

Shop Manual

4D98 SERIES 4D106 SERIES S4D106 SERIES

DIESEL ENGINE

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FOREWORD

This manual describes the service procedures for the 4TNE94-98-106(T) engines (direct injection) for industrial use.


Please use this manual for accurate, quick and safe servicing of the said engine. Since the explanation in this manual assumes the standard type engine, the specifications and components may partially be different from the engine installed on individual work equipment (power generator, pump, compressor, etc.). Please also refer to the service manual for each work equipment for details.


The specifications and components may be subject to change for improvement of the engine quality. If any modification of the contents described herein becomes necessary, it will be notified in the form of a correction information each time.





This product has been developed, designed and manufactured in a plant certified by the JMI, BSI and EQNET to conform to the quality assurance system standard provided as ISO 9001 (International Standard for Quality Assurance).

For Safe Servicing

- Most accidents are caused by negligence of basic safety rules and precautions. For accident prevention, it is important to avoid such causes before development to accidents. Please read this manual carefully before starting repair or maintenance to fully understand safety precautions and appropriate inspection and maintenance procedures. Attempting at 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 in addition to the matters marked  CAUTION. 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 **[NOTICE]** in this manual is especially important in servicing. If not observed, the product performance and quality may not be guaranteed.

Precautions for Safe Servicing

(A) Service Shop (Place)

WARNING



- **Place allowing sufficient ventilation**

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

[Otherwise]

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

CAUTION

- **Sufficiently wide and flat place**

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

[Otherwise]

An accident such as a violent fall may be caused.

CAUTION

- **Clean, orderly arranged place**

No dust, mud, oil or parts shall left uncleaned on the floor surface.

[Otherwise]

An unexpected accident may be caused.

CAUTION



- **Bright, safely illuminated place**

The working place should be illuminated sufficiently and safely. For a job in a dark position involving difficulty in observation, use a portable safety lamp. The bulb shall be covered with a wire cage.

[Otherwise]

The bulb may be broken accidentally to cause ignition of leaking oil.

CAUTION



- **Place equipped with a fire extinguisher**

Keep a fast aid kit and fire extinguisher close at hand in preparation for an emergency of fire starting.

(B) Working Wear

CAUTION



- **Wears for Safe Operation**

Wear a helmet, working clothes, safety shoes and other safety protectors matching each job. Especially, wear well-fitting working clothes.

[Otherwise]

A serious accident such as trapping by a machine may arise.

(C) Tools to Be Used

WARNING

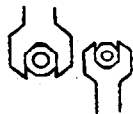
- **Appropriate holding and lifting**

Never operate when the engine is supported with blocks or wooden pieces or only with a jack. To lift and hold the engine, always use a crane with a sufficient allowance in limit load or a rigid jack.

[Otherwise]

A serious accident may arise.

WARNING



- **Use of Appropriate Tools**

Use tools matching the jobs to be done. Use a correctly sized tool for loosening or tightening a machine part.

[Otherwise]

A serious injury or engine damage may arise.

(D) Use of Genuine Parts, Oil and Grease

CAUTION



- **Always use genuine parts.**

[Otherwise]

Shortening of engine life or an unexpected accident may arise.

(E) Bolt and Nut Tightening Torques

WARNING



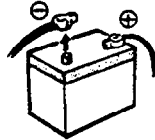
- **Always tighten to the specified torque if designated in the manual.**

[Otherwise]

Loosening or falling may cause parts damage or an injury.

(F) Electrical Parts

WARNING



- **Harness Short-circuit**
Disconnect the battery negative (-) terminal before starting the service job.
[Otherwise]
Shorting of a harness may occur to start a fire.

WARNING



- **Battery Charging**
Since flammable gas is generated during battery charging, keep any fire source away.
[Otherwise]
Explosion may arise.

WARNING



- **Battery Electrolyte**
Since the electrolyte is diluted sulfuric acid, do not let it be splashed onto clothes or skin.
[Otherwise]
The clothes or skin may be burnt.

(G) Waste Treatment

CAUTION

Observe the following instructions with regard to waste disposal. Negligence of each instruction will cause environmental pollution.

- Waste fluids such as engine oil and cooling water shall be discharged into a container without spillage onto the ground.
- Do not let waste fluids be discharged into the sewerage, a river or the sea.
- Harmful wastes such as oil, fuel, solvents, filter elements and battery shall be treated according to the respective laws and regulations. Ask a qualified collecting company for example.

(H) Handling the Product

WARNING



- **Supplying the Fuel**
When supplying the fuel, always keep any fire source like a cigarette or match away.
[Otherwise]
A fire or explosion may arise.

WARNING



- **Pay attention to hot portions.**
Do not touch the engine during running or immediately after it is stopped.
[Otherwise]
Scalding may be caused by a high temperature.

WARNING



- **Pay attention to the rotating part.**
Never bring clothes or a tool close to the rotating part during engine running.
[Otherwise]
Injury may be caused by entrapping.

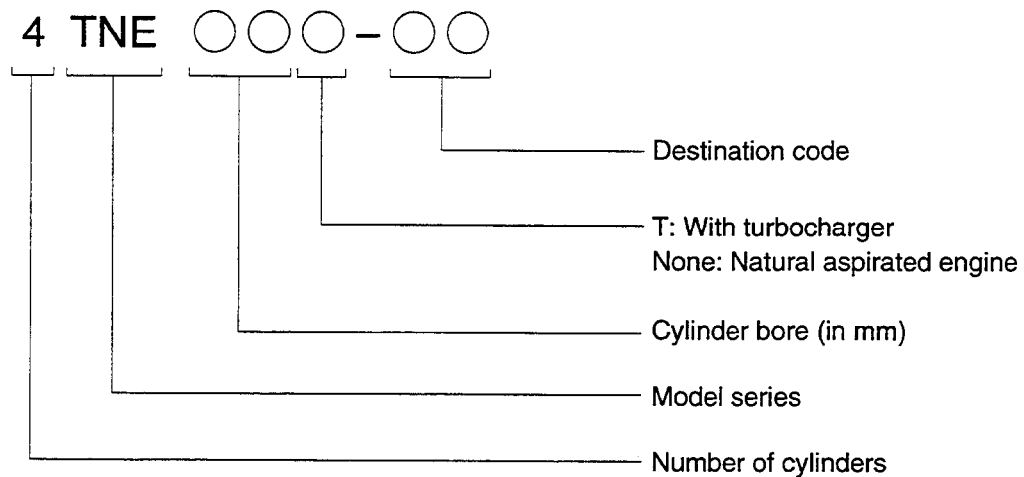
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1.1 Engine Nomenclature



- Engine application class

	Application	Revolving speed	Number of revolutions (rpm)
CL	Generator driving	Constant speed	1500/1800
VM	General purpose	Variable speed	2000~2500

※The engine application class (CL or VM) is described in the specifications table.

1.2 Specifications

(1) 4TNE94

Engine name		Unit	4TNE94						
Engine specification class		—	CL		VM				
Type		—	Vertical, in-line, 4-cycle, water-cooled diesel engine						
Combustion chamber		—	Direct injection						
Number of cylinders		—	4						
Cylinder bore × stroke		mm × mm	94 × 100						
Displacement		ℓ	2.776						
Continuous rating	Revolving speed	rpm	1500	1800	—				
	Output	kW (hp)	26.1 (35.0)	31.3 (42.0)	—				
Rated output	Revolving speed	rpm	1500	1800	2000	2200	2400	2500	
	Output	kW (hp)	29.1 (39.0)	34.6 (46.4)	35.3 (47.3)	38.2 (51.2)	41.6 (55.8)	43.0 (57.7)	
Fuel injection timing (FID, bTDC)		deg	10~12						
Fuel injection pressure		MPa (kgf/cm ²)	21.57~ 22.55 (220~230)						
Ignition order		—	1-3-4-2 (No. 1 cylinder on flywheel side)						
Power take off		—	Flywheel						
Direction of rotation		—	Counterclockwise (viewed from flywheel)						
Cooling system		—	Radiator						
Lubrication system		—	Forced lubrication with trochoid pump						
Starting system		—	Electric						
Applicable fuel		—	Diesel oil-ISO 8217 DMA, BS 2869 A1 or A2 (cetane No. 45 min.)						
Applicable lubricant		—	API grade class CD						
Battery capacity		V-AH	12-64 (5HR) or above						
Lubricant capacity (oil pan)	Total	ℓ	10.2						
	Effective	ℓ	4.5						
Cooling water capacity (engine only)		ℓ	4.2						
Engine dimensions	Overall length	mm	720						
	Overall width	mm	508						
	Overall height	mm	689						
Engine weight (dry)		kg	223						

(2) 4TNE98

Engine name		Unit	4TNE98					
Engine specification class		-	CL		VM			
Type		-	Vertical, in-line, 4-cycle, water-cooled diesel engine					
Combustion chamber		-	Direct injection					
Number of cylinders		-	4					
Cylinder bore x stroke		mm x mm	98 x 110					
Displacement		ℓ	3.319					
Continuous rating	Revolving speed	rpm	1500	1800	-			
	Output	kW (hp)	30.9 (41.4)	36.8 (49.3)	-			
Rated output	Revolving speed	rpm	1500	1800	2000	2200	2400	2500
	Output	kW (hp)	34.6 (46.4)	41.2 (55.3)	41.9 (56.2)	45.6 (61.2)	49.3 (66.1)	51.1 (68.5)
Fuel injection timing (FID, bTDC)		deg	10~12					
Fuel injection pressure		MPa (kg/cm ²)	21.57~ 22.55 (220~230)					
Ignition order		-	1-3-4-2 (No. 1 cylinder on flywheel side)					
Power take off		-	Flywheel					
Direction of rotation		-	Counterclockwise (viewed from flywheel)					
Cooling system		-	Radiator					
Lubrication system		-	Forced lubrication with trochoid pump					
Starting system		-	Electric					
Applicable fuel		-	Diesel oil-ISO 8217 DMA, BS 2869 A1 or A2 (cetane No. 45 min.)					
Applicable lubricant		-	API grade class CD					
Battery capacity		V-AH	12-64 (5HR) or above					
Lubricant capacity (oil pan)	Total	ℓ	10.2					
	Effective	ℓ	4.5					
Cooling water capacity (engine only)		ℓ	4.2					
Engine dimensions	Overall length	mm	720					
	Overall width	mm	508					
	Overall height	mm	689					
Engine weight (dry)		kg	223					

1. General

(3) 4TNE106

Engine name		Unit	4TNE106					
Engine specification class		-	CL		VM			
Type		-	Vertical, in-line, 4-cycle, water-cooled diesel engine					
Combustion chamber		-	Direct injection					
Number of cylinders		-	4					
Cylinder bore × stroke		mm × mm	106 × 125					
Displacement		ℓ	4.412					
Continuous rating	Revolving speed	rpm	1500	1800	-			
	Output	kW (hp)	44.9 (60.2)	53.7 (72.0)	-			
Rated output	Revolving speed	rpm	1500	1800	2000	2200	2400	2500
	Output	kW (hp)	49.3 (66.1)	58.8 (78.8)	56.6 (75.8)	61.4 (82.3)	65.5 (87.8)	67.7 (90.7)
Fuel injection timing (FID, bTDC)		deg	13~15					
Fuel injection pressure		MPa (kgf/cm ²)	21.57~ 22.55 (220~230)					
Ignition order		-	1-3-4-2 (No. 1 cylinder on flywheel side)					
Power take off		-	Flywheel					
Direction of rotation		-	Counterclockwise (viewed from flywheel)					
Cooling system		-	Radiator					
Lubrication system		-	Forced lubrication with trochoid pump					
Starting system		-	Electric					
Applicable fuel		-	Diesel oil-ISO 8217 DMA, BS 2869 A1 or A2 (cetane No. 45 min.)					
Applicable lubricant		-	API grade class CD					
Battery capacity		V-AH	12-88 (5HR) or above					
Lubricant capacity (oil pan)	Total	ℓ	12.5					
	Effective	ℓ	5.5					
Cooling water capacity (engine only)		ℓ	6.0					
Engine dimensions	Overall length	mm	789					
	Overall width	mm	535					
	Overall height	mm	750					
Engine weight (dry)		kg	301					

(4) 4TNE106T

Engine name		Unit	4TNE106T					
Engine specification class		–	CL		VM			
Type		–	Vertical, in-line, 4-cycle, water-cooled diesel engine					
Combustion chamber		–	Direct injection					
Number of cylinders		–	4					
Cylinder bore × stroke		mm × mm	106 × 125					
Displacement		ℓ	4.412					
Continuous rating	Revolving speed	rpm	1500	1800	–			
	Output	kW (hp)	54.8 (73.4)	65.5 (87.8)	–			
Rated output	Revolving speed	rpm	1500	1800	2000	2200	2400	2500
	Output	kW (hp)	60.3 (80.8)	72.1 (96.6)	69.9 (93.7)	75.8 (101.6)	81.6 (109.3)	84.2 (112.8)
Fuel injection timing (FID, bTDC)		deg	11~13					
Fuel injection pressure		MPa (kgf/cm ²)	21.57~ 22.55 (220~230)					
Ignition order		–	1–3–4–2 (No. 1 cylinder on flywheel side)					
Power take off		–	Flywheel					
Direction of rotation		–	Counterclockwise (viewed from flywheel)					
Cooling system		–	Radiator					
Lubrication system		–	Forced lubrication with trochoid pump					
Starting system		–	Electric					
Applicable fuel		–	Diesel oil-ISO 8217 DMA, BS 2869 A1 or A2 (cetane No. 45 min.)					
Applicable lubricant		–	API grade class CD					
Battery capacity		V-AH	12–88 (5HR) or above					
Lubricant capacity (oil pan)	Total	ℓ	12.5					
	Effective	ℓ	5.5					
Cooling water capacity (engine only)		ℓ	6.0					
Engine dimensions	Overall length	mm	789					
	Overall width	mm	547					
	Overall height	mm	855					
Engine weight (dry)		kg	306					

1.3 Fuel Oil, Lubricating Oil and Cooling Water

(1) Fuel oil

[NOTICE]

Use of other than the specified fuel oil may fail to obtain the full engine performance or cause parts failures.

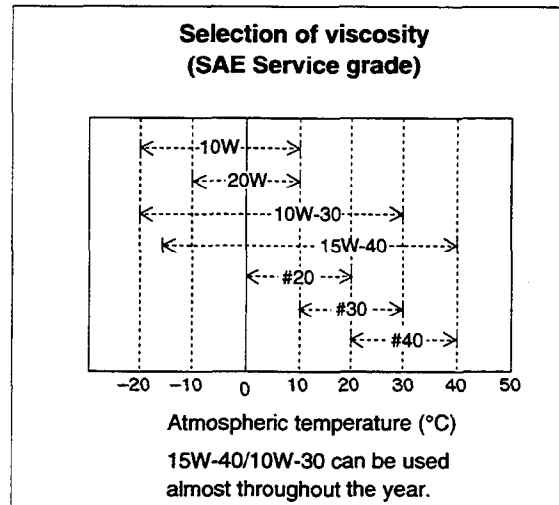
- Applicable fuel
Always use diesel gas oil ISO 8217DMA, BS 2869A1 or A2 (cetane No. 45 min.) that is most suitable for desired engine performance.

(2) Lubricating oil

[NOTICE]

Use of other than the specified lubricating oil may cause inner parts seizure or early wear, leading to shortening of the engine service life.

- Applicable lubricating oil
Use lubricating oil of CD class of API Service Classification.
Select the viscosity number according to the ambient temperature by referring to the table below.
- Handling of lubricating oil
 - 1) Carefully store and handle the oil so as to prevent dust or dirt entrance. When supplying the oil, pay careful attention and clean around the filler port.
 - 2) Do not use mixture of different types of oil as it may degrade the lubricating performance.



(3) Cooling water

Use clean drinkable water (tap water or rainwater) as the cooling water.

[NOTICE]

Always add antirust or antifreeze in the cooling water. Especially in cold weather, be sure to add antifreeze to prevent freezing. Since scale or rust will be generated in the water piping when only clear water is used, the cooling performance is worsened. In a cold weather, the cooling water may be expanded by freezing to cause damage to the cooling system parts.

1) Rust preventive agent

Be sure to add the rust preventive agent to the cooling water. However, do not use it in cold weather because freezing will occur.

When you use a rust preventive agent sold on the market, be sure to follow the mixing rate designated by the manufacturer.

Replace the rust preventive agent once a year.

2) Antifreeze

In cold weather, be sure to add the antifreeze to prevent freezing.

If you use antifreeze, addition of the rust preventive agent is unnecessary. Antifreeze can be used throughout the year.

The mixing rate should be between 30% and 55%.

[NOTICE]

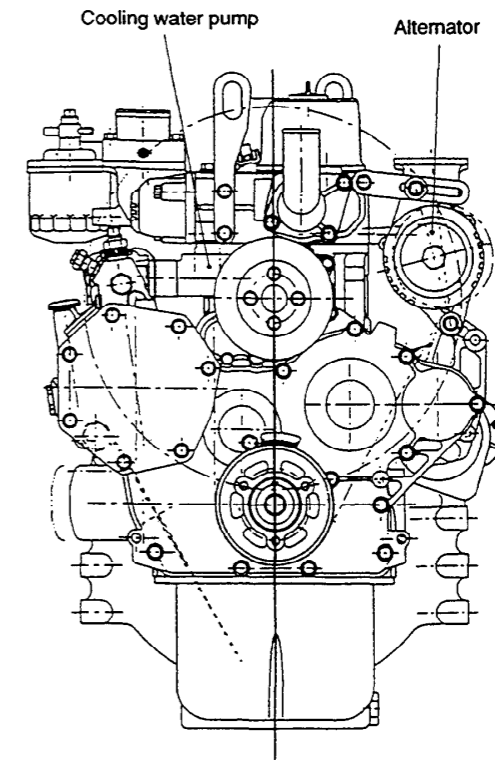
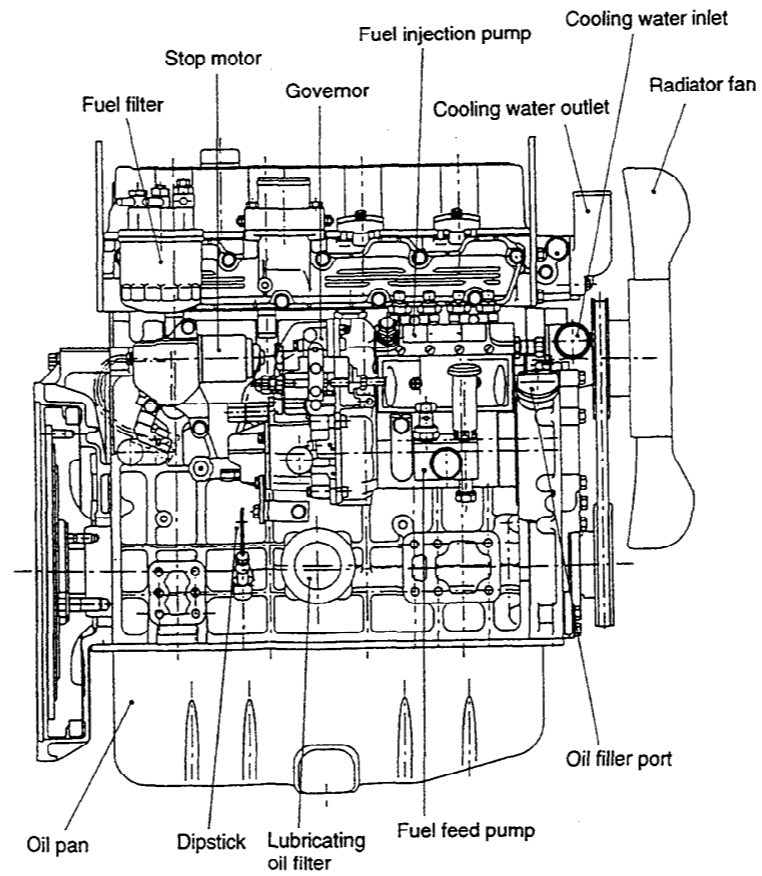
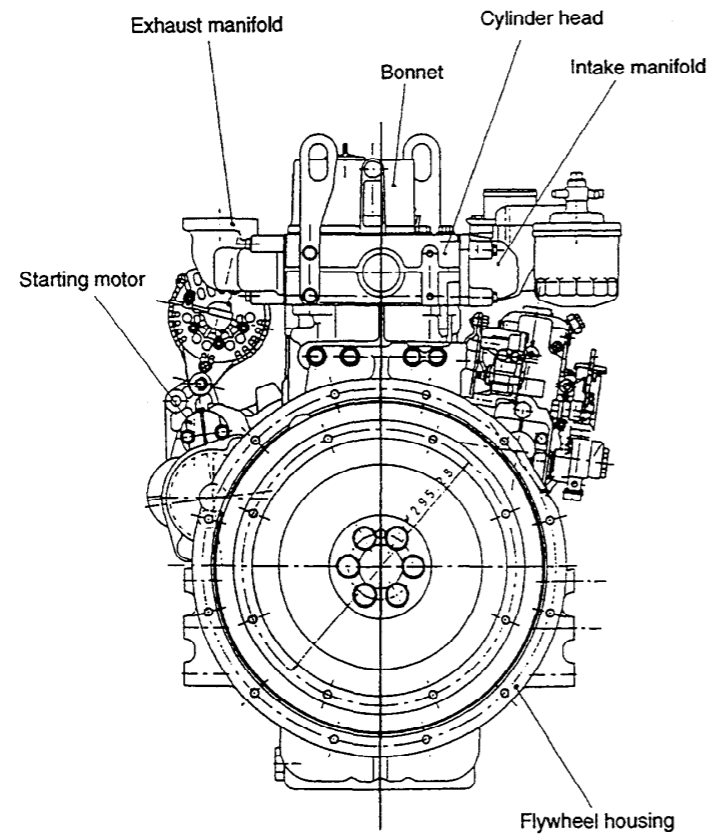
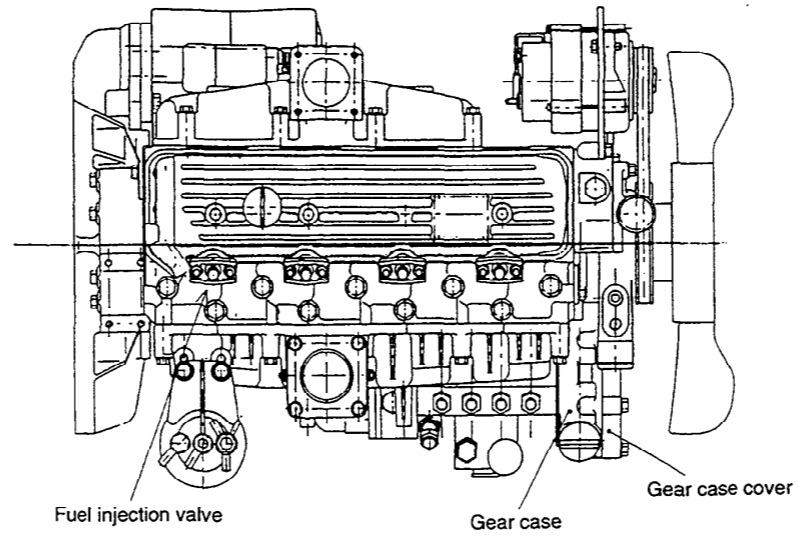
Excessive addition of antifreeze will worsen engine cooling. Always observe the mixing rate specified by the manufacturer for each ambient temperature.

Lowest atmospheric temperature °C	-15 or above	-20	-25
Mixing rate %	30	35	40

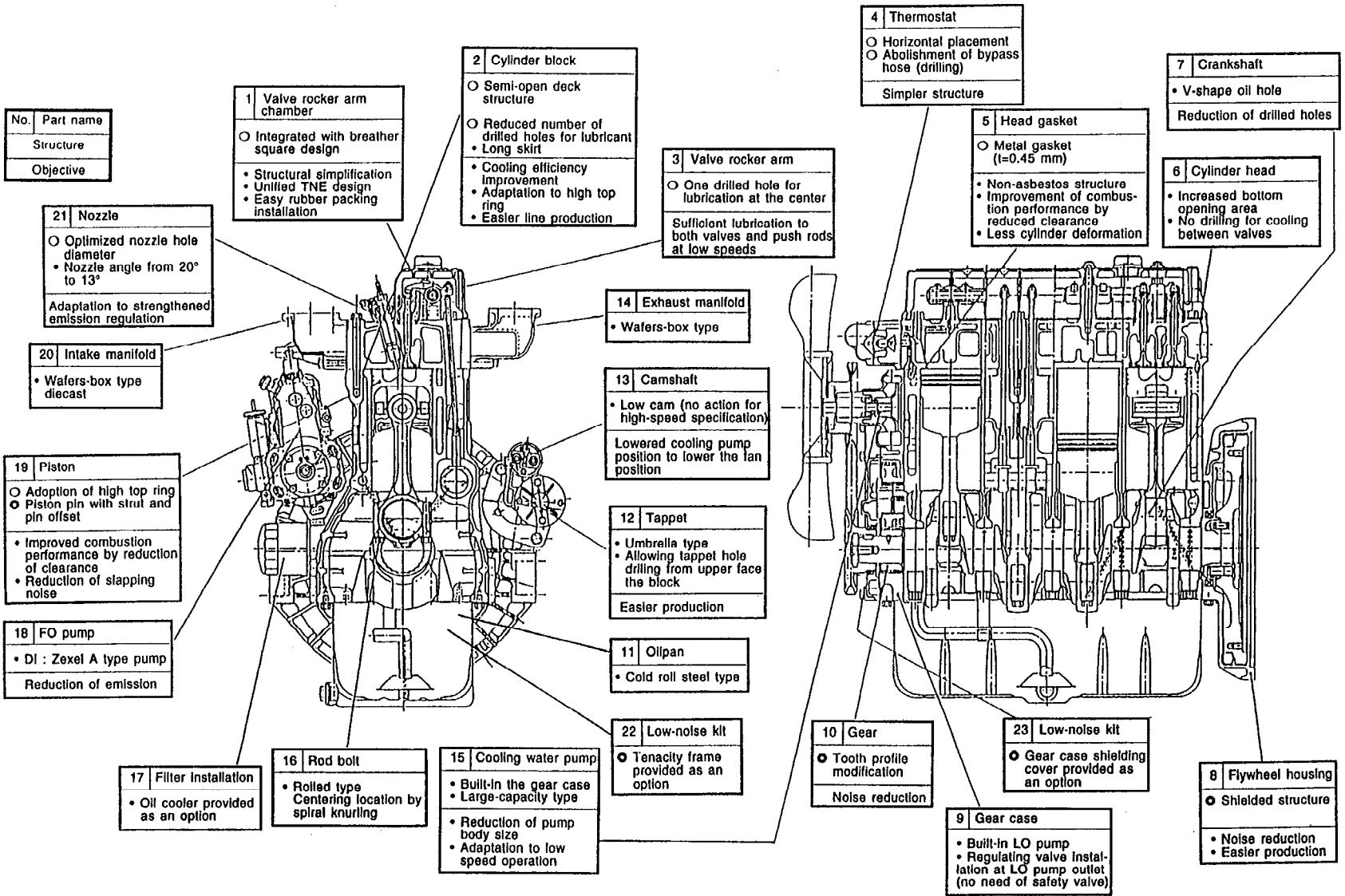
When you use an antifreeze sold on the market, be sure to follow the mixing rate designated by the manufacturer.

Replace the antifreeze once a year.

1.4 Engine External Views



1.5 Structural Description



1.6 How to Read This Manual

(1) Range of Operation Explanation

This manual explains the troubleshooting, installation/removal, replacement, disassemble/reassembly, inspection, adjustment and adjusting operation procedures for the 4TNE94/98/106 (T) engine.

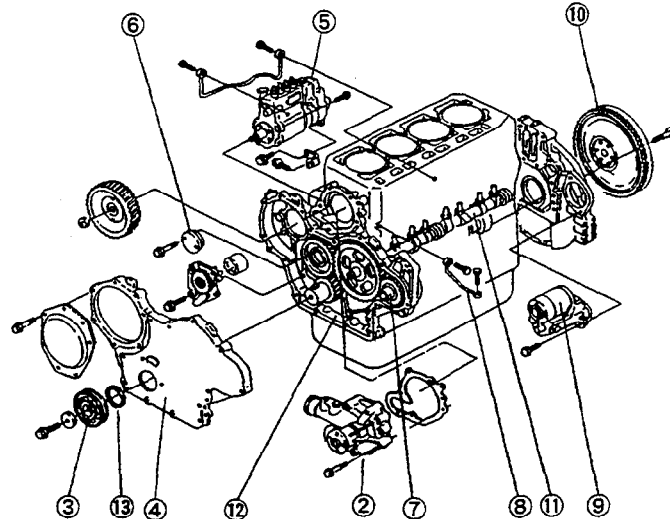
Refer to the manufacturer's manual for each of the fuel injection pump, governor, starting motor and alternator except for their installation.

(2) How to Read The Explanations

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

Description Example

• Illustration



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

• Disassembly procedure

- (1) Follow steps (1) to (12) of the cylinder head disassembly procedure.
- (2) Remove the cooling water pump.
- (3) Remove the crankshaft pulley. (**Point 1**)

• Operation Points

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

Operation point to be explained on a later page.

- **Contents omitted in this manual**

Though the following jobs are omitted in the explanation in this manual, they should be conducted in actual work:

- (1) Jacking up and lifting
- (2) Cleaning and washing of removed parts as required
- (3) Visual inspection

(3) Definition of Terms

[NOTICE] Instruction whose negligence is very likely to cause an accident. Always observe it.

Standard: Allowable range for inspection and adjustment

Limit: The maximum or minimum value that must be satisfied during inspection or adjustment

(4) Abbreviations

Abbreviation	Meaning	Abbreviation	Meaning
Assy	assembly	T.D.C.	top dead center
Sub-Assy	sub-assembly	B.D.C.	bottom dead center
a.T.D.C	after top dead center	OS	oversize
b.T.D.C.	before top dead center	US	undersize
STD	Standard	rpm	revolutions per minute
IN	Intake	PS	output (metric horsepower)
EX	Exhaust	T	Bolt/nut tightening torque

1.7 Precautions for Service Work

(1) Precautions for Safety

Read the safety precautions given at the beginning of this manual carefully and always mind safety in work.

(2) Preparation for Service Work

Preparation is necessary for accurate, efficient service work. Check the customer ledger file for the history of the engine.

- (2.1) Preceding service date
- (2.2) Period/operation hours after preceding service
- (2.3) Problems and actions in preceding service
- (2.4) Replacement parts expected to be required for service
- (2.5) Recording form/check sheet required for service

(3) Preparation before Disassembly

- (3.1) Prepare general tools, special service tools, measuring instruments, oil, grease, non-reusable parts, and parts expected to be required for replacement.
- (3.2) When disassembling complicated portions, put matchmarks and other marks at places not adversely affecting the function for easy reassembly.

(4) Precautions in Disassembly

- (4.1) Each time a part is removed, check the part installed state, deformation, damage, roughening, surface defect, etc.
- (4.2) Arrange the removed parts orderly with clear distinction between those to be replaced and those to be used again.
- (4.3) Parts to be used again shall be washed and cleaned sufficiently.
- (4.4) Select especially clean locations and use clean tools for disassembly of hydraulic units such as the fuel injection pump.

(5) Precautions for Inspection and Measurement

- (5.1) Inspect and measure parts to be used again as required to determine whether they are reusable or not.

(6) Precautions for Reassembly

- (6.1) Reassemble correct parts in correct order according to the specified standards (tightening torques, and adjustment standards). Apply oil to important bolts and nuts before tightening when specified.
- (6.2) Always use genuine parts for replacement.
- (6.3) Always use new oil seals, O-rings, packings and cotter pins.
- (6.4) Apply sealant to packings depending on the place where they are used. Apply oil or grease to sliding contact portions, and apply grease to oil seal lips.

(7) Precautions for Adjustment and Check

- (7.1) Use measuring instruments for adjustment to the specified service standards.

1.8 Tightening Torques for Standard Bolts and Nuts

(Lubricating oil not applied)

Item	Nominal thread diameter × pitch	Tightening torque Nm(kgf-m)	Remarks
Hexagon bolt (7T)/nut	M 6 × 1	9.8-11.8 (1.0-1.2)	1) Use 80% of the value at left when the tightening side is aluminum. 2) Use 60% of the value at left for 4T bolts and lock nuts.
	M 8 × 1.25	22.5-28.4 (2.3-2.9)	
	M10 × 1.5	44.1-53.9 (4.5-5.5)	
	M12 × 1.75	78.4-98 (8.0-10)	
PT plug	1/8	9.8 (1.0)	_____
	1/4	19.6(2.0)	
	3/8	29.4(3.0)	
	1/2	58.8(6.0)	
Pipe joint bolt	M 8	12.7-16.7 (1.3-1.7)	_____
	M12	24.5-34.3 (2.5-3.5)	
	M14	39.2-49 (4.0-5.0)	
	M16	49-58.8 (5.0-6.0)	

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2. TROUBLESHOOTING

2.1 Quick Reference Table for Troubleshooting

The following table summarizes the general trouble symptoms and their causes. If any trouble symptom occurs, take corrective action before it develops into a serious problem so as not to shorten the engine service life.

Cause	Trouble symptom	Starting failure		Insufficient engine output		Poor exhaust color		High knocking sound during combustion	Abnormal engine sound	Uneven combustion sound	Hunting		Difficulty in returning to low speed	Excessive fuel consumption	Lubricating oil			Cooling water		Air intake		Corrective action				
		Engine does not start.	Engine starts but stops soon.		Exhaust color		During work				During idling	During work			Large engine vibration	Excessive consumption	Dilution by fuel oil	Mixture with water	Low L.O. pressure	Much blow-by gas	Overheat		Low water temperature	Pressure drop	Pressure rise	Exhaust temperature rise
			None	Little	Much	Ordinary																				
Engine system	Improper clearance of intake/exhaust valve	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>				<input type="checkbox"/>										<input type="checkbox"/>	<input type="checkbox"/>	Adjust the valve clearance. (See 3.5 in Chapter 3.)					
	Compression leakage from valve seat	<input type="checkbox"/>			<input type="checkbox"/>				<input type="checkbox"/>					<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	Lap the valve seat. (See 4.2(6) in Chapter 4.)					
	Seizure of intake/exhaust valve	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>	Correct or replace.					
	Blowout from cylinder head gasket				<input type="checkbox"/>												<input type="checkbox"/>	<input type="checkbox"/>			Replace the gasket. (See 4.2(2) - ⑩ in Chapter 4.)					
	Seized or broken piston ring	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	Replace the piston ring. (See 4.4(2) - ⑤, ⑩ in Chapter 4.)					
	Worn piston ring, piston or cylinder	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>						<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	Perform honing and use oversize parts. See 4.4(5)-(5.1), (5.4) and (6) in Chapter 4.					
	Seized crankpin metal or bearing	<input type="checkbox"/>	<input type="checkbox"/>						<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>			Repair or replace.					
	Improper arrangement of piston ring joints		<input type="checkbox"/>		<input type="checkbox"/>										<input type="checkbox"/>			<input type="checkbox"/>			Correct the ring joint positions. (See 4.4 (4)-6 in Chapter 4.)					
	Reverse assembly of piston rings				<input type="checkbox"/>		<input type="checkbox"/>								<input type="checkbox"/>			<input type="checkbox"/>			Reassemble correctly. (See 4.4 (4)-6 in Chapter 4.)					
	Worn crankpin and journal bearing				<input type="checkbox"/>				<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>			Measure and replace. (See 4.4 (5)-(5.2) - ③ in Chapter 4.)					
	Loosened connecting rod bolt								<input type="checkbox"/>			<input type="checkbox"/>						<input type="checkbox"/>			Tighten to the specified torque. (See 4.4 (4)-2 in Chapter 4.)					
	Foreign matter trapped in combustion chamber	<input type="checkbox"/>							<input type="checkbox"/>						<input type="checkbox"/>			<input type="checkbox"/>			Disassemble and repair.					
	Excessive gear backlash								<input type="checkbox"/>												Adjust gear meshing. (See 4.3 (4)-2 in Chapter 4.)					
	Worn intake/exhaust valve guide					<input type="checkbox"/>									<input type="checkbox"/>			<input type="checkbox"/>			Measure and replace. (See 4.2 (5)-(5.2) and (7) in Chapter 4.)					
	Defective governor		<input type="checkbox"/>									<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>						Make adjustment. (See 3.8 in Chapter 3.)					
	Improper open/close timing of intake/exhaust valves	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>											Adjust the valve clearance. (See 3.5 in Chapter 3.)					
Turbocharger	Fouled blower					<input type="checkbox"/>		<input type="checkbox"/>												Wash the blower.						
	Waste gate malfunction					<input type="checkbox"/>		<input type="checkbox"/>												Disassemble and inspect.						
	Worn floating bearing				<input type="checkbox"/>		<input type="checkbox"/>													Disassemble and inspect.						

Cause	Trouble symptom	Starting failure			Insufficient engine output		Poor exhaust color		High knocking sound during combustion	Abnormal engine sound	Hunting		Large engine vibration	Difficulty in returning to low speed	Excessive fuel consumption	Lubricating oil			Cooling water		Air intake		Corrective action		
		Engine does not start.	Engine starts but stops soon.		Exhaust color		During work				Excessive consumption	Dilution by fuel oil				Mixture with water	Low L.O. pressure	Much blow-by gas	Overheat	Low water temperature	Pressure drop	Pressure rise		Exhaust temperature rise	
			Exhaust smoke		Ordinary	White	Black	White																	Black
			None	Little																					
Cooling Water System	Excessive cooling effect of radiator																					Defective thermostat (kept closed) (See 3.9 (1) in Chapter 3.)			
	Insufficient cooling effect of radiator																						Defective thermostat (kept opened) (See 3.9 (1) in Chapter 3.) or slipping fan belt (See 3.4 in Chapter 3.)		
	Insufficient cooling water level																						Check water leakage from cooling water system.		
	Cracked water jacket																						Repair or replace.		
	Slackened fan belt																						Adjust the belt tension. (See 3.4 in Chapter 3.)		
	Defective thermostat																						Check or replace. (See 3.9 (1) in Chapter 3.)		
Lubricating System	Improper properties of lubricating oil																						Use proper lubricating oil. (See 1.3 (2) in Chapter 1.)		
	Leakage from lubricating oil piping system																						Repair.		
	Insufficient delivery capacity of trochoid pump																						Check and repair. (See 5.5 in Chapter 5.)		
	Clogged lubricating oil filter																						Clean or replace.		
	Defective pressure regulating valve																						Clean, adjust or replace.		
	Insufficient lubricating oil level																						Add proper lubricating oil. (See 3.1 in Chapter 3.)		
Fuel System	Too early timing of fuel injection pump																						Check and adjust. (See 3.7 in Chapter 3.)		
	Too late timing of fuel injection pump																						Check and adjust. (See 3.7 in Chapter 3.)		
	Improper properties of fuel oil																						Use proper fuel oil. (See 1.3 (1) in Chapter 1.)		
	Water entrance in fuel system																						Perform draining from the fuel filter.		
	Clogged fuel filter																						Clean or replace.		
	Air entrance in fuel system																						Perform air bleeding.		
	Clogged or cracked fuel pipe																						Clean or replace.		
	Insufficient fuel supply to fuel injection pump																						Check the fuel tank cock, fuel filter, fuel pipe, and fuel feed pump.		
	Uneven injection volume of fuel injection pump																						Check and adjust. (See Chapter 7.)		
	Excessive fuel injection volume																						Check and adjust. (See Chapter 7.)		
	Poor spray pattern from fuel injection nozzle																						Check and adjust. (See 3.6 in Chapter 3.)		
	Priming failure																						Foreign matter trapped in the valve inside the priming pump. (Disassemble and clean.)		
	Clogged strainer at feed pump inlet																						Clean the strainer.		

Cause	Trouble symptom	Starting failure															Insufficient engine output				Poor exhaust color		Hunting		Lubricating oil				Cooling water		Air intake		Corrective action
		Engine does not start.			Engine starts but stops soon.			Exhaust color			During work		High knocking sound during combustion	Abnormal engine sound	Uneven combustion sound	During idling		Large engine vibration	Difficulty in returning to low speed	Excessive fuel consumption	Excessive consumption		Much blow-by gas	Overheat	Low water temperature	Pressure drop	Pressure rise	Exhaust temperature rise					
		None	Little	Much	Ordinary	White	Black	White	Black	During	During	Excessive				Dilution by fuel oil	Mixture with water				Low L.O. pressure												
																						Exhaust smoke							Exhaust color	During work	During idling	During work	
Air/Exhaust Gas System	Clogged air filter			<input type="checkbox"/>			<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>															Clean.					
	Engine used at high temperatures or at high altitude						<input type="checkbox"/>	<input type="checkbox"/>										<input type="checkbox"/>					<input type="checkbox"/>		<input type="checkbox"/>			Study output drop and load matching.					
	Clogged exhaust pipe						<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>													<input type="checkbox"/>	Clean.						
Electrical System	Starting motor defect	<input type="checkbox"/>																									Repair or replace. (See Chapter 9.)						
	Alternator defect	<input type="checkbox"/>																									Repair or replace. (See Chapter 10.)						
	Open-circuit in wiring	<input type="checkbox"/>																									Repair.						
	Battery voltage drop	<input type="checkbox"/>																									Inspect and charge the battery. (See 3.10 in Chapter 3.)						

2.2 Troubleshooting by Measuring Compression Pressure

Compression pressure drop is one of major causes of increasing blowby gas (lubricating oil contamination or increased lubricating oil consumption as a resultant phenomenon) or starting failure. The compression pressure is affected by the following factors:

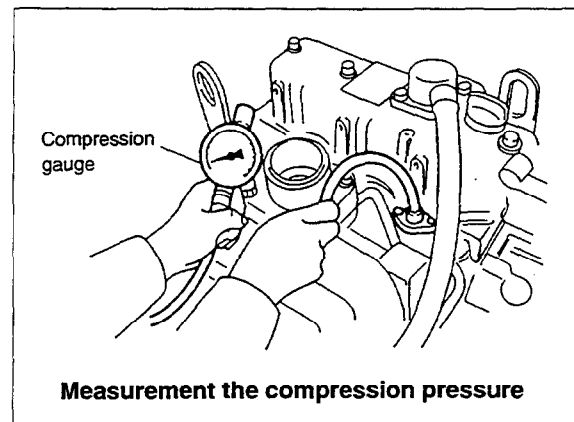
1. Degree of clearance between piston and cylinder
2. Degree of clearance at intake/exhaust valve seat
3. Gas leak from nozzle gasket or cylinder head gasket

In other words, the pressure drops due to increased parts wear and reduced durability resulting from long use of the engine.

A pressure drop may also be caused by scratched cylinder or piston by dust entrance from the dirty air cleaner element or worn or broken piston ring. Measure the compression pressure to diagnose presence of any abnormality in the engine.

(1) Compression pressure measurement method

- ① After warming up the engine, remove the fuel injection pump and valves from the cylinder to be measured.
- ② Crank the engine before installing the compression gage adapter.
 - *1. Perform cranking with the regulator handle at the stop position (no injection state).
 - *2. See 11.2 – 18 in Chapter 11 for the compression gage and compression gage adapter.
- ③ Install the compression gage and compression gage adapter at the cylinder to be measured.
 - *Never forget to install a gasket at the tip end of the adapter.
- ④ With the engine set to the same state as in ② *1, crank the engine by the starting motor until the compression gage reading is stabilized.



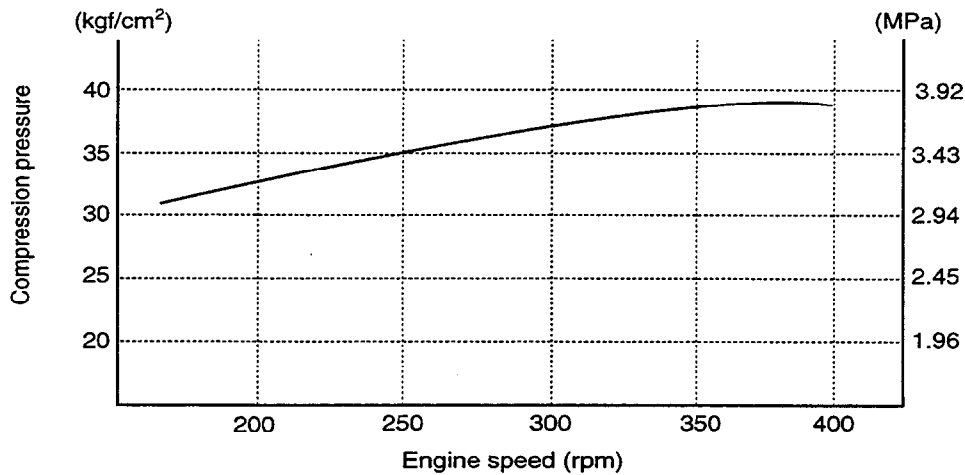
(2) Standard compression pressure

[Engine compression pressure list (reference value)]

Engine model	Compression pressure Mpa(kgf/cm ²) at 250 rpm		Dispersion among cylinders (kgf/cm ²)
	Standard	Limit	
4TNE94/98/106(T)	3.43±0.1(35±1)	2.75±0.1(28±1)	0.2~0.3(2 ~ 3)

2. Troubleshooting

(3) Engine speed and compression pressure (reference)



(4) Measured value and troubleshooting

When the measured compression pressure is below the limit value, inspect each part by referring to the table below.

No.	Item	Cause	Corrective action
1	<ul style="list-style-type: none"> Air cleaner element 	<ul style="list-style-type: none"> Clogged element Broken element Defect at element seal portion 	<ul style="list-style-type: none"> Clean the element. Replace the element.
2	<ul style="list-style-type: none"> Valve clearance 	<ul style="list-style-type: none"> Excessive or no clearance 	<ul style="list-style-type: none"> Adjust the valve clearance. (See 3.5 in Chapter 3.)
3	<ul style="list-style-type: none"> Valve timing 	<ul style="list-style-type: none"> Incorrect valve clearance 	<ul style="list-style-type: none"> Adjust the valve clearance. (See 3.5 in Chapter 3.)
4	<ul style="list-style-type: none"> Cylinder head gasket 	<ul style="list-style-type: none"> Gas leak from gasket 	<ul style="list-style-type: none"> Replace the gasket. Retighten the cylinder head bolts to the specified torque. (See 4.2 (2) ⑫ in Chapter 4.)
5	<ul style="list-style-type: none"> Intake/exhaust valve Valve seat 	<ul style="list-style-type: none"> Gas leak due to worn valve seat or foreign matter trapping Sticking valve 	<ul style="list-style-type: none"> Lap the valve seat. (See 4.2 (6) in Chapter 4.) Replace the intake/exhaust valve.
6	<ul style="list-style-type: none"> Piston Piston ring Cylinder 	<ul style="list-style-type: none"> Gas leak due to scratching or wear 	<ul style="list-style-type: none"> Perform honing and use an oversized part. (See 4.4 (5)-(5-1),(5-4) and (6) in Chapter 4.)

3. INSPECTION AND ADJUSTMENT

..... **3-1~3-15**

3.1	OIL INSPECTION.....	3-1
3.2	COOLING WATER INSPECTION	3-1
3.3	INSPECTING WATER LEAK FROM COOLING WATER SYSTEM AND RADIATOR.....	3-1
3.4	FAN BELT TENSION INSPECTION AND ADJUSTMENT	3-2
3.5	ADJUSTING THE VALVE CLEARANCE	3-3
3.6	INSPECTING THE FUEL INJECTION VALVE INJECTION PRESSURE AND SPRAY PATTERN	3-4
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3.1 Oil Inspection

• Standard

The level shall be between the upper and lower limit lines on the dipstick.

	4TNE94•98	4TNE106(T)
Total volume	10.2 ℓ	12.5 ℓ
Effective volume	4.5 ℓ	5.5 ℓ

- ① The oil shall not be contaminated heavily and have appropriate viscosity. No cooling water or diesel gas oil shall be mixed.
- ② Insert the dipstick fully and check the oil level.

[NOTICE]

The oil should not be overfilled to exceed the upper limit line. Otherwise, oil may jet out from the breather or the engine may become faulty.

3.2 Cooling Water Inspection

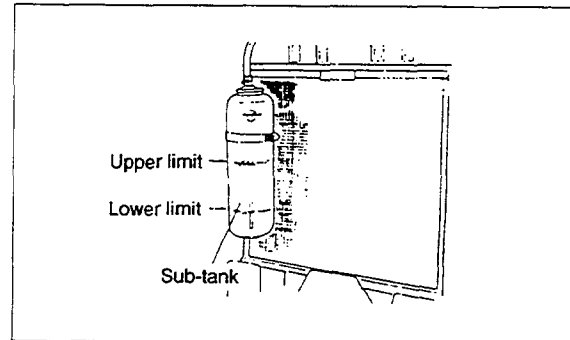
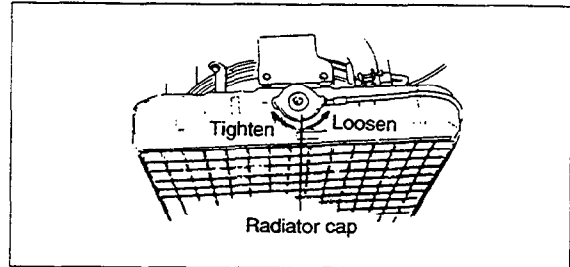
• Standard

Engine: The radiator shall be filled up.

Sub-tank: The water level shall be between the upper and lower limit lines.

		4TNE94•98	4TNE106(T)
Capacity	Engine	4.2 ℓ	6.0 ℓ
	Sub-tank	Approx. 0.8 ℓ	

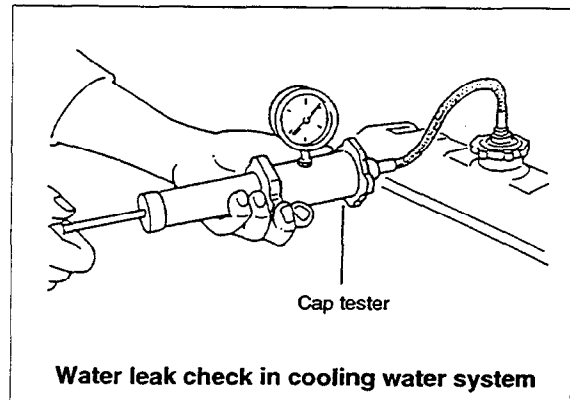
- ① The cooling water shall be checked when the engine is cold.
- ② If the water level is normal in the sub-tank but low in the radiator, check loosened clamping of the rubber hose between the radiator and sub-tank or tear in the hose.



3.3 Inspecting Water Leak from Cooling Water System and Radiator

(1) Water leak check in cooling water system

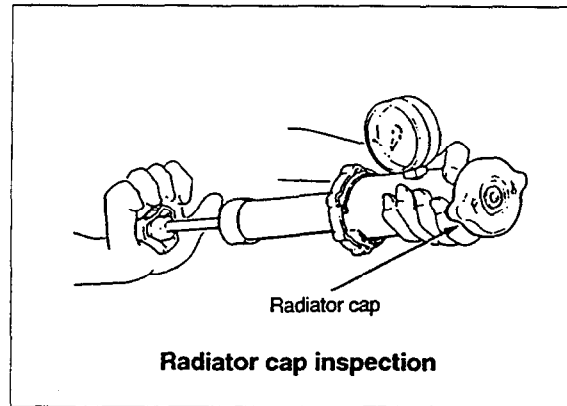
- ① Fill cooling water to the normal level in the radiator, and install the cap tester on the radiator.
- ② Operate the manual pump to set the pressure to 0.9 ± 0.15 kgf/cm². If the cap tester pressure gage reading drops then, water is leaking from the cooling water system. Check the water leaking point.



