1.3 Fuel Oil, Lubricating Oil and Coolant Water

1.3.1 Fuel oil

IMPORTANT:
Only use the recommended fuel to obtain the best engine performance and prevent damage of parts, also prevent air pollution.

(1) Selection of fuel oil

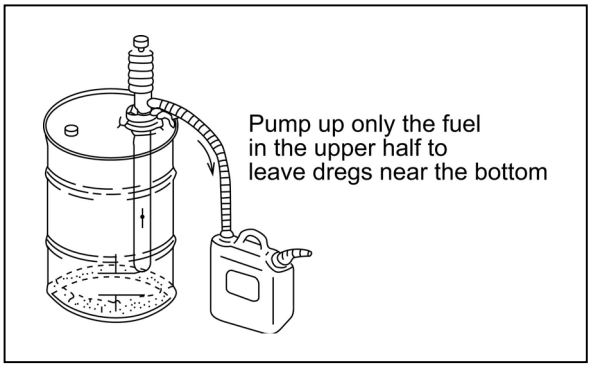
Use the following diesel fuels for best engine performance:
BS 2869 A1 or A2

Fuels equivalent to Japanese Industrial Standard, JIS. No. K2204-2

Fuel cetane number should be 45 or greater

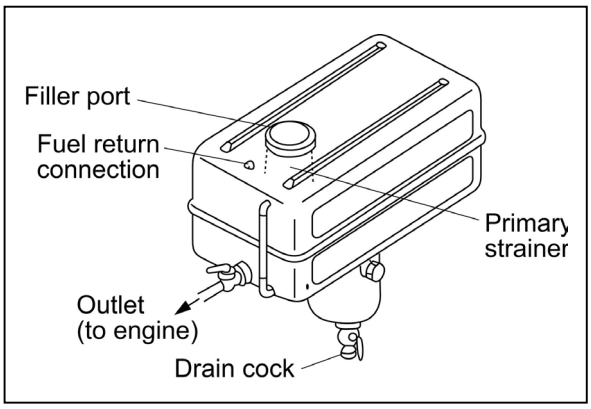
(2) Fuel handling

- Water and dust in the fuel oil can cause operation failure. Use containers which are clean inside to store fuel oil. Store the containers away from rain water and dust.
- Before supplying fuel, let the fuel container rest for several hours so that water and dust in the fuel are deposited on the bottom. Pump up only the clean fuel.



(3) Fuel tank

Be sure to attach a drain cock, precipitation trap and primary strainer to the fuel tank as shown illustration right.

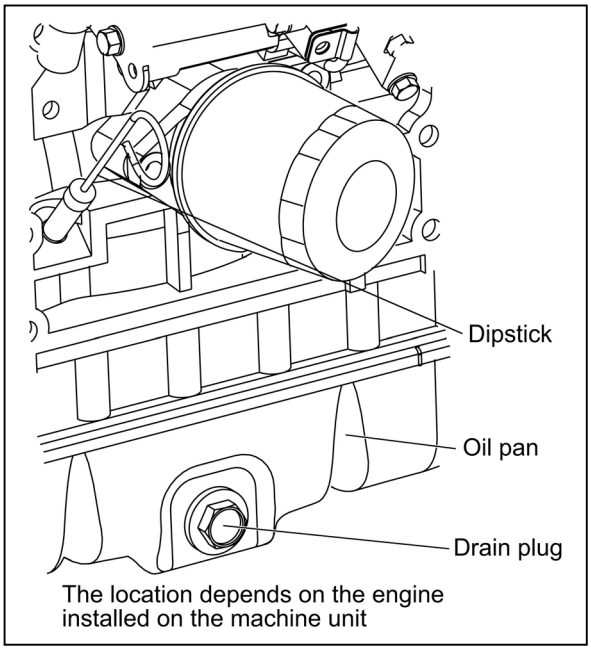


In early period of use, the engine oil gets dirty rapidly because of the initial wear of internal parts. Replace the engine oil earlier.
Lube oil filter should also be replaced when the engine oil is replaced.
The procedure of lube oil and lube oil filter replacement is as follows.

(a) Drain engine oil

- Prepare a waste oil container collecting waste oil.
- Remove the oil filler cap to drain easily while draining the lube oil.
- Loosen the drain plug using a wrench (customer procured) to drain the lube oil.
- Securely tighten the drain plug after draining the lube oil.

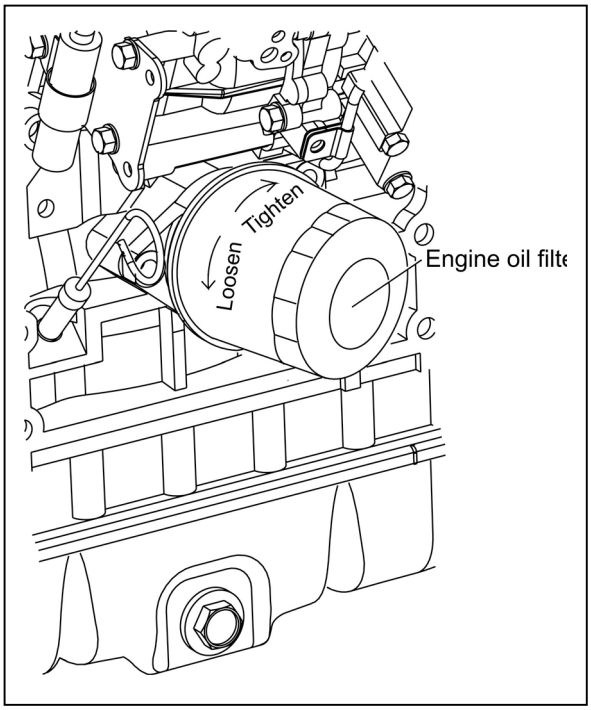
[NOTICE]
Use a socket wrench or a closed wrench when removing or tightening a drain plug.
Don't use a spanner because it has the possibility that the spanner will slip and it will get hurt.



