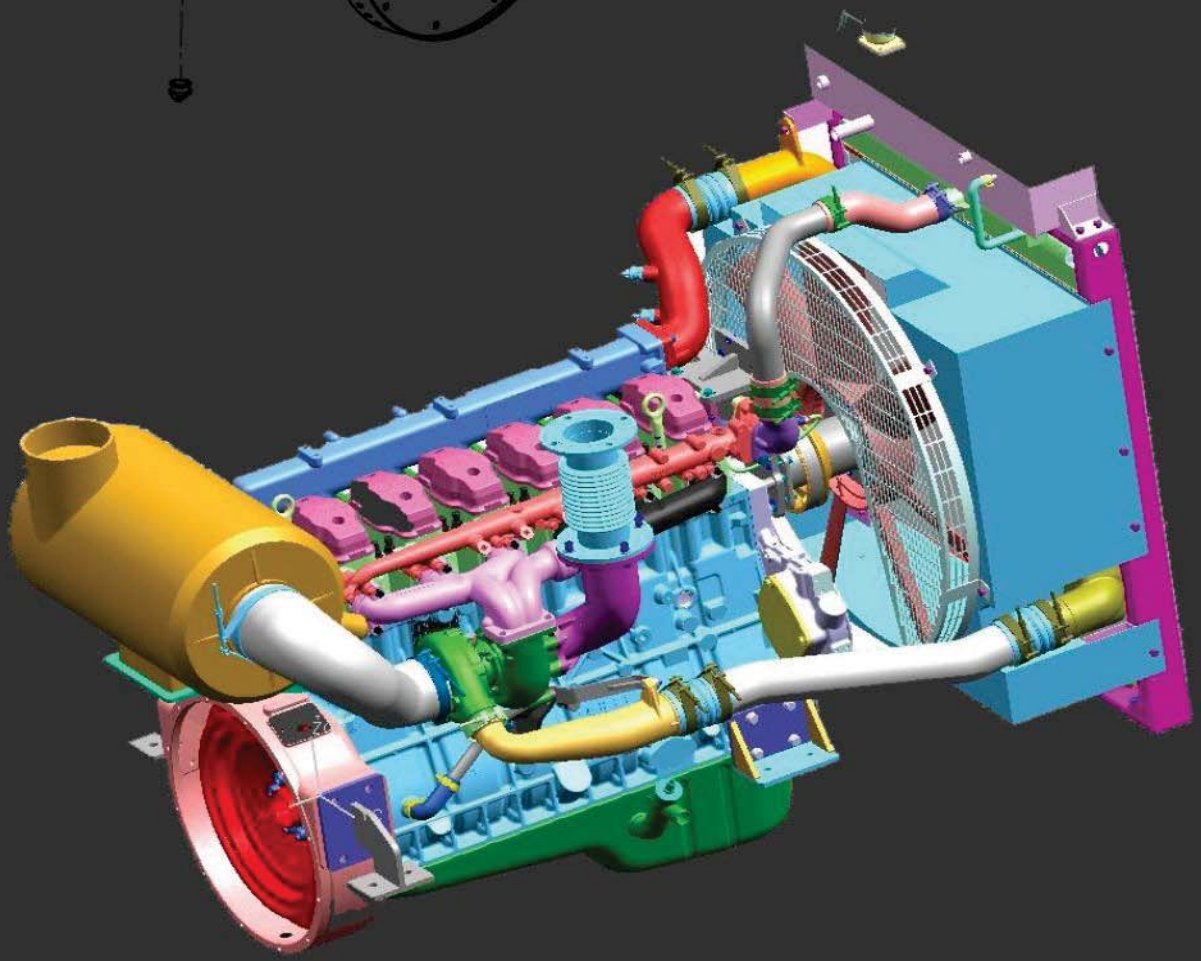
Mahindra NAVISTAR Engines (P) Limited



ACTEON 6.12 MECHANICAL

WORKSHOP MANUAL

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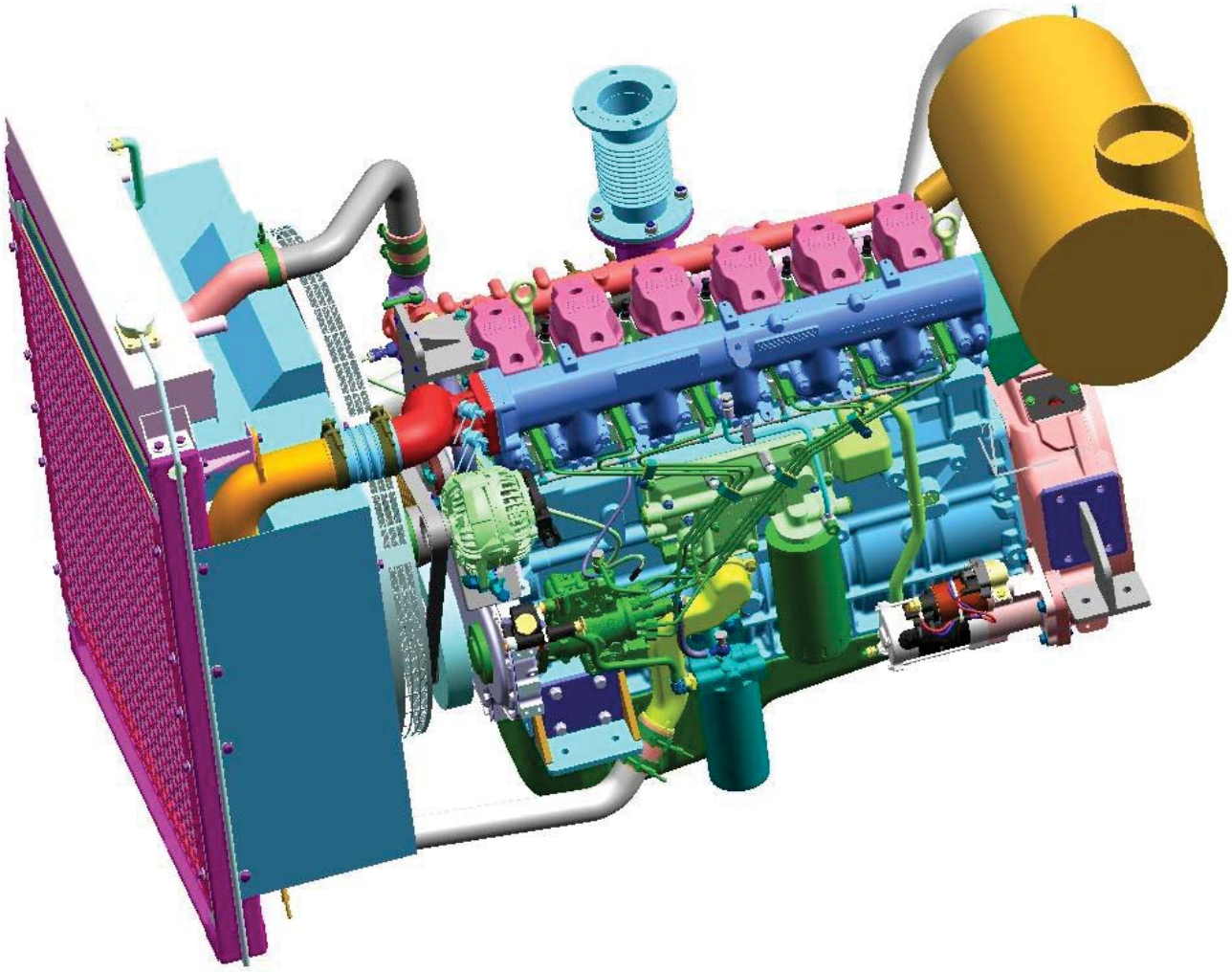
Mahindra NAVISTAR
Engines (P) Limited

Workshop Manual



Mahindra Navistar Engines Pvt. Ltd.,

Plot NO# A-1/1,Chakan Industrial Area,

PHASE- IV ,Village Nigoje Chakan

Tal.Khed,Dist Pune-410 501

Presentation
Group 01

Introduction

This manual contains complete information and specification to assembly and disassembly MAXXFORCE 7.2 engines and all components manufactured by **MAHINDRA NAVISTAR ENGINES PVT LTD.** .

Read and follow all safety instructions. Consult the item ATTENSION 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. **MAHINDRA NAVISTAR ENGINES PVT LTD.** reserves the right of making any change, at any moment. **MAHINDRA NAVISTAR ENGINES PVT LTD.** 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 MNEPL Authorized Distributor or the factory.

The components used in MNEPL engines production are produced with last generation technology components with high level quality standards. When parts changes are necessary, it is recommended to use only MIM genuine spare parts.

How to Use this Manual

To create this Manual it has been taken as base a generic MAXXFORCE 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 19 specific sections. For your convenience, the organization of the Manual is consistent with MNEPL Service Bulletins.

MANUAL CONTENT

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

SECTIONS CONTENT

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.

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 otherinjuries 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.
- TheMNEPLcoolant 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 MNEPL 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 MNEPL.Avoid that outsiders make any service in the engine, because this cancels the warranty.
- To use a parallel battery to start the engfine,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.

Cleaning General Instructions

CLEANING WITH ACIDS AND SOLVENTS

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

MAHINDRA NAVISTAR ENGINES PVT LTD. 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.

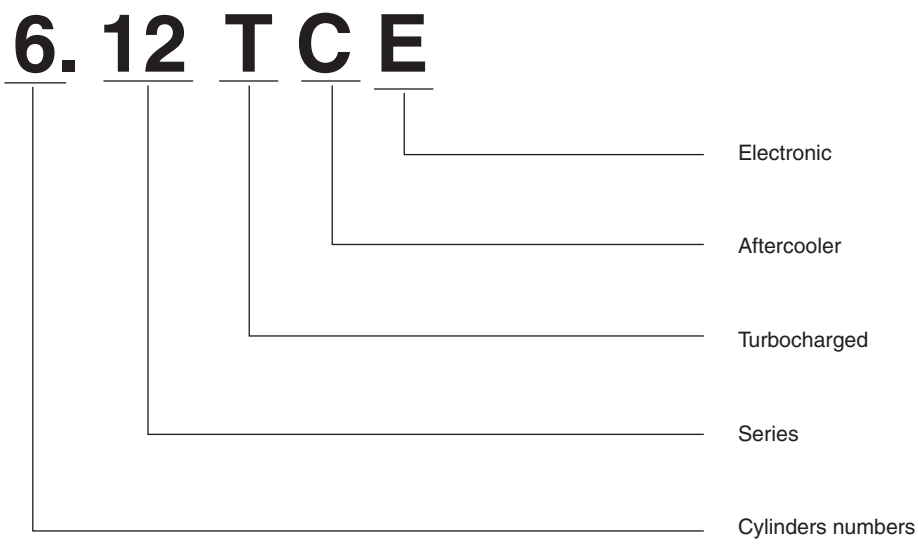
The following parts cannot be cleaned with vapour:

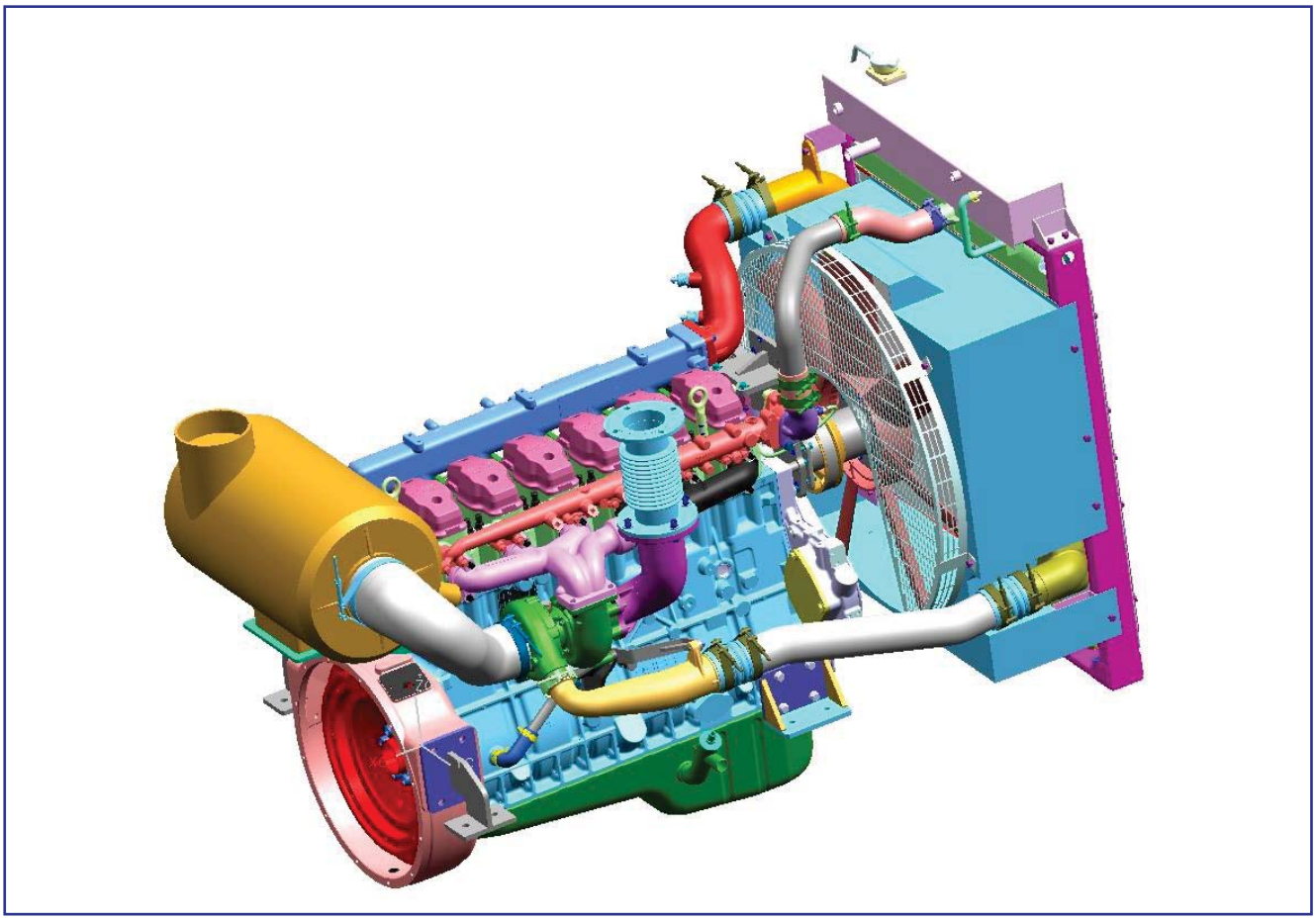
1. Electric and electronics components;
2. Electric harness;
3. Fuel injectors;
4. High pressure pump;
5. Belts, pipes and hoses;
6. Bearings.

Engine Serial Number Identification and Location

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

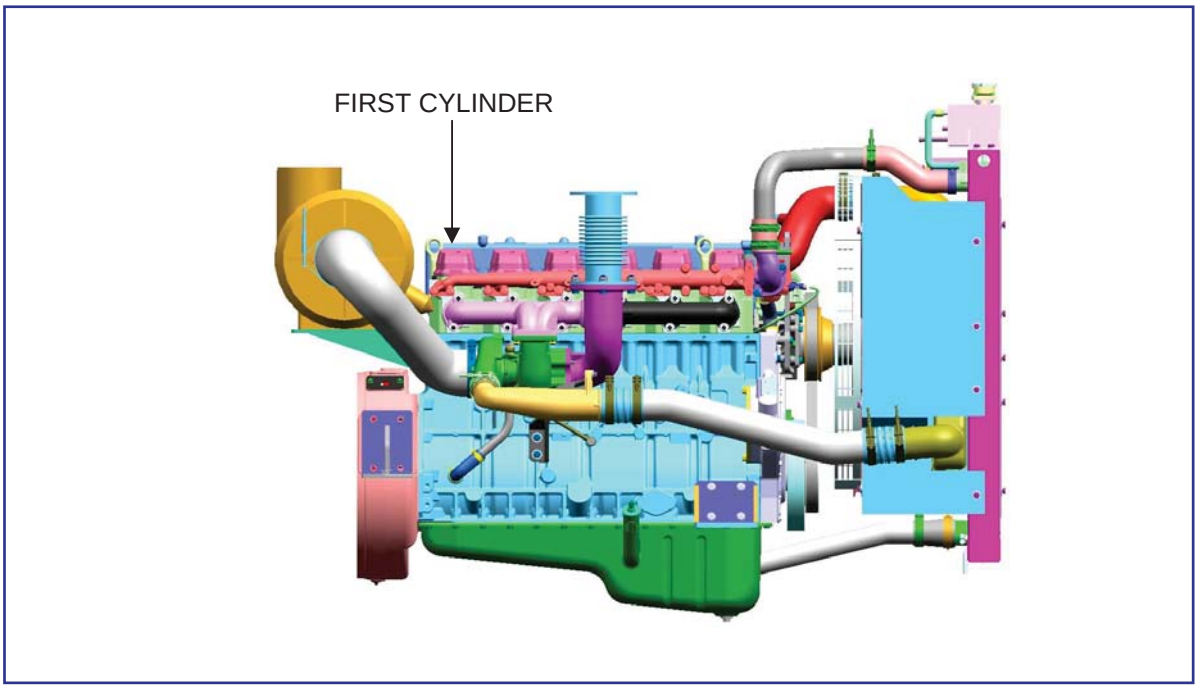
1. Identification plate on the water pipe.
2. Engraving on the right side of the engine block, close to the cylinder head of the cylinder #3.





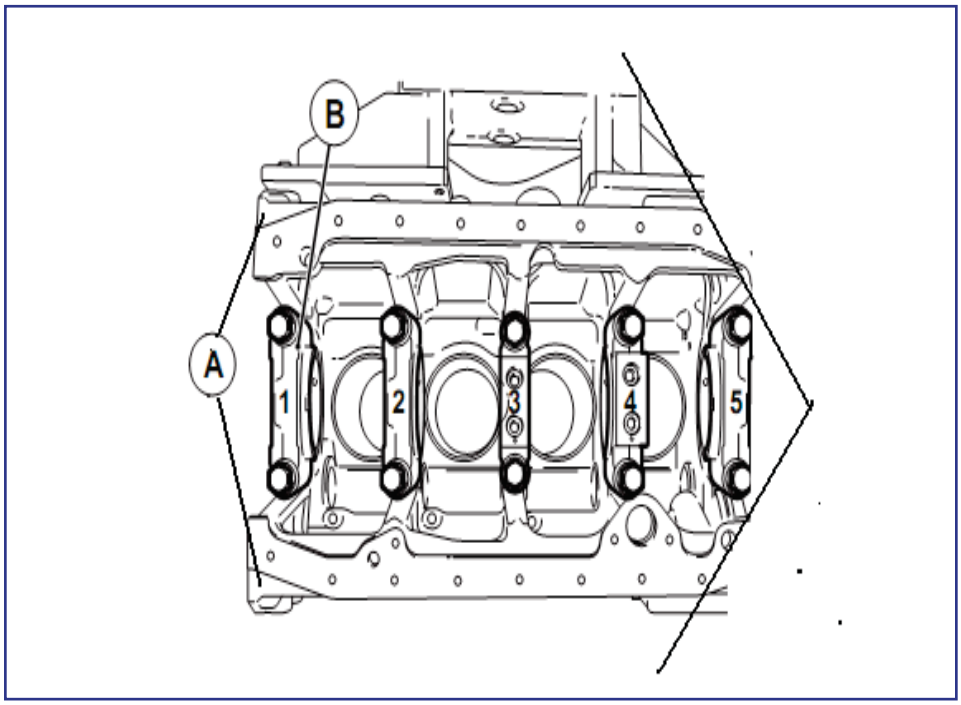
Cylinders Numeration

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



During the assembly, check the numbers on the block (A) and on the bearings (B), that must be the same number, corresponding to the correct block.

The bearing number must start from flywheel to front side.

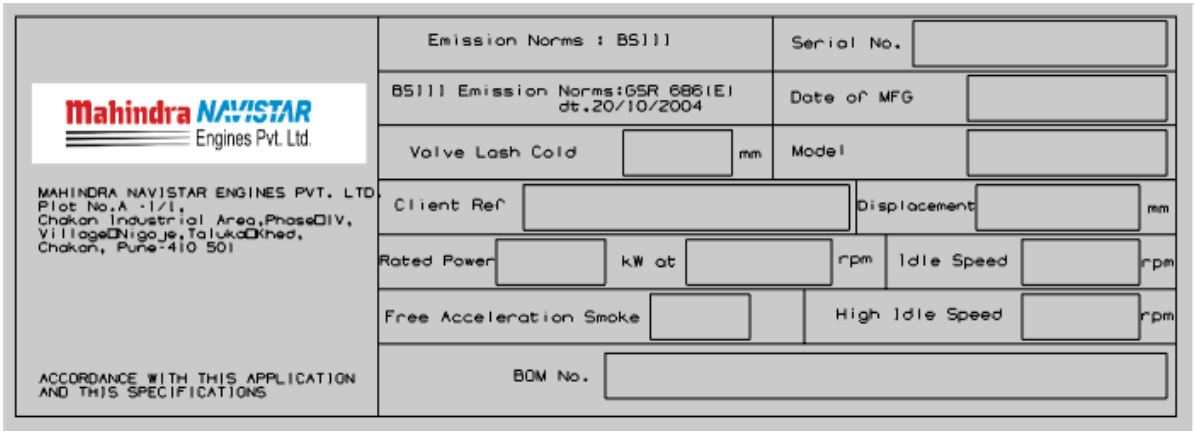


Engine Identification

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.

6.12 TCA Engine Data Plate:



ENGINE ACCESSORIES

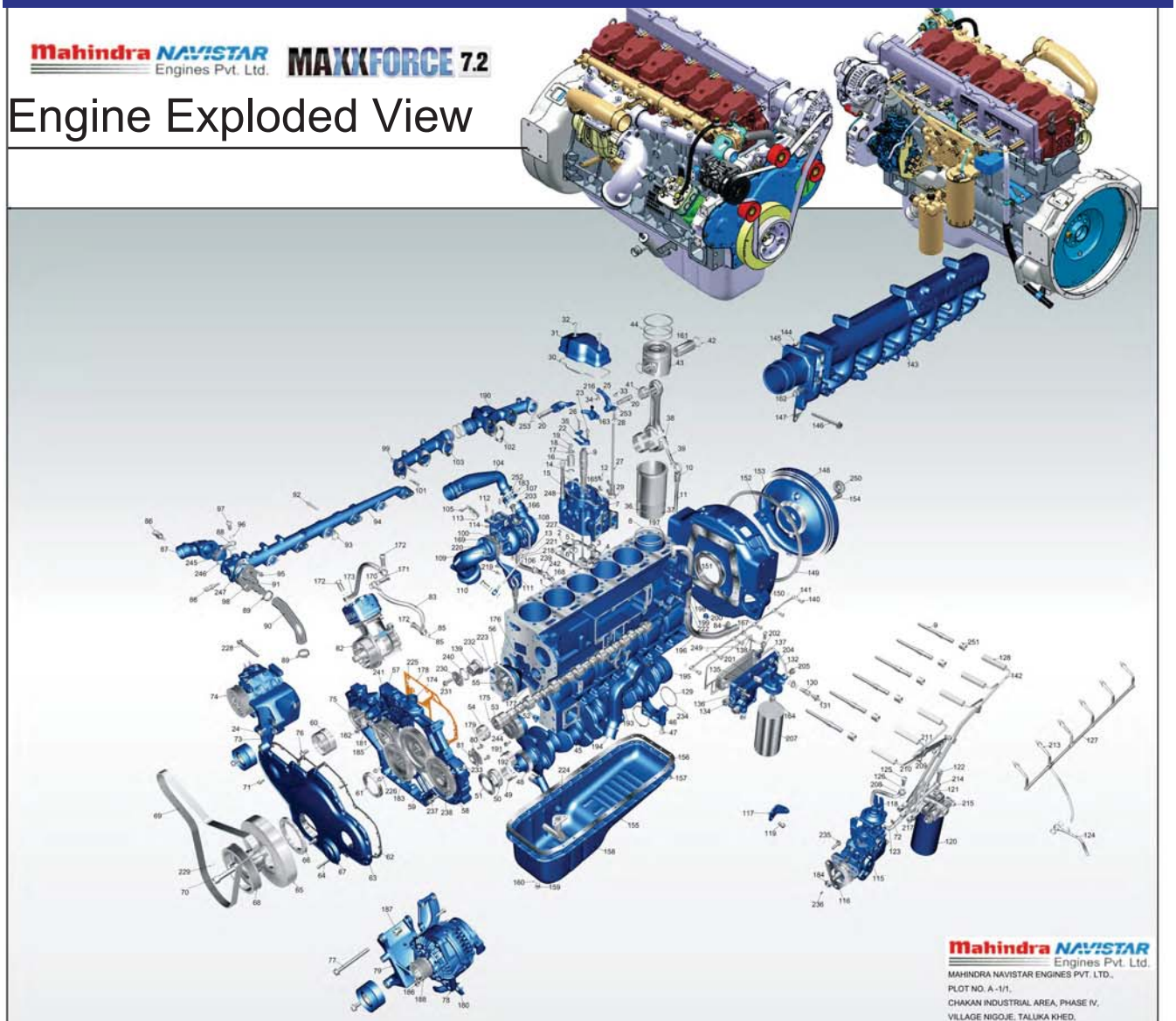
The following engine accessories have manufacturer's labels or identification plates:

- Turbocharger
- **Fuel Injection Pump (Stanadyne Rotory)**

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

Mahindra NAVISTAR Engines Pvt. Ltd. MAXXFORCE 7.2

Engine Exploded View



Mahindra NAVISTAR Engines Pvt. Ltd.
MAHINDRA NAVISTAR ENGINES PVT. LTD.,
PLOT NO. A -1/1,
CHAKAN INDUSTRIAL AREA, PHASE IV,
VILLAGE NIGOJE, TALUKA KHED,
CHAKAN,
PUNE - 410501

1	ENGINE BLOCK
2	CYLINDER HEAD GASKET
3	SEAT-INTAKE VALVE
4	INTAKE VALVE
5	EXHAUST VALVE
6	SEAT-EXHAUST VALVE
7	CYLINDER HEAD
8	LINER O-RING
9	FUEL INJECTOR
10	ENGINE LIFTING HOOK
11	CYLINDER HEAD BOLT
12	WELCH PLUG
13	TURBO OIL OUTLET GASKET
14	SPRING RETAINER - LOWER
15	CYLINDER HEAD BOLT
16	VALVE SPRING
17	SPRING RETAINER - UPPER
18	VALVE LOCK
19	VALVE SEAL
20	ROCKER SHAFT
21	EXHAUST ROCKER ARM
22	INJECTOR HOLDER
23	SPL. SCREW INJECTOR HOLDER
24	A/C COMPRESSOR BRACKET BOLT
25	INTERMEDIATE ROCKER ARM
26	FASTNING BRIDGE BOLT
27	PUSH ROD
28	VALVE SETTING SCREW
29	TAPPET
30	VALVE COVER GASKET
31	VALVE COVER
32	VALVE COVER BOLT
33	VALVE SETTING NUT
34	SEAT-PIVOT ROCKER ARM
35	FASTNING BRIDGE
36	LINER RING
37	LINER
38	CONNECTING ROD
39	CONNECTING ROD BOLT
40	CONNECTING ROD BEARING
41	CONNECTING ROD BUSHING
42	CIRCLIP
43	PISTON
44	PISTON RINGS KIT
45	CRANK SHAFT
46	BEARING CAP
47	BEARING CAP BOLT
48	CRANKSHAFT GEAR
49	MAIN BEARING - LOWER
50	CRANKSHAFT BUSHING - FRONT
51	DEFLECTOR
52	LUBRICANT OIL EJECTOR
53	CAM SHAFT
54	CAMSHAFT BUSHING
55	WATER PUMP GEAR
56	WATER PUMP
57	GEAR CASE
58	FIP GEAR
59	GEAR CASE LUBRICATION PIPE
60	TENSIONER PULLEY
61	FRONT OIL SEAL
62	FRONT COVER GASKET
63	FRONT COVER
64	FRONT COVER BOLT
65	DAMPER
66	DAMPER RING
67	INSPECTION COVER
68	CRANK SHAFT PULLEY
69	V-BELT
70	CRANKSHAFT PULLEY BOLT
71	FRONT COVER BOLT
72	NUT
73	A/C COMPRESSOR BRACKET
74	A/C COMPRESSOR
75	INTERMEDIATE GEAR
76	TENSIONER PULLEY BOLT
77	ALTERNATOR BOLT
78	ALTERNATOR
79	ALTERNATOR BRACKET
80	CLOSING PLATE
81	CLOSING PLATE GASKET
82	AIR COMPRESSOR ASSY.
83	HOSE-WATER OUTLET TUBE TO COMPRESSOR
84	BREATHER HOSE CLIP WITH BOLT
85	SEALING WASHER
86	WATER TEMPERATURE SENSOR
87	WATER OUTLET CONNECTION PIPE
88	BANJO UNION
89	SPRING CLAMP THEMOSTAT CONNECTION HOSE
90	THEMOSTAT CONNECTION HOSE
91	NIPPLE
92	WATER OUTLET TUBE BOLT
93	O'RING
94	WATER OUTLET TUBE
95	BY-PASS CONNECTION BOLT
96	SEALING WASHER
97	BANJO BOLT
98	CONNECTION BY-PASS
99	EXHAUST MANIFOLD NUT
100	EXHAUST ELBOW GASKET
101	EXHAUST MANIFOLD STUD
102	EXHAUST MANIFOLD GASKET
103	EXHAUST MANIFOLD
104	TURBOCHARGER ELBOW TUBE
105	TURBO ELBOW BRACKET BOLT
106	TURBO OIL RETURN TUBE
107	T-BOLT CLAMP
108	TURBOCHARGER
109	EXHAUST COVER NUT
110	EXHAUST ELBOW
111	TURBO BRACKET
112	EXHAUST MANIFOLD TURBO STUD
113	TURBO ELBOW BRACKET
114	EXHAUST MANIFOLD TURBO NUT
115	FUEL PUMP
116	FIP GASKET
117	FIP BRACKET
118	ACCELERATOR BRACKET
119	FIP BRACKET BOLT
120	FUEL FILTER
121	FUEL FILTER ADAPTER
122	NON RETURN VALVE
123	FILTER TO FIP PIPE
124	FUEL RETURN PIPE
125	BANJO BOLT
126	SEALING WASHER
127	FUEL RETURN TUBE
128	INJECTOR CONNECTOR
129	THRUST BEARING UPPER
130	HOLLOW BOLT
131	OIL PRESSURE SWITCH
132	OIL TUBE-FILTER TO MAIN LINE
133	PLUG
134	PLUG
135	OIL FILTER HEAD
136	OIL FILTER HEAD BOLT
137	OIL MAIN LINE BRACKET
138	OIL TUBE- MAIN LINE TO CYLINDER HEAD
139	IDLER SHAFT
140	BANJO BOLT
141	SEALING WASHER
142	HIGH PRESSURE TUBE
143	INTAKE MANIFOLD
144	INTAKE COVER GASKET
145	INTAKE COVER
146	INTAKE MANIFOLD BOLT
147	INTAKE MANIFOLD GASKET
148	FLYWHEEL
149	RING GEAR
150	FLYWHEEL HOUSING
151	REAR OIL SEAL
152	COVER PLATE
153	COVER PLATE BOLT
154	BOLT-FLYWHEEL
155	OIL PAN
156	OIL PAN GASKET
157	OIL PAN BOLT
158	OIL SUCTION TUBE
159	DRAIN PLUG
160	DRAIN PLUG WASHER
161	PISTON PIN
162	INTAKE DUCT BOLT
163	INTAKE ROCKER ARM
164	NIPPLE
165	CYLINDER HEAD LUBRICATION BOLT
166	SEALING WAHSER
167	TEE CONNECTION VALVE
168	TURBO OIL RETURN CONNECTION
169	EXHAUST COVER STUD
170	BANJO UNION
171	SEALING WASHER
172	BANJO BOLT
173	HOSE-COMPRESSOR TO WATER OUTLET TUBE
174	TIMING CASE CONNECTION
175	CLAMP IN BUSH,MAIN BEARING
176	CAMSHAFT LOCK PLATE
177	DOWEL PIN
178	GASKET
179	CLOSING PLATE BOLT
180	ALTERNATOR PULL ROD BRACKET
181	TENSIONER LEVER WASHER
182	TENSIONER LEVER BOLT
183	FIP INTERMEDIATE GEAR
184	FIP NUT
185	IDLER GEAR
186	ALTENATOR BRACKET BOLT
187	ALTERNATOR BUSH
188	ALTERNATOR PULLEY
189	O'RING
190	EXHUAST MANIFOLD
191	MAIN BEARING UPPER
192	CRANK SHAFT DOWEL PIN
193	WATER INLET PIPE GASKET
194	WATER INLET PIPE
195	WATER INLET PIPE BOLT
196	BREATHER HOSE
197	BREATHER HOUSING RING
198	BREATHER HOUSING
199	BREATHER HOUSING BOLT
200	FLYWHEEL HOUSING CAP
201	HIGH PRESSURE NUT, BIG
202	OIL PIPE BOLT
203	TURBOCHARGER BOLT
204	OIL FILTER HEAD PLUG
205	OIL FILTER HEAD PLUG
206	OIL COOLER BOLT
207	OIL FILTER
208	BANJO CONNECTION
209	HIGH PRESSURE PIPE BOLT
210	HIGH PRESSURE PIPE NUT
211	HIGH PRESSURE PIPE BRACKET
212	TURBO INLET OIL TUBE
213	CONNECTION, FUEL RETURN
214	BANJO UNION
215	OIL FILTER BOLT
216	PIVOT PIN
217	HIGH PRESSURE PIPE NUT
218	TURBO OIL RETURN BOLT
219	TURBO BRACKET BOLT
220	EXHAUST COVER WASHER
221	TURBO OIL OUTLET FLANGE
222	BREATHER TUBE
223	WATER PUMP SCREW
224	OIL SUCTION TUBE, O'RING
225	CAMSHAFT GEAR
226	CAMSHAFT BOLT
227	VALVE CAP
228	A/C COMPRESSOR BOLT
229	CRANK SHAFT PULLEY DOWEL PIN
230	IDLER SHAFT WASHER
231	IDLER SHAFT BOLT
232	IDLER SHAFT DOWEL PIN
233	GEAR CASE PLUG
234	THRUST BEARING LOWER
235	FIP BOLT
236	FIP WOODRUFF KEY
237	GEAR CASE BANJO BOLT
238	WASHER
239	TURBO OIL RETURN HOSE
240	IDLER SHAFT BUSH
241	GEAR CASE BOLT
242	TURBO HOSE PIPE CLAMP
243	OIL PUMP
244	OIL PUMP BOLT
245	THERMOSTAT
246	THEROMOSTAT O'RING
247	O'RING
248	INJECTOR WASHER
249	GASKET
250	PILOT BEARING
251	CONNECTOR ADAPTER
252	RADIATOR ELBOW O'RING
253	ROCKER SHAFT O'RING

Technical Data

Engine Data	MAXXFORCE 7.2
Engine type	Vertical cylinders in line, 4 strokes
Injection type	**Mechanical**
Cylinder bore	105 mm
Cylinder stroke	137 mm
Unit displacement	1.2 L
Total displacement	**7.118 litres**
Quantity of cylinders	6
Compression rate	16.8:1
Firing order	1 - 5 - 3 - 6 - 2 - 4
Rotation sense	Counter clockwise (seen by flywheel side)
Dry engine weight	570Kg
Power @ 2200 rpm	154 KW
Torque @ 1350 ~ 1450 rpm	856 N.m
Valves clearance (cold)	0.20 to 0.40 mm
Emissions	CPCB
Cylinder Head	Individual cylinder head with 4 valves per cylinder and “cross flow”

Fuel System

Description	6 Cylinders
Maximum fuel inlet restriction (for gears pump)	0.6 to 1.2 bar
Fuel pressure range in the fuel filter outlet (at crank speed)	9.7 to 12.8 bar
Range of fuel pressure in fuel filter fuel inlet (at operation speed)	10.5 to 13 bar
Maximum pressure load reduction in the fuel filter	0.8 bar

Lubrication System

Description	MAXXFORCE 7.2
Oil pressure • Nominal speed • Idling speed	 5.3 bar (hot engine) 3.5 bar (hot engine)
Oil temperature • Nominal • Maximum	 90 - 110 °C 120 °C
Oil capacity	18 ℓ

Cooling System

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

Thermostat

Thermostat	Opening beginning	Total opening	Maximum opening course
0304CAV00010N	79 ± 2°C	90°C	10.0 mm

Engine Description

FEATURES

MAXXFORCE 7.2 is in-line six cylinder engines with 7.2 Litre displacement.

The firing order of the cylinders is 1–5–3–6–2–4

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 durability and engine performance this engine uses the hot and cold side concept for components distribution.

Cold side (left engine side)

- Fuel Supply System
- Intake Air Manifold

Hot side (right engine side)

- Turbocharger system
- 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 lightweight.

Seven main bearings support the crankshaft for MAXXFORCE 7.2 engines respectively.

One insert bushing support the camshaft for each engine, the other support is assembeled 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.

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

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

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

An electric feed pump / mechanical feed pump draws fuel from the fuel tank through a fuel filter assembly that includes a strainer, filter element, drain valves, and water in fuel (WIF) sensor. After filtering, fuel goes to Stanadyne rotary pump and the high pressure fuel goes to the injectors..

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

ACCESSORIES FEATURES

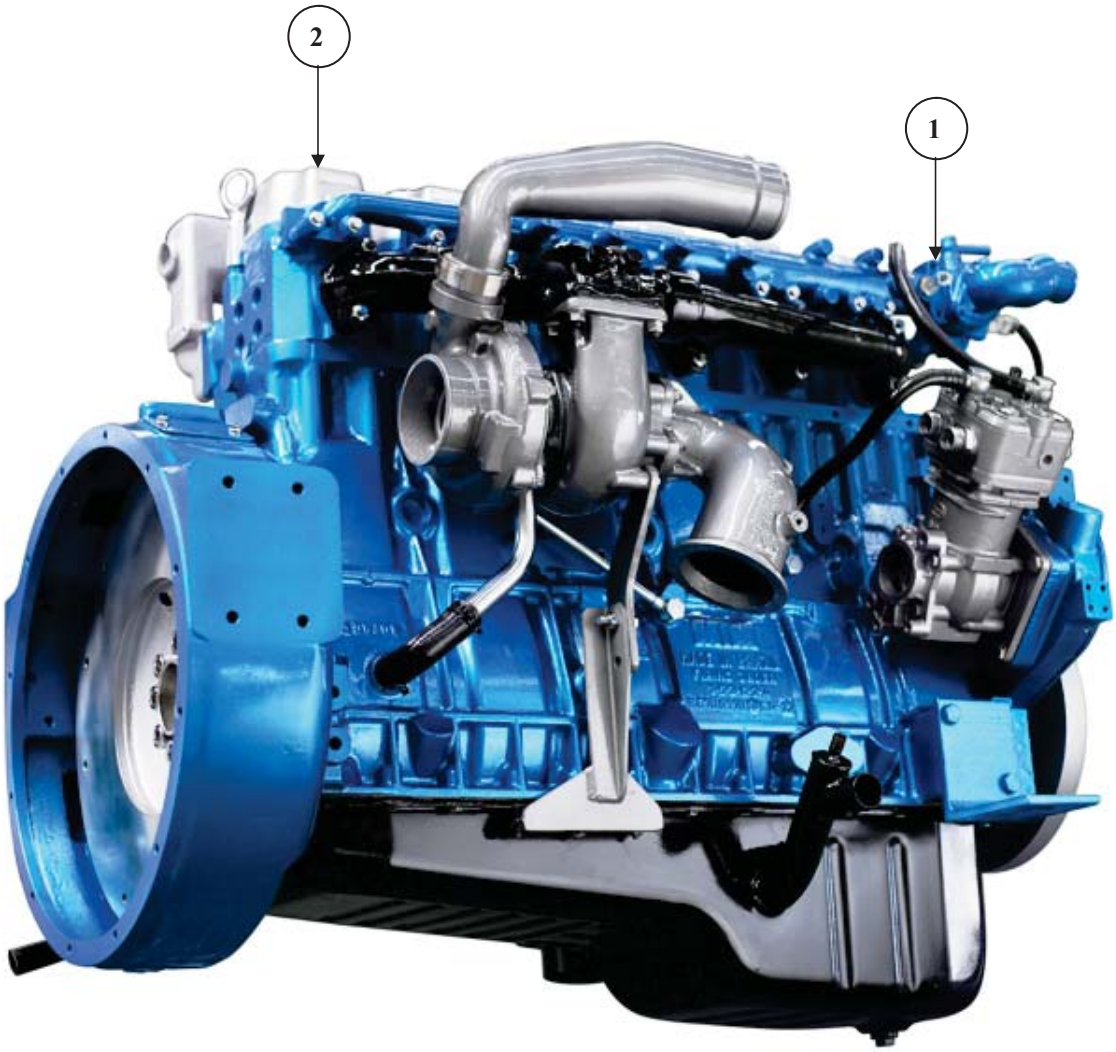
The air compressor is commonly used for air brakes, doors control or air suspension. A hydraulic power steering pump is assembled with the air compressor. In the MAXXFORCE 7.2 L engines both components are located in the hot side next to the powertrain.

The alternator is used to charge the battery and to power a vehicle system when the 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.

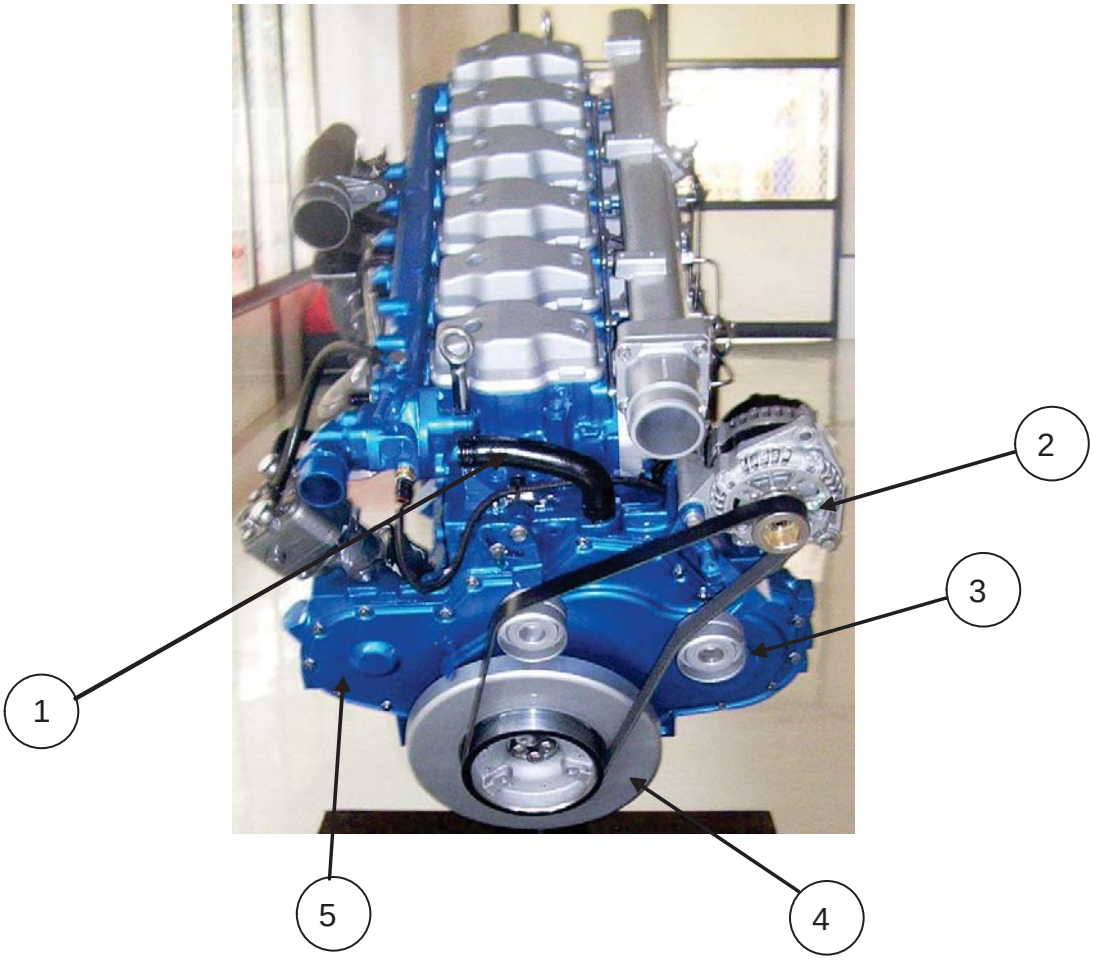
Honeywell turbocharger is an air compressor used for forced- induction of an internal combustion engine The purpose of a turbocharger is to increase the air mass entering the engine to create more power. In the MAXXFORCE engine it's located on the hot side , next to the waterpipe.

Engine Component Locations



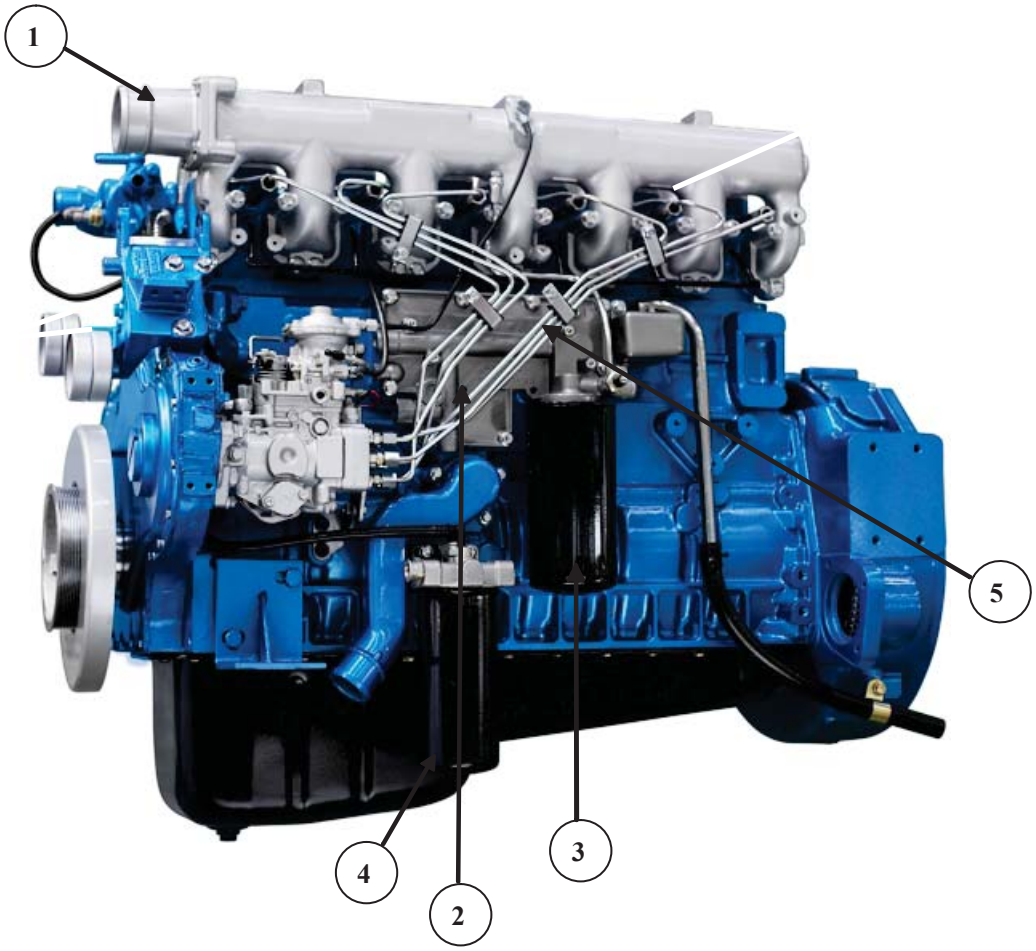
TOP VIEW

1. Coolant temperature sensor (ECT)
2. Valve cover



FRONT VIEW

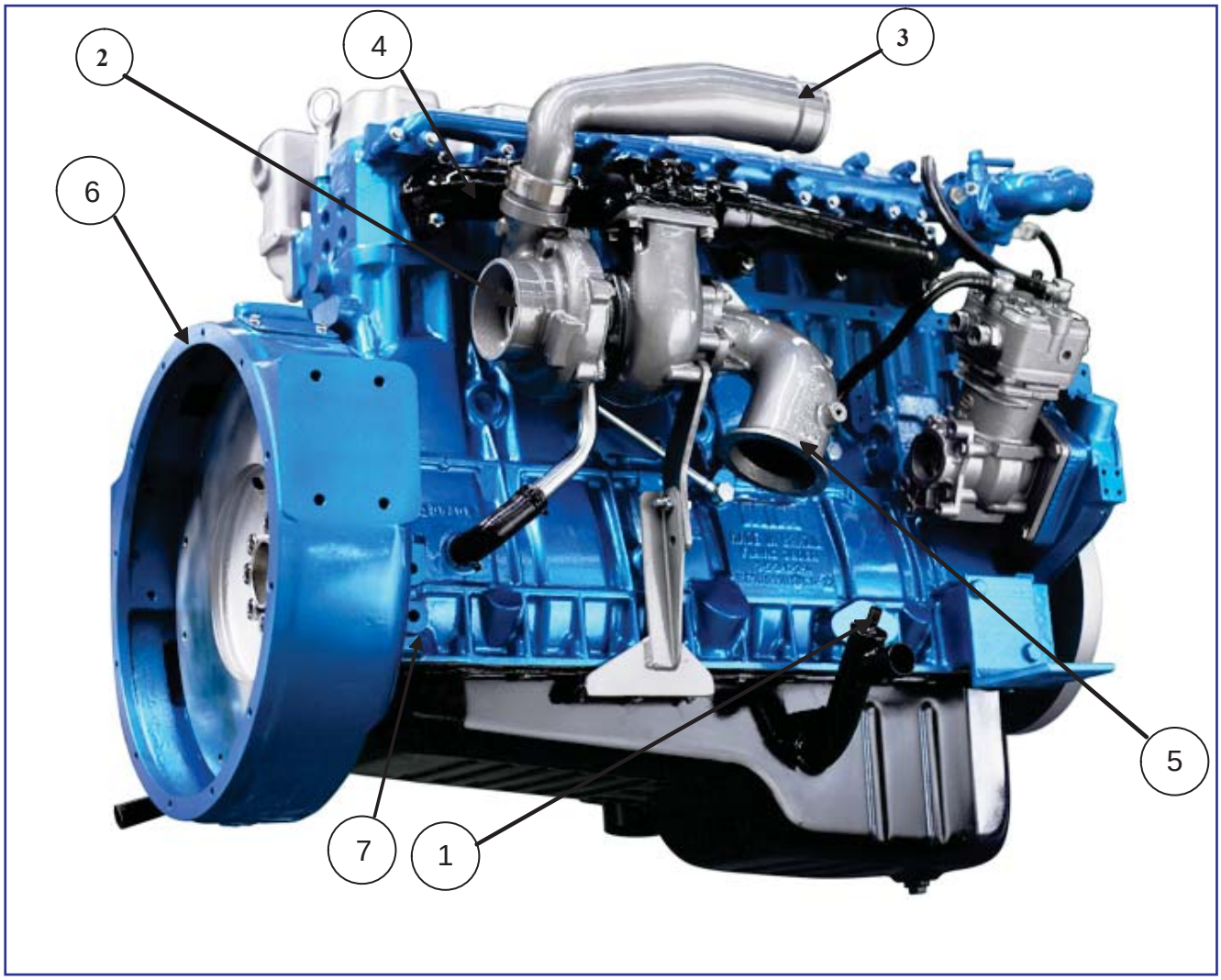
1. Water bypass tube assembly thermostat outlet
2. Alternator
3. Pulley
4. Vibration damper
5. Front cover



LEFT VIEW (COLD SIDE)

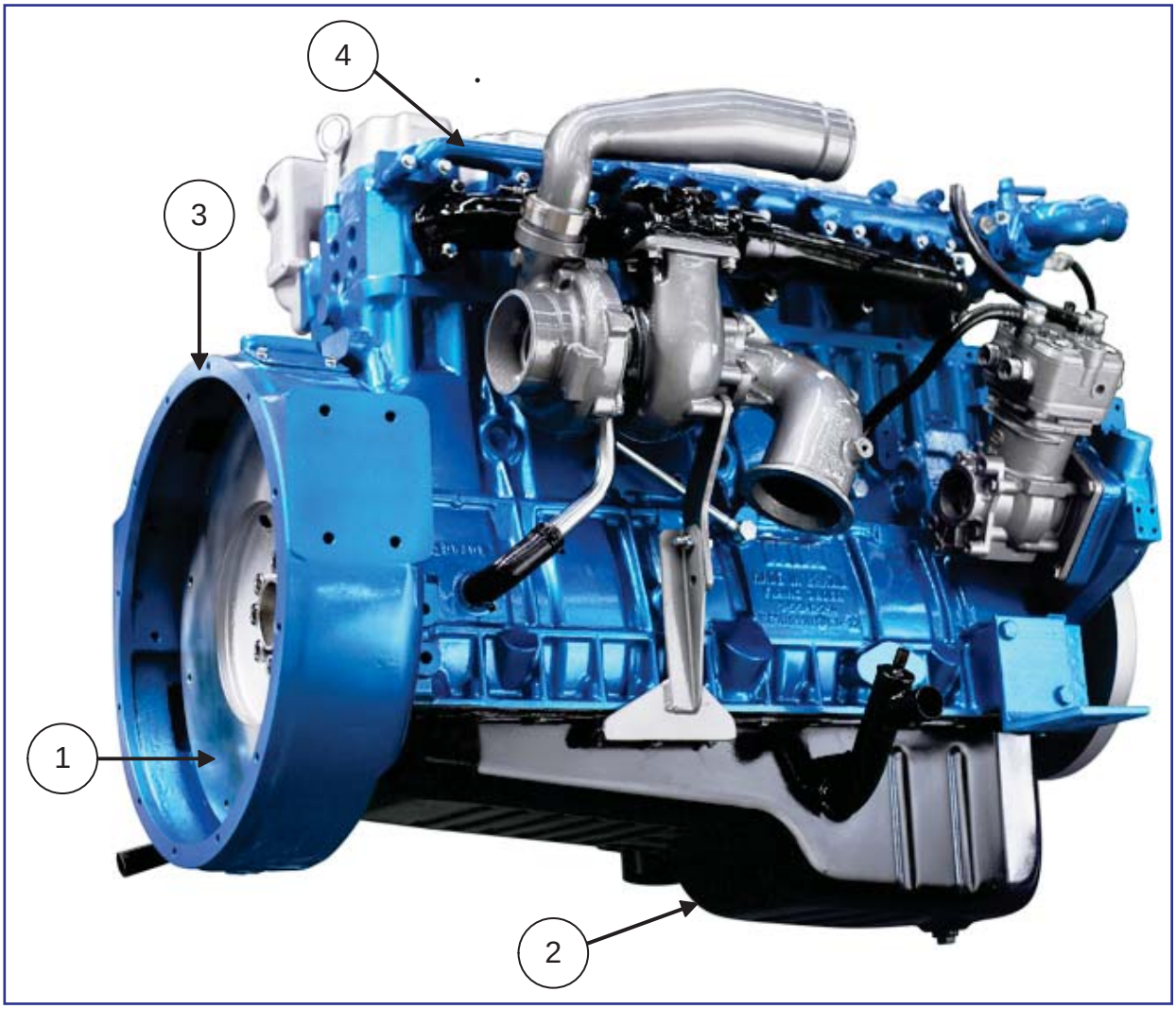
Mechanical Components

1. Manifold, Intake
2. Oil cooler assembly
3. Oil filter
4. Fuel filter
5. High pressure pipes



RIGHT VIEW (HOT SIDE)

1. Oil dipstick
2. Turbo inlet pipe
3. Turbo outlet pipe
4. Exhaust manifold
5. Turbo exhaust curve
6. Flywheel housing
7. Cylinder block



REAR VIEW

1. Flywheel
2. Lube Oil sump
3. Flywheel Housing
4. Water Outlet tube

Engine Systems

FOUR VALVES CYLINDER HEAD

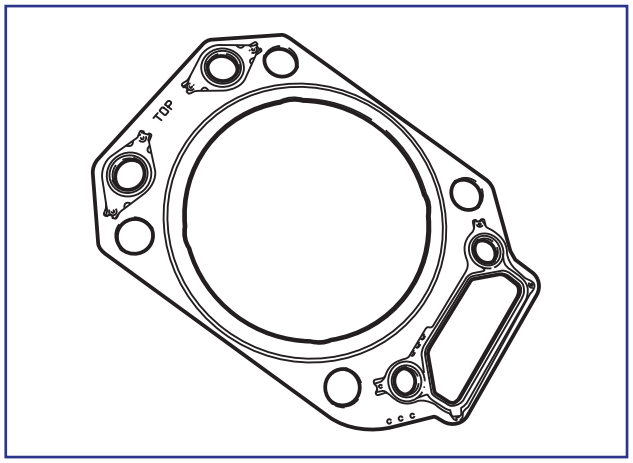
This engine offers an overhead, 4 valves per cylinder and crossflow cylinder head.

A crossflow cylinder head is a cylinder head that features the intake and exhaust ports on opposite sides increasing its performance as the gases can be thought to flow across the head and don't have to change direction and hence are moved into and out of the cylinder more efficiently (no continous flow because of valve opening and closing).

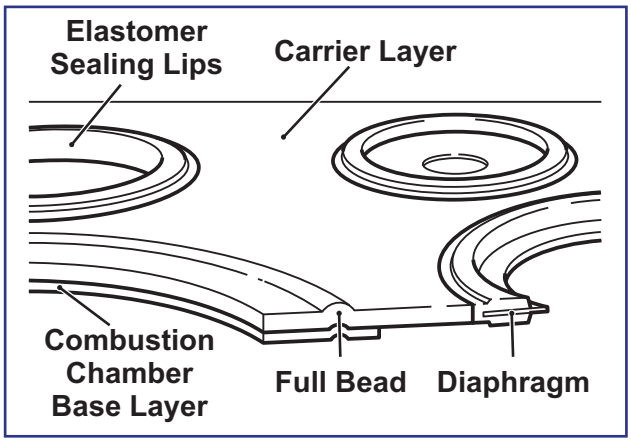
Considering the internal combustion engines, the 4 valves are responsible to control (open/close) the air/gases inlet and outlet. For the 4 valves system, the intake valve is wider than exhaust valve to allow gases entrance to the cylinders. In such configuration there are 2 valves for intake and 2 valves for exhaust.

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 heavy-duty 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

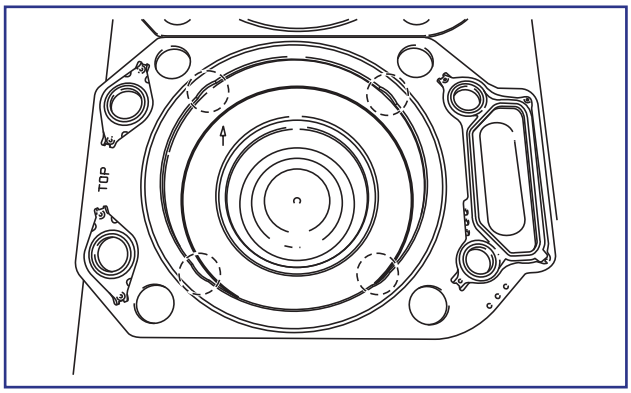
This generates a balanced compressive strenght along the edge of the combustion chamber.

Diaphragm

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

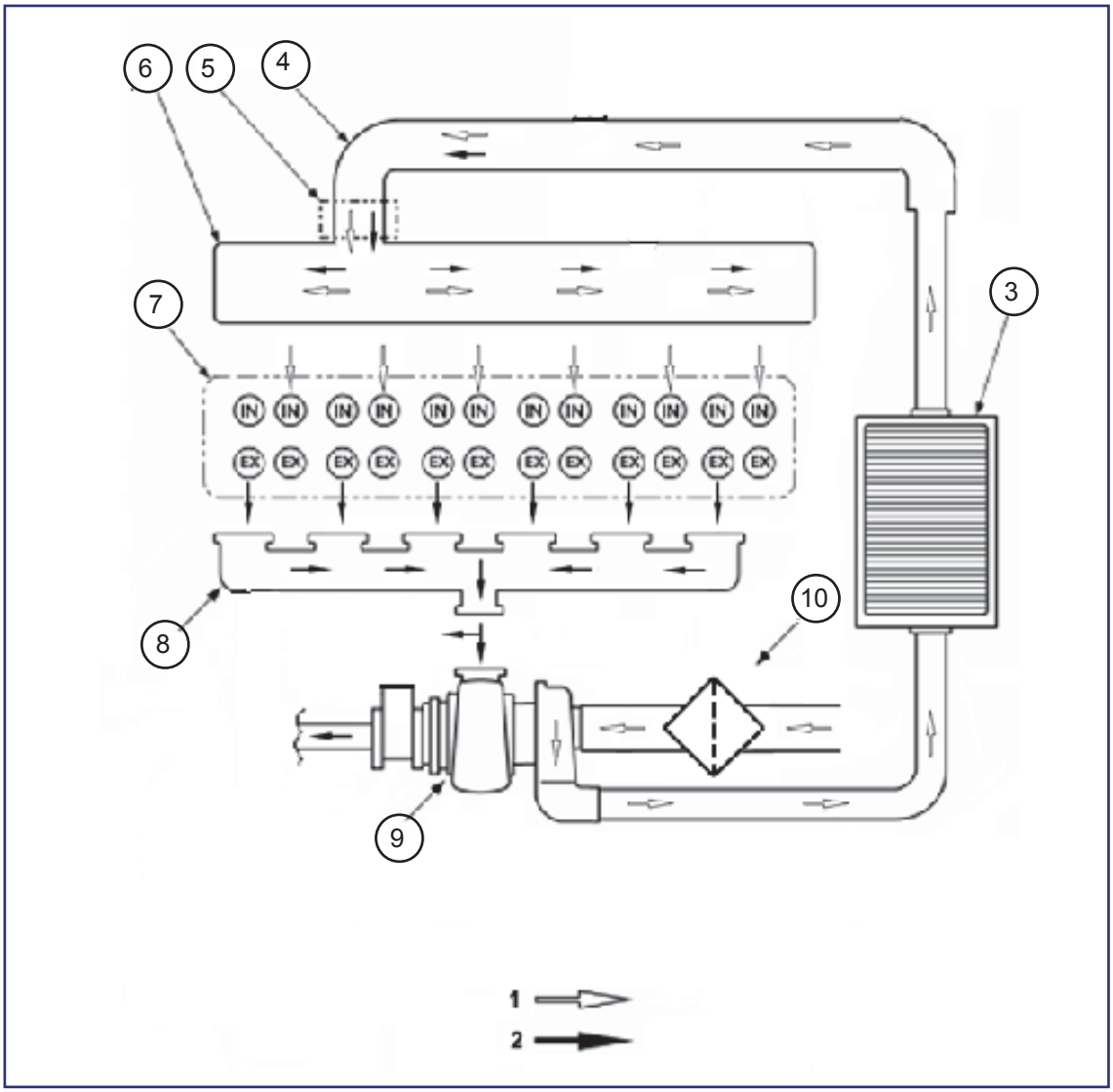
Complex Geometric

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



AIR MANAGEMENT SYSTEM

Air Management Components and Air Flow



1. Intake air
2. Exhaust gas
3. Charge Air Cooler (CAC)
4. Intake air duct
5. Crossover
6. Intake manifold
7. Cylinder head 4V per cylinder
8. Exhaust manifold
9. Turbocharger
10. Air filter

THE AIR MANAGEMENT SYSTEM INCLUDES THE FOLLOWINGS

- Air filter assembly
- Charged Air Cooler (CAC)
- Intake manifold
- Exhaust system

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 ingress the Charged Air Cooler (CAC).

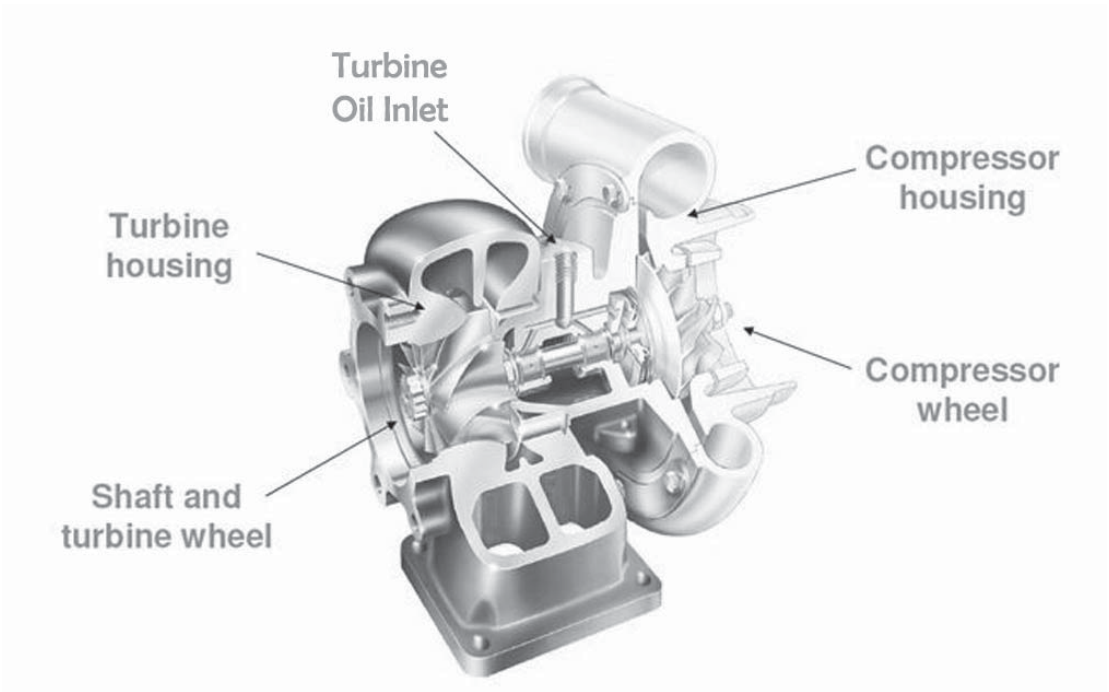
- The exhaust gas remaining flows to the Turbocharger spins and expands through the turbine wheel, varying boost pressure.
- The Turbocharger compressor wheel compresses the mixture of filtered air.

CHARGED AIR COOLER (CAC)

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

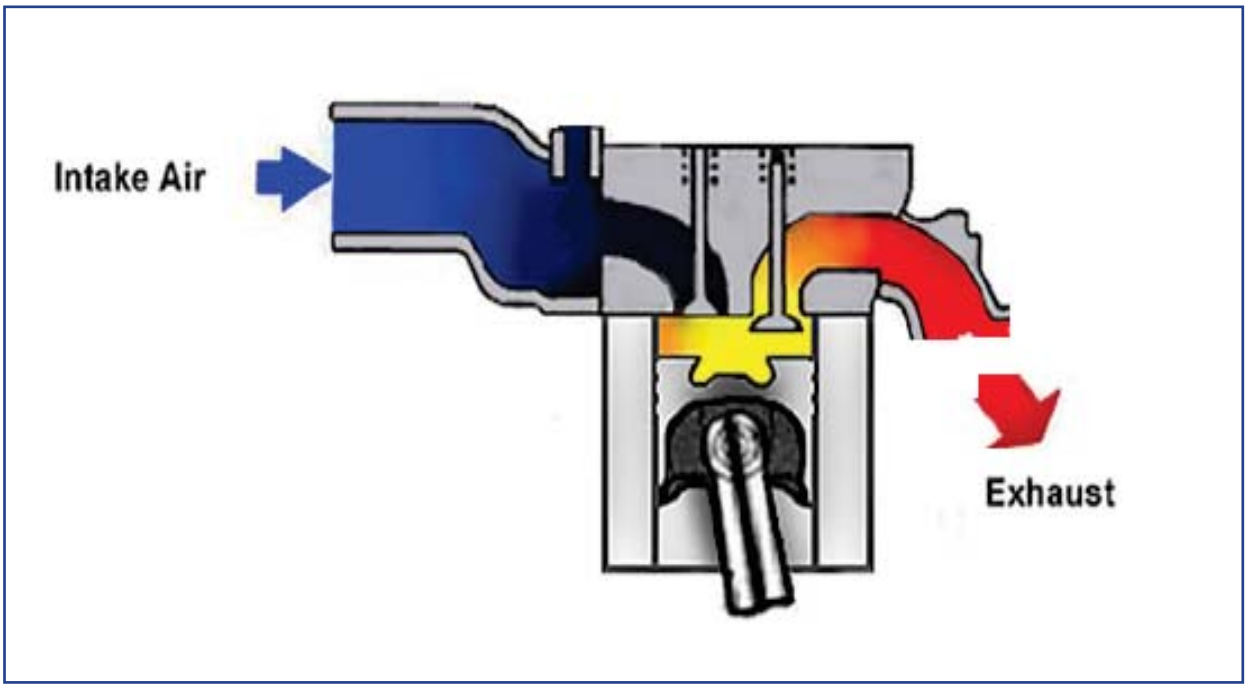


Exhaust System

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 manfifofld 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.



NOTES

Operation and Maintenance

Group - 02

Engine Operation

Start / Stop

- Before operating the MAXXFORCE 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. 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 apply 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 at 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 depends on the cares taken during first operation phase.

As general rule, it is considered as running-in, a period of 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

INDIAN DIESEL SPECIFICATION

S. No	Characteristic	BSII	BSIII	BSIV
1	Density Kg/m^3 15 ^{0} C	820-800	820-845	820-845
2	Sulphur Content mg/kg max	500	350	50
3(a)	Cetane Number minimum and / or	48	51	51
3(b)	Cetane Index	or 46	and 46	and 46
4	Polycyclic Aromatic Hydrocarbon	-	11	11
5	Distillation			
(a)	Reco. Min. At 350 ^{0} C	85	-	-
(b)	Reco. Min. At 370 ^{0}C	95	-	-
(c)	95%Vol Reco at 0° C max	-	360	360

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 for easy the drainage.
- Drain the oil removing the carter plug and washer. Replace the washer.
- 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 cloth without threads.
- 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 MNEPL recommended genuine engine 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 means presence of fuel in the lubricant oil.The presence of bubbles or a milky coloration indicates 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 CI-4 (or upper) specifications and to the recommended viscosities.

Attention: Do not mix different oil brand / grade. Use only MNEPL recomended oil

Check Lubricant oil Condition

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

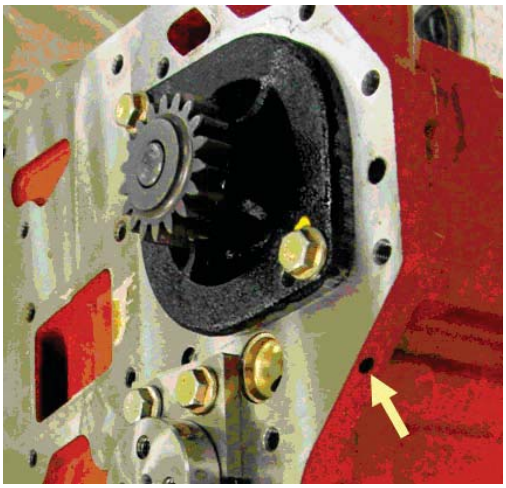
Cooling Fluid and Coolant

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 and 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 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.



Note: Image is shown with gear housing removed

If water is coming from this hole, it means there is a leakage coming from the water pump.

Maintenance Table

MAINTENANCE PLAN	Mahindra NAVISTAR Engines (P) Limited								
DURATION IN MONTHS		3	6	9	12	15	18	21	24
FOR MAXXFORCE 7.2 MECHANICAL GENSET ENGINE	DAILY	250 HRS	500 HRS	750 HRS	1000 HRS	1250 HRS	1500 HRS	1750 HRS	2000 HRS
LUBRICATION SYSTEM									
CHECK ENGINE OIL LEVEL	●								
CHANGE ENGINE OIL FILTER		●		●		●		●	
ENGINE OIL CHANGE (SAE 15W40 API CI-4)		●		●		●		●	
COOLANT SYSTEM									
CHECK COOLANT LEVEL	●								
CHECK COOLANT CONCENTRATION		●		●		●		●	
REPLACE COOLANT	Every 6000 Hrs								
FUEL SYSTEM									
DRAIN WATER FROM FUEL WATER SEPARATOR	●								
CHANGE FUEL FILTER		●		●		●		●	
RECALIBRATION OF INJECTOR NOZZLES	Free from Maintenance								
RECALIBRATION OF FIP	Free from Maintenance								
AIR SYSTEM									
CHECK AIR FILTER SERVICE INDICATOR	●								
CLEAN AIR FILTER	Not Recommended								
CHANGE AIR FILTER PRIMARY ELEMENT (OUTER)	IF Service indicator is red or every 1750 Hrs								
CHANGE AIR FILTER SAFETY ELEMENT (INNER)	Every 3500 Hours								
CHECK BELT TENSION/CONDITION		●		●		●		●	
REPLACE BELT								●	
CHECK TURBOCHARGER PLAY				●				●	
OTHER MAINTENANCE									
CHECK FOR LEAKS IN THE ENGINE	●								
CHECK PIPE CONNECTIONS & HOSES (PHYSICAL CONDITION)		●		●		●		●	
ADJUST VALVE CLEARANCES (cold setting 0.20 to 0.40 mm)		●		●		●		●	
CHECK ELECTRICAL CONNECTIONS		●		●		●		●	
CLEAN AND RETIGHTEN BATTERY TERMINALS		●	●	●	●	●	●	●	●
RETIGHTEN ENGINE FIXATION CUSHIONS		●						●	
RADAITOR FINS CLEANING (EXTERNALLY WITH AIR)								●	
CHECK ENGINE SAFETY TRIP CONNECTIONS		●		●		●		●	

Remarks:

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 (phase, speed, air pressure, temperature, oil pressure and water temperature sensors) are free of maintenance and checked by recommended diagnose scanner for errors stored in failure memory.

Note: Mentioned parts are under evaluation and maintenance fequency can get changed after evaluation.

Conservation for Inactive Engines for Long Period

MNEPL 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 and coolant according to the recommended proportion.
5. Fill up the oil sump 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 oil sump. 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. Apply protective oil on machined surfaces.
11. Remove belt(s).
12. 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.

ENGINE PREPARATION TO RETURN FOR 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 the cooling system with clean water and coolant in the recomended proportion
4. Change engine lubricant oil filter.
5. Fill the oil pan with new recomended grade of 15W40 engine oil in recomended quantity.
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.

Starting Engine Preparation

CLEAN ENGINE

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. Cap all turbocharger and manifold openings to prevent water and degreased agents from entering any engine components internally.
2. Use an appropriate detergent mixed in the correct ratio of water and applies to engine using a warm water and moderate pressure washer or similar cleaning equipment.

NOTE Do not use high pressure or excessive hot water temperature as it may damage the engine components.

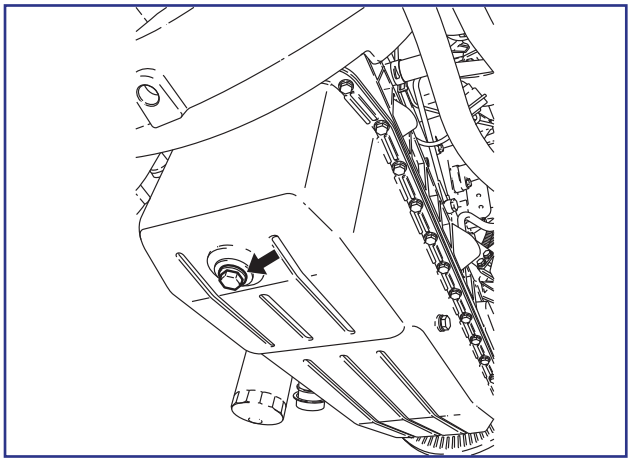
NOTE Do not use solvent, thinner or any product that derivates from petrol as these products may damage the wiring harness and other plastics made components.

DRAIN ENGINE FLUIDS

Draining the Oil

1. Place an oil drain pan beneath the oil drain plug to collect the oil.
2. Remove oil pan drain plug **(R ½")** and washer. Drain engine oil and dispose of used engine oil according to applicable laws.
3. Discard washer, inspect drain plug and replace if necessary. Place a new washer onto drain plug and install to oil pan. Apply the torque of **55 to 75 N.m**.

6 Cylinders Engine

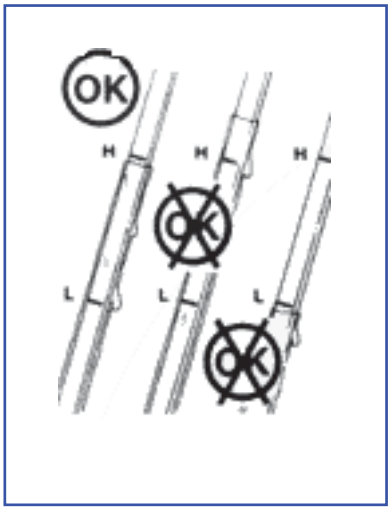


Priming the Lubrication System Preferred Method

When the engine has been assembled, lubricate the engine with oil before starting. This will aid internal components with the proper lubrication requirements during the critical initial startup phase. The following procedure is the preferred method to use when priming the lubrication system.

1. If engine was completely disassembled and rebuilt, remove the plug assembly and pressurize the lubrication system with sufficient oil to fill the oil filter and charge the entire lubrication system.

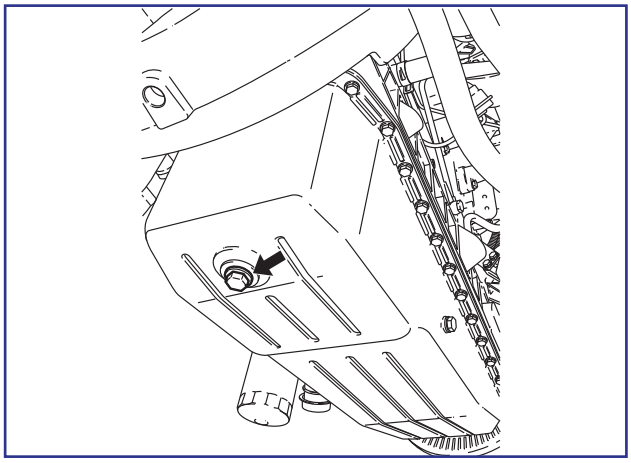
2. Check the oil level before starting engine.



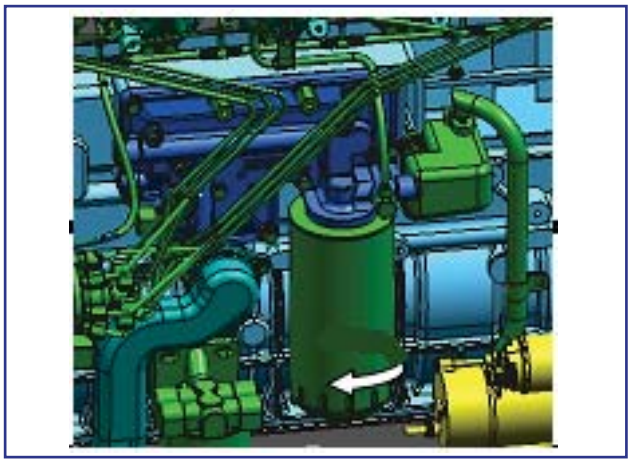
Oil Element

REMOVAL

1. Remove the drain plug **(R ½") and discard the** washer. Drain engine oil and dispose of used engine oil according to applicable laws.



2. Using the wrench indicated, unscrew the filter



INSTALLATION

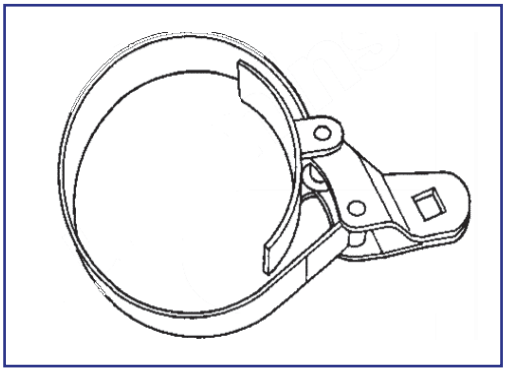
1. **Clean area around oil filter head, clean gasket** surface of filter head.

2. Lubricate oil filter gasket with fresh engine oil.

3. Fill the oil filter with fresh engine oil.

4. Tighten the filter untill the gasket contacts the filter head surface.

5. Use oil filter wrench to tighten the filter an additional 3/4 of a turn.



6. Operate the engine and check for leakages

Mounting Adapter Plate and Engine Lifting

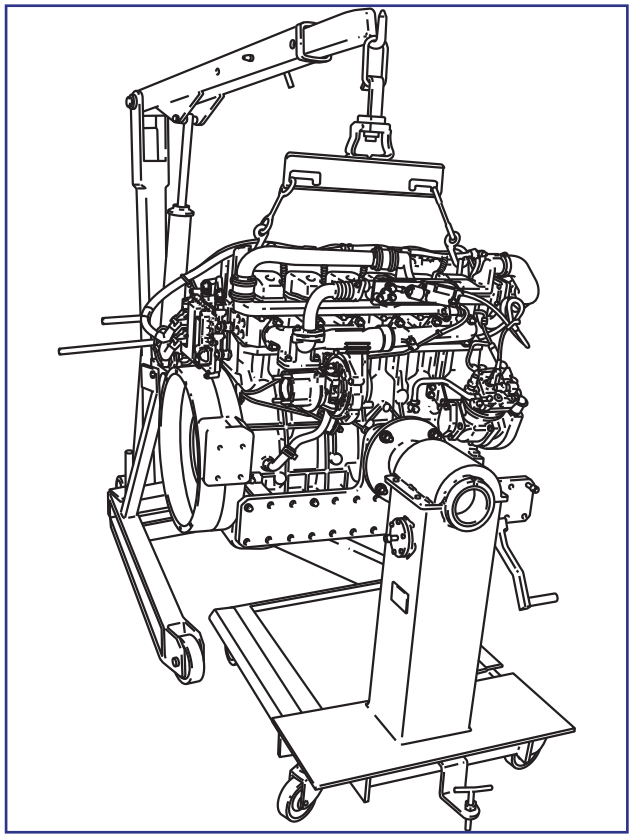
ADAPTER PLATE

Warning: To avoid serious personal injury, possible death or damage to the engine or vehicle use a minimum 3 ton chain hoist, equipped with safety hooks to lift the engine at designated lifting eyes.

Warning: To avoid serious personal injury, possible death, damage to the engine or vehicle, use only metric grade 10.9 or SAE grade 8 bolts when mounting adapter plate to engine as well as the engine stand.

