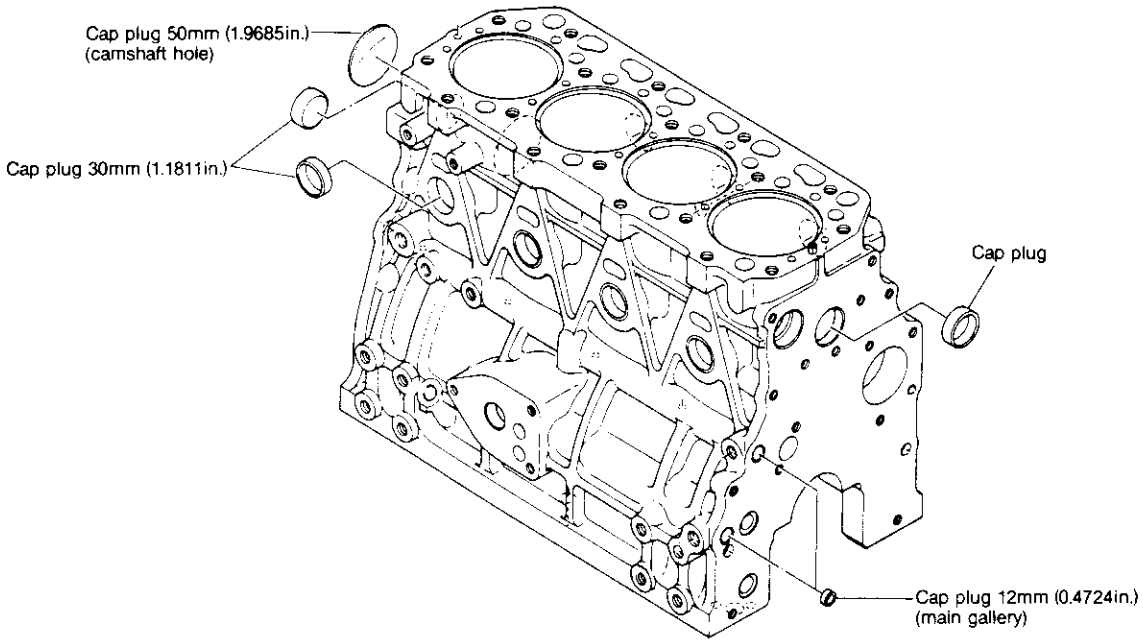
CHAPTER 2

INSPECTION AND SERVICING OF BASIC ENGINE PARTS

1. Cylinder Block

The cylinder block is thin-skinned, (low-weight), short skirt type with rationally placed ribs. The side walls are wave shaped to maximize ridigity for strength and low noise.



1-1 Inspection of parts

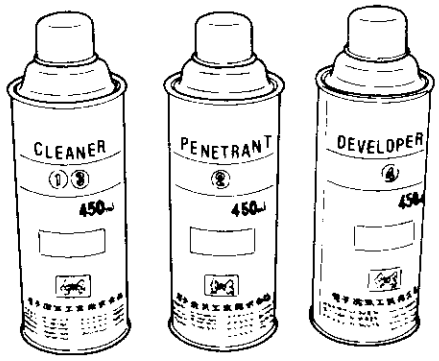
Make a visual inspection to check for cracks on engines that have frozen up, overturned or otherwise been subjected to undue stress. Perform a color check on any portions that appear to be cracked, and replace the cylinder block if the crack is not repairable.

1-2 Cleaning of oil holes

Clean all oil holes, making sure that none are clogged up and the blind plugs do not come off.

Color check kit
Part code No. 97550-004560

	Quantity
Penetrant	1
Developer	2
Cleaner	3



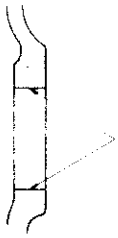
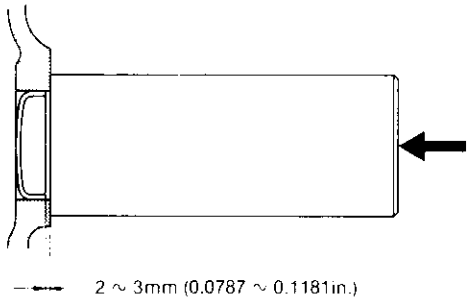
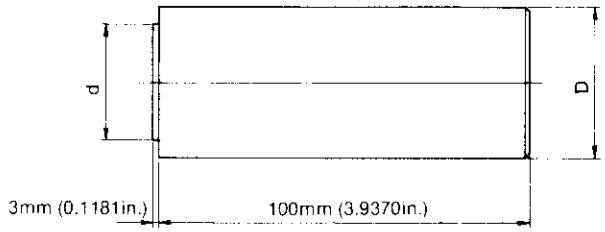
1-3 Color check procedure

(1) Clean the area to be inspected.
(2) Color check kit
The color check test kit consists of an aerosol cleaner, penetrant and developer.
(3) Clean the area to be inspected with the cleaner.
Either spray the cleaner on directly and wipe, or wipe the area with a cloth moistened with cleaner.
(4) Spray on red penetrant
After cleaning, spray on the red penetrant and allow 5 ~ 10 minutes for penetration. Spray on more red penetrant if it dries before it has been able to penetrate.
(5) Spray on developer
Remove any residual penetrant on the surface after the penetrant has penetrated, and spray on the developer. If there are any cracks in the surface, red dots or a red line will appear several minutes after the developer dries.
Hold the developer 300 ~ 400mm (11.8110 ~ 15.7480in.) away from the area being inspected when spraying, making sure to coat the surface uniformly.
(6) Clean the surface with the cleaner.

NOTE: Without fail, read the instructions for the color check kit before use.

Printed in Japan
0000A0A1647

1-4 Replacement of cup plugs

Step No.	Description	Procedure	Tool or material used
1.	Clean and remove grease from the hole into which the cup plug is to be driven. (Remove scale and sealing material previously applied.)	 Remove foreign materials with a screw driver or saw blade.	•Screw driver or saw blade •Thinner
2.	Remove grease from the cup plug.	Visually check the nick around the plug.	•Thinner
3.	Apply Threebond No. 4 to the seat surface where the plug is to be driven in.	Apply over the whole outside of the plug.	•Threebond No. 4
4.	Insert the plug into the hole.	Insert the plug so that it sits correctly.	
5.	Place a driving tool on the cup plug and drive it in using a hammer.  2 ~ 3mm (0.0787 ~ 0.1181in.) *Using the special tool, drive the cup plug to a depth where the edge of the plug is 2mm (0.0787in.) below the cylinder surface.	Drive in the plug parallel to the seating surface.  	•Driving tool •Hammer

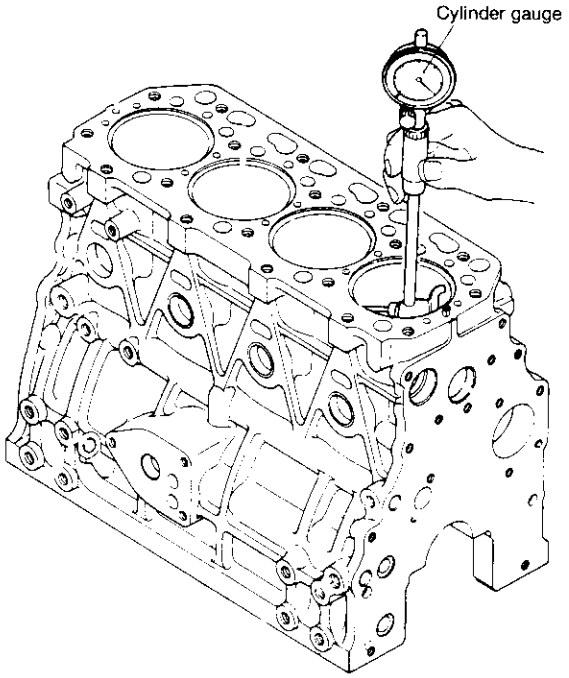
mm (in.)

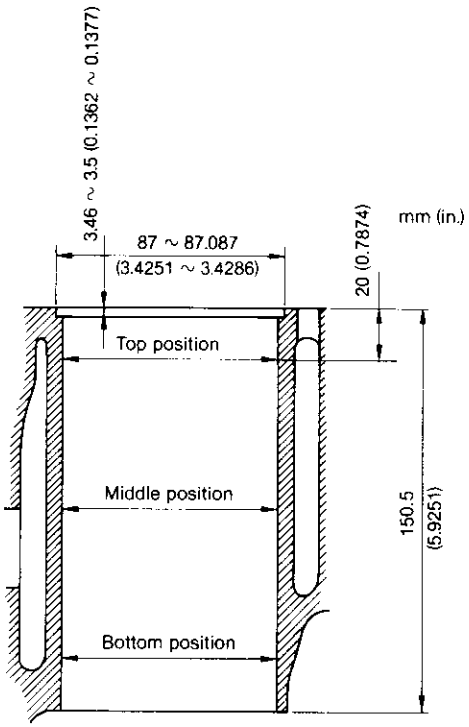
Plug dia.	d	D
ø12	ø11.9 ~ 12.0 (ø0.4685 ~ 0.4724)	ø20 (ø0.7874)
ø30	ø29.9 ~ 30.0 (ø1.1770 ~ 1.8110)	ø40 (ø1.5748)

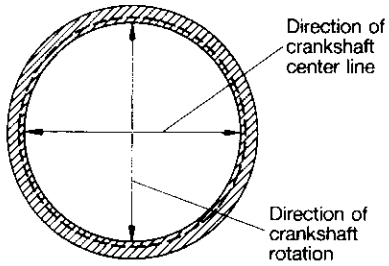
Printed in Japan
0000A0A1647

1-5 Cylinder bore measurement

Measure the bore diameter with a cylinder gauge at the positions shown in the figure.
Replace the cylinder bore when the measured value exceeds the wear limit. Measurement must be done at least at 3 positions as shown in the figure, namely, top, middle and bottom positions in both directions along the crankshaft rotation and crankshaft center lines.







mm (in.)

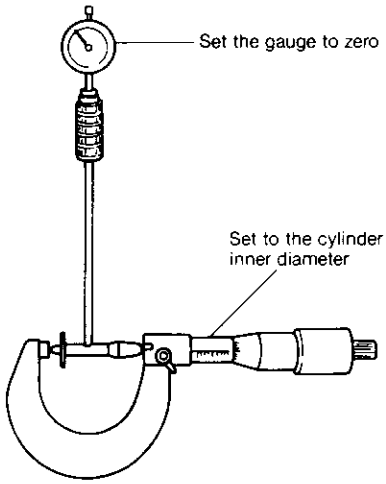
	Standard	Wear limit
Cylinder bore dia.	ø82.00 ~ 82.03 (3.2283 ~ 3.2295)	ø82.06 (3.2307)
Cylinder roundness	0 ~ 0.01 (0 ~ 0.0004)	0.02 (0.0008)

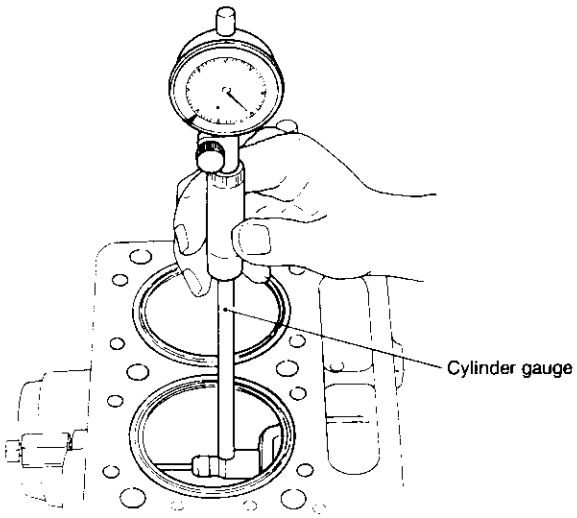
Printed in Japan
0000A0A1647

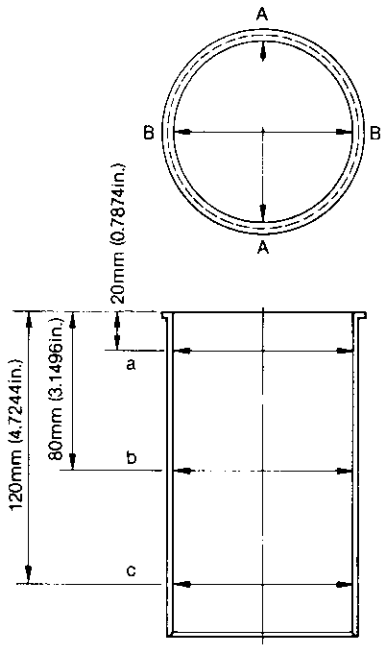
2. Cylinder Liners

2-1 Measuring cylinder liners

Measure the inner diameter of each cylinder with a cylinder gauge and replace the cylinder liner if it exceeds the wear limit.







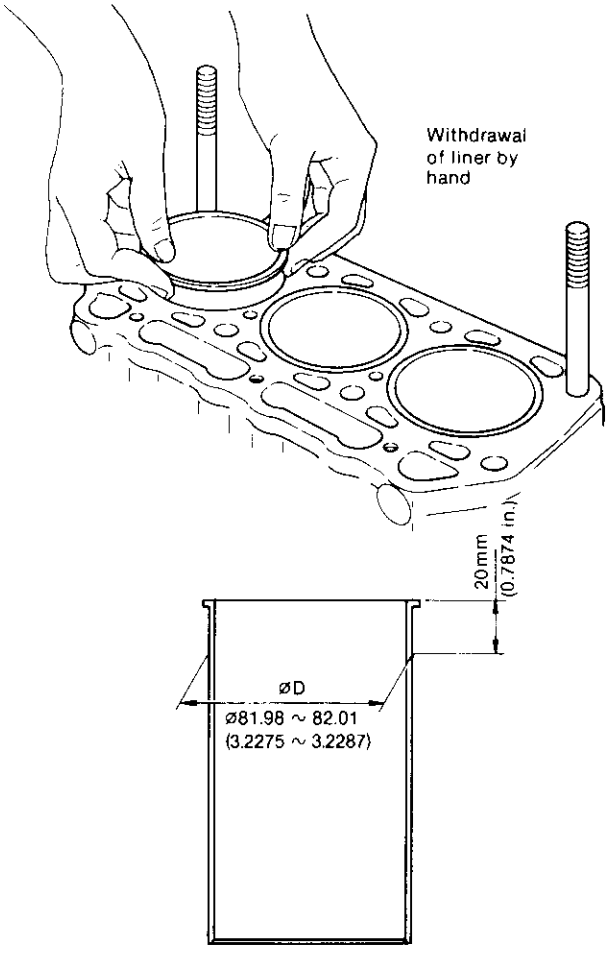
mm (in.)

	Standard	Wear limit
Cylinder liner	ø78.00 ~ 78.03 (ø3.0708 ~ 3.0720)	ø78.12 (ø3.0755)

NOTE: Be sure to measure A-A, B-B and a, b and c

2-2 Inserting cylinder liners

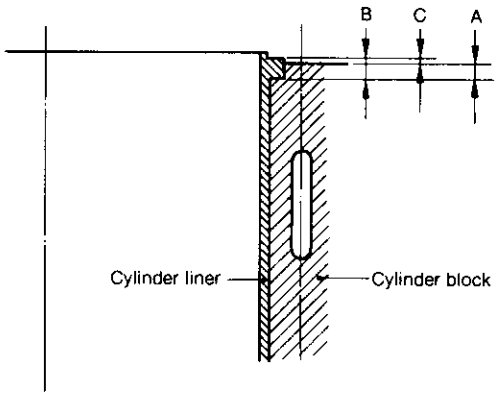
Coat the outside of the liner with oil, and insert lightly by hand. Do not tap with a wooden hammer as this may deform the liner.



Printed in Japan
0000A0A1647

2-3 Measuring cylinder liner projection

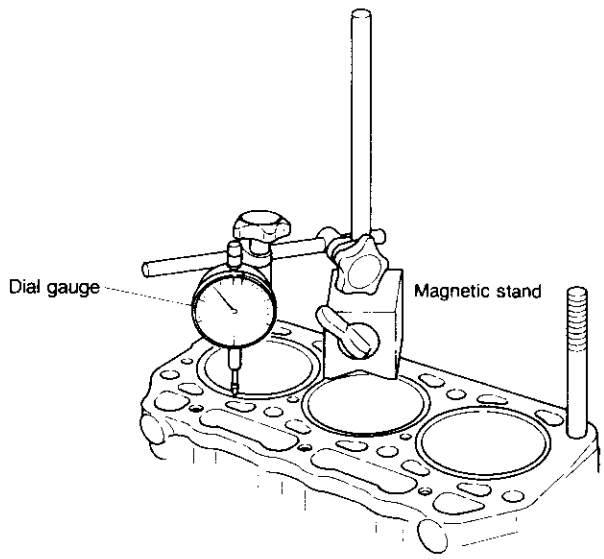
Make sure the cylinder liner flange projects only slightly above the block.



mm (in.)

A	3.46 ~ 3.50 (0.1362 ~ 0.1378)
B	3.53 ~ 3.55 (0.1390 ~ 0.1398)
C	0.03 ~ 0.09 (0.0011 ~ 0.0035)

NOTE: Excessive cylinder liner projection is frequently caused by incomplete removal of the rust on the ledge (Part D of figure) of the cylinder block.

