Oil inlet tube and elbow removal:
   a. Remove the oil inlet tube hollow bolt and its two washers. Discard the washers.
   b. Remove the elbow to turbocharger clamp.

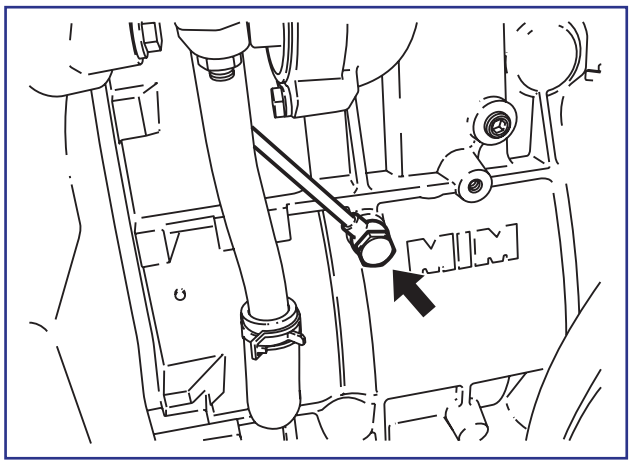


2. Remove the elbow support bracket bolt.

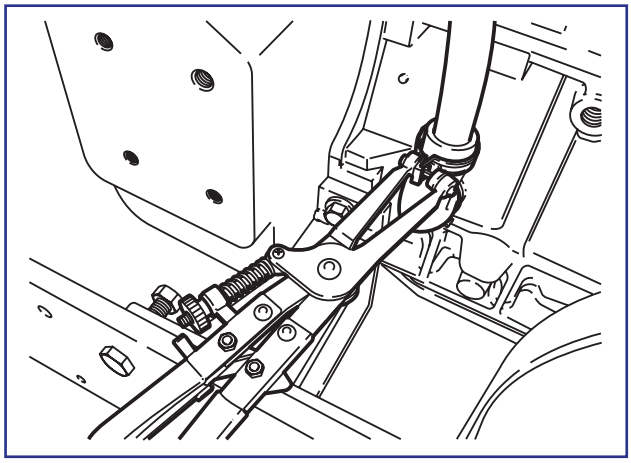
3. Remove the elbow and discard its O-Ring after removal.



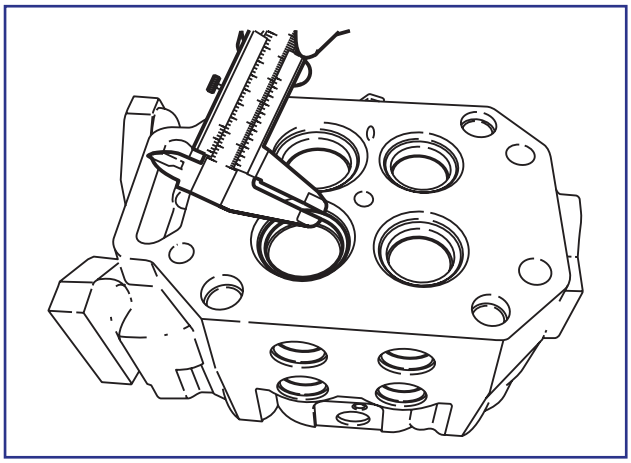
4. Remove the hollow bolt from oil inlet tube.



5. Using the tool illustrated, remove the clamp from outlet pipe.



6. Release the clamp and remove the wastegate actuator hose.

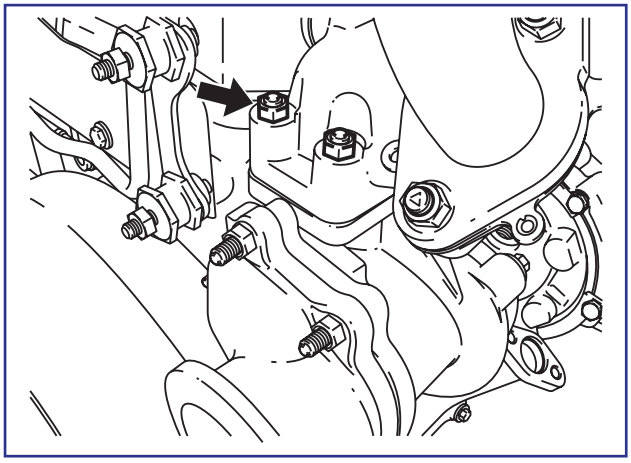


7. Remove the turbocharger mounting nuts (four nuts).

8. Remove the turbocharger assembly.

9. Discard turbo mounting gasket, washers and mounting nuts.

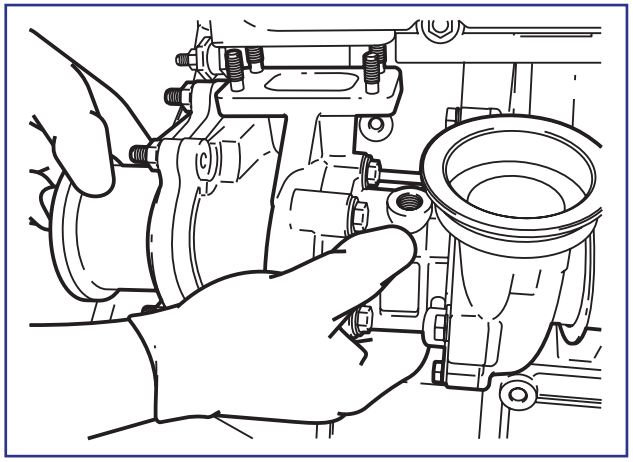
NOTE: After removal, cover the turbocharger holes to avoid dirty ingress that may damage its internal components.



Cleaning

Turbocharger and Related Parts

1. Use soap and water to clean piping between turbocharger and air cleaner assembly. Use filtered compressed air to dry all piping.
2. Use filtered compressed air to clean the air inlet piping and connecting hoses.
3. Use a suitable solvent and a nylon brush to clean the oil inlet tube and oil drain tube. Use filtered compressed air to dry the tubes. Replace any damaged tubes.
4. Clean off any remaining gasket material from the turbine housing and exhaust manifold mounting surfaces.



1. Place a new outlet pipe mounting gasket onto turbocharger.
2. Place four new mounting nuts to the turbocharger, new O-Ring onto elbow each end of the turbo oil drain tube and lubricate with clean engine oil.
3. Mount turbocharger assembly onto exhaust manifold and thread four new mounting nuts onto the top studs and leave loose.
4. Install the hose and its clamp to the wastegate actuator.
5. Before place the oil inlet tube, lubricate the turbocharger axle applying new oil engine through the oil inlet hole.

