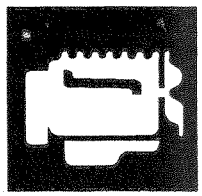
SECTION 07
ENGINE AND ACCESSORY
EX12,15,22,30



CONTENTS

NOTICE

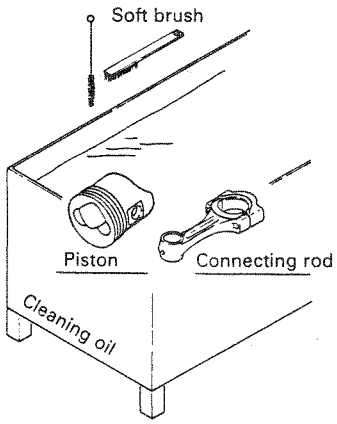
This Manual is edited to provide a repair and adjusting method of 3KC1, 3KR1 and 3KR2 engines.

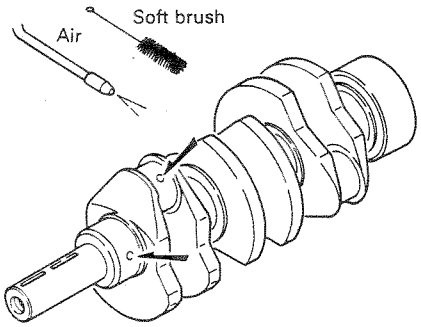
In order to maintain the engine in the best condition, utilize the Manual during maintenance work.

This manual applies to the 1990 year and later models.

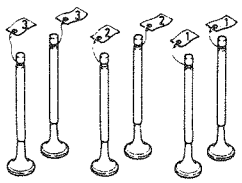
GENERAL REPAIR INSTRUCTIONS

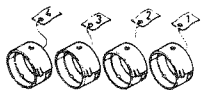
1. Before inspection and service work, disconnect a cable from the battery to protect harnesses from damage caused by shortcircuit.
2. Use the specified Isuze special tools.
3. Use the Isuzu genuine parts.
4. As a rule, do not reuse gaskets, oil seals, and lock washers.
5. Keep the disassembled parts tidy by group to ensure service work.
6. Clean parts before inspection and reassembly. Also, check by the compressed air to see if an oil hole is clogged.

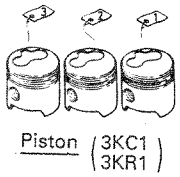


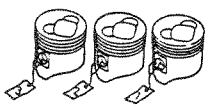


7. Attach a number tag to each valve, bearing and piston according to the cylinder number to avoid confusion.









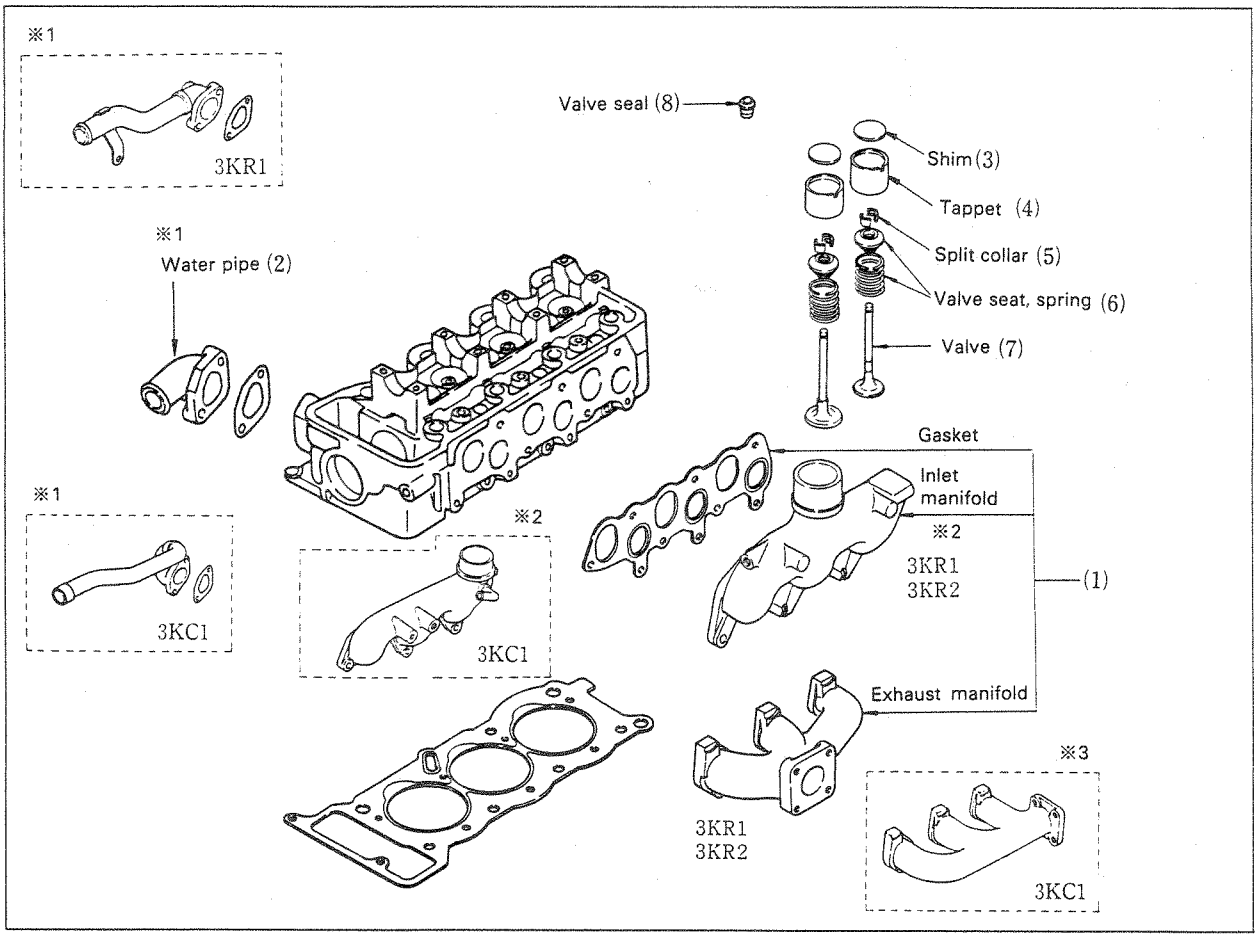
8. Apply oil or grease to rotating parts or slideways to obtain smooth movement before reassembly.
9. Use sealer as a gasket to prevent leakage, if necessary.
10. Tighten the bolts and nuts to the specified torque.
11. After inspection and servicing, perform final check to confirm that service was carried out properly.

HOW TO USE THIS MANUAL

1. Look for a proper section following the grand contents.
2. Each section contains disassembly, inspection, replacement and reassembly in this order.
3. The stress of description is put on the important work such as "adjustment method" and "torque", and description on removal of parts from the unit is omitted.
4. The section for inspection and servicing work starting with the disassembly figure of the unit clarifies components and inspection steps.
   Reference parts catalogue No.: 3KC1 model 5-8871-0206-2
   3KR1 model 5-8871-0179-4
   3KR2 model 5-8871-0240-0

(Example)

Main components
The parenthesized numbers indicate the order of disassembly, inspection, servicing and reassembly.



6. Each item contains:
   (1) Important work or caution
   (2) Special tool number
   (3) Symbols showing inspection and servicing steps to be executed. (For the symbols, see below.)
   (4) A table listing main data and specifications (torque).
7. The following symbols show inspection and servicing work.

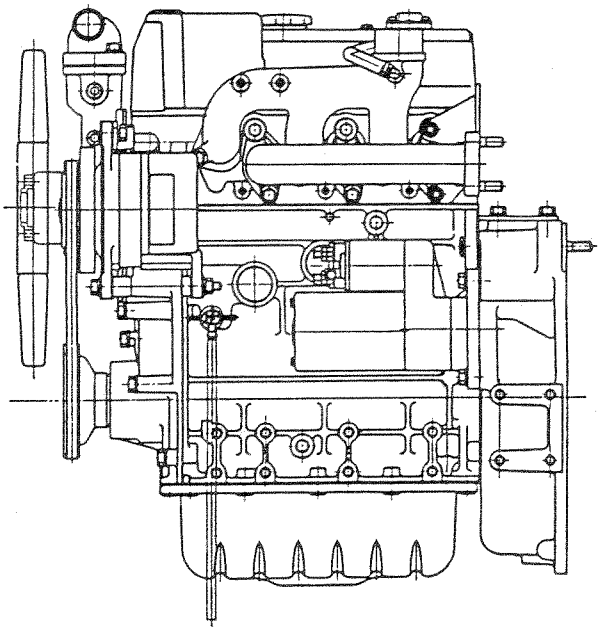
	... Remove		... Adjustment
	... Install		... Clean
	... Disassemble		... Pay close attention — important
	... Reassemble		... Tighten to specified torque
	... Align the marks		... Use special tool(s) (Isuzu's tool(s))
	... Correct direction		... Use special tool(s) (parts manufacturer's tool(s))
	... Inspect		... Lubricate with oil
	... Take measurement		... Lubricate with grease

8. The "standard" and "limit" imply:
   The "standard" specifies standard value in a reassembly step.
   The "limit" specifies the maximum allowable value, and a part exceeding the limit requires repair or replacement.

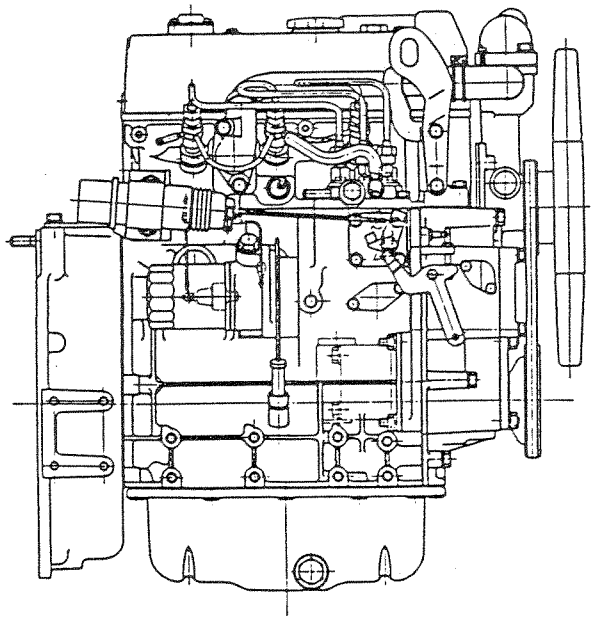
APPEARANCE

1. 3KC1 model

Left side view

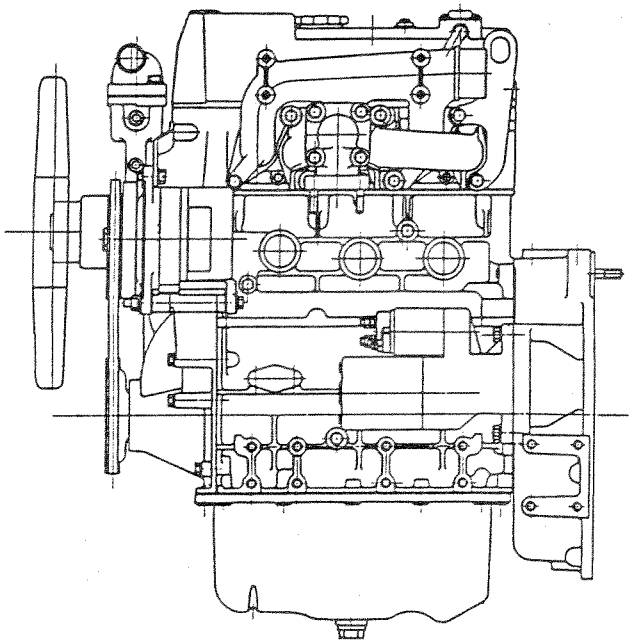


Right side view

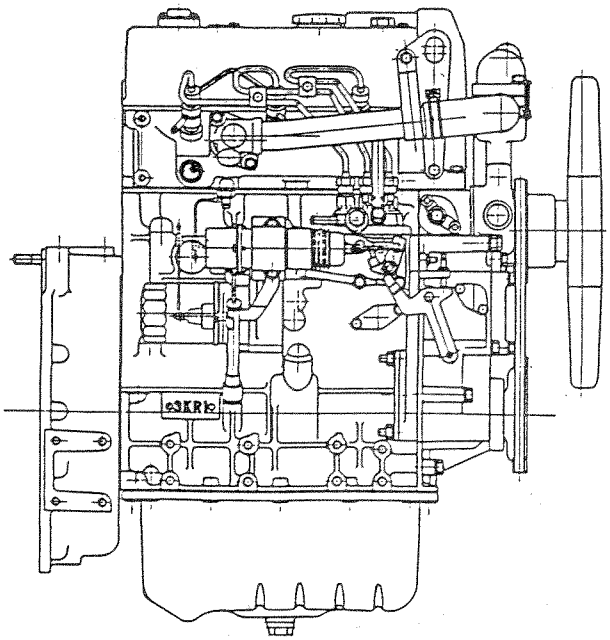


2. 3KR1 model

Left side view

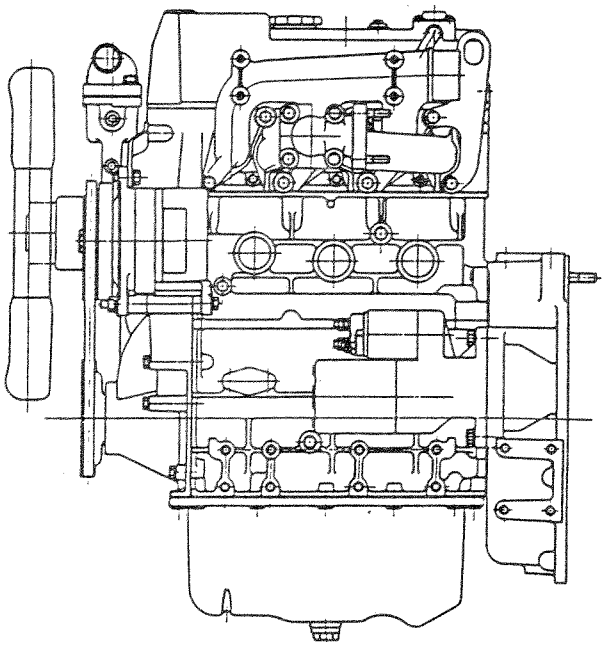


Right side view

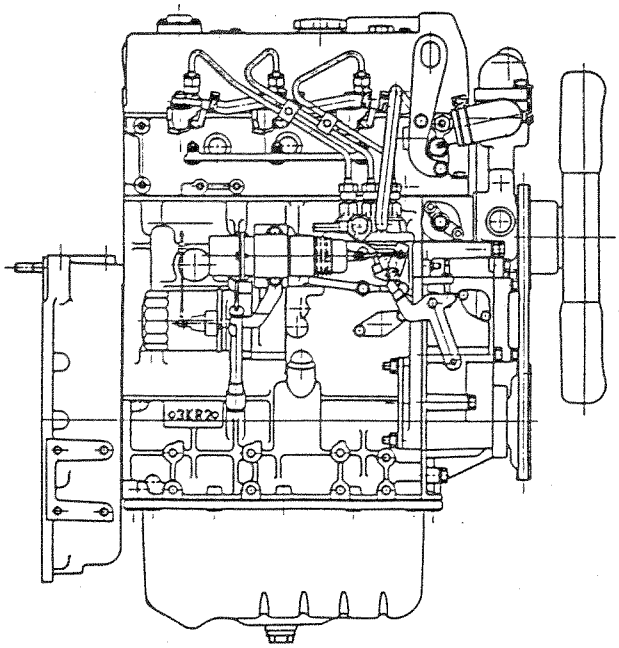


3. 3KR2 model

Left side view



Right side view



MAIN DATA AND SPECIFICATIONS

1. 3KC1 model

Items \ Engine model(s)			3KC1 (EX12, 15)
Type			In-line water-cooled 4-cycle OHC diesel engine
Timing drive system			Gear and chain system
Number of piston rings			Compression rings 2, oil ring 1
No. of cylinders – bore X stroke (mm)			3 – 74 X 76
Piston displacement (cc)			980
Compression ratio			23 : 1
Combustion chamber type			In line swirl chamber type
Overall length X width X height (mm)			560 X 458 X 585
Dry weight (kg)			128
Fuel injection timing (BTDC)			12°
Firing order			1 – 3 – 2
Fuel			Diesel fuel oil (JIS K-2204)
Idling speed (r.p.m.)			1000
Compression pressure (kg/cm^2)			31 or more / 250 r.p.m.
Valve clearance (cold) (mm)		Intake	0.25
		Exhaust	0.25
Valve operating timing	Intake valve	Open (BTDC)	12°
		Close (ABDC)	48°
	Exhaust valve	Open (BBDC)	51°
		Close (ATDC)	9°
Injection pump			Bosch type
Governor			Mechanical type
Nozzle			Throttle type
Injection pressure (kg/cm^2)			120
Oil pump			Trochoid type
Oil filter			Cartridge type
Lubricant capacity: Oil pan capacity (ℓ)			Approx. 4.5
Generator (V–A)			12–20
Starter (V–KW)			12–1.4

Note: Specifications are subject to change without notice.

2. 3KR1, 3KR2 models

Items \ Engine model(s)			3KR1 (EX22)	3KR2 (EX30)
Type			In-line water-cooled 4-cycle OHC diesel engine	
Timing drive system			Gear and chain system	
Number of piston rings			Compression rings 2, oil ring 1	
No. of cylinders – bore × stroke (mm)			3 – 81 × 92	
Piston displacement (cc)			1422	
Compression ratio			21 : 1	19 : 1
Combustion chamber type			In line swirl chamber type	Direct injection type
Overall length × width × height (mm)			616 × 513 × 672	
Dry weight (kg)			154	
Fuel injection timing (BTDC)			16°	
Firing order			1 – 3 – 2	
Fuel			Diesel fuel oil (JIS K-2204)	
Idling speed (r.p.m.)			1100	
Compression pressure (kg/cm^2)			31 or more / 250 r.p.m.	
Valve clearance (cold) (mm)		Intake	0.25	
		Exhaust	0.25	
Valve operating timing	Intake valve	Open (BTDC)	12°	
		Close (ABDC)	48°	
	Exhaust valve	Open (BBDC)	51°	
		Close (ATDC)	9°	
Injection pump			Bosch type	
Governor			Mechanical type	
Nozzle			Throttle type	Hole type
Injection pressure (kg/cm^2)			120	220
Oil pump			Trochoid type	
Oil filter			Cartridge type	
Lubricant capacity: Oil pan capacity (ℓ)			Approx. 5.5	
Generator (V–A)			12–20	
Starter (V–KW)			12–1.4	

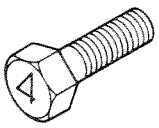
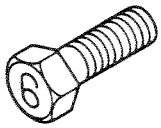
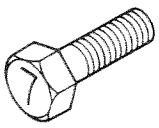
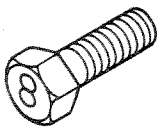
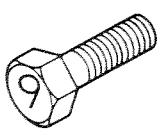
Note: Specifications are subject to change without notice.

TORQUE SPECIFICATIONS

STANDARD BOLTS

The tightening torque values listed below are applied to the bolts unless otherwise specified.

kg·m

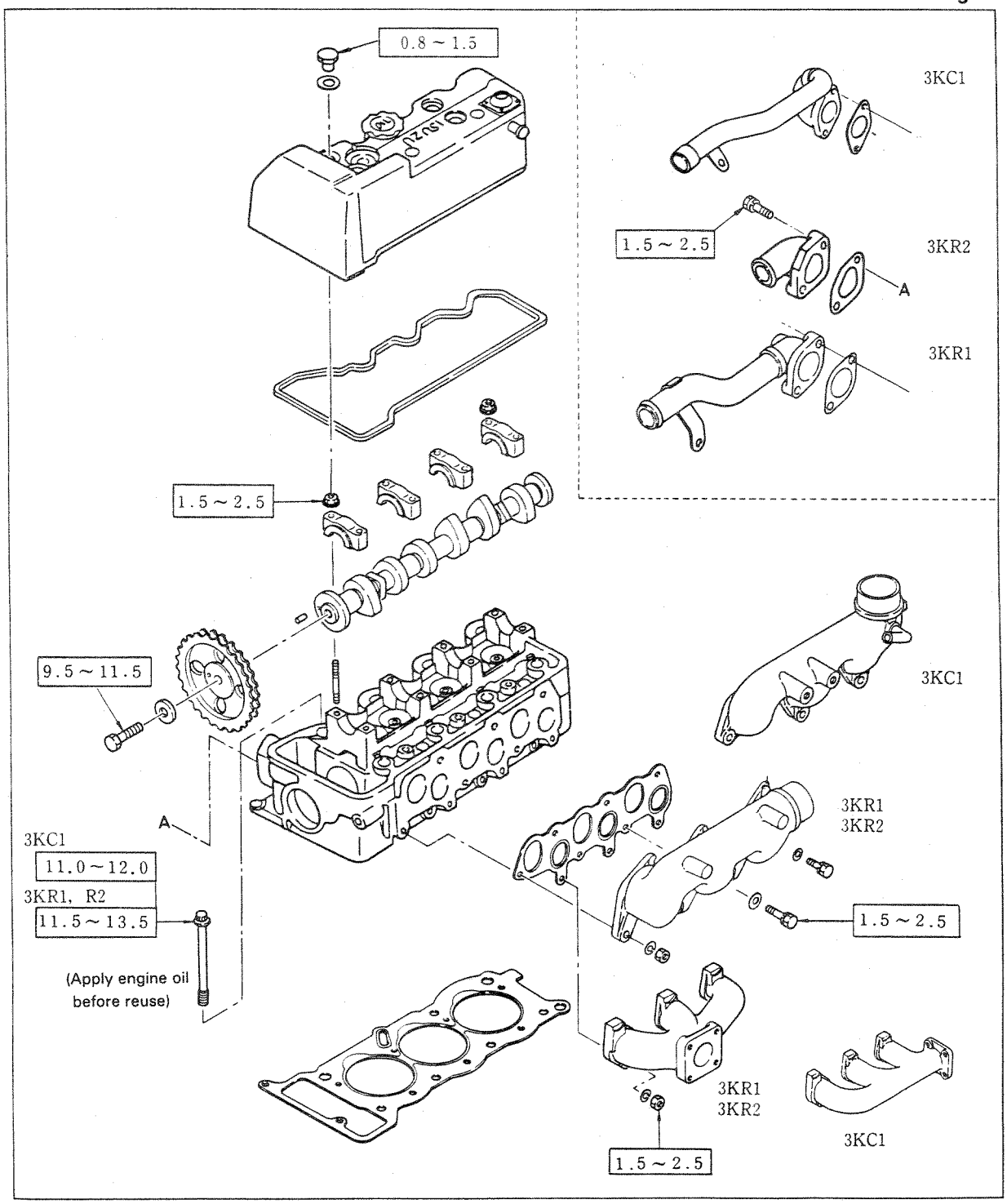
Bolt head marking / Nominal size (Dia.×pitch)					
M6×1	0.6 ± 0.2	0.7 $^{+0.2}_{-0.3}$	0.8 $^{+0.2}_{-0.3}$	0.9 $^{+0.2}_{-0.3}$	—
M8×1.25	1.3 ±0.5	1.6 $^{+0.4}_{-0.6}$	1.8 $^{+0.5}_{-0.6}$	2.1 $^{+0.5}_{-0.7}$	2.4 ±0.7
M10×1.25	2.8 ±0.7	3.3 $^{+0.8}_{-0.9}$	3.8 $^{+0.9}_{-1.0}$	4.3 ±0.9	5.1 ±1.3
*M10×1.5	2.7 ±0.7	3.2 ±0.8	3.7 ±0.9	4.2 ±1.0	4.9 ±1.2
M12×1.25	6.2 $^{+1.3}_{-1.2}$	6.7 $^{+1.4}_{-1.3}$	7.7 $^{+1.6}_{-1.5}$	8.8 $^{+1.8}_{-1.7}$	9.7 $^{+1.9}_{-2.0}$
*M12×1.75	5.8 ±1.2	6.3 ±1.2	7.2 ±1.4	8.2 ±1.6	9.1 ±1.8
M14×1.5	9.7 $^{+2}_{-1.9}$	10.4 $^{+2}_{-2.1}$	11.9 $^{+2.3}_{-2.4}$	13.6 $^{+2.6}_{-2.8}$	14.5 ±2.9
*M14×2	9.1 ±1.8	9.8 ±1.9	11.2 ±2.2	12.8 ±2.5	13.6 ±2.7
M16×1.5	13.3 ±2.7	15.1 ±3.1	17.3 ±3.5	19.7 ±4.0	20.4 ±4.1
*M16×2	12.7 ±2.5	14.4 ±2.9	16.5 ±3.3	18.8 ±3.8	19.5 ±3.9
M18×1.5	19.2 ±3.8	21.7 $^{+4.4}_{-4.3}$	24.9 ±5.0	28.4 ±5.7	29.3 ±5.9
*M18×2.5	19.2 ±3.8	21.8 $^{+4.4}_{-4.3}$	25.0 ±5.0	18.5 ±5.7	29.4 $^{+5.9}_{-5.8}$
M20×1.5	26.3 ±5.3	30.0 $^{+6.1}_{-6}$	34.4 ±6.9	39.2 $^{+7.9}_{-7.8}$	40.4 ±8.1
*M20×2.5	24.3 ±4.9	27.8 $^{+5.5}_{-5.6}$	31.8 ±6.4	36.3 $^{+7.2}_{-7.3}$	37.4 ±7.5
M22×1.5	32.0 $^{+10.2}_{-6.4}$	40.4 ±8.1	46.3 $^{+9.2}_{-9.3}$	52.8 $^{+10.5}_{-10.6}$	54.1 ±10.8
*M22×2.5	27.8 ±5.6	37.6 ±7.5	43.1 ±8.6	49.1 ±9.8	50.3 ±10.1
M24×2	45.8 ±9.2	47.9 $^{+15.4}_{-9.6}$	54.9 $^{+17.6}_{-11.0}$	62.6 $^{+20.1}_{-12.6}$	70.6 ±14.1
*M24×3	43.1 ±8.6	45.1 ±9.0	51.7 ±10.3	58.9 $^{+11.8}_{-11.7}$	66.4 ±13.3

*Data is for female screws of soft material such as cast iron.

TORQUE FOR BOLTS AND NUTS ON MAJOR COMPONENTS

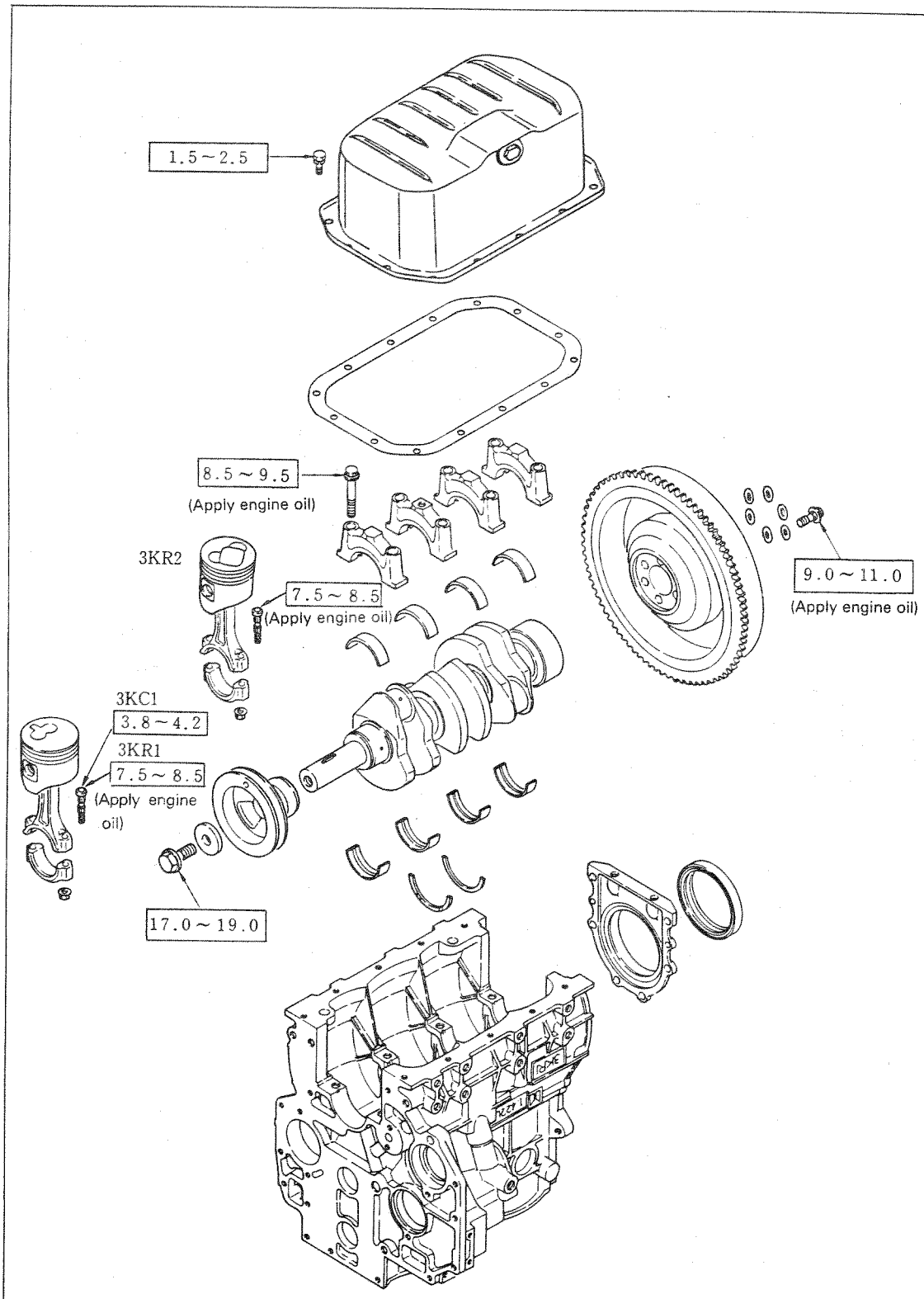
CYLINDER HEAD AND CYLINDER HEAD COVER

kg·m



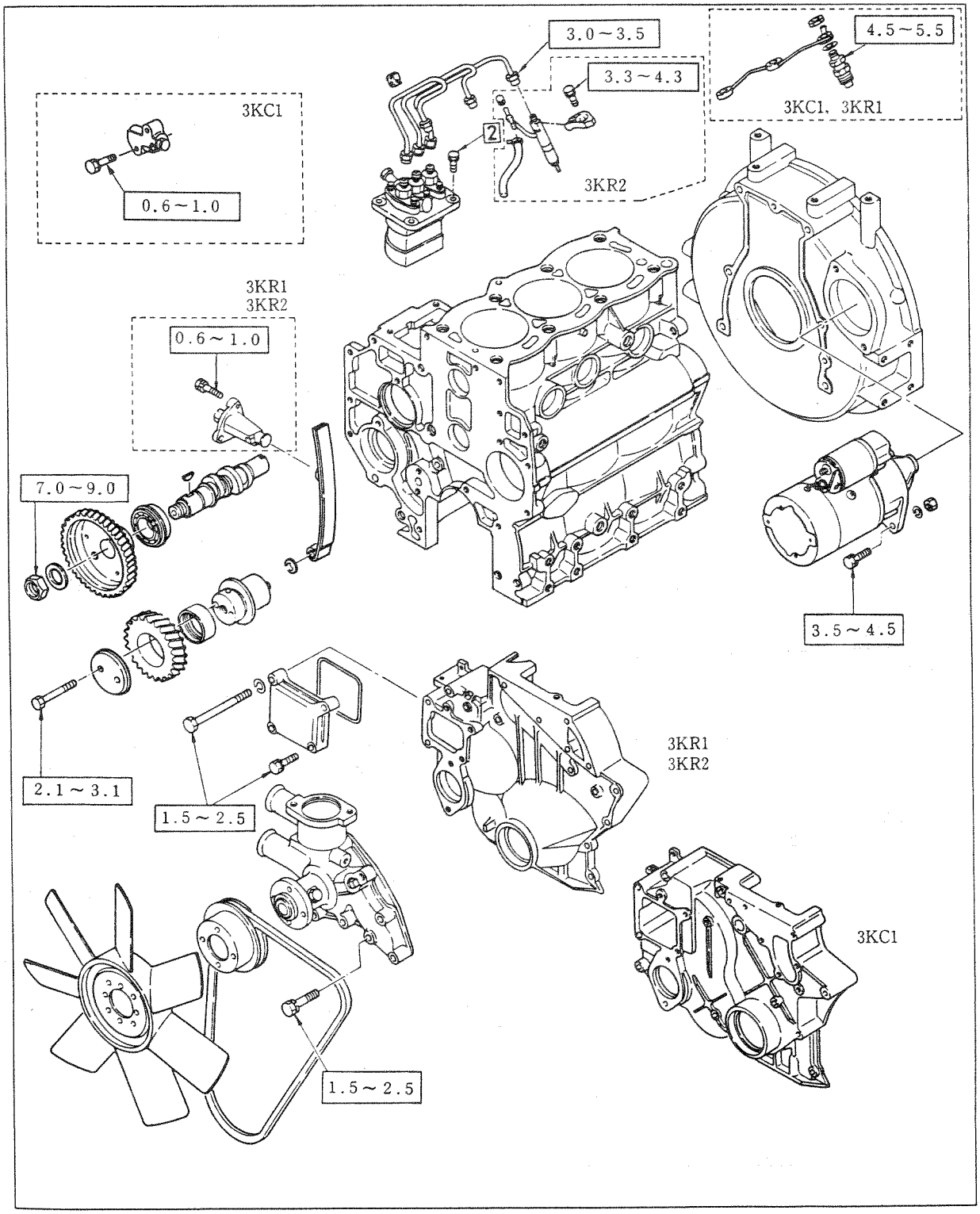
CYLINDER BODY AND OTHER COMPONENTS (1)

