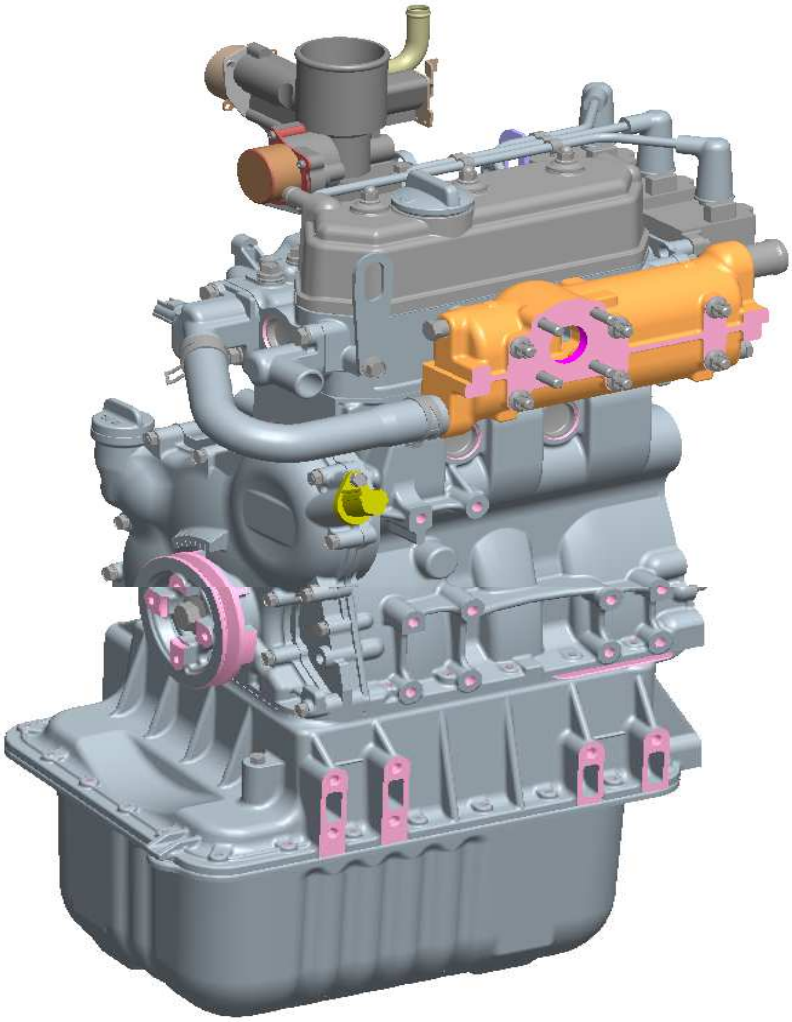
REPAIR MANUAL

Engine Model : 1KS CHP/GHP ENGINE

PART NO. : 16000-UJ090



No. RP-1KS-5

TOYOTA INDUSTRIES CORPORATION

Date : 2013/3/5

CONTENTS

CONTENTS

CONTENTS

Section0
GENERAL

Section Contents

SPECIFICATIONS

Engine model		Toyota 1KS	
Type		Natural gas	
Cycle		4	
Number of cylinder and arrangement		In-line 3cylinders, longitudinal arrangement	
Combustion chamber type		Heron Type	
Valve mechanism		OHV, Gear drive	
Bore × Stroke mm		72.0×78.0	
Piston Displacement L		0.952	
Firing order		1-2-3 (front, center, back)	
Compression ratio		12.0	
Compression pressure (normal) Engine at operating temperature Spark plugs removed		1.6MPa @ 400rpm	
Compression pressure (minimum) Engine at operating temperature Spark plugs removed		1.1MPa @ 400rpm	
Dimensions mm （Length×Width×Height）		488×402×651	
Service Weight kg		72.5	Without oil and water
Number of piston rings		2 Compression rings and 1 Oil ring	
Intake valve timing	Open	BTDC 10°	
	Close	ABDC 45°	
Exhaust valve timing	Open	BBDC 45°	
	Close	ATDC 10°	
Valve clearance mm	Intake	0.25	
	Exhaust	0.25	

HOW TO READ THIS MANUAL

EXPLANATION METHOD

1. OPERATION PROCEDURE

This manual describes detailed explanations of operational procedures, information, standards, and cautions with illustrations and pictures showing various components of 1KS gas engine and how to operate them.

2. MATTERS OMITTED IN THIS MANUAL

This manual omits descriptions of the following jobs, but perform them in actual operation:

(1) Cleaning and washing of removed parts as required

(2) Visual inspection (partially described)

3. TERMINOLOGY

Warning Items that may lead to an injury to either the operator or another person, and items and operation points which, if not followed, may lead to an injury or accident.

Caution Items that must not be performed because doing so will result in damage to unit or it's components, and items in the operation to which special attention should be paid.

Note Supplemental explanations for performing the operation easily.

Standard Value showing the allowable range in inspection or adjustment.

Limit The maximum or minimum value allowed in inspection or adjustment.

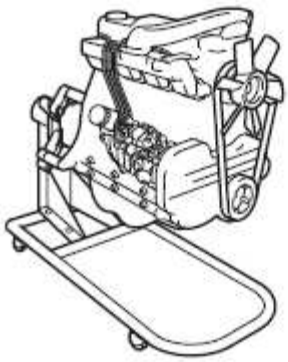
4. ABBREVIATIONS

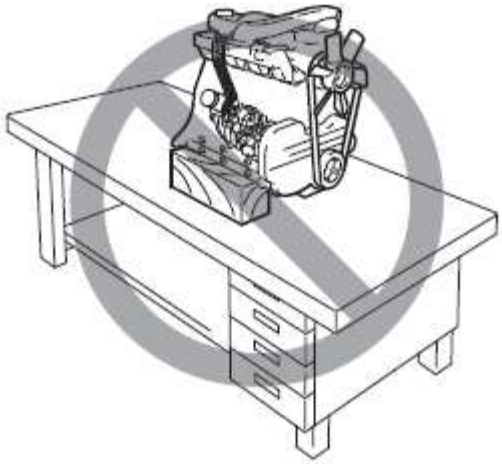
Abbreviation	Original term	Abbreviation	Original term
ASSY	Assembly	LH	Left hand
ABDC	After bottom dead center	OPT	Option
ATDC	After top dead center	RH	Right hand
BBDC	Before bottom dead center	SST	Special service tool
BTDC	Before top dead center	STD	Standard
BDC	Bottom dead center	SUB−ASSY	Sub assembly
EX	Exhaust	TDC	Top dead center
IN	Intake		

OPERATING TIPS

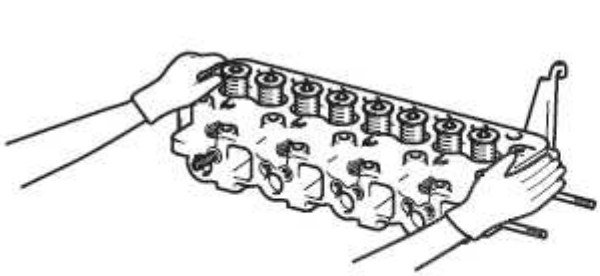
POINTS FOR WHICH SPECIAL CARE MUST BE TAKEN

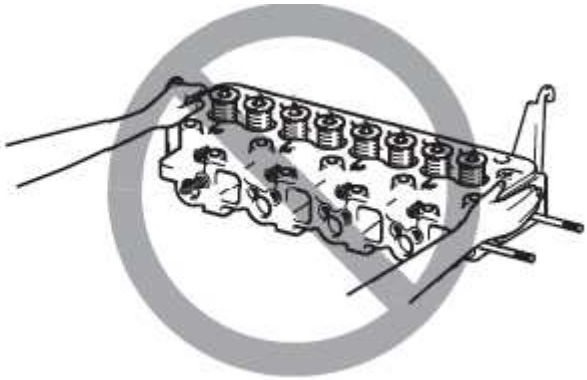
1. Always set the engine on an engine stand for carrying out assembly and disassembly of an engine. Never operate on a workbench or on the floor as this is dangerous.





2. When handling and moving the cylinder head ASSY or the cylinder block, always wear gloves and do not use your bare hands.





GENERAL INSTRUCTIONS

1. For safe operation
   (1). Wear the correct safety gear (cap, safety goggles, gloves, safety shoes).
   (2). To prevent bums, do not touch the radiator, muffler or exhaust pipe directly after stopping the engine.
   (3). Do not put your clothing or tool near to the rotating part when the engine is turning.
   (4). When the engine is not on. Always have the engine switch OFF, and remove the starter key.

2. Preparation for disassembly
   (1). Prepare general tools, SSTs, measuring instruments, lubricant and parts that cannot be reused.
   (2). When disassembling
   the function of the part in order to facilitate easy reassembly.

3. Prevention of entry of foreign bodies
   Foreign bodies such as dust, sand and metal pieces inside the engine cause faults to occur.
   (1). Thoroughly remove sand and mud etc. sticking to the engine exterior.
   (2). Protect disassembled parts from dust with a plastic cover or similar.

4. Prevention of damage to parts
   Damage to contact surfaces or rotating parts can cause oil leakage or burning.
   (1). To disassemble contact surface of parts, do not use a screw driver or such,
   but tap them lightly with a plastic hammer to separate them.
   (2). When clamping parts in a vice, do not clamp them directly in the vice, but between aluminum plates.

5. Washing parts
   (1). Before reassembling each part, wash thoroughly, dry by blowing them with air and apply the specified oil.
   (2). Parts that may not be washed in treated oil (kerosene, non-residue solvent etc.).
   Rubber parts

6. Removal and installation of fuel system parts
   (1). Work area for removal and installation of fuel system parts
      (a). Work in a well-ventilated area where there are no sparks from surrounding welding equipment, grinder, drills, electric motors, or stoves.
      (b). Do not work in or near a pit that could fill up with the vapor from evaporated fuel.
   (2). Removal and installation of fuel system parts
      (a). Prepare a fire extinguisher before beginning work.
      (b). To prevent static electricity, attach an earth wire to the fuel changer, unit, fuel tank and forth, and spread as much water on the floor as can be spread without causing slipping.
      (c). Do not use electric pumps or working lights as these may give off sparks or become hot.
      (d). Do not use a steel hammer as there is a possibility of a spark being generated during use.
      (e). Dispose of fuel-soaked waste closes separately.

7. Position and orientation when reassembling
   (1). Reassemble each part with the same position and orientation from before it was disassembled
   (2). Reassemble the correct parts in the correct order, keeping to the specified standards (tightening torque, adjustment values etc.). (Reassemble using the middle value within the range for tightening torque and adjustment values).
   (3). Always use genuine parts for replacements.
   (4). Always use new parts for oil seals, gaskets, cotter-pins and so forth.
   (5). Before reassembling apply seal packing for gaskets depending on their place of application, apply the specified oil or grease
   oil seals.

8. Handing hose clamps
   (1). Before removing a hose, check the insertion depth of the hose, and the position of the hose clamps so that you can definitely return them to their original positions.
   (2). Replace deformed or fatigued clamps with new parts.
   (3). When reusing the hose, align the new clamp over the mark left on the hose by the previous clamp.
   (4). Adapt leaf spring clamps by applying force in the direction of tightening after attaching them.

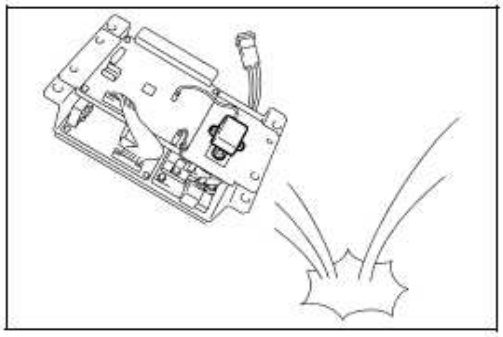
9. Adjustment and checking operations
   Use a gauge of tester to adjust to the specified service standard.

10. Disposal of waste fluids
   When draining waste fluid from the unit, always drain it into an appropriate container.
   Careless discharge of oil, fuel, coolant, of filter, battery or other harmful substances may adversely affect human health and the environment. Always collect and sort them well, and ask specialized companies for appropriate disposal.
   Also, be sure to collect or wipe up spilled waste fluids.

11. Protection of functional parts
   Before connecting the battery terminal after unit inspection or maintenance, thoroughly check each connector foe any connection failure or imperfect connection.
   Failure to connect, or imperfect connection of connectors related to controllers, especially, may damage elements inside the controllers.

ELECTRICAL PARTS INSPECTION

1. Always disconnect the battery plug before inspecting or servicing electrical parts.
2. Pay sufficient attention when handling electronic parts.



(1). Never subject electronic parts, such as computers and relays, to impact.
(2). Never expose electronic parts to high temperature or humidity.
(3). Do not touch connector terminals, as they may be deformed or damaged due static electricity.

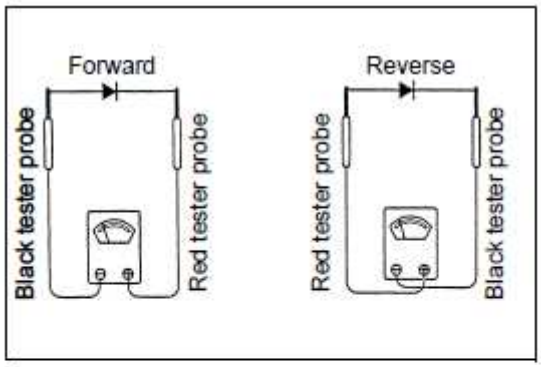
3. Use a circuit tester that matches the object and purpose of measurement.

Analog type : This type is convenient for observing movement during operation and operating condition. The measured value should be used only for reference or rough judgment.

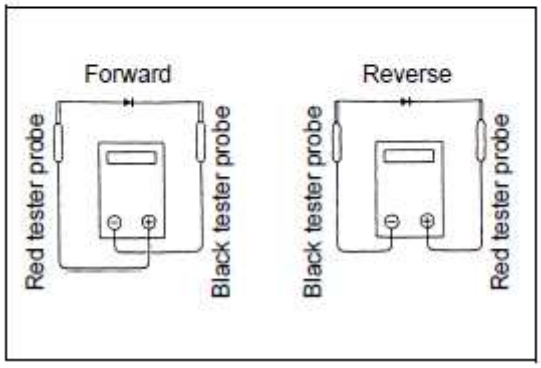
Digital type : A fairly accurate reading is possible. However, it may be difficult to observe variation or movement.

(1) Difference between results of measurement with analog and digital types

The results of measurements using the analog type and the digital type may be different.
Use the circuit tester according to its instruction manual.
Differences between the polarities of the analog type and the digital type are described below.

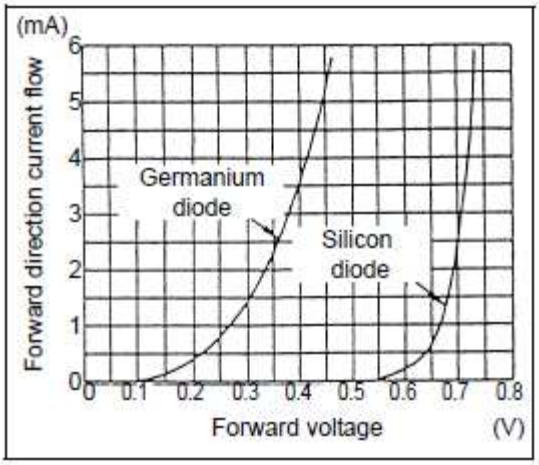


a). Analog circuit tester
Example of measurement result
Tester range : kΩ range
Forward direction : Continuity 11kΩ
Reverse direction : No Continuity ∞



b). Digital circuit tester
Example of measurement result
Tester range : 2MΩ range
Forward direction : Continuity 2MΩ
Reverse direction : No continuity 1

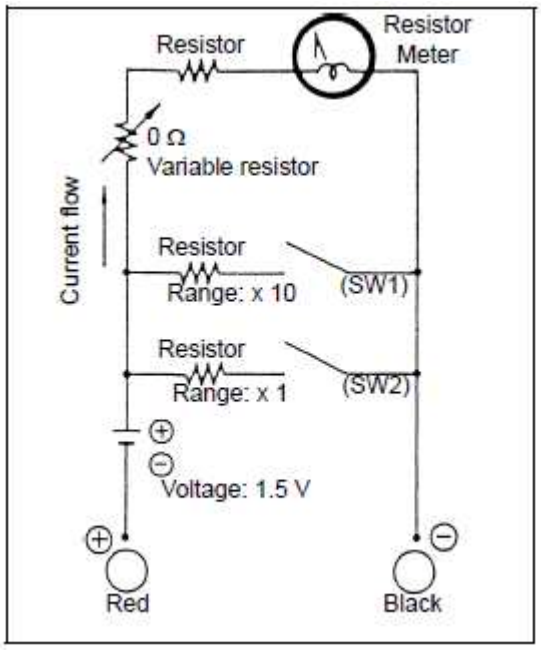
(2). Differences in results of measurement with circuit testers



The circuit tester power supply voltage depends on the tester type : 1.5V, 3.0V and 6.0V
The resistance of a semiconductor such as a diode varies with the circuit tester power supply voltage.
Diode characteristics are shown in the figure to the left.
The resistance values of the same diode measured with two types of circuit testers having different power supply voltage are different.

This manual described the results of measurement with an analog circuit tester with a power supply voltage of 3.0V.

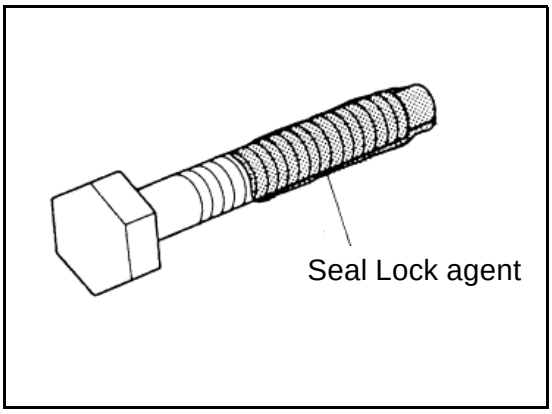
(3). Differences in results of measurement by measurement range.



In the analog type circuit tester, changing the measurement range switches over the internal circuit to vary the circuit resistance. Even when the same diode is measured, the measurement result varies according to the measurement range.

Always use the range described in the repair manual for measurement.

PRECOATED BOLTS
(BOLTS WITH SEAL LOCK AGENT COATING ON THREADS)



- BOLT, STUD for INLET OUTLET WATER
- SWITCH ASSY, OIL PRESSURE
- SENSOR, WATER TEMPERATURE

1. Do not use precoat bolts in any of the following cases:
   (1) When a precoat bolt is removed
   (2) When a precoat bolt is removed as a result of tightening torque check, etc.
   (Loosened or tightened)

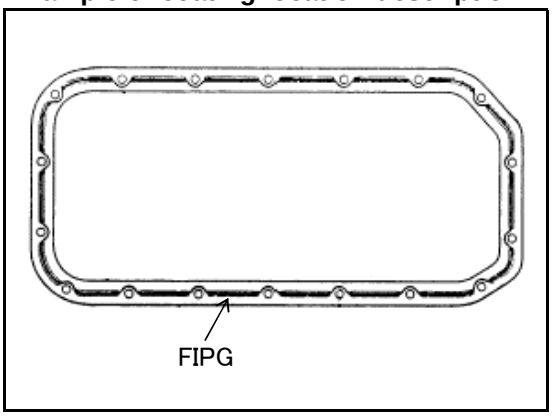
NOTE:
Check the torque with the lower limit of the tightening torque. If it moves, retighten it according to the following procedure:

2. Reusing of precoat bolts
   (1) Clean off the old adhesive from the bolt, nut or threads
   (Also clean the threads when replacing the bolt.)
   (2) Dry with compressed air.
   (3) Coat the specified seal lock agent to the bolt thread.

HANDLING THE FIPG (LIQUID GASKET)

Use 1280B made by THREEBOND or seal packing black for the FIPG
The part number is set as 08826-76001-71

Example of coating location description



Coating method and parts reassembly procedure

CAUTION
When removing the gasket, make sure that shreds from the gasket do not enter the engine

(1) Clean the connection surface of parts and their contact parts with a cloth to eliminate any oil, moisture or dirt
(2) Coat the part to be reassembled with FIPG. The parts that require coating are described in the key point operations in each section
(3) Do not coat excessively or insufficiently. And be sure to overlap the beginning and end of the coat
(4) Do not move the parts after they are reassembled
(5) Reassemble within 3 minutes of coating the parts
(6) Do not charge coolant, supply oil or start the engine for 2 hours after the reassembly

Section1
TROUBLESHOOTING

Section Contents

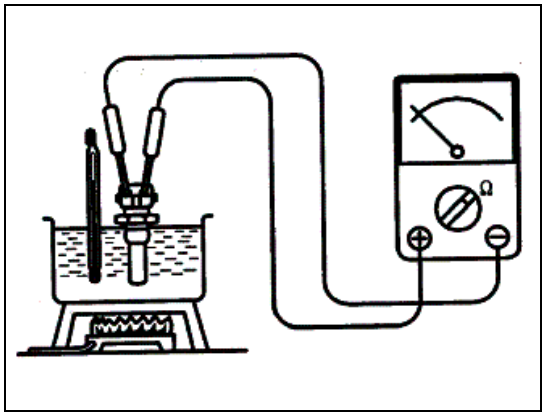


Fig.1-Inspecting the water temperature sensor

INSPECTION
WATER TEMPERATURE SENSOR

(1) Remove the water temperature sensor.

(2) Use the circuit tester, measure the resistance value between the terminals according to temperature changes.

Standard

Temperature	℃	20	80
Resistance	kΩ	2.2 ～ 2.6	0.29 ～ 0.35

(3) Install the water temperature sensor.

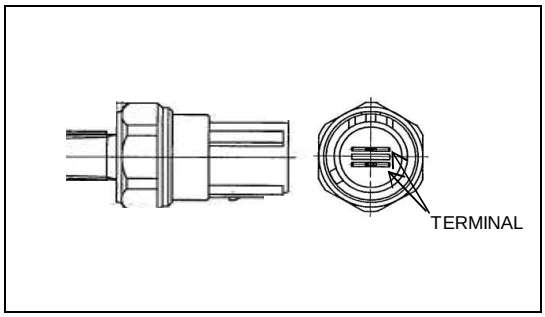


Fig.2-Inspecting the oil pressure switch

INSPECTION OIL PRESSURE SWITCH

1. Inspection at engine stop

(1) Disconnect the connectors, check the terminals of Oil pressure switch to see if they are not loose.

(2) Check electrical connection between terminals.

2. Inspection at engine running

(1) Check the oil pressure, disconnect the connectors soon after starting the engine.

(2) Check electrical disconnection between terminals.

Standard:
At engine stop: Conduction between terminals
At engine running: No conduction between terminals

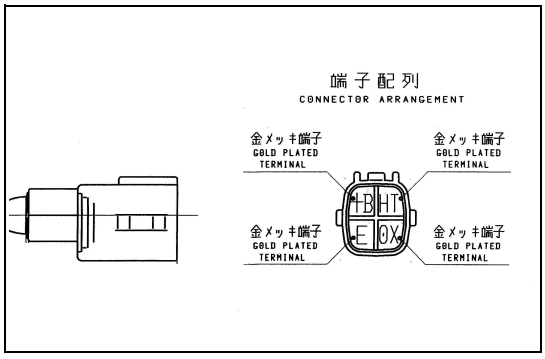


Fig.3-Inspecting the oxygen sensor

INSPECTION OXYGEN SENSOR

Since a sensor output (the terminal OX) is based on engine A/F, alone it cannot be inspected.

(1) Use the circuit tester, measure the resistance value between the terminal HT and the termina +BI at normal air temperature(ref. 20℃).

Standard:
11.7Ω～15.6Ω

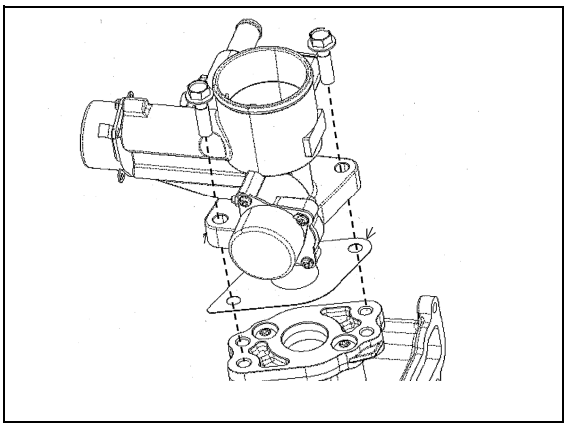


Fig. 1 - Removing ADAPTER

REMOVING ADAPTER

1. Remove two bolts and remove adapter Fig.1.

NOTICE
Remove the deposit and the foreign substance adhered in the adapter.

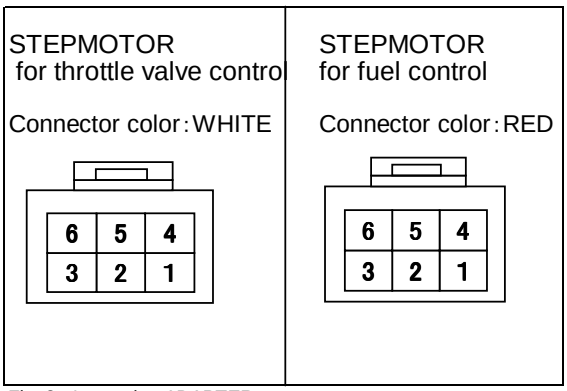


Fig. 2 - Inspection ADAPTER

INSPECTION STEPMORTOR

1. A tester is attached between the combination terminals of the following table, and resistance is measured.

The standard value between terminals

Wiring color (Terminal No)		Resistance
		STEPMORTOR
RED(4)	WHITE(5)	99Ω～121Ω
RED(4)	BROWN(6)	99Ω～121Ω
WHITE(5)	BROWN(6)	198Ω～242Ω
ORANGE(1)	YELLOW(2)	99Ω～121Ω
ORANGE(1)	BLUE(3)	99Ω～121Ω
YELLOW(2)	BLUE(3)	198Ω～242Ω

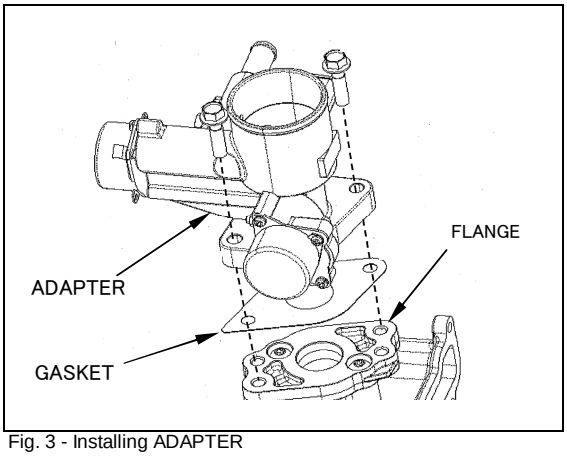


Fig. 3 - Installing ADAPTER

INSTALLING ADAPTER

1. Use 2 bolts install the adapter with a new gasket in-between.
   Torque bolts to 21 Nm.

NOTICE
Replace the gaskets with new parts.

TROUBLESHOOTING

MECHANICAL TROUBLE

The causes of engine faults are divided into 3 factors of gas engines.

3 Factors of gas engines

3 factors	Main functional parts
Good air-fuel mixture	Mixer etc
Good compression	Engine body (Intake and exhaust valves, piston rings, cylinders etc.)
Good ignition	Ignition coil, spark plugs, resistive cord and ignition

The basics are as described above, however, since insufficient maintenance also gives rise to faults. Carry out pre-inspection of the following items

Pre-inspection item	
Coolant	Spark plugs
Engine oil	Ignition timing
Battery and terminals	Looseness in any engine part
Air cleaner	

For the troubleshooting of the electronic control system, please refer to the repair manual for each unit

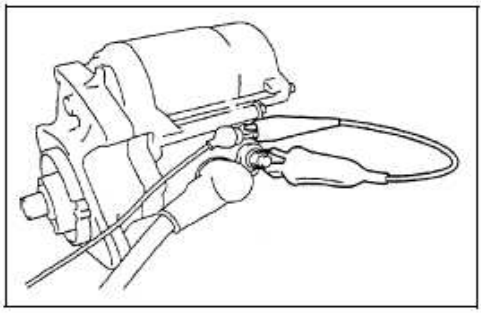
List of Items

Statue	Fault
Engine has trouble in starting or does not start	Engine does not crank normally
	Engine does not start easily, or does not start at all
Engine running rough	Engine is rough, or stops, during idling Cannot accelerate smoothly (including hesitation) Insufficient power output (including hunting)
Engine overheats	-
Excessive fuel consumption	-
Abnormal combustion	Knocking Run on After fire Back fire
Abnormal engine noise, or noisy engine	Noise that changes with operation of the clutch pedal Noise that is often heard during idling Noise that is often heard at a certain engine speed Noise that is often heard regardless of engine speed
Excessive engine oil consumption	-

ENGINE DOES NOT CRANK NORMALLY

When the ignition key switch is turned ON, the starter motor does not respond, or makes an abnormal noise

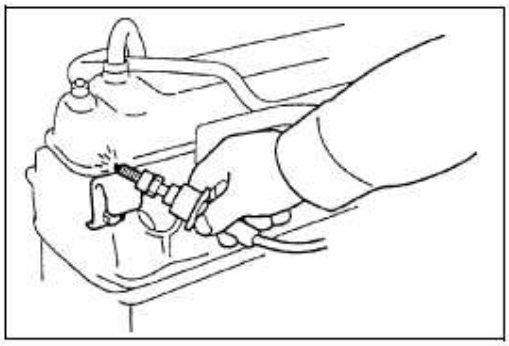
Phenomenon	Main places for inspection and adjustment
Starter does not response 【Point 1】	1. Battery
	2. Battery cables
	3. Ignition key switch
	4. Starter unit
	5. Neutral safety switch
Slow cranking speed or clicking sound	1. Battery
	2. Starter motor
	3. Engine body (When all the plugs are removed, the engine should rotate easily)
"Rev and rattle" sound	1. Starter clutch
	2. Ring gear
	3. Magnetic switch



【Point 1】
To test whether the fault is with the circuit to the starter motor, or with the starter motor itself. connect the starter motor directly to the battery with the 30 terminal and 50 terminal leads. If the starter motor turns, then the fault is in the circui

ENGINE DOES NOT START EASILY, OR DOES NOT START AT ALL

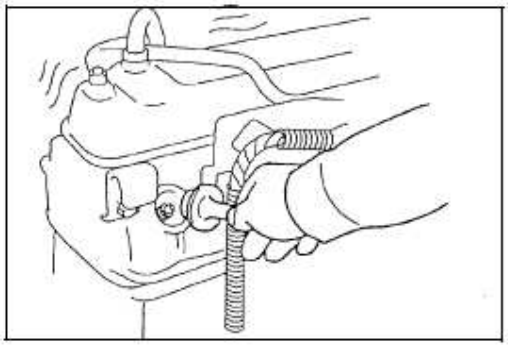
Phenomenon	Main places for inspection and adjustment
Ignition 【Point 1】	1. Spark plugs
	2. Plug cords
	3. Ignition key switch
	4. Ignition coil
	5. Igniter
	6. Ignition timing
Fuel	1. Fuel
	2. Mixer
Compression	1. Valve
	2. Piston rings
	3. Piston
	4. Cylinder



【Point 1】
Inspect sparks using the spark plug
Remove the spark plug and position it about 6 to 8mm (0.24 to 0.31 in.) away from earth. Normally, during cranking, a strong spark should fly out. Check all the plugs in the same way.
If there is no spark at all, inspec

ENGINE IS ROUGH, OR STOPS, DURING IDLING

Phenomenon	Main places for inspection and adjustment
Engine is rough during idling【Point 1】	1. Mixer
	2. Resistive cord
	3. Ignition coil
	4. Ignition timing
	5. Valve contact
	6. Plug



【Point 1】
Inspect non-combusting cylinders
Hold the bottom of the resistive cord and pull it off from the plug. Work though each cylinder, disconnecting the cord end from the spark plug terminal and stopping the spark. Inspect for the presence of combustion by chec

CANNOT ACCELERATE SMOOTHLY (INCLUDING HESITATION)

Phenomenon	Main places for inspection and adjustment
Ignition	1. Spark plugs
	2. Ignition timing
	3. Ignition circuit
Compression	1. Intake and exhaust valve contact
	2. Piston rings
	3. Piston
	4. Cylinder

INSUFFICIENT POWER OUTPUT (INCLUDING HUNTING)

Phenomenon	Main places for inspection and adjustment
Ignition	1. Ignition timing
	2. Ignition circuit
Fuel	1. Mixer
Compression	1. Valve
	2. Piston rings
	3. Piston
	4. Cylinder

ENGINE OVERHEATS

Phenomenon	Main places for inspection and adjustment
Ignition	1. Ignition timing
Compression	1. Cylinder Head gasket
	2. Cylinder head
	3. Cylinder block
Cooling	1. Coolant

EXCESSIVE FUEL CONSUMPTION

Before beginning troubleshooting, ask the following questions and respond as necessary.