ENGINE HOIST

Keep in mind that safety is the first concern when choosing an engine hoist that is required for safe lifting of engines and heavy parts.



DIESEL ENGINE STAND

A good engine stand is one of keys to a stress-free engine build, eliminating the need to struggle with rebuilding engines on a bench or on the ground. A recommended diesel stand must be solid built, stable, offer oil drip pan to keep assembly lube and motor oil out of the floor, easy engine rotation with 360o and for safety is recommended a floor lock to keep stand from moving during repairs.

NOTE:

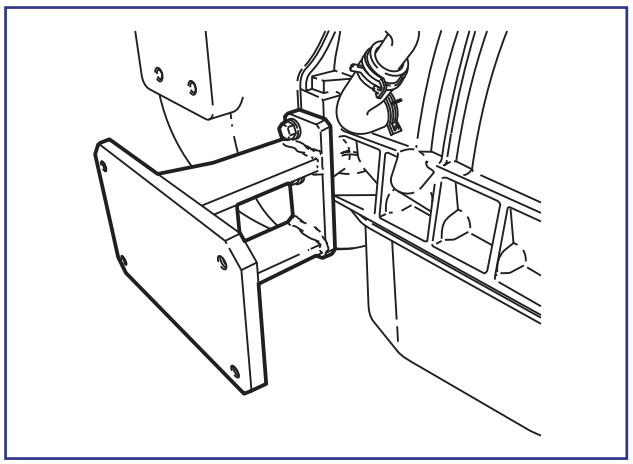
The oil drip pan is an important accessory to the engine stand as it catches the oil that ALWAYS drips from the engine when you are working on it, keeping the oor dry. Therefore the people do not walk and slip in the oil puddles, tracking oil all around the shop.

INSTALLING THE ENGINE TO THE STAND

Raise the engine with the hoist and using the **special tool No.9.610.0.690.011.6** (adapter plate kit), an engine stand and **bolts M12X45**, visually match up adapter plate with bolt holes on right side of engine to determine adapter plate orientation to the engine stand.

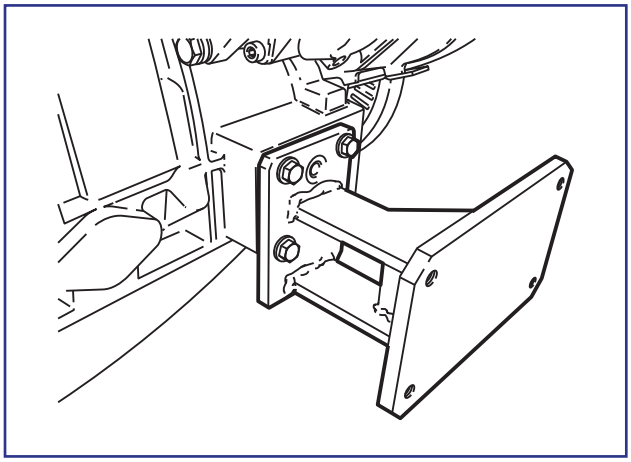
NOTE: Let all bolts loosen to make easier adapters to be fitted onto the engine and stand plate. Apply the torque only after fit all bolts adapters to plate and engine.

Rear engine side support adapter shown (2 holes fixation)



Front engine side support adapter (use of 4 holes for 6cyl engine or 3 holes for 4 cyl).

6cyl engine shown

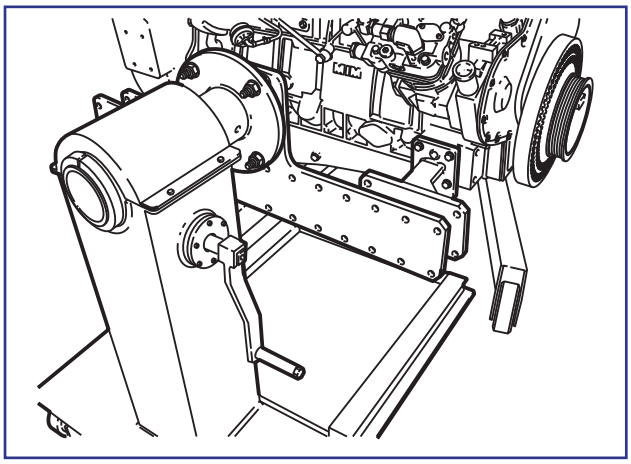


Install recommended adapter plate to engine stand and secure it by using grade 8 bolts and nuts.

NOTE: Let all bolts loosen to make easier adapters to be fitted onto the engine and stand plate. Apply the torque only after fit all bolts adapters to plate and engine.

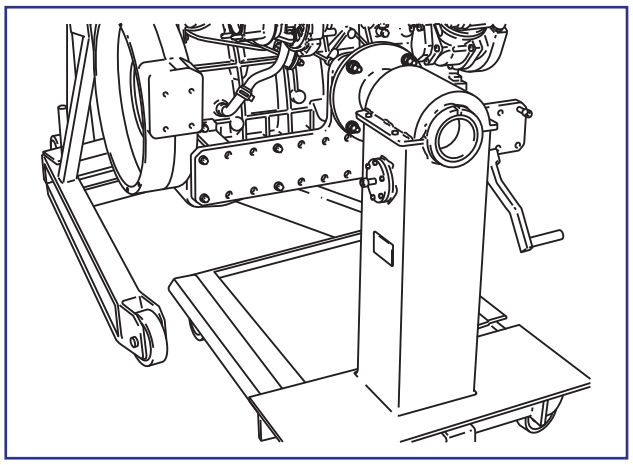
Using the hoist, align engine stand to match the adapter plate to engine, rotating stand and / or raising engine to match adapter plate. Secure one bolt and rotate stand if necessary to thread remaining bolts.

Use metric grade 10.9 bolts M12X45 or longer to secure engine to adapter plate.



Tighten bolts to the standard torque value (General Torque Guidelines).

Remove safety chain hooks from engine lifting eyes.

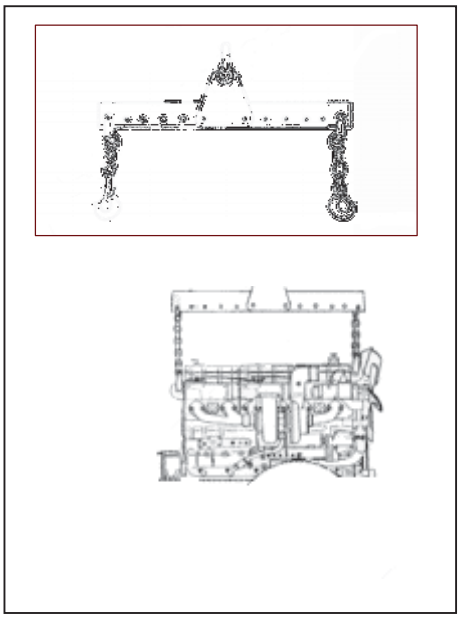


NOTES

Engine Disassembly Sequence

Group - 03

Engine lifting equipment and brackets.



Warning: The engine lifting equipment must be designed to safely lift the engine as an assembly. The dry weight of engine is 570 kg.

Use a properly rated hoist and engine lifting fixture, such as shown in fig. attached to the eye bolt provided on engine.

Install the engine on suitable engine support stand.

Engine – Preparation for steam cleaning.

Install plastic caps or tapes on all engine openings to prevent moisture and dirt's from entering the engine.

Cover all electrical components. This will prevent water damages.

Engine – Steam Cleaning
Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam will cause serious personal injury.

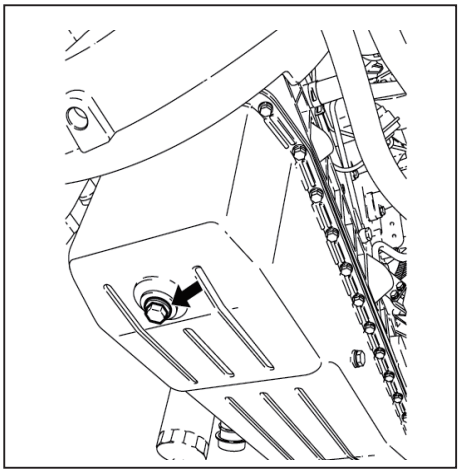
Lubricating Oil – Draining

19 mm

Note: The total system lubricating oil capacity includes the lubricating oil filter is 19.5 liters

Remove the drain plug and discard the drain plug sealing washer.

Drain the lubricating oil.



Coolant – Draining

Open the coolant banjo at the cylinder block.

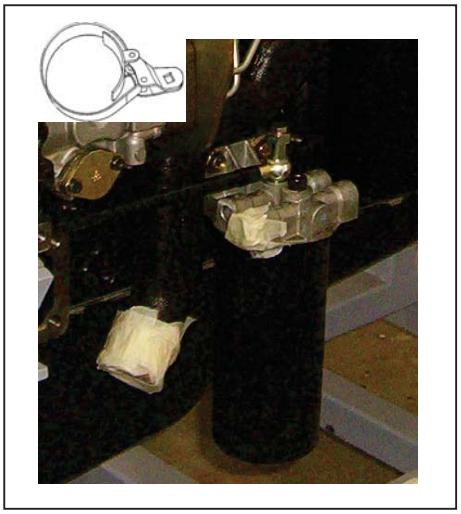
Lubricating oil filter – Removal

Remove and discard the engine oil filter if not needed for a failure analysis.

Fuel filter – Removal

90 - 95 mm filter wrench

Remove and discard the fuel filter and the sealing rings.



Fuel Filter Head – Removal

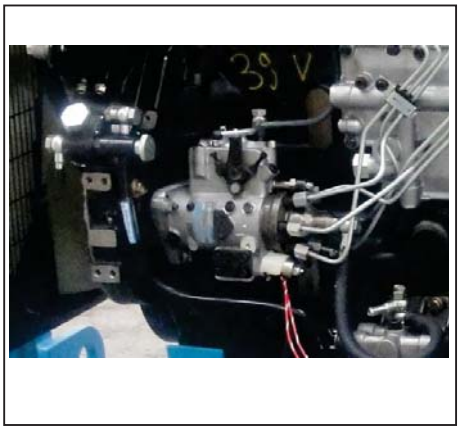
13 mm
Remove the fuel filter head

Fuel Lines Low Pressure – Removal

17 mm

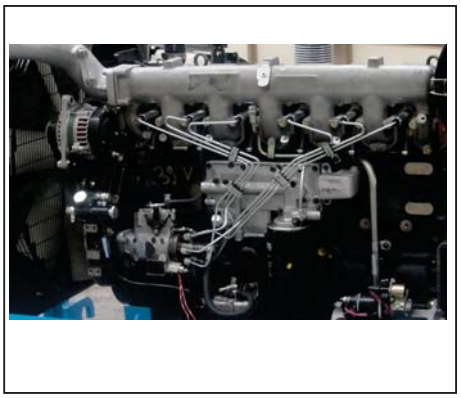
Disconnect the low pressure fuel lines.
Note: To avoid damaged to the fuel transfer pump, use two wrench when loosening the low pressure lines.

Discard all copper / aluminum washers.



Fuel lines High Pressure – Removal

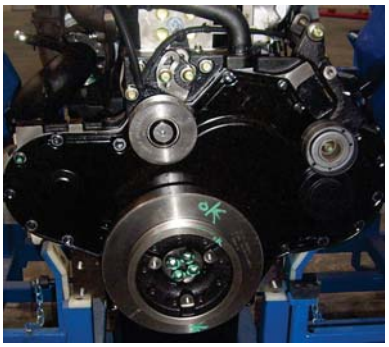
17 mm
Remove the high pressure fuel lines



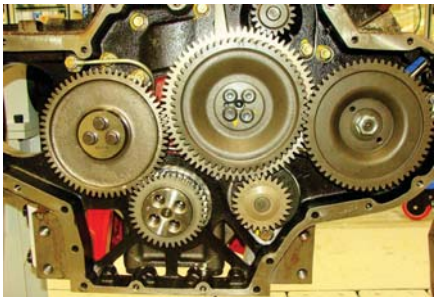
Caution: Cover the injectors and fuel pump high pressure outlet connections to avoid damage from contamination.

Fuel Injection Pump – Removal

Remove the fiber cover from front cover, shown in fig.



22 mm
Remove the nut and lock washer from the fuel injection pump side.



Fuel pump gear puller

Pull the fuel injection pump drive gear loose from the shaft.

13 mm
Remove the fuel injection pump flange mounting nuts.

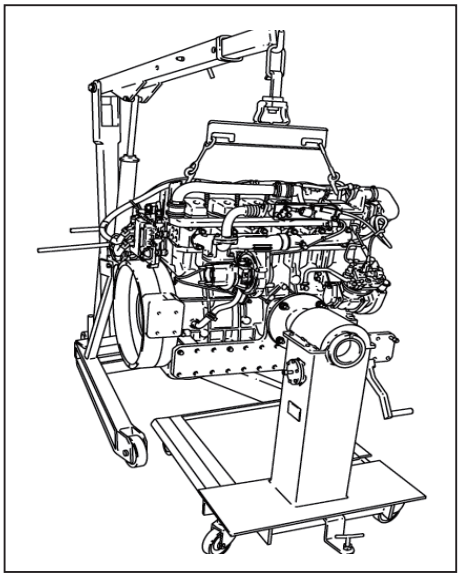
Remove the fuel injection pump supporting bracket capscrews.

Engine Installation on to Engine Rebuild Stand

Engine lifting Fixture

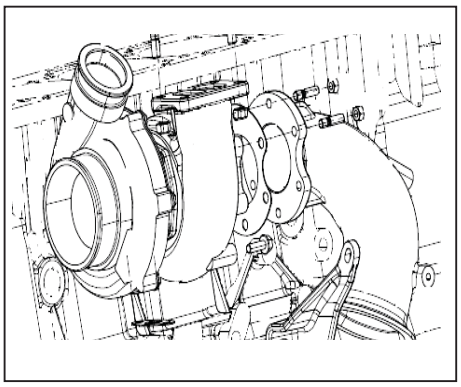
Caution: Dry weight of engine is 570 kg. Use proper engine lifting bracket.

Use 4 capscrews to install the engine on stand.



Turbocharger Exhaust Outlet Connection – Removal

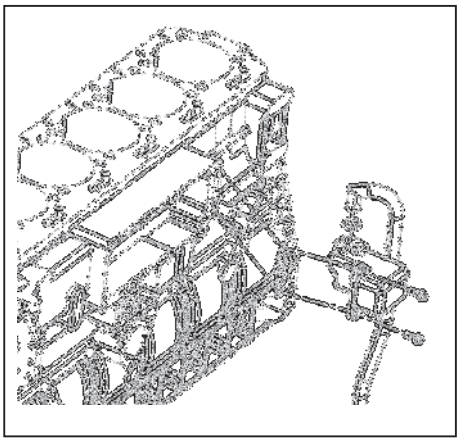
13 mm
Remove the turbocharger exhaust outlet connection by loosening the screws.
Discard the screws.



Crank Case Breather Tube – Removal

10 mm

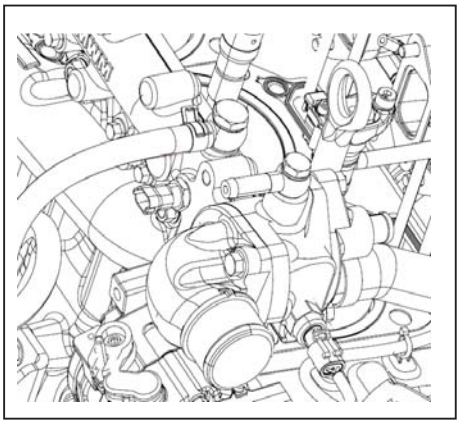
Remove the crankcase breather tube support bracket cap screws.



Coolant Temperature / Water Temperature Sensor – Removal

Mm
Mm
Remove the electrical connections to the temperature sensors.

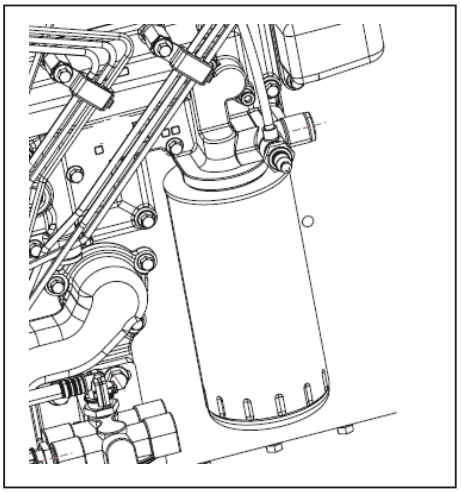
Remove the sensors.



Lubricating oil pressure Sensor – Removal

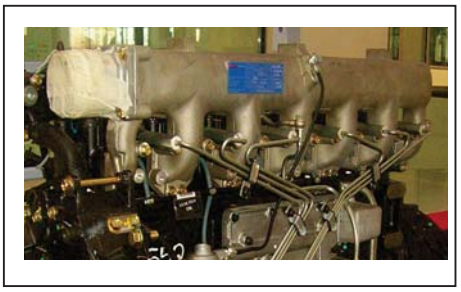
Mm

Remove the oil pressure sensor.



Intake Manifold – Removal

13mm
Remove the intake manifold.
Discard the gasket.



Fuel Drain Manifold – Removal

Pull the fuel drain manifold tube.

Lubrication Tube From Oil Filter To Cylinder Head – Removal

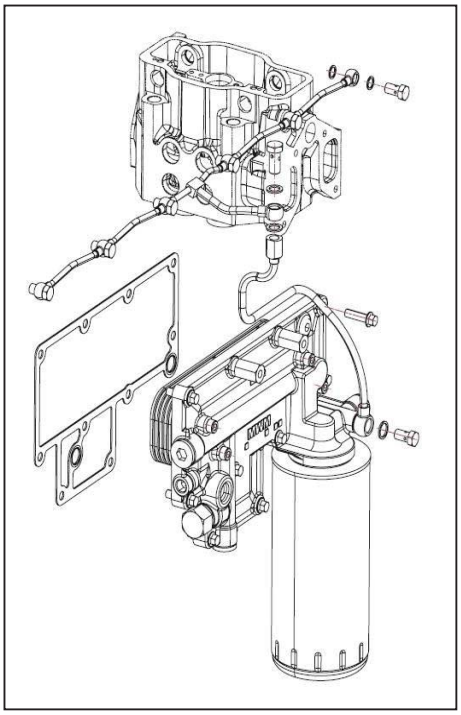
19 mm, 17 mm, 14 mm

Remove the 19 mm banjo from oil filter side.

Remove the 17 mm banjo from connection between oil cooler and cylinder head.

Remove the 14 mm banjo from cylinder head side.

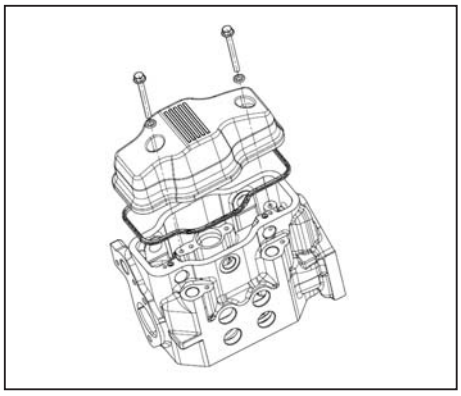
Discard all aluminum / copper washers.



Valve Cover – Removal

Mm

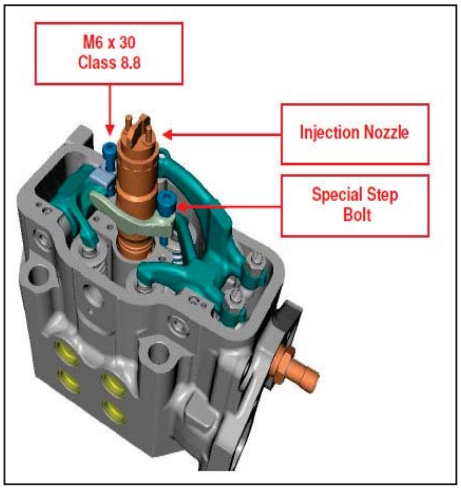
Remove the 6 valve covers.
Discard the valve cover gasket.



Injectors and Connector – Removal

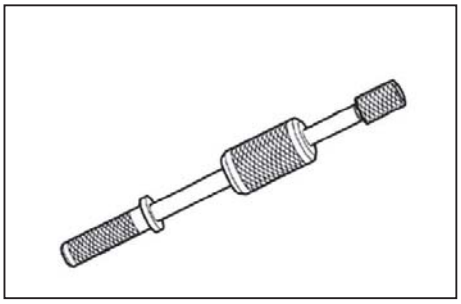
22 mm
Loosen the connector socket.

Pull the connector with connector puller. Keep it in proper pallet and dust free place.
5 mm Allen
Loosen the two screws provided to clamp the injector.



Remove the clamps.

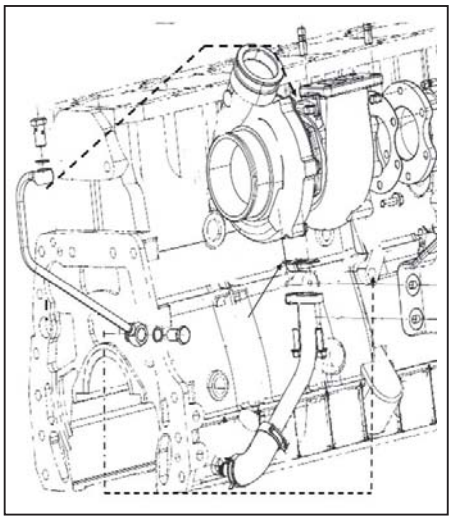
Use injector puller to pull out the injectors.



Keep the injectors in proper pallet with proper masking. Ensure to put cylinder number tag.

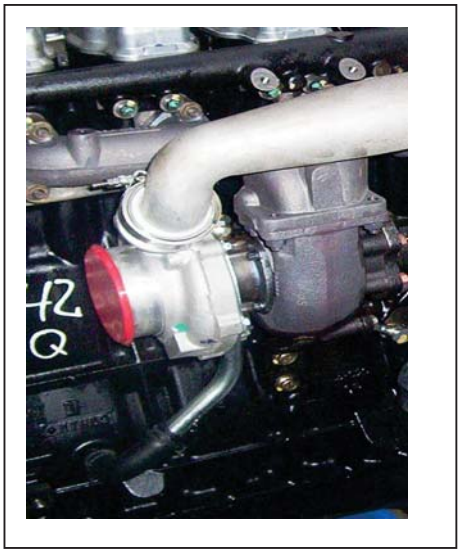
Turbocharger Oil Supply Hose – Removal

19 mm, 19 mm
Remove the oil supply line from cylinder block side and turbo side.



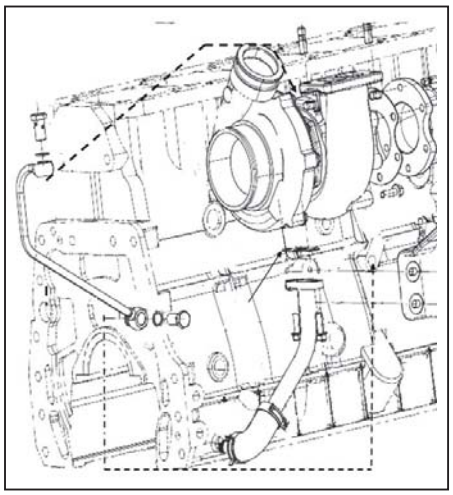
Turbocharger Oil Drain Tube – Removal

10 Mm
Remove the turbo oil drain tube.



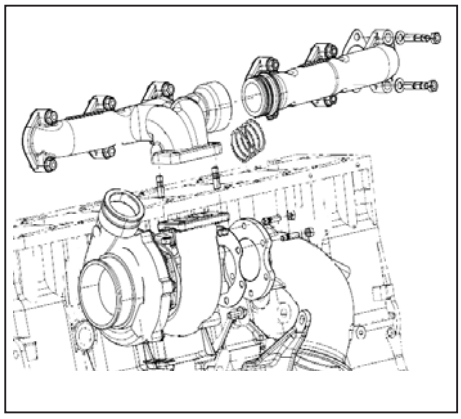
Turbocharger - Removal

15 mm
Remove the 4 nuts.
Discard the nuts.



Exhaust Manifold – Removal

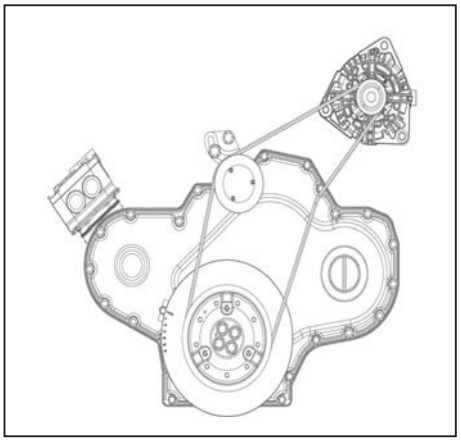
15 mm
Remove the exhaust manifold nuts.
Discard the nuts.



Drive Belt – Removal

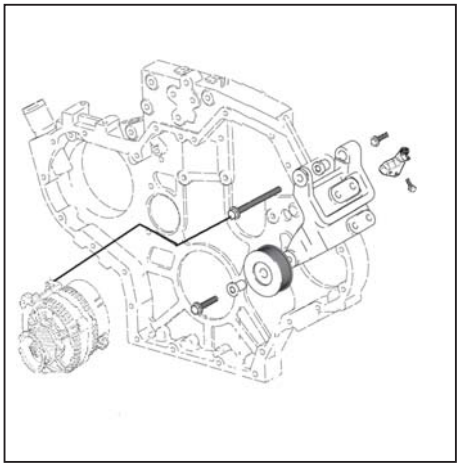
Remove the belt tensioner.

Remove the belt.



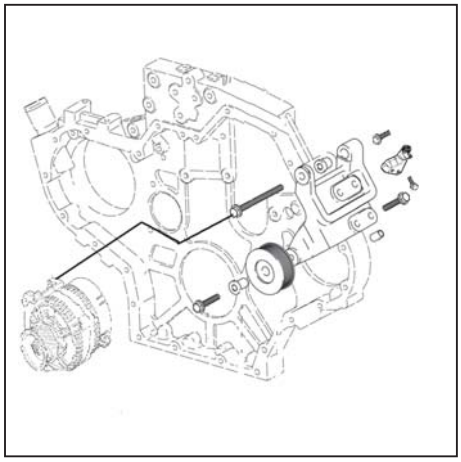
Alternator – Removal

Remove the alternator mounting cap screws.
Remove the alternator.



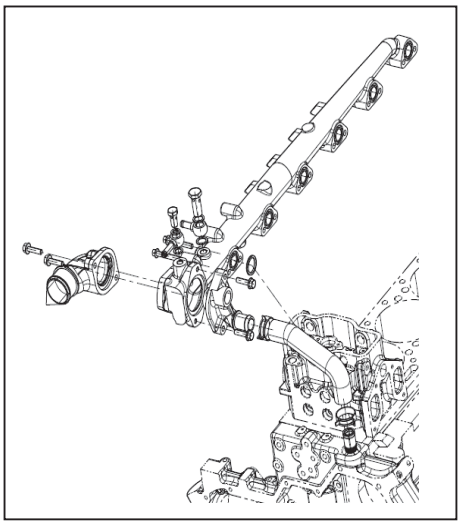
Alternator Mounting Bracket – Removal

Remove the alternator bracket mounting bracket.



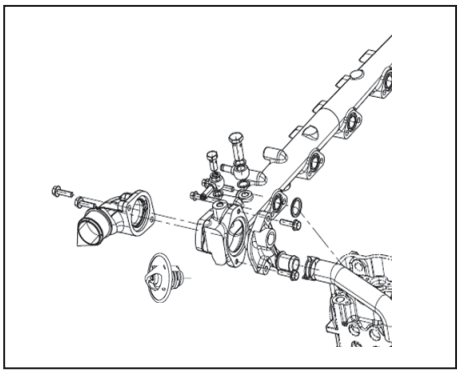
Coolant Outlet Connection – Removal

10 Mm
Remove the coolant outlet connection.
Discard the gasket.



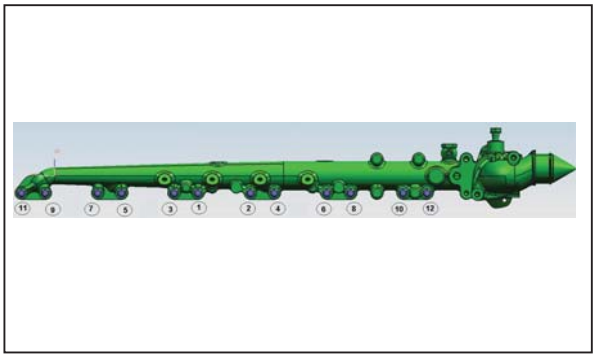
Thermostat – Removal

Pull the thermostat.

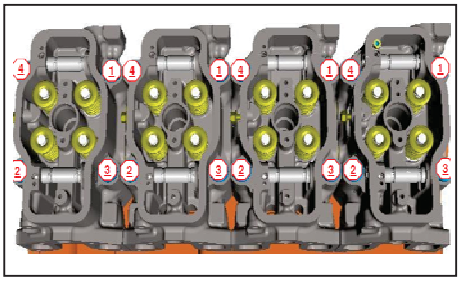


Water Outlet Manifold – Removal

10 mm
Remove the cap screws.
Discard the O-rings.

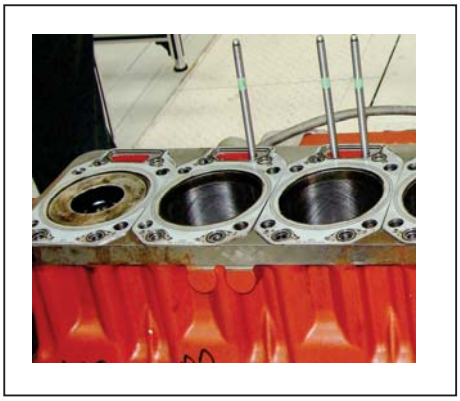


Cylinder Head – Removal



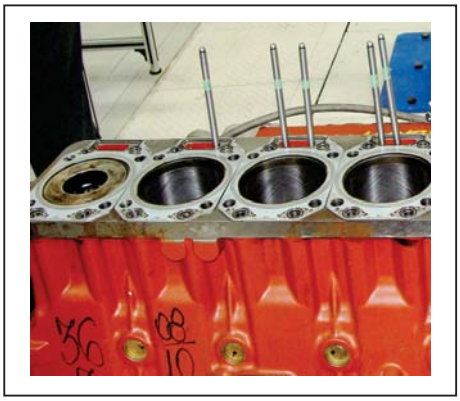
15 mm (Bi-Hex)
Loosen and remove the cylinder head cap screws in the illustrated sequence.

Note : To prevent damage to the combustion face , make sure the head is removed in a direct upward motion.



Discard the cylinder head gasket.

Push Rod – Removal



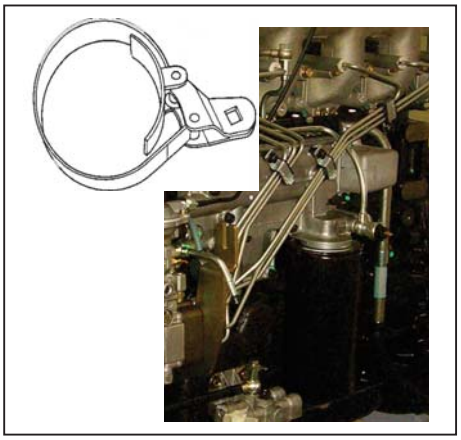
Pull the pushrod.

Lubricating Oil Filter – Removal

Remove the oil filter.

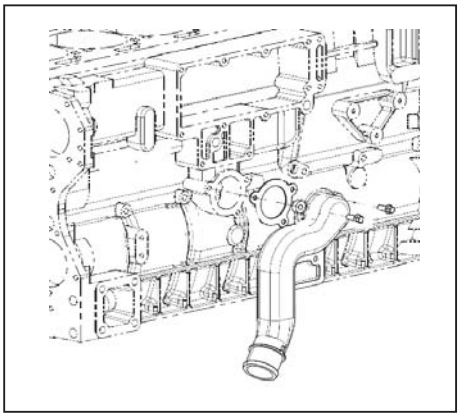
Lubricating Oil Cooler – Removal

10mm
Remove the oil cooler assembly.
Discard gasket.



Coolant Inlet Connection – Removal

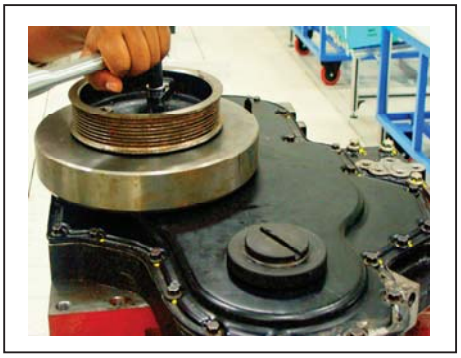
10 mm
Remove the cap screws.
Discard the gasket.



Vibration Damper – Removal

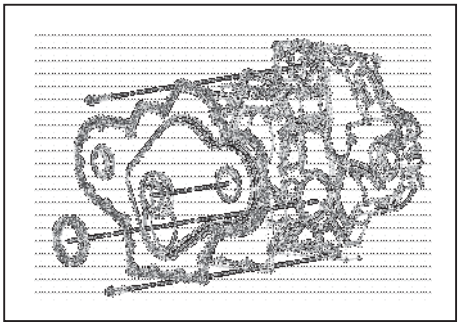
14 mm Allen

Remove the vibration Damper along with pulley.



Gear Cover – Removal

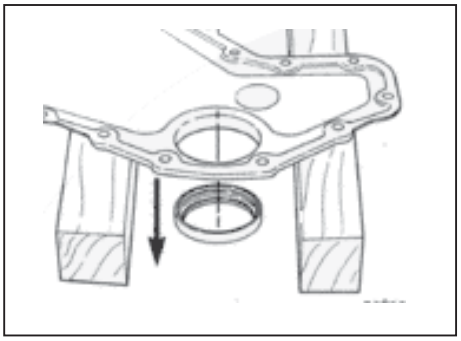
10 mm
Remove the cap screws.



Seal, Front Crankshaft – Removal

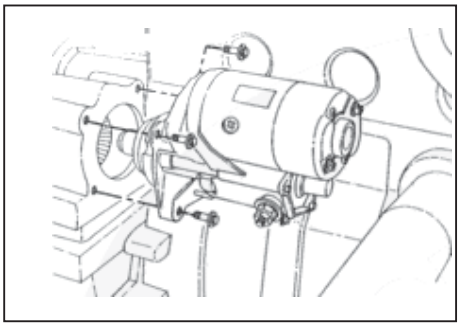
Hammer, Punch

Drive or press the seal out of the gear cover.
Discard the oil seal.



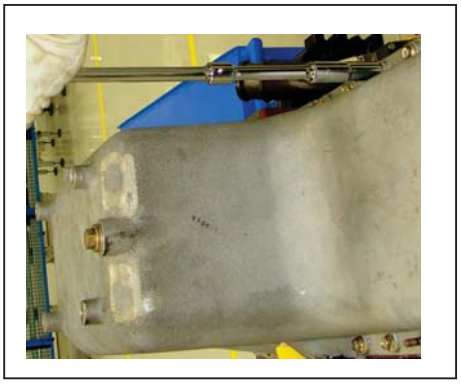
Starter Motor – Removal

Remove the three capscrews and the starting motor.



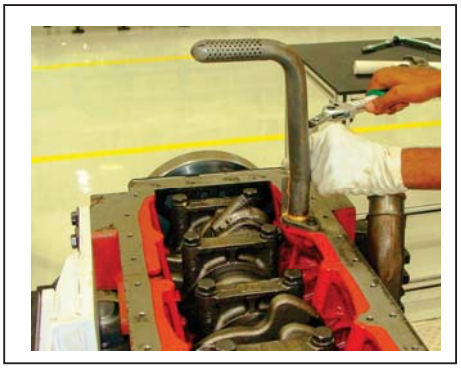
Lubricating Oil Pan – Removal

13 mm
Rotate the engine on rebuild stand and remove the oil pan and gasket.
Discard the gasket.



Lubricating Oil Suction Tube – Removal

10 mm
Remove the suction tube and O-ring.
Discard the o-ring.

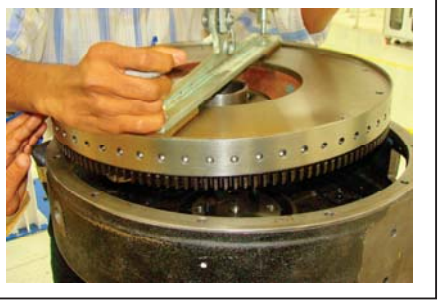


Flywheel – Removal

15 mm [alen]
Remove the cap screw 180 deg apart. Install two M12 x 1.25x90 mm guide pins.

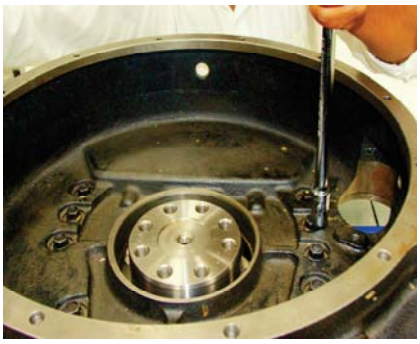
Note : Flywheel is heavy component.
Determine the cap screw thread design and size and install two “T-handles” in the flywheel at point a and b

Remove the six flywheel mounting cap screws.
Remove the flywheel from guide pin.



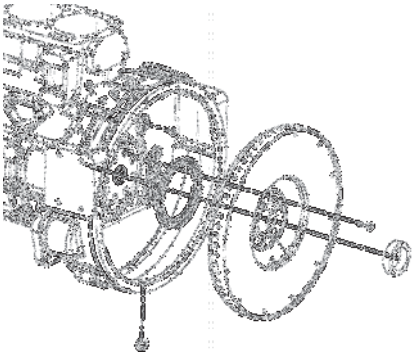
Flywheel housing - Removal

15 mm
Remove the flywheel housing.



Seal, Rear Crankshaft – Removal

Support the flywheel housing and press/drive out the seal.
Discard the seal.



Water Pump – Removal

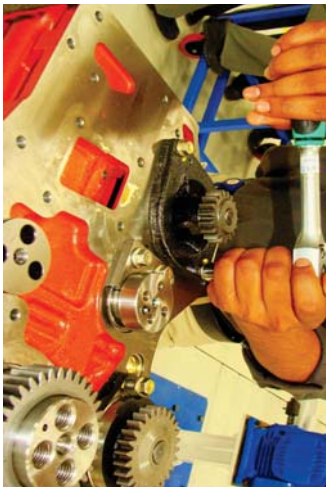
Water Pump Gear Backlash – Measurement.

Position the indicator on a tooth of the gear.

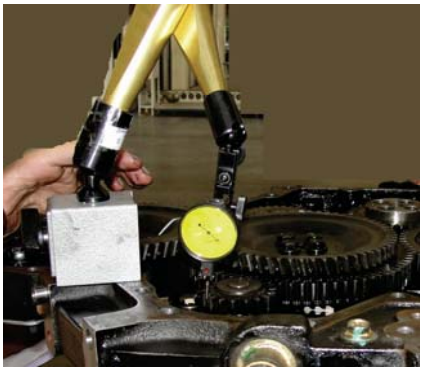
Note the camshaft gear backlash (a).k the camshaft gear and crankshaft gear for further analysis if backlash exceed limits.

Water Pump Gear Backlash limits

MIN	**0.05**	**mm**
MAX	**0.25**	**mm**



13 mm
Remove the cap screws.
Tighten these screws at point (a) to push the water pump against cylinder block.
Remove and discard the o-ring.



Lubricating Oil Pump Gear Backlash – Measurement.

Position the indicator on a tooth of the gear.

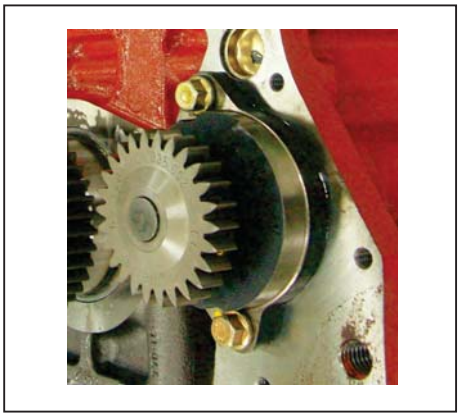
Note the camshaft gear backlash (a).k the camshaft gear and crankshaft gear for further analysis if backlash exceed limits.

Oil Pump Gear Backlash limits

MIN	**0.05**	**mm**
MAX	**0.25**	**mm**

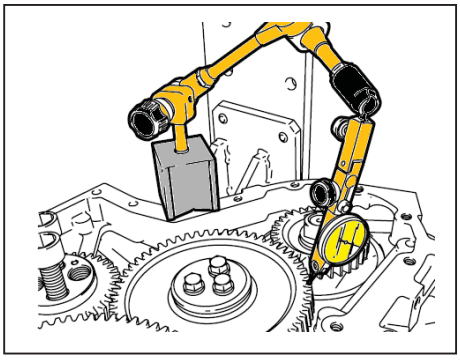
Lubricating Oil Pump – Removal

13 mm
Remove the lubricating oil pump.
NOTE: Refer to procedure for cleaning and inspection.



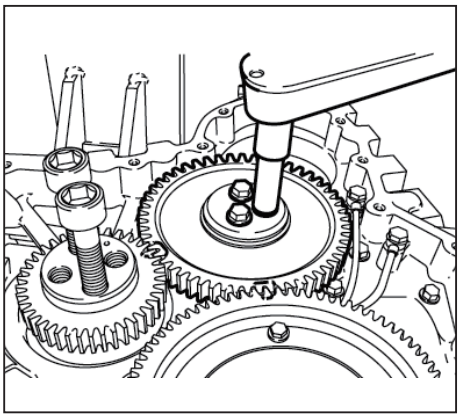
Intermediate Gear – Removal

Gear Backlash Measurement
Position an indicator on a tooth of the idler gear.
Note the idler gear backlash (a).k the idler gear and crankshaft gear for further analysis if backlash exceed limits.



Idler Gear Backlash limits

MIN	**0.05**	**mm**
MAX	**0.25**	**mm**

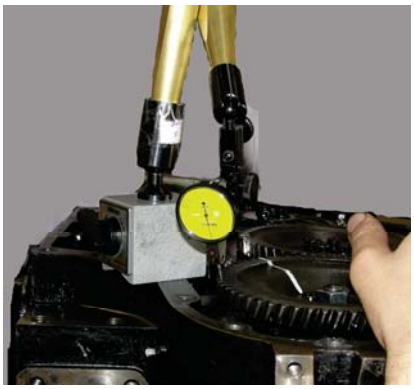


NOTE: Hold the adjoining gear from moving when checking backlash or the reading will be the total for both gears

13 mm
Remove the idler gear.

Camshaft – Removal

Gear Backlash Measurement
Position an indicator on a tooth of the camshaft gear.
Note the camshaft gear backlash (a).k the camshaft gear and crankshaft gear for further analysis if backlash exceed limits.



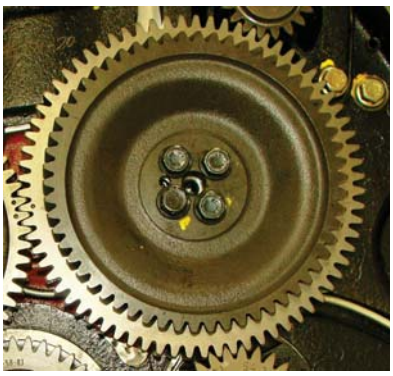
Camshaft Gear Backlash limits

MIN	**0.05**	**mm**
MAX	**0.25**	**mm**

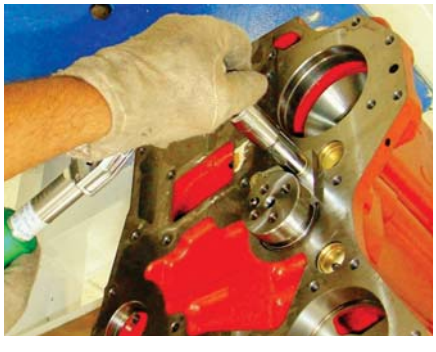
NOTE: Hold the adjoining gear from moving when checking backlash or the reading will be the total for both gears.

Align the timing mark on the gears.
Refer to procedure

13 mm
Remove the camshaft gears.



10 mm
Remove the camshaft thrust plate cap screws.



Remove the camshaft and thrust plate from the cylinder block. Take care not to drop the thrust plate.

NOTE: Refer to procedure for camshaft cleaning and inspection.

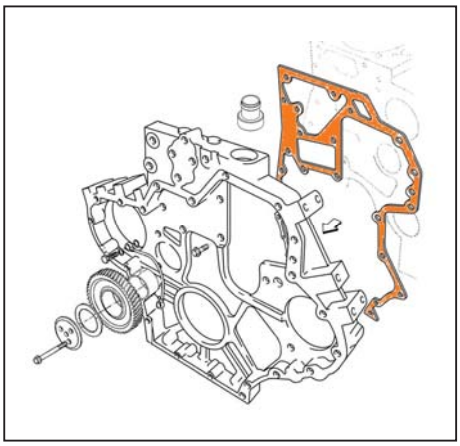
Valve Tappet – Removal

Remove the valve tappets and mark for location as illustrated.

CAUTION: When reusing the camshaft and tappets, the tappets must be matched to their companion lobe on the camshaft to prevent accelerated camshaft wear. Discard tappets that were not marked during removal.

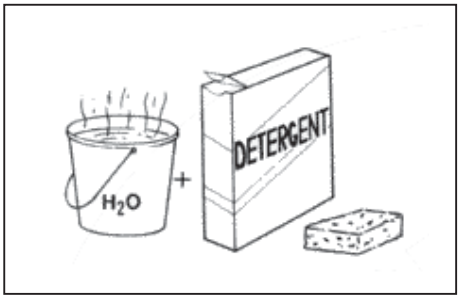
Gear Housing – removal

13 mm
Remove the cap screws, gear housing and gasket.
Discard the gasket.

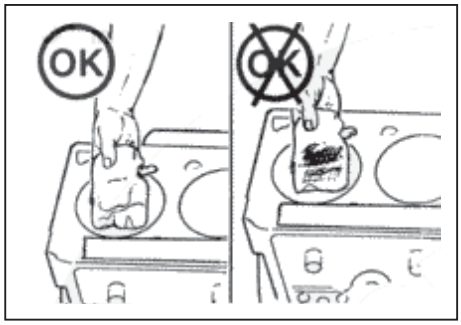


Cylinder Liner Carbon Deposits – Removal

For cleaning the cylinder block a strong solution of hot water and detergent to clean the cylinder bore.

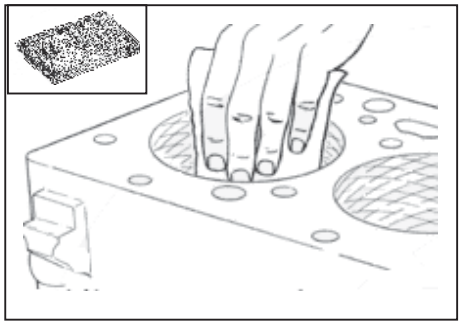


Caution: Do not use emery cloth or sandpaper to remove the carbon from the cylinder liners & cylinder block and
cylinder head mounting surface. Aluminum oxide or silicon particles from emery cloth or sand paper can cause serious engine damage.



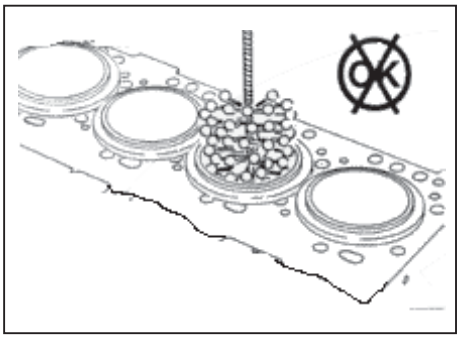
Rotate the crankshaft to expose the carbon ridge above the ring travel area in the cylinder liner.

Warning: When performing the following procedures, wear eye protection. Also, if the brush is motor driven, make sure the wire brush is rated for the RPM being used.



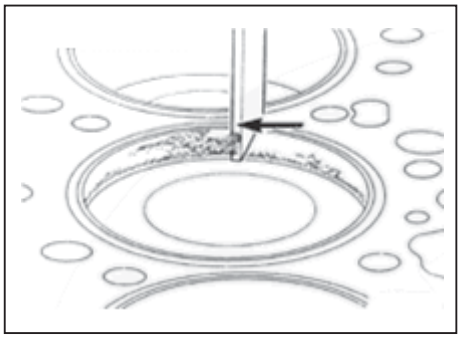
Use a rotary wire brush to remove the carbon ring from the top of the cylinder liner.

Do not use the steel wire wheel in the piston travel area.
Operate the wheel in a circular motion to remove the deposits.



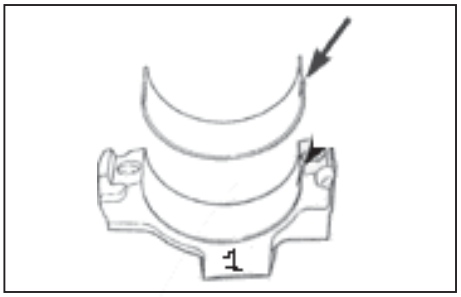
Use lint-free paper to remove all the broken wire bristles and loose carbon from the cylinders.

If a rotary wire brush is not available, use a scrapper that has an aluminum blade.
Use a fine fibrous abrasive pad such as Scotch-Brite or equivalent, to remove the remaining carbon.

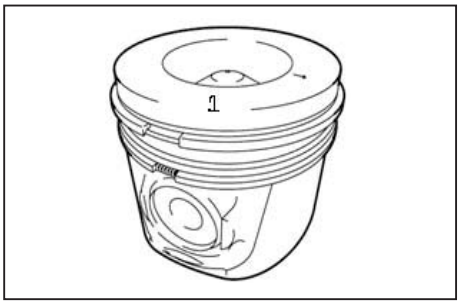


Piston Assembly – Removal

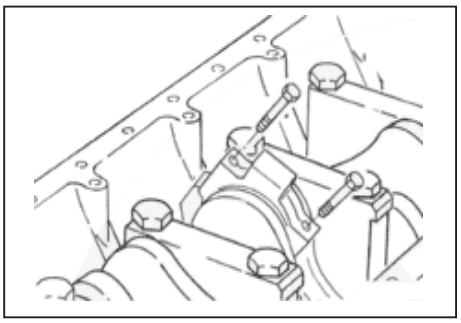
Mark each connecting rod cap according to cylinder number.



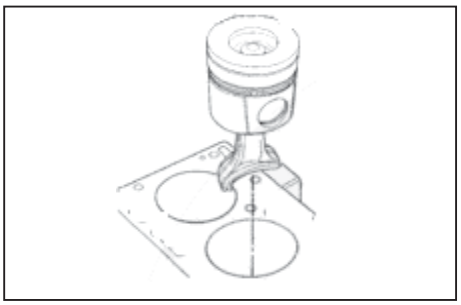
Mark each piston according to the corresponding cylinder number.



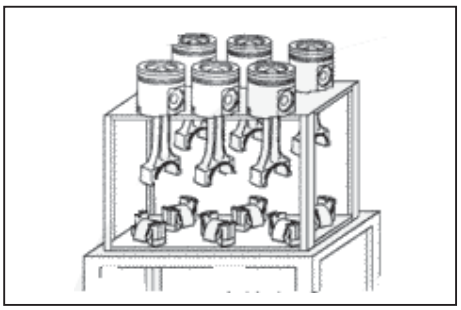
15 mm (Bi- Hex), Plastic Hammer
Remove the bolt from connecting rod cap.
Remove the lower connecting rod bearing. Mark the cylinder number and the letter “L” (lower) in the flat surface of the bearing tang.



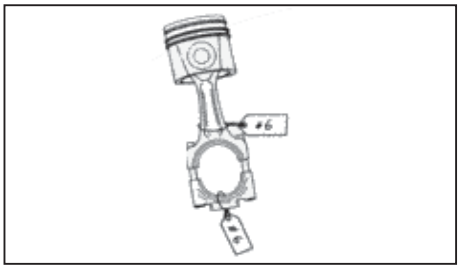
Catch the piston with one hand while pushing the connecting rod and piston assembly out of the cylinder bore. Care must be taken not to damage the crankshaft journal.



Place the connecting rod and piston assemblies on a rack to protect them from damage.
Note: The piston and connecting rod assemblies must be installed in the same cylinder number they were removed from to be sure proper fit of worn mating surface if parts are used again.

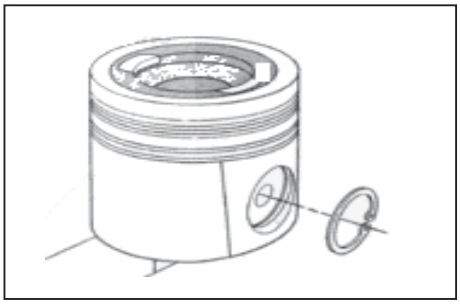


Use a tag to mark the cylinder number each piston and connecting rod assembly was removed from.



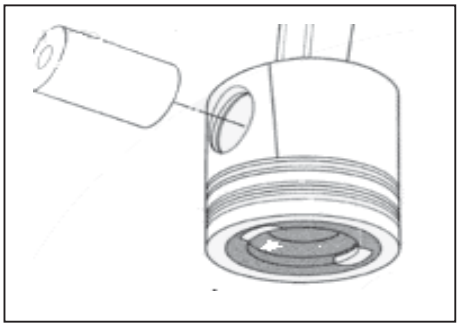
Piston Pin – Removal

Use internal snap ring pliers to remove the retaining rings from both side of the piston.



Remove the piston pin.

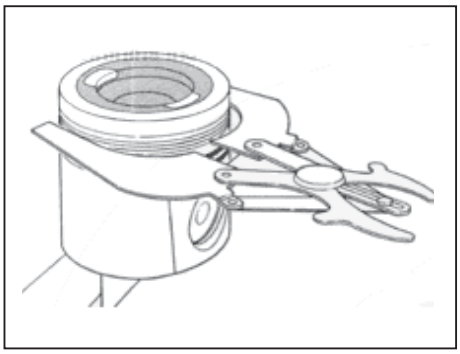
NOTE: Heating the piston is not recommended.



Piston Ring – Removal

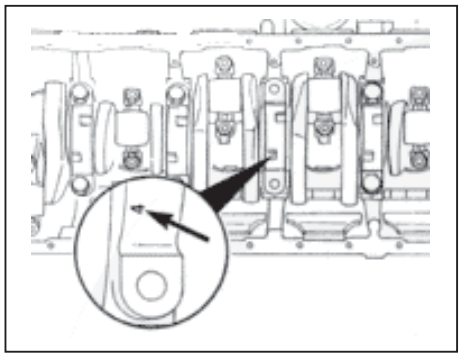
Piston Ring Expander.

Use piston ring expander to remove the piston rings.



Place a tag on the piston rings and record the cylinder number of the piston on the tag.

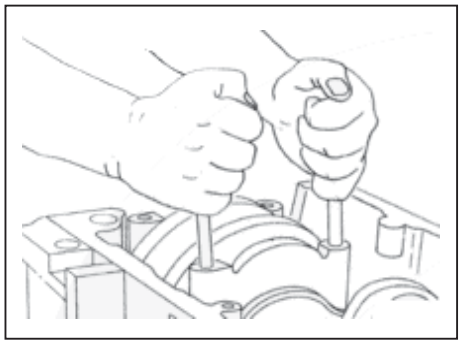
Main Bearing Cap – Removal



22 mm
Rotate the engine to a horizontal position and remove the main bearing cap screws.

The main bearing caps should be numbered.

Use a steel stamp to mark any main bearing cap with out a number before the main bearing cap is removed.

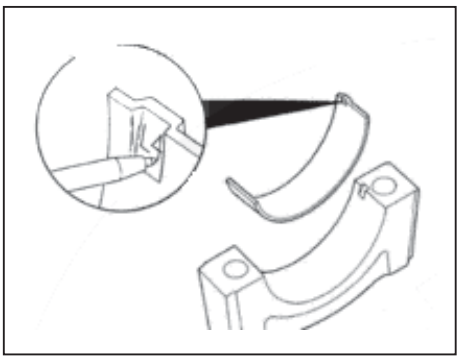


Remove the main bearing caps.

Do not prey on the main bearing caps to free them from cylinder block.

Use two main bearing cap capscrews to “wiggle” the main bearing cap loose, being careful not to carnage the capscrews thread.

Main Bearing (Lower) – Removal

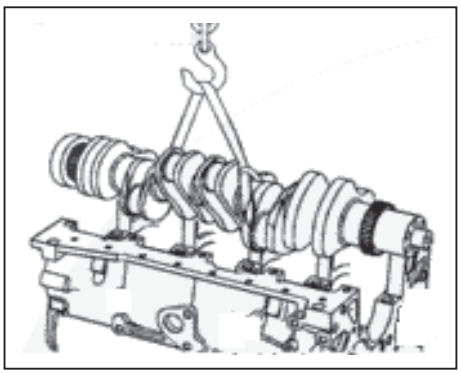


Remove the lower main bearing shells from the main bearing caps.
Mark the main bearing shells with the journal number they were removed from in the flat surface of the main bearing tang.

Do not mark on the main bearing to crankshaft mating surface. Damage to the engine can result if the main bearings are used again.

Crankshaft – Removal

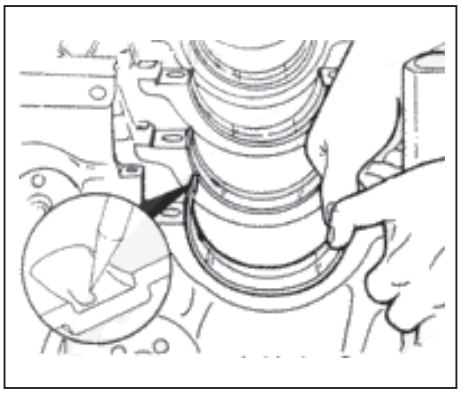
The component weight is more than 25 kg. To avoid personal injury, use a hoist or get assistance to lift the component.



Lift the crankshaft straight up to avoid damage to the crankshaft or cylinder block.

Install nylon lifting sling around the number “3” and “4” rod bearing journal. Attach the sling to a hoist and remove the crankshaft.

Main Bearing (Upper) – Removal.



Use both thumbs to remove the upper main bearing shells.

Mark the main bearing shells with the journal number they were removed from in the flat surface of the main bearing tang.

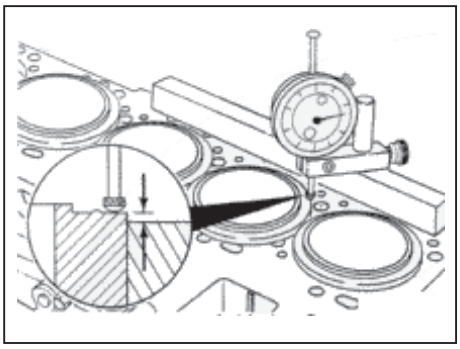
Do not mark on the main bearing to crankshaft mating surface. Damage to the engine can result if the main bearings are used again.

Piston Cooling Jet – Removal

12 mm
Remove the banjo and piston cooling jet.

Cylinder Liner Protrusion - Checking

Cylinder liner protrusion is the distance the cylinder liner protrudes above the block face. Before removing the liners, check the protrusion in the “undamped” state.

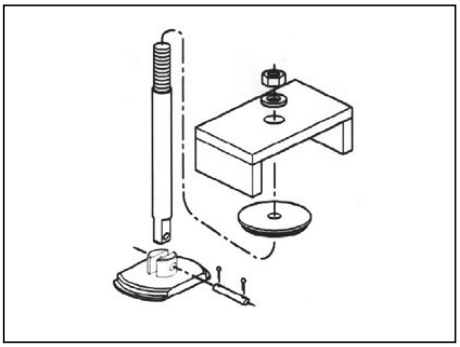


Cylinder Liner Protrusion

Max 0.02 mm

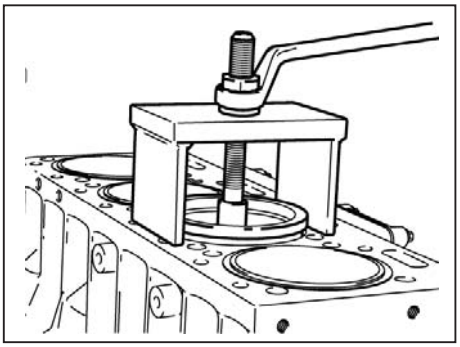
Cylinder Liner – Removal

Use service tool



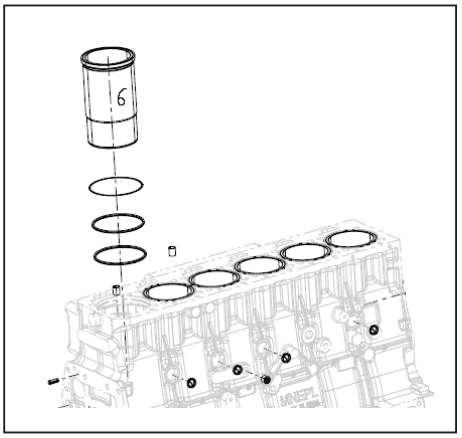
Caution: Cylinder liner puller must be installed and used as described to avoid liner / block damage.

Insert the cylinder liner puller in the top of the cylinder block.



Turn the cylinder liner jackscrew clockwise to loosen the cylinder liner from the cylinder block.

Use both hand to remove cylinder liner.



Mark the cylinder number on each cylinder liner.
Remove and discard the o-ring and shim.

Expansion Plug – Replacement

All expansion plugs must be replaced if the component is cleaned in a “hot tank”, spray washer or similar equipment. The cleaning activity can interrupt the sealing capacity of the sealant.

Expansion Plug – Removal

To remove expansion plugs:
Use a hammer and center punch to mark the expansion plug for drill.
Drill a 3mm hole in the expansion plug
Use a dent puller to remove the expansion plug

Cylinder Block – Removal from Engine Rebuild Stand

Remove the cylinder block from the engine rebuild stand.

The component weight is more than 25 kg. To avoid personal injury, use a hoist or get assistance to lift the component.

Refer to procedure for cleaning and inspection of the cylinder block.

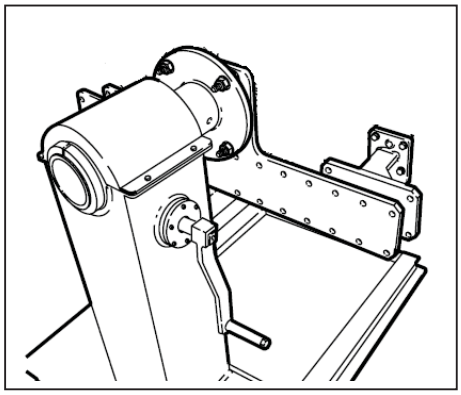
NOTES

Maintenance Table

Group - 04

Cylinder Block – Installation onto Engine Rebuilt Stand.

NOTE: The component weight is more than 25 kg. To avoid personal injury, use a hoist or get assistance to lift the component.

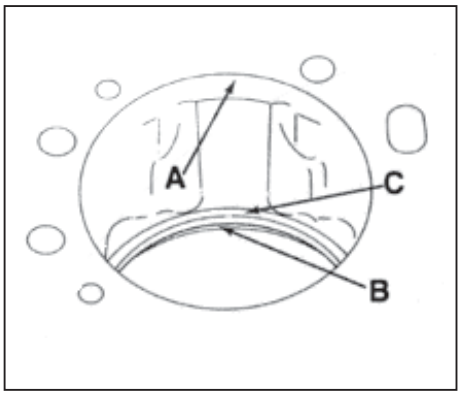


Use a hoist, Engine lifting sling to lift the cylinder block

Use engine build stand.

Cylinder Liner – Installation

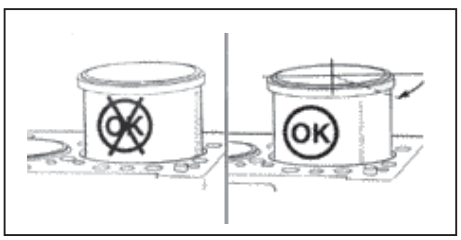
Caution: Clean all deposits and debris from sealing surface A,B and C. Use scotch-brite or equivalent and cleaning solvent to polish the surface. However, due to critical machined tolerance, care should be taken not to remove any additional material.



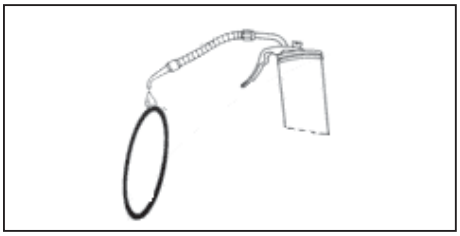
Refer procedure in workshop manual for cylinder liner counterbore inspection.

Lubricate surface A and B with clean 15W-40 engine oil.

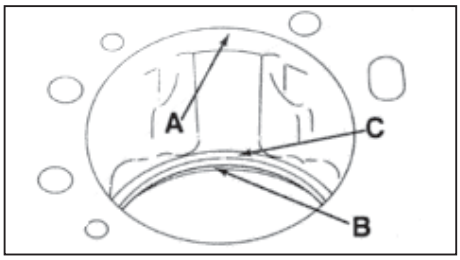
Note: When reusing liners, install the liner in the same cylinder from which they were removed and rotate them 45 degrees from their original position. When correctly installed, any cylinder liner pitting should be positioned as illustrated so that pitting surface is rotated away from the location where pitting occurs.



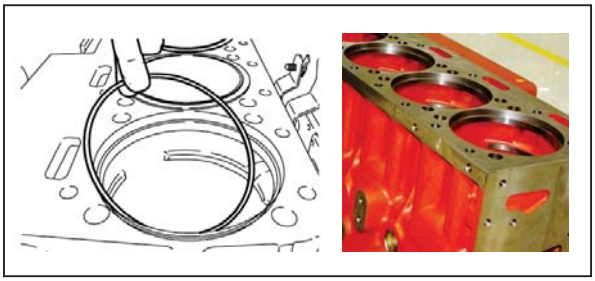
Use clean 15W-40 engine oil to coat the cylinder liner o-ring seals.



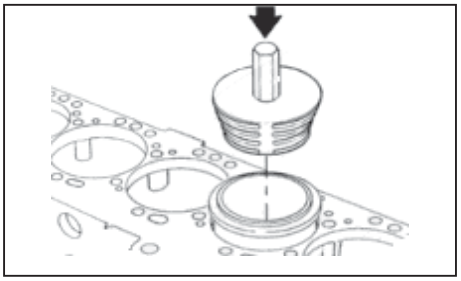
Install the two numbers o-ring seals in cylinder block groove.



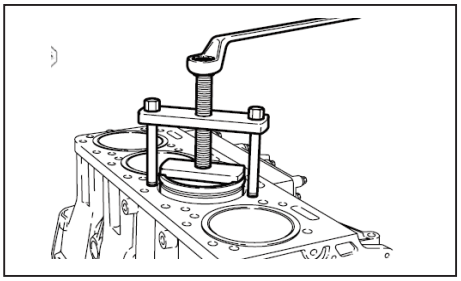
Install the cylinder liner shims.



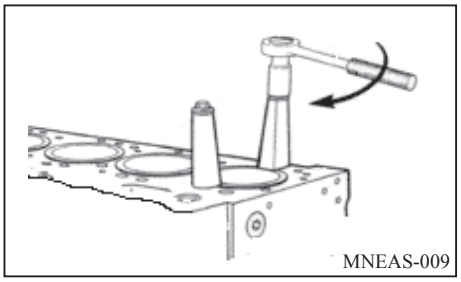
Install the cylinder liner into the block. Use liner installation tool.



Use cylinder liner driver and leather mallet to drive the cylinder liner into the bore.



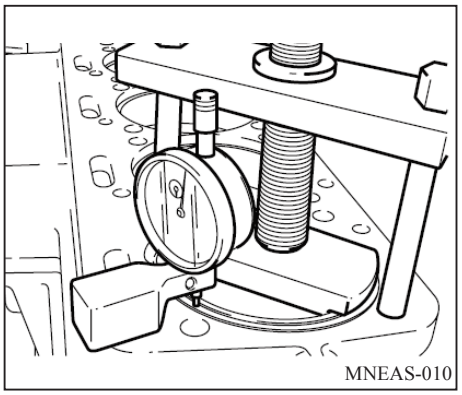
NOTE: If the cylinder liner does not rest on the cylinder block counterbore seat, remove the cylinder liner. Inspect the counterbore seat and cylinder liner for nicks, burrs or dirt. Install the cylinder liner.


MNEAS-009

Cylinder liner protrusion is the distance the cylinder liner protrudes above the block face. Before removing the liners, check the protrusion in the “undamped” state.

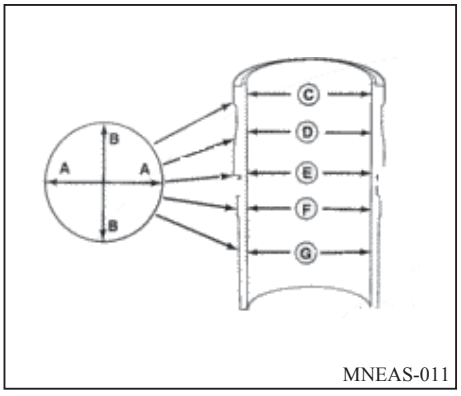
Cylinder Liner Protrusion

Max	**0.10 mm**
Min	**0.03 mm**


MNEAS-010

Measure the cylinder liner bore for out of roundness at points “C”,”D”,”E”, AND “G”. Measure each point in the direction “AA” and “BB”. The cylinder liner bore must not be more than 0.02 mm out of roundness.

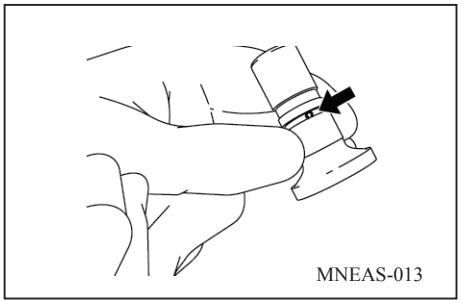
NOTE: If the cylinder liner bore is more than 0.02 mm out of round:
Remove the cylinder liner so the cylinder block liner bore can be measured.



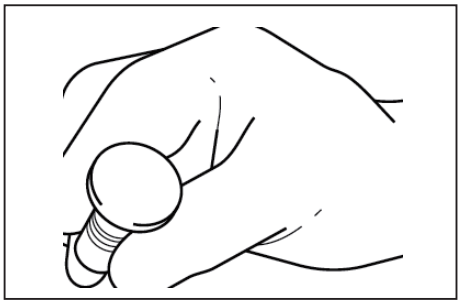
MNEAS-011

Valve Tappet – Installation

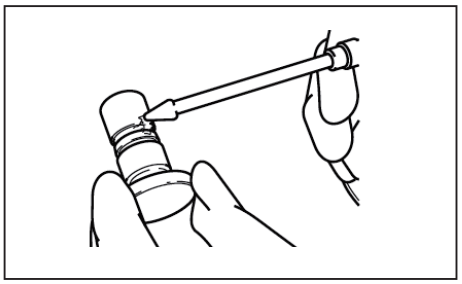
Caution: Observe the following guidelines for tappet installation.
When reusing the camshaft and tappets, the tappet must be matched to their companion lobe on the camshaft. If the tappet were not marked upon removal, they must not be reused.


MNEAS-013

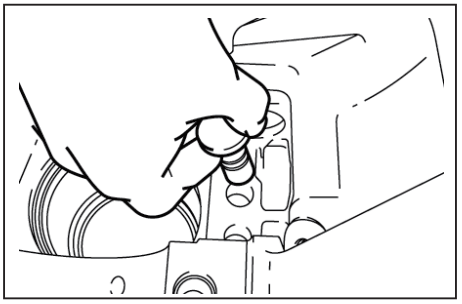
Do not install used tappets with a new camshaft.
Mixed of new and used tappets when reusing the camshaft is permissible, providing the used tappets are kept with there companion lobes of the camshaft.



Lubricate the tappets heads stem and sockets with fresh engine oil 15W-40.
Install the valve tappets.



Install the tappets.

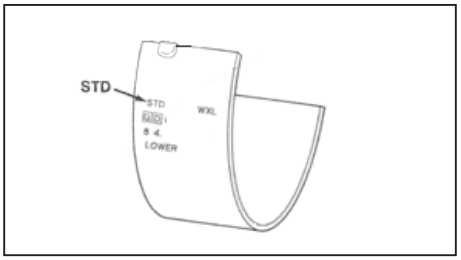


Piston Cooling Nozzle – Installation

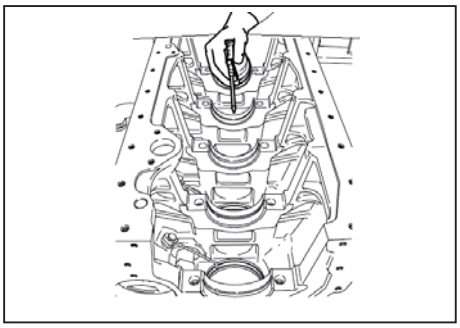
12 mm
Tighten the banjo bolt and install the piston cooling nozzle.

Main Bearing (Upper) – Installation

The upper bearings contain one oil holes. The lower bearings do not. Both upper and lower main bearings are marked on the back to indicate either standard (STD) or oversize (OS) thickness.

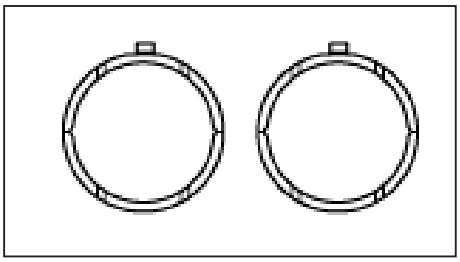


Caution: The pin must be present on the block bearing surface.



Install upper main bearing shell.

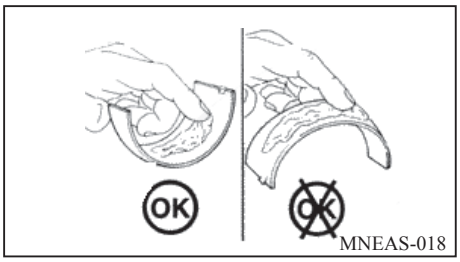
Note: If used bearing shells are to be installed, each must be installed in its original location in the engine.
The main bearing journal number should have been marked in the bearing tangs during disassembly.



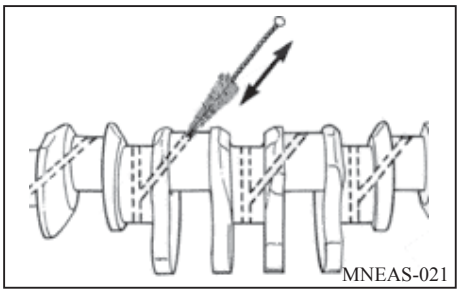
Note: The thrust bearing is at main bearing 1.

Lubricate the main bearing with clean engine oil 15W-40.

Caution: Do not lubricate the back of the main bearing.
Prevent dirt from mixing with the lubricant. Dirty lubricant will accelerate main bearing wear.

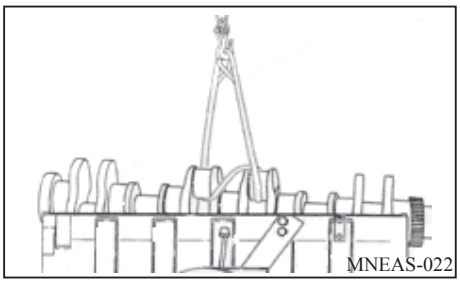


Crankshaft – Installation
Use a lint free cloth. Clean the crankshaft bearing journals.
Ensure there are no chips / burrs present in oil holes.



NOTE: The component weight is more than 25 kg. To avoid personal injury, use a hoist or get assistance to lift the component.

Use hoist and nylon lifting sling.



Install the sling around the numbers “3” and “4” connecting rod bearing journals.

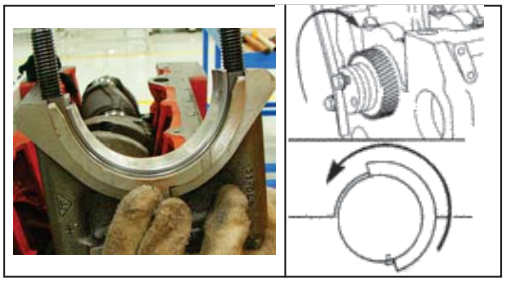
Do not damage or move the main bearing shells when the crankshaft is installed.

Install the crankshaft.

Main Bearing (Lower) – installation

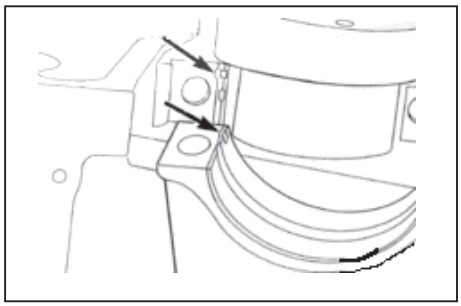
Install the lower main bearing shells with the tang in the slot of the main bearing cap.
Use clean engine oil 15W-40 to coat the inside diameter of the main bearing shells.

Thrust Bearing – Installation
Install the thrust pads at 7th Journal.



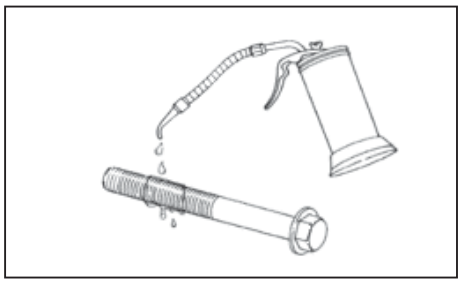
Main Bearing Cap – Installation

The main bearing cap is numbered from location no.1 starts with the flywheel side of block.



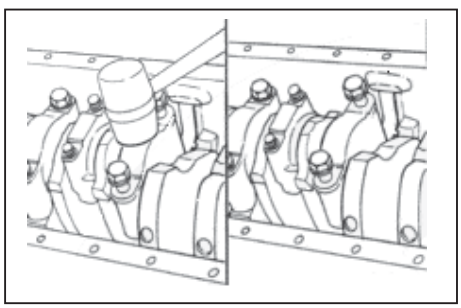
Position the main bearings and main bearing caps onto the crankshaft.

Care should be taken to be sure that thrust bearing is placed as shown in figure.



Lubricate the main bearing capscrew thread and underside of the capscrew head with clean engine oil.

Small Plastic or Rubber Mallet
Tap the main bearing cap gently into position.



Make sure the main bearing is still aligned with the cap.

When seated, the main bearing capscrew can be threaded in by hand.

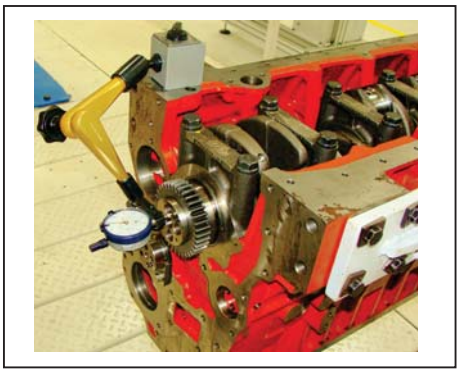
22 mm

Tighten the main bearing capscrews evenly following the illustrated sequence.

Torque Values:

Step		
1	**50**	**Nm**
2	**90**	**Degree**
3	**60**	**Degree**

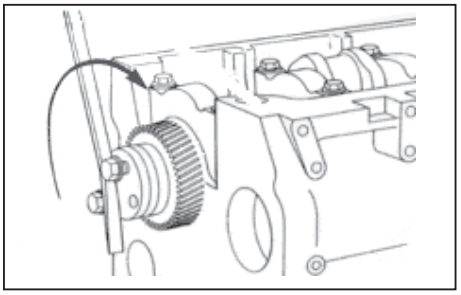
The crankshaft must rotate freely after the main bearings have been torqued.



Check the main bearing installations and the size of the main bearings if the crankshaft does not rotate freely.

Measure the end clearance of the crankshaft as follows:

- Install a dial indicator to the oil pan flange.
- Put the tip of the gauge against the crankshaft counterweight.
- Push the crankshaft towards the rear of the cylinder block.
- Slide the dial indicator at zero.
- Push the crankshaft towards the front of the cylinder block.



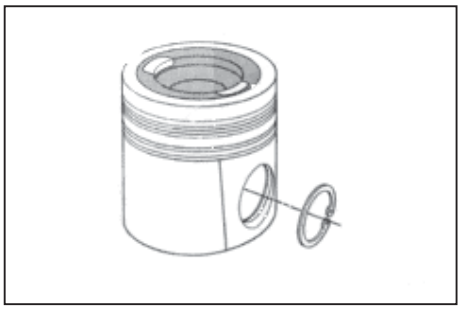
- If the end clearance is less than 0.08 mm , do the following.

- Loosen the main bearing capscrews on turn.
- Push the crankshaft towards the front and then towards the rear of the cylinder block.

Tighten the main bearing capscrews in the sequence shown to the torque values listed in the installation procedure.

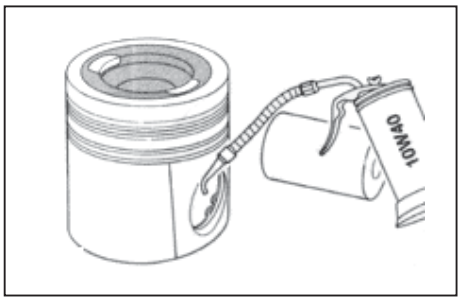
Piston Pin – Installation

Use clean 15W-40 engine oil to coat the connecting rod piston pin bore and piston pin.



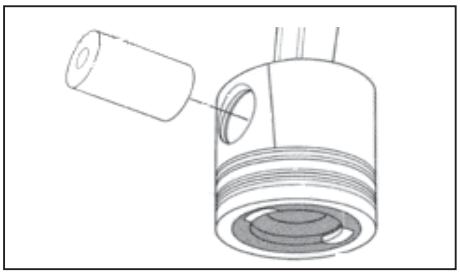
Caution: Be sure Mark on piston and the number on connecting rod and connecting rod cap are oriented as illustrated.

Snap Ring Pliers



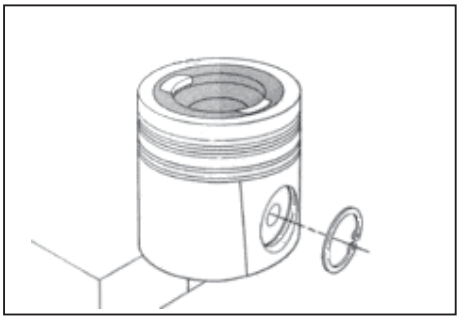
NOTE: Piston do not require heating to install the piston pin, however, the pistons do need to be at room temperature or above.

