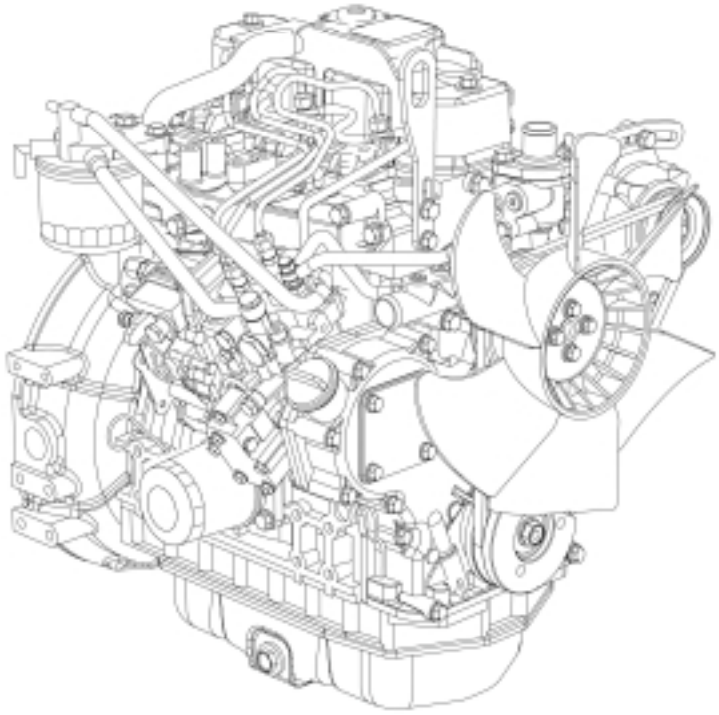
Ingersoll-Rand Engine Workshop Manual



Model Series

3IRH2N 3IRH8N
4IRH8N 4IRI8N
4IRI8T

Ingersoll-Rand
Portable Power
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P/N 22333660 (8/03)

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PREFACE

This manual describes the service procedures for the IR series engines of direct injection system that have been certified by the US EPA, California ARB and/or the 97/68/EC Directive 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 without notice. If any modification of the contents described herein becomes necessary, it will be notified in the form of correction information each time.

SAFETY LABELS

- 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.

- **NOTICE**-indicates that if not observed, the product performance or quality may not be guaranteed.

Safety Precautions

1. SERVICE AREA

⚠ WARNING

- **Sufficient Ventilation**

Inhalation of exhaust fumes and dust particles may be hazardous to ones health. Running engines welding, sanding, painting, and polishing tasks should be only done in well-ventilated areas.

⚠ CAUTION

- **Safe / Adequate Work Area**

The service area should be clean, spacious, level and free from holes in the floor, to prevent “slip” or “trip and fall” type accidents.

⚠ CAUTION

- **Bright, Safely Illuminated Area**

The work area should be well lit or illuminated in a safe manner. For work in enclosed or dark areas, a “drop cord” should be utilized. The drop cord must have a wire cage to prevent bulb breakage and possible ignition of flammable substances.

⚠ CAUTION

- **Safety Equipment**

Fire extinguisher(s), first aid kit and eye wash / shower station should be close at hand (or easily accessible) in case of an emergency.

2. WORK – WEAR (GARMENTS

- Safe Work Clothing

Appropriate safety wear (gloves, special shoes/boots, eye/ear protection, head gear, harness', clothing, etc.) should be used/worn to match the task at hand. Avoid wearing jewelry, unbuttoned cuffs, ties or loose fitting clothes around moving machinery. *A serious accident may occur if caught in moving/rotating machinery.*

3. TOOLS

- Appropriate Lifting / Holding

When lifting an engine, use only a lifting device (crane, jack, etc.) with sufficient lifting capacity. Do not overload the device. Use only a chain, cable, or lifting strap as an attaching device. Do not use rope, serious injury may result.
To hold or support an engine, secure the engine to a support stand, test bed or test cart designed to carry the weight of the engine. Do not overload this device, serious injury may result
Never run an engine without being properly secured to an engine support stand, test bed or test cart, serious injury may result.

- Appropriate Tools

Always use tools that are designed for the task at hand. Incorrect usage of tools may result in damage to the engine and or serious personal injury.

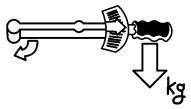
4. GENUINE PARTS and MATERIALS

- Genuine Parts

Always use genuine INGERSOLL-RAND parts or INGERSOLL-RAND recommended parts and goods. Damage to the engine, shortened engine life and or personal injury may result.

