CHAPTER 3

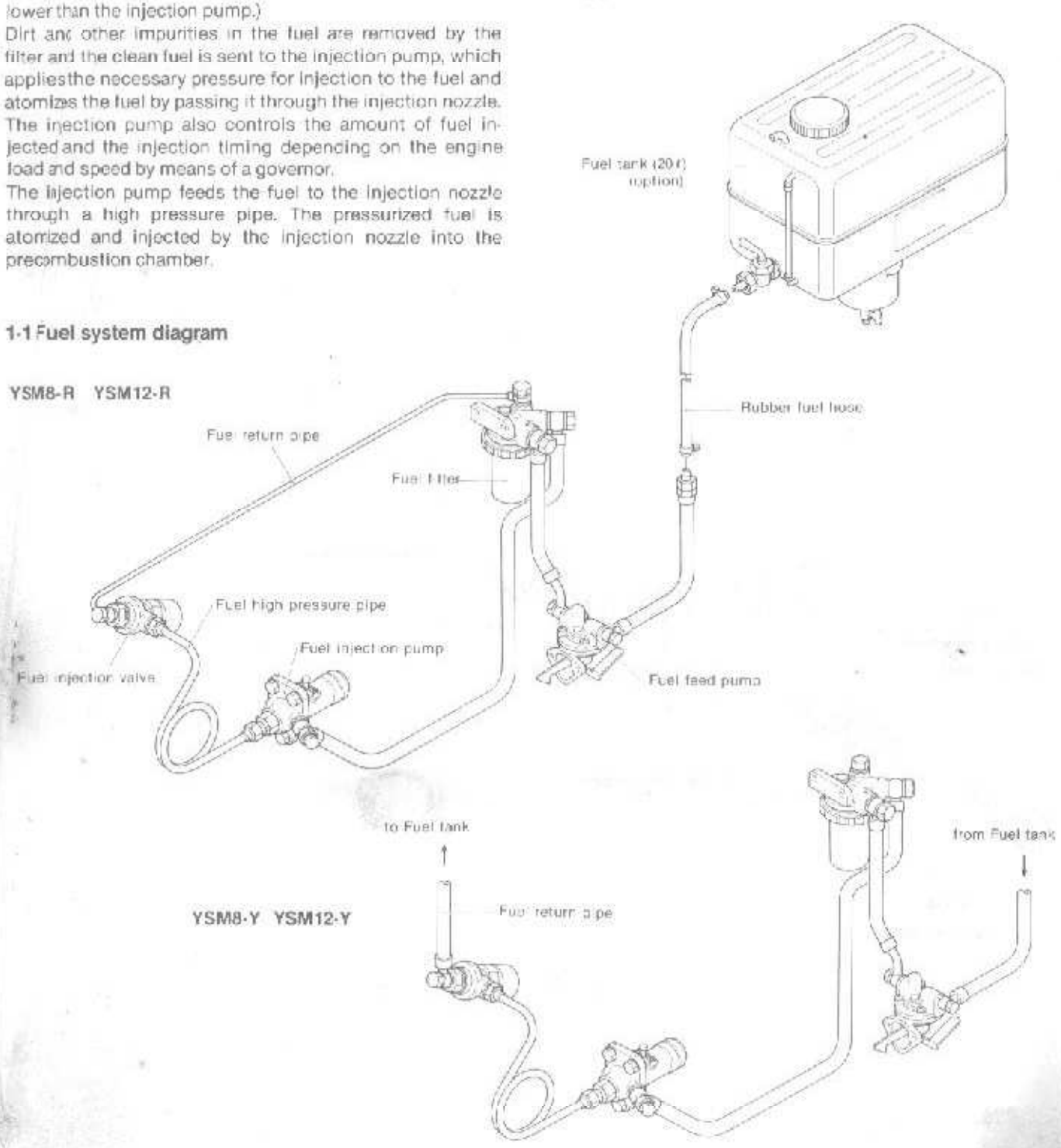
FUEL SYSTEM

1. Construction

The fuel system consists mainly of an injection pump, injection pipe, and an injection nozzle, plus a fuel tank, feed pump, fuel filter and other associated parts. The injection pump is driven by a fuel cam mounted on one end of the camshaft and is controlled by a governor. Fuel stored in the fuel tank is fed to the fuel filter through the feed pump. (The feed pump is indispensable when the fuel tank is installed lower than the injection pump.)
Dirt and other impurities in the fuel are removed by the filter and the clean fuel is sent to the injection pump, which appliesthe necessary pressure for injection to the fuel and atomizes the fuel by passing it through the injection nozzle. The injection pump also controls the amount of fuel injected and the injection timing depending on the engine load and speed by means of a governor.
The injection pump feeds the fuel to the injection nozzle through a high pressure pipe. The pressurized fuel is atomized and injected by the injection nozzle into the precombustion chamber.

Fuel that overflows the injection nozzle is returned to the fuel filter through the fuel return pipe. The quality of the equipment and parts comprising the fuel injection system directly affects combustion performance and has a considerable effect on engine performance. Therefore, this system must be inspected and serviced regularly to ensure top performance.

1-1 Fuel system diagram



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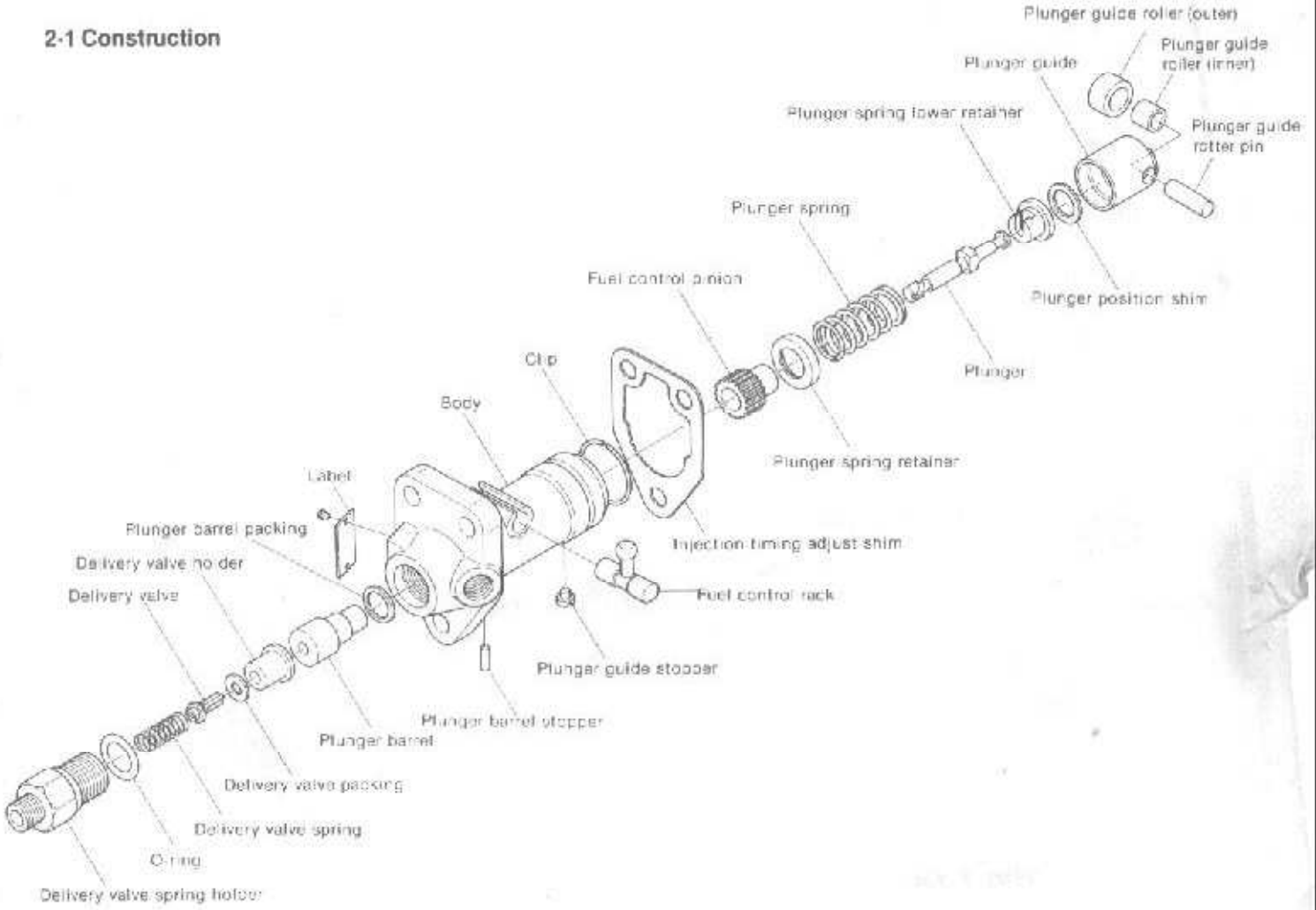
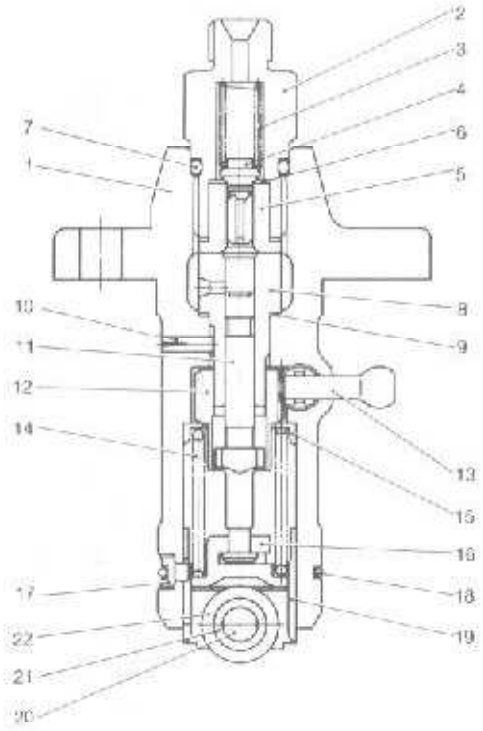
2. Injection Pump

The injection pump is the most important part of the fuel system. This pump feeds the proper amount of fuel to the engine at the proper time in accordance with the engine load.
This engine uses a Bosch type injection pump. It is designed and manufactured by Yanmar, and is ideal for the fuel system of this engine.
Since the injection pump is subjected to extremely high pressures and must be accurate as well as deformation and wear-free, stringently selected materials are used and precision-finished after undergoing heat treatment.

The injection pump must be handled carefully. Since the delivery valve and delivery valve holder and the plunger and plunger barrel are lapped, they must be changed as a pair.

2-1 Construction





1 Body
2 Delivery valve spring holder
3 Delivery valve spring
4 Delivery valve
5 Delivery valve holder
6 Delivery valve packing
7 O-ring
8 Plunger barrel
9 Plunger barrel packing
10 Plunger barrel stopper
11 Plunger
12 Fuel control pinion
13 Fuel control rack
14 Plunger spring
15 Plunger spring retainer
16 Plunger spring lower retainer
17 Plunger guide stopper
18 Clip
19 Plunger guide
20 Plunger guide roller pin
21 Plunger guide roller (inner)
22 Plunger guide roller (outer)

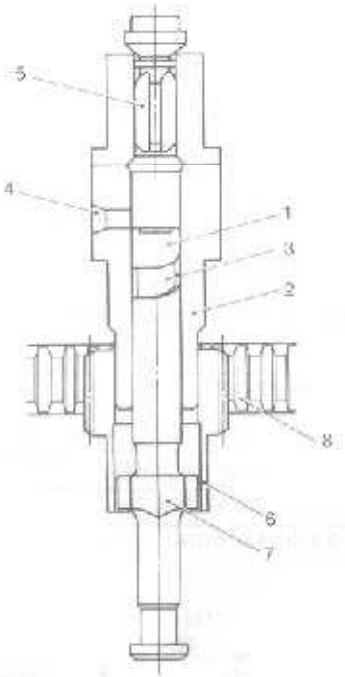
2-2 Specifications

mm (in.)

