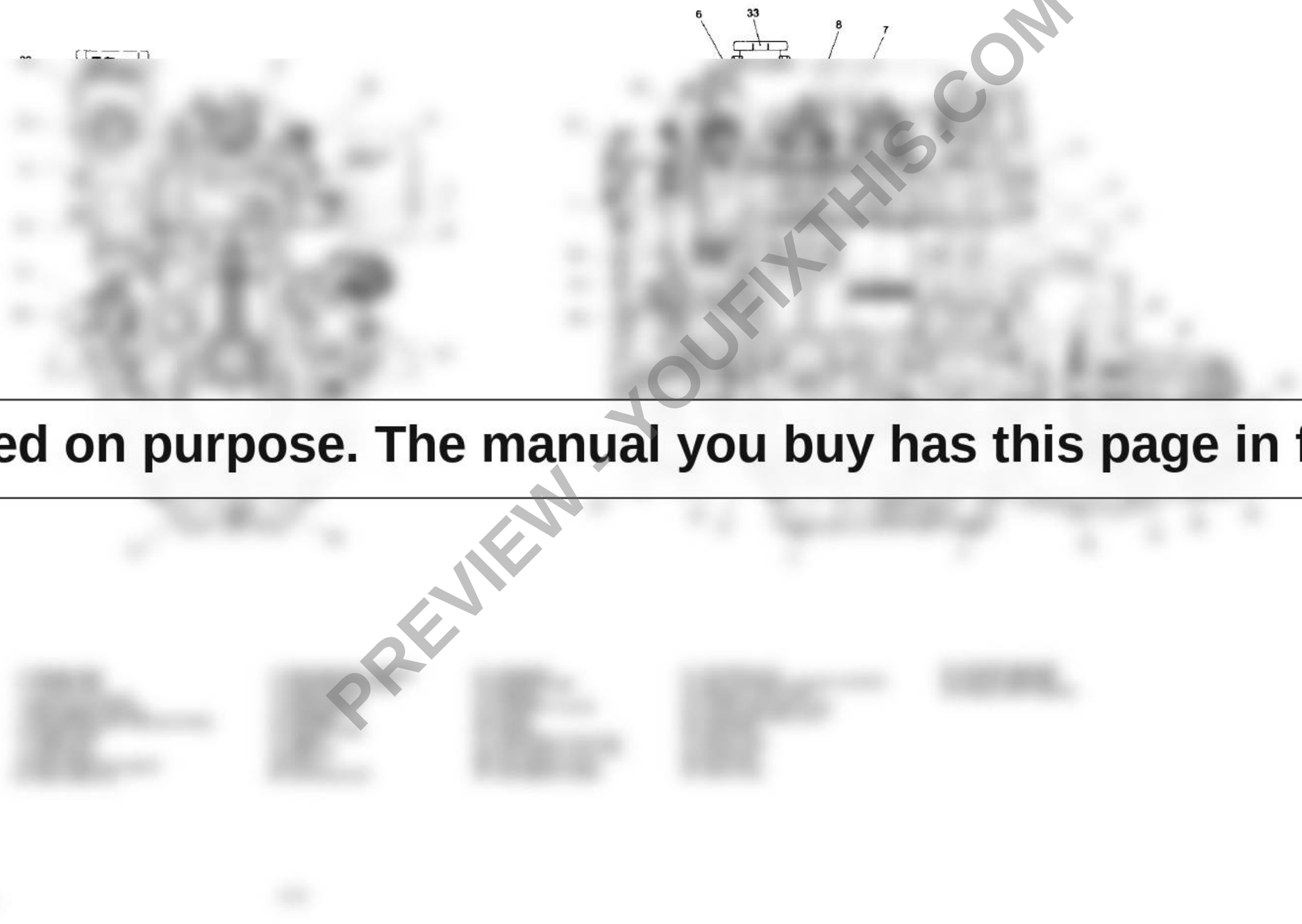
1. Specifications

1-1 Direct Sea Water Cooling Type

Model		1GM10	2GM20	3GM30	3HM35
Type		Vertical 4-cycle water cooled diesel engine			
Combustion chamber		Swirl pre-combustion chamber			
Number of cylinders		1	2	3	3
Bore × stroke	mm	75 × 72			80 × 85
Displacement	L	0.318	0.636	0.954	1.282

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5-6 3GM30F



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kgf-m(ft-lb)

	All models
Camshaft end nut	7.0 ~ 8.0 (50.6 ~ 57.9)
Crankshaft nut	8.0 ~ 10.0 (57.9 ~ 72.3)

NOTE: When tightening or loosening the crankshaft nut, take care that the spanner does not touch the governor weight or weight support.

(4) assembling model 1GM10(C) cooling water pump
When model 1GM10(C) cooling water pump is assembled, ensure that the pump shaft engages with the slit of the rotor shaft end of the lubricating oil pump and with the bearing. Check by rotating the crankshaft.



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1-1.7 Fuel handling precautions

(1) Fill the fuel tank after work to prevent condensation of water in the tank.
(2) Always use a tank inlet strainer. Water mixed in the fuel can be removed by removing the strainer quickly.
(3) Remove the plug at the bottom of the fuel tank and drain out the water and sediment after every 100 hours of operation, and when servicing the pump and nozzle.
(4) Do not use fuel in the bottom of the fuel tank because it contains large amounts of dirt and water.

1-2.2 Required lubricating oil conditions

(1) Must be of suitable viscosity
If the viscosity is too low, the oil film will be too thin and the lubricating action insufficient. If the viscosity is too high, the friction resistance will be increased and starting will become especially difficult.
(2) Viscosity change with temperature must be small. While the lube oil temperature goes from low at starting to high during operation, the viscosity index should be high at all temperatures.

