Operation Manual

2TL · 3TL

YANMAR
DIESEL ENGINE

2TL·3TL形

OPERATION MANUAL
取扱書

ヤンマーディーゼル株式会社
YANMAR DIESEL ENGINE CO., LTD.

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Instruction Book of YANMAR DIESEL ENGINE Model 2TL, 3TL

This instruction book contains information for the proper installation, operation, and maintenance of Model TL engine. It is suggested that this instruction book be thoroughly read and then kept handy for your reference when necessary. This Yanmar TL engine is the result of proven engineering design, highest quality materials, and expert craftmanship.

Thorough inspection and testing assures you that this engine will give performance as expected.

I. INSTALLATION OF ENGINE

1. Unpacking and inspection

When the cargo is unpacked, please take care not to damage the wooden base on which the engine is mounted and inspect the following points.

① Are not bolts and nuts loose or missing due to long transportation?

② Is not there any rust found on the machine due to rain water during transportation?

③ Is not a part of engine is broken, chipped off or concaved due to transportation?

④ Are all accessories present and in good shape?

II. PRECAUTIONS FOR HANDLING NEW ENGINE

While the engine is still new, various parts are not well fitted, and if the engine is overworked while it is still new, you may shorten the life of machine.

The initial 150 hrs. or so should be regarded as a break-in period and during such period, please abide by the following.

① Within the initial 50 hrs., never compel the engine to be overworked. (Run it below the continuous B.H.P.)

② Replace lubricating oil at 50th hr. In this instance, clean the lubricating oil strainer.

③ Again replace lubricating oil at 150th hr. Hereafter replace it every 250 hrs. Thus you can prolong the life of engine and be most economical in the long run.

④ To replace lubricating oil, first discharge the old oil completely while the engine is still warm, then thoroughly clean the inside of the oil sump with light oil and then feed new lubricating oil.

III. BEFORE OPERATION

1. Feeding of lubricating oil

a) Lubricating Oil

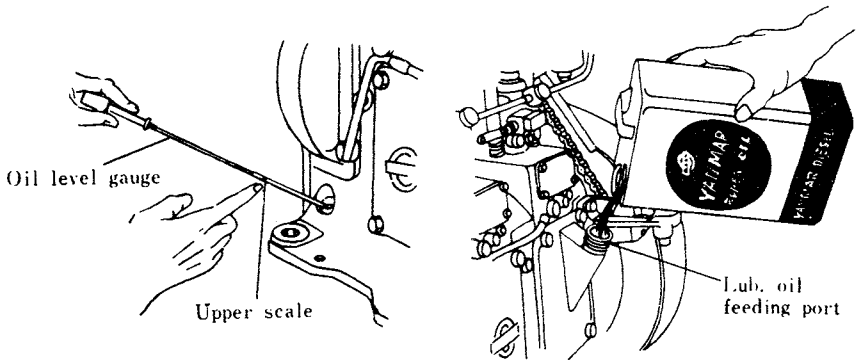
To make the engine easier to start and ensure efficient distribution of the oil and best fuel economy it is essential to select the appropriate viscosity grade, which depends upon the ambient temperature.

For your guidance herebelow is given a table by which the most suitable lube oil can be chosen easily.

Supplier	Brand Name	SAE No.			
		below 10°C	10–20°C	20–35°C	over 35°C
SHELL	Shell Rotella Oil	10W 20/20W	20/20W	30 40	50
	Shell Talona Oil	10W	20	30 40	50
	Shell Rimula Oil	20/20W	20/20W	30 40	
CALTEX	RPM Delo Marine Oil	10W	20	30 40	50
	RPM Delo Multi-Service Oil	20/20W 10W	20	30 40	50
MOBIL	Delvac Special	10W	20	30 40	
	Delvac 20W–40	20W–40	20W–40		
	Delvac 1100 Series	10W 20–20W	20–20W	30 40	50
	Delvac 1200 Series	10W 20–20W	20–20W	30 40	50
ESSO	Estor HD	10W	20	30 40	
	Esso Lube HD		20	30 40	50
	Standard Diesel Oil	10W	20	30 40	50
B. P.	B.P. Energol ICM B.P.Vanellus	20W		30 40	50

B) Feeding of lubricating oil into the crank case

Remove the cover of oil feeding port and fill the lubricating oil up to the upper graduation of oil level gauge. When you measure the oil level by oil level gauge simply insert the rod but do not screw it in. The oil level should not be less than the lower graduation of the gauge. Make it sure that it comes up to the upper graduation. But do not feed it so much that the level comes over the upper graduation.



The amount of oil to be fed into oil sump should be as follows:

Upper graduation of oil level gauge	About 8 ℓ for 2TL
	About 12 ℓ for 3TL

C) Oiling of each part

Feed lubricating oil occasinally to such parts as starting chain, metals of starting free gear and lock pin of fuel injection pump (connecting point with governor lever).

2. Feeding of fuel oil

A) Fuel Oil

To obtain clean cumbustion and satisfactory performance it is essential to use a distillate fuel such as "high speed diesel fuel", "automotive gas oil, "DERV", and "solar oil" etc.

The use of low quality fuel oil may involve this engine in dark exhaust gas, carbon deposits on the exhaust valve and valve seat, and finally damages to the fuel injection pump and valve.

For example the following brands fuel oils are available throughout the world.

Supplier	Brand name
SHELL	Shell diesoline or local equivalent
CALTEX	Caltex diesel oil
MOBIL	Mobil diesel oil
ESSO	Esso diesel oil
B. P.	B.P. diesel oil

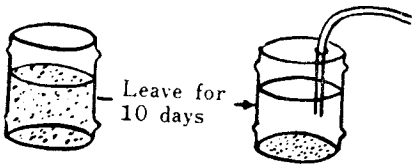
B) Fuel tank

Feed fuel oil into fuel tank.

C) Water or dust in the fuel oil will become the cause of engine trouble.

① Please make sure that it is good quality oil before you use it, because sometimes poor quality oil is sold as if good diesel oil.

② Leave oil drum quietly for long time, so that the water or dust existing in the oil will sedimentate on the bottom. Filter the clear oil with thoroughly washed fine mesh cotton cloth or silk cloth before use. (Never use the sedimentation in the bottom of the drum, as it will cause trouble. Do not shake the drum either.)



D) In order to remove water or dust precipitated at the bottom of fuel tank, please open the drain cock before daily use. The cock will open when you push the knob aside.

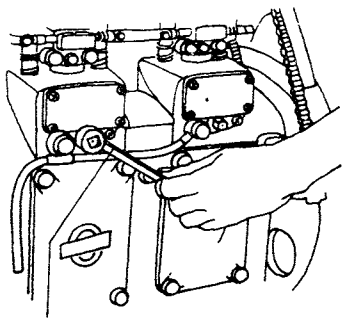
3. Preparation for fuel injection

① When the engine is newly installed, or the fuel pipe is once removed, do priming of **fuel oil pipe, fuel injection pipe, fuel injection pump** and **strainer**

in order to completely vent air in the system. (Refer to the next page for air venting of fuel injection equipment).

② Place regulator handle at the position of "normal use."