5. FASTENER TORQUE

⚠ WARNING



- Torqueing Fasteners

Always follow the torque values and procedures as designated in the service manual. Incorrect values, procedures and or tools may cause damage to the engine and or personal injury.

6. Electrical

⚠ WARNING

- Short Circuits

Always disconnect the (-) Negative battery cable before working on the electrical system. An accidental “short circuit” may cause damage, fire and or personal injury. Remember to connect the (-) Negative battery cable (back onto the battery) LAST

⚠ WARNING

- Charging Batteries

Charging wet celled batteries produces hydrogen gas. Hydrogen gas is extremely explosive. Keep sparks, open flame and any other form of ignition away. Explosion may occur causing severe personal injury.

⚠ WARNING

- Battery Electrolyte

Batteries contain sulfuric acid. Do NOT allow it to come in contact with clothing, skin and or eyes, severe burns will result.

7. WASTE MANAGEMENT

⚠ CAUTION

Observe the following instructions with regard to hazardous waste disposal. Negligence of these will have a serious impact on environmental pollution concerns.

- Waste fluids such as lube oil, fuel and coolant shall be carefully put into separate sealed containers and disposed of properly.
- Do NOT dispose of waste materials irresponsibly by dumping them into the sewer, overland or into natural waterways.
- Waste materials such as oil, fuel, coolant, solvents, filter elements and batteries, must be disposed of properly according to local ordinances. Consult the local authorities or reclamation facility.

8. FURTHER PRECAUTIONS

- Fueling / Refueling

Keep sparks, open flames or any other form of ignition (match, cigarette, etc.) away when fueling/refueling the unit. *Fire and or an explosion may result.*

- Hot Surfaces.

Do NOT touch the engine (or any of its components) during running or shortly after shutting it down. *Scalding / serious burns may result.* Allow the engine to cool down before attempting to approach the unit.

- Rotating Parts

Be careful around moving/rotating parts. Loose clothing, jewelry, ties or tools may become entangled causing damage to the engine and or severe personal injury.

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.

- Preceding service date
- Period/operation hours after preceding service
- Problems and actions in preceding service
- Replacement parts expected to be required for service
- Recording form/check sheet required for service

3.Preparation before Disassembly

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

4.Precautions in Disassembly

- Each time a parts is removed, check the part installed state, deformation, damage, roughening, surface defect, etc.
- Arrange the removed parts orderly with clear distinction between those to be replaced and those to be used again.
- Parts to be used again shall be washed and cleaned sufficiently.
- 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

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

6.Precautions for Reassembly

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

7.Precautions for Adjustment and Check

Use measuring instruments for adjustment to the specified service standards.