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2-5 Storage when moored for an extended period

(1) Securely close engine room windows and doors so that rain and snow cannot enter.
Also plug the exhaust outlet since water that enters the cylinder from the exhaust pipe will be compressed when the engine is started, causing serious trouble.
(2) The boat may also sink because of water leakage at the stern tube stuffing box packing. This can be prevented by tightening the packing.
(3) Change the lubricating oil before cranking the engine.
(4) Wipe off each part and coat with oil to prevent rusting of the engine exterior.
(5) Coat the regulator handle stand and each link with a thin film of lube oil or grease.
(6) Run the engine once a week to lubricate each part.This will prevent rusting of the bearings, pistons, and cylinder liners.

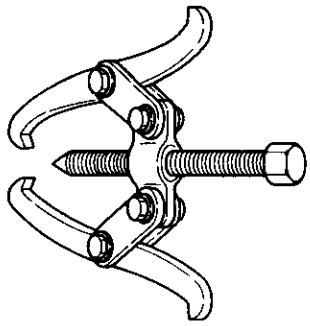
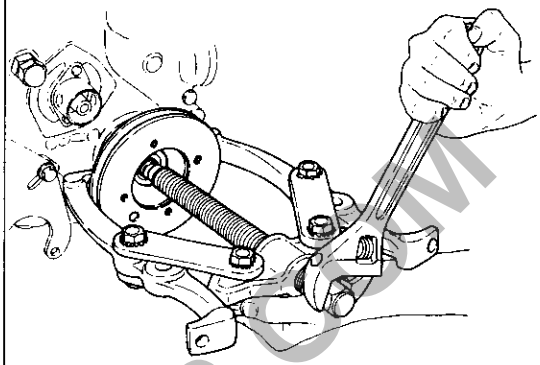
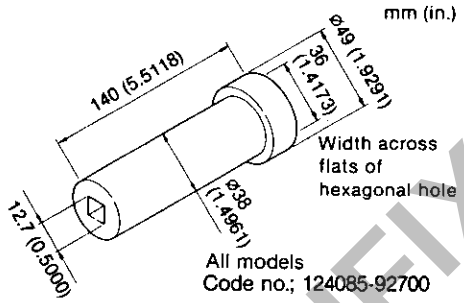
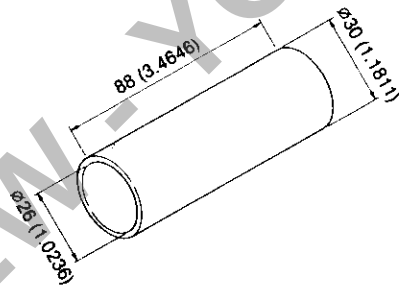
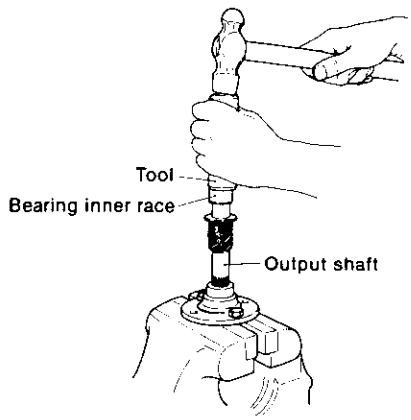
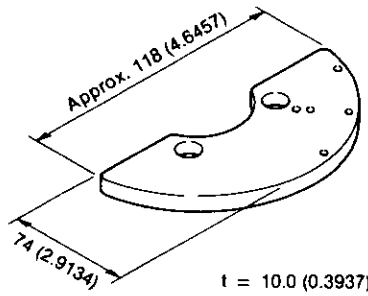
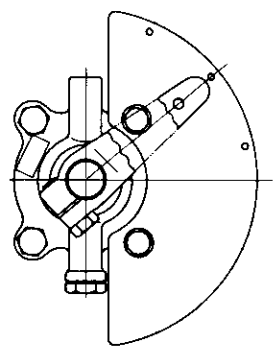
2-6 Emergency stop

(1) Loosen the fuel valve high-pressure pipe to release the fuel.
(2) Pull the decompression lever (decompression mechanism) so that compression is not applied to the combustion chamber.
(3) Block the air intake port so that air does not enter the combustion chamber.

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Name of tool	Shape and size	Application
Pulley puller	 Rocal supply	 Removing the coupling
Tool for turning crankshaft gear nut Tightening the crankshaft gear nut	mm (in.)  All models Code no.; 124085-92700	
Driving tool for bearing inner race (for models 1GM10, 2GM20(F), 3GM30(F)	mm (in.)  Code no.; 177088-09150	 The bearing inner race of the drive output shaft.
Operation lever locating jig [for models 1GM10 2GM20(F) and 3GM30(F)]	mm (in.)  Code no.; 177088-09160	 Adjusting the operation lever