(b) Replacing oil filter

- Turn the lube oil filter counter-clockwise using a filter wrench (customer procured) to remove it.
- Clean the mounting face of the oil filter.
- Moisten the new oil filter gasket with the engine oil and install the new engine oil filter manually turning it clockwise until it comes into contact with the mounting surface, and tighten it further to 3/4 of a turn with the filter wrench.

  Tightening torque: 20～24N·m (2.0～2.4kgf·m)



Model	Applicable oil filter Part No.
3TNV82A～4TNV98(T)	129150-35151
4TNV106(T)	119005-35100

(c) Filling oil and inspection

- Fill with new engine oil until it reaches the specified level.

IMPORTANT:
Do not overfill the oil pan with engine oil.
Be sure to keep the specified level between upper and lower limit on the dipstick.

- Warm up the engine by running for 5 minutes while checking any oil leakage
- Stop the engine after warming up and leave it stopping for about 10 minute to recheck the engine oil level with dipstick and replenish the engine oil. If any oil is spilled, wipe it away with a clean cloth.

2.2.7 Inspection every 2000 hours or 2 years

Be sure to check the following points every 2,000 hours or two years operation, whichever comes first.

No.	Inspection Item
(1)	Coolant water path flushing and maintenance
(2)	Fuel pipe and coolant water pipe inspection and maintenance
(3)	Intake/exhaust valve seat lapping
(4)	Fuel injection timing adjustment Fuel injection pump inspection and adjustment

(1) Coolant water path flushing and maintenance

Rust and water scale will accumulate in the cooling system through many hours of operation. This lowers the engine cooling effect. Oil coolers (attached to turbocharged engines and some of naturally aspirated engines) quickly deteriorate the lube oil. The cleaning and maintenance of the following parts are necessary in accordance with the coolant water replacement.
Cooling system parts: radiator, cooling water pump, thermostat, cylinder block, cylinder head, oil cooler.

(2) Fuel pipe and coolant water pipe inspection and maintenance

Regularly check the rubber hoses of the fuel system and cooling water system. If cracked or degraded, replace them with new one. Replace the rubber hoses at least every 2 years even if 2,000 hours doesn't come.

(3) Intake/exhaust valve seat lapping

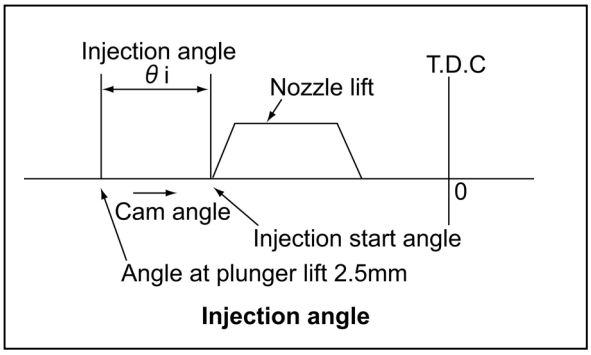
The adjustment is necessary to maintain proper contact of the valves and seats. Refer to 4.2.6 in Chapter 4.

(4) Fuel injection timing adjustment / Fuel injection pump inspection and adjustment

The fuel injection timing and the fuel injection pump are adjusted so that engine performance may become the best condition. As for the inspection and adjustment of the fuel pump, it is based on the service manual of the MP pump of the separate volume. The fuel injection timing is adjusted by the following procedure.

As for the engine, which adopts a MP type fuel injection pump, the fuel injection angle θ_i (note) is adjusted for the fuel injection timing adjustment, because the adjusting method of fuel injection timing like an inline fuel pump can't be applied.

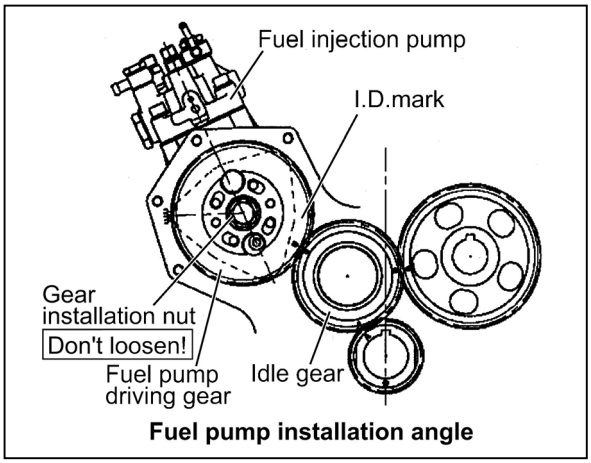
Note) The fuel injection angle θ_i (cam angle) is the difference from the injection valve opening angle while the fuel injection pump being driven by a motor and the angle at the plunger lift 2.5mm of the fuel pump.
And, as for the actual fuel injection angle θ_i, the measured value is recorded on the pump body by each every fuel pump.