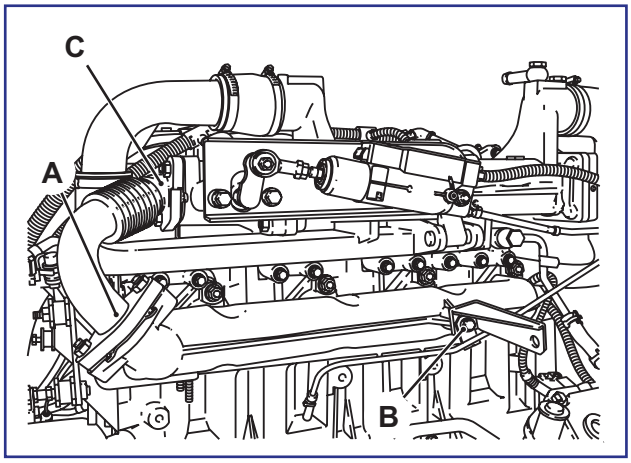
NOTE: This procedure is important to avoid damages by leak of turbo lubrication during the first engine start.

5. Install oil inlet tube into turbocharger upper side placing the four new washers. Applies the torque 25 ± 5 N.m to the hollow bolt.
6. Install outlet pipe to the lower turbocharger side. Applies the torque 12 ± 2 N.m.
8. Tighten all four mounting turbocharger nuts applying the torque 70 ± 10 N.m.
9. Place the new O-Ring to the elbow and mount it onto the turbocharger using the clamp.
10. Install the elbow bracket applying the torque 25 ± 5 N.m.

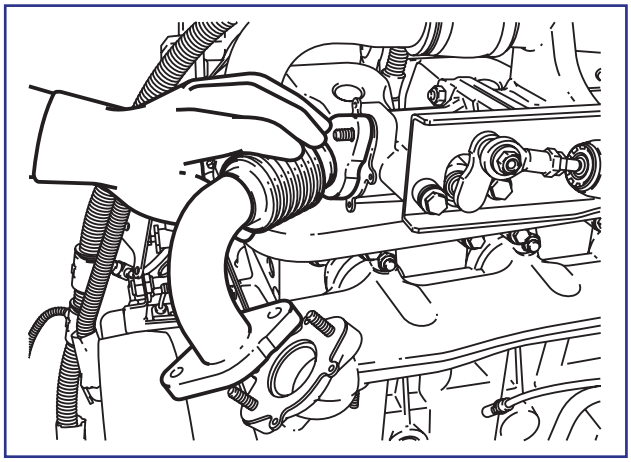
Exhaust Manifold

Removal

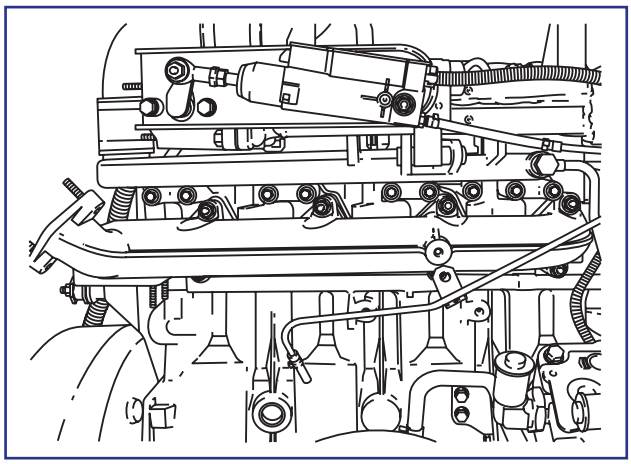
1. Remove the turbocharger assembly. See removal procedure in this section.



2. Exhaust and manifold pipe bracket bolt removal:
   a. Remove the lower EGR to manifold pipe nuts.
   b. Remove the turbo pipe actuator bracket bolt.
   c. Remove the upper EGR to turbo pipe mounting bolts.



3. Remove the pipe and both metallic gaskets.



4. Remove the exhaust manifold mounting nuts and discard them.

Cleaning and Inspection

Exhaust Manifold

1. Remove the gaskets remaining onto the manifold holes and clean exhaust manifold thoroughly with a suitable non-caustic solvent. Scrape off excess scale and rust from manifold surfaces.

2. After cleaning, blow dry using filtered compressed air.

3. Check manifold for cracks and damage. Replace the manifold as necessary.

4. Check for warpage of the manifold and engine:

   Install the exhaust manifold without the gasket to a cleaned cylinder head mating surface, applies a low level torque to the bolts enough to provide contact between the two surfaces and measure the gap between the mating surfaces using a 0.25mm feeler gauge. If necessary, recheck the cylinder heads alignment. If persists the gap, replace the exhaust manifold.

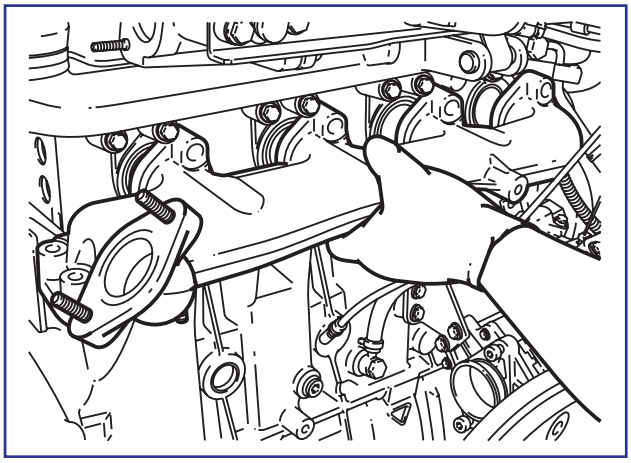
Installation

Exhaust Manifold

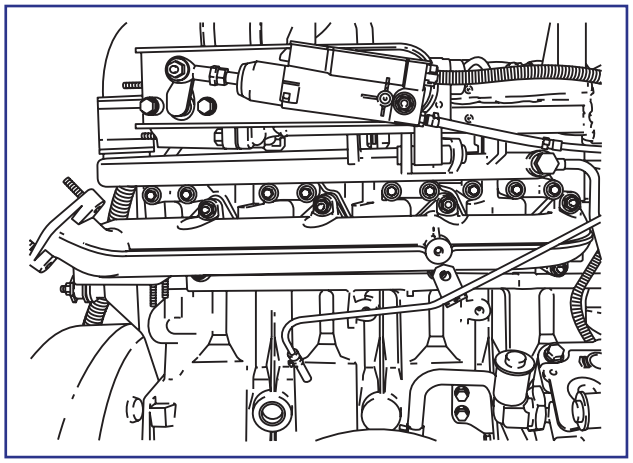
Warning: **To avoid manifold or cylinder head damages, make sure the cylinder heads are aligned before proceed the exhaust manifold installation.**