		YSM8-R(Y) YSM12-R(Y)
Fuel cam lift		7 (0.2756)
Plunger	Diameter × stroke	ø6 × 7 (0.2362 × 0.2756)
	Configuration	(Injection amount increases at starting)
Fuel adjusting rack sliding resistance (pump standstill)		less than 80 (0.132)
Plunger upper clearance (mounting dimension 76.0 −0.05mm)		1.0 (0.0394)
Plunger position shim		0.1, 0.2, 0.3 (0.0394, 0.0787, 0.1181) (3 kinds)
Plunger spring	Free length	35.0 (1.3780)
	Mounted length	27.0 (1.0630)
	Mounting load	10.4 kg (22.9280lb.)
Delivery valve spring	Free length	31.0 (1.2205)
	Mounted length	23.96 (0.9433)
	Mounting load	2.885 kg (6.3603 lb.)

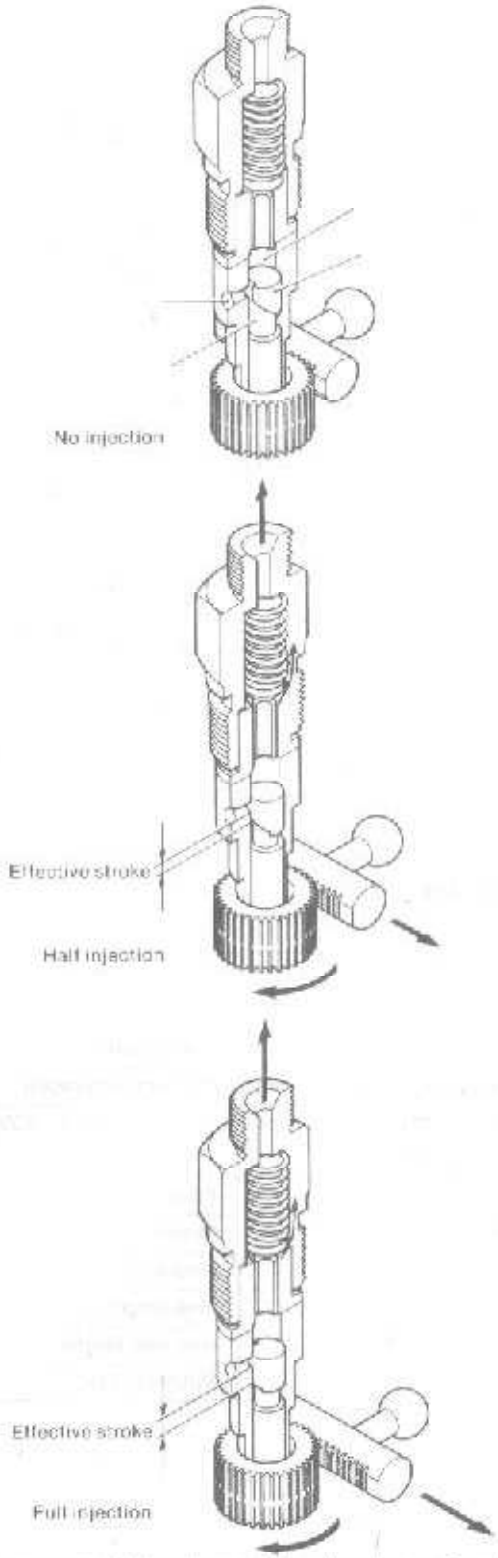
2-3 Fuel Injection pump

The fuel injection pump force-feeds the fuel by means of the plunger (1) which operates at a constant stroke. Since the plunger is lap fitted into the plunger barrel (2) for super precison, it can be replaced only as a set. The cylindrical surface of the plunger has an obliquely cut lead (3) and a groove which connects the lead to the plunger head. The plunger has an intake hole (4) through which the fuel passes and is force-fed by the plunger. Then the fuel opens the delivery valve (5), goes through the fuel injection tube, and is injected into the spiral-vortex type pre-combustion chamber from the injection valve. The plunger is fitted with the fuel control gear (6), and its flange (7) fits into the groove which is longitudinally cut into the inner surface of the lower end of the control gear. The fuel control gear is in mesh with the fuel control rack, the motion of which rotates the plunger to constantly vary the amount of fuel injected from zero to maximum.



2-3.1 Fuel control

When the plunger (1) is at bottom dead center, the oil, which comes in through the oil hole, fills the delivery chamber (3) to above the plunger; the oil pressure then builds up as the plunger rises and closes the oil hole, and by opening the delivery valve, is force-fed toward the fuel injection tube. As the plunger, pushed by the plunger guide, rises further, the pressure of the oil between the delivery chamber and the nozzle also increases. When this oil pressure builds up to 155 to 165 kg/cm², the nozzle opens, and the fuel oil is injected into the spiral vortex type combustion chamber. However, if the plunger keeps rising and the lead groove (4) lines up with the oil hole (2), the oil under high pressure in the delivery chamber passes the lead from the longitudinal groove up the lead and is driven back into the suction chamber from the oil hole. At the same force feeding of the fuel is suspended.

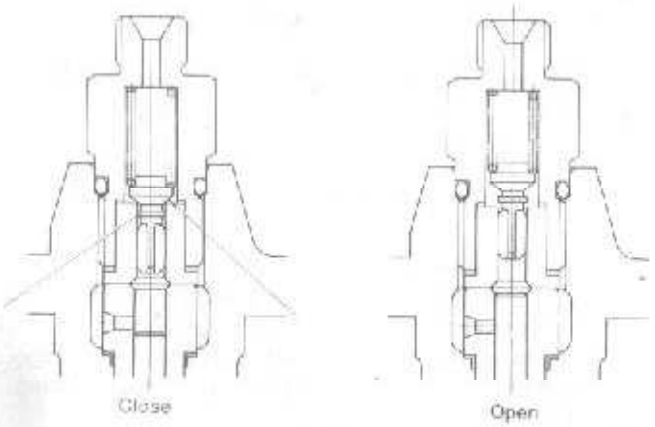


As a result of the above action, the plunger is rotated by the fuel control rack and the angle of this rotation changes the effective stroke of the plunger and controls the discharge of the pump. Also, when the fuel control rack lines up the longitudinal groove on the plunger with the oil hole, the oil hole does not close, despite the rise of the plunger, but rather the fuel is driven back to the suction chamber. As a result the fuel is not force-fed but the amount of injection

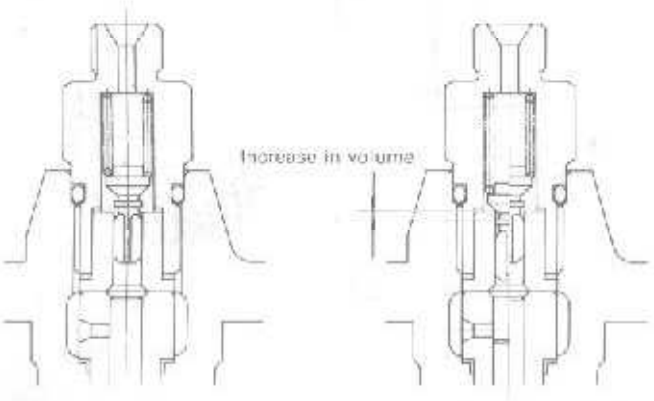
is reduced to zero. At this time the fuel control rack is at the cylinder side end; when it reaches the opposite side end the maximum amount of fuel is injected. Before the maximum injection level is reached, the fuel injection control shaft regulates the amount of fuel injected to the normal operation level.

2-3.2 Action of the delivery valve and the sucking-back of fuel

The delivery valve on top of the plunger prevents the fuel within the injection tube from flowing backward toward the plunger side and also serves to suck back the fuel to prevent the backward dripping of the nozzle valve. When the notch (lead) of the plunger comes up to the oil hole of the plunger barrel, the feeding pressure acting on the fuel oil drops, and the delivery valve falls due to the force of the spring. After the sucking-back collar (1) has first shut off the fuel injection tube and the delivery chamber the delivery valve drops further until it comes into contact with the seat surface. (2) corresponding to the amount of fall (i.e., increase in volume), the fuel oil pressure within the injection tube drops, speeding up the closure of the nozzle valve, and sucking up the fuel before it drips back. This enhances the durability of the nozzle and improves fuel oil combustion.



Action of the delivery valve



Function of the delivery valve

2-4 Disassembly

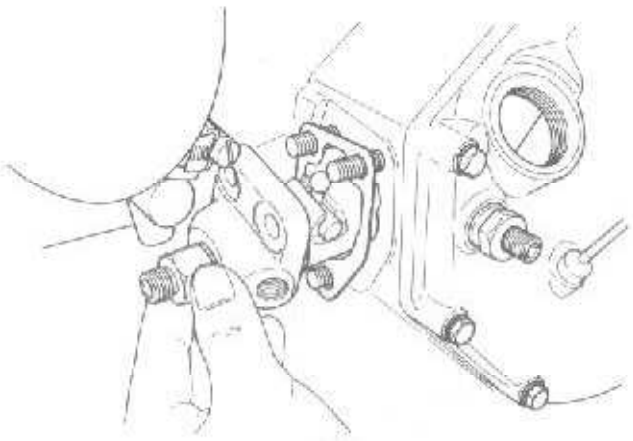
2-4.1 Removal of Fuel Injection Pump

(1) Remove the parts in the following order.
1) Fuel injection pipe and fuel pipe
2) Oil port
3) Fuel limiter end nut

NOTE: After removing the fuel oil pipe, screw in the pipe-connecting bolt so that no dust gets into the pump.

(2) Loosen the fuel limiter lock nut, and pull out the fuel limiter about 10 mm.
(3) Loosen the four fuel injection pump lock nuts evenly and remove the pump.

NOTE: During removal be careful not to bump the fuel injection rack and the full injection timing plate against the cylinder block.

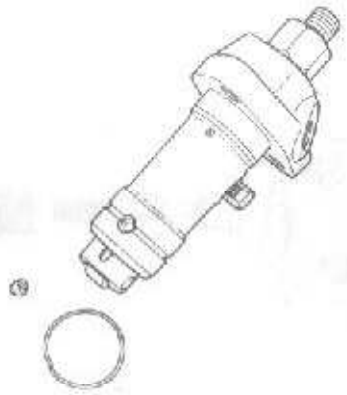


Pump removal

2-4.2 Disassembly of fuel injection pump

NOTE: 1) Before disassembly wash the pump in clean oil, and after assembly arrange all parts carefully.
2) Make sure the work area is exceptionally clean.

(1) Remove the plunger guide stopper pin with needle nose pliers.



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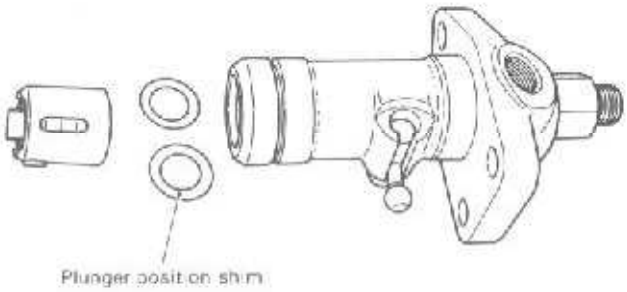
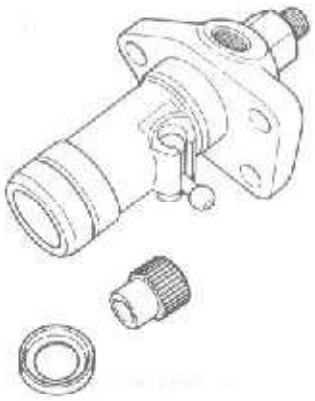
(2) Remove the plunger guide stopper.
The stopper can be removed by pushing the plunger guide down with the palm of your hand.
(3) Remove the plunger guide.

