

**Presentation**

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## Introduction

This manual contains complete information and specification to assembly and disassembly MWM Acteon engines and all components manufactured by **MWM Motores Diesel Ltda.**

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

The repairing procedures, described in this manual, consider that the engine is positioned on an appropriate stand. Some of the assembly and disassembly procedures require special tools.

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

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

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

## How to Use this Manual

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

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

## Content of the Manual

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

## Content of the Sections

Each section contains the following information:

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

## Remissive Index

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

## Information on Metric System

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

## Important Safety Remarks

### Attention

- ***Incorrect procedures and lack of care can cause burns, cuts, mutilation, asphyxia or other injuries and even death.***

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

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

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

Relief the pressure of the pneumatic (brakes), lubrication and cooling systems before removing or disconnect any piping, connections or other elements. Pay attention to the pressure existence before to disconnect any item of a pressurized system. Do not check pressure leakages with the hand. Oil or fuel at high pressure can cause injuries.

- To avoid injuries, use a crane, or ask for help to lift components which weight more than 20 kg. Make sure that all lift equipments as chains, hooks or belts are in good conditions and have the correct load capacity. Make sure that hooks are correctly positioned. Always use an extension when necessary. The lift hooks must **not** receive side loads.
- Never leave the engine operating in a closed and non ventilated area. The engine exhaust gases are harmful to health.
- The MWM coolant has alkaline substances. **Avoid** the contact with the eyes. Avoid the prolonged or repetitive contact with the skin. **Do not** ingest. In case of contact with the skin, wash immediately with water and soap. In case of contact with the eyes, abundantly wash with water for, at least 15 minutes. CALL MEDICAL HELP IMMEDIATELY. KEEP AWAY FROM THE REACH OF THE CHILDREN AND ANIMALS.

**Presentation**

- 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 MWM spare parts.
- Some international public health institutions prove that used lubricant oil can be cancerous and contaminates the human reproducer system. Avoid inhaling vapours, ingesting or keeping prolonged contact with these substances.
- People with pacemaker must avoid standing close to the engine electronic injection system.

**General Instructions**

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

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

## Cleaning General Instructions

### Cleaning with Acids and Solvents

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

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

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

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

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

The following parts cannot be cleaned with vapour:

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

**MWM Motores Diesel Ltda.**

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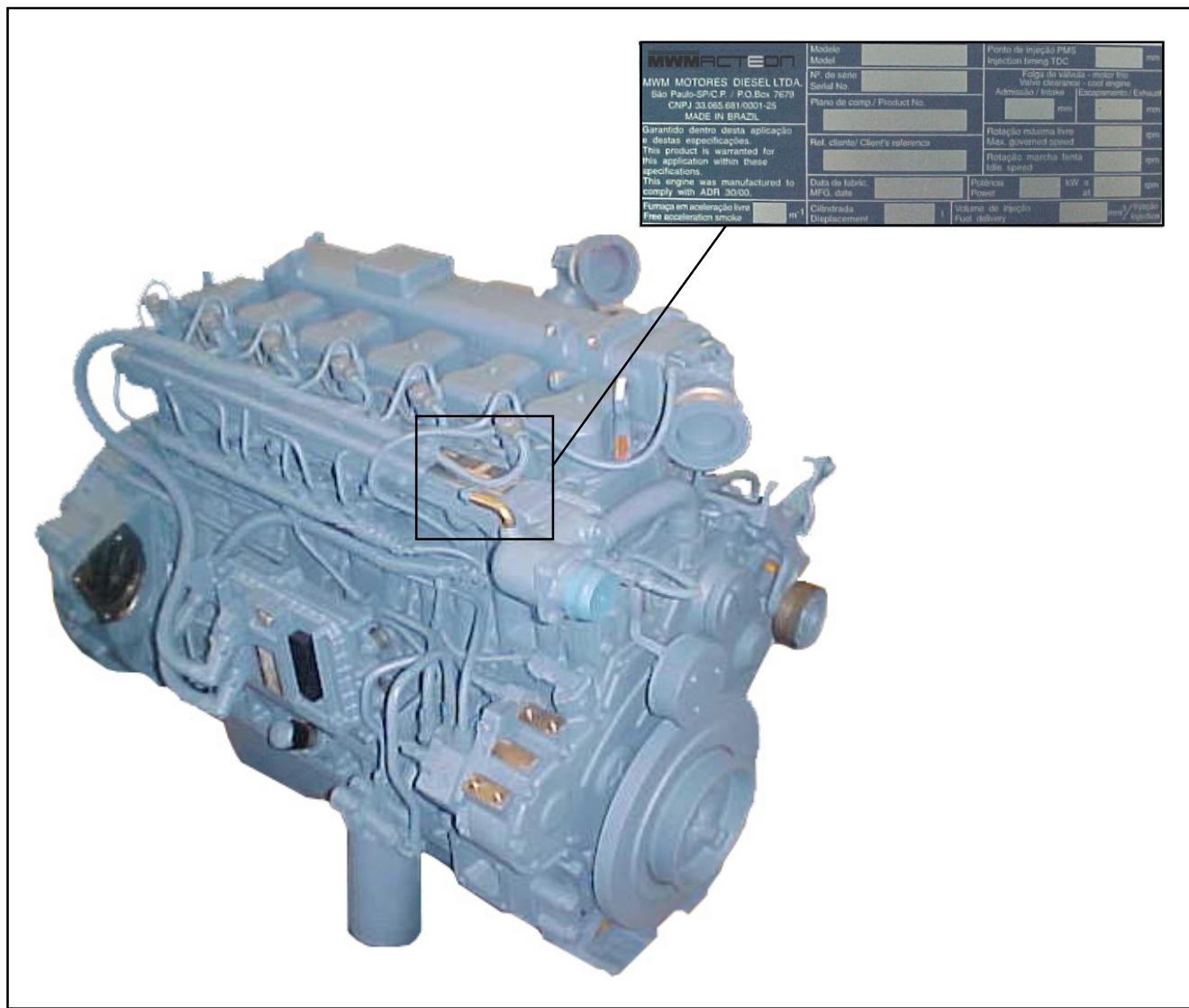
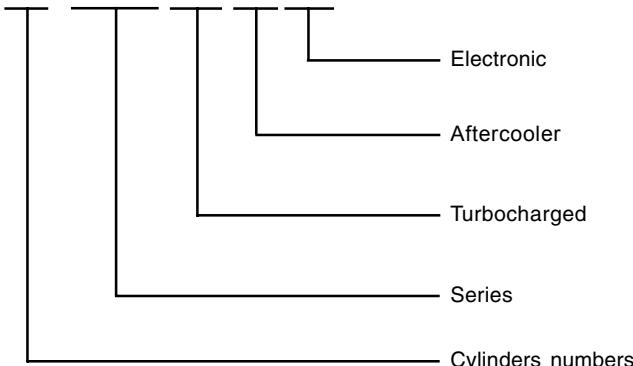
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## Identification and Location of the Serial Number

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

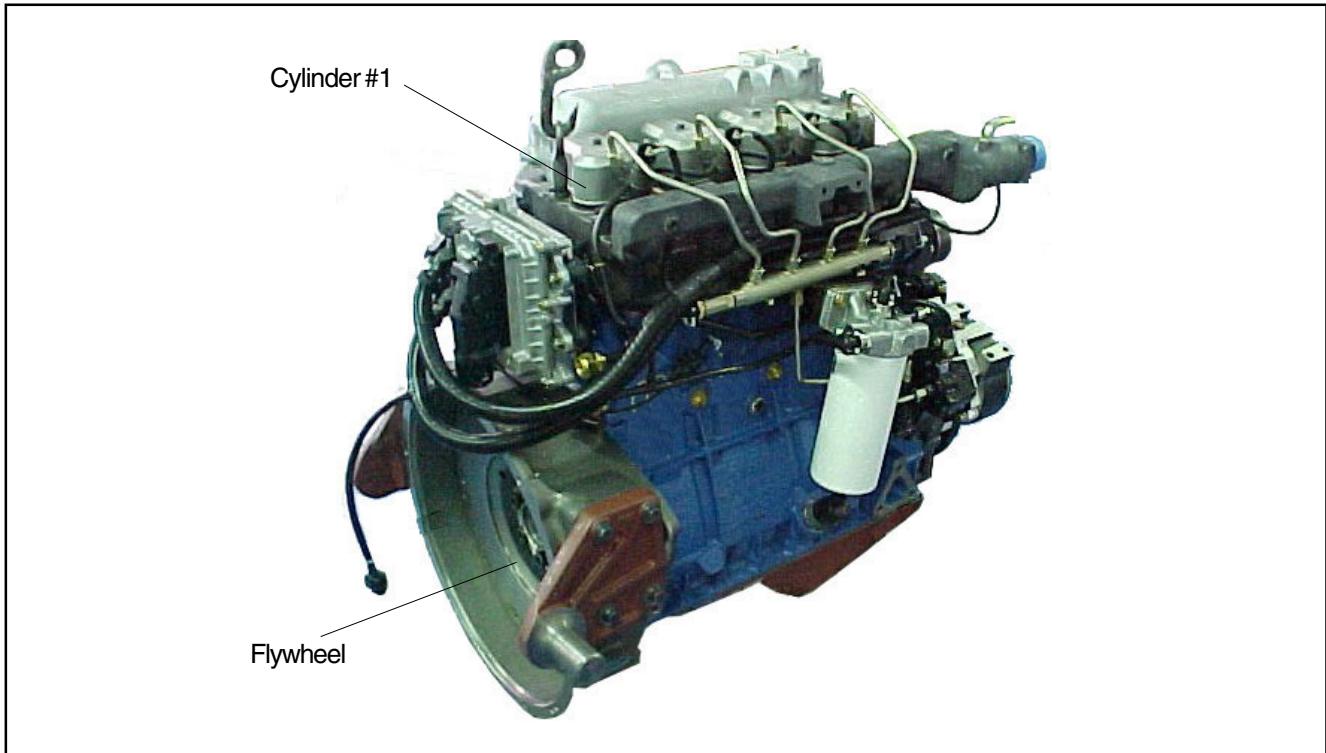
1. Identification plate on the water pipe.
2. Engraving on the right side of the engine block, close to the cylinder head of the cylinder #3.

# 6.12 TCE

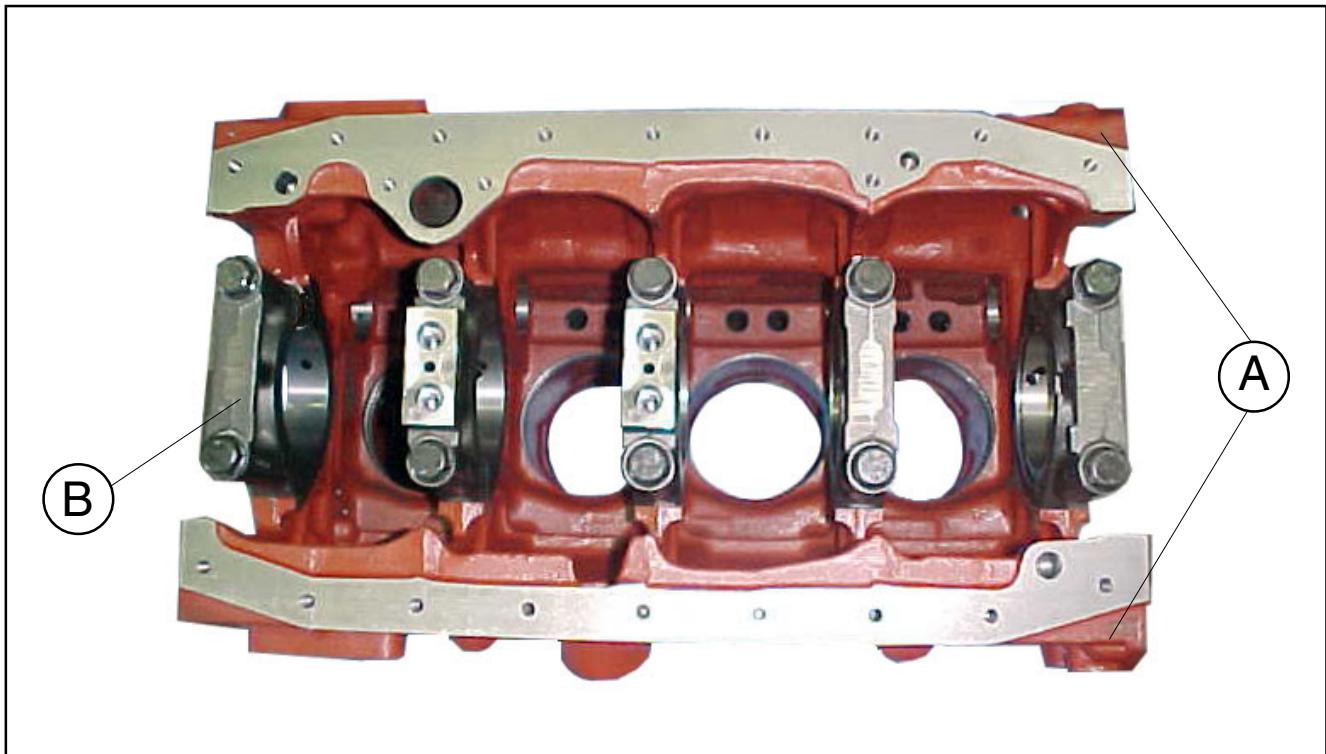


## Cylinders Numeration

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



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



## NOTES

**Technical Data**

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**Technical Data**

<b>Engine Data</b>	<b>4.12TCE</b>	<b>6.12TCE</b>	
<b>Engine type</b>	Vertical cylinders in line, 4 strokes		
<b>Injection type</b>	Direct with electronic management		
<b>Cylinder bore</b>	105 mm		
<b>Cylinder stroke</b>	137 mm		
<b>Unit displacement</b>	1,2 l		
<b>Total displacement</b>	4,745 litres	7,118 litres	
<b>Quantity of cylinders</b>	4	6	
<b>Compression rate</b>	16,8:1		
<b>Firing order</b>	1 - 3 - 4 - 2	1 - 5 - 3 - 6 - 2 - 4	
<b>Rotation sense</b>	Counter clockwise (seen by flywheel side)		
<b>Dry engine weight</b>	~450 Kg	~570 Kg	
<b>Power</b>	150 hp 105 kW	210 hp 152 kW	260 hp 191 kW
<b>Torque</b>	500 Nm	700 Nm	900 Nm
<b>Valves clearance (cold)</b>	0,2 to 0,4 mm		

**Fuel System**

<b>Description</b>	<b>4 Cylinders</b>	<b>6 Cylinders</b>
<b>Maximum fuel inlet restriction (for gears pump)</b>	0.6 to 1.2 bar	
<b>Rail pressure</b>	350 to 1400 bar	
<b>Fuel pressure strip in the fuel filter outlet (at crank speed)</b>	9.7 to 12.8 bar	
<b>Strip of fuel pressure in fuel filter fuel inlet (at operation speed)</b>	10,5 to 13 bar	
<b>Maximum pressure reduction in fuel filter</b>	$\leq 0,8$ bar	

### Lubrication System

Description	4.12TCE		6.12TCE	
<b>Oil pressure</b>				
• Nominal speed	4.5 bar (hot engine)			
• Idling speed	1.0 bar (hot engine)			
<b>Oil temperature</b>			90 - 110 °C	
• Nominal			120 °C	
<b>Oil capacity</b>	5 ℥	13 ℥	17 ℥	13 ℥
• Minimum	8 ℥	17 ℥	29 ℥	17 ℥
• Maximum (without filter)	9,2 ℥	18,2 ℥	30,2 ℥	18,7 ℥
• Maximum (with filter)			33,7 ℥	
• Variation pressure of the filter to open by-pass			2,5 + 1,2 bar - 0,3 bar	

### Cooling System

Description	4.12TCE		6.12TCE	
<b>Volume of water in the engine, without radiator</b>	7 ℥		9 ℥	
<b>Water temperature</b>			80 - 90 °C	
• Nominal			100 °C	
• Maximum				

### Thermostat

17.210E OD Thermostat	Opening beginning	Total opening	Minimum operation course
9.412.0.757.001.6	75 ± 2°C	90°C	10.0 mm

9.150E / 17.260E OT Thermostat	Opening beginning	Total opening	Minimum operation course
9.412.0.757.002.6	80 ± 2°C	95°C	10.0 mm

## NOTES

**Operation and Maintenance**

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## Operation and Maintenance

### Engine operation

#### Start

Before operating the MWM Acteon 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.) or objects or impurities entrance through intake.

To maximize the turbo lifetime follow these cautions:

- Do not accelerate the engine immediately after the start.
- Wait 30 seconds with the engine at idling speed before stop it.
- Pre-lubricate the turbocharger after oil change or other service that evolves oil drain. Crank the engine a few times before start the engine. Then run the engine and allow it to run at idling speed for a period of time to establish a complete circulation and oil pressure before to perform high speeds and load.
- In low temperatures or when the engine is being reactivated after a long period without operation, start the engine and let it running at idling speed before operating in high speeds.
- Avoid operating the engine at idling speed for long periods of time.

## Running-in

All MWM engines are assembled and tested in the factory, making sure its immediate operation. However, it needs to be correctly ran-in, regarding that its performance and durability depend, largely, on the cares taken during first operation phase.

As general rule, it is considered as running-in period the first 2,000 km for vehicular engines or the firsts 50 service hours for stationary, industrial and agriculture engines. The vehicle or equipment 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 forcing the engine at high speeds, that is to say, to do not apply extreme conditions of load or, in the case of the vehicular, 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

MWM Acteon engine must operate with regular Diesel fuel. It is recommended to use fuel of specification according to the Brazilian Resolution CNP nr. 07/80 of Petroleum National Council.

The fog point (beginning of paraffin segregation) must be below the ambient temperature and the Cetan index must not be less than 40.

## Lubricant oil

### Oil Level Check

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

## Oil Change

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

## Oil Filter Change

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

**Attention**

- ***Always use genuine MWM filter.***

## Lubricant Oil

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

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

## Lubricant Oil Specifications

It must be used multi-viscous type lubricant oil that accomplish, at least, to the API CG4 (or upper) specifications and to the recommended viscosities.

