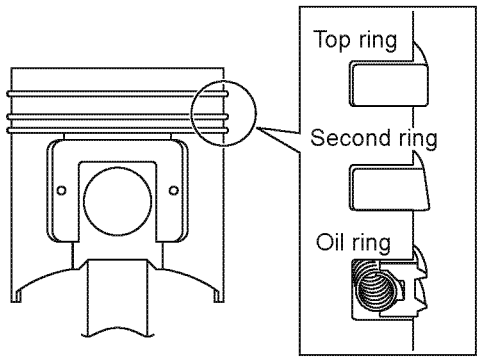
5.3.3 Piston rings

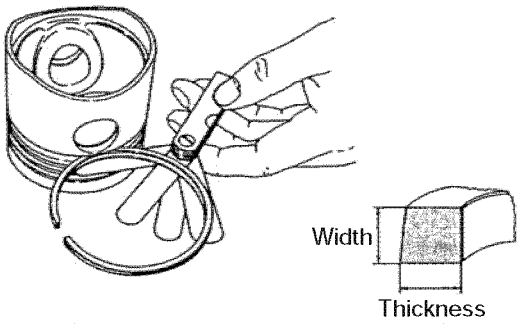
There are two compression rings and one oil ring.
The absence of an oil ring on the piston skirt prevents oil from being kept on the thrust surface and in turn provides good lubrication.



(Ring components)

(1) Measuring the rings.

Measure the thickness and width of the rings, and the ring-to-groove clearance after installation. Replace if wear exceed the limit.



(Measuring side clearance)

3YM30 mm

		Standard	Limit
Top ring	Groove width	1.550-1.570	-
	Ring width	1.470-1.490	1.450
	Clearance	0.060-0.100	-
Second ring	Groove width	1.580-1.595	1.695
	Ring width	1.430-1.450	1.410
	Clearance	0.013-0.165	0.285
Oil ring	Groove width	3.010-3.030	3.130
	Ring width	2.970-2.990	2.950
	Clearance	0.020-0.060	0.180

3YM20/2YM15 mm

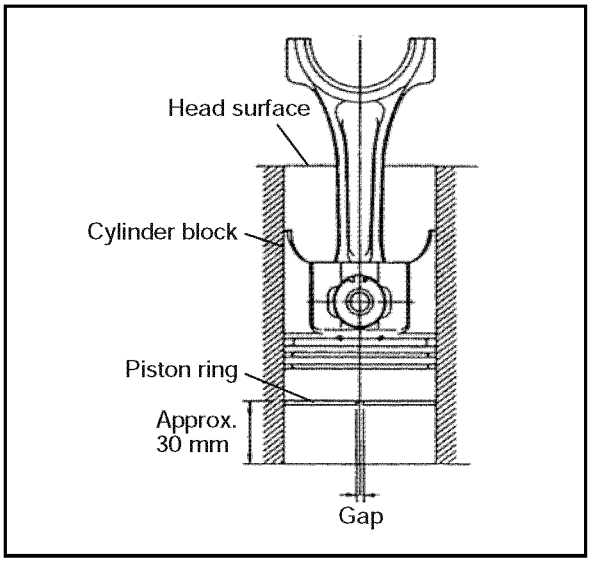
		Standard	Limit
Top ring	Groove width	1.550-1.570	-
	Ring width	1.470-1.490	1.450
	Clearance	0.060-0.100	-
Second ring	Groove width	1.540-1.560	1.660
	Ring width	1.470-1.490	1.450
	Clearance	0.050-0.090	0.210
Oil ring	Groove width	3.010-3.030	3.130
	Ring width	2.970-3.010	2.950
	Clearance	0.020-0.060	0.180

(2) Measuring piston ring gap

Press the piston ring onto a piston liner and measure the piston ring gap with a gauge. Press on the ring about 30mm from the bottom of the liner.

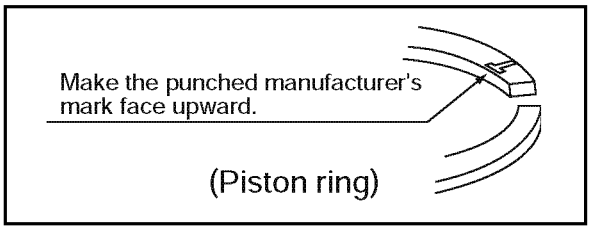
3YM30/3YM20/2YM15 mm

		Standard	Limit
Top ring gap		0.15-0.30	0.390
Second ring gap		0.18-0.33	0.420
Oil ring gap	3YM30	0.20-0.45	0.540
	3YM20 2YM15	0.15-0.35	0.44

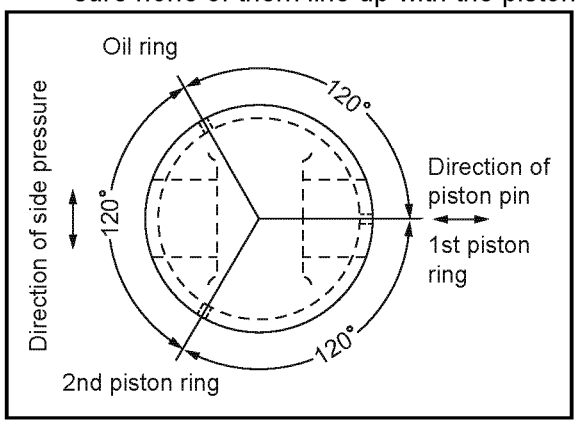


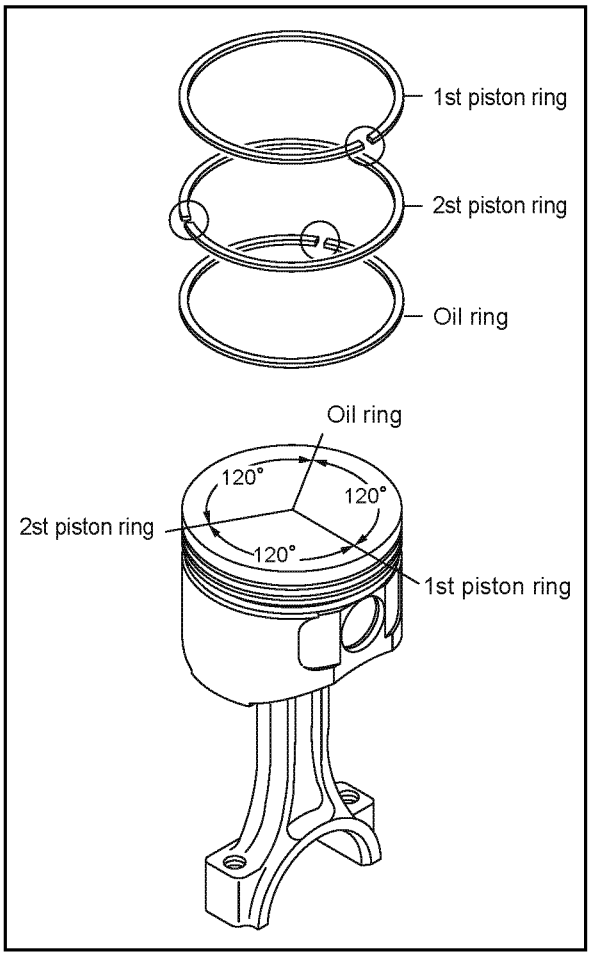
(3) Removing the piston rings

1) Thoroughly clean the ring grooves when removing piston rings.
2) The side with the manufacturer's mark should face up.

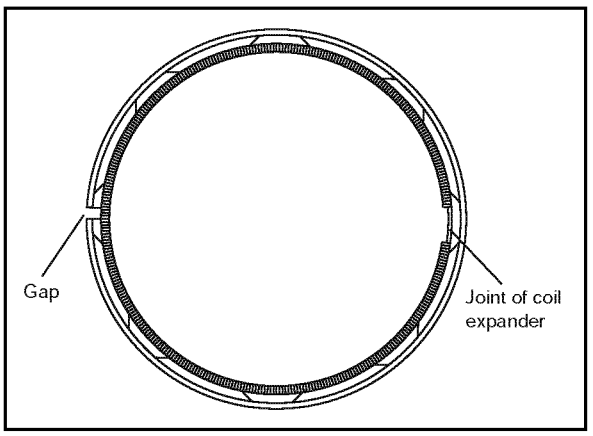


3) After fitting the piston ring, make sure it moves easily and smoothly.
4) Stagger the piston rings at 120° intervals, making sure none of them line up with the piston.



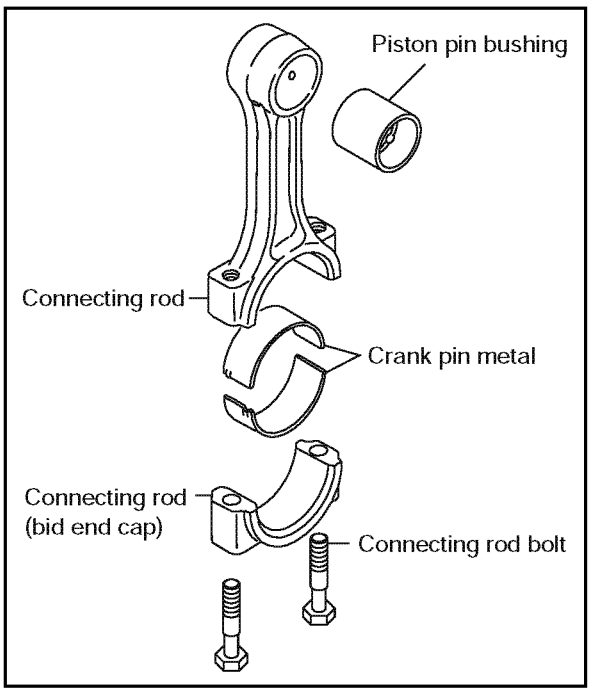


5) The oil ring is provided with a coil expander. The coil expander joint should be opposite (staggered 180°) the oil ring gap.



5.4 Connecting rod

The connecting rod is made of high-strength forged carbon steel.
The large end with the aluminium metal can be separated into two and the small end has a 2-layer copper alloy coil bushing.



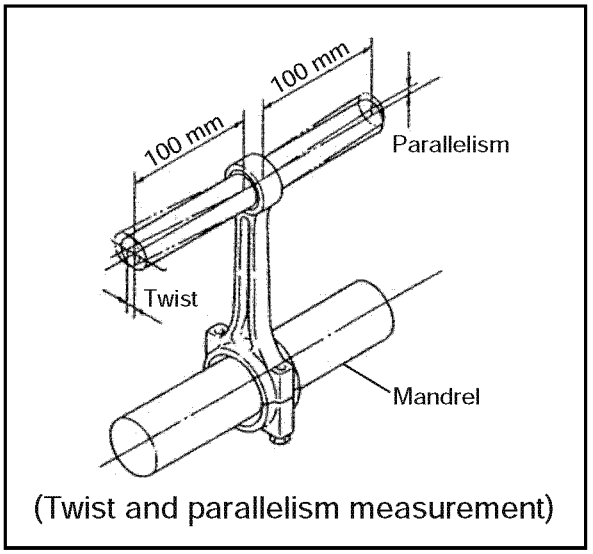
5.4.1 Inspecting the connection rod

(1) Twist and parallelism of the large and small ends

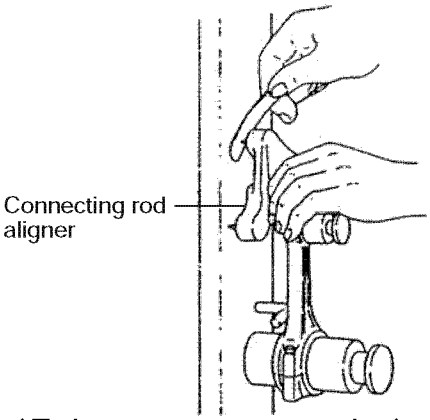
Insert the measuring tool into the large and small ends of the connecting rod. Measure the extent of twist and parallelism and replace if they exceed the tolerance.

mm

	Standard	Limit
Connecting rod twist and parallelism	Less than 0.03 per 100 mm	0.08



(Twist and parallelism measurement)

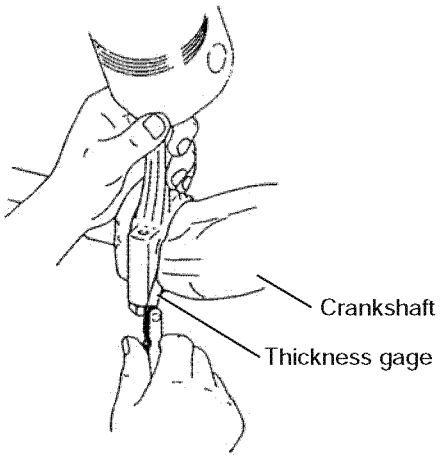


(Twist measurement using a connecting rod aligner)

(2) Checking the side clearance of a connecting rod

Fit the respective crank pins to the connecting rod and check to make sure that the side clearance in the crankshaft direction is correct.

	Standard	Limit
Connecting rod side clearance	0.20-0.40	0.55



(Connecting rod side gap)

5.4.2 Crank pin metal

(1) Checking crank pin metal

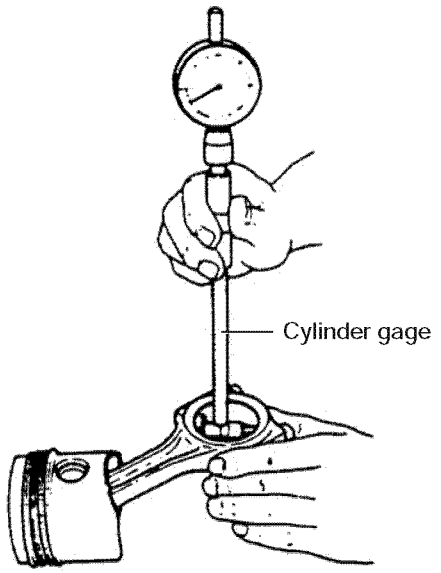
Check for flaking, melting or seizure on the contact surface of the crank pin metal.

(2) Measuring crank pin oil clearance

Measure the crankpin outside diameter and the crank pin metal inside diameter. Calculate the oil clearance from the measured values.
(Refer to 5.5.1(3) for measuring the crank pin outside diameter.)

Replace the crank pin metal if the oil clearance becomes about the limit dimension of the below table.
Correct by grinding if unevenly wear, roundness exceeding the limit or insufficient outside diameter is found. Also use an undersized metal if necessary.

[NOTICE]
When measuring the inside diameter of the rod big end, install the crank pin metal in the rod big end not to mistake the top and bottom of the metals and tighten the rod bolts by the standard torque.



(Rod bushing I.D. measurement)

N•m (kgf•m)

Rod bolt tightening torque	22.6-27.5 (2.3-2.8)

3YM30 mm

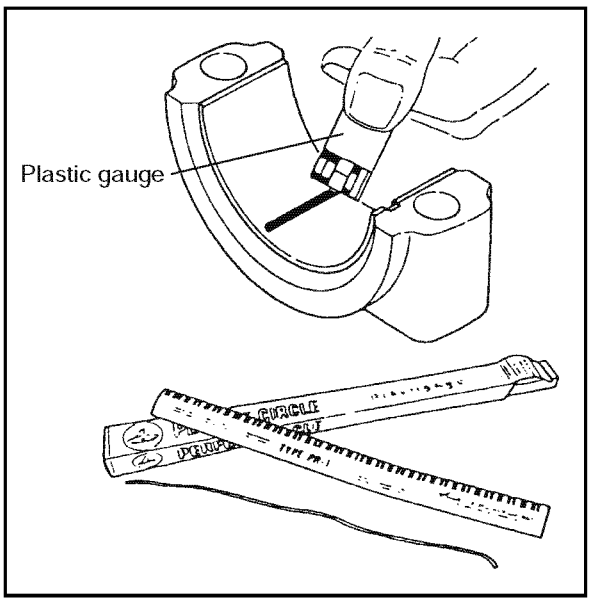
Item	Standard	Limit
Crankpin O.D.	41.952-41.962	41.902
Metal I.D.	41.982-42.010	-
Metal thickness	1.503-1.509	-
Clearance	0.020-0.058	0.120

3YM20/2YM15 mm

Item	Standard	Limit
Crankpin O.D.	37.952-37.962	37.902
Metal I.D.	37.982-38.010	-
Metal thickness	1.503-1.509	-
Clearance	0.020-0.058	0.120

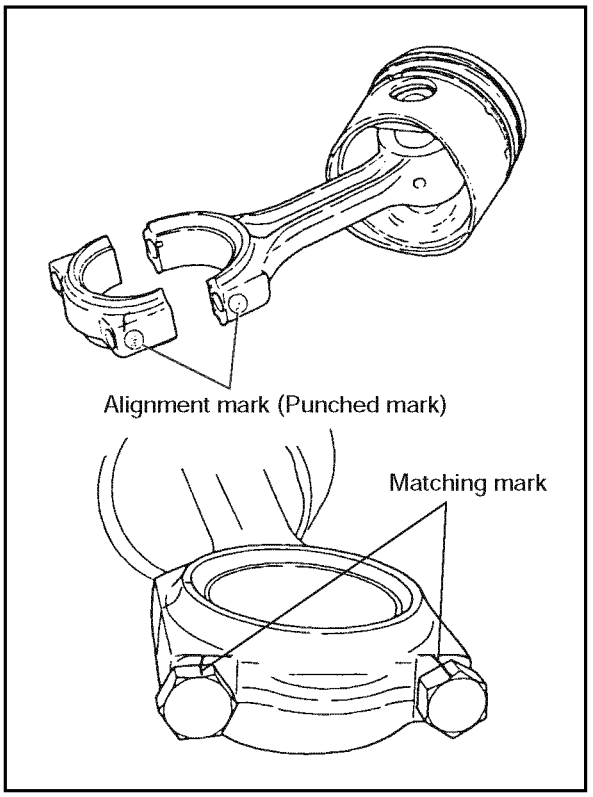
• Other procedure of measuring crank pin oil clearance

1) Use the press gauge (Plastic gauge) for measuring the oil clearance of the crank pin.
2) Mount the connecting rod on the crank pin (tighten to specified torque).
3) Remove the connecting rod and measure the broken plastic gauge with measuring paper.



(3) Precautions on replacement of crank pin metal

1) Wash the crank pin metal.
2) Wash the large end cap, mount the crank pin metal and make sure that it fits tightly on the large end cap.
3) When assembling the connecting rod, match up the large end and large end cap number. Coat the bolts with engine oil and gradually tighten them alternately to the specified torque.
   If a torque wrench is not available, make match marks on the bolt heads and large end cap before disassembling (to indicate the proper torque position) and retighten the bolts to those positions.
4) Make sure there is no sand, metal cuttings or other foreign matter in the lube oil, and that the crankshaft is not scratched. Take special care in cleaning the oil holes.



5.4.3 Piston pin bushing

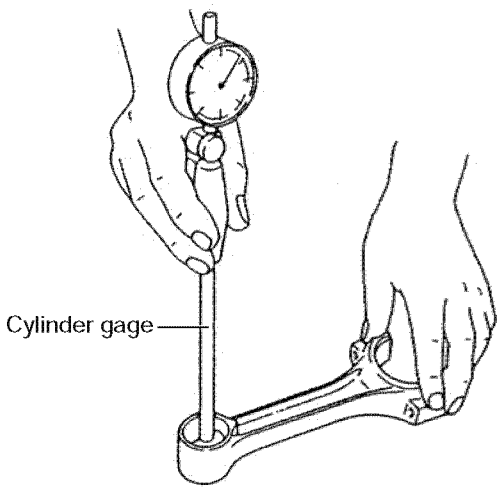
(1) Measuring piston pin clearance.

Excessive piston pin bushing wear may result in damage to the piston pin or the piston itself.

Measure the piston pin bushing inside diameter and the piston pin outside diameter. Calculate the oil clearance from the measured values. (Refer to 5.3.2 for the piston pin.)

mm

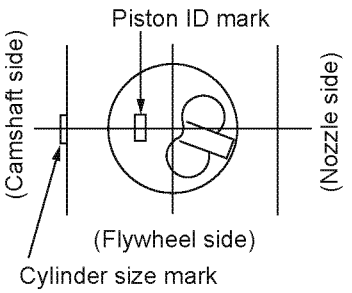
	Standard	Limit
Piston pin metal I.D.	22.025-22.038	22.068
Pin O.D.	21.991-22.000	21.963
Clearance	0.025-0.047	0.105

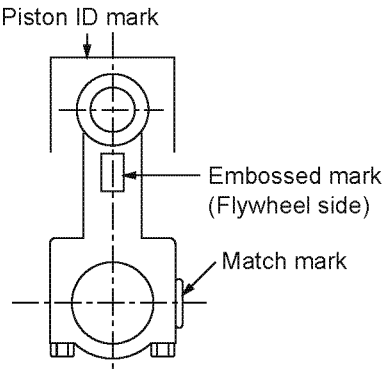


(Connecting rod small end)

5.4.4 Assembling piston and connecting rod

The piston and connecting rod should be assembled so that the match mark on the connecting rod large end faced the fuel nozzle side and the combustion chamber above the piston is close to the fuel nozzle.

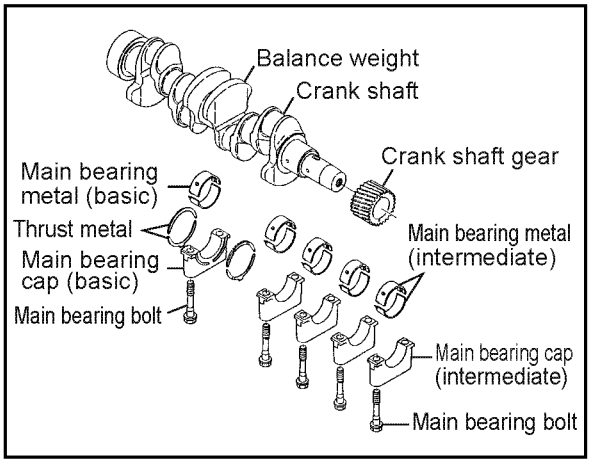




(Assembly direction of connecting rod and piston)

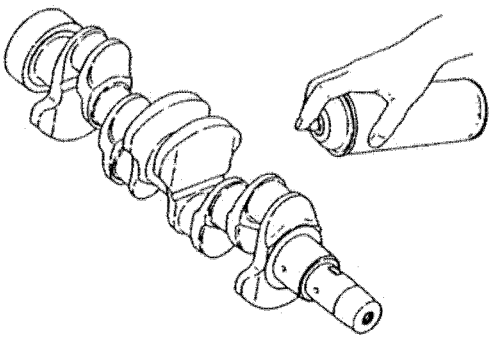
5.5 Crankshaft and main bearing

The crank pin and crank journal have been induction hardened for superior durability, and the crankshaft is provided with four balance weights for optional balance. The crankshaft main bearing is of the hanger type. The upper metal (cylinder block side) is provided with an oil groove. There is no oil groove on the lower metal (bearing cap side). The bearing cap (location cap) of the flywheel side has a thrust metal which supports the thrust load.



5.5.1 Crankshaft

(1) Color check after cleaning the crankshaft, and replace the crank shaft if there is any cracking or considerable damage.



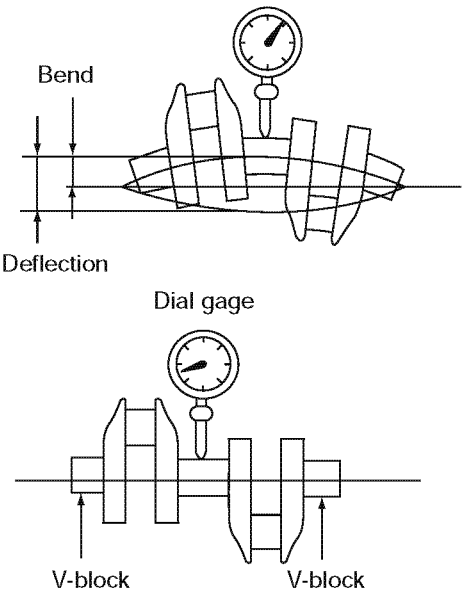
(Inspection by color check)

(2) Bending of the crankshaft

Support the crankshaft with V-blocks at both ends of the journals. Measure the deflection of the center journal with a dial gauge while rotating the crankshaft to check the extent of crankshaft bending. The total indicating reading on the dial gauge is divided by two to obtain the crankshaft bend.

mm

Crankshaft bend limit	0.01



(Crankshaft bend measurement)

(3) Measuring the crank pin and journal

Measure the outside diameter, roundness and taper at each crank pin and journal.
Correct by grinding if unevenly wear, roundness exceeding the limit or insufficient outside diameter is found. Replace if the defect is excessive.

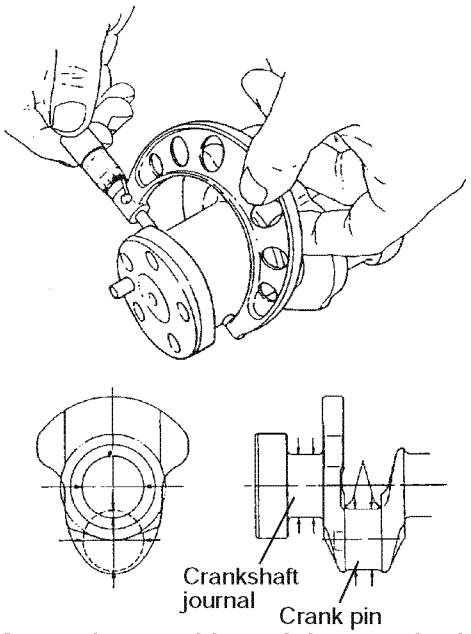
mm

Item	Standard (Diameter)	Limit (Diameter)
Roundness Taper	0.01 or less	0.02

To look for the oil clearance of crank pin, measure the inside diameter of crank pin metal. (Refer to 5.4.2(2).)

mm

		Standard	Limit
Crank pin 3YM30	Outside dia.	41.952-41.962	41.902
	Oil clearance	0.020-0.058	0.120
Crank pin 3YM20/2YM15	Outside dia.	37.952-37.962	37.902
	Oil clearance	0.020-0.058	0.120
Crank journal (Selective pair) All models	Outside dia.	46.952-46.962	46.902
	Oil clearance	0.020-0.050	0.120



(Measuring position of the crank pin and crank journal)

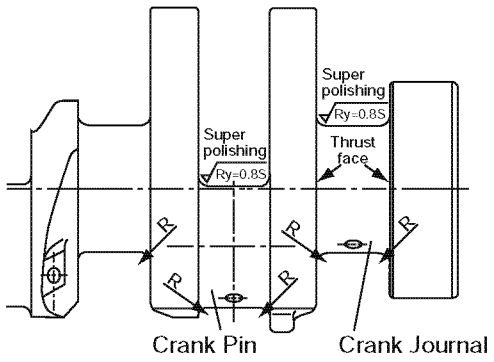
- Dimension R and finishing precision of crankshaft journal and pin

  As for grinding processing of journal and pin, machine it by using the grinding wheel of the dimension R of below table.

  Surface finishing precision standard on journal and pin:

  Ry = 0.8S super polishing

  Surface finishing precision standard on the thrust side of crankshaft arm : 1.6



(Crankshaft R machining)

Finishing precision standard of dimension R (mm)
3.5+0.3/0

NOTICE:

1) If the oil clearance is excessive though the thickness of the journal and crankpin metals are normal or if partial uneven wear is observed, re-grind the crankshaft and use an undersize metals.
2) If rust or surface roughening exists on the rear side of the metals, coat it with blue or minimum. Then assemble the crankpin metal to the connecting rod, and tighten the rod bolt to the specified torque to check the metal for contact. If the contact surface occupies 75% or more, the metal is normal. If the contact surface is insufficient, the metal interference is insufficient. Replace the metal with a new one.

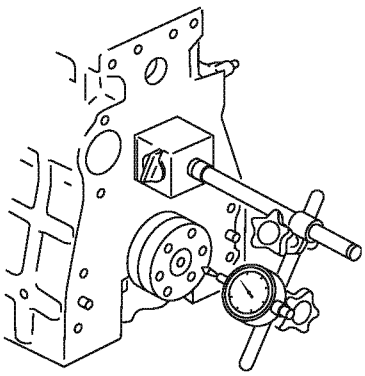
(4) Checking the side gap of a crankshaft

After assembling the crankshaft, tighten the main bearing cap to the specified toque, and move the crankshaft to one side, placing a dial gauge on one end of the shaft to measure thrust clearance.

Replace the thrust bearing if it is worn beyond the limit.

mm

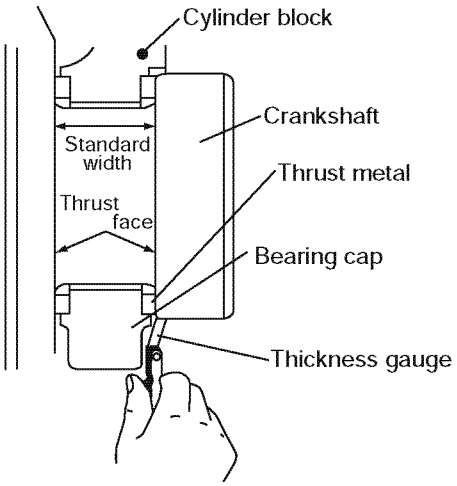
	Standard	Limit
Crankshaft side gap	0.111-0.250	0.30



(Side gap measurement 1)

001544-00E

Other measurement method can also be effective. Insert the thickness gauge directly into the clearance between the thrust metal and crankshaft thrust face.