Warning: **To avoid engine damage, make sure the manifold gasket and exhaust manifold are aligned before tightening bolts to the specified torque value.**

1. After cleaning and inspection manifold procedure, place new exhaust manifold gaskets.



2. Align and hold the gaskets while placing the manifold. Install the new mounting nuts to the turbocharger.



3. Torque all exhaust manifold bolts in the sequence above and using the three torque steps below.

   Torque: 6 ± 2 Nm (stud)

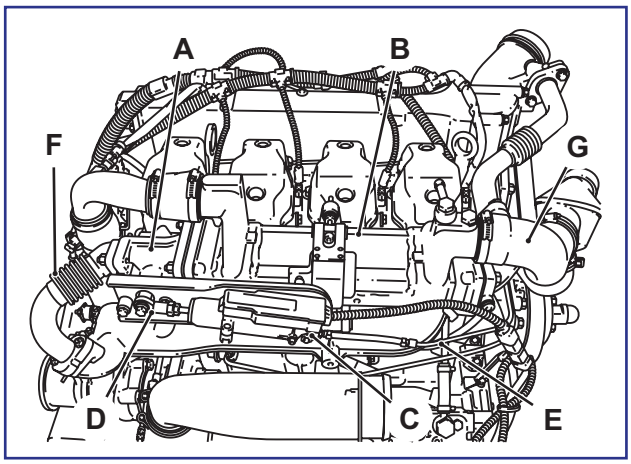
   70 ± 10 Nm (Nut)

4. Follow the remaining installation procedures using the inverse sequence of removal procedure and applying the torque indicated.
   - Upper EGR to turbo pipe torque bolts: 30 ± 5 Nm
   - Turbo pipe actuator bracket bolt: 20 ± 3 Nm
   - Lower EGR to manifold pipe nuts: 30 ± 5 Nm

5. Install the turbocharger assembly. See installation procedure in this section.

NOTE: Shown the 6 cylinder. When considering 4 cylinder versions, use the same steps from numbers 1 to 8, as indicated above.

Cooled egr



EGR system – General View

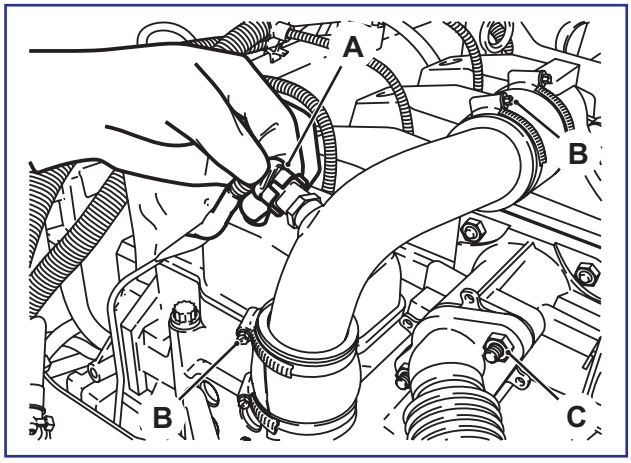
a. EGR valve
b. EGR cooler
c. EGR position sensor
d. EGR actuator
e. PWM to EGR valves control pipe
f. EGR air mixer duct
g. Water duct

Removal

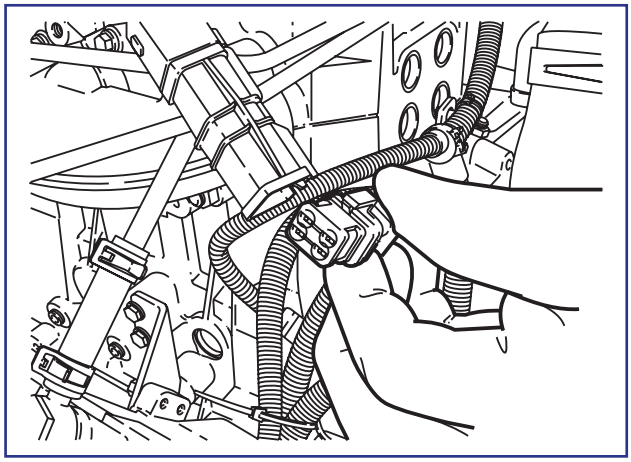
Warning: **To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.**

Warning: **To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle.**

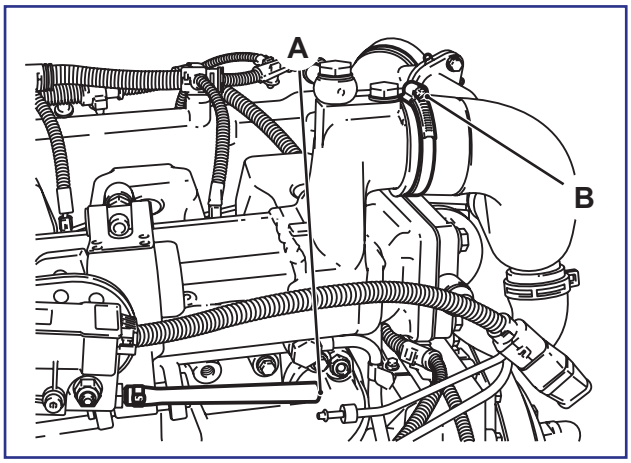
1. Remove the water temperature connector, hose and duct:
   a. Remove the water temperature sensor connector.
   b. Release the water hose clamps from both sides. Lift the water pipe and remove it.
   c. Remove the upper air mixer duct mounting bolts.