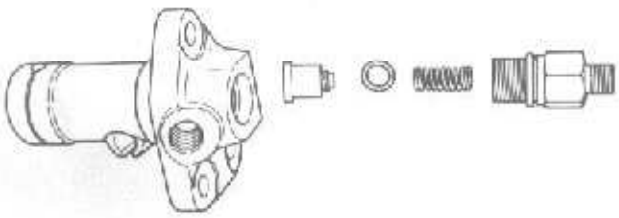
NOTE: Be careful not to lose the plunger adjusting shim which is located inside the plunger guide.



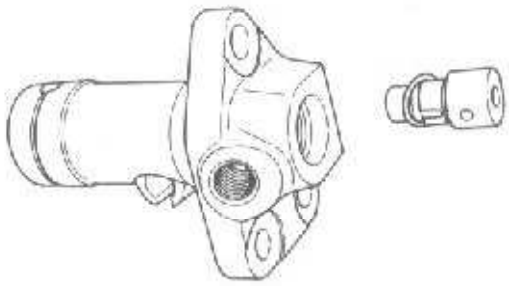
(4) Remove the plunger and plunger spring lower retainer be careful not to damage the plunger.
(5) Remove the plunger spring, fuel control pinion and plunger spring upper retainer, using your fingers or tweezers.



(6) Remove the fuel control rack.
(7) Remove the delivery valve holder; be careful not to damage the O-ring.
(8) Remove the delivery valve spring.
(9) Remove the delivery valve.



(10) Remove the plunger barrel by pushing it toward the delivery valve side.



NOTE: 1. Line up the plunger valve and the plunger, and put them in order.
2. Immerse the delivery valve, plunger, etc. in clean oil.
3. Do not loosen or remove the injection control plate, etc.

2-5 Inspecting injection pump parts

2-5.1 Rinse each component part in clean light oil before inspecting it.

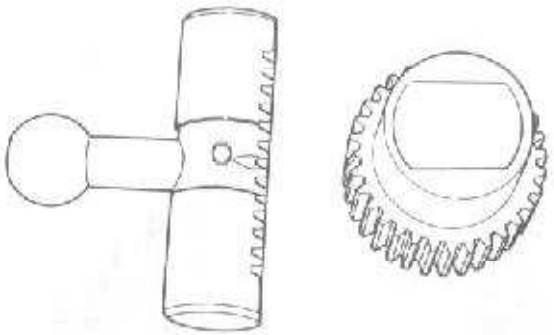
NOTE: Do not touch the sliding surface of the plunger and the delivery valve with your fingers during handling.

2-5.2 Control rack and pinion

(1) Check control rack teeth and sliding surface for damage and abnormalities. If found, replace.

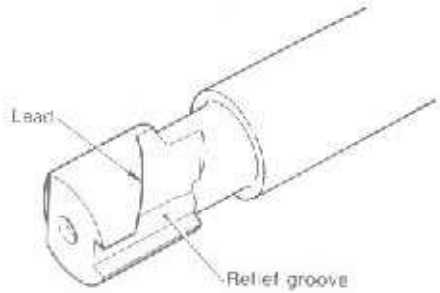
NOTE: When replacing control rack, adjust fuel discharge amount with a fuel injection pump tester and stamp a rack mark.

(2) Replace pinion if teeth are damaged or worn unevenly.



2-5.3 Plunger

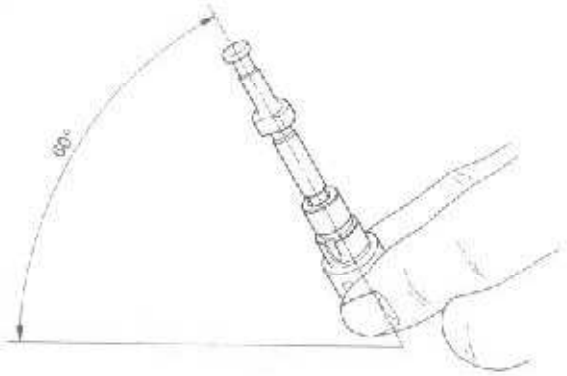
(1) Inspect the plunger for wear, scoring and discoloration around the lead. If any problems are found, conduct a pressure test and replace the plunger and plunger barrel assembly.



(2) Inspect the outside sliding surface of the plunger with a magnifying glass. Lap or replace the plunger and plunger barrel assembly when corrosion, hairline cracks, staining and/or scoring are detected.

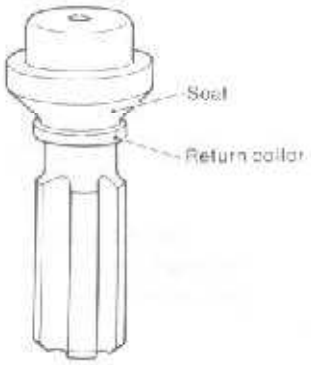
(3) Check the clearance between the plunger collar and control pinion groove. Replace these parts when wear exceeds the specified limit.

(4) After cleaning the plunger, tilt it approximately 60°, as shown in the figure, and slowly slide it down. Repeat this several times while rotating the plunger. The plunger should slide slowly and smoothly. If it slides too quickly, or binds along the way, repair or replace it.



2-5.4 Delivery valve

(1) Replace the delivery valve if the return collar and seat are scored, dented or worn.



(2) Raise the delivery valve and put a finger over the hole on the valve seat bottom. Let go of the delivery valve. If it sinks quickly and stops at the position where the suck-back collar closes the valve seat hole, the delivery valve may be considered normal. If this is not the case, replace the delivery valve as a set.

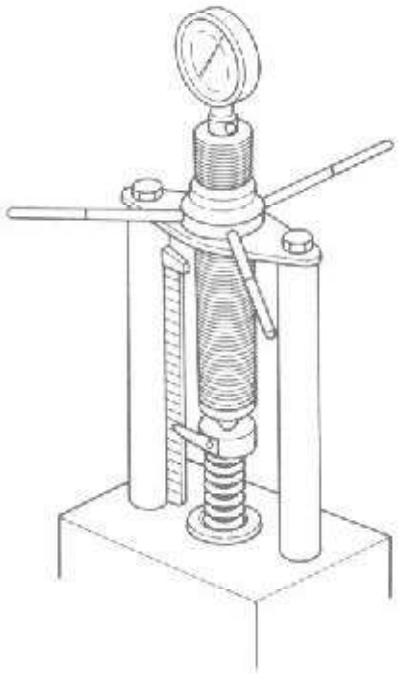
(3) Place your finger over the hole in the bottom of the valve seat and insert the valve into the valve body. If the valve returns to its original position when you remove your finger, the valve is okay. If some defect is found, replace with a new valve.

(4) If the valve closes completely by its own weight when you remove your finger from the hole on the bottom of the valve seat, the valve is okay. If it doesn't close perfectly replace with a new valve.

NOTE: When using a brand-new set, wash off the rust-proof oil with clean oil or gasoline. Then, wash once more with clean oil, and follow the steps outlined above.

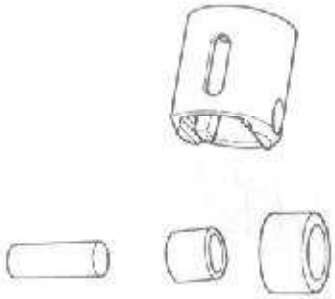
2-5.5 Plunger spring and delivery valve spring

Inspect the plunger spring and delivery valve spring for fractured coils, rust, inclination and permanent strain. Replace the spring when faulty. (See 2-2)



2-5.6 Plunger guide

Check the tappet roller (inside and outside) and roller pin for damage and uneven wear, and replace if required.
Measure the clearance between the plunger and plunger guide. If the clearance exceeds the limit, replace.



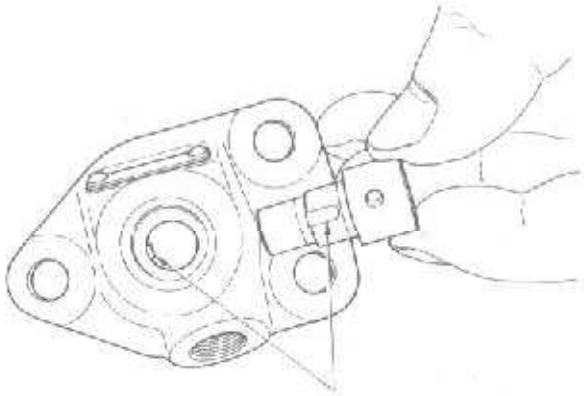
mm (in.)

Clearance limit	0.3 (0.0118)

2-6 Assembling the fuel injection pump

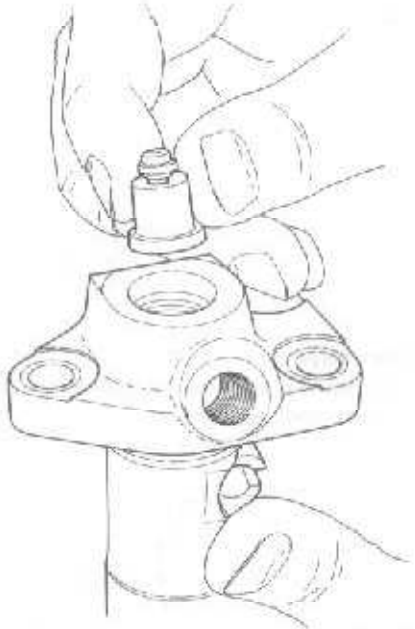
NOTE: 1. After inspection, divide the components into two groups, i.e. the components to be replaced, and those that are reusable. Rinse the components and store the two groups separately.
2. Replace the packing with a new one.

(1) While lining up the plunger barrel positioning groove with the dowel of the main unit, attach the plunger barrel to the main unit.



Attaching the plunger barrel to the main unit

(2) Attach the delivery valve seat and the delivery valve to the main unit.



Attaching the delivery valve to the main unit

NOTE: If the delivery valve tip projects noticeably above the top of the main unit of the pump, the plunger barrel has been installed incorrectly, and must be re-attached.

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(3) Attach the delivery valve packing and the delivery valve spring to the main unit and carefully tighten the delivery valve holder.

NOTE: Tighten the delivery valve holder with a torque wrench after attaching the plunger and while checking the fuel control rack for sliding motion.

kg-cm (ft-lb)

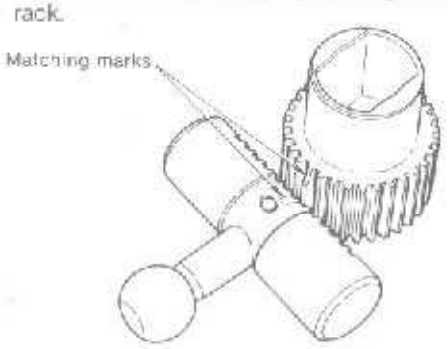
Tightening torque	400 to 450 (28.92 to 32.54)

(4) With the matching mark of the fuel control rack directed towards the lower part of the main unit of the pump, attach the fuel control rack to the main unit.

NOTE: Make sure the fuel control rack moves smoothly along its entire stroke.

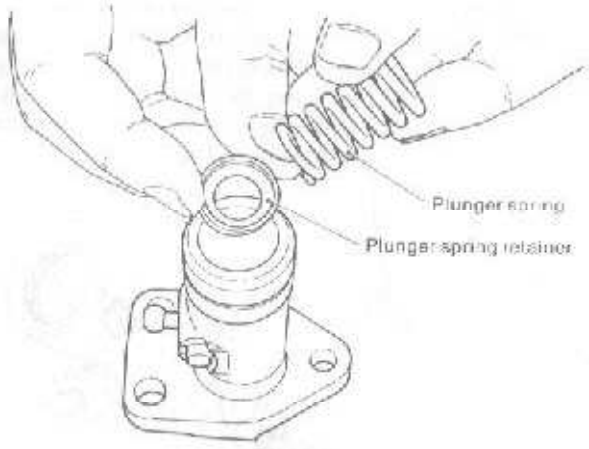
(5) By aligning the matching mark on the fuel control pinion with that on the fuel control rack, attach the fuel control pinion to the main unit.