(Side gap measurement 2)

5.5.2 Main bearing

(1) Inspecting the main bearing

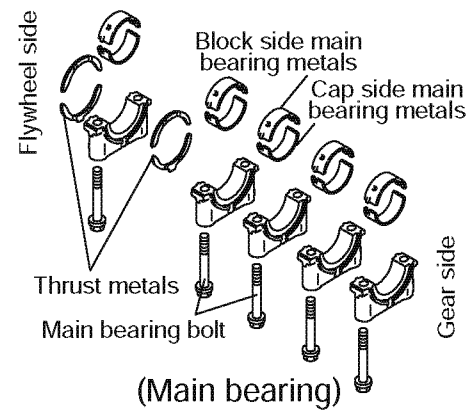
Check for flaking, seizure or burning of the contact surface and replace if necessary.

(2) Measuring the inner diameter of metal

Tighten the cap to the specified torque and measure the inner diameter of the metal.

N•m (kgf•m)

Tightening torque	75.5-81.5 (7.7-8.3)

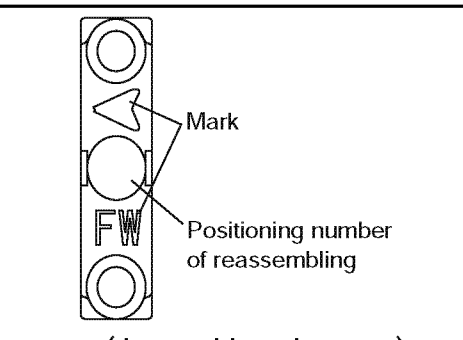


(Main bearing)

NOTE:

When assembling the bearing cap, keep the following in mind.

1) The lower metal (cap side) has no oil groove.
2) The upper metal (block side) has an oil groove.
3) Check the cylinder block alignment number.
4) The “FW” on the cap lies on the flywheel side.

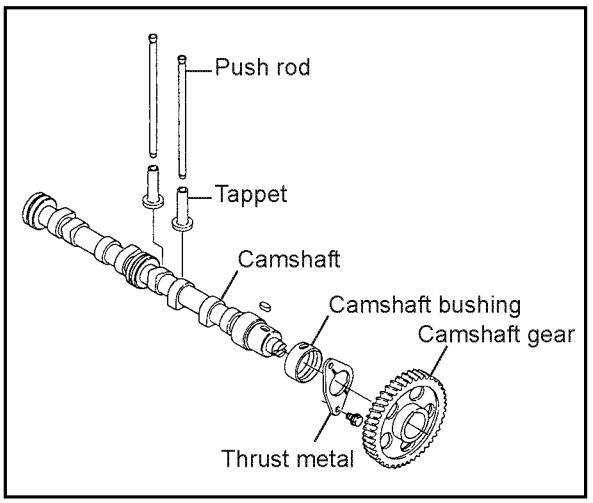


(Journal bearing cap)

5.6 Camshaft and tappets

5.6.1 Camshaft

The camshaft is normalized and the cam and bearing surfaces are surface hardened and ground. The cams have a curve that minimized the repeated shocks on the valve seats and maximizes valve seat life.

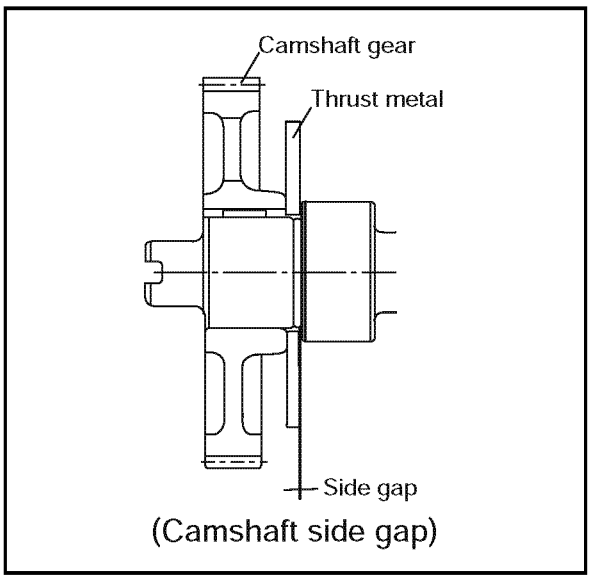


(1) Checking the camshaft side gap

Measure the thrust gap before disassembly. As the cam gear is shrink-fitted to the cam, be careful when replacing the thrust bearing.

mm

	Standard	Limit
Camshaft side gap	0.05-0.15	0.25

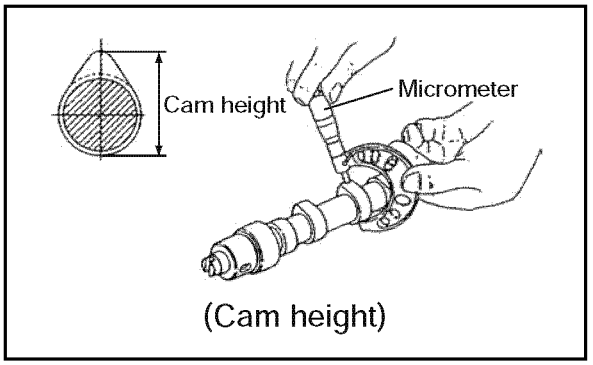


(Camshaft side gap)

(2) Measure the cam height, and replace the cam if it is worn beyond the limit.

3YM30 mm

		Standard	Limit
Cam height	Intake	34.135-34.265	33.89
	Exhaust		



(Cam height)

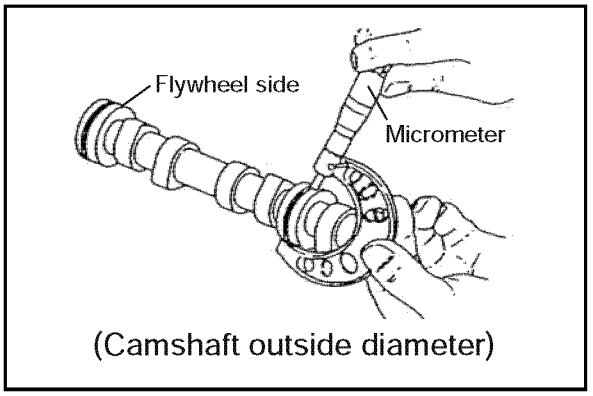
3YM20/2YM15 mm

		Standard	Limit
Cam height	Intake	34.535-34.665	34.29
	Exhaust		

(3) Camshaft and bearing hole measurement

mm

		Standard	Limit
Cam height	Intake	34.135-34.265	33.89
	Exhaust		



(Camshaft outside diameter)

Measure the camshaft outside diameter with a micrometer. The oil clearance shall be calculated by subtracting the measured camshaft outside diameter from the inside diameter of the camshaft bearing or bushing. The camshaft bushing at gear case side is measured with a cylinder gage after insertion to the cylinder. Replace if they exceed the limit or are damaged.

mm

	Item	Standard	Limit
Gear side	Bushing I.D.	40.000-40.075	40.150
	Camshaft O.D.	39.940-39.960	39.905
	Oil clearance	0.040-0.135	0.245
Intermediate position	Bushing I.D.	40.000-40.025	40.100
	Camshaft O.D.	39.910-39.935	39.875
	Oil clearance	0.065-0.115	0.225
Flywheel side	Bushing I.D.	40.000-40.025	40.100
	Camshaft O.D.	39.940-39.960	39.905
	Oil clearance	0.040-0.085	0.195

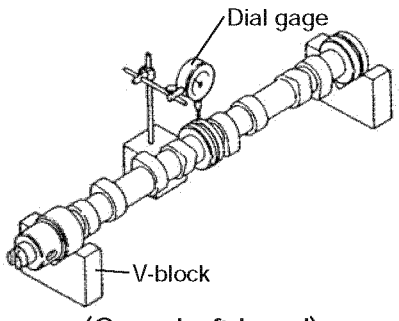
(4) Bending of the camshaft

Support both ends of the camshaft with V-blocks, place a dial gauge at the central bearing areas and measure bending. Replace if excessive.

NOTE:
The reading on the dial gauge is divided by two to obtain the camshaft bend.

mm

	Standard	Limit
Camshaft bend	0.02 or less	0.05

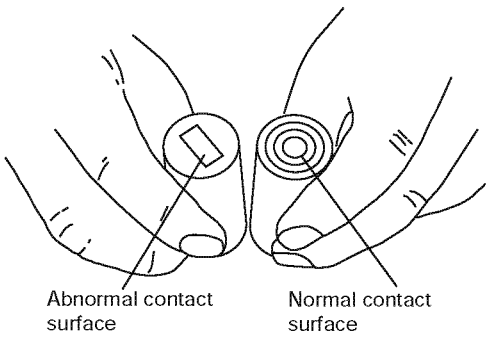


(Camshaft bend)

5.6.2 Tappets

(1) The tappets are offset to rotate during operation and thereby prevent uneven wearing. Check the contact of each tappet and replace if excessively or unevenly worn.

NOTE:
When removing tappets, be sure to keep them separate for each cylinder and intake/exhaust valve.

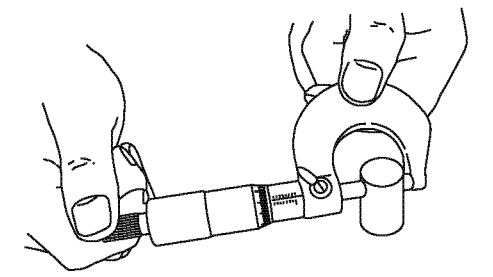


(Tappet) 001552-00E

(2) Measure the outer diameter of the tappet, and replace if worn beyond the limit.

mm

	Standard	Limit
Tappet outside diameter	20.927-20.960	20.907
Tappet guide hole inside dia. (cylinder block)	21.000-21.021	21.041
Oil clearance	0.040-0.094	0.134

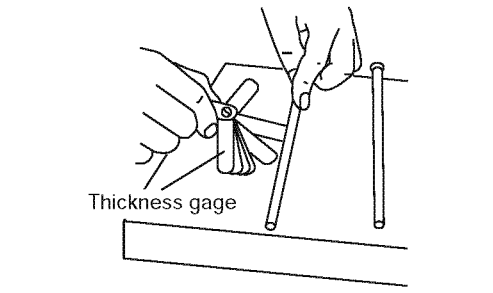


(Tappet stem outside diameter measurement) 001553-00E

(3) Measuring push rods.
Measure the bend of the push rods.

mm

	Standard	Limit
Push rod bend	Less than 0.03	0.03



(Push rod bend) 001554-00E

5.7 Timing gear

The timing gear is helical type for minimum noise and specially treated for high durability.

5.7.1 Inspecting the gears

(1) Inspect the gears and replace if the teeth are damaged or worn.

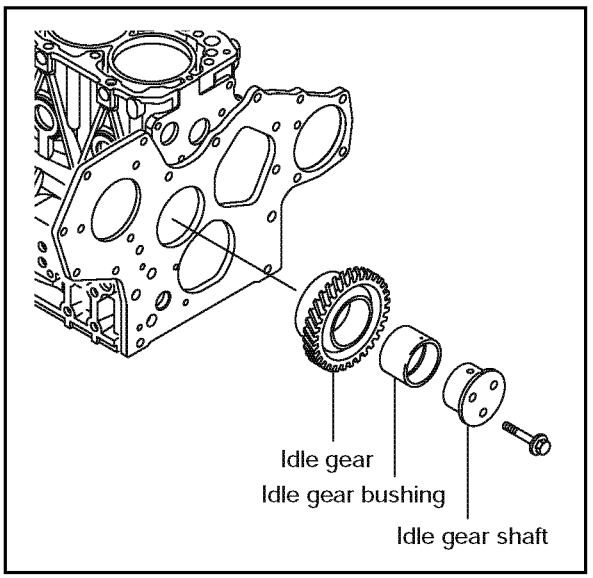
(2) Measure the backlash of all gears that mesh, and replace the meshing gears as a set if wear exceeds the limit.

NOTE:
If backlash is excessive, it will not only result in excessive noise and gear damage, but also lead to bad valve and fuel injection timing and a decrease in engine performance.

mm

	Standard	Limit
Backlash	0.06-0.12	0.14

(3) Idling gear
The bushing is pressure fitted into the idling gear.
Measure the bushing inner diameter and the outer diameter of the shaft, and replace the bushing or idling gear shaft if the oil clearance exceeds the wear limit.
A, B and C are inscribed on the end of the idling gear.
When assembling, these marks should align with those on the cylinder block.

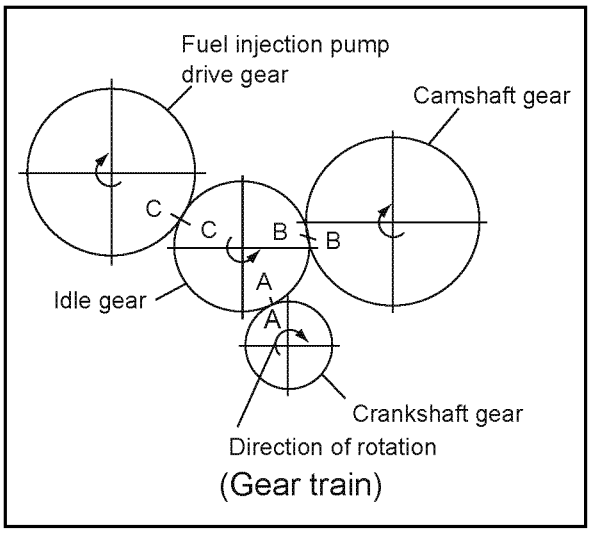


mm

	Standard	Limit
Idle gear shaft diameter	36.950-36.975	36.900
Idle gear bushing inside dia.	37.000-37.025	37.075
Oil clearance	0.025-0.075	0.175

5.7.2 Gear timing marks

Match up the timing marks on each gear when assembling (A, B and C).

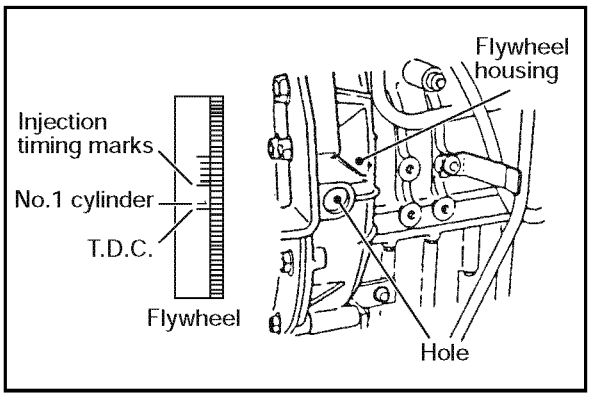


5.8 Flywheel and housing

The function of the flywheel is through inertia, to rotate the crankshaft in a uniform and smooth manner by absorbing the turning force created during the combustion stroke of the engine, and by compensating for the decrease in turning force during the other strokes.
The flywheel is mounted and secured by 6 bolts on the crankshaft end at the opposite end to the gear case; it is covered by the mounting flange (flywheel housing) which is bolted to the cylinder block.
The fitting surface for the damper disc is on the crankshaft side of the flywheel. The rotation of the crankshaft is transmitted through this disc to the input shaft of the reduction and reversing gear. The reduction and reversing gear is fitted to the mounting flange.
The flywheel's unbalanced force on the shaft center must be kept below the specified value for the crankshaft as the flywheel rotates with the crankshaft at high speed.
To achieve this, the valance is adjusted by drilling holes in the side of the flywheel, and the unbalanced momentum is adjusted by drilling holes in the circumference.
The ring gear is shrink fitted onto the circumference of the flywheel, and this ring gear serves to start the engine by meshing with the starter motor pinion.
The stamped letter and line which show top dead center of each cylinder are positioned on the flywheel circumference, and by matching these marks with the arrow mark at the hole of the flywheel housing, the rotary position of the crankshaft can be ascertained in order to adjust tappet clearance or fuel injection timing.

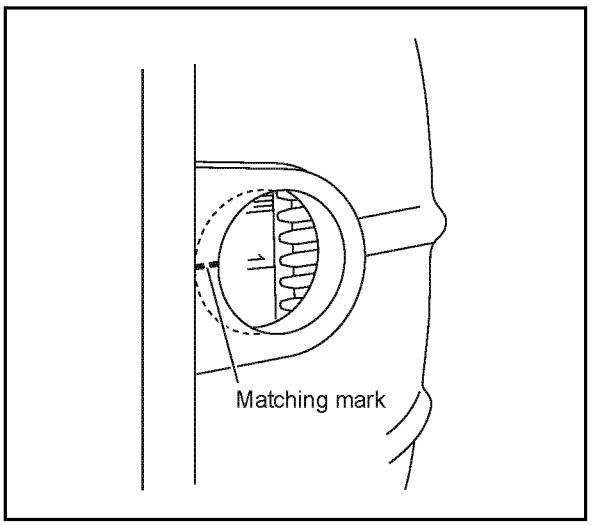
5.8.1 Position of top dead center and fuel injection timing

(1) Marking

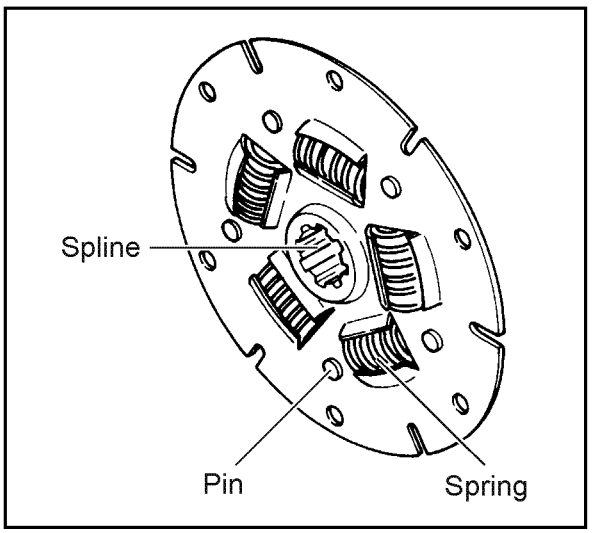


(2) Matching mark

The matching mark is made at the hole of the flywheel housing.



5.8.2 Damper disc



(1) Spline part
Whenever uneven wear and/or scratches are found, replace with new one.

(2) Spring
Whenever uneven wear and/or scratches are found, replace with new one.

(3) Pin wear
Whenever uneven wear and/or scratches are found, replace with new one.

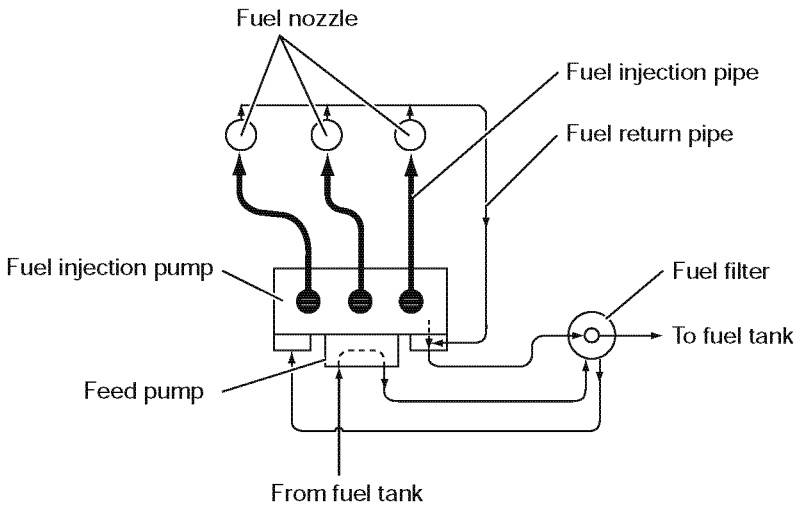
(4) Whenever a crack or damage to the spring slot is found, replace the defective part with new one.

6. Fuel injection equipment

6.1 Fuel Injection pump/governor

Refer to the service manual of the YPES-ML fuel injection pump for the disassembly, assembly and adjustment procedure.

6.1.1 Fuel system diagram



(3 cylinder eng.)

6.1.2 Fuel injection pump service data and adjustment

(1) Service data

1) Service data for 3YM30

Part code (Back No.)			-	728990-51350 (TMR1)	
Adjustment SPEC			-	ENGINE SPEC	SERVICE STD
Item	Fuel valve (Valve pressure)		-	A (120)	(170)
	Nozzle type (ID mark)		-	NP-DN0PDN158	DN-12SD12
	Fuel injection pipe		mm	Ø 2 x 320	Ø2 x 600
Injection adjustment	Starting	Pump speed N_D	min^{-1}	200	-
		Average injection volume Q_D	mm^3/st	38 ± 5	-
	Rated load	Pump speed N_A	min^{-1}	1800	-
		Injection volume Q_A	mm^3/st	22.4 ± 0.75	-
		Variation	%	± 3	-
	Torque rise	Pump speed N_C	min^{-1}	1300	-
		Injection volume Q_C	mm^3/st	25.9 ± 0.5	-
		Variation	%	± 5	-
	Hi-idle	Pump speed N_B	min^{-1}	1925	-
		Injection volume Q_B	mm^3/st	(4)	-
	Idle	Pump speed N_E	min^{-1}	425	-
		Injection volume Q_E	mm^3/st	(4)	-
Plunger stroke			mm	7.0	
Plunger diameter			mm	Ø 6	
Retraction volume of delivery valve			mm	20.1	
Pre-stroke			mm	2.9	
Top clearance			mm	1.4	
Governor spring		Spring constant	N/cm (kgf/cm)	4.23 (0.431)	
		Free length	mm	42	

Note : The value in parentheses is a reference value.

2) Service data for 3YM20

Part code (Back No.)			-	728890-51300 (TMM1)	
Adjustment SPEC			-	ENGINE SPEC	SERVICE STD
Item	Fuel valve (Valve pressure)		-	C (120)	(170)
	Nozzle type (ID mark)		-	NP-DN0PDN159	DN-12SD12
	Fuel injection pipe		mm	Ø 2 x 300	Ø2 x 600
Injection adjustment	Starting	Pump speed N_D	min^{-1}	200	-
		Average injection volume Q_D	mm^3/st	30± 5	-
	Rated load	Pump speed N_A	min^{-1}	1800	-
		Injection volume Q_A	mm^3/st	17.4 ± 0.5	-
		Variation	%	± 3	-
	Torque rise	Pump speed N_C	min^{-1}	1300	-
		Injection volume Q_C	mm^3/st	19.6 ± 0.5	-
		Variation	%	± 5	-
	Hi-idle	Pump speed N_B	min^{-1}	1945	-
		Injection volume Q_B	mm^3/st	(6)	-
	Idle	Pump speed N_E	min^{-1}	425	-
		Injection volume Q_E	mm^3/st	(5)	-
Plunger stroke			mm	7.0	
Plunger diameter			mm	Ø 6	
Retraction volume of delivery valve			mm	23.5	
Pre-stroke			mm	2.5	
Top clearance			mm	1.0	
Governor spring		Spring constant	N/cm (kgf/cm)	5.54 (0.565)	
		Free length	mm	42	

Note : The value in parentheses is a reference value.

3) Service data for 2YM15

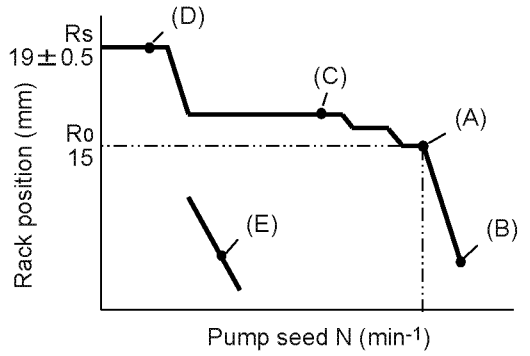
Part code (Back No.)			-	728890-51300 (TMM1)	
Adjustment SPEC			-	ENGINE SPEC	SERVICE STD
Item	Fuel valve (Valve pressure)		-	C (120)	(170)
	Nozzle type (ID mark)		-	NP-DN0PDN159	DN-12SD12
	Fuel injection pipe		mm	Ø 2 x 300	Ø2 x 600
Injection adjustment	Starting	Pump speed N_D	min^{-1}	200	-
		Average injection volume Q_D	mm^3/st	30± 5	-
	Rated load	Pump speed N_A	min^{-1}	1800	-
		Injection volume Q_A	mm^3/st	17.9 ± 0.5	-
		Variation	%	± 3	-
	Torque rise	Pump speed N_C	min^{-1}	1300	-
		Injection volume Q_C	mm^3/st	20.6 ± 0.5	-
		Variation	%	± 5	-
	Hi-idle	Pump speed N_B	min^{-1}	1925	-
		Injection volume Q_B	mm^3/st	(6)	-
	Idle	Pump speed N_E	min^{-1}	425	-
		Injection volume Q_E	mm^3/st	(5)	-
Plunger stroke			mm	7.0	
Plunger diameter			mm	Ø 6	
Retraction volume of delivery valve			mm	23.5	
Pre-stroke			mm	2.5	
Top clearance			mm	1.0	
Governor spring		Spring constant	N/cm (kgf/cm)	5.54 (0.565)	
		Free length	mm	42	

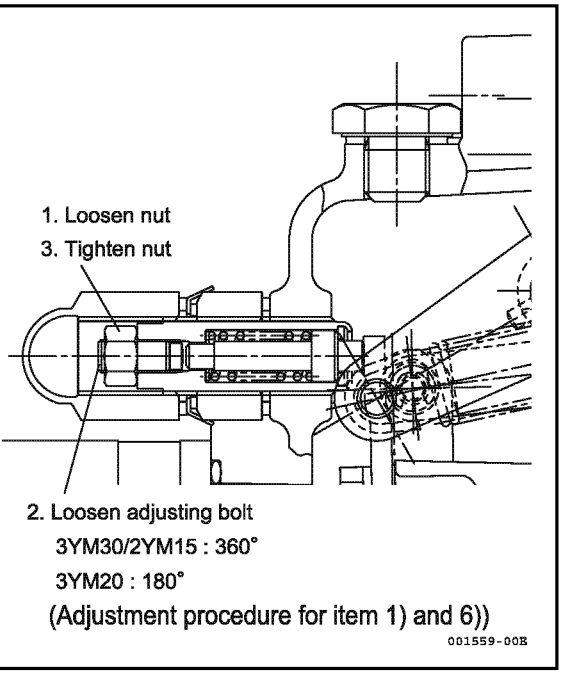
Note : The value in parentheses is a reference value.

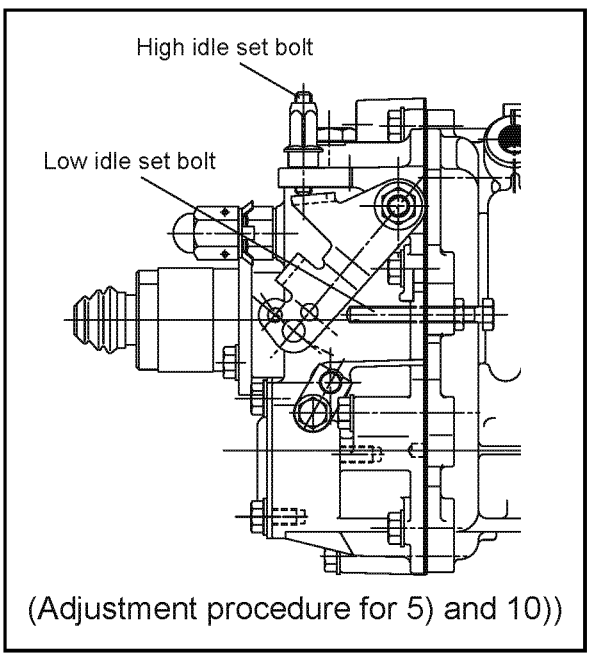
(2) Fuel adjustment procedure

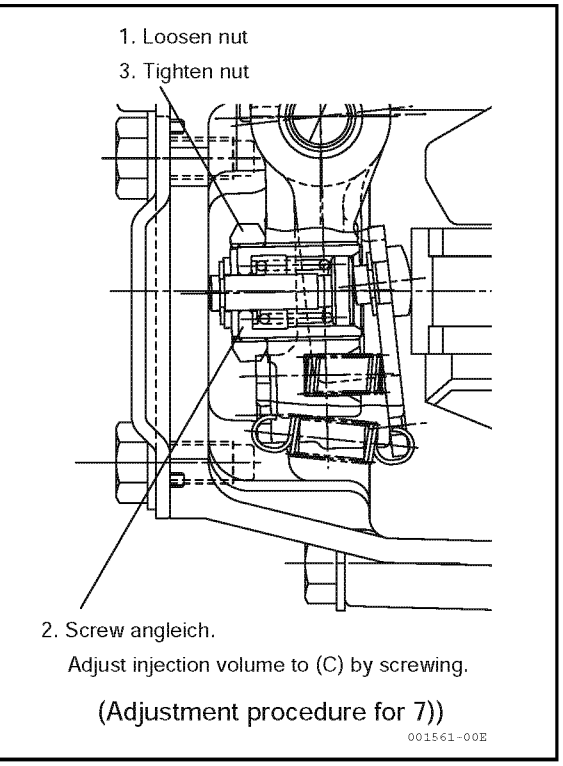
• Fuel adjustment for 3YM30 and 2YM15

1) Loosen the nut of the FO limiter, and screw the adjusting bolt to the bottom. Tighten the nut.
2) Adjust the rack position to R0 (15mm) with the FO limiter, and measure the injection volume (A) at the rated speed.
3) When the measured injection volume (A) is out of the standard, readjust the injection volume by screwing the FO limiter.
4) Pull the control lever to high idle side at full rack position.
5) Adjust the position of the high idle set bolt at high idle speed as to get the specified injection volume (B).
6) Loosen the nut of the FO limiter, and loosen the adjusting bolt at 360°. Fix the nut.
7) Screw the angleich at the torque-rise speed to get the specified injection volume (C).
8) Confirm the injection volume (D) at the specified speed at starting.
9) Push the control lever to low idle side.
10) Adjust the position of the low idle set bolt at low idle speed as to get the specified injection volume (E).