**Attention**

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

## Check Lubricant oil Condition

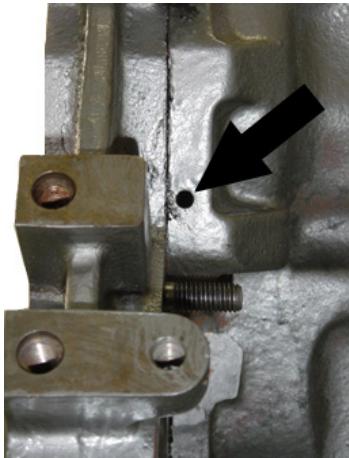
The condition of the lubricant oil is very important for a good conservation of the inner components of the engine.

## Cooling Fluid and Coolant

### Oil Level Check

#### Attention

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



### Water Pump Check

Check for leaks through the pump drain hole.

## Cooling Fluid Filling Procedure

Fill the system with the necessary amount of MWM coolant and complete with clean water. Put the engine in operation up to the normal operation temperature. Only complete the level of the system with clean water + MWM coolant in the correct proportion.

After filled the system, operate the engine checking for leaks.

### MWM COOLANT



Denomination	Concentrate Coolant
Properties	Anticorrosive / Anti-boiling / Antifreeze
Application	Modern Diesel Engines in General
Colour	Red
Proportion	50% ± 10%
Change Interval	50,000 km or 6 months
Composition	Anticorrosive, Ethleneglycol, Borates, Silicates and Colouring
Validity of the bottle	5 years

## Cooling System Cleaning

1. Remove the cap from the engine radiator or from the expansion reservoir of the vehicle;
2. Drain the cooling system fluid through the lateral plug of the engine block;
3. Flush the whole system until to leave only clean water;
4. Close the system and fill with clean water;
5. Operate the engine until to reach the normal operation temperature and leave it running for 15 minutes;

**Remark:** If the vehicle has hot air conditioning, turn the button in hot position.

6. Stop the engine and wait to cool down;
7. Open the drain, remove the radiator cap and leave the water to flow out all again;
8. Close the drain outlet and fill the system with clean water and MWM coolant according to the recommended proportion;
9. Operate the engine up to the normal operation temperature and leave it running for 15 minutes;

**Remark:** If the vehicle has hot air conditioning, turn the button in hot position.

10. Check the level of the cooling system completing if it is necessary.

**MAINTENANCE TABLE**  
**MWM ACTEON VEHICULAR ENGINES**

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

- Remark:**
- 1) This table is only for guidance. The Maintenance Table of the vehicle prevails over this table.
  - 2) For heavy-duty and off-road services perform maintenance in the half of the indicated periods in the table above.
  - 3) If the engine stays inactive for a long time, it must perform an idling speed test fortnightly, until to reach the operation temperature.
  - 4) Independent of the intervals indicated for engine lubricant oil changes, it must be changed at each 6 months.
  - 5) Electronic parts of BOSCH (phase, speed, air pressure and temperature, oil pressure and temperature, water temperature sensors) are free of maintenance and checked by recommended diagnose scanner with errors stored in failure memory.

## Conservation for Inactive Engines for Long Period

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

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

### Remarks:

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

## Preparation of the Engine to Return to Service

Before operating an engine which stayed inactive for a long period, follow these procedures:

1. Clean the outer parts of the engine.
2. Fill cooling system with clean water and MWM coolant in the recommended proportion.
3. Change engine lubricant oil filter.
4. Fill the carter with new lubricant oil according recommendation.
5. Install belt(s) and adjust tension.
6. Remove valves cover and lubricate rocker arms with engine oil. Reinstall covers.
7. Drain the fuel mixture from the reservoir and fill with new fuel.
8. Change fuel filter.

**Protective Oils**

Manufacturer	Recommended Products (*)
Castrol	Rustilo 652 (SAE 20)
Texaco	Engine Oil DBH 20 W 20
Ipiranga	Ultramo Turbo SAE 20

**Graxas**

Manufacturer	Recommended Products (*)
Castrol	LM 2
Texaco	Marifac MP2
Ipiranga	Ipiflex 2
Petrobrás	Lubrax GMA-2

(\*) Other products with similar technical features could be used with a previous approval of MWM.

## NOTES

## Engine Block

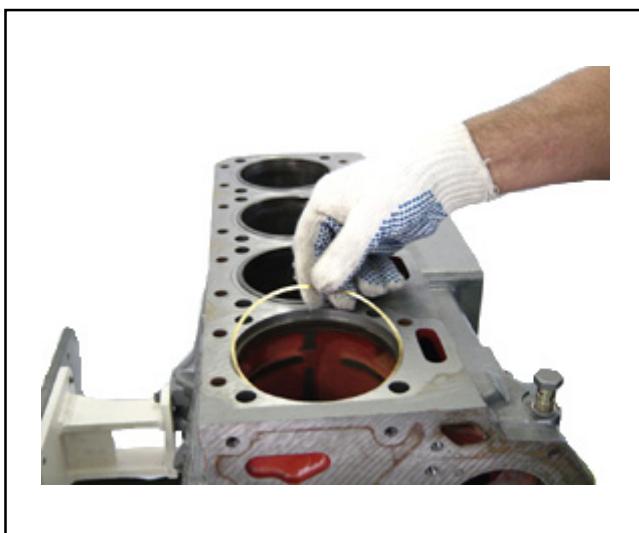
<b>Disassembly Notes .....</b>	<b>4-2</b>
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**Engine Block****Disassembly Notes**

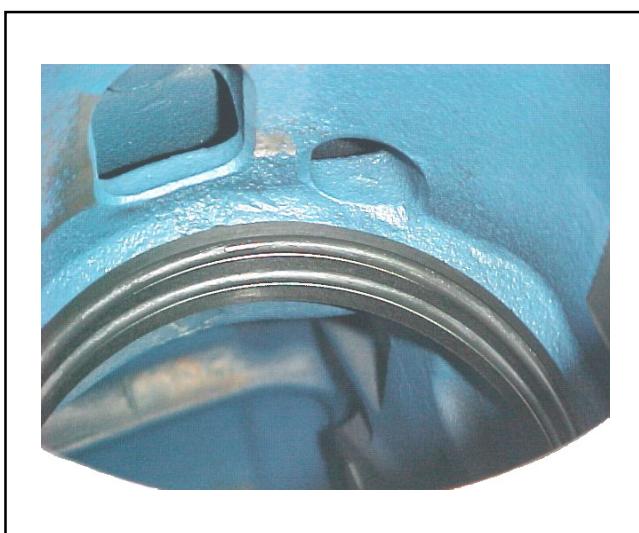
The cylinder liners removal must be made with the special tool MWM nr. 9.610.0.690.017.6 in order to do not damage the engine block or the liners.

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.



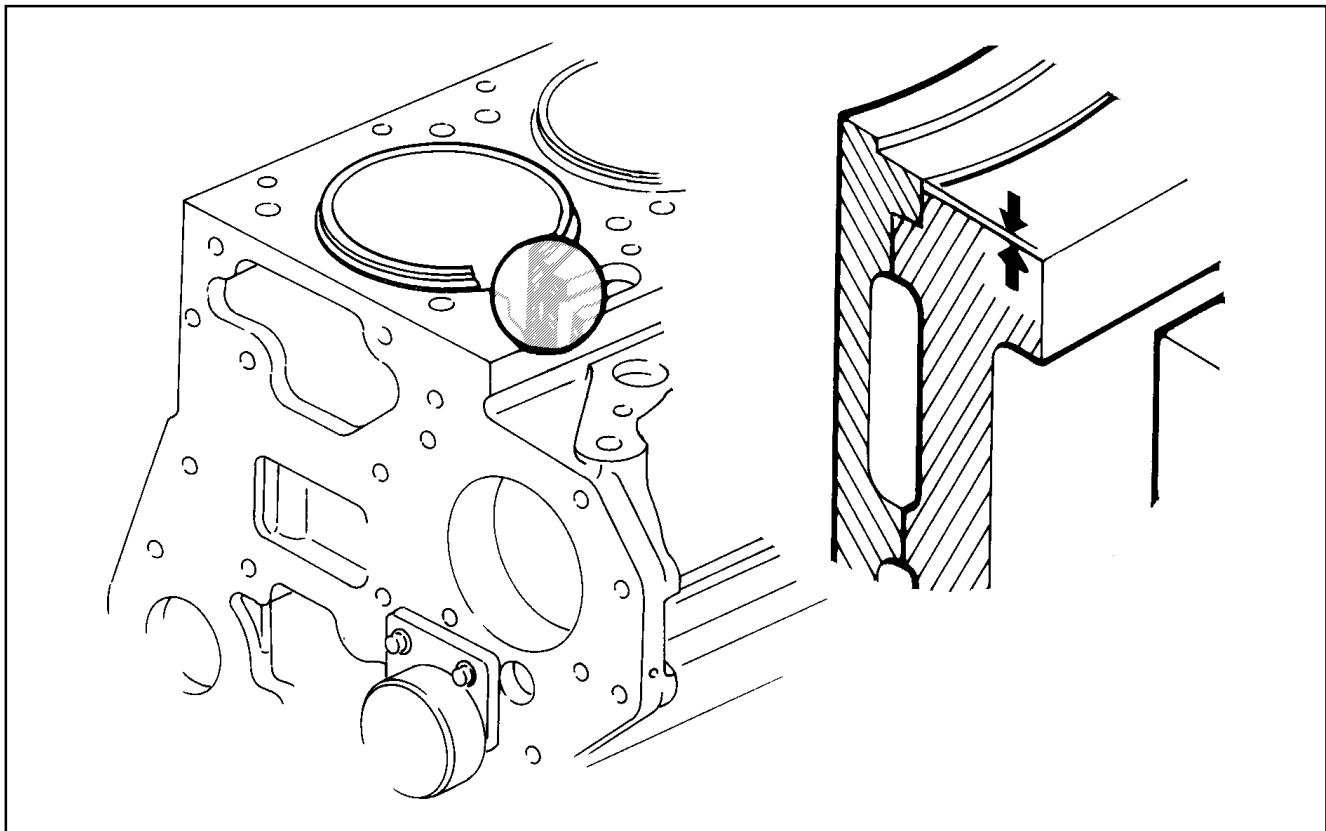
Remove Tombak rings.



Remove liners sealing rings.

## Pre-Assembly Inspections and Measurements

### Liner Protrusion Specification



#### Liner over Engine Block Surface

Measure	mm
Protrusion	*0.04 - 0.09

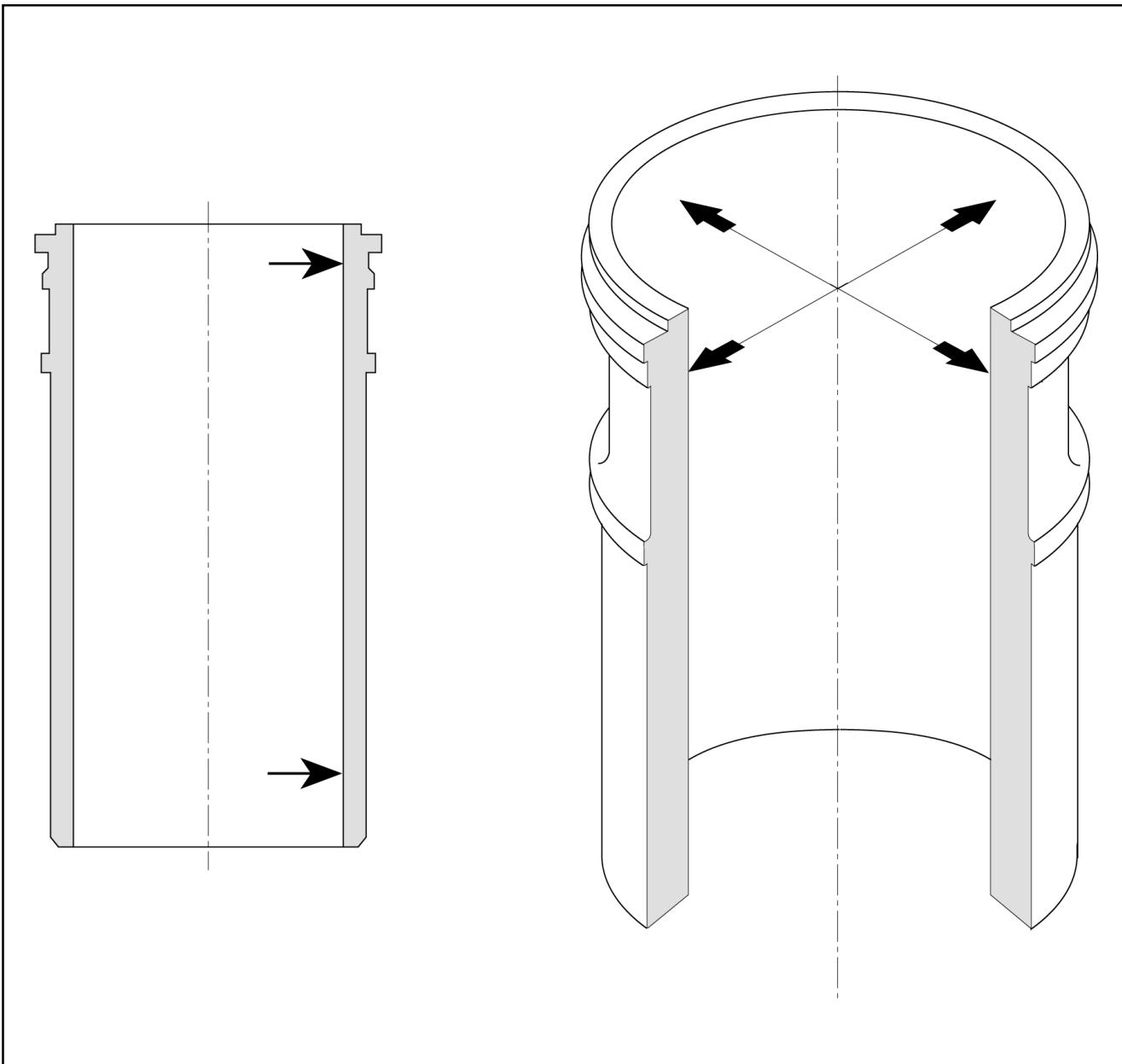
\*Affect emissions level

#### TOMBAK Ring

Thickness	mm
9.612.0.340.002.4	0.15

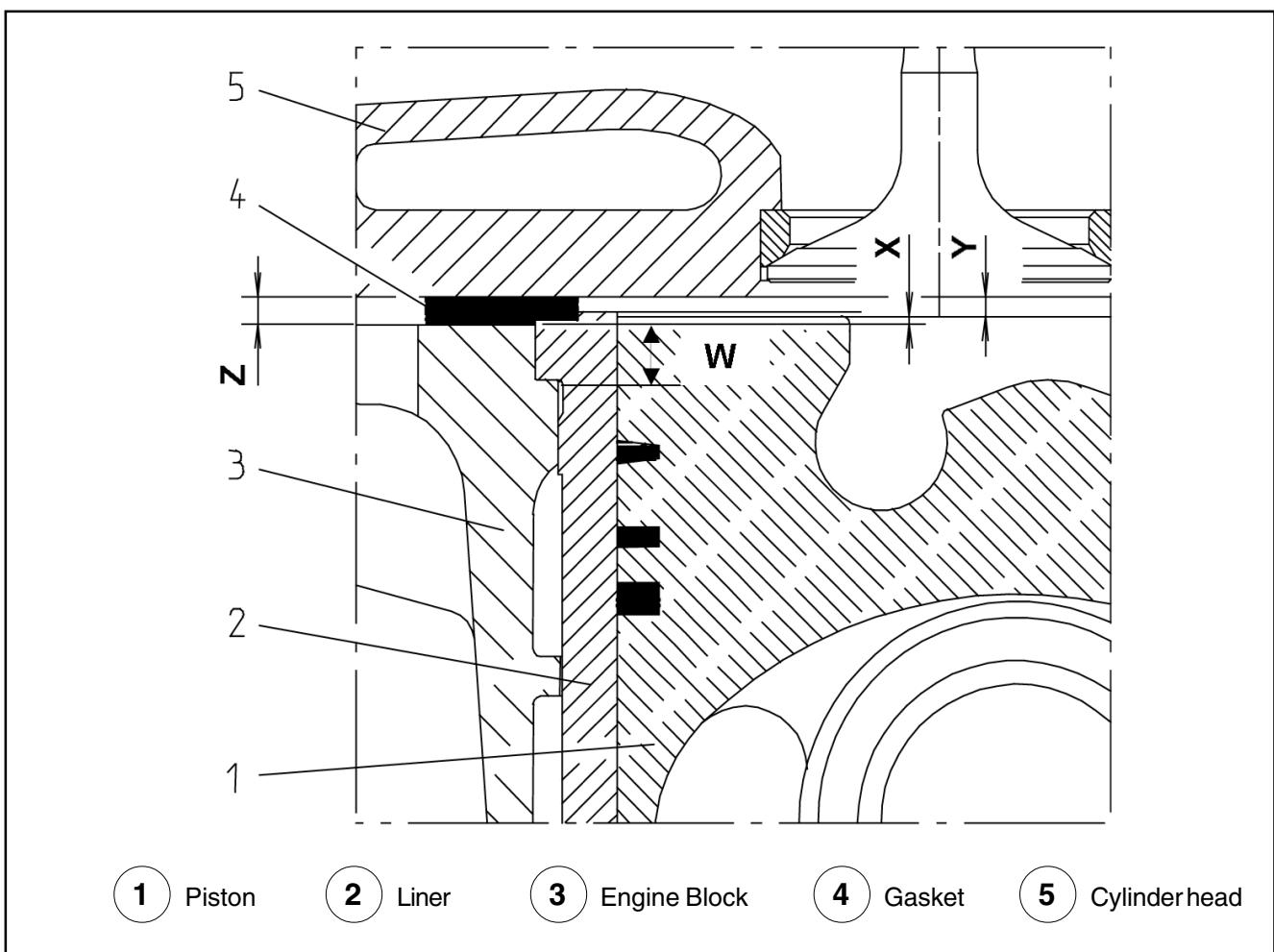
#### Protrusion Adjustment Shims (when necessary)