kg·m



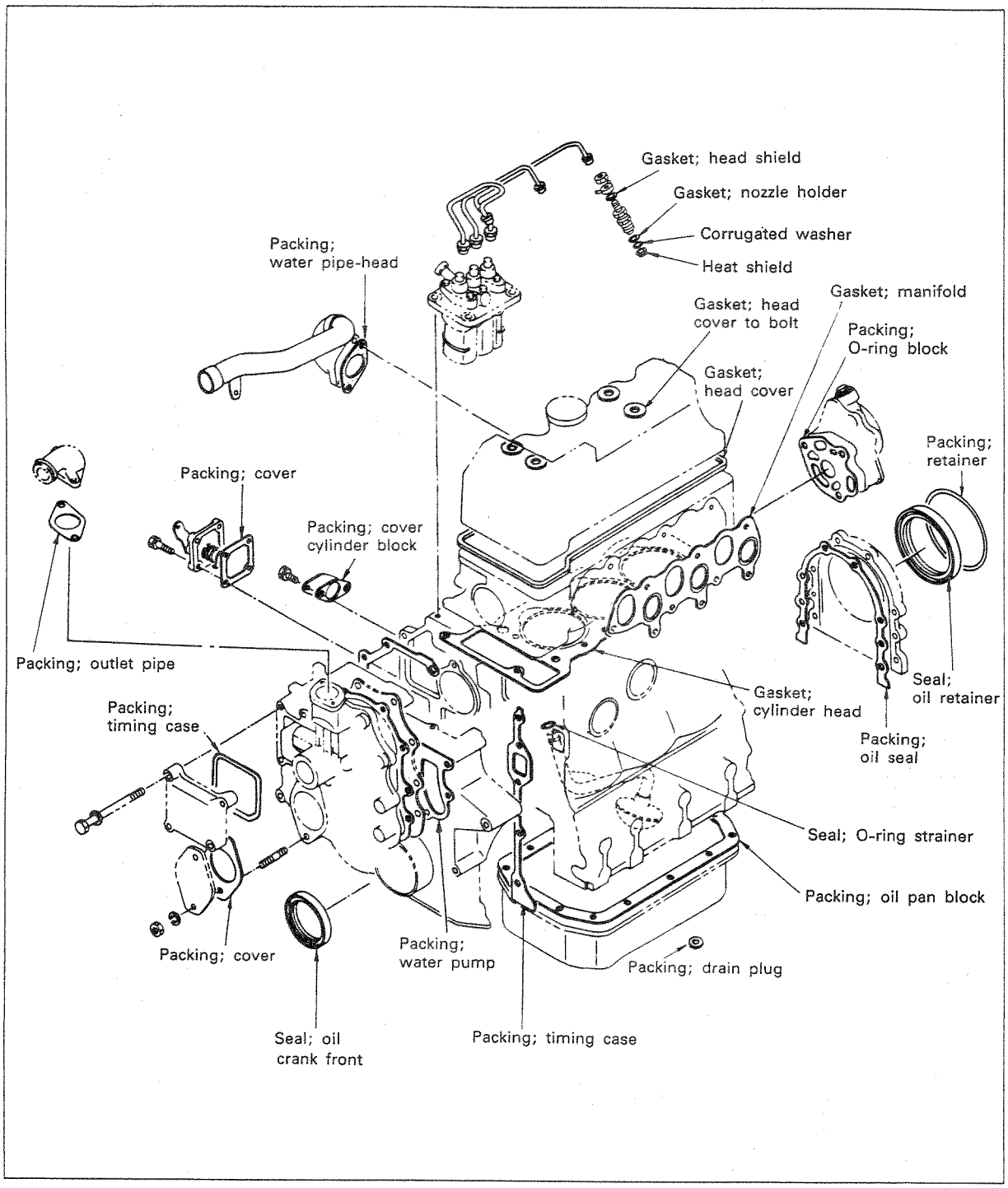
CYLINDER BODY AND OTHER COMPONENTS (2)

kg·m

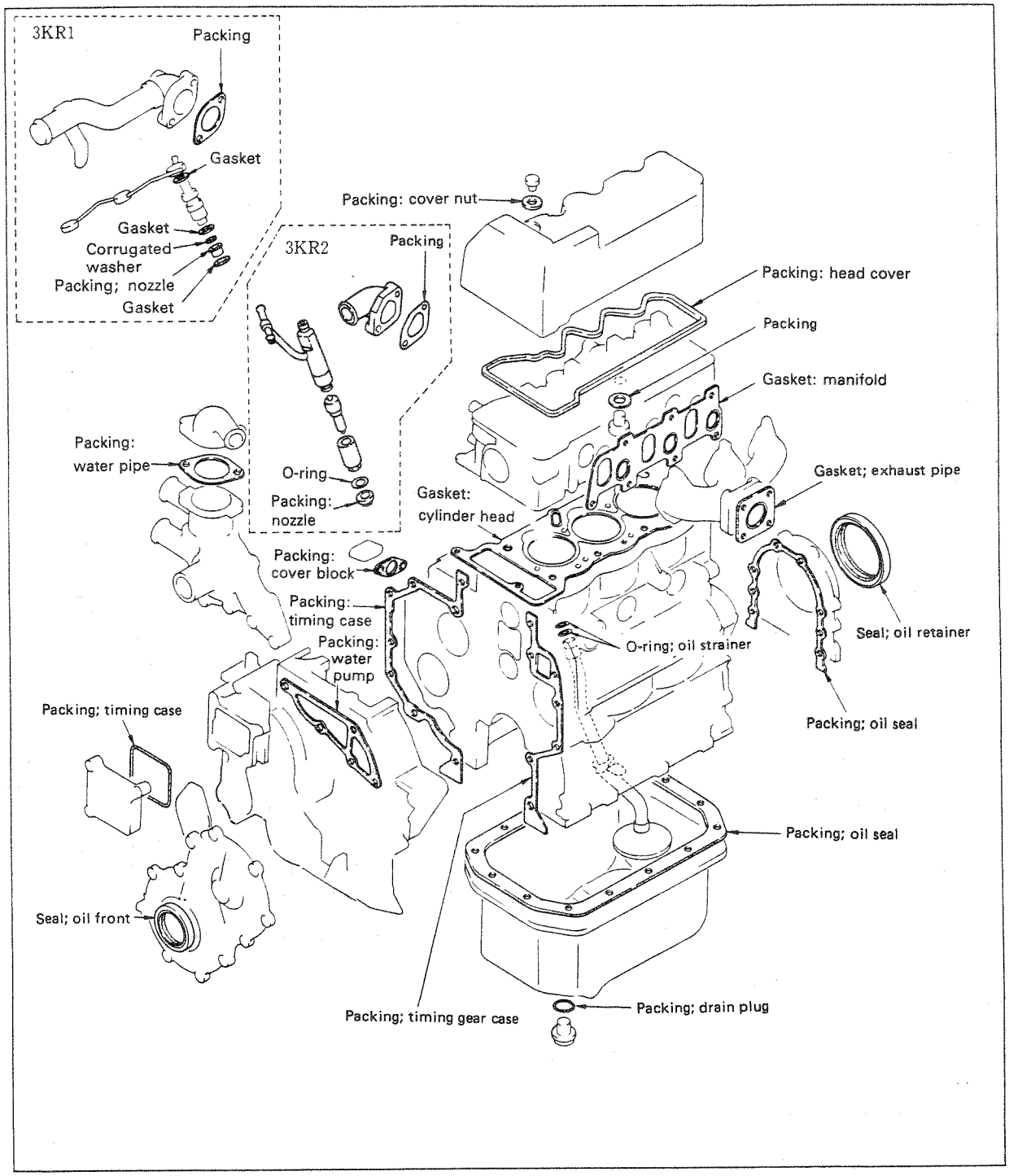


PACKING LOCATION

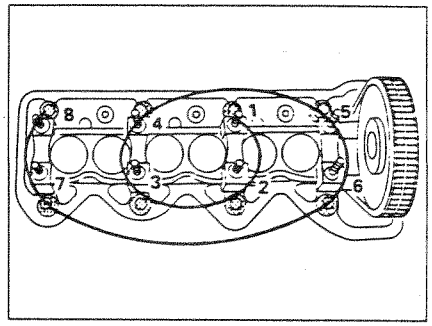
1. 3KC1 model



2. 3KR1, 3KR2 models



INSPECTION AND SERVICING



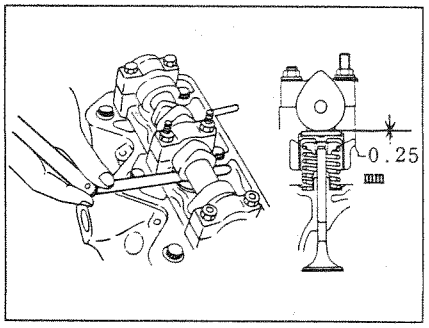
Cylinder head bolts

Tighten the bolts in the order shown to left.

(kg·m)

		3KC1	3KR1, 3KR2
Torque	New	9.5~10.5	11.5~13.5
	Reuse	11.0~12.0	13.0~15.0

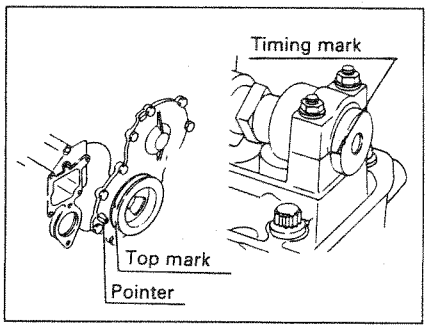
Apply engine oil to threads.



Adjust valve clearance in the cold condition using a thickness gauge.

(mm)

Inlet valve Exhaust valve	0.25 ± 0.05



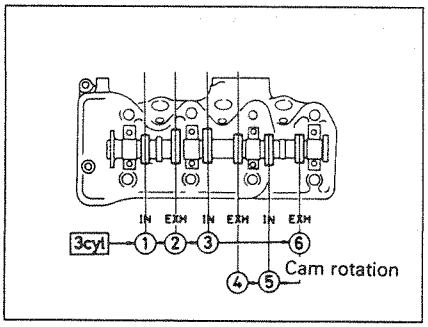
Adjustment of valve clearance

Turning the crankshaft, align a top mark on the crankshaft with a pointer on the timing gear case cover. The No.1 cylinder piston is in the top dead center if a timing mark on the training end of camshaft aligns with the mark on the left side of bracket.

① Under this condition, measure clearance of ① – ② – ③ – ⑥ from the front side. (○ mark in the table)

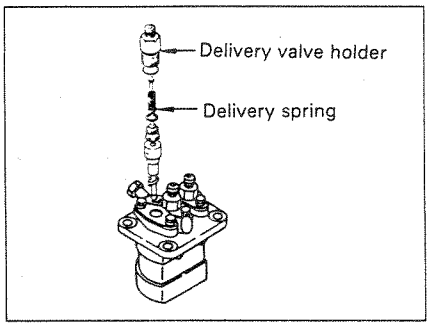
② Rotate the camshaft by 180°, and measure clearance of ④ – ⑤ (◎ mark in the table)

③ If a value out of the range is measured, press the tappet with a special tool and increase or decrease the shim to the specified value.



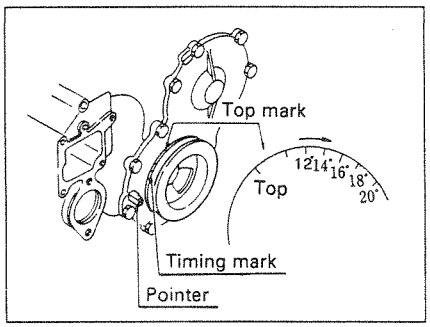
Special tool: Valve setter; 894409 - 7060

Cylinder No.	1		2		3	
Valve arrangement	I	E	I	E	I	E
No.1 cylinder TDC	○	○	○			○
No.2, 3 cylinders TDC				◎	◎	



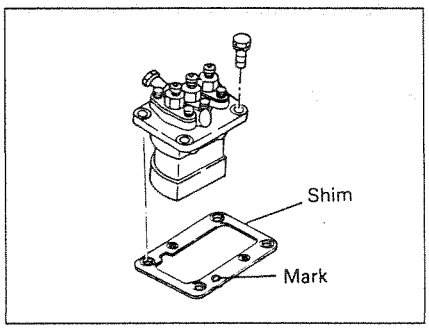
Injection timing

Remove the delivery valve holder on the injection pump, and remove a delivery spring. Install the delivery valve holder without a spring. Then, rotate the crankshaft slowly and stop it when fuel flow stops and the next oil level starts to move.



Read a value where the injection timing mark on the crankshaft pulley aligns with a pointer on the gear case cover. Adjust if this value is out of the specification.

Injection timing	3KC1	BTDC 12°
	3KR1	BTDC 16°
	3KR2	



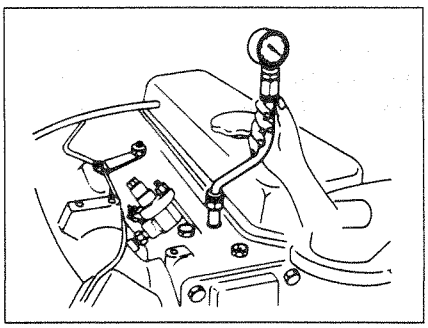
Adjustment of injection timing

Adjust injection timing with a shim between injection pump body and cylinder body.

The 0.1 mm shim thickness corresponds to crankshaft angle 1°.

(mm)

Mark	Thick	Mark	Thick	Mark	Thick	Mark	Thick
2	0.2	5	0.5	8	0.8	11	1.1
3	0.3	6	0.6	9	0.9	12	1.2
4	0.4	7	0.7	10	0.1		



Compression pressure

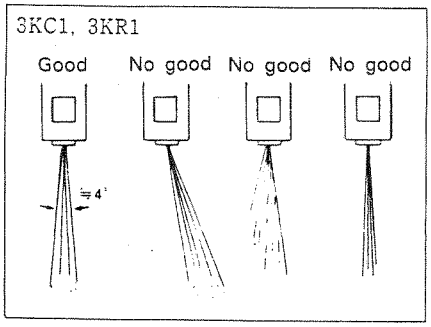
Remove an injection nozzle from the cylinder, and measure compression pressure of each cylinder with a pressure gauge by the starter.

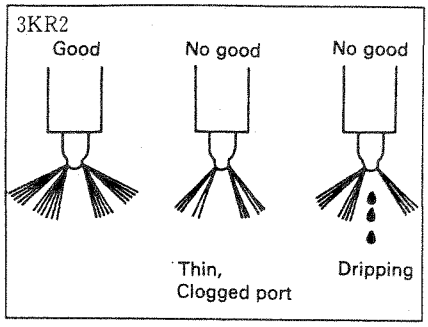
kg/cm² (250 r.p.m.)

Standard	Limit
31 or more	26 or less

Adapter gauge: 5 - 8840 - 2009 - 0

Compression gauge: 5 - 8840 - 2008 - 0





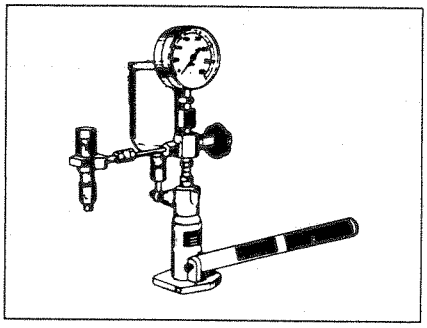
Fuel system

Injection nozzle

Check spray condition and injection pressure, and adjust.

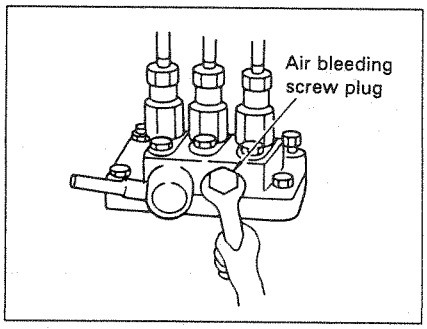
(kg/cm²)

Injection pressure	3KC1	120
	3KR1	
	3KR2	220



Using a nozzle tester, adjust injection pressure with a shim.

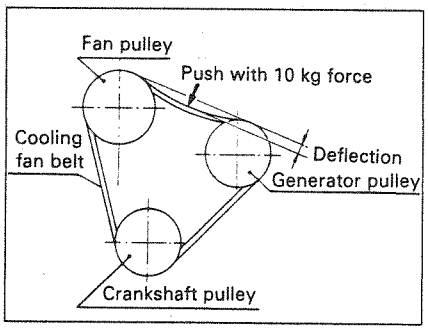
Special tool: Nozzle tester; 5 - 8840 - 9016 - 0



Air bleeding

(If a feed pump is not available)

Loosen an air bleeding screw plug on the injection pump, and tighten it when no bubble is found in the fuel flowing out of the screw plug.



Fan belt

(mm)

Belt deflection	approx. 10

RECOMMENDED LUBRICATING OIL

LUBRICATING OIL

The following lubricating oil should be used.
Idemitsu "Apolloil Superwide 15W-40" (API service classification: class CD)

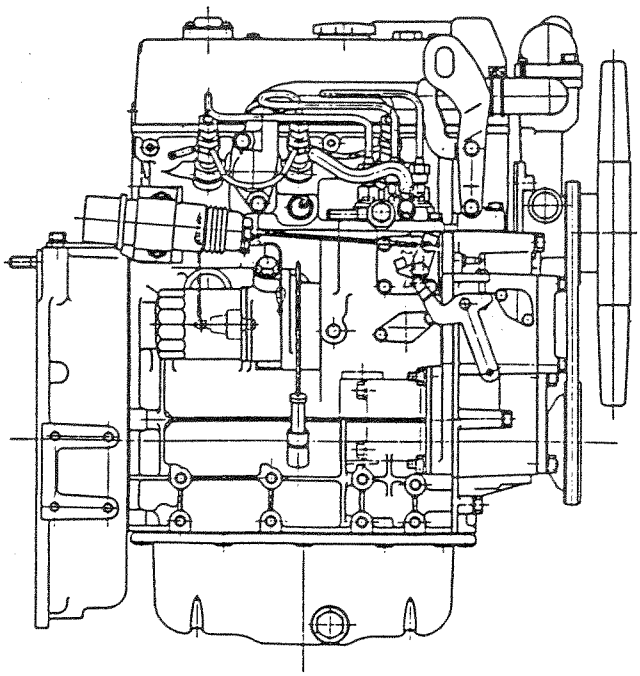
LUBRICATING OIL CAPACITY (including filter)

3KC1 ..... Approx. 4.5 ℓ
3KR1, 3KR2 ..... Approx. 5.5 ℓ

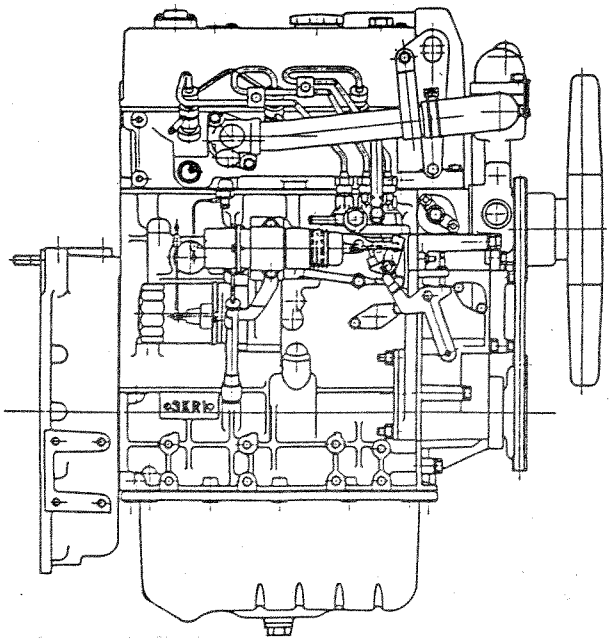
ENGINE

GENERAL VIEW OF ENGINE

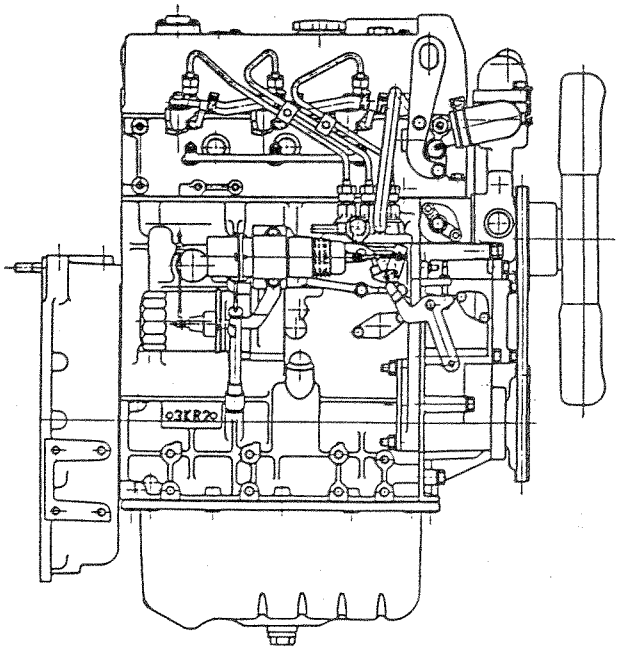
3KC1 model



3KR1 model

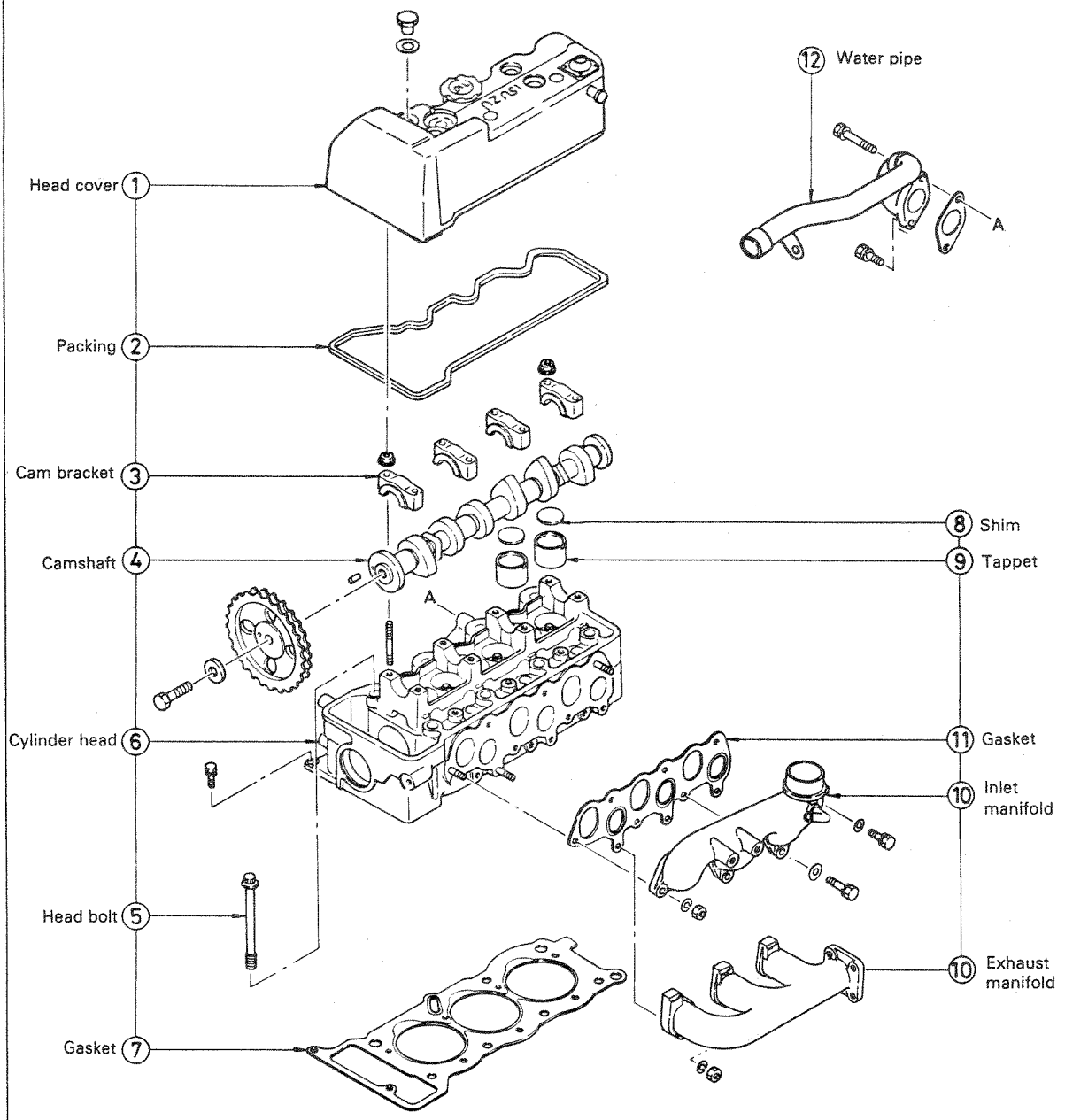


3KR2 model



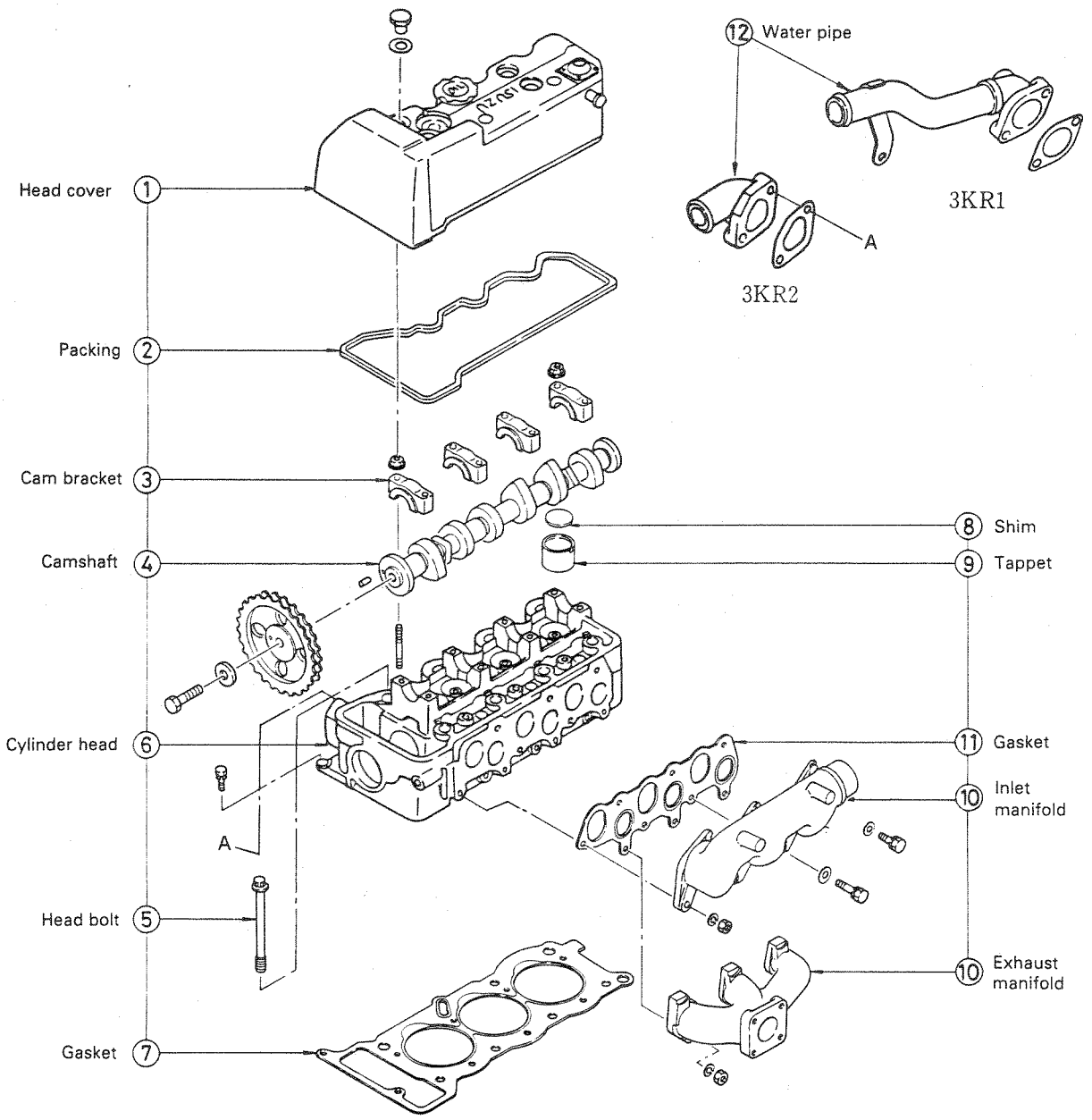
DISASSEMBLY STEPS (1)

3KC1 model



The encircled numbers indicate disassembly steps.

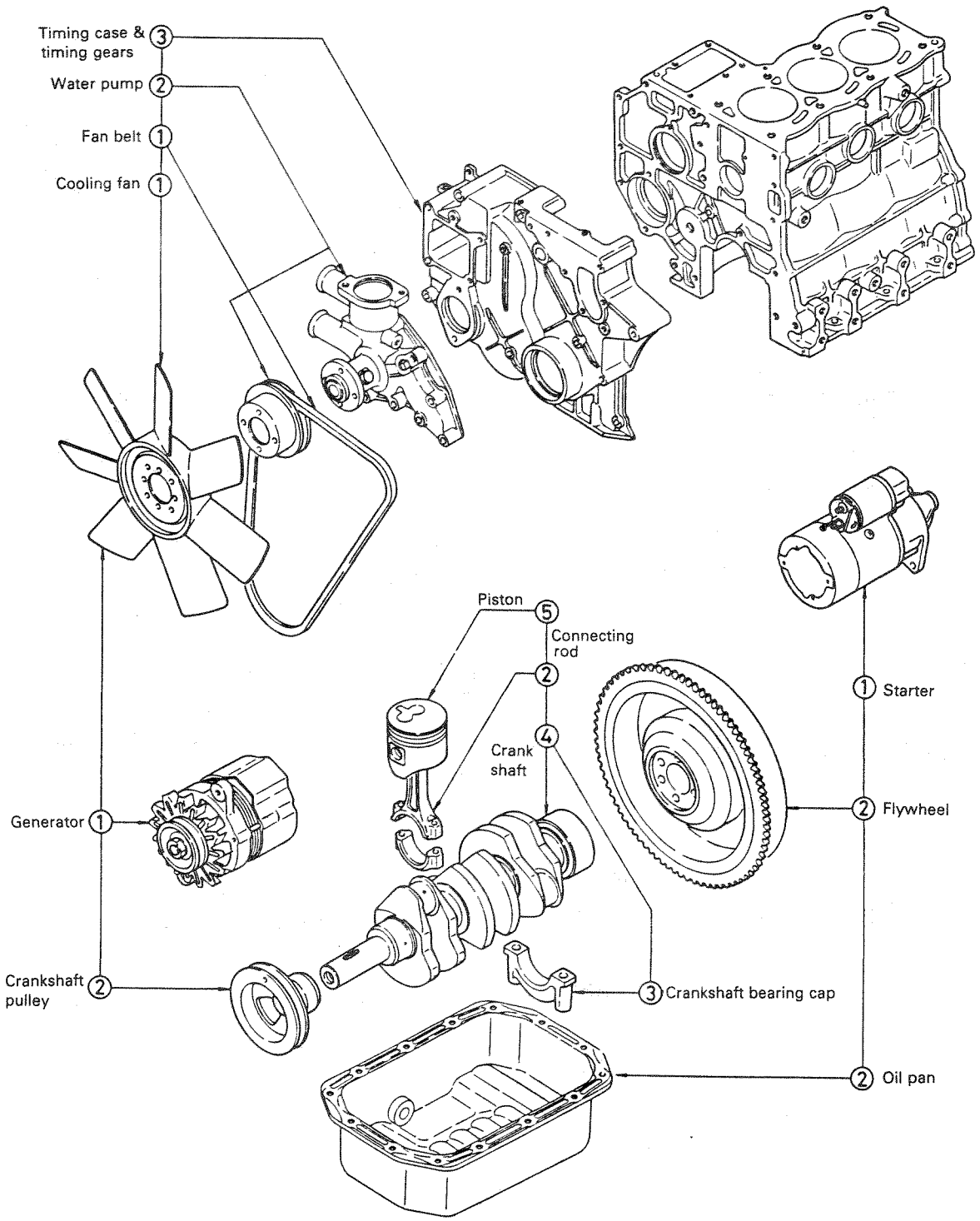
3KR1, 3KR2 models



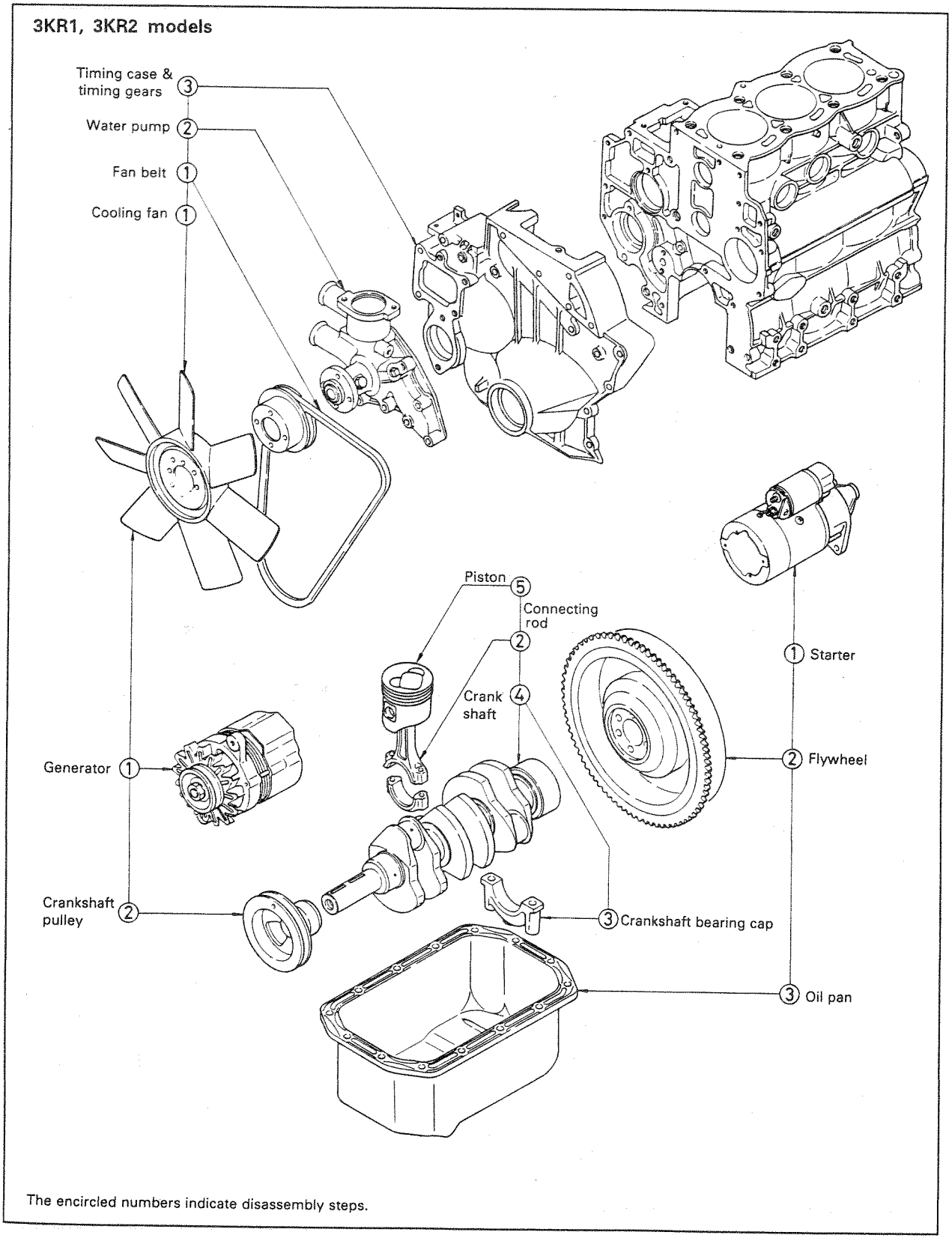
The encircled numbers indicate disassembly steps.