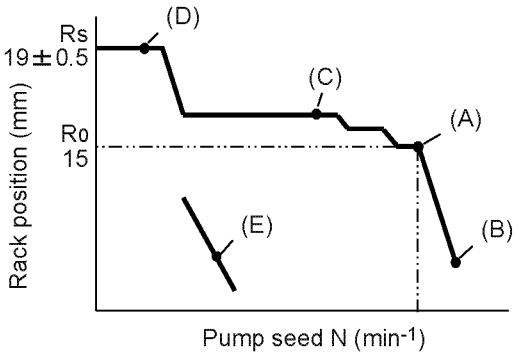


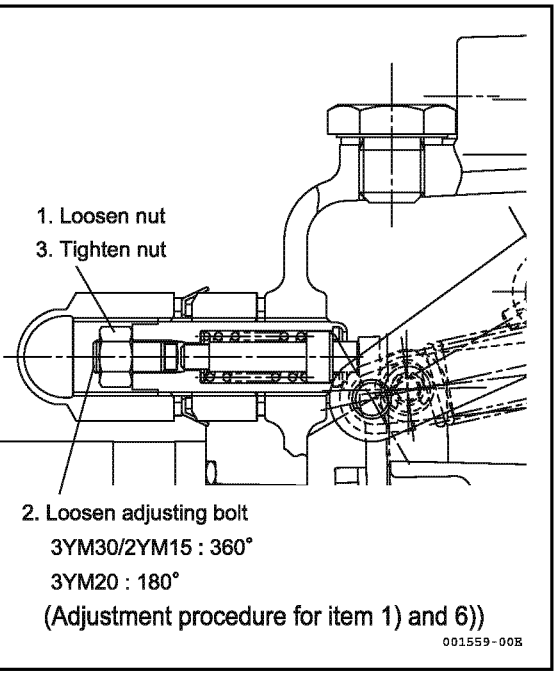


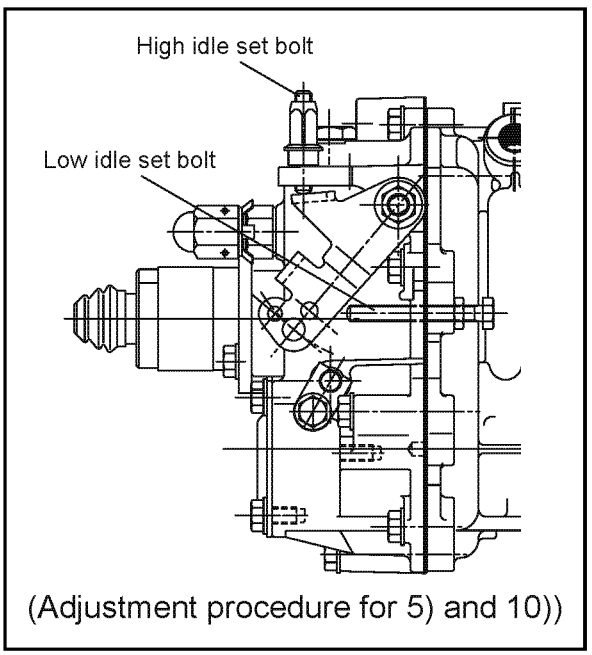


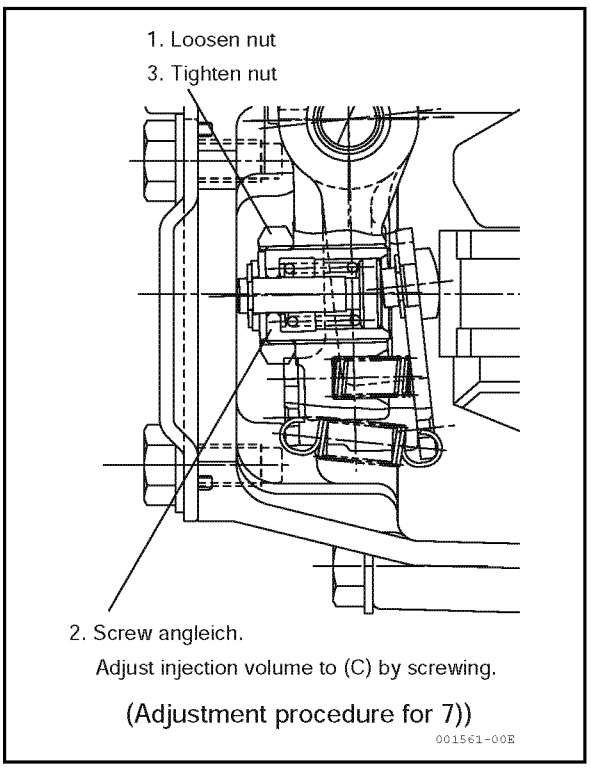
- Fuel adjustment for 3YM20

1) Loosen the nut of the FO limiter, and screw the adjusting bolt to the bottom. Tighten the nut.
2) Adjust the rack position to R0 (15mm) with the FO limiter, and measure the injection volume (A) at the rated speed.
3) When the measured injection volume (A) is out of the standard, readjust the injection volume by screwing the FO limiter.
4) Pull the control lever to high idle side at full rack position.
5) Adjust the position of the high idle set bolt at high idle speed as to get the specified injection volume (B).
6) Loosen the nut of the FO limiter, and loosen the adjusting bolt at 180°. Fix the nut.
7) Screw the angleichi at the torque-rise speed to get the specified injection volume (C).
8) Confirm the injection volume (D) at the specified speed at starting.
9) Push the control lever to low idle side.
10) Adjust the position of the low idle set bolt at low idle speed as to get the specified injection volume (E).



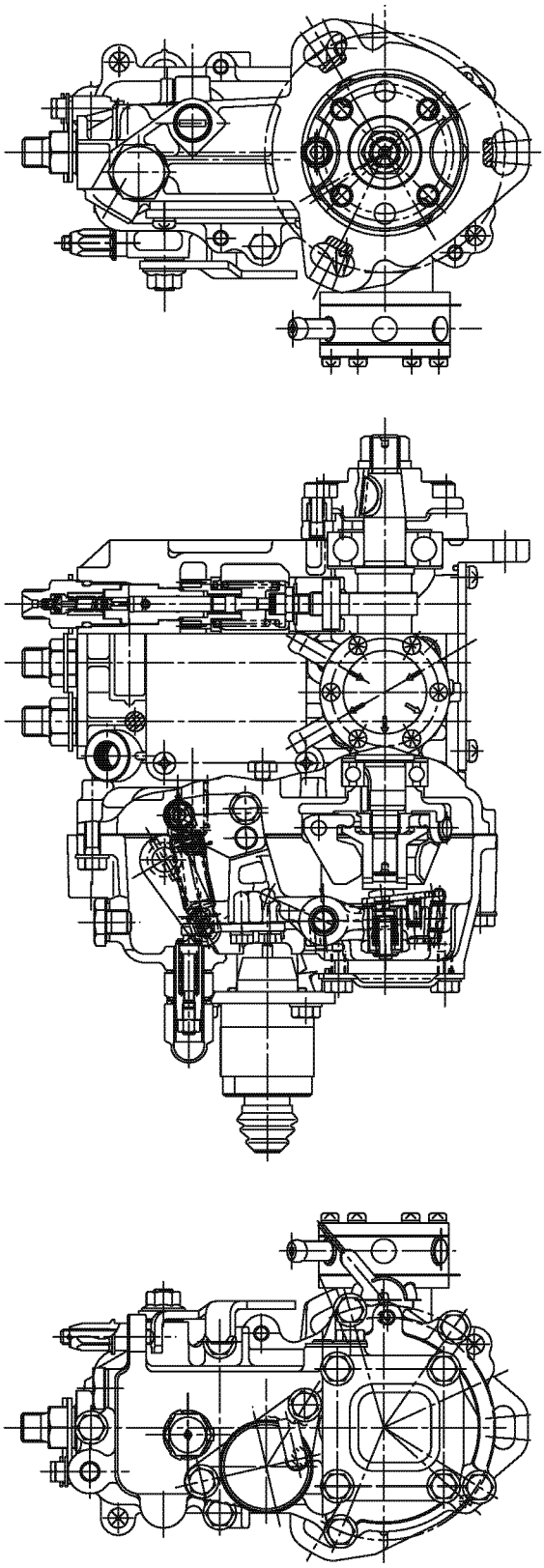






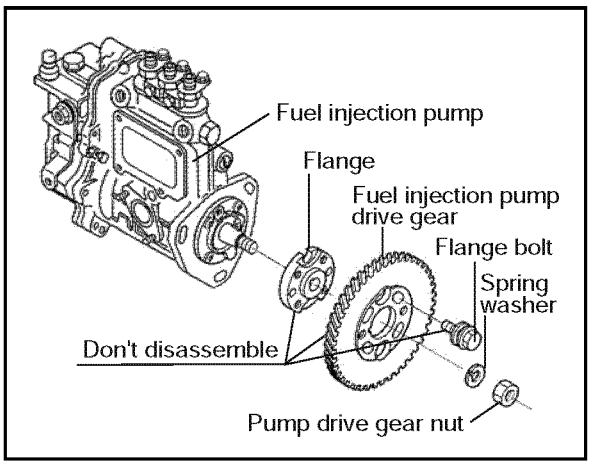
6.1.3 Fuel injection pump structure

Section of a fuel injection pump/ governor for 3YM30.



6.1.4 Removing a fuel injection pump

The procedure to remove a fuel injection pump from the gear case is shown.



[NOTICE]
Be sure to remove a flange and a fuel injection pump drive gear with a pair without loosening the flange bolts.

1) Remove fuel injection pipes, fuel pipes and a remote control wire. Block the entrance with tape so that trash may not enter the fuel injection pipes and the fuel injection pump.
2) Mark the position of the timing marks of a fuel pump and a gear case. Or, put a mark on the gear case at the position to agree the timing mark of a fuel pump.
3) Remove a pump cover from the gear case.
4) Give the marks on a fuel injection pump drive gear and a idle gear with paint or the like.
5) Loosen fuel injection pump installation nuts (three nuts).
6) Loosen a installation nut of a fuel injection pump drive gear.
7) Pull a fuel injection pump drive gear and a flange with a pair to your side by gear puller.
8) Remove a pump drive gear nut and a washer.
9) Remove a fuel injection pump. Leave the pump drive gear in the gear case.

6.1.5 Installing a fuel injection pump

[NOTICE]
- Use a new O-ring on the fuel pump flange and apply grease.
- Confirm whether the marks of the pump drive gear and the idle gear is correct.

1) Turn a camshaft so that the key of the pump camshaft may almost agree in a position of the key groove of a pump drive gear.
2) Insert a fuel injection pump into the installation hole of the gear case straight to prevent the damage of the O-ring. Insert a fuel pump while confirming whether the key of a camshaft and the key groove of a drive gear agree.
3) Assemble a pump drive gear nut and a washer together temporarily.
4) Turn a fuel injection pump to the position where the marks of the fuel injection pump and the gear case agrees.
5) Fasten pump installation nuts (three nuts) on the fuel injection pump.
6) Tighten the pump installation nut by the specified standard torque.

Tightening torque of the pump drive gear nut (without lube oil)

Tighteningtorque	N•m(kgf•m)
58.8-68.8 (6.0-7.0)	

6.1.6 Adjusting fuel injection timing

Refer to 2.2.6(1) in chapter 2.

6.1.7 Troubleshooting of fuel injection pump

Complete repair means not only replacing defective parts, but finding and eliminating the cause of the trouble as well. The cause of the trouble may not necessarily be in the pump itself, but may be in the engine or the fuel system. If the pump is removed prematurely, the true cause of the trouble may never be known. Before removing the pump from the engine, at least go through the basic check points given here.

Basic checkpoints

- Check for breaks or oil leaks throughout the fuel system, from the fuel tank to the nozzle.
- Check the injection timings for all cylinders. Are they correctly adjusted? Are they too fast or too slow?
- Check the nozzle spray.
- Check the fuel delivery. Is it in good condition? Loosen the fuel pipe connection at the injection pump inlet, and test operate the fuel feed pump.

6.1.8 Major faults and troubleshooting

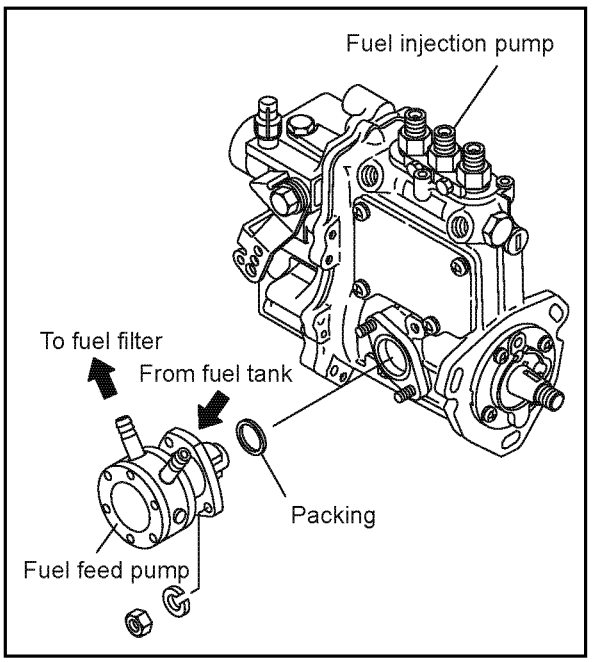
Fault		Cause	Remedy
1. Engine won't start	Fuel not delivered to injection pump	(1) No fuel in the fuel tank. (2) Fuel tank cock is closed. (3) Fuel pipe system is clogged (4) Fuel filter element is clogged (5) Air is sucked into the fuel due to defective connections in the piping from the fuel tank to the fuel pump. (6) Defective valve contact of feed pump (7) Piston spring of feed pump is broken. (8) Inter-spindle or tappets of feed pump are stuck	Re-supply Open Clean Disassemble and clean, or replace element Repair Repair or replace Replace Repair or replace
	Fuel delivered to injection pump.	(1) Defective connection of control lever and accel rod of injection pump. (2) Plunger is worn out or stuck. (3) Delivery valve is stuck (4) Control rack doesn't move (5) Injection pump coupling is damaged, or the key is broken.	Repair or adjust Repair or replace Repair or replace Repair or replace Replace
	Nozzle doesn't work.	(1) Nozzle valve doesn't open or close normally (2) Nozzle seat is defective. (3) Case nut is loose. (4) Injection nozzle starting pressure is too low (5) Nozzle spring is broken. (6) Fuel oil filter is clogged. (7) Excessive oil leaks from the nozzle sliding area.	Repair or replace Repair or replace Inspect and tighten Adjust Replace Repair or replace Replace the nozzle assembly
	Injection timing is defective.	(1) Injection timing is retarded due to failure of the coupling. (2) Camshaft is excessively worn. (3) Roller guide incorrectly adjusted or excessively worn. (4) Plunger is excessively worn.	Adjust Replace camshaft Adjust or replace Replace plunger assembly

Fault		Cause	Remedy
2. Engine starts, but immediately stops.		(1) Fuel pipe is clogged. (2) Fuel filter is clogged. (3) Improper air- tightness of the fuel pipe connection or pipe is broken and air is being sucked in. (4) Insufficient fuel delivery from the feed pump	Clean Disassemble and clean, or replace the element Replace packing repair pipe Repair or replace
3. Engine's output is insufficient.	Defective injection timing and other failures.	(1) Knocking sounds caused by improper (too fast) injection timing. (2) Engine overheats or emits large amount of smoke due to improper (to slow) injection timing. (3) Insufficient fuel delivery from feed pump.	Inspect and adjust Inspect and adjust Repair or replace
	Nozzle movements is defective.	(1) Case nut loose. (2) Defective injection nozzle performance. (3) Nozzle spring is broken. (4) Excessive oil leaks from nozzle.	Inspect and retighten Repair or replace nozzle Replace Replace nozzle assembly
	Injection pump is defective.	(1) Max delivery limit boll is screwed in too far. (2) Plunger is worn (3) Injection amount is not uniform. (4) Injection timings are not even. (5) The 1st and 2nd levers of the governor and the control rack or the injection pump are improperly lined up. (6) Delivery stopper is loose. (7) Delivery packing is defective. (8) Delivery valve seat is defective. (9) Delivery spring is broken.	Adjust Replace Adjust Adjust Repair Inspect and retighten Replace packing Repair or replace Replace
4. Idling is rough.		(1) Movement of control rack is defective. 1) Stiff plunger movement or sticking. 2) Rack and pinion fitting is defective. 3) Movement of governor is improper 4) Delivery stopper is too tight. (2) Uneven injection volume. (3) Injection timing is defective. (4) Plunger is worn and fuel injection adjustment is difficult. (5) Governor spring is too weak. (6) Feed pump can't feed oil at low speeds. (7) Fuel supply is insufficient at low speeds due to clogging of fuel filter.	 Repair or replace Repair Repair Inspect and adjust adjust adjust Replace Replace Repair or replace Disassemble and clean, or replace element
5. Engine runs at high speeds, but cuts out at low speeds.		(1) The wire or rod of the accel is caught. (2) Control rack is caught and can't be moved.	Inspect and repair Inspect and repair
6. Engine doesn't reach max. speed		(1) Governor spring is broken or excessively worn. (2) Injection performance or nozzle is poor	Replace Repair or replace

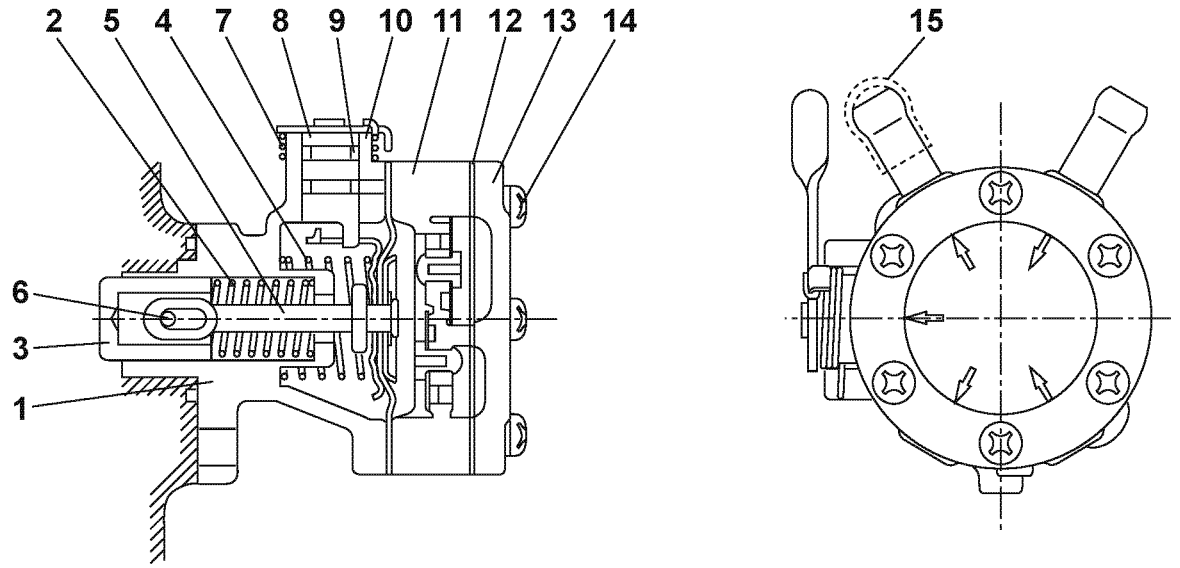
Fault		Cause	Remedy
7. Loud knocking.		(1) Injection timing is too fast or too slow. (2) Injection from nozzle is improper. Fuel drips after each injection. (3) Injection nozzle starting pressure is too high (4) Uneven injection. (5) Engine overheats, or insufficient compression.	Adjust Adjust Adjust Adjust Repair
8. Engine exhausts too much smoke.	When exhaust smoke is black:	(1) Injection timing is too fast. (2) Air volume intake is insufficient. (3) The amount of injection is uneven. (4) Injection from nozzle is improper.	Adjust Inspect and repair Adjust Repair or replace
	When exhaust smoke is white:	(1) Injection timing is too slow. (2) Water is mixed in fuel. (3) Shortage or lube oil in the engine. (4) Engine is over-cooled.	Adjust Inspect fuel system, and clean Repair Inspect

6.2 Fuel feed pump

The fuel feed pump feeds fuel from the fuel tank, passes it through the fuel filter element, and supplies it to the fuel injection pump.
The fuel feed pump is mounted on the side of this engine and is driven by the (eccentric) cam of the fuel pump camshaft. It is provided with a manual priming lever so that fuel can be supplied when the engine is stopped.



6.2.1 Construction of fuel feed pump



1. Bottom body
2. Piston spring
3. Piston
4. Diaphragm spring
5. Diaphragm assembly
6. Pin
7. Lever return spring
8. Lever assembly
9. O-ring
10. Stop pin
11. Top body assembly
12. Packing
13. Cover
14. Small screw
15. Cap

001565-00E

6.2.2 Fuel feed pump specifications

Head	1m
Discharge volume	230 cm^3/min at 1500 min^{-1} (cam), discharge pressure of 0.020 MPa (0.2 $kgf/cm^{2)}$
Closed off pressure	0.029 MPa (0.3 $kgf/cm^{2)}$ or more at 400 min^{-1} (cam)

6.2.3 Disassembly and reassembly of fuel feed pump

(1) Disassembly

1) Remove the fuel feed pump mounting nut, and take the fuel feed pump off the fuel injection pump.
2) Clean the fuel feed pump assembly with fuel oil.
3) After checking the orientation of the arrow on the cover, make match marks on the upper body and cover, remove the small screw, and disassemble the cover, upper body and lower body.

(2) Reassembly

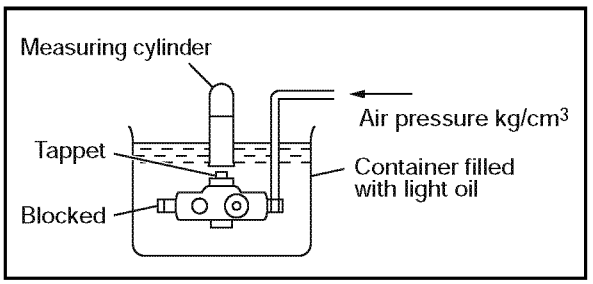
1) Clean all parts with fuel oil, inspect, and replace any defective parts.
2) Replace any packing on parts that have been disassembled.
3) Make sure that the intake valve and discharge valve on upper body are mounted in the proper direction , and that you don't forget the valve packing.
4) Assemble the diaphragm into the body, making sure the diaphragm mounting holes are lined up (do not force).
5) Align the match marks on the upper body of the pump and cover, and tighten the small screws evenly.

N•cm(kgf•cm)

Tightening torque	147-245 (15-25)

6.2.4 Fuel feed pump inspection

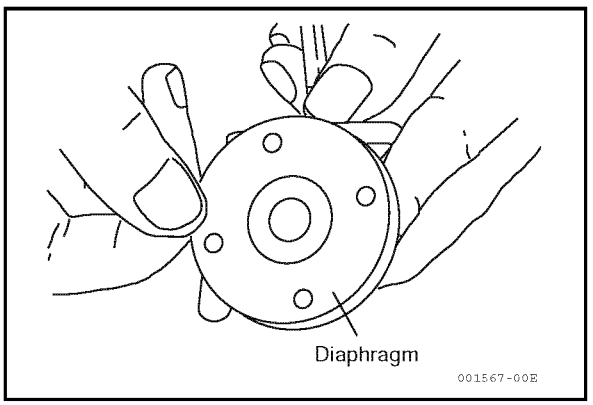
(1) Place the fuel feed pump in kerosene, cover the discharge port with your finger, move the priming lever and check for air bubbles (Repair or replace any part which emits air bubbles).



(2) Attach a vinyl house to the fuel feed pump intake, keep the pump at the specified depth from the fuel oil surface, move the priming lever by hand and check for sudden spurts of fuel oil from the discharge port. If oil is not spurted out, inspect the diaphragm and diaphragm spring and repair/replace as necessary.

(3) Diaphragm inspection

Parts of the diaphragm that are repeatedly burned will become thinner or deteriorate over a long period of time.
Check the diaphragm and replace if necessary.

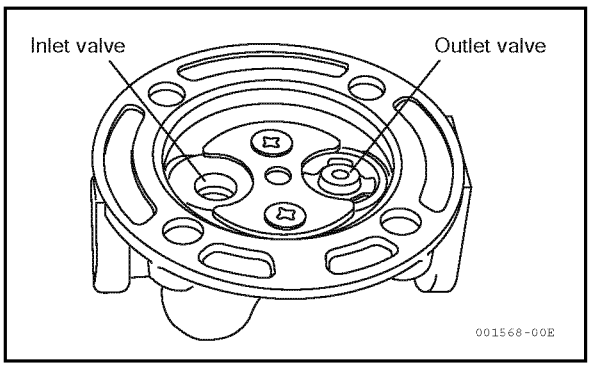


(4) Valve contact/mounting

Clean the valve seat and valve with air to remove any foreign matter.

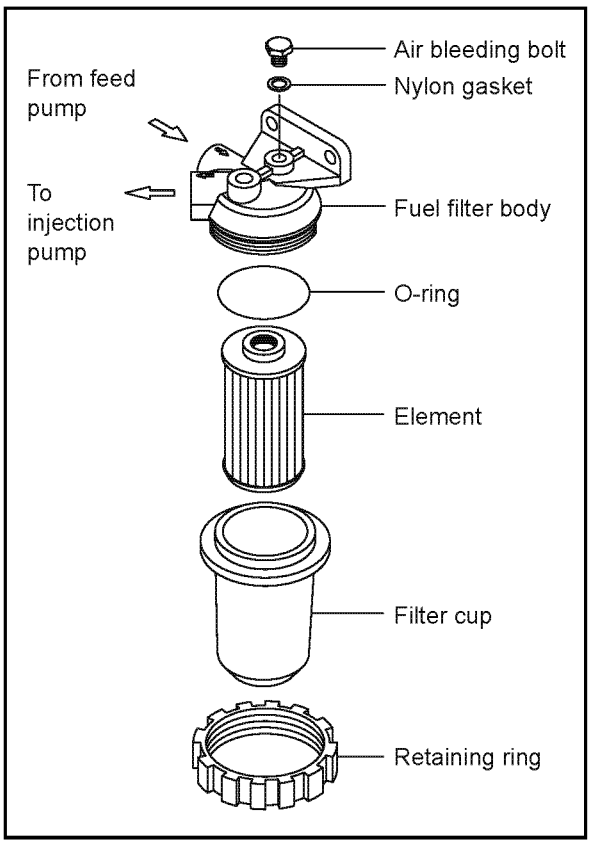
(5) Inspect the diaphragm spring and piston spring for settling and the piston for wear, and replace as necessary.

NOTE: Replace parts as an assembly.



6.3 Fuel filter

The fuel filter is installed between the feed pump and injection pump, and serves to remove dirt and impurity from the fuel 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 impurity 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.
Loosen the bolt fitted to the fuel filter body before starting or after dismantling and reassembly to bleed the air in the fuel system to the fuel filter.