How to Read this Manual

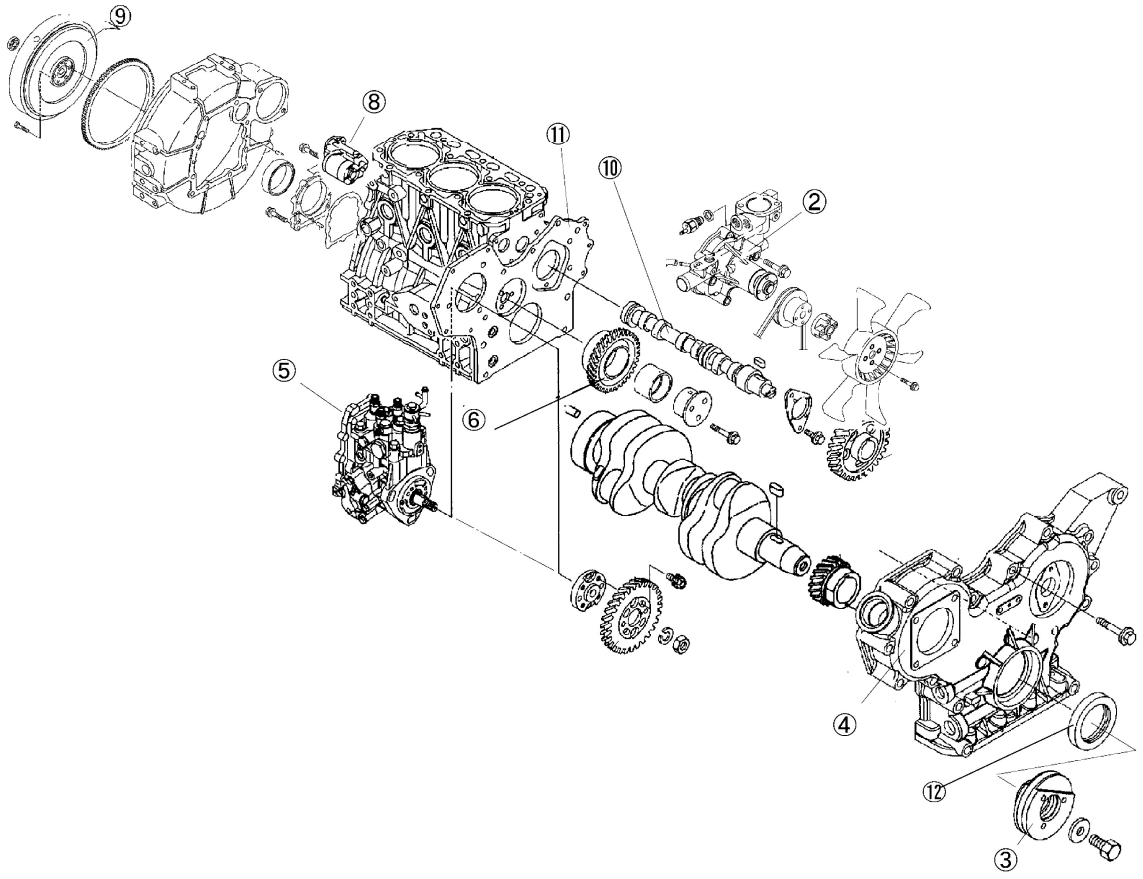
(1) Range of Operation Explanation

This manual explains the troubleshooting, installation/removal, replacement, disassemble/reassembly, inspection, adjustment and adjusting operation procedures for the IR series engines with direct injection system.
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

- 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.
- For the removal/installation of each part, the procedure is shown with the procedural step No. in the illustration.
- 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



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

- Disassembly procedure

1) Follow steps (1) to (15) of the cylinder head disassembly procedure.
2) Remove the cooling water pump.
3) Remove the crankshaft pulley. (**Point 1**) ←Operation point to be explained on a later page.

- Operation points

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

- 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.

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

CONTENTS

1.General

1.1Engine Nomenclature

4 IR H8 N

4= Number of cylinders

IR= Ingersoll-Rand

H8= Cylinder bore (in mm)

N= Natural aspirated

T= With turbocharger

The engine specification class

Classification	Load	Engine speed	Available engine speed (min^{-1})
CL	Constant load	Constant speed	1500/1800
VM	Variable load	Variable speed	2000-3000

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

1.2 Specifications

NOTE:

1) The information described in the engine specifications tables (the next page and after) is for "standard" engine. To obtain the information for the engine installed in each machine unit, refer to the manual provided by the equipment manufacturer.

2) Engine rating conditions are as follows (SAE J1349, ISO 3046/1)

- Atmospheric condition: Room temp. 25°C, Atmospheric press. 100 kPa (750mm Hg), Relative humidity 30%
- Fuel temp: 25°C (Fuel injection pump inlet)
- With cooling fan, air cleaner, exhaust silencer (Ingersoll-Rand standard parts)
- After running-in hours. Output allowable deviation: ±3%

1.3IRH2N

Engine name		Unit	3IRH2N								
Engine specification class		-	CL	VM							
Type		-	Vertical, in-line, 4-cycle, water-cooled diesel engine								
Combustion chamber		-	Direct injection								
Number of cylinders		-	3								
Cylinder bore x stroke		mmxmm	82x84								
Displacement		L	1.331								
Continuous rating	Revolving speed	Min^{-1}	1500	1800	-						
	Output	kW (hp)	9.9 (13.5)	12.0 (16.3)	-						
Rated output	Revolving speed	Min^{-1}	1500	1800	2000	2200	2400	2500	2600	2800	3000
	Output	kW (hp)	11.0 (14.9)	13.2 (17.9)	14.6 (19.9)	16.0 (21.8)	17.5 (23.8)	18.2 (24.8)	19.0 (25.8)	20.4 (27.8)	21.9 (29.8)
Max. speed at non-load (±25)		min^{-1}	1600	1895	2205	2420	2615	2725	2810	2995	3210
Ignition order		-	1-3-2-1(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 or CF								
Lubricant capacity (oil pan) *	Total	L	3.6							5.5	
	Effective	L	1.2							2.2	
Cooling water capacity (engine only)		L	1.8								
Engine Dimensions ** (with flyw Crankshaft V pulley diameter & heel housing)	Overall length	mm	553	528							
	Overall width	mm	489								
	Overall height	mm	565								
Engine mass (dry) ** (with flywheel housing)		kg	138	128							
Cooling fan (std.)		mm	335 mm O/D, 6 blades pusher type								
Fan V pulley diameter (std.)		mm	120x90	110x110							