1. When did it start? (Since the unit was new, recently, since it has become colder etc.)
2. High fuel consumption compared with what? (The unit used previously, a similar unit, other manufacture's unit
3. What is the unit being used for?
4. Others

Factors in high fuel consumption	1. Engine structure (Compression ratio, improved fuel bumming, cooling loss, mechanical efficiency etc)
	2. Unit structure (drivetrain system etc.)
	3. Conditions in the usage environment (weather, load environment, operation method altitude etc.
	4. Maintenance status of the engine and unit (Ignition timing, air-fuel mixture, compression pressure etc.)

Places for inspection and adjustment when fuel consumption has become greater than previously

Classification	Main places for inspection and adjustment
Ignition	1. Ignition timing
Fuel	1. Mixer
Compression	1. Valve
	2. Piston rings
	3. Piston
	4. Cylinder
Cooling	1. Coolant temperature【Point 1】

【Point 1】
If the temperature of the engine coolant becomes too high or too low, optimal fuel combustion cannot be achieved and fuel consumption increases. In particular, if repeated traveling and loading is carried out when the engine is cold, the combustion timing

ABNORMAL COMBUSTION

The abnormal noises and other noises caused by abnormal combustion in the engine are classified as follows

1. Knocking
   On sudden acceleration, a high pitched "ping ping" knocking sound is heard. This has a bad effect on the piston and valves, and will also damage the engine
2. Run on
   Even after the ignition key switch has been turned OFF, combustion continues in the combustion chamber, and the engine continues to run erratically.
3. After fire
   When traveling for a long time under engine braking, or when the throttle valve is suddenly released, a loud "bang" is heard due to an explosion in the exhaust system, with flame being visible around the
4. Back fire
   The combustion does not complete within the explosion cycle, and continues until the intake valve opens for the next cycle, igniting the air-fuel mixture while it is still being intake. This causes a back fire, in which the air-fuel mixture in the intake

Knocking

Classification	Main places for inspection and adjustment
Ignition	1. Ignition timing
	2. Spark plugs
	3. Carbon build-up in the combustion chamber

Run on

Classification	Main places for inspection and adjustment
Ignition	1. Spark plugs
	2. Carbon build-up in the combustion chamber

After fire

Item	Inspection content
Fuel, intake system	Check the operation and adjustment of parts that might make the air-fuel mixture too rich. ・ Air cleaner element clogging
Ignition timing, spark advance	Check the initial setting of the ignition timing and that the spark advance is operating norm ・ Is the timing too retarded when idling? ・ Spark advance operation inspection (Do the vacuum advancer and the governor controller start operating a little late when the throttle valve is suddenly released?) ・ Is the stationary plate not sliding well?
Spark plugs, ignition device	Correct the cause of any occasional missing of the ignition Are the specified spark plugs being sued? Inspect for soling, wear or gap defect of the spark plugs. Inspect for soling or poor connection in the secondary circuit of the ignition system.

Back fire

Item	Inspection content
Fuel, intake system	Check the operation and adjustment of parts that might make the air-sue mixture too lean. ・ Air being sucked in from the intake manifold
Ignition timing, spark advance	Inspect to see whether the ignition timing is too retarded ・ Is the timing too retarded when idling? ・ Timing control operation inspection (this occurs easily after engine O/H, or reinstalling of the Crank position sensor - whenever the timing is extremely out)
Valve timing	Is the valve timing out?

ABNORMAL ENGINE NOISE, OR NOISY ENGINE

Further breakdown of abnormal noises, or excessive noise generation is as follows.

1. Noise that changes with operation of the throttle valve
2. Noise that is often heard during idling
3. Noise that is often heard at a certain engine speed
4. Noise that often heard regardless of engine speed

Noise that is often heard during idling

Probable cause	Example of sound	Notes
Oil seal squeal	Squealing sound Chirping sound	Apply engine oil from outside the seal, or spray an anti-squealing agent. ・ The sound becomes quieter or stops.
Crankshaft thrust direction play	Gravely sound Ratting sound	Put a sound scope near the timing gear cover to check. ・ When the engine is warmed up, the sound can be heard clearly When the engine is warm, if the engine is taken from idle to high speed, the sound becomes small, or stops. Inspect the sprocket gear run out.
Camshaft bearing wear	Knocking sound Dull knocking sound	Put a sound scope on the camshaft bearing section to check. ・ The sound becomes quieter at high speed.
Wear inside the oil pump drive gear	Whirring sound Clattering sound	Put a so0und scope on the oil pump drive gear check. Remove the oil pump drive gear
Defective contact of the valve and seat	Clicking sound	Check the valve clearance. Put a sound scope near the cylinder head valve to check. ・ The sound becomes smaller or stops when the valve is sticking
Improper contact or damage to the valve lifter	Clicking sound	Put a sound scope in the cylinder head to check. ・ This sound often occurs when a pushrod is not turning. ・ Remove the lifter and inspect the contact surface.
Run out of oil on valve rocker arm	Grating sound Squeaking sound	The sound becomes smaller or stops if engine oil is applied, or if the valve rocker arm position is shifted.
Air intake noise	Sucking noise Hissing noise	Inspect the intake manifold and air cleaner for appropriate installat ・ Try plugging the place where the air gets in with engine oil, grease or cotton waste.

Noise that is often heard at a certain engine speed

Probable cause	Example of sound	Notes
Side knocking of the piston	Knocking sound	The knocking sound is loud when the engine is cold, and grows quieter or stops as the engine warms up. ・ Since aluminium alloy piston expand more than the cylinder, the piston clearance grows smaller and the side knock grows smaller
		If the spark plug is disconnected, the sound changes and generally grows quieter.
Knocking of the connecting rod bearing	Knocking sound	This can be heard loudly from the bottom of the engine when acceleration after warm-up or directly after acceleration. When the engine is at the speed when the knocking sound usually occurs (about 1000rpm), if the spark plug is disconnected, the sound changes, generally becoming quieter.
Crankshaft bearing knocking	knocking sound	This can be heard loudly from the bottom of the engine when accelerating after warm-up or directly after acceleration. ・ The sound does not change even if the spark plug is disconnec ・ This is a somewhat lower, sharper sound than the connecting rod bearing knocking.
piston pin knocking	Knocking sound Ratting sound	The noise gets louder as the engine warms up, and is a harder sound than the piston side knocking When the engine is at the speed when the knocking sound usually occurs (about 1000rpm), if the spark plug is disconnected, the knocking sound changes.
Timing chain wear	Grating sound Scraping sound	Put a sound scope on the timing chain cover to check. The noise becomes louder if the engine id run at high speed.

Noise that is often heard regardless of engine speed

Probable cause	Example of sound	Notes
Excess valve clearance or faulty contact	Clicking sound Clattering sound	Inspect for the presence of valve clearance using a thickness gaug ・ If there is a clearance, the sound stops. In this case, correct the oil tappet. ・ If the sound does not stop, there is a defect in the contact of the rocker arm and the valve
Valve sticking sound	Creaking sound Squeaking sound	Put a sound scope on the valve section to check. ・ The sound becomes quieter or stops if engine oil is applied, or an anti-squealing agent is sprayed on.
Exhaust leak	A "raspberry"sound A "put-put"sound	Check by holding a wet cloth to the spot on the exhaust system to plug where the leak is suspected to be. ・ The noise becomes louder when the engine speeds
Compression leak	Hissing sound	Disconnect the spark plug to inspect. ・ When disconnected, the sound becomes quieter or stops. Apply oil to the cylinder head gasket and to the spark plug gasket attachment section to check. ・ If there is a leak. The oil blows out. If the gasket is destroyed, the combustion gas may leak into the cooling system, causing bubbles to from in the top of the radiator.

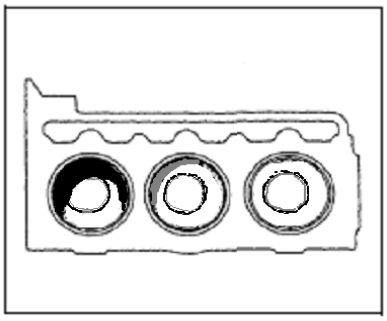
EXCESSIVE ENGINE OIL CONSUMPTION

A classification of oil consumption by the main phenomena is as follows

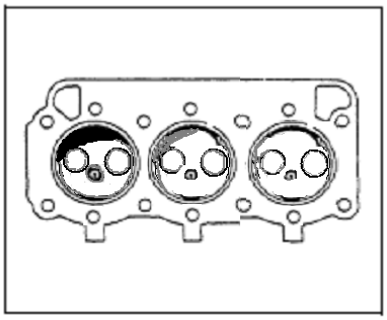
1. Oil loss via the piston ring
   This is when the oil that lubricates the cylinder walls gets into the combustion chamber.
   After the engine has warmed up, after left idling or operated at about 1000 rpm for 4 to 5 minutes, if the engine is raced, a large amount of white-purple exhaust is output for the first 30 to 60 seconds, thereafter tending to become less. In this case, i

2. Oil loss via the valve guide
   This is when the oil enters the combustion chamber from the clearance between the valve stem and the valve guide.
   After warming the engine, race it at about 2000 rpm and inspect the exhaust gas. At this time, a large amount of white-purple exhaust gas is exhausted, and their output increases gradually if the engine speed is increased.
3. In-flow from the crankcase emission control system (PCVdevice)

Phenomenon	Main places for inspection and adjustment
Leaking to the exterior of the engine	1. Engine body
Leaking to the interior of the engine	1. Cylinder head
	2. Cylinder block
	3. Head gasket
	4. Oil loss via the piston ring【Point 1】
	5. Oil loss via the valve guide【Point 2】



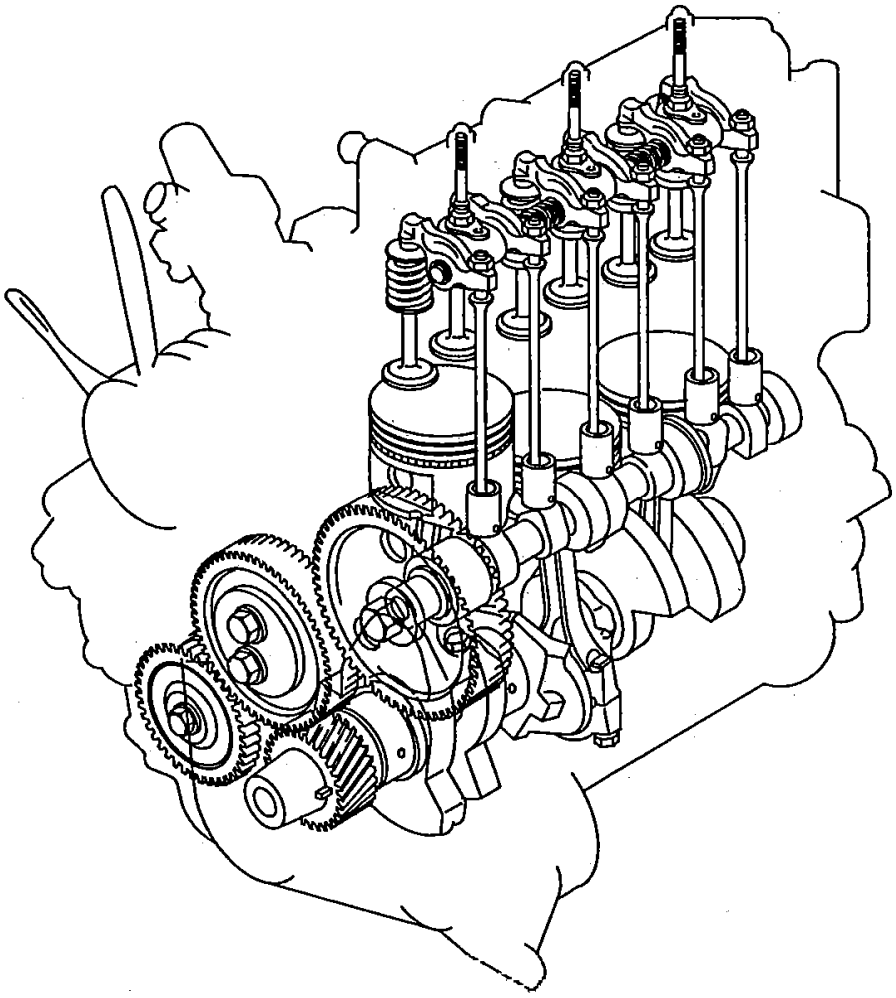
【Point 1】
Inspect for oil loss the piston ring
A lot of carbon built-up will be visible around the top of the piston.



【Point 2】
Inspect for oil loss the valve guide
This can be determined from the carbon build-up on the intake valve head and on the top of the piston, and how wet with oil the valve head is.

Section2
CYLINDER HEAD & VALVE

Section Contents



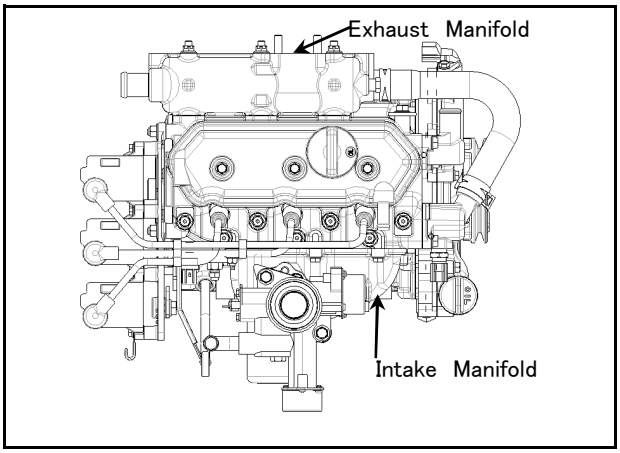


Fig.1-Remove Exhaust Manifold

REMOVING CYLINDER HEAD

1. Remove Water hoses
2. Remove Intake and Exhaust Manifold

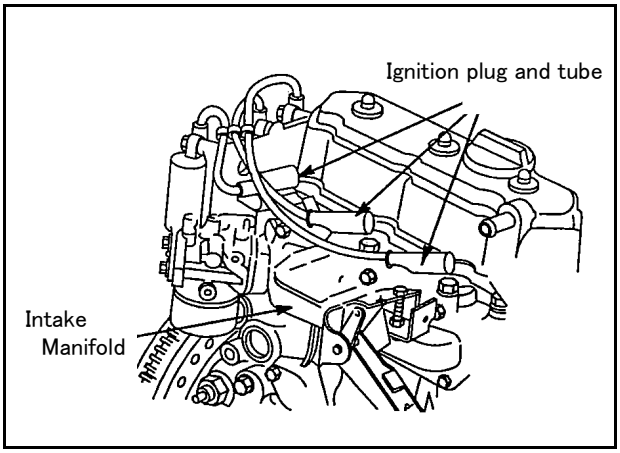


Fig.2-Remove Intake Manifold

3. Remove Intake Manifold
4. Remove Ignition plug and tube

   Use an ignition plug wrench and remove ignition plugs (3pcs.) and ignition plug tube (3 pcs.)

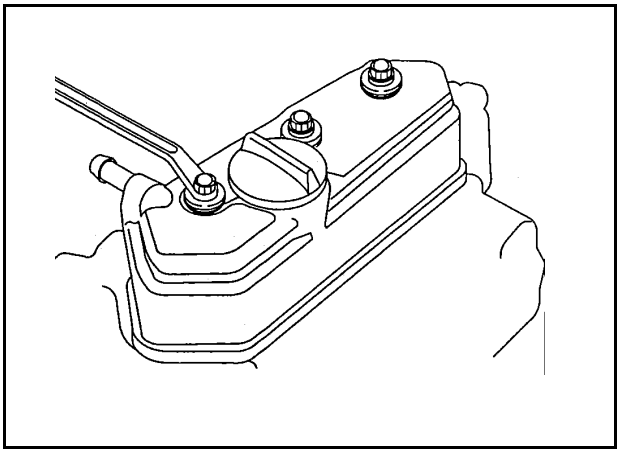


Fig.3-Remove cylinder head cover

5. Remove Cylinder head cover

   (1) Cap Nut (3 pcs.)
   Gasket (3 pcs.)
   (2) Cylinder head cover Gasket

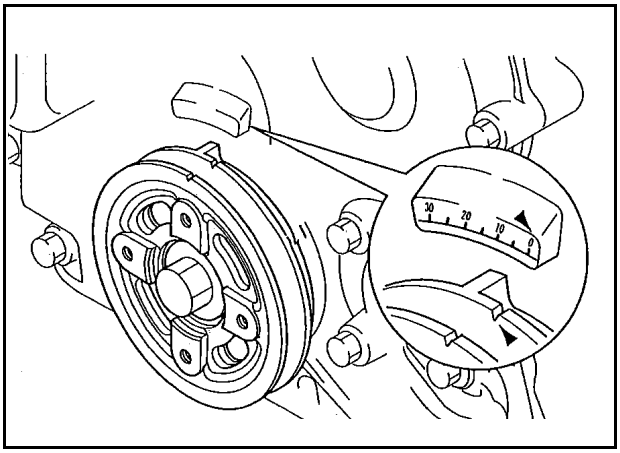


Fig.4-Set Cylinder No. 1 At TDC

6. Set No. 1 piston at TDC

   (1) Rotate crankshaft pulley until timing mark on pulley is aligned with reference point on timing cover.

   (2) If intake and exhaust valves have clearance, No. 1 piston is at TDC - compression stroke.

   (3) If intake and exhaust valves do not have clearance, turn crankshaft pulley one complete revolution. Valves will then have clearance.

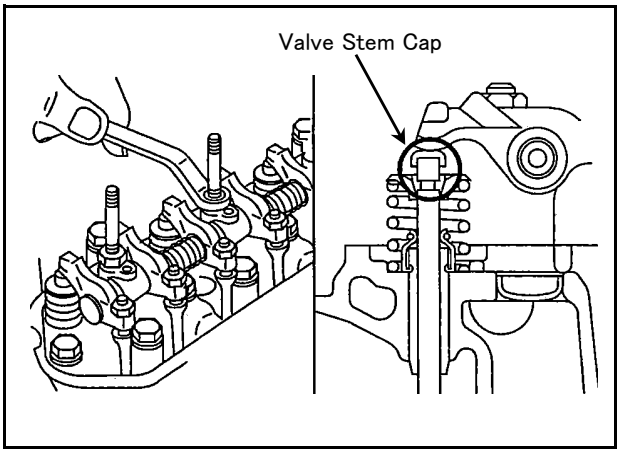


Fig.5-Remove valve rocker shaft

7. Remove Valve rocker shaft assy

   (1) Nut (3 pcs.) , Washer (3 pcs.)

   (2) Remove the valve rocker shaft ASSY.

   (3) Remove the Valve Stem Cap

8. Remove Valve push rod

NOTE
Mark push rods so that they may be reassembled in their original position.

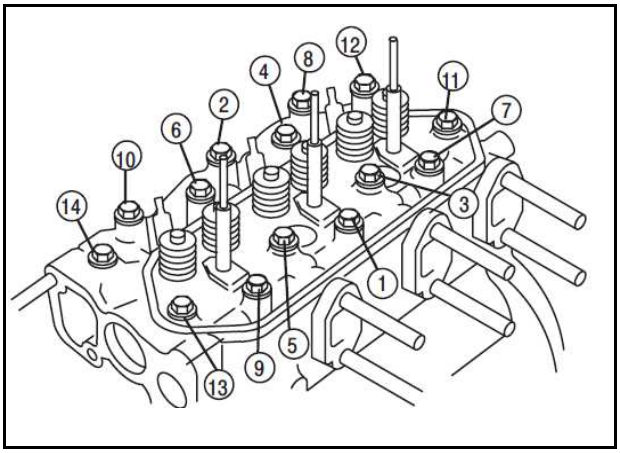


Fig.6-Loosen Cylinder Head Bolts

9. Remove cylinder head assembly.

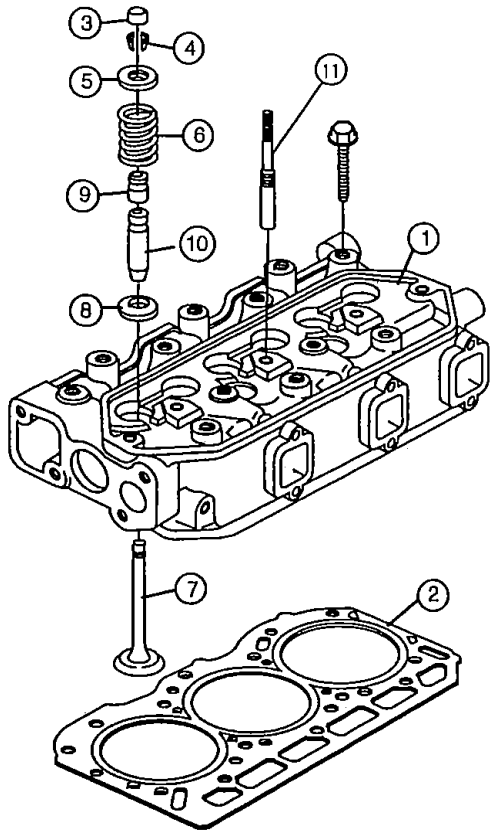
   (1) Loosen cylinder head bolts in the order shown.

   (2) Remove set bolts hanger.

   (3) Remove the cylinder head from the cylinder block.

NOTE
Carefully prevent the cylinder head installation surface from any damage.

DISASSEMBLE CYLINDER HEAD



1 . HEAD, CYLINDER
2 . GASKET, CYLINDER HEAD
3 . CAP, VALVE STEM
4 . LOCK, VALVE SPRING RETAINER
5 . RETAINER, VALVE SPRING
6 . SPRING, COMPRESSION
7 . VALVE
8 . SEAT, VALVE SPRING
9 . SEAL, VALVE STEM OIL
10 . BUSHING, VALVE GUIDE
11 . BOLT, STUD

CYLINDER HEAD COMPONENTS

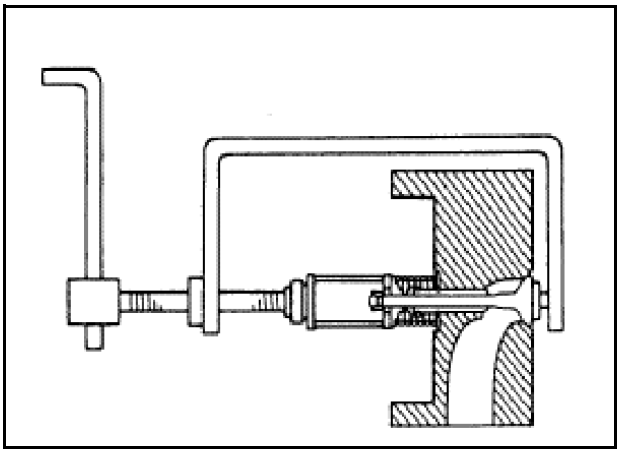


Fig.7-Remove the valve

1. Remove Valve

   (1) Set the Valve Spring Compressor to the valve to comp the valve spring, and remove two retainer locks.

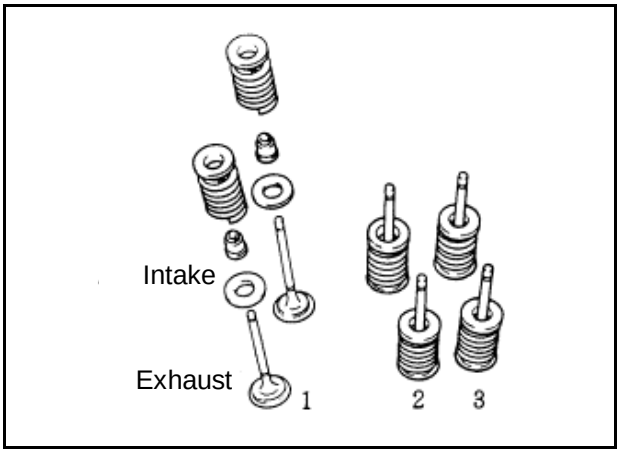


Fig.8-Valve components

   (2) Remove spring retainers, springs, seats, valve and oil seal.

NOTE

Remove parts shall be arranged orderly for each cylinders.

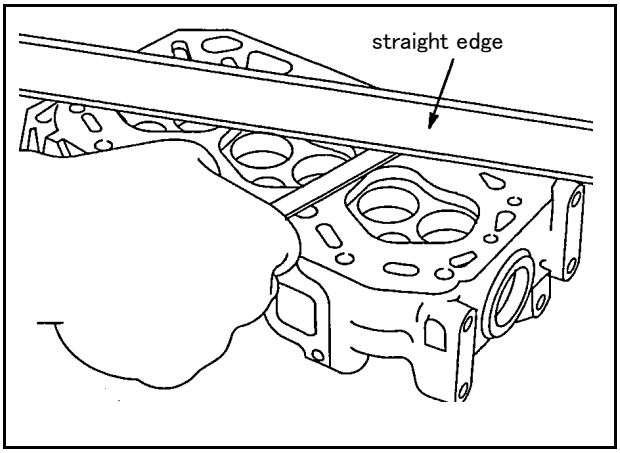


Fig.9-Check Cylinder Head For Distortion

INSPECT AND REPAIR

Be sure all gasket material is removed from surfaces before checking. Use a gasket scraper if necessary.

a. Inspect cylinder head for cracks or damage.

b. Use a straight edge and check cylinder head lower surface for distortion.

c. Check intake and exhaust manifold mounting surfaces.

If mounting surfaces are distorted more than 0.1 mm, the cylinder head must be replaced.

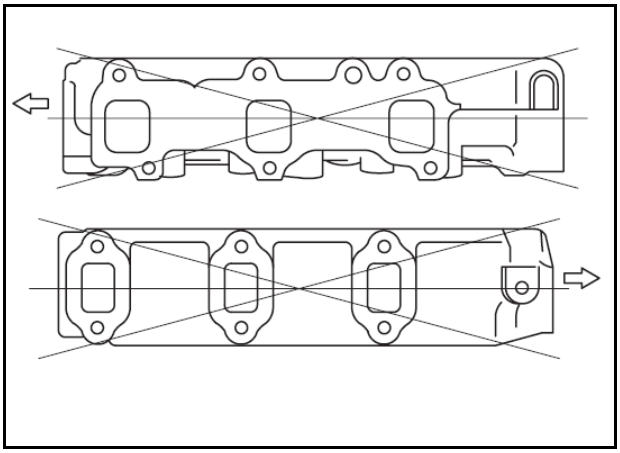


Fig.10-Check Cylinder Head For Distortion

It is not recommended that cylinder head mounting surfaces be resurfaced.

NOTE

Intake manifold and exhaust manifold may be checked in the same manner. Use same specifications as cylinder head.

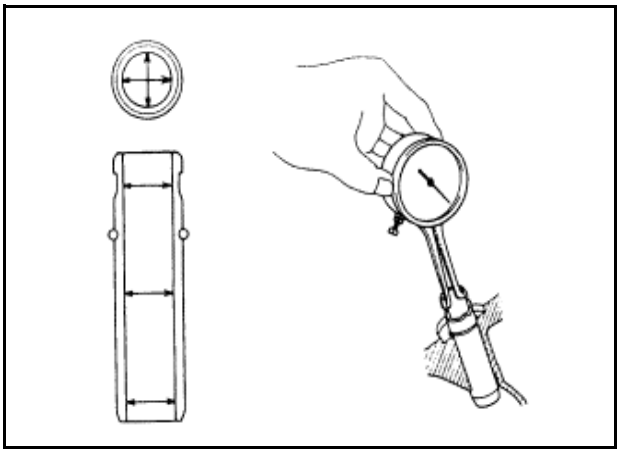


Fig.11-Check the valve guide bush inside diameter

3. Check Valve guide bush

   (1) Use a caliper gauge and measure the inside diameter of the valve guide bush.

   LIMIT 6.10mm

   If the limit is exceeded, replace the valve guide bush

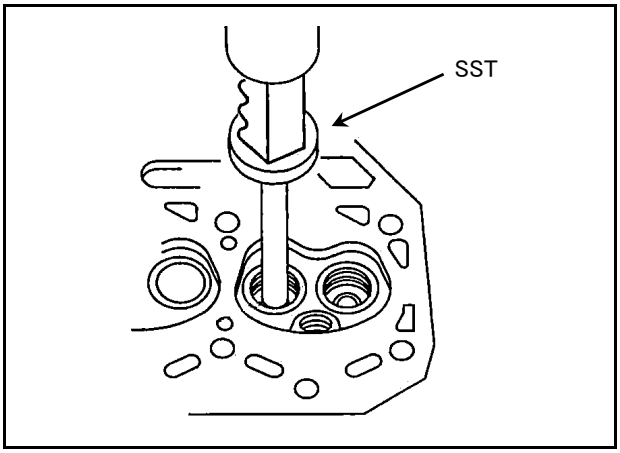


Fig.12-Remove Valve Guide Bushing

4. Remove valve guide bushing if required.

   (1) Use bushing driver, SST, press out valve guide bushing from combustion chamber side.

   (2) Check valve guide bushing OD. Then see specifications below.

   Std. Bushing OD: - 11.05 mm
   Replacement Bushing OD: - 11.08 mm

   (3) If bushing OD measurement indicates that a replacement bushing has already been installed, the cylinder head must be replaced.