3. Inspection and Adjustement

(2) Radiator cap inspection

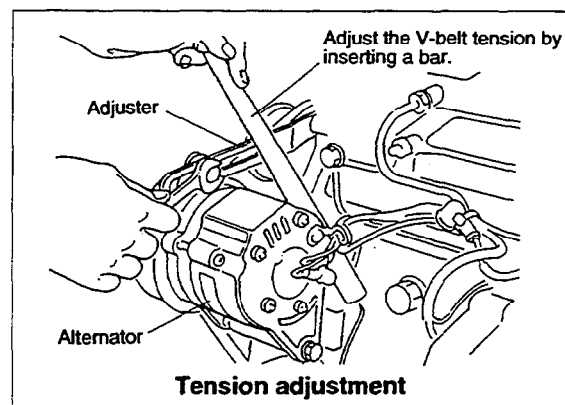
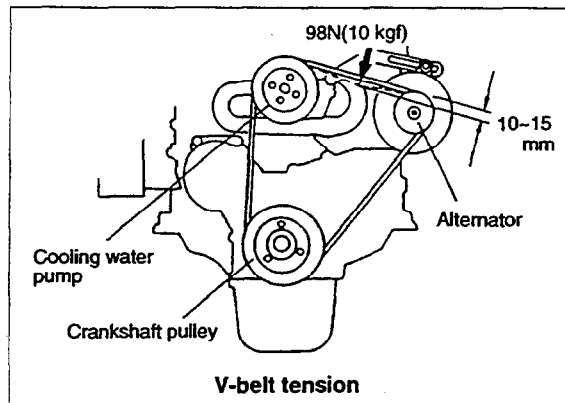
Install the radiator cap on the cap tester.
Set the tester pressure to $0.9 \pm 0.15 \text{ kgf/cm}^2$
and see that the cap is opened.
If the cap does not open, replace the cap
since it is abnormal.



3.4 Fan Belt Tension Inspection and Adjustment

**Standard: 10~15 mm/98N (10 kgf)
(7~9 mm in initial state)**

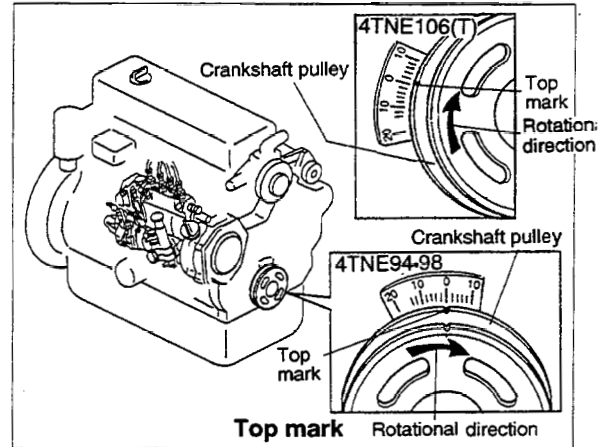
Push the center of the V belt between the alternator and cooling water with a finger. The V belt tension is normal if the deflection is 10 to 15 mm. If not, adjust the V belt tension by the alternator adjuster.



3.5 Adjusting the Valve Clearance

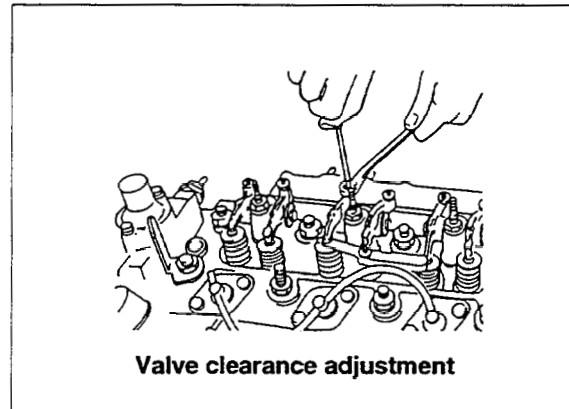
Make adjustment while the engine is cold.

- ① Remove the hood above the cylinder head.
- ② Turn the crankshaft to bring the piston of the No.1 cylinder to its compression top dead center while watching the rocker arm motion, timing scale and the top mark position of the crankshaft pulley.
(Position where both the intake and exhaust valves are closed.)



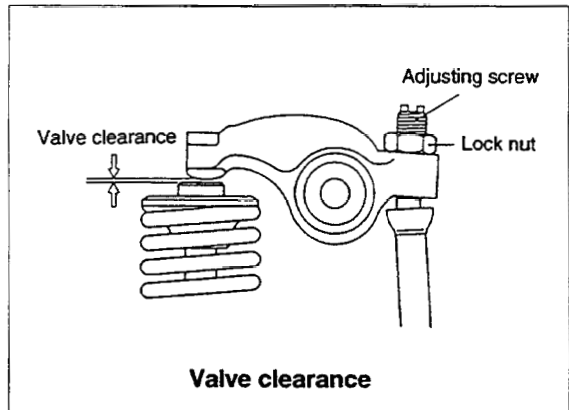
(Notes)

- The crankshaft shall be turned clockwise as seen from the radiator side.
- The No.1 cylinder position is on the opposite side of the radiator and the ignition order shall be 1-3-4-2-1 at 180° intervals.
- Since the intake and exhaust valve rocker arms are operated the same and there is a clearance between the arm and valve generally at the top dead center, the position can be checked by means of the play when the arm head is held with a hand. Also see that the crankshaft pulley top mark is positioned at zero on the timing scale. If there is no valve clearance, inspection in the disassembled state is necessary since the valve seat may be worn abnormally.

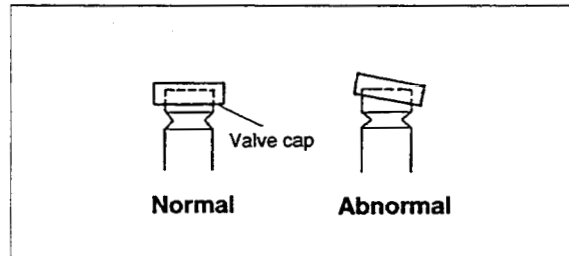


Valve clearance adjustment

- ③ Insert a thickness gage between the rocker arm and valve cap, and record the measured valve clearance. (Use it as the data for estimating the wear state.)
- ④ Loosen the lock nut and adjusting screw, and check the valve for any inclination, entrance of dirt or wear.
- ⑤ Insert a 0.2 or 0.3 mm thickness gage between the rocker arm and valve cap, and tighten the adjusting screw to adjust the valve clearance.



Valve clearance



	4TNE94•98	4TNE106(T)
Standard valve clearance (mm)	0.15~0.25	0.25~0.35

Lock nut tightening torque T=14.7~19.6 Nm (1.5~2.0 kgf•m)

3. Inspection and Adjustment

- ⑥ Apply oil to the contact between the adjusting screw and push rod.
- ⑦ Turn the crankshaft 180° then and make adjustment for the No.3 cylinder. Then adjust the No.4 and No.2 cylinders in this order.

The cylinder to be adjusted first does not have to be the No.1 cylinder. Select and adjust the cylinder where the piston is the nearest to the top dead center after turning, and make adjustment for other cylinders in the order of ignition by turning the crankshaft 180° each time.

3.6 Inspecting the Fuel Injection Valve Injection Pressure and Spray Pattern

⚠ WARNING

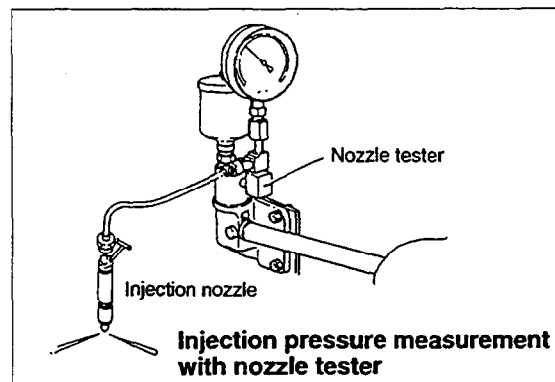
Wear protective glasses when testing injection from the fuel injection valve. Never approach the injection nozzle portion with a hand. The oil jetting out from the nozzle is at a high pressure to cause loss of sight or injury if coming into careless contact with it.

(1) Injection pressure measurement

Standard	MPa	21.57-22.55
	kgf/cm ²	220-230

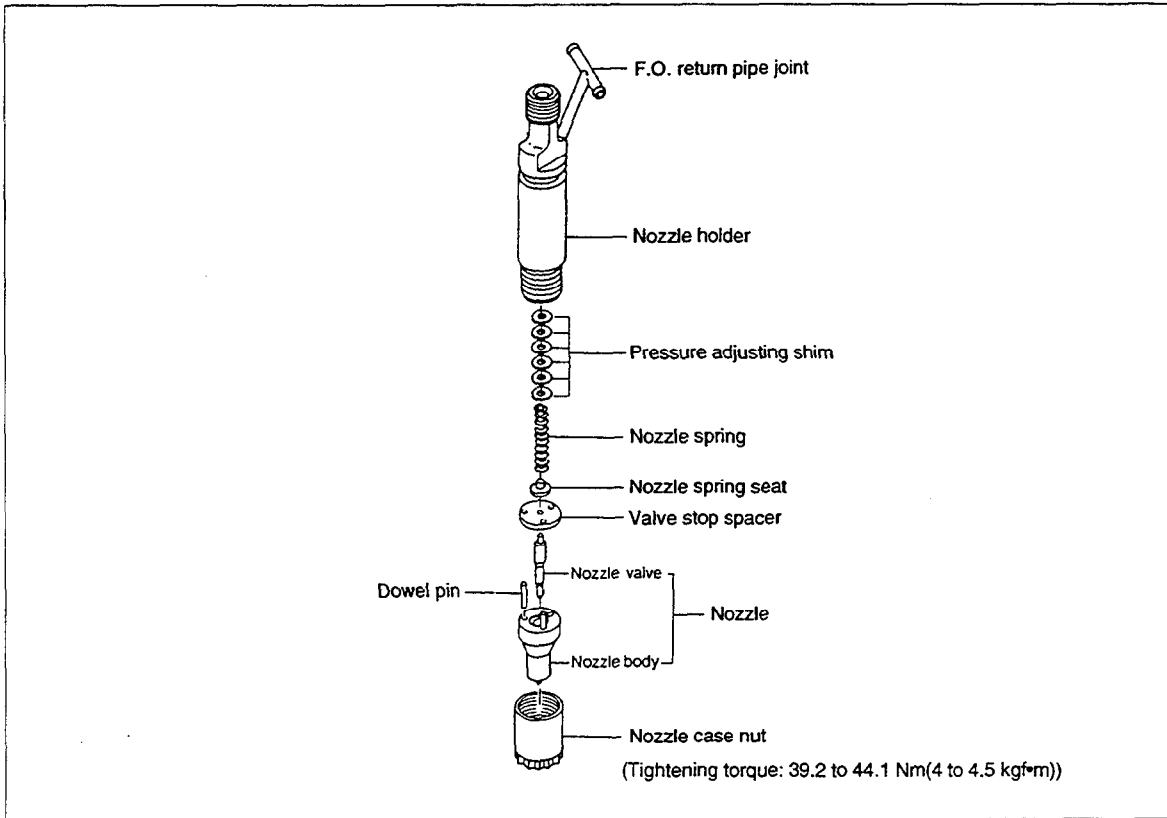
* Remove carbon deposit at the nozzle hole thoroughly before measurement.

- ① Connect the fuel injection valve to the high pressure pipe of the nozzle tester.
- ② Operate the nozzle tester lever slowly and read the pressure at the moment when the fuel injection from the nozzle starts.
- ③ If the measured injection pressure is lower than the standard level, replace the pressure adjusting shim with a thicker one.



Type of pressure adjusting shim thickness (mm)	Injection pressure adjustment
0.13, 0.15, 0.18, 0.4, 0.5, 0.8	The injection pressure is increased by approx. 1.87 MPa(19 kgf/cm ²) when the adjusting shim thickness is increased by 0.1 mm.

[Reference: Fuel injection valve structure]

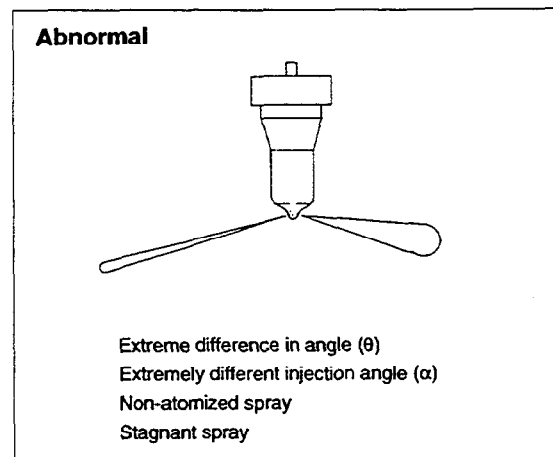
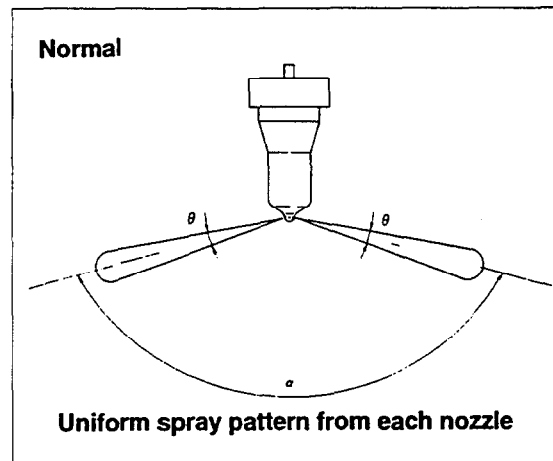


3. Inspection and Adjustment

(2) Spray pattern inspection

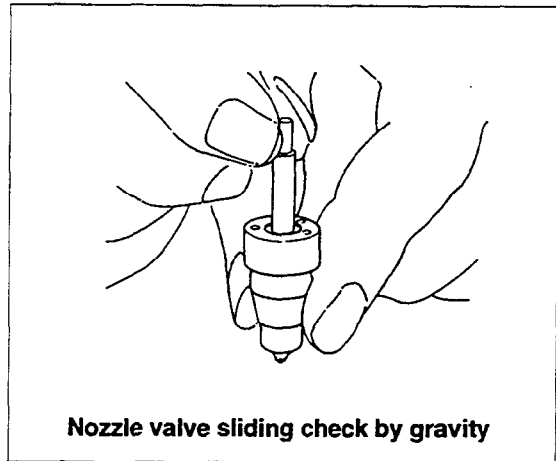
After adjustment to the specified valve opening pressure, use a nozzle tester and check the spray pattern and seat oil-tightness.

- ① Seat oil-tightness check
 - After injecting a few times, increase the pressure gradually. Hold the pressure for about 5 seconds at a little before the valve opening pressure of 1.96 MPa (20 kgf/cm²), and check to see that oil does not drip from the tip end of the nozzle.
 - If extreme oil leak from the overflow joint exists during injection by the nozzle tester, check after retightening. If much oil is leaking, replace the nozzle assembly.
- ② Spray and injection states
 - Operate the nozzle tester lever at a rate of once or twice a second and check no abnormal injection.
 - If normal injection as shown below cannot be obtained, replace the fuel injection valve.
 - No extreme difference in angle (θ)
 - No extreme injection angle difference (α)
 - Finely atomized spray
 - Excellent spray departure

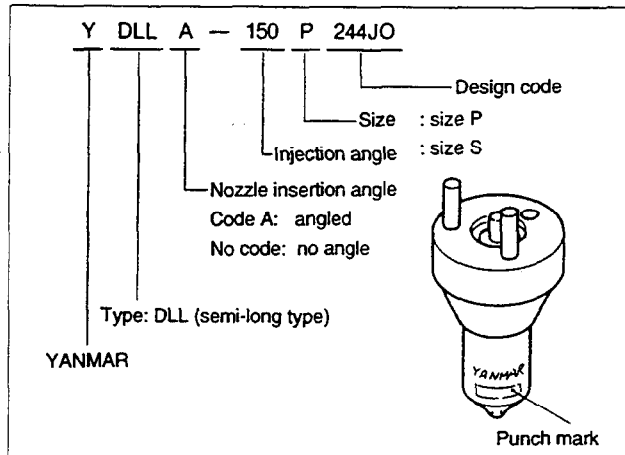


(3) Nozzle valve sliding test

Wash the nozzle valve in clean fuel oil. Place the nozzle body vertically and insert the nozzle into the body to about 1/3 of its length. The valve is normal if it smoothly falls by its own weight into the body. In case of a new nozzle, remove the seal peel, and immerse it in clean diesel oil or the like to clean the inner and outer surfaces and to thoroughly remove rust-preventive oil before using the nozzle. Note that a new nozzle is coated with rust-preventive oil and is pasted with the seal peel to shut off outer air.



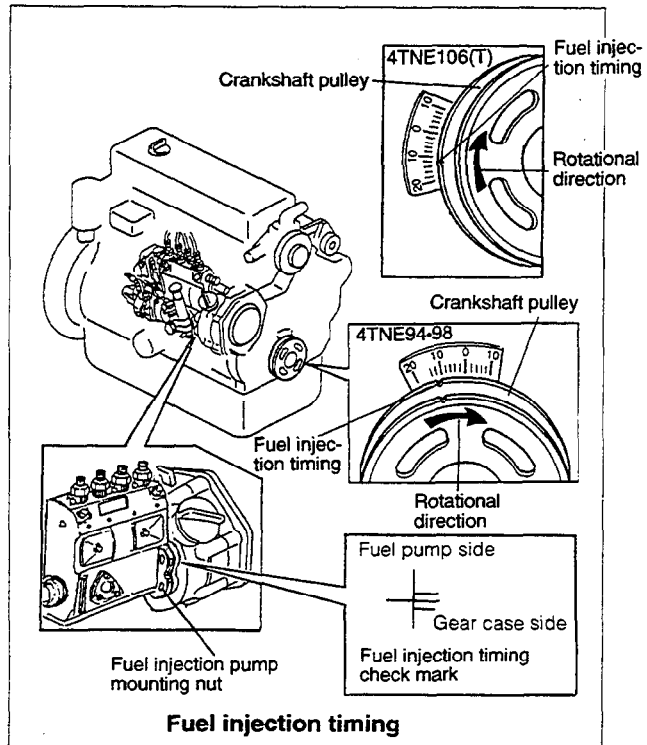
(4) Nozzle punch mark



3. Inspection and Adjustment

3.7 Fuel Injection Timing Inspection and Adjustment

- 1) Set the engine ready for starting.
(Complete air bleeding from the fuel line.)
- 2) See that the fuel injection timing check mark on the fuel pump mounting flange and gear case are aligned.
- 3) Set the control valve at the operating position.
- 4) Disconnect the high pressure tube for the No.1 cylinder on the fuel pump side.
(Do not remove the delivery valve.)
- 5) Check fuel discharge from the delivery holder while turning the crankshaft (clockwise as seen from the radiator), and stop turning it when the fuel comes out.
- 6) Check the crankshaft pullet top mark position on the timing scale. The No.1 piston can be checked at its top dead center when the position is between 10° before the top (10 graduations on the left from 0) and 10° after the top.



- 7) Then wipe the outlet of the delivery holder clean. Turn the crankshaft in the opposite direction to return to approx. 20° before the top.
- 8) Slowly turn the crankshaft clockwise. As the oil surface in the deliver holder rises, stop rotation upon rising and check the position on the timing scale. The injection timing is normal if the top mark is positioned in the timing scale range shown in the table below on the left side from 0.

	4TNE94-98	4TNE106	4TNE106T
Standard: Degrees bTDC (FID)	10~12	13~15	11~13

- 9) Repeat steps 6) to 8) a few times.

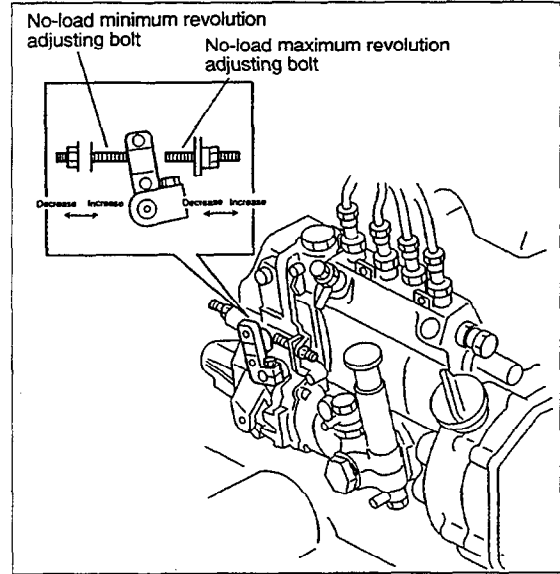
(Note)

Injection timing check for one cylinder is generally sufficient. If it is to be checked for all four cylinders, turn the crankshaft 180° each time and check in the order of cylinders No.1, No.3, No.4, No.2 and No.1. (The No.1 cylinder is positioned furthest from the radiator.)
The cylinder to be checked is not limited to the No.1 cylinder but any desired one may be checked.

- 10) If the ignition timing is outside the standard, loosen the fuel pump mounting nut and rotate the fuel pump toward or away from the engine for adjustment. Rotate toward the engine to advance the timing, and away from the engine to delay the timing.
(One graduation on the gear case scale corresponds to one degree in ignition timing.)

3.8 Adjusting the No-load Maximum (or Minimum) Revolutions

- ① After warming the engine up, gradually raise the speed and set it at the no-load maximum revolution.
- ② If the no-load maximum revolution is outside the standard range, adjust it by turning the no-load maximum revolution adjusting bolt.
- ③ Then set the no-load minimum revolution by adjusting the no-load minimum revolution adjusting bolt.



• Standards

Engine application class	Rating	No-load maximum rpm	No-load minimum rpm
CL	1500	1575-1625	1200 or less
	1800	1870-1920	1200 or less
VM	2000	2180-2230	800 or less
	2200	2395-2445	800 or less
	2400	2590-2640	800 or less
	2500	2700-2750	800 or less

Note) The rpm values above for adjustment vary slightly with the load equipment on which the engine is to be mounted.

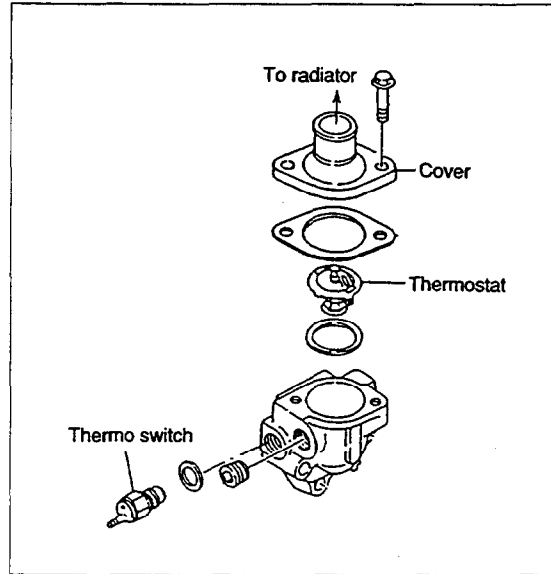
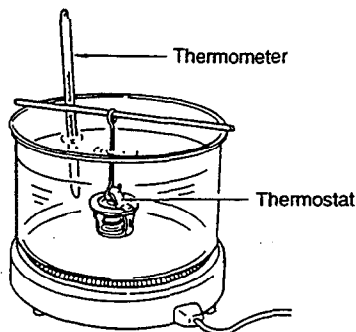
3.9 Sensor Inspection

(1) Thermostat and Thermal Switch Inspection

① Thermostat

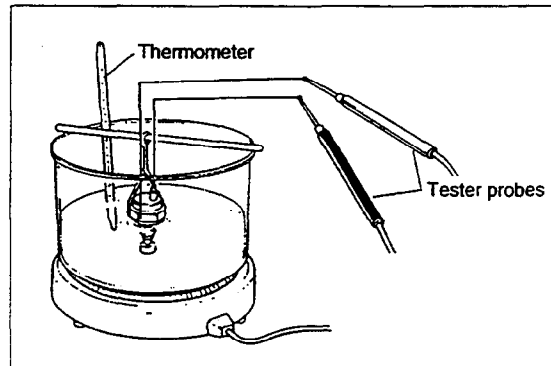
Place the thermostat in a container filled with water. Heat it while measuring the water temperature, and see that the thermostat is actuated at temperature of following table.

	4TNE94*98	4TNE106(T)
Valve opening temperature (°C)	71 ~ 85	82 ~ 95



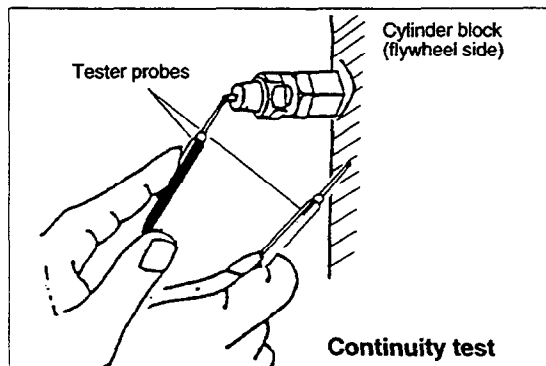
② Thermoswitch

Place the thermoswitch in a container filled with antifreeze or oil. Heat it while measuring the fluid temperature. The switch is normal if the voltammeter shows continuity when the fluid temperature is 107°C ~ 113°C.



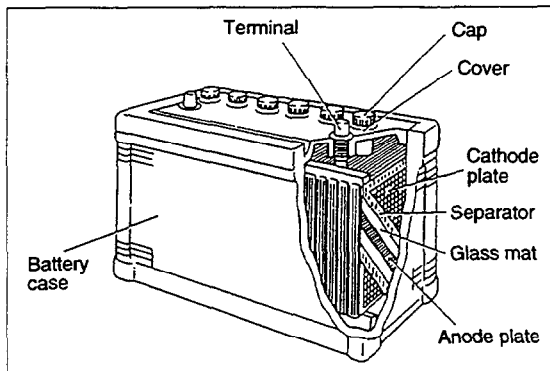
(2) Oil pressure switch

Disconnect the connector from the oil pressure switch. Keep the voltammeter probes in contact with the switch terminal and cylinder block while operating the engine. It is abnormal if circuit is closed.



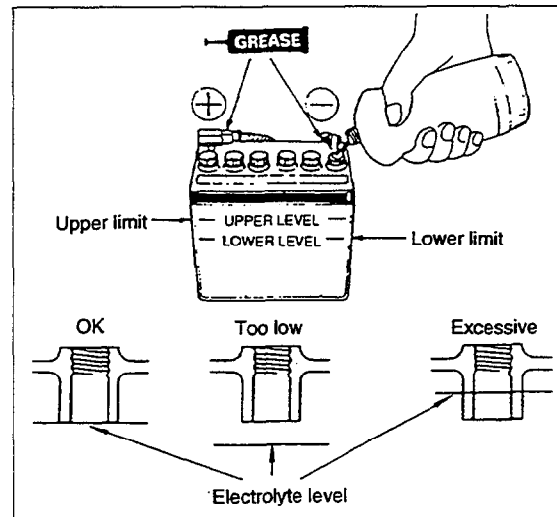
3.10 Battery Inspection

(1) Battery structure



(2) Battery inspection

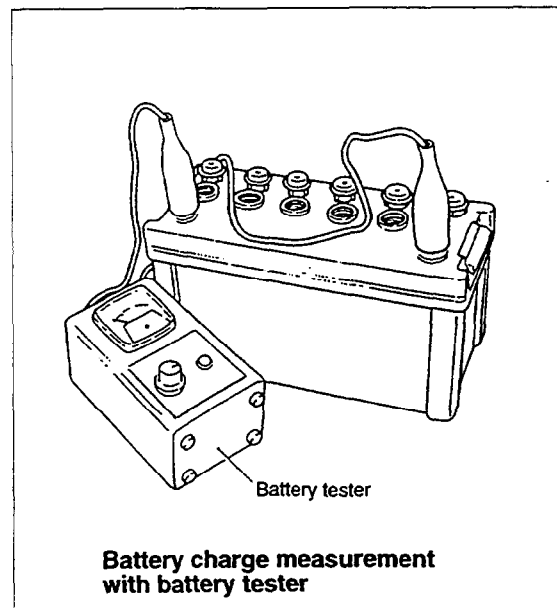
- ① Electrolyte level
Add distilled water to the upper limit if the level is low.



- ② Battery charge
Use a battery tester or hydrometer and check the battery condition. If the battery is discharged, recharge it.

- Measurement with a battery tester
When checking the battery with the batter tester, connect the red clip of the tester to the battery positive (+) terminal and black clip to the battery negative (-) terminal by pinching them securely, and judge the battery charge level from the indicator position.

- Green zone: Normal
- Yellow zone: Slightly discharged
- Red zone: Defective or much discharged



3. Inspection and Adjustment

- Measurement with hydrometer

When using a hydrometer, the measured specific gravity must be corrected according to the temperature at the time of measurement. The specific gravity of battery electrolyte is defined with 20°C as the standard. Since the specific gravity increases or decreases by 0.0007 when the temperature varies by 1°C, correct the value according to the equation below.

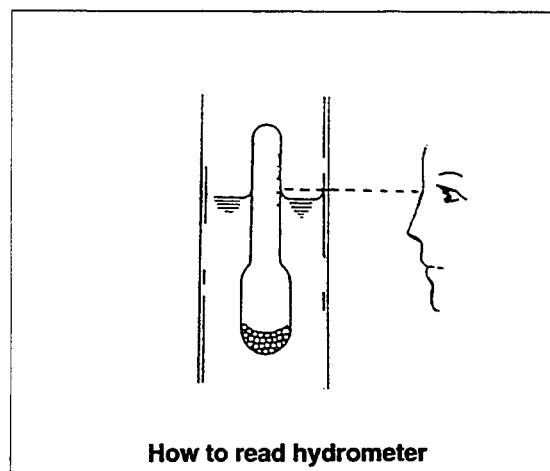
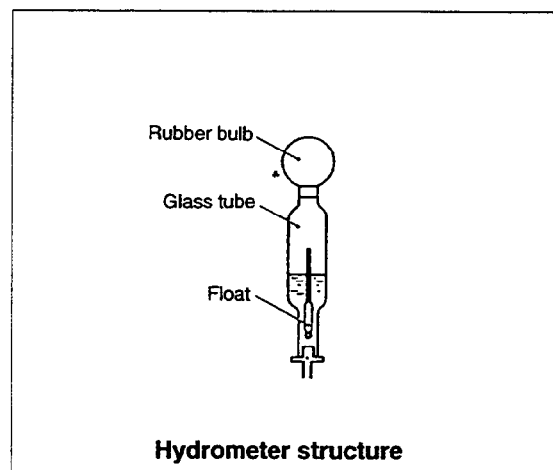
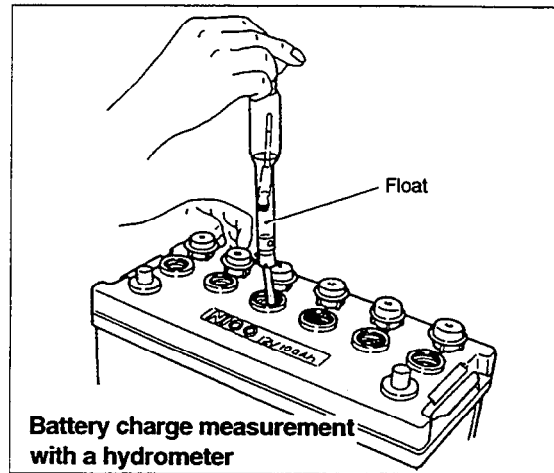
$$S_{20} = S_t + 0.0007 (t - 20)$$

S_{20} ————— Converted specific gravity at 20°C
 S_t ————— Specific gravity at measurement
 t ————— Electrolyte temperature at measurement

Specific gravity and remaining battery charge

Specific gravity (20°C)	Discharged quantity of electricity (%)	Remaining charge (%)
1.260	0	100
1.210	25	75
1.160	50	50
1.110	75	25
1.060	100	0

- ③ Terminals
Clean if corroded or soiled.
- ④ Mounting bracket
Repair or replace it if corroded.
Retighten if loosened.
- ⑤ Battery appearance
Replace the battery if cracked or deformed.
Clean with fresh water if contaminated.



3.11 Adjusting Operation

Perform adjusting operation as follows after the maintenance job:

- (1) Supply the fuel oil, lubricating oil and cooling water.

Note: Check the levels of the lubricating oil and cooling water again after test running (for about 5 minutes) and add as required.

- (2) Start the engine, and carry out idling at a low revolution (700 to 900 rpm) for a few minutes.
- (3) Run in the engine for about five minutes at the rated revolution (no-load). Check any water, fuel or oil leak and existence of abnormal vibration or noise. Also check the oil pressure, cooling water temperature and exhaust gas color.
- (4) Adjust the no-load minimum and maximum revolutions according to the specifications.
- (5) Perform loaded operation as required.

3.12 Long Storage

Observe the following instructions when the engine is to be stored for a long period without operation:

- (1) Always drain cooling water in a cold season or before a long storage. (This is unnecessary when antifreeze is used.)

[NOTICE]

Negligence of water draining will cause the cooling water remaining inside the engine to be frozen and expanded to damage the engine parts.

Water draining procedure

- ① Remove the radiator cap.
 - ② Loosen the water draining cock under the radiator to drain water from the inside.
 - ③ Loosen the drain cock on the side surface of the cylinder to drain water from the inside.
 - ④ After draining water, tighten the radiator cap and drain plug and cocks.
- (2) Remove the mud, dust and oil deposit and clean the outside.
 - (3) Perform the nearest periodic inspection before the storage.
 - (4) Drain or fill the fuel oil fully to prevent condensation in the fuel tank.
 - (5) Disconnect the battery cable from the battery negative (-) terminal.
 - (6) Cover the silencer, air cleaner and electric parts with PVC cover to prevent water and dust from depositing or entrance.
 - (7) Select a well-ventilated location without moisture and dust for storage.
 - (8) Perform recharging once a month during storage to compensate for self-discharge.

3.13 Periodic Maintenance Schedule

The engine periodic inspection timing is hard to determine as it varies with the application, load status, qualities of the fuel and lubricating oils used and handling status. General rules are described here.

○: Inspection ⊙: Parts replacement

Classification	Item	Daily	Maintenance period				
			Every 50 hours	Every 250 hours	Every 500 hours	Every 1000 hours	Every 2000 hours
Fuel oil system	Fuel tank level check and fuel supply	○					
	Fuel tank draining		○				
	Water separator draining (Option)		○	Every 100 hours			
	Water separator cleaning (Option)				○		
	Fuel filter element replacement				⊙		
Lubricating oil system	Lube oil level check	○					
	Lube oil replacement		⊙	⊙			
	Lube oil filter replacement		1st time	2nd time and thereafter			
Cooling water system	Cooling water level check and replenish	○					
	Radiator fin cleaning			○			
	Cooling fan V-belt tension check	○					
	Cooling water replacement				⊙		
	Cooling water path flushing and maintenance						○
Fuel oil, lube oil and cooling water leakage check		○					
Rubber hose	Fuel pipe and cooling water pipe inspection and maintenance						○
Air intake system	Air cleaner cleaning and element replacement			○	⊙		
	Turbocharger blower cleaning					○	
Electrical system	Warning lamp & instruments function check	○					
	Battery electrolyte level check and battery recharging	○					
Cylinder head	Intake/exhaust valve head clearance adjustment					○	
Fuel injection pump and valve	Fuel injection valve pressure inspection					○	
	Fuel injection timing inspection						○

4. ENGINE BODY 4-1~4-30

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(7)	Piston pin bushing replacement	4-30
(8)	Oil seal replacement	4-30

4.1 Introduction

Make preparation as follows before starting engine inspection and service:

- (1) Fix the engine on a horizontal base.

⚠ CAUTION

Be sure to fix the engine securely to prevent injury or damage to parts due to falling during the work.

- (2) Remove the cooling water hose, fuel oil pipe, wire harness, control wires etc. connecting the driven machine and engine, and drain cooling water, lubricating oil and fuel.
- (3) Clean soil, oil, dust, etc. from the engine by washing with solvent, air, steam, etc. Carefully operate so as not to let any foreign matter enter the engine.

⚠ CAUTION

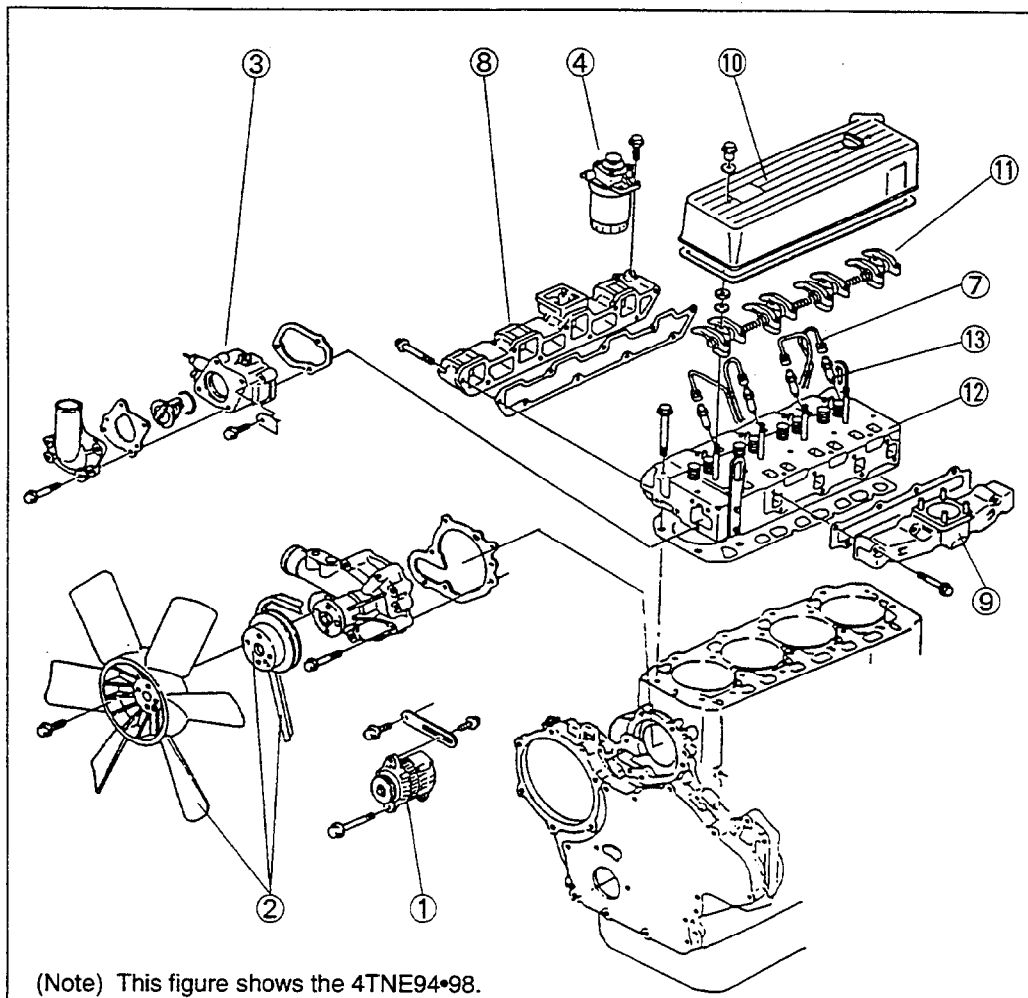
Always wear glasses or other protectors when using compressed air or steam to prevent any foreign matter from getting in the eyes.

[NOTICE]

- *Any part which is found defective as a result of inspection or any part whose measured value does not satisfy the standard or limit shall be replaced.*
- *Any part predicted to dissatisfy the standard or limit before the next service as estimated from the state of use should be replaced even when the measured value then satisfies the standard or limit.*

4.2 Cylinder Head

(1) Components



(2) Disassembly procedure:

Disassemble in the order of the numbers shown in the illustration.

- ① Remove the alternator assy. **(Point 1)**
- ② Remove the fan, pulley and V belt.
- ③ Remove the thermostat case. **(Point 2)**
- ④ Remove the fuel filter and fuel oil piping. **(Point 3)**
- ⑤ Remove the oil level gage assy.
- ⑥ Remove the oil filter. **(Point 4)**
- ⑦ Remove the fuel injection pipes. **(Point 5)**
- ⑧ Remove the intake manifold assy.
- ⑨ Remove the exhaust manifold assy.
- ⑩ Remove the bonnet Assy.
- ⑪ Remove the rocker shaft assy, push rods and valve caps. **(Point 6)**
- ⑫ Remove the cylinder head assy and head gasket. **(Point 7)**
- ⑬ Remove the fuel injection valves and fuel return pipe. **(Point 8)**
- ⑭ Remove the intake/exhaust valves, stem seals and valve springs. **(Point 9)**
- ⑮ Remove the rocker arms from the rocker shaft.

- (3) **Reassembly procedure:**
Reverse order of the disassembly procedure.

(4) **Servicing points**

Point 1

Disassemble:

- Loosen the mounting bolt while supporting the alternator.

CAUTION

Do not tilt the alternator toward the cylinder block in a haste since it may damage the alternator or pinch a finger.

Reassemble:

- The belt deflection shall be 10~15 mm (7 ~ 9 mm for a new belt).

Reassemble:

- Replace the belt with a new one if cracked, worn or damaged.
- Carefully prevent the belt from being smeared with oil or grease.

Point 2

Reassemble:

- Check the thermostat function. (See 3.9 in Chapter 3 for the check procedure.)

Point 3

Reassemble:

- Replace the fuel filter element with a new one.

Disassemble:

- Cover the fuel pipe opening with tape to prevent intrusion of foreign matters.

Point 4

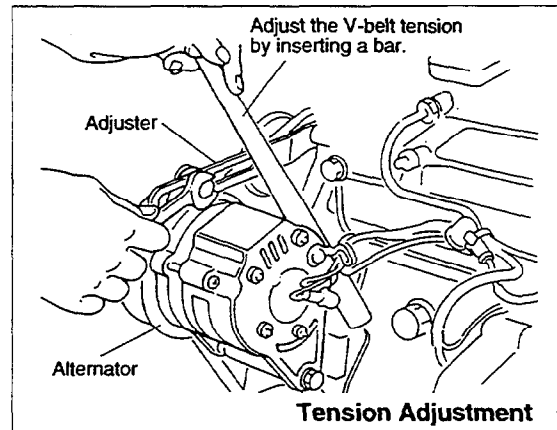
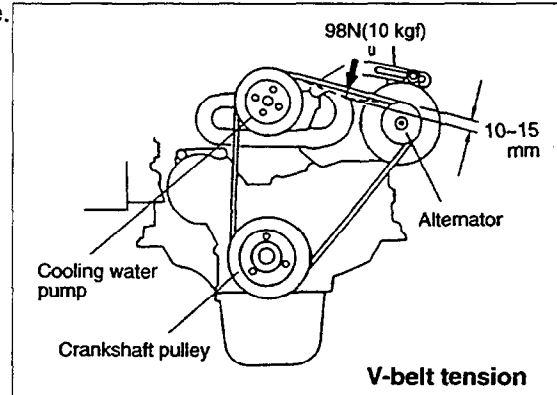
Reassemble:

- Replace the oil filter with a new one.
- After fully tightening the filter manually, retighten it with a filter wrench (see 11.1-6 in Chapter 11) by 3/4 turn.

Point 5

Disassemble:

- Cover the fuel injection pipe and pump inlets and outlets with tape or the like to prevent intrusion of foreign matters.



4. Engine Body

Point 6

Disassemble:

- Keep the removed push rods by attaching tags showing corresponding cylinder Nos.

Reassemble:

- Always apply oil to the contact portions of the push rods and valve clearance adjusting screws.

Point 7

Disassemble:

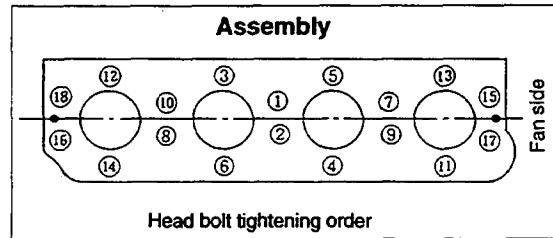
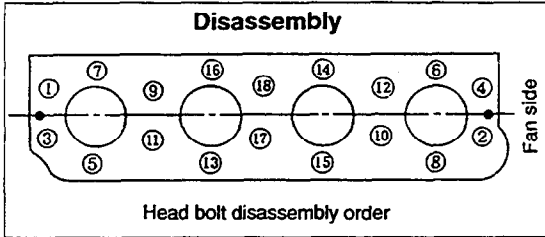
- Loosen the cylinder head bolts in two steps in the illustrated order.
- Place the cylinder head assy on a paper board to prevent the combustion face from any damage.

Reassemble:

- Remove the head gasket with a new one.
- Uniformly install the head bolts manually after applying oil on the threaded and seat portions.
- They shall be tightened in two steps in the reverse of the order for disassembly.

- Tightening torque

	4TNE94•98	4TNE106 (T)
First step:	49~58.8 (5~6)	88.3~98.1 (9~10)
Second step:	102.9~112.7 (10.5~11.5)	181.4~191.2 (18.5~19.5)



Point 8

Disassemble:

- Carefully remove the fuel injection valve so as not to leave the tip end protector from being left inside the cylinder.

Reassemble:

- Replace the fuel injection valve protector with a new one.

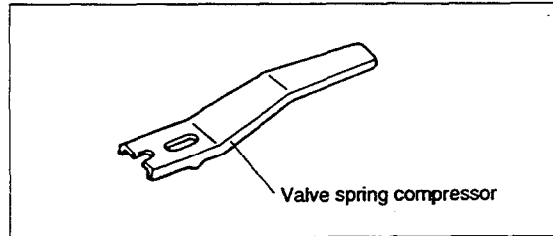
Point 9

Disassemble:

- When removing each intake/exhaust valve from the cylinder head, use a valve spring compressor (see 11.1-4 in Chapter 11) and compress the valve spring and remove the valve cotter.
- Keep each removed intake/ exhaust valve after attaching a tag showing the corresponding cylinder No.
- If cotter burr is seen at the shaft of each intake/exhaust valve stem, remove it with an oil-stone and extract the valve from the cylinder head.

Reassemble:

- Replace the stem seal with a new one when an intake/exhaust valve is disassembled.
- Carefully install each valve after oil application so as not to damage the stem seal.



- Different stem seals are provided for the intake and exhaust valves. Do not confuse them since those for exhaust valves are marked with yellow paint.
- After assembling the intake/exhaust valve, stem seal, valve spring, seat, and cotter, tap the head of the valve stem lightly for settling.
- Do not forget to install the valve cap.

(5) Parts Inspection and measurement

(5.1) Cylinder head

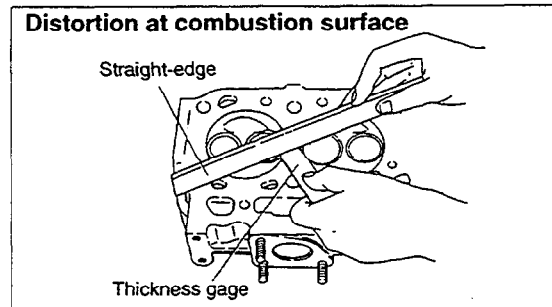
Clean the cylinder head, mainly the combustion surface, valve seats and intake/exhaust ports, remove carbon deposit and bonding agent, and check the surface state.

(a) Appearance check

Check mainly discoloration and crack.
If crack is suspected, perform color check.

(b) Combustion surface distortion

Apply a straight-edge in two diagonal directions and on four sides of the cylinder head, and measure distortion with a thickness gage.

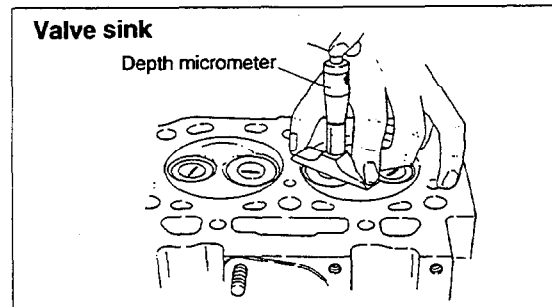


(mm)

—	Standard	Limit
Distortion	0.05 or less	0.15

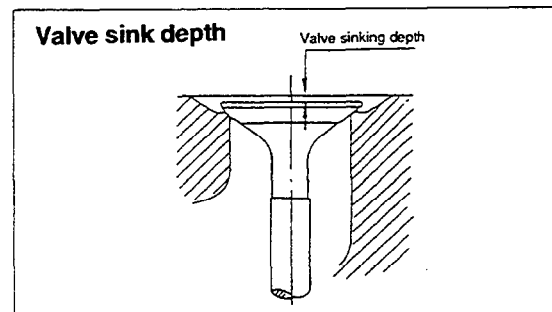
(c) Valve sink

Measure with the valve inserted to the cylinder head.



(mm)

—		Standard	Limit
4TNE94•98	Intake	0.5~0.7	1.0
	Exhaust	0.6~0.8	1.1
4TNE106 (T)	Intake	0.7~0.9	1.2
	Exhaust	0.9~1.1	1.4



4. Engine Body

(d) Seat contact

Apply a thin coat of minium on the valve seat. Insert the valve in the cylinder and push it against the seat to check seat contact.

Standard: Continuous contact all around

(5.2) Valve guide

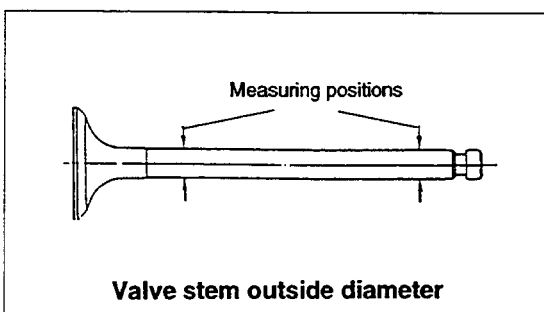
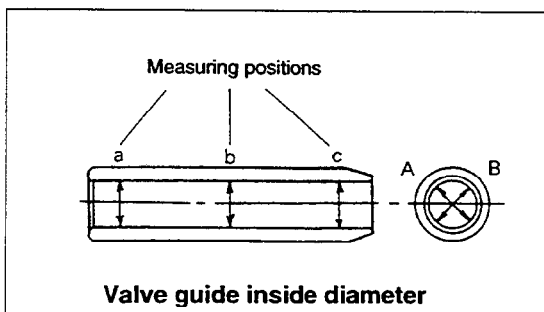
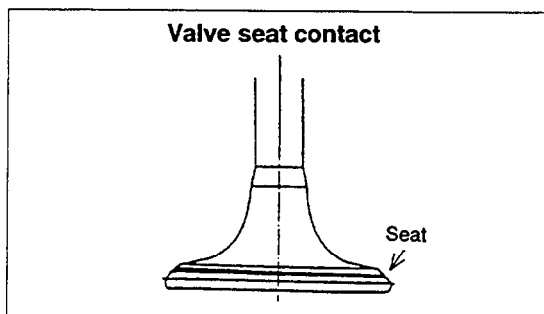
Mainly check damage and wear on the inside wall. Apply supply part code when replacing the part.

-	Service part code
4TNE94•98	129150-11810
4TNE106 (T)	119000-11170

① Inside diameter

(mm)

-	Standard	Limit
4TNE94•98		
Intake value	Guide I.D.	8.015~8.030
	Stem O.D.	7.965~7.980
	Clearance	0.035~0.065
Exhaust value	Guide I.D.	8.015~8.030
	Stem O.D.	7.955~7.970
	Clearance	0.045~0.075
4TNE106 (T)		
Intake value	Guide I.D.	9.000~9.015
	Stem O.D.	8.950~8.965
	Clearance	0.035~0.065
Exhaust	Guide I.D.	9.000~9.015
	Stem O.D.	8.940~8.955
	Clearance	0.045~0.075

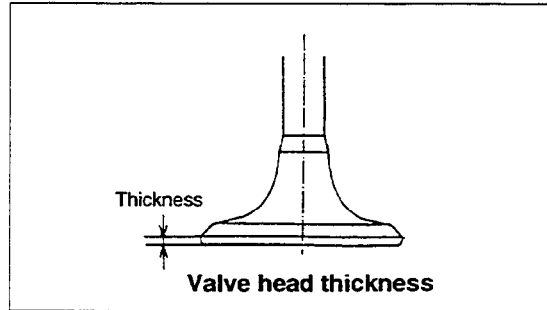


(5.3) Intake/exhaust valve

Mainly clean and check damage and wear at the valve stem and seat.