③ Utilizing the function of decompression handle, turn flywheel 5~6 times by starting handle or insert priming handle into priming shaft and prime the injection equipment 2~3 times. If you hear the sound of fuel injection, sounding like "bitz"... "bitz"..., then it is in order.



Priming handle

④ When you hear no such fuel injection sound, it means that there exists air in the fuel injection pump or in fuel injection pipe or in other injection system. So vent air before use. The procedure of venting air is given in the section of "Air Venting of Fuel Injection Equipment."

4. Inspection from the outside

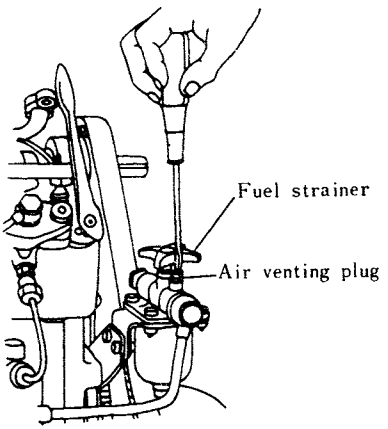
Check if the nuts are not loose or missing. Utilizing the function of decompression handle, turn engine about 10 times with starting handle to check if there is any abnormal sound.

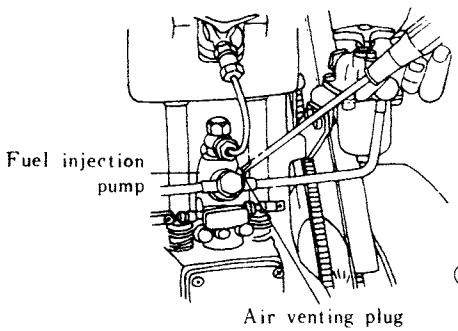
This turning of the engine will supply the oil to all metals so do this without fail. In this case the regulator handle should be in "stop" position. At the start of new engine or restarting it after overhaul or long hours of idleness (more than 2 weeks), turn the engine until lubricating oil fills up the oil cooler (until the indicator of pressure gauge moves).

IV. AIR VENTING OF FUEL INJECTION EQUIPMENT

The fuel injection equipment includes fuel tank, fuel strainer, fuel injection pump, high-pressure fuel injection pipe, and fuel injection valve. If there exists air in this system, the fuel does not inject. Vent air according to the following procedure.

① Open the cock of fuel tank and loosen the air venting plug of fuel strainer. When the fuel free from bubbles come out, tighten the plug securely.





② Loosen the air venting plug of fuel injection pump and when the fuel coming out is completely free from bubbles then tighten the plug securely.

③ Loosen the pipe joint and nipple at both ends of high-pressure fuel injection pipe and place regulator handle at "normal use" position and insert priming handle into priming shaft and do priming for 5~6 times Then the air comes out with fuel oil at the injection pump side. When the oil coming out becomes completely free from bubbles, tighten the pipe joint at injection pump side securely.

④ Do priming for 5—6 times again, then bubbles come out from air venting hole of fuel strainer pipe of fuel injection valve. When the oil coming out becomes completely free from bubbles, tighten the nipple on injection valve side securely.

⑤ When the above procedure is followed for all cylinders, prime the equipment by priming handle, then you hear the fuel injection sound like "bitz"... "bitz"... This means that all the air in the injection equipment is completely vented.

Once you followed this procedure, you do not have to do it again, unless the fuel tank becomes empty or a part of fuel oil system is dismounted.

(Note) The priming of fuel injection pump can not be done if the fuel cam is pushing the pump.

V. STARTING

1. How to start 2TL engine (Starting by hand)

(The following procedure also applies to 3TL engine with the chain starting.)

① Place the regulator handle in "normal use" position.

② Place decompression handle of both cylinders in action and turn the starting handle for 5~6 times vigorously, thus giving inertia to flywheel.

③ Let down the decompression handle and turn it 2~3 times continuously with same intensity. Then the engine will start. You may start up two cylinders at the same time or one cylinder at a time. It is easier to start one cylinder at a time, but in this case start up the second cylinder as soon as possible.

2. Details of electric starting equipment of 3TL engine and method of starting

A) Outline

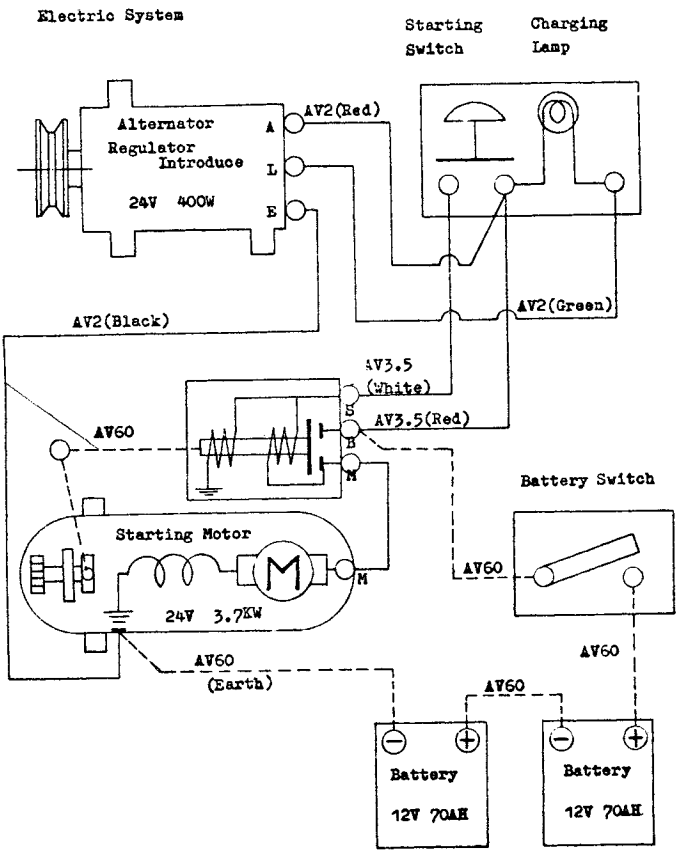
The electric components are composed of starting motor, alternator, battery switch and starting switch. Please observe the instruction manual especially in using battery.

B) Wiring

After the engine is installed, connect the same marks at each terminal according to the wiring diagram. The wiring indicated by solid lines in the diagram have already been completed at the factory. As for the dotted lines in the diagram, do wiring them by using cable in specified diameter. Use the wires insulated with led vinyl chloride for plus side, black one for minus side, blue one for plus side of charge circuit, and white one for magnetic side. When electric components get wet, they may cause troubles. So take particular care against moisture. The grounding should be wired exactly according to the diagram. If it is connected to the installation bolts & etc., it will accelerate electric corrosion inside the engine. Each terminal should be connected by welding, soldering or adhering with pressing so that the wire may not come off. If a part of wire is exposing the inner copper, wrap it insulation tape. After wiring is completed, switch

on the battery switch. Where the red lamp is lighted, it proves that electric circuit is working correctly. Supply lub. oil to the pinion shaft of starting motor once a week.

Note : If the pinion clutch plate get oiled, clutch will slip. So supply lub. oil to only pinion shaft properly.