NOTE: After attaching the fuel control pinion to the main unit, check its meshing by moving the fuel control rack.



Matching marks on the fuel control pinion and fuel control rack

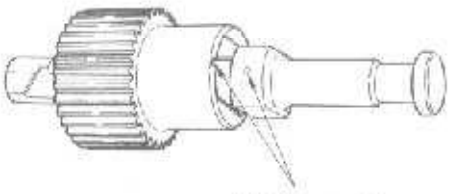
(6) Insert the plunger spring retainer and attach the plunger spring to the main unit.



Attaching the plunger spring to the main unit

NOTE: The plunger spring retainer should face the underside of the pump.

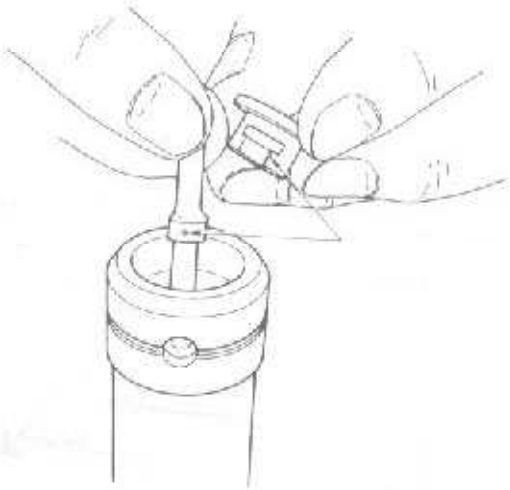
(7) After aligning the matching mark on the plunger flange with that on the fuel control pinion, attach the plunger to the main unit.



Attaching the plunger to the main unit

NOTE: By inverting and standing the main unit of the pump upright attach the plunger to it carefully.

(8) Mount the plunger lower retainer onto the plunger.



Socket for the lower part of the plunger spring

(9) Insert the plunger adjusting shims.

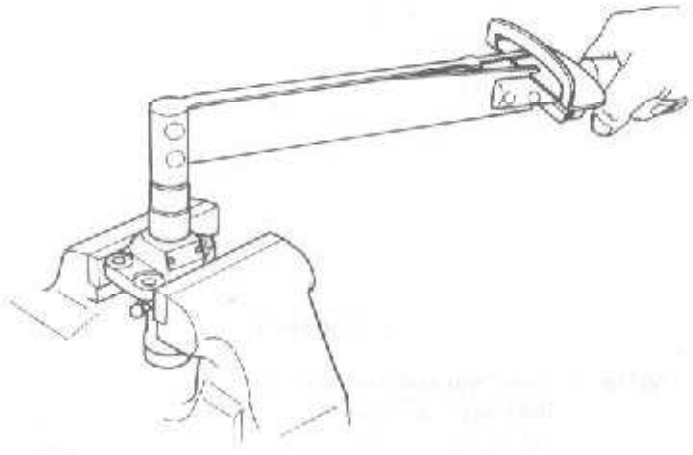
NOTE: 1. Insert the same number of shims with the same thickness as those inserted before disassembling the pump. After re-assembling the pump, measure and adjust the top clearance of the plunger.

(10) While adjusting the direction of the detent (stopper) hole for the plunger guide, insert the plunger guide carefully.
When the detent hole is lined up with the plunger guide, insert the detent. Then mount the retaining ring (clip).

(11) After attaching tighten the delivery valve holder with a torque wrench.

kg-cm (lb-ft)

Tightening torque	550 to 600 (39.77 ~ 43.38)



Tighting the delivery valve holder

2-7 Inspection after reassembly

When the engine doesn't run smoothly and the injection pump is suspected as being the cause, or when the pump has been disassembled and parts replaced, always conduct the following tests.

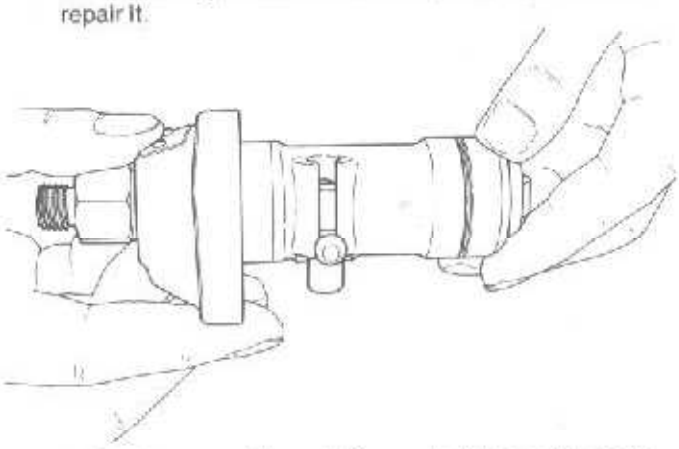
2-7.1 Control rack resistance test

After reassembling the pump, wash it in clean fuel, move the rack and check resistance as follows:

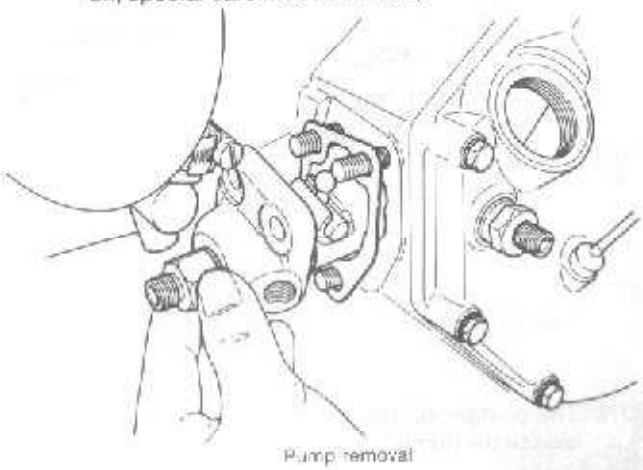
(1) This test is performed to determine the resistance of the control rack. When the resistance is large, the engine will run irregularly or race suddenly.

(2) Place the pump on its side, hold the control rack up and allow it to slide down by its own weight. The rack should slide smoothly over its entire stroke. Place the pump on end and perform the above test again: check for any abnormalities.[Resistance below 60g (0.132 lbs)]

(3) Since a high sliding resistance is probably a result of the following, disassemble the pump and wash or repair it.



(a) Resistance of the rotating and sliding parts of the plunger assembly is too high.
(b) Delivery valve holder is too tight (plunger barrel distorted).
(c) Control rack or control pinion teeth and control rack outside circumference are dirty or damaged.
(d) Injection pump body control rack hole is damaged.
(e) Plunger barrel packing is not installed correctly and the barrel is distorted. (Since in this case fuel will leak into the crankcase and dilute the lubricating oil, special care must be taken).



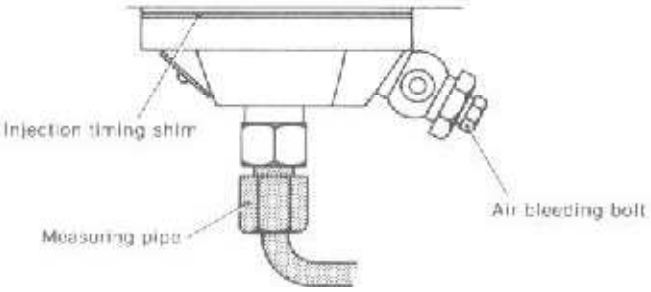
Pump removal

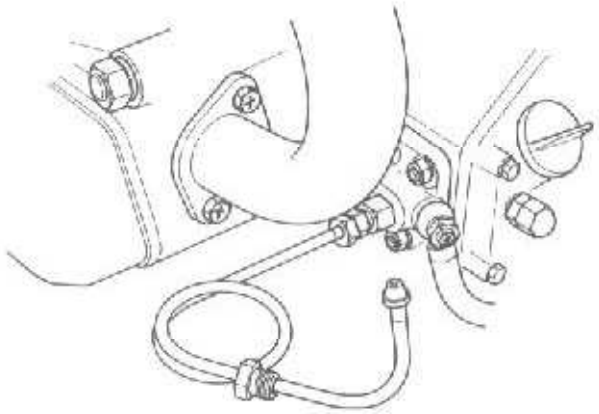
2-7.2 Fuel injection timing

Fuel injection timing is adjusted by timing shims inserted between the pump body and gear case pump mounting seat.

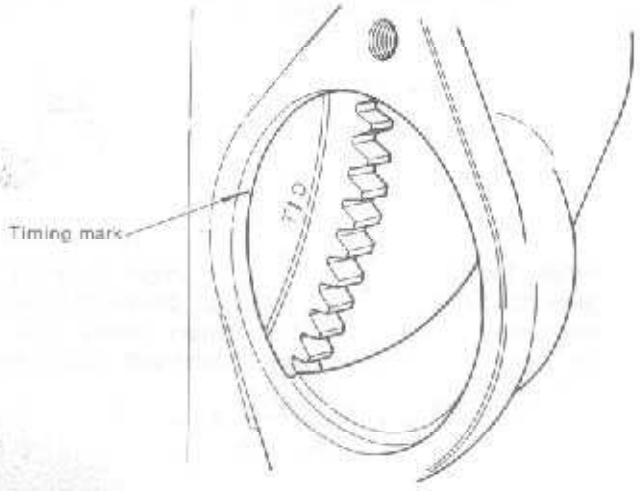
Adjusting the injection timing

(1) Remove the injection pipe from the pump.
(2) Install a measuring pipe.
(3) Bleed the air from the injection pump.





(4) Set the control rack to the middle fuel injection position.
(Pull the lever when setting the accelerator lever.)
(5) Turn the crankshaft slowly by hand, and read the timing mark (TD) on the flywheel the instant fuel appears at the measuring pipe.
(FID – Fuel injection from delivery valve.)



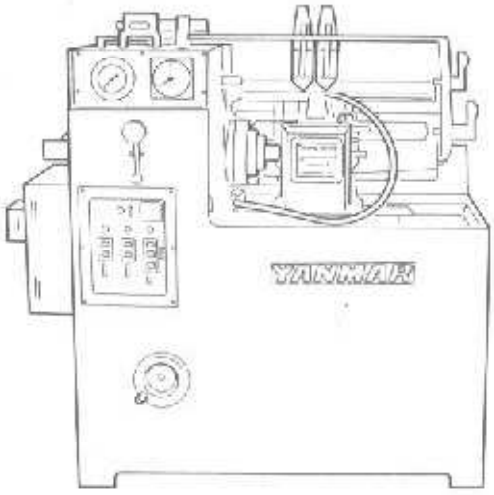
(6) If the injection timing is off, add adjusting shims when the timing is fast, and remove shims when the timing is slow.

Fuel injection timing	b. TDC 25° ±1°
Injection timing shim	Thickness 0.1 mm (0.004 in.), 0.3 mm (0.012 in.) Injection timing change 1° (crankshaft) per 0.1 mm

(8) Finally, turn the crankshaft slowly and confirm that it turns easily. If it is stiff or does not rotate, the plunger head gap is too small.

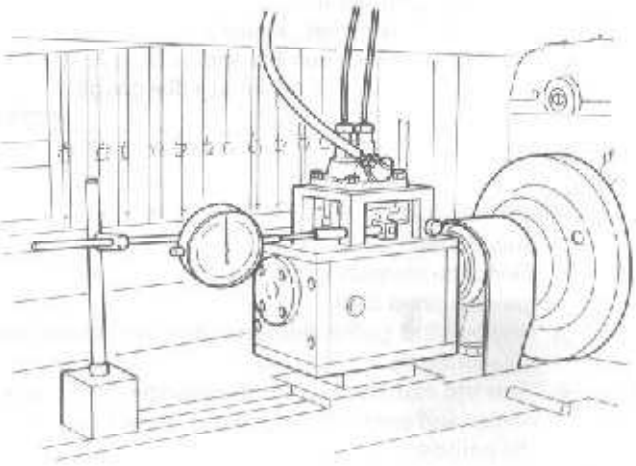
2-8 Injection pump adjustment

The injection pump is adjusted with an injection pump tester after reassembly.