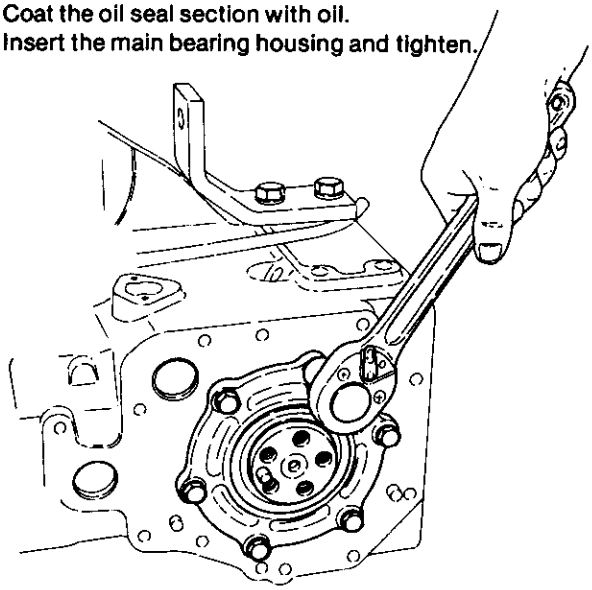
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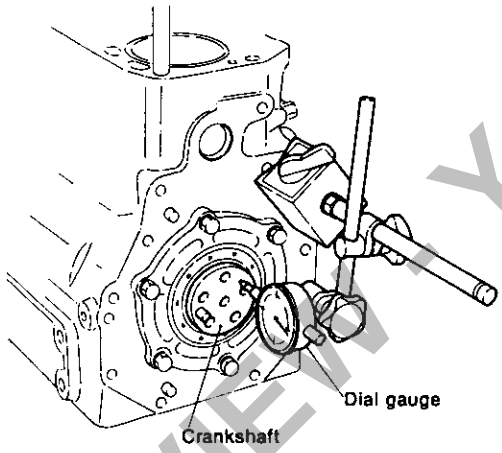
5-3.5 Install the main bearing housing

(1) Coat the oil seal section with oil.
(2) Insert the main bearing housing and tighten.



Tightening torque	2.5kgf-m(18ft-lb)

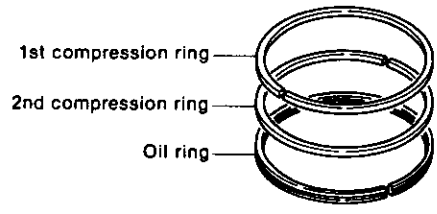
(3) Check that the crankshaft rotates smoothly.
(4) Measure the crankshaft side gap, and adjust it to the prescribed value using the thickness of the packing.

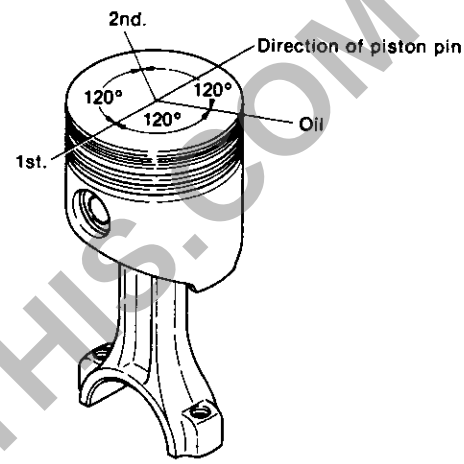


Crankshaft side gap	0.09 ~ 0.18mm (0.035 ~ 0.0071in.)

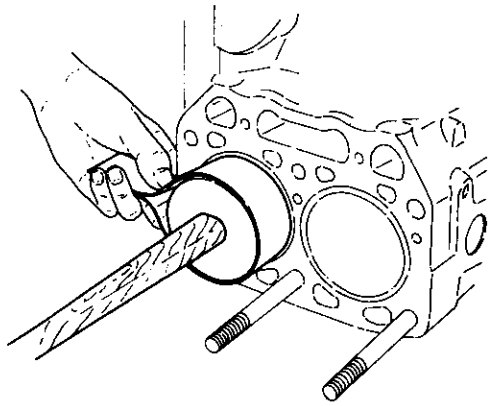
5-3.6 Assemble the piston and connecting rod assembly

(1) Coat the crankpin section with oil and position it so that the insertion side crank is at the top.
(2) Coat the piston and crankpin bearing with oil.
(3) Position the piston rings so that the gaps are 120° apart; make sure that there is no gap at the side pressure section.

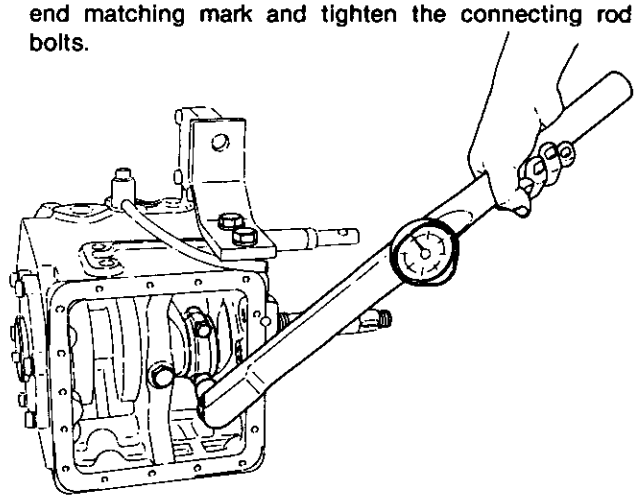




(4) Insert the piston connecting rod assembly so that the side of the connecting rod large end with the identification number is on the exhaust side.
Install the piston rings with a piston ring inserter.



(5) After the connecting rod large end makes contact with the crankpin, push the piston crown down slowly to turn the crankshaft to bottom dead center.
(6) Align the connecting rod cap and connecting rod large end matching mark and tighten the connecting rod bolts.



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2. Exhaust Gas Regulations

The engines conform to the EPA exhaust gas regulations (under 8 kW, 8kW and 19kW under, 19kW and under 37 kW for each) for a low emission engine.

The ARB standard is the same as the EPA's

Test cycle: ISO 8178-4 E3 mode

Power Range kW (Gross power)	Standard (g/kWh)(Tier 1)			Smoke (US Opacity %) transient mode
	NOx + NMHC	CO	PM	
Range < 8	10.5	8.0	1.0	Not applicable
8 ≦ Range < 19	9.5	6.6	0.80	
19 ≦ Range < 37	9.5	5.5	0.80	

3. Guarantee Conditions for Emission Standard

The following guarantee conditions are set down in the operation manual. In addition to making sure that these conditions are met, check for any deterioration that may occur before the required periodic maintenance times.