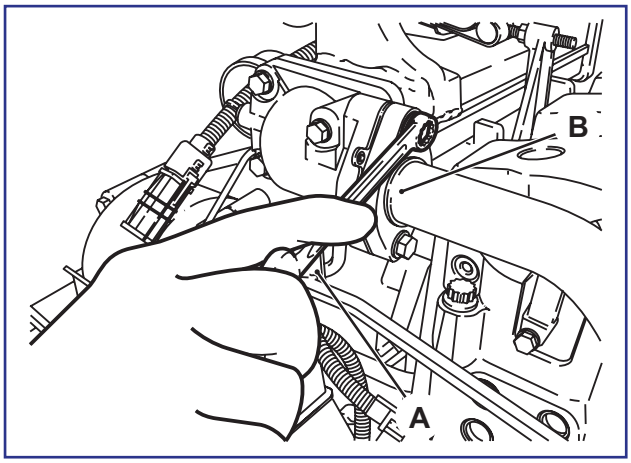
4. Remove the EGR valve position connector.



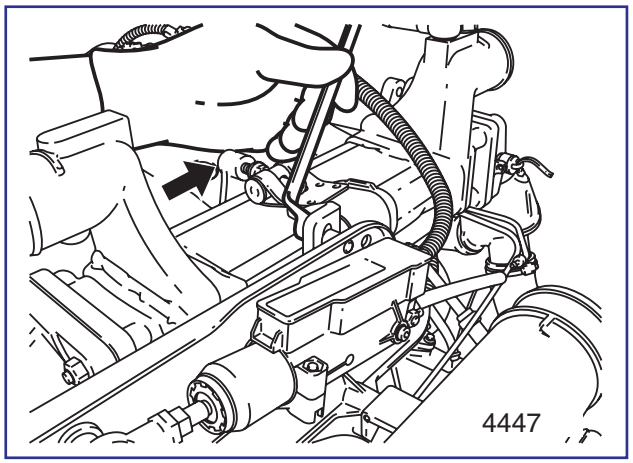
5. Cooler water hose and EGR valve control pipe removal:
   a. Cut the retaining clamp and detach the PWM valve pipe from hose.
   b. Release the water hose clamp and remove it.



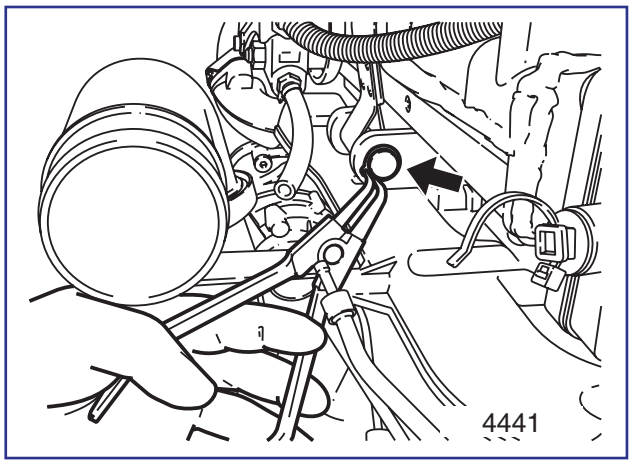
6. Water and EGR valve control pipe removal:
   a. Remove the valve control pipe mounting bolt.
   b. Remove the water pipe bolts and metallic gasket. Discard the gasket.



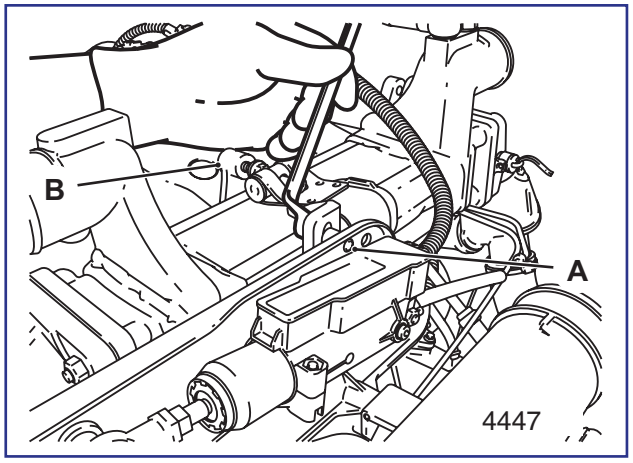
7. Loosen the cooler to support bolt.



8. Remove the pin lock-ring to cooler support. Then remove the pin.



9. Cooler support removal:
   a. Remove the EGR sensor assembly mounting bolt.
   b. Using an Allen, remove the support mounting bolt.
10. Pull the cooler support, EGR valve and sensor assembly away.
11. Discard and replace the gaskets.



Cleaning

EGR System Components

1. Clean off any gasket material and carbon deposits between the EGR cooler, EGR valve and air mixer ducts mating surfaces.
2. Clean mating surfaces between air mixer duct and EGR valve.
4. Clean mating surfaces between EGR valve and intake mixer duct.

Inspection

EGR Cooler

1. Check under visual tests for any damages or cracks.
2. Equipments to perform pressure tests onto the removed EGR cooler are expensive. For this reason the functionality must be realized with assembled components.

   A EGR cooler defective may present:

   – leak of power;
   – excessive smoke;
   – damage in the internal engine components due water leakage mixing with the air mixer duct and flowing to the air intake duct.

Installation

EGR System Components

1. Place new metallic gaskets, mounting nuts, clamps and lock-ring for the installation procedure.
2. Mount the EGR cooler assembly and support. Make sure the support fully engages the EGR cooler assembly.
3. Mount the pin and place the new lock-ring.
4. Install the cooler to support mounting bolt.
5. Install the water and EGR valve control pipe.
6. Install a new EGR valve control hose and clamp.
7. Install the EGR valve position connector.
8. Install the temperature sensor connector.
9. Place the upper air mixer duct retaining bolts.
10. Install the duct with new water hoses and clamps.

Failures Diagnosis

Introduction

Next they are presented some typical problems which the engine may present, their probable causes and possible corrections for these problems.

Attention :

- Study in full detail the problem before trying any action.
- First check the simplest and obvious.
- Find the main cause and correct the problem.