6.3.1 Fuel filter specifications

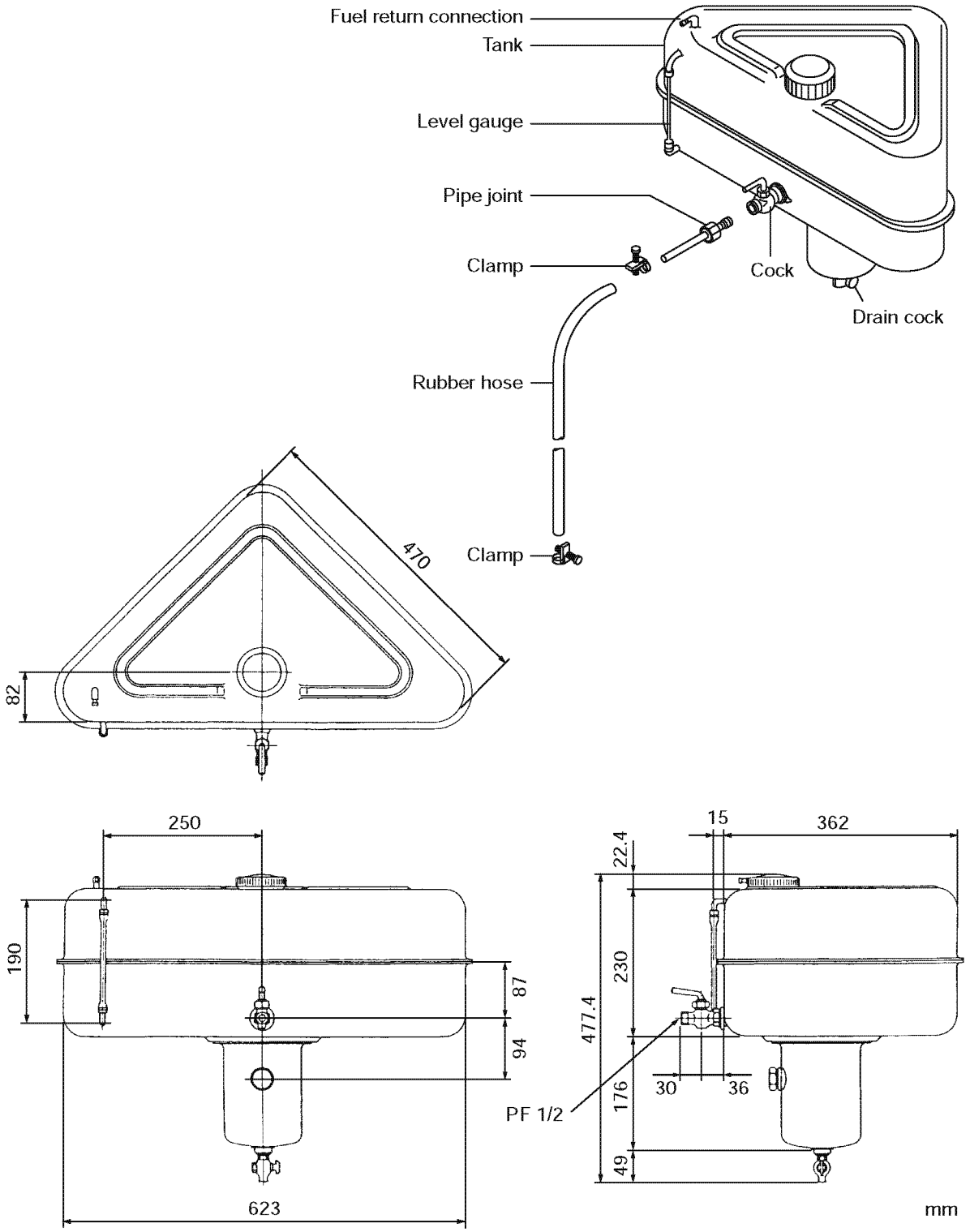
Filtering area	333 cm^2 (20.3 $in.^2$)
Material of element	Cotton fiber
Filter mesh	10-15 μ

6.3.2 Fuel filter 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 250 hours, but the element should be replaced whenever it is dirty or damaged, even if the 250 hour replacement period has not elapsed.

6.4 Fuel tank

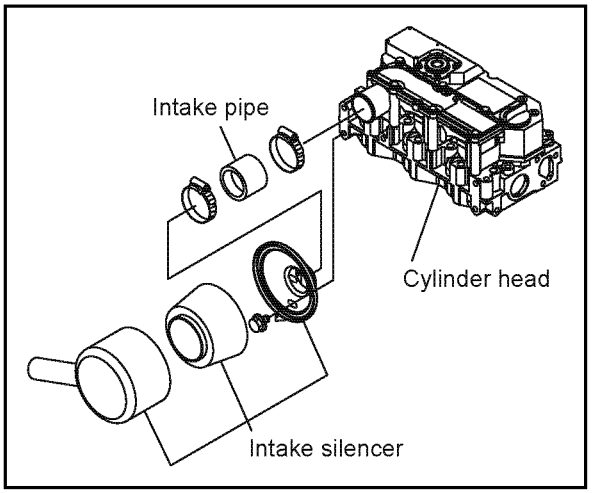
A triangular 30 liter fuel tank with a 2000mm (78.7402 in.) rubber fuel hose to fit all models is available as an option.
A fuel return connection is provided on top of the tank of which a rubber hose can be connected to return fuel from the fuel nozzles.



7. Intake and exhaust system

7.1 Intake system

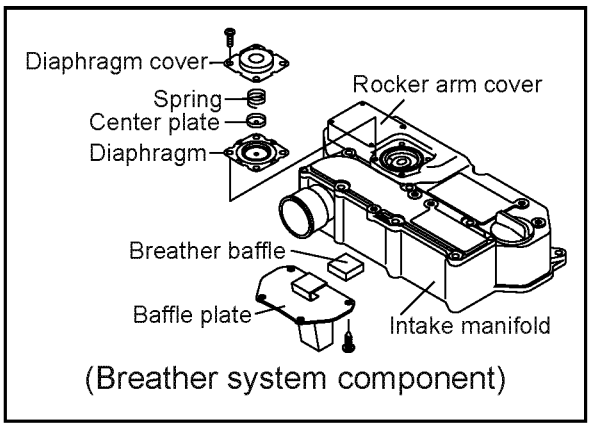
Air enters in the intake silencer mounted at the end of the intake manifold (rocker arm cover). It is fed to the intake manifold and then on to each cylinder.
Exhaust gas goes into exhaust manifold (in the fresh water tank) mounted on the cylinder head outlet. After cooling, the exhaust gas enters the mixing elbow, which is directly connected with the exhaust manifold, and is discharged from the ship along with seawater.
When the inside of the intake manifold becomes dirty, intake air resistance is increased and reduces engine power. Periodically check the inside of the intake manifold. In the same way, the intake air silencer should be checked for dirt periodically and cleaned.
Care should also be taken to insure there is no air leakage.
Do not operate with the intake air silencer removed.



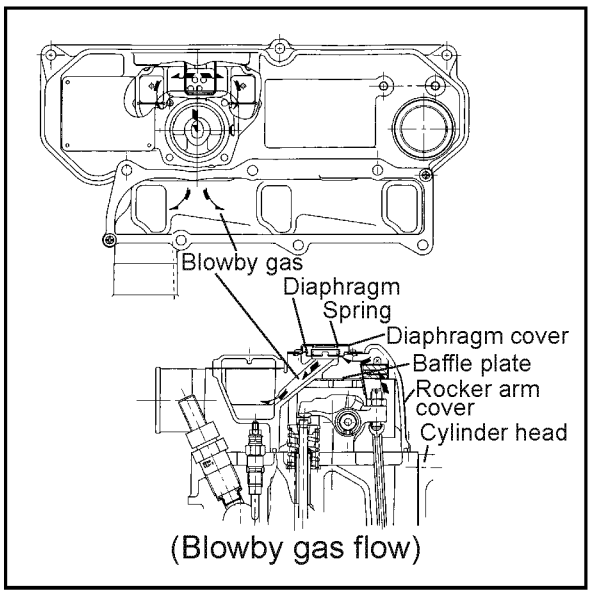
7.1.1 Breather system (A reductor to intake air system of blowby gas)

Emitting blowby gas is harmful to natural environment. Therefore blowby gas reductor is adopted as breather system.
Some of the combustion gas passes through the clearance between cylinder and piston, and flows to the crankcase. This is said as blowby gas. While it passes into cylinder head and rocker arm cover, the blowby gas mixes with splash oil, and becomes oil mist-blowby gas. The gas passes through the baffle plate inside a rocker arm cover. And it passes through a diaphragm assy, and reaches a intake silencer. The gas is reduced in the combustion chamber.
Pressure inside a crankcase is controlled by the function of the diaphragm assy, and suitable amount of blowby gas is reduced in intake air system.

[Disassemble]
When a rocker arm cover is taken off, check whether oil or the like enter the diaphragm space from a small hole on the side of a diaphragm cover or not without disassembling the diaphragm.



(Breather system component)



(Blowby gas flow)

[NOTICE]

1) When a diaphragm is damaged, pressure control inside the crankcase becomes insufficient, and troubles occur. When the internal pressure of the crankcase decreases too much due to the damage of a spring, much blowby gas containing oil is reduced in intake air system, and it may cause the combustion defect by the early dirt of the intake valve or the urgent rotation of the engine by the oil burning.
   When pressure progresses in the crank case too much due to the wrong operation of the diaphragm and so on, it is considered that oil leakage from the joint of a oil pan, a oil seal and so on will occur. When a diaphragm is damaged, blowby is discharged from the breathing hole on the side of diaphragm cover, and not reduced in the intake manifold. Therefore, be careful of the diaphragm trouble.
2) At lubricating oil replacement or lube oil supply
   The amount of lubricating oil isn't to be beyond the standard upper limit (in the engine horizontality, the upper limit mark of the dipstick). Since the blowby gas reductor is adopted, be careful that the amount of oil mist may be inducted in the combustion chamber and the oil hammer sometimes may occur, when the lubricating oil quantity is beyond the upper limit or an engine is operated beyond the allowable maximum angle of an engine.

[Reassembly]

Replace the diaphragm with new one, when it is damaged.

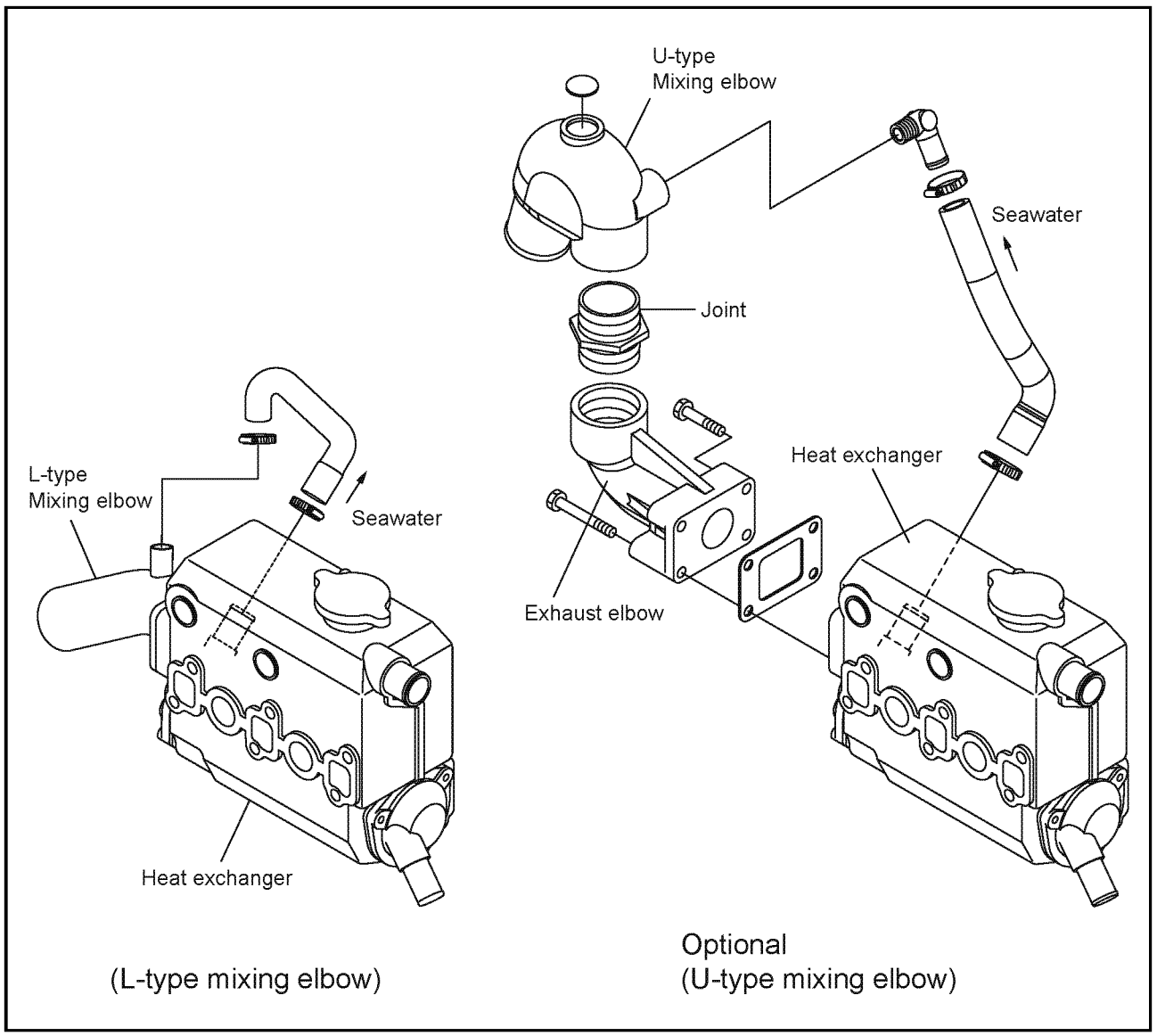
7.1.2 Diaphragm assy inspection

Refer to 2.2.6(5) for the inspection procedure.

7.2 Exhaust system

7.2.1 Construction

There are two types of mixing elbows, the L-type and the U-type. The mixing elbow is attached to the exhaust manifold.



7.2.2 Mixing elbow inspection

(1) Clean dirt and scale out of the gas and cooling water lines.

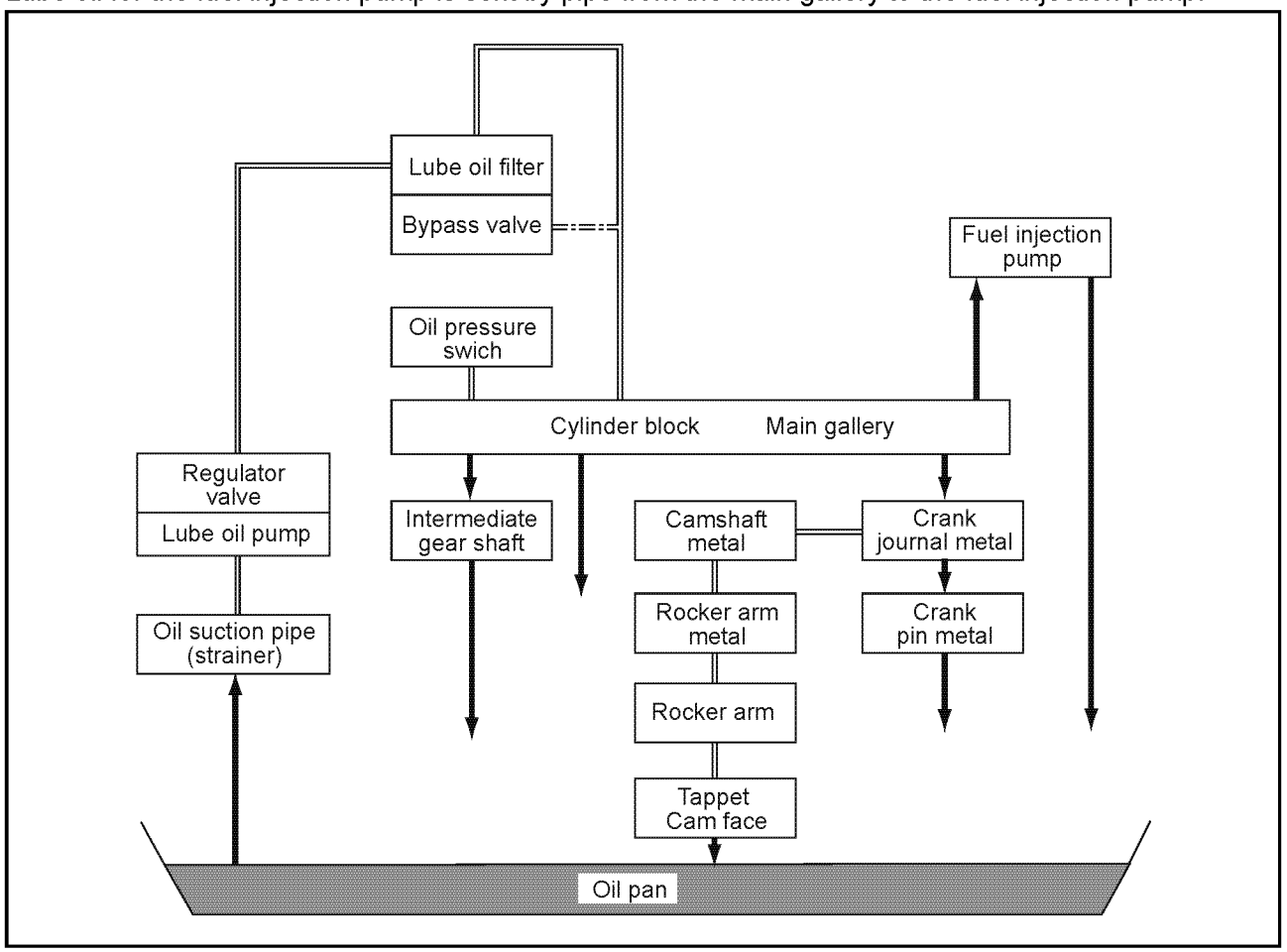
(2) Repair crack or damage to welds, or replace.

(3) Inspect the gasket packing and replace as necessary.

8. Lubrication system

8.1 Lubrication system

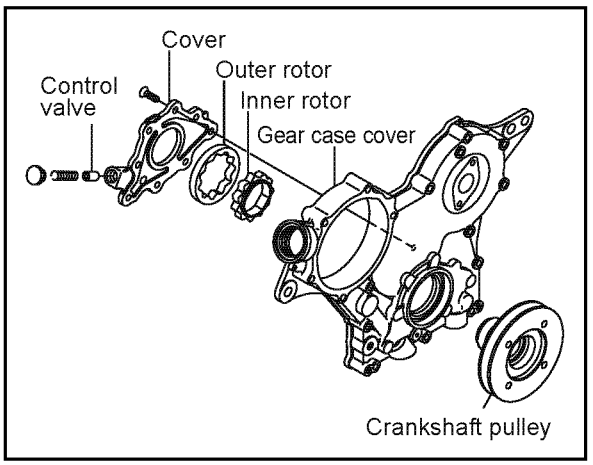
The lube oil in the oil pan is pumped up through the intake filter and intake piping by the lube oil pump, through the holes in the cylinder body and on to the lube oil pump, through the holes in the cylinder body and on to the discharge filter.
The lube oil, which flows from the holes in the cylinder body through the bracket to the oil element, is filtered. The oil pressure is regulated, and lube oil is fed back to main gallery in the cylinder body.
The lube oil which flows in the main gallery goes to the crankshaft journal, lubricates the crank pin from the crankshaft journal, and a option of the oil is fed to the camshaft bearings.
Oil is sent from the gear case camshaft bearings through the holes in the cylinder body and cylinder head to the valve arm shaft to lubricate the valve arm and valves.
Oil is also sent through the intermediate gear bearing (oil) holes to lubricate the intermediate gear bearings and respective gears.
Lube oil for the fuel injection pump is sent by pipe from the main gallery to the fuel injection pump.



8.2 Lube oil pump

8.2.1 Lube oil pump construction

The trochoid type lube oil pump is mounted in the gear case cover, and the inner rotor is driven by the crankshaft pulley.
The lube oil flows from the intake filter mounted on the bottom of the cylinder body through the holes in the cylinder body and engine plate, and out from the holes in the engine plate and cylinder body to the discharge filter.
The lube oil pump is fitted with a control valve, which controls the discharge oil pressure at the specified pressure.



8.2.2 Specifications of lube oil pump

Lube oil pump specifications

Engine speed	3600 (min^{-1})	800 (min^{-1})
Pump speed	3477 (min^{-1})	772 (min^{-1})
Delivery quantity	≧19.0 (l/ min^{-1})	≧8.0 (l/ min^{-1})
Delivery pressure	0.43 MPa (4.4 kgf/cm^2)	≧0.049 MPa (0.5 kgf/cm^2)
Oil temp.	60±5 (°C)	←

8.2.3 Lube oil pump disassembly and reassembly

Disassembly

(1) Remove the crankshaft pulley.

(2) Remove the gear case cover.

(3) Remove the lube oil pump cover from the gear case cover. Do not disassemble the inner /outer rotors, and check that the pump rotates smoothly.

(4) Remove the pressure control valve from the lube oil pump cover.

Note :
Only wash the control valve. Disassembly is unnecessary unless any abnormality in operation is detected.

Reassembly

[NOTICE]
Always check if the pump rotates smoothly after installation on the gear case.
Running the engine when the pump rotation is heavy may cause the pump to be burnt.

(1) Apply lube oil to rotor (outer/inner) insertion part.

(2) Fasten the pump cover by the standard torque.

Tightening torque	5.9-7.9 N•m (0.6-0.8 kgf•m)

(3) When replacing the lube oil pump, replace the whole assy.

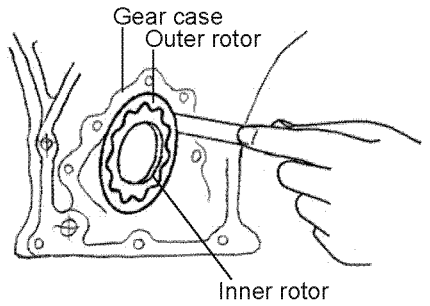
8.2.4 Lube oil pump inspection

(1) Outside diameter clearance and side clearance of outer rotor

Insert a gap gauge between the outer rotor and the gear case cover, and measure outside diameter gap.
Put a ruler on the end face of the gear case cover, and insert a gap gauge between rotor, and measure a side gap.

Outside clearance mm

Standard	Limit
0.12-0.21	0.30



(Outer diameter clearance)

(2) Tip clearance between outer rotor and inner rotor

Insert a gap gage between an outer rotor and an inner rotor, and measure the tip clearance.

Tip clearance mm

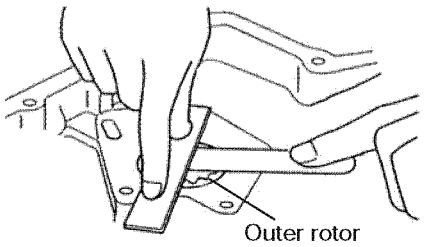
Standard	Limit
-	0.16

(3) Side clearance

When measuring a side clearance, put a right-angle gage to the pump body, insert a gap gage and measure the clearance.

Side clearance mm

Standard	Limit
0.02-0.07	0.12



(Side clearance)

(4) Outside diameter clearance of inner rotor centering location part

Measure the outside diameter of inner rotor centering location part and the hole diameter of gear case cover. Calculate the clearance from that difference.

Inspection item	Standard	Limit
Gear case cover I.D.	46.13-46.18	-
Inner rotor O.D.	45.98-46.00	-
Rotor clearance	0.13-0.20	0.25

8.2.5 Pressure control valve construction

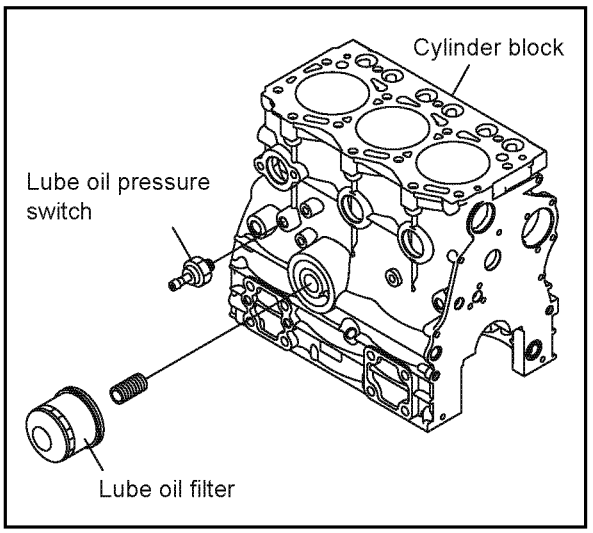
The pressure control valve controls the oil pressure from the time the lube oil leaves the filter.
When the pressure of lube oil entering the cylinder body main gallery exceeds the standard, the control valve piston opens the bypass hole and lube oil flows back into the oil pan.

Standard oil pressure	0.29-0.44 MPa (3.0-4.5 kgf/cm^2)

8.3 Lube oil filter

8.3.1 Lube oil filter construction

The lube oil filter is a full-flow paper element type mounted to the side of the cylinder block. The cartridge type filter is easy to remove.
To prevent seizure in the event of the filter clogging up, a bypass circuit is provided in the oil filter. When the difference of the pressure in front and behind the paper element reaches 0.08-0.12 MPa (0.8-1.2 kgf/cm^2), the bypass valve inside the filter opens and the lube oil is sent to each part automatically as an emergency measure, without passing through the filter.



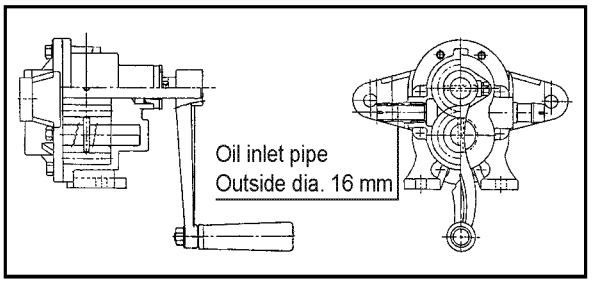
Type	Full flow, paper element
Filtration area	0.10 m^2
Discharge volume	30 l/min
Pressure loss	0.03-0.05 MPa (0.3-0.5 kgf/cm^2)
By-pass valve regulating pressure	0.08-0.12 MPa (0.8-1.2 kgf/cm^2)

8.3.2 Lube oil filter replacement

Refer to 2.2.2(2).

8.4 Rotary waste oil pump (Optional)

A rotary waste oil pump to pump out waste oil is available as an option.



