SERVICE MANUAL

LOADALL (ROUGH TERRAIN VARIABLE REACH TRUCK)
533-105, 535-v125, 540-140, 540-170, 540-200, 540-v140, 540-v180, 550-140, 550-170

EN - 9813/9100 - ISSUE 1 - 11/2017

Foreword

The Operator's Manual

⚠

You and others can be killed or seriously injured if you operate or maintain the machine without first studying the Operator's Manual. You must understand and follow the instructions in the Operator's Manual. If you do not understand anything, ask your employer or JCB dealer to explain it.

Do not operate the machine without an Operator's Manual, or if there is anything on the machine you do not understand.

Treat the Operator's Manual as part of the machine. Keep it clean and in good condition. Replace the Operator's Manual immediately if it is lost, damaged or becomes unreadable.

Contents

00 - General

Introduction

The valve train system opens and closes the valves with correct timing in relation to the piston movements.

Each push rod has one end in a hydraulic tappet and the other end under a rocker arm.

The hydraulic tappet automatically adjusts the clearance between the rocker and push rods.

The valves extend through the cylinder head. There are no sleeves or valve guides in the cylinder head. The valves are made from a special metal to provide a long service life. Damaged or worn valves cannot be lapped or reground and must be replaced with new ones. Each valve stem has an oil seal.

The valve seat inserts are pressed into the cylinder head. The seat inserts are also made from a special metal to provide for a long service life. Damaged or worn seat inserts can be removed and replaced with new ones.

Technical Data

Table 106. Inlet and Exhaust Valve Data

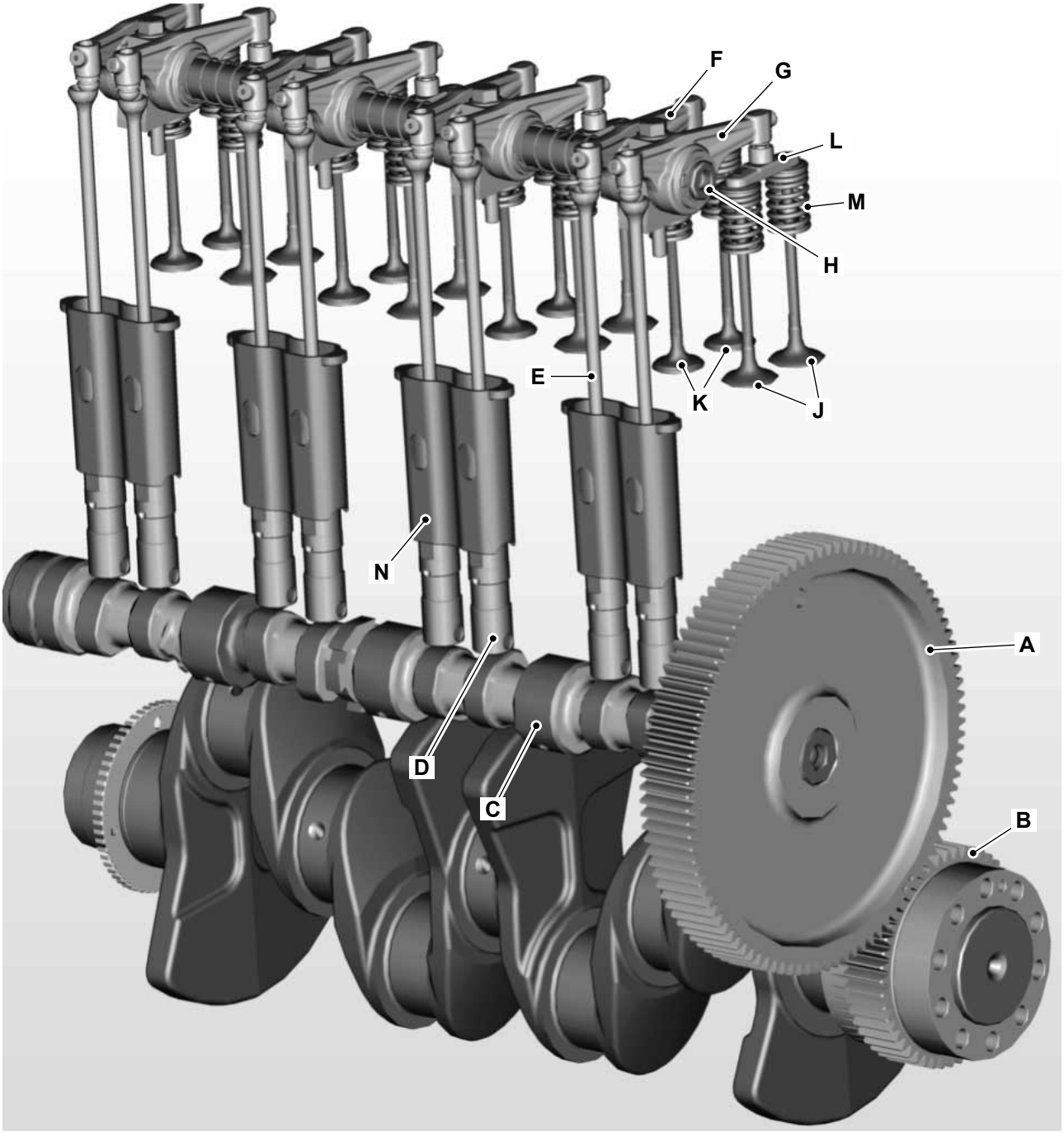
Max lift Inlet	7.56mm @ 101°ATDC (After Top Dead Centre)
Max lift Exhaust	7.32mm @ 109 BTDC (Before Top Dead Centre)
Inlet opens (top of ramp)	4.4°BTDC
Inlet closes	50.6°ABDC (After Bottom Dead Centre)
Exhaust opens	48.4°BBDC (Before Bottom Dead Centre)
Exhaust closes	34.6°ATDC
Valve stem diameter	
- Inlet	5.94–5.955mm
- Exhaust	5.93–5.945mm
Valve spring free length(1)	47.2mm
Valve guide bore diameter	
- min	5.992mm
- max	6.008mm
Valve face angle	
- Inlet	60.5°
- Exhaust	45.1°
Valve length	111.05–111.55mm
Valve sealing	Stem seal with garter spring
Valve head depth (below cylinder head surface)	
- Inlet	0.624–1.024mm
- Exhaust	0.6–1mm
Valve timing	-0.1mm lash (compensated)

(1) The valve spring is an asymmetric coil pitch spring. The spring is assembled with a particular orientation.

