HINO
INDUSTRIAL ENGINE

EH 700

Workshop Manual

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HINO MOTORS, LTD.
TOKYO JAPAN
GENERAL INSTRUCTION

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FOREWORD

This shop manual is a general description of the instructions and repairs required for HINO MODEL EH700 industrial diesel engine. It also covers the constructions and operational characteristics of the engine.

Daily and periodical inspection and maintenance are the most important factors governing the high performance of the engine. The proper sequences and methods outlined should be followed in repairs.

It is recommended that the customers make full use of this manual in order to attain the maximum efficiency maintenance and repair.

HINO MOTORS, LTD.
1-2 GENERAL INSTRUCTIONS

ENGINE SERIAL NUMBER

The engine serial number is curved on the left hand of the engine cylinder block.

![Engine serial number](image)

**Fig. 1-1 Engine serial number**

**NOTE:**

All specifications appearing in this manual are based on the metric system. However, as a ready reference, conversion has been made as shown below:

- mm (in), m (ft), km (mile)
- cm² (sq.in)
- mm³ (cu.in), cc (cu.in), m³ (cu.ft), liter (cu.in), liter (Imp.gal/U.S.gal)
- g (oz), kg (lb)
- kg-cm (lb.ft.), kg-m (lb.ft.), kg/mm (lb/in), kg/cm² (lb/sq.in)
- m/s (ft/s), km/h (mph)
SPECIFICATIONS
DIESEL ENGINE FOR INDUSTRIAL USE

HINO   EH700

APPLICATION: ELECTRICAL GENERATORS, WATER PUMPS, AIR COMPRESSORS, HYDRAULIC CRANES & SHOVELS, ROLLERS, TOWING TRACTORS, FORK-LIFT TRUCKS, SHUNTING LOCOMOTIVES AND OTHER GENERAL POWER PLANTS

● PERFORMANCE & PERFORMANCE CURVE (STD. specs.)

<table>
<thead>
<tr>
<th>GENERAL USE (SAE J1349 Gross)</th>
<th>GENERATOR USE (SAE J1349 Gross)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output, intermittent rating kW (HP) at rpm</td>
<td>Output at 1,500 rpm kW (HP)</td>
</tr>
<tr>
<td>Output, continuous rating kW (HP) at rpm</td>
<td>Max. torque Nm (lb.ft) at rpm</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>106 (142) at 2,800</td>
<td>91 (122) at 2,800</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ambient conditions:

- SAE
- Intake air temperature: 25°C
- Barometric pressure: 100 kPa
- Water vapour pressure: 1.0 kPa
- DIN
- Intake air temperature: 20°C
- Barometric pressure: 736 mmHg
- Water vapour pressure: 10.5 mmHg

● ENGINE DESCRIPTION

1. Type: Diesel, 4-cyc., 6-cyl., in-line, overhead valve, water-cooled
2. Combustion system: Direct injection type
3. Cylinder:
   - Bore x Stroke: 110 x 113 mm (4.33 x 4.45 in)
   - 6.443 liters (393.2 cu.in)
4. Piston displacement: 17.9
5. Compression ratio: Counter-clockwise viewed from flywheel
6. Direction of rotation: Approx. 1,150 x 735 x 875 mm (45.3 x 28.9 x 34.4 in)
7. Dimensions (L X W x H): Approx. 500 kg (1,100 lb)
8. Dryweight:

● FEATURES

1. Cylinder block: Single piece cast iron with replaceable dry liner
2. Cylinder head: Mono block cast iron
3. Crank shaft: Induction-hardened die forged special steel with counter weights
4. Piston and rings: Heat-resistance alminum alloy
5. Camshaft: Three compression rings, chrome plated
6. Valves: One oil ring, chrome plated with coil expander
7. Induction hardered carbon steel
8. Heat resistance steel
### GENERAL INSTRUCTION

#### STANDARD EQUIPMENT
1. Flywheel housing  
   - HINO own (SAE No. 3 type)
2. Flywheel  
   - HINO own (SAE 11½ in. type)
3. Fuel injection pump  
   - BOSCH “A” type
4. Governor  
   - Centrifugal, all speed control type
5. Fuel injection nozzle  
   - BOSCH hole type
6. Fuel filter  
   - Paper element type
7. Water separator
8. Cooling system  
   - Forced-circulation by volute pump
9. Lubricating system  
   - Full-forced pressure feed by gear pump
10. Oil filter  
    - Paper element type (Full flow)
11. Intake manifold  
    - Inlet position at rear
12. Exhaust manifold with flange plate  
    - Upward exhaust
13. Generator  
    - Alternator with integral regulator
14. Starter  
    - 24V, 20A
15. Safety valve  
16. Connectors of electrical equipments

#### OPTIONAL EQUIPMENT
1. Cooling fan (suction or blowout)
2. Main switch
3. Battery switch
4. Battery relay
5. Starter switch with key
6. Ammeter
7. Fuse box
8. Engine shut off solenoid
9. Emergency relay
10. Coolant temperature switch
11. Coolant temperature gauge sender
12. Coolant temperature gauge
13. Oil pressure switch
14. Oil pressure gauge sender
15. Oil pressure gauge
16. Intake heater
17. Intake heater relay
18. Intake heater indicator
19. Tachometer with hourmeter
20. Tachometer cable
21. Muffler
22. Air cleaner
23. Air cleaner cap
24. Radiator with cooling fan shroud
NOTE:  
1) These specifications are subject to change without notice.  
2) These specifications are for export models.  
3) All specifications of the products are with normal manufacturing allowances and tolerances.  
4) The performance and drawings are for standard specifications.

HINO MOTORS, LTD.  TOKYO, JAPAN
# Recommended Lubricants for All Hino Engine

<table>
<thead>
<tr>
<th>LUBRICANTS</th>
<th>POSITIONS</th>
<th>ATMOSPHERIC TEMP.</th>
<th>S.A.E. NO.</th>
<th>BP</th>
<th>CALTEX</th>
<th>CASTROL</th>
<th>ESSO</th>
<th>GULF</th>
<th>MOBIL</th>
<th>SHELL</th>
<th>TOTAL</th>
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<tbody>
<tr>
<td><strong>ENGINE OIL</strong></td>
<td>Above</td>
<td>Above</td>
<td>32°C (90°F)</td>
<td>40</td>
<td>Vanexus C-3 40</td>
<td>RPM DELO 400 Oil SAE 40 or 15W/40</td>
<td>RPM DELO 300 Oil SAE 40</td>
<td>Caltrol or Dowcot</td>
<td>Castrol or Dowcot</td>
<td>Gulf Super Duty</td>
<td>Mobil Delvac 1240</td>
</tr>
<tr>
<td></td>
<td>30° C</td>
<td>30° C</td>
<td>90° C (32°F)</td>
<td>30</td>
<td>Vanexus C-3 30</td>
<td>RPM DELO 400 Oil SAE 30 or 15W/40</td>
<td>RPM DELO 300 Oil SAE 30</td>
<td>Caltrol or Dowcot</td>
<td>Castrol or Dowcot</td>
<td>Gulf Super Duty</td>
<td>Mobil Delvac 1230</td>
</tr>
<tr>
<td></td>
<td>0° - 12° C</td>
<td>0° - 12° C</td>
<td>12° 10°F</td>
<td>20</td>
<td>Vanexus C-3 20W</td>
<td>RPM DELO 400 Oil SAE 20/20W 15W/40</td>
<td>RPM DELO 300 Oil SAE 20/20W</td>
<td>Caltrol or Dowcot</td>
<td>Castrol or Dowcot</td>
<td>Gulf Super Duty</td>
<td>Mobil Delvac 1230</td>
</tr>
<tr>
<td><strong>COOLANT PUMP BEARING GREASE</strong></td>
<td>Above</td>
<td>Above</td>
<td>32°C (90°F)</td>
<td>40</td>
<td>Vanexus M 40</td>
<td>RPM DELO 200 Oil SAE 40</td>
<td>RPM DELO 100 Oil SAE 30</td>
<td>Caltrol or Dowcot</td>
<td>Castrol or Dowcot</td>
<td>Gulf Super Duty</td>
<td>Mobil Delvac 1240</td>
</tr>
<tr>
<td></td>
<td>30° C</td>
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<td>Vanexus M 30</td>
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<td>Caltrol or Dowcot</td>
<td>Castrol or Dowcot</td>
<td>Gulf Super Duty</td>
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<td>0° - 12° C</td>
<td>12° 10°F</td>
<td>20</td>
<td>Vanexus M 20W</td>
<td>RPM DELO 200 Oil SAE 20/20W</td>
<td>RPM DELO 100 Oil SAE 20/20W</td>
<td>Caltrol or Dowcot</td>
<td>Castrol or Dowcot</td>
<td>Gulf Super Duty</td>
<td>Mobil Delvac 1120</td>
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<tr>
<td><strong>COOLANT PUMP BEARING GREASE</strong></td>
<td>Below</td>
<td>Below</td>
<td>32°C (90°F)</td>
<td>40</td>
<td>Vanexus M 40</td>
<td>RPM DELO 200 Oil SAE 40</td>
<td>RPM DELO 100 Oil SAE 30</td>
<td>Caltrol or Dowcot</td>
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<td>Mobil Delvac 1240</td>
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<tr>
<td></td>
<td>30° C</td>
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<td>90° C (32°F)</td>
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<td>Vanexus M 30</td>
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<td>Castrol or Dowcot</td>
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<tr>
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<td>0° - 12° C</td>
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<td>RPM DELO 200 Oil SAE 20/20W</td>
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<td>Caltrol or Dowcot</td>
<td>Castrol or Dowcot</td>
<td>Gulf Super Duty</td>
<td>Mobil Delvac 1120</td>
</tr>
</tbody>
</table>

Note: Lubricants were amended according to new classification by A.P.I. (American Petroleum Institute)
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INTRODUCTION

Model EH700 engine is 4 cycle, direct injection type diesel engine having 6 cylinder in-line water cooled and overhead valves.

DEFINITION OF TERMS

The terms adopted in this Workshop Manual are defined as follows:

Rotation:
This engine rotates clockwise seen from the timing gear side.

Nominal dimension:
Basic dimension excluding tolerance.

Nominal clearance:
Space allowed between two parts on account of difference of tolerance when fixed together.

Repair limit:
Parts which reach this limit should be repaired. The mark (+) or (−) expresses increase or decrease as compared with the nominal dimension.

Serviceable:
The utmost that can be serviceable and parts which reach this limit should be replaced. The mark (+) or (−) expresses increase or decrease as compared with the nominal dimension.
Fig. 3-1-1  Model EH 700 Engine
Fig. 3-1-2  Engine right side view

Fig. 3-1-3  Engine front view
DATA & SPECIFICATIONS

GENERAL
Model ........................................... HINO EH700
Type ............................................. Diesel, 4 cycle, vertical 6 cylinder in-line overhead valve
water-cooled direct injection type
Bore and stroke .......................... 110 x 113 mm (4.33 x 4.45 in)
Piston displacement .................. 6,443 liters (393 cu.in)
Output, intermittent KW (HP) at r.p.m. 106 (142) at 2,800 r.p.m.
(SAE J1349 Gross) 87 (130) at 2,400 r.p.m.
84 (112) at 2,000 r.p.m.
68 (91) at 1,600 r.p.m.
Output, continuous KW (HP) at r.p.m. 91 (122) at 2,800 r.p.m.
(SAE J1349 Gross) 84 (112) at 2,400 r.p.m.
72 (97) at 2,000 r.p.m.
57 (77) at 1,600 r.p.m.
Max. torque Nm (lbf-ft) at r.p.m. 408 (301) at 1,800 r.p.m.
Compression ratio ......................... 17.9 : 1
Firing order .................................. 1-4-2-6-3-5
Compression pressure ................ 29 — 35 kg/cm² (413 — 497 lb/sq.in) at 270 — 310 rpm
Weight ........................................ 500 kg (1,057 lb)

CYLINDER HEAD
Type ............................................ Single-piece casting
Material ..................................... Cast iron

VALVE MECHANISM
Valve seat angle, Intake ....................... 30°
Exhaust ..................................... 45°
Valve face angle; Intake ...................... 30°
Exhaust ..................................... 45°
Valve material; Intake ....................... Heat resistance steel
Exhaust ..................................... Special heat resistance steel
Valve timing (flywheel travel); Intake opens 16° before T.D.C.
Intake closes 40° after B.D.C.
Exhaust opens 51° before B.D.C.
Exhaust closes 13° after T.D.C.
Valve clearance, Intake (when cooled) ..... 0.30 mm (0.0118 in)
Exhaust (when cooled) ...................... 0.40 mm (0.0157 in)
Tappet ...................................... Special cast iron
Push rod ................................... Hollow, carbon steel

CYLINDER BLOCK, CYLINDER LINER AND CAMSHAFT
Cylinder block ................................ Mono-block, six cylinder, cast iron
Cylinder liner .......................... Dry type, replaceable, special chrome alloy, centrifugally cast
Camshaft .................................. Case-hardened die-forged carbon steel in material
Camshaft bearing Number and material .... 7, white metal with carbon steel back metal
CONNECTING ROD AND PISTON
Connecting rod ............................................. 6, carbon steel
Small end bearing; Material ........................ Bronze
Large end bearing; Material ......................... Thin-kelmet with lead alloy
Piston .............................................. Heat-resistance aluminum alloy
Piston ring; Compression ..................... Three, with chromeplated
Oil ring ............................... One, chromeplated with coil expander

CRANKSHAFT AND CRANKSHAFT BEARING
Crankshaft ............................................. Induction-hardened die forged special steel with counter weights
Crankshaft bearing; Material .................. Iridium plated over kelmet

TIMING GEAR
Timing gear drive .............................................. Helical gear

FUEL SYSTEM
Fuel injection pump ........................................ BOSCH line type, driven by engine, 1/2 x engine rpm, clockwise
seen from the drive side
Injection timing (flywheel travel) .............. 17° before 1st cyl. T.D.C.
Governor ............................................. BOSCH type, mechanical all speed control (RSV)
Timer ............................................... Automatic timer, clockwise rotation seen from the drive side,
max. advancing angle 3°
Fuel feed pump ............................................. Piston type, driven by injection pump camshaft, max. feeding,
pressure 1.3 kg/cm² (18.5 lb/sq.in)
Nozzle .............................................. Multi-hole nozzle type
Nozzle holder ........................................ Injection pressure 220 kg/cm² (4,125 lb/sq.in)
Fuel filter ............................................ Replaceable paper element type

LUBRICATING SYSTEM
Type .............................................. Forced-feed lubrication with oil pump
Oil capacity ............................................. 14 liter (3.07 Imp.gal/3.70 U.S.gal)
Oil pressure ......................................... 1.0 – 5.0 kg/cm² (14.22 – 71.1 lb/sq.in)
Oil filter ............................................ Full flow paper element oil filter
Oil pan .............................................. Pressed sheet steel in material

COOLING SYSTEM
Type .............................................. Forced recirculation type
Cooling system water capacity ............... 11 liters (2.42 Imp.gal/2.90 U.S.gal)
(Only cylinder block) ................................. 
Coolant pump ............................................. Centrifugal, belt-driven by engine crankshaft, 0.936 x engine rpm
Fan; Type ............................................. Six-blades type, mounted on cylinder block
Drive .................................................. Fully shrouded belt-driven by engine crankshaft pulley
0.936 x engine rpm
Thermostat ............................................. Wax type, bottom by pass system, open at 76.5°C (170°F),
max. lift 10.0 mm (0.393 in) at 90°C (194°F)
PERFORMANCE CURVE CONDITION (MODEL: EH700)

(1) Ambient conditions:
   - Intake air temperature: 20°C
   - Barometric pressure: 736 mmHg
   - Water vapor pressure: 10.5 mmHg

(2) Net rating with fan alternator (unloaded), air cleaner, and exhaust silencer installed.

(3) Specific fuel consumption curve shows under 1-hour rating.

Intermittent rating (DIN 6270B)
Continuous rating (DIN 6270A)

**Fig. 3-1-4**
PERFORMANCE CURVE CONDITION (MODEL: SAE)

(1) Ambient conditions: SAE
   - Intake air temperature 25°
   - Barometric pressure 100 kPa
   - Water vapor pressure 1.0 kPa

(2) Net rating with fan alternator (unloaded), air cleaner, and exhaust silencer installed.

(3) Specific fuel consumption curve shows under 1-hour rating.

Intermittent rating (SAE J1349 Gross)
Continuous rating (SAE J1349 Gross)
ENGINE OVERHAUL

1. Factors Affecting the Timing of Engine Overhaul

Among the various factors necessitating engine overhaul-
ing is the wear of the cylinder liner, piston, and the
piston ring. These defects present themselves in various
ways, making it difficult to correctly judge when to
conduct an overhaul.

It is, therefore, desirable that maintenance and inspec-
tion be conducted periodically, so that the timing of
engine overhauling may be determined based on data
obtained through such work. Listed below are some of
the factors which should be taken into consideration in
deciding when to conduct an engine overhaul.

1. Lowering of compression pressure

One of the most reliable elements based on which to
time the timing of engine overhauling is the com-
pression pressure. The standard compressing pressure
of this engine is 29 – 35 kg/cm² (413 – 497 lb/sq.in)
at 270 – 310 rpm.

Overhaul is needed when the compression pressure
drops to less than 25 kg/cm² (356 lb/sq.in) at 270 –
310 rpm, or when the compression pressure between
individual cylinders varies by more than 3 kg/cm²
(43 lb/sq.in).

<table>
<thead>
<tr>
<th>Engine model</th>
<th>Standard value</th>
<th>Absolute value</th>
<th>Difference between each cylinder</th>
</tr>
</thead>
<tbody>
<tr>
<td>EH700</td>
<td>29 – 35</td>
<td>25</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>(413 – 497)</td>
<td>(366)</td>
<td>(43)</td>
</tr>
<tr>
<td></td>
<td>at 270 – 310</td>
<td>at 270 – 310</td>
<td></td>
</tr>
</tbody>
</table>

2. Increase of consumption of engine oil

The standard engine oil consumption is approximately
1/100 of the amount of fuel consumed. Consumption
of engine oil will, however, increase as various com-
ponent parts wear out. It is advisable that oil con-
sumption be estimated based on the average consump-
tion during a period of one month or two.

3. Other factors

Besides the lowering of compression pressure and the
increase of consumption of engine oil mentioned
above, the following conditions may also be taken
into account in judging when to overhaul the engine:

(1) The blow-by explosive gas into the crank case
will increase, and an increased amount of gas
will come out of the breather pipe, oil filler
pipe thru. cylinder head holes for rocker arm
push rod etc.

(2) The engine will not start easily.

(3) Engine output decreases.

(4) Fuel consumption increases.

(5) Engine makes a larger noise.

(6) Oil pressure ceases.

These defects present themselves, often combined
with one another, as factors calling for engine over-
hauling. It should be noted that of the defects listed
above (2) has a great deal to do with the condition of
the battery and that (2), (3) and (4) are influenced by
the full injection amount and timing of the injection
pump as well as by the wear of the plunger and the
condition of the nozzle. These facts must also be
taken into due consideration.

2. Compression Pressure Measurement

1. Before measurement

(1) Check and confirm that the valve clearance is
correct.

(2) Fully charge the battery.

(3) Idle the engine until the water temperature rises
to 80°C (176°F).

(4) Remove the air cleaner so as to reduce suction
resistance.

2. Measurement

The starter motor is used to turn the engine when
checking compression. The compression pressure
gauge is composed of an adapter unit, pressure gauge
and pipe. (Make sure that the pressure gauge is cor-
rectly calibrated before testing.)

![Compression pressure gauge](KT3-197)

(1) Remove the six nozzle holders, by removing all
six nozzle holders engine drag is reduced, bat-
tery power conserved, and the engine can be
turned at high speed.
(2) Place the adapter unit at the position of the removed nozzle holder for the cylinder to be checked and couple it to the pressure gauge properly to prevent gas leakage.

(3) Energize the starter motor and when the engine is turning at maximum speed, read the pressure gauge. This requires two persons: one to read the pressure gauge and the other to watch the engine tachometer.

(4) Repeat the above for the remaining cylinders. Be sure to check all cylinders, result from a few cylinders does not mean that the remainder are also satisfactory.

3. General Cautions on Engine Overhauling

1. In disassembling the engine, prepare a work bench on which to place the component parts as they are removed, and keep all parts neatly arranged on it according to the order to disassembly.

2. In disassembly, observe the assembly marks so that the engine can be correctly re-assembled after overhauling. If necessary, put assembly marks on parts that are not marked.

Since the engine has many cylinders, put cylinder numbers on the following parts to prevent confusion at the time of re-assembly.

(1) Main bearing
(2) Connecting rod bearing
(3) Piston (including piston ring)
(4) Cylinder liner
(5) Valve
(6) Push rod
(7) Tappet
(8) Rocker arm
(9) Connecting rod

3. During disassembly and cleaning, always check for any abnormality so as not to miss any defect which cannot be detected after assembly or cleaning.

(1) The following bolts need to be checked for correct tightening torque.

(i) Cylinder head bolts
(ii) Connecting rod bolts
(iii) Main bearing cap bolts

Bolts other than these should also be checked, depending upon the reason for which the parts they are used in were disassembled.

(2) Inspection and measurement of the following parts at the time of overhauling will also make it easier to judge afterwards whether or not they need replacement.

(i) Uniform contact of the cylinder head gasket
(ii) Cracks of the cylinder head, gasket, grommet
(iii) Protrusion of the cylinder liner from the crankcase
(iv) Crush of the main bearing
(v) Crush of the connecting rod bearing
(vi) End play of the crankshaft
(vii) Backlash of gears

4. In assembly and disassembly, always use correct tools to prevent damage. In assembly, lubricate parts that need lubrication, and in parts where the amount of tightening torque is specified, apply oil on the threaded portion of the bolts and nuts and tighten them, applying the specified amount of torque.

5. Avoid using old packings and gaskets to prevent oil or gas leakage.
SPECIAL TOOL
Prior to start of engine overhaul, it is necessary to prepare special tools.

FRONT OIL SEAL PRESS.
09482-1090

FRONT SLEEVE PULLER
09420-1071

SLEEVE PRESS
09482-1400

SLEEVE PRESS
09420-1420

VALVE LAPPING TOOL
09431-1010

ADAPTOR
09462-1130

TIMING WRENCH
09819-3003
09819-3004

WIRE
09491-1010

NOZZLE SLEEVE BAR
09472-1210

NOZZLE SEAT PRESS (STEEL BALL)
9800-06100

GAUGE ADAPTOR
09408-1010

GAUGE ADAPTOR
09552-1030
3-2 CYLINDER HEAD & VALVE MECHANISM

DESCRIPTION

1. Cylinder Head & Related Parts

1. Cylinder head
2. Valve guide
3. Intake valve seat
4. Exhaust valve seat
5. Push rod guide pipe
6. Nozzle seat (copper sleeve)
7. O-ring

Fig. 3-2-1 Cylinder head
1. Cylinder head cover
2. Cylinder head cover gasket
3. Cylinder head gasket
4. Oil filler cap
5. Ventilator
6. Cylinder head bolt
7. Cylinder head bolt
8. Vent pipe

Fig. 3-2-2 Cylinder head & related parts
2. Valve Mechanism

1. Intake valve
2. Exhaust valve
3. Valve stem cap
4. Valve spring lower seat
5. Valve spring
6. Valve spring upper seat
7. Valve stem key
8. Tappet
9. Push rod
10. Rocker arm support
11. Rocker arm support
12. Rocker arm support
13. Rocker arm
14. Rocker arm
15. Adjusting screw
16. Adjusting screw nut
17. Support bolt
18. Rocker arm shaft

Fig. 3-2-3 Valve system
CONSTRUCTION

1. Combustion Chamber

The combustion chamber is of a toroidal-type with a direct injection system. With the nozzle holder near the center of the piston, the combustion chamber shows excellent combustion with improved intake distribution and efficiency through a special shaped intake port.

![Sectional view of cylinder head](image)

Fig. 3-24 Sectional view of cylinder head

2. Cylinder Head

(1) The highly rigid, 6-cylinder, one-piece, special cast iron cylinder head has a cross-flow system in which the intake and exhaust valves are alternated in a slightly ZIG ZAG pattern.

(2) The intake port is a special shape that produces optimum swirl in the cylinder providing excellent combustion qualities. To extend the lifetime of the cylinder head, inserts are used for both of the intake and exhaust valve seats, and water jet nozzles inside the water jacket force-cool the cylinder head wall surrounding the valves. See Fig. 3-2-6.

(3) The nozzle holder is housed in a copper sleeve (nozzle seat) which is caulked into the cylinder head. This is cooled by a water jet which directs a stream of coolant directly on the sleeve and the cylinder head wall between the intake and exhaust valves. Six cylinder head bolts of 14 mm dia. are arranged around each cylinder (26 bolts in total), and another six head bolts of 10 mm dia. on the tappet side, providing the tight fit of cylinder head gasket which ensure oil, air, and gas seal integrity.

![Arrangement of head bolts](image)

Fig. 3-26 Arrangement of head bolts
3. Valve System

(1) The push rod is solid, and the rocker arm shaft is hollow and one piece. The rocker arm shaft has six rocker arm supports. The four center supports are identical but the two end supports are a special configuration which incorporates an additional support arm.

(2) A special steel stem cap on top of the valve stem virtually eliminates any problems with wear.

(3) The oil channel through to the top of the rocker arm assures a stable and reliable supply of oil. On the push rod side, the oil channels in the push rod are so designed as to pull oil from the rocker arm shaft oil channels on the up-stroke only, thus providing the push rod with exactly the proper oil supply.

Intake and exhaust valves stem seals deliver an adequate quantity of oil to the sliding surfaces of the valves and the valve guides.

(4) The rocker arms are special forged steel. Their length is different for the intake and exhaust valves. The surface hardened carbon steel rocker arm shaft is supported with six rocker arm supports. The No.1 support has an oil channel.

Oil seal fed under pressure through the main hole → No.1 cam journal → cylinder head → No.1 rocker arm support, to lubricate each rocker arm evenly and properly, oil also goes to each rocker arm bushing through the oil channel inside of the rocker arm shaft, lubricating the push rods and each valve as well.

OVERHAUL

DISASSEMBLY
Disassembly of Rocker Arm Assembly
(1) Remove the breather pipe clip.
(2) Loosen the rocker arm cover clamping bolts, then remove the rocker arm cover.
(3) Loosen the rocker arm supports bolts, and the head bolts from both sides, then remove the rocker arm assembly.

(4) Remove the push rod

(5) Remove the valve stem cap

(6) To disassemble the rocker arm assembly, loosen the rocker support bolts, and remove the rocker supports, plain washers spring, spacers, rocker arms, etc.

**NOTE:**

To avoid a difference in the clearance when reassembling the rocker arm shafts and the rocker arms, mark each rocker arm with a number or arrange them in installation sequence.

Note that the length of the rocker arms for intake and exhaust are different.

**NOZZLE HOLDER REMOVAL**

Remove dirt, dust and other foreign matter from the area surrounding the nozzle holder before removal.

1. Remove the fuel injection pipe and leakage pipe from each cylinder.

2. Remove the bolts from the nozzle holder. Be sure to using sliding hammer (special tool 09420-1441) to remove the nozzle holder.

**CYLINDER HEAD REMOVAL**

Open the drain cock located in the left rear of the cylinder block and drain the coolant from the engine before removing the cylinder head.

1. Loosen the hoseclip between coolant pump through thermostat case.
(2) Loosen the thermostat case clamping bolts for cylinder head front side, then remove the thermostat case.
(3) Remove the exhaust manifold from the cylinder head.

(4) Remove the coolant pipe connecting between the cylinder head and the oil cooler.
(5) Remove the oil level gauge.
(6) Disconnect the fuel hose from the fuel filter.
(7) Remove the link rod connecting the accelerator lever and the intake shutter of the fuel injection pump.
(8) Remove the intake manifold.
(9) Remove the cylinder head bolts, then remove the cylinder head assembly.

NOTE:
1. When removing the cylinder head gasket, take care not to scratch the cylinder block.
2. When handling the disassembled cylinder head, take care not to scratch the copper sleeve that projects beyond the cylinder head upper surface.

Disassembly Valve System

(1) Compress the valve springs with a valve spring press (special tool 09470-1021) to remove the valve stem keys. Then remove the upper seats of valve spring, valve springs and lower seats of valve spring, from the top of the cylinder head.
(2) Remove the valves downward of cylinder head.

NOTE:
1. Mark the removed valves with numbers, or arrange them in installation sequence so as to save the lapping work against the seats when reassembling.
2. Measure the valve guides and seats for wear while still in the cylinder head. Do not remove them from the cylinder head unless they must be replaced.
INSPECTION, MEASUREMENT AND REPAIR

Inspection of Rocker Arm and Rocker Arm Shaft

(1) Inspect the rocker arm valve stem contact surfaces for wear. Replace the rocker arm if excessively worn, if slightly uneven wear is visible, reface the rocker arm using a valve refacer.

(2) Measure the inside diameter of rocker arm bushing with a cylinder gauge. If it exceeds the limit replace the bushing.

Rocker arm bushing I.D. Unit: mm (in)

<table>
<thead>
<tr>
<th>Standard</th>
<th>Serviceable limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.2 (0.9527)</td>
<td>+0.08 (+0.0031)</td>
</tr>
</tbody>
</table>

(4) Calculate the clearance between rocker arm bushing and rocker arm shaft from the difference between the bushing inside diameter and the shaft outside diameter. If the clearance exceeds the serviceable limit, replace either the bushing or the shaft.

Clearance between rocker arm and shaft

<table>
<thead>
<tr>
<th>Standard</th>
<th>Serviceable limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.020 – 0.062</td>
<td>0.15 (0.006)</td>
</tr>
<tr>
<td>0.0008 – 0.0024</td>
<td></td>
</tr>
</tbody>
</table>

Inspection of Adjusting Screws, Tappets and Push Rods

(1) If the contact surface of the adjusting screw is extremely worn, or if the threads are damaged replace the adjusting screw.

(2) Bent of push rod

Roll the push rod along a level surface and insert a thickness gauge to check for bent. The limit on push-rod deflection is 0.5 mm (0.0196 in).
Wear of tappet

If the clearance between tappet outside diameter and tappet hole of cylinder block exceeds 0.1 mm (0.0039 in), replace.
Standard tappet outside diameter is 32 mm (1.260 in).