- (a) Seat contact: See 5.1-(d) above.
- (b) Stem outside diameter: See 5.2-① above.
- (c) Valve head thickness

		(mm)	
		Standard	Limit
4TNE94•95	Intake	1.71	1.00
	Exhaust	1.65	1.00
4TNE106 (T)	Intake	2.00	1.30
	Exhaust	2.00	1.30

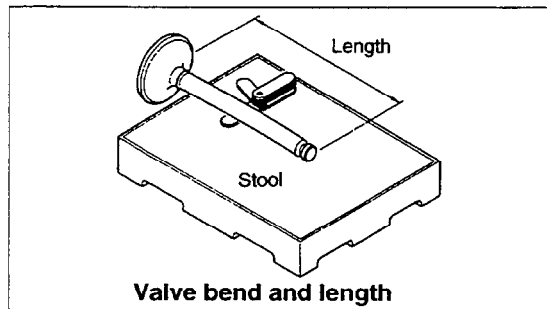


- (d) Valve stem bend

Limit	0.01 mm
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- (e) Overall length

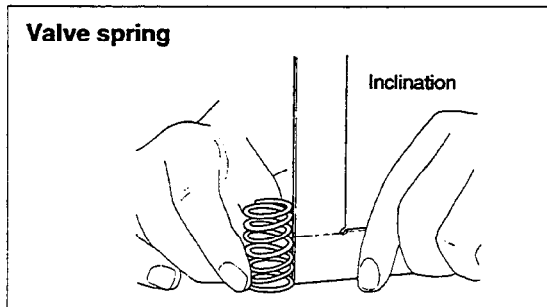
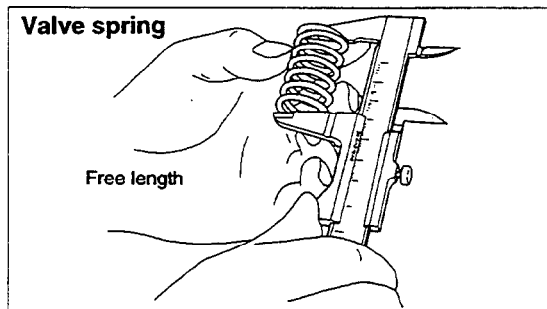
		(mm)	
		Standard	Limit
4TNE94•98	Intake • Exhaust	115	114.5
	Intake • Exhaust	126	125.5



(5.4) Valve spring

Mainly inspect damage and corrosion.

		(mm)	
	Free length standard	Inclination limit	
4TNE94•98	47.5	1.2	
4TNE106 (T)	50.6		



4. Engine Body

(5.5) Valve rocker arm

Mainly inspect valve head cap contact surface, inside surface defects and wear.

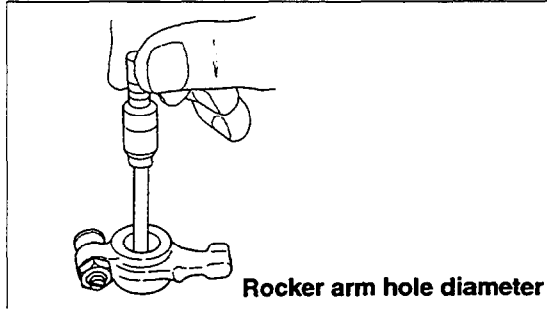
Slight surface defects shall be corrected with an oilstone:

(mm)

	Standard	Limit
Arm hole diameter	18.50~18.52	18.57
Shaft O.D.	18.47~18.49	18.44
Clearance	0.01~0.05	0.13

(5.6) Valve rocker arm shaft

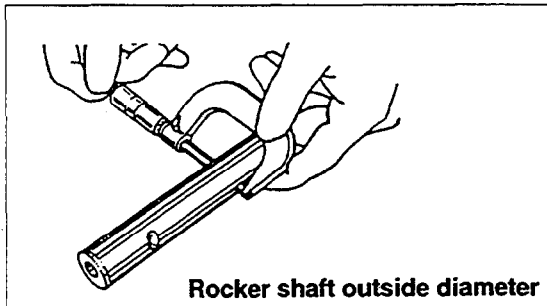
Mainly inspect seizure and wear at the surface in sliding contact with the arm. The rocker shaft diameter shall be as specified in (5.5) above.



(5.7) Push rod

Mainly inspect the surface in contact with the tappet and adjusting screw. Slight defects shall be corrected with an oilstone.

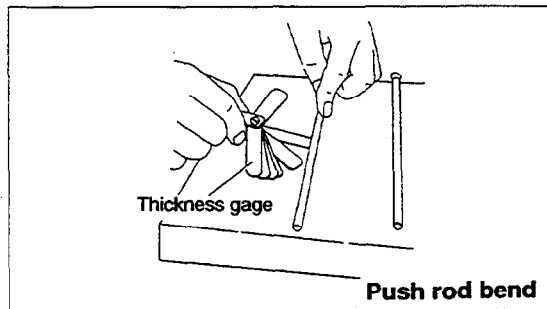
Bend limit	0.03 mm or less
------------	-----------------



(5.8) Valve clearance adjusting screw

Mainly inspect the surface in contact with the push rod.

Slight defects shall be corrected with an oilstone.



(5.9) Rocker arm spring

Mainly inspect surface defects and corrosion.

(6) Valve seat correction

[NOTICE]

Always check the oil clearance between the valve and valve guide before correcting the valve seat. If it exceeds the limit, replace the valve or valve guide first to make the clearance satisfy the standard. After correction, wash the valve and the cylinder head sufficiently with diesel oil to remove all grinding powder or compound.

- ① If the seat surface is slightly roughened: perform **[A]** and **[B]** below.
- ② If the seat is heavily roughened but the width is almost normal, correct with a seat grinder or seat cutter first. Then perform lapping **[A]** and **[B]** below.

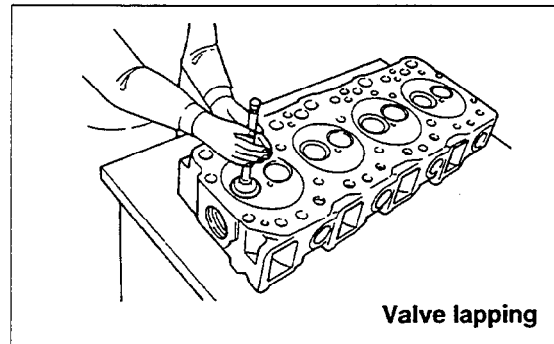
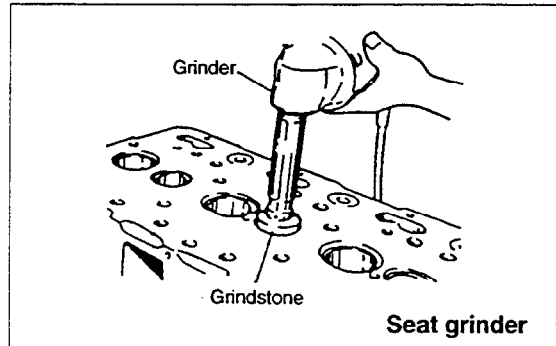
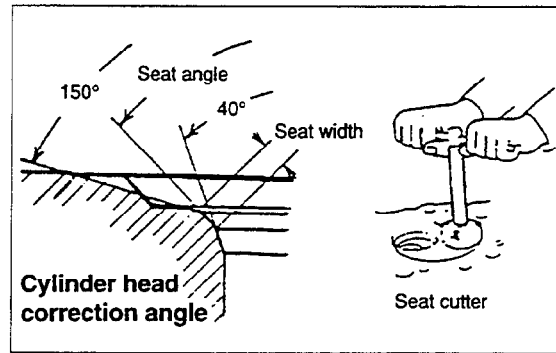
Seat cutter angle	Intake	Exhaust
	120	90

- ③ If the seat is heavily roughened and the width is much enlarged, grind the seat inner surface with a seat grinder whose center angle is 40° , then grind the seat outer surface with a grinder whose center angle is 150° to make the seat width match the standard. Then perform seat correction as described in ②, and then carry out lapping **[A]** and **[B]** below.

Grinding wheel angle	θ_1	θ_2
	40	150

[A]: Lap the valve and seat with a mixture of valve compound and engine oil.

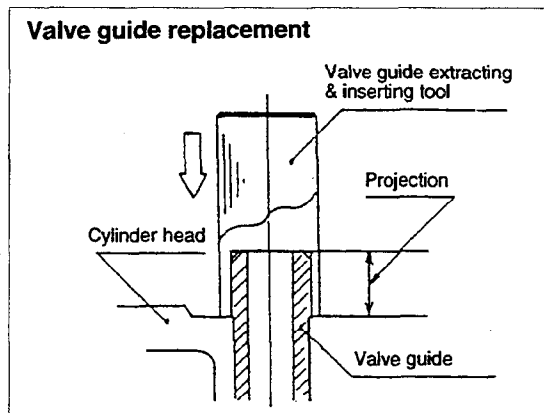
[B]: Lap with engine oil only.



4. Engine Body

(7) Valve guide replacement

- ① Use a valve guide extraction tool (11.1-1 in Chapter 11) and extract the valve guide from the cylinder head.
- ② Put liquid nitrogen or ether (or alcohol) with dry ice added in a container and put the valve guide for replacement in it for cooling. Then insert it in with a valve guide inserting tool (10.1-2 in Chapter 10).
- ③ Check the inside diameter and finish to the standard inside diameter as required with a reamer.
- ④ Check the projection from the cylinder head.



-	Projection (mm)
4TNE94•98	14.7~15.0
4TNE106 (T)	13.2~13.5

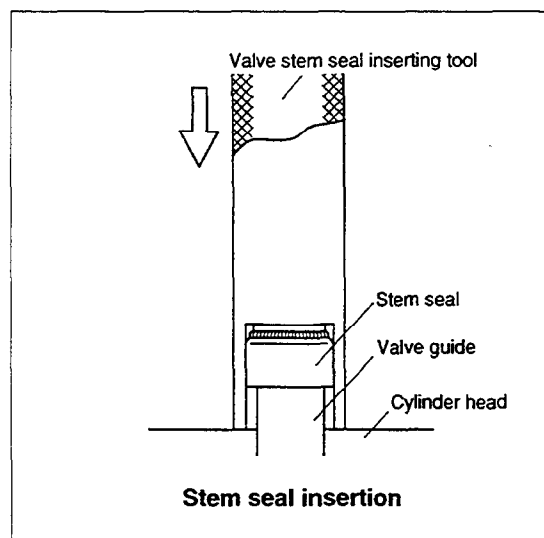
⚠ CAUTION

Do not touch the cooled valve guide with bare hands to avoid skin damage.

(8) Valve stem seal replacement

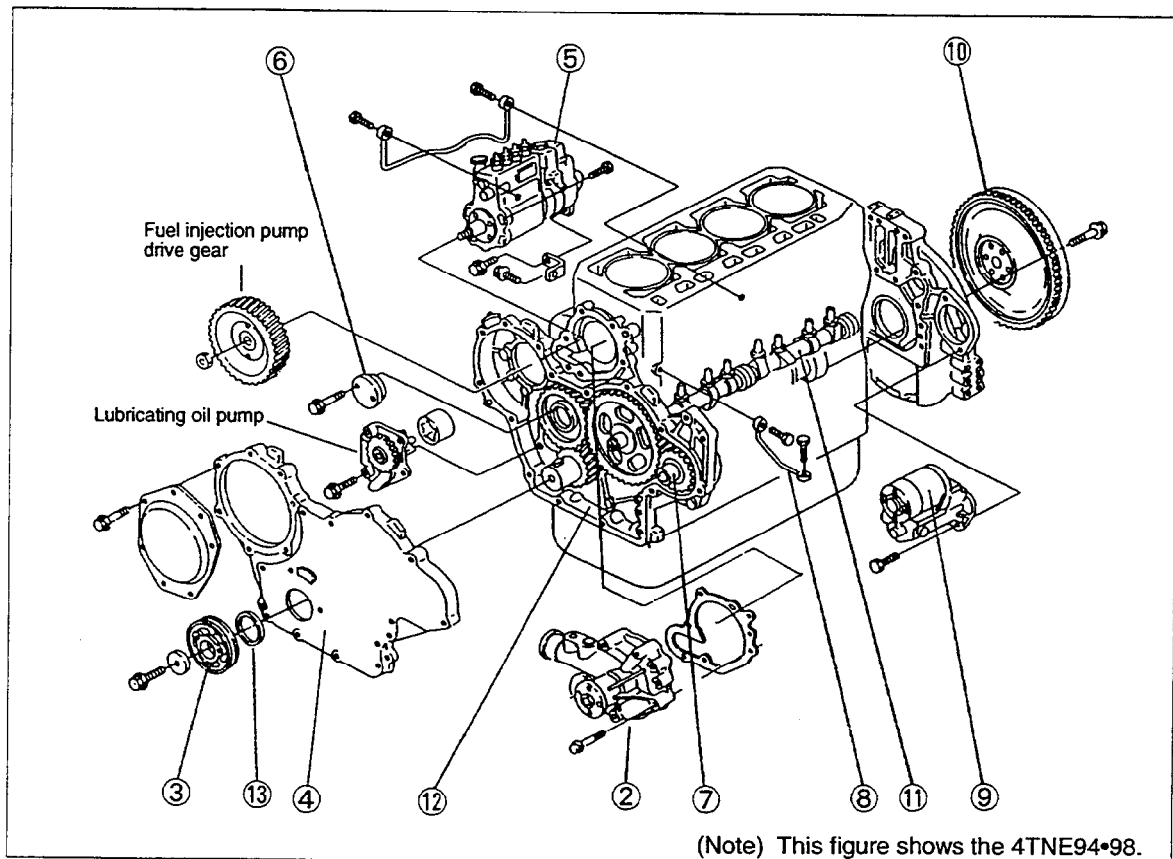
Always use a new seal after the intake/exhaust valve is disassembled. Since the one for the exhaust valve is marked with yellow paint, do not confuse the intake and exhaust valves.

- ① Apply engine oil to the lip.
- ② Push with the inserting tool (11.1-5 in Chapter 11) for installation.



4.3 Gear Train and Camshaft

(1) Components



(2) Disassembly procedure:

Disassemble in the order of the numbers in the illustration.

- ① Perform steps ① to ⑫ of the cylinder head disassembly procedure.
- ② Remove the cooling water pump.
- ③ Remove the crankshaft pulley. **(Point 1)**
- ④ Remove the gear case cover. **(Point 2)**
- ⑤ Remove the fuel injection pump. **(Point 3)**
- ⑥ Remove the idle gear assy. **(Point 4)**
- ⑦ Remove the PTO drive gear. **(Point 5)**
- ⑧ Remove the PTO lubrication pipe.
- ⑨ Remove the starting motor.
- ⑩ Remove the flywheel. **(Point 6)**
- ⑪ Remove the camshaft assy. **(Point 7)**
- ⑫ Remove the gear case. **(Point 8)**
- ⑬ Remove the oil seal from the gear case cover. **(Point 9)**

(3) Reassembly procedure:

Reverse of the disassembly procedure.

4. Engine Body

(4) Servicing points

Point 1

Disassemble:

- Remove the crankshaft pulley using a gear puller after removing the mounting bolt. When removing the pulley with the gear puller, use a pad and carefully operate so as not to damage the thread. Set the gear puller securely to prevent the pulley from being damaged.

Reassemble:

- When installing the crankshaft pulley, apply lube oil to the bolt and carefully assemble so as not to damage the oil seal.

T=107.9~127.5 Nm (11~13 kgf-m)

Point 2

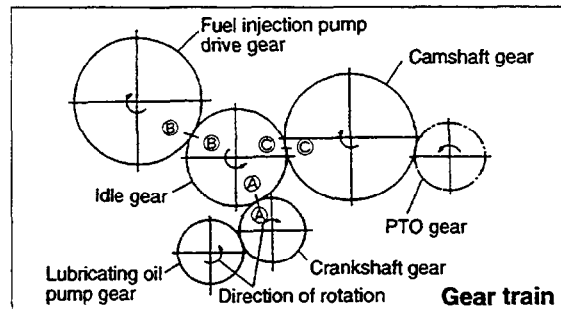
Reassemble:

- When installing the gear case cover, do not forget to install the two reinforcing bolts at the center.

- Measure the backlash of each gear.

(mm)

-	Standard	Limit
Crankshaft gear, Camshaft gear, Fuel injection pump gear, Idle gear, PTO gear,	0.08~0.14	0.16
Lubricating oil pump gear	0.09~0.15	0.17



- Apply sealant and install the gear case cover by correctly positioning the two dowel pins.

Point 3

Disassemble:

- Remove the fuel injection pump drive gear mounting nut, remove the gear using the gear puller, and remove the fuel injection pump. Do not forget to remove the stay on the rear side. When extracting the gear using the gear puller, use a pad at the shaft and carefully operate so as not to damage the thread.

Reassemble:

- Drive gear nut $T = 83.4\sim 93.2\text{Nm}$ (8.5~9.5 kgf-m)

Point 4

Reassemble:

- Assemble crankshaft gear A, fuel injection pump drive gear B and camshaft gear C at the same time by aligning with idle gear A, B and C marks.
- Install the idle gear shaft with the oil hole facing upward.

Point 5

Reassemble:

- Install the PTO drive gear with its inner spline side facing the flywheel.

Point 6

Disassemble:

- Install a bolt as a handle in the hole at the end face of the flywheel and remove carefully so as not to damage the ring gear.

Reassemble:

Flywheel mounting bolt T = 186.3~205.9Nm (19~21kgf-m), apply lube oil

Point 7

Disassemble:

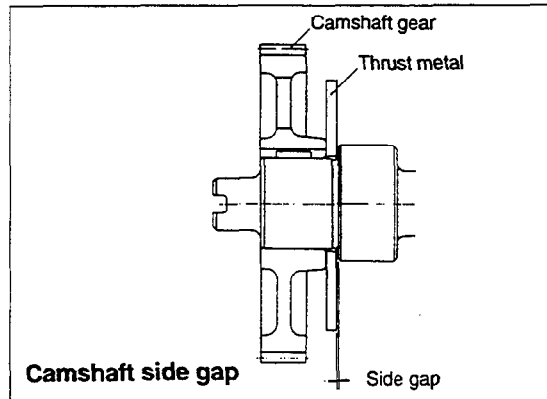
- Measure the camshaft side gap.

(mm)		
—	Standard	Limit
Side gap	0.05~0.20	0.30

- If the measured side gap exceeds the limit, replace the thrust metal.

Disassemble:

- Since the camshaft gear is shrink-fit, heat it to 180 °C~200 °C for extraction.
- For camshaft removal, raise the engine with its mounting flange at the bottom. After removing the thrust metal mounting bolt from the camshaft gear hole, extract the camshaft carefully so as not to damage the bearing bushing.
- Rotate the camshaft a few turns before extracting it to prevent the tappet from being caught by the cam.
- After removing the camshaft, set the engine horizontal and fix it on the base.



⚠ CAUTION

Unforeseen injury may arise due to falling or slipping when raising the engine vertically or returning it to the horizontal position. Proceed carefully so as not to lose balance.

Point 8

Reassemble:

- Do not forget to install the oil pan mounting bolts on the bottom side when installing the gear case.
- Apply sealant (code No. 977770-01212) and install the gear case by matching the two dowel pins.

Point 9

Reassemble:

- Replace the oil seal whenever disassembled.
- Apply lithium grease at the time of assembly.

4. Engine Body

(5) Parts inspection and measurement

(5-1) Camshaft

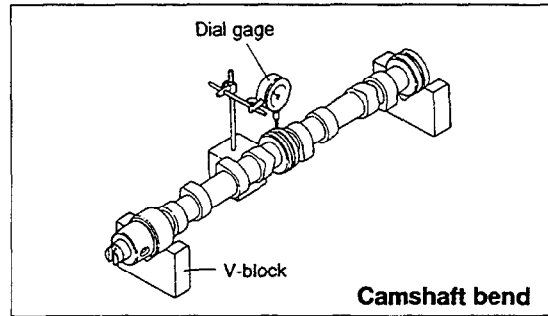
Mainly check the contact between the tappet and cam contact surface, bearing seizure and wear, and gear damage.

① Shaft bend measurement

Support the camshaft with V blocks. Rotate the camshaft and measure the runout at the center of the camshaft and at each journal with a dial gage. Half of the runout is the bend.

(mm)

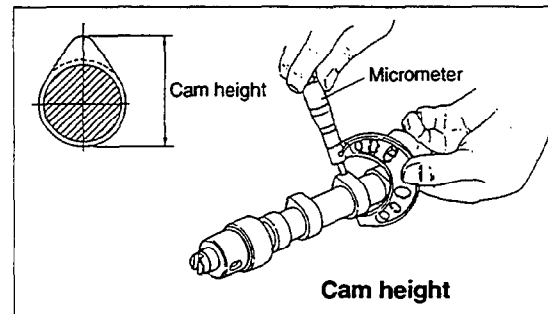
—	Standard	Limit
Bend	0~0.02	0.05



② Intake/exhaust cam height measurement

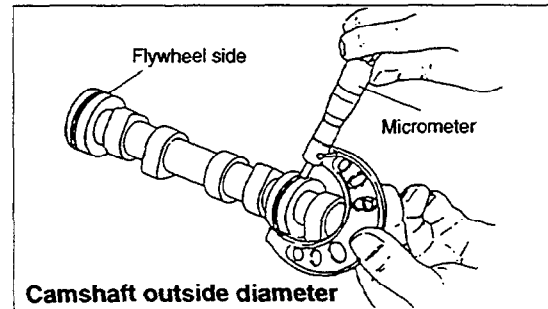
(mm)

—	Standard	Limit
4TNE94•98	42.435~42.565	42.185
4TNE106 (T)	49.435~49.529	49.185



③ Camshaft outside diameter and bearing hole diameter measurement

Measure the camshaft outside diameter with a micrometer. The oil clearance shall be calculated by subtracting the measured camshaft outside diameter from the the camshaft bushing inside diameter after insertion to the cylinder measured with a cylinder gage.



(mm)

-		Standard	Limit
4TNE94•98			
Gear side	Bushing I.D.	49.990~50.055	50.130
	Camshaft O.D.	49.925~49.950	49.890
	Oil clearance	0.040~0.130	0.240
Inter-mediate position	Block I.D.	50.000~50.025	50.100
	Camshaft O.D.	49.910~49.935	49.875
	Oil clearance	0.065~0.115	0.225
Wheel side	Block I.D.	50.000~50.025	50.100
	Camshaft O.D.	49.925~49.950	49.890
	Oil clearance	0.050~0.100	0.210
4TNE106 (T)			
Gear side	Bushing I.D.	57.98~58.05	58.125
	Camshaft O.D.	57.910~57.94	57.875
	Oil clearance	0.040~0.140	0.250
Inter-mediate position	Block I.D.	58.000~58.030	58.105
	Camshaft O.D.	57.895~57.925	57.860
	Oil clearance	0.075~0.135	0.245
Wheel side	Block I.D.	58.000~58.030	58.105
	Camshaft O.D.	57.910~57.940	57.875
	Oil clearance	0.050~0.120	0.230

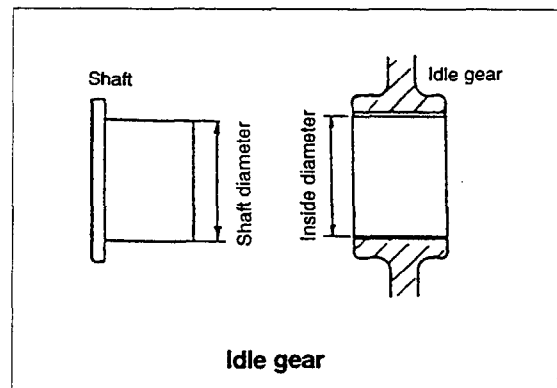
(5.2) Idle gear

Mainly check the bushing seizure and wear, and gear damage.

- ① Shaft outside diameter and bushing inside diameter measurement

(mm)

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



(5.3) PTO drive gear

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

4. Engine Body

(6) Oil seal replacement

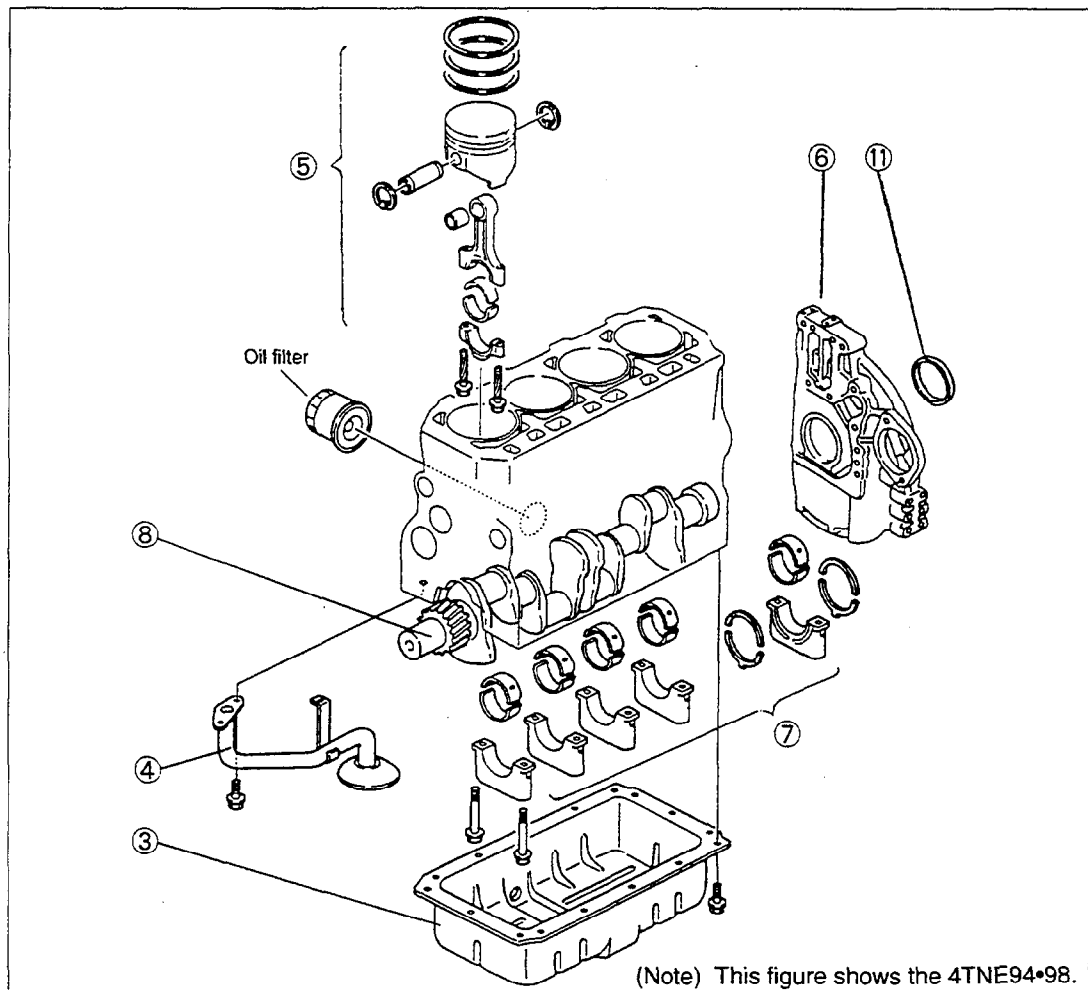
- ① Replace the oil seal with a new one when the gear case is disassembled.
Extract the used oil seal.
- ② Insert a new oil seal using the oil seal inserting tool.
- ③ Apply lithium grease.

(7) Camshaft bushing replacement

Replace the bushing using the special service tool (see 11.1-7 in Chapter 11).

4.4 Cylinder Block

(1) Components



(2) Disassembly procedure:

Disassemble in the order of the numbers in the illustration.

- ① Perform steps ① to ⑫ in the cylinder head disassembly procedure.
- ② Perform steps ① to ⑫ in the gear train disassembly procedure.
- ③ Remove the oil pan. **(Point 1)**
- ④ Remove the lubricating oil suction pipe.
- ⑤ Remove the piston w/rod. **(Point 2)**
- ⑥ Remove the mounting flange. **(Point 3)**
- ⑦ Remove the bearing metal caps. **(Point 4)**
- ⑧ Remove the crankshaft. **(Point 5)**
- ⑨ Remove the tappets.
- ⑩ Remove the pistons and rings. **(Point 6)**
- ⑪ Remove the oil seal from the mounting flange. **(Point 7)**

(3) Reassembly procedure:

Reverse of the disassembly procedure.

4. Engine Body

(4) Servicing points

Point 1 Oil pan

Disassemble:

- Sealant is applied to the oil pan mounting surface on the block. Carefully operate so as not to damage or distort the bonding surface.

Reassemble:

- Apply sealant (code No. 977770-01212) before reassembly.

Point 2 Piston w/rod

Disassemble:

- Measure the connecting rod side gap.

Standard	0.20 ~ 0.40 mm
----------	----------------

- Carefully remove the carbon deposit on top of the cylinder so as not to damage the inner side of the cylinder.
- Set the piston at the BDC position and remove the connecting rod cap. Then set the piston at the TDC position, and push the connecting rod big end with the wooden shaft of a hammer. Proceed carefully so as not to cause the cylinder block catch the rod big end. Set the rod caps and crankpin metals in their correct combinations.

Reassemble:

- Apply oil especially carefully to the sliding contact surfaces of the pistons, rods and rings.
- Use the piston insertion tool (see 11.1-9 in Chapter 11) to insert each piston w/rod in the cylinder block and install the bearing metal cap.

Nm(kgf•m)

	Standard (apply lube oil)
4TNE94*98	53.9~58.8 (5.5~6.0)
4TNE106 (T)	78.5~83.4 (8.0~8.5)

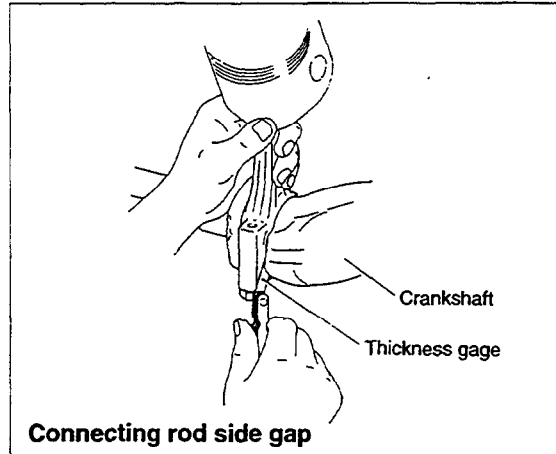
Point 3 Mounting flange

Disassemble:

Place the engine on a stable base with the cylinder block upper surface facing down, and remove the mounting flange carefully so as not to damage the combustion surface.

Reassemble:

Apply sealant (code No. 977770-01212) and install the mounting flange by matching the two dowel pins. After assembly, raise the engine with its mounting flange on the bottom side.



⚠ CAUTION

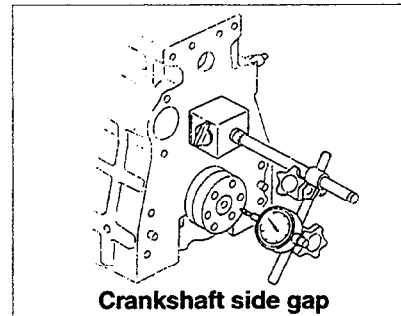
Unforeseen injury may arise due to falling or slipping when raising or reversing the engine. Carefully operate so as not to lose balance.

Point 4 Journal bearing cap

Disassemble:

- Before removing the journal bearing, measure the crankshaft side gap.

	(mm)	
	Standard	Limit
4TNE94•98	0.11 ~ 0.21	–
4TNE106 (T)	0.13~0.23	–



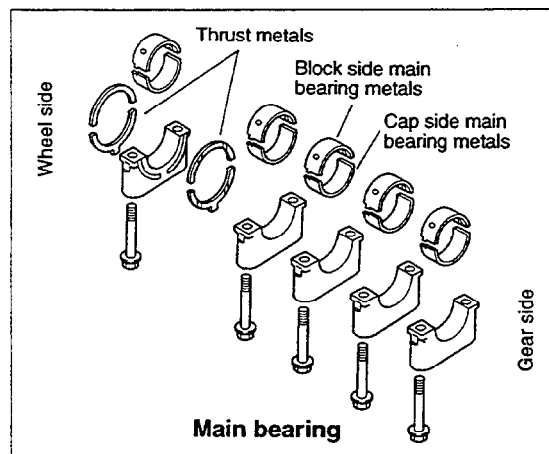
Reassemble:

- If the side gap exceeds the standard, replace the thrust metal with an oversize one.

0.25 DS	Thrust metal		Standard thickness (mm)
	Upper	Lower	
4TNE94•98	129900-02370	129900-02360	2.055~2.105
4TNE106 (T)	123900-02370	123900-02360	2.555~2.605

Disassemble:

- Remove the bearing caps, cap side bearings, and thrust metals. Place each thrust metal with identification of the position and direction.
- Carefully install each thrust metal so that the grooved one is positioned away from the cap.
- Do not confuse the upper and lower main bearing metals. The upper main bearing metal (block side) has an oil hole, and the lower one does not. The "wheel and arrow" marks on the cap shall face the flywheel.



Nm (kgf•m)

	Standard (apply lube oil)
4TNE94•98	107.9~117.7 (11~12)
4TNE106 (T)	186.3~205.9 (19~21)

Point 5 Crankshaft

Disassemble:

- Remove the crankshaft. Remove each main bearing metal upper (block side) and pair it with the metal cap side lower metal.

CAUTION

Carefully prevent damage to the bearing or finger injury when removing the crankshaft because it is heavy.

4. Engine Body

Point 6 Piston pin and rings

Disassemble:

- Use the piston ring replacer (see 11.1-10 in Chapter 11), remove the piston rings.
- Remove the circlip and remove the piston pin by pushing it out.

Reassemble:

- Install each piston ring on the piston, with the punched manufacturer's mark facing upward.

Reassemble:

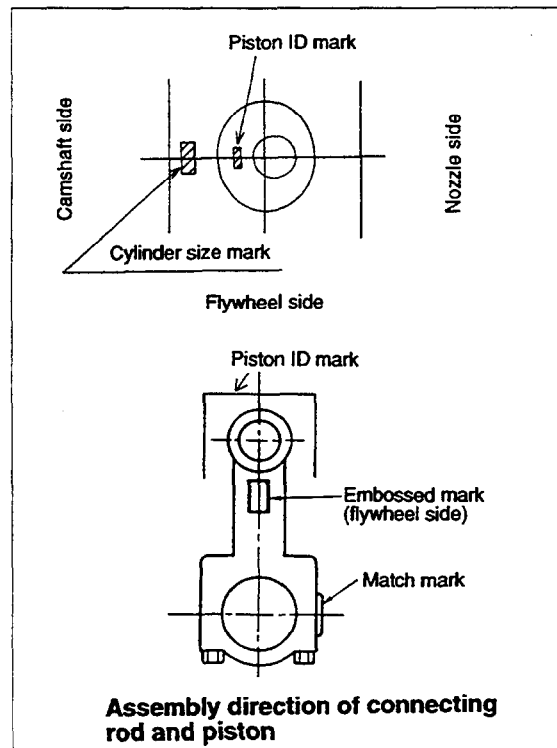
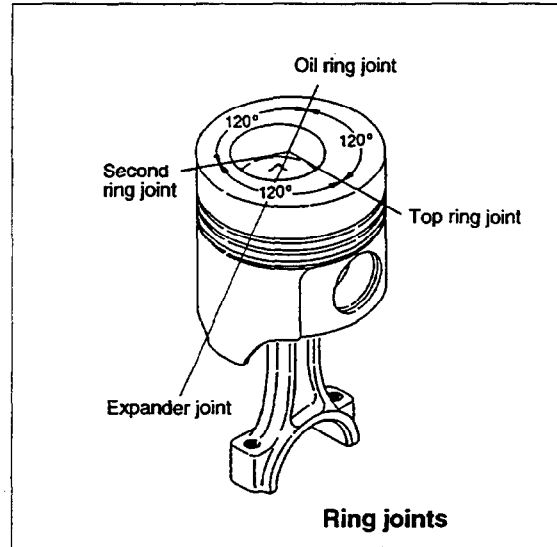
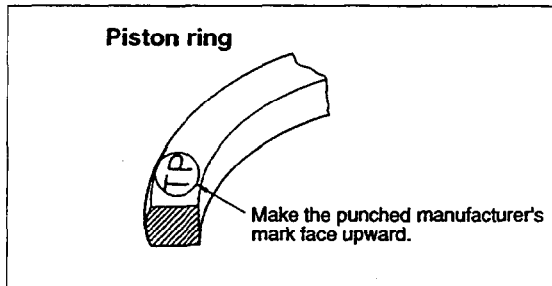
- The piston ring joints shall be staggered at by 120° intervals. Do not position the top ring joint vertical to the piston pin. The coil expander joint shall be opposite to the oil ring joint.

Reassemble:

- When installing the piston pin to the rod and piston, the punched match mark on the big end of the connecting rod shall be opposite to the size mark on the piston top.

Reassemble:

- Install the piston in the cylinder block with the punched mark on the big end of the rod on the nozzle side. (The embossed mark at the connecting rod I-beam section shall be on the flywheel side.)



Point 7 Oil seal

Reassemble:

- Replace the oil seal with a new one whenever disassembled. Apply lithium grease at the time of assembly.

(5) Parts inspection and measurement

(5.1) Cylinder block

Especially clean head surface, cylinder bores and oil holes, and check after removing any carbon deposit and bonding agent.

① Appearance inspection

Check if there is any discoloration or crack. If crack is suspected, perform color check. Sufficiently clean the oil holes and check they are not clogged.

② Cylinder bore and distortion

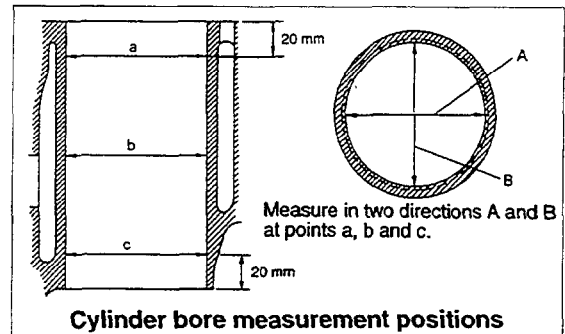
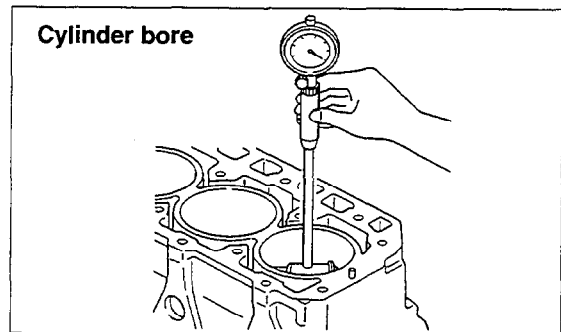
Measure at 20 mm below the crest of the liner, at 20 mm from the bottom end and at the center.

Roundness:

Maximum value of the difference between the measured values in the same cross section.

Cylindricity:

Maximum value of the difference between the measured values in the same direction.



		Standard	Limit
Cylinder inside diameter	mm	4TNE94	94.000~94.030
		4TNE98	98.000~98.030
		4TNE106 (T)	106.000~106.030
Cylinder bore	Roundness	0.01 or less	0.03
	Cylindricity		

4. Engine Body

- ③ If the limit is exceeded or any surface defect is found, repair by boring and honing. Use an oversized piston (and new piston rings) as required.

- Oversized piston (0.25 mm)

—	Code No.	Standard (mm)
4TNE94	129900-22700	φ94.250
4TNE98	129902-22700	φ98.250
4TNE106	123900-22700	φ106.250
4TNE106T	123901-22700	φ106.250

- Cylinder boring dimension

—	Boring dimension (mm)
4TNE94	φ94.250 ~ φ94.280
4TNE98	φ98.250 ~ φ98.280
4TNE106 (T)	φ106.250 ~ φ106.280

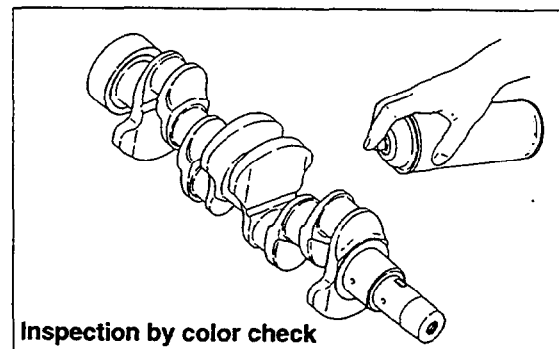
- Piston ring for oversized (0.25 mm)

—	Piston ring code No.(Assy)
4TNE94	129901-22950
4TNE98	129903-22950
4TNE106 (T)	129300-22950

(5.2) Crankshaft

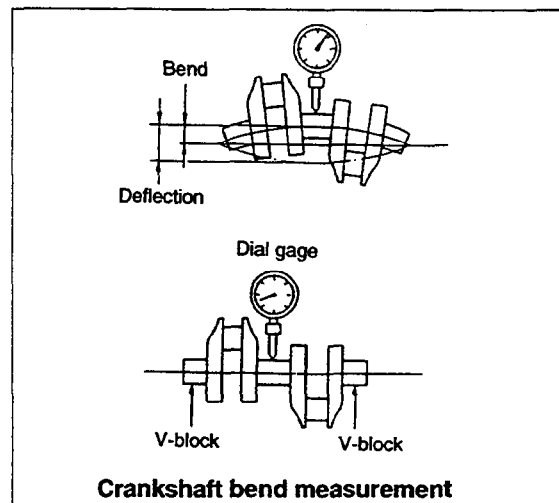
Mainly check seizure and wear of the crankpins and journals. Since the crankshaft gear is shrink-fitted, heat to 180 to 200°C when extraction is necessary.

- ① Shaft portion color check
After washing the crankshaft, inspect it by means of color check or a magnaflux inspector. Replace it if cracked or heavily damaged. Slight defects shall be corrected by grinding.



- ② Crankshaft bend
Support the crankshaft journals at both ends with V-blocks. Use a dial gage and measure the runout at the center journal while rotating the shaft to inspect the bend.

Limit	0.02 mm or less
--------------	------------------------



- ③ Crankpin and journal measurement
 Measure the outside diameter, roundness and taper at each crankpin and journal.
 Correct by grinding if uneven wear, roundness exceeding the limit or insufficient outside diameter is found. Replace if the defect is excessive.

• Crankpin

(mm)

-	Standard	Limit
4TNE94•98		
Pin outside diameter	57.952~57.962	57.902
Metal thickness	1.492~1.500	-
Oil clearance	0.038~0.074	0.150
4TNE106 (T)		
Pin outside diameter	63.952~63.962	63.902
Metal thickness	1.984~1.992	-
Oil clearance	0.054~0.090	0.150

If the oil clearance exceeds the limit, use an undersized bearing.

• Undersized bearing (0.25 mm)

-	Code No.	Standard thickness (mm)
4TNE94•98	129900-23350	1.617~1.625
4TNE106 (T)	123900-23350	2.109~2.117

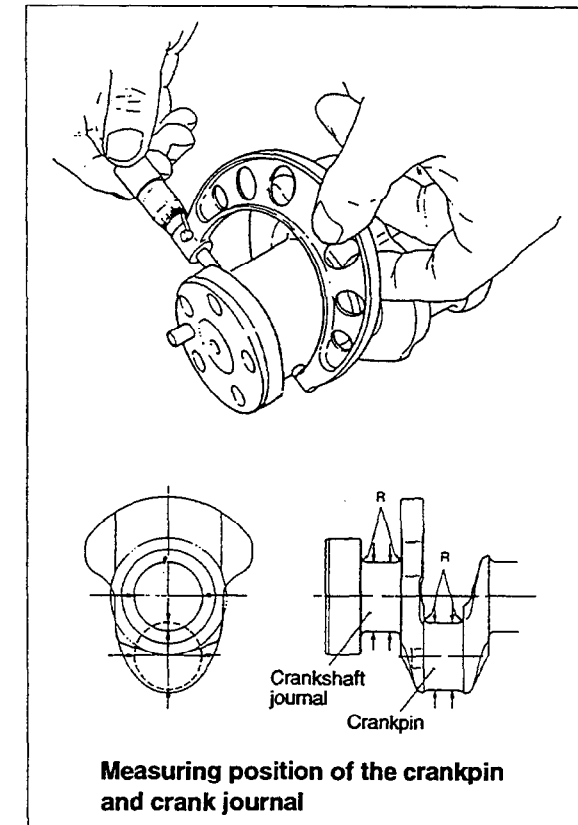
• Pin machining dimension

-	Pin machining dimension (mm)
4TNE94•98	φ57.702 ~ 57.712
4TNE106 (T)	φ63.702 ~ 63.712

• Crank journal

(mm)

-	Standard	Limit
4TNE94•98		
Journal O.D.	64.952~64.962	64.902
Metal thickness	1.995~2.010	-
Oil clearance	0.038~0.068	0.150
4TNE106 (T)		
Journal O.D.	75.952~75.962	75.902
Metal thickness	2.488~2.503	-
Oil clearance	0.052~0.090	0.150



If the clearance limit is exceeded, use an undersized bearing.

4. Engine Body

- Undersized bearing (0.25 mm)

-	Code No.		Standard thickness (mm)
	Upper	Lower	
4TNE94•98	129900-02320	129900-02330	2.120~2.135
4TNE106 (T)	123900-02320	123900-02330	2.613~2.628

- Journal bearing machining dimension

-	Journal bearing machining dimension (mm)
4TNE94•98	φ64.702~64.712
4TNE106 (T)	φ75.702~75.712

[NOTICE]

- (1) **If the oil clearance is excessive though the thicknesses of the journal and crankpin metals are normal or if partial uneven wear is observed, re-grind the crankshaft and use an oversized 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.**

(5.3) Thrust metal inspection

Inspect any damage or wear.

① Thickness

- Thrust metal thickness

	(mm)	
	Standard	Limit
4TNE94•98	1.930~1.980	1.850
4TNE106 (T)	2.430~2.480	2.35

If the side gap is exceeded, use an oversized thrust metal.

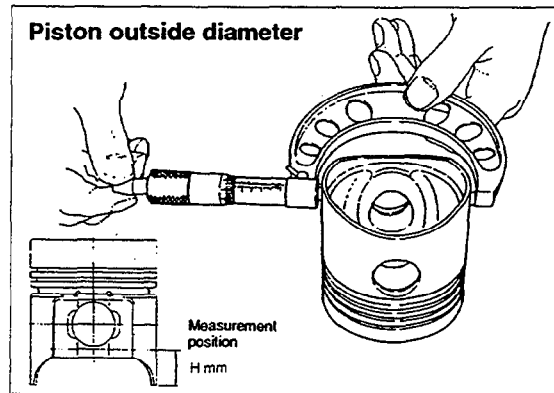
- Oversized metal (0.25 mm)

-	Code No.		Standard thickness (mm)
	Upper	Lower	
4TNE94•98	129900-02370	129900-02360	2.055~2.105
4TNE106 (T)	123900-02370	123900-02360	2.555~2.605

(5.4) Piston

Especially clean the combustion surface, circumference, ring grooves and piston pin bosses, and check after removing any carbon deposit. Any burr at a ring groove or snap ring groove shall be removed. If crack is suspected, inspect by color check.

- ① Piston outside diameter measurement
Measure the long diameter at H mm from the bottom end of the piston of the oval hole in the vertical direction to the piston pin hole.



• Piston outside diameter

-		Standard	Limit	Measurement position (H)
4TNE94		93.945~93.955	93.900	22
4TNE98		97.945~97.955	97.900	22
4TNE106 (T)		105.930~105.960	105.880	30
Clearance between piston and cylinder	Min.	-	0.050	-
	Max.	-	0.080	

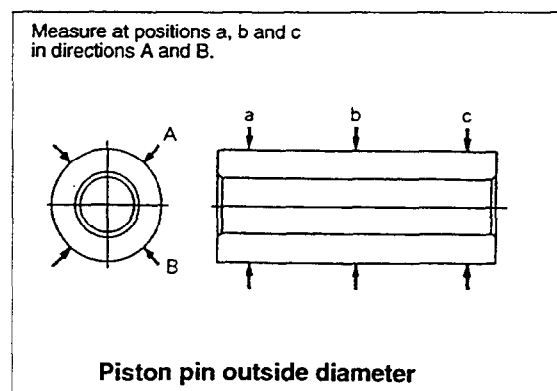
If the clearance between piston and cylinder exceeds the limit, use an oversized piston.

• Oversized piston (0.25 mm)

-	Code No.	Standard (mm)
4TNE94	129900-22700	φ94.250
4TNE98	129902-22700	φ98.250
4TNE106	123900-22700	φ106.250
4TNE106T	123901-22700	φ106.250

• Cylinder boring dimension

-	Boring dimension (mm)
4TNE94	φ94.250~φ94.280
4TNE98	φ98.250~φ98.280
4TNE106 (T)	φ106.250~φ106.280

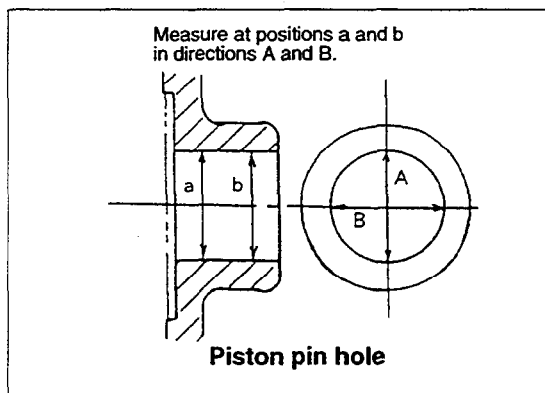


4. Engine Body

② Piston pin hole measurement

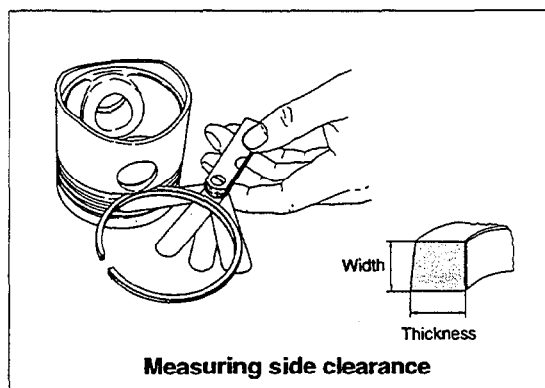
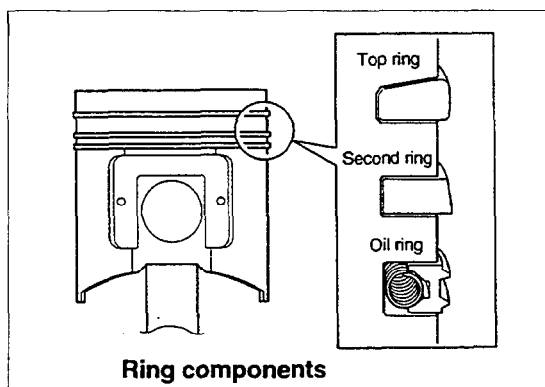
(mm)

	Standard	Limit
4TNE94•98		
Pin I.D.	30.000~30.009	30.039
Pin O.D.	29.989~30.000	29.959
Clearance	0.000~0.020	0.080
4TNE106 (T)		
Pin I.D.	37.000~37.011	37.039
Pin O.D.	36.989~37.000	36.959
Clearance	0.000~0.0220	0.080



③ Piston ring, ring groove and end clearance measurement

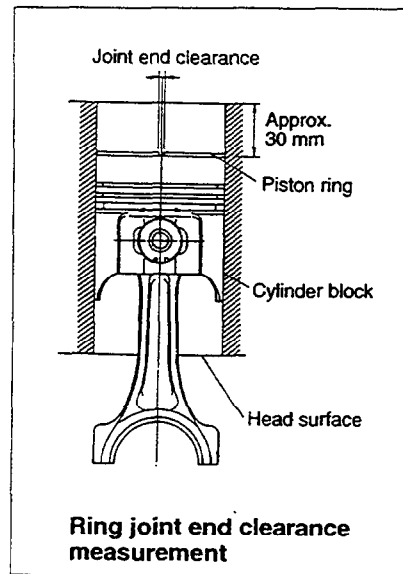
- Except for the top ring, to measure the piston ring groove width, first measure the width of the piston ring. Then insert the piston ring into the ring groove. Insert a thickness gage in between the piston ring and groove to measure the gap between them. Obtain the ring groove width by adding ring width to the measured side clearance.
- To measure the end clearance, push the piston ring into the sleeve using the piston head, insert a thickness gage in end clearance to measure. The ring shall be pushed in to approx. 30 mm above the bottom end of the cylinder. For the top ring, measure only the piston ring joint end clearance in normal state.