Refer to: PIL 15-30-00.

Component Identification

Figure 312.



A Camshaft gear
B Crankshaft gear
C Camshaft
D HLA (Hydraulic Lash Adjuster) (x8)
E Push rods (x8)
F Rocker - exhaust (x4)
G Rocker - inlet (x4)
H Rocker shaft
J Valve - inlet (x8)
K Valve - exhaust (x8)
L Bridge piece (x8)
M Valve spring (x16)
N HLA Guide (x4)

Remove and Install

Special Tools

Description	Part No.	Qty.
Valve Stem Seal Installation Tool (430 Engine)	320/03890	1

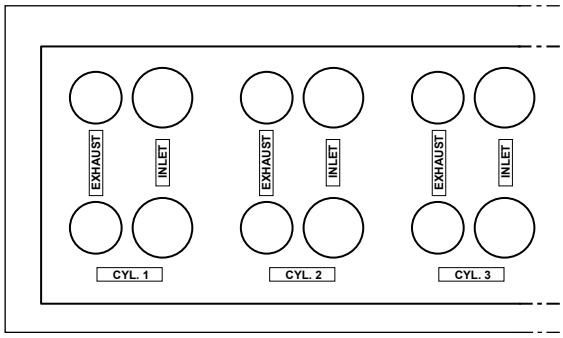
Before Removal

1. This procedure requires service parts. Make sure you have obtained the correct service parts before you start. Refer to Parts Catalogue.
2. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
3. Get access to the engine.
4. Remove the cylinder head assembly.

   Refer to: PIL 15-06-00.
5. Measure the valve recession with a suitable DTI (Dial Test Indicator). Clean the carbon deposits from a small area of the valve heads for location of the DTI probe. If the valve recession is outside the serviceable limits, it is advisable to obtain a new or reconditioned cylinder head assembly.

   Refer to: PIL 15-06-00.
6. To aid removal and Installation, use a wooden valve stand to retain the valves after removal. Add labels to make sure that the valves are correctly replaced.

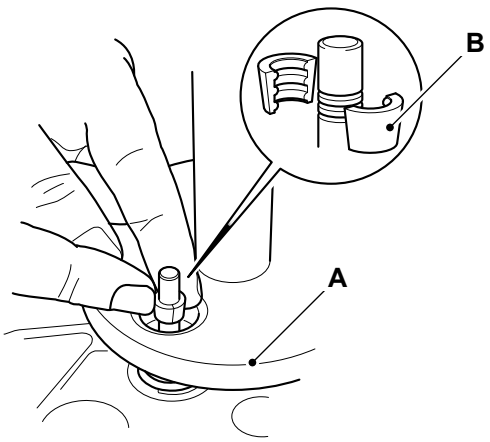
Figure 313. Valve Stand



Remove

1. Use a spring compressor tool to compress each valve spring and remove the collets. Make sure that the springs are compressed squarely.

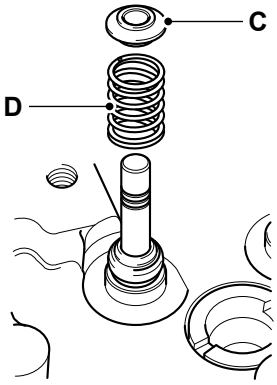
Figure 314.



A Spring compressor tool
B Collets

2. Remove the spring compressor tool and lift off the retainer and valve spring.

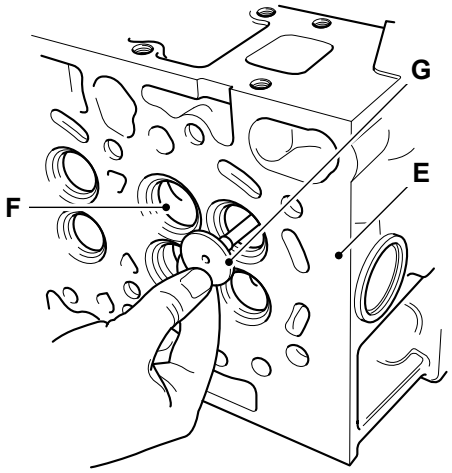
Figure 315.



C Retainer
D Valve spring

3. Turn the cylinder head on its side and withdraw the inlet valves and exhaust valves as shown.

Figure 316.

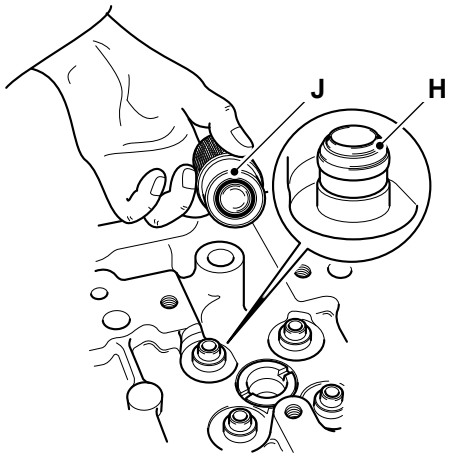


E Cylinder head
F Inlet valves
G Exhaust valves

4. When removing, note the respective position of each valve. Use a suitable valve stand to keep the valves together and identify them with their respective cylinder. The exhaust valves have smaller diameter heads.

5. Remove the valve stem seals. Discard the seals.

Figure 317.