![Fig. 3-2-20 Measuring tappet O.D.](KT3-208)

**Inspection of Valves, Valve Guides and Valve Seats**

1. Check the intake and exhaust valves for carbon deposits, burn out, contact surface wear, and cracks on the bevel area and stem head.

![Fig. 3-2-21 Measuring valve stem](EF:149)

2. Measure the outside diameter of the valve stem and the inside diameter of the valve guide.

1) Measure with a micrometer and a cylinder gauge. Calculate the clearance between the valve stem and the valve guide from the difference between the diameters. If each measurement point (A, B or C in Fig. 3-2-22) exceeds the serviceable limit, replace either the valve guide or the valve.

<table>
<thead>
<tr>
<th>Valve stem O.D.</th>
<th>Unit: mm (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard</td>
</tr>
<tr>
<td>Intake</td>
<td>9 (0.354)</td>
</tr>
<tr>
<td>Exhaust</td>
<td>9 (0.354)</td>
</tr>
</tbody>
</table>

![Clearance between stem and guide](| Standard | Serviceable limit |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake</td>
<td>0.056 – 0.088</td>
</tr>
<tr>
<td></td>
<td>(0.00217 – 0.00346)</td>
</tr>
<tr>
<td>Exhaust</td>
<td>0.070 – 0.103</td>
</tr>
<tr>
<td></td>
<td>(0.00276 – 0.00406)</td>
</tr>
</tbody>
</table>

Be extremely careful not to wrench the valve guide tip when inserting the guide into the cylinder head.
The valve guides projections are as illustrated in the following figure.

![Fig. 3-2-22 Projecting dimension of valve guides](INTAKE EXHAUST CYLINDER HEAD UPPER FACE CYLINDER HEAD LOWER FACE VALVE SINK)

**NOTE:**

Take utmost care not to damage the top of the valve guides during installation.

**Replacement of Valve Stem Seals**

Replace the valve stem seals if the clearance between the valve stem and the seal is excessive, or if the guide has been replaced. After installing the lower seat, coat the sealing lip area with engine oil, and drive the seal into the guide with a stem seal press (special tool 09472-1200).
Apply the contact surfaces of the valve with red lead. Check the contact surfaces for contacting condition by tapping the valve vertically while turning it with a valve lapping tool (09431-1010).

### Standard valve seat angle

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake</td>
<td>30°</td>
</tr>
<tr>
<td>Exhaust</td>
<td>45°</td>
</tr>
</tbody>
</table>

### Standard valve face angle

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake</td>
<td>30°</td>
</tr>
<tr>
<td>Exhaust</td>
<td>45°</td>
</tr>
</tbody>
</table>

(1) If the contact surface of the valve seat is not evenly coated with red lead, correct the valve seat with a cutter.

(2) When the valve seat has been corrected, replace the valve or reface the contact surface of valve using a valve refacer.

(3) After correction, be sure to fit the contact surface and recheck for proper contact.

(4) Correct any flaws, dents, and other defects on the contact surface with a valve refacer.
(5) Measure the sink of the valve below the cylinder head with a straight edge and a thickness gauge or a depth gauge. When the sink exceeds the limit, replace the valve. If the depth does not reach the standard even with new valve, replace the valve seat also.

2) Valve seat mounting

(Mounting method using liquid nitrogen)

Heat the cylinder head well in boiling water. At the same time, place the valve seat in a wooden container (or any well insulated container) and pour in liquid nitrogen. When the valve has been immersed in liquid nitrogen for about one minute, it will be cooled to about −196°C, and the valve seat will contract. Pick up the cold valve seat with metal tongs and insert in the heated cylinder head.

The valve seat can easily be tapped into the cylinder head.

(7) Valve seat section machining specifications

Valve sink

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Standard</th>
<th>Serviceable limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake</td>
<td>+0.25</td>
<td>−0.25</td>
<td>−0.0197</td>
</tr>
<tr>
<td></td>
<td>(+0.0036)</td>
<td>(−0.0068)</td>
<td></td>
</tr>
<tr>
<td>Exhaust</td>
<td>+0.25</td>
<td>−0.25</td>
<td>−0.0197</td>
</tr>
<tr>
<td></td>
<td>(+0.0008)</td>
<td>(−0.0008)</td>
<td></td>
</tr>
</tbody>
</table>

(6) To replace valve seats, proceed as follows:

1) Valve seat removal

Cut the circumference of a valve at about three places with a grinder for electric welding as illustrated in Fig. 3-2-29. Then drive the valve seat out with a hammer and a pillow block.

Cylinder head dimension

<table>
<thead>
<tr>
<th></th>
<th>Unit: mm (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>52±0.019</td>
</tr>
<tr>
<td></td>
<td>(2.05±0.007)</td>
</tr>
<tr>
<td>Exhaust</td>
<td>45.5±0.016</td>
</tr>
<tr>
<td></td>
<td>(1.79±0.0006)</td>
</tr>
</tbody>
</table>

Valve seat dimension

<table>
<thead>
<tr>
<th></th>
<th>Unit: mm (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>52±0.100</td>
</tr>
<tr>
<td></td>
<td>(2.05±0.004)</td>
</tr>
<tr>
<td>Exhaust</td>
<td>45.5±0.145</td>
</tr>
<tr>
<td></td>
<td>(1.79±0.006)</td>
</tr>
</tbody>
</table>
Check of the valve spring

1) Valve spring
   Measure the free length and loaded valve of the springs with a spring tester. (Refer to Fig. 3-2-31). The free length may also be measured with calipers. If the spring is less than 62 mm (2.44 in) respectively, the springs should be replaced. Check the alignment of the spring by placing on an even surface and using a straight edge along the side of the spring. (Refer to Fig. 3-2-32).

   \[\text{Fig. 3-2-31 Measuring the loaded spring length} \]


(3) Check the upper and lower valve spring seats. If excessively worn, replace them.

\[\text{Fig. 3-2-33 Valve spring seats} \]

Spring force

<table>
<thead>
<tr>
<th>Mounting height</th>
<th>Spring force (kg lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm (in)</td>
<td>Standard Limit</td>
</tr>
<tr>
<td>Valve spring</td>
<td>52 (2.0472)</td>
</tr>
<tr>
<td></td>
<td>28.4 (62.59)</td>
</tr>
<tr>
<td></td>
<td>28.5 (62.81)</td>
</tr>
</tbody>
</table>

(2) Measure the straightness of a valve spring on a flat base with a square. If it exceeds 1.5 mm (0.059 in) replace.

\[\text{Unit: mm (in)} \]

<table>
<thead>
<tr>
<th>Portion</th>
<th>Standard Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3.0 (0.118)</td>
</tr>
<tr>
<td>B</td>
<td>1.0 (0.039)</td>
</tr>
</tbody>
</table>
1. Cylinder Head
   Check for carbon contamination, cracks, scaling, rust, and deflection.

   1. Carbon
      Carbon is apt to accumulate around the valve seats, and the cylinder head exhaust manifold mounting portions. Use a wire brush of soft metal scraper to remove.

   2. Cracks
      Check by magnetic flaw detection, staining, or hydraulic methods.

   3. Scaling and rust
      If excessive scaling or rust is existed, cooling efficiency and cylinder strength may be decreased. Clean with detergent.

   ![Fig. 3-2-34 Measuring direction](KT3-213)

4. If necessary, shut up the water passage in the cylinder head, send air into it from one port, then put the cylinder head in a water tank to see if there are any cracks. The air pressure should be 2.5 kg/cm² (35.53 lb/sq.in).

5. Distortion
   Check the head for distortion along the bottom face with a straight edge and thickness gauge if the distortion exceeds the repair limit. Correct with a suitable surface grinder. Measurements should be made along the sides and across the corners as shown in Fig. 3-2-35 below. When a head has been ground down on previous occasions so that there is insufficient metal for another grind, replace the head with a new one.

   ![Fig. 3-2-35 Checking the cylinder head surface for distortion](KT3-213)

**Surface distortion**

<table>
<thead>
<tr>
<th>Standard</th>
<th>Serviceable limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05 (0.0020)</td>
<td>0.10 (0.0039)</td>
</tr>
</tbody>
</table>

**Head thickness**

<table>
<thead>
<tr>
<th>Standard</th>
<th>Serviceable limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>95 ± 0.1 (3.74 ± 0.0039)</td>
<td>0.30 (0.0118)</td>
</tr>
</tbody>
</table>

(2) To mount
1) Apply adhesive (Super Three Bond No. 1210) to the lower part of new copper sleeve.

2) Set O-ring into cylinder head and carefully fit in new sleeve.

3) Press the sleeve against cylinder head with until properly seated, using the sleeve bar (09472-1210).

4) Insert a 9.5±0.5 mm (0.374±0.00197 in) diameter steel ball (9800-06100) into the sleeve. Push the pin with the sleeve bar (09472-1210) so that the power part of sleeve will jam against the cylinder head.

   ![Fig. 3-2-36 Removing the nozzle seat](KT3-214)
5) Machine the lower part of nozzle sleeve to 120°.

2. Push rod guide
   (1) Removing the old guide pipe
   Pick the caulked part of the guide pipe at both upper and lower sides by a driver carefully so that you do not damage the guide pipe. Then take out the guide pipe. And also, be careful not to remain the tip-flakes in the cylinder head.

   (2) Fitting the new guide pipe
   Clean off any dirt and dust from the caulking part of the cylinder head at both upper and lower and apply “Three bond No. 1215” or equivalent to it sufficiently.
   To prevent the pipe from projecting out of the lower surface, put the cylinder head on such a flat and smooth face as the flat base, facing the upper side upwards. Insert the new clean guide pipe into the hole until the guide pipe lower end face and cylinder head lower surface become a smooth flat.

   (3) Caulking the guide pipe
   Insert the special tool (09482-1320) and hit in it until the grooved part in the special tool goes down below the guide pipe upper end face. Then push out the special tool by hitting in pin from the lower side of the cylinder head. And vice versa.

4) Checking
   Finally check the sealing efficiency.

3. To assemble and adjust
   To assemble valve system
   (1) Insert intake and exhaust valves from the bottom of cylinder head. Insert the valve spring, and upper spring seat, in that order. Finally, fit valve stem key securely to upper spring seat with valve spring press (09470-1021).
NOTE:
1. Apply engine oil to valve stem before inserting it in valve guide.
2. To mount outer and inner valve springs, both of which have irregular pitches, see that their white-painted sides are turned down.
3. Take care in using special tool so that the valve stem seal on the top of the valve guide is not damaged by contact with upper spring seat.

4. To assemble cylinder head

(1) Clean cylinder block where cylinder head is to be mounted. Place cylinder head gasket on the top of cylinder block following the cylinder head gasket guiding boss.

NOTE:
1. Be sure not to use an old cylinder head gasket. This is necessary to prevent gas leakage.
2. Mount cylinder head gasket with the side stamped part No.(11115-1121) upwards. (see Fig. 3-2-40). Gasket should be kept free from oil or water.

(2) Place cylinder head on the head gasket.
(3) Insert tappet.
(4) Insert the push rod, after applying oil to both ends.
(5) Make sure that both top end of valve and inside of valve stem cap are free from dust. Apply oil to the surface of valve head to insert in valve stem cap, taking care not to let the cap fall into the engine.
(6) Apply oil to the end of rocker arm and the surface of the adjusting screw.
(7) Make sure the No.1 rocker support has an oil inlet port on the bottom, and that the upper surface of rocker-arm shaft between No.3 and No.4 cylinders is marked "UP."
This is necessary to avoid incorrect assembly which results in the valve system seizing up.

(8) Make sure the top surface of cylinder head and the bottom of rocker support are free from dust, chips, and other foreign matter. Then set the rocker-arm assembly.
(9) Make sure that the push rod interlocks with adjusting screw. Then screw in all six rocker support bolts two or three threads by hand to fix their position. Then, tighten them in No. 3, 4, 2, 5, 1 and 6 sequence (see Fig. 3-2-44).
Tightening torque:

<table>
<thead>
<tr>
<th>Bolt No.</th>
<th>O.D.</th>
<th>Unit: kg-cm (lb.ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 26</td>
<td>14 mm</td>
<td>1,800 – 1,900</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(131 – 137)</td>
</tr>
<tr>
<td>27 – 32</td>
<td>10 mm</td>
<td>650 – 750</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(48 – 54)</td>
</tr>
</tbody>
</table>

**NOTE:**
Rocker arm supports are also tightened by the six cylinder head bolts (Shaded number in Fig. 3-2-45).

(11) Mount nozzle holder

Tightening torque: 130–190 kg-cm (10–13 lb.ft.)

(12) Retighten cylinder head bolt

After retightening cylinder head bolt, run the engine for about thirty minutes at a water temperature of about 80°C. Then loosen cylinder each head bolt 1/8 – 1/4 turn and retighten, in sequence, to specified torque.

**Engine 3-27**

Fig. 3-2-47 Special tool for retightening

**NOTE:**
1. Be sure to loosen one bolt at a time, then retighten it before going on to the next bolt.
2. Retighten the six bolts Nos. 4, 5, 12, 13, 20 and 21 (Fig. 3-2-49) with special socket wrench No. 09839-1701.
3. By retightening, face pressure of cylinder head is restored from point B to C as shown in Fig. 3-2-48.

Fig. 3-2-48 Effect of retightening

**Mounting intake and exhaust manifold**

(1) To mount intake and exhaust manifolds.

<table>
<thead>
<tr>
<th>Unit: kg-cm (lb.ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake manifold</td>
</tr>
<tr>
<td>Exhaust manifold</td>
</tr>
</tbody>
</table>

(2) Assemble all other parts in reverse order of their removal.
Adjusting the valve clearance

1. 6-time adjusting
   (1) Turning the crankshaft, fit the mark "1-6" of the flywheel to the pointer. Then either piston No. 1 or 6 will be top dead center.

2. If there is play in both No.1 intake and exhaust rocker arms, No.1 piston is top dead center in the compression stroke.

3. After positioning the No.1 piston at the top dead center, insert a feeler gauge between the rocker arm and valve stem adjust.
   The clearance by turning the adjuster screw with a screw driver. Then set the clearance by the locking nut. Adjust the intake and exhaust valves of each cylinder at the same time.

Locking nut tightening torque

400 - 500 kg·cm (29 - 36 lb·ft.)

<table>
<thead>
<tr>
<th>Valve clearance</th>
<th>Unit: mm [in]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake</td>
<td>Exhaust</td>
</tr>
<tr>
<td>0.30 (0.0118)</td>
<td>0.40 (0.0159)</td>
</tr>
</tbody>
</table>

(4) Turning the crankshaft (crank pulley) clockwise by 120°. Adjust the valve clearance for each cylinder in the firing order (1-4-2-6-3-5), as shown in Fig. 3-2-51.

2. Secondary adjustment
   Set No.1 piston to top dead center of the compression stroke as per above. In this position the valve and may be adjusted. Rotate the crankshaft 360° so the piston of the No.6 cylinder will be top dead center, then valves and may be adjusted.

<table>
<thead>
<tr>
<th>Cylinder No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve arrangement</td>
<td>I</td>
<td>E</td>
<td>I</td>
<td>E</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Clearance can be adjusted at these valves (*) with No.1 piston at T.D.C. on compression stroke</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cylinder No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve arrangement</td>
<td>I</td>
<td>E</td>
<td>I</td>
<td>E</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Clearance can be adjusted at these valves (*) with No.6 piston at T.D.C. on compression stroke</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

NOTE:
If cylinder head is retightened after valve clearance has been adjusted. The clearances will change therefore the cylinder head should be tightened before adjusting valve clearance.

Fig. 3-2-49 Timing mark on flywheel

Fig. 3-2-50 Adjusting valve clearance

Fig. 3-2-51 Firing order

Fig. 3-2-52 Valve arrangement
2. Adjusting injection timing

(1) Turn flywheel in the normal direction (counter-clockwise).

Stop as 17° mark before No.1 piston reaches TOP Dead Center, and make sure that the inscribed line on the injection pump timer is also aligned with the pointer.

| Injection timing | 17° before top dead center |

If misaligned, loosen the two coupling bolts, turn timer counterclockwise (in the direction indicated with the arrow) to align the inscribed liner with the pointer. Finally, tighten the bolts. (The injection pump itself turns clockwise).

| Tightening torque: | 300 – 350 kg·cm (21.7 – 25.3 lb·ft) |
3-3 CYLINDER BLOCK, LINER & CAMSHAFT

DESCRIPTION

1. Cylinder Block and Liner

Cylinder block

The dry liner-type, special cast iron cylinder block is comparable to the EH100 or EH300 in overall rigidity. Moreover, this block has additional reinforcing around the cylinder walls to further enhance its inherent rigidity.

The cylinder liner is of high tensile cast iron, surface treated inside and out. It is designed to fit the cylinder block perfectly, and sustain the fittness at all times.

Cylinder liner

The dry liner-type special cast iron cylinder liner, is super-precision machined on both inner and outer surfaces. Moreover, it is subjected to heat treatment so the sleeve well fit in with cylinder block with proper clearance.
2. Camshaft

![Camshaft Diagram]

1. Camshaft  
2. Thrust plate  
3. Camshaft gear  
4. Collar  
5. Nut  
6. Thrust plate  
7. Bushing  
8. Idler gear  
9. Thrust bearing  
10. Pin  
11. Idle gear shaft

**Fig. 3-3-2 Camshaft**

The carbon steel camshaft has seven journals. The surfaces of cam and journal are subjected to induction heat treatment and grinding work. Then they are Parkerized to assure exact fit in low tolerances. The specially curved cam profile improves suction efficiency, and operates quietly.

**Removal**

1. **Removal of cylinder liner**
   
   (1) Remove cylinder head and related parts.  
   (2) Remove cooling fan and pulley.  
   (3) Remove timing cover and gear.  
   (4) Remove the oil pan and related parts.  
   (5) Loosen connecting rod cap bolt and remove piston and connecting rod.

   (6) Withdraw each cylinder liner from cylinder head side with a cylinder liner puller (09420-1210). Number the removed cylinder liners in order and arrange them in clean place.

**Fig. 3-3-3 Removal of cylinder liner**

KT3-224
NOTE:
Before removing cylinder liner, put line-up marks on cylinder block and liner flange surface with paint or indelible ink. Do not scratch. Liners must be replaced in their original positions. Too much force may cause distortion as liners are very thin.

2. Removal of camshaft

(1) Remove crankshaft pulley.
(2) Remove timing gear cover.
(3) Remove oil slinger.
(4) Remove fuel injection pump coupling.
   Remove the two thrust bearing set bolts and take out pump drive gear and shaft. Use puller or press to remove pump drive gear from shaft.
(5) Remove the two thrust bearing set bolts and take out camshaft assembly.

(6) Remove the two set bolts to take out idle gear. Remove flange set bolts and take out idle gear shaft with a sliding hammer.

(7) Remove drive gear from camshaft.
To remove, put the cam gear in a vise with a wooden pillow block on the jaws. Loosen the lock washer and remove the nut. Use a press to remove the gear.

INSPECTION AND REPAIR

1. Cylinder Block

1. Visually inspect the cylinder block for cracks and check the condition of the bores (into which the liners are fitted). Visually inspect the cylinder head, timing gear case, and flywheel housing for damage, examining the locating pins for galling or distortion and the screw threads for stripping.

2. If a crack is found, determine whether it can be repaired or not. A minor crack can be repaired satisfactorily by manual-arc welding, patching or caulking. Use a low-temperature welding electrode when welding and lead wire as filler when patching or caulking.

3. Check the warpage along the top face of cylinder block with a straight edge and feeler gauge. The measurements should be made along the sides and across the corners of the cylinder block. Slight or minor distortion can be corrected by grinding with a suitable grinder.
When a block is distorted so badly that there is insufficient metal to grind, replace the block.

<table>
<thead>
<tr>
<th>Standard</th>
<th>0.05 mm (0.00197 in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repair limit</td>
<td>0.10 mm (0.00394 in)</td>
</tr>
</tbody>
</table>
2. Cylinder Liner

1. Check for interior wear, stains, deformation ridges, cracks, scaling and rust.

2. Use a cylinder gauge to measure cylinder liner wear. Measure inside diameter of the liner.
   At each point of measurement take two measurements at right angle with each other.
   The standard inside diameter of the cylinder liner is 110 mm (4.331 in). Replace the liner if worn more than 0.15 mm (0.0059 in).

3. When replacing the piston rings only, ensure to check the inside of the cylinder liner thoroughly. If there is stepped wear, ream out with the ridge reamer.

3. Clearance between piston and cylinder liner

Measure the minimum inside diameter of cylinder liner on its lower part and the maximum outside diameter of piston at right angles to piston pin 64.2 mm (2.528 in) above the piston skirt, with cylinder gauge and micrometer. The clearance is the difference between the two figures. If the clearance is too much, replace both sleeves and piston rings.

<table>
<thead>
<tr>
<th>Diameter of piston and liner</th>
<th>Standard clearance</th>
<th>Measuring position</th>
</tr>
</thead>
<tbody>
<tr>
<td>110 (4.331)</td>
<td>0.192 – 0.224</td>
<td>Lower part of piston</td>
</tr>
<tr>
<td>(0.0076 – 0.0088)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:**

Lower part of piston means at right angles to the pin and 64.2 mm (2.528 in) from the bottom of the piston.
4. Inspection of camshaft
1. Check cam lobe and journal for damage and wear.
   Bent of cam shaft support: fix both ends of camshaft Fig. 3-3-12 to V-block, place dial gauge on the
   center journal, and turn camshaft checking for bent. If bent is beyond the limit, replace shaft, or correct
   it with at press.

   Limit: 0.05 mm (0.00197 in)

   NOTE: Actual is half the gauge reading.

   Fig. 3-3-12 Measuring camshaft bent

2. Measure the diameter of each camshaft journal, front rear and in the directions of X and Y with
   a micrometer. If the measurement value is beyond the limit, replace camshaft.

   Fig. 3-3-13 Measuring journal outside diameter

Journal outside diameter

<table>
<thead>
<tr>
<th>No.</th>
<th>Journal outside diameter</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>61.5 (2.421)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>61.3 (2.413)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>61.1 (2.406)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>60.9 (2.398)</td>
<td>−0.15</td>
</tr>
<tr>
<td>5</td>
<td>60.7 (2.390)</td>
<td>(−0.0059)</td>
</tr>
<tr>
<td>6</td>
<td>60.5 (2.382)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>58.3 (2.295)</td>
<td></td>
</tr>
</tbody>
</table>

If cam or journal is only slightly damaged or developing a ridge, correct them with an oil stone.

Fig. 3-3-14 Journal outside diameter measuring position

3. Journal and bearing wear
   Measure the journal outside diameter and bearing inside diameter at several points, compare this value
   with the nominal size (refer to the Table of REPAIR SPECIFICATIONS) to determine the wear. Check clearance between journal and bearing with a cylinder gauge and micrometer. If the wear exceeds 0.15 mm (0.0059 in), replace.

Fig. 3-3-15 Measuring camshaft bearing inside diameter
4. Measurement of cam
Take measurement at two points, rear and front on the cam lobe by means of micrometer. If the camshaft is found beyond the limit, replace.

![Fig. 3-3-16 Cam lift](image)

<table>
<thead>
<tr>
<th></th>
<th>A dimension</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake</td>
<td>52.98 (2.0858)</td>
<td>-0.08 (-0.0031)</td>
</tr>
<tr>
<td>Exhaust</td>
<td>51.97 (2.0486)</td>
<td></td>
</tr>
</tbody>
</table>

5. Assembly and Adjustment
Cylinder liner and cylinder block are of four kinds selective fit. Liner flange is stamped with different marks indicating liner outside diameter; W, X, Y, and Z. The top surface of cylinder boock and its side are stamped with corresponding marks indicating inside diameter of the cylinder liner.

1) Insertion of new cylinder liner
Insert new cylinder liner, after making sure the marks W, X, Y, and Z on the liner flange and cylinder block are the same.

![Fig. 3-3-18 W.X.Y. and Z marks on cylinder block](image)

5. Camshaft end play
Measure the clearance between thrust bearing and No.1 journal of the camshaft with a feeler gauge. If the clearance exceeds 0.3mm (0.012 in), replace.

![Fig. 3-3-17 Measuring cam shaft end play](image)

![Fig. 3-3-19 W.X.Y. and Z marks on cylinder liner](image)
(2) To insert a used cylinder liner
Be sure to align the cylinder liner with the line up marks made when disassembling.

2. Cylinder liner protrusion measurement
Use liner puller to press [tighten to 100 kg-cm (7.3 lb-ft.)] torque. Then, measure the flange portion protruding from the top of cylinder block with a dial gauge or straight edge, and a feeler gauge. If the measurement is below the tolerance, Liner puller (09420-1210).

(3) To insert cylinder liner, apply engine oil or spindle oil lightly to the outer surface and apply uniform pressure to the whole liner flange. If it is difficult to insert the liner manually, use special tool 09480-1040).

Fig. 3-3-20 Inserting the cylinder liner
KT3-236

Fig. 3-3-21 Inserting the cylinder liner
KT3-237

Fig. 3-3-22 Checking the liner protrusion
KT3-238

Fig. 3-3-23 Protrusion

PROTRUSION 0.01 – 0.07 mm (0.0004 – 0.0028 in)  PRESSURE 500 kg (1,100 lb)
3-4 PISTON, PISTON RING & CONNECTING ROD

DESCRIPTION

1. Connecting rod
The big end of the connecting rods is cut horizontally as shown in Fig. 3-4-1. The bushing in the large end of the rod is thin kelmet with lead alloy plating for improved contact smooth. The bushing in the small end is bronze. There is an oil passage from the big-end of con-rod (crank pin side) to the small-end (piston pin side).

Oil goes through this passage from the big end, lubricates the piston pin and also cools the inside of the piston.

2. Piston, piston pin, piston ring
1. Piston is made of heat resistant aluminum alloy and has toroidal combustion chamber for efficient fuel consumption. The barrel-shaped configuration is least distorted by thermal expansion and piston head shaking. It consists of an oval top section, a composite-oval ring land middle section, a single-oval bottom section.

Fig. 3-4-1 Piston and connecting rod

Fig. 3-4-2 Piston
2. The piston rings consist of three compression rings and an oil ring with coil expander incorporated. Moreover, the top, third, and oil rings are chrome-plated for abrasion resistance. The rings are so designed and constructed for optimum lubrication, minimum friction loss and to prevent compression leakage and interior abrasion.

<table>
<thead>
<tr>
<th>TOP RING</th>
<th>HARD CHROME PLATED</th>
</tr>
</thead>
<tbody>
<tr>
<td>SECOND RING</td>
<td></td>
</tr>
<tr>
<td>THIRD RING</td>
<td>HARD CHROME PLATED</td>
</tr>
<tr>
<td>OIL RING</td>
<td>HARD CHROME PLATED</td>
</tr>
</tbody>
</table>

Fig. 3-4-3 Piston ring

3. The full-floating piston pin is made of case-hardened steel.

(5) Withdraw piston and connecting rod through the top of the block. Remove the pistons in pairs as follows: No.1 – No.6, No. 2 – No.5, and No.3 – No.4.

Fig. 3-4-5 Removing piston

NOTE:

1. When withdrawing the piston, keep the big end of connecting rod from scoring the inside of the cylinder liner.
2. Be careful not to drop the bearing from the big end of the connecting rod, or damage it in any way.
3. Keep the pistons, connecting rods, etc. in order, by cylinder No. and installation sequence and connecting rod or cap side.
4. Before removing the piston, scrape off any carbon deposits on the inside of the cylinder liner with a scraper or sand paper (#150).

DISASSEMBLY

1. Removing the piston pin

1. Use pliers to remove the pin retainer ring at either end. Hold the connecting rod firmly by hand, and tap the piston pin out with a mallet and wood dowel. If difficult, do not force. Warm the piston first in hot water 80 – 90°C (176 – 194°F) and then tap out the pin.

Fig. 3-4-4 Removing connecting rod cap  KT3-240

Fig. 3-4-6 Removing piston pin  KT3-242
2. Remove the piston ring with piston ring expander No. (09442-1011).

Fig. 3-4-7 Removing piston ring

NOTE:
1. Take care in holding the piston rings which are made of special cast iron that is subjected to breakage.
2. If reusing the piston rings, be careful to reassemble them in the correct order. Therefore, place the rings aside in order they are removed.

2. Inspection and adjustment

Completely clear the top of piston and ring groove of carbon, sludge, etc. and wash them in solvent.

1. Inspection of pistons and piston rings
   (1) Check the circumference of the top surface of piston for cracks and melting and the ring groove for damage. If they are faulty, replace them.
   (2) Check piston rings for wear, torsion, and damage. If faulty, replace.
   (3) Piston ring groove clearance
       After piston rings are set in the piston ring grooves, measure the clearance with a feeler gauge. When the clearance exceeds tolerance, measure the clearance once more. If it still exceeds limit, replace either piston or piston ring.

Piston ring/ring groove clearance

<table>
<thead>
<tr>
<th></th>
<th>Clearance</th>
<th>Ring groove width</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard</td>
<td>Limit</td>
</tr>
<tr>
<td>Top ring</td>
<td>0.06 – 0.10</td>
<td>0.4 (0.0024 – 0.0039)</td>
</tr>
<tr>
<td>Second ring</td>
<td>0.04 – 0.08</td>
<td>0.4 (0.0016 – 0.0031)</td>
</tr>
<tr>
<td>Third ring</td>
<td>0.04 – 0.08</td>
<td>0.4 (0.0016 – 0.0031)</td>
</tr>
<tr>
<td>Oil ring</td>
<td>0.02 – 0.06</td>
<td>0.08 (0.0008 – 0.0024)</td>
</tr>
</tbody>
</table>

(4) Piston ring gap

Put the piston ring in the cylinder liner and measure the gap in the ends of the ring with a feeler gauge. Insert the ring from the piston skirt. Take the measurement at the point of least wear. When the measurement exceeds the limit replace the piston rings.

Fig. 3-4-9 Clearance measurement of piston ring fitting

NOTE:
If the liner is new, the measurement can be taken anywhere.