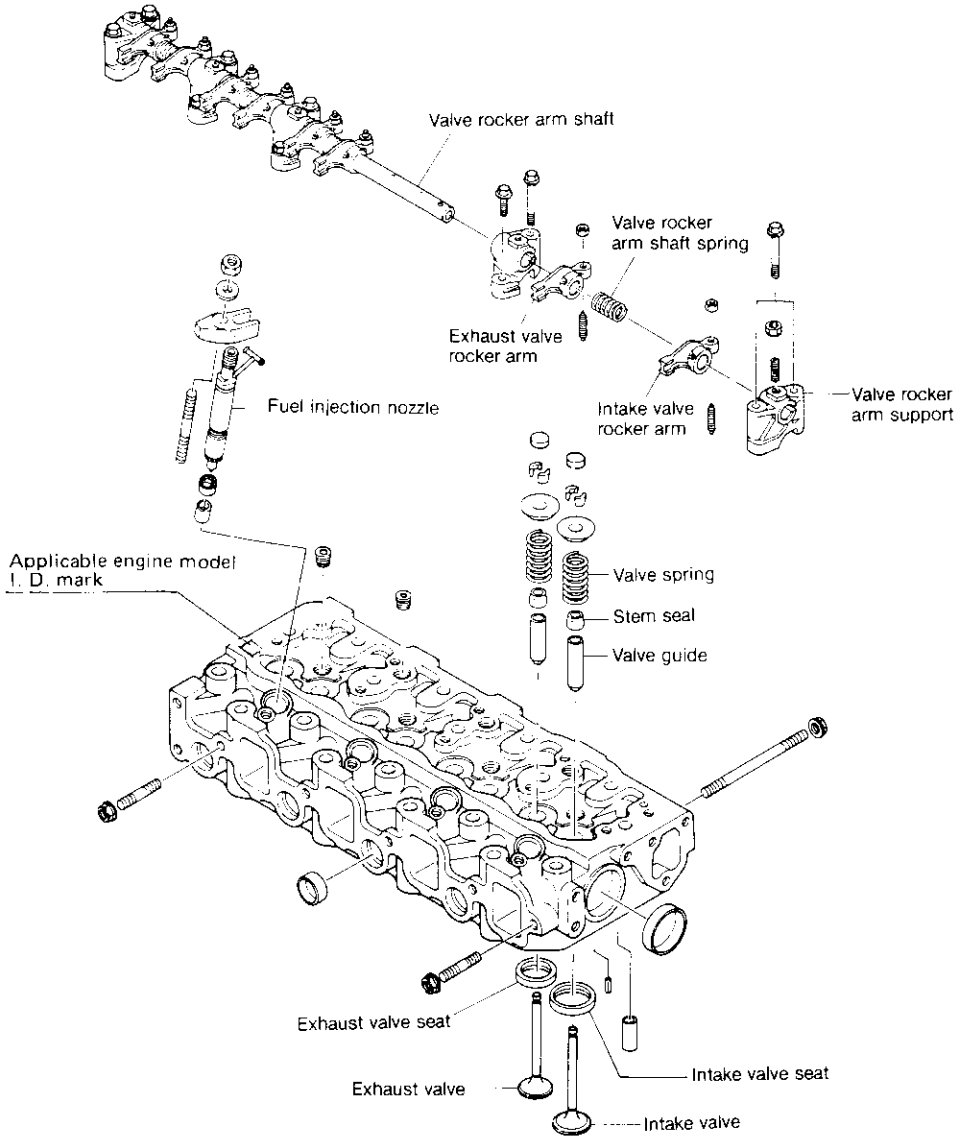


Printed in Japan
0000A0A1647

3. Cylinder Head

The cylinder head is of 4-cylinder integral construction, mounted with 18 bolts. Special alloy stellite with superior resistance to heat and wear is fitted on the seats, and the area between the valves is cooled by a water jet.

IMPORTANT:
Cylinder head assembly differs among engine models. If an incorrect cylinder head is installed, combustion performance will drop. Be sure to check the applicable engine model identification mark (I. D. Mark) on the cylinder head assembly to insure use of the correct part.



Cylinder Head Ass'y

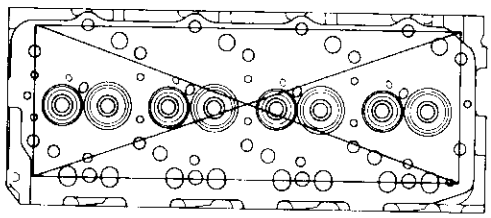
	I.D. Mark	Applicable Engine Model & E/#	
Old type	1	4JHE	E/#01000 and before
	1	4JH-TE	E/#11000 and before
	5	4JH-HTE	E/#21000 and before
New type	SL	4JHE	E/#01001 and after
	SG	4JH-TE	E/#11001 and after
	SG	4JH-HTE	E/#21001 and after
	SG	4JH-DTE	E/#30101 and after

*Engines produced at YANMAR plant on and after June 21, 1985

Printed in Japan
0000A0A1647

3-1 Inspecting the cylinder head

The cylinder head is subjected to very severe operating conditions with repeated high pressure, high temperature and cooling. Thoroughly remove all the carbon and dirt after disassembly and carefully inspect all parts.



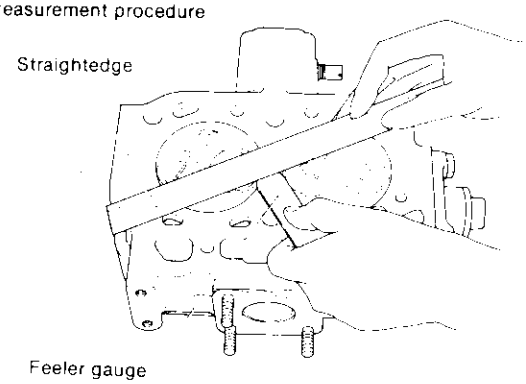
3-1.1 Distortion of the combustion surface

Carefully check for cylinder head distortion as this leads to gasket damage and compression leaks.

(1) Clean the cylinder head surface.

(2) Place a straight-edge along each of the four sides and each diagonal. Measure the clearance between the straight-edge and combustion surface with a feeler gauge.

Measurement procedure

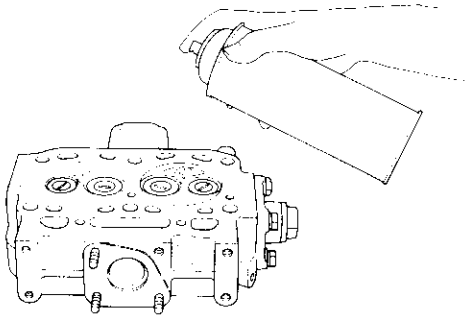


mm (in.)

	Standard	Wear limit
Cylinder head distortion	0.05 (0.0019) or less	0.15 (0.0059)

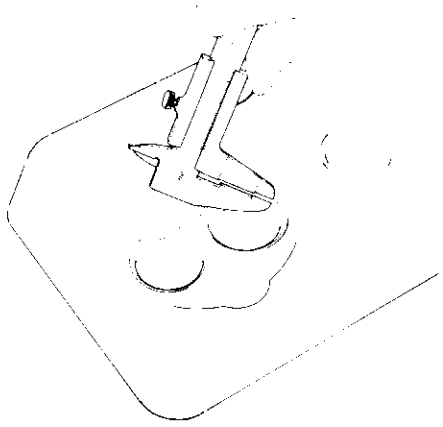
3-1.2 Checking for cracks in the combustion surface

Remove the fuel injection nozzle, intake and exhaust valve and clean the combustion surface. Check for discoloration or distortion and conduct a color check test to check for any cracks.



3-1.3 Checking the intake and exhaust valve seats

Check the surface and width of the valve seats.
If they are too wide, or if the surfaces are rough, correct to the following standards:

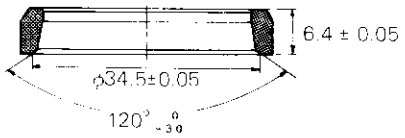


Seat angle	Intake	120°
	Exhaust	90°

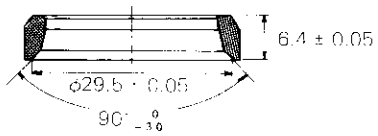
mm (in.)

Seat width	Standard	Wear limit
Intake	1.28 (0.0504)	1.78 (0.0700)
Exhaust	1.77 (0.0697)	2.27 (0.0894)

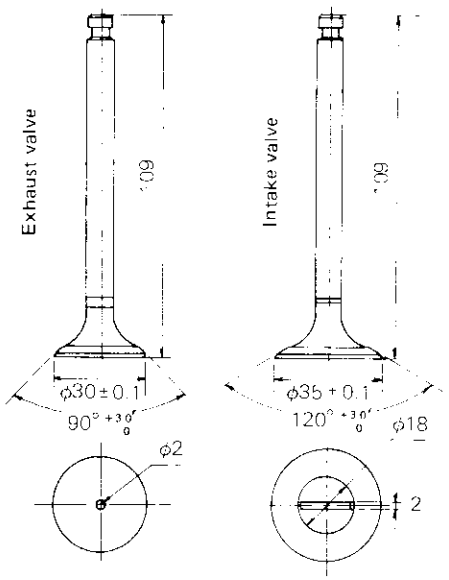
Intake valve seat



Exhaust valve seat



Standard dimension

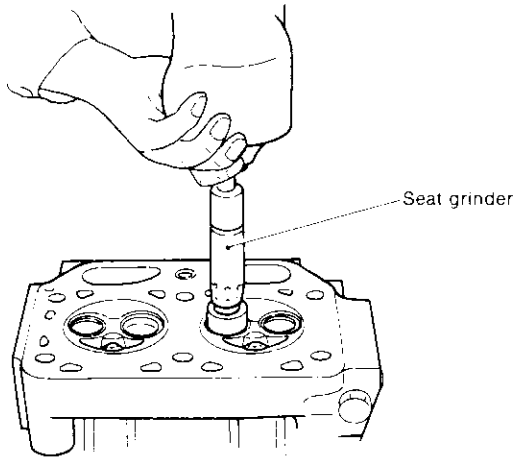


Printed in Japan
0000A0A1647

3-2 Valve seat correction procedure

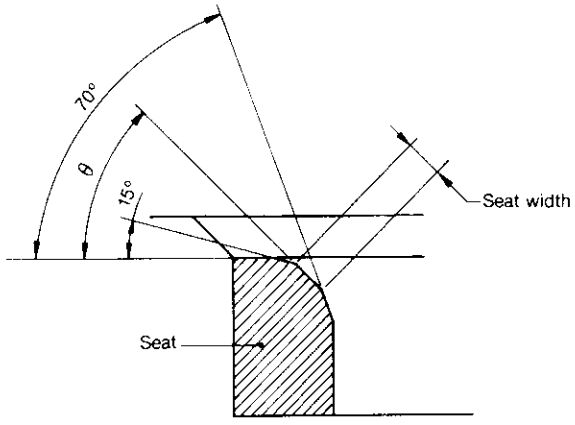
The most common method for correcting unevenness of the seat surface with a seat grinder is as follows:

(1) Use a seat grinder to make the surface even.
As the valve seat width will be enlarged, first use a 70° grinder, then grind the seat to the standard dimension with a 15° grinder.



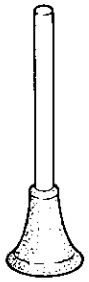
Seat grinder	Intake valve	30°
	Exhaust valve	45°

NOTE: When seat adjustment is necessary, be sure to check the valve and valve guide. If the clearance exceeds the tolerance, replace the valve or the valve guide, and then grind the seat.

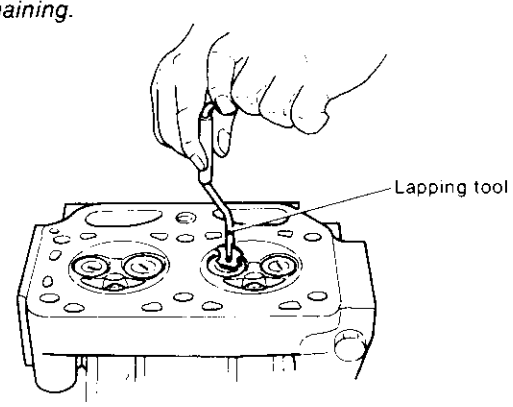


(2) Knead valve compound with oil and finish the valve seat with a lapping tool.
(3) Final finishing should be done with oil only.

Lapping tool
Use a rubber cap type lapping tool for cylinders without a lapping tool groove slit.



NOTE: Clean the valve and cylinder head with light oil or the equivalent after valve seat finishing is completed, and-make sure that there are no grindings remaining.

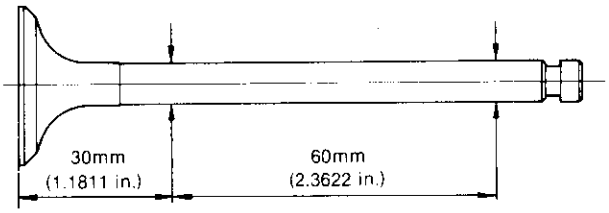


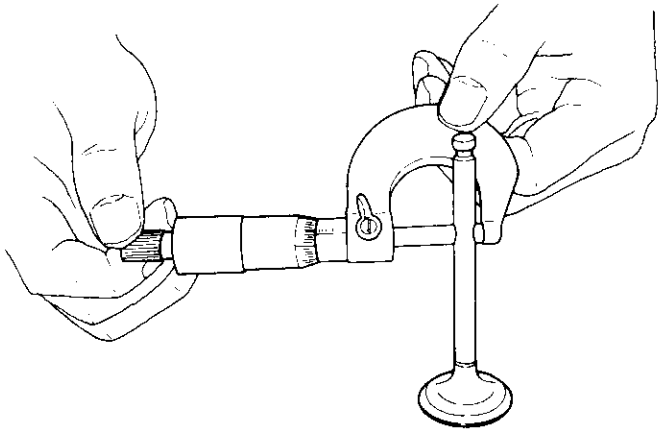
NOTE: 1. Insert adjusting shims between the valve spring and cylinder head when seats have been refinished with a seat grinder.
2. Measure valve distortion after valve seat refinishing has been completed, and replace the valve and valve seat if it exceeds the tolerance.

3-3 Intake/exhaust valves, valve guides

3-3.1 Wearing and corrosion of valve stem

Replace the valve if the valve stem is excessively worn or corroded.





mm (in.)

Valve stem outside dia.	Standard	Wear limit
Intake	ø7.960 ~ 7.975 (ø0.3134 ~ 0.3140)	−0.13 (−0.0051)
Exhaust	ø7.955 ~ 7.970 (ø0.3132 ~ 0.3138)	−0.13 (−0.0051)

Printed in Japan
0000A0A1647

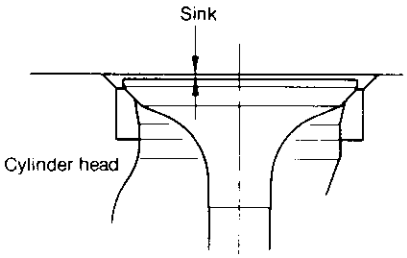
3-3.2 Inspection of valve seat wear and contact surface

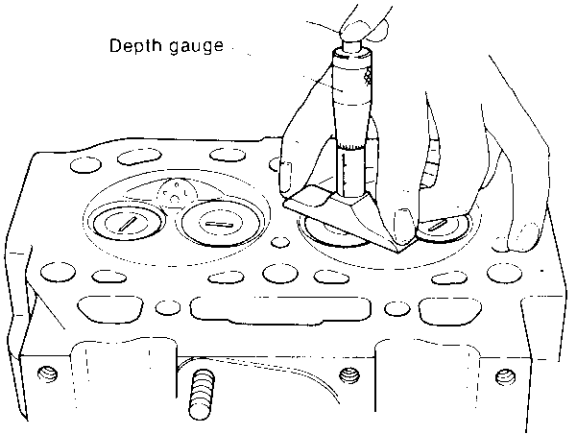
Inspect for valve seat scratches and excessive wear. Check to make sure the contact surface is normal. The seat angle must be checked and adjusted if the valve seat contact surface is much smaller than the width of the valve seat.

NOTE: Keep in mind the fact that the intake and discharge valve have different diameters.

3-3.3 Valve sinking

Over long periods of use and repeated lappings, combustion efficiency may drop. Measure the sinking distance and replace the valve and valve seat if the valve sink exceeds the tolerance.





mm (in.)

	Standard	Wear limit
Valve sink	0.4 ~ 0.6 (0.0157 ~ 0.0236)	1.5 (0.0590)

3-3.4 Valve guide

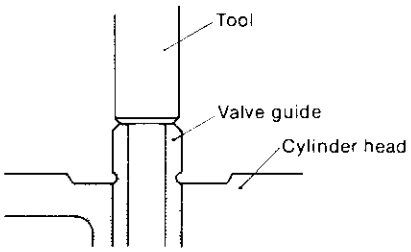
(1) Measuring inner diameter of valve guide.
Measure the inner diameter of the valve guide and replace it if it exceeds the wear limit.