Injection angle

The adjustment of fuel injection angle θ_i

In case that a fuel pump cover, installed with a gear case cover and the fuel pump are removed, and reassembled, the procedure of fuel injection angle adjustment is as follows. (As for the disassembly of a fuel injection pump, refer to 7.2.3 in chapter 7.)

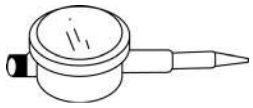
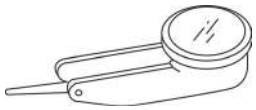
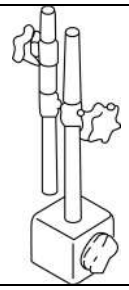
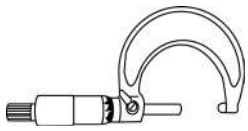
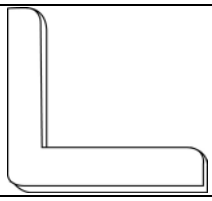


Fuel pump installation angle

[NOTICE]

Never loosen four flange bolts, which fasten a pump flange and a fuel pump drive gear at the time of the removal of the fuel pump. When it is loosened, the adjustment of the fuel injection timing becomes very difficult.

(2) Measuring instruments

No.	Instrument name	Application	Illustration
1	Dial gage	Measurements of shaft bending, and strain and gap of surfaces	
2	Test indicator	Measurements of narrow or deep portions that cannot be measured by dial gage	
3	Magnetic stand	For holding the dial gage when measuring using a dial gage, standing angles adjustable	
4	Micrometer	For measuring the outside diameters of crankshaft, pistons, piston pins, etc.	
5	Cylinder gage	For measuring the inside diameters of cylinder liners, rod metal, etc.	
6	Calipers	For measuring outside diameters, depth, thickness and width	
7	Depth micrometer	For measuring of valve sink	
8	Square	For measuring valve spring inclination and straightness of parts	

mm

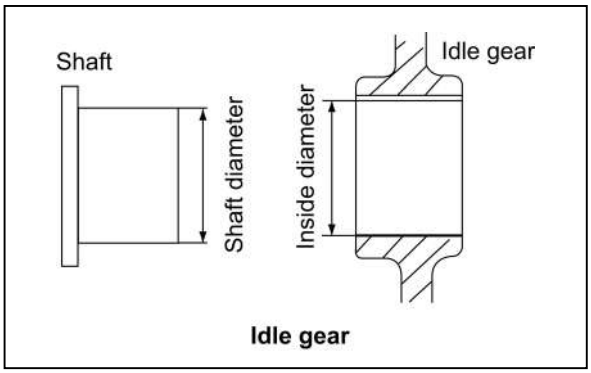
Model	Place	Item	Standard	Limit
3TNV82A～TNV88	Gear side	Bushing I.D.	44.990～45.055	45.130
		Camshaft O.D.	44.925～44.950	44.890
		Oil clearance	0.040～0.130	0.240
	Intermediate position	Bushing I.D.	45.000～45.025	45.100
		Camshaft O.D.	44.910～44.935	44.875
		Oil clearance	0.065～0.115	0.225
	Wheel side	Bushing I.D.	45.000～45.025	45.100
		Camshaft O.D.	44.925～44.950	44.890
		Oil clearance	0.050～0.100	0.210
TNV94L/98(T)	Gear side	Bushing I.D.	49.990～50.055	50.130
		Camshaft O.D.	49.925～49.950	49.890
		Oil clearance	0.040～0.130	0.240
	Intermediate position	Bushing I.D.	50.000～50.025	50.100
		Camshaft O.D.	49.910～49.935	49.875
		Oil clearance	0.065～0.115	0.225
	Wheel side	Bushing I.D.	50.000～50.025	50.100
		Camshaft O.D.	49.925～49.950	49.890
		Oil clearance	0.05～0.100	0.210
4TNV106(T)	Gear side	Bushing I.D.	57.980～58.050	58.105
		Camshaft O.D.	57.910～57.940	57.875
		Oil clearance	0.040～0.140	0.250
	Intermediate position	Bushing I.D.	58.000～58.030	58.105
		Camshaft O.D.	57.895～57.925	57.860
		Oil clearance	0.075～0.135	0.245
	Wheel side	Bushing I.D.	58.000～58.030	58.105
		Camshaft O.D.	57.910～57.940	57.875
		Oil clearance	0.050～0.120	0.230

(2) Idle gear

Mainly check the bushing seizure and wear, and gear damage.
Shaft outside diameter and bushing inside diameter measurement

mm

Item	Standard	Limit
Shaft outside diameter	45.950～49.975	45.900
Bushing inside diameter	46.000～46.025	46.075
Clearance	0.025～0.075	0.175



(3) PTO drive gear

Mainly check sticking of bearings on both sides, gear damage and looseness, and gear shaft damage and wear.