Fig. 3-4-8 Measurement of piston ring groove

KT3-243

KT3-245

KT3-244
3-40 ENGINE

Piston ring gap

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>Limit</th>
<th>Remarks (Free length)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.3 – 0.45</td>
<td>2.5 (0.0984)</td>
<td>Approx. 11 (0.433)</td>
</tr>
<tr>
<td>Top ring</td>
<td>(0.0118 – 0.0177)</td>
<td>(0.0118 – 0.0177)</td>
<td>(0.0118 – 0.0177)</td>
</tr>
<tr>
<td>Second ring</td>
<td>0.3 – 0.45</td>
<td>1.2 (0.0472)</td>
<td>15.5 (0.6103) (Nippon Piston Ring)</td>
</tr>
<tr>
<td></td>
<td>(0.0118 – 0.0177)</td>
<td>(0.0118 – 0.0177)</td>
<td>15.0 (0.5905) (Riken Piston Ring)</td>
</tr>
<tr>
<td>Third ring</td>
<td>0.3 – 0.45</td>
<td>1.2 (0.0472)</td>
<td>Approx. 14.5 (0.5709)</td>
</tr>
<tr>
<td></td>
<td>(0.0118 – 0.0177)</td>
<td>(0.0118 – 0.0177)</td>
<td>(0.0118 – 0.0197)</td>
</tr>
<tr>
<td>Oil ring</td>
<td>0.3 – 0.5</td>
<td>1.2 (0.0472)</td>
<td>Approx. 12.5 (0.4921) (Nippon Piston Ring)</td>
</tr>
<tr>
<td></td>
<td>(0.0118 – 0.0197)</td>
<td>(0.0118 – 0.0197)</td>
<td>Approx. 10.5 (0.4134) (Riken Piston Ring)</td>
</tr>
</tbody>
</table>

2. Inspection of piston pin, piston pin hole, and the small end of the connecting rod
(1) Measurement of clearance between piston pin and piston pin hole

![Fig. 3-4-10 Measurement of piston pin O.D.](KT3-246)

Measure the inner diameter of piston pin hole and outer diameter of piston pin with a cylinder gauge and micrometer subtract to find the clearance between them. If the clearance exceeds serviceable limit, replace either pistons or piston pins.

Outer diameter of piston pin

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>Serviceable limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>39 (1.5354)</td>
<td>38.86 (1.5300)</td>
</tr>
</tbody>
</table>

Clearance between piston hole and piston pin

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>Serviceable Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.013 T – 0.014 L</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>(-0.00051 – 0.00055)</td>
<td>(0.0039)</td>
</tr>
</tbody>
</table>

NOTE: T: interference fit.
L: clearance

3. Connecting Rod

1. Small end bushing
   Measure the inside diameter of the bushing and outside diameter of piston pin. If clearance between bushing and piston pin exceeds 0.1 mm (0.0039 in), replace the bushing. The standard clearance is 0.015 – 0.036 mm (0.0006 – 0.0014 in).

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>Serviceable limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.015 – 0.036</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>(0.0006 – 0.0014)</td>
<td>(0.0039)</td>
</tr>
</tbody>
</table>

When replacing bushings, press in the new bushing so that the oil hole coincides with the hole in the connecting rod.
2. Inspection of connecting rod

(1) Check the inside of the connecting rod end holes for damage.

(2) Each connecting rod has oil channels for lubricating the bushing on the small end and for cooling the lower part of the piston. Use a wire or compressed air to make sure this oil channel is not blocked.

NOTE:
There is another oil hole on top of the small end of the connecting rod besides the one shown in Fig. 3-4-1.

(3) Bent and distortion measurement of connecting rod

Measure the bent and distortion of connecting rod with a connecting rod aligner. If the bent or distortion exceeds the serviceable limit, either straighten with a press, or replace.

Bent and distortion of connecting rod

<table>
<thead>
<tr>
<th>Unit: mm (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limit of bent per 100 (per 3.937)</td>
</tr>
<tr>
<td>Limit of distortion per 100 (per 3.937)</td>
</tr>
</tbody>
</table>

Length of connecting rod: 183.5 mm (7.2244 in.)

(4) Inside diameter of the big end hole

Tighten the cap bolts by tightening torque 1,850 - 1,850 kg-cm (120 - 134 lb-ft.) without the bearings and measure the inside diameter.

<table>
<thead>
<tr>
<th>Unit: mm (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard dia.</td>
</tr>
<tr>
<td>Roundness</td>
</tr>
</tbody>
</table>
(5) Measurement of connecting rod end-play
Clamp connecting rod to the corresponding crankshaft with the bearing. Tighten to standard torque 1,650 – 1,850 kg-cm (120 – 134 lb.ft.). Measure the end-play exceeds the serviceable limit, replace either the connecting rod or the bearing.

End-play of connecting rod

<table>
<thead>
<tr>
<th>Standard</th>
<th>Serviceable limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.20 – 0.50</td>
<td>0.60</td>
</tr>
<tr>
<td>(0.0078 – 0.0195)</td>
<td>(0.0236)</td>
</tr>
</tbody>
</table>

3. Inspection of connecting rod bearing
(1) Check the connecting rod bearings for wear, score and seizure.
(2) Measurement of oil clearance of connecting rod
Measure the inside diameter of the connecting rod bearing and outside diameter of crankshaft pin with a micrometer and cylinder gauge. The difference is the oil clearance. Before measuring the inside diameter of bearing, tighten the cap bolts to standard torque, loosen once, then tighten the bolts to torque 1,650 – 1,850 kg-cm (120 – 134 lb.ft.) again.
Now measure the inside diameter at several points as shown in Fig. 3-4-19.

Fig. 3-4-19 Bearing measuring position

When the clearance between bearing and crankpin exceeds the limit, replace the bearings.
When crankpin shows extreme wear (see Item on crankshaft) or eccentric abrasion, grind the pin down and fit with undersized bearing (comes in four kinds of 0.25mm (0.0098 in), 0.50mm (0.0197 in), 0.75mm (0.0295 in), and 1.0mm (0.0394 in)).

Oil clearance

<table>
<thead>
<tr>
<th>Standard</th>
<th>Serviceable limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.031 – 0.082</td>
<td>0.30</td>
</tr>
<tr>
<td>(0.0013 – 0.0032)</td>
<td>(0.0119)</td>
</tr>
</tbody>
</table>

NOTES:
1. Plastigauge may be used to measure oil clearance.
2. Replace connecting rod bearings in sets of two, a combination of upper and lower bearings.
(3) Spread dimension of the bearing

The spread dimension (dimension A in Fig. 3-4-20) of the bearing is measured in its free state as a unit.

Standard: \[69.75 - 70.25 \text{ mm (2.746 - 2.766 in)}\]

Fig. 3-4-20 Spread of bearing

Never forcibly spread metal making apparent bearing spread.

(4) Crush height measurement

There is no need to measure crush height if the oil clearance is well controlled and bearing spread and roundness of the large end of connecting rod are within tolerances.

NOTE:
Do not loosen the cap bolts on one to measure the crush with a feeler gauge. Results thus obtained are unreliable.

4. Assembling

Apply engine oil to each rotating component before assembly.

1. Assembling piston and connection rod

See Fig. 3-4-21. See that mark "0" on top of piston and matching mark on connecting rod are positioned opposite to each other.

Fig. 3-4-21 Marks on piston

(1) To put piston pin in piston, fit one retainer ring to the end of piston pin hole; warm the piston in \[80^\circ - 90^\circ\text{C (176^\circ - 194^\circ}\text{F}}\] hot water; apply oil to piston pin hole; insert piston pin; fit remaining retainer ring to other side.

NOTE:
1. When holding the piston in a vise, use waste between the vise jaws and the piston head to prevent damage.
2. Take care not to damage the retainer ring already mounted by trying to force the piston pin in.

2. Mounting of piston ring

(1) To fit piston ring to piston, place piston skirt down and use piston ring expander (special tool No. 09442-1011). Hold piston ring stamped side up (top side of piston), and fit, beginning with the bottommost ring and working up in the sequence of Fig. 3-4-23 and Fig. 3-4-24.

Fig. 3-4-23 Fitting piston ring

(2) When fitting the oil ring, first determine the direction of the built-in coil expander.

1. Tightly close the joint of coil expander.
When the joint, \[180^\circ\], opposite to the joint of oil ring, put coil expander in oil ring.

(See Fig. 3-4-24).
2) Be careful not to confuse oil ring with other rings, as the oil ring is a set of coil and ring.

3) As shown in Fig. 3.4-27, mount piston so that the mark "0" on the piston head is on the tappet chamber side.

3. Mounting piston, connecting rod and others

(1) Fitting connecting rod bearing

As shown in Fig. 3.4-25, fit the bearing with two holes 4 mm (0.157 in) dia. to the cap side; one hole 6 mm (0.236 in) dia. to the connecting rod side. See that the seat at one end of bearing fits in with the slot at the end of connecting rod.

NOTE:

When fitting old bearings, make sure that they are mounted exactly where they were before disassembly.

(2) Fitting piston to cylinder

1) Turn crankshaft to set that piston at bottom dead center.
2) As shown in Fig. 3.4-26, arrange each ring, and push in piston head with a piston ring holder (special tool No. 09441-1041) and a wooden rod.

(3) Fitting connecting rod

1) Fit connecting rod and bearing to crankshaft pin. Observing the matching marks, mount cap and bearing.
2) Apply engine oil to the threads and seat surface of the cap bolt. Tighten bolt at the specified torque, and then loosen it. Retighten it to the specified torque.

![Image of engine parts](image)

Fig. 3-4-29 Tightening the cap bolt

KT3-261

3) Complete the mounting of connecting rod and piston in 1-6, 2-5, 3-4 sequence.

4) Turning the crankshaft, after completion of mounting of piston, may sometimes cause the liner to slip. To prevent this, use the Liner Stopper shown in Fig. 3-4-30.

![Image of engine parts](image)

Fig. 3-4-30 Liner stopper

KT3-262

(4) Mounting the strainer

1) After checking the suction pipe and strainer for damage and cracks, temporarily tighten the bolts 1 – 4 as shown in Fig. 3-4-31.

![Image of engine parts](image)

Fig. 3-4-31 Suction strainer

2) Tighten the bolts in the sequence of (1), (2), (3), and (4), while making sure the suction pipe and strainer O-ring sealing surface are properly aligned.

<table>
<thead>
<tr>
<th>Bolt No.</th>
<th>Tightening Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>450 – 500 (33 – 36)</td>
</tr>
<tr>
<td>1, 2, 3</td>
<td>130 – 180 (10 – 13)</td>
</tr>
</tbody>
</table>

Unit: kg-cm (lb-ft.)

(5) Fitting oil pan

The oil pan gasket is a double fitting type. Fit the gasket with its teeth positioned on the oil pan side (See Fig. 3-4-32).

![Image of engine parts](image)

Fig. 3-4-32 Fitting the gasket

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Tightening torque:
180 – 230 kg-cm (14 – 16 lb.ft.)

NOTE:
1. Straighten the flange of the oil pan if it is bent or damaged.
2. There is no need to apply a bonding agent to the oil pan gasket.
3. Tighten the oil pan drain plug securely on its gasket.

6. Mount cylinder head on the head gasket. (To mount the cylinder head, see 3-26, 4. To assemble cylinder head.) Mount other related parts.

Fig. 3-4-33 Oil pan and gasket
1. Crankshaft

Crankshaft is made of specially forged steel. The filler R of each pin and journal is subjected to induction heat treatment to provide proper strength. Front oil seal is equipped with dust slinger to keep dust out. In addition, more flywheel mounting bolts increases the forces of clamping crankshaft and flywheel together.
2. Removal and disassembly
   1. Remove fan-pulley assembly.
   2. Loosen bolts on timing gear case, flywheel and oil seal retainer and remove them.
   3. Remove journal bearing caps and connecting rod caps.
   4. Withdraw the crankshaft sleeve with a puller front (09420-1071), rear (09420-1420).
   5. Withdraw crankshaft from cylinder block.

NOTE:
Do not remove crankshaft gear, unless absolutely necessary.

3. Inspection and Repair
   1. Crankshaft
      Clean crankshaft completely with solvent the use compressed air to check the oil channel bore for blockage.

Fig. 3-5-3 Oil seals on crankshaft

Fig. 3-5-4 Removing crankshaft sleeve

Fig. 3-5-5 Removal of crankshaft

Fig. 3-5-6 Measuring outside diameter of pin and journal

Fig. 3-5-7 Measuring points
2. Check crankshaft for cracks with die or magnetic detector. In particular, carefully check oil channel bore and fillet R of pin and journal.
3. Check surface of crankshaft pin and journal for roughness or scores. If faulty, either replace or regrind the crankshaft.
4. Measurement of outside diameter of crankshaft journal and pin
   Measure with a micrometer as shown in Fig. 3-5-8, by grinding down to take an undersized bearing (see Table for crankshaft machining). If the value exceeds the serviceable limit, replace.

<table>
<thead>
<tr>
<th>Under size</th>
<th>Outside diameter (Standard)</th>
<th>Outside diameter (Serviceable limit)</th>
<th>Outside diameter (Repair limit)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crankpin</td>
<td>Journal</td>
<td></td>
</tr>
<tr>
<td>0.25 US</td>
<td>64.75 - 0.04 mm</td>
<td>73.75 - 0.04 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.5492 - 0.0016 in)</td>
<td>(2.9035 - 0.0016 in)</td>
<td></td>
</tr>
<tr>
<td>0.50 US</td>
<td>64.50 - 0.04 mm</td>
<td>73.50 - 0.04 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.5394 - 0.0016 in)</td>
<td>(2.8937 - 0.0016 in)</td>
<td></td>
</tr>
<tr>
<td>0.75 US</td>
<td>64.25 - 0.04 mm</td>
<td>73.25 - 0.04 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.5295 - 0.0016 in)</td>
<td>(2.8839 - 0.0016 in)</td>
<td></td>
</tr>
<tr>
<td>1.00 US</td>
<td>64.00 - 0.04 mm</td>
<td>73.00 - 0.04 mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.5197 - 0.0016 in)</td>
<td>(2.8740 - 0.0016 in)</td>
<td></td>
</tr>
</tbody>
</table>

To correct crankshaft by grinding, make sure the fillet R of pin or journal is not small. Also, make sure the fillet forms a continuous curve at the corner.

<table>
<thead>
<tr>
<th>Dimension of fillet R</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin</td>
<td>4 ± 0.2 (0.157 ± 0.0078)</td>
</tr>
<tr>
<td>Journal</td>
<td>3 ± 0.5 (0.118 ± 0.0197)</td>
</tr>
</tbody>
</table>

Fig. 3-5-8 Fillet radius
4. Crankshaft bent
Support both ends of crankshaft journal on the V blocks, and attach a dial gauge on the center journal and check its alignment.

Fig. 3-5-9 Measuring the crankshaft bent

If the value is more than 0.09 mm (0.0035 in), regrind the crankshaft to undersize or repair by press.
1. Inspection of crankshaft main bearing
   (1) Bearing cap roundness measurement
   Clamp main bearing cap of crankshaft to cylinder block at specified torque, then loosen it. Retighten it at specified torque of 1,400 – 1,600 kg·cm (102 – 115 lb·ft.). Take roundness measure of the section with a cylinder gauge. If measurement exceeds the limit, either line bore after padding, or make replace the cylinder block.

(2) Measurement of inside diameter of crankshaft bearing
   With crankshaft main bearing set to cylinder block and cap, tighten cap bolt to specified torque. Measure inside diameter with a cylinder gauge. Also, measure outside diameter of crankshaft journal with a micrometer. The difference between the two measurements is the oil clearance. If the clearance exceeds tolerance, replace the bearings.
Oil clearance

<table>
<thead>
<tr>
<th>Standard</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1 - No. 7 bearing</td>
<td>0.051 - 0.102 (0.0020 - 0.0040)</td>
</tr>
</tbody>
</table>

If crankshaft journal is extremely worn shows eccentric abrasion, correct by grinding down to take an undersized bearing (available in four kinds of 0.25mm (0.001 in), 0.50mm (0.02 in), 0.75mm (0.03 in), and 1.00mm (0.04 in)).

**NOTE:**
1. Oil clearance measurement can also be taken with plastigauge.
2. Be sure to replace bearings in sets of upper and lower bearings.

(3) Spread dimension of the bearing
Spread dimension (dimension A in Fig. 3-5-13) of the bearing is measured in its free state as a unit.
Standard: 79.75 - 80.25 mm (3.14 - 3.16 in.)

Fig. 3-5-13 Spread dimension of bearing

(4) Crush height measurement
There is no need to take a crush height measurement if the oil clearance, bearing spread and cap roundness meet tolerances.

**NOTE:**
Do not measure with a feeler gauge after loosening one cap bolt as such a measurement is not accurate. Never correct the fitting surface between cylinder block and cap by grinding.

(5) End play
Measure end play with a thickness gauge while moving to the side with a screw driver or lever as shown in Fig. 3-5-14. Nominal play is 0.05 - 0.219 mm (0.0020 - 0.0086 in). If more than 0.5 mm (0.0197 in), replace the thrust bearing. After endplay is correct, lock the cap bolt.

![Fig. 3-5-14 End play measurement](KT3-272)

Inspection of oil seal
Check the lip of the crankshaft oil seal for wear and damage.

Assembling and mounting
(1) Insert crankshaft gear in crankshaft with a press.
(2) Mount crankshaft rear sleeve.
To mount, fit O-ring to the inside of sleeve, apply engine oil to O-ring, and drive it in with a sleeve press (09482-1400). Insertion is complete when the press contacts the surface of crankshaft.

Fig. 3-5-15 Fitting sleeve

![Fig. 3-5-15 Fitting sleeve](KT3-273)
(3) Clean cylinder block with solvent, then blow any remaining grit or dust off with compressed air.

(4) Fit crankshaft bearings to cylinder block with bearing caps.

(5) Fit thrust bearing to the No.4 bearing cap side. As shown in Fig. 3-5-17, see that the four thrust bearings at either end of journal support and No.4 bearing cap, are mounted with the oil groove facing to the crankshaft side.

(8) Fit crankshaft bearing cap. Tighten it to specified torque then loosen. Retighten to specified torque. Tightening torque: 1,400 – 1,600 kg-cm (102 – 115 lb-ft.)

(9) After tightening each cap, turn crankshaft to be sure that it rotates smoothly.

(10) Mount oil pump, timing gear case, suction strainer, and oil pan.

(11) Fit crankshaft pulley center to crankshaft, insert collar, and tighten front nut.

(12) Mount crank pulley.

(13) Mount rear oil seal and oil seal retainer.
4. Mounting oil seal

Use the jig placed as shown in Fig. 3-5-21 to press the sleeve in. Apply lithium grease to the oil sealing lips.

Fig. 3-5-20 Oil seal

Fig. 3-5-21 Mounting oil seal

5. Mounting/dismounting of front sleeve and dust slinger

Fig. 3-5-22 Mounting dust slinger

Fig. 3-5-23 Mounting/dismounting of front sleeve
6. Flywheel and ring gear

1. Remove ring gear. To remove, leave flywheel with ring gear in hot water at about 100°F for 3 - 4 minutes, then place something holding ring gear and tap the flywheel lightly around the edges until it comes out.

7. Inspection and Correction

1. Inspection of flywheel

   (1) Check friction surface of flywheel for cracks and damage. Replace if excessively damaged. Repair correctable faults.

   (2) Measure the thickness of flywheel with appropriate device. Replace if the thickness exceeds the serviceable limit.

   | Thickness of flywheel | 17.0 mm (0.67 in) |
   | Serviceable limit     | 16.0 mm (0.63 in) |

(3) Measure the distortion of flywheel friction surface with a dial gauge. If the distortion exceeds 0.3 mm (0.0118 in) correct by grinding.

2. Inspection of ring gear

   Check ring gear teeth for wear and damage. Replace faulty gears.

3. Inspection of flywheel housing

   Check for cracks.
8. Assembling and mounting

1. Mount flywheel ring gear
   Leave ring gear in hot water at temperature of about 100°C (212°F) for 3 – 4 minutes. Then, fit it quickly to flywheel and bolt down.
   Tightening torque: 260–320 kg-cm (19–23 lb.ft.)

2. Installing flywheel housing to cylinder block
   Tightening torque:
   400–500 kg-cm (29–36 lb.ft.) (10 mm dia bolt)
   650–870 kg-cm (47–62 lb.ft.) (12 mm dia bolt)

9. Mounting Crankshaft and Flywheel

Carefully clean the mounting surfaces of the crankshaft and flywheel. Match the “O” marks on flywheel and crankshaft collar and tighten opposite bolts evenly, tightening slightly each time in sequence. The final tightening torque is 1,800 – 2,000 kg-cm (131 – 144 lb.ft.)
3-6 TIMING GEAR & CASE

DESCRIPTION

The arrangement of the timing gears is shown Fig. 3-6-1. The gears are helical, reducing noise and extending their service life. All gears are stamped with identification marks as shown in Fig. 3-6-1, to facilitate assembly.

Fig. 3-6-1 Gear train
OVERHAUL

DISASSEMBLY

Fig. 3-6-2 Timing gear case

1. Timing cover
2. Timing gear cover gasket
3. Oil seal

Fig. 3-6-3 Timing gear

1. Camshaft gear
2. Idler gear
3. Thrust plate
4. Bushing
5. Thrust plate
6. Pin
7. Idler gear shaft
8. Injection pump gear
9. Crank shaft gear
10. Oil pump gear
(1) After removal of crank pulley, loosen the timing gear cover clamping bolt to dismount the cover.

NOTE: In removing the cover (aluminum alloy), pay utmost attention not to damage it.

(2) Camshaft removal
Remove two thrust plate clamping bolts from the crankcase, and remove the gear, raise the turnups of the lock-washer, and use a puller after removal of the nut.

(3) Injection pump drive gear removal
Remove the coupling from the injection pump, loosen the nut, and remove the pump gear and shaft block.
To remove the gear from the shaft, use a puller.

(4) Idle gear removal
Loosen the clamping bolt, and remove the idler gear. To remove the idle gear shaft, loosen the flange clamping bolts and use a sliding hammer to remove the idle gear shaft.

1. INSPECTION

1. Inspection of injection pump drive shaft
(1) Check for wear and damage. Replace if faulty.
(2) Measurement of outside diameter of pump drive shaft
Measure outside diameter of drive shaft, also measure inside diameter of bushing, with a micrometer and a dial gauge. The difference between the two measurements is the clearance between shaft and bushing.

Clearance between shaft and bushing Unit: mm (in)

<table>
<thead>
<tr>
<th>Standard</th>
<th>Serviceable limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.030 – 0.072</td>
<td>0.3</td>
</tr>
<tr>
<td>(0.0012 – 0.0028)</td>
<td>(0.0118)</td>
</tr>
</tbody>
</table>

Fig. 3-6-5 End play measurement of pump gear

2. Inspection of idle gear shaft
(1) Check gear teeth for wear and damage. If faulty, replace.
(2) Measure idle gear shaft outside diameter and gear bushing inside diameter.
Measure clearance between idle gear and idle gear shaft with a micrometer and a cylinder gauge.

Fig. 3-6-6 Measuring idle gear shaft O.D.
Idle gear and idle gear shaft

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>Serviceable limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearance</td>
<td>0.025 - 0.075</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>(0.0010 - 0.0029)</td>
<td>(0.0078)</td>
</tr>
<tr>
<td>Outer diameter</td>
<td>34</td>
<td>33.85</td>
</tr>
<tr>
<td>of shaft</td>
<td>(1.3386)</td>
<td>(1.3328)</td>
</tr>
</tbody>
</table>

(3) End play measurement of idle gear
Insert feeler gauge between idle gear and thrust bearing to measure end play. If the measurement exceeds serviceable limit, replace the thrust bearings.

End play

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>Serviceable limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.03 - 0.11</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>(0.0012 - 0.0043)</td>
<td>(0.0119)</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 3-6-8 Mounting the camshaft drive gear

(2) Mount idle gear shaft, making sure of it oil hole and cylinder block oil channel. Check oil hole of idle gear shaft for blockage, and see that shaft end is complete with screw (blind plug).

<table>
<thead>
<tr>
<th></th>
<th>Unit: kg-cm (lb-ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idler gear shaft filling bolt</td>
<td>500 - 650 (36 - 47)</td>
</tr>
<tr>
<td>Idler filling bolt</td>
<td>1,100 - 1,300 (80 - 94)</td>
</tr>
</tbody>
</table>

Fig. 3-6-9 Cylinder block oil channel

(3) Mount injection pump drive gear and shaft to cylinder block.
Thrust plate tightening torque:
190 - 260 kg-cm (14 - 19 lb-ft.)

(4) Mount idle gear, observing timing mark.
Thrust plate tightening torque:
1,100 - 1,300 kg-cm (80 - 94 lb-ft.)

(5) Mount oil pump
Tightening torque: 380 - 500 kg-cm (28 - 36 lb-ft.)

(6) Backlash measurement of each gear
Measure with dial gauge. Replace if faulty.

ASSEMBLY AND ADJUSTMENT

(1) Mount the camshaft assembly into the cylinder block and tighten the thrust plate with two bolts.
Tightening torque:
500 - 600 kg-cm (37 - 43 lb-ft.)

Note:
When installing the camshaft drive gear to the shaft, it must be tightened with following torque.
Tightening torque:
2,500 - 3,000 kg-cm (181 - 217 lb-ft.)
Backlash

<table>
<thead>
<tr>
<th>Gears</th>
<th>Standard</th>
<th>Serviceable limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crank gear — Idle gear</td>
<td>0.051 — 0.11</td>
<td>0.3</td>
</tr>
<tr>
<td>Idle gear — Camshaft drive gear</td>
<td>(0.0020 — 0.0043)</td>
<td>(0.0118)</td>
</tr>
<tr>
<td>Idle gear — Injection pump drive gear</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Camshaft drive gear — Oil pump drive gear</td>
<td>0.07 — 0.22</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0028 — 0.0086)</td>
<td></td>
</tr>
</tbody>
</table>

(7) Mount oil slinger
(8) Fit timing gear cover to cylinder block. Cut off any packing extending over oil pan surface.
(9) Inspect timing gear case and oil seal for cracks, wear on lip, tension, and deposits of foreign matter.
3-7 FUEL SYSTEM

DATA & SPECIFICATIONS

NOZZLE
   Type ........................................ BOSCH type, NIPPON DENSO make (ND-DLLA-150S31-33ND97)

NOZZLE HOLDER
   Injection pressure .................. 220 kg/cm² (3,128 lb/sq.in)

FUEL FILTER
   Type ........................................ Replaceable paper element type

DESCRIPTION

Fig. 3-7-1 Fuel system
1. Injection pump assy
2. Coupling assy
3. Auto timer assy
4. Injection pump assy
5. Governor assy
6. Fuel feed pump assy
7. Injection pump bracket
8. Injection pump drive gear
9. Injection pump drive shaft
10. Woodruff key
11. Woodruff key
12. Thrust bearing
13. Oil seal
14. Fuel filter assy
15. Retainer bracket
16. Clip
17. Fuel hose
18. Fuel hose
19. Bolt
20. Through feed pipe
21. 3-way joint
22. Fuel pipe bracket
23. Fuel injection pipe No. 1
24. Fuel injection pipe No. 2
25. Fuel injection pipe No. 3
26. Fuel injection pipe No. 4
27. Fuel injection pipe No. 5
28. Fuel injection pipe No. 6
29. Fuel injection pipe protection
30. Rubber cap skirt
31. Clip
32. Bolt
33. Soft washer
34. Oil pipe
35. Oil pipe
36. Bolt
37. Soft washer
38. Clip
39. Nozzle and holder assy
40. Nozzle holder assy
41. Nozzle assy
42. Packing pipe leakage ring
43. Nozzle leakage pipe

Fig. 3-7-2 Fuel system in position
1. Fuel System Piping and Its Operation

As shown in Fig. 3-7-1, the fuel feed pump draws fuel from the fuel tank. The fuel passes through the fuel filter and is fed to the fuel injection pump. The injection pump forces the fuel, under high pressure, through the injection lines to the nozzles where it is injected. Some fuel reached the nozzle lubricates the nozzle needle. After lubricating, it returns to the tank through the leakage pipe.

On the injection pump, a governor and timer are installed. The governor controls the idling speed and maximum speed of the engine, the timer adjusts the fuel-injection timing.

2. Precautionary Notes

1. Bleeding air from the fuel system.
   Never be air bubbles in the fuel. Bleed air from the fuel system in cases below;
   (1) When a new pump is used.
   (2) When the pump is used after a long period of cessation.
   (3) When the piping is loosened or replaced.
   (4) When air bubbles are found in the fuel.

Procedure
1) Between fuel tank and feed pump
   Loosen the connector at the feed pump outlet.
   Move the primary pump on the feed pump up and down to discharge the fuel, and close the connector when the air bubbles in the fuel have disappeared.

2) Between feed pump and filter
   Loosen the air bleeder screw equipped on the fuel filter and conduct air bleeding in accordance with the instructions given in 1) above.

3) Between filter and injection pump
   Air bleeding between filter and injection pump can be conducted automatically through the overflow pipe by operating the priming pump several times.

4) When bleeding has been completed, screw the priming pump knob firmly into the cylinder body so as to prevent the entry of air through it.

2. Injection steel pipe

Use the specified injection steel pipe because its resistance and length have a considerable effect on both injection volume and efficiency.

In the case of new piping, use it after cleaning for approximately twenty minutes under an injection pressure of 200 - 300 kg/cm² (2,844 - 4,266 lb/sq.in.)

---

NOZZLE & NOZZLE HOLDER

DESCRIPTION

The nozzle employed is of direct injection Bosch-hole type, with a spray angle of 150°. To improve combustion efficiency, this nozzle employs a combination injection hole system having two holes of 0.31 mm (0.0122 in.) I.D. and two holes of 0.33 mm (0.0130 in) I.D. The nozzle is designed to open at 220 kg/cm². The nozzle holder is housed in a copper sleeve which is caulked into the cylinder block. And this nozzle holder is cooled by way of the sleeve which is cooled by the water jet in the water jacket.

The nozzle is located by a dowel pin provided in the nozzle holder body. The flanged nozzle holder is inserted in and tightened with 2 bolts to the cylinder head. The setting angle and positioning of the nozzle holder are, therefore, determined automatically.

---

Fig. 3-7-3 Injection nozzle
TEST OF NOZZLE

1. Visual Checks of Nozzle and Nozzle Holder, and Cautions for Assembling

A fuel injection nozzle is a high precision product, and therefore be handled with utmost care.

(1) Nozzle
Check the nozzle for choking at the injection hole and carbon deposit. Also check the seat and needle valve sliding portion. Then, put the nozzle body and needle valve in clean light oil to check them for sliding condition.

(2) Nozzle Holder
Carefully check the contact surface with the nozzle, push rod tip and nozzle spring for damage. Also, check to see whether or not the push rod is bent.