C) Starting

① Switch in the battery switch and insert key in the starting switch. Put decompression lever into function and push key under non-compression condition and turn the engine for 5~10 sec., in order to send oil to every part.

② Elevate the governor handle to "operation" position. Return the decompression lever to compression position.

③ When you push the starting switch, the engine will start up. When the engine starts, clear your hand off the starting switch immediately.

Remarks

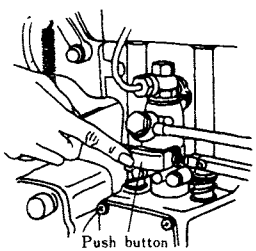
① The running of starting motor should not be over 20 seconds each time. If the engine does not start in the first trial, leave it for about 30 seconds then repeat a starting. You may use the method of accelerating start introduced in the next.

② When you restart the engine, please confirm if the flywheel is still, then push the starting switch.

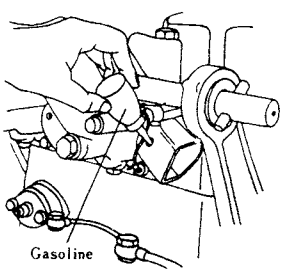
③ When starting is particularly difficult as in the cold season, turn the starting motor under non-compression condition using decompression lever. When the engine acquired sufficient inertia, return the decompression lever. Thus you can start engine easier and can save electric power.

3. Accelerating starting

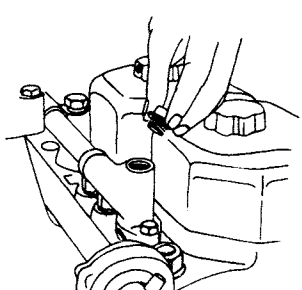
① When starting is difficult, push the point of roulette on starting acceleration and push button of fuel injection pump. Then the control lever draws into full extent. Then start the engine in this status.


Push button

② When starting is difficult as in cold season, feed gasoline into the accelerating start atomizer. When the temperature is high or when the engine is warm, it is not necessary to feed gasoline. **(If you feed too much gasoline, it may cause knocking or compression leak.)**


Gasoline

③ In cold season, when lubricating oil is coagulated or when there are other reasons which make startings harder, such as abrasion of liners or rings, following methods may be helpful. Remove cooling water outlet bend plug at the cylinder head and pour hot

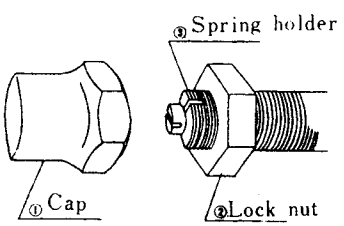

Cooling water outlet bend plug

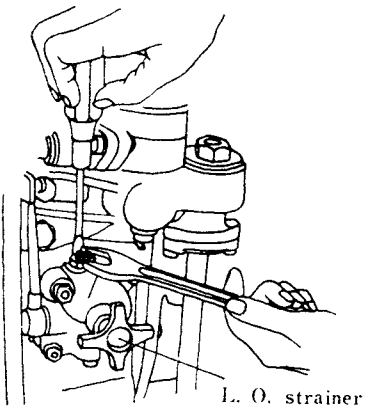
water to warm up cylinder. This will make the starting easier.

4. When the engine is started

① Check the pressure gauge to see if lubricating oil is circulating rightly. The oil pressure may increase even over 4 kg/cm^2 immediately after high speed rotation in winter season or it may go down below 1 kg/cm^2 in non-load operation at low speed. Both of these cases are free from worry but even in non-load operation at low speed it should not be below 0.5 kg/cm^2 and in normal rotation speed it should not be below 2 kg/cm^2. When the oil pressure is 2 kg/cm^2 with warm oil circulation, the engine is in a good condition. The adjustment of oil pressure is done by removing the cap (1) of oil pressure adjusting valve of lubricating oil filter and loosening the lock nut (2) and turning spring holder (3).

When it is turned to the right (screwed in) the oil pressure goes up, and when it is turned to the left (screwed out) it goes down.





② Confirm if the lubricating oil is fed to the valve lever shaft, the valve lever, and the valve guide. Remove the bonnet of cylinder head and see if oiling is applied to the valve lever shaft, the valve lever, and the valve guide.

③ Check if the cooling water is circulating.

④ Check if there is any abnormal noise, water leakage or oil leakage.

VI. DURING OPERATION

① Check if the lubricating oil is circulating satisfactorily by looking into pressure gauge. When the oil pressure is not sufficient, it maybe because the lubricating oil is too old, so it is necessary to replace oil. There is no worry if the oil pressure is low when the engine is run at low speed. When the oil level in crank case is low and air is drawn into oil feeding pump intermediately, the indicator of pressure gauge goes up and down. In such case check the oil level by oil level gauge.

② In full-load operation, outside temperature of each bearing will become about 50–60°C (if you touch these parts by hand, you feel hot). If the temperature is too high, it may be due to the low oil level. So check these points.

③ Check occasionally if the cooling water is circulating all right. When the circulation is spasmodic, stop the engine and check the passage of cooling water or the pump.

④ Check the level gauge of fuel tank and replenish fuel oil before it runs out. When fuel oil level becomes too low, air may mix into the fuel injection equipment and the engine may stop.

⑤ Lubricating oil is fed automatically to the valve lever, suction and exhaust valve guides, and valve lever shaft. So it is not necessary to feed oil to these parts manually. But for safety sake, remove the bonnet and confirm if these parts are oiled well.

⑥ The condition of combustion can be judged by the color of exhaust. If black smoke comes out, it indicates that the engine is overburdened. Do not continue such operation for a long time.

"Always good exhaust" should be the passwords between you and the engine.

⑦ When the fuel does not inject, check if the delivery valve of fuel injection pump is clogged or the fuel injection valve is sticking or not.

⑧ Check if there is any water leaks, gas leaks, etc.

⑨ Inspect if there is any part which is particularly heated.

⑩ **Never take off the battery switch during running engine. In condition of taking off the switch during running engine, the alternator will be troubled. But if charging from outside, take off the battery switch.**

VII. STOPPING

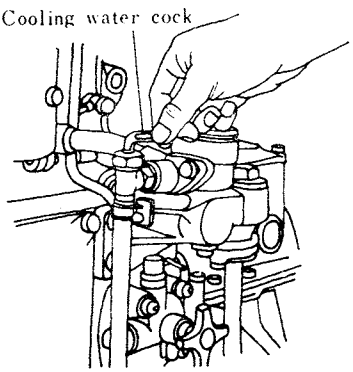
① To stop the engine, after running the engine for sometime without a load, place the reversing gear handle into the neutral position then bring the regulator handle to the "stop" position.

If the engine is stopped by decompressing it completely by the decompression handle, the fuel is injected to the piston head and stay there; thus it is dangerous for the next starting-up. So please do not stop the engine by the decompression handle.

② In winter, the cooling water may freeze, so please drain out the water after stopping. If you leave the engine idle for a long time you better drain out the cooling water completely.

ⓐ As for 2TL engine, first remove the plug on the cooling water pipe between water pump and lubricating oil cooler, then the water in the cylinder is all drained out.