NOTE: The retaining ring must be seated completely in the piston bore to prevent engine damage during engine operation.



Install a new retaining ring into the piston pin bore.

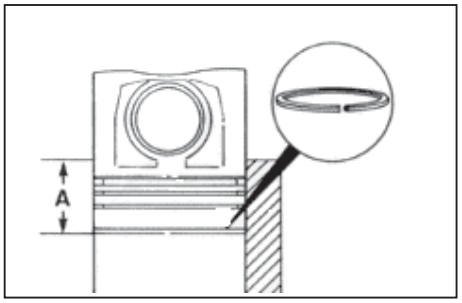
Align the piston pin bore of the connecting rod with the piston pin bore of the piston and install the piston pin.



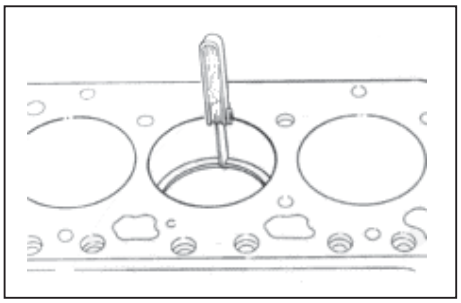
Install the second retaining ring.

Piston Ring End Gap – Measurement

Rotate the engine on the rebuild stand until the crankshaft is vertical and the crank gear is facing down word.



NOTE: If the engine is rotated more than 90 degrees, the valve tappets can fall out.



To check the piston ring gap, use the top end of the piston to align the piston rings in the wear area of the cylinder liner in which they will be used.

Use a filler gauge to measure the piston ring gap. Replace the ring if it does not meet the following specifications:

New Piston Ring Gap in mm

	mm	
TOP	**0.30**	**MIN**
	0.55	**MAX**
INTERMEDIATE		
	0.60	**MIN**
	0.85	**MAX**
OIL CONTROL		
	0.25	**MIN**
	0.55	**MAX**

NOTE: Add 0.09 mm for every 0.03 mm of cylinder liner bore wear up to the maximum worn limit.

Identify the ring set for installation in the cylinder in which the end gap was measured.

Piston Ring – Installation

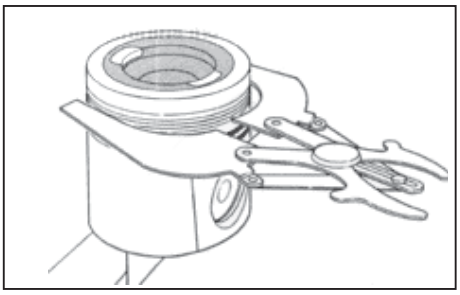
The top surfaces of the upper and intermediate rings are identified by MARK.
Assemble with the mark facing upward.
The bottom or oil ring can be installed with either side up.

NOTE: The two- piece oil control ring must be installed with the expander ring gap 180 degrees from the gap of the oil ring.

Piston Ring Expander

Install the rings on the piston.

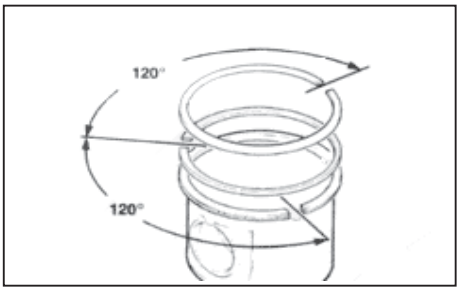
Position the oil ring expander in the oil control ring groove.



Install the oil control ring with the end gap opposite the end on the expander.

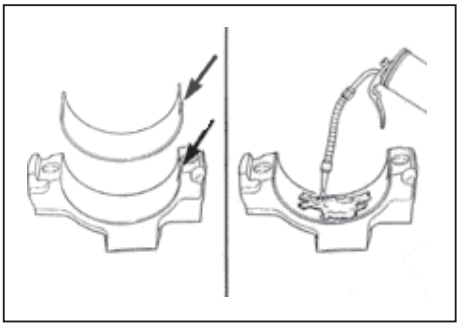
Install the intermediate ring.

Install the top ring.

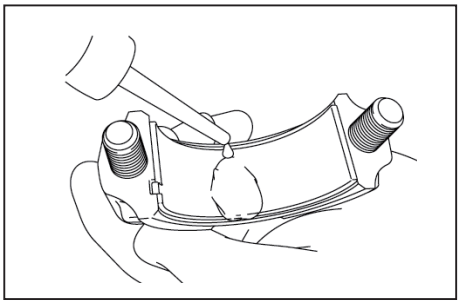


Piston Assembly – Installation

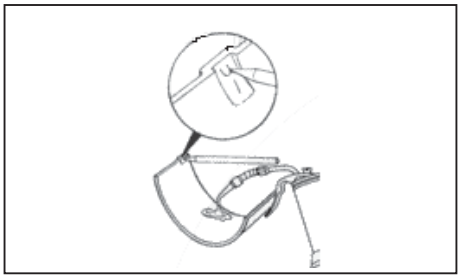
Install the connecting rod bearing shells into both the connecting rod and connecting rod cap. Make sure the tang on the connecting rod bearing shell is in the slot of the connecting rod cap and connecting rod.



Connecting rod bearing are marked on the back to indicate either standard (STD) or oversize (OS) thickness.

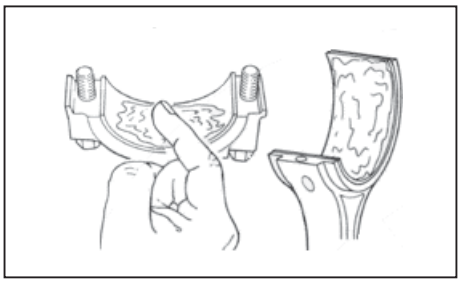


NOTE: If used connecting rod bearing shells are to be installed, each bearing shell must be installed in its original location.



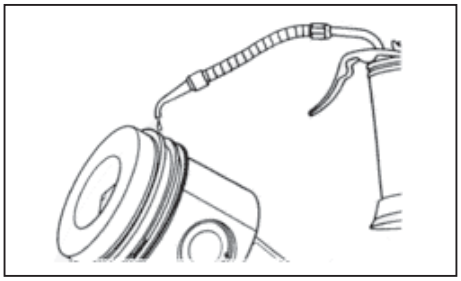
Caution: Do not lubricate the back of the connecting rod bearing shells.

Caution: Prevent dirt from mixing with the lubricant.
Dirty lubricant will accelerate connecting rod bearing wear.

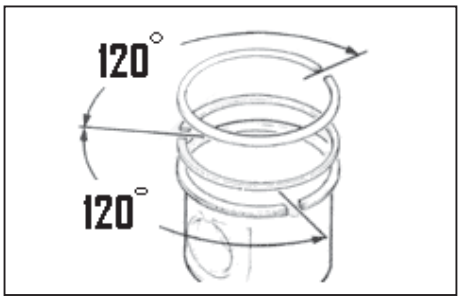


Lubricate the connecting rod bearings with a light film of 15W-40 clean engine oil.

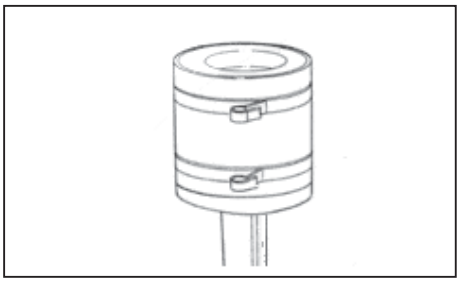
Lubricate the piston rings and piston skirts with clean 15W-40 engine oil.



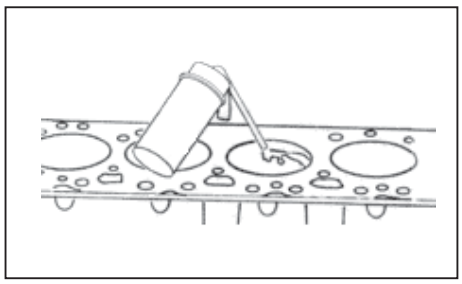
Position the ring gap 120 degrees apart.



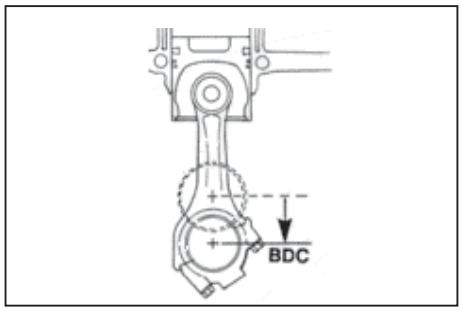
Piston Ring Compressor
Compress the rings using the piston ring compressor.



Use clean lint – free cloth to clean the crankshaft bearing journals.



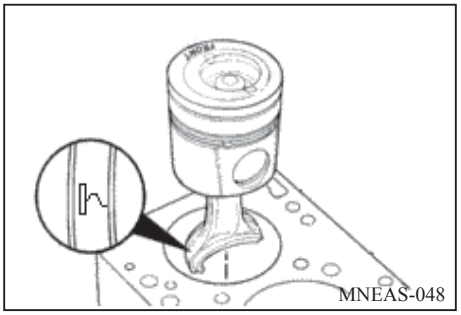
Use a clean lint-free cloth to wipe the cylinder bores. Lubricate the cylinder bore with clean 15W-40 engine oil.



Rotate the crankshaft to position the journal for the connecting rod , which is being installed , at bottom dead centre (BDC)

Caution: Be sure Mark on piston and the numbers on the connecting rod and connecting rod cap are oriented as illustrated.

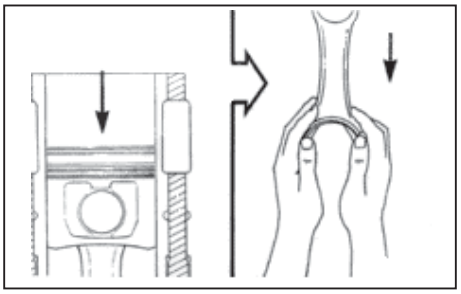
Caution: Use care when installing the piston and connecting rod co the cylinder bore is not damaged.



Position the piston and connecting rod assembly into the cylinder bore with the MARK on the piston towards the front of the cylinder block.

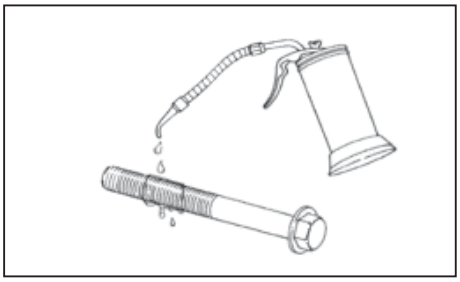
Hold the piston ring compressor against the cylinder liners. Push the piston through the ring compressor and into cylinder liner.

Note: If the piston does not move freely, remove the piston and inspect for broken or damaged rings.



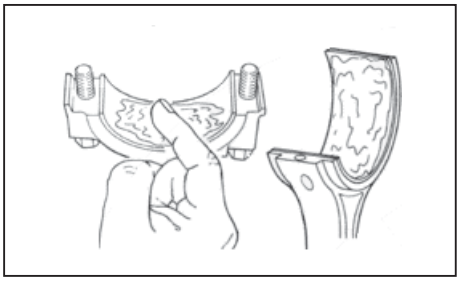
Push the piston into bore until the top of the piston is approximately 50 mm below the top of the bore. Then pull the connecting rod into the crankshaft journal.

Use clean 15W-40 engine oil to lubricate the threads of the connecting rod capscrews.



Note: The number marked on the connecting rod and the connecting rod cap must be the same. The tang slot side of the connecting rod cap must be on the same side as the tang slot in the connecting rod when the connecting rod cap is installed.

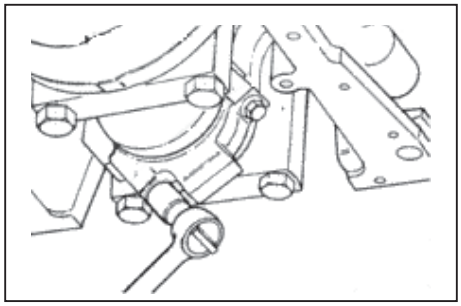
Use clean engine oil to cote the inside diameter of the connecting rod bearing shell.



Install the connecting rod cap and tighten the connecting rod bolts to specified torque and angle.

15 mm (Bi – Hex)
Alternately tighten the connecting rod bolts.

Step 1:	**40**	**Nm**
Step2:	**90**	**Degree**



Shake the connecting rod after tightening to verify side clearance.

Measure the side clearance between the connecting rod and the crankshaft.

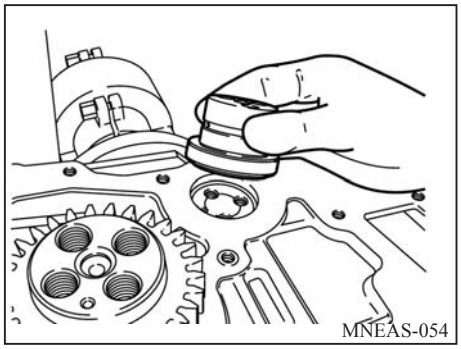
MIN	**0.30**	**mm**
MAX	**0.90**	**mm**

NOTE: The crankshaft must rotate freely.
Check for freedom of rotation as the connecting rod caps are installed. If the crankshaft does not rotate freely, check the installation of the connecting rod bearings and the bearing size.

Idler Shaft – Installation

NOTE: The three holes in idler shaft are not equidistant.

Push the idler shaft in the cylinder block counter bore, match the holes.

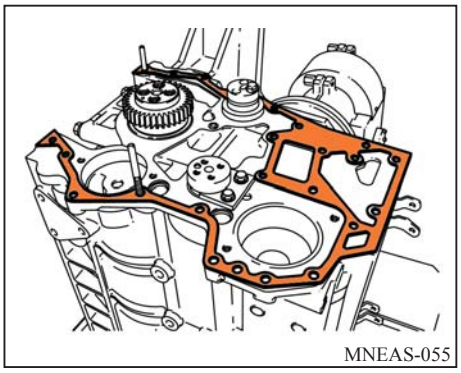


Gear Housing – Installation

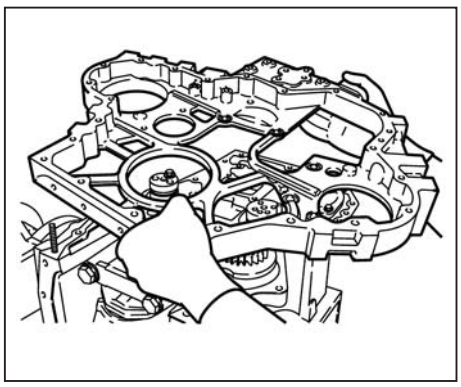
Install the two gear housing dowel pins, if removed.

NOTE: The tapered end of the dowel fits into the cylinder block. Drive the pin to the bottom of the hole.

Position the gasket onto the alignment dowels.



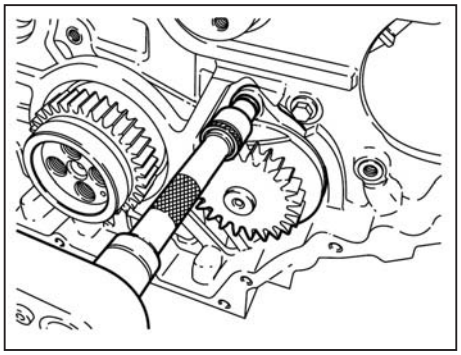
13 mm
Install the gear housing and its capscrews.



Lubricating Oil Pump – Installation

Lubricate the lubricating oil pump with clean 15W-40 engine oil.

NOTE: Fill the lubricating oil pump with oil during installation to aid in quicker oil suction when the engine is started.



13 mm
Tighten the lubricating oil pump capscrews

Torque Value:

MIN	**15**	**Nm**
MAX	**25**	**Nm**

Use a dial indicator with a magnetic base to measure the oil pump gear backlash.

Measure the gear backlash.

NOTE: Hold the adjoining gears from moving when checking backlash or the reading will be the total of both gears.

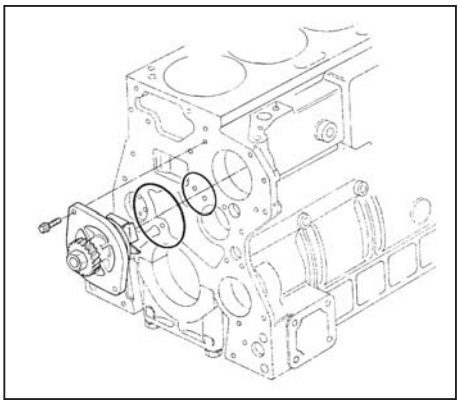
Oil Pump and Camshaft Gear Backlash

MIN	**0.05**	**mm**
MAX	**0.25**	**mm**

Water Pump - Installation

Install an o-ring into the groove on the water pump mounting flange.

Position the water pump assembly into the pump cavity of the cylinder block.



13 mm

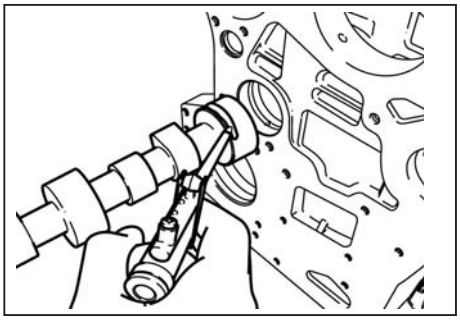
Tighten the water pump capscrews.

Torque Value:

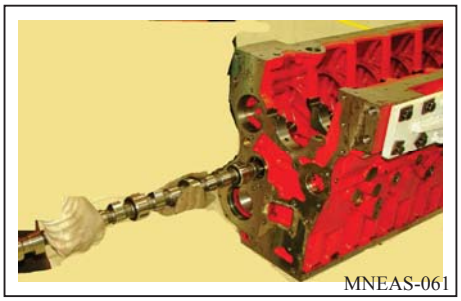
MIN	**15**	**Nm**
MAX	**25**	**Nm**

Camshaft – Installation

Lubricate the camshaft bore with LubriplateTM 105.

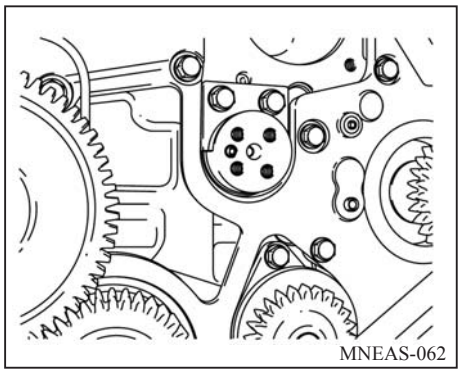


Service Tip: The crankshaft should be positioned with the No.6 cylinder at approximately top dead center (TDC), so the camshaft does not hit the crankshaft counterweight during installation.


MNEAS-061

Lubricate the camshaft journals and lobes , and thrust plate with clean engine oil 15W-40.

Caution: If the engine is in the vertical position, be sure the camshaft assembly does not drop on your fingers when installing the thrust plate.


MNEAS-062

Install the camshaft into the cylinder block up to last journal.

13 mm
Install the camshaft thrust place capscrews.
Torque value: 24 Nm

Measure the camshaft end clearance.

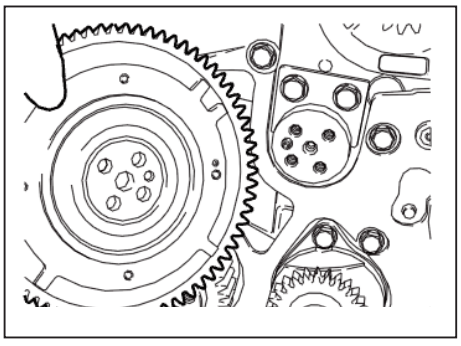
End clearance is controlled by the thickness of the thrust plate and the grove in the camshaft.


MNEAS-063

Camshaft End Clearance

MIN	**0.05**	**mm**
MAX	**0.19**	**mm**

Install camshaft front gear with 80 teeth.
Align the hole in gear with the dowel pin in camshaft face.



NOTE: The threaded holes in camshaft face are not equidistant.

Push the gear to fit on the camshaft.

13 mm

Tighten the 58 number teeth gear on the camshaft.

Torque Value:
Step 1

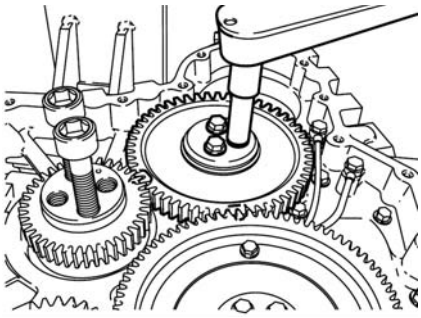
MIN	**14**	**Nm**
MAX	**16**	**Nm**

Step 2 : 30º

Idler Gear – Installation

NOTE: Idler gear bush must be free from dust. Apply a fine layer of clean engine oil 15W-40

13 mm
Install the gear by sliding over the shaft.
Install the thrust plate and tighten the three cap screws at specified torque.



Torque Value:

MIN	**55**	**Nm**
MAX	**65**	**Nm**

Timing Mark – Alignment (Between Idler, Crankshaft and Camshaft Gear)

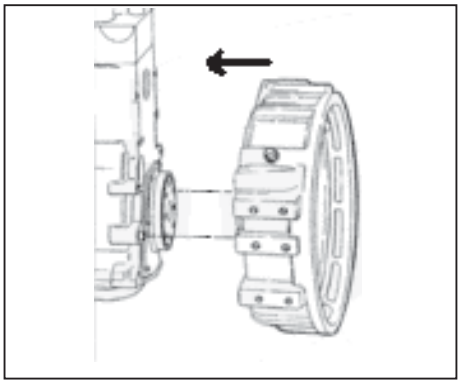
Align the timing mark

Be sure the camshaft backlash is correct.
Use dial indicator to measure backlash.
Cam Shaft Gear Backlash Limit

MIN	**0.05**	**mm**
MAX	**0.25**	**mm**

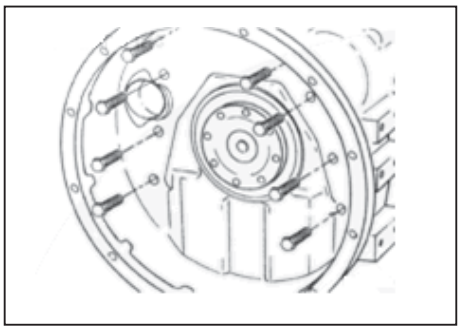
Flywheel Housing – Installation

Install the two dowel pins into the block of the cylinder block.
Drive the dowels in until they are against the bottom of the bore.



Install two M12 X 1.75 X 100 mm guide pins into the cylinder block to help support and align the flywheel housing during installation.

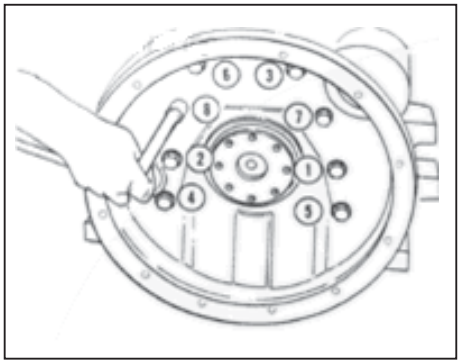
Visually inspect the rear face of the cylinder block and flywheel housing mounting surface for cleanliness and raised nicks or burrs.



Apply anabond on the rear face of the cylinder block and flywheel mounting surface.

Remove the two M12 X 1.75 X 100 mm guide pins.

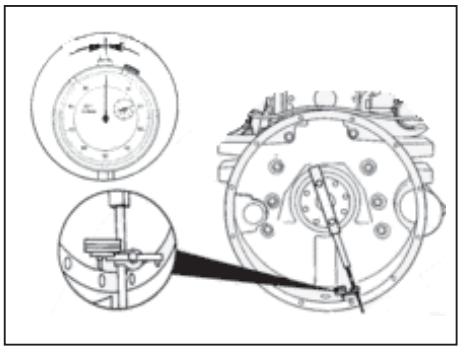
15 mm
Install and tighten the flywheel housing mounting capscrews using the pattern shown in the chart.



Torque Value:

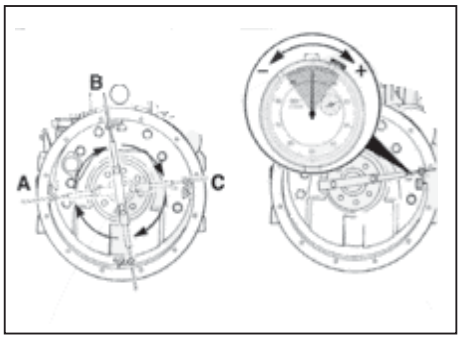
MIN	**95**	**Nm**
MAX	**105**	**Nm**

Flywheel Housing Bore – Concentricity Checking



Dial Gauge Attachment.
Attach a dial indicator to the crankshaft. The dial indicator can be mounted by any method that holds the extension bar of the indicator rigid so it does not sag. If the bar sags or the indicator slips , the reading obtained will not be accurate.

Position the indicator in the 6:00 o'clock position and zero the gauge.



Slowly rotate the crankshaft. Record the readings obtained at the 9:00 o'clock , 12:00 o'clock and 3:00 o' clock position as a,b, and c in the concentricity worksheet. Check zero at the 6:00 o'clock position again.

Rotate the crankshaft until the dial indicator is at the 12:00 o'clock position and zero the gauge.
Do not force the crankshaft beyond the point where the bearing clearance has been removed.
Do not pry against the flywheel housing. These actions could cause false bearing clearance readings.
Use a pry bar to raise the rear of the crankshaft to its upper limit. Record the value as [d] in the concentricity worksheet. This is vertical bearing clearance adjustment and will always be positive.

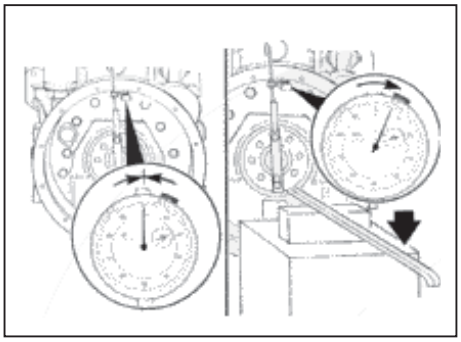
Use the concentricity work sheet to determine the value of the "total vertical" and "total horizontal" values.

The "total horizontal' is equal to the 9:00 o'clock reading , [a] , minus the 3:00 o'clock readings [c].

The “total vertical” is equal to the 12:00 o’clock reading [b] , plus the bearing clearance [d].

Example :

6:00 o’clock = ref = .000 mm
9:00 o’clock = ref = .102 mm
12:00 o’clock = ref = .076 mm
3:00 o’clock = ref = -0.051mm



Using the worksheet and the number from the example, the total horizontal value = 0.152 mm and the total vertical value = 0.127 mm.

Mark the total horizontal value on the horizontal side of the chart and the total vertical on the vertical side of the chart.

Use straight edge to find the intersection point of the “total horizontal” and “total vertical” values. The intersection point must fall within the shaded area for the flywheel housing concentricity to be within specification.
Use the “total horizontal” and “total vertical” values from the previous example, the intersection point falls within the shaded area. Therefore, the flywheel housing concentricity is within specification.

If the inspection point falls outside the shaded area, the ring dowels must be removed and the housing repositioned.

NOTE: The ring dowels are not required to maintain concentricity of the housing. The clamping force of the capscrews holds the flywheel housing in position.
After the ring dowel is discarded, install the flywheel housing on the engine.
To position the housing, tighten the capscrews enough to hold the flywheel housing in place, but loose enough to enable small movement when struck lightly with a mallet.
Check the concentricity again by following the above process.

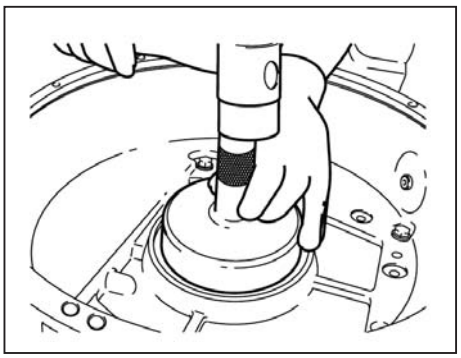
Use the pattern shown in the chart to install and tighten the mounting flywheel housing capscrews.

Torque Value:

MIN	**95**	**Nm**
MAX	**105**	**Nm**

Rear Oil Seal - Installation

Install the rear oil seal with the special tool.

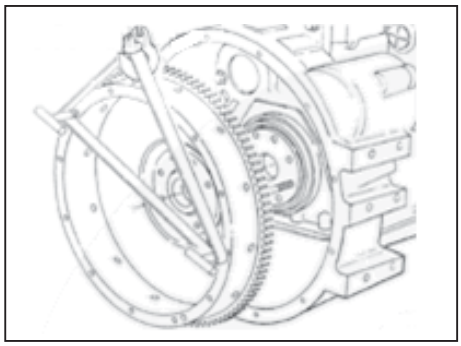


Flywheel – Installation

NOTE: Use a new pilot bearing when installing a new or rebuilt clutch.
Use a mandrel and hammer to remove the pilot bearing.
Use a Scotch-Brite cleaning pad , to clean the pilot bore.

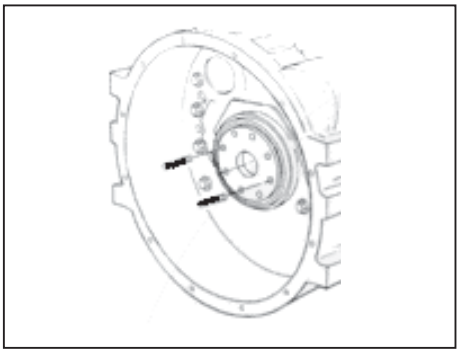
Use am mandrel and hammer to install the pilot bearing.

NOTE: The pilot bearing must be installed even with the pilot bore surface.



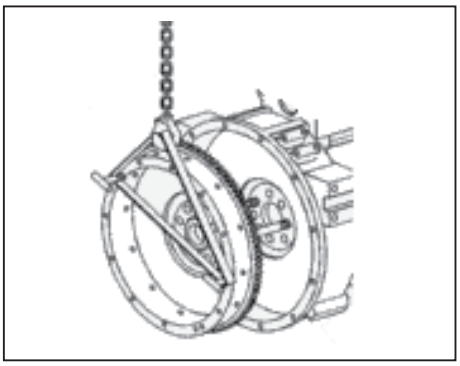
Install the two M12x1.25x90 mm guide pins into the crankshaft flange 180 degrees apart.

Holes can be metric or standard. Be sure to use correct capscrews.
Determine the capscrews thread design and size and install two " T-handles" into the flywheel at points [1] and [2]



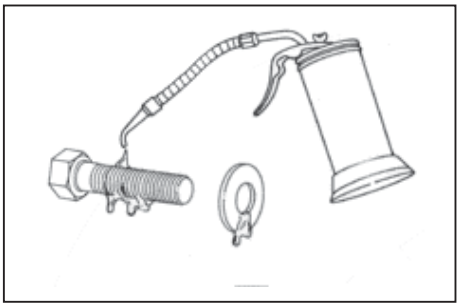
Visually inspect the rear face of the crankshaft and flywheel mounting flange for cleanliness and raised nicks or burrs.

Caution: The weight of the component is more than 25 kg . To avoid personal injury, use a hoist or get assistance to lift the component



Install the flywheel on the guide pins.

Lubricate the threads of the flywheel capscrews and the surface of the washers with clean 15W-40 engine oil.

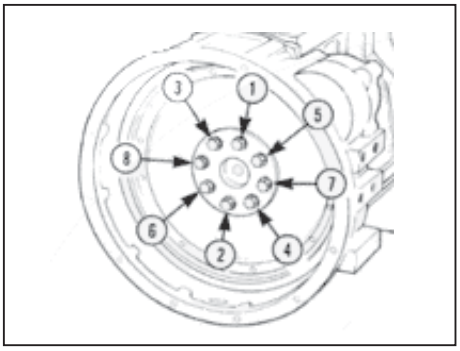


Install the eight flywheel capscrews.

Remove the " T-handle" and guide pins.
Install the remaining flywheel capscrews into the holes from which the guide pins were removed.

15 mm (Alen)

Hold the crankshaft when tightening the flywheel capscrews.
Tighten the flywheel capscrews in the pattern as illustrated.



Torque Value:

MIN	**260**	**Nm**
MAX	**290**	**Nm**

Lubricating Oil Suction Tube – Installation

Rotate the engine towards crankshaft side.

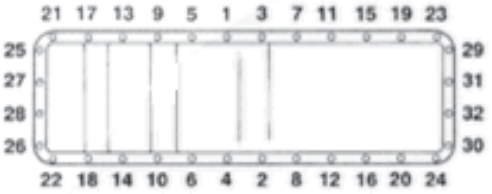
Place a new o-ring in the grove of oil suction tube.
Make sure that oil suction tube is clean.

10 mm
Install the lubricating oil suction tube over the gasket and align the mounting holes.

Torque Value:

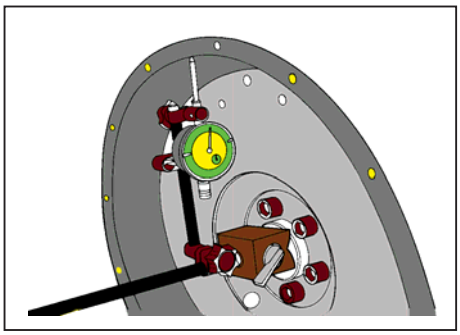
MIN	**20**	**Nm**
MAX	**30**	**Nm**

Oil Pan - Installation



13 mm
Install the oil pan in sequence as shown

Flywheel Housing Bore Run out – Measurement



Use the dial indicator gauge[1] or its equivalent and dial gauge attachment to inspect the flywheel surface runout [2]

Install the attachment to the flywheel housing. Install the gauge on the attachment.

Install the contact tip of the indicator against the inside diameter of the flywheel bore, and set the dial indicator at zero.

Rotate the crankshaft one complete revolution (360 degrees)

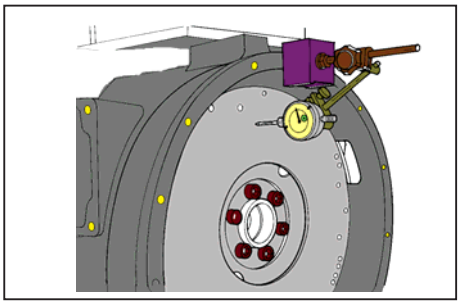
NOTE: The total indicator reading must not exceed **0.20 mm**

NOTE: If the TIR is greater than the specification, do the following:

- Remove the flywheel.
- Inspect the flywheel mounting surface for dirt or damage.
- Inspect the crankshaft for dirt or damage.
- Install the flywheel, and inspect the flywheel bore runout. Again.
- Replace the flywheel if the flywheel bore runout does not meet specifications.

Flywheel Face Run out – Measurement

Install the contact tip of the indicator against the flywheel face, as close to the outside diameter as possible, to inspect the face [1] run out.



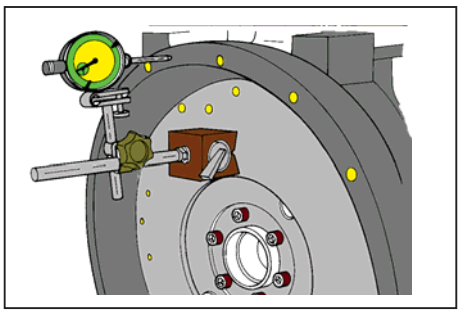
NOTE: Push the flywheel forward to remove the crankshaft end clearance. Adjust the dial on the indicator until the needle points to zero.

Rotate the crankshaft one complete revolution. Measure the flywheel run out at four equal points on the flywheel.

NOTE: The flywheel must be pushed towards the front of the engine to remove the crankshaft end clearance each time a point is measured.

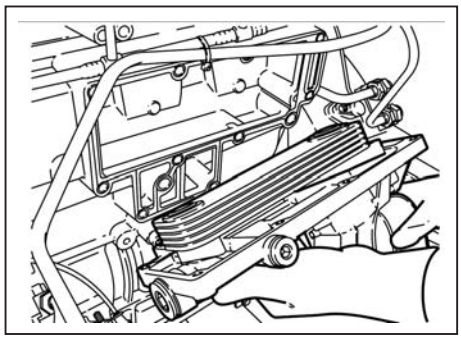
The total indicator reading must not exceed 0.30 mm

If the flywheel face run out is not within specifications, remove the flywheel. Check for nicks, burrs, or foreign material between mounting surface and the crankshaft flange.



Flywheel Housing Face Run out – Measurement
The total indicator reading must not exceed 0.20 mm

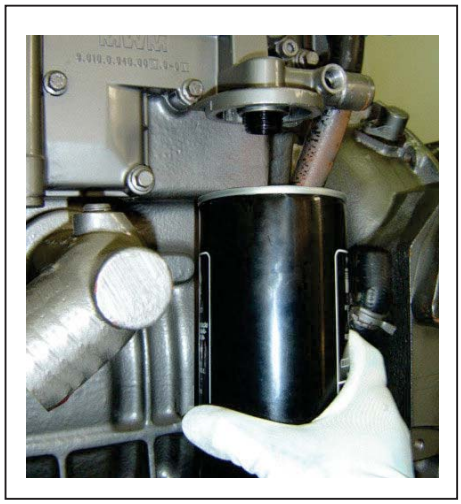
Lubricating Oil Cooler – Installation



10 mm
Install the gasket on the cylinder block
Install the oil cooler assembly and apply proper torque to the flange screws.

Lubricating Oil Filter – Installation

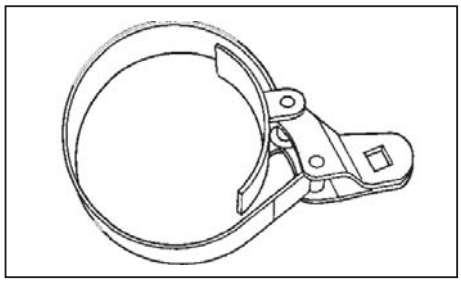
Apply a light film of clean 15W-40 engine oil to the gasket sealing surface before installing the filter.



NOTE: The filter must be installed with in 15 minutes from the time oil was applied to the rubber seal.

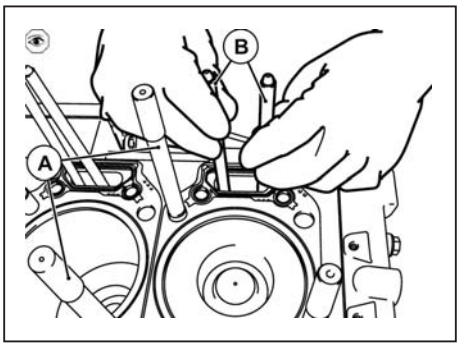
Fill the oil filter with clean 15W-40 engine oil.

Caution: Mechanical over tightening may distort the threads or damage the filter element seal.



Install the filter as specified by the filter manufacturer.

Push Rod – Installation



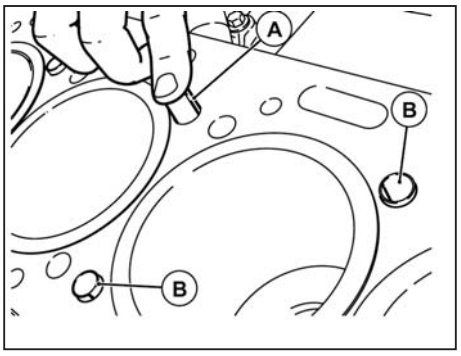
Check the pushrod for straightness.

Install the pushrods into the sockets of the valve tappets from which they were removed.
Lubricate the push rod sockets and valve stems with clean 15W-40 engine oil.

Cylinder Head – Installation

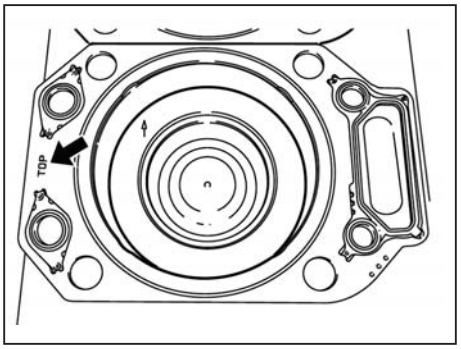
The cylinder block and head must be clean and dry.

NOTE: The maximum allowable piston protrusion above the top of the block with a standard gasket is mm.

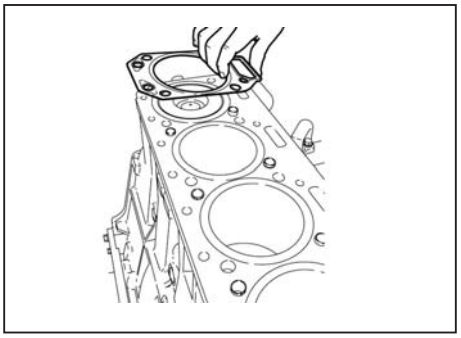


Make Sure the gasket is properly aligned with the holes in the cylinder block.

Position the gasket onto the dowel.

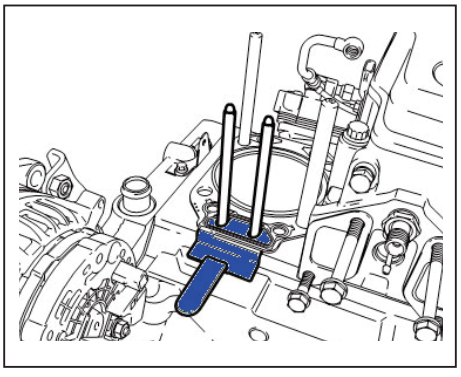


Caution: Do not drop the cylinder head on the cylinder head gasket. The gasket material will be damaged.

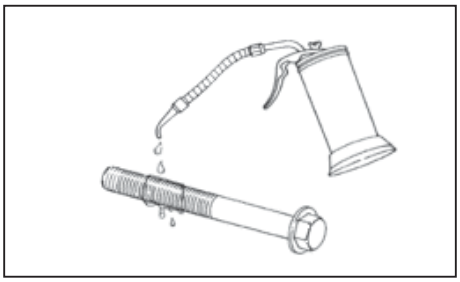


Align the pushrods with special tool.

Carefully install the cylinder head onto the gasket and cylinder block. Make sure the cylinder head is installed onto the dowels in the cylinder block.

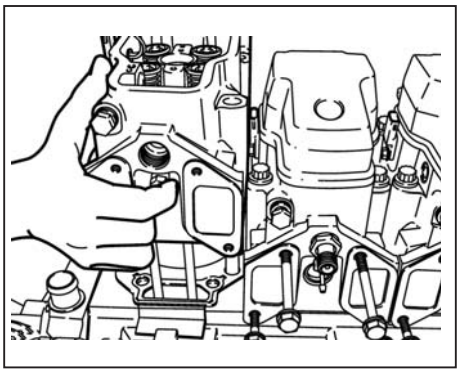


Use clean 15W-40 engine oil to coat the cylinder head capscrew threads and underneath the head flange.

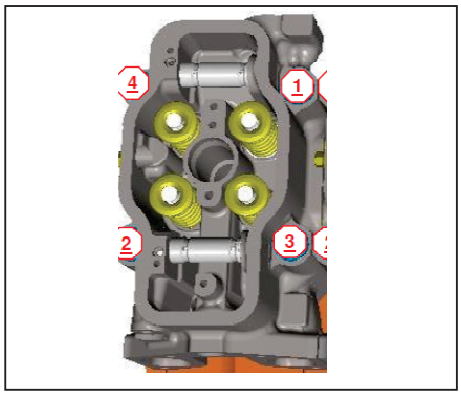


Caution: Allow the excess oil to drain from the capscrews thread before installation.

Install the capscrews into the cylinder head.



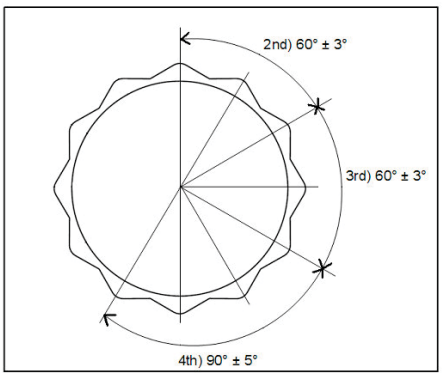
Follow the proper sequence for tightening the cylinder head capscrews.



Caution: To prevent damage to the rocker lever or push rod, make sure the adjusting screw ball is positioned in the socket of the pushrod when tightening the cylinder head bolts.

Torque value:

Step1 : 40 + 5 Nm
Step2 : 60 + 10 Nm
Step3 : 60 ± 3 Degree
Step4 : 60 ± 3 Degree
Step5 : 90 ± 3 Degree



Valve Clearance – Adjustment

13 mm , ½ Inch Drive , 15 mm

Rotate the crankshaft and bring the mark on crankshaft gear and camshaft 80 teeth gear at approximately 70 degree from centre of idle gear shaft.
Loosen the idler gear cap screws and pull the gear from shaft.

Align the crank mark with idler gear and camshaft 80 tooth gear mark with idler gear and slide the idler gear on the shaft.
Tighten the capscrews as per the specified torque.

This is the Top dead centre (TDC) of cylinder number 6.

Adjust the valve with engine cold (below 60 degree C.

NOTE: The clearance is correct when slight resistance is felt as the filler gauge is moved between the valves and stem and rocker lever.

Valve Clearance Specification
INTAKE 0.20 - 0.40 mm
EXHAUST 0.20 - 0.40 mm

Valve Arrangement

Beginning at the front of the cylinder head, the first valve is INTAKE, the second one is EXHAUST. The same orientation is used for all cylinders.

Locate **TDC** for cylinder number **6** (Seen from fan side of engine, i.e. Fan side)
Adjust the valves indicated for chart A.
Tighten the lock nut.
Torque Value Nm.
Check the valve clearance again.

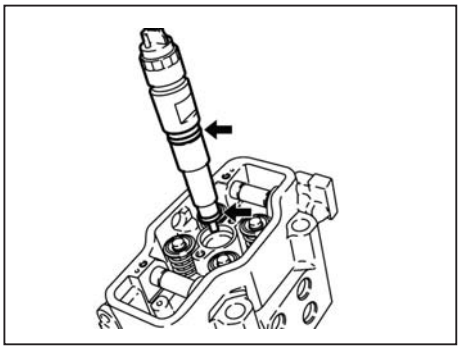
Mark the end of crankshaft or flywheel. Rotate the crankshaft 360 degree.

Adjust the valve indicated for chart B. Tighten the locknut.

Check the valve clearance again.

Injector – Installation

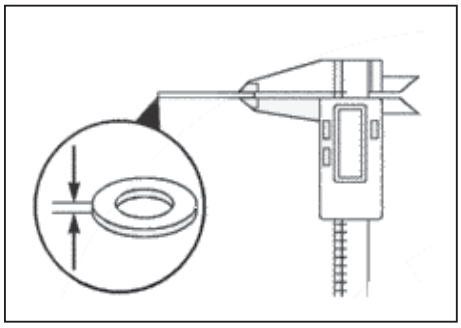
Assemble the injector, sealing ring , a new copper sealing washer and hold down clamp.



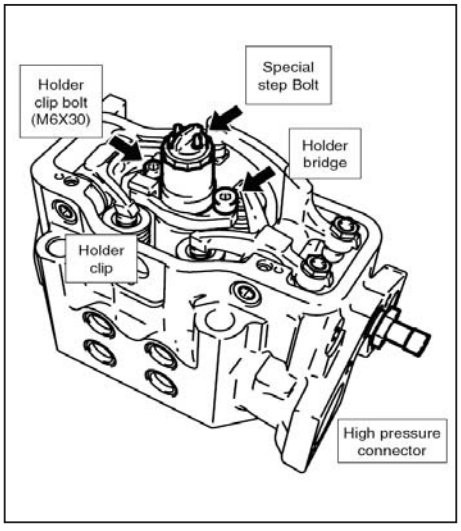
Use of the incorrect sealing washer can cause high-pressure fuel leaks and/or performance problems because of incorrect injector protrusion.

Verify that the new injector sealing washer is the correct thickness.

Injector seating washer. 1.5 mm



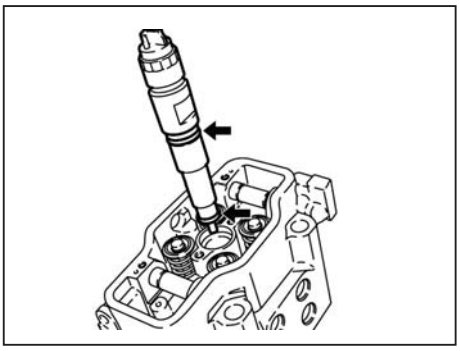
NOTE: Sealing washers are configured in a flat (1) or saucer (2) shape. When replacing the injector sealing washer, only the saucer style washer should be used, and not the flat style washer.



Verify a new and correct sealing washer has been installed on the tip of the injector.

Make sure the injector bore is clean and that **only** one sealing washer is installed on the injector nozzle.

Verify a new injector o-ring is used and lubricate it with clean engine oil.



Align the injector in the cylinder head in the proper orientation (fuel inlet toward the high-pressure fuel connector).

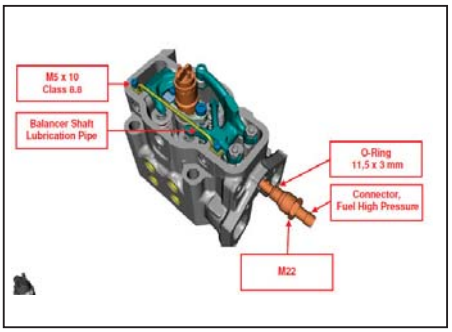
Using the injector shipping sleeve, make sure the injector is seated in the injector bore.

NOTE: A new fuel connector must be installed if a new injector is being installed.

Lubricate the fuel connector o-ring and the threads on the fuel connector retaining nut with clean engine oil.

Carefully insert the fuel connector. Align the guide with the anti-rotation slot in the cylinder head at the 12-o'clock position.

Start the high-pressure fuel connector retaining nut, but do **not** tighten.



NOTE: To prevent the possibility of damage, use even, axial force when installing. Be sure to not tear the o-ring as the connector is being installed.

Install the injector hold-down and injector hold-down capscrews, but do **not** tighten.

Apply the preliminary torque to the fuel connector retaining nut to begin seating the fuel connector to the injector.

NOTE: This is not the final torque for the high-pressure fuel connector retaining nut.

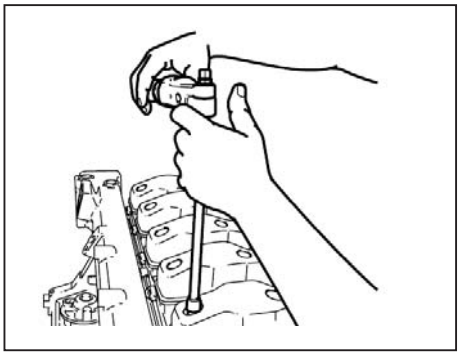
Torque Value: 52 Nm

Tighten the injector hold-down capscrews.

NOTE: Be sure to tighten the hold-down capscrews evenly. Verify that the gap between the hold-down clamp and the injector is equally spaced around the injector body.

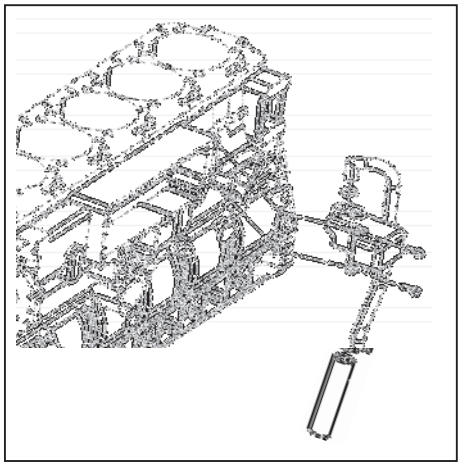
NOTE: Do not over torque the connector retaining nut. Over torque of the retaining nut can cause the connector to rotate out of the connector retaining slot.

Valve Cover – Installation
Install the rubber seal into the groove in the valve cover. Do not stretch the rubber seal. If the seal has expanded replace it.



8 mm
Install the valve cover capscrew and tighten.
Torque Value: 24 Nm

Crank case Breather Tube – Installation



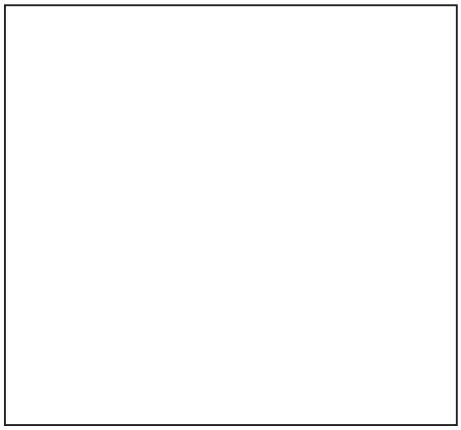
13 mm
Install the breather tube and hose clamps. Tighten the capscrews for the breather housing.

Torque Values:

MIN	**20**	**NM**
MAX	**30**	**NM**

Fuel Drain Manifold – Installation

Install the fuel drain manifold.

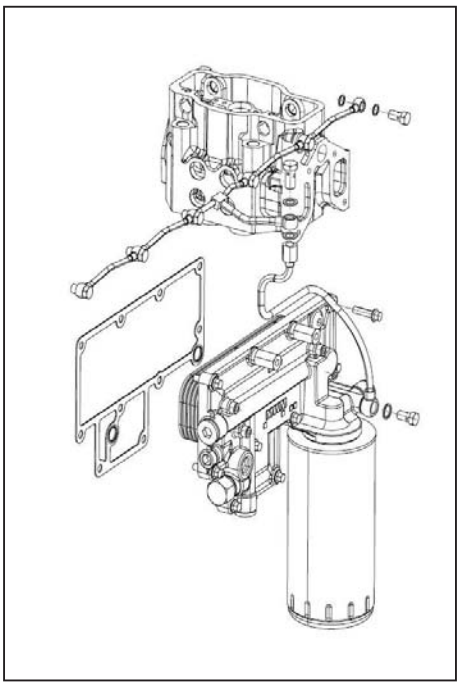


With new washer tighten the bingo at point [A] and then tighten the banjo at oil filter head.[B]

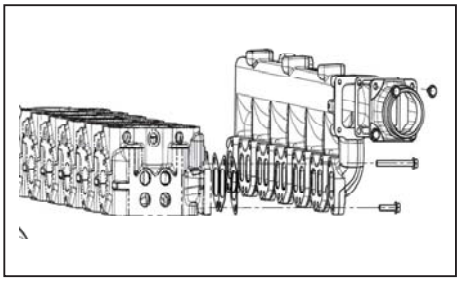
Cylinder Head Lubricating Manifold - Installation

Install the oil manifold and new copper washer as illustrated at cylinder head side.

Torque Value:
MIN 22 NM
MAX 28 NM



Intake Manifold – Installation
13 mm
Use new gasket.
Note: Cylinder head surface must be clean.
Install the intake manifold as illustrated.



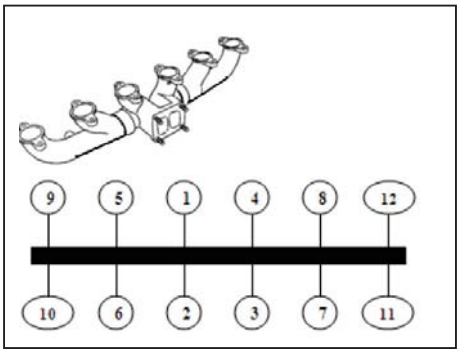
Exhaust Manifold – Installation

Install the exhaust manifold, new gaskets, and nuts.

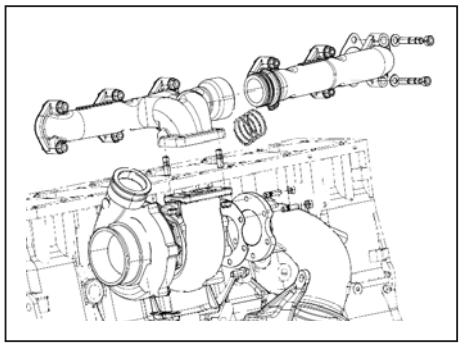
Follow the tightening sequence shown in the illustration.

Tighten the exhaust manifold mounting capscrews

15 mm
Torque Value:
MIN 18 Nm
MAX 22 Nm



Turbocharger – Installation



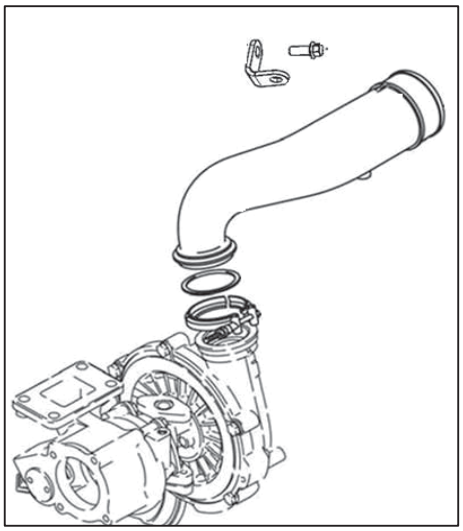
Apply a film of high-temperature anti-seize compound to the turbocharger mounting studs.

Install and tighten the four mounting nuts.

NOTE: The torque values given have been established using anti-seize compound as a lubricant.

Torque Value:

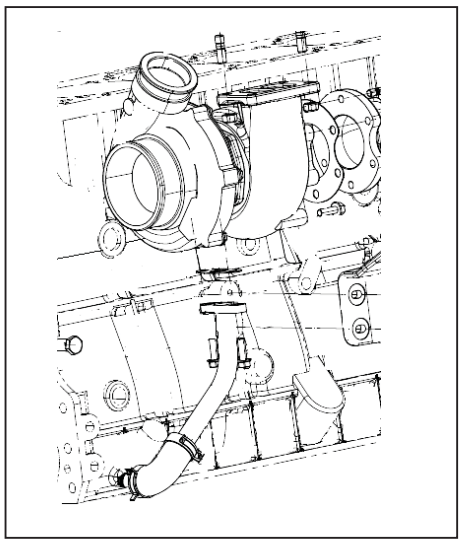
MIN	**60**	**NM**
MAX	**80**	**Nm**



Install the turbocharger compressor outlet elbow, v-band clamp, and a new o-ring seal on the turbocharger compressor discharge outlet if applicable.

Tighten the clamp.

Turbocharger Oil Drain Line – Installation



Apply a thin film of clean engine oil to the drain line o-rings.

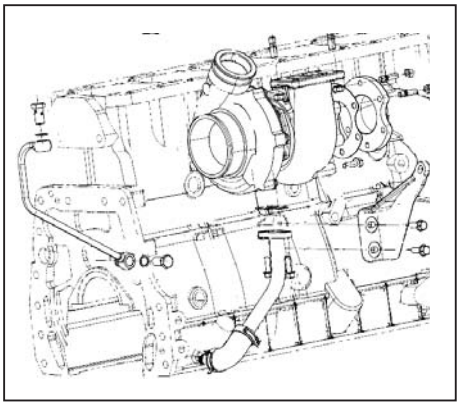
Push the drain line into the oil drain line boss. Make sure both o-rings are completely seated in the bore.

Install a new gasket on the oil drain line.

Install the oil drain line mounting capscrews and tighten.

Torque Value: **12 ± 2 NM**

Turbocharger Oil Supply Line – Installation



19 mm

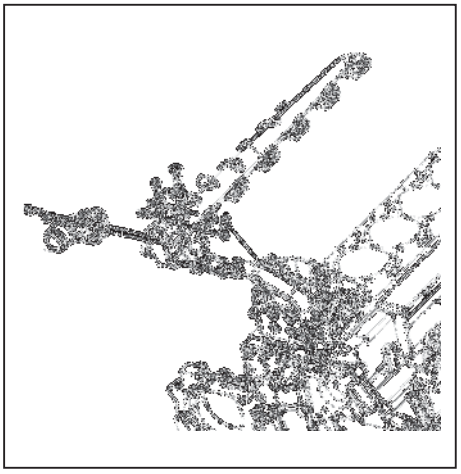
Fill the turbo oil inlet with clean 15W-40 engine oil.

Install the oil supply line at the turbocharger bearing housing and the cylinder block, using new copper sealing washers

Tighten the oil supply line to final torque at both ends.

.Torque Value: **25 ± 5 NM**

Water Manifold – Installation

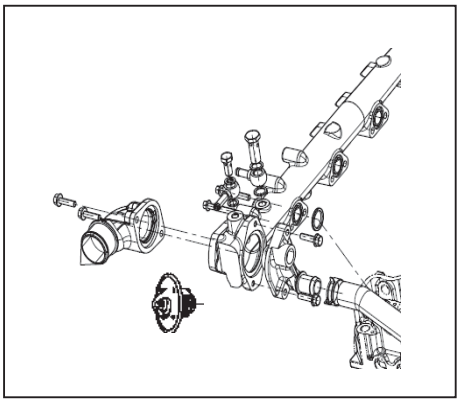


10 mm

Use new o-rings.
Install the water manifold and tighten the cap screw as the sequence illustrated.

Torque Value: 25 ± 4 NM

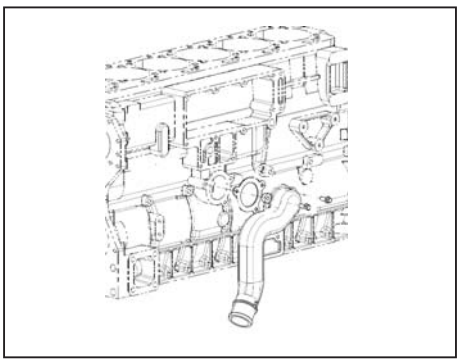
Thermostat – Installation



Install the thermostat keeping the giggle pin upward.

Use new o-ring.
Tighten the coolant outlet connection

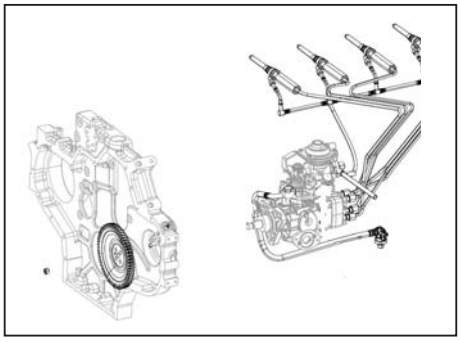
Coolant Inlet Connection – Installation



10 mm
Use new gasket.
Install the coolant inlet connection and tighten the cap screws.

Torque Value : 25 ± 4 NM

Fuel Injection Pump – Installation
Loctite is used to help retain the injection pump mounting stud.

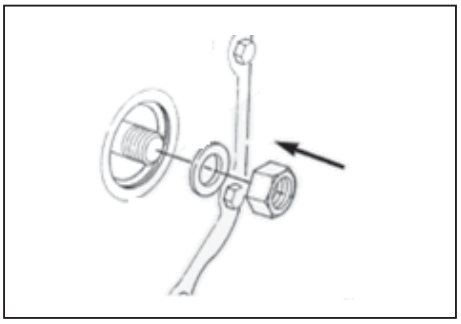


Apply Loctite 242 at the thread of the stud.

13 mm
Use 2 nuts locked together as illustrated to install the stud.

Make sure the piston in cylinder no. 6 (near fan) is at TDC , refer to procedure

Follow the procedure of FIP timing.



The drive gear requires a wood rough key.

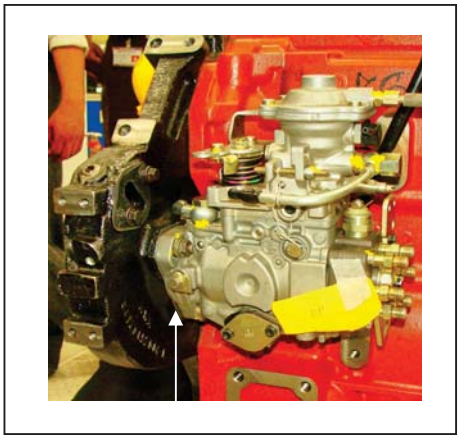
13 mm
Fuel Pump Mounting
Install the mounting nuts.
Rear support bracket
M10 Block and bracket capscrews

22 mm
Install the fuel pump gear, retaining nut and washer.

Ensure the gear alignment with the key way slot and mark on FIP gear and Camshaft gear.

Initial Torque Value:60 NM

Unlock the FIP cam lock.

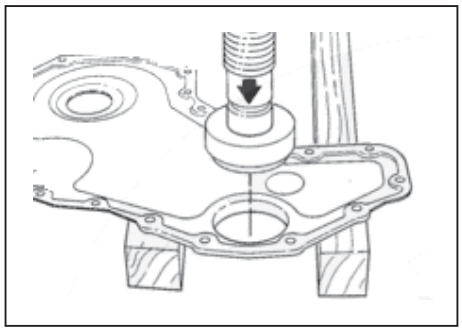


Tighten the fuel injection pump drive gear nut.
Torque Value: **105 ± 5 NM**

Refer to procedure FIP timing setting.

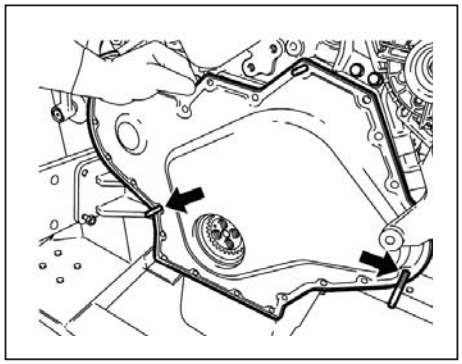
13 mm
Tighten the fip mounting flange nut.
Torque Value : 45 ± 5 NM

Front Cover – Installation



Seal , Front cover
Position the seal on the service tool, with the lubricating oil seal dust lip facing outward.
NOTE: Properly support the front cover lubricating oil seal flange to prevent damage to the lubricating oil seal and front cover.
Press the lubricating oil seal into the front cover from the back side of the cover towards the front side of the front cover.
Press the lubricating oil seal until the service tool bottoms against the front cover.

Gear Cover – Installation



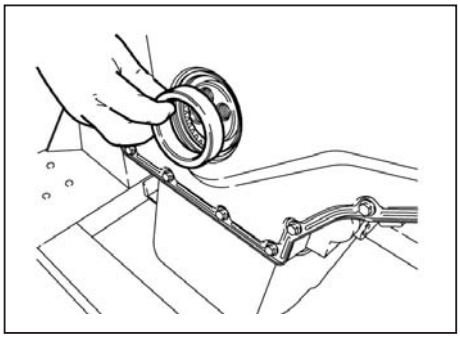
Caution: The seal lip and the sealing surface on the crankshaft must be free from all oil residues to prevent seal leakages.
Thoroughly clean and dry the front seal area of the crankshaft.

Apply a coat of three bond sealant .on both side of gasket.
Install the gear cover, with the seal pilot tool, over the nose of the crankshaft.

13 mm
Tighten the gear cover capscrews.
Torque values: 25 ± 3 NM

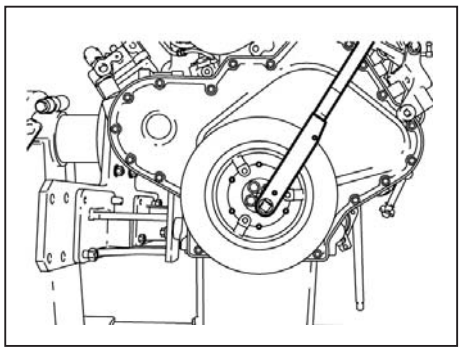
Remove the seal tool pilot from the nose of the crankshaft.

Install the crankshaft bush.



Vibration Damper – Installation

15 mm Allen
Align the dowel pin provided on crankshaft face with the hole provided on damper pulley.



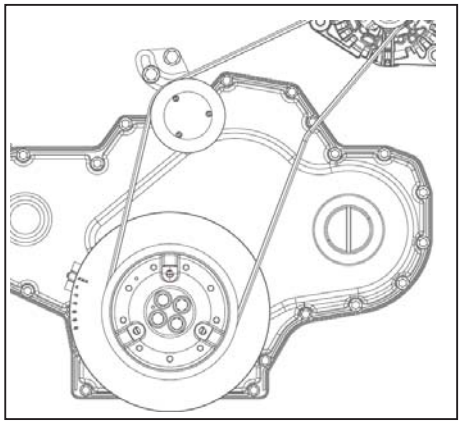
Lock the engine.
Tighten the Allen screw with the specified torque.

Torque Value:

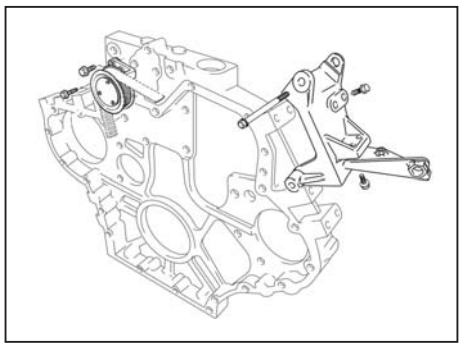
MIN	**260**	**NM**
MAX	**290**	**NM**

Belt Tensioner – Installation

13 mm
Install the belt tensioner pulley assembly to the cylinder block.



Alternator Mounting Bracket – Installation



Mm

Install the guide dowel on the gear housing.
Install the alternator mounting bracket.

Torque Value : 40 ± 6 Nm

NOTES

Engine Block

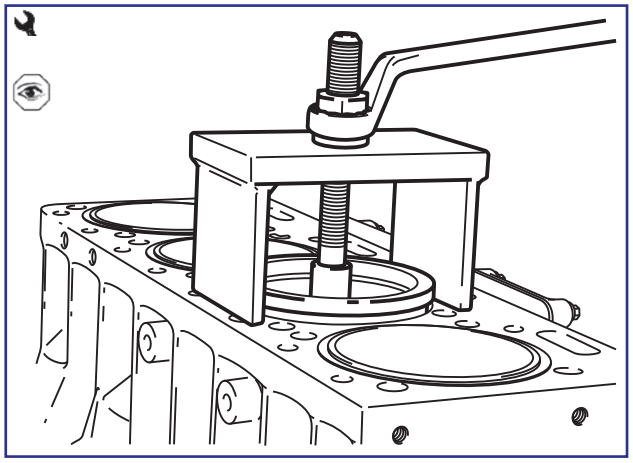
Group - 05

Disassembly Notes

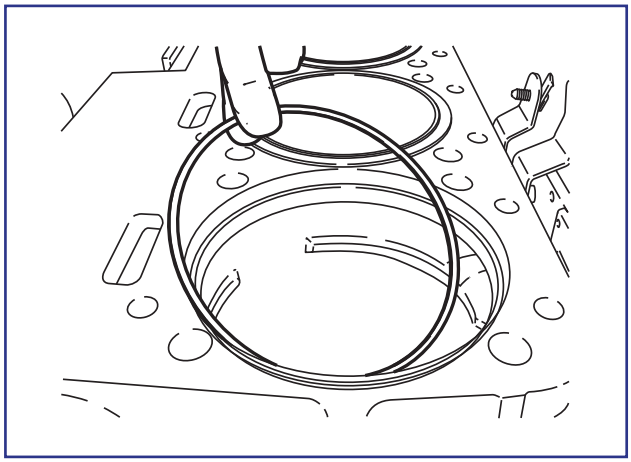
The cylinder liners removal must be made with the special tool MIM nr. 9.610.0.690.017.6 in order to do not damage the engine block or the liners.

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

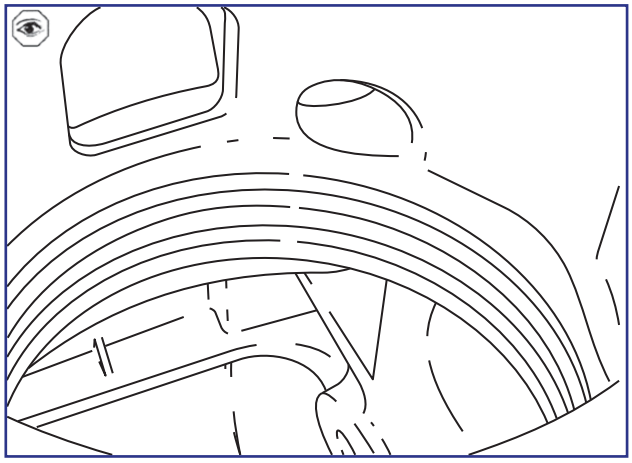
The liner can be removed screwing the nut of the puller.



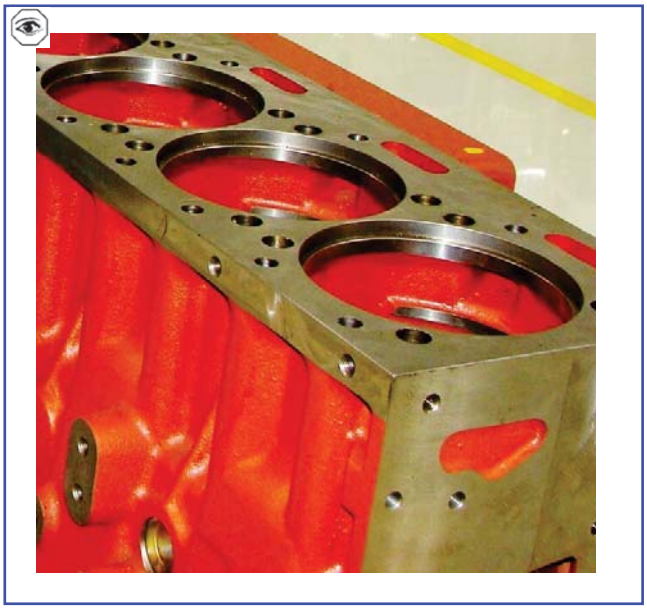
Remove the liner shims



Remove linears sealing rings and replace for new points.

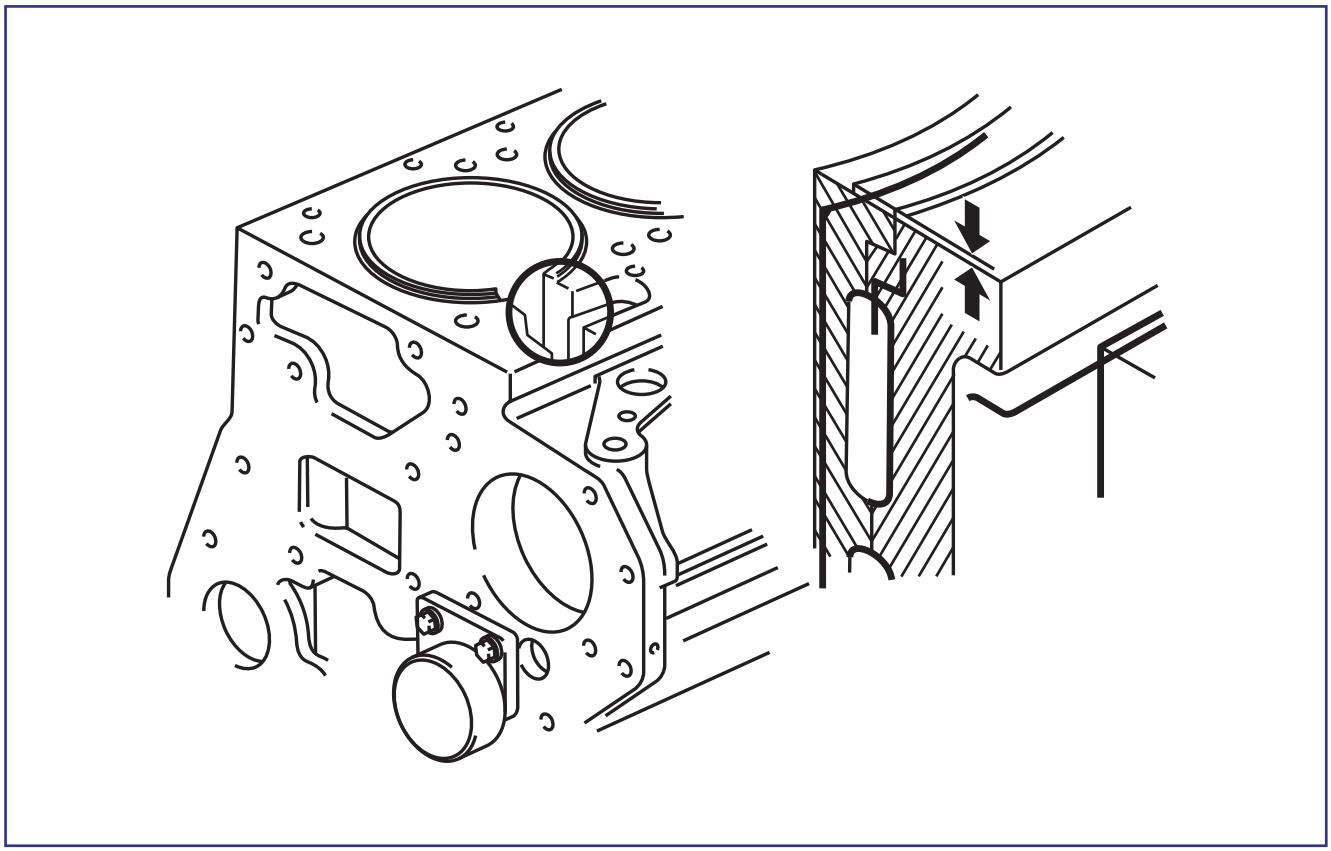


Clean the block surface cylinder head that must be free of dust or wear.



Inspections and Measurements

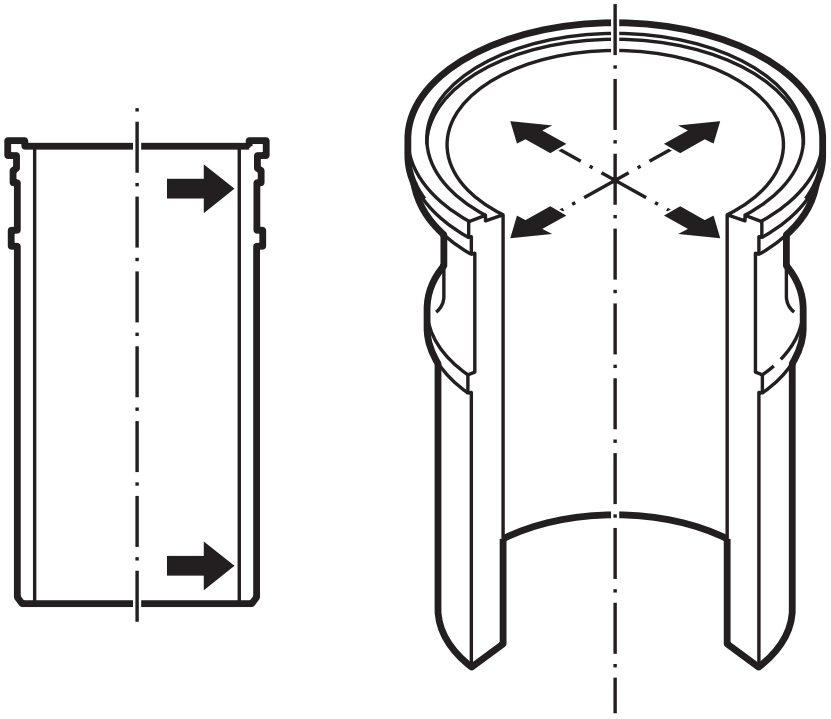
LINER PROTRUSION



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

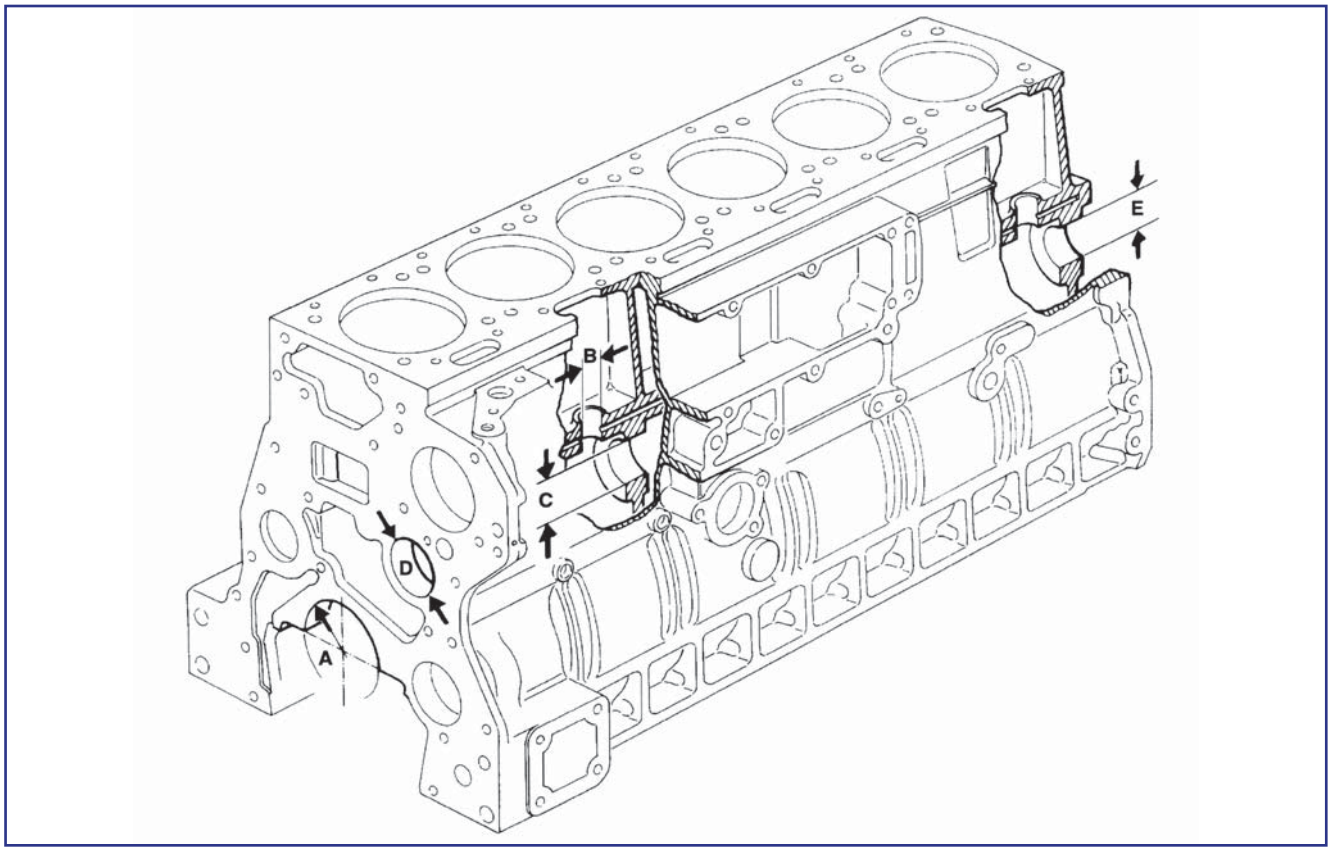
*Affect emissions level

LINERS



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

ENGINE BLOCK



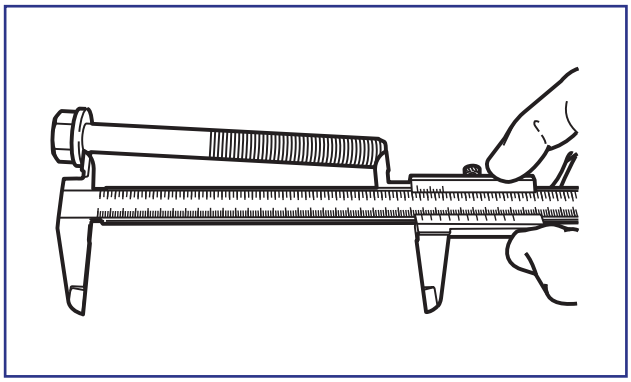
Engine Block	
	mm
Parallelism	0,05
Perpendicularity	0,04

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 bearing bolts length..