(3) Cleaning Carbon
Clean carbon off from the surface of the nozzle and nozzle holder with carbon cleaner or carbon cleaning tool with care taken not to damage the nozzle. Then, rinse the parts with clean light oil. Incomplete rinsing will degrade nozzle functions causing its life to be shortened.
(4) When Assembling Nozzle to Nozzle Holder
Assemble the nozzle to its holder with the pressure adjusting screw kept loose and with care not to allow the nozzle center to deviate from the nozzle holder center.

2. Hand Test with Nozzle Tester
The quality of a nozzle is determined by the pattern and angle of injected mist, the end timing of injection, the leak condition after injection, and other factors. Note that the state of mist will differ depending on the property or temperature of the test oil, and the speed at which the hand lever of the nozzle tester is operated.

(1) Injection Starting Pressure Test
Set the specified injection starting pressure by turning the adjusting screw of the nozzle holder. Dust in the nozzle can not only result in incorrect injection but also vary the injection starting pressure every time when injection is made.

(2) Nozzle Spray Test
Operate the nozzle tester hand lever at a stroke of 4-6 per second and check the spray mist to see that it is uniform without abnormality due to the blocked injection hole.

The nozzle will provide coarse mist compared with an ordinary nozzle if the hand lever is operated at a lower speed. Actually, however, an engine is not run at such a low fuel injection rate. It therefore is not necessary to check mist when the lever is operated at such a low speed.

Spray Mist from Good Nozzle at Hand Test
Lever speed for nozzle test
(4-6 strokes/second)

Condition at lower lever speed
(1 stroke/second)

Fig. 3-7-6 (Coarse)

Uniform spray mist can be obtained at the specified lever speed though the mist is coarse when the lever speed is low.

(3) Valve Seat Test
Keep the fuel pressure 20 kg/cm² lower than the specified injection pressure by the nozzle tester (for 30 seconds) and confirm that no fuel drops down from the nozzle tip.

3. Nozzle Replacement Intervals
Whether or not the nozzle can be used continuously is determined by conducting a hand test with a nozzle tester, seeing the sliding condition of the needle valve, and performing visual checks to see the degree of wear. Always keep in mind that the spray mist will become coarse as the nozzle tester hand lever is operated slowly. In case a nozzle is found unacceptable through an valve seat test or visual checks, do not attempt to correct the faulty nozzle by fitting the nozzle body with the needle valve seat but change new nozzle assembly.
FUEL FILTER

DESCRIPTION

Contaminated fuel may damage the injection pump and nozzles, increase wear and hamper operation. For this reason, the fuel must be filtered properly. That is, the fuel from the feed pump is filtered as it passes from the periphery of the filter element toward its center, and the filtered fuel is fed into the injection pump. This fuel filter contains a synthetic resin-processed, paper element.

OVERHAUL

Dismounting
1. Disconnect the fuel line.
   Loosen the fuel and injection pump connections, and that of the fuel filter. Handle the fuel pipe with care.
2. Take out the two retaining bolts and remove the filter assembly.

Disassembly
1. Loosen the cap center bolt, take out the center bolt, and disassemble.
2. Remove the bleeder screw and drain plug.

Cleaning
1. Plug the upper and lower filter-element openings so that dirt cannot enter, and immerse the element in the solvent. Clean thoroughly by moving it briskly about in the solvent.
2. Clean the other parts with clean solvent and dry with compressed air.

Assembly
1. Position the barrel gasket correctly, and tighten the center bolt carefully. Excessive tightening will damage the barrel and O-rings.
2. Tighten the air bleeder and drain plug until no leakage is evident. Excessive tightening will damage the gasket.

Mounting
Mount the filter on the engine, connect the fuel lines and bleed the air.
3-8 LUBRICATING SYSTEM

DESCRIPTION

1. Function of Engine Oil

Engine oil functions in the following manner:
1. Friction reducing action
   It insures a minimum loss of power by reducing the friction of moving parts (bearings, pistons, etc.)
2. Cooling action
   It prevents engine temperature from becoming excessively high by transmitting the heat generated by friction and combustion.
3. Sealing action
   It checks compression or combustion pressure leaks by sealing between the piston rings and cylinder walls. Thus the highest engine performance is maintained.
4. Detergent action
   It cleans the lubricated parts of dusts or metal dust or cylinder like carbon, thus preventing the premature wear of the lubricated parts which may be caused by those admixtures and furthermore, it disperses carbon and sludge into oil so that those may not collect in the lubricated parts or in the oil line.
5. Anti-corrosive action
   It prevents the metals from rusting by corrosive gas or moisture.

2. Oil Circulating System

Lubricating oil is pumped up through the strainer by the oil pump in the timing gear case on the front side of the crank case. It makes heat exchange with the cooling water while passing through the oil cooler. The oil coming out from the oil cooler is sent to the full-flow filter in which dust and sludge are removed through 10—40 micron voids. After having the pressure adjusted by the regulator valve, the oil passes through the main oil hole.
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In the crank case lubricating the main bearing cam bearing, etc. After passing the oil cooler, a part of oil is sent instead of entering the full-flow filter and fine dust and sludge are filtered. Then the oil returns to the oil pan.

A part of oil, reaching the main bearing, passes through the oil hole of the crank shaft, lubricating the big-end of the connecting rod, then enters the oil hole of the connecting rod and lubricates its small-end. A part of oil reaching the small-end of the connecting rod is jetted from the oil hole at the upper part of the small-end toward the lower surface of the piston and functions positively to cool the piston.

To the piston and the liner splash lubrication is applied in most cases.

The oil coming through above routes returns to the oil pan passing the lower part of the crank case.

On the other hand, the oil supplied to the idler gear shaft becomes spray to lubricate the timing gear. This oil comes back to the oil pan passing the lower end of the timing gear case.

For the lubrication of the rocker arm shaft, oil is sent through the cam shaft head.

Via the cylinder head, pedestal and the rocker shaft, then, guided to the rocker arm. A part of this oil passes the hole in the rocker arm and comes along the rocker arm to lubricate the top of the valve stem. The oil passing the above routes drops from the hole of the push rod on the upper surface of the cylinder head and lubricates the tappet guide, then returns to the oil pan.

2. Lubricating Oil capacity

It takes about 14 liter (3.0 Imp. gal/3.70 U.S. gal) to fill the engine lubricating system.

---

**Fig. 3-8-2 Lubricating system**

1. Oil pump assy
2. O-ring
3. Oil strainer
4. O-ring
5. Oil pump inlet pipe
6. Oil pipe bracket
7. O-ring
8. Oil cooler assy
9. Gasket
10. Oil cooler case
11. O-ring
12. Filter assy
13. Oil filter gasket
14. Water hose
15. Clamp
16. O-ring
17. Coolant oil cooler pipe
18. Exhaust manifold heat insulator
3. Exchanging the Engine Oil
As to interval of exchanging the engine oil.
Shorten the interval as necessary, according to operational conditions. Engine oil gets dirty sooner than usual while the engine is still new or immediately after an overhaul or — during break-in periods. Change engine oil after 30 hours of operation during such periods.
Do not drain oil until its temperature has sufficiently resin. Cold oil lacks fluidity and may fail to completely discharge the sludge deposited on the bottom. In such a case, new oil filled after draining will become dirty quickly.

OIL PUMP

DESCRIPTION

![Diagram of Oil Pump](fig3-8-4-oil-pump)

PUMP DRIVE GEAR
CASE
DRIVE GEAR
DRIVE SHAFT
DRIVEN SHAFT
DRIVEN GEAR
COVER

Fig. 3-8-4 Oil pump

(1) Oil pump
Gear-type pump mounted on the front of cylinder

![Diagram of Oil Pump Disassembled](fig3-8-5-oil-pump-disassembled)

Fig. 3-8-5 Oil pump disassembled

Oil block is driven with the cam shaft gear. Supplies enough oil to cool piston and valve stem.
OVERHAUL

Disassembly

1. Remove the clamp bolt from the drive gear, and pull the drive gear out of the drive shaft by means of a puller.
2. Remove the cover and driven shaft en bloc.
3. Remove the drive gear (together with shaft) and driven gear from the case.

4. Use a press or hammer to separate the drive gear from the drive shaft (keyed), and the case from the driven shaft (press fitted).

NOTE:
In separating each parts with a press or puller pay utmost attention not to damage them (aluminum alloy).

Fig. 3-8-6 Oil pump

Inspection and Repair

Clean and inspect each part, and replace it with a new one if it is found worn out beyond service limit.

1. Measure the gap between the pump case and gear teeth with a thickness gauge.
   Standard value: 0.030 – 0.100 mm
   (0.0012 – 0.0039 in.)
   Serviceable limit: 0.13 mm (0.0051 in.)
   At this time, check for wornout or seriously defective gears also. They should be renewed.

2. Place a straight edge on the cover mounting surface of the case, and measure the gear end play with a thickness gauge.
   Standard value: 0.040 – 0.088 mm
   (0.0016 – 0.0035 in.)
   Serviceable limit: 0.15 mm (0.0059 in.)

Fig. 3-8-7 Measure the clearance between teeth and case
(3) Check the gap between the drive shaft and case with a micrometer and a cylinder gauge.

Standard value: 0.040 – 0.085 mm  
(0.0016 – 0.0033 in.)

Serviceable limit: 0.1 mm (0.0039 in.)

Assembly and Adjustment

(1) Before assembling the pump, apply clean engine oil to the shafts, gears, and pump case.

(2) Assembly the pump by reversing the sequence of disassembling steps, making sure to refit the keys properly to secure the pump drive gear and helical gear in place and to lock the nut by bending the lock washer after the helical has been mounted on the drive shaft.

OIL COOLER

DESCRIPTION

The oil cooler is provided to keep automatically the proper temperature of oil to be supplied to all parts of Engine.

Oil cooler is incorporated in the water jacket on the right hand side of cylinder block. Its multiple disc construction, with little pressure loss, head exchange. This maintains proper oil temperature, extending the life of both engine metal and engine oil.

The oil supplied by the oil pump runs in the inside of the oil cooler unit and the cooling water flows along its outside. When the temperature of oil is higher than that of water, it functions as an oil cooler and oil is cooled.

In the reverse case, it functions as an oil heater and oil is heated. Thus, the proper temperature is always maintained. The function of oil heater makes it possible to raise rapidly the oil temperature even in the cold season.
This is effective not only in making idling time shorter but also in the prevention of abrasion at various parts of the engine.
When the inside becomes dirty and clogged, the passing resistance increases and the oil circulation becomes unfavorable. In such case, disassemble it and wash it with the oil sludge detergent or aqueous solution of caustic soda. Fit it after washing thoroughly with water.

Generally, it will be all right to wash it at every mileage of 60,000km. A safety valve is provided to bypass the oil to prevent the abnormal rise of oil pressure when the oil temperature is low and the resistance of oil cooler is high.
The opening pressure of this valve that is installed in the oil filter is 2.0 kg/cm² (28.44 lb/sq.in).
DISASSEMBLY

In disassembling separate it from the side of the oil filter in contact with the cooler. Desist from an attempt to separate the oil cooler body from the pipe connected.

INSPECTION

Testing pressure of the element 6 kg/cm² (85.32 lb/sq.in).
If any leak is found, replace it. Never use it again by repairing.

---

1. Case
2. Taper plug
3. Taper plug
4. Oil cooler element
5. Element gasket
6. Plain washer
7. Lock washer
8. Nut
9. Oil cooler pipe
10. O-ring
11. Bolt
12. O-ring

Fig. 3-8-14
REASSEMBLING
Do not use O-ring and gaskets again but replace each time they are removed. Before reassembling make sure that the gap between the flange of connecting pipe fitted to the cooler and the oil filter is less than 0.5 mm (0.02 in.)

Tightening torque:

<table>
<thead>
<tr>
<th></th>
<th>Unit: kg-cm (lb.ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil cooler fitting bolt</td>
<td>190 - 260 (14 - 18)</td>
</tr>
<tr>
<td>Oil cooler element fitting nut</td>
<td>150 - 180 (11 - 13)</td>
</tr>
</tbody>
</table>

Fig. 3-8-15

OIL FILTER

DESCRIPTION

Fig. 3-8-16 Oil filter
The oil filter is fitted at the lower side of the exhaust manifold in the center part of the engine. The filter cover is made of aluminum casting. Fitted on its lower side is a full flow filter of paper element type. The full-flow type paper filter increases combustion efficiency, and permits longer oil and element replacement intervals under standard working conditions.

The oil pressure at the main fall is kept at $1 - 5 \text{ kg/cm}^2$ (14.22 – 71.10 lb/sq.in.) by the regulator valve. The opening pressure of the regulator valve is 4 kg/cm$^2$ (56.88 lb/sq.in.).
**DISASSEMBLY**

First loosen the drain plug at the end of the center bolt in order to drain oil included in the filter. Loosen the bolt in the center on the bottom of the filter case.

**Cleaning**

1. Wash all parts, except the element, in cleaning oil and dry with compressed air. Pass air through the throttle opening in the oil inlet port cover after first cleaning with wire.
2. Wash the element separately in clean gasoline or fresh cleaning oil, being careful to allow no foreign matter to enter. Immerse in the cleaner and remove sludge with a brush.

**ASSEMBLY**

Cautions only for assembling.

**Full-flow filter**

1. Tightening torque of the plugs for valves.
   
   400 - 500 kg-cm (29 - 36 lb.ft)

2. Tightening torque of the center bolt for the full flow filter case.
   
   First tighten it at 700 kg-cm (51 lb.ft) then loosen it until 400 - 500 kg-cm (29 - 36 lb.ft.)

3. Installing way the oil filter assembly to the crank case.
   
   Refer to cautions explained in oil cooler.
OVERHAUL

Dismounting

1. Remove the drain plug to drain the engine oil. It is suggested that a 30-gauge screen be placed over the container into which engine oil is drained. In this way, foreign particles in the oil may be retained and examined.
2. Remove the oil pan retaining bolts, leaving one bolt in place on the left and right sides. Support the oil pan before removing these last two bolts and lower the pan slowly as they are taken out.
3. Remove the suction strainer from the crankcase.

Cleaning and Inspection

1. Before cleaning the oil pan, examine the sediment. If many metal shavings are found, the bearings should be inspected.
2. Clean the oil pan and strainer in solvent and dry with compressed air. Check the curved oil strainer line and welds for cracks.

REMOUNTING

Coat a new gasket with gasket sealing compound and position the gasket. Mount the oil pan in the reverse sequence of removal, i.e., insert one bolt in the left and right sides while supporting the oil pan in position, partially tighten and replace the remaining bolts. Tighten all bolts evenly.
1. Circulating System

The coolant pump at the front of the engine circulates the coolant water. After being cooled in the radiator, the coolant water passes through a connection in the lower portion of the radiator to the pump. This coolant pump feeds the coolant water directly to the left side of the engine (seen from the fan side) where it enters the distribution system, cooling all cylinders equally.

Part of the coolant fed to the cylinder head to cool nozzle holder, exhaust port, etc. gathers in the thermostat case on the front end of cylinder head. Part of the coolant which cooled the cylinders is taken out from the side wall of cylinder block on the manifold side and fed to cylinder head after heat exchange with lubricant in oil cooler. Coolant gathered in the thermostat case is returned to radiator or coolant pump.

A drain cock on the right rear side of the engine (seen from the fan side) permits coolant water to be drained from the cylinder block.

The radiator is drained by opening the drain cock on the right at the bottom of the radiator.

MAINTENANCE

1. Cleaning the Radiator Core

Mud and trash tend to accumulate on the front of the radiator during driving. This impedes the flow of air through the cooling fins, and the core should be cleaned carefully with water.

2. Checking the Coolant-water Level and Replenishing

Every day before operating the vehicle, check the water level and pour water, if necessary.

Remove the radiator cap by turning to the left. Pour the soft water until it appears at the bottom of the filler. When putting the radiator cap back on, be sure to screw it in until it firmly goes into the "second detent" of its lock.

Always use soft water.
3. Cleaning and Coolant Lines

When these lines become clogged with sediment, cooling efficiency decreases. The entire system should be flushed with the cleaning solvent.

1. Remove the radiator cap first so that air may enter.
   
   Open two drain cocks (for cylinder block and radiator).

2. Fill the radiator with cleaning solvent and operate the engine until the water temperature rises to about 80° C (176° F). Keep the engine in motion for 15 to 30 minutes.

3. Open the drain cock and quickly discharge the solvent.

4. Pour clean water and run the engine again for a while maintaining its temperature at about 80° C (176° F). Then discharge the water after dropping the water temperature.

4. Handling Caution in Extremely Low Temperatures

Use antifreeze in extremely low temperature.

When antifreeze is not used, be sure to drain the coolant water from the radiator upon completion of work. If the water is left undrained, the radiator and the engine will freeze, which can cause grave accidents.

1. Brand of antifreeze
   
   Please refer to “Recommended lubricants list”.

2. Use of antifreeze

   1) Before pouring antifreeze, check the radiator core, hose, drain cock, etc. for leakage.

   2) Remove the radiator cap and open the radiator and engine drain cocks to completely drain the coolant water.

   3) If the drained coolant water is notably dirty, the cooling system must be thoroughly cleaned.

   4) Use soft water for mixture with antifreeze.

   5) Mixture ratios for different temperatures are as indicated in the table below.

<table>
<thead>
<tr>
<th>Safe working temperature °C (°F)</th>
<th>Antifreeze %</th>
<th>Soft water %</th>
<th>Freezing temperature °C (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2 (-28)</td>
<td>15</td>
<td>85</td>
<td>-6 (-21)</td>
</tr>
<tr>
<td>-4 (-25)</td>
<td>20</td>
<td>80</td>
<td>-9 (-15)</td>
</tr>
<tr>
<td>-8 (-18)</td>
<td>25</td>
<td>75</td>
<td>-13 (-9)</td>
</tr>
<tr>
<td>-11 (-12)</td>
<td>30</td>
<td>70</td>
<td>-16 (-3)</td>
</tr>
<tr>
<td>-16 (-3)</td>
<td>35</td>
<td>65</td>
<td>-21 (-6)</td>
</tr>
<tr>
<td>-20 (-4)</td>
<td>40</td>
<td>60</td>
<td>-25 (-13)</td>
</tr>
<tr>
<td>-26 (-15)</td>
<td>45</td>
<td>55</td>
<td>-31 (-24)</td>
</tr>
<tr>
<td>-33 (-27)</td>
<td>50</td>
<td>50</td>
<td>-37 (-35)</td>
</tr>
<tr>
<td>-40 (-40)</td>
<td>55</td>
<td>45</td>
<td>-45 (-49)</td>
</tr>
</tbody>
</table>

NOTE:

Observe safe working temperatures in mixing.

6) The level of the coolant should be 40-50mm (1.48-1.97 in.) below the bottom of the filler, this is prevent expansion due to heat during operation from causing the antifreeze to overflow and be wasted.

7) Antifreeze used for replenishment must have the same concentration as that used in initial filling.

8) Hang a sign reading “Antifreeze Used” on the radiator cap.

TROUBLE SHOOTING

1. Overheated Engine

   1) Coolant water is insufficient.

   Check for leaks and add water.

   2) V-belt is loosened.

   Adjust to proper tension.

   3) V-belt is slippage.

   Remove belts and wash with gasoline.

   4) Thermostat valve is closed causing grease.

   Remove and check.

   5) Cooling system is clogged, sediment accumulates having in it.

   Flush the cooling system with cleaning solvent.

   6) Water pump is inoperative.

   Check for pump seizure and damage pump pulley.

2. Engine Running too Cold

   1) Leave thermostat valve open.

   Remove and check. Replace if necessary.

   2) Air temperature is low in cold weather.

   Install cover on front of radiator.

3. Drop in Coolant Water Level

   1) Leaks in radiator, hose connections, pump, etc.

   Find leak and tighten or replace.

   2) Cylinder head gasket is defective.

   Replace and tighten the head bolts with standard torque.

   3) Cylinder head or block is cracked.

   Repair if not serious, or replace.

   4) Leaks in expansion plug.

   Repair of replace plug.

4. Unusual Sounds from Cooling System

   1) Water pump bearing is worn.

   Disassemble and replace bearing.

   2) Cooling fan is loosed.

   Tighten or repair.
COOLANT PUMP & FAN

DESCRIPTION

The pump is on the upper front of the engine, and its construction is shown in Fig. 3-9-2. There is a six-bladed cooling fan mounted on the front of the engine. The fan, together with the alternator, is driven by crankshaft through V-belts. The speed is 0.9 times greater than that of the crankshaft. To adjust V-belt tension, vary the position of the alternator. The leak prevention for the water pump is effected by the carbon plastic plate, rubber and spring fitted to the water vane. The leakage is completely prevented by the rubber which rotates with its one end pressed against the vane by the force of the internal spring, and the other against the bushing applied for the setting of the carbon plastic plate to the pump body. For the lubrication of the ball bearing of the pump shaft, supply the coolant pump grease at every 500 hours operation.

OVERHAUL

Fig. 3-9-2 Coolant pump

Fig. 3-9-3 Coolant pump

1. Case
2. Shaft
3. Vane
4. Coolant seal
5. Radial ball bearing
6. Bearing collar
7. Ball bearing
8. Ball bearing
9. Washer
10. Retainer ring
11. Plain washer
12. Lock washer
13. Nut
14. Feather key
15. Lubrication fitting
16. Coolant pump cover gasket
17. Plate
18. Bolt
Dismounting

1. Loosen the alternator-brace-adjusting bolt and move the alternator all the way to the engine.
2. Remove the four cooling-fan-retaining bolts and take off the fan.
3. Remove the V-belts by hand and cooling fan pulley by loosening the center nut.
4. Remove the suction-pipe-flange bolts and take off the pipe.
5. Remove the four coolant-pump-retaining bolts and take off the pump assembly.

Disassembly

1. Remove the pulley by making use of a puller.

2. Loosen and remove the coolant pump case and case cover plate bolts.

3. Remove the coolant pump shaft.
   Take off the feather key and force out the pump shaft in the direction of the vane with a press.
   **NOTE:**
   Don’t remove the vane from shaft, if not necessary.

4. Remove the ball bearing collar from the pump case.
   Take out the retaining ring and force out the bearings and collar in the direction of the pulley with a press.

Inspection and Repair

1. **Coolant Pump**
   1. Remove any traces of the gasket from pump case and cover. Wash all parts in solvent thoroughly and dry with compressed air.
   2. Check the bearing race for wear and fatigue, if defective, replace.
   3. Check carefully to make sure that the water seal is not cracked or torn. If defective, replace.
   4. Check for deformed pump shaft keyway, feather key, and threads on the vane side. Correct any defects or replace parts.

2. **Cooling Fan**
   Check for cooling fan cracks, etc.

Assembly and Adjustment

1. Coat the bearing grease to the bearings and insert them in pump case through the spacer by means of a press, but do not press the inner race. Then fit the retainer ring.
2. Fit the water seal to the shaft and insert the shaft in the pump case by means of a press.
3. Place the feather key in the pump shaft, align the pump pulley with the key and drive it in place. Tighten the pulley in place with the nut.
4. Replace the pump case cover, using a new gasket, and tighten the cover in place.
5. Check for smooth rotation, turning the cooling fan manually after assembly is completed.

6. Checking the tension of V-belt

The V-belts which drive the alternator and water pump should have the correct tension, if not, the belts will slip and the required speed will be lost. Check this belt tension and adjust as needed by following.

(1) Loosen the alternator brace adjusting bolt until brace and adjusting plate are free.

(2) Move the alternator to the position in which the belt tension is correct and seat the brace and adjusting plate. Tighten the adjusting bolt slightly.

(3) Apply a force of approx. 10 kg (22 lb) to the belts at the center of alternator and fan pulley.

![Image](image-url)

Fig. 3-9-6 Checking the tension of V-belt

The amount of belt slackness should be approximately 10 ~ 15 mm (0.39 ~ 0.59 in)

---

**THERMOSTAT**

**DESCRIPTION**

This is a wax type thermostat. As shown in Fig. 3-9-7 wax is sealed in the pellet. When the temperature rises, the wax expands and pushes up the pin, and the valve is opened by the reaction of the pin.

When the coolant water temperature drops below 76.5°C (170°F), the thermostat valve is closed to shut off the radiate flow, and all of the coolant water flows through the bypass of the pump, and it is provided preventing engine temperature drop.

Above 76.5°C (170°F), the thermostat valve is opened properly as shown in Fig. 3-9-10, and engine temperature remain the proper degree; max. lift is 10 mm (0.393 in) at 90°C (194°F).

![Diagram](diagram-url)

Fig. 3-9-7 Thermostat
Fig. 3-9-8  Thermostat and coolant manifold

1. Loosen the hose clamp on the thermostat case side, and take off the rubber hose between the thermostat case and the radiator.
2. Remove the two clip bands from the bypass pipe
3. Remove the four mounting bolts in the thermostat case and take out the case.
4. Take out the thermostat.
3-84 ENGINE

Mounting

Install components in the reverse order to disassembly, paying attention to following items:

1. Clean fur from thermostat case.
2. Be sure so that the jiggle valves face upwards when installing.

3. Be sure to place corroded, scared or permanently strained O-rings with new ones.

2. Place the thermostat in warm water as shown in Fig. 3-9-10.

When the temperature rises more than 90°C (193°F) the lift should be approximately 10mm (0.39 in.) and the bypass port in the side of the main unit must be completely closed.

Fig. 3-9-9 Jiggle valve

MAINTENANCE

1. Inspecting the Thermostat Function

Every 1,000 hours operation check the function.

1. At ordinary temperatures (below 70°C (158°F)). If the thermostat conical section, used for valve action, is not in close contact with the main unit, the thermostat should be replaced.

Fig. 3-9-10 Testing the thermostat function
3-10 EXHAUST SYSTEM

MANIFOLD & MUFFLER

DESCRIPTION

1. Intake manifold
2. Gasket
3. Intake pipe
4. Gasket
5. Intake air heater
6. Intake pipe
7. Gasket
8. Exhaust manifold
9. Exhaust manifold
10. Ring seal

Fig. 3-10-1 Air intake & Exhaust system
(1) The one-piece, 6 cylinder intake manifold uniformly distributes suction and provides high suction efficiency by being matched with the valve system. The end of intake manifold has a noise suppressor (butterfly valve type) which is interlocked with the injection pump load lever, to suppress incidental noise in and around combustion chamber from the exhaust brake.

(2) Exhaust manifold
The exhaust manifold is made of cast iron with special ingredients added. It is built in three parts to prevent thermal deformation. At the joint section of the manifold, a seal ring seals gas and oil and a wire-containing stainless gasket (steel plate type) on the flange prevents gas leakage.