• Piston ring dimension

(mm)

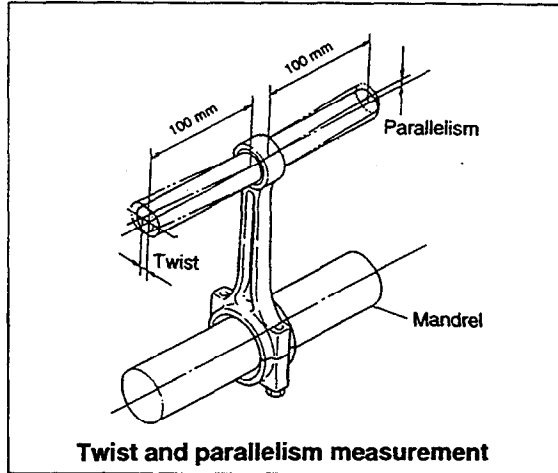
			Standard	Limit
4TNE94•98	Top ring	Ring groove width	2.040~2.060	—
		Ring width	1.940~1.960	1.920
		Side clearance	0.080~0.120	—
		End clearance	0.250~0.450	0.540
	Second ring	Ring groove width	2.080~2.095	2.195
		Ring width	1.970~1.990	1.950
		Side clearance	0.090~0.125	0.245
		End clearance	0.450~0.650	0.730
	Oil ring	Ring groove width	3.015~3.030	3.130
		Ring width	2.970~2.990	2.950
		Side clearance	0.025~0.060	0.180
		End clearance	0.250~0.450	0.550
4TNE106(T)	Top ring	Ring groove width	2.520~2.540	—
		Ring width	2.440~2.460	2.420
		Side clearance	0.060~0.100	—
		End clearance	0.300~0.450	0.540
	Second ring	Ring groove width	2.070~2.085	2.185
		Ring width	1.970~1.990	1.950
		Side clearance	0.080~0.115	0.235
		End clearance	0.450~0.600	0.680
	Oil ring	Ring groove width	3.015~3.030	3.130
		Ring width	2.970~2.990	2.950
		Side clearance	0.025~0.060	0.180
		End clearance	0.300~0.500	0.600



4. Engine Body

(5.5) Connecting rod

- ① Appearance inspection
Inspect the portion near the boundary of the chamfered portion and I-beam section of the big and small ends of the connecting rod as well as the portion near the oil hole of the bushing at the small end for cracks, deformation, and discoloration.
- ② Twist and parallelism measurement
Use a connecting rod aligner and measure the twist and bend.



(mm)

—	Standard dimension	Limit dimension
Twist and parallelism	0.03 or less per 100	0.08

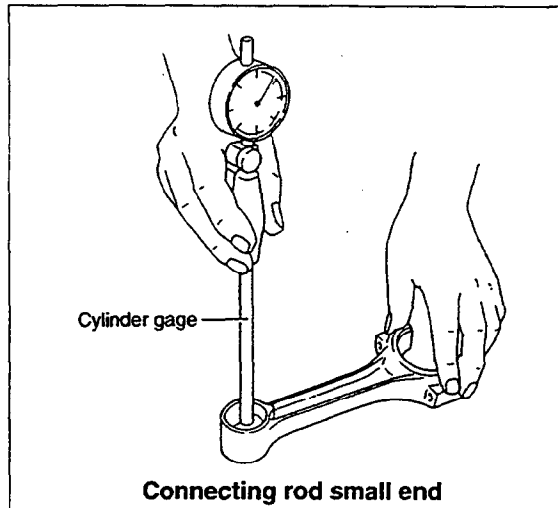
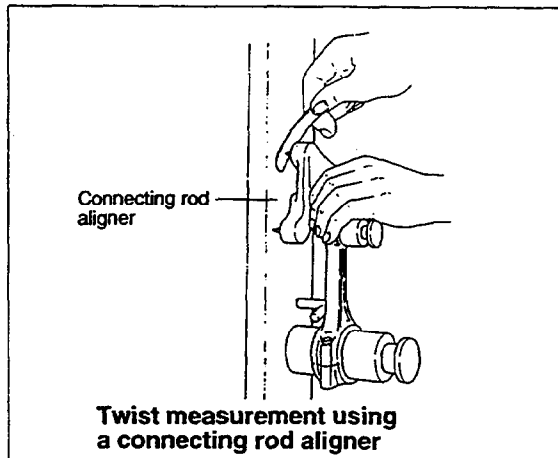
- ③ Rod small end measurement
Measure the pin outside diameter according to (5.4)① described above.

(mm)

—	Standard	Limit
4TNE94•98		
Piston pin I.D. bushing	30.025~30.038	30.068
Pin O.D.	29.987~30.000	29.959
Clearance	0.025~0.051	0.109
4TNE106 (T)		
Piston pin I.D. bushing	37.025~37.038	37.068
Pin O.D.	36.989~37.000	36.961
Clearance	0.025~0.049	0.107

If the bushing is to be replaced because the oil clearance exceeds the limit, use spare part.

—	Service part code
4TNE94•98	129900-23910
4TNE106 (T)	129300-23910



- ④ Rod big end measurement
Measure the crankpin and bushing according to (5.2)③ described above.

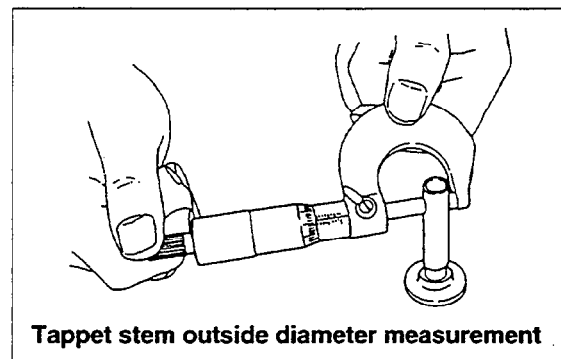
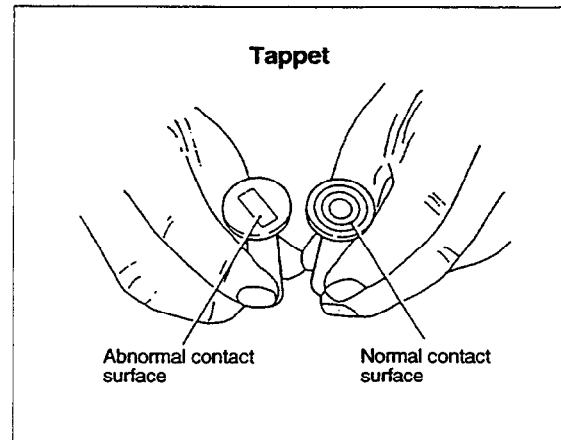
(5.6) Tappet

Mainly check the tappet contact surface with the cam and push rod. Slight surface defects shall be corrected with an oilstone.

- ① Tappet stem outside diameter measurement

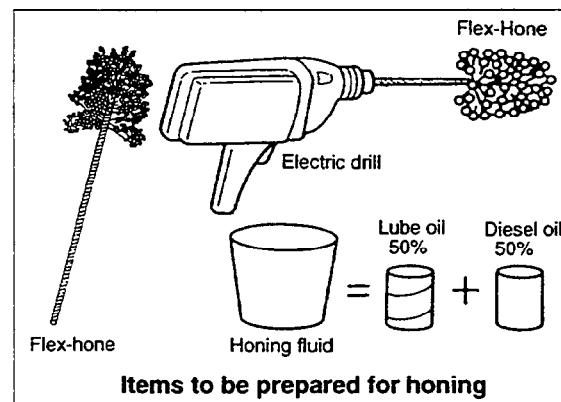
(mm)

-	Standard	Limit
4TNE94•98		
Tappet hole I.D.	12.000~12.018	12.038
Stem O.D.	11.975~11.990	11.955
Clearance	0.010~0.043	0.083
4TNE106 (T)		
Tappet hole I.D.	14.000~14.018	14.038
Stem O.D.	13.966~13.984	13.946
Clearance	0.015~0.052	0.092



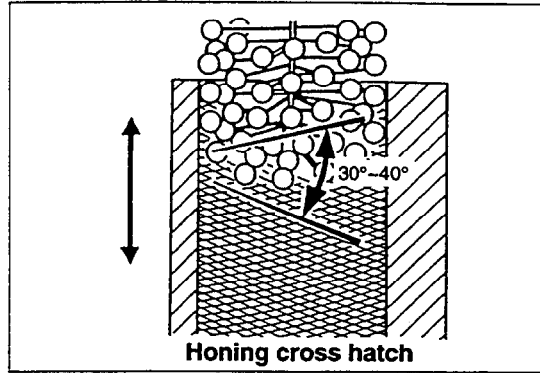
(6) Cylinder bore correction

- ① Slight uneven worn, flawed, etc. shall be corrected by honing only. If the cylinder is unevenly worn partially, flawed or otherwise damaged and cannot be repaired simply by honing, rebore the cylinder first and then hone. See (5) (5.1)③ for the boring dimension.
- ② Items to be prepared for honing
 - Flex-Hone (see 11.1-8 in Chapter 11)
 - Electric drill
 - Honing fluid (50:50 mixture of lube oil and diesel oil)



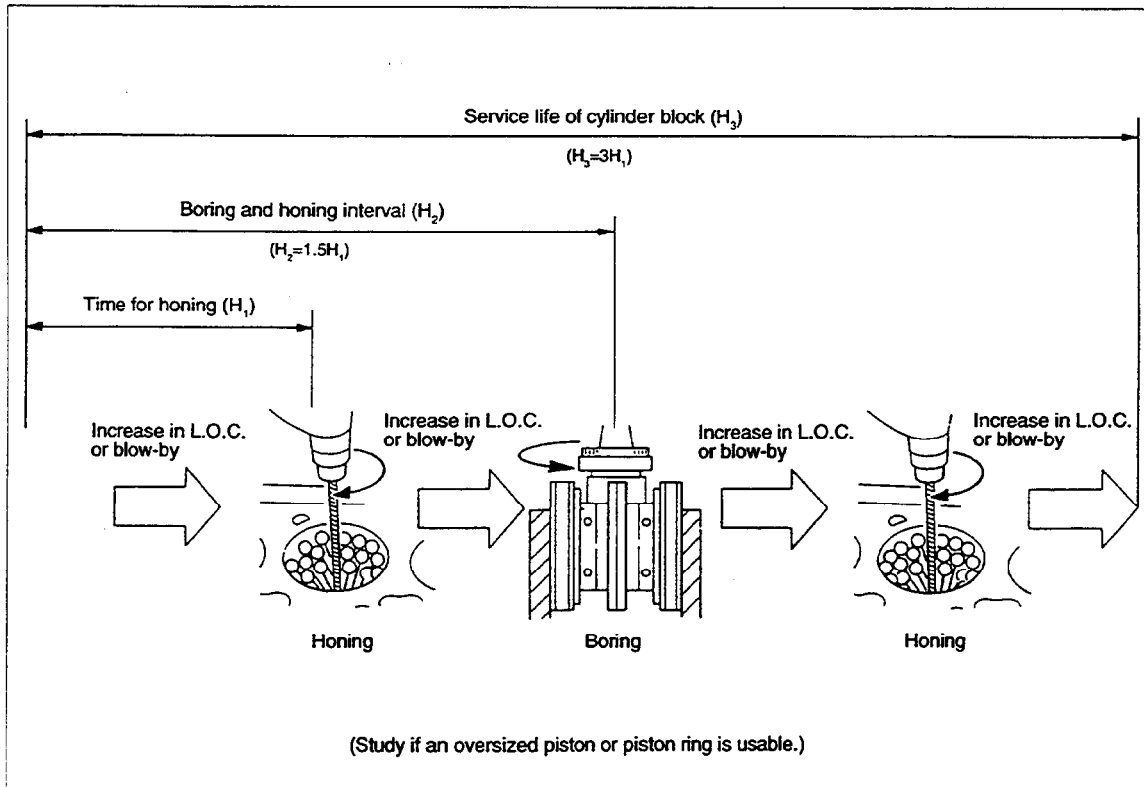
4. Engine Body

- ③ Apply the honing fluid to the Flex-Hone and turn the electric drill at 300 to 1200 rpm. Then insert the Flex-Hone into the cylinder bore while turning it, and move it up and down for about 30 sec. to obtain a honing mark with a cross hatch angle of 30 to 40°.



[NOTICE]

- (1) *Avoid faster revolution than 1200 rpm since it may cause breakdown.*
- (2) *Do not insert or extract the Flex-Hone in stopped state because the cylinder will be damaged.*
- (3) ?



(7) Piston pin bushing replacement

Replace bushing by using the special service tool (see 11.1-3 in Chapter 11).

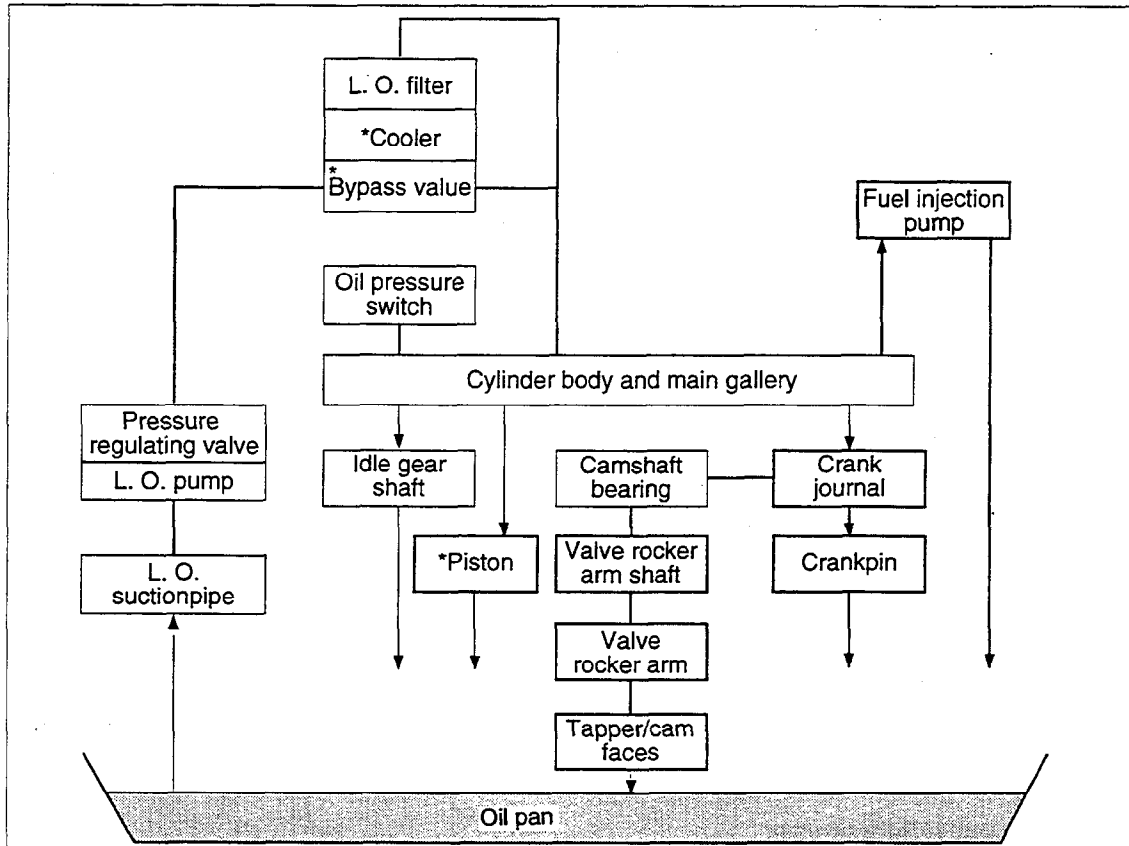
(8) Oil seal replacement

- ① Replace oil seal, when mounting flange is removed. Extract the used oil seal.
- ② Insert a new oil seal with the oil seal insertion tool.
- ③ Apply lithium grease.

5. LUBRICATION SYSTEM 5-1~5-2

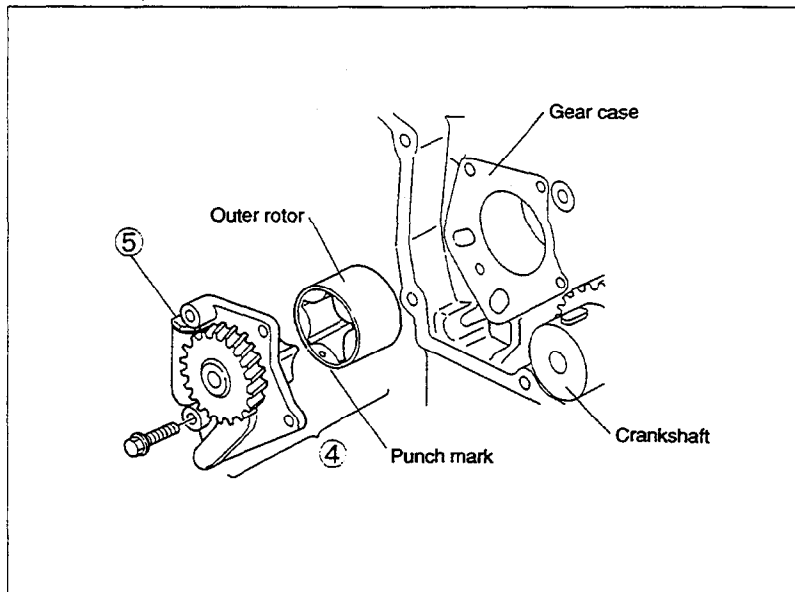
5.1	LUBRICATION SYSTEM DIAGRAM	5-1
5.2	TROCHOID PUMP COMPONENTS	5-1
5.3	DISASSEMBLY	5-2
5.4	SERVICING POINTS	5-2
5.5	PARTS INSPECTION AND MEASUREMENT	5-2

5.1 Lubrication System Diagram



Note) The asterisked (*) cooler, bypass valve and piston jet cooling are installed on the 4TNE106(T).

5.2 Trochoid Pump Components



5. Lubrication System

5.3 Disassembly (Reverse the procedure below for assembly)

- ① Loosen the belt, and remove the radiator pulley, fan and V-belt. See 4.2(2)② in Chapter 4.
- ② Remove the crankshaft pulley. See 4.3 (2)③ in Chapter 4.
- ③ Remove the gear case cover. See 4.3 (2)④ in Chapter 4.
- ④ Remove the lubricating oil pump assy from the gear case. **(Point 1)**
- ⑤ Remove the pressure regulating valve from the lubricating oil pump body. **(Point 2)**

5.4 Servicing Points

Point 1

Disassemble:

- Check if the pump rotates smoothly and see that there is no play between the shaft and gear, and inner rotor.

Reassemble:

- Install the outer rotor in the gear case so that the punch mark on the end face is seen.
- For installation on the gear case, tighten four bolts uniformly in several steps.

[NOTICE]

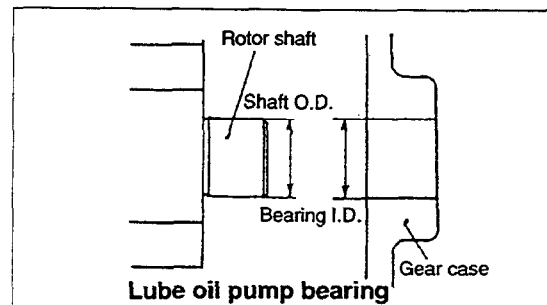
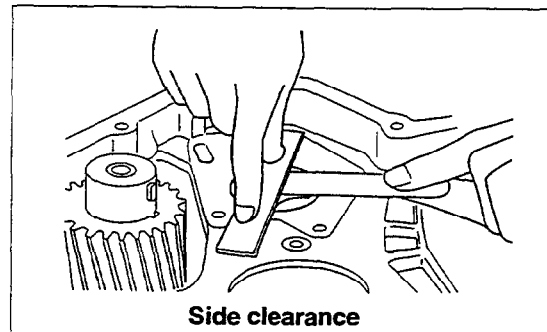
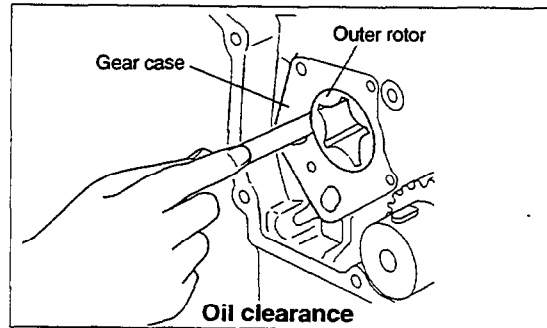
Always check if the pump rotates smoothly after installation on the gear case. Running the engine when the pump rotation is heavy may cause the pump to be burnt.

- When replacing the lubricating oil pump, replace the whole assy.

Point 2

Disassemble-Reassemble:

- Only wash the pressure regulating valve. Disassembly is unnecessary unless any abnormality in operation is detected.



5.5 Parts Inspection and Measurement

(1) Outer rotor

	(mm)	
-	Standard	Limit
Oil clearance		
4TNE94*98	0.100~0.155	0.25
4TNE106 (T)	0.100~0.165	
Side clearance	0.05~0.10	0.15

(2) Rotor shaft

	(mm)	
-	Standard	Limit
Shaft O.D.	12.955~12.970	12.945
Bearing I.D.	12.980~13.020	13.050
Clearance	0.010~0.065	0.105

6. COOLING SYSTEM 6-1~6-2

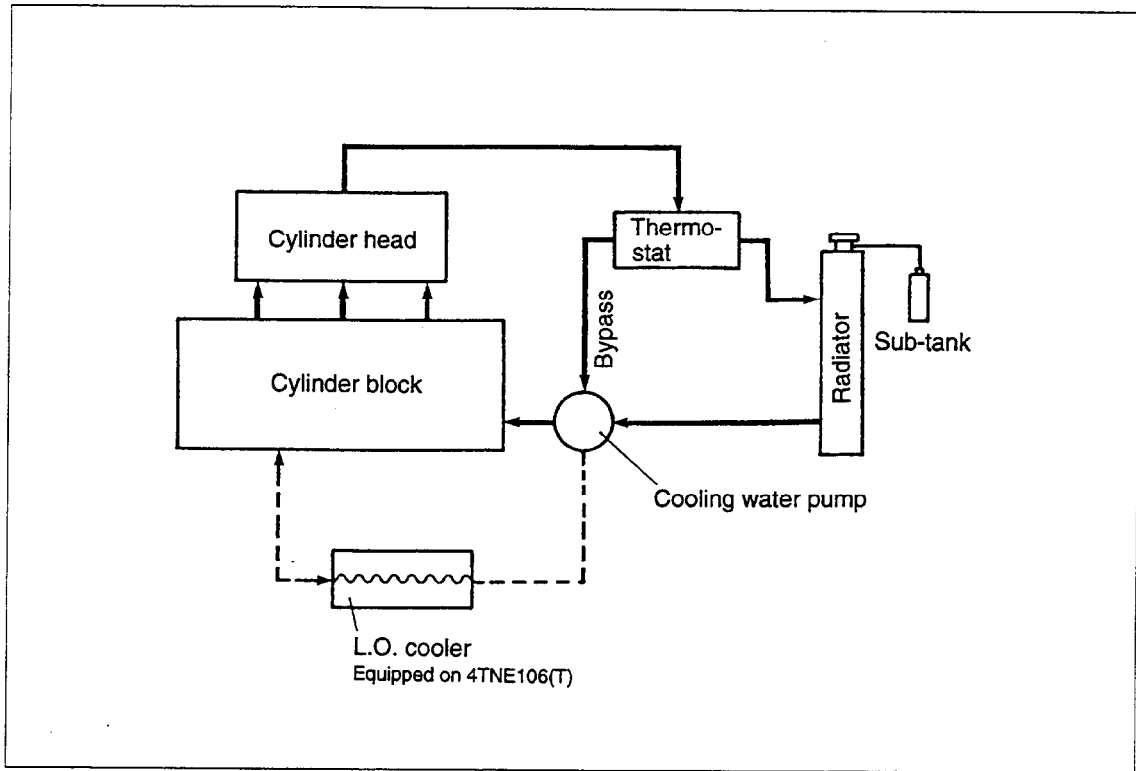
6.1 COOLING WATER SYSTEM 6-1

6.2 COOLING WATER PUMP COMPONENTS..... 6-1

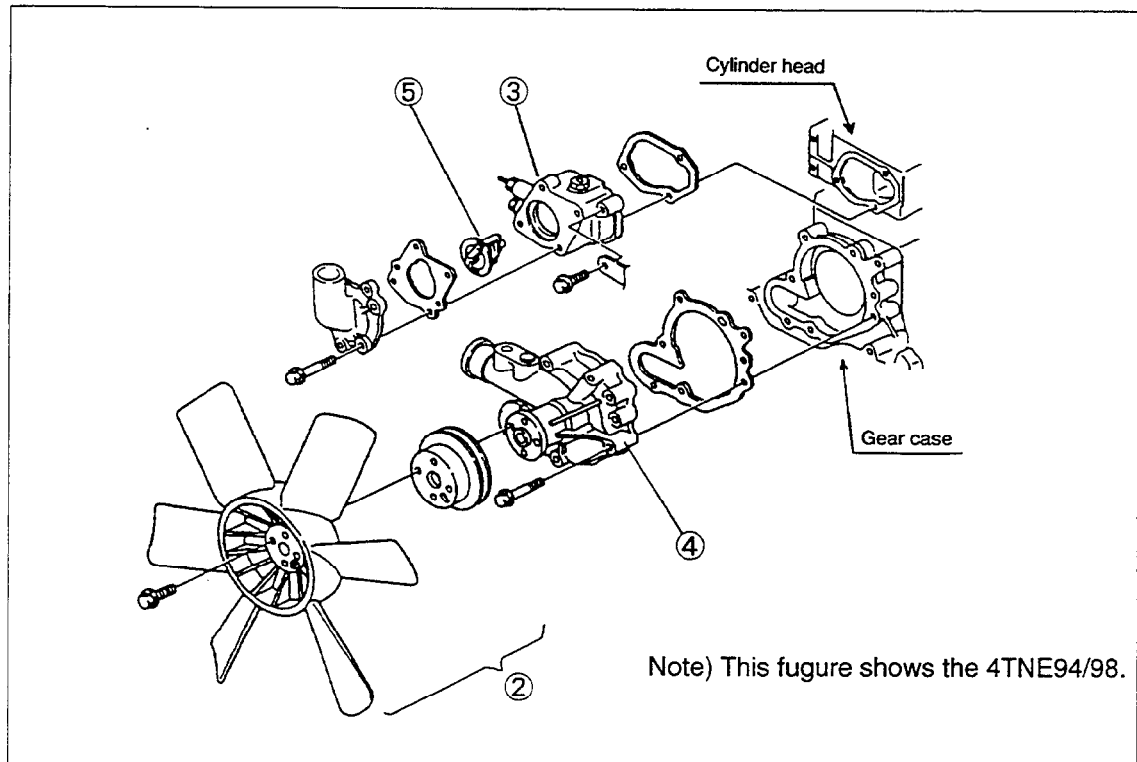
6.3 DISASSEMBLY 6-2

6.4 SERVICING POINTS 6-2

6.1 Cooling Water System



6.2 Cooling Water Pump Components



6. Cooling System

6.3 Disassembly (Reverse the procedure below for assembly)

- ① Remove the alternator. See 4.2(2)① in Chapter 4.
- ② Remove the fan, V-belt and pulley. See 4.2(2)② in Chapter 4.
- ③ Remove the thermostat cover. See 4.2(2)③ in Chapter 4.
- ④ Remove the cooling water pump. **(Point 1)**
- ⑤ Remove the thermostat. **(Point 2)**

6.4 Servicing Points

Point 1

Disassemble-Reassemble:

- Check to see that the cooling water pump bearing is free from abnormal noise, sticking or play and water leakage from the bearing. If replacement is necessary, replace the whole cooling water pump assy.

Point 2

Disassemble:

- Check the thermostat function. See 3.9(1)① in Chapter 3 for the inspection method.

7. FUEL INJECTION PUMP/ GOVERNOR 7-1~7-9

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	(2) Components	7-2
	(3) Disassembly procedure:.....	7-2
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	(6) Parts inspection and measurement.....	7-5
7.3	FUEL INJECTION VALVE	7-7
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	(2) Diassembly procedure	7-8
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7.6	SPECIAL SERVICE TOOLS FOR DISASSEMBLY/ASSEMBLY	7-9

7.1 Introduction

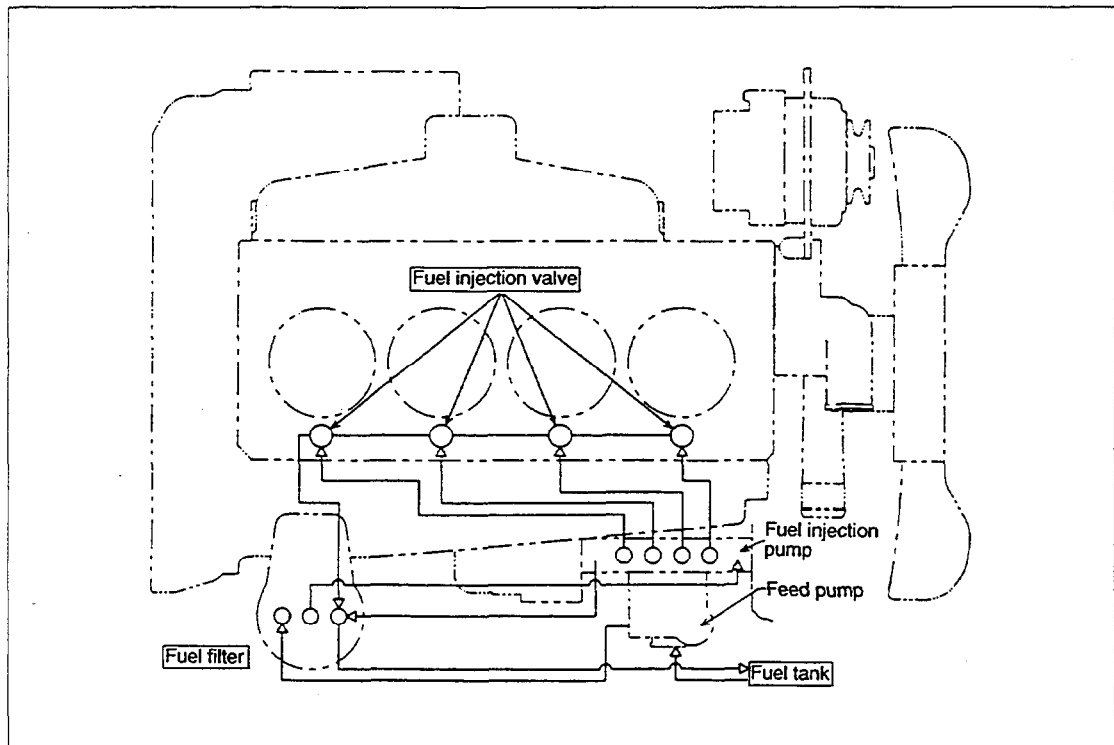
Zexel's products are adopted as the fuel injection pump and governor for this engine. Because of the need of implementing the special service tools including the pump test stand, extract from Zexel's Service Manual is summarized here to enable disassembly, inspection and maintenance in an emergency.

The portions not described in this manual, therefore, should not be disassembled and adjusted.

When detailed adjustment is needed, contact Zexel and ask their service.

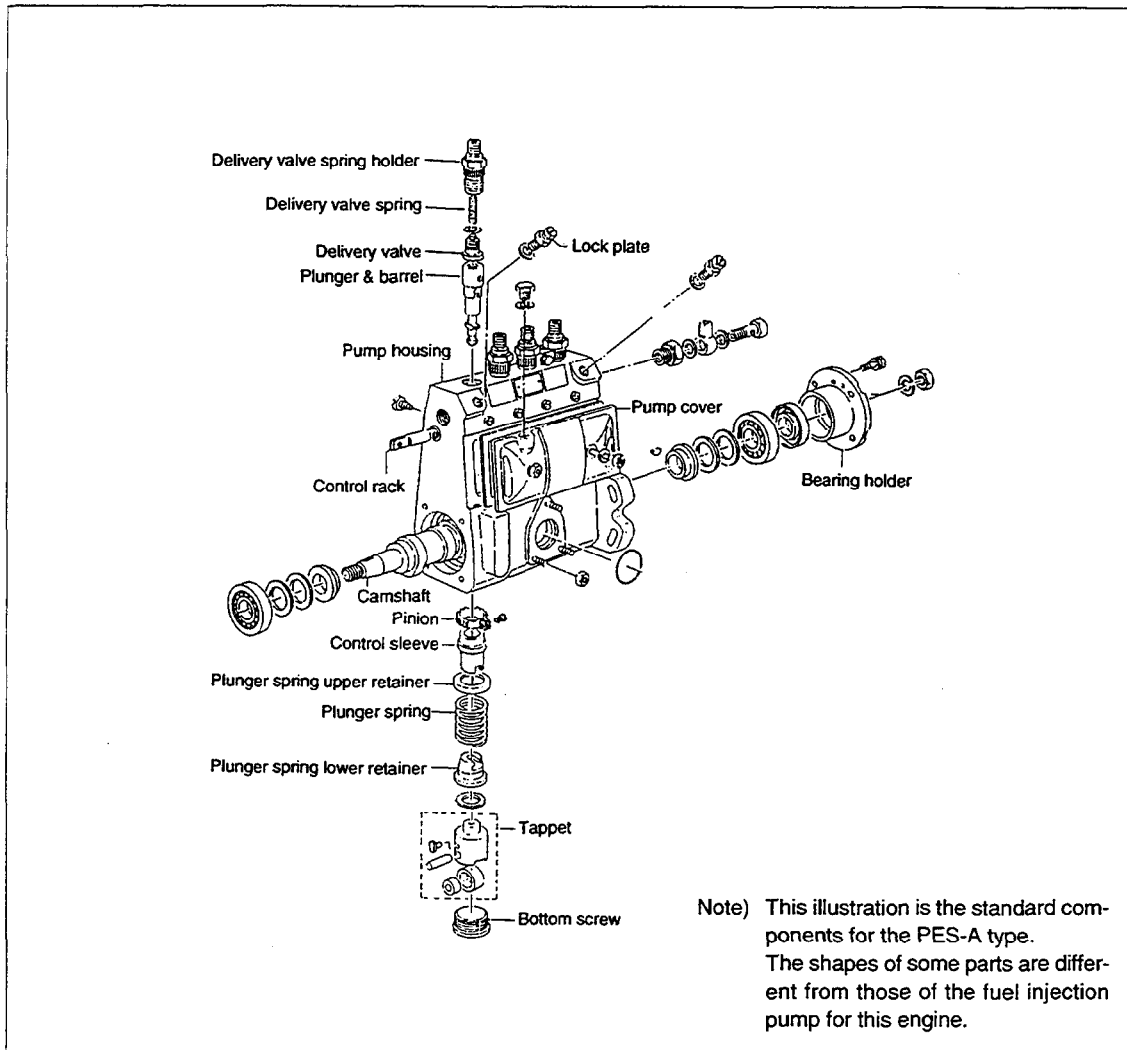
7.2 Fuel Injection Pump

(1) Fuel system diagram



7. Fuel Injection System/Governor

(2) Components



(3) Disassembly procedure:

(3.1) Disassembly from the engine body

- ① Remove the cooling fan, pulley and V-belt. See 4.2(2)② in Chapter 4.
- ② Remove the fuel injection pipe, fuel oil piping, fuel return pipe and rear stay. See 4.2(2)⑦ in Chapter 4.
- ③ Remove the fuel injection pump drive gear cover. See 4.3(1) in Chapter 4.
- ④ Remove the fuel injection pump drive gear. See 4.3(1) in Chapter 4. **(Point 1)**
- ⑤ Remove the fuel injection pump. See 4.3(2)⑤ in Chapter 4.

(3.2) Fuel injection pump disassembly

- ① Remove the fuel feed pump. See 7.4(1) Components.
- ② Remove the governor cover. See 7.5(1) Components. **(Point 2)**
- ③ Remove the governor housing. See 7.5(1) Components. **(Point 3)**
- ④ Remove the bottom screw from the bottom. **(Point 4)**
- ⑤ Remove the fuel injection pump cover.
- ⑥ Bring the tappet away from the camshaft. **(Point 5)**
- ⑦ Remove the bearing holder. **(Point 6)**
- ⑧ Remove the camshaft. **(Point 7)**

- ⑨ Remove the tappet. *(Point 8)*
- ⑩ Remove the plunger, spring and spring retainer, control sleeve and pinion.
- ⑪ Remove the lock plate, and remove the delivery valve, holder and spring.
- ⑫ Remove the plunger & barrel.
- ⑬ Remove the control rack from the pump housing.

[NOTICE]

Tappets, shims, springs, spring retainer, plunger & barrel, delivery valves, springs and delivery valve holders shall be grouped for each cylinder to enable mounting at original positions unless abnormalities are found.

(4) Assembly procedure

Reverse the disassembly procedure.

(5) Servicing points

Point 1

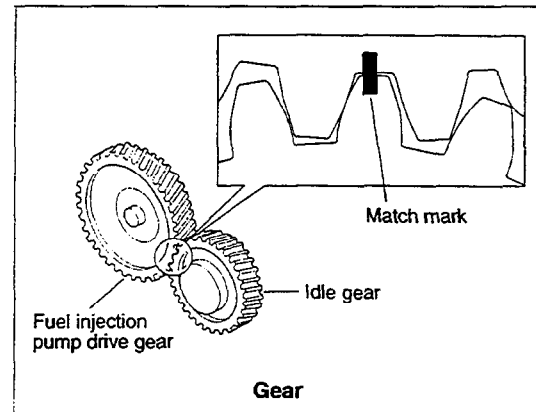
Disassemble:

- Remove the fuel injection pump drive gear and idle gear after putting a match mark.

Reassemble:

- Assemble them by aligning the match marks.

**Pump drive gear nut: T = 83.3~93.1Nm
(8.5~9.5kgf-m)**



Point 2

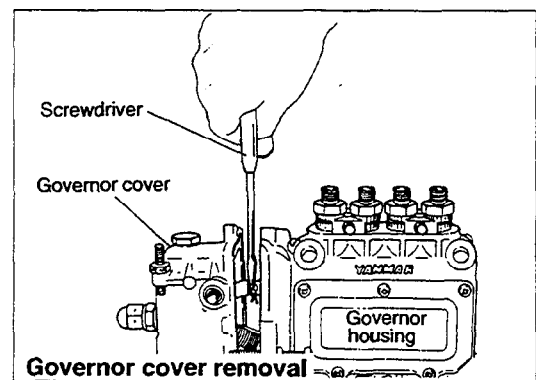
Disassemble:

- Governor cover removal (See 7.5(1) governor components.)

Because the link is connected to the control rack and the starting spring is connected to spring eye, disconnect the link connection by shifting the governor cover to the left (or right) after pushing the link leaf spring down with a screwdriver and disconnect the starting spring from the spring eye with long-nosed pliers before separating the governor cover from the governor housing.

[NOTICE]

When removing the governor cover, carefully operate so as not to bend the governor cover to either side from the governor housing. If the governor cover is bent while the link is connected, the link is bent to increase the sliding resistance of the control rack upon completion of the governor assembly, resulting in stiff governor movement.



Reassemble:

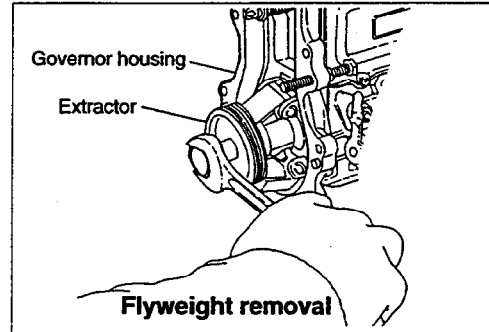
- Coat sealant (code No. 977770-01212) on the mating faces of the governor cover and governor housing.

7. Fuel Injection System/Governor

Point 3

Disassemble:

- Governor housing removal (See 7.5(1) governor components.)
 - a) To remove the flyweight from the camshaft, first use the special wrench (157915-0100) and remove the camshaft nut and spring washer. Then, screw the extractor (157926-5110) into the flyweight holder threaded portion and remove the flyweight assy.
 - b) To remove the governor housing from the injection pump housing, insert the tappet holder (157931-2500) first between the tappet adjusting bolt and nut in the pump housing to disconnect the camshaft and tappet. Then remove seven bolts fastening the governor housing. Remove the governor housing by tapping it with a wooden or plastic hammer.



Reassemble:

- Flyweight mounting nut tightening torque: 53.9~63.7 Nm (5.5~6.5 kgf-m)
- Coat sealant (code No. 977770-01212) on the mating faces of the governor housing and pump housing.

Point 4

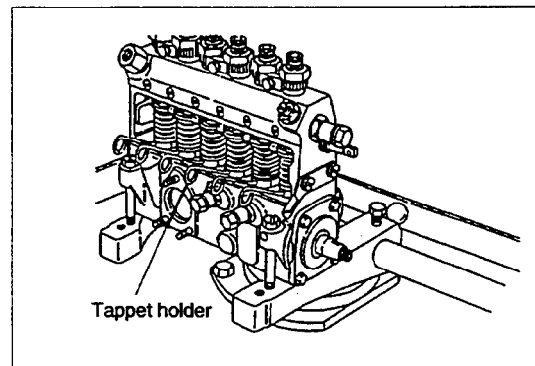
Disassemble-Reassemble:

- Remove the bottom screw by using a socket wrench handle.

Point 5

Disassemble:

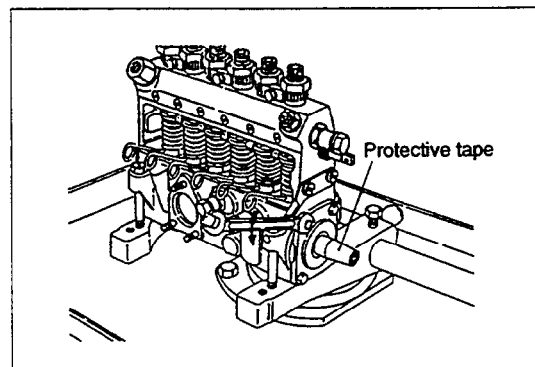
- To separate between the tappet and the cam, place the cam at the TDC and insert the special service tool (tappet holder) into the hole in the tappet. (Zexel's code No. 157931-2500)



Point 6

Disassemble:

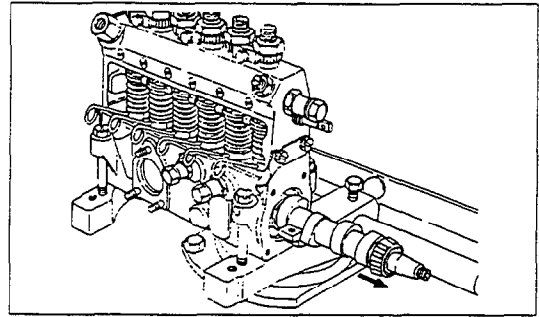
- When removing the bearing cover, wrap oil seal protecting tape on the key groove and thread. Take this action also at the time of assembly.
- Tap the camshaft from the opposite side.
- Insert a screwdriver into the gap and pry for removal.



Point 7

Disassemble:

- Set the drive side cam at the TDC and pull the camshaft toward the drive side for removal.



Point 8

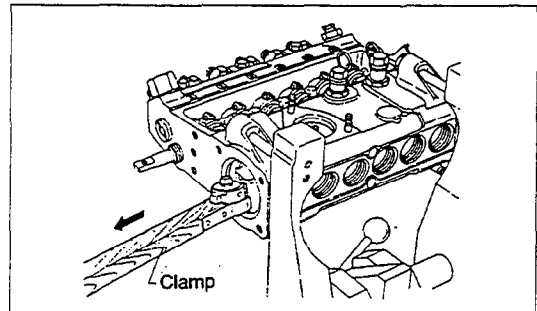
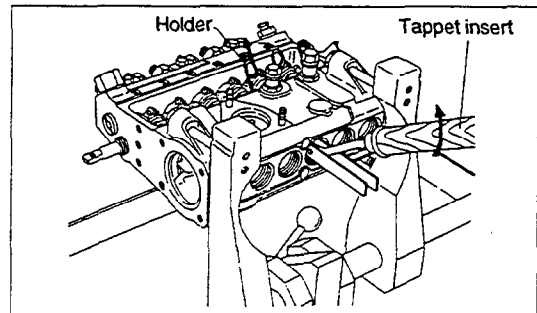
Disassemble:

- For tappet removal, push the tappet roller up with the tappet insert from below to remove the tappet holder, and take the tappet out from the camshaft hole with the clamp.

Zexel's codes

Tappet insert: 157921-0120

Clamp: 157931-6120



(6) Parts inspection and measurement

(6.1) Pump housing

Mainly check for crack, wear and damage at threaded hole.

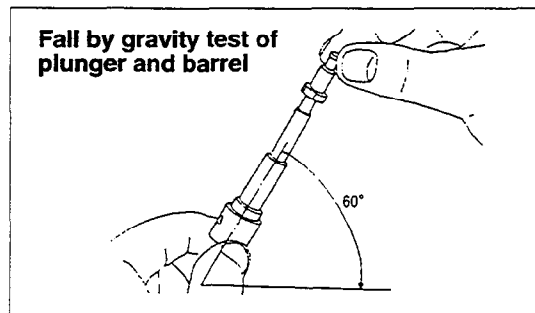
(6.2) Springs (plunger and delivery)

Mainly check for surface defect, crack, uneven wear, corrosion and rust.

(6.3) Plunger & barrel

Check for surface defect, uneven corrosion and wear mainly at the lead portion. After washing, tilt the barrel by around 60°.

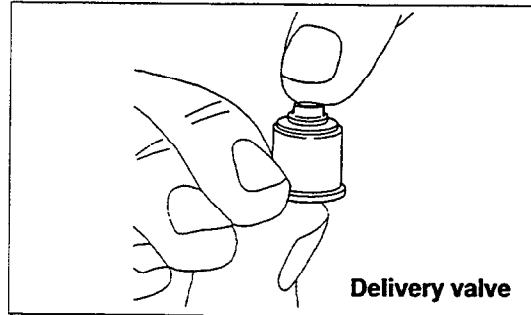
Pull the plunger out and release it. The state is normal if the plunger slips down smoothly by its own weight. Test several times while turning the plunger to different angles.



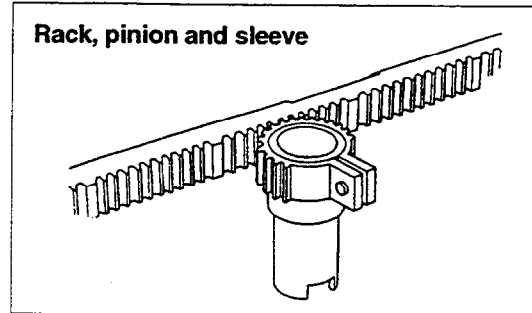
7. Fuel Injection System/Governor

(6.4) Delivery valve

Mainly check for surface defect, corrosion and wear mainly at the piston.

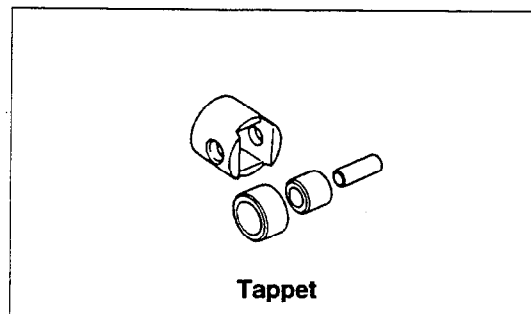


- (6.5) Check mainly the control rack for bend, the pinion for wear and damage at the gear portion, and the sleeve for wear at the contact face with the plunger collar portion.



(6.6) Tappet

Check mainly for wear and damage at the pin hole, roller, pin and bushing.

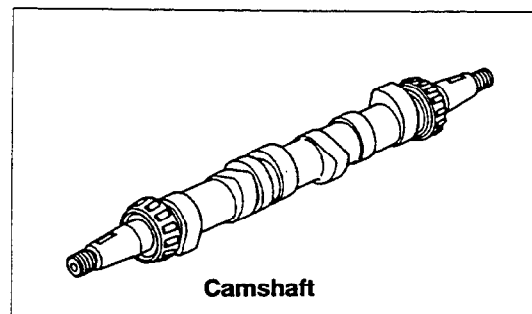


(6.7) Camshaft

Check mainly the cam surface for damage and wear, the key groove and thread for deformation, and the shaft for bend.

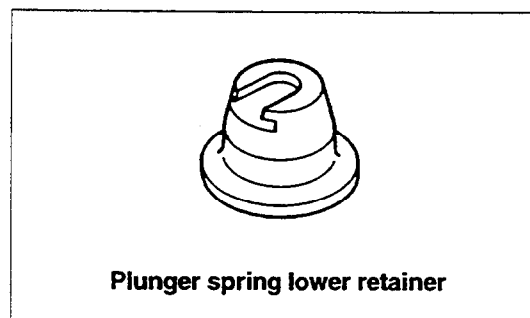
(6.8) Bearing

Check mainly the roller bearing for wear, and the outer race for surface defect.



(6.9) Plunger spring lower retainer

Check mainly the portion in contact with the plunger for deformation and wear.



7.3 Fuel Injection Valve

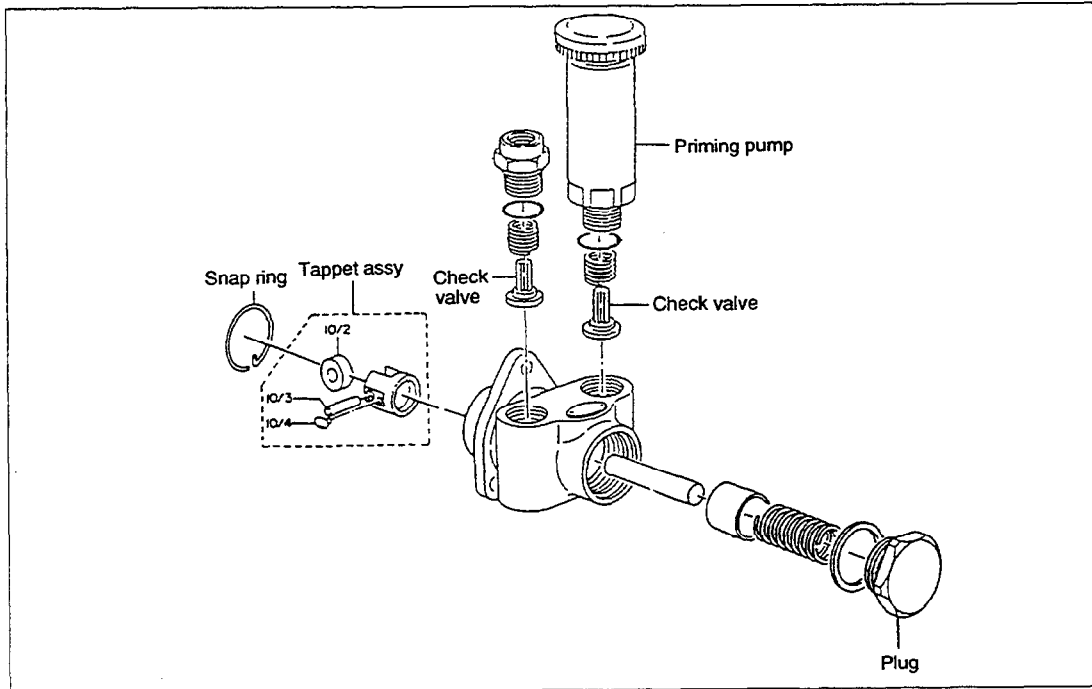
Point 1

Disassemble:

- Check the fuel injection pressure and spray pattern. See 3.6 in Chapter 3 for the inspection method.