- **Requirement on engine installation condition**

(1) Air intake depression

kPa (mmH_2O)

Permissible
≦ −0.49 (−50)

(2) Exhaust gas back pressure

kPa (mmH_2O)

Permissible
≦ 6.86 (700)

- **Fuel oil and lubricating oil**

(1) Fuel: The diesel fuel oil [ISO 8217 DMA, BS 2869 A1 or A2 (Cetane No.45 min.)]
(2) Lube oil: API grade, class CD

- **Do not remove the seals restricting injection quantity and high idling engine speed.**
- **Perform maintenance without fail.**

Note: Inspections to be carried out by the user and by the maker are divided and set down in the "List of Periodic Inspections" on the operation manual and should be checked carefully.

EPA allows to apply Maintenance schedule for Emission related parts as follows.

—	Check Fuel Injection Nozzle and clean	Adjust, cleaning and repair of Fuel Injection Pump, Fuel Valve Nozzle and Turbocharger
kW ≦ 130	1500 hours of use and at 1500-hour intervals thereafter	3000 hours of use and at 3000-hour intervals thereafter

- **Quality guarantee period for exhaust emission related parts**

For exhaust emission related parts, follow the inspections outlined in the "List of Periodic Inspections", on the operation manual, and use the table below to carry out inspections based on operation hours or time in years. Whichever comes first is the guarantee period.

Range < 19	1500 hours or 2 years
19 ≦ Range < 37	3000 hours or 5 years

The specific emissions-related parts are (1) Fuel injection nozzle (2) Fuel injection pump (3) Turbocharger. (if installed)

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Models **1GM10(C)**
2GM20(F)(C)
3GM30(F)(C)
3HM35(F)(C)

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1. For Safe Servicing

- Most accidents are caused by failing to observe basic safety rules and precautions. To prevent accidents, it is important to recognize the signs of approaching problems, and eliminate the problems in the early stage before they can cause accidents.
  Please read this manual carefully before starting repairs or maintenance to fully understand safety precautions and appropriate inspection and maintenance procedures. Attempting a repair or maintenance job without sufficient knowledge may cause an unexpected accident.

- It is impossible to cover every possible danger in repair or maintenance in the manual.
  Sufficient consideration for safety is required. Especially for safety precautions in a repair or maintenance job not described in this manual, receive instructions from a knowledgeable leader.

- Safety marks used in this manual and their meanings are as follows:

⚠DANGER	**DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.**
⚠WARNING	**WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.**
⚠CAUTION	**CAUTION indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.**

- Any matter marked NOTE in this manual is especially important in servicing. If not observed, the product performance and quality may not be guaranteed.

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FOREWORD

This service manual has been compiled for engineers engaged in sales, service, inspection and maintenance. Accordingly, descriptions of the construction and functions of the engine are emphasized in this manual while items which should already be common knowledge are omitted.

One characteristic of a marine diesel engine is that its performance in a vessel is governed by its applicability to the vessel's hull construction and its steering system.

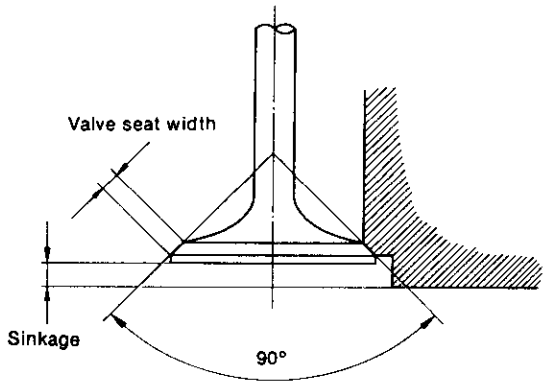
Engine installation, fitting out and propeller selection have a substantial effect on the performance of the engine and the vessel. Moreover, when the engine runs unevenly or when trouble occurs, it is essential to check a wide range of operating conditions—such as installation on the hull and suitability of the ship's piping and propeller—and not just the engine itself. To get maximum performance from this engine, you should completely understand its functions, construction and capabilities, as well as proper use and servicing.

Use this manual as a handy reference in daily inspection and maintenance, and as a text for engineering guidance.

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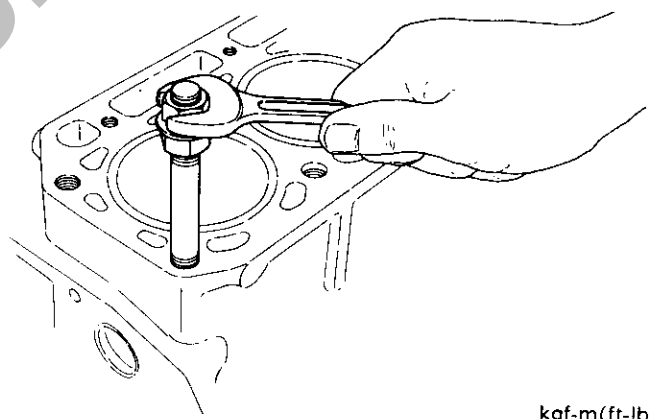
	1GM10(C), 2GM20(F)(C), 3GM30(F)(C)		3HM35(F)(C)	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Valve sinkage	0.95 (0.0374)	1.25 (0.0492)	1.25 (0.0492)	1.55 (0.0610)

2-2.8 Rocker arm support positioning pin [for model 1GM10(C)]

Check if the guide pin is damaged or if the hole is clogged, and replace the pin if faulty.

2-3 Dismounting and remounting the cylinder head

When dismounting and remounting the cylinder head, the mounting bolts must be removed and installed gradually and in the prescribed sequence to prevent damaging the gasket packing and to prevent distortion of the cylinder head. Since the tightening torque and tightening sequence of the mounting bolts when remounting the cylinder head are especially important from the standpoint of engine performance, the following items must be strictly observed.