Thickness	mm
9.612.8.340.004.4	0.05
9.612.8.340.005.4	0.10
9.612.8.340.006.4	0.20
9.612.8.340.007.4	0.50

**Pre-Assembly Inspections and Measurements****Liners Specification**

<b>Liners</b>	
<b>Measure</b>	<b>mm</b>
Maximum waste	0.06
Out-of-roundness	0.02
Ø Inner	105.000 - 105.022

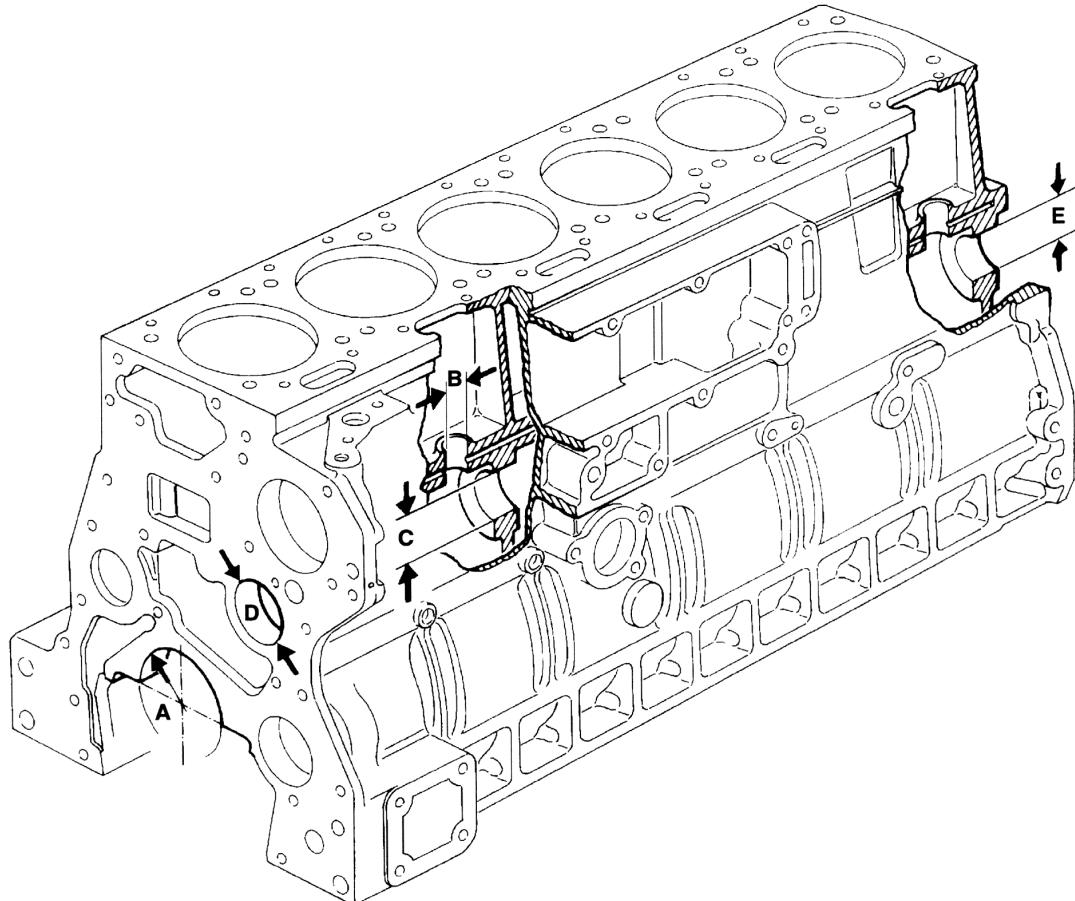
## Liners and Pistons Assembly Specifications



Liners Assembly				
W	X	Y	Z	Gasket nr. / Application
8.04 to 8.06	0.23 to 0.59	0.95 to 1.10	1.35 to 1.69	9.612.0.854.003.4 / Spare part

## Engine Block

## Engine Block Specifications

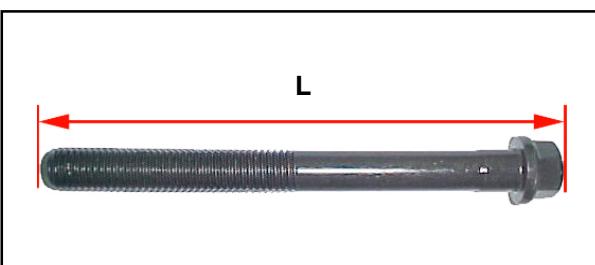


Main Bearings (A)	
Diameter	mm
Inner	92.000 - 92.022

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

Measure main bearings bolt lengths.

Discard bolts longer than 133.5 mm.



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

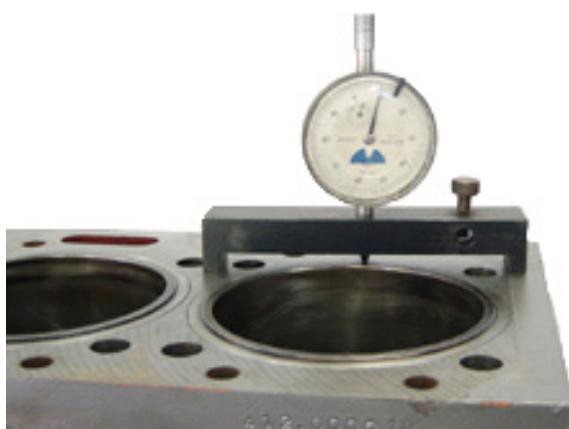
Camshaft Bearing (D)	
Ø inner	mm
without bushing	54.000 - 54.030
with bushing	49.990 - 50.050

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

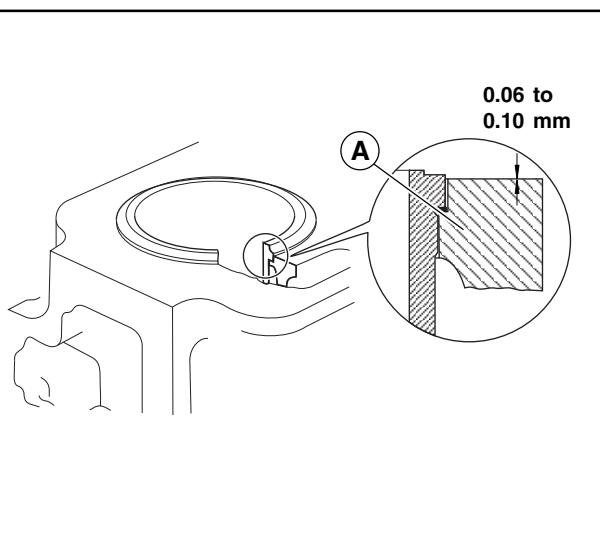


### Inspections and Measurements

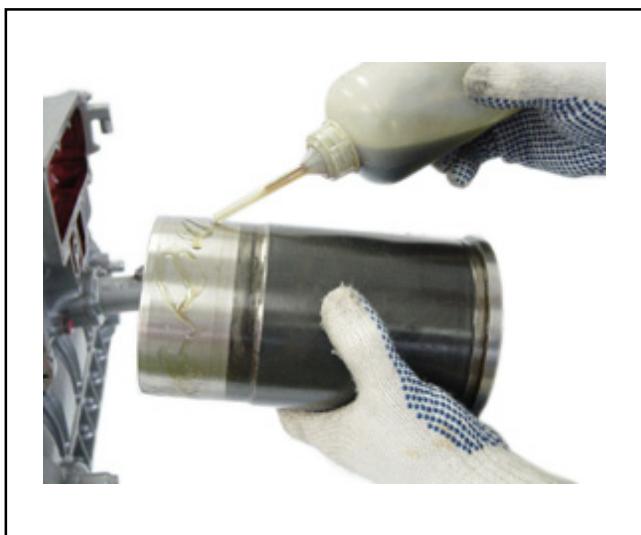
With the liners out of the engine block, perform four measurements, two on the upper part and two on the lower part, turning the bore gauge  $90^\circ$  between them. Check liners out-of-roundness, taper and waste.



Measure liner protrusion in relation to the upper surface of the engine block with a dial indicator gauge. As a bracket to the dial indicator gauge, it can be used the special tool MWM nr. 9.407.0.690.031.6. If necessary, use a stainless steel ring underneath Tombak ring to obtain the specified height. The protrusion measurement must be performed on the first step of the liner, at four positions at  $90^\circ$  each.



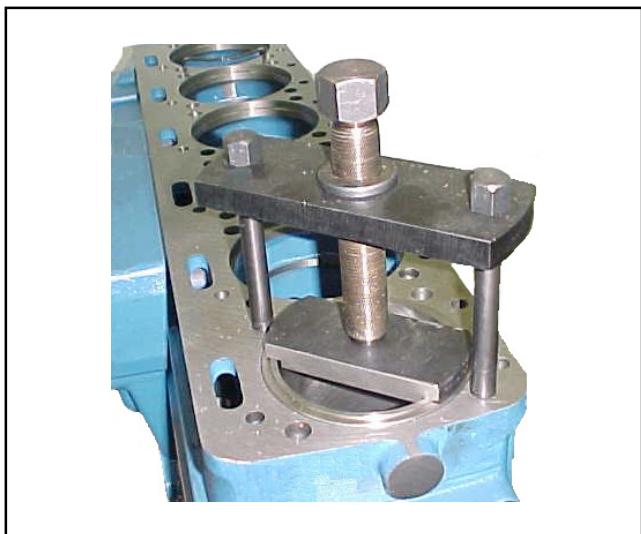
Clean liner housing and install Tombak ring (A).



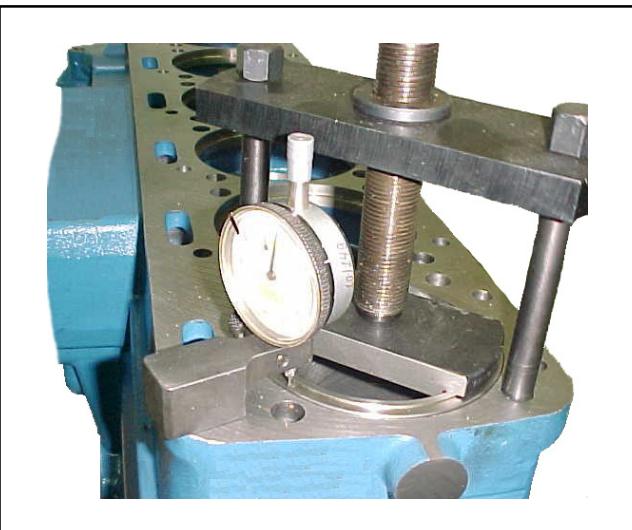
Lubricate with engine oil the contact area of the liner with the sealing rings, if they are assembled in the engine block.



Temporarily install the liner in the engine block, with the Tombak ring but without the rubber sealing rings.



To measure liner protrusion with the sealing rings installed, compress the liners using the special tool MWM nr. 9.610.0.690.025.4.  
Torque at 40 Nm.

**Engine Block**

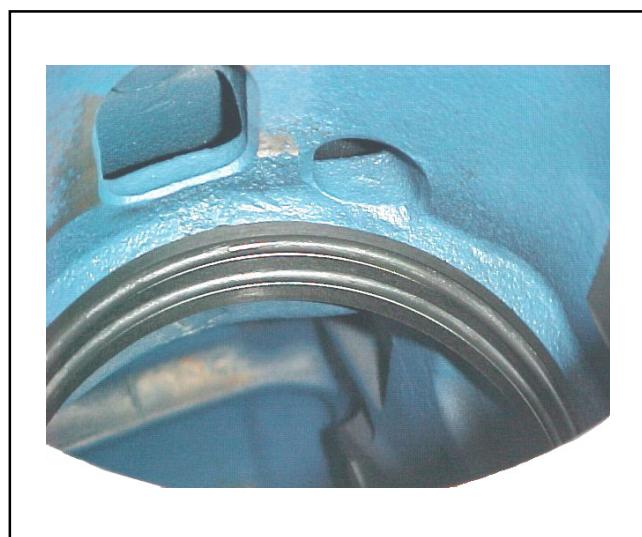
Measure the liner protrusion in relation to the upper surface of the engine block with a dial indicator gauge.



Remove the liner again using the procedure described previously.

**⚠ Attention**

- ***The rings must be completely clean to avoid torsion or cut during the assembly, causing lubricant oil contamination with water.***



## Assembly

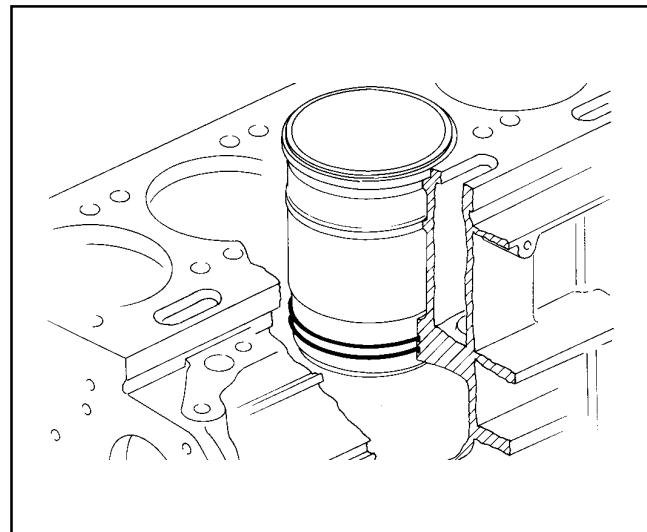
Install the sealing rings.



Install the Tombak ring.



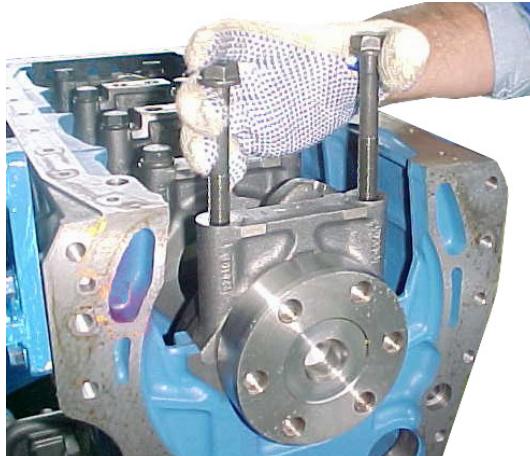
Install the liners according to the procedure described previously.



Rings correct position with the assembled liner.

## Crankshaft

<b>Disassembly Notes .....</b>	<b>5-2</b>
<b>Crankshaft Specification .....</b>	<b>5-3</b>
<b>Main Journals Specification .....</b>	<b>5-4</b>
<b>Crankpins Specification .....</b>	<b>5-5</b>
<b>Out-of-roundness and Taper Specification .....</b>	<b>5-6</b>
<b>Radial Clearance .....</b>	<b>5-7</b>
<b>Fillets .....</b>	<b>5-8</b>
<b>Pre-Assembly Inspections and Measurements .....</b>	<b>5-9</b>
<b>Crankshaft .....</b>	<b>5-9</b>
<b>Engine Block Bearings .....</b>	<b>5-10</b>
<b>Bearing Shells .....</b>	<b>5-12</b>
<b>Main Bearings Specifications .....</b>	<b>5-12</b>
<b>Crankshaft .....</b>	<b>5-15</b>
<b>Bolts Tightening Specification .....</b>	<b>5-16</b>
<b>Assembly .....</b>	<b>5-17</b>
<b>Measurements After Assembly .....</b>	<b>5-20</b>
<b>Axial Clearance Specification .....</b>	<b>5-20</b>

**Crankshaft****Disassembly Notes**

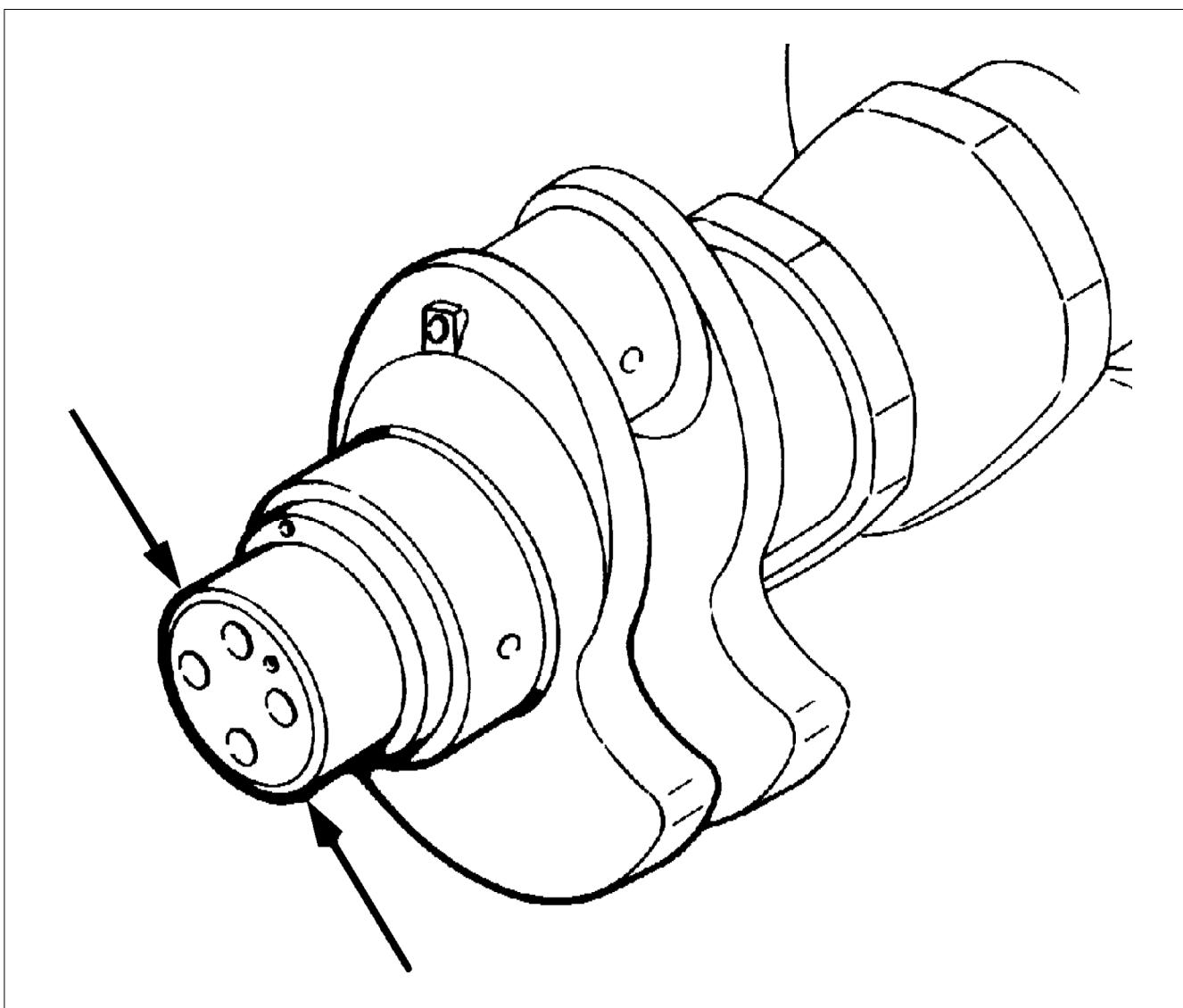
After removing the carter, pistons and connecting rods, flywheel and pulley, position the engine on the stand in upright position and loosen the main bearing caps. To remove the bearing caps use the fixation bolts.