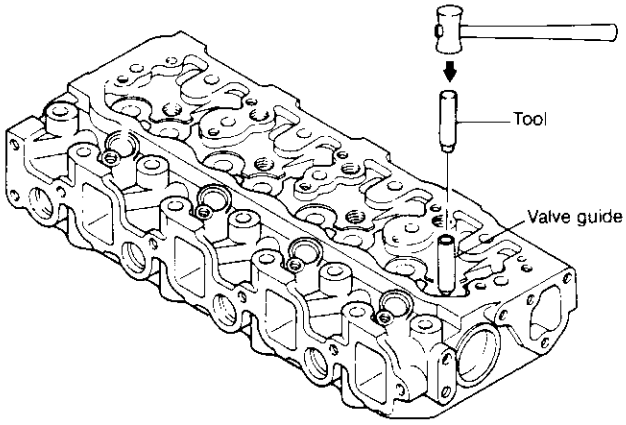
mm (in.)

		Standard	Wear limit
Valve guide inside dia.	Intake	ø8.015 ~ 8.030 (ø0.3156 ~ 0.3161)	+0.2 (0.0079)
	Exhaust	ø8.015 ~ 8.030 (ø0.3156 ~ 0.3161)	+0.2 (0.0079)

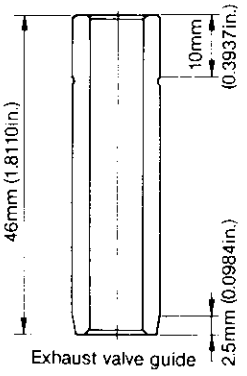
NOTE: The inner diameter standard dimensions assume a pressure fit.

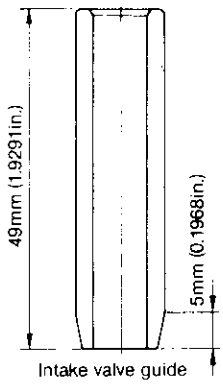
(2) Replacing the valve guide
Use the insertion tool and tap in the guide with a mallet.



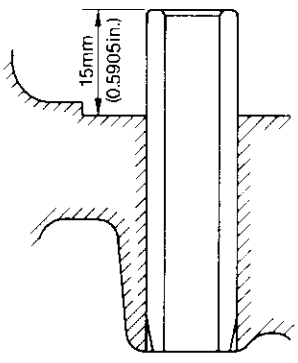


The intake valve guide and exhaust valve guide are of different shapes/dimensions. The one with a groove around it is the exhaust valve guide and the one without is the intake valve guide.



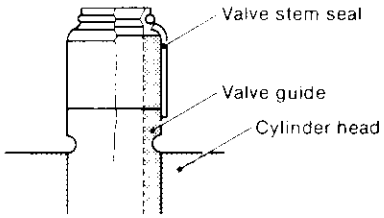


(3) Valve guide projection
The valve guide should project 15mm from the top of the cylinder head.



Printed in Japan
0000A0A1647

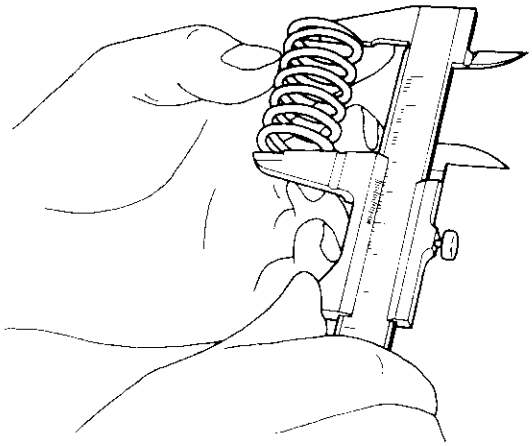
(4) Valve stem seals
The valve stem seals in the intake/exhaust valve guides cannot be re-used once they are removed—be sure to replace them.
When assembling the intake/exhaust valves, apply an adequate quantity of engine oil on the valve stem before inserting them.



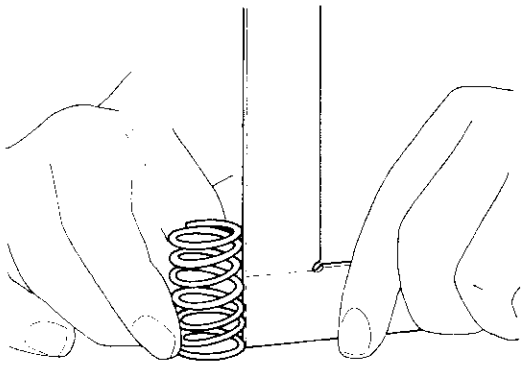
3-4 Valve springs

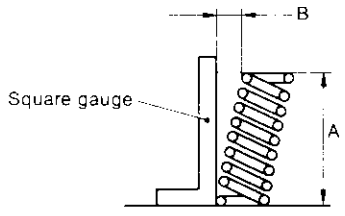
3-4.1 Checking valve springs

(1) Check the spring for scratches or corrosion.
(2) Measure the free length of the spring.

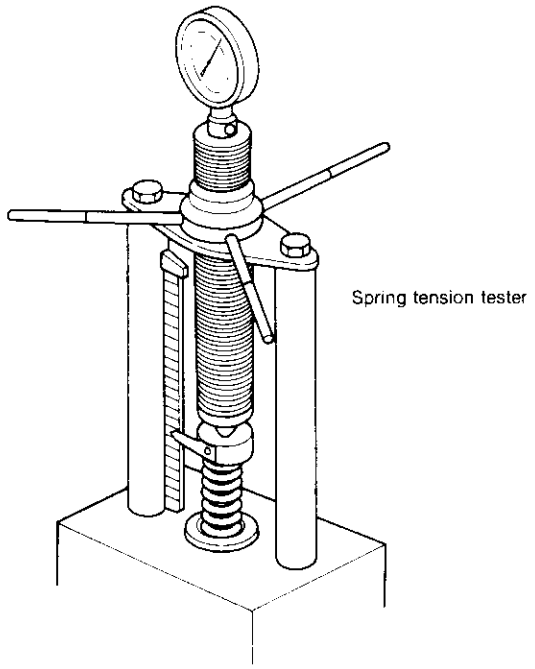


(3) Measure inclination.





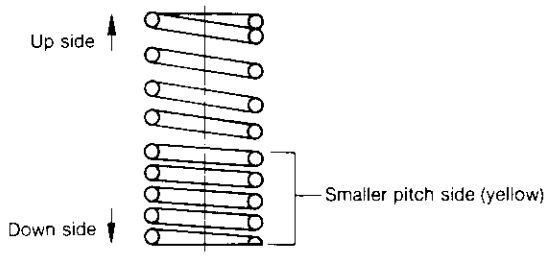
(4) Measure spring tension.



mm (in.)

Valve spring	Standard	Wear limit
Free length	44.4 (1.7480)	43 (1.6929)
Length when attached	40 (1.5748)	—
Load when attached	12kg (26.46 lb.)	10kg (22.05 lb.)

Assembling valve springs
The side with the smaller pitch (painted yellow) should face down (cylinder head).



NOTE: The pitch of the valve spring is not even. The side with the smaller pitch (yellow) should face down (cylinder head) when assembled.

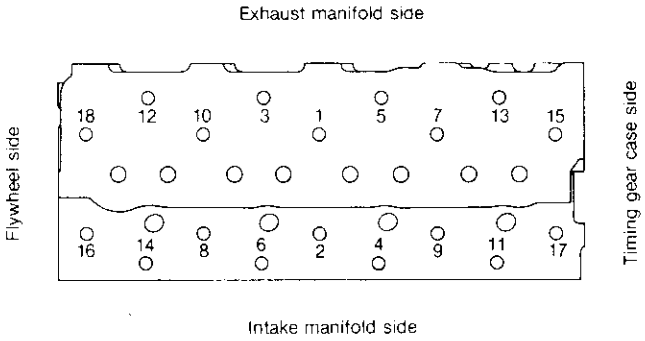
(5) Spring retainer and spring cotter
Inspect the inside face of the spring retainer, the outside surface of the spring cotter, the contact area of the spring cotter inside surface and the notch in the head of the valve stem. Replace the spring retainer and spring cotter when the contact area is less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

Printed in Japan
0000A0A1647

3-5 Assembling the cylinder head

Partially tighten the bolts in the specified order and then tighten to the specified torque, being careful that head does not get distorted.

(1) Clean out the cylinder head bolt holes.
(2) Check for foreign matter on the cylinder head surface that comes in contact with the block.
(3) Coat the head bolt threads and nut seats with lube oil.
(4) Use the positioning pins to line up the head gasket with the cylinder block.
(5) Match up the cylinder head with the head gasket and mount.

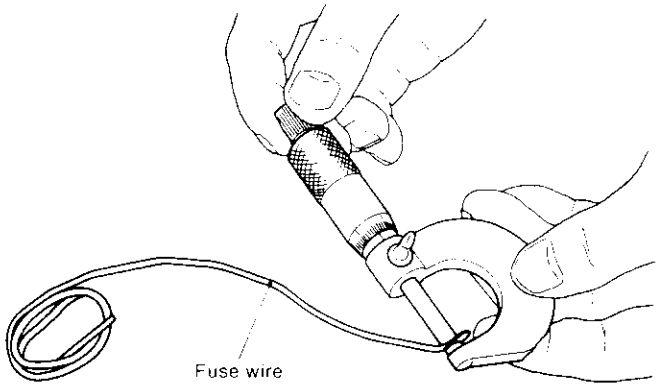


kg-m (ft-lb)

	First	Second
Tightening torque	3.5 ~ 4.5 (25.32 ~ 32.55)	7.5 ~ 8.5 (54.25 ~ 61.48)

3-6 Measuring top clearance

(1) Place a high quality fuse (ø1.5mm (0.0591in.), 10mm (0.3937in.) long) in three positions on the flat part of the piston head.
(2) Assemble the cylinder head gasket and the cylinder block and tighten the bolts in the specified order to the specified torque.
(3) Turn the crank, (in the direction of engine revolution), and press the fuse against the piston until it breaks.
(4) Remove the head and take out the broken fuse.
(5) Measure the three positions where each fuse is broken and calculate the average.
(0.71 ~ 0.75mm (0.0280 ~ 0.0295in.) is ideal)

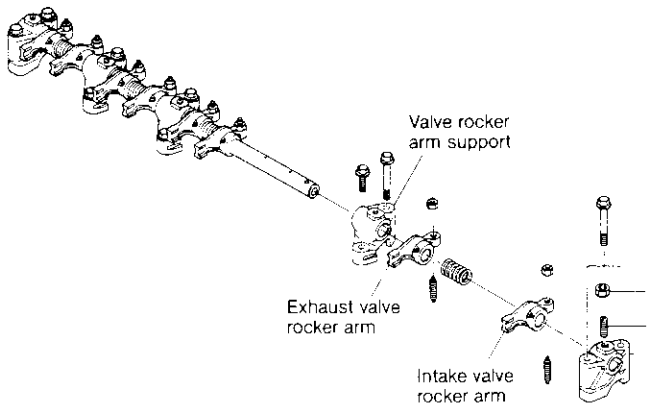


mm (in.)

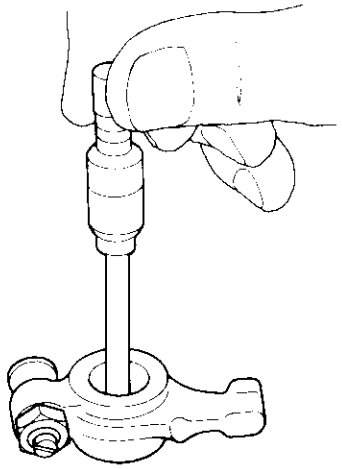
Top clearance	0.71 ~ 0.89 (0.0280 ~ 0.0350)

3-7 Intake and exhaust valve arms

Valve arm and valve arm bushing wear may change opening/closing timing of the valve, and may in turn affect engine performance according to the extent of the change.



(1) Valve arm shaft and valve arm bushing
Measure the outer diameter of the shaft and the inner diameter of the bearing, and replace if wear exceeds the limit.



mm (in.)

		Standard	Wear limit
Intake and exhaust valve rocker arm shaft outside dia.	A	15.966 ~ 15.984 (0.6285 ~ 0.6292)	15.955 (0.6281)
Intake and exhaust valve rocker arm bushing inside dia. (assembled)	B	16.000 ~ 16.018 (0.6299 ~ 0.6306)	16.090 (0.6334)
Valve rocker arm shaft and bushing clearance at assembly		0.016 ~ 0.052 (0.0006 ~ 0.0020)	0.135 (0.0053)

Replace the valve arm shaft bushing if it moves and replace the entire valve arm if there is no tightening clearance.

Printed in Japan
0000A0A1647

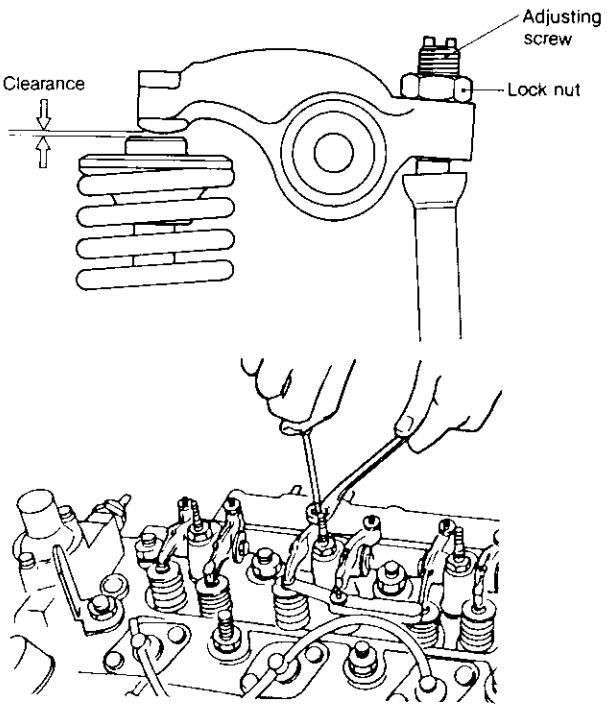
(2) Valve arm spring
Check the valve arm spring and replace it if it is corroded or worn.
(3) Valve arm and valve top retainer wear
Inspect the contact surface of the valve arm and replace it if there is abnormal wear or flaking.
(4) Inspect the contact surface of the valve clearance adjustment screw and push rod and replace if there is abnormal wear or flaking.

3-8 Adjustment of valve head clearance

(1) Make adjustments when the engine is cool.

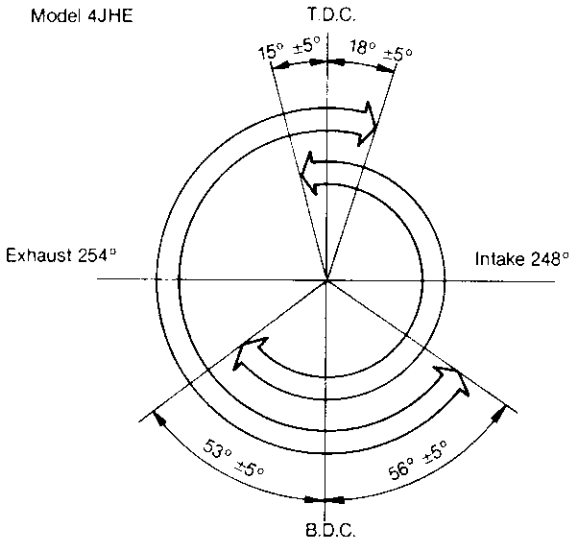
mm (in.)

Intake and exhaust head clearance	0.2 (0.0079)

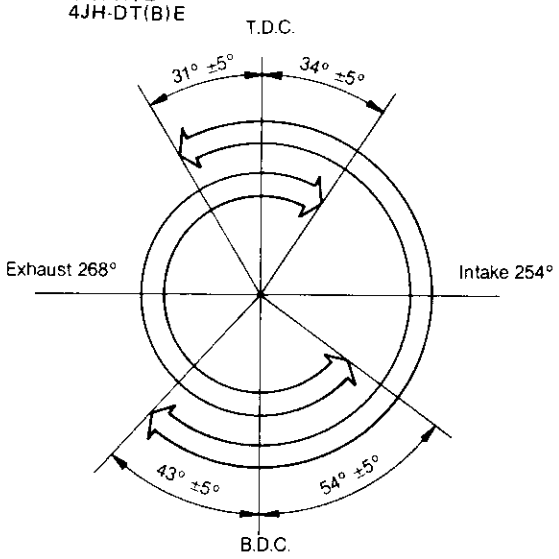


(2) Be sure that the opening and closing angles for both the intake and the exhaust valves are checked when the timing gear is disassembled (The gauge on the flywheel is read when the push rod turns the flywheel).

