CHAPTER 2

BASIC ENGINE

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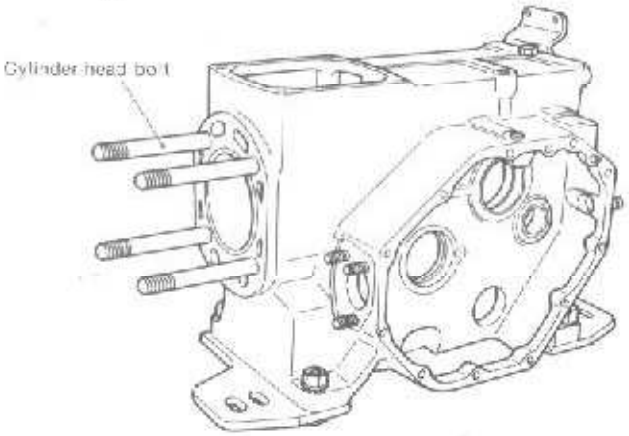
1. Cylinder Block

1-1 Construction of cylinder block

The cylinder, crank case and gear case are housed in a monoblock type cylinder block cast of high-grade cast iron. On the basis of stress analysis tests, the shape and thickness of each part have been optimized, and special ribs have been effectively arranged for increased rigidity and strength.



1-2 Cylinder block inspection

1-2.1 Inspecting each part for cracks

If the engine has been frozen or dropped, visually inspect it for cracks and other abnormalities before disassembling. If there are any abnormalities or the danger of any abnormalities occurring, make a color check.

1-2.2 Inspecting the water jacket of the cylinder for corrosion

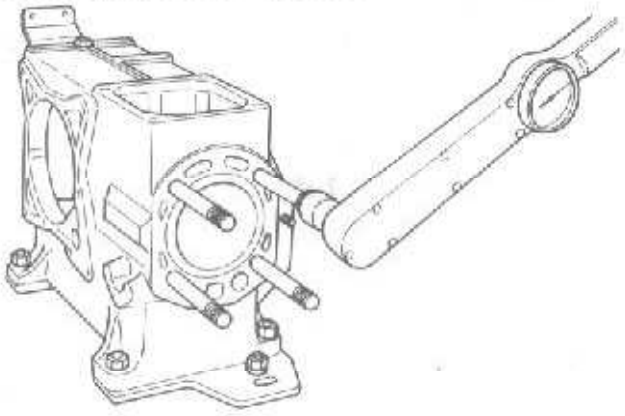
Inspect the cooling water passages and cylinder liner contact parts for sea water corrosion, scale, and rust. Replace the cylinder body if corrosion, scale or rust is severe.

Cylinder body jacket corrosion depth limit: 1.5mm

1-2.3 Cylinder head bolts

Check for loose cylinder head bolts and for cracking caused by abnormal tightening, either by visual inspection or by a color check.

Replace the cylinder block if cracked.



kg•cm (ft•lb)

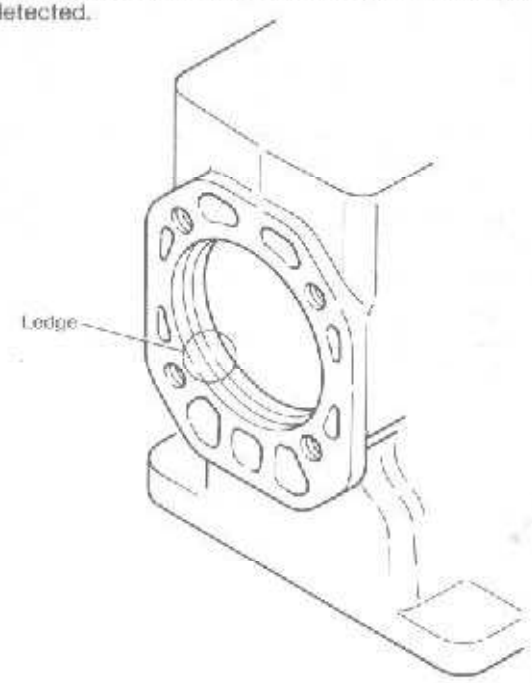
	YSM8	YSM12
Stud bolt tightening torque	450 (32.55)	450 (32.55)

1-2.4 Oil and water passages

Check the oil and water passages for clogging and build-up of foreign matter.

1-2.5 Cylinder bore and ledge

Perform a color check on the ledge at the top of the cylinder head bore, and replace the cylinder if any cracks are detected.



1-2.6 Inspection of oil hole and cooling water hole

Check each oil hole and cooling water hole for continuity. When disassembling, also check each fitting surface for impressions, etc.

1-2.7 Color check flaw detection procedure

(1) Clean the inspection point thoroughly.

(2) Procure the dye penetration flaw detection agent. This agent comes in spray cans, and consists of a cleaner, penetrant, and developer in one set.

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(3) Pretreat the inspection surface with the cleaner. Spray the cleaner directly onto the inspection surface, or wipe the inspection surface with a cloth moistened with the cleaner.

(4) Spray the red penetration liquid onto the inspection surface. After cleaning the inspection surface, spray the red penetrant (dye penetration flaw detection agent) onto it and allow the liquid to penetrate for 5-10 minutes.
If the penetrant fails to penetrate the inspection surface because of the ambient temperature or other conditions, allow it to dry and respray the inspection surface.

(5) Spray the developer onto the inspection surface. After penetration processing, remove the residual penetrant from the inspection surface with the cleaner, and then spray the developer onto the inspection surface. If the inspection surface is flawed, red dots or lines will appear on the surface within several minutes. When spraying the developer onto the inspection surface, hold the can about 30—40cm from the surface and sweep the can slowly back and forth to obtain a uniform film.

(6) Reclean the inspection surface with the cleaner.

NOTE: Before using the dye penetration flaw detection agent, read its usage instructions thoroughly.

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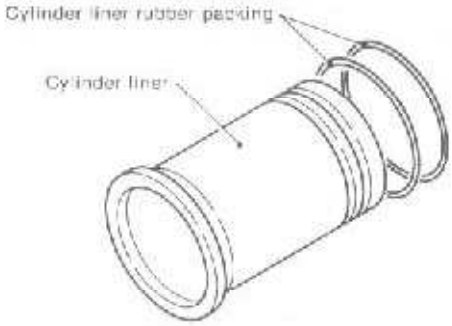
2. Cylinder Liner

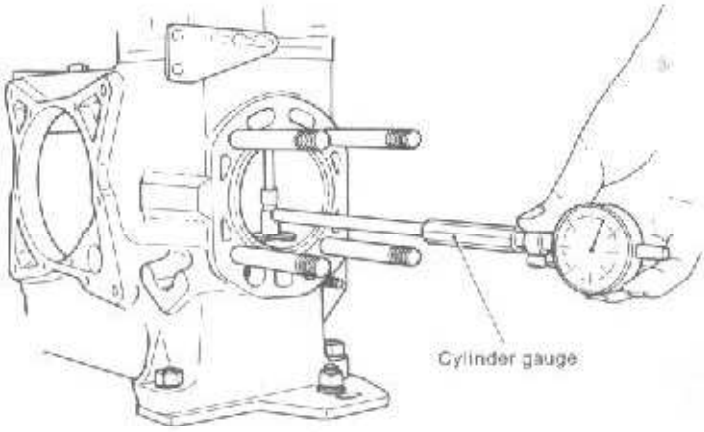
2-1 Construction of cylinder liner

The cylinder liner is made of a special, highly wear-resistant cast iron. Its inner surfaces are finished by precision honing, thereby holding lubricating oil properly and greatly improving the wear-resistant properties of the piston rings and the cylinder liner itself. Two grooves for O-rings are cut into the outer surface of the cylinder liner. The two O-rings prevent the deformation and distortion of the cylinder liner, and at the same time, maintain maximum water tightness between the cylinder block and the cooling water jacket.



2-2 Inspection

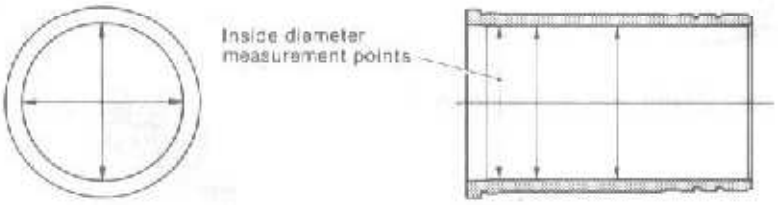
Since the piston and piston rings constantly slide against the cylinder liner while the engine is in operation, and side pressure is applied to the cylinder liner by the movement of the crankshaft, eccentric wear occurs easily.
Moreover, if lubrication and cooling are insufficient, the inner surface will be damaged or rusted. Inspect the inner surface and replace the cylinder liner if the surface is noticeably damaged or rusted.



2-3 Cylinder liner bore diameter measurement

Measure the bore diameter of the cylinder liner with a cylinder gauge at the positions shown in the figure.

Replace the cylinder liner when the measured value exceeds the wear limit.



mm (in.)

		Maintenance standard	Maximum allowable clearance	Wear limit
YSM8	Cylinder liner diameter	$\varnothing 75\ ^{+0.03}_{0}$ ($2.9528\ ^{+0.00118}_{0}$)	0.3 (0.0118)	ø75.17 (2.9594)
	Piston outside diameter	ø75 (2.9528)		
	Cylinder liner circularity	0.02 (0.0008)	—	0.1 (0.0039)
YSM12	Cylinder liner diameter	$\varnothing 85\ ^{+0.035}_{0}$ ($3.3465\ ^{+0.00137}_{0}$)	0.3 (0.0118)	ø85.19 (3.3539)
	Piston outside diameter	ø85 (3.3465)		—
	Cylinder liner circularity	0.02 (0.0008)	—	0.1 (0.0039)

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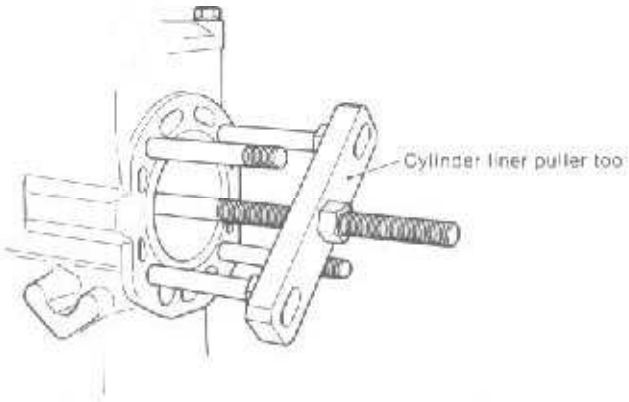
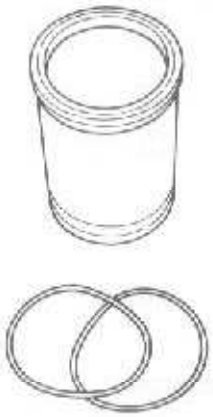
2-4 Cylinder liner replacement

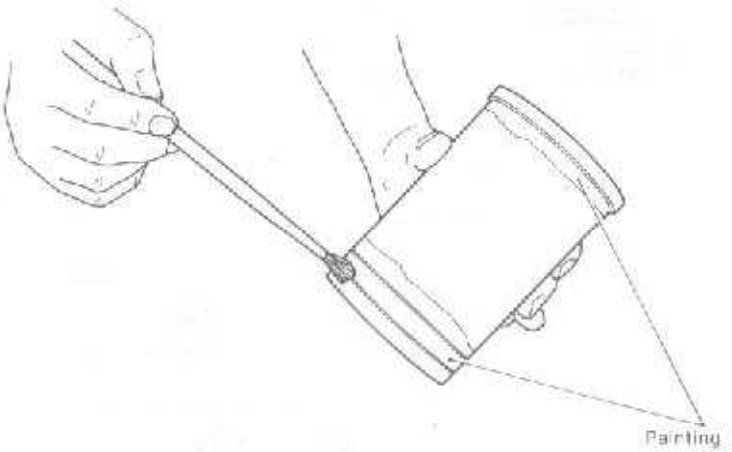
(1) Pull the cylinder liner to the top of the cylinder block as shown in the figure, using the special cylinder liner puller tool.



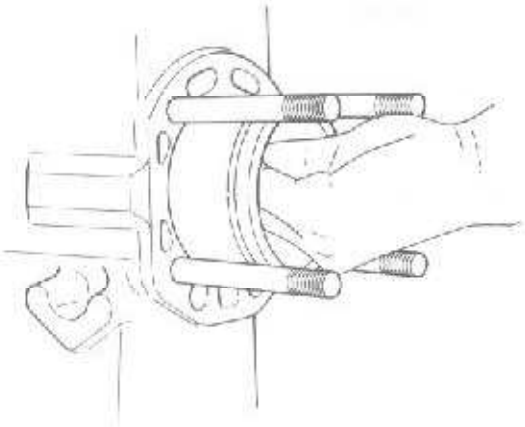
(2) Remove the rust from the area where the cylinder liner contacts the cylinder block.
(3) Install new O-rings in the two O-ring grooves of the cylinder liner.



(4) Coat the outside of the cylinder liner with waterproof paint or grease.



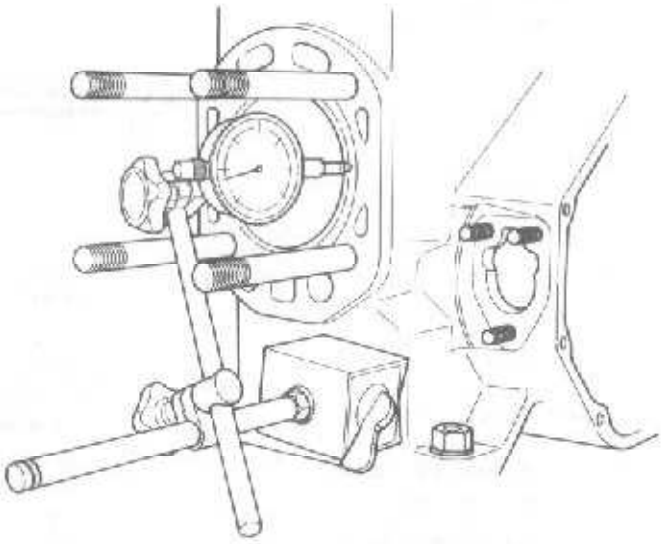
(5) Push the cylinder liner into the cylinder liner hole of the cylinder block.



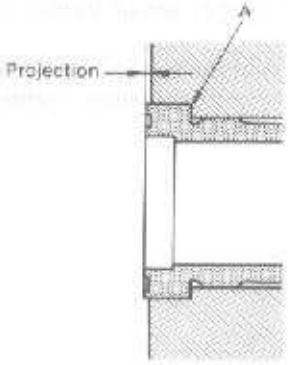
(6) After inserting the liner, measure its bore diameter.
(7) Measure the amount of liner projection.

Notes: 1. Determine whether or not the cylinder liner can be lightly inserted in the cylinder block in the absence of the rubber packing for cylinder liner.
2. Do not force the cylinder liner into the cylinder block. If there is some resistance when the liner is inserted, the cylinder block has not been derusted properly.
3. Always use a brand new rubber packing for the cylinder liner.

2-5 Measuring cylinder liner projection



If the cylinder liner projects too far from the block, the torque reactance will increase, causing the compression ratio to drop and the gasket packing to be damaged.
Excessive cylinder liner projection is frequently caused by incomplete removal of the rust at the ledge (part A of figure) of the cylinder block.



mm (in.)

Cylinder liner projection (YSM8/YSM12)	0.06 ~ 0.14 (0.0024 ~ 0.0055)

3. Cylinder Head

3-1 Construction

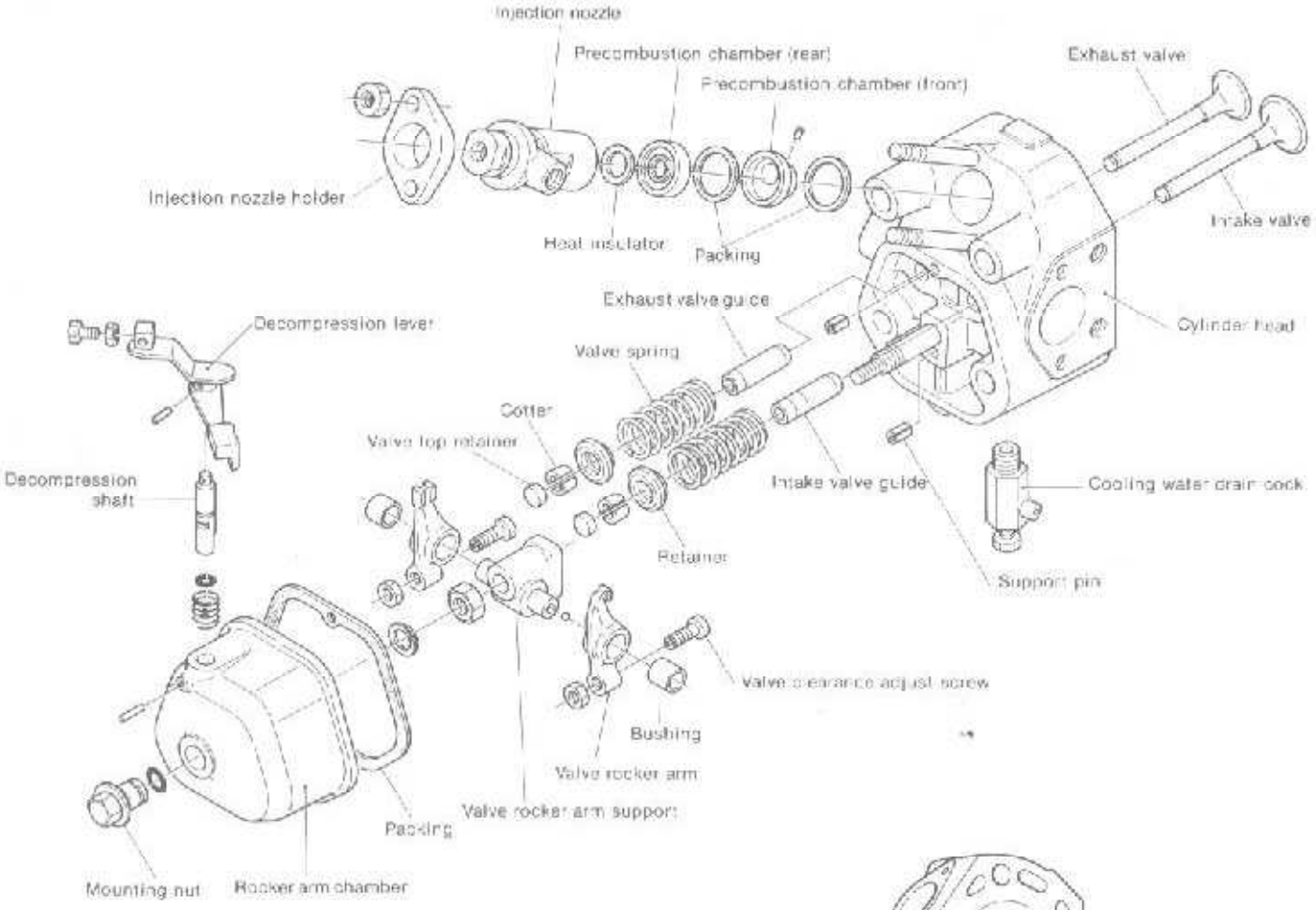
The cylinder head is of the gasket packing type and is independent of the valve guide. It is strong and rigid, and is fastened to the cylinder block with four bolts.