As for 3TL engine, remove the drain plug at the lower part of the cylinder block (water pump side) and also open the drain cock at the lower part of the radiator, then the water in the cylinder and the lubricating oil cooler is drained out completely.



ⓑ Remove the plug at the lower part of cooling water pump, then the water in the pump is drained out completely.

③ While the engine is still warm, wipe off all the dusts and clean the engine.

VIII. DISASSEMBLY, ADJUSTMENT AND ASSEMBLY

1. Precautions for disassembly

To keep the engine in good condition all the time, periodical checking, disassembly, and maintenance should be done. Do not neglect the routine checking and do repairing while a trouble is still minor. There are many examples where frequent checkings of engines discovered abnormalities in early stage and did necessary repairings promptly and thus prevented all the troubles which may have otherwise resulted. Even if you can not check it daily, it is worthwhile for you to develop a habit to check it regularly on specified date even by visual observation as much as you can detect. Besides you must do the disassembly and the maintenance about once a year.

Precautions for disassembly

① Prior to disassembly, study thoroughly the structure and function of each part and their set status so that you should not touch the unnecessary part and waste your time nor damage the parts. Start a disassembly only after you take a record of the structure so that you can assemble it in a right order.

② Prepare a table or board on which you can put the disassembled parts. Wash each part clean and then put them on the table neatly according to the order of disassembly.

③ Use proper tools for disassembly. Do not force it too much. If you do, you may break or damage the parts.

④ The disassembled bolts or nuts should not be put separately but they should be put away in convenient groups. It may seem to be troublesome, but after all it saves your time and prevents loss of parts.

⑤ At a disassembly, check the position of matching marks. The matching marks are given to the following points.

At a big end of connecting rod and the nut for connecting rod bolt; the cam shaft gear and the crank shaft gear; fuel control rings of injection pump and the fuel adjusting lever, fuel control rings of injection pump and the plunger; etc.

When you see it necessary, give matching marks to the required spots by yourself.

⑥ When you discover an abrasion, contact, scratching or other injuries, make a

necessary repairing. You need not have to remove completely a large scratch, but plane it smooth so that it will not stick.

⑦ Those parts where it is difficult to clean, like the outside surface of the engine or the inside of the crank case do a thorough cleaning, availing yourself of the opportunity of disassembly.

2. Precautions for assembly

Assembly should be done in the reversed order of disassembly. In this instance feed oil to all necessary points.

Precautions for assembly

① Clean and wash the parts and match the marks or knocks, so that the center will not be out of position.

② Do not tighten bolts or nuts unbalancely.

③ Discard old split pins, packings, and bend washers, and use new ones.

④ Use a split pin which is not too loose but fits well into the hole. After it is fixed, be sure to split its end. Also securely bend a bend washer.

⑤ Smear clean lubricating oil to gliding parts, like piston or bearing or the inserted parts. Do not use a used rug, etc., to smear the oil.

⑥ Please give special cares to matching marks of big end of the connecting rod and the rod bolt nut; an adjustment of governor and fuel injection equipment; and adjustments of fuel injection time, valve clearance (valve setting), top clearance, etc.

⑦ Please set the big end of connecting rod and each gear in such way that the marks on these parts are matching.

⑧ When assembly is over, turn the flywheel to check if there is any knocking or abrasion.

⑨ Before starting engine, check if there is any leakage at cooling water pipe and lubricating oil pipe.

When assembly is over, reconfirm if there is any abnormality. If there is not, feed fuel and lubricating oil and do a test run. When you have replaced the cylinder liner or the piston, etc., at least 3 hrs. of low-load run is necessary for lapping of replaced parts. Check if there is any abnormality during a lapping and test run and if there is any, please correct it immediately.

As to its method of operation, please refer to the section entitled "During Operation."

IX. PERIODICAL CHECKINGS

A periodical checking is necessary to keep the engine always in good conditions. The frequency of periodical checking may vary depending upon the purpose of using engine, condition of use, fuel oil to be used, quality of lubricating oil and method of handling of engine. It is, therefore, difficult to generalize it.

Item	Contents	Daily	Every 50 hrs.	Every 250 hrs.	Every 500 hrs.	Every 1000 hrs.
Fuel oil	Checking and feeding	○	(before feeding)			
	Fuel tank draining	○				
	Fuel strainer draining		○			
	Fuel strainer cleaning			○		
Lubricating oil	Checking oil level in crank case	○				
	Lubricating oil strainer draining		○			
	Lubricating oil strainer cleaning			○		
	Replacement of crank case lubricating oil			○		
Cooling water	Checking of packing gland	○				
	Condition of cooling water circulation	○				
Fuel injection pump	Oiling of adjusting lever	○				
	Priming of fuel injection	○				
	Confirmation of fuel injection time			○		
Fuel injection valve	Cleaning of strainer			○		
	Cleaning of needle valve				○	
Cylinder head	Adjustment of clearance of suction & exhaust valves			○		
	Retightening			○		
	Cleaning of combustion chamber faces				○	
	Cleaning of pre-combustion chamber				○	
	Lapping of suction & exhust valves				○	
	Checking of valve lever and valve guide				○	
Piston	Disassembly & checking of rings					○
Anti-corrosive zinc					○	

1. Daily

1) Checking and replenishment of fuel oil

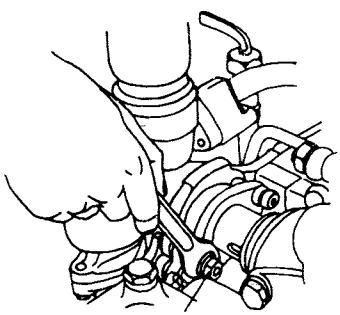
(a) Open the drain cock of fuel tank and remove water or dregs sedimented at the bottom of the tank.

(b) Check the oil level of fuel tank and if it is too low replenish oil.

2) Checking and replenishment of lubricating oil

Check the oil level of crank case and replenish lubricating oil up to the upper graduation of oil level gauge.

3) Check the tightness of packing gland of cooling water pump and if necessary re-tighten it.



Lock nut for cooling water pump packing gland

4) Turn the handle of fuel strainer and strainer at the lubricating oil outlet right or left to remove dust sticking to the strainer plates.

5) Oiling to each part

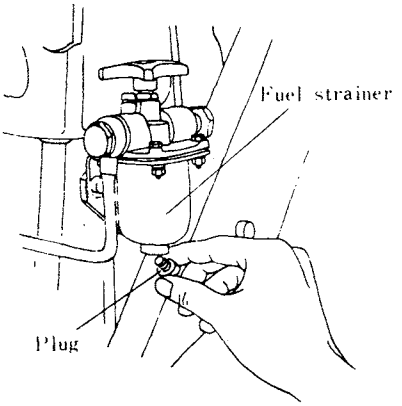
Remove the cover of valve lever chamber and confirm if sufficient oil is sent to the valve lever and the valve guide. Give lubricating oil to the starting chain, the metal of starting release gear, the fuel injection pump control rack and ring.