Mounting of exhaust manifold seal rings
Seal rings are fitted to each connecting section of the exhaust manifold to prevent gas and oil leakage. Install new seal rings so that none of the ring end gaps are lined up, as shown in Fig. 3-10-2.
### 3-11 REPAIR SPECIFICATIONS

**SERVICE STANDARD**

<table>
<thead>
<tr>
<th>Item</th>
<th>Nominal dimensions</th>
<th>Assembly standard</th>
<th>Repair limit</th>
<th>Service limit</th>
<th>Corrective measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cylinder liner and piston</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liner inside diameter</td>
<td>110 (4.331)</td>
<td></td>
<td></td>
<td>+0.15 (+0.0056)</td>
<td>Replace liner</td>
</tr>
<tr>
<td>Clearance between liner and piston (at 64.2 mm (2.528 in) from piston bottom)</td>
<td>110 (4.331)</td>
<td>0.192 – 0.224 (0.0076 – 0.0088)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Piston outside diameter</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top</td>
<td>In cylinder</td>
<td>110 (4.331)</td>
<td>0.3 – 0.45 (0.0118 – 0.0177)</td>
<td>2.5 (0.0984)</td>
<td></td>
</tr>
<tr>
<td>Free clearance</td>
<td>Approx. 11 (0.433)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd</td>
<td>In cylinder</td>
<td>110 (4.331)</td>
<td>0.3 – 0.45 (0.0118 – 0.0177)</td>
<td>1.2 (0.0472)</td>
<td></td>
</tr>
<tr>
<td>Free clearance</td>
<td>Approx. 15.5 (NPR) (0.610) 15.0 (RIKEN) (0.590)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3rd</td>
<td>In cylinder</td>
<td>110 (4.331)</td>
<td>0.3 – 0.5 (0.118 – 0.0196)</td>
<td>1.2 (0.0472)</td>
<td></td>
</tr>
<tr>
<td>Free clearance</td>
<td>Approx. 14.5 (0.5709)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Side clearance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top</td>
<td>In cylinder</td>
<td>110 (4.331)</td>
<td>0.3 – 0.5 (0.118 – 0.0196)</td>
<td>1.2 (0.0472)</td>
<td></td>
</tr>
<tr>
<td>Free clearance</td>
<td>Approx. 12.5 (NPR) (0.4921) Approx. 10.5 (RIKEN) 0.4134</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Oil clearance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top</td>
<td>Ring thickness</td>
<td>3.0 (0.118)</td>
<td>0.06 – 0.10 (0.0024 – 0.0039)</td>
<td>0.4 (0.0157)</td>
<td>-0.25 (-0.0098) Replace ring</td>
</tr>
<tr>
<td>Groove width</td>
<td>3.0 (0.118)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd</td>
<td>Ring thickness</td>
<td>2.5 (0.0984)</td>
<td></td>
<td></td>
<td>-0.25 (-0.0098) Replace ring</td>
</tr>
<tr>
<td>Groove width</td>
<td>2.5 (0.0984)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3rd</td>
<td>Ring thickness</td>
<td>5.0 (0.1969)</td>
<td></td>
<td></td>
<td>-0.05 (-0.0019) Replace ring</td>
</tr>
<tr>
<td>Groove width</td>
<td>5.0 (0.1969)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Piston pin outside diameter</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piston hole and clearance</td>
<td>39 (1.535)</td>
<td>0.013T – 0.014L (0.0005 – 0.0006)</td>
<td>0.1 (0.0039)</td>
<td>T = interference L = clearance fit</td>
<td></td>
</tr>
<tr>
<td>Con-rod bushing inside diameter and clearance</td>
<td>39 (1.535)</td>
<td>0.015 – 0.036 (0.0006 – 0.0014)</td>
<td>0.1 (0.0039)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Journal outside diameter</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Bearing thickness</td>
<td>2.5 (0.0984)</td>
<td>0.061 – 0.102 (0.0022 – 0.004)</td>
<td>0.30 (0.0118)</td>
<td>Correct by regrinding if worn unevenly more than 0.10 mm (0.0039) replace bushing if wear is more than 0.12 (0.0472), available under signed bearings: 0.25 (0.0098), 0.75 (0.0295), 1.00 (0.0393)</td>
<td></td>
</tr>
<tr>
<td><strong>Clearance</strong></td>
<td></td>
<td></td>
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<tr>
<td>No. 1 – 7</td>
<td></td>
<td></td>
<td></td>
<td>-0.20 (-0.0079) Replace thrust bearing</td>
<td></td>
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<tr>
<td><strong>Journal and crank pin</strong></td>
<td></td>
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<tr>
<td>Central main shaft width</td>
<td>4.3 (0.169)</td>
<td>0.05 – 0.219 (0.0019 – 0.0086)</td>
<td>0.5 (0.0196)</td>
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<tr>
<td>Bearing thickness</td>
<td>2.5 (0.0984)</td>
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<td></td>
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</tr>
<tr>
<td>Item</td>
<td>Nominal dimensions</td>
<td>Assembly standard</td>
<td>Repair limit</td>
<td>Service limit</td>
<td>Corrective measures</td>
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</tr>
<tr>
<td>Connecting rod large and inside diameter</td>
<td>69 (2.7165)</td>
<td></td>
<td>-0.20 (-0.0079)</td>
<td>-1.20 (-0.0472)</td>
<td>Correct by regrinding if worn unevenly more than 0.10 (0.0039); regrind if wear is more than 0.2 (0.0079), and replace crankshaft if wear is more than 1.20 (0.0472).</td>
</tr>
<tr>
<td>Roundness</td>
<td></td>
<td></td>
<td>0.06 (0.0023)</td>
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<tr>
<td>Pin outside diameter</td>
<td>65.0 (2.5590)</td>
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<tr>
<td>Con-rod bearing thickness</td>
<td>2.0 (0.0787)</td>
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<tr>
<td>Clearance</td>
<td>0.031 - 0.082 (0.0013 - 0.0032)</td>
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<td></td>
<td>If clearance is more than 0.3 (0.0118), replace available undersized bearings: 0.25 (0.0098), 0.500 (0.0198), 0.75 (0.0295), 1.00 (0.0393).</td>
</tr>
<tr>
<td>End-play, pin width</td>
<td>42.0 (1.6535) 0.2 - 0.5 (0.0079 - 0.0008) 0.6 (0.0236)</td>
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<tr>
<td>Crankshaft bent</td>
<td></td>
<td>0.09 (0.0035)</td>
<td></td>
<td></td>
<td>Grind to undersize or straighten with press</td>
</tr>
<tr>
<td>No. 1</td>
<td>61.5 (2.421)</td>
<td></td>
<td></td>
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<tr>
<td>No. 2</td>
<td>62.3 (2.413)</td>
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<tr>
<td>No. 3</td>
<td>61.1 (2.408)</td>
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<tr>
<td>No. 4</td>
<td>60.9 (2.398)</td>
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<tr>
<td>No. 5</td>
<td>60.7 (2.390)</td>
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<tr>
<td>No. 6</td>
<td>60.5 (2.382)</td>
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<tr>
<td>No. 7</td>
<td>58.3 (2.295) 0.030 - 0.080 (0.0012 - 0.0034)</td>
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<tr>
<td>Camshaft outside diameter</td>
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<tr>
<td>No. 1</td>
<td>61.5 (2.421)</td>
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<tr>
<td>No. 2</td>
<td>61.3 (2.413)</td>
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<tr>
<td>No. 3</td>
<td>61.1 (2.408)</td>
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<tr>
<td>No. 4</td>
<td>60.9 (2.398)</td>
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<td>No. 5</td>
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<td>No. 6</td>
<td>60.5 (2.382)</td>
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<tr>
<td>No. 7</td>
<td>58.3 (2.295)</td>
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<tr>
<td>End-play thrust bearing thickness</td>
<td>8.0 (0.3149) 0.1 - 0.178 (0.004 - 0.0070) 0.3 (0.0118)</td>
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<td>Replace thrust plate</td>
</tr>
<tr>
<td>Cam lift</td>
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</tr>
<tr>
<td>Intake</td>
<td>7.1840 (0.2829)</td>
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<tr>
<td>Exhaust</td>
<td>8.1723 (0.3217)</td>
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<tr>
<td>Camshaft bent</td>
<td></td>
<td>0.05 (0.0019)</td>
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<td>Straighten with press</td>
</tr>
<tr>
<td>Tappet outside diameter</td>
<td>32 (1.2598) 0.020 - 0.071 (0.0008 - 0.0028) 0.10 (0.0038)</td>
<td></td>
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<td></td>
<td>Replace tappet</td>
</tr>
<tr>
<td>Rocker arm shaft outside diameter</td>
<td>24.2 (0.952)</td>
<td></td>
<td></td>
<td>-0.08 (-0.0031)</td>
<td>Replace rocker arm shaft</td>
</tr>
<tr>
<td>Rocker arm bushing inside diameter</td>
<td>24.2 (0.952)</td>
<td></td>
<td></td>
<td>+0.08 (+0.0031)</td>
<td>Replace bushing</td>
</tr>
<tr>
<td>Clearance</td>
<td></td>
<td></td>
<td>0.15 (0.0059)</td>
<td></td>
<td>Replace bushing</td>
</tr>
<tr>
<td>Item</td>
<td>Nominal dimensions</td>
<td>Assembly standard</td>
<td>Repair limit</td>
<td>Corrective measures</td>
<td></td>
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<tr>
<td><strong>Valve</strong></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Intake valve stem</td>
<td>9.0 (0.3543)</td>
<td>0.055 – 0.088</td>
<td>8.86 (0.3496)</td>
<td>Replace valve or guide</td>
<td></td>
</tr>
<tr>
<td>Exhaust valve stem</td>
<td>9.0 (0.3543)</td>
<td>0.07 – 0.103</td>
<td>8.88 (0.3496)</td>
<td>Replace valve or guide</td>
<td></td>
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<tr>
<td>Exhaust valve stem</td>
<td></td>
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</tr>
<tr>
<td>Intake valve head</td>
<td></td>
<td></td>
<td>–0.5</td>
<td>Replace valve seat</td>
<td></td>
</tr>
<tr>
<td>Exhaust valve head</td>
<td></td>
<td></td>
<td>–0.5</td>
<td>Replace valve seat</td>
<td></td>
</tr>
<tr>
<td>Exhaust valve head</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Valve countersink</td>
<td></td>
<td></td>
<td>–0.5</td>
<td>Replace valve seat</td>
<td></td>
</tr>
<tr>
<td>Valve countersink</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Intake valve clearance</td>
<td>0.30 (0.0118)</td>
<td></td>
<td></td>
<td>Adjust while engine is cool.</td>
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<tr>
<td>Exhaust valve clearance</td>
<td>0.40 (0.0157)</td>
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<tr>
<td><strong>Valve system</strong></td>
<td></td>
<td></td>
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<tr>
<td>Setting length</td>
<td>52.0 (2.047)</td>
<td></td>
<td>26.5 (58.4)</td>
<td>Replace if distorted more</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>than 2.0 (0.0787)</td>
<td></td>
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<tr>
<td>Preload kg (lb)</td>
<td>28.4 (62.6)</td>
<td></td>
<td>26.5 (58.4)</td>
<td>Replace spring</td>
<td></td>
</tr>
<tr>
<td>Free length</td>
<td>62.0 (2.44)</td>
<td></td>
<td>–3.0</td>
<td>Replace spring</td>
<td></td>
</tr>
<tr>
<td>Straightness</td>
<td></td>
<td></td>
<td>–0.1181</td>
<td></td>
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</tr>
<tr>
<td>Seat angle</td>
<td>30°</td>
<td>30° – 30°30’</td>
<td></td>
<td>Correct</td>
<td></td>
</tr>
<tr>
<td>Exhaust valve seat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Face angle</td>
<td>30°</td>
<td>29°30’ – 30°</td>
<td>Correct</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seat angle</td>
<td>45°</td>
<td>45° – 45°30’</td>
<td>Correct</td>
<td></td>
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<tr>
<td>Face angle</td>
<td>45°</td>
<td>44°30’ – 45°</td>
<td>Correct</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Push rod bent</td>
<td>0.5 (0.0196)</td>
<td></td>
<td>Replace gear</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crankshaft – idler gear</td>
<td>0.061 – 0.11</td>
<td>(0.0020 – 0.0043)</td>
<td>Replace gear</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Camshaft – idler gear</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Injection pump – idler</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>gear</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Camshaft – oil pump</td>
<td>0.07 – 0.22</td>
<td>(0.0028 – 0.0086)</td>
<td>Replace gear</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Idle shaft and bushing</td>
<td>34.0 (1.3385)</td>
<td>0.025 – 0.075</td>
<td>0.20 (0.0079)</td>
<td>Replace bushing or shaft,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0009 – 0.0029)</td>
<td></td>
<td>change mounting position</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>if worn unevenly more than 0.03 (0.0012)</td>
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</tr>
<tr>
<td>End-play</td>
<td>38.5 (1.516)</td>
<td>0.03 – 0.11</td>
<td>0.3</td>
<td>Replace bushing</td>
<td></td>
</tr>
<tr>
<td>Idle shaft length</td>
<td></td>
<td>(0.0012 – 0.0043)</td>
<td></td>
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<tr>
<td>Bushing thickness</td>
<td>2.5 (0.0984)</td>
<td></td>
<td>0.0118</td>
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<tr>
<td>Gear tooth radial clearance in case</td>
<td>0.030 – 0.10</td>
<td>(0.0012 – 0.0039)</td>
<td>0.13 (0.0051)</td>
<td>Replace gear or shaft</td>
<td></td>
</tr>
<tr>
<td>Gear side face and pump side clearance in case</td>
<td>0.04 – 0.088</td>
<td>(0.0018 – 0.0035)</td>
<td>0.15 (0.0059)</td>
<td>Replace gear</td>
<td></td>
</tr>
<tr>
<td>Drive gearshaft clearance in case</td>
<td>0.04 – 0.085</td>
<td>(0.0016 – 0.0033)</td>
<td>0.1 (0.0039)</td>
<td>Replace pump case or shaft</td>
<td></td>
</tr>
<tr>
<td>Drive gear shaft clearance in gear</td>
<td>0.04 – 0.083</td>
<td>(0.0016 – 0.0033)</td>
<td>0.1 (0.0039)</td>
<td>Replace gear or shaft</td>
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<tr>
<td>Gear back lash</td>
<td>0.15 – 0.28</td>
<td>(0.006 – 0.011)</td>
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<tr>
<td>Item</td>
<td>Nominal dimensions</td>
<td>Assembly standard</td>
<td>Repair limit</td>
<td>Service limit</td>
<td>Corrective measures</td>
</tr>
<tr>
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</tr>
<tr>
<td>V-belt tension</td>
<td>Between alternator and coolant pump</td>
<td>10 – 15 (0.39 – 0.59)</td>
<td></td>
<td></td>
<td>Apply force 10 kg (22 lb)</td>
</tr>
<tr>
<td>Cylinder head surface evenness</td>
<td></td>
<td>0 – 0.05 (0 – 0.002)</td>
<td>0.1 (0.0039)</td>
<td></td>
<td>Correct by regrinding</td>
</tr>
<tr>
<td>Crankcase top surface evenness</td>
<td></td>
<td>0 – 0.05 (0 – 0.002)</td>
<td>0.1 (0.0039)</td>
<td></td>
<td>Correct by regrinding</td>
</tr>
<tr>
<td>Protrusion of cylinder liner above block</td>
<td></td>
<td>0.01 – 0.07 (0.00039 – 0.0028)</td>
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<tr>
<td>Compression</td>
<td>270 – 310 r.p.m.</td>
<td></td>
<td>29 – 35 kg/cm² (413 – 497 lb/sq.in.)</td>
<td>25 kg/cm² (356 lb/sq.in.)</td>
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<tr>
<td>pressure (lb/sq.in.) (Turn with starter)</td>
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<tr>
<td>Tightening position</td>
<td>kg-cm</td>
<td>lb-ft</td>
<td></td>
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<td>-------------------------------------</td>
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<tr>
<td>Cylinder head bolt</td>
<td>1,800 – 1,900</td>
<td>131 – 137</td>
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<tr>
<td>Cylinder head bolt (Additional)</td>
<td>650 – 750</td>
<td>48 – 54</td>
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<tr>
<td>Main bearing cap bolt</td>
<td>1,400 – 1,600</td>
<td>102 – 115</td>
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<tr>
<td>Connecting rod cap bolt</td>
<td>1,650 – 1,850</td>
<td>120 – 134</td>
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<tr>
<td>Crankshaft nut</td>
<td>5,500 – 7,000</td>
<td>398 – 508</td>
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<tr>
<td>Cam shaft gear nut</td>
<td>2,500 – 3,000</td>
<td>181 – 217</td>
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<tr>
<td>Cam shaft thrust plate bolt</td>
<td>190 – 260</td>
<td>13 – 18</td>
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<tr>
<td>Idle gear shaft fitting bolt</td>
<td>500 – 650</td>
<td>37 – 47</td>
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<tr>
<td>Idle gear fitting bolt</td>
<td>1,100 – 1,300</td>
<td>80 – 94</td>
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<tr>
<td>Flywheel to crankshaft</td>
<td>1,800 – 2,000</td>
<td>131 – 144</td>
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<tr>
<td>Flywheel housing bolt</td>
<td>400 – 500 (10φ)</td>
<td>29 – 36</td>
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<tr>
<td>Oil pan bolt</td>
<td>180 – 230</td>
<td>14 – 16</td>
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<tr>
<td>Manifold to cylinder head</td>
<td>Intake 260 – 320</td>
<td>19 – 23</td>
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<tr>
<td></td>
<td>Exhaust 300 – 350</td>
<td>22 – 25</td>
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<tr>
<td>Rocker arm support bolt</td>
<td>700 – 800</td>
<td>51 – 58</td>
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<tr>
<td>Rocker arm support bolt (on both side)</td>
<td>190 – 260</td>
<td>14 – 19</td>
<td></td>
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<tr>
<td>Oil pump to crank case</td>
<td>380 – 500</td>
<td>28 – 38</td>
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<tr>
<td>Injection pump drive gear</td>
<td>190 – 260</td>
<td>14 – 19</td>
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<td></td>
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<tr>
<td>Injection pump set bolt</td>
<td>190 – 260</td>
<td>14 – 19</td>
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<tr>
<td>Injection pump bracket bolt</td>
<td>380 – 500</td>
<td>27 – 36</td>
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<tr>
<td>Injection pump thrust plate bolt</td>
<td>190 – 260</td>
<td>14 – 19</td>
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<tr>
<td>Injection pipe (both end nipple)</td>
<td>300 – 400</td>
<td>22 – 29</td>
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<tr>
<td>Injection pipe (mounting nut)</td>
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<td>Adjusting screw lock nut</td>
<td>400 – 500</td>
<td>29 – 36</td>
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<td>Nozzle holder bolt</td>
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<td>10 – 14</td>
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<td>Starter to flywheel housing</td>
<td>650 – 870</td>
<td>47 – 63</td>
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<tr>
<td>Cooling fan bolt</td>
<td>200 – 300</td>
<td>14 – 22</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Coolant pump setting bolt</td>
<td>380 – 500</td>
<td>28 – 36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil filter setting bolt</td>
<td>380 – 500</td>
<td>27 – 36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil filter center bolt</td>
<td>400 – 500</td>
<td>29 – 36</td>
<td></td>
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<tr>
<td>Coolant pump pulley bolt</td>
<td>1,800 – 2,400</td>
<td>130 – 174</td>
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<tr>
<td>Water gallery cover bolt</td>
<td>190 – 260</td>
<td>14 – 19</td>
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<tr>
<td>Oil cooler bolt</td>
<td>190 – 260</td>
<td>14 – 19</td>
<td></td>
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<td></td>
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<tr>
<td>Alternator mounting bolt</td>
<td>800 – 900</td>
<td>58 – 65</td>
<td></td>
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</tbody>
</table>
FUEL INJECTION PUMP

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**FUEL INJECTION PUMP**

**DATA & SPECIFICATIONS**

**FUEL INJECTION PUMP**

- **Type**: BOSCH type, NIPPON DENSO make
- **Cylinder**: 6
- **Plunger diameter**: 9.5mm (0.394 in.)
- **Delivery valve diameter**: 6mm (0.236 in.)
- **Cam max. lift**: 8mm (0.315 in.)
- **Control rod max. stroke**: 21mm (0.827 in.)
- **Pre-stroke of 1st cylinder**: 3.1 ± 0.05mm (0.122 ± 0.0020 in.)
- **Injection order**: 1-4-2-6-3-5
- **Injection interval**: 60° ± 30°
- **Tappet top clearance**: More than 0.2 mm (0.0079 in.)
- **Pump revolution**: 1/2 X Engine rpm
- **Matching for engine**: B.T.D.C. 17°

**GOVERNOR**

- **Type**: BOSCH type, NIPPON DENSO make, mechanical, All-speed-control type (RSV)

**TIMER**

- **Type**: BOSCH type, NIPPON DENSO make, automatic type
- **Revolution direction**: Right hand seen from drive side.
- **Max. advance angle**: 5°

**FUEL FEED PUMP**

- **Type**: BOSCH type, NIPPON DENSO make, piston type
- **Piston diameter**: 22mm (0.866 in.)
- **Max. feeding pressure**: 3.5 kg/cm² (49.78 lb/sq.in.) = 600 rpm

The injection pump is driven by the engine crankshaft through the idler gear. It pressure-feeds to the nozzle a specified amount of fuel from the feed pump at a specified time, in a specified order and at a specified internal. The injection pump is of the Bosch type and assembled with the governor, timer and feed pump.

**Fig. 4-1 Fuel injection pump** 04-0479
4-2 FUEL INJECTION PUMP

1. Structure of the injection pump
The internal construction of the injection pump is shown in Fig. 4-2.
The pump housing has a fuel gallery, which is kept filled with fuel fed from the feed pump. The plunger barrel inlet hole leads to the fuel gallery.

The plunger repeats the motion of being pushed up by cam of the cam shaft and pushed down by the plunger spring.

Fig. 4-2 Fuel injection pump

Fig. 4-3 Fuel injection pump

2. Fuel-pressure-feed operation

Fig. 4-4 Plunger operation

- Plunger barrel
- Fuel gallery
- Feed hole

(1) Feed hole is closed
(2) Delivery valve opening
(3) Feed hole is opened
Press feed beginning
Press feeding
Press feed end
1. When the plunger is at bottom dead center, fuel flows from the fuel gallery through the feed hole, and into the plunger barrel, as shown in Fig. 4-4 (1).

2. At the moment when the plunger rises through rotation of the camshaft and the upper portion of the plunger is aligned with the top of the feed hole, fuel-pressure-feeding begins, Fig. 4-4 (2).

3. In accordance with plunger stroke, fuel then opens the delivery valve and flows to the nozzle, Fig. 4-4 (3).

4. The plunger rises further and at the moment when the lower portion of the control groove is meet with the top of the feed hole, the fuel is pressure.returned to the fuel chamber through the center hole of the plunger, and the fuel pressure drops, fuel feed ends, (Fig. 4-4 (4)).

3. Injection-volume-adjusting operation

1. Plunger effective stroke

   The stroke from the point where the plunger-barrel feed hole is closed by the upper portion of the plunger to the point at which the upper portion of the plunger control groove meets with the lower end of the feed hole is the effective stroke.

   The plunger control groove being helical, the effective stroke is varied by turning the plunger to change its position relative to the plunger barrel. Thereby the volume of pressure-feeding being regulated. This is a lower helix type plunger, in which the beginning of pressure-feeding is always constant and its end varies. Fig. 4-6 shows injection volume at each plunger rotating position.

   1) Since the feed hole leads to the control groove before it is closed by the upper portion of the plunger, no pressure is applied to fuel and the injection volume is zero.

   2) By turning the plunger in the arrow direction, the stroke “A” is obtained before the feed hole meets the control groove, and fuel is injected.

3) By turning the plunger to the position shown in Fig. 4-5 (3), injection volume becomes maximum, which means effective stroke is maximum.

2. Plunger rotating device

   The teeth of the control rod engage with the pinion, and the pinion is secured on the control sleeve which rotates freely around the periphery of the barrel. The driving face in the lower portion of the plunger is inserted in the lower part of the sleeve. Therefore, the amount of injection is varied, as the control rod is moved forward or backward, and thereby the plunger is turned. (Refer to Fig. 4-6.)

   The control rod engages with each pinion of the six cylinders. Therefore, it is possible to vary the volume of injection for the six cylinders simultaneously.

   Pulling the rod toward the governor side decreases the volume of injection, and pushing it toward the timer side results in an increasing effect.

   Engine speed increases or decreases as the volume of fuel injection increases or decreases.

3. Rod position

   Position of the rod is expressed as “rod position: . . mm.” When the rod is pulled all the way toward the governor side, the rod is in contact with the rod stopper and stops there. The position of the rod is indicated by the distance it moves toward the timer side from the point where it is in contact with the stopper, that is, “Rod position: 5 mm” means the rod is pushed 5 mm (0.197 in) toward the timer side from the point where it is contact with the stopper.

   Thus, as the rod position value grows large, fuel injection will increase and engine speed will rise accordingly.
4. Injection volume performance curve

Injection volume performance curve is shown in Fig. 4-7, 8.
Injection volume varies almost linearly in accordance with the position of the rod, as shown in Fig. 4-7, when the pump speed is constant.

![Graph](image)

**Fig. 4-7** Rod position — injection volume

Otherwise, fix the rod at either 5 mm (0.197 in) or 15.4 mm (0.669 in), and slowly increase pump speed, in this case, the injection volume will be shown in Fig. 4-8. This graph shows that the injection volume per stroke (rotation) increases gradually in accordance with the increase in pump speed.

![Graph](image)

**Fig. 4-8** Pump speed — injection volume

4. Function of delivery valve

The delivery valve functions in two ways: it prevents the reverse flow of the fuel in the high pressure pipe toward the plunger side and also draws back fuel to prevent dripping at the nozzle. When the delivery valve is brought down by the delivery valve spring upon completion of fuel pressure-feeding, the piston of the valve first cuts off the high pressure pipe and plunger sides (as shown in Fig. 4-9 (a)) and then it further descends until it is in contact with the seat surface (as shown in Fig. 4-9(b)). The fuel in the high pressure pipe is drawn back the amount equal to that designated by "A" in Fig. 4-9 and the pressure in the high pressure pipe is slightly reduced, in this way drops of the fuel remaining at the nozzle tip are eliminated.

In addition, and as shown in Fig. 4-9 (b), the delivery valve contacts the valve seat to prevent the reverse flow of the fuel from the high pressure pipe to the pump cylinder.

![Diagram](image)

**Fig. 4-9** Delivery valve

(a) (b)
OVERHAUL

SPECIAL TOOL (N.D. made)

Prior to start of injection pump overhaul, it is necessary to prepare special tools.

A-TYPE PUMP BODY TOOL KIT (95905-03000)

- Delivery valve puller
- Plunger puller
- Driving flange
- Tappet clamp
- Tappet inserter
- Camshaft bearing outer race puller
- Open end wrench
- Delivery valve gasket inserter
- Box wrench
- Holding wrench
- Oiler
- Holding wrench

Specifications:
- Delivery valve puller: 95905-05050
- Plunger puller: 95905-11030
- Driving flange: 95905-01040
- Tappet clamp: 95905-10030
- Tappet inserter: 95905-08030
- Camshaft bearing outer race puller: 95905-04050
- Open end wrench: 95905-08003
- Delivery valve gasket inserter: 95905-07006
- Box wrench: 95805-06004 (10 mm)
- Holding wrench: 95906-04020
- Oiler: 95905-01090
- Holding wrench: 95905-01020
GOVERNOR TOOL KIT (95907-02000)

Governor weight extractor

Idle adjust wrench

Adapter

Arm

Wrench

Governor puller

Torque measuring tool

Control sleeve extractor

Lever

Tool case

Pressing screw

Weight spring nut wrench

95907-01030

95905-07050

95907-01002

95099-08000

95907-07080

95907-02004
**TIMER TOOL KIT (95906-03000)**

- **Spring guide**
  - Part number: 95906-01030

- **Band wrench**
  - Part number: 95906-02050

- **Timer extractor**
  - Part numbers: 95906-02050, 95906-08050

- **Oil seal guide**
  - Part number: 95906-01070

- **Holding wrench**
  - Part number: 95906-03020

- **Handle**
  - Part number: 95906-01062

- **Tool case**
  - Part number: 95099-08000

- **Band**
  - Part number: 95906-01061

- **Timer repair tool**
  - Part number: 95906-07050

- **Timer setting stand**
  - Part number: 95906-05100
BOX WRENCH KIT (95905-05000)
Governor round nut wrench box
95907-05010
Governor plug wrench box
95905-04004
Timer wrench box
95907-07010
Screw plug wrench box
95906-05004
Box
95905-07005
95905-06005
T-Handle
95044-33380
Extension bar
95044-34150
Wrench
95044-30250
Tool case
95099-05000
P-type plug setting wrench box
95905-04010
Timer round nut wrench box
95906-03010
PUMP HOLDER KIT (95905-02100)

- Pump stand
  - 95905-01100

- Pump stand adapter
  - 95905-01110
  - 95905-01111
  - 95905-01112

- Pump holder
  - 95905-02110

Pump setting angle
- 95905-06101

TORQUE WRENCH KIT (95047-01000)

- 95047-21300

Fig. 4-10 Special tools
DISMOUNTING

1. Dismounting the injection Pump with Governor, Timer and Feed Pump
   1. Disconnecting the fuel pipe
      Disconnect pipe joints at the feed pump inlet and outlet and the injection pump inlet and outlet.
      After disconnecting, cover the pipe ends to prevent the entry of dust.
   2. Disconnecting the lever link
      Remove the joint pin of the governor fuel lever to disconnect the link.
   3. Put matching marks in paint on both faces (with the disc in between) of the coupling in front of the timer, that is the timing gear case side and the injection pump side.
   4. Remove the four injection pump mounting bolts and move the injection pump backward so that it will be disconnected from the coupling.
      After removing the pump from the engine, thoroughly clean it and check for external damage before disassembling.

2. Removing the Main Unit
   1. Drain the oil from the drain plug.
   2. Dismount the feed pump after removing three retaining bolts.
   3. Dismount the governor.
   4. Dismount the timer.

DISASSEMBLY

Fig. 4-11 Fuel injection pump body

1. Injection pump housing
2. Injection pump camshaft
3. O-ring
4. Distance ring
5. Shim
6. Taper roller bearing
7. Oil seal
8. Bearing cover
9. Bearing
10. Control rod
11. Joint bolt
12. Plunger control sleeve
13. Control pinion
14. Upper seat
15. Pump plunger spring
16. Plunger spring lower seat
17. Injection pump element
18. Injection pump tappet
19. Injection pump tappet
20. Plug
21. Delivery valve holder
22. Delivery valve spring
23. Delivery valve
24. Gasket
25. Valve holder lock plate
26. Stopper
27. Cover
28. Adapter
29. Stud
30. Washer
31. Round nut
32. Lockwasher
33. Woodruff key
34. Control rod cover
35. Pin
36. Bleeder screw
1. Caution in disassembling
1. It is very important that disassembly and assembly be made in a clean workshop, as the pump is a high-precision part.
2. Always use the delivery valve as a set with the plunger.

DISASSEMBLING

1. Placing the Tappet Insert
1. Remove the fuel feed pump.
2. Remove the plate cover.
3. Insert the tappet inserter (part No. 95905-03008) into the bore of the tappet in order to isolate the camshaft from them.

2. Removal of Camshaft
1. Remove the plug and screw from the lower part of the housing with a T-Handle (Part No. 95044-33380).
2. Remove the cover and bearing outer race from the automatic timer.
3. Remove the camshaft towards the timer.

3. Removal of Tappet Assembly
1. Remove the tappet assembly by making use of tappet inserter (Part No. 95905-06030) and tappet clamp (Part No. 45905-10030).

Fig. 4-14 Removal of tappet 04-029

4. Removal of Plunger
1. Remove the plunger spring lower seat and plunger en-bloc by making use of plunger puller (Part No. 95905-11030).

NOTE:
Sort the removed plungers to identify with the cylinders.

2. Then, remove the plunger spring.

Fig. 4-15 Removal of plunger 04-030

5. Removal of Control Sleeve
1. Remove the control sleeve and plunger spring upper seat.

6. Removal of Delivery Valve Holder
1. Remove the lock plate assembly, and then pull out the delivery valve holder and delivery valve spring by means of socket wrench.
7. Removal of Delivery Valve

1. Dismantle the delivery valve by fingers.

NOTE:
Assort the removed delivery valves to make with the formerly assorted plungers.

---

8. Removal of Control Rod

1. Loosen the rack screw on the back of the housing, and remove the control rod out of the governor.

CLEANING

1. Remove the delivery valve gasket from the delivery valve and thoroughly wash them in gasoline. Then place them, as a unit, in a diesel fuel oil tank.

2. Clean the plunger in a similar manner.

3. Wash the exterior and interior of the pump housing using a small brush. The portion where the plunger barrel fits in must be cleaned with special care. Dry the pump housing after washing, by applying compressed air.

4. Similarly, wash all other parts in gasoline and keep them classified according to cylinders to which they belong.

---

INSPECTION AND REPAIR

1. Plunger.

Remove the plunger out of the plunger barrel, and check it for scars, traces of seizure and rust development.

Put the end of plunger into the barrel, and tilt the barrel some 60°. Turn the plunger, if the plunger falls gently, the plunger set-up is justifiable. The replacement should be carried out as to a complete set of the plunger and barrel.

Half replacement is prohibitive. See Fig. 4-17.

---

2. Delivery valve

Check the piston in the same manner as the plunger, and check the valve seat for stepped wear, scars, etc. Also check the drawing back action of the delivery valve as follows.

1. Thoroughly wash the delivery valve in diesel fuel oil. Allow a light coating of oil to remain on its surface.

2. Close the port by fingers as shown in Fig. 4-18.

---

3. Control rod

Check for bending. If found bent, the control rod must be repaired or replaced.

If there is an excessive clearance between the control rod and the bushing, replace the bushing. The control rod should be replaced also when its gear teeth are excessively worn.
4. Control sleeve
   When the gear teeth of the pinion are worn, replace the
   pinion only.
   Replace the pinion set screw if its groove is deformed.
   Adjustment after assembly will be difficult with such
   a set screw.
   Also check and confirm that the control sleeve and
   the pinion are firmly secured.