Symptoms Table

SYMPTOM	PROBABLE CAUSES
Low crank speed	01-02-03
Engine does not start	05-06-07-08-09-10-14-15-16-17-22 23-25-26-27-29-40-53
Difficult start (engine delays to start up)	01-02-03-05-07-08-09-10-14-15-16 17-18-22-25-26-27-29-40-53
Power lack / Performance	07-08-09-10-14-15-16-17-18-19-20 21-22-23-25-26-27-29-44-53-54-5657
Engine misfiring	07-08-09-10-14-15-16-17-19-20-21 22-23-24-26-29-44-53
Excessive fuel consumption	09-14-15-17-18-21-22-23-25-26-27 29-57-60
Black smoke	09-14-15-17-18-21-22-23-25-26-27 29-53-54-57-60
White-bluish smoke	04-14-15-17-19-21-22-23-25-26-27 28-29-39-40-44
Low oil pressure	04-29-30-31-32-33-34-36-37-38-52
Engine inner beats	14-17-22-23-25-26-28-29-30-33-36 39-40-53
Excessive vibration	10-15-17-29-41-42-43-61-62
High oil pressure	04-32-35
Overheating	09-14-18-19-39-44-45-46-47-48-51 58-63-64-65
Excessive pressure in the crankcase with possible oil leakages	19-25-27-28-39-49-67
Low compression	09-14-19-22-23-25-26-27-28-40-53
Engine starts and stops	08-09-10-17-29

Symptoms Table (Continuation)

SYMPTOM	PROBABLE CAUSES
Engine and go off	29-49-55
High lubricant oil consumption	04-12-13-15-25-27-28-39-49-54-55
	58-59-60-66
Water mixed to lubricating oil	10-19-50
Water mixed to lubricating oil	50
Irregular idle speed	07-08-09-10-16-17-29-59
Engine stops during vehicle stop	06-07-08-10-17-29
Engine misfiring	10-17-29

Symptoms Table (Continuation)

Nr.	Probable Cause	What to do
01	Low battery charge	Charge or change battery
02	Bad contact on the electrical connections	Clean and retighten the connections
03	Defective starter motor	Correct the starter motor
04	Inadequate lubricant oil viscosity	Use oil of correct viscosity
05	Low start tension	Check connections, battery and starter motor
06	Fuel tank empty	Fill with fuel
07	Low pressure fuel pipe obstructed	Clean the system
08	Fuel filters obstructed	Clean fuel filters or change elements
09	Restriction in the air intake system	Free the intake system or clean air filter element (dry type)
10	Air in fuel system	Bleed the system
11	Leakages through sealing rings	Change cylinder liners sealing rings
12	Irregular rings seating	Change
13	High oil level in the carter	Correct level
14	Incorrect camshaft gear timing	Get the correct timing
15	Low compression	Measure compression and remove the failure
16	Fuel tank breathe obstructed	Free breathe
17	Inadequate fuel	Use recommended combustible
18	Obstructed exhaust	Free pipes, silencers, etc.
19	Leak through cylinder head gasket	Change gasket and check the causes of the leakage

Symptoms Table (Continuation)

Nr.	Probable Cause	What to do
20	Overheating	Check cooling system, and operation and installation conditions
21	Engine excessively cold	Check thermostat
22	Incorrect valves clearance	Adjust valves clearance
23	Griped valves	Correct the operation of the valves
24	Incorrect high pressure pipes	Change
25	Cylinders wear	Correct
26	Valves and seats burnt	Recondition or change
27	Broken, worn or griped rings	Change
28	Valves stems and guides worn	Change
29	Failure in electronic fuel injection system	Perform Diagnosis on the system according to the “Diagnosis Manual” of the engine
30	Damaged or worn bearings	Change
31	Low oil level in the carter	Complete level
32	Oil pressure indicator faulty	Change
33	Lubricant oil pump with inner wear	Change
34	Oil pump pressure relief valve locked open	Free and correct
35	Oil pump pressure relief valve locked closed	Free and correct
36	Pressure relief valve spring broken	Change
37	Defective oil pump suction pipe	Correct
38	Oil filter blocked	Change element
39	Piston griped	Repair cylinders

Symptoms Table (Continuation)

Nr.	Probable Cause	What to do
40	Incorrect piston height in relation to the engine block surface	Use correct pistons
41	Damaged fan	Change
42	Defective engine bracket cushions	Change / Correct assembly
43	Flywheel or flywheel housing misaligned	Align
44	Defective thermostat	Change
45	Water galleries restriction / liners with crusts	Clean the system
46	Fan belts loosen	Tension
47	Radiator blocked outside or inside	Clean
48	Defective water pump	Change
49	Carter breathe blocked	Clean
50	Oil cooler leakage	Correct
51	Lack of water in the cooling system	Complete level
52	Oil pump suction pipe sieve blocked	Clean
53	Valve spring broken	Change
54	Turbocharger damaged or needing cleanness	Repair or clean
56	Leakages through turbocharger oil seals	Change seals
57	Exhaust manifold linked to turbocharger	Change gaskets
58	Intake air low pressure	Check turbocharger. Correct leakages
59	Outer leakages (gaskets, seals, etc.)	Correct
60	Inadequate engine inclination angle	Correct

Symptoms Table (Continuation)

Nr.	Probable Cause	What to do
60	Engine operates overloaded	Operate the engine inside the load limit
61	Balancer unit out of position (4 cylinders engines)	Correct
62	Defective damper	Change
63	Liner protrusion below specification (leakage through liner collar)	Correct
64	Thermostat bad seating	Change
65	Lack or incorrect coolant proportion in the cooling system	Correct
66	Leakage through valve guide seals	Change
67	Defective PCV	Change

Appendix A

Engine Block

Qtd.	Description	Size	Application	Torque (Nm)		
2	Bolt	M14	Bearing Cap to Block	1st.	2nd.	Torq. Range
				50 - 5	155º ± 5º	170 to 282

Other Related Engine Parts

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
2	Engine Lifting Hook	M14	Cylinder Head Mouting Bolt	80 ± 10	**
1	Plug	3/8”	Water Drain Plug to Block	10 + 5	Loctite 638
1	Hollow Bolt	M8x1	Oil Ejector to Block	10 ± 1,5	**
1	Plug	M10x1	Oil Galery Plug to Block	10 + 5	Loctite 638

Conecting Rod

Qtd.	Description	Size	Application	Torque (Nm)		
2	Bolt	MJ 12x58	Conecting Rod to Crankshaft	1st.	2nd.	Torq. Range
				40 ± 5	80º ± 2º	114 to 144

Camshaft

Qtd.	Description	Size	Application	Torque (Nm)		
4	Bolt	M8x30	Gear to Camshaft	1st.	2 nd.	Torq. Range
				15 ± 1	30º ± 2º	35 to 65
2	Bolt	M8x16	Camshaft Lock to Block	30 ± 5		
4	Bolt	M6x12	Pulse Wheel to Camshaft Gear	8,5 ± 1		