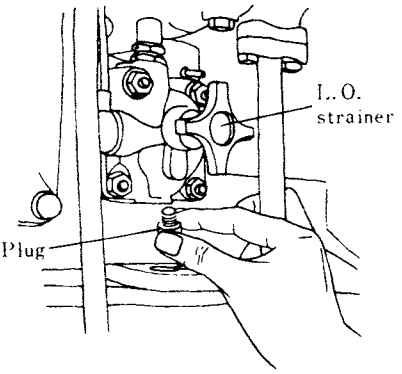
6) By priming inspect the fuel injection condition.

7) Once a day, turn the handle of fuel oil strainer and the lubricating oil outlet strainer several times right and left to scrape off the dusts sticking to the strainers.

2. Every 50 hrs.

1) Loosen the drain plug of fuel strainer and lubricating oil strainer to remove water and dusts accumulated in the strainers.





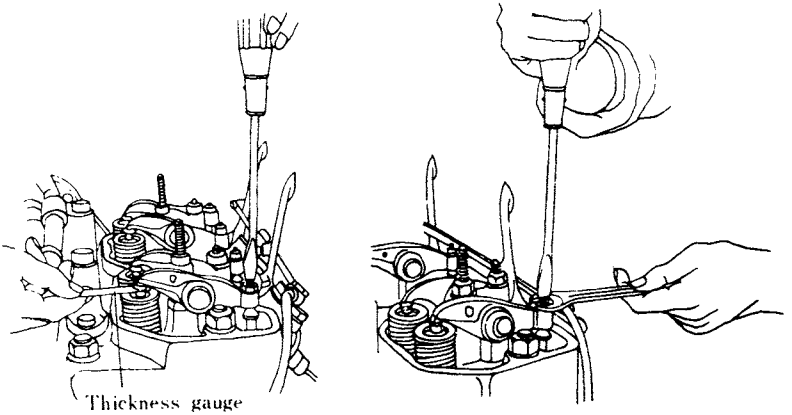
3. Every 250 hrs.

1) Inspect the clearance of suction valve and exhaust valve

A valve clearance should be so adjusted that when the engine is cool and the suction and exhaust valves are completely closed (Top Dead Center), there should be a clearance of 0.2 mm in between the valve lever and the valve head. Do the adjustment with a thickness gauge attached to each cylinder.

ⓐ Loosen lock nuts and turn valve clearance adjusting screws and do an adjustment of suction valve and exhaust valve by a thickness gauge.

ⓑ When the adjustment is made, fix adjusting screws by lock nuts.

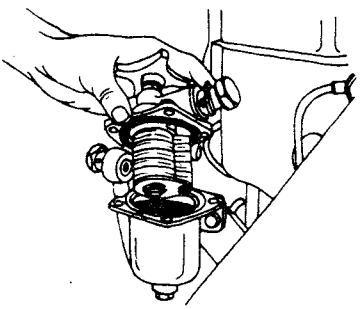


2) Check important bolts and nuts and do re-tightening, if necessary.

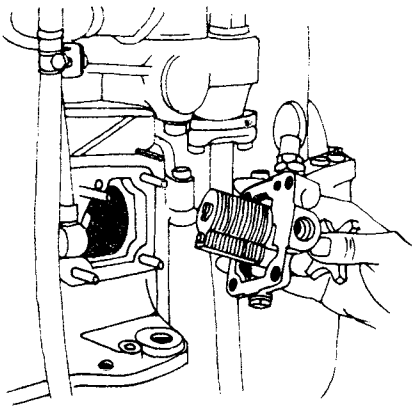
Especially like cylinder head, where many nuts are used together, you

should tighten two nuts at a time in the opposite direction together, so that the tightening will not be unbalanced.

3) **Remove the fuel strainer and the lubricating oil strainer, and then remove dusts sticking to the strainer plates and clean insides.**



Fuel strainer



L.O. strainer

4) **Remove the fuel strainer of fuel injection valve and wash the fuel strainer clean with light oil.**
(cf. disassembly of fuel injection valve)

5) **Drain out all lubricating oil in crank case and wash the inside of crank case with light oil and feed fresh lubricating oil.**

6) **Checking and adjustment of fuel injection time.**

4. Every 500 hrs.

1) **Remove the cylinder head and wipe off carbon sticking to the wall of combustion chamber faces with light oil, using a care not to damage valve or valve seat.**

2) **Dismount pre-combustion chamber and clean the its inside and the injection nozzle.**

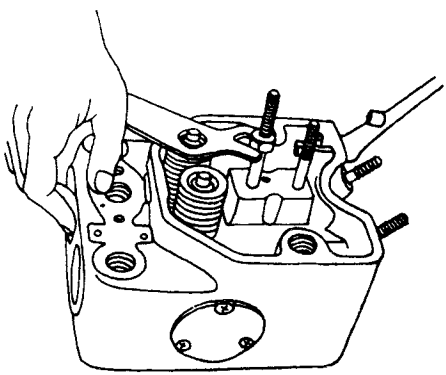
It is not necessary to disassemble the pre-combustion chamber often,

but when you run the engine for long time under undesirable combustion condition, it may deposit carbon inside the pre-combustion chamber. So in such case dismount the pre-combustion chamber from the cylinder head as follow. First dismount the fuel injection valve from the cylinder head then take out pre-combustion chamber and clean it. In case when pre-combustion chamber does not come off due to sticking of carbon, you can stuff fabrics in the chamber and turn the flywheel lightly then the chamber comes off easily. In this case the chamber may jump out suddenly, so please be careful. Clean inside the injection nozzle. Also inspect the copper packing to see if it is not damaged or scared. If it is, replace it with new one, because an inferior packing may become a cause of compression loss.

3) **Disassemble the fuel injection valve and remove the nozzle and the needle valve and wash them clean.**
(cf. separate section)

4) **Do lapping of suction and exhaust valves.**

Scrape off the carbon sticking to the valve or cylinder head clean and do lapping by the following procedure.



ⓐ To remove the valve, hold the spring in such way as shown in the figure on the right, by using a spring mounting and dismounting tool and take out a spring holder ston metal.

ⓑ Grind off the irregularity of the contact surface, by using rough lapping powders. Then do lapping of the surface with the lapping powder and lastly with lubricating oil so that the contact of the seat surface is even at every point.

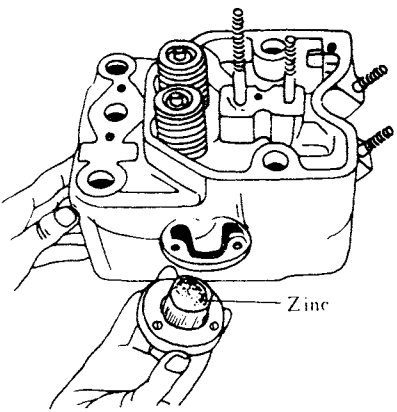
ⓒ Lapping should be done by turning the valve little by little by tapping the valve lightly, rather than turning the valve around.

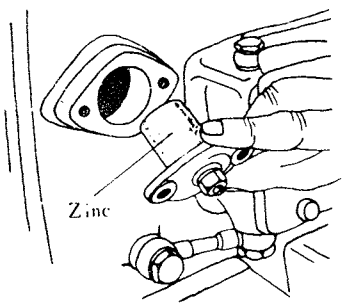
ⓓ After a lapping, smear the valve seat with a blue paint or a chalk and insert the valve and wriggle it 2 to 3 times up and down, to find out the contact point. If the contact is at the complete circumference and such contact is uninterrupted, the lapping is done satisfactory.