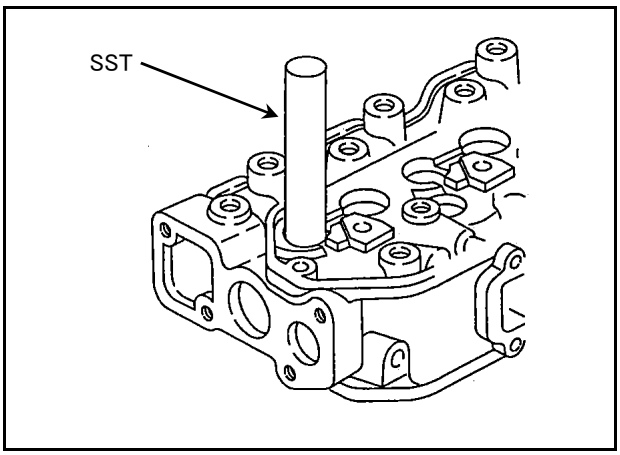


Fig.13-Installing Valve Guide Bushing

5. Using bushing driver, SST, press in new valve guide bushing until tool bottoms on cylinder head

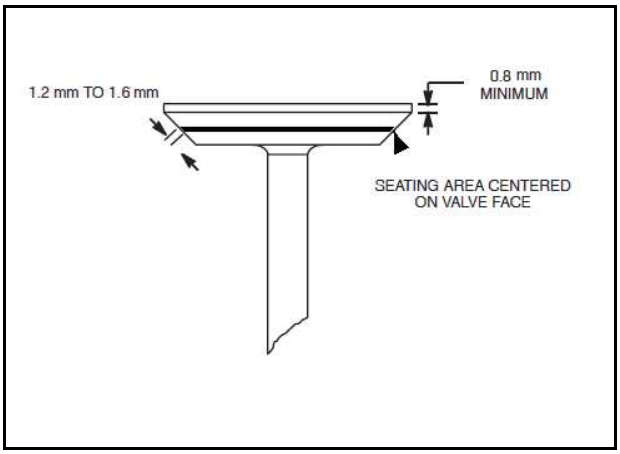


Fig.14-Valve Dimensions

6. Check Valve

   (1) Measure the valve head margin thickness

   Standard 1.2～1.6mm

   Limit 0.8mm

   If the thickness is less than the limit, replace the valve

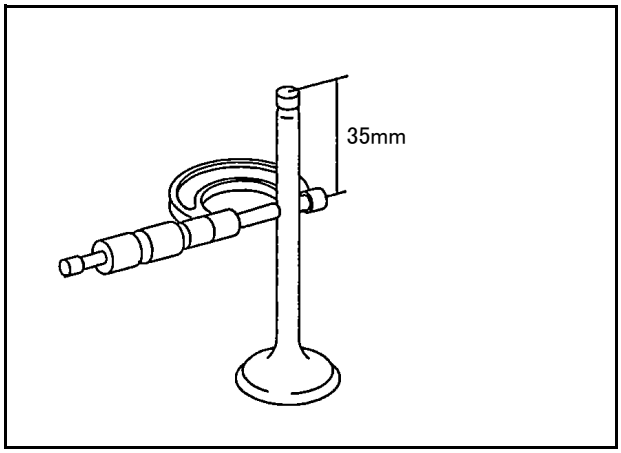


Fig.15-Measure Valve Stem Diameter

(2) Measure valve stem diameter at specified distance from end of valve, as shown in Fig.15.

LIMIT IN: 5.952mm
EX: 5.948mm

If the limit is exceeded, replace the valve

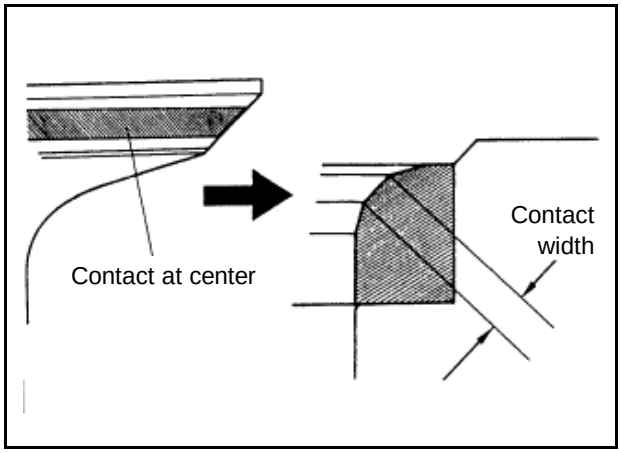


Fig.16-Check the valve contact position and width

7. Check Valve and valve seat contact
   (1) Thinly coat red lead on the valve face
   (2) Insert the valve into the valve guide bush. Push the valve lightly against the valve seat, and inspect the contact position and width
   Standard
   Contact position:
   Center on whole valve circumference
   Contact width:
   1.2～1.6mm

NOTE
Do not rotate the valve when it is in contact with the seat

If standard is not satisfied, replace the valve or correct the valve seat

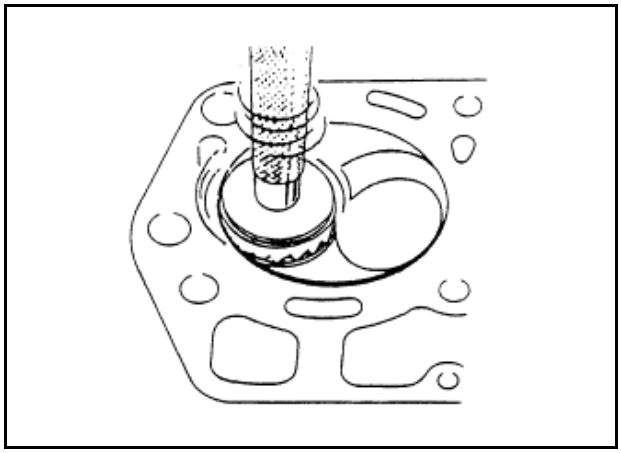


Fig.17-Correcting the Valve seat (1)

8. Valve seat correction

NOTE

- **Always inspect the valve contact position and width during the correction.**
- **Gradually release the force near the end of cutting to prevent stepping on the cut surface.**
- **Start the correcting operation after inspecting the valve guide bush.**

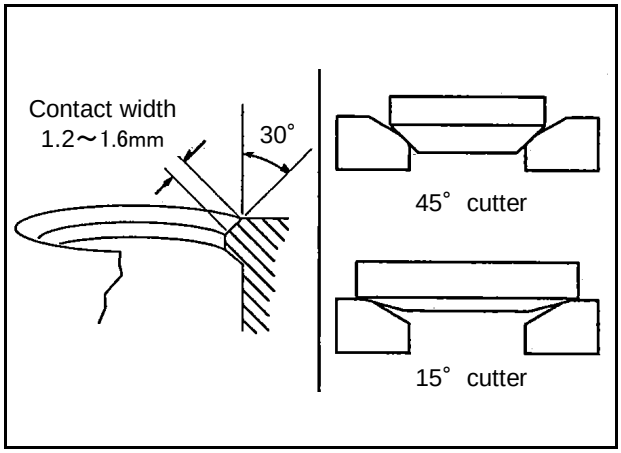


Fig.18-Correcting the valve seat (2)

(1) Use a 30°cutter and cut the minimum contact width to become wider than the standard

(2) Cut so that the contact position comes to the center of the valve face

(a) If the contact position is deviated to the outside, cut with a 15°cutter

(b) If the contact position is deviated to the inside, cut with a 45°cutter

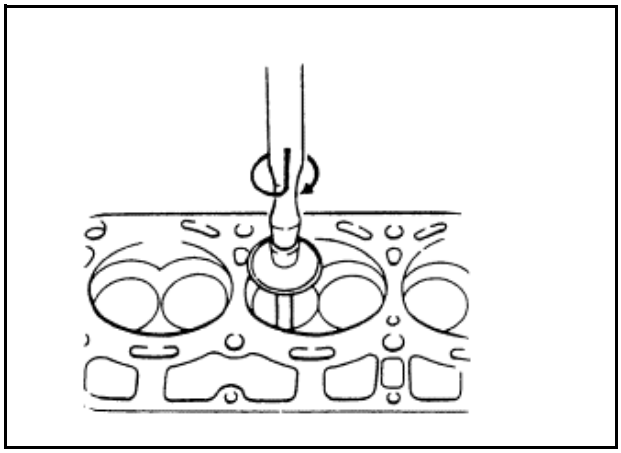


Fig.19-Lapping the valve

(3) Use a compound and lap the valve

(4) After lapping, use red lead and check that the valve contact is uniform on the whole circumference

CAUTION

Thoroughly remove the compound after valve lapping

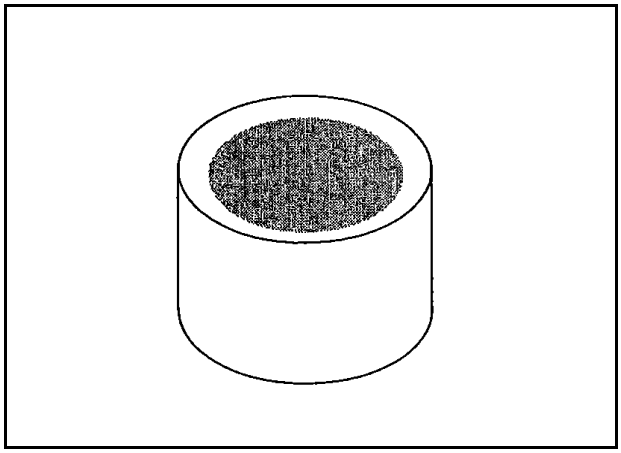


Fig.20-Check Valve Stem Cap

9. Inspect valve stem cap for wear.

   Replace if cap is worn recessed.

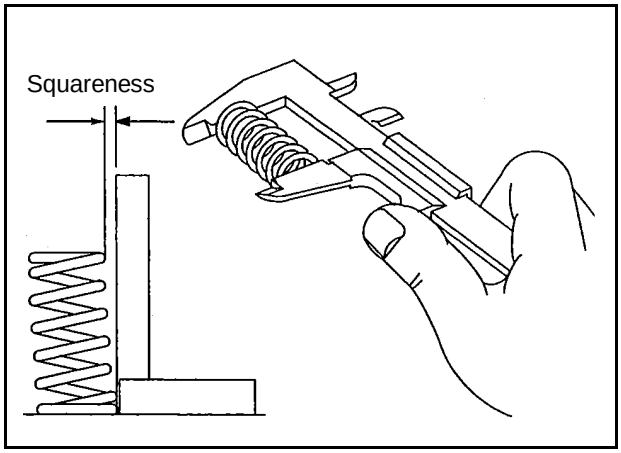


Fig.21-Check Valve Springs

10. Check valve springs for squareness and free length.

(1) Use a straight edge and thickness gauge, and measure the squareness at the top end of the valve spring.

Limit: 1.0mm

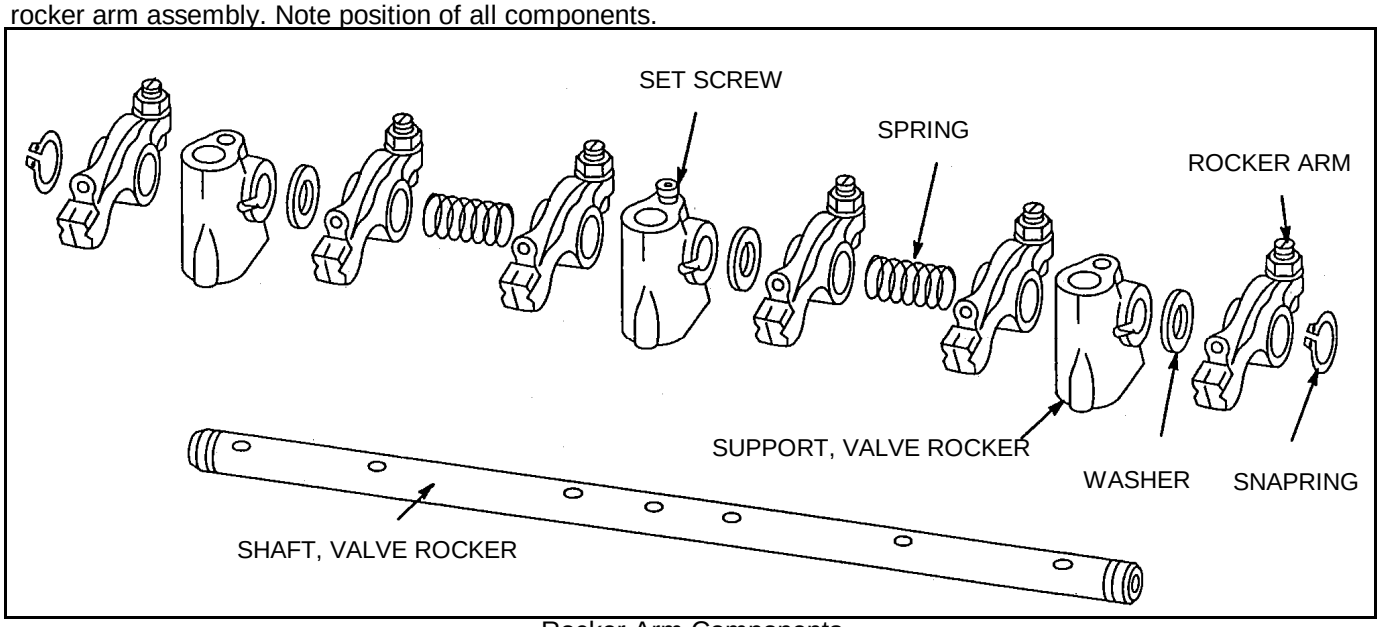
(2) Use a vernier caliper and measure the free length of the valve spring.

Limit: 30.7mm

Replace the valve spring if the limit is exceeded.

DISASSEMBLE ROCKER ARM SHAFT

Remove snap rings from ends of rocker arm shaft. Remove set screw from center rocker arm support. Disassemble rocker arm assembly. Note position of all components.



Rocker Arm Components

(1) Snapring removal (2 pcs.)
(2) Setscrew removal (1 pcs.)
(3) Other parts removal

CAUTION
Remove parts shall be arranged orderly

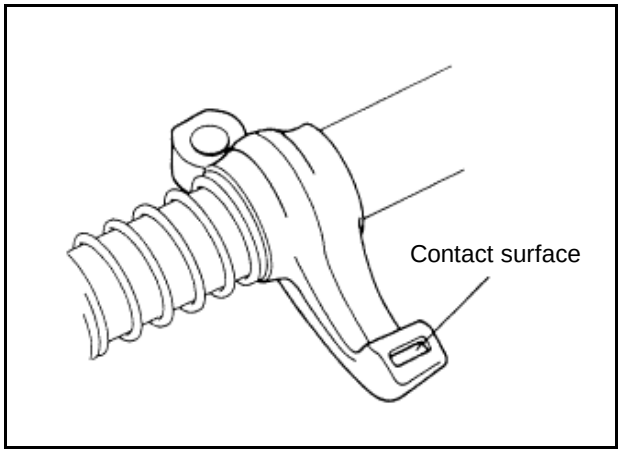


Fig.22-Check the valve rocker arm (1)

1. Check Valve rocker arm

   (1) Check the rocker arm for the wear and damage of the surface in contact with the valve stem.

   (2) If slight surface defect is found, correct with an oil stone.
   If heavily worn or damaged, replace the rocker arm.

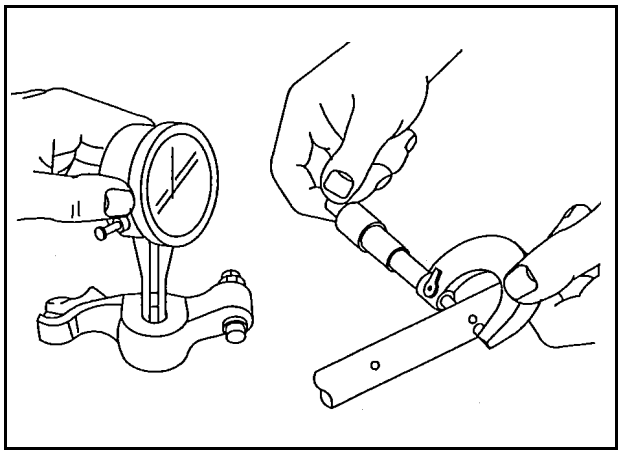


Fig.23-Checking Rocker Arm And Shaft

2. Check Rocker arm and shaft

   (1) Use a caliper gauge and measure the rocker arm inside diameter.

   Limit: 10.03mm

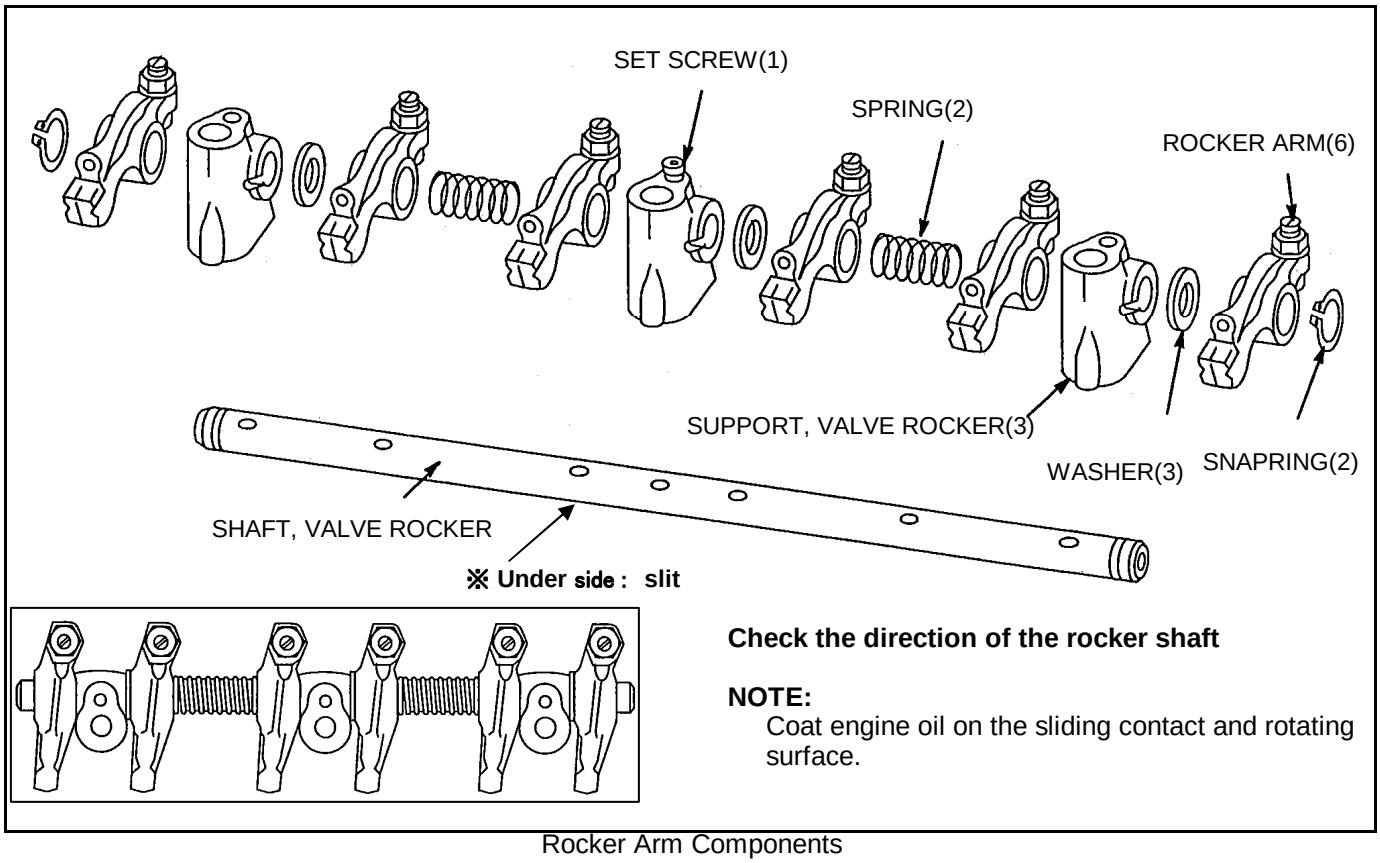
   (2) Use a micrometer and measure the rocker arm shaft outside diameter.

   Limit: 9.957mm

   If the limit is exceeded, replace the rocker arm and rocker shaft.

ASSEMBLE ROCKER ARM SHAFT

Oil all components before assembling. Small grooves in rocker shaft next to oil holes must face down. Assemble rocker arm components, noting order of assembly as shown in Fig. Note position of three thrust washers. Install set screw in center rocker arm shaft support.

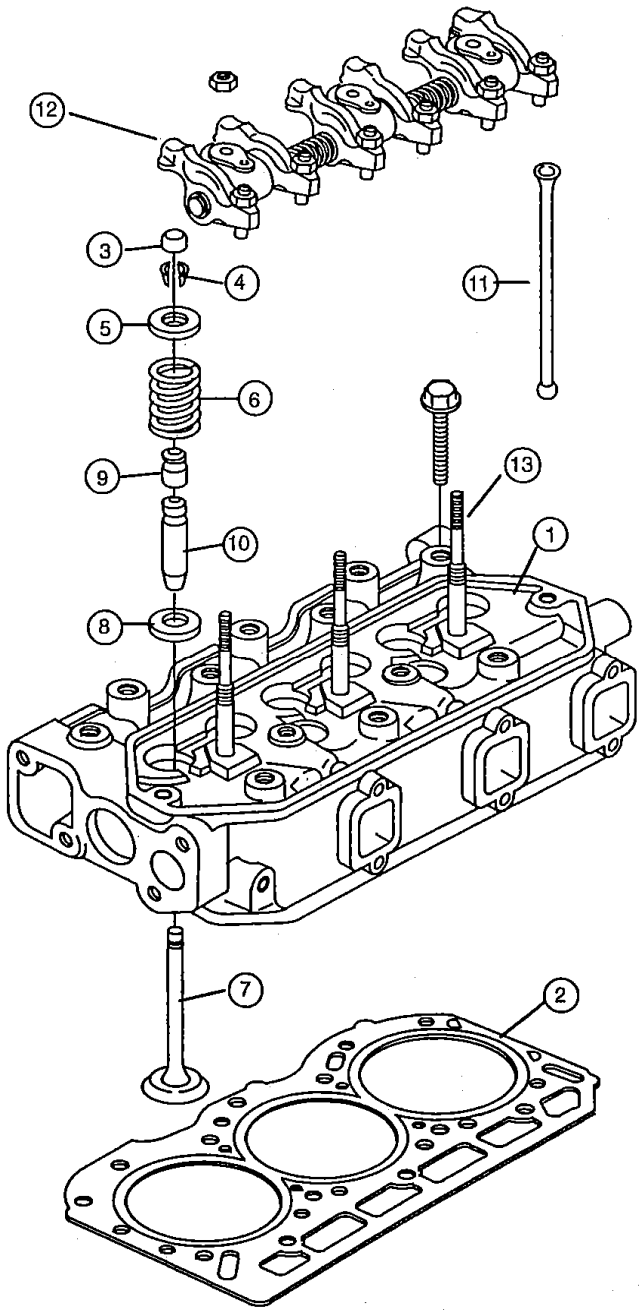


Check the direction of the rocker shaft

NOTE:
Coat engine oil on the sliding contact and rotating surface.

Rocker Arm Components

ASSEMBLE CYLINDER HEAD



1 . HEAD, CYLINDER

2 . GASKET, CYLINDER HEAD

3 . CAP, VALVE STEM

4 . LOCK, VALVE SPRING RETAINER

5 . RETAINER, VALVE SPRING

6 . SPRING, COMPRESSION

7 . VALVE

8 . SEAT, VALVE SPRING

9 . SEAL, VALVE STEM OIL

10 . BUSHING, VALVE GUIDE

11 . ROD, VALVE PUSH

12 . SHAFT ASSY, VALVE ROCKER

13 . BOLT, STUD (T=12Nm)

NOTE:
When replacing rocker arm studs, torque to 20.0 Nm

CYLINDER HEAD COMPONENTS

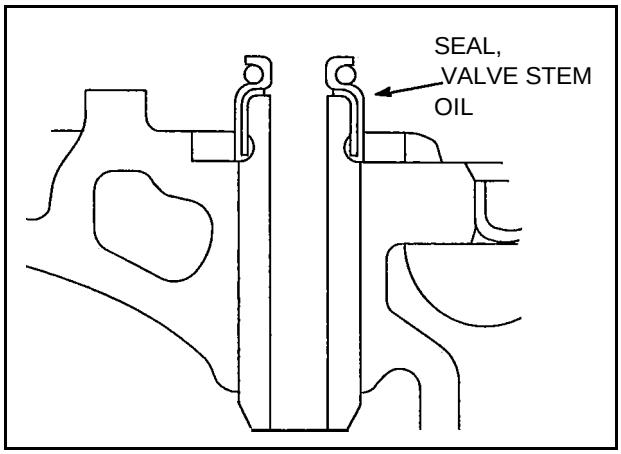


Fig.24-Install SEAL, VALVE STEM OIL

1. Install new valve stem seals.
   Oil inner surface and lip of seal before installing.
   Press seal on to valve guide bushing until it bottoms.

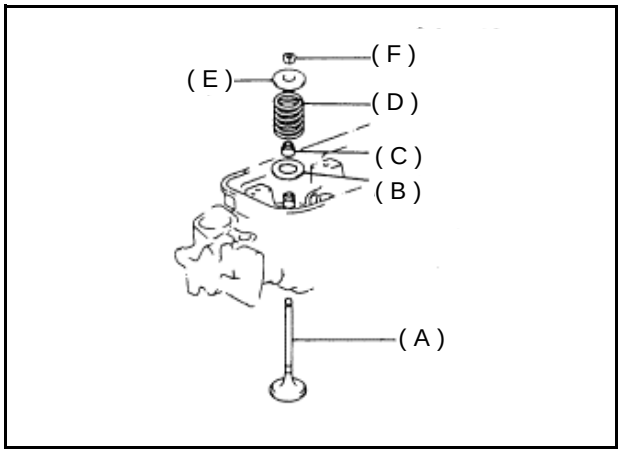


Fig.25-Assembling the valve (1)

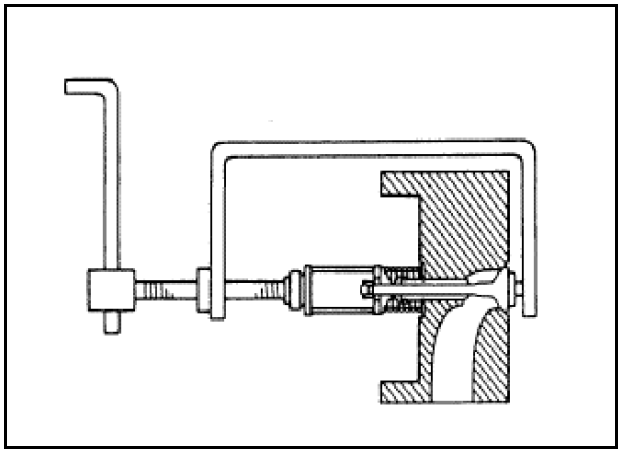


Fig.26-Assembling the valve (2)

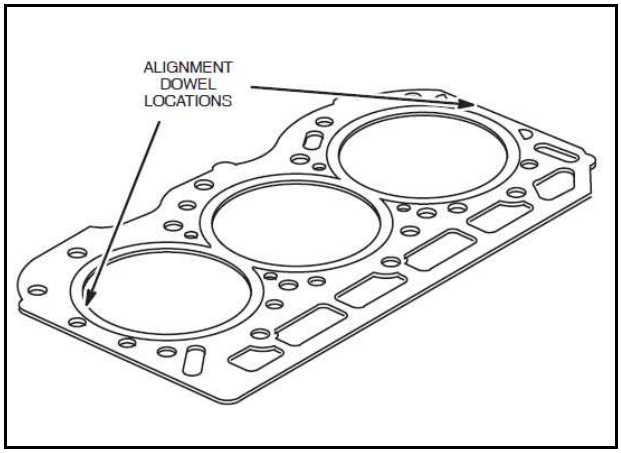


Fig.27-Install Cylinder Head Gasket

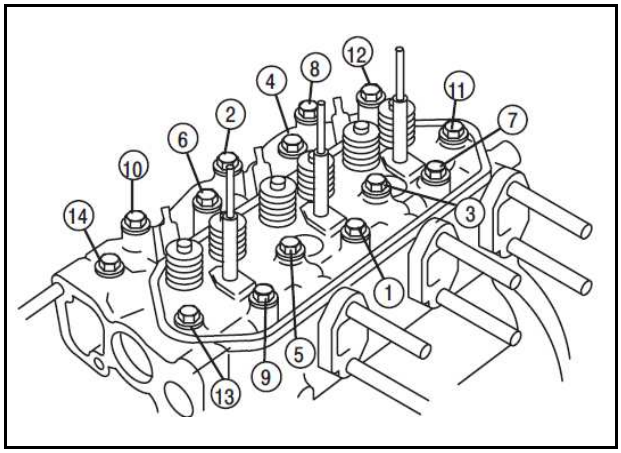


Fig.28-Install Cylinder Head Assembly

NOTE:
- Thoroughly clean the parts to be assembled.
- Coat engine oil on the sliding contact and rotating surface.
- Replace the gaskets and oil seals with new parts.

2. Valve assembly

   (1) Insert valve(A) into the valve guide bush.

   (2) Install valve spring seat(B) and oil seal(C). Coat engine oil on the valve stem and oil seal lip.

   (3) Install valve spring (D) and spring retainer (E).

   (4) Use the SST to compress the valve spring, and install spring retainer lock (F).

   (5) Tap the valve at the top lightly with a plastic hammer to settle the spring.

INSTALL CYLINDER HEAD

1. Place cylinder head gasket over alignment dowels on cylinder block

2. Install cylinder head assembly
   Lubricate threads of cylinder head bolts with engine oil.
   Torque head bolts in 13.0 Nm increments in sequence shown.
   Torque head bolts in 35.0 Nm increments in sequence shown.

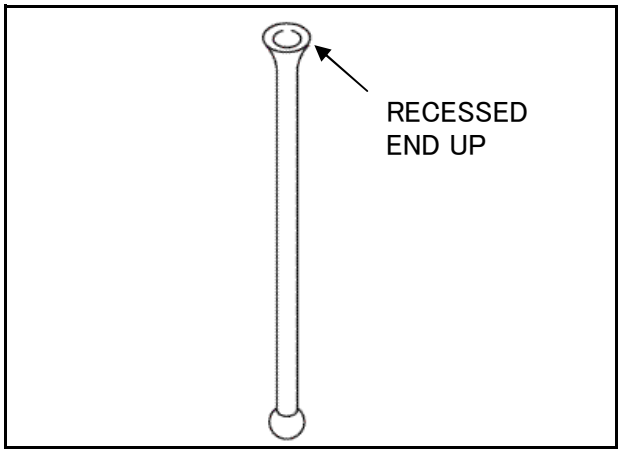


Fig.29-Install Push Rods

3. Lubricate push rods with engine oil then install with recessed end up

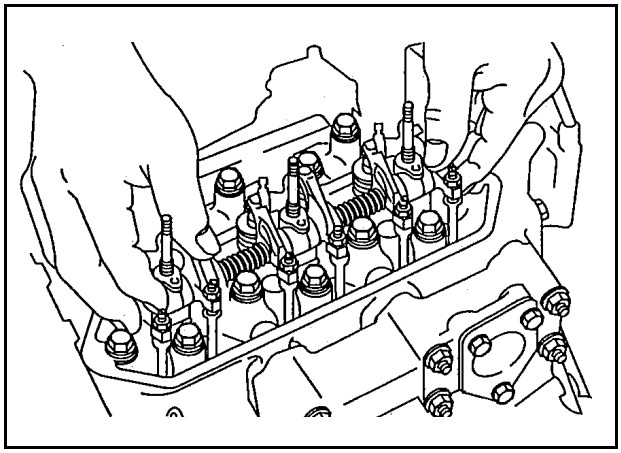


Fig.30-Install the valve rocker shaft ASSY

4. Install Valve rocker shaft ASSY

   (1) Install CAP, VALVE STEM at its original position before removal.

   (2) Install the valve rocker shaft ASSY to the cylinder head.

   (3) Install washers and torque nuts, 3 set.

   T = 19 Nm

NOTE
Make sure rocker adjustment studs are seated in recessed end of push rods.