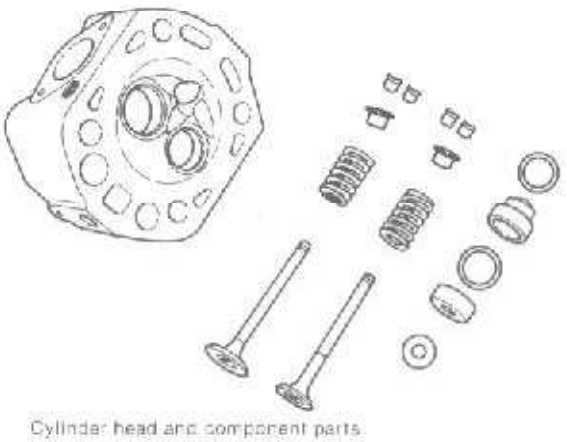
The unique Yanmar swirl type precombustion chamber is at an angle in the cylinder head, and form the combustion chamber, together with the intake and exhaust valves.

Large diameter intake valves and smoothly shaped intake and exhaust ports provide high intake efficiency and superior combustion performance.

Special consideration has also been given to the shape of the cooling water passages so that the combustion surface and precombustion chamber are uniformly cooled by an ample water flow.

In addition, lubrication of the exhaust and intake valves is done through the forced-circulation completely-sealed method.





Cylinder head and component parts

3-2 Cylinder head inspection and measurement

3-2.1 Measurement of carbon build-up at combustion surface and intake and exhaust ports

Visually check for carbon build-up around the combustion surface and the port near the intake and exhaust valve seats, and remove any build-up.
When a large amount of carbon has been built up, check the top of the chamber combustion for oil flow at the intake and exhaust valve guides, and take suitable corrective action.

3-2.2 Deposit build-up at water passages

Check for build-up of deposit at the water passages, and remove any deposit with a deposit remover. When a large amount of deposit has been built up, check each part of the cooling system.

3-2.3 Inspection of corrosion at water passages

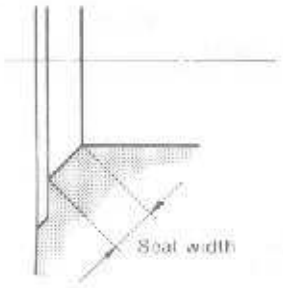
Inspect the state of corrosion of the water passages, and replace the cylinder head when corrosion is severe.
Corrosion pitting limit: 2mm (0.0787in.)

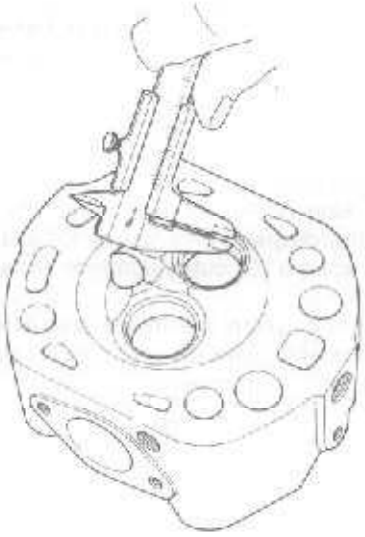
3-2.4 Cracking of combustion surface

The combustion surface is exposed to high temperature, high pressure gas and low pressure air, and is repeatedly flexed during operation. Moreover, it is used under extremely severe conditions, such as high temperature gradient of the combustion surface and cooling water passages.
Inspect the combustion surface for cracking by the color check, and replace the cylinder head if any cracking is detected. At the same time, check for signs of overloading and check the cooling water flow.

3-2.5 Cylinder head valve seat

The valve seats become wider with use. If the seats become wider than the maintenance standard, carbon build-up at the seats will cause compression leakage. On the other hand, if the seats are too narrow, they will wear quickly and heat transmission efficiency will deteriorate. Clean the carbon and other foreign matter from the valve seats, and check that the seats are not scored or dented.
Measure the seat width with a vernier calipers, and repair or replace the seat when the wear limit is exceeded.
When the valves have been lapped and/or ground, measure the amount of valve recess, and replace the valve when the wear limit is exceeded.





mm (in.)

	YSM8		YSM12	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Seat width	1.41 (0.0555)	2.1 (0.0827)	2.12 (0.0835)	2.5 (0.0984)
Seat angle	90°	—	90°	—

NOTE: Before adjusting the valve seat part be sure to check the intake and exhaust valve guides for wear; replace them if they are worn out.

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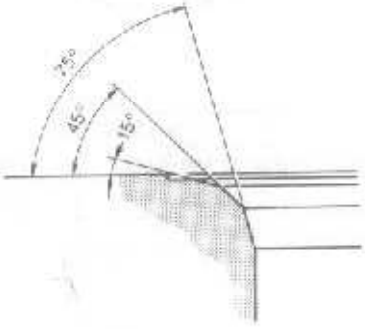
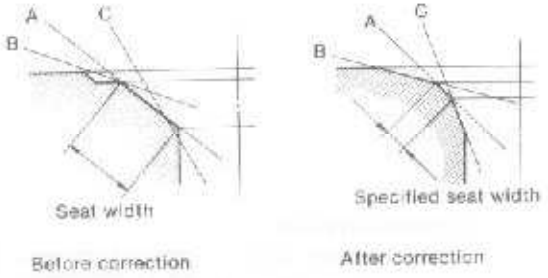
(1) Lapping the valve seat.
When scoring and pitting of the valve seat is slight, coat the seat with valve compound mixed oil, and lap the seat with a lapping tool.
At this time, be sure that the compound does not flow to the valve stem and valve guide.

(2) Correcting valve seat width.
When the valve seat is heavily pitted and when the seat width must be corrected, repair with a seat grinder.

1) After correcting the contact area of the valve seat using a valve refacer, etc., note the spot where it comes into contact with the seat section for reference when applying seat cutters.
2) Apply the seat cutters according to the sequence shown in the diagram. First use a 45°-cutter, then a 15°-cutter; apply a 75°-cutter lightly to correct the contact surface.
3) The position at which the intake and exhaust valve comes into contact with the seat section should be at the center of the contact surface of the valve.
Therefore, when applying a 15°- or 75°-cutter, take carefully note the spot at which the valve comes into contact with the seat.

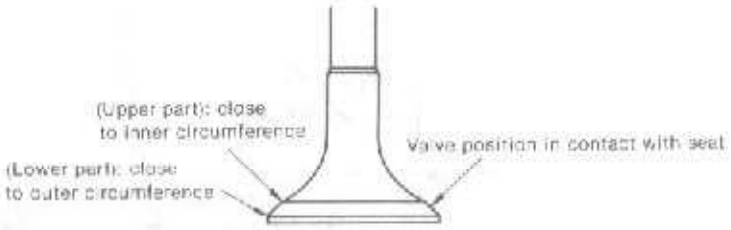


4) Mix the compound with oil, and lap the valve.
5) Finally, lap with oil.



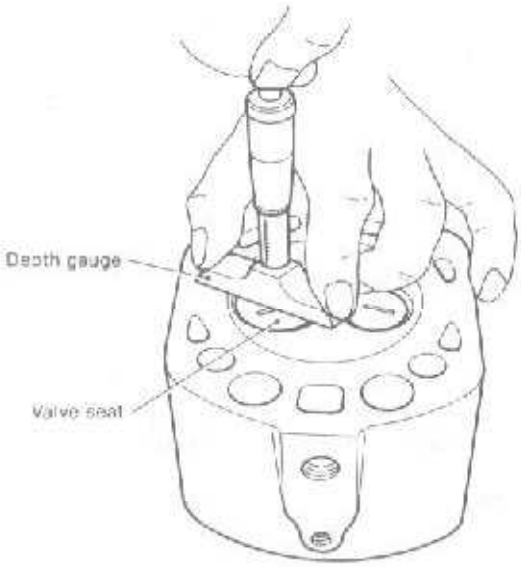
(A) Grind with a 45° grinder
(B) Grind with a 15° grinder
(C) Grind with a 65° ~ 75° grinder

NOTE: (1) When the valve seat has been corrected with a seat grinder, insert an adjusting shim between the valve spring and cylinder head.
(2) When the lower part of the valve comes into contact with the seat, correct the contact position with a 45°- and 75°-cutter. When the upper part of the valve is in contact with the seat, correct the contact position using a 15°- and 45°-cutter.



3-2.6 Measuring valve recess

When the valve has been lapped many times, the valve will be recessed and will adversely affect the combustion performance. Therefore, measure the valve recess, and replace the valve and cylinder head when the wear limit is exceeded.



mm (in.)

	YSM8		YSM12	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Valve recess	1.25 (0.0492)	1.55 (0.0610)	1.15 (0.0453)	1.45 (0.0570)

3-2.7 Other inspections

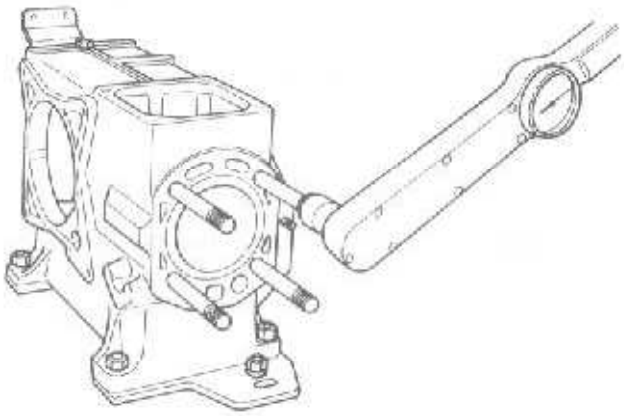
(1) Check the fitting hole of the precombustion chamber for corrosion, cracks, etc.
(2) Check the valve rocker arm fitting bolt, injection nozzle holder fitting bolt, and other bolts for bending, looseness, etc.
(3) Check the valve rocker arm chamber cover and valve rocker arm support pin for damage, etc.
(4) Check the cylinder head drain plug for water leakage, etc.

3-3 Dismounting and remounting the cylinder head

When dismounting and remounting the cylinder head, the mounting bolts must be removed and installed gradually and in the prescribed sequence to prevent damaging the gasket packing and to prevent distortion of the cylinder head. Since the tightening torque and tightening sequence of the mounting bolts when remounting the cylinder head are especially important from the standpoint of engine performance, the following items must be strictly observed.

3-3.1 Cylinder head stud bolt assembly sequence

(1) Check for loose cylinder head stud bolts, and lock any loose bolts with two nuts and then tighten to the prescribed torque.
Cylinder head stud bolt tightening torque: 4.5kg-m (32.55ft-lb)



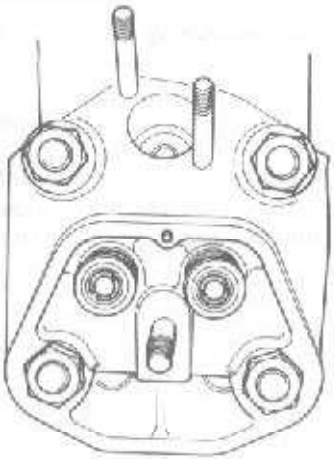
(2) Checking the gasket packing mounting face.
Confirm correct alignment of the front and rear of the gasket packing, and install the packing by coating both sides with Three Bond 50.
(3) Installing the cylinder head ass'y.
Position the cylinder head ass'y parallel to the top of the cylinder block, and install the ass'y to the block, being careful that the cylinder head ass'y does not touch the threads of the cylinder head bolts.

3-3.2 Tightening the cylinder head tightening nuts

(1) Cylinder head nut tightening sequence kg•m (ft-lb)

YSM8	YSM12
9.7 (70.16)	13.6 (98.37)

1) Coat the threads of the cylinder head bolts with lubricating oil, and screw the cylinder head nuts onto the bolts.

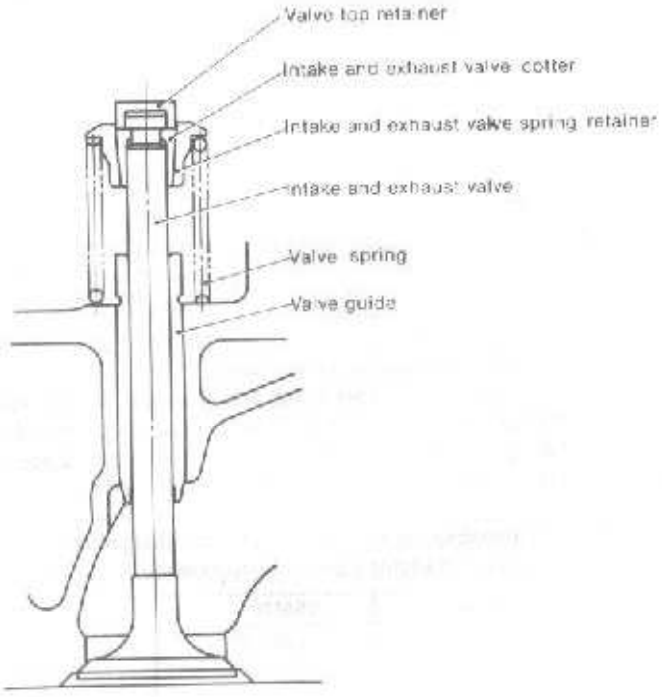


2) First, tighten the nuts sequentially to 1/3 of the prescribed torque.
3) Second, tighten the nuts sequentially to 2/3 of the prescribed torque.
4) Third, tighten the nuts to the prescribed torque.
5) Recheck that all the nuts have been properly tightened.

3-3.3 Cylinder head nut loosening sequence

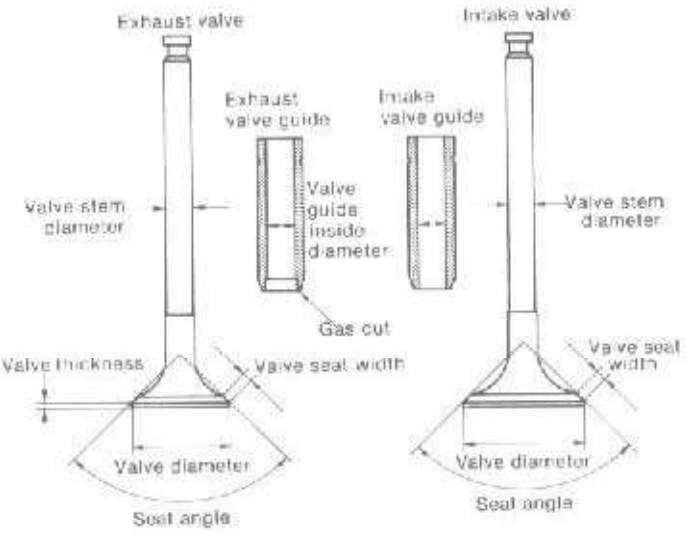
When loosening the cylinder head nuts, reverse the tightening sequence.

3-4 Intake and exhaust valves, valve guide and valve spring



3-4.1 Inspecting and measuring the intake and exhaust valves

(1) Valve seat wear and contact width.
Inspect valve seats for carbon build-up and heavy wear.
Also check if each valve seat contact width is suitable. If the valve seat contact width is narrower than the valve seat width, the seat angle must be checked and corrected.



mm (in.)

	YSM8		YSM12	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Valve seat width	2.8 (0.1102)	—	3.4 (0.1339)	—
Valve seat angle	90°	—	90°	—
Valve thickness	1.0 (0.0394)	0.5 (0.0197)	1.1 (0.0433)	0.5 (0.0197)

(2) Valve stem bending and wear.
Check for valve stem wear and staining, and repair when such damage is light. Measure the outside diameter and bend, and replace the valve when the wear limit is exceeded.

mm (in.)

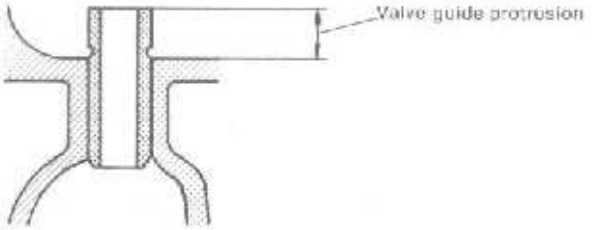
	YSM8	YSM12
Valve stem bend limit	0.03 (0.00118)	0.03 (0.00118)

(3) Valve seat hairline cracks.
Inspect the valve seat by the color check, and replace the seat if cracked.