5. Tappet and roller
   Check the tappet, rollers and pin for wear.
   If any wear on them is found, replace them.

6. Camshaft and ball bearing
   Check the camshaft for scoring and excessive wear
   as well as for deformation of the thread at each
   end and deformation of the key groove. Check the
   ball bearing for the wear and fatigue of balls or the
   race surface, and replace it if any defect is noted.
   Assemble the camshaft into the injection pump
   housing and measure its end play. If it exceeds 0.1
   mm (0.0039 in.), adjust it to 0.03 – 0.05 mm
   (0.0017 – 0.0019 in.), placing shims.

7. Plunger spring and delivery valve
   Check the springs for cracks. Also measure their
   free length and verticality. Replace them if they
   are over the lengths specified below.

<table>
<thead>
<tr>
<th>Item</th>
<th>Vertically</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plunger spring</td>
<td>49.4 ± 1 mm</td>
</tr>
<tr>
<td></td>
<td>(1.94 ± 0.039 in)</td>
</tr>
<tr>
<td>Delivery valve</td>
<td>19.0 mm</td>
</tr>
<tr>
<td>spring</td>
<td>(0.75 in)</td>
</tr>
</tbody>
</table>

8. Check the injection pump housing for cracks, damage to the threaded portion, etc.

**ASSEMBLY**

In assembly, observe the assembly marks on various parts to avoid erroneous assembly. Check and confirm, during assembly, that all moving parts will move smoothly.

1. Installing the control rod
   Insert the control rod to the housing and tighten
   the rod guide screw, after which confirm that the
   rod will move smoothly.

2. Installing the plunger barrel
   Place the plunger barrel (only the barrel, without
   the plunger) in each cylinder. See to it at this time
   that the feed hole of the barrel will come to the
   front of the pump (opposite side of the rack).

3. Installing the delivery valve
   Put a new delivery valve gasket on the delivery
   valve and tap it lightly with a pipe *that fits the
   periphery of the gasket*, so that the delivery valve
   will closely contact the plunger barrel. Then place
   the delivery valve spring and tighten the delivery
   valve holder with 250 – 350 kg-cm (18 – 26 lb-ft.).
   **Similarly install the delivery valve in each cylinder.**

**Fig. 4-19 Tightening the valve holder**

**NOTE:**

*This tapping tool may be made by grinding the threaded portion of a delivery valve holder.
**Excessive tightening of the delivery valve holder may cause major troubles such as the breakage of the pump housing and defective movement of the control rod, etc. Care must be taken accordingly.*

(2) Lay the injection pump

4. Installing the control sleeve
   Set the control rod so that the distance from the
   end surface of the case to the punch mark at the
   end of the control rod will be equal on each side.
   Then place the control sleeve in the plunger barrel
   and engage it with at the position where the clamp
   portion of the pinion will be perpendicular to the
   rod.

5. Installing the plunger spring
   Install the spring upper seat and the spring.

6. Inserting the plunger into the barrel.
   Dip the plunger in clean diesel fuel oil, and then
   hold it with the plunger holder (special tool shown
   in Fig. 4-20) horizontally. Then, put the lower spring
   seat on the plunger, holding its flange portion,
   and insert it through the plug hole, maintaining it
   horizontally.
The feed hole of the barrel and the control groove of the plunger should be in the same direction. If installation is incorrect, injection volume cannot be adjusted.

When the spring and the spring seat have been put together completely, loosen the plunger holder and draw out the holder.

This must be conducted very carefully, so that the spring seat will not be dropped before the plunger is inserted.

Camshaft end play should be from 0.03 – 0.05 mm (0.00118 – 0.00196 in.) if not, adjust with shims.

After this, draw out the tappet insert (special tool).

10. Install the screw plug

11. Installing the body cover

Correctly install the cover of the pump body and secure the cover screw to prevent the entry of water into the pump body (this leads to rust damage).

TESTING (1)

1. Inspecting the Sliding Resistance of Control Rod

The rod should slide smoothly to the left or right under a load of less than 50 g (1.76 oz) when the pump rotates at 1,000 rpm and under a load of less than 150 g (5.29 oz) when the pump stops. Measure the sliding resistance by using the spring balancer.

<table>
<thead>
<tr>
<th>Pump speed</th>
<th>Sliding resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000 rpm</td>
<td>* Less than 50 g (1.76 oz)</td>
</tr>
<tr>
<td>At stopping</td>
<td>* Less than 150 g (5.29 oz)</td>
</tr>
</tbody>
</table>

TESTING (2)

After assembling, inspect and adjust the function of the injection pump.

1. Injection timing
2. Injection volume
3. Fuel tightness
1. Tester
Specified testers are necessary for testing. Contact a service station when proper testers are not available. One of the specified tester is shown in Fig. 4-22.
1. Set the injection pump correctly in the tester.
2. Fill the Engine Oil from the plug until the oil overflows from the hole of the plug.

2. Injection timing
1. Measuring and adjusting the pre-stroke of the first cylinder.
   The plunger stroke from the point where the cam lift is zero to the point where pressure feeding begins (the upper end of the plunger closes the feed hole) is called the pre-stroke. (Refer to Fig. 4-23) Measure and confirm, using a measuring device as shown in Fig. 4-24, that the pre-stroke of the first cylinder is $3.1 \pm 0.05$ mm ($0.122 \pm 0.00197$ in.).
   Place this device at the injection pump housing holding it with hand, and allow its contactor to touch the upper surface of the tappet. Then slowly turn the cam with hand and read the stroke on the dial gauge.

2. Measuring and adjusting the injection interval
   After fixing the pre-stroke of the first cylinder, ensure that the others begin injection at interval $60^\circ \pm 30'$ in the order of cylinder 1-4-2-6-3-5.
3. Insuring the tappet top clearance
The tappet top clearance is the distance from the upper end of the plunger flange to the lower end of the barrel, when the cam lifts maximum. (Refer to Fig. 4-27).

Fig. 4-27 Tappet top clearance

Insure that the tappet top clearance is more than 0.2 mm (0.0078 in.), for all six cylinders, using the device shown in Fig. 4-24, by the same method for measuring the pre-stroke, and tappet gas instrument.

If this clearance is less than 0.2 mm (0.0078 in.), adjust it by the adjusting shims.

Fig. 4-28 Measuring the tappet clearance

4. Insuring the injection timing mark
After these adjustments are completed, check and confirm that the mark on the bearing cover of the pump and the one on the automatic timer are matched, at the position where the pressure-feeding of the first cylinder begins. (Refer to Fig. 4-29). If they are not, remark it.

That is the moment these marks are matched is the injection start timing of the first cylinder.

Fig. 4-29 Injection timing mark

3. Injection Volume
When necessary the injection volume adjustment, should be made as follows (refer to supplementary data sheet).

1. Loosen the control rod fixing device and move the rod to one side all the way and loosen the rod pinion screw of the cylinder which needs injection volume adjustment.

2. Insert the adjusting pin into the hole in the control sleeve and slightly move the sleeve. (Refer to Fig. 4-30).

As the control sleeve is moved to the timer side, injection volume will decrease.

As the control sleeve is moved to the governor side, injection volume will increase.

Adjust the movement of the control sleeve, watching the matching marks scribed on the control sleeve and the pinion. (Refer to Fig. 4-29).
(3) When adjustment has been completed, once again check the injection volume with a tester, and repeat adjustment until the specified injection volume is obtained.

(4) Upon completion of the adjustment, put a matching mark on the control sleeve and the pinion.

**Fig. 4-30 Adjusting the injection volume**

---

**MOUNTING**

1. Matching with engine

When mounting the fuel injection pump on engine, match it with the engine as follows.

With the engine stopped, align the mark on the end of the bearing cover (on the end of the injection pump) with the mark on the back of the automatic timer. (Refer to **Fig. 4-29**). This sets the primary plunger in the position of maximum injection.

At this time, adjust the injection coupling so that the pointer, viewed through the opening on the flywheel housing, indicates 17° (B.T.D.C.). This is found on the graduations punched around the periphery of the flywheel.

**Fig. 4-31 Flywheel scribed marks**
GOVERNOR

DESCRIPTION

The RSV governor is a centrifugal, variable-speed type governor. This governor is capable of holding a steady speed in the range between idling and maximum speed positions.

Fig. 4-32 Structure of the governor
1. Structure

(1) The flyweight assembly is mounted on the pump camshaft as shown in Fig. 4-33. The camshaft bushing, with which two flyweights are connected, is keyed to the pump camshaft by key and round nut. These two flyweights can swing on weight-supporting shaft. When the flyweights swing outward, the roller at the end of the flyweights are pressed against the shoulder of the governor sleeve. The governor sleeve can be moved along the stub of the camshaft bushing and rotates with the camshaft bushing. The ball bearing connects the governor sleeve with the control block. The control block does not rotate but move back and forth along the projected axis of the camshaft and is connected with the guide lever.

![Diagram of flyweight assembly](image)

Fig. 4-33 Structure of flyweight assembly

(2) Lever and Spring

The tension lever and guide lever pivot on the lever supporting shaft at the top of the governor. The guide lever has a pivot pin, on one end of which the control lever is fixed and can swivel. A stud of the control lever guided in a slot of supporting lever locates the control lever at its lower end. The shackle assembly connects the control lever to the control rod. The swivelling lever pivots in bushing on each side of the governor cover. The adjusting lever is fastened to one end of the swivelling lever. The start spring is hooked to the top of the control lever and in a hole of bracket fixed to the governor housing. The speed control spring is hooked to the rocker arm of the swivelling lever and into the eye of the tension lever.

The adaptor assembly, adjustable threaded bushing is screwed into the tension lever at its lower end, and serves to increase fuel delivery when the engine is pulled down by overload in the medium-to full load rpm range. The idling spring is fitted in an adjustable threaded bushing which is screwed into the governor cover nearly at its center, and provides satisfactory governing at low speed without affecting high speed performance. The maximum speed stopper provides the full load position to the adjusting lever and the stop-adjusting screw provides the stop position to the adjusting lever.

(3) Stop device

The stop device is shown in Fig. 4-34. The supporting lever of the stop device is coupled to the shut-off shaft and stop lever by pressure spring. When the stop lever is turned to "stop position", the control lever pivots on the shaft through the supporting lever. Therefore, control rod is directly moved to "no fuel delivery" position regardless of other linkage and lever operation.

![Diagram of stop device](image)

Fig. 4-34 Stop device
1. Governor housing
2. Plate
3. Stopper
4. Governor cover
5. Stopper
6. Cap nut
7. Stroke adjusting screw
8. Bushing
9. Tension lever
10. Control lever
11. Supporting lever shaft
12. Screw plug
13. Supporing slider
14. Idle spring
15. adjusting screw
16. Shackie
17. Woodruff key

18. Flyweight
19. Round nut
20. Sleeve
21. Plate washer
22. Swiveling lever
23. Lever bushing
24. O-ring
25. Snap washer
26. Speed control spring
27. Start spring
28. Adapter
29. Adapter spring
30. Lock nut
31. Oil seal
32. Steel collar
33. Adjusting lever

52. Lever cap
53. Stopper lever
54. Cover plate
55. Plate packing
56. Pressure spring
57. Bearing bushing
58. Spring cover
59. Pressure spring
60. Governor shaft
61. Spring cup
62. Support lever
63. Return spring
64. Cap plate
65. Pressure spring
66. Torque lever
67. Support pin

Fig. 4-35 Governor main component parts
2. Working Principle

(1) When a camshaft to which the two flyweights are keyed, rotates, these flyweights swing outward as shown in Fig. 4-35. The force swinging out the flyweights is called the centrifugal force. As the speed of the camshaft increases, the centrifugal force also increases.

**Case 1**

When the speed increases the flyweights swing outward and move point A, at the end of flyweight arms, to the right. This pushes on the control block. At this time, the centrifugal force overcomes the spring force, as shown in Fig. 4-35. This movement will stop at a position where the forces on the flyweights and spring are balanced.

(2) Function of speed control spring

Control speed can be varied by changing the tension of the speed control spring, due to the mechanism as shown in Fig. 4-36.

The fulcrum of the swivelling lever and the eye of the tension lever into which the speed control spring is hooked are offset. Therefore, when the swivelling lever is moved in the arrow direction as shown in Fig. 4-36, the distance “DE” becomes longer and then the tension of the speed control spring becomes stronger.

The force of the speed control spring is meant to be balanced with the centrifugal force working on the lower end of the tension lever. If the tension of the speed control spring becomes weak (i.e., the swivelling lever is turned to the right) as shown in Fig. 4-37, even a weak centrifugal force of the flyweights can overcome the spring force. This means that control speed shifts to low speed.

If the tension of the speed control spring becomes stronger, control speed shifts to high speed due to the strong spring force.

**Case 2**

When the speed decreases, the centrifugal force becomes less. Finally the spring force exceeds the centrifugal force, and the flyweights swing back. The control block is then moved to the left. This movement stops at a balanced position.

On a injection pump body, a governor-operated control rod is connected to the control sleeve and plunger to regulate the quantity of fuel delivered to the engine. Pushing the control rod toward the injection pump body increases the fuel delivery quantity. On the contrary, pulling the control rod toward the governor decreases the fuel delivery quantity.

As described above, the control block moves the control rod through the governor linkage system to control engine speed.
3. Operation

(1) Starting the engine

When moving the adjusting lever to the starting position to be pressed against the maximum speed stopper with the engine stopped, the speed control spring is fully tensioned by the swivelling lever and thus pulls the tension lever to be pressed against the full load stopper.

The tension lever will move the guide lever, control block and governor sleeve to the left. In the course of these movements, the governor sleeve moves the flyweights to rest against the governor sleeve.

At the same time the start spring pulls the control lever to the left and moves the control rod all the way to “starting fuel” position via the shackle assembly. When the starter is cranking the engine, the injection pump begins delivering additional fuel to the engine for starting. Once the engine has started, the centrifugal force of the flyweights overcomes the force of the start spring, moving the control rod back to a position where the forces on the flyweight and speed control spring are balanced.

(2) Idling speed control

When the engine is idling, the governor starts to function automatically. With the adjusting lever in idling position, the speed control spring is almost free of tension as shown in Fig. 4-39. Therefore, the flyweights can swing outward even at low speed with very little resistance, pushing the tension lever to the right via the governor sleeve and control block.

As the force of the speed control spring is weak, the tension lever is moved to a position where to contact the idling spring, slightly compressing the adaptor spring.

Thus, the control lever moves on pivot A to the right and pulls the control rod to a position where the forces on the flyweights and springs such as the speed control spring and idling spring are balanced, resulting in maintaining desired idling speed.
(3) Maximum speed control
With the adjusting lever in full load position (to be pressed against the maximum speed stopper), the speed control spring is fully tensioned and then pulls the tension lever up against the full load stopper with great force. This movement causes the control rod to move into maximum fuel delivery position, resulting in increasing the engine speed.
Once the tension lever is pulled up against the full load stopper, the adaptor spring is continually compressed.
As soon as the centrifugal force exceeds the force of the speed control spring, the governor linkage moves the control rod in fuel-decreasing direction to prevent the engine speed from exceeding the specified maximum speed.
When the engine speed reaches the full load speed, the governor regulates fuel delivery to maintain the engine speed between full load and fast idle as long as the load on the engine is not great enough to cause an overload.

(4) Operation of adaptor spring
When at maximum control speed the load on the engine is sufficiently reduced, the adaptor spring overcomes the flyweights force and moves the guide lever to the left. This means that the control rod moves in the fuel-increasing direction, delivering more fuel to the engine.
When the engine speed gradually increases, the flyweights force increases and starts compressing the adaptor spring. This movement causes the control rod to move in the fuel-decreasing direction. Adaptor operation stops at a position where the adaptor spring is completely compressed.

Fig. 4-41 Adaptor operation

(5) Function of adaptor spring
The purpose of the adaptor spring is to increase fuel delivery when the engine is pulled down by overload, thereby providing an acceptable level of torque control.
With the control rod fixed, as the pump speed increases, fuel delivery per stroke increases. This characteristic is peculiar to the single-acting, plunger-type injection pump. On the other hand, inlet air quantity reduces as the engine speed increases, owing to increasing resistance to air flow. Fig. 4-42 shows above mentioned characteristics and fuel requirement of the engine in full against the engine speed.
With the control rod held in full load position, if the engine speed increases, fuel delivery lines (dotted lines) are obtained as shown in Fig. 4-42. To avoid insufficient torque at low speed (line a'b) and
smoking at high speed (line ab'), the fuel delivery characteristic should coincide as closely as possible with the fuel requirement characteristic for the engine.

For satisfying this requirement, the adaptor spring is installed on the governor. When the engine is pulled down to low speed with the adjusting lever in full load position, the adaptor spring acts on the governor linkage in order to increase rod travel, that is, to provide sufficient torque to the engine.

Fig. 4-42 Characteristics of fuel requirement and fuel delivery

(6) Stopping the engine

Engine equipped with governor without the stop device is stopped regardless of the flyweights position by moving the adjusting lever into the stop position (Fig. 4-43). Shortly before the adjusting lever is moved in the stop position, that is, before the rocker of the swivelling lever contacts the stop adjusting screw, the projection of the swivelling lever presses against the guide lever and push the control rod to the stop position via the guide lever, control lever and Fig. 4-43. Stopping the engine with the adjusting lever checkle assembly.

On engine equipped with governor with stop device, moving the stop lever in the stop position actuates the stop device to force the control rod to move also in the stop position regardless of the positions of the flyweights and control lever (Fig. 4-44).
(7) Speed droop (Degree of irregularity)

Speed droop is the variation in engine speeds between full load and no load speed range, and usually is expressed as a percent of rated speed.

If an engine has been operating under full load, and this load is suddenly removed, the engine speed will increase to the fast idle speed.

The speed droop is defined as follows:

$$\frac{N_n - N_f}{N_f} \times 100\%$$

$N_n$, Maximum speed obtained by a position of the adjusting lever (no load).

$N_f$, Full load speed obtained by the same position of the adjusting lever (full load).

Example:

If $N_n = 1360$ rpm, $N_f = 1300$ rpm,

$$\text{Speed droop} = \frac{1360 - 1300}{1300} \times 100 = 4.6\%$$

Speed droop is a scale for measuring the quality of the governing effect.
The smaller the speed droop is, the better control is obtained.

(8) Characteristics of governor

Fig. 4-45 shows characteristics of RSV governor. When with the adjusting lever in full load position gradually increasing the pump speed from low speed, characteristic curve A-B-C-D-E-F is obtained.

At starting, the control rod is pulled to "starting fuel" position by the start spring, exceeding full load position (line A-B). During line B-C the control block contacts the adaptor assy but the adaptor spring is not almost compressed since the centrifugal force of the flyweights is weaker than the adaptor spring force.

The adaptor spring functions during line C-D. At point D the adaptor spring completely is compressed but the flyweights force can not overcome the force of the speed control spring until the pump speed reaches maximum governing speed (point E), resulting in constant rod travel during line D-E. At point E the flyweights force begins overcoming the force of the speed control spring and the control rod is pushed toward the governor.

Characteristic curve H-I-J-K shows the characteristic of idling speed control with the adjusting lever in idling position. During line H-I the centrifugal force of the flyweights is weak. Therefore, the start spring pulls the control rod toward the maximum fuel delivery position. At point I the idling spring con-

4. Disassembly and assembly

Before beginning the governor disassembly and assembly, the following tools are required.

a. Screwdriver
b. Spanner set
c. A pair of needle nose pliers
d. Flyweight round nut wrench
   (ND No. 95907-07010)
e. Flyweight extractor
   (ND No. 95907-01050)
f. Tool set for disassembling and assembling the governor

Thoroughly clean the exterior of the pump and the governor. Before disassembling, make preliminary inspection of the governor in attempt to determine the extent of failure and use a parts box to avoid mismatching crucial parts. Be sure that work area and tools are spotlessly clean.
1) Governor cover removal
   a) Remove the idling spring screw.
   b) Remove six attaching screws.
   c) Separate the governor cover from housing.

   CAUTION:
   Hold a small pan or container under governor to catch
   lubricating oil drainage when separation is made.

   d) Cover is still attached by latch pin of shackle and
      start spring.
      Disconnect the locking clip and force the latch
      pin free from the control rod with screw driver.

2) Flyweight removal
   a) Remove the round nut using the round nut
      wrench box (Part No. 95907-07010).

   b) Remove the flyweight assembly using the flyweight
      extractor (Part No. 95907-01050).

3) Supporting lever shaft removal
   Remove the two screw plugs at the top of the
   governor cover and drive out the supporting lever
   shaft on which the tension lever is suspended.
(4) Tension lever removal

Maneuver the tension lever from under swivelling lever as shown in Fig. 4-51. Unhook the speed control spring from the eye of the tension lever from the eye of the swivelling lever locker arm. Remove the tension lever.

(5) Swivelling lever removal

a) Remove the adjusting lever and two retaining circlip on each end of the swivelling lever.

b) Tap out swivelling lever bushings and remove the swivelling lever.

(6) Remove the guide lever, the control lever and governor sleeve as a complete unit.

(7) Stop device removal

To remove the stop device, first remove the full load stop screw. And remove the stop lever, spring cover and return spring. Push shut-off shaft into governor cover. Spring cap can be removed by removing the retaining clip and three springs.

(8) Governor sleeve removal

a) Separate the governor sleeve from control block using the control sleeve extractor (Part No. 95905-07050).

b) Remove the snap ring using the snap ring pliers.
ASSEMBLY

Assembly takes place in the reverse order of disassembly.

Pay attention to the following points:

1. Installation of the flyweight
   - install the key and the flyweight to the pump camshaft and place spring washer on it.
   - Securely tighten the round nut to 5 - 6 kg-cm (36.2 - 43.4 lb.ft.) torque using governor round nut box and torque wrench.

2. Installation of governor sleeve and control block
   (1) Put the thrust bearing into the governor sleeve and place the governor sleeve into position against the contact block in the flyweight. The flyweight should be in rest position. Place shims on the thrust bearing and check the assembling dimension as shown in Fig. 4-57.
   - The fitting dimension of the control block must be 19.0 to 19.2 mm (0.748 - 0.756 in). If not, change thickness of shims. The shim plates are available in the following thickness 0.1, 0.2, 0.3, 0.4, 1.0 mm.

   Fig. 4-57 Assembling dimension of flyweight

   (2) Slip shims determined in step above on the control block.
   - Press the control block into the thrust bearing as shown in Fig. 4-58.

   CAUTION:
   - Be sure not to strike the guide lever directly.

   Fig. 4-58 Pressing control block into thrust bearing

3. Installation of swivelling lever
   - Insert shaft of swivelling lever into the two governor bearing bores so that the groove in the swivelling lever is up. Insert the two bearing bushings with sealing rings from the outside into the governor cover. Press bearing bushing into position so the grooves for circlips are accessible. Snap circlips into position.

4. Installation of speed control spring
   - Attach the speed control spring to eye in tension lever and into eye of swivel lever rocker as shown in Fig. 4-60.
   - Take care to direction of the spring.

   Fig. 4-60 Installing speed control spring

5. Check ease of movement of levers and linkages.
6. Check for the stop device operation.
3. ADJUSTMENT OF MEDIUM SPEED CONTROL

Drive the pump at \( N_1 \) rpm. Pull the adjusting lever to full load position and temporarily fix it. Turn the full load stopper in or out with screwdriver so that the rod travel will become \( R_1 \) mm as shown in Fig. 4-62. Then tighten the lock nut.

Turning the full load stopper in (clockwise) increases the rod travel. On the contrary, turning it out (counterclockwise) decreases the rod travel.

![Fig. 4-62](image)

4. ADJUSTMENT OF ADAPTER SPRING

(1) Move the adjusting lever to full load position and fix it. Install the adapter assembly to the lower end of the tension lever.

(2) Adjust the adapter screw so that the rod travel will become \( R_2 \) mm when driving the pump at \( N_2 \) rpm. Screwing the adapter screw increases the rod travel and unscrewing reduces the rod travel.
(3) Adjust the spring tension with shims so that with the pump speed at $N_3$ rpm, $R_3$ mm rod travel is obtained. Add, reduce or replace shims between the adapter spring and adapter screw (Fig. 4-65).

(3) Check the rod travel $R_7$ mm at $N_7$ rpm. Then set the stop adjusting screw to contact the adjusting lever, and tighten the lock nut (Fig. 4-67).

(4) Check the rod travel $R_4$ mm at $N_4$ rpm.

5. ADJUSTMENT OF IDLING SPEED CONTROL

(1) Set the adjusting lever free and install the idle adjusting screw with the idling spring to the governor cover.

Adjust the idle adjusting screw so that with the pump speed at $N_5$ rpm the rod travel is $R_5$ mm (Fig. 4-66).

Secure it by tightening lock nut.

(2) Drive the pump at $N_6$ rpm. Move the adjusting lever in idling position so that the rod travel becomes $R_6$ mm.

6. ADJUSTMENT OF MAXIMUM SPEED CONTROL

(1) Break-away speed is the speed obtained when the control rod starts to decrease after the full load speed was reached. To adjust the break-away speed, increase the pump speed slowly up to $N_9$ rpm from $N_8$ rpm and move the adjusting lever so that the rod travel becomes $R_8$ mm at $N_9$ rpm. Temporarily fix the adjusting lever and screw the maximum speed stopper to contact the adjusting lever and tighten lock nut.
(2) Adjusting of speed droop

Increase the pump speed up to $N_{10}$ rpm. Check the rod travel $R_{10}$ mm. If the specified rod travel $R_{10}$ mm. is not obtained, turn the adjusting screw of the swivelling lever out or in to obtain $R_{10}$ mm position. Turning in the adjusting screw provides better governing effect (small speed droop). Backing out the adjusting screw provides worse governing effect (large speed droop). Value X indicated in test specifications sheet of injection pump means how many clicks the adjusting screw should be backed out from a position where the adjusting screw is turned all the way in (4 clicks is one full turn of the adjusting screw).

**CAUTION:**

When adjusting the governor, don't back out the adjusting screw of the swivelling lever more than 24 clicks (6 complete turns) from a position where the adjusting screw is turned all the way in.

(3) Readjustment

After adjusting the adjusting screw of the swivelling lever, the tension of the speed control spring is changed. Therefore, the break-away speed is varied. Readjust the maximum speed stopper to meet test specifications in accordance with “a) Adjusting break-away speed”.

(4) Check the rod travel is less than $R_{11}$ mm at $N_{11}$ rpm.

![Fig. 4-68](image)

**Fig. 4-68**

7. **CHECKING OF THE STOP LEVER OPERATION**

Drive the pump at $N_9$ rpm and move the adjusting lever to the idling position. When pulling the stop lever, check the rod travel to be less than 2 mm.

8. **ADJUSTMENT OF PUMP WITH GOVERNOR OPERATION**

Drive the pump at the specified speed shown in the test specifications, and move the adjusting lever to the full load position. Check the injection volume. If not within the specification, adjust the full load stopper.

![Fig. 4-70 Lever position](image)

**Fig. 4-70 Lever position**

![Fig. 4-69 Adjustment of adjusting screw](image)

**Fig. 4-69 Adjustment of adjusting screw**
Operation

The right half illustration on Fig. 4-71 shows a static state of the automatic timer. As will be clear from the illustration, the flyweight cannot be raised while the engine speed is within a certain limit (up to some 1000 rpm), because the centrifugal force of the flyweight gives way to the loaded force of the timer spring; namely, the mounting length of the timer spring is at largest, L.

As the engine speed increases, the flyweight is raised little by its centrifugal force. The mounting length of the timer spring will attain the shortest value (L') at an engine speed of 2700 rpm (pump speed: 1350 rpm).

Since part “B” appearing in the figure is flange leg, its relative position of the pump drive shaft cannot be changed.

Accordingly, the flyweight holder pin A is attracted by “E” by the resultant lift (amount of rise) of the flyweight. The movement of A works to turn the pump camshaft with respect to the engine drive shaft, making it possible to change the injection timing.
1. Remove the injection pump assembly with timer.
2. Remove the round nut using the socket wrench (Part No. 95906-03010) and holding wrench (Part No. 95806-03020) shown in Fig. 4-73.
3. Pull out the timer assembly using the extractor shown in Fig. 4-74.

**INSPECTION**

1. Check whether the timer spring is fatigued, defective or degraded in rectangularity.
   
   **Rectangularity:**
   
   **Standard** 1.5 mm (0.059 in.)
   
   **Limit** 2.0 mm (0.078 in.)

   **NOTE:**
   
   If the spring is fatigued, it could advance the revolution at starting point.

2. Axial play between flyweight holder and flange:
   
   **Standard** 0.02 – 0.10 mm
   
   (0.0007 – 0.0039 in.)
   
   **Limit** 0.20 mm (0.0078 in.)

3. Gap between flyweight pin and pin hole:
   
   **Standard** 0.05 – 0.10 mm
   
   (0.0019 – 0.0039 in.)
   
   **Limit** 0.20 mm (0.0078 in.)

   **NOTE:**
   
   When the pin in worn out, the engagement will become jolly, increasing the variations in speed and making the injection timing unsteady. This is turn results in poor output performance.
ASSEMBLY

Install driving flange guide on the flyweight holder. Install spring guide (Part No. 95906-01030) beneath the spring. (Refer to Fig. 4-79), and using holding wrench, turn the flange to compress the spring and push in and install the flange.

LUBRICATION

After assembling, remove two plugs lubricated the Timer Grease from the plug until the grease overflows from the other plug.
It amounts to approx. 150 g (5.3 oz)

MOUNTING

After lubricating, mount the timer on the injection pump. The tightening torque of the timer round nut is 600 – 700 kg·cm (43 – 50 lb·ft.).

FUEL FEED PUMP

DESCRIPTION

Fig. 4-81 Fuel feed pump

The fuel feed pump is installed on the side of the injection pump. It is a piston type pump and is driven by the injection pump camshaft.
It draws the fuel from the tank and feeds it to the injection pump.
Besides this, a priming pump is also available to enable manual fuel feeding, when the engine is not in motion.
This is used when starting the engine or when bleeding air from the fuel system.

1. Function

During engine operation, the driving force of the injection pump camshaft is communicated to the piston through the cam, tappet roller, tappet and push rod in turn. A manual priming pump is also provided for the purpose of manual fuel feed at the time of start-up and air purging.
OVERHAUL

DISMOUNTING

1. Remove the injection pump assembly with the feed pump.
2. Drain the lubricant oil by loosening the drain plug of the injection pump.
3. Remove the three retaining bolts.