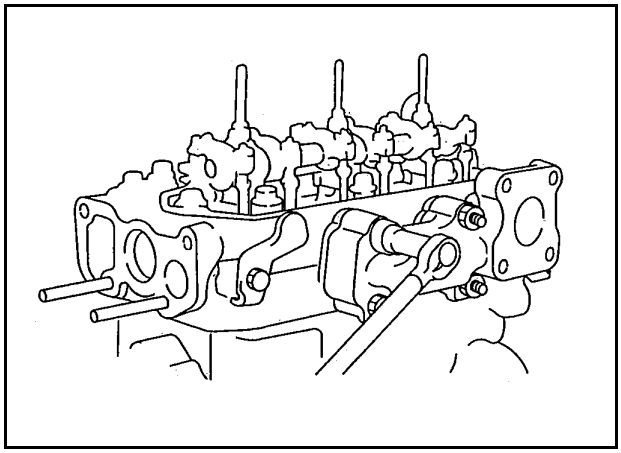


Fig.31-Install the Exhaust Manifold

5. Install Exhaust Manifold

   (1) Install a new gasket

   (2) Install the manifold ASSY, 6 set nuts.

   T = 19 Nm

6. Install Intake Manifold

   (1) Install a new gasket

   (2) Install the manifold ASSY, 4 set bolts and 2 set nuts.

   T = 8 Nm

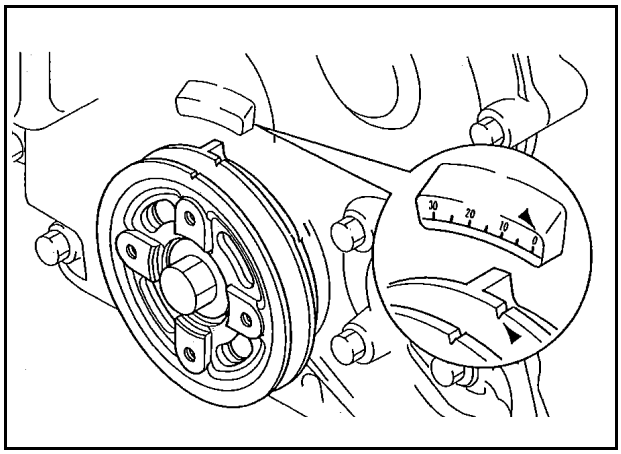


Fig.32-Set cylinder No.1 at TDC

ADJUST VALVES

1. Before adjusting valves, make sure that No. 1 cylinder is at TDC - compression stroke.

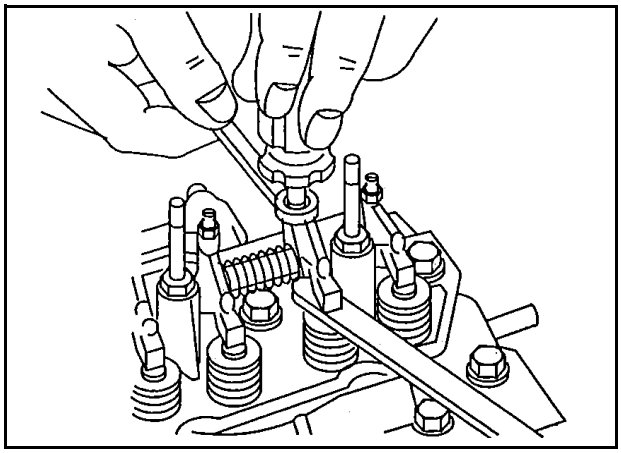


Fig.33-Adjust Valve Clearances

2. Vallve clearance adjustment

(1) Loosen the lock nut and turn the adjusting screw for adjustment.

Standard: IN 0.25±0.05mm (Cool engine)
EX 0.25±0.05mm (Cool engine)

(2) Tighten the lock nut and recheck the valve clearance

T = 11 Nm

Piston Position Cylinder		1	2	3
No. 1 piston at TDC, of compression stroke	IN	●		●
	EX	●	●	
Rotate Crankshaft 360° clockwise	IN		●	
	EX			●

Table 1-Piston position

With No. 1 piston at TDC of compression stroke, check and adjust valve clearances for cylinders shown in chart at left.

Rotate crankshaft one complete turn (360°)"clockwise to check and adjust remaining valves.

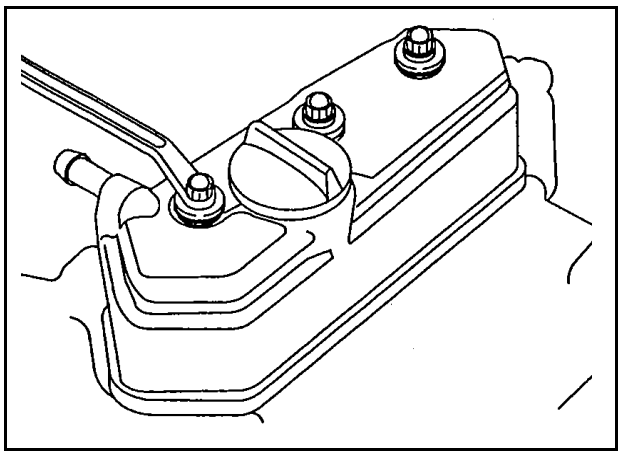


Fig.34-Install cylinder head cover

3. Install Cylinder head cover and gasket

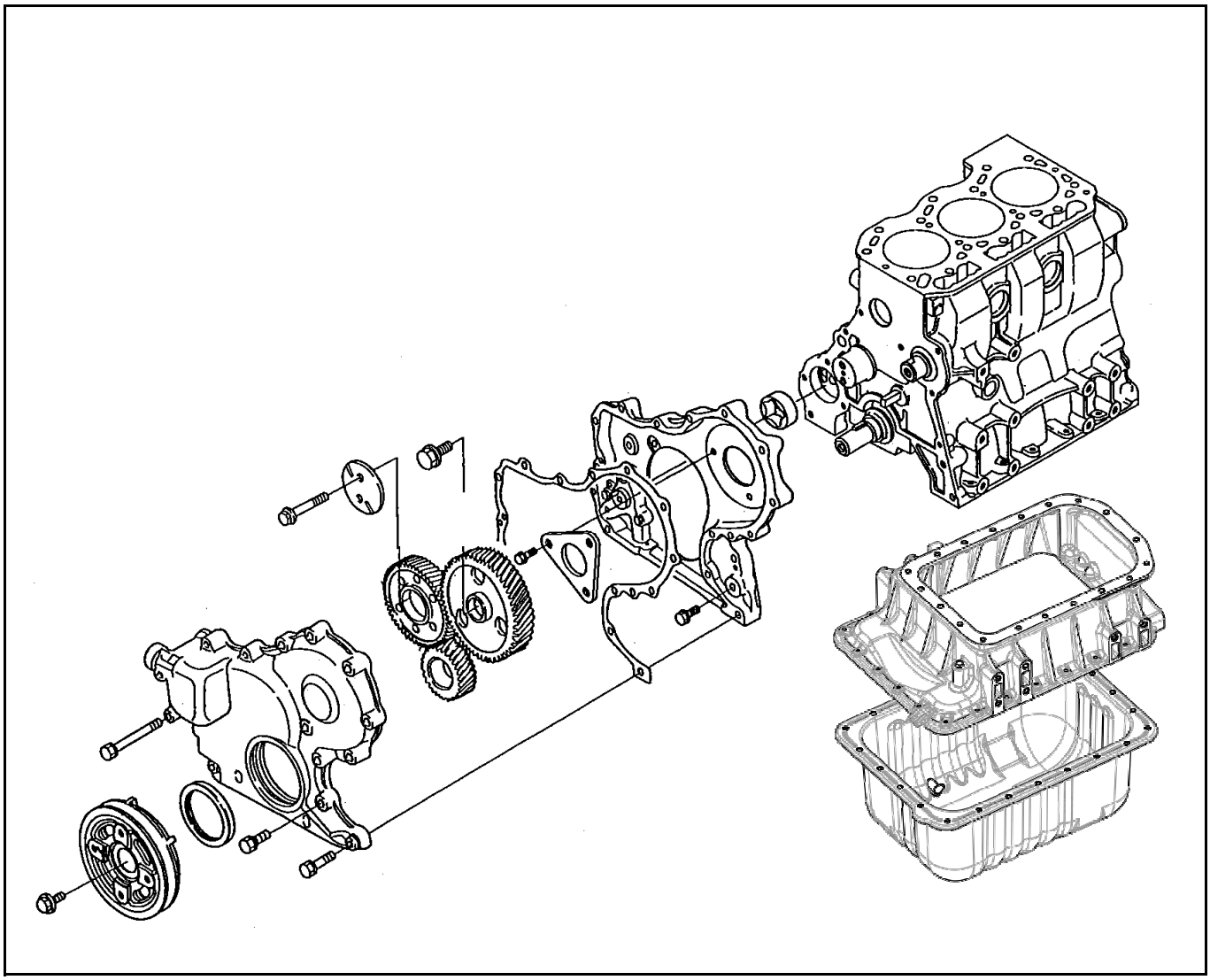
(1) Install the gasket and cylinder head cover SUB-ASSY.

(2) Install 3 gaskets and 3 nuts.

T = 6 Nm

NOTE
Make sure rubber seal is in groove in Cylinder head cover.

Section3
TIMING GEAR & GEARCASE
Section Contents



REMOVING TIMING GEAR COVER AND GEARS

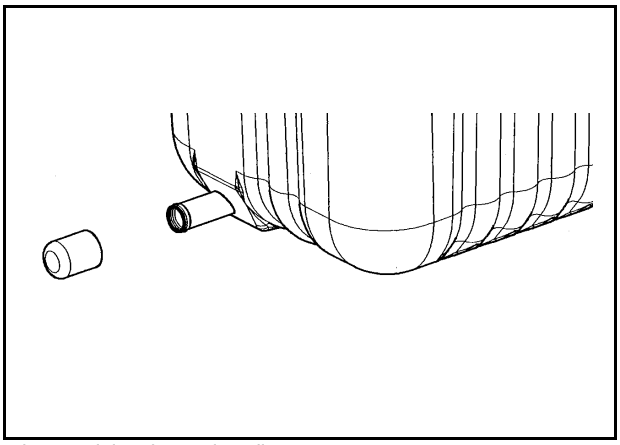


Fig.1-Draining the engine oil

1. Engine oil draining

   (1) Prepare a container for drained oil

   (2) Remove the oil pan plug to drain the engine oil

WARNING
- **Please go in a cool state. There might be the burn by hot oil.**

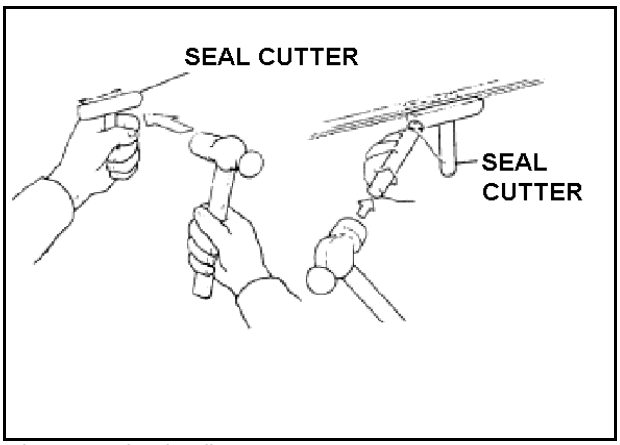


Fig.2-Removing the oil pan

2. Remove Oil pan

   (1) Remove 20 set bolts and 4 set nuts.

   (2) Insert the blade of the SST between the OIL PAN NO.2 and OIL PAN NO.1, and cut the sealant to remove the oil pan.

NOTICE
- **Do not use the SST on the timing chain cover side. Use a screwdriver if necessary.**
- **Slowly operate so as not to deform the oil pan flange.**

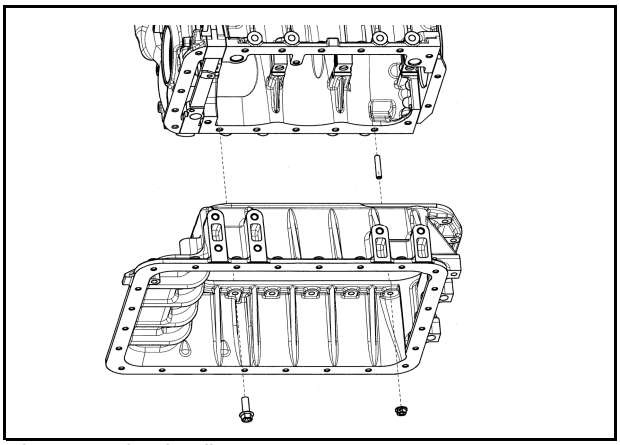


Fig.3-Removing the oil pan NO,1

   (3) Remove 17 set bolts and 2 set nuts.

   (4) Remove two strainer set bolts and two strainer set nuts and remove the oil strainer.

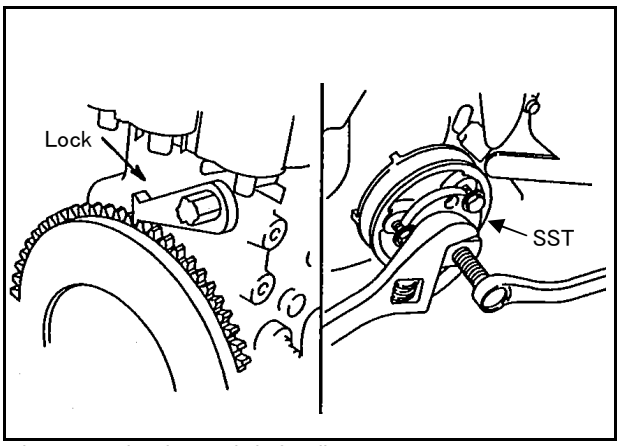


Fig.4-Removing the crankshaft pulley

3. Remove Crankshaft pulley

   (1) Install SST(flywheel holder)

   (2) Remove the pulley bolt

   (3) Remove crankshaft pulley using Tool SST.

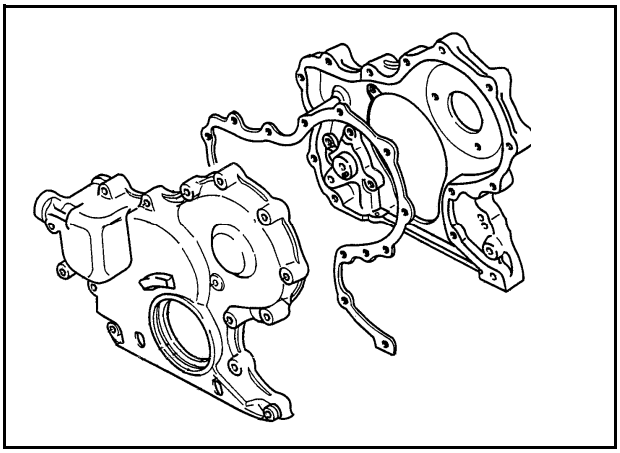


Fig.5-Removing the timing gear cover

4. Remove timing gear cover

   (1) Remove set bolts (12pcs), and set nuts (2pcs) cover

   (2) Discard timing gear cover gasket.

NOTE
Carefully prevent the timing gear cover and timing gear case installation surface from any damage.

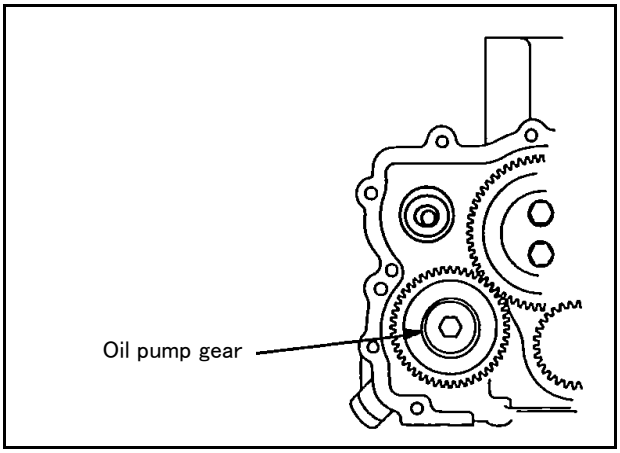


Fig.6-Removing the oil pump gear

5. Remove oil pump drive gear.

   (1) Remove set bolt

   (2) Check oil pump drive gear for damaged teeth.

CHECKING GEARS

Inspect gear teeth for wear or damage.

CHECK GEARS IN SEQUENCE SHOWN.

1. Check gear backlash between idler gear and crankshaft gear using dial indicator as shown in Fig.7.

   a. Set tip of indicator on gear tooth, then rock idler gear back and forth noting indicator reading.

NOTE
Crankshaft must not turn while checking.

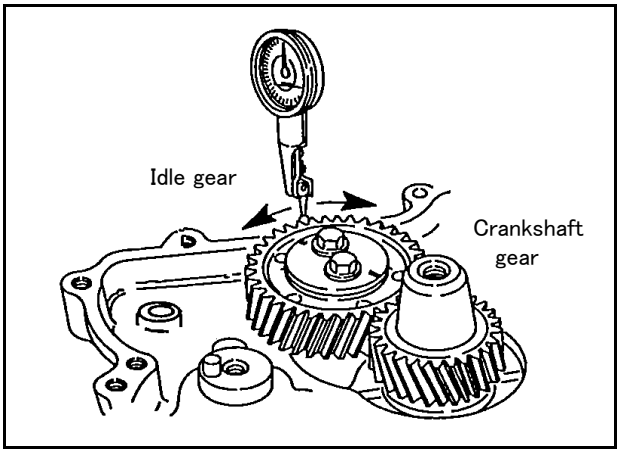


Fig.7-Checking Idler Gear Backlash

2. If backlash exceeds 0.2 mm check idler gear bearing and shaft for wear, Fig.8.

   Reject Dimension:
   Idler Gear ID - 34.17 mm
   Idler Gear Shaft OD - 33.91 mm

   a. If idler gear bearing and shaft are within specification, replace with new idler gear and recheck.

   b. If backlash exceeds 0.2 mm with NEW idler gear, crankshaft gear is worn.

NOTE
If crankshaft gear is worn the crankshaft must be replaced.

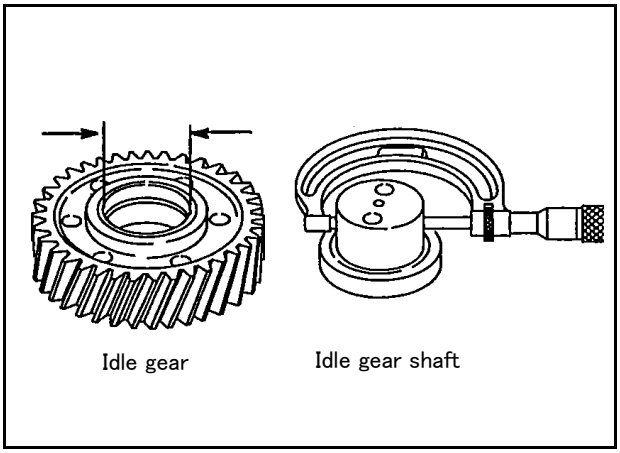


Fig.8-Checking Idler Gear And Shaft

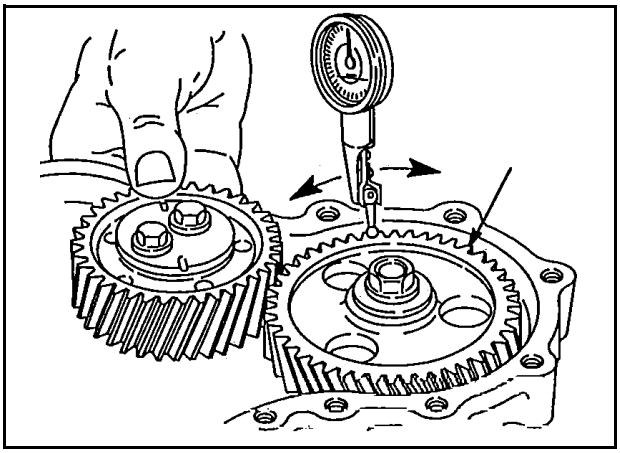


Fig.9-Checking Camshaft Timing Gear Backlash

3. Hold idler gear as shown and check gear backlash between camshaft timing gear and idler gear using dial indicator, Fig.9.

Camshaft timing gear backlash must not exceed 0.2 mm.

NOTE
Idler gear must not turn while checking.

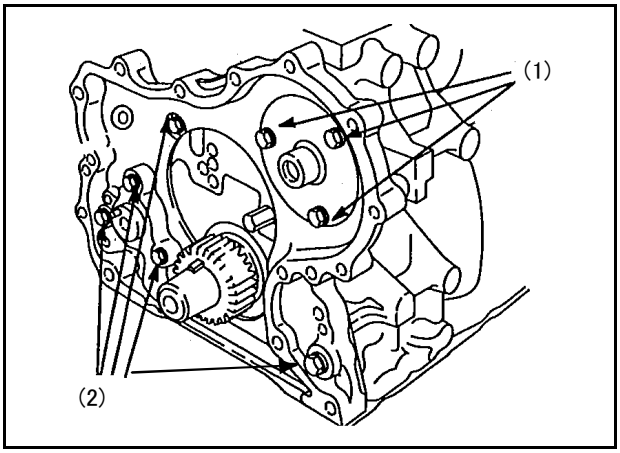


Fig10-Removing Timing Gear Case

REMOVING GEAR CASE

(1) Remove camshaft thrust plate set bolt

(2) Remove 5 set bolts

(3) Remove timing gear case and discard gasket

(4) Remove oil pump rotor from cylinder block.

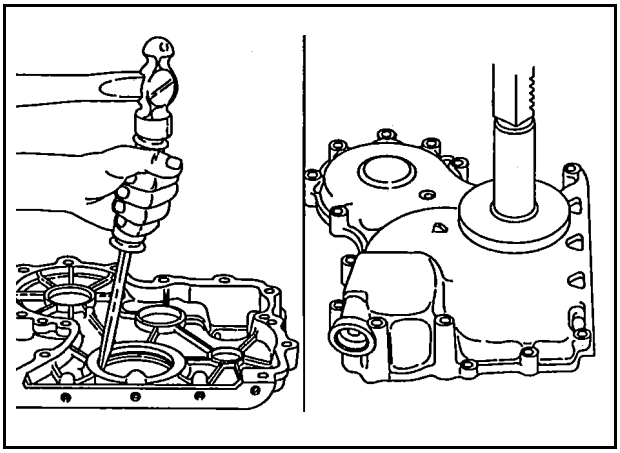


Fig.11-Replacing Oil Seal

REPLACE TIMING GEAR COVER OIL SEAL

(1) Use a screwdriver and a hammer to drive out the oil seal

(2) Use SST, to install new oil seal

(3) Coat MP grease on the oil seal lip

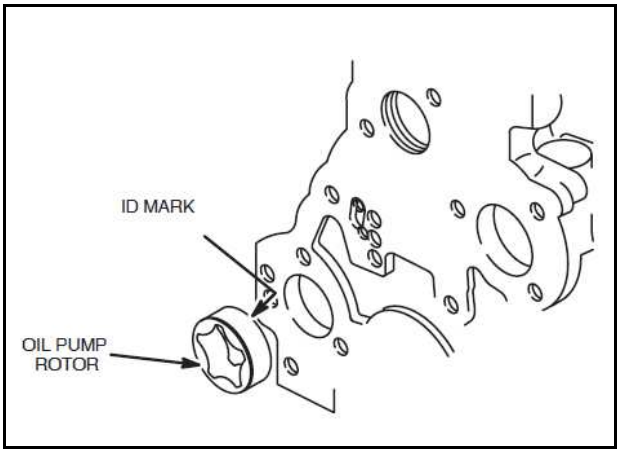


Fig.12-Installing Oil Pump Rotor

ASSEMBLE TIMING GEAR CASE AND GEARS

1. Clean and lubricate oil pump rotor with engine oil and install in cylinder block, Fig.12.

   a. ID mark on rotor must face cylinder block.

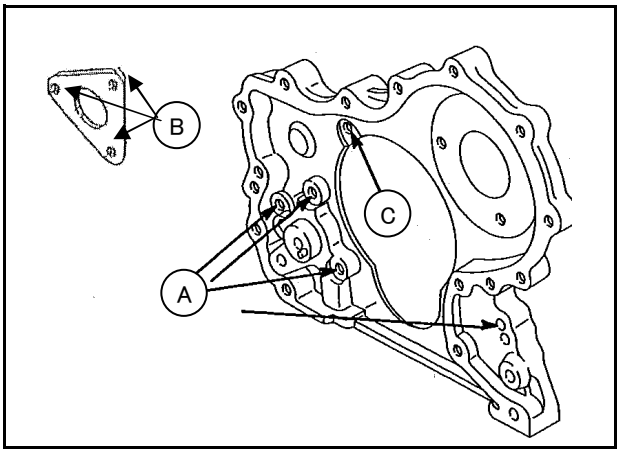


Fig.13-Installing Timing Gear Case

2. Install timing gear case with new gasket. Install camshaft retainer, Fig.13.

NOTE It may be necessary to rotate oil pump drive to engage oil pump rotors.

NOTE Position camshaft retainer so that center hole does not interfere with camshaft.

Note position, length and number of bolts as shown.

a. M6 x 28 mm : 4
b. M6 x 18 mm : 3
c. M6 x 16 mm : 1

Torque bolts to 8.0 Nm.

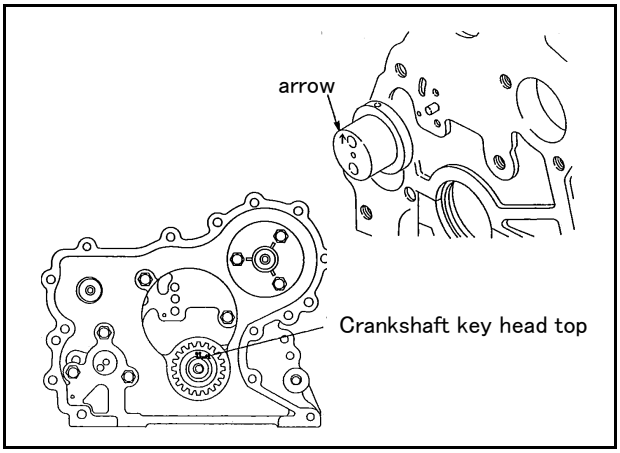


Fig.14-Installing Idler Gear Shaft

3. Assemble idler gear shaft with arrow up.

4. Check that the NO,1 cylinder is in the TDC.

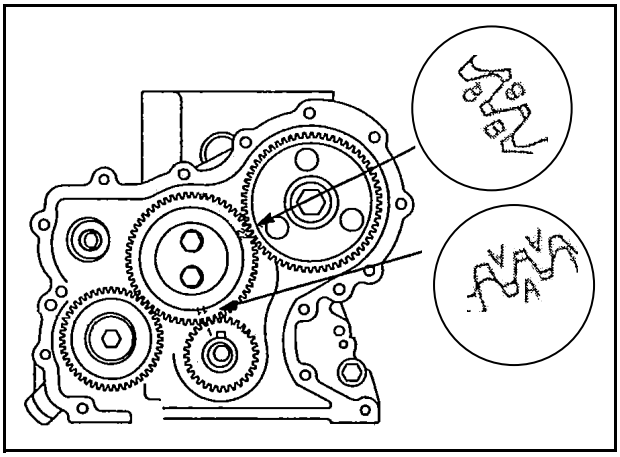


Fig.15-Aligning Timing Marks -Typical

5 With crankshaft key at 12 o'clock position, assemble idler gear so that timing mark AA is aligned with timing mark A on crankshaft gear, timing mark BB is aligned with timing mark B on camshaft gear, as shown in Fig.15.

a. Install oil pump gear.

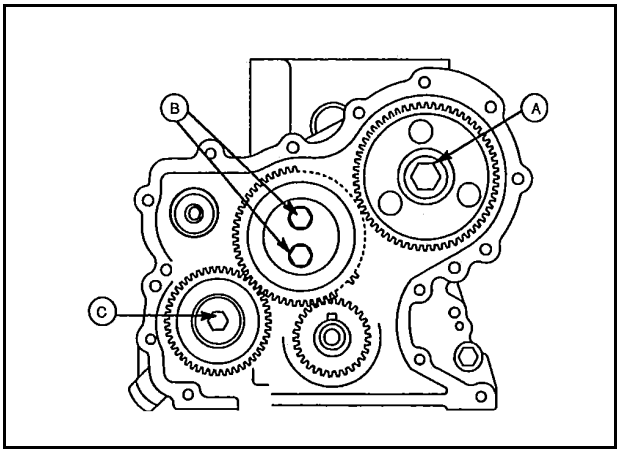


Fig.16-Torque Screws

6. Tighten 5 bolts

A	M10 × 29mm(1pcs)	T	=	43Nm
B	M8 × 45mm(2pcs)	T	=	26Nm
C	M8 × 20mm(1pcs)	T	=	19Nm

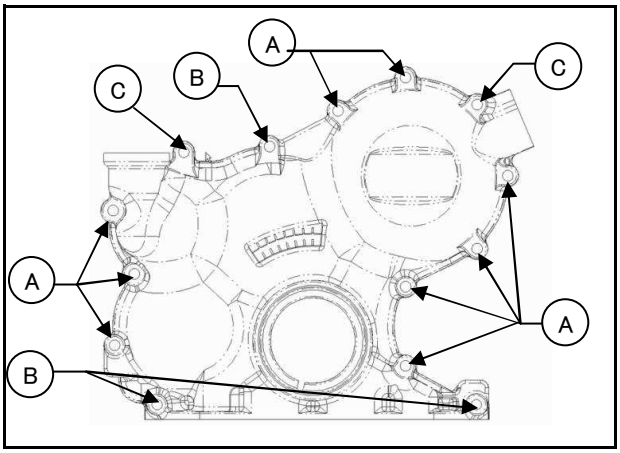


Fig.17-Installing Timing Gear Cover

7. Install timing gear cover with new gasket.

   Use 12 bolts and 3 nuts and install the timing gear cover with a new gasket in-between.

   A M6 × 30mm(9pcs) T = 8Nm
   B M6 × 55mm(3pcs) T = 8Nm
   C M6 Nut(2pcs) T = 8Nm

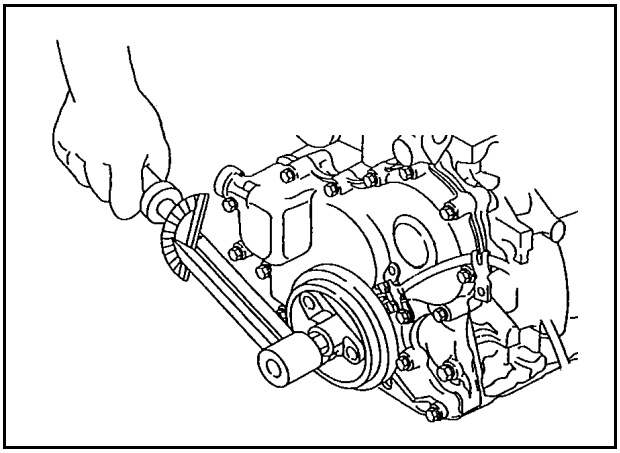


Fig.18-Installing Crankshaft Pulley

8. Install crankshaft pulley with timing mark at 12 o'clock position (#1 cylinder)

   NOTE:
   Be sure alignment pin in crankshaft gear is seated in hole in pulley.
   a. Torque bolt to 88.0 Nm.
   b. Remove flywheel holder.

9 Use 2 bolts and 2 nuts and install the oil strainer with a new gasket in-between.

   T = 8Nm

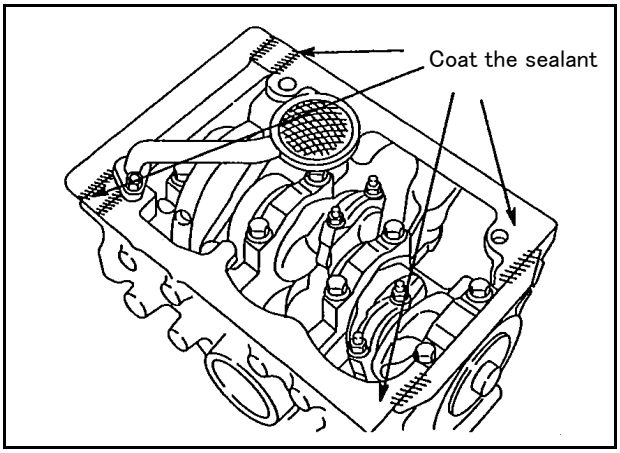


Fig.19-Installing Oil Pan

10. Oil pan installation

   (1) Remove the sealant (FIPG) adhered to the oil pan and cylinder block mating surface with a screwdriver, wire brush and gasket scraper.