DISASSEMBLY STEPS (2)

3KC1 model

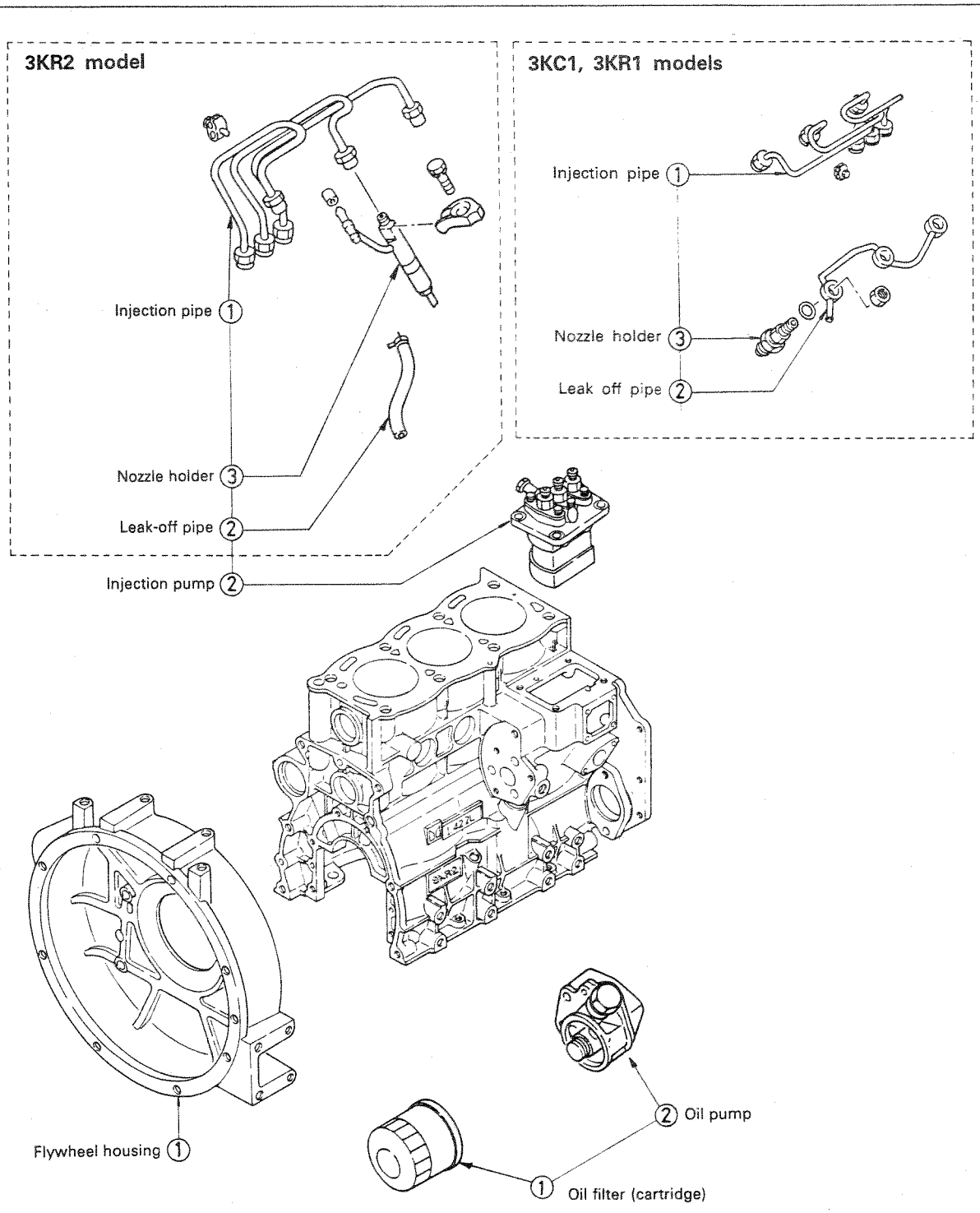


The encircled numbers indicate disassembly steps.



The encircled numbers indicate disassembly steps.

DISASSEMBLY STEPS (3)



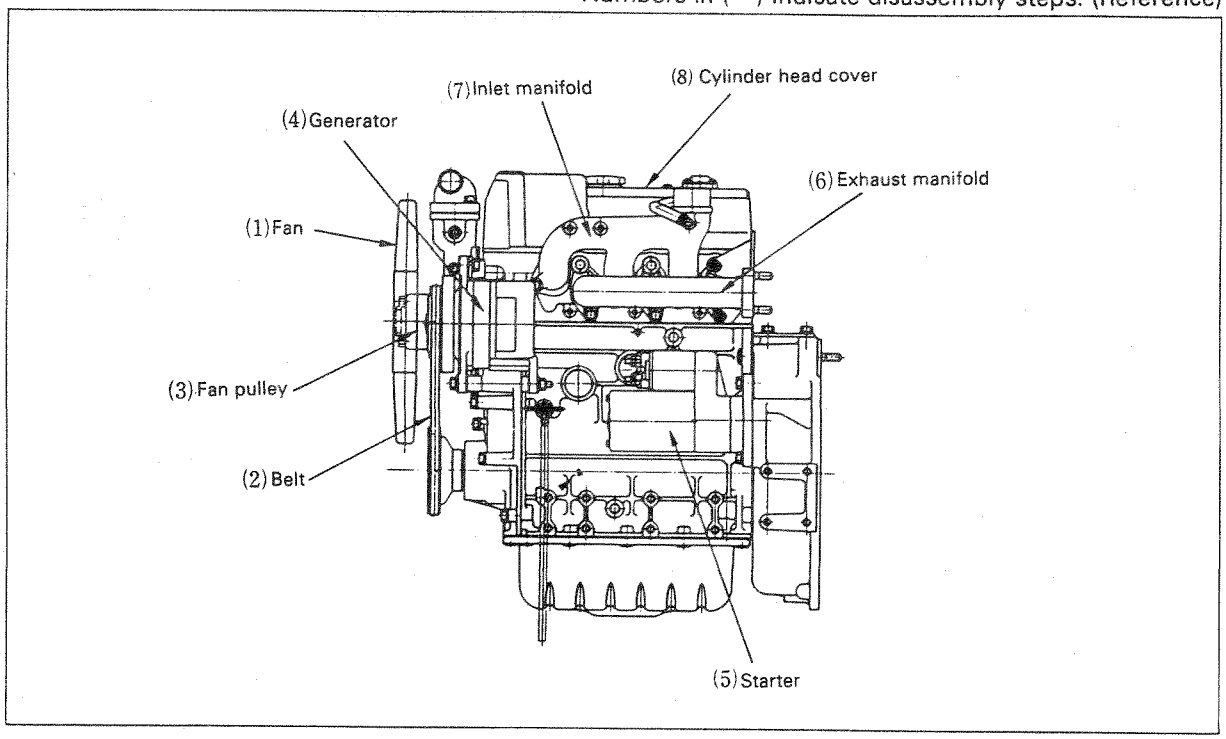
The encircled numbers indicate disassembly steps.

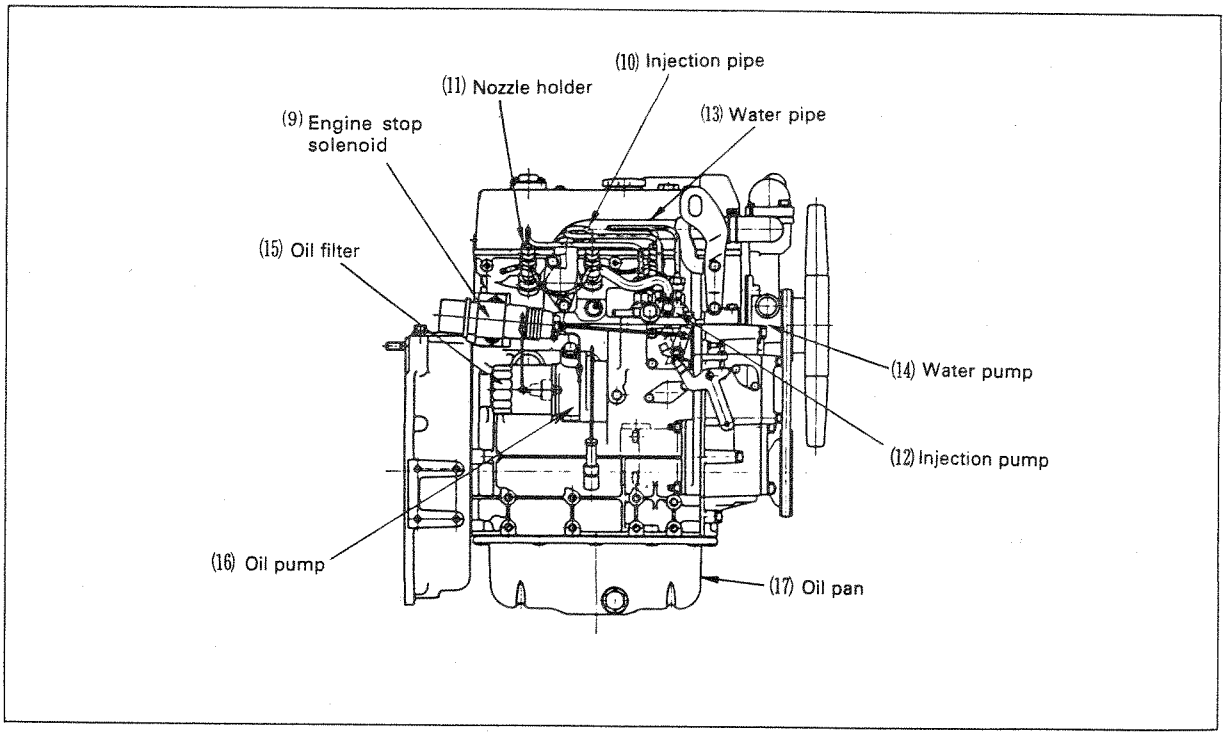
DISASSEMBLY

EXTERNAL PARTS

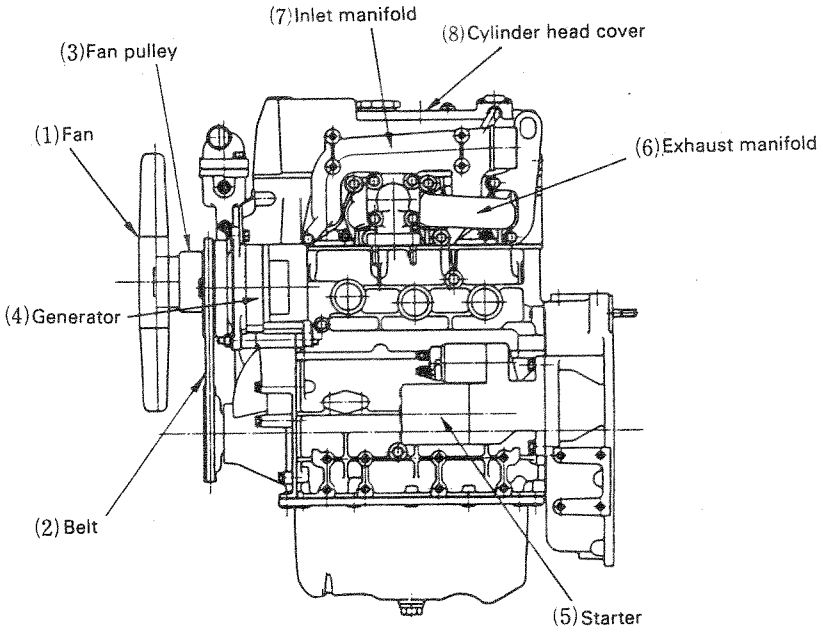
1. 3KC1 model

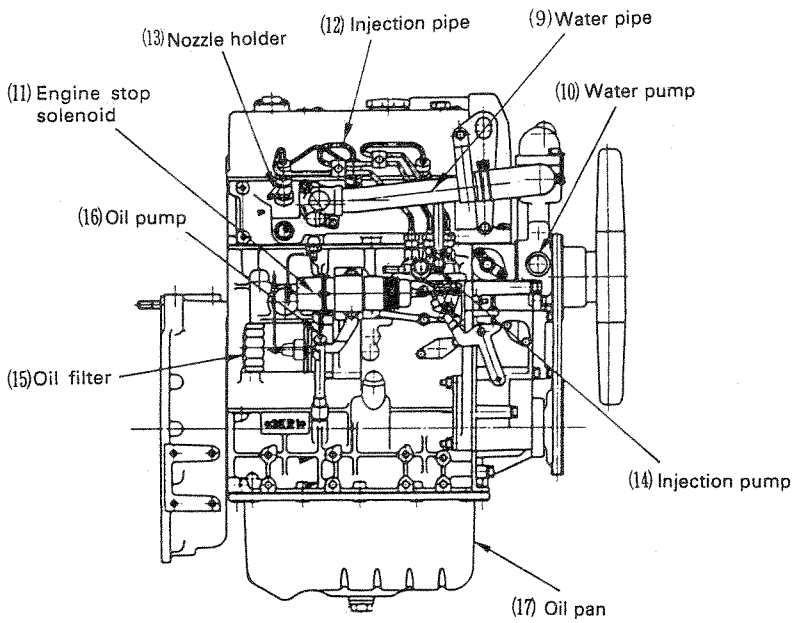
Numbers in ( ) indicate disassembly steps. (Reference)



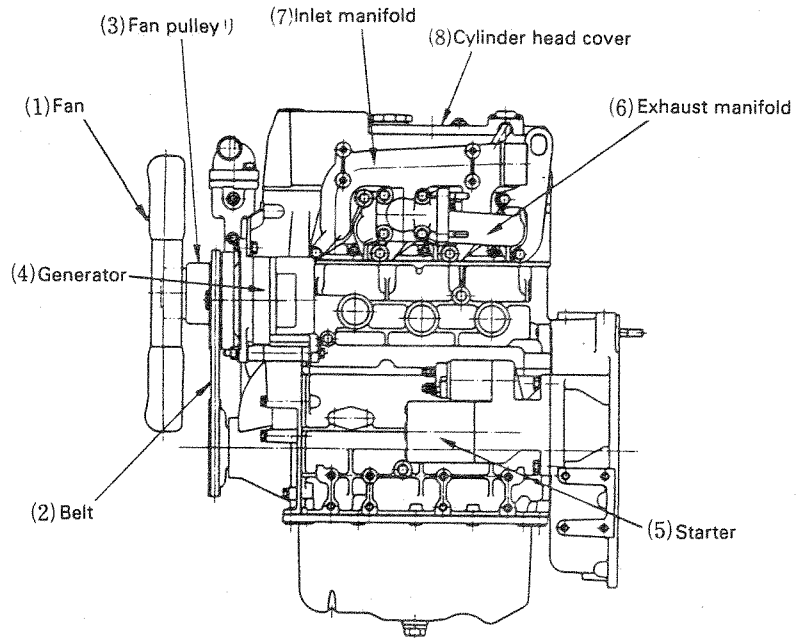


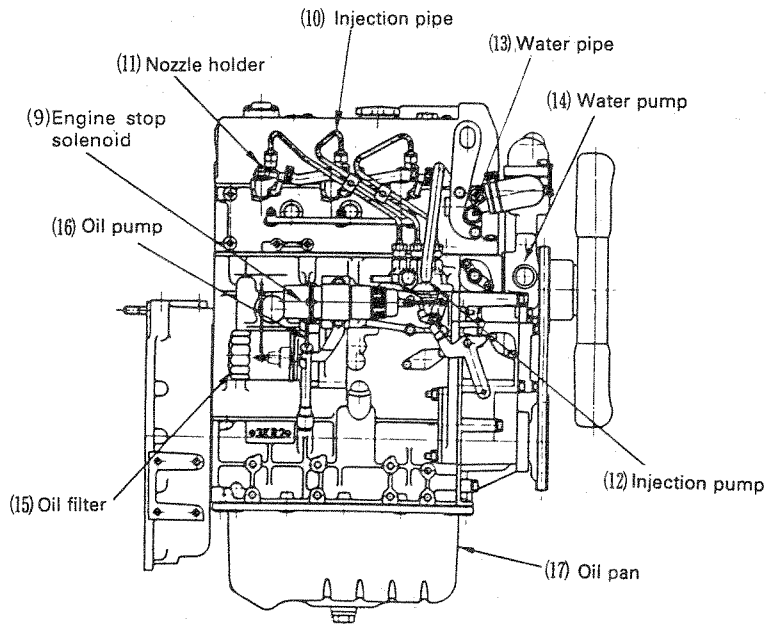
2. 3KR1 model

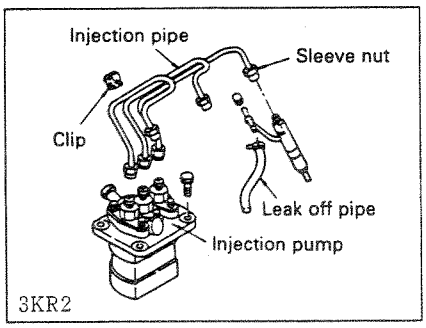

(7) Inlet manifold
(8) Cylinder head cover
(3) Fan pulley
(1) Fan
(6) Exhaust manifold
(4) Generator
(2) Belt
(5) Starter


(13) Nozzle holder
(12) Injection pipe
(9) Water pipe
(11) Engine stop solenoid
(10) Water pump
(16) Oil pump
(15) Oil filter
(14) Injection pump
(17) Oil pan

3. 3KR2 model


(3) Fan pulley
(7) Inlet manifold
(8) Cylinder head cover
(1) Fan
(6) Exhaust manifold
(4) Generator
(2) Belt
(5) Starter

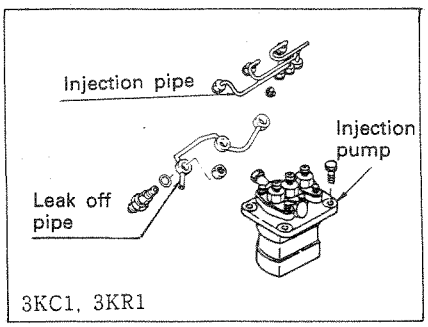

(10) Injection pipe
(13) Water pipe
(11) Nozzle holder
(14) Water pump
(9) Engine stop solenoid
(16) Oil pump
(15) Oil filter
(12) Injection pump
(17) Oil pan



Injection pipe
Leak off pipe
Injection pump

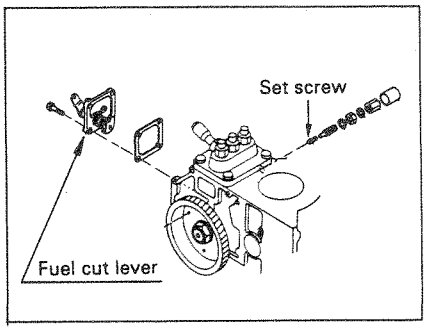
(1) Remove clips.
(2) Loosen sleeve nuts on the nozzle holder side and injection pump side, then disconnect injection pipes.
(3) Disconnect leak off pipes.
(4) Remove the injection pump.

Note 1 : Cap the removed pump to prevent dust from entering the delivery valve holder.
Note 2 : Before removing the pump, disengage a set spring from the link plate.
Note 3 : Hook the removed spring to an oblong hole in the link plate.



Fuel cut lever (3KR1, 3KR2 ..... with solenoid)
Set screw (idle)

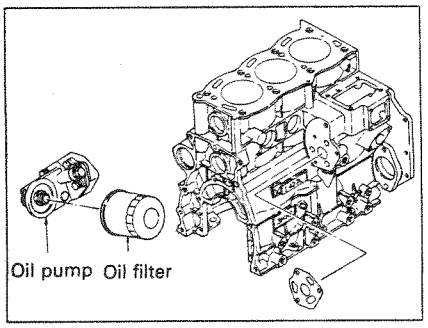
Note 1 : An idle set screw and spring must be removed when the injection pump assembly is installed on the engine. (Otherwise, a spring will fall into the engine.)



Oil filter (cartridge)
Oil pump

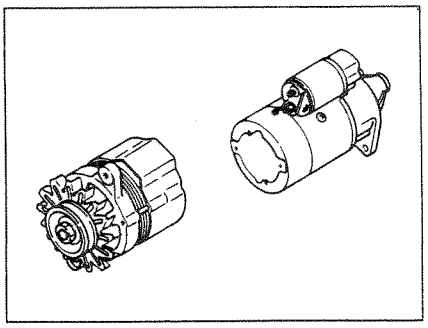
(1) Remove the oil filter. (It is screwed in the oil pump.)
(2) Remove the oil pump.

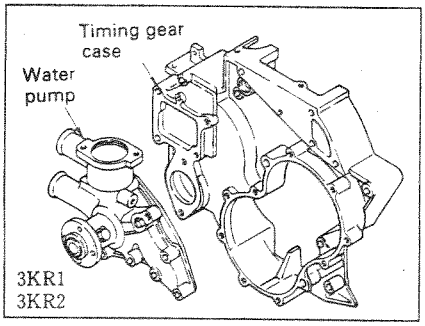
Special tool: 5 - 8840 - 9015 - 0

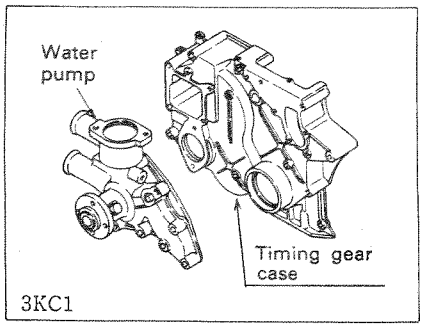


Starter
Generator

(1) Remove the starter from flywheel housing.
(2) Remove the generator along with adjust plate.





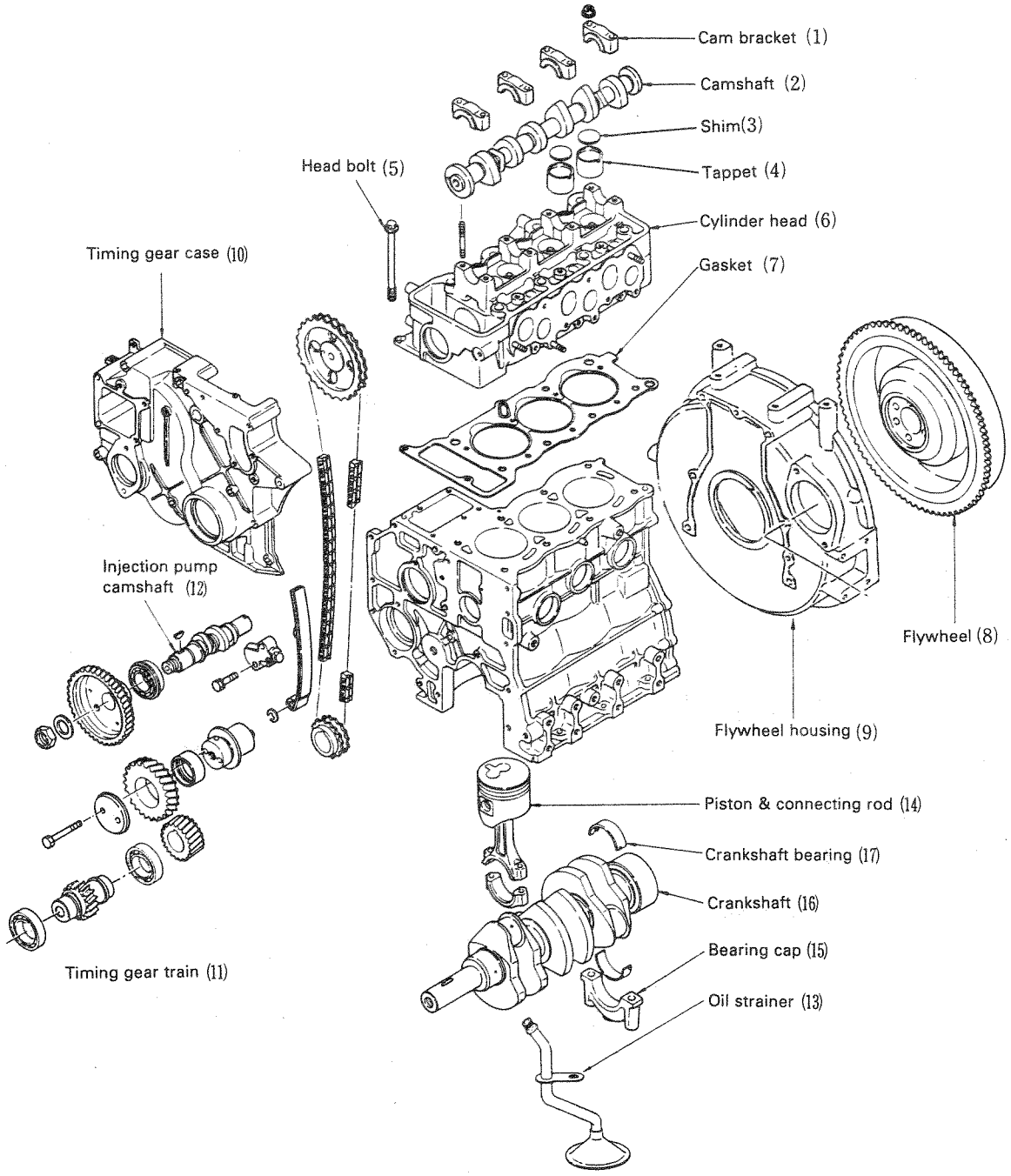


Water pump

Remove the water pump from timing gear case.

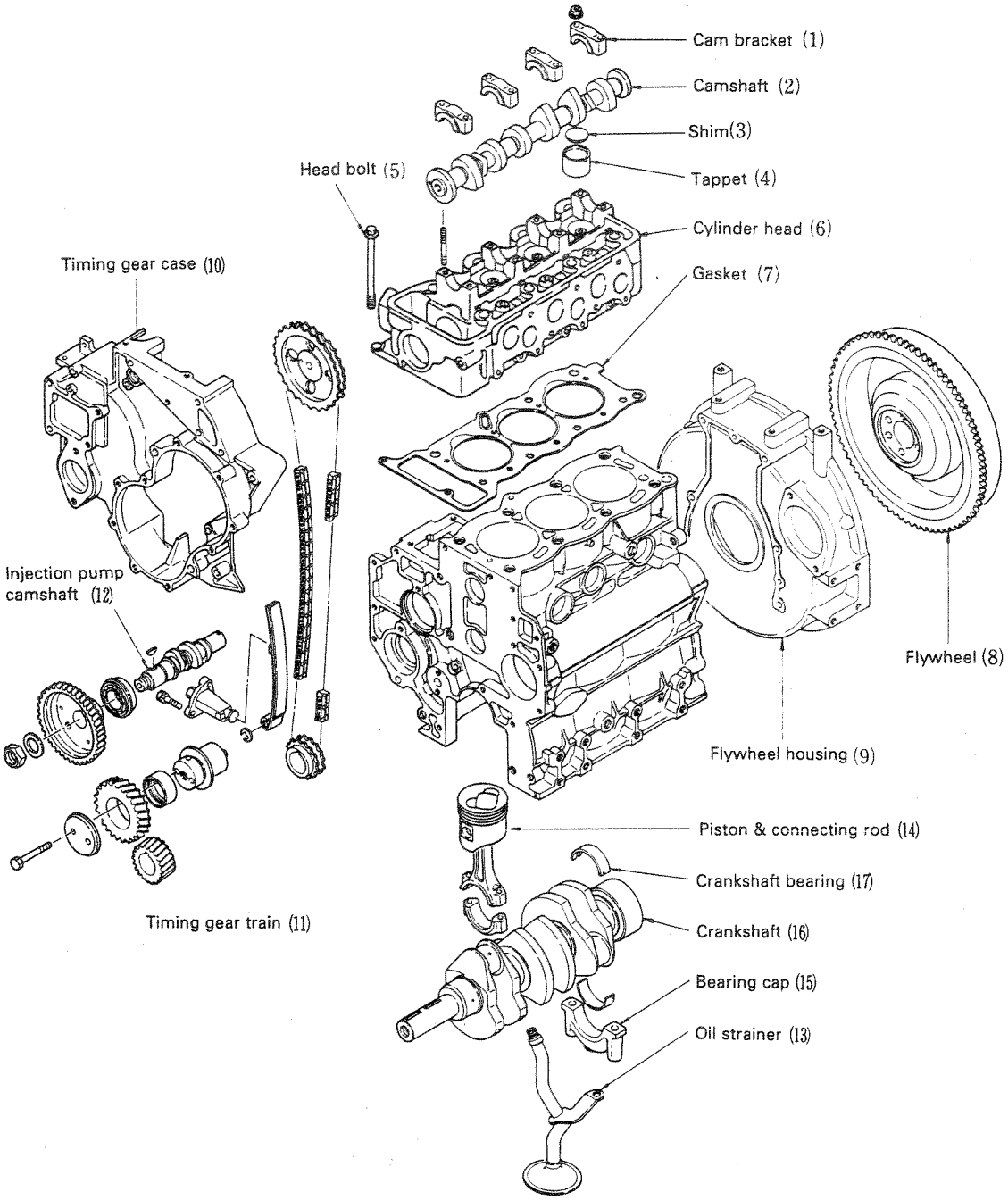
INTERNAL PARTS

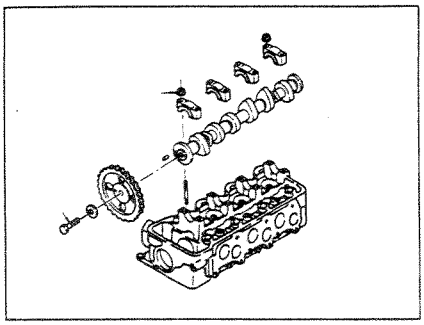
3KC1 model



The numbers in ( ) indicate disassembly steps.

3KR1, 3KR2 models





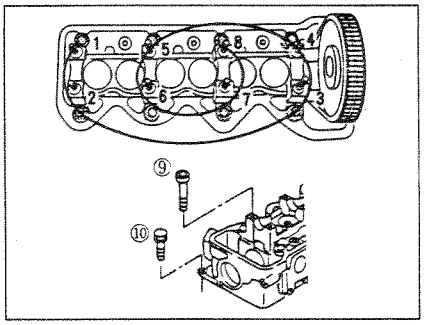
Camshaft

(1) Remove the cam wheel.

(2) Remove the cam bracket lock nuts, then the cam bracket.

(3) Remove the camshaft.

(4) Remove the tappet and shim.
Lock the camshaft to protect the chain from external force.



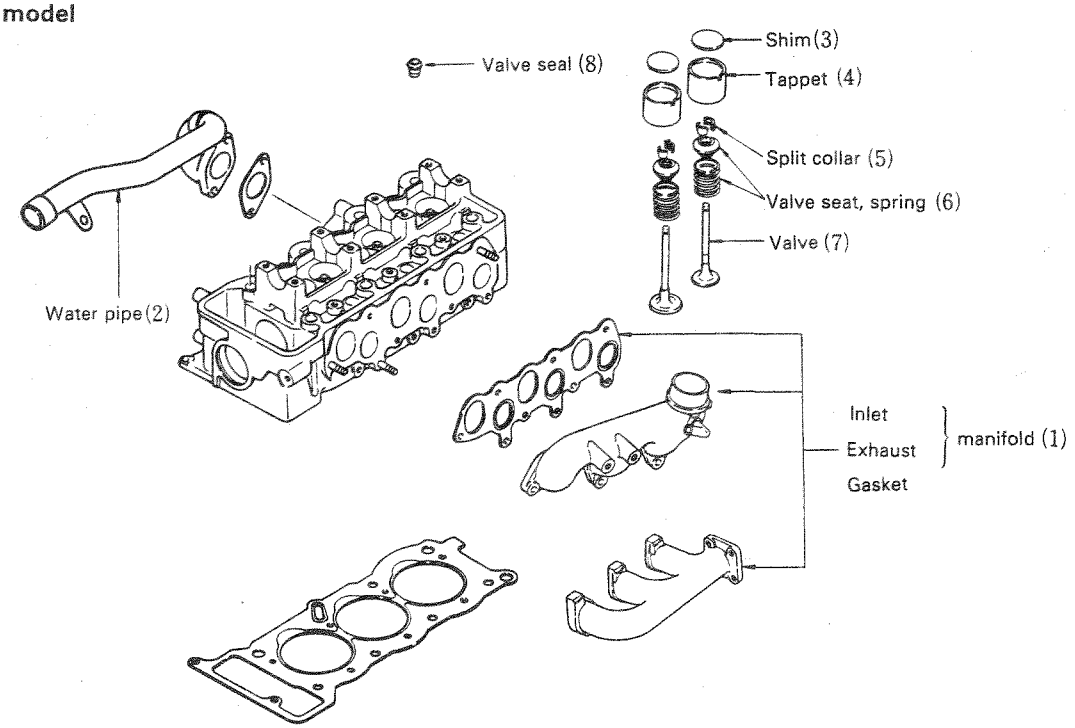
Cylinder head

Loosen slowly the cylinder head bolts a little at a time in the order shown to the left. Remove bolts ⑨ and ⑩ on the timing gear case before removing the cylinder head bolts.