H Valve stem seals
J Punch tool

Inspection

1. Carefully clean the carbon deposits from the valves, take care not to damage the valve seats.

2. Check that the valves and valve seats are not cracked, burnt or damaged.

3. Check the valve stems and valve guides for wear.

   Refer to: PIL 15-30-00.

If there is evidence of wear or damage to the valves, guides or seats, it is advisable to obtain a new or reconditioned cylinder head assembly.

Before Installation

1. Position the cylinder head upside down in a suitable jig or fixture.

2. Make sure that all items are clean and free from damage and corrosion.

3. Install the injectors into the cylinder head to do a trial check of the nozzle protrusion. Note the relative positions for the injectors, and then remove the injectors for installation at a later stage.

Installation

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.

2. Install the new valve stem seals as shown. Use the installation tool to avoid damaging the seals. Pre-assemble the seal into the tool. Locate the tool over the valve guide and gently press the seal into place. Lubricate the seal with P80 fluid.

   Special Tool: Valve Stem Seal Installation Tool (430 Engine) (Qty.: 1)

3. With the cylinder head on its side, insert the inlet valves and exhaust valves as shown. Make sure that the valves are installed in the correct positions. Lubricate the valve stems with clean engine oil before assembly. Carefully push the end of the valve stem through the stem seals.

4. Install the valve springs on to the valve stems, together with a retainer.

   4.1. Make sure that the valve springs are orientated correctly, the white painted end of the valve spring must go at the top.

5. Use the spring compressor tool to compress each valve spring and insert the collets. Make sure that the collets are correctly seated in the valve stem grooves before you remove the spring compressor tool.

After Installation

1. Pop the valves by tapping the valve stems in turn using a rubber mallet.

Check (Condition)

1. Check the bearing shell surfaces for signs of damage and excessive wear.

   Refer to: PIL 15-33-00.

2. Measure the crank pin diameters to confirm they are within service limits.

   Refer to: PIL 15-12-00.

3. Renew any parts that are worn or not within the specified tolerances.

Remove and Install

Special Tools

Description	Part No.	Qty.
Torque Wrench (10-100Nm)	993/70111	1

Before Removal

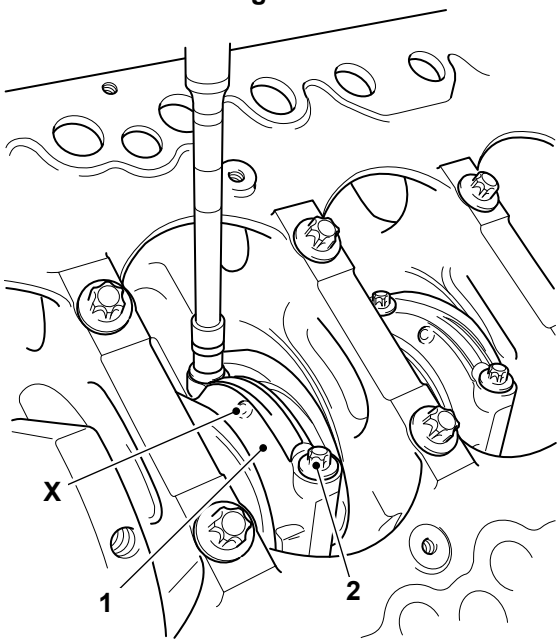
1. This procedure requires service parts. Make sure you have obtained the correct service parts before you start. Refer to Parts Catalogue.
2. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
3. Get access to the engine.
4. Disconnect and remove the fuel pipes from the injectors. Refer to (PIL 18-96).
5. Remove the rocker cover. Refer to (PIL 15-42).
6. Remove the fuel injectors. Refer to (PIL 18-18).
7. Drain the oil from the engine. Refer to (PIL 15-21).
8. Remove the oil sump. Refer to (PIL 15-45).
9. Position the engine upside down in a suitable jig or fixture, supported at the front of the crankcase.

The connecting rod and the big-end bearing cap have been fracture split and must be kept together as a set. Care must be taken to avoid contamination and or damage to the fracture split surfaces.

Remove

1. It is recommended that the big-end bearing caps are removed in pairs, cylinders 1 and 4 and cylinders 2 and 3. Rotate the crankshaft so that the big-end bearing caps on cylinders 2 and 3 are positioned as shown.
2. Remove the bolts and lift off the big-end bearing caps from the connecting rods. The bolts must not be re-used, discard the bolts.

Figure 318.

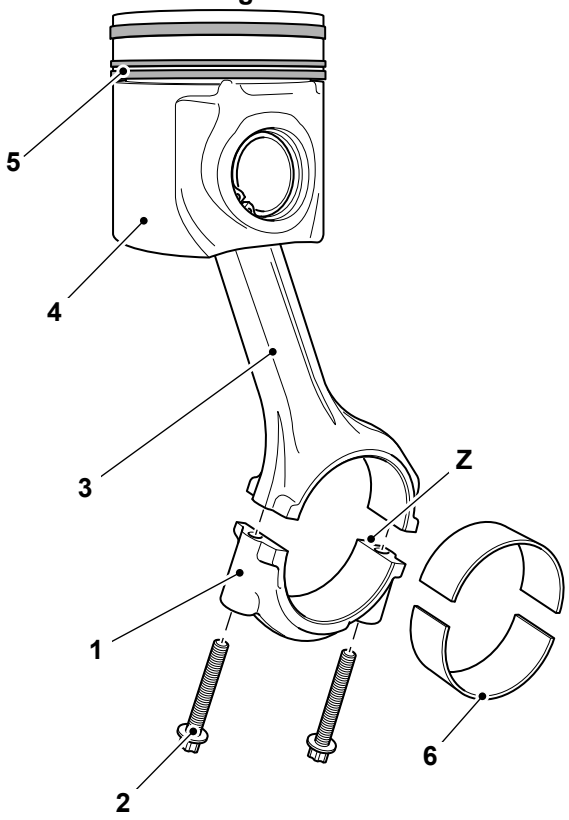


1 Big-end bearing caps
2 Big-end bearing cap bolts
X Cast notch

2.1. Make sure that the tool is kept in inline with the bolt to avoid damaging the screw thread.

3. Lift out the bearing shells from the bearing caps. Carefully rotate the crank to disengage from the connecting rods and get access to the upper bearing shells. Lift out the upper bearing shells. It is recommended that the bearing shells are renewed. If they are to be reused, label the bearing shells to make sure that they are installed in their original positions on assembly.