* Engine oil capacity may differ from the above depending on an engine installed on a machine unit.
** Engine mass and dimensions without radiator

2.3IRH8N

Engine name		Unit	3IRH8N							
Engine specification class		-	CL	VM						
Type		-	Vertical, in-line, 4-cylinder, water-cooled diesel engine							
Combustion chamber		-	Direct injection							
Number of cylinders		-	3							
Cylinder bore x stroke		mmxmm	88x90							
Displacement		L	1.642							
Continuous rating	Revolving speed	Min^{-1}	1500	1800	-					
	Output	kW (hp)	12.3 (16.7)	14.8 (20.1)	-					
Rated output	Revolving speed	Min^{-1}	1500	1800	2000	2200	2400	2500	2600	2800	3000
	Output	kW (hp)	13.5 (18.4)	16.3 (22.1)	18.0 24.5)	19.9 (27.0)	21.6 (29.4)	22.6 (30.7)	23.5 (31.9)	25.2 (34.2)	27.1 (36.8)
Max. speed at non-load (±25)		min^{-1}	1600	1895	2205	2420	2615	2725	2810	2995	3210
Ignition order		-	1-3-2-1(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 or CF							
Lubricant capacity (oil pan) *	Total	L	4.7							7.2
	Effective	L	1.8							3.5
Cooling water capacity (engine only)		L	2.0							
Engine dimensions ** (with flywheel housing)	Overall length	mm	589	564						
	Overall width	mm	486							
	Overall height	mm	622							
Engine mass (dry) ** (with flywheel housing)		kg	155							
Cooling fan (std.)		Mm	350 mm O/D, 6 blades pusher type							
Crankshaft V pulley diameter & Fan V pulley diameter (std.)		Mm	120x90	120x90						

* Engine oil capacity may differ from the above depending on an engine installed on a machine unit.

** Engine mass and dimensions without radiator

3.4IRH8N

Engine name		Unit	4IRH8N								
Engine specification class		-	CL	VM							
Type		-	Vertical, in-line, 4-cylinder, water-cooled diesel engine								
Combustion chamber		-	Direct injection								
Number of cylinders		-	4								
Cylinder bore x stroke		mmxmm	88x90								
Displacement		L	2.190								
Continuous rating	Revolving speed	Min^{-1}	1500	1800	-						
	Output	kW (hp)	16.4 (22.3)	19.6 (26.7)	-						
Rated output	Revolving speed	Min^{-1}	1500	1800	2000	2200	2400	2500	2600	2800	3000
	Output	kW (hp)	18.0 (24.5)	21.6 (29.4)	24.1 (32.7)	26.5 (36.0)	28.8 (39.2)	30.1 (40.9)	31.3 (42.5)	33.7 (45.8)	35.4 (48.1)
Max. speed at non-load (±25)		min^{-1}	1600	1895	2205	2420	2615	2725	2810	2995	3210
Ignition order		-	1-3-4-2-1(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 or CF								
Lubricant capacity (oil pan) *	Total	L	5.8								8.6
	Effective	L	2.3								4.2
Cooling water capacity (engine only)		L	2.7								
Engine dimensions ** (with wheel housing)	Overall length	mm	683	658							
	Overall width	mm	498.5								
	Overall height	mm	618								
Engine mass (dry) ** (with flywheel housing)		kg	183	170							
Cooling fan (std.)		mm	370 mm O/D, 6 blades pusher type								
Crankshaft V pulley diameter & Fan V pulley diameter (std.)		mm	120x90	110x110							

* Engine oil capacity may differ from the above depending on an engine installed on a machine unit.
** Engine mass and dimensions without radiator