To remove the bolt ⑨, use a Hex wrench key.

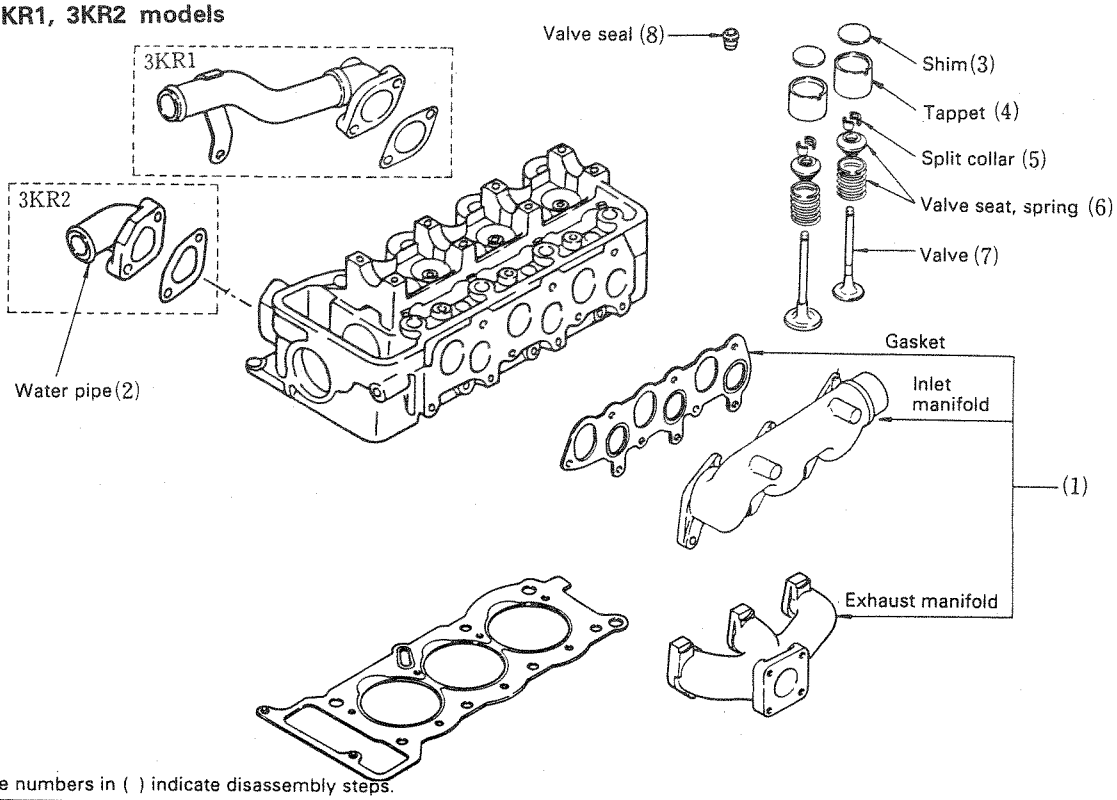
CYLINDER HEAD ASSEMBLY

3KC1 model

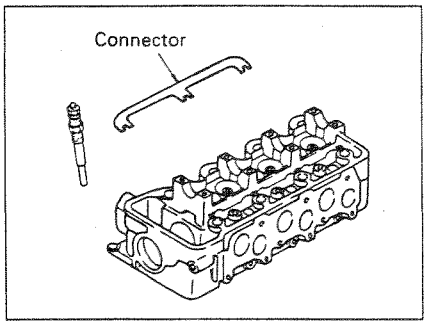


The numbers in ( ) indicate disassembly steps.

3KR1, 3KR2 models

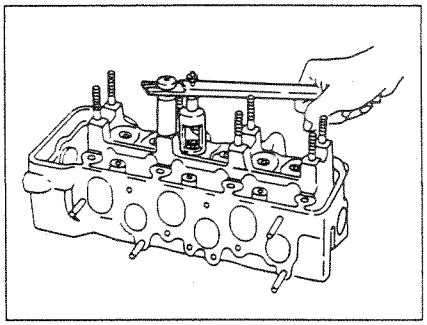


The numbers in ( ) indicate disassembly steps.



Before disassembling the valve assembly, remove the nozzle holder and connector, then glow plug.

In addition, remove the inlet manifold, exhaust manifold (together with gasket) and water pipe.



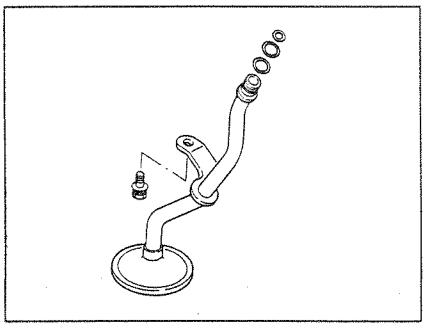
Valve

Valve spring

Compressing the valve spring, remove split collar, spring seat, valve spring and valve.

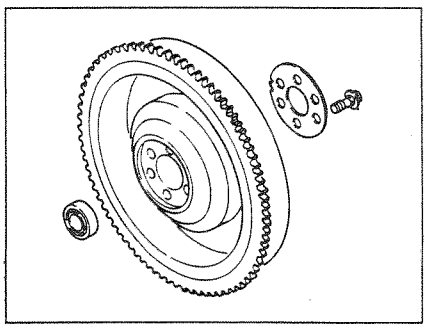
Special tool: Replacer; 5 - 8840 - 9001 - 0

CYLINDER BODY



Oil strainer

Remove the oil strainer clamp bolt on bearing cap, and disconnect a pipe from the cylinder body.



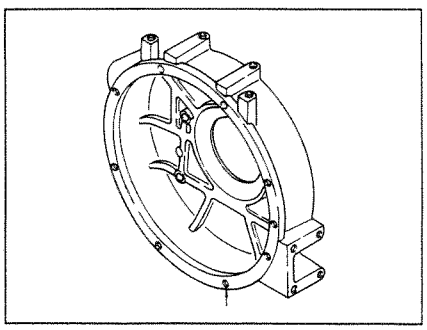
Flywheel

(1) Lock the crankshaft, and remove clamp bolts.

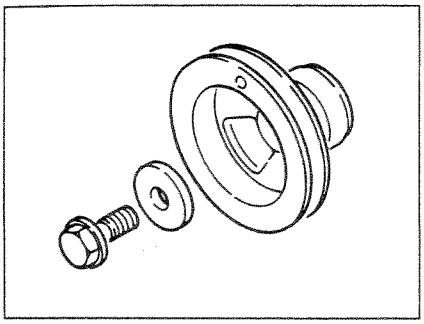
(2) Draw an align mark on the flywheel housing, flywheel and crankshaft since the clamp bolts on flywheel are unevenly spaced.

(3) Remove the flywheel while hitting it lightly with a plastic hammer.

Note:
Do not damage the ring gear.

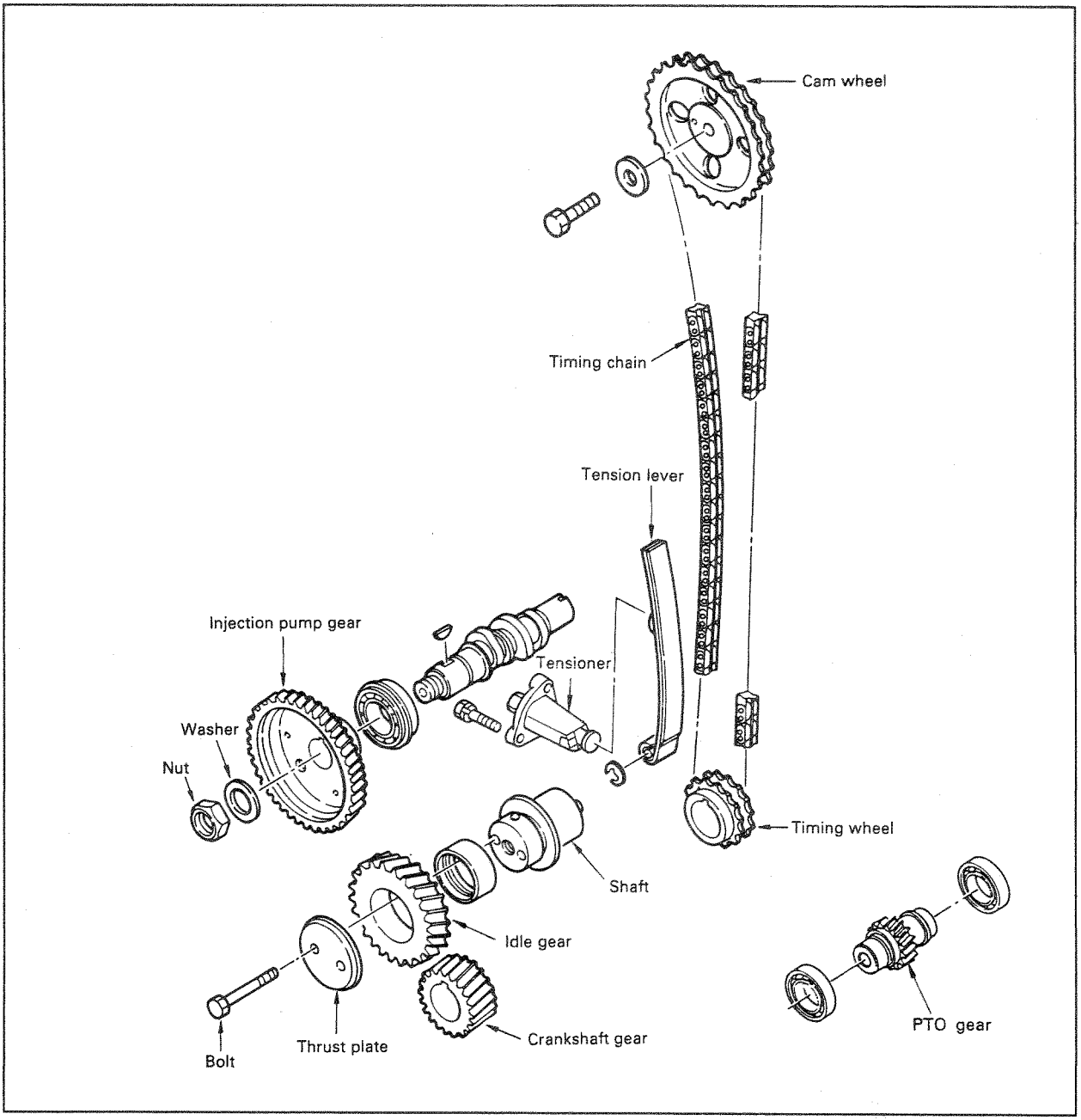


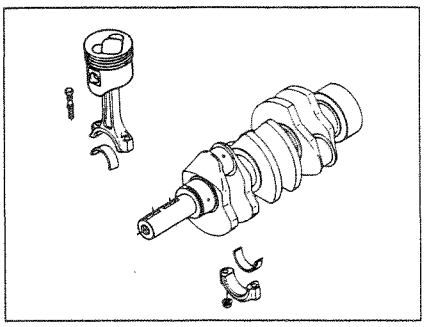
Flywheel housing



Crankshaft pulley

TIMING GEAR TRAIN





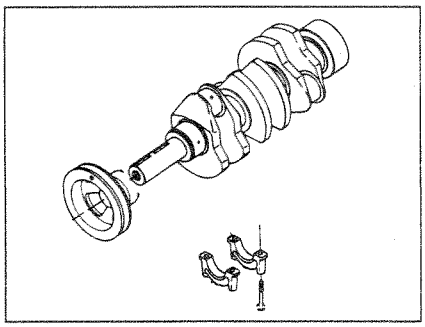
Piston and Connecting Rod Assembly

(1) Loosen a nut on the cap and remove a nut, bolt and cap at the bottom dead center.

(2) Turning the crankshaft, position the piston at the top dead center. Push the piston and connecting rod assembly out of the cylinder body with a hammer stem or bar.

Note:

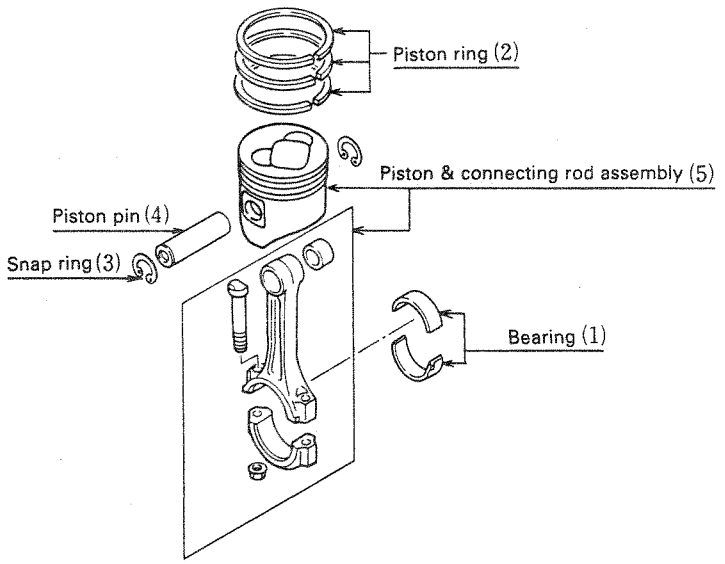
Before removing the piston, scrape the carbon deposit off the cylinder wall.



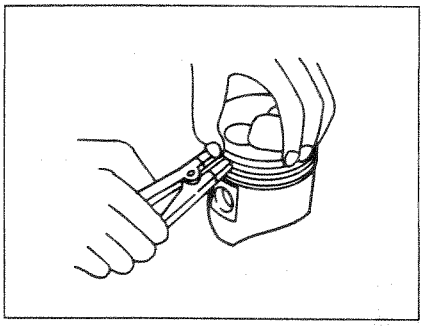
Crankshaft

Remove bolts on the bearing cap, then the crankshaft.

PISTON AND CONNECTING ROD



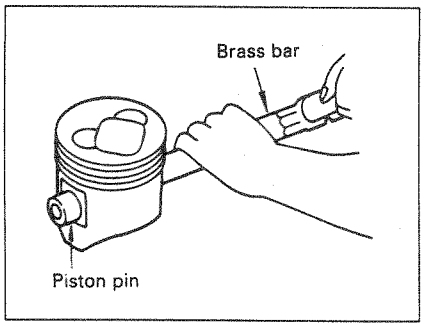
The numbers in ( ) indicate disassembly steps.



Piston ring

Special tool: Piston ring remover

1 - 85221 - 029 - 0



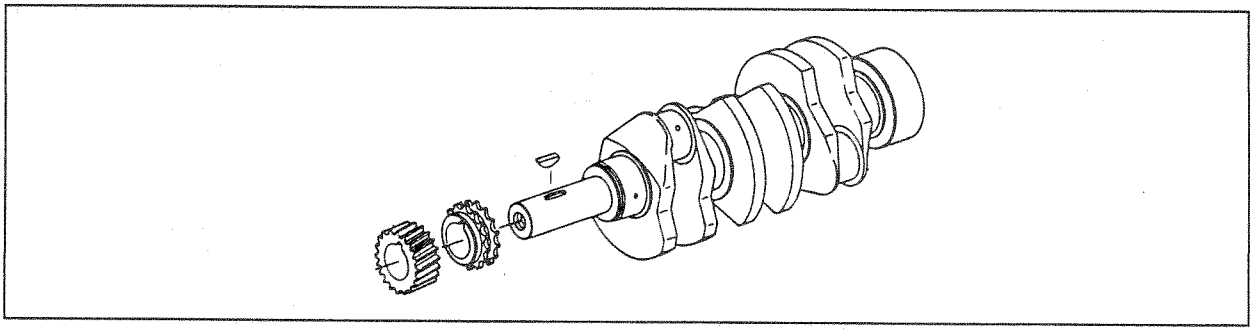
Piston pin

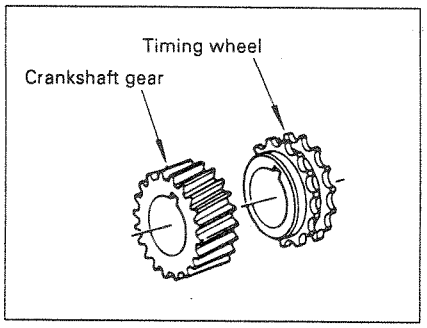
Remove a piston pin by hitting lightly a brass bar on the pin with a hammer.

Note:

Sort pistons, piston pins and connecting rods by cylinder.

CRANKSHAFT



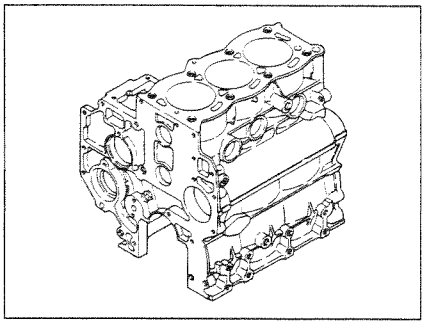


Remove the crankshaft gear and timing wheel.

INSPECTION AND REPAIR

Repair or replace a part if it is worn out or damaged or any other fault is found during inspection.

CYLINDER BODY



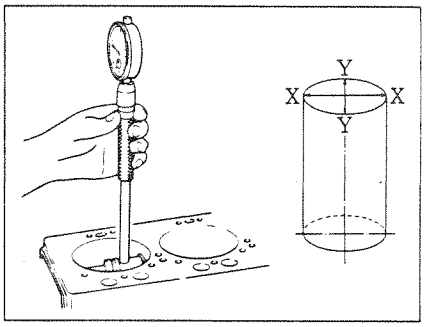
Cylinder body

Crank the cylinder body for wear, damage, leakage or other fault.

(1) Block the water line with a wood plug to check for leakage.

(2) Check for damage using a flaw detective agent.
Leakage: Water pressure test 5 kg/cm^2 (3 minutes)

(3) Check piston cooling jet holes for evidence of clogging.



Cylinder bore

Measurement position: 13 mm below the top (measure in X—X and Y—Y directions).

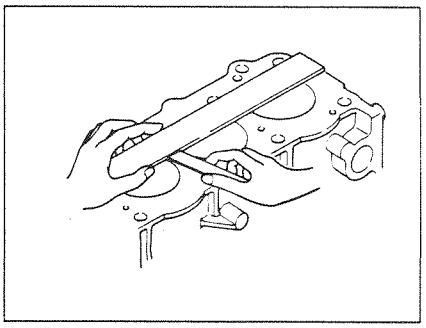
(Near 1st, compression ring)

(mm)

	Value requiring repair	Limit	Repair method
3KC1	0.4 or more	74.50 ϕ	Perform boring and honing of inner diameter meeting the piston.
3KR1	0.2 or more	81.54 ϕ	
3KR2			

Note:

Be sure to perform honing after boring.
The cylinder bore must be finished by honing to 0 — 0.03 of oversize dimension. Also, inner diameter difference between cylinders must be 0.02 or less.

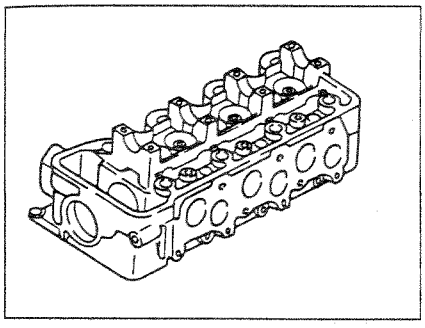


Distortion of top surface

(mm)

Standard	Value requiring repair	Repair method
0.075 or less	0.15 or more	Repair with a grinder within a total ground amount 0.3 of cylinder head and body. In this case, the gasket must be replaced.

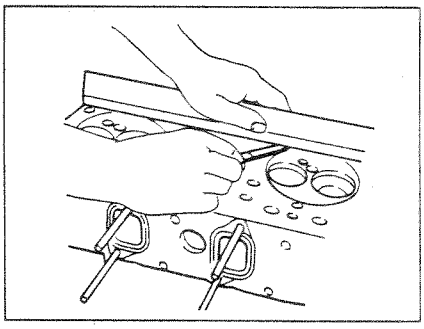
CYLINDER HEAD



Cylinder head

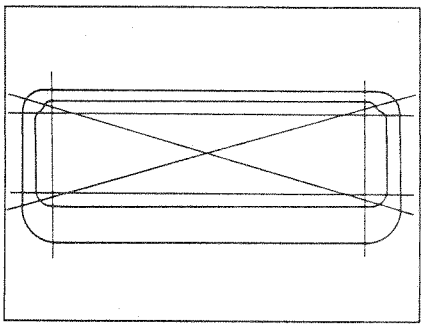
Remove carbon deposit on bottom surface of head with a care not to damage the valve seat. Also, check each part for presence of damage using a flaw detective agent.

Leakage: Water pressure test 5 kg/cm^2 (3 minutes)



Distortion of bottom surface

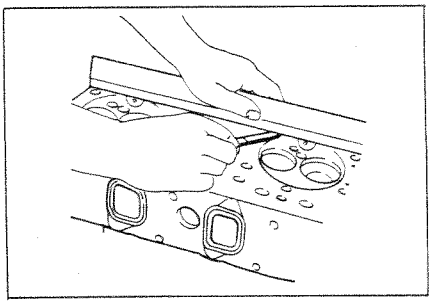
Measure distortion in diagonal directions using a straight edge and thickness gauge.



(mm)

Standard	Value requiring repair	Repair method
0.075 or less	0.15 or more	Repair with a grinder within a total ground amount 0.3 of cylinder head and body. In this case, the gasket must be replaced.

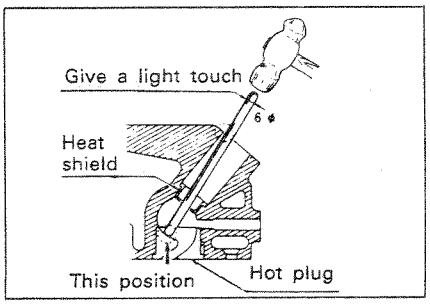
HOT PLUG (3KC1, 3KR1)



Depression of hot plug

Put the linear scale on each hot plug and measure a depression of it. In case the degree is beyond the limit, replace it with new one.

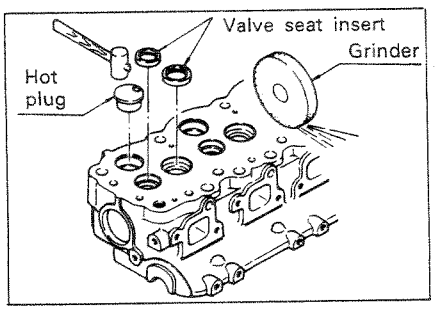
Limit	(mm)	0.05



Hot plug replacement

Insert an appropriate bar with a diameter of 3~5 ϕ to the hot plug through the nozzle of the cylinder head and push it so that the bar runs against the hot plug, then tap it by a hammer slightly to remove off.

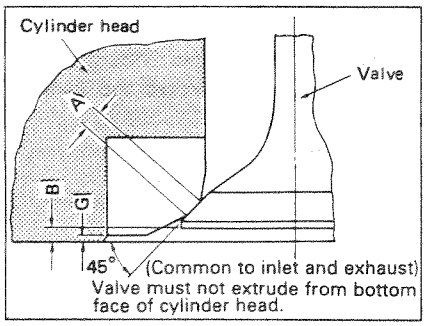
(Note) Mark the cylinder number on the surface of the hot plug in order not to mistake the order.



Installation of new hot plug

(1) Set the knock ball of the hot plug on the positioning groove at the head side and drive it by a plastic hammer slightly until it is fixed securely.
(2) Put an appropriate dolly block having a smooth surface on the hot plug without damaging the surface and push them into the hot plug by means of the press with a pressure of 4,000~5,000kg.
(3) After grinding the surface of the hot plug, be sure the surface is free from any protruding portion.

VALVE, VALVE SEAT INSERT AND VALVE SEAL



Valve seat

(1) Contact width: Inspection A

(2) Sink amount: Inspection B

(mm)

	Standard	Limit	Repair method
Contact width: A	1.75	2.5	Repair or replace valve and insert.
Sink amount: B	3.2	3.7	
G	0.7	1.4	

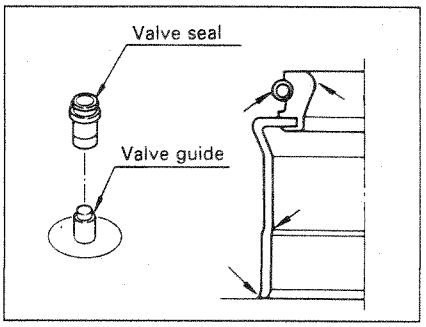
Valve seat insert

Press in the insert using a soft plate with a care not to damage the insert surface. (4000 kg)

Notes in removing valve seat insert

(1) Heat the inside of valve seat insert at diagonal two places using a gas burner. (700 — 800°C)

(2) Allow it in the air for 3 to 5 minutes to cool, then remove the insert by hitting lightly the cylinder head with a care not to damage the cylinder head.



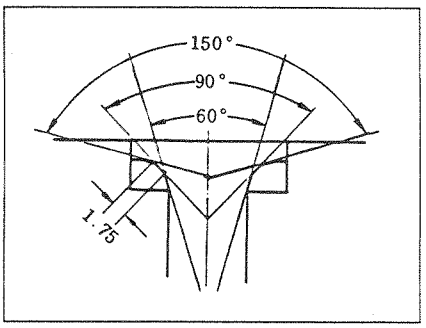
Valve seal

Note 1: Press in the seal until it gets stuck against the top face of cylinder head.

Note 2: Apply oil to the outer surface of valve guide when pressing in the seal.

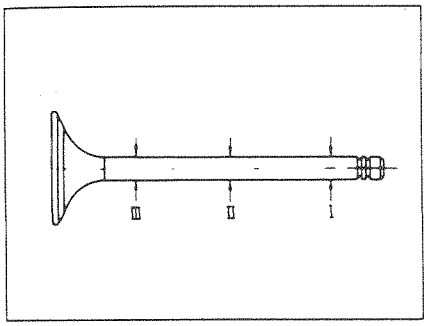
Note 3: Take care not to damage the lip portion of seal.

Note 4: Make sure that a spring does not drop off after pressing in the seal.



Repair of valve seat

Remove carbon on the valve seat surface, then cut the seat surface to eliminate nick and void with a seat cutter (60°, 90°, 150°) so that the contact width becomes standard value (1.75).

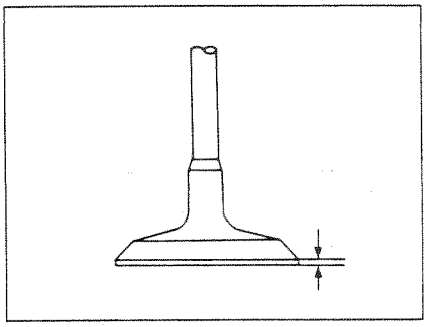


Wear of valve stem

Repair the valve stem if it is stepped a little using an oil stone.

(mm)

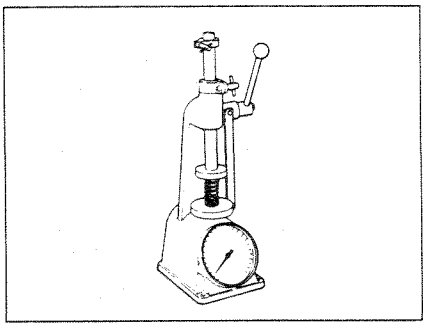
	Nominal	Limit	Repair method
Inlet	7ϕ	6.85ϕ	Replace
Exhaust	7ϕ	6.80ϕ	



Valve thickness

(mm)

Nominal	Limit	Repair method
1.0	0.7	Replace

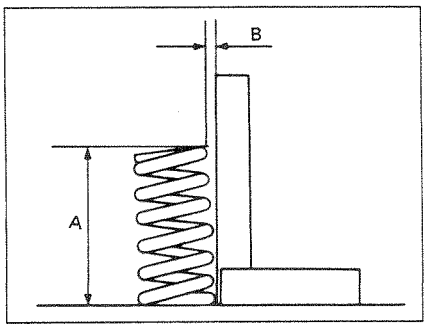


Valve spring force (tension)

Read the spring tester when compressing the spring to the specified dimension.

(kg)

	Standard	Limit	Repair method
Compressed to 34.7 mm	21.3	18.0	Replace



Measurement of free height and squareness

(1) Free height (free length); A

(mm)

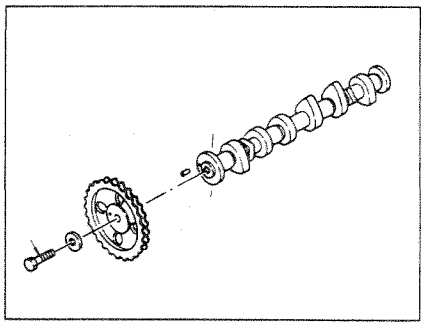
Standard	Limit	Repair method
45.45	44.0	Replace

(2) Squareness; B

(mm)

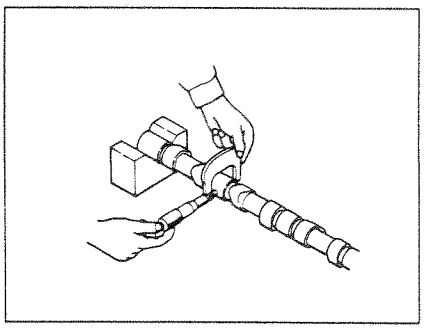
Standard	Limit	Repair method
2.0 or less	2.4 or more	Replace

CAMSHAFT



Inspection of camshaft

Check the journal and cam for evidence of wear, damage or any other defect.

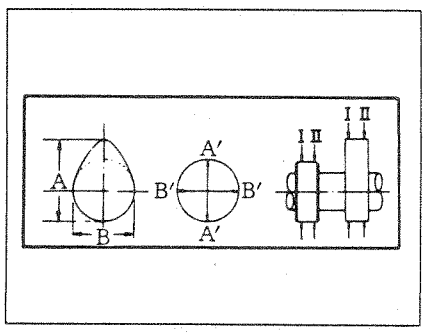


Measurement of journal and cam

(1) Cam height (A—B)

(mm)

		Nominal	Limit	Repair method
Inlet	3KC1	7.75	7.25	Replace
	3KR1			
	3KR2	8.68	8.15	
Exhaust	Common	8.68	8.15	Replace



(2) Journal diameter

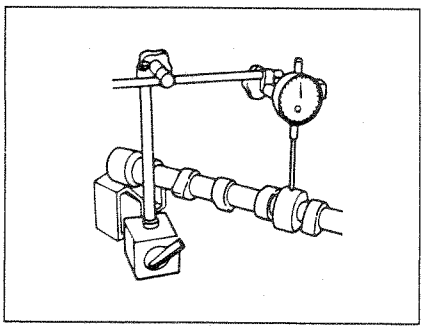
(mm)

Nominal	Limit	Repair method
26ϕ	25.86ϕ	Replace

(3) Uneven wear of journal

(mm)

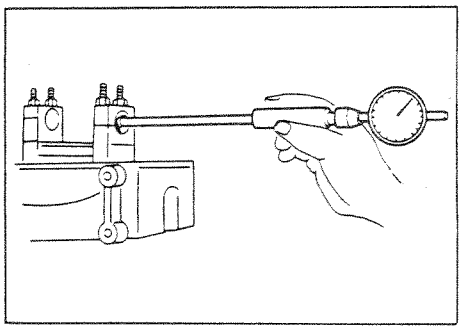
Nominal	Limit	Repair method
26ϕ	0.05 or more	Replace



Runout of camshaft

(mm)

Standard	Limit	Repair method
0.02	0.1 or more	Replace

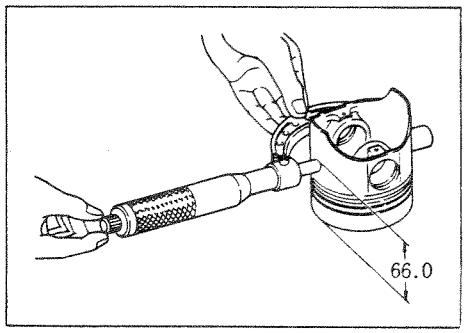


Clearance between cam journal and cam bracket

(mm)

Standard	Limit	Repair method
0.04 — 0.082	0.12 or more	Replace camshaft or cylinder head

PISTON, PISTON PIN AND PISTON RING



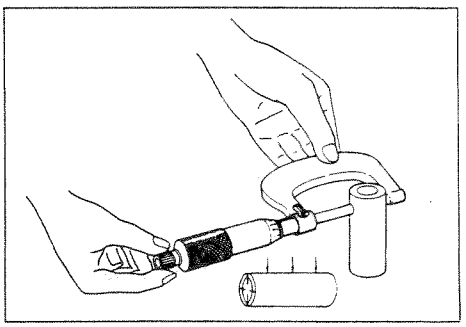
Clearance between piston and cylinder bore

(1) Measure piston at 66.0 mm from top in right angle direction to the piston pin (in the unit of 1/1,000 mm).

(mm)

Clearance against large diameter	0.032 — 0.050

(2) There are two kinds of oversize (0.25, 0.50) allowable for piston.



Wear of piston pin (outside diameter)

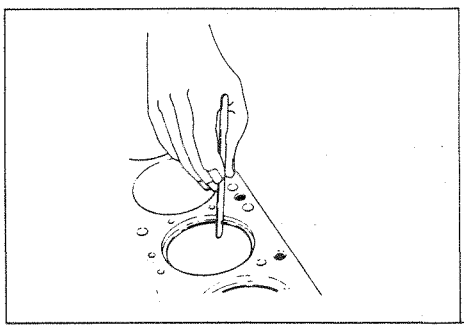
(mm)

	Nominal	Limit	Repair method
3KC1	21 ϕ	—	Replace if disassembled
3KR1	25 ϕ	24.97 ϕ	Replace
3KR2			

Clearance between piston pin and piston

(mm)

3KC1	0.016~0.020
3KR1, 3KR2	0.002~0.012

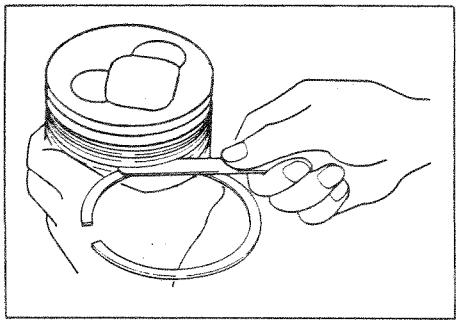


Piston ring gap

Insert the ring into a cylinder bore and push it with piston head so that it is right angle to the cylinder.