Figure 319.



1 Big-end bearing cap
2 Bolts
3 Connecting rod
4 Piston
5 Piston rings
6 Big end bearing shells
Z Fracture split surfaces

4. Carefully rotate the crankshaft to position the big-end bearing caps of cylinders 1 and 4. Make sure that the crank does not foul the connecting rods of cylinders 2 and 3. Remove the bearing caps and bearing shells as described in previous steps.

5. Inspect the big-end bearings for signs of damage and excessive wear. Refer to Check Condition (PIL 15-12).

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.

2. Make sure that all items are clean and free from damage and corrosion.

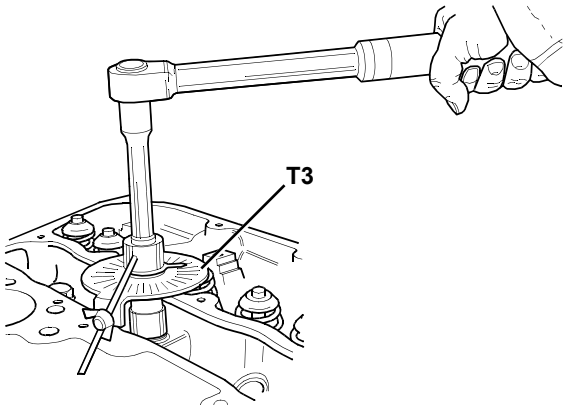
3. Install the upper bearing shell to the connecting rod. Lubricate the bearing shell with clean engine oil.

4. Install the lower bearing shell to the big-end bearing cap. Lubricate the bearing shell with clean engine oil. Install the big-end bearing cap to the connecting rod. Make sure that the cast notch on the bearing cap faces to the front of the engine. Use compressed air to clean the fracture surfaces before assembly.

5. Install new fixing bolts. Tighten the new bolts in three stages to the correct torque value.

   Special Tool: Torque Wrench (10-100Nm) (Qty.: 1)

Figure 320.

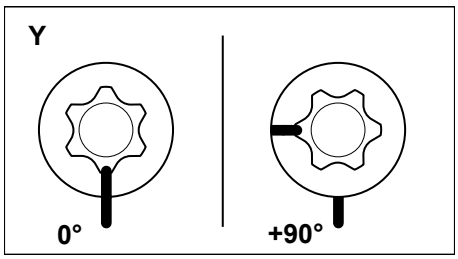


T3 Angle gauge (obtain locally)

5.1. Make sure that the tool is kept in inline with the bolt to avoid damaging the screw thread.

6. The bolts are tightened using a torque and angle method. Refer to Fasteners and Fixings, General, Introduction (PIL 72-00).

Figure 321.



After Installation

1. Carry out the procedures listed in Before Removal in reverse order.

Table 108.