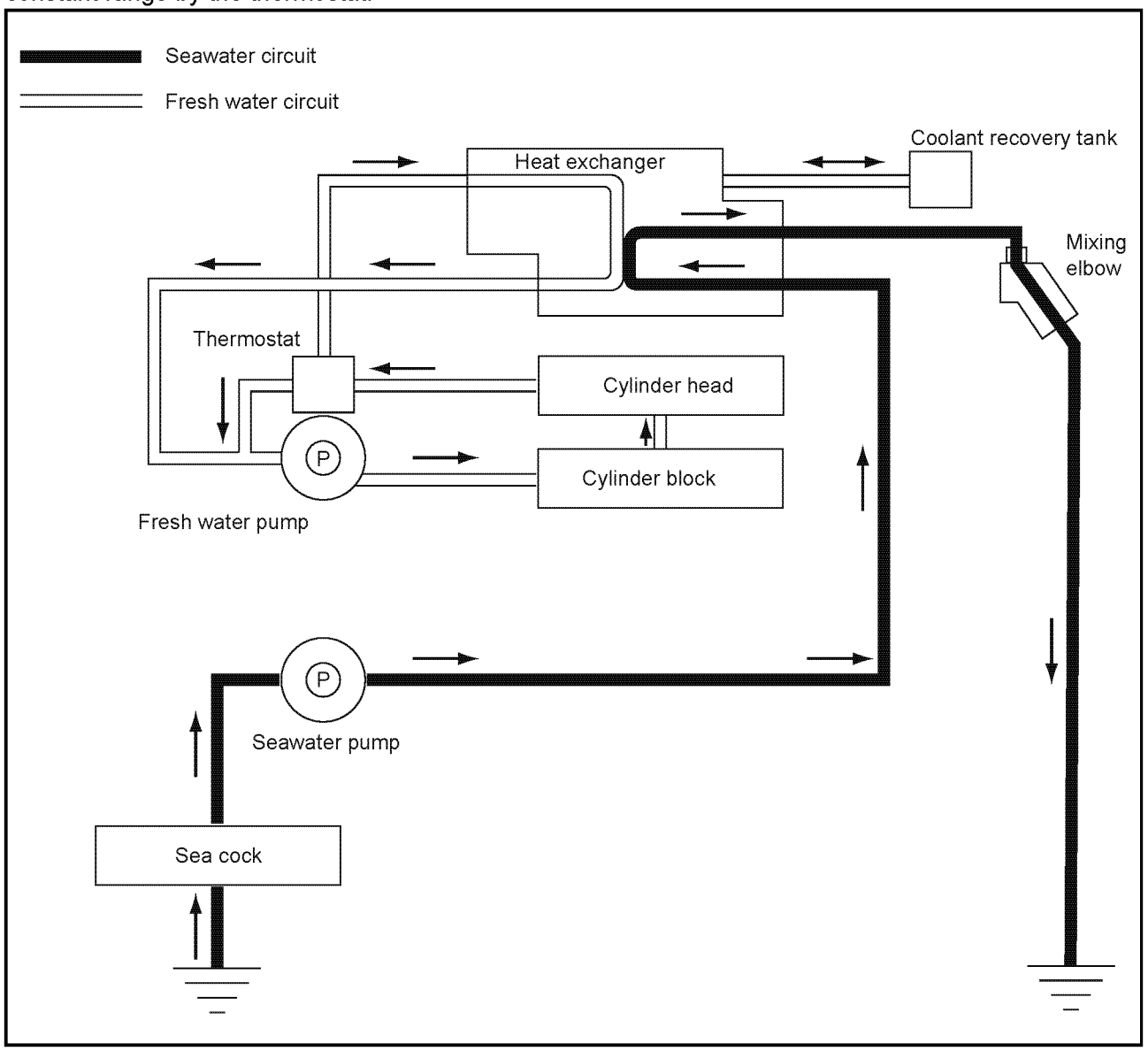
Rotary waste oil pump

Delivery capacity per one revolution	0.057 L
Delivery pressure	0.15 MPa (1.5 kg/cm^2) or below
Suction head	less than 1m
Part No.	124413-39100

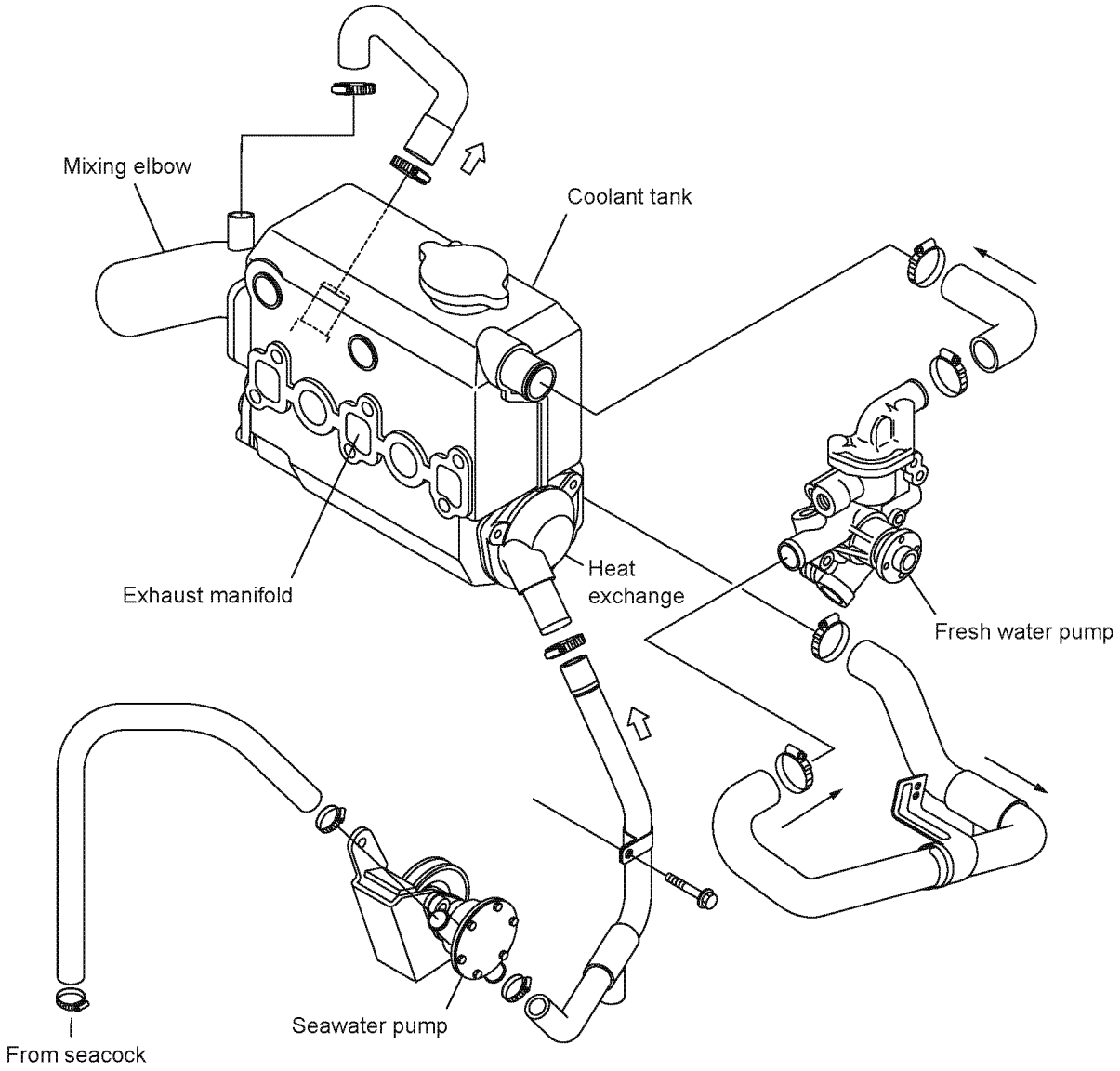
9. Cooling water system

9.1 Cooling water system

The cooling water system is of the indirect seawater cooled, fresh water circulation type. The cylinders, cylinder heads and exhaust manifold are cooled with fresh water, and fresh water cooler (heat exchanger) use seawater.
Seawater pumped in from the sea by the seawater pump goes to the heat exchanger, where it cools the fresh water. Then it is sent to the mixing elbow and is discharged from the ship with the exhaust gas.
Fresh water is pumped by the fresh water pump to the cylinder jacket to cool the cylinders and the cylinder head. The fresh water pump body also serves as a discharge passageway (line) at the cylinder head outlet and is fitted with a thermostat.
The thermostat is closed when the fresh water pump temperature is low, immediately after the engine is started and during low load operation, etc. Then the fresh water flows to the fresh water pump inlet, and is circulated inside the engine without passing through the heat exchanger.
When the temperature of the fresh water rises, the thermostat opens, fresh water flows to the heat exchanger, and it is then cooled by the seawater in the tubes as it flows through the cooling pine. The temperature of it flows through the cooling pine. The temperature of the fresh water is thus kept within a constant range by the thermostat.



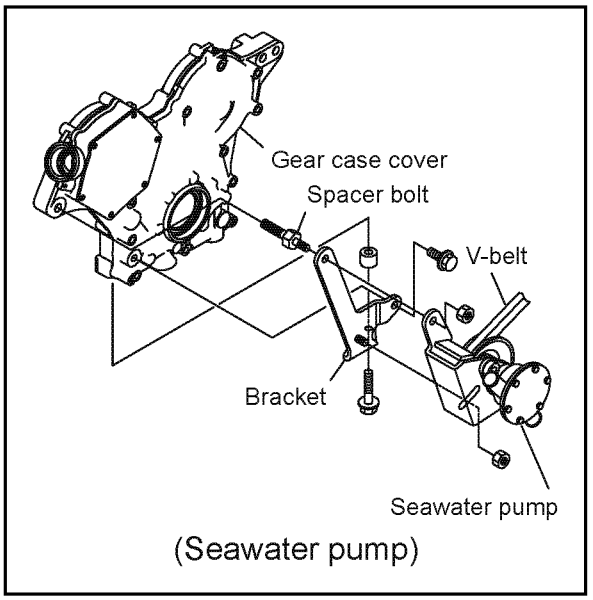
Cooling water line



(Cooling water pipes)

9.2 Seawater pump

The seawater pump is driven by a V-belt.



(Seawater pump)

9.2.1 Specifications of seawater pump

Performance

Flow	Min. 1650 L/h at engine speed 3600 min^{-1}

9.2.2 Seawater pump disassembly

Refer to 2.2.5.(5).

(1) Remove the rubber hose from the seawater pump outlet and then remove the seawater pump assembly from the gear case cover.

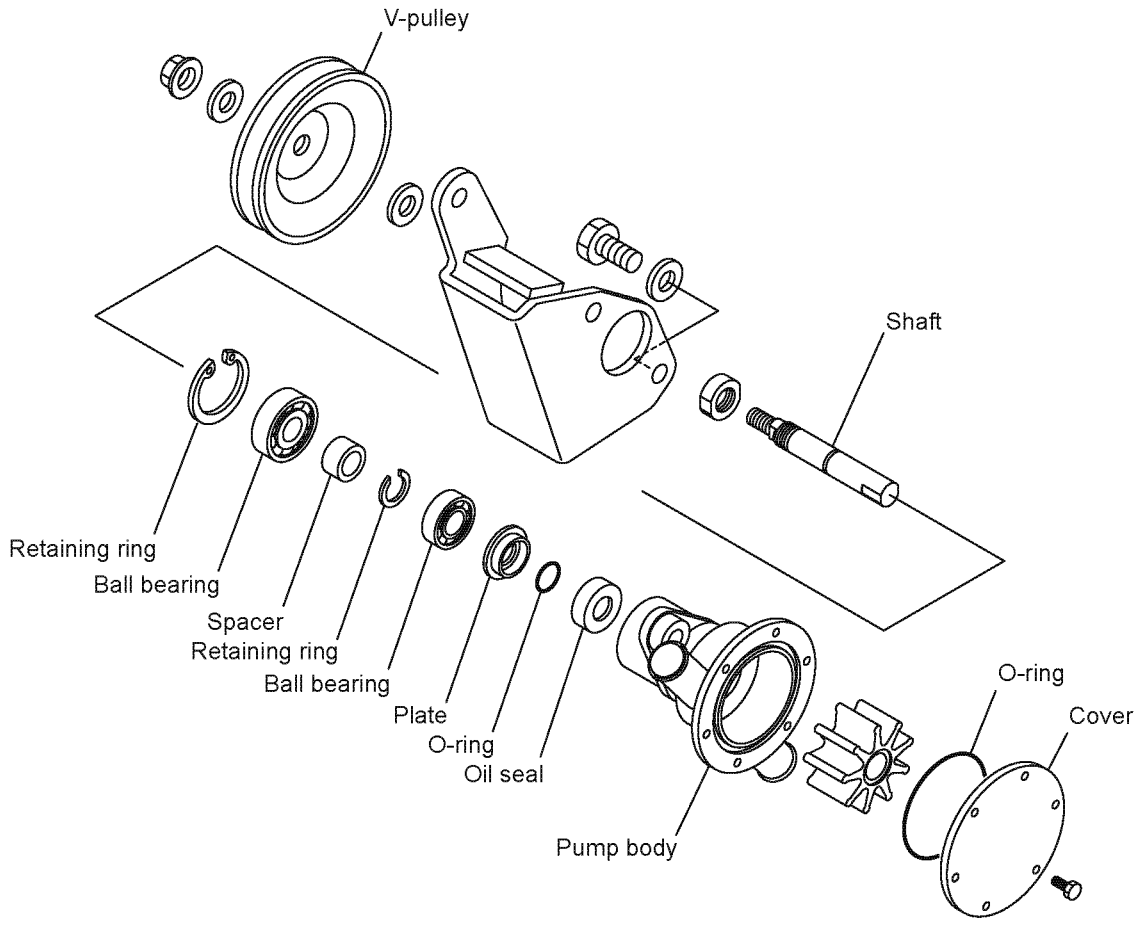
(2) Remove the seawater pump cover and take out the O-ring, and impeller.

(3) Remove the oil seal and the pump shaft if necessary.

9.2.3 Seawater pump Inspection

(Refer to 2.2.4(5).)

(1) Inspect the rubber impeller, checking for splitting around the outside, damage or cracks, and replace if necessary.



(Seawater pump)

(2) Inspect the oil seal and replace if it is damaged. Also replace the oil seal if there is considerable water leakage during operation.

Cooling water leakage	less than 3 cm^3/h

(3) Make sure the ball bearings rotate smoothly. Replace if there is excessive play.

9.2.4 Seawater pump reassembly

(1) When replacing the oil seal, coat with grease and insert.

(2) Mount the pump shaft, ball bearing and V-pulley to the pump unit and fit the bearing retaining ring.

NOTE:
Coat the shaft with grease.

(3) Mount the impeller.

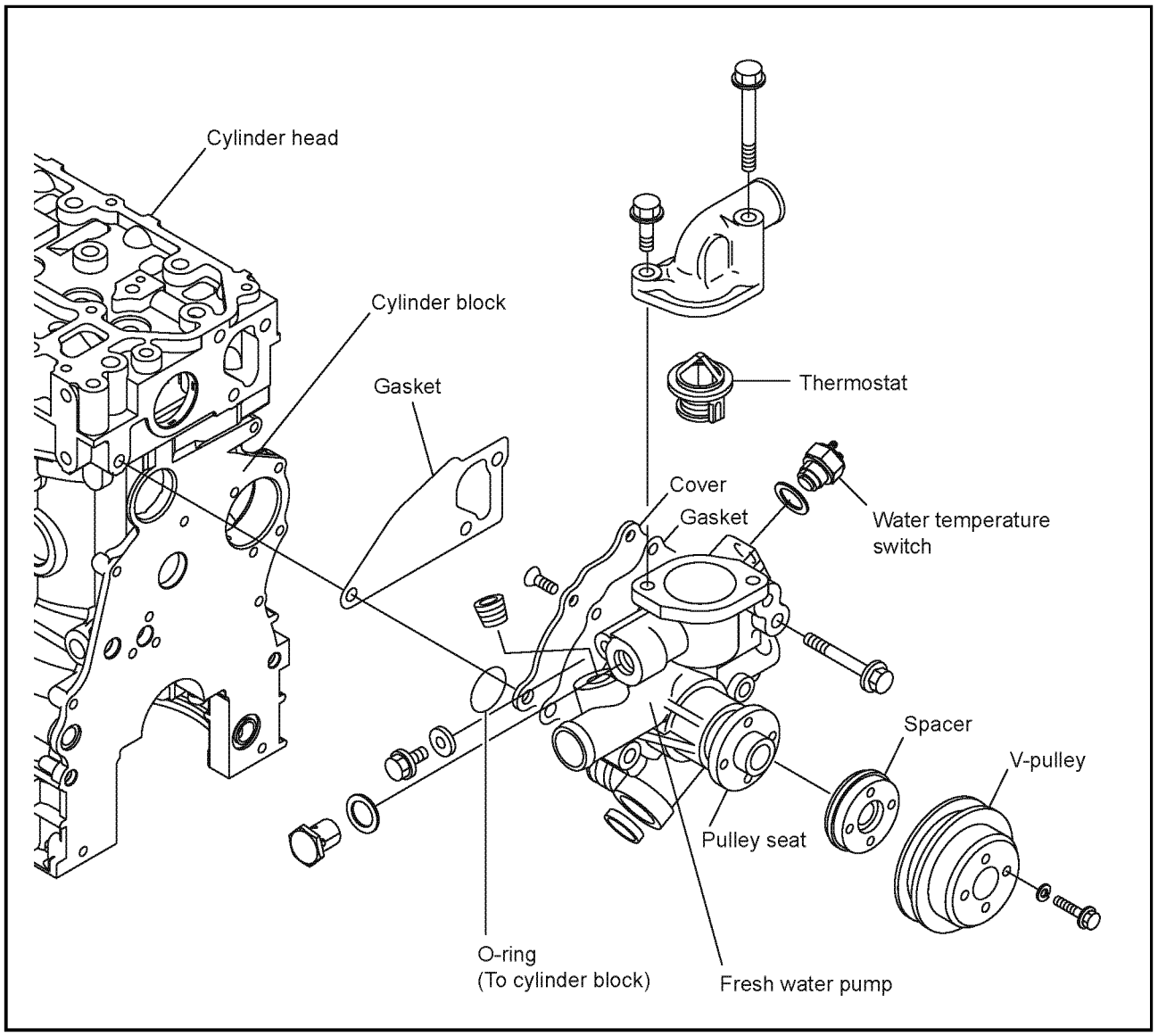
(4) Mount the O-ring and the cover.

NOTE:
Replace the O-ring with new one.

9.3 Fresh water pump

9.3.1 Fresh water pump construction

The fresh water pump is of the centrifugal (volute) type, and circulates water from the fresh water tank to the cylinder block and the cylinder head.
The fresh water pump consists of the pump body, impeller, pump shaft, bearing unit and mechanical seal. The V-pulley on the end of the pump shaft is driven by a V-belt.
The bearing unit assembled in the pump shaft uses grease lubricated ball bearings and cannot be disassembled.



9.3.2 Specifications of fresh water pump

Pump shaft speed	3860 ± 30 min^{-1}
Delivery capacity	66.7 L/min or more
Total head	4 m Aq

9.3.3 Fresh water pump disassembly

(1) Do not disassemble the fresh water pump. It is difficult to disassemble and, once disassembled, even more difficult to reassemble. Replace the pump as an assembly in the event of trouble. When the fresh water pump and the cover are disassembled, retighten to the specified torque.

Tightening torque	9.3-11.3 N•m (0.95-1.2 kgf•m)

(2) When removing the fresh water pump, replace the O-ring (inlet to cylinder).

9.3.4 WFresh water pump inspection

(1) Bearing unit inspection
Rotate the impeller smoothly. If the rotation is not smooth or abnormal noise is head due to excessive bearing play or contact with other parts, replace the pump as an assembly

(2) Impeller inspection
Check the impeller blade, and replace if damaged or corroded or if the impeller blade is worn due to contact with pump body.

(3) Check the holes in the cooling water and bypass lines, clean out any dirt or other foreign matter and repair as necessary.

(4) Replace the pump as an assembly if there is excessive water leakage due to mechanical seal or impeller seal wear or damage.

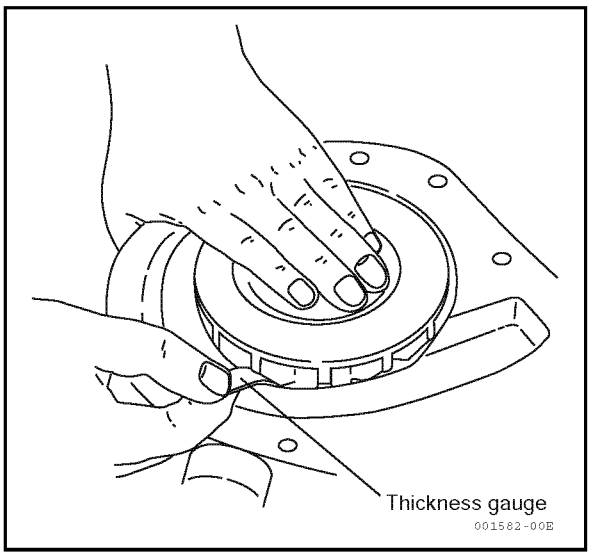
(5) Inspect the fresh water pump body, clean off scale and rust, and replace if corroded.

(6) Measure the outside clearance between the impeller and the pump body, by pushing the impeller all the way towards the body, and inserting a thickness gauge diagonally between the impeller and the body.
Measure the side clearance between the impeller and the plate by placing a straight-edge against the end of the pump body and inserting a thickness gauge between the impeller and the straight-edge.

Measuring outside clearance between impeller and pump body.

mm

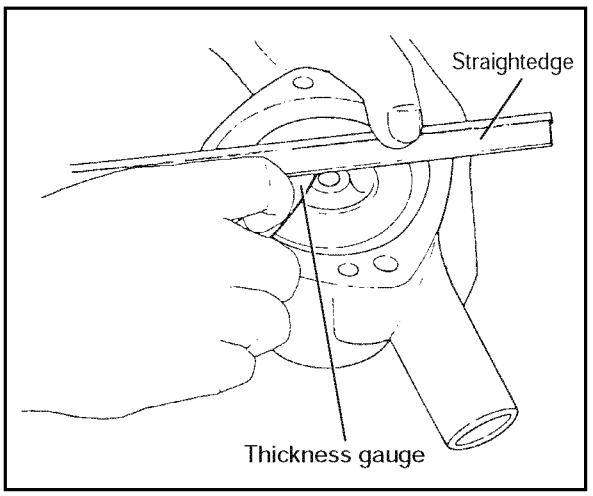
	Standard	Limit
Outside clearance between impeller and body	0.3-1.1	1.5



Measuring side clearance between impeller and plate.

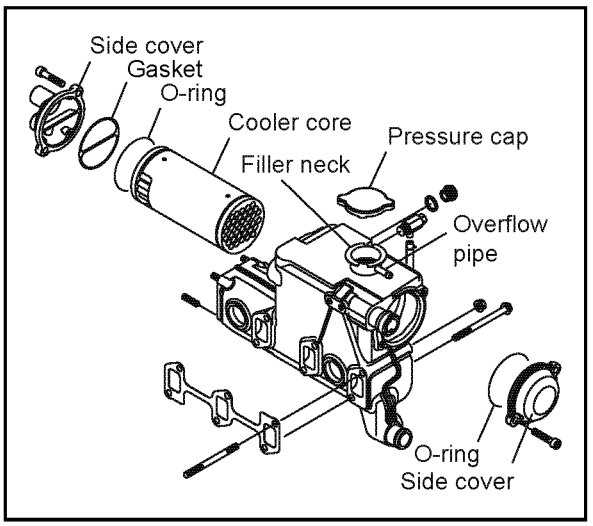
mm

	Standard	Limit
Side clearance between impeller and plate	0.5	-



9.4 Heat exchanger

9.4.1 Heat exchanger construction



The heat exchanger cools the hot fresh water, that has cooled the inside of the engine, with seawater.
The cooler core consists of many small diameter tubes, baffle plates and tube cover.
The seawater flows through the maze formed by the baffle plates.
There is a reservoir above the cooler core, which serves as the fresh water tank.
There is an exhaust gas passageway in the reservoir, which forms a water cooled exhaust manifold.
The pressure cap (filler cap) on top of the heat exchanger has a pressure valve, which lets off steam through the overflow pipe when pressure in the fresh water system exceeds the specified value. It also takes in air from the overflow pipe when pressure in the fresh water system drops below the normal value.

9.4.2 Disassembly and reassembly of the heat exchanger

(1) Remove the side covers on both sides of the cooler core and take out the cooler core and O-ring(s).

NOTE:
Replace the O-ring(s) when you have removed the cooler core.

(2) Remove the pressure cap.

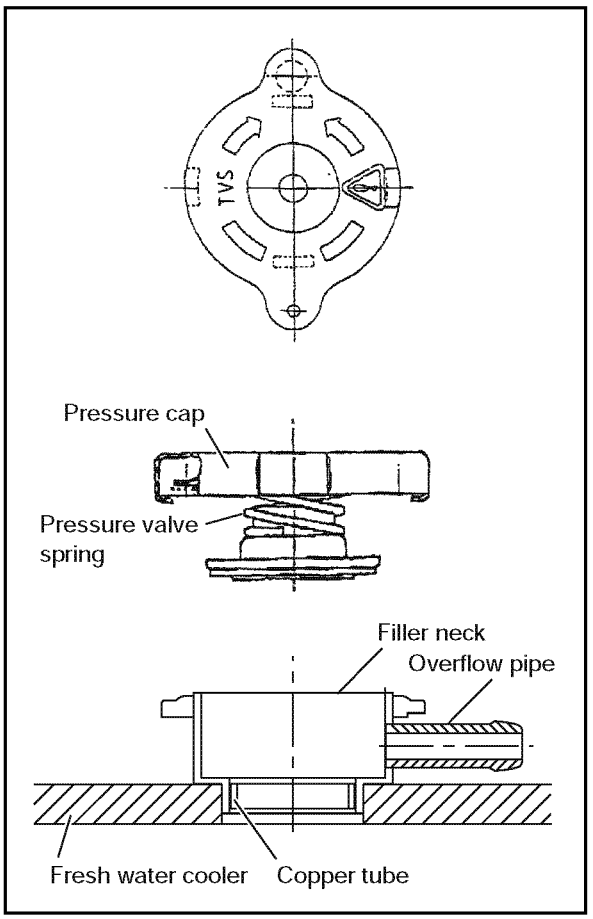
9.4.3 Heat exchanger inspection

Refer to 2.2.6(4).

9.5 Pressure cap and coolant recovery tank

9.5.1 Pressure cap construction

The pressure cap mounted on the filler neck incorporates a pressure control valve. The cap is mounted on the filler neck cam by placing it on the rocking tab and rotating. The top seal of the cap seals the top of the filler neck, and the pressure valve seals the lock seat.



9.5.2 Pressure cap pressure control

The pressure valve and the vacuum valve seal both the valve seats, when the pressure in the fresh water system is within the specified value of 88 kPa (0.9 kgf/cm^2). This seals the fresh water system.
When the pressure within the fresh water system exceeds the specified value, the pressure valve opens, and steam is discharged through the overflow pipe. When the fresh water is cooled and the pressure within the fresh water system drops below the normal value, atmospheric pressure opens the vacuum valve, and air is drawn in through the overflow pipe.

The coolant recovery tank (which sill be described later), keeps the water level from dropping due to discharge of steam when the pressure valve opens.

Action of pressure control valve

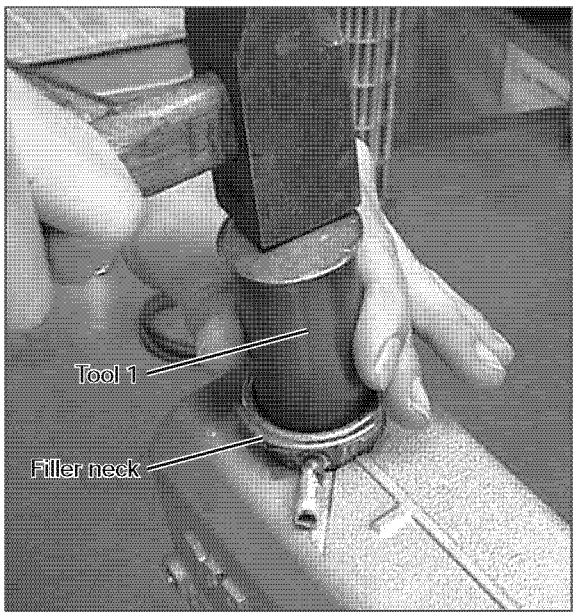
Pressure valve	Open at 82-109 kPa (0.84-1.11 kgf/cm^2, 0.82-1.09 bar)
Vacuum valve	Open at 8 kPa (0.08 kgf/cm^2) or below

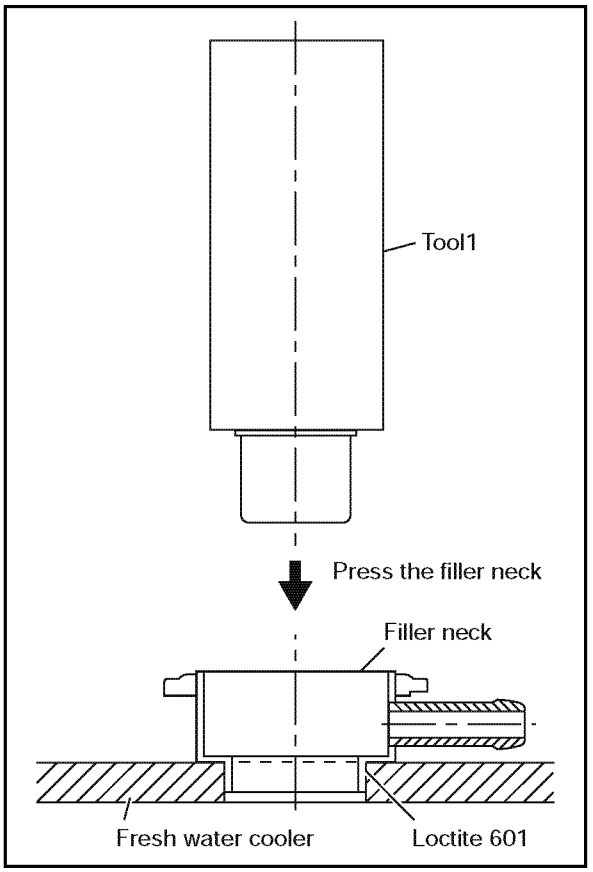
9.5.3 Pressure cap inspection

Refer to 2.2.6(4).

9.5.4 Replacing filler neck

1) Take out the copper pipe inside the filler neck with striking a circumference with a driver and so on. When the filler neck is removed, remove it with being careful not to damage the fresh water cooler, and scrap it.
2) Clean both new filler neck and the insertion part of fresh water cooler. Apply T7471 type activator or equivalent on both the surfaces and let it evaporate.
3) Apply Loctite 603 (improved 601) glue or equivalent on filler neck outside contour and press the filler neck into the fresh water cooler with the special tool.





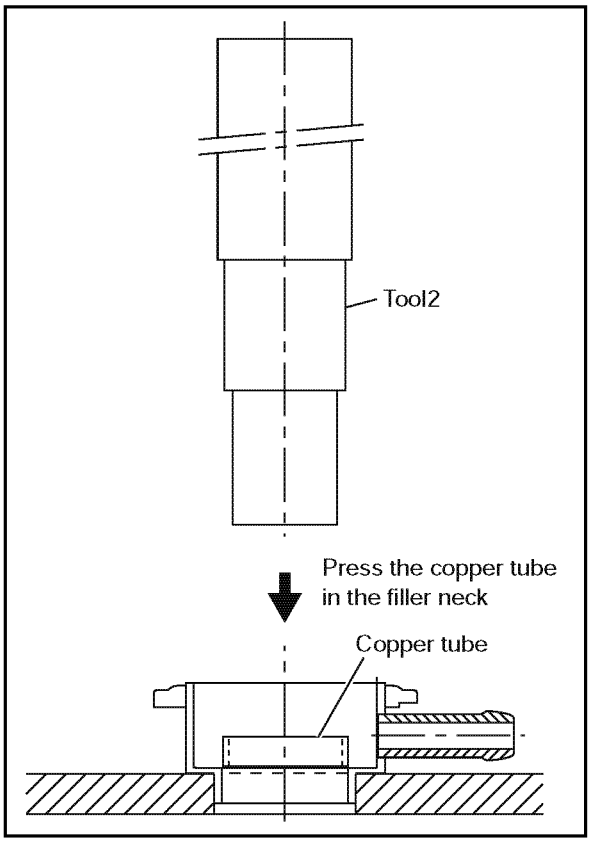
4) To fix the filler neck on the fresh water cooler, press the small copper tube inside the filler neck with the special tool.

Note:
The top of this tube should be under the sealing surface of the filler neck for the pressure cap.

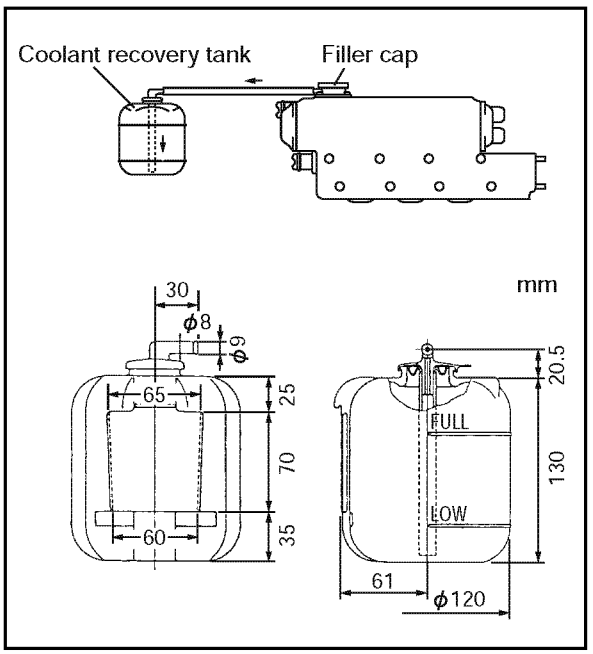
5) Fit the pressure cap on the filler neck.

