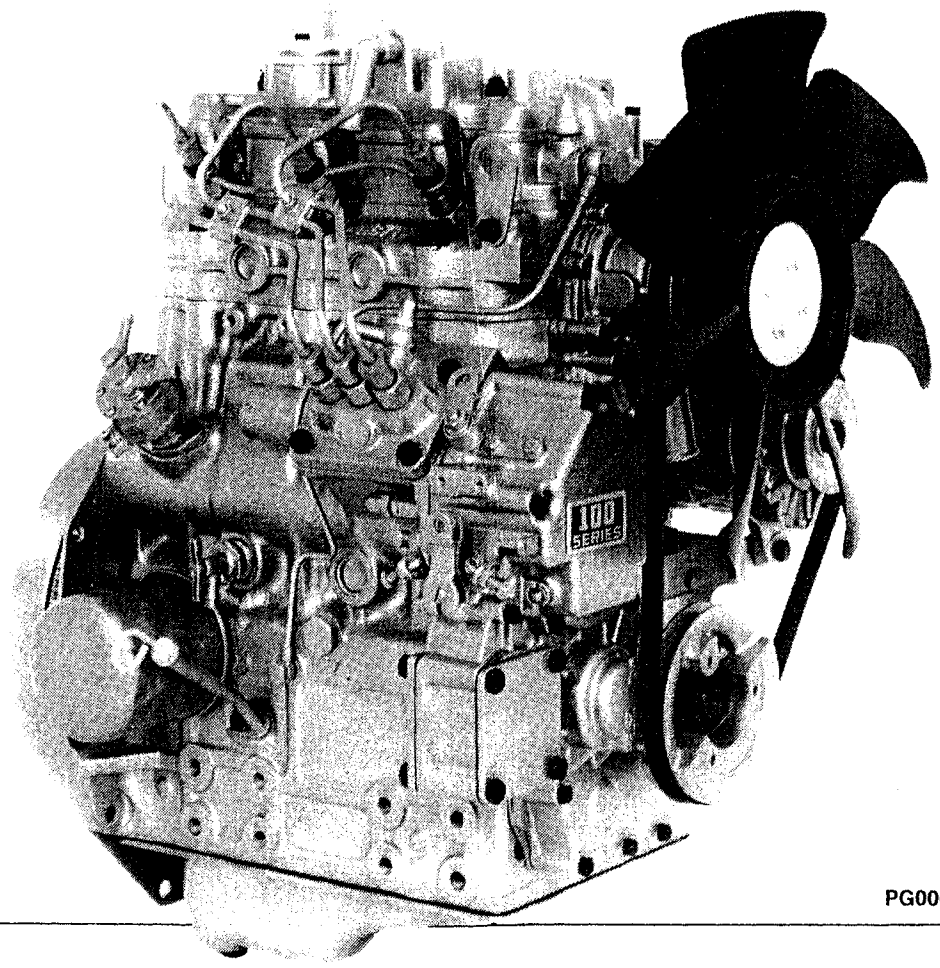
PERKINS

100 SERIES

Perkins Engines

WORKSHOP MANUAL



PG000

Perkins 100 Series:

103-12/103-13/103-15/104-19

Part # 6SE904

workshop manual for 100 SERIES 103-12/103-13/103-15/104-19

This publication is written for worldwide use. In territories where legal requirements govern engine smoke emission, noise, safety factors, etc., then all instructions, data and dimensions given must be applied in such a way that, after servicing (preventive maintenance) or repairing the engine, it does not contravene the local regulations when in use.

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In addition to the above, there are Perkins Distributors in the majority of countries. For further details, apply to Perkins Engines Ltd., Peterborough, or to one of the above companies.

CONTENTS

Abbreviations and codes

Engine Build List (Parts List) Numbering System

The standard engine parts list numbering code system is defined as follows:

Code	I	II	III	IV	V
Example:	KE	30259	J	000001	M

Code I Engine Type

KE = 103–15 IDI
KF = 104–19 IDI
KG = 103–12
KH = 103–13
KJ = 103–15 DI
KK = 104–19 DI

Code II Engine Parts List

Parts list increases numerically for both OEMS and distributors.

Code III Country of Manufacture

J = Made in Japan

Code IV Engine Serial Number

Individual engine serial number commencing with 000001 increasing numerically

Code V Year of Manufacture

M = 1985
N = 1986
O is Omitted
P = 1987
Q/S = 1988
T = 1989
U = 1990

FOREWORD

This Workshop Manual has been compiled for use in conjunction with normal workshop practice. Mention of certain accepted practices, therefore, has been purposely omitted in order to avoid repetition.

Reference to renewing joints and cleaning off joint faces, has to a great extent been omitted from the text, it being understood that this will be carried out where applicable. Similarly, it is understood that in reassembly and inspection, all parts are to be thoroughly cleaned, and where present, burrs and scale are to be removed.
It follows that any open ports of high precision components, e.g. fuel injection equipment, exposed by dismantling, will be blanked off until reassembled, to prevent the ingress of foreign matter.

When fitting setscrews into "through" holes into the interior of the engine, a suitable sealant should be used.

Throughout this manual, whenever the "left" or "right" hand side of the engine is referred to, it is that side of the engine when viewed from the flywheel end.

This publication is produced by the Compact Engines Division of Perkins Engines Ltd. and every endeavour is made to ensure that the information contained in this manual is correct at the date of publication, but due to continuous development, the manufacturers reserve the right to alter this specification without notice.

Safety Precautions

THESE SAFETY PRECAUTIONS ARE MOST IMPORTANT. Reference must also be made to the local regulations in the country of operation.

Do not use these engines in marine applications .

Do not change the specification of the engine.

Do not smoke when you put fuel in the tank.

Clean away any fuel which has spilled and move material which has fuel contamination to a safe place.

Do not put fuel in the tank during engine operation (unless absolutely necessary).

Never clean, lubricate or adjust the engine during operation (unless you have had the correct training when extreme caution must be used to prevent injury).

Do not make any adjustments you do not understand.

Ensure the engine is not in a position to cause a concentration of toxic emissions.

Persons in the area must be kept clear during engine and equipment or vehicle operation.

Do not permit loose clothing or long hair near parts which move.

Keep away from parts which turn during operation. Note that fans cannot be seen clearly while the engine is running.

Do not run the engine with any safety guards removed.

Do not remove the radiator cap while the engine is hot and the coolant is under pressure as dangerous hot coolant can be discharged.

Do not use salt water in the fresh water cooling system or any other coolant which can cause corrosion.

Keep sparks or fire away from batteries (especially while during charge) or combustion can occur. The battery fluid can burn and is also dangerous to the skin and especially the eyes.

Disconnect the battery terminals before you make a repair to the electrical system.

Only one person must be in control of the engine.

Ensure the engine is only operated from the control panel or operators position.

If your skin comes into contact with high pressure fuel, get medical assistance immediately.

Diesel fuel and used engine oils can cause skin damage to some persons. Use protection on the hands (gloves or special skin protection solutions).

Do not move equipment unless the brakes are in good condition.

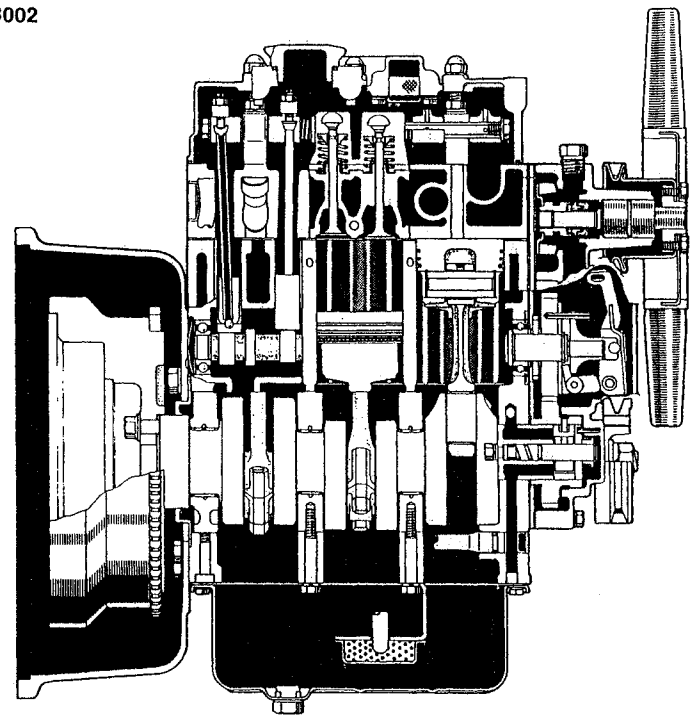
Ensure that the transmission drive control is in "Neutral" position before the engine is started.

Fit only genuine Perkins Parts.

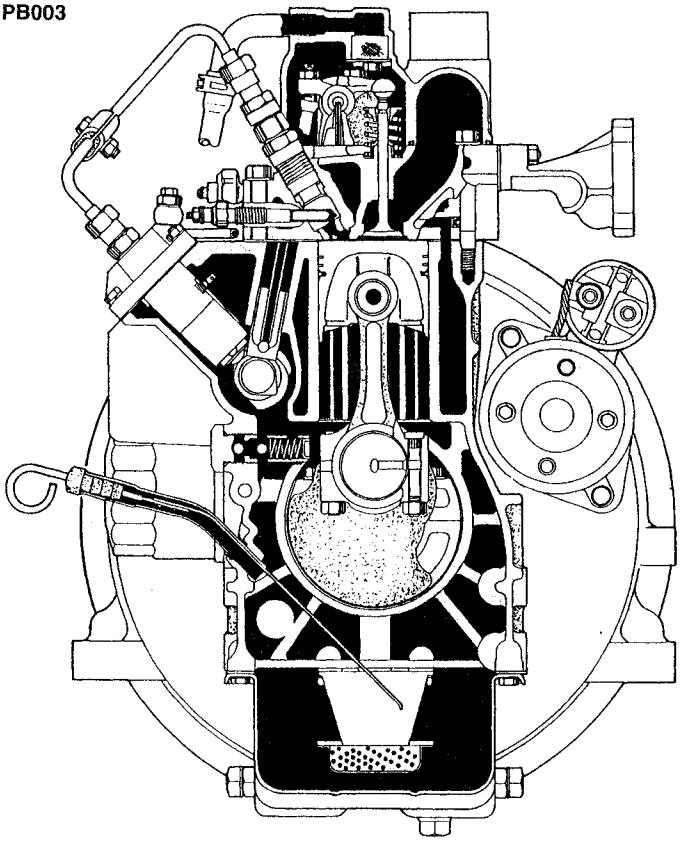
Do not use ether to start these engines.

Engine cross sectional views

PB002



PB003



Perkins 100 Series: 103-12/103-13/103-15/104-19

DESCRIPTION; GENERAL

The Perkins 100 Series is a three or four cylinder four stroke, liquid cooled, compression ignition engine, designed for durability, low weight and compactness. The liner-less cylinder block, three-piece helical gear train and flange mounted fuel injection pump on the engine cam, reduce frictional power loss, and engine weight. The special direct-injection or swirl chamber along with the small bore multi-cylinder design offers good fuel consumption, low noise and excellent startability.

The Perkins 100 Series offers easy maintenance with all service items on the right hand side of engine.

DESCRIPTION; COMPONENT ASSEMBLY

Cylinder Block:
The cylinder block is made from high grade cast iron with copper and chrome additives and is integral with the crankcase. The crankcase features four or five main bearings of the tunnel block design, with crankcase walls extending well below the crankshaft centre line for strength and rigidity. The cylinder bores are plateau honed for oil retention and extended ring life. The non-machined surfaces are sealed to ensure cleanliness.

Crankshaft:
The crankshaft is a chrome-molybdenum steel forging, fully machined, static and dynamically balanced with integral counterweights. All bearing surfaces are induction hardened. The axial location is by thrust washers at number four or five main bearing. The four/five main journals run in replaceable steel-backed cast copper/lead alloy bearings. The front of the crankshaft is keyed.

Pistons and Connecting Rods:
Pistons are cast from high silicon aluminium alloy and are heat treated for low weight with high strength and good thermal conductivity. The piston is fitted with three rings; two cast iron, chrome-faced compression rings and one steel, chrome-faced controlled oil ring. The fully floating gudgeon pin (wrist pin) is made of chrome molybdenum steel alloy hardened by carburizing and retained by the conventional circlip method. The connecting rods are machined from high strength forged steel. The big end bearings are renewable steel-backed, copper/lead alloy overlay with tin plating. The small end bearings are a press fit plain bush of tin-backed lead/bronze.

Camshaft:
The camshaft is made of forged steel and is induction hardened. Three or four additional lobes at the front operate the fuel injection pump. At the rear a fuel lift pump eccentric is machined. The camshaft is supported by roller and needle bearings and lubricated by splash feed. The nose of the camshaft supports the tachometer drive, cam gear, governor weight cage and governor slider assembly.

Cylinder Head:
The cylinder head is made of high grade copper chrome cast iron, and incorporates replaceable heat resistant alloy steel valve seats. Inlet and exhaust valves are made of high grade heat resistant alloy steel with tuftrided stems and induction hardened heads. Each stem is fitted with a chrome molybdenum steel cap for long life.

The valves are operated by cold drawn seamless tube pushrods with hardened steel ball and forged cup ends. Flat based tappets are made from case carburized chrome molybdenum steel operating in machined bores in the cylinder block. The rocker shaft is an induction hardened hollow steel tube. Valve clearances are adjusted by hardened ball ended screws and locknuts.

Rocker Cover and inlet manifold:
The cover is made of cast aluminium with an air intake, oil filler and crankcase breather. It is located in position by rocker pillar studs and secured by cap nuts.

Gear Train:
The gear train consists of three helical gears; the crankshaft gear, located by a woodruff key. The idler gear houses the lube oil pump and the cam gear incorporates the governor weight cage.

Fuel System:
A flange mounted, Bosch type fuel injection pump is mounted in the cylinder block and operated by lobes machined on the engine cam. The fuel lift pump is located on the right-hand side of the cylinder block and also operated by the engine camshaft.

Balancer:
A dynamic balancer unit is fitted to certain four cylinder versions of the engines which will be rigidly mounted. The purpose of the balancer unit is to reduce the effect of the out-of-balance forces to a satisfactory condition.

Lubricating System:
A trochoid lobe type oil pump located in the centre of the idler gear sends lubricating oil to the main oil galley via a relief valve through a spin-on bypass oil filter to the main oil gallery. The rockers are pressure fed via an externally mounted oil pipe, from the main oil gallery to the cylinder head.

Cooling System:
A belt driven centrifugal water pump circulates coolant via the internal water passages. The coolant is radiator-cooled and temperature controlled by a conventional thermostat.

SECTION II
General Engine Data

	KG 103-12	KH 103-13	KE 103-15	KJ 103-15	KK 104-19	KF 104-19
Type	Vertical in-line 4 stroke naturally aspirated					
	3 cyl.	3 cyl.	3 cyl.	3cyl.	4 cyl.	4 cyl.
Basic Thread and Size	Metric					
Bore mm (inch)	82 (3.23)	84 (3.31)	84 (3.31)	84 (3.31)	84 (3.31)	84 (3.31)
Stroke mm (inch)	80 (3.15)	80 (3.15)	90 (3.54)	90 (3.54)	90 (3.54)	90(3.54)
Combustion System	I.D.I. (Special Swirl)			DI (Direct Injection)		IDI (Special Swirl)
Compression Ratio	22.5:1	23:1	22.5:1	19:1		22:1
Swept Volume litre (inch^3)	1,267 (77.32)	1,330 (81,16)	1,496 (91,29)	1,496 (91,29)	1,995 (121,7)	1,995 (121,7)
Firing Order	1-2-3	1-2-3	1-2-3	1-2-3	1-3-4-2	1-3-4-2
Rotation	Anti-clockwise viewed from flywheel					
Injection Pump	Flange mounted, Bosch type plunger and barrel					
Injectors	Bosch type throttle			Bosch type hole		Bosch type throttle
Injector Setting						
Kilograms/sq. cm (kgf/cm^2)	155-165			215-225		155-165
Atmospheres (atm)	153-163			212-222		155-165
Pounds per sq. inch (PSI)	2204-2346			3057-3200		2204-2346
Governor	Mechanical all speed					
Cooling System	Liquid with water pump and radiator					
Industrial Cooling System Capacity (less radiator) litres	2,5	2,5	2,65	2,80	3,75	4,0
Thermostat Operating Temperature (deg. C)	71/82					
Lubricating System	Pressure feed with Trochoid pump					
Typical Lubricating Oil Capacity (including filter) litres	5.8	5.8	5.8	5.8	7.1	7.1
Oil Pressure Relief	35-50 PSI					
Oil Pressure Switch	4.3 PSI					
Electrical System						
Starter	12V					
Alternator	12V					
Battery 12V	70 AH min				100 AH min	100 AH min.
Weight, Bare Engine (Industrial) kg	125	125	135	135	178	178
Height mm	613	613	638	638	669	669
Length F/F mm	530	530	540	540	623	623
Width mm	462	462	462	462	455	455
Min. Idle Speeds	800 rev/min					
Recommended Engine Fluids						
Coolant	Clean soft water. Maximum antifreeze concentration 50% (ethanediol base–ethylene glycol with corrosion inhibitor to BS 6850:1985 or ASTM D3306-74 or AS 2108-1977)					
Fuel	Cetane number – 45 minimum, Viscosity – 2.5/4.5 centistokes at 40°C Density – 0.835/0.855 kg/litre, Sulphur – 0.5% of mass maximum Distillation 85% at 350°C (Aviation fuel JP4 is not recommended, however JP5 and JET-A are acceptable providing 5% spindle oil added)					

Lubricating oil

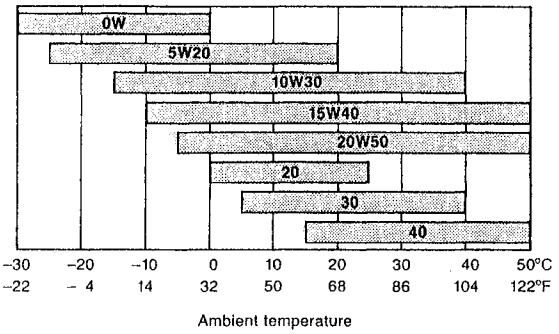
Lubricating oil specification

Engine type	Specifications	
	API CC/SE MIL-L-46152 CCMC D1	API CD/SE MIL-L-2104C CCMC D2
Naturally aspirated	•	•(1)

(1) Not recommended during the first 20/50 hours of operation

NB: Ensure correct fluids are used and oil and coolant are filled SLOWLY and to the correct quantities.

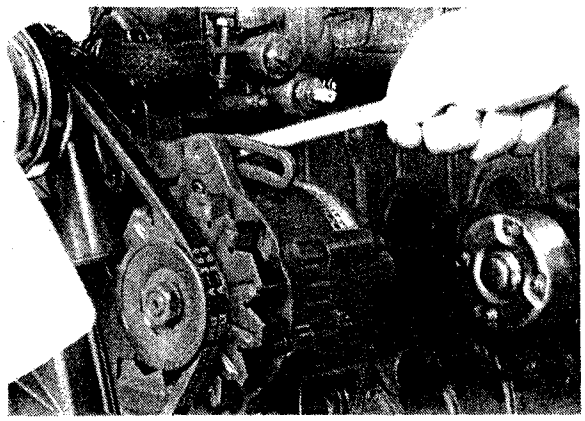
Recommended SAE viscosity grades



SECTION III
Dismantling Sequence

Alternator

A. Remove alternator and adjusting bracket.



PH005

Remove Cooling Fan and Pulley

Fuel Injection Pipe

A. Loosen fuel pipe nuts from fuel injection pump and injectors. Remove pipes as an assembly.

B. Remove spring clamp and fuel return hose.

Atomizer Assembly

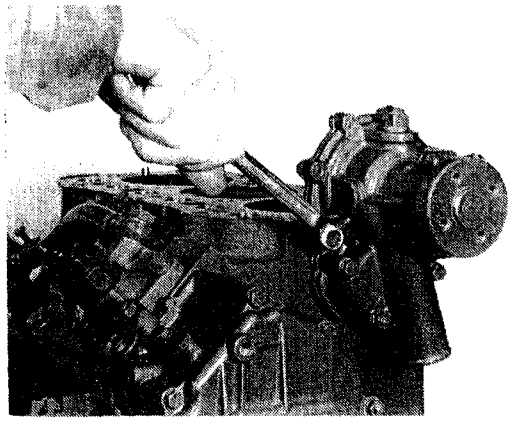
A. Loosen and remove securing nuts. Remove leak-off rail. Remove aluminium washers and discard. Remove atomizers.

Contact Switches

A. Remove water and oil sender units.

Water Pump Assembly

A. Loosen securing bolts and remove water pump assembly and set plate.

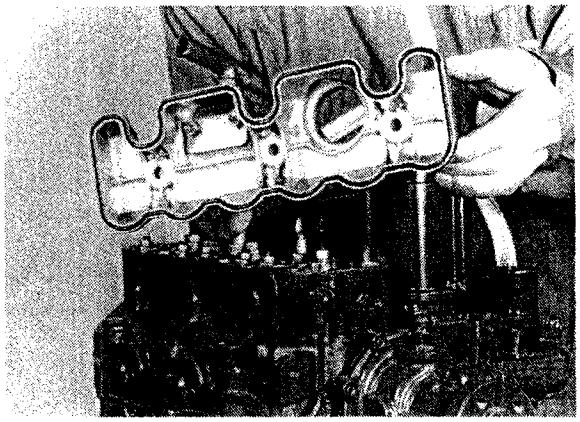


PG013

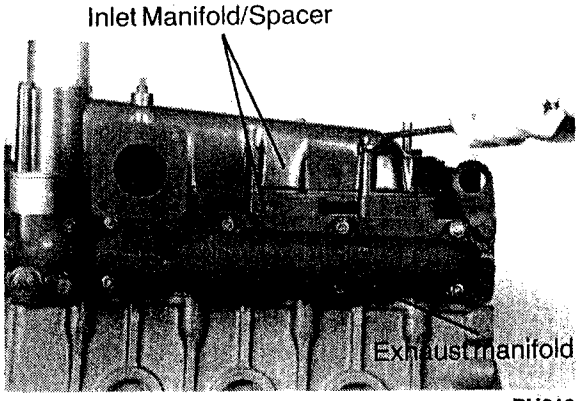
Rocker Cover/Inlet manifold/ Exhaust manifold

A. Remove breather hose. Loosen and remove three/four cap nuts with washers. Lift rocker cover assembly ref. PG008.

B. Remove inlet manifold, spacer and exhaust manifold ref. PH010.



PG008

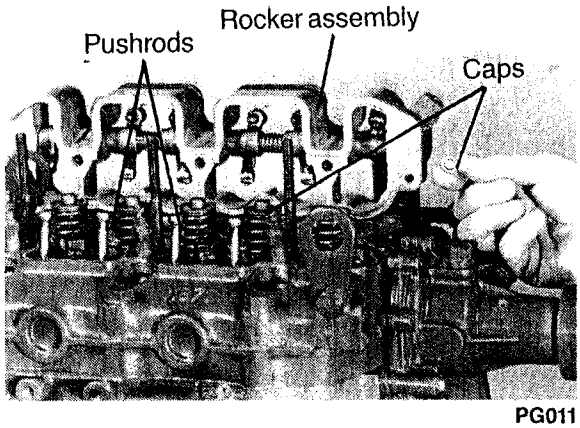


PH010

Rocker Assembly

A. Loosen and remove nuts, lock washers and flat washers from rocker pillar stud. Lift rocker assembly.

B. Remove push rods, and valve stem caps.

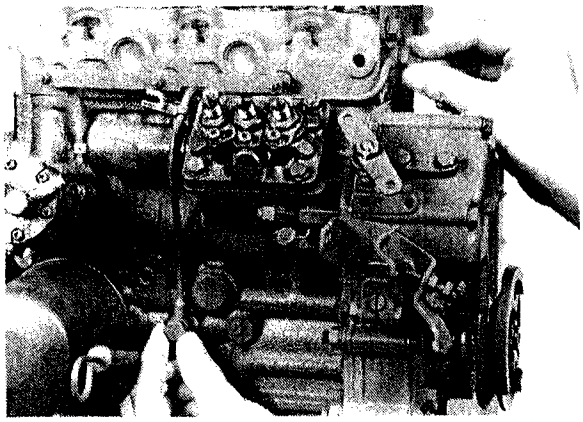


PG011

External Oil Pipe

A. Loosen and remove two banjo bolts at cylinder block main oil gallery and cylinder head assembly.

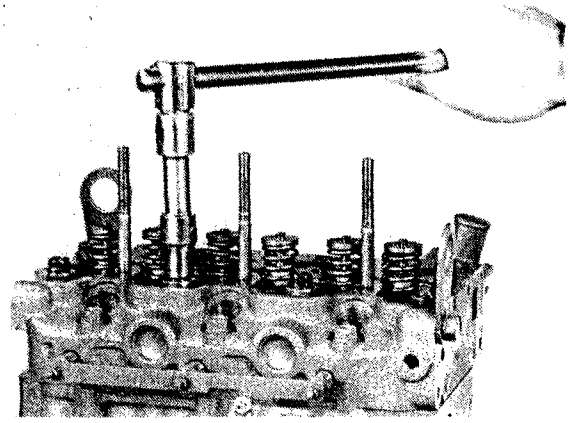
B. Remove clamp from fuel injection pump.



PB008

Cylinder Head Assembly

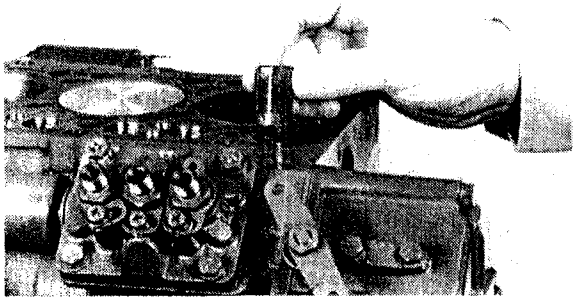
A. Loosen cylinder head bolts starting from the centre, in a circular pattern using several steps of equal torque. Remove head.



PB009

Tappets

A. Pull tappets from the machined bores in cylinder block.

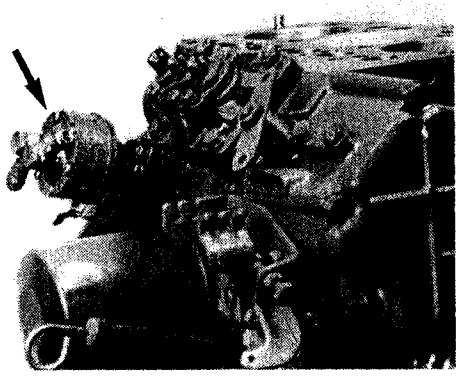


PB010

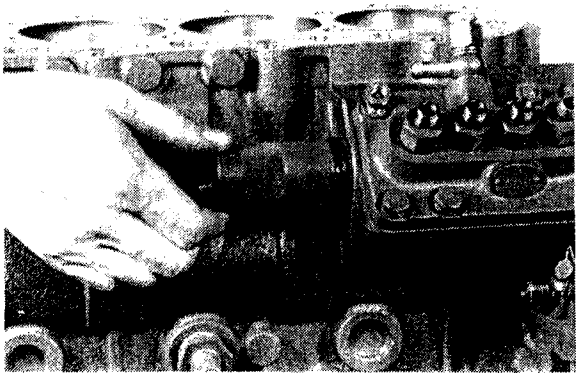
Fuel Lift Pump/Stop Solenoid

A. Loosen two cap screws and lift from its bore; remove joint. (PB011)

B. Unscrew stop solenoid if fitted (PH016).



PB011



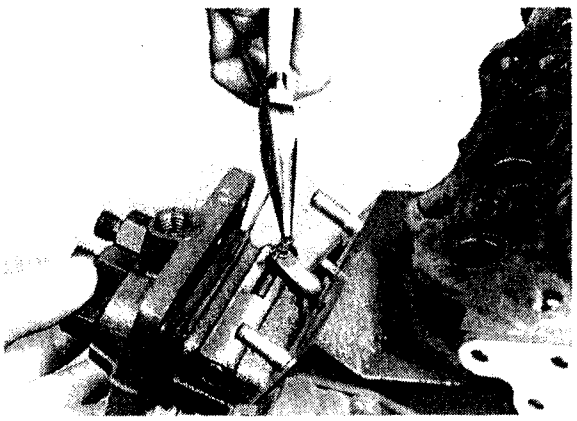
PH016

Fuel Injection Pump Assembly

A. Remove bolts and nuts securing fuel injection pump to cylinder block. Slowly lift and position fuel injection pump until access to link snap pin is gained.

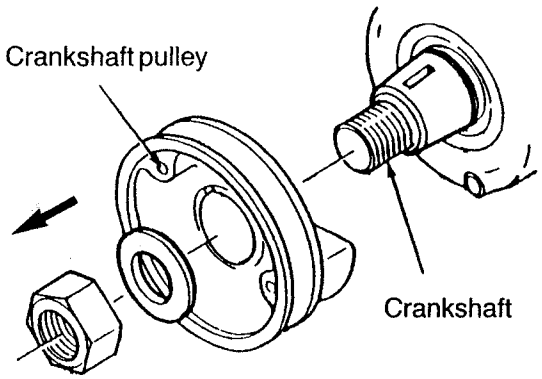
B. Remove snap pin and remove link from control rack. Remove fuel injection pump and shim pack.

NOTE: Injection timing is determined by the shim pack between fuel injection pump flange and cylinder block mounting face. The thickness and number of shims should be checked and recorded to aid re-assembly.



Crank Pulley

A. Loosen pulley nut and remove pulley.



E0012

Oil Filter

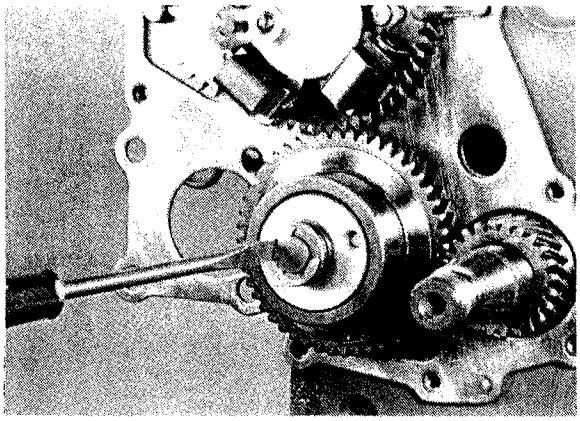
A. Remove spin-on type oil filter and discard.

Gear Cover and Governor Assembly

A. Remove securing bolts and lift cover assembly off the locating dowels.
N.B. Ensure fuel pump is removed first.

Idler Gear and Oil Pump Assembly

A. Remove circlip. Remove entire assembly.



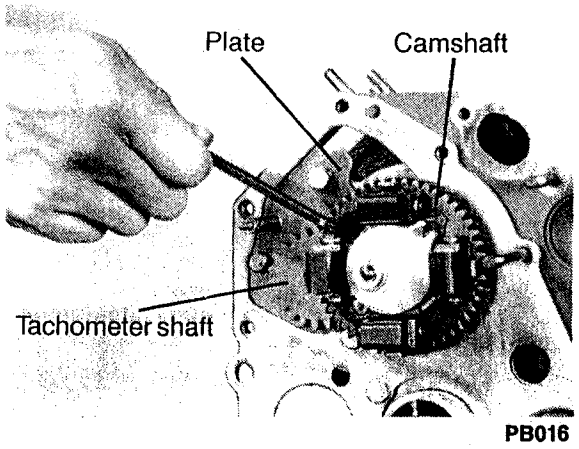
PB015

Camshaft Assembly, Tachometer Drive

A. Using access hole in cam gear, remove keeper plate.

B. Slide cam shaft with fly weight retainer out of camshaft bore.

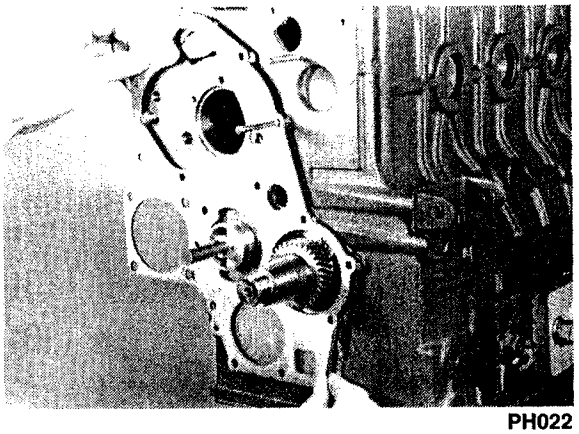
C. Pull tachometer drive shaft from its bore.