DISASSEMBLY

Fig. 4-83 Feed pump
(1) Clamp the feed pump in a vise, and remove the priming pump.

(2) Remove the check valve and check valve spring.

(3) Loosen the plug screw to remove the piston spring.

(4) Undo the snap spring and remove the tappet.

(5) Dismount the piston.

(6) Pull the push rod away.
4-38 FUEL INJECTION PUMP

INSPECTION AND REPAIR

1. Replace the check valve seat, when the seat surface is worn and dented.
2. Check the piston and the cylinder for scars.
3. Replace the push rod together with the housing, if there is any leakage from between the push rod and the housing.
4. Check the case for scars and cracks and also for damage to the threaded portion.

Many parts are kept oil-tight by their contact with the plug end surface, without the use of gaskets. Check such surface for roughness.
5. Priming the piston and the cylinder for rust. Also check the valve seat for wear or dent.

ASSEMBLY

(1) After setting the tappet into the feed pump housing, lock it with a snap ring, and insert the push rod in position from the plug screw side.
(2) Insert the piston through the plug screw hole.
(3) Load the piston spring, and then tighten up the plug screw.
(4) Set the check valve and check valve spring into the feed pump housing, and secure the priming pump to the suction port and the screw plug to the discharge port.

TESTING

1. Pump suction head capacity test

Connect a pipe to the feed pump suction port, and work the piston which is located some 1 m (39.37 in.) above the oil level, at a speed of 150 rpm. The fuel should be sucked up and discharged in about 45 Sec. after start-up of the pump.

2. Pump feed rate test

When the feed pump is driven at 1,000 rpm, the feed rate should be more than 900 c.c. per min. When the discharge port is plugged the feed pressure should be 2.5 - 3.5 kg/cm² (35.5 - 49.8 lbs/in²) at 600 rpm.

3. Pump air-tightness test

After cap-plugging the outlet hole apply 2 kg/cm² (28.4 lb/sq. in.) of air pressure from the inlet side and place the pump in to light oil. The leakage of air bubbles from the space between the push rod and housing and from the other parts should not be at all.
### Fuel Injection Pump 4-39

#### Repair Specification

<table>
<thead>
<tr>
<th>Item</th>
<th>Assembly Standard</th>
<th>Repair limit</th>
<th>Service limit</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gap between housing and tappet</td>
<td>0.03–0.07</td>
<td>0.2</td>
<td>(0.0011–0.0027)</td>
<td>Replacement of either tappet or housing</td>
</tr>
<tr>
<td>Gap between housing and bearing cover</td>
<td>0.005–0.05</td>
<td>0.1</td>
<td>(0.0001–0.0019)</td>
<td>Replacement of either cover or housing</td>
</tr>
<tr>
<td>Total lift of cam</td>
<td>8 (0.3149)</td>
<td>−0.2</td>
<td>(−0.0078)</td>
<td>Replacement of camshaft</td>
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<tr>
<td>Buckling of camshaft</td>
<td>smaller than 0.05</td>
<td>0.15</td>
<td>(0.00059)</td>
<td>Repair or replacement</td>
</tr>
<tr>
<td>Camshaft axial play</td>
<td>0.03–0.05</td>
<td>0.1</td>
<td>(0.0019)</td>
<td>Adjustment with shim</td>
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<tr>
<td>Tappet, outside diameter</td>
<td>24 (0.9448)</td>
<td>−0.03 (−0.0011)</td>
<td>(−0.0039)</td>
<td>Replacement of tappet</td>
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<tr>
<td>Play in tappet roller pin</td>
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<td>0.2</td>
<td>(0.0078)</td>
<td>Replacement of roller, bush and pin</td>
</tr>
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<td>Rectangularity of delivery valve spring</td>
<td>smaller than 0.7</td>
<td>1.0</td>
<td>(0.0393)</td>
<td>Parts replacement</td>
</tr>
<tr>
<td>Rectangularity of plunger spring</td>
<td>smaller than 1.0</td>
<td>1.5</td>
<td>(0.0590)</td>
<td>Parts replacement</td>
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<tr>
<td>Play between control rack and pinion</td>
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<td>0.25</td>
<td>(0.0098)</td>
<td>Replacement of either rack or pinion</td>
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<td>Slider resistor of control rack</td>
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<td>Correction</td>
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<td>Cylinder injection interval</td>
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<td>±0.5°</td>
<td>Correction</td>
<td></td>
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<tr>
<td>Tappet clearance</td>
<td>more over 0.2</td>
<td>0.2</td>
<td>(0.0078)</td>
<td>Adjustment</td>
</tr>
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<td>Gap between tention lever, guide lever</td>
<td>0.02–0.09</td>
<td>0.2</td>
<td>(0.0007–0.0035)</td>
<td>Replacement of pin and bush</td>
</tr>
<tr>
<td>Gap between tention lever, shaft and lever</td>
<td>0.04–0.08</td>
<td>0.15</td>
<td>(0.0015–0.0031)</td>
<td>Replacement of lever shaft and bush</td>
</tr>
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<td>Gap between flyweight pin and bush</td>
<td>0.02–0.05</td>
<td>0.08</td>
<td>(0.0007–0.0019)</td>
<td>Parts replacement</td>
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<td>Flange width</td>
<td>10 (0.3937)</td>
<td>0.2</td>
<td>(0.0078)</td>
<td>Replacement of flyweight and holder</td>
</tr>
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<td>Gap between flyweight and holder</td>
<td>0.05–0.1</td>
<td>0.2</td>
<td>(0.0019–0.0039)</td>
<td>Replacement of flyweight and holder</td>
</tr>
<tr>
<td>Rectangularity of timer spring</td>
<td>2.0 (0.78)</td>
<td>2.5</td>
<td>(0.098)</td>
<td>Spring replacement</td>
</tr>
<tr>
<td>Air tight test</td>
<td>No air leakage permitted from oil seal, O-ring and other parts with 0.5kg/cm² of air pressure applied inside the timer.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Play between tappet roller and pin</td>
<td>0.02–0.07</td>
<td>0.3</td>
<td>(0.0007–0.0027)</td>
<td>Parts replacement</td>
</tr>
<tr>
<td>Roller, outside diameter</td>
<td>15 (0.590)</td>
<td>0</td>
<td>−0.02 (−0.0007)</td>
<td>Roller replacement</td>
</tr>
<tr>
<td>Gap between housing and piston</td>
<td>0.03–0.06</td>
<td>0.15</td>
<td>(0.0011–0.0023)</td>
<td>Piston replacement</td>
</tr>
</tbody>
</table>

**Governor**

**Timer**

**Feed pump**

**Air tightness of push rod**

Totally close the discharge part. Apply 2 kg/cm² of air pressure, and immerse the pump into diesel fuel oil if air bubbles of millet grain size evolve continuously at a rate of from the push rod parts must be replaced. As the oil seal is fitted, air leakage cannot occur. If any air leakage is found, it should be replaced as a housing assembly.

**Suction head capacity**

Connect a pipe to the suction port. If the pump is able to discharge at a rate of 25 strokes when placed 1 m below the oil level, the pump performance is warrantable. If more than 25 strokes are required, the pump must be overhauled.

**Discharge rate**

Drive the feed pump at a speed of 1000 rpm. The pump is justifiable if it is able to discharge more than 900 cc in 60 sec. If it fails the discharge rate falls short of 900 cc, the pump must be subjected to overhaul inspection.
### TIGHTENING TORQUE

<table>
<thead>
<tr>
<th>Pump proper &amp; Timer</th>
<th>Tightening position</th>
<th>kg-cm</th>
<th>lb.ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Valve holder</td>
<td>400 - 450</td>
<td>29 - 33</td>
</tr>
<tr>
<td></td>
<td>Screw plug, pump bottom</td>
<td>550 - 750</td>
<td>40 - 62</td>
</tr>
<tr>
<td></td>
<td>Round nut</td>
<td>500 - 600</td>
<td>37 - 43</td>
</tr>
<tr>
<td></td>
<td>Timer round nut</td>
<td>850 - 1,000</td>
<td>61 - 72</td>
</tr>
<tr>
<td>Governor</td>
<td>Bearing bushing, adjusting lever</td>
<td>300 - 400</td>
<td>22 - 28</td>
</tr>
<tr>
<td></td>
<td>Fitting bolt, adjusting lever</td>
<td>80 - 90</td>
<td>5.8 - 6.5</td>
</tr>
<tr>
<td></td>
<td>Bearing bushing, tension lever</td>
<td>300 - 400</td>
<td>22 - 28</td>
</tr>
<tr>
<td></td>
<td>Bearing bushing, guide lever</td>
<td>200 - 300</td>
<td>14 - 22</td>
</tr>
<tr>
<td></td>
<td>Plug setting screw</td>
<td>100 - 120</td>
<td>7.2 - 8.6</td>
</tr>
</tbody>
</table>
GENERATOR
GENERADOR
GENERATRICE

SYMBOL MARKS
SIMBOLOS
SYMBOLES .................................................. 21-1

A GLOSSARY OF TECHNICAL TERMS
GLOSARIO DE TERMINOS TECNICOS
LEXIQUE DES TERMES TECHNIQUES .................. 21-2

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DATOS Y ESPECIFICACIONES
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OVERHAUL
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REPAIR SPECIFICATIONS
ESPECIFICACIONES DE REPARACION
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SYMBOL MARKS
The following symbols have been adapted for simplicity and for easy comprehension.

**SIMBOLOS**
Se han adoptado los siguientes símbolos para simplicidad y fácil comprensión.

**SYMBOLES**
Les symboles suivants ont été adoptés afin de simplifier et de faciliter la compréhension.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Symbol</th>
<th>Symbol</th>
<th>Symbol</th>
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</thead>
<tbody>
<tr>
<td><img src="image" alt="Assembly" /></td>
<td><img src="image" alt="Tightening" /></td>
<td><img src="image" alt="Cleaning" /></td>
<td><img src="image" alt="Important" /></td>
</tr>
<tr>
<td>ASSEMBLY</td>
<td>ARMADO</td>
<td>ASSEMBLAGE</td>
<td>TIGHTENING</td>
</tr>
<tr>
<td>DISASSEMBLY</td>
<td>DESARMADO</td>
<td>DESASSEMBLAGE</td>
<td>APRIETE</td>
</tr>
<tr>
<td>INSTALLATION</td>
<td>INSTALACION</td>
<td>MISE EN PLACE</td>
<td>LIMPIEZA</td>
</tr>
<tr>
<td>REMOVAL</td>
<td>REMOCION</td>
<td>DEPOSE</td>
<td>IMPORTANT</td>
</tr>
<tr>
<td>INSPECTION</td>
<td>INSPECCION</td>
<td>CONTROLE</td>
<td>ADJUSTMENT</td>
</tr>
<tr>
<td>MEASUREMENT</td>
<td>MEDICION</td>
<td>MESURE</td>
<td>LUBRICATION</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>REGLAGE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GRAISSAGE</td>
</tr>
<tr>
<td>ENGLISH</td>
<td>ESPAÑOL</td>
<td>FRANÇAIS</td>
<td></td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------</td>
<td>-----------------------</td>
<td></td>
</tr>
<tr>
<td>1. About</td>
<td>1. Alrededor de</td>
<td>1. Environ</td>
<td></td>
</tr>
<tr>
<td>3. And</td>
<td>3. Y</td>
<td>3. ET</td>
<td></td>
</tr>
<tr>
<td>4. At</td>
<td>4. A</td>
<td>4. A</td>
<td></td>
</tr>
<tr>
<td>8. Insulation resistance</td>
<td>8. Resistencia de aislamiento</td>
<td>8. Résistance d'isolement</td>
<td></td>
</tr>
<tr>
<td>10. Limit</td>
<td>10. Límite</td>
<td>10. Limite</td>
<td></td>
</tr>
<tr>
<td>11. Less than</td>
<td>11. Menos de</td>
<td>11. Inférieur(e) à</td>
<td></td>
</tr>
<tr>
<td>17. Voltage meter</td>
<td>17. Indicadora de tensión</td>
<td>17. Compteur de tension</td>
<td></td>
</tr>
</tbody>
</table>
**GENERATOR**

**DATA AND SPECIFICATIONS**

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Alternator</td>
</tr>
<tr>
<td>Output power</td>
<td>24V, 20A</td>
</tr>
<tr>
<td>Normal voltage</td>
<td>24V</td>
</tr>
<tr>
<td>Charging rotation and voltage</td>
<td>900 r.p.m., 27V</td>
</tr>
<tr>
<td>Direction of rotation</td>
<td>Right (From the pulley side)</td>
</tr>
<tr>
<td>Allowable max. speed</td>
<td>7,200 r.p.m.</td>
</tr>
<tr>
<td>Power and rotating speed</td>
<td>28V, 20A, at 5,000 r.p.m.</td>
</tr>
</tbody>
</table>
DESCRIPTION

GENERATOR
1. Brush
2. I.C. Regulator
3. Stator
4. Rotor
5. Pulley

Fig. 21-1
1. Rotor
2. Stator
3. Bearing retainer
4. Rear bearing
5. Felt cover
6. Felt
7. Front bracket
8. Collar
9. Fan
10. Pulley
11. Front bearing
12. Terminal insulation
13. Heat sink with rectifier
14. Condenser
15. Connector
16. O-ring
17. Rear bracket
18. Regulator
19. Cover
20. Brush holder
21. Brush
22. Brush spring

Fig. 21-2
ALTERNATOR
Dismounting
1. Disconnect the battery terminal.

2. Disconnect the B and E terminal.

3. Remove the alternator set bolts and alternator assembly.
DISASSEMBLY

1. Disassemble the regulator and brush.
   1) Remove the brush cover.

2) Remove the regulator.

3) Remove the brush holder set screws.

2. Disassemble the rotor.
   1) Remove the through bolts.
2) Remove the front bracket assembly.

3) Remove the pulley, fan and collar.

4) Remove the rotor by using a press.

5) Remove the bearing retainer.
6) Remove the front bearing.

7) Remove the rear bearing.

3. Remove the stator assembly.
   1) Unsolder the regulator lead wires.

2) Remove the stator coil assembly.
3) Remove the heat sink assembly.

**INSPECTION**

1. **Brush**
   1) Measure the brush length.

2) Confirm that the brush is movable freely with the brush holder.

2. **Rotor**
   1) Check the conduction of the rotor coil.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 mm</td>
<td>7 mm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance</td>
<td>About 12.5Ω</td>
</tr>
</tbody>
</table>
2) Check the insulation between the slip ring and the core.

3) Measure the outside diameter of the slip ring.

3. Stator
1) Check the conduction.
(U,V,W terminal)

<table>
<thead>
<tr>
<th>Standard</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>34.5 mm</td>
<td>33.5 mm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N – U</th>
<th>N – V</th>
<th>N – W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance</td>
<td>About 0.4 Ω</td>
<td></td>
</tr>
</tbody>
</table>
2) Check the insulation.

4. Heat sink
   1) Inspect the each positive side rectifier condition.
      (1) Connect the circuit tester $\oplus$ lead to the rectifier holder and the $\ominus$ lead to the rectifier terminal.
      1) Inspeccione la condición del rectificador de cada lado positivo:
         (1) Conecte el conductor $\oplus$ del probador de circuito al terminal del rectificador y el conductor $\ominus$.
      (2) $\oplus$ lead to the rectifier terminal and $\ominus$ lead to the rectifier holder.
      (2) El conductor $\oplus$ con el terminal del rectificador y el conductor $\ominus$.
      (2) Connecter le conducteur $\oplus$ à la borne de l'ondulateur et le conducteur $\ominus$.

2) Inspect the each negative side rectifier condition.
   (1) Connect the circuit tester $\ominus$ lead to the rectifier terminal and the $\oplus$ lead to the rectifier holder.
   2) Inspeccione la condición del rectificador de cada lado negativo
      (1) Conecte el conductor $\ominus$ del probador de circuito con el terminal del rectificador y el conductor $\oplus$.
   2) Vérifier que chacun des redresseurs côté négatif est en bonne condition.
      (1) Connecter le conducteur $\ominus$ du contrôleur de circuit à la borne de redresseur et le conducteur $\oplus$.
5. I.C. regulator
1) Check the resistance between each terminal.

5. Regulador I.C.
1) Revise la resistencia entre cada terminal.

5. Régulateur à circuit intégral
1) Vérifier la résistance entre les bornes.

<table>
<thead>
<tr>
<th>Tester</th>
<th>Resistance</th>
<th>Tester</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ Lead</td>
<td>– Lead</td>
<td>+ Lead</td>
<td>– Lead</td>
</tr>
<tr>
<td>R L</td>
<td>10Ω</td>
<td>L R</td>
<td>∞</td>
</tr>
<tr>
<td>R F</td>
<td>10Ω</td>
<td>F R</td>
<td>∞</td>
</tr>
<tr>
<td>R C</td>
<td>∞</td>
<td>C R</td>
<td>∞</td>
</tr>
<tr>
<td>R E</td>
<td>1.5K</td>
<td>E R</td>
<td>∞</td>
</tr>
<tr>
<td>L F</td>
<td>10Ω</td>
<td>F L</td>
<td>2K</td>
</tr>
<tr>
<td>L C</td>
<td>90Ω</td>
<td>C L</td>
<td>∞</td>
</tr>
<tr>
<td>L E</td>
<td>100Ω</td>
<td>E L</td>
<td>1.5K</td>
</tr>
<tr>
<td>F C</td>
<td>10Ω</td>
<td>C F</td>
<td>∞</td>
</tr>
<tr>
<td>F E</td>
<td>180Ω</td>
<td>E F</td>
<td>∞</td>
</tr>
<tr>
<td>C E</td>
<td>40Ω</td>
<td>E C</td>
<td>∞</td>
</tr>
</tbody>
</table>
6. Condenser
   1) Inspect the condenser function.
      (1) Connect the test leads.
      (2) Reverse the polarity of the test leads.
   2) Measure the condenser capacity.
      (Condenser tester)

Fig. 21-31

 Capacity | About 0.5 \( \mu F \)

7. Connector
   1) Check the resistance between each terminal.

Fig. 21-32

1. R Lead
2. L Lead
3. N Lead
4. Support

RESISTANCE BETWEEN EACH TERMINAL

<table>
<thead>
<tr>
<th>Tester</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ Lead</td>
<td>- Lead</td>
</tr>
<tr>
<td>R</td>
<td>L</td>
</tr>
<tr>
<td>L</td>
<td>Support</td>
</tr>
<tr>
<td>Support</td>
<td>L</td>
</tr>
</tbody>
</table>
ASSEMBLY

1. Install the stator assembly.
   1) Install the heat sink assembly.
   NOTE: Be careful with the position of two heat sinks. Install the (-) pole heat sink, which has printed circuit, lower.

2) Install the O-ring into the rear bracket.

3) Install the stator.
   Solder the lead wires of the stator to the each terminal of the heat sink as shown in the figure.

2. Installation of the rotor.
   1) Install the felt, bearing and the bearing retainer into the front bracket.
2) Install the rotor into the front bracket.

3) Install the fan and pulley.

4) Install the through bolts.

3. Installation of the regulator and the brush holder assembly.
   1) Install the brushes into the holder.
      And then solder the lead wires to the support.

   NOTE: In installing the brushes, solder the wires so that
   brush projection should be 16 mm.

   NOTE: Suit the concave face of the brush to the convex
   face of the slip ring.
2) Install the brush holder.

3) Install the I.C. regulator.

CHARGING SYSTEM CIRCUIT

- Precautions -

1. Note the battery polarity carefully so as not to make reverse connections. If the connections are reversed, the diodes will short the circuit and allow large current to flow through and damage the diodes and IC regulator as well as burn up the wiring harness.

2. Use care not to make wrong connections of terminals.

3. When charging the battery with a quick charge. Disconnect the battery terminals.

4. Do not perform tests with high voltage insulation resistance tester.

5. When in operation, never disconnect the battery.
INSPECTION

1. Measure the resistance between each terminal after assembling.
   (1.5V circuit tester, x 1)

<table>
<thead>
<tr>
<th>Tester</th>
<th>+ Lead</th>
<th>- Lead</th>
<th>Resistance (Ω)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>R</td>
<td></td>
<td>∞</td>
</tr>
<tr>
<td>B</td>
<td>N</td>
<td>E</td>
<td>7–10</td>
</tr>
<tr>
<td>R</td>
<td>L</td>
<td>E</td>
<td>400–500</td>
</tr>
<tr>
<td>R</td>
<td>E</td>
<td>L</td>
<td>∞</td>
</tr>
<tr>
<td>L</td>
<td>E</td>
<td>N</td>
<td>∞</td>
</tr>
</tbody>
</table>

2. Inspect the alternator performance.
   1) Turn on switch SW₁ and off SW₂ to increase the rotation of the alternator slowly.
   2) Inspeccione el funcionamiento del alternador.
      1) Posicionar en “ON” el interruptor SW₁ y en “OFF” SW₂ y aumentar de a poco la rotación del alternador.
   2) Inspecter la performance de l’alternateur.
      1) Augmenter lentement la rotation de l’alternateur, l’interrupteur SW₁ étant mis sur la position ON et SW₂ sur la position OFF.

2) When voltage reaches 28V, turn on switch SW₂, regulate load resistance. Increase the rotation of the rotor keeping voltage at 28V.
   2) Cuando el voltaje llega a 28V, posicionar en “ON” el interruptor SW₂ para regular la resistencia de carga. Aumente la rotación del rotor manteniendo el voltaje a 28V.
   2) Lorsque la tension arrive à 28V, mettre SW₂ sur la position ON. Augmenter la rotation du rotor tout en maintenant la tension à 28V par réglage de la résistance de charge.
3. Inspect the IC regulator performance. Turn on switch SW₁ and off SW₂ to increase the rotation of rotor to 5,000 rpm.

3. Inspeccion el funcionamiento del regulador de IC. Posicionar el interruptor SW₁ en “ON”, SW₂ en OFF y aumentar la rotación del alternador a 5000 ppm.

3. Inspecter la performance du régulateur à C.I. Porter la rotation du rotor à 5,000 tr/min, SW₁ étant mis sur la position ON et SW₂ sur la position OFF.

### MOUNTING

1. Adjust the V-belt tension and tighten the set bolt.

1. Ajuste la tensión de la correa en V y apriete el perno de fijación.

1. Réglez la tension de la courroie trapézoïdale et serrz le boulon de blocage.

2. Connect the battery terminal.

2. Conecte el terminal de batería.

2. Connecter la borne de batterie.

### PRECAUTIONS ON THE VEHICLE

1. Note the battery polarity carefully so as not to make reverse connections.
   
   If the connections are reversed, the diodes will short the circuit and allow large current to flow through and damage the diodes and IC regulator as well as burn up the wiring harness.

2. Do not disconnect the alternator terminals when in operation.

3. When charging the battery with a quick charge disconnect the battery terminals.

4. Do not inspect with a megger tester.

5. When in operation, never disconnect the battery.
TROUBLESHOOTING

When charging current is not conducted
- Fuse is blown out
- Poor operation of meter
- Poor connecting or wiring of each terminals
- Breaking of short-circuit of coil and wiring inside the alternator
- Poor diode
- Trouble of regulator

Charging is insufficient
- Poor wiring
- Belt is loosened
- Poor regulating voltage of regulator
- Trouble of alternator (Short-circuit of coil, poor diode)
- Poor battery

Note: Charging current will be reduced when the battery's charging is almost completed.

When charging current is excessive
- Poor alternator or regulator (Short-circuit of wiring, coil, transistor)
- Regulating voltage of regulator is too high
### Repair Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Standard</th>
<th>Service limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brush length mm</td>
<td>20</td>
<td>5.5</td>
</tr>
<tr>
<td>Outside diameter of slip ring mm</td>
<td>32.5</td>
<td>32.1</td>
</tr>
<tr>
<td>Resistance of coil (Ω)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stator</td>
<td>0.91</td>
<td>–</td>
</tr>
<tr>
<td>Rotor</td>
<td>9.0</td>
<td>–</td>
</tr>
</tbody>
</table>

### Tightening Torque

<table>
<thead>
<tr>
<th>Item</th>
<th>kg·cm</th>
<th>lb·ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulley lock nut</td>
<td>980 – 1,300</td>
<td>71 – 94</td>
</tr>
<tr>
<td>Through bolt</td>
<td>60 – 90</td>
<td>4 – 6.5</td>
</tr>
<tr>
<td>Others</td>
<td>19 – 25</td>
<td>1.3 – 1.8</td>
</tr>
<tr>
<td>M6 x 1</td>
<td>33 – 45</td>
<td>2.4 – 3.3</td>
</tr>
<tr>
<td>Section</td>
<td>Page</td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>Generator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data &amp; Specification</td>
<td>21- 1</td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>21- 1</td>
<td></td>
</tr>
<tr>
<td>Overhaul</td>
<td>21- 3</td>
<td></td>
</tr>
<tr>
<td>Repair Specification</td>
<td>21- 7</td>
<td></td>
</tr>
<tr>
<td>Regulator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>21- 7</td>
<td></td>
</tr>
<tr>
<td>Overhaul</td>
<td>21- 8</td>
<td></td>
</tr>
</tbody>
</table>
The generator is driven by the engine and it supplies electricity to various electrical instruments and at the same time, it charges the battery. The generator is an alternator with built-in rectifier and separate voltage regulator type and its power is 24V, 25A, and 35A for optional, and its rotating direction is clockwise when viewed from the pulley side. The speed of the Generator is 2.34 times the crankshaft rotation speed.

**CONSTRUCTION**

As illustrated in Fig. 21-1, the generator comprises stator, rotor, rear cover, front cover and pulley. The stator plays an important role of generating electric power, and consists of laminated iron sheets in which a number of slots are provided to accommodate three-phase windings. The rotor serves as an exciting means...
21-2 GENERATOR

of the impulsive type in which two thick iron sheets wound with coils are opposed. The alternator rotor having N and S poles to communicate magnetic flux through the stator is equipped with an insulating forming into which two slip-rings are set. The rear bracket is provided with a diode which converts alternating current developed in the stator coil into direct. The diode allows one-way flow of current, and blocks the current from flowing in the other way. The diode used here is provided with NP junction silicon pellet on a copper base from which a lead wire is tapped out. Namely, the diode has one lead terminal and the other is grounded on the case. (See Fig. 21-2)

Fig. 21-2 Structural design of the diode

![Diode Diagram]

CURRENT FLOW (PN) CURRENT FLOW (NP)

As shown in Fig. 21-3, the diode is available in two types, NP diode and PN diode. These are quite different in polarity. The diode characteristics are shown in Fig. 21-4 in which it is clear that while current cannot flow in the forward direction when the voltage is small. All of a sudden at a little voltage drop the current begins flowing, when the applied voltage exceeds a specified value (approx. 0.6 to 0.7 V).

Fig. 21-3 Current flow

![Diode Characteristic Curve]

Fig. 21-4 Diode characteristic curve

On the other hand, the diode shows a high resistance against the reverse direction; even if it is applied with a high voltage, its leakage current is very small.

**WIRING AND FUNCTION**

When the rotor is turned with current forced through it, the alternator stator will develop AC voltage. This AC voltage cannot be applied directly to the battery, and must be rectified into DC current. To accomplish this end, the present alternator is equipped with six diodes on its output circuit arranged as shown in Fig. 21-7.

![Three-phase AC Waveform]

Fig. 21-5 Stator coil connection diagram

![Three-phase Full-wave Rectifying Circuit]

Fig. 21-7 Three-phase full-wave rectifying circuit

Let us now consider the terminal voltage across A and B. In case the voltage at terminal A is positive, and that at terminal B is negative, current will flow through A, a', S1, B(+), R, B(-), S3, b' and B in the said order, beginning from terminal A.

On the other hand, if terminal B is held positive, and terminal A negative, current will pass B, b', S3, B(+), R, B(-), S1, a' and A in the said order.

While the direction of current flow varies depending on the polarity of terminals, the current that flows through resistor R is unidirectional; namely, the rectified waveform has less ripples as compared with single-phase full-wave rectified waveform. The battery can be charged if it is connected across this resistor.
OVERHAUL

1. Stator assembly
2. Rear cover
3. Heatsink assembly (B)
4. Heatsink assembly (E)
5. Insulating bush
6. Bolt
7. Insulating
8. Terminal bolt
9. Lead plate
10. Insulating plate
11. Insulating bush
12. Insulating washer
13. Terminal bolt (F.N)
14. Lead assembly
15. Insulating plate
16. Insulating bush
17. Insulating bush
18. Bolt
19. Brush and spring housing
20. Condenser assembly
21. Condenser holder
22. Brush cover
23. Rotor assembly
24. Grease retainer
25. Rear bearing
26. Woodruff key
27. Lockwasher
28. Locknut
29. Front cover
30. Front bearing
31. Grease retainer
32. Bearing retainer
33. Felt holder
34. Oil felt
35. Through bolt
36. Brush and holder assembly
37. Brush holder
38. Brush
39. Brush spring
40. Insulating plate
41. Lead plate
42. Pulley with fan

Fig. 21-9 Generator

DISMOUNTING

(1) Cut off the battery switch, and disconnect three leads from the alternator.
(2) Remove the through bolt from the crankcase and the set bolt.

DISASSEMBLY

(1) Loosen the locknut (28) provided on the end of pulley to remove the fan pulley (42). Then, remove two bolts from the brush cover on the rear cover, and remove the brush cover (40) to take brush 4 holder assembly (36) out.
(2) Remove the through bolt (35) which has connected the front cover and the rear cover together, and take out the front cover (29) and rotor (23) from the stator (1).
(3) Loosen and remove four bearing retainer bolts to separate the rotor (23) and front cover (29) from each other.
To separate the rotor, front ball bearing (30) and rear ball bearing (25) from each other, hold the bearings and force the rotor shaft out.
(4) Disconnect the stator coil lead from the diode at a soldered part by making use of a soldering iron, and disconnect the stator coil (1) and rear cover (2). Prior to disconnecting leads, it is recommended to provide match marks for the convenience of reassembling.

(5) The diode is mounted on the heat sinks (3, 4). To disconnect the diode, remove the lead from the soldered part of the diode first, loosen the set bolt (6) of the heat sinks, and remove the heat sink assembly from the rear cover.

(6) Once the cut type has been removed, it can no longer be used. When removing the diode, pay utmost attention not to mar the heat sink. The soldered diode should be replaced together with its heat sink assembly.