Model 4JHE



Model 4JH-TE
4JH-HTE
4JH-DT(B)E



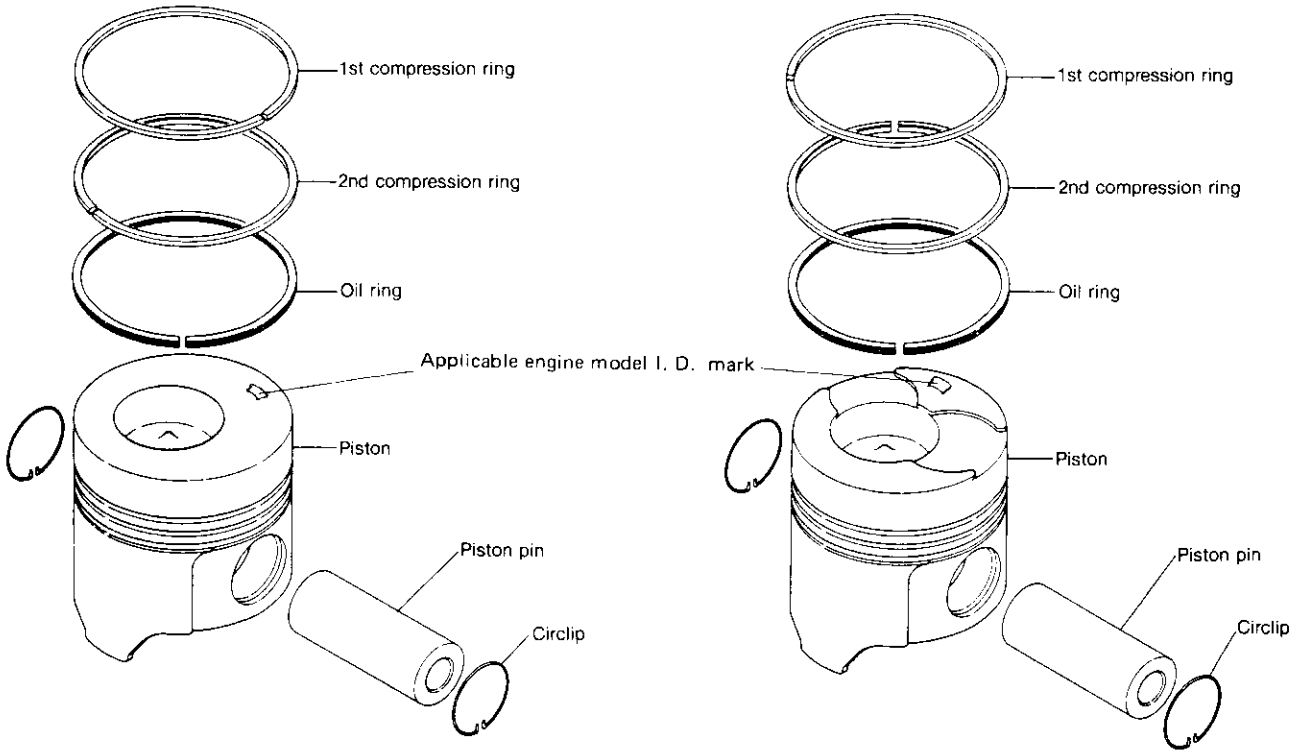
		4JHE	4JH-TE 4JH-HTE 4JH-DT(B)E
Intake valve open	b.TDC	10° ~ 20°	26° ~ 36°
Intake valve closed	a.BDC	48° ~ 58°	38° ~ 48°
Exhaust valve open	b.BDC	51° ~ 61°	49° ~ 59°
Exhaust valve closed	a.TDC	13° ~ 23°	29° ~ 39°

Printed in Japan
0000A0A1647

4. Pistons and Piston Pins

Pistons are made of a special light alloy with superior thermal expansion characteristics, and the top of the piston forms a swirl type toroidal combustion chamber. The opposite face of the piston combustion surface is oil-jet cooled.
Pistons for engines with superchargers have a valve recess for the intake and exhaust valves.
The clearance between the piston and cylinder liner is kept at the proper value by the piston and cylinder liner property fit effected during assembly at the Yanmar factory.

IMPORTANT:
Piston shape differs among engine models. If an incorrect piston is installed, combustion performance will drop. Be sure to check the applicable engine model identification mark (I. D. Mark) on the piston to insure use of the correct part.



I. D. Mark for Piston

	I.D. Mark	Applicable Engine Model & E/#	
Old type	1	4JHE	E/#01000 and before
	2	4JH-TE	E/#11000 and before
	5	4JH-HTE	E/#21000 and before
New type	A	4JHE	E/#01001 and after
	B	4JH-TE	E/#11001 and after
	C	4JH-HTE	E/#21001 and after
	C	4JH-DTE	E/#30101 and after

*Engines produced at YANMAR plant on and after June 21, 1985

Printed in Japan
0000A0A1647

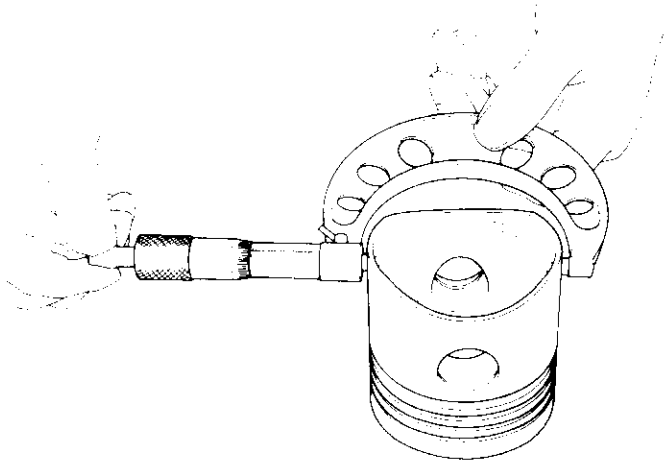
4-1 Piston

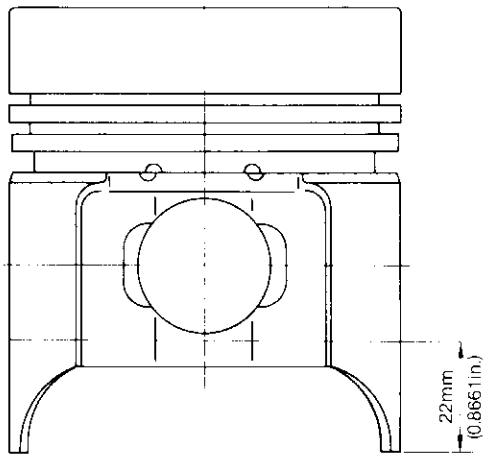
4-1.1 Piston head and combustion surface

Remove the carbon that has accumulated on the piston head and combustion surface, taking care not to scratch the piston. Check the combustion surface for any damage.

4-1.2 Measurement of piston outside diameter/inspection

(1) Replace the piston if the outsides of the piston or ring grooves are worn.
(2) Measure the piston 22mm (0.8661in.) from the bottom at right angles to the piston pin.



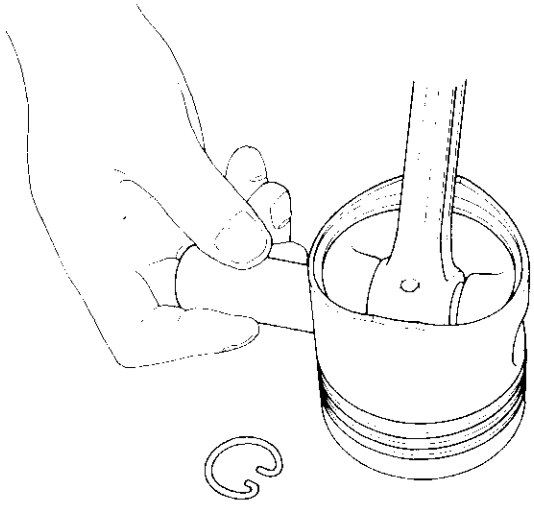


mm (in.)

Standard	Wear limit
77.91 ~ 77.94 (3.0673 ~ 3.0685)	77.81 (3.0633)

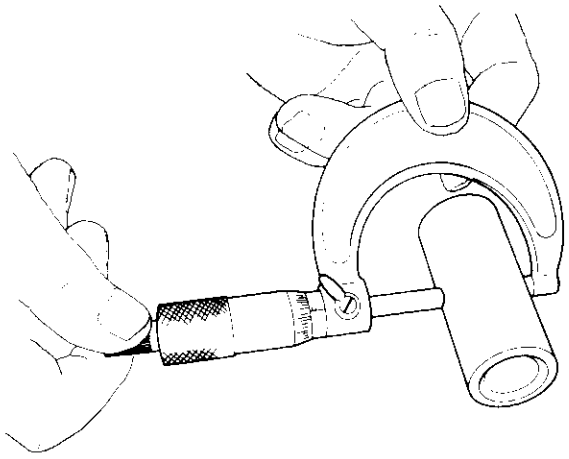
4-1.3 Replacing the piston

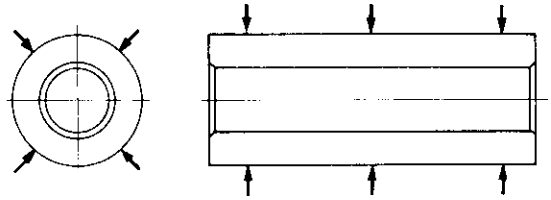
A floating type piston pin is used in this engine. The piston pin can be pressed into the piston pin hole at room temperature (coat with oil to make it slide in easily).



4-2 Piston pin

Measure the outer diameter and replace the pin if it is excessively worn.





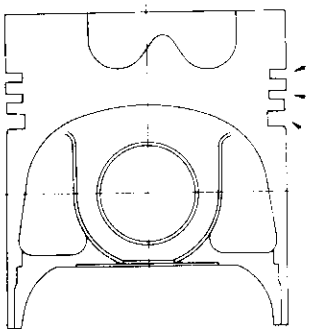
mm (in.)

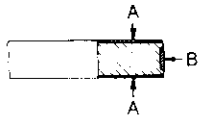
	Standard	Wear limit
Piston pin insert hole dia.	ø26.000 ~ 26.009 (ø1.0236 ~ 1.0240)	+0.020 (0.0008)
Piston pin outside dia.	ø25.987 ~ 26.000 (ø1.0231 ~ 1.0236)	−0.025 (0.0009)
Standard clearance	0 ~ 0.022 (0 ~ 0.0009)	0.045 (0.0018)

Printed in Japan
0000A0A1647

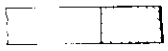
4-3 Piston rings

There are 2 compression rings and 1 oil ring.
The absence of an oil ring on the piston skirt prevents oil from being kept on the thrust surface and in turn provides good lubrication.





Barrel face
B-side chrome plated.
A-side friction-proof hardening processed

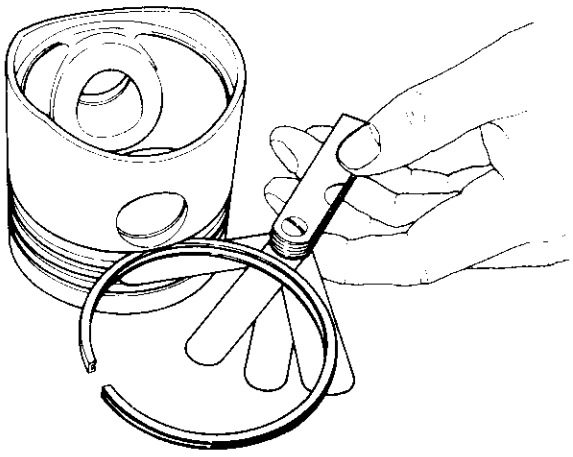


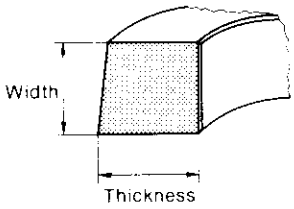
Tapered inner cut

Coil expander

4-3.1 Measuring the rings

Measure the thickness and width of the rings, and the ring-to-groove clearance after installation. Replace if wear exceeds the limit.



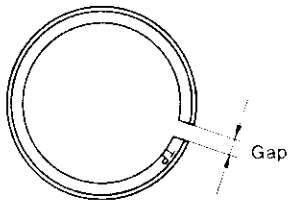


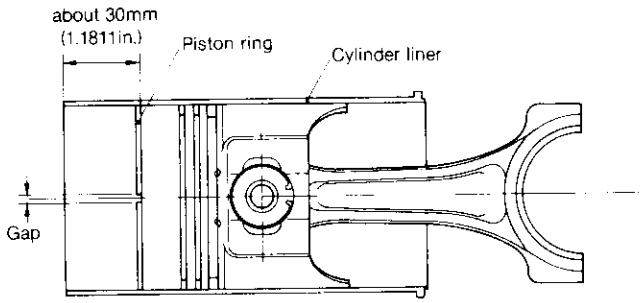
mm (in.)

		Standard	Wear limit
First piston ring	Groove width	2.060 ~ 2.075 (0.0811 ~ 0.0816)	—
	Ring width	1.975 ~ 1.990 (0.0777 ~ 0.0783)	—
	Groove and ring clearance	0.070 ~ 0.100 (0.0027 ~ 0.0039)	0.2 (0.0078)
Second piston ring	Groove width	2.025 ~ 2.040 (0.0797 ~ 0.0803)	—
	Ring width	1.975 ~ 1.990 (0.0777 ~ 0.0783)	—
	Groove and ring clearance	0.035 ~ 0.065 (0.0013 ~ 0.0025)	0.2 (0.0078)
Oil ring	Groove width	4.020 ~ 4.035 (0.1582 ~ 0.1588)	—
	Ring width	3.975 ~ 3.990 (0.1564 ~ 0.1570)	—
	Groove and ring clearance	0.030 ~ 0.060 (0.0011 ~ 0.0023)	0.2 (0.0078)

4-3.2 Measuring piston ring gap

Press the piston ring onto a piston liner and measure the piston ring gap with a gauge. Press on the ring about 30mm (1.811in.) from the bottom of the liner.





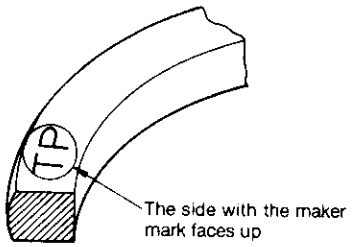
mm (in.)

	Standard	Wear limit
First piston ring gap	0.25 ~ 0.40 (0.0098 ~ 0.0157)	1.5 (0.0590)
Second piston ring gap	0.25 ~ 0.40 (0.0098 ~ 0.0157)	1.5 (0.0590)
Oil ring gap	0.20 ~ 0.40 (0.0078 ~ 0.0157)	1.5 (0.0590)

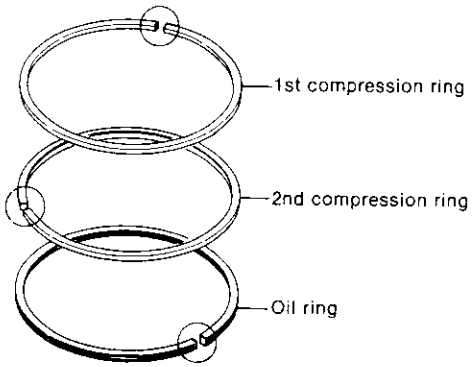
Printed in Japan
0000A0A1647

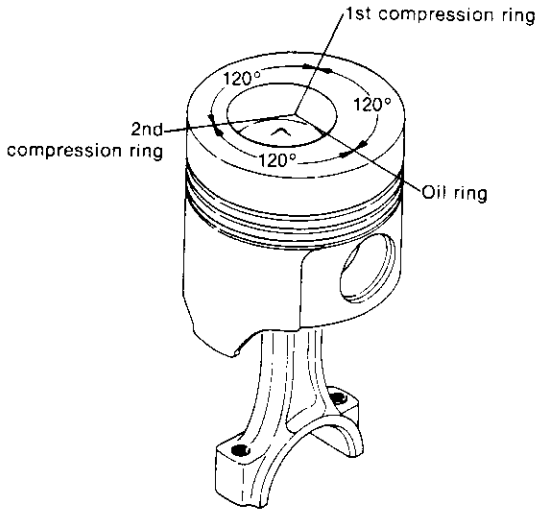
4-3.3 Replacing the piston rings

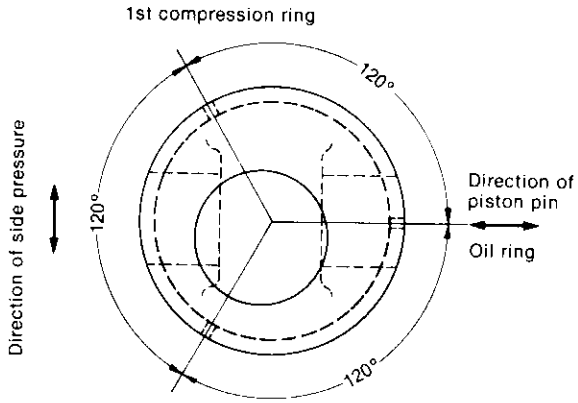
(1) Thoroughly clean the ring grooves when replacing piston rings.
(2) The side with the manufacturer's mark (near piston ring gap) should face up.