8.1.3 Structural and functional outline

No.	Part name
1	Turbine shaft
2	OiN thrower
3	Turbine side seal ring
4	Seal plate
5	Journal bearing
6	Thrust bearing
7	Compressor housing
8	M5 hexagon bolt
9	M5 spring washer
10	Compressor side clamp
11	Turbine housing
12	M6 hexagon bolt
13	Turbine side clamp
14	Lock washer
15	Bearing housing
16	Retaining ring
17	M3 countersunk flat head screw
18	Compressor wheel
19	Shaft end nut
20	Heat protector

(1) Turbine

The exhaust gas from the engine is accelerated at the nozzle portion in the turbine housing and blown onto the turbine impeller to rotate the turbine shaft.
This is called the turbine. A seal ring and heat insulating plate are installed to prevent the bearing from adverse influence of the gas.

(2) Compressor

The compressor impeller installed on the turbine shaft rotates with the shaft to suck and compress air for feeding into the intake manifold.
This is called the blower or compressor.

(3) Bearings

Thrust bearing

As the turbine shaft is constantly applied with a thrust force, this bearing prevents the shaft from being moved by the thrust force.

Radial bearing

A floating bearing is adopted. Since the bearing moves with the turbine shaft as the oil films are formed both inside and outside the bearing, the bearing sliding speed is slower than the turbine shaft speed, resulting in higher dynamic stability.

(4) Compressor side sealing mechanism

To prevent the intake air and oil form leaking, a seal ring and a seal plate are provided to form a double wall structure on the rear side of the compressor impeller.

(5) Waste gate

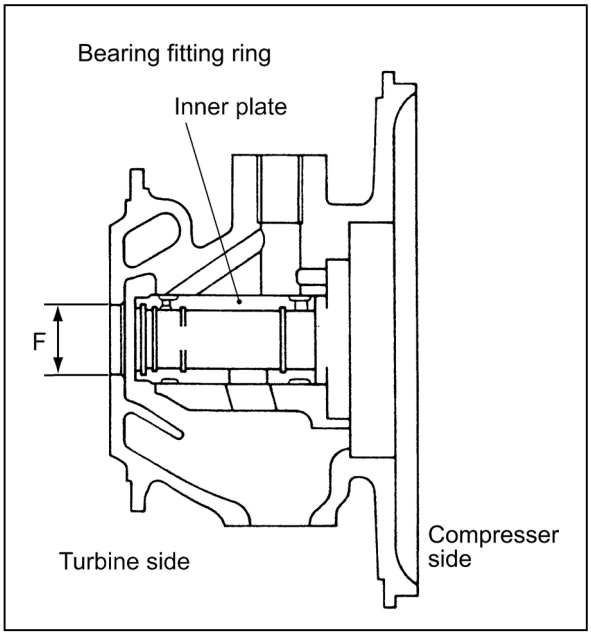
When the blower side pressure (intake air pressure) exceeds the specified level, the exhaust gas at the turbine inlet is partially bypassed to the exhaust discharge side to control the turbine rpm so as to maintain the intake pressure at the specified level for improving the response to load variation in the low to medium speed range and to minimize black smoke generation. It consists of a control assembly separated from the turbocharger and a valve assembly installed in the turbine impeller chamber.

(8) Bearing housing 15

1) Inspect the housing for cast surface exfoliation due to oxidation and degradation, dent or crack.
2) Inspect circlip 16 for chipping or crack, and replace with a new one if defective.
3) Measure the (B) and (F) portions of the bearing housing shown in the figure below. Replace with a new one if either wear limit is exceeded.

Wear limit of bearing housing inside diameter (B)
RHF5 ····· 12.42mm
RHB51 ····· 12.42mm
RHB31 ····· 10.01mm

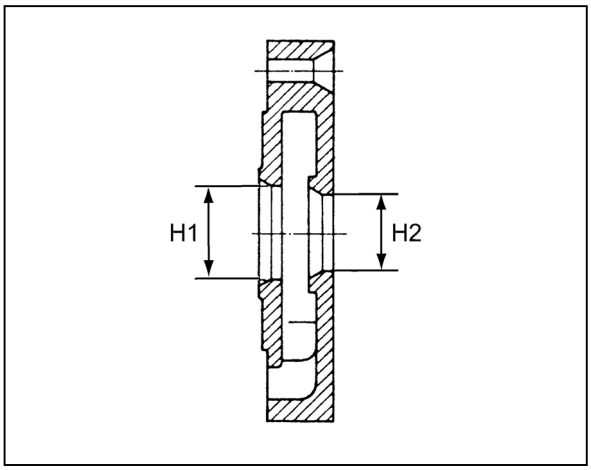
Wear limit of turbine side seal ring inserting portion (F)
RHF5 ····· 15.05mm
RHB51 ····· 15.05mm
RHB31 ····· 11.03mm



(9) Seal plate 4

1) Inspect the seal plate for any contact trace, joint surface defect, dent or crack. Replace it if defective.
2) Measure the seal ring inserting dimensions (H1 and H2) on the compressor side, and replace the seal ring with a new one if either wear limit is exceeded.

Wear limits
RHF5 ····· H1: 12.45mm, H2: 10.05mm
RHB51 ····· H1: 12.45mm, H2: 10.05mm
RHB31 ····· H1: 10.04mm, H2: 8.01mm



(10) Seal rings

Replace seal rings with new ones.

(11) Inspect keep plates 10, 13 and bolts for any deformation, and replace defective parts with new ones. Also replace M3 Torx machine screws with new ones.