3-4.2 Inspecting and measuring valve guides

The valve guide is different for the intake valve and exhaust valve in that the inner face of the exhaust valve has a gas cut.
Be sure that the correct guide is used when replacing the guides.

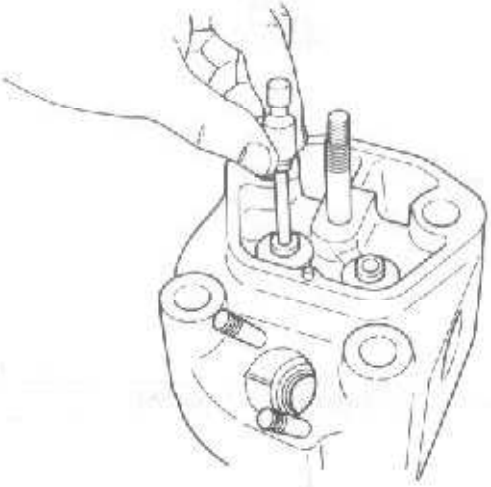
(1) Floating of the intake and exhaust valve guides.
Check for intake and exhaust valve guide looseness and floating with a test hammer, and replace loose or floating guides with guides having an oversize outside diameter.

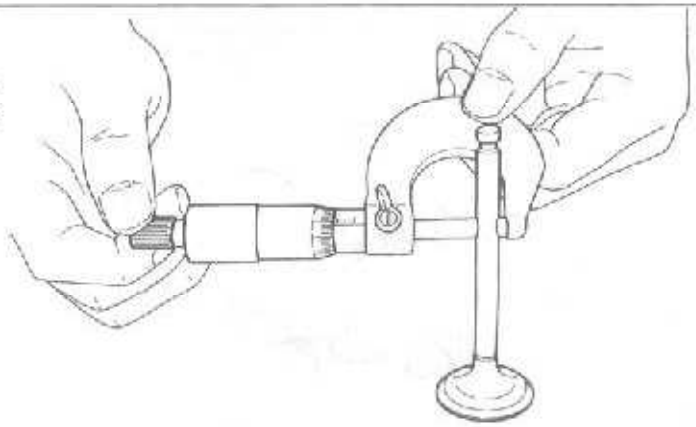


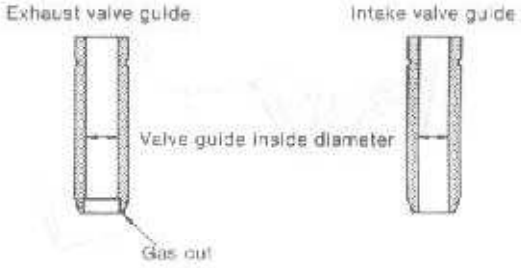
mm (in.)

	YSM8	YSM12
Valve guide protrusion	7 (0.2756)	10 (0.3937)

(2) Measuring the valve guide inside diameter.
Measure the valve guide inside diameter and clearance, and replace the guide when wear exceeds the wear limit.







mm (in.)

			Maintenance standard	Clearance at assembly	Maximum allowable clearance	Wear limit
YSM8	Intake	Valve guide inside diameter (after assembly)	ø7 $^{+0.015}_{0}$ (0.2756 ~ 0.2762)	0.040 ~ 0.065 (0.0016 ~ 0.0026)	0.15 (0.0059)	ø7.08 (0.2787)
		Stem outside diameter	ø7 $^{-0.04}_{-0.06}$ (0.2736 ~ 0.2740)			ø6.90 (0.2717)
	Exhaust	Valve guide inside diameter (after assembly)	ø7 $^{+0.02}_{+0.005}$ (0.2758 ~ 0.2764)	0.045 ~ 0.075 (0.0018 ~ 0.003)	0.15 (0.0059)	ø7.08 (0.2787)
		Stem outside diameter	ø7 $^{-0.04}_{-0.05}$ (0.2736 ~ 0.2740)			ø6.90 (0.2717)
YSM12	Intake	Valve guide inside diameter (after assembly)	ø8 $^{+0.025}_{+0.010}$ (0.3154 ~ 0.3159)	0.040 ~ 0.065 (0.0016 ~ 0.0026)	0.15 (0.0059)	ø8.08 (0.3181)
		Stem outside diameter	ø8 $^{-0.03}_{-0.04}$ (0.3134 ~ 0.3138)			ø7.90 (0.3110)
	Exhaust	Valve guide inside diameter (after assembly)	ø8 $^{+0.030}_{+0.015}$ (0.3156 ~ 0.3161)	0.045 ~ 0.070 (0.0018 ~ 0.0028)	0.15 (0.0059)	ø8.08 (0.3181)
		Stem outside diameter	ø8 $^{-0.03}_{-0.04}$ (0.3134 ~ 0.3138)			ø7.90 (0.3110)

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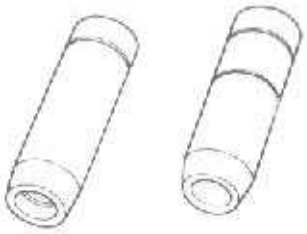
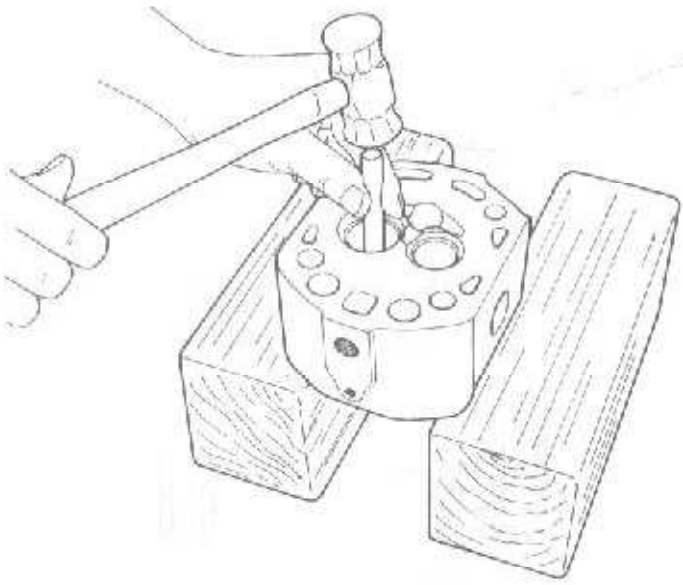
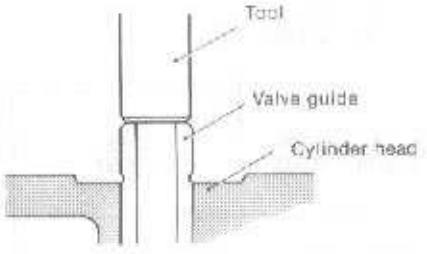
(3) Replacing the intake/exhaust valve guide
(1) Using a special tool for extracting and inserting the valve guide, extract the valve guide.



(2) Using the above tool, drive the valve guide into position by starting from the valve spring side and finish the inside diameter with a reamer.





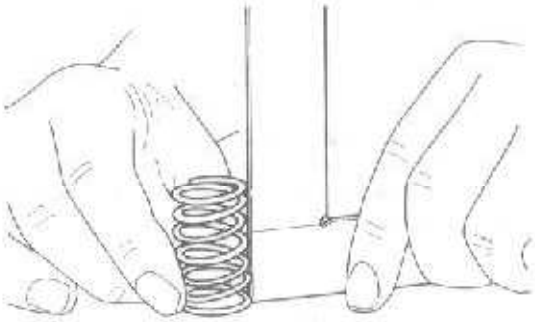
mm (in.)

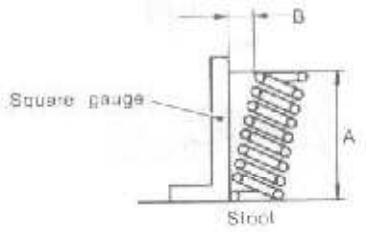
	YSM8	YSM12
Amount of interference of valve guide	0.015 ± 0.014 (0.00004 ~ 0.00114)	

NOTE: Insert the valve guide until the groove on its outer surface reaches the cylinder head surface.

3-4.3 Valve spring

(1) Valve spring inclination.
Since inclination of the valve spring is a direct cause of eccentric contact of the valve stem, always check it at disassembly.
Stand the valve upright on a stool, and check if the entire spring contacts the gauge when a square gauge is placed against the outside diameter of the valve spring.
If there is a gap between the gauge and spring, measure the gap with a feeler gauge.
When the valve spring inclination exceeds the wear limit, replace the spring.

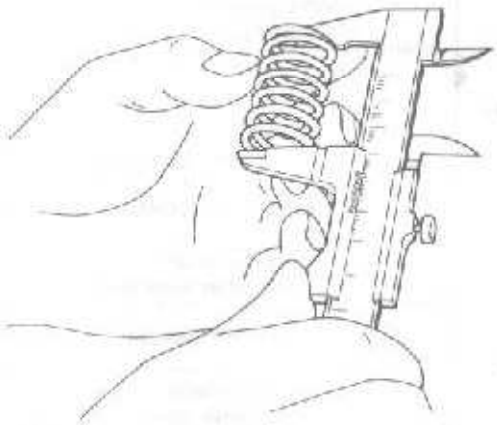




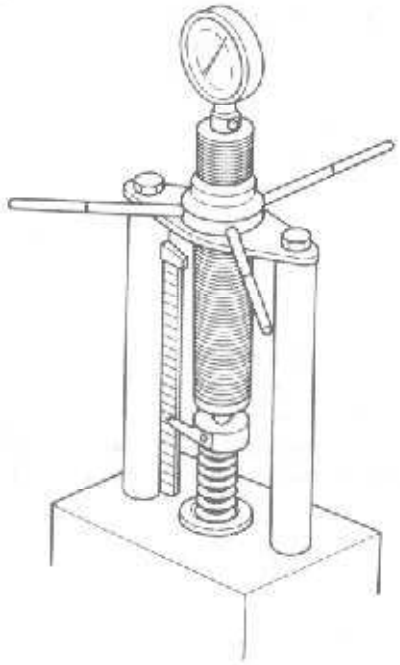
mm (in.)

Inclination limit (gap B)	1.4 (0.055)

(2) Valve spring free length.
Measure the free length of the valve spring, and replace the spring when the wear limit is exceeded.



Also, measure the tension of the spring with a spring tester. If the tension is below the prescribed limit, replace the spring.

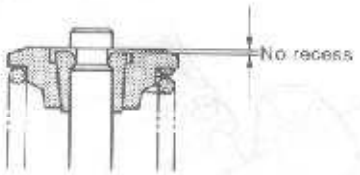


mm (in.)

	YSM8		YSM12	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Valve spring free length	41mm (1.6141)	39.5mm (1.5551)	40mm (1.5748)	38.5mm (1.5157)
Length when attached	30.8mm (1.2125)	—	33.3mm (1.3110)	—
Load applied when attached	16.4kg (36.15 lb)	—	15.3kg (33.73 lb)	—

3-4.4 Spring retainer and spring cotter pin

Inspect the inside face of the spring retainer and the outside surface of the spring cotter pin, and the contact area of the spring cotter pin inside surface and the notch in the head of the valve stem. Replace the spring retainer and spring cotter pin when the contact area is less than 70% or when the spring cotter pin has been recessed because of wear.



3-4.5 Valve top retainer

Make sure the valve top retainer surface is in contact with the valve rocker arm. If it is worn out, replace it with a new one.

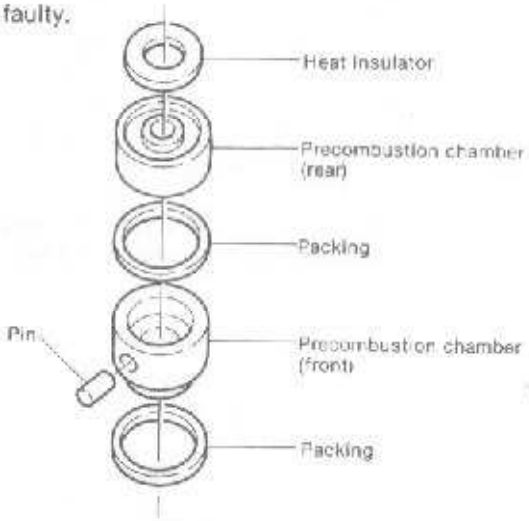
3-5 Precombustion chamber and top clearance

3-5.1 Precombustion chamber

Remove the packing and insulation packing at the precombustion chamber's front and rear chambers, and inspect.

Check for burning at the front end of the precombustion chamber front chamber, acid corrosion at the pre-combustion chamber rear chamber, and for burned packing.

Replace if faulty.



3-5.2 Insulation packing

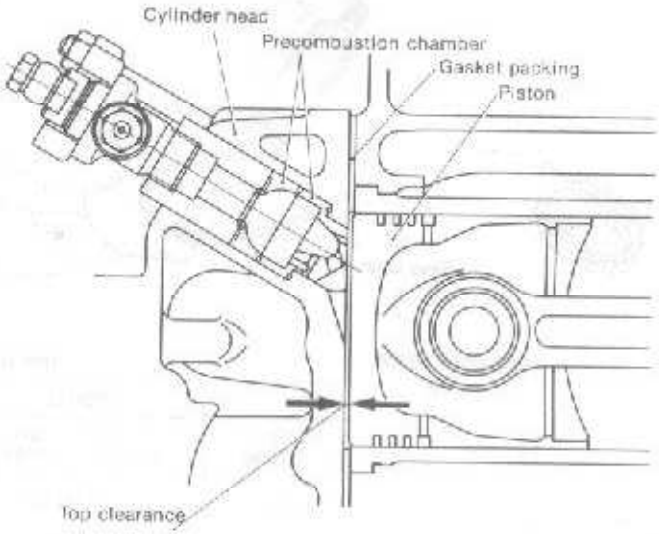
The insulation packing prevents transmission of heat from the precombustion chamber to the nozzle valve and serves to improve the nozzle's durability.

Always put in a new insulation packing when it has been disassembled.

3-5.3 Top clearance

Top clearance is the size of the gap between the cylinder head combustion surface and the top of the piston at top dead center.

Since top clearance has considerable effect on the combustion performance and the starting characteristic of the engine, it must be checked periodically.



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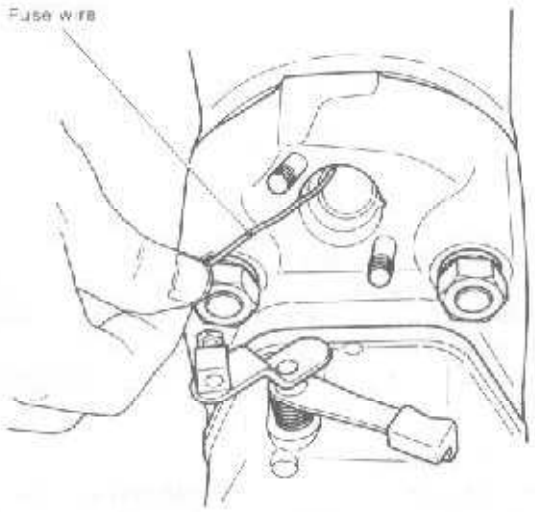
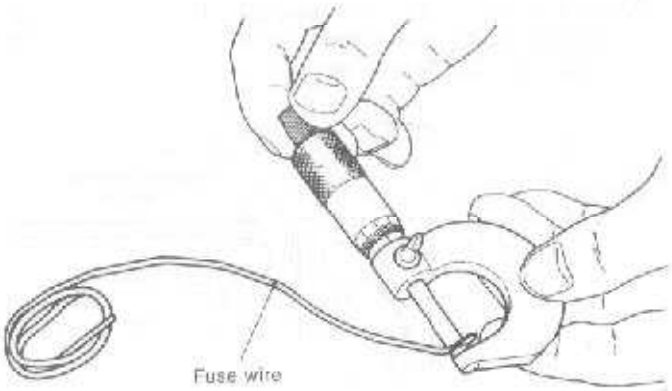
(1) Top clearance measurement
1) Check the cylinder head mounting bolts and tightening torque.
2) Remove the fuel injection valve and pre-combustion chamber.
3) Lower the piston.
4) Insert quality fuse wire through the nozzle holder hole. (Be careful that the wire does not enter the intake and exhaust valve and the groove in the combustion surface.)
5) Crush the fuse wire by moving the piston to top dead center by slowly cranking the engine by hand.
6) Lower the piston by hand cranking the engine and remove the crushed fuse wire, being careful not to drop it.
7) Measure the thickness of the crushed part of the fuse wire with vernier calipers or a micrometer.





(2) Top clearance value. mm (in.)

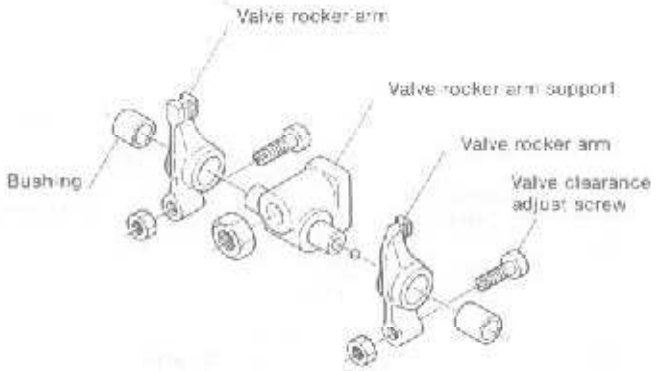
	YSM8	YSM12
Top clearance	0.6 ~ 0.93 (0.0236 ~ 0.0366)	1.10 ~ 1.50 (0.0433 ~ 0.0551)
Fuse to be used	ø1.0 (0.039)	ø1.5 (0.059)

When the top clearance value is not within the above range, check for damaged gasket packing, distortion of the cylinder head combustion surface, or other abnormal conditions.

(3) How to deal with too-large top clearance
When the top clearance is too large, check for the following:
1) The cylinder head is clamped wrong.
2) The bearing metal for the crankpin, journal, and piston pin sections is worn.
3) Check the connecting rod for bending, etc., and if any malfunctioning part is found, replace the connecting rod.