2-8.1 Setting pump on tester

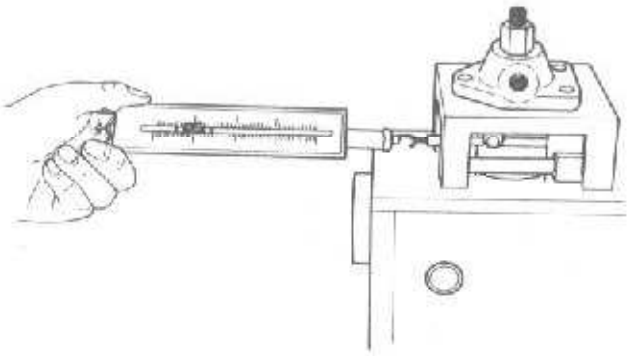
(1) After the injection pump has been disassembled and reassembled, install it on a pump tester (cam lift: 7mm (0.276in.).
(2) Confirm that the control rack slides smoothly. If it does not, inspect the injection pump and repair it so that the rack does slide smoothly.



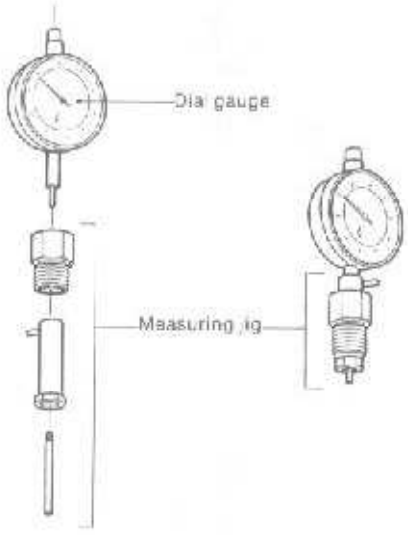
(3) Run the pump tester at low speed, loosen the air bleeder screw, and bleed the air from the injection pump.

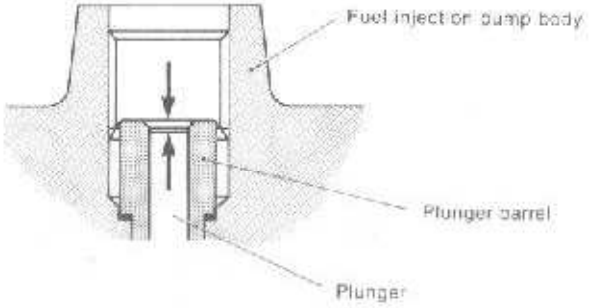
2-8.2
Measuring the sliding resistance of the fuel control rack
Measure the sliding resistance of the fuel control rack with a spring scale (balance).

1. Number of pump rotations/sliding resistance:0rpm/less than 60 g



Measuring the sliding resistance of the fuel control rack





NOTE: If the sliding resistance is unsatisfactory, disassemble, inspect and repair the fuel control rack.

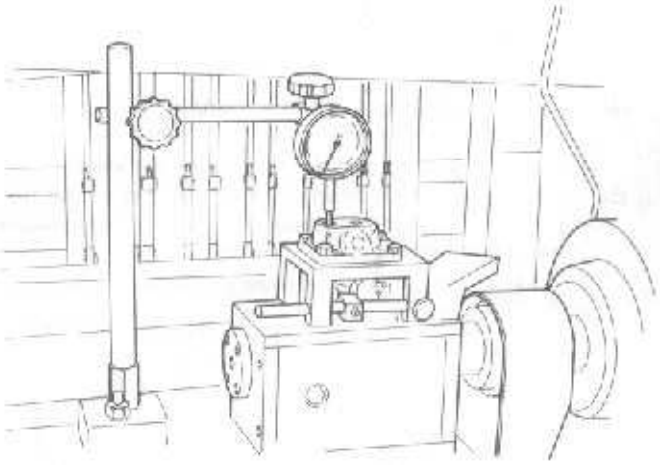
2-8.3 Adjusting the plunger head gap

(1) Set the pump installation dimension (end of plunger barrel when the roller is on the cam base cycle) at 83mm (3.268in.), remove the delivery valve holder and delivery valve, and set the plunger to top dead center by turning the camshaft. Measure the difference in height (head gap) between the end of the plunger and the end of the plunger barrel using a dial gauge.

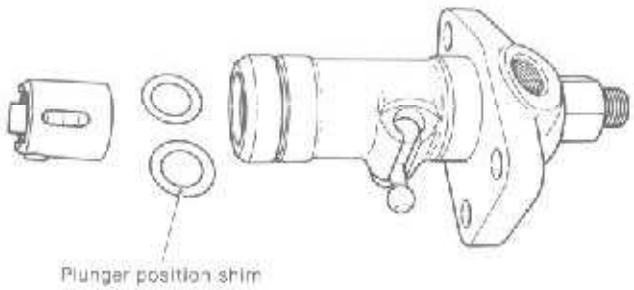
mm (in.)

Plunger head gap	1.15 ~ 1.25 (0.0453 ~ 0.0492)

(2) Using the plunger head gap measuring jig
   1) Install a dial gauge on the measuring jig.
   2) Stand the measuring jig on a stool and set the dial gauge pointer to O.
   3) Remove the pump delivery valve and install the measuring jig.
   4) Turn the camshaft to set the plunger to top dead center and read the dial gauge. The value given is the plunger head gap.

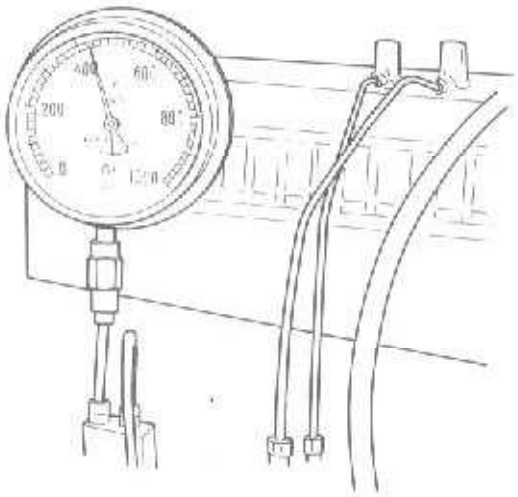


(3) When the plunger head gap is larger than the prescribed value, remove the plunger guide and insert plunger shims between the plunger spring lower retainer and the plunger guide. Adjust both pumps in the same manner.
Plunger shim thickness: 0.1mm (0.004in.),
0.2mm (0.008in.)



(4) After rechecking adjustment, install the delivery valve.
Delivery valve holder tightening torque: 4.0 ~ 4.5kg-m (29. ~ 32.6 lb-ft)

2-8.4 Plunger pressure test



(1) Install a 1,000kg/cm² (14,223 lb/in.²) pressure gauge to the delivery valve holder.

(2) Fix the fuel control rack at the discharge stop position. By developing an engine speed of 200 rpm, shift the control rack. When the built-up pressure exceeds 300 kg/cm² in the vicinity of the matching mark, there should be no sudden pressure drops.

(3) When the pressure has reached 300 kg/cm², set the rack to the discharge reducing position and stop the tester. (4.266 lb/in²)

NOTE: The delivery valve must be of high quality.

Pressure gauge AVT 1/2 × 150 × 1,000 kg/cm²

2-8.5 Testing the delivery valve for oil tightness

(1) Follow procedures similar to those used for the plunger test. When the pressure gauge indication exceeds 120 kg/cm², stop the rotation and set the fuel control rack to the 0 mm position. (1707 lb/in²)

(2) Measure the time required for the pressure gauge indication to drop from 100 kg/cm² to 90 kg/cm² at 10 kg/cm².

Time required at 10 kg/cm² (142.2 lb/in²)	less than 5 sec.

(3) If both the plunger and the delivery valve fail the test, replace them.

2-8. 6 Adjusting the amount of injection

Performance of pump

	YSM8	YSM12
Pump speed	1600 rpm	1500 rpm
Plunger diameter × stroke	ø6 × 7 mm (0.2362 × 0.2756 in.)	ø6 × 7 mm (0.2362 × 0.2756 in.)
Injection nozzle type	YDN-0SDYD1	YDN-0SDYD1
Pressure for fuel injection	160 kg/cm² (2276 lb/in.²)	160 kg/cm² (2276 lb/in.²)
Amount of injection at rack mark position	27 ±0.5 cc	42 ±0.5 cc
Stroke	1000	1000

NOTE: Maintain the pressure for feeding oil to the injection pump at 0.5 kg/cm².

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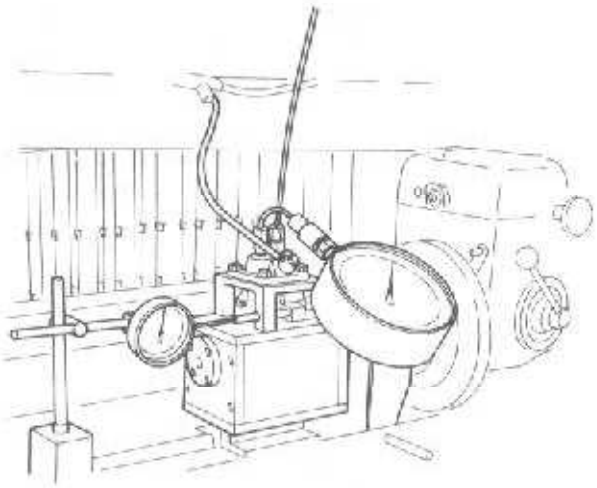
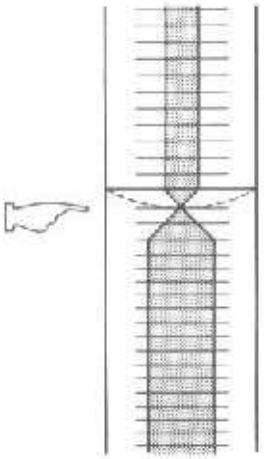


Measuring the fuel injection volme

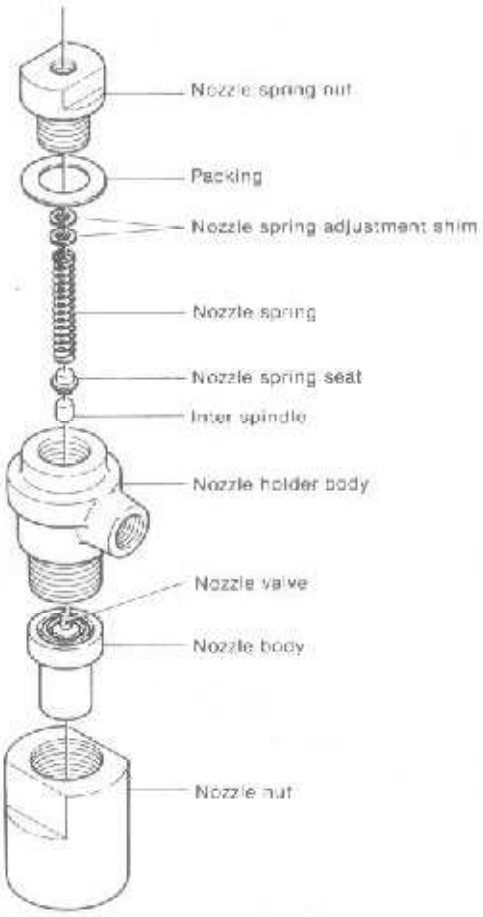


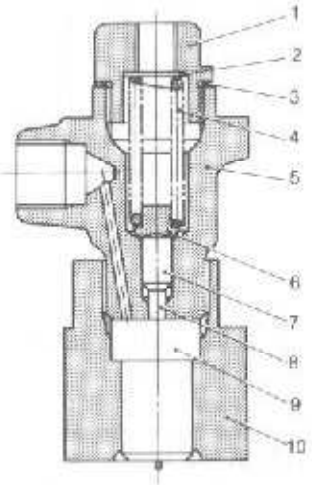
Measuring the degree

3. Injection Nozzle

3-1 Construction

The injection nozzle atomizes the fuel sent from the injection pump and injects it into the precombustion chamber in the prescribed injection pattern to obtain good combustion through optimum fuel/air mixing.
The main parts of the injection nozzle are the nozzle holder and nozzle body. Since both these parts are exposed to hot combustion gas, they must be extremely durable. Moreover, since their operation is extremely sensitive to the pressure of the fuel, high precision is required. Both are made of quality alloy steel that has been specially heat treated and lapped, so they must always be handled as a pair.