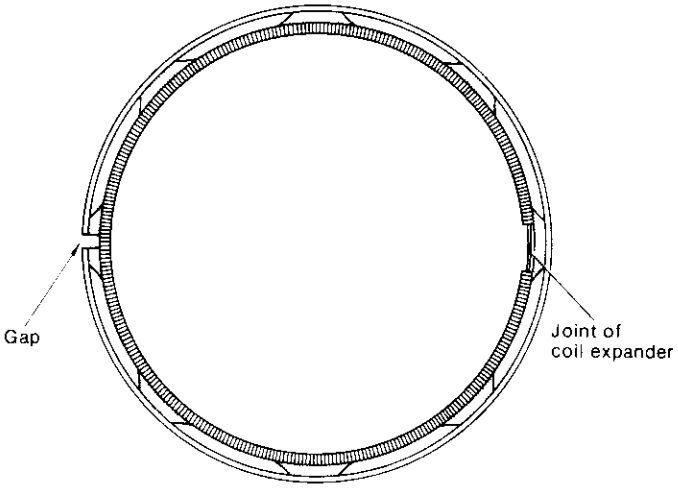
(3) After fitting the piston ring, make sure it moves easily and smoothly.
(4) Stagger the piston rings at 120° intervals, making sure none of them line up with the piston.







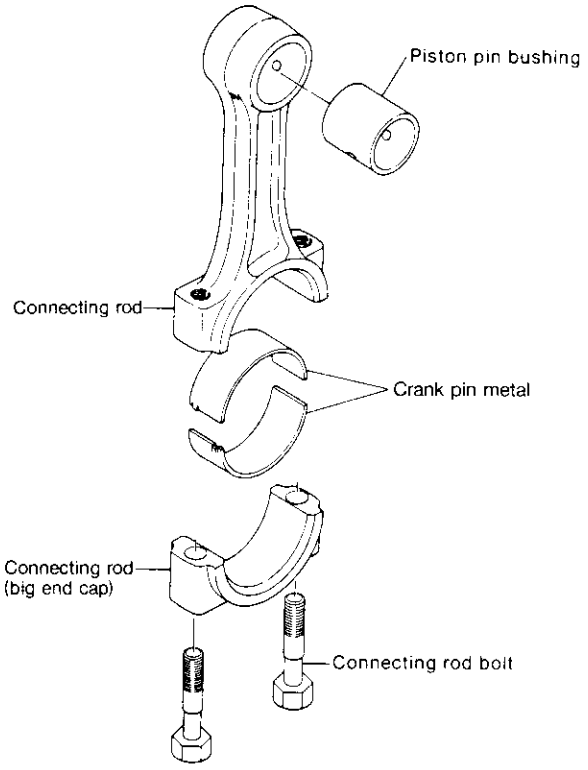
(5) The oil ring is provided with a coil expander. The coil expander joint should be opposite (staggered 180°) the oil ring gap.



Printed in Japan
0000A0A1647

5. Connecting Rod

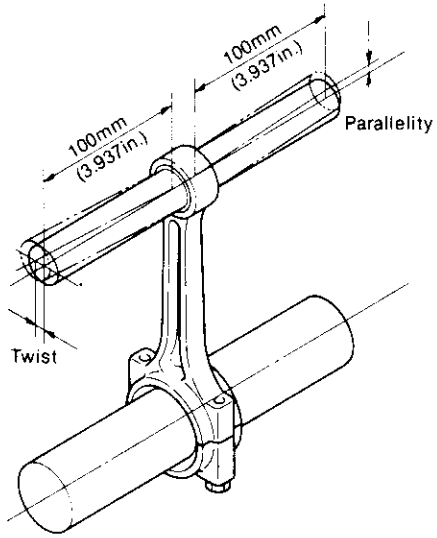
The connecting rod is made of high-strength forged carbon steel.
The large end with the 3-layer kelmet can be separated into two and the small end has a 2-layer copper alloy coil bushing.

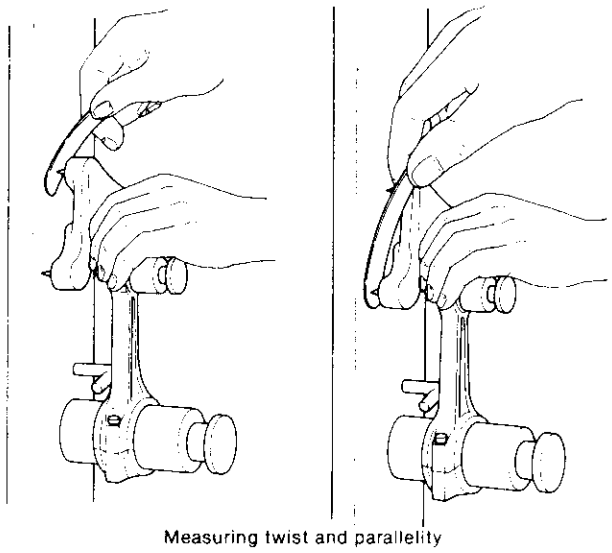


5-1 Inspecting the connection rod

5-1.1 Twist and parallelism of the large and small ends

Insert the measuring tool into the large and small ends of the connecting rod. Measure the extent of twist and parallelism and replace if they exceed the tolerance.



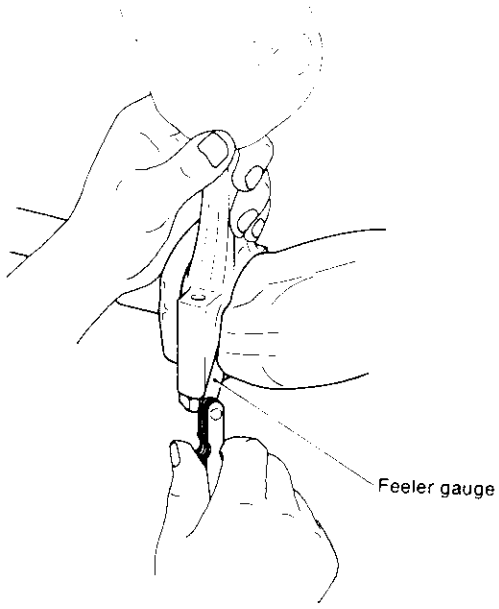

Measuring twist and parallelity

mm (in.)

	Standard	Wear limit
Connecting rod twist and parallelity	0.05 (0.0019)	0.07 (0.0027)

5-1.2 Checking thrust clearance

Fit the respective crank pins to the connecting rod and check to make sure that the clearance in the crankshaft direction is correct.



mm (in.)

	Standard	Wear limit
Connecting rod side clearance	0.20 ~ 0.40 (0.0078 ~ 0.0157)	0.55 (0.0216)

Printed in Japan
0000A0A1647

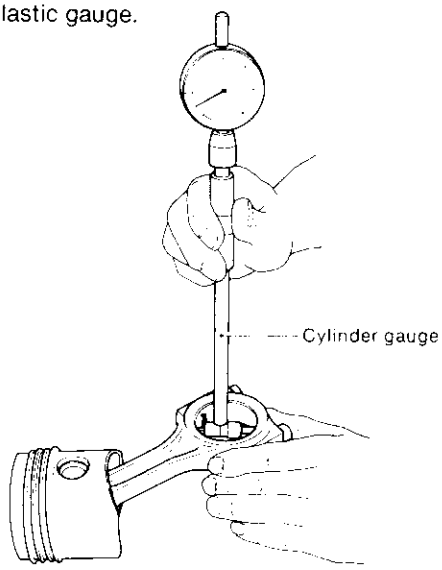
5-2 Crank pin bushing

5-2.1 Checking crank pin bushing

Check for flaking, melting or seizure on the contact surface.

5-2.2 Measuring crank pin oil clearance

Use a plastic gauge.



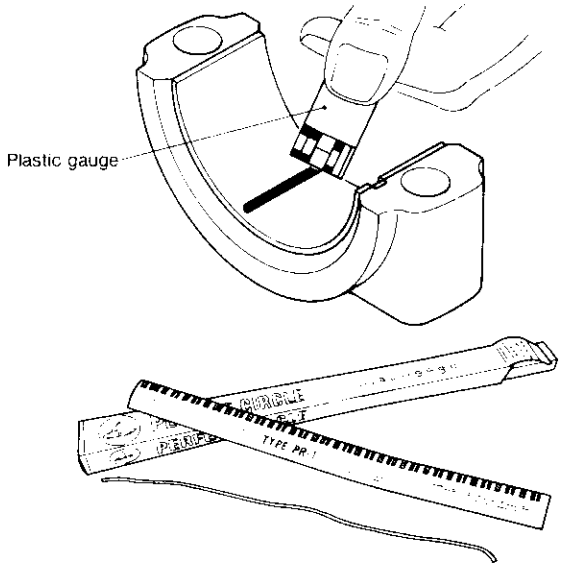
Procedure

(1) Use the press gauge (Plastigage) for measuring oil clearance in the crank pin.

(2) Mount the connecting rod on the crank pin (tighten to specified torque).

Connecting rod tightening torque	4.5 ~ 5.0 kg-m (32.5 ~ 36.1 ft-lb)

(3) Remove the connecting rod and measure the broken plastic gauge with measuring paper.

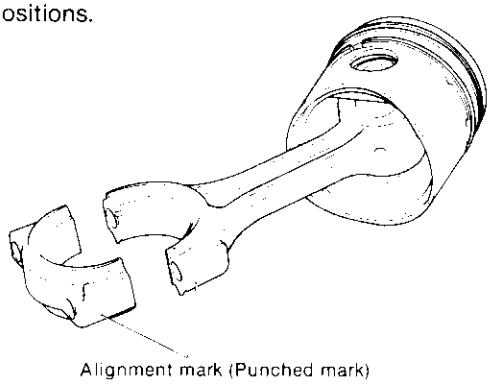


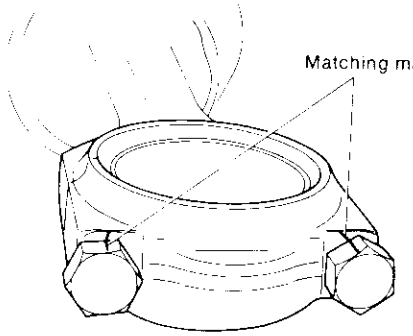
5-2.3 Precautions on replacement of crank pin bushing

(1) Wash the crank pin bushing.

(2) Wash the large end cap, mount the crank pin bushing and make sure that it fits tightly on the large end cap.

(3) When assembling the connecting rod, match up the large end and large end cap number. Coat the bolts with engine oil and gradually tighten them alternately to the specified torque.
If a torque wrench is not available, make match marks on the bolt heads and large end cap (to indicate the proper torque position) and retighten the bolts to those positions.

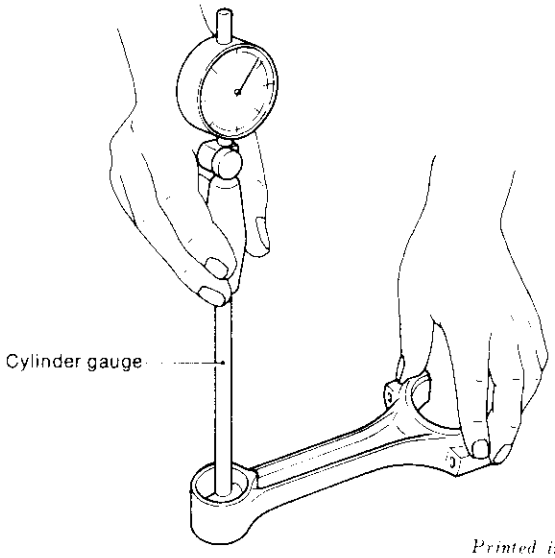




(4) Make sure there is no sand, metal cuttings or other foreign matter in the lube oil, and that the crankshaft is not scratched. Take special care in cleaning the oil holes.

5-3 Piston pin bushing

(1) Measuring piston pin clearance
Excessive piston pin bushing wear may result in damage to the piston pin or the piston itself.



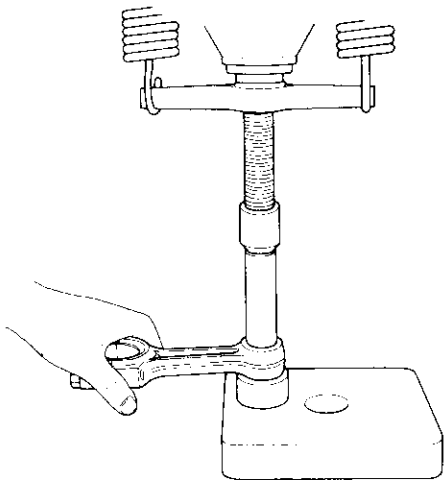
Printed in Japan
0000A0A1647

mm (in.)

	Standard	Wear limit
Piston pin bushing inside dia.	26.025 ~ 26.038 (1.0246 ~ 1.0251)	26.1 (1.0275)
Piston pin and bushing oil clearance	0.025 ~ 0.051 (0.0009 ~ 0.002)	0.11 (0.0043)

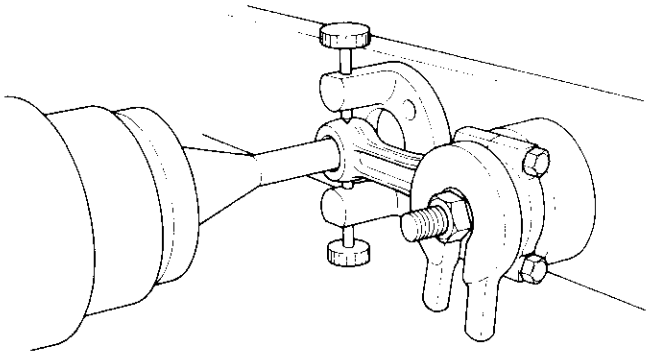
(2) Replacing piston pin bushing

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.

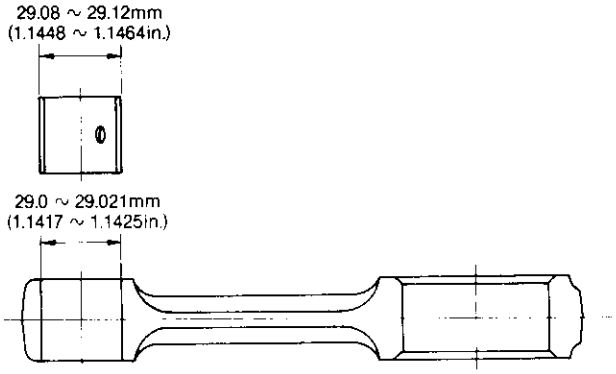


NOTE: Force the piston pin bushing into position so that its oil hole coincides with the hole on the small end of the connecting rod.

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.

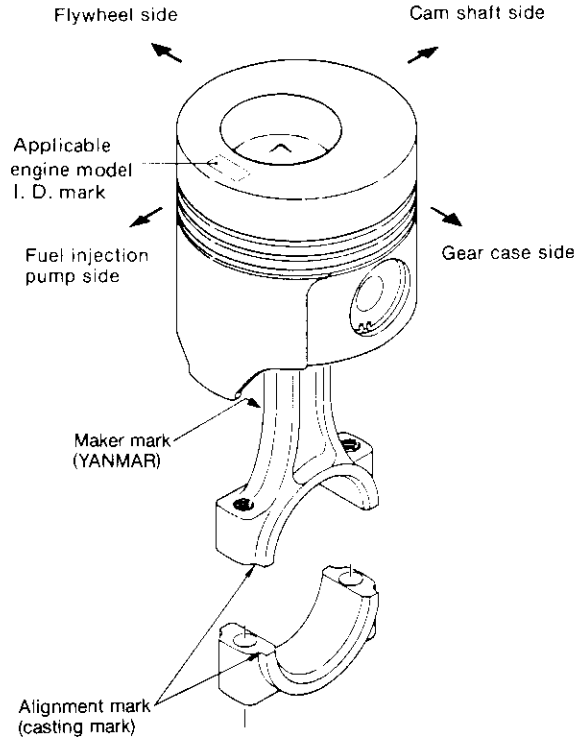


NOTE: Attach the bushing to the piston pin so that a pin, coated with engine oil can be pushed into position with your thumb.



5-4 Assembling piston and connecting rod

The piston and connecting rod should be assembled so that the match mark on the connecting rod large end faces the fuel injection pump side and the combustion chamber above the piston is close to the fuel injection pump.