3-6 Intake and exhaust valve rocker arm

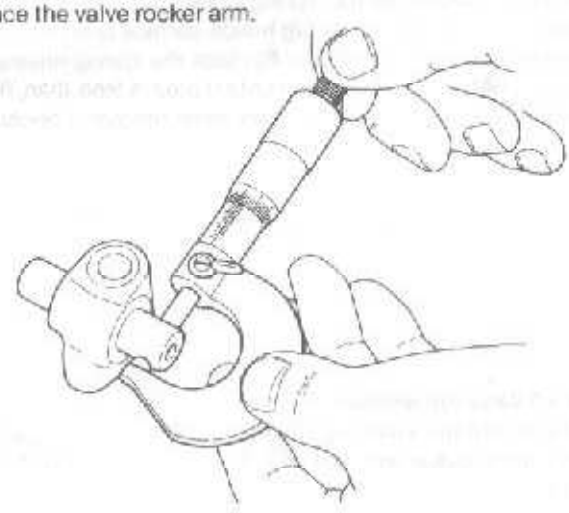
Since the intake and exhaust valve rocker arm shaft and bushing clearance and valve head and push rod contact wear are directly related to the valve timing, and have an effect on engine performance, they must be carefully serviced.

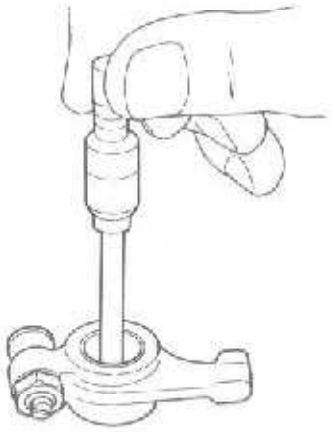


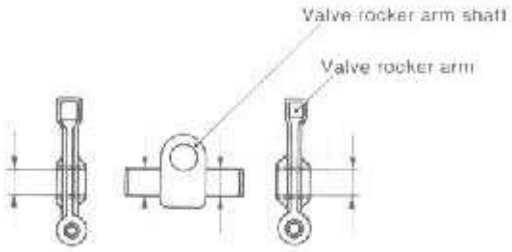
3-6.1 Measuring the valve rocker arm shaft and bushing clearance

Measure the outside diameter of the valve rocker arm shaft and the inside diameter of the bushing, and replace the rocker arm or bushing if the measured value exceeds the wear limit.

Replace a loose valve rocker arm shaft bushing with a new bushing. However, when there is no tightening allowance, replace the valve rocker arm.







mm (in.)

			Maintenance standard	Clearance at assembly	Maximum allowable clearance	Wear limit
YSM8	Intake and exhaust valve rocker arm shaft outside diameter	A	ø12 $^{0}_{-0.018}$ (0.4717 ~ 0.4724)	0.016 ~ 0.052 (0.00063 ~ 0.00205)	0.15 (0.0059)	ø11.9 (0.4685)
	Intake and exhaust valve rocker arm bushing inside diameter (assembled)	B	ø12 $^{+0.034}_{+0.016}$ (0.4731 ~ 0.4738)			ø12.1 (0.4764)
YSM12	Intake and exhaust valve rocker arm shaft outside diameter	A	ø16 $^{0}_{-0.018}$ (0.6292 ~ 0.6299)	0.016 ~ 0.052 (0.00063 ~ 0.00205)	0.15 (0.0059)	ø15.9 (0.6260)
	Intake and exhaust valve rocker arm bushing inside diameter (assembled)	B	ø16 $^{+0.034}_{+0.016}$ (0.6306 ~ 0.6313)			ø16.1 (0.6339)

3-6.2 Valve rocker arm and valve head contact and wear

Check the valve rocker arm and valve head contact, and replace when there is any abnormal wear or peeling.

NOTE: Correct a trifle stepped wear in the contact surface of the stem and valve rocker arm by using an oil stone, etc.

3-6.3 Valve clearance adjusting screw

Inspect the valve clearance adjusting screw and push rod contact, and replace when there is any abnormal wear or peeling.

3-7 Adjusting intake and exhaust valve head clearance

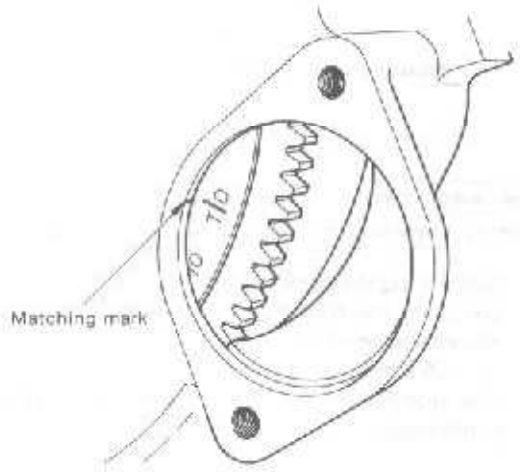
Adjustment of the intake and exhaust valve head clearance governs the performance of the engine, and must be performed accurately. The intake and exhaust valve head clearance must always be checked and readjusted, as required, when the engine is disassembled and reassembled, and after every 300 hours of operation. Adjust the valve head clearance as described below.

3-7.1 Adjustment

Make this adjustment when the engine is cold.

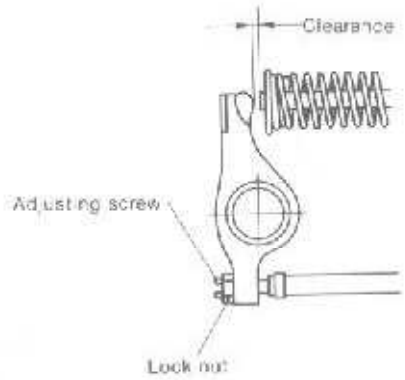
(1) Remove the valve rocker arm cover.

(2) Crank the engine and set the piston to top dead center (TDC) on the compression stroke.



NOTE: Set to the position at which the valve rocker arm shaft does not move even when the crankshaft is turned to the left and right, centered around the TD mark.

(3) Loosen the valve clearance adjusting screw lock nut, adjust the clearance to the maintenance standard with a feeler gauge, and retighten the lock nut.

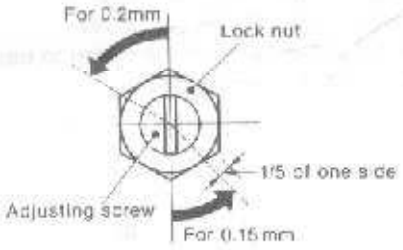


mm (in.)

Intake and exhaust valve head clearance (cold engine)	0.20 (0.00787)

3-7.2 Adjusting without a feeler gauge

Set the head clearance to zero by tightening the adjusting screw, being careful not to tighten the screw too tight. Then adjust the valve clearance to the maintenance standard by backing off the adjusting screw by the angle given below.



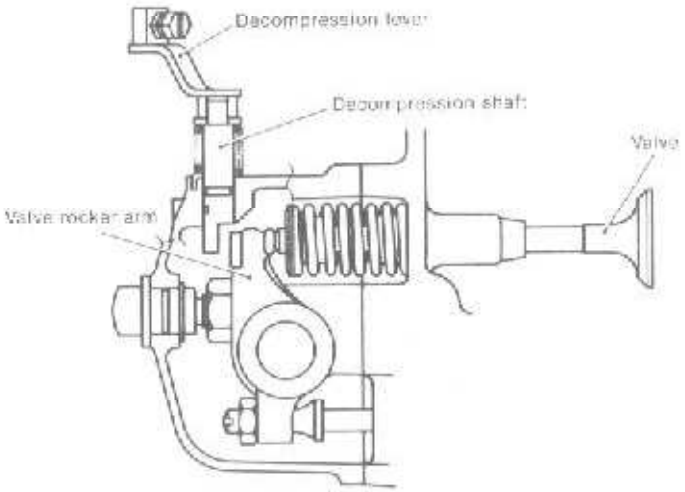
mm (in.)

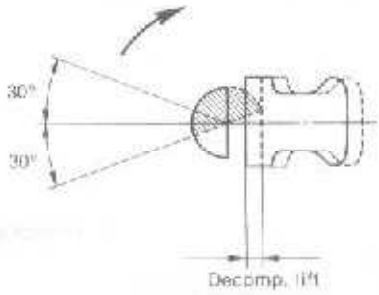
Valve clearance adjusting screw	M8 × 1.25
Adjusting screw backoff angle	Approx 58° ~ 60°

NOTE: Calculating the backoff angle.
Calculate the 0.2mm advance angle from 1.25mm advance at one turn = 360°.
0.2/1.25 × 360° = 57.6° ≒ 58°.
One side (60°) of the hexagonal nut should be used to measure.

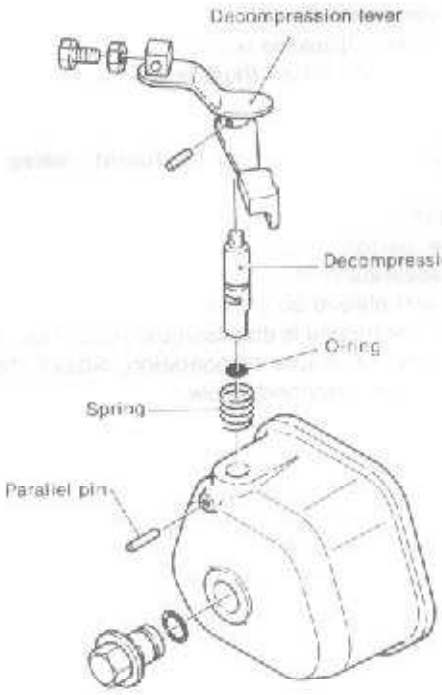
3-8 Decompression mechanism

The decompression mechanism is used when the starter motor fails to rotate sufficiently because the battery is weak, and to facilitate starting in cold weather.
When the decompression lever is operated, the valve is pushed down, the engine is decompressed, the engine turns over easily and the flywheel inertia increases, thus making starting easy.



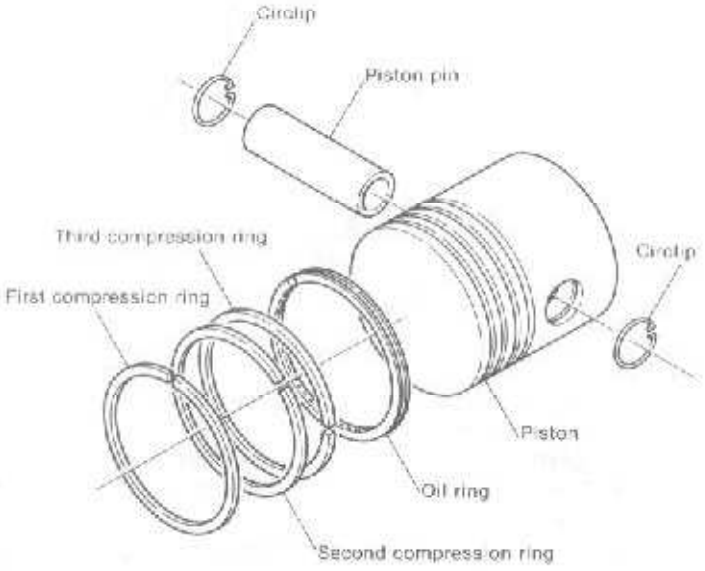


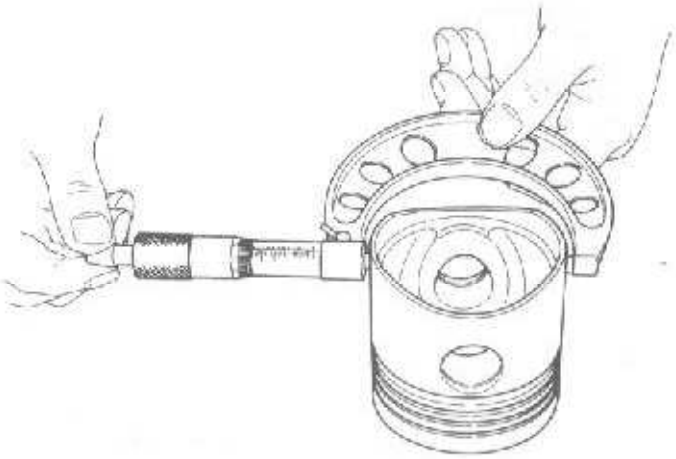
With this engine, there is no need to adjust the decompression lift.



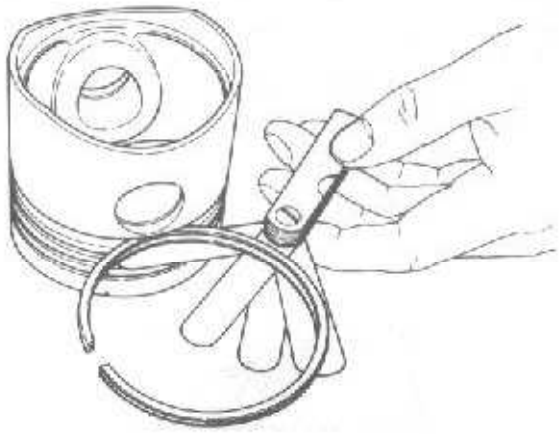
4. Piston

The piston is cast of an Lo-Ex aluminum alloy with a small thermal expansion coefficient and excellent cooling properties. Its ellipsoid shape makes for better contact on the cylinder surface and reduces oil consumption. In addition the lowly constructed land area between the third ring and the oil ring allows the lubricating oil to stay longer, thereby providing better lubrication of the piston and cylinder and reducing oil comsumption. A total of four piston rings are installed, three compression rings and one oil ring, to ensure good compression and lubrication. To improve the rigidity of the piston skirt no ring is installed on the skirt itself so that the piston seldom becomes deformed and retains stable contact.
The piston pin is of the floating type. Both its ends are fastened with a circlips.





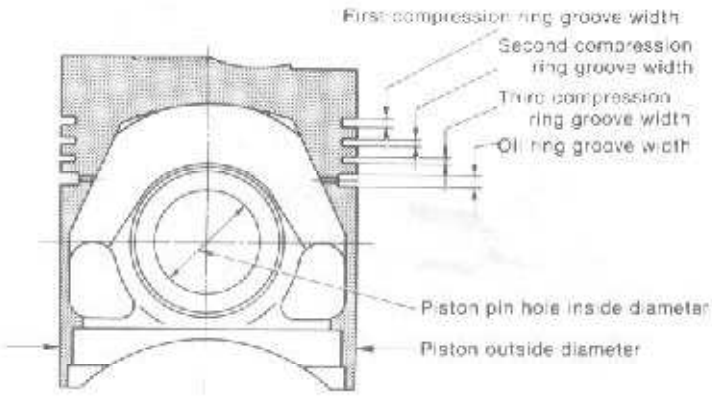
(2) Measure the clearance between the piston ring or oil ring and the ring groove with a thickness gauge.



4-2 Piston

4-2.1 Inspection

(1) Measuring important dimensions
Measure each important dimension, and replace the piston when the wear limit is exceeded.



mm (in.)

	YSM8		YSM12	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Piston outside diameter (axial direction)	ø75 $^{-0.125}_{-0.165}$ (2.9467 ~ 2.9478)	ø74.8 (2.9448)	ø85 $^{-0.115}_{-0.145}$ (3.3407 ~ 3.3419)	ø84.8 (3.3386)
Piston pin hole inside diameter	ø23 (0.9055)	—	ø28	—
First compression piston ring-to-groove clearance	0.050 ~ 0.080 (0.00196 ~ 0.00314)	0.2 (0.00787)	0.050 ~ 0.095 (0.00197 ~ 0.00374)	0.2 (0.00787)
Second and third compression piston ring-to-groove clearance	0.020 ~ 0.055 (0.00078 ~ 0.00216)	0.2 (0.00787)	0.020 ~ 0.055 (0.00078 ~ 0.00216)	0.2 (0.00787)
Oil ring-to-groove clearance	0.020 ~ 0.055 (0.00078 ~ 0.00216)	0.15 (0.0059)	0.020 ~ 0.055 (0.00078 ~ 0.00216)	0.15 (0.0059)

(3) Piston pin outside contact and ring groove carbon build-up.
Check if the piston ring grooves are clogged with carbon, if the rings move freely, and for abnormal contact around the outside of the piston. Repair or replace the piston if faulty.

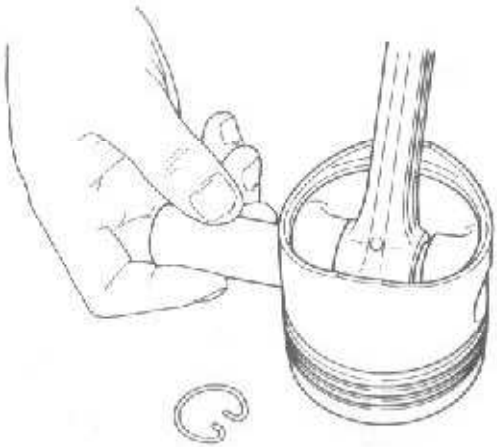
4-2.2 Replacing a piston

If the dimension of any part is worn past the wear limit or outside of the piston is scored, replace the piston.

(1) Replacement

1. Install the piston pin circlip at one side only.
2. Immerse the piston in 80°C oil for 10 ~ 15 minutes.

3. Remove the piston from the hot oil and place it on a bench with the piston head at the bottom.
4. Insert the small end of the connecting rod into the piston, insert the piston pin with a rotating motion, and install the other piston pin circlip.
Use wooden hammer if necessary.