**INSPECTION OF ALTERNATOR**

**Brush Service Limit**

Check the brush length; if it is short of the service limit specified below, renew it.

- **Brand new**: 18 mm (0.7087 in.)
- **Service limit**: 10 mm (0.3937 in.)

**Brush Replacement Procedure**

Remove the brushholder assembly, and remove the brush holder, plate and spring, and then remove the brush. The brush projected 12.5 mm (0.4921 in.) from the end of the brush holder.

Make sure that the brush movement is smooth.

**Grounding Test for Stator Coil**

Connect a circuit tester between the stator core and stator lead. If the resistance becomes infinity, the stator insulation is justifiable.

**Location of Breaks in Stator Coil**

Connect a circuit tester between the neutral terminal
lead and one of three other terminals, and then between the neutral terminal lead and the other terminal, and so on.

If the resistance values at any terminal are zero, the stator coil is justifiable.

![Location of breaks in the stator coil](image)

Location of Breaks in Rotor Coil

Carry out conduction test between two slip-rings. If there is no sign of conduction between slip-rings, the rotor coil is suspected to be broken. Renew the rotor coil.

The rotor coil resistance

- 0211 601 0133 (24V 25A) ............... 18 Ω
- 0211 102 0222 (24V 35A) ............... 17.5 Ω

![Location of breaks in rotor coil](image)

Rotor Coil Grounding Test

Examine the conduction between two slip-rings and rotor shaft. If they are conductive, the rotor should be replaced with a new one.

Resistance value: : infinity

JUDGEMENT CRITERIA FOR RECTIFIER PERFORMANCE

If a sound diode is examined with a circuit tester, it will show diversified results depending on the kind of tester used, source cell voltage temperature, and other various factors. For this reason, the use of circuit tester is not adequate for this diode examination.

If you stick to the circuit tester, then how to judge the diode. The only solution is to judge a subject diode to be good if the difference in its resistance between the forward direction and inverse direction is substantially large. The best way is to use a diode checker which is able to measure diode characteristics directly. However if such an excellent means is not available, the alternator tester is perform required, which measures the forward current and inverse current with a specified voltage applied to the subject diode.

![Diode characteristics](image)

<table>
<thead>
<tr>
<th>Rectifier characteristics</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward characteristics</td>
<td>When a DC current of 20A is forced in the forward direction at normal temperatures, the voltage drop between the rectifier lead terminal and the holder is not more than 1.2 V.</td>
</tr>
<tr>
<td>Inverse characteristics</td>
<td>When DC 100 V is applied in the reverse direction at normal temperatures, the reverse current is not more than 1.5mA.</td>
</tr>
</tbody>
</table>

1. Rectifier shortcircuit test

(1) The shortcircuit test for the positive side rectifier can be accomplished by connecting (−) stick of the circuit tester to “B” terminal and (+) stick to “N” terminal.

- Resistance value: Infinity Normal Nearly zero Shortcircuit fault

![Shortcircuit test for positive side rectifier](image)
21-6 GENERATOR

(2) For the shortcircuit test of \((-\) side rectifier, apply 
\((+)\) stick of the circuit tester to "E" terminal and 
\((-\) stick to "N" terminal.

Resistance value:  Infinity  Normal  Nearly zero  Shortcircuit fault

**Fig. 21-18 Shortcircuit test for negative side rectifier**

2. Open Circuit Test for Rectifier

The open circuit test can be accomplished with the 
rectifier disconnected from the stator coil.

(1) The open circuit test for the positive side rectifier 
can be made with \((+)\) stick of the circuit tester 
applied to the positive side heat sink and \((-\) stick to the rectifier lead.

- Resistance value:  Nearly zero  Normal  Infinity  Open circuit fault

**Fig. 21-19 Open circuit test for positive side rectifier**

(2) The open circuit test for the negative side rectifier 
can be accomplished with \((+)\) stick of the circuit tester 
applied to the rectifier lead and \((-\) stick to the negative side heat sink.

- Resistance value:  Nearly zero  Normal  Infinity  Open circuit fault

**Fig. 21-20 Assembling of pulley**

**Fig. 21-21 Alternator Assembly**

**Fig. 21-21 Alternator Assembly**

**ASSEMBLE OF ALTERNATOR**

The assembling is carried out just in the reciprocal way of the disassembling. It should be borne in mind that 
the following precautions be strictly observed.

1. When it is required to set up the pulley onto the 
rotor, set a key on the rotor shaft first, and then 
mount the pulley.

2. When it is required to assemble the rotor on the 
stator, raise the brush from inside the stator, and 
hold the brush by reeving a wire through outside 
the rectifier end frame, and then set up the rotor.

- If this precaution is dismissed, the brush could be 
damaged.

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The assembling is carried out just in the reciprocal way of the disassembling. It should be borne in mind that 
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stator, raise the brush from inside the stator, and 
hold the brush by reeving a wire through outside 
the rectifier end frame, and then set up the rotor.

- If this precaution is dismissed, the brush could be 
damaged.

**PERFORMANCE TEST**

**No-Load Test**

With switch "S2" opened, drive the alternator by 
means of a variable speed motor, and close switch "S1" 
to increase the alternator speed little by little. Measure 
the alternator speed at 27 V. The alternator speed 
(under cold conditions) should range from 650 rpm to 
850 rpm.
REPAIR SPECIFICATION

SERVICE STANDARD

<table>
<thead>
<tr>
<th>Item</th>
<th>Standard value</th>
<th>Service limit</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial charging voltage, V</td>
<td>27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial charging speed, rpm</td>
<td>less than 900</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed ratio</td>
<td>2.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slip-ring diameter mm (in)</td>
<td>37.5 (1.476)</td>
<td>-2 (-0.079)</td>
<td>Replacement</td>
</tr>
<tr>
<td>Height mm (in)</td>
<td>18 (0.7087)</td>
<td>10 (0.394)</td>
<td>Replacement</td>
</tr>
<tr>
<td>Spring pressure, gr (lb)</td>
<td>195 ~ 265</td>
<td>130</td>
<td>Replacement</td>
</tr>
<tr>
<td></td>
<td>(0.429 ~ 0.584)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotor coil resistance</td>
<td>24 V 25 A</td>
<td>18 Ω</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24 V 35 A</td>
<td>17.5 Ω</td>
<td></td>
</tr>
</tbody>
</table>

REGULATOR

DESCRIPTION

When switch S is turned on, current flows from the battery (+) to S, VC₂, R₄ and then into E(−). Thus the coil VC₂ of the field relay attracts the armature equipped with point FP. When FP is closed, current flows into E from the battery after passing through FP and VP in turn, energizing the field coil (rotor). With this, when the engine is started, the rotor turns, generating 3-phase AC voltage in the stator coil. This voltage is then rectified through diodes and fed to the battery through B terminal.

When the battery terminal voltage is increased (i.e., the alternator voltage), the voltage across the regulator voltage coil VC₁ also increase. Accordingly, the voltage point (VP) is attracted towards the lower point (LP), forcing the field coil current to pass through resistor R₃. When the voltage is increased up further, the point of VP₁ is totally stuck to the lower point (LP), thus the exciting current is grounded to point E after passing...
through resistor Rₕ and lower point (LP), making the field current smaller. In this way the generating voltage can be regulated at a specified value.

When the generator voltage decreases, the attractive force of VC₁ decrease, releasing the armature to the original position by the force of coil spring.

In this way, the voltage regulator automatically on/off controls VP depending on size of the voltage generated by the alternator, controlling the field current to keep the alternator voltage at a constant value.

OVERHAUL

DISASSEMBLING

(1) Remove the set screw to remove the cover.
(2) Remove the point holder and point set screw, and disconnect the lead wire at the soldered part to remove the point.
(3) Remove the armature set screw, and separate the armature from the adjusting spring and yoke.

Then, loosen the adjusting nut to remove the adjusting bolt.
(4) The disassembling of the field relay can be accomplished in the same manner as in the case of voltage regulator relay.
INSPECTION AND TEST

Inspect for Burnt
Under normal operating conditions, the points will be gray in color. If the surface of the contact points has been burnt or oxidized (black in appearance) or has become encrusted or rough, clean and polish the point with crocus or emery cloth. After polishing the points wipe them off with a clean dry rag so that no dust remains. Remember that the points is the most important part of the regulator and cleaning must be done with utmost care.

Coil insulator plate, point spring, B.R.F.E. terminal, Inspect not burnt or damaged.

Inspect for Looseness
Make sure that all soldered portions are properly connected and soldered.

Make sure that the screws, nuts and rivets in each equipment component are properly tightened and the spring washers have been properly applied.

Make sure that the points is firmly secured.

SETTING-UP AND ADJUSTMENT

The assembling is carried out just in the reverse way to the disassembling. Note however that the regulator should be adjusted while being assembled.

(1) Adjustment of armature air gap:
Loosen the point holder set screw in advance.
Insert a thickness gauge between the pole and armature as shown in Fig. 21-26, and tighten up the point holder set screw while giving a strong push over the point holder.
In this case, pay attention not to make the points staggered from each other.

Adjusting value: 1.1 ~ 1.3 mm
   (0.0433 ~ 0.0512 in.)

(2) Adjustment of point gap
Measure the gap between the points with a thickness gauge as illustrated in Fig. 21-27, and adjust it by making use of a long-nose pliers or other suitable means.

Adjusting value: 0.3 ~ 0.7 mm
   (0.0118 ~ 0.0276 in.)

Fig. 21-27 Adjustment of point gap

(3) Adjustment of field relay yoke gap
Follow the same method that has been explained with reference to the voltage regulator.

Yoke air gap: 0.25 ~ 0.35 mm (0.0099 ~ 0.0137 in.)
Point gap: 0.4 ~ 0.6 mm (0.0158 ~ 0.0236 in.)

Fig. 21-28 Adjusting field relay

(4) Voltage adjustment
Arrange the voltage regulator as shown in Fig. 21-29 for voltage adjustment.
21-10 REGULATOR

1. Use a battery which has been fully charged (specific gravity: 1.260).

2. Turn the adjusting nut shown in Fig. 21-30 clockwise to attain an increased tightening of the adjusting spring.

3. Increase the alternator speed up to 3,000 rpm. When the charging current is reduced lower than 5A, turn the adjusting nut clockwise or counterclockwise to obtain a required voltage while watching a voltmeter.

Adjusting voltage: $29 \pm 1 \text{ V}$

![Adjusting voltage regulator](image)
# STARTER

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7. LIST OF MAINTENANCE DATA ............................... 22-15
# STARTER

## 1. SPECIFICATIONS

<table>
<thead>
<tr>
<th>Unit</th>
<th>Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal output</td>
<td>KW</td>
<td>5.5</td>
</tr>
<tr>
<td>Circuit voltage</td>
<td>V</td>
<td>24</td>
</tr>
<tr>
<td>Rating</td>
<td>seconds</td>
<td>30</td>
</tr>
<tr>
<td>Revolving direction (as seen from the pinion side)</td>
<td></td>
<td>Right</td>
</tr>
<tr>
<td>Gearing system</td>
<td>Pinion shift</td>
<td></td>
</tr>
<tr>
<td>Clutch system</td>
<td>Roller</td>
<td></td>
</tr>
<tr>
<td>Circuit system</td>
<td>Body earth</td>
<td></td>
</tr>
<tr>
<td>Protection system</td>
<td>Simplified water tight</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>kg</td>
<td>Approx. 10.5</td>
</tr>
</tbody>
</table>

### Pinion Specifications

<table>
<thead>
<tr>
<th>Number of teeth</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module</td>
<td>3</td>
</tr>
<tr>
<td>Pressure angle</td>
<td>degrees</td>
</tr>
<tr>
<td>Amount of addendum modification</td>
<td>mm</td>
</tr>
<tr>
<td>Hardness</td>
<td>HrC</td>
</tr>
</tbody>
</table>

### Non-loaded

<table>
<thead>
<tr>
<th>Terminal voltage</th>
<th>V</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>A</td>
<td>Less than 100</td>
</tr>
<tr>
<td>Number of revolution</td>
<td>rpm</td>
<td>More than 4,000</td>
</tr>
</tbody>
</table>

### Loaded

<table>
<thead>
<tr>
<th>Terminal voltage</th>
<th>V</th>
<th>17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>A</td>
<td>500</td>
</tr>
<tr>
<td>Torque</td>
<td>kg-m</td>
<td>More than 3.8</td>
</tr>
<tr>
<td>Number of revolution</td>
<td>rpm</td>
<td>More than 1,200</td>
</tr>
</tbody>
</table>

### Constrained

<table>
<thead>
<tr>
<th>Terminal voltage</th>
<th>V</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>A</td>
<td>Less than 1,200</td>
</tr>
<tr>
<td>Torque</td>
<td>kg-m</td>
<td>More than 7.8</td>
</tr>
</tbody>
</table>

### Remarks

<table>
<thead>
<tr>
<th>Applicable type</th>
<th></th>
</tr>
</thead>
</table>

2. CONSTRUCTION

Shown below is a cross section of the reduction starter. Its main components with their respective functions are as described below.

![Diagram of the reduction starter showing motor, armature, gears, pinion, and clutch.]

(1) **Motor**

A section where power is generated, composed of the armature, the field, the brush, etc.

1) The armature is a part revolving with such a high speed that it employs ball bearings. To give heat resistance, the commutator and the coil are brazed.

2) The field coil is also an important part where power is generated by working together with the armature. It permits such a large current to pass that it is connected in series to the armature using pillar copper wires with a large current capacity. Some motors have two kinds of coils; one, connected in series to the armature as the main coil, is for power generation and the other, connected in parallel to the armature as the auxiliary (shunt) coil, is for braking the motor electrically to keep its revolution from going into an excessive speed.

3) The brush, made of metal graphite, is to let current flow to the armature.

(2) **Reduction Gears**

A section where motor revolution is reduced (at the same time, motor torque is increased) by means of gear ratio.

1) Multiple spindle type: Composed of the gear mounted on the motor and the gear mounted on the output shaft, they transmit motor revolution to the output shaft by either inscribing or circumscribing the two spur gears.

(3) **Power Transmission Pinion & Clutch**

A section composed of the pinion gear to transmit motor power to the engine and the clutch to keep engine revolution from being transmitted to the motor after the engine has been started. While the pinion gear is to work with the ring gear of the engine, the clutch is a roller type utilizing the contact resistance of the roller, which prevents slides by full clutching during engine running and permits itself to slide during reverse running of the engine, thus to keep the armature from overrunning.

(4) **Engage Switch (Auxiliary Operation)**

A device composed of two coils, contacts and cores, which operates to gear the pinion into the ring gear at the same time with making and breaking of power to the motor. One is called a magnetic coil (current coil = P) which, connected in series to the armature, attracts the core upon being conducted and the other (voltage coil = H), connected in parallel to the motor, holds attraction to keep letting current flow to the motor after the core has been attracted, by holding the pinion to stay at the ring gear and the contacts to be in touch with each other.
3. OPERATION OF STARTER

The following drawings show the electrical circuits of the reduction starter and the relations between the pinion and the ring gear. Although block relays and safety relays (those for preventing re-gearing during inertia revolution) are employed in the circuits actually applied, explanations here will be given on basic circuits without any such relays (with the starter only).

Operation of Starter of 0350 and 0351 Series

(1) With the starter switch (SS) closed, current from the battery flows in the directions shown with arrows in the following current diagrams:

The engage coil (P, h), with its electromagnetic attraction overcoming the return spring, attracts the core to move in the direction of the contact. At the same, it pushes the pinion into the ring gear via the lever, causing them to be geared with each other.

(2) Upon the pinion having been geared completely into the ring gear, the engage contacts (K) get in touch with each other, causing current from the battery to flow directly to the motor through (K) as shown with arrows below:

With this current, the motor rotates to the full and its rotation, transmitted from the output shaft and through the pinion, drives the engine. At this time, coil (P) of the engage coil is shorted at contact (K) and electromagnetic force goes out. However, the current in coil (h) which is parallel connection continues to flow, keeping the core attracted, the contacts in touch with each other and the pinion and the ring gear working together.
22.4 STARTER

(3) Starting operation completes itself when the starter engine quickly opens upon starting of the engine which has received revolution from the starter. At this moment of the switch opening, current flows in the direction of (I) because contacts (K) are in touch with each other. As the electromagnetic forces generated by coils (P) and (h) are in the opposite directions, respectively, they are counteracted, causing the attraction of the core to be lost. The core is drawn back by the force of the spring and, at the same time, the pinion leaves the ring gear and the contacts get out of touch from each other.

![Fig. 22-5](image)

4. DISASSEMBLING AND ASSEMBLING OF STARTER

As a general practice, the starter should be disassembled from its outside and assembled in reverse order. In assembling it, clamping of bolts, nuts, etc., should always be done in the order of diagonal lines. In describing the disassembling practices below, it is to be understood that assembling can be done in reverse except in some special cases.

![Fig. 22-6](image)

2) Remove connect bar.
(As.) Clamping torque for M Terminal: 200 ~ 240 kg-cm
(14 ~ 17 lb.ft.)

3) Remove Engage Set Bolt
(As.) Clamping torque for Engage Set Bolt: 60 ~ 90 kg-cm
(4 ~ 7 lb.ft.)

![Fig. 22-7](image)

Note:
(As.) in the following paragraphs applies to assembling.

(1) Amounting and Dismounting of Engage Switch
1) Remove the nuts for M Terminal of the engage switch and M Terminal of the motor.
4) Pull out the engage switch in the direction arrow in Fig. 22-8 (A).

5) Move the end of Moving Core from (1) to (2) in the order of arrows in Fig. 22-8 (B) and separate. (Ass.) Apply grease (Albania No.2) over the part marked.

(2) Mounting and Dismounting of Pinion Clutch
1) Remove the through bolt for setting the pinion case.  
   (Ass.) Clamping torque for the through bolt:  
   $140 ~ 160$ kg·cm ($10 ~ 12$ lb·ft.)

2) Remove Pinion Case  
   (Ass.) Clamping Pinion Case Set Bolt (the through bolt for mounting pinion Case from End Bracket) first will ease assembling work.

3) Remove Pinion Stopper  
   Push the pin into the hole (or slot) or Stopper (Fig. 22-11 (A)) and take out the clip (Fig. 22-11 (B)).

4) Take the two hooks out of the shaft. Take out the clip, push Stopper toward the pinion side and then take out the hooks.  
   (Ass.) See that the clip is secure after Stopper has been mounted.

5) Push the lever upward and remove Pinion Clutch.  
   (Ass.) Apply grease (Albania No. 2) over the roller of the lever. Thinly apply oil (#30) over the output shaft.
6) Unlock the lock plate, and remove the lever set bolt.

(Ass.) Lock plate . . . . . . Use the new lock plate for assembling.

(3) Mounting and Dismounting of Output Shaft

1) Separate Bracket Center

2) Remove Adjuster Shim from the output shaft (Fig. 22-15 (A)).

Note:
Take care not to lose Adjuster Shim.
(Ass.) Put grease (Coronex EP2) in the grease pot of Bracket Center
(Ass.) Measure thrust gap (Fig. 22-15 (B)). Move it in the order of ‡ to check the gap. The thrust gap should be 0.1 ~ 0.3 mm (0.0039 ~ 0.0118 in).

3) Remove Output Shaft
(Ass.) Apply grease (Lowtemp) over each gear to about 2 mm (0.00787 in) thick and push Output Shaft Gear into Gear Guide.

4) Remove Shim Plate
(Ass.) Be sure to put two shim plates. Put them in like pasting on Gear Guide.
(Ass.) Put grease (Lowtemp) into the grease pot (round hole)

(4) Disassembling and Assembling of Motor

1) Remove the dust cover (cover band).
(Ass.) Be careful of the mounting position.

2) Remove the four brush set screws.

3) Lift the brush spring and remove the brush.
(Ass.) To clamp the brush with set screws after mounting it, cross the leads in mounting the brush as shown in the figure.
6) Remove the armature from the gear housing.

Fig. 22-20

7) Separate the bracket end from the yoke.
   (Ass.) Align the knocking position in assembling together.

Fig. 22-21

5. QUALITY CHECKING OF COMPONENTS
   (REFER TO MAINTENANCE DATA)

   With small differences in checking or measuring positions depending on equipment type, practically the same methods as described below apply. For specific values, refer to the Maintenance Data.
(1) Armature

1) Refer Shoting Test of Coils Test quality of coils by operating the armature tester with an iron piece put on it. (No vibration of the iron piece proves the coil to be good.)

2) Insulation Test of Coils
   Using a megger, measure the insulation resistance between the core and the coil.
   Standard: More than 1 MΩ

3) Measurement of Deflection of Commutator
   Using a dial gauge, measure deflection of the commutator.
   Standard: Less than 0.02 mm (0.0008 in)
   Service limit: 0.1 mm (0.0039 in)

4) External Dimensions of Commutator
   Using a slide calipers, measure the dimensions of the rough part of the segment after cutting it.
   Standard: 40 mm (1.575 in)
   Service limit: 38 mm (1.496 in)

5) Measure the depth of under cut.
   Standard: 0.5 ~ 0.8 mm
   (0.0197 ~ 0.0315 in)
   Service limit: 0.2 mm (0.0079 in)

---

Fig. 22-22

Fig. 22-23

Fig. 22-24

Fig. 22-25

Fig. 22-26
(2) Field coil
1) Conductance Test
   Use a tester to check:

<table>
<thead>
<tr>
<th>Terminal position where to apply the tester</th>
</tr>
</thead>
<tbody>
<tr>
<td>0350 and 0351 Series Starters</td>
</tr>
<tr>
<td>Between the terminal and body of the direct-wound coil</td>
</tr>
</tbody>
</table>

2) Insulation Test
   Use a tester to check
   Standard: More than 1 MΩ

<table>
<thead>
<tr>
<th>Terminal position where to apply the tester</th>
</tr>
</thead>
<tbody>
<tr>
<td>0350 and 0351 Series Starters</td>
</tr>
<tr>
<td>Between the coil terminals and body (Measurement to be made with the terminal and body floated after removing earth screws)</td>
</tr>
</tbody>
</table>

(3) Output Shaft
1) Using a dial gauge, measure curve at the center of the output shaft. (Good if the curve is within Repair limit: 0.05 mm (0.0020 in)

(4) Abrasion on Gear Surface
   Inspect the spline and internal gear for abrasion and damage.

(5) Metal
1) Measure the inside diameter of the metals.
   (a) Front metal
      Using a dial gauge
      Standard: 17 mm (0.669 in)
      Service limit: 17.3 mm (0.681 in)
(b) Center metal
   Standard:  28 mm (1.102 in)
   Service limit:  28.3 mm (1.1142 in)

(7) Brush Holder
   1) Insulation of Brush Holder
      Using a megger, check the insulation between the brush holder and bracket.
      Standard:  More than 1 MΩ

   2) Tension of Brush Spring
      Using a spring gauge.
      Standard:  1.4 kg (3 lb)
      Service limit:  1.0 kg (2 lb)

(8) Engage Switch
   1) Conductance Test of Coil
      (a) Test conductance between C Terminal and the body.
(b) Test conductance between C Terminal and the coil terminal.

(9) Pinion & Clutch
1) Clutch Effect

Turn the gear to left and right with the shaft fixed. Good if it turns lightly in the direction of arrow (for preventing overrunning) only.

(Standard torque for slides in the direction of overrunning protection: 6 ~ 8 kg·cm.)

6. CHECKING AFTER ASSEMBLING

Measurement of Timing Gap

Have the engage switch conducted and measure the gap between the pinion and pinion case and that between the pinion and the pinion stopper when the pinion is slided by the attracting force of the engage switch.

(1) How to Make Connections for Measurement

For 0350 and 0351 Series Starter:

Set the switch (S1) between the C Terminal and Battery of the engage switch and the switch (S2) between the M terminal of the engage switch and the M Terminal of the motor as shown in Fig. 22-39, and then complete connections.

(2) How to Make Measurement

1) Turn on switch (S1) and then close switch (S2).
2) Open switch (S2) after the pinion has slided.
3) Lightly push back the pinion with the switch positions left as they are.
4) Measure the gap between the pinion and the pinion stopper. (Refer to Fig. 22-40.)

Standard: 0.5 ~ 1.5 mm
(0.0197 ~ 0.0591 in)
22-12 STARTER

Adjustment of Timing Gap

1) Adjustment Using Shim Washer In case the gap is large (or smaller), than specified, put (or pull out) the adjusting plate into (or from) the engage mounting position for making adjustment.

Output Characteristic Test of Starter

After starter has been assembled, check each operation and output characteristic using the bench tester. For applicable values of output characteristic, refer to the specifications and the output characteristic curve (reference columns).

(1) Gearing Test

Mount the starter on the tester (Starter Bech Tester) after making connections as shown in Fig. 22-42 and fix (but not fully) the ring gear before proceeding with the test.

1) Gearing Test

Make and break starter switch (SS1) more than 20 times for gearing and de-gearing tests.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Terminal voltage not to be lower than 24 ~ 20V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Judgement</td>
<td>Good if more than 90% of over 20 times of gearing test prove satisfactory</td>
</tr>
</tbody>
</table>

2) Minimum Gearing Voltage Test

Gradually increase voltage applied to the C Terminal using the variable resistor (VR) with (SS1) open and (SS2) closed, and measure the minimum voltage enabling the pinion to gear into the ring gear.

| Judgement       | Gearing voltage should be lower than 18V |

Fig. 22-41

Fig. 22-42
(2) Output Characteristic Test

The purpose of this test is to check the driving force (torque and number of revolution) of the starter. Set the starter on the bench tester, determine current of the starter (current: I (A) varies with the load applied to the ring gear of the bench tester: brake), and measure the torque and number of revolution at that time.

As this test may cause drops in battery voltage or in the wiring due to load current, it should be performed in the state of small voltage drops (the battery to be fully charged and the wiring to be a capacity large enough).

![Diagram](Fig. 22-43)

1) Load Test

Make wirings as shown in Fig. 22-43, set load current (Ia) to the specified value, run the starter and then measure the voltage, number of revolution and torque of the starter.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>For values of load current I (A), refer to the specifications or the output characteristic curve</td>
<td>For torque, number of revolution, refer to the specifications of the output characteristic curve</td>
</tr>
</tbody>
</table>

2) Lock Test

After completion of load characteristic test, further increase load current (by fixing the ring gear) and then measure the load current (Ia), torque (T) and voltage (V) when starter revolution has become 0.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of revolution to be 0.</td>
<td>For terminal voltage (starter), refer to the specifications or the output characteristic curve,</td>
</tr>
<tr>
<td>For values of load current I (A), refer to the specifications or the output characteristic curve.</td>
<td>For number of revolution, refer to the specifications and the output characteristic curve.</td>
</tr>
</tbody>
</table>

3) No-load Test

Have the pinion of the starter in the state of not gearing into the ring gear, let current flow and then measure the voltage, current and number of revolution at that time.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal voltage: 22 ~ 24V (10 ~ 12V for the 12 Series)</td>
<td>For current values, refer to the specifications or the output characteristic curve.</td>
</tr>
<tr>
<td>Measure when 5 ~ 15 seconds have elapsed (when the number of revolution has settled down. Take care not to continue this test for too long.</td>
<td>For number of revolution, refer to the specifications and the output characteristic curve.</td>
</tr>
</tbody>
</table>
(3) Other Measurements

1) Measurement of Voltage Drops of Contact
   This is to measure quality of touch at contacts, judgement being made according to volume of voltage drop. Apply the voltmeter as shown in Fig. 22-44, determine motor current and then measure the voltage drops at B-M of the magnetic switch.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Set passing current at contacts (B,K,M) to 500A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Judgement</td>
<td>Good if voltage drop (voltage resulted) is lower than 0.2V.</td>
</tr>
</tbody>
</table>

2) Insulation Test
   Make measurements referring to the circuit diagrams of each starter. The following practices may apply to most starters:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Use a megger of 500V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Judgement</td>
<td>Insulation to be more than 1MΩ. Practically good if it is more than 0.5MΩ.</td>
</tr>
</tbody>
</table>
### 7. LIST OF MAINTENANCE DATA

The 0350 and 0351 Series

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Standard</th>
<th>Usable Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front</td>
<td>mm</td>
<td>17</td>
<td>17.2</td>
</tr>
<tr>
<td>Center</td>
<td>mm</td>
<td>28</td>
<td>28.2</td>
</tr>
<tr>
<td>Commutator</td>
<td>mm</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Gear</td>
<td>mm</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>External Diameter</td>
<td>mm</td>
<td>40</td>
<td>38</td>
</tr>
<tr>
<td>Deflection</td>
<td>mm</td>
<td>0.05</td>
<td>Less than 0.1</td>
</tr>
<tr>
<td>Undercut</td>
<td>mm</td>
<td>0.5 ~ 0.8</td>
<td>Less than 0.2</td>
</tr>
<tr>
<td>Brush Height</td>
<td>mm</td>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>Brush Spring Pressure</td>
<td>g</td>
<td>1,400</td>
<td>1,000</td>
</tr>
<tr>
<td>Shunt Field Resistance</td>
<td>(Standard)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engage switch</td>
<td>Ω</td>
<td>0.1 ~ 0.3</td>
<td></td>
</tr>
<tr>
<td>Trap Coil Resistance</td>
<td>Ω</td>
<td>1.5 ~ 2.5</td>
<td></td>
</tr>
<tr>
<td>Contactor Spring Distortion</td>
<td>mm</td>
<td>1 ~ 2</td>
<td></td>
</tr>
<tr>
<td>Slide of Clutch Effect</td>
<td>kg-cm</td>
<td>6 ~ 8</td>
<td>Less than 9, more than 5</td>
</tr>
<tr>
<td>Output Shaft</td>
<td>mm</td>
<td>0.05</td>
<td>Less than 0.1</td>
</tr>
<tr>
<td>Thrust Gap</td>
<td>mm</td>
<td>0.5 ~ 1.5</td>
<td></td>
</tr>
<tr>
<td>Insulation Resistance</td>
<td>MΩ</td>
<td>More than 1</td>
<td>Less than 0.5</td>
</tr>
</tbody>
</table>

#### Motor

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>M Terminal</td>
<td>kg-cm</td>
</tr>
<tr>
<td>Through Bolt</td>
<td>kg-cm</td>
</tr>
<tr>
<td>Engage Set</td>
<td>kg-cm</td>
</tr>
<tr>
<td>Pinion Case Set</td>
<td>kg-cm</td>
</tr>
</tbody>
</table>