Gear Housing

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
10	Bolt	M8x20	Gear Housing to Block	25 ± 5	**
3	Bolt	M8x50	Gear Housing to Block	25 ± 5	**
1	Hollow Bolt	M8x1	Lubrication pipe to Gear Housing	5+5	**
1	Hollow Bolt	M8x1	Lubrication Pipe to Block	5+5	**
3	Bolt	M10x70	Intermediated Bearing with Gear to Block	60 ± 5	**
2	Plug	M10x1	Gear Housing (Rear Half)	10 ± 5	**
2	Cylindrical Bolt	M6x20	Pressure and Oil Temperature Sensor to Gear Housing	8,5 ± 1	**
1	Cylindrical Bolt	M6x20	Phase Sending Unit to Gear Housing	8,5 ± 1	**

Balancer Unit

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
4	Bolt	M10x100	Balancer Unit to Bearing	60 ± 5	**
3	Bolt	M8x10	Balancer Unit Deflector to Balancer Unit	20 ± 3	**

Oil Pump

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
2	Bolt	M8x20	Oil Pump to Block	20 ± 5	**

Water Pump

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
2	Bolt	M8x20	Water Pump to Block	20 ± 5	**

Valve Lubrication Pipes

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
4	Hollow Bolt	M10x1	Valve Lubrication pipe to Cylinder Head	10 ± 5	**
1	Hollow Bolt	M10x1	Valve Lubrication Pipe to Oil Cooler	10 ± 5	**

Front Cover

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
14	Bolt	M8x16	Front Cover to Gear Housing	25 ± 3	**
9	Bolt	M8x55	Front Cover to Gear Housing To Block	25 ± 3	**

Water Outlet Pipe

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
8	Bolt	M8x55	Water Outlet Pipe to Cylinder Head	25 ± 4	**

Starter Engine

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
3	Bolt	M10x30	Starter Engine to Flywheel Housing	56 ± 8	**

Electronic Control Unit

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
3	Bolt	M10x20	Block to ECU Bracket	35 ± 4	**
4	Cushion	M8x16	ECU Bracket to Cushion	30 ± 5	**
4	Nut	M8	ECU Cooler to Cushion	25 ±3	**
8	Bolt	M6x30	ECU Cooler to ECU	8 ± 1	**

Harness

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
2	Bolt	M6x12	Harness Bracket to Gear Housing	8 ± 1	**

Turbocharging

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
4	Stud	M8x20	Turbocharger Spacer to Turbocharger	6 ± 2	**
4	Stover Nut	M8	Turbocharger Spacer to Turbocharger	70 ± 10	**
4	Stud	M8x25	Turbocharger to Exhaust Manifold	6 ± 2	**
4	Stover Nut	M8	Turbocharger Stud to Exhaust Manifold	70 ± 10	**
1	Hollow Bolt	M12x1,5	Turbochager Inlet Lubrication Pipe to Turbocharger	25 ± 5	**
1	Hollow Bolt	M14x1,5	Turbochager Inlet Lubrication Pipe to Block	25 ± 5	**
2	Bolt	M6x16	Turbocharger Lubrication Return Pipe to Turbocharger	12 ± 2	**

Alternator Bracket

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
4	Bolt	M10x35	Alternator Bracket to Gear Housing	40 ± 6	**
1	Bolt	M10x110	Alternator Bracket to Alternator to Bush	40 ± 6	**
2	Bolt	M8x20	Alternator Bracket to Gear Housing	20 ± 3	**
1	Bolt	M12x40	Alternator Bracket to Alternator	25 ± 5	**
1	Bolt	M10x50	Pulley to Alternator Bracket	40 ± 6	**

High Pressure Pump

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
3	Cylindrical Bolt (Allen)	M10x40	High Pressure Pump yo High Pressure Pump Flange	50 ± 5	**
3	Cylindrical Bolt (Allen)	M10x40	High Pressure Pump Flange to Gear Housing	50 ± 5	**
1	Nut	M18x1,5	Gear to High Pressure Pump	105 ± 5	**

Fuel Filter

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
2	Bolt	M10x25	Fuel Filter to Block	35 ± 4	**
2	Connection	M14x1,5	Fuel Inlet - Outlet to Filter Head	20 + 6	**
1	Nut	M16	Pipe - Fuel Filter to High Pressure Pump	30 ± 2	**
1	Nut	M16	Pipe - High Pressure Pump Outlet to Fuel Filter	30 ± 2	**

EGR Control Valve

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
2	Bolt	M8x90	EGR Control Valve to EGR Control Valve Bracket	20 ± 3	**
2	Bolt	M8x50	EGR Control Valve to EGR Control Valve Bracket	20 ± 3	**
2	Bolt	M8x35	EGR Control Valve Bracket to Engine Block	20 ± 3	**
2	Bolt	M8x25	Air Distribuitor to Intake Manifold	20 ± 3	**
1	Bolt	M8x16	EGR Control Valve Tube to Exhaut Manifold	20 ± 3	**
2	Bolt	M8x20	EGR Control Valve Tube to Intake Manifold	20 ± 3	**

High Pressure Pipe

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
5	Nut	M18	High Pressure Pipe to Rail	30 ± 3	**
4	Nut	M14	High Pressure Pipe to High Pressure Fuel Connector	30 + 3	**
1	Nut	M14	High Pressure Pipe to High Pressure Pump	30 + 3	**
1	Bolt	M8x30	Rail to Intake Manifold	15 + 5	**

Low Pressure Pipe

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
4	Connection	M8x1	Fuel Return Pipe to Cylinder Head	8 ± 1	**
1	Nut	M16	High Pressure Pump to Fuel Return Pipe	25 ± 2	**
1	Nut	M16	ECU Cooler Pipe to High Pressure Pump	25 ± 2	**
2	Nut	M16	Inlet and Return Fuel Pipes to Inlet and Return Fuel Pipes Bracket	25 ± 2	**
2	Bolt	M8x16	Inlet and Return Fuel Pipes Bracket to Flywheel Housing	25 ± 2	**