   (2) Degrease the sealant coating area and mating surface

   (3) Coat the sealant on the oil pan as illustrated.
   FIPG : 08826-76001-71

   CAUTION
   - **The sealant coating width shall be about 3mm.**
   - **Coat the sealant on the inner sides of bolt hole and on the center groove at other places.**
   - **The sealant shall be coated without dis-continuity, and always overlap the coating starting point and end point.**
   - **Install the oil pan within 3 minutes after coating the sealant.**
   - **Do not fill coolant and engine oil and do not start the engine within 2 hours after installation.**

   (4) Install the oil pan to the cylinder block and tighten 17 set bolts, and 2 nuts to the specified torque.
   T = 8 Nm

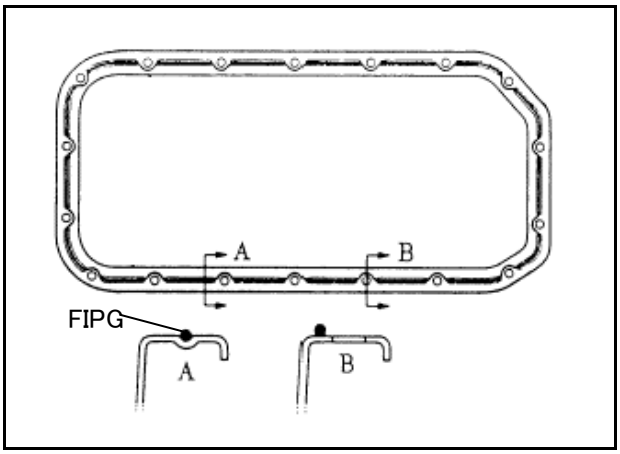
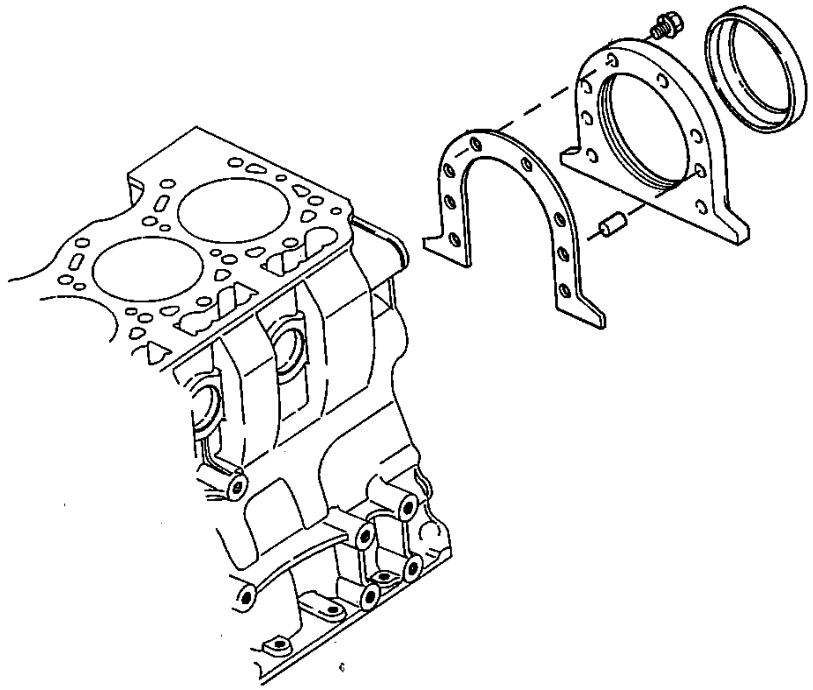


Fig.20-Sealant coating area

Section4
RETAINER, OIL SEAL
Section Contents



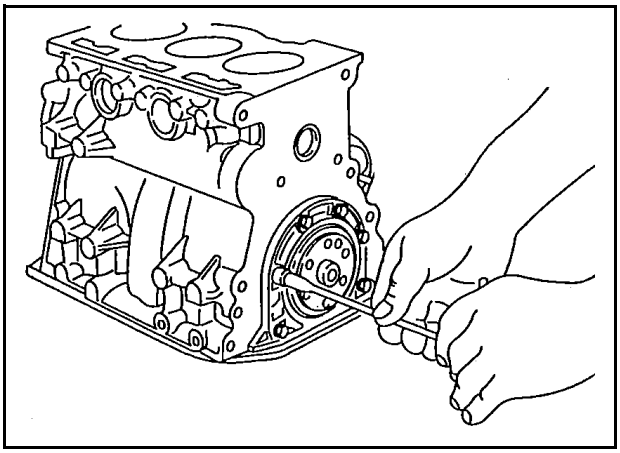


Fig.1-Removing Seal Retainer

REMOVING PAN

1. Remove Oil pan (see section 3)

REMOVING REAR SEAL RETAINER

1. Remove rear seal retainer and discard gasket.

   (1) Remove set bolts (6pcs)

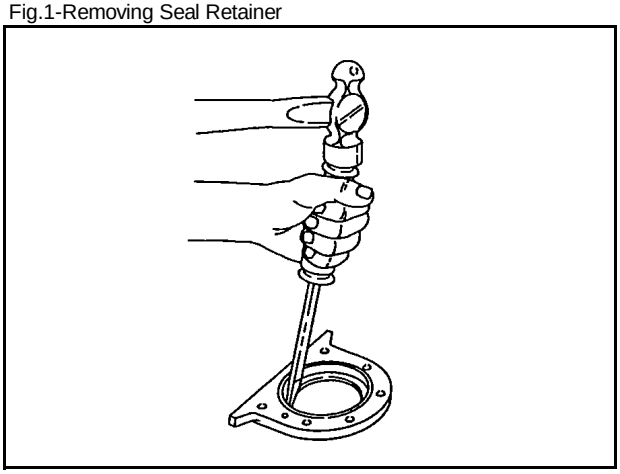


Fig.2-Removing Oil Seal

REPLACING OIL SEAL

1. Remove oil seal.

   Use a screwdriver and a hammer to tap out the oil seal

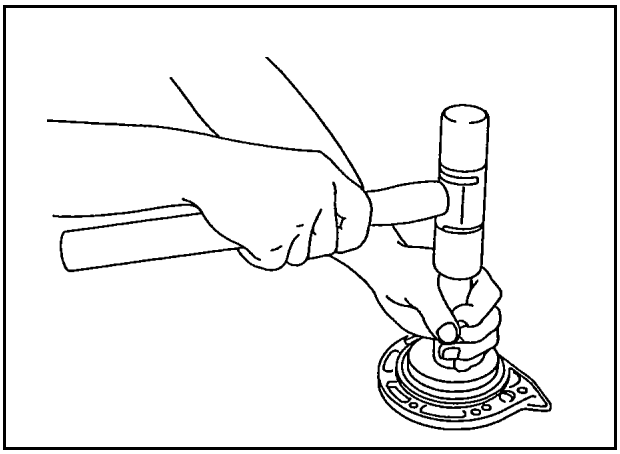


Fig.3-Installing Oil Seal

2. Lubricate outside diameter of oil seal.

   Use the SST and hammer, and drive in the oil seal until it becomes flush with the end surface of the retainer

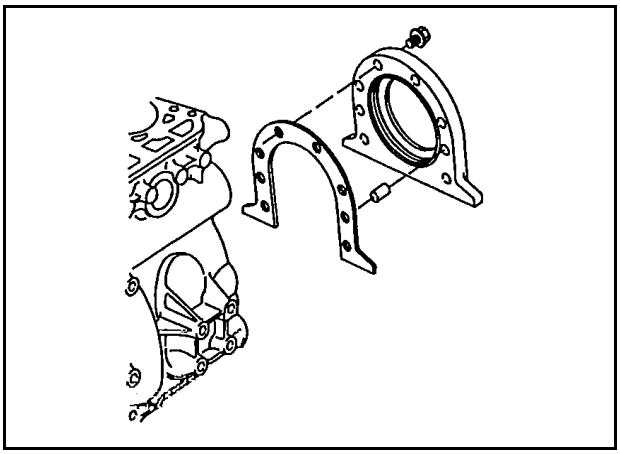


Fig.4-Installing Seal Retainer

INSTALLING REAR SEAL RETAINER

1. Install rear seal retainer with new gasket.

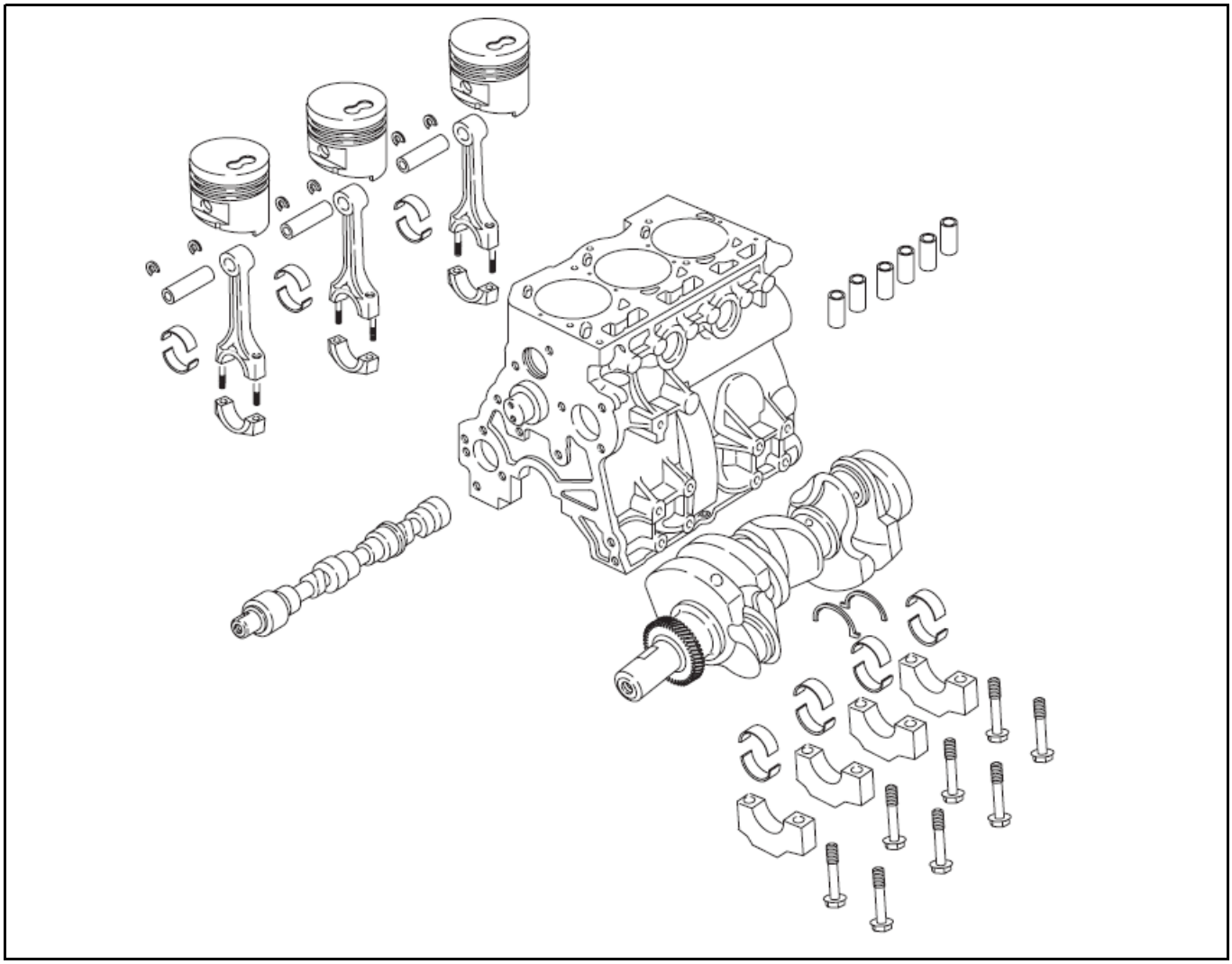
   (1) Use 6 bolts install the Oil seal retainer with a new gasket in-between.

   T = 6Nm

2 Oil pan installation (see section 3)

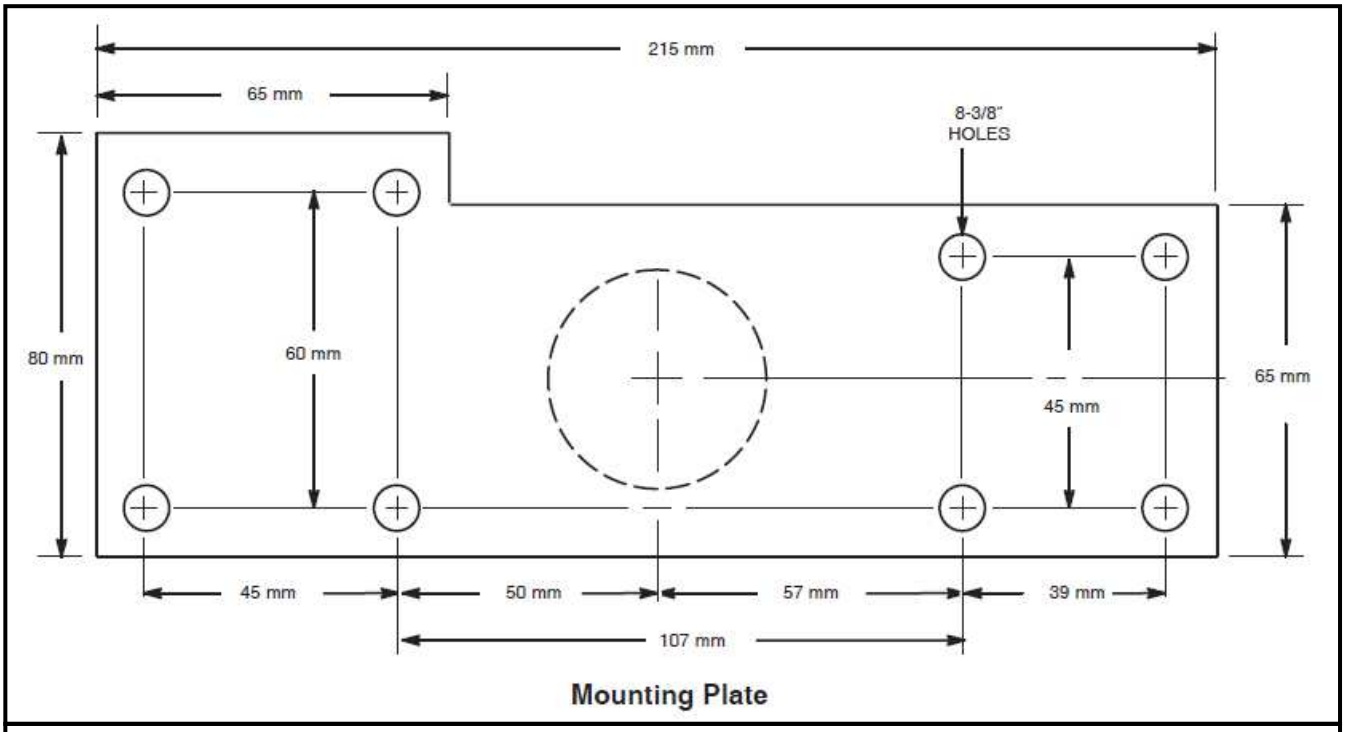
Section5
CYLINDER BLOCK DISASSEMBLY

Section Contents

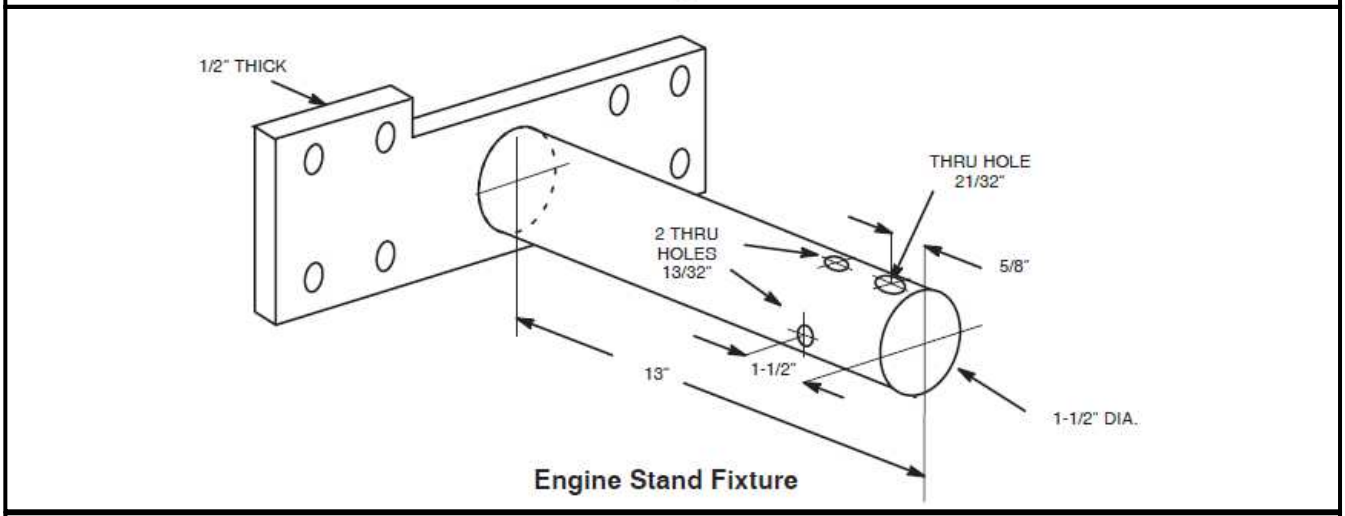


ENGINE STAND

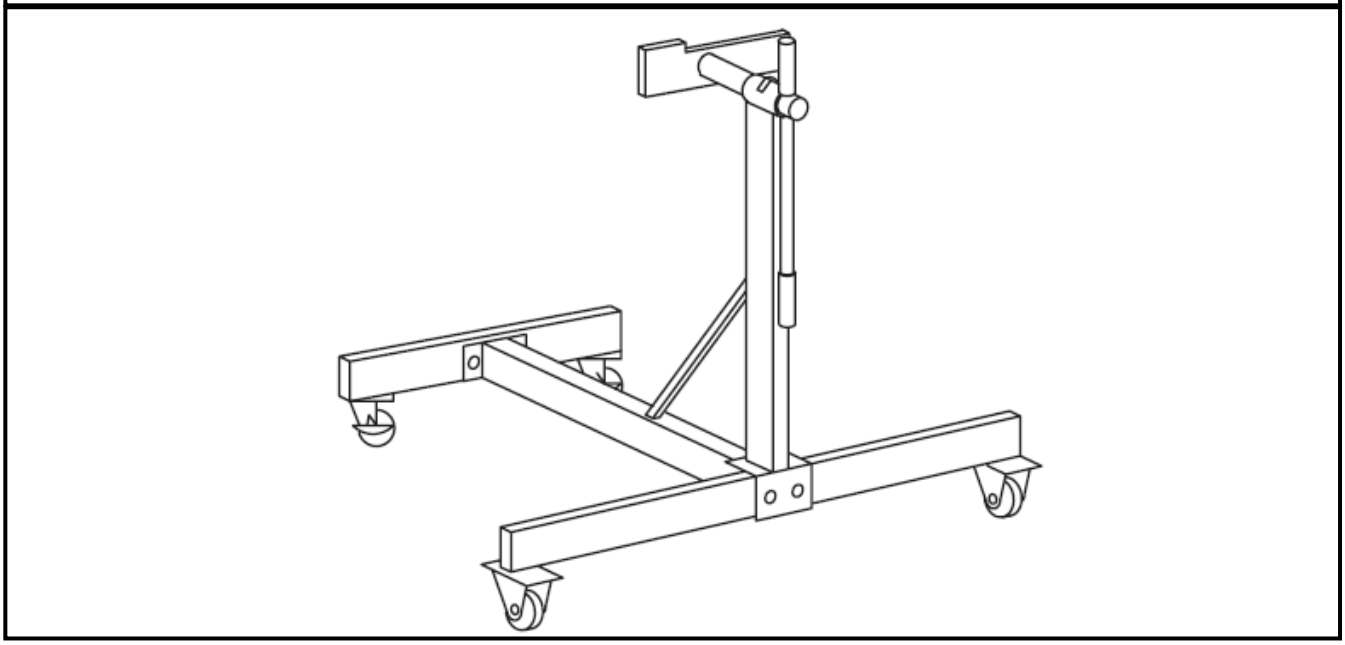
An automotive type engine stand is recommended when complete engine disassembly is required. See drawings below for dimensions to make an engine stand mounting fixture.



Mounting Plate



Engine Stand Fixture



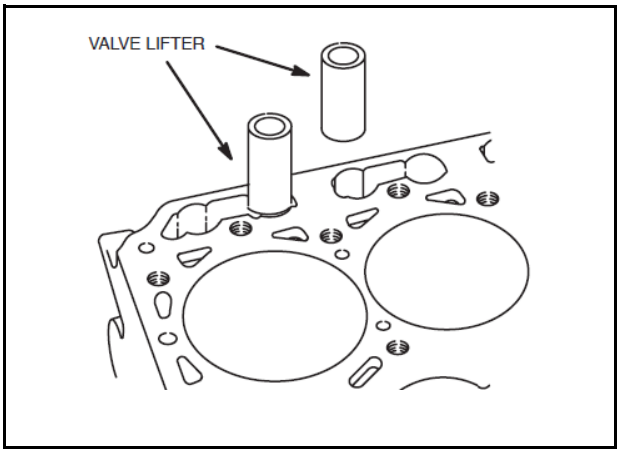


Fig.1-Removing Valve Lifters

DISASSEMBLE CYLINDER BLOCK

1. Remove cylinder head. See Sec. 2.
2. Remove oil pan, oil pick up tube, timing cover, gears and gear case. See Sec. 3.
3. Remove flywheel and rear seal retainer. See Sec. 4.
4. Remove valve lifters.
   a. Number lifters so that they may be re-installed in the same position.

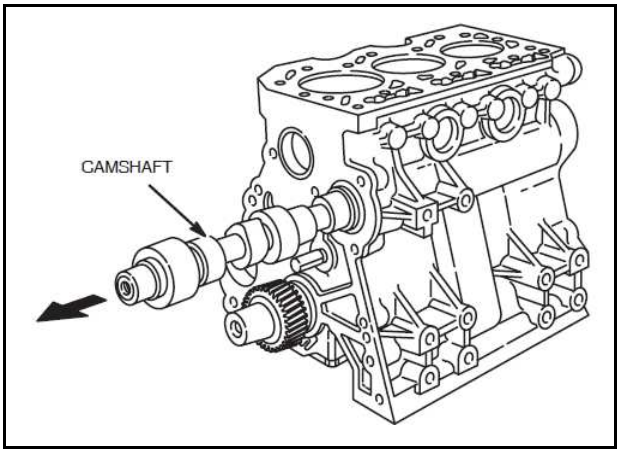


Fig.2-Removing Camshaft

5. Remove camshaft.

NOTE
Use care when removing camshaft to prevent damaging cam bearing, journals and lobes.

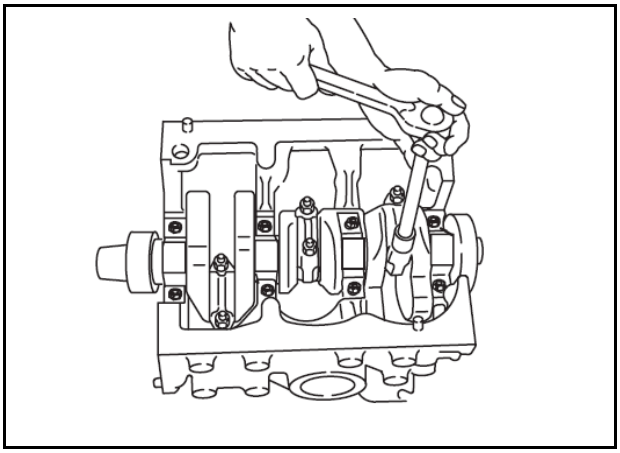


Fig.3-Removing Connecting Rod Assembly

6. Remove connecting rod and piston assemblies.

NOTE
Remove carbon or ridge from cylinder and number connecting rod/piston assemblies before removing from cylinders.

   a. Remove connecting rod cap with lower bearing.
   b. Push connecting rod and piston out through top of cylinder.
   c. Reassemble connecting rod cap to connecting rod to prevent interchanging components.

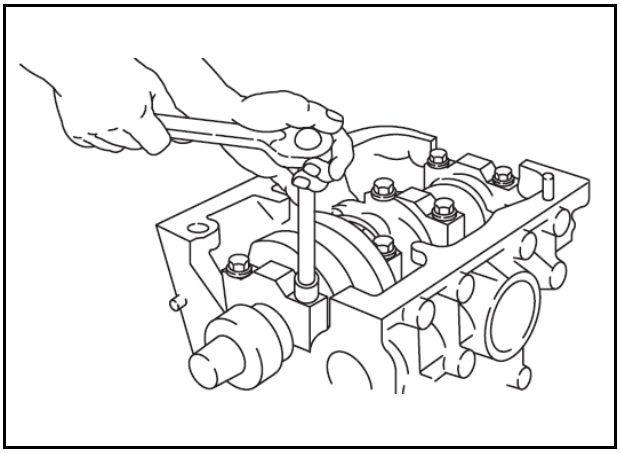


Fig.4-Removing Main Bearing Caps

7. Remove crankshaft main bearing caps, keeping main bearings with their respective caps

NOTE
Main bearing caps are numbered 1 through 4.

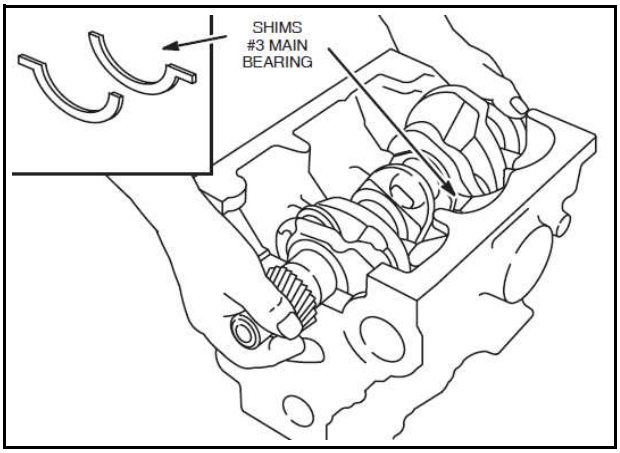


Fig.5-Removing Crankshaft

8. Remove crankshaft.

   a. Remove crankshaft thrust washers (#3 mainbearing).
   b. Remove upper main bearings from saddles and place with respective bearing caps.

Section 6
CYLINDER BLOCK INSPECTION AND REPAIR
Section Contents

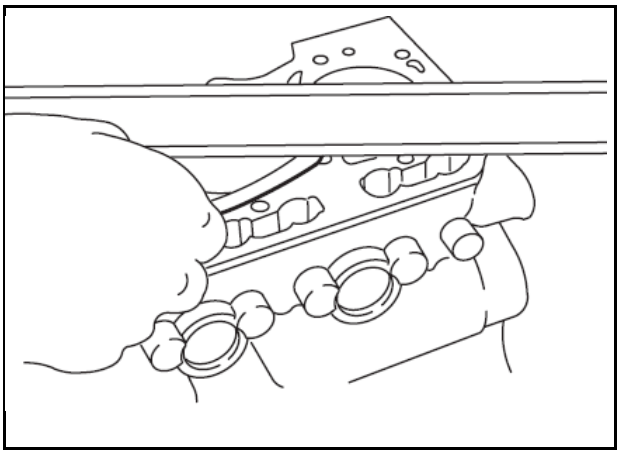


Fig.1-Checking Cylinder Block

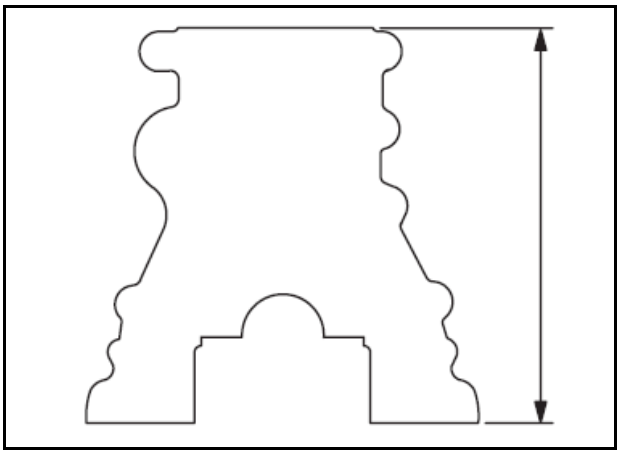


Fig.2-Cylinder Block Height

CHECKING CYLINDER BLOCK

Remove all traces of sealant and gasket material from mounting surfaces. Inspect cylinder block for damage, cracks and stripped threads. Inspect cylinder bores for damage or scores.

1. Check cylinder block deck for distortion, Fig.1.
   Distortion Limit: 0.08 mm

2. If cylinder block exceeds limit shown, it may be resurfaced, Fig.2.

   Std Dimension:
   238.70-239.30 mm
   Minimum Dimension:
   238.60 mm (After Resurfacing)

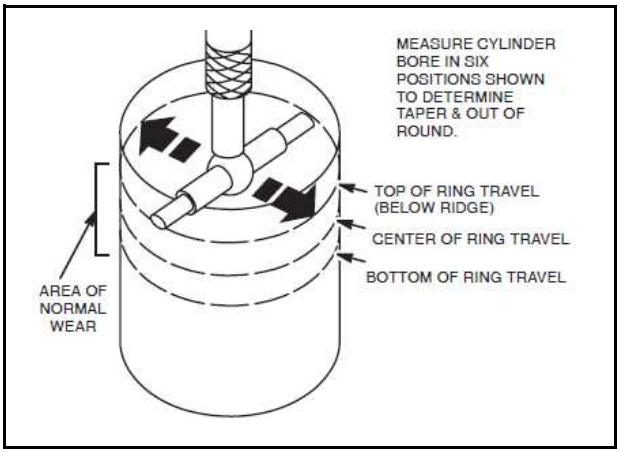


Fig.3-Checking Cylinder Bore

3. Check cylinder bores for wear, Fig.3.
   Standard Bore Size:
   Model Series:
   ϕ 72.00-72.030 mm

   a. Measure cylinder bore in 6 points at right angles as shown, Fig.3.
   b. If cylinder bore is worn more than 0.075 mm or more than 0.035 mm out of round, it must be resized.

   Always resize to exactly .25 mm over standard bore size. If this is done accurately, the service oversize rings and pistons will fit perfectly and proper clearances will be maintained.