Filler neck Part No.	Copper tube Part No.
129673-44110	129673-44150

Refer to 4.2.2 for tool 1 and tool 2.



9.5.5 Function of the coolant recovery tank



The pressure valve opens to discharge steam when the steam pressure in the fresh water tank exceeds 90 kPa (0.9 kgf/cm^2).
This consumes water. The coolant recovery tank maintains the water level by preventing this discharge of water.
The steam discharged into the coolant recovery tank condenses into watch, and the water level in the tank rises.
When the pressure in the fresh water system drops below the normal value, the water in the coolant recovery tank is sucked back into the fresh water tank to raise the water back to its original level.
The coolant recovery tank facilitates long hours of operation without water replacement and eliminates the possibility of burns when the steam is ejected from the filler neck because the pressure cap does not need to be removed.

9.5.6 Specifications of coolant recovery tank

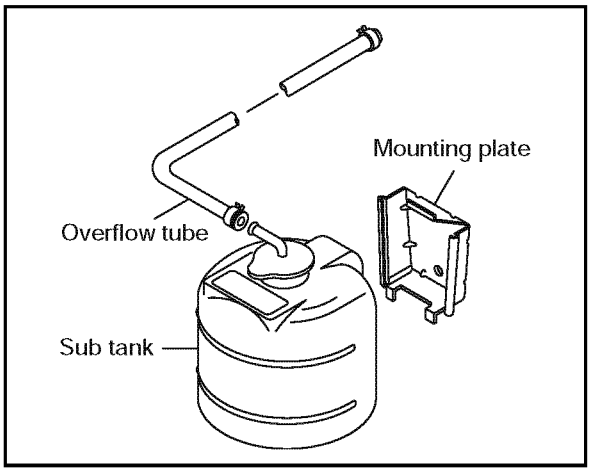
Capacity of coolant recovery tank	Overall capacity	1.3 L
	Full-scale position	0.8 L
	Low-scale position	0.2 L

9.5.7 Mounting the coolant recovery tank

(1) The coolant recovery tank is mounted at approximately the same height as the heat exchanger (fresh water tank).
(allowable difference in height : 300 mm (11.8110 in.) or less)

(2) The overflow pipe should be less than 1000 mm (39.3701 in) long, and mounted so that it does not sag or bend.

NOTE : Make sure that the overflow pipe of the coolant recovery tank is not submerged in bilge. If the overflow pipe is submerged in bilge, water in the bilge will be siphoned into the fresh water tank when the wafer is being cooled.



9.5.8 Precautions on usage of the coolant recovery tank

(1) Check the coolant recovery tank when the engine is cool and refill with fresh water as necessary to bring the water level between the low and full marks.

(2) Check the overflow pipe and replace if bent or cracked. Clean out the pipe if it is clogged up.

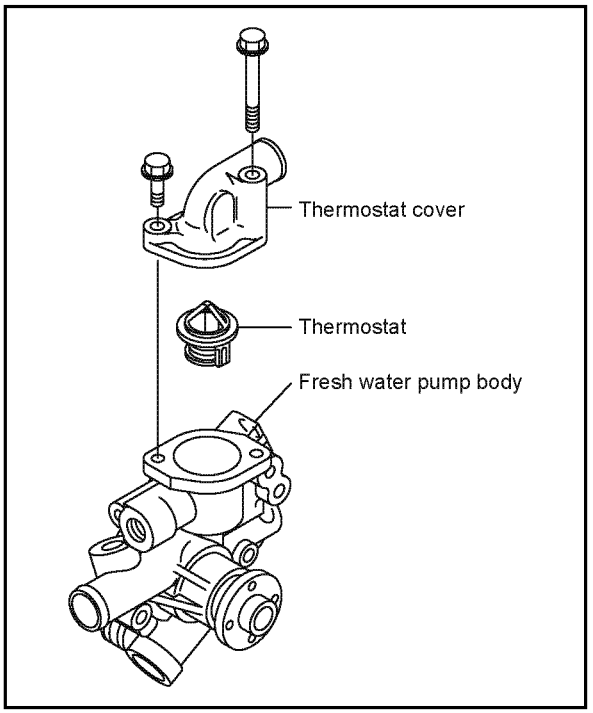
9.6 Thermostat

9.6.1 Functioning of thermostat

The thermostat opens and closes a valve according to changes in the temperature of the fresh water inside the engine, controlling the volume of water flowing to the heat exchanger from the cylinder head, and in turn maintaining the temperature of the fresh water in the engine at a constant level.
The thermostat is bottom bypass type. It is located in a position connected with the cylinder head outlet line at the top of the top of fresh water pump unit.
When the fresh water temperature exceeds the above temperature, the thermostat opens, and a portion of the water is sent to the heat exchanger and cooled by seawater, the other portion going from the bypass line to the fresh water pump intake.
The bypass line is closed off as the thermostat valve opens and is completely closed when the fresh water temperature reaches 81.5°C (valve lifts 4 mm (0.1575 in)), sending all of the water to the heat exchanger.

9.6.2 Thermostat construction

The thermostat used in this engine is of the wax pellet type, with a solid wax pellet located in a small chamber. When the temperature of the cooling water rises, the wax melts and increases in volume. This expansion and construction is used to open and close the valve.



9.6.3 Characteristics of thermostat

Opening temperature	69.5-72.5°C
Full open temperature	85°C
Valve lift at full open	8 mm or more

9.6.4 Thermostat inspection

Remove the thermostat cover on top of the fresh water pump and take out the thermostat. Clean off scale and rust and inspect, and replace if the characteristics (performance) have changed, or if the spring is broken, deformed ar corroded.

9.6.5 Testing the thermostat

Refer to 2.5 in chapter 2.

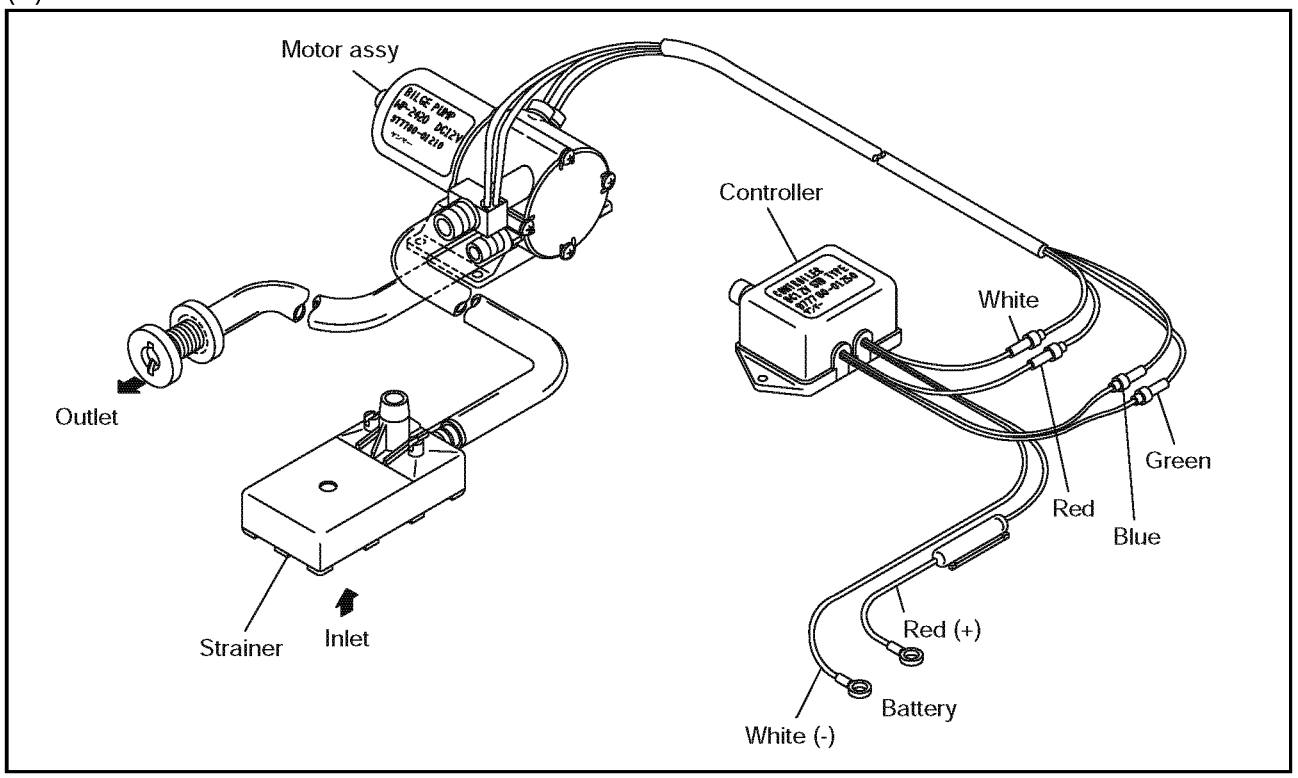
9.7 Bilge pump and bilge strainer (Optional)

9.7.1 Introduction

(1) General Introduction

Name	Bilge pump
Time	10 minutes
Rotation direction	Right (viewed from the impeller side)
Weight	Pump 1.4 kg
Negative pressure detector	Diaphragm type
Temperature	-30°C~80°C

(2) Exterior



Pump dimensions

Length	225 mm
Yoke diameter	Ø61
Assembly hole diameter	Ø5.3
Assembly pitch	50 x 90 mm

9.7.2 Description

(1) Characteristics

1) Discharge at lift : 0 m discharge capacity : 20 liters/min. or greater.
2) Automatic feeding height : 1 m or greater
   (Limit for automatic feeding height: new pump with inside parts wet, approx. 2 m)
3) Automatic feeding time : 2-5 seconds.
   (Limit for automatic feeding time: new pump with inside parts wet, approx. 1 second.)
4) Automatic stopping : Air intake causes negative pressure triggering automatic stopping.

(2) Insulation

1) Insulation resistance : 500V with a megatester when the difference between the continuity point and the body is 1MΩ or greater.
2) Insulation proof stress : AC50 between the continuity point and the body, or 60hz 500V for 1 minute when impressed current leakage is 10 mA or lower.

(3) Durability

Rated voltage when there is 3% salt water 60L + engine oil 3%, and operation is at 1800 cycles and there are no difficulties.

(4) Vibration proof

Amplitude 0.51 mm (one side of the amplitude)
Vibration frequency 10-55 Hz
Sweep time 90 seconds.
Direction of vibration each direction 4 hours
No difficulties after test period

9.7.3 Cautions

(1) Attach at a position higher than the bilge water away from rain or other water, and 50-70 cm above the bottom of the boat.

(2) Never run the pump dry. Be sure that the strainer is inserted in the drain water before pushing the switch. If no water is being drawn up after a period of 10 seconds or more, prime the pump. (Do not run the pump for longer than 10 seconds when no water is being drawn up.)

(3) When the pump has not been used for a long period of time, the inside of the pump will be dry and drawing ability will be lowered. Before reusing, clean the inside of the pump or prime it to insure that it is wet, and check to be sure that the pump is then operating correctly.

(4) When charging the diesel engine oil, wait a period of 30 minutes or longer from the time of stopping (oil temperature 20-70°C). Refrain from operation when the oil temperature is below 15°C, or above 50°C.

(5) When the bilge inside the pump or hose freezes, completely melt the water with a steaming towel before beginning operation. When the temperature inside the pump is low, it will take a longer amount of time for the pump to drain off the bilge.

(6) The impeller replacement kit includes one impeller and 3 washers for adjusting the side gap. If after replacing the impeller the pump does not drain, place side gap adjustment washers underneath the bottom plate to adjust. Select the number of washers used in accordance with the following. (When the pump is draining, the electric current load is about 10A for 12V and 5A for 24V. When there are too many washers, the electric current value will be too great and will blow a fuse.)

(7) The pump cannot be used to drain off rain water or large amounts of flood water. The pump can be run continuously for a period of 10 minutes. After this time it must shut off for a period of 2 hours before reusing.

(8) Do not use the pump for showering.
If the pump outlet is deformed for showering, the increase in water pressure will increase the load on the motor and cause motor seizure.

(9) Fix the strainer so that it will not turn upside down or on its side.

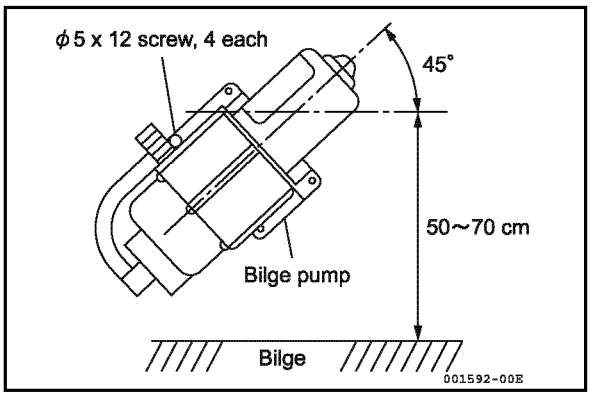
(10) When sludge has built up in the bilge to be drained, position the strainer about 20 mm above the sludge. When the pump is stopped, be sure there is no sludge remaining inside the pump.

(11) The specific gravity for the battery fluid is 1.25 or more.

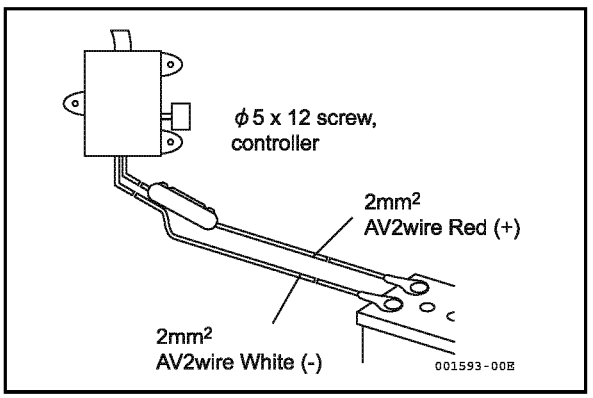
9.7.4 Assembly procedure

When bilge is being used, assemble in accordance with the following.

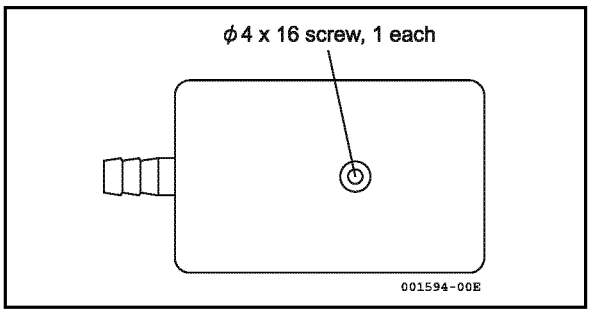
(1) Assembling the bilge pump
- Select a dry place above the bilge water level.
- Select the location for the bilge pump taking into consideration the length of the switch cable (approx. 3 m) and its attachment point, and the position of the battery.
- Position at a 45° angle as shown in the illustration with the nozzle facing up, and 50-70 cm from the bottom of the boat.



(2) Assembling the switch
- Attach in a place to insure easy operation away from rainwater.
- Connect the terminal to the battery.
(When the cord will not reach the battery, an extension of no greater than 3 m length suitable for AV3cm^2 can be attached.)

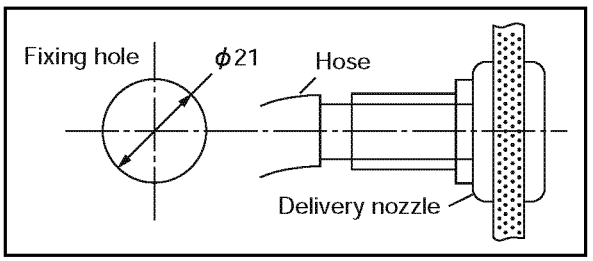


(3) Positioning the strainer
- Attach at the place where the greatest amount of water is collected when the boat is stopped.
- It is best to place the strainer as close to the bilge pump as possible. Cut the 3 m hose to a length of 1.2 m-1.8 m and attach allowing plenty of give.
- Check the strainer during a test operation before screwing firmly into place.
(When the strainer is screwed in, be especially careful not to damage the bottom of the boat.)
- The strainer contains a weight, and can be used with the weight in place.
- Always keep the strainer clean.



(4) Attaching the delivery nozzle (outlet)

- Make a fixing hole of Ø21 or less for attaching the nozzle. The hose attached at the nozzle should be 1.8 m or less and should reach without any strain, therefore care should be taken in deciding on the best position.
- Fix the nozzle (outlet) in place and attach on the discharge side of the pump.



(5) Attaching the hose

- Attach the hose from the strainer to the pump inlet.
- Attach the delivery nozzle hose to the pump outlet.
- Make the hose as short as possible and avoid sharp bends.

(6) Test operation

- Collect water in the bottom of the boat, and check for any problems with the hose or wiring. After doing this, connect the battery.
- Turn on the pump switch, and check to see that water is being taken in and discharged properly. The pump will stop automatically when there is no water left.
- If the inside of the pump is dry, or if the water is not being drawn up initially after a period of 10 seconds, lift the strainer above the water surface and stop the pump. Prime the pump before starting it up again.

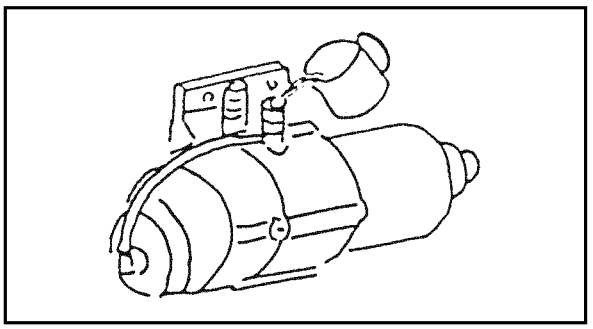
(7) Fixing the strainer

- After the test operation, fix the strainer into place with screws.
  (Be careful not to damage the bottom of the boat with the screws.)

9.7.5 Cautions for assembling

Observe the following cautions for handling.

- Do not use gasoline or solvents.
  1) gasoline 2) ester 3) benzol 4) battery fluid 5) liquids at 70°C or greater or engine oil
- Never run when there is no water in the bilge.
  Check to be sure that the strainer is in the water before turning on the switch.
- Keep the cord terminal away from the water. Water inside the motor or switch may lead to damage. When the insulation around the cord is damaged, water can seep in to the wires; thus, care should be taken not to scratch or nick the cord.
- When the pump has not been used for a long period of time, the inside of the pump will be dry and it may not operate properly at first. If after 10 seconds the pump is not working, turn off the switch and prime the pump before trying again.
  (Never run the pump dry for period of greater than 10 seconds.)



- Replace the diesel engine oil only after the engine has been stopped for a period of 30 minutes (oil temp. 20-70°C). Whenever possible refrain from operation when the oil temperature is below 15°C or above 50°C.
- Bilge water left in the hose or inside the pump can freeze, and care should be taken to see that any excess bilge is completely discharged. If bilge water should freeze, and care should be taken to see that any excess bilge is completely discharged. If bilge water should freeze inside the hose or pump, it should be completely melted before starting up the pump. When the temperature inside the pump is low, it will take a longer time for the pump to operate. (0°C, 5-10 seconds.)
- Keep the pump in a dry place away from rain or other water.
- Use the regulation hose; do no use thin vinyl hose or hose which is not heat-resistant.
- The pump cannot be used to drain off rainwater or large quantities of flood water. This pump can be operated continuously for a period of 10 minutes.
- Do not use the pump for showering.
  If the pump outlet is deformed for showering, the increase in water pressure will increase the load on the motor and cause motor seizure.
- When sludge has built up in the bilge to be drained, position the strainer about 20 cm above the sludge. When the pump is stopped, be sure there is sludge remaining inside the pump housing.
- The specific gravity for the battery fluid is 1.25.
- Refer to your local dealer for impeller replacement.
  The local dealer will perform the following.
  The impeller replacement kit includes one impeller and 3 films for adjusting the side gap. If after replacing the impeller the pump does not drain, place side gap adjustment washers underneath the bottom plate to adjust. Select the number of films used in accordance with the following. (When the pump is draining, the electric current load is about 10A for 12V and 5A for 24V. The pump operates efficiently at these electric current loads.)

Steps for replacement

1) Remove the impeller plate by taking out the M4 screws (4) and opening the top of the diaphragm switch.
   (Screw lock has been applied to the screw, and a dryer should be used to heat the screw before removing it.)
2) Clean the inside of the pump.
3) Grease the plate, impeller, and film for side gap adjustment, and then reassemble the pump by inserting first the film plate and then the impeller.

9.7.6 Troubleshooting

Refer to the following countermeasures for difficulties that arise.

Problem	Cause	Countermeasure
1. Pump does not turn	Faulty wiring	Check the wiring between the motor and battery.
	Faulty battery	Check to see if the specific gravity of the battery fluid is greater than 1.25. Recharge or replace the battery.
	Faulty starter switch	Consult your local dealer.
	Faulty pump	Consult your local dealer.
2. Pump turns but does not draw up water.	Draws up air.	Check hose connections. Retighten pump screws.
	Low voltage in battery.	Check to see if the specific gravity of the battery fluid is greater than 1.25. Recharge or replace the battery.
	The distance between the pump and the surface of the water is too great.	Lower the pump. (Position the pump so that it is closer to the surface of the water.)
	The pump is too high.	Lower the pump. (Position the pump so that it is 50-70 cm above the bottom of the boat.)
	Pump intake is weak.	If intake is still faulty after priming, consult your local dealer.
3. Pump turns, but the amount of discharge is low.	Clogged strainer	Clean strainer.
	Hose is broken or damaged.	Check for damage and repair. If incorrect hose has been used, replace with the regulation type of hose.
4. Water leakage from pump	Water leakage from packing	Retighten pump screws.
	Faulty pump seal	Consult your local dealer.
5. Pump draws up bilge, but motor stops when hand is removed from starter switch.	Faulty diaphragm switch	Check for loose wiring in diaphragm switch and correct.
	Damaged diaphragm switch	Consult your local dealer.
6. Motor does not stop, when there is no bilge water left	Clogged strainer or hose	Clean strainer or hose.
	Damaged diaphragm switch	Check for continuity of diaphragm switch terminal. Consult your local dealer if there is continuity.

10. Reduction and reversing gear

Marine gear KM2P-1 is applied to the 3YM30, 3YM20 and 2YM15 series engines.

Refer to chapter 10 in the service manual of the GM series engines for inspection, disassembly and reassembly.

10.1 Specifications

Model			KM2P-1		
For engine models			3YM30, 3YM20, 2YM15		
Clutch			Constant mesh gear with servo cone clutch (wet type)		
Reduction ratio	Forward		2.21	2.62	3.22
	Reverse		3.06	3.06	3.06
Propeller shaft speed (at continuous power, Forward) min^{-1}			1580	1332	1083
Direction of rotation	Input shaft		Counter-clockwise, viewed from stern		
	Output shaft	Forward	Clockwise, viewed from stern		
		Reverse	Counter-clockwise, viewed from stern		
Remote control	Control head		Single lever control		
	Cable		Morse. 33-C (cable travel 76.2 mm)		
	Clamp		YANMAR made. standard accessory		
	Cable connector		YANMAR made. standard accessory		
Output shaft coupling	Outer diameter		100 mm		
	Pitch circle diameter		78 mm		
	Connecting bolt holes		4 - 10.5 mm		
Position of shift lever, viewed from stern			Left side		
Lubricating oil			API CC class, SAE #10W30		
Lubricating oil capacity			0.3 liters		
Dry mass			9.8 kg		

11. Remote control (Optional)

11.1 Remote control system

11.1.1 Construction of remote control system

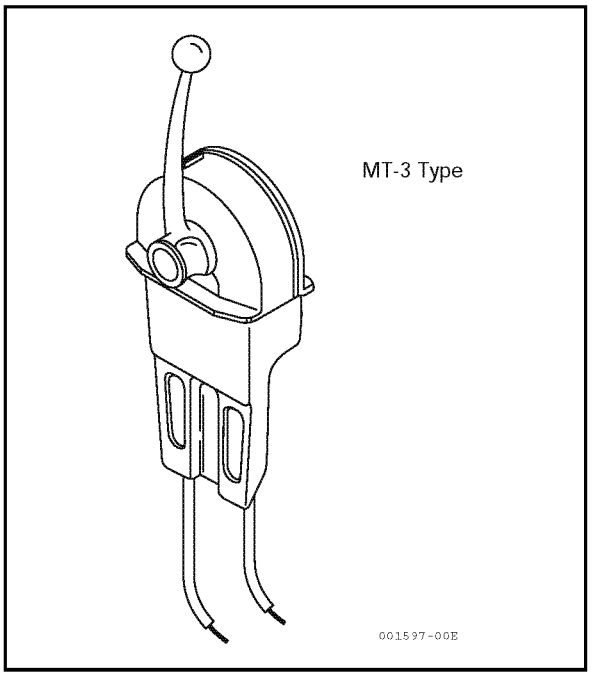
The remote control permits one handed control of the engine speed changing from forward to reverse, and stopping.
Fittings which allow for easy connection of the remote control cables with the fuel injection pump and transmission are provided with the remote control set.
The use of Morse remote control cables, clamps and a remote control head, are also provided for the device to stop the engine is electric and will be explained under the section on electrical equipment.

11.1.2 Remote control device components

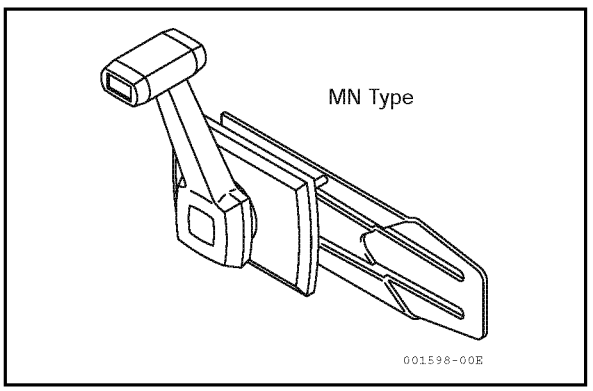
	Morse description
Remote control head	Morse MT3 top mounting single lever Morse MN side mounting single lever
Remote control cable	Morse 33C x 4m Morse 33C x 7m
Engine stop cable	Yanmar 4m Yanmar 7m

(1) Remote control handle

The model MT-3 remote control has been designed so that operation of the clutch (shift) and governor (throttle) can be effected with one lever.
Two cables are required for the MT-2 single, one for the clutch and the other for the governor.
When warming up the engine, to freely control the governor separately from the clutch put the lever in-neutral, the central position and pull the knob in the center of the control lever. When the lever is returned to the neutral position, the knob automatically returns to its original position, and the clutch is free. The governor can then be freely operated.

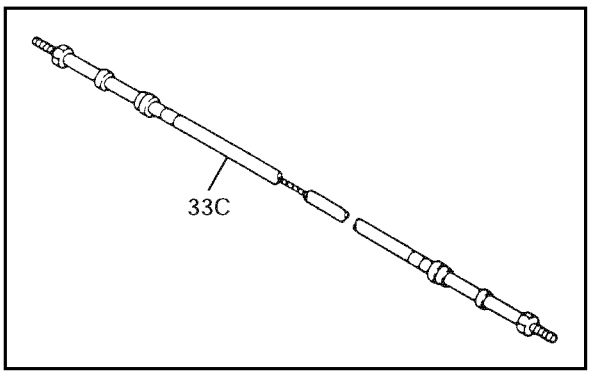


The MN type controller has been designed so that operation of the clutch and throttle can be effected with one lever. When the button next to the control lever is pulled out with the lever in the central position, it holds the clutch in the neutral position so that the throttle can be opened all the way and warm up the engine. When the engine is warmed up, return the handle to the central position and push the button back in. Control of the clutch and throttle is thus effected with one handle.

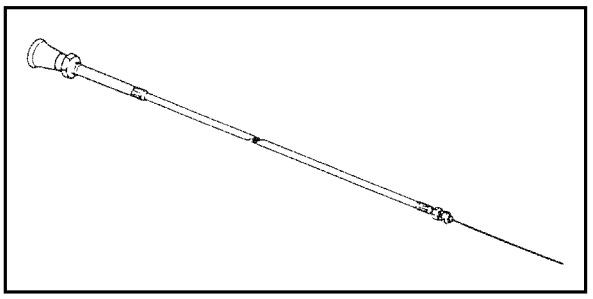


(2) Remote control cable

Use only Super Responsive Morse Control Cables. These are designed specifically for use with Morse control heads. This engineered system of Worse cables, control head and engine connection kits ensures dependable, smooth operation with an absolute minimum of backlash.