Item	Torque Value
2 - 1st Stage	35N·m
2 - 2nd Stage	65N·m
2 - Final Stage	90°

Technical Data

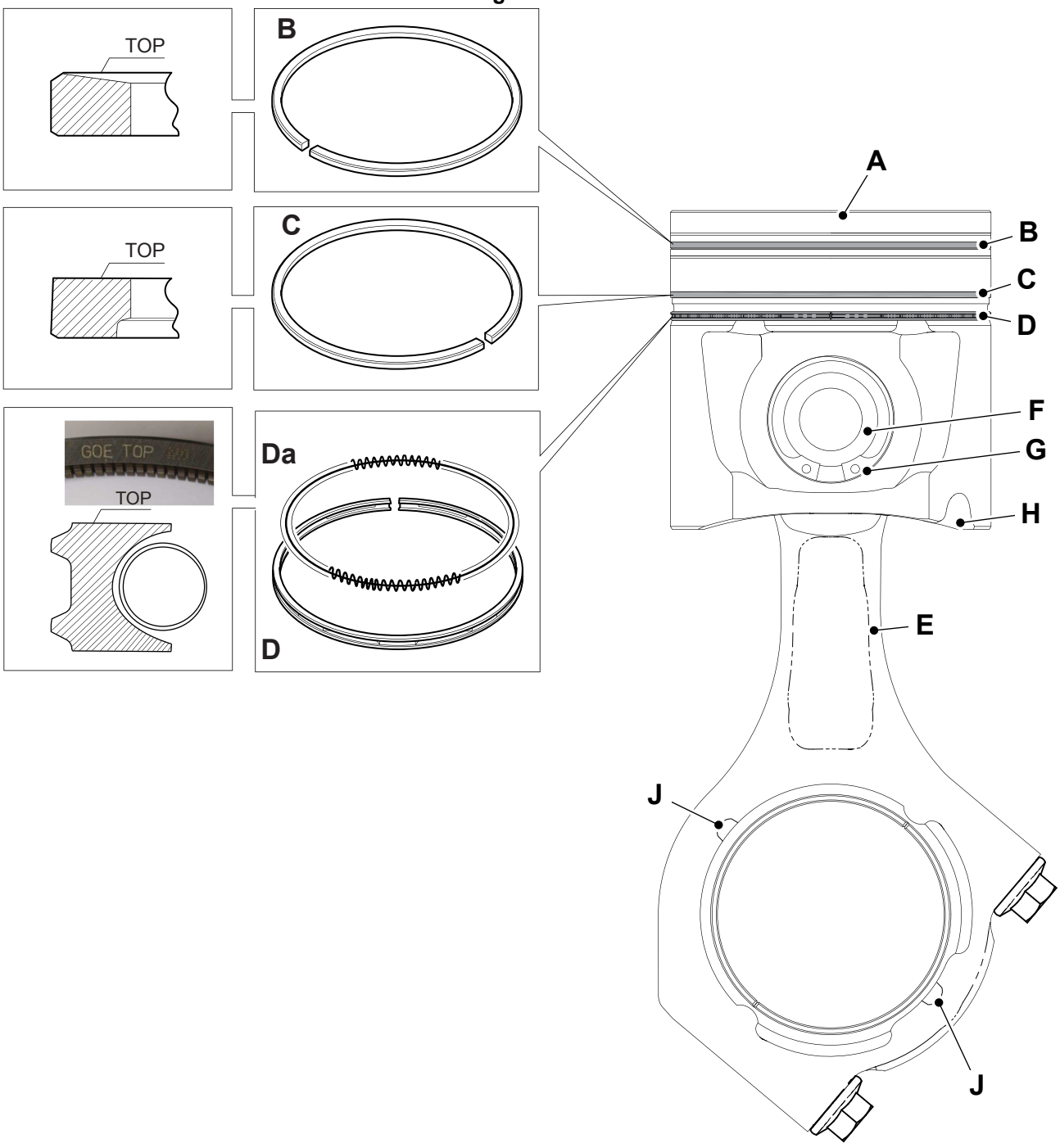
Table 109. Piston Data

Gudgeon pin bore diameter	
- min.	36.01mm
- max.	36.015mm
Piston ring clearance	
- Top ring	0.155–0.12mm
- Middle ring	0.13–0.09mm
- Bottom (oil) ring	0.08–0.02mm
Piston ring gap	
- Top ring	0.25–0.35mm
- Middle ring	0.6–0.8mm
- Bottom (oil) ring	0.25–0.5mm
Piston height above crankcase (cold)	0.239–0.558mm(1)
Piston groove width	
- Top ring	1.952mm(2)
- Middle ring	1.83–1.85mm
- Bottom (oil) ring	2.53–2.55mm
Piston skirt	91.861–91.879mm
Piston pin	35.994–36mm

(1) Nominal measurement is 0.426mm
(2) Measure at gauge diameter 88.01 ± 0.38mm

Component Identification

Figure 322.



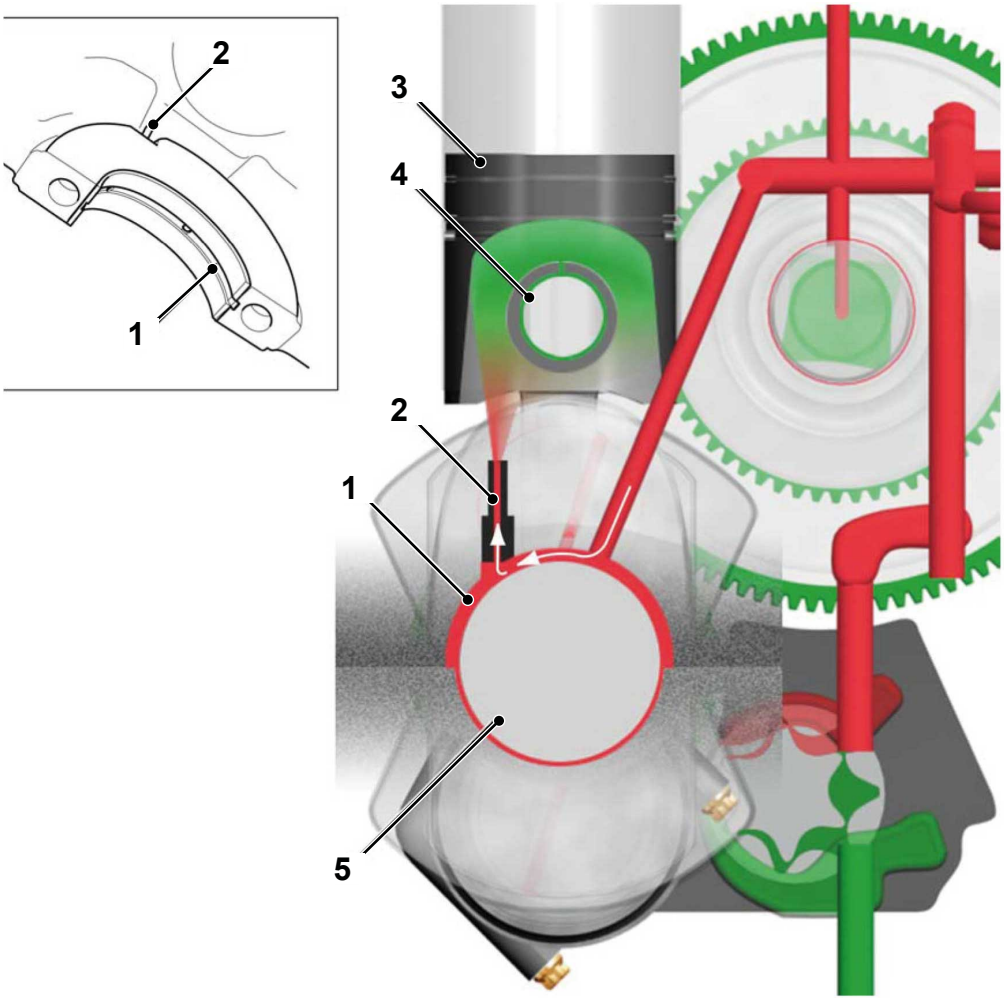
A Piston
B Piston ring - compression No.1
C Piston ring - compression No.2
D Piston ring - oil control ring
Da Spiral wire - oil control ring
E Connecting rod
F Piston pin
G Retaining circlip (x2)
H Piston orientation cut out
J Main bearing cap orientation mark

Operation

The groove around the diameter of the upper main bearing shells allows oil transfer to an oil jet located in the crankcase bearing saddle. Jets are installed at the main bearing positions.