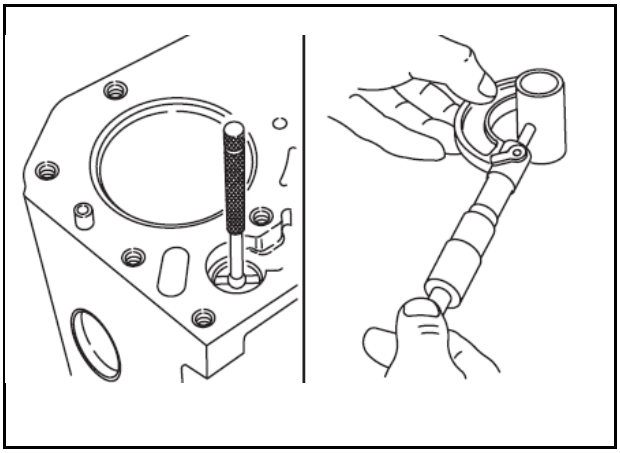


Fig.4-Checking Valve Lifter And Bore

4. Check valve lifter bore, Fig. 4.
   Std. Dimension: 18.018 mm
   Reject: 18.05 mm
5. Check valve lifter, Fig. 4.
   Std. Dimension: 17.98 mm
   Reject: 17.91 mm

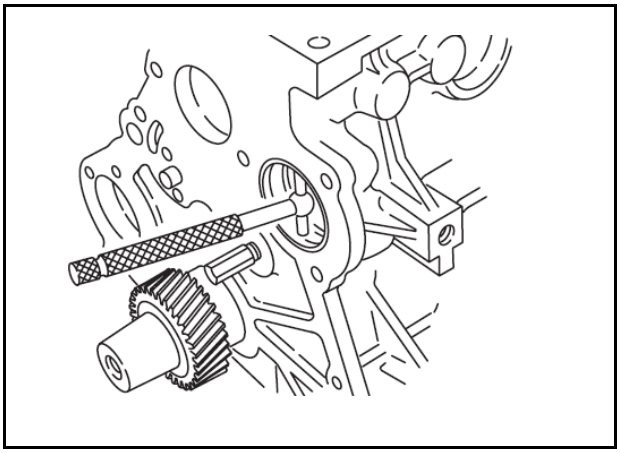


Fig.5-Checking Cam Bearing

6. Check camshaft bearing.
   Replace if greater than 36.06 mm

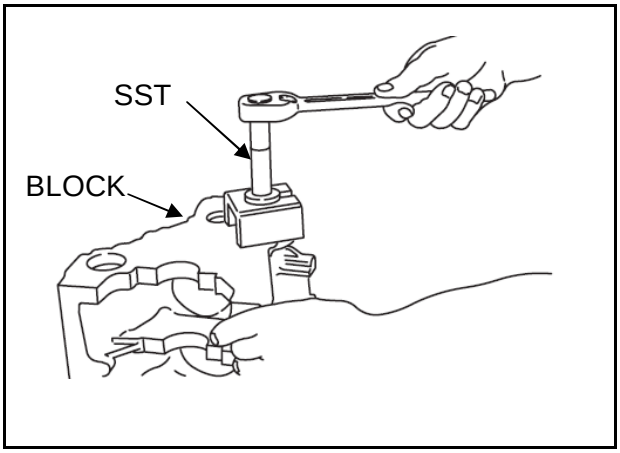


Fig.6-Removing Cam Bearing

REPLACING CAMSHAFT BEARING

1. Remove camshaft bearing, Fig.6.
a. Use camshaft bearing puller,SST.

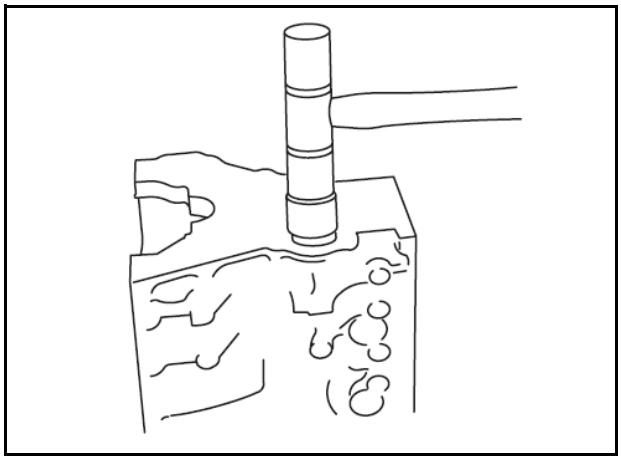


Fig.7-Installing Cam Bearing

2. Install camshaft bearing, Fig. 7.
a. Use camshaft bearing driver, SST.

NOTE
Notch on camshaft bearing must face out. Be sure oil hole in bearing is aligned with oil hole in cylinder block.

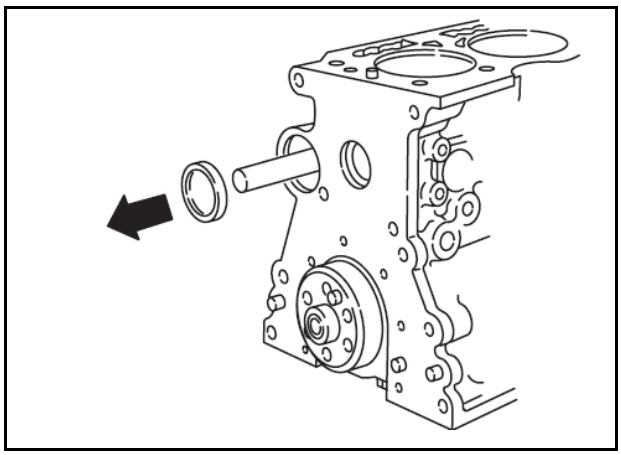


Fig.8-Removing Camshaft Plug

REPLACING CAMSHAFT PLUG

1. Remove rear camshaft plug, Fig.8.
a. Use a wood dowel or brass rod to prevent damage to camshaft bearing.

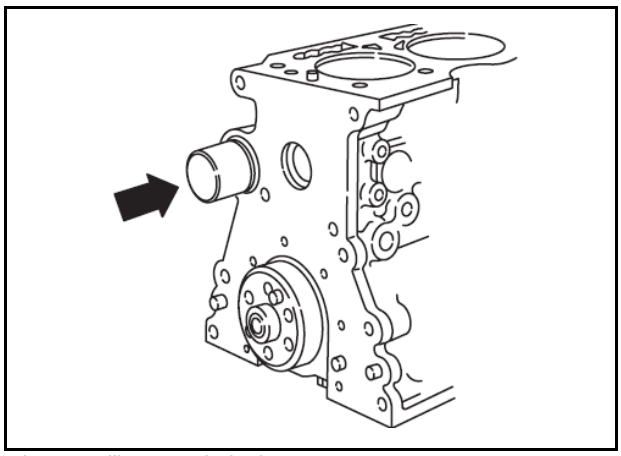


Fig.9-Installing Camshaft Plug

2. Install new camshaft plug using camshaft bearing driver, SST.
a. Install camshaft plug flush with cylinder block

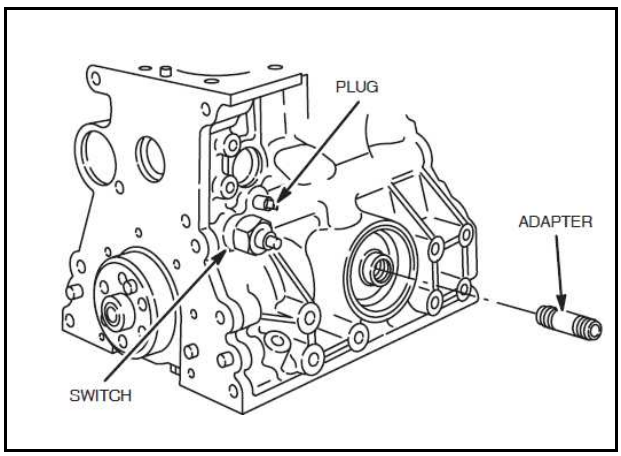


Fig.10-Removing Oil Pressure Switch

If cylinder block is being resized, the following parts should be removed so that cylinder block may be thoroughly cleaned.

3. Remove oil pressure switch, water gallery plug and oil filter adapter, Fig.10.

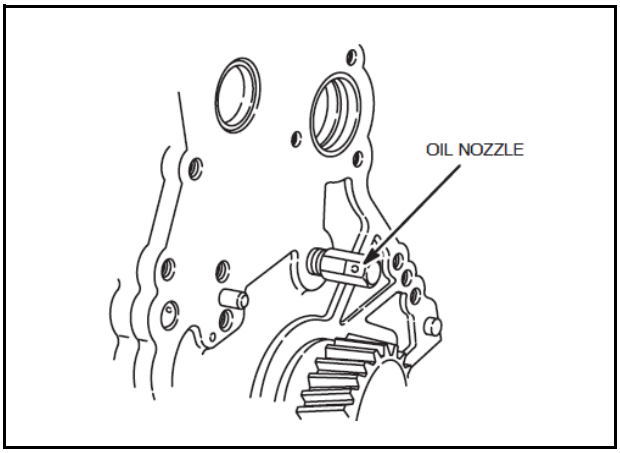


Fig.11-Removing Oil Nozzle

4. Remove timing gear oil nozzle, Fig.11.

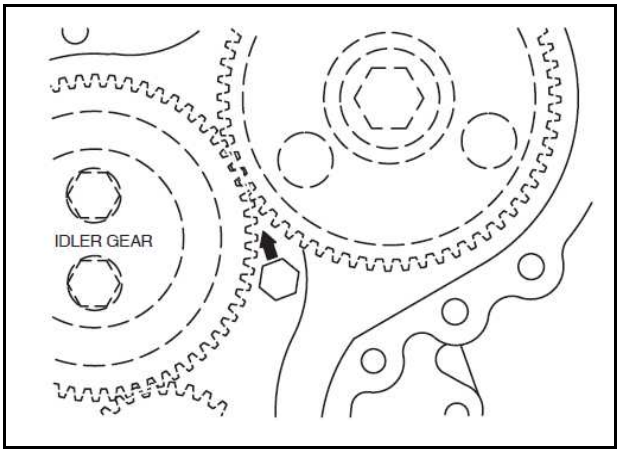


Fig.12-Installing Oil Nozzle

5. When re-installing oil nozzle, oil hole must be positioned at 45°angle, pointing towards idler gear, Fig.12.

Section 7
CRANKSHAFT AND BEARINGS
Section Contents

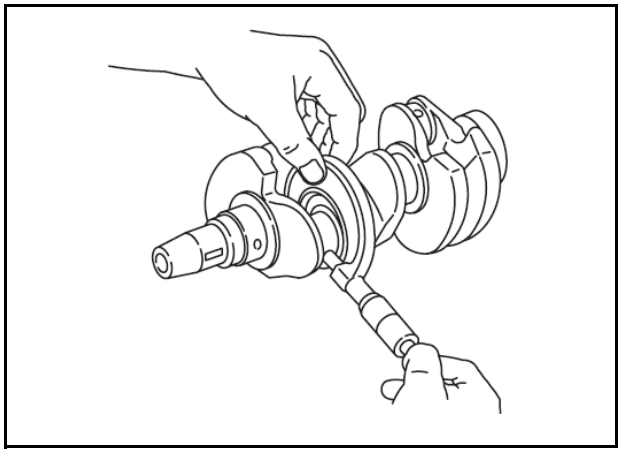


Fig.1-Checking Journals

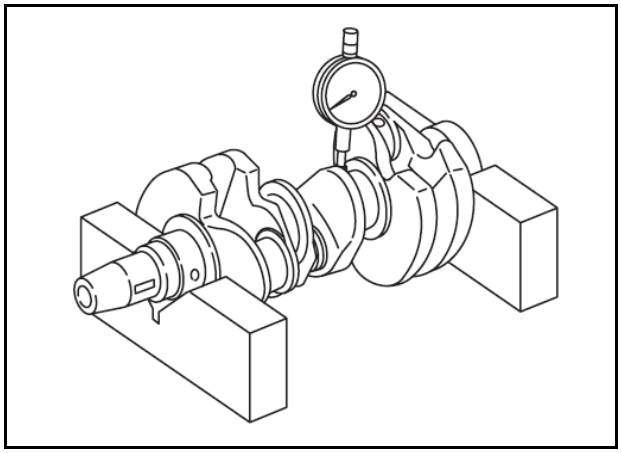


Fig.2-Checking Run-out

CHECKING CRANKSHAFT

Inspect crankshaft journals for grooves or signs of scoring. If found, crankshaft must be re-ground or replaced.

1. Check the main bearing and crankpin journals for wear and taper, Fig. 1.

Standard size:
Main - 41.976-42.000 mm
Crankpin - 36.976-37.000 mm
Maximum out of round and taper: 0.02 mm

If crankshaft journals are not within specification, the crankshaft may be re-ground and .25 mm undersize bearings installed. See illustrated parts list for part numbers.

2. Check the crankshaft for run-out at #3 main bearing journal, Fig.2.

Maximum Run-out: 0.06 mm

   a. If run-out exceeds specification shown, the crankshaft must be replaced.

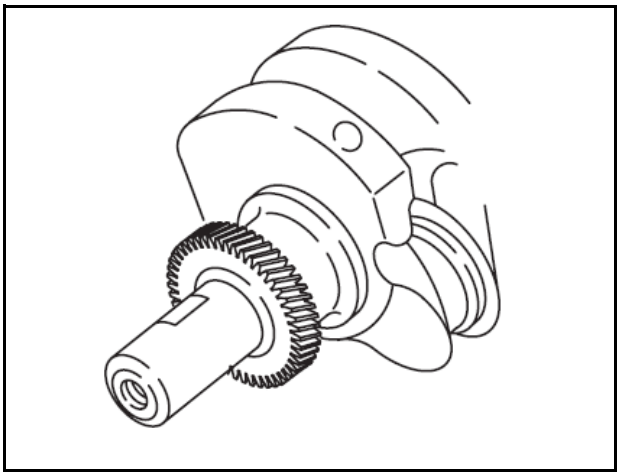


Fig.3-Checking Timing Gear

3. Check crankshaft timing gear teeth for damaged teeth, Fig. 3.

NOTE

See Section 3 for procedure to check crankshaft timing gear for wear.

If crankshaft timing gear teeth are damaged or worn, the crankshaft must be replaced.

CHECKING MAIN BEARING CLEARANCES

If main bearings show signs of flaking or scoring, bearings must be replaced.
Main bearing saddles in cylinder block, main bearing caps, main bearings and crankshaft journals must be clean and free of oil.

1. With upper main bearings installed, install crankshaft.
   a. Lay a strip of plastigage lengthwise on journal, Fig.4.

   Do not lay plastigage across oil hole in crankshaft journal.

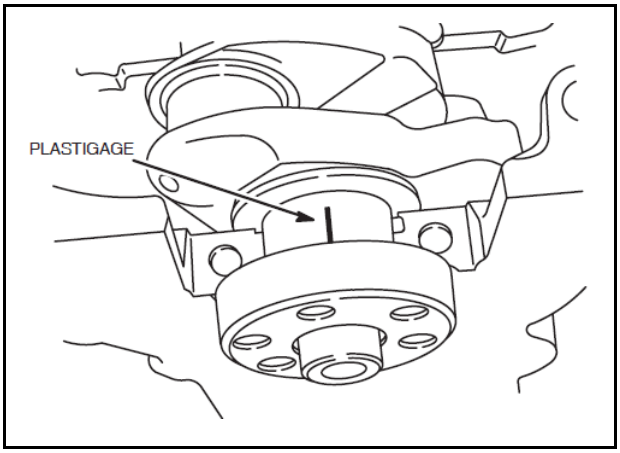


Fig.4-Install Plastigage

2. Assemble main bearing cap with bearing and torque to 58.3 Nm, Fig. 5.

   DO NOT ALLOW CRANKSHAFT TO ROTATE.

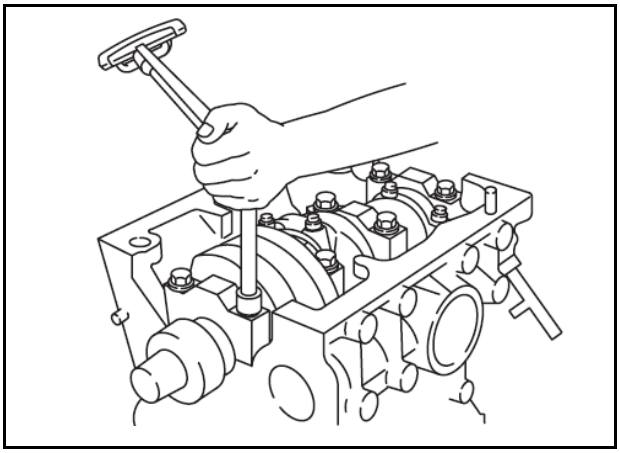


Fig.5-Torque Bearing Cap

3. Remove the bearing cap. Measure the plastigage at its widest point, Fig. 6. If the clearance is not within specification, replace the bearings.

   Crankshaft Main Bearing Clearance:
   STD: 0.020-0.044 mm
   Reject: 0.07 mm

   Repeat procedure for each main bearing.

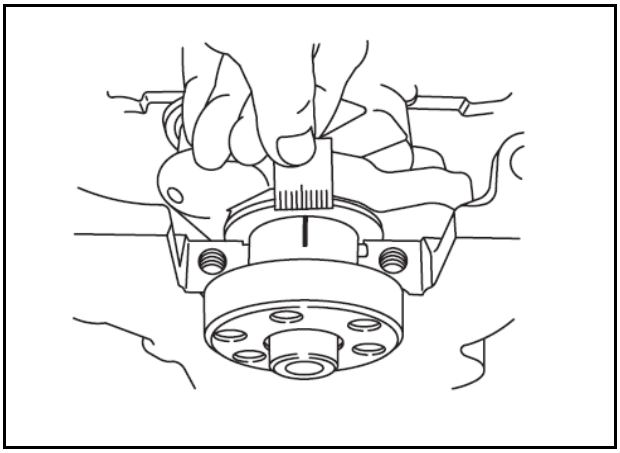


Fig.6-Measure Clearance

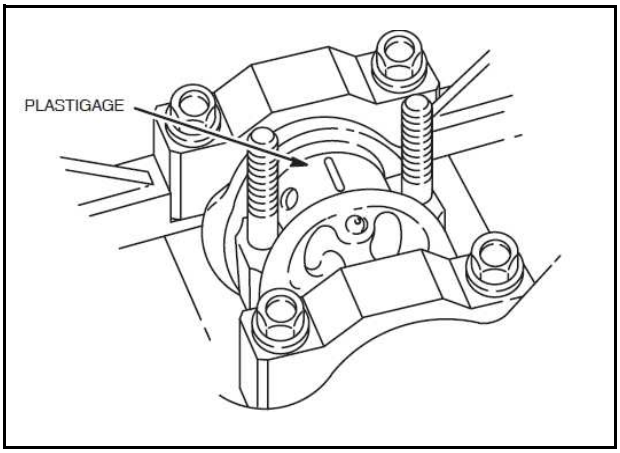


Fig.7-Install Plastigage

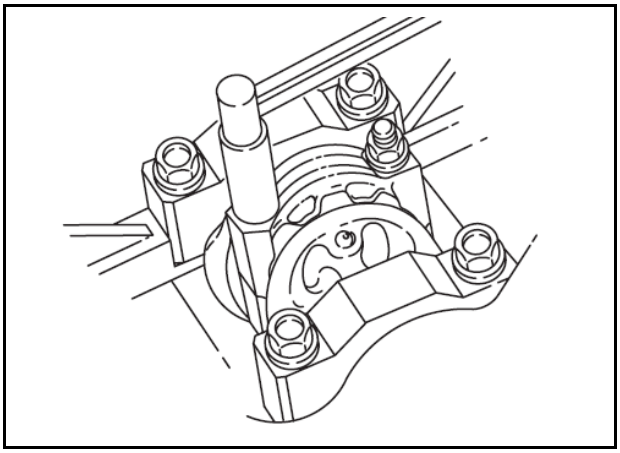


Fig.8-Torque Rod Cap

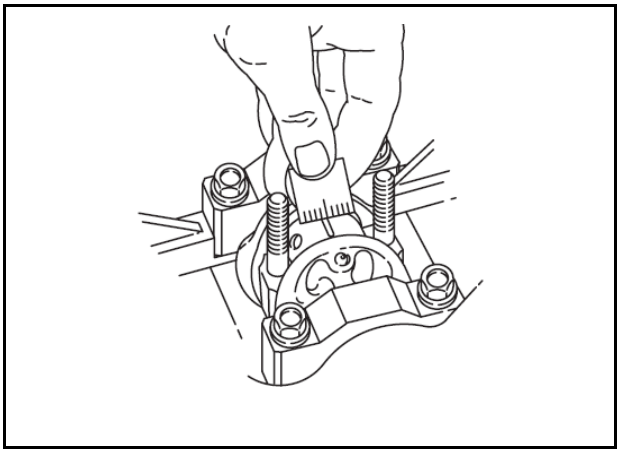


Fig.9-Measure Clearance

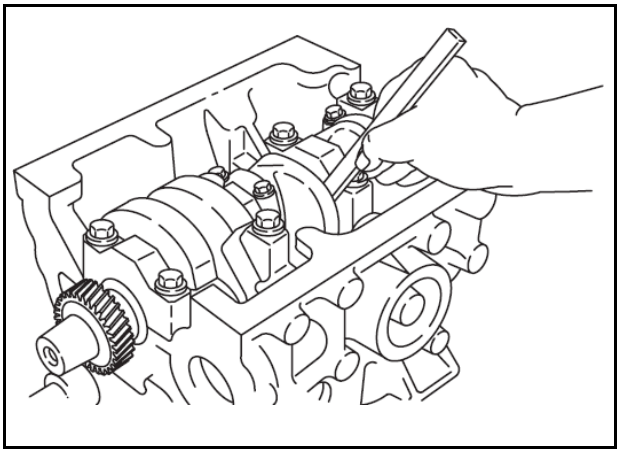


Fig.10-Checking Crankshaft End Play

CHECKING CONNECTING ROD BEARING CLEARANCES

If connecting rod bearings show signs of flaking or scoring, bearings must be replaced.
Connecting rod bearings and crankpin journals must be clean and free of oil.

1. With upper bearing assembled to connecting rod, install connecting rod.

   a. Lay a strip of plastigage lengthwise on journal, Fig.7.

   Do not lay plastigage across oil hole in crankpin journal.

2. Assemble connecting rod cap with bearing and torque to 36.0 Nm, Fig.8.

   DO NOT ALLOW CRANKSHAFT TO ROTATE.

3. Remove the connecting rod cap. Measure the plastigage at its widest point, Fig. 9. If the clearance is not within specification, replace the bearings.

   Connecting Rod Bearing Clearance:
   STD: 0.020-0.044 mm
   Reject: 0.07 mm

   Repeat procedure for each connecting rod.

CHECKING CRANKSHAFT END PLAY

With thrust washers installed, check crankshaft end play at #3 main bearing as shown, Fig. 10.

Crankshaft End Play:
STD: 0.020-0.24 mm
Limit: 0.30 mm

If end play exceeds limit, .125 mm over size thrust washers are available. See illustrated parts list.

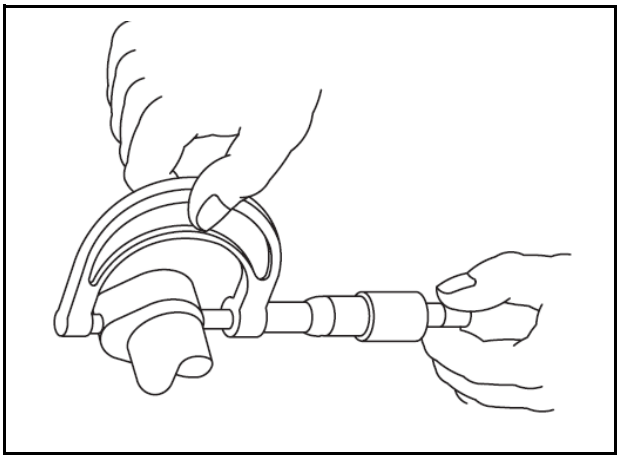


Fig.11-Checking Camshaft Lobes

CHECKING CAMSHAFT

1. Measure camshaft lobe height, Fig.11. If lobes are not to specification, replace the camshaft.
   Intake and Exhaust:
   STD: 30.065-30.135 mm
   Reject: 29.965 mm

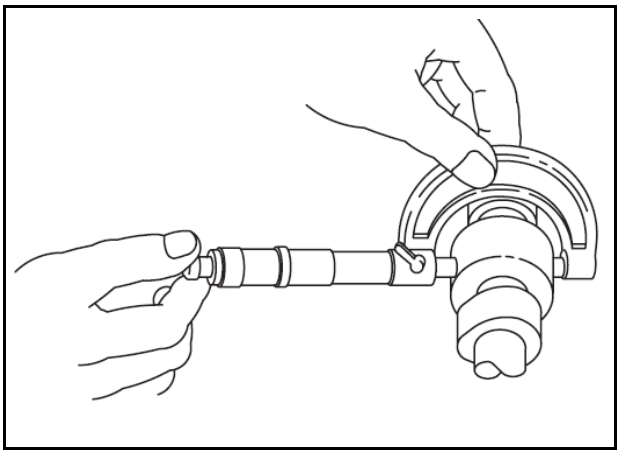


Fig.12-Checking Camshaft Journals

2. Measure camshaft journals, Fig. 12.

   STD: Front - 35.959-35.975 mm
   Reject: 35.890 mm

   STD: Center - 35.910-35.955 mm
   Reject: 35.84 mm

   STD: Rear - 35.910-35.955 mm
   Reject: 35.84 mm

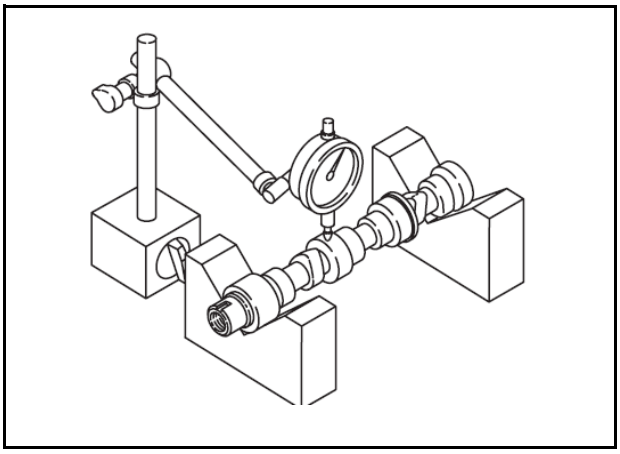


Fig.13-Checking Run-out

3. Measure camshaft run-out, Fig. 13.

Maximum Run-out: 0.03 mm

   a. If run-out exceeds specification shown, the camshaft must be replaced.

Section 8
PISTON, RINGS AND CONNECTING ROD INSPECTION AND ASSEMBLY

Section Contents

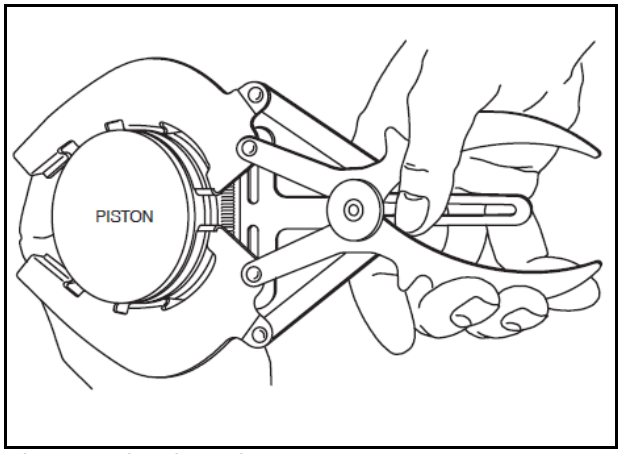


Fig.1-Removing Piston Rings

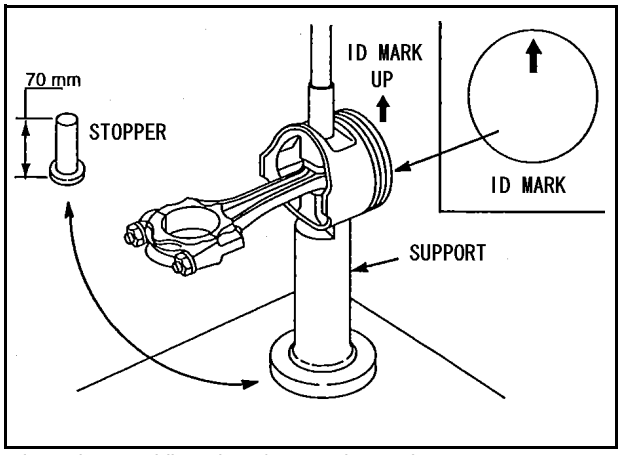


Fig.2-Disassembling Piston/Connecting Rod

DISASSEMBLE PISTON AND CONNECTING ROD

1. Remove compression rings and oil ring using ring expander, Fig. 1.

2. Disassemble piston from connecting rod to use the SST.

NOTE
To take out Stopper in the bottom of Support.

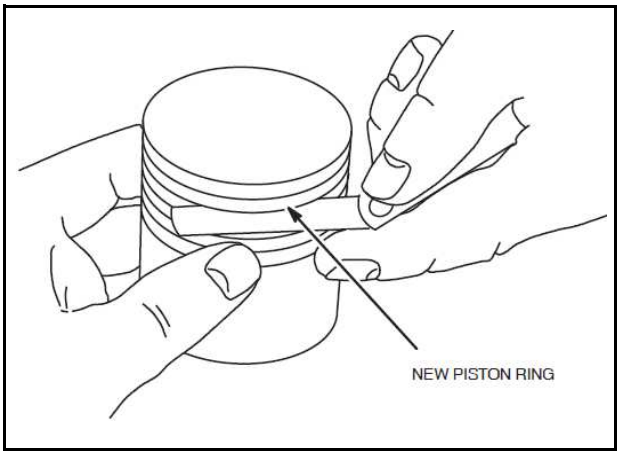


Fig. 3 - Checking Ring Grooves

CHECKING PISTON AND RINGS

If the cylinder bore is to be resized there is no reason to check the piston as a new oversized piston will be used. If the cylinder is not going to be resized and the piston shows no signs of scoring, the piston should be checked.

1. Check side clearance of ring grooves using NEW rings, Fig. 3. If a 0.11 mm feeler gauge can be inserted, the ring groove is worn. The piston must be replaced.

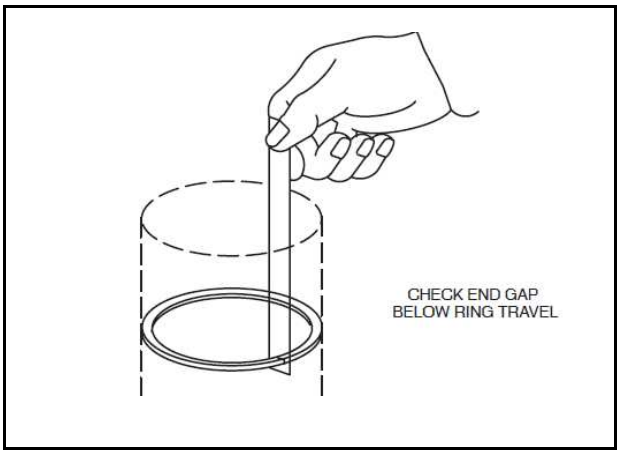


Fig. 4 - Checking End Gap

2. Check ring end gap, Fig. 4.

a. Clean carbon from end of rings and using the piston, insert approximately 25 mm into cylinder (below ring travel).