(d) Armature and commutator run-out
Use a dial gage and measure the armature core run-out and commutator run-out. Correct or replace if the limit is exceeded.

mm

	Standard	Limit
Armature	0.03	0.2
Commutator	0.03	0.2

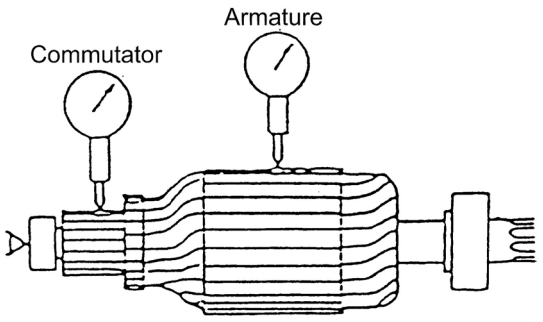


Fig. 13

(e) Commutator surface inspection
If the commutator surface is roughened, grind with #500 to #600 emery cloth.

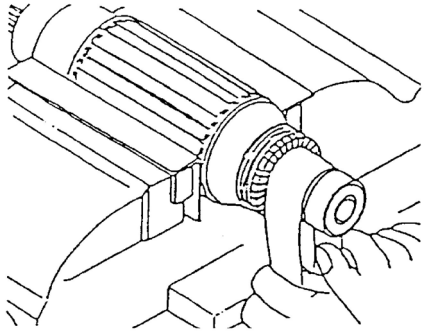


Fig. 14

(f) Commutator insulation depth
Measure the depth of the insulating material between commutator segments, and correct it if it is less than the limit.

mm

Standard	Limit
0.5∼0.8	0.2

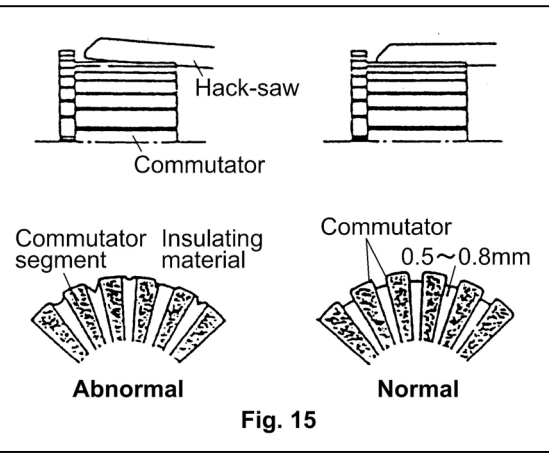
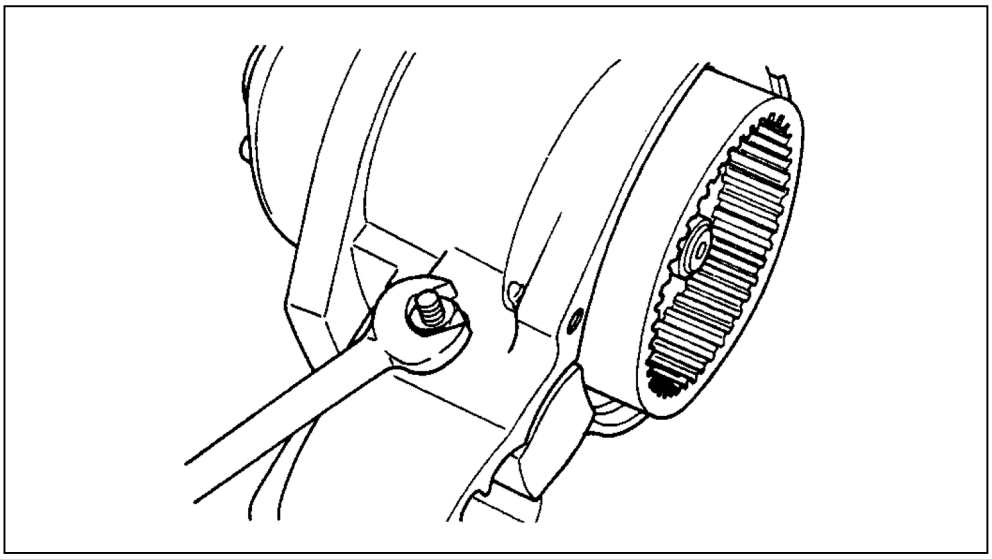
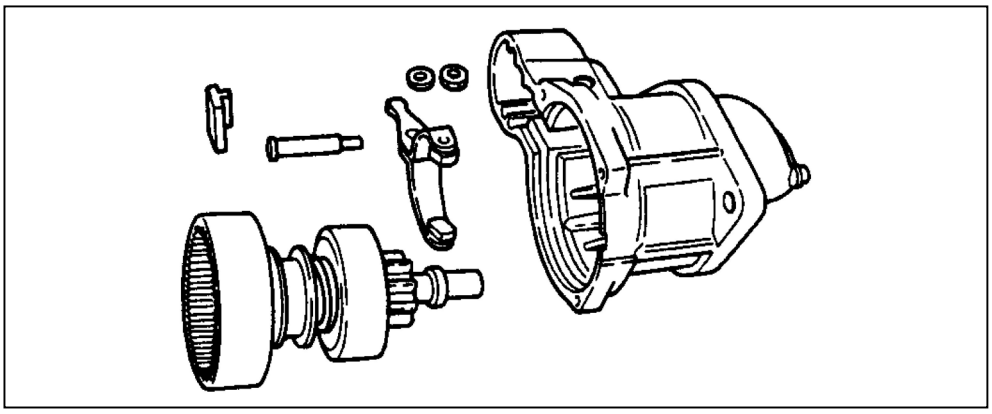


Fig. 15

(6) Removal of shift lever pin

Remove the M6 nut (10mm) and pull out the shift lever pin.
Now. the dustcover, shift lever, gear case and gear shaft can be removed.