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

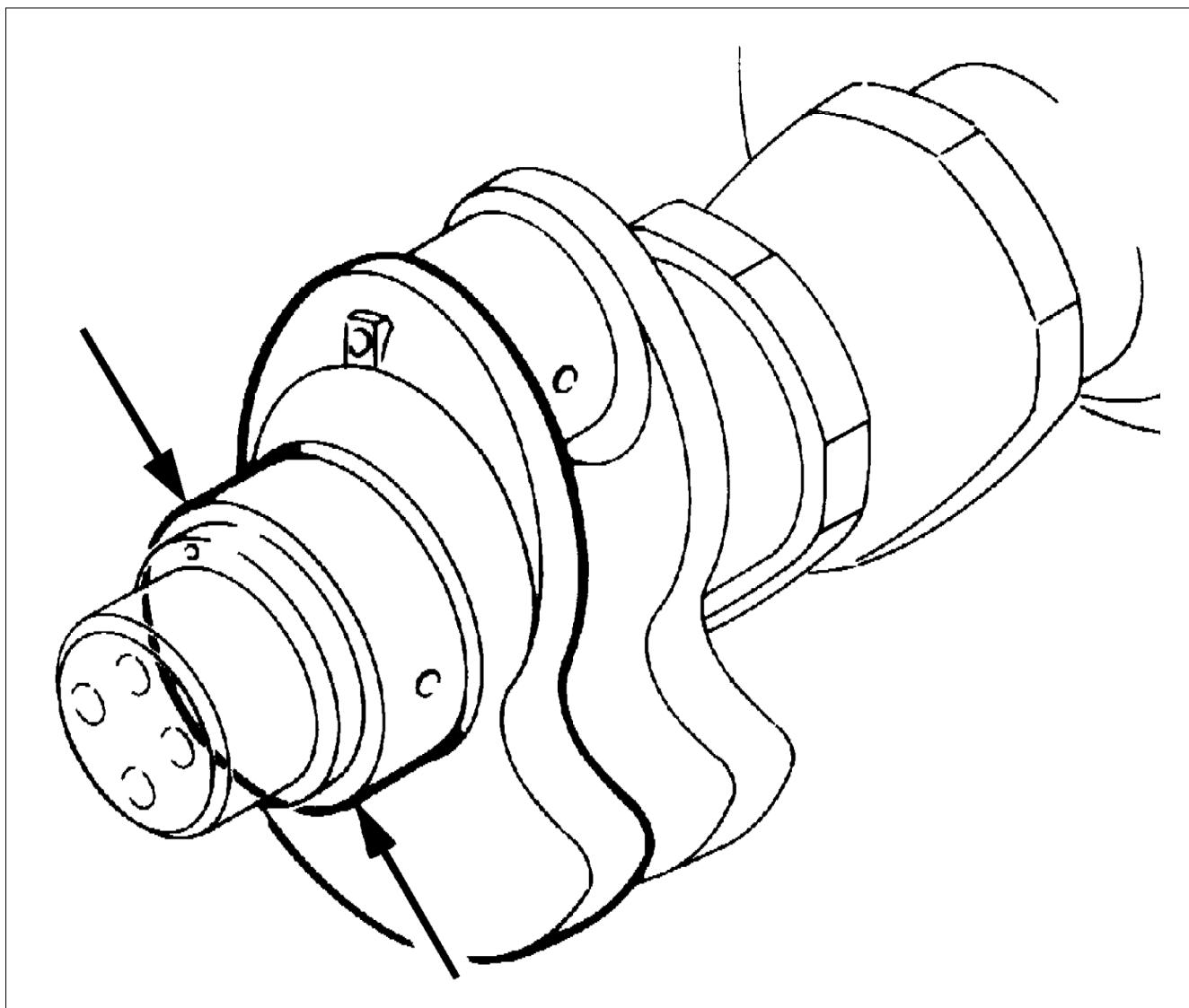


Carefully remove crankshaft in order to do not hit on any part of the engine block, avoiding damaging it. The storage of the crankshaft must always be done in upright position, avoiding any warping possibility.

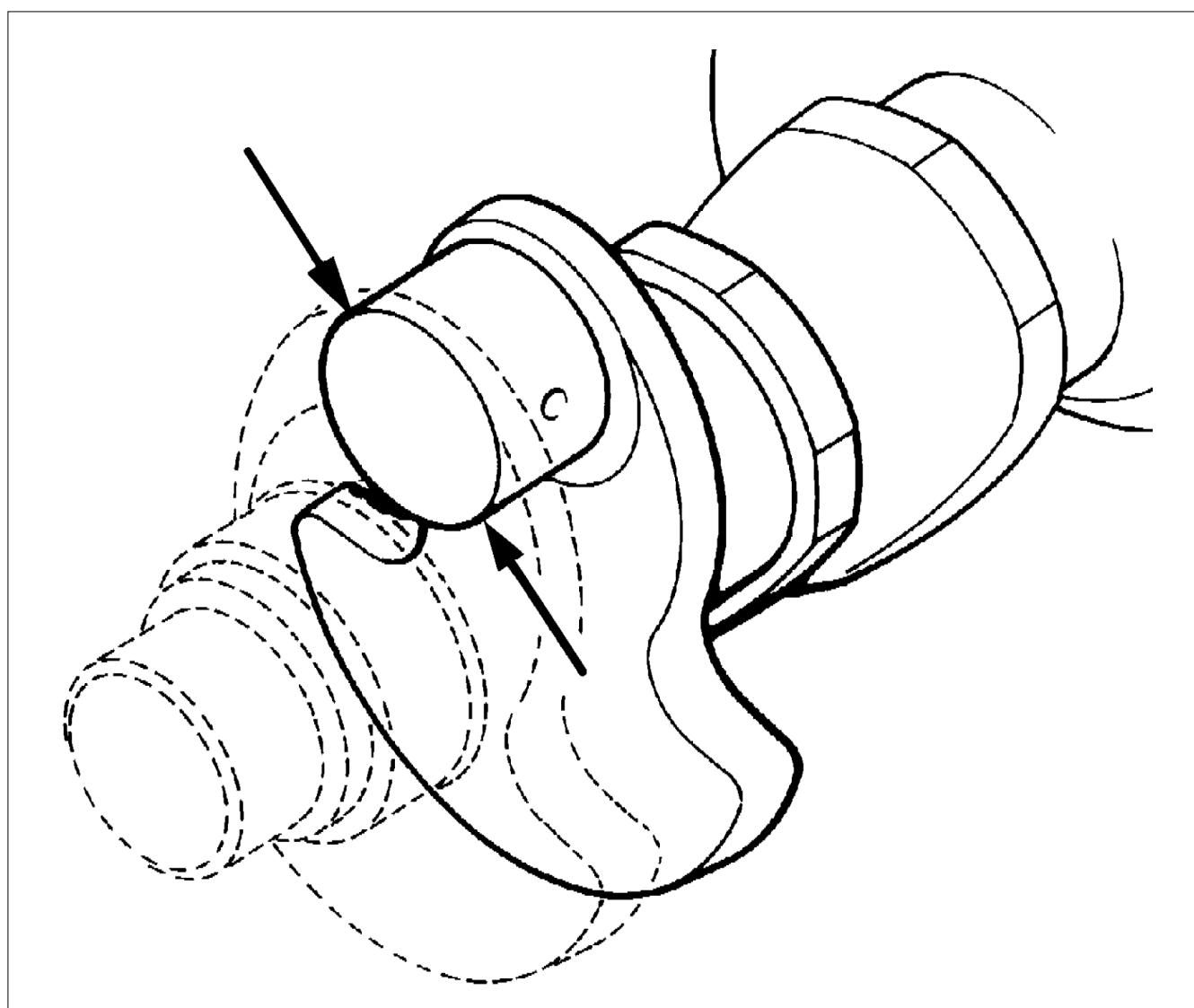
**Crankshaft Specification**

Gear	
Diameter	mm
Seat	60.020 - 60.059

## Main Journals Specification

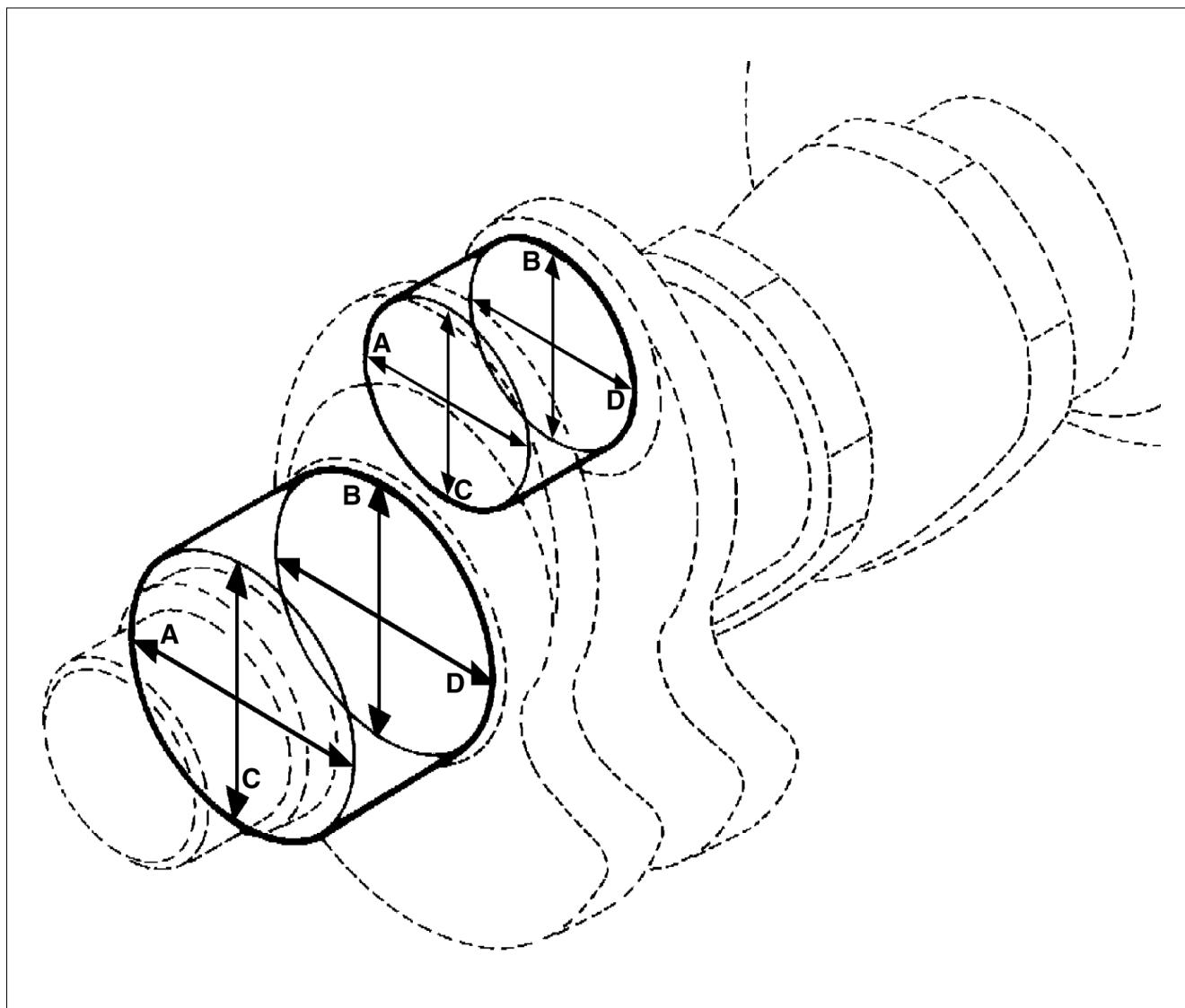


Main Journal	
Diameter	mm
Standard	85.942 - 85.964
1st repair	85.692 - 85.714
2nd repair	85.442 - 85.464
3rd repair	85.192 - 85.214
4th repair	84.942 - 84.964

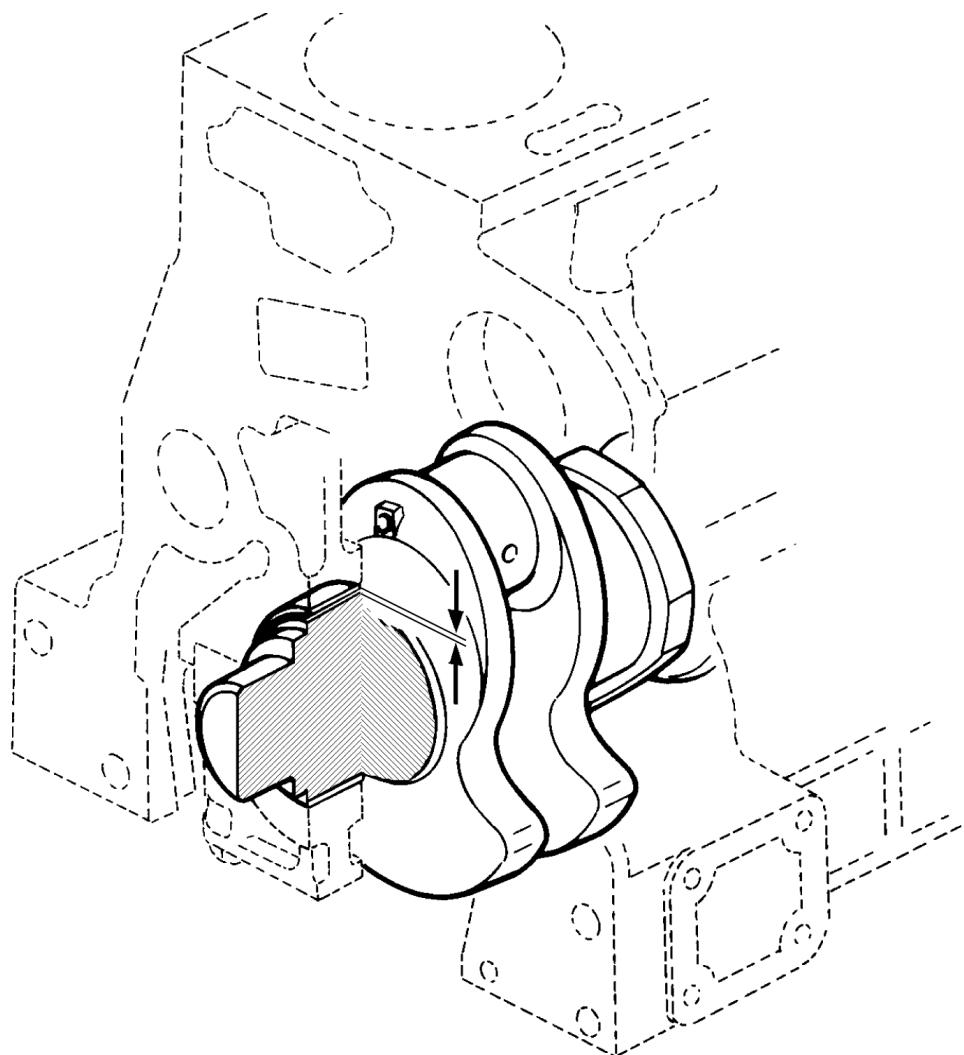
**Crankpins Specification**

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

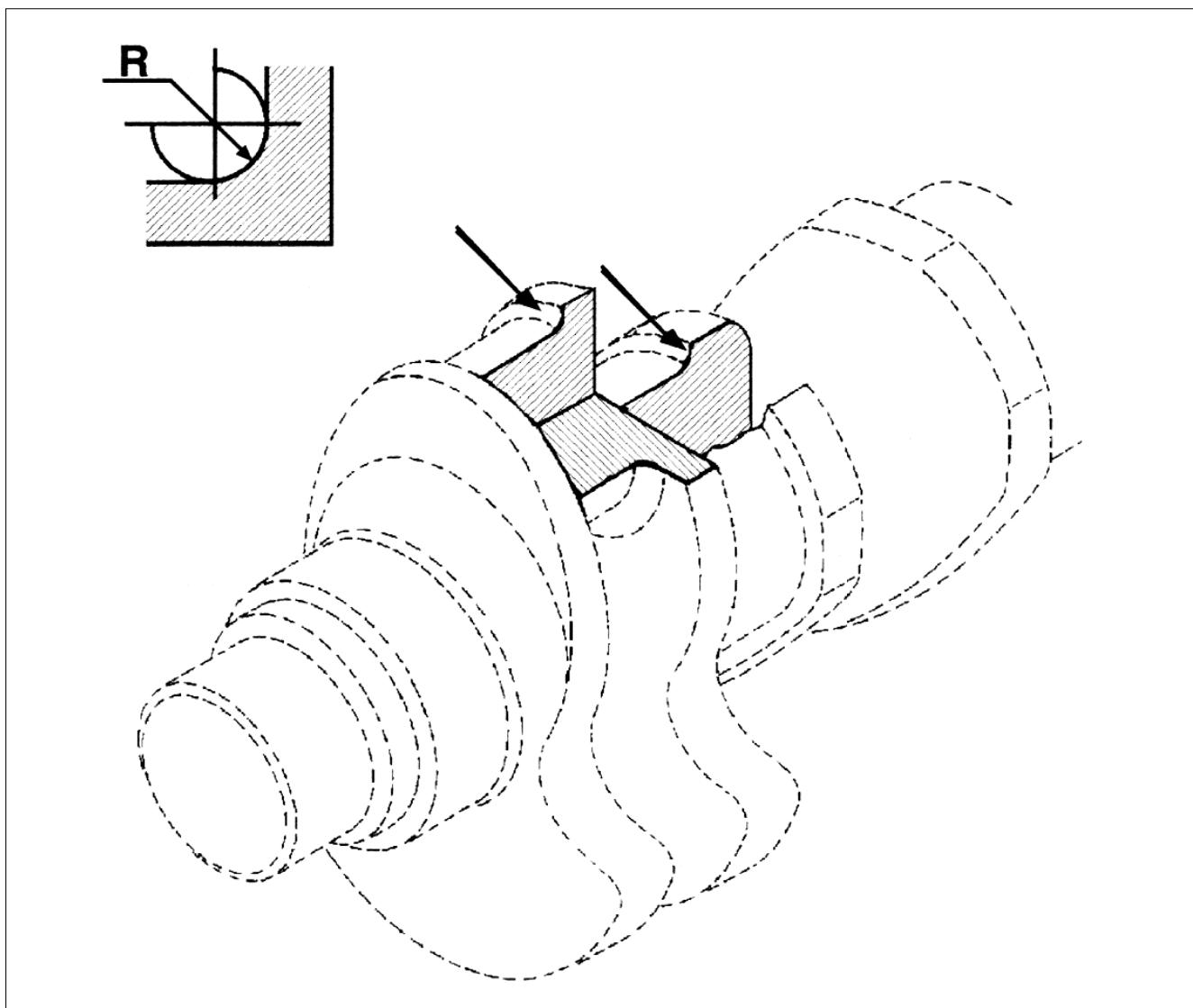
## Out-of-roundness and Taper Specification