1. Nozzle spring nut
2. Nozzle spring adjestment shim
3. Packing
4. Nozzle spring
5. Nozzle holder body
6. Nozzle spring seat
7. Inter spindle
8. Nozzle valve
9. Nozzle body
10. Nozzle nut

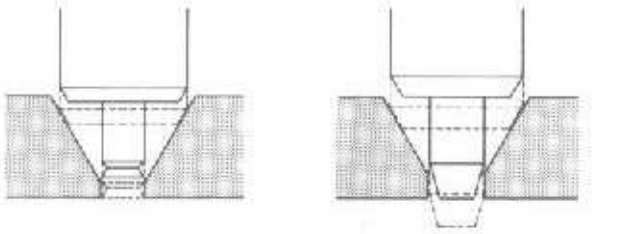
3-2 Specifications for nozzle valve

Model		YDN-OSDYD1
Nozzle	Type of nozzle valve	Throttle
	Valve opening pressure	160 +5 kg/cm² (2205 ~ 2347 lb/in.²)
	Diameter of injection nozzle	ø1 mm (0.0394 in.)
	Angle of injection	5° ~ 10°
Nozzle spring	Free length	30.0 mm (1.1811 in.)
	Mounted length	28.7 mm (1.1299 in.)
	Mounted load	14.14 kg
Nozzle spring adjusting plate (for adjusting nozzle opening pressure)		0.1, 0.2, 0.3, 0.4 mm (4 kinds)

Nozzle valve

3-3 Yanmar throttle nozzle

The semi-throttle nozzles used in this engine are designed and manufactured by Yanmar. A semi-throttle nozzle resembles a pintle nozzle, except that with the former the nozzle hole at the end of nozzle and nozzle body are longer and the end of the nozzle is tapered. This nozzle features a "throttling effect": relatively less fuel is injected into the precombustion chamber at the initial stage of injection, and the volume is increased as the nozzle rises. This type of throttle nozzle ideal for small, high-speed engines.



Pintle nozzle　　Yanmar semi-throttle nozzle

3-4 Nozzle operation

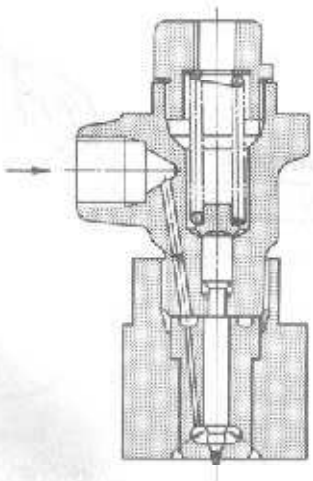
The nozzle is pushed down to its lowest position by the pressure-adjusting nozzle spring and contacts the valve seat of the nozzle body.

Under high pressure, fuel from the fuel pump passes through the hole drilled in the nozzle holder, enters the circular groove at the end of the nozzle body and then enters the pressure chamber at the bottom of the nozzle body.

When the force acting in the axial direction on the differential area of the nozzle at the pressure chamber overcomes the force of the spring, the nozzle is pushed up and the fuel is injected into the precombustion chamber through the throttle hole.

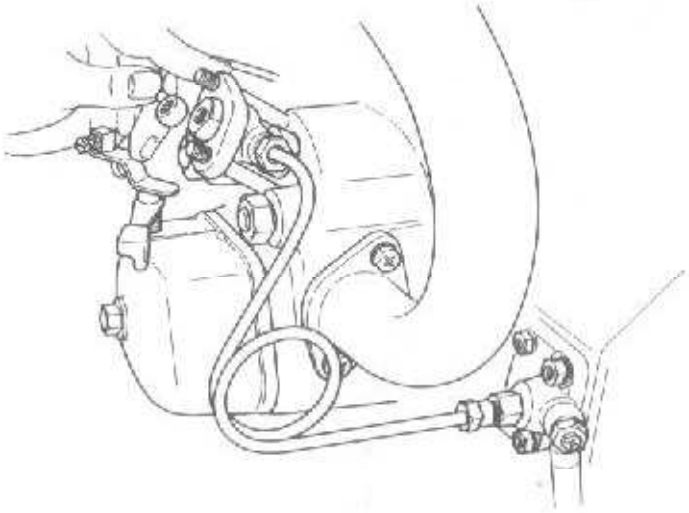
The nozzle is closed again when the pressure in the nozzle body's pressure chamber drops below the force of the spring.

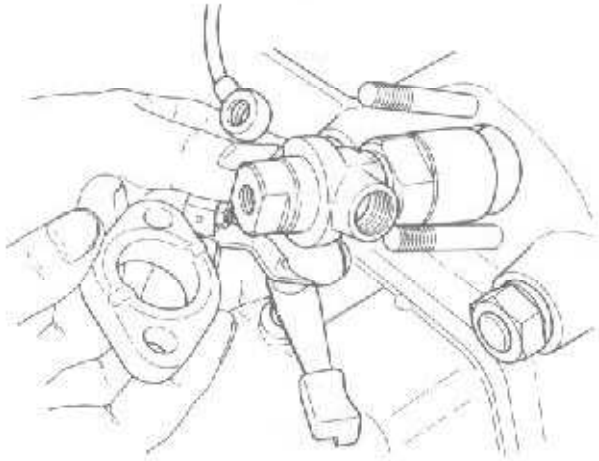
This cycle is repeated at each opening and closing of the injection pump delivery valve.



3-5 Disassembly and reassembly

3-5.1 Disassembly sequence





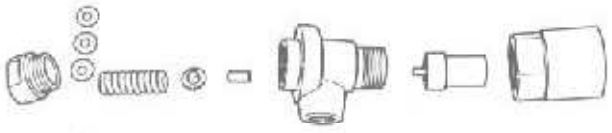
(1) Remove the carbon from the nozzle end.
(2) Loosen the nozzle spring holder.
(3) Remove the nozzle holder body from the nozzle mounting nut.

(4) Remove the nozzle body and nozzle ass'y from the nozzle mounting nut.
(5) Remove the nozzle spring retainer from the nozzle holder body, and remove the nozzle spring retainer, inter-spindle etc.

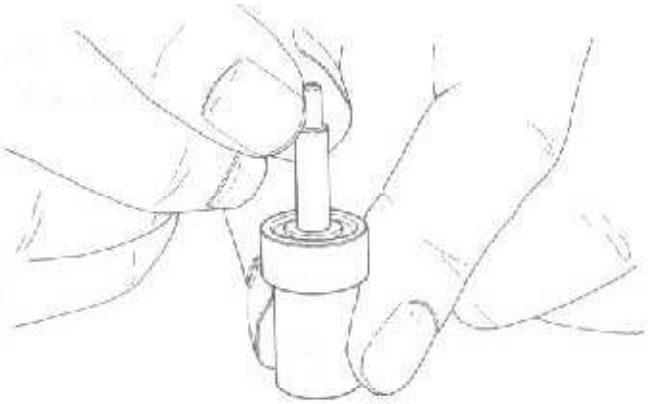
Reassemble in the reverse order of disassembly, paying special attention to the following items.

3-5.2 Disassembly and reassembly precautions

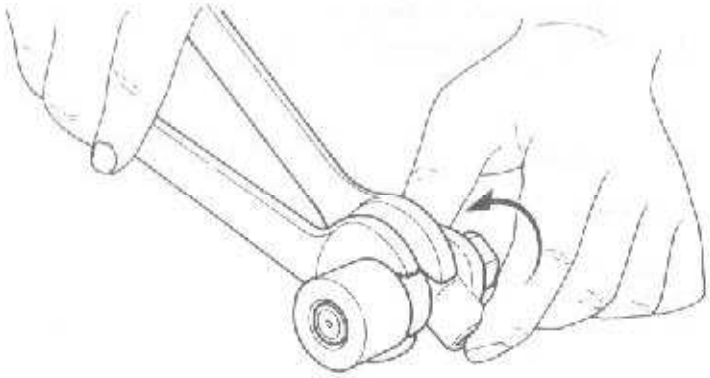
(1) The disassembled parts must be washed in fuel oil, and carbon must be completely removed from the end of the nozzle body, the nozzle body and the nozzle mounting nut fitting section.
If reassembled with any carbon remaining, the nozle will not tighten evenly, causing faulty injection.



(2) Precautions when using a new nozzle.
First immerse the new nozzle in rust-preventive oil, and then seal it on the outside with seal peel. After removing the seal peel, immerse the nozzle in diesel oil and remove the rust-preventive oil from both the inside and outside of the nozzle.
Stand the nozzle holder upright, lift the nozzle about 1/3 of its length; it should drop smoothly by it own weight when released.



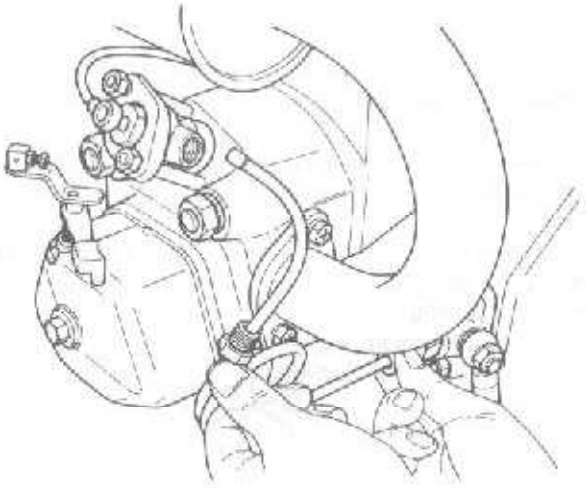
(3) The nozzle must be assembled to the nozzle holder with the nozzle spring retainer loosened.
If the nozzle is installed with the nozzle spring tightened, the nozzle mounting nut will be tightened unevenly and oil will leak from between the end of the nozzle holder body and the end of the nozzle mounting nut, causing faulty injection.

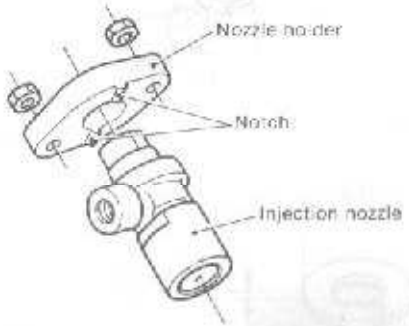


kg-cm (lb-ft)

Nozzle tightening torque	Nozzle nut	1000 (72.36)
	Nozzle spring nut	700 ~ 800 (50.65 ~ 57.89)

(4) When installing the injection nozzle on the cylinder head, tighten the nozzle holder nuts alternately, being careful to tighten them evenly. Tightening torque:
2 kg-m (14.5ft-lb)
Moreover, the nozzle holder must be installed with the notch side on the nozzle side.





3-6.6 Inspecting the nozzle spring

Inspect the nozzle spring for fractured coils, corrosion, and permanent strain, and replace the spring when faulty.

3-6.7 Inspecting the nozzle spring retainer and inter-spindle

Inspect the nozzle spring retainer and inter-spindle for wear and peeling of the contact face, and repair or replace the spring if faulty.