2-3.1 Cylinder head assembly sequence

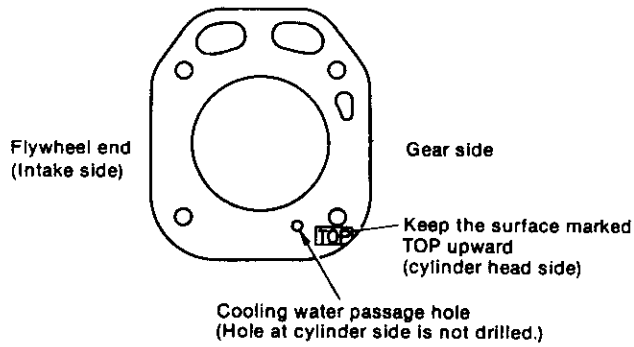
(1) Check for loose cylinder head stud bolts, and lock any loose bolts with two nuts and then tighten to the prescribed torque.
The cylinder head is fitted to the engine with 4 stud bolts in model 1GM10(C), but in other engine models both stud bolts and collar head bolts are used.

kgf-m(ft-lb)

	1GM10(C)	2GM20(F)(C), 3GM30(F)(C)	3HM35(F)(C)
Stud bolt diameter of cylinder head	M10	M12	M12
Cylinder head stud bolt tightening torque	6.0 (43.4)	8.0 (57.9)	10.0 (72.3)

(2) Checking the gasket packing mounting face.
Confirm correct alignment of the front and rear of the gasket packing, and install the packing by coating both sides with Three Bond 50.
Assemble the gasket packing keeping the flat surface upward (cylinder head side). Make sure that the gasket hole aligns with the drilled hole in the cooling water passage in the cylinder block.

1) For Model 1GM10(C)



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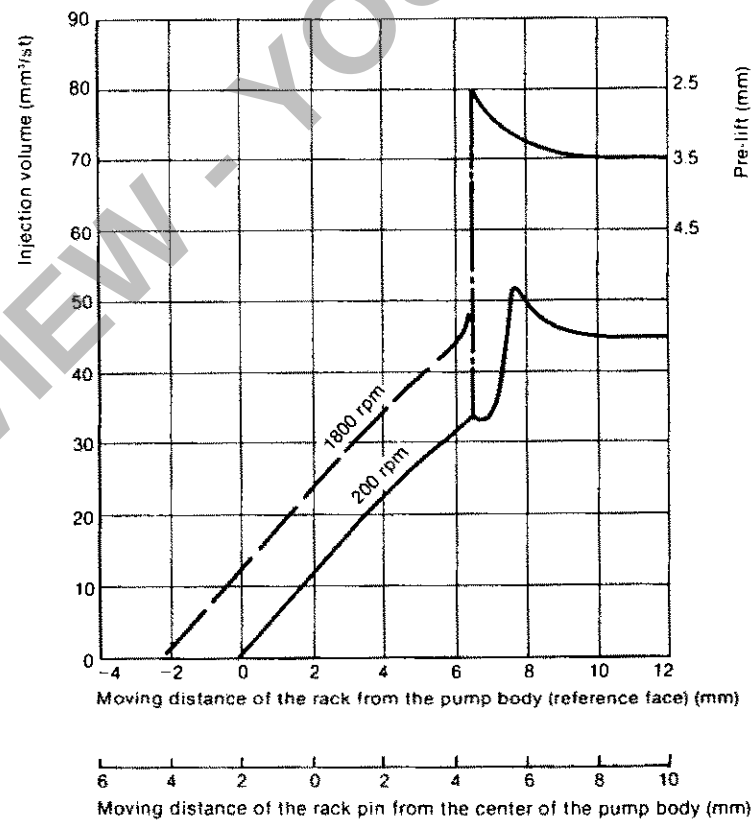
2-2 Specifications and performance of fuel injection pump

2-2.1 Specifications of fuel injection pump

			1GM10(C)	2GM20(F)(C)	3GM30(F)(C)	3HM35(F)(C)
Plunger diameter			6mm (0.2362in.)			6.5mm (0.2559in.)
Standard plunger stroke			7mm (0.2756in.)			
Static mechanical lift at injection			2.5mm (0.0984in.) [at starting 3.2mm (0.1260in.)]			
Sliding resistance of fuel volume adjusting rack (when pump stops)			60g (0.002 lb) or less			
Top clearance of plunger (at the set dimension of 76 ±0.05mm)			1.0mm (0.0394in.)			
Thickness of plunger position adjusting shim			0.1mm (0.0039in.), 0.2mm (0.0079in.), 0.3mm (0.0118in.)			
Plunger spring (124950-51190 commonly used)	Free length		35.5mm (1.3976in.)			
	Spring constant		1.93 kgf/cm (10.8 lb/in.)			
	Load	At upper limit	25.1 kg (55.3 lb)			
		At lower limit	11.6 kg (25.6 lb)			
		At static injection	16.4 kg (36.2 lb)			
Suction volume of delivery valve			23.5mm³ (0.0014in.³) (24.5 according to 1GM10(C) drawing)			
Opening pressure of delivery valve			Approx. 16.3 kgf/cm² (231.8 lb/in.²)			
Delivery valve spring (124550-51320 commonly used)	Free length		21.0mm (0.8268in.)			
	Spring constant		0.64 kgf/cm (9.1 lb/in.)			
Rack stroke			Approx. 15mm (0.5906in.)			