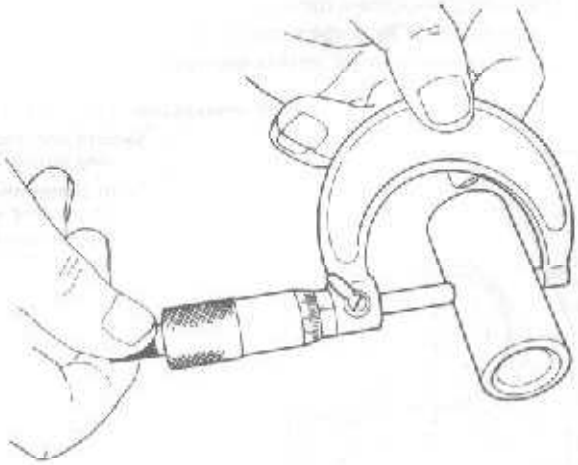
(2) Precautions

1. Before inserting, check whether the piston pin is in the connecting rod.
2. Coat the piston pin with oil to facilitate insertion.
3. Check that the connecting rod and piston move freely.
4. Insert the pin quickly, before the piston cools.

4-3 Piston pin and piston pin bushing

4-3.1 Piston pin

Measure the dimensions of the piston pin, and replace the pin if it is worn past the wear limit or severely scored.



mm (in.)

	YSM8		YSM12	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Piston pin outside diameter	ø23 $^{0}_{-0.009}$ (0.9052 ~ 0.9055)	ø22.98 (0.9047)	ø28 $^{0}_{-0.009}$ (1.1020 ~ 1.1024)	ø27.98 (1.1016)

mm (in.)

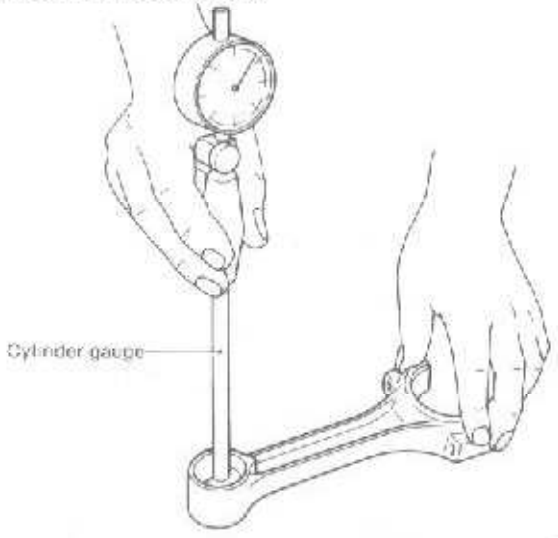
	YSM8	YSM12
Piston pin hole inside diameter	ø22.995 ~ 23.008 (0.9053 ~ 0.9058)	ø27.995 ~ 28.008 (1.1022 ~ 1.1027)
Piston pin outside diameter	ø22.991 ~ 23.000 (0.9052 ~ 0.9055)	ø27.991 ~ 28.000 (1.1020 ~ 1.1024)
Pin and pin hole tightening allowance	−0.005 ~ 0.017 (−0.0002 ~ 0.0007)	−0.005 ~ 0.017 (−0.0002 ~ 0.0007)
Pin fitting temperature	50° ~ 60°	50° ~ 60°

4-3.2 Piston pin bushing

A copper alloy wound bushing is pressed onto the piston pin.

Since a metallic sound will be produced if the piston pin and piston pin bushing wear is excessive, replace the bushing when the wear limit is exceeded.

The piston pin bushing can be easily removed and installed with a press. However, when installing the bushing, be careful that it is not tilted.



mm (in.)

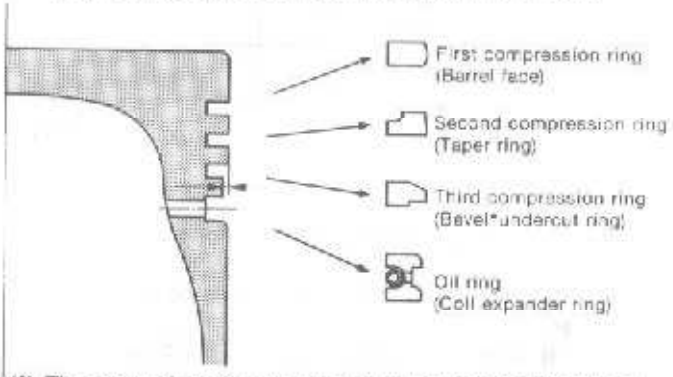
	YSM8		YSM12	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Piston pin bushing inside diameter	ø23 (0.9055)	ø23.1 (0.9094)	ø28 (1.1023)	ø28.1 (1.1063)

NOTE: "Piston pin bushing inside diameter" is the dimension after pressing onto the connecting rod.

4-4 Piston rings

4-4.1 Piston ring configuration

(1) The first compression ring is a barrel face ring that effectively prevents abnormal wear caused by engine loading and combustion gas blowby at initial run-in.



(2) The second compression ring is a taper ring having a sliding face taper of 30' ~ 1°30'. Since the cylinder liner is straight, and the contact area at initial operation is small, it is easily seated to the cylinder liner. Moreover, the bottom of the sliding face is sharp, and oil splash is excellent and air-tightness is superb.

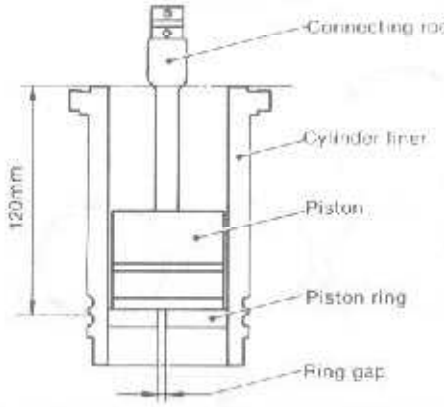
(3) Since the third compression ring has a cross-section that combines the shape of a bevel ring and undercut ring, oil splash is superb and oil upflow control is excellent.
The land (A in figure) between the third compression ring and the oil ring has a small 1.0mm outside diameter that effectively improves oil collection and reduces oil consumption.

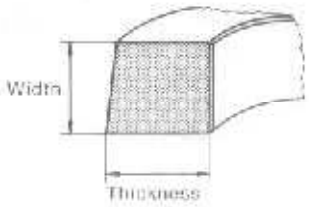
(4) The oil ring is a chrome-plated coil expander having a small contacting face, and exerts high pressure against the cylinder liner wall. Oil splash at the bottom of the sliding face is excellent, and its oil control effect is high.

4-4.2 Inspection

(1) Piston ring contact
Inspect the piston ring contact, and replace the ring when contact is faulty. Since the oil ring side contact is closely related to oil consumption, it must be checked with particular care.

(2) Measuring the piston ring gap
Insert the piston into the cylinder liner by pushing the piston ring at the head of the piston as shown in the figure, and measure the piston ring gap with a feeler gauge. Measure the gap at a point about 120mm from the top of the cylinder liner.

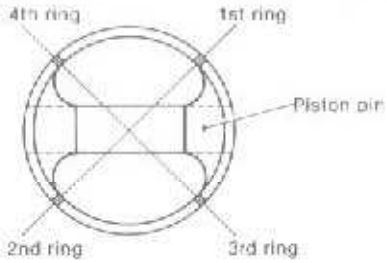




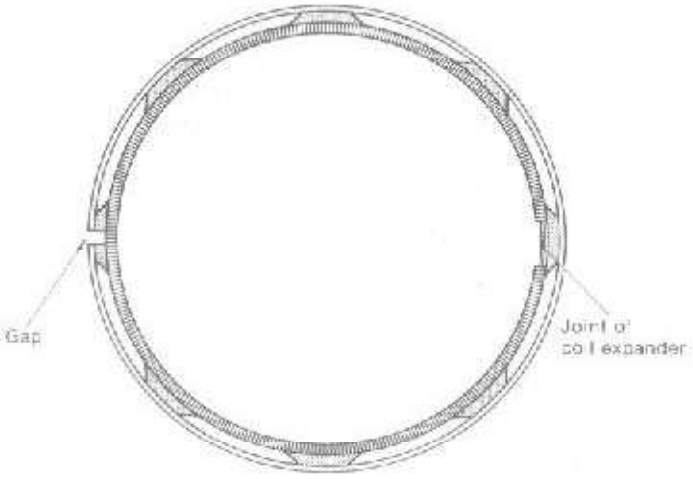
mm (in.)

		YSM8		YSM12	
		Maintenance standard	Wear limit	Maintenance standard	Wear limit
Piston ring (1, 2, 3)	Thickness	$3.3^{-0.1}$ (0.1259 ~ 0.1338)	—	3.6 ± 0.1 (0.1378 ~ 0.1457)	—
	Width	$2^{-0.01}_{-0.03}$ (0.0775 ~ 0.0783)	1.90 (0.0748)	$2.5^{-0.01}_{-0.03}$ (0.0972 ~ 0.0980)	2.40 (0.0945)
Oil ring	Thickness	2.6 ± 0.2 (0.0945 ~ 0.1102)	—	2.9 ± 0.2 (0.1063 ~ 0.1220)	—
	Width	$4.0^{-0.01}_{-0.03}$ (0.1562 ~ 0.1570)	3.90 (0.1535)	$4.0^{-0.01}_{-0.03}$ (0.1562 ~ 0.1570)	3.90 (0.1535)
Piston ring gap (1, 2, 3)		0.2 ~ 0.4 (0.00787 ~ 0.01574)	1.5 (0.0591)	0.3 ~ 0.5 (0.0118 ~ 0.0197)	1.5 (0.0591)
Oil ring gap		0.2 ~ 0.4 (0.00787 ~ 0.01574)	1.5 (0.0591)	0.2 ~ 0.4 (0.00787 ~ 0.01574)	1.5 (0.0591)

(3) Piston ring replacement precautions
When attaching the piston rings to the piston, make sure they are in the correct sequence and face the proper direction.
1) Clean the ring grooves carefully when replacing the rings.
2) When installing the rings, assemble the rings so that the manufacturer's mark near the gap is facing the top of the piston.
3) After assembly, check that the rings move freely in the grooves.
4) The rings must be installed so that the gaps are 180° apart. At this time, be careful that the ring gap is not lined up with the piston side pressure part.



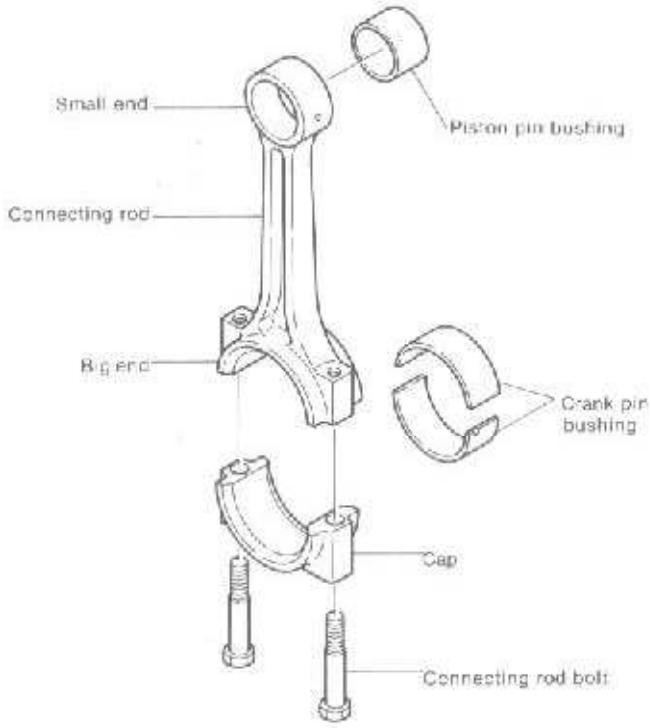
5) Since the oil ring is equipped with a coil expander, attach it to the piston so that the joint of the ring is shifted 180° from that of the coil expander.



5. Connecting Rod

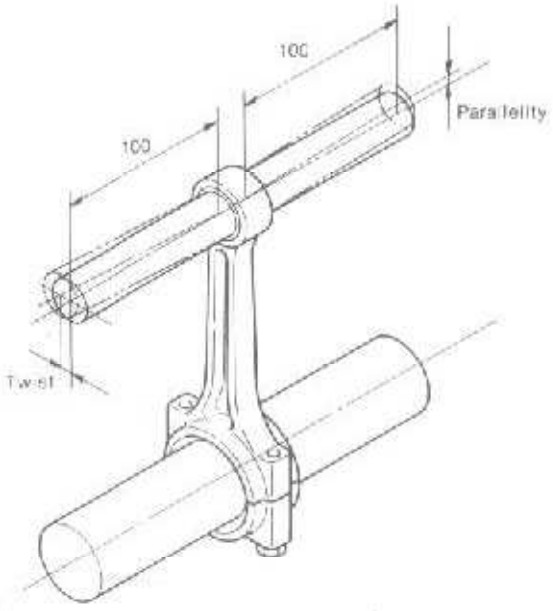
5-1 Connecting rod ass'y construction

The connecting rod connects the piston pin and crank pin and transmits the explosive force of the piston to the crankshaft. It is a stamp forging designed for extreme lightness and ample strength against bending. A kelmet bushing split at right angles is installed to the big end of the rod, and a round copper alloy is pressed onto cap.

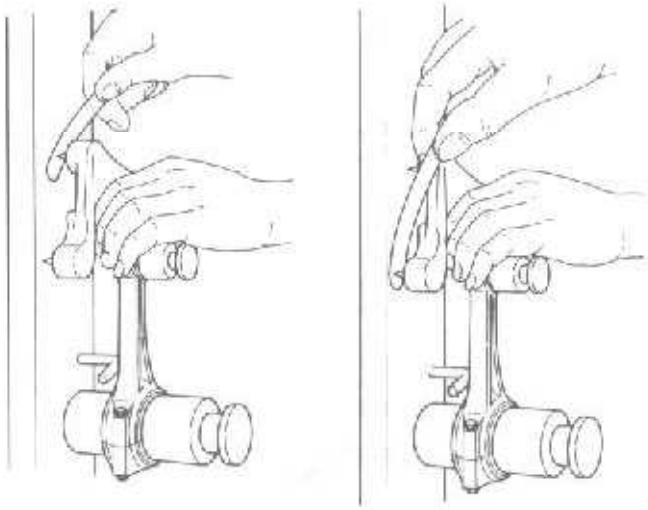


5-2 Inspection

5-2.1 Large and small end twist and parallelity



Pass a test bar through the large end and small end holes of the connecting rod, place the bars on a V-block on a stool and center the large end test bar. Then set the sensor of a dial indicator against the small end test bar and measure twist and parallelity. When the measured value exceeds the wear limit, replace the connecting rod. Twisting and poor parallelity will cause uneven contact of the piston and bushing and shifting of the piston rings, resulting in compression leakage and excessive oil consumption.



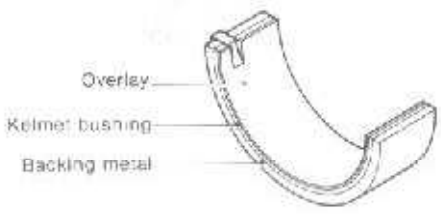
Measuring twist and parallelity

Connecting rod twist and parallelity mm (in.)

Maintenance standard	0.03/100 or less (0.0018/3.937)
Limit	0.08/100 or less (0.00315/3.937)

5-3 Crank pin bushing

Since the crank pin bushing slides while receiving the load from the piston, an easy-to-replace kelmet bushing with a wear-resistant overlay is used.



5-3.1 Crank pin bushing inside diameter

Tighten the large end of the connecting rod to the prescribed torque with the connecting rod bolts, and measure the inside diameter of the crank pin bushing. Replace the bushing if the inside diameter exceeds the wear limit or the clearance at the crank pin part exceeds the wear limit.

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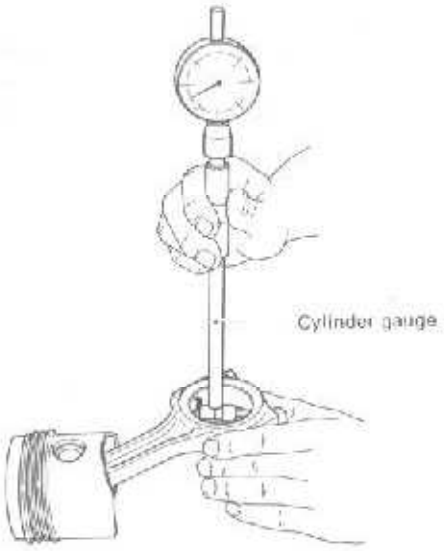


mm (in.)

	YSM8		YSM12	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Crank pin bushing inside diameter	ø42.000 ~ 42.042 (1.6535 ~ 1.6551)	ø42.1 (1.6574)	ø46.000 ~ 46.042 (1.8110 ~ 1.8126)	ø46.1 (1.8149)
Crank pin and bushing oil clearance	ø0.028 ~ 0.086 (0.0011 ~ 0.0033)	ø0.14 (0.0055)	ø0.027 ~ 0.090 (0.0010 ~ 0.0035)	ø0.17 (0.0066)
Connecting rod bolt tightening torque	4kg-m (28.9 ft-lb)		5.5kg-m (39.8 ft-lb)	

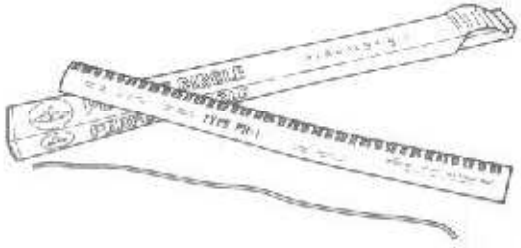
NOTE: The crank pin bushing inside diameter must always be measured with the connecting rod bolts tightened to the prescribed torque.