11.2.2 Starter

In the cases listed below the warranty shall not be deemed to apply. Please be sure to read these conditions carefully when planning to use it with other equipment. Also be certain to give appropriate guidance on usage to the user.

(1) Starting performance in the case of using an untested battery

The starting performance of the engine is closely dependent on the battery capacity. This battery capacity is itself affected by the climate and the type of equipment installation. The details regarding ambient temperature and equipment installation vary depending on the OEM.
Confer in advance after checking these conditions and
fix the battery capacity on the basis of confirmatory tests.

(2) When the resistance of the battery cable exceeds the specified value

The combined total resistance of the battery cable in both directions between the starting motor and battery should be within the value indicated on the wiring diagram. The starting motor will malfunction or break down if the resistance is higher than the specified value.

(3) When the resistance of the starter circuit exceeds the specified value

The combined total resistance of the wiring between the starting motor and key switch (or power relay or safety relay, depending on the application) should be within the value indicated on the wiring diagram. Engine starting will be difficult if the resistance is higher than the specified value. This can also cause welding of the magnet switch at the point of contact and resultant burning of the armature coil.

(4) When there is no safety relay

Over-running (when the electric current flows for too long) is a major cause of starting failure. This burns the armature coil and causes clutch failure. Excessive work and failure of the key switch to return properly are the main causes of over-running. The user must be given sufficient warning about this.
Be sure to use the safety relay to prevent over-running. This safety relay is supplied as an option.
First when planning to install a safety relay at your own company. In the case of
failure, our warranty will not be applied to all the electrical equipment.

(5) When there is too much rust due to the entry of water

The water-proofing of the starting motor is equivalent to R2 of JIS D 0203. This guarantees that there will be no damage from the sort of exposure encountered in rain or when water is poured on from a bucket. You should, however, avoid the use of high-pressure washing and steeping in water.

(6) Regarding the heat resistance of the starter motor

The starter motor has heat resistance for an ambient temperature of 80℃ and surface temperature of 100℃. Insulators must be installed to prevent overheating when used near high temperature parts such as the exhaust system.

(7) Corrosion of magnet switch contact point by corrosive gas.

When using equipment with a dry clutch, ammonium gas generated by friction is liable to corrode the contact of the magnet switch. Be sure to install a vent in the clutch case.

Piston ring

mm

Model	Inspection item		Standard	limit	Reference page
3TNV82A TNV84	Top ring	Ring groove width	2.065~2.080	-	4.4.5.(4)
		Ring width	1.970~1.990	1.950	
		Side clearance	0.075~0.110	-	
		End clearance	0.200~0.400	0.490	
	Second ring	Ring groove width	2.035~2.050	2.150	
		Ring width	1.970~1.990	1.950	
		Side clearance	0.045~0.080	0.200	
		End clearance	0.200~0.400	0.490	
	Oil ring	Ring groove width	4.015~4.030	4.130	
		Ring width	3.970~3.990	3.950	
		Side clearance	0.025~0.060	0.180	
		End clearance	0.200~0.400	0.490	
TNV88	Top ring	Ring groove width	2.060~2.075	-	
		Ring width	1.970~1.990	1.950	
		Side clearance	0.070~0.105	-	
		End clearance	0.200~0.400	0.490	
	Second ring	Ring groove width	2.025~2.040	2.140	
		Ring width	1.970~1.990	1.950	
		Side clearance	0.035~0.070	0.190	
		End clearance	0.200~0.400	0.490	
	Oil ring	Ring groove width	4.015~4.030	4.130	
		Ring width	3.970~3.990	3.950	
		Side clearance	0.025~0.060	0.180	
		End clearance	0.200~0.400	0.490	
4TNV94L/98	Top ring	Ring groove width	2.040~2.060	-	
		Ring width	1.940~1.960	1.920	
		Side clearance	0.080~0.120	-	
		End clearance	0.250~0.450	0.540	
	Second ring	Ring groove width	2.080~2.095	2.195	
		Ring width	1.970~1.990	1.950	
		Side clearance	0.090~0.125	0.245	
		End clearance	0.450~0.650	0.730	
	Oil ring	Ring groove width	3.015~3.030	3.130	
		Ring width	2.970~2.990	2.950	
		Side clearance	0.025~0.060	0.180	
		End clearance	0.250~0.450	0.550	
4TNV106(T)	Top ring	Ring groove width	2.520~2.540	-	
		Ring width	2.440~2.460	2.420	
		Side clearance	0.060~0.100	-	
		End clearance	0.300~0.450	0.540	
	Second ring	Ring groove width	2.070~2.085	2.185	
		Ring width	1.970~1.990	1.950	
		Side clearance	0.080~0.115	0.235	
		End clearance	0.450~0.600	0.680	
	Oil ring	Ring groove width	3.015~3.030	3.130	
		Ring width	2.970~2.990	2.950	
		Side clearance	0.025~0.060	0.180	
		End clearance	0.300~-0.500	0.600	

1.2. Safety Precautions

⚠ WARNING

- Place allowing sufficient ventilation

  Jobs such as engine running part welding and polishing the paint with sandpaper should be done in a well-ventilated place.