PB016

Front End Plate Assembly

A. Remove retaining bolts and lift front plate off its locating dowels. Remove joint and discard.



PH022

Dipstick Assembly

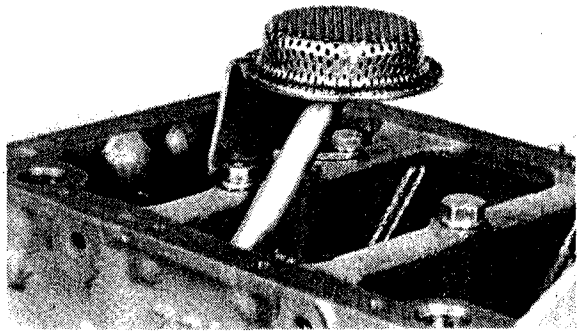
A. Loosen fixing bolt and remove assembly.

Oil Sump

A. Remove all bolts, lower sump and discard joint.

Suction Pipe and Strainer

A. Remove two securing bolts. Rotate suction pipe out of its bore.

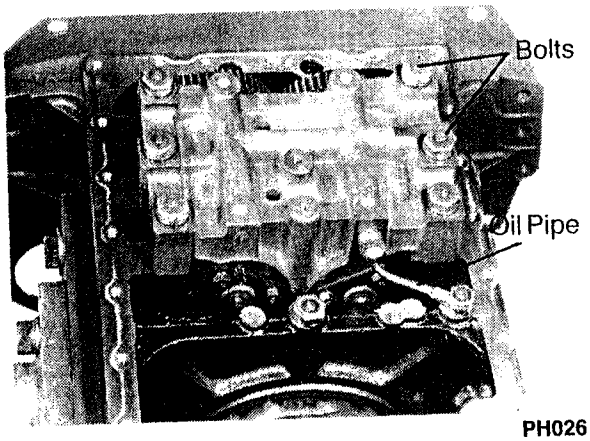


PB019

Dynamic Balancer (Some 4 cylinder models)

A. Remove oil pipe. Remove the balancer assembly from the cylinder block.

NOTE: Keep any shims fitted between balancer and cylinder block.

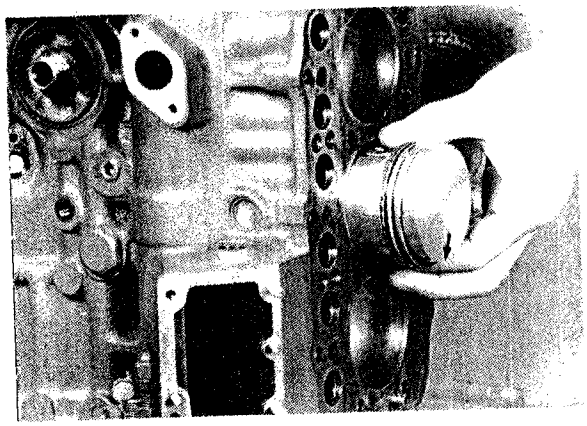


PH026

Connecting Rod and Piston

A. Loosen connecting rod nuts and remove rod cap.

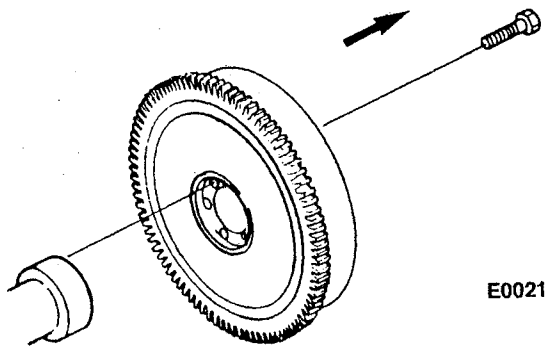
B. Remove carbon from cylinder bore. Push piston and connecting rod through cylinder block. Replace rod cap to piston assembly. Keep together in cylinder sequence.



PB020

Flywheel Assembly

A. Loosen bolts, remove flywheel.



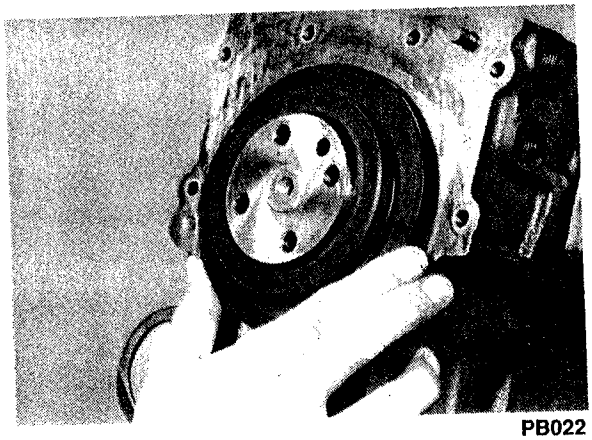
E0021

Back Plate

A. Loosen two starter retaining nuts; remove starter.

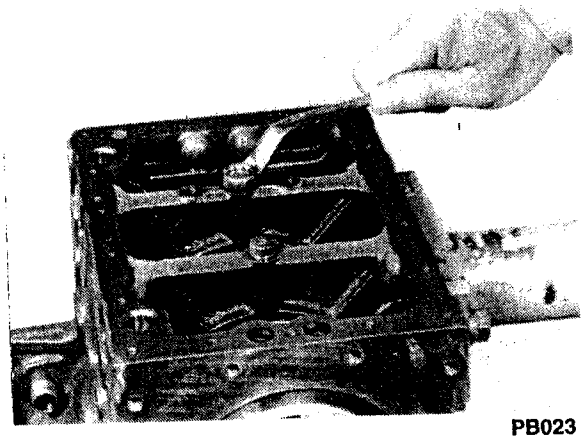
B. Loosen back plate retaining bolts and remove back plate.

Remove Oil Seal



PB022

Crankshaft and Main Bearing Assembly

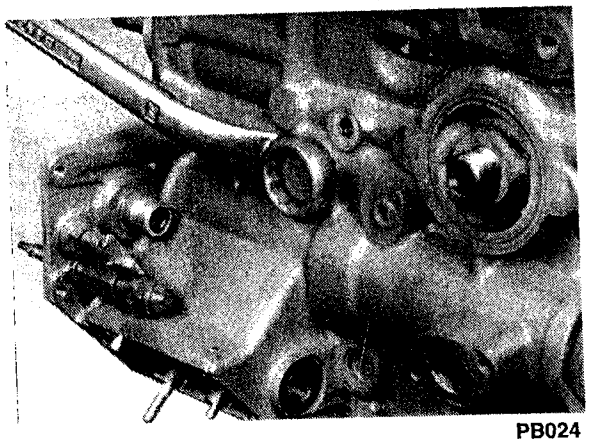


PB023

A. Remove bolts fitted through crankcase cross members.

B. Slide out crankshaft and main bearing assembly.

Remove Relief Valve Assembly



PB024

SECTION IV
Disassembly, inspection, fits and clearances of component assemblies

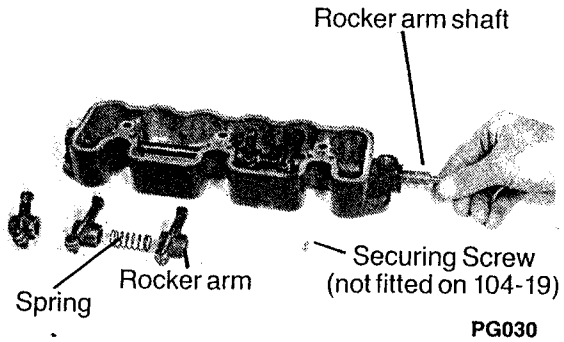
Rocker Arm Assembly

– Disassembly

A. Loosen M8 bolt at the rocker arm shaft end, if fitted.

B. Remove screw located in No. 1 cylinder rocker arm bracket, if fitted.

C. Pull out the rocker arm, spring and bracket.



PG030

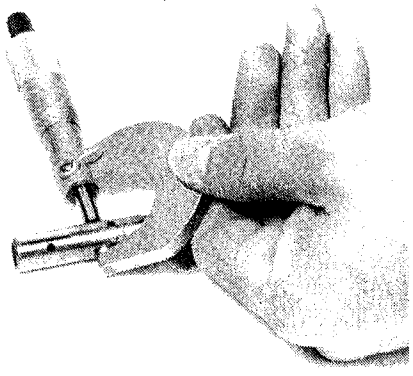
– Inspection and Correction

A. Wear of rocker arm shaft

Using a micrometer, check outside diameter of the rocker arm shaft. If the rocker arm shaft is worn beyond allowable limit, replace.

103-12/13/103-15 IDI

Standard dimension	Allowable limit
11.65-11.67mm (.459-.460″)	11.57mm (.456″)
103-15 DI /104-19	
14.95-14.97mm (.588-.589″)	14.87mm max (.585″)



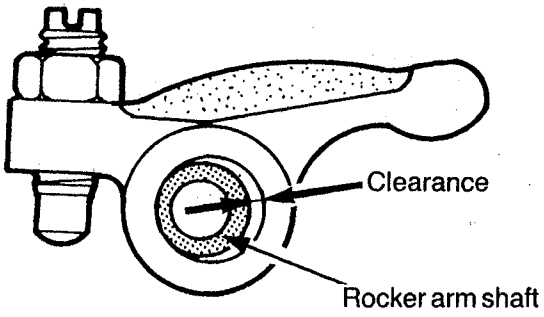
PB026

B. Rocker arm-to-shaft clearance

Measure the inside diameter of the rocker arm. Calculate the clearance between the rocker arm and rocker arm shaft. If the clearance is excessive, replace.

103-12/13/103-15

Standard Clearance	Allowable limit
0.032-0.068mm (.001-.026″)	0.2mm (.008″)
104-19	
0.030-0.093mm (.0012-.0037″)	0.2mm (.008″)



E0027

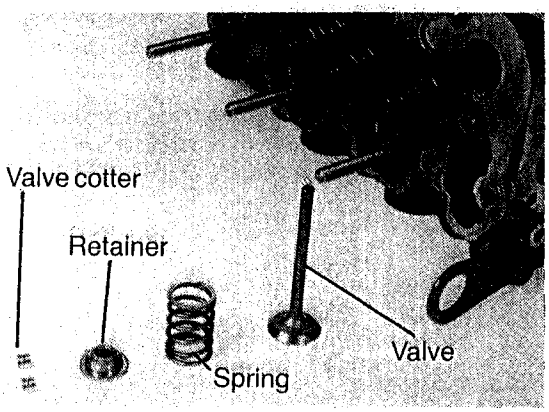
C. Wear on valve stem contact face of the rocker arm.

Check the face for step wear or score. Slight wear may be corrected using an oil stone.

Cylinder Head Assembly

A. Using a valve spring replacer, compress the valve spring to remove the valve collets, retainer, spring and valve.

B. Remove valve guide seals and glow plugs.

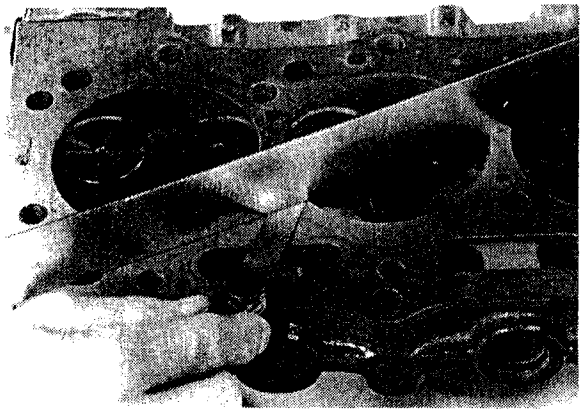


PB028

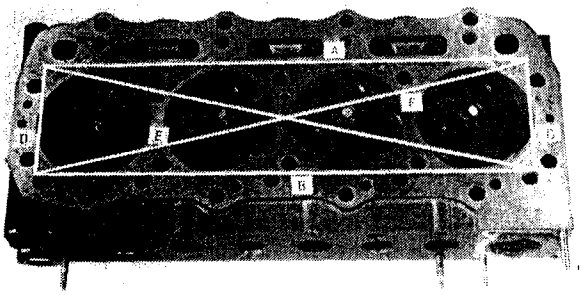
– Inspection and Correction

A. Cylinder head

With a straight edge and a thickness gauge, check for warping of the cylinder head lower face.



PG035



PH038

Check six positions (A to F lines, as shown) for warping. If found to be warped excessively, correct with a surface grinder.

Standard value	Allowable limit
0.05mm or less (.002″)	0.12mm (.005″)

B. Valve guide and valve stem

a. Check the valve stem for excessive wear or damage. If found to be excessively damaged, replace.

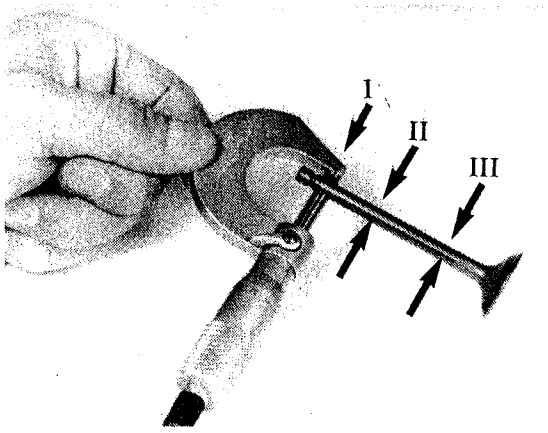
b. Check valve stem diameters at positions I, II and III with a micrometer. If the diameter is less than allowable limit, replace.

Intake valve 103-12/13/15/104-19

Standard diameter	Allowable limit
6.955-6.97mm (.274″)	6.89mm (.271″)

Exhaust valve 103-12/13/15/104-19

Standard diameter	Allowable limit
6.94-6.95mm (.274″)	6.84mm (.269″)



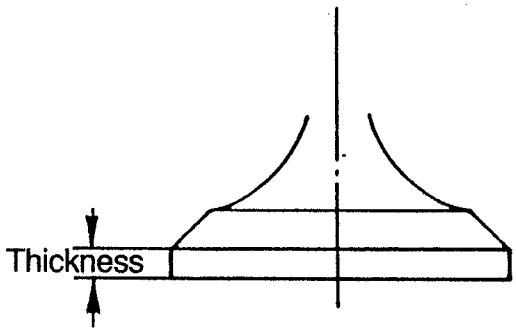
PB031

c. Thickness of valve head

If valve head thickness is less than allowable limit, replace valve.

All engines

Standard thickness	Allowable limit
0.925-1.075mm (.036″-.042″)	0.5mm (.020″)



PB127

d. Valve to valve-guide clearance

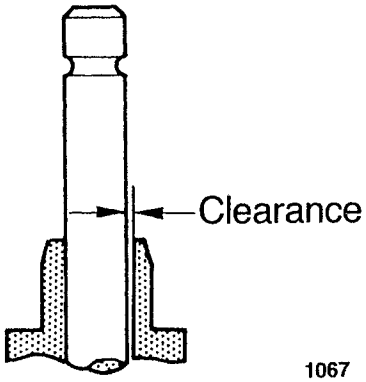
Check the clearance between the valve and valve guide. If the clearance exceeds the allowable limit, replace.

Intake valve-All engines

Standard clearance	Allowable limit
0.03-0.06mm (.0012-.0024")	max. 0.2mm (.008")

Exhaust valve-All engines

Standard clearance	Allowable limit
0.05-0.075mm (.002-.003")	max. 0.25mm (.010")



1067

C. Valve seat

a. Valve seat contact width

If the contact width of the valve seat is more than allowable width, check wear condition of the valve guide first.

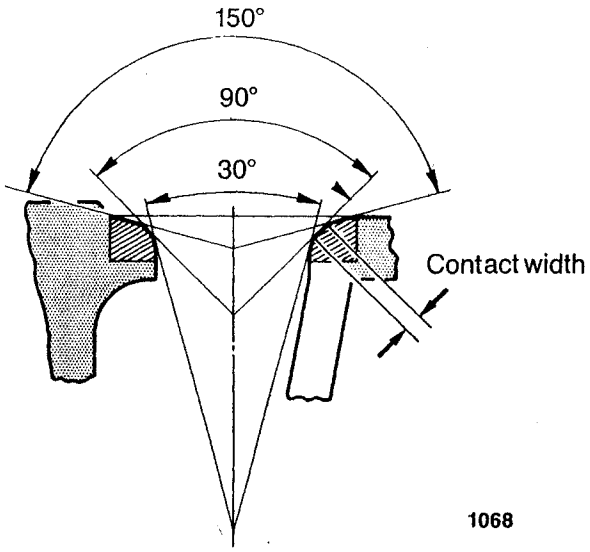
Using the seat cutters of 15° 45° and 75° correct the seat.

103-12/13/15 IDI-Intake

Standard width	Allowable limit
1.66-1.87mm (.065-.074")	2.5mm max (.098")
103-12/13/15 IDI-Exhaust	
1.66-1.73mm (.065-.068")	2.5mm max. (.098")
103-15 DI-Intake	
1.95-2.16mm (.077-.085")	2.5mm max (.098")
103-15 DI-Exhaust	
1.93-2.13mm (.076-.084")	2.5mm max. (.098")

104-19-Intake

Standard width	Allowable limit
1.5-2.0mm (.06-.08")	2.5mm max. (.098")
104-19-Exhaust	
1.94-2.16mm (.076-.085")	2.5mm max. (.098")



1068

b. Recess of valve seat

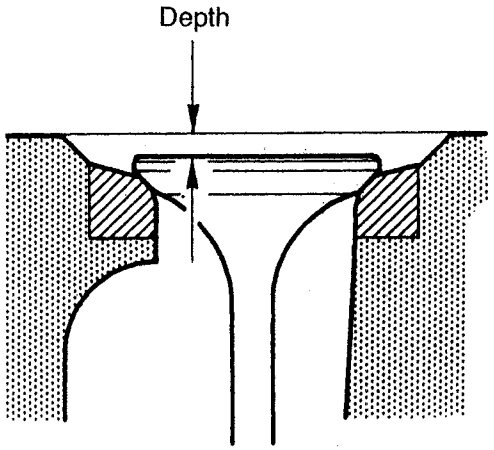
If the recess is more than allowable limit, replace the valve seat (if fitted).

103-12/13/15 IDI

Standard recess	Allowable limit
0.85-1.15mm (.034-.045")	1.8mm max. (.071")
104-19	
0.65-0.95mm (.026-.037")	1.6mm max. (.063")

103-15 DI

Standard clearance	Allowable limit
0.75-0.85mm (.030-.033")	max. 1.6 max (.063")



1069

Replacement of valve seat insert (where fitted):

Either 1. Using gas burner (700 to 800°C), heat diagonally across the valve seat insert. Leave in air for 3 to 5 minutes and remove the valve seat insert by light tapping (ensuring the head is not damaged).

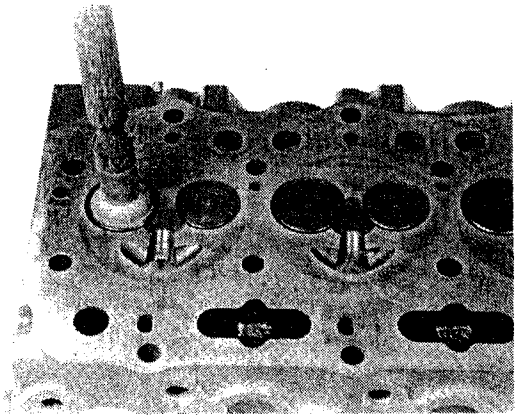
Or 2. Machine the insert out taking care not to damage the head.

Clean up the insert bore and fit new insert using a press (1,000 to 1,500kgf) and a suitable smooth surface tool. To assist process, chill the valve seat insert with liquid nitrogen etc or heat the head to between 60 and 100°C.

c. Lapping of contact face of the valve seat

Correct valve seat contact using a valve lapper and lapping compound.

When using a new cylinder head, obtain correct seat contact width and seat recess using the seat cutter. Then, carry out lapping.



PB036

D. Valve spring

Visually inspect the valve spring for damage.

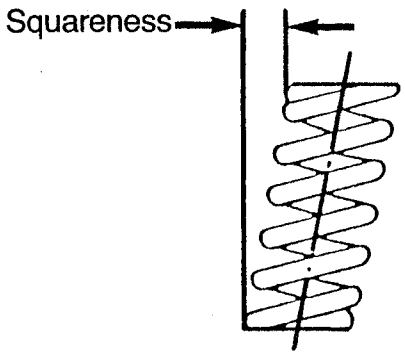
Position the valve spring on a flat surface and check the squareness of it using a square, as shown in the illustration. If it exceeds allowable limit, replace the spring.

Using a spring tester, check spring force and free length.

Replace if found to be beyond allowable limit.

All engines

	Standard value	Allowable limit
Squareness (mm)	(1.2) .047"	(2.0) .079"
Free length (mm)	(35) 1.378"	(33.5) 1.319"
Spring force (kg) (when compressed to 30.4mm 1.197")	(8.1) 17.9 lbf	(7) 15.4 lbf



PB128

E. Inner face of combustion chamber

Check and clean the combustion chamber. (IDI models).

– Reassembly

Reassemble the parts in the reverse order of disassembly.

NOTE 1: When assembling the valve spring, retainer and collets, take care not to damage the valve guide seal.

2. Tighten glow plugs to 1.5-2.0 kgfm (11-15 lb/ft).

Cylinder block

– Inspection and Correction

A. Cylinder block top face

Inspect the cylinder block top face for cracks, damage and warping in the same way as for the cylinder head.

If outside limit, replace cylinder block.

Standard value	Allowable limit
Less than 0.05mm (.002")	0.12mm (.005")

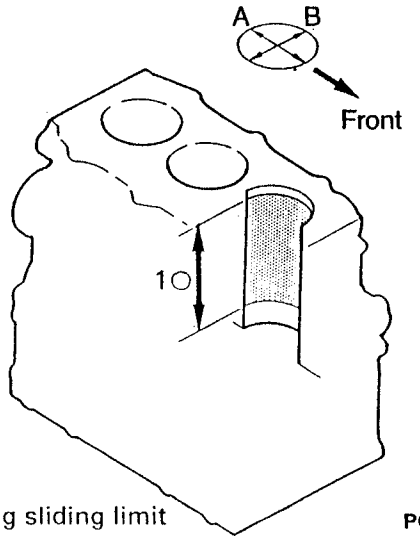
B. Cylinder bore

a. Visually inspect cylinder bore. There should be no scoring, rust or corrosion.

b. Measure the cylinder bore at the upper, middle and lower areas (Piston ring contact area) in the direction of the crankshaft (A direction) and at right angle to the crankshaft (B direction).

The upper area described in the above (b) corresponds to the top ring when the piston is at the T.D.C., (about 10mm below the cylinder block top surface). The lower area corresponds to the piston oil ring when the piston is at the B.D.C. (about 100mm from top face).

Check the bore using a cylinder gauge.



1 Ring sliding limit

PG044

c. If the bore is found to be outside allowable limit, re-bore to the oversize dimension as shown.

Grinding stone size: 100L x 4W
Speed: 162 rpm
Feed (shaft direction): 13 m/min
Gauge pressure:
15 kg/cm^2 (5 kg/cm^2 – finish)
Finish stroke: 9
Honing depth: 0.04mm (diameter)
Cross hatch angle: 40°
Surface roughness: 2-4 micron

Bore spec 103-12

Standard bore	Allowable limit
82-82.019mm (3.228-3.229″)	82.2mm (3.236″)

First re-bore 0.5mm (.02″)

New standard bore	Allowable limit
82.5-82.519mm (3.248-3.249″)	82.7mm (3.256″)

Second re-bore 0.5mm (.02″)

New standard bore	Allowable limit
83-83.019mm (3.267-3.268″)	83.2mm (3.276″)

Replace the block

Bore spec 103-13,103-15,104-19

Standard bore	Allowable limit
84-84.019mm (3.307-3.308″)	84.2mm (3.315″)

First re-bore 0.5mm (.02″)

New standard bore	Allowable limit
84.5-84.519mm (3.327-3.328″)	84.7mm (3.335″)

Second re-bore 0.5mm (.02″)

New standard bore	Allowable limit
85-85.019mm (3.346-3.347″)	85.2mm (3.354″)

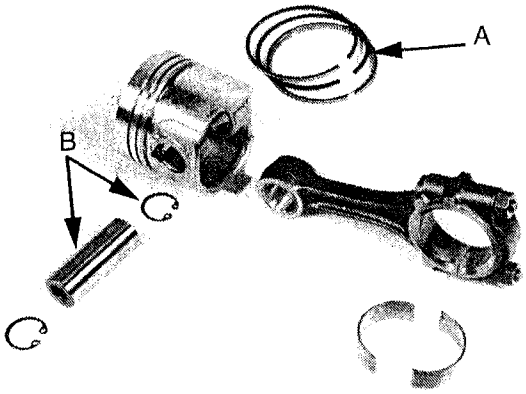
Replace the block

Piston and piston rings

– Disassembly

A. Remove piston rings using a piston ring tool.

B. Remove the circlip and extract the gudgeon pin.



PB040

– Inspection

A. Piston

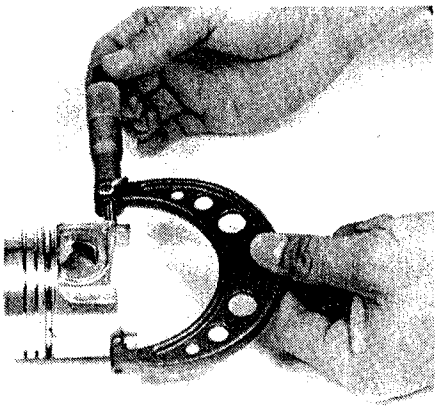
a. If outer surface of the piston is excessively damaged (cracked score, burning, etc.), replace.

b. Piston skirt

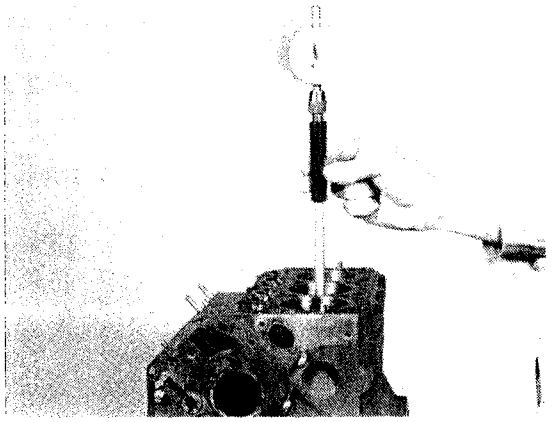
Check the larger diameter of the piston skirt (10mm from bottom), and check inside diameter (thrust direction) of the cylinder. Calculate the clearance between the cylinder and piston. If this clearance is more than allowable, or piston diameter is less than allowable limit, replace the piston.

c. Oversized piston

When the cylinder is oversized, ensure that oversized piston is used.



PB041



PB042

103-12

Standard clearance	Allowable limit
0.038-0.072mm (.0015-.0028″)	0.25mm max. (.010″)
Standard diameter	Allowable limit
81.948-81.963mm (3.2263-3.2269″)	81.7mm min (3.2165″)

Piston size	Larger diameter of piston skirt
Standard	81.948-81.963mm (3.2263-3.2269″)
0.5mm oversize	82.448-82.463mm (3.2460-3.2466″)
1.0mm oversize	82.948-82.963mm (3.2657-3.2663″)

103-13

Standard clearance	Allowable limit
0.038-0.072mm (.0015-.0028″)	0.25mm max (.010″)

Standard diameter (Piston)	Allowable limit
83.948-83.963mm (3.3050-3.3056″)	83.7mm min (3.2953″)

Piston size	Larger diameter of piston skirt
Standard	83.948-83.963mm (3.3050-3.3056″)
0.5mm oversize	84.448-84.463mm (3.3247-3.3253″)
1.0mm oversize	84.948-84.963mm (3.3444-3.3450″)

103-15 DI/104-19 DI

Standard clearance	Allowable limit
0.042-0.076mm (.0017-.003″)	0.25mm max (.010″)

Standard diameter (Piston)	Allowable limit
83.943-83.958mm (3.3048-3.3054″)	83.7mm min (3.2953″)

Piston size	Larger diameter of piston skirt
Standard	83.943-83.958mm (3.3048-3.3054″)
0.5mm oversize	84.443-84.458mm (3.3245-3.3251″)
1.0mm oversize	84.943-84.958mm (3.3442-3.3448″)

103-15 IDI/104-19 IDI

Standard clearance	Allowable limit
0.038-0.072mm (.0015-.0028″)	0.25mm max. (.010″)
Standard diameter (piston)	Allowable limit
83.948-83.963mm (3.3050-3.30567″)	83.7mm min (3.2953″

Piston size	Larger diameter of piston skirt
Standard	83.948-83.963mm (3.3050-3.3056″)
0.5mm oversize	84.448-84.463mm (3.3247-3.3253″)
1.0mm oversize	84.948-84.963mm (3.3444-3.3450″)

d. Clearance between gudgeon pin hole and gudgeon pin.

Check the inside diameter of the gudgeon pin hole and the outside diameter of the gudgeon pin, and calculate the clearance between them.

If the clearance is more than allowable limit, replace.

All engines

Standard clearance	Allowable limit
−0.001 to +0.007mm (−.000039 to +.00028″)	0.02mm (.0008″)

B. Piston ring

a. If the piston ring is worn or damaged, replace it.

b. Piston ring gap

Insert the rings into the cylinder at right angle to the cylinder bore and measure the gaps with a thickness gauge. If the gap is more than the allowable limit, replace.

103-12

	Standard gap	Allowable limit
No. 1 ring	0.20-0.35mm (.008-.014″)	1.0mm (.039″)
No. 2	0.15-0.30mm (.006-.012″)	1.0mm (.039″)
Oil ring	0.15-0.30mm (.006-.012″)	1.0mm (.039″)

103-13/103-15/104-19

	Standard gap	Allowable limit
No. 1 ring	0.20-0.35mm (.008-.014″)	1.0mm (.039″)
No. 2	0.20-.40mm (.008-.016″)	1.0mm (.039″)
Oil ring	0.20-0.40mm (.008-.016″)	1.0mm (.039″)

c. Measure the clearance between the piston ring groove and ring. If the clearance exceeds the allowable limit, replace the ring.

All engines

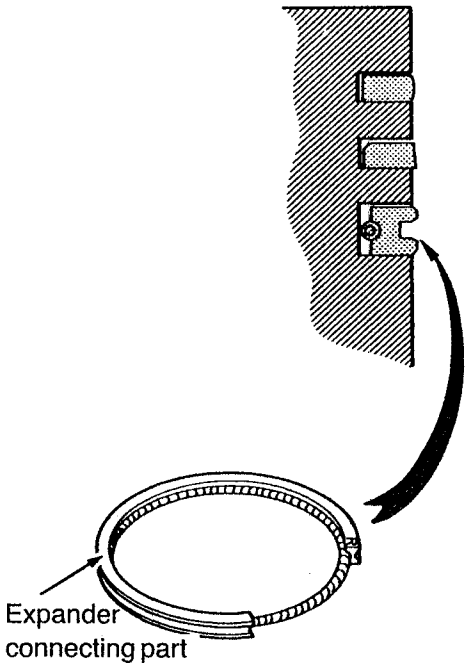
	Standard clearance	Allowable limit
No. 1 ring	0.07-0.11mm (.0028-.0043″)	0.25mm (.0098″)
No. 2 ring	0.04-0.08mm (.0016-.0032″)	0.25mm (.0098″)
Oil ring	0.02-0.06mm (.0007-.002″)	0.15mm (.0059″)
103-12		
Oil ring	0.03-0.07mm (.0012-.0028″)	0.15mm (.0059″)

d. Oversize piston ring

If the cylinder is oversized, oversize piston ring set should be employed.

e. Mounting position of the piston ring

Confirm that the piston ring is set as shown in the illustration 1077.



1077

C. Gudgeon pin

Check the outside diameter of the gudgeon pin. If it is less than the allowable limit, replace.