I. D. Mark for Piston

	I.D. Mark	Applicable Engine Model & E/#	
Old type	1	4JHE	E/#01000 and before
	2	4JH-TE	E/#11000 and before
	5	4JH-HTE	E/#21000 and before
New type	A	4JHE	E/#01001 and after
	B	4JH-TE	E/#11001 and after
	C	4JH-HTE	E/#21001 and after
	C	4JH-DTE	E/#30101 and after

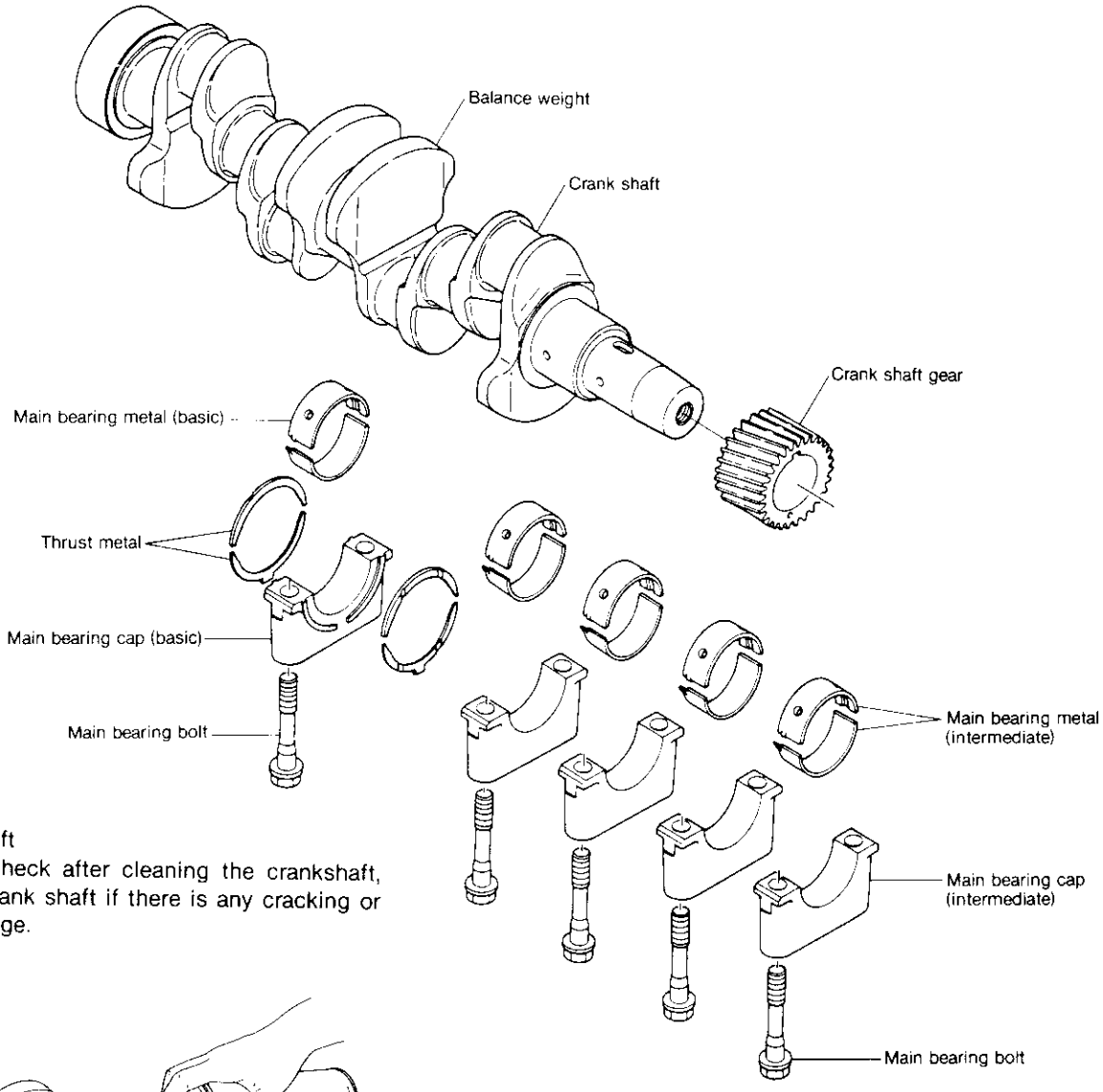
*Engines produced at YANMAR plant on and after June 21, 1985

Printed in Japan
0000A0A1647

6. Crankshaft and Main Bearing

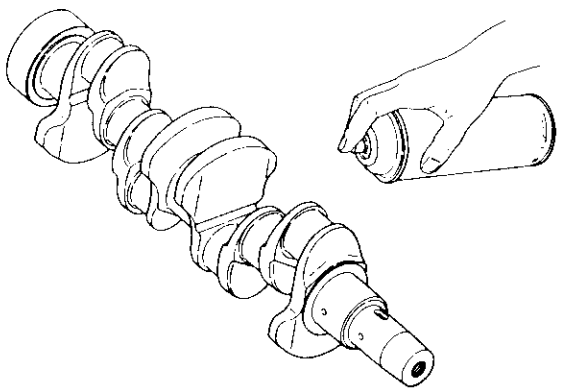
The crank pin and crank journal have been induction hardened for superior durability, and the crankshaft is provided with four balance weights for optional balance. The crankshaft main bearing is of the hanger type. The upper metal (cylinder block side) is provided with an oil groove. There is no oil groove on the lower metal (bearing cap side). The bearing cap (location cap) of the flywheel side has a thrust metal which supports the thrust load.

IMPORTANT:
Although the size is identical, the crankshaft material of models 4JHE and 4JH-TE differ from that used in models 4JH-HTE and 4JH-DTE.
Please note that the crankshaft for models 4JHE and 4JH-TE cannot be used for models 4JH-HTE and 4JH-DTE since the crankshaft is not durable enough.



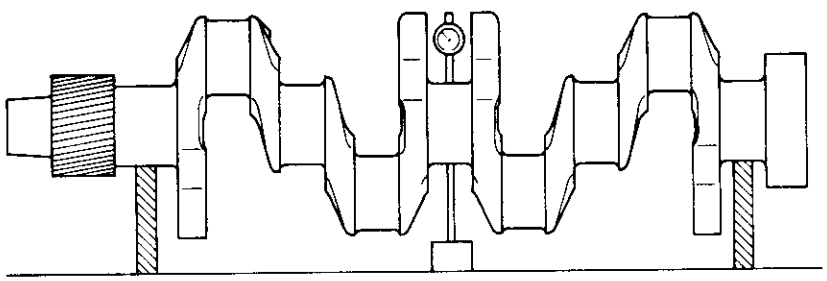
6-1 Crankshaft

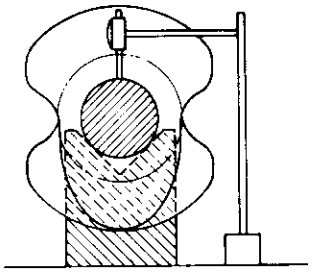
(1) Color check of shaft
Perform a color check after cleaning the crankshaft, and replace the crank shaft if there is any cracking or considerable damage.

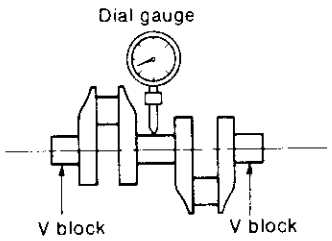


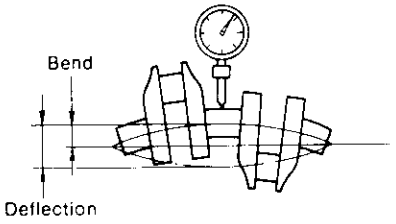
Printed in Japan
0000A0A1647

(2) Bending of the crankshaft
Support the crankshaft with V-blocks at both ends of the journals. Measure the deflection of the center journal with a dial gauge while rotating the crankshaft to check the extent of crankshaft bending.



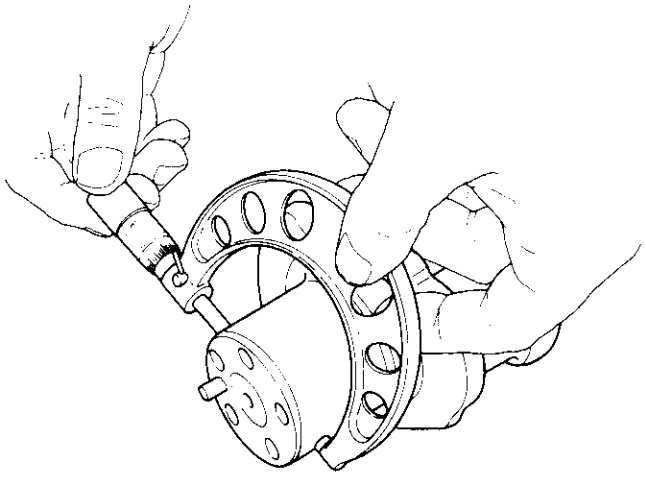


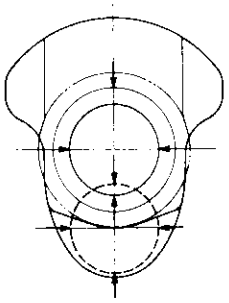


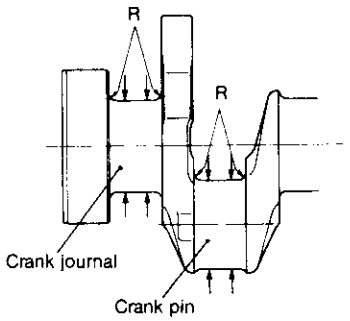


Crankshaft bend	Less than 0.02mm (0.0007 in.)

(3) Measuring the crank pin and journal
Measure the extent of journal wear (roundness, taper). Regrind it to the proper shape if it is within the outer diameter limit, and replace if not.







mm (in.)

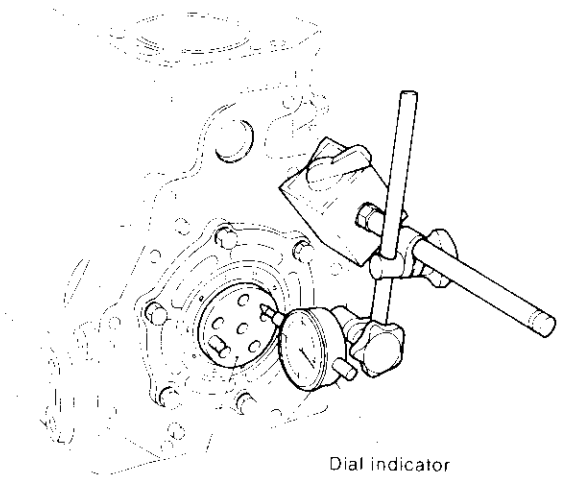
		Standard	Wear limit
Crank pin	Outside dia.	47.952 ~ 47.962 (1.8878 ~ 1.8882)	47.75 (1.8799)
	Bushing inside dia.	48.000 ~ 48.045 (1.8897 ~ 1.8915)	48.10 (1.8937)
	Crank pin and bushing oil clearance	0.038 ~ 0.093 (0.0014 ~ 0.0036)	0.25 (0.0098)
Crank journal	Outside dia.	49.952 ~ 49.962 (1.9666 ~ 1.9670)	49.75 (1.9586)
	Bushing inside dia.	50.000 ~ 50.045 (1.9685 ~ 1.9702)	50.10 (1.9724)
	Crank journal and bushing oil clearance	0.038 ~ 0.093 (0.0014 ~ 0.0036)	0.25 (0.0098)
Fillet rounding of crank pin and journal		3.500 ~ 3.800 (0.1377 ~ 0.1496)	

Printed in Japan
0000A0A1647

(4) Checking side clearance of the crankshaft
After assembling the crankshaft, tighten the main bearing cap to the specified torque, and move the crankshaft to one side, placing a dial gauge on one end of the shaft to measure thrust clearance.
This measurement can also be effected by inserting the gauge directly into the clearance between the thrust bearing and crankshaft thrust surface.
Replace the thrust bearing if it is worn beyond the limit.

mm (in.)

	Standard	Wear limit
Crankshaft side gap	0.090 ~ 0.271 (0.0035 ~ 0.0106)	0.30 (0.0118)

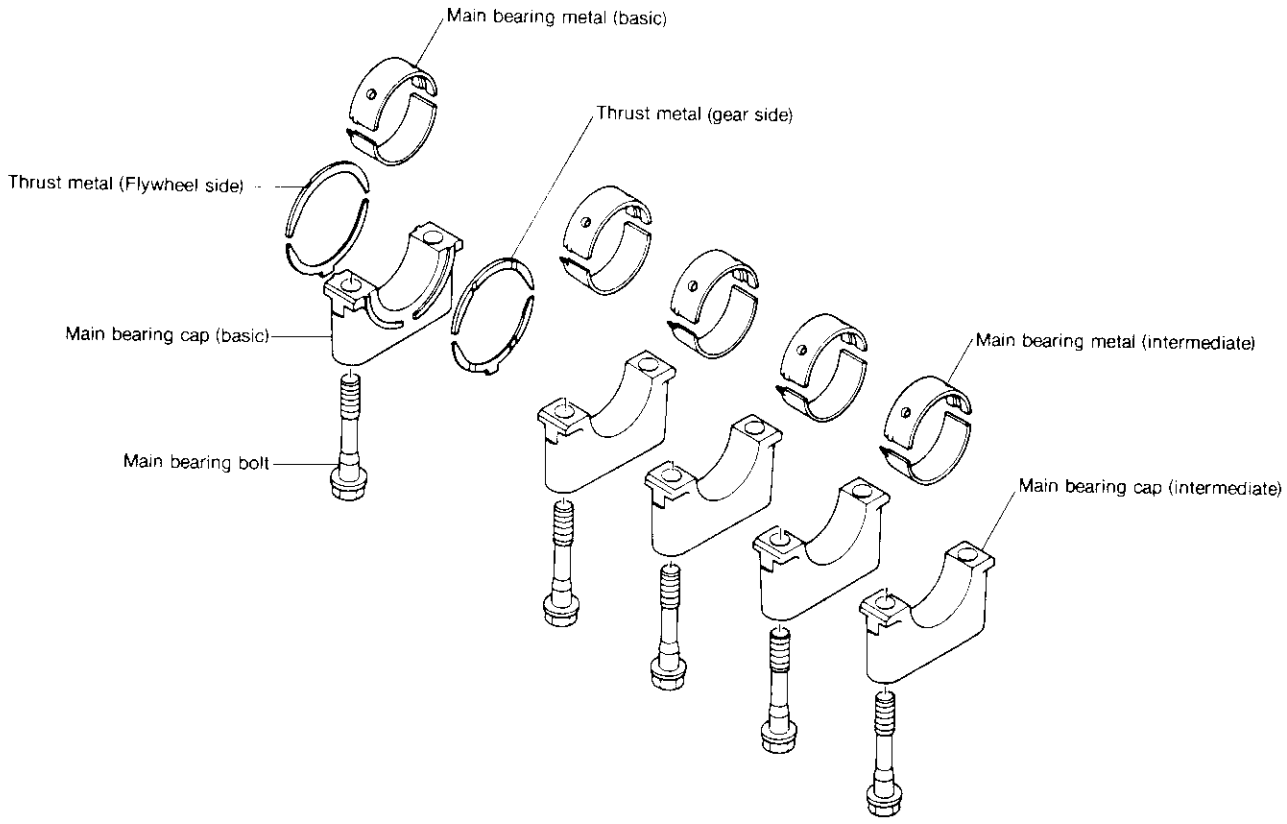


6-2 Main bearing

(1) Inspecting the main bearing
Check for flaking, seizure or burning of the contact surface and replace if necessary.
(2) Measuring the inner diameter of metal
Tighten the cap to the specified torque and measure the inner diameter of the metal.

Bearing cap bolt tightening torque	9.5 ~ 10.5 kg-m (68.71 ~ 75.84 ft-lb)

NOTE: When assembling the bearing cap, keep the following in mind.
1) The lower metal (cap side) has no oil groove.
2) The upper metal (cylinder block side) has an oil groove.
3) Check the cylinder block alignment No.
4) The "FW" on the cap lies on the flywheel side.

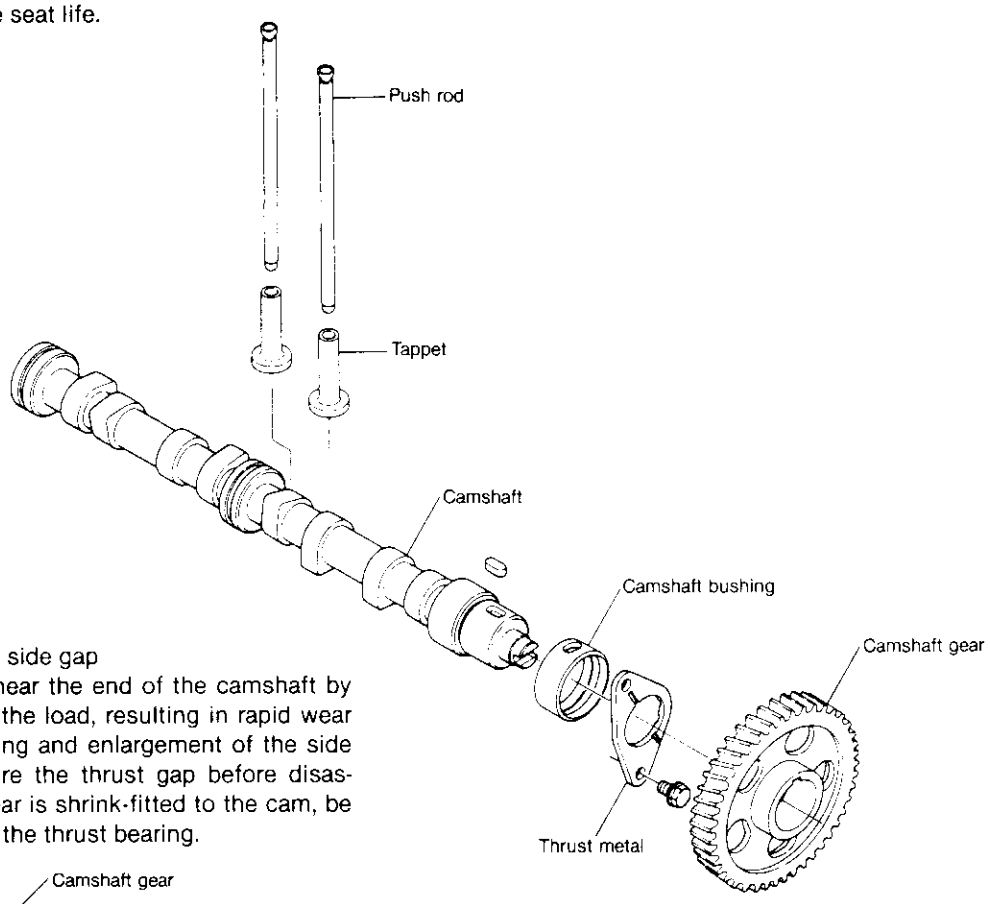


Printed in Japan
0000A0A1647

7. Camshaft and Tappets

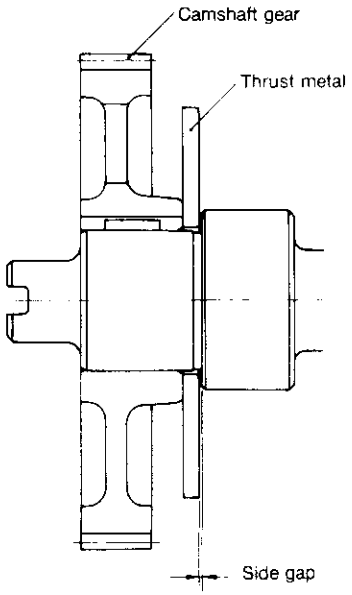
7-1 Camshaft

The camshaft is normalized and the cam and bearing surfaces are surface hardened and ground. The cams have a curve that minimizes the repeated shock on the valve seats and maximizes valve seat life.