ⓔ Before you assemble the valve, wash it clean so that no lapping powder is left over. Then feed fresh oil to friction parts and seat surfaces. The head size of the suction valve and exhaust valve is different. So do not misplace each other at assembly.

5) Inspect the anti-corrosion zinc

The anti-corrosion zinc is used for a prevention of electric corrosion of cylinder. It is attached to the cylinder head and the exhaust pipe side of cylinder. Inspect the zinc plate and replace it when the corrosion is significant.





5. Every 1,000 hrs.

1) Disassemble the piston and check the piston ring

(cf. "detail disassembly of the piston")

ⓐ The cylinder liner of this engine is **chromium-plated. So never use a chromium-plated ring.**

A piston ring should be replaced if its gliding surface is not shiny around all circumference, and there is vertical scar or gas leaks or the clearance between upper and lower surface is more than 0.2 mm.

X. DISMOUNTING AND MOUNTING OF CYLINDER HEAD

A dismounting of cylinder head should be done according to the following procedure.

Drain the cooling water completely and remove the cooling water outlet main pipe and then dismount the chain cover, the chain starting shaft support, the bonnet, and the fuel injection pipe.

It is easier to remove the valve lever shaft support, the fuel injection valve, and the pre-combustion chamber, prior to the removal of cylinder head from the cylinder.

Remove the valve lever axle oiling pipe and the pipe joint.
Loosen the set nuts of cylinder head little by little evenly for all nuts.

At the removal of cylinder head, be sure to leave push rod cover at the cylinder side.

Be careful not to loose the rubber packing (O-ring).

At the assembly of cylinder head, tighten the set nuts little by little evenly for all nuts, tightening two nuts at a time in opposite direction and lastly use a spanner and tighten them with full force by two hands. (Tightening torque of 15 mkg).

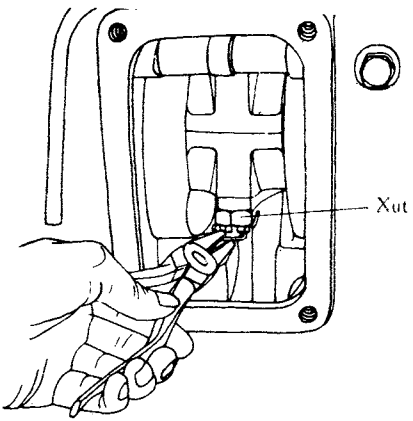
The rubber packing of cooling water connecting pipe located between the cylinder and the cylinder head should all be replaced with new ones.

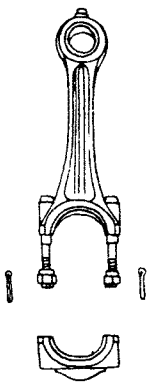
The top clearance is between 0.8 mm and 1.0 mm. When you replace a copper packing of the head, the top clearance may become different. So be careful.

XI. DISASSEMBLY AND ASSEMBLY OF PISTON AND CONNECTING ROD

① Remove the cover on the cylinder side and draw out a split pin of set nut of rod bolt.

② Remove a set nut of rod bolt, paying an attention not to slip the spanner Then take out the lower part of connecting rod and rod bolt.





③ Draw out the piston and the connecting rod upwards.

④ Do a temporary assembling of connecting rod and bolt immediately, so that they will not be misassembled.

⑤ A crank pin bearing (rod metal) has a forged steel back metal in which kelmet metal is thinly cast and its upper surface is plated with a lead alloy so that the initial acclimatization will be facilitated. During the use, the lead alloy plating on the surface will be abrased off and a copper-colored kelmet metal will appear. But you can use it as it is. This bearing can not be adjusted by the shim nor lapped.

Precautions for assembly of piston and connecting rod

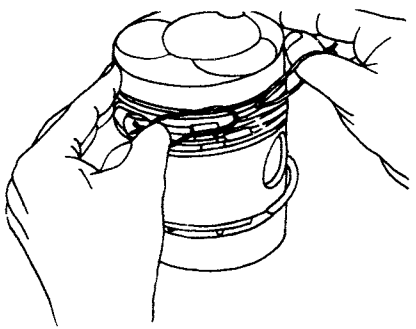
① At assembly of connecting rod to the crank shaft, be sure to fix it in the original direction and to the original cylinder. It is better to use the same bolts and nuts to each cylinder.

② Lightly tighten rod bolts and nuts by a spanner and turn the crank shaft 4 or 5 times and when it is confirmed that the crank shaft turns lightly, then re-tighten the bolts and nuts 2 to 3 times one after the other. When the original parts are placed in original position, you can tighten them until the matching marks of nut and that of connecting rod meet together and match the groove for split pin of nut and the hole on the bolt. Insert a split pin. The tip of pin should be split and bent securely. Split pin should be replaced each time but use the one of same thickness.

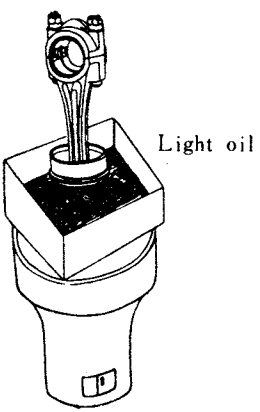
(Note) Be careful not to scratch the rod bolt. The bolt having even a slightest scar or flaw should be replaced. The one which has been use 4~5000 hrs. should be replaced with new one even when there is no flaw. We recommend you to replace it together with a new nut.

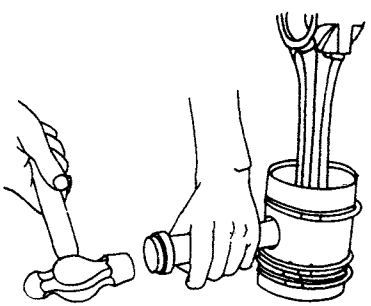
XII. DISASSEMBLY AND ASSEMBLY OF PISTON

① To assemble or disassemble the piston ring, hook a wire to the section shown in the figure and remove it or insert. (If you remove forcibly, you may break the ring.)



② When piston is at normal temperature, there is certain allowance between the piston pin and the hole. Therefore, to remove the piston pin from the piston, remove a stop ring at both ends (wipe off the edge of pin hole clean) and dip the piston in about 80°C light oil for about 10 min. to warm it up, then place a piece of wood to piston and tap it lightly. Then the pin comes off easily.





③ At an assembly of piston, warm it up a little bit as in a case of disassembly.