(mm)

	Standard	Limit	Repair method
1st and 2nd compression rings	0.2 — 0.4	2.0	Replace
Oil ring	0.2 — 0.4	1.0	



Clearance between piston ring groove and ring

Measure clearance at several places circumferentially.

(1) 3KC1

(mm)

		Standard	Limit	Repair method
Compression ring	1st	0.045–0.085	0.3	Replace ring or piston.
	2nd	0.030–0.070		
Oil ring		0.020–0.060	0.15	

(2) 3KR1, 3KR2

(mm)

		Standard	Limit	Repair method
Compression ring	1st	0.070–0.110	0.3	Replace ring or piston.
	2nd	0.050–0.090		
Oil ring		0.030–0.070	0.15	

Piston ring tension

(1) 3KC1

(kg)

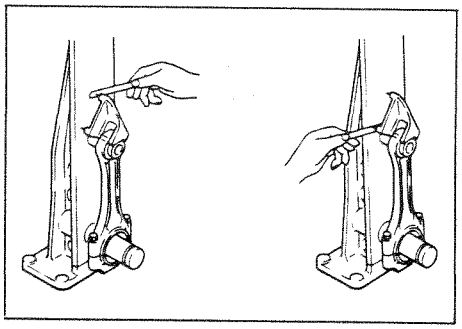
		Standard	Limit	Repair method
Compression ring	1st	0.84–1.26	0.4	Replace
	2nd	0.62–0.98	0.3	
Oil ring		2.05–3.85	0.6	

(2) 3KR1, 3KR2

(kg)

		Standard	Limit	Repair method
Compression ring	1st	0.98–1.42	0.6	Replace
	2nd	0.84–1.26	0.6	
Oil ring		2.60–4.40	1.8	

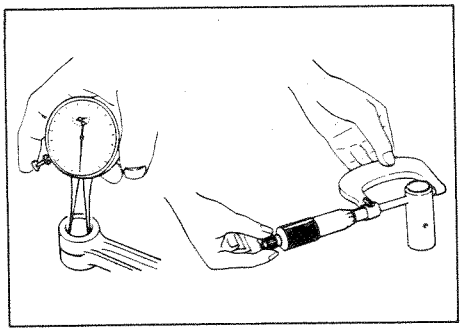
CONNECTING ROD AND CONNECTING ROD BEARING



Torsion and parallelism of connecting rod

(mm)

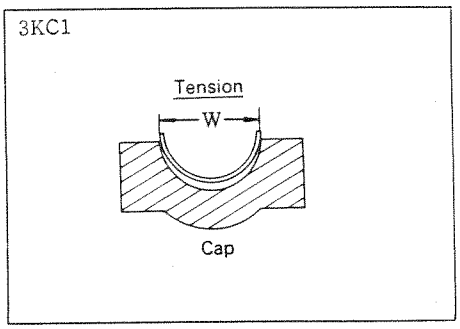
	Standard	Limit	Repair method
Torsion (per 100 mm)	0.05	0.2 or more	Repair or replace
Parallelism (per 100 mm)	0.05	0.15 or more	



Clearance between small end pin hole and piston pin

(mm)

	Standard
3KC1	0.020~0.041
3KR1, 3KR2	0.008~0.020

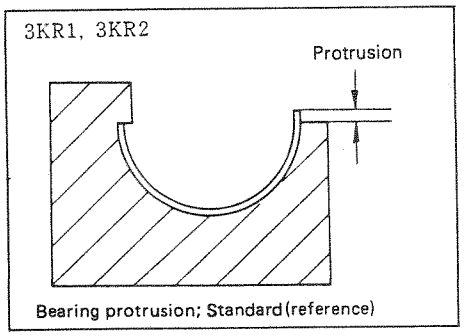


Protrusion of connecting rod bearing

Check that the bearing protrudes properly.

(1) 3KC1 (mm)

Standard	Limit	Repair method
W=46.9~47.7	W=46.3	Use a protruded and tensioned bearing and make its back fit closely to the connecting rod.



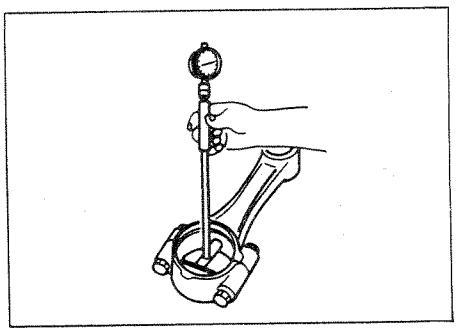
(2) 3KR1, 3KR2 (mm)

Standard	Repair method
0.040 — 0.080	Use a protruded and tensioned bearing and make its back fit closely to the connecting rod.

Installation of bearing cap

(kg·m)

Torque	3KC1	4.0
	3KR1	7.5~8.5
	3KR2	

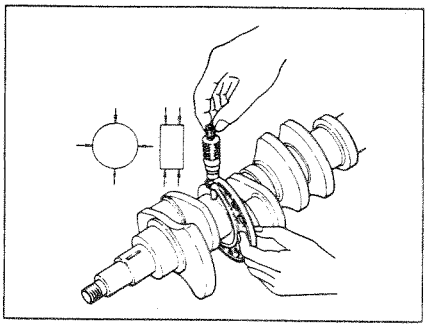


Clearance between bearing and crank pin

(mm)

Standard	Limit	Repair method
0.035 — 0.073	0.12 or more	Replace bearing

CRANKSHAFT AND CRANKSHAFT BEARING



Outside diameter of journal and pin

(1) Nominal

(mm)

	Journal	Pin
3KC1	52 ϕ	43 ϕ
3KR1	60 ϕ	49 ϕ
3KR2		

(2) Uneven wear

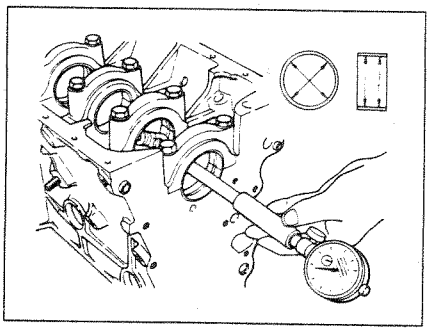
(mm)

	Limit	Repair method
Journal	0.05	Replace crankshaft
Pin		

(3) Wear

(mm)

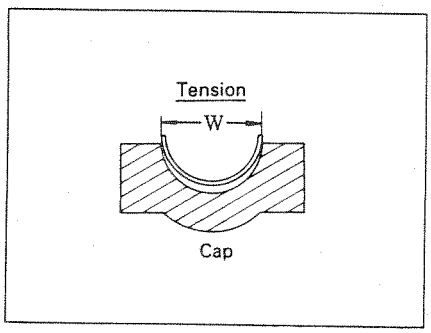
	Limit	Repair method
Journal	0.14	Replace crankshaft
Pin	0.13	



Clearance between journal and bearing

(mm)

Standard	Limit	Repair method
0.029 — 0.072	0.12	Replace bearing



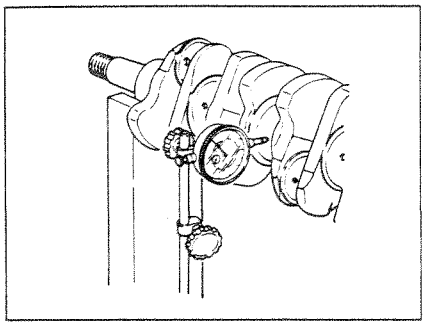
Tension of main bearing

Check that the bearing is tensioned properly.

(mm)

	Standard	Limit
3KC1	W=46.9~47.7	W=46.3
3KR1	W=64.7~65.5	—
3KR2		

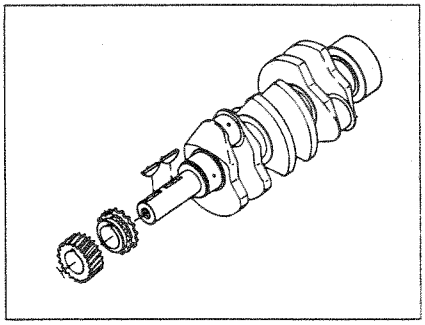
Repair method: Use a protruded and tensioned bearing and make its back fit closely to the connecting rod.



Runout of crankshaft

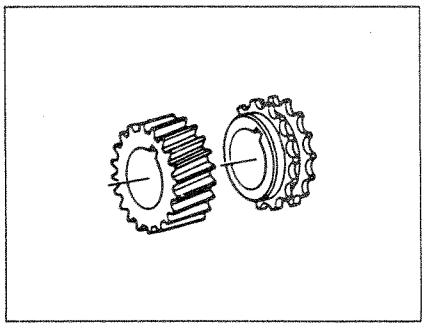
(mm)

Standard	Limit	Repair method
0.025	0.05 or more	Replace

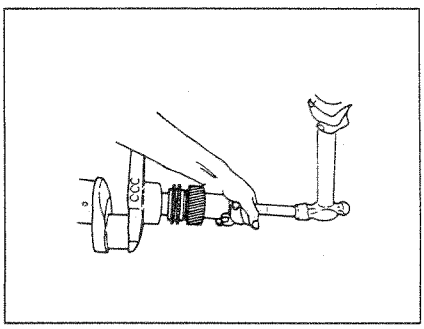


Crankshaft gear and timing wheel

Visual check for damage or other defect
Replace if damage or extreme pitting is found.

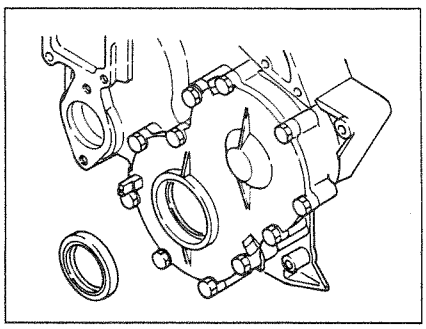


Crankshaft gear and timing wheel



Crankshaft gear and timing wheel

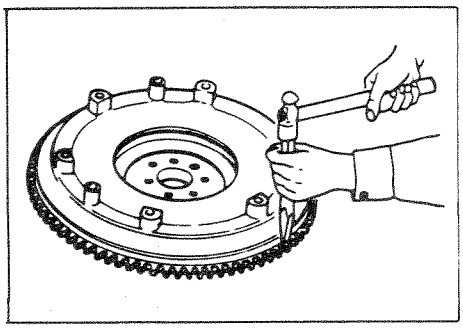
Install the timing wheel onto the crankshaft by hitting a brass bar on the wheel with a hammer.



Oil seal

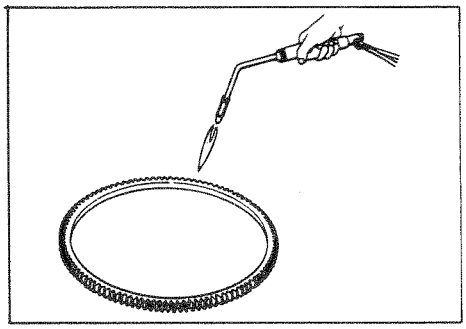
Replace an oil seal with new one if oil seal lip is defective.

Special tool: 5 - 8840 - 9003 - 0
5 - 8840 - 0007 - 0



Removal of ring gear

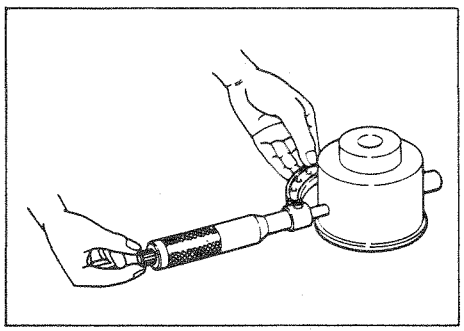
Remove the ring gear by hitting a brass bar on the gear with a hammer.



Installation of ring gear

Install the ring gear by heating it with a gas burner, then hitting it with a hammer.

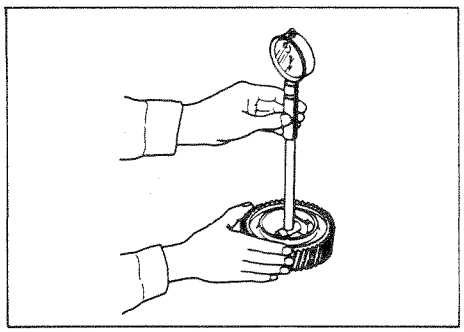
TIMING GEAR, TIMING GEAR CASE AND OTHERS



Uneven wear of idle gear shaft

(mm)

Nominal	Limit	Repair method
45ϕ	0.1 or more	Replace



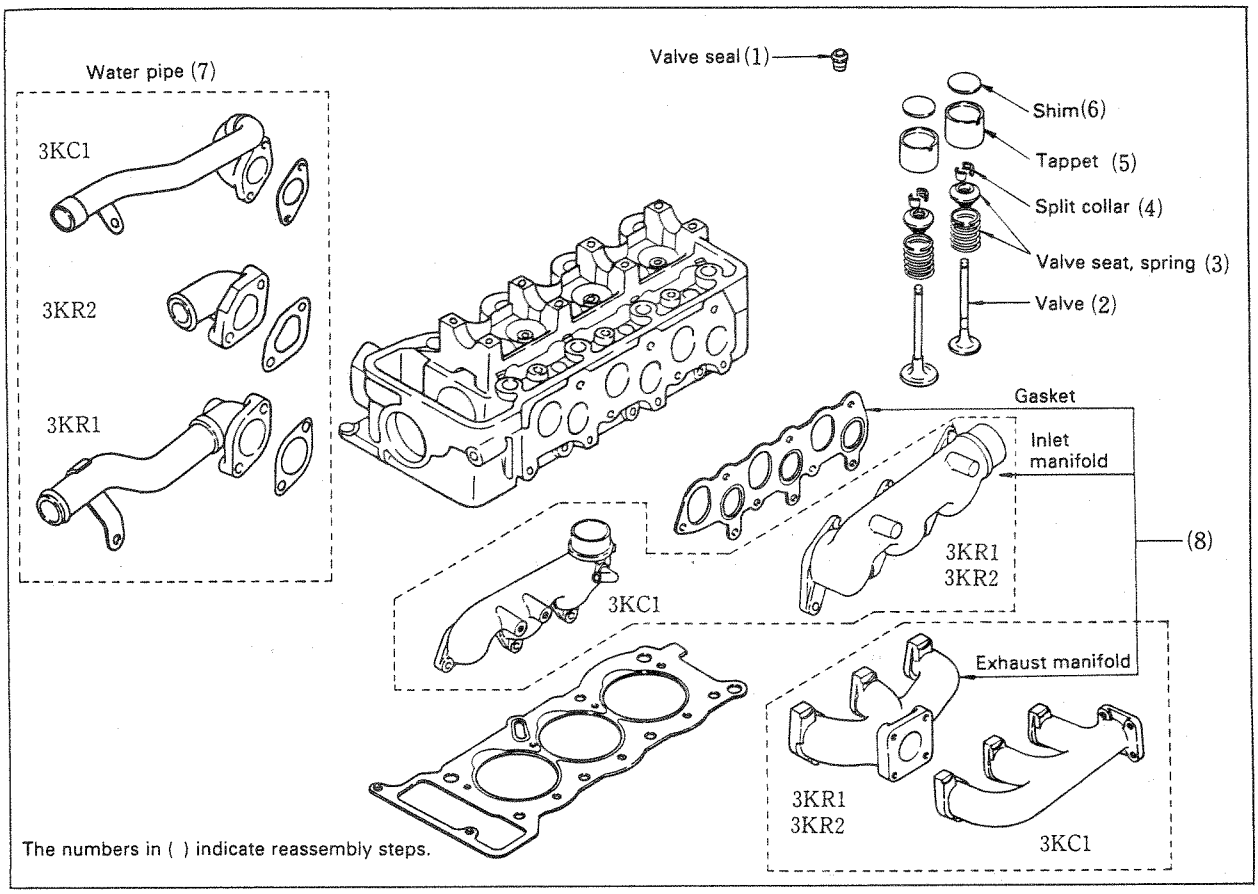
Clearance between idle gear bushing and shaft

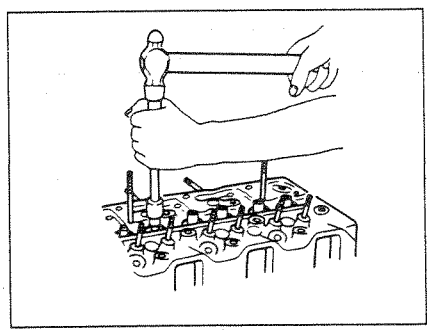
(mm)

Standard	Limit	Repair method
0.025 — 0.085	0.2 or more	Replace bushing or shaft

REASSEMBLY

CYLINDER HEAD ASSEMBLY





Valve seal

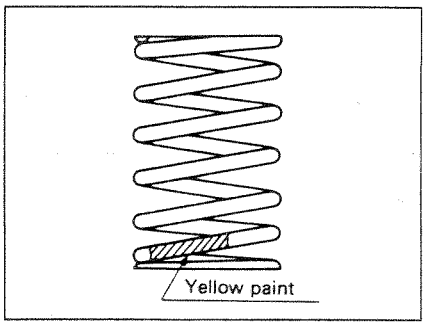
Apply engine oil to outer surface of valve guide when the valve seal is pressed in.

Special tool: 5 - 8840 - 9007 - 0

Note 1: Press in the seal until it gets stuck against the top surface of head.

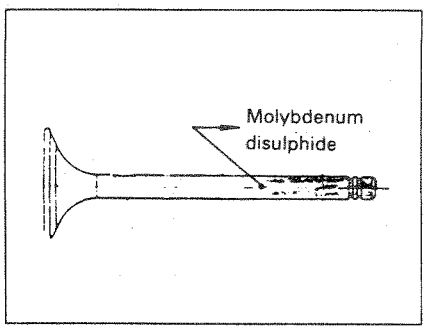
Note 2: Take care not to damage the seal lip.

Note 3: After pressing in the seal, confirm that sleeve is attached.



Spring seat, spring

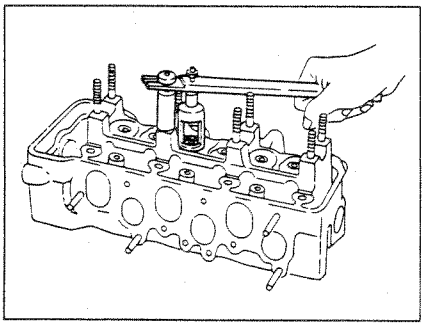
Install the spring with smaller pitch (yellow paint side) faced down.



Valve

(1) Apply a mixture of oil and molybdenum disulfide to the valve stem.
Engine oil : Molybdenum = 1 : 1

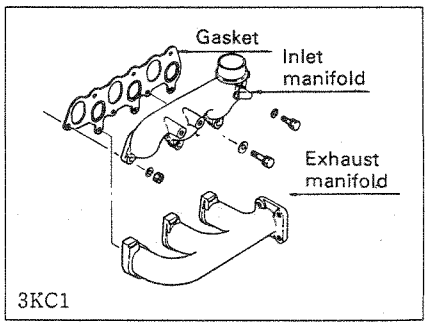
(2) After installing the valve, prevent the valve from dropping off and form being damaged.



Split collar

Special tool: 5 - 8840 - 9001 - 0

Insert the collar by compressing a spring with the replacer.



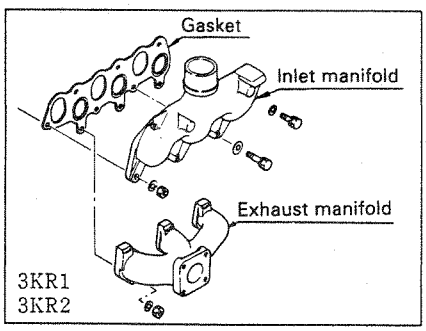
Inlet manifold

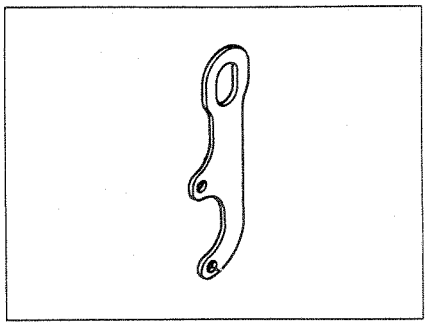
Exhaust manifold

Gasket

(kg·m)

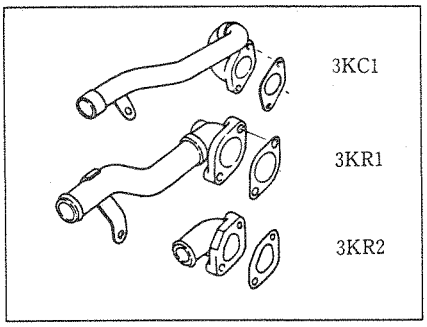
Torque	1.5 — 2.5





Rear hanger

Tighten the rear hanger together with the manifold.



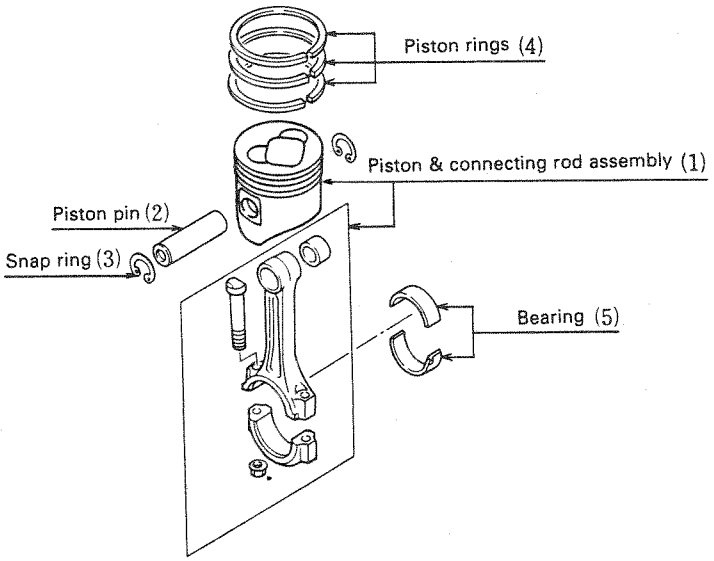
Water pipe

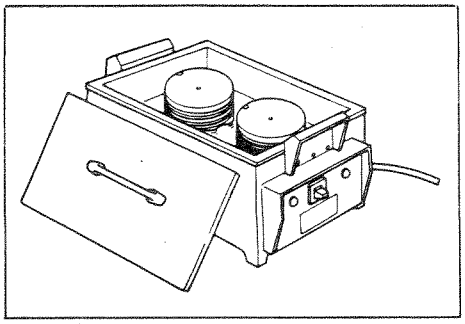
(kg·m)

Torque	1.5 – 2.5

PISTON AND CONNECTING ROD

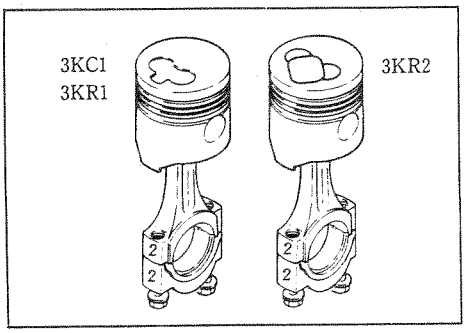
The numbers in ( ) indicate reassembly steps.



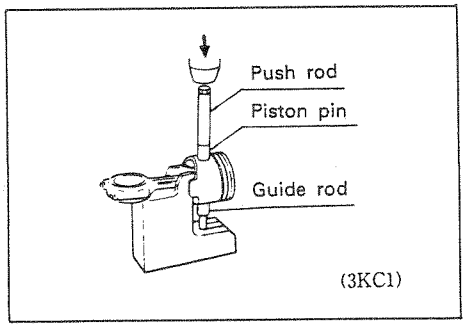


Reassembly of piston and connecting rod

Warm the piston to about 100°C with the piston heater.



Press in a piston pin with cylinder number on connecting rod in combustion chamber direction.

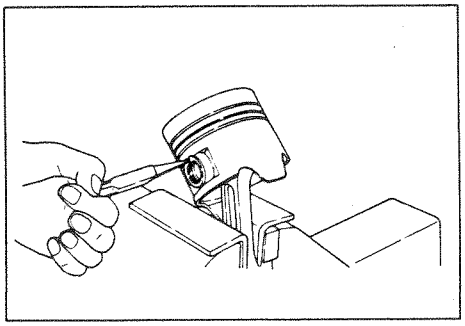


Press in a piston pin by the press machine (3KC1).

Special tool: 5-8840-9002-0

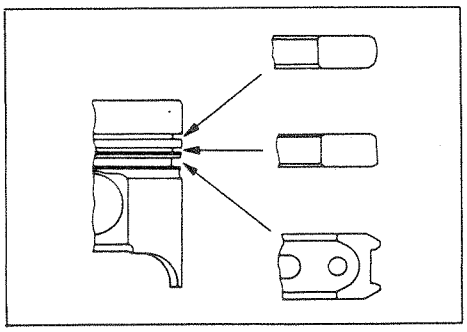
Note 1: Apply engine oil to the piston pin hole when the piston pin is pressed in.

Note 2: After pressed in, make sure all of the pistons are in good oscillating condition. The piston which is not in good condition should be prohibited to use.



Snap ring

Insert a snap ring to lock the piston pin.



Piston ring

Insert 1st and 2nd piston rings and coil expander to re-assemble the oil ring.

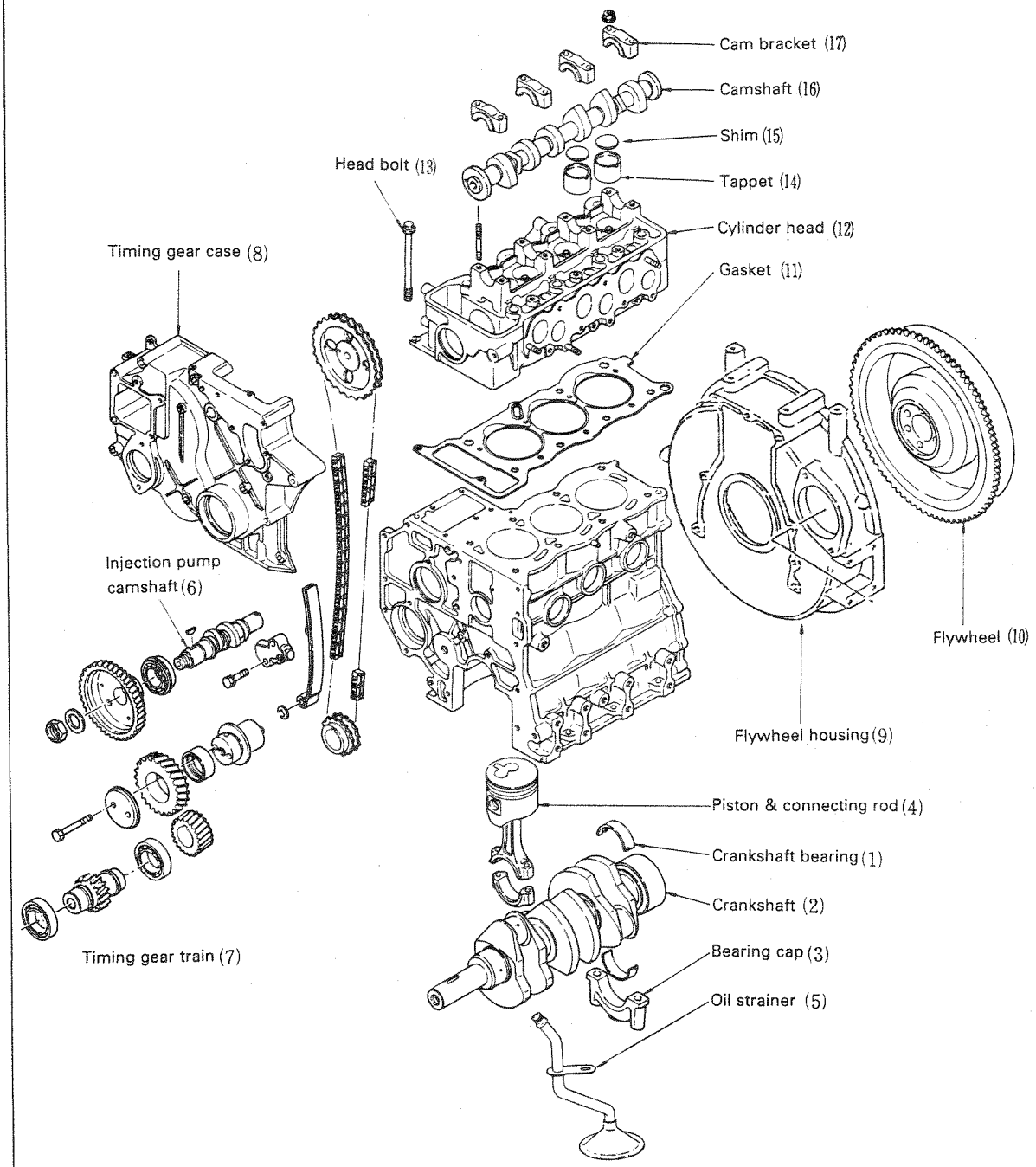
Note 1: Marking N or IN on the piston ring must be on up side.

Note 2: Both piston ring gaps must be staggered by 180°.

Note 3: No gap is allowed in the joint part of coil expander.

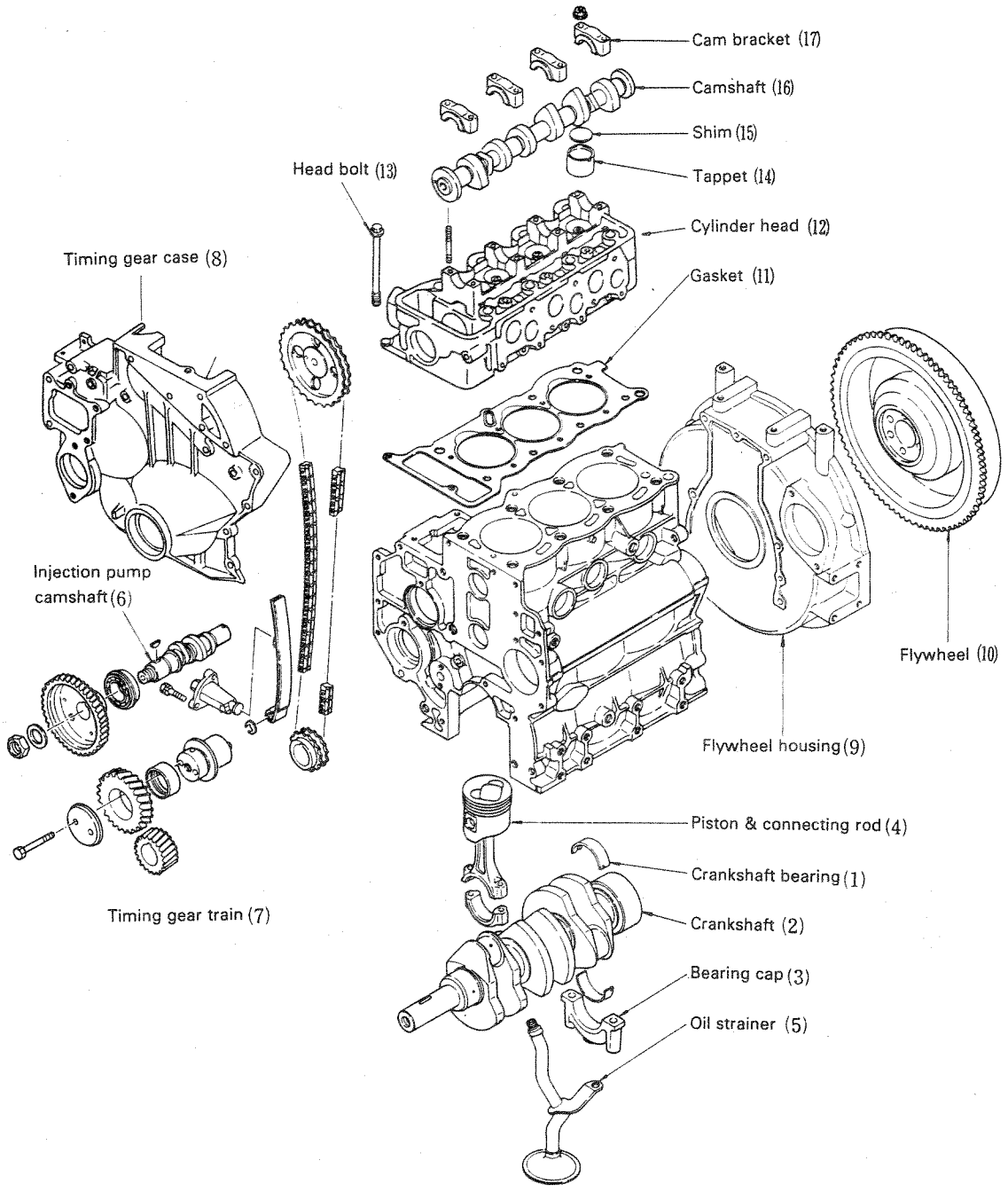
INTERNAL PARTS

3KC1 model

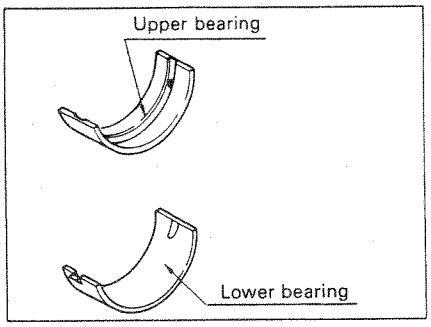


The numbers in ( ) indicate reassembly steps.