7.4 Fuel Feed Pump

(1) Components



(2) Disassembly procedure (Reverse the procedure below for assembly.)

- ① Remove the feed pump assy from the fuel injection pump.
- ② Remove the priming pump and check valve.
- ③ Remove the plug and check valve from the fuel outlet side.
- ④ Remove the plug, and remove the piston.
- ⑤ Remove the snap ring, and remove the tappet assy, spring and push rod.

(3) Parts inspection and measurement

(3.1) Check valve

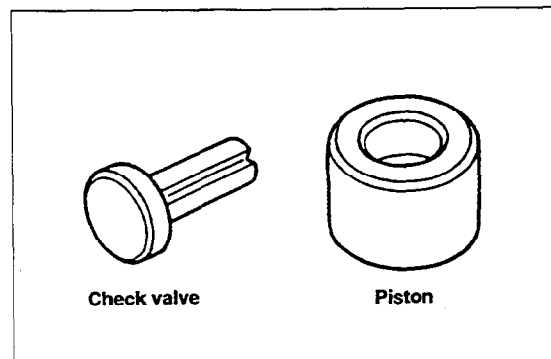
Replace with a new one as a rule.
Check mainly for deformation and partially wear.

(3.2) Piston

Check mainly for surface defect and wear.

(3.3) Springs (piston and check valve)

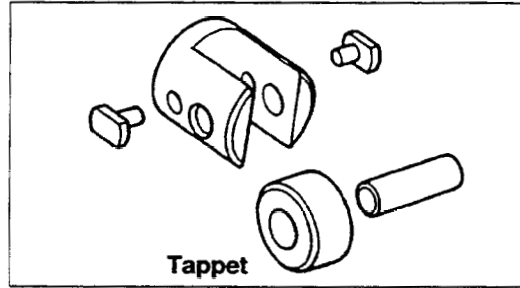
Check mainly for surface defect, fatigue and rust.



7. Fuel Injection System/Governor

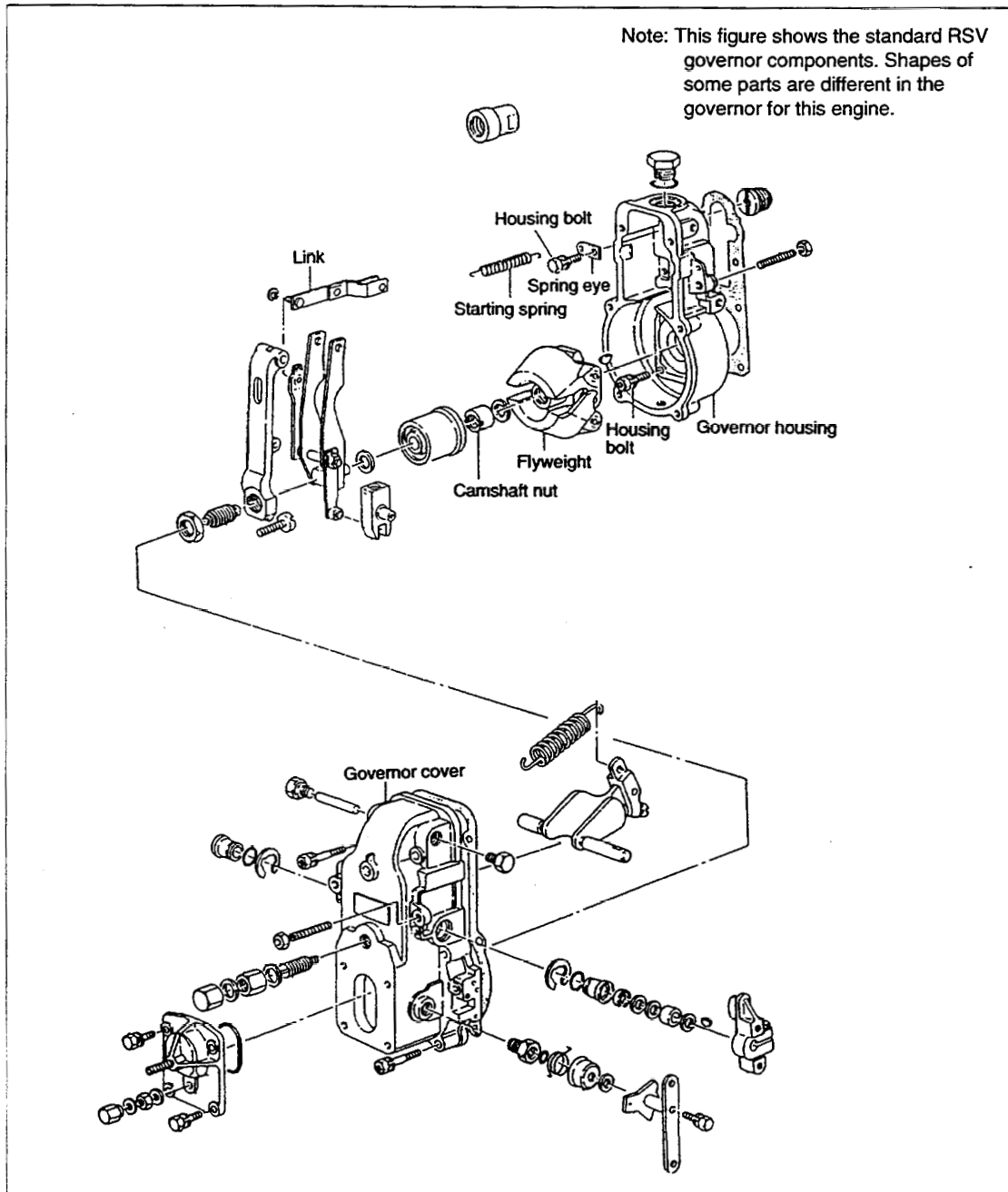
(3.4) Tappet assy and push rod

Check mainly for surface defect and wear. If the push rod outer surface is worn, replace the whole housing assy.



7.5 Governor

(1) Components



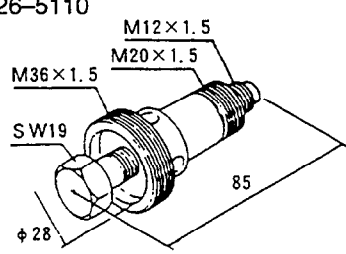
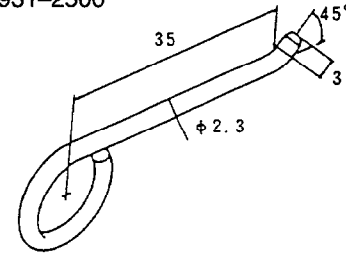
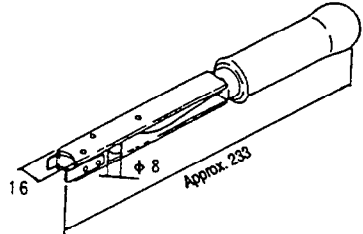
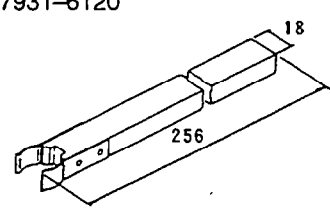
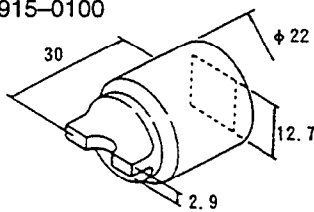
(2) Disassembly procedure (Reverse the procedure for assembly.)

- ① Follow steps ② and ③ in fuel injection pump disassembly procedure 7.2 (3.2).

(3) Parts inspection and measurement

Generally end disassembly in this stage and wash the parts for inspection.
See that each parts is not worn excessively or play.

7.6 Special Service Tools for Disassembly/Assembly

No.	Tool name	Application	Manufacturer's code and illustration
1	Extractor	Flyweight removal	157926-5110  <p>M12×1.5 M20×1.5 M36×1.5 SW19 85 φ 28</p>
2	Tappet holder	Tappet and cam contact separation	157931-2500  <p>35 45° 3 φ 2.3</p>
3	Tappet insert	Pushing tappet up	157921-0120  <p>16 φ 8 Approx. 233</p>
4	Clamp	Tappet removal	157931-6120  <p>18 256</p>
5	Wrench	Flyweight nut removal	157915-0100  <p>30 φ 22 12.7 2.9</p>

8. TURBOCHARGER (FOR 4TNE106T) 8-1~8-18

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8.1 Structure and Functions

(1) Structural and functional outline

(1.1) Turbine

The exhaust gas from the engine is accelerated at the nozzle portion in the turbine housing and blown onto the turbine impeller to rotate the turbine shaft.

This is called the turbine. A seal ring and heat insulating plate are installed to prevent the bearing from adverse influence of the gas.

(1.2) Compressor

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

This is called the blower or compressor.

(1.3) Bearings

- Thrust bearing:

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

- Radial bearing:

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

(1.4) Compressor side sealing mechanism

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

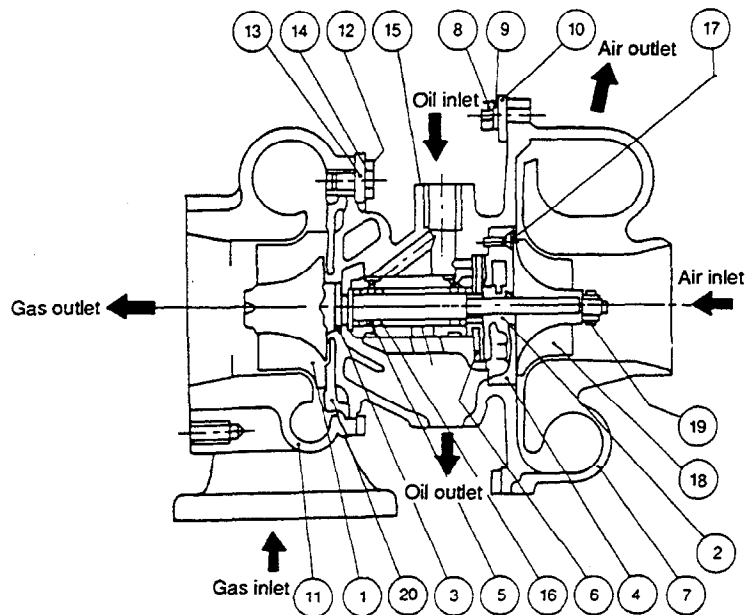
(1.5) Waste gate

When the blower side pressure (intake air pressure) exceeds the specified level, the exhaust gas at the turbine inlet is partially bypassed to the exhaust discharge side to control the turbine rpm so as to maintain the intake pressure at the specified level for improving the response to load variation in the low to medium speed range and to minimize black smoke generation.

It consists of a control assembly separated from the turbocharger and a valve assembly installed in the turbine impeller chamber.

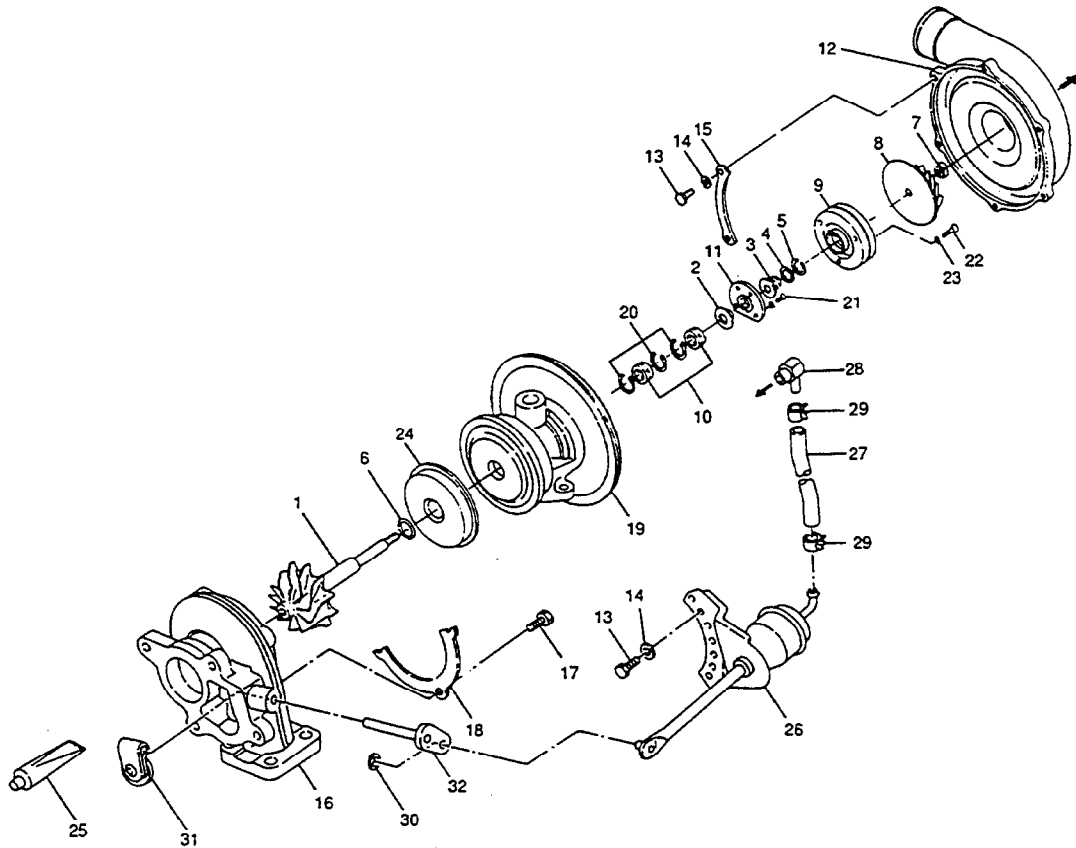
8. Turbocharger (for 4TNE106T)

(2) Structure



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

(3) Components

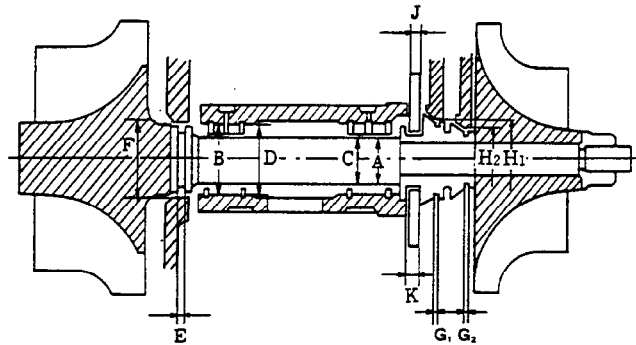


No.	Part name	No.	Part name
1	Turbine shaft	17	Bolt
2	Thrust bushing	18	Lock plate
3	Oil thrower	19	Bearing housing
4	Seal ring	20	Retaining ring
5	Seal ring	21	Screw
6	Seal ring (turbine side)	22	Screw
7	Lock nut	23	Lock washer
8	Impeller	24	Heat protector
9	Seal plate	25	Liquid gasket
10	Journal bearing	26	Waste gate actuator
11	Thrust bearing	27	Hose
12	Compressor housing	28	Adapter
13	Flanged bolt	29	Clip
14	Spring washer	30	Retaining ring
15	Clamp	31	Waste gate valve
16	Turbine housing	32	Link plate

8. Turbocharger (for 4TNE106T)

8.2 Service Standards

(1) Service standards



Unit ; mm

		Standard dimension	Wear limit
Turbine shaft	Turbine shaft journal outside diameter (A)	7.99 to 8.00	7.98
	Turbine shaft seal ring groove width (E)	1.25 to 1.28	1.29
	Compressor side seal ring groove width (G ₁)	1.22 to 1.23	1.31
	Compressor side seal ring groove width (G ₂)	1.02 to 1.03	1.11
	Turbine shaft runout	0.002	0.011
Bearing	Journal bearing inside diameter (C)	8.01 to 8.03	8.04
	Journal bearing outside diameter (D)	12.32 to 12.33	12.31
	Bearing housing inside diameter (B)	12.40 to 12.41	12.42
Thrust bearing	Thrust bearing width (J)	3.99 to 4.01	3.98
	Thrust bushing groove dimension (K)	4.04 to 4.05	4.07
Seal ring fixing area	Turbine side (bearing housing) (F)	15.00 to 15.02	15.05
	Compressor side (seal ring) (H ₁)	12.40 to 12.42	12.45
	Compressor side (seal ring) (H ₂)	10.00 to 10.02	10.05
Rotor play in axial direction		0.03 to 0.06	0.09
Rotor play in radial direction		0.08 to 0.13	0.17

(2) Tightening torque

Part	Thread diameter	Tightening torque	
		kgf·cm	N·m
Turbine housing set bolt	M8	285±10	28±1
Compressor housing set bolt	M5	48±5	4.7±0.5
Thrust bearing set screw	M3	13±1	1.3±0.1
Seal plate set screw	M3	13±1	1.3±0.1
Blower impeller set nut (left-handed screw)	M5	20±2	2.0±0.2

8.3 Periodic Inspection Procedure

(1) Periodic inspection intervals

Periodically inspect the turbocharger for the overall conditions and fouling.

The inspection interval varies with the operating conditions, but refer to the table below for the guideline for each application.

Application	Inspection interval		
For vehicles (automobiles)	Every 6 months or 60,000 km	Every 12 months or 150,000 km	Every 24 months or 300,000 km
For construction machinery	Every 6 months or 500 hours	Every 12 months or 1,000 hours	Every 24 months or 2,000 hours
For farming machinery	Every 6 months or 200 hours	Every 12 months or 400 hours	Every 24 months or 800 hours
For marine use	Every 6 months or 1,500 hours	Every 12 months or 3,000 hours	Every 24 months or 6,000 hours
Inspection item			
Rotor rotation	○		
Rotor play		○	
Overhaul and overall inspection			○
Oil filter cleaning and inspection	Shall conform to engine manufacturer's manual.		
Engine oil replacement			

(2) Inspection procedure

(2.1) Rotor rotation

Inspect the rotor rotation by listening to any abnormal sound generation during rotation.

For inspection with a sound detecting bar, bring the tip end of the bar into strong contact with the turbocharger case and raise the engine speed gradually.

If any high pitch sound is generated at intervals of 2 to 3 seconds, the rotation is abnormal. Since the bearing or rotor may be defective in this state, either replace or overhaul the turbocharger.

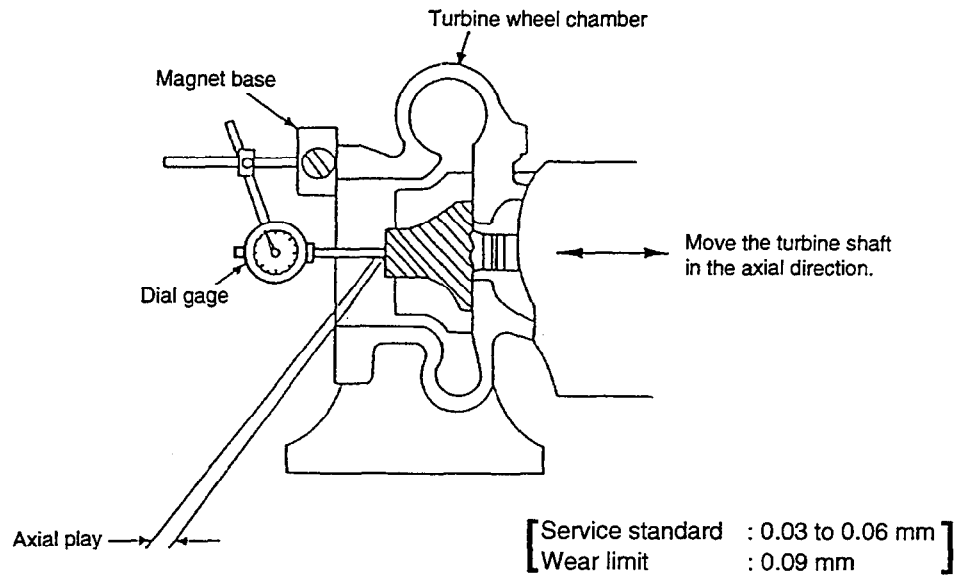
(2.2) Rotor play inspection

Remove the turbocharger from the engine and inspect the rotor play in the axial and radial directions according to the procedure below.

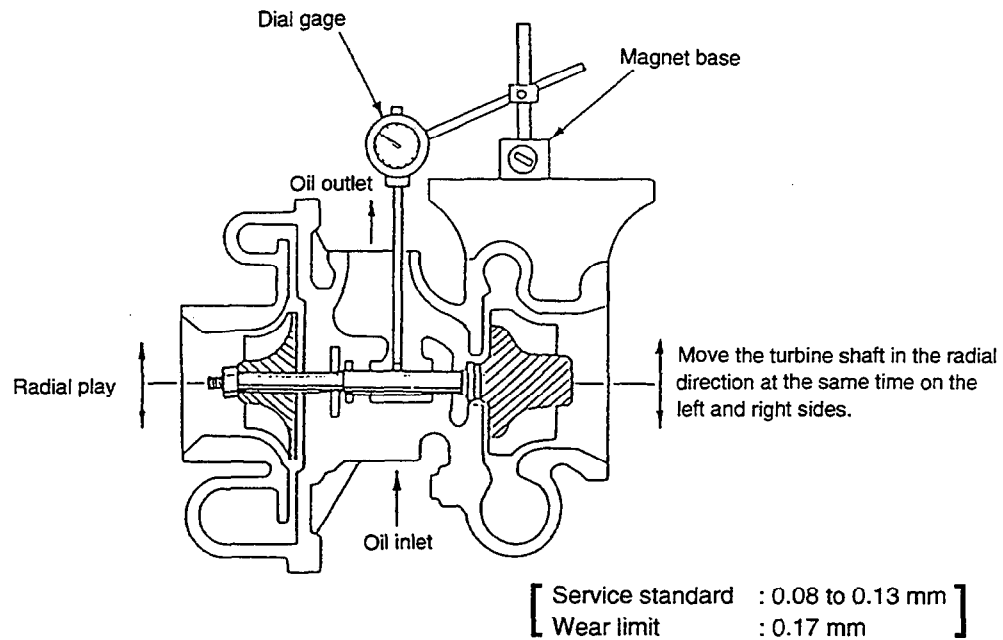
After removing the turbocharger from the engine, always blind the oil inlet and outlet holes with adhesive tape.

8. Turbocharger (for 4TNE106T)

- Rotor play in axial direction



- Rotor play in radial direction



(3) Waste gate valve adjustment procedure

It is indispensable to adjust the waste gate valve opening pressure and lift after its overhaul or inner parts replacement.

Negligence of this adjustment will adversely affect the engine performance.

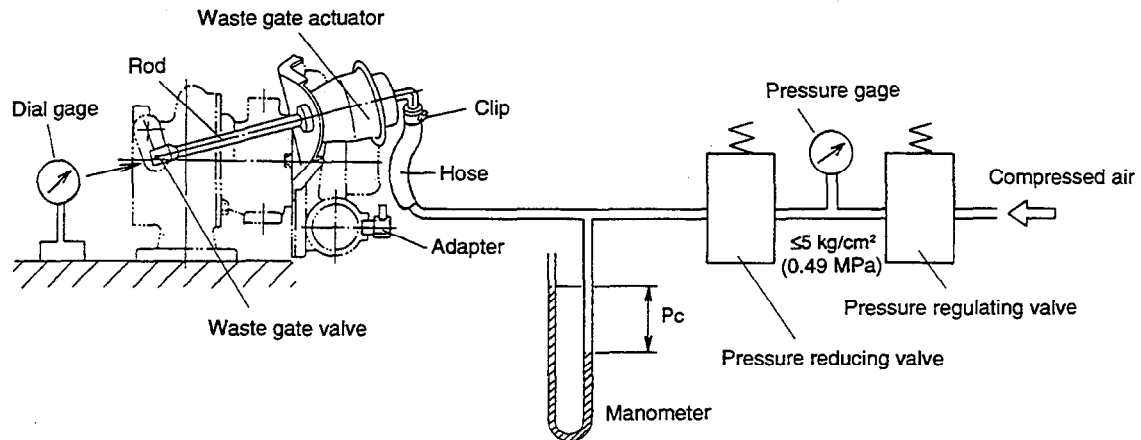
[NOTICE]

If the adjustment is impossible, give up overhaul but replace the whole turbocharger assembly.

(3.1) Method for checking the waste gate valve opening pressure and lift

- ① Equipment
Prepare the equipment shown in the figure below.
- ② Measuring instruments and devices

Dial gage	Capable of measuring 0 to 10 mm (A flat head type is recommendable.)
Manometer	Mercury column or electrical type (capable of measuring 0 to 1500 mmHg)
Pressure regulating valve	Allowing gradual adjustment in a range between 0 and 2 kgf/cm ² (0.196 Mpa)
Pressure reducing valve	Used for suppressing the air supply pressure at 5 kgf/cm ² (0.49 Mpa) or less.
Pressure gage	Bourdon tube pressure gage (0 to 10 kgf/cm ² (0.98 Mpa))



[Note] P_c (controller pressure) varies with the set output in a range between 600 and 750 mmHg.

- ③ Check method
 - a. Set the manometer control pressure (P_c) applied to the waste gate actuator to 0 and set the dial gage to the zero point.
 - b. Gradually open the pressure regulating valve and measure the P_c value when the actuator rod is operated by 2 mm.
 - c. For the hysteresis, let the rod move to 3 mm first. The gradually close the pressure regulating valve, measure the pressure when the rod is moved to 2 mm and obtain the difference from the pressure measured in b. above.
- ④ Precautions
 - Set the dial gage on the extension line of the actuator rod.
 - The piping and joints shall completely be free from leak.
 - Fix the turbocharger and dial gage securely.
 - If an electric manometer is used, it shall have sufficient precision.
 - Even when an electric manometer is used, use of a mercury column type manometer in combination is recommended for calibration and daily check.
 - The speed for increasing/decreasing P_c by means of the pressure regulating valve shall be very slow near the measuring point. If the 2 mm position is exceeded, restart from the beginning.
 - Do not apply over 5 kgf/cm² (0.49 MPa) to the actuator.

(3.2) Waste gate actuator leak test

Apply 1.2 kgf/cm² (0.12 Mpa) to the actuator and hold the state for 1 minute. The actuator is good if the pressure then is 1.1 kgf/cm² (0.11 MPa) or above.

8. Turbocharger (for 4TNE106T)

8.4 Disassembly Procedure

(1) Preparation for disassembly

In addition to the general tools, the following special tools are required for turbocharger disassembly and reassembly:

Tool name	Use	Illustration
Bar	For removing thrust bearing and thrust bushing	<p>mm (in.) 75 (2.9527) ø7.5 (0.2952) Material : Copper or brass</p>
Pliers	For removing floating bearing circlip	
Pliers	For removing seal ring	
Torque driver for TORX bolt (multi-functional type) 5 to 50 kgf-cm (0.5 to 4.9N-m)	For thrust bearing installation (for M3): 13 kgf-cm (1.3N-m) For seal plate installation (for M3): 13 kgf-cm (1.3 N-m)	<p>Item sold on market (Type : TORX TT20 or equivalent)</p>
Box wrench	For fixing turbine shaft (10 mm x dodecagonal)	<p>Box only may be used.</p>
Torque wrench (single purpose)	For following bolts and nuts: M8 : 13 mm, 285 kgf-cm (28 N-m) M5 : 8 mm, 48 kgf-cm (4.7 N-m) M5 : 8 mm, 20 kgf-cm (2.0 N-m)	
Probe	For measuring play in axial and radial directions	<p>To be installed on a dial gage</p> <p>mm (in.) To be knurled here R10 (0.3937) ø5 (0.1968) 7 (0.2755) R5 (0.1968) M2.6 P0.45 8 (0.3149) 40 (1.5748) 10 (0.3937) 15 (0.5905) Mount to dial gage</p>

(2) Inspection before disassembly

(2.1) Inspect the turbine wheel and compressor impeller for any undesirable contact and the rotor for smooth rotation.

(2.2) Measure the rotor play as described in section 8.3 (2.2).

- Rotor axial play Wear limit : 0.09 mm
- Rotor radial play Wear limit : 0.17 mm

(3) Disassembly

The mounting angles of the turbine housing, bearing housing and compressor housing are determined according to its mounting state on the engine. Put match marks before starting disassembly.

Note) The number after each part is the one described in the structural drawing in 8.1 (2).

(3.1) Compressor housing removal

- ① Remove flanged hexagon bolt 8 and compressor side keep plate 10.
- ② Remove compressor housing 7.

Note-1) Liquid gasket is applied on the surface of compressor housing 7 where bearing housing 15 is mounted.

Note-2) When disassembling compressor housing 7, carefully operate so as not to damage the compressor impeller.

(3.2) Compressor impeller removal

- ① Set a box spanner (10 mm) on the turbine side end of the turbine shaft, and remove shaft end clamp 18.

Note) Pay attention to the loosening direction since the shaft end nut has left-handed screw.

- ② Remove compressor impeller 18.

(3.3) Turbine housing removal

- ① Remove hexagon nut 12 and turbine side keep plate 13.
- ② Remove turbine housing 11.

(3.4) Turbine shaft extraction

- ① Hold heat insulating plate 20 lightly with a hand, and extract turbine shaft 1.

Note) If the turbine shaft is hard to be extracted, tap the compressor side end of the shaft lightly with a wooden hammer.

- ② Remove heat insulating plate 20.

(3.5) Seal plate removal

- ① Use the Torx driver and loosen M3 Torx T-type machine screw 17 for seal plate mounting.
- ② Remove seal plate 4.

Note) Liquid gasket has been applied to the seal plate and bearing housing mounting surface.

- ③ Remove oil thrower 2 from the seal plate.

8. Turbocharger (for 4TNE106T)

(3.6) Slide bearing and thrust bushing removal

- ① Use the Torx driver and loosen the M3 Torx T-type machine screw for thrust bearing installation.
- ② Use the bar (copper) and remove thrust bearing 6 and thrust bushing.

(3.7) Floating bearing removal

- ① Use the stop ring pliers and remove circlip 16 from bearing housing 15.
- ② Remove floating bearing 5 from bearing housing 15.

(3-8) Seal ring removal

- ① Remove turbine side seal ring 3 from turbine shaft 1.
- ② Remove compressor side seal ring (small) and compressor side seal ring (large) from oil thrower 2.

8.5 Washing and Inspection procedure

(1) Washing

(1.1) Inspection before washing

Visually inspect each part before washing to check trace of seizure, wear, foreign matter or carbon adhesion.

Carefully inspect for identifying the cause of trouble especially when a fault has occurred.

<Major inspection items>

Check point	Checking position
Carbon adhesion state	1) Turbine shaft 1, turbine side seal ring and rear side of turbine wheel 2) Heat insulating plate 20 mounting portion and inside of bearing housing 15
Lubrication status (wear, seizure, discoloration, etc.)	1) Turbine shaft 1, journal portion and thrust bushing oil thrower 2 2) Floating bearing 5 and thrust bearing 6 3) Bearing housing 15 and inner wall of bearing fitting ring
Oil leak state	1) Inner wall of turbine housing 11 2) Outer surface of bearing housing 11 and heat insulating plate 20 mounting portion 3) Turbine shaft 1 turbine side seal ring portion and rear side of turbine wheel 4) Inner wall of compressor housing 7 5) rear side of compressor impeller 18 6) Surface and seal ring inserting portion of seal plate 4

(1.2) Washing procedure

Keep the following in mind when washing the parts.

Part	Tools and detergent	Procedure
(1) Turbine shaft	1. Tools 1) Bucket (500 × 500) 2) Heat source: Steam or gas burner 3) Brush 2. Detergent Standard carbon removing agent	1) Boil the turbine in the washing bucket. Do not strike the blade to remove the carbon. 2) Immerse in the detergent until the carbon and other deposits are softened. 3) Use a plastic scraper or hard hair scrubber to remove the softened deposits. 4) Protect the bearing surface and seal ring groove on the turbine shaft so as not to be damaged. 5) Any deposit remaining on the turbine shaft due to improper washing may cause unbalancing. Be sure to remove thoroughly. Never use a wire brush.
(2) Turbine wheel chamber	1. Tools Same as for turbine shaft 2. Detergent Same as for turbine shaft	1) Boil the turbine in the washing bucket. 2) Immerse in the detergent until the carbon and other deposits are softened. 3) Use a plastic scraper or hard hair scrubber to remove the softened deposits.
(3) Blower blade and chamber	1. Tools 1) Bucket (500 × 500) 2) Brush 2. Detergent	1) Immerse in the washing bucket until the deposit is softened. 2) Use a plastic scraper or hard hair scrubber to remove the softened deposits. Never use a wire brush.
(4) Others	(1) Wash all other parts with diesel oil. (2) Clean the lubricating oil path by blowing with compressed air. (3) Be especially careful so as not to damage or corrode the parts.	

(2) Inspection procedure

(2.1) Compressor housing 7

Inspect the compressor housing for any contact trace with the compressor impeller, surface defect, dent or crack at joint surface, and replace it if defective.

(2.2) Turbine housing 11

Inspect any trace of contact with the turbine wheel, exfoliation due to degradation by oxidation of the cast surface, thermal deformation or crack.

Replace with a new one if defective.

(2.3) Compressor impeller 18

Inspect any contact trace, chipping, corrosion or deformation.

Replace with a new one if defective.

8. Turbocharger (for 4TNE106T)

(2.4) Turbine shaft 1

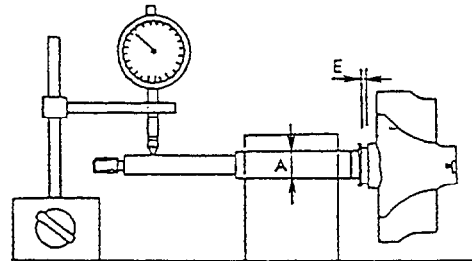
- ① Inspect any contact trace, chipping, thermal discoloration or deformation at the turbine wheel. Check the shaft portion for bend, the journal portion for thermal discoloration or abnormal wear, and the seal ring groove for surface defect or wear. Replace with a new one if defective.
- ② Measure the turbine shaft journal outside diameter (A) and seal ring groove width (E). Replace with a new turbine shaft if beyond the wear limit.

Journal outside diameter (A)

Wear limit : 7.98 mm

Ring groove width (E)

Wear limit : 1.29 mm



V block

- ③ Measure the turbine shaft run-out, and replace with a new turbine shaft if it exceeds 0.011 mm.

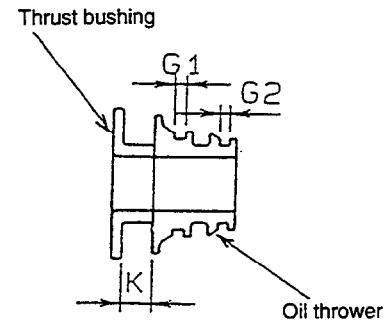
(2.5) Heat insulating plate 20

Inspect the heat insulating plate for any contact trace, thermal deformation or corrosion. Replace with a new one if defective.

(2.6) Thrust bushing, oil thrower 2 and thrust bearing 6

Inspect each part for wear, surface defect and discoloration. Replace with a new one if defective even within the wear limit.

- ① Thrust bushing
Measure the distance between grooves (K) of the thrust bushing, and replace with a new one if the wear limit is exceeded.
Wear limit : 4.07 mm
- ② Oil thrower 2
Measure the seal ring groove widths (G1) and (G2), and replace with a new one if the wear limit is exceeded.
Wear limits : G1: 1.31 mm, G2: 1.11 mm
- ③ Thrust bearing 6
Measure the thrust bearing width (J), and replace with a new one if the wear limit is exceeded.
Wear limit : 3.98 mm



(2.7) Floating bearing 5

- ① Inspect the floating bearing for abnormal wear, discoloration or surface defect. Replace with a new one if defective.
- ② Measure the inside diameter (C) and outside diameter (D). Replace the bearing if either wear limit is exceeded.
Wear limits:

Outside diameter (D): 12.31 mm Inside diameter (C): 8.04 mm

(2.8) Bearing housing 15

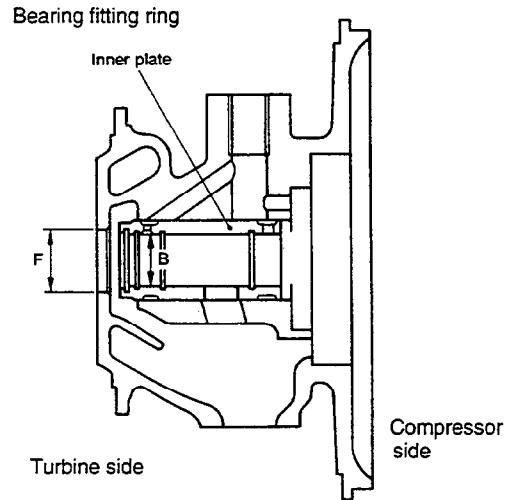
- ① Inspect the housing for cast surface exfoliation due to oxidation and degradation, dent or crack.
Replace with a new one if defective.
- ② Inspect circlip 16 for chipping or crack, and replace with a new one if defective.
- ③ Measure the (B) and (F) portions of the bearing housing shown in the figure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

Bearing housing inside diameter (B)

Wear limit : 12.42 mm

Turbine side seal ring inserting portion (F)

Wear limit : 15.05 mm

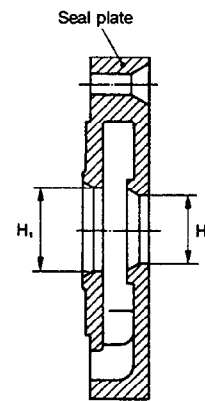


(2.9) Seal plate 4

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

Wear limits : H1 : 12.45 mm

H2 : 10.05 mm



(2.10) Seal rings

Replace seal rings with new ones.

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

8.6 Reassembly Procedure

(1) Preparation for reassembly

- ① Prepare general tools, special tools, liquid gasket (Three Bond No.1207) and Loctite No.242 before reassembling the turbocharger.
- ② Always replace the following parts with new ones:
 - Turbine side seal ring 1 pc.
 - Compressor side seal ring (large) 1 pc.
 - Compressor side seal ring (small) 1 pc.
 - M3 machine screws 3 pcs.
 - M3 machine screws 4 pcs.

(2) Reassembly

(2.1) Floating bearing installation

- ① Use the snap ring pliers and install inner circlip 16 on bearing housing 15.
- ② Install floating bearing 5 in bearing housing 15.
- ③ Use the snap ring pliers and install outer circlip 16 on bearing housing 15.

Note-1) The circlip joint shall be positioned as shown in the figure at right above.

The rounded side of the circlip shall face the bearing.

Note-2) Apply lubricating oil on the floating bearing before reassembly.

(2.2) Turbine shaft installation

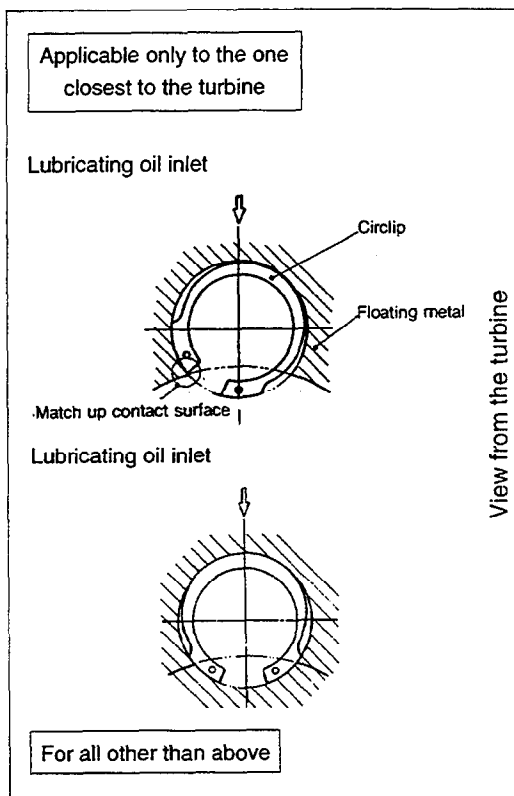
- ① Fit the seal ring onto turbine shaft 1.
- ② Install heat insulating plate 20 on the turbine side of bearing housing 15.
- ③ Apply lubricating oil on the journal portion of the turbine shaft and insert the shaft from the turbine side of bearing housing 15.

Note) Carefully operate so as not to damage the floating bearing by the turbine shaft. The seal ring joint shall be positioned on the lubricating oil inlet side after centering with the turbine shaft.

(2.3) Thrust bearing installation

- ① Fit thrust bushing on turbine shaft 1.
- ② Apply lubricating oil on the bearing portion of thrust bearing 6 and install it in bearing housing 15.
- ③ Apply Loctite on the threaded portion of M3 Torx T machine screw 17 for thrust bearing installation, and use Torx torque driver for installation by tightening to the specified torque.

Tightening torque: 13 ±1 kgf-cm (1.3 ± 0.1 N-m)



(2.4) Seal plate installation

- ① Fit the seal ring on oil thrower 2.
- ② Insert oil thrower 2 into seal plate 4.

Note) The seal ring joint portion shall be positioned as illustrated above.

- ③ Apply liquid gasket (Three Bond No. 1207) on the seal plate mounting surface on the compressor side of bearing housing 15.

Note) See the illustration at right for the applying position.

Applying thickness : 0.1 to 0.2 mm

- ④ Install seal plate 4 on bearing housing 15.
- ⑤ Apply Locktite on the threaded portion of M3 machine screw for seal plate mounting, and tighten it with a torque screwdriver.

Tightening torque:
13±1 kgf-cm (1.3±0.1 N-m)

(2.5) Compressor impeller installation

- ① Fit compressor impeller 18 onto turbine shaft 1.
- ② Set a box spanner (10 mm) on the turbine side end of turbine shaft 1, and tighten shaft end nut 19.

Note) Since the shaft end nut has left-handed screw, pay attention to the tightening direction.

Tightening torque: 20±2 kgf-cm (2.0±0.2 N-m)

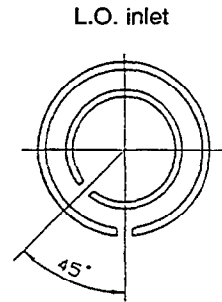
(2.6) Turbine housing installation

- ① Install bearing housing 15 on turbine housing 11 by aligning the match marks put before disassembly.

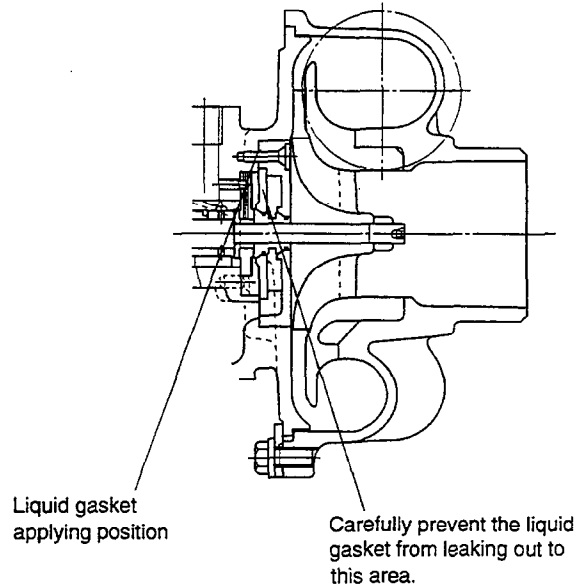
Note) In case of part replacement, check the oil inlet and outlet positions and the exhaust gas inlet position before reassembly.

- ② Install the turbine side keep plate and tighten M8 hexagon bolt 12.

Tightening torque: 285±10 kgf-cm (28±1 N-m)



View from the compressor



8. Turbocharger (for 4TNE106T)

(2.7) Compressor housing installation

- ① Apply liquid gasket (Three Bond No. 1207) on the compressor side flange of bearing housing 15.

Note See section (2.4) ③ for the portion to be applied.

Applying thickness : 0.1 to 0.2 mm

- ② Install compressor side keep plate 10, and tighten M8 hexagon bolt 8.
Tightening torque : 48 ± 5 kgf-cm (4.7 ± 0.5 N-m)

(2.8) Rotor play measurement

See the inspection procedure in section 8.3 (2.2) for the measurement method.

If the rotor play does not satisfy the standard, reassembly is necessary since assembly error or use of a wrong part is conceivable.

- ① Rotor play in axial direction
Service standard : 0.03 to 0.06 mm
- ② Rotor play in radial direction
Service standard : 0.08 to 0.13 mm

8.7 Handling after Disassembly and Reassembly

When installing the turbocharger on the engine or handling the turbocharger after installation, strictly observe the instructions given below.

Especially pay careful attention for preventing foreign matter entrance into the turbocharger.

(1) Instructions for turbocharger installation

<Lubrication system>

- ① Pour new lubricating oil through the oil filler port before installation on the engine, and manually turn the turbine shaft to lubricate the floating and thrust bearings.
- ② Flush the oil inlet pipe from the engine and outlet pipe, and check no crushed pipe nor dirt or foreign matter remaining in the pipes.
- ③ Connect the pipes securely so as to ensure no oil leak from joints.

<Intake system>

- ① Check no foreign matter or dirt in the intake line.
- ② Connect securely to prevent any air leak from joints with the intake duct and air cleaner.

<Exhaust system>

- ① Check no dirt or foreign matter in the exhaust system.
- ② Since heat resistant steel is used for the bolts and nuts, do not use general bolts and nuts for installation. Always apply anti-seizure agent on fastening bolts and nuts to be tightened.
(Use heat-resistant hexagon bolts for the turbine housing.)
- ③ Connect exhaust pipes securely to prevent gas leak from each pipe joint.

8.8 Troubleshooting

Sufficient turbocharger performance and required engine output cannot be obtained if there is any fault. In such a case, first check each engine part to see there is no engine fault. Then inspect the turbocharger for troubleshooting according to the procedure shown below.

(1) Excessively exhaust smoke

<Insufficient intake air volume>

Cause	Corrective action
1) Clogged air cleaner element	• Replace or wash the element.
2) Blocked air intake port	• Correct to the normal state.
3) Leak from a joint in intake line	• Inspect and repair.

<Turbocharger revolution failure>

Cause	Corrective action
1) Deposit of impurities in oil sticking on the turbine side seal portion to make turbine revolution heavy	• Turbocharger overhaul (disassembly and washing) with lubricating oil replacement
2) Sticking bearing <ul style="list-style-type: none"> • Insufficient lubrication or clogged lubrication piping • Excessively high oil temperature • Unbalanced rotating part • Insufficient warming up or sudden stop from loaded operation (no-load operation) 	<ul style="list-style-type: none"> • Turbocharger overhaul (disassembly and repair) • Lubricating oil line inspection, repair of defective portion and lubricating oil replacement • Rotating part replacement or washing • Strict observance of instructions in operation manual
3) Contact or breakdown of turbine wheel or blower vane <ul style="list-style-type: none"> • Excessive revolution • Excessive exhaust temperature rise • Foreign matter invasion • Worn bearing • Assembly defect 	<ul style="list-style-type: none"> • Inspection and repair of each engine part • Perfect foreign matter elimination in disassembled state, followed by inspection and repair of individual air cleaner and engine components • Turbocharger overhaul (disassembly and repair) • Reassembly

<Influence of exhaust resistance>

Cause	Corrective action
1) Exhaust gas leak before the turbocharger to decrease its revolutions	• Joint inspection and correction
2) Deformed or clogged exhaust pipe to decrease turbocharger revolutions	• Correct to the normal state.