2-2.2 Injection volume characteristics of fuel injection pump

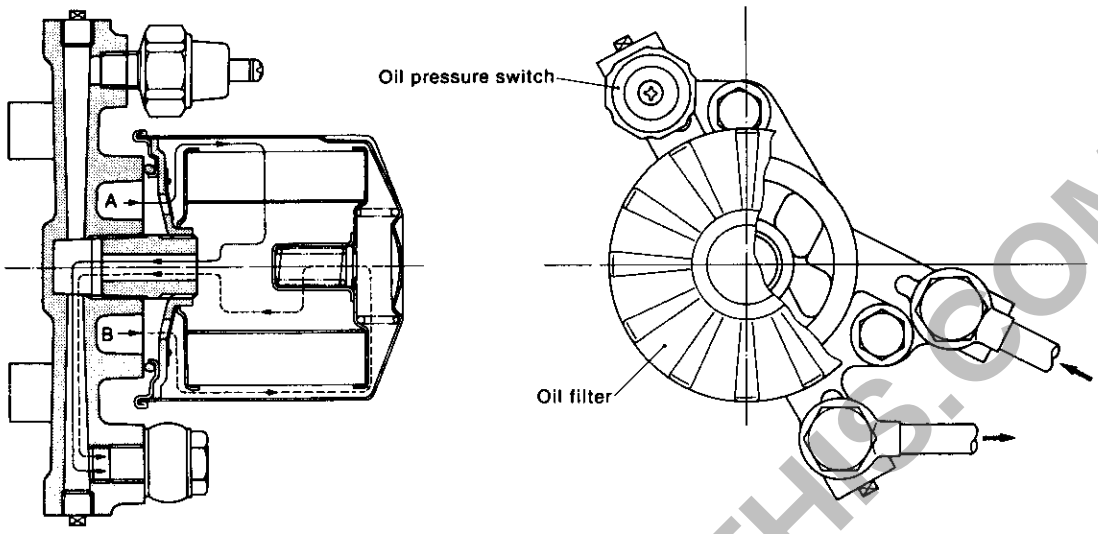
(1) Model 1GM10(C)



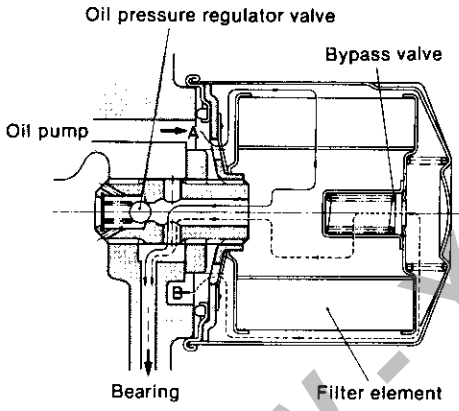
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1GM10(C)



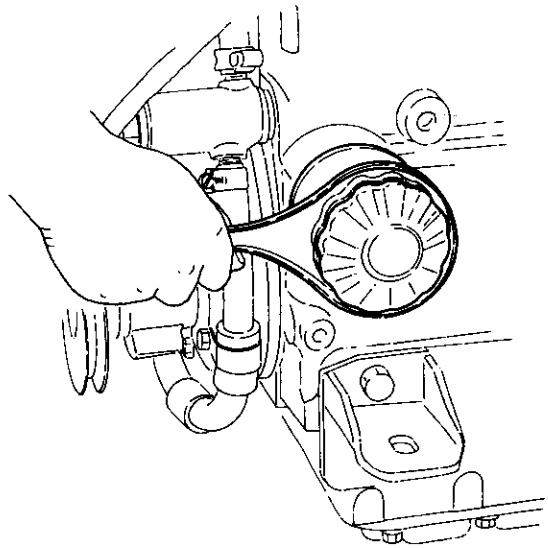
2GM20(F)(C), 3GM30(F)(C) and 3HM35(F)(C)



3-2 Replacement

When the oil filter has been used for an extended period, the filter paper will become clogged, unfiltered lubricating oil will be sent directly to each part from the bypass circuit, and wear of moving parts will be accelerated. Therefore, it is important that the filter be periodically replaced.
Because this is a cartridge type oil filter, it is replaced as a complete unit.