103-12,103-13

Standard OD	Allowable limit
24.996-25.0mm (.9841-.9843″)	24.98mm min (.9835″)

103-15/104-19

Standard OD	Allowable limit
27.996-28.0mm (1.1022-1.1024″)	27.98mm min (1.1016″)

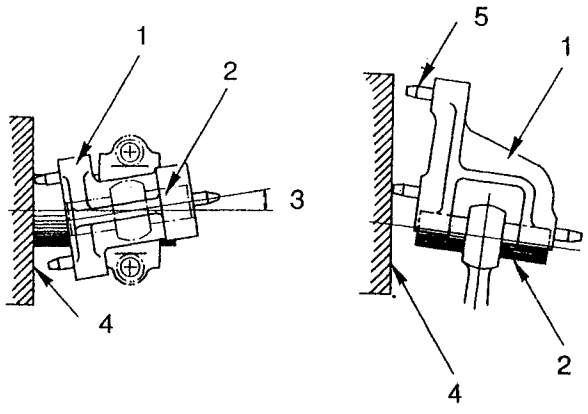
Connecting Rod

– Inspection

A. Distortion or damage.

Check the connecting rod for distortion between the large and small ends of the connecting rod with a connecting rod aligner. If the result exceeds the allowable limit, replace.

	Standard value	Allowable limit
Distortion (for 100mm) (3.937″)	Less than 0.08mm (.003″)	0.2mm (.0078″)
Parallel (for 100mm) (3.937″)	Less than 0.05mm (.0019″)	0.15mm (.0059″)



1078

1. Gauge
2. Gudgeon pin
3. Distortion
4. Flat surface of the Aligner
5. Pin

B. Clearance between small end bush and the gudgeon pin.

Measure the inside diameter of the connecting rod small end bush.

If the clearance exceeds the allowable limit, replace.

All engines

Standard clearance	Allowable limit
0.010-0.025mm (.0004-.001″)	0.08mm (.003″)

C. Play between the connecting rod and the crankshaft.

Assemble the connecting rod to the crankshaft, and measure the play in shaft direction. If the play is more than the allowable limit, replace the connecting rod.

All engines

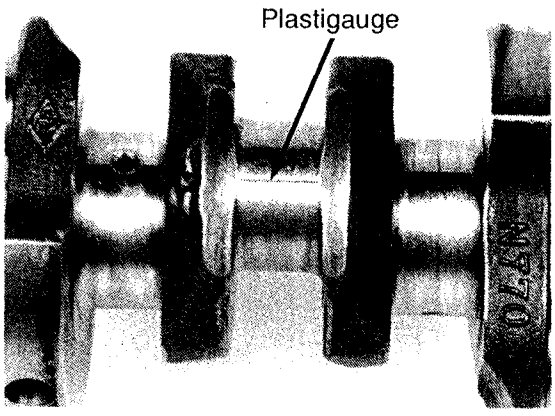
Standard play	Allowable limit
0.1-0.3mm (.0039-.0118″)	0.7mm (.0275″)

D. Oil clearance

Using the plastigauge, check the oil clearance as follows.

Remove oil or foreign matter from the bearing and crankshaft.

Cut the plastigauge to the same width as the bearing. Place it on the crankshaft. Avoid the oil hole.



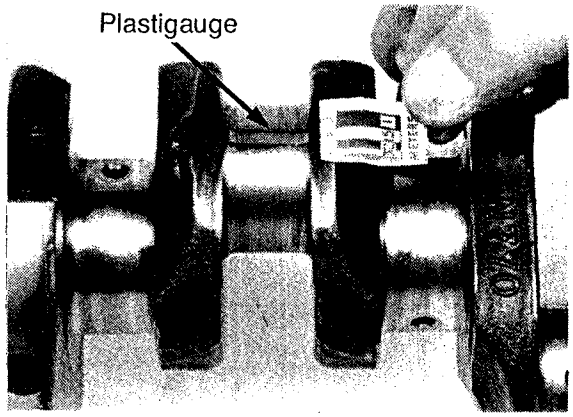
PB046

Assemble the connecting rod and connecting rod cap, and tighten to the specified torque.
All engines 5.0-5.5Kgfm
(36-40 lbf ft).

NOTE: Never rotate the connecting rod.

Remove the connecting rod cap. Measure the oil clearance with the scale printed on the gauge bag.

NOTE: Measure the widest area.



PB047

All engines

Standard clearance	Allowable limit
0.035-0.085mm (.001-.003″)	0.2mm (.0078″)

If the oil clearance exceeds the allowable limit, replace the bearing. Or, grind the crankshaft and use oversize bearing.

NOTE: When grinding the outside diameter of the crankshaft, ensure that the oil clearance is correct before reassembly.

103-12, 103-13

Bearing size	Crankshaft pin O.D. dimension (mm)
Standard	43.964-43.975mm (1.7309-1.7313″)
0.25mm U.S. (.0098″)	43.714-43.725mm (1.7210-1.7215″)
0.50mm U.S. (.0196″)	43.464-43.475mm (1.7112-1.7116″)

103-15,104-19

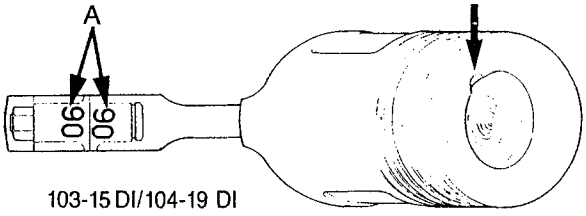
Bearing size	Crankshaft pin O.D. dimension (mm)
S.T.D.	51.964-51.975mm (2.0458-2.0463″)
0.25mm US. (.010″)	51.714-51.725mm (2.0360-2.0364″)
0.50mm U.S. (.020″)	51.464-51.475mm (2.0261-2.0266″)

– Reassembly

A. Reassemble the piston on the connecting rod as follows.

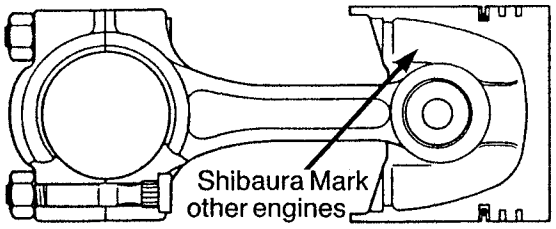
B. With a piston heater or the like, heat the piston to approximately 100°C. Then, assemble the piston to the connecting rod by aligning the set marks.

C. Set the 'SHIBAURA' marks or other mark as shown in the illustrations PB048 and PH055. Align the set marks (figures) at (A) on the connecting rod.



103-15 DI/104-19 DI

PH055



PB048

D. Replace the piston ring on the piston. Position scribe mark uppermost.

E. When the connecting rod or piston/gudgeon pin has been replaced, difference in weight of the assembly (connecting rod plus piston rings) should not exceed 10 grams between cylinders.

Bearing Holder

– Disassembly and Inspection

A. Centre bearing

a. Remove the bearing holder, and check it for peeling, melting, stepped wear and other damage. If it is excessively damaged, replace.

b. Using the plastigauge, measure the oil clearance between the crankshaft centre journal and the bearing.

If the oil clearance is more than the allowable limit, replace the bearing. Or, grind the crankshaft centre journal, and use undersized bearing (Refer to "Crankshaft").

All engines

Standard oil clearance	Allowable limit
0.044-0.102mm (.0017-.0040″)	0.2mm (.0078″)

103-12,103-13

Bearing size	Crankshaft centre journal diameter (mm)
Standard	57.957-57.970mm (2.2818-2.2823″)
0.25mm U.S. (.0098″)	57.707-57.720mm (2.2719-2.2724″)
0.50mm U.S. (.0196″)	57.457-57.470mm (2.2621-2.2626″)

103-15/104-19

Bearing size	Crankshaft center journal diameter
S.T.D.	67.957-67.970mm (2.6755-2.6760″)
U.S 0.25 (.010″	67.707-67.720mm (2.6656-2.6661″)
U.S 0.50 (.020″	67.457-67.470mm (2.6558-2.6563″)

B. Thrust clearance.

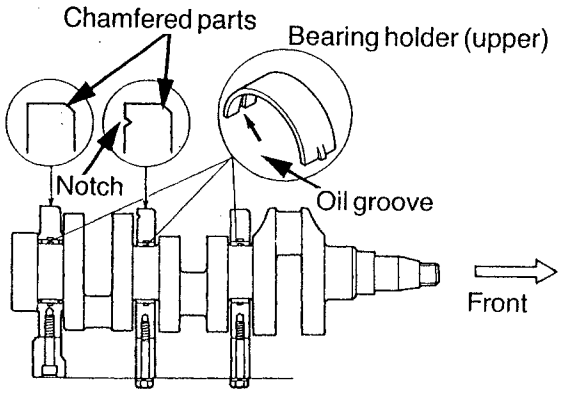
Check the thrust washer for wear, poor contact, burning or other defects. Defective washers must be replaced.

Standard Thickness	Allowable limit
2.95-3.0mm (.116-.118″)	2.8mm (.11″)

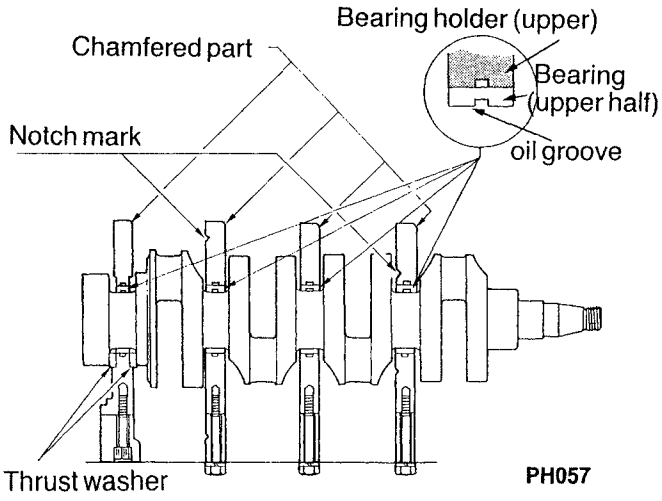
– Reassembly

A. Reassemble the bearing holder, centre bearing and thrust washer as follows:
   a. Face the chamfered part of the bearing holder toward front. Install the bearing holder which has notch as shown in PB050 and PH057. Then install the bearing holder on which the thrust washer is to be mounted at the flywheel side.
   b. Install the thrust washer. Face its oil groove toward thrust face of the crankshaft.

      Tightening torque of the bearing holder: 5.0-5.5kgf m (36-40 lbf ft).
   c. Set the bearing with oil groove to upper part, while setting the bearing without the groove to lower part.



PB050



PH057

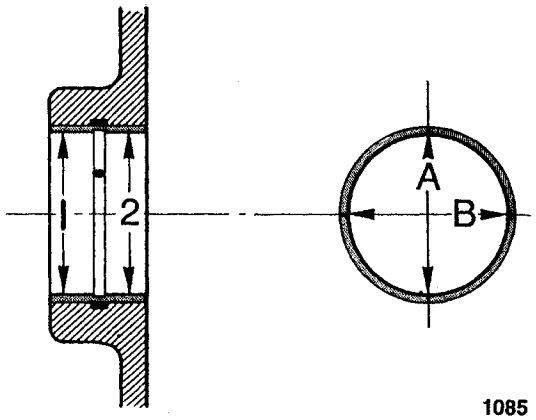
Crankshaft Bearing (bush)

– Inspection

A. Check the bearing (bush) for peeling, melting, seizure or poor contact. If found to be defective, replace.

B. Using cylinder gauge and micrometer, measure the oil clearance between the bearing (bush) and the crankshaft journal.

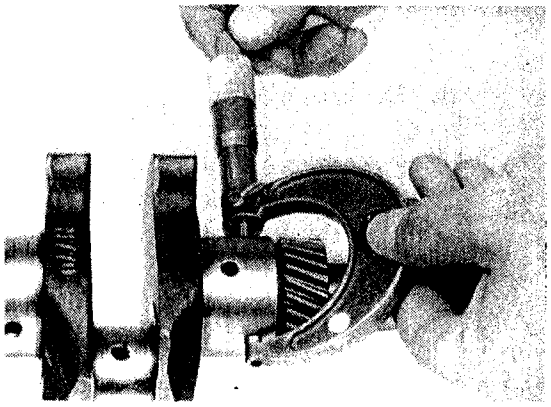
C. Measure inside diameters at positions 1 and 2 (1085). At each position, measure in both directions A and B as shown. The oil clearance can be obtained by subtracting this value from the maximum crankshaft journal diameter.



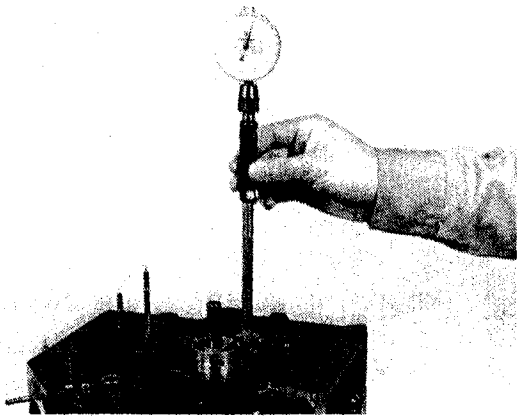
1085

All engines

Standard oil clearance	Allowable limit
0.044-0.116mm (.0017-.0046″)	0.2mm (.0078″)



PB052



PB053

D. If the oil clearance exceeds the allowable limit, replace the bearing (bush). Or, grind the crankshaft journal. In this case, use undersize bearing (bush).

E. When replacing the crankshaft journal (bush), use a press to install.

Crankshaft journal (bush)

103-12/,103-13

Size	Outside diameter
Standard	57.957-57.970mm (2.2818-2.2823″)
0.25mm U.S. (.0098″)	57.707-57.720mm (2.2719-2.2724″)
0.50mm U.S. (.0196″)	57.457-57.470mm (2.2621-2.2626″)

103-15,104-19

Size	Outside diameter
Standard	67.957-67.970mm (2.6755-2.6760″)
0.25mm U.S. (.0098″)	67.707-67.720mm (2.6656-2.6661″)
0.50mm U.S. .0196″)	67.457-67.470mm (2.6558-2.6563″)

How To Replace Bush

1. Removal of bush
   Remove the bush from the housing (Cylinder Block) using Bush Driving Tool to prevent damage.
2. Press fitting the bush
   2.1 Prior to installing the bush inspect the bush housing for marks, scratches, etc.
   2.2 The bush should be smoothly pressed in to correct depth by using Bush Driving Tool, adjusting the oil hole and direction of bush as per attached PH061 and following sequence.

(1) Press in the bush to cylinder block from engine front side.

Note:
Must not press in the bush to cylinder block from the opposite side.
The correct pressing side is chamfered etc, to allow smooth operation.

(2) Align oil hole of the housing and bush.

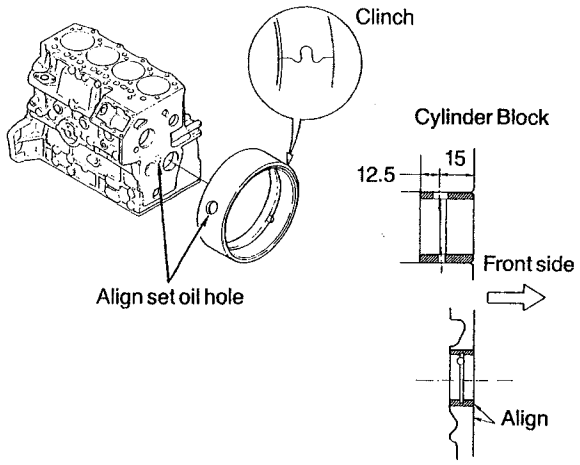
(3) install the bush confirming the mark and oil groove (hole).

(4) Lubricate at outer surface of the bush.

(5) Press in the bush to the housing until correct depth by using Bush Driving Tool.

2.3 Confirm after installation

Confirm the alignment of oil hole of the housing and the bush, also check inner diameter is within tolerance.



PH061

F. After grinding the crankshaft journal, check the oil clearance.

Crankshaft

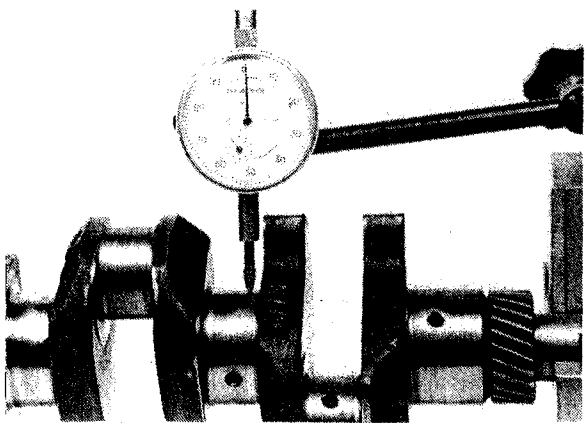
– Inspection

A. Crankshaft deflection

Support the crankshaft with V-block. Position a dial gauge on the crankshaft centre journal, and turn the crankshaft gradually by one full turn. If the gauge reading is more than allowable limit, correction or replacement of the crankshaft is needed.

All engines

Standard deflection	Allowable limit
0.03mm or less (.0011″)	0.06mm (.0023″)



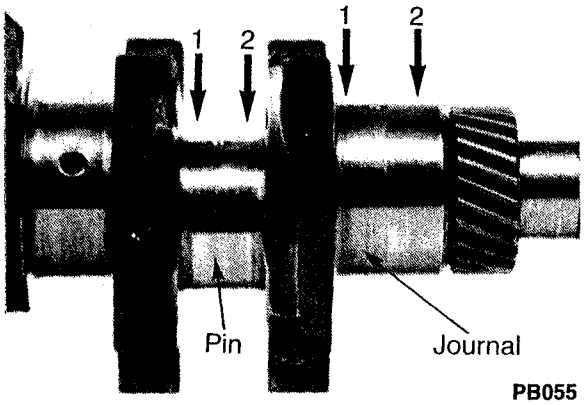
B. Oil Seal contact face and oil hole

Check the oil seal contact face for damage or wear.

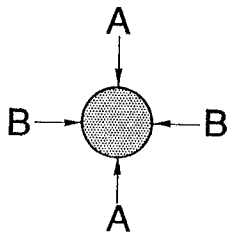
Check oil holes for clogging.

C. Crankshaft journal and pin for stepped wear.

Take four measurements (AA and BB diameters at positions "1" and "2"). If the maximum difference between the measurements is more than allowable limit, correction is required.



PB055



Allowable difference (stepped wear)
0.05mm (.0019")

When measured diameter is less than the allowable limit, correct by grinding and use undersize bearings and bush.

103-12,103-13
Shaft diameter of crankshaft journal

	Standard diameter	Allowable limit
Standard	57.957-57.970mm (2.2818-2.2823")	57.9mm (2.280")
0.25mm U.S. (0.010")	57.707-57.720mm (2.2719-2.2724")	57.6mm (2.268")
0.50mm U.S. (0.020")	57.457-57.470mm (2.2621-2.2626"*)	57.4mm* (2.260")

103-12, 103-13
Shaft diameter of crankshaft pin

	Standard diameter	Allowable limit
Standard	43.964-43.975mm (1.7309-1.7313")	43.90mm (1.728")
0.25mm U.S. (.010")	43.714-43.725mm (1.7210-1.7215")	43.65mm (1.719")
0.50mm U.S. (.020")	43.464-43.475mm (1.7112 1.7116")	43.40mm* (1.709")

* If the diameter is less than this value, the crankshaft must be replaced with new.

Crankshaft pin diam. (ø) 103-15, 104-19

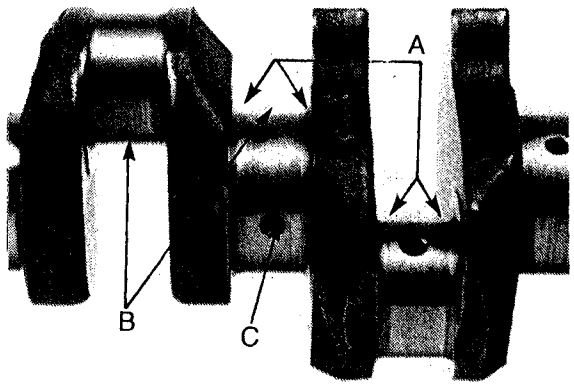
	Standard diameter	Allowable limit
Standard	51.964-51.975mm (2.0458-2.0463)	51.90mm (2.0433")
U.S. 0.25 (.01")	51.714-51-725mm (2.0360-2.0364")	51.65mm (2.0335"
U.S. 0.50 (0.02")	51.464-51.475mm (2.0261-2.0266")	51.4* (2.0236")

Crankshaft journal shaft diam. (ø) 103-15, 104-19

	Standard diameter	Allowable limit
Standard	67.957-67.970mm (2.6755-2.6760")	67.90mm (2.6732")
U.S. 0.25 (.01")	67.707-67.720mm (2.6656-2.6661")	67.65mm (2.6634")
U.S. 0.50 (.02")	67.457-67.470 (2.6558-2.6563")	67.40mm* (2.6535")

* Replace crankshaft if U.S. 0.50 is exceeded.

NOTE: When grinding the crankshaft, work with the following specifications:



PB057

(A): Radius at pin/journal
3mm ± 0.2mm
.118 .0078
(B): Finish precision
1.6Z (▽▽▼)

(C): Radius around oil hole:
.0787"/2mm maximum
.196"/5mm minimum

Use No. 400 emery cloth for final polishing.

Dynamic Balancer some 104-19 engines

— Disassembly

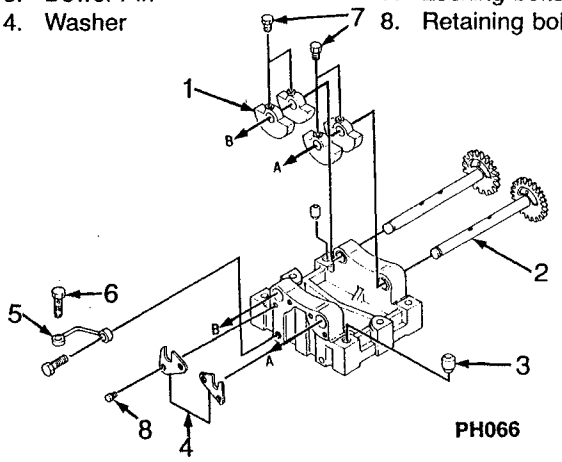
A. Remove the bolts (6) and oil pipe (5).

B. Remove the counterweight to shaft locking bolts (7), thereby freeing the retaining washers (4).

C. Remove the four bolts from balancer set retaining bolts (8).

D. Draw out the two shafts (2) and balancer weight (1).

1. Balancer weight
2. Shaft assembly
3. Dowel Pin
4. Washer
5. Oil pipe
6. Bolts
7. Locking bolts
8. Retaining bolts



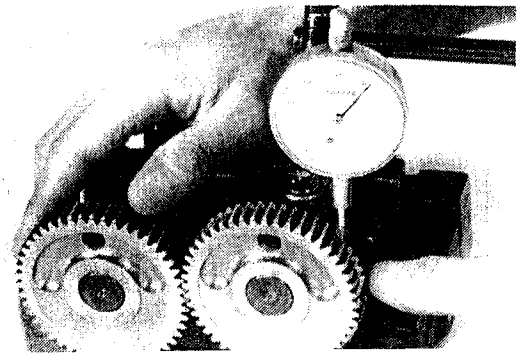
PH066

— Inspection

A. Inspect the balancer drive gears and crankshaft gear teeth for excess wear or other damage.
If any of the gears are damaged, replace all the gears as a set.

B. While the balancer is assembled, check the gear backlash.
Replace the balancer gears if the backlash exceeds 0.15mm (.006").

C. Inspect the bushes for roughness or excess wear.
Replace damaged bushes as needed.



— Assembly

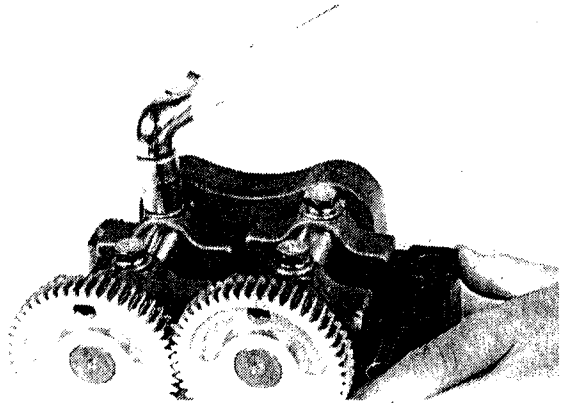
A. Reassembly of the balancer follows the disassembly procedure in reverse.

B. Place number one and four piston at top-dead-centre.

C. Position the balancer assembly if the backlash between the balancer gear and the drive gear with the crankshaft is less than 0.05mm (.00187").

D. Install the balancer bolts and tighten to specified torque.
Rotate the shaft by hand to be sure they turn freely and no binding exists.

*Tightening Torque
Locking Bolts (Balancer Weight)
2.4-2.9kgf.m (17.4-20.9lb/ft)
Balancer Assembly Installation
5-5.5kgf.m (36.2-39.8lb/ft)



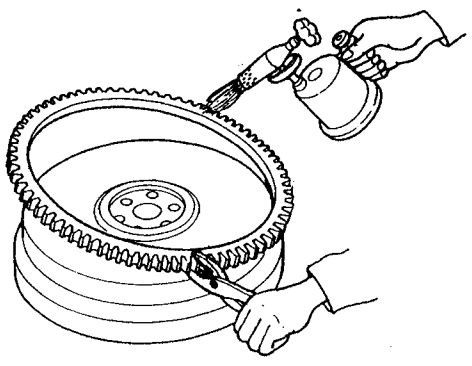
PH068

Flywheel and Ring gear

– Inspection

A. Check the ring gear. If it is excessively damaged or worn, replace it.

B. When wear is not excessive, remove the ring gear and reinstall 90° from original position. To install, preheat the ring gear up to 120° to 150°C.



Camshaft Assembly

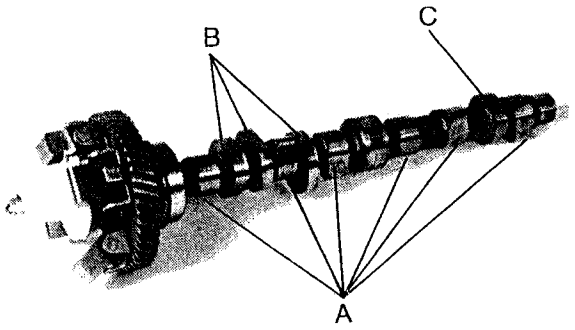
– Inspection

A. Check the journals and cams for wear and damage. Replace if the allowable limit is exceeded.

B. Correct uneven wear or small scratches on the cam surface with oil stone.

All engines (except 103-15 DI)
(A) Cam height (intake and exhaust cams)

Standard value	Allowable limit
34.065-34.12mm (1.3411-1.3433")	33.7mm (1.3268")
103-15 DI	
34.485-34.54mm (1.3577-1.3598")	34.1mm (1.3425")



PB059

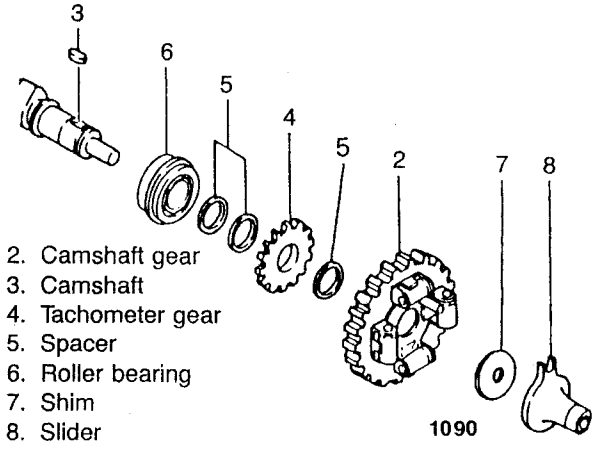
All engines (except 103-15 DI)
(B) Height of cam for injection pump

Standard height	Allowable limit
41.94-42.06mm (1.6512-1.6559")	41.8mm (1.6457")
103-15 DI	
42.94-43.06mm (1.6906-1.6953")	42.8mm (1.6850")

(C) Height of cam for fuel feed pump
– All engines

Standard height	Allowable limit
31.9-32.0mm (1.2559-1.2598")	30.0mm (1.1811")

C. Camshaft gear and bearing assembly:



2. Camshaft gear
3. Camshaft
4. Tachometer gear
5. Spacer
6. Roller bearing
7. Shim
8. Slider

1090

If these items have been replaced it is essential the spacers and shims etc are assembled in the order illustrated in 1090.

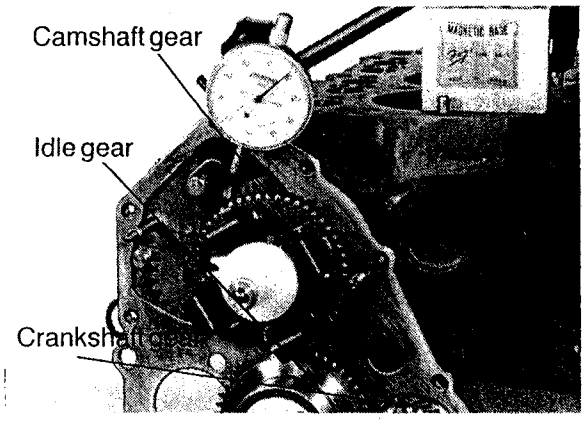
Timing Gear

– Inspection

A. Check the timing gears for wear and damage on the contact area. Replace if any defect is found.

B. Measure the back-lash of gears with a thickness gauge or dial gauge. If the allowable limit is exceeded, replace all timing gears.

Standard back-lash	Allowable limit
0.08mm (.003")	0.25mm (.010")



PB060

Oil Pump

– Disassembly

A. Remove the snap ring.

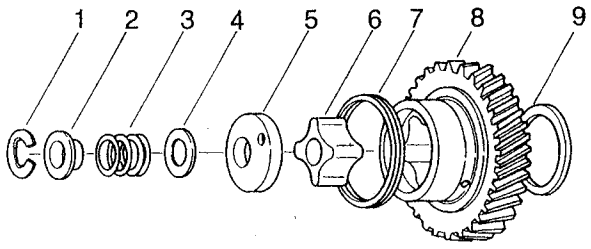
B. Take out collar spring and shim.

C. Remove idle gear vane and oil pump cover together.

D. Pull out rotor and thrust washer.

E. Pull out the oil pump cover from idle gear.

F. Remove spring from the idle gear. Remove the knock pin. (Where fitted).



1. Snap ring
2. Collar
3. Spring
4. Shim
5. Oil pump cover
6. Rotor
7. Spring
8. Idle gear
9. Thrust washer

PB061

– Inspection

A. Check oil pump cover, rotor and vane for wear. If excessively worn or damaged; replace.

B. Check the clearance between the rotor and vane. (As item C reassembly).

If the clearance is excessive, replace.

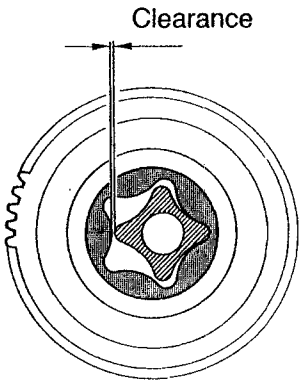
C. If the idler gear hub needs replacing contact Perkins service department for procedure.

– Reassembly (see section V — idle gear)

A. Reassemble the oil pump in reverse order of disassembly.

B. Align set marks on the crankshaft gear and idle gear to reassemble.

C. Check the tip clearance between the rotor and vane is 0.01 to 0.15mm (.0004 to .006"). Allowable limit 0.25mm (.0098").



1094

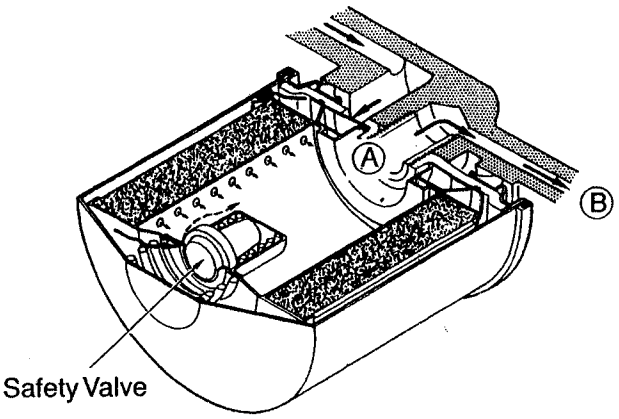
Oil Filter

– Construction and Function

This engine employs a cartridge type filter.

Pressurized oil from the pump enters from (A); and is filtered by a full flow filter, before discharge through (B).

When the full flow filter is clogged, the safety valve opens to bypass the oil.