The jets spray oil directly to the under side of the pistons effectively transferring heat away from the top of the pistons. Oil spray also enters the small end bearing bushes via a feed hole on the top of each connecting rod.

Figure 323.



1 Groove
2 Oil jet
3 Pistons
4 Bearing bushes
5 Crankshaft

Check (Condition)

1. Check the piston for signs of damage and excessive wear. Measure the piston skirt diameter, piston pin bore and the clearance in the piston ring grooves to confirm they are within service limits.

   Refer to: PIL 15-36-00.

2. Check the piston pin for signs of damage and excessive wear. Measure the pin diameter to confirm it is within service limits. Refer to Piston.

   Refer to: PIL 15-36-00.

The connecting rod small end bearing bush is not renewable. If the small end bearing bush is damaged or worn the connecting rod must be renewed as a complete assembly.

Calibrate

Piston Height Measurement Above Cylinder Block- DTI Method

In the event of sufficient liquid entering the engine, a hydraulic lock can occur. This may result in bending of one or more of the connecting rods. Bending of the connecting rod(s) can occur even when the engine is cranked by the starter motor.

Bending of the connecting rod may be very slight and can be checked by carrying out this procedure prior to a full strip down:

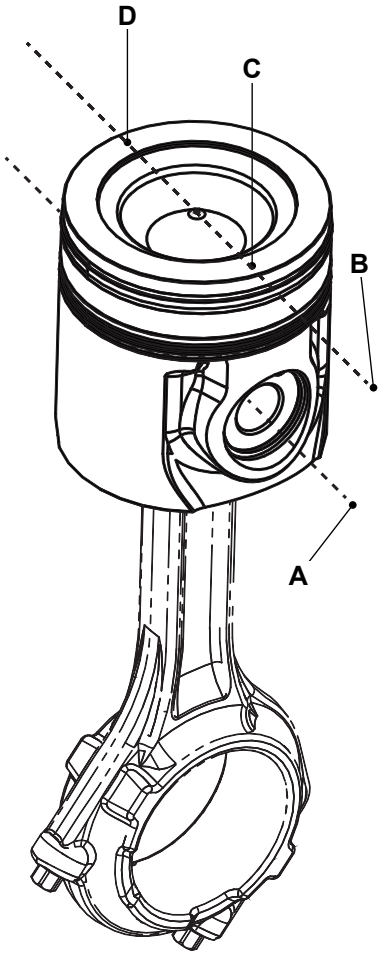
1. With the cylinder head removed, make sure the surface of the engine block and piston are clean.
2. Zero a DTI (Dial Test Indicator) on the top face of the cylinder block adjacent to the area on the piston to be measured. The aim of the procedure is to use the DTI to take a measurement across 2 locations on the piston that are on the axis of the gudgeon pin. This will be towards the front and rear of the engine.
3. Rotate the engine and bring the piston up until it is 3mm below the engine block face. Carefully reposition the zeroed DTI above the area of the piston to be measured.
4. Rotate the engine to bring the piston up to exactly TDC (Top Dead Centre) and record the measurement at position 1.
5. Repeat steps 2 to 4 for position 2.
6. Calculate the average of the 2 readings to give a figure of the piston height above the cylinder block.
7. Compare the reading obtained to the technical data.

   Refer to: PIL 15-36-00.

   7.1. If the reading obtained is lower than zero, the connecting rod may be bent.

   7.2. If the reading obtained is equal to the range stated in technical data, the connecting rod is not bent.
8. Repeat steps 2 to 7 to check all connecting rods/ pistons.
9. If any connecting rods are bent, strip the engine and check for further damage.
10. If the engine is serviceable, any connecting rod that is bent must be replaced.

Figure 324. DTI Measurement



A Gudgeon pin axis
B Line of measurement above gudgeon pin axis
C Piston measurement point 1
D Piston measurement point 2

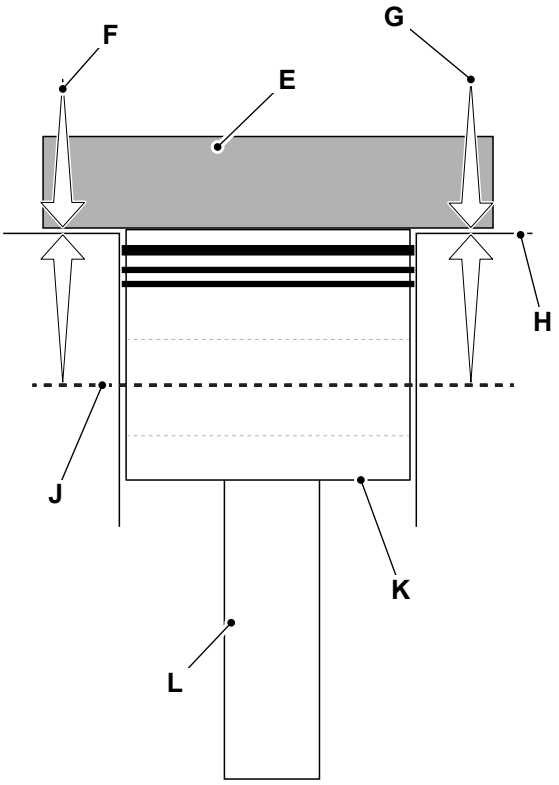
Piston Height Measurement Above Cylinder Block- Straight Edge Method

If a DTI is not available, a calibrated straight edge may be used to take a measurement. The measurement will be less accurate.

1. With the cylinder head removed, make sure the surface of the engine block and piston are clean.
2. Rotate the engine until the piston to be measured is at TDC.
3. Position the straight edge on top of the piston along the axis of the gudgeon pin.
4. Use feeler gauges to measure the gap between the cylinder block face and underside of the straight edge on both sides, position 1 and position 2.
5. Calculate the average of the 2 readings to give a figure of the piston height above the cylinder block.
   - 5.1. If the reading obtained is lower than zero, the connecting rod may be bent.
   - 5.2. If the reading obtained is equal to the range stated in technical data, the connecting rod is not bent.