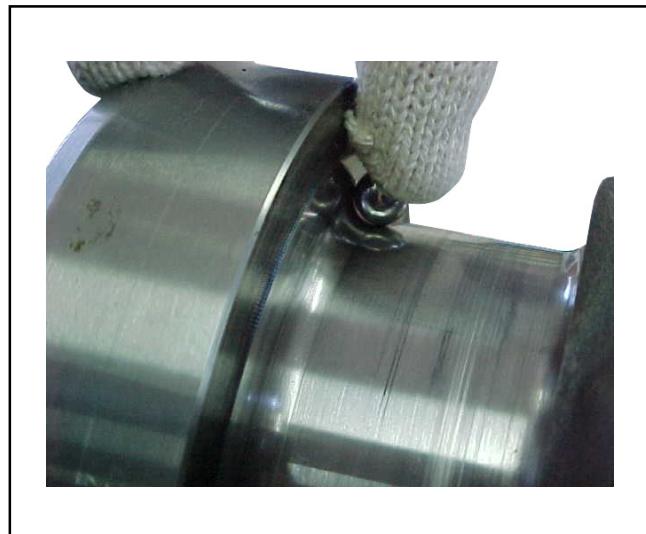
Maximum Out-of-roundness	mm
A x C and B x D	0.01
Maximum Taper	mm
A x B and C x D	0.01

**Radial Clearance**

Radial Clearance	mm
nominal	0.036 - 0.096
maximum	0.245

**Fillets**

Fillet	mm
Nominal	3.8 - 4.0



## Pre-Assembly Inspections and Measurements

### Crankshaft

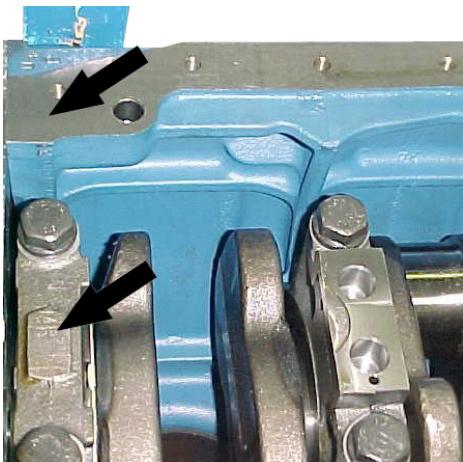
Crankshaft, as well as the bearings, can be visually checked. It is necessary to check for overheating signs, deep scratches, cracks or other types of damage.

Presenting anyone of these damages it is necessary to check the possibility of machining and to use oversized bearing shells.

Measure the fillets with a calibrated sphere.

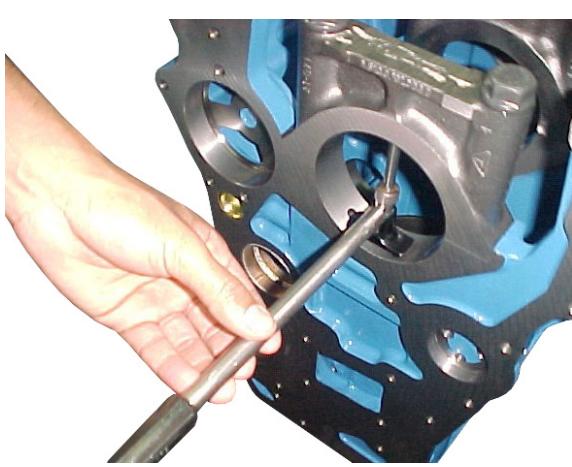


The measurement of the fillets can also be performed with a radius shim.

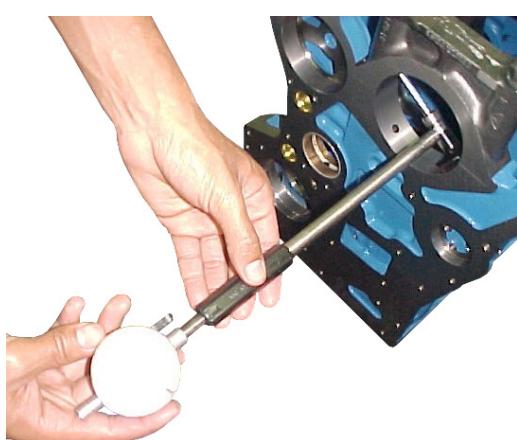
**Crankshaft****Engine Block Bearings**

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.

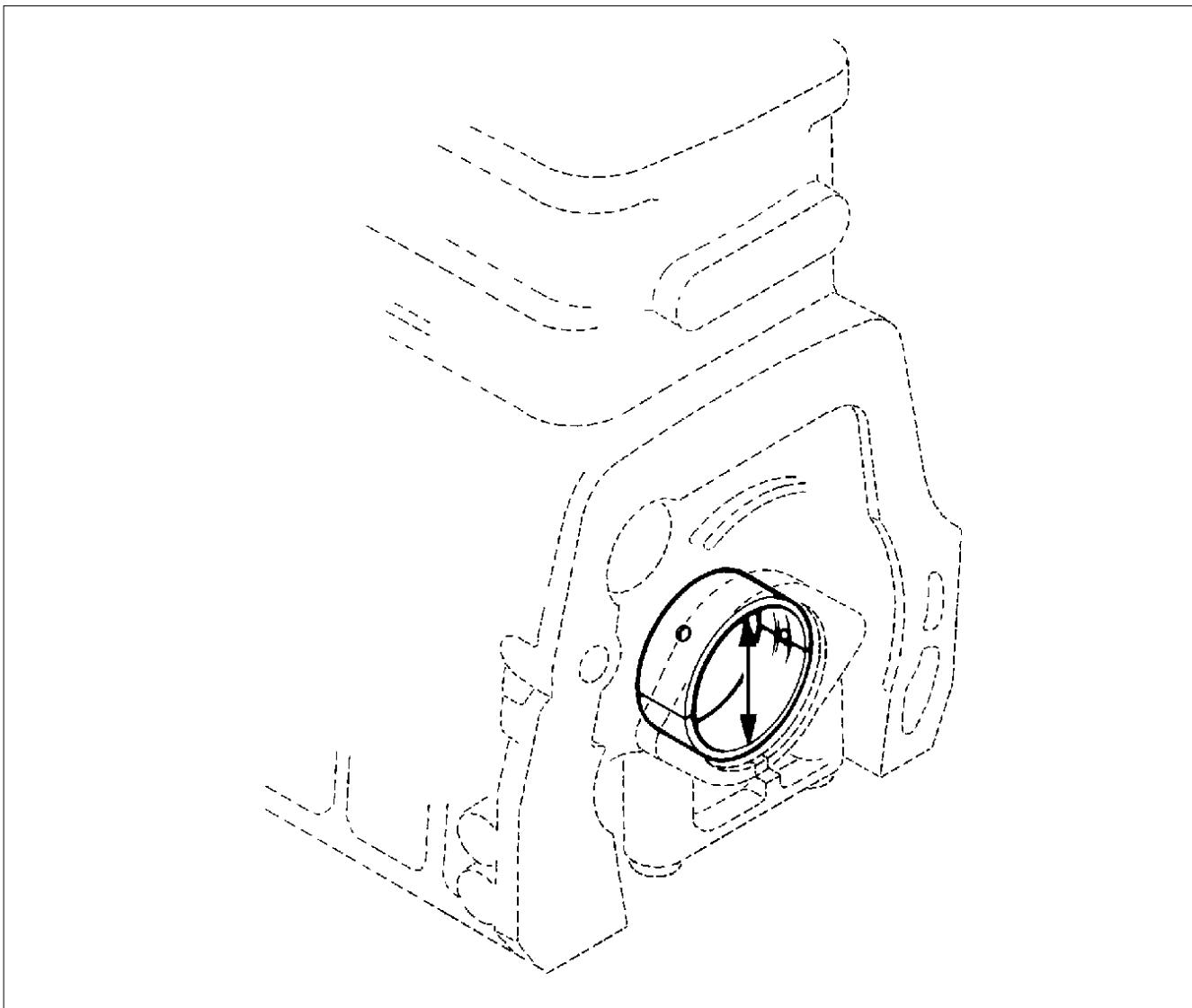
Install bearing caps and tighten according to the specification.



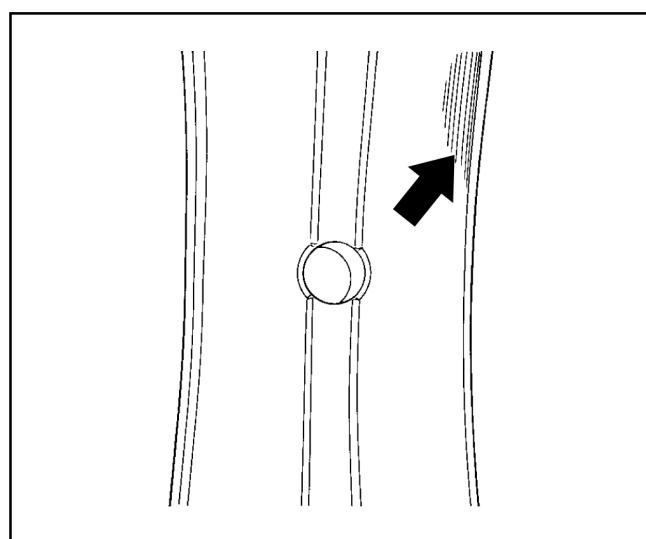
Measure bearings diameter, out-of-roundness and taper without bearing shells.



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

**Bearing shells****Main Bearings Specifications**

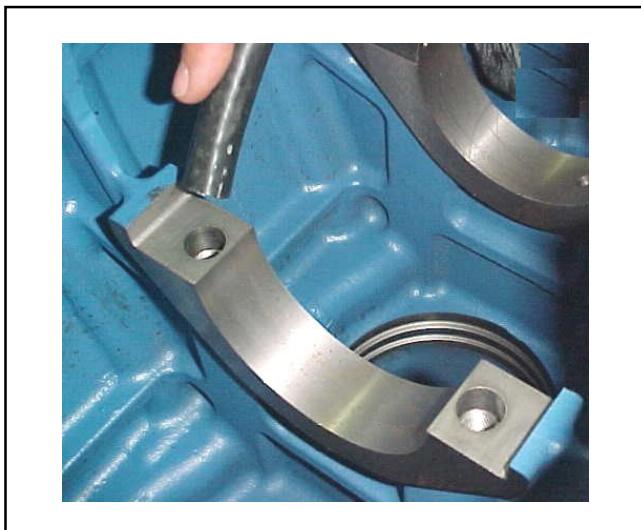
<b>Engine Block</b>	
<b>Diameter</b>	<b>mm</b>
Without bearing shell	92.000 - 92.022
<b>Bearing shell</b>	
<b>Diameter</b>	<b>mm</b>
Standard	86.000 - 86.038
1st repair	85.750 - 85.788
2nd repair	85.500 - 85.538
3rd repair	85.250 - 85.288
4th repair	85.000 - 85.038



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



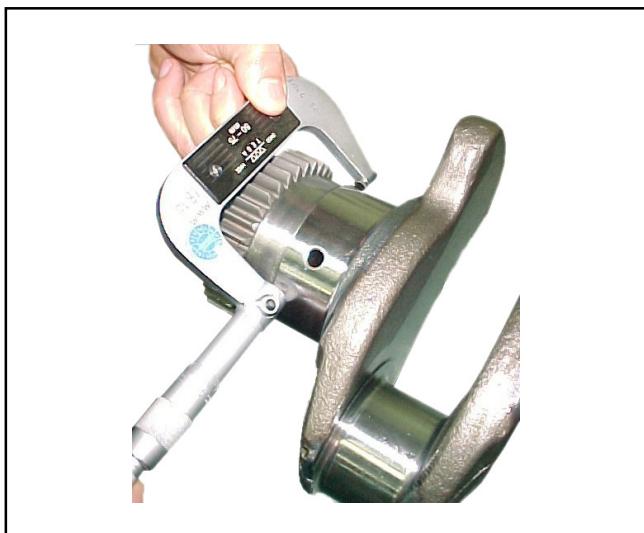
To perform the measurement of the bearings with the bearing shells installed, well clean the bearing cap, avoiding distortion due to oil or dirt presence.



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



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



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

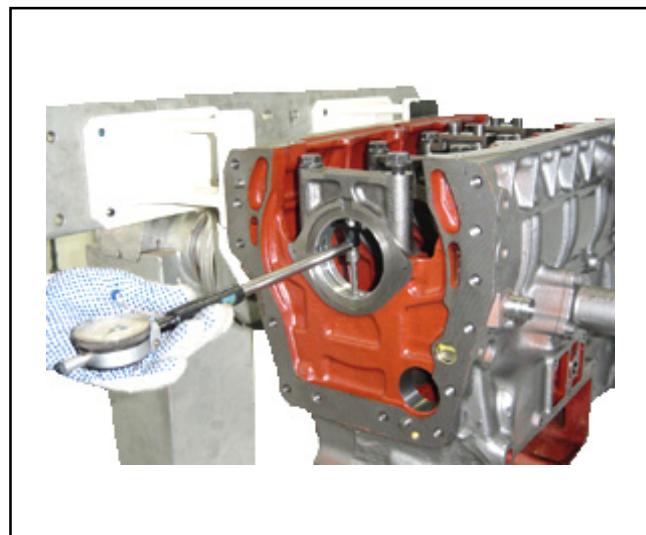


Compare the clearances obtained on the crankshaft through the bore gauge.



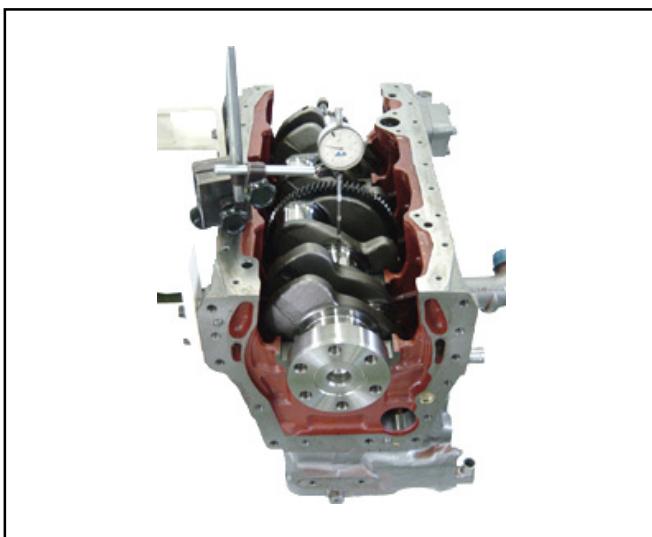
Assembly bearing caps and tighten according specification. Perform the measurements in the same way that they were performed for the bearings without bearing shells to obtain the radial force.

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



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

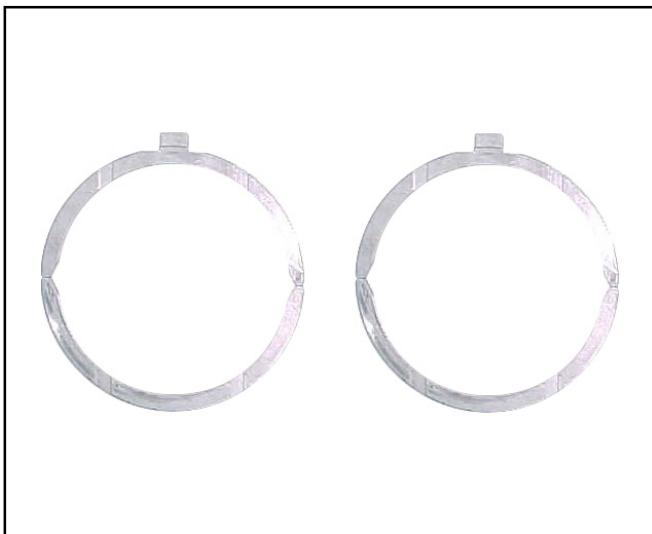
Pre-tension: 0.025 - 0.060 mm.