3KR1, 3KR2 models

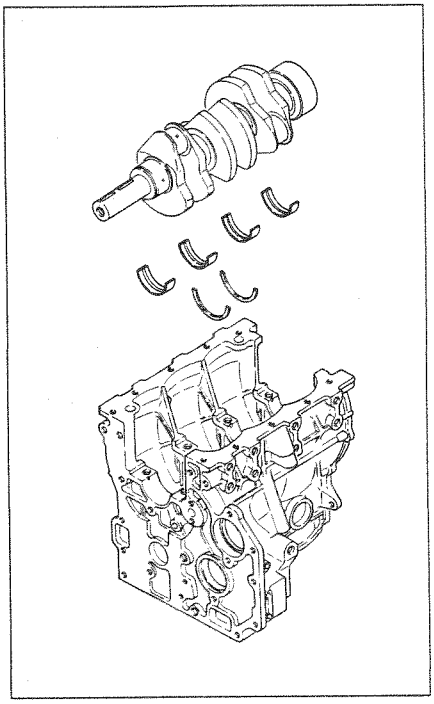


The numbers in ( ) indicate reassembly steps.



Crankshaft bearing

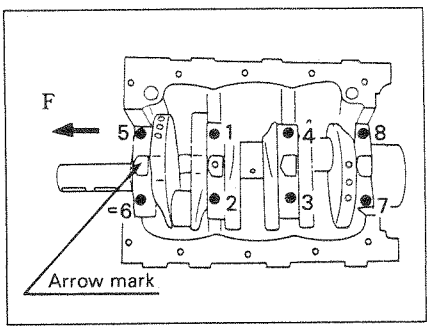
Note that there is an oil hole and oil groove in upper bearing (on body side), but not in lower bearing (on bearing cap side).



Assemble bearings in the body and apply engine oil to inside of bearings.
Place gently the crankshaft, the assemble thrust bearings with oil groove faced outside.

Note:

Insert tab into a notch completely. Take care not to contaminate the mating surface with dust.



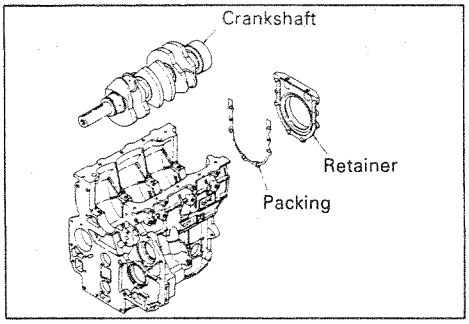
Crankshaft bearing cap

Insert bearings in bearing cap, apply engine oil, then install the cap with arrow mark faced front side.

(kg·m)

Torque	8.5 — 9.5

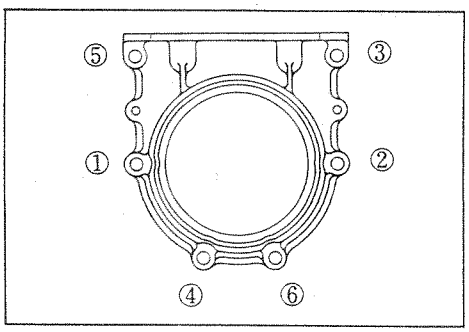
After installation, confirm that the crankshaft rotates smoothly.



Installation of retainer

Apply engine oil to the oil seal lip and install it.
Take care not to attach dust on the big end of crankshaft.
Install the retainer, and cut off protruded packing.

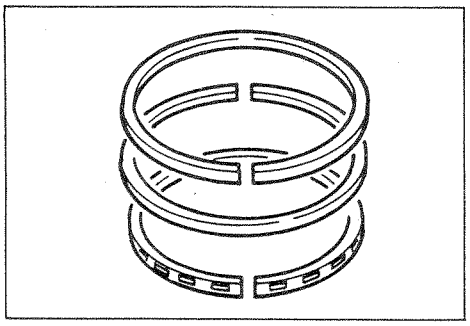
Special tool: 5 - 8840 - 9004 - 0
5 - 8840 - 0007 - 0



Tighten bolts on the retainer to the following torque in the order shown to the left.

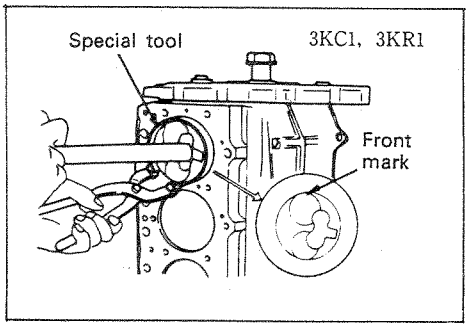
(kg·m)

Torque	1.5 — 2.5



Piston and connecting rod

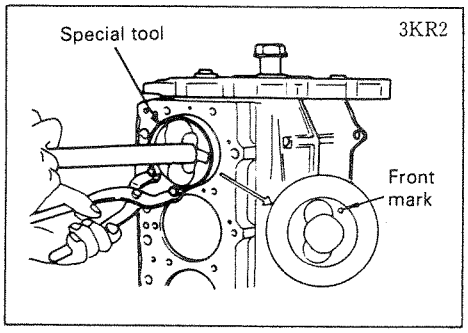
Set piston rings as shown to the left before inserting them in the cylinder.

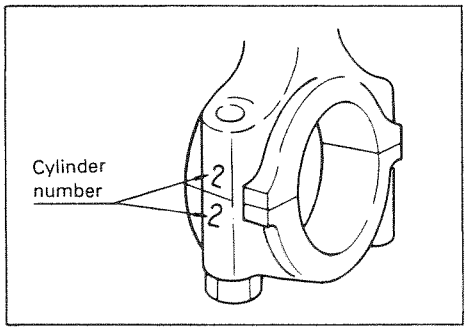


Special tool: Setting tool

Push in the piston rings with its front mark faced front side (apply engine oil to cylinder and piston).

Special tool: 5 - 8840 - 9018 - 0





Connecting rod

Make sure that each cylinder number on connecting rod and bearing cap is on the injection pump side. In addition, confirm that each cylinder number is correct.

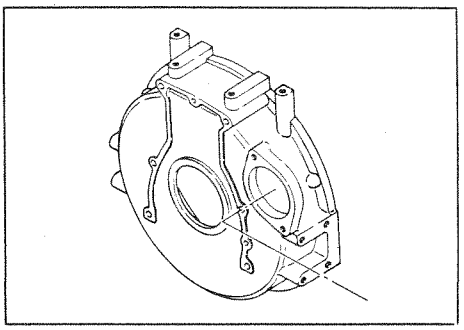
Apply engine oil to the bearings and crank pins

(kg·m)

Torque	3KC1	3.8~4.2
	3KR1	7.5~8.5
	3KR2	

Note:

After installation, confirm that the crankshaft rotates smoothly.

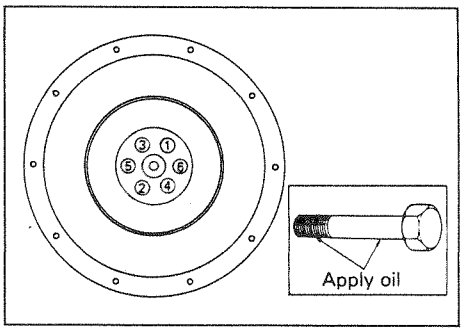


Flywheel housing

Install the flywheel housing on the cylinder body.

(kg·m)

Torque	3.5 — 4.5

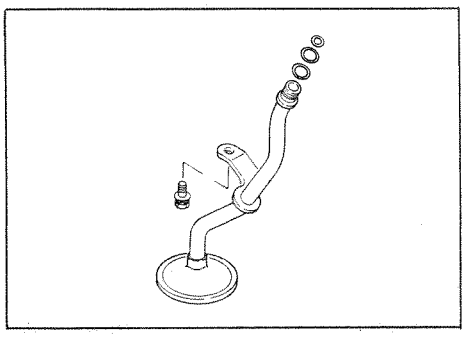


Flywheel

Apply engine oil to the thread and seat of each bolt.

(kg·m)

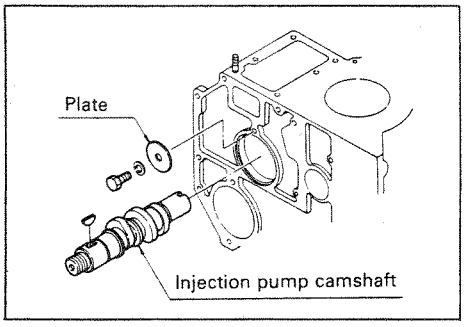
Torque	9.0 — 11.0



Oil strainer

Install the oil strainer, then perform cranking to confirm that there is no interference.

Apply engine oil to the portion that is inserted in the body.



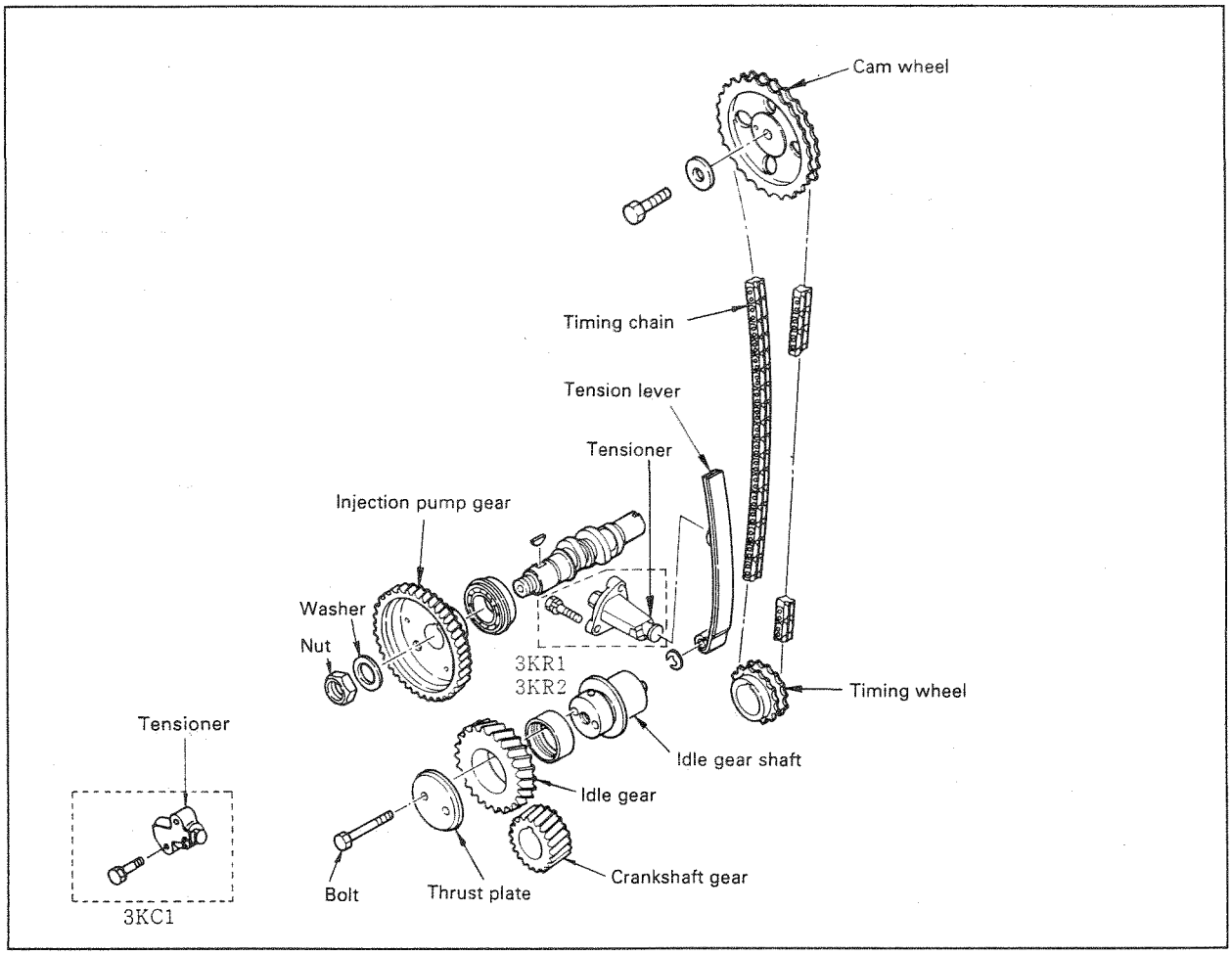
Injection pump camshaft

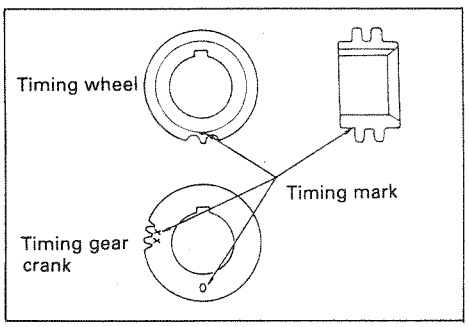
Drive in the injection pump camshaft until it gets stuck against the cylinder body.

Apply oil to the bushing portion of cylinder body.

After installation, confirm that the camshaft rotates smoothly.

TIMING GEAR TRAIN





Reassembly of timing gear

Idle gear shaft

Timing wheel

Crank gear

Install the idle gear shaft on the cylinder body.
Install the crankshaft, timing wheel and crank gear in this order.

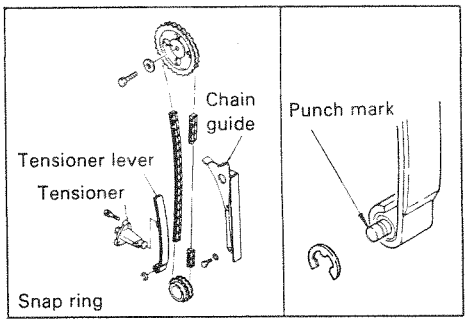
Note:

Install the above parts with the timing mark faced front side.

Backlash of gear

(mm)

Standard	Limit	Repair method
0.06	0.3	Replace gear



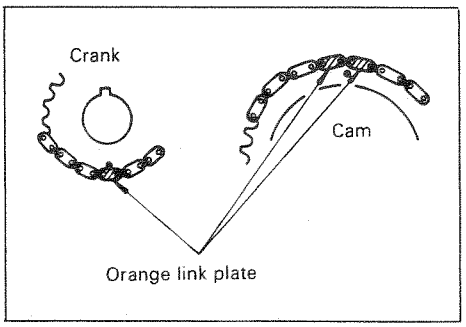
Tensioner, chain guide and tensioner lever

Insert a snap ring into the tensioner lever without fail.

(kg·m)

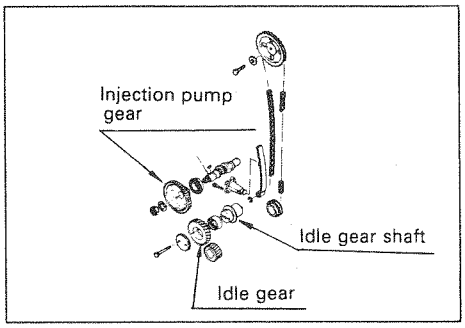
Torque	Tensioner	0.6 — 1.0 (M6 x 1.0)
	Chain guide	1.5 — 2.5 (M8 x 1.25)

Special tool: 5-8840-9009-0

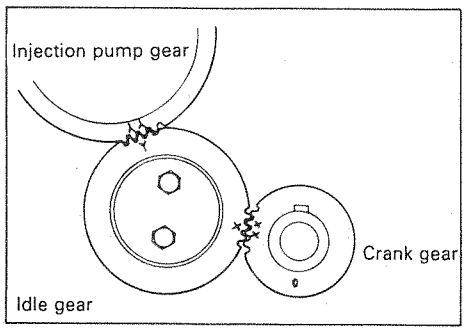


Timing chain and cam wheel

Align a timing mark (orange link plate) on the chain with that of cam wheel and timing wheel (crank).



Idle gear and injection pump gear



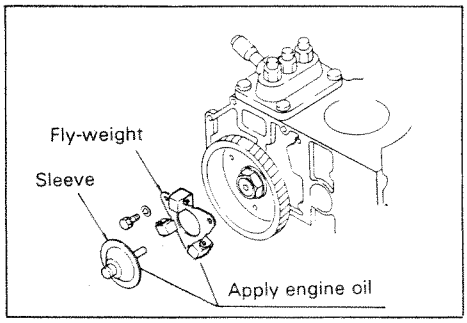
Idle gear and injection pump gear

Install with respective timing marks aligned.

(kg·m)

Torque for idle gear shaft	2.1 — 3.1
Torque for injection pump gear	7.0 — 9.0

Apply oil to inside of bushing when installing the idle gear.



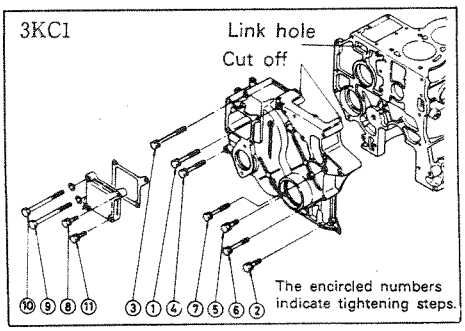
Fly-weight and sleeve

Install a fly-weight and sleeve on the injection pump gear.

Note: 1 Apply engine oil to the sliding face of sleeve shaft and fly-weight.

Note: 2 Insert the flange of sleeve into a recess of fly-weight.

Note: 3 Confirm that the sleeve shaft rotates smoothly.



Timing gear case

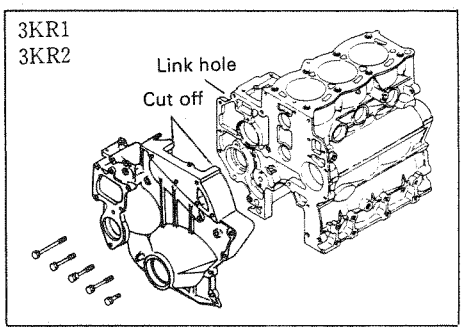
To install the timing gear case, tighten bolts in the order of 1 to 11 as shown to left.

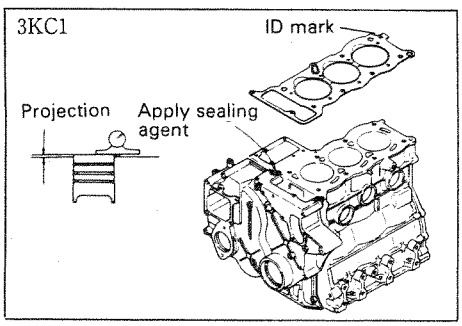
(kg.m)

Torque	1.5 — 2.5

Note 1: Insert a governor link plate and set spring into a pump link hole before installing the timing gear case.

Note 2: Cut off protrusion of packing (4 places) after tightening the case.





Measurement of piston head projection

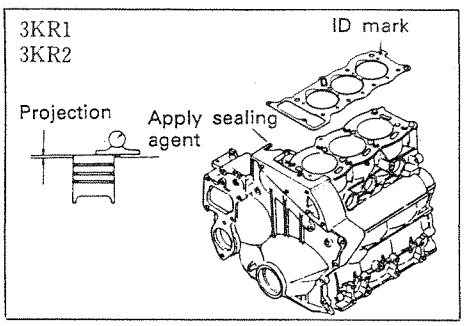
Measure piston head projection in the engine assembly line, and select and insert a cylinder head gasket of proper thickness.

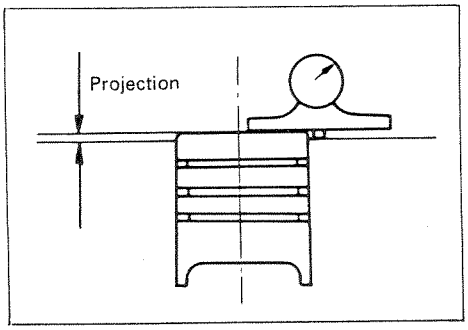
For assembly line

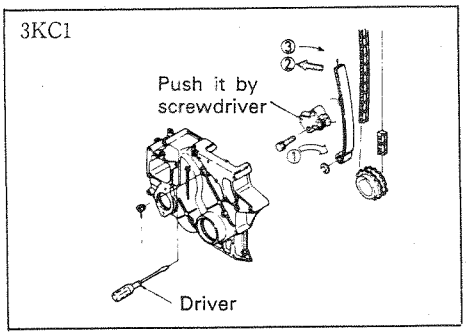
Piston projection	Gasket identification mark
below 0.694	A
above 0.694	B

For service

	Identification mark
If head & body are not	Use B
If head & body are reground	Use OS



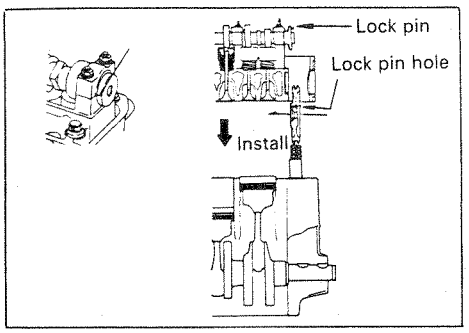




Reset of the tensioner ratchet (3KC1)

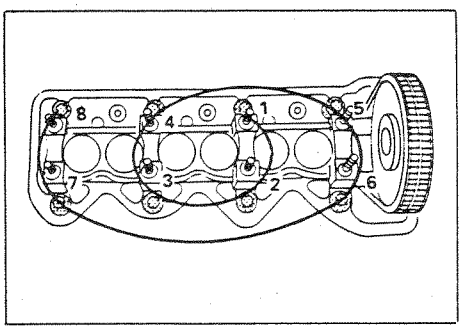
Before commencing with the installation of the cam wheel, reset the tensioner ratchet. (Release a tightening tension of the chain)

(1) Put the screwdriver through the plug mounting hole of the timing case and push the lever of the tensioner in the arrow direction 「⇨」.
(2) Push the lever of the tensioner in the arrow direction 「⬅」.
(3) Take off the screwdriver, and move the lever of the tensioner in the arrow direction 「→」 gradually, then the tensioner ratchet will be locked automatically.



Cylinder head

(1) Avoid interference between cylinder head and extruded parts such as cam wheel and injection pump. Do not damage gasket.
(2) Tighten temporarily the bolts with a lock pin on the camshaft aligned with lock pin hole.

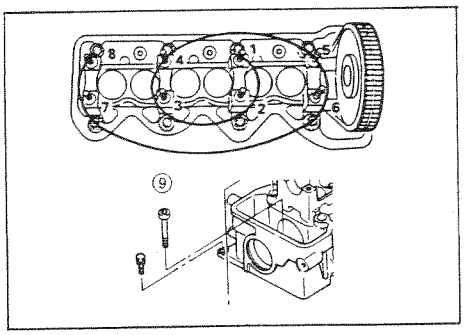


A Semi-tighten bolts (3 — 5 kg·m) in the order shown to left, then tighten again to the specified torque.

(kg·m)

		New	Reuse
Torque	3KC1	9.5~10.5	11.0~12.0
	3KR1	11.5~13.5	13.0~15.0
	3KR2		

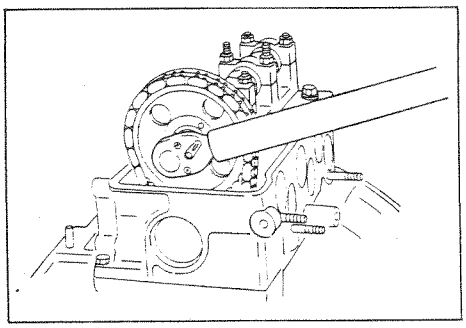
Apply engine oil to the threads.



(kg·m)

Torque for bolts between cylinder head & timing gear case	1.5 — 2.5

* Use a hexagonal wrench key when tightening the bolt ⑨.



Cam wheel

During installation, lock the cam wheel not to give force to the chain.

(kg·m)

Torque	9.5 — 11.5

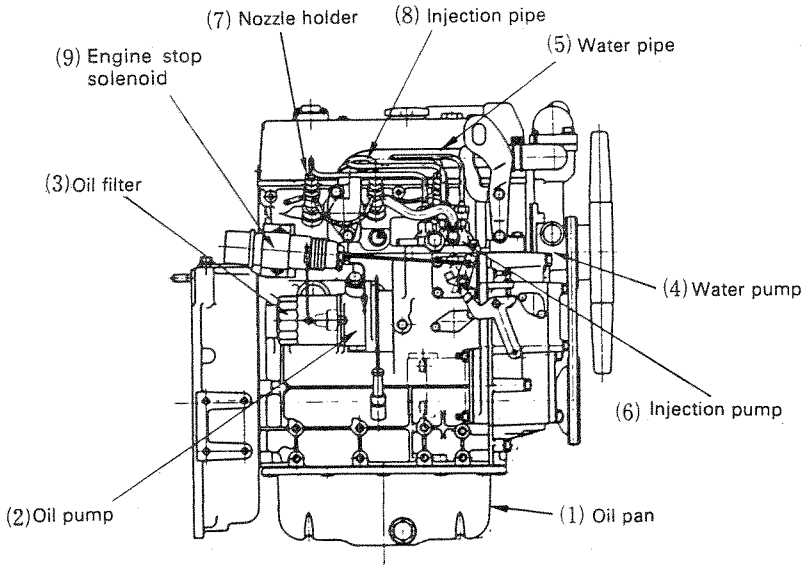
See "Inspection and Service".

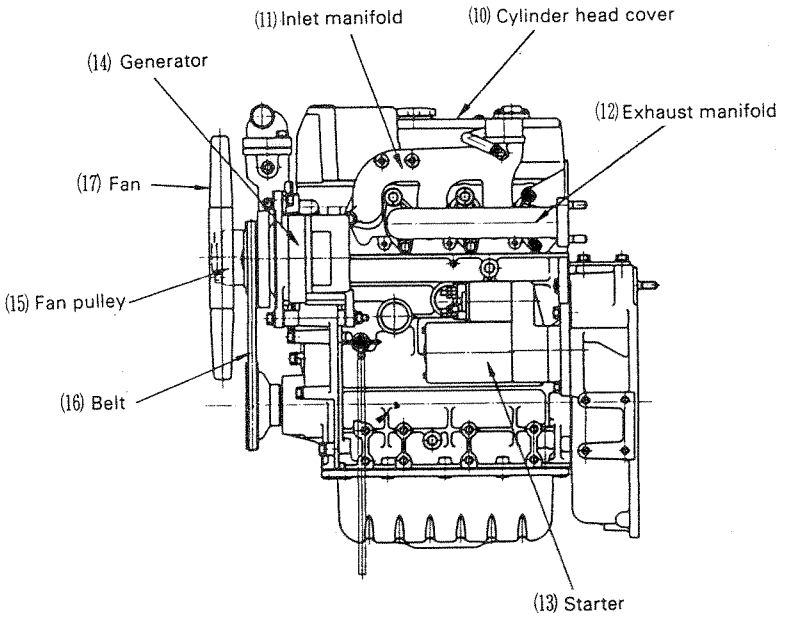
Adjustment of valve clearance

EXTERNAL PARTS

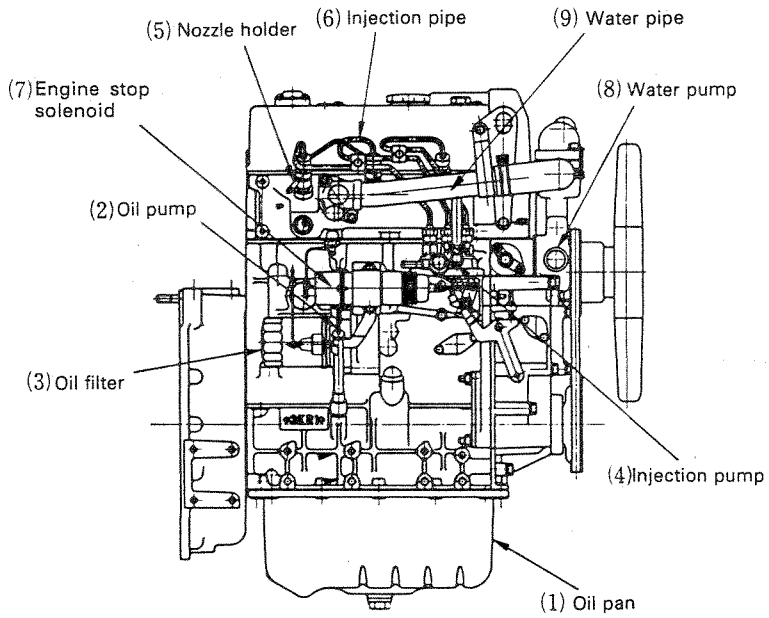
1. 3KC1 model

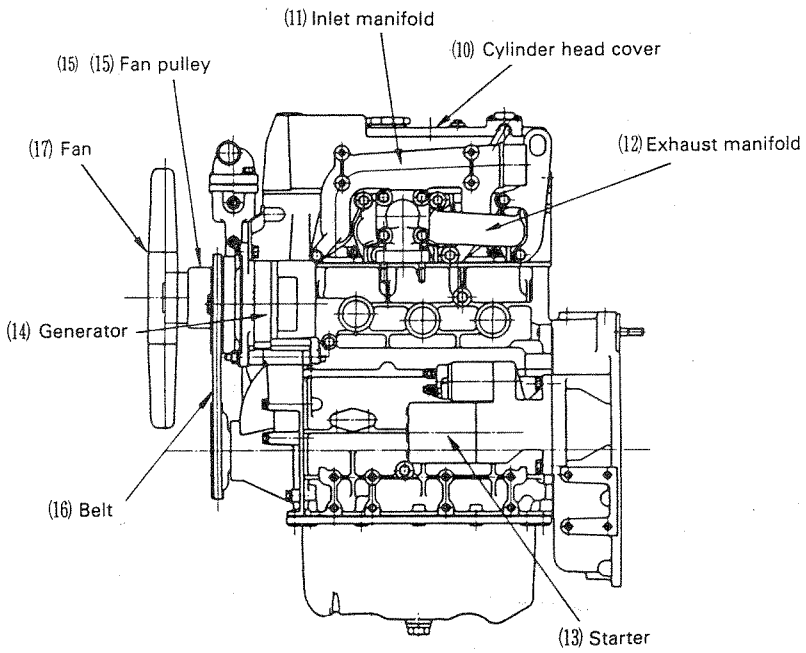
The numbers in ( ) indicate the reassembly steps. (Reference)



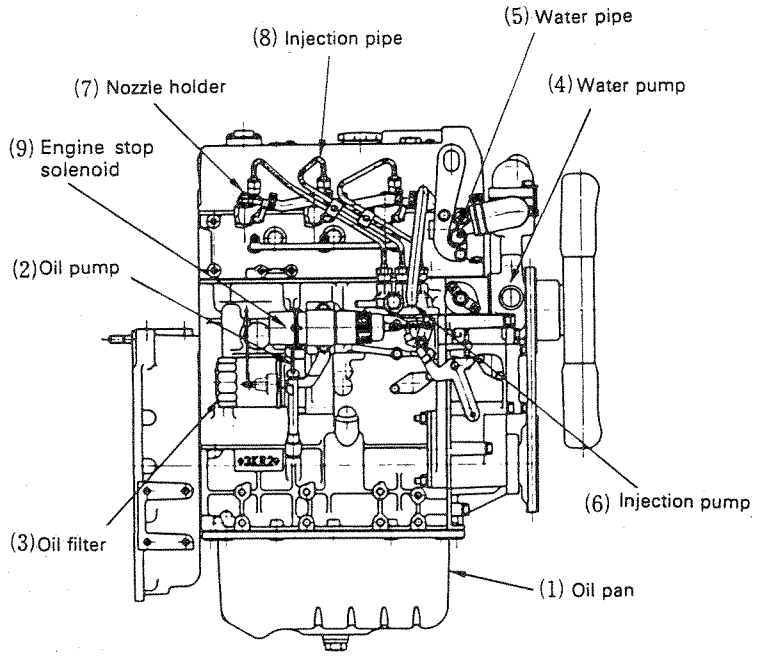


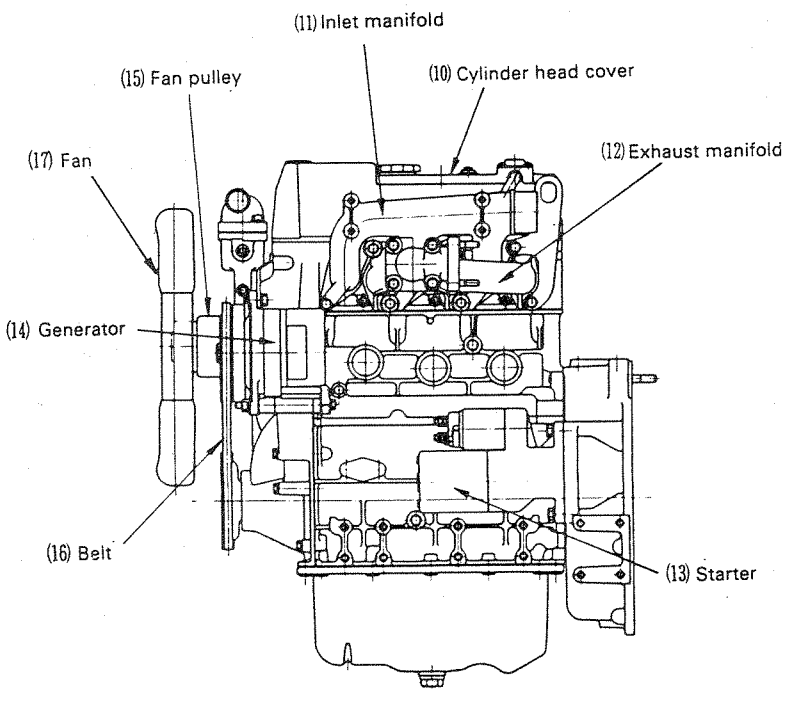
3KR1 model

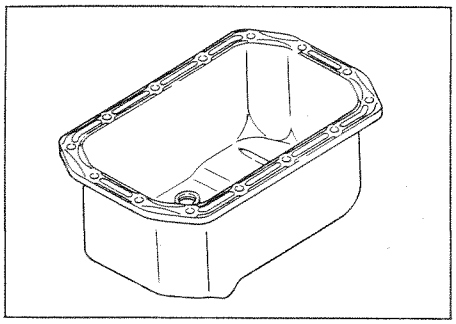

(5) Nozzle holder
(6) Injection pipe
(9) Water pipe
(7) Engine stop solenoid
(8) Water pump
(2) Oil pump
(3) Oil filter
(4) Injection pump
(1) Oil pan


(11) Inlet manifold
(15) (15) Fan pulley
(10) Cylinder head cover
(17) Fan
(12) Exhaust manifold
(14) Generator
(16) Belt
(13) Starter

3. 3KR2 model


(5) Water pipe
(8) Injection pipe
(7) Nozzle holder
(4) Water pump
(9) Engine stop solenoid
(2) Oil pump
(6) Injection pump
(3) Oil filter
(1) Oil pan


(11) Inlet manifold
(15) Fan pulley
(10) Cylinder head cover
(17) Fan
(12) Exhaust manifold
(14) Generator
(16) Belt
(13) Starter

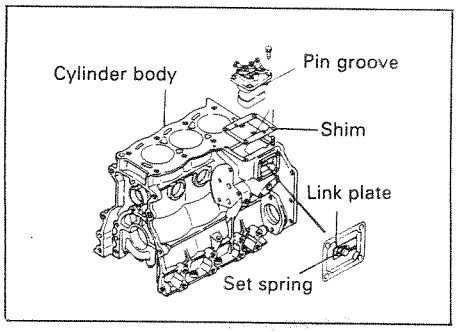


Important work

Oil pan

(kg·m)

Torque	1.5 — 2.5



Injection pump

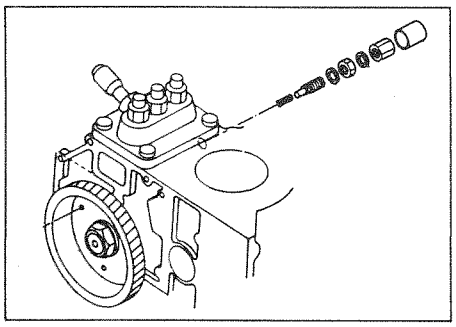
Shim

Tighten the injection pump together with shim.