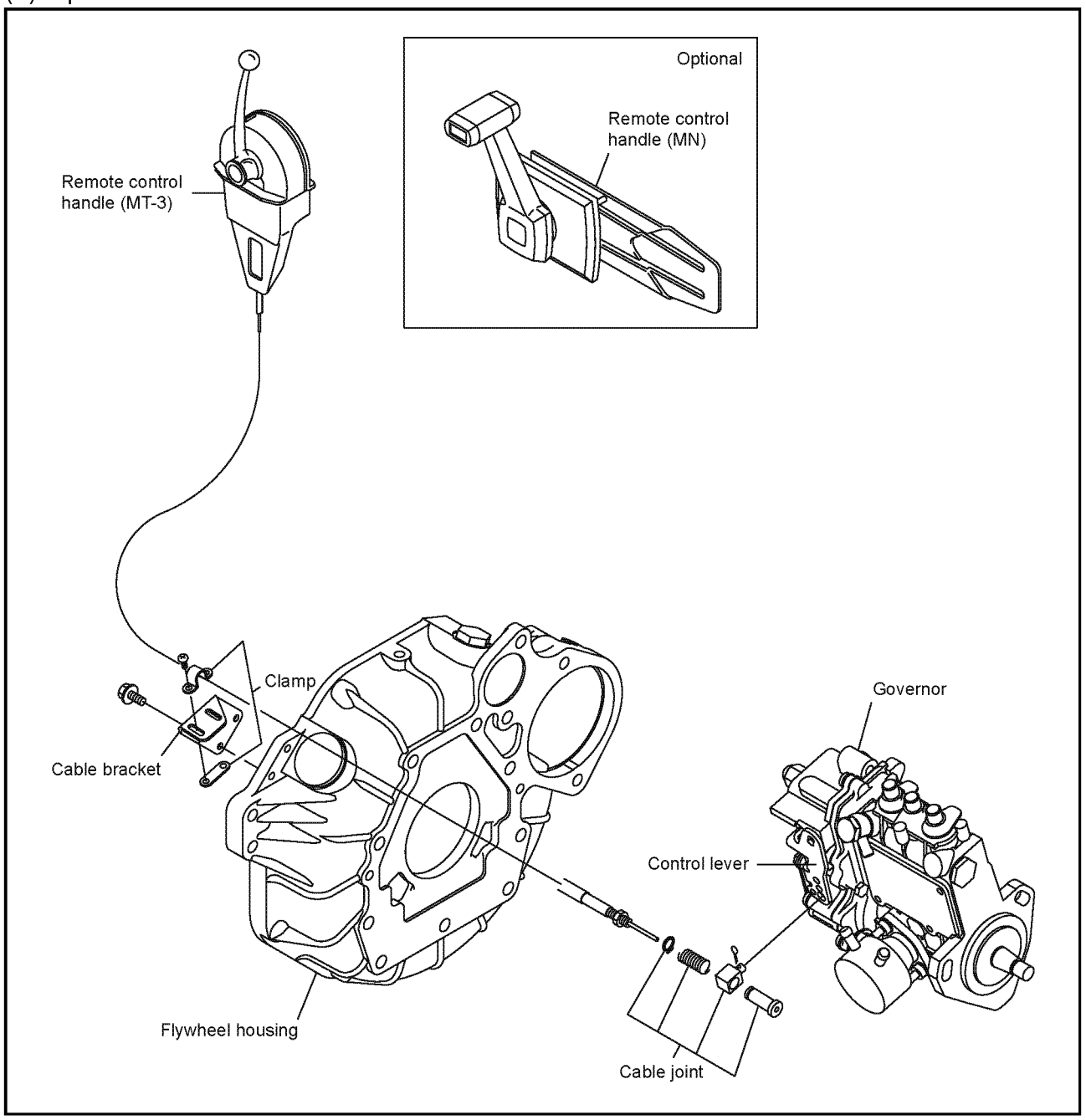


(3) Engine stop cable

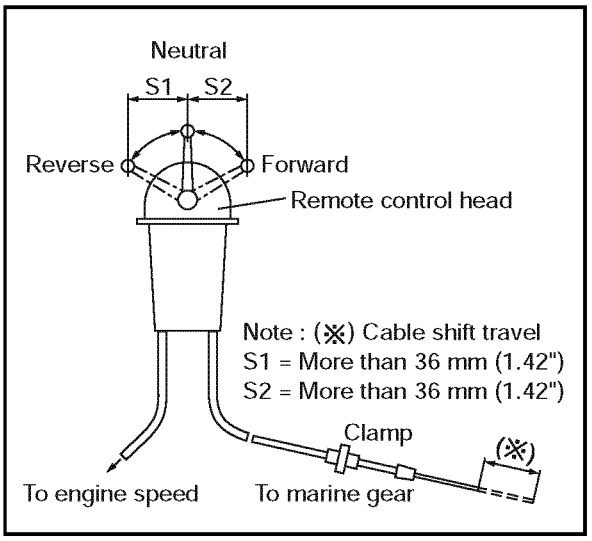


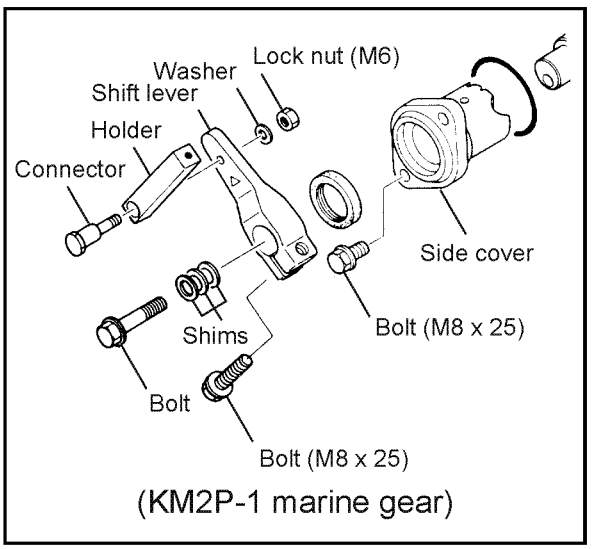
11.2 Remote control installation

(1) Speed control

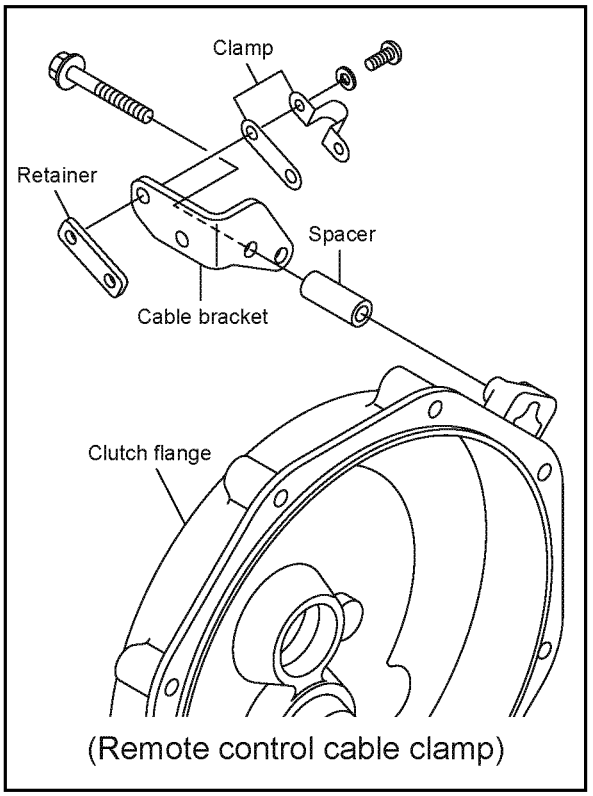


(2) Clutch control





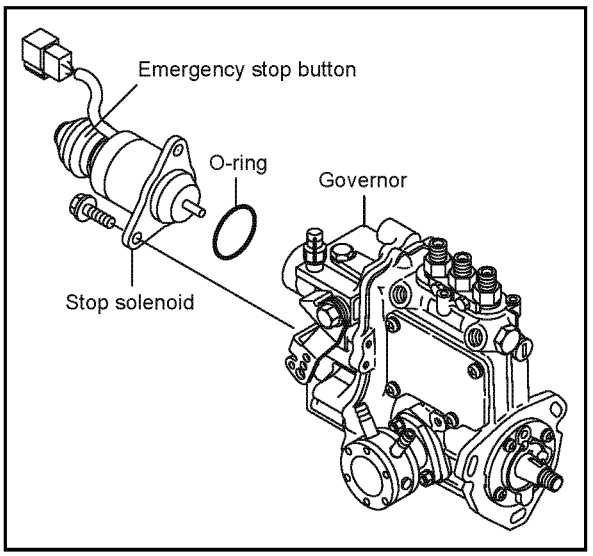
(KM2P-1 marine gear)



(Remote control cable clamp)

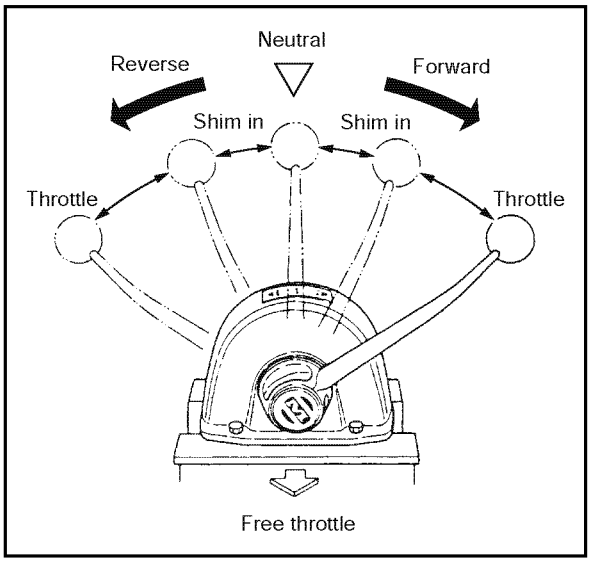
(3) Engine stop

Usually, when an engine is stopped, the stop button of an instrument panel is pushed, and the engine is stopped.
Moreover, an emergency stop button after the stop solenoid is pushed, and the engine is stopped.



11.3 Remote control inspection

(1) When the control lever movement does not coincide with operation of the engine, check the cable end stop nut to see whether or not it is loose, and readjust/retighten when necessary.



(2) Too many bends (turns) in the cable or bends at too extreme angle will make it difficult to turn the handle. Reroute the cable to reduce the number of bends and enlarge the bending radius as much as possible (to 200 mm or more).

(3) Check for loose cable bracket/clamp bolts or nuts and retighten as necessary.

(4) Check cable connection screw heads, cable sleeves and other metal parts for rust or corrosion. Clean off minor rust and wax or grease the parts. Replace if the parts are heavily rusted or corroded.

11.4 Remote control adjustment

(1) Shift lever adjustment

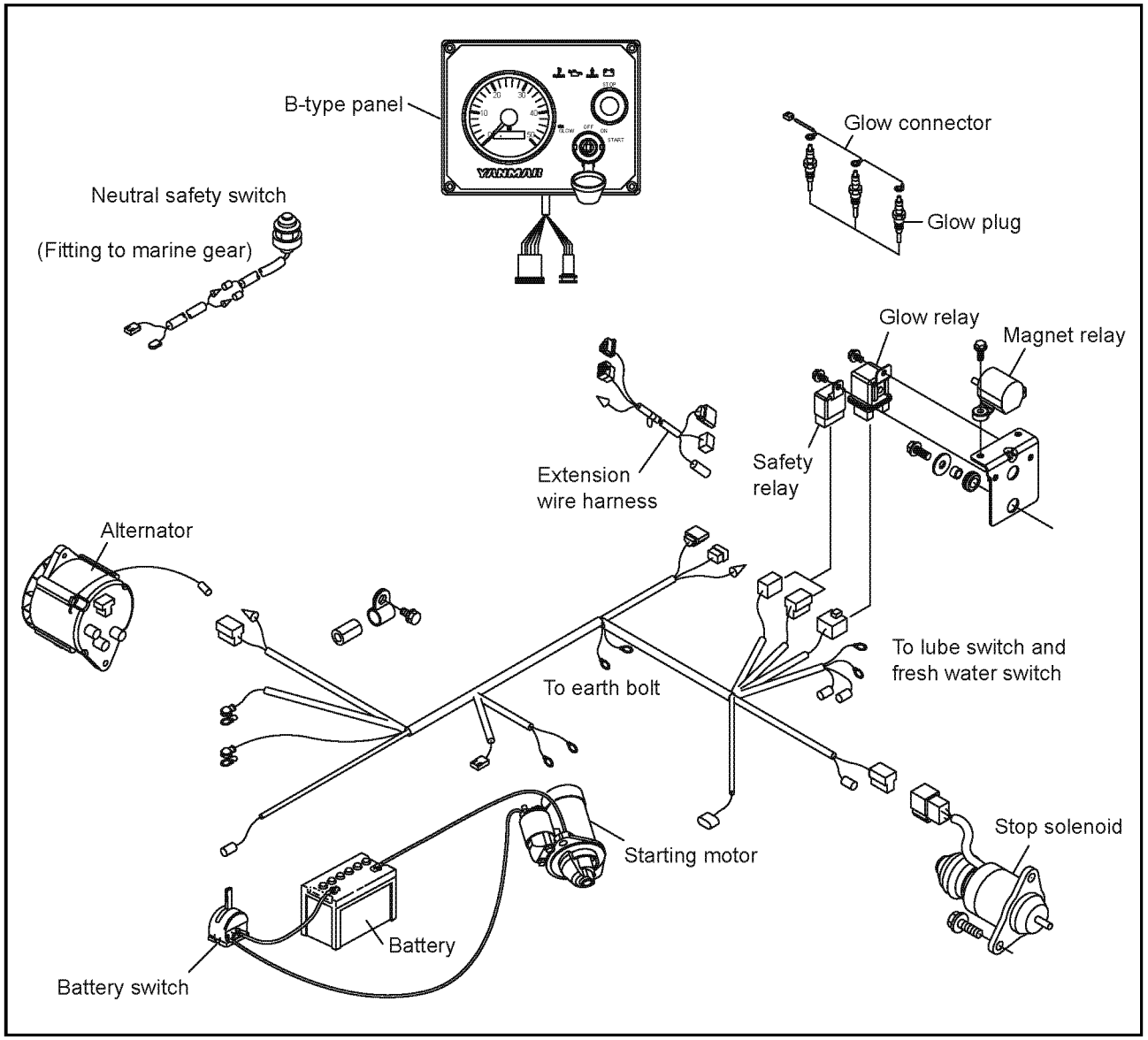
Move the lever several times-the movement of the clutch lever on the engine from forward, neutral and reverse must coincide with the forward, neutral and reverse on the control lever. If they do not coincide, adjust the fittings as necessary (first engine side, then controller side).

(2) Throttle lever adjustment

Move the control lever all the way to full throttle several times, and then return. The throttle lever on the engine must lightly push against the idle switch when it is returned. If it is property adjusted, the knob can be easily pulled out when the lever is in the neutral position, and will automatically return when the control lever is brought back to the neutral position. If the control lever presses too hard against the knob, it may not return automatically, in which case the cable end must be adjusted as explained for the clutch. The knob cannot be pulled out when the lever is not in the neutral (central) position.

12. Electrical system

12.1 Electrical system

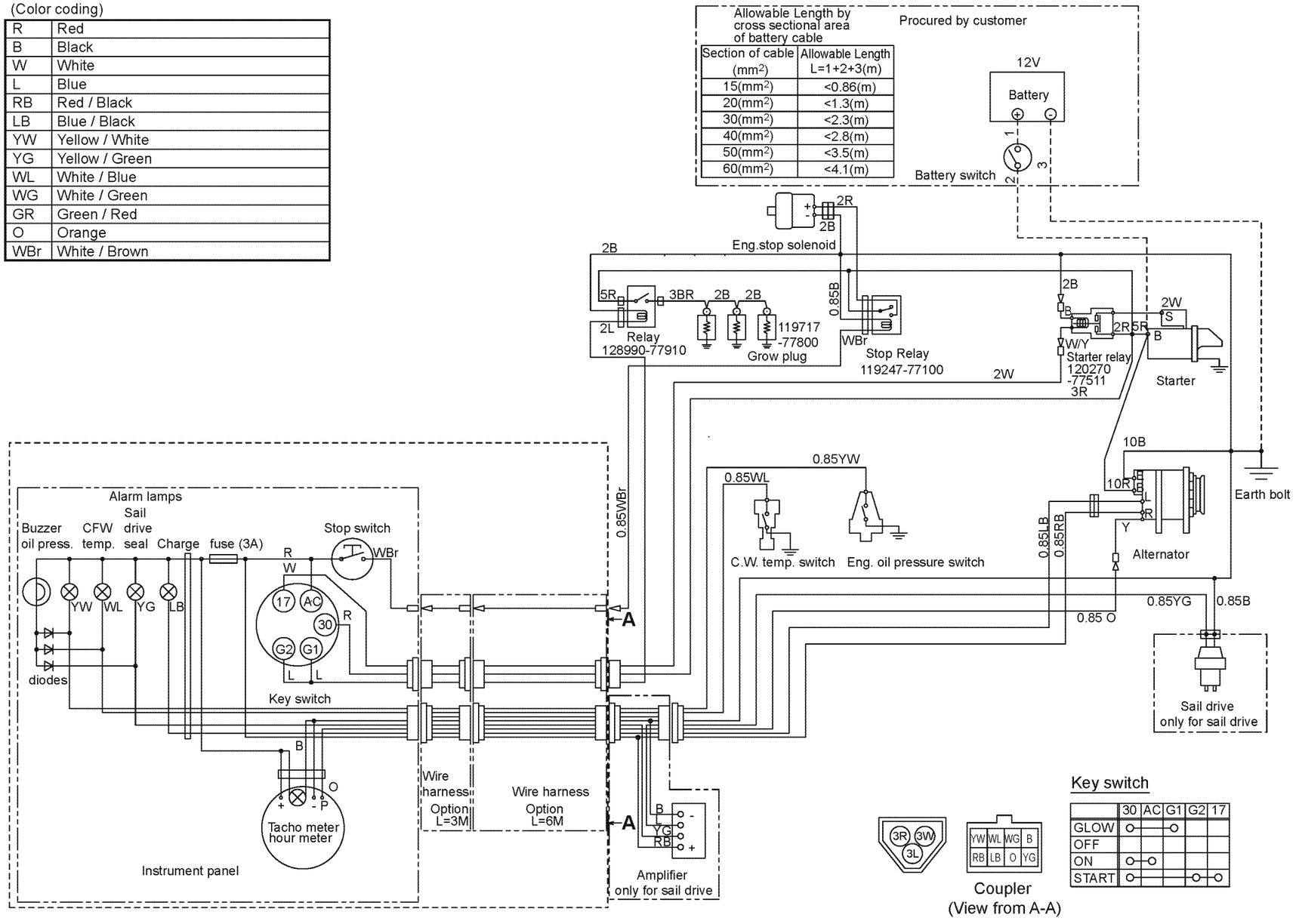


12.1.1 Wiring diagram

For B-type instrument panel

(Color coding)

R	Red
B	Black
W	White
L	Blue
RB	Red / Black
LB	Blue / Black
YW	Yellow / White
YG	Yellow / Green
WL	White / Blue
WG	White / Green
GR	Green / Red
O	Orange
WBr	White / Brown



12.2 Battery

The new type instrument panels are applied for 3YM30 series engines. The features are compactness, waterproof and independence from pulse by ring gear teeth number.
The engine speed, indicated with the instrument panel is activated by the pulse from flywheel ring gear. The engine speed with new panel is activated by alternator B terminal pulse.

(1) Battery capacity

Battery capacity (5 hours rating)	12V-64 AH or more (type 95D31L equivalent)

(2) Battery cable

Wiring must be performed with the specified electric wire. Thick, short wiring should be used to connect the battery to the starter. Using wire other than that specified may cause troubles.

The overall length of the wire between the battery (+) terminal and the starter (B) terminal, and between the battery (-) terminal and the starter (E) terminal, should be determined according to the following table.

Voltage system	Allowable wiring voltage drop	Conductor cross section area	Allowable overall length
12 V	0.2 V or less/100A	20 mm^2	Up to 2.5 m
		40 mm^2	Up to 5 m

Note :
Excessive resistance in the key switch circuit (between the battery and start [S] terminals) can cause improper pinion engagement. To prevent this, follow the wiring diagram carefully.

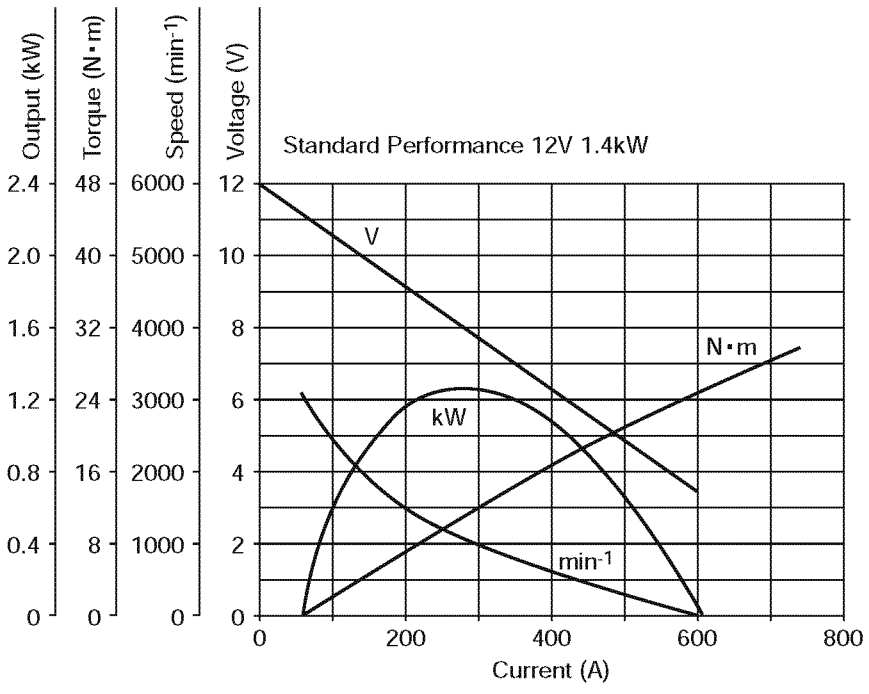
12.3 Starting motor

A starting motor turns the ring gear installed on a engine flywheel by the pinion while overcoming resistance such as the compression pressure and the friction loss of the engine and makes the engine start.

12.3.1 Specifications

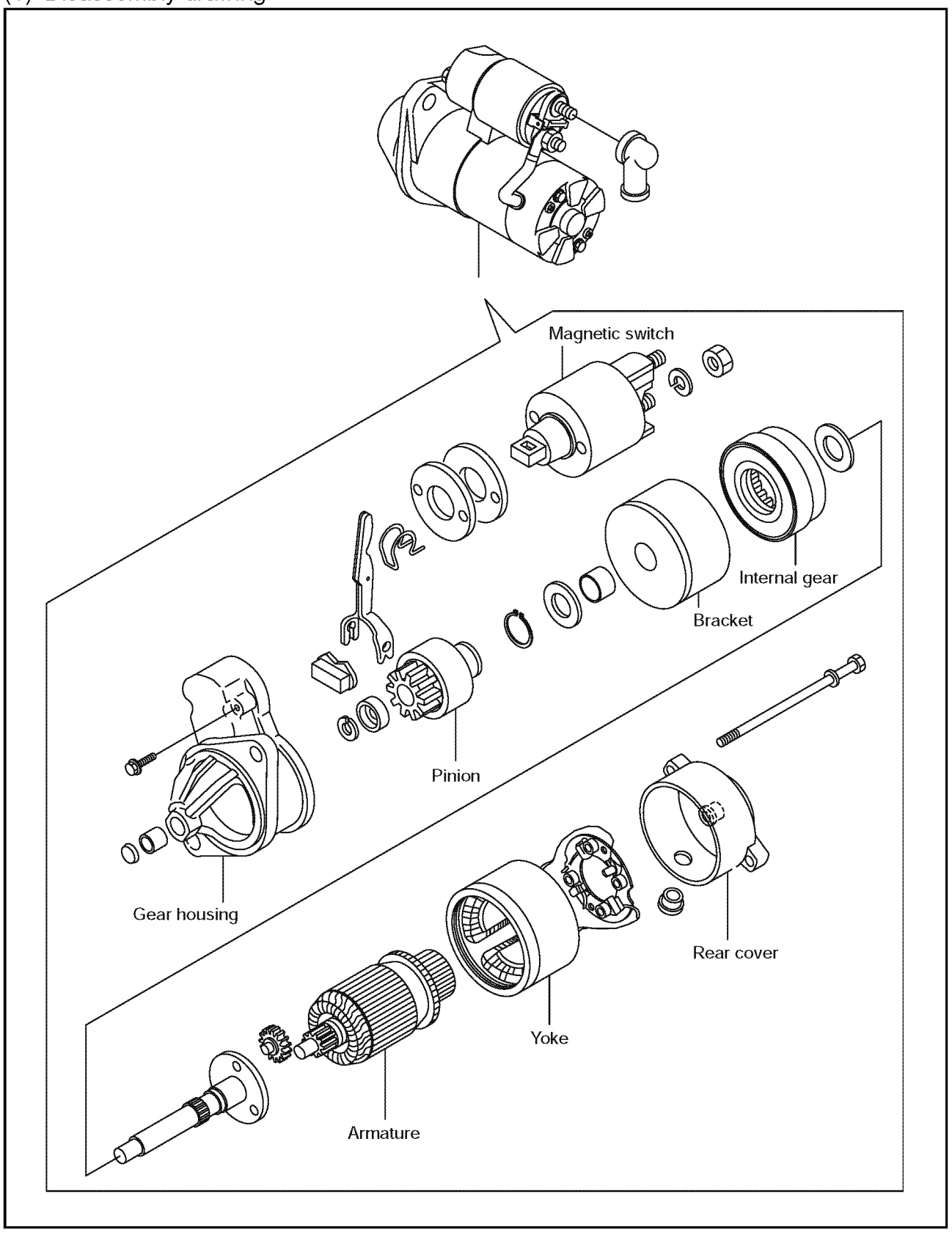
YANMAR Part No.		129608-77010
HITACHI Model No.		S114-817A
Nominal power (kW) Nominal voltage (V) Rating (sec) Direction of rotation (Looking from the pinion side) Number of pinion teeth Weight (kg)		1.4 12 30 Clockwise 11 3.0
No load	Terminal voltage (V) Electric current (A) Revolutions (min^{-1})	11 90 (MAX) 2,700 (MIN)
Load	Terminal voltage (V) Electric current (A) Torque (N•m) Revolutions (min^{-1})	8.4 250 8.3 (MIN) 1,000 (MIN)

12.3.2 Characteristics



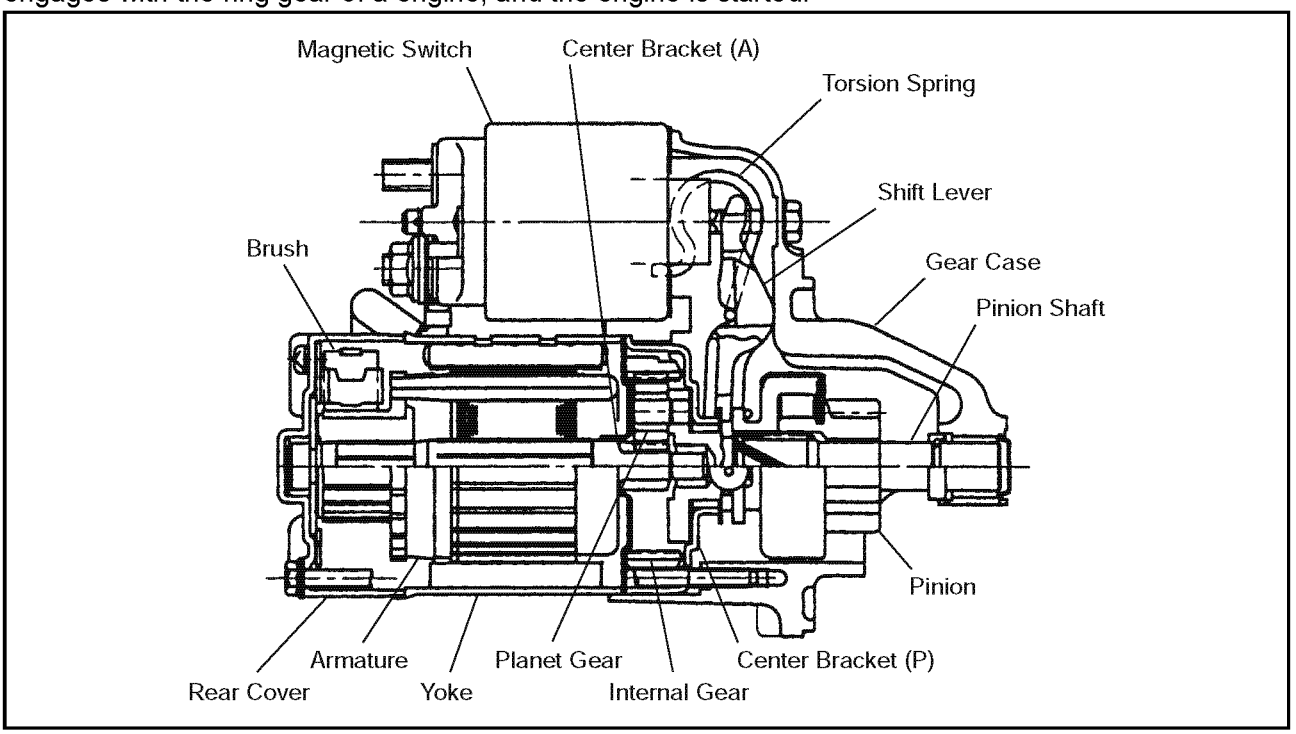
12.3.3 Structure

(1) Disassembly drawing



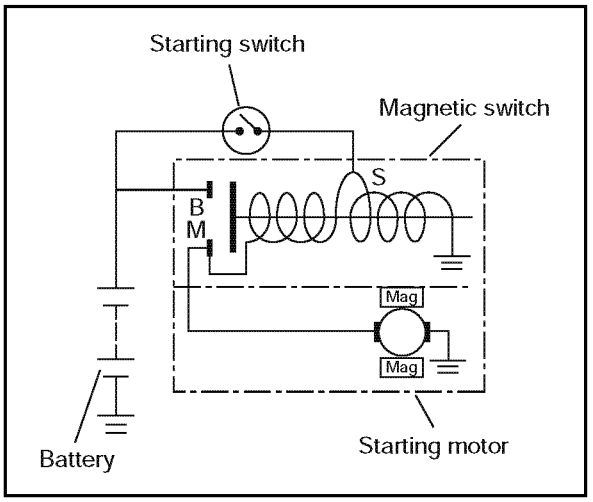
(2) Structure

When the starting switch is turned on, a magnet switch takes a voltage, and a pinion projects. The pinion engages with the ring gear of a engine, and the engine is started.