(2) White smoke generation

Cause	Corrective action
1) Clogged or deformed oil return pipe causing oil flow to the blower or turbine side	• Repair or pipe replacement
2) Excessive bearing wear causing abnormal wear or damage of seal ring	• Turbocharger disassembly and repair

8. Turbocharger (for 4TNE106T)

(3) Sudden oil decrease

Cause	Corrective action
1) Excessive bearing wear causing abnormal wear or damage of seal ring	<ul style="list-style-type: none"> • Turbocharger disassembly and repair

(4) Decrease in output

Cause	Corrective action
1) Gas leak from any part in exhaust piping	<ul style="list-style-type: none"> • Inspection and repair of defective portion • Element cleaning or replacement • Turbocharger disassembly and repair or replacement
2) Air leak from discharge side of blower	
3) Clogged air cleaner element	
4) Fouled or damaged turbocharger	

(5) Poor (slow) response (starting) of turbocharger

Cause	Corrective action
1) Hard carbon deposit on the turbine side (wheel sealing portion) to make turbine shaft revolution heavy	<ul style="list-style-type: none"> • Turbocharger disassembly and washing with lubricating oil replacement • Engine combustion state inspection, followed by improvement of combustion to normal state
2) Incomplete combustion	

(6) Abnormal sound or vibration

<Abnormal sound generation>

Cause	Corrective action
1) Excessively narrowed gas path due to clogged nozzle in turbine wheel chamber or reverse flow of blower discharge in acceleration (generally called surging)	<ul style="list-style-type: none"> • Turbocharger disassembly and washing • Turbocharger disassembly and repair or replacement
2) Contact rotating part	

<Vibration>

Cause	Corrective action
1) Loosened intake, exhaust or oil pipe connection with the turbocharger	<ul style="list-style-type: none"> • Turbocharger installation status check and repair of defective portion • Turbocharger disassembly with repair or replacement, or perfect removal of foreign matters in case of foreign matter invasion • Repair or replacement of rotating part
2) Damaged bearing, contact between rotating part and adjacent part, or chipping of turbine wheel or blower vane due to foreign matter invasion	
3) Unbalanced rotating part	

9. STARTING MOTOR 9-1~9-29

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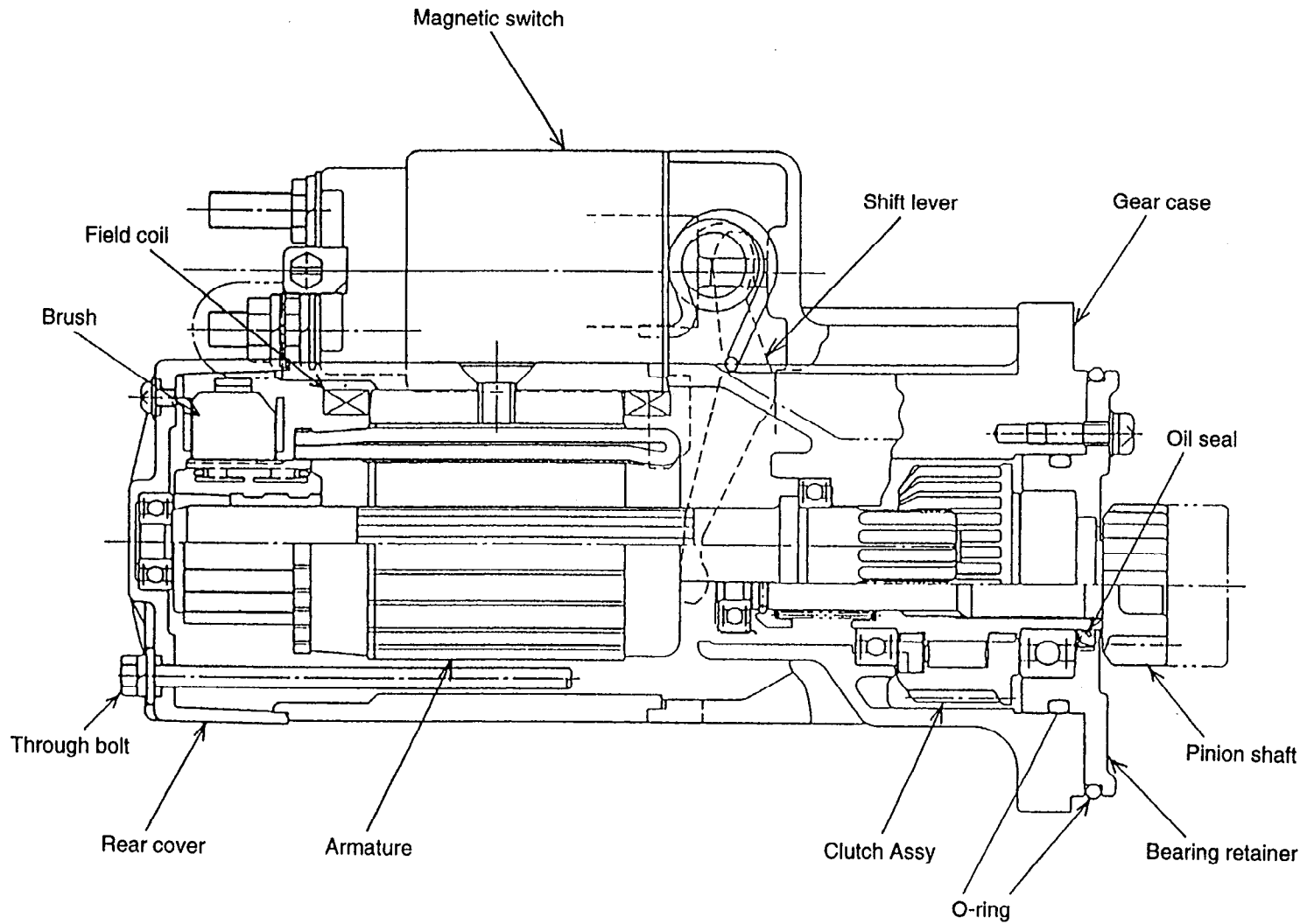
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9.1 For 4TNE94/98

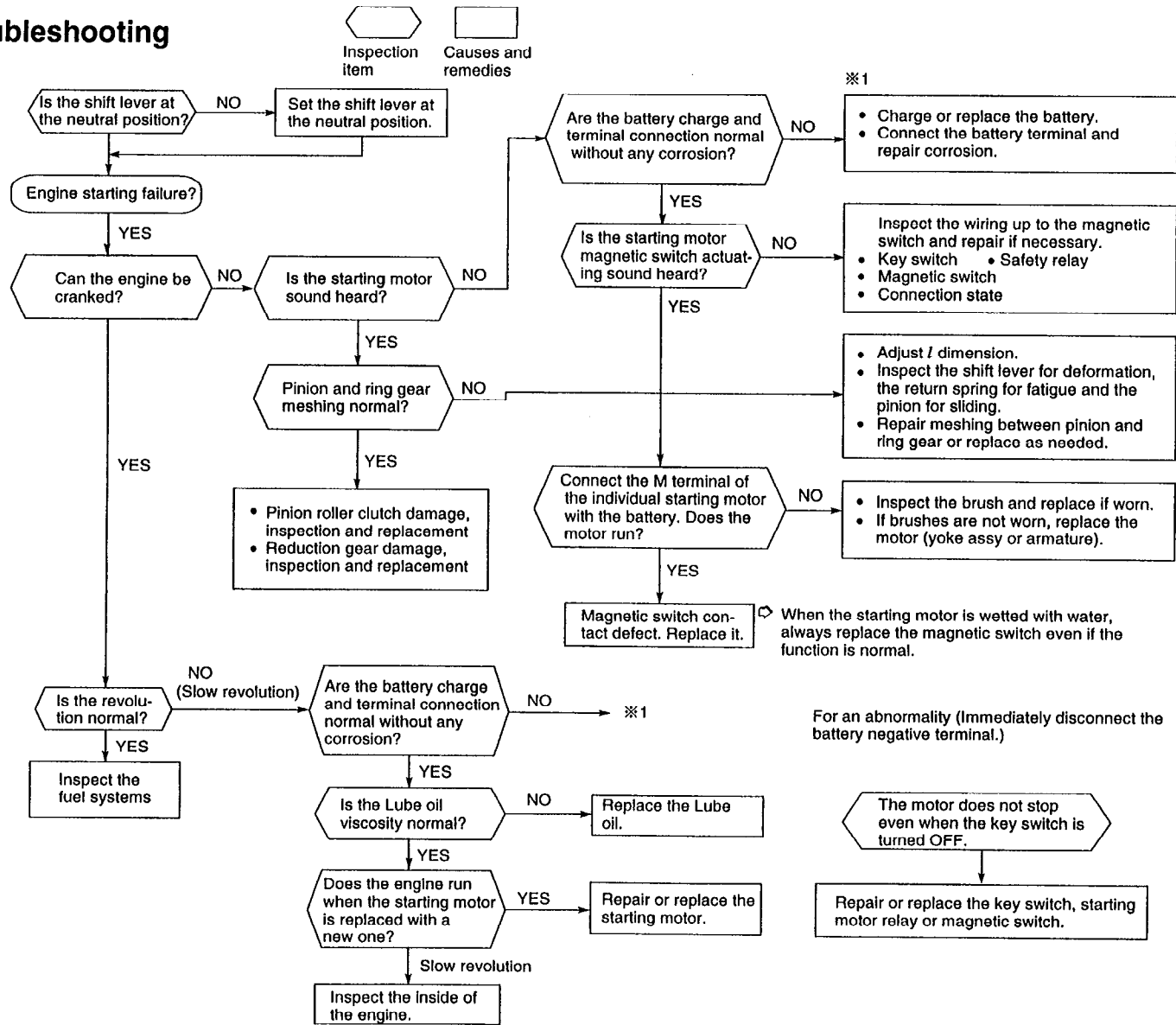
9.1.1 Specifications

Manufacturer's model (Hitachi)		—	S13-204	S13-205
Yanmar code		—	129900-77010	129900-77020
Nominal output		kW	2.3	2.3
Weight		kg	5.5	5.5
Revolution direction (as viewed from pinion)		—	Clockwise	Clockwise
Engagement system		—	Magnetic shift	Magnetic shift
No-load	Terminal voltage/current	V/A	11/140 or less	11/140 or less
	Revolution	rpm	4100 or above	4100 or above
Loaded	Terminal voltage/current	V/A	2.5/1050 or less	2.5/1050 or less
	Torque	Nm(kgf•m)	24.5 (2.5) or above	
Clutch system		—	Overrunning	Overrunning
Pinion projection voltage (at 100°C)		V	8.6 or less	8.6 or less
Pinion DP or module/number of teeth		—	M3/9	M3/9
Difference (O-ring, oil seal)		—	Dry (none)	Wet (provided)
Application		—	Standard	Option

9.1.2 Components



9.1.3 Troubleshooting



9. Starting Motor

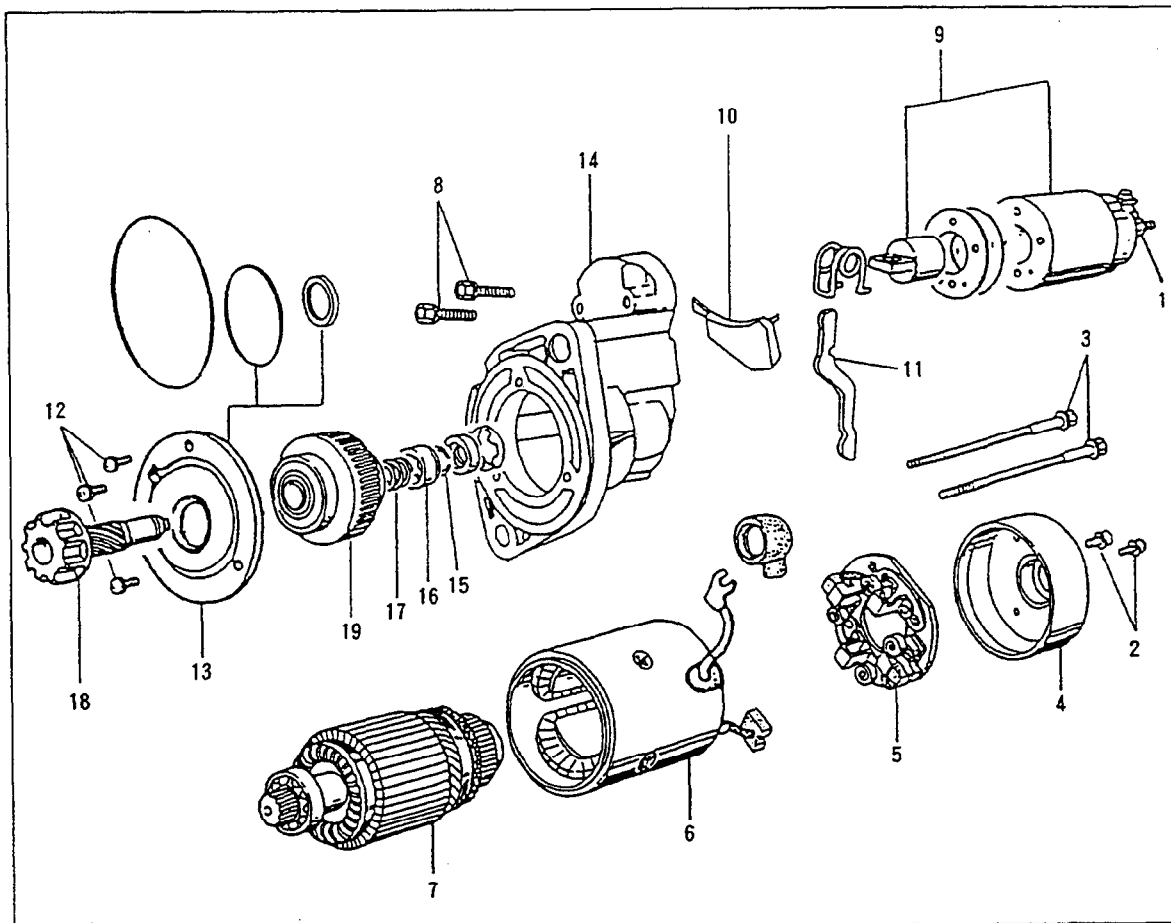
9.1.4 Names of parts and disassembly procedure

Disassembling order

- | | |
|---|--------------------------|
| ▲ (1) Nut M8
(Disconnect the connecting wire.) | (10) Dust cover |
| (2) Screw M4 (2) | (11) Shift lever |
| (3) Through bolt M5 (2) | (12) Screw M4 (3) |
| (4) Rear cover | (13) Bearing retainer |
| (5) Brush holder | (14) Gear case |
| (6) Yoke assy | (15) Pinion stopper clip |
| (7) Armature | (16) Pinion stopper |
| (8) Bolt M6 (2) | (17) Return spring |
| (9) Magnetic switch | (18) Pinion shaft |
| | (19) Clutch assy |

▲: See the disassembly drawing.

Disassembly drawing



Disassembly procedure

1) Nut M8

Remove the magnetic switch nut M8 (12 mm), and disconnect the connecting wire.

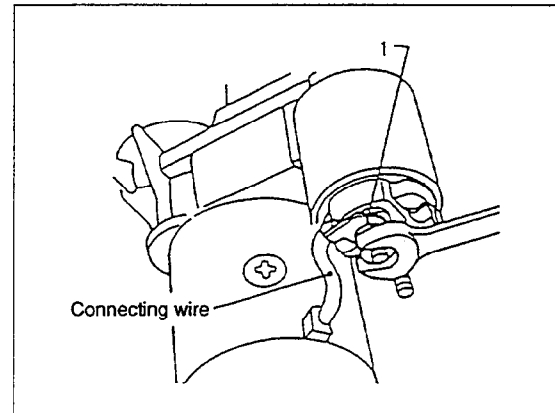


Fig. 1

2) Screw M4 (2)

3) Through bolt M5 (2)

4) Rear cover

Remove the M4 screw fastening the brush holder and remove through bolt M5 for rear cover removal.

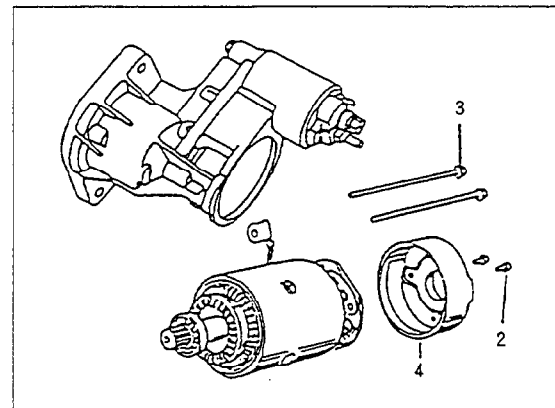


Fig. 2

5) Brush holder

Pull the brush spring up with the brush spring puller. On the negative (-) side, bring the brush spring into contact with the side of the brush for lifting from the commutator surface. On the positive (+) side, extract the brush from the brush holder.

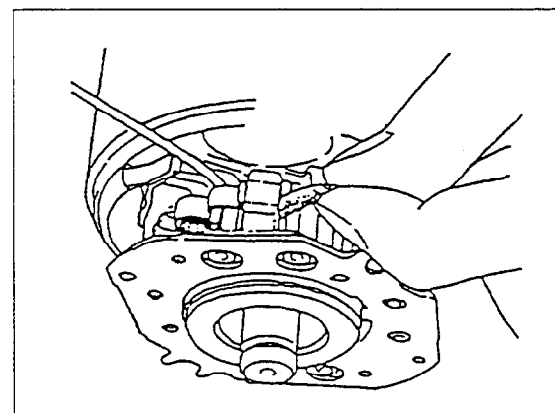


Fig. 3

9. Starting Motor

6) Yoke Assy

7) Armature

Remove the brush holder. The armature and yoke assy can now be removed.

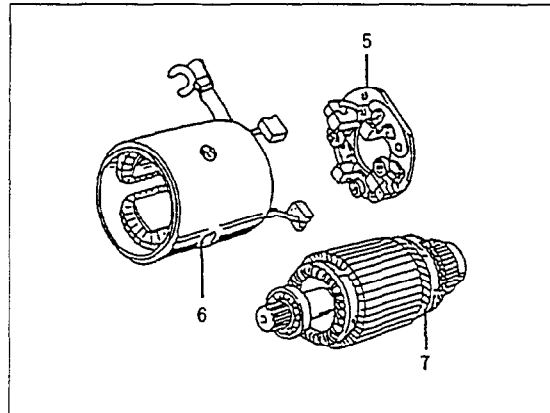


Fig. 4

8) Bolt M6 (2)

9) Magnetic switch

Remove bolt M6 (10 mm), and the magnetic switch can be removed.

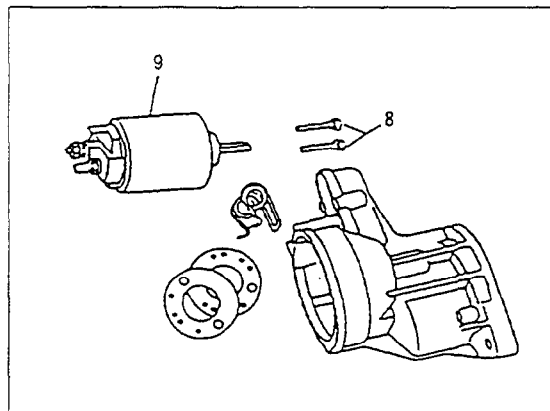


Fig. 5

10) Dust cover

11) Shift lever

Take the dust cover out from the gear case. The shift lever can be removed.

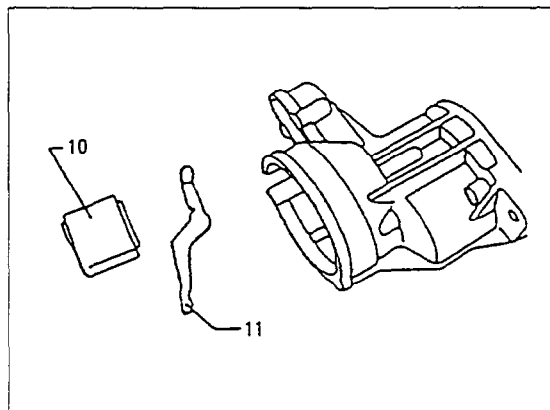


Fig. 6

- 12) Screw M4 (3)
- 13) Bearing retainer
- 14) Gear case

Remove screw M4, and the bearing retainer and clutch assy can be removed.

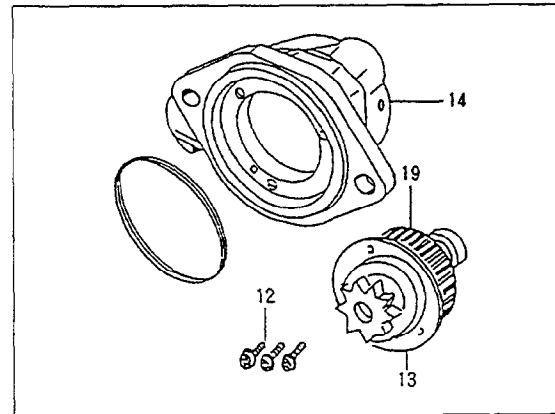


Fig. 7

- 15) Pinion stopper clip

Remove the bearing retainer at the edge and the bearing, and shift the pinion stopper toward the pinion. Use a plain screwdriver and pry to remove the pinion stopper clip.

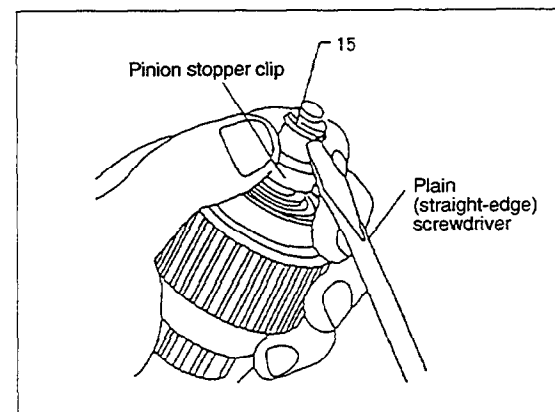


Fig. 8

- 16) Pinion stopper
- 17) Return spring
- 18) Pinion shaft
- 19) Clutch Assy

Remove the pinion stopper clip. The pinion stopper, return spring, pinion shaft and bearing retainer can be removed. Disassembly is completed now.

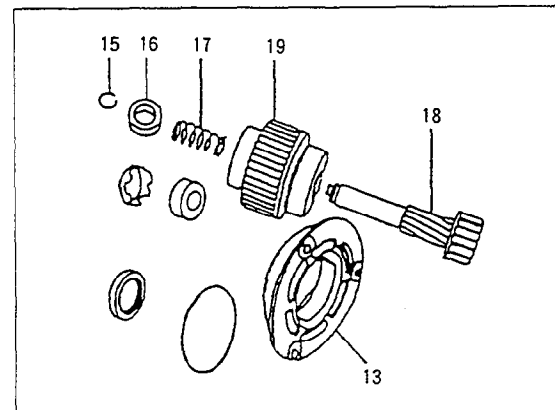


Fig. 9

9. Starting Motor

9.1.5 Inspection and Maintenance

(1) Armature

(a) Commutator outside diameter

Measure the commutator outside diameter and replace the commutator if the measured value is less than the limit.

(mm)

Standard	Limit
36.5	35.5

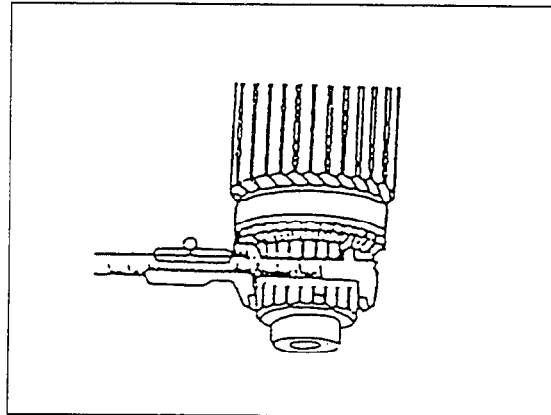


Fig. 10

(b) Armature coil continuity test

Check continuity between commutator segments with a multimeter. Good if continuity exists.

No continuity

(Coil disconnection)
Replace the armature.

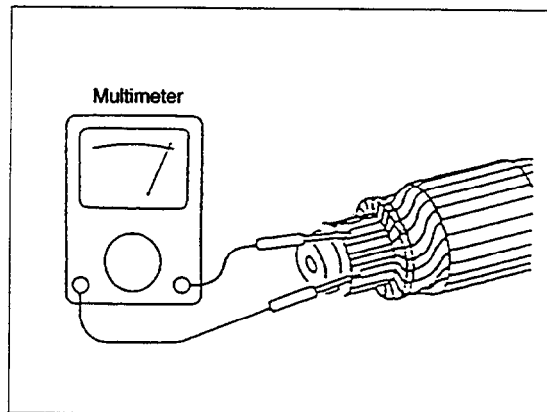


Fig. 11

(c) Armature coil insulation test

Inspect the continuity between a commutator segment and the shaft or core with a multimeter. Good if no continuity exists.

Continuity exists

(Coil short circuit)
Replace the armature.

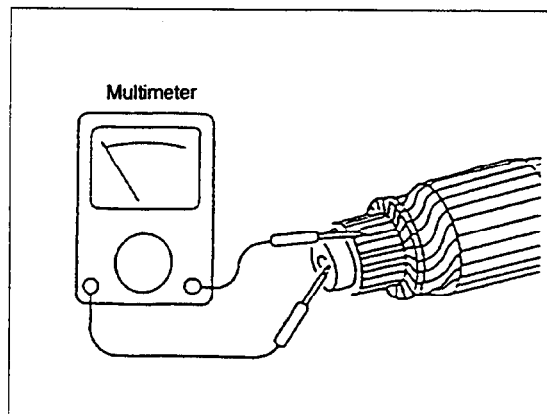


Fig. 12

(d) Armature and commutator runout

Use a dial gage and measure the armature core runout and commutator runout. Correct or replace if the limit is exceeded.

(mm)

	Standard	Limit
Armature	0.03	0.2
Commutator	0.03	0.2

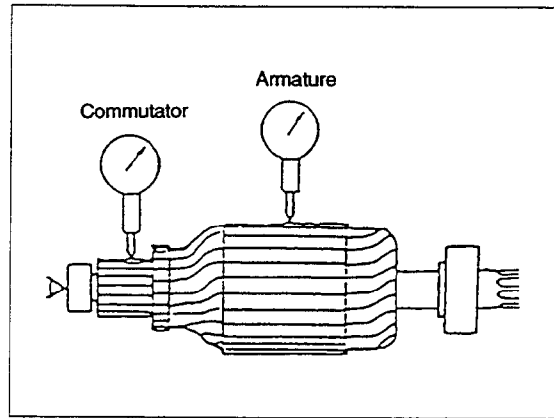


Fig. 13

(e) Commutator surface inspection

If the commutator surface is roughened, grind with #500 to #600 emery cloth.

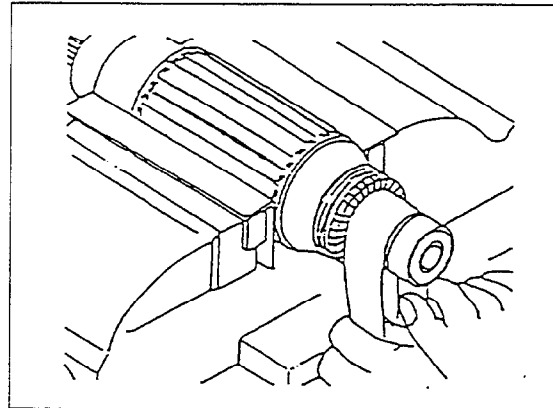


Fig. 14

(f) Commutator insulation depth

Measure the depth of the insulating material between commutator segments, and correct it if it is less than the limit.

(mm)

Standard	Limit
0.5~0.8	0.2

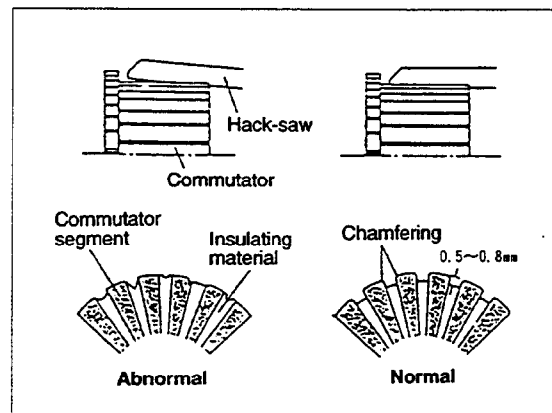


Fig. 15

9. Starting Motor

(2) Field coil

(a) Field coil continuity test

Check continuity between field coil terminals. Good if continuity exists.

No continuity

(Coil disconnection)
Replace the field coil.

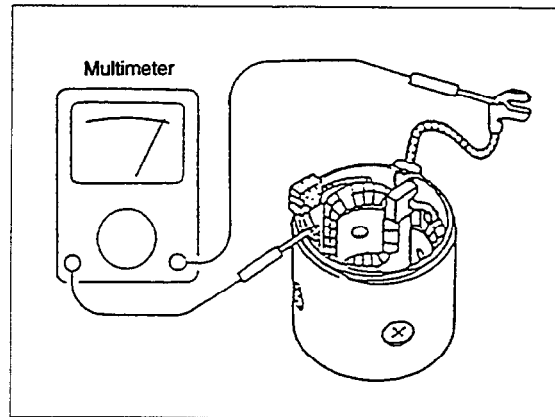


Fig. 16

(b) Field coil insulation test

Check continuity between field coil terminal and yoke. Good if no continuity exists.

Continuity exists

(Coil short circuit)
Replace the armature.

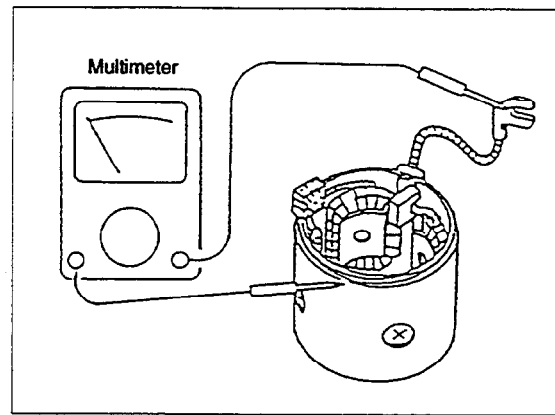


Fig. 17

(3) Brush

Measure the length of the brush. Replace with a good one if the length is less than the limit.

(mm)

Standard	Limit
15	9

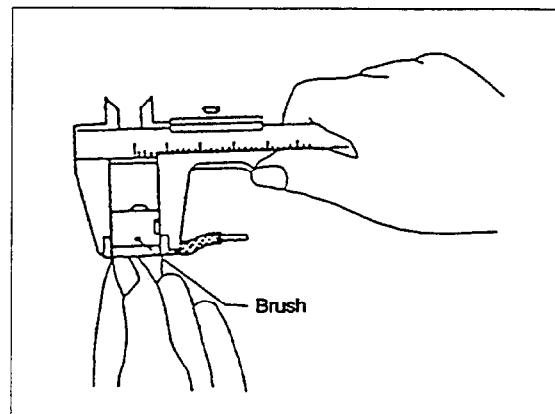


Fig. 18

(4) Brush holder

(a) Brush holder insulation test

Check the continuity between the brush holder (⊕ side) and base (⊖ side) with a multimeter. Good if no continuity exists.

Continuity exists

Insulation defect
Replace the brush holder.

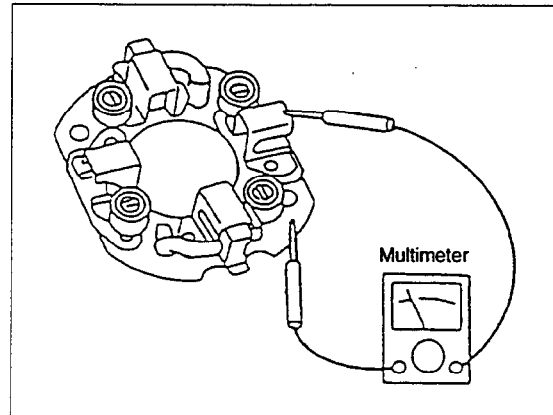


Fig. 19

(b) Brush spring inspection

Inspect the brush spring pressure.

Standard spring pressure
31~39 N (3.1~3.9 kgf)

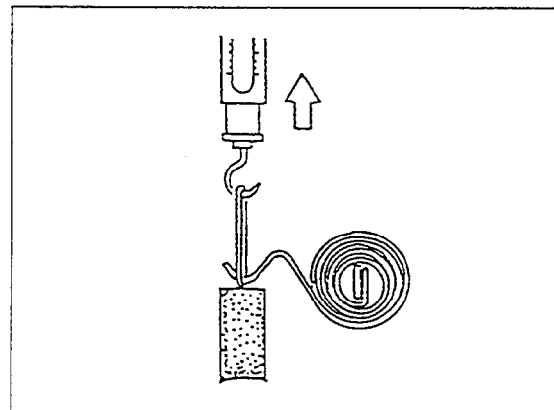


Fig. 20

(5) Magnetic switch

When the starting motor is wetted with water, always replace the magnetic switch with a new even if the function is normal.
--

(a) Shunt coil continuity test

Check the continuity between the S terminal and the switch body. Good if continuity exists.

No continuity

(Coil disconnection)
Replace the magnetic switch.

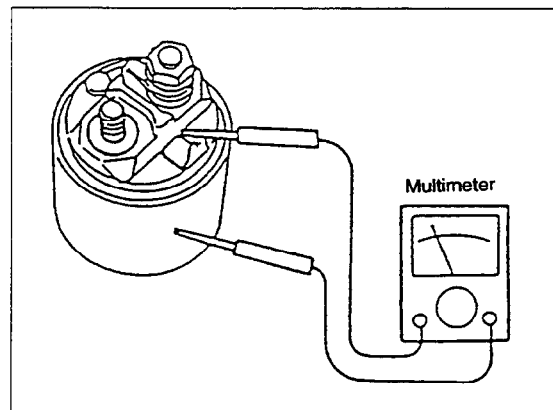


Fig. 21

9. Starting Motor

(b) Series coil continuity test

Check continuity between the S and M terminals. Good if continuity exists.

No continuity

(Coil disconnection)
Replace the magnetic switch.

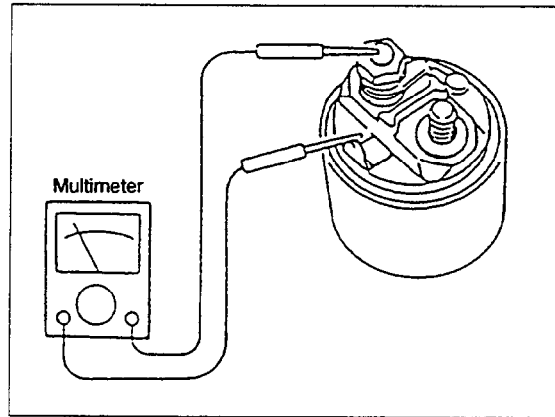


Fig. 22

(c) Contact continuity test

Depress the magnetic switch with the plunger at the bottom. Check continuity between the B and M terminals with a multimeter. Good if continuity exists.

No continuity

(Contact continuity defect)
Replace the magnetic switch.

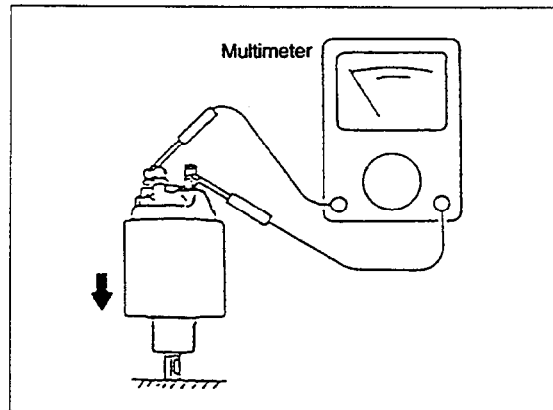


Fig. 23

(6) Pinion clutch

(a) Pinion inspection

Manually rotate the pinion. Inspect if it is rotated smoothly in the driving direction, and is locked in the opposite direction. Replace the pinion clutch if abnormal.

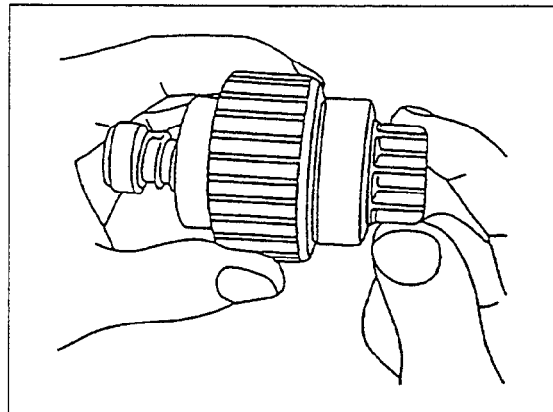


Fig. 24

(b) Pinion sliding inspection

Check if the pinion slide smoothly in the axial direction.
If damaged, rusted or heavy in sliding, repair it.
If grease is applied too much on the pinion shaft, sliding becomes heavy.

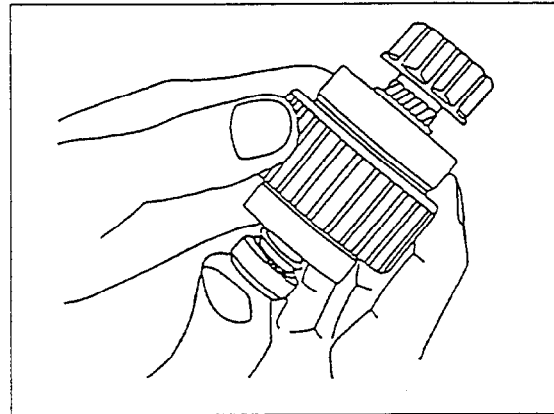


Fig. 25

(c) Ball bearing inspection

Rotate the ball bearing while holding the outer race with fingertips. Inspect if it is sticking or if there is play.

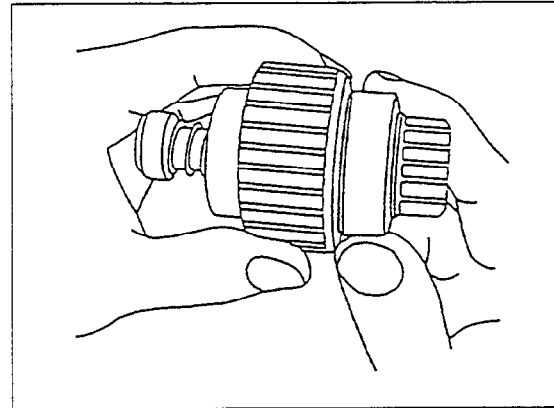


Fig. 26

9. Starting Motor

9.1.6 Service standards

Brush	Spring force		N (kgf)	35 (3.6)
	Standard height/wear limit		mm	15/9
Magnetic switch resistance, series coil/shunt coil (at 20°C)			Ω	0.27/0.60
Commutator	Standard diameter/limit diameter		mm	36.5/35.5
	Difference between maximum and minimum diameter	Repair limit/repair accuracy	mm	0.2/0.03
	Mica undercut depth chips	Repair limit/repair accuracy	mm	0.2/0.5~0.8
Bearing type	Armature front	Nominal number	—	6903DDU
	Armature rear		—	608DDU
	Pinion front		—	6004DDU
	Pinion rear		—	6904DDU
ℓ dimension (pinion projection length)			mm	0.3~1.5

9.1.7 Assembly

The assembly procedure is the reverse of the disassembly procedure, but pay attention to the following points:

(1) Grease application points

- Gears in the gear case
- Shift lever operating portion
- Pinion sliding portion
- Magnetic switch plunger sliding portion

Use the specified grease as below table at all points.

Pinion and magnetic switch plunger sliding portions	NPCFG-6A
Gears	MALTEMP SRL
Shift lever operating portion	ALBANIA No. 1

(2) Magnetic switch assembly

- (a) Install the shift lever on the magnetic switch with the torsion spring in-between.

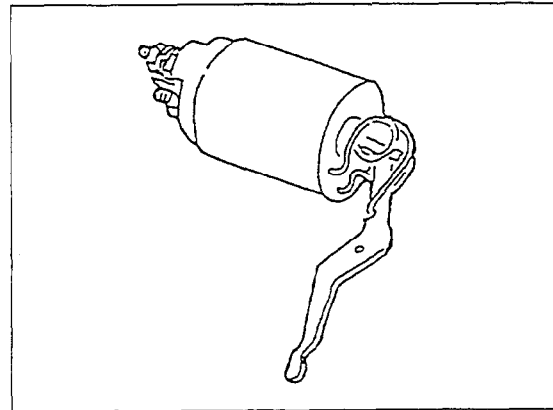


Fig. 27

- (b) For installation on the gear case, install the magnetic switch with the shift lever on the gear case after pulling the pinion out. Fix the magnetic switch by tightening a built-in bolt M6. Do not forget to install the dust cover (adjusting shim).

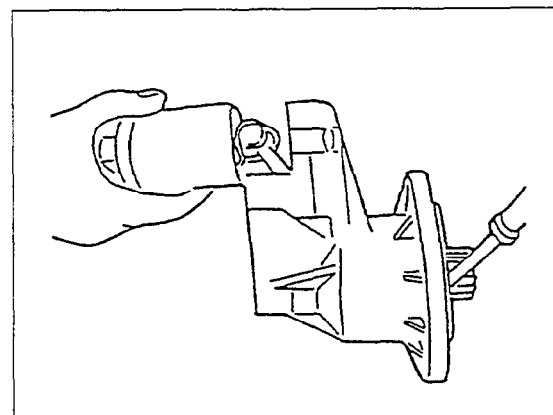


Fig. 28

9. Starting Motor

(3) Pinion projection length

Connect the positive (+) lead from the battery to terminal S and negative (-) lead to terminal M. Turn the switch ON and measure the pinion moving distance l in the thrust direction.

Perform this test within 10 seconds.

	Standard
l	0.3 ~ 1.5 mm

Note: *Before measuring the dimension, pull the pinion out lightly in the direction of the arrow.*

If the measured l dimension is outside the standard range, either insert or remove the dust cover (adjusting shim 0.5 mm, 0.8 mm) for adjustment.

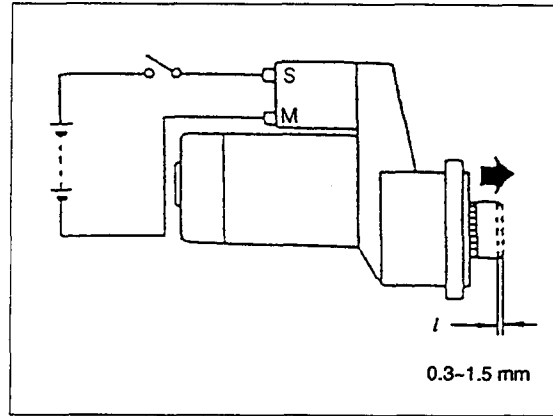


Fig. 29

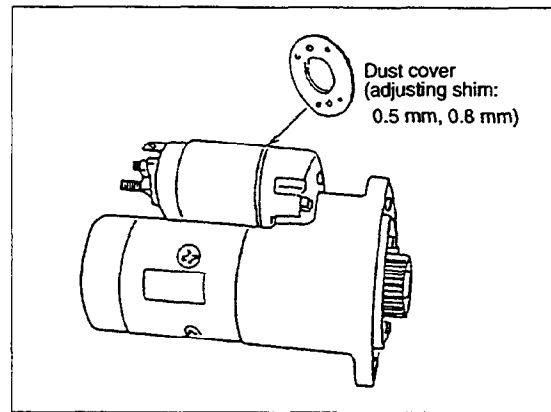


Fig. 30

9.1.8 Characteristic test

Since the characteristics can be checked roughly by means of a simple no-load test as explained below.

※ Complete the test quickly since the rating of the starting motor is 30 seconds.

1. No-load test

Fix the starting motor on a test bench and connect wiring as shown in Fig. 31. When the switch is closed, a current flows in the starting motor, which is rotated at no-load. Measure the current, voltage and number of revolutions then and check if they satisfy the specified characteristics.

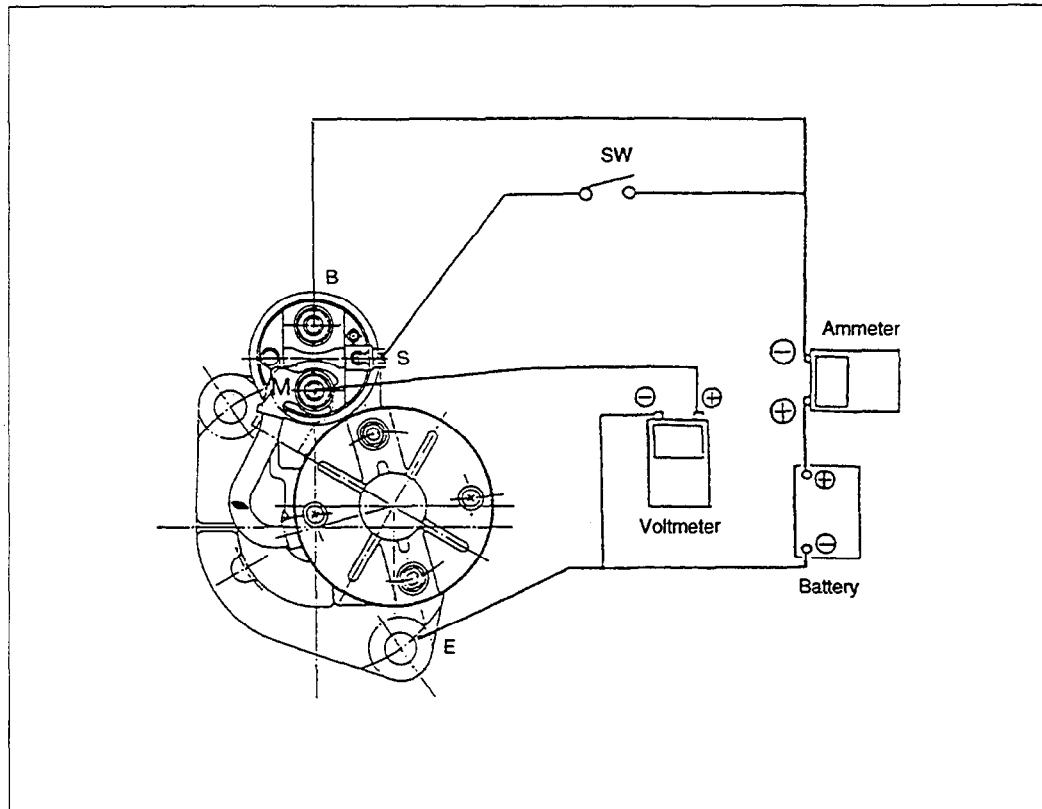


Fig. 31

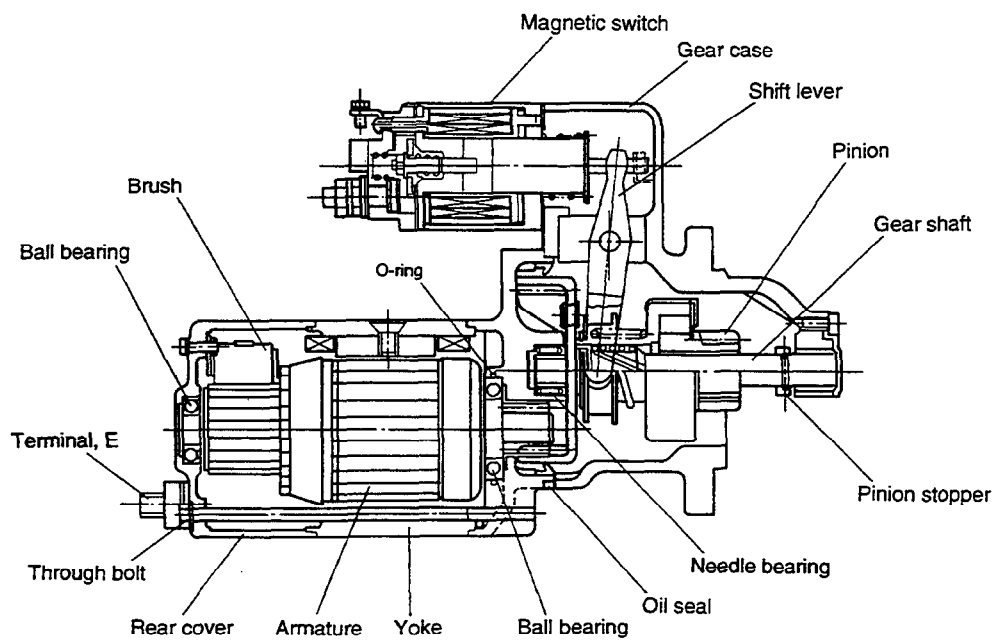
9. Starting Motor

9.2 For 4TNE106(T)

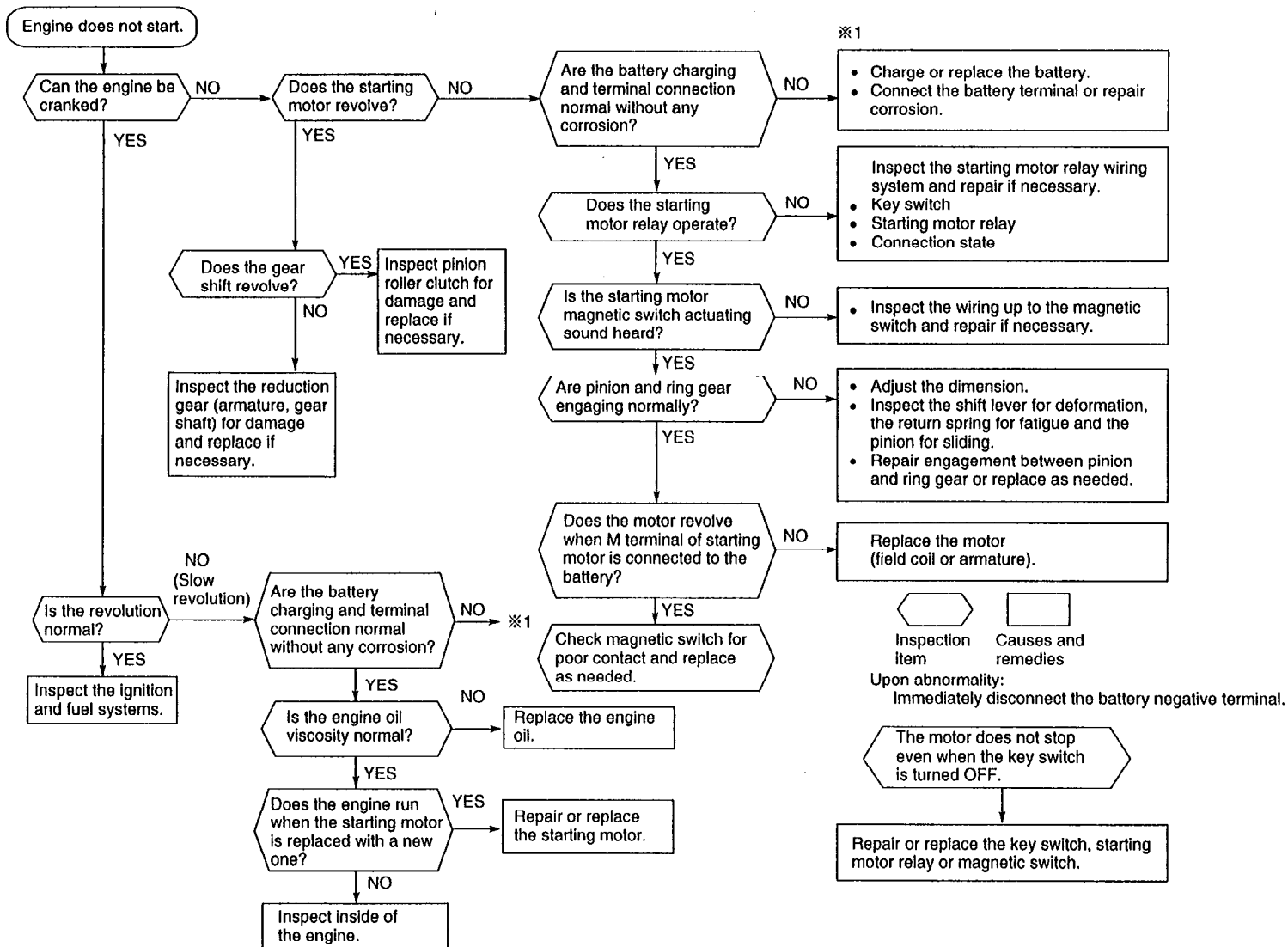
9.2.1 Specifications

Manufacturer's model (Hitachi)		—	S13-138
Yanmar code		—	129953-77010
Nominal voltage		V	12
Nominal output		kW	3.0
Rating		Sec	30
Revolution direction (as viewed from pinion)		—	Clockwise
Clutch system		—	Roller clutch
Engagement system		—	Magnetic shift
Pinion : Module/number of teeth		—	M3/9
Weight		kg	7.3
Pinion projection voltage (at 100°C)		V	8 or less
No-load	Terminal voltage/current	V/A	12/180 or less
	Revolution	rpm	3000 or more
Loaded	Terminal voltage/current	V/A	9/500
	Torque	N/m	16.7 (1.7 kg-m) or more
	Revolution	rpm	1270 or more

9.2.2 Configuration drawing



9.2.3 Troubleshooting



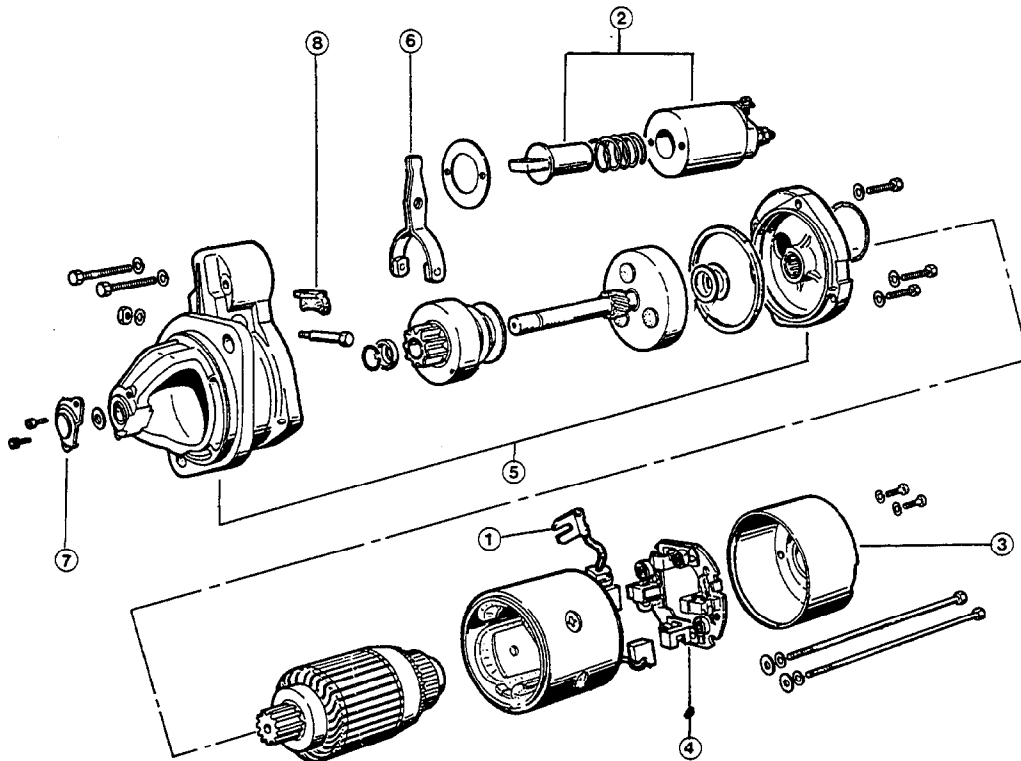
9. Starting Motor

9.2.4 Component names and disassembly procedure

(1) Disassembly procedure

- ① Disconnect the lead.
- ② Remove the magnetic switch.
- ③ Remove the rear cover.
- ④ Remove the brush holder.
- ⑤ Disassemble the gear case and center bracket.
- ⑥ Remove the shift lever pin.
- ⑦ Remove the gear case dust cover.
- ⑧ Remove the pinion.