– Maintenance

A. The oil filter must be replaced every 100 hours of operation.

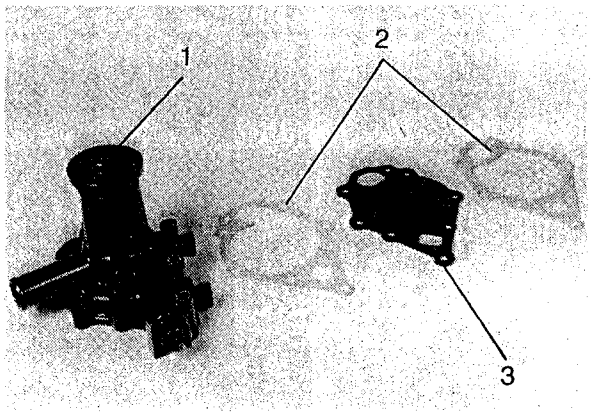
When installing a new filter, coat its mounting face with clean oil then hand tighten only.

Water Pump Assembly and Thermostat housing

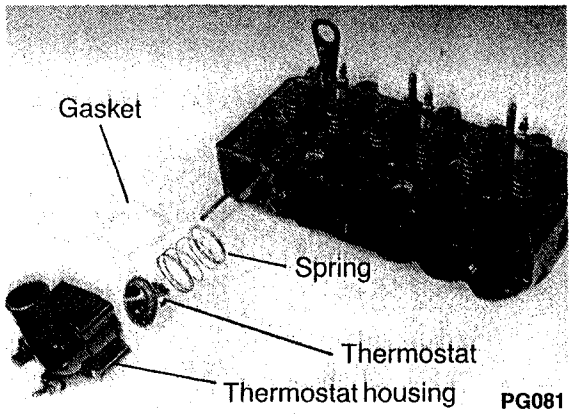
– Disassembly

A. Remove the set plate and gaskets.

B. Take out the thermostat and spring from the thermostat housing.



PB064



PG081

– Inspection

Thermostat

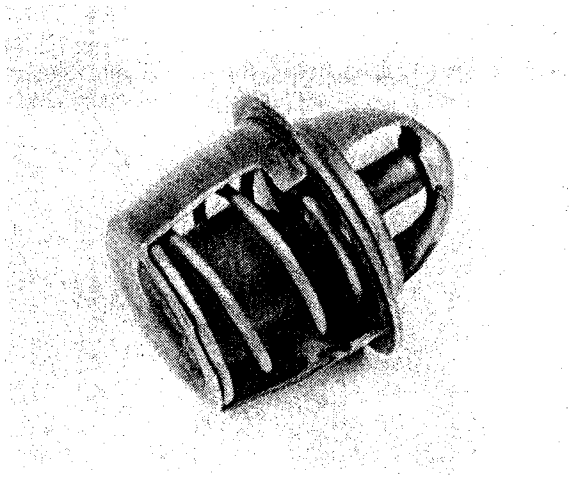
A. Replace the thermostat if the valve opens at ambient temperature.

B. Place the thermostat into water. Raise the water temperature gradually and inspect the valve opening temperature and valve lift. (Standard values are as described in the "Specifications".)

NOTE: 3 to 5 minutes will be required before the valve starts operating.

All engines

Type	Wax pellet type
Temperature when starting to open	69 to 73°C
Temperature when fully open	82°C
Valve lift (when the water temperature is 82°C	8.0mm (.315")



PB066

Water Pump

A. Check for cracks, wear, leaks, bearing roughness or damage. If defective replace assembly.

– Reassembly

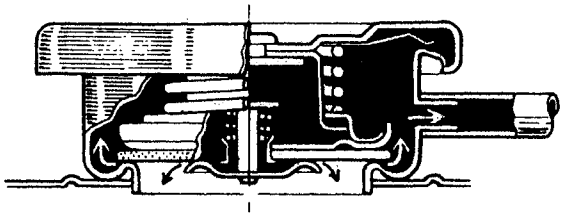
A. Assemble the thermostat and spring in the housing. Install the gasket and set plate on the water pump.

B. Rotate the fan holder to confirm that there is no fouling.

Radiator

A pressure type radiator cap is employed to obtain higher cooling efficiency. When the coolant pressure builds up to the range of 0.9 ±0.15kg/cm^2 (6.5lb/ft to 10.8lb/ft) excessive pressure is relieved from the overflow pipe. (shown by white arrow).

When coolant temperature falls coolant pressure may become less than atmospheric pressure. As this may fracture the radiator, the vacuum relief valve opens at 0.04 to 0.05kg/cm^2 (2.9lb/ft to 3.6lb/ft) to protect the radiator. (black arrow).



E0073

– Inspection

A. Check the radiator for water leaks. If water leaks, repair or replace the radiator.

B. Check radiator fins for clogging by mud and/or other foreign matter. If clogged, clean the fins.

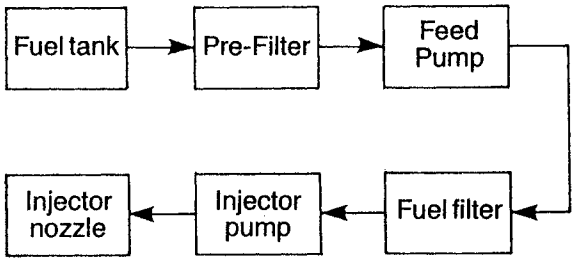
C. Check the pressure cap and vacuum pressure relief cap for operating pressure or contacting condition. If found to be defective, replace.

D. Check the radiator hoses. If damaged or perished replace.

Fuel Filter

The fuel line is shown in the illustration.

The fuel which lubricated the injection nozzle needle is returned to the tank through the overflow pipe.



PB068

– Inspection

A. Check inside the fuel filter. If water or foreign matter is found, remove it. If needed, replace the fuel filter.

– Disassembly/Reassembly

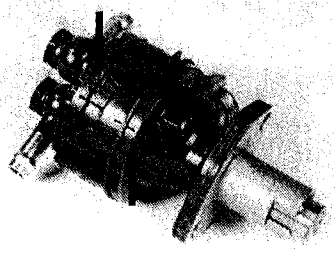
A. Turn the filter counterclockwise to remove it.

B. Coat the mounting face of the element with grease, and install it hand tight.

Feed Pump Assembly

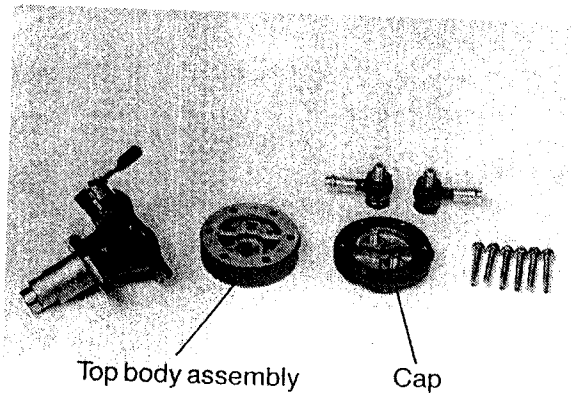
– Disassembly

A. Before disassembly see section A, B, C of Inspection and then note reference marks on the diaphragm cap, top body assembly and bottom body as shown in the figure.



PB069

B. Remove the bolt to remove the cap and top body assembly.

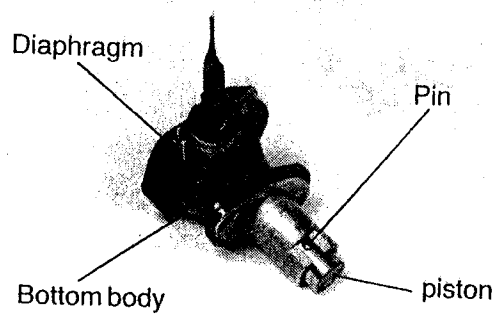


PB070

C. Remove the diaphragm from the bottom body, and turn the piston to align the bottom body groove with the pin hole.

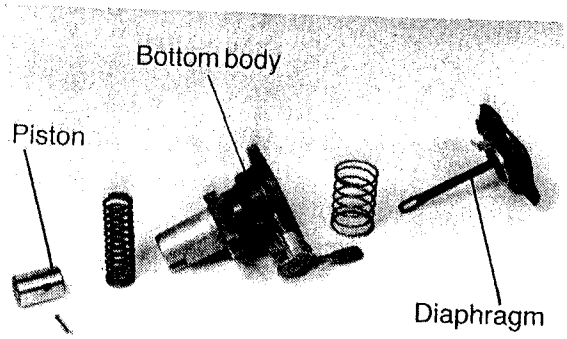
D. Remove the pin from the piston.

NOTE: Pay attention to the inner spring.



PB071

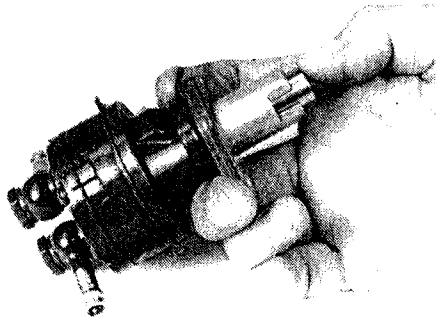
E. Take out the piston, spring and diaphragm from the bottom body.



PB072

– Inspection

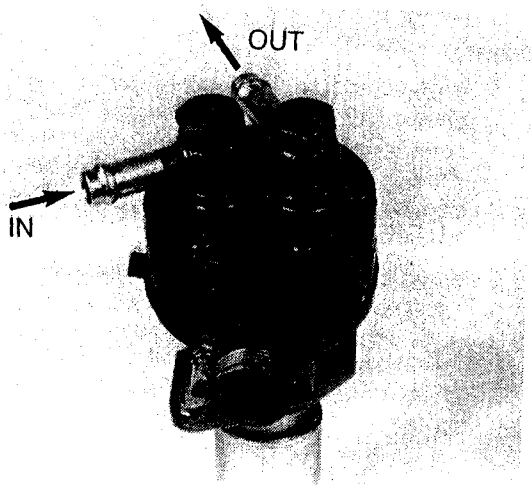
A. Before disassembling the feed pump, confirm that the piston and bottom body are not seized.



PB073

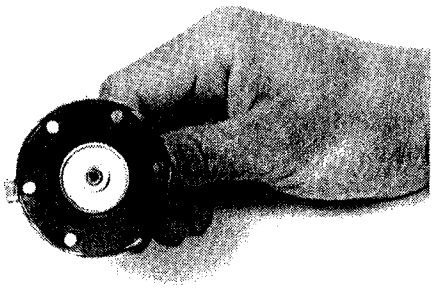
B. Drain all fuel in the feed pump.

C. Check condition of the top body as follows. Draw air from IN side with vacuum and put air into OUT side. If air stops in both cases, the body is normal.



PB074

D. Confirm that the diaphragm has no damage, such as cracks.



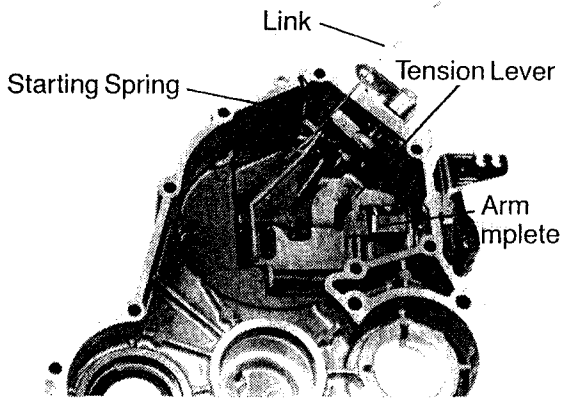
PB075

– Reassembly

A. Reassemble the feed pump in the reverse order of its disassembly.

Governor

– Construction/Function



PH084

A. A mechanical all speed governor is used. It is housed in the gear case.

A flyweight assembly is mounted on the camshaft. The movement of the flyweight is transmitted to the injection pump control rack by way of the slider, control lever and link. A spring which is hooked to the arm and tension lever regulates the movement of the flyweight.

By changing the set angle of the governor lever, tension on this spring is changed. Thus, the engine speed can be regulated by the governor lever.

B. Maximum speed set bolt.

Set bolt is mounted on the cylinder block. This bolt limits the movement of the arm and has been adjusted and sealed at the factory.

C. Max. fuel and start spring.

These are built into the cylinder block, to regulate fuel injection at high speed. Regulation of fuel injection in the middle speed range is by torque spring to realize higher torque.

A start spring is placed between the gear case and link. This spring automatically functions to increase fuel during the start mode.

An idling spring at the gear case stabilizes engine idling speed.

The max. fuel has been adjusted at the factory and sealed.

Nozzle and Holder

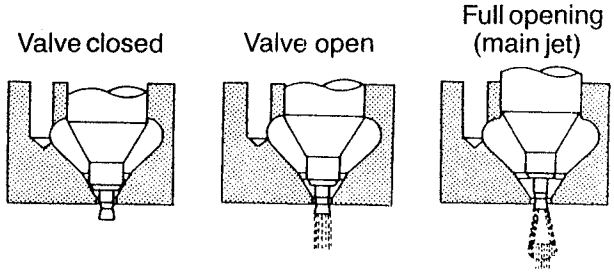
– Specification

Item	103-12, 103-13, 103-15 IDI,104-19 IDI	104-19 DI, 103-15 DI
Part code	131406360	131406370
Assembly number	105148-1170	105118-4560
Nozzle holder	105078-0100	105048-2020
Nozzle	105007-1170 (NP-DN4PDN117)	105017-0450 (NP-DLLA155PN045
Nozzle type	Throttle type	Bosch type hole
Needle valve diameter	4mm	4 jets
Pintle diameter	1mm	0.23mm jet diameter
Valve setting pressure	155-165kg/cm^2 (153-163atm)	215-225kg/cm^2 (212-222atm)
Spraying angle	4°	—

– Construction/Function

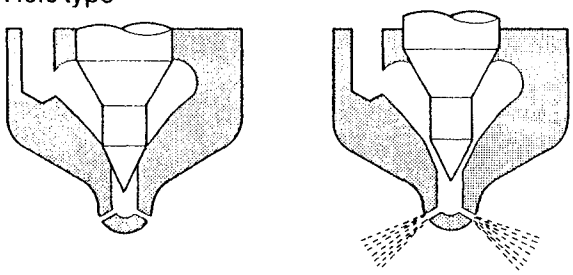
A. The nozzle has been machined to inject fuel, which is pressure-fed from the injection pump to the combustion chamber. Fuel is pressure-fed from the oil hole of the nozzle holder to the nozzle body and sprayed from the nozzle compressing the spring when the pressure exceeds the specified value. Some fuel lubricates and cools the nozzle and nozzle body, and returns via the return pipe.

Throttle type



1117

Hole type



PH089

– Disassembly/Inspection

A. Place the nozzle holder (body) in a vice and turn the nozzle nut to disassemble.

NOTE: Care should be taken so that the needle valve does not fall when the nozzle is removed.

B. Wash the nozzle body and needle valve and inspect the nozzle for seizure, sticking and fuel leakage on the seat surface. If fuel leakage is detected, replace the nozzle.

C. Inspect the upper and lower contact surfaces of the distance piece and correct so that positive contact can be obtained.

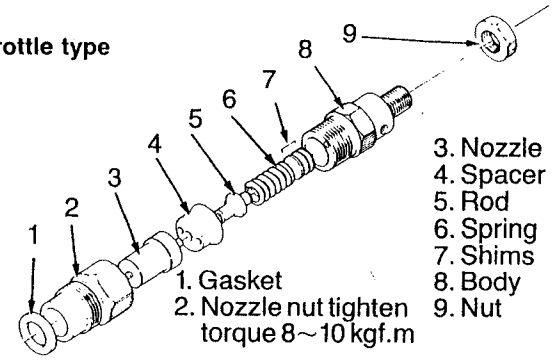
D. Check the nozzle needle valve-contact surface on the push rod for wear, and spring seat for cracks.

– Reassembly/Adjustment

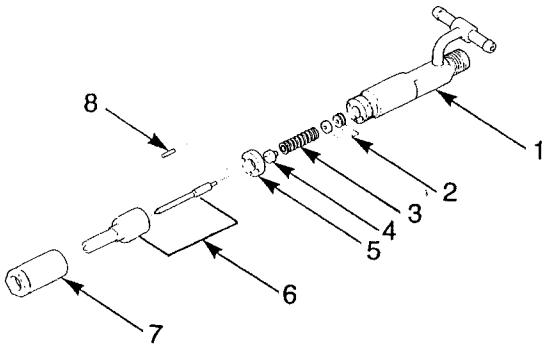
A. Before fitting a new nozzle assembly, soak it in heated light oil (50°-60°C) to remove anti-corrosive agent from the nozzle. Then, slide the body on the needle valve so that they slide smoothly.

B. Turn the nozzle body upside down, fit the shim, spring, rod, piece and nozzle in this order, and tighten with a nozzle nut.

Throttle type



1118



1. Body
2. Shims
3. Spring
4. Spring seat
5. Spacer
6. Nozzle
7. Retainer nut
8. Pin

PH088

C. After reassembly, inspect the injection pressure of the nozzle.

Adjust the pressure with adjusting shims using a nozzle tester so that the injection starts at 150kg/cm^2 (throttle type) and 210kg/cm^2 (hole type). (The pressure increases or decreases about 10kg/cm^2 142psi 9.7ats with a shim of 0.1mm thick.)

D. Spray condition — Throttle type

a. Fuel drops should not be mixed in the spray pattern.

b. Fuel should be sprayed in conical shape with respect to the nozzle axis.

c. Check that the fuel is sprayed in a circular shape when tested.

d. Hold the pressure at 100kg/cm^2, 97ats, lower by 20kg/cm^2, 20ats, than specified (120kg/cm^2) and check that no test oil drops from the nozzle tip.

Spray condition — hole type

a. Fuel drops should not be mixed in the spray.

b. Fuel should be sprayed in 4 directions (0°, 90°,180° and 270°) from the nozzle axis.

c. Check that the fuel is sprayed in the same shape when tested with white paper placed at a distance of about 30cm.

d. Keep the pressure at 20kg/cm^2 lower than specified and check that no test oil drops from the nozzle tip.

Fuel Injection Pump

— If trouble has been traced to this pump, disassembly, inspection, assembly and testing/setting must only be carried out by fuel equipment specialists.

Air Cleaner

– Construction/Function

The cyclonic air cleaner houses a paper element which removes dirt or dust from air drawn in.

– Inspection/Replacement

A. At every 100-200 hours of operation, take out the element and clean it by blowing compressed air (pressure lower than 100psi.)

B. When oil or soot is stuck to the element, soak it in synthetic detergent for approximately 15 minutes. Then, rinse it in the detergent several times, and wash it in clean water. Finally, leave to dry.

C. When operating the machine in dusty environment, increase service frequency.

D. At every sixth cleaning or every year, replace the element.

E. After cleaning the element, put a light inside the element, and check it for cracks, holes or wear.

If damage is found or the gasket is broken, replace the element.

F. Do not install the element until completely dry.

SECTION V
Reassembly

Precautions Before Assembling

A. Wash parts before assembling. (Especially, oil gallery, bearings, pistons and cylinder bores should be washed thoroughly.)

B. Apply new oil to sliding and rotating surfaces of cylinder bores, pistons and bearings, etc.

C. Replace gasket, packing, etc. Use liquid gasket to prevent oil leakage where necessary.

D. Never overtighten bolts and nuts used on aluminium alloy: tighten to specified tightening torques.

Relief Valve Assembly

A. Install an O-ring on the relief valve assembly.

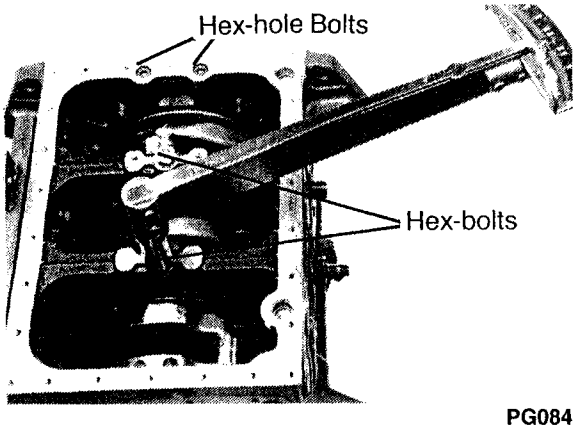
Relief valve tightening torque:
6.0 to 7.0kgf.m (43 to 50lbf/ft.)

Crankshaft and Bearing Holder Assembly

A. Install the bearing holders on the crankshaft. Insert this in the bush at the front end of the cylinder block.

B. Align the bolt hole at lower part of the cylinder block with thread hole on the bearing holder, and tighten with bolts. For flywheel end, use two special bolts, hex. recess in its head.

Bearing holder tightening torque:
Hex hole bolts 2.5 to 3.0kgf.m (18-22lbf/ft),
Hex bolts 5.0-5.5kgf.m (36-40lbf/ft).

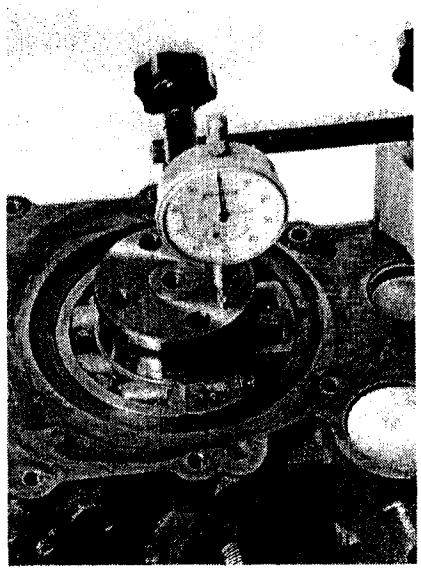


PG084

C. Measure crankshaft end float.

All engines

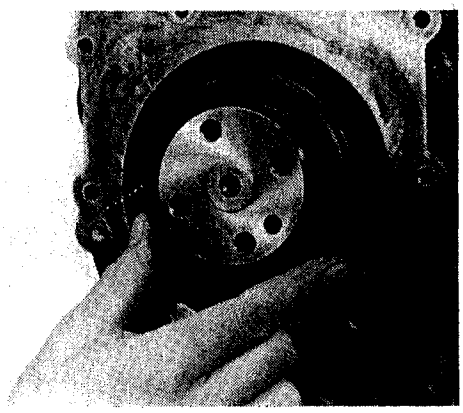
Standard play	Allowable limit
0.1-0.4mm (.004-.016")	0.5mm (.020")



PB083

Rear Oil Seal

A. This is a pressfit, retained by the back plate.

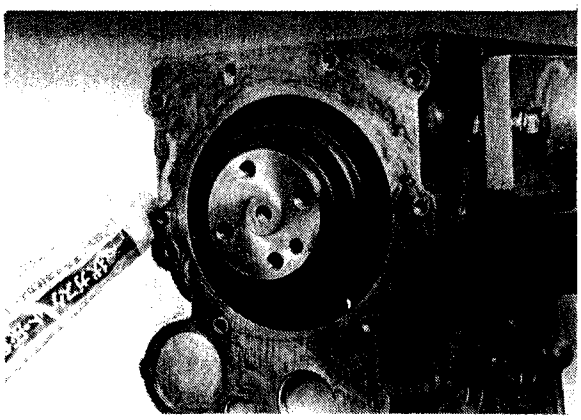


PB084

Back Plate/Flywheel Housing

A. Coat the area around the M8 threaded holes with liquid packing solvent based sealant and fix the back plate with bolts.

Back plate tightening torque:
1.3-1.7kgf.m (10-13 lbf/ft).
Housing tightening torque:
2.4-2.9 kgf.m (18-21lbf/ft).

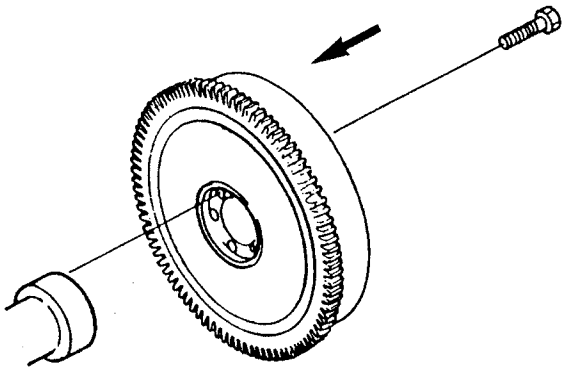


PB085

Flywheel

A. Fit the flywheel, note location of the spring pin.

Flywheel tightening torque:
6.0 to 7.0kgf.m (43 to 50lbf/ft).



E0021-1

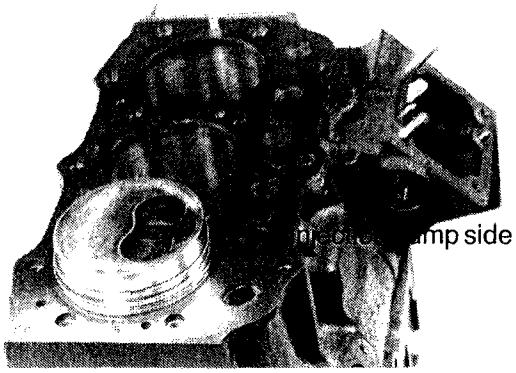
Piston and Connecting Rod

A. Coat bearing face, piston and piston ring with clean engine oil.

B. Slide the piston ring to permit sufficient amount of oil to be applied in the groove. Set piston ring gaps 90 degrees apart from each other. However, do not position these gaps toward the gudgeon pin or the right angle of the pin.

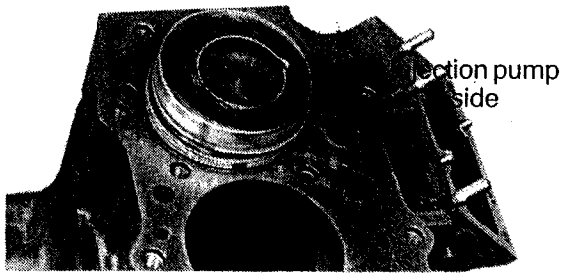
C. Insert the piston using a ring compressor. Face the reference mark on the piston toward the injection pump side. As indicated on PG090 and PH099. Also face the connecting rod mark towards the fuel pump side.

(IDI)



PG090

(DI)



PH099

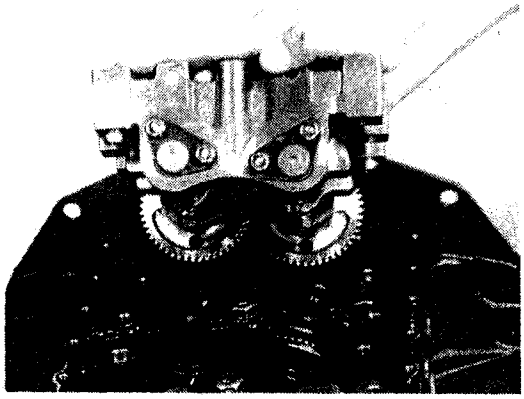
NOTE: Install pistons from front in ascending order.

D. Tighten the connecting rod cap to specified torque.

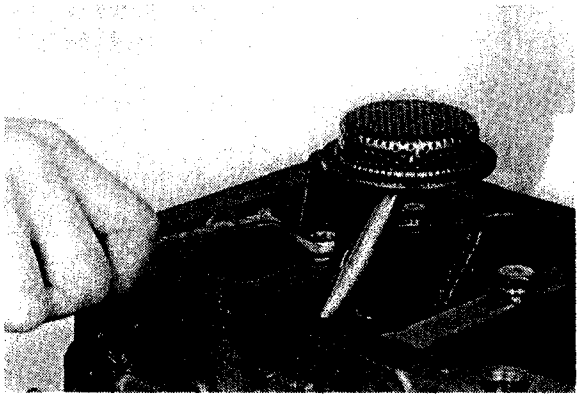
Connecting rod tightening torque:
5.0-5.5kgf.m (36-40lbf/ft).

NOTE: After installation ensure that the crankshaft moves freely. Ensure the axial play of 0.1 to 0.3mm (.004 to .012) is provided.

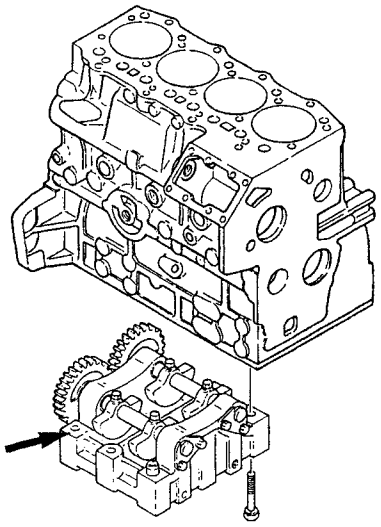
Dynamic Balancer. (Where fitted)



PH101



PB088



PH102

A. Place number one and four pistons at TDC. Re-install balancer to block using shims removed during disassembly.

B. Tighten balancer assembly using torque of 5-5.5kgf.m (36-40lbf/ft).

C. Tighten eyebolt for oil pipe to torque of 1.0-1.3 kgf.m (7-9lbf/ft).

Suction Pipe and Suction Filter

A. Fix an O-ring on the suction pipe, and insert the pipe into the cylinder block.

B. Fit the end of the suction pipe to the oil strainer and fix the oil strainer.

Suction filter tightening torque:
0.9 to 1.3kgf.m (6.5 to 10lbf/ft).

Sump

A. Tighten the bolts diagonally and evenly.

Dipstick and tube

A. Install the dipstick and tube using two O-rings.

Front Plate

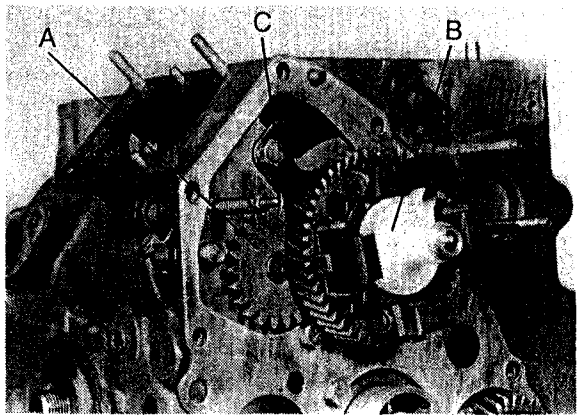
Camshaft Assembly, Tachometer and Plate

A. Install the tachometer shaft.

B. Install the camshaft assembly. Avoid damaging bearings.

C. Fix the tachometer shaft and camshaft with the retaining plate.

Plate tightening torque:
0.9 to 1.3kgf.m (6.5 to 10lbf/ft).

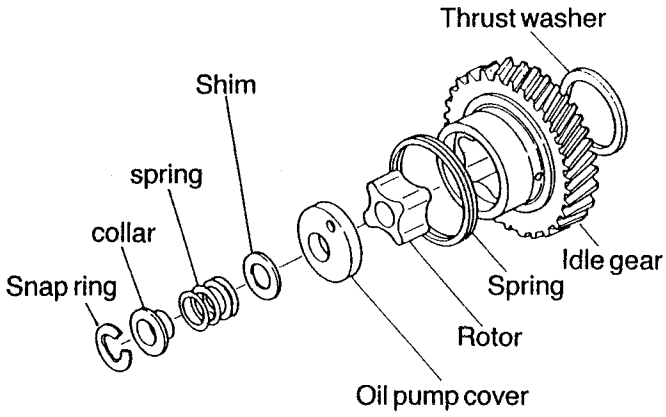


PB089

Idle Gear and Oil Pump Assembly
(See Section IV Oil Pump)

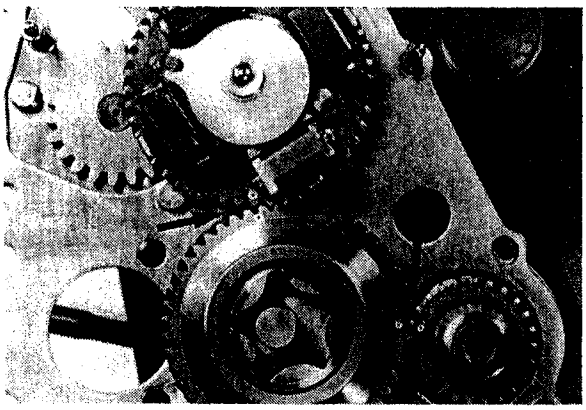
A. Install the thrust washer on the idle gear shaft.