     Refer to: PIL 15-36-00.
6. Repeat steps 1 to 5.2 to check all connecting rods/pistons.

Figure 325. Straight Edge Measurement



E Straight edge
F Measurement position 1
G Measurement position 2
H Cylinder block- top face
J Gudgeon pin axis
K Piston
L Connecting rod

Remove and Install

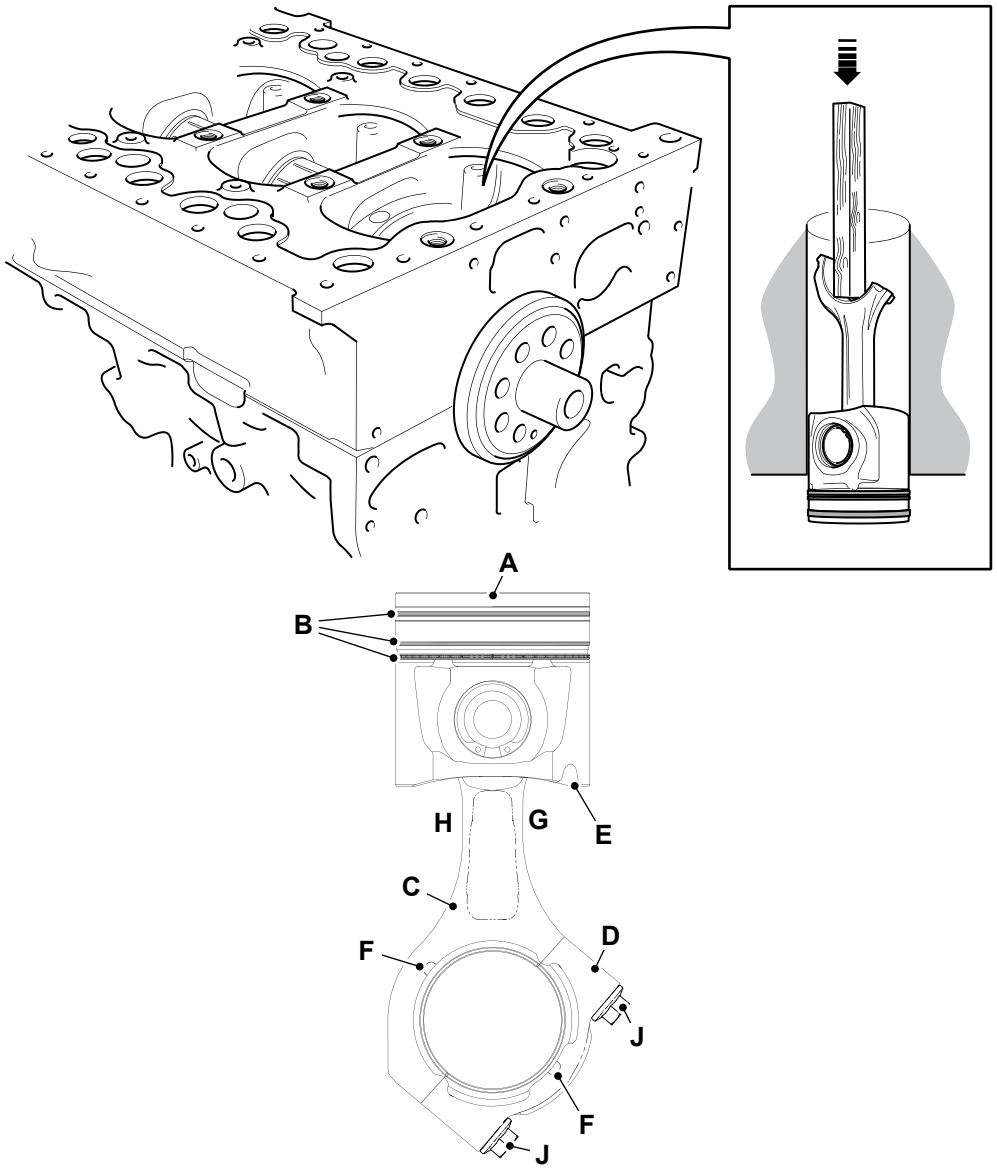
Before Removal

This procedure requires service parts. Make sure you have obtained the correct service parts before you start. Refer to Parts Catalogue.

The following procedure is for one piston and connecting rod assembly. Each assembly must be replaced in the same cylinder bore. Label each piston and connecting rod assembly to make sure it is installed in the correct position on assembly.

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Remove the engine from the machine.
   Refer to: PIL 15-00-00.
3. Remove the ECM (Engine Control Module).
   Refer to: PIL 33-45-06.
4. Remove the fuel injector cover.
   Refer to: PIL 18-18-04.
5. Remove the fuel injectors.
   Refer to: PIL 18-18-03.
6. Remove the rocker cover.
   Refer to: PIL 15-42-06.
7. Remove the cylinder head assembly.
   Refer to: PIL 15-06-00.
8. Remove the oil sump.
   Refer to: PIL 15-45-00.

Figure 326.



A Piston
B Piston rings
C Connecting rod
D Big end bearing cap
E Piston cut out - intake side of crankcase
F Big end bearing cap orientation marks
G Shortest side of connecting rod - intake side of crankcase
H Longest side of connecting rod - exhaust side of crankcase
J Big end bearing cap bolts

Remove

The piston and connecting rod assemblies are removed through the top of the crankcase.

1. Remove the big end bearing caps.
2. Use a suitable scraper and wire wool to clean off the carbon deposits from around the top of the cylinder bore. Take care not to scratch or damage the cylinder bore.
3. Use a hammer and a short length of wood to tap the piston from the connecting rod side. Take care not to scratch or damage the cylinder bore or the connecting rod bearing surface.

Before Installation

1. Check the big end bearings and the crank shaft for signs of wear.

   Refer to: PIL 15-33-06.