Failure to Observe

Very dangerous for human body due to the possibility of inhaling poisonous gas or dust.

⚠ CAUTION

- Sufficient wide and flat place

  The floor space of the service shop for inspection and maintenance should be sufficiently wide and flat without any holes.

Failure to observe

An accident such as a violent fall may be caused.

⚠ CAUTION

- Clean, orderly arranged place

  No dust, mud, 0il or parts should be left on the floor surface.

Failure to Observe

An unexpected accident may be caused.

⚠ CAUTION

- Bright, safety illuminated place

  The working place should be illuminated sufficiently and safety. For a job in a dark place where it is difficult to see, use a portable safety lamp. The bulb should be covered with a wire cage for protection.

Failure to observe

The bulb may be broken accidentally causing ignition of leaking oil.

⚠ CAUTION

- Place equipped with a fire extinguisher

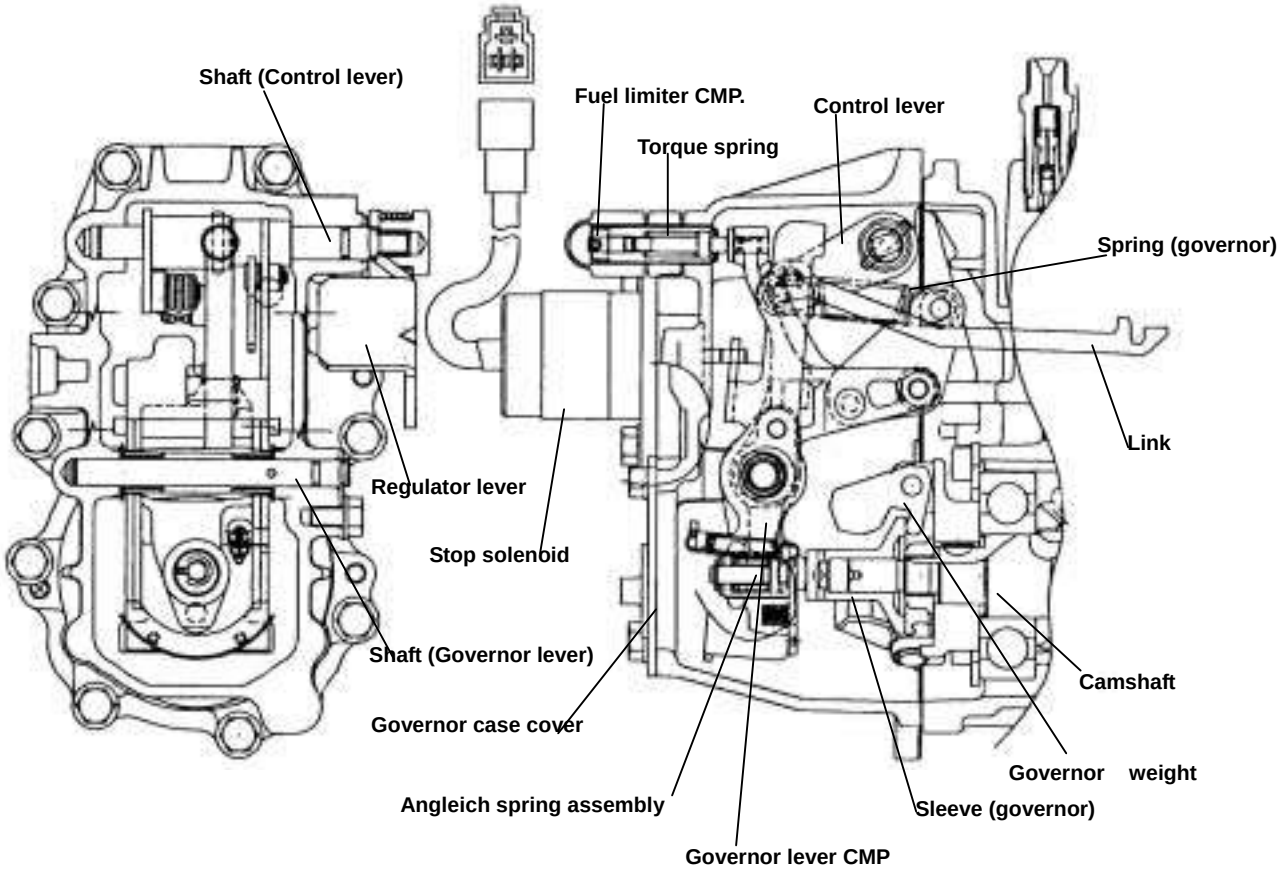
  Keep a first aid kit and fire extinguisher c1ose at hand in preparation for fire emergencies

2.4.2. Governor Part

2.4.2.1. Construction of Governor

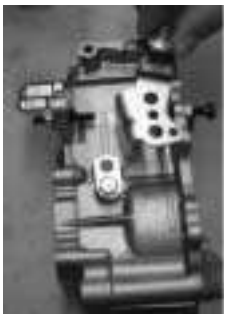
Usage condition of diesel engines are extremely varied, with a wide range of loads and speeds. The governor plays an important role in the operation of the engine by quickly adjusting the position of the control rack to control the amount of fuel injected, according to changes of engine speed.
It also automatically controls the engine to prevent engine speed from exceeding the maximum ,and keeps the engine from stopping.