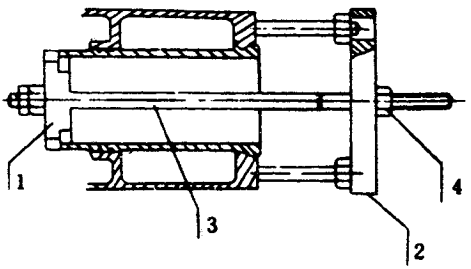
XIII. REPLACEMENT OF CYLINDER LINER

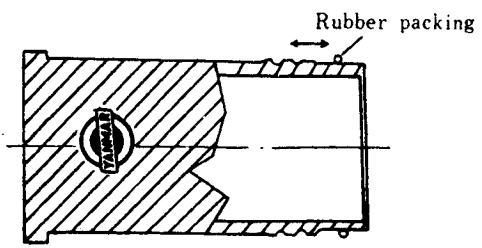
1) Removing-out

At a replacement of cylinder liner, place the round plate (1) of liner removing tool at the lower part of liner, insert the metal (2) over the nut which is screwed over the cylinder head set bolt, connect the round plate (1) and a metal (2) by a bolt (3), and tighten the upper nut (4) little by little.

2) Insertion

To mount a new liner, clean all the dusts and paint at the contact surface inside the cylinder and outside the liner and using a care not to twist it, insert a new rubber packing into the liner groove (cf. the figure at lower right). Then paint it and slowly insert the liner and tap it lightly with a wood hammer.





The rubber packing should be inserted at the position shown in the figure and then roll it several times to the direction shown by the arrow and then fix it into the groove. It should not be fixed in a twisted condition.

3) Check if there is no distortion of the inside diameter, using a cylinder gauge. If such distortion is less than 0.02 mm,iit is all right.

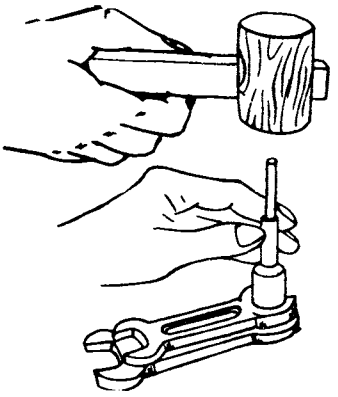
4) Insert the cylinder head and tighten 4 nuts interchangeably, then the liner is completely fixed.

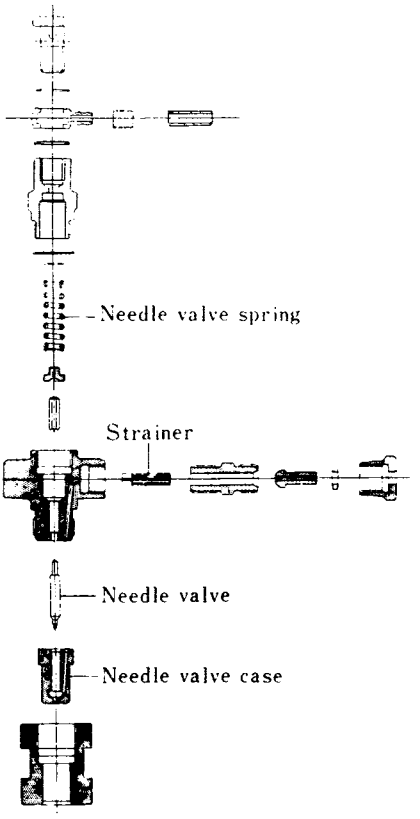
Note:

For replacements of piston or liner, please consult you Yanmar dealer.

XIV. DISASSEMBLY AND ASSEMBLY OF FUEL INJECTION VALVE

To remove the fuel strainer from the fuel strainer pipe, use the small end of attached removing tool. The big end of this removing tool is used for removing the nozzle from the fuel injection valve nut.





Note:

Before dismounting the fuel injection valve from the cylinder head, loosen the spring holder of fuel injection valve. (But do not remove the spring holder completely).

When you dismounted the spring holder of fuel injection valve, you can see the injection pressure adjusting plates inside. Don't misplace them. The injection pressure of this machine is 160 kg/cm^2.

The needle valve and nozzle are very precisely machined. Please handle them carefully so that absolutely no dust should be allowed to the inside.

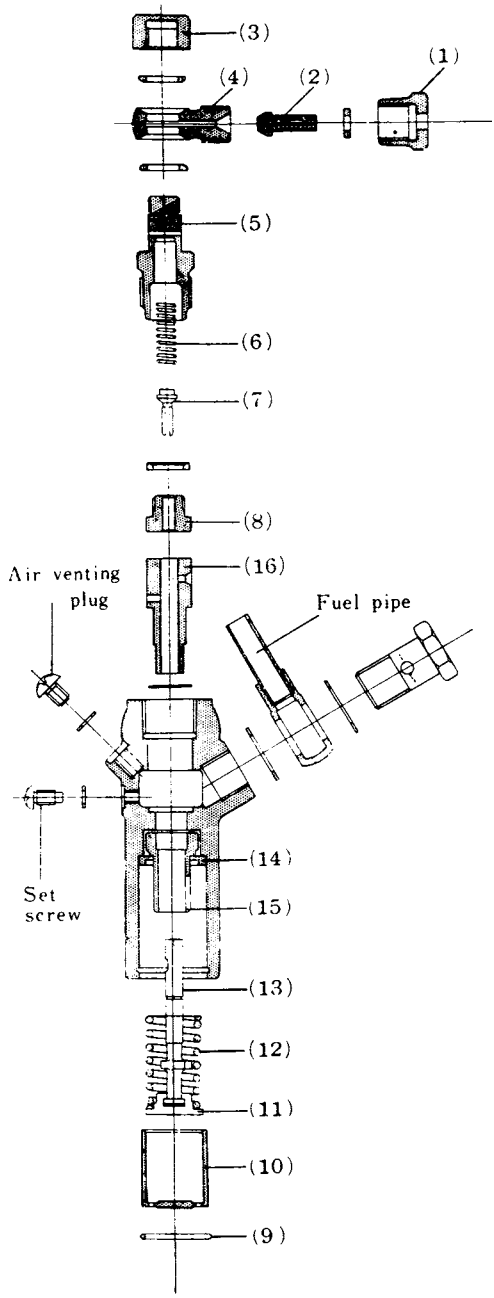
XV. DISASSEMBLY & ASSEMBLY OF FUEL INJECTION PUMP

The disassembly of fuel injection pump is done according to the following procedure.

① Remove the spring holder (5) of delivery valve and take out the delivery valve spring (6) and the delivery valve (7).

② To remove the delivery valve guide (8) (delivery valve seat), use collar of attached removing tool and place it on the upper surface of pump body and screw in the removing bolt with a nut into the screwing part of the delivery valve guide, by using a screwdriver. Then tighten the nut gradually. The valve guide will come out together with a washer.

③ Dismount the plunger guide stop metal (9); and the plunger guide (10), the plunger (11), the plunger spring (12), and the plunger (13) will all come down easily.



The plunger (13) of fuel injection pump and the plunger barrel (16) are very precisely machined, so please handle them carefully.
When you replace the plunger, replace it with a plunger barrel.