Ring End Gap Reject Size	
Compression Rings	Oil Ring
0.53mm	0.68mm

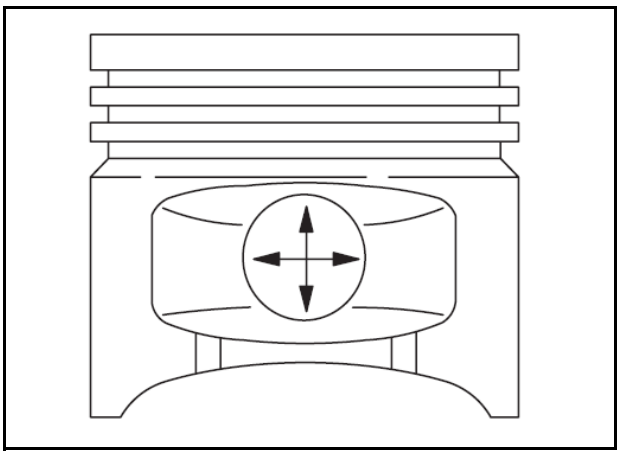


Fig. 5 - Checking Piston Pin Bore

3. Check piston pin bore, Fig. 5.
   a. Replace if greater than 18.03 mm or 0.01 mm out of round.

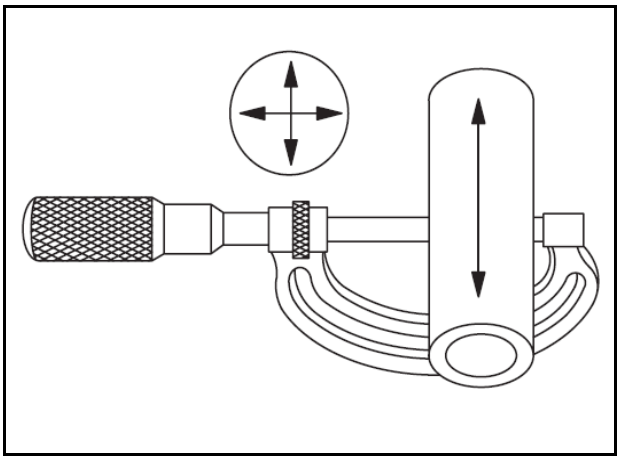


Fig. 6 - Checking Piston Pin

CHECKING PISTON PIN AND CONNECTING ROD

1. Check piston pin, Fig. 6.
   a. Replace if less than 17.98 mm or 0.01 mm out of round.

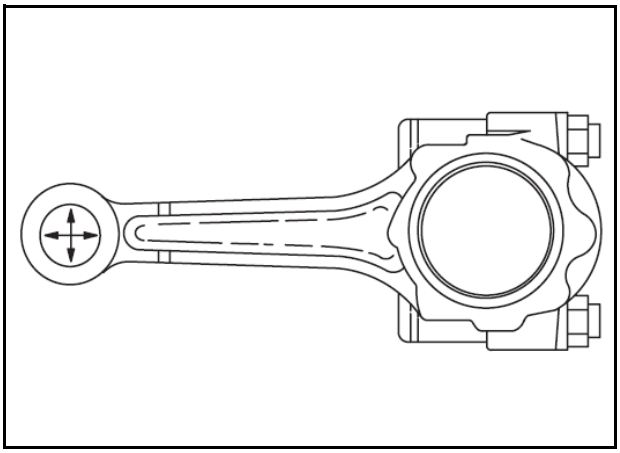


Fig. 7 -Checking Piston Pin Bearing

2. Check piston pin bearing, Fig. 7.

   a. Replace if greater than 17.98 mm or 0.01 mm out of round.

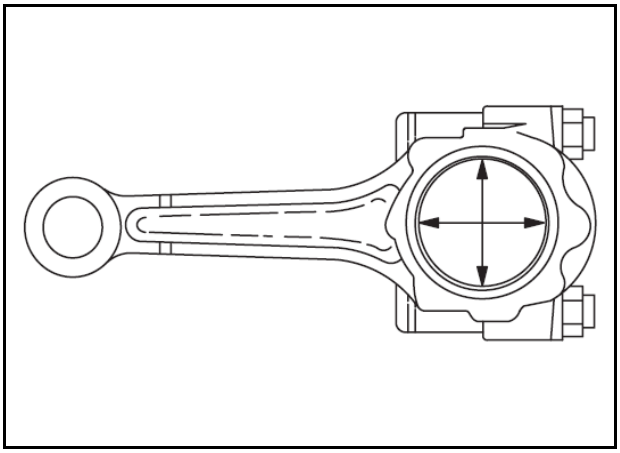


Fig. 8 - Checking Crankpin Bearing End

3. Check crankpin bearing end of connecting rod for out of round, Fig. 8.

   a. With bearing inserts removed, assemble connecting rod cap and torque to 33.9 Nm.

      Maximum out of round: 0.02 mm.

   b. If out of round exceeds specification shown, the connecting rod must be replaced.

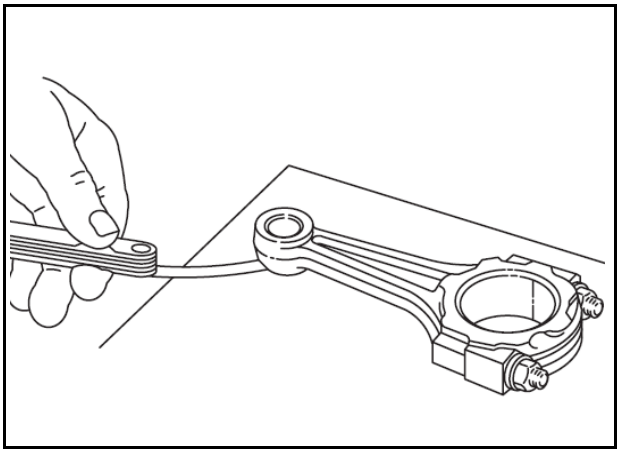


Fig. 9 -Checking Connecting Rod

4. Check for bent or twisted connecting rod, Fig. 9.

   NOTE:
   Thrust faces must be free of any burrs or nicks or connecting rod will not lay flat on surface plate.

   a. With connecting rod on a surface plate, any distortion will be evident by a rocking motion.
   b. If a 0.05 mm feeler gauge can be inserted at piston pin end of connecting rod the rod must be replaced.

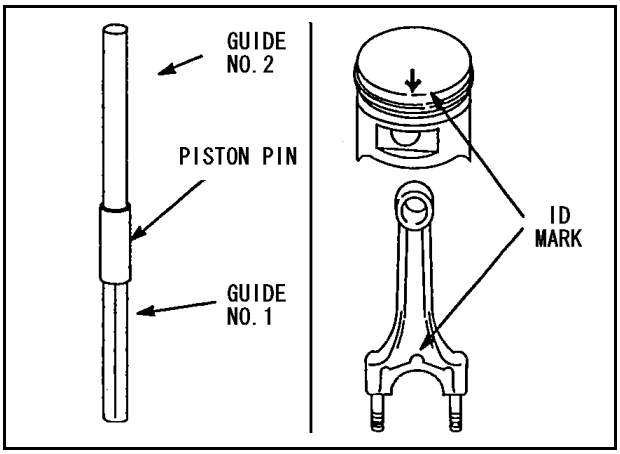


Fig.10 -Assembling Piston/Connecting Rod

ASSEMBLE PISTON AND CONNECTING ROD

Piston and connecting rod assembly
Use the SST to press the piston pin.

NOTE
Match the front marks on the piston and connecting rod.

1. Coat engine oil on the piston pin.
   Piston pin put in the Guide NO.2, screwing the Guide NO.1.

a. Turn on the ID mark of Piston and connecting rod.
   Piston and connecting rod through the Guide No.1.

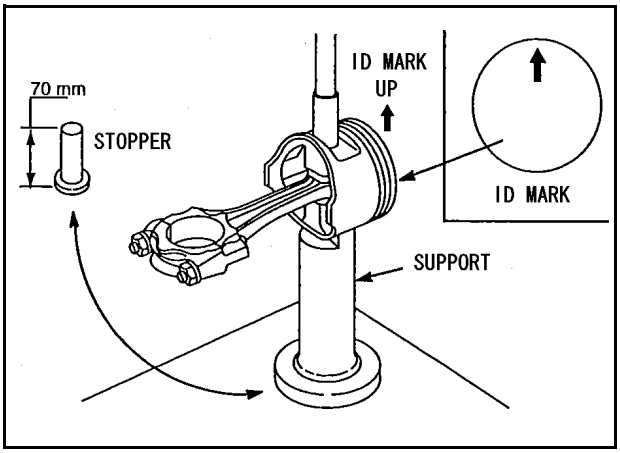


Fig.11 -Assembling Piston/Connecting Rod

2. To insert Stopper in the bottom of Support.

   a. Turn on the ID mark of the piston.

   b. Piston and guide NO.2 keep to support.
   Press fit the piston pin to guide No.1 hit stopper.

After assembly, shake from side to side and holding the Piston and Connecting rod make sure that Connecting rod is free to swing

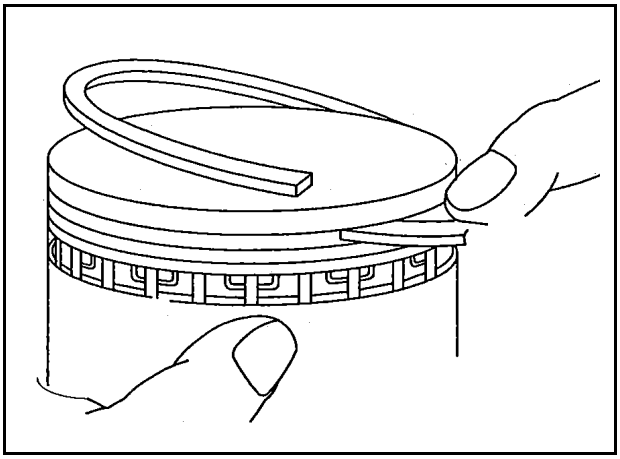


Fig.12 -Assembling Oil Ring

ASSEMBLE PISTON RINGS TO PISTON

1. Install oil ring coil expander.

a. Install lower side ring , through the top ring and center ring channel while turning.

b. Install upper side ring in the same way.

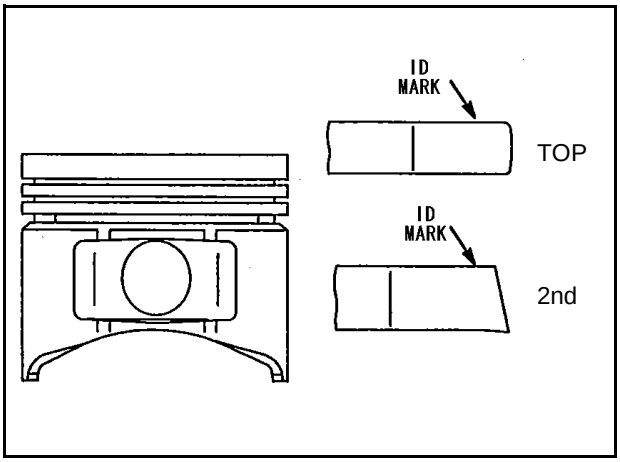


Fig. 13 - Installing Piston Rings

2. Install piston rings using ring expander.

   Install center compression ring then, top compression ring with ID marks up.

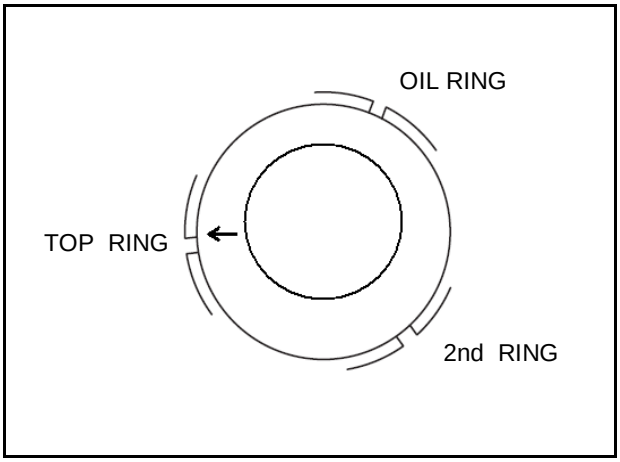


Fig. 14 - Stagger Ring End Gaps

3. Stagger ring end gaps as shown, Fig. 14.

Section 9
CYLINDER BLOCK ASSEMBLY

Section Contents

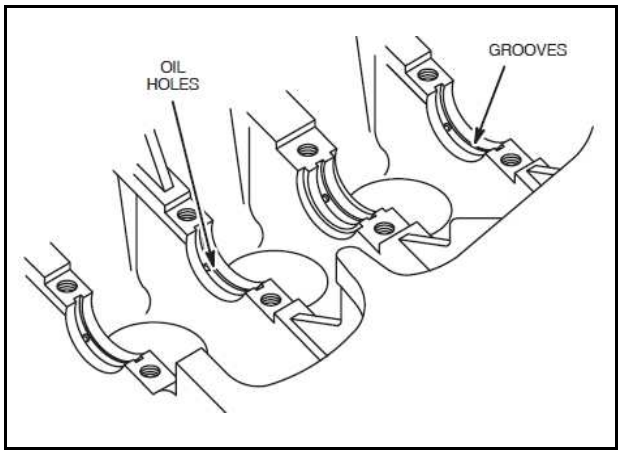


Fig.1-Installing Upper Main Bearings

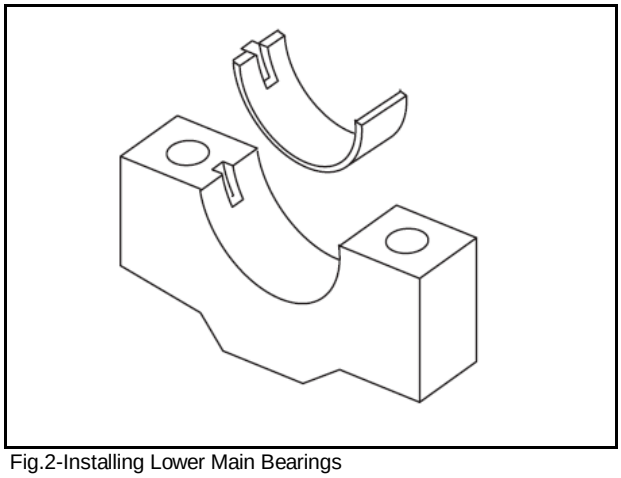


Fig.2-Installing Lower Main Bearings

INSTALL CRANKSHAFT

Install main bearings in cylinder block, Fig. 1.

NOTE
Upper bearing has an oil groove and oil holes.

1. Install upper main bearings in their respective saddles.

   a. Be sure bearing is seated in saddle and tang in bearing is aligned with notch in saddle.

   b. Lubricate bearings with engine oil..

2. Install lower main bearings in bearing caps, Fig. 2.

a. Be sure bearing is seated in bearing cap and tang in bearing is aligned with notch in bearing cap.

b. Lubricate bearings with engine oil.

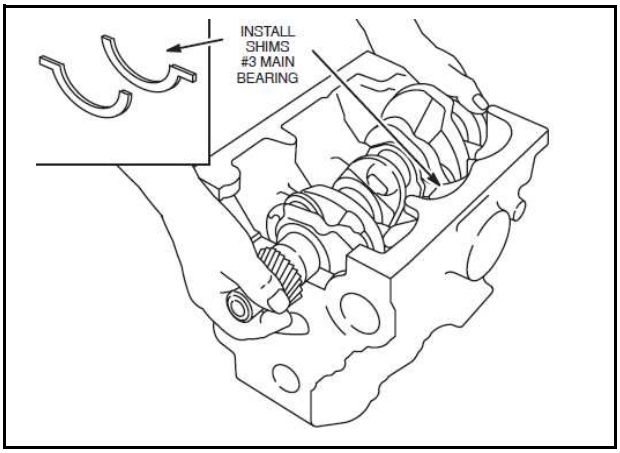


Fig. 3 -Installing Crankshaft

3. Install crankshaft with gear facing front of cylinder block, Fig. 3. Take care not to damage journals or bearings.

   a. Install crankshaft shims on #3 main bearing web with grooves facing out.

   b. Lubricate journals with engine oil.

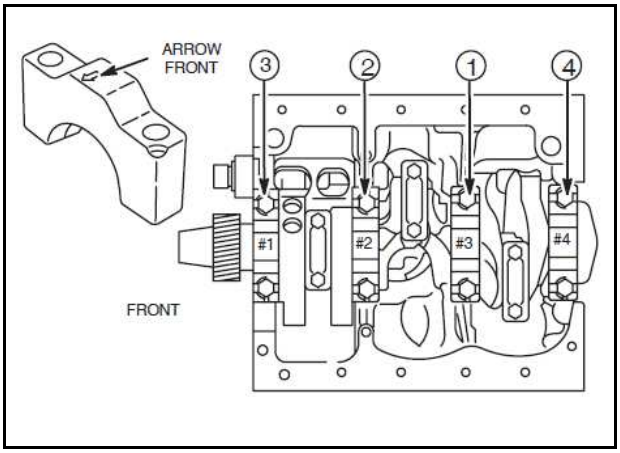


Fig. 4 - Installing Main Bearing Caps

4. Install main bearing caps, Fig. 4. Lubricate threads of screws with engine oil.

   a. Install bearing caps in their respective positions with arrows facing front.

   b. Starting with #3 bearing cap, torque bearing caps one at a time in sequence shown to 61.0Nm.

   c. Recheck crankshaft end play.

Crankshaft End Play: 0.025-0.23 mm

NOTE

After torquing bearing cap, make sure crankshaft rotates freely before proceeding to next bearing cap.

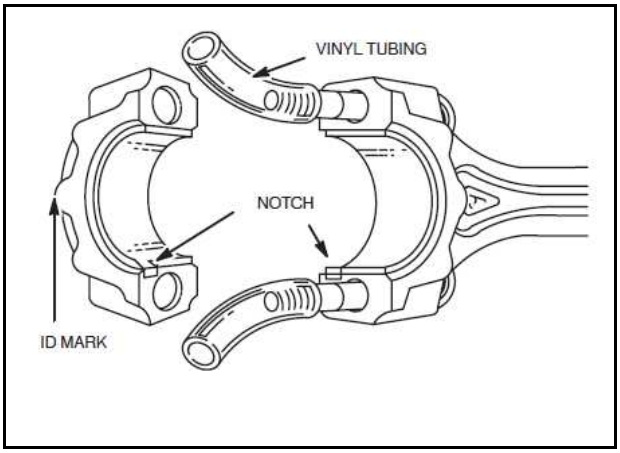


Fig. 5 - Installing Connecting Rod Bearings

INSTALL PISTONS AND CONNECTING RODS

1. Install connecting rod bearings, Fig. 5. Be sure tang on bearing is seated in notch in connecting rod and cap.

   a. Install a piece of vinyl tubing over each connecting rod screw to prevent damage to screw threads or crankpin when installing piston and connecting rod.

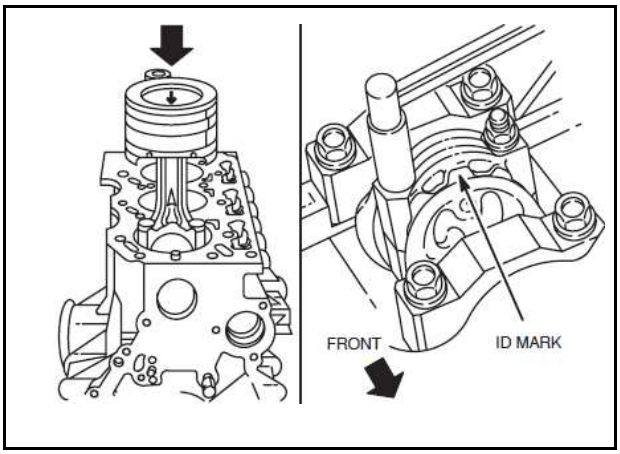


Fig. 6 - Installing Piston And Connecting Rod

Rotate crankshaft so that crankpin is at bottom of stroke. Then, lubricate cylinder walls, piston and rings, bearings and crankpins.

2. Using ring compressor, SST, install piston and connecting rod assemblies with arrow on piston facing front, Fig. 6.
   a. Install connecting rod cap with ID mark facing front. Lubricate threads and torque nuts to 34.0 Nm.

NOTE:

After torquing rod cap, make sure crankshaft rotates freely before proceeding to next cylinder.

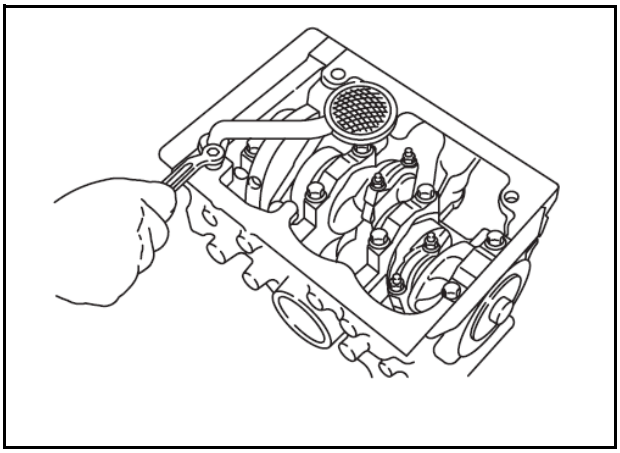


Fig. 7 - Installing Oil Pick-Up

GENERAL ASSEMBLY 1

1. Install gasket, oil pick-up tube and strainer, Fig. 7.
   a. Torque bolts to 8.0 Nm

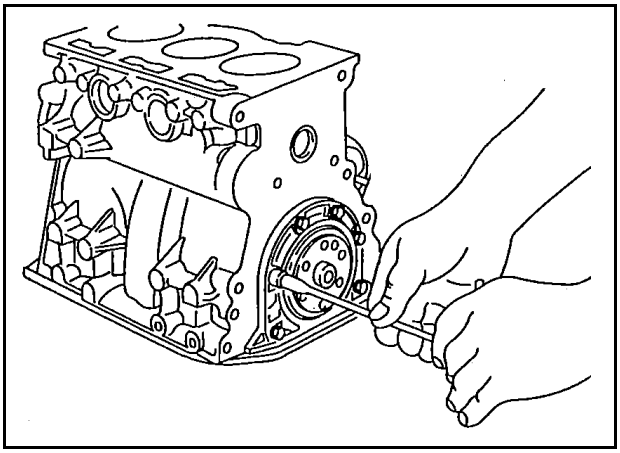


Fig. 8 - Installing Rear Seal Retainer

2. Install gasket and rear seal retainer, Fig. 8.
   a. Torque bolts to 6.0 Nm

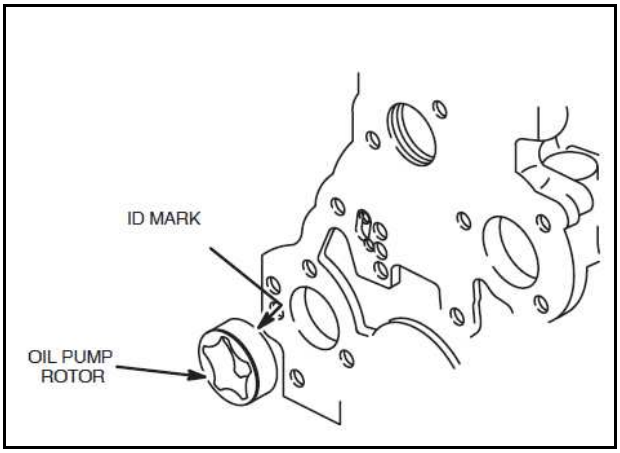


Fig. 9 - Installing Oil Pump Rotor

INSTALL TIMING GEAR CASE, CAMSHAFT AND GEARS

1. Lubricate oil pump rotor with engine oil and install in cylinder block, Fig. 9.
   a. ID mark on rotor must face cylinder block.

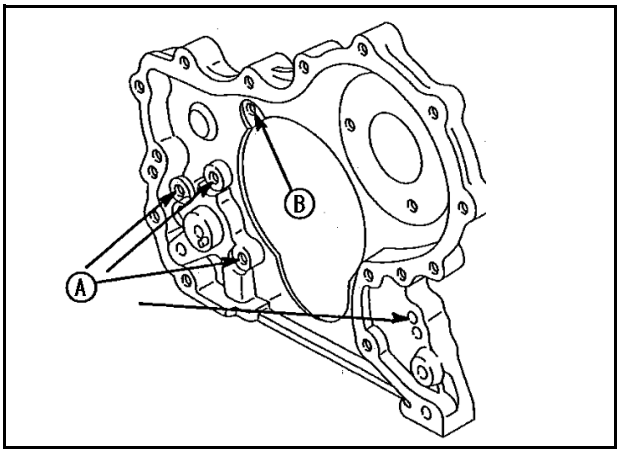


Fig. 10 - Installing Gear Case

2. Install timing gear case with new gasket.

NOTE:
It may be necessary to rotate oil pump drive to engage oil pump rotors.

Note position, length and number of screws as shown, Fig. 10.

A. M6 x 28 mm : 4
B. M6 x 16 mm : 1
Torque screws to 8.0 Nm.

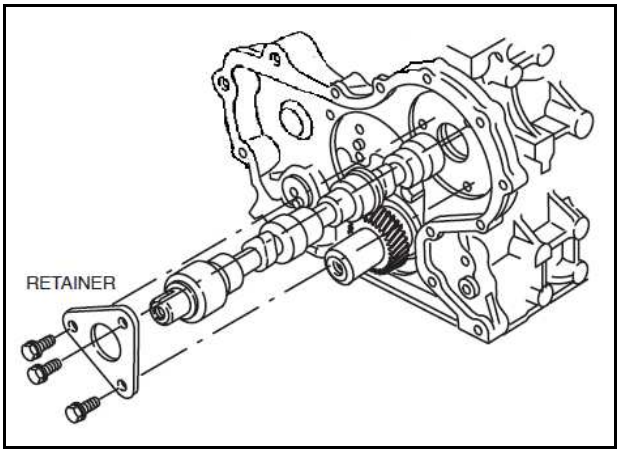


Fig. 11 - Installing Camshaft

3. Lubricate, then install camshaft in cylinder block, Fig. 11. Take care not to damage lobes or cam bearing.

a. Install camshaft retainer.
b. M6 x 18 mm : 3

Torque bolts to 8.0 Nm

NOTE:
Position camshaft retainer so that center hole does not interfere with camshaft.

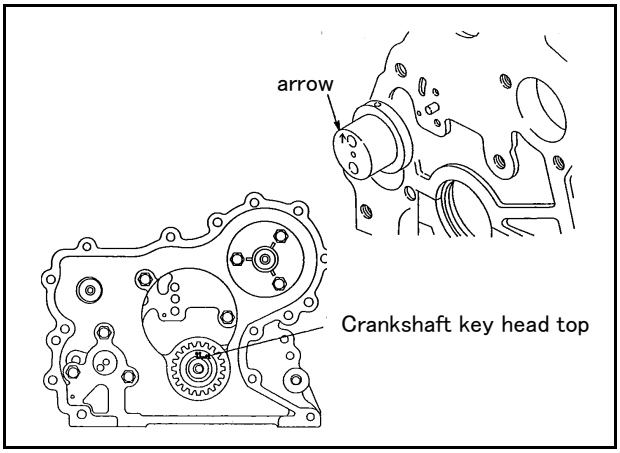


Fig.12 - Installing Idler Gear Shaft

4. Assemble idler gear shaft with arrow up.

5. Check that the NO,1 cylinder is in the TDC.

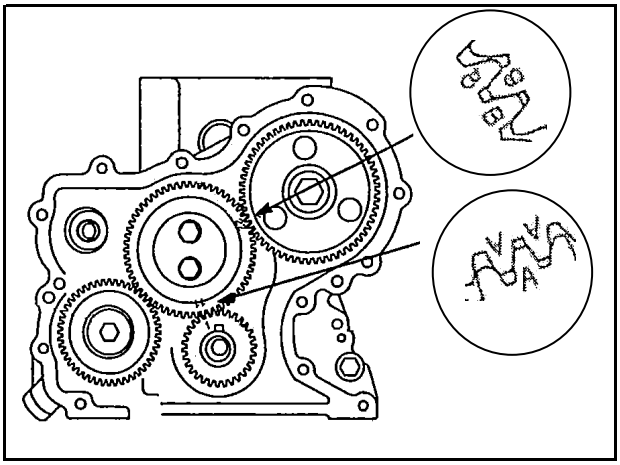


Fig. 13 - Aligning Timing Marks

6 With crankshaft key at 12 o'clock position, assemble idler gear so that timing mark AA is aligned with timing mark A on crankshaft gear, timing mark BB is aligned with timing mark B on camshaft gear, as shown in Fig.13.

a. Install oil pump gear.

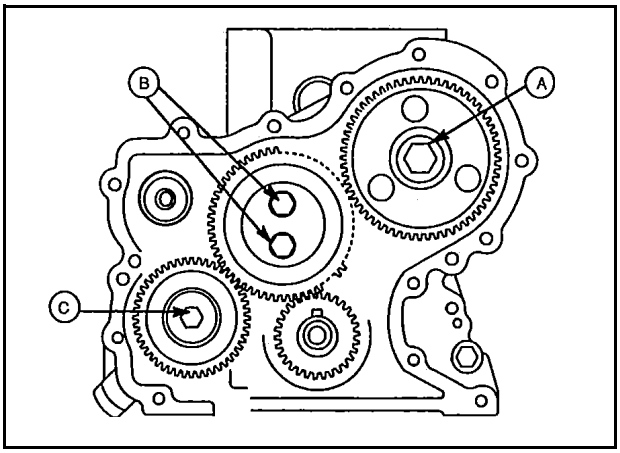


Fig.14-Torque Screws

7. Tighten 5 bolts Fig.14

A	M10 × 29mm(1pcs)	T	=	41Nm
B	M8 × 45mm(2pcs)	T	=	25Nm
C	M8 × 20mm(1pcs)	T	=	19Nm

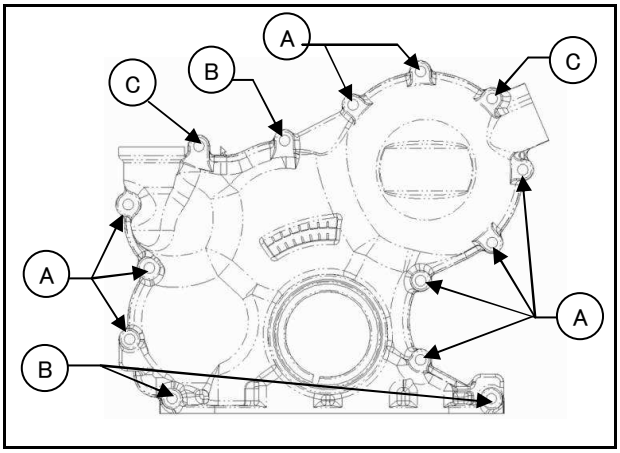


Fig.15-Installing Timing Gear Cover

8. Install timing gear cover with new gasket.

Use 12 bolts and 3 nuts and install the timing gear cover with a new gasket in-between,Fig.15.

A	M6 × 30mm(9pcs)	T	=	8Nm
B	M6 × 55mm(3pcs)	T	=	8Nm
C	M6 Nut(2pcs)	T	=	8Nm

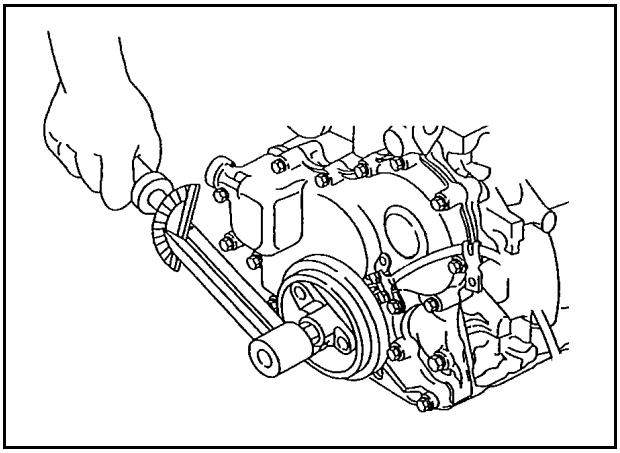


Fig.16-Installing Crankshaft Pulley

9. Install crankshaft pulley with timing mark at 12 o'clock position (#1 cylinder),Fig.16.

NOTE:
Be sure alignment pin in crankshaft gear is seated in hole in pulley.
a. Torque bolt to 88.0 Nm.
b. Remove flywheel holder.