B. Assemble the vane, knock pin and spring on the idle gear.



PB090

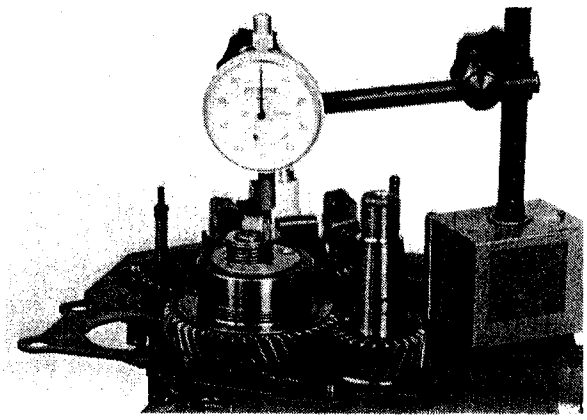
C. Align set marks on idle gear, crankshaft gear and camshaft gear, and assemble on the idle gear shaft.



PB091

D. Install the rotor.

E. Install the oil pump cover, shim, spring and collar. Fix them with the circlip.



F. Adjust with shim 0.1, 0.15, 0.2, 0.5mm so that the axial clearance of oil pump, rotor and vane is in the range of 0.1 to 0.15mm. Allowable limit 0.2mm (.008").

NOTE: Coat both faces of the rotor and vane with grease for assembly.

NEVER TURN the crankshaft until the timing gear case is fitted.

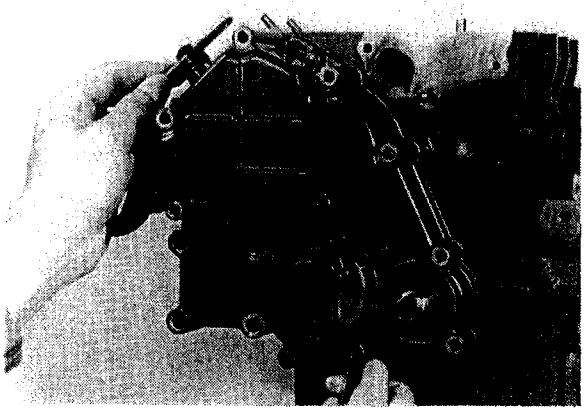
By turning the oil pump cover to either direction, set the spring pin insert hole to the middle position. Then, fit the gear case.

Timing Gear Case

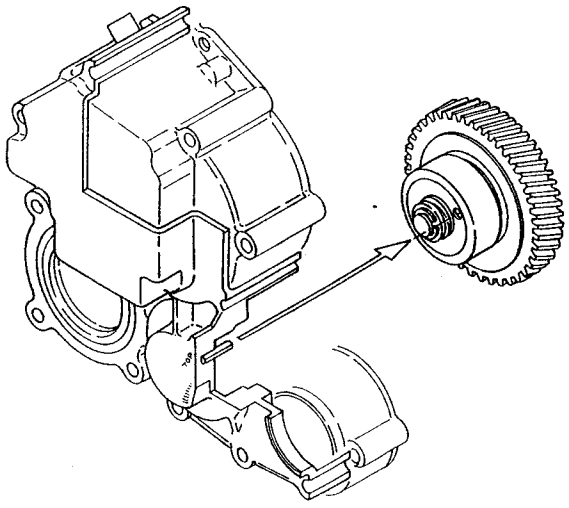
A. Install the start spring.

B. Insert link through hole in cylinder block. Rotate oil pump cover to position spring pin hole to centre position. Install cover locating pin in oil pump cover plate. (PB094).

NOTE: 1. Do not damage the oil seal when fitting.
2. Turn the mechanical stop lever clockwise to assist assembly.



PB093

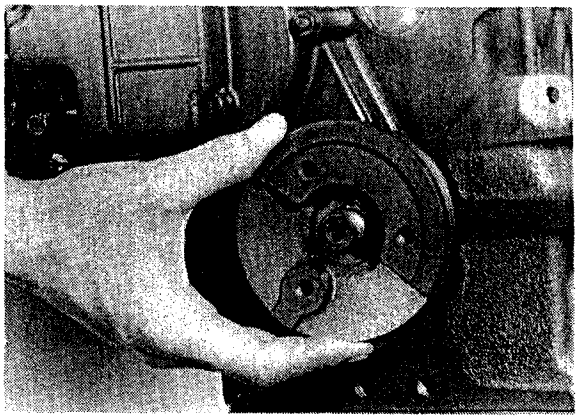


PB094

Crankshaft Pulley

A. Align the key way and key on the crankshaft pulley and crankshaft, and assemble them.

Crankshaft pulley tightening torque:
28 to 34kgf.m (203-246lb/ft).

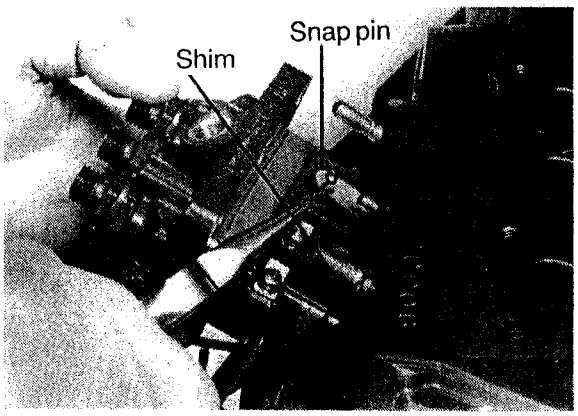


PB095

Injection Pump Assembly

A. Reinstall the shim. Connect the control rack of the injection pump with the link, and fix with the snap pin.

B. Tighten the injection pump bolts and nuts.



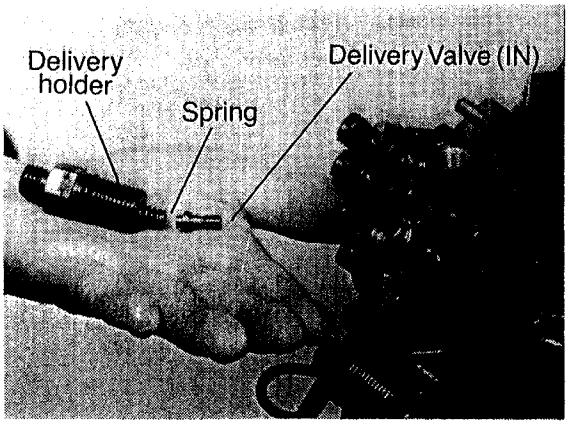
PB096

Adjusting the Fuel Injection Timing

Normally this procedure provides correct injection timing. However, when new injection pump, camshaft assembly, or cylinder block is used, fuel injection timing should be adjusted as explained below.

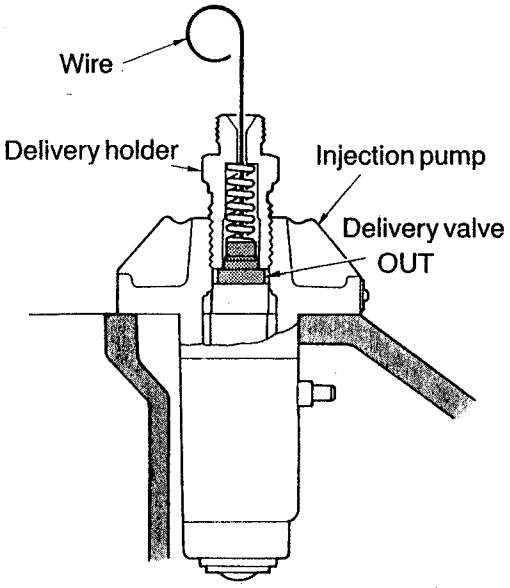
A. Reassemble the injection pump according to the procedures above. Use the shim of 0.5mm thickness.

B. Remove the delivery valve holder at the front side (radiator side) of the injection pump.



PB097

C. Pull out the delivery valve (IN), and reinstall the spring and delivery valve holder.



1139

NOTE: When re-assembling the delivery holder, adjust the location of the delivery valve (OUT) to correct position using a wire.

D. Move the governor control lever to "Maximum Fuel" position, and send fuel with the No 1 piston at around 'X' degrees BT.DC in its compression stroke. At this time, fuel flows from the delivery holder.

Injection Timing and crankshaft positions

Engine Model	Degrees Crank BTDC			
	X	Y	Z	Injection Timing
103-12,103-13 103-15,IDI	25	22	23	22-23
104-19 IDI	25	20	21	20-21
103-15 DI/ 104-19 DI	23	18	20	18-20

E. Then slowly turn the crankshaft clockwise until flowing fuel from delivery holder is stopped. Check the piston position at this point. If the position is later than 'Y' BTDC, use thinner shim. If the position exceeds 'Z' BTDC, use thicker shim.

Changing the shims thickness by 0.1mm will change the timing approximately one degree. Adding shims decreases the angle while subtracting shims increases the angle.

Piston Position in relation to the crankshaft angle (BTDC)

103-12,103-13 (All lists)		103-15, 104-19 (All lists)	
Crankshaft angle (BTDC)	Position mm (inch)	Crankshaft angle (BTDC)	Position mm (inch)
20	3.135 (.1234")	16	2.278 (.0897")
21	3.451 (.1359")	17	2.569 (.1011")
22	3.780 (.1488")	18	2.875 (.1132")
23	4.124 (.1624")	19	3.199 (.1259")
24	4.482 (.1765")	20	3.539 (.1393")
25	4.853 (.1911")	21	3.895 (.1533")
		22	4.267 (.1680")
		23	4.655 (.1833")
		24	5.058 (.1991")
		25	5.477 (.2156")
		26	5.912 (.2328")
		27	6.361 (.2504")
		28	6.826 (.2687")
		29	7.304 (.2876")

NOTE: When the shim is not needed, assemble by coating using liquid sealant.

F. Assemble the delivery valve (IN).

NOTE: Delivery holder tightening torques: 4.0-4.5kgf.m (29-33lbf/ft).

Oil Filter

A. Coat the mounting face with a thin film of oil, and hand tighten.

Feed Pump

A. Insert using securing bolts.

Tappet

A. Coat the tappet with oil, and assemble.

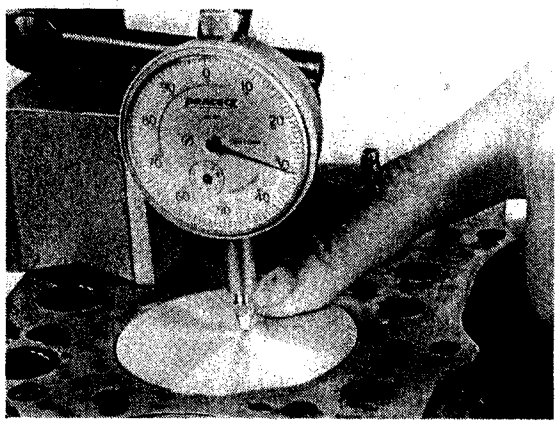
Cylinder Head

A. Set the piston to the top dead centre, measure the amount of protrusion above the cylinder block with depth gauge or dial gauge.

NOTE: Take measurement by pressing the piston lightly.

Measure the protrusions for three/four cylinders. And, use the highest reading as a reference.

B. Ensure the cylinder head gasket meets the tolerance levels.



PB099

103-12

Measurement (mm)	Gasket No.	Tightened thickness
0.5-0.8 .02-.031"	111147170	t=1.4mm

103-13, 103-15

Measurement (mm)	Gasket No.	Tightened thickness
0.5-0.8 .02-.031"	111147001	t=1.4mm

104-19

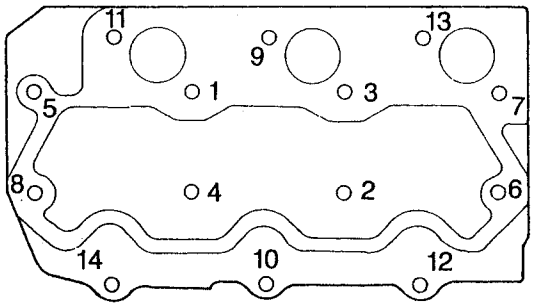
Measurement (mm)	Gasket No.	Tightened thickness
0.5-0.8 (.02-.031")	111147200	t=1.4mm

NOTE: Last four digits of code numbers are stamped on the head gasket. Install the head gasket with code numbers at top.

C. Tighten the cylinder head in 3-step procedures, in the order shown in the illustration. Finally tighten with specified torque.

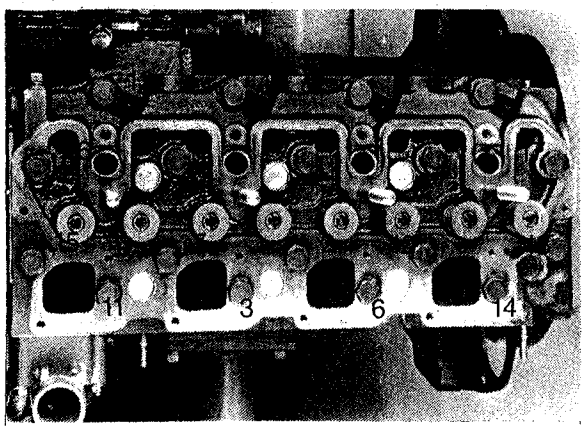
Specified torque:
9.0-9.5kgf.m. (65-69 lbf/ft).

3 Cylinder Engines



E0098

4 Cylinder Engines



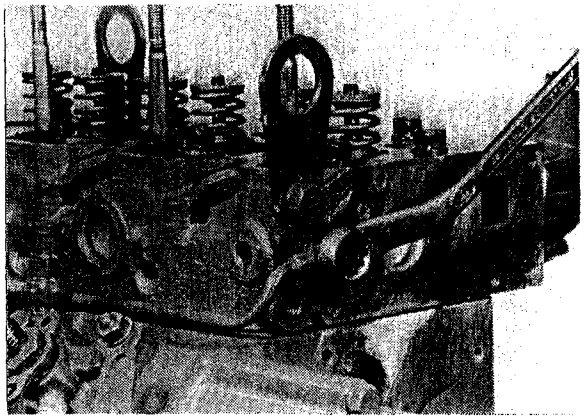
PH114

NOTE: Spring pin is used for positioning.

Coat threads of bolts with grease based with molybdenum disulphide.

Oil Pipe

Eyebolt tightening torque:
1.0 to 1.3kgf.m (7 to 9lbf/ft).



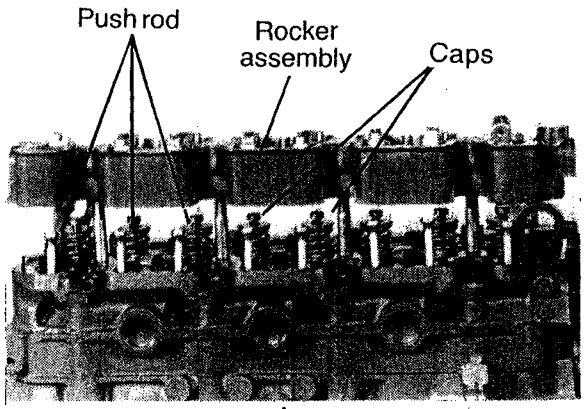
PB101

Cap, Push Rod and Rocker Arm Assembly

A. Install the cap on the end of valve stem.

B. Install the push rod and rocker arm assembly.

Rocker arm assembly tightening torque:
2.0 to 2.5kgf.m (14.5 to 18.1lbf/ft). 3 cylinder engines (not 103-15 DI).
2.8 to 4.0kgf.m (20 to 29lbf/ft) 4 cylinder engines and 103-15 DI.



PH115

Valve Clearance Adjustment

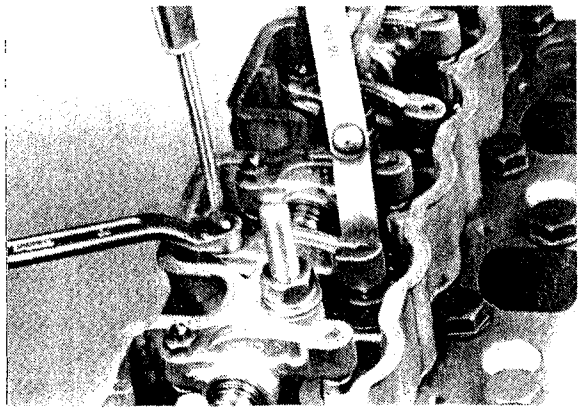
A. Loosen the nut and adjust the clearance of both the intake and exhaust valves to 0.2mm (.0078") with the adjust screw.

3 Cylinder Engines

NOTE: Adjust when the engine is cold. Set the No. 1 piston to the top dead centre, and adjust the clearances of intake/exhaust valves of No. 1 cylinder and exhaust valve of No. 2 cylinder. Then, turn the crankshaft counter-clockwise by 240° (viewed from the front) to adjust clearance of intake valve of No. 2 cylinder and intake/exhaust valves of No. 3 cylinder.

4 Cylinder Engines

NOTE: Adjust when the engine is cold. Set the No. 1 piston to TDC of compression stroke and adjust No. 1 cylinder intake, exhaust valves, No. 2 cylinder intake valve, No. 3 cylinder exhaust valve. Then turn the crankshaft 360° in clockwise direction viewed from front and adjust the remaining valves.



PH116

Cylinder Head Cover

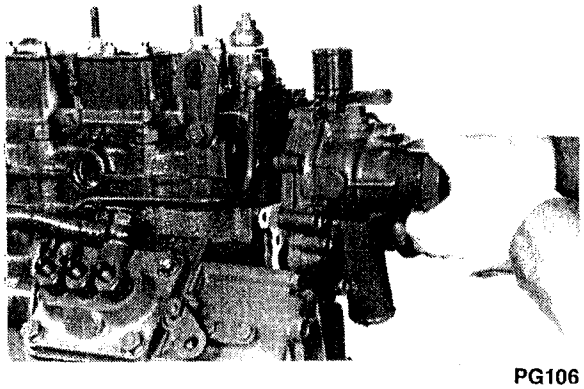
A. Evenly tighten the cylinder head cover. Ensure oil ring gasket remains in location

Cylinder head cover tightening torque:
0.8 to 1.2kgf.m (6 to 9lbf/ft) 3 cylinder engines not 103-15 DI.
1.2 to 1.6kgf.m (9 to 12lbf/ft) 4 cylinder engines and 103-15 DI.

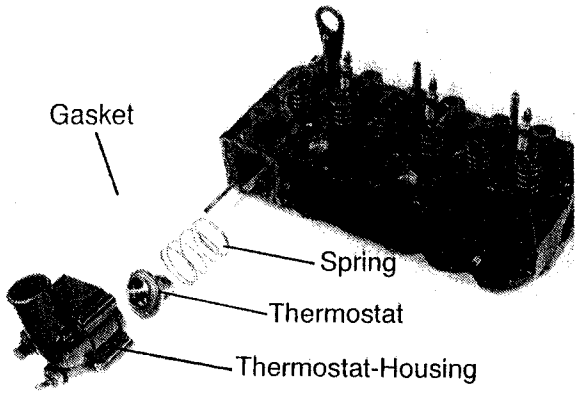
Water Pump Assembly and Thermostat Housing

A. Install in the sequence of gasket, plate, gasket and water pump assembly.

B. Connect thermostat housing and hoses.



PG106



PG081

Glow Plug and Connector

Glow plug tightening torque:
1.5 to 2.0kgf.m (11 to 14.5lbf/ft).

Mano-Contact

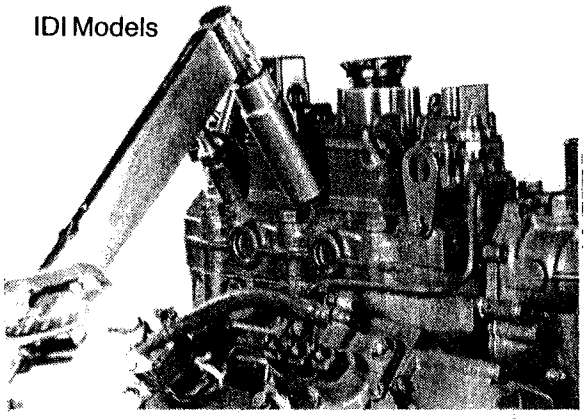
Mano-contact tightening torque:
1.5 to 2.0kgf.m (11 to 14.5lbf/ft).

Nozzle/Holder Assembly

A. Install the nozzle and holder assembly with socket for the nozzle holder. Install the return pipe.

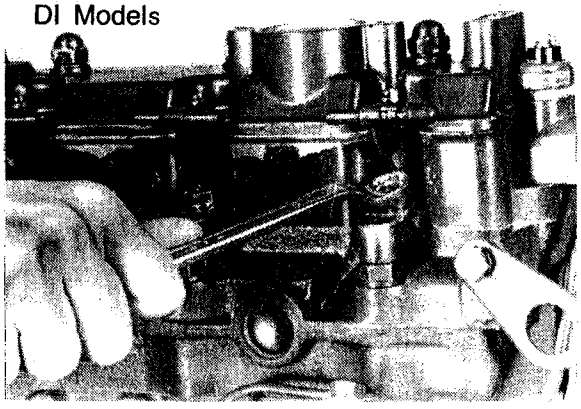
Nozzle/holder tightening torque:
103-12, 103-13, 103-15 IDI:
6.7kgf.m. (44-51lbf/ft)
103-15 DI/104-19 DI: 2.0-2.5kgf.m (15-18lbf/ft).

IDI Models



PG107

DI Models

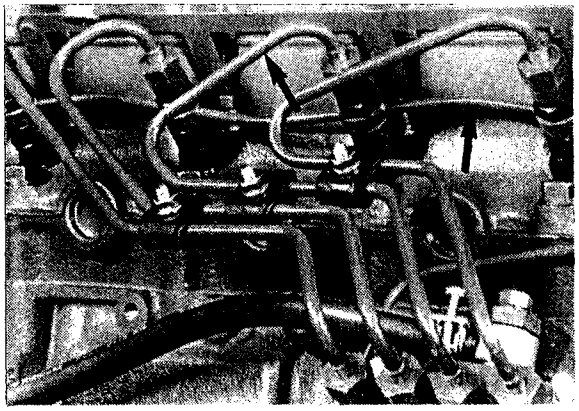


PH119

Return Pipe and Injection Pipe

A. After installing the return pipe, mount injection pipes.

Injection pipe tightening torque:
1.5 to 2.5kgf.m (11 to 18lbf/ft).



PH120

Alternator Assembly

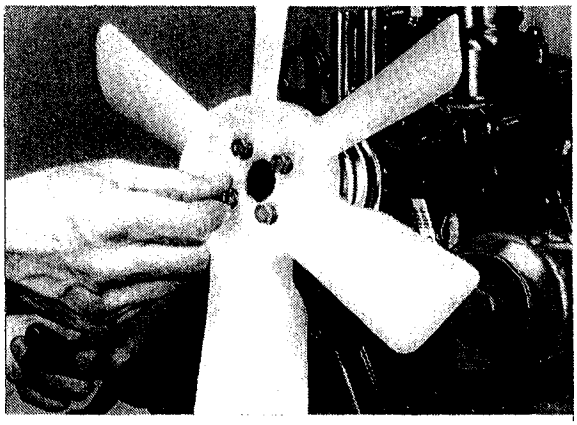
A. Install the assembly. Check belt groove alignment.

V Belt, Fan Pulley and Cooling Fan

A. After mounting the fan pulley and cooling fan, install the V belt.

B. Depress the belt at the centre between the crankshaft pulley and the alternator pulley, with finger force of approximately 1kg, (.5lbf/ft). The fan belt tension should be adjusted such that the deflection becomes 5mm (.2″) upon the above check.

Cooling fan tightening torque:
0.9 to 1.3kgf.m (6.5 to 9.5lbf/ft).

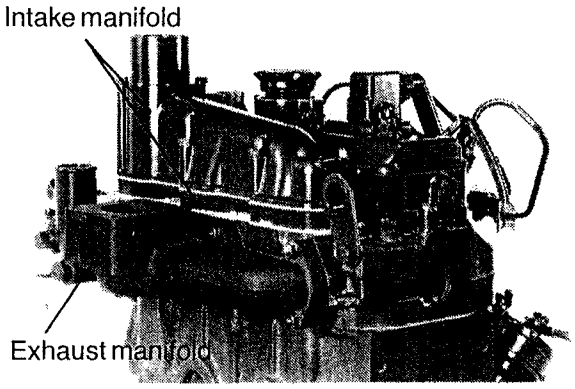


PB106

Intake/Exhaust Manifolds

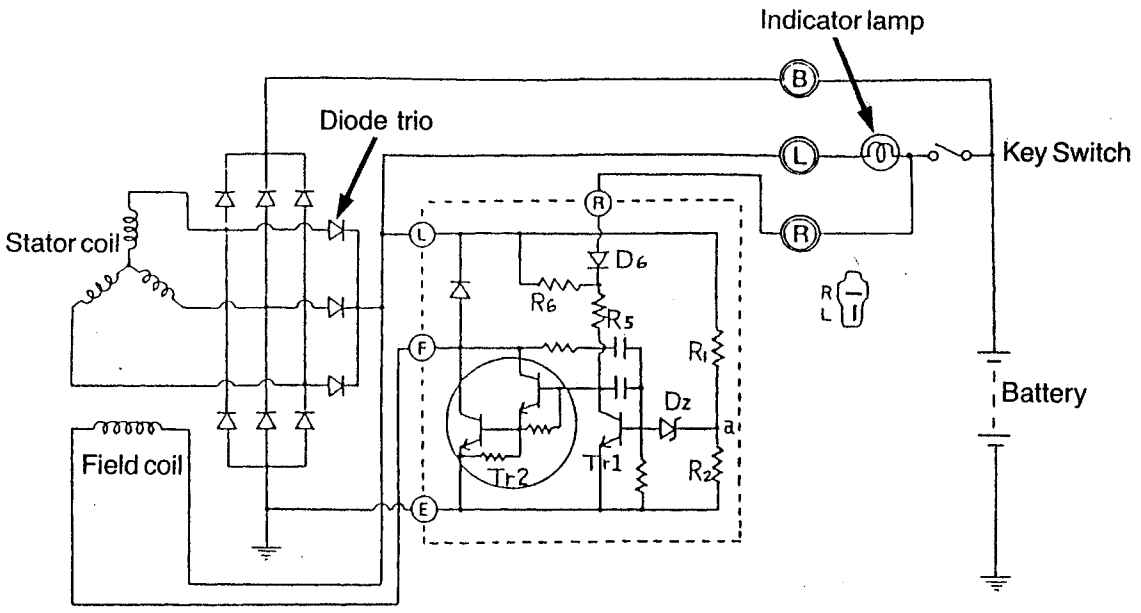
A. Install in sequence of gasket, spacer, gasket and intake manifold.

B. Install exhaust manifold.



PG108

SECTION VI
Electrical Systems



Note: ◯ Represents the alternator terminal

PG110

Alternator (35 amp version)

Charging circuit

– Description

The charging circuit and internal connection are shown in PG110. The charging system consists of an IC regulator built in alternator, a battery and connecting wires. Because of the use of IC, the voltage regulator is very compact and is built into the alternator.

A. As the regulator is incorporated in the alternator, there is no need to provide a wire harness between the alternator and the regulator.

B. The field current flows directly from the diode trio to the field coil without passing through the external circuit. Consequently, there are no voltage drops caused by the key switch or the wiring as with the conventional vibrating-contact regulators mounted separately from the alternator.
But to help the initial voltage build up when the engine is started, the field current is supplied through the indicator lamp from the battery.

– Principle of IC Regulator

The basic circuit of the IC regulator is shown in PG110.

The part enclosed by a dotted line represents the IC regulator.

The basic function of the IC regulator to make terminal voltage constant by detecting generated voltage and increasing/decreasing field current is not different from that of the vibrating-contact regulator.

As indicated, the regulator consists of two basic sections: a voltage control device and an output device to handle the field current. The voltage control device includes a voltage divider network (R1, R2), a zener diode (DZ) for voltage reference, and a signal amplifying transistor (Tr1). The output device is a darlington type amplifier which is called power transistor (Tr2). The transistor Tr2 is placed in series with the alternator field coil and ground.

The transistor Tr1, as mentioned earlier, senses the generated voltage and turns the transistor Tr2 on and off many times per second most of the time that the engine is in operation.

The basic operating principles are explained as follows:

A. When the key switch is closed, current from the battery flows through the indicator lamp and resistor R6, which are in parallel, to the field coil. From here it continues to flow on through the field coil to ground, completing the circuit back to the battery.

Battery —— Key Switch < Indicator lamp / Terminal R- Resistor R6 >

Alternator terminal L——Field Coil——Tr2 ——Ground

B. When the alternator begins to rotate, A.C. voltages are generated in the stator coil. The diodes in the rectifier assembly change the stator A.C. voltages to a D.C. voltage which appears between ground and the terminal B.

The stator, also supplies D.C. field current through the diode trio, the field coil, Tr2 and then through the diodes in the rectifier assembly back to the stator.

Diode trio——Field coil——Tr2——Ground

C. When the generated voltage is low, no current flows in the zener diode (DZ) since the voltage at point A is lower than the zener voltage.

D. As the speed and voltage increase the voltage at point A also increases until it reaches the limiting value set by the factory. As the zener diode (DZ) breaks down current flows through R1, DZ and the base-emitter circuit of Tr1 to ground. This renders Tr1 conductive, so that much of the current flows the collector-emitter circuit of Tr1. This reduces the base current of Tr2 thereby reducing the field current. This means that TR1 turns on and Tr2 turns off.

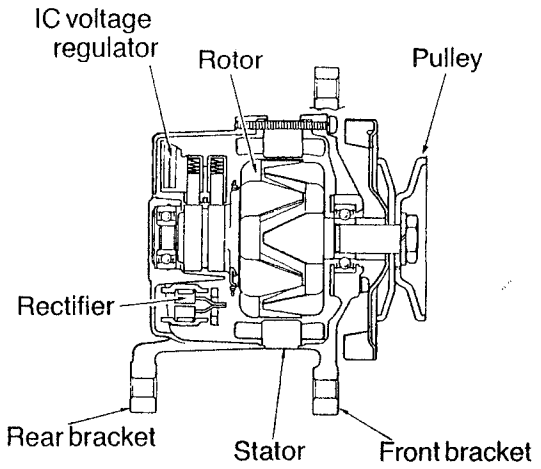
Regulator Terminal L——R1——DZ > Tr1——Ground
Regulator terminal R——R6——R5 >

E. When the generated voltage decreases, the zener diode (DZ) again turns off and Tr1 also turns off.

This cycle then repeats many times per second, and the alternator output voltage is, therefore, regulated within narrow limit.

In other words, the action is similar to the conventional vibrating-contact regulator, in that current to the field coil is varied to limit the output voltage, but in place of the voltage coil and spring system, there is a potential divider (R1 and R2) and a zener diode.

– Construction



PG111

Sectional view of the IC alternator

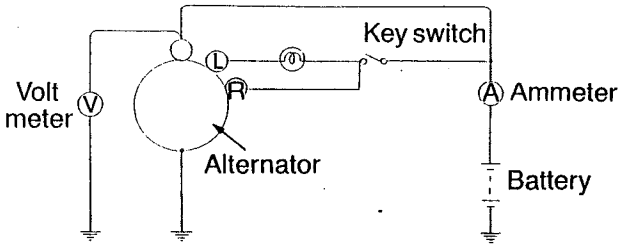
The principal components of the IC alternator are the stator, the rotor, the rectifier assembly, the IC voltage regulator, the front bracket, the rear bracket and the pulley.

The rectifier assembly consists of two heat sinks, one positive and one negative, and diode trio. The diode trio is used as field supply diode and is connected to the field coil and the terminal L on the alternator.

The built-in IC regulator is a solid state unit so that it can only be serviced as an assembly.

– Check on the Equipment

A. **Checking the regulator adjusting voltage.**



PG112

a. In the case of equipment without an ammeter, connect a test ammeter (40A capacity) at the position shown in PG112.

In the case of equipment with an ammeter, make use of the ammeter on the equipment.

b. Connect a voltmeter between the terminal B of the alternator and the ground.

In this state, confirm that the reading on the voltmeter indicates the battery voltage.

If the voltmeter reading is zero, the wiring between the terminal B and the battery is faulty.

c. With the test ammeter terminals short-circuited, start the engine.

CAUTION In the case of where the test ammeter is connected at the position shown in PG112, make sure that no starting current is applied to the ammeter when the engine is started.

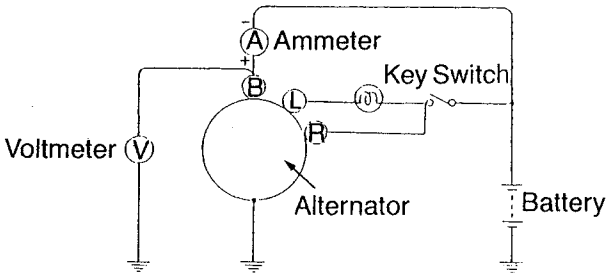
d. Remove the short circuit across the test ammeter terminals and increase the engine speed immediately to approx. 2000 rpm. Take the ammeter reading.

e. If the ammeter reading is 5A or less, take the voltmeter reading without changing the engine speed (approx. 2000 r.p.m.). The reading is the adjusting voltage.

f. If the ammeter reading is more than 5A, continue to charge the battery until the reading falls to less than 5A or replace the battery with a fully charged one.