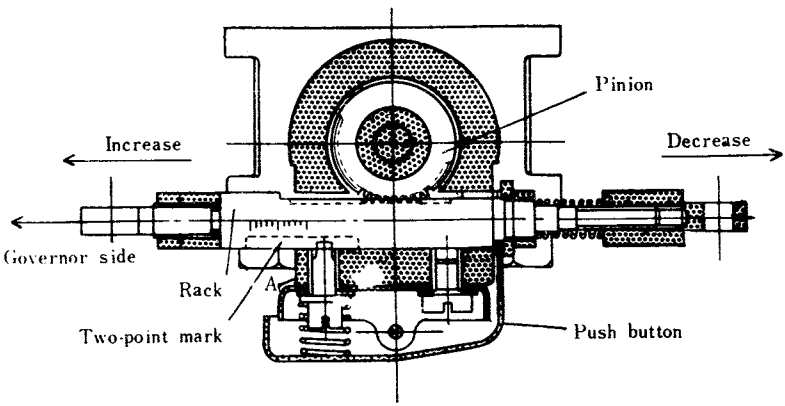
④ Assembly is done in the opposite order of disassembly. But do not mistake matching marks.
Match the marks of rack and pinion and the marks of pinion and plunger.

XVI. ADJUSTMENT OF FUEL INJECTION VOLUME CONTROL EQUIPMENT

Fuel injection volume control equipment corresponds to the nerve system of human body. The function of governor is react sensitively to the changes of load on the engine thus to keep a constant speed. The function of fuel injection valve control equipment is to transmit the action of governor to the fuel injection pump correctly.

The correct method of adjustment of this equipment is as follows:

① Low the governor handle, and confirm that the fuel control rack easily shifts to the right and left.



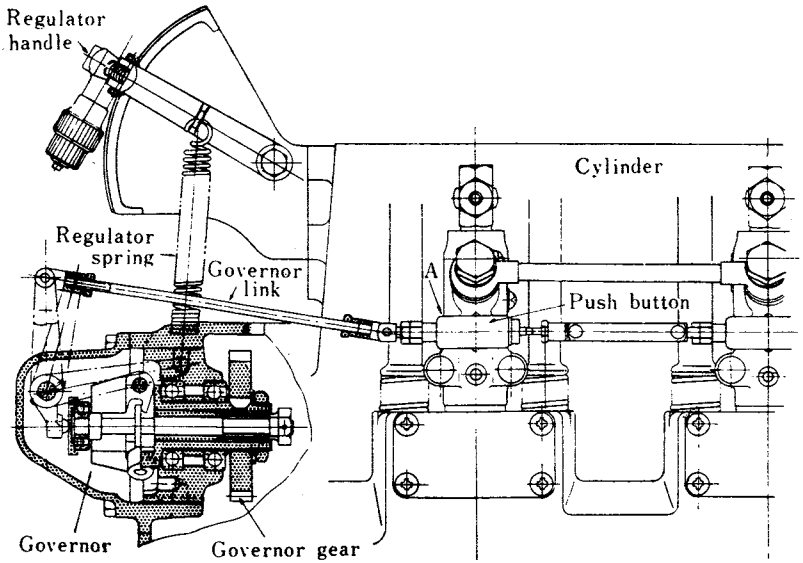
② The two-point mark engraved on the rack indicates the injection volume at continuous B.H.P. Adjust the equipment in such way that the said mark and surface A of pump main agree each other for each pump.

③ In order to adjust for the maximum injection, elevate the governor handle to the full-speed position.

④ Loosen the nuts at both ends of governor link which combines the governor lever and the rack of fuel injection pump, push the start-up button, and adjust it so that one-point mark agrees with surface A.

When the injection volume of each cylinder is adjusted, sometimes the two-point mark does not agree. In such case you can do an adjustment by (1) unifying an exhaust temperature, (2) unifying the position fo injection start, (3) making an

adjustment for each cylinder separately by listening to injection sounds, etc.



XVII. CONFIRMATION AND ADJUSTMENT OF FUEL INJECTION TIME

1. Confirmation of fuel injection time

To find out fuel injection time, remove the high-pressure pipe on fuel valve side and turn the flywheel and function the pump, and then read the graduation on the flywheel at the moment when the oil at the high-pressure pipe outlet side moves.

When the fuel injection time is not correct, engine efficiency is not full displayed. After long hours of use, confirm it at every 250 hrs. The detailed procedure is as follows:

① Remove the high-pressure pipe from tne fuel injection pump and reset it on the pump side and turn the pipe outlet of fuel valve side upwards.

② Match the two-point mark of rack to the surface A of pump body. (Injection time will become varied unless it is in this position.)

③ Turn the engine and vent air in the high-pressure pipe. When the fuel comes out from the end of high-pressure pipe which was turned upward, watch the oil level in the pipe end . . . .

④ Turn the flywheel slowly to the direction of rotation.

⑤ At the instance when the oil level moved, stop the flywheel.

⑥ At this position read the graduation indicated by a indicator.

⑦ When the indicated graduation is **10~12° before T.D.**, the injection time is correct. If it is not, make an adjustment by refering to the **"(2) Adjustment of Fuel Injection Time."**

When the indicator is matched to the graduation of flywheel which is marked T.D., the piston of that cylinder comes to the top. This position is called the top dead center or **T.D.** There are two cases of T.D., but the injection starts at **10~12° before T.D. in compression stroke when both suction and exhaust valves are completely closed.** On the flywheel there is **I.O.** graduation preceeding T.D. and this **I.O.** is at **10° before T.D.** (**I.O.** is the mark for "inlet valve open" and **I.C.** is for "inlet valve close," which **E.O.** is for "exhaust valve open" and **E.C.** is for "exhaust valve close.")

The figure in front of **T.D.** mark indicates the cylinder number. The cylinder on the flywheel side is numbered No.1, and then No.2, No.3, etc. Therefore, **I.T.D.** means that the first cylinder is at the top position.

2. Adjustment of fuel injection time

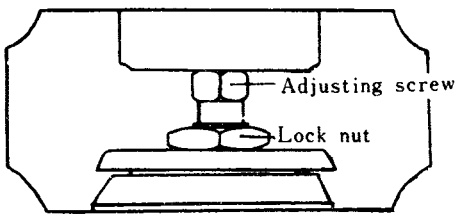
The fuel injection time rarely needs a correction. But if it was found necessary as the result of preceeding test, consult with a special sales agent or a sales store as much as possible.

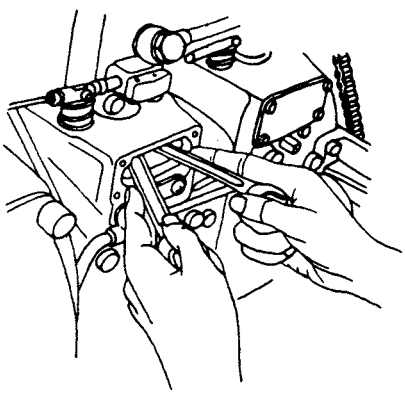
Adjustment is as follows:

① Match the two-point mark on the rack to the surface A of the pump body.

② Open the adjusting window at the lower part of fuel injection pump (draw out 4 bolts of 6 mm).

③ Loosen the lock nut and screw in the adjusting screw by a spanner. As the injection time delays, it approaches **T.D.** of flywheel graduation.
When it is screwed out, the injection time gains.
After the adjustment, securely tighten the lock nut so that the adjusting screw does not get loose. In this case use a care so that the screw and a nut will not turn together.





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