Oil filter replacement period	Every 300 hours of engine operation



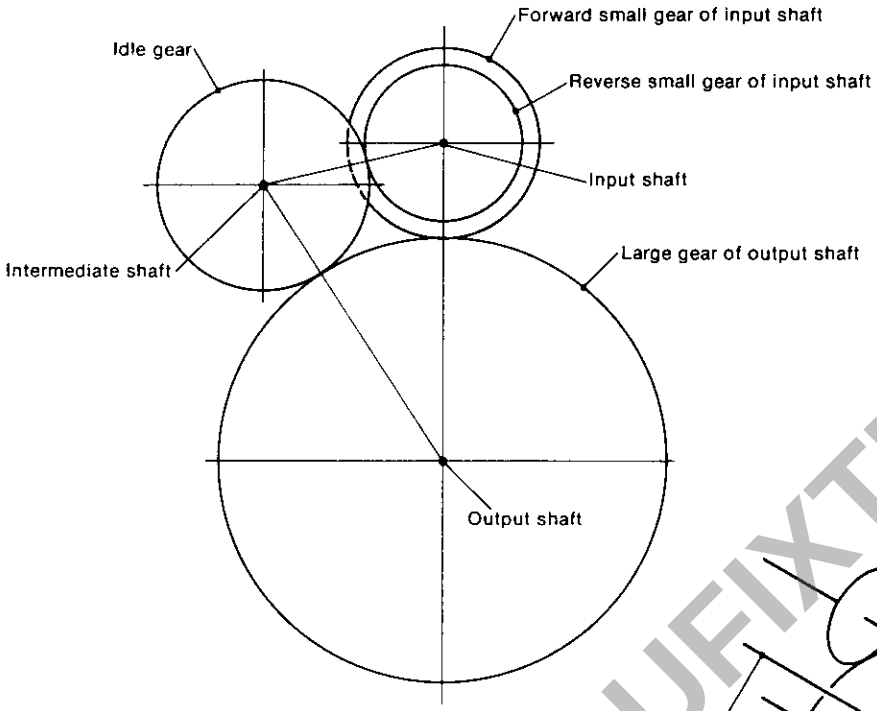
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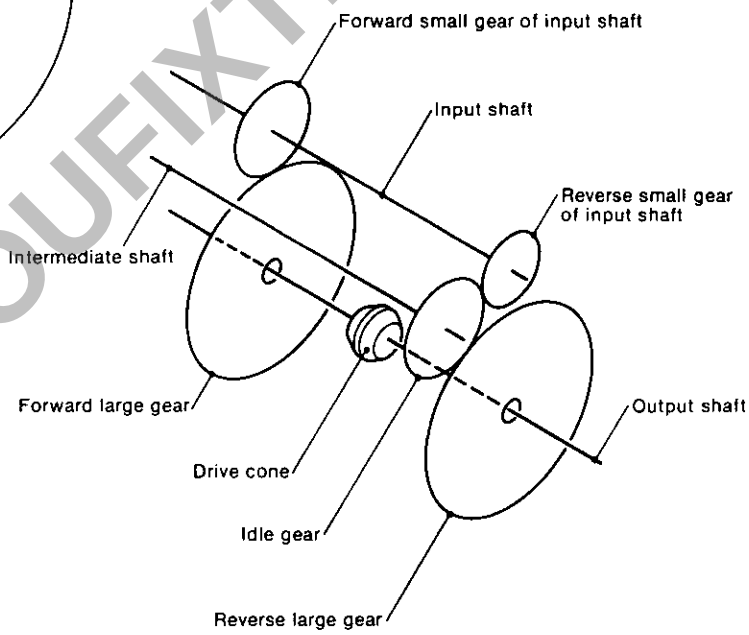
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1-3 Power transmission system

1-3.1 Arrangement of shafts and gears





1-3.2 Reduction ratio

Forward

Model	No. of teeth of forward small gear Zif	No. of teeth of forward large gear Zof	Reduction ratio Zof/Zif
KM2-C	24	53	53/24 = 2.21
	21	55	55/21 = 2.62
	18	58	58/18 = 3.22
KM3-A	25	59	59/25 = 2.36
	23	60	60/23 = 2.61
	20	64	64/20 = 3.20

Reverse

Model	No. of teeth of reverse small gear Zir	No. of teeth of intermediate shaft gear Zi	No. of teeth of reverse large gear Zdr	Reduction ratio Zi/Zir·Zdr/Zi
KM2-C	18	26	55	55/18 = 3.06
KM3-A	19	26	60	60/19 = 3.16

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3. Inspection and Servicing

3-1 Clutch case

(1) Check the clutch case with a test hammer for cracking.
Perform a color check when required.
If the case is cracked, replace it.
(2) Check for staining on the inside surface of the bearing section.
Also, measure the inside diameter of the case.
Replace the case if it is worn beyond the wear limit.

3-2 Bearing

(1) Rusting and damage.
If the bearing is rusted or the taper roller retainer is damaged, replace the bearing.
(2) Make sure that the bearings rotate smoothly.
If rotation is not smooth, if there is any binding, or if any abnormal sound is evident, replace the bearing.

3-3 Gear

Check the surface, tooth face conditions and backlash of each gear. Replace any defective part.
(1) Tooth surface wear.
Check the tooth surface for pitting, abnormal wear, dents, and cracks. Repair the lightly damaged gears and replace heavily damaged gears.
(2) Tooth surface contact.
Check the tooth surface contact. The amount of tooth surface contact between the tooth crest and tooth flank must be at least 70% of the tooth width.
(3) Backlash.
Measure the backlash of each gear, and replace the gear when it is worn beyond the wear limit.

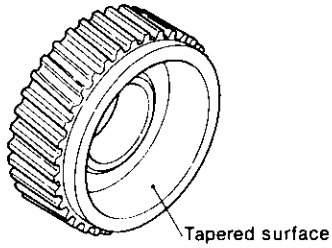
mm (in.)

	Maintenance standard	Wear limit
Input shaft forward gear and output shaft forward gear	0.06 ~ 0.12 (0.0024 ~ 0.0047)	0.2 (0.0079)
Input shaft reverse gear and intermediate gear	0.06 ~ 0.12 (0.0024 ~ 0.0047)	0.2 (0.0079)
Intermediate gear and output shaft reverse gear	0.06 ~ 0.12 (0.0024 ~ 0.0047)	0.2 (0.0079)

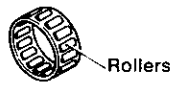
(The same dimensions apply to both KM2P and KM3P)

3-4 Forward and reverse large gears

(1) Contact surface with drive cone.
Visually inspect the tapered surface of the forward and reverse large gears where they make contact with the drive cone to check if any abnormal condition or sign of overheating exists.
If any defect is found, replace the gear.

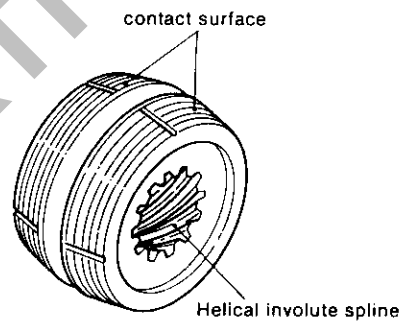


(2) Forward/reverse gear needle bearing.
When an abnormal sound is produced at the needle bearing, visually inspect the rollers; replace the bearing if the rollers are faulty.