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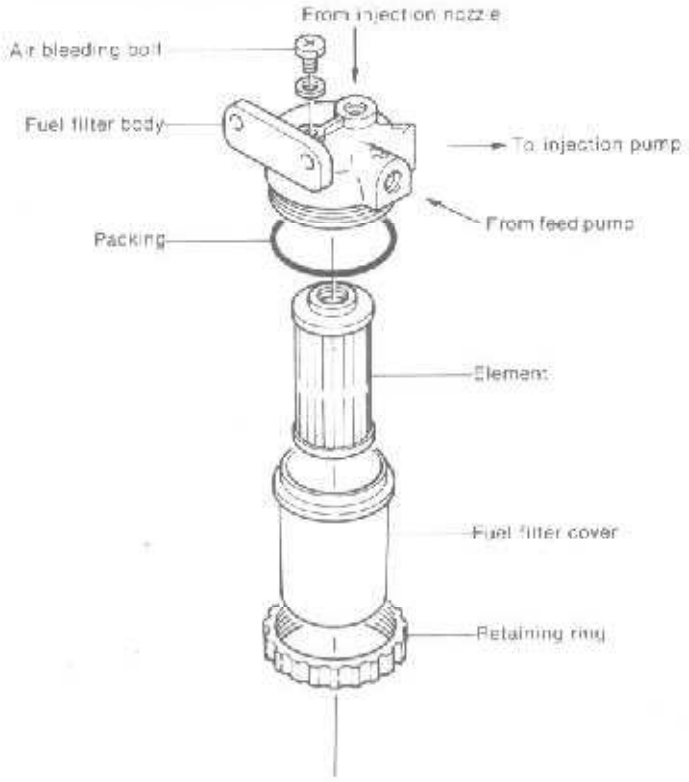
4. Fuel Filter

4-1 Construction

The fuel filter is installed between the feed pump and injection pump, and serves to remove dirt and impurities from the oil fed from the fuel tank through the feed pump.

The fuel filter incorporates a replaceable filter paper element. Fuel from the fuel tank enters the outside of the element and passes through the element under its own pressure. As it passes through, the dirt and impurities in the fuel are filtered out, allowing only clean fuel to enter the interior of the element. The fuel exits from the outlet at the top center of the filter and is sent to the injection pump.

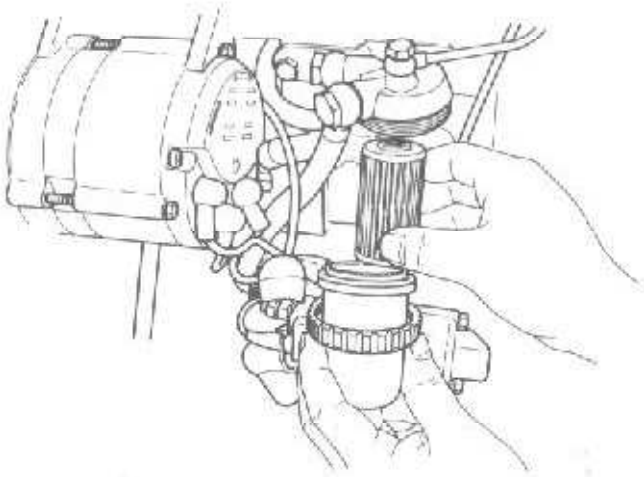
An hexagonal head bolt for air bleeding and a threaded hole for fuel return are provided in the fuel filter body. The surplus fuel at the injection nozzle is returned to the fuel filter and then to the injection pump.



4-2 Inspection

The fuel filter must be periodically inspected. If there is water and sediment in the filter, remove all dirt, rust, etc. by washing the filter with clean fuel.

The normal replacement interval for the element is 100 hours, but the element should be replaced whenever it is dirty or damaged, even if the 100-hour replacement period has not elapsed.



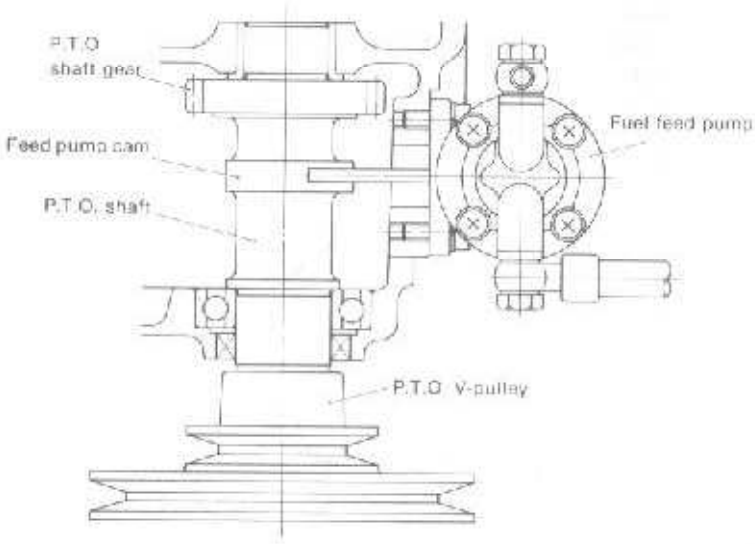
Filter cleaning	Every 50 hours
Filter element replacement	Every 100 hours
Part No.	104800—55710

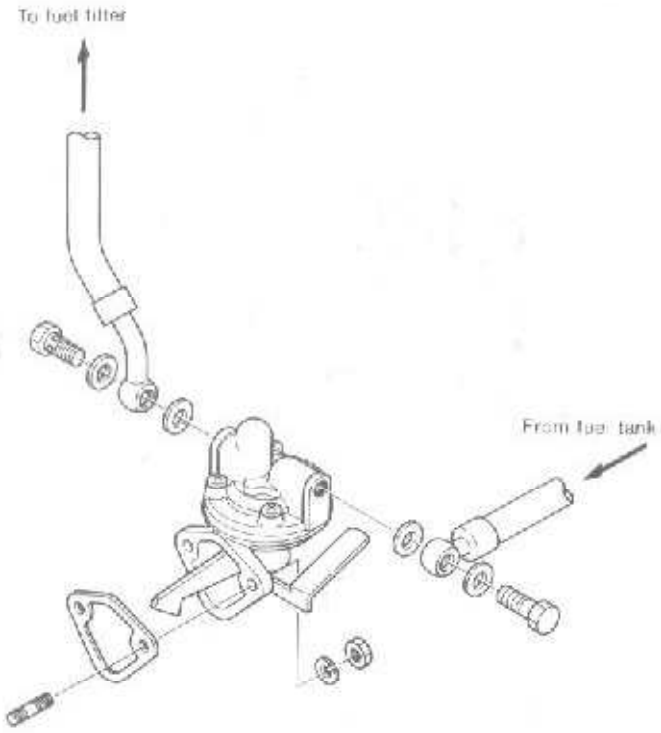
5. Fuel Feed Pump

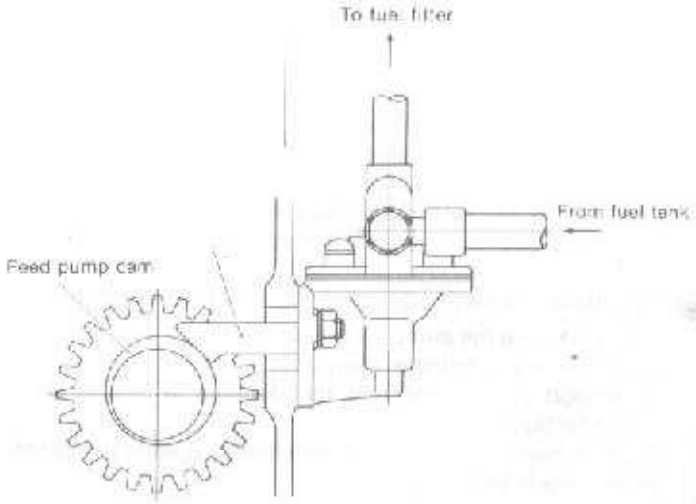
5-1 Construction

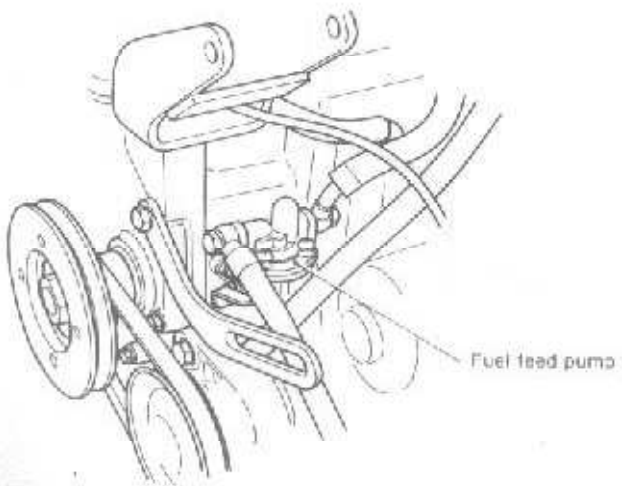
The fuel pump feeds the fuel from the fuel tank to the injection pump through the fuel filter. When the fuel tank is installed at a higher position than the fuel filter and injection pump, the fuel will be fed by its head pressure, but if the fuel tank is lower than the filter and injection pump, a fuel pump is required.

The fuel pump of this engine is a diaphragm type and is installed on the gear case side of the cylinder body. The diaphragm is operated by the movement of a lever by the fuel feed pump cam at the P.T.O. shaft.





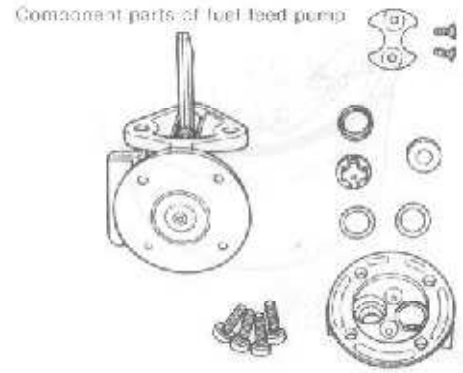




5-2 Disassembly and Reassembly

5-2.1 Disassembly

Clean the outside of the pump, scribe a matching mark on the upper body and lower body of the pump, disassemble and put the components in order.



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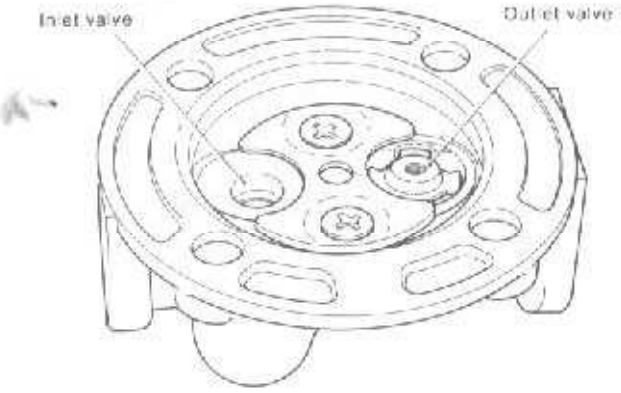
5-2.2 Reassembly

Assemble the pump by reversing the disassembling procedures. Pay close attention to the following:

1. Clean the components, blow compressed air against them, and inspects. Replace any defective components.
2. Replace the packings, etc. with new ones.
3. When mounting the valves, be careful not to mix up the inlet and outlet valves. Also, don't forget the valve packing.



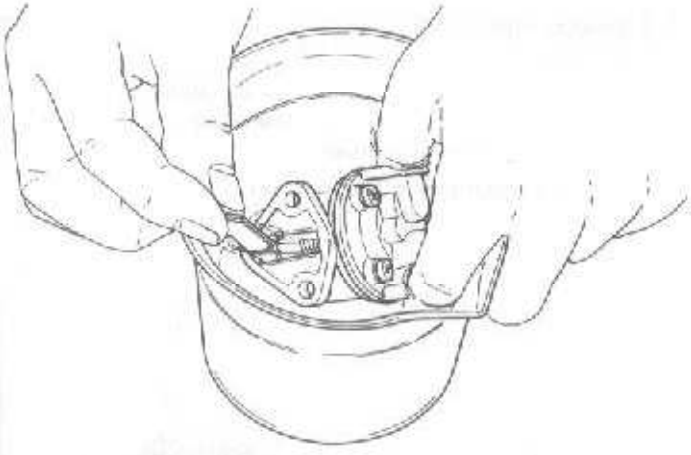
4. Make sure the diaphragm mounting hole is in the correct position and gently attach the diaphragm to the pump body.
5. Line up the matching marks on the pump body, and clamp on the pump body evenly.