## Crankshaft

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

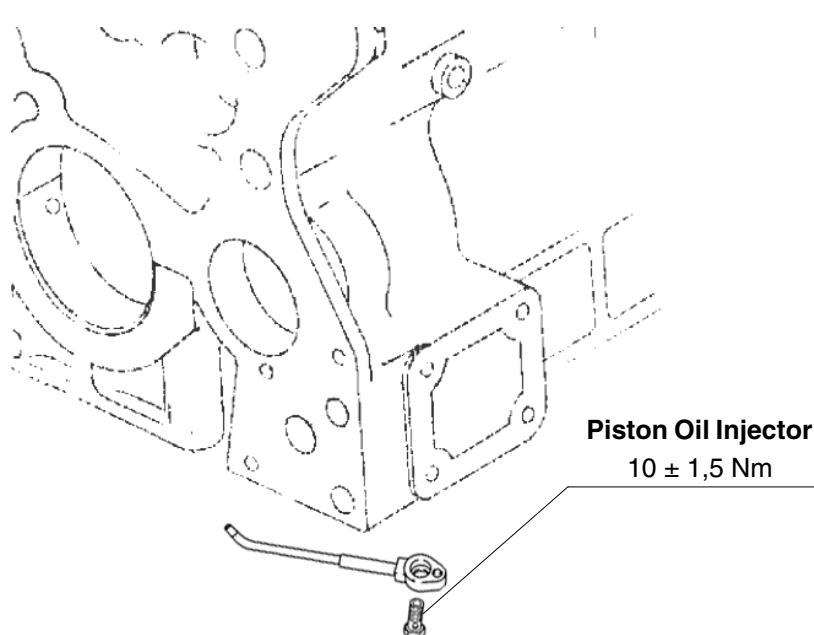
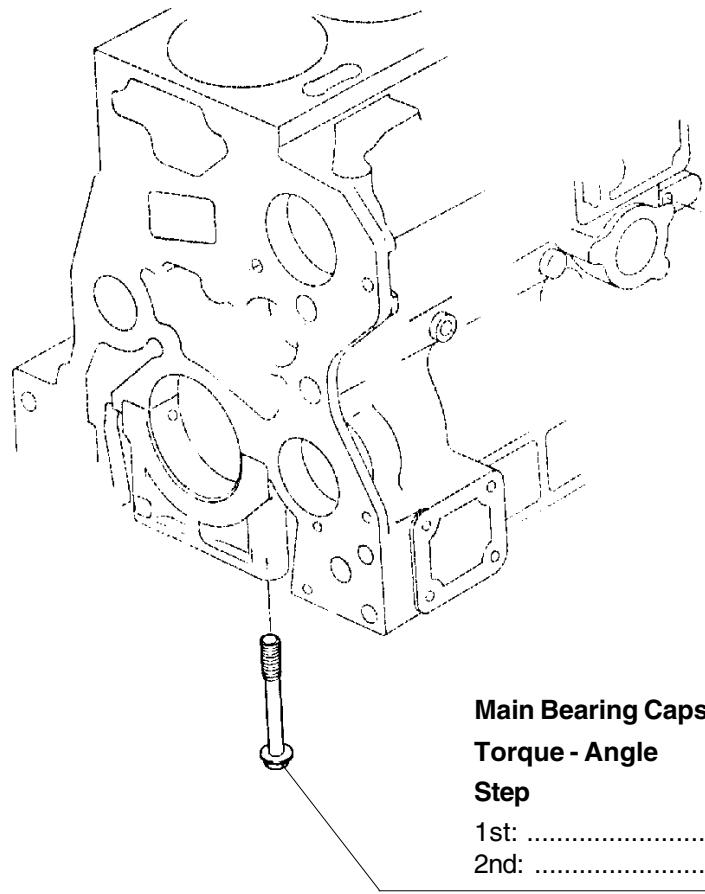
	4 cyl.	6 cyl.
Maximum Warping (mm)	0.11	0.15

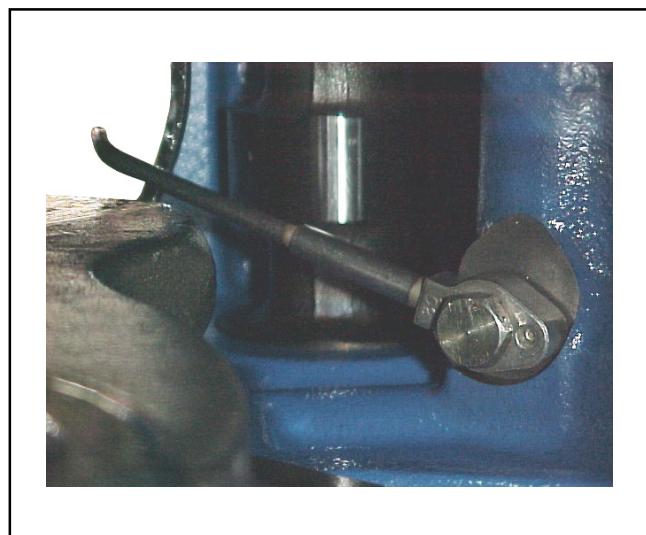


Check crankshaft thrust rings. Check for damages existence or excessive waste. In the assembly, the side with two grooves must be toward the shaft.

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

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

**Crankshaft****Bolts Tighten Torque Specification**

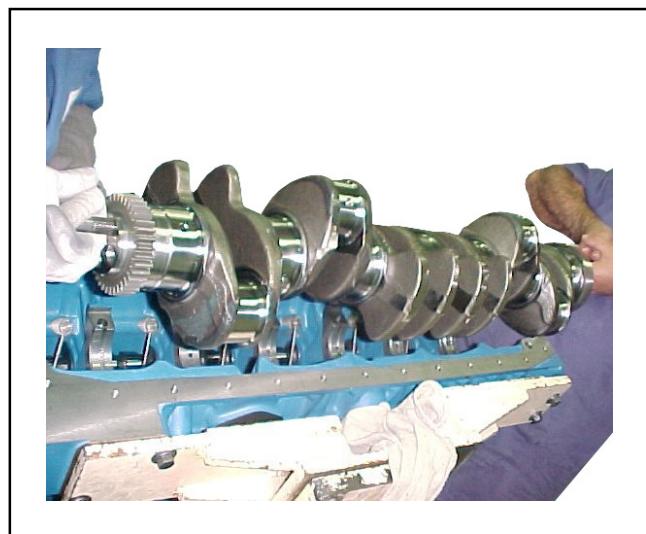


## Assembly

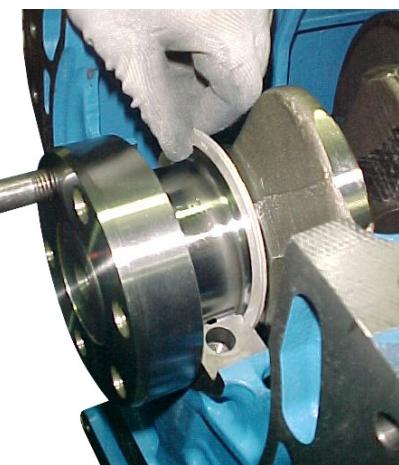
Install piston cooling oil injectors.  
Apply torque of  $10 \pm 1.5$  Nm.



Install and oil 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.



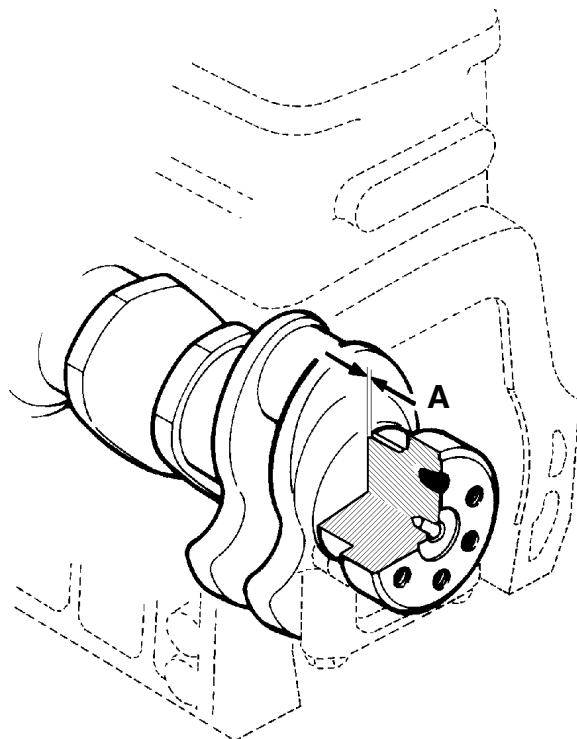
Tighten bolts in two steps and tighten according the specification.

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

## Crankshaft

## Measurements After Assembly

## Axial Clearance Specification



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

Measure the crankshaft axial clearance.



**Camshaft**

<b>Disassembly Notes .....</b>	<b>6-2</b>
<b>Camshaft Specifications .....</b>	<b>6-3</b>
<b>Tappets and Lock Plate Specification .....</b>	<b>6-4</b>
<b>Pre-Assembly Inspections and Measurements .....</b>	<b>6-5</b>
<b>Bolts Tightening Specifications .....</b>	<b>6-9</b>
<b>Assembly .....</b>	<b>6-10</b>

**Camshaft****Disassembly Notes**

Remove camshaft gear.

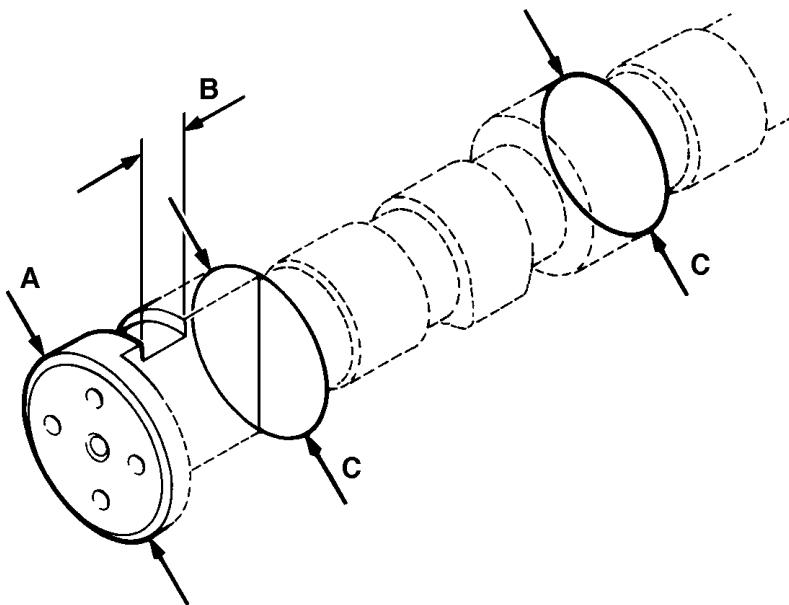


Remove camshaft lock.



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

## Camshaft Specifications



## Gear seat

Diameter (A)	mm
Nominal	51.971 - 51.990

## Axial Clearance Limitation Groove

Width (B)	mm
Nominal	7.100 - 7.190
Maximum	7.275

## Main journals

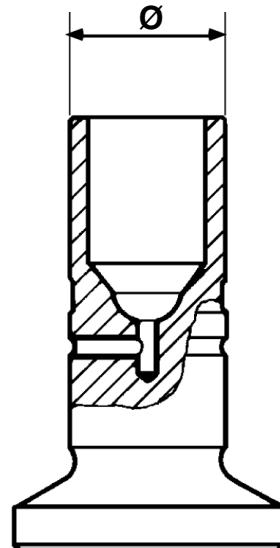
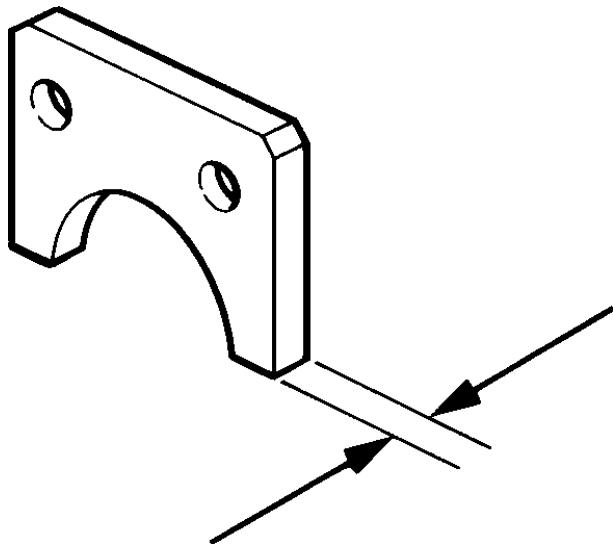
Diameter (C)	mm
Standard	49.920 - 49.940

## Bearing Clearance

	mm
Axial	0.05 - 0.19
Radial	0.05 - 0.13

## Camshaft

## Tappets and Lock Plate Specification



Lock Plate	
Thickness	mm
Nominal	7.00 - 7.05

Tappets	
Diameter	mm
Standard Nominal Minimum	17.983 - 17.994 17.975
1st repair Nominal	18.483 - 18.494



## Pre-Assembly Inspections and Measurements

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

### ⚠ Attention

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



Visually check tappet lubrication holes.

### ⚠ Attention

- *The lubrication holes of the tappets cannot be obstructed.*



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



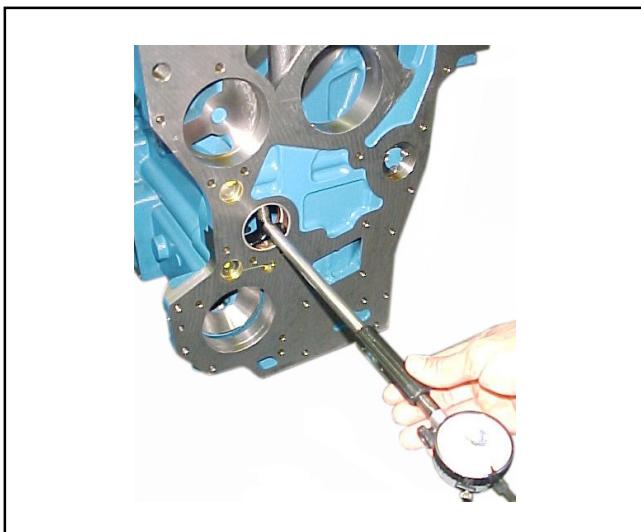
Measure the tappets diameter.



Measure the camshaft bearing diameters.



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

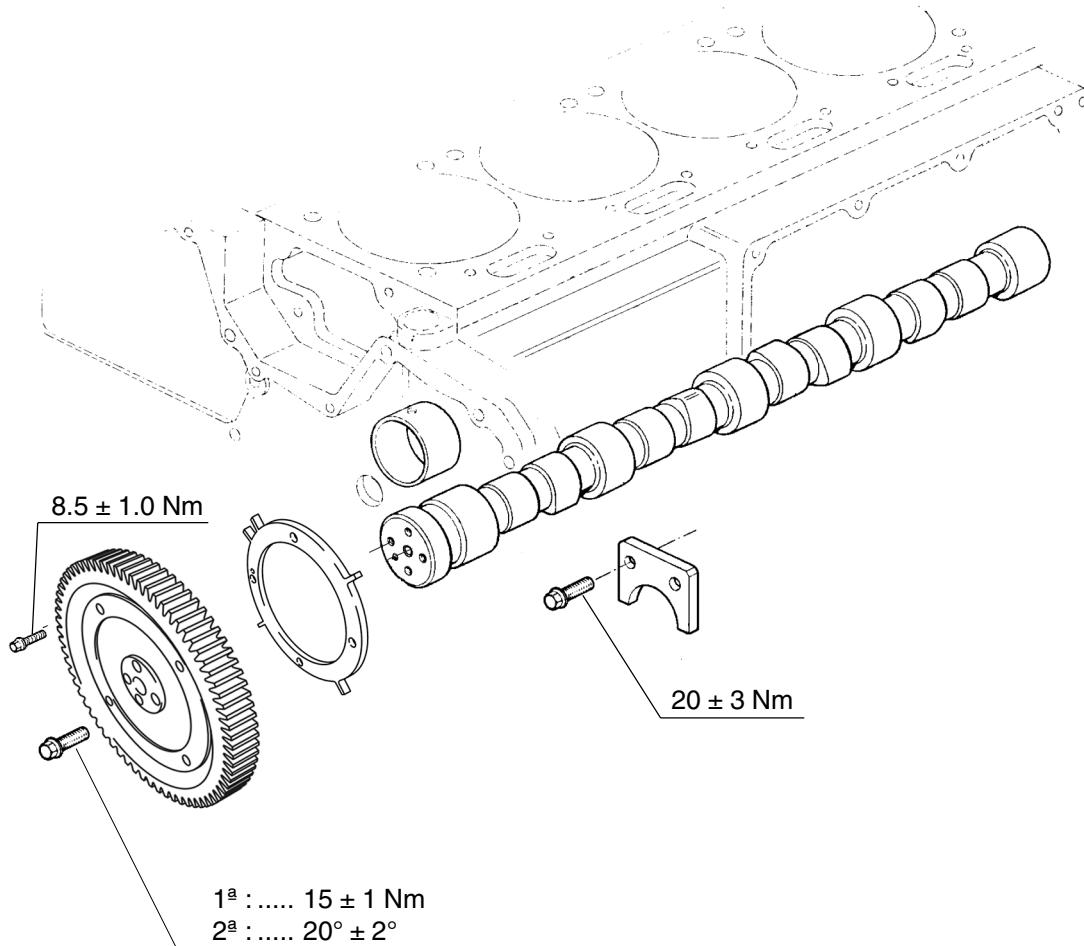


Measure the camshaft bearing housing bores.