EGR

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
2	Stover Nut	M8	EGR Valve Tube to Exhaust Manifold	30 ± 5	**
2	Stud	M8x25	EGR Valve Tube to Exhaust Manifold	6 ± 2	**
2	Stover Nut	M8	EGR Valve Tube to EGR Valve	30 ± 5	**
2	Stud	M8x25	EGR Valve Tube to EGR Valve	6 ± 2	**
4	Stover Nut	M8	EGR Valve to EGR Cooler	30 ± 5	**
4	Stud	M8x25	EGR Valve Tube to EGR Valve	6 ± 2	**
2	Bolt	M8x65	EGR Cooler to Outlet Exhaust Gases Flange	27 ± 4	**
2	Bolt	M8x25	EGR Cooler to Outlet Exhaust Gases Flange	27 ± 4	**
2	Bolt	M8x25	Outlet Exhaust Gases Flange to Inlet Gases Tube	27 ± 4	**
2	Bolt	M8x25	Inlet Gases Tube to Intake Air Elbow	20 ± 3	**
1	Hollow Bolt	M12x1,5	EGR Cooler	20 ± 5	**
1	Allen Bolt	M8x60	EGR Cooler Clamp	20 ± 2	**
1	Allen Bolt	M6x60	EGR Valve	8 ± 1	**

Intake Manifold

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
8	Bolt	M8x35	Intake Manifold to Cylinder Head	20 ± 3	**
8	Bolt	M8x80	Intake Manifold to Cylinder Head	20 ± 3	**
1	Bolt	M6x16	Air Pressure and Temperature Sensor to Intake Manifold	3 ± 0,5	**

Intake Elbow

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
2	Bolt	M8x70	Intake Elbow to Intake Manifold	20 ± 3	**
2	Bolt	M8x120	Intake Elbow to Intake Manifold	20 ± 3	**
1	Bolt	M8x16	Bracket to Turbocharging Elbow	25 + 5	**
1	Bolt	M8x16	Bracket to Exhaust Manifold	25 + 5	**

Exhaust Manifold

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
8	Stud	M10x45	Exhaust Manifold to Cylinder Head	6 ± 2	**
8	Stover Nut	M10	Exhaust Manifold to Stud to Cylinder Head	70 ± 10	**

Exhaust Elbow

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
8	Stud	M10x45	Exhaust Manifold to Cylinder Head	6 ± 2	**
8	Stover Nut	M10	Exhaust Manifold to Stud to Cylinder Head	70 ± 10	**

Engine Breather

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
2	Bolt	M8x35	Breather to Cooler to Block	25 ± 5	**
1	Bolt	M8x16	Clamp to Engine Breather Tube Bracket	25 ± 5	**
1	Bolt	M8x25	Engine Breather Tube Bracket to Oil Pan to Block	25 ± 5	**

Compressor LK39

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
3	Cylindrical Bolt	M10x40	Air Compressor to Gear Housing	45 ± 5	**
1	Hollow Bolt	M14x1,5	Air Compressor Inlet Water Hose Connector to Block	20 + 6	**
1	Hollow Bolt	M14x1,5	Air Compressor Outlet Water Hose Connector to Water Outlet Pipe	20 + 6	**
1	Nut	M20	Gear to Air Compressor	230 ± 20	**
2	Bolt	M8x20	Air Compressor Bracket to Air Compressor	20 ± 6	**
2	Bolt	M8x20	Air Compressor Bracket to Block	20 ± 6	**

Hydraulic Pump

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
2	Bolt	M10x25	Hydraulic Pump to Air Compressor	45 ± 5	**

Oil Pan

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
22	Bolt	M8x16	Oil Pan to Gear Housing to Flywheel Housing to Engine Block	25 + 5	**
4	Stud	M8x25	Oil Pan to Block	10 ± 2	**
4	Nut	M8	Stud to Oil Pan to Block	25 + 5	**
1	Plug	R ½	Oil Pan	65 ±10	**

Flywheel

Qtd.	Description	Size	Application	Torque (Nm)		
6	Cylindrical Bolt	M16x40	Flywheel to Crankshaft	1st.	2nd.	3rd.

Crankshaft Pulley

Qtd.	Description	Size	Application	Torque (Nm)	
4	Cylindrical Bolt	M16x65	Crankshaft Pulley to Crankshaft	1st.	2 nd.
				100 ± 10	275 ± 15
6	Bolt	M10x20	Dumper to Crankshaft Pulley	70 ± 5	

Engine Bracket

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
3	Bolt	M12x70	LS Front Bracket to block	100 ± 15	**
1	Bolt	M12x70	RS Front Bracket to Block	100 ± 15	**
1	Bolt	M16x85	Central Front Bracket To Front Brackets	250 + 20	**

Fan Bracket and Tightener

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
1	Bolt	M10x25	Fun Hub to Washer	40 ± 6	**
3	Bolt	M8x110	Fun Bracket to Gear Housing to Block	20 ± 3	**
1	Bolt	M10x70	Fun Bracket to Front Cover	40 ± 6	**
1	Bolt	M10x85	Belt Tightener to Fun Bracket	50 ± 5	**
4	Bolt	M10x16	Fun Pulley to Fun Hub	40 ± 6	**

Flywheel Housing

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
13	Bolt	M12x30	Flywheel Housing to Block	100 ± 5	**
1	Liquid gasket	**	Flywheel Housing to Block	**	Loctite 515-67
1	Cylindrical Bolt	M6x16	Rotation Sending Unit to Flywheel Housing	13 ± 1,5	**

Oil Suction Pipe

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
2	Bolt	M8x20	Oil Suction Pipe to Block	25 ± 4	**

Water Filler

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
3	Bolt	M8x20	Water Inlet Connection to Block	20 ± 3	**

Lubricating Oil Filter Head and Oil Cooler

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
2	Allen Bolt	M8x25	Oil Filter Head to Oil Cooler	25 + 5	**
8	Bolt	M8x30	Oil Cooler to Block	25 ± 3	**
1	Screw Plug	M20	Oil Filter Head	45 + 5	**
1	Screw Plug	M30	Oil Filter Head	90 + 5	**
1	Cover	**	Cover to Oil Filter Head	30 + 5	**
1	Allen Bolt	M8x45	Oil Filter Head to Oil Cooler	25 + 5	**
1	Allen Bolt	M8x60	Oil Filter Head to Oil Cooler	25 + 5	**

Cylinder Head

Qtd.	Description	Size	Application	Pre-Torque	Torque	Torque 1 (º)	Torque 2 (º)	Torque 3 (º)	Torque Range
4	Bolt	M14x152	Cylinder Head to Block	40 + 5	60 + 10	60 ± 3	60 ± 3	90 ± 3	120 to 260