4.4IRI8N

Engine name		Unit	4IRI8N					
Engine specification class		-	CL		VM			
Type		-	Vertical, in-line, 4-cylinder, water-cooled diesel engine					
Combustion chamber		-	Direct injection					
Number of cylinders		-	4					
Cylinder bore x stroke		mmxmm	98x110					
Displacement		L	3.318					
Continuous rating	Revolving speed	Min^{-1}	1500	1800	-			
	Output	kW (hp)	30.9 (42.0)	36.8 (50.0)	-			
Rated output	Revolving speed	Min^{-1}	1500	1800	2000	2200	2400	2500
	Output	kW (hp)	34.6 (47.0	41.2 (56.0)	41.9 (57.0)	45.6 (62.0)	49.3 (67.0)	51.1 (69.5)
Max. speed at non-load (±25)		min^{-1}	1600	1895	2205	2420	2615	2725
Ignition order		-	1-3-4-2-1(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 or CF					
Lubricant capacity (oil pan) *	Total	L	10.2					
	Effective	L	4.5					
Cooling water capacity (engine only)		L	4.2					
Engine dimensions ** (with flywheel housing)	Overall length	mm	719					
	Overall width	mm	498					
	Overall height	mm	717					
Engine mass (dry) ** (with flywheel housing)		kg	248 (equivalent to SAE#3)		235 (equivalent to SAE#4)			
Cooling fan (std.)		mm	410 mm O/D, 6 blades pusher type					
Crankshaft V pulley diameter & Fan V pulley diameter (std.)		mm	130x130					

* Engine oil capacity may differ from the above depending on an engine installed on a machine unit.
** Engine mass and dimensions without radiator

5.4IRI8T

Engine name		Unit	4IRI8T						
Engine specification class		-	CL		VM				
Type		-	Vertical, in-line, 4-cylinder, water-cooled diesel engine						
Combustion chamber		-	Direct injection						
Number of cylinders		-	4						
Cylinder bore x stroke		mmxmm	88x110						
Displacement		L	3.318						
Continuous rating	Revolving speed	Min^{-1}	1500	1800	-				
	Output	kW (hp)	37.9 (51.5)	45.6 (62.0)	-				
Rated output	Revolving speed	Min^{-1}	1500	1800	2000	2200	2400	2500	2600
	Output	kW (hp)	41.9 (57.0)	50.4 (68.5)	50.7 (69.0)	55.5 (75.5)	60.3 (82.0)	62.5 (85.0)	64.0 (87.0)
Max. speed at non-load (±25)		min^{-1}	1600	1895	2205	2420	2615	2725	2810
Ignition order		-	1-3-4-2-1(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 or CF						
Lubricant capacity (oil pan) *	Total	L	10.2						
	Effective	L	4.5						
Cooling water capacity (engine only)		L	4.2						
Engine dimensions ** (with flywheel housing)	Overall length	mm	715						
	Overall width	mm	575						
	Overall height	mm	779						
Engine mass (dry) ** (with flywheel housing)		kg	258 (equivalent to SAE#3)		245 (equivalent to SAE#4)				
Cooling fan (std.)		mm	430 mm O/D, 8 blades suction type						
Crankshaft V pulley diameter & Fan V pulley diameter (std.)		mm	130x130						

* Engine oil capacity may differ from the above depending on an engine installed on a machine unit.
** Engine mass and dimensions without radiator

1.3 Fuel Oil, Lubricating Oil and Cooling Water

1.3.1 Fuel oil

IMPORTANT:
Only use the recommended fuel to obtain the best engine performance and prevent damage of parts, also prevent air pollution.

(1) Selection of fuel oil

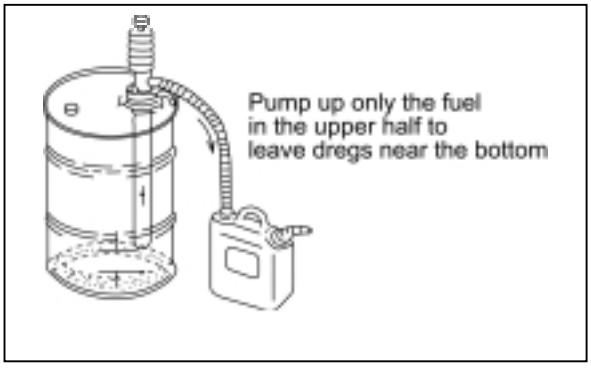
Use the following diesel fuels for best engine performance:
BS 2869 A1 or A2

Fuels equivalent to Japanese Industrial Standard, JIS. No. K2204-2

Fuel cetane number should be 45 or greater

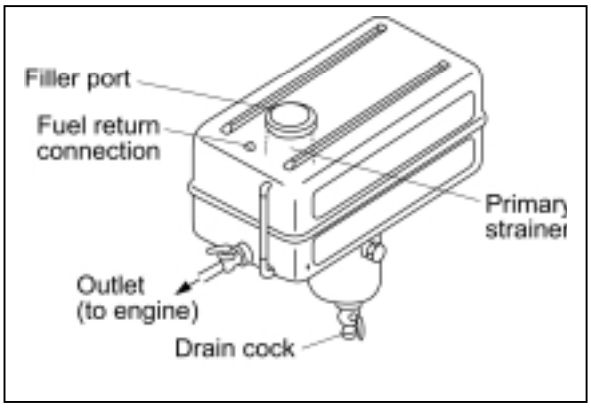
(2) Fuel handling

- Water and dust in the fuel oil can cause operation failure. Use containers, which are clean inside to store fuel oil. Store the containers away from rainwater and dust.
- Before supplying fuel, let the fuel container rest for several hours so that water and dust in the fuel are deposited on the bottom. Pump up only the clean fuel.