An alternative method is to limit the charging current by connecting a ¼Ω (25W) resistor in series with the battery.

B. **Checking output**



PG113

If the previous section 'A' check is satisfactory, check the output as follows:

a. After opening the battery switch, disconnect the terminal B of the alternator and connect an ammeter (30A capacity) at the position shown in PG113.

b. Connect the voltmeter between the terminal B of the alternator and the ground. Confirm that the voltmeter indicates the battery voltage.

c. Close the key switch.

d Start the engine and turn on all the lamps. Immediately accelerate the engine to 2000 r.p.m. or more and measure the maximum value indicated on the ammeter.

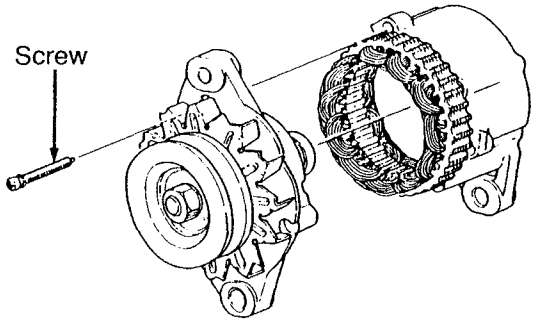
e. If this value is more than 70% of the nominal output (refer to Section on "Service Specifications"), the alternator can be considered as working almost satisfactorily.

NOTE: To make the above judgement more accurate, remove the alternator from the engine and check it on a test bench.

– Disassembly

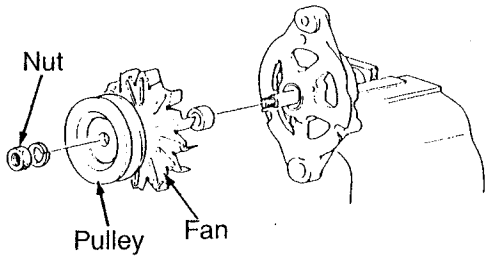
A. Mark both brackets and the stator with a scribe mark for assembly.

B. Remove the three through bolts. Pry between the stator and front bracket with blade of a screwdriver. Carefully separate the front bracket, pulley and rotor assembly away from the stator and rear bracket assembly.



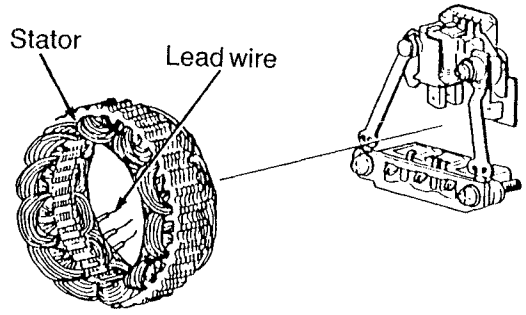
PG114

C. Place the rotor in a vice with soft jaws and remove the pulley nut, washer, pulley, fan, spacer, rear bracket and two dust seals from the rotor.



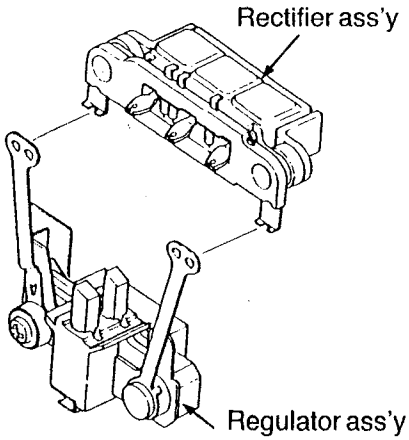
PG115

D. Unsolder three stator leads and remove the stator.



PG116

E. Remove the voltage regulator assembly and rectifier assembly.

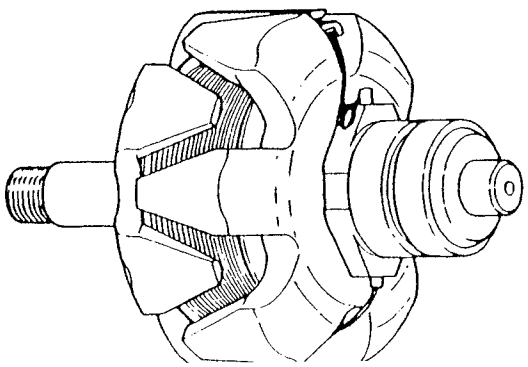


PG117

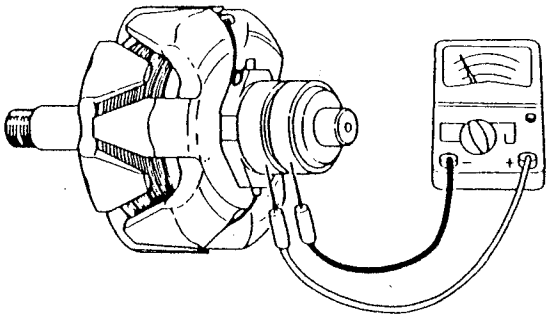
– Inspection of Parts

A. **Rotor**

a. Inspection of slip ring surface.
Correct stain or scratches on the slip ring surface with a sand paper of about 400-600#.
A badly roughened slip ring or a slip ring worn down beyond the service limit should be replaced.

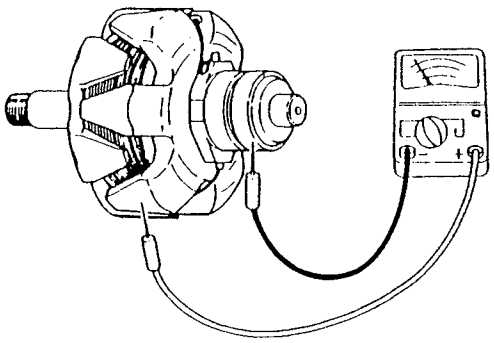


b. Check for continuity between both the slip rings.
If there is no continuity, the field coil is defective.
Replace the rotor assembly.



PG119

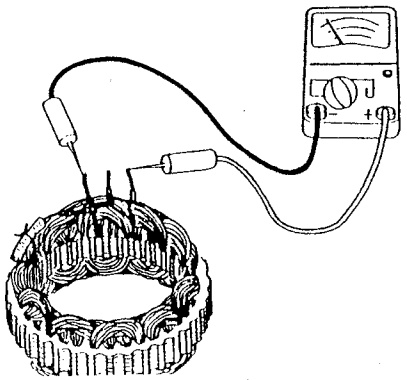
c. Check for continuity between the slip ring and shaft (or core).
If there is continuity, it means that the coil or slip ring is grounded.
Replace the rotor assembly.



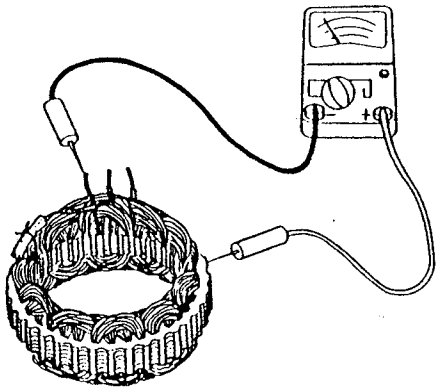
PG120

B. **Stator**

a. Check for continuity between the leads of the stator coil.
If there is no continuity, the stator coil is defective.
Replace the stator assembly.



b. Check for continuity between any stator lead and stator core.
If there is continuity, it means that the coil is grounded.
Replace the stator assembly.

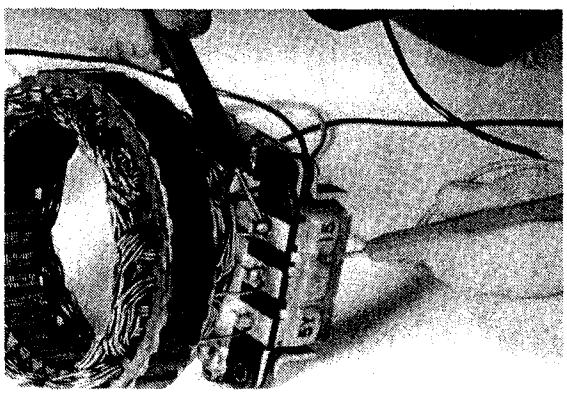


PG122

C. **Rectifier Assembly**

a. Positive Heatsink

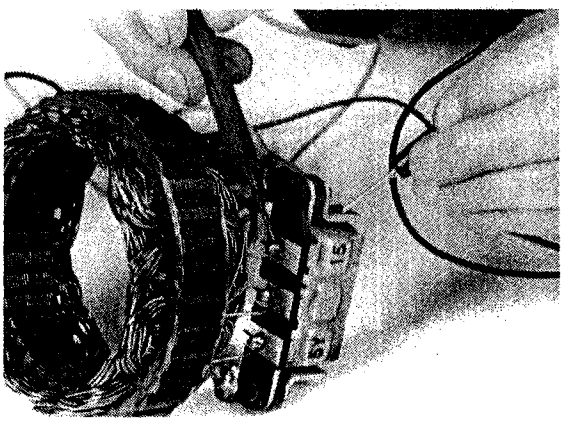
Check for continuity between the positive (+) heat sink and stator coil lead connection terminal with a circuit tester.
If there is continuity in both directions, the diode is short-circuited. Replace the rectifier assembly.



PG123

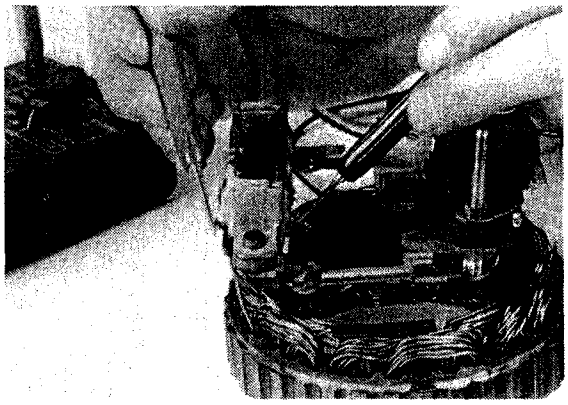
b. Negative Heatsink

Check for continuity between the negative (−) heat sink and stator coil lead connection terminal.
If there is continuity in both directions, the diode is short-circuited. Replace the rectifier assembly.



PG124

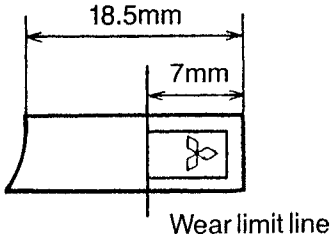
c. Diode Trio
Using a circuit tester, check the three small diodes for continuity in both directions.
If there is either continuity or an open circuit in both directions, the diode is defective.
Replace the rectifier assembly.



PG125

d. Brush and Brush Spring

1. Check the length of the brush.
A brush worn down to the wear limit line should be replaced.
2. Check the brush spring pressure and make sure the brush moves smoothly in the brush holder.

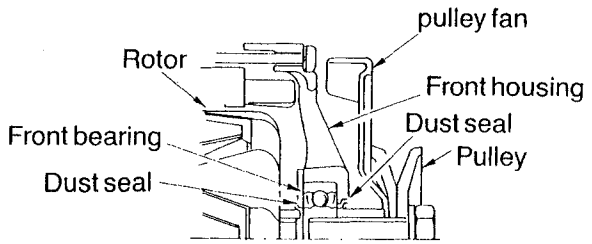


PG126

– Reassembly

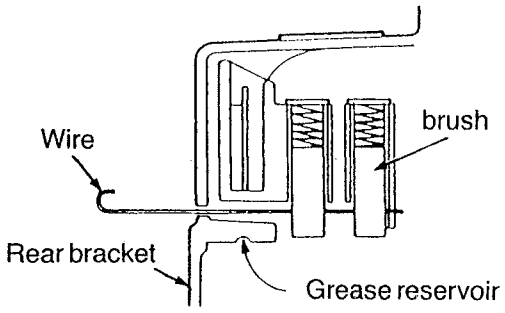
Reverse the disassembly procedure except for the following.

A. Install dust seals before and behind the front bearing.



PG127

B. Installing rotor.
Push brushes into brush holder, insert a wire to hold them in raised position.
Install rotor and remove wire.

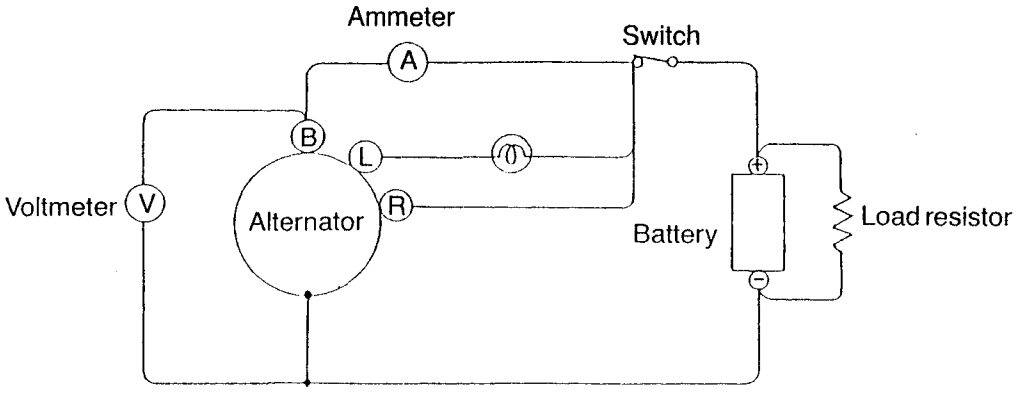


PG128

– Bench Check

To check the alternator on a test bench, proceed as follows.

A. Make connection as shown in the figure, except leave the Load Resistor disconnected.



B. Slowly increase the alternator speed and observe the voltage.

C. If the voltage is uncontrolled with speed and increases above 15V, check the alternator.

D. If voltage is below 15V, connect the load resistor as shown in the figure.

E. Operate the alternator at 2500 r.p.m. and adjust the load resistor as required to obtain maximum output.

F. Measure the output current.
The output must be within the limits shown in the Section on "Service Specifications".
If the output is less than specified value the alternator should be disassembled and checked.

– Precautions

A. Reversed battery connections will damage the alternator and/or wiring.

B. When connecting a booster battery, make certain to connect negative battery terminals together and positive battery terminals together.

C. When a fast charger is used to charge the battery, the equipment battery cables should be disconnected.

D. Grounding of the alternator output terminal will damage the alternator and/or circuit.

E. Do not connect a load of over 1A to the terminal "L".

F. If the alternator is operated with the terminal L and B short-circuited, it may damage the diode trio.

– Service Specifications

Item		Model Name	A001T25087
Nominal output		(V-A)	12-35
Polarity			Negative ground
Weight		(kg)	Approx. 3.4 (7.5lb)
Rotational direction (Viewed from the pulley)			Clockwise
Load characteristics (cold)	Terminal voltage	V	13.5
	Current	(A)	Min. 30
	Revolution number	(rpm)	2500
Brush length	Original	(mm)	18.5 (0.728″)
	Limit	(mm)	7.0 (0.276″)
Brush spring tension	Original	(g)	310-430 (0.683-0.946 lb)
	Limit	(g)	210 (0.462 lb)
Bearing	Rear side		6201ZZ
	Front side		6202ZZ
Slip ring diameter	Original	(mm)	33.0 (1.299″)
	Limit	(mm)	32.4 (1.276″)
Field coil resistance		(Ω/ at 20°C)	3.4
Adjusting voltage		(V) (at 5000 rpm)	14.1-14.7

– Fault Finding

Trouble	Parts	Cause	Remedy
No charging	Wiring, ammeter	Disconnection, short circuit, loosened connection	Correct
	Alternator	Disconnection of coils, earth, short circuit	Replace
		Defective rectifier	Replace
		Disconnection of RF resistor	Replace
	Regulator	Defective regulator	Replace
		Defective terminal connection of alternator and regulator	Correct
Insufficient charging	Wiring	Disconnection, short circuit, loosened connection	Correct
	Alternator	Loosened alternator belt	Correct
		Layer short of rotor coil	Replace
		Layer short of stator coil	Replace
		Defective rectifier	Replace
		Insufficient contact of brush, stained slip ring	Correct
	Regulator	Defective regulator	Replace
		Insufficient contact of alternator and regulator	Correct
Overcharge	Battery	Internal short circuit	Replace
	Regulator	Defective regulator	Replace
Unstable charging current	Wiring	Disconnection or breakage of wire	Replace
	Alternator	Slackened alternator drive belt	Replace
		Short of rotor coil, breakage of wire	Replace
		Shortage of stator coil, breakage of wire	Replace
		Insufficient contact of brush, stained brush and slip ring	Correct
		Broken brush and spring	Replace
		Insufficient contact of terminals	Correct
	Regulator	Defective regulator	Replace
		Insufficient contact to alternator and regulator	Correct
Abnormal noise of alternator	Alternator	Incorrect installation of alternator	Correct
		Defective bearing	Replace
		Rotor core and stator core in contact	Correct
		Defective diode	Replace
		Short of stator coil	Replace

Starter motor

– Specifications

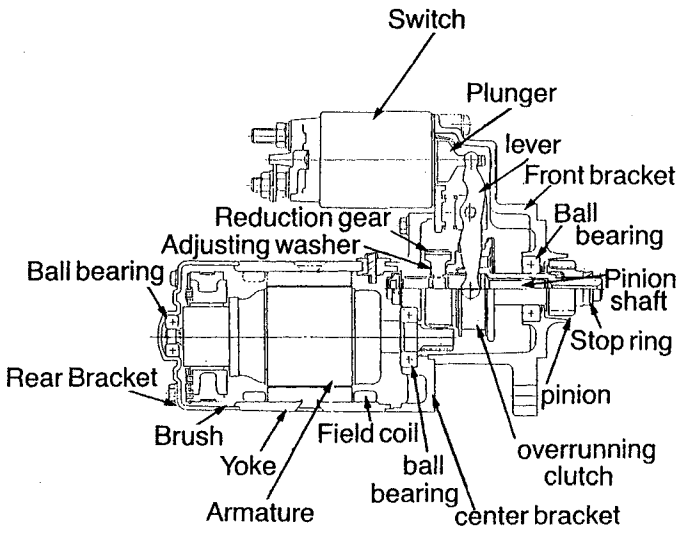
Part code number	185086291 — 185086410 (104-19)
Model name	M002T54085 — M002T54091 (104-19)
Output	2 kw
Rated voltage	12 V
Motor type	Four-pole series wound motor
Engaging system	Magnetic shift
Rotation	Clockwise (Viewed from pinion side)
Weight	Approx. 4.9 kg

– Construction

This starting motor is a four-pole series wound, high speed machine with a solenoid operated roller clutch and a gear reduction. The gear reduction consists of a pair of reduction gears in a front bracket.

The smaller gear is a part of the armature shaft.

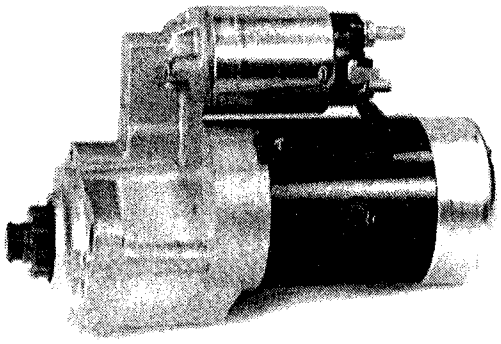
The larger gear which is called reduction gear mounts on the pinion shaft which has a pinion gear at the other end of it. This provides additional torque and greater cranking power without increasing the size of the starting motor.



PG130

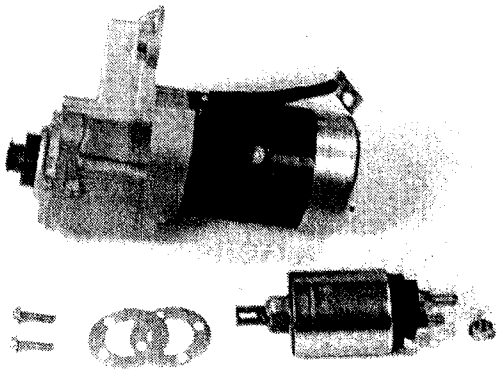
– Disassembly

A. Starting motor before disassembly.



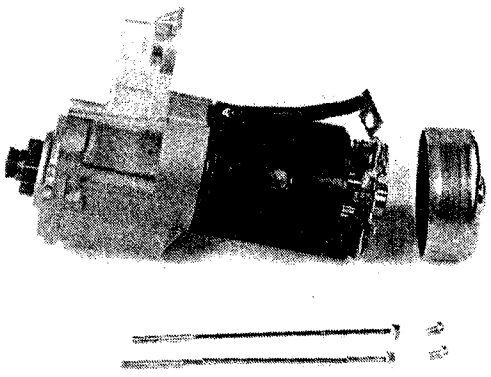
PG131

B. Loosen nut on M terminal of switch, and disconnect copper strap.
Remove two retaining screws and remove switch assembly from front bracket



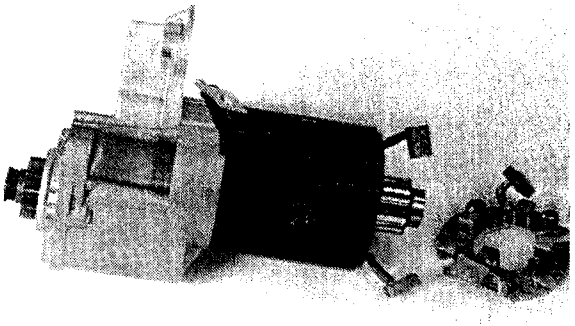
PG132

C. Remove two screws retaining brush holder and two through bolts, and remove rear bracket.



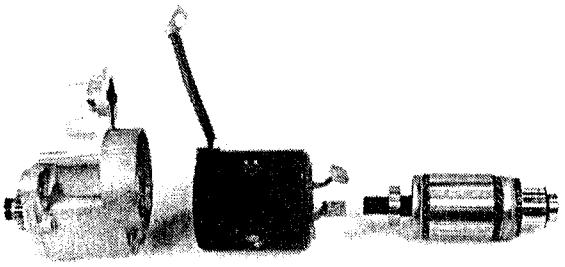
PG133

D. Remove two positive brushes from their holders, and remove brush holder



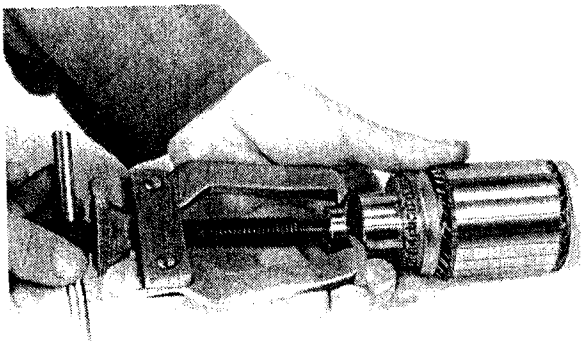
PG134

E. Remove yoke, and pull out armature.



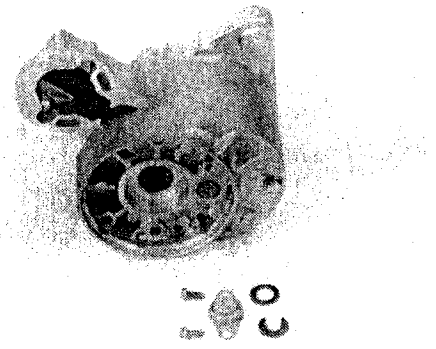
PG135

F. Remove ball bearings fitted to the ends of armature shaft with an ordinary bearing puller.



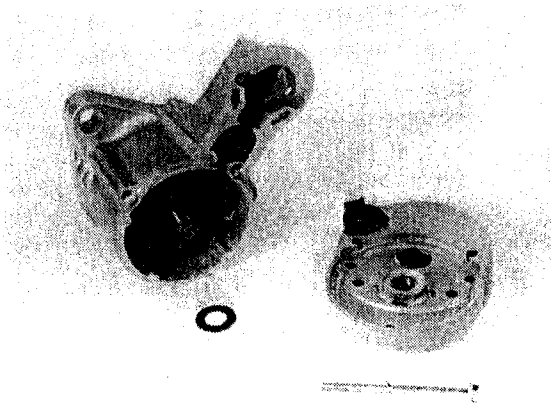
PG136

G. Remove two screws securing cover, and remove the cover, C-shaped washer and washer.



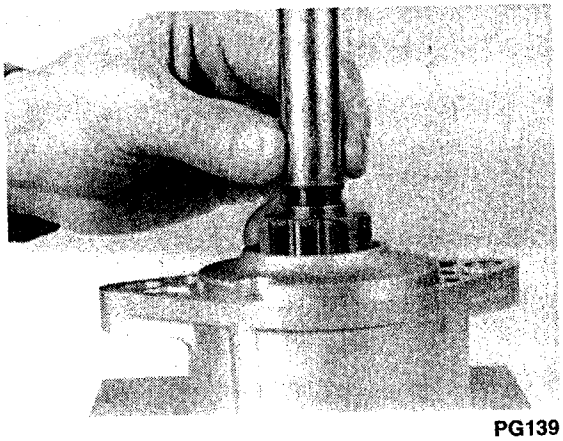
PG137

H. Remove retaining screw, and remove center bracket.
Remove washers (several pieces) for adjusting pinion shaft end play.



PG138

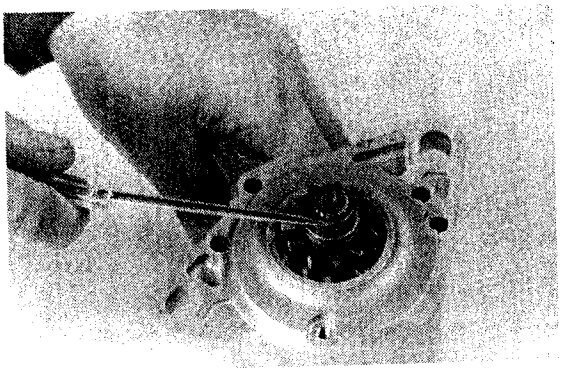
I. Slide a pipe coupling or other metal cylinder of suitable size onto shaft, so end of coupling or cylinder butts against edge of stop ring.
Tap end of coupling with a hammer to expose snap ring.



PG139

J. Remove snap ring from groove in shaft using a nail or stiff wire with sharp end.

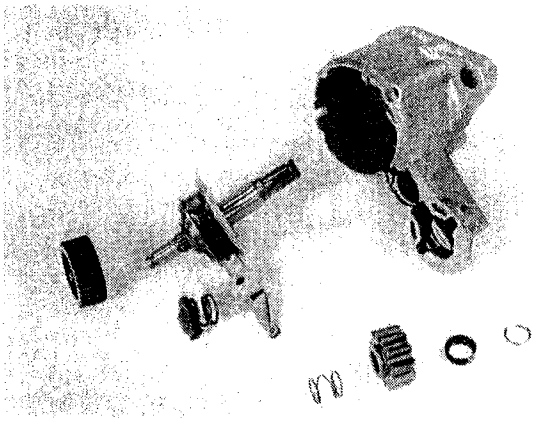
NOTE: If the ring is too badly distorted during removal it may be necessary to use a new one when reassembling pinion.



K. Remove stop ring, pinion and spring. Remove spring holder, spring and lever assembly. Remove reduction gear and pinion shaft assembly from front bracket.

NOTE: Lay lever assembly, spring and spring holder in the order removed so that they can be restored to their original positions.

L. If front bracket ball bearing is defective, replace the front bracket.

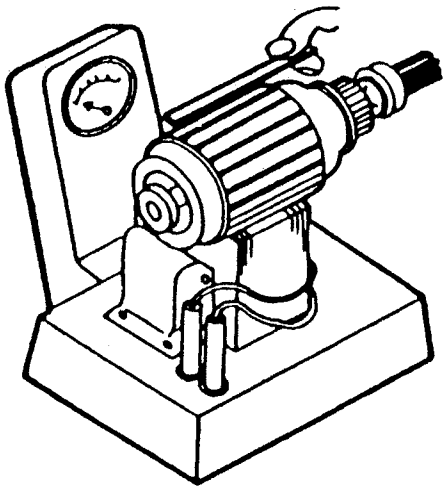


PG141

– Inspection

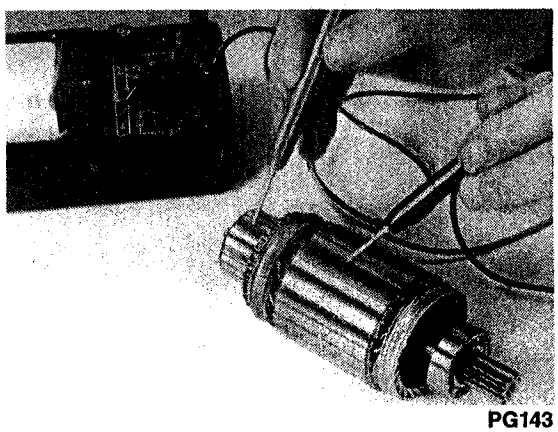
A. Armature

a. Inspect armature coil for short-circuit with a growler.
Replace armature if it is in a faulty condition.



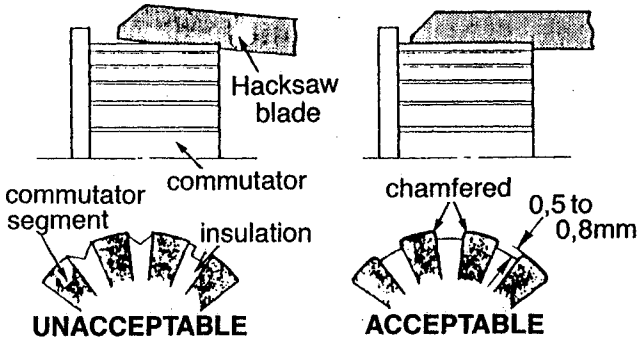
PG142

b. Inspect armature coil for ground with a circuit tester.
Replace armature if there is any continuity between commutator and shaft (or core).



PG143

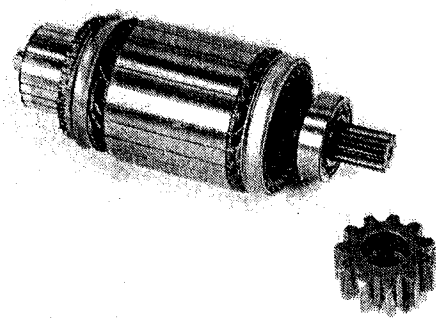
c. Check commutator for runout with a dial gauge and "V" block. If commutator is rough, or more than 0.05mm (.002") out-of-round, turn it down or replace it.
Undercut moulding between segments if the depth is 0.2mm (.01").



PG144

d. Check gear teeth for wear or damage, and replace armature as necessary.

e. Check bearings for any scraping noise, roughness or lubricant leakage, and replace them as necessary.



PG145

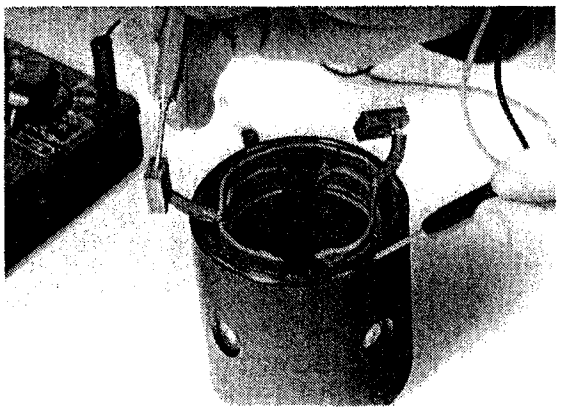
B. Field coil

a. Inspect field coil for open circuit with a circuit tester.
Replace yoke assembly if there is no continuity between two ends of the coil (two brushes).

PG146

b. Inspect field coil for ground with a circuit tester.
If any continuity is noted between connector (or brush) and yoke, check and locate faulty portion of insulation, and repair or replace yoke assembly, depending on the extent of insulation failure.

c. Check field poles and coil for tightness.
Replace yoke assembly if loose or improperly seated coils are detected.



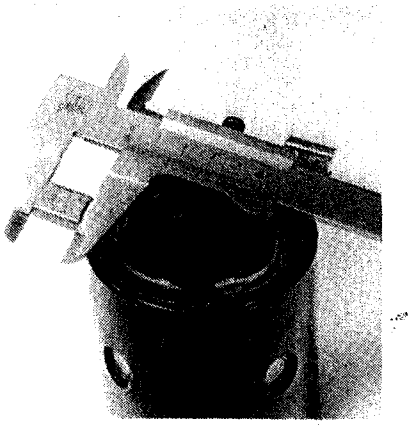
PG147

C. Brushes

a. Clean brushes and adjacent parts, removing carbon particles by wiping with a clean cloth.

b. Check each brush for wear.
Replace brushes if they are worn down to the limit.