Components of the Cylinder Head

Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
1	Cap Bolt	M6x30	Fuel Injector Fixing Bridge	See Tightening Sequence in the Cylinder Head Assembly Section	**
1	Special Step Bolt	**	Fuel Injector Fixing Clip	See Tightening Sequence in the Cylinder Head Assembly Section	**
1	Nut	M22	Fit of High Pressure Connection to the Head	See Tightening Sequence in the Cylinder Head Assembly Section	**
2	Cap Bolt	M5x10	Lubrication Pipe to the Cylinder Head	5 ± 1	**

Injection Nozzle Wiring Harness and Valve Cover

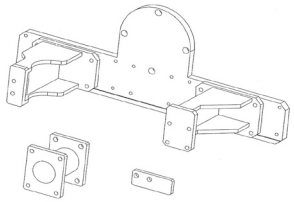
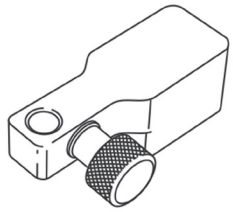
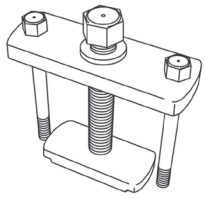
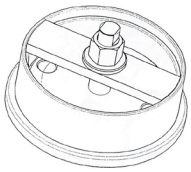
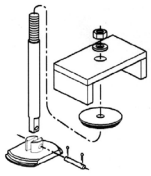
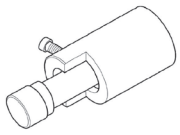
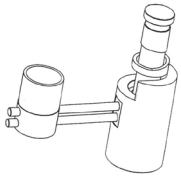
Qtd.	Description	Size	Application	Torque (Nm)	Required Sealing
2	Nut, Lock	M4	Fuel Injector Nozzle Terminal	1,5 + 0,25	**
1	Bolt	M6x12	External Injection Nozzle Wiring Harness	8,5 ± 1	**
2	Bolt	M6x60	Valve Cover	8,5 ± 1	**

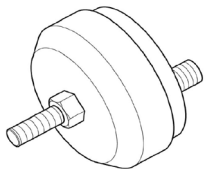
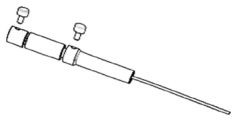
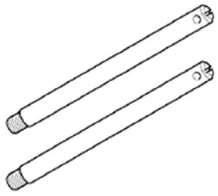
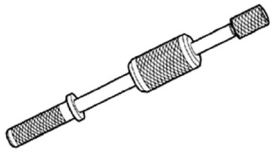
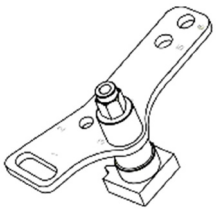
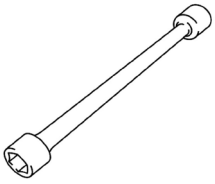
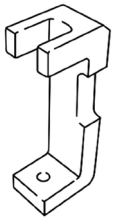
"Standard Torque Table for Normal Steel Bolts (according to DIN 2230) "

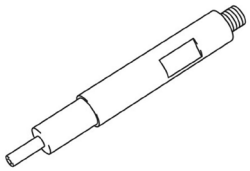
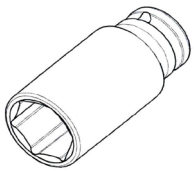
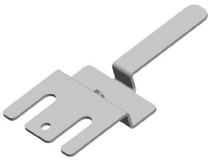
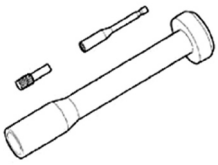
Nominal Size	Bolt Class (Nm)		
	8.8	10.9	12.9
M5	6 ± 1	9 ± 1	10 ± 1,5
M6	10 ± 1,5	15 ± 2	18 ± 3
M8	25 ± 4	37 ± 6	43 ± 7
M10	50 ± 8	73 ± 11	84 ± 13
M12	86 ± 13	124 ± 19	145 ± 22
M14	135 ± 20	198 ± 30	231± 35
M16	207 ± 31	304 ± 46	325 ± 49
M18	298 ± 45	424 ± 64	497 ± 75
M20	418 ± 63	595 ± 89	696 ± 104
M22	569 ± 85	810 ± 122	948 ± 142

NOTE: This table is only applied when the Torque isn't reffered in the Service Manual. For all other conddi-tions use the special torques provided by the related procedures.

Special Tools

CÓDIGO MIM	TIPO DE FERRAMENTA	COMPONENTE	FIGURA
9.610.0.690.011.6	Adapter	Engine Support	
9.610.0.690.025.4	Dial Indicator Measure Device	“Cylinder Head Cylinder Liner”	
9.610.0.690.024.6	Installer	Cylinder Liner	
9.610.0.690.020.6	Installer	Rear seal	
9.610.0.690.017.6	Extractor	Cylinder Liner	
XXXXXXXXXX	Installer/Removal device	Connecting rod bushing	
XXXXXXXXXX	Extractor/Installer	Connecting rod bushing	

CÓDIGO MIM	TIPO DE FERRAMENTA	COMPONENTE	FIGURA
XXXXXXXXXX	Installer	Front seal	
9.610.0.690.062.4	Dial indicator adapter	Piston height measure	
9.407.8.690.030.4	Guided-pins	Cylinder Head	
9.407.0.690.040.6	“Impact hammer 0,5Kg and adapter “	“Fuel injector with adapter”	
D7000600C1	Locking device	Flywheel	
9.612.0.690.002.4	Device for manifold bolt	Intake manifold	
9.612.0.690.001.4	Extractor	“Fuel Injector use with 9.407.0.690.040.6”	

CÓDIGO MIM	TIPO DE FERRAMENTA	COMPONENTE	FIGURA
9.612.0.690.003.4	Cylinder compression and timing test adapter	Fuel injector	
9.407.0.690.065.4	Socket SW27	fuel pressor sensor (rail)	
D7000598C1	Extractor/ Spring compressor	Spring valve	
D7000595C1	Aligner for cylinder head installation	Cylinder head	
9.407.0.690.043.6	Installer	Valve retainer	
D7000597C1	Adapter for use with installer 9.407.0.690.043.6	Valve retainer	
D7000596C1	Extractor for use with tool 9.407.0.690.040.6	rocker arm guided-shaft	

REMARK: The illustrations may be different from the real tools.

NOTES

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