(3) Fuel tank

Be sure to attach a drain cock, precipitation trap and primary strainer to the fuel tank as shown illustration right.



1.3.2 Lubricating oil

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

(1) Selection of engine lube oil

Use the following engine oil:
Ingersoll-Rand Pro-Tec (15W-40) Engine Oil for optional Extended Engine Warranty.

- API classification ---------- CI-4, CH-4, CG-4, CF-4, CF/SL, SH
  (Standards of America Petroleum Institute)
- SAE viscosity ---------- 10W-30 or 15W-40
  (Standard of Society of Automotive Engineering)

Engine oil with 10W30 or 15W40 can be used throughout the year.
(Refer to the right figure.)

(2) Handling of engine oil

- Carefully store and handle the oil so as to prevent dust or dirt entrance. When supplying the oil, pay attention and clean around the filler port.
- Do not mix different types of oil as it may adversely affect the lubricating performance.

⚠ CAUTION

When touching engine oil by hand, the skin of the hand may become rough. Be careful not to touch oil with your hands without protective gloves. If touch, wash your hands with soap and water thoroughly.

1.3.3 Cooling water

Use clean soft water and be sure to add the Long Life Coolant Antifreeze (LLC) in order to prevent rust built up and freezing. If there is any doubt over the water quality, distilled water or pre-mixed coolant should be used.
The coolants / antifreezes, which are good performance for example, are shown below.

- TEXACO LONG LIFE COOLANT ANTIFREEZE, both standard and pre-mixed.
  Product codes 7997 and 7998
- HAVOLINE EXTENDED LIFE ANTIFREEZE / COOLANT
  Product code 7994

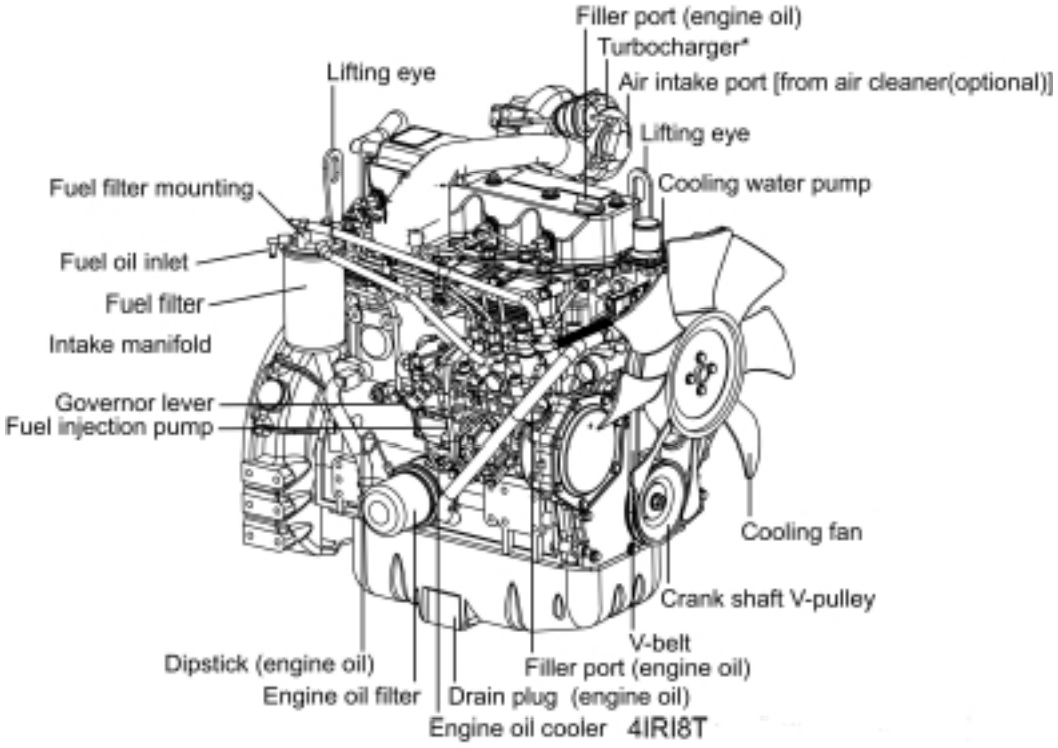
IMPORTANT:

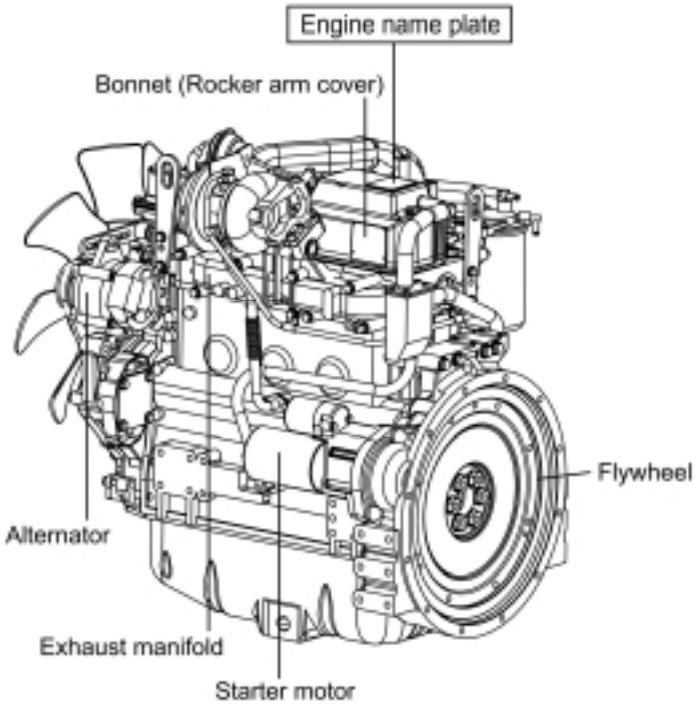
- Be sure to add Long Life Coolant Antifreeze (LLC) to soft water. In cold season, the LLC is especially important. Without LLC, cooling performance will decrease due to scale and rust in the cooling water line. Without LLC, cooling water will freeze and expand to break the cooling line.
- Be sure to use the mixing ratios specified by the LLC manufacturer for your temperature range.
- Do not mix different types (brand) of LLC, chemical reactions may make the LLC useless and engine trouble could result.
- Replace the cooling water every once a year.

⚠ CAUTION

When handling Long Life Coolant Antifreeze, wear protective rubber gloves not to touch it. If LLC gets eyes or skin, wash with clean water at once.