(1) Checking the camshaft side gap

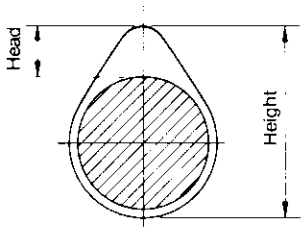
The standard bearing near the end of the camshaft by the cam gear receives the load, resulting in rapid wear of the end of the bearing and enlargement of the side gap. Therefore, measure the thrust gap before disassembly. As the cam gear is shrink-fitted to the cam, be careful when replacing the thrust bearing.



mm (in.)

	Standard	Wear limit
Camshaft side gap	0.05 ~ 0.25 (0.0019 ~ 0.0098)	0.4 (0.0157)

(2) Measure the camshaft height, and replace the cam if it is worn beyond the limit.

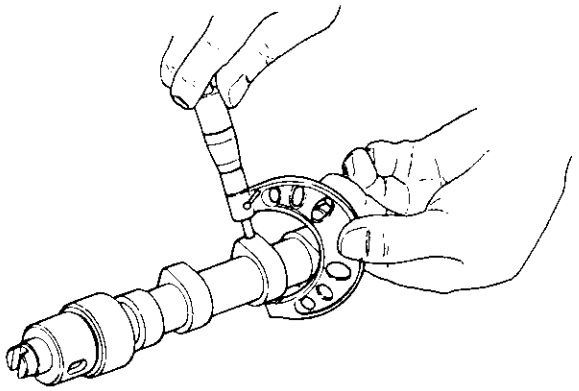


Camshaft height mm (in.)

Engine model		Standard	Wear limit
4JHE	Intake cam	38.66 ~ 38.74 (1.5220 ~ 1.5251)	38.4 (1.5118)
	Exhaust cam		
4JH-TE 4JH-HTE 4JH-DT(B)S	Intake cam	38.66 ~ 38.74 (1.5220 ~ 1.5251)	38.4 (1.5118)
	Exhaust cam	38.86 ~ 38.94 (1.5299 ~ 1.5330)	38.6 (1.5196)

Printed in Japan
0000A0A1647

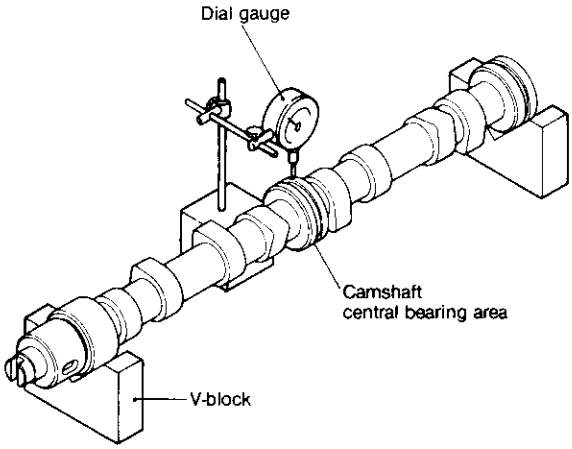
(3) Measure the camshaft outer diameter and the camshaft bearing inner diameter. Replace if they exceed the wear limit or are damaged.



mm (in.)

	Standard			Wear limit
	Gear case side	Intermediate	Flywheel side	
Camshaft journal outside dia.	44.925 ~ 44.950 (1.7687 ~ 1.7696)	44.910 ~ 44.935 (1.7681 ~ 1.7690)	44.925 ~ 44.950 (1.7687 ~ 1.7696)	44.8 (1.7637)
Camshaft journal bushing inside dia.	44.990 ~ 45.050 (1.7712 ~ 1.7736)	—	—	—
Cylinder block bearing inside dia.	—	45.000 ~ 45.025 (1.7716 ~ 1.7726)	45.000 ~ 45.025 (1.7716 ~ 1.7726)	—
Oil clearance	0.040 ~ 0.130 (0.0015 ~ 0.0050)	0.065 ~ 0.115 (0.0025 ~ 0.0045)	0.050 ~ 0.100 (0.0019 ~ 0.0039)	0.2 (0.0078)

(4) Bending of the crankshaft
Support both ends of the crankshaft with V-blocks, place a dial gauge against the central bearing areas and measure bending. Replace if excessive.



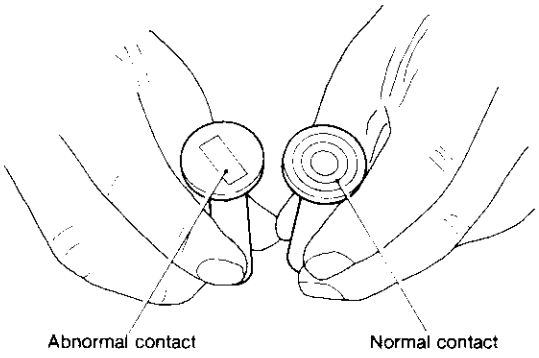
NOTE: The reading on the dial gauge is divided by two to obtain the extent of bending.

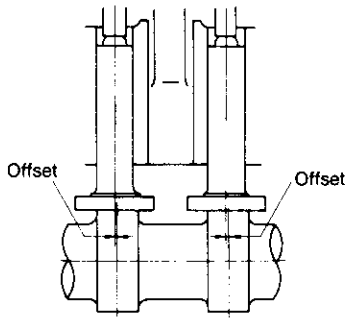
mm (in.)

	Wear limit
Camshaft deflection	0.02 (0.0007)

7-2 Tappets

(1) The tappets are offset to rotate during operation and thereby prevent uneven wearing. Check the contact of each tappet and replace if excessively or unevenly worn.

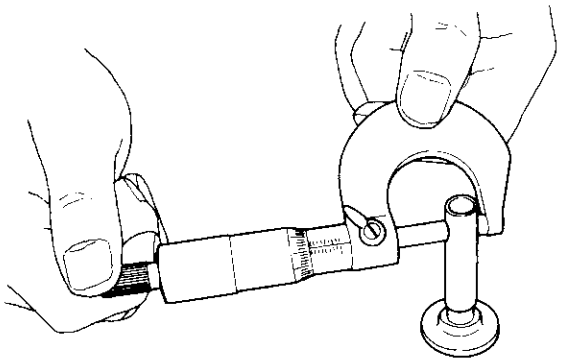




NOTE: When removing tappets, be sure to keep them separate for each cylinder and intake/exhaust valve.

Printed in Japan
0000A0A1647

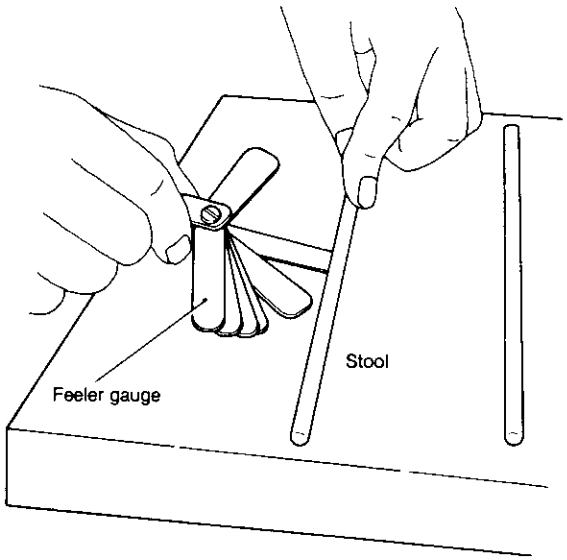
(2) Measure the outer diameter of the tappet, and replace if worn beyond the limit.



mm (in.)

	Standard	Wear limit
Tappet stem outside dia.	11.975 ~ 11.990 (0.4714 ~ 0.4720)	11.93 (0.4696)
Tappet guide hole inside dia. (cylinder block)	12.000 ~ 12.018 (0.4724 ~ 0.4731)	12.05 (0.4744)
Tappet stem and guide hole oil clearance	0.010 ~ 0.043 (0.0003 ~ 0.0016)	0.10 (0.0039)

(3) Measuring push rods.
Measure the length and bending of the push rods.



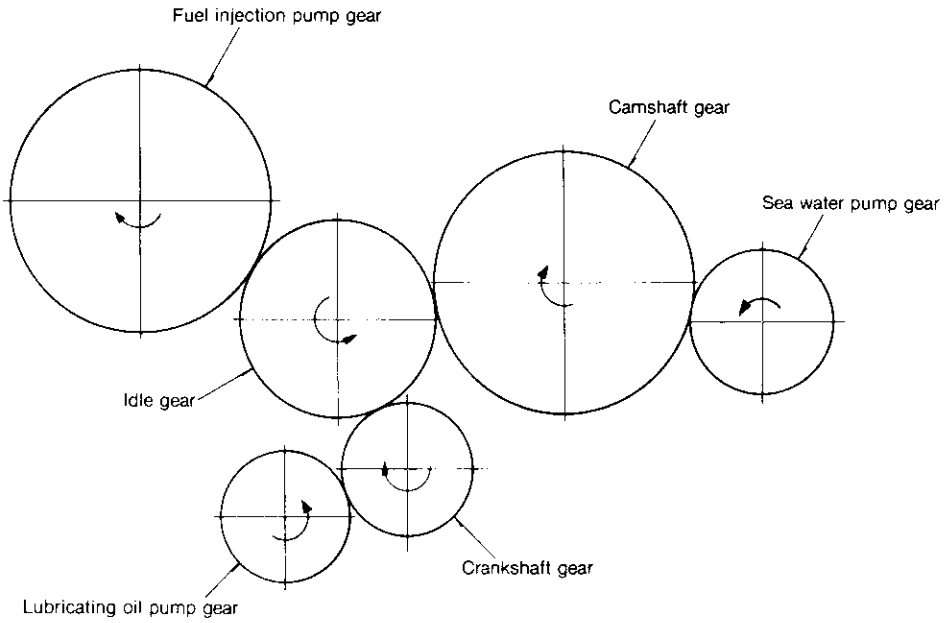
mm (in.)

	Standard	Wear limit
Push rod length	178.25 ~ 178.75 (7.0177 ~ 7.0374)	—
Push rod bend	Less than 0.03 (0.0011)	0.3 (0.0118)
Push rod dia.	8 (0.3149)	—

Printed in Japan
0000A0A1647

8. Timing Gear

The timing gear is helical type for minimum noise and specially treated for high durability.



mm (in.)

	No. of teeth	Face width	Spiral angle	Center distance	Back lash	Back lash Wear limit
Sea water pump gear	31	12.0	right	92.544 ~ 92.592 (3.6434 ~ 3.6453)	0.04 ~ 0.12 (0.0015 ~ 0.0047)	0.2 (0.0078)
Camshaft gear	56	18.0	left	105.318 ~ 105.380 (4.1463 ~ 4.1488)	0.04 ~ 0.12 (0.0015 ~ 0.0047)	0.2 (0.0078)
Idle gear	43	18.0	right	75.525 ~ 75.573 (2.9734 ~ 2.9753)	0.04 ~ 0.12 (0.0015 ~ 0.0047)	0.2 (0.0078)
Crankshaft gear	28	40.0	left	60.629 ~ 60.677 (2.3869 ~ 2.3888)	0.04 ~ 0.12 (0.0015 ~ 0.0047)	0.2 (0.0078)
Lubricating oil pump gear	29	8.0	right			
Idle gear	43	18.0	right	105.254 ~ 105.316 (4.1438 ~ 4.1462)	0.04 ~ 0.12 (0.0015 ~ 0.0047)	0.2 (0.0078)
Fuel injection pump gear	56	10.0	left			

8-1 Inspecting the gears

(1) Inspect the gears and replace if the teeth are damaged or worn.

(2) Measure the backlash of all gears that mesh, and replace the meshing gears as a set if wear exceeds the limit.

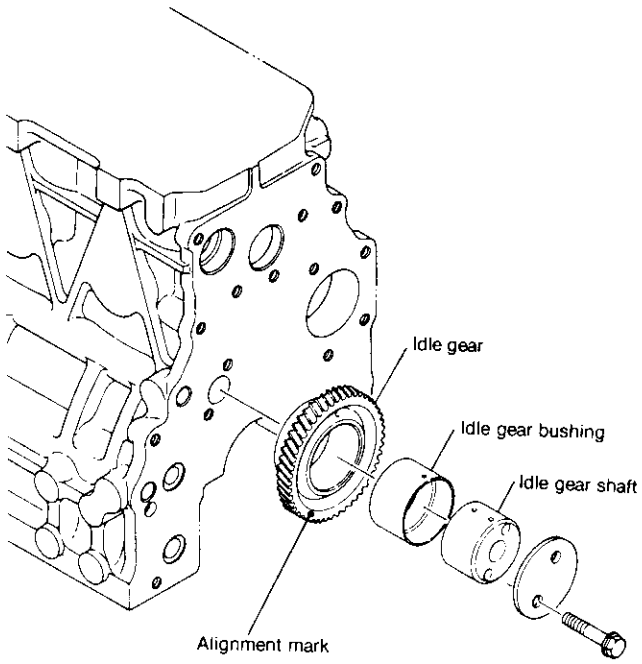
NOTE: If backlash is excessive, it will not only result in excessive noise and gear damage, but also lead to bad valve and fuel injection timing and a decrease in engine performance.

(3) Idling gear

The bushing is pressure fitted into the idling gear. Measure the bushing inner diameter and the outer diameter of the shaft, and replace the bushing or idling gear shaft if the oil clearance exceeds the wear limit.

A, B and C are inscribed on the end of the idling gear. When assembling, these marks should align with those on the cylinder block.

Printed in Japan
0000A0A1647

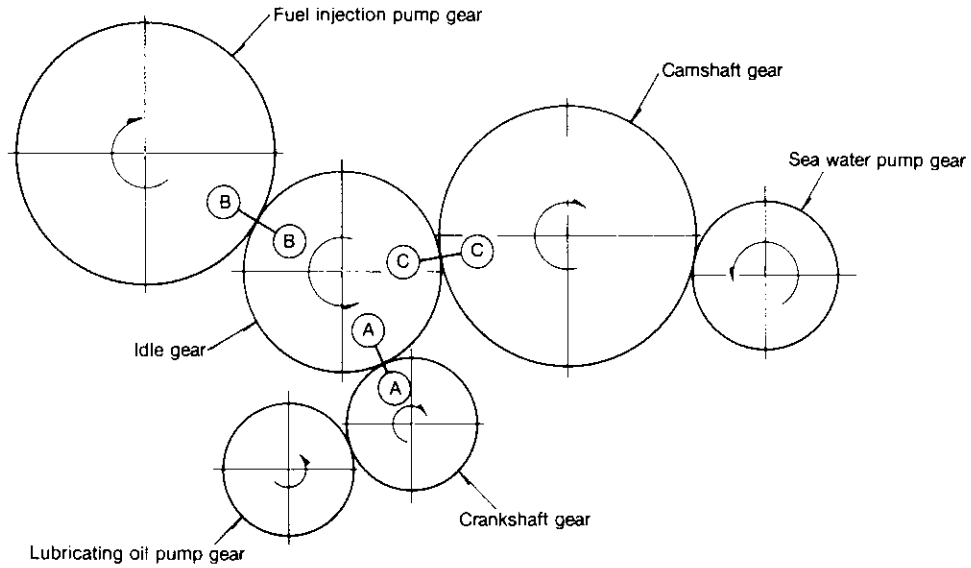


mm (in.)

	Standard	Wear limit
Idle shaft dia.	45.950 ~ 45.975 (1.8090 ~ 1.8100)	45.88 (1.8062)
Idle shaft bushing inside dia.	46.000 ~ 46.025 (1.8110 ~ 1.8120)	—
Idle shaft and bushing oil clearance	0.025 ~ 0.075 (0.0009 ~ 0.0029)	0.15 (0.0059)

8-2 Gear timing marks

Match up the timing marks on each gear when assembling (A, B and C).