Install

1. Make sure that all items are clean and free from damage and corrosion.
2. Make sure that the big end bearing shells are installed correctly.
3. Lubricate the cylinder bore with clean engine oil.
4. Lubricate the big end bearings with clean engine oil.
5. Use a suitable compressor tool to compress the piston rings.
6. Insert the piston and connecting rod assembly into the cylinder bore. Make sure that the longest side of the connecting rod is on the exhaust side of the crankcase and the piston cut-out is on the intake side of the engine. Take care not to damage the cooling jets when you guide the connecting rod down the cylinder bore and over the crank pin diameter.
7. Install the big end bearing cap. Make sure that it is orientated correctly, the orientation mark should be on the same side as the orientation mark on the connecting rod.
8. Install new big end bearing cap bolts. Tighten the bolts in three stages to the correct torque value.

After Installation

1. The after installation procedure is the opposite of the before removal procedure.

Table 110. Torque Table

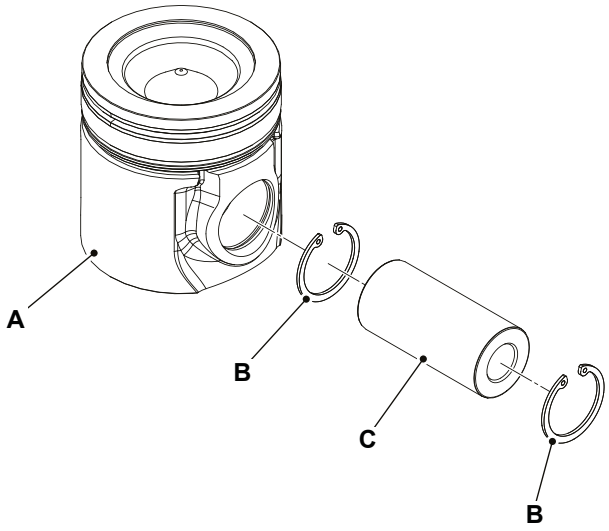
Item	Torque Value (Nm)	Angle (degrees)
J (1st Stage)	35	
J (2nd Stage)	65	
J (Final Stage)		90

Disassemble and Assemble

Dismantle

1. Clamp the connecting rod in a vice. Take care not to damage the connecting rod.
2. It is recommended that the piston rings are renewed. If they are to be reused, label the rings to ensure they are installed in the correct positions and the correct way up on assembly. Carefully remove the piston rings from the piston. To avoid damage or distortion to the rings, use a suitable piston ring expander tool. Note that the oil control ring is installed with a spiral wire. Pull the wire apart and remove it.
3. Remove the circlips and push out the piston pin.

Figure 327.



A Piston
B Circlip (x2)
C Piston pin

4. Use a suitable cleaning agent, clean the carbon deposits from the piston.

Inspect

1. Inspect the pistons for signs of wear or damage.

Assemble

1. The assembly procedure is the opposite of the disassembly procedure. Additionally do the following steps.
2. Make sure that all items are clean and free from damage and corrosion.
3. Lubricate the piston pin with clean engine oil. Assemble the connecting rod to the piston and insert the piston pin. Make sure that the short side of the connecting rod is on the same side as the cut out in the piston.
4. Install new circlips. Make sure that they are installed correctly in the groove in the piston.
5. Lubricate the piston with clean engine oil. Install the piston rings to the piston in sequence as follows:
   5.1. Install the spiral wire for the oil control ring in the bottom groove and locate the locking wire inside both ends of the spiral as shown. Using a piston ring expander tool to install the oil control ring in the bottom groove and locate the locking wire inside both ends of the spiral as shown. Make sure that the ring gap is positioned 180° to the locking wire. The correct ring orientation can also be determined from the profile shape of the ring.

   Refer to: PIL 15-36-00.

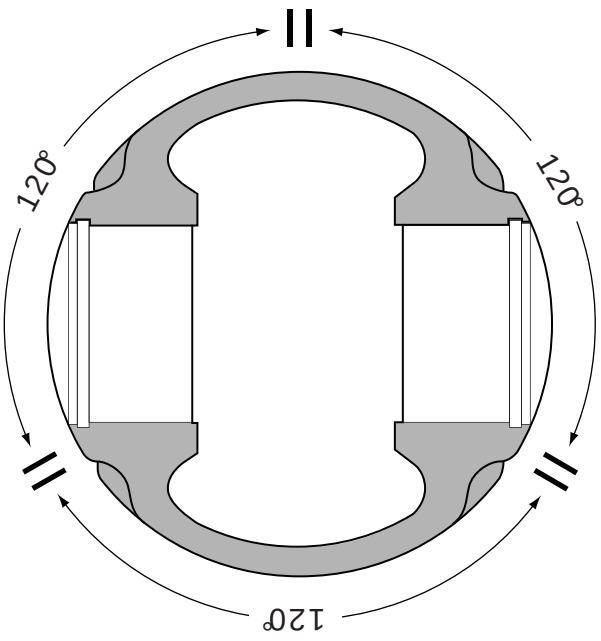
   5.2. Install the No.2 compression ring into the middle groove. New rings have a reference number etched on one face. Make sure that this face is installed uppermost in the piston groove. The correct ring orientation can also be determined from the profile shape of the ring.

   Refer to: PIL 15-36-00.

   5.3. Install the No.1 compression ring into the top groove. New rings have a reference number etched on one face. Make sure that this face is installed uppermost in the piston groove. The correct ring orientation can also be determined from the profile shape of the ring.

   Refer to: PIL 15-36-00.
6. Rotate the piston rings so that the ring gaps are 120° apart as shown.

Figure 328.



03 - Piston Ring

Introduction

Gas sealing inside the piston is achieved by the use of piston rings. The rings are loosely installed into grooves in the piston. The rings are split at a point in the rim, to allow them to press against the cylinder with a light spring pressure.

Two types of ring are used:

- Upper rings have solid faces and provide gas sealing

- Lower rings have narrow edges and have a U-shaped profile, to act as oil scrapers.