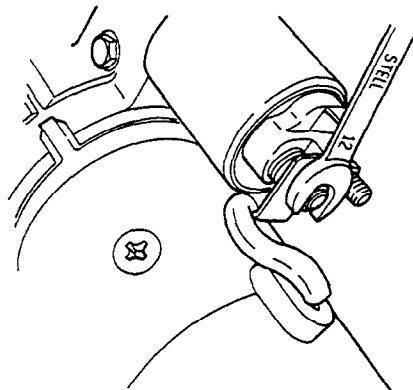
(2) Disassembly diagram



9.2.5 Disassembly procedure

(1) Disconnecting the lead

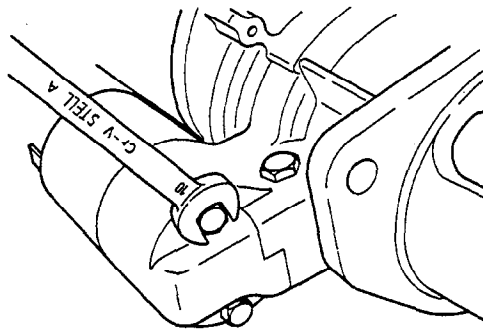
Loosen the M8 nut (12 mm) of the magnetic switch and disconnect the lead.



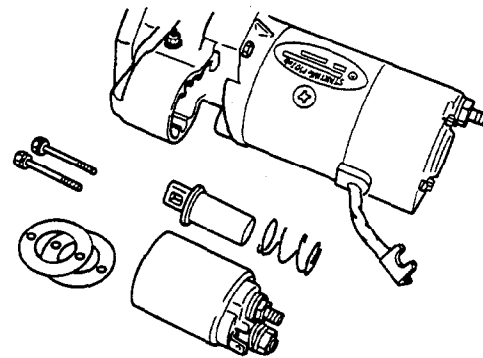
(Loosening the M8 nut)

(2) Removal of magnetic switch

Remove the M6 bolts (10 mm × 2).



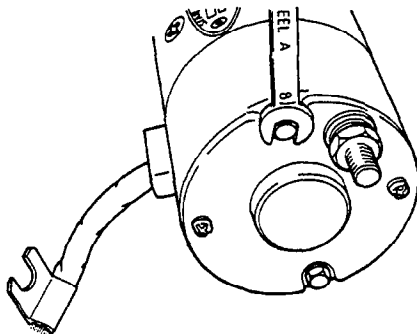
(Removing M6 bolts)



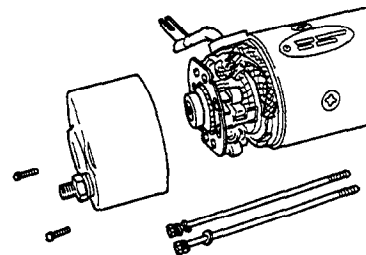
(After disassembly)

(3) Removal of rear cover

Remove the brush holder tightening screws (4 mmφ × 2) and the M5 through bolts (× 2). Next, disconnect the rear cover from the yoke using a ⊖ screwdriver.



(Removing through bolt)



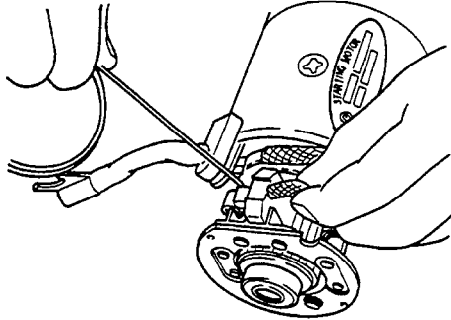
(After disassembly)

(4) Removal of brush holder

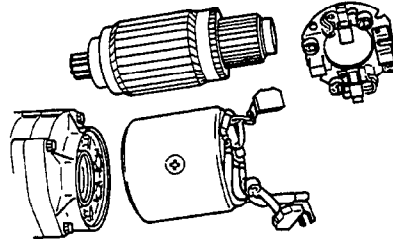
For the negative \ominus brush, bring the brush spring into contact with the side of the brush for lifting from the commutator surface.

For the positive \oplus brush, extract the pull out the brush from the brush holder.

After the brush holder is removed, the armature and yoke can be disassembled.



(Lifting up the brush)

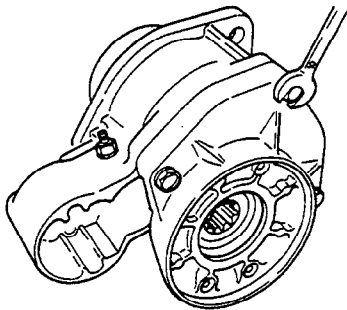


(After disassembly)

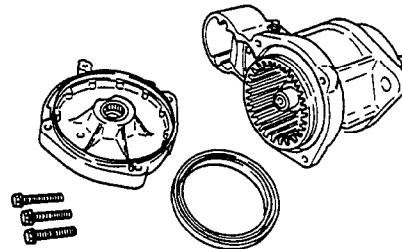
(5) Separating gear case from center bracket

Remove three M6 bolts (10 mm) fastening the gear case to the center bracket.

After removal of the M6 bolts, the center bracket and oil seal can be removed.



(Removing M6 bolts)

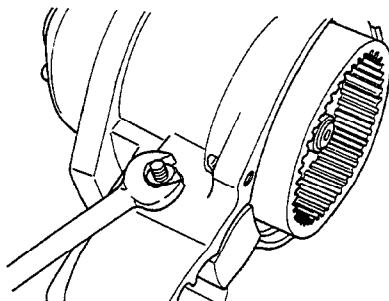


(Disassembling the center bracket)

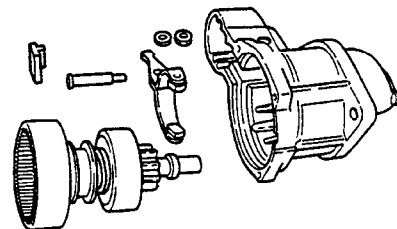
(6) Removal of shift lever pin

Remove the M6 nut (10 mm) and pull out the shift lever pin.

Now, the dustcover, shift lever, gear case and gear shaft can be removed.



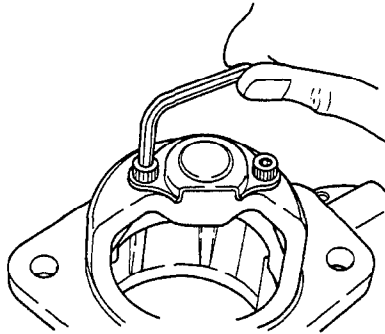
(Removing M6 nut)



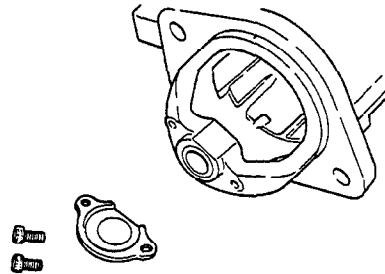
(Disassembling the gear case and gear shaft)

(7) Removal of gear case dust cover

Remove the two M5 bolts (using 4 mm hexagon wrench) to disassemble the dust cover from the gear case.



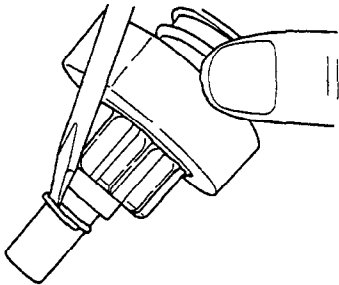
(Removing M5 bolt)



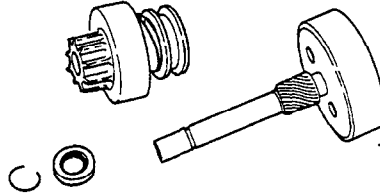
(Disassembling the dust cover)

(8) Removal of pinion

Slide the pinion stopper towards the pinion and remove the pinion stopper clip using a ⊖ screwdriver.



(Removing pinion stopper clip)

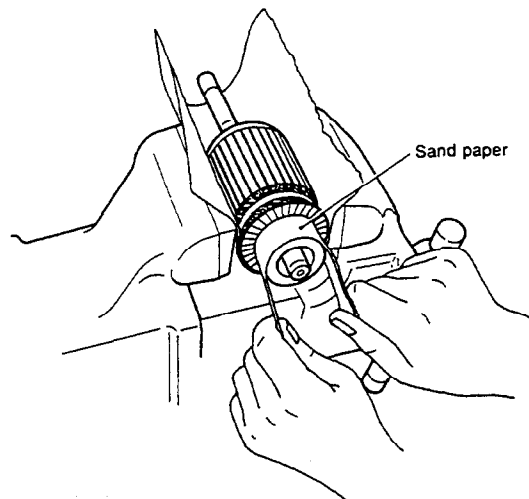


(After disassembly of pinion)

9.2.6 Inspection and maintenance

(1) Armature

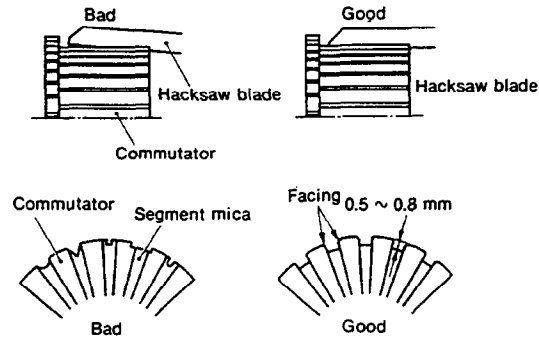
- a) Check the commutator for rough surface. If so, smooth the surface using #500 to #600 emery cloth. If the outside periphery of the commutator has been deflected over 0.2 mm, repair by a lathe.



(Sanding commutator surface)

9. Starting Motor

- b) Measure the depth of the insulating material between commutator segments, and correct if it is less than 0.2 mm.

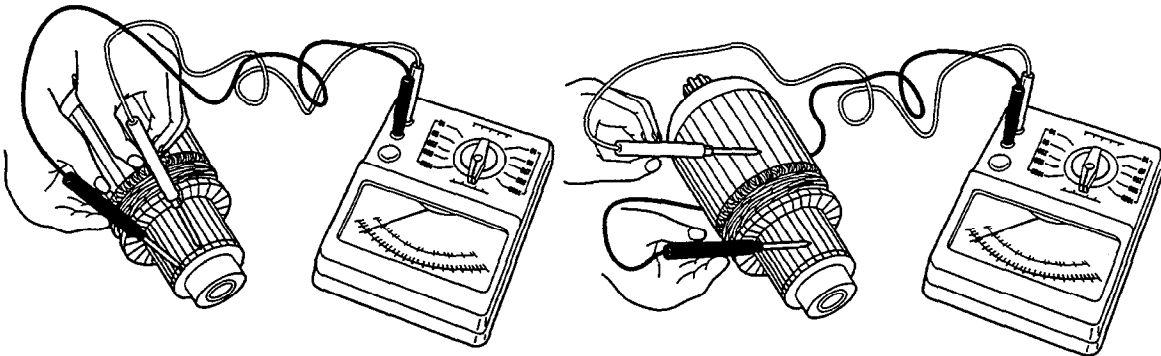


(Under-cutting method)

- c) Armature coil continuity and earth tests

Test type	Measurement point	Normal	Abnormal (cause)
Continuity test	Across commutator	Yes	None (open circuit)
Earth test	Between commutator and shaft or armature	None	Yes (short-circuiting)

Replace if needed.



(Armature coil continuity test)

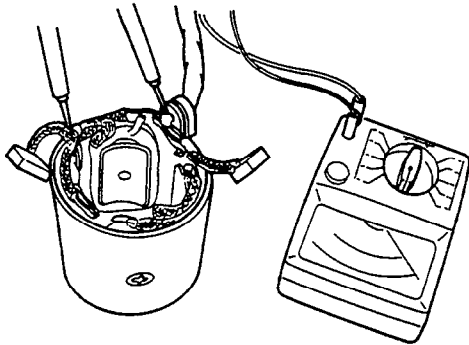
(Armature coil insulation test)

(2) Field coil

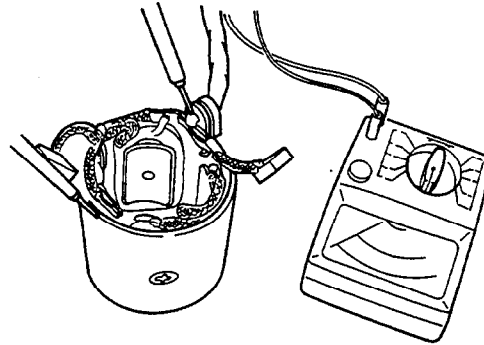
a) Field coil continuity and earth tests

Test type	Measurement point	Normal	Abnormal (cause)
Continuity test	Across field coils	Yes	None (open circuit)
Earth test	Between commutator and yoke	None	Yes (short-circuiting)

Replace if needed.



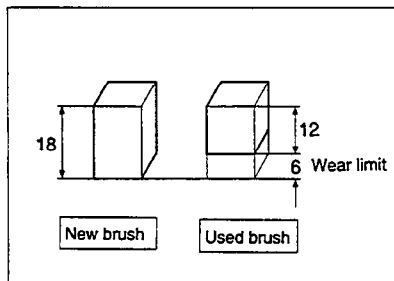
(Field coil continuity test)



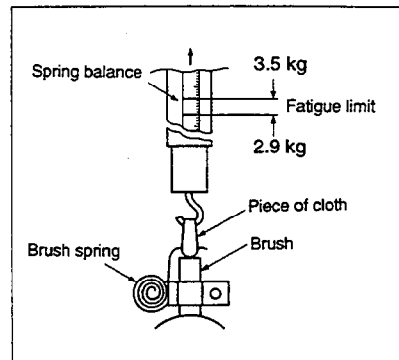
(Field coil insulation test)

(3) Brush

a) Check wear of the brush and the brush spring force.



(Wear limit for brush)



(Measuring brush spring force)

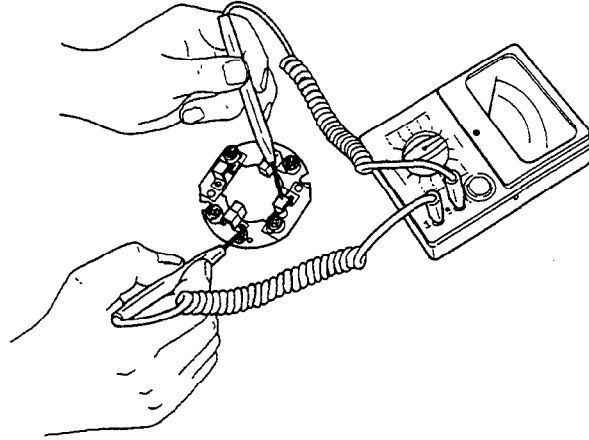
9. Starting Motor

b) Check of brush movement

If the brush does not move smoothly, inspect the brush holder for bending and the brush holder sliding surface for dirt. Repair or clean as needed.

c) Check the continuity between the insulated brush holder (positive (+)) and the brush holder base (negative (-)).

If they are electrically continuous, replace since the holder is grounded.

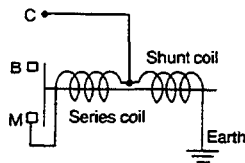


(Checking insulation of brush holder)

(4) Magnetic switch continuity test

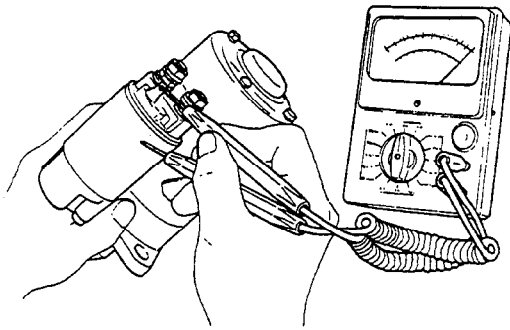
Continuity test	Measurement point	Normal	Abnormal (cause)
Shunt coil	Between C and ground	Yes	None (open circuit)
Series coil	C and M	None	Yes (short-circuiting)

Replace if needed.

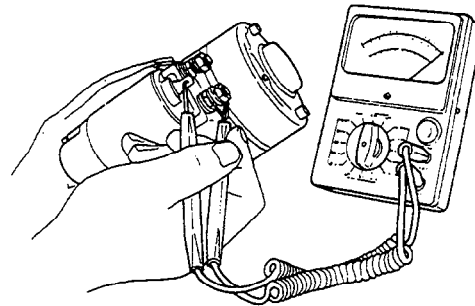


S13-138	
Resistance (at 20°C)	
Shunt coil	0.6
Series coil	0.218

(Magnetic switch connection diagram)



(Shunt coil continuity test)



(Series coil continuity test)

(5) Pinion

- a) Check the pinion teeth for wear and damage. Replace with a new one, if necessary.
- b) Check if the pinion slides smoothly. If it is damaged or rusted or does not slide smoothly, repair.
- c) Check springs for damage, and replace if necessary.

(6) Ball bearing

If abnormalities such as irregular noises are detected to the ball bearing, replace with a new one.

9.2.7 Assembly

The assembly procedure is reverse of the disassembly procedure, but pay attention to the following points.

(1) Apply grease as instructed below.

Greasing point	Grease type
Sliding portions and head of plunger	NPC-FC6A Grease
Pinion metal and metal portions of gear case	
Spline portions of pinion	
Sliding portions of shift lever	
Deceleration gear	MALTEMP SRL Grease

(2) Armature thrust

No adjustments are needed for the thrust.

(3) Gear shaft thrust

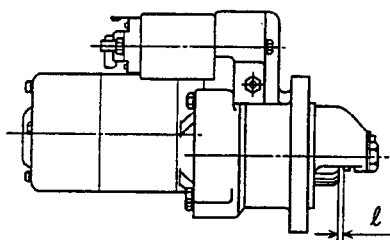
Some thrust washers of 1.0 and 0.25 mm thickness are provided between the center bracket and gear shaft supporting surface. Make sure to check them at reassembly.

If washers are deformed or worn, replace them with new ones.

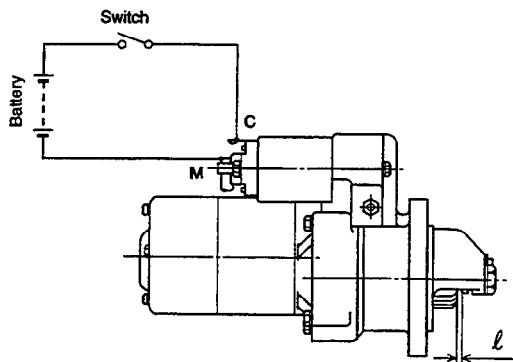
The appropriate thrust is from 0.05 to 0.3 mm. If it is over 0.3 mm, add the appropriate thrust washer, but pay attention so that the thrust is not 0.

9.2.8 Adjustment

(1) Pinion projection length l by magnetic switch



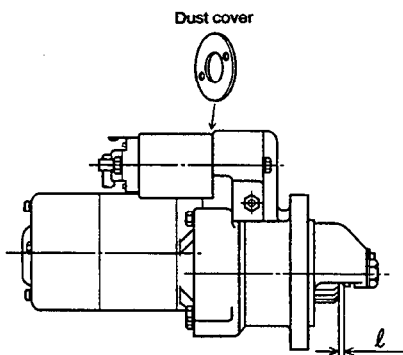
(Pinion projection length)



(Measurement method)

Measure the pinion moving distance l (0.3 to 1.5 mm) in the thrust direction when the pinion is protruded by the magnetic switch.

If the distance l is outside the standard range, adjust by the dust cover as shown below.



(Adjustment by dust cover)

9.2.9 Service standards

Brush	Spring force N (kgf)		31.4 (3.2)
	Standard / Limit height		18/6
Commutator	Outside diameter	Standard	37
		Limit	36
	Deflection	Limit	0.2
		Correction accuracy	0.05
	Depth of insulation mica	Limit	0.2
		Correction accuracy	0.5 to 0.8
Standard dimensions	Armature shaft diameter	Front	25
		Rear	12
	Bearing on gear case side	Gear shaft diameter	13.95 to 13.968
		Hole diameter	14.00 to 14.018
	Sliding portion of pinion	Shaft diameter	13.95 to 13.968
		Hole diameter	14.03 to 14.05
Ball bearing	Armature	Front	6905DDU
		Rear	6001DDU
Length l (pinion projection length)			0.3 to 1.5

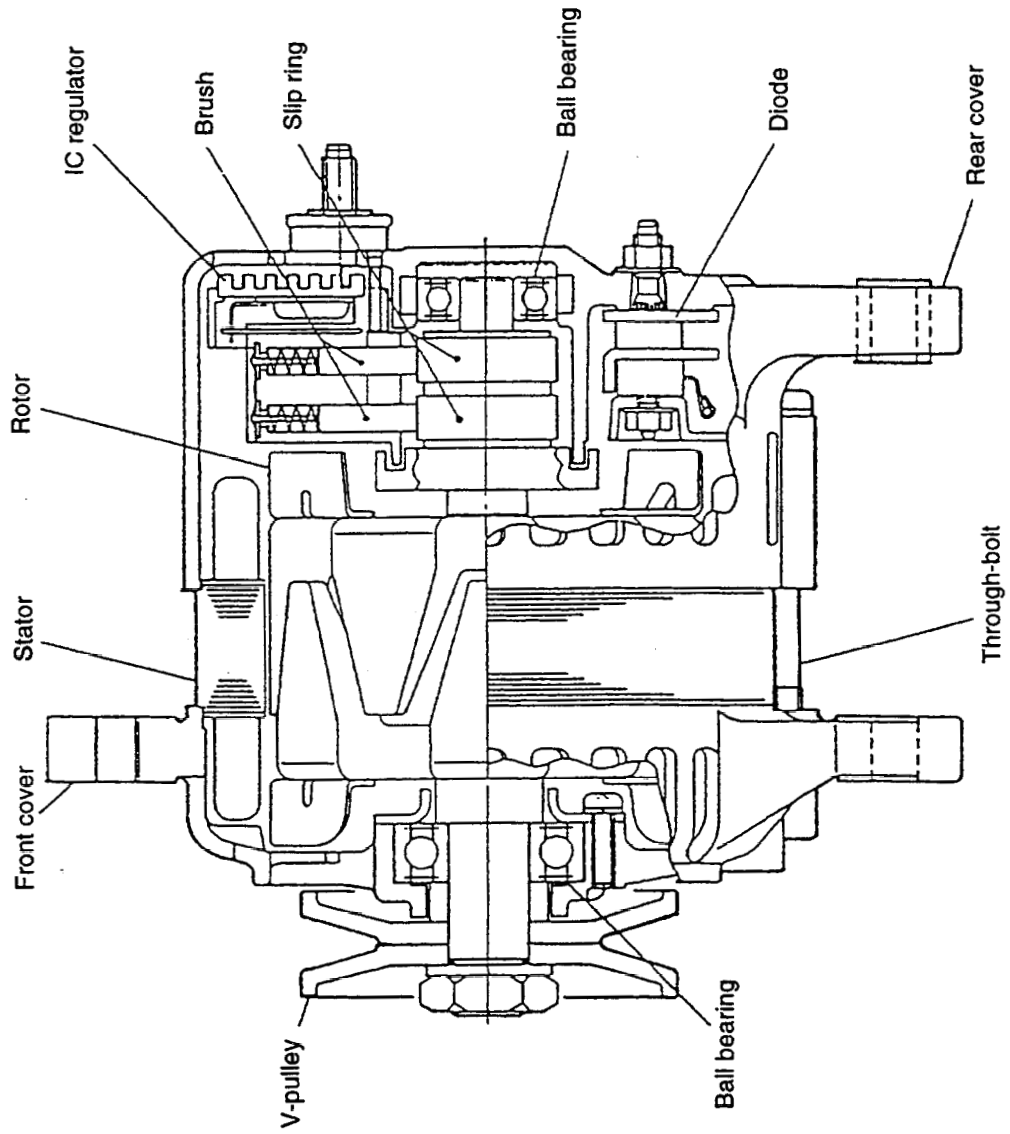
10. ALTERNATOR 10-1~10-21

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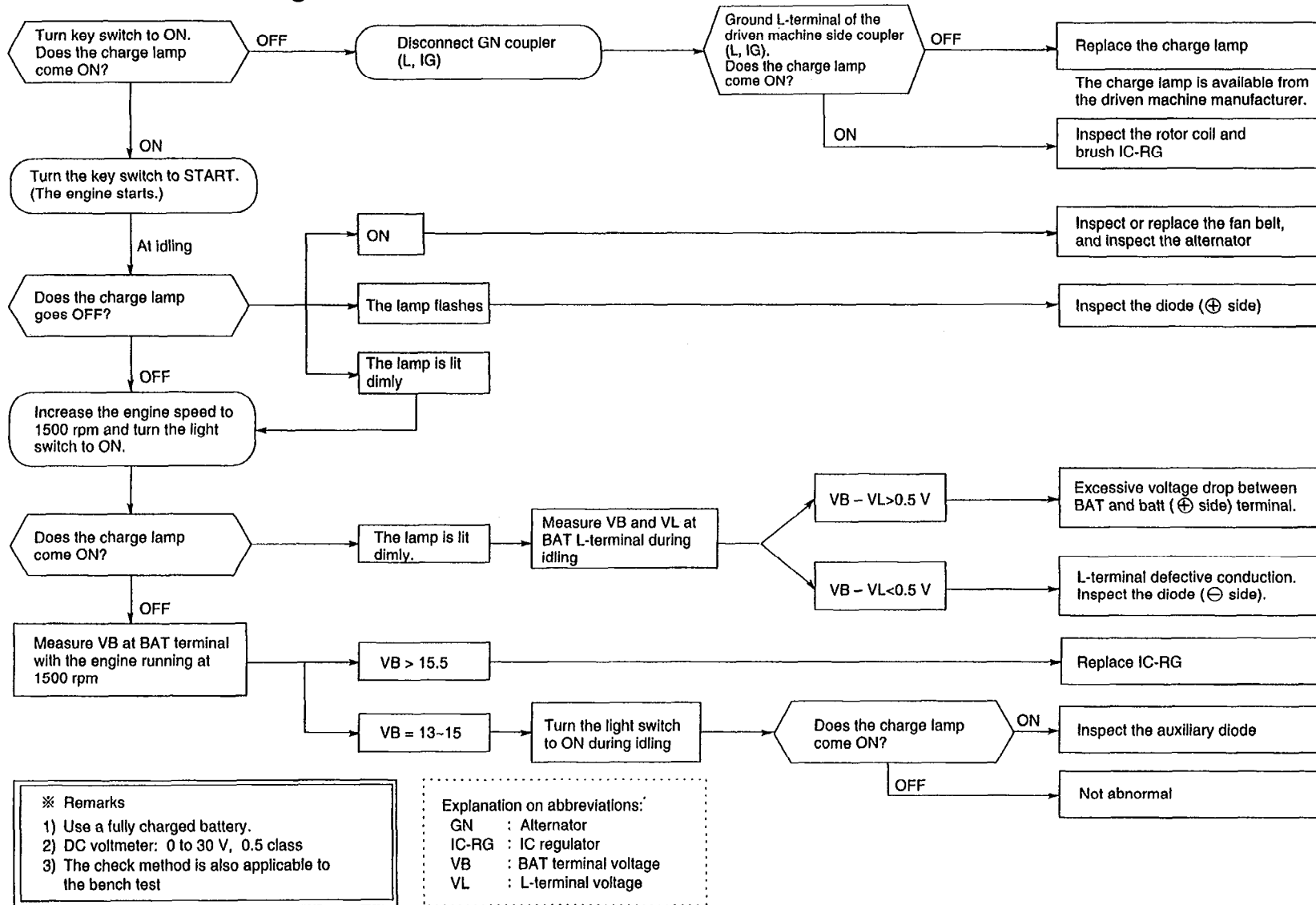
10.1 For 4TNE94/98**10.1.1 Specifications**

Manufacturer's model (Hitachi)	—	LR140-714
Yanmar code	—	119836-77200
Rating	—	Continuous
Battery voltage	V	12
Nominal output	V × A	12 × 40
Rated revolution	rpm	5000
Operating revolution	rpm	1050~12400
Grounding characteristics	—	⊖
Direction of revolution (viewed from pulley)	—	Clockwise
Weight	kg	3.5
Pulley (outside diameter)	mm	70
Belt shape	—	Type A

10.1.2 Sectional view



10.1.3 Troubleshooting



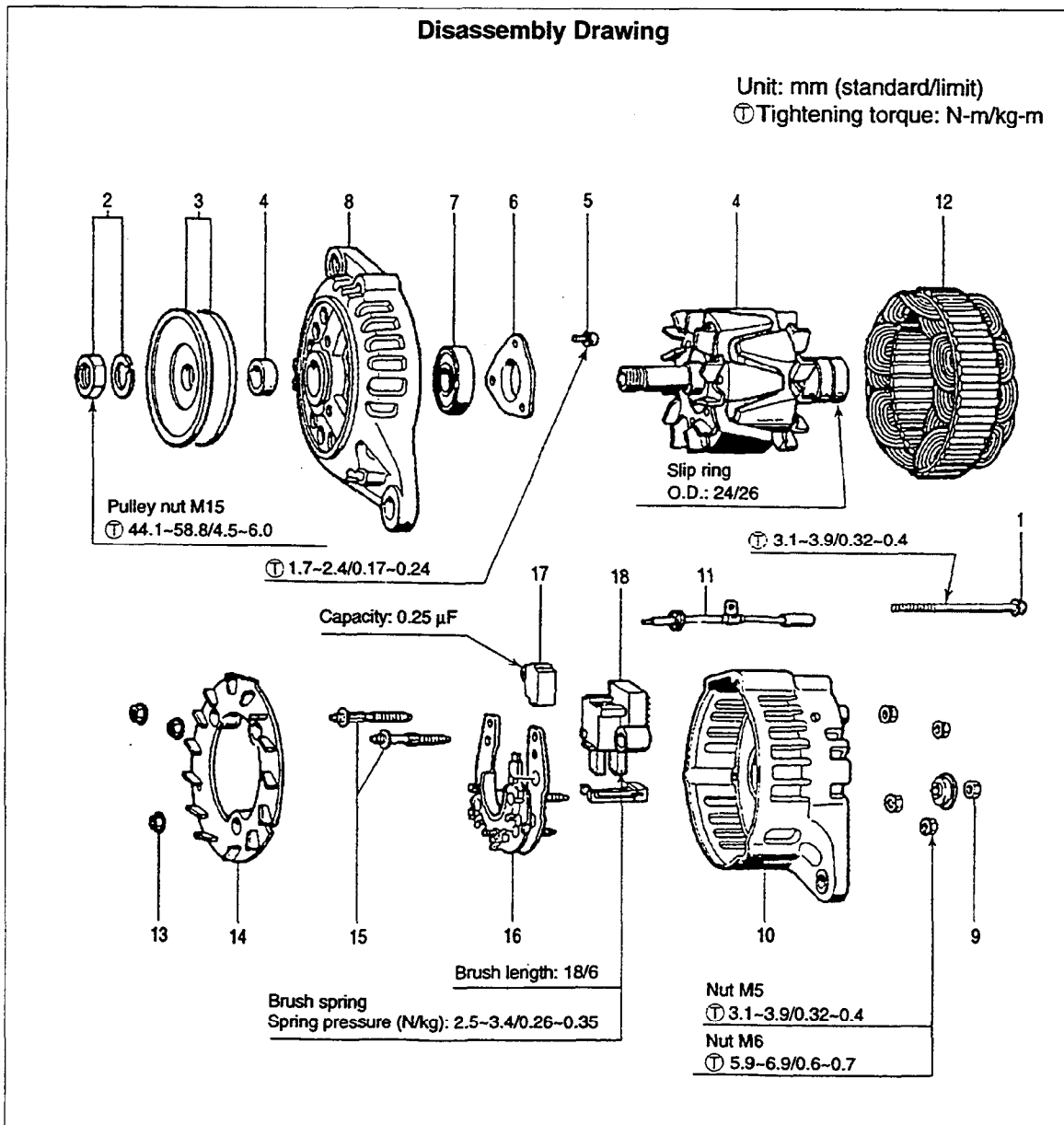
10. Alternator

10.1.4 Parts names and disassembly procedure

Disassembly Procedure

- | | |
|---|--|
| <ul style="list-style-type: none"> △ (1) Through bolt M5 (2) Pulley nut (3) Pulley assembly △ (4) Rotor (5) Screw M5 (6) Bearing retainer (7) Ball bearing △ (8) Front cover (9) Nuts M5 and M6 (10) Rear cover | <ul style="list-style-type: none"> △ (11) Lead wire assembly △ (12) Stator (13) Nut M4 △ (14) Fan guide (Disassembly hereafter is unnecessary if the diode is faulty.) △ (15) Battery terminal, bolt M5 (16) Diode (17) Capacitor △ (18) Brush regulator assembly |
|---|--|

△ : Refer to the disassembly drawing.



Disassembly Procedures

1) Through bolt M5

Remove the M5 through bolt. Increase the temperature at the center of the rear cover by about 20°C using a soldering iron, insert two flat-head screwdrivers between the front cover and the stator core and separate the assembly into the front side (front cover and rotor) and the rear side (rear cover and stator).

Note: *Be careful not to damage the stator coil with the edges of the screwdrivers.*

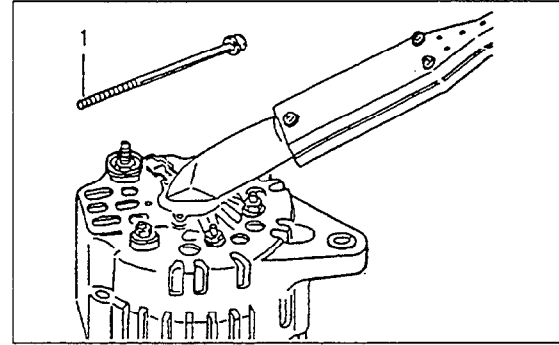


Fig. 1

2) Pulley nut**3) Pulley assembly****4) Rotor**

Fix the rotor in a vice and remove the M15 (22 mm) pulley nut to separate the pulley, front cover and rotor.

※ *Dimensions shown in () indicate the spanner sizes to be used.*

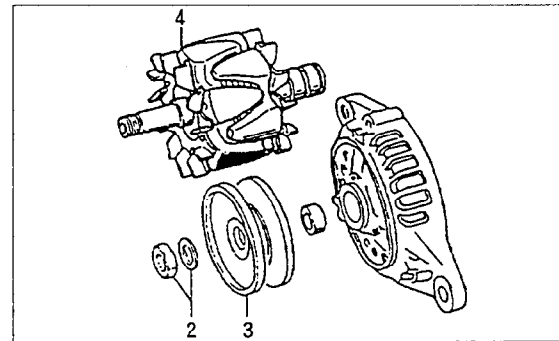


Fig. 2

5) Screw M4**6) Bearing retainer****7) Ball bearing****8) Front cover**

Remove the M5 screw securing the bearing retainer to separate the bearing retainer, ball bearing and front cover.

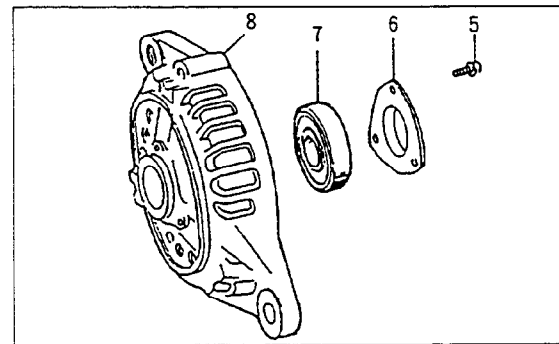


Fig. 3

9) Nuts M5 and M6**10) Rear cover****11) Lead wire assembly**

Remove the M5 and M6 nuts securing the diode and IC regulator. Press in the grommet and lead wire of the lead wire assembly into the hole in the rear cover to separate the stay and rear cover.

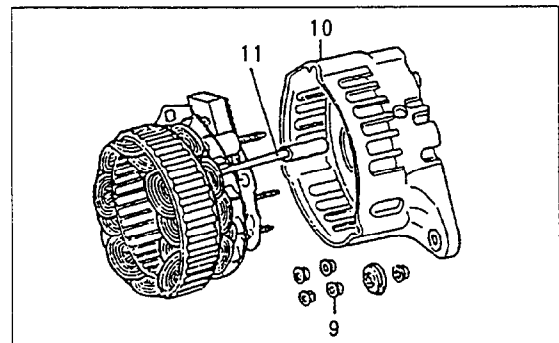


Fig. 4

10. Alternator

12) Stator

Disconnect soldering of the diode to remove the stator.

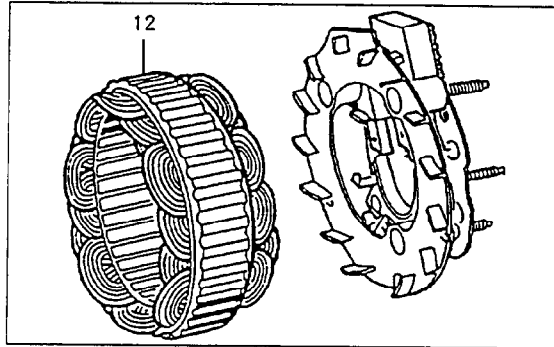


Fig. 5

13) Nut M4

14) Fan guide

Remove the M4 nut securing the fan guide to separate the fan guide.

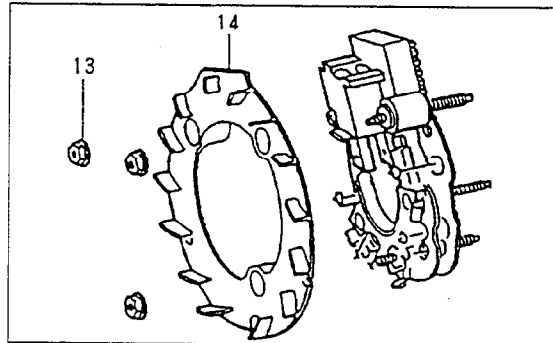


Fig. 6

15) Battery terminal, M5 bolt

16) Diode

17) Capacitor

18) Brush regulator assembly

Remove the M5 bolt and battery terminal. Disconnect the diode L-terminal and soldering of the brush regulator to remove the brush regulator assembly, capacitor and diode.

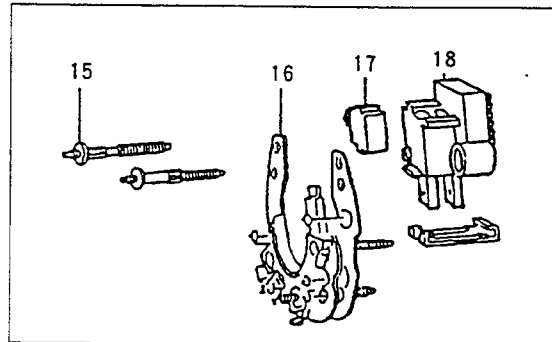


Fig. 7

10.1.5 Inspection and overhaul

(1) Diode

The diode makes the current flow only in the direction shown in Fig. 8. Check electrical continuity between two terminals (for example, terminals BAT and U) using a tester as shown in Fig. 9 and, if they are continuity, the diode is acceptable. If not, the diode is damaged. The diode is acceptable if two terminals are not continuity when the tester is connected in the reverse manner. The diode is damaged if they are continuity.

If even a single diode is faulty as a result of the above measurements, replace the entire diode assembly.

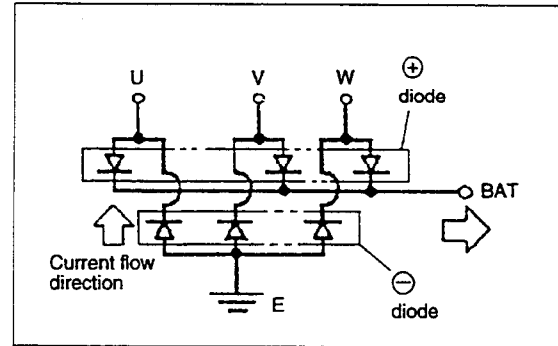


Fig. 8

Tester leads

U, V and W terminals \ E terminal	⊕	⊖
	⊕	-
⊖	Continuity	-

Checking (+) diode

Tester leads

U, V and W terminals \ BAT terminal	⊕	⊖
	⊕	-
⊖	Not continuity	-

Checking (-) diode

Note:

Never use a high-voltage insulation ohmmeter such as a megger for testing. Otherwise, the diode may be damaged.

(2) Rotor

(a) Wear limit for slip spring

Measure the outside diameter of the slip spring. If wear exceeding 1 mm from the standard size is measured, replace the rotor assembly.

Standard: 27 mm, Wear limit: 26 mm

(b) Check of slip ring surface

Check that the slip ring surface is smooth and free from contamination by oil, etc. If the surface is rough, polish using #500 to #600 emery cloth. If it is dirty, clean using alcohol.

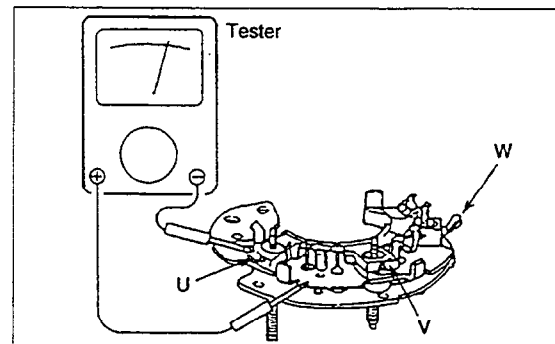


Fig. 9

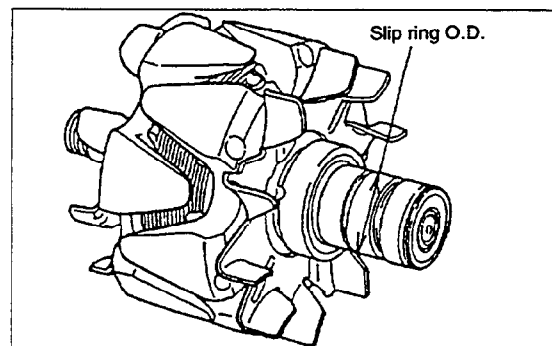


Fig. 10

10. Alternator

(c) Rotor coil continuity test

Check electrical continuity between slip rings using a tester.

Not continuity:

Open circuit of rotor coil
Replace the rotor.

Rotor coil resistance at 20°C: 3.45Ω

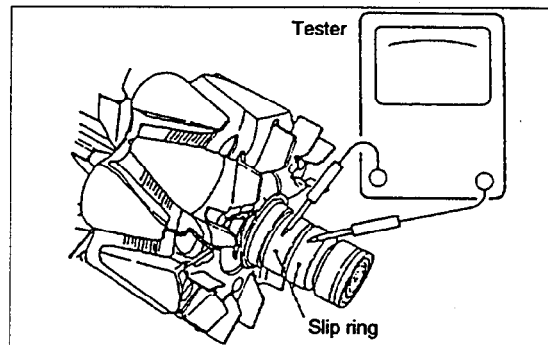


Fig. 11

(d) Rotor coil insulation test

Check electrical continuity between the slip ring and the rotor core or shaft using a tester.

Continuity:

Short-circuiting of rotor coil
Replace the rotor.

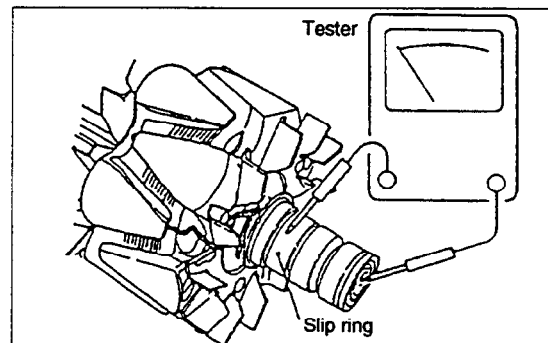


Fig. 12

(e) Checking ball bearing

Check the rear ball bearing. If rotation is unsmooth or abnormal noise is generated, replace the ball bearing.

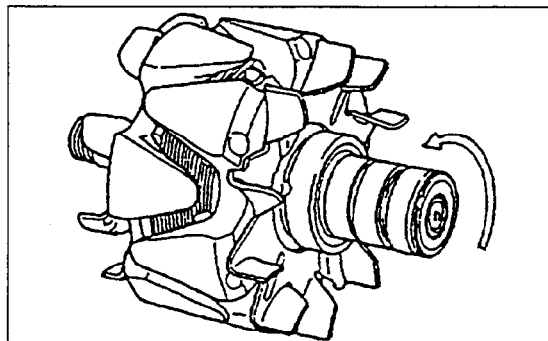


Fig. 13

(3) Stator

(a) Stator coil continuity test

Check electrical continuity between two respective terminals using a tester.

Not continuity:

Open circuit of stator coil
Replace the stator.

Stator coil resistance at 20°C:

0.108Ω/phase

Resistance between terminals

U and V: 0.216Ω

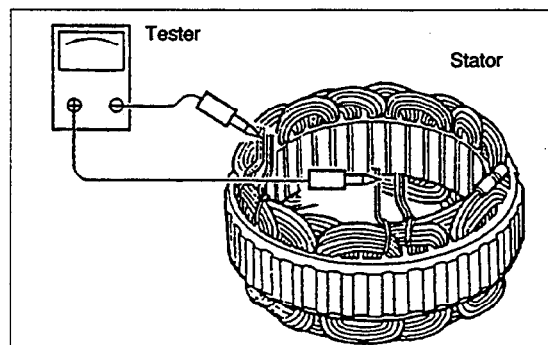


Fig. 14

- (b) **Stator coil insulation test**
Check electrical continuity between one of the stator coil terminals and the stator core using a tester.

Continuity:

Short-circuiting of stator coil
Replace the stator.

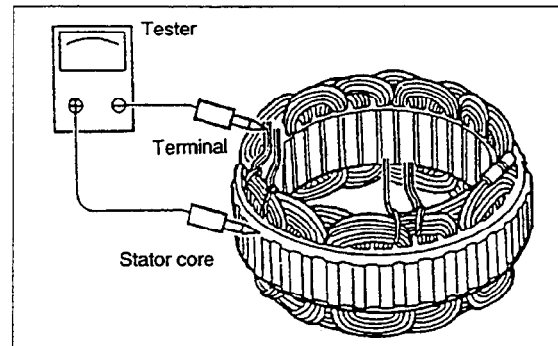


Fig. 15

(4) Brush

Measure the brush length. If wear exceeds the limit (6 mm), replace with a new brush holder assembly. The wear limit line is indicated on the brush.

Standard: 18, Wear limit: 6 (mm)

Caution on Brush Lead:

- 1) Temperature of soldering iron:
300°C ~ 350°C
Always use the non-acidic paste.

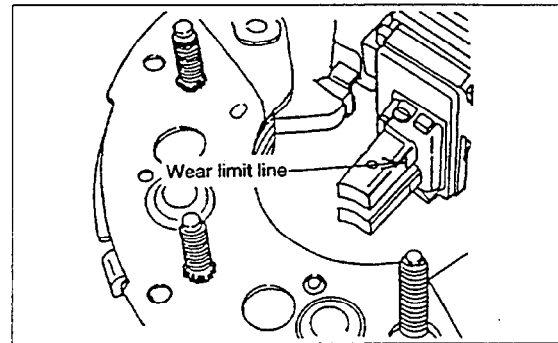


Fig. 16

(5) Check of IC regulator

Prepare the connection for test setup as shown in Fig. 17, using a variable resistor, two 12V batteries, an ohmmeter and a voltmeter.

(a) Jigs required

- ① Variable resistor (RV): 0 ~ 300Ω, 12W (1)
- ② Resistor (R1): 10Ω, 3W (1)
- ③ Battery (BAT1, BAT2): 12 V (2)
- ④ DC voltmeter (4 measurement points): 0 ~ 50 V, Class 0.5 (1 set)

(b) Measurement procedure

(Refer to Fig. 17.)

- ① Measure voltage at V1 (BAT1). If the measured value is between 10 V and 13 V, the battery is acceptable.
- ② Measure voltage at V3 (voltages of BAT1 + BAT2). If the measured value is between 20 V and 26 V, both batteries 1 and 2 are acceptable.

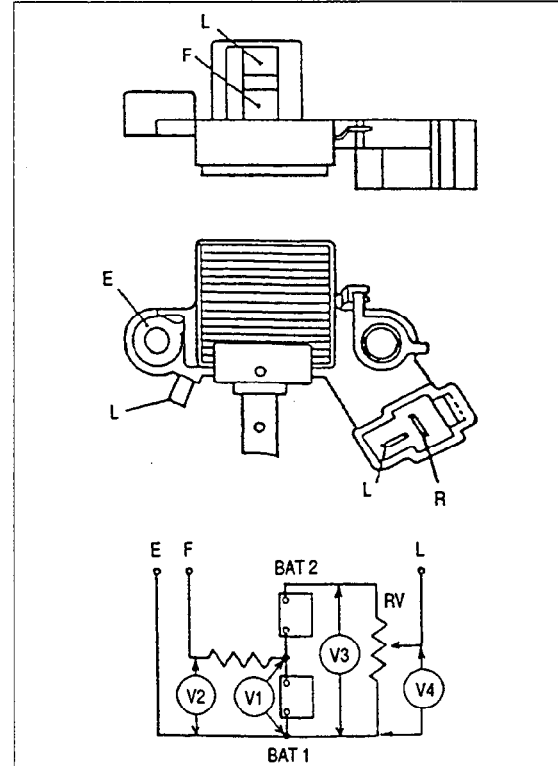


Fig. 17 Test circuit for IC regulator alone

10. Alternator

- ③ Measure voltage at V2 (voltage across terminals F and E) while gradually increasing the resistance of the variable resistor starting from 0 V. Check that there is a point where the V2 voltage reaches 2.0 V or less of the V1 value of BAT1 measured in ① above. If no change occurs, the regulator is faulty. So, replace it with a new one.
- ④ Measure voltage at V4 (voltage across the intermediate tap of the variable resistor and E-terminal), with variable resistor Rv being fixed. If the measured value is within the specified range, the regulator is acceptable. If not, the regulator is faulty. So, replace it with a new one.

10.1.6 Assembly

While the reassembly procedures are the reverse of the respective disassembly procedures, pay attention to the following precautions.

- (1) For the tightening torque of each screw, see page 9-4, Disassembly drawing.
- (2) High-temperature soldering is used for connection between the diode and the stator coil lead, and the diode and the brush holder.

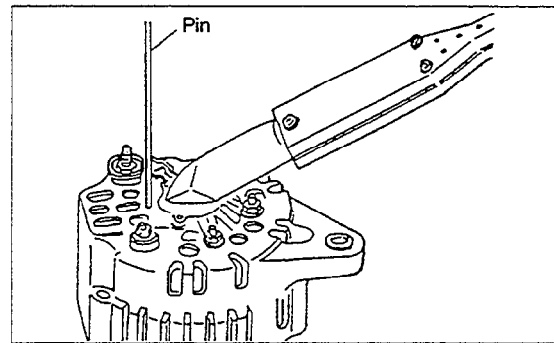
Work condition : Soldering iron temperature: 300°C to 380°C

Connection time : Must be complete within 5 seconds.

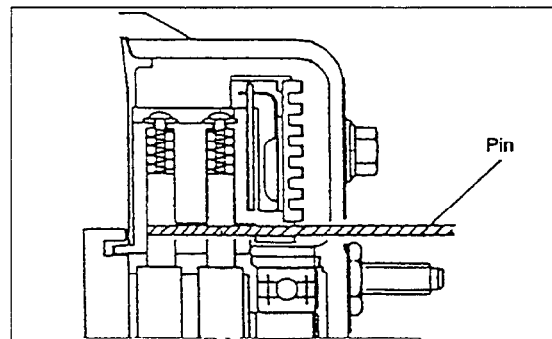
Solder used : 1:5 solder (JIS H16A)

- (3) Reassembly of the front and rear

- (a) Since the rear ball bearing is fixed by the dead stopping method, increase the temperature at the center of the rear cover by about 20°C using a soldering iron before beginning reassembly.



- (b) Insert the pin from the outside of the rear cover and press the brush into the brush holder before reassembling.



- (c) After reassembly is complete, remove the pin by pulling it out.