5-3.2 Crank pin and bushing clearance (oil clearance)

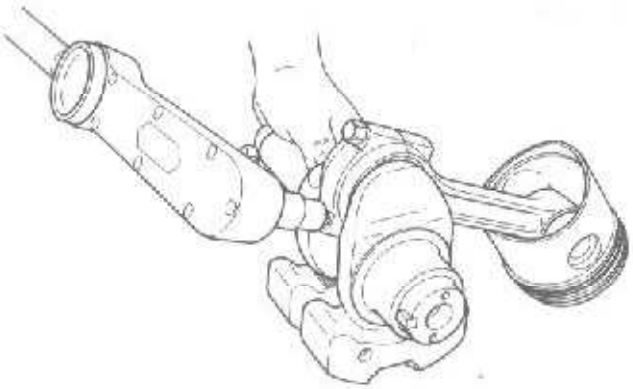
Since the oil clearance affects both the durability of the bushing and lubricating oil pressure, it must always be the prescribed value. Replace the bushing when the oil clearance exceeds the wear limit.

(1) Measurement

1) Thoroughly clean the inside surface and crank pin section of the crank pin bushing.
2) Install the connecting rod on the crank pin section of the crankshaft and simultaneously fit a Plasti gauge on the inside surface of the crank pin bearing.



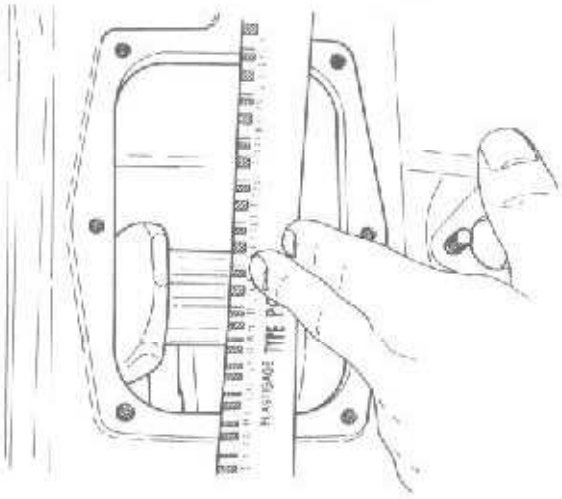
3) Tighten the connecting rod bolt to the prescribed tightening torque.



kg•m (ft-lb)

	YSM8	YSM12
Connecting rod tightening torque	4 (28.9)	5.5 (39.8)

4) Loosen the connecting rod bolt and slowly remove the connecting rod big end cap, then measure the crushed Plasti gauge with a gauge.



NOTE: Never adjust by shims or machine the crank pin bushing. Always replace the crank pin bushing with a new one.

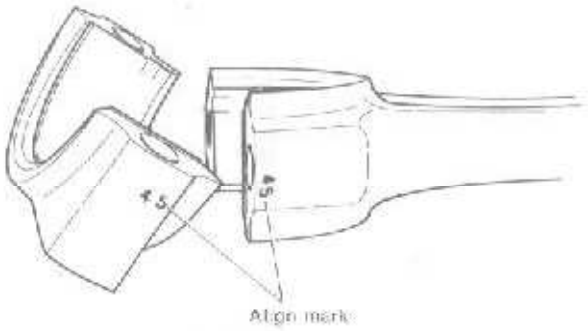
5) The crank pin and bushing clearance (oil clearance) may also be measured with a micrometer, in addition to measurement with a Plasti gauge. With this method, the outside diameter of the crankshaft crank pin section and the inside diameter of the connecting rod's big end bushing, when the connecting rod bolt has been tightened to the prescribed torque, are

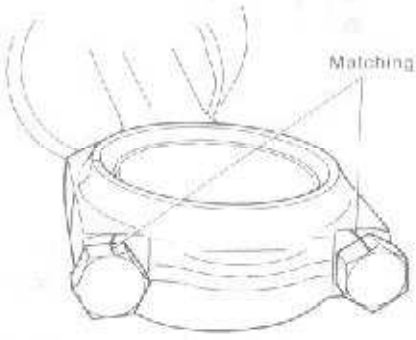
measured, and the difference between the large end bushing inside diameter and crank pin outside diameter is set as the oil clearance.

(2) Measurement precautions
   1) Be careful that the Plastigauge does not enter the crank pin oil hole.
   2) Be sure that the crankshaft does not turn when tightening the connecting rod bolt.

5-3.3 Crank pin bushing replacement precautions

(1) Thoroughly clean the crank pin bushing and the rear of the crank pin bushing.
(2) Also clean the big end cap, and install the crank pin bushing and check if the bushing contacts the big end cap closely.
(3) When assembling the connecting rod, match the number of the big end section and the big end cap, coat the bolts with engine oil, and alternately tighten the bolts gradually to the prescribed tightening torque. If a torque wrench is not available, put matching marks (torque indication lines) on the bolt head and big end cap before disassembly and tighten the bolts until these two lines are aligned.





(4) Check that there is no sand or metal particles in the lubricating oil and that the crankshaft is not pitted. Clean the oil holes with particular care.

5-4 Connecting rod side clearance

After installing the connecting rod on the crankshaft, push the rod to one side and measure the side clearance by inserting a feeler gauge into the gap produced at the other side.
The connecting rod bolts must also be tightened to the prescribed tightening torque in this case.

mm (in.)

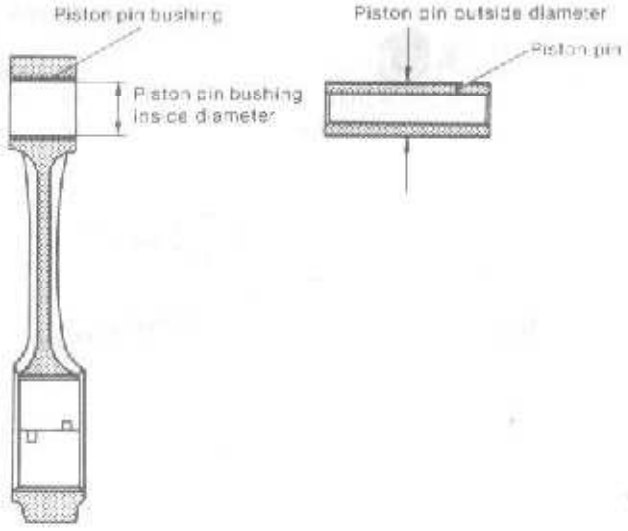
Connecting rod side clearance	0.25 ±0.1 (0.0059 ~ 0.0137)

5-5 Piston bushing and piston pin

The piston bushing is a round copper alloy bushing driven onto the small end of the connecting rod. During use, the piston pin bushing and piston pin will wear. If this wear becomes excessive, a metallic sound will be produced and the engine will become noisy.

5-5.1

Measure the oil clearance between the piston pin and the piston pin bushing. If it exceeds the prescribed limit, replace the piston pin and its bushing.



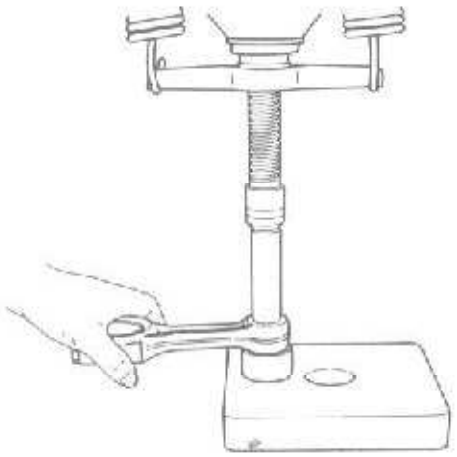
mm (in.)

	YSM8		YSM12	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Piston pin bushing inside diameter	ø23.025 ~ 23.038 (0.9065 ~ 0.9070)	ø23.12 (0.9102)	ø28.025 ~ 28.038 (1.1033 ~ 1.1038)	ø28.12 (1.1071)
Piston pin and bushing clearance	0.025 ~ 0.047 (0.00098 ~ 0.00185)	0.1 (0.00394)	0.025 ~ 0.048 (0.00098 ~ 0.00189)	0.1 (0.00394)

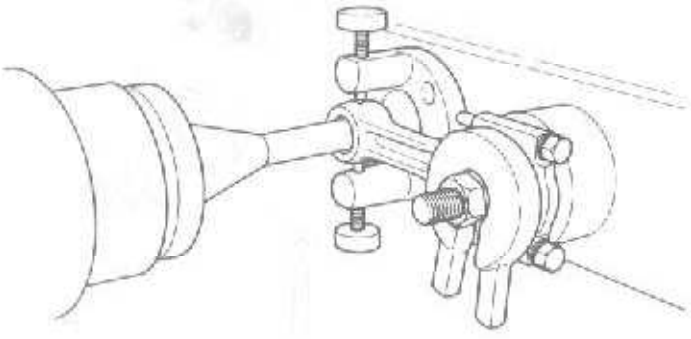
5-5.2 Replacing the piston pin bushing

(1) When the bushing for the connecting rod piston pin is either worn out or damaged, replace it by using the "piston pin extracting tool" installed on a press.

NOTE: Force the piston pin bushing into position so that its oil hole coincides with the hole on the small end of the connecting rod.



(2) After forcing the piston pin bushing into position, finish the inner surface of the bushing by using a pin honing machine or reamer so that it fits the piston pin to be used.



NOTE: Attach the bushing to the piston pin so that a pin, coated with engine oil can be pushed into position with your thumb.

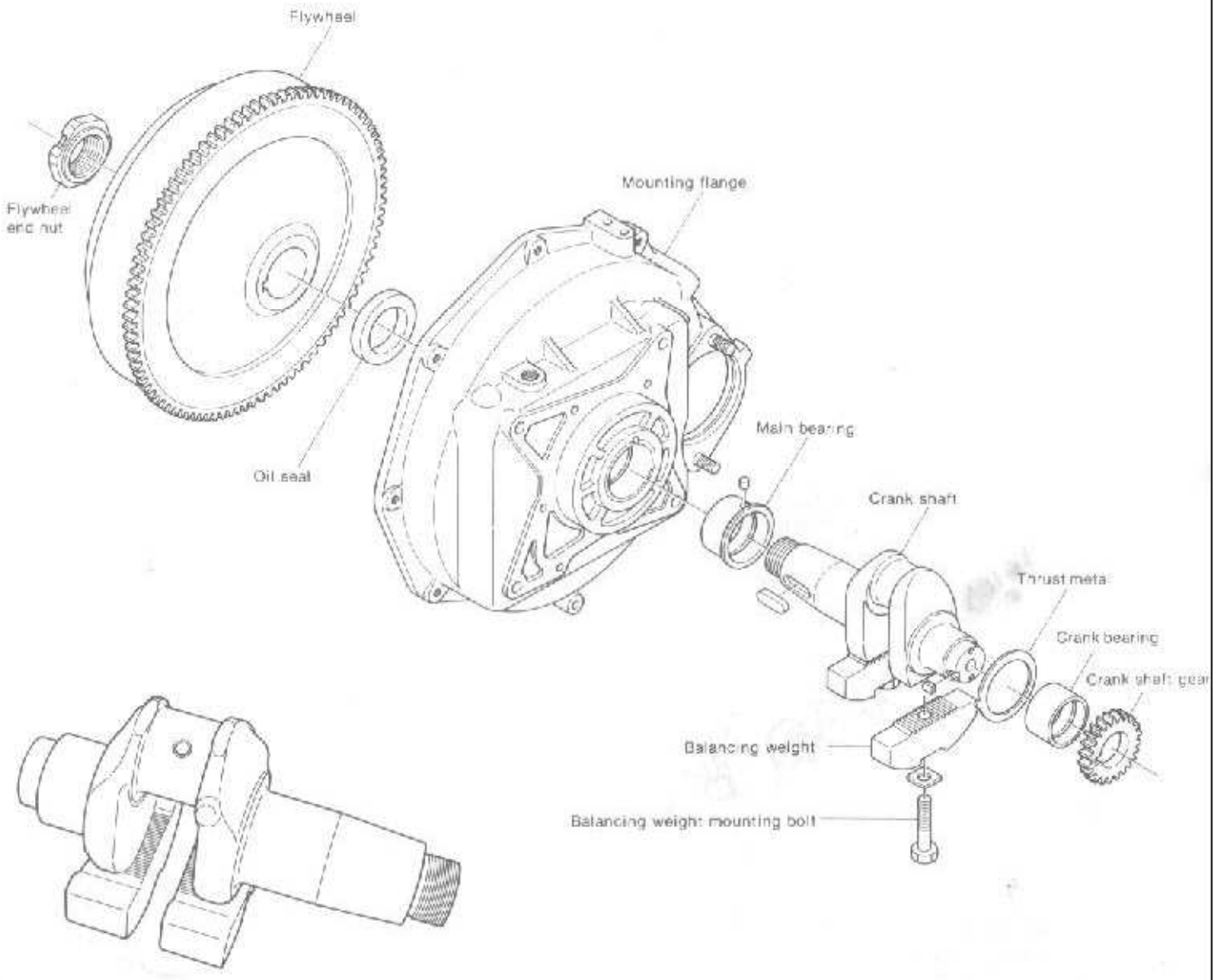
6. Crankshaft

6-1 Crankshaft ass'y and bearing construction

The crankshaft is stamp-forged,and the crank pin and journal sections are high-frequency induction hardened and ground and polished to a high precision finish. Therefore, the contact surface with the bushing is excellent and durability is superb.

The crankshaft is supported by two types of main bearing, namely, the main bearing for the cylinder body and the main bearing for the mounting flange. On one end the flywheel is mounted and on the other end is the crankshaft gear. In order to effect the proper balance, a balancing weight is mounted on each crank arm by serration matching.

The oil passage for the crankshaft journal and pin is shaped (see the diagram) so that the crankshaft can withstand low and high-speed operations.



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6-2 Inspection

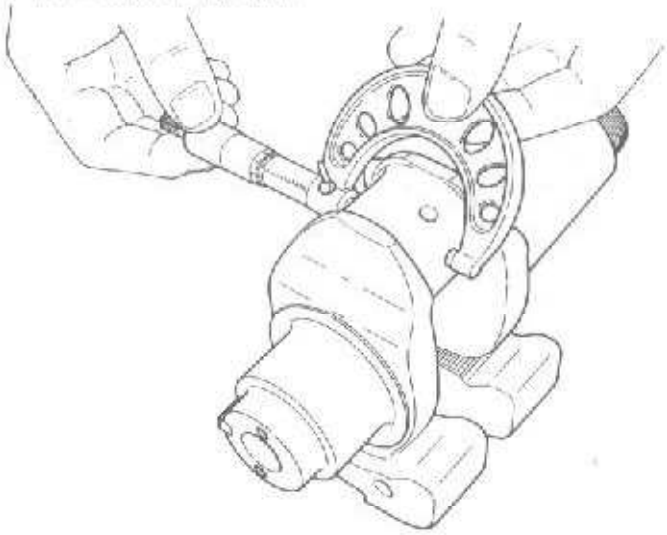
6-2.1 Crank journal and crank pin

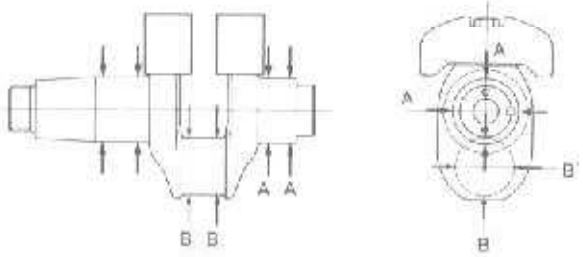
(1) Cracking

If cracking of the crank journal or crank pin is suspected, thoroughly clean the crankshaft and perform a color check on the shaft, or run a candle flame over the crankshaft and look for oil seepage from cracks. If any cracks are detected, replace the crankshaft.

(2) Crank pin and crank journal outside diameter measurement.

When the difference between the maximum wear and minimum wear of each bearing section exceeds the wear limit, replace the crankshaft. Also check each bearing section for scoring. If the scoring is light, repair it with emery cloth.





		YSM8		YSM12	
		Maintenance standard	Wear limit	Maintenance standard	Wear limit
Crankshaft journal wear	A A'	ø43.950 ~ 43.965 (1.7303 ~ 1.7309)	ø43.85 (1.7264)	ø51.952 ~ 51.973 (2.0454 ~ 2.0462)	ø51.85 (2.0413)
Crank pin wear	B B'	ø41.956 ~ 41.972 (1.6518 ~ 1.6524)	ø41.87 (1.6484)	ø45.952 ~ 45.973 (1.8091 ~ 1.8100)	ø44.87 (1.7665)
Crank journal and bushing oil clearance	Gear side	0.035 ~ 0.105 (0.0014 ~ 0.0041)	0.17 (0.0067)	0.027 ~ 0.088 (0.0011 ~ 0.0035)	0.18 (0.0071)
	Flywheel side	0.045 ~ 0.095 (0.0018 ~ 0.0037)	0.17 (0.0067)	0.037 ~ 0.092 (0.0015 ~ 0.0036)	0.18 (0.0071)
Crank pin and crank pin bushing oil clearance		0.028 ~ 0.088 (0.0011 ~ 0.0034)	0.14 (0.0055)	0.027 ~ 0.090 (0.0011 ~ 0.0035)	0.17 (0.0067)

6-3 Crankshaft side gap

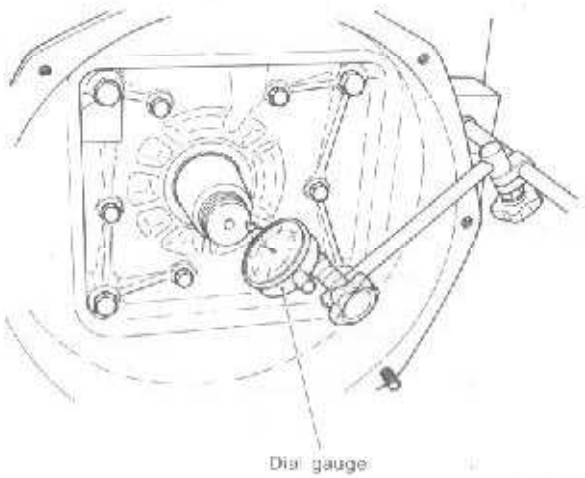
6-3.1 Side gap

The clearance in the axial direction after the crankshaft has been assembled is called the side gap.