Measure the camshaft warping.

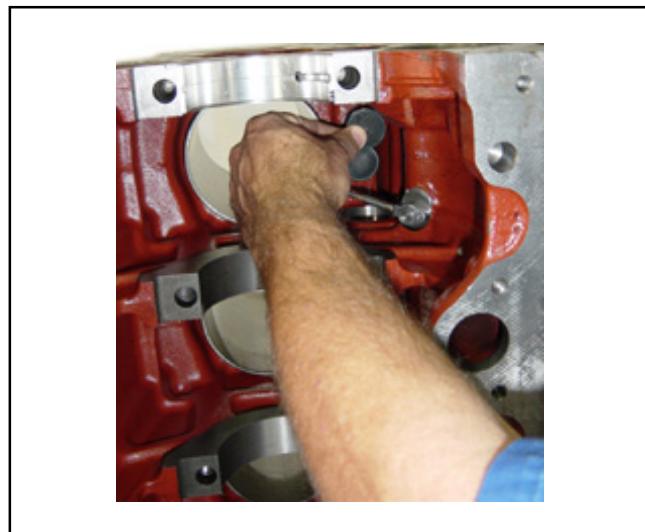
	4 cyl.	6 cyl.
Maximum warping (mm)	0.04	0.04

**Bolts Tightening Specification**

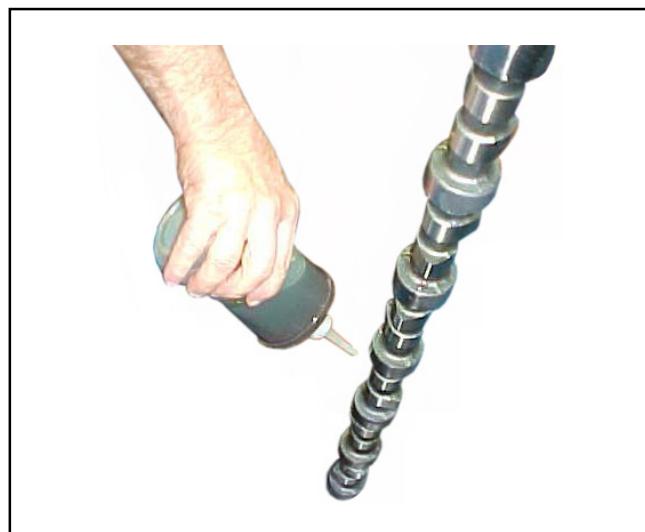


## Assembly

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.



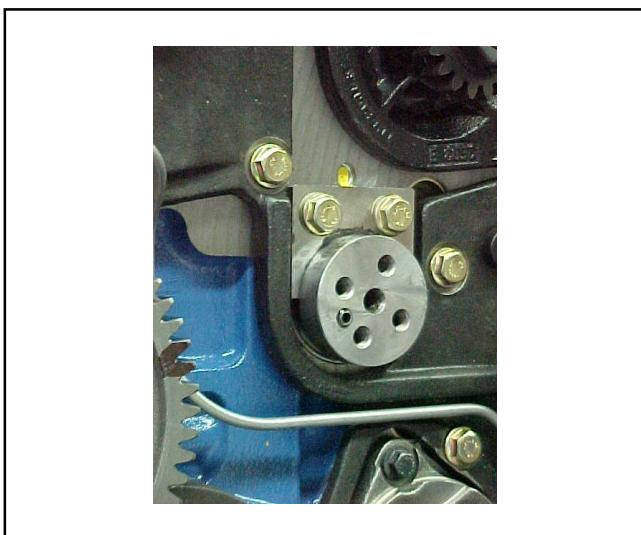
Well clean and lubricate camshaft bearings.



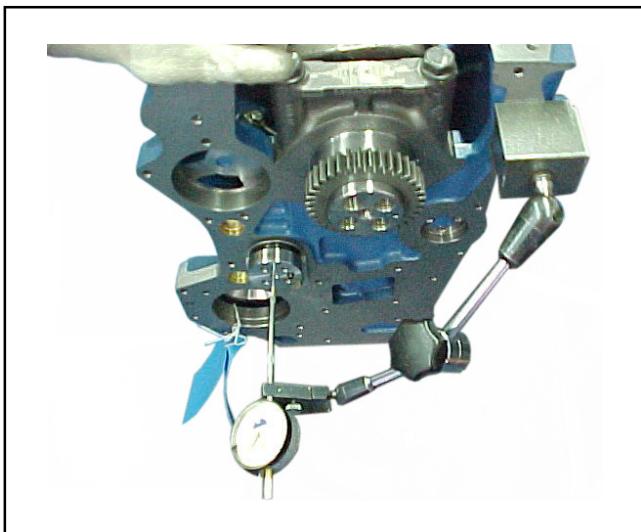
Install it with the hands making rotating movements.  
Take care to do not damage the bushings in the engine  
block.

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





View of the assembled camshaft and lock.



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



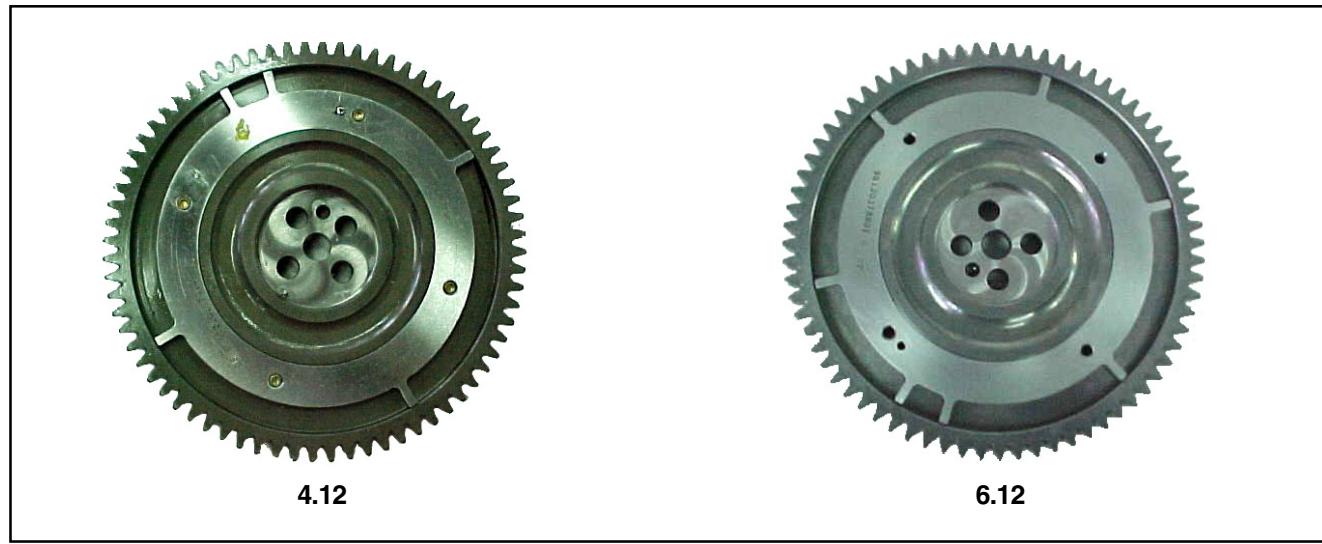
Assembly the pulse-wheel. Attention to the expansion bushing, which guides the correct positioning.

**Camshaft**

Assembly pulse wheel fixation bolts and tighten according the specification.



Install camshaft gear.



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

**Pistons and Connecting Rods**

<b>Disassembly Notes .....</b>	<b>7-2</b>
<b>Pre-Assembly Inspections and Measurements .....</b>	<b>7-4</b>
<b>Piston Grooves Specifications .....</b>	<b>7-6</b>
<b>Ring Ends Gaps Specification .....</b>	<b>7-7</b>
<b>Connecting Rod Bearings Specification .....</b>	<b>7-7</b>
<b>Connecting Rods Specification .....</b>	<b>7-9</b>
<b>Piston and Pin .....</b>	<b>7-10</b>
<b>Pre-Assembly Inspections and Measurements .....</b>	<b>7-11</b>
<b>Connecting Rod Bolts Tightening Specification .....</b>	<b>7-16</b>
<b>Assembly .....</b>	<b>7-17</b>



### 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**

- *Check the position of the oil piston injector for avoiding harms when to remove the set of piston and connecting rod.*

### Pre-Assembly Inspections and Measurements

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



Letter	Weight Strip	Application
X	1625g - 1666g	Production
Y	1667g - 1707g	Production
Z	1708g - 1748g	<b>Spare Part</b>

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



#### Connecting Rod Mark

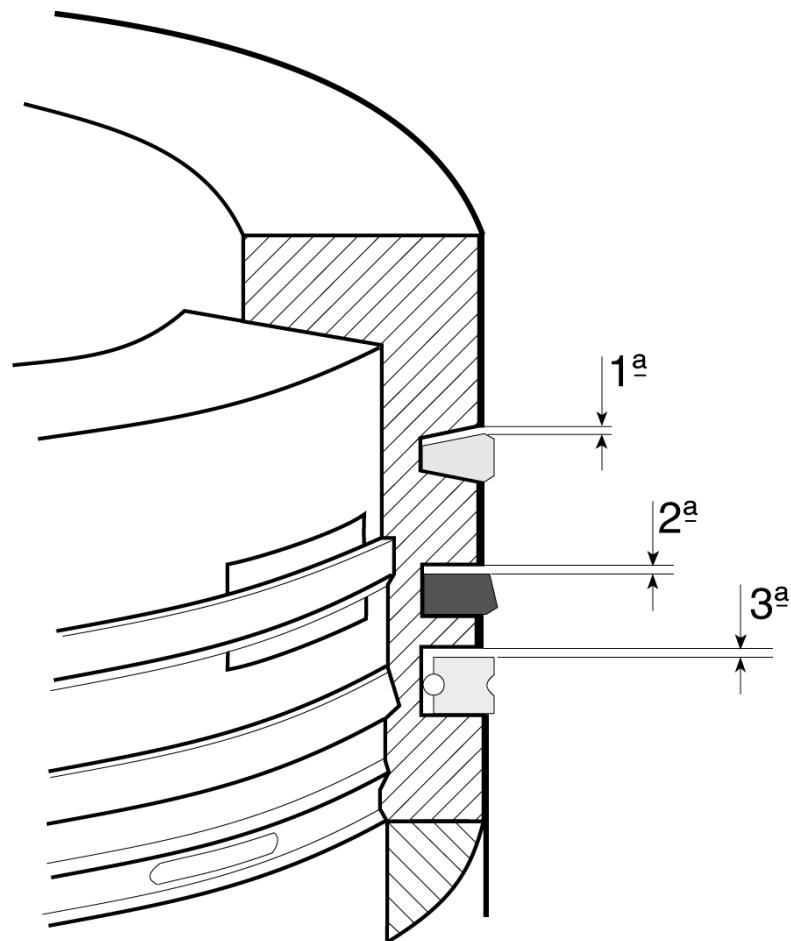
The connecting rod stem / cap pair is made by the coincidence of the digits engraved on the connecting rod stem with the first 4 digits engraved on the connecting rod cap.

**Identification code:**

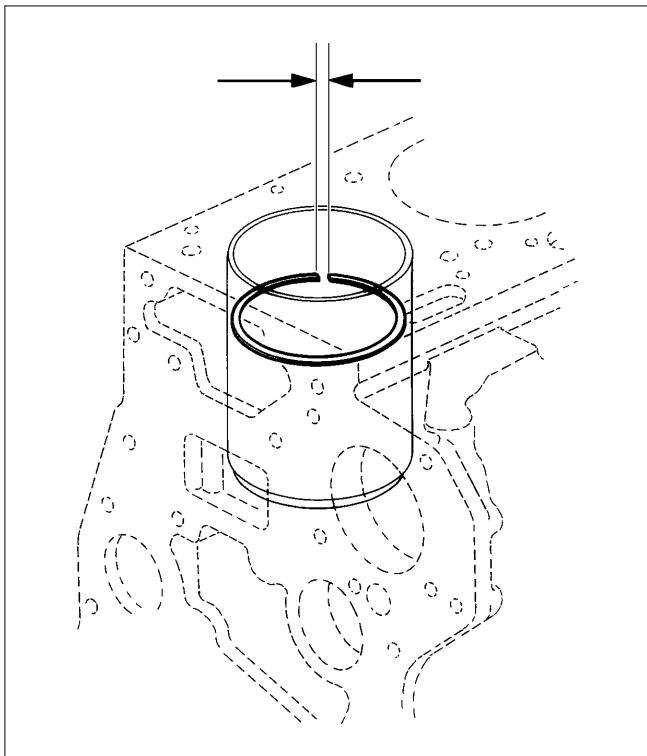
Serial Nr.	Mass Strip	Manufacturing Date	Production Shift
0245	Y	23 A 3	A
4 Digits (sequential)	One letter	Two digits	One letter
	X = 1625-1666g	0-31	A = January
	Y = 1667-1707g (*)		B = February
	Z = 1708-1748g		C = March
			D = April
			E = May
			F = June
			G = July
			H = August
			I = September
			J = October
			K = November
			L = December
			0-9
			A = 1st Shift
			B = 2nd Shift
			C = 3rd Shift

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

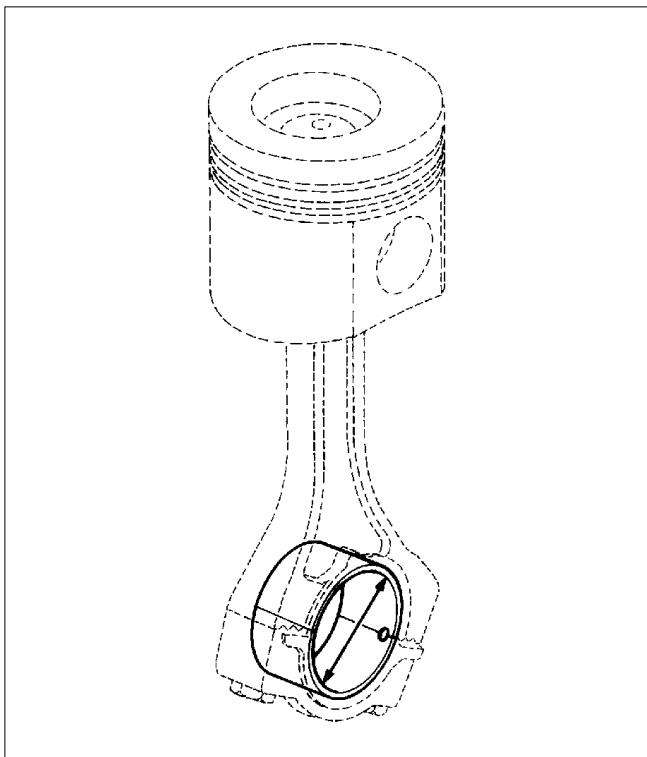
**Important:** Do not assembly connecting rods of "X" and "Z" mass strip in the same engine, because these connecting rods exceed the maximum limit of mass difference.

**Piston Grooves Specifications**

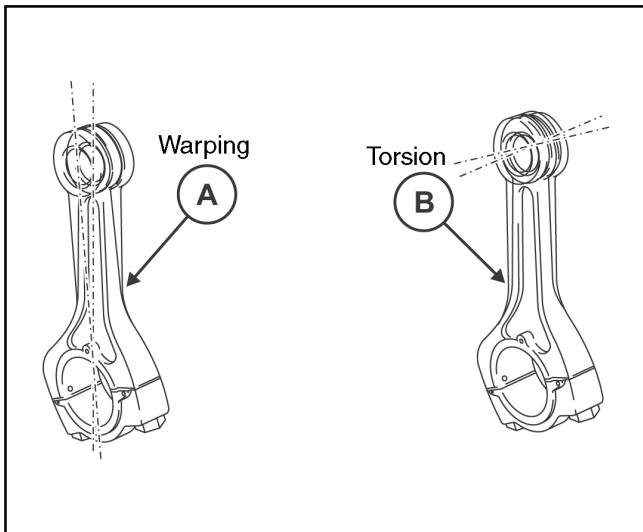
Rings Dimensions and Clearances in the Grooves		
Groove	Dimensions (mm)	Clearance (mm)
1st	103.0 x 3.0 x 4.40	0.25
2nd	107.0 x 2.5 x 4.40	0.20
3rd	103.0 x 4.0 x 3.98	0.15

**Ring Ends Gaps Specification**

Ends Gap	(mm)
1st and 2nd groove Nominal	0.40 - 0.65
Maximum	2.0
3rd groove Nominal	0.25 - 0.55
Maximum	2.0