12.3.4 Wiring diameter of a starting motor

1) When a starting switch is turned on, a magnet switch is charged, and a moving core is absorbed, and a pinion clutch is moved forward through a lever, and the pinion engages with a ring gear.
2) When the pinion engages the ring gear, because a main contact point is closed and the main electric current flows and a pull coil is short-circuited by the main contact point and it stops being charged with electricity, the pinion is kept at the position by a holding coil during the start.
3) When the starting switch is turned off, the main contact point becomes open, and the pinion clutch is returned to the stop position by a return spring.



12.4 Alternator standard, 12V/60A

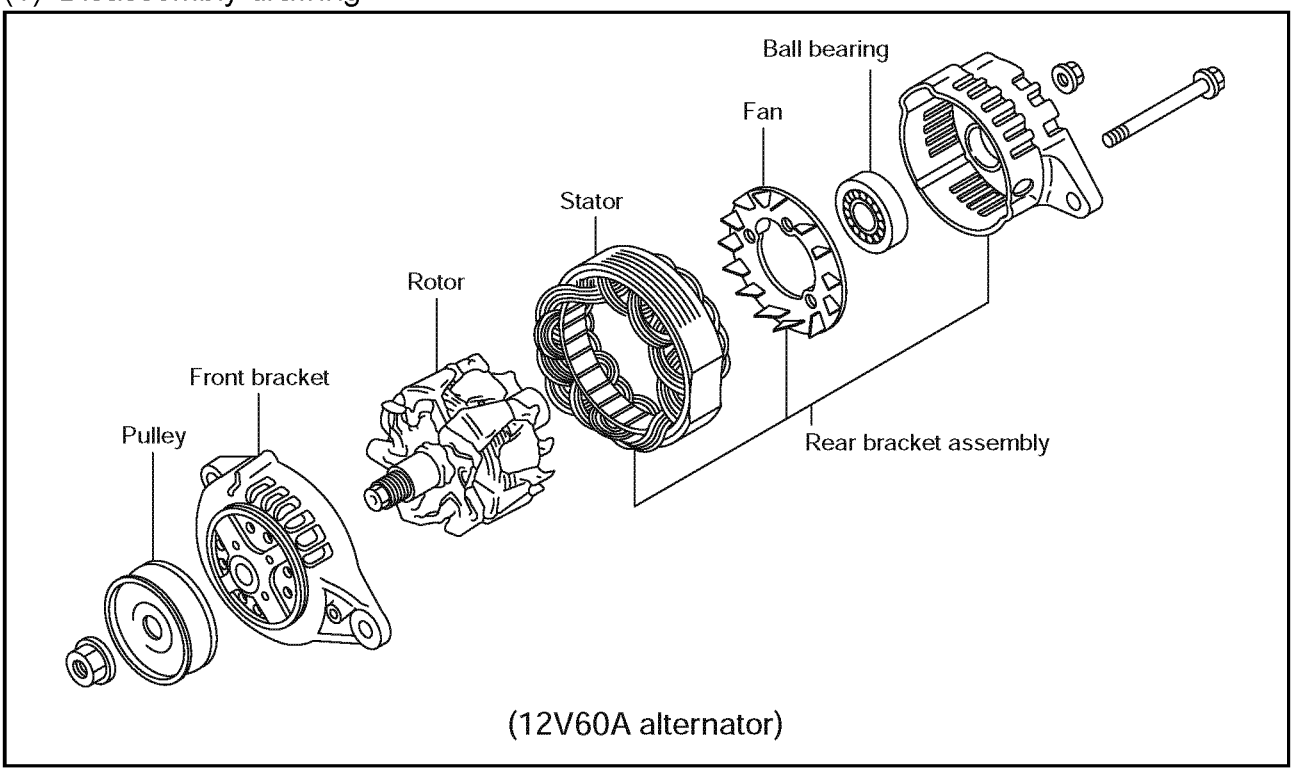
The alternator serves to keep the battery constantly charged. It is installed on the cylinder block by a bracket, and is driven from the V-pulley at the end of the crankshaft by a V belt.
The type of alternator used in this engine is ideal for high speed engines with a wide range of engine speeds. It contains diodes that convert AC to DC, and an IC regulator that keeps the generated voltage constant even when the engine speed changes.

12.4.1 Specifications

Yanmar code	128271-77200
Model of alternator	LR160-741 (HITACHI)
Model of IC regulator	SA-A (HITACHI)
Battery voltage	12V
Nominal output	12V/60A
Earth polarity	Negative earth
Direction of rotation (viewed from pulley end)	Clockwise
Weight	4.2 kg
Rated speed	5000 min^{-1}
Operating speed	1,050-18,000 min^{-1}
Speed for 13.5V at 20°C	1050 min^{-1} or less
Output current for 13.5V	56A or more/ 5000 min^{-1}
Regulated voltage	14.4±0.3V (at 20°C, voltage gradient, -0.01V/°C)

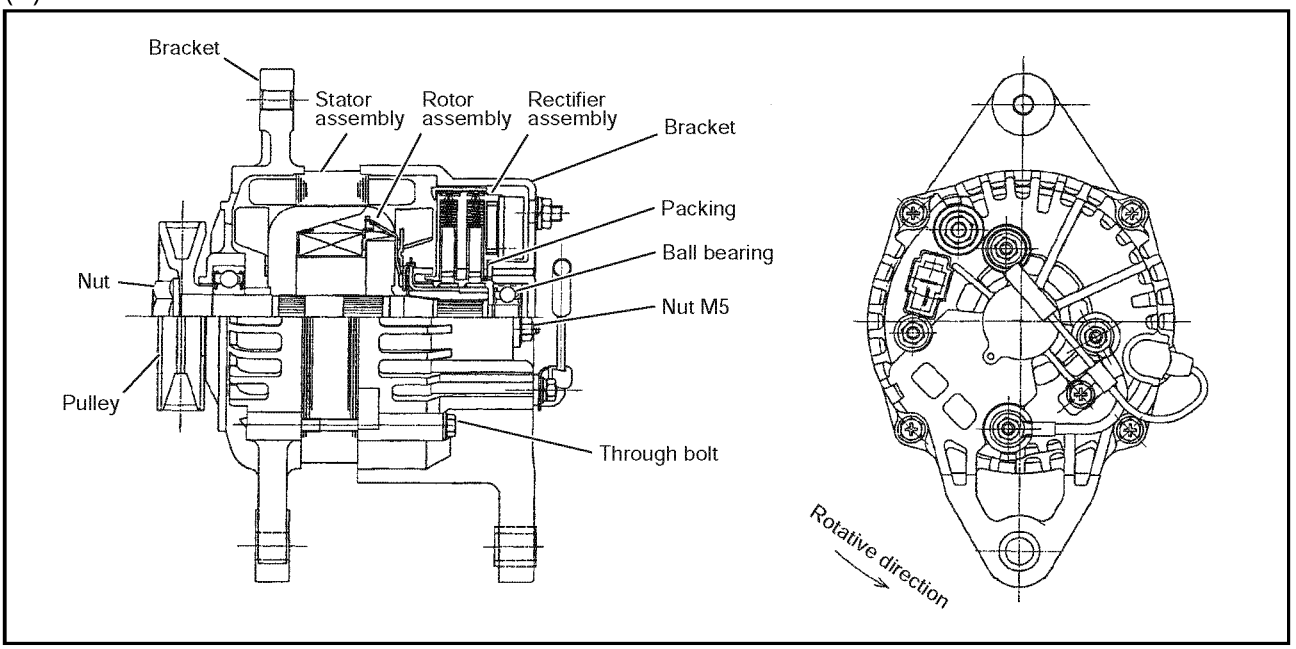
12.4.2 Structure

(1) Disassembly drawing

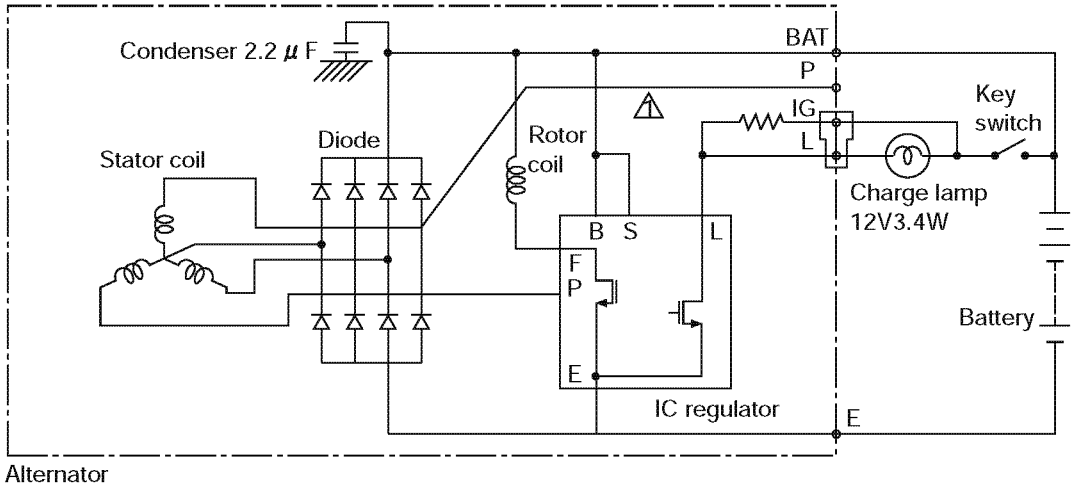


(12V60A alternator)

(2) Structure



12.4.3 Wiring diagram

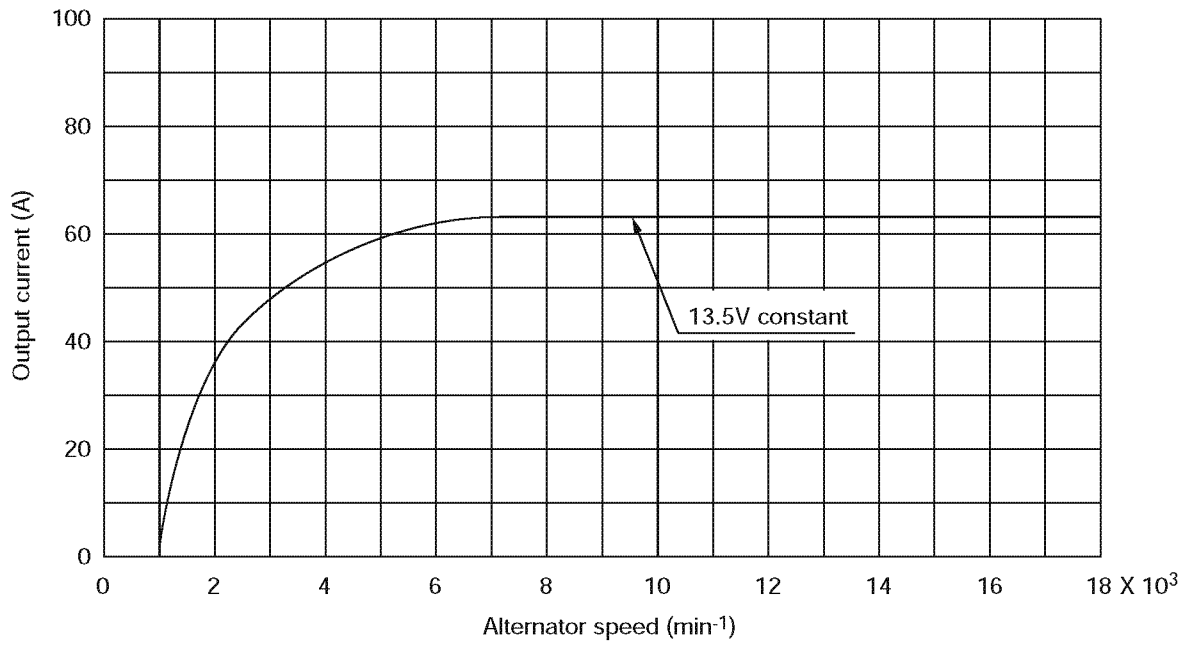


[NOTICE]

1) Don't do mis-connecting and short-circuit of each terminal.
2) Don't remove a battery terminal and a B terminal when rotating.
3) Shut out a battery switch during the alternator stop.

12.4.4 Standard output characteristics

The standard output characteristics of this alternator are shown as the below figure.

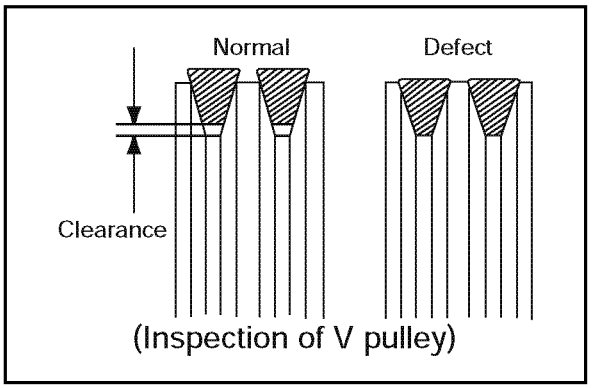


(Standard characteristics)

12.4.5 Inspection

(1) V belt inspection

1) Inspect the matter whether there are not crack, stickiness and wear on the belt visually.
Check that a belt doesn't touch the bottom part of the pulley groove. If necessary, replace the V belt set.
2) V belt tension :
(Refer to 2.2.2.(4) in Chapter 2.)



(Inspection of V pulley)

(2) Visual check of wiring and check of unusual sound

1) Confirm whether wiring is right or there is no looseness of the terminal part.
2) Confirm that there is no unusual sound from the alternator during the engine operation.

(3) Inspection of charge lamp circuit

1) Move a start switch to the position of on. Confirm lighting of the charge lamp.
2) Start an engine, and confirm the lights-out of the lamp. Repair a charge lamp circuit when a lamp doesn't work.

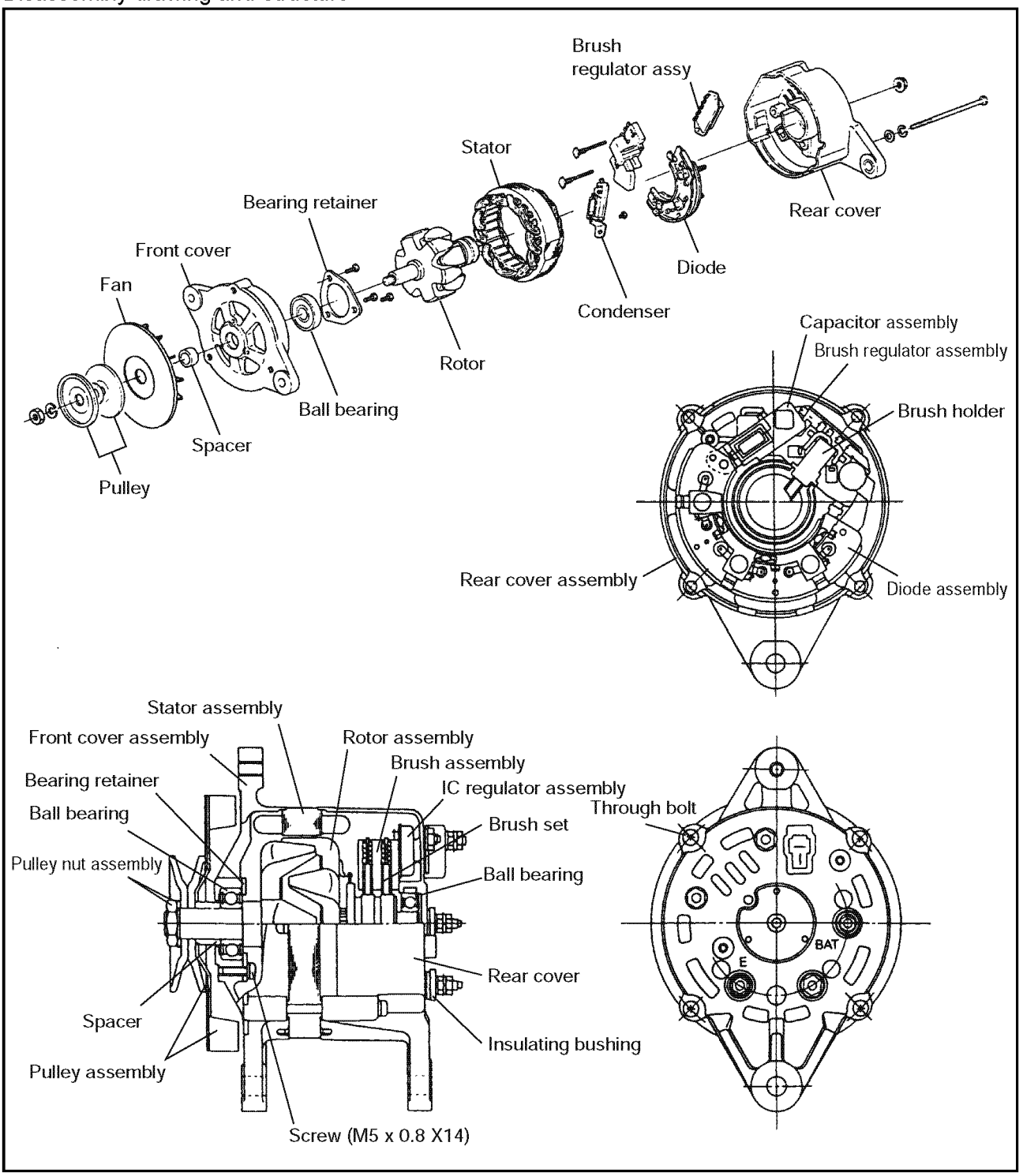
12.5 Alternator 12V/80A (Optional)

12.5.1 Specifications

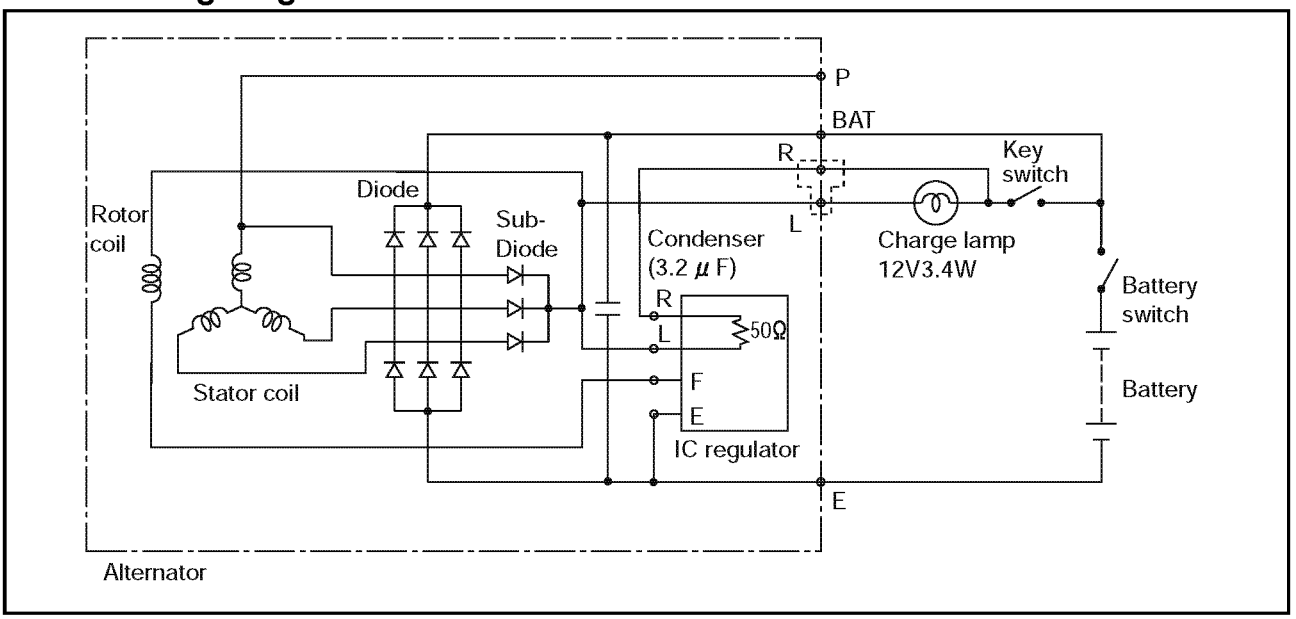
Yanmar code	119573-77201
Model of alternator	LR180-03C (HITACHI)
Model of IC regulator	TR1Z-63 (HITACHI)
Battery voltage	12V
Nominal output	12V/80A
Earth polarity	Negative earth
Direction of rotation (viewed from pulley end)	Clockwise
Weight	5.4 kg
Rated speed	5000 min^{-1}
Operating speed	1,200-9,000 min^{-1}
Speed for 13.5V at 20°C	1,200 min^{-1} or less
Output current for 13.5V	75A or more/ 5000 min^{-1}
Regulated voltage	14.5 ± 0.3V (at 20°C, voltage gradient, -0.01V/°C)

12.5.2 Structure

Disassembly drawing and Structure



12.5.3 Wiring diagram

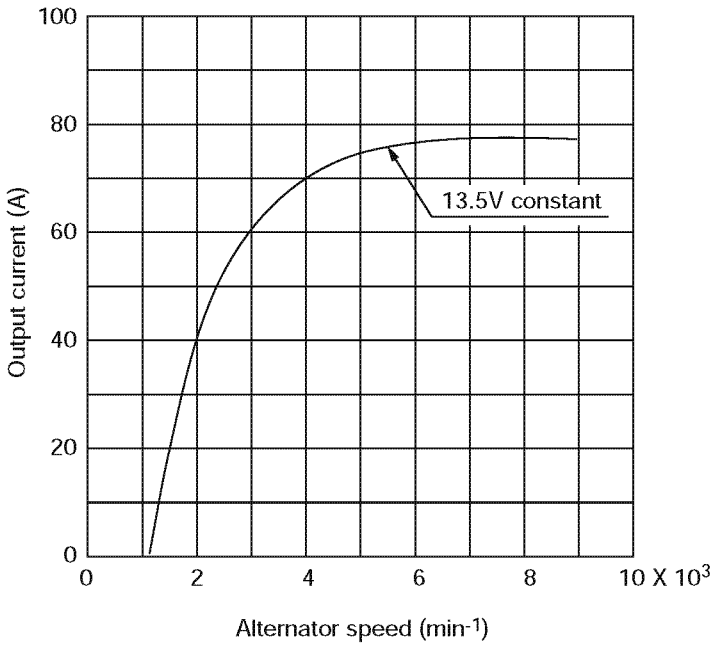


[NOTICE]

1) Don't do mis-connecting and short-circuit of each terminal.
2) Don't remove a battery terminal and a B terminal when rotating.
3) Shut out a battery switch during the alternator stop.

12.5.4 Standard output characteristics

The standard output characteristics of this alternator are shown as the below figure.

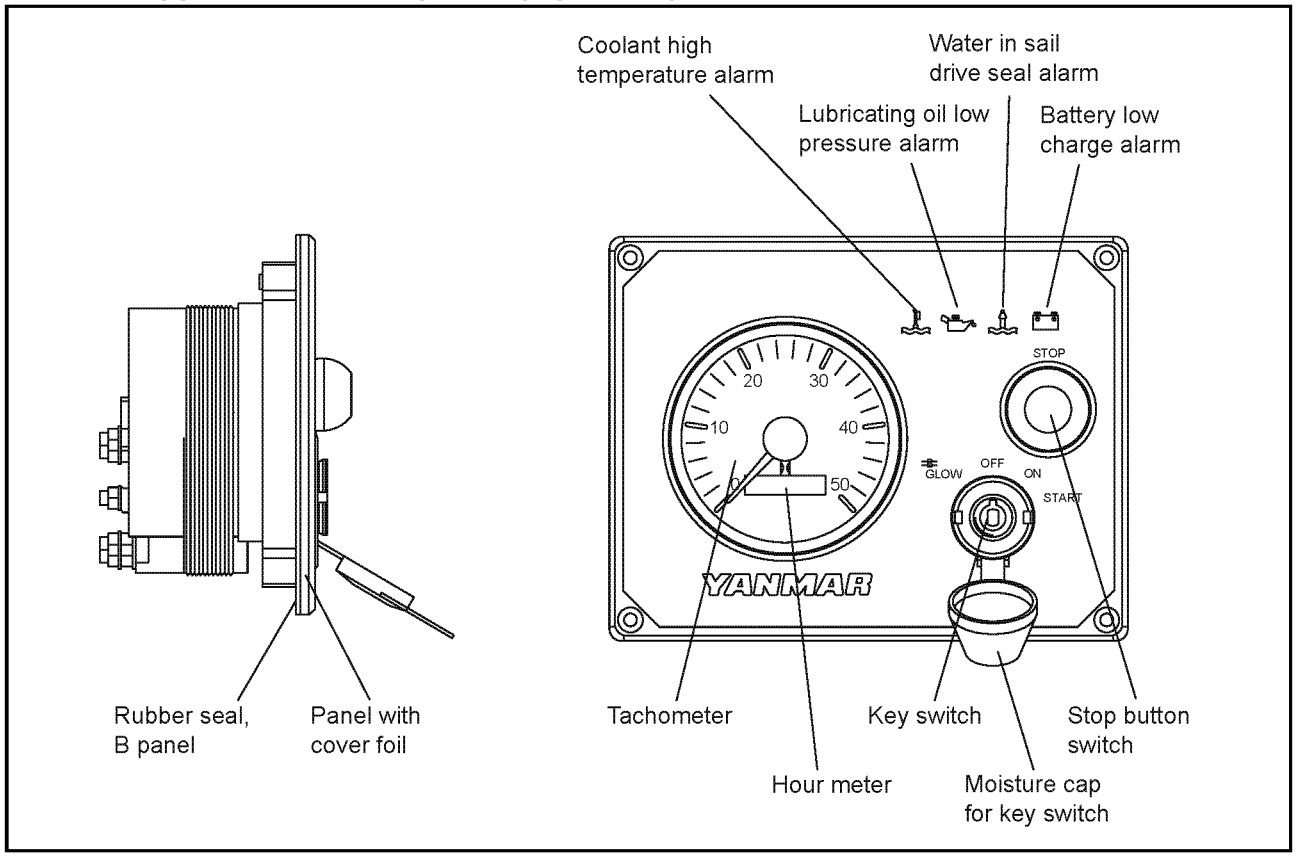


(Standard characteristics)

12.6 Instrument panel

The new type instrument panels are applied for 3YM30/3YM20/2YM15 series engines. The features are compactness, waterproof and independence from pulse by ring gear teeth number.
The engine speed, indicated with the instrument panel is activated by the pulse from flywheel ring gear. The engine speed with new panel is activated by alternator B terminal pulse

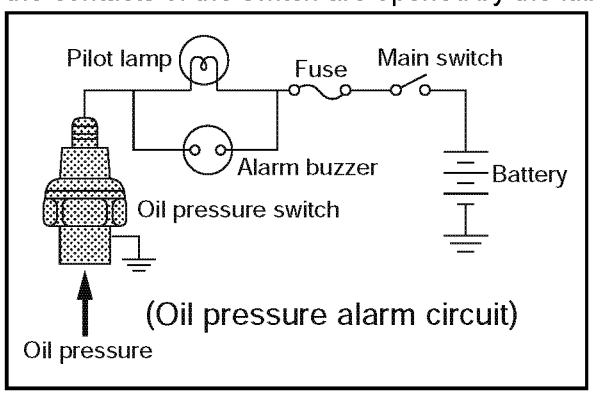
12.6.1 B-type instrument panel (Optional)



12.7 Warning devices

12.7.1 Oil pressure alarm

If the engine oil pressure is below 0.01-0.03 MPa (0.1-0.3 kgf/cm^2, 1.42-4.26 lb/in.^{2}), with the main switch in the ON position, the contacts of the oil pressure are closed by a spring and the lamp is illuminated through the lamp → oil pressure switch → ground circuit system. If the oil pressure is normal, the contacts of the switch are opened by the lubricating oil pressure and the lamp remains off.



Rated voltage	12V
Operating pressure	0.04-0.06 MPa (0.4-0.6 kgf/cm^2)
Lamp capacity	5 W