10. Alternator

10.1.7 Service standards

Characteristic	Unit	Standard
Revolution at 13.5 V (cold at 20°C)	rpm	1050 or less
Adjustment voltage	V	14.2~14.8
Standard temperature slope	V/°C	-0.01
13.5 V constant output current (hot at 20°C)	A/rpm	40/5000 or above
Coil resistance (at 20°C)		
	Stator	0.108 (phase)
	Rotor	3.45

10.1.8 Performance test

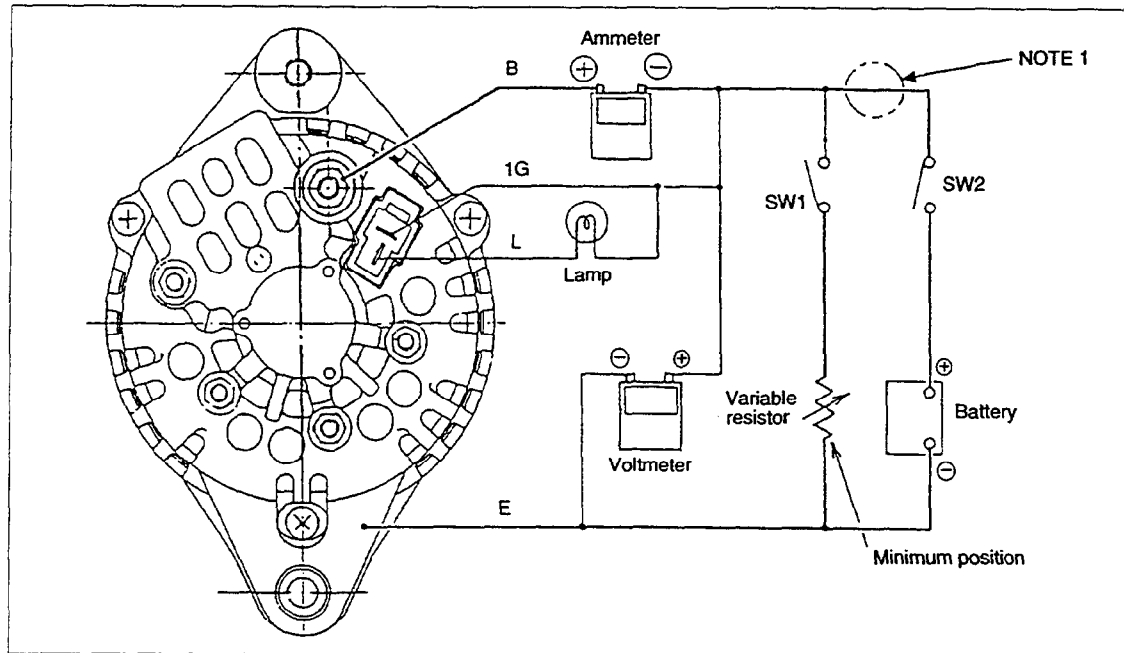


Fig. 20 Test Circuits

NOTE: The 0.25Ω resistor is connected when the battery is discharging.

Measurement jigs required:

- | | | |
|---------------------|-------------------------------------|---------|
| ① Voltmeter | : DC voltmeter 0 to 30 V, Class 0.5 | (1 set) |
| ② Ammeter | : DC ammeter 0 to 100 A, Class 1 | (1 set) |
| ③ Variable resistor | : 0 to 0.25Ω , 1 kW | (1) |
| ④ Resistor | : 0.25Ω , 25 W | (1) |

(1) Voltage measurement for adjustment

With the test circuits shown in Fig. 20, open SW1 and close SW2, increase the alternator revolution to the rated speed of 5000 rpm and measure the voltage.

Adjustment voltage: Acceptable if the measured value is between 14.2 V and 14.8 V.

(2) Revolution at 13.5 V

With the test circuits shown in Fig. 20, open SW1 and close SW2, gradually increase the alternator revolution until the voltmeter reads 13.5 V and measure the revolution. The measured value is the operating speed at 13.5 V.

Operating speed: Acceptable if the measured value is 1050 rpm or less.

(3) Output current measurement

With the test circuits shown in Fig. 20, set the variable resistor to the min. position, close SW1 and SW2, and increase each output of the alternator. Adjust the variable resistor so that the voltmeter reads 13.5 V and measure the current. The measured value is at each output current.

(4) Cautions on performance test

- (a) Use thick wires having a min. cross section of 8 mm^2 and max. length of 2.5 m long connecting the alternator B and battery (+) terminals, and the E and battery (-) terminals.
- (b) Use switches having small contact resistances.

10. Alternator

10.2 For 4TNE106(T)

10.2.1 Specifications

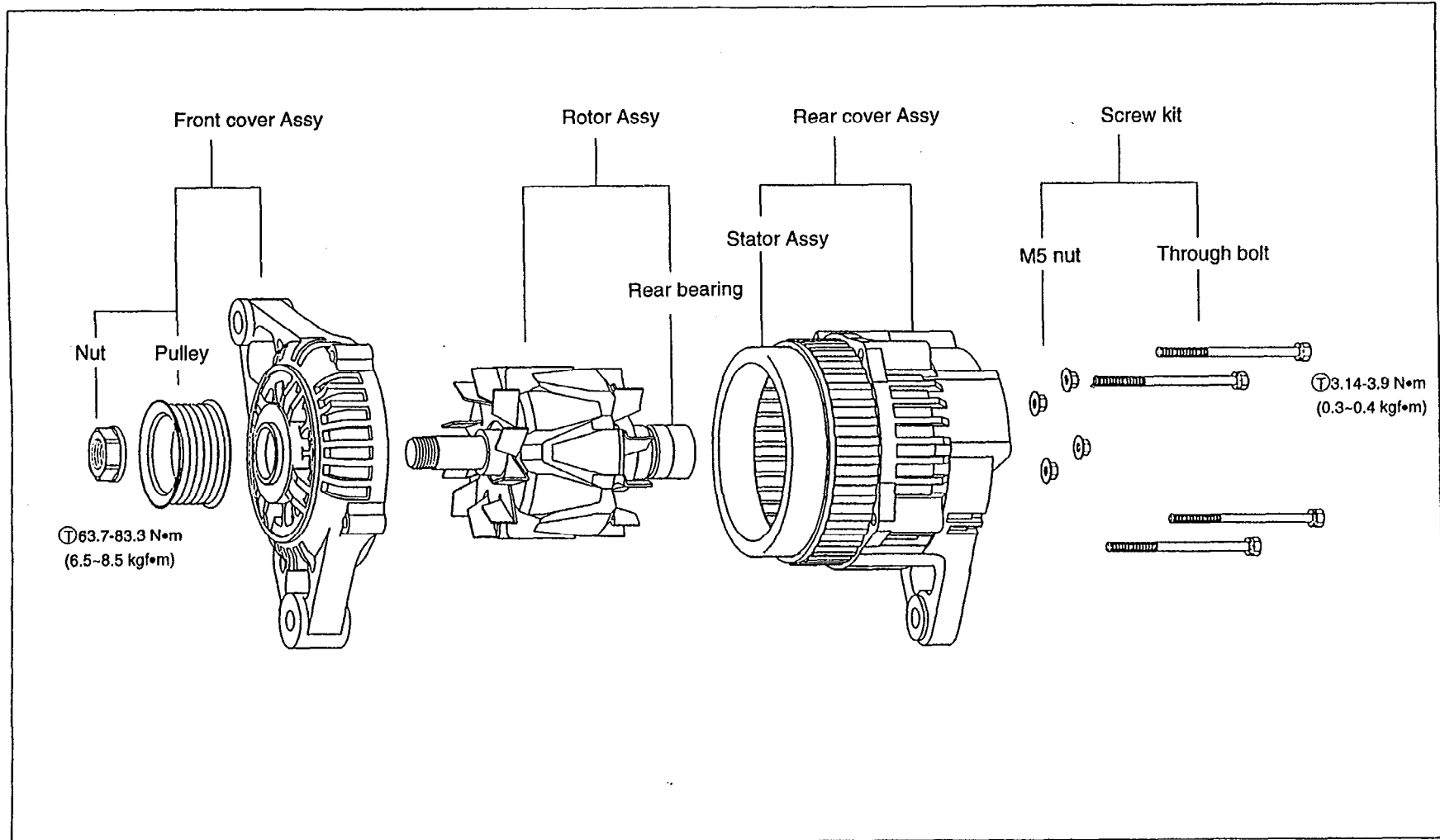
(1) Specifications

Manufacturer and model: Hitachi	-	LR160-735B
Yanmar code	-	123900-77210
Rating	-	Continuous
Battery voltage	V	12
Nominal output	-	12 V 60 A
Rated rpm	rpm	5000
Operating rpm	rpm	1050 to 18000
rpm for generating 13.5 V (cold at 20°C)	-	1050
Polarity	-	⊖ Ground
Direction of rotation (as seen from pulley)	-	Clockwise
Weight	kg	4.2
Regulated voltage	V	14.4
Standard temperature gradient	V/°C	-0.01
Rotor coil resistance	Ω	2.33
V pulley outside diameter	mm	82
Belt type	-	B type

(2) Characteristic

Output current (13.5 V hot at 20°C)	A/rpm	56/5000
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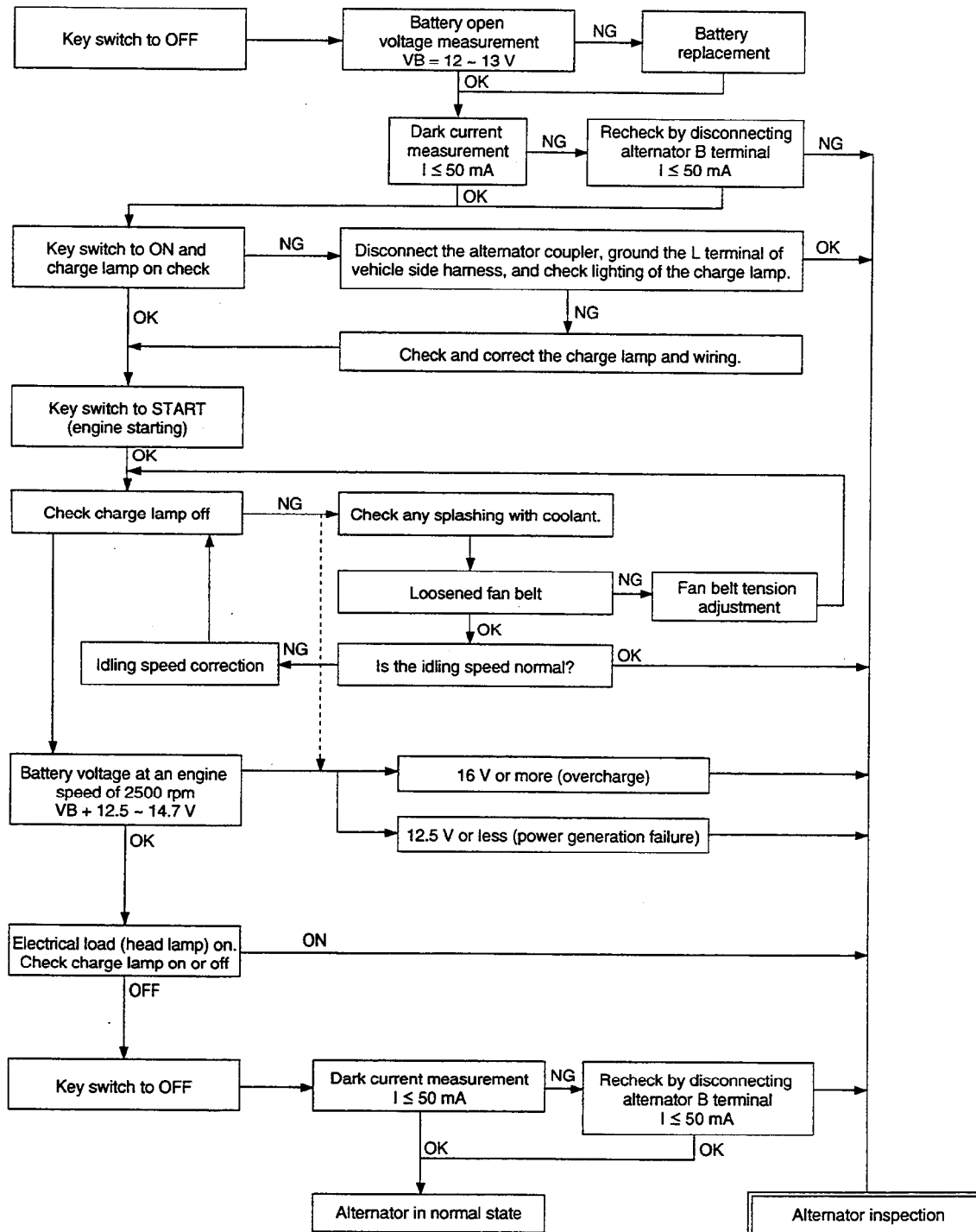
10.2.2 Exploded View



10. Alternator

10.2.3 Troubleshooting

Battery over-discharge, charge lamp on or overcharge



10.2.4 Disassembly Procedure

(1) M5 through bolt

Remove the M5 through bolt. Then raise the temperature at the center of the rear cover by approx. 50°C by blowing with a dryer. Insert the tip end of a flat head screwdriver into the gap between the front cover and stator core (at 2 places) to separate the front side (front cover and rotor) from the rear side (rear cover and stator).

Note: Carefully operate so as not to damage the stator core with the flat head screwdriver.

Dryer conditions

Dryer : 1 to 1.5 kW
 Time : 1 minute
 Distance : From the upper side

(2) Pulley nut assy

(3) Pulley

(4) Rotor

Fix the rotor in a vise, and remove the M16 pulley nut (24 mm). The pulley, front cover and rotor can be removed.

*Parenthesized dimension is the wrench size.

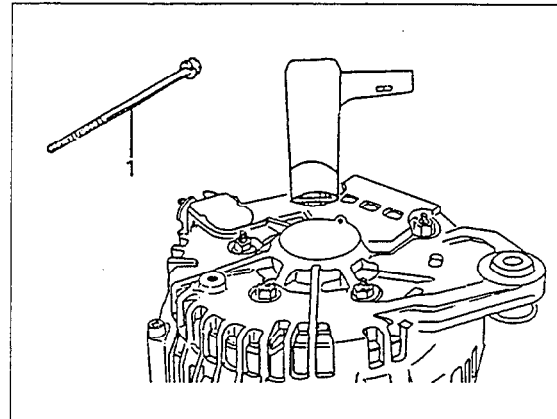


Fig. 21

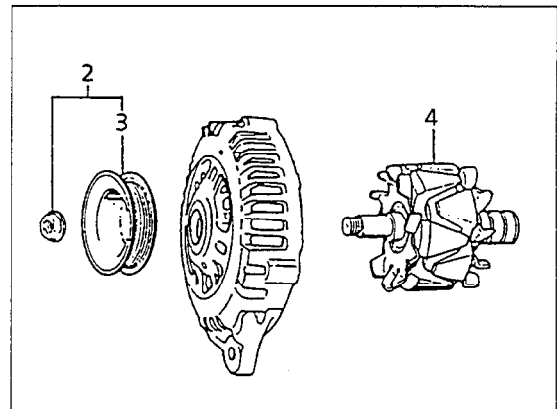


Fig. 22

10.2.5 Inspection and Maintenance

(1) Rotor

a) Slip ring wear limit

Measure the outside diameter of the slip ring. If it is worn by 1 mm or more from the standard dimension, replace the slip ring.

b) Slip ring surface inspection

Outside diameter (mm)

Standard	Limit
27	26

Check the slip ring surface for smoothness and no oil adhesion.

If roughened, correct with a sandpaper, and wipe with cloth wetted with alcohol if stained.

c) Rotor coil continuity check

Use a circuit tester and check continuity between slip rings.

Disconnection in rotor coil:

Replace the rotor.

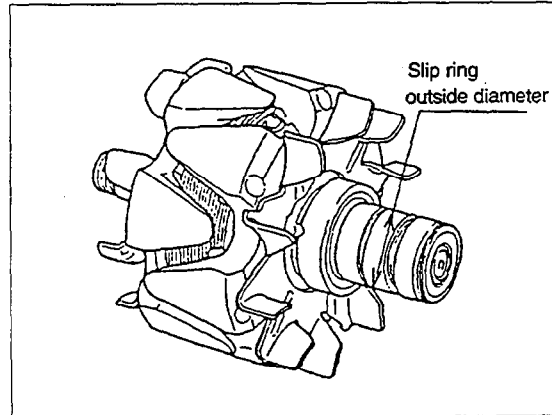


Fig. 23

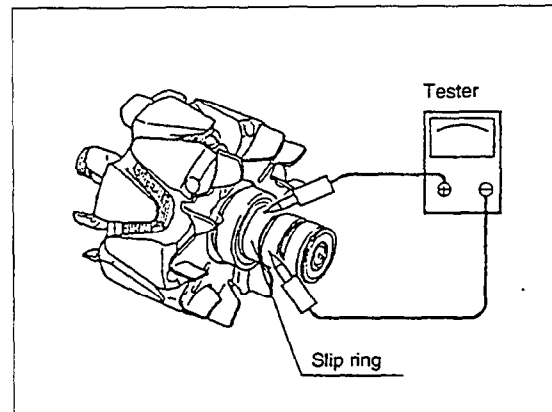


Fig. 24

d) Rotor coil insulation test

Use a circuit tester and check continuity between the slip ring and rotor core or shaft.

Continuity:

Short circuit of rotor coil.
Replace the rotor.

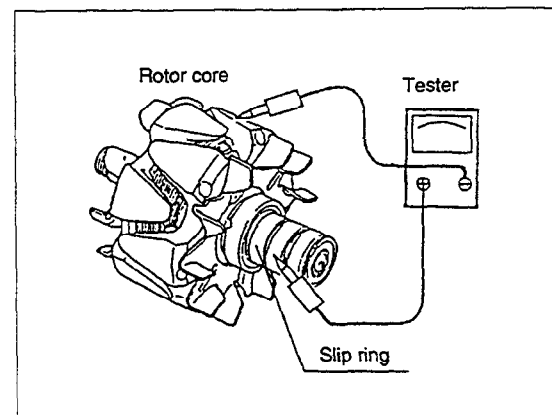


Fig. 25

- e) **Ball bearing inspection**
Inspect the rear side ball bearing. If the rotation is heavy or any abnormal sound is heard, replace the ball bearing.

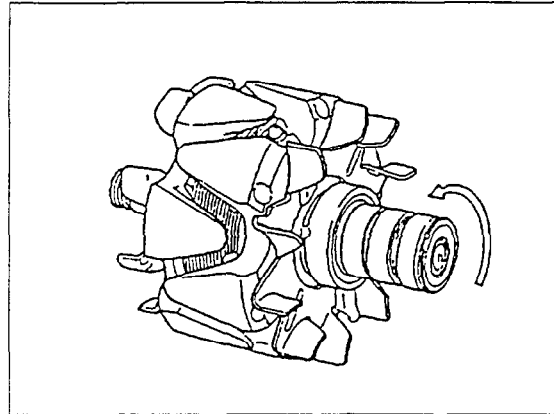


Fig. 26

10.2.6 Reassembly Procedure

Reverse the disassembly procedure with attention paid to the following points:

(1) See section 10.2.2 for the tightening torque of each part.

- 1) Reassembly on front and rear sides
 - a) Always replace the ball bearing on the rear side after disassembling the alternator.
 - b) Two nylon bands are embedded in the outer race of the ball bearing on the rear side with slight protrusion from the outer surface of the bearing. The nylon bands, therefore, will be cut unless the rear bracket is heated as in the case of disassembly.
- c) Insert a pin from the outside of the bracket and push the brush into the brush holder.

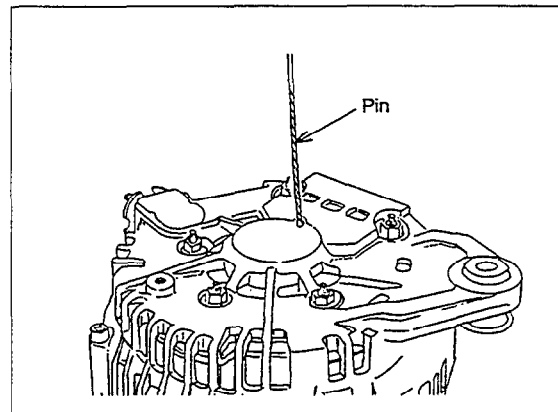


Fig. 27

- d) Before reassembly, raise the temperature at the center of the rear bracket by approx. 50°C (to 70°C or more when the room temperature is 20°C) by blowing with a dryer as in the case of the rear bracket disassembly.

Dryer conditions

- Dryer : 1 to 1.5 kW
Time : 1 minute
Distance : From the upper side

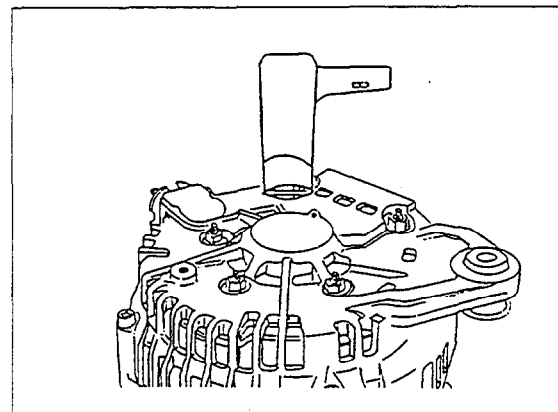


Fig. 28

10. Alternator

- e) Extract the pin after the end of reassembly.

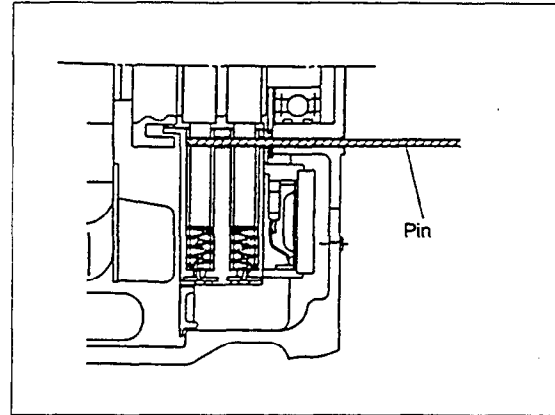
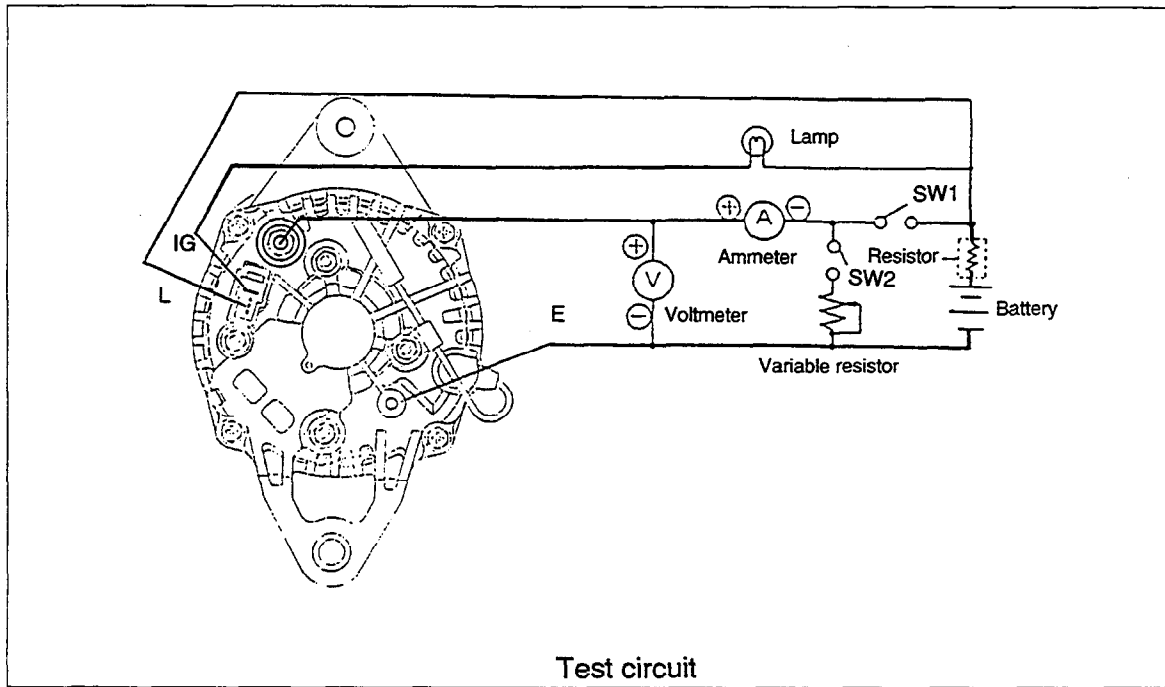


Fig. 29

10.2.7 Performance Test



Note: 0.25 Ω resistor (Connect when the battery is discharged.)

Measuring instruments, etc.

- Voltmeter : 0.5 class DC voltmeter for 0 to 30 V.
- Ammeter : 1 class DC ammeter for 0 to 100 A.
- Variable resistor : 0 to 0.25 Ω , 1 kW variable resistor
- Resistor : 0.25 Ω , 25 W

(1) Regulated voltage measurement

Open SW2 and close SW1 in the test circuit, and measure the voltage after raising the alternator speed to the rated speed (5,000 rpm).

The regulated voltage is normal if it is between 14.1 and 14.7 V.

(2) rpm at 13.5 V

Open SW2 and close SW1 in the test circuit to gradually raise the alternator speed and measure it when the voltmeter indicates 13.5 V.

It is the operating speed at 13.5 V.

The operating speed is normal if it is 1,000 rpm or less.

(3) Output current measurement

Set the variable resistor to the minimum position and close SW1 and SW2 in the test circuit to obtain each alternator output speed. Adjust the variable resistor for a voltmeter reading of 13.5 V, and measure the current.

It is the output current.

(4) Precaution for performance test

a) Use a lead with a sectional area of 8 mm² or more (thick lead) and 2.5 m or less in length for each of connections between the alternator B terminal and battery positive terminal and between E and battery negative terminal.

b) Use switches with small contact resistance in the test circuit.

11. SPECIAL SERVICE TOOLS .. 11-1~11-5

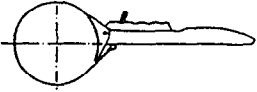
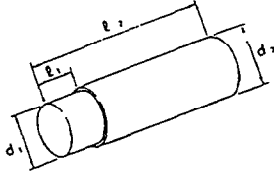
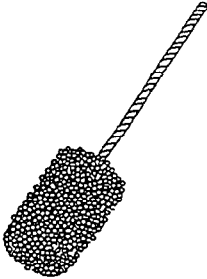
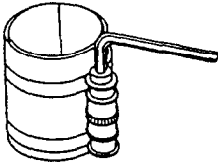

11.1 SPECIAL TOOLS 11-1

11.2 MEASURING INSTRUMENTS..... 11-3

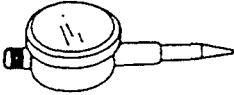
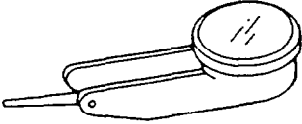
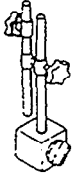
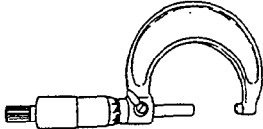
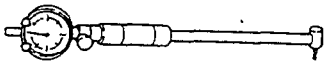

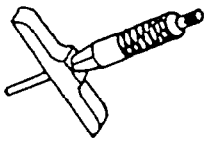
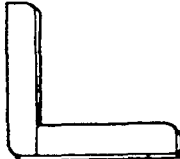
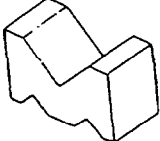
11.1 Special Tools

No.	Tool name	Applicable model and tool size	Illustration															
1	Valve guide tool (for extracting valve guide)	<p>(mm)</p> <table border="1"> <thead> <tr> <th>Applicable model</th> <th>ℓ1</th> <th>ℓ2</th> <th>d1</th> <th>d2</th> </tr> </thead> <tbody> <tr> <td>4TNE94•98</td> <td>20</td> <td>75</td> <td>7.5</td> <td>11</td> </tr> <tr> <td>4TNE106 (T)</td> <td>20</td> <td>75</td> <td>8.5</td> <td>12</td> </tr> </tbody> </table> <p>※ Locally manufactured</p>	Applicable model	ℓ1	ℓ2	d1	d2	4TNE94•98	20	75	7.5	11	4TNE106 (T)	20	75	8.5	12	
Applicable model	ℓ1	ℓ2	d1	d2														
4TNE94•98	20	75	7.5	11														
4TNE106 (T)	20	75	8.5	12														
2	Valve guide tool (for inserting valve guide)	<p>(mm)</p> <table border="1"> <thead> <tr> <th>Applicable model</th> <th>ℓ1</th> <th>ℓ2</th> <th>d1</th> <th>d2</th> </tr> </thead> <tbody> <tr> <td>4TNE94•98</td> <td>15⁰_{-0.3}</td> <td>65</td> <td>13.5</td> <td>20</td> </tr> <tr> <td>4TNE106 (T)</td> <td>13.5⁰_{-0.3}</td> <td>65</td> <td>14</td> <td>20</td> </tr> </tbody> </table> <p>※ Locally manufactured</p>	Applicable model	ℓ1	ℓ2	d1	d2	4TNE94•98	15 ⁰ _{-0.3}	65	13.5	20	4TNE106 (T)	13.5 ⁰ _{-0.3}	65	14	20	
Applicable model	ℓ1	ℓ2	d1	d2														
4TNE94•98	15 ⁰ _{-0.3}	65	13.5	20														
4TNE106 (T)	13.5 ⁰ _{-0.3}	65	14	20														
3	Connecting rod bushing replacer (for removal/ installation of connecting rod bushing)	<p>(mm)</p> <table border="1"> <thead> <tr> <th>Applicable model</th> <th>ℓ1</th> <th>ℓ2</th> <th>d1</th> <th>d2</th> </tr> </thead> <tbody> <tr> <td>4TNE94•98</td> <td>20</td> <td>100</td> <td>30^{0.3}_{-0.6}</td> <td>33^{0.3}_{-0.6}</td> </tr> <tr> <td>4TNE106 (T)</td> <td>20</td> <td>100</td> <td>37^{0.3}_{-0.6}</td> <td>40^{0.3}_{-0.6}</td> </tr> </tbody> </table> <p>※ Locally manufactured</p>	Applicable model	ℓ1	ℓ2	d1	d2	4TNE94•98	20	100	30 ^{0.3} _{-0.6}	33 ^{0.3} _{-0.6}	4TNE106 (T)	20	100	37 ^{0.3} _{-0.6}	40 ^{0.3} _{-0.6}	
Applicable model	ℓ1	ℓ2	d1	d2														
4TNE94•98	20	100	30 ^{0.3} _{-0.6}	33 ^{0.3} _{-0.6}														
4TNE106 (T)	20	100	37 ^{0.3} _{-0.6}	40 ^{0.3} _{-0.6}														
4	Valve spring compressor (for removal/ installation of valve spring)	<table border="1"> <tr> <td>Yanmar code No.</td> </tr> <tr> <td>129100-92630</td> </tr> </table>	Yanmar code No.	129100-92630														
Yanmar code No.																		
129100-92630																		
5	Stem seal inserter (for inserting stem seal)	<p>(mm)</p> <table border="1"> <thead> <tr> <th>Applicable model</th> <th>ℓ1</th> <th>ℓ2</th> <th>d1</th> <th>d2</th> </tr> </thead> <tbody> <tr> <td>4TNE94•98</td> <td>21±0.5</td> <td>65</td> <td>16.5</td> <td>23</td> </tr> <tr> <td>4TNE106 (T)</td> <td>17.5±0.5</td> <td>65</td> <td>17</td> <td>23</td> </tr> </tbody> </table> <p>※ Locally manufactured</p>	Applicable model	ℓ1	ℓ2	d1	d2	4TNE94•98	21±0.5	65	16.5	23	4TNE106 (T)	17.5±0.5	65	17	23	
Applicable model	ℓ1	ℓ2	d1	d2														
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4TNE106 (T)	17.5±0.5	65	17	23														

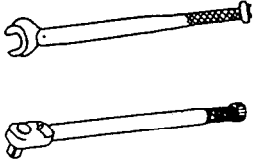
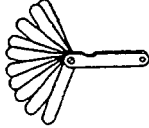
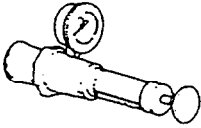
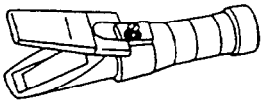
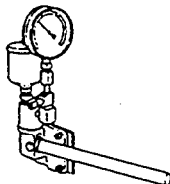
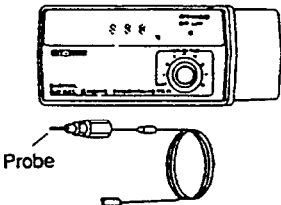
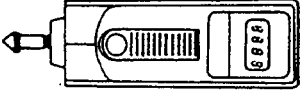
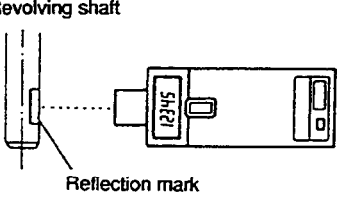
11. Special Service Tools

No.	Tool name	Applicable model and tool size	Illustration															
6	Filter wrench (for removal/installation of L.O. filter)	Available on the market																
7	Camshaft bushing tool (for extracting camshaft bushing)	<p style="text-align: right;">(mm)</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Applicable model</th> <th>ℓ1</th> <th>ℓ2</th> <th>d1</th> <th>d2</th> </tr> </thead> <tbody> <tr> <td>4TNE94•98</td> <td>18</td> <td>70</td> <td>50^{-0.3}_{-0.6}</td> <td>53^{-0.3}_{-0.6}</td> </tr> <tr> <td>4TNE106 (T)</td> <td>18</td> <td>70</td> <td>58^{-0.3}_{-0.6}</td> <td>61^{-0.3}_{-0.6}</td> </tr> </tbody> </table> <p style="text-align: center;">※ Locally manufactured</p>	Applicable model	ℓ1	ℓ2	d1	d2	4TNE94•98	18	70	50 ^{-0.3} _{-0.6}	53 ^{-0.3} _{-0.6}	4TNE106 (T)	18	70	58 ^{-0.3} _{-0.6}	61 ^{-0.3} _{-0.6}	
Applicable model	ℓ1	ℓ2	d1	d2														
4TNE94•98	18	70	50 ^{-0.3} _{-0.6}	53 ^{-0.3} _{-0.6}														
4TNE106 (T)	18	70	58 ^{-0.3} _{-0.6}	61 ^{-0.3} _{-0.6}														
8	Flex-Hone (for re-honing of cylinder liner)	<p style="text-align: right;">(mm)</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Applicable engine model</th> <th>Yanmar code No.</th> <th>Applicable bore</th> </tr> </thead> <tbody> <tr> <td>4TNE94</td> <td>129400-92430</td> <td>83-95</td> </tr> <tr> <td>4TNE98</td> <td>129400-92440</td> <td>89-101</td> </tr> <tr> <td>4TNE106(T)</td> <td>129400-92450</td> <td>95-108</td> </tr> </tbody> </table>	Applicable engine model	Yanmar code No.	Applicable bore	4TNE94	129400-92430	83-95	4TNE98	129400-92440	89-101	4TNE106(T)	129400-92450	95-108				
Applicable engine model	Yanmar code No.	Applicable bore																
4TNE94	129400-92430	83-95																
4TNE98	129400-92440	89-101																
4TNE106(T)	129400-92450	95-108																
9	Piston insertion tool (for inserting piston)	<table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td style="text-align: center;">Yanmar code No.</td> </tr> <tr> <td style="text-align: center;">95550-002476</td> </tr> </table> <p style="text-align: center;">※ The above piston insertion tool is applicable to 60 ~ 125-mm diameter pistons.</p>	Yanmar code No.	95550-002476														
Yanmar code No.																		
95550-002476																		
10	Piston ring replacer (for removal/installation of piston ring))	Available on the market																

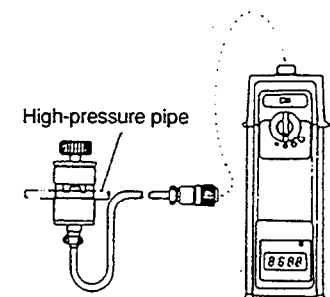
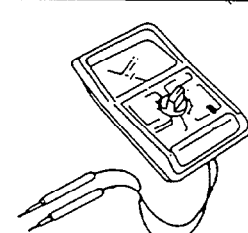
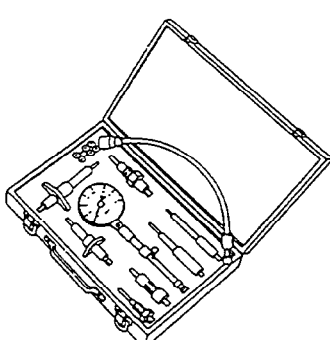
11.2 Measuring Instruments

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

11. Special Service Tools

No.	Instrument name	Application	Illustration
10	Torque wrench	For tightening nuts and bolts to the specified torque	
11	Thickness gage	For measuring gaps between ring and ring groove, and shaft joints during assembly	
12	Cap tester	For checking water leakage	
13	Battery coolant tester	For checking concentration of antifreeze and the battery electrolyte charge status	
14	Nozzle tester	For measuring injection spray pattern of fuel injection nozzle and injection pressure	
15	Digital thermometer	For measuring temperatures	
16	Contact type	For measuring revolution by contacting the mortise in the revolving shaft	
	Photoelectric type	For measuring revolution by sensing the reflecting mark on the outer periphery of the revolving shaft	

11. Special Service Tools

No.	Instrument name	Application	Illustration
16	Speedometer Fuel high-pressure pipe clamp type	Measures the revolution regardless of the center or periphery of the revolving object.	
17	Circuit tester	For measuring resistance, voltage and continuity of electrical circuits	
18	Compression gage kit	For measuring compression pressure <div style="border: 1px solid black; padding: 5px; margin: 10px auto; width: fit-content;"> Yanmar code No. TOL-97190080 </div>	

12. SERVICE STANDARDS 12-1~12-7

12.1	ENGINE TUNING	12-1
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12.1 Engine Tuning

No.	Inspection item		Standard		Limit	Reference page
1	Gap at intake/exhaust valve heads	mm	4TNE94•98	0.15~0.25	—	3-3
			4TNE106(T)	0.25~0.35	—	
2	V-belt tension 98N finger pressure (10 kgf)	New part	mm	7~9	—	3-2
		Used part	mm	10~15	—	
3	Fuel injection pressure	MPa(kgf/cm ²)		21.57~22.55 (220~230)	—	3-4
4	Fuel injection timing (FID) degrees (bTDC)		4TNE94•98	10~12	—	3-8
			4TNE106	13~15	—	
			4TNE106T	11~13	—	
5	Compression (at 250 rpm)	Mpa(kgf/cm ²)	4TNE94•98	3.43 (35)±1	2.75 (28)	2-5
			4TNE106 (T)			
6	Cooling water capacity	ℓ	4TNE94•98	4.2	—	3-1
			4TNE106(T)	6.0	—	
7	Lubricating oil capacity (oil pan)	ℓ	—	Total	Effective	—
			4TNE94•98	10.2	4.5	—
			4TNE106 (T)	12.5	5.5	—
8	Lubricating oil pressure	MPa (kgf/cm ²)	—	At rated output	At idling	—
			4TNE94•98	0.29(3.0)~0.39(4.0)	0.06(0.6) or above	—
			4TNE106 (T)	0.44(4.5)~0.54(5.5)	0.06(0.6) or above	—
9	Oil pressure switch operating pressure	MPa (kgf/cm ²)		0.05 (0.5±0.1)	—	—
10	Thermostat valve opening temperature	°C	4TNE94•98	71~85	—	3-10
			4TNE106 (T)	82~95	—	
11	Thermoswitch actuating temperature	°C		107~113	—	

12. Service Standards

12.2 Engine Body

(1) Cylinder head

(1.1) Cylinder head

Inspection item				Standard	Limit	Reference page
Combustion surface distortion mm				Max. 0.05	0.15	4-5
Valve sink mm	4TNE94•98	Intake	0.5 ~ 0.7	1.0		
		Exhaust	0.6 ~ 0.8	1.1		
	4TNE106 (T)	Intake	0.7 ~ 0.9	1.2		
		Exhaust	0.9 ~ 1.1	1.4		
Valve seat	Seat angle Deg.	Intake	120	-	4-9	
		Exhaust	90	-		
	Seat correction angle Deg.	40, 150	-			

(1.2) Intake/exhaust valve and guide

Inspection item				Standard	Limit	Reference page
4TNE9498	Intake	Guide inside diameter mm	8.015 ~ 8.030	8.100	4-6	
		Valve stem outside diameter mm	7.965 ~ 7.980	7.915		
		Clearance mm	0.035 ~ 0.065	0.185		
	Exhaust	Guide inside diameter mm	8.015 ~ 8.030	8.100		
		Valve stem outside diameter mm	7.955 ~ 7.970	7.905		
		Clearance mm	0.045 ~ 0.075	0.195		
4TNE106 (T)	Intake	Guide inside diameter mm	9.000 ~ 9.015	9.085	4-10	
		Valve stem outside diameter mm	8.950 ~ 8.965	8.900		
		Clearance mm	0.035 ~ 0.065	0.185		
	Exhaust	Guide inside diameter mm	9.000 ~ 9.015	9.085		
		Valve stem outside diameter mm	8.940 ~ 8.955	8.890		
		Clearance mm	0.045 ~ 0.075	0.195		
Valve guide projection from cylinder head mm		4TNE94•98	14.7~15.0	-	4-10	
		4TNE106 (T)	13.2~13.5	-		
Valve guide driving-in method				Cold-fitted	-	

(1.3) Valve spring

Inspection item				Standard	Limit	Reference page
Free length mm	4TNE94•98	47.5	-	4-7		
	4TNE106 (T)	50.6	-			
Inclination mm				-	1.2	

(1.4) Rocker arm and shaft

Inspection item		Standard	Limit	Reference page
Arm shaft hole diameter	mm	18.50 ~ 18.52	18.57	4-8
Shaft outside diameter	mm	18.47 ~ 18.49	18.44	
Clearance	mm	0.01 ~ 0.05	0.13	

(1.5) Push rod

Inspection item		Standard	Limit	Reference page
Bend	mm	—	0.03	4-8

(2) Gear train and camshaft

(2.1) Camshaft

Inspection item		Standard	Limit	Reference page	
Side gap	mm	0.05 ~ 0.20	0.30	4-13	
Bending (1/2 the dial gage reading)	mm	0 ~ 0.02	0.05	4-14	
Cam height	mm	4TNE94•98	42.435 ~ 42.565		42.185
		4TNE106 (T)	49.435 ~ 49.529		49.185
Shaft outside diameter • Metal outside diameter				mm	
4TNE94•98	Gear side	Bushing inside diameter	49.990 ~ 50.055	50.130	4-15
		Camshaft outside diameter	49.925 ~ 49.950	49.890	
		Clearance	0.040 ~ 0.130	0.240	
	Intermediate	Block inside diameter	50.000 ~ 50.025	50.100	
		Camshaft outside diameter	49.910 ~ 49.935	49.875	
		Clearance	0.065 ~ 0.115	0.225	
	Wheel side	Block inside diameter	50.000 ~ 50.025	50.100	
		Camshaft outside diameter	49.925 ~ 49.950	49.890	
		Clearance	0.050 ~ 0.100	0.210	
4TNE106(T)	Gear side	Bushing inside diameter	57.980 ~ 58.050	58.105	
		Camshaft outside diameter	57.910 ~ 57.940	57.875	
		Clearance	0.040 ~ 0.140	0.250	
	Intermediate	Block inside diameter	58.000 ~ 58.030	58.105	
		Camshaft outside diameter	57.895 ~ 57.925	57.860	
		Clearance	0.075 ~ 0.135	0.245	
	Wheel side	Block inside diameter	58.000 ~ 58.030	58.105	
		Camshaft outside diameter	57.910 ~ 57.940	57.875	
		Clearance	0.050 ~ 0.120	0.230	

12. Service Standards

(2.2) Idle gear shaft and bushing

Inspection item		Standard	Limit	Reference page
Shaft outside diameter	mm	45.950 ~ 49.975	45.900	4-15
Bushing inside diameter	mm	46.000 ~ 46.025	46.075	
Clearance	mm	0.025 ~ 0.075	0.175	

(2.3) Backlash of each gear

Inspection item		Standard	Limit	Reference page
Crank gear, cam gear, idle gear, fuel injection pump gear and PTO gear		0.08 ~ 0.14	0.16	4-12
Lubricating oil pump gear		0.09 ~ 0.15	0.17	

(3) Cylinder block

(3.1) Cylinder block

Inspection item		Standard	Limit	Reference page
Cylinder inside diameter	mm	4TNE94	94.000 ~ 94.030	4-21
		4TNE98	98.000 ~ 98.030	
		4TNE106 (T)	106.000 ~ 106.030	
Cylinder bore	Roundness	0.01 or less		
	Inclination	0.03		

(3.2) Crankshaft

Inspection item			Standard	Limit	Reference page	
Bending (1/2 the dial gage reading)		mm	—	0.02		
Crank pin	mm	4TNE94•98	Pin outside diameter	57.952 ~ 57.962	57.902	4-23
			Metal thickness	1.492 ~ 1.500	—	
			Clearance	0.038 ~ 0.074	0.150	
	4TNE106 (T)	Pin outside diameter	63.952 ~ 63.962	63.902		
		Metal thickness	1.984 ~ 1.992	—		
		Clearance	0.054 ~ 0.090	0.150		
Crank journal	mm	4TNE94•98	Pin outside diameter	64.952 ~ 64.962	64.902	
			Metal thickness	1.995 ~ 2.010	—	
			Clearance	0.038 ~ 0.068	0.150	
	4TNE106 (T)	Pin outside diameter	75.952 ~ 75.962	75.902		
		Metal thickness	2.488 ~ 2.503	—		
		Clearance	0.052 ~ 0.090	0.150		

(3.3) Thrust bearing

Inspection item		Standard	Limit	Reference page
Crankshaft side gap	mm	4TNE94•98	0.11 ~ 0.21	4-19
		4TNE106 (T)	0.13 ~ 0.23	

(3.4) Piston and ring

Inspection item		Standard	Limit	Reference page	
Piston outside diameter mm (Measure in the direction vertical to the piston pin.)	4TNE94	93.945 ~ 93.955	93.900	4-25	
	4TNE98	97.945 ~ 97.955	97.900		
	4TNE106 (T)	105.930 ~ 105.960	105.880		
Piston outside diameter measure mm position (Upward from the bottom end of the piston)	4TNE94•98	22	-		
	4TNE106 (T)	30	-		
Piston pin mm	4TNE94•98	Hole inside diameter	30.000 ~ 30.009	30.039	4-26
		Pin outside diameter	29.989 ~ 30.000	29.959	
		Clearance	0.000 ~ 0.020	0.080	
	4TNE106(T)	Hole inside diameter	37.000 ~ 37.011	37.039	
		Pin outside diameter	36.989 ~ 37.000	36.959	
		Clearance	0.000 ~ 0.022	0.080	
Piston ring				mm	
4TNE94•98	Top ring	Ring groove width	2.040 ~ 2.060	-	4-27
		Ring width	1.940 ~ 1.960	1.920	
		Side clearance	0.080 ~ 0.120	-	
		End clearance	0.250 ~ 0.450	0.540	
	Second ring	Ring groove width	2.080 ~ 2.095	2.195	
		Ring width	1.970 ~ 1.990	1.950	
		Side clearance	0.090 ~ 0.125	0.245	
		End clearance	0.450 ~ 0.650	0.730	
	Oil ring	Ring groove width	3.015 ~ 3.030	3.130	
		Ring width	2.970 ~ 2.990	2.950	
		Side clearance	0.025 ~ 0.060	0.180	
		End clearance	0.250 ~ 0.450	0.550	
4TNE106(T)	Top ring	Ring groove width	2.520 ~ 2.540	-	
		Ring width	2.440 ~ 2.460	2.420	
		Side clearance	0.060 ~ 0.100	-	
		End clearance	0.300 ~ 0.450	0.540	
	Second ring	Ring groove width	2.070 ~ 2.085	2.185	
		Ring width	1.970 ~ 1.990	1.950	
		Side clearance	0.080 ~ 0.115	0.235	
		End clearance	0.450 ~ 0.600	0.680	
	Oil ring	Ring groove width	3.015 ~ 3.030	3.130	
		Ring width	2.970 ~ 2.990	2.950	
		Side clearance	0.025 ~ 0.060	0.180	
		End clearance	0.300 ~ 0.500	0.600	

12. Service Standards :rds

(3.5) Connecting

Inspection item		Standard	Limit	Reference page
Thrust clearance mm		0.2 ~ 0.4	—	4-18
Rod		mm		
4TNE94•98	Bushing inside diameter	30.025 ~ 30.038	30.068	4-28
	Pin outside diameter	29.987 ~ 30.000	29.959	
	Clearance	0.025 ~ 0.051	0.109	
4TNE106(T)	Bushing inside diameter	37.025 ~ 37.038	37.068	
	Pin outside diameter	36.989 ~ 37.000	36.961	
	Clearance	0.025 ~ 0.049	0.107	

(3.6) Tappet

Inspection item		Standard	Limit	Reference page
4TNE94•98	Tappet hole (block) inside diameter mm	12.000 ~ 12.018	12.038	4-29
	Tappet stem outside diameter mm	11.975 ~ 11.990	11.955	
	Clearance mm	0.010 ~ 0.043	0.083	
4TNE106(T)	Tappet hole (block) inside diameter mm	14.000 ~ 14.018	14.038	
	Tappet stem outside diameter mm	13.966 ~ 13.984	13.946	
	Clearance mm	0.015 ~ 0.052	0.092	

12.3 Lubricating Oil System (Trochoid Pump)

Inspection item		Standard	Limit	Reference page
Clearance between outer rotor and gear case mm	4TNE94•98	0.100 ~ 0.155	0.25	5-2
	4TNE106 (T)	0.100 ~ 0.165	—	
Side clearance mm		0.05 ~ 0.10	0.15	
Rotorshaft mm	Bearing inside diameter (gear case)	12.980 ~ 13.020	13.050	
	Shaft outer diameter	12.955 ~ 12.970	12.945	
	Clearance	0.010 ~ 0.065	0.105	

12.4 Tightening Torques for Main Bolts and Nuts

Tightening position		Thread diameter × pitch (mm)	Tightening torque Nm (kgf·m)	Lubricating oil application (threaded portion, and bearing seat surface)	Reference page
Cylinder head bolt	4TNE94•98	M11 × 1.25	102.9 ~ 112.7 (10.5 ~ 11.5)	Necessary	4-4
	4TNE106 (T)	M13 × 1.5	181.4 ~ 191.2 (18.5 ~ 19.5)		
Connecting rod bolt	4TNE94•98	M10 × 1.0	53.9 ~ 58.8 (5.5 ~ 6.0)	Necessary	4-18
	4TNE106 (T)	M11 × 1.0	78.5 ~ 83.4 (8.0 ~ 8.5)		
Flywheel set bolt		M14 × 1.5	186.3 ~ 205.9 (19 ~ 21)	Necessary	4-13
Bearing cap set bolt	4TNE94•98	M11 × 1.25	107.9 ~ 117.7 (11.0 ~ 12.0)	Necessary	4-19
	4TNE106 (T)	M14 × 1.5	186.3 ~ 205.9 (19 ~ 21)		
Crankshaft pulley set bolt		M14 × 1.5	107.9 ~ 127.5 (11 ~ 13)	Necessary	4-12
Fuel valve set bolt		M6 × 1.0	6.9 ~ 8.8 (0.7 ~ 0.9)	Unnecessary	—
Fuel pump drive gear set nut		M14 × 1.5	83.4 ~ 93.2 (8.5 ~ 9.5)	Unnecessary	4-12

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