(kg·m)

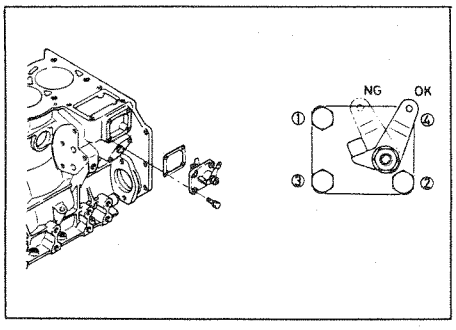
Torque	1.5 — 2.5

After installing the injection pump, insert a link plate and set spring hook into a pin groove.
Install the injection timing adjust shim after checking the shim thickness.
(Shim thickness ... see W06-01-17)
Expel the air from injection pump.
(See W06-01-18)



Set screw assembly; idle sub

Install the set screw assembly to the cylinder body.

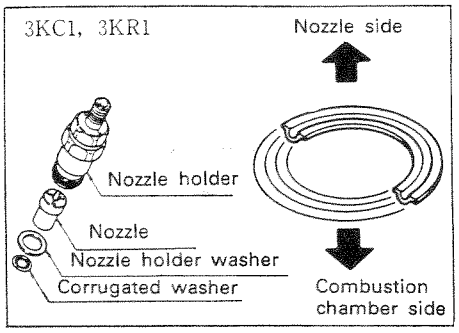


Fuel cut lever

(1) Avoid dislocation or dragging-in of packing during installation.

(2) After installation, confirm that the lever moves smoothly.

(3) Do not tilt the lever during installation. Tighten bolts in the order of 1 to 4 as shown to left.

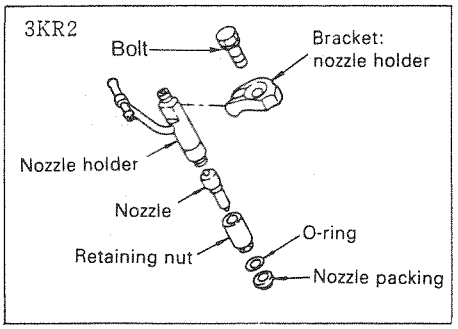


Corrugated washer
Nozzle holder washer | **3KC1, 3KR1**
Nozzle holder

(kg·m)

Torque	4.5–5.5

Note 1: Do not allow dust and foreign matter to attach to the nozzle tip or do not damage it.
Note 2: Take care of the installation direction of corrugated washer.



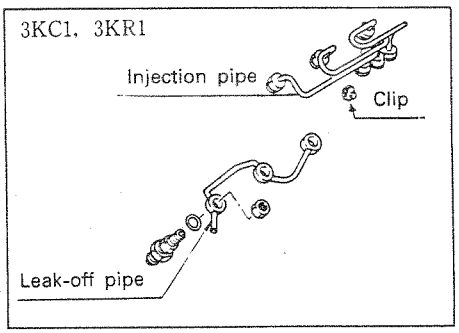
Nozzle holder 3KR2

(kg·m)

Clamp bolt; bracket Torque	3.3 — 4.3

Note:

Do not allow dust and foreign matter to attached to the nozzle tip or do not damage it.

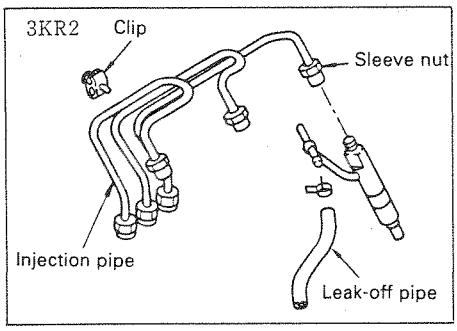


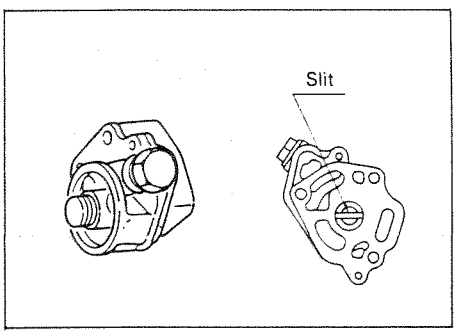
Injection pipe
Leak-off pipe
Clip

(kg·m)

Sleeve nut Torque	3.0 — 3.5

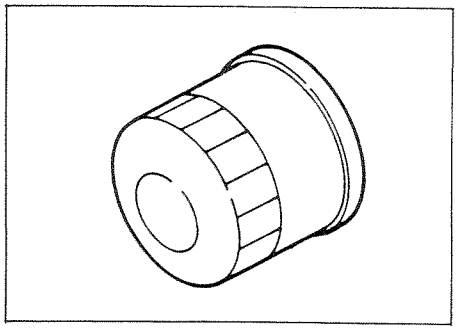
Note 1: Avoid interference between injection pipes.
Note 2: Do not settle the clip at the radius portion of pipe.





Oil pump

Install the oil pump with its slit aligned with a slit on the rear end of camshaft of injection pump.

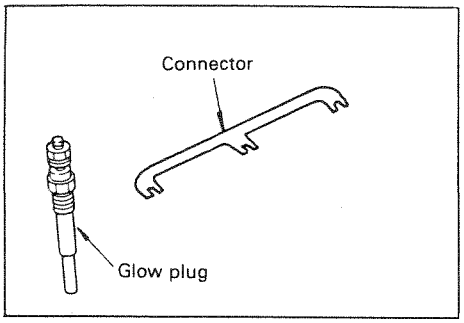


Cartridge: oil filter

Install the oil filter after applying engine oil to the O-ring on the cartridge.

(kg·m)

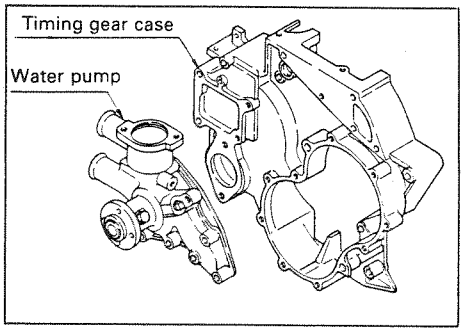
Torque	1.5 — 2.1



Glow plug

Connect a glow plug to the connector.

Note: The shape of the connector will differ a little according to the type of engine used.



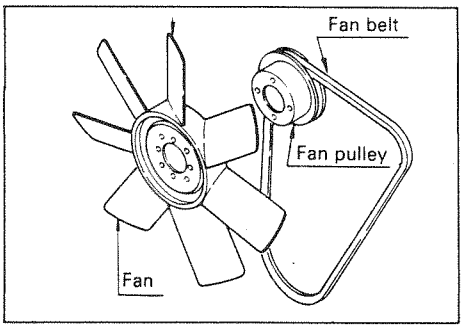
Water pump

Install the water pump onto the timing gear case.

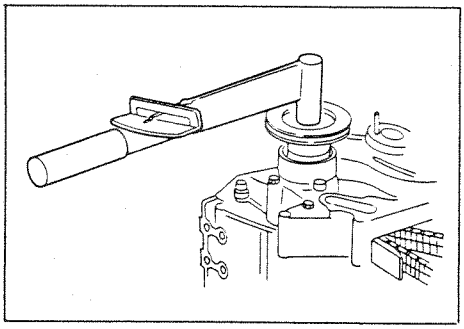
(kg·m)

Torque	1.5 — 2.5

Note: The shapes of the gear case and pump will differ a little according to the type of engine used.



Fan, Fan pulley, Fan belt



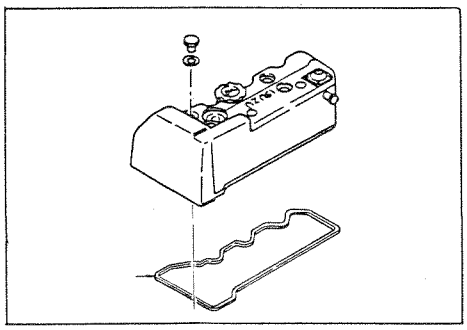
Front oil seal

Crank pulley

Before installing the crank pulley, apply oil to the lip of front oil seal.

(kg·m)

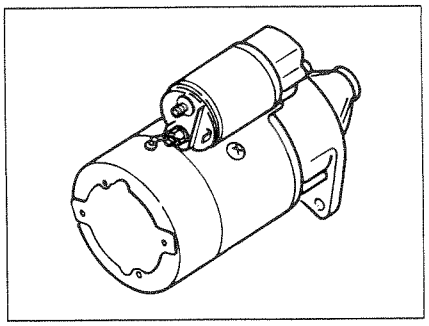
Pulley Torque	17.0 — 19.0



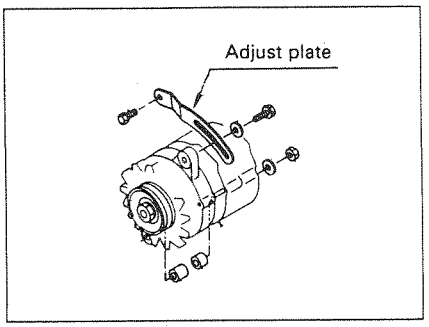
Cylinder head cover

(kg·m)

Torque	0.8 — 1.5



Starter



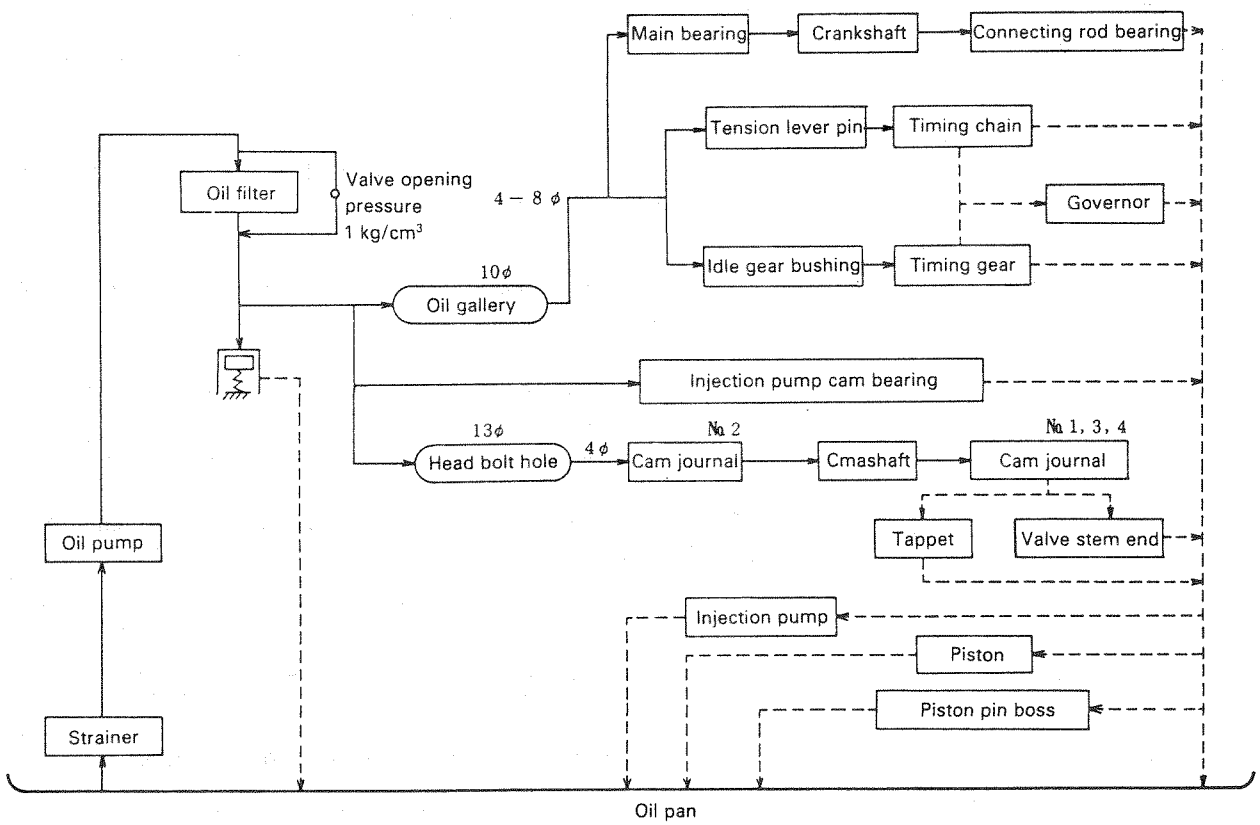
Generator

Adjust plate

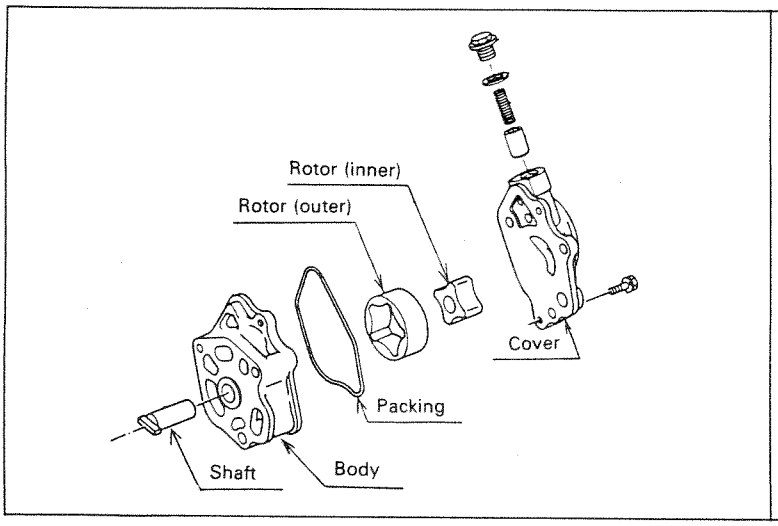
Adjust the fan belt tension. (See page W06-01-18)

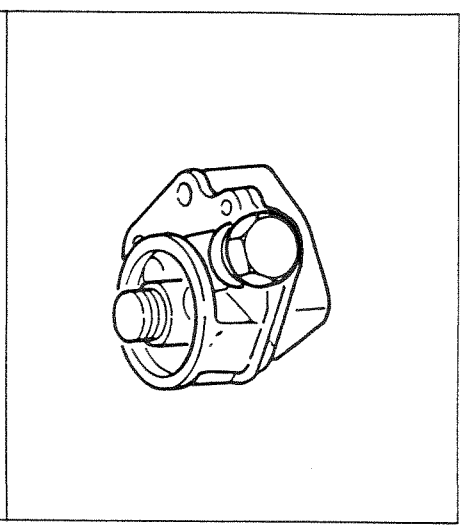
LUBRICATING SYSTEM

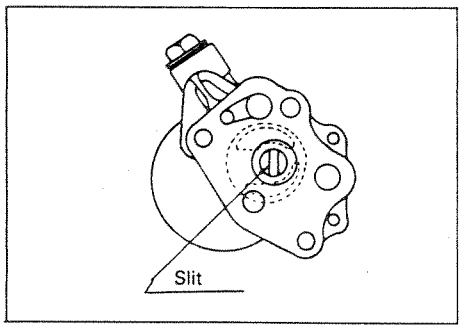
LUBRICATING OIL FLOW DIAGRAM



OIL PUMP







Inspection and repair

Repair or replace the rotor, etc. if there is wear, damage or other defects.

Install the oil pump with its slit aligned with a slit on the rear end of camshaft.

Clearance between outer or inner rotor and pump cover

(mm)

Standard	Limit	Repair method
0.040 — 0.090	over 0.15	Replace

Clearance between O.D. of outer rotor and pump body

(mm)

Standard	Limit	Repair method
0.20 — 0.28	over 0.4	Replace

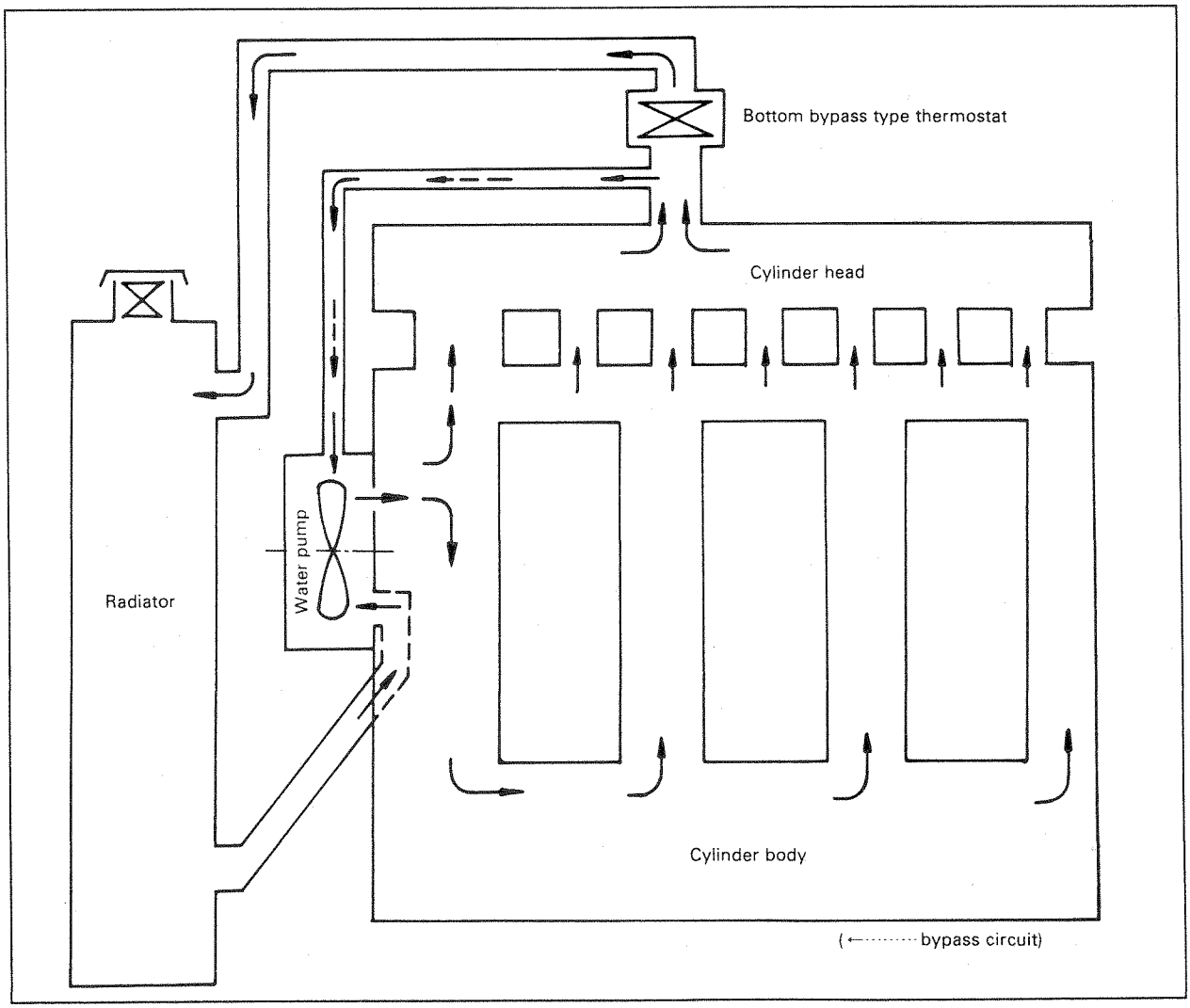
Tip clearance between inner rotor and outer rotor

(mm)

Standard	Limit	Repair method
below 0.17	over 0.2	Replace

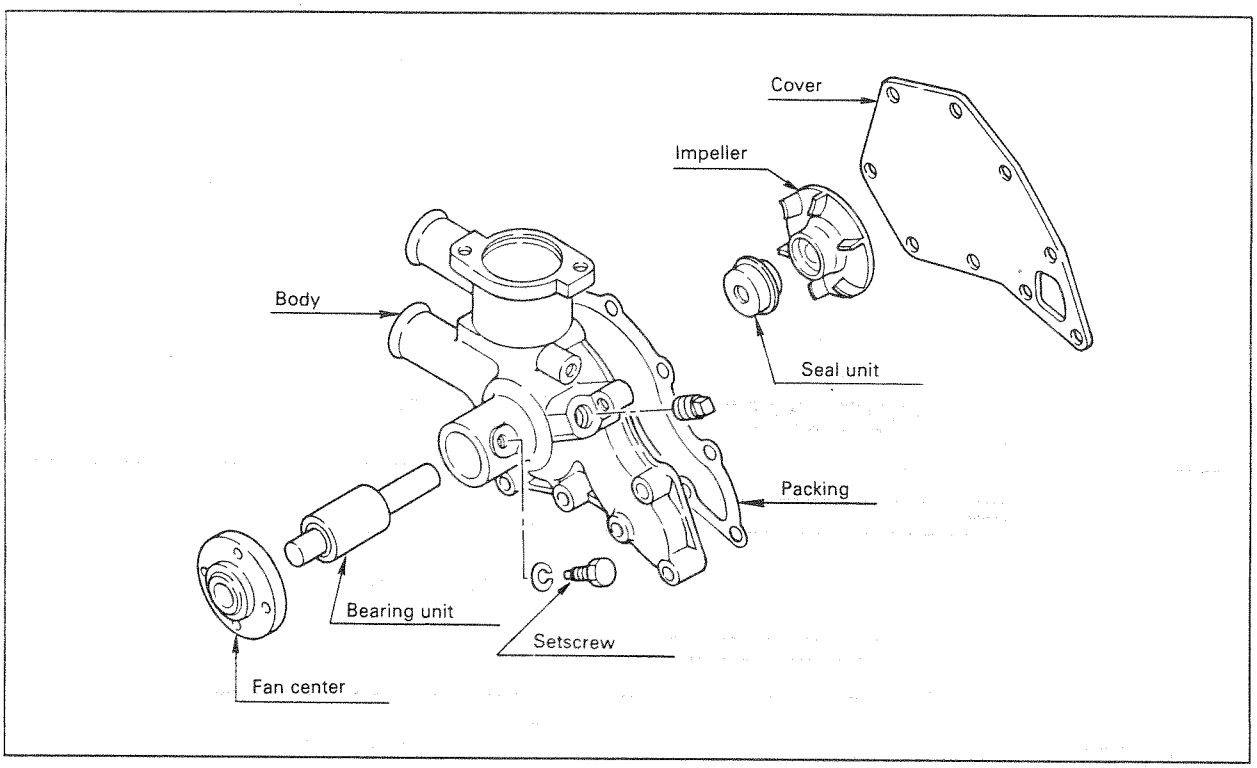
COOLING SYSTEM

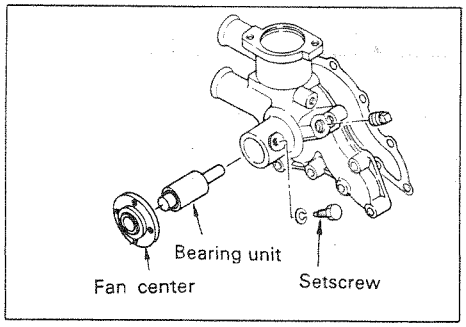
COOLANT FLOW DIAGRAM



WATER PUMP

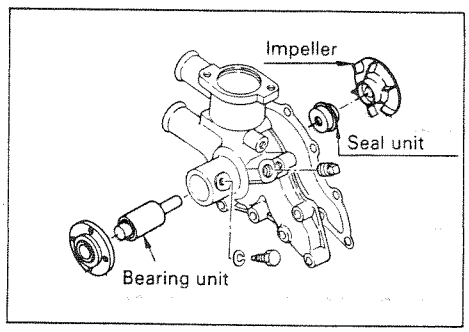
DISASSEMBLY





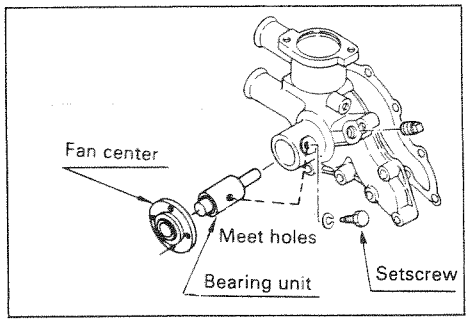
Fan center

Loosen a setscrew.



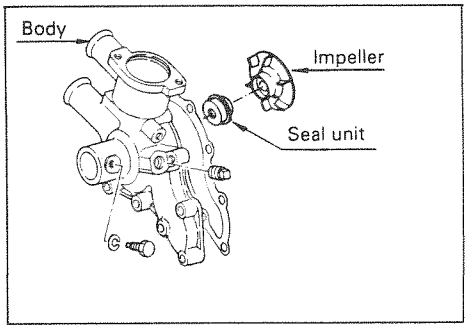
Impeller
Seal unit
Bearing unit

REASSEMBLY



Bearing unit

Meeting a hole in the bearing unit with a hole in the body, lock the bearing unit with a setscrew.



Seal unit

Impeller

Apply the bond to the face where the unit contacts the body.

Clearance, play and tightening allowance between parts

(1) Clearance between pump impeller and body

(mm)

Standard	Repair method
0.3 — 0.9	Repair or replace if impeller contacts body

(2) Play in water pump ball bearing

(mm)

Standard	Limit	Repair method
0.008 — 0.010	over 0.2	Replace

(3) Tightening allowance of fan center and bearing shaft

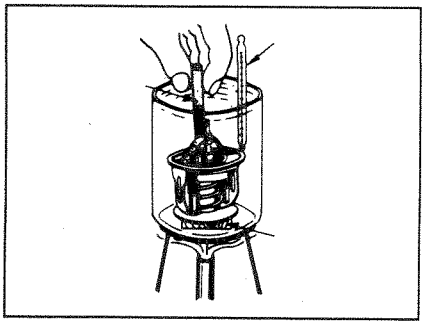
(mm)

Standard	0.026 — 0.061

THERMOSTAT

INSPECTION AND REPAIR

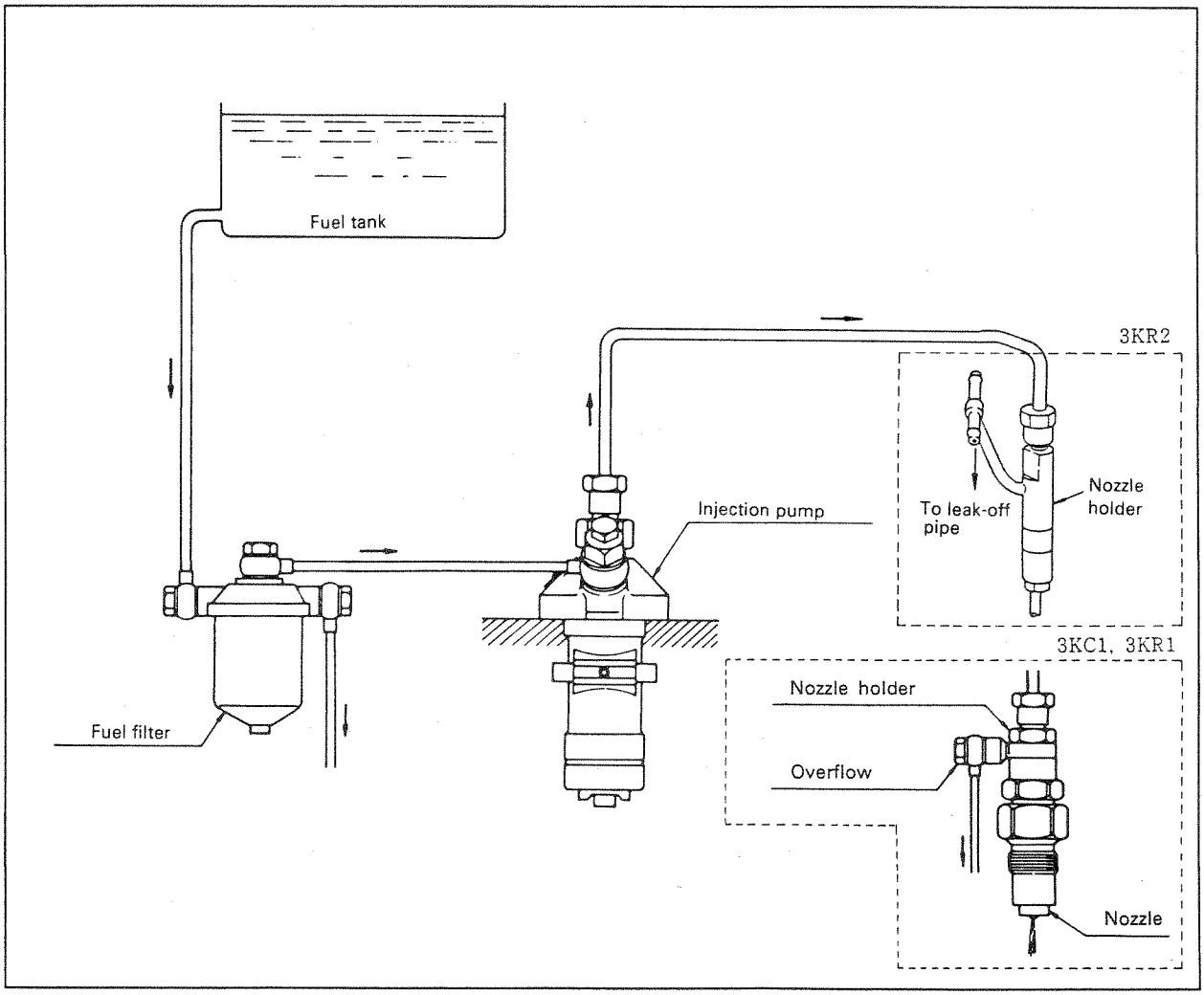
Replace thermostat if there is wear, damage or other defects.



Opening temperature	75 — 78°C
Valve lift (mm)	8 or more (at 90°C)

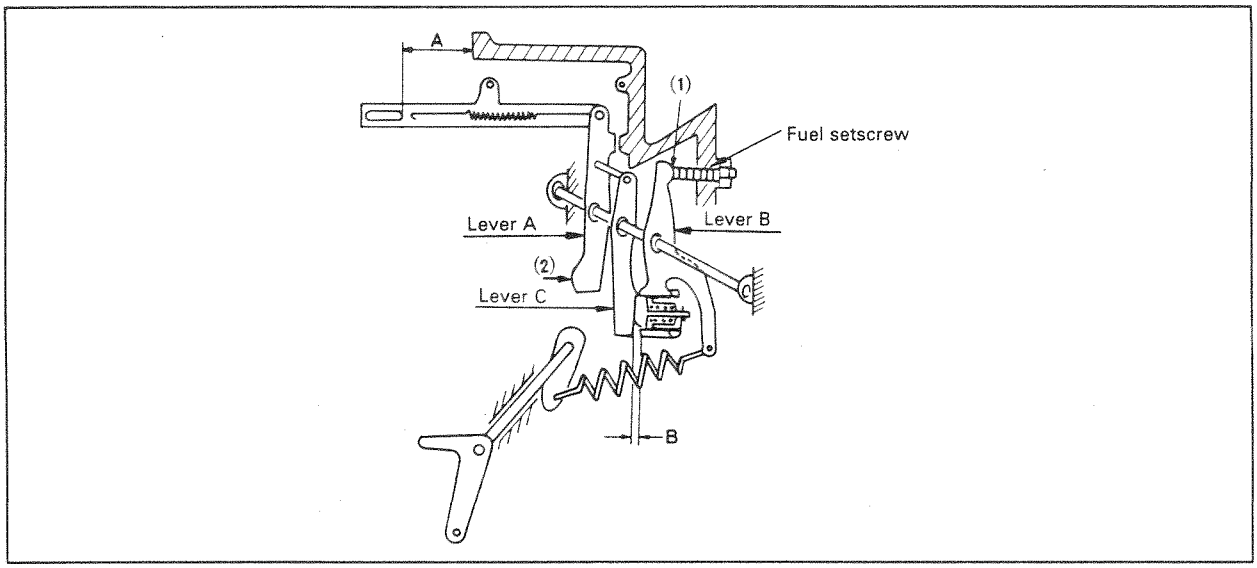
FUEL SYSTEM

FUEL FLOW DIAGRAM



GOVERNOR

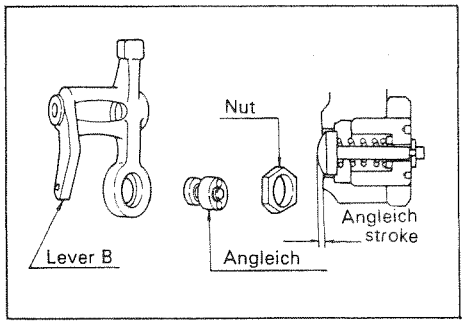
1. Adjustment of governor requires the engine performance test.
2. Before disassembly, measure dimensions A and B to ensure the same dimensions in reassembly.
3. Do not disassemble the governor if the performance test cannot be conducted after reassembly.



Measurement of dimension A (from link plate rack pin hole to timing cover end face)

(1) Pull the speed control lever and bring lever B in contact with the fuel setscrew.