If the side gap is too large, contact with pistons will be uneven, the clutch disengagement position will change, and other troubles will occur. If it is too small, the crankshaft sliding resistance will increase and cranking will become stiff.

6-3.2 Measuring side gap

Move the crankshaft to one side, attach dial gauge to the crankshaft tip, and measure the clearance between the crankshaft and the thrust bearing metal. Or, using a thickness gauge, measure the clearance between the thrust bearing metal on the housing side of the main shaft and the crankshaft. If the clearance exceeds the specified limit, replace the thrust bearing metal.



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6-3.3 Side gap maintenance standard and wear limit mm (in.)

	YSM8		YSM12	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Crank shaft side gap	0.155~0.315 (0.0061~0.0124)	0.45 (0.0177)	0.114~0.294 (0.0045~0.0116)	0.45 (0.0177)

6-4 Main bearing

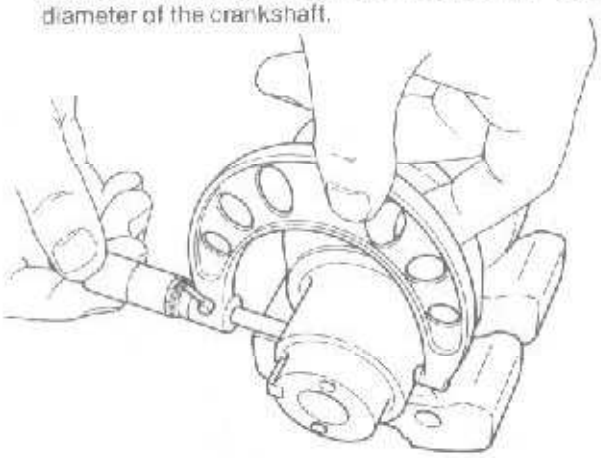
6-4.1 Construction

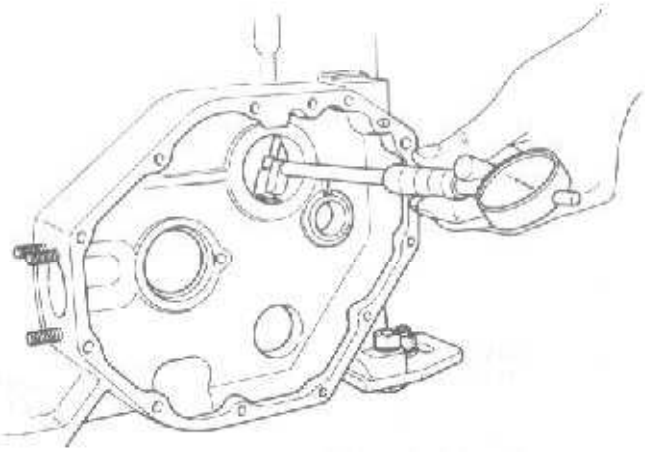
The main shaft bearing metal is round, made of a copper-lead series sintered alloy, and is highly wear resistant. As for the gear side main shaft bearing metal, the crank bearing metal and the thrust bearing metal are installed separately. With the flywheel side main shaft bearing metal, the above two bearing metals are installed together.

6-4.2 Inspecting the crank bearing

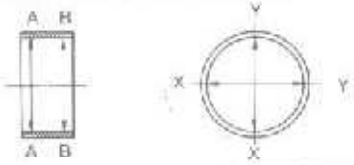
(1) Check the crank bearing metal for scaling, deposited metal and seizure. Also check the condition of the contact surface. If defects are found, replace.
If the bearing metal contact is too unsymmetrical, carefully check all related component parts which might be responsible, and take proper measures.

(2) Determine the oil clearance by measuring the inside diameter of the crankshaft bearing and the outside diameter of the crankshaft.





NOTE: Measure the crank bearing at the four points shown in the figure and replace the bearing if the wear limit is exceeded at any of these points.



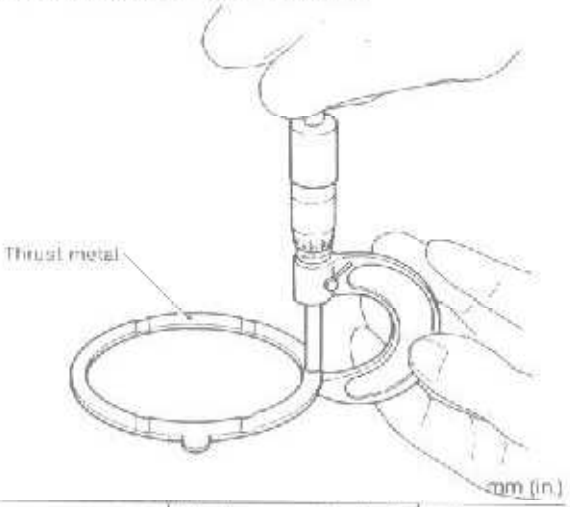
mm (in.)

mm (in.)

		YSM8		YSM12	
		Maintenance standard	Wear limit	Maintenance standard	Wear limit
Flywheel side	Main bearing inside diameter	ø44.010 ~ 44.045 (1.7327 ~ 1.7341)	ø44.14 (1.7378)	ø52.010 ~ 52.040 (2.0476 ~ 2.0488)	ø52.14 (2.0528)
	Crankshaft journal outside diameter	ø43.950 ~ 43.965 (1.7303 ~ 1.7309)	ø43.85 (1.7264)	ø51.952 ~ 51.973 (2.0847 ~ 2.0462)	ø51.85 (2.0413)
	Oil clearance	0.045 ~ 0.095 (0.0018 ~ 0.0037)	0.17 (0.0067)	0.037 ~ 0.088 (0.0015 ~ 0.0036)	0.18 (0.0071)
Opposite side of flywheel	Main bearing inside diameter	ø44.000 ~ 44.055 (1.7323 ~ 1.7344)	ø44.14 (1.7378)	ø52.000 ~ 52.060 (2.0472 ~ 2.0496)	ø44.14 (1.7378)
	Crankshaft journal ouside diameter	ø43.950 ~ 43.965 (1.7303 ~ 1.7309)	ø43.85 (1.7264)	ø51.952 ~ 51.973 (2.0847 ~ 2.0462)	ø51.85 (2.0413)
	Oil clearance	0.035 ~ 0.105 (0.0014 ~ 0.0041)	0.17 (0.0067)	0.027 ~ 0.108 (0.0011 ~ 0.0043)	0.18 (0.0071)

6-4.3 Inspecting the thrust metal

Measure the thickness of the thrust metal and replace the metal when wear exceeds the wear limit.



mm (in.)

	Maintenance standard	Wear limit
Thrust metal thickness	2.5 (0.098)	2.30 (0.090)

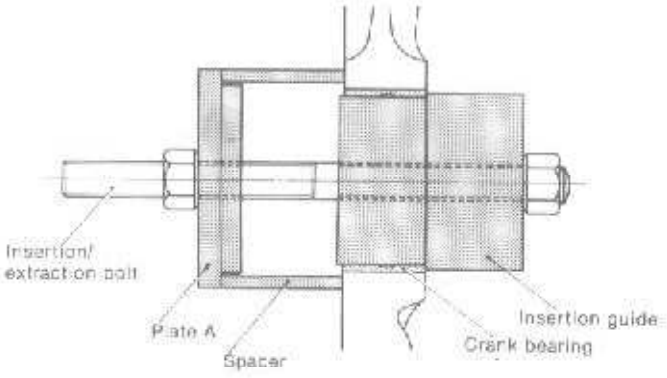
6-4.4 Replacing the crank bearing

Since the crank bearings at both ends of the crankshaft are pressed to the cylinder block and bearing housing with a press, a force of approximately 1.0 ~ 1.5 tons (2200 ~ 3300 lbs) is required to remove them.

Moreover, since the crankshaft will not rotate smoothly and other trouble may occur if the bearing is distorted, it must always be installed with the special tool.

(1) Removal

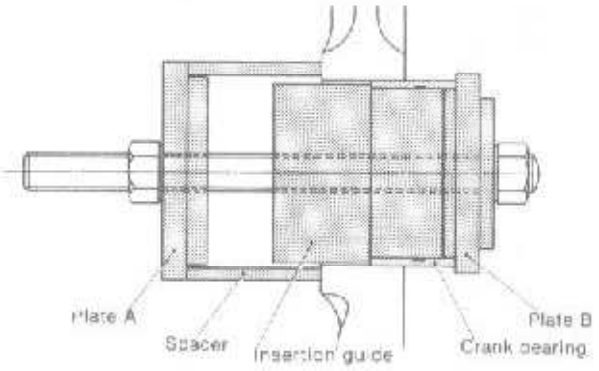
Assemble the spacer and plate A as shown in the figure, place the puller/extractor against the bearing from the opposite end and pull the bearing by tightening the nut of the special tool. Remove the oil seal before pulling the bearing pressed to the bearing housing.



(2) Installation

Coat the outside of the bearing with oil and align the positions of the bearing oil holes. Then press in plate B until it contacts the cylinder block or bearing housing, using the puller/extractor as a guide, as shown in the figure.

After inserting the bearing, measure its outside diameter. If the bearing is distorted, remove it again and replace it with a new bearing.



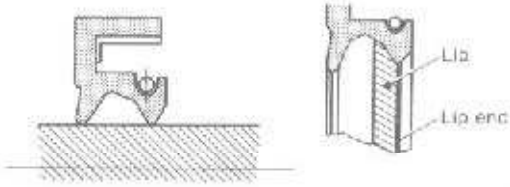
(3) Crank bearing installation precautions

1) Pay careful attention to the crank bearing insertion direction. Insert the bearing so that the side with the outside fillet is at the outside.
2) Align the oil hole of the crank bearing with the oil holes of the cylinder block and bearing housing.
3) After inserting the crank bearing, check that the crankshaft rotates easily with the thrust metal and bearing housing installed.
4) Be careful that the bearing is not tilted during insertion.

6-5 Crankshaft oil seal

6-5.1 Oil seal type and size

T-type oil seal is employed at the flywheel end of the crankshaft.



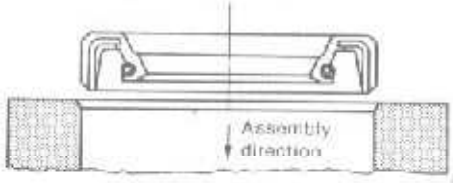
mm

	Size	Part No.
YSM8	44 • 60 • 9	104211-02220
YSM12	52 • 70 • 9	104511-02220

6-5.2 Oil seal insertion precautions

(1) Clean the inside of the housing hole, ascertaining that the hole was not dented when the seal was removed.

(2) Be sure that the insertion direction of the oil seal is correct. Insert so that the main lip mounting the spring is on the inside (oil side).



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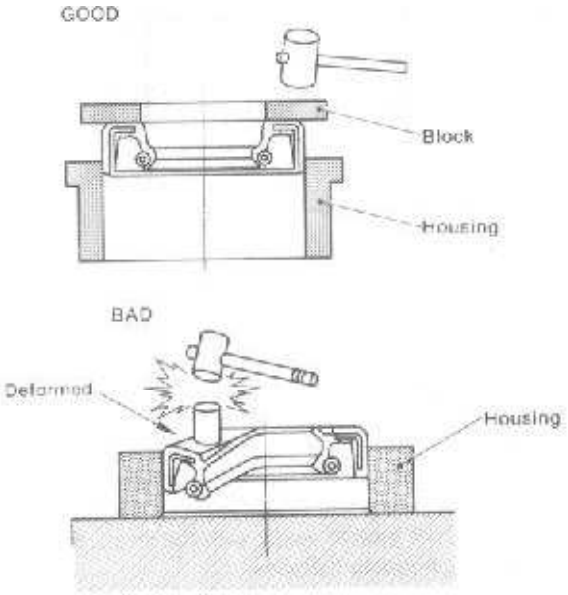
(3) Insert the oil seal with a press. However, when unavoidable, the seal may be installed by tapping the entire periphery of the seal with a hammer, using a block. In this case, be careful that the oil seal is not tilted.
Never tap the oil seal directly.

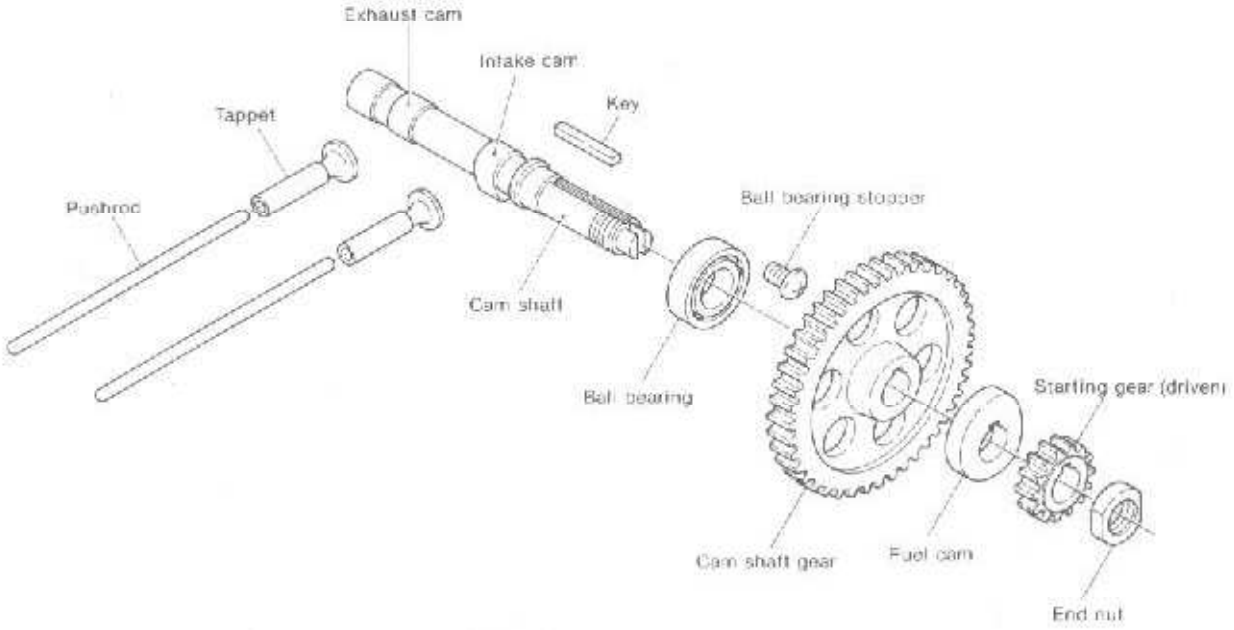


7. Camshaft

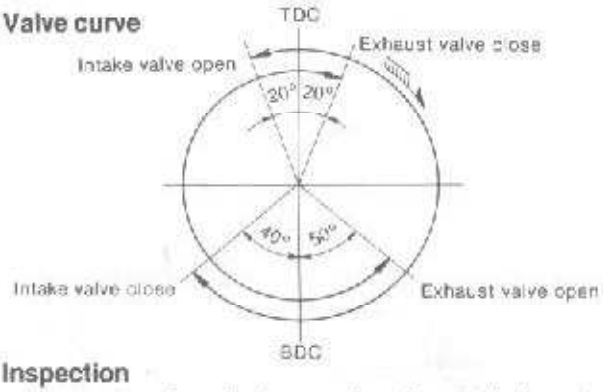
7-1 Construction

The camshaft is made of carbon steel. The bearings on the gear case side are ball bearings and its clutch side is directly borne by the block. The camshaft end is provided with a slit for inserting the lubricating oil pump. Its gear side is constructed so that the cam for driving the fuel injection pump can be mounted on it. The cam and its bearings have been treated with induction hardening to give them high hardness, better wear resistance and toughness.

Since the intake and exhaust cam profile is a parabolic acceleration cam with a buffering curve, movement of the valve at high speed is smooth, improving the durability of the intake and exhaust valve seats.



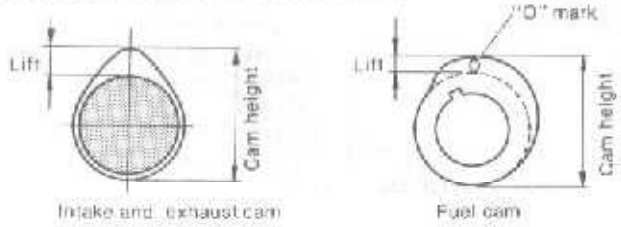
7-2 Valve curve

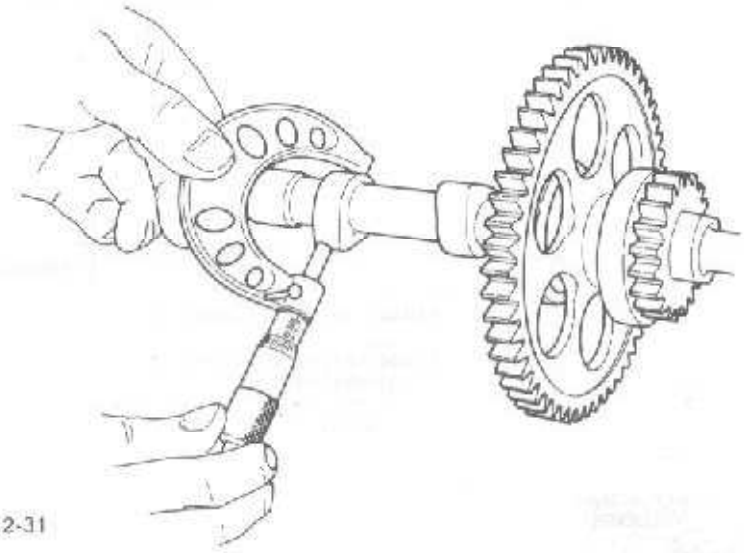


Intake and exhaust valve head clearance	0.20mm (0.00787in.)
Intake valve open b. TDC	20°
Intake valve close a. BDC	40°
Exhaust valve open b. BDC	50°
Exhaust valve close a. TDC	20°

7-3 Inspection

Since the cam surface is tempered and ground, there is almost no wear. However, measure the height of the intake and exhaust cams, and replace the camshaft when the measured value exceeds the wear limit.