10. Use 2 bolts and 2 nuts and install the oil strainer with a new gasket in-between.

T = 8Nm

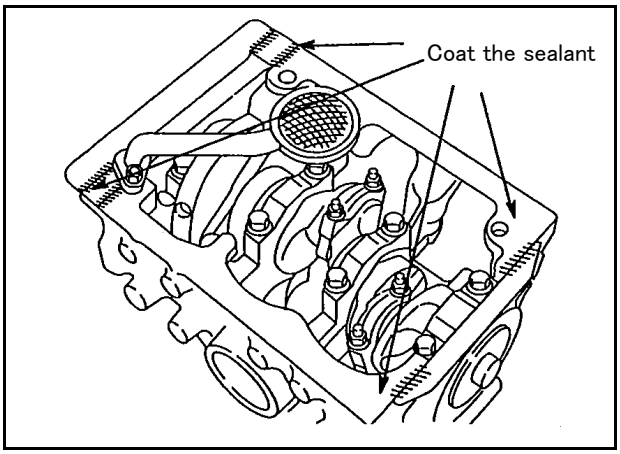


Fig.17-Installing Oil Pan

11. Oil pan installation,Fig.17.

(1) Remove the sealant (FIPG) adhered to the oil pan and cylinder block mating surface with a screwdriver, wire brush and gasket scraper.
(2) Degrease the sealant coating area and mating surface
(3) Coat the sealant on the oil pan as illustrated.
FIPG : 08826-76001-71
(4) Install the oil pan NO,1 to the cylinder block and tighter 17 set bolts, and 2 nuts to the specified torque.
T = 8Nm
(5) Install the oil pan NO,2 to the oil pan NO,1 and tighten 20 set bolts, and 4 nuts to the specified torque.
T = 8Nm

GENERAL ASSEMBLY 2

1. Lubricate tappets with engine oil and install in cylinder block.
2. See Section 2 for install

Section 10
IGNITION SYSTEM

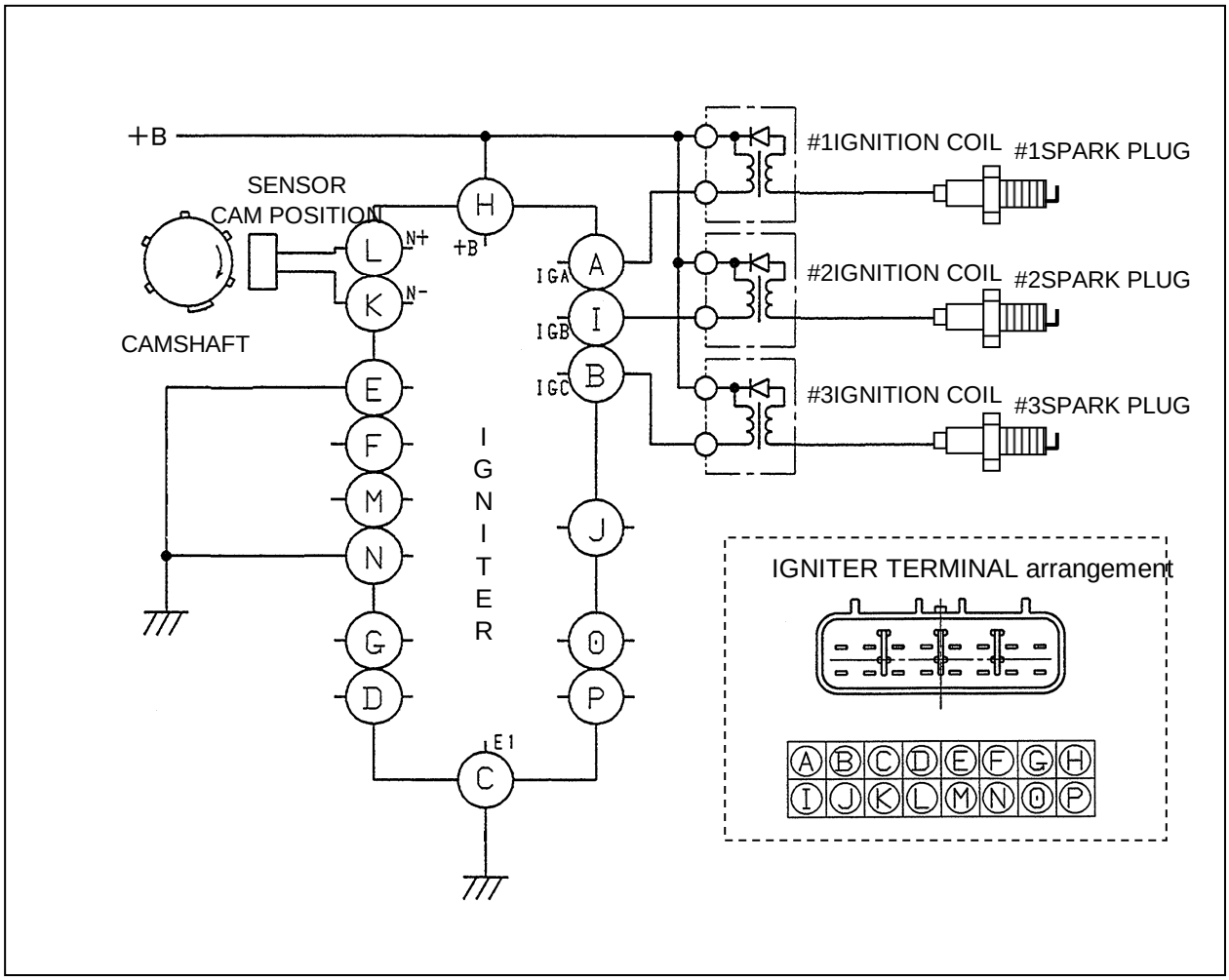
Section Contents

IGNITION SYSTEM PARTS

Ignition system consists of three main component parts.

1. Cam position sensor of a permanent magnet and Camshaft rotor for ignition signals
2. Igniter which controls ignition timing based on the signal from cam position sensor
3. Ignition coil prepared for every cylinder

IGNITION SYSTEM CIRCUIT



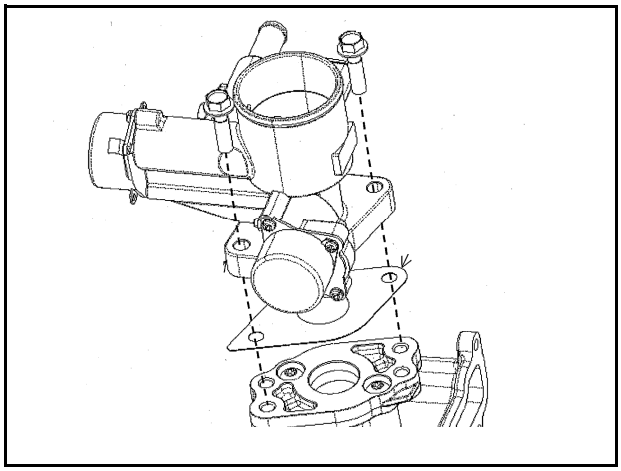


Fig. 1 - Removing ADAPTER

REMOVING AND INSTALL ADAPTER

1. Remove two bolts and remove adapter Fig.1.

NOTICE

Remove the deposit and the foreign substance adhered in the adapter.

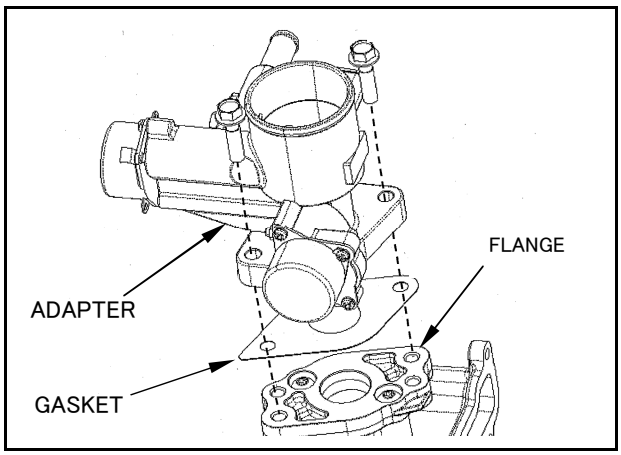


Fig. 2 - Installing ADAPTER

2. Use 2 bolts install the adapter with a new gasket in-between.
   Torque bolts to 21 Nm.

NOTICE

Replace the gaskets with new parts.

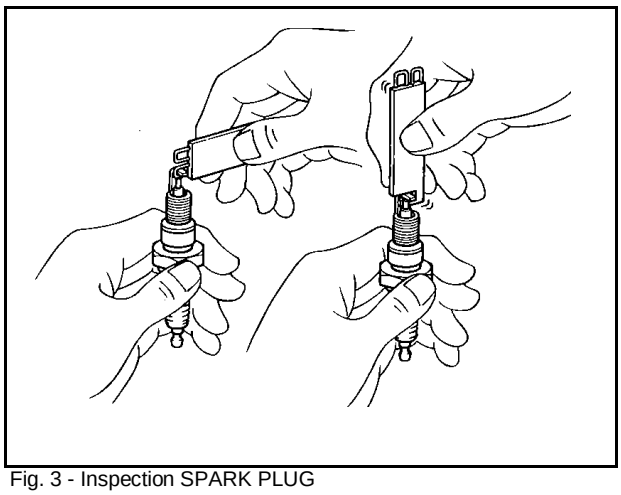


Fig. 3 - Inspection SPARK PLUG

INSPECTION SPARK PLUG

1. Remove spark plug.
2. Clean and inspect spark plug.
   Replace it if damaging.
3. Check and adjust the gap of spark plug.

   Standard : 0.7 - 0.8 mm
4. Install spark plug.

   Torque to 18Nm

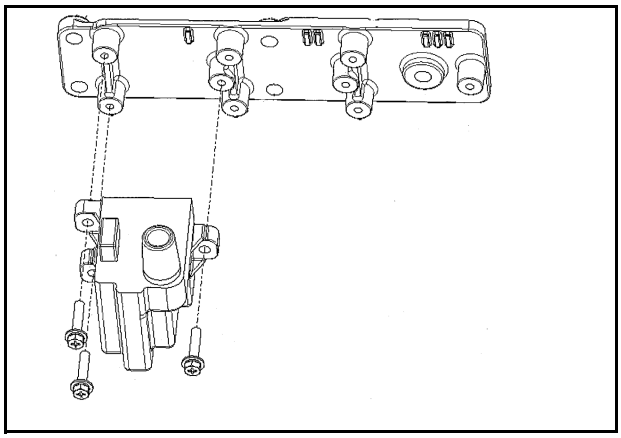


Fig. 4 - Removing IGNITION COIL

INSPECTION IGNITION COIL

REMOVING IGNITION COIL

1. Remove three bolts and remove ignition coil Fig.4.

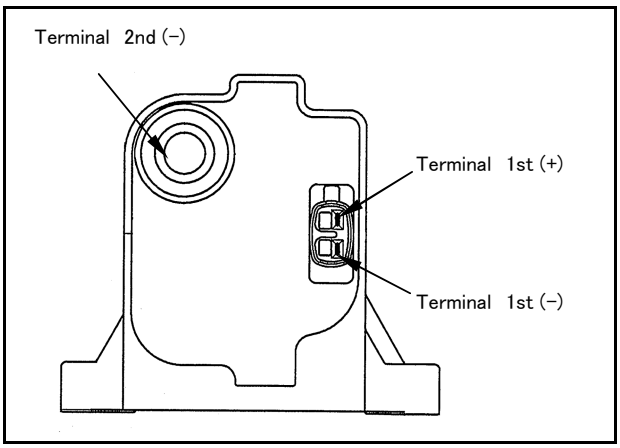


Fig. 5 - Terminal of the IGNITION COIL

INSPECTION IGNITION COIL

1. Use the circuit tester, measure the resistance value between the 1st terminal (+) and (-).

   Standard : 2.52 - 3.08 Ω (20℃)

2. Use the circuit tester (+) to the 2nd terminal (-) and the circuit tester (-) to the 1st terminal (+), the electrical connection is checked.

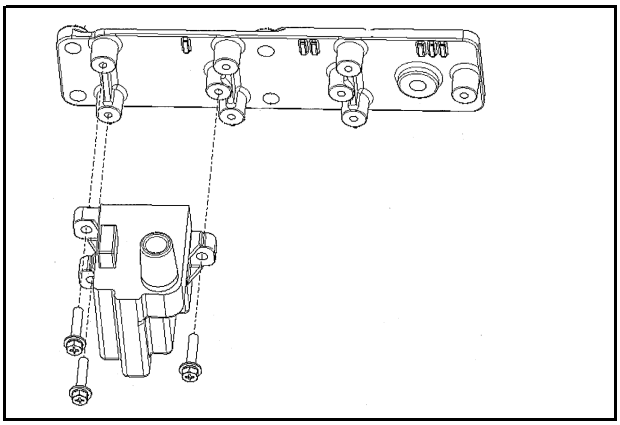


Fig. 6 - Installing IGNITION COIL

INSTALLING IGNITION COIL

1. Use 3 bolts install the ignition coil.Fig.6

   Torque bolts to 3.5 Nm.

INSPECTION OF IGNITER

Since the check by an igniter simple is difficult, it judges a quality by the result of the troubleshooting.

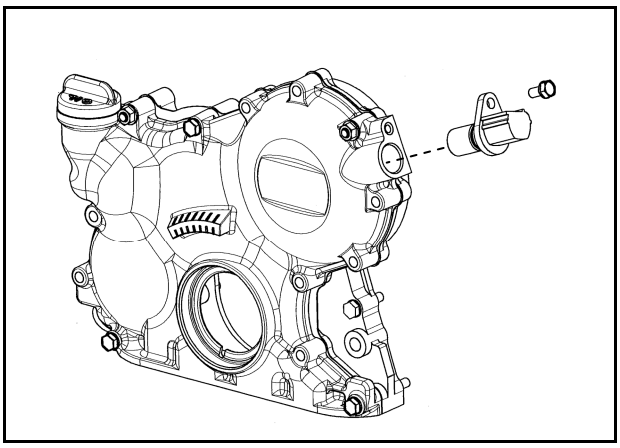


Fig. 7 – Removing Cam position sensor

REMOVING, INSPECTION AND INSTALLATION CAM POSITION SENSOR

1. Remove Cam position sensor

   (1) Remove a bolt and remove Cam position sensor.Fig.7

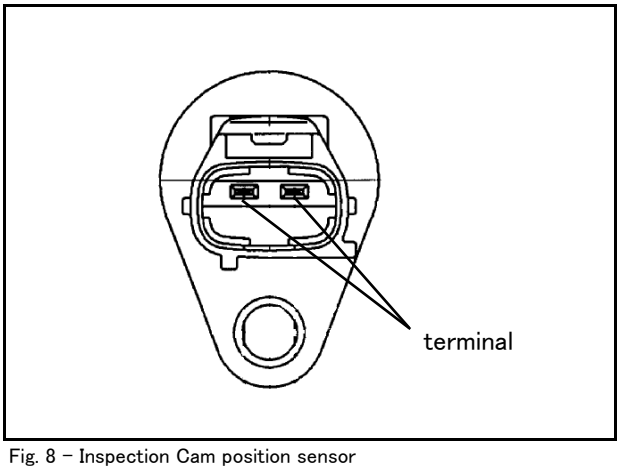


Fig. 8 – Inspection Cam position sensor

2. Inspection of Cam position sensor

   (1) Measure the resistance between 2 terminals using circuit tester.

   Standard: 950 - 1,250 Ω (20°C)

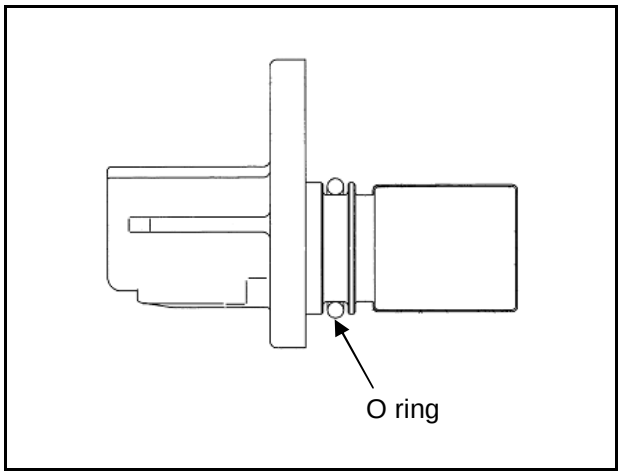


Fig.9-Installing the cam position sensor

3. Cam position sensor installation

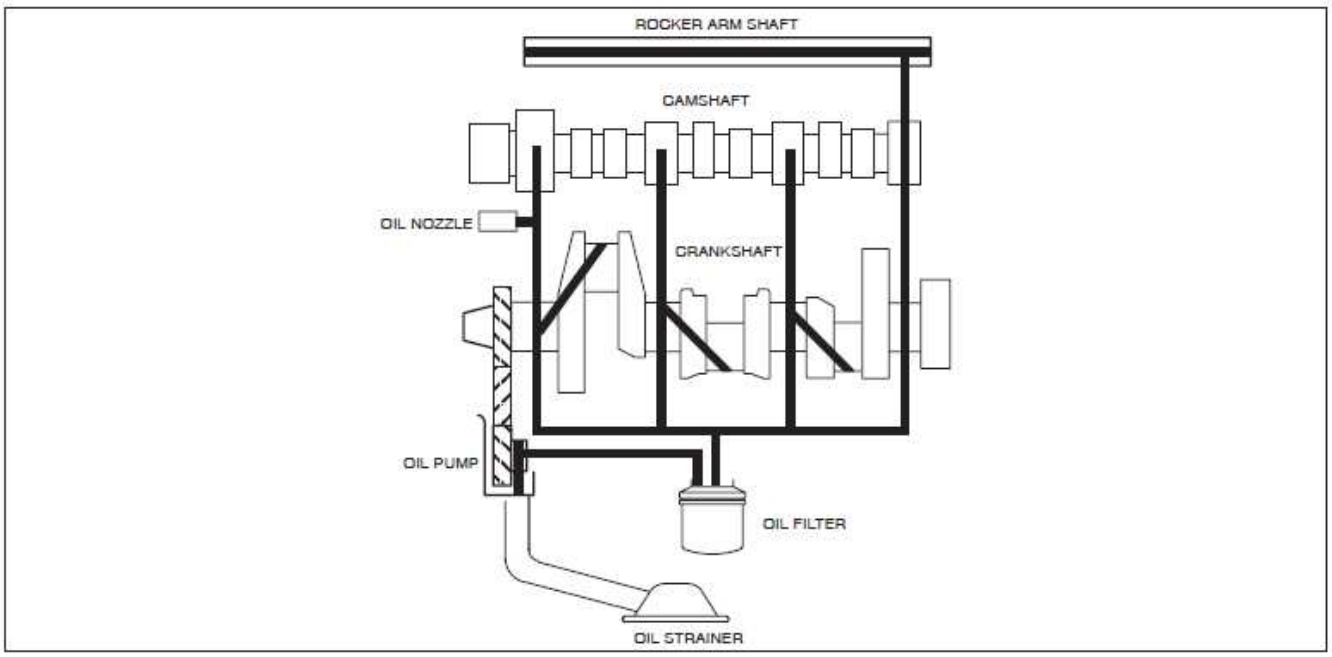
(1) Coat clean engine oil on the O ring.Fig.9.

(2) Set Cam position sensor to the engine, tighten 1 set bolt.

Torque bolt to 8.0 Nm.

Section 11
LUBRICATION SYSTEM

Section Contents



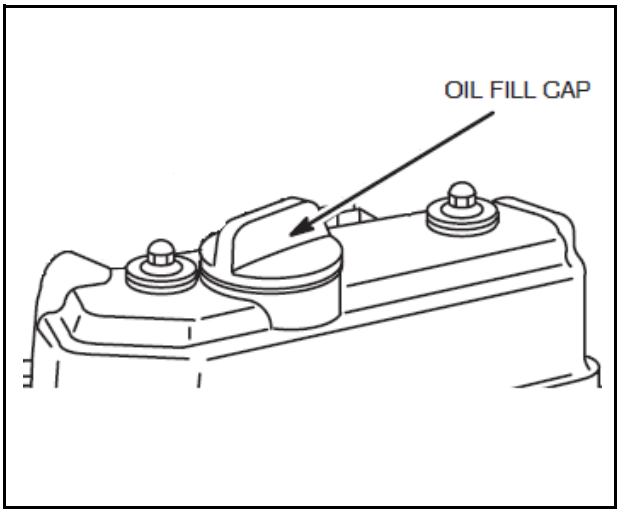


Fig.1-Oil Fill Cap

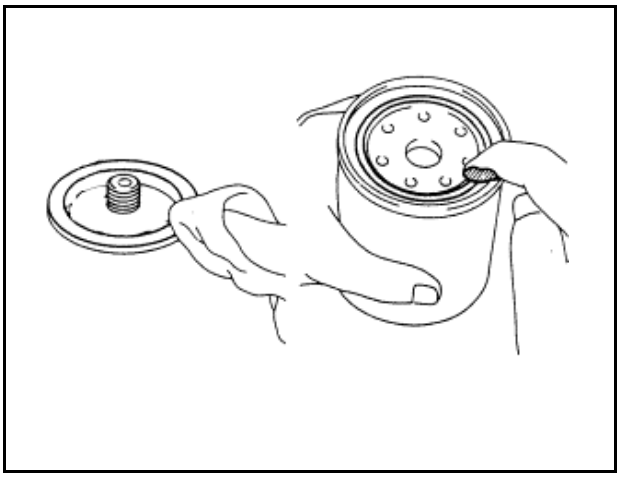


Fig.2-Checking Oil Pressure

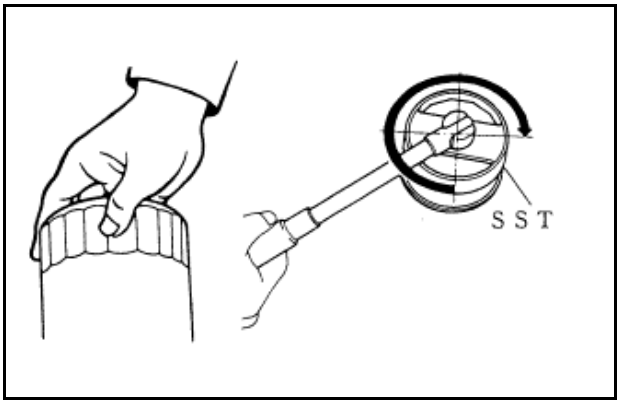


Fig.3-Checking Oil Pressure

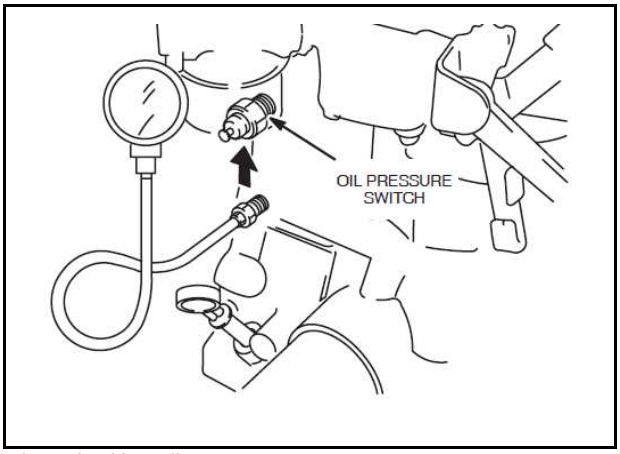


Fig.4-Checking Oil Pressure

DESCRIPTION

1KS engine use a full pressure lubrication system with an oil filter. The gear driven oil pump draws oil from a screened oil pickup in the oil pan and pumps the oil through the oil filter.
The filtered oil flows through oil galleries in the cylinder block and is distributed to the main bearings, connecting rod bearings, camshaft bearings and rocker arm shaft.
A pressure relief valve limits the maximum oil pressure in the system.

CHANGING OIL

Remove oil fill cap and refill with oil of recommended grade and viscosity.

CHANGING OIL FILTER

0. Engine oil drain. See 3-2 1.Engine oil draining.

1. Oil filter removal
   (1) Use the SST to remove the oil filter.

2. Oil filter installation
   (1) Clean the oil filter mounting surface.

   (2) Cost clean engine oil on the gasket.

   (3) Lightly screw in the oil filter by hand until the gasket is brought into contact with the filter bracket.

   (4) Use the SST. Torque=17.5Nm

CHECKING OIL PRESSURE

1. Remove oil pressure switch.
2. Install oil pressure gauge.
3. Start the engine and allow it to reach normal operating temperature.
4. Check oil pressure at 3000 RPM.
   Oil Pressure: 2.0 ~ 5.0 Bar (28 ~ 70 psi)
   See charts below for troubleshooting guide.

Low Oil Pressure
Engine RPM Too Low
Wrong Viscosity or Diluted Oil
Low Oil Level
Broken Pressure Relief Spring
Missing Pressure Relief Plunger
Worm Bearings

High Oil Pressure
Wrong Viscosity Oil
Plugged Oil Galleries

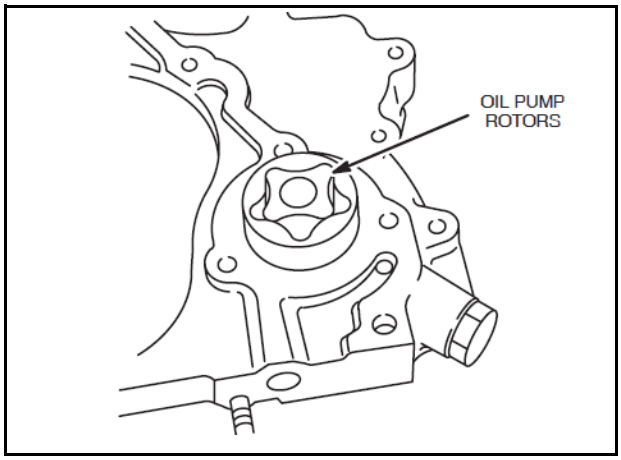


Fig. 5 - Inspect Rotors

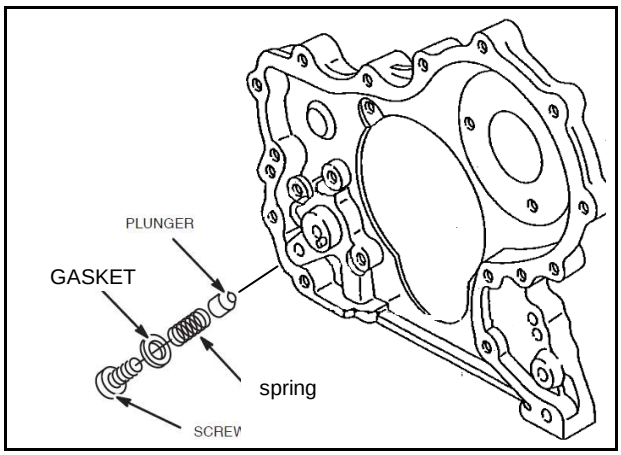


Fig. 6 - Checking Pressure Relief Valve

DISASSEMBLE GEAR CASE, REMOVING OIL PUMP

1. Remove GEAR CASE. See Sec. 3.

2. Inspect rotors for wear or damage, Fig. 5.

NOTE:
If pump rotors are worn or damaged, replace the gear case.

3. Remove and check pressure relief valve assembly, Fig. 6.

   a. Make sure plunger has no nicks or burrs.
   b. Check pressure relief valve spring free length.

4. Spring free length: 35.5 mm ± 1.0 mm

5. Assemble GEAR CASE. See Sec. 3.

Section 12
SPECIAL SERVICE TOOL

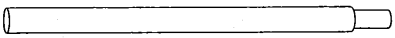
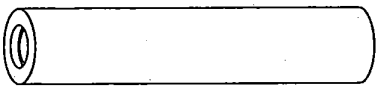
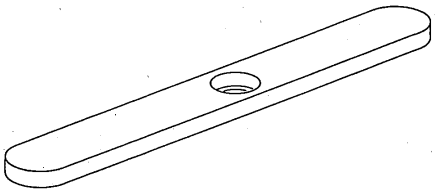
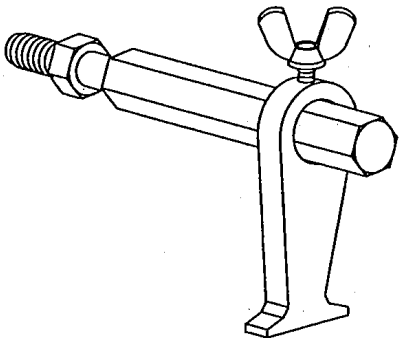
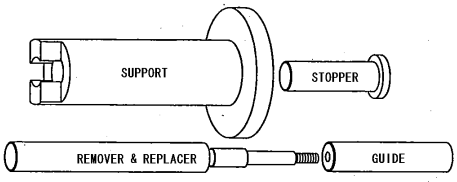
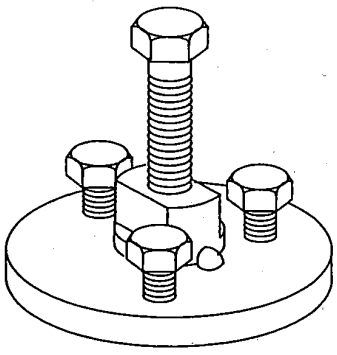
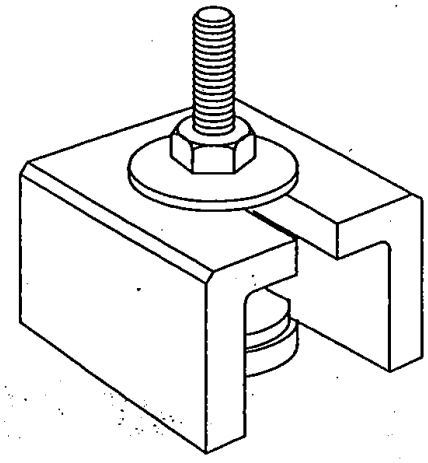
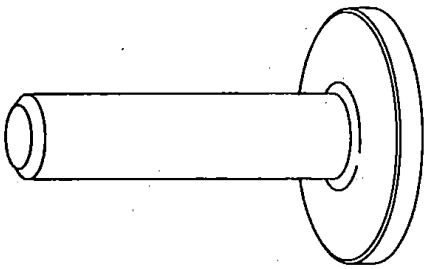
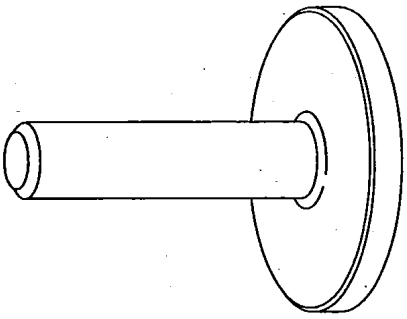
ILLUSTRATION	PART NO.	PART NAME
	————	VALVE GUIDE BUSHING REMOVER
	————	VALVE GUIDE BUSHING REPLACER
	————	VALVE SPRING REPLACER
	————	FLYWHEEL HOLDER
	————	PISTON PIN REMOVER & REPLACER
	————	CRANKSHAFT PULLEY REPLACER

ILLUSTRATION	PART NO.	PART NAME
	————	CAMSHAFT BEARING REMOVER
	————	CAMSHAFT BEARING REPLACER
	————	TIMING GEAR COVER OIL SEAL REPLACER
	————	REAR OIL SEAL REPLACER