- Mechanical governor



The governor weight mounted on the end of the fuel injection pump cam shaft rotates around the governor support pin, driven by the cam shaft, and is forced outwards by the centrifugal force acting on the weight.
The thrust force acting on the cam shaft due to this centrifugal force acts on the lower part of the tension lever through the sleeve A starting excess fuel spring is mounted on the bottom of the tension lever.
0ne end of the governor spring is hooked to the right upper end of the tension lever, and the other end to the spring lever of the control lever shaft.

3.2. Disassembling the Governor



Remove the lock nut, (Control lever).

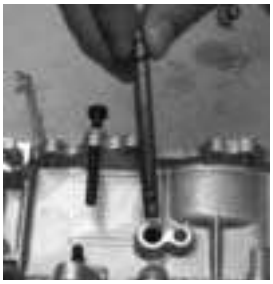
Remove the regulator lever.

Remove the shim.

Remove the removal stop, (governor lever shaft) fixing bolt.

Remove the removal stop, (governor lever shaft).

Pull out the governor lever shaft.



Removed governor lever shaft

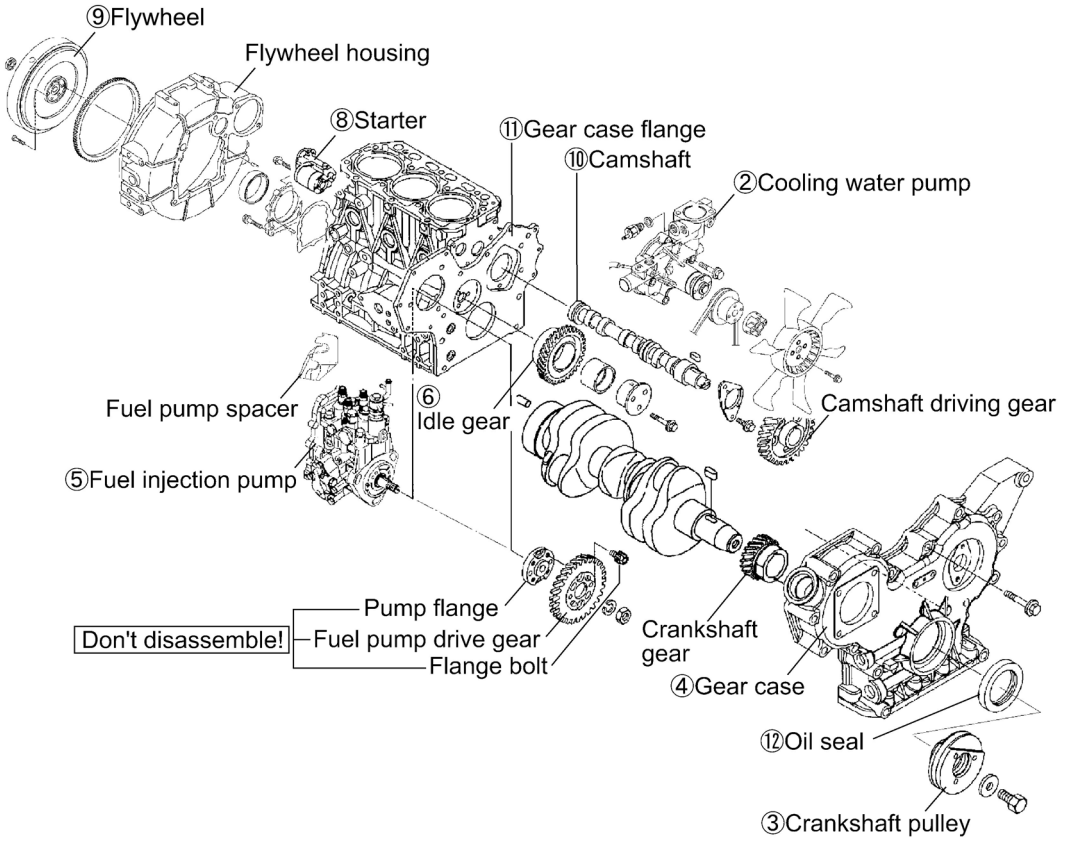
Take out the governor lever CMP.

Remove the spring.

(2) How to Read the Explanations

- An exploded view, sectional views, a system diagram, etc. are shown at the beginning of each section as required for easy understanding of the mounted states of the components.
- For the removal/installation of each part, the procedure is shown with the procedural step No. in the illustration.
- Precautions and key points for disassembly and reassembly of parts are described as **points**. In the explanation for each point, detailed operation method, information, standard and precautions are described.

Description Example



Note) This figure shows the 3TNV84.

The job contents are described in the disassembly procedure for Nos. not shown in the illustration.

- Disassembly procedure

1) Follow steps (1) to (15) of the cylinder head disassembly procedure.
2) Remove the cooling water pump.
3) Remove the crankshaft pulley. (**Point 1**) ← Operation point to be explained on a later page.

- Operation points

Disassemble: Service point for removal
Reassemble: Service point for installation
Disassemble-Reassemble: Service point required in both removal and installation.