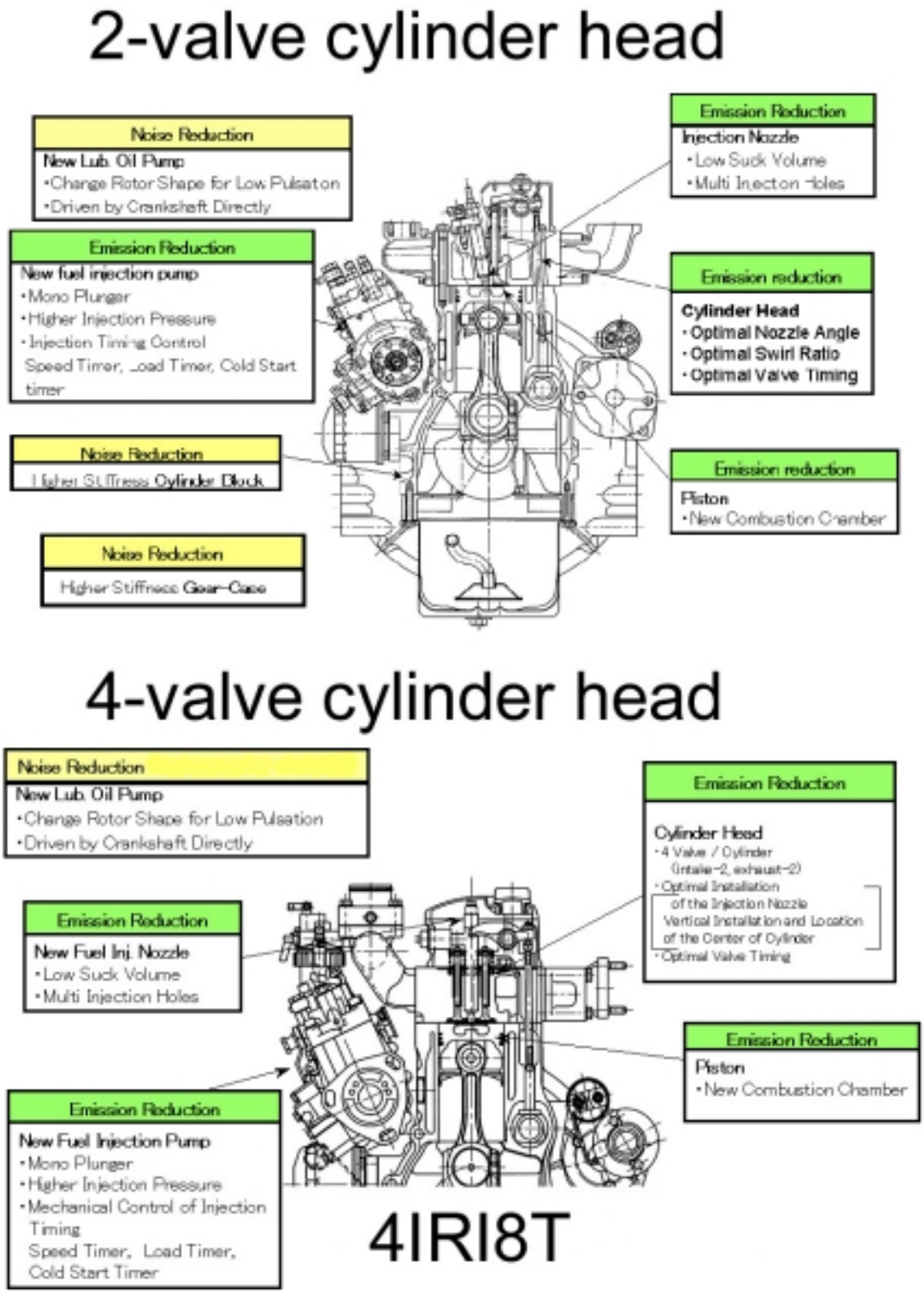
1.4 Engine External Views





Note) • This illustration shows the 4IRI8T engine (with turbocharger).
• The drain plug (engine oil) location depends on the engine installed on the machine unit to be on the fuel injection pump side (above illustration) or starter motor side.

1.5 Structural Description



1.6 Exhaust gas emission regulation

The US EPA, CALIFORNIA ARB and/or the 97/68/EC Directive have certified the engines in this manual.

California
Proposition 65 Warning
Diesel engine exhaust and some of its constitutions are known to the State of California to cause cancer, birth defects, and other reproductive harm.

California
Proposition 65 Warning
Battery posts terminals and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm.

1.6.1 The Emission Standard in USA

(1) EPA Non-road Diesel Engine Emission Standards

g/kW·hr(g/bhp·hr)

Engine Power	Tier	Model Year	NOx	HC	NMHC+NOx	CO	PM
KW<8 (hp < 11)	Tier 1	2000	-	-	10.5 (7.8)	8.0 (6.0)	1.0 (0.75)
	Tier 2	2005	-	-	7.5 (5.6)	8.0 (6.0)	0.80 (0.60)
8 <= kW < 19 (11 <= hp < 25)	Tier 1	2000	-	-	9.5 (7.1)	6.6 (4.9)	0.80 (0.60)
	Tier 2	2005	-	-	7.5 (5.6)	6.6 (4.9)	0.80 (0.60)
19<= kW < 37 (25 <= hp < 50)	Tier 1	1999	-	-	9.5 (7.1)	5.5 (4.1)	0.80 (0.60)
	Tier 2	2004	-	-	7.5 (5.6)	5.5 (4.1)	0.60 (0.45)
37 <= kW < 75 (50 <= hp < 100)	Tier 1	1998	9.2 (6.9)	-	-	-	-
	Tier 2	2004	-	-	7.5 (5.6)	5.0 (3.7)	0.40 (0.30)
	Tier 3	2008	-	-	4.7 (3.5)	5.0 (3.7)	-*
75 <= kW < 130 (100 <= hp < 175)	Tier 1	1997	9.2 (6.9)	-	-	-	-
	Tier 2	2003	-	-	6.6 (4.9)	5.0 (3.7)	0.30 (0.22)
	Tier 3	2007	-	-	4.0 (3.0)	5.0 (3.7)	-*

Note1) The EPA emission regulation under 130kW is mentioned below.
Note2) As for Model year, the year, which a regulation is applicable to, is shown.

Engine classification	Transient smoke standards % opacity (acceleration/lug/peak modes)
Constant speed engine	