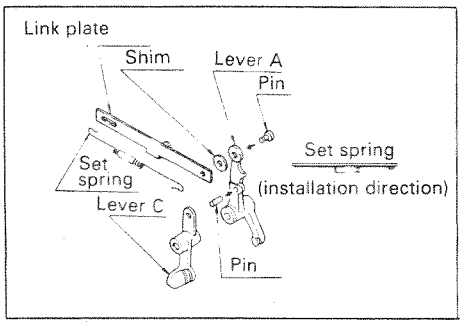
(2) Push lightly the lever A at the sleeve contact face to bring lever C in contact with the Angleich sleeve. (Do not give strong force to avoid deflection of Angleich spring.)



Measurement of dimension B (Angleich stroke)

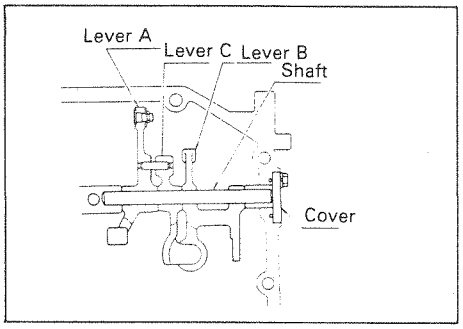
Lock the nut so that the dimension B becomes the one before disassembly.

The Angleich assembly (spring constant, setting force) is different depending on the engine model.



Reassembly of lever A and lever C

Take care not to tilt a pin when fitting it into the lever A. In installing a set spring, insert its hook into a groove of pin. In such a case, take case of the installation direction of set spring.

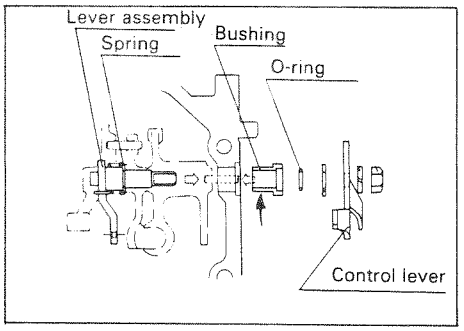


Installation of levers A, B and C

Install levers A, B and C on the timing gear case.

Confirm that each lever moves smoothly after reassembly. Also, confirm with levers A, B and C locked that the shaft rotates smoothly.

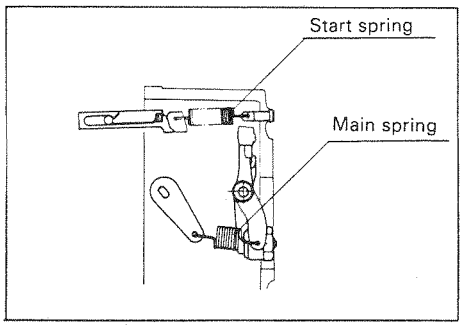
In reassembling levers, apply engin oil.



Reassembly of control lever

Apply Loctite 601 to the bushing before fitting.

Engage return spring completely with respective notches of pin and lever assembly.



Installation of main and idle springs

Install a main spring and start spring to the governor lever. Do not confuse the main spring, since it differs depending on the engine model.

Note: Main spring is colored for marking as follows.

Yellow : Spring on stant 0.3 kg/m
Orange : Spring on stant 0.16
White : Spring on stant 0.35
Red : Spring on stant 0.175

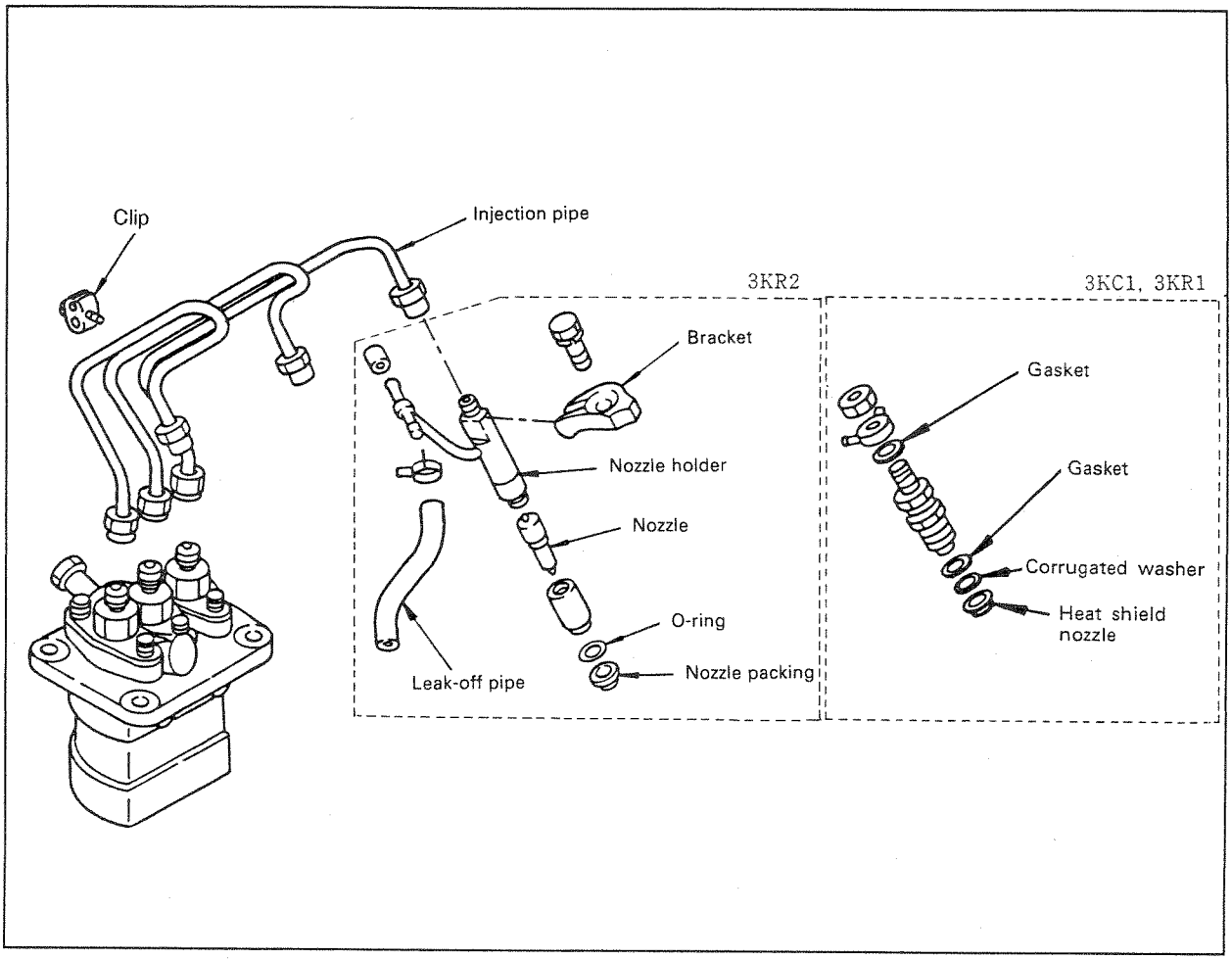
Confirm dimension A (before disassembly)

Note:

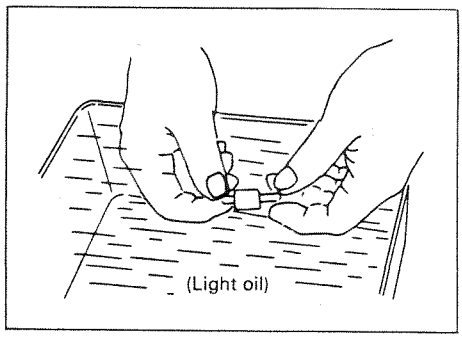
See measurement of dimension A.

NOZZLE HOLDER ASSEMBLY

DISASSEMBLY



NOZZLE ASSEMBLY



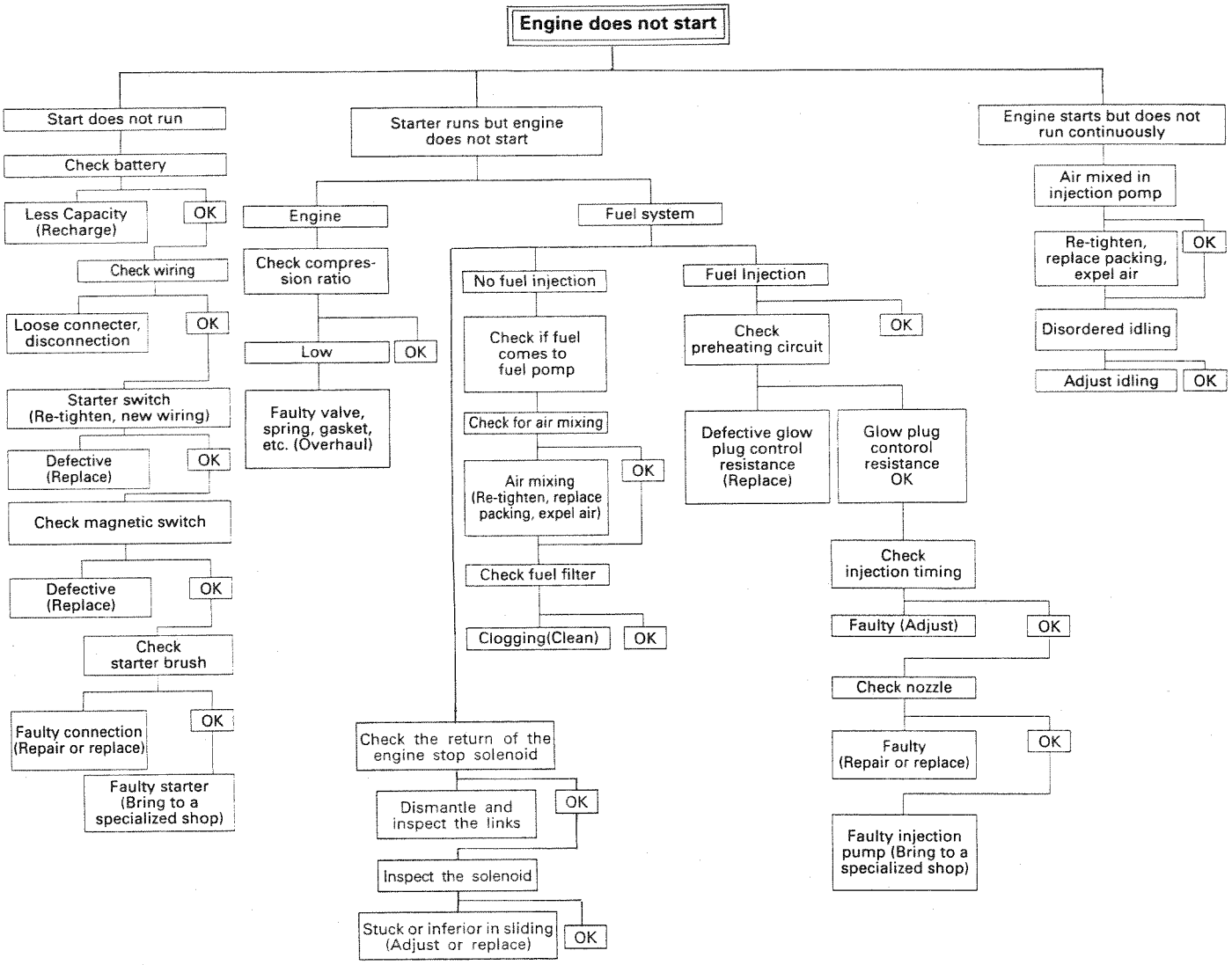
Inspection and repair

Put the removed nozzle in clean light oil, disassemble nozzle body and needle valve, and wash them. Then, check that the valve moves smoothly in the body. If not smooth, repair or replace the nozzle.

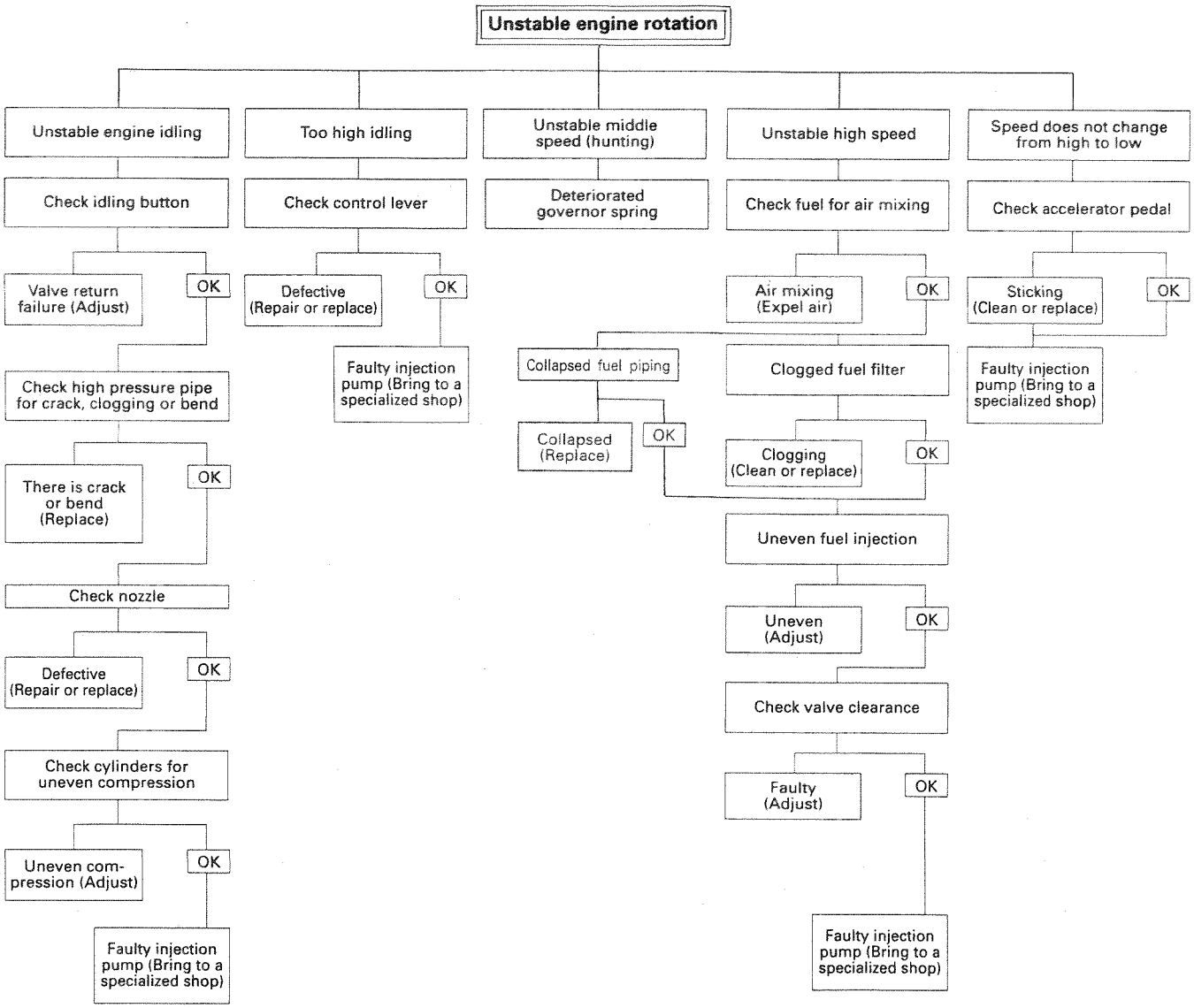
Adjustment

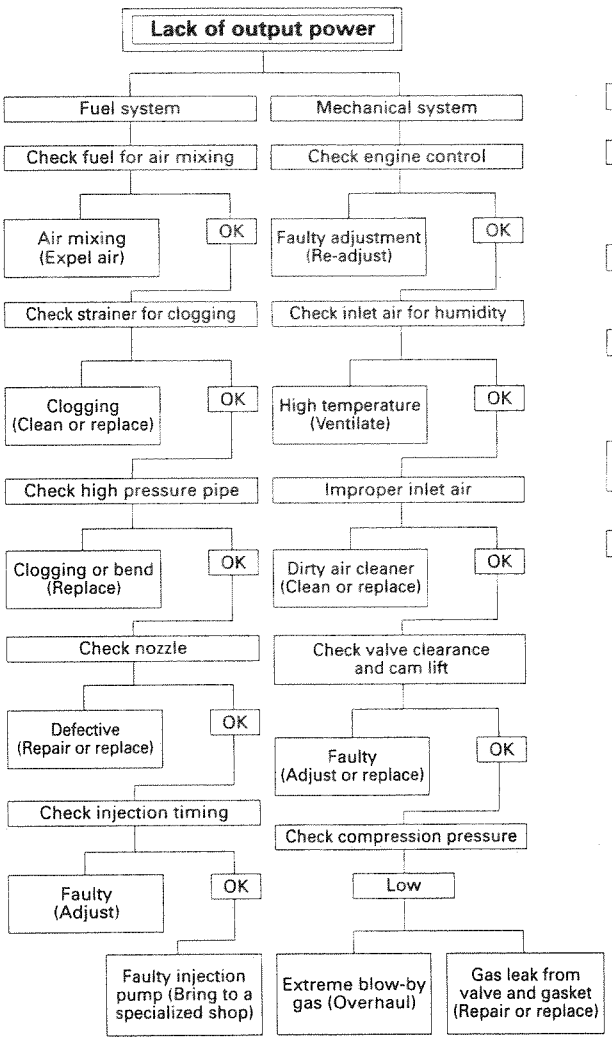
For the injection pressure adjustment and injection condition, see W06-01-18 ~ W06-01-16

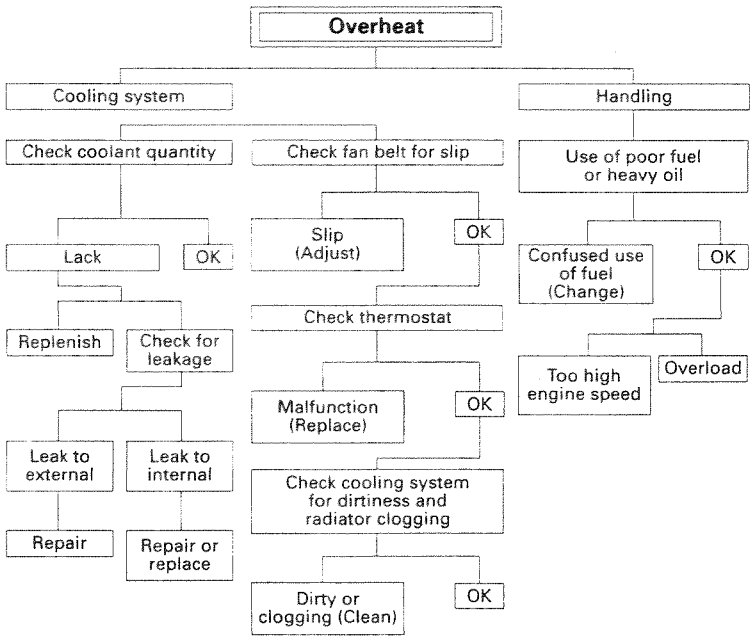
TROUBLESHOOTING

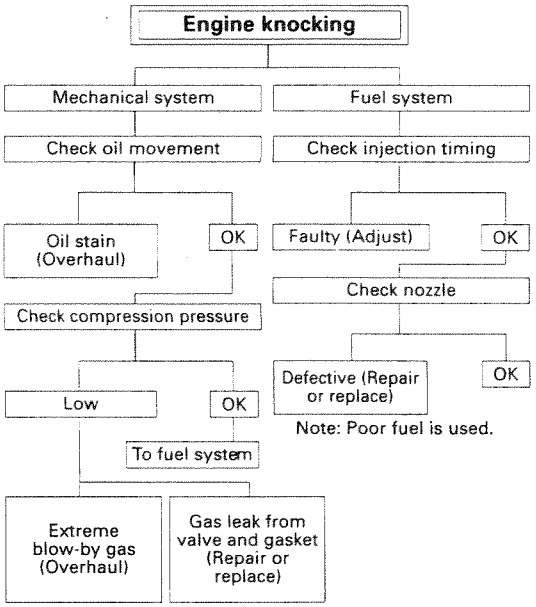


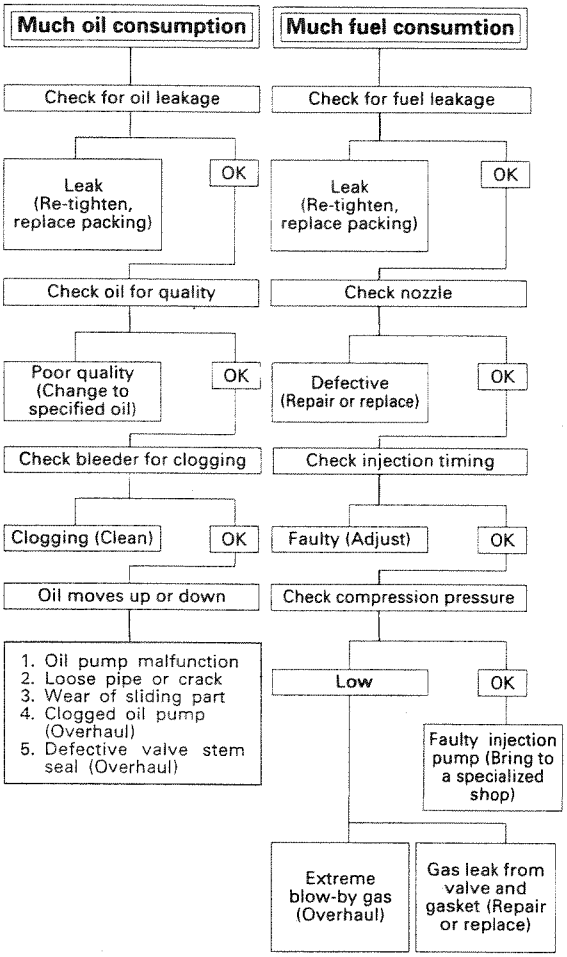
Note: "Bring to a specialized shop" means that faulty parts must be brought to a specialized shop for repair.

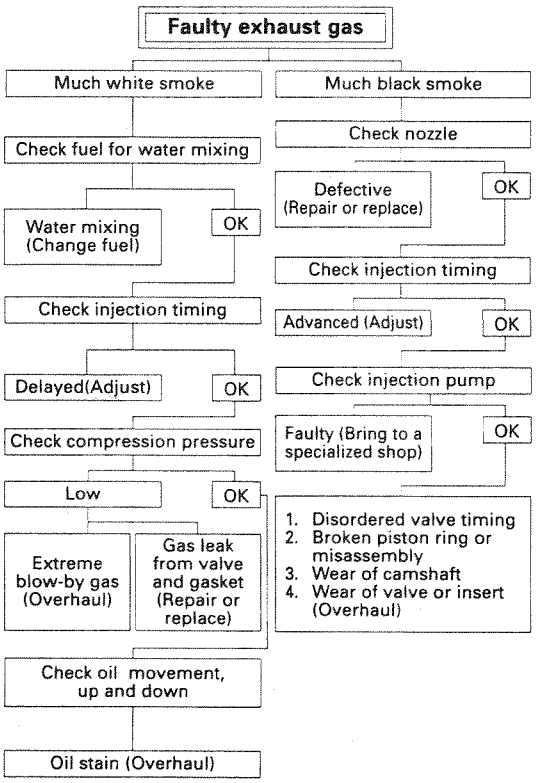

Unstable engine rotation
Unstable engine idling
Too high idling
Unstable middle speed (hunting)
Unstable high speed
Speed does not change from high to low
Check idling button
Check control lever
Deteriorated governor spring
Check fuel for air mixing
Check accelerator pedal
Valve return failure (Adjust)
OK
Defective (Repair or replace)
OK
Air mixing (Expel air)
OK
Sticking (Clean or replace)
OK
Faulty injection pump (Bring to a specialized shop)
Collapsed fuel piping
Clogged fuel filter
Faulty injection pump (Bring to a specialized shop)
Check high pressure pipe for crack, clogging or bend
Collapsed (Replace)
OK
Clogging (Clean or replace)
OK
There is crack or bend (Replace)
OK
Uneven fuel injection
Check nozzle
Uneven (Adjust)
OK
Defective (Repair or replace)
OK
Check valve clearance
Check cylinders for uneven compression
Faulty (Adjust)
OK
Uneven compression (Adjust)
OK
Faulty injection pump (Bring to a specialized shop)
Faulty injection pump (Bring to a specialized shop)

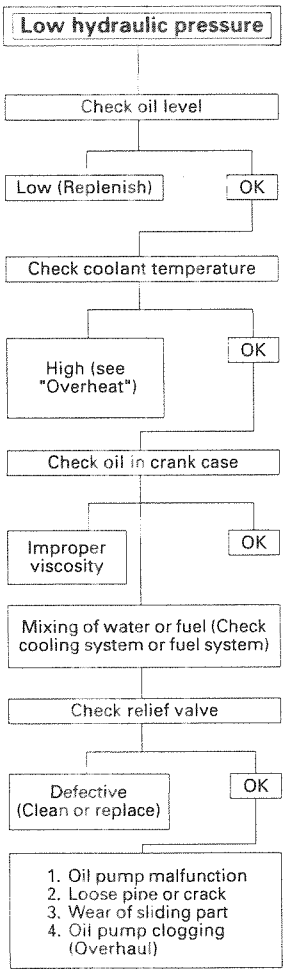

Lack of output power
Fuel system
Mechanical system
Check fuel for air mixing
Check engine control
Air mixing (Expel air)
OK
Faulty adjustment (Re-adjust)
OK
Check strainer for clogging
Check inlet air for humidity
Clogging (Clean or replace)
OK
High temperature (Ventilate)
OK
Check high pressure pipe
Improper inlet air
Clogging or bend (Replace)
OK
Dirty air cleaner (Clean or replace)
OK
Check nozzle
Check valve clearance and cam lift
Defective (Repair or replace)
OK
Faulty (Adjust or replace)
OK
Check injection timing
Check compression pressure
Faulty (Adjust)
OK
Low
Faulty injection pump (Bring to a specialized shop)
Extreme blow-by gas (Overhaul)
Gas leak from valve and gasket (Repair or replace)

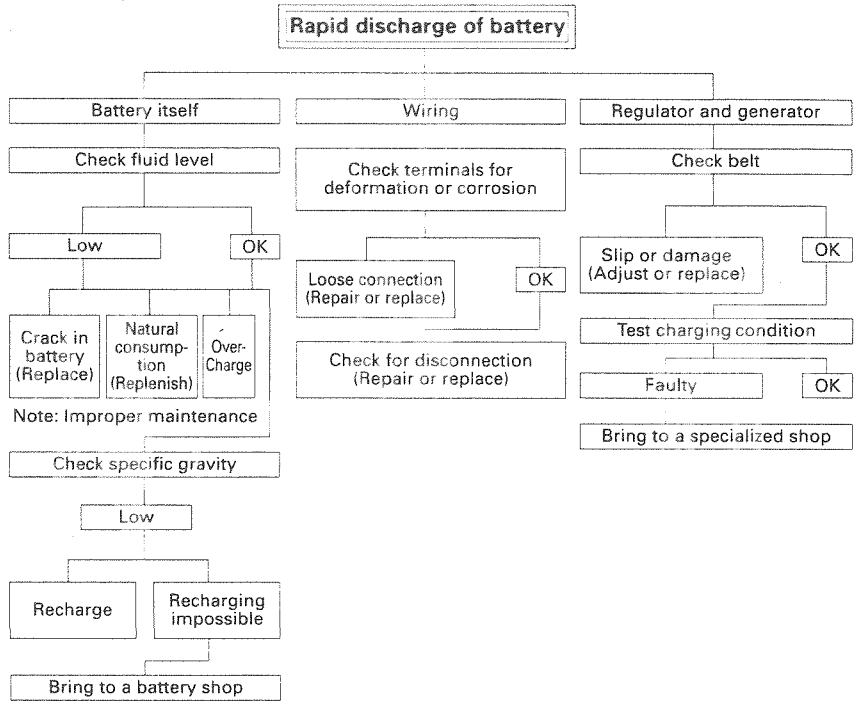

Overheat
Cooling system
Handling
Check coolant quantity
Check fan belt for slip
Use of poor fuel or heavy oil
Lack
OK
Slip (Adjust)
OK
Confused use of fuel (Change)
OK
Replenish
Check for leakage
Check thermostat
Too high engine speed
Overload
Malfunction (Replace)
OK
Leak to external
Leak to internal
Check cooling system for dirtiness and radiator clogging
Repair
Repair or replace
Dirty or clogging (Clean)
OK


Engine knocking
Mechanical system
Fuel system
Check oil movement
Check injection timing
Oil stain (Overhaul)
OK
Faulty (Adjust)
OK
Check nozzle
Check compression pressure
Defective (Repair or replace)
OK
Low
OK
Note: Poor fuel is used.
To fuel system
Extreme blow-by gas (Overhaul)
Gas leak from valve and gasket (Repair or replace)


Much oil consumption
Much fuel consumtion
Check for oil leakage
Check for fuel leakage
Leak (Re-tighten, replace packing)
OK
Leak (Re-tighten, replace packing)
OK
Check oil for quality
Check nozzle
Poor quality (Change to specified oil)
OK
Defective (Repair or replace)
OK
Check bleeder for clogging
Check injection timing
Clogging (Clean)
OK
Faulty (Adjust)
OK
Oil moves up or down
Check compression pressure
1. Oil pump malfunction
2. Loose pipe or crack
3. Wear of sliding part
4. Clogged oil pump (Overhaul)
5. Defective valve stem seal (Overhaul)
Low
OK
Faulty injection pump (Bring to a specialized shop)
Extreme blow-by gas (Overhaul)
Gas leak from valve and gasket (Repair or replace)

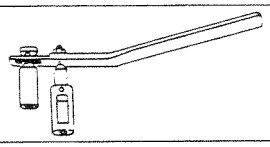
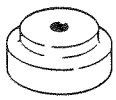
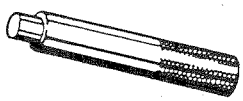
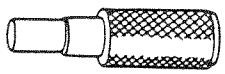
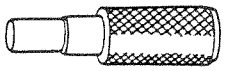

Faulty exhaust gas
Much white smoke
Much black smoke
Check fuel for water mixing
Check nozzle
Defective (Repair or replace)
OK
Water mixing (Change fuel)
OK
Check injection timing
Check injection timing
Advanced (Adjust)
OK
Delayed(Adjust)
OK
Check injection pump
Check compression pressure
Faulty (Bring to a specialized shop)
OK
Low
OK
1. Disordered valve timing
2. Broken piston ring or misassembly
3. Wear of camshaft
4. Wear of valve or insert (Overhaul)
Extreme blow-by gas (Overhaul)
Gas leak from valve and gasket (Repair or replace)
Check oil movement, up and down
Oil stain (Overhaul)

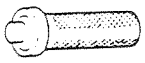
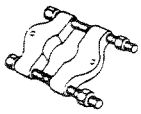
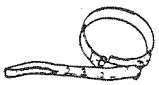
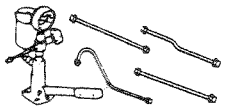
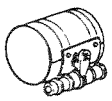
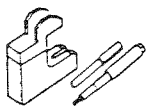
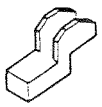
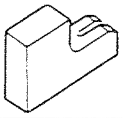

Low hydraulic pressure
Check oil level
Low (Replenish)
OK
Check coolant temperature
High (see "Overheat")
OK
Check oil in crank case
Improper viscosity
OK
Mixing of water or fuel (Check cooling system or fuel system)
Check relief valve
Defective (Clean or replace)
OK
1. Oil pump malfunction
2. Loose pipe or crack
3. Wear of sliding part
4. Oil pump clogging (Overhaul)


Rapid discharge of battery
Battery itself
Wiring
Regulator and generator
Check fluid level
Check terminals for deformation or corrosion
Check belt
Low
OK
Loose connection (Repair or replace)
OK
Slip or damage (Adjust or replace)
OK
Crack in battery (Replace)
Natural consump-tion (Replenish)
Over-Charge
Check for disconnection (Repair or replace)
Test charging condition
Faulty
OK
Note: Improper maintenance
Bring to a specialized shop
Check specific gravity
Low
Recharge
Recharging impossible
Bring to a battery shop

SPECIAL TOOLS

Part numbers in ( ) are assigned by tool maker.

No.	Sketch	Part Number	Part Name	Page
1.		5-8840-9001-0 (JKM-1003)	Valve spring compressor	W06-02-17 W06-02-34
2.		5-8840-9003-0 (JKM-1005)	Setting; Oil seal front	W06-02-31
3.		5-8840-9004-0 (JKM-1006)	Setting; Oil seal rear	W06-02-40
4.		5-8840-0007-0 (J-8092)	Drive handle	W06-02-40 W06-02-31
5.	※ 	5-8840-9005-0 (JKM-1007)	Bush setting; Injection pump cam	—
6.	※ 	5-8840-9006-0 (JKM-1008)	Bush remover; Injection pump cam	—
7.		5-8840-9007-0 (JKM-1009)	Setting; Valve guide seal	W06-02-33
8.	※ 	5-8840-9008-0 (JKM-1010)	Gauge plate; Injection pump (T-10.0 m)	—
9.	※ 	5-8840-9009-0 (JKM-1011)	Pin setting; Tension lever	W06-02-43

No.	Sketch	Part Number	Part Name	Page
10.		5-8840-0024-0 (JKM-3035)	Remover; Setting; pilot bearing	—
11.	※ 	5-8840-0015-0 (J-22912-01)	Remover bearing	—
12.		5-8840-2008-0 (J-29762)	Compression gauge	W06-01-17
13.		5-8840-2009-0 (J-26999-20)	Adapter; compression gauge	W06-01-17
14.		5-8840-9015-0 (JKM-9004)	Oil filter wrench	W06-02-11
15.		5-8840-9016-0 (J-28829)	Tester; nozzle	W06-01-18
16.		5-8840-9018-0 (J-8037)	Piston ring compressor	W06-02-40
17.		894409-7060	Valve setter	W06-01-16
18.		1-85221-029-0	Remover; piston ring	W06-02-20
19.		5-8840-9002-0 (JKM-1004)	Piston pin replacer assembly	W06-02-36
(19)		5-8840-9010-0 (JKM-1004-1)	Head; piston pin replacer (with 4 bolts)	W06-02-36
(19)		5-8840-9011-0 (JKM-1004-2)	Body; piston pin replacer	W06-02-36
(19)		5-8840-9012-0 (JKM-1004-3)	Push rod and guide rod	W06-02-36

*: Reference