Printed in Japan
0000A0A1647

9. Flywheel and Housing

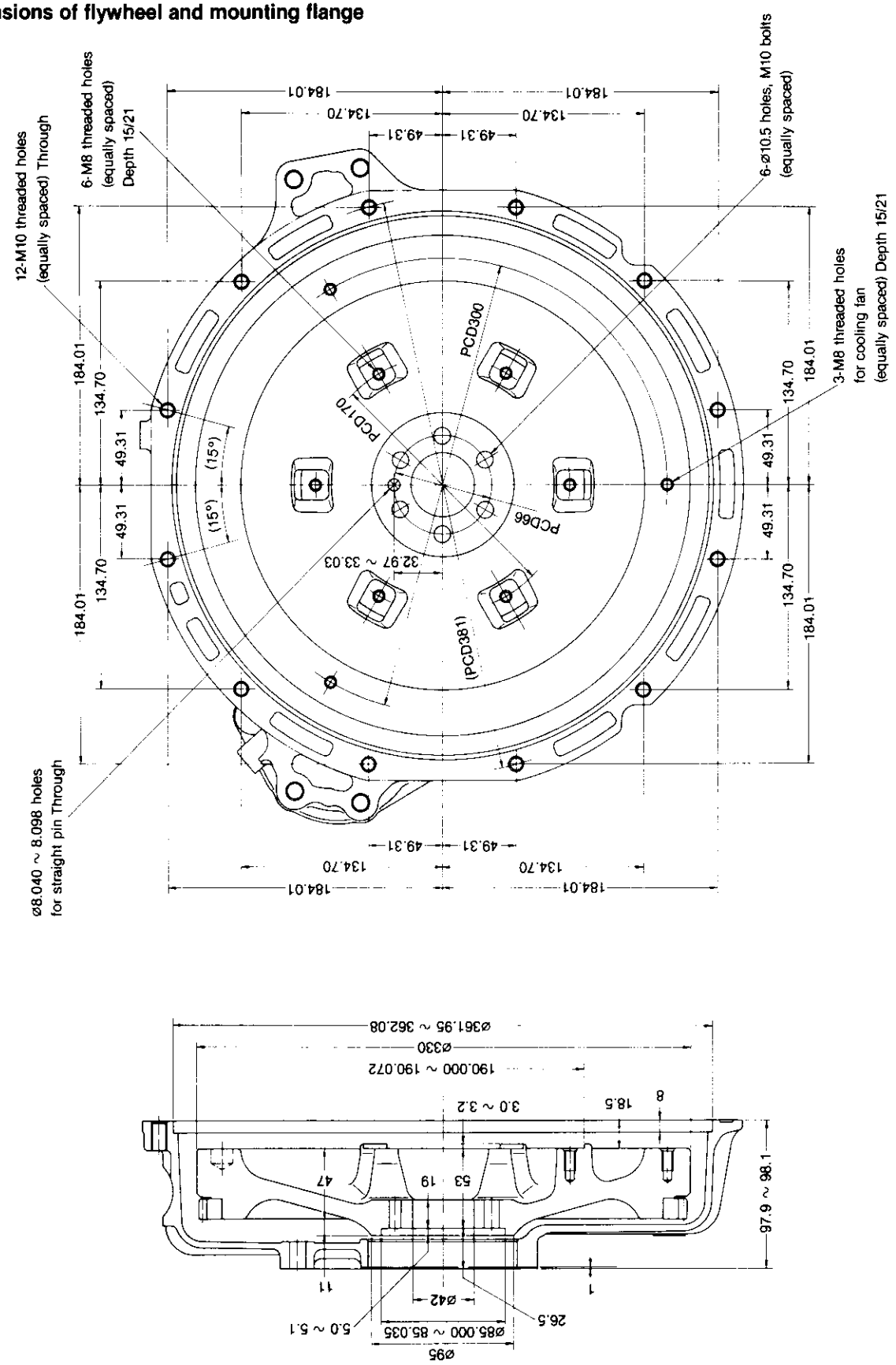
The function of the flywheel is, through inertia, to rotate the crankshaft in a uniform and smooth manner by absorbing the turning force created during the combustion stroke of the engine, and by compensating for the decrease in turning force during the other strokes.
The flywheel is mounted and secured by 6 bolts on the crankshaft end at the opposite end to the gear case; it is covered by the mounting flange (flywheel housing) which is bolted to the cylinder block.
On the crankshaft side of the flywheel is the fitting surface for the damper disc, through which the rotation of the crankshaft is transmitted to the input shaft of the reduction and reversing gear. The reduction and reversing gear is fitted to the mounting flange.
The flywheels unbalanced force on the shaft center must be kept below the specified value for the crankshaft as the flywheel rotates with the crankshaft at high speed. To achieve this, the balance is adjusted by drilling holes in the side of the flywheel, and the unbalanced momentum is adjusted by drilling holes in the circumference.
The ring gear is shirink fitted onto the circumference of the flywheel, and this ring gear serves to start the engine by meshing with the starter motor pinion.
The stamped letter and line which show top dead center of each cylinder are positioned on the flywheel circumference, and by matching these marks with the arrow mark at the hole of the flywheel housing, the rotary position of the crankshaft can be ascertained in order to adjust tappet clearance or fuel injection timing.

9-1 Specifications of flywheel

Outside dia. of flywheel		mm	ø330
Width of flywheel		mm	47
Weight of flywheel (including ring gear)		kg	13.17
GD² value		kg-m²	1.10
Circumferential speed		m/s	62.2 (3600rpm)
Speed fluctuation rate		δ	1/346 (3600rpm)
Allowable amount of unbalance		g-cm	22
Fixing part of damper disc	Pitch circle dia. of bolts	mm	170
	No. of bolts × bolt dia.		6-M8 thread equally spaced
Fixing part of crankshaft	Pitch circle dia. of bolts	mm	66
	No. of thread holes	mm	6-M10
	Fit joint dia.		ø85.000 ~ 85.035
Model of reduction and reversing gear			KBW-20 & KBW-21
Mounting flange No.			SAE No.4 (in metric unit)
Ring gear	Center dia.	mm	322.58
	No of teeth		127

Printed in Japan
0000A0A1647

9-2 Dimensions of flywheel and mounting flange

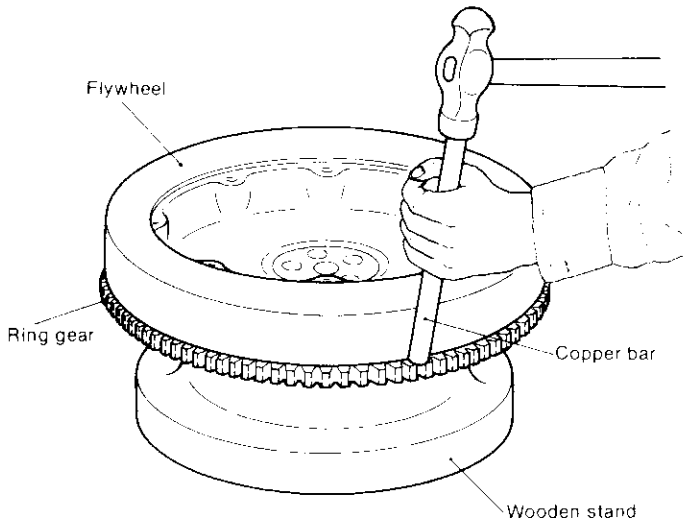


9-3 Ring gear

When replacing the ring gear due to excessive wear or damaged teeth, heat the ring gear evenly at its circumference, and after it has expanded drive it gradually off the flywheel by tapping it with a hammer, a copper bar or something similar around the whole circumference.

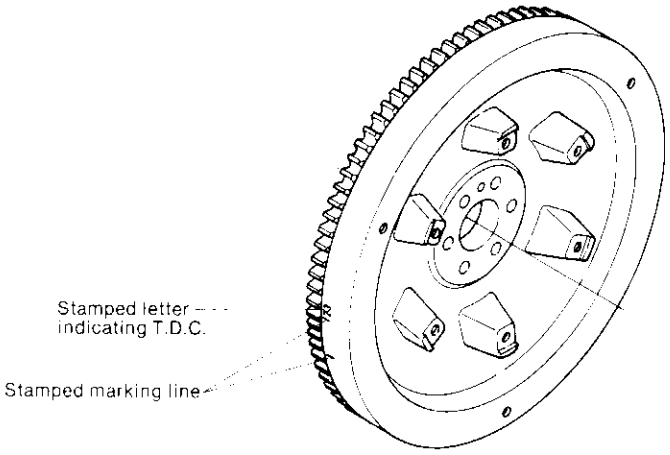
mm (in.)

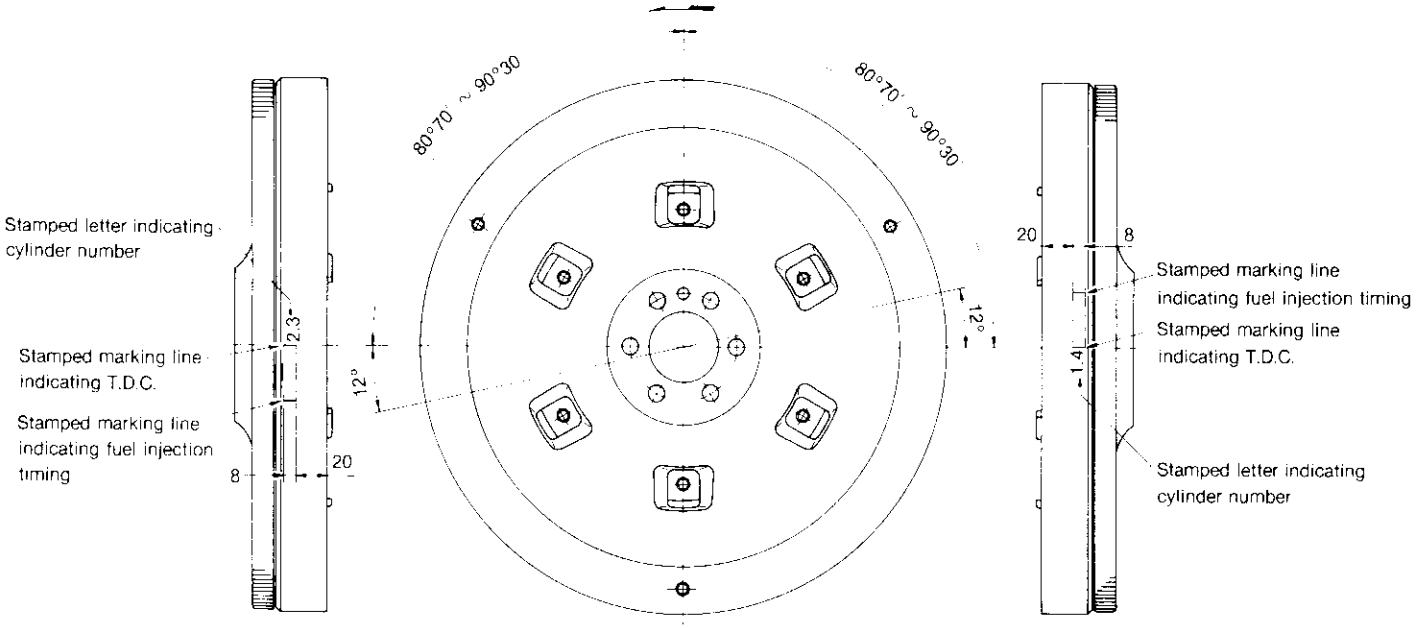
Interference of ring gear	0.158 ~ 0.250 (0.0062 ~ 0.0098)



9-4 Position of top dead center and fuel injection timing

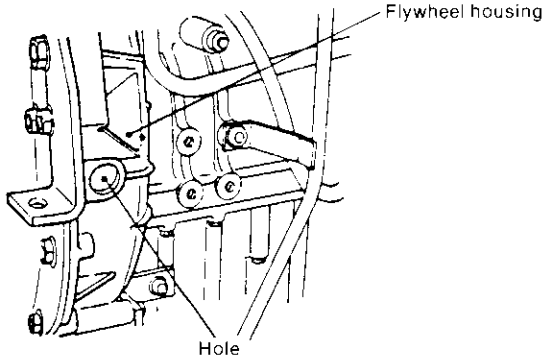
(1) Marking

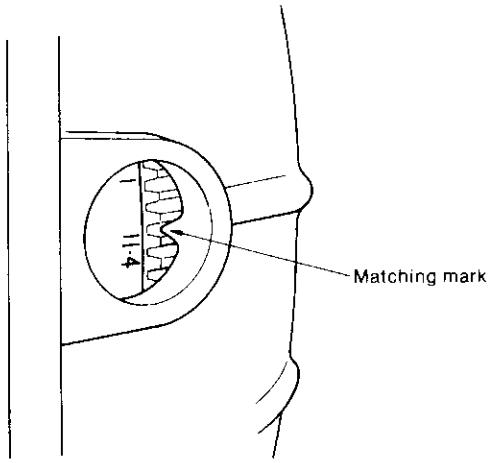




Printed in Japan
0000A0A1647

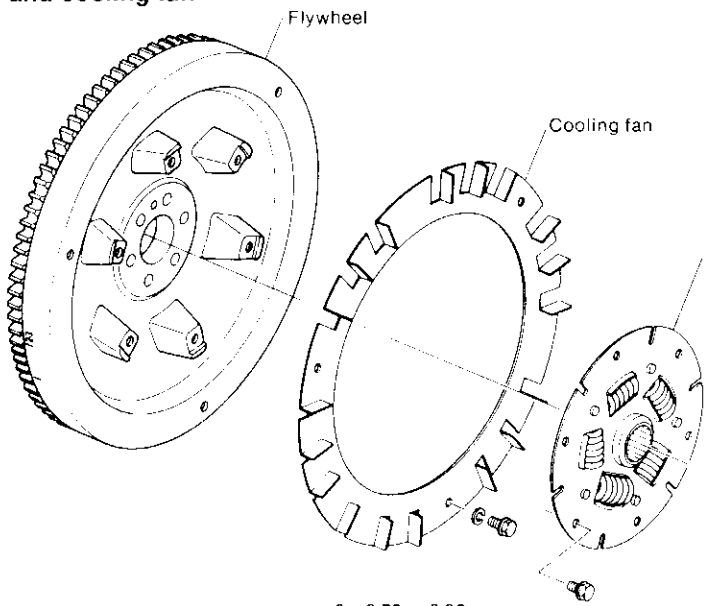
(2) Matching mark



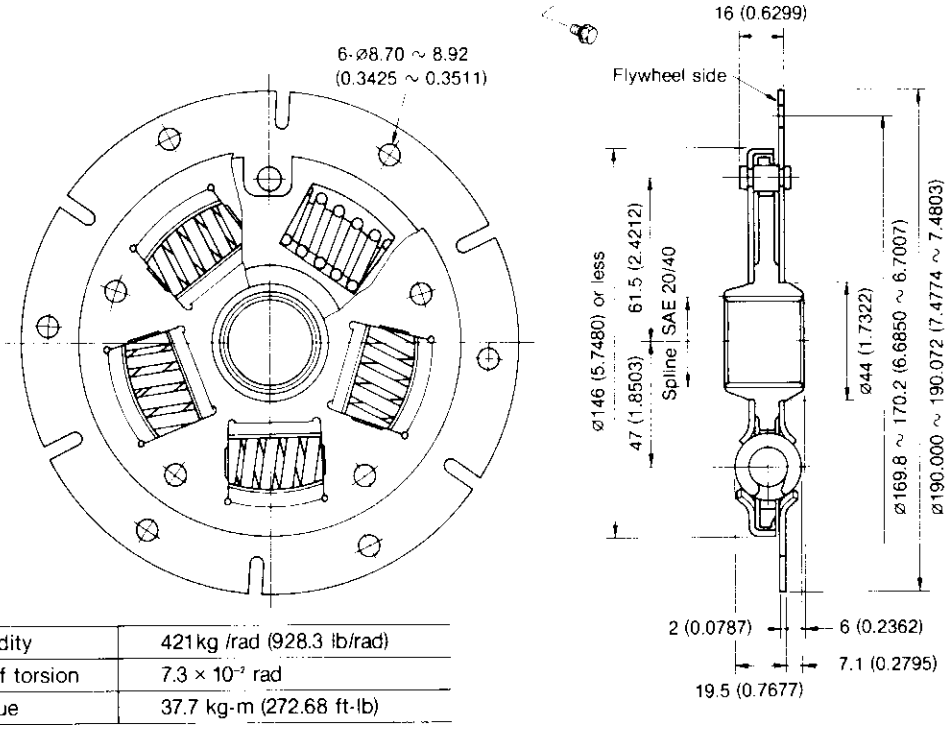


The matching mark is made at the hole of the flywheel housing.

9-5 Damper disc and cooling fan



mm (in.)



Torsional rigidity	421kg /rad (928.3 lb/rad)
Max. angle of torsion	7.3×10^{-2} rad
Stopper torque	37.7 kg-m (272.68 ft-lb)

Printed in Japan
0000A0A1617