5-3 Inspecting and adjusting the fuel feed pump

5-3.1 Checking the pump for fuel oil leaks

After removal, immerse the pump in kerosene, stop its outlet port with a finger and, by operating the rocker arm, check for bubbles.

If any bubbles are present, this indicates a defective point which should be replaced.

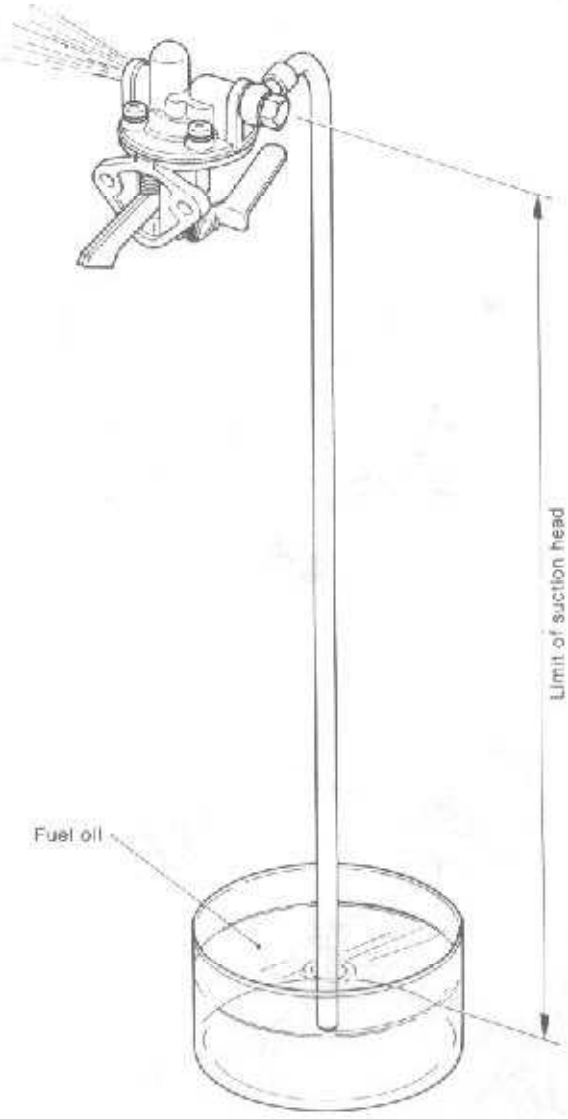


5-3.2 Checking the pump for engine oil leaks

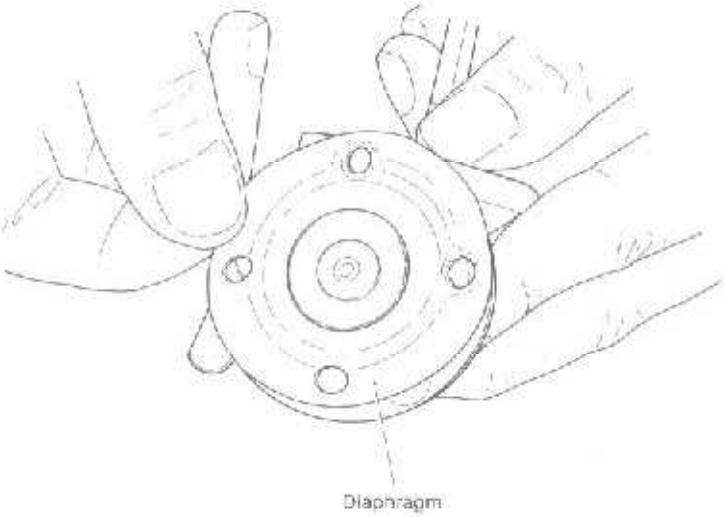
Check pump mounting bolts for looseness and the pump packing for breaks. Retighten any loose bolts and replace defective packing.

5-3.3 Measuring the sucking power

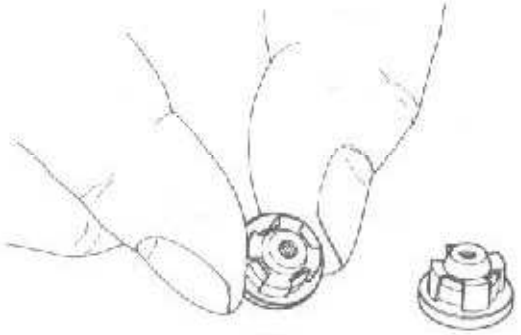
Attach a piece of vinyl hose to the inlet port, keep the pump at a specified height (head) above the fuel oil level, and operate the rocker arm by hand. If the fuel oil spurts out from the outlet port, the pump is all right. A simpler method of testing pump power is as follows: cover the inlet port with a finger and, by operating the rocker arm by hand, estimate the pump's sucking power by judging the suction on the finger. Although this is not an exact method, it can at least confirm that the diaphragm, valves, etc. are operating.



5-3.4 Aging, breakdown and cracking of the diaphragm
Since the diaphragm constantly in motion, the cloth on its flexible parts becomes thin, cracked, and sometimes breaks down after long periods of use. A broken diaphragm causes fuel oil leakage and often fragments of the diaphragm get into the engine oil, either seriously hampering fuel oil discharge or blocking it altogether.



5-3.5 The contact area and mounting condition of valve
Test the valve seat as follows: Remove the valve and blow into the valve seat from the direction in which the valve spring is mounted. If air leaks, replace the seat with a new one. If fuel oil leaks as a result of dust, foreign objects, etc. caught in the valve seat, rinse it and clean it by blowing air into it.



5-3.6 Diaphragm spring and rocker arm spring
Check the diaphragm spring and rocker arm spring for permanent deformation, and the rocker arm and rocker pin for wear. If any of these components are defective, replace them with new ones.

NOTE: When it becomes necessary to replace any of these parts, the entire fuel feed pump assembly should be replaced.

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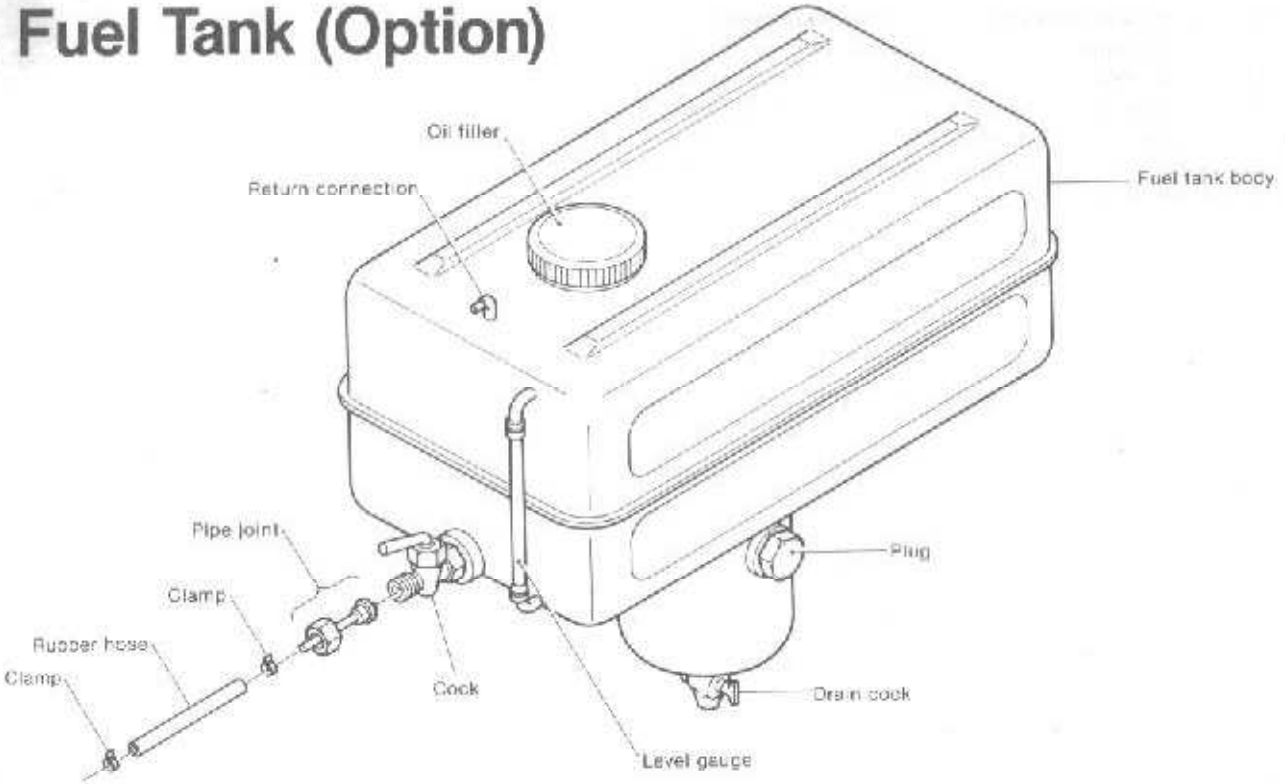
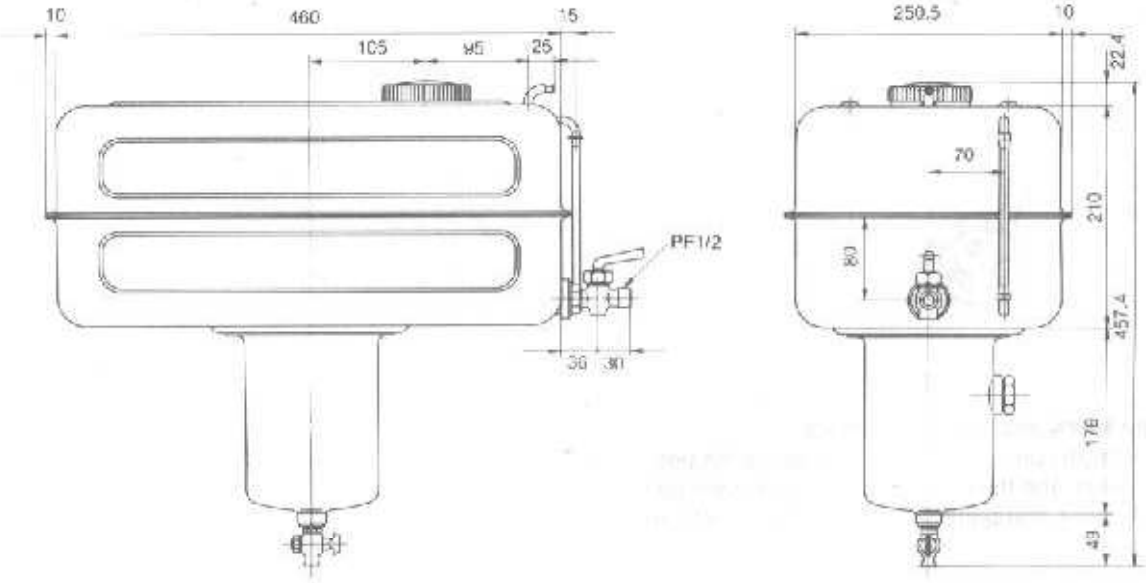
6. Fuel Tank (Option)



Material	Steel plate
Capacity	20ℓ
Thread of outlet cock	PF 1/2
Size of rubber hose	ø7/ø13 × 2000 mm (0.2756/0.5118 × 78.74in.)



Draining the fuel oil tank

In order to keep the injection system from developing repeated troubles, drain the fuel oil tank at intervals of every 100 hours and after servicing the fuel injection valve and fuel injection pump.

When mounting the fuel oil tank, be careful not to mix up its pipe joints and bolts with those of other components, and after attaching the fuel oil tank, test it for oil leakage.

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