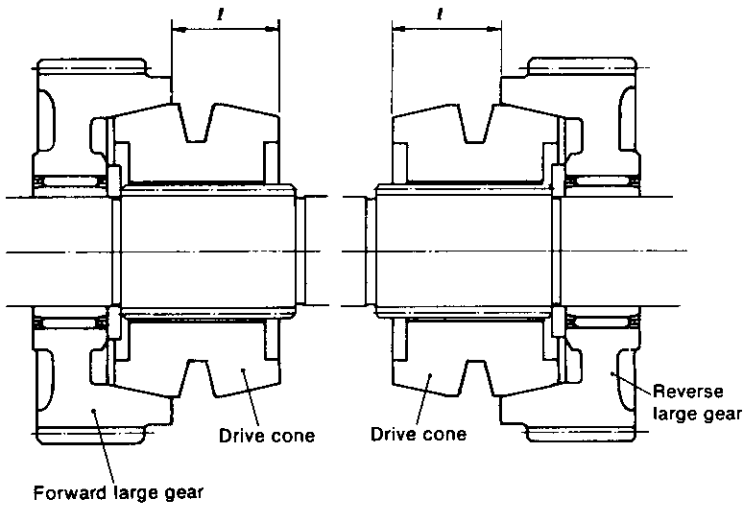


3-5 Drive cone

(1) Visually inspect that part of the surface that comes into contact with the circumferential triangular slot to check for signs of scoring, overheating or wear. If deep scoring or signs of overheating are found, replace the cone.



(2) Check the helical involute spline for any abnormal condition on the tooth surface, and repair or replace the part should any defect be found.
(3) Measure the amount of wear on the tapered contact surface of the drive cone, and replace the cone when the wear exceeds the specified limit.



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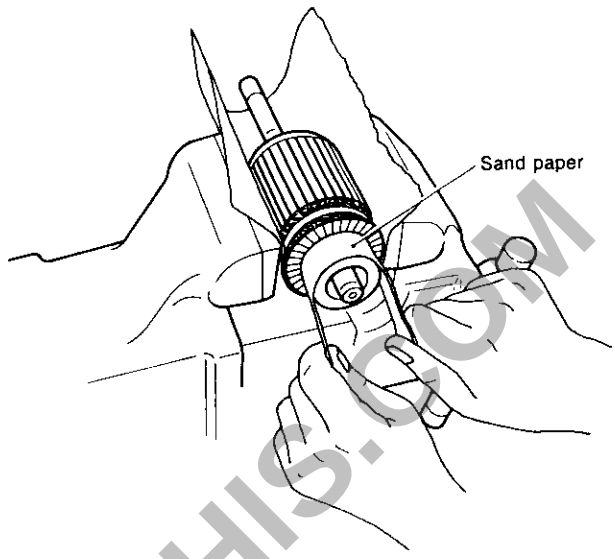
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3-6 Inspection

3-6.1 Armature

(1) Commutator

Inspect the surface of the commutator. If corroded or pitted, sand with #500 ~ #600 sandpaper. If the commutator is severely pitted, grind it to within a surface roughness of at least 0.4 by turning it on a lathe. Replace the commutator if damage is irreparable.

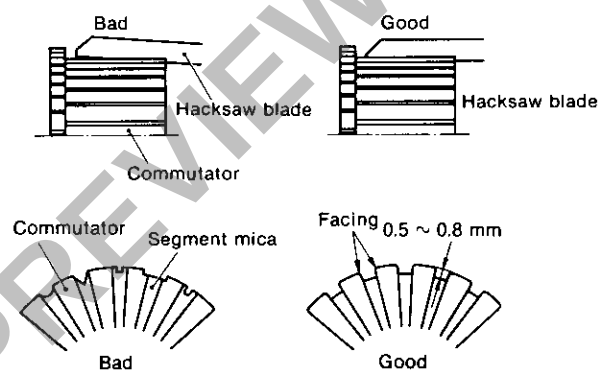


mm (in.)

	S114-303		S12-77A	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Commutator outside diameter	ø33 (1.299)	ø32 (1.260)	ø43 (1.693)	ø40 (1.575)
Commutator run-out	Within 0.03 (0.0012)	0.2 (0.0079)	Within 0.03 (0.0012)	0.2 (0.0079)
Difference between maximum diameter and minimum diameter	Repair limit 0.4 (0.0157)	Repair accuracy 0.05 (0.002)	Repair limit 0.4 (0.0157)	Repair accuracy 0.05 (0.002)

(2) Mica undercut

Check the mica undercut, correct with a hacksaw blade when the undercut is too shallow.



mm (in.)

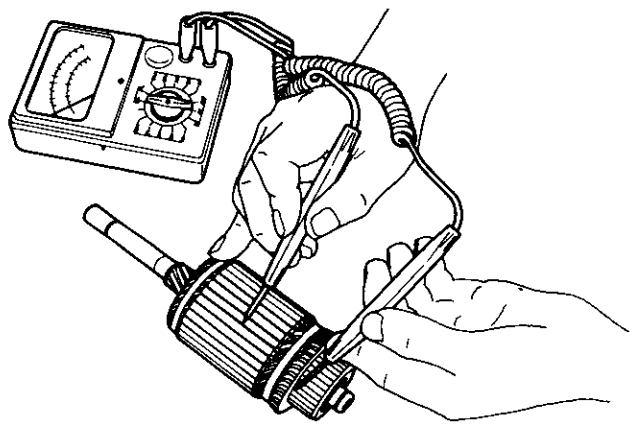
	Maintenance standard	Repair limit
Mica undercut	0.2 (0.0079)	0.5 ~ 0.8 (0.0197 ~ 0.0315)

(3) Armature coil ground test

Using a tester, check for continuity between the commutator and the shaft (or armature core). Continuity indicates that these points are grounded and that the armature must be replaced.

1) Short test...existence of broken or disconnected coil.
2) Insulation test...between commutator and armature core or distortion shaft.

Checking commutator for insulation defects.



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