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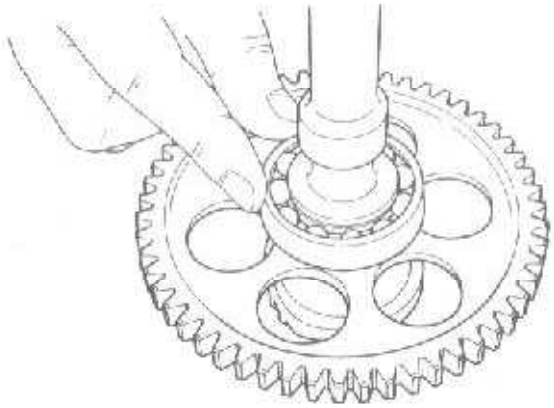
mm (in.)

		YSM8		YSM12	
		Maintenance standard	Wear limit	Maintenance standard	Wear limit
Camshaft height	Intake and exhaust cam	30.8 (1.2125)	30.5 (1.2007)	34.5 (1.3582)	34.2 (1.3464)
	Fuel cam	45 (1.771)	44.9 (1.7677)	60 (2.3622)	59.9 (2.3582)

7-4 Camshaft ball bearing

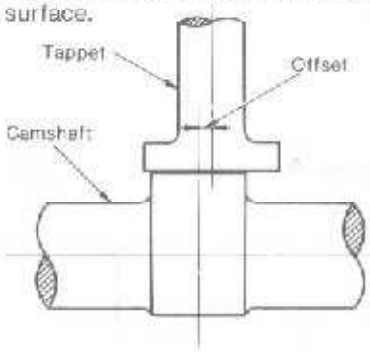
The camshaft bearing is a single row deep groove ball bearing. The construction and material of this ball bearing such that it can withstand the radial load, thrust loads in both directions, and a combination of both these loads. Replace the main camshaft bearing if their components have the following defects: balls, inner or outer race, cage, etc., have flaws, impressions, etc.; components that will not rotate smoothly; components that produce noise; components that loose; components that have discolored due to seizure; etc.

1. When the bearings are rotated by hand, they should not rang up anywhere.
2. When they are rotated rapidly, they should not produce any abnormal sound.



7-5 Tappets

These mushroom type tappets feature a special iron casting with chill-hardened contact surfaces for high wear resistance. The center of the cam surface width and the center of the tappet are offset to prevent eccentric wear of the contact surface.

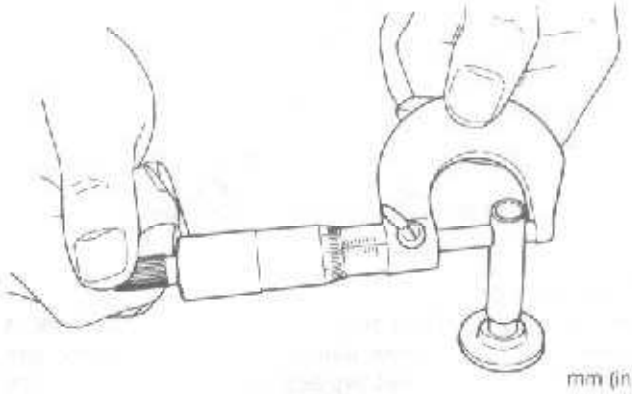


7-5.1 Tappet disassembly precautions

Intake and exhaust must be clearly indicated when disassembling the camshaft and tappets.

7-5.2 Tappet stem wear and contact

Measure the outside diameter of the tappet stem, and replace the tappet when the wear limit is exceeded or contact is uneven.



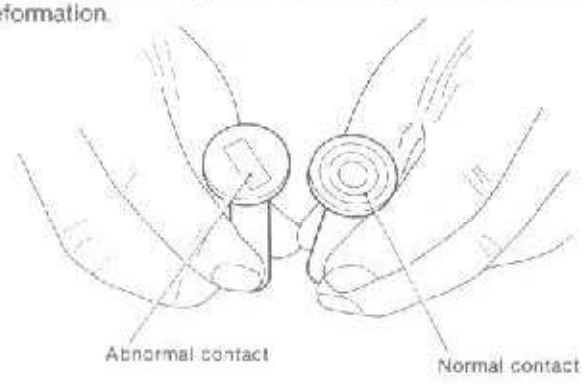
mm (in.)

	YSM8		YSM12	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Outside diameter of tappet stem	ø9.980 ~ 9.995 (0.39291 ~ 0.39350)	9.95 (0.39173)	ø10.980 ~ 10.995 (0.43228 ~ 0.43287)	10.95 (0.43110)
Inside diameter of tappet guide (cylinder block)	ø10.000 ~ 10.027 (0.3937 ~ 0.39476)	—	ø11.000 ~ 11.027 (0.43307 ~ 0.43413)	—
Oil clearance	ø0.005 ~ 0.047 (0.00019 ~ 0.00185)	0.1 (0.00393)	ø0.005 ~ 0.047 (0.00019 ~ 0.00185)	0.1 (0.00393)

7-5.3 Tappet and cam contact surface

Since the tappet and cam are offset, the tappet rotates in an up and down movement during operation, so there is no uneven contact.

Since eccentric wear will occur if cam tappet contact is poor, replace the tappet if there is any uneven contact or deformation.

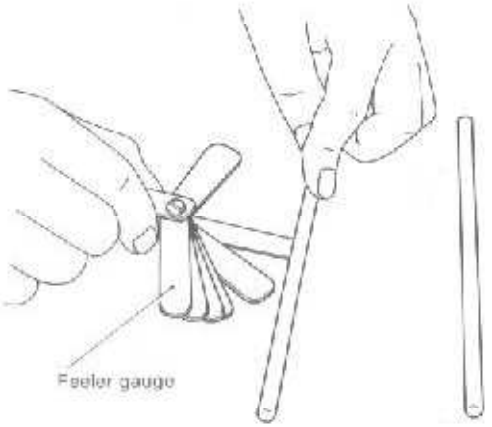


NOTE: If the sliding surface of the tappet and the cam is damaged, check the camshaft also.

7-6 Push rods

The push rods are sufficiently rigid and strong to prevent bending.

Place the push rod on a stool or flat surface and measure the clearance between the center of the push rod and the flat surface, and replace the push rod if the wear limit is exceeded.



Check both ends for wear and peeling, and replace the push rod if faulty.

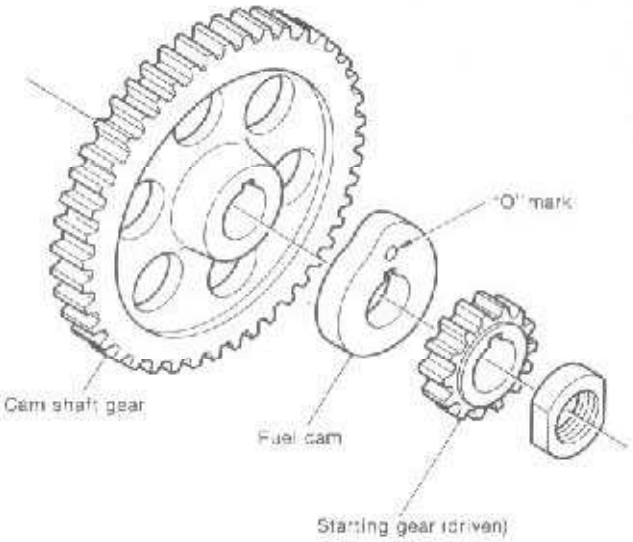
mm(in.)

	Maintenance standard	Wear limit
Push rod bend	0.03 or less (0.00118 or less)	0.3 (0.0118)

7-7 Fuel cam assembly precautions

Install the fuel cam by aligning it with the key of the camshaft. If the installation direction is not correct, the fuel injection timing will be considerably off and the engine will not start.

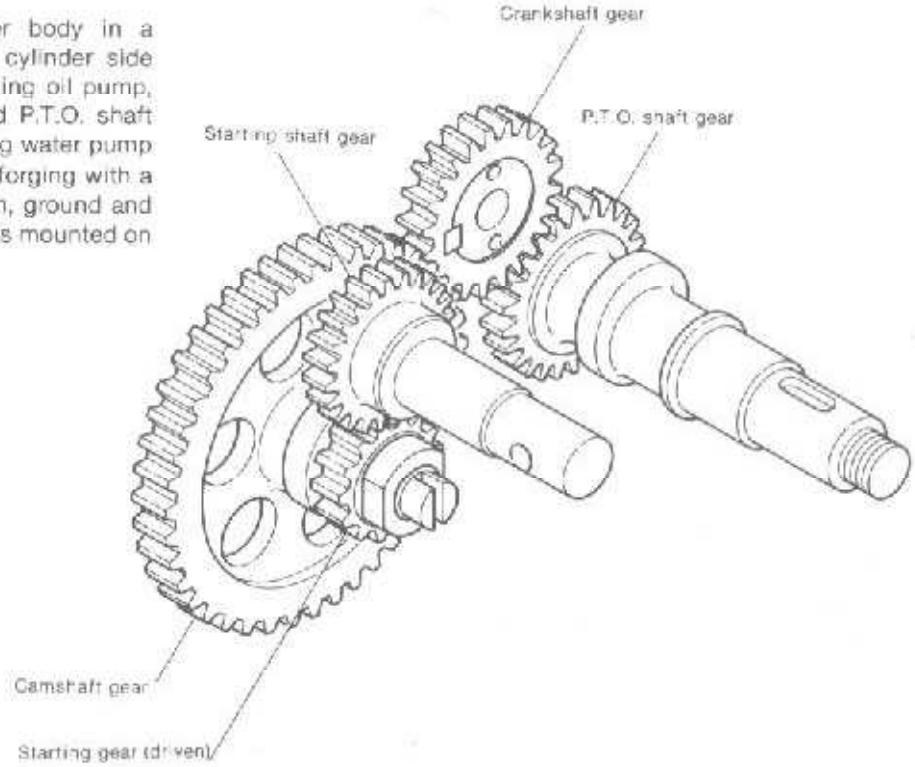
When assembling the fuel cam, be sure that the "0" mark side of the cam is opposite the camshaft gear.

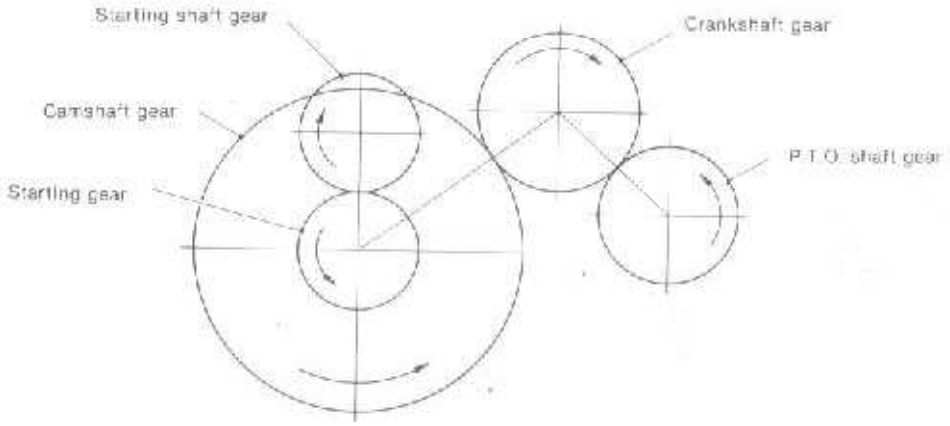


8. Timing Gear

8-1 Timing gear train construction

The gear case is cast with the cylinder body in a monoblock casting and is formed by the cylinder side cover. It is mounted along with the lubricating oil pump, lubricating oil filter, fuel control device and P.T.O. shaft (which drives the fuel feed pump), the cooling water pump and alternator. The camshaft gear is a steel forging with a hardened tooth face that has been precision, ground and finished. It is driven by the crank gear which is mounted on the crankshaft.





	YSM8				YSM12			
	Module	Number of teeth	Tooth width	Center-to-center distance	Module	Number of teeth	Tooth width	Center-to-center distance
P.T.O. shaft gear	2.5	23	10.5 (0.4134)	P.T.O. shaft gear ~ Crankshaft gear ...58 (2.2835) Crankshaft gear ~ Camshaft gear ...86.75 (3.4154) Starting gear ~ Starting shaft gear ...43.225 (1.7018)	2.5	23	10.5 (0.4134)	P.T.O. shaft gear ~ Crankshaft gear ...62.5 (2.4606) Crankshaft gear ~ Camshaft gear ...101.25 (3.9862) Starting gear ~ Starting shaft gear ...50 (1.9685)
Crankshaft gear	2.5	23	11 (0.4331)		2.5	27	11 (0.4331)	
Camshaft gear	2.5	46	10 (0.3937)		2.5	54	11 (0.4331)	
Starting gear (driven)	2.5	15	10 (0.3937)		2.5	20	10 (0.3937)	
Starting shaft gear	2.5	20	9.7 (0.3819)		2.5	20	9.7 (0.3819)	

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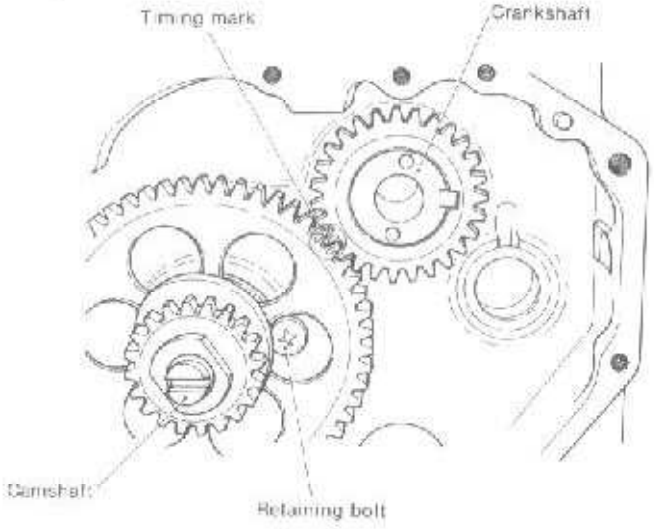
8-2 Disassembly and reassembly

Timing mark

A timing mark is provided on the crankshaft gear and camshaft gear to adjust the timing between opening and closing of the intake and exhaust valves and fuel injection when the piston is operated.

Always check that these timing marks are aligned when disassembling and reassembling the timing gear.

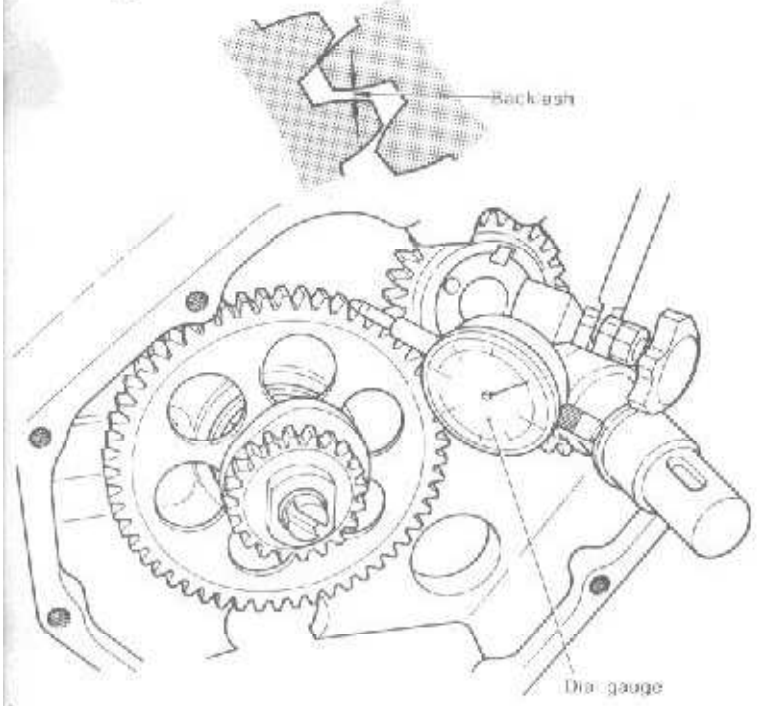


8-3 Inspection

8-3.1 Backlash

Unsuitable backlash will cause excessive wear or damage at the tooth top and abnormal noise during operation. Moreover, in extreme cases, the valve and fuel injection timing will deviate and the engine will not run smoothly.

When the backlash exceeds the wear limit, repair or replace the gears as a set.



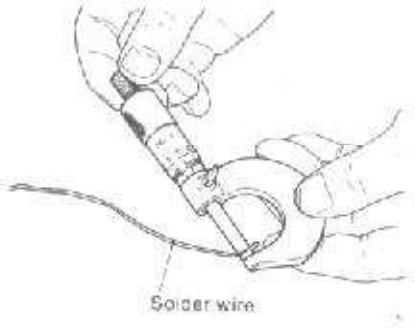
mm (in.)

	Maintenance standard	Wear limit
Crankshaft gear and camshaft gear backlash	0.08 ~ 0.16 (0.0031 ~ 0.0062)	0.3 (0.0118)
Crankshaft gear and P.T.O shaft gear backlash		

Measuring backlash

(1) Lock one of the two gears to be measured and measure the amount of movement of the other gear by placing a dial gauge on the tooth surface.

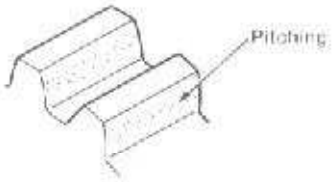
(2) Insert a piece of quality solder between the gears to be measured and turn the gears. The backlash can be measured by measuring the thickness of the crushed part of the solder.



8-3.2 Inspecting the gear tooth surface

Check the tooth surface for damage caused by pitching and check tooth contact. Repair if the damage is light. Also inspect the gears for cracking and corrosion.

When gear noise becomes high because of wear or damage, replace the gears as a set.



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