Standard Length	18mm (.71")
Service Limit	11mm (.43")

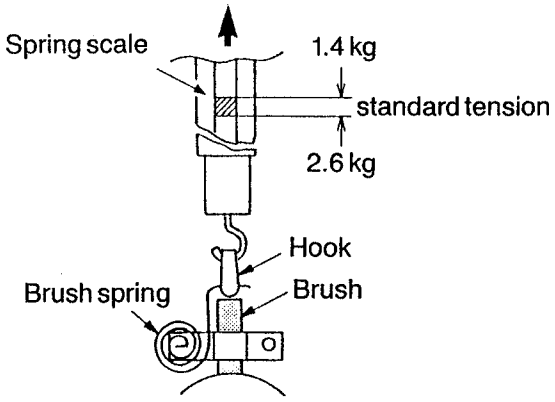


PG148

c. Move each brush in holder to be sure that it is capable of smooth sliding movement.

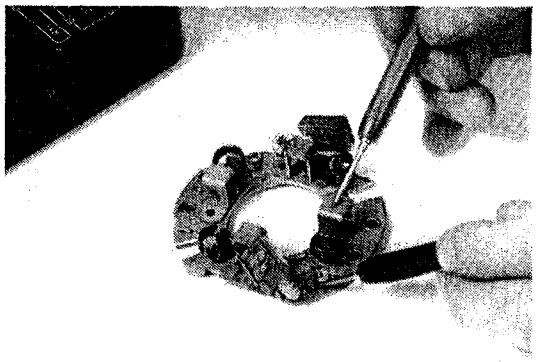
d. Check brush spring tension. Replace the springs if the tension is not within specified limits.

Standard Tension	1.4-2.6kg (3.1-5.7lb)
Service Limit	0.9kg (2lb)



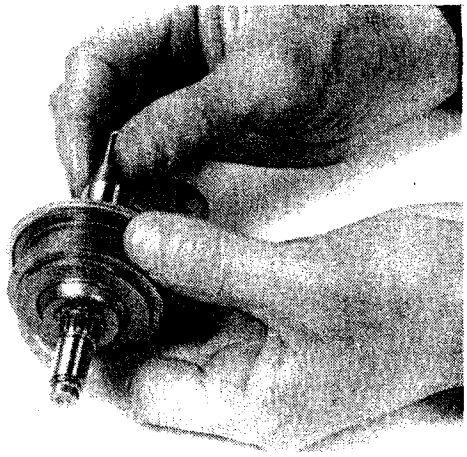
PG149

e. To check brush holder assembly for ground, touch one probe of a circuit tester to holder plate and the other probe to each of insulated holders. Replace brush holder assembly if any continuity is noted.



D. Overrunning clutch
While holding clutch housing, rotate pinion. Pinion should rotate smoothly in one direction (not necessarily easily), but should not rotate in opposite direction. If the clutch does not function properly replace it.

NOTE: Overrunning clutch should not be cleaned with grease dissolving solvents, since these would dissolve the lubricant in the clutch mechanism.

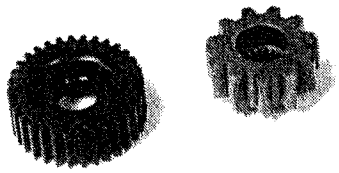


PG151

E. Front bracket
Replace front bracket as an assembly including ball bearing if the bearing fails to rotate smoothly, if it is noisy, or if sleeve bearing is badly worn.

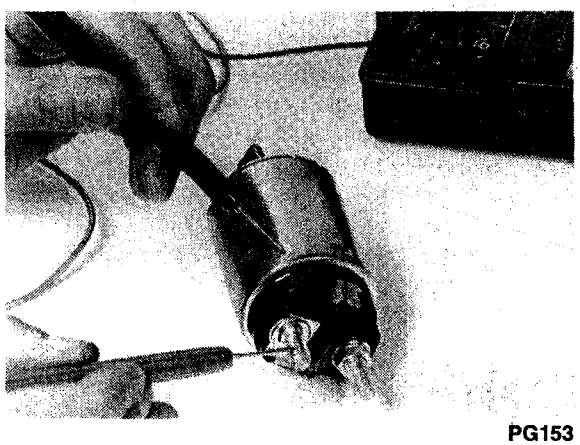
F. Reduction gear
Replace the gear if its teeth are badly worn or damaged.

G. Pinion gear
If pinion gear is worn or burred, replace it.



PG152

H. Switch
Check continuity between M terminal and body (ground).
Replace the switch if no continuity is noted.

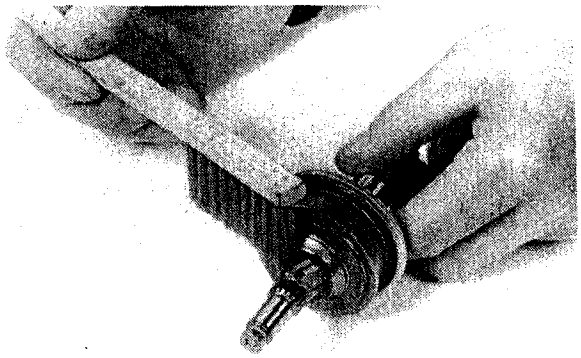


PG153

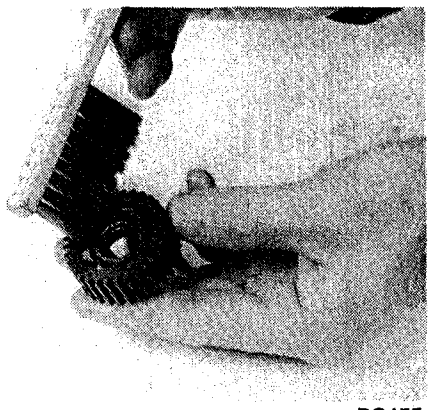
– Reassembly and Adjustment

To reassemble the starter, follow the reverse of disassembling procedure, and observe the following precautions.

A. Apply grease to the following parts during assembly.
   a. Armature shaft gear.
   b. Reduction gear.
   c. Ball bearings (fitted to ends of armature shaft).
   d. C-shaped washer and plain washer on pinion shaft.
   e. Sliding surfaces of sleeve bearings, pinion, lever and plunger.

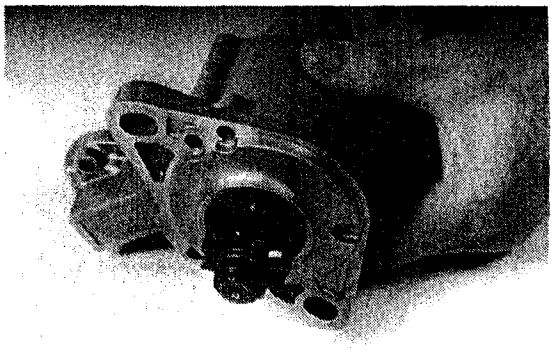


PG154



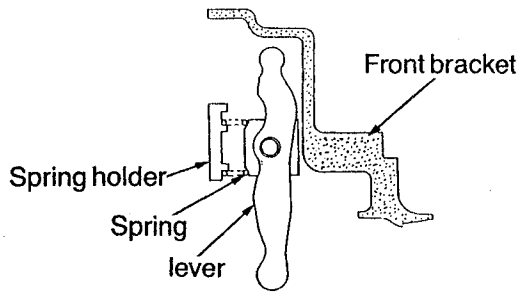
PG155

B. Assembling pinion
Slide spring, pinion and stop ring over pinion shaft with the cupped surface of stop ring facing the end of the shaft. While forcing pinion and stop ring down against front bracket, install snap ring into groove in the shaft.
To force stop ring over snap ring, use an ordinary puller.
While using puller, it may be necessary to tap snap ring with top end of a screwdriver to seat the ring in the stop ring's groove.



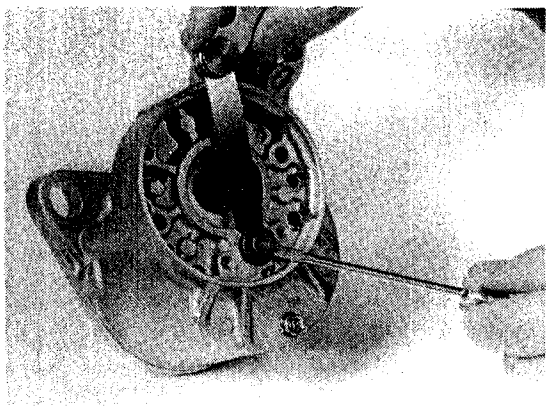
PG156

C. Install lever assembly in the direction as shown in right figure.



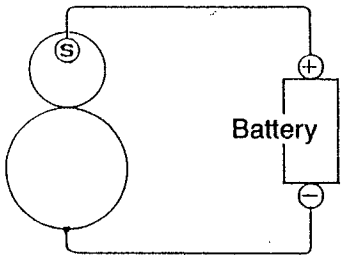
PG157

D. Pinion shaft end play adjustment.
Install plate, washer and C-shaped washer onto the end of pinion shaft. With bolt securing centre bracket tightened, measure end play as shown. Move pinion shaft in the axial direction with a screwdriver to see whether a proper end play is obtained. If the play is out of specification, adjust it by means of adjusting washers.



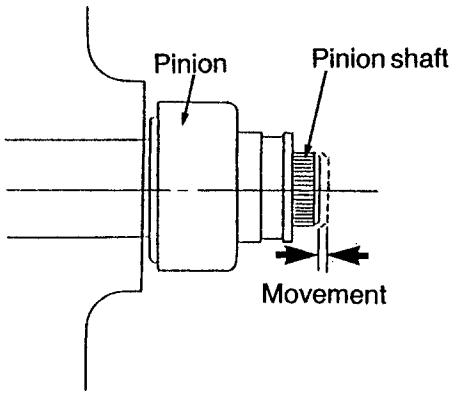
E. Pinion position adjustment
After completing reassembly, check pinion position to be sure that it is between 0.5 and 2.0mm (.020 and .079″). To adjust, proceed as follows.

a. Connect the starter to a battery, as shown. Close switch. This will shift pinion into cranking position.



PG159

b. Push pinion shaft back by hand and measure the amount of pinion shaft movement. The amount corresponds to pinion clearance of current starters. If the amount does not fall within limit, adjust it by adding or removing shims which are located between switch and front bracket.
Adding shims decreases the amount of the movement.



PG160

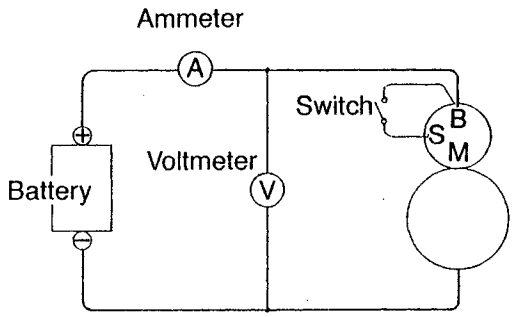
– No-load test

A. After adjusting pinion position, form a test circuit with a voltmeter and an ammeter, as shown in right figure.

NOTE: Use wires as thick as possible and tighten each terminal fully.

B. Close the switch and compare the R.P.M., current and voltage readings with the Service Specifications.

C. If any abnormality is noted, check it according to the Inspection.



PG161

–Service Specifications

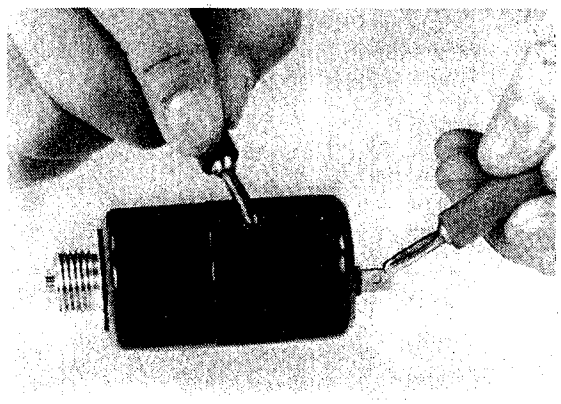
Item			Standard Value or Service Limit
No-load test	Volts	V	11
	Current	A	130 Max.
	Rotating speed	R.P.M.	4000 Min.
Commutator	Outer Dia	mm	32 (1.26″)
	Service Limit	mm	31 (1.22″)
Brush	Length	mm	18 (0.71″)
	Service Limit	mm	11 (0.43″)
Brush spring	Tension	kg	1.4-2.6 (3.1-5.7lb)
	Service Limit	kg	0.9 (2lb)
Pinion shaft end play		mm	0.1-0.5 (0.004-0.020″)
Pinion position (Pinion movement)		mm	0.5-2.0 (0.020-0.079″)

– Trouble shooting

A. Pinion fails to advance when key switch is closed.		
Fault Location	Probable Cause	Remedy
Wiring	Open circuit, battery and switch terminal connections loose, improper insertion, and other defective contact.	(1) Repair and retighten (2) Replace fusible link
Key switch	No current flow due to defective contact.	Correct contacting part or replace.
Starting motor	Sleeve bearing burnt out	Replace or repair
	Lever spring or shift lever broken.	Replace
Magnetic switch	Magnetic switch plunger movement defective or coil open or shorted.	Repair or replace

Stop Solenoid

– Engine stop solenoid is in normal state if plunger is drawn into main body when one terminal is connected to battery + and other terminal to main body



PG166

WIRING DIAGRAMS

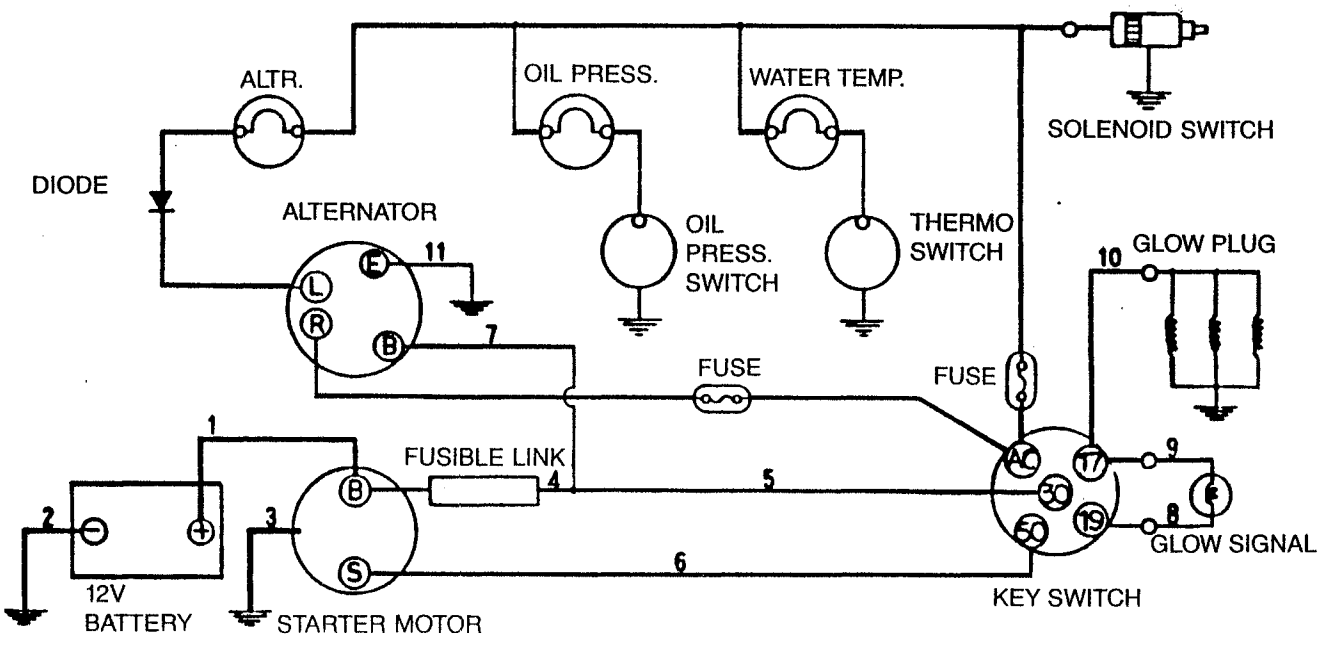
– 103-12, 103-13, 103-15, 104-19

WIRING DIAGRAM MAXIMUM CIRCUIT RESISTANCE

RESISTANCE OF BATTERY CABLES 1, 2 & 3 NOT TO EXCEED 0.0018 OHM

Circuit	Cable No.	Circuit Current	Maximum Circuit Resistance	Maximum Circuit Volt Drop	Rewards
Alternator Charging	4 7,11	 35 Amp	 0.0143 OHM	0.5 Volt	See Glow Plugs Circuit
Starting Motor Solenoid	4 5 6	 15.75 Amp	 0.04 OHM	 0.63 Volt	See Glow Plugs Circuit See Glow Plugs Circuit
Glow Plugs (Via Glow Signal)	4,5,8,9,10	27 Amp 36 Amp	0.0185 OHM 0.0139 OHM	0.5 Volt 0.5 Volt	3 cyl Engines 4 cyl Engines

WIRING DIAGRAM (103-12, 103-13, 103-15, 104-19)



Glow Plug

A sheathed type glow plus is employed and provides excellent starting.

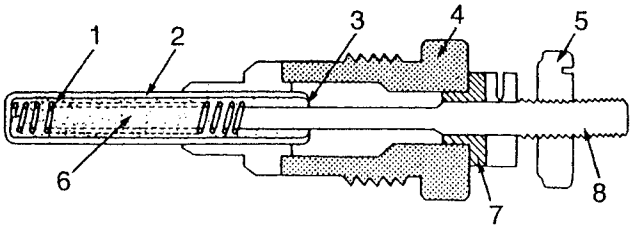
– Specification

Part No. 185366060 IDI MODELS

Rated voltage	Current
10.5V	6.9A

Part No. 185366110 DI MODELS

10.5V	6.9A



1. Heat wire
2. Sheath
3. Asbestos
4. Body
5. Nut
6. Magnesium oxide power
7. Insulation bush
8. Core

Fig 2-124

– Structure

Coiled thin heat wire is placed in the sintered magnesium oxide powder enclosed by stainless sheath. One end of the heat wire is welded to the sheath end and the other end to the central electrode. By setting the starter switch to the position of Heat (H), the heat wire preheats the air in the combustion chamber.

– Troubleshooting

A. Disconnection of the heat wire.
The glow plug operates even when any one of the heat wires is disconnected because it is connected in parallel. However, when disconnected, preheating time of the glow signal is extremely extended.

Check/Remove the connector and check the continuity between each plug terminal and body earth. If continuity is not observed, it shows disconnection. Then replace the heat wire.

B. Short circuit
The glow plug is of a simple structure and short circuit is rarely caused. However, if the central electrode, body, sheath, etc. come in contact, wiring of preheating circuit is burnt during starting.

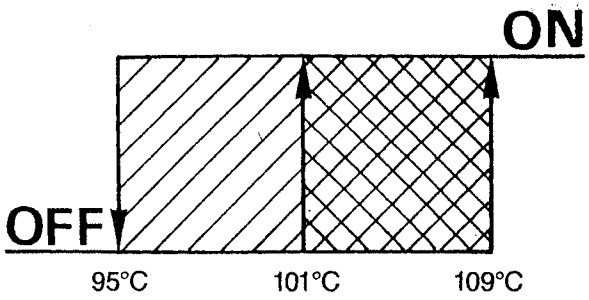
Correction: Remove the connector and measure the resistance of each plug terminal and earth with a tester. The tester reading should be 0.7 ± 0.16Ω

Resistance of 0 indicates short circuit.

Thermoswitch

– Specifications

Part No.	385720101
Type	TB-121A
Operating load	12V-3W
Switching temperature	101 to 109°C (Off to On)
Switching off temperature	95°C and higher



PB123

Oil Pressure Switch

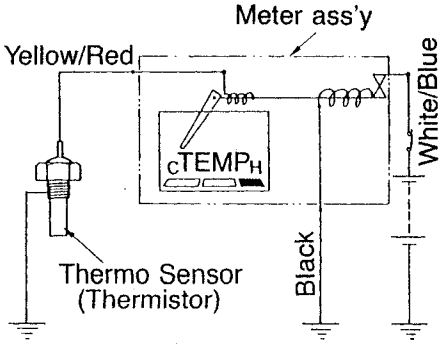
Part No. 185246060
Oil pressure switch operating range:
0.2 to 0.4kg/cm² (2.8-5.7 psi)

A. The oil pressure switch is a warning device to inform low engine lubricating oil pressure. When oil pressure becomes less than specified the warning light is activated.
This pressure switch houses a diaphragm and contact points.

Thermosensor and Gauge

– Specifications

Part No.	385720070
Operating range	50°C to 120°C
Standard resistance (Ohm)	50°C $53.9\pm^{2.5}_{2.0}$ 120°C $16.1\pm^{1.2}_{1.2}$



PG163

E. GAS (WHITE OR BLUE) SMOKE

CAUSE	REMEDY
Excess engine oil	Inspect and correct the level.
Too low viscosity of the engine oil	Inspect and replace the oil to correct one.
Faulty injection timing	Too late: correct.

F. DARK GREY SMOKE

CAUSE	REMEDY
Unsuitable fuel	Inspect and replace to correct grade.
Excess injection	Inspect and adjust (in a service shop).
Faulty function of the engine	Repair in a service shop.
Overloading	Reduce the load.
Clogged air cleaner	Clean.

G. FAULTY CHARGING

CAUSE	REMEDY
Loose fan belt	Correct the tension.
Faulty wiring	Inspect and correct.
Faulty battery	Repair.
Worn out alternator brush	Replace.
Broken fuse	Replace.

H. STARTER MOTOR DOES NOT RUN

CAUSE	REMEDY
Loose or disconnected wiring	Inspect and tighten.
Dropped voltage of the battery	Charge the battery.
Damaged starter motor	Repair in a service shop.
Broken fusible link	Replace.

I. OIL PRESSURE LAMP NOT TURNED ON (KEY SWITCH 'ON' WITH ENGINE NOT STARTED)

CAUSE	REMEDY
Broken lamp bulb	Replace the bulb.
Broken wire between battery to the lamp	Correct it.

J. OIL PRESSURE LAMP NOT TURNED OFF

CAUSE	REMEDY
Lack of engine oil	Supply oil up to the specified level.
Fault in the pressure switch (mano-contact)	Replace the switch.
Oil leakage from the lubricating system	Inspect and retighten.
Clogged oil filter	Replace with new one.
Short-circuit between oil pressure lamp and mano-contact	Repair.

SECTION VII
Trouble Shooting

A. ENGINE DOES NOT START

CAUSE	REMEDY
Faulty key switch and or stop solenoid	Correct the connection and contact.
Insufficient charging or complete discharging of the battery	Charge.
Lack of fuel	Supply fuel.
Air mixed in the fuel system	Bleed the air.
Clogged fuel filter	Replace.
Irregular and faulty fuel supply (Injection pump trouble)	Repair in an authorized service shop.
Glow plug not heated	Breakage of the glow plug: replace.
Improper viscosity of the lubricating oil	Inspect and replace.
Clogged air cleaner	Clean.
No compression	Repair in a service shop.
Broken fusible link	Replace.

B. IRREGULAR RUNNING OF THE ENGINE

CAUSE	REMEDY
Air mixed in the fuel system	Bleed the air.
Uneven fuel injection (Faulty fuel injection pump)	Repair at authorized shop.
Clogged fuel filter	Replace.
Defective governor	Check and correct.
Engine itself defective	Repair in a service shop.

C. ENGINE STOPS DURING OPERATION

CAUSE	REMEDY
Lack of fuel in the fuel tank	Supply fuel and bleed air.
Clogged fuel filter	Replace.
Air mixed in the fuel system	Bleed the air.
Faulty function of the engine	Repair in a service shop.

D. OVERHEAT OF THE ENGINE

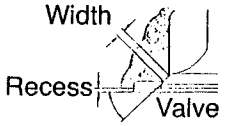
CAUSE	REMEDY
Lack of cooling water	Supply water. Inspect leakage and correct.
Loose or slipping fan belt	Remove oil, dust, etc. and tighten.
Damaged fan belt	Replace.
Clogged radiator	Flush the radiator.
Clogged radiator fin	Clean.
Dust or scale clogged in the cooling water passage	Flush the system.
Faulty function of the thermostat	Inspect or replace thermostat.
Lack of lubricating oil	Add oil.
Overloading	Decrease the load.

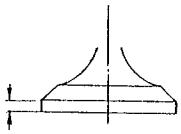
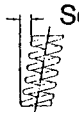
Inspection Items			Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
PISTON PIN							
Pin outside diameter			28 (1.1024")	27.996-28.000 (1.1022-1.1024")		27.98 (1.1016")	
Rod small end bush to pin clearance				0.01-0.025 (.0004-.001")		0.1 (.004")	Oil clearance
PISTON RING							
Piston ring groove to ring clearance							
		1st ring		0.07-0.11 (.0028-.0043")		0.25 (.01")	
		2nd ring		0.04-0.08 (.0015-.0031")			
		Oil ring		0.02-0.06 (.0008-.0023")		0.15 (.006")	
Ring width							
		1st ring	2 (.08")				
		2nd ring	1.5 (.06")				Oversize (0.5, 1.0) (.020/.040")
		Oil ring	4 (.16")				
Piston ring end gap							
		1st ring		0.20-0.35 (.008-.014")		1.0 (.04")	
		2nd ring		0.20-0.40 (.008-.016")			
		Oil ring					

SECTION VIII
Service Standards
103-12,103-13,103-15 IDI

Maintenance Standards Table

Note: Numerical values without units indicated in inspection item shall be in mm units.

Inspection Items	Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
CYLINDER HEAD					
Compression pressure of cylinder kg/cm² (psi)		more than 30 (426.6)	25 (355.5)		Engine 200rpm
Cylinder head tightening torque (kgf-m) (lb/ft)		9.0-9.5 (65.1-68.7)			
Cylinder head mounting surface warpage		0.05 max (.002″)	0.12 (.005″)		
Valve seat (intake/exhaust)  PB125		0.85-1.15 (.034″-.045″)	1.8 (.07″)		Valve seat 45°
Valve seat width (intake)		1.66-1.87 (.065-.074″)	2.5 (.098″)		
Valve seat width (exhaust)		1.66-1.73 (.065-.068″)	2.5 (.098″)		
CYLINDER BLOCK					
Type	Dry type (Unit type)				
Bore (103-12)	82 (3.228″)	82.000-82.019 (3.228-3.229″)	82.2 (3.236″)	83.2 (3.276″)	Oversize (.5, 1.0) (.020/.040″)
Bore (103-13, 103-15)	84 (3.307″)	84.000-84.019 (3.307-3.308″)	84.2 (3.315″)	85.2 (3.354″)	Oversize (.5, 1.0) (.20/.040″)
Cylinder block type surface warpage		0.05 max (.002″)	0.12 (.005″)		
PISTON					
Skirt long-diameter size (103-12)	81.955 (3.227″)	81.948-81.963 (3.2263-3.2269″)		81.7 (3.217″)	Oversize (.5, 1.0) (.020/.040″)
Skirt long-diameter size (103-13, 103-15)	83.995 (3.3053″)	83.948-83.963 (3.3050-3.3056″)		83.7 (3.295″)	Oversize (.5, 1.0) (.020/.040″
Clearance with cylinder		0.038-0.072 (.0015-.0028″)		0.3 (.012″)	At 20°C
Piston pin hole inside diameter (103-12.103-13)	25 (.98″)	24.999-25.003 (.9842-.9843″)			
Piston pin hole inside diameter (103-15)	28 (1.102″)	27.999-28.003 (1.1023-1.1025″)			
Piston pin hole to pin clearance		−0.001-+0.007 (.00004-.0003″)		0.02 (.0008″)	

Inspection Items	Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
CAMSHAFT					
 Height PB126	34.09 (1.342″)	34.065-34.12 (1.341-1.343″)		33.7 (1.327″)	Intake and exhaust cams
Camshaft deflection		0.03 max. (.0012″)	0.1 max. (.004″)		
Cam gear backlash		0.08 (.003″)		0.3 (.012″)	
VALVE					
Intake valve, valve stem	6.97 (.274″)	6.955-6.97 (.273-.274″)		6.89 (.271″)	
Exhaust valve, valve stem	6.95 (.273″)	6.94-6.95 (.2732-.2736″)		6.84 (.2693″)	
Valve stem to valve guide clearance					
Intake		0.03-0.06 (.0012-.0024″)		0.2 (.008″)	
Exhaust		0.05-0.075 (.002-.003″)		0.25 (.01″)	
Valve clearance (intake & exhaust)		0.2 (.008″)	0.5 (.02″)		Cold
Valve thickness  Thickness PB127	1.0 (.039″)	0.925-1.075 (.0364-.0423″)		0.5 (.02″)	
Valve spring					
Spring force (at 30.4mm) (kg) lb.		8.1 (17.86)		7 (15.43)	
Free height		35 (1.378″)		33.5 (1.319″)	
Squareness  Squareness PB128		1.2 max. (.047″)		2.0 (.079″)	
Intake valve					
103-12 / 103-13 Open-Before T.D.C.	10°				
103-12 / 103-13 Close-After B.D.C.	46°				
103-15 Open-Before T.D.C.	16°				
103-15 Close-After B.D.C.	40°				
Exhaust valve					
103-12 / 103-13 Open-Before B.D.C.	40°				
103-12 / 103-13 Close-After T.D.C.	16°				
103-15 Open-Before B.D.C.	46°				
103-15 Close-after T.D.C.	10°				
PUSH ROD					
Overall length					
103-12 / 103-13	174.3 (6.862″)	174.1-174.5 (6.854-6.870″)			
103-15	196 (7.717″)	195.8-196.2 (7.709-7.724″)			
Outside diameter	6.3 (.248″)	6.2-6.4 (.244-.252″)			

Inspection Items		Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
CONNECTING ROD						
Large end to small end hole twist (per 100mm)			0.08 mx. (.003″)	0.2 max. (.008″		
Large end to small end hole parallelism (per 100mm)			0.05 max. (.002″)	0.15 max. (.006″)		
Con-rod to crankpin axial play			0.1-0.3 (.004-.01″)		0.7 max. (.028″)	
Con-rod bearing to crankpin clearance			0.035-0.083 (.0014-.0033″)		0.2 (.008″)	Oil clearance
Large end bearing tightening reserve						
	103-12 103-13	23.506 (.925″)	0.00-0.04 (0.00-.0016″)			Crush height
	103-15	27.507 (1.083″)	0.01-0.05 (.0004-.002″)			
Con-rod bearing (bore x width)						
	103-12 103-13	44 x 19.8 1.732 x .779″				
	103-15	52 x 19.8 2.047 x .779″				
Con-rod tightening torque (kgf-m) lb/ft			5.0-5.5 (36.2-39.8)			
Weight difference after piston assembly (g) lb			10 max (.022)			
Small end bushing tightening reserve (crush height)						
	103-12 103-13		0.036-0.095 (.0014-.0037″)			Crush height
	103-15		0.035-0.081 (.0014-.0032″)			
CRANKSHAFT						
Journal diameter						
	103-12 103-13	58 (.283″)	57.957-57.97 (2.281-2.282″)		57.4 (2.26″)	Under size (0.25, 0.5) (.010 .020″)
	103-15	68 (2.677″)	67.957-67.970 (2.6754-2.6759″)		67.4 (2.654″)	
Crankpin diameter						
	103-12 103-13	44 (1.732″)	43.964-43.975 (1.730-1.731″)		43.4 (1.709″)	Under size (0.25, 0.5) (.010/.020″)
	103-15	52 (2.047″)	51.964-51.975 (2.045-2.046″)		51.4 (2.024″)	
Journal and pin finish accuracy		1.6Z (.064″)				
Crankshaft deflection			0.03 max. (.0012″)	0.06 max. (.0024″)		
Crankshaft axial play			0.1-0.4 (.0039-.0157″)		0.7 (.027″)	
Thrust washer thickness		3 (.118″)	2.95-3 (.116-.118″)		2.8 (.11″)	
Bush (journal brg.) I.D. x O.D.						
	103-12 103-13	58 x 62 2.283x2.441″				Under size (0.25, 0.5″) (.010/.020″)
	103-15	68 x 72 2.677x2.835″				
Bush (journal brg.) interference			0.065-0.114 (.0026-.0045″			
Crank journal to bush clearance			0.044-0.116 (.0017-.0046″)		0.2 (.008″)	Oil clearance
Centre bearing (I.D. x O.D.)						
	103-12 103-13	58 x 62 2.283x2.441″				Under size (0.25, 0.5) (.010/.020″)
	103-15	68 x 72 2.677x2.835″				
Crank journal to center brg. clearance			0.044-0.102 (.0017-.004″)		0.2 (.008″)	Oil clearance
Centre bearing interference						
	103-12 103-13	31.010 (1.221″)	0.00-0.04 (0.00-.0016″)			
	103-15	36.010 (1.418″)				