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.

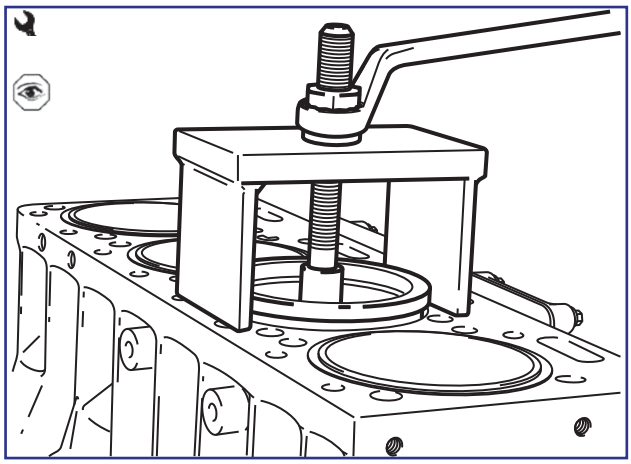
Liners

REMOVAL

Usfing the specfial tool MNEPL Nº 9.610.0.690.017.6, remove the liners carefully in order to avoid damages to the block and/or liners.

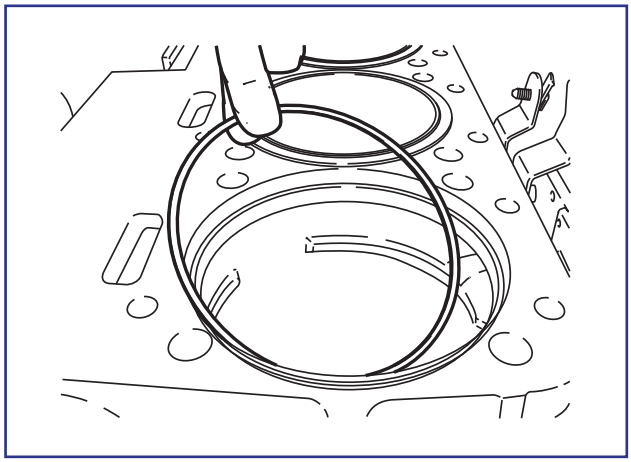
Fit the lower part of the tool to the liner lower border.

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

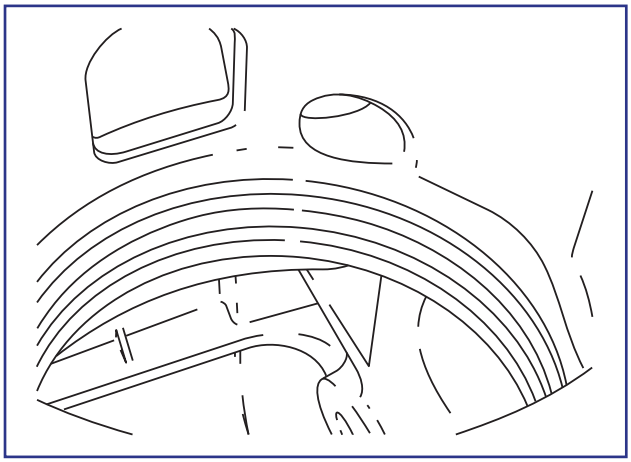


Remove the stainless steel liners rings.

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



Remove and install new sealing O-Rings.



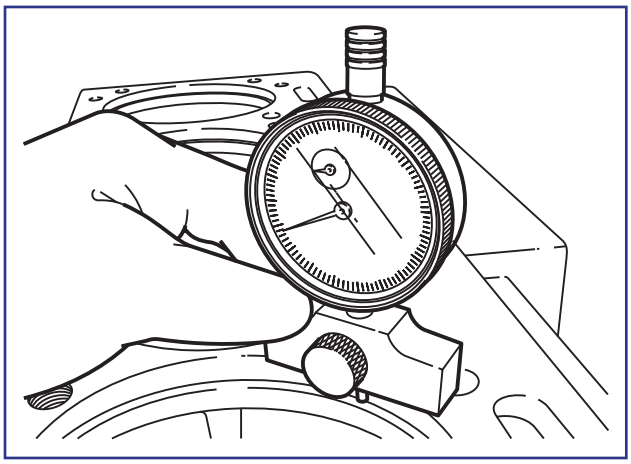
INSTALLATION

Cylinder Liners and Stainless Steel 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.

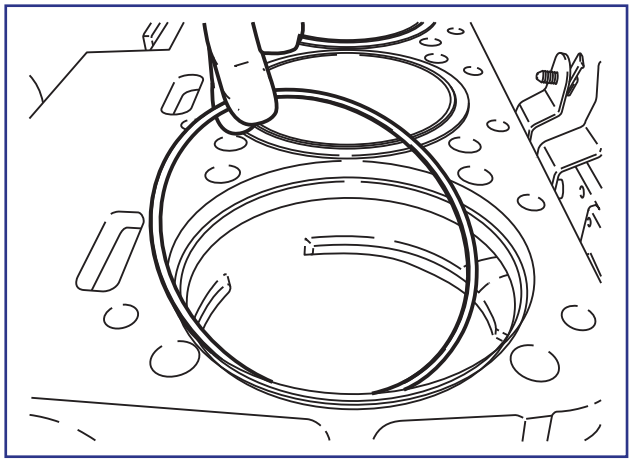


To obtain the correct protrusion measurement, use the inox rings with different thickness values.

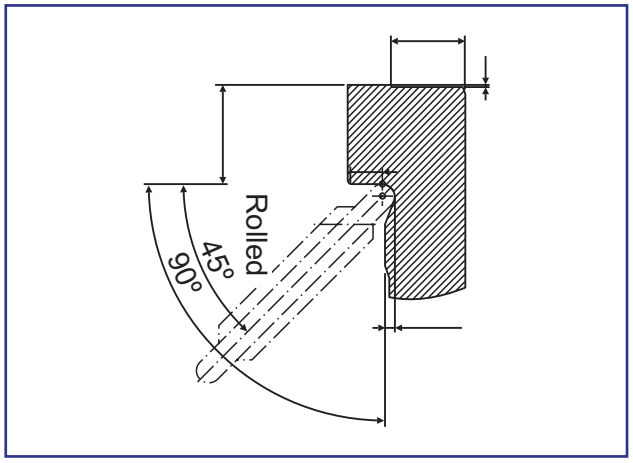
Install new stainless steel rings (only one for each cylinder)

Stainless steel ring thickness available:

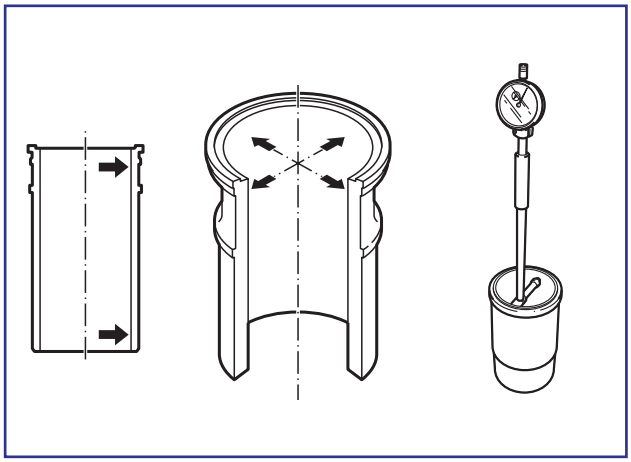
0302AAV00090N **= 0.15 mm**



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

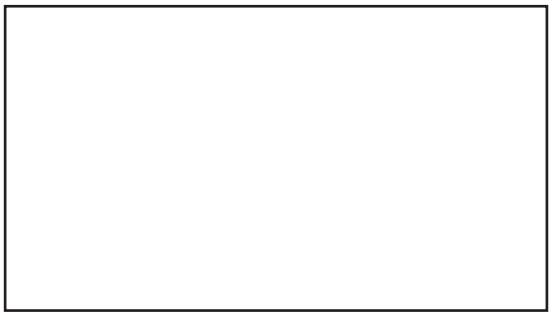


Liners Inspection	
Measure	**mm**
Out-of-roundness	0.02
Ø Inner	105.000 - 105.022

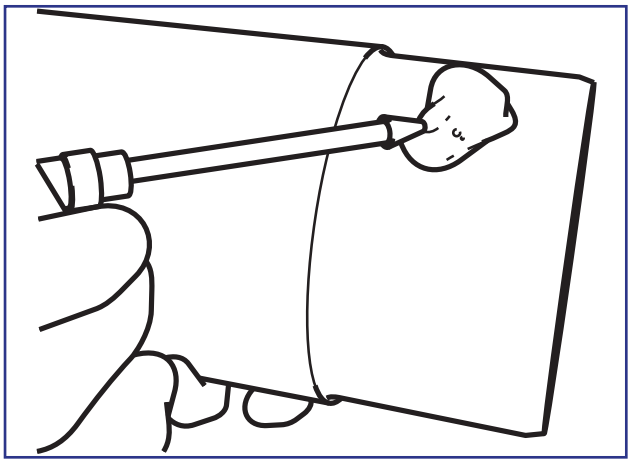


NOTE: The O- ring must be completely clean to avoid possibility of torsion , cut or damages during assembly procedure, which may cause water to mix with oil.

Place the O - ring in the grove of cylinder block, It should be wet with fresh engine oil.

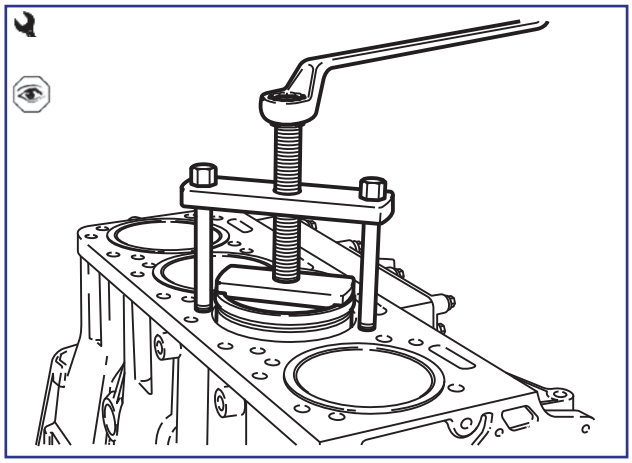


Lubricate the liners with engine oil applying the oil to the sealing rings contact area.

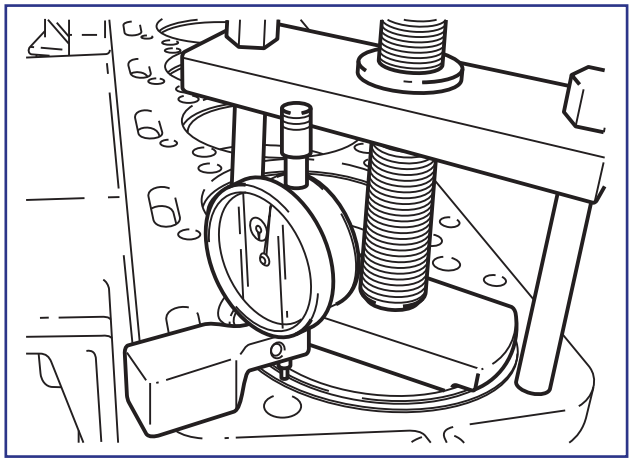


Manually install the liners in the cylinder block.

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

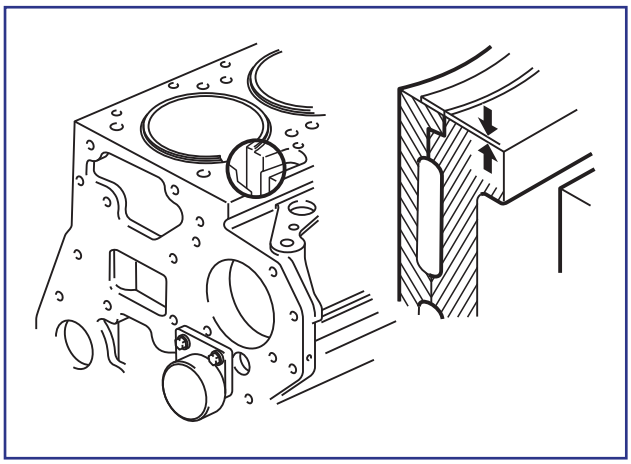


Using a dial indicator gauge, measure the liner protrusion to the block surface.

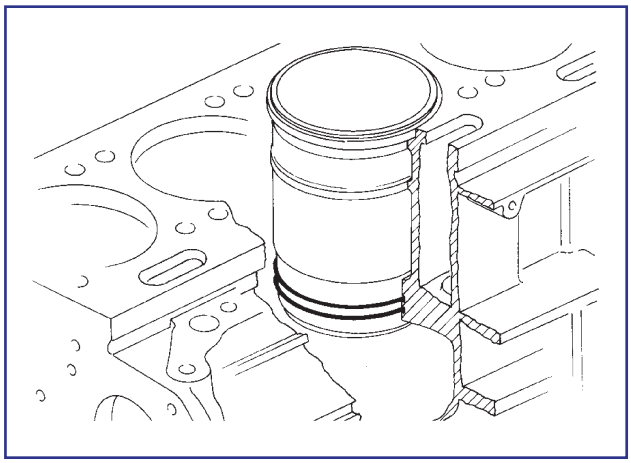


The protrusion must be measured considering 4 points at equal distant each other.

The protrusion must be **0.03 mm to 0.10 mm** otherwise the liner must be removed and select a new inox ring.



liner. Rings in the correct position with the assembled



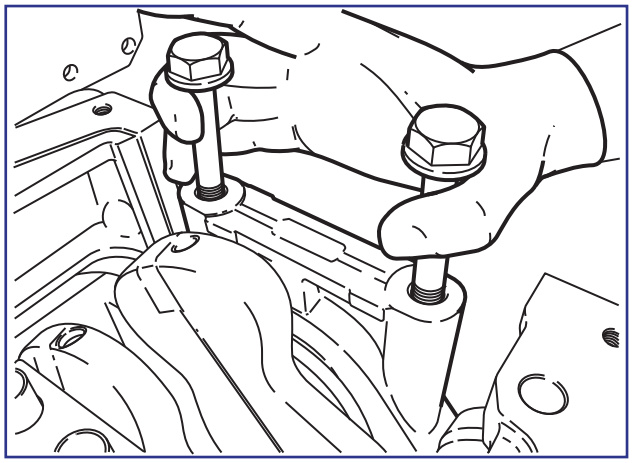
NOTES

Crankshaft

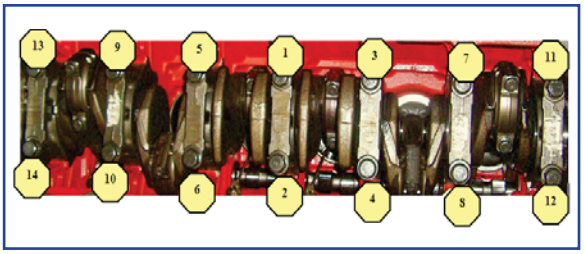
Group - 06

Disassembly Notes

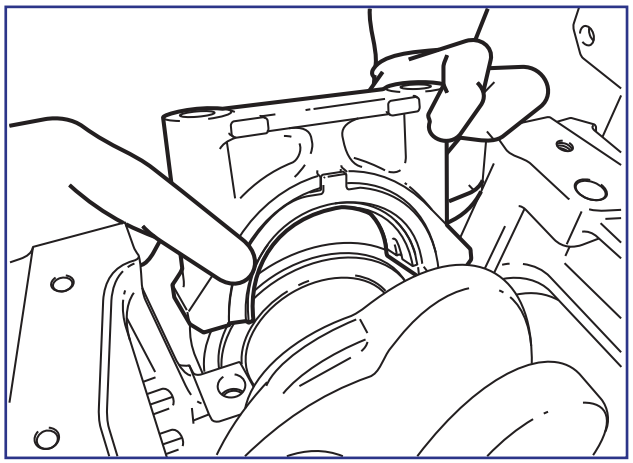
After removing the carter, pistons and connecting rods, flywheel, pulley and gear housing, position the engine on the stand in upright position and loosen the main bearing caps. To remove the bearing caps use the fixation bolts.



Follow the sequence of loosening the main bearing cap screws.



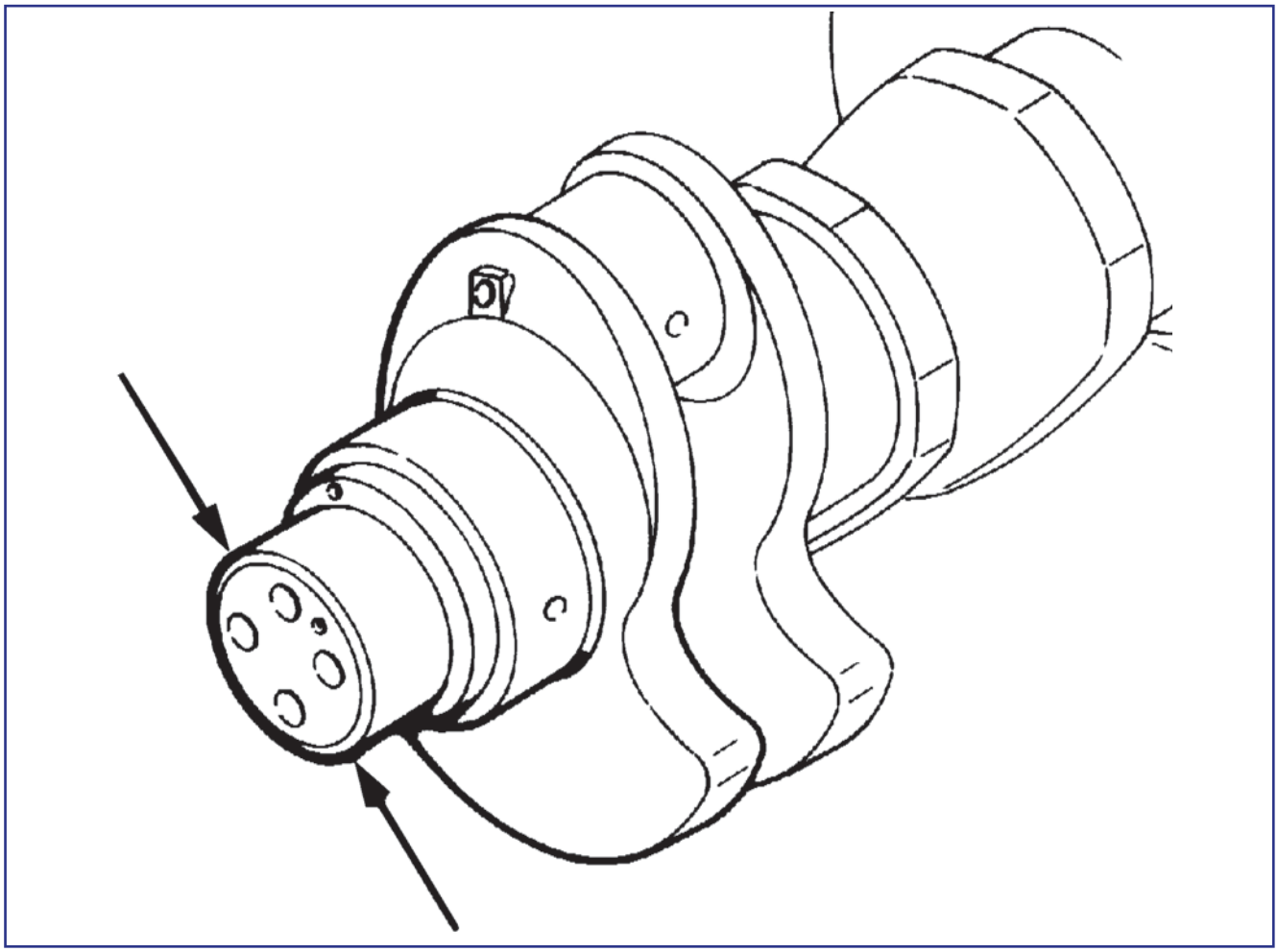
Remove the axial thrust ring from bearing #1 (flywheel side).



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.

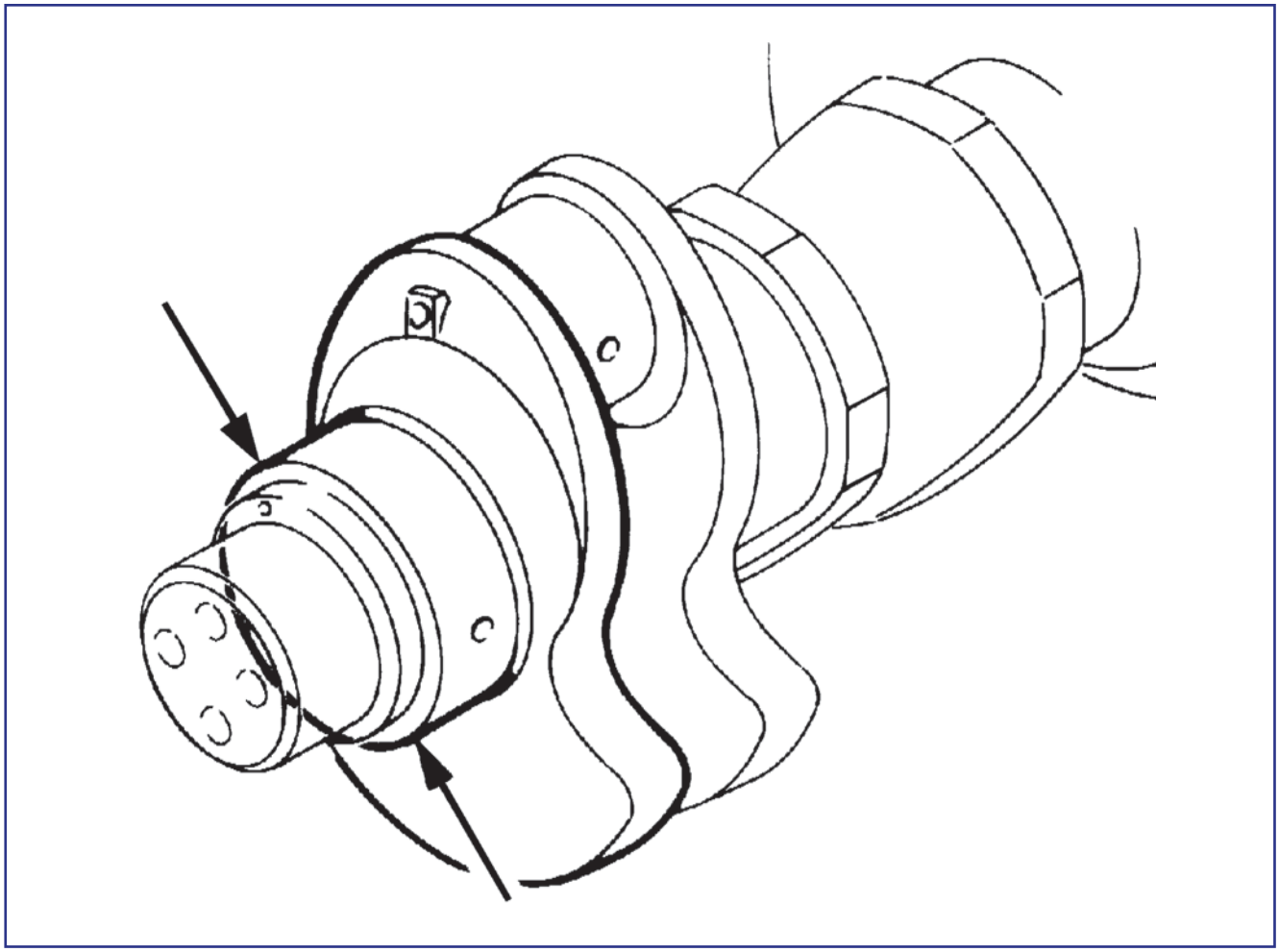
Specifications

CRANKSHAFT



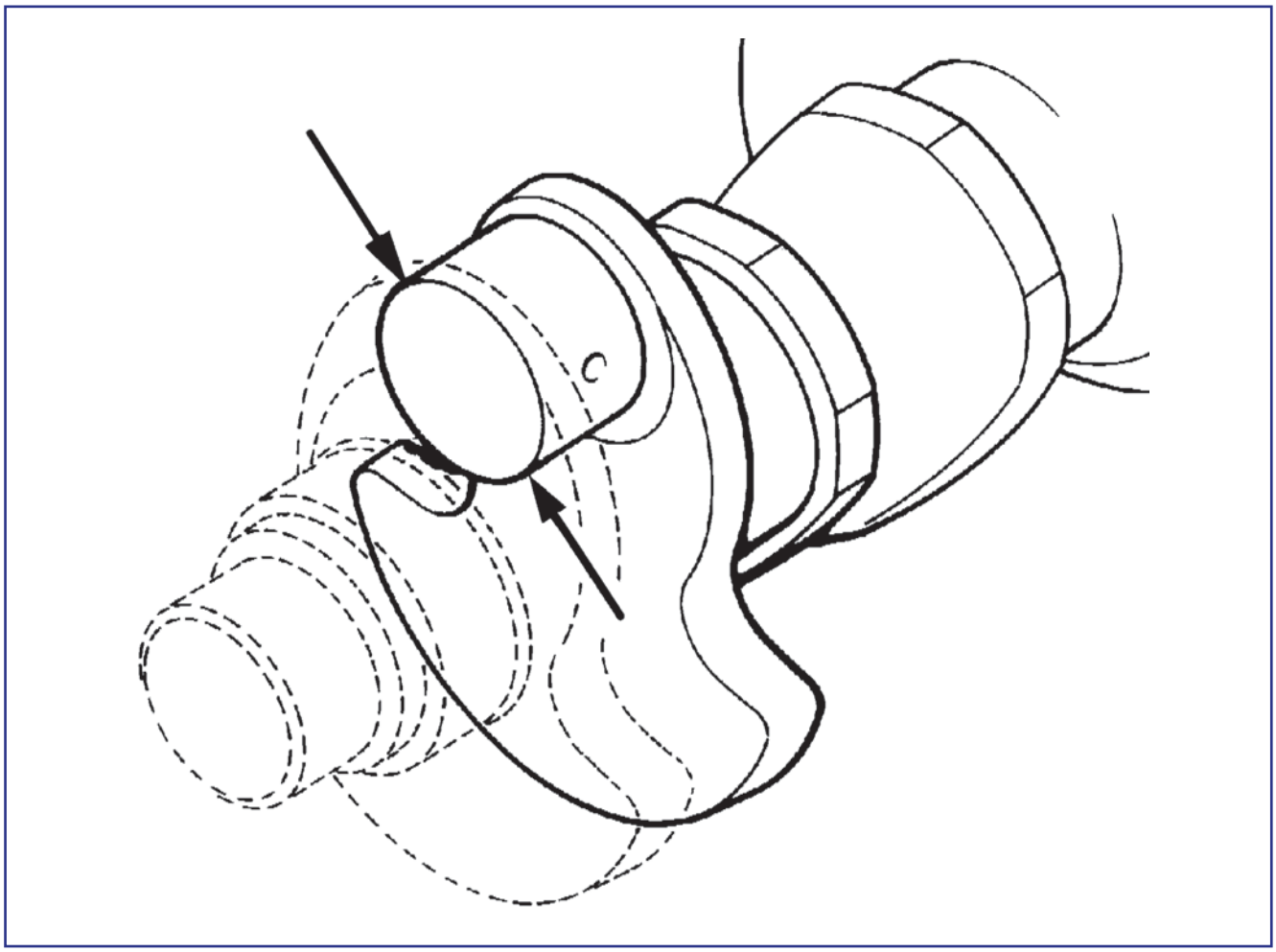
Gear	
Diameter	**mm**
Seat	60.020 - 60.039

MAIN JOURNALS



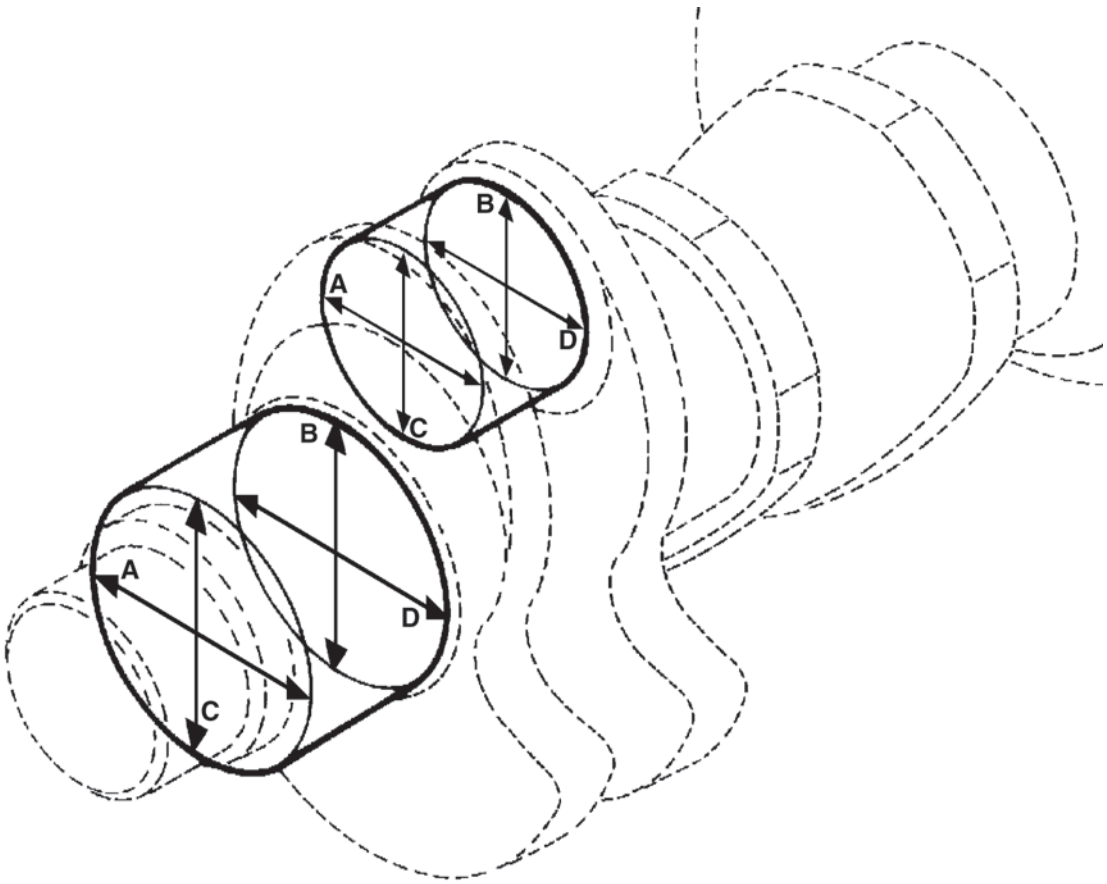
Main Journal	
Diameter	**mm**
Standard	85.942 - 85.964
1st repair	85.692 - 85.714
2nd repair	85.442 - 85.464
3rd repair	85.192 - 85.214
4th repair	84.942 - 84.964

CRANKPINS



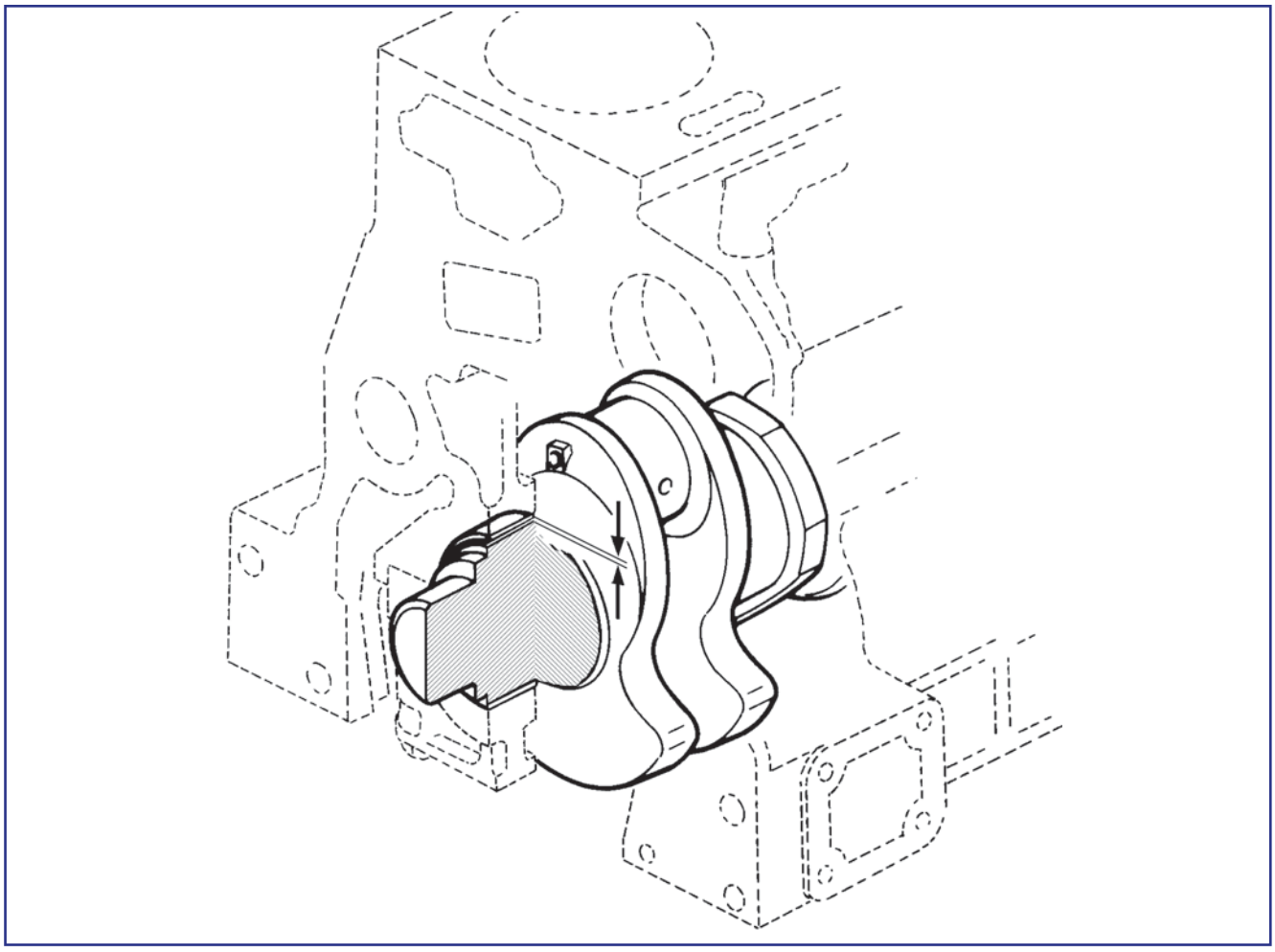
Main Journal	
Diameter	**mm**
Standard	62.951 - 62.970
1st repair	62.701 - 62.720
2nd repair	62.451 - 62.470
3rd repair	62.201 - 62.220
4th repair	61.951 - 61.970

OUT-OF-ROUNDNESS AND TAPER



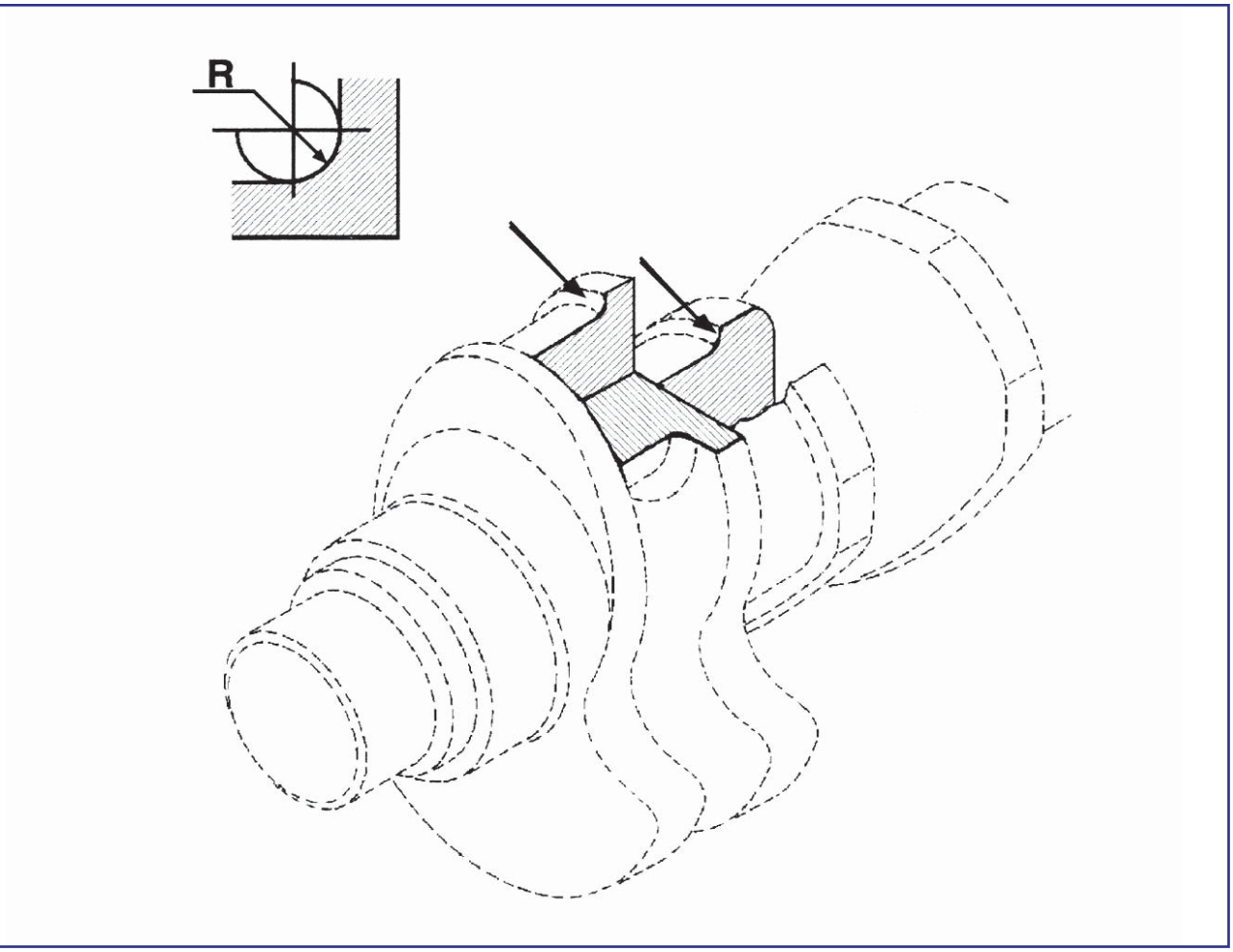
Maximum Out-of-roundness	**mm**
A x C and B x D	0.01
Maximum Taper	**mm**
A x B and C x D	0.01

RADIAL



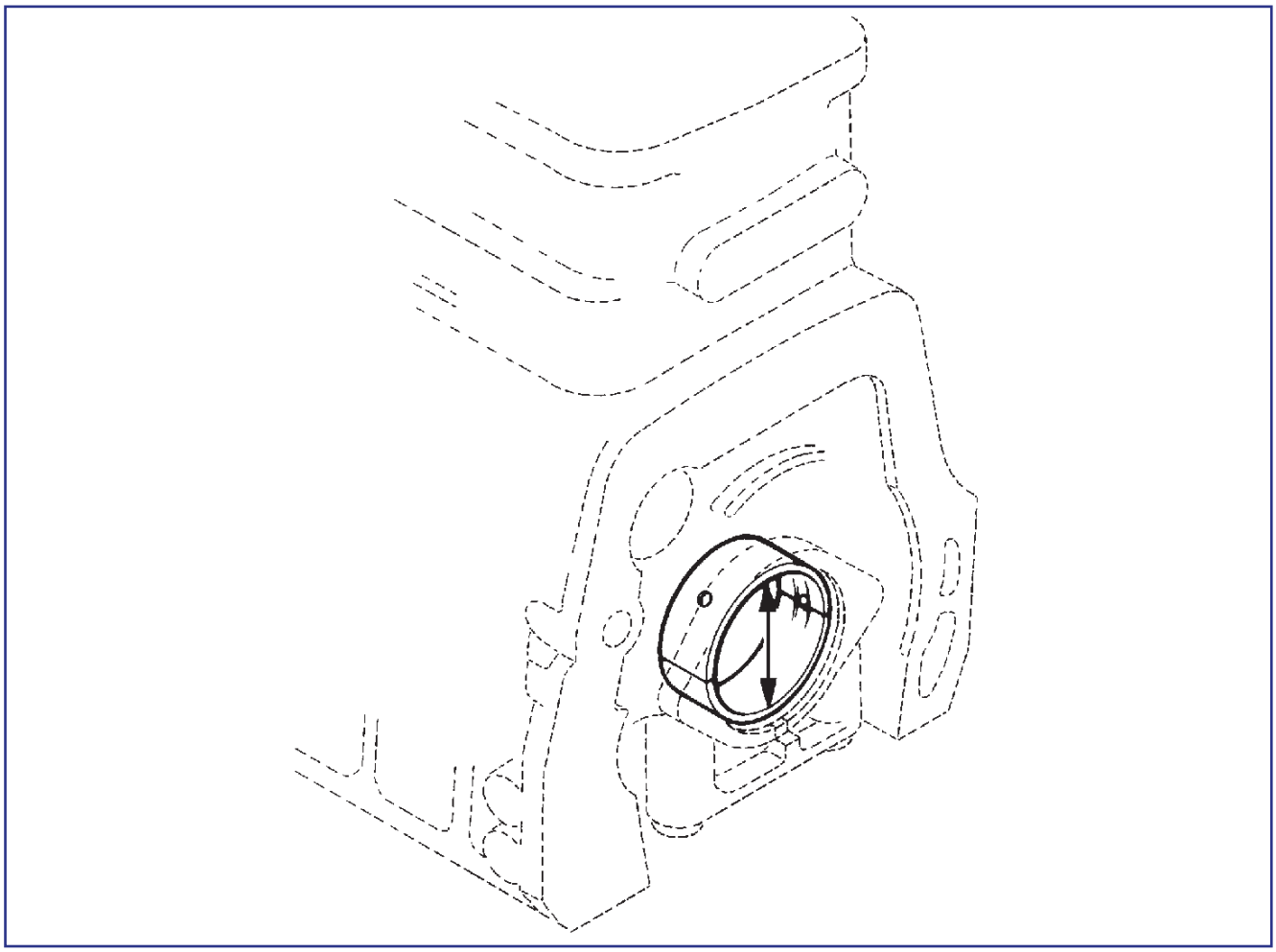
Radial Clearance (except central main journal)	mm
nominal	0.036 - 0.096
maximum	0.245

FILLETS



Fillet	mm
Nominal	3.8 - 4.0

MAIN BEARINGS



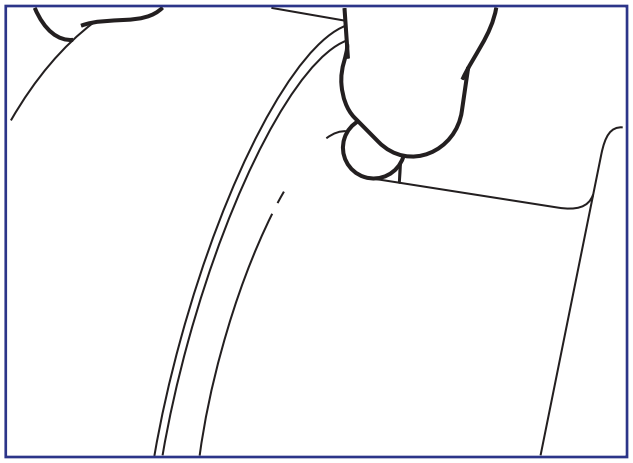
Engine Block	
Diameter	**mm**
Without bearing shell	92.000 - 92.022
Engine Block	
Diameter	**mm**
Standard	86.019 - 86.035
1st repair	85.769 - 85.785
2nd repair	85.519 - 85.535
3rd repair	85.269 - 85.285
4th repair	85.019 - 85.035
Pre-tension	0.05 - 0.15

Inspections and Measurements

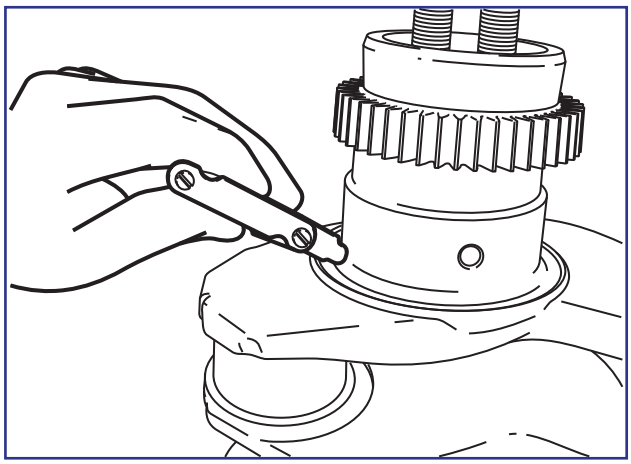
CRANKSHAFT

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.

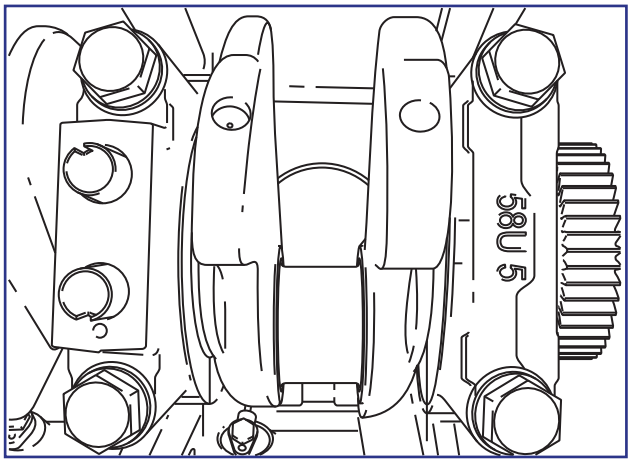


ENGINE BLOCK BEARINGS

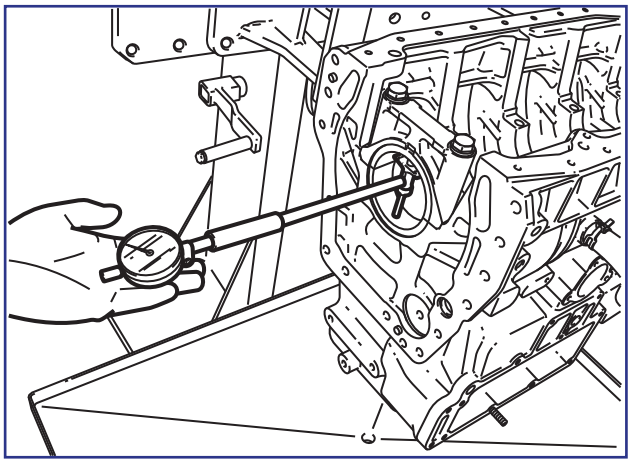
Before doing any check on the caps and main bearings, make sure that the numeration engraved on the engine block corresponds to the bearing cap.

- Install bearing caps and tighten according to the specification.

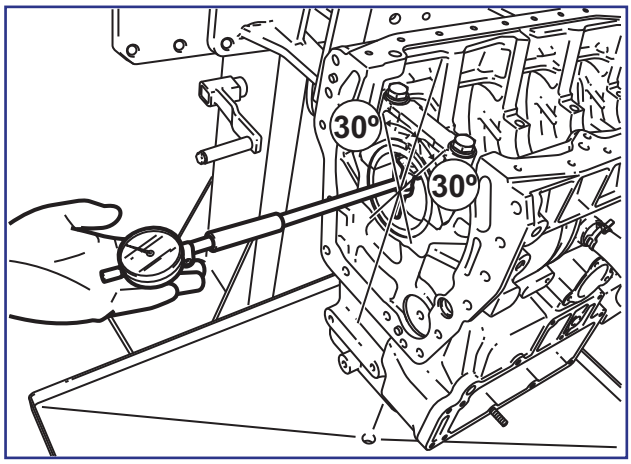
1st	45 to 50 N.m
2nd	150° ± 5°
Torque Range	170 to 282 N.m



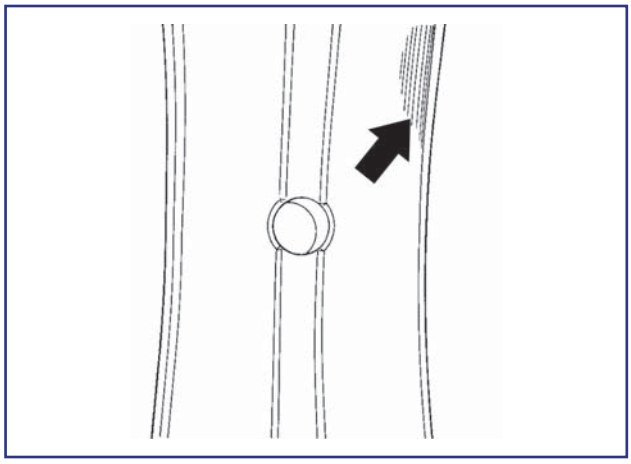
Measure bearings diameter, out-of-roundness and taper without bearing shells.



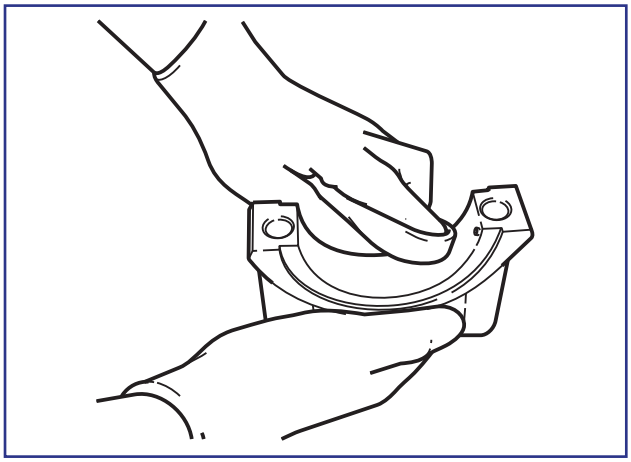
Measure bearing with the bore gauge at 30° to the left and 30° to the right from the central position.



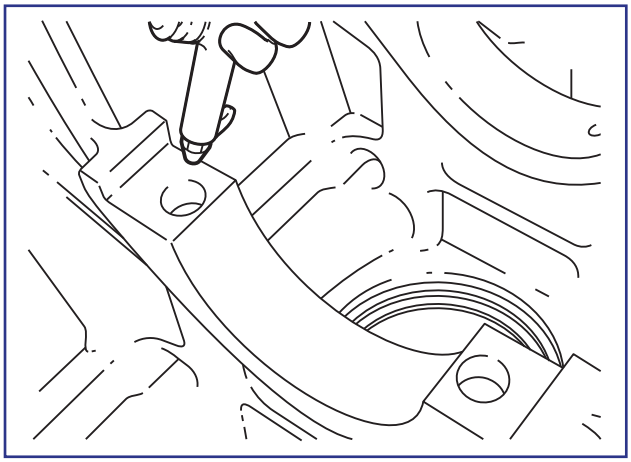
Depending on the defect from bearing shells, it is possible to identify what is the cause in the engine: excessive clearance, out-of-roundness or taper. A failure or excessive clearance also can be detected by the reduction of lubricant oil pressure. The prolonged operation with low oil pressure may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



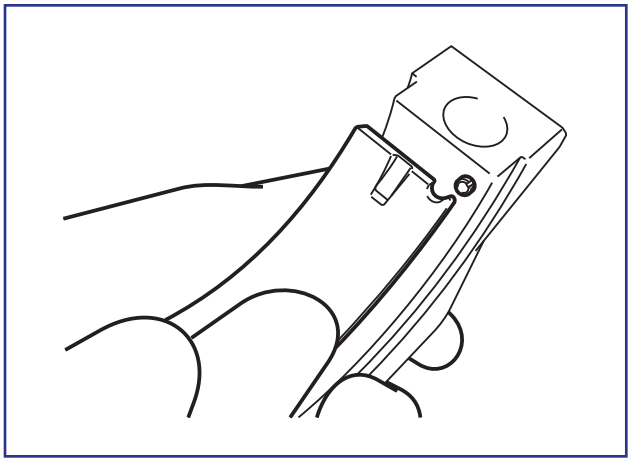
To measure the bearings with the bearing shells installed, clean well the bearing cap, avoiding distortion due to oil or dirt presence.



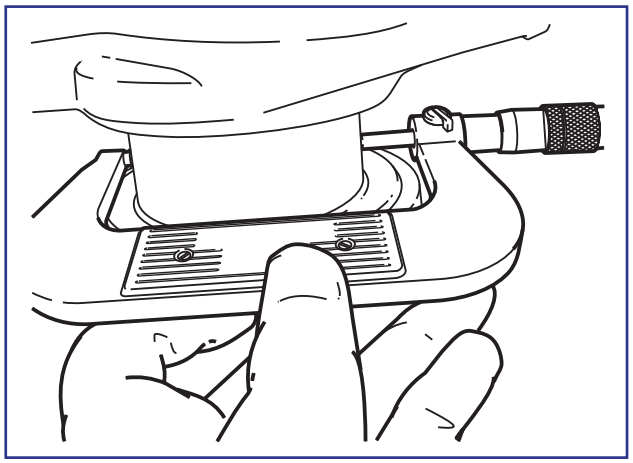
Also clean bearing bolt holes. The holes must be completely free of oil residues and impurities.



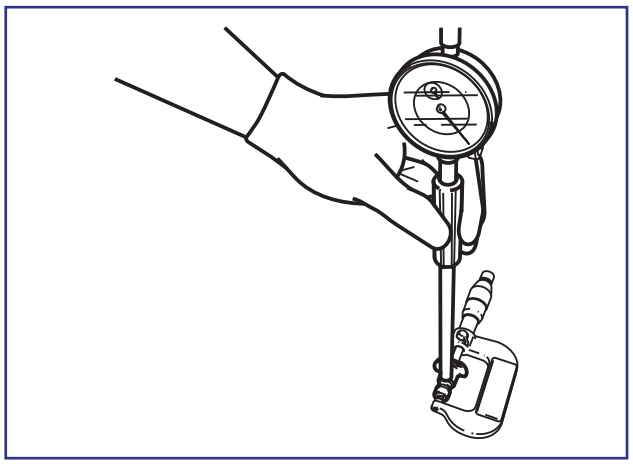
Place the bearing shells with the aid of the expansion pin.



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

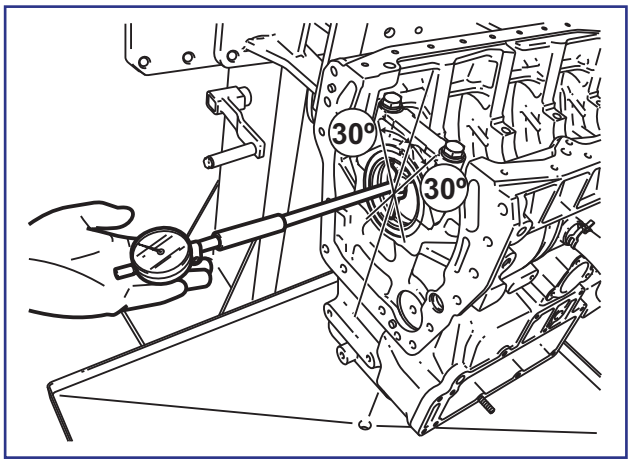


Compare the clearances obtained in the crankshaft through the bore gauge.



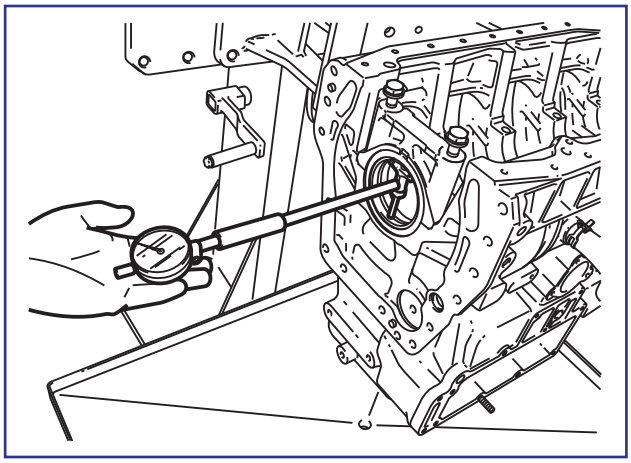
Install bearing caps and tighten according specification. Measure using same procedure from bearings without bearing shells to verify the radial force.

The 1st measurement is made in the centre of the bearing 0.036 – 0.096.



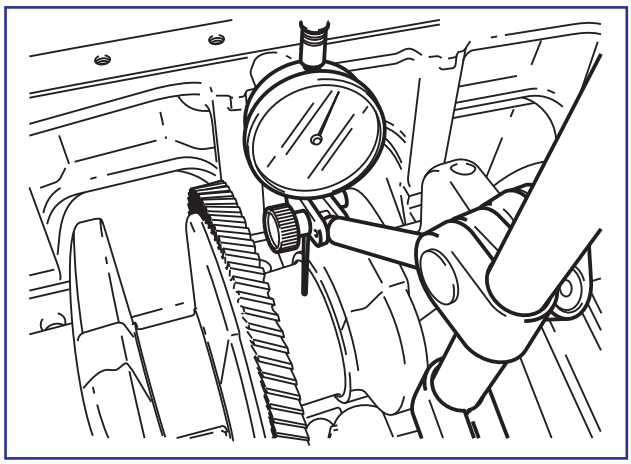
Remove one of the bolts bearing and measure bearing pre-tension.

Pre-tension: 0.05 - 0.15 mm.



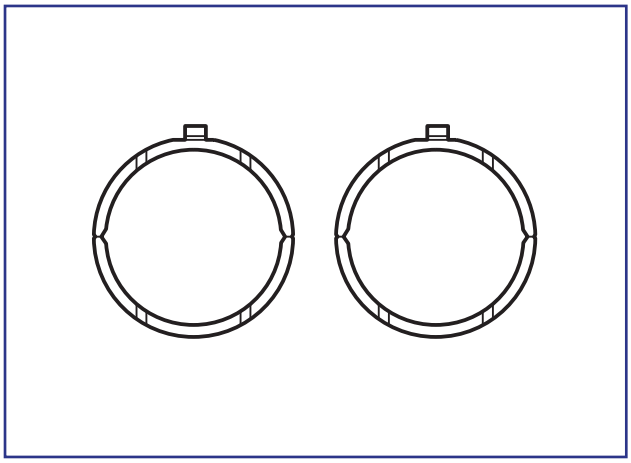
Place crankshaft with the bearing shells of the first and last bearings only installed and oiled. With a dial indicator gauge on the central main journal, turn crankshaft and measure warping.

	6 cyl.
Maximum Warping (mm)	0.15



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

When needed it may utilize over-sized thrust ring, which must have its flat surface adjusted, in order to provide the correct axial clearance.

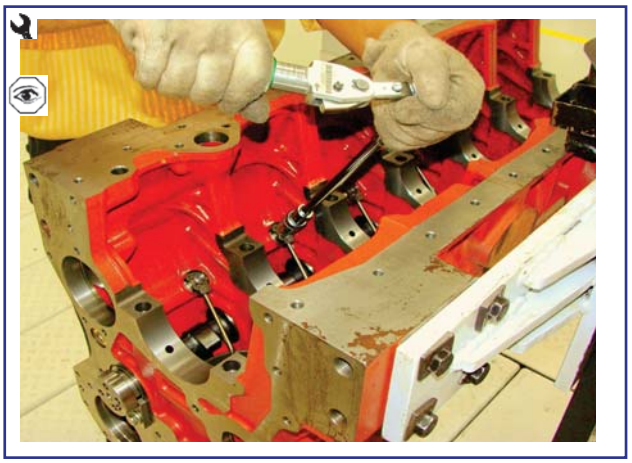


Crankshaft Thrust Ring	
Thickness	mm
Standard	3.42 - 3.47
Over-size	3.67 - 3.72

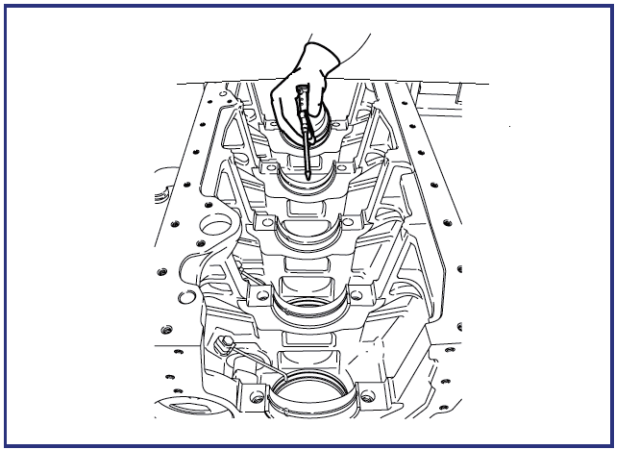
Assembly

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

Apply torque of 10 ± 1.5 Nm.

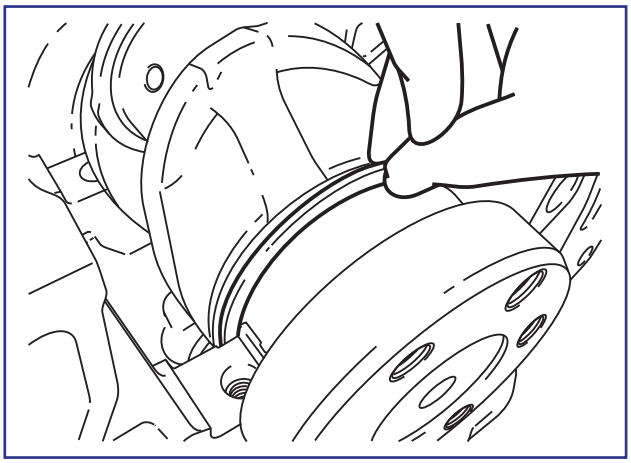


Install and apply oil onto all bearing shells.

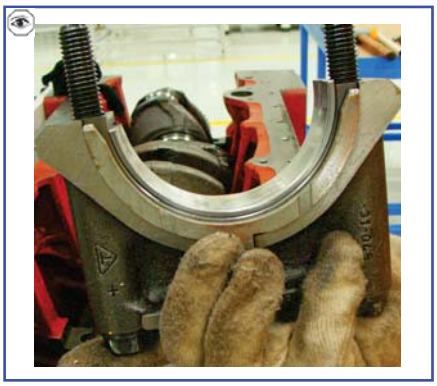


Install crankshaft.

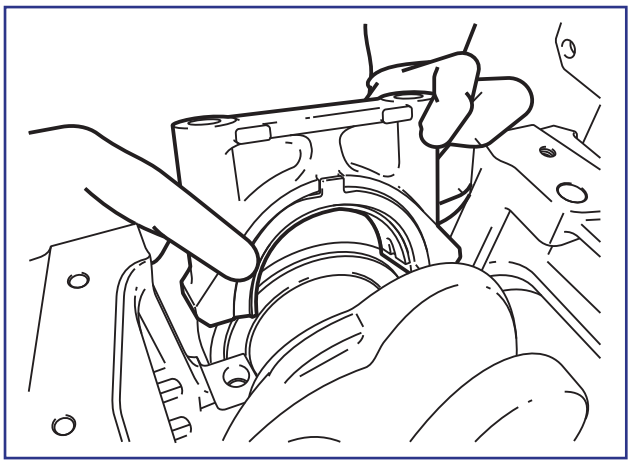
Install first bearing lower thrust ring.



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

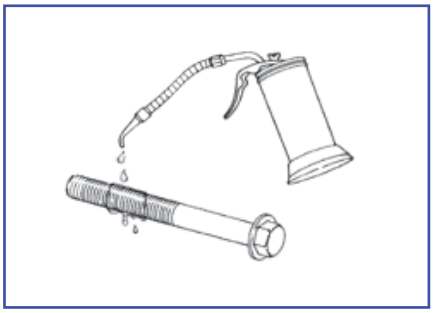


Assembly bearing caps with the upper thrust ring.



Thrust Ring	
Thickness	mm
Standard	3.42 – 3.47
Oversize	3.67 – 3.72

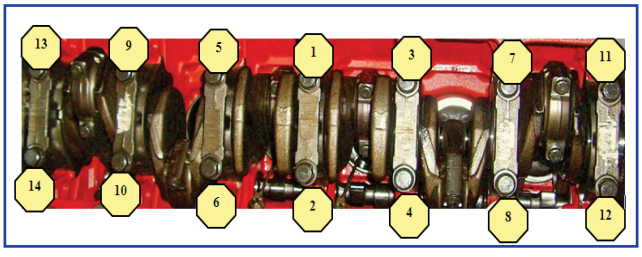
Use clean engine oil to lubricate the cap screw threads. Drain the excess oil from the cap screws before installing them.



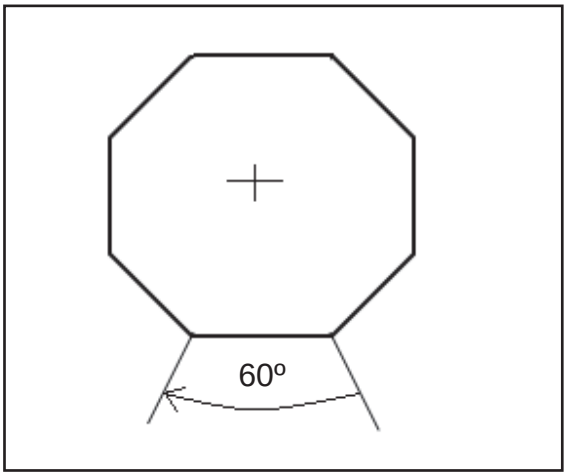
- Tighten bolts in two steps and tighten according the specification.

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

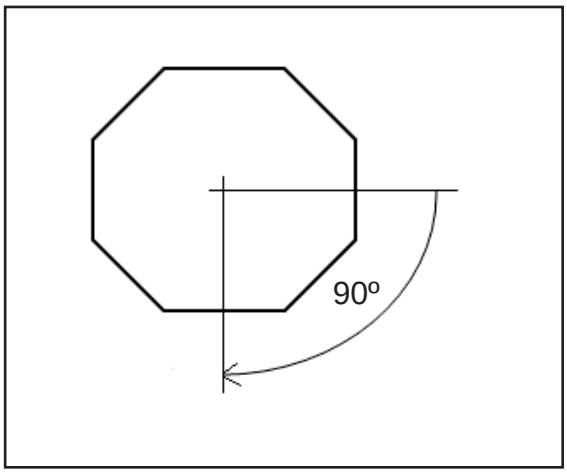
1st	50-5 N.m
2nd	155° ± 5°
Torque Range	170 to 282 N.m

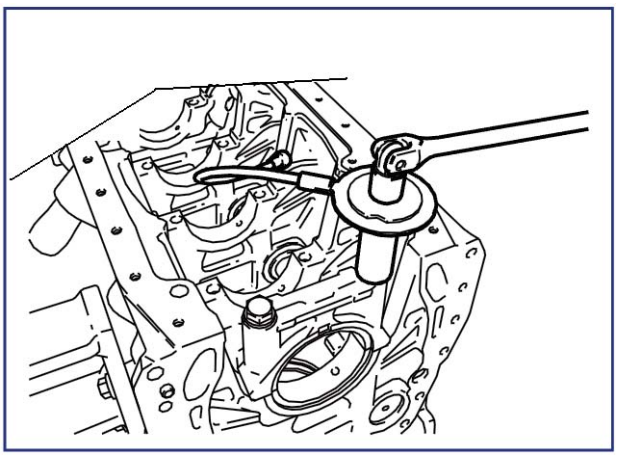


For giving angle torque first give 60°



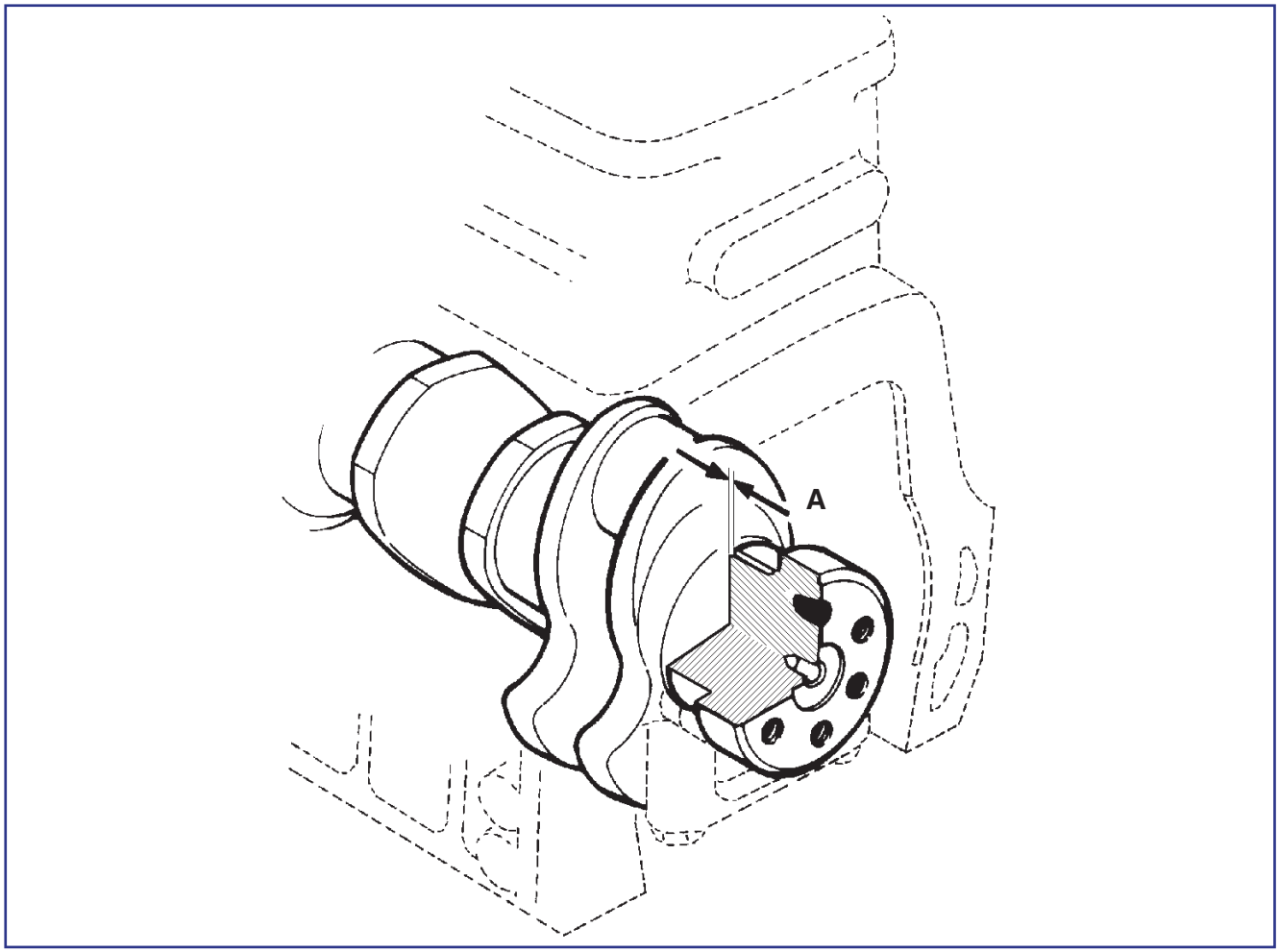
Then give angle torque of 90° . Therefore the total angle will be 150°



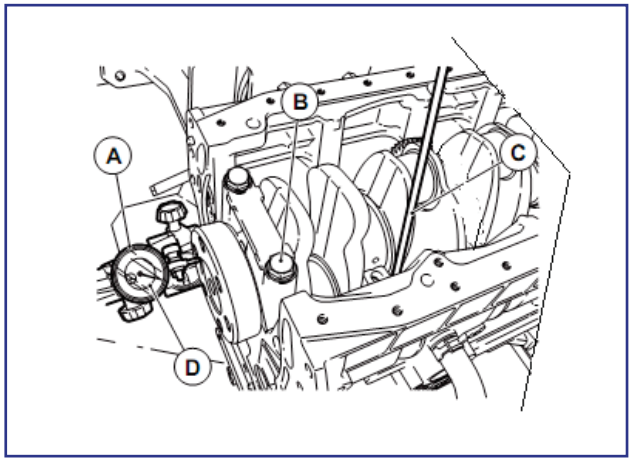


Measurements After Assembly

AXIAL CLEARANCE



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



Measure the crankshaft axial clearance.

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

NOTES

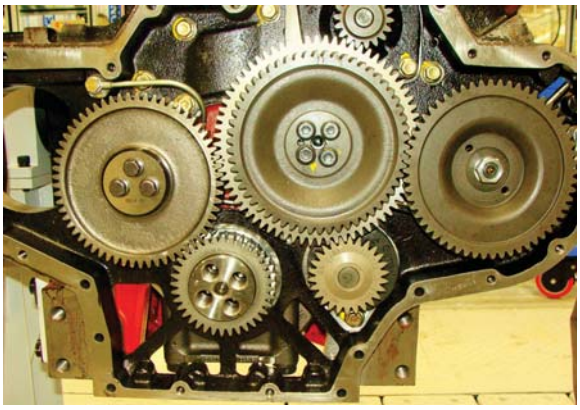
Camshaft

Group - 07

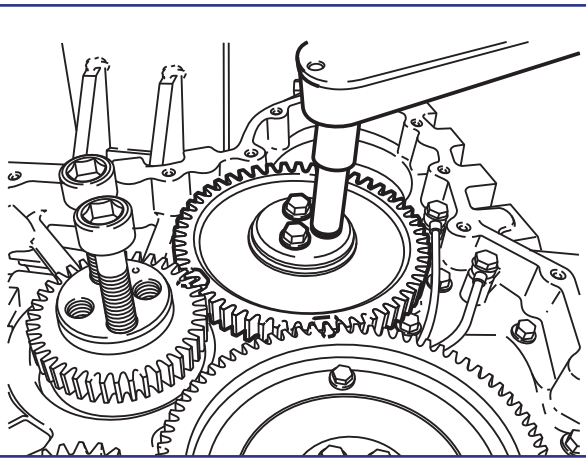
Disassembly Notes

REMOVAL

- First remove the FIP gear then remove the idle gear. Then fianlly remove the thw gears mounted on camshaft.

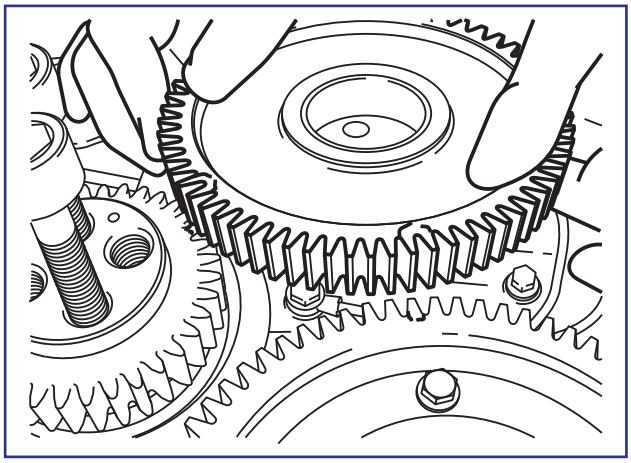


- Remove the screw from idle gear



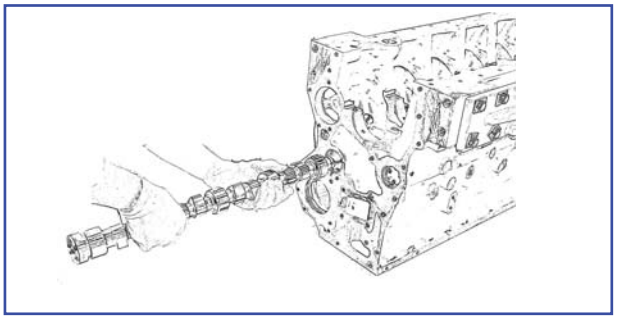
Remove the spacer from idle gear

Remove the idle gear from shaft.



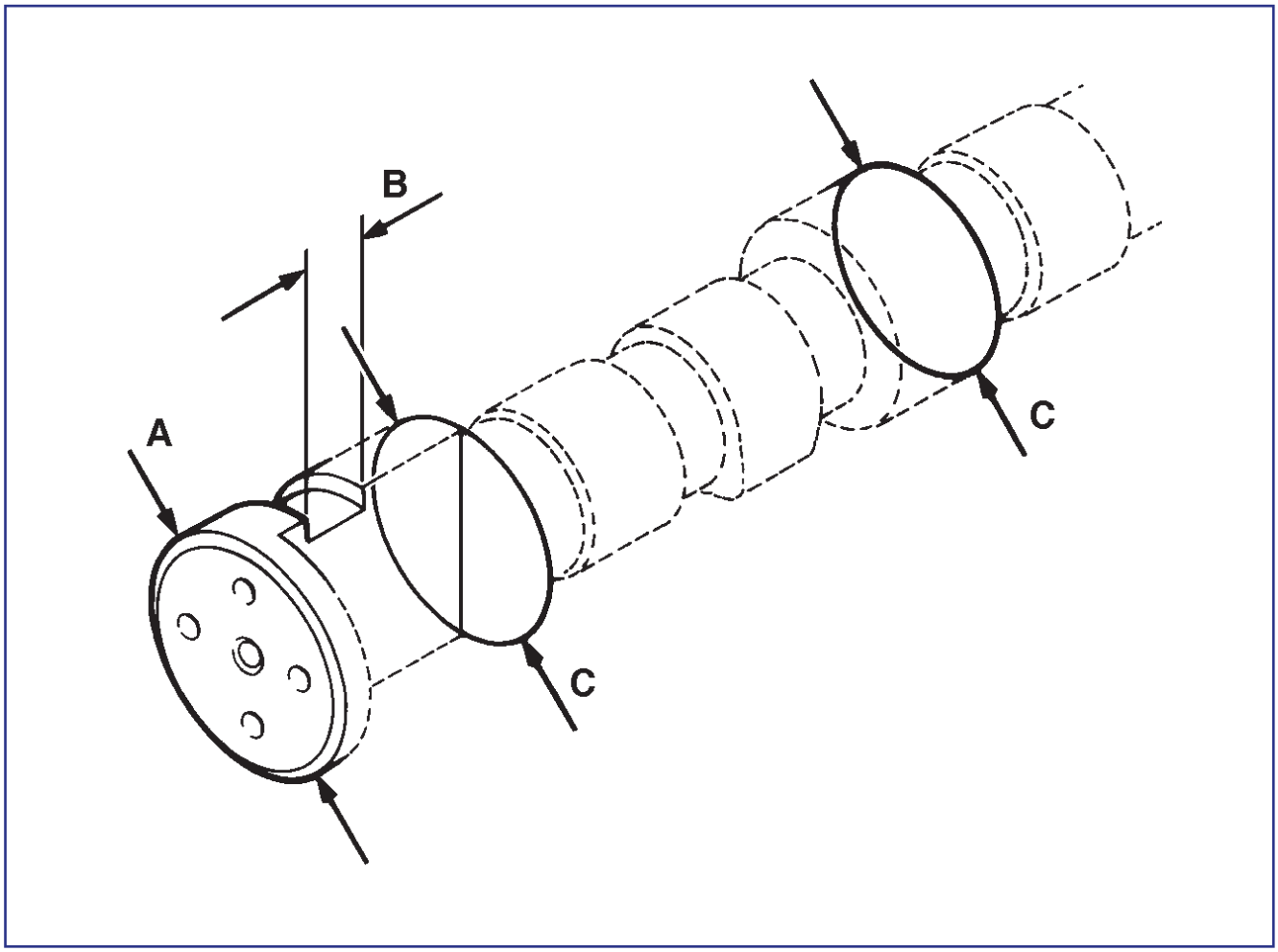
- Remove camshaft lock mounting bolts and its lock plate.

Rotate the engine assembly, 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.



Specifications

CAMSHAFT



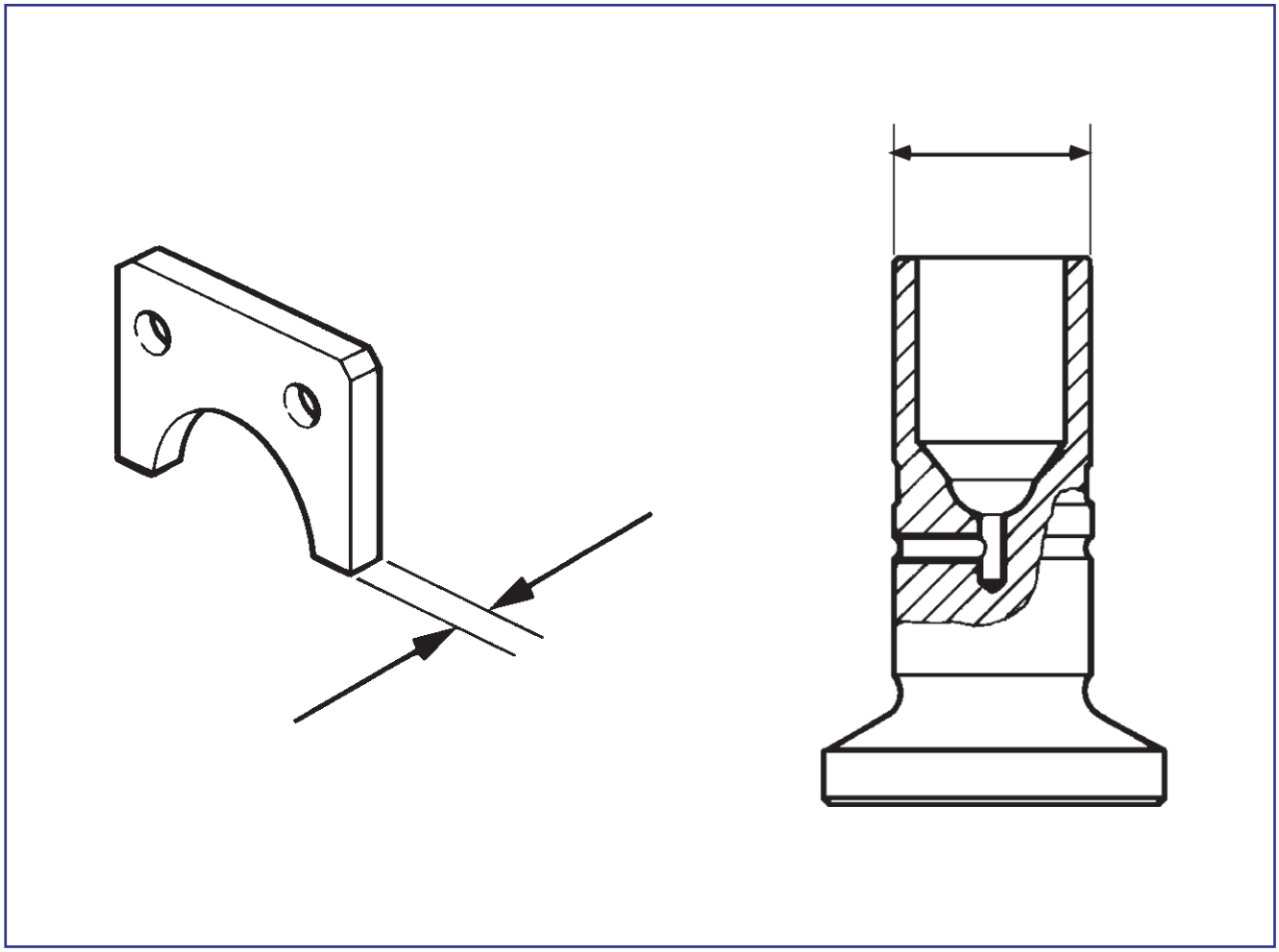
Gear seat	
Diameter (A)	**mm**
Nominal	51.971 - 51.990

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

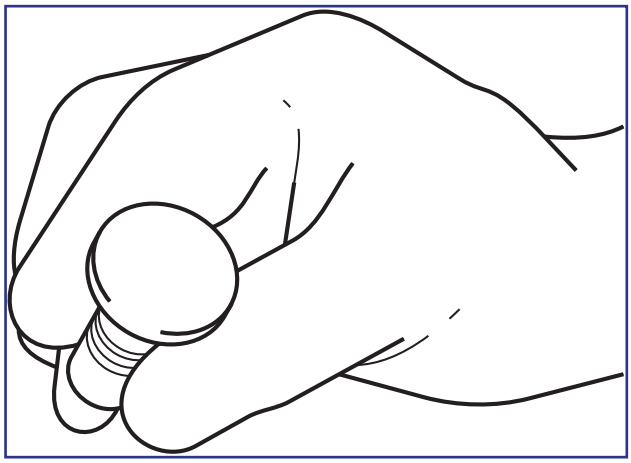


Lock Plate	
Thickness	**mm**
Nominal	7.00 - 7.05

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

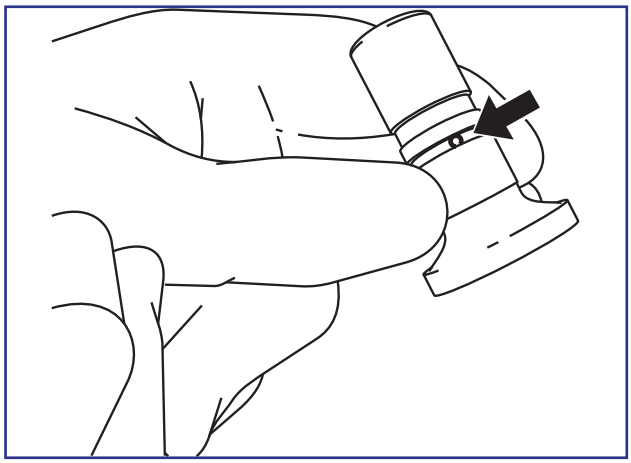
Inspections and Measurements

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



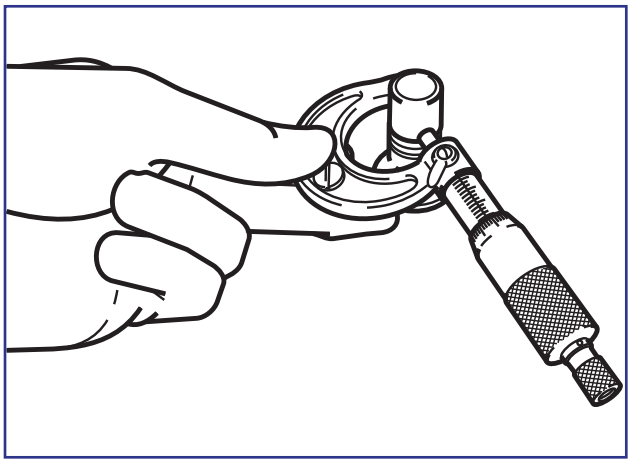
Attention: During its operation the tappets perform a rotating movement, responsible for a uniform distribution of the force, uniforming the waste. It must not have waste on only one area.

Visually check tappet lubrication holes.

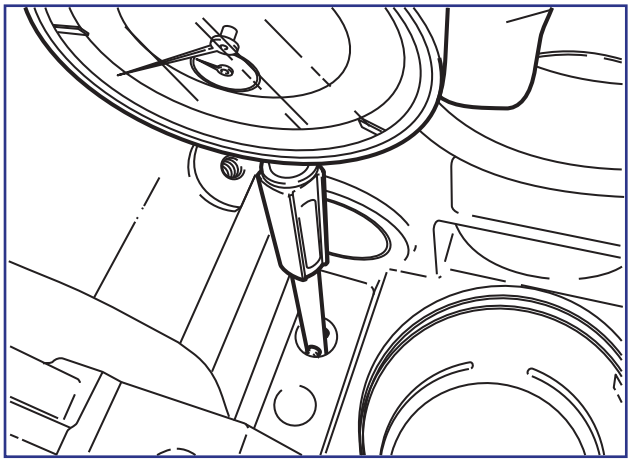


Attention: The lubrication holes of the tappets cannot be obstructed.

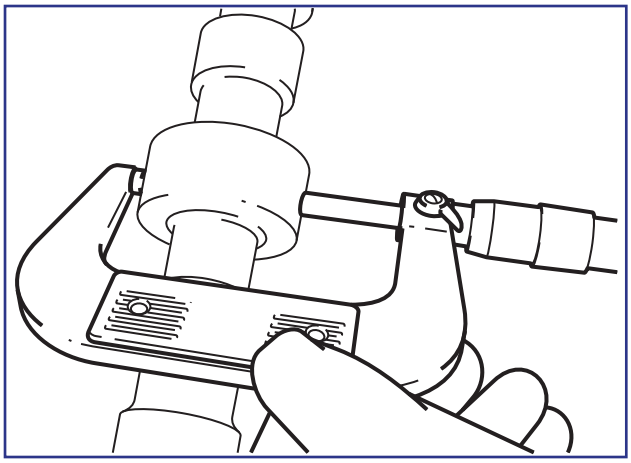
Measure the diameter and out-of-roundness of the tappets housing.



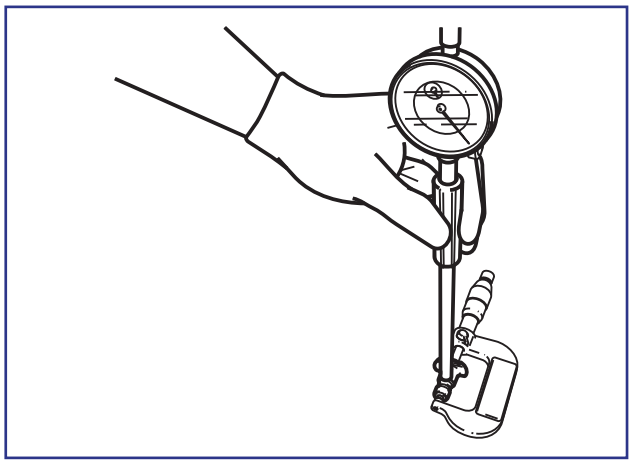
Measure the tappets bore diameter in cylinder block



Measure the camshaft bearing diameters.



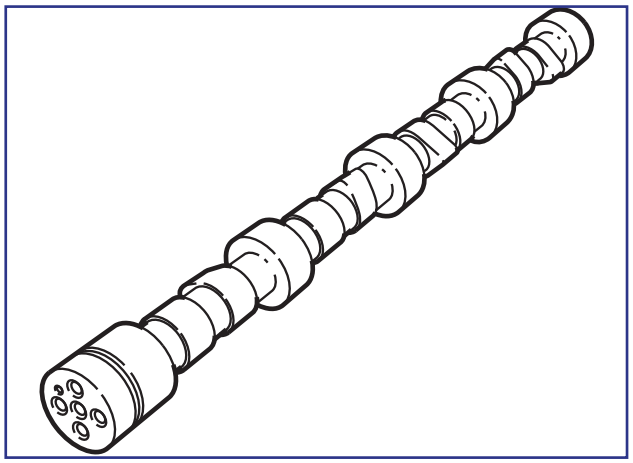
Comparing the performed measurements, obtain the clearance between the bearing and the housing.



Measure the camshaft bearing housing bores.

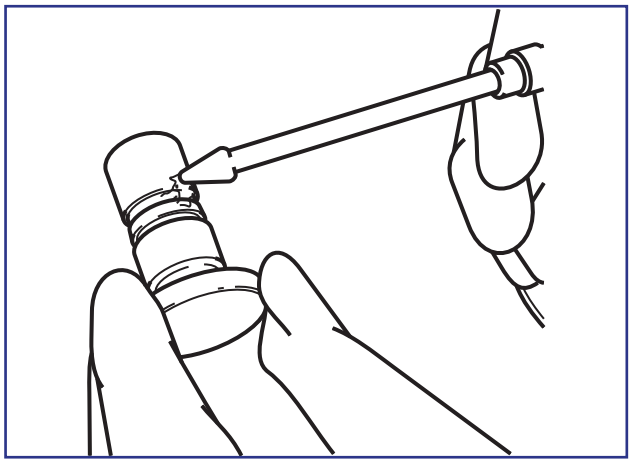
Measure the camshaft warping.

	6 cyl.
Maximum warping (mm)	0,04

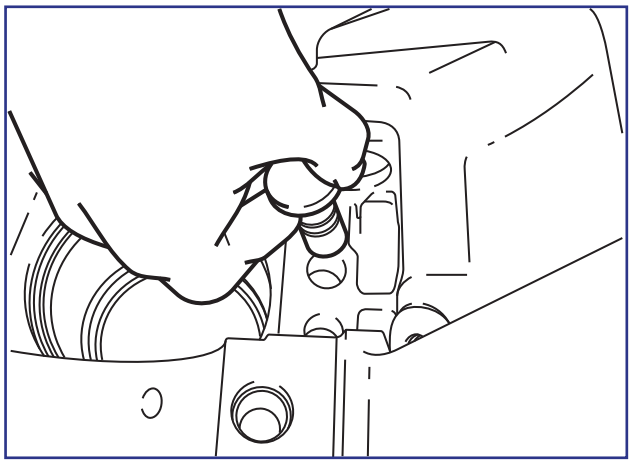


Assembly

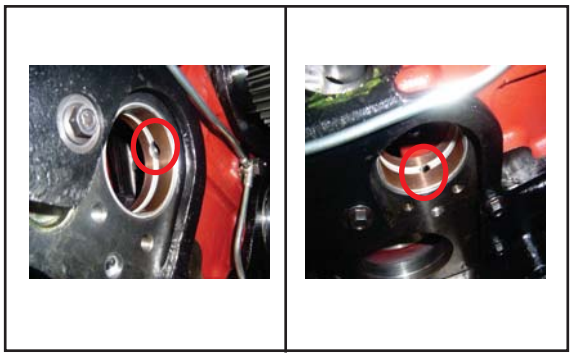
Clean and lubricate the tappets and the tappets housing.



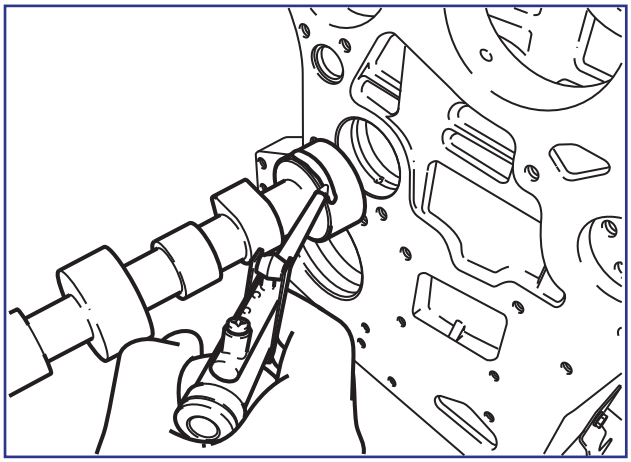
Install them with the hands. If it is not necessary to change the tappets check the original position in that they were installed and reinstall them in the same positions.



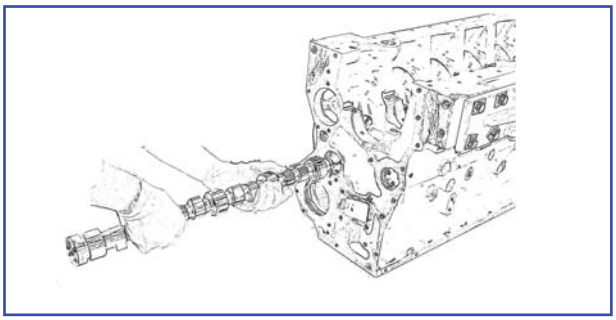
Check for the cambush oil hole position.
It should match with the oil holes in the cylinder block.



Clean and lubricate camshaft bearings.

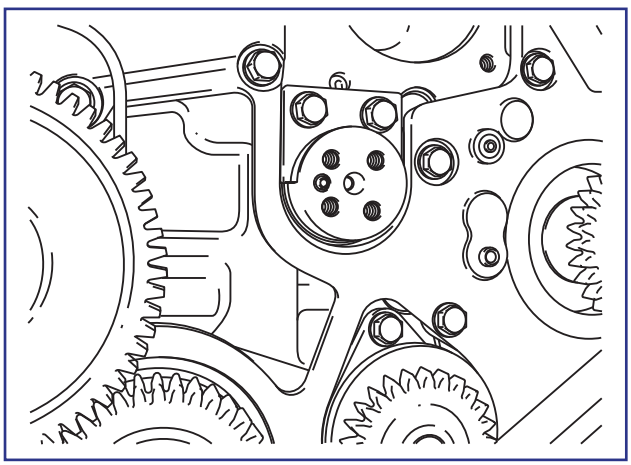


Install it with the hands making rotating movements. Take care to do not damage the bushings in the engine block.



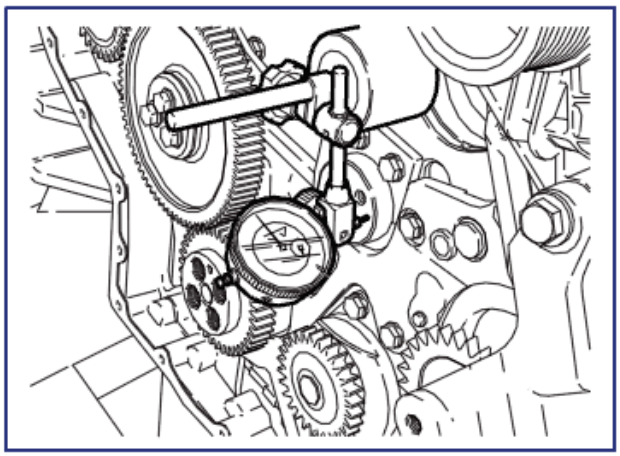
After camshaft installation, install the axial lock and tighten fixation bolts according to the specification.

Apply torque: 30 ± 5 N.m



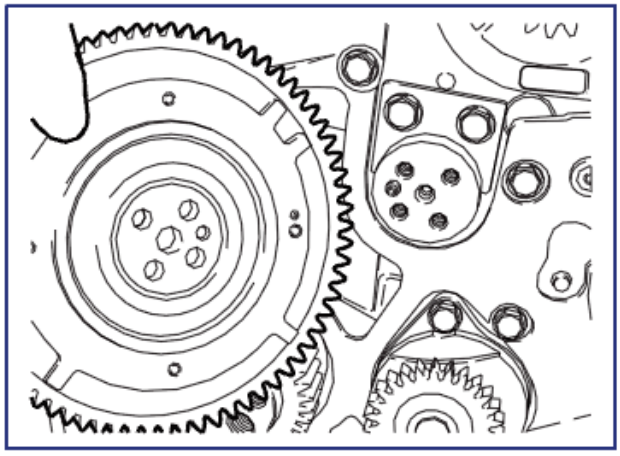
Assembly

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

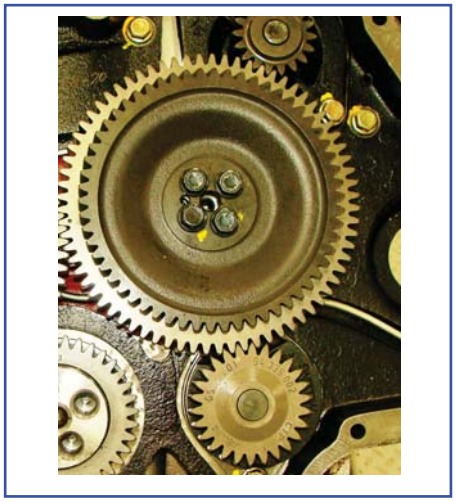


Install camshaft gear.

(shown 6 cylinders camshaft gear)

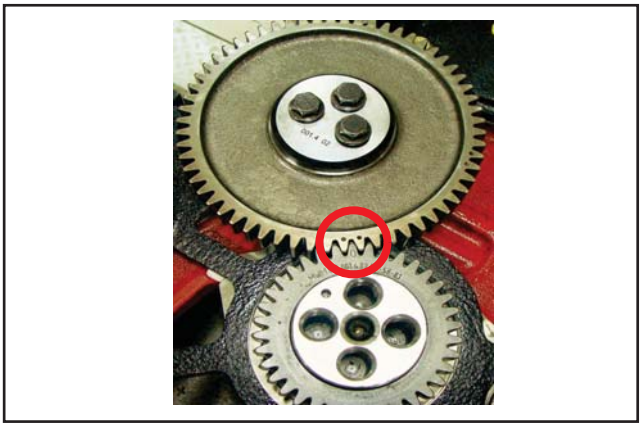


Install camshaft small gear and tighten the screws

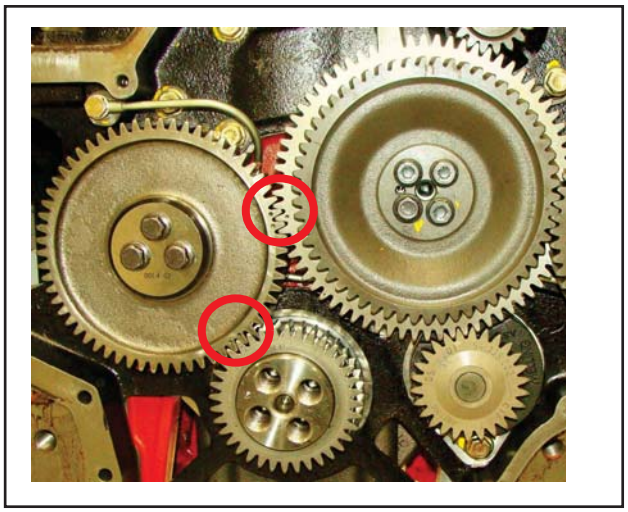


Install idle gear.

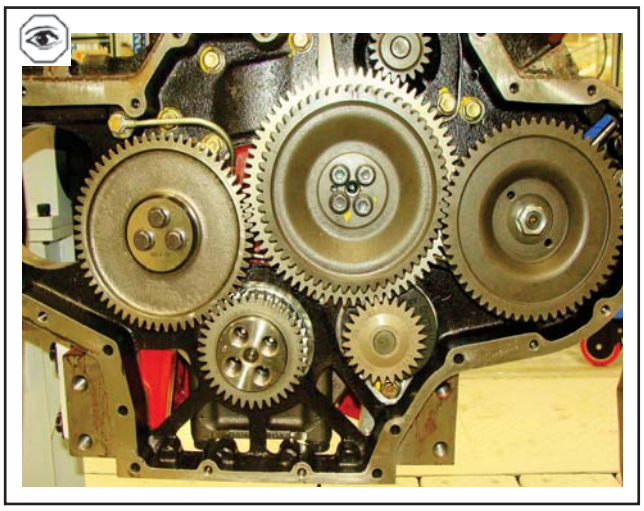
Tighten the bolt at 6.0 ± 5 torque



During installation of idle gear make sure to match the timing marks with respect to crank gear and camshaft big gear



Then install the FIP gear and tighten the gear mounting nut at specified torque



NOTES

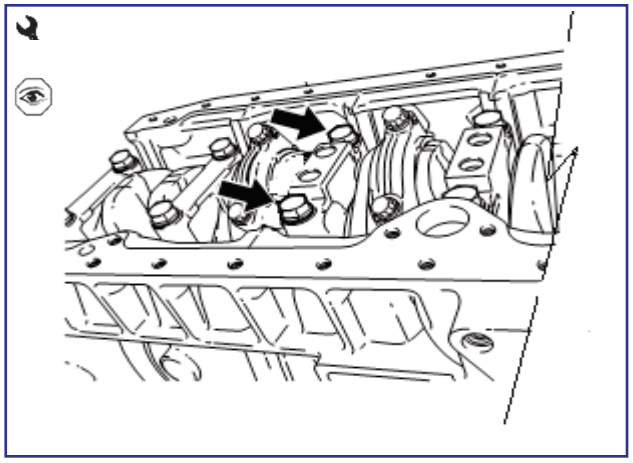
Pistons and Connecting Rods

Group - 08

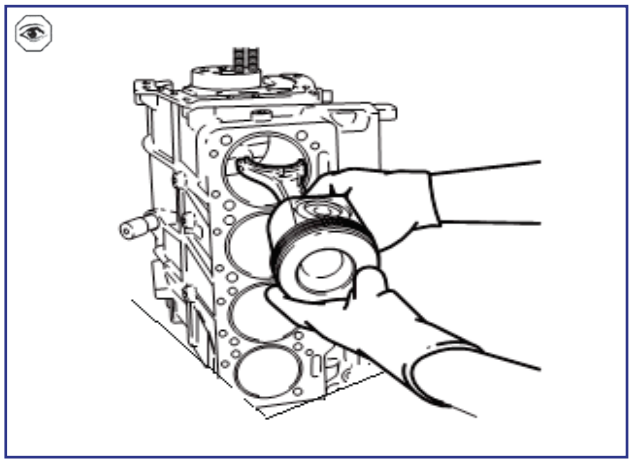
Disassembly Notes

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.



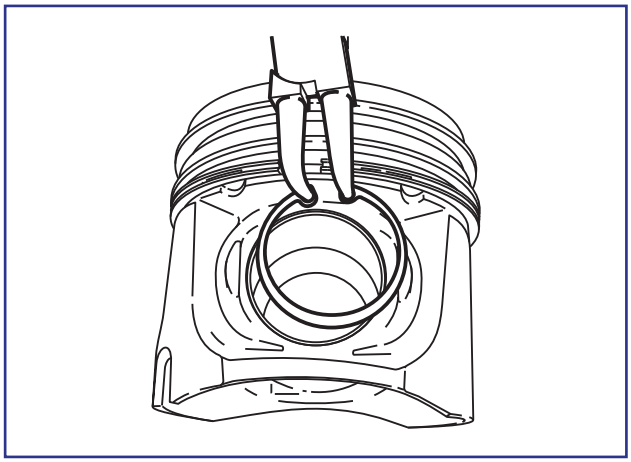
Before removing the piston, clean the inner part of the liner to remove residues of coal and impurities. With the connecting rod caps out, carefully remove the piston / connecting rod set through the upper side of the engine.



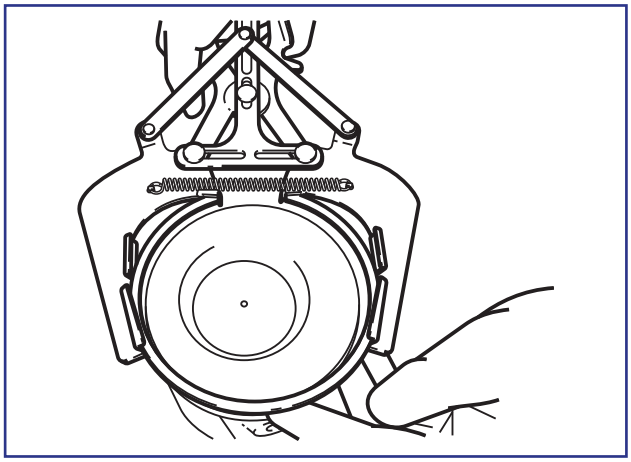
Remove piston pin snap rings. The piston pins must move freely.

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.



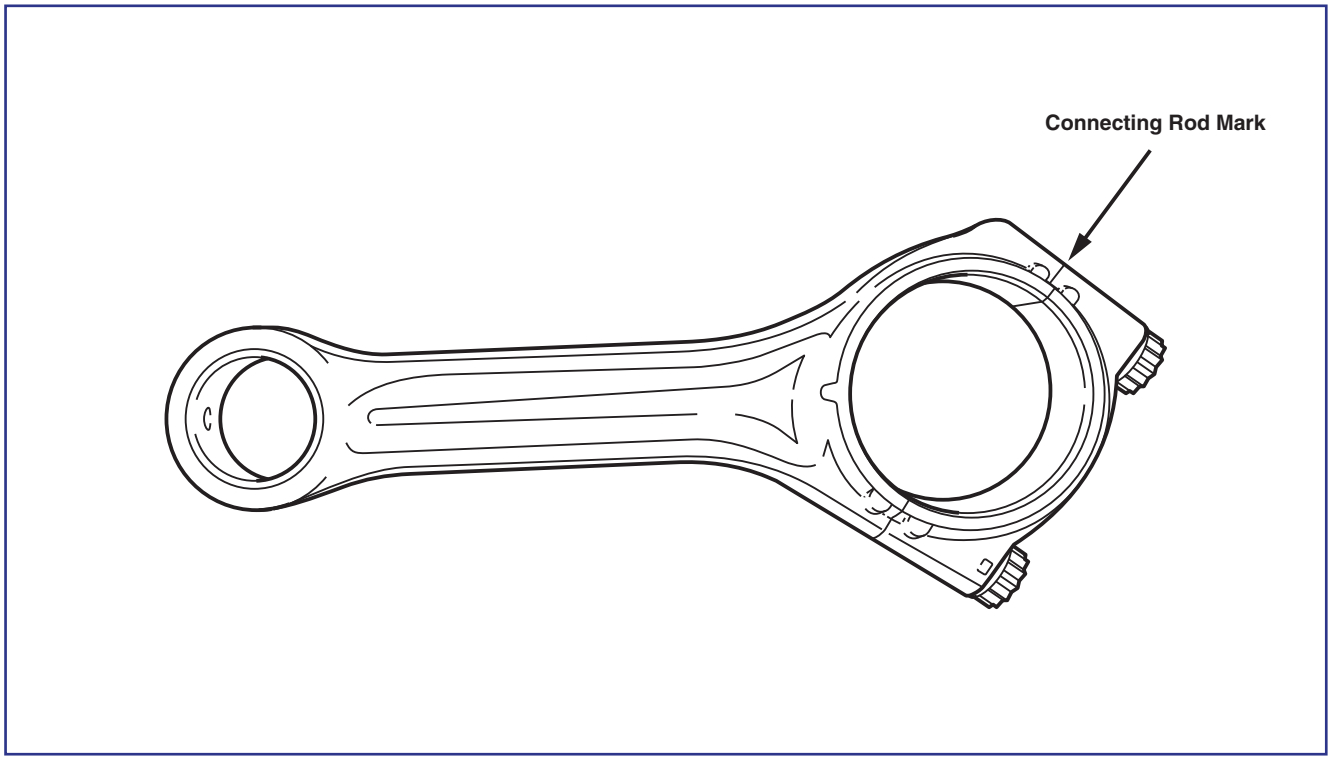
Remove piston rings with an appropriate device.



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

Specifications

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.



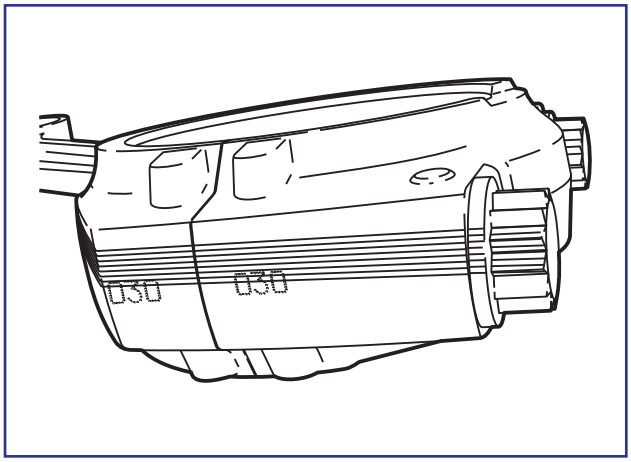
WEIGHT CLASS

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

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

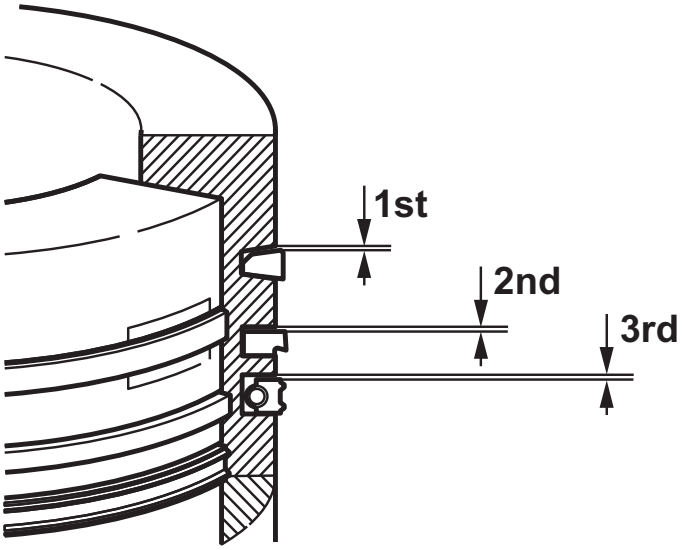
CONNECTING ROD MARK

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.



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 GROOVES

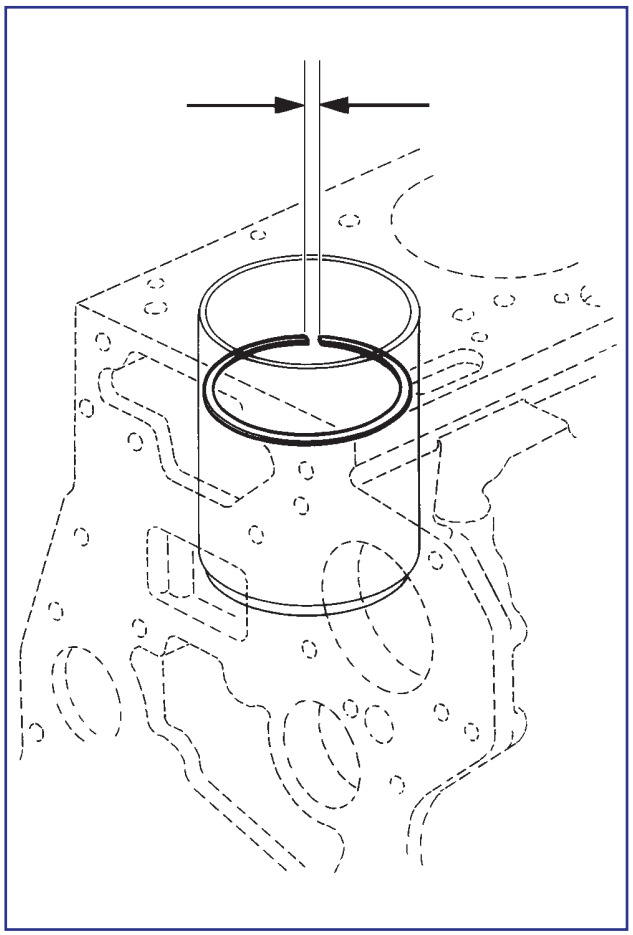


Remark:

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

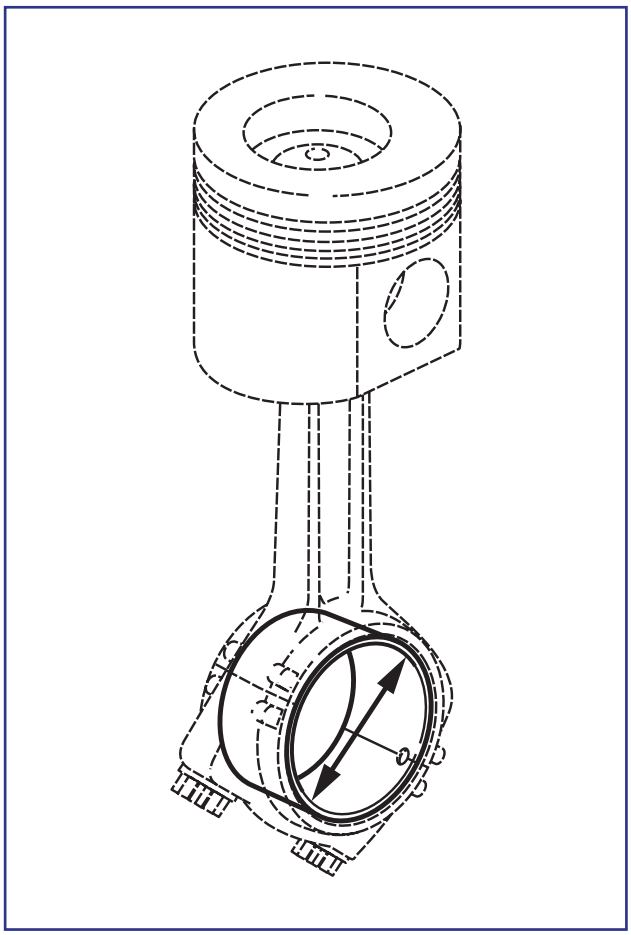
Rings Dimensions and Clearances in the Grooves (Standard)			
Groove	Dimensions (mm)	Clearance (mm)	Strip Code
1st	105.0 x 3.0 x 4.55	0.25	Orange
2nd	105.0 x 2.5 x 4.35	0.05 to 0.09	Yellow
3rd	105.0 x 3,5 x 2.65	0.07 to 0.11	Green

RING ENDS GAPS



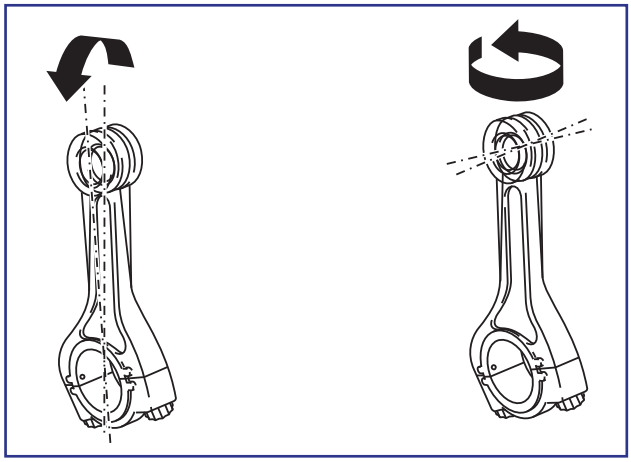
Ends Gap	(mm)
1st groove	
Nominal	0.30 - 0.55
2nd groove	
Nominal	0.60 - 0.85
3rd groove	
Nominal	0.25 - 0.55

CONNECTING ROD BEARINGS



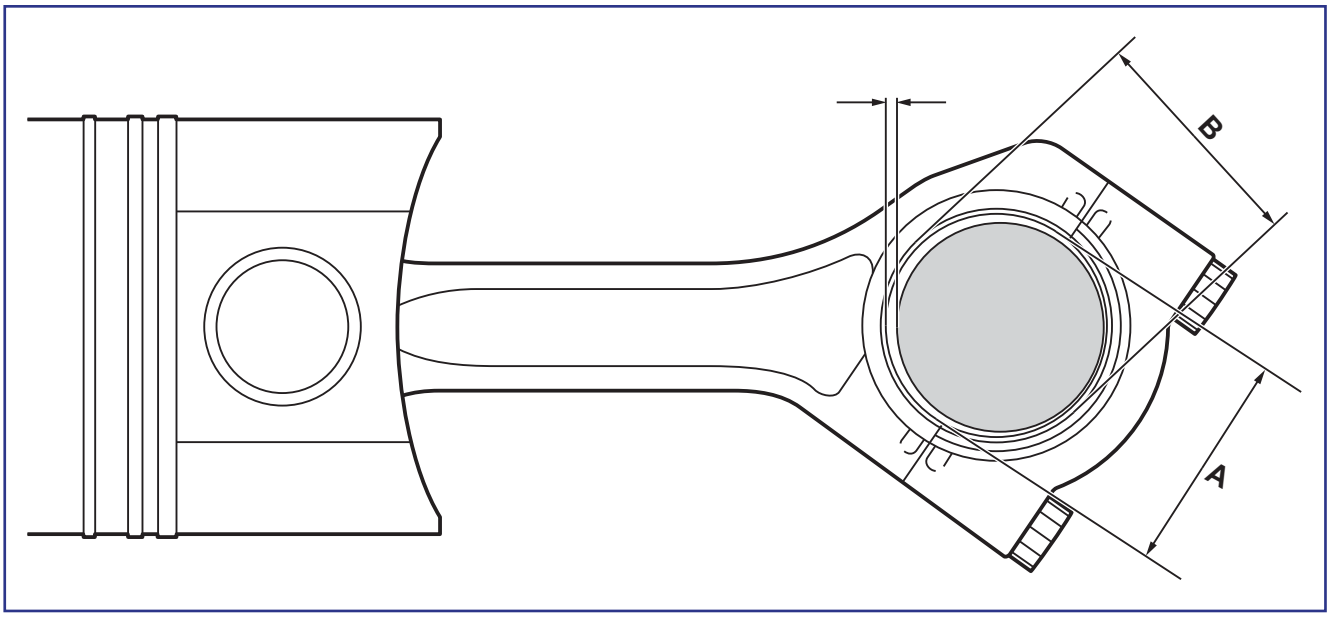
Connecting Rod Bearing, Ø (bore)	
Diameter	**(mm)**
Standard Repair 1 Repair 2	62.992 to 63.037 62.746 to 62.791 62.496 to 62.541
Pre tension	0.06 to 0.12

CONNECTING ROD WARPING



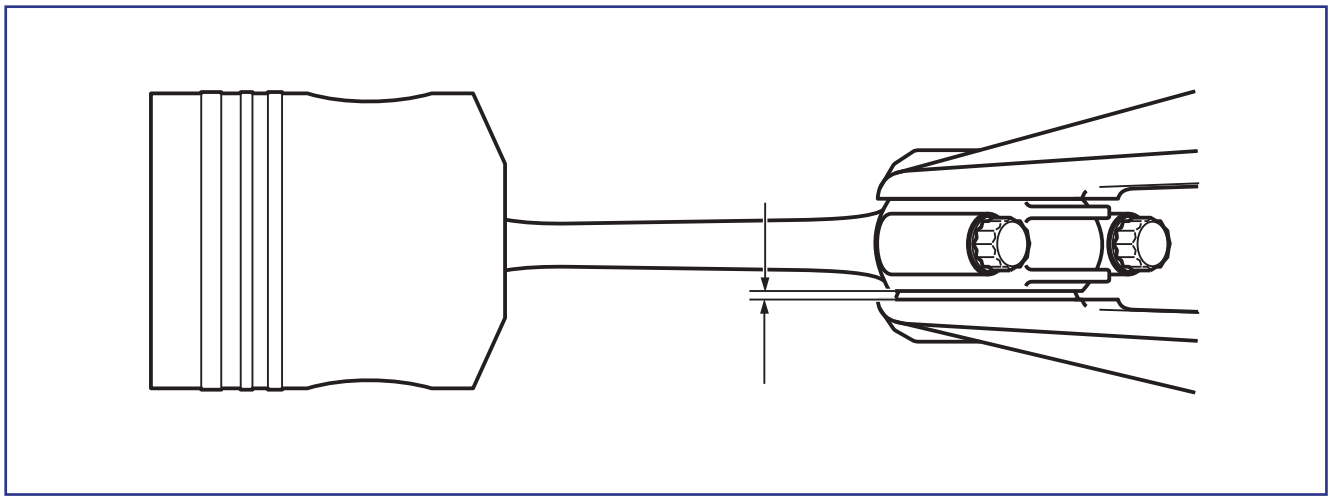
Maximum Torsion	Maximum Warping
0.10	0.03

CONNECTING RODS



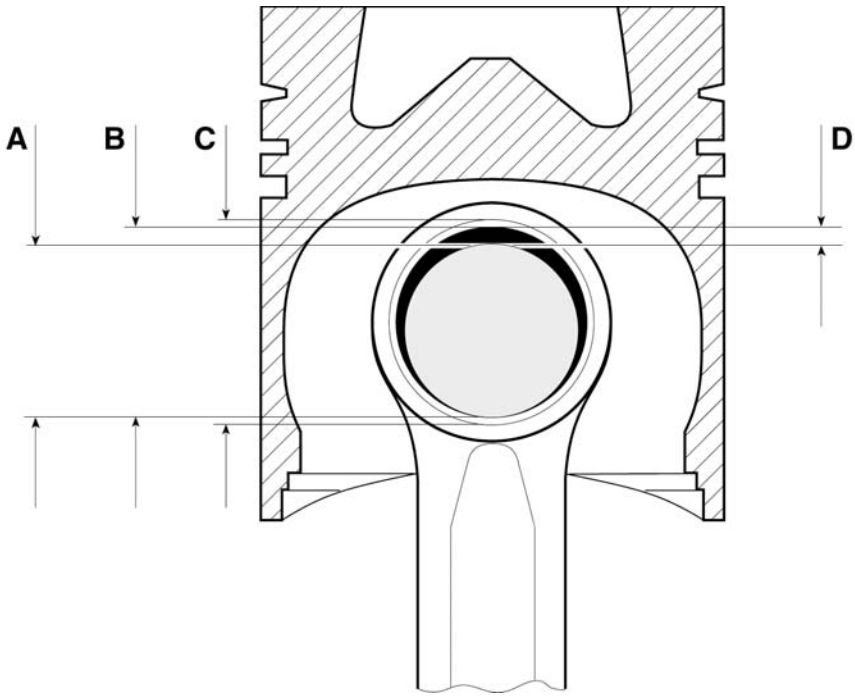
Radial Clearance	(mm)
Nominal	0.026 - 0.081
Maximum	0.178

Diameter Ø	(mm)
A (With Connecting Rod Bearing)	63.015 - 63.031
B (Without Connecting Rod Bearing)	67.000 - 67.019



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

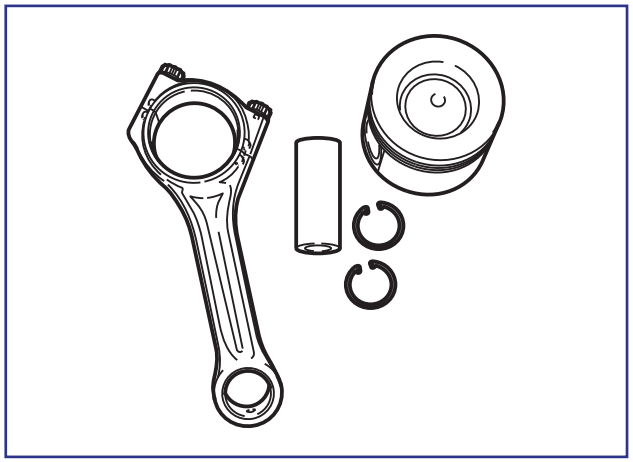
ØB Connecting Rod Bushing (assembled)	
Diameter	**(mm)**
Nominal	38.037 to 38.095
Maximum	38.140

ØC Connecting Rod Bushing (housing)	
Diameter	**(mm)**
Nominal	41.455 to 41.480

D Piston Pin to Connecting Rod Bushing Clearance	
	(mm)
Nominal	0.037 to 0.101
Maximum	0.150

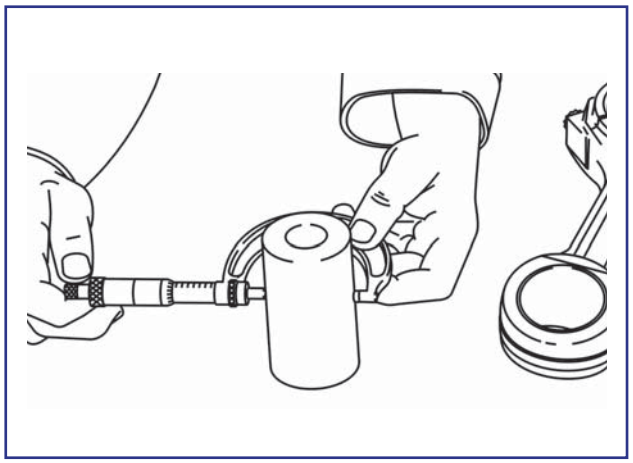
Inspections and Measurements

Visually check pistons, pins and connecting rods.

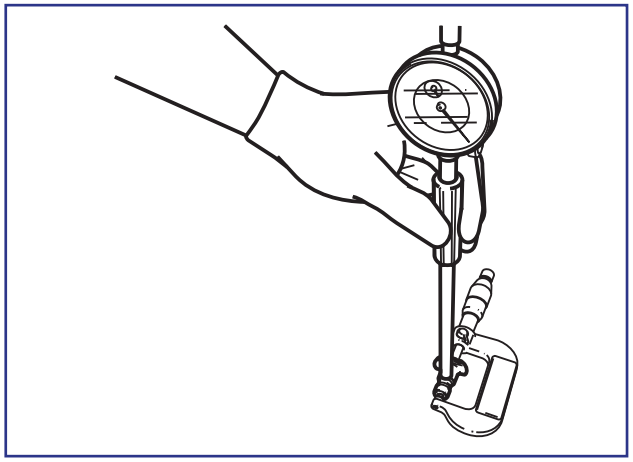


Check piston pin for marks, scratches or excessive waste.

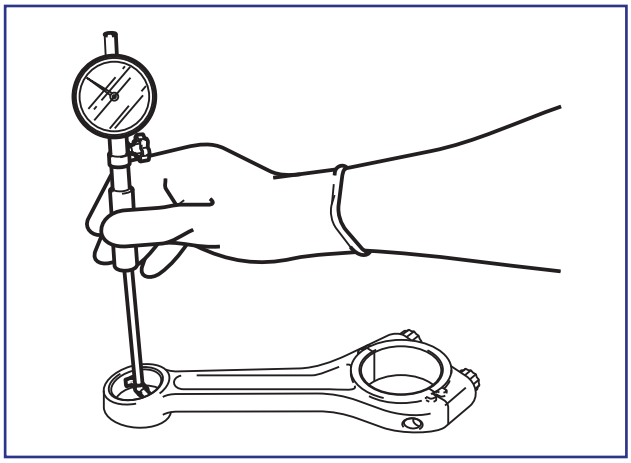
Measure the diameter of the pin. Check pins taper and out-of-roundness.



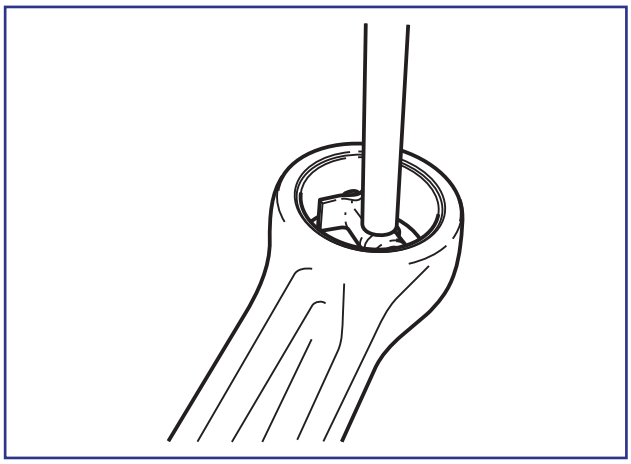
Transfer the piston pin measured to the telescope gauge.



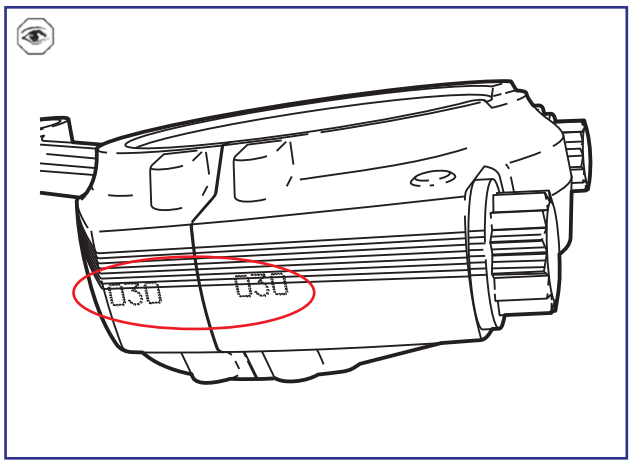
Measure the clearance of the connecting rod bushing housing to the piston pin. Check connecting rod, possible damages, marks or waste. Damages on the connecting rod stem (profile “I”) could case cracks and ruptures of the connecting rod.



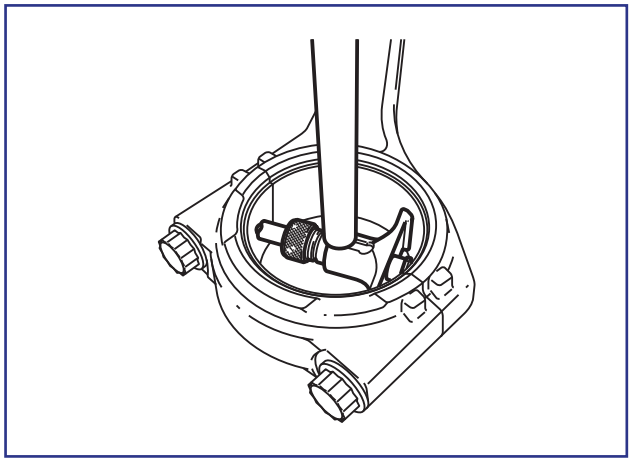
With the bushing assembled, measure the diameter of the housing of the piston pin.



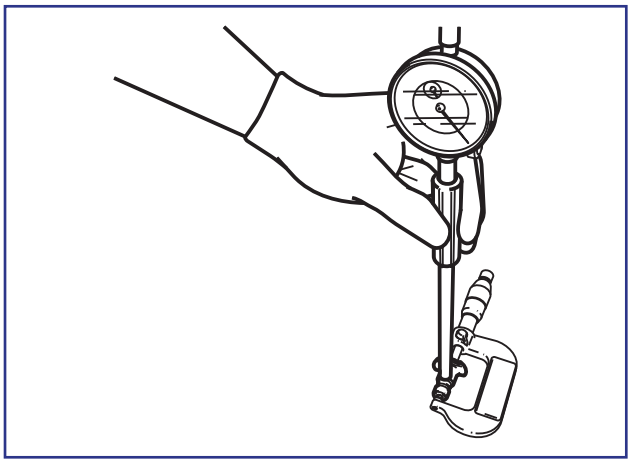
Before performing the measurement of the bearings, check the mark codes on the cap and on the connecting rod. These codes indicate the parity between connecting rod and cap, guaranteeing the perfect seating of the bearing shells in the assembly. Loosen the bolts of the connecting rod, disassembling the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



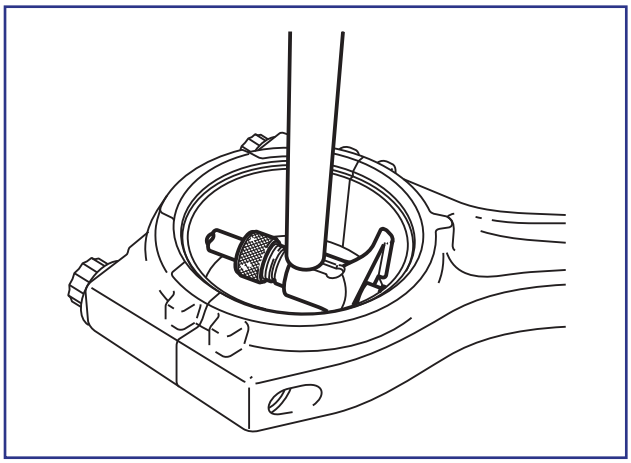
Assembly the connecting rod cap tightening according to the specification (without the bearing shells) and checking whit 2 points 90° distant each other starting from 30° of the partition of the connecting rod, checking out-of-roundness.



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

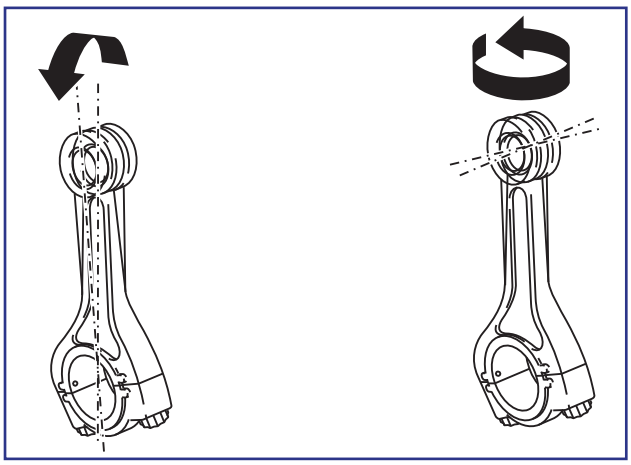


With bearing shells assembled measure the clearance with the telescop gauge.



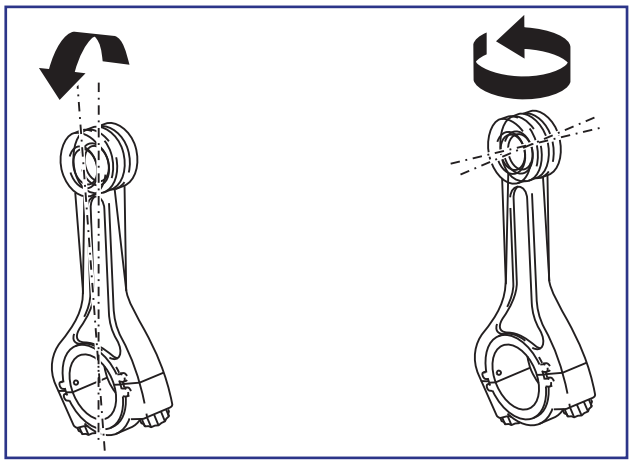
Check connecting rod torsion.

Maximum Torsion = 0.10 mm

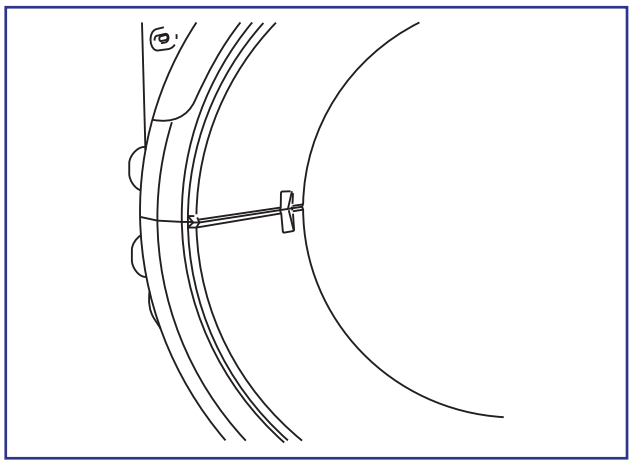


Check connecting rod warping.

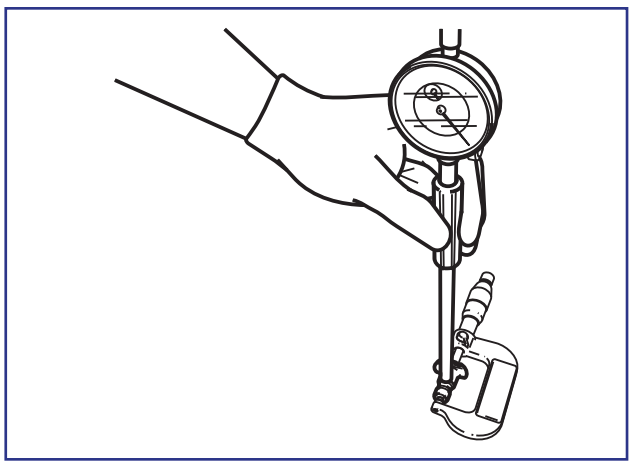
Maximum Warping = 0.03 mm



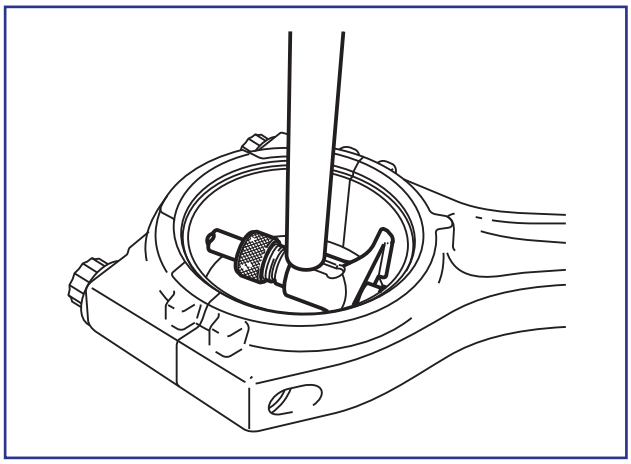
Loosen connecting rod cap, assembly the bearing shells with the aid of the expansion pin, assembly again the connecting rod cap and tighten according to specification.



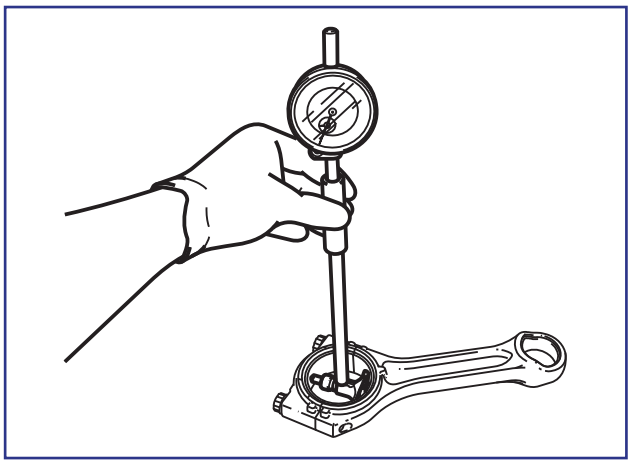
Compare the clearances obtained from the crankpins with the bore gauge.



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



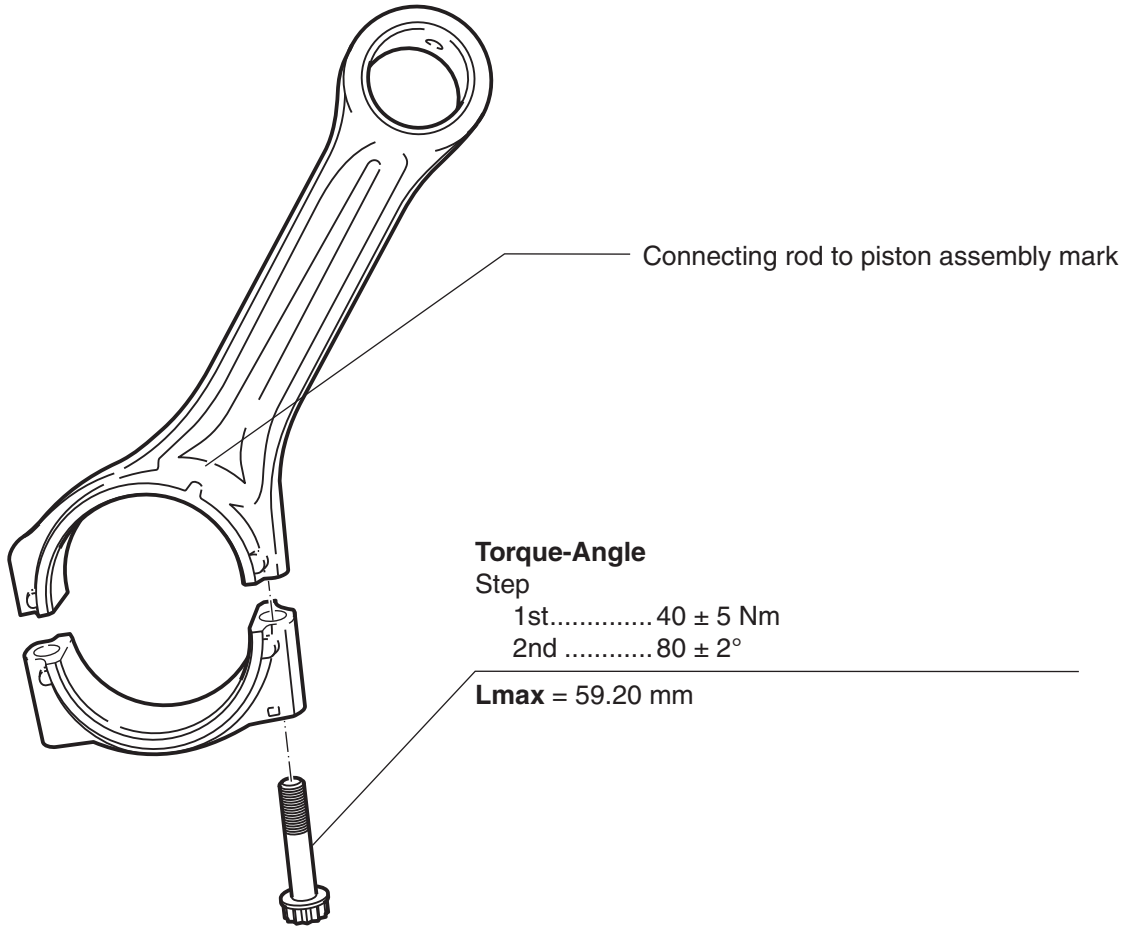
With the telescoping gauge at 90° from the partition of the connecting rod, reset the dial indicator gauge, remove one of the connecting rod bolts and measure its pre-tension.



Pre tension: 0.06 - 0.12

CONNECTING ROD BOLTS TIGHTENING

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.



IDENTIFICATION MARK ON PISTON RING

See the mark on top , intermediate ring before installing on piston.

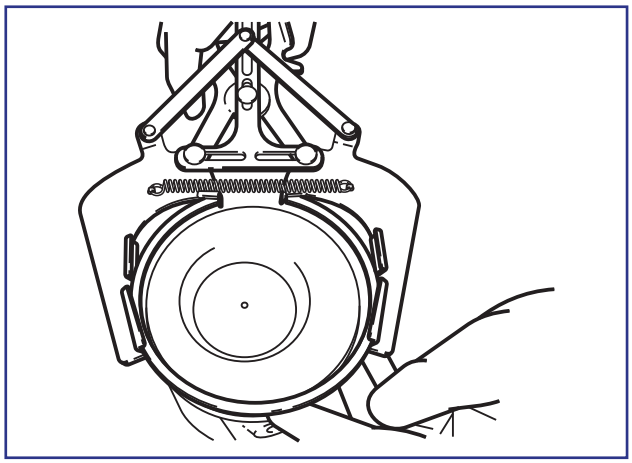
First compression ring has " MTOP " mark embossed on the ring surface. This portion of ring should be on top.

Second compression ring has " MTOP " mark embossed on the ring surface. This portion of ring should be on top.

Oil control ring has " MTOP " mark embossed on the ring surface. This portion of ring should be on top.

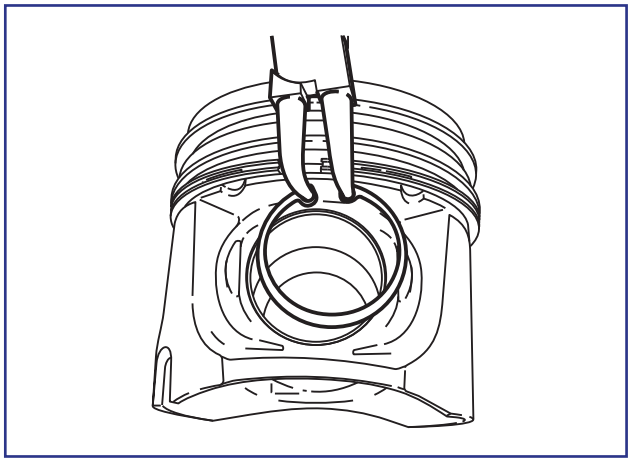
Assembly

Assembly the piston rings.

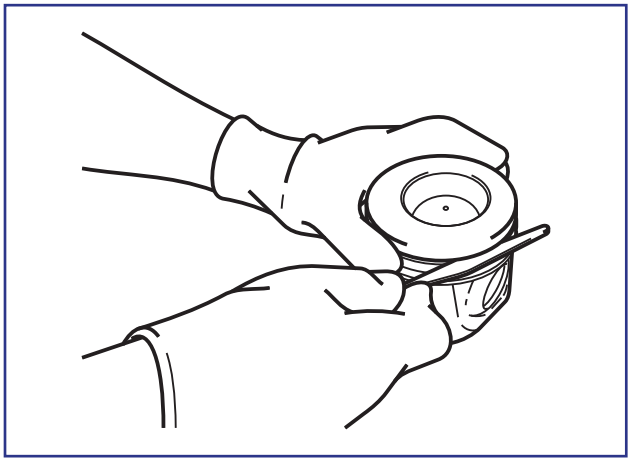


Lubricate the piston pin , assembel the piston in the connecting rod , observing the correct positioning between them. The mark on piston top showing towards flywheel should be on the side of " MNE 20 " mark provided on connecting rod.

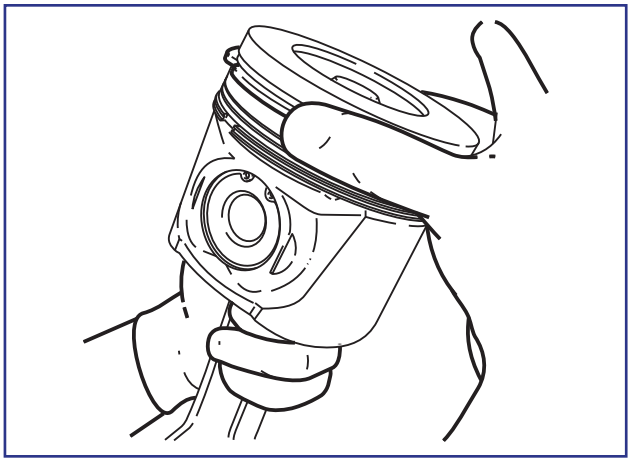
Clean the backs of the bearing shells and assembly on the stem and on the connecting rod cap that also must be clean.



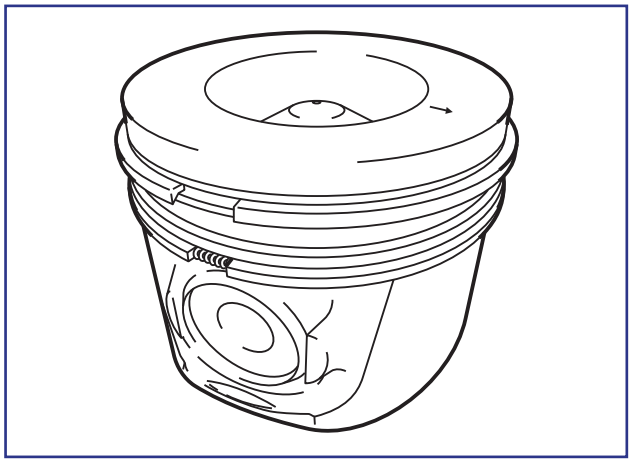
Check the ring grooves, pin housing and the skirt of the piston. Check the clearance of the rings in the piston grooves.



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



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

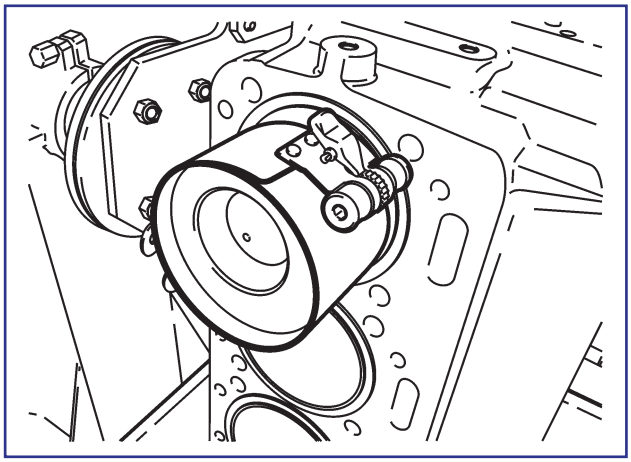


NOTE: The mark in the piston head must face to the flynwheel side.

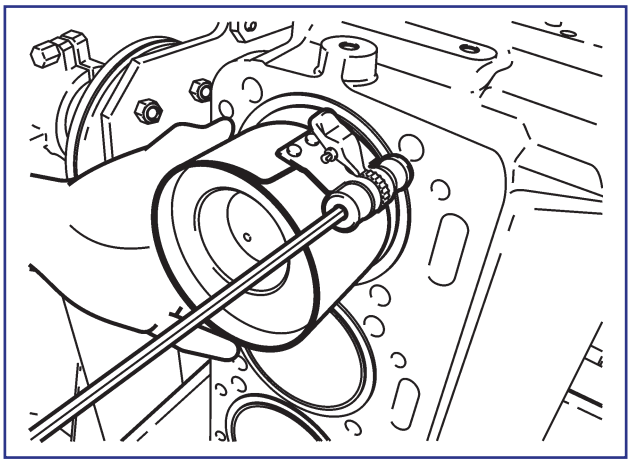
To assembly the connecting rod with body and cap, it is necessary to observe the protuberance that shown the correct position.

Install the device for piston assembly to close the rings.

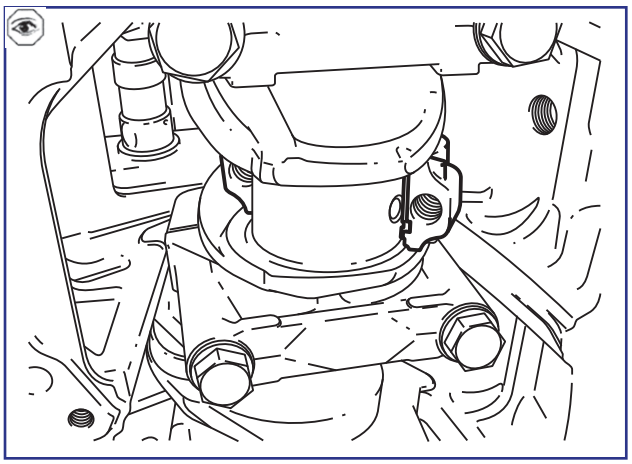
NOTE: Position the engine flywheel upward.This avoids the contact of the connecting rod with the oil injectors.



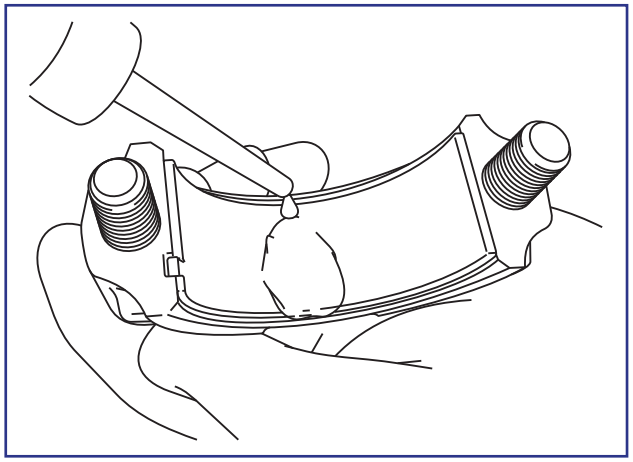
Carefully push the piston inside the cylinder. Never hit directly on the top of the piston.



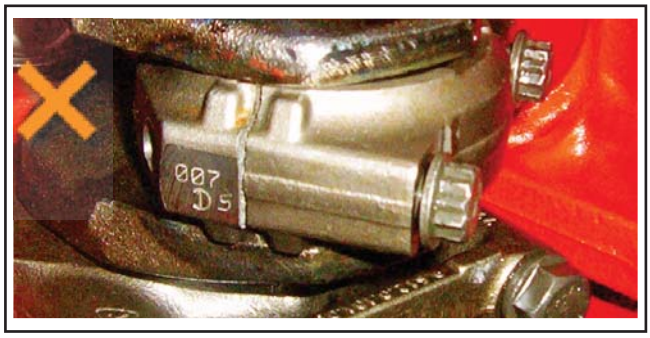
Observe the correct position to the crankshaft.

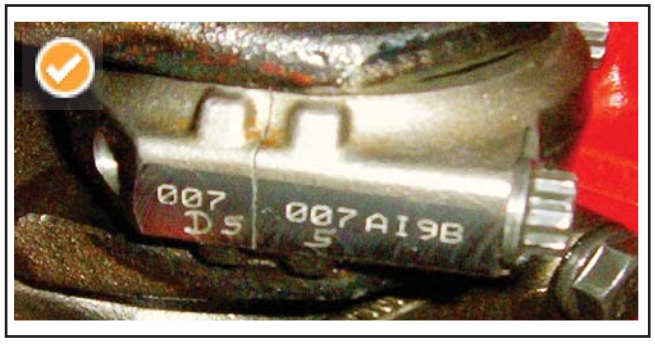


Lubricate the two inner halves of the bearing shells.



Check the cap position at the time of assembly

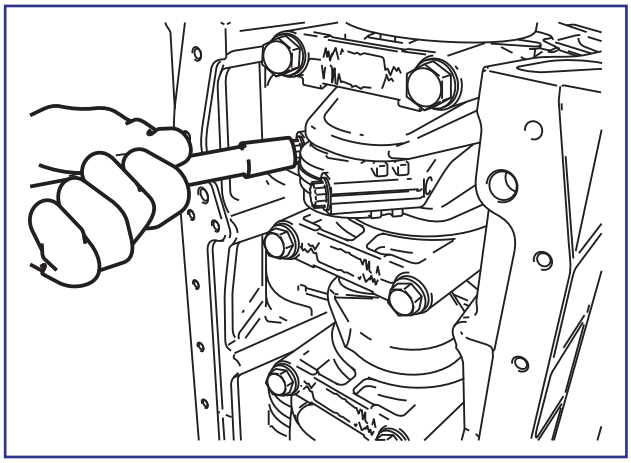




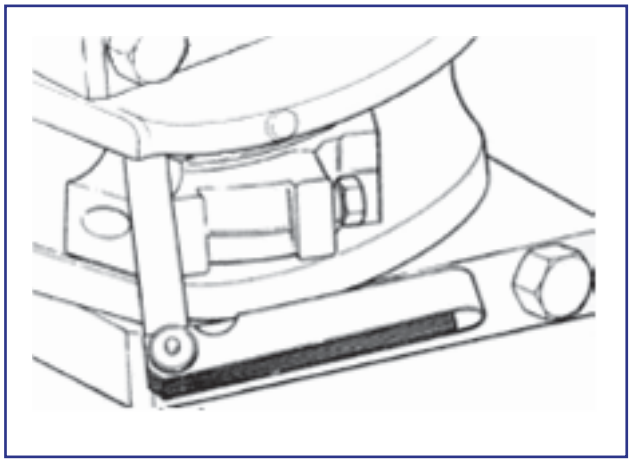
Number punched on con rod and cap must be one side

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 not hittong the piston skirt otherwise injector may brake or bend

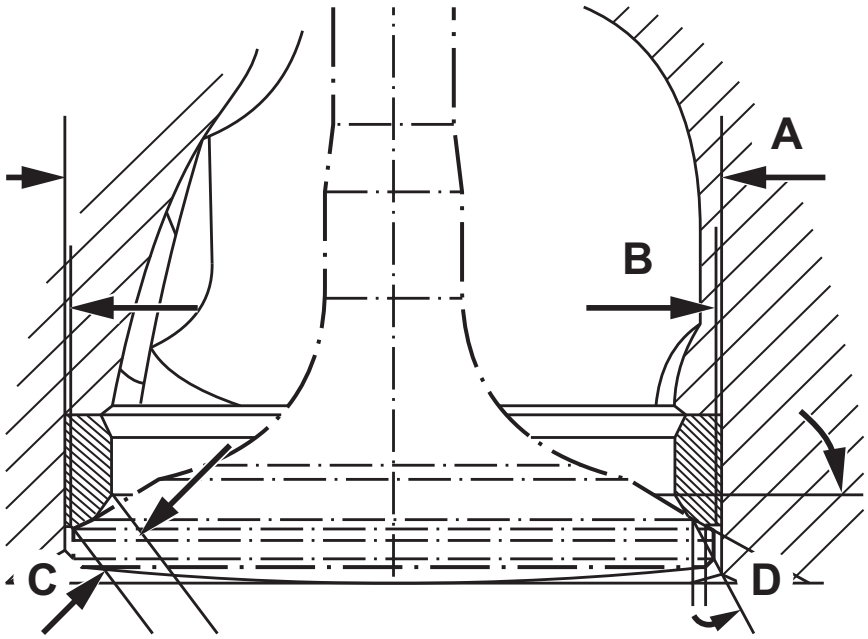
NOTES

Cylinder Heads

Group - 09

Specifications

VALVE SEATS



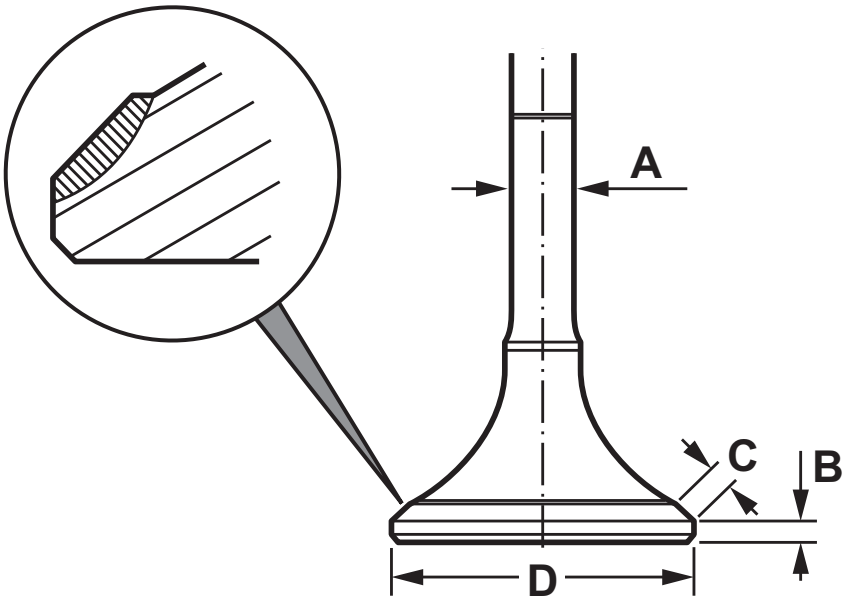
ØA	
Housing	**(mm)**
Standard Intake Exhaust	 37,600 - 37,625 33,500 - 33,525

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

(C)	
Seat Width	**(mm)**
Standard Intake Exhaust	 0.60 0.57

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

VALVES



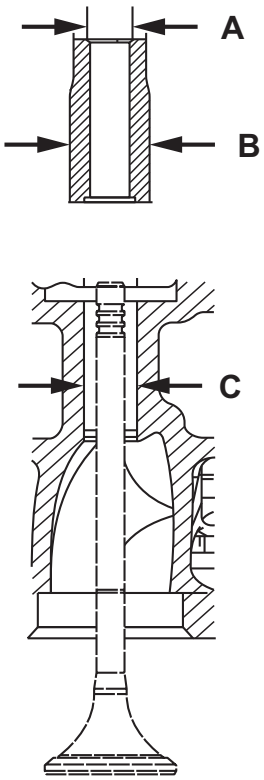
ØA	
Stem	**(mm)**
Nominal	6,956 - 6,970

(B)	
Head height	**(mm)**
Intake Exhaust	1.7 1.6

(C)	
Surface width	**(mm)**
Intake Exhaust	5.6 2.7

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

VALVE GUIDES



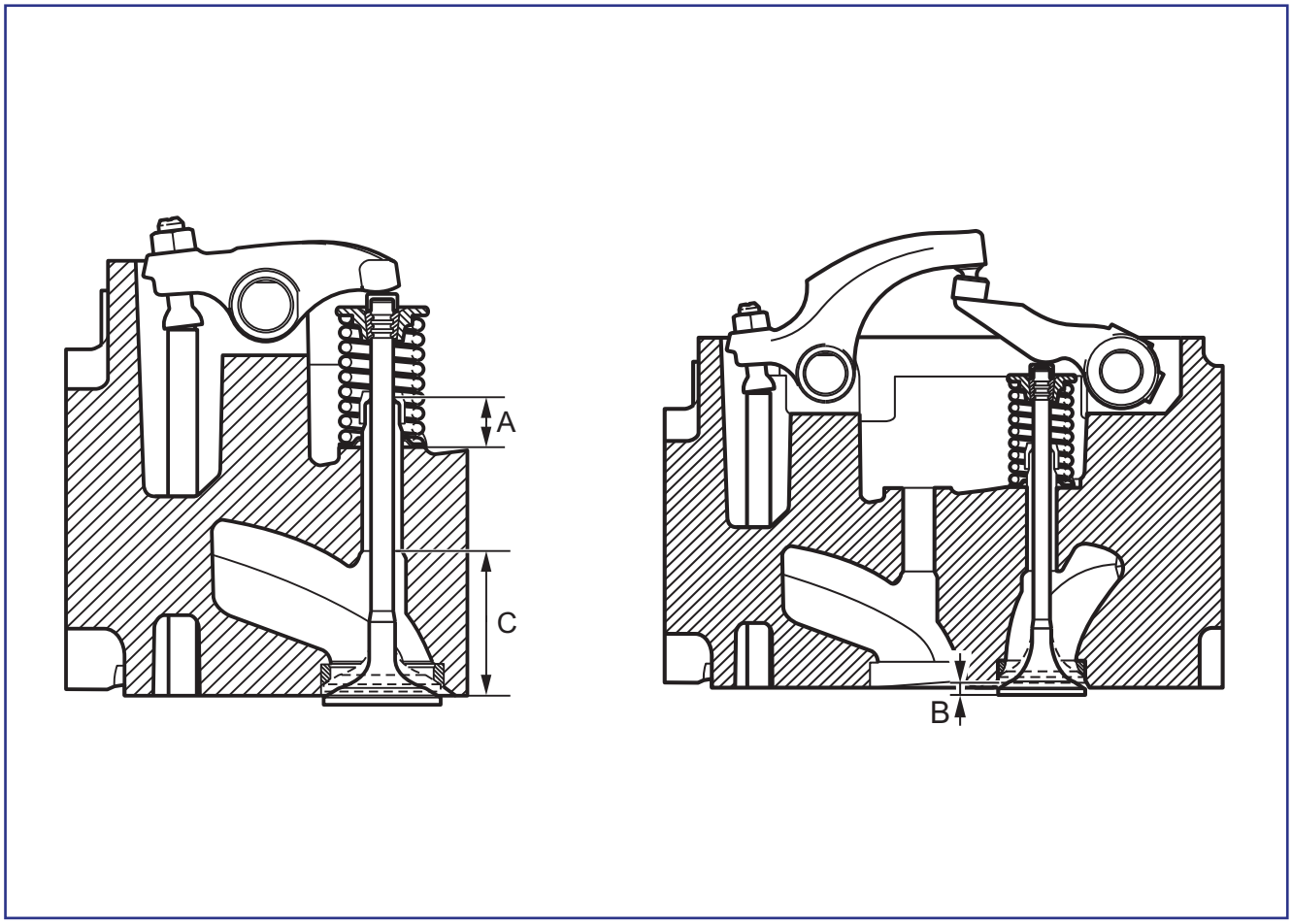
ØA	
After assembly	**(mm)**
Nominal Repair Maximum	6.65 - 6.80

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

Ø (C)	
Housing	**(mm)**
Nominal	12

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

GUIDE HEIGHT AND DISTANCE TO CYLINDER HEAD SURFACE

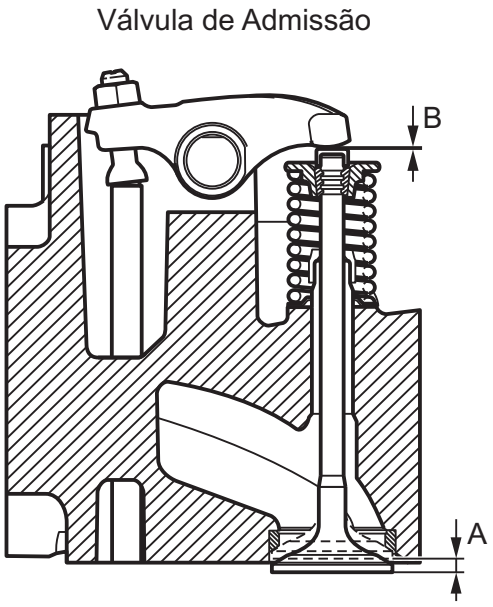


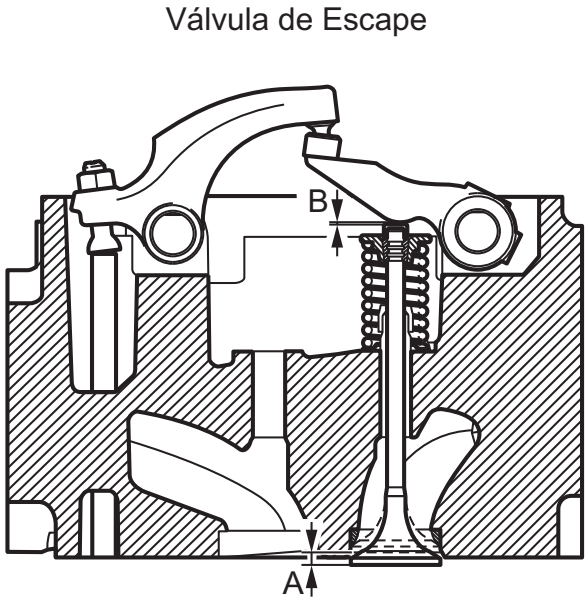
Valve Guide Height (A)	(mm)
Intake and Exhaust	11.3 – 12.6

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



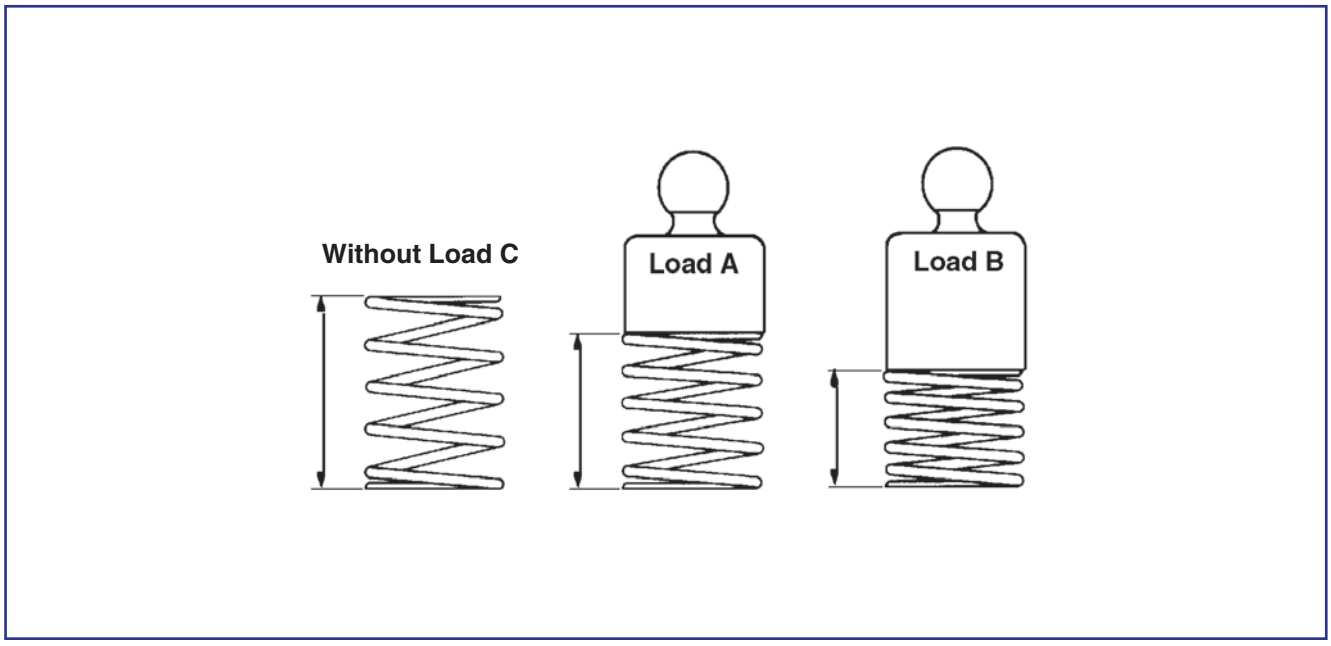


ØA	
Course	**(mm)**
Intake Exhaust	11.10 - 11.34 11.22 - 11.46

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

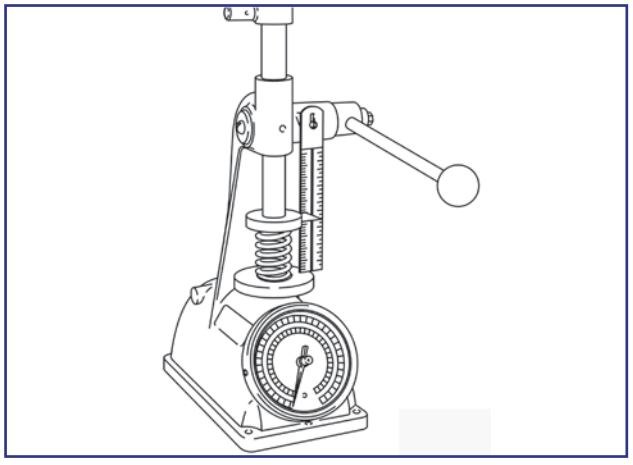
SPRING VALVES

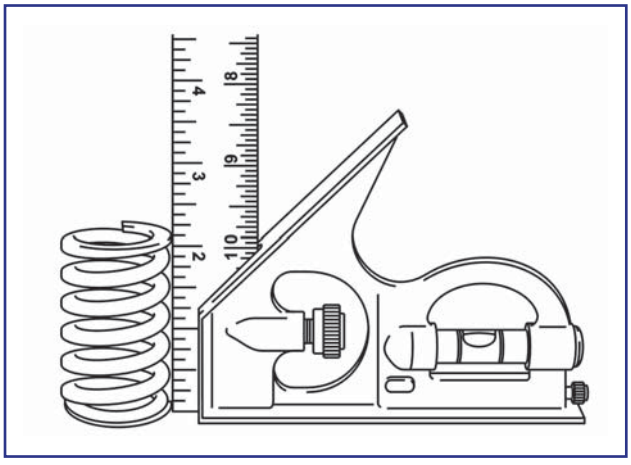
The test is performed placing the springs on a special device and reading the closing force for two different deflections according to the following table.The intake valves springs are single (only one spring) and exhaust valves springs are double.



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.

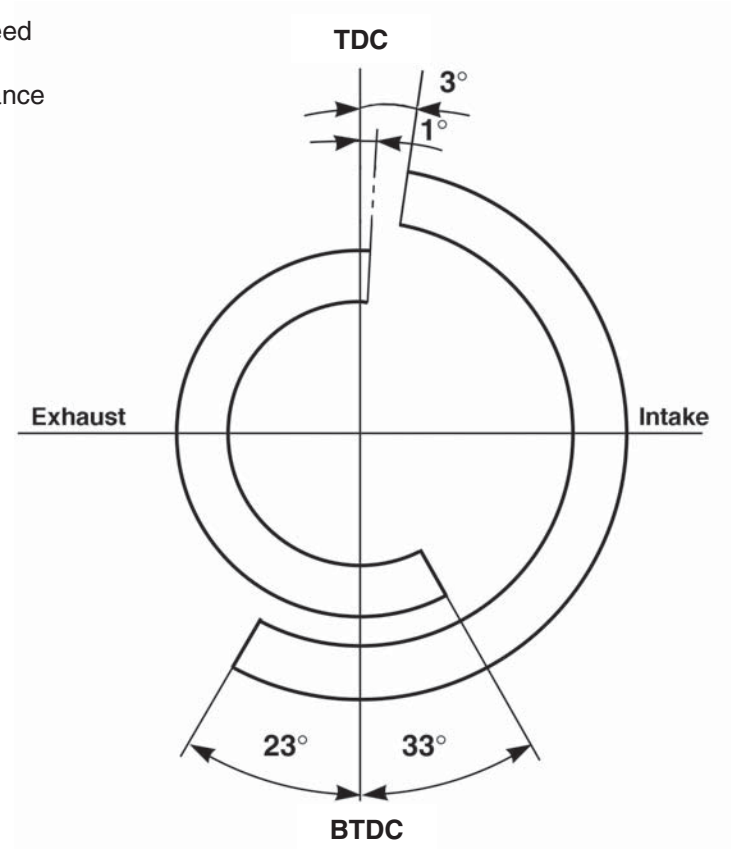




VALVES DIAGRAM

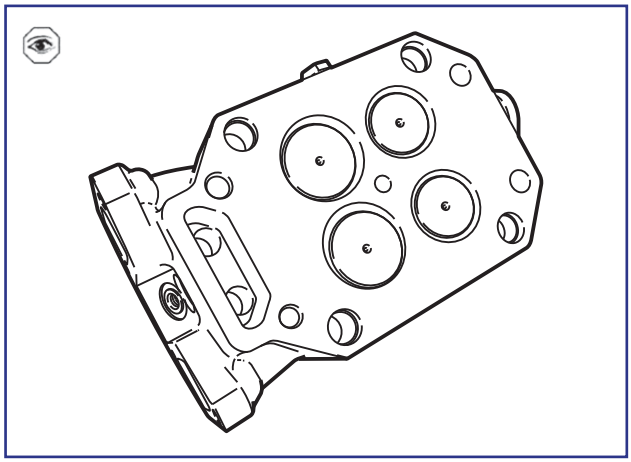
Valves clearance: 1 mm (adjust the valves clearance previously to 1 mm before proceed the checking)
(After the check, readjust the valves clearance to 0.40 mm)

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

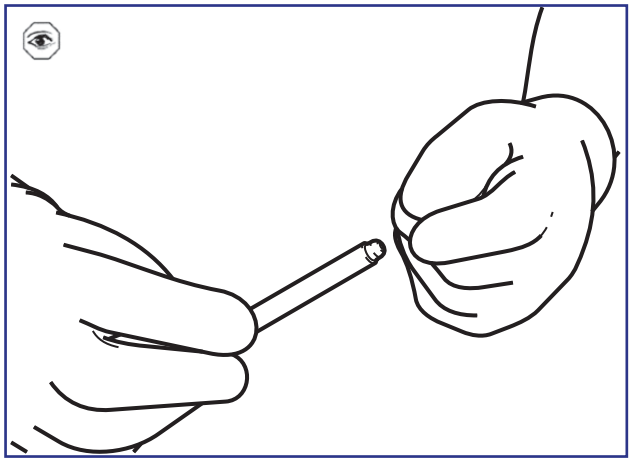


Inspections and Measurements

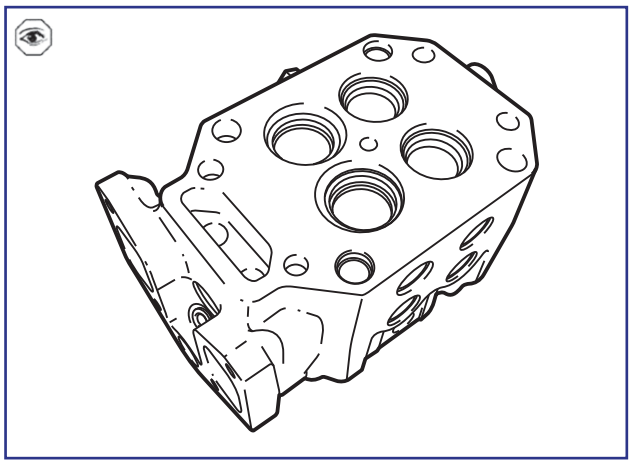
Visually check cylinder heads for leaks.



Check push rods. The push rods ends must not be loosen or cracked. Check for excessive wear. Check if the push rods are not warped.

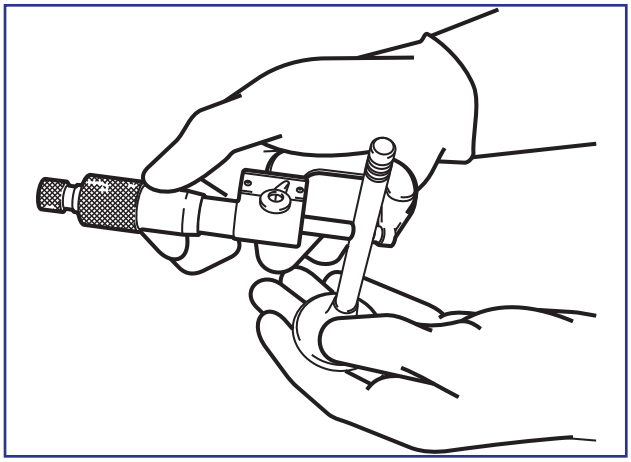


Cylinder heads surfaces must never be machined.

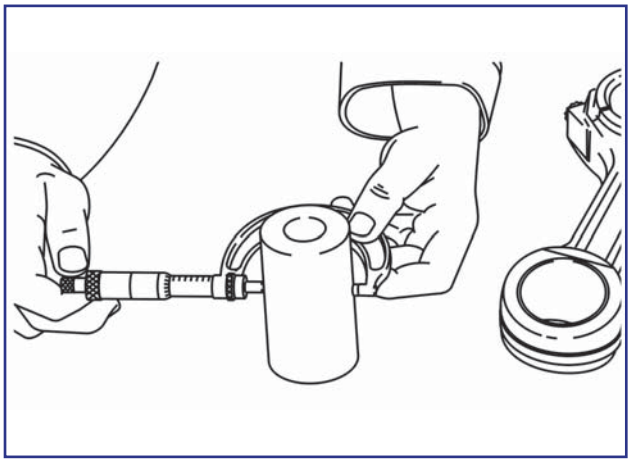


Measure the outer diameter of the valve stem in 3 different points:

- Upper part
- Central part
- Lower part



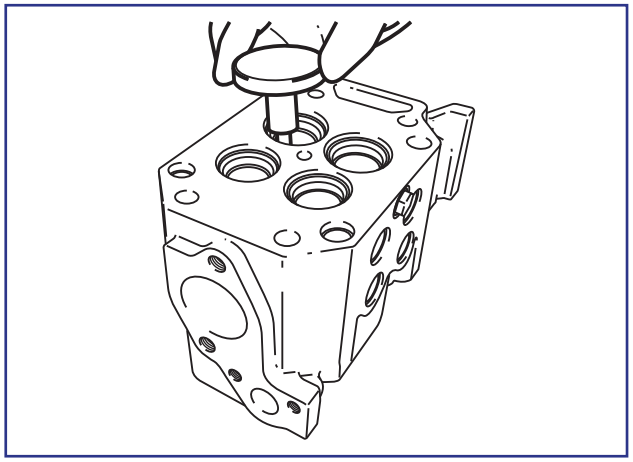
Measure the outer diameter of the valve guide.



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

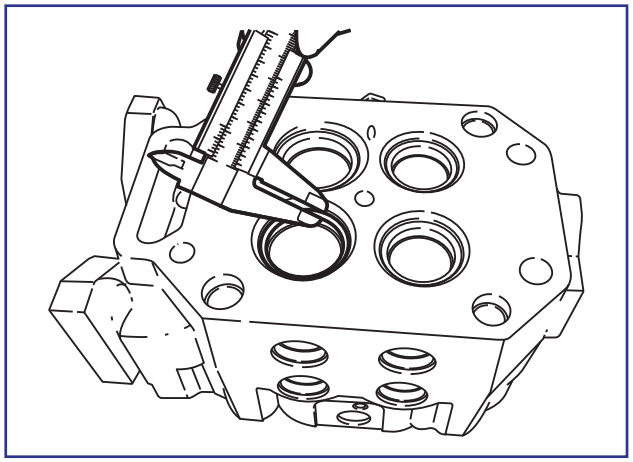
Measure valve guide housing bore.

After the measurements, install valve guides with the special tool shown.

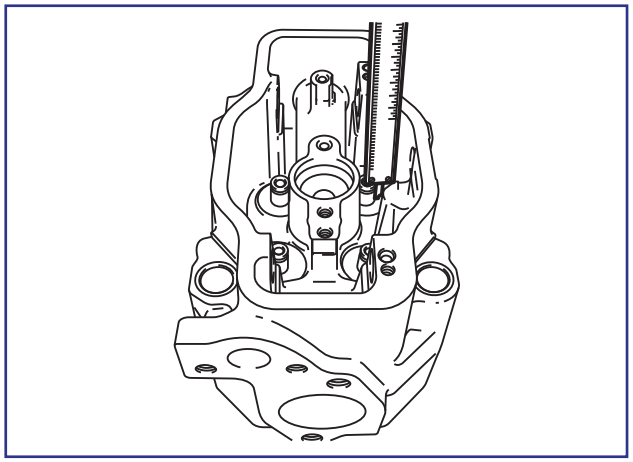


Measure the bore of the assembled valve guide.

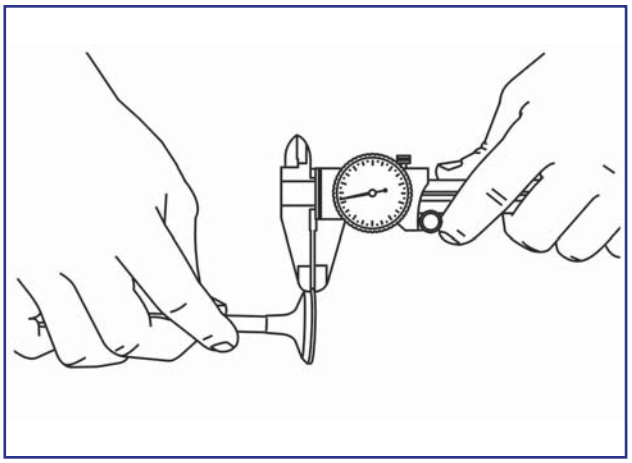
Measure the width of the valve contact surface.



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



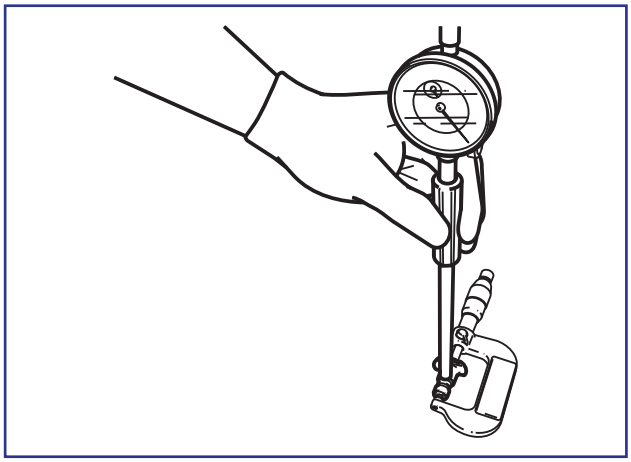
Measure the width of the valves seat.



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

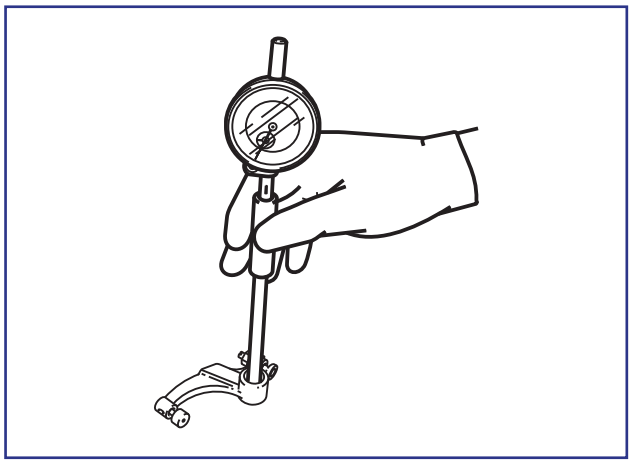
Measure the rocker arm shaft and out of roundness.

Check with the micrometer.



Measure the shaft housing bore.

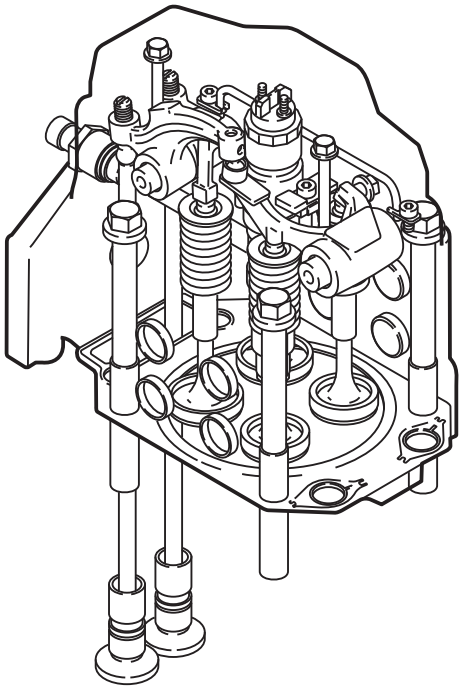
Check rocker arms ends axial clearance in the shafts and deformities like roundness and taper.



Remark:

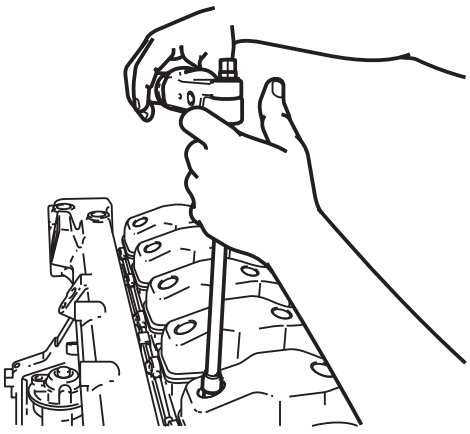
Before beginning the assembly of cylinder head set, all parts must be cleaned well.

General View

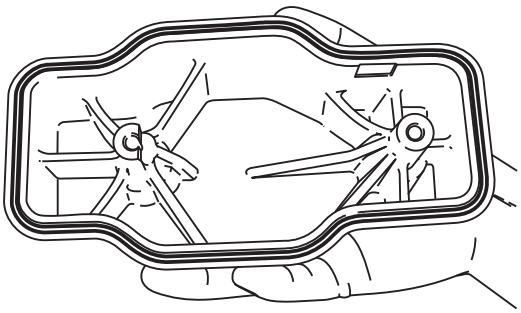


Removal

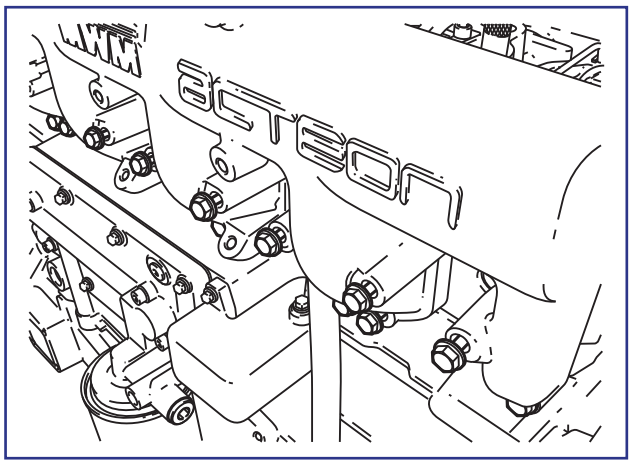
Remove the valve cover.



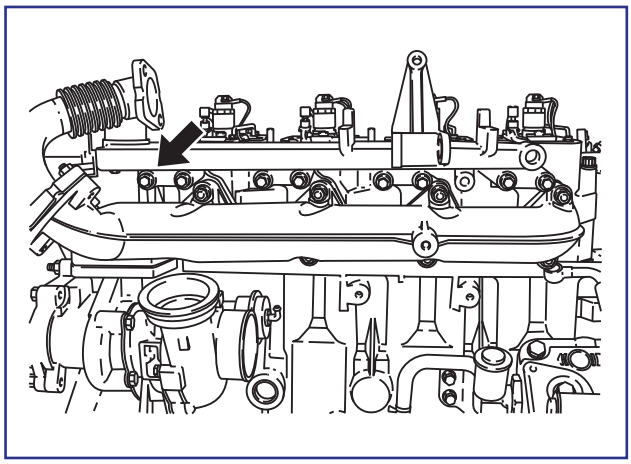
Remove valve cover sealing ring.



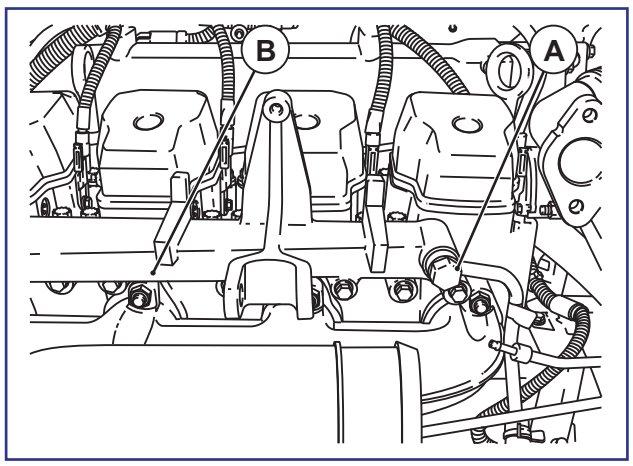
- Remove the intake manifold.



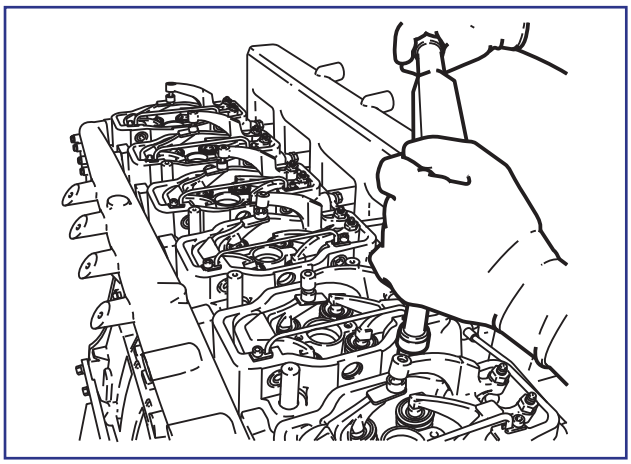
- Remove the water pipe mounting bolts.



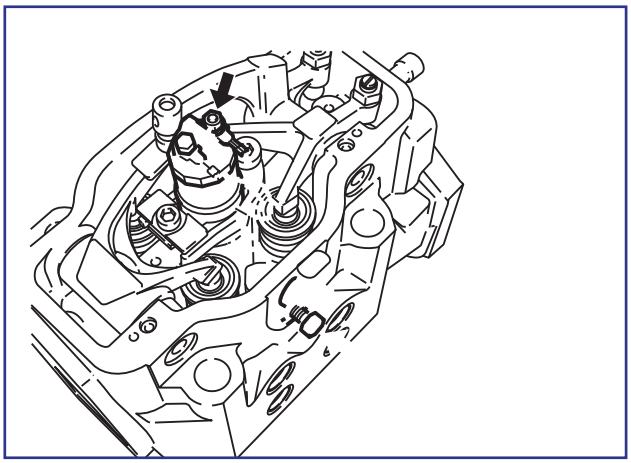
- Remove the water outlet pipe.



- Remove the cylinder head mounting bolts ⓑ.

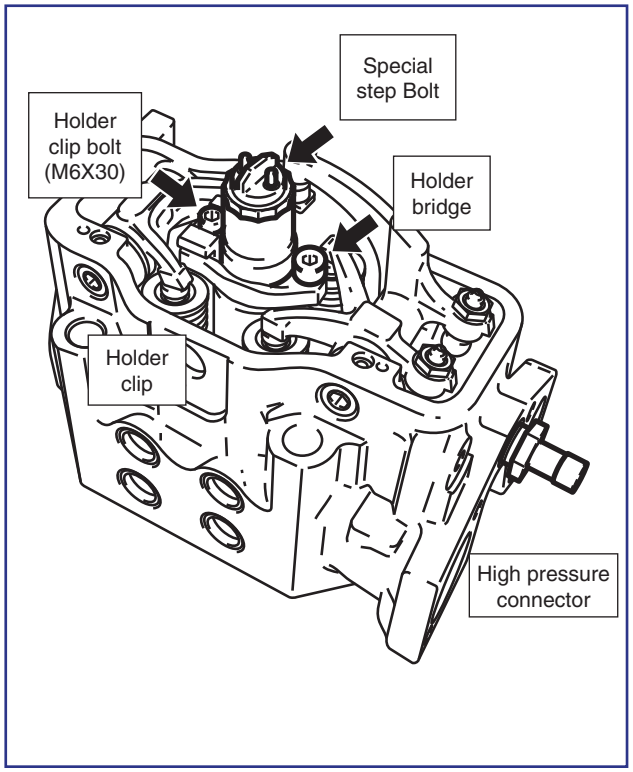


- Remove the bolt and disconnect external injection nozzle connector.

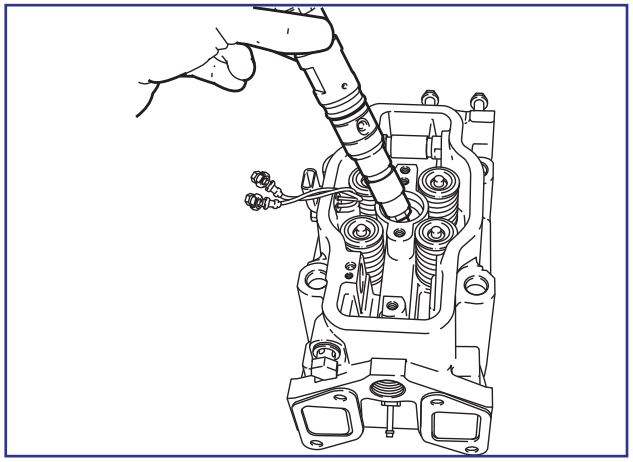


PROCEDURE TO REMOVE THE INJECTION NOZZLE

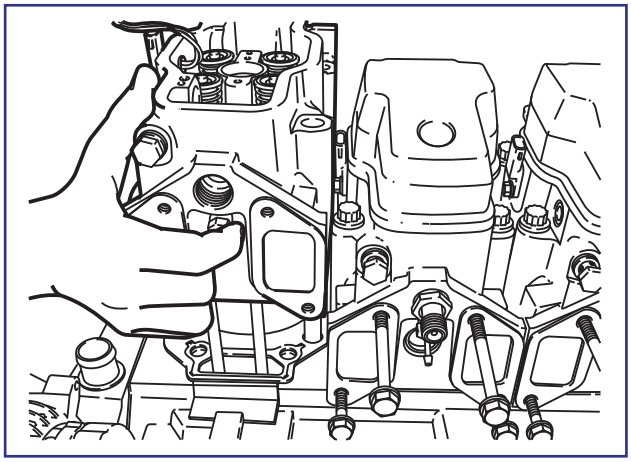
- Remove the clip, bridge and the two bolts.
- Remove special step bolt.
- Remove the holder clip bolt.
- Remove the holder clip.
- Remove the holder bridge.
- Remove the high pressure connector.



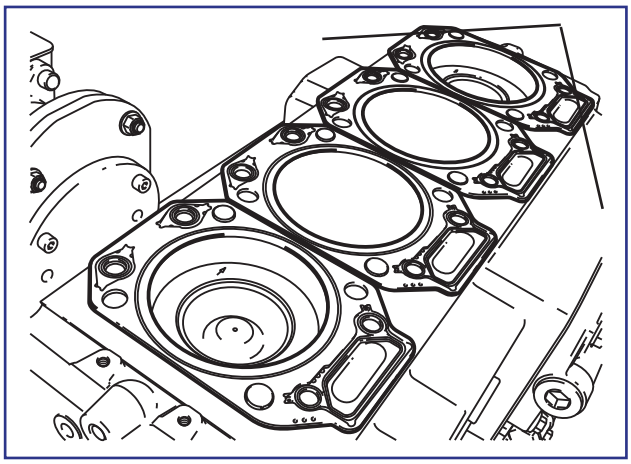
- Remove the fuel injector to the cylinder head.



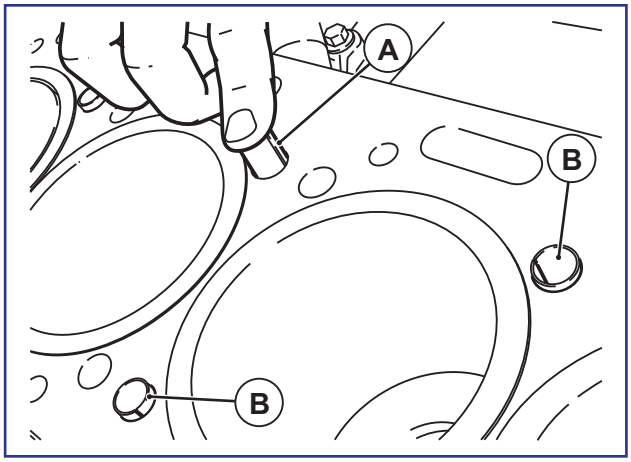
- Remove the cylinder head.



- Remove the push rods.
- Remove the gaskets.

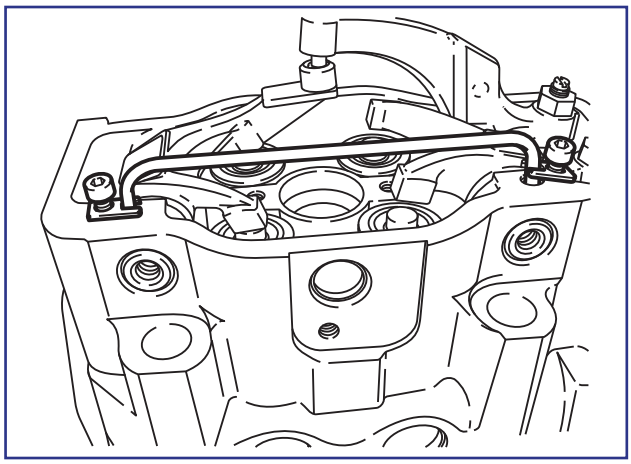


- Remove the guide bushings.

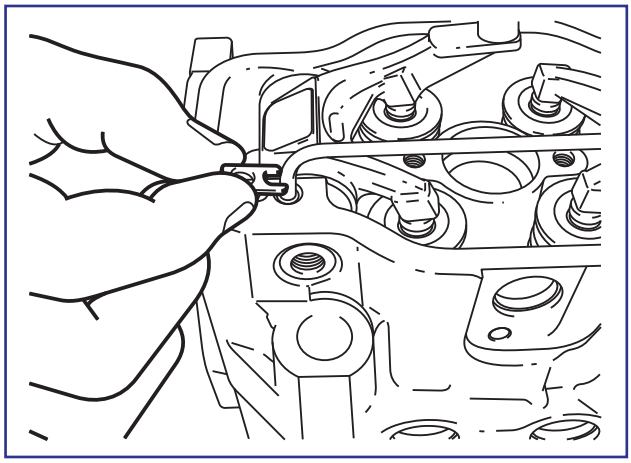


Disassembly

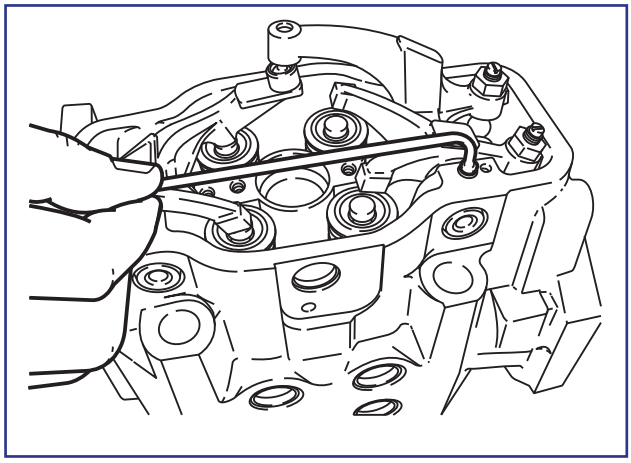
- Remove the M5X10 bolts.



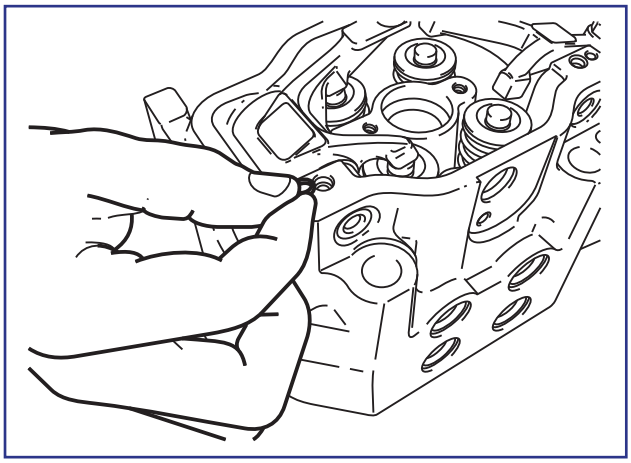
- Remove the lubrication pipe locker.



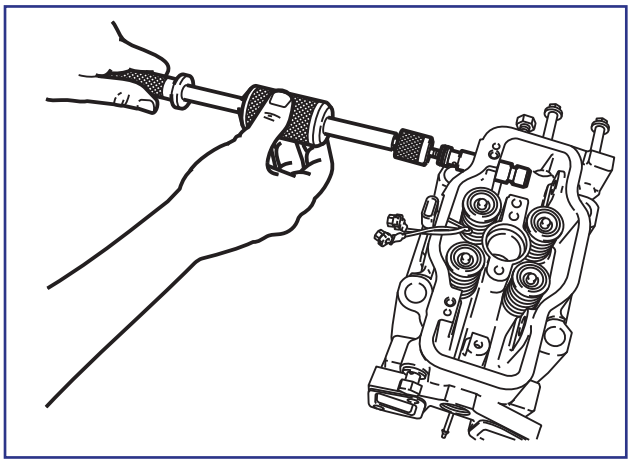
- Remove the balancer shaft lubrication pipe locker.



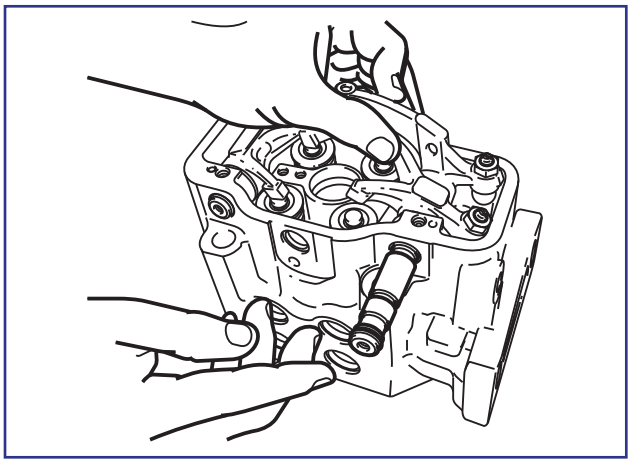
- Remove the O-Ring.



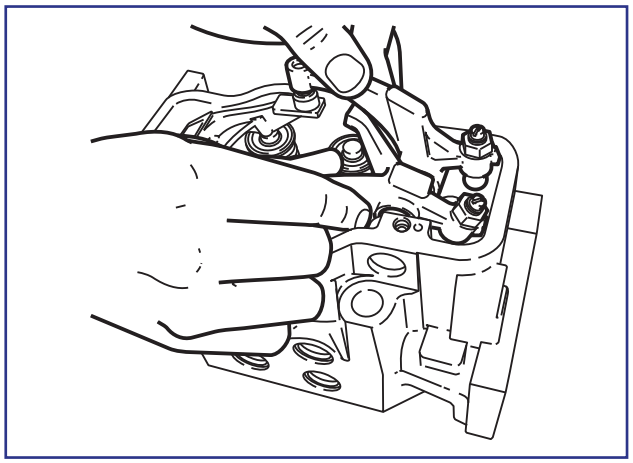
- To remove the balancer rocker arm shaft, utilize the special tools MIM No. D700596C1 and 9.407.0.690.040.6.



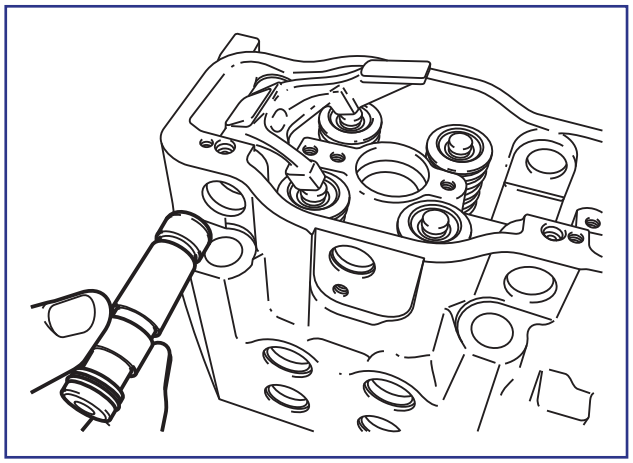
- Remove the balancer shaft with the O-Ring.



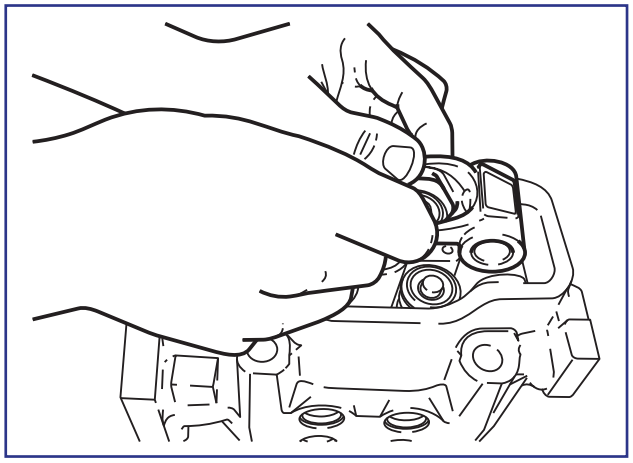
- Remove the intake rocker arms.



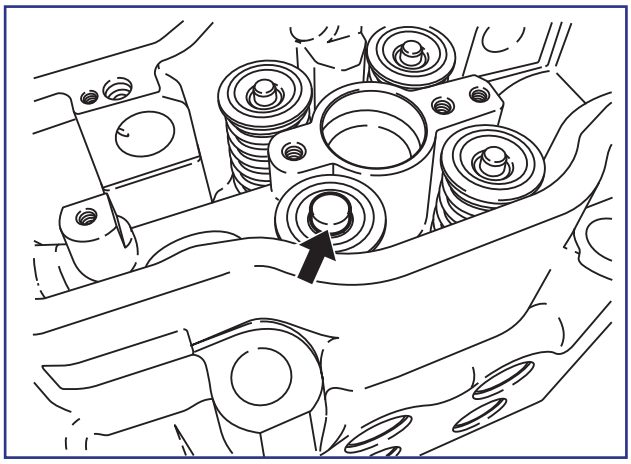
- Remove the balancer shaft with the O-Ring.



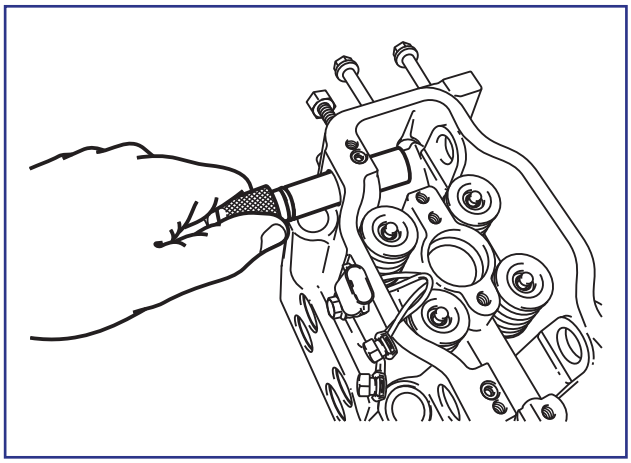
- Remove the exhaust rocker arm.



- Remove the valve slip chip.

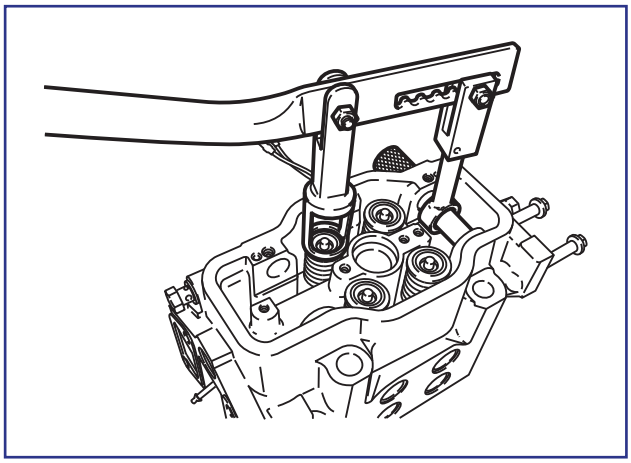


Install the special tool guide No. D7000598C1, as shown.

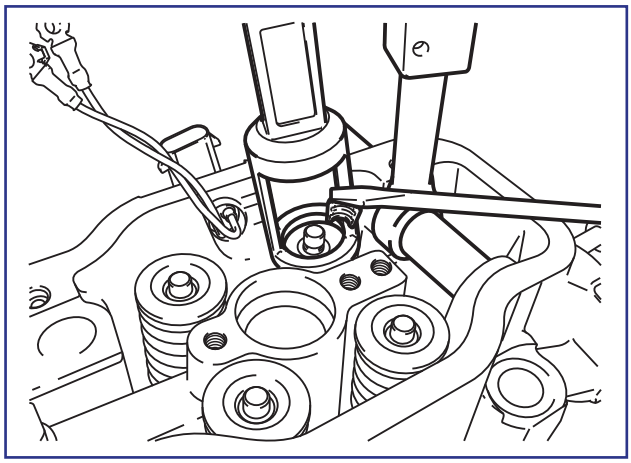


To compress and remove the valve spring locks, use the special tool No. D7000598C1.

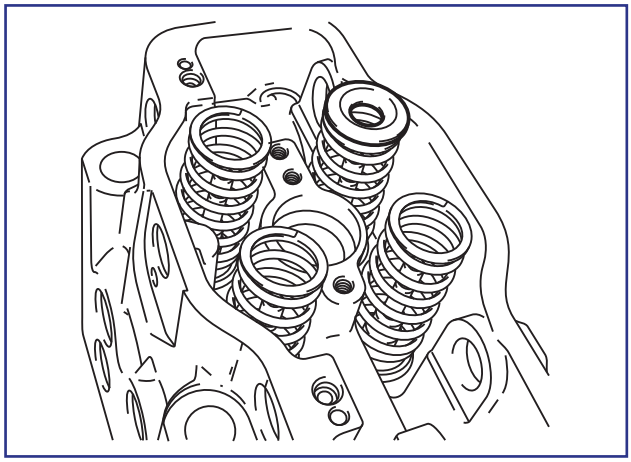
Install the special tool lever to the guide, as shown.



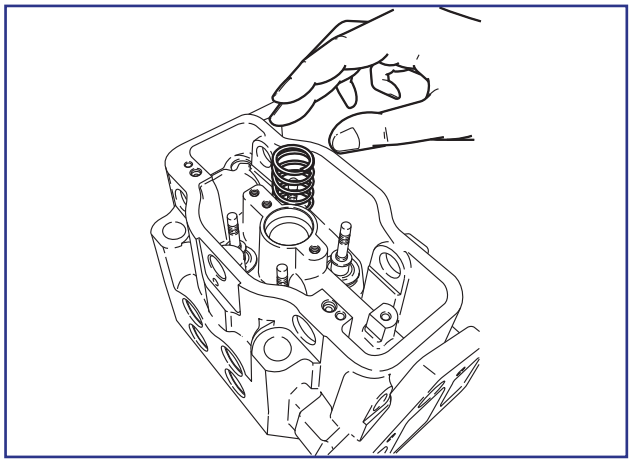
Compress the spring and remove the spring locks, as shown.



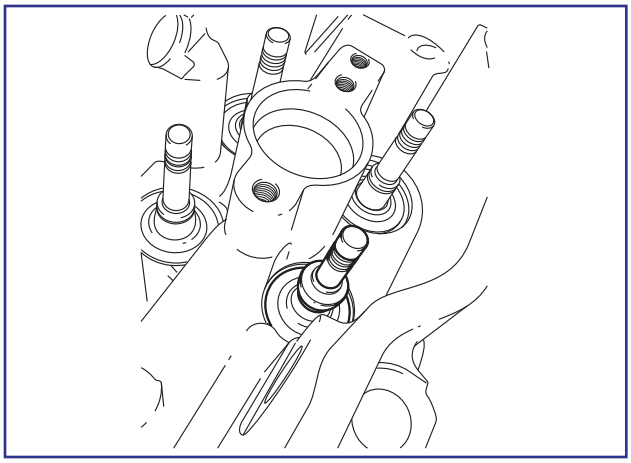
Remove the spring upper discs.



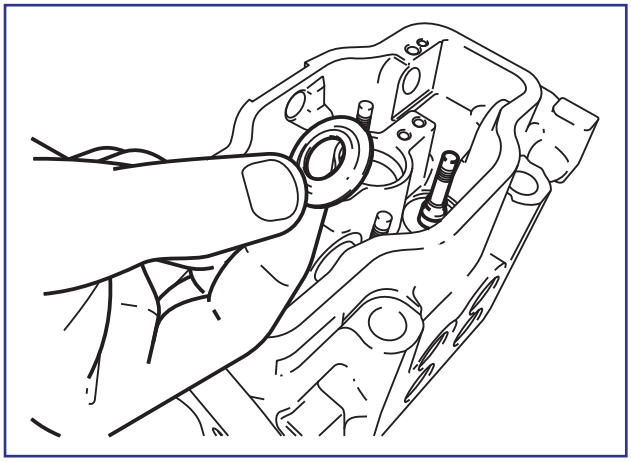
Remove the spring valves.



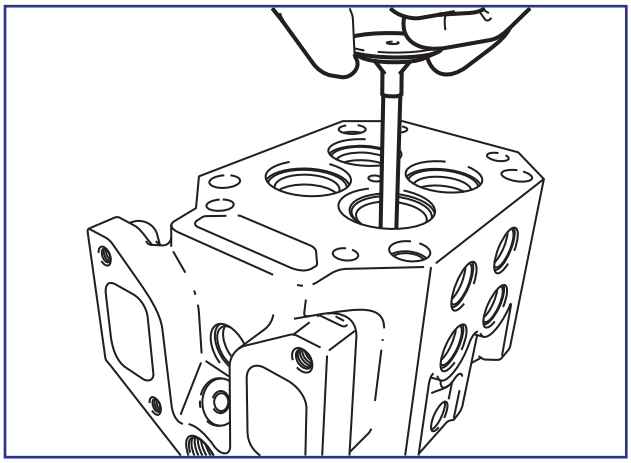
Remove the valve retainers of its housing.



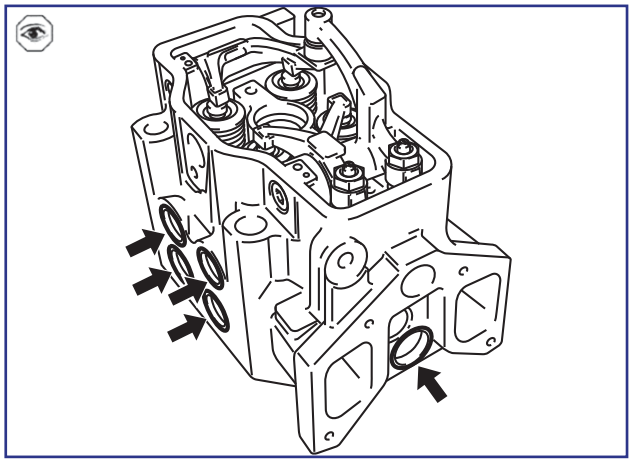
Remove the lower spring discs.

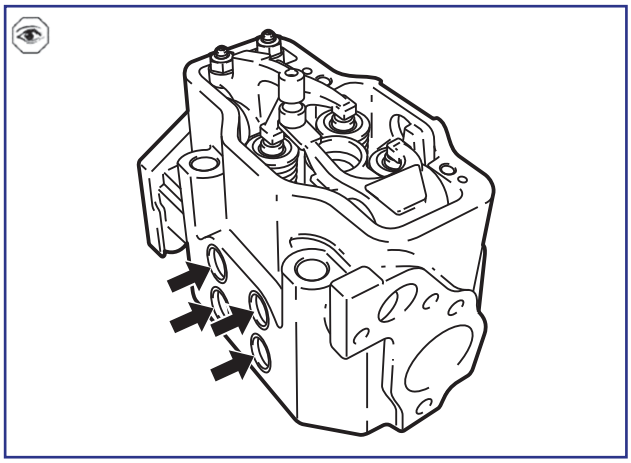


Remove the 4 valves.



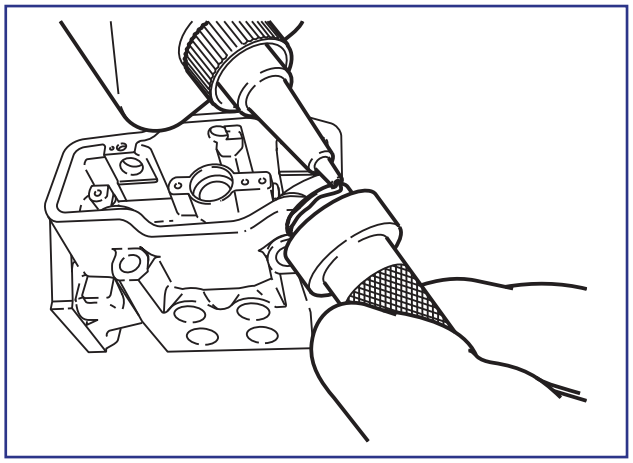
Check the 9 sealing plugs illustrated regarding to leakage, corrosion or damages. Replace it, if necessary.

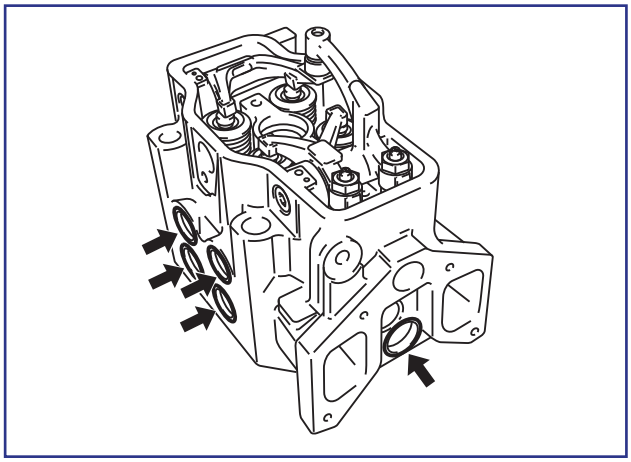




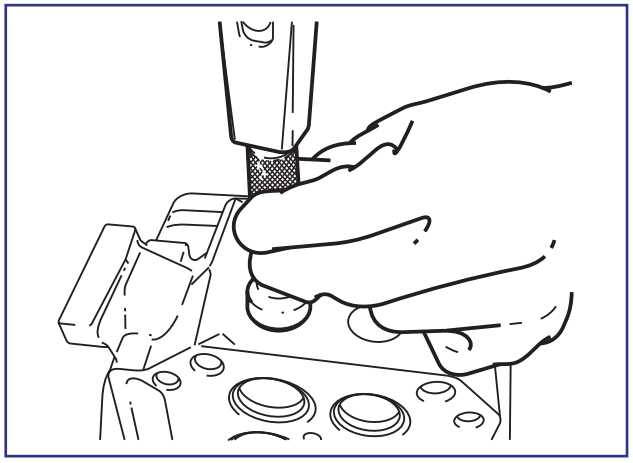
Assembly

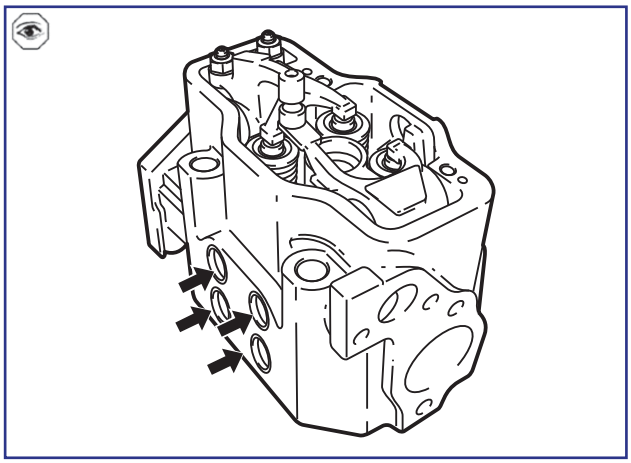
Apply loctite 648 or equivalent to the sealing.



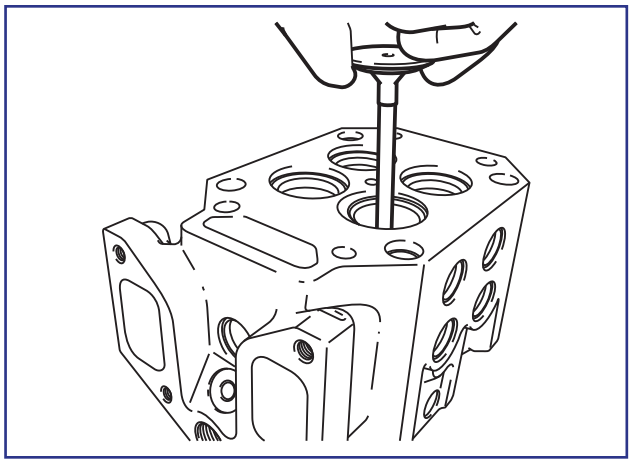


Install the 9 sealing plugs. See the following illustration for sealing cover locations.

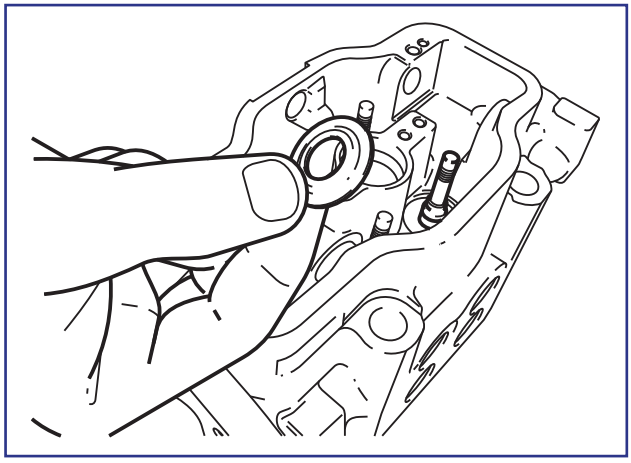




Install the 4 valves.



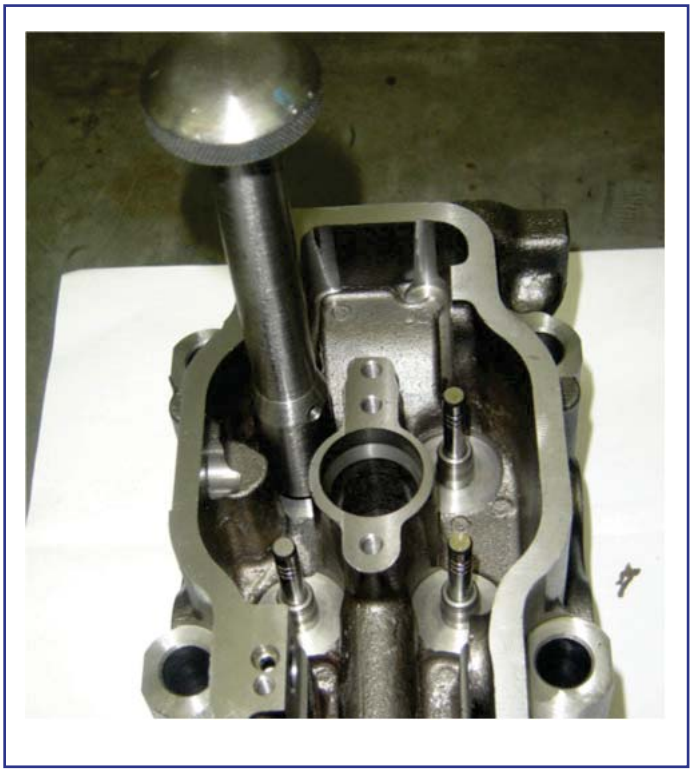
Install the lower spring discs.



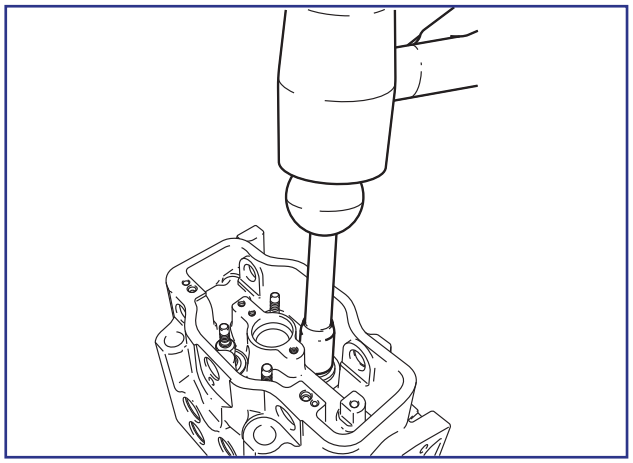
Install the special tool No. D7000597C1 to slide the valve retainer.

Put the valve retainers in the shown position.

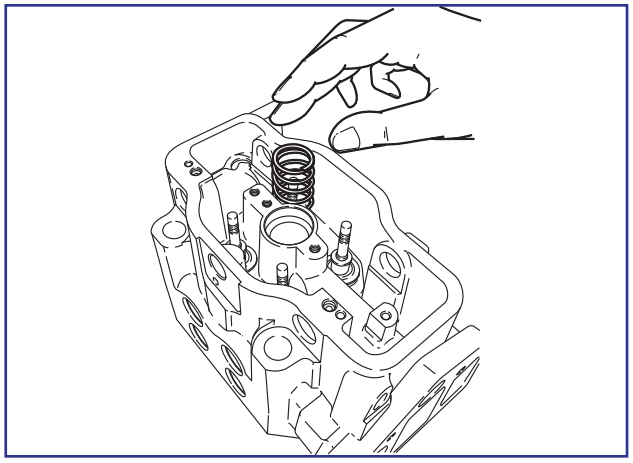
Using the special tool No. D7000597C1 and its spacer, install the valve retainer in its housing.



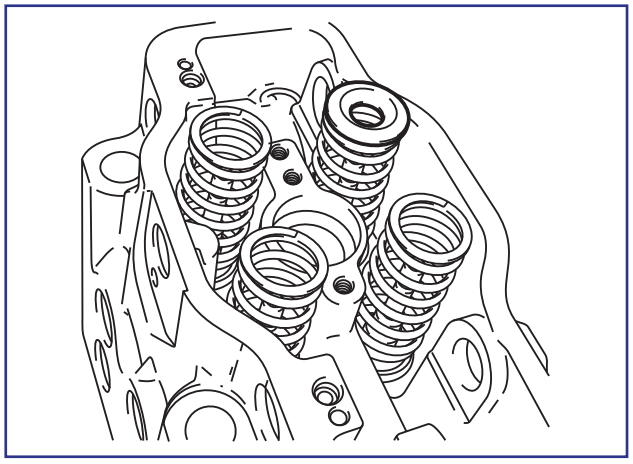
To assure the valve retainer is fully fitted onto the stem of cylinder head valve guide, the special tool spacer must reachs the cylinder head surface. Using a rubber hammer, apply light blows over the special tool observing the spacer reachs its position.



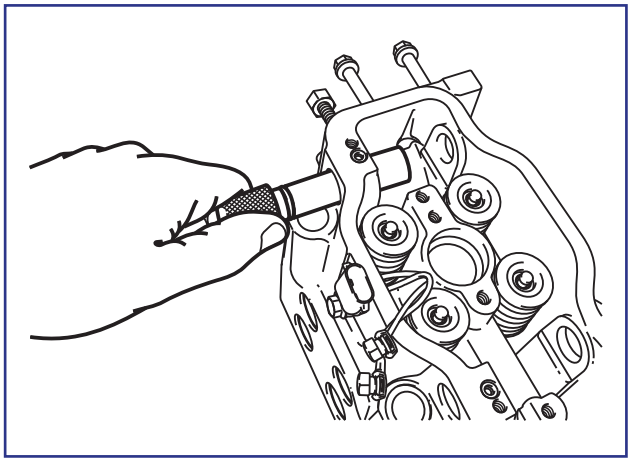
Install the spring valves.



Install the spring upper discs.

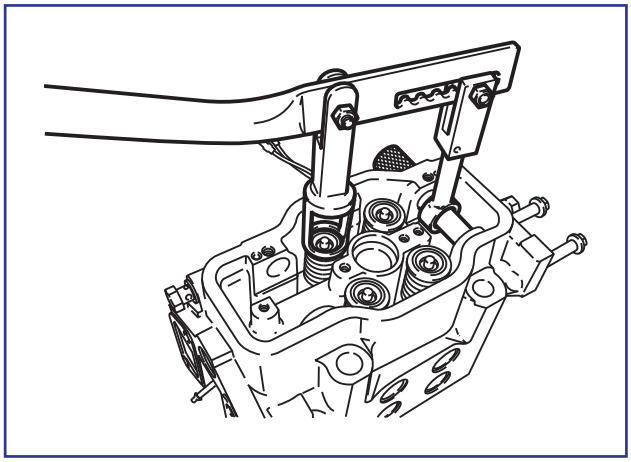


Install the special tool guide No. D7000596C1, as shown.

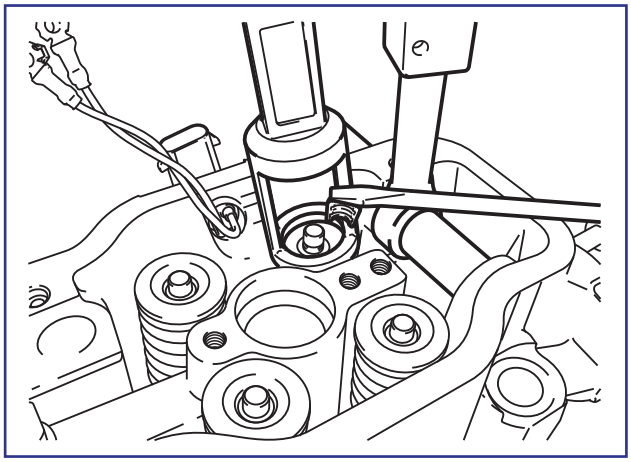


To compress and install the valve spring locks, use the special tool No. D7000598C1.

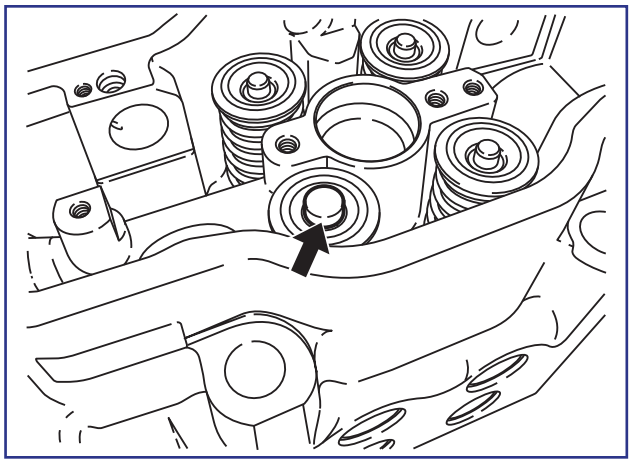
Install the special tool lever to the guide, as shown.



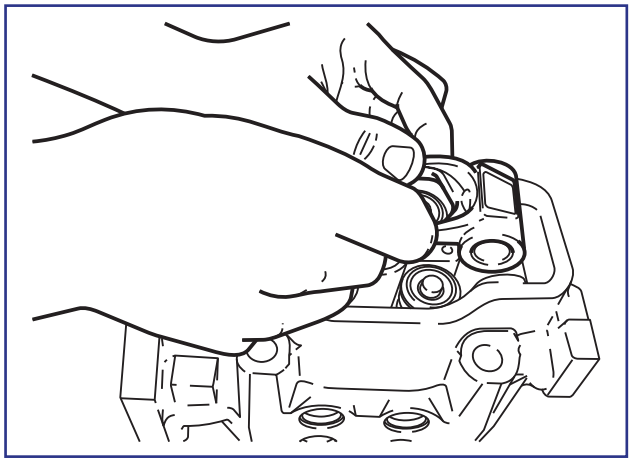
Compress the spring and install the spring locks, as shown.



Install the valve slip chip.

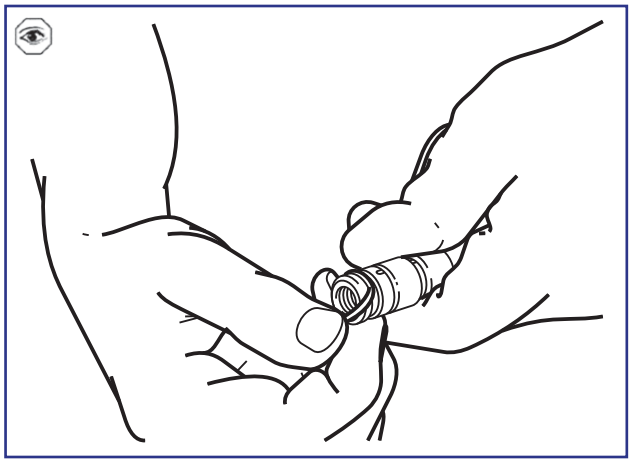


Install the exhaust rocker arm.

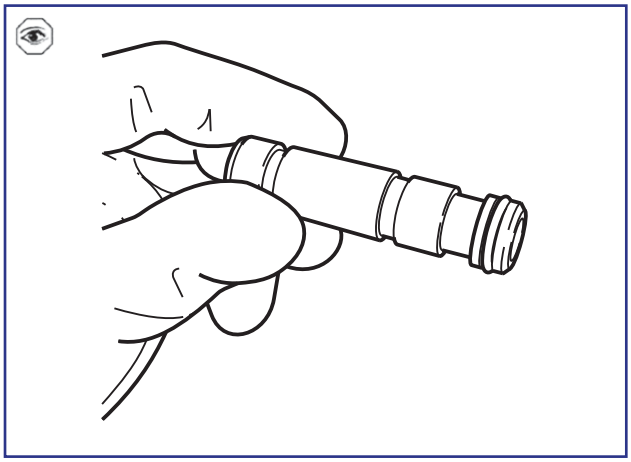


Apply vaseline or clean oil engine to the O-Ring previously.

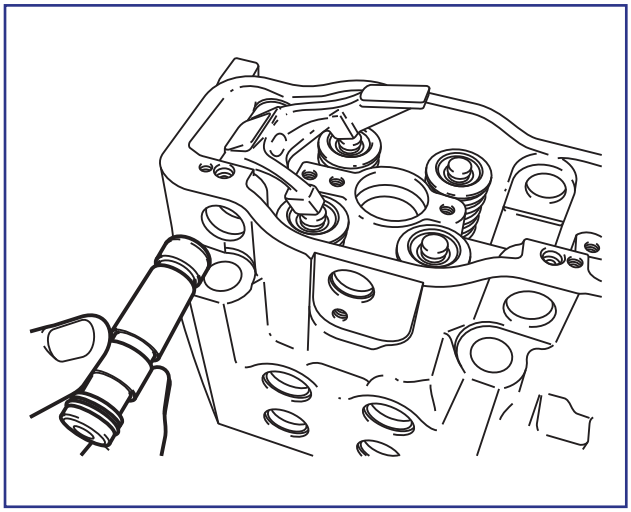
Install the O-Ring on its balancer shaft housing.



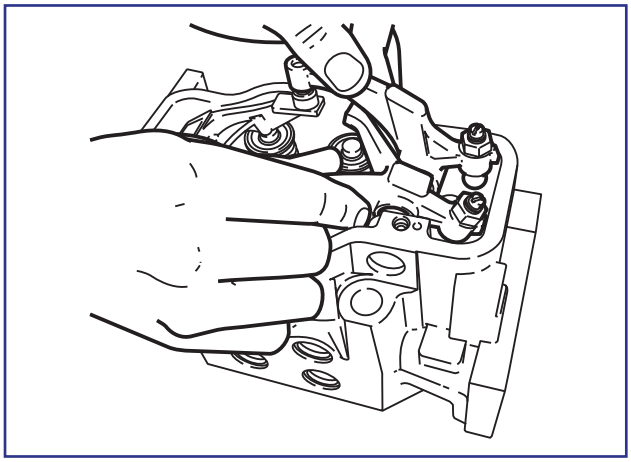
Note: When mounting the balancer shaft, make sure that the O-Ring fits correctly, to avoid any damage.



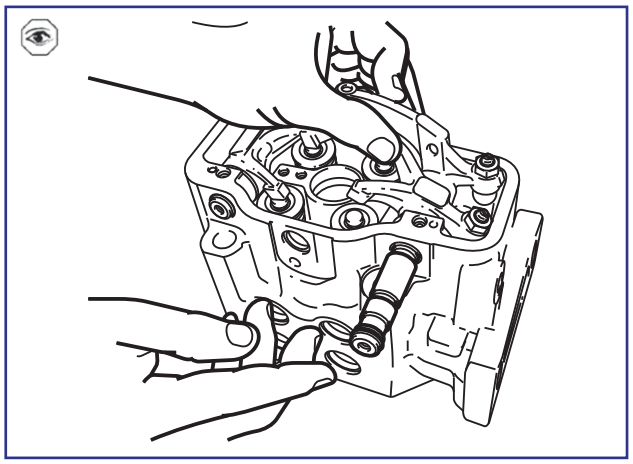
Install the balancer shaft with the O-Ring to the outer side.



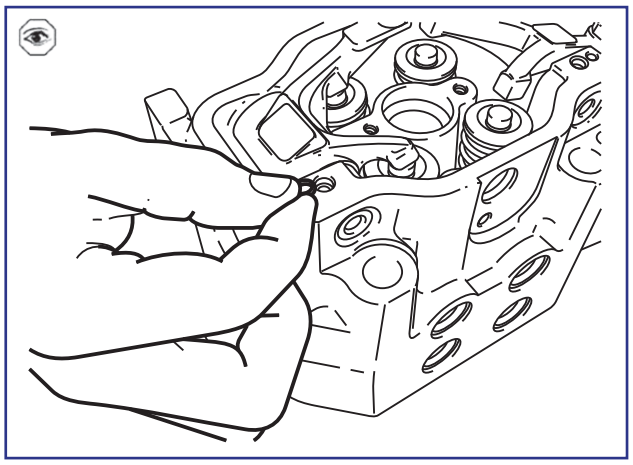
Install the intake rocker arms.



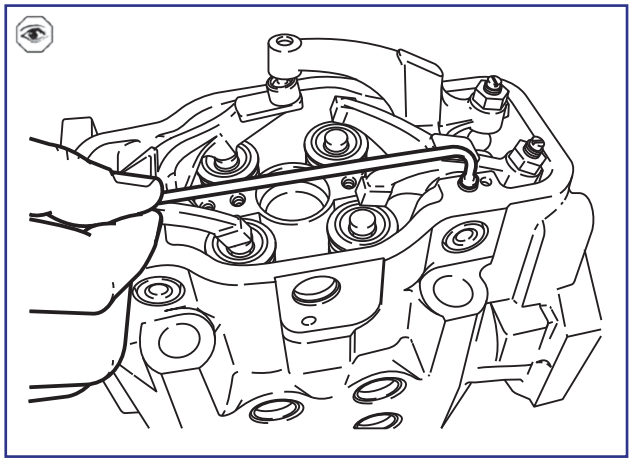
With the O-Ring previously installed, mount the balancer shaft with the O-Ring to the outer side.



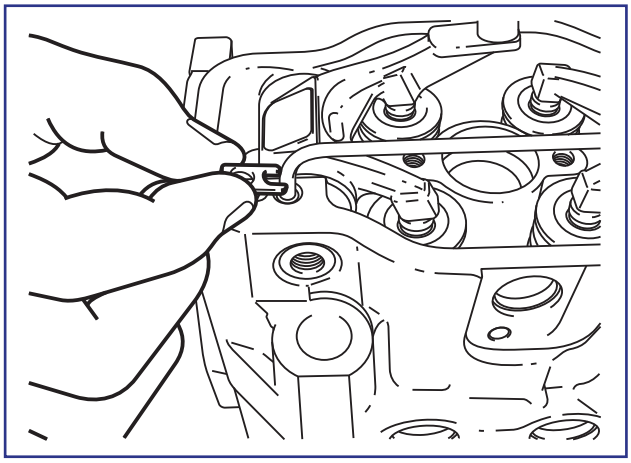
Install the O-Ring.



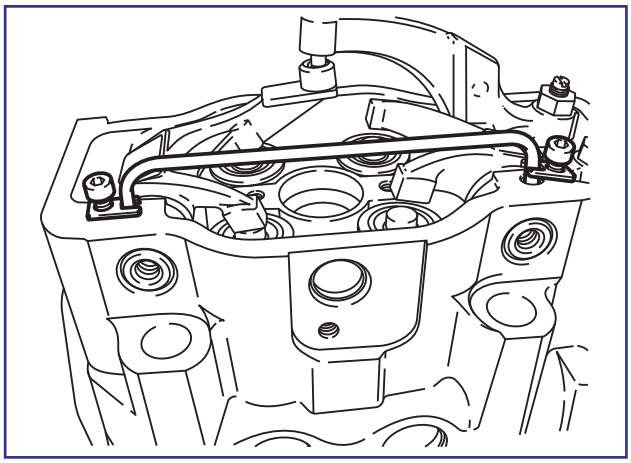
Install the balancer shaft lubrication pipe locker.



Install the lubrication pipe locker.

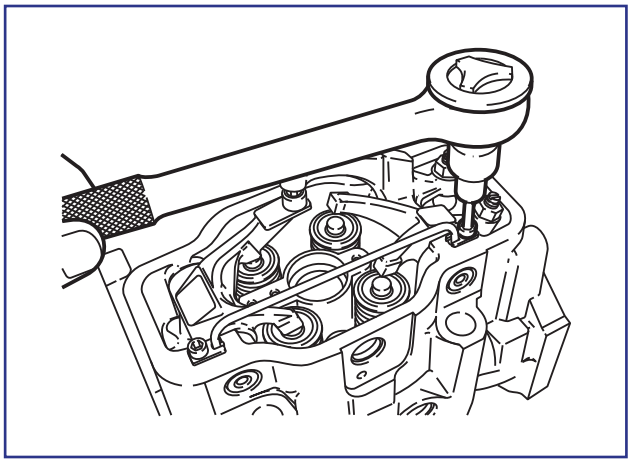


Install the M5X10 bolts.



Tighteen the bolt.

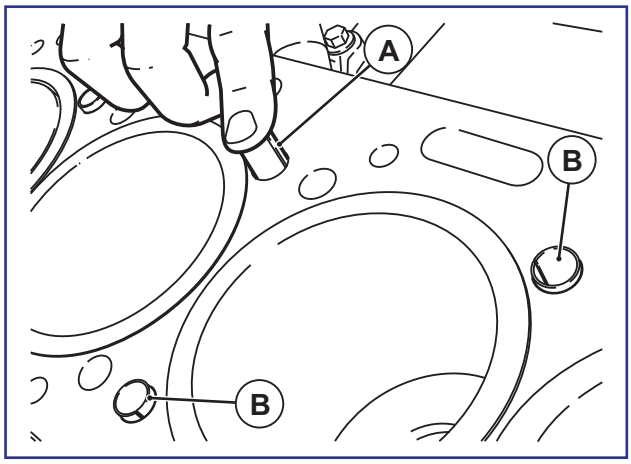
Torque: 4 to 6 N.m



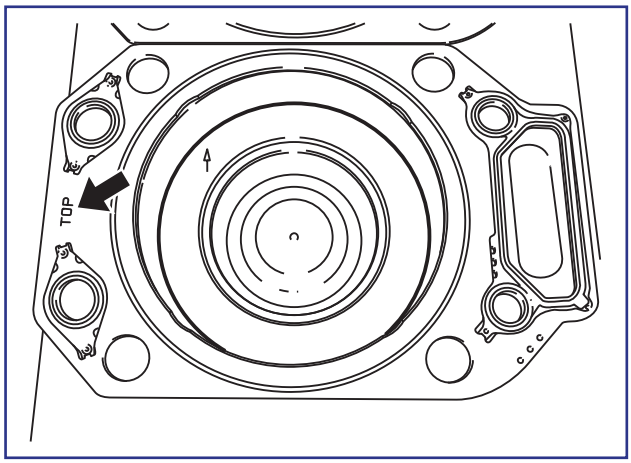
Installation

Install the guide bushings.

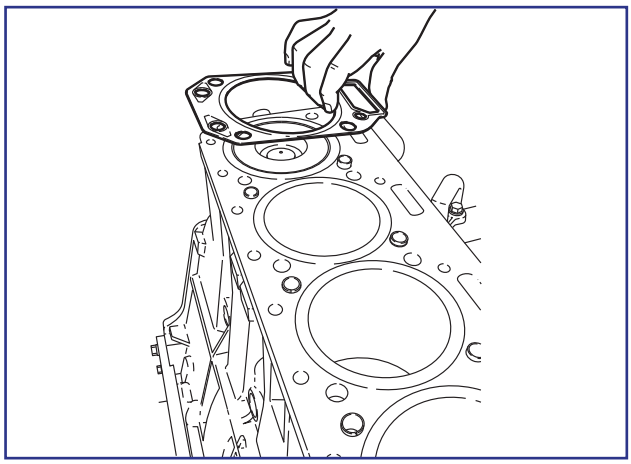
Two guides for each cylinder at opposite sides, as shown.



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

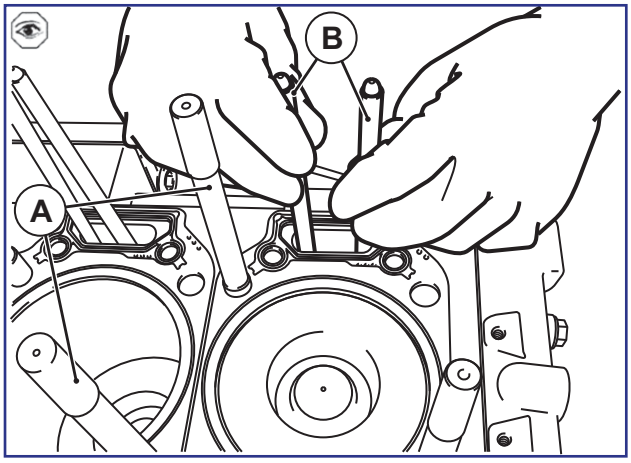


Install the gasket that must fits to guide bushings.

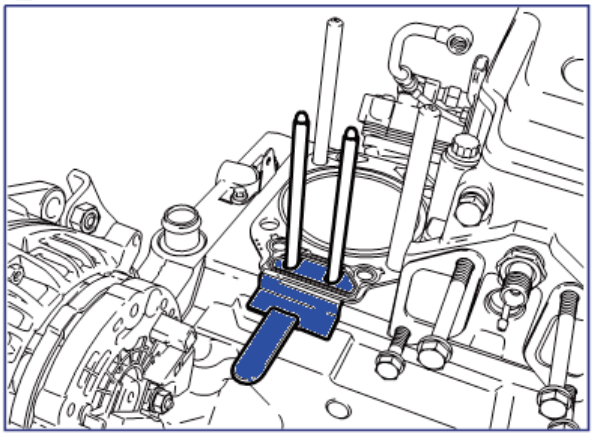


ⓐ Install the guide pin special tool No. 9.407.8.690.030.4 to align the cylinder heads

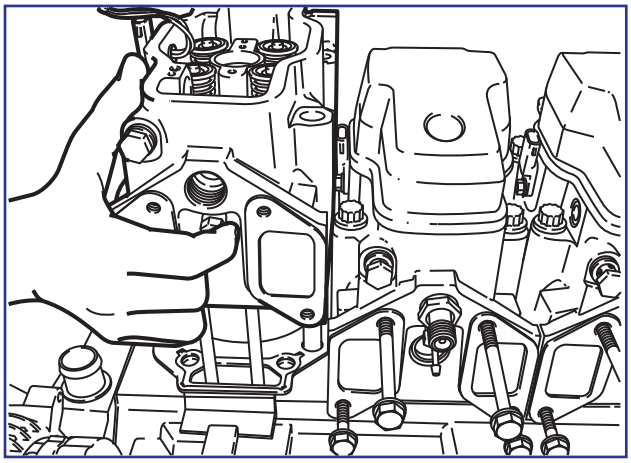
ⓑ Install the push rods.

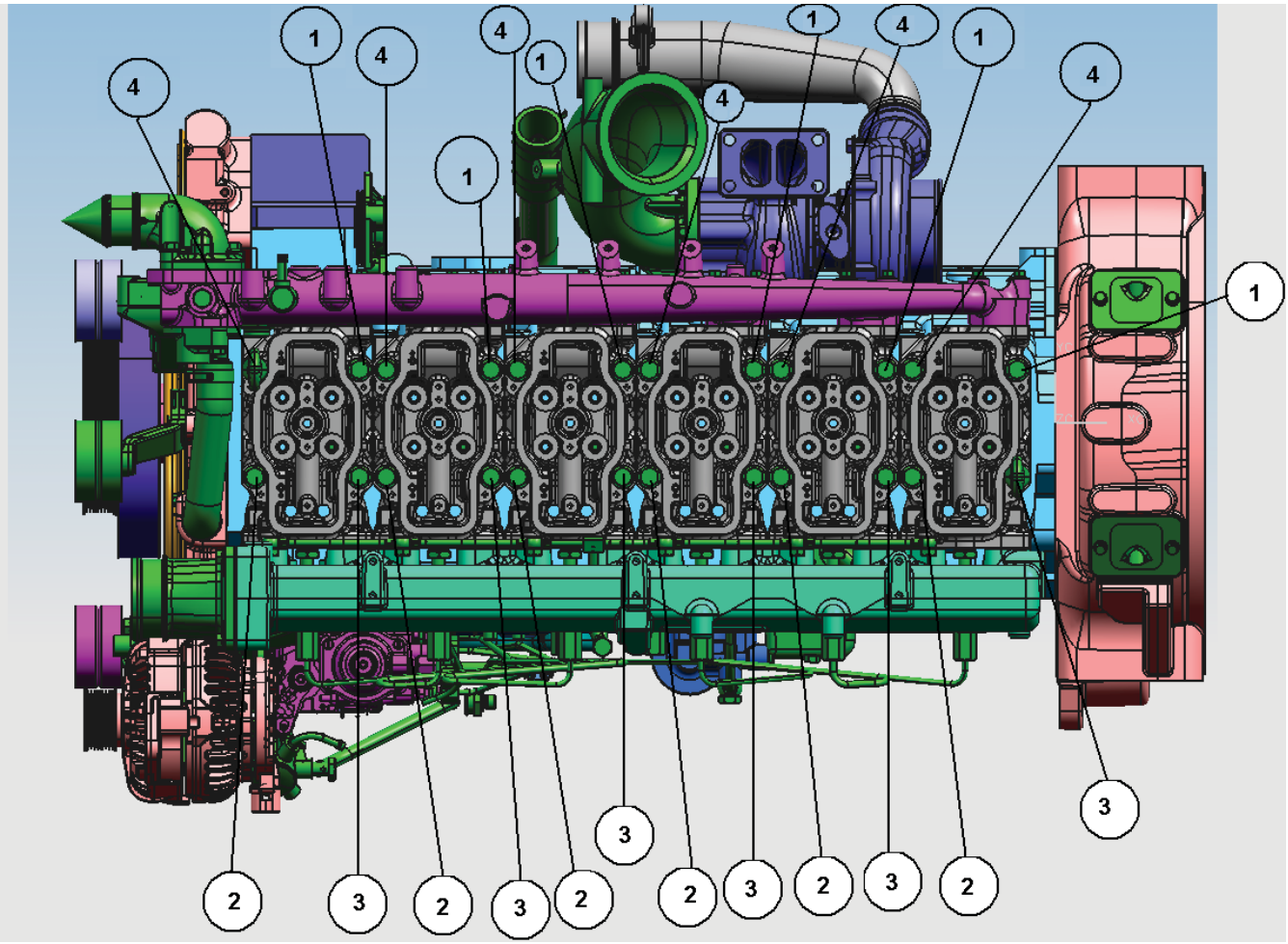


Install the special tool No. D7000595C1 to align the push rods.



Install the cylinder head.





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

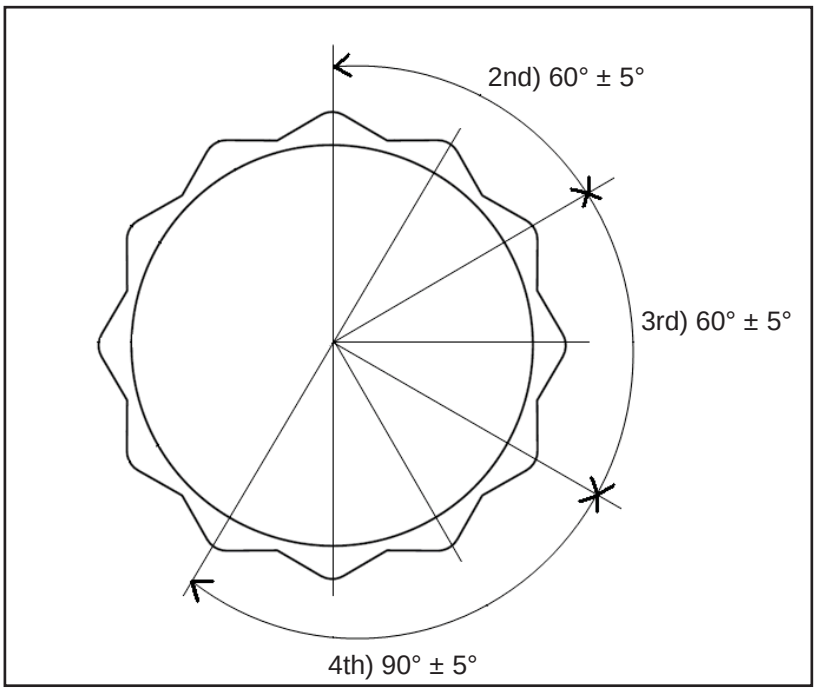
- **Torque conventional and angular:**

  1st) 60 to 70 N.m

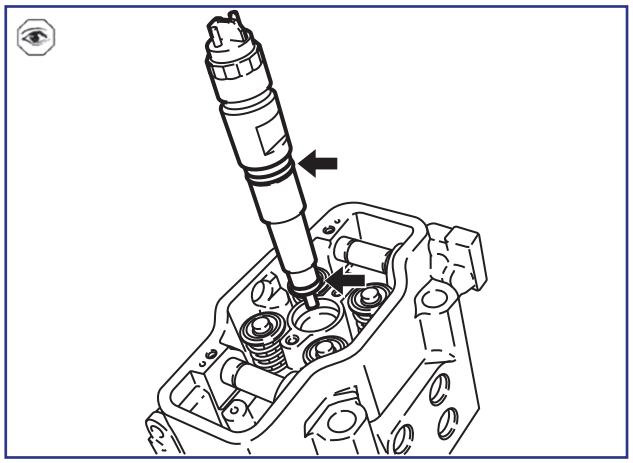
  2nd) 60° ± 3°

  3rd) 60° ± 3°

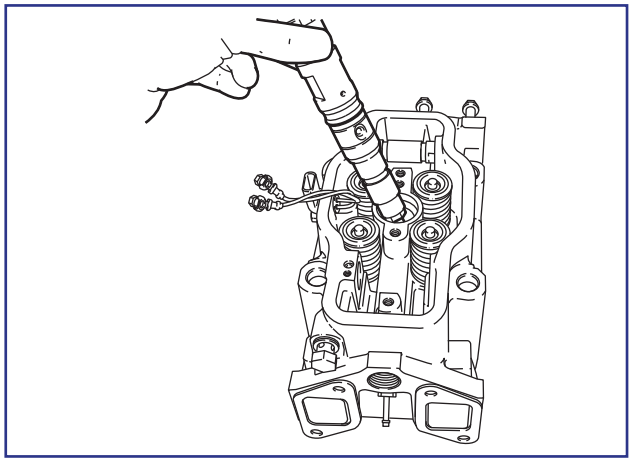
  4th) 90° ± 5°



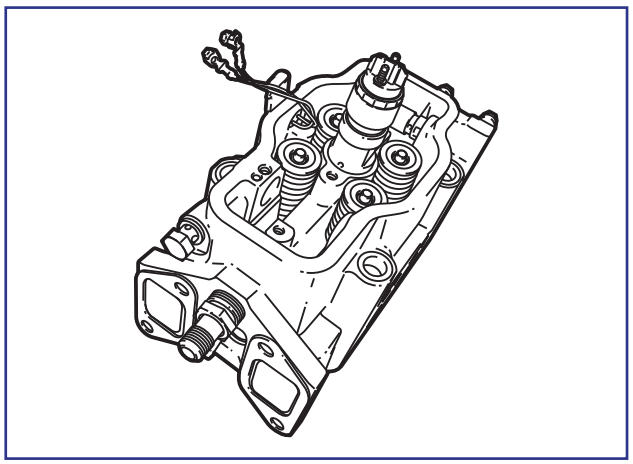
Install new O-Ring and sealing washer to the injector and observe its correct position.



Install the fuel injector to the cylinder head.



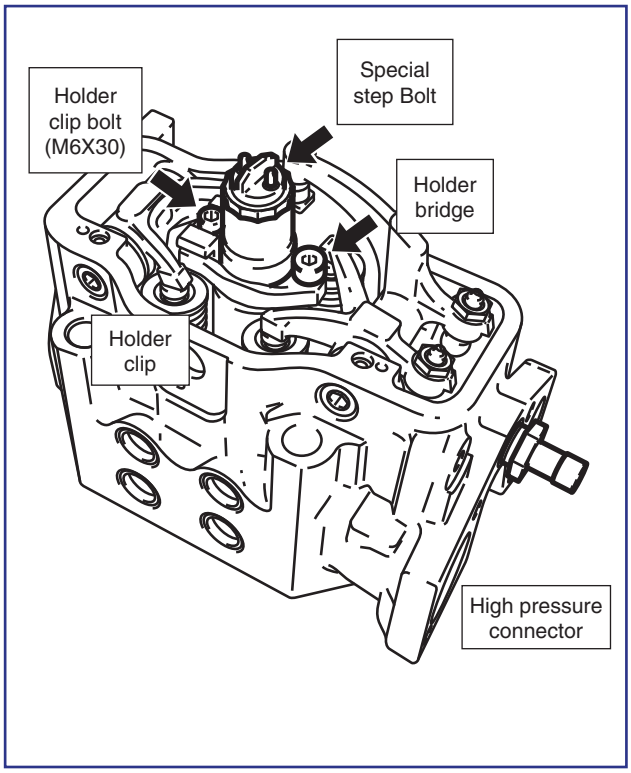
Install the High pressure connector on its correct position.



PROCEDURE TO INSTALL THE INJECTION NOZZLE

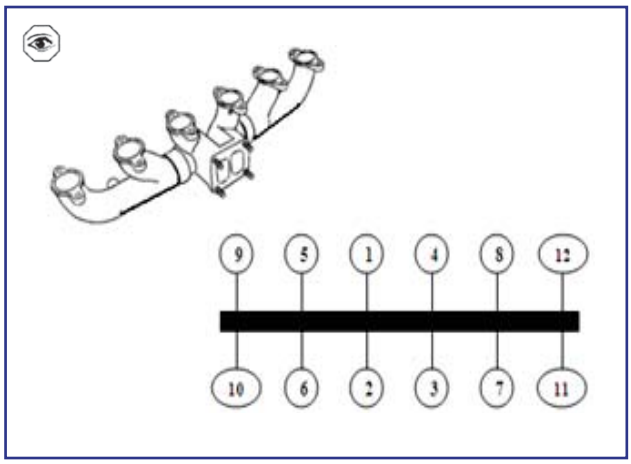
- Manually mount the clip, bridge and the two bolts.
- Apply a torque of 3 to 5 N.m to the special step bolt.
- Apply a torque of 1 to 1.5 N.m to the holder clip bolt.
- Relieve the torque from holder clip bolt to 0 N.m.
- Apply a torque of 15 to 20 N.m to the high pressure connector.
- Apply a torque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



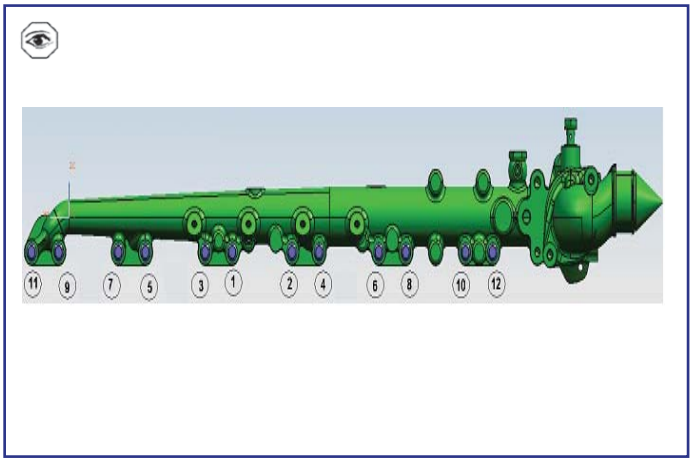
Install the exhaust manifold.

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



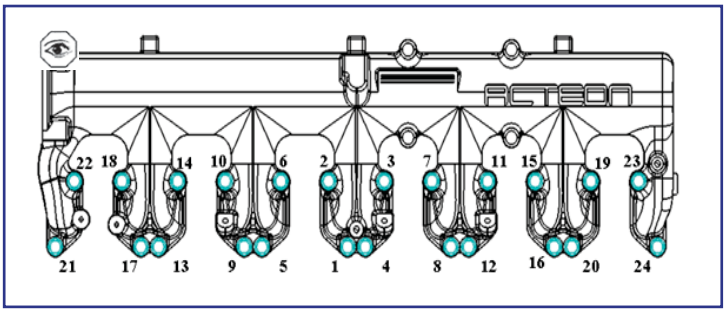
Install the water outlet pipe.

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



Install the intake manifold.

Torque: 20.±03N.m (apply crossed torque from center to the outside)



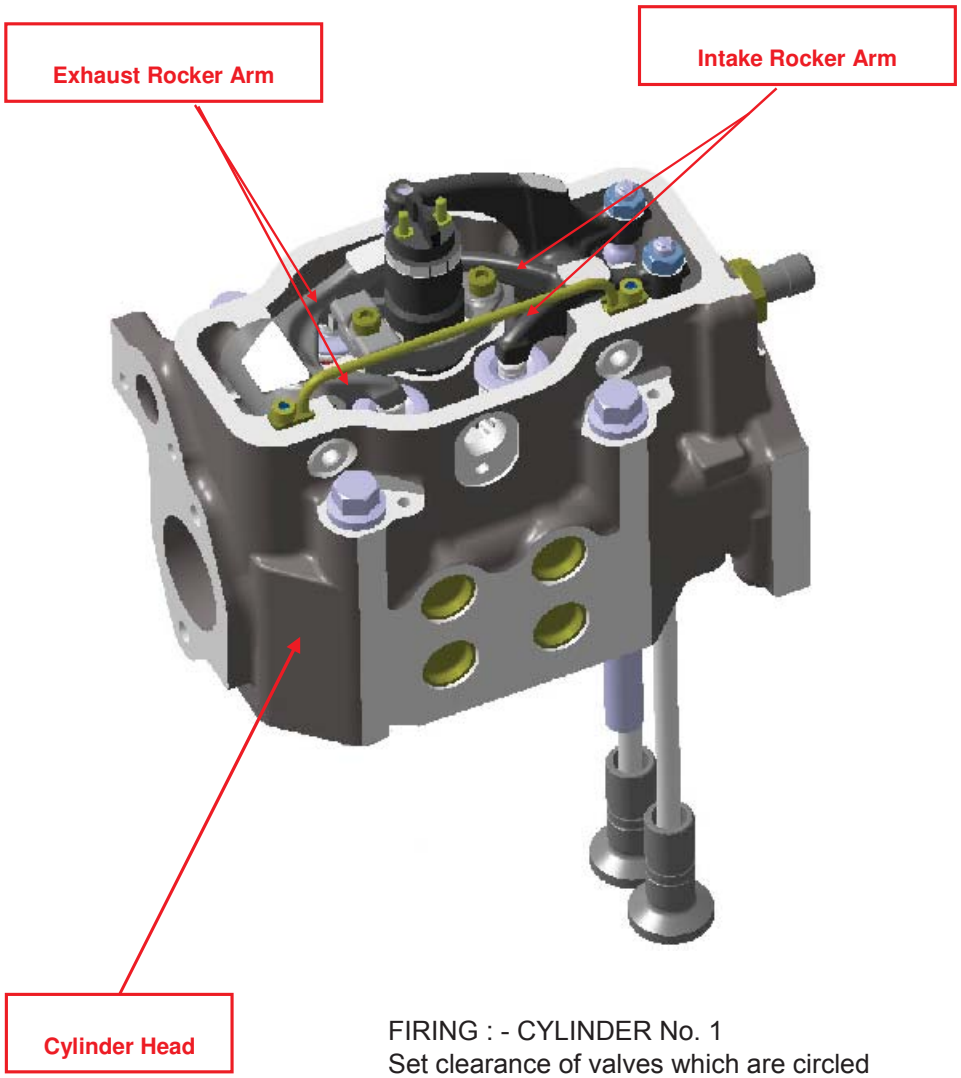
Adjust valve clearance as per the procedure given.

A VALVE ADJUSTMENT (TAPPET SETTING) PROCEDURE FOR MAXXFORCE 6.12 TCA ENGINE

Adjustment Sequence

1. for setting remaining valve adjustment turn the flywheel housing by 360 deg. (one full rotation) to set cylinder no.1 at firing. Here take a reference of damper marking.

Set cylinder no.1 at firing and follow the steps:
Set clearance in valve 1 of cylinder 1
Set clearance in valve 2 of cylinder 1
Set clearance in valve 4 of cylinder 2
Set clearance in valve 5 of cylinder 3
Set clearance in valve eight of cylinder 4
Set clearance in valve nine of cylinder 5



FIRING : - CYLINDER No. 1
Set clearance of valves which are circled

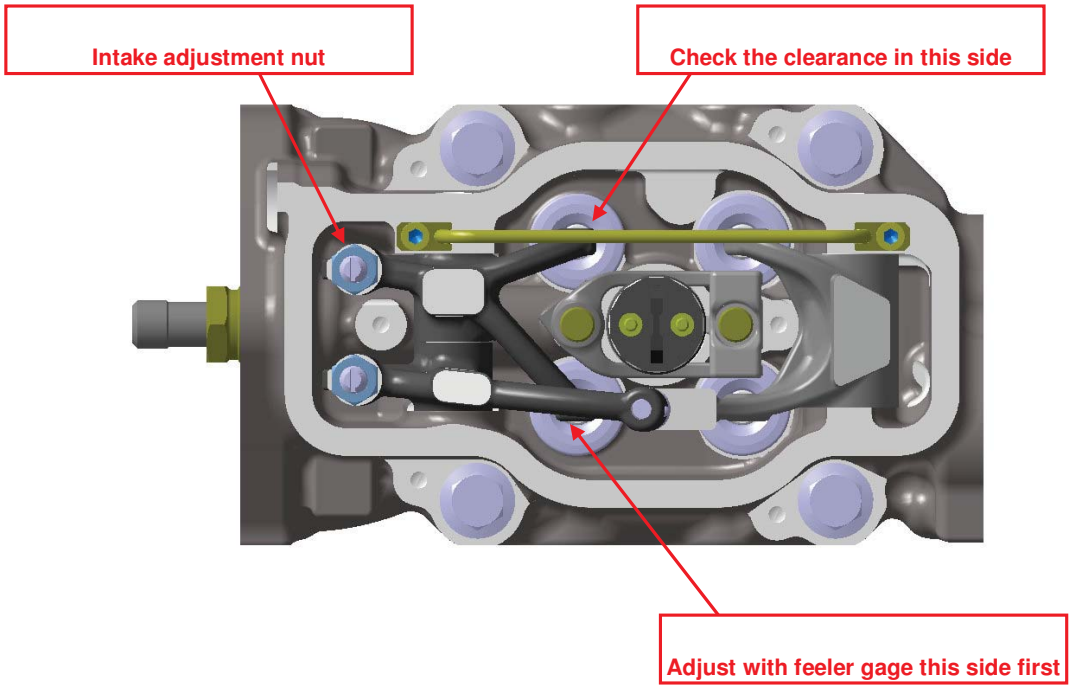
DAMPER SIDE

CYL. 6		CYL. 5		CYL. 4		CYL. 3		CYL. 2		CYL. 1	
IN.	EX.	IN.	EX.	IN.	EX.	IN.	EX.	IN.	EX.	IN.	EX.
12	11	10	(9)	(8)	7	6	(5)	(4)	3	(2)	(1)

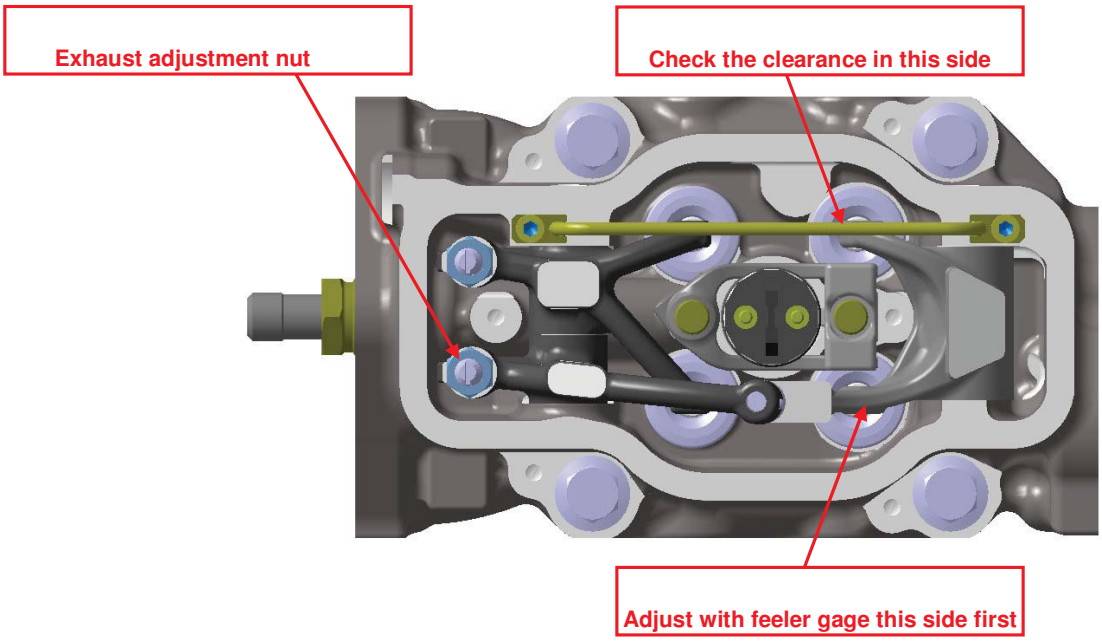
FLYWHEEL HOUSING SIDE

1/4

Intake



Exhaust



2. To adjust the valve cap and rocker arm follow the sequ ence below.
When the engine is cold, turn the crankshaft until cylinder 6 intake and exhaust valves are closed, ensuring that camshaft is not acting the rocker arm that will be adjusted.
In this position check clearance for following valves and respective cylinder.
Cylinder no. 1 is to be counted from flywheel housing side.
Set cylinder no. 6 (damper side) at firing and follow the steps:
Set clearance in valve 3 of cylinder 2
Set clearance in valve 6 of cylinder 3
Set clearance in valve seven of cylinder 4
Set clearance in valve 10 of cylinder 5
Set clearance in valve 11 of cylinder 6
Set valve 12 of cylinder no.6

VALVE ADJUSTMENT	Min.	Max.
Exhaust valve (mm)	0.20	0.40
Intake valve (mm)	0.20	0.40

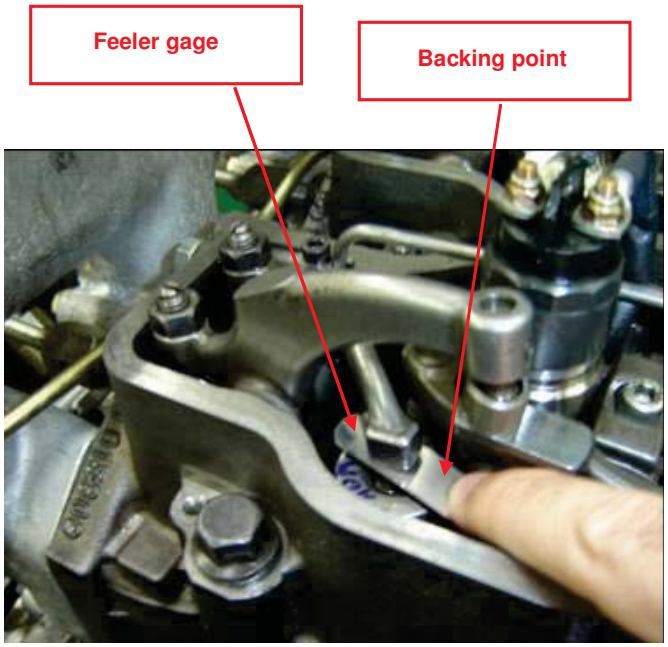


FIGURE 1

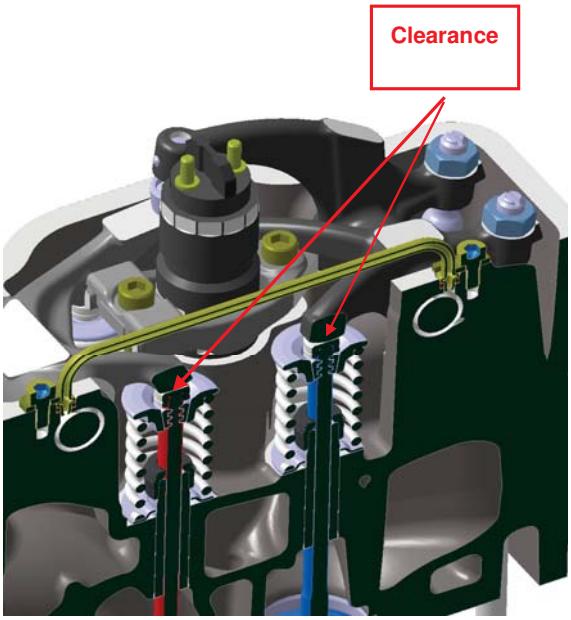


FIGURE 2

FIRING : - CYLINDER No. 6
Set clerance of valves which are circled.

DAMPER SIDE

CYL. 6		CYL. 5		CYL. 4		CYL. 3		CYL. 2		CYL. 1	
IN.	EX.	IN.	EX.	IN.	EX.	IN.	EX.	IN.	EX.	IN.	EX.
(12)	(11)	(10)	9	8	(7)	(6)	5	4	(3)	2	1

FLYWHEEL HOUSING SIDE

3. With a turnscrew, tighten the adjustment until remove clearances between feeler gauge and both of contact front. (rocker arm and valve cap) Certifying that still can be removed.

After this operation, tighten with 20 + 6 Nm the adjustment nut.
Note that it is necessary to insert the feeler with fingers for removing any scrub, compressing the analysis just in contact zone between the rocker arm and valve cap .

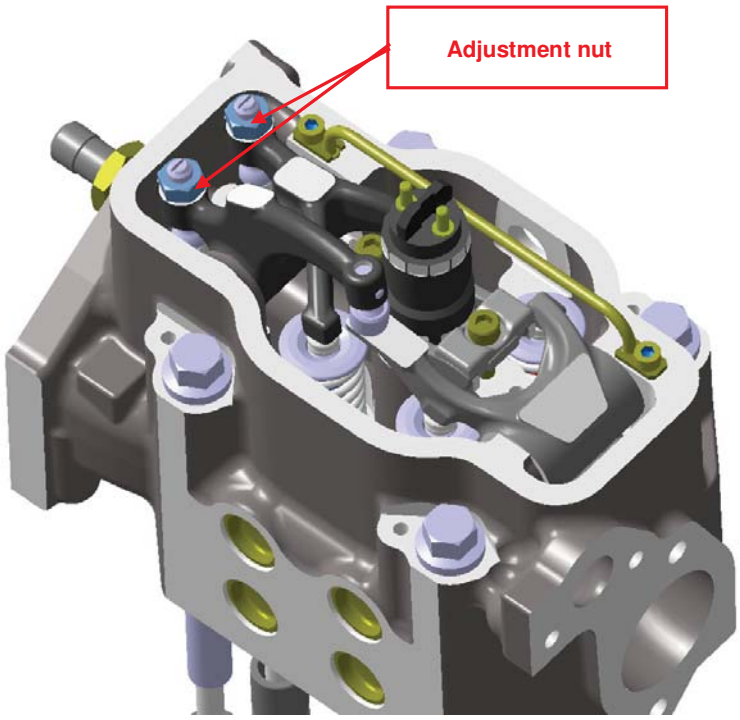


FIGURE 3

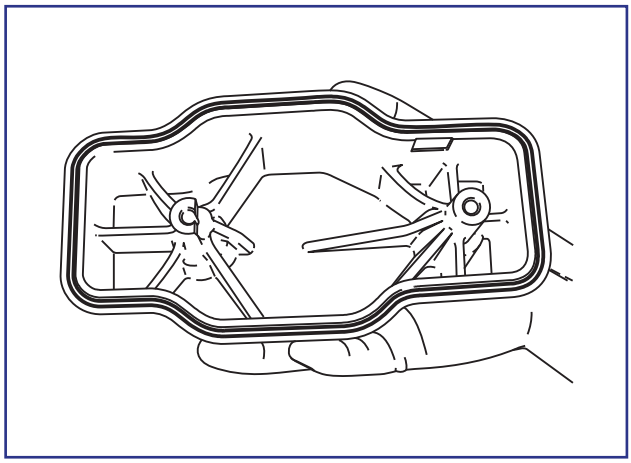
4. Once concluded the adjustment nut tightening torque it's necessary to check the clearance of second intake valve, in opposite side. If the tolerance zone is between 0.2mm to 0.4mm, the intake adjustment it is complete for this cylinder.

Obs: If adjustment clearance of the second valve is larger than 0.4mm, it is necessary to return to the first valve and to readjust it with a smaller clearance, using the feeler gage of 0.2mm instead of 0.3mm. Than check the clearance of the second valve, it must be between 0.2mm and 0.4mm. However if the adjustment of the second valve will be inferior 0.2mm, it's necessary to return to the first valve and to readjust with larger clearance, using the feeler gage of 0.4mm instead of 0.3mm. Check again the clearance of the second valve, it must be between 0.2mm and 0.4mm.

5.To finish, all these clearances must be inferred in tolerance zone to 0.2mm to 0.4mm

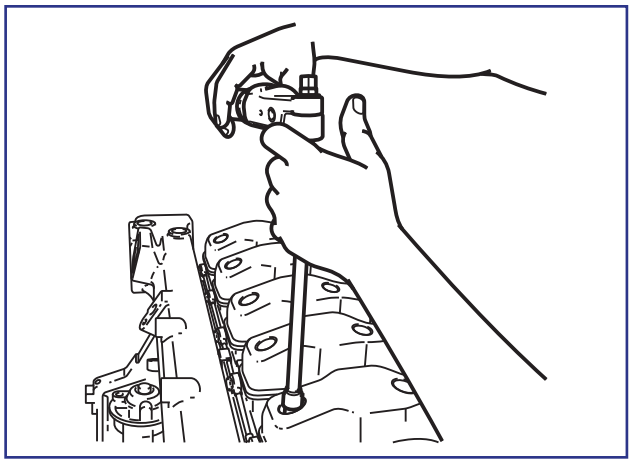
VALVE COVER INSTALLATION

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



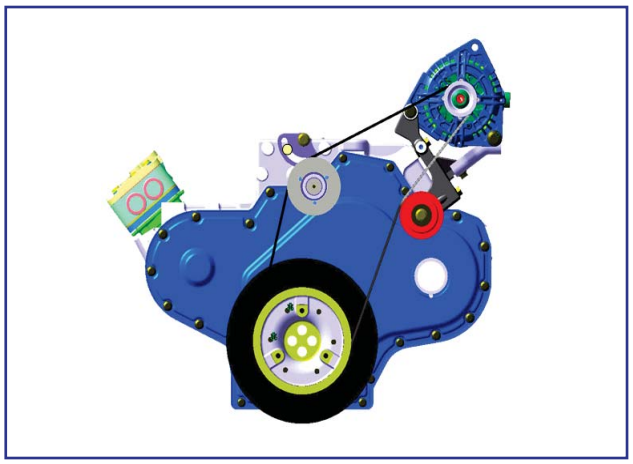
NOTES

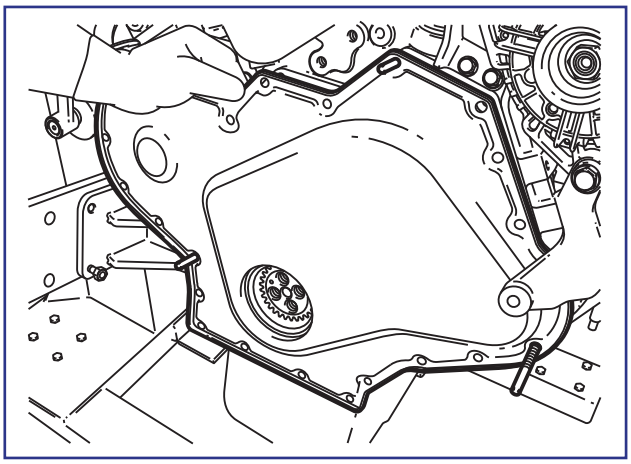
Gear Housing

Group - 10

Disassembly Notes

. Remove the belt acessories by a wrench to loose the tightener.

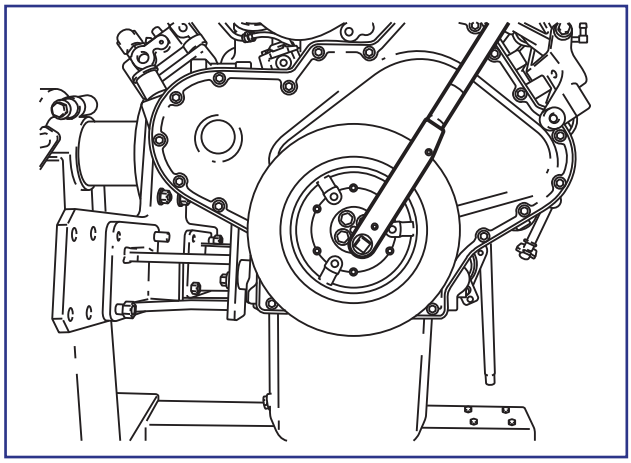




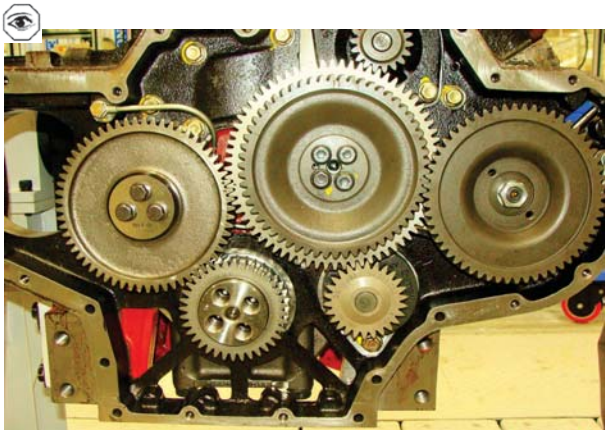
Remove the acessory pulley.

Loosen the bolts of crankshaft pulley

Remove the crankshaft pulley and damper set.



Inspections and Measurements



Visually check damper and pulley(s).

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

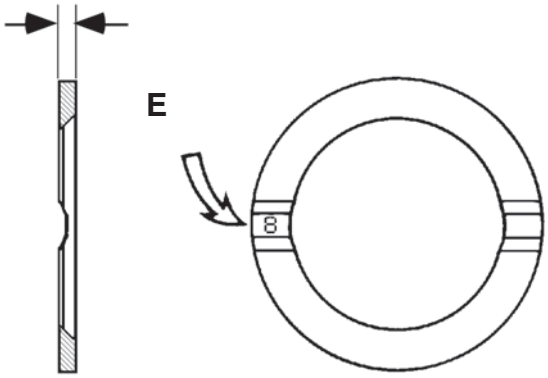
Presenting those defects, the gears must be replaced.

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

Specifications

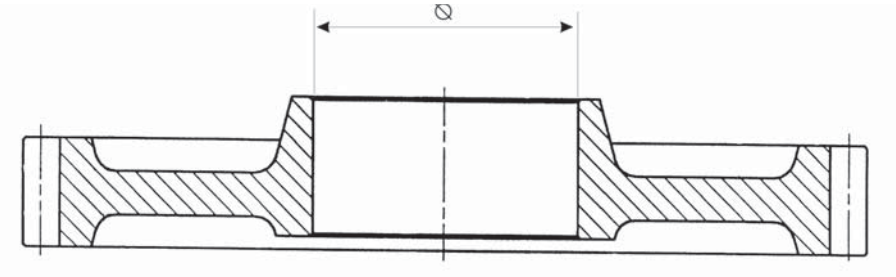
Idle gear bearing	
Measurements	**mm**
Ø nominal	44.995 -45.011
Gear clearances	**mm**
Radial Axial	0.013 - 0.075 0.06 - 0.14

9-3-2

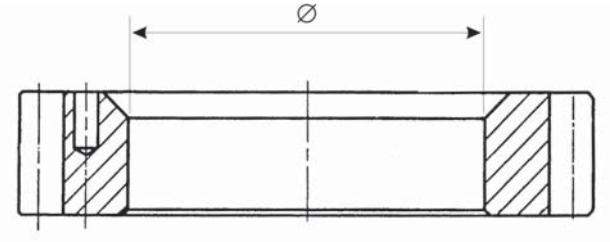


Thrust ring (for intermediate ring)	
E (mm)	**MIM nr.**
3.41 - 3.45	9.610.0.433.004.4
3.46 - 3.50	9.610.0.433.005.4
3.52 - 3.56	9.610.0.433.006.4

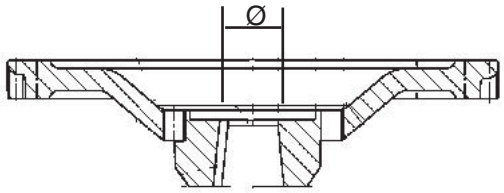
Idle gear	
Ø hole	**mm**
Without bushing	50.000 - 50.016
With bushing	45.024 - 45.076
Quantity of teeth	61



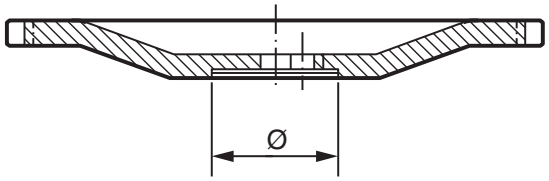
Crankshaft front gear	
Ø hole	59.994 - 60.019 mm
Quantity of teeth	36



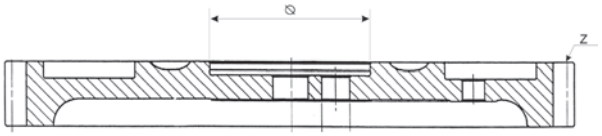
High pressure pump gear	
Ø hole	25.000 - 25.033 mm
Quantity of teeth	58



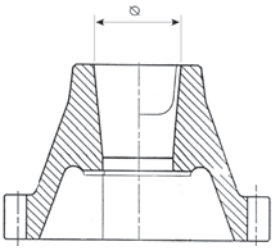
Camshaft front gear (Camshaft to fuel pump driving gear)	
Ø hole	50.000 - 50.032 mm
Quantity of teeth	72



Camshaft back gear (Camshaft timing gear)	
Ø hole	52.00 - 52.03 mm
Quantity of teeth	58

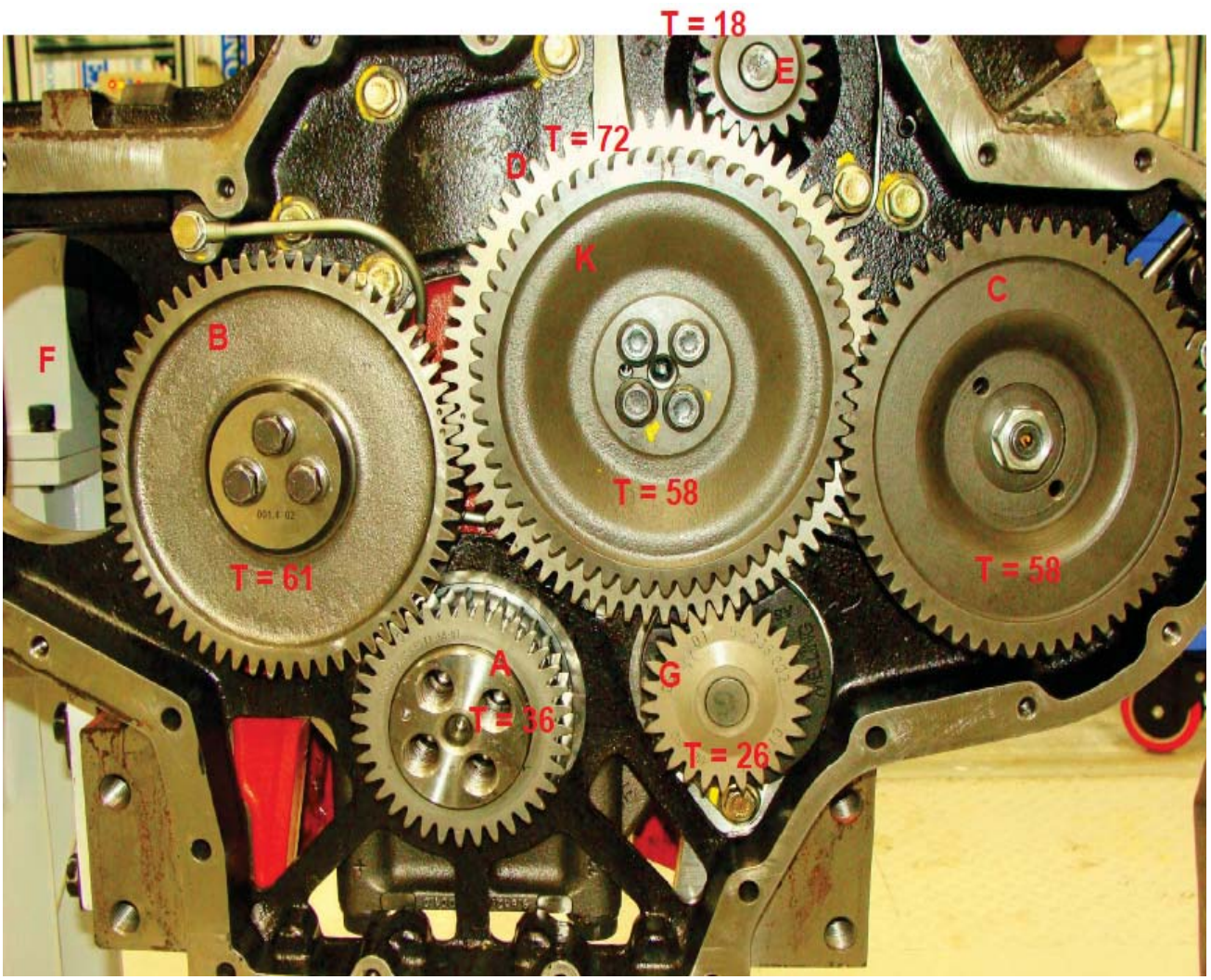


Air compressor gear	
Ø hole	30.00 - 30.033 mm
Quantity of teeth	32



GEARS CLEARANCES

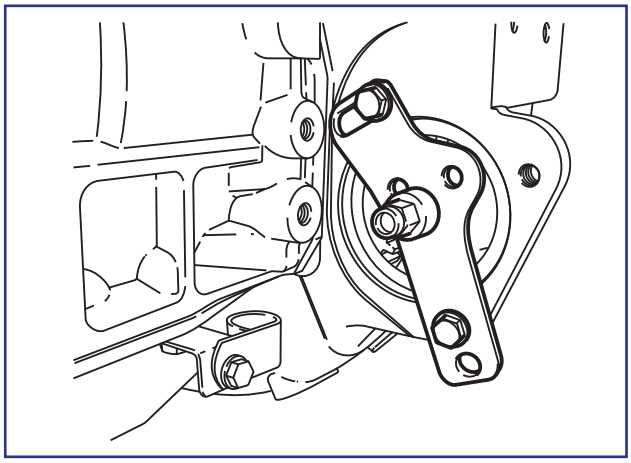
ID	DENOMINATION
A	Crankshaft gear
B	Idle gear
C	High pressure fuel pump gear
D	Camshaft back gear
E	Water pump gear
F	Air compressor gear
G	Oil pump gear
K	Camshaft front gear



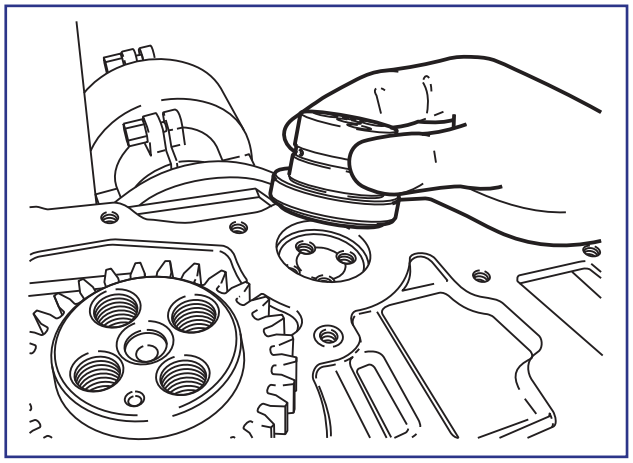
Gears backlash	0.05-0.18 mm

Assembly

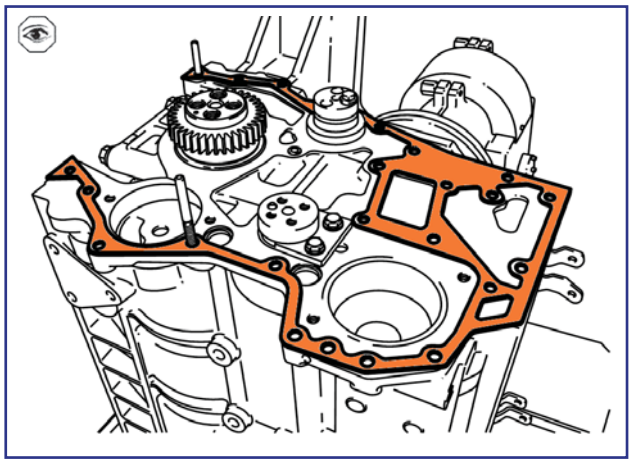
Lock the engine with the special tool No. D7000600C1. With the starter removed install the tool as indicated.



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

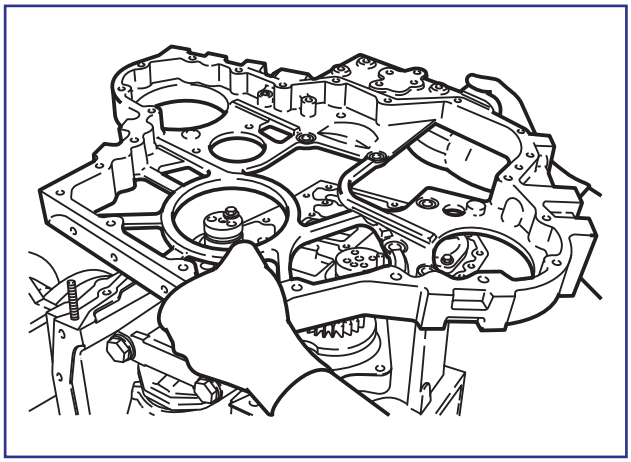


Place the gear housing to block gasket.



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

Torque: 25 ± 5 Nm

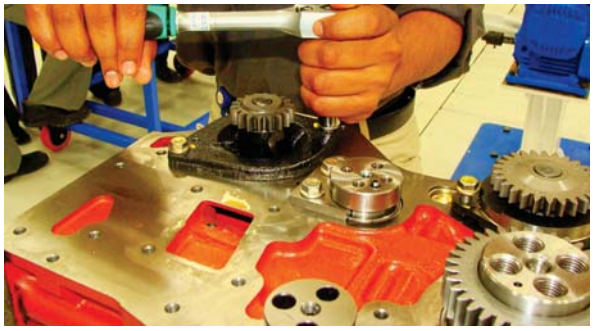


Attention: The centralization of the gear housing is important to guarantee the specified clearances of the distribution gears.

Attention: When removing/installing only water pump, flock the crankshaft and timing gears.

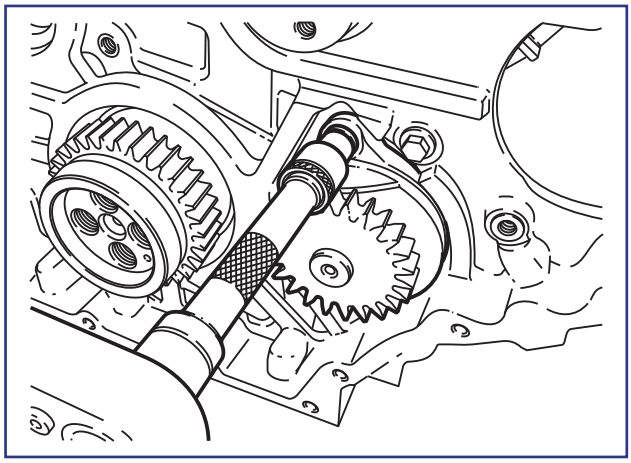
Install the water pump, tightening according to the specification.Take care to do not damage the sealing ring.

Torque: 20 ± 5 Nm



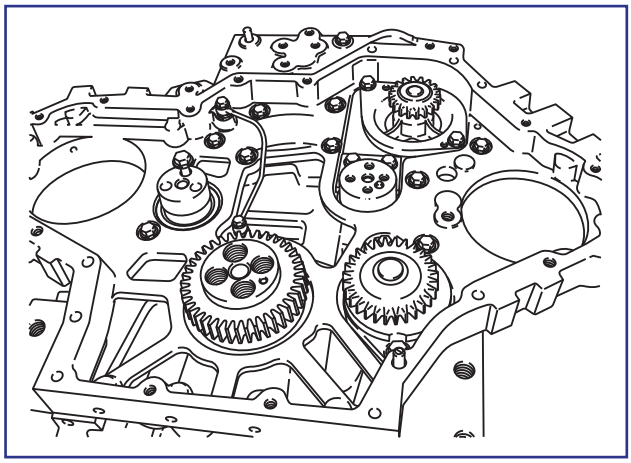
Install lubricant oil pump tightening according to the specification.Take care to do not damage the sealing ring.

Torque: 20 ± 5 Nm



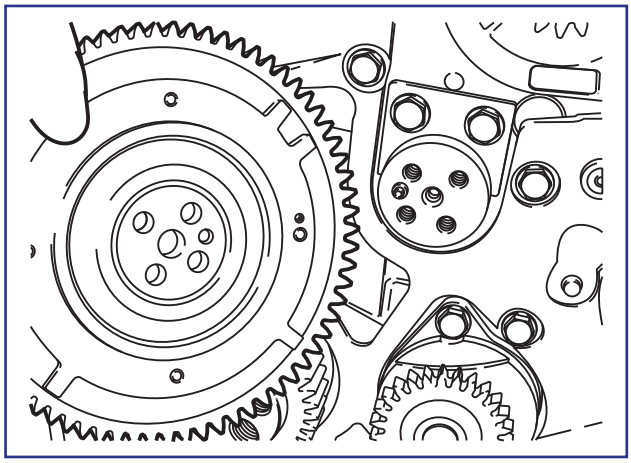
Install lubrication pipes tightening according to the specification (electronic engine shown).

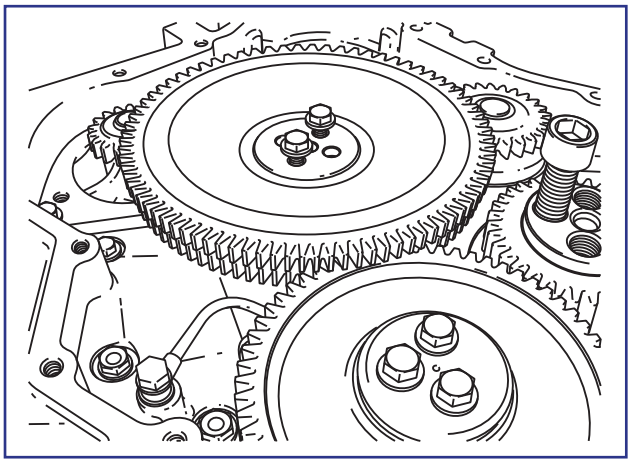
Torque: 5 ± 5 Nm



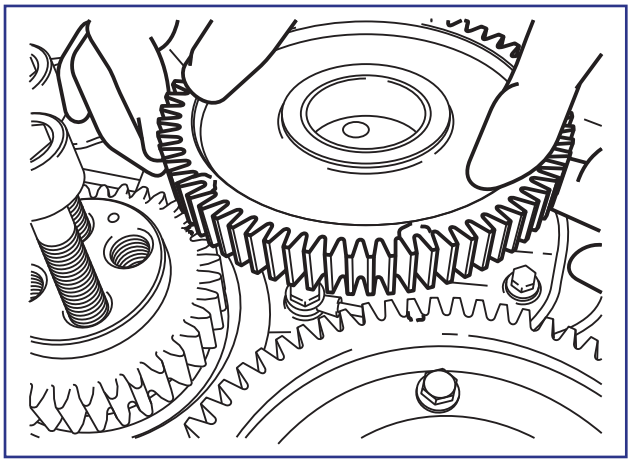
Assembly camshaft gear and tighten the bolts according to the specification.

Torque: 1st: 15±01
2nd: 28° to 32° (torque range from 35 to 65 Nm)

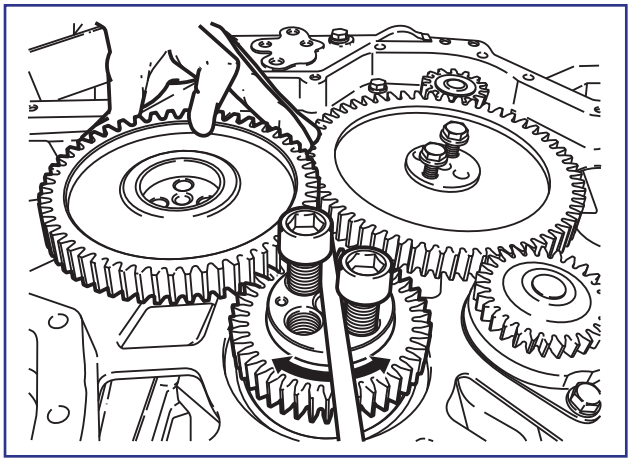




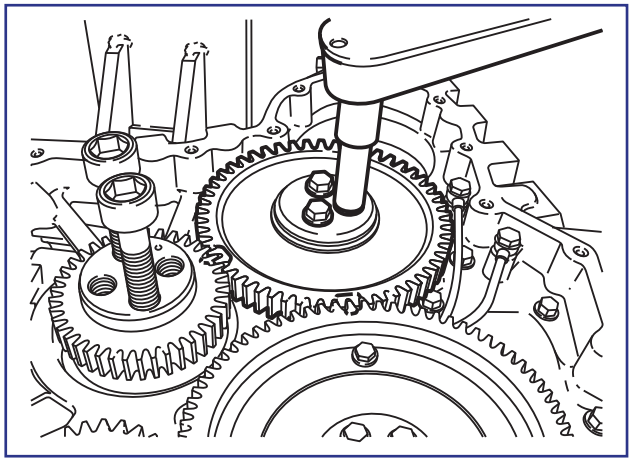
Assembly the idle gear.



To assembly the gears in the correct timing position, use a screwdriver to make short turns. Observe the timing gear marks.

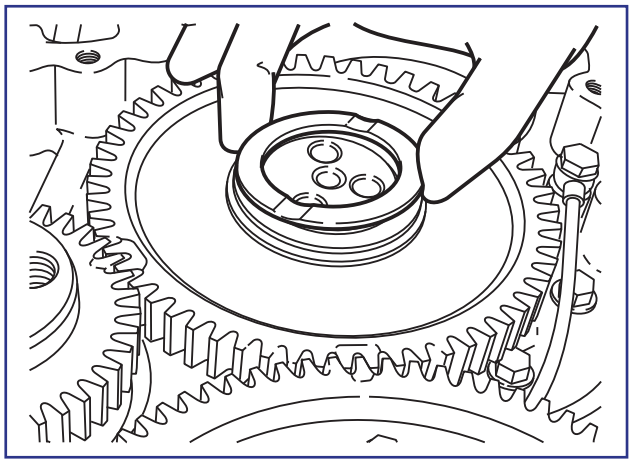


Install the bolts of the idle bearing.

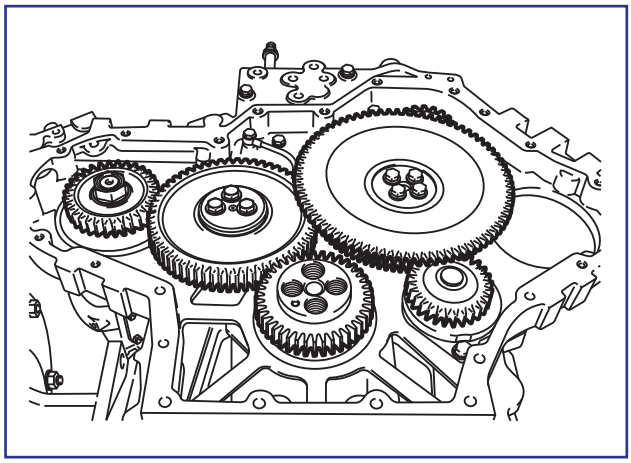


Torque: 55 to 65 Nm

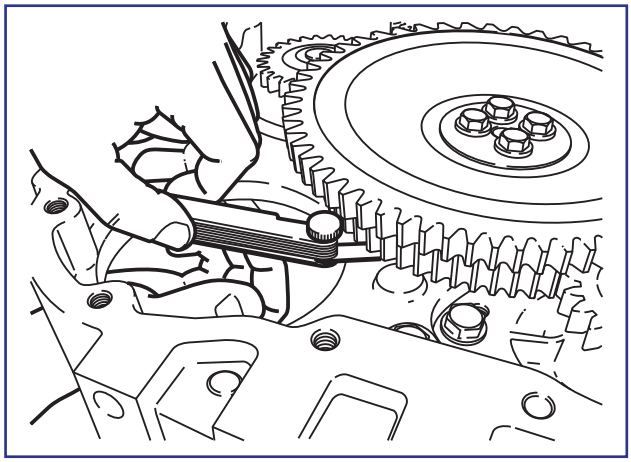
Install the thrust ring of the idle gear.The two grooves must stay towards the side of the shaft. There are 3 different thickness of thrust ring in order to guarantee the axial clearance of the idle gear.

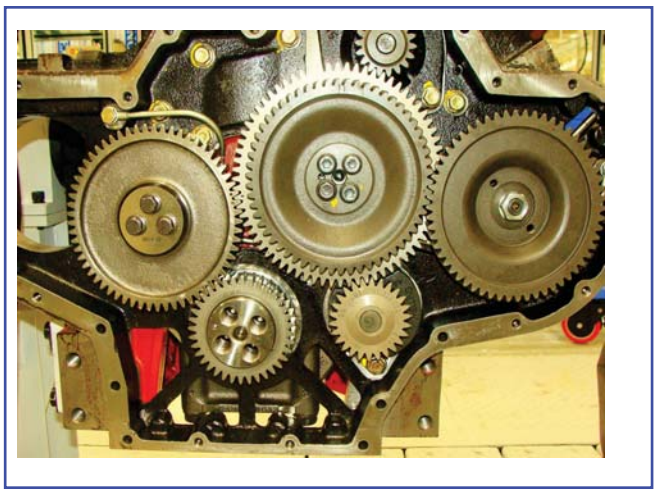


Tighten all mounting bolts of timing gears with the specified torques. See special torques table in Appendix A.

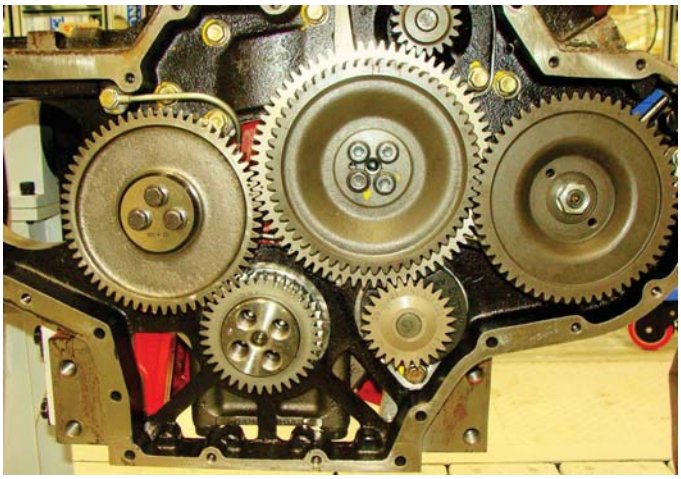


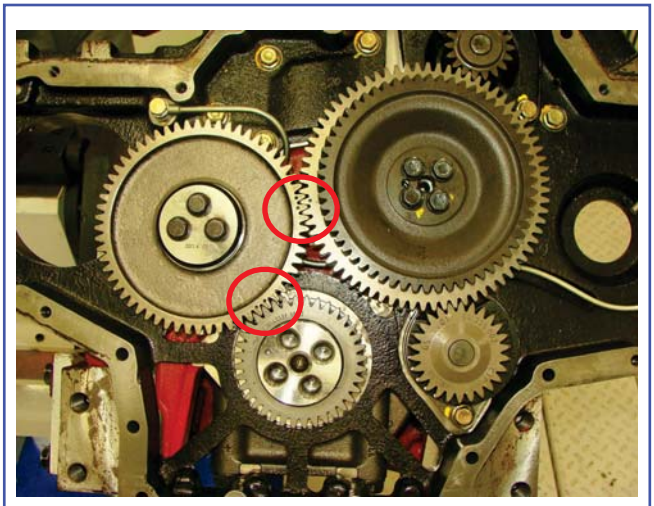
Measure the clearance between high pressure pump timing gear and camshaft gear.





View of assembled gears set.



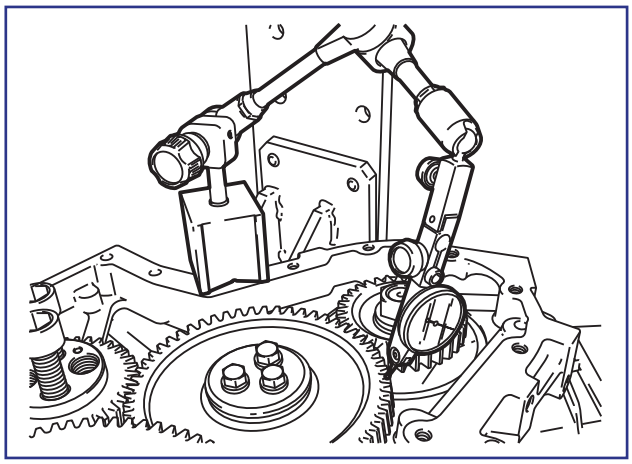


Attention:

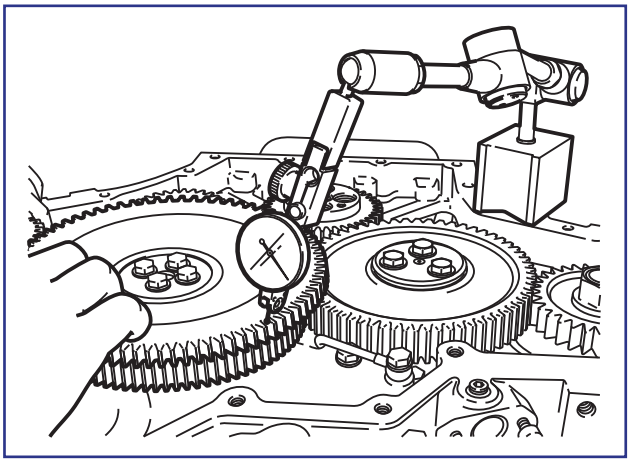
- During the engine operation there must not be gearing noise.
- A noisy operation indicates too much clearance between gears or teeth excessive wear.

Measure the clearance between both timing gears.

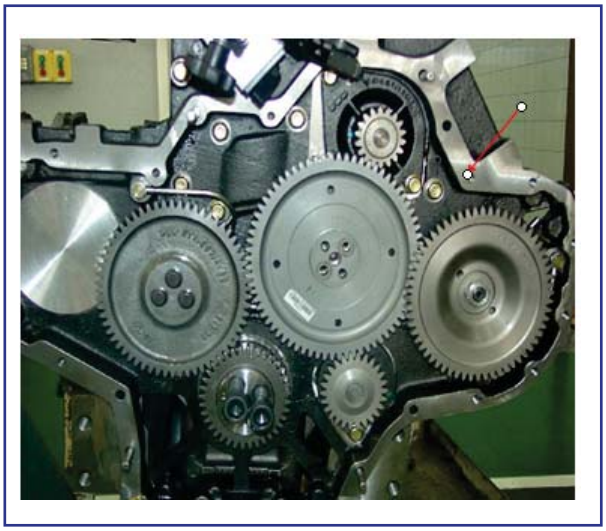
Clearance: 0,05 to 0.25 Nm



Clearance: 0,05 to 0.25 Nm

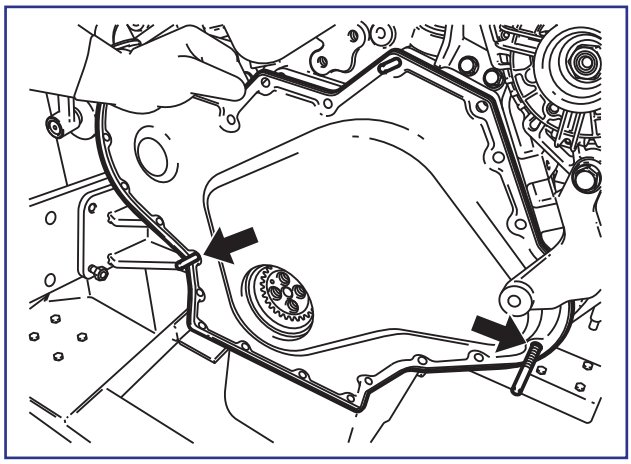


Place a new gasket to the front cover gear housing.



Centre the front cover with the special tool MWM nr.

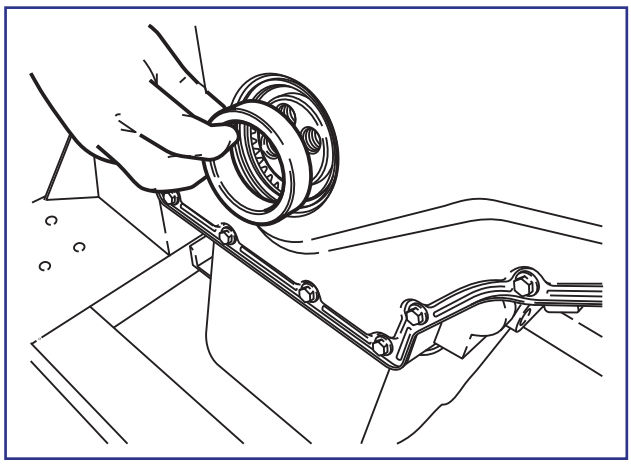
9.610.0.690.019.6.



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

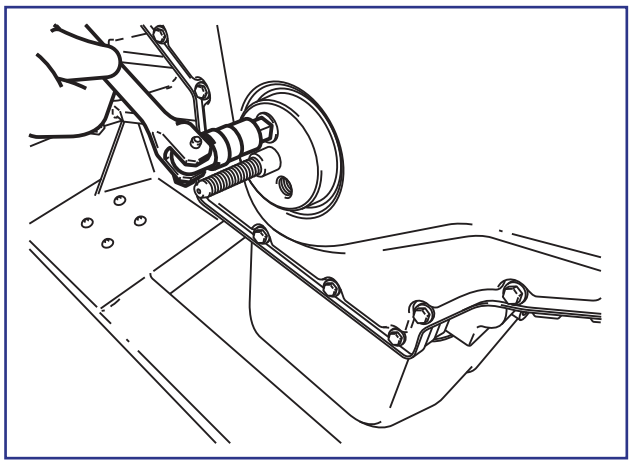
Tighten the fixation bolts of the front cover.

Torque: 22 to 28 Nm

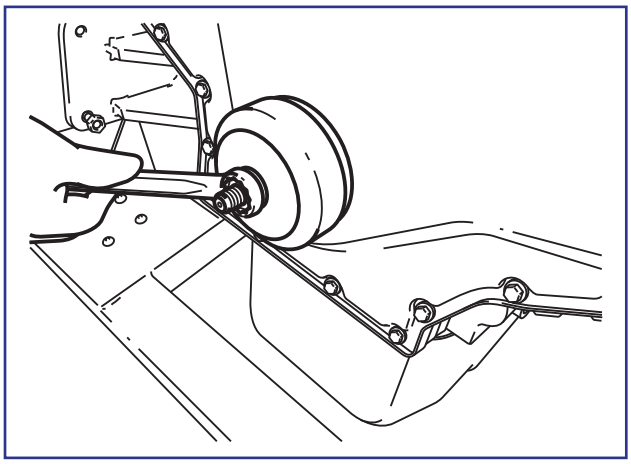


Install the special tool MWM nr. 9.610.0.690.019.6.

Tighten the 2 bolts indicated to fit the tool onto the gear.



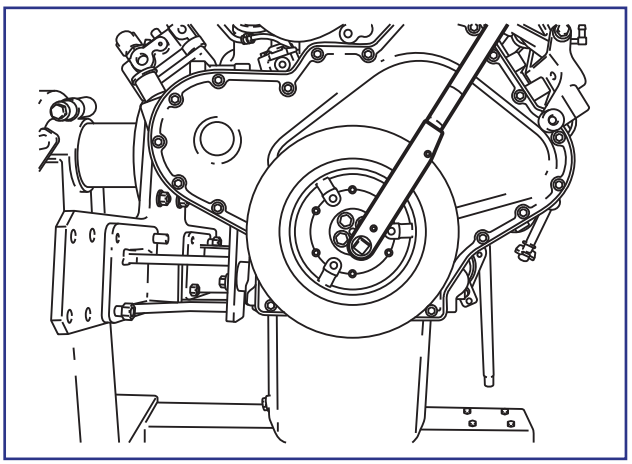
Place the new front seal and the special tool hub and tighten as indicated placing the seal to its housing.



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

Torque: **1st: 100 ± 10 Nm**

2nd: 275 ± 15 Nm



NOTES

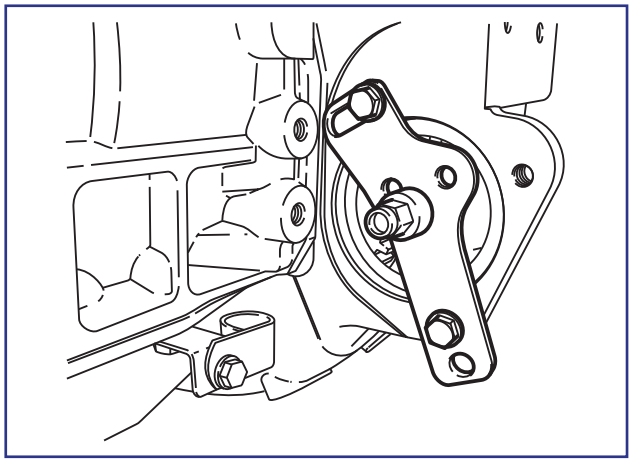
Flywheel and Flywheel Housing

Group - 11

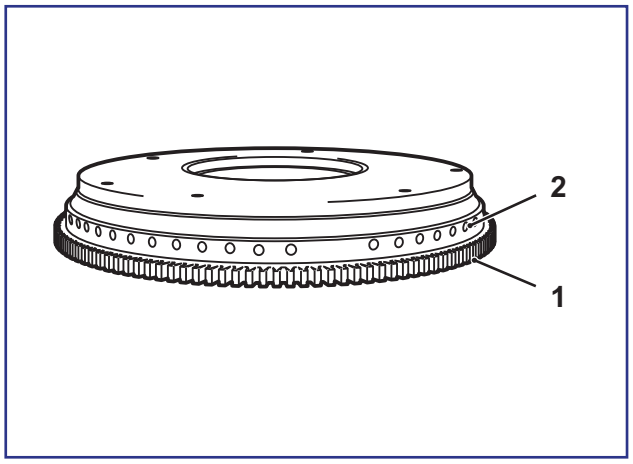
Disassembly Notes

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

With the starter removed install the tool as indicated.

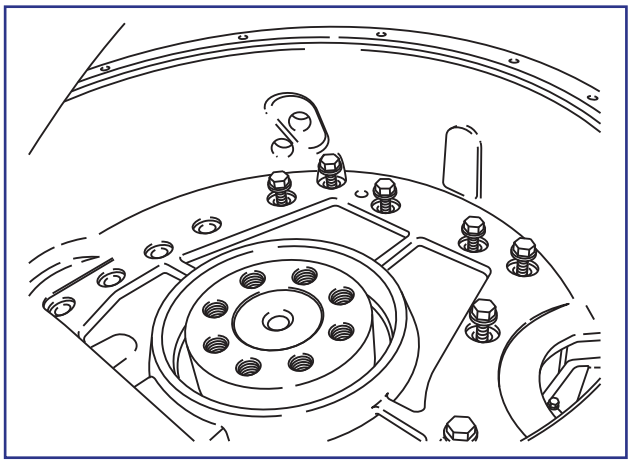


To remove the gear ring (1) from the flywheel (2), heat the gear at 180° C and hit it.



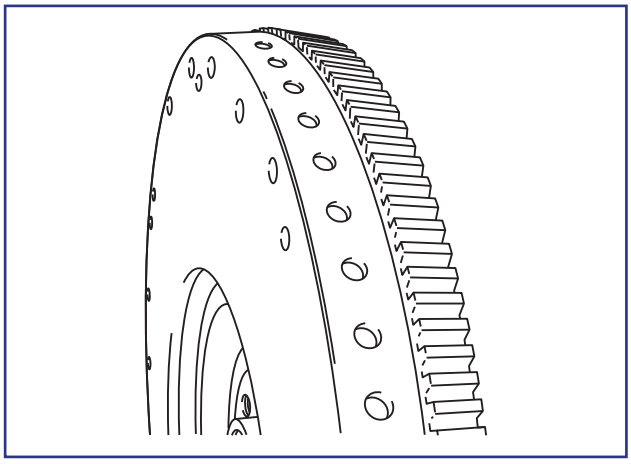
PRE-ASSEMBLY INSPECTIONS

Visually check flywheel housing for cracks or any damage.



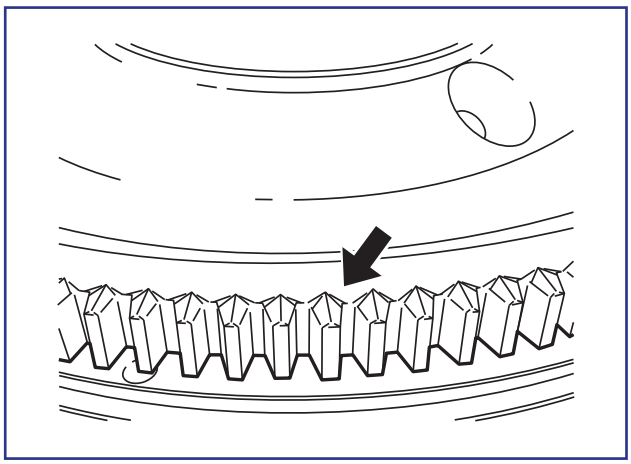
Visually check flywheel and gear ring. Failures in the starter motor gearing may be caused by broken gear ring or damage teeth.

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



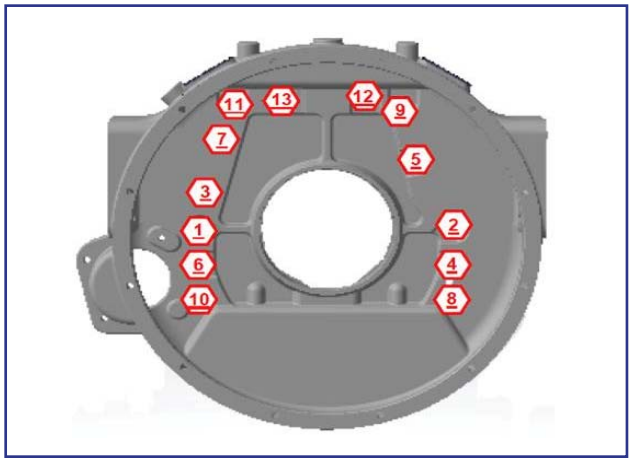
Assembly

To install the gear ring on the flywheel, first heat it up to a temperature around 250°C and assembly it paying attention to face the teeth with the V shape to the starter gear side.

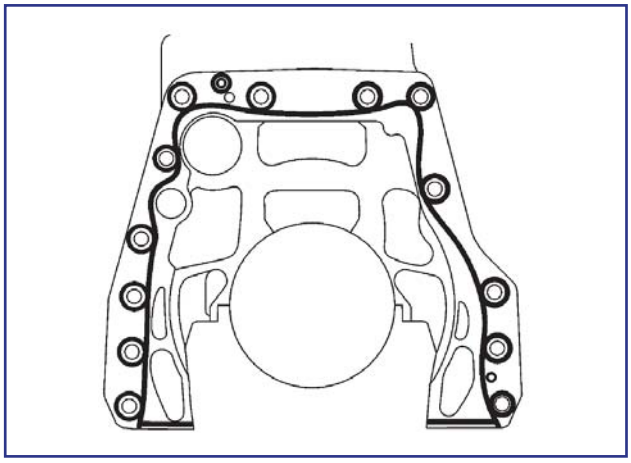


Assembly the housing on the engine block and tighten the bolts according to the specification.

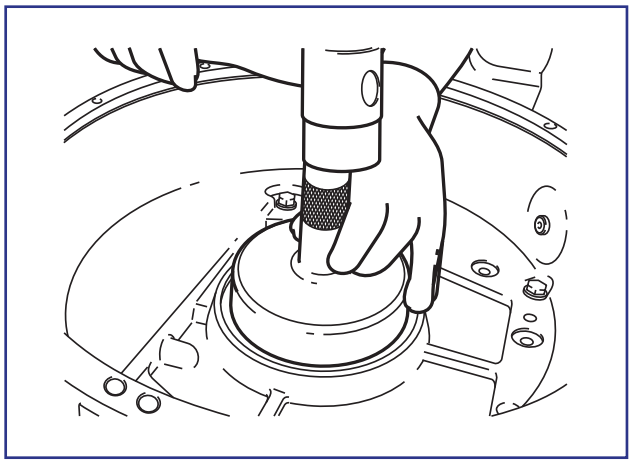
Torque: 100±5 N.m



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, as illustrated.

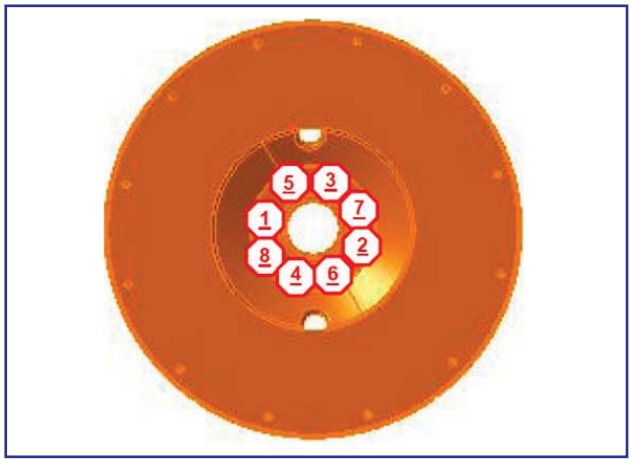


Install the rear seal with the special tool MIM No. 9.610.0.690.020.6.



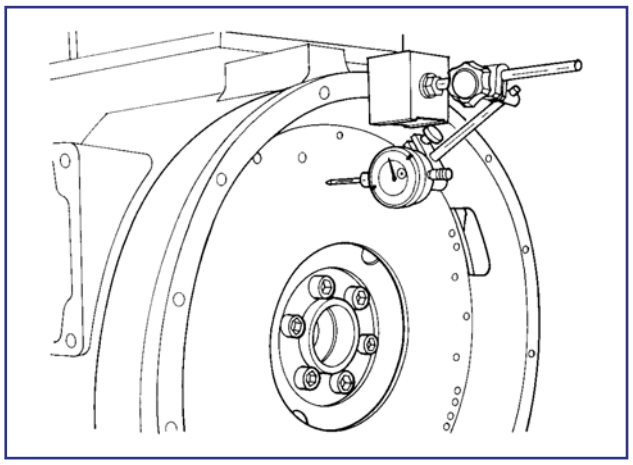
With the engine locked, assembly the flywheel. Tighten the crankshaft fixation bolts according to the specification.

Apply torque: 1st: 90 to 110 Nm
2nd:260 to 290 Nm



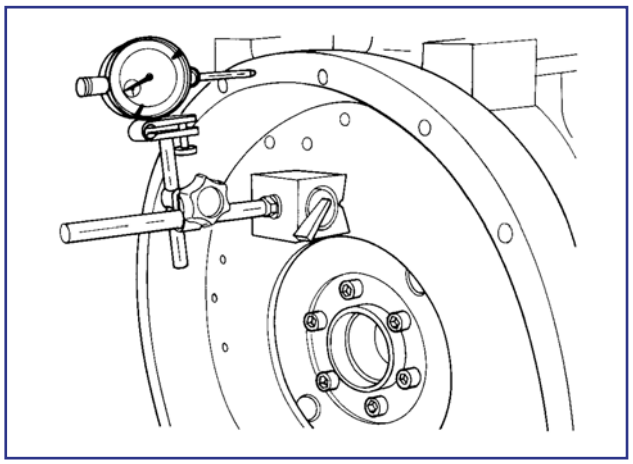
Check the side oscillation of the flywheel.

Maximum side oscillation = 0.30 mm



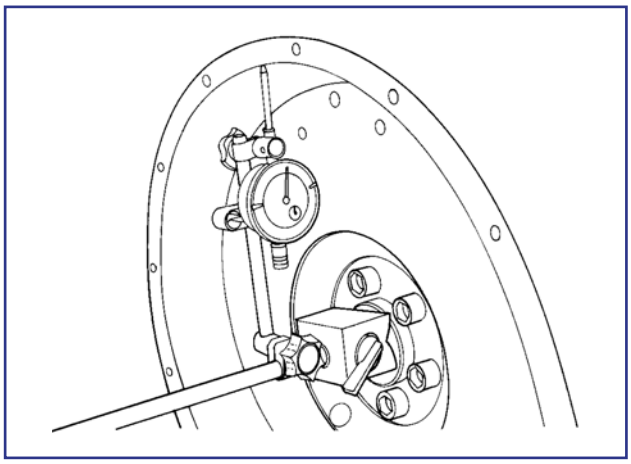
Check the parallelism from flywheel to the housing.

Maximum parallelism = 0.20 mm



Check the concentricity of flywheel to the housing.

Maximum concentricity = 0.20 mm



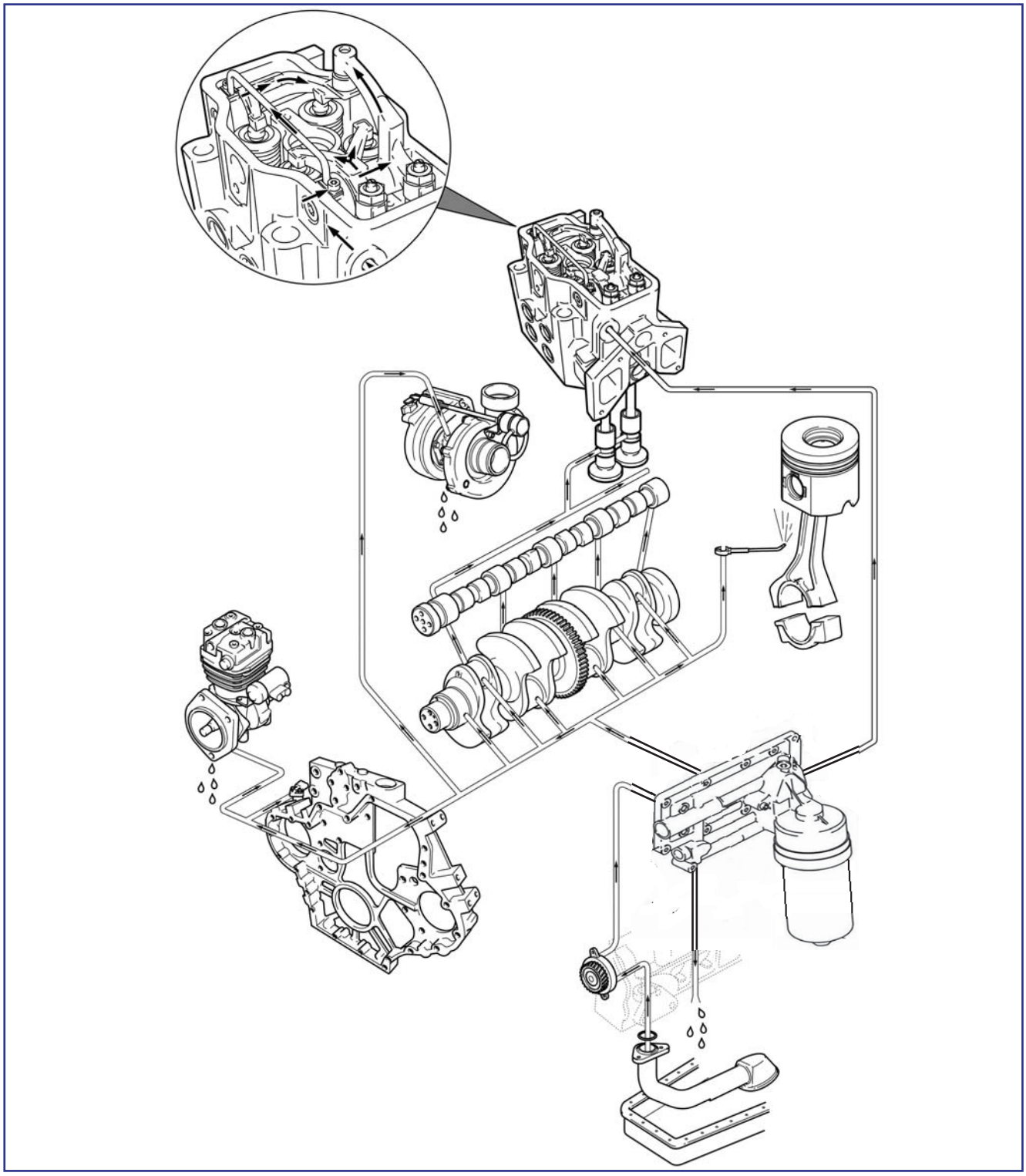
NOTES

Lubrication System

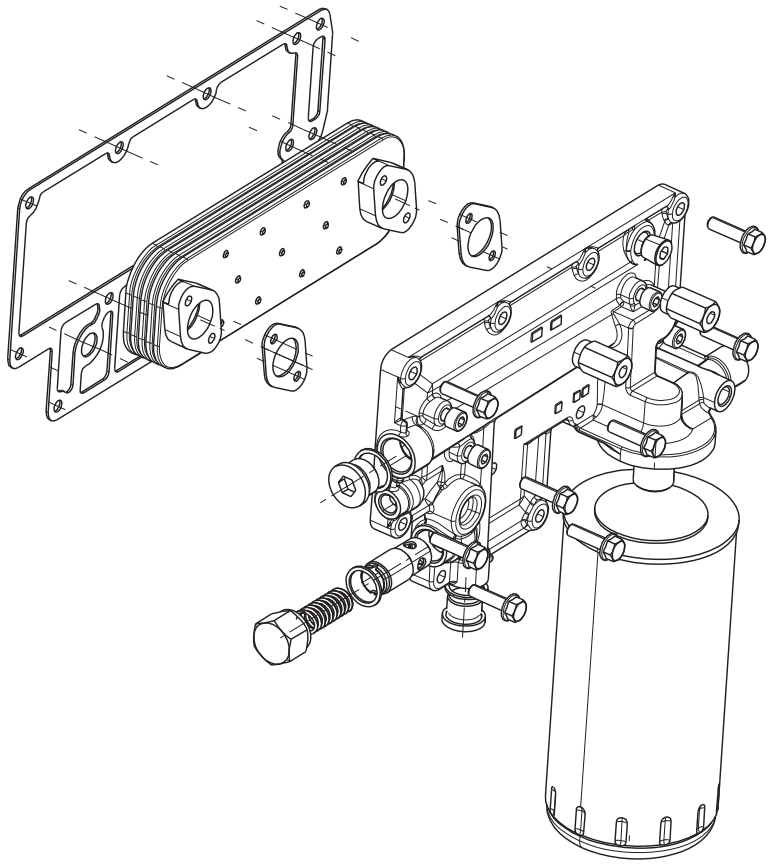
Group - 12

Lubrication System

OIL LUBRICATION CIRCUIT



Oil System Module (Ecological Filter)



Oil system module (Ecological filter module)

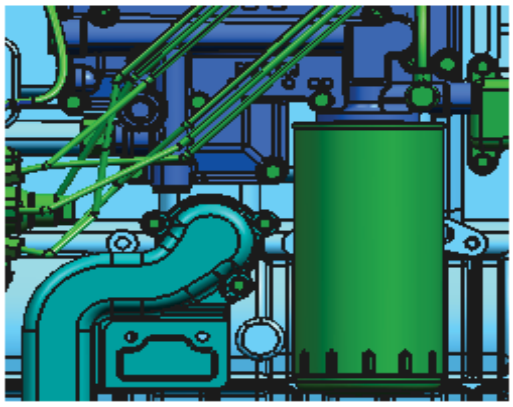
1. Oil pressure valve regulator
2. Oil cooler gasket
3. Oil cooler
4. Oil cooler gasket
5. Oil cooler gasket
6. Mount˜ing bolt
7. O˜il f˜ilter
8. Allen screw for ti˜ghten˜ing Oil cooler

Disassembly Notes

Remove lubricant oil cooler by 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 “Torx” bolts 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.



Removal

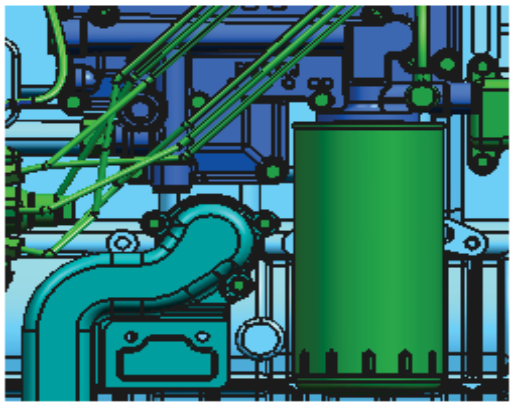
OIL SYSTEM MODULE

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.

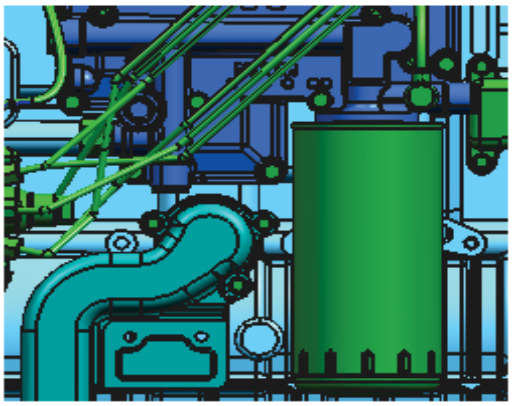
Warning: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle.

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.

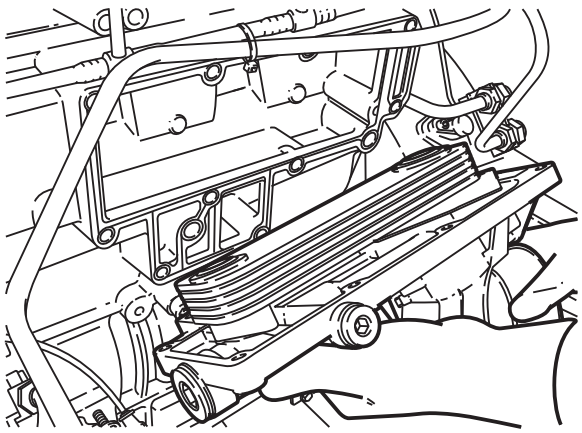
1. Remove the drain plug, the washer and drain the **engine oil. Discard the washer.**
2. **Remove the oil filter cartridge. See specific** procedure in engine preparation section.
3. Using the tool indicated, remove the clamp and the hose.



4. Remove all oil cooler to block mounting bolts.

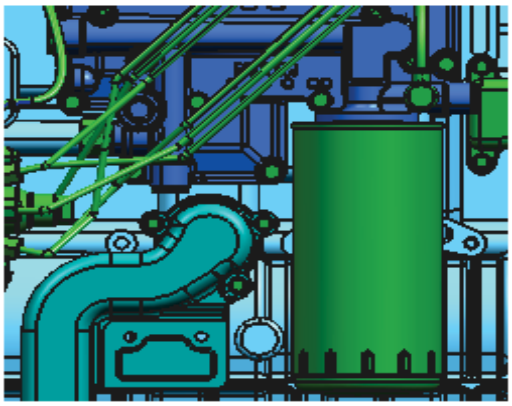


5. Remove the oil module and gasket. Discard the gasket.



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

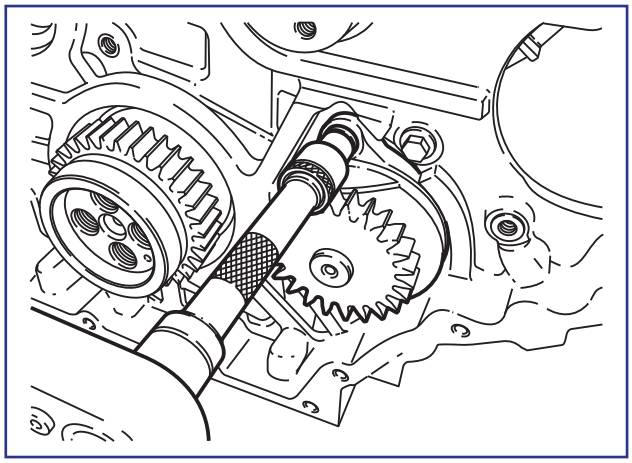
1. Place two new gaskets onto the oil cooler. Install the four allen mounting bolts and tighten to the torque of 25 to 30 N.m.
2. Place a new oil module gasket and mount the the oil module onto the engine block.
3. Install the oil cooler to block bolts applying the torque of 22 to 28 N.m.
4. Install the clamp and the hose to the oil module.
5. Install the oil element and cover. See specific procedure in Engine Preparation section.

Inspection of Oil Pump

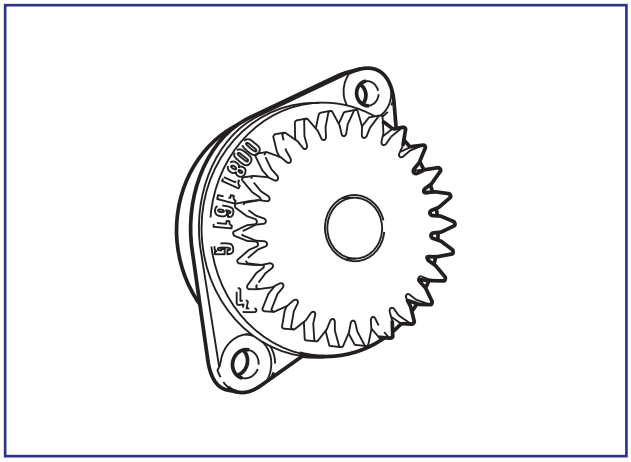
Clean and check the oil suction pipe in the engine for cracks or blockings.

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 wear.



Assembly

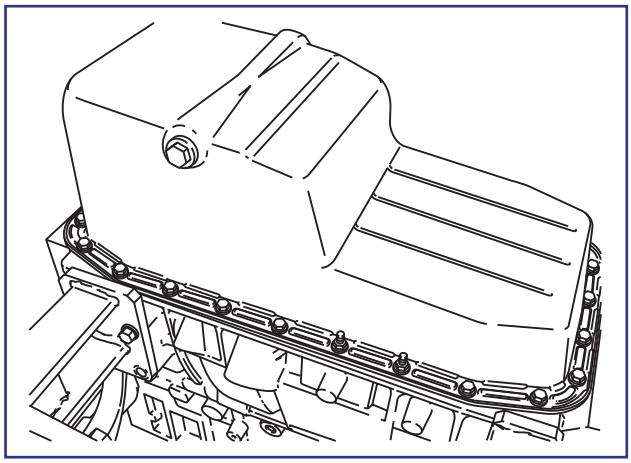
Carefully install the oil suction pipe in order to do not let the sealing ring to fall inside the suction gallery.

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.

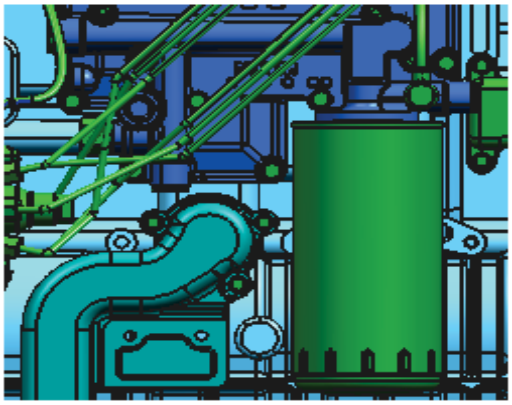
Torque: 25 ± 5 Nm (for bolts and nuts)

10 ± 2 Nm (for studs)

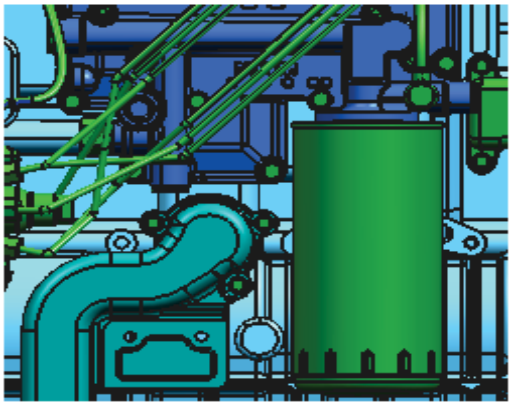


Clean the sealing surfaces and carefully assembly, reinstalling the oil cooler.Tighten the hexagonal bolts crosswise applying the specified torque.

Torque: 22 to 28 Nm



Then tighten again using the same torque (22 to 28 Nm) and the sequence shown.



NOTE: This procedure is important to avoid oil leakage from oil module to block surface.

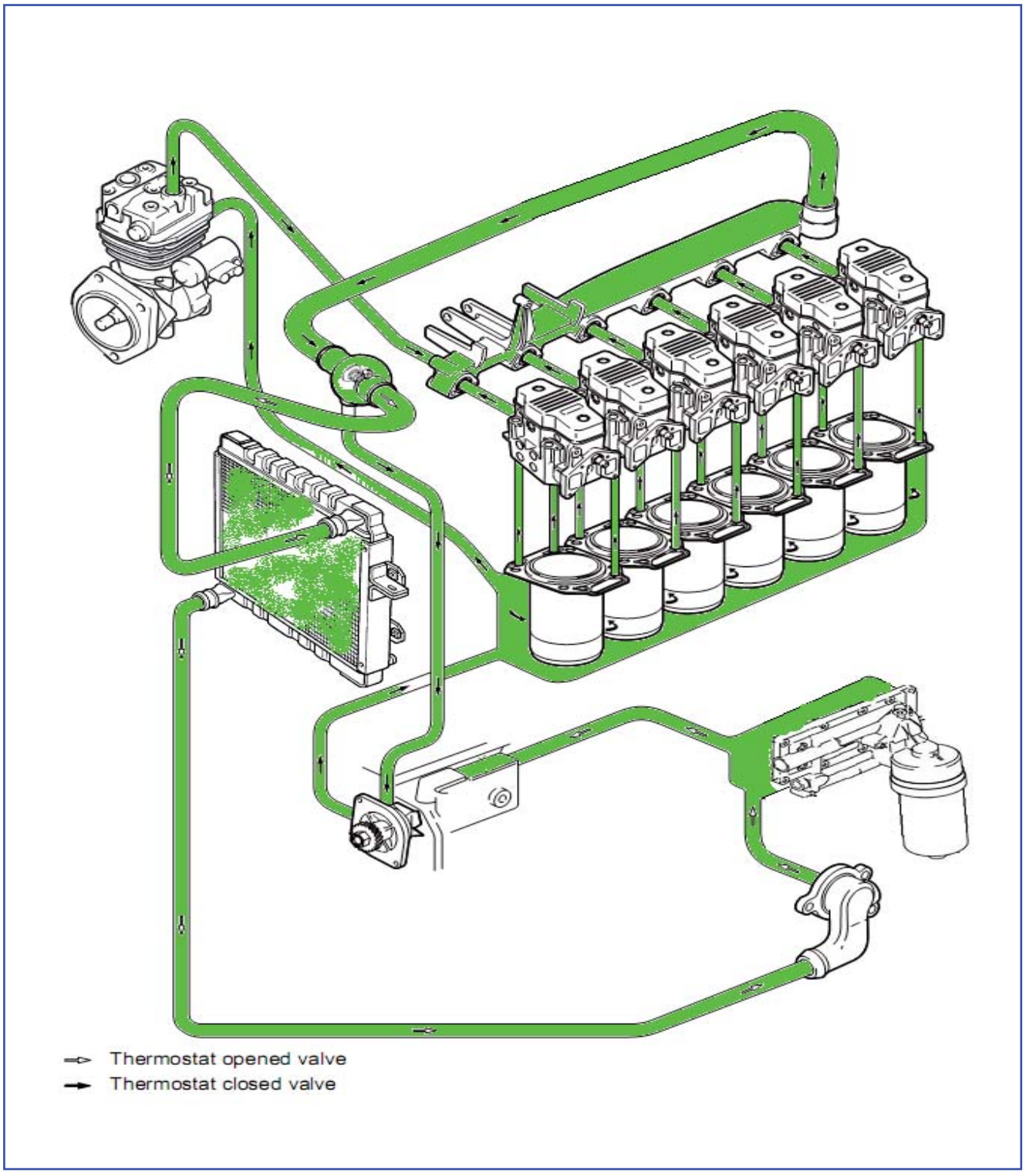
NOTES

Cooling System

Group - 13

Cooling System

COOLING CIRCUIT



Disassembly Notes

WATER PUMP

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

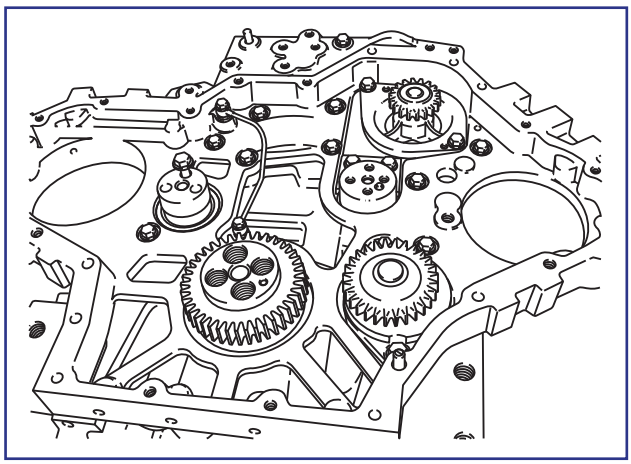
Avoid touching the components of the cooling system soon after the operation of the engine, this can cause burns.

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.

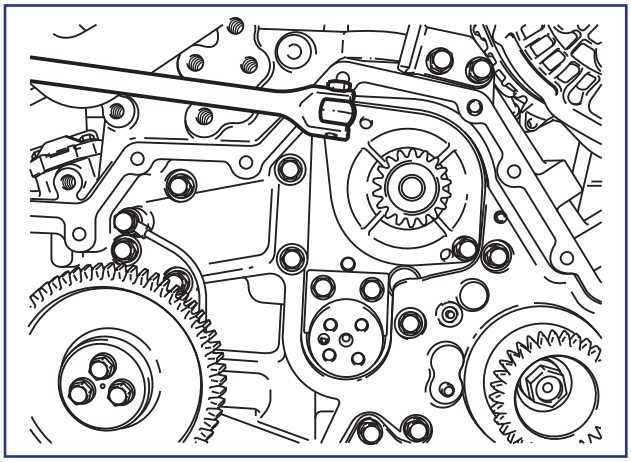
To access the water pump, remove the front cover and camshaft gear, see gear housing removal in the section 9.

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

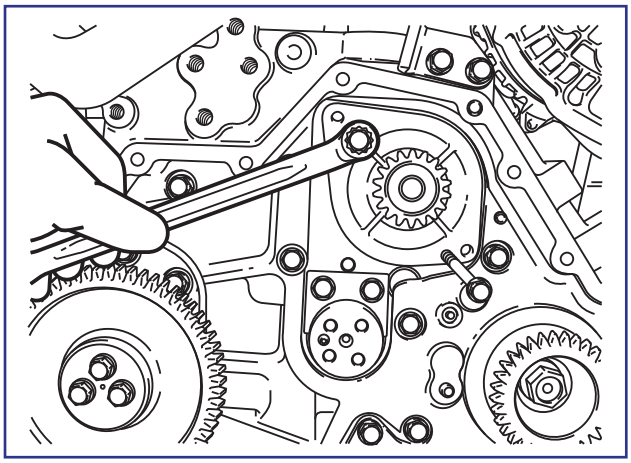
Screwing the bolts the water pump will be removed.



Remove the water pump mounting bolts.

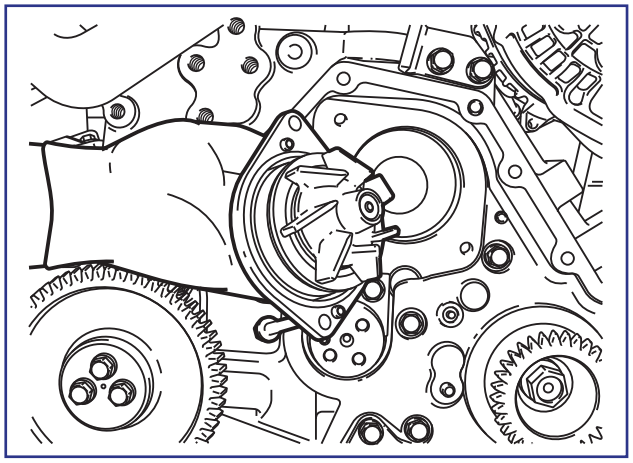


Reinstall the mounting bolts in the other holes, as indicated, and then tighten the bolts to remove the water pump from its housing.



Inspections

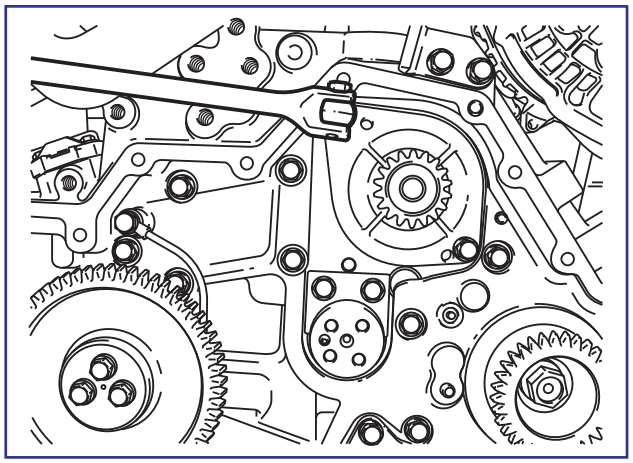
Check water pump carcass and rotor.



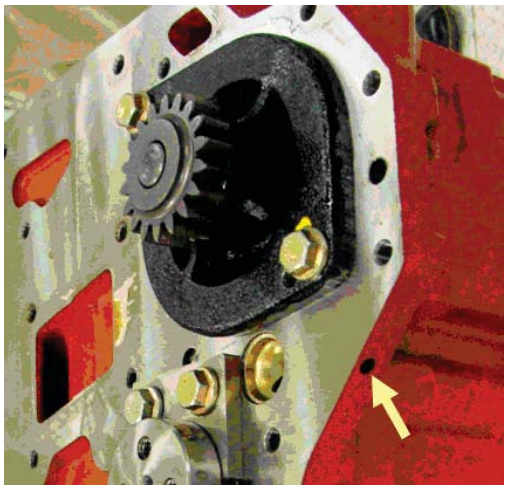
Attention: When removing/installing only water pump, lock the cankshaft and timing gears.

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

Torque: 20 ± 5 Nm



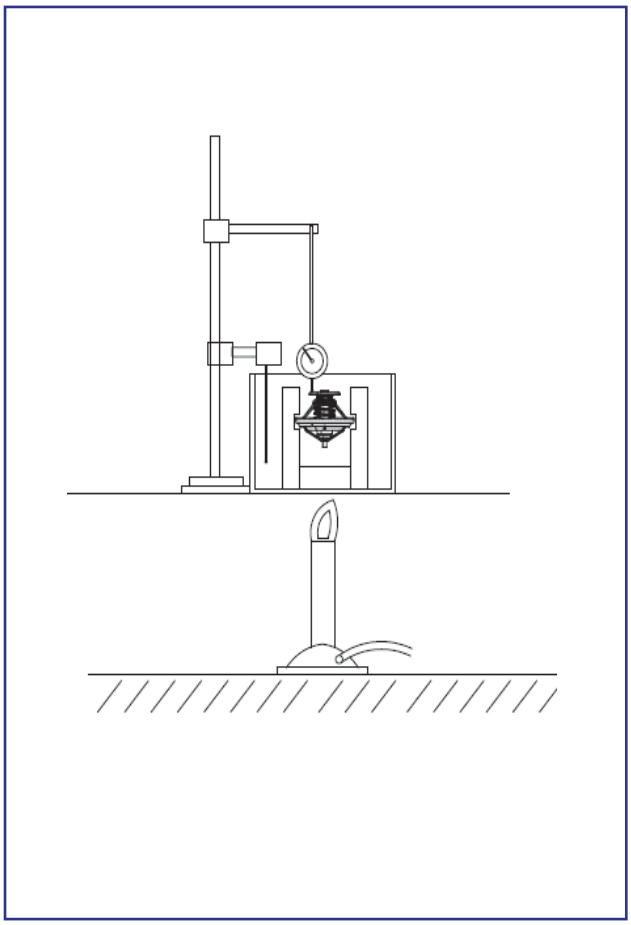
Check the inspection hole located on the left side of the engine block (seen by the flywheel side). If there are signs of water or oil leakage, probably there is leakage through the water pump or through the sealing rings. Check and replace, if necessary.



Thermostat Test Procedure

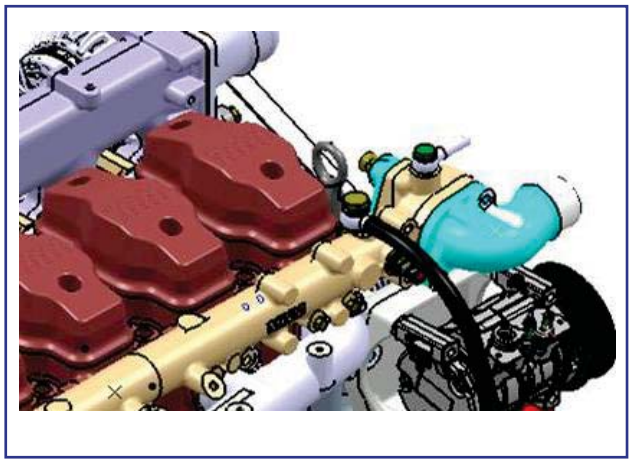
Test the thermostat and check its operation conditions according to the procedure below:

- Place the thermostat in a recipient and fill in 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

THERMOSTAT

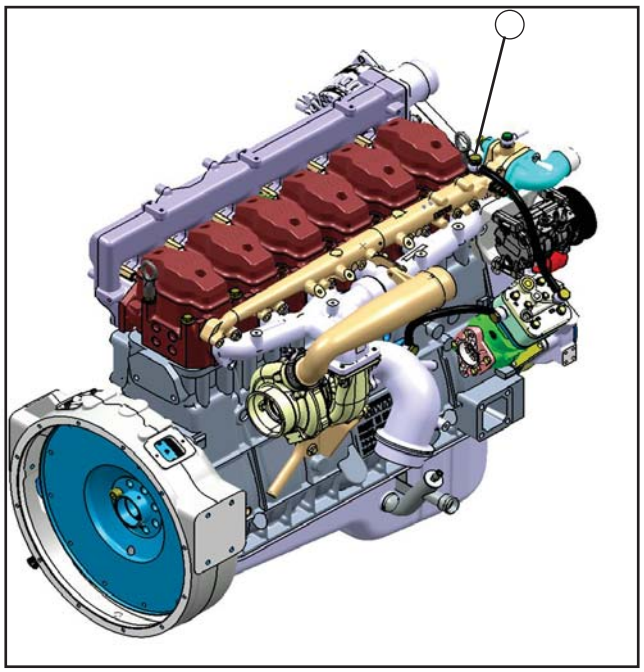


Attention: Never operate the engine without the thermostat, because the engine will not reach the correct operation temperature.

The sealing rings of the removal component must be replaced.

Water Pipe

REMOVAL



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

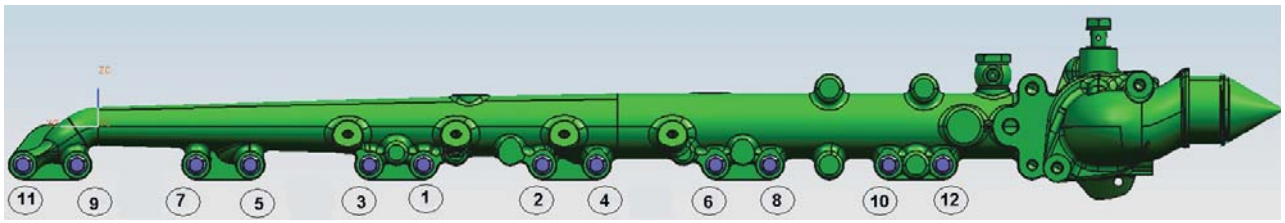
CLEANING

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 on those components and burns on cylinder head gaskets.

NOTES

Fuel Injection System

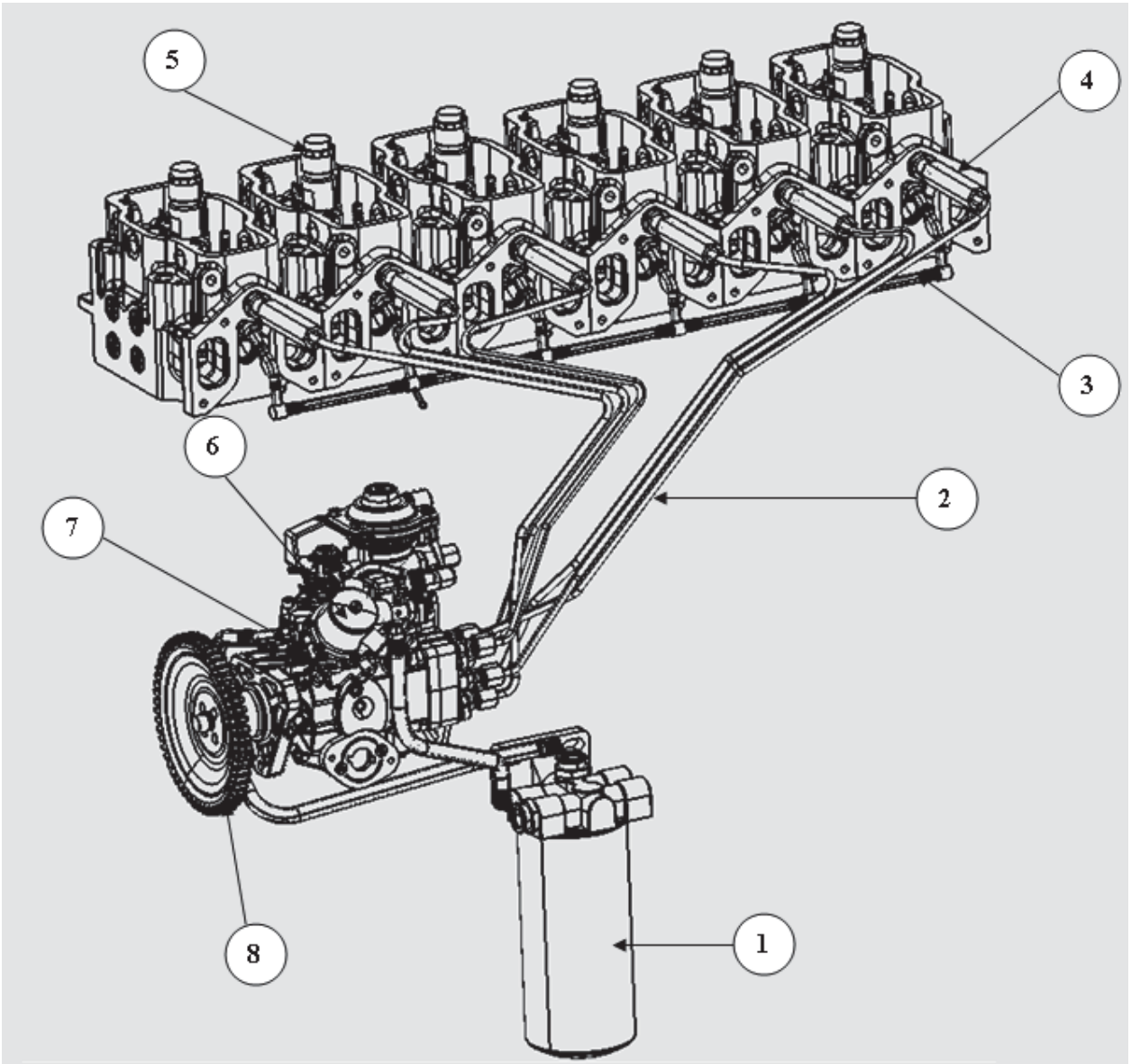
Group - 14

Attention:

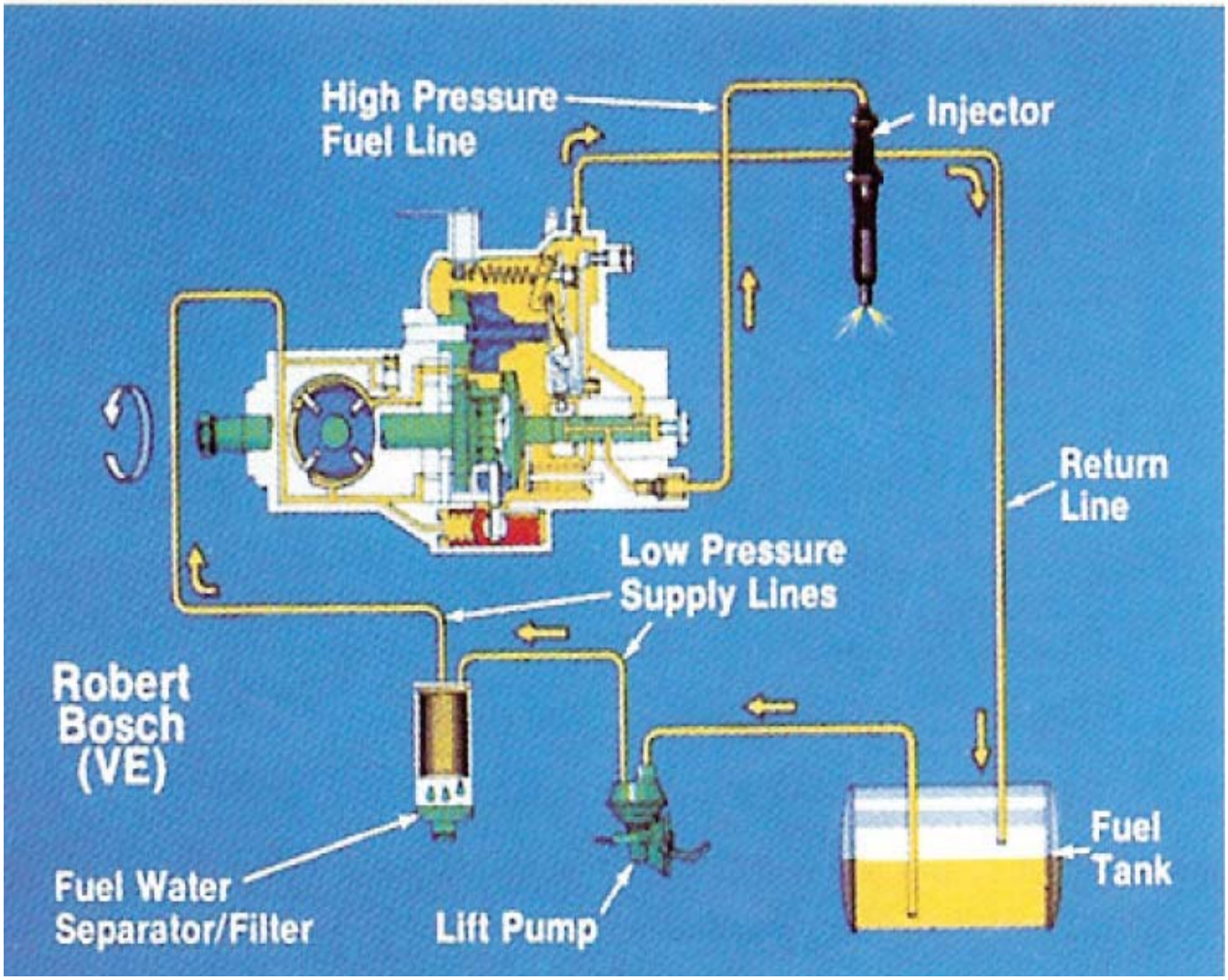
- Never perform service on any component of the system while the engine is running.
- Do not smoke while is servicing on the fuel system or any other system of the engine.
- Avoid contact with electric components that may produce sparks.
- Always check tanks, piping, hoses and other components of the fuel system for leakages.

.

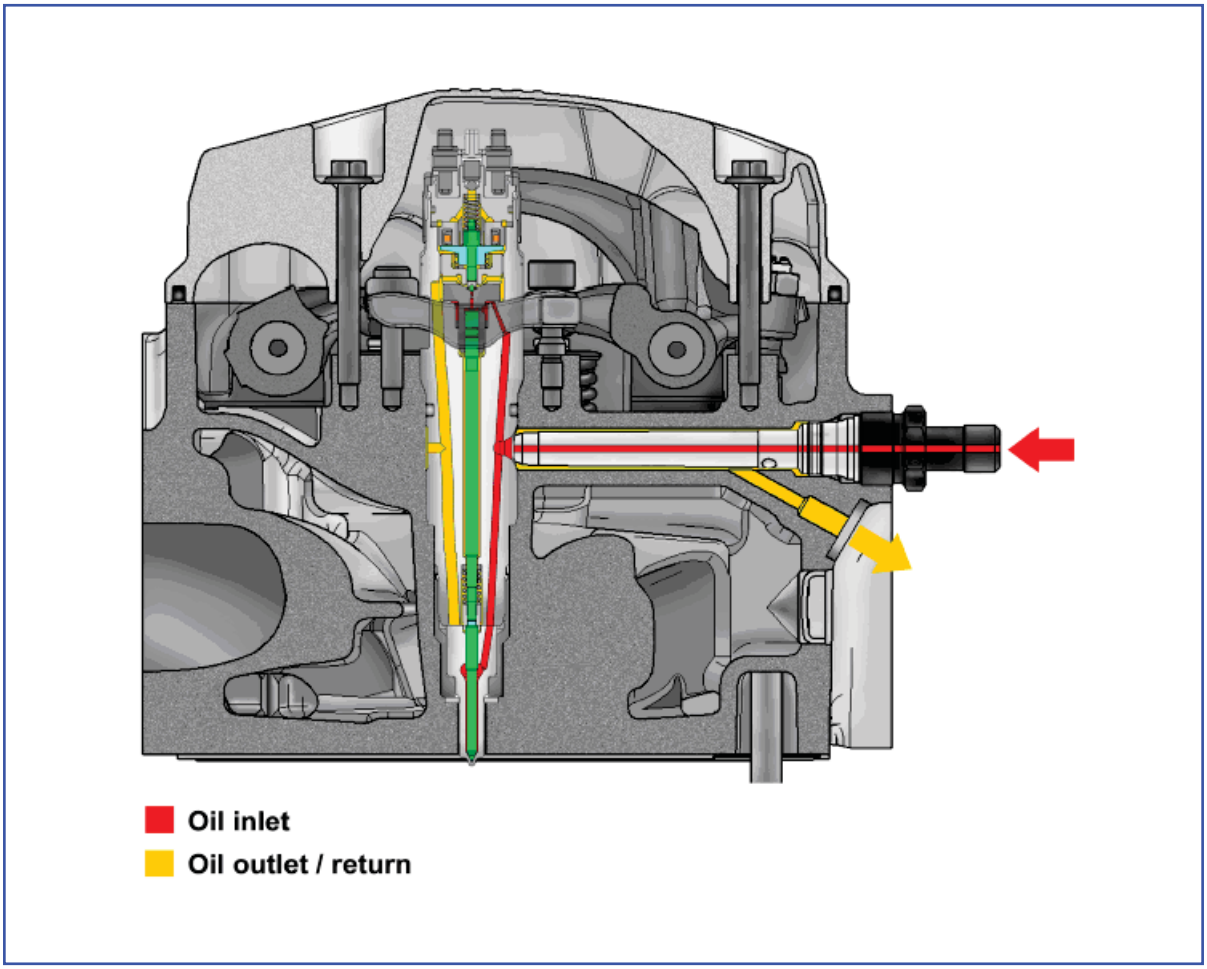
- Do not bleed the fuel injection system with the engine in operation. The high pressure in the system can cause serious injuries if disassembled.



1	Oil filter
2	High Pressure Lines
3	Fuel Return line
4	Connector
5	Injector
6	Mechanical Feed Pump
7	Fuel Injection Pump
8	FIP Gear

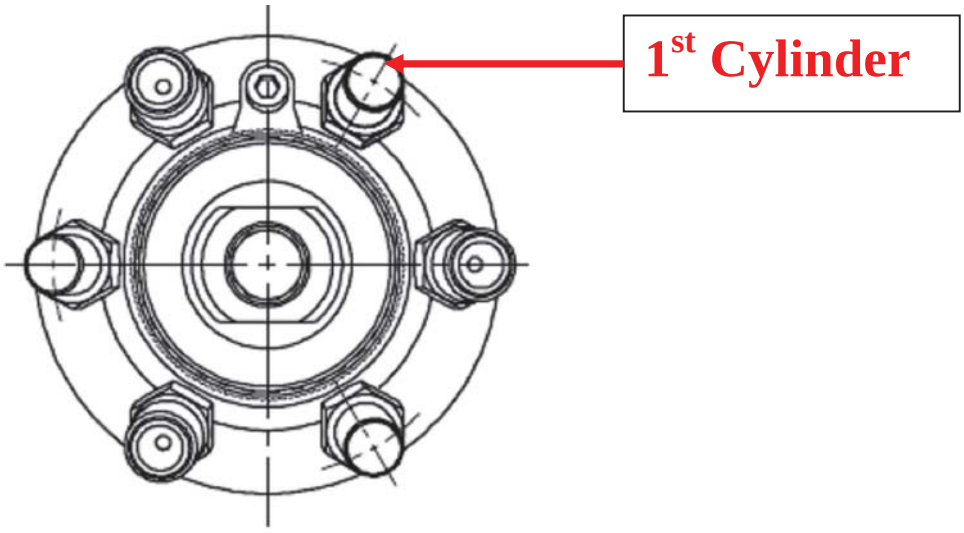

High Pressure Fuel Line
Injector
Return Line
Low Pressure Supply Lines
Robert Bosch (VE)
Fuel Water Separator/Filter
Lift Pump
Fuel Tank

Injectors



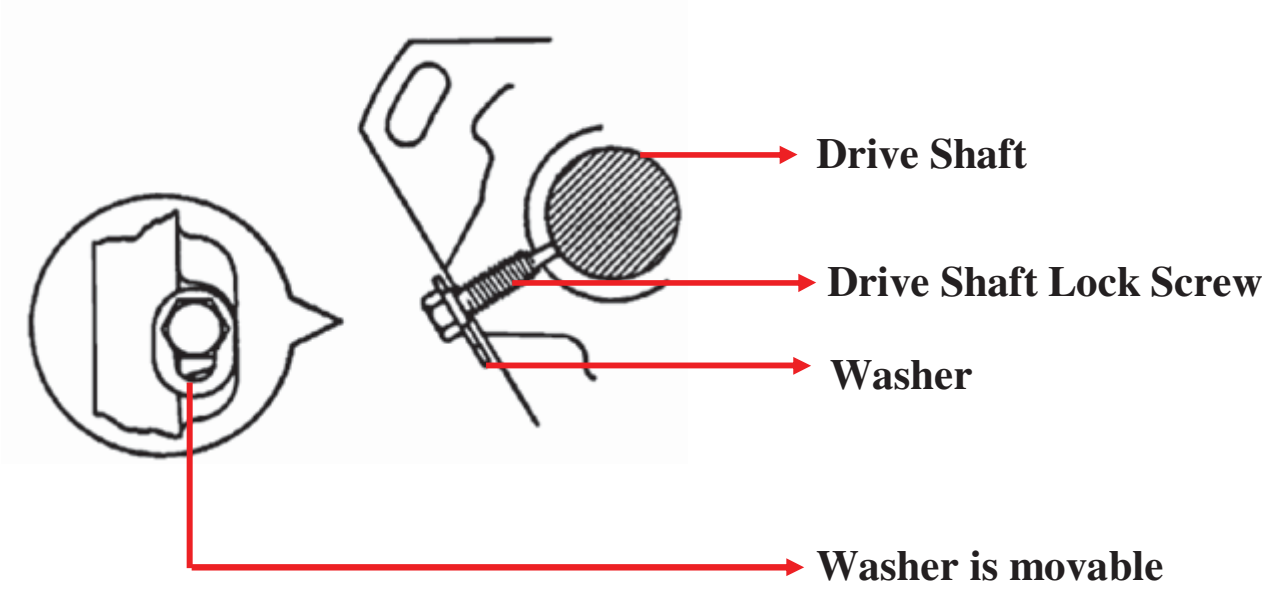
Pump Installation Procedure (Locked shaft Feature)

- Locate cylinder Number 1 for TDC on the compression stroke
- The drive shaft on the sample pump provided is locked at the timing position including the static injection timing. The pump number 1 outlet is @ 1'O clock position looking at the pump outlets with 12'O clock being in the vertical position.
- After verifying the cylinder number 1 is at TDC, Install the pump. NOTE: It is best to install the pump with pump mounting studs / screws centered in the pump kidney slots. This allows for greater timing flexibility if fine tuning needs to be done.
- Attach the pump by finger tightening the 3mounting nuts and or bolts. The pump must be free to move in the slots
- Attach the pump drive shaft nut and washer. Pre-torque to 15-20Nm (11-15ft-lb). This is not the final torque
- Take up gear lash by rotating pump against the direction of drive rotation
- Tighten pump retaining nut and or bolts to 24Nm (18ft-lb)
- Loosen the fuel injection pump drive shaft lock screw and position the special washer behind the lock screw head. Tighten the lock screw to 5.1-6.2Nm. See the attached file labeled "Drive shaft locked.ppt" for a view of the unlocked position.
- Caution: The pump drive shaft must be unlocked after installation to prevent pump damage
- Final torque of the drive shaft to the engine drive gear can be done at this time. The recommended torque 190-203Nm. In order to achieve this final torque, the engine must be pinned from rotating.
- Install gear cover access cap
- Be sure to disengage / remove engine anti rotation device
- Install high pressure injection lines
- Install fuel return and low pressure supply lines
- Connect electric shut-off solenoid wiring
- Bleed all air from fuel system

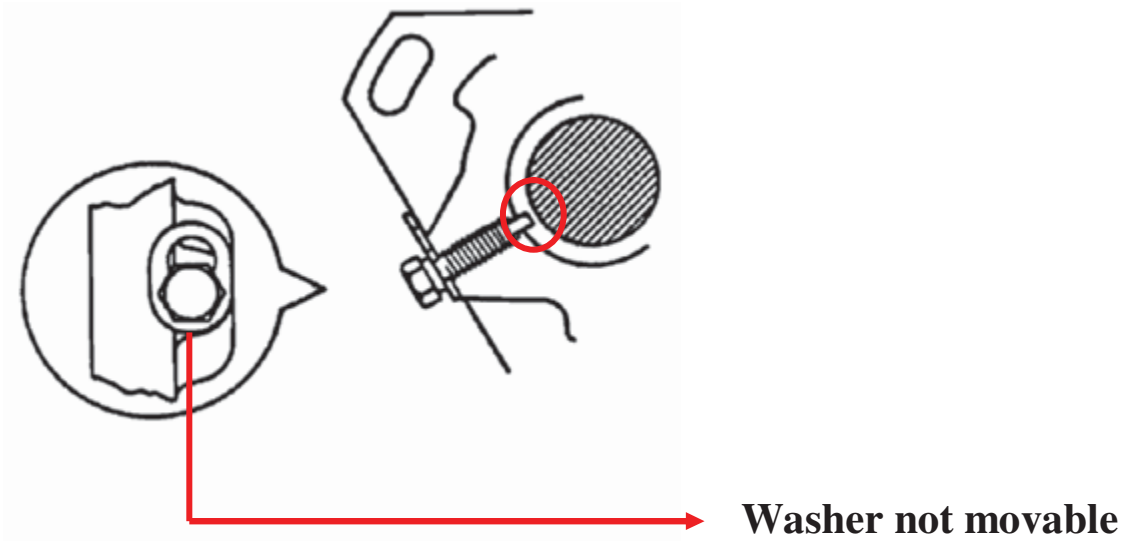


Locked Drive Shaft Timing

Drive Shaft Locked Condition (Lock Shaft Screw holding the Drive Shaft)



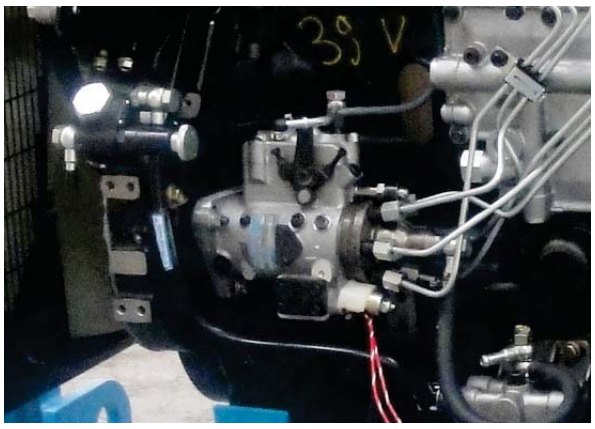
Drive Shaft Unlocked Condition (Lock Shaft Screw not holding the drive shaft)



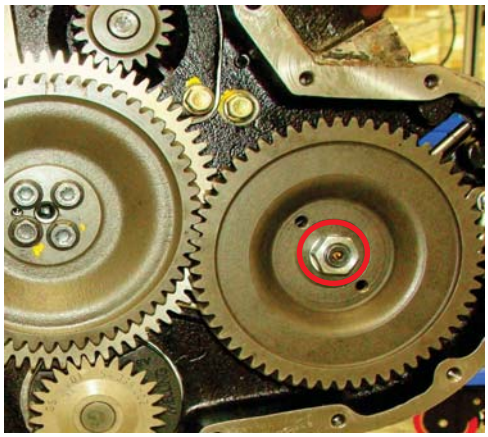
Fuel High-Pressure Pump

REMOVAL

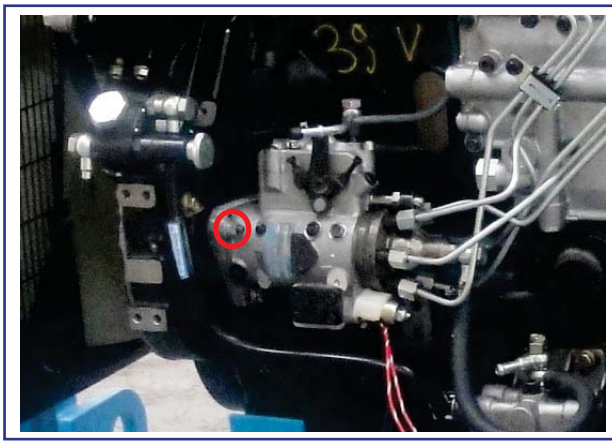
- After loosening and removing the pipes, loosen high pressure pump fixation bolts on the intermediary piece.



- 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, loosen the bolts and remove the high pressure pump.



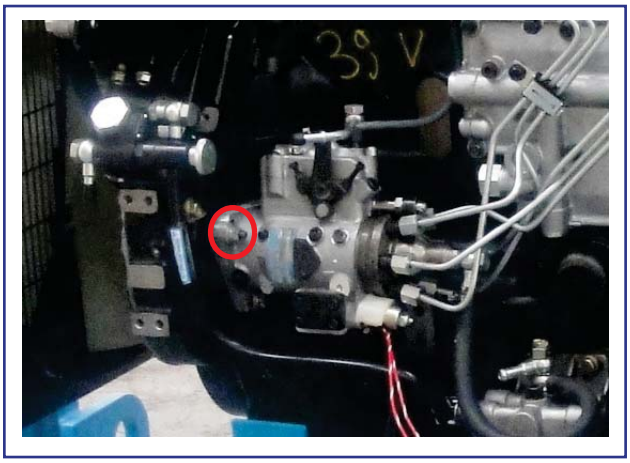
The removal must be done with caution. The friction between the o-ring and the housing of the pump can difficult its removal. As it is a component that requires extreme care, keep it in a reserved place and far from accidents.

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.

INSTALLATION

-



NOTES

Intake, Exhaust and Turbocharger System

Group - 15

Air Intake Manifold

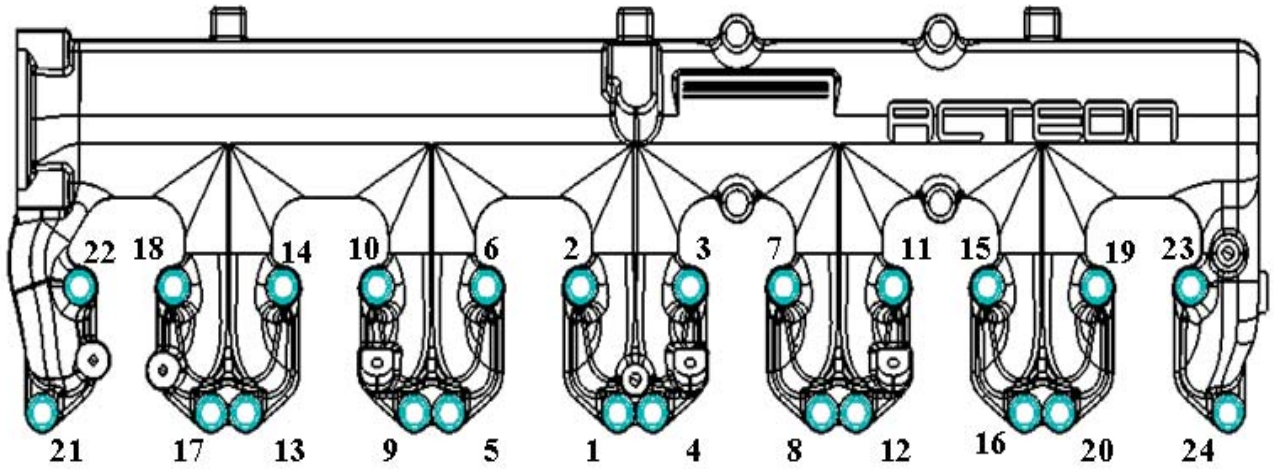
Warning: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

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



- Remove the manifold mounting bolts.
- Lay down the intake manifold and then remove it, as shown.
- Discard manifold gaskets and remove all gaskets remaining over the cylinder heads and intake manifolds holes.

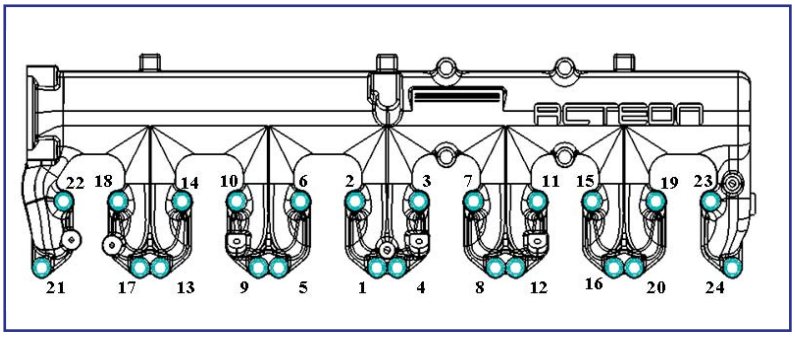
Installation

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

- Insert an intake manifold bolt into each end of the intake manifold (both top holes).
- Place intake manifold gasket over these two bolts to ensure proper alignment between the manifold and gasket.
- Place all manifold bolts into bolt hole mounting finger tight, in their correct positions.



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

  Torque through 20 ± 3 Nm.

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

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:

- Intake Air Elbow
- Water Pipe
- Exhaust Manifold

Turbocharger

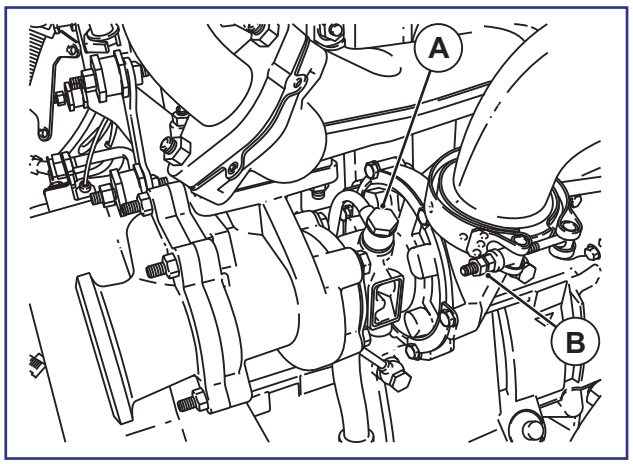
REMOVAL

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.

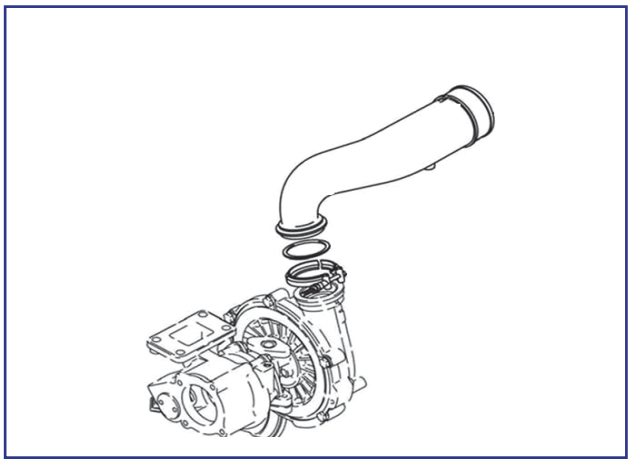
Warning: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure that the engine has cooled down sufficiently before attempting to remove turbocharger assembly.

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.

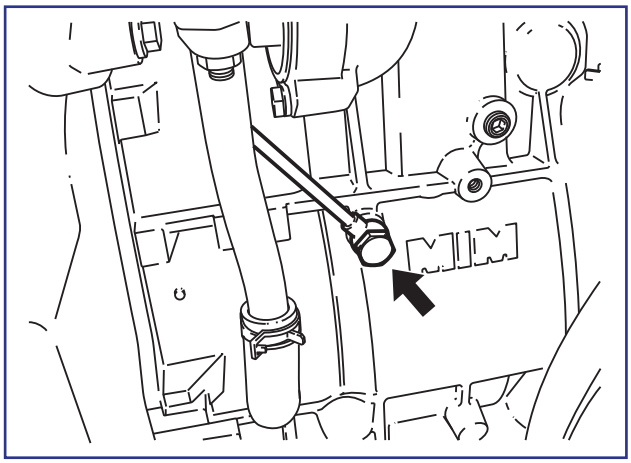
- Oil inlet tube and elbow removal:
  - ⓐ Remove the oil inlet tube hollow bolt and its two washers. Discard the washers.
  - ⓑ Remove the elbow to turbocharger clamp.



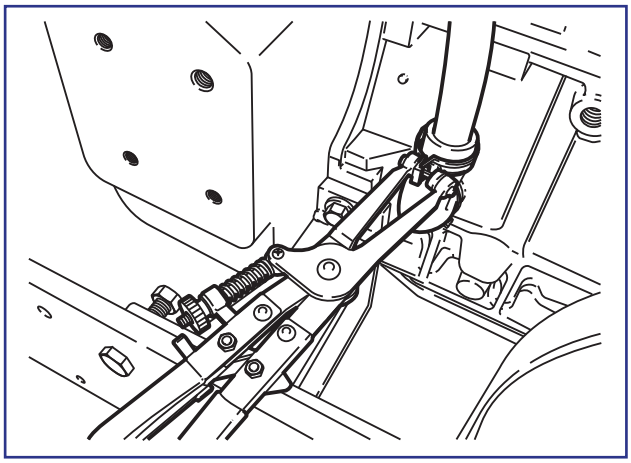
- Remove the elbow support bracket bolt.
- Remove the elbow and discard its O-Ring after removal.



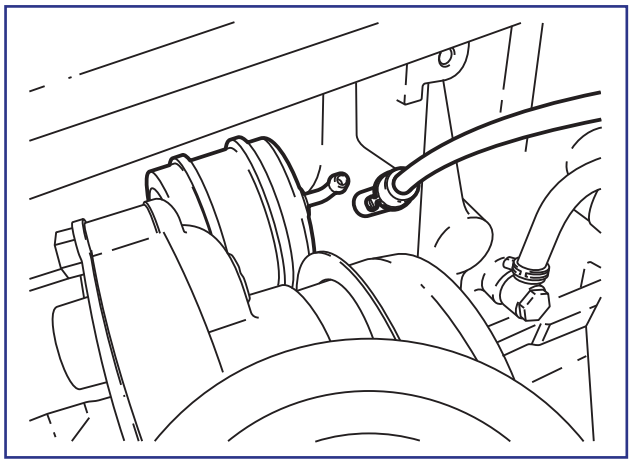
- Remove the hollow bolt from oil inlet tube.



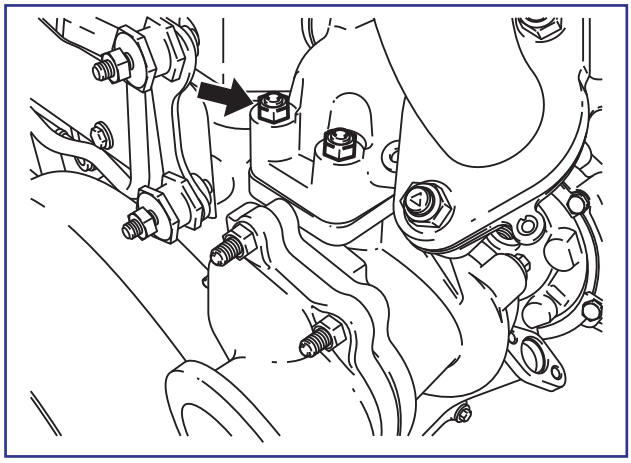
- Using the tool illustrated, remove the clamp from outlet pipe.



- Release the clamp and remove the wastegate actuator hose.



- Remove the turbocharger mounting nuts (four nuts).



- Remove the turbocharger assembly.
- Discard turbo mounting gasket, washers and mounting nuts.

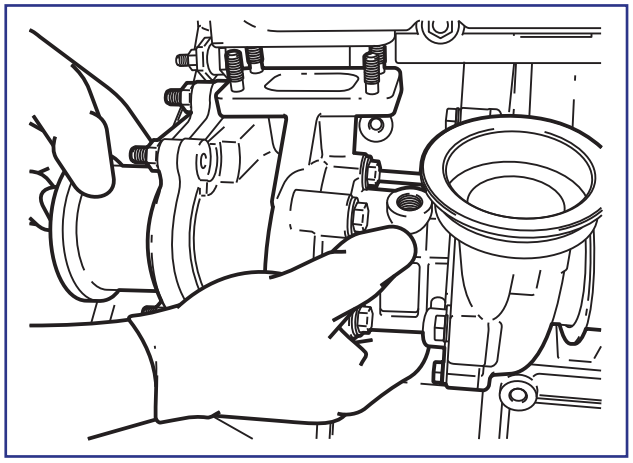
NOTE: After removal, cover the turbocharger holes to avoid dirty ingress that may damage its internal components.

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.

INSTALLATION



- Place a new outlet pipe mounting gasket onto turbocharger.
- 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.
- Mount turbocharger assembly onto exhaust manifold and thread four new mounting nuts onto the top studs and leave loose.
- 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.

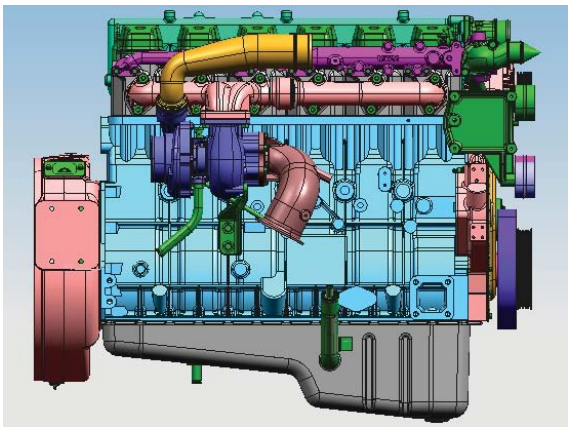
NOTE: This procedure is important to avoid damages by leak of turbo lubrication during the first engine start.

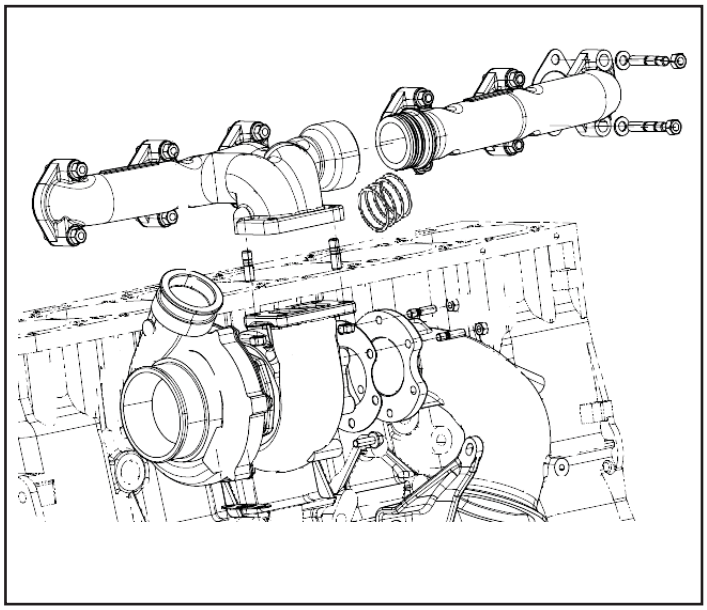
- Install oil inlet tube into turbocharger upper side placing the four new washers. Applies the torque 20 to 30 N.m to the hollow bolt.
- Install outlet pipe to the lower turbocharger side. Applies the torque 10 to 14 N.m.
- Tighten all four mounting turbocharger nuts applying the torque 60 to 80 N.m.
- Place the new O-Ring to the elbow and mount it onto the turbocharger using the clamp.
- Install the elbow bracket applying the torque 20 to 30 N.m.

Exhaust Manifold

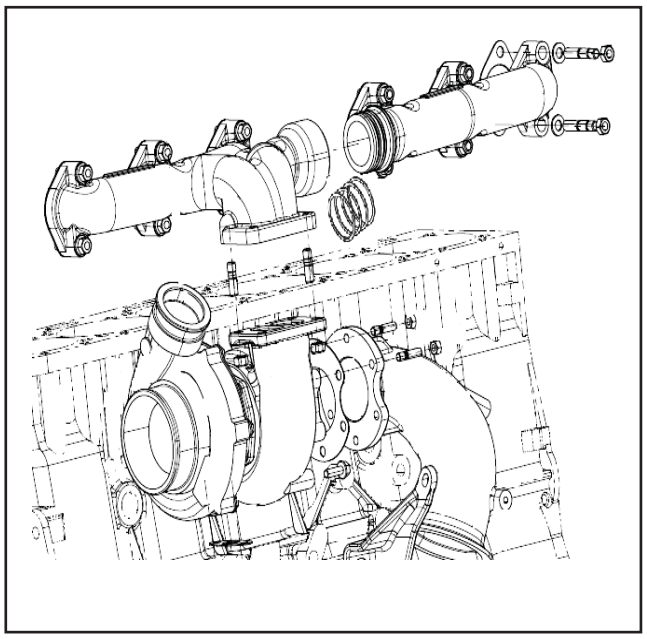
REMOVAL

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





- Remove the exhaust manifold mounting nuts and discard them.



CLEANING AND INSPECTION

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:

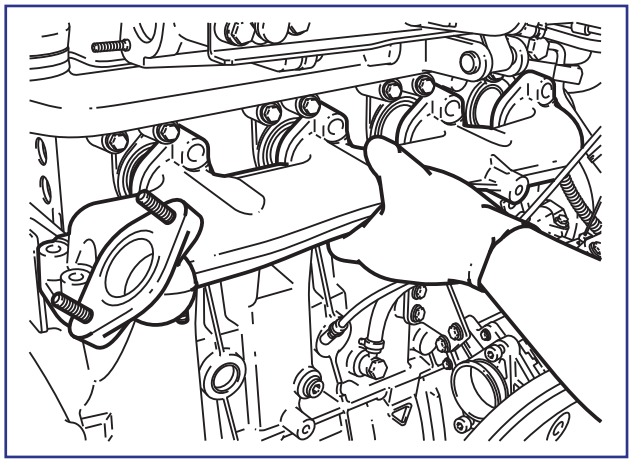
   Install the exhaust manifold without the gasket to a cleaned cylinder head mating surface, applies a low level torque to the bolts enough to provide contact between the two surfaces and measure the gap between the mating surfaces using a 0.25mm feeler gauge. If necessary, recheck the cylinder heads alignment.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

INSTALLATION

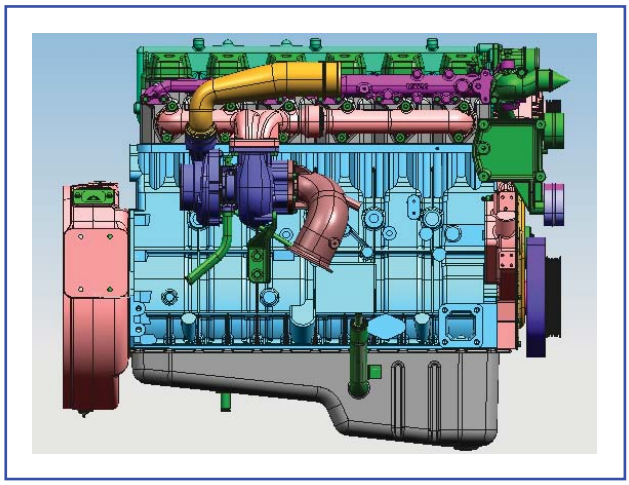
Warning: To avoid manifold or cylinder head damages, make sure the cylinder heads are aligned before proceed the exhaust manifold installation.

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.



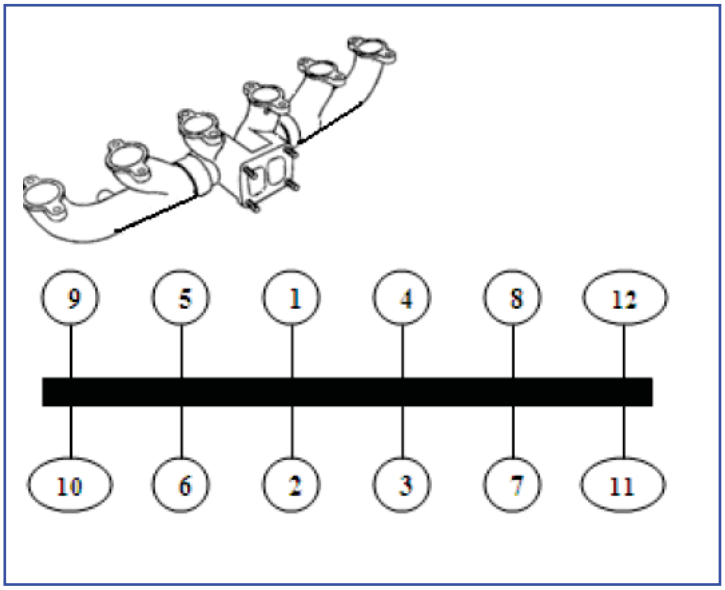
2. Align and hold the gaskets while placing the manifold. Install the new mounting nuts to the turbocharger.



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

  Torque: 4 to 6 Nm (stud)

  60 to 80 Nm (Nut)



- Follow the remaining installation procedures using the inverse sequence of removal procedure and applying the torque indicated.

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

NOTES

Diagnosis Failures

Group - 16

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.

Trouble Shooting MAXXFORCE 7.2 Mechanical		COMPLAINTS	Hard Starting or Failure to Start	Engine Missing	Excessive Black Smoke at Idle	Excessive White Smoke at Idle	Excessive Blue Smoke	Coolant Temperature Too High	Loss of Coolant	Engine Output Power Low	Cannot Reach rated RPM	Engine Oil Spewing out from Breather Tube	Excessive oil Consumption	Excessive Fuel Consumption	Engine Surges (Speed change)	Low oil Pressure	High Oil Pressure	Lubricating Oil Contaminated with Fuel	Lubricating Oil Contaminated with Coolant	Fuel/ Oil Leaking from Exhaust Manifold	Engine Starts but doesnot keep running
	Cause																				
Air System	Restricted Air Intake		●		●					●				●						●	●
	High Exhaust Back Pressure				●					●											●
	Air Leakage Between Yurbocharger and Intake Manifold				●					●											
	Defective Turbocharger				●					●	●		●							●	
	Charge Air Cooler Malfunctioning				●																
	Air Filter Choked				●																
Fuel System	Low/ Out of Fuel		●												●						●
	Air in Fuel System		●	●						●					●						●
	Restricted Fuel Lines		●	●						●											
	Injector Defective		●	●	●	●				●	●			●	●			●		●	
	Injector Installed with More Than One Sealing Washer					●															
	Broken fuel Pump Drive Shaft		●																		
	Throttle Linkage Worn or Incorrectly Adjusted									●	●										
	Shutoff Lever partialy engaged									●	●										
	Water in Fuel										●										●
	High Pressure/ Fuel Leakage			●						●				●	●						
	Fuel Filter Choked		●																		
	FIP Timing Incorrect		●		●	●				●				●							
	FIP Rack Sticky		●																		
	Fuel Shutoff Not Actuating		●																		
	FIP Caliberation Defective		●	●	●						●			●	●						
	FIP Internal Plunger Seal Leakage																	●			
	Fuel temperature High									●											
	Fuel Return Line Restricted		●																		●
	Fuel Lift Pump Defective		●							●								●			
Lubricating System	Oil Pressure Transducer / Gauge Defective															●	●				
	Incorrect Grade oil											●	●			●	●				
	Defective oil Pump															●	●				
	External / Internal Leakage												●			●			●		
	Dirty oil Filter															●					
	Faulty Cylinder Oil Control					●							●								
	Oil Suction Line Restricted															●					
	Leakage From Valve Stem Oil Seal					●							●							●	
	Faulty Oil Pressure Regulator															●	●				
	Crankcase Low or Out of Oil						●									●					
	Oil Cooler Leakage												●						●		
	Oil Cooler Pluged															●					
	Turbocharger Drain Line Obstruction																			●	
	Oil Level Too High											●	●								
Cooling System	Insuffecient Coolant							●													
	Defective Water Pump							●													
	Faulty Thermostat							●													
	Damage Hose							●													
	External coolant Leakage								●												
	Low Coolant Capacity / Dirty radiator							●													
	Leaking Radiator							●	●												
	Radiator Pressure Cap incorrect							●	●												
Operation and Maintenance Practice	Driving Technique													●							
	Dirty Filters/ Breather																				●
	Long Idle Periods	●	●	●																●	
	Engine Overloaded									●	●			●							●
	Oil Needs Changing																				
Mechanical Adjustments or Repair	Engine Idle Speed Too low		●												●						●
	Cylinder Head Gasket Leak Blown Off				●			●											●		
	Cracked Cylinder Head							●													
	Valve Leakage / Valve Lash Bad	●	●							●				●							
	Broken or Worn Piston Rings	●										●	●							●	
	Engine Camshaft Out of Time	●	●																		
	Engine Compression Low	●	●									●		●		●					
	Rocker Adjusting Screw Cup not seated properly on Push rod ball		●	●	●																
	Loose Cylinder Cap Screw																				
	Worn or Scored Liners or Pistons											●	●								
	Air Compressor Pumping Oil												●								

NOTES