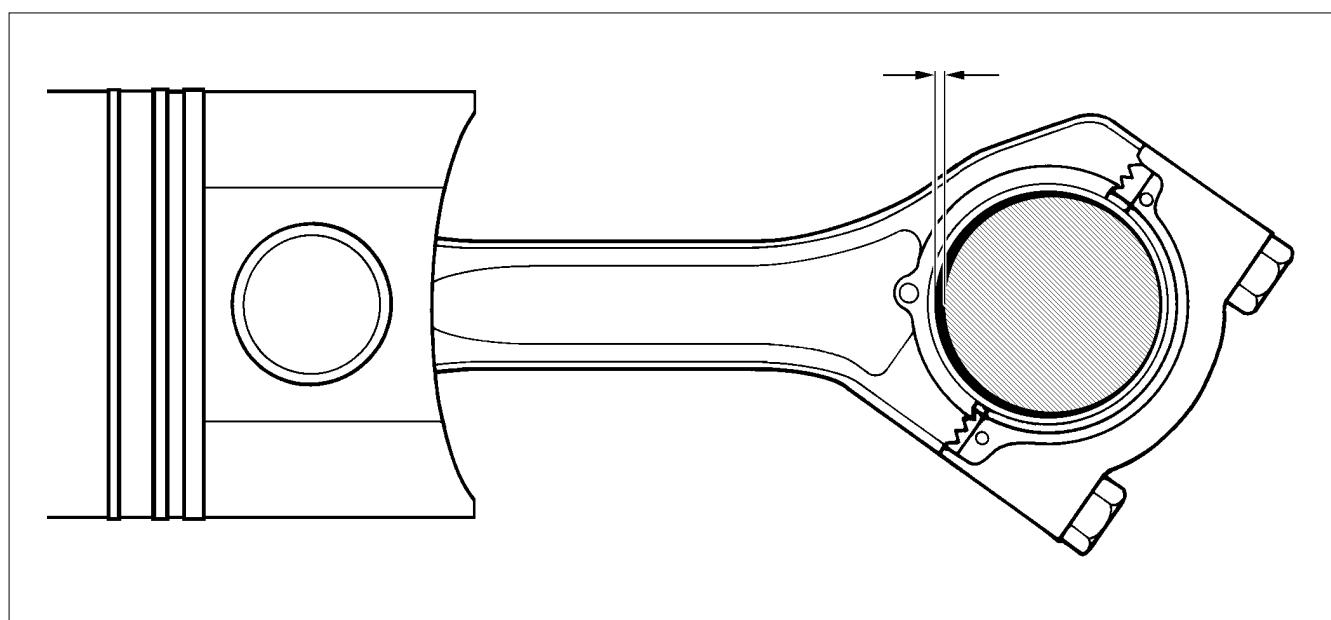
**Connecting Rod Bearings Specification**

Connecting Rod Bearing, Ø (bore)	
Diameter	(mm)
standard	62.992 to 63.037
repair 1	62.746 to 62.791
repair 2	62.496 to 62.541
repair 3	62.246 to 62.291
repair 4	61.996 to 62.041

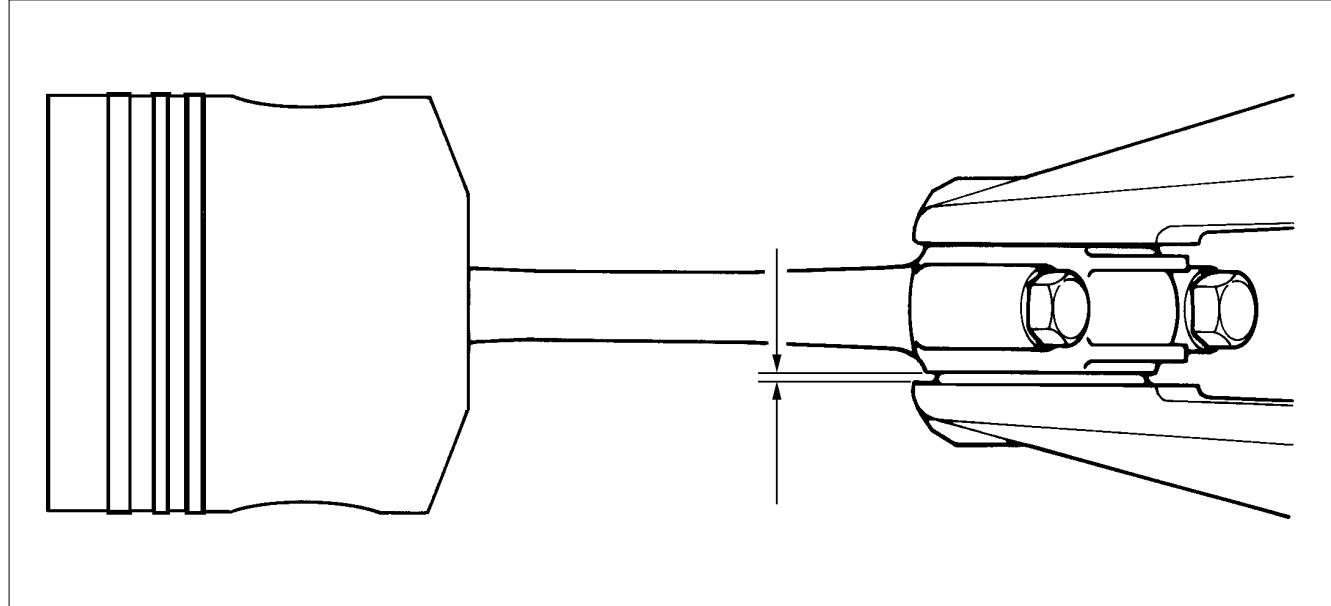
**Connecting Rod Warping**

Maximum Torsion	Maximum Warping
0.10	0.03

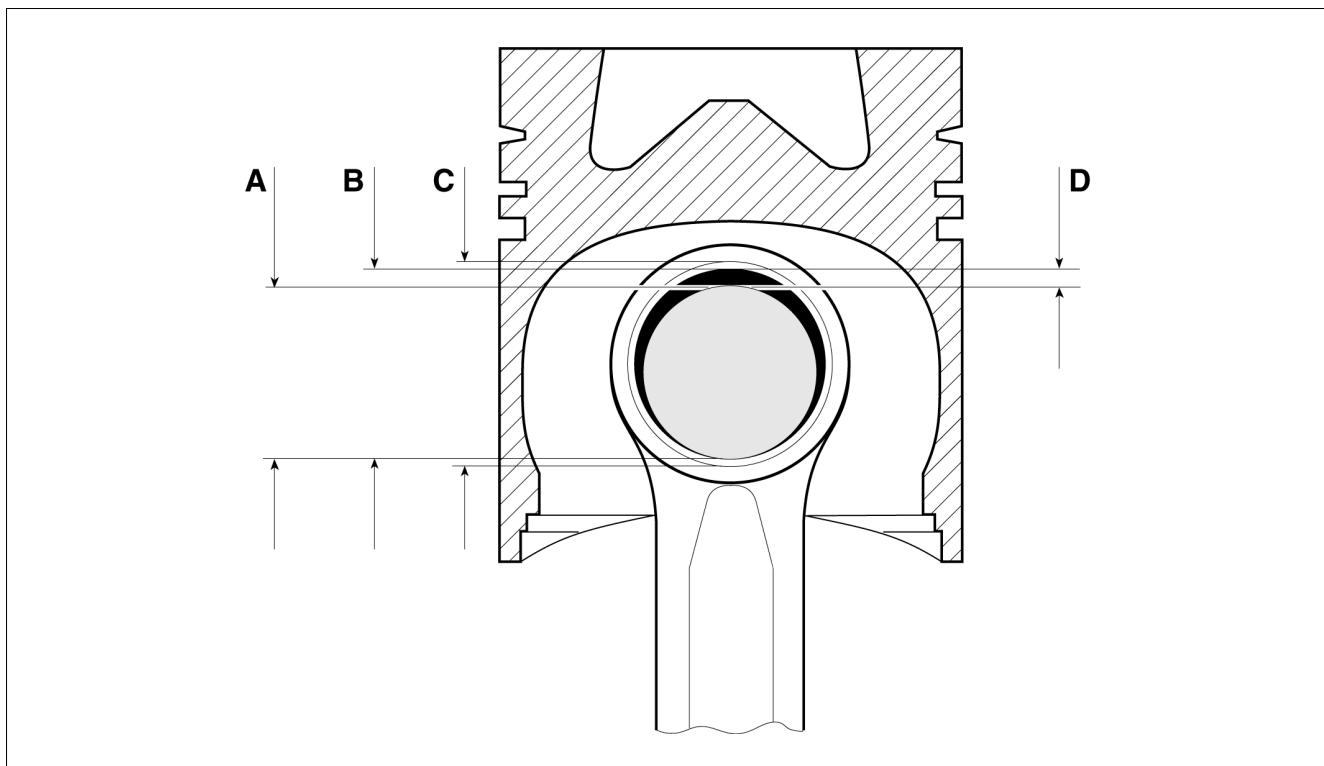
## Connecting Rods Specifications



Radial Clearance	(mm)
Nominal	0.022 - 0.087
Maximum	0.178



Side Clearance	(mm)
Nominal	0.30 - 0.50
Maximum	0.90

**Piston and Pin**

<b>ØA Piston Pin</b>	
<b>Diameter</b>	<b>(mm)</b>
Nominal	37.994 to 38.000
Maximum	37.900

<b>ØB Connecting Rod Bushing (assembled)</b>	
<b>Diameter</b>	<b>(mm)</b>
Nominal	38.030 to 38.080
Maximum	38.140

<b>ØC Connecting Rod Bushing (housing)</b>	
<b>Diameter</b>	<b>(mm)</b>
Nominal	41.000 to 41.016

<b>ØD Piston Pin</b>	
<b>Clearance</b>	<b>(mm)</b>
Nominal	0.030 to 0.086
Maximum	0.150



## Pre-Assembly Inspections and Measurements

Visually check pistons, pins and connecting rods.



Check piston pin for marks, scratches or excessive waste.

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



Check connecting rod, possible damages, marks or waste. Damages on the connecting rod stem (profile "I") could cause cracks and rupture of the connecting rod. Measure the bore of the connecting rod bushing housing.

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). Measure the diameter of the connecting rod without the bearing shells, at 30° of the partition of the connecting rod, checking out-of-roundness.

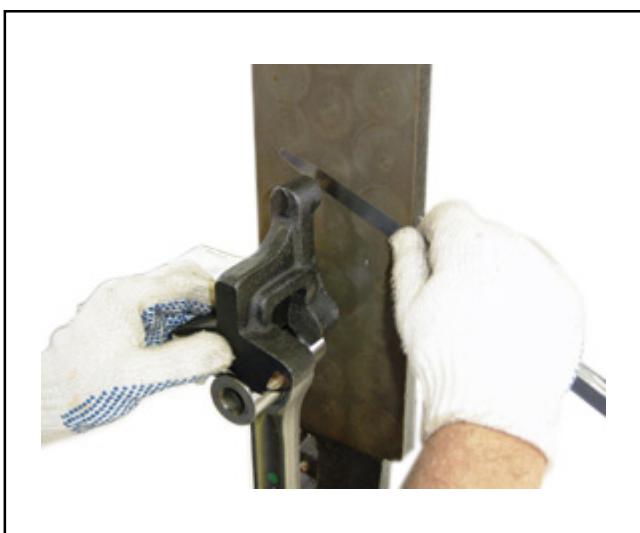


Turn the bore gauge 90° and perform the second measurement of the diameter.



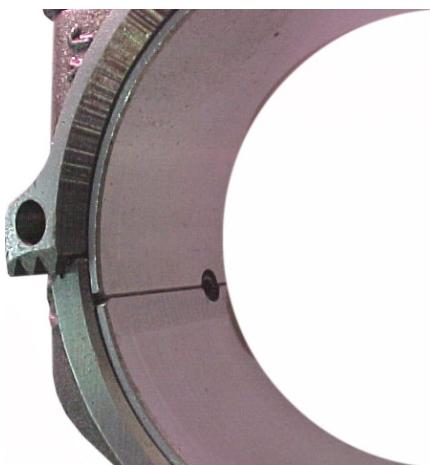
Check connecting rod torsion.

**Maximum Torsion = 0.10 mm**



Check connecting rod warping.

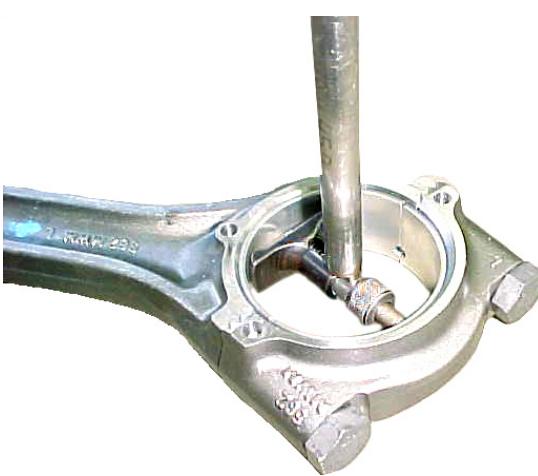
**Maximum Warping = 0.03 mm**



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



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

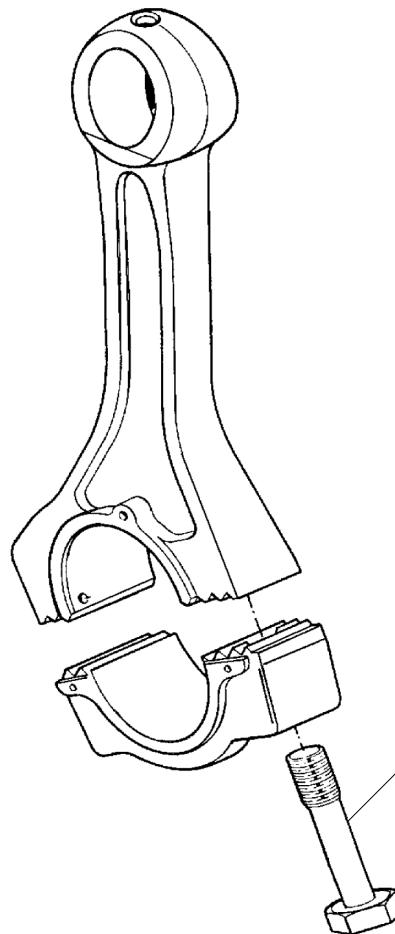


Measure the clearance with the bore gauge turned 90° from the partition of the bearing shells.



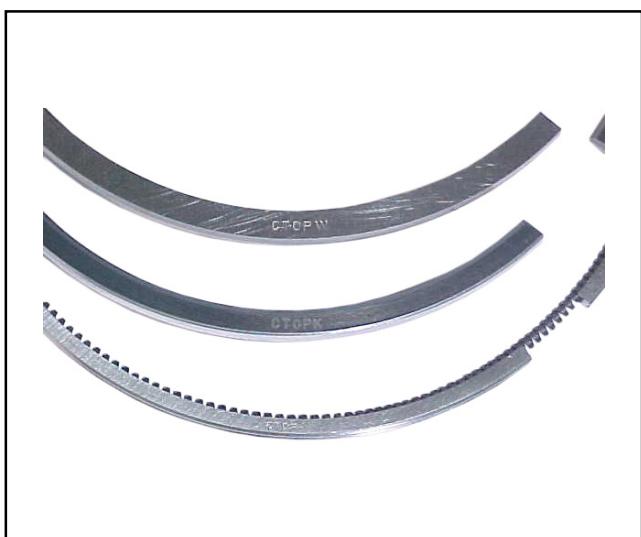
With the bore gauge at 90° from the partition of the connecting rod, reset the dial indicator gauge, remove one of the connecting rod bolts and measure its pre-tension.

**Pre-tension = 0.06 - 0.12 mm**

**Connecting Rod Bolts Tightening Specification****Torque-Angle****Etep**

1st .....  $30 \pm 5$  Nm  
2nd .....  $60^\circ \pm 3^\circ$

**Lmax = 59.20 mm**



## Assembly

The "CTOPW", "CTOPK" and "CTOP" marks must be upward.



Assembly the piston rings.



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

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

**Pistons and Connecting Rods**

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



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



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

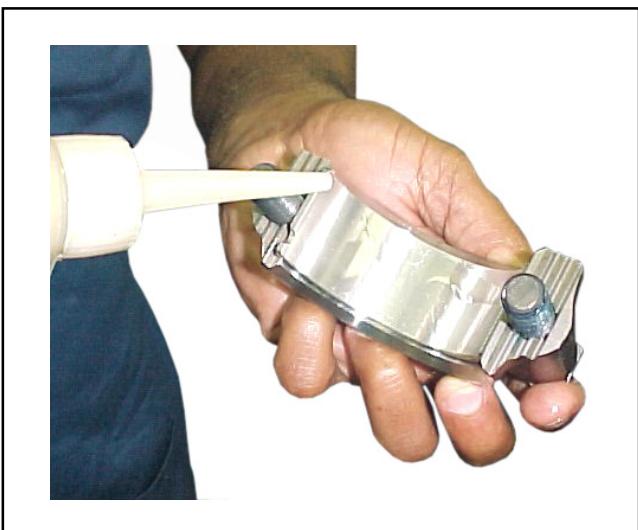


Install the device for piston assembly to close the rings.

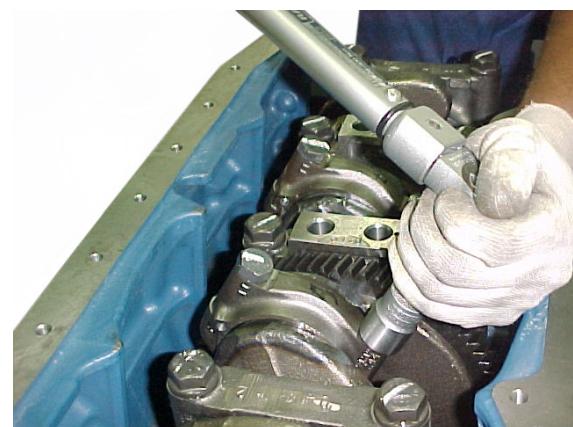
**Note:** Position the engine flywheel upward. This avoids the contact of the connecting rod with the oil injectors.



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



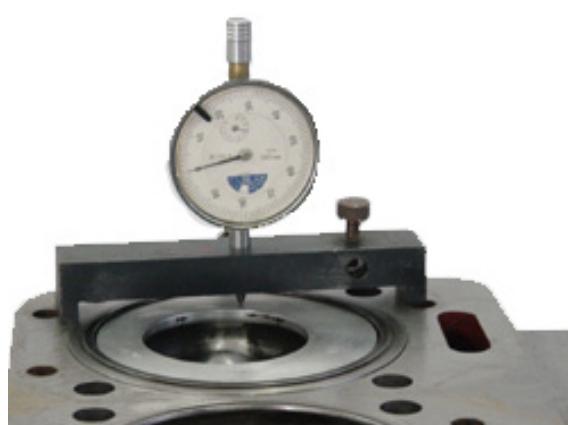
Lubricate the two inner halves of the bearing shells.

**Pistons and Connecting Rods****MWM ACTEON**

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



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



With the piston on TDC, measure the surface height in relation with the engine block surface. Check the positions of the piston arrows.