Inspection Items	Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
STARTER MOTOR					
Type	MITSUBISHI M002T54085 (12V-2kw Reduction) (Part No. 185086291)				
Pinion gear No. teeth	9 (.354″)				
Pinion gear shift system		Magnetic shift system			
Commutator diameter wear	32 (1.26″)			31 (1.220″)	
Commutator diameter eccentric wear		0.03 (.0012″)		0.2 (.0008″)	
Armature shaft bending			0.05 (.002″)		
Brush length	18 (.709″)			11 (.433″)	
Brush spring pressure (kg) (lb)	1.4-2.6 (3.09-5.73)			0.9 (1.98″)	
ALTERNATOR					
Type	MITSUBISHI A001T25087 (Part No. 185046200)				12V-35A
Rotor shaft bending			0.07 (.0028″)		
Slip Rings					
Diameter	33 (1.299″)			32.4 (1.276″)	
Diameter eccentric wear			0.05 (.002″)	0.3 (.012″)	
Surface condition			If dirty or damaged correct with emery cloth.		
Brush length	18.5 (.728″)			7 (.276″)	
Brush spring pressure (g) (lb)	370 (.816″)	310-430 (.683-.948″)		210 (.0463″)	

Inspection Items	Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
ROCKER ARM					
Rocker arm shaft wear	11.66 (0.459″)	11.65-11.67 (.4587-.4594″)		11.57 (.456″)	
Rocker arm to shaft clearance		0.032-0.068 (.0013-.0027″)		0.2 (.008″)	Oil clearance
OIL PUMP					
Oil pressure switch actuating pressure (kg/cm^2) (psi)	0.3 (4.266)	0.2-0.4 (2.844-5.688)			
Relief valve opening pressure (kg/cm^2) (psi)		2.5-3.5 (35.55-49.77)			
Tip clearance (rotor to vane gap)		0.01-0.15 (.0004-.006″)		0.25 (.01″)	
Axial clearance (rotor to cover)		0.1-0.15 (.004-.006)		0.2 (.008″)	
INJECTION PUMP					
Type	104294-3120 (Part No. 131017400)				Diesel KiKi
Pump plunger diameter	5.5 (.216″)				
Pump plunger stroke	7 (.276″)				
Injection timing					
Before top dead center (BTDC)		22°-23°			
Piston displacement (mm)					
103-12 103-13		3.780-4.124 (.149-.162″)			
103-15		4.267-4.655 (.168-.183″)			
INJECTION NOZZLE					
Type	NP-DN4PDN117 105148-1170 (Part No 131406360)				Diesel KiKi
Injection pressure (kg/cm^2) (psi)	150 (2133)	155-165 (2204.1-2346.3)	130 (1848.6)		
Injection angle	4°				
COOLING					
Cooling system	Water cooled forced circulation				
Thermostat opening temp. (°C)	71	(69-73)			
Thermostat full open temp. (°C)	82				
V belt (fan) slack (1kg at center)		5 (.197″)			Size FM 36.5

Inspection Items		Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
PISTON PIN						
Pin outside diameter		28 (1.1024″)	27.996-28.0 (1.1022-1.1024″)		27.98 (1.1016″)	
Rod small end bush to pin clearance			0.010-0.025 (.0004-.0098″)		0.08 (.0031″)	Oil clearance
PISTON RING						
Piston ring groove to ring clearance						
	1st ring		0.07-0.11 (.0028-.0043″)		0.25max. (.0098″)	
	2nd ring		0.04-0.08 (.0016-.0031″)			
	Oil ring		0.02-0.06 (.0008-.0024″)		0.15 max. (.006″)	
Ring width						
	1st ring	3.5 (.1378″)	3.4-3.6 (.1339-.1417″)			
	2nd ring	3.6 (.1417″)	3.5-3.7 (.1378-.1457″)			
	Oil ring	2.5 (.0984″)	2.3-2.7 (.0906-.1063″)			
Piston ring end gap						
	1st ring		0.2-0.35 (.0079-.0138″)		1.0 (.0394″)	
	2nd ring		0.2-0.4 (.0079-.0157″)			
	Oil ring		0.2-0.4 (.0079-.0157″)			

Inspection Items	Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
CONNECTING ROD					
Twist between small and large end holes (per 100mm)		0.08 max. (.0031″)		0.2 (.0079″)	
Straightness at 100mm between small and large end hole		0.05 max. (.0020″)		0.15 (.0059″)	
Front-to-rear clearance between connecting rod and crank pin		0.1-0.3 (.004-.012″)		0.7 (.0276″)	
Connecting rod bearing-to-crank pin clearance		0.035-0.085 (.0014-.0033″)		0.2 (.0079″)	Oil clearance
Crush height of large end bearing		27.517-27.557 (1.0833-1.0849″)			
Connecting rod bearing (inner diameter x width)	55 x 19.8 (2.1654 x 0.779″)				
Connecting rod bolt torque kgf.m (lb/ft)		5.0-5.5 (36.2-39.8″)			
Weight difference with piston assembly g (lb)		less than 10 (·022)			

SECTION VIII
Service Standards
103-15 DI

Maintenance Standards Table

Note: Numerical values without units indicated in inspection item shall be in mm units.

Inspection Items	Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
CYLINDER HEAD					
Compression pressure of cylinder kg/cm² (psi)		more than 30 (426.6)	25 (355.5)		Engine 200rpm
Cylinder head tightening torque (kgf-m) (lb/ft)		9.0-9.5 (65.1-68.7)			
Cylinder head mounting surface warpage		0.05 max (.002″)	0.12 (.005″)		
Valve seat (intake/exhaust)		0.75-0.85 (.030″-.033″)	1.6 (.063″)		Valve seat 45°
Valve seat width (intake)		1.95-2.16 (.077-.085″)	2.5 (.098″)		
Valve seat width (exhaust)		1.93-2.13 (.076-.084″)	2.5 (.098″)		
CYLINDER BLOCK					
Type	Dry type (Unit type)				
Bore	84 (3.307″)	84.000-84.019 (3.307-3.308″)	84.2 (3.315″)	85.2 (3.354″)	Oversize (.5, 1.0) (.20/.040″)
Cylinder block type surface warpage		0.05 max (.002″)	0.12 (.005″)		
PISTON					
Skirt long-diameter size		83.943-83.958 (3.3048-3.3054″)		83.7 (3.295″)	Oversize (.5, 1.0) (.020/.040″)
Clearance with cylinder		0.042-0.076 (.0017-.003″)		0.25 (.01″)	At 20°C
Piston pin hole inside diameter	28 (1.102″)	27.999-28.003 (1.1023-1.1025″)			
Piston pin hole to pin clearance		−0.001-+0.007 (.00004-.0003″)		0.02 (.0008″)	

Inspection Items		Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
CAMSHAFT						
			34.485-34.54 (1.3577-1.3598″)		34.1 (1.3425″)	Intake and exhaust cams
Camshaft deflection			0.03 max. (.0012″)	0.1 max. (.004″)		
Cam gear backlash			0.08 (.003″)		0.3 (.012″)	
VALVE						
Intake valve, valve stem		6.97 (.274″)	6.955-6.97 (.273-.274″)		6.89 (.271″)	
Exhaust valve, valve stem		6.95 (.273″)	6.94-6.95 (.2732-.2736″)		6.84 (.2693″)	
Valve stem to valve guide clearance						
	Intake		0.03-0.06 (.0012-.0024″)		0.2 (.008″)	
	Exhaust		0.05-0.075 (.002-.003″)		0.25 (.01″)	
Valve clearance (intake & exhaust)			0.2 (.008″)	0.5 (.02″)		Cold
Valve thickness		1.0 (.039″)	0.925-1.075 (.0364-.0423″)		0.5 (.02″)	
Valve spring						
	Spring force (at 30.4mm) (kg) lb.		8.1 (17.86)		7 (15.43)	
	Free height		35 (1.378″)		33.5 (1.319″)	
	Squareness		1.2 max. (.047″)		2.0 (.079″)	
Intake valve						
	Open-Before T.D.C.	13°				
	Close-After B.D.C.	43°				
Exhaust valve						
	Open-Before B.D.C.	43°				
	Close-after T.D.C.	13°				
PUSH ROD						
Overall length						
			205.1-205.9 (8.075-8.106″)			
Outside diameter		6.3 (.248″)	6.2-6.4 (.244-.252″)			

Inspection Items	Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
CONNECTING ROD					
Large end to small end hole twist (per 100mm) Large end to small end hole parallelism (per 100mm)		0.08 mx. (.003") 0.05 max. (.002")	0.2 max. (.008") 0.15 max. (.006")		
Con-rod to crankpin axial play		0.1-0.3 (.004-.01")		0.7 max. (.028")	
Con-rod bearing to crankpin clearance		0.035-0.083 (.0014-.0033")		0.2 (.008")	Oil clearance
Large end bearing tightening reserve					
	27.507 (1.083")	0.01-0.05 (.0004-.002")			Crush height
Con-rod bearing (bore x width)					
	52 x 19.8 2.047 x .779"				
Con-rod tightening torque (kgf-m) lb/ft		5.0-5.5 (36.2-39.8)			
Weight difference after piston assembly (g) lb		10 max (.022)			
Small end bushing tightening reserve (crush height)					
		0.035-0.081 (.0014-.0032")			Crush height
CRANKSHAFT					
Journal diameter					
	68 (2.677")	67.957-67.970 (2.6754-2.6759")		67.4 (2.654")	Under size (0.25, 0.5) (.010 .020")
Crankpin diameter					
	52 (2.047")	51.964-51.975 (2.045-2.046")		51.4 (2.024")	Under size (0.25, 0.5) (.010/.020")
Journal and pin finish accuracy	1.6Z (.064")				
Crankshaft deflection		0.03 max. (.0012")	0.06 max. (.0024")		
Crankshaft axial play		0.1-0.4 (.0039-.0157")		0.7 (.027")	
Thrust washer thickness	3 (.118")	2.95-3 (.116-.118")		2.8 (.11")	
Bush (journal brg.) I.D. x O.D.					
	68 x 72 2.677x2.835"				(0.25, 0.5") (.010/.020")
Bush (journal brg.) interference		0.065-0.114 (.0026-.0045"			
Crank journal to bush clearance		0.044-0.116 (.0017-.0046")		0.2 (.008")	Oil clearance
Centre bearing (I.D. x O.D.)					
	68 x 72 2.677x2.835"				Under size (0.25, 0.5) (0.020")
Crank journal to center brg. clearance		0.044-0.102 (.0017-.004")		0.2 (.008")	Oil clearance
Centre bearing interference					
	36.010 (1.418")	0.00-0.04 (0.00-.0016")			

Inspection Items	Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
STARTER MOTOR					
Type		MITSUBISHI M002T54085 (12V-2kw Reduction)			
Pinion gear No. teeth	9 (.354″)				
Pinion gear shift system		Magnetic shift system			
Commutator diameter wear	32 (1.26″)			31 (1.220″)	
Commutator diameter eccentric wear		0.03 (.0012″)		0.2 (.0008″)	
Armature shaft bending			0.05 (.002″)		
Brush length	18 (.709″)			11 (.433″)	
Brush spring pressure (kg) (lb)	1.4-2.6 (3.09-5.73)			0.9 (1.98″)	
ALTERNATOR					
Type		MITSUBISHI A001T25087			12V-35A
Rotor shaft bending			0.07 (.0028″)		
Slip Rings					
Diameter	33 (1.299″)			32.4 (1.276″)	
Diameter eccentric wear			0.05 (.002″)	0.3 (.012″)	
Surface condition			If dirty or damaged correct with emery cloth.		
Brush length	18.5 (.728″)			7 (.276″)	
Brush spring pressure (g) (lb)	370 (.816″)	310-430 (.683-.948″)		210 (.0463″)	

Inspection Items	Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
ROCKER ARM					
Rocker arm shaft wear		14.95-14.97 (.5886-.5894")		14.87 (.5854")	
Rocker arm to shaft clearance		0.032-0.093 (.0013-.0037")		0.2 (.008")	Oil clearance
OIL PUMP					
Oil pressure switch actuating pressure (kg/cm^2) (psi)	0.3 (4.266)	0.2-0.4 (2.844-5.688)			
Relief valve opening pressure (kg/cm^2) (psi)	3.2 (45.5)	2.5-3.5 (35.55-49.77)			
Tip clearance (rotor to vane gap)		0.01-0.15 (.0004-.006")		0.25 (.01")	
Axial clearance (rotor to cover)		0.1-0.15 (.004-.006)		0.2 (.008")	
INJECTION PUMP					
Type	104294-3120 (Part No. 131017470)				Diesel KiKi
Pump plunger diameter	6.5 (.256")				
Pump plunger stroke	7 (.276")				
Injection timing					
Before top dead center (BTDC)	18°	18°-20°			
Piston displacement (mm)					
	2.875 (.1132")	2.875-3.539 (.1132-.1393")			
INJECTION NOZZLE					
Type	105118-4560 (Part No. 131406370)				Diesel KiKi DI
Injection pressure (kg/cm^2) (psi)	210 (2987)	215-225 (3057-3199)			
Injection angle	4°				
COOLING					
Cooling system	Water cooled forced circulation				
Thermostat opening temp. (°C)	71	(69-73)			
Thermostat full open temp. (°C)	82				
V belt (fan) slack (1kg at center)		5 (.197")			Size FM 36.5

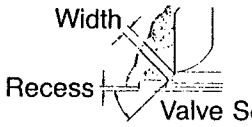
Inspection Items		Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
PISTON PIN						
Pin outside diameter		28 (1.1024")	27.996-28.0 (1.1022-1.1024")		27.98 (1.1016")	
Rod small end bush to pin clearance			0.010-0.025 (.0004-.0098")		0.08 (.0031")	Oil clearance
PISTON RING						
Piston ring groove to ring clearance						
	1st ring		0.07-0.11 (.0028-.0043")		0.25max. (.0098")	
	2nd ring		0.04-0.08 (.0016-.0031")			
	Oil ring		0.02-0.06 (.0008-.0024")		0.15 max. (.006")	
Ring width						
	1st ring	3.5 (.1378")	3.4-3.6 (.1339-.1417")			
	2nd ring	3.6 (.1417")	3.5-3.7 (.1378-.1457")			
	Oil ring	2.5 (.0984")	2.3-2.7 (.0906-.1063")			
Piston ring end gap						
	1st ring		0.2-0.35 (.0079-.0138")		1.0 (.0394")	
	2nd ring		0.2-0.4 (.0079-.0157")			
	Oil ring		0.2-0.4 (.0079-.0157")			

Inspection Items	Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
CONNECTING ROD					
Twist between small and large end holes (per 100mm)		0.08 max. (.0031")		0.2 (.0079")	
Straightness at 100mm between small and large end hole		0.05 max. (.0020")		0.15 (.0059")	
Front-to-rear clearance between connecting rod and crank pin		0.1-0.3 (.004-.012")		0.7 (.0276")	
Connecting rod bearing-to-crank pin clearance		0.035-0.085 (.0014-.0033")		0.2 (.0079")	Oil clearance
Crush height of large end bearing		27.517-27.557 (1.0833-1.0849")			
Connecting rod bearing (inner diameter x width)	55 x 19.8 (2.1654 x 0.779")				
Connecting rod bolt torque kgf.m (lb/ft)		5.0-5.5 (36.2-39.8")			
Weight difference with piston assembly g (lb)		less than 10 (.022)			

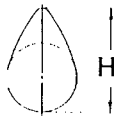
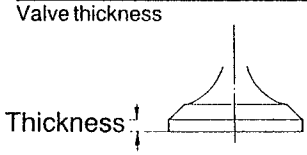
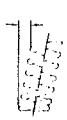
Service Standards
104-19 IDI and DI (KF/KK)

Maintenance Standards Table

Note: Numerical values without units indicated in inspection item shall be in mm units.

Inspection Items	Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
CYLINDER HEAD					
Compression pressure of cylinder kg/cm² (psi) KF,KK		more than 30 (426.6)	Less than 25 (355.5)		
Tightening torque of cylinder head (kgf.m) (lb/ft)		9.0-9.5 (65.1-68.7)			
Distortion of face of cylinder head		0.05 max (.002″)	0.12 (.0047″)		
Valve seat depth (Both intake and exhaust)  PB125		0.65-0.95 (.026-.037″)	1.6 (.063″)		Valve seat angle 45°
Valve seat width (intake)		1.5-2.0 (.06-.08″)	2.5 (.1″)		
Valve seat width (exhaust)		1.94-2.16 (.076-.085″)	2.5 (.1″)		
CYLINDER BLOCK					
Type		Dry type (Unit type)			
Bore	84 (3.307″)	84-84.019 (3.307-3.308″)	84.2 (3.315″)	85.2 (3.354″)	Oversize 0.5, 1.0 (.02 .04″)
Cylinder block type surface warpage		0.05 max (.002″)	0.12 (.0047″)		
PISTON					
Skirt long-diameter size (KF)	84 (3.307″)	83.948-83.963 (3.3050-3.3056″)		83.7 (3.295″)	Oversize 0.5, 1.0 (.02/.04″)
Skirt long-diameter size (KK)	84 (3.307″)	83.943-83.958 (3.3048-3.3054″)		83.7 (3.295″)	
Clearance with cylinder (KF)		0.038-0.072 (.0015-.0028″)		0.25 (.01″)	20°C
Clearance with cylinder (KK)		0.042-0.076 (.0017-.003″)		0.25 (.01″)	
Piston pin hole inside diameter	28 (1.1024″)	27.999-28.003 (1.1023-1.1025″)			
Piston pin hole to pin clearance		−0.001-+0.007 (−.00004-+.00028″)		0.02 .(.0008″)	

Inspection Items		Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
ROCKER ARM						
Rocker arm shaft O.D.			14.95-14.97 (.5886-.5894″)		14.87 (.5854″)	
Rocker arm to shaft clearance			0.030-0.093 (.0012-.0037″)		0.2 (.008″)	Oil clearance
OIL PUMP						
Oil pressure switch actuating pressure (kg/cm^2) (psi)		0.3 (4.266)	0.2-0.4 (2.844-5.688)			
Relief valve opening pressure (kg/cm^2) (psi)		3.2 (45.5)				
Tip clearance (rotor to vane gap)			0.01-0.15 (.0004-.006″)		0.25 (.0098″)	
Axial clearance (rotor to cover)			0.1-0.15 (.004-.006″)		0.2 (.008″)	
INJECTION PUMP (1) MODEL: KF						
Type		104294-4011 (Part No. 131017252) Diesel KiKi				
Pump plunger diameter		5.5 (.217″)				
Pump plunger stroke		7.0 (.276″)				
Injection timing	Before top dead centre	20°	20-21°			
	Piston displacement (BTDC)	3.539 (.1393″)	3.539-3.895 (.1393-.1533″)			
INJECTION PUMP (2) MODEL: KK						
Type		104296-4000 (Part No. 131017370) Diesel KiKi				
Pump plunger diameter		6.5 (.256″)				
Pump plunger stroke		7.0 (.276″)				
Injection timing	Before top dead centre	18°	18-20°			
	Piston displacement (BTDC)	2.875 (.1132″)	2.875-3.539 (.1132-.1393″)			
INJECTION NOZZLE (1) MODEL: KF						
Type		105148-1170 (Part No. 131406360) Diesel KiKi				
Injection pressure (kg/cm^2) (psi)		150 (2133)	155-165 (2204.1-2346.3)	130 (1849)		
Injection angle						
INJECTION NOZZLE (2) MODEL: KK						
Type		105118-4560 (Part No. 131406370) Diesel KiKi				
Injection pressure kg/cm^2 (psi)		210 (2987)	215-225 (3057.3-3199.5)			
Injection angle						

Inspection Items		Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
CRANKSHAFT						
Diameter of journal		68 (2.677″)	67.957-67.970 (2.6755-2.6760″)		67.4 (2.654″)	Undersize (0.25, 0.5) (.01″, .02″)
Diameter of pin		52 (2.047″)	51.964-51.975 (2.0458-2.0463″)		51.4 (2.024″)	Under size (0.25, 0.5) (.01″, .02″)
Roughness, main journal and crank pin		1.6Z				
Crankshaft deflection			0.03 max. (.0012″)		0.06 (.0024″)	
Axial play of crankshaft			0.1-0.4 (.004-.016″)			
Thickness of thrust washer			2.95-3.0 (.116-.118″)		2.8 (.110″)	
O.D. x I.D. of bush (journal bearing)		72 x 68 (2.8346 x 2.6772″)				
Clearance between crankshaft and journal (bush)			0.044-0.116 (.0017-.0046″)		0.2 (.008″)	Oil clearance
O.D. x I.D. of center bearing		72 x 68 (2.8346 x 2.6772″)				
Clearance between crankshaft journal and center bearing			0.044-0.102 (.0017-.0040″)		0.2 (.008″)	Oil clearance
CAMSHAFT						
 Height PB126	For intake/exhaust		34.065-34.12 (1.3411-1.3433″)		33.7 (1.3268″)	
	For injection pump		41.94-42.06 (1.6512-1.6559″)		41.8 (1.6457″)	
	For feed pump		31.9-32.0 (1.2559-1.2598″)		30.0 (1.1811″)	
Camshaft deflection			0.03 max. (.0012″)		0.1 (.004″)	
Cam gear backlash			0.08 (.00315″)		0.25 (.01″)	
VALVE						
Diameter of intake valve stem		6.97 (.2744″)	6.955-6.97 (.2738-.2744″)		6.89 (.2713″)	
Diameter of exhaust valve stem		6.95 (.2736″)	6.94-6.95 (.2732-.2736″)		6.84 (.2693″)	
Clearance between valve stem and valve guide	Inlet		0.03-0.06 (.0012-.0024″)		0.2 (.008″)	
	Exhaust		0.05-0.075 (.002-.003″)		0.25 (.01″)	
Valve thickness  Thickness PB127			0.925-1.075 (.0364-.0423″)		0.5 (.02″)	
Valve clearance (intake & exhaust)			0.2 (.008″)	0.5 (.02″)		Cold
Valve Spring	Spring force (at 30.4mm) kg (lb)		8.1 (17.86)		7 (15.43)	
	Free height		35 (1.378″)		33.5 (1.319″)	
	Squareness  Squareness PB128		1.2 max. (.047″)		2.0 (.079″)	
Intake valve	Opening angle BTDC	13°				
	Closing angle ABDC	43°				
Exhaust valve	Opening angle BBDC	43°				
	Closing angle ABDC	13°				
PUSH ROD						
Overall length			205.1-205.9 (8.075-8.106″)			
Outside diameter			6.2-6.4 (.244-.252″)			

Inspection Items	Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
COOLING					
Cooling system	Water cooled forced circulation				
Cooling water quantity (l) (Without Radiator)	MODEL KF: 4.0 KK: 3.75				
Thermostat opening temp	71°C (159°F)	(69-73) (156.2-163.4°F)			
Thermostat full open temp.	82°C (189°F)				
V belt (fan) slack (1kg at center)	5 (.2")				

Inspection Items	Standard Dimension	Standard Value	To Be Repaired	Allowable Limit	Remarks
STARTER MOTOR					
Type	MITSUBISHI M002T54091 (12V-2kw Reduction)				
Pinion gear No. teeth	9				
Pinion gear shift system	Magnetic shift				
Commutator diameter wear	32 (1.26")			31 (1.22")	
Commutator diameter eccentric wear		0.03 (.0012")		0.2 (.0008")	
Armature shaft bending			0.05 (.002")		
Brush length	18 (.71")			11 (.43")	
Brush spring pressure kg (lb)	1.4-2.6 (3.09-5.73)			0.9 (1.98)	
ALTERNATOR					
Type	MITSUBISHI A001T25087 12V-35A				
Rotor shaft bending			0.07 (.0028")		
Slip Rings					
Diameter	33.0 (1.299")		32.4 (1.276"		
Diameter eccentric wear			0.05 (.002")	0.3 (.012")	
Surface condition			If dirty or damaged correct with emery cloth.		
Brush length	18.5 (.728")			7.0 (.276")	
Brush spring pressure g (lb)	370 (.816")	310-430 (.683-.948")		210 (.463)	

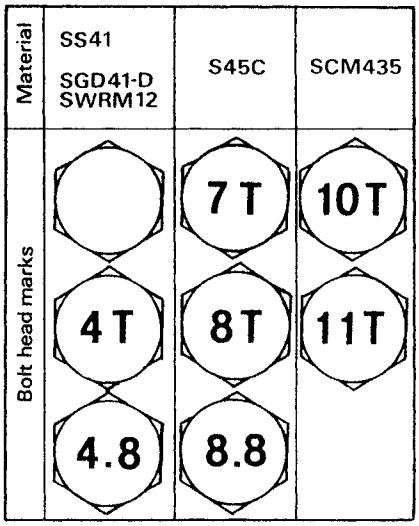
SECTION IX
Recommended Torque Tensions for 103-12, 103-13, 103-15, 104-19

Tensions kgf m (lbf ft)

COMPONENT	Setting/Remarks
Bearing holder bolts—hex hole type	2.5-3.0 (19-22)
—hex bolt type	5.0-5.5 (36-40)
Rear plate bolts	1.3-1.7 (10-13)
Flywheel housing bolts	2.4-2.9 (18-21)
Flywheel bolts	6.0-7.0 (43-51)
Connecting rod nuts	5.0-5.5 (36-40)
Suction filter bolts	0.9-1.3 (7-9)
Sump bolts	0.9-1.3 (7-9)
Crankshaft pulley nut	28-34 (203-246)
Cylinder head bolts	9.0-9.5 (65-69)/oiled
Injection pump bolts	0.9-1.3 (7-9)
Injection pump nuts	0.9-1.3 (7-9)
Rocker arm nuts	2.0-2.5 (15-19)/3 cylinder engines (except DI engine)
Rocker arm nuts	2.8-4.0 (20-29)/4 cylinder engines (and 103-15 DI engine)
Head cover nuts	0.8-1.2 (6-9)/3 cylinder engines (except DI engine)
Head cover nuts	1.2-1.6 (9-12)/4 cylinder engines (and 103-15 DI engine)
Cooling fan bolts	0.9-1.3 (7-9)
Oil pipe banjo bolts	1.0-1.3 (7-9)
Oil sump drain bolt	3.0-4.0 (22-29)
Injection nozzle	6-7 (43-51) IDI engines
Injection nozzle clamp	2-2.5 (15-18) DI engines
Injection pipe	1.5-2.5 (11-18)
Thermo switch	2.5-3.0 (19-22)
Oil pressure switch	1.5-2.0 (11-15)
Glow plug	1.5-2.0 (11-15)
Stop solenoid	1.5-2.0 (11-15)
Oil relief valve	6.0-7.0 (44-51)
Smokeset nut (max fuel)	2.0-2.5 (15-19)
Adjusting screw nuts	1.3-1.7 (7-12)

TIGHTENING TORQUE TABLES

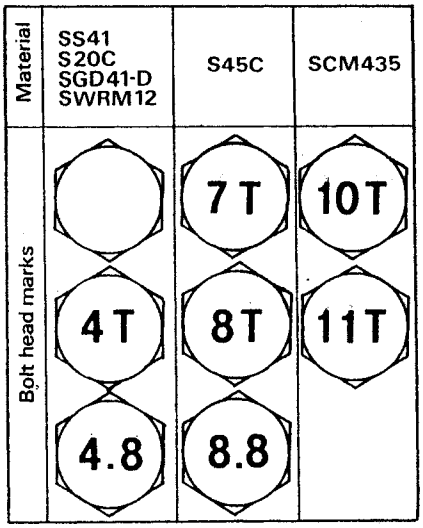
Screw size	Bolt head identification marks as per grade	Coarse thread			Fine thread		
		Screw pitch (mm)	Tightening torque		Screw pitch (mm)	Tightening torque	
			lbs-ft	N.m		lbs-ft	N.m
M6	4T, 4.8	1.0	3.6~5.1	4.9~6.9			
	7T, 8T, 8.8		6.1~8.3	8.3~11.3			
	10T, 11T		8.7~11.6	11.8~15.7			
M8	4T, 4.8	1.25	9.4~12.3	12.7~16.7	1.0	11.2~14.8	15.2~20.1
	7T, 8T, 8.8		16.6~21.0	22.6~28.4		19.5~25.3	26.5~34.3
	10T, 11T		21.0~26.8	28.4~36.3		22.4~29.7	30.4~40.2
M10	4T, 4.8	1.5	18.8~24.6	25.5~33.3	1.25	21.0~26.8	28.4~36.3
	7T, 8T, 8.8		32.6~41.2	44.1~55.9		36.2~46.3	49.0~62.8
	10T, 11T		39.8~51.4	53.9~69.6		42.7~54.3	57.9~73.6
M12	4T, 4.8	1.75	27.5~34.7	37.3~47.1	1.25	31.8~40.5	43.2~54.9
	7T, 8T, 8.8		55.7~61.5	65.7~83.4		55.0~69.5	74.5~94.1
	10T, 11T		68.0~85.4	92.2~116		73.1~93.3	99.1~127
M14	4T, 4.8	2.0	46.3~59.3	62.8~80.4	1.5	51.4~64.4	69.6~87.3
	7T, 8T, 8.8		76.7~96.9	104~131		86.1~109	117~148
	10T, 11T		103~129	139~175		109~137	147~186
M16	4T, 4.8	2.0	63.7~81.0	86.3~110	1.5	67.3~84.6	91.2~115
	7T, 8T, 8.8		110~136	149~184		116~142	157~192
	10T, 11T		152~188	206~255		163~199	221~270
M18	4T, 4.8	2.0	83.9~104	114~141	1.5	96.9~120	131~163
	7T, 8T, 8.8		145~174	196~235		170~206	230~279
	10T, 11T		203~246	275~333		221~271	299~368
M20	4T, 4.8	2.5	106~132	144~179	1.5	127~156	172~211
	7T, 8T, 8.8		177~213	240~289		203~246	275~333
	10T, 11T		268~326	363~441		293~358	397~485



SECTION X
Conversion Formulas

TIGHTENING TORQUE TABLES

Screw size	Bolt head identification marks as per grade	Coarse thread		Fine thread	
		Screw pitch (mm)	Tightening torque (kgf.cm)	Screw pitch (mm)	Tightening torque (kgf.cm)
M4	4T, 4.8	0.7	15~ 21		
	7T, 8T, 8.8		27~ 37		
	10T, 11T		36~ 50		
M5	4T, 4.8	0.8	29~ 41		
	7T, 8T, 8.8		50~ 70		
	10T, 11T		68~ 96		
M6	4T, 4.8	1.0	50~ 70		
	7T, 8T, 8.8		85~ 115		
	10T, 11T		120~ 160		
M8	4T, 4.8	1.25	130~ 170	1.0	155~ 205
	7T, 8T, 8.8		230~ 290		270~ 350
	10T, 11T		290~ 370		310~ 410
M10	4T, 4.8	1.5	260~ 340	1.25	290~ 370
	7T, 8T, 8.8		450~ 570		500~ 640
	10T, 11T		550~ 710		590~ 750
M12	4T, 4.8	1.75	380~ 480	1.25	440~ 560
	4T, 8T, 8.8		670~ 850		760~ 960
	10T, 11T		940~1,180		1,010~1,290
M14	4T, 4.8	2.0	640~ 820	1.5	710~ 890
	7T, 8T, 8.8		1,060~1,340		1,190~1,510
	10T, 11T		1,420~1,780		1,500~1,900
M16	4T, 4.8	2.0	880~1,120	1.5	930~1,170
	7T, 8T, 8.8		1,520~1,880		1,600~1,960
	10T, 11T		2,100~2,600		2,250~2,750
M18	4T, 4.8	2.0	1,160~1,440	1.5	1,340~1,660
	7T, 8T, 8.8		2,000~2,400		2,350~2,850
	10T, 11T		2,800~3,400		3,050~3,750
M20	4T, 4.8	2.5	1,470~1,830	1.5	1,750~2,150
	7T, 8T, 8.8		2,450~2,950		2,800~3,400
	10T, 11T		3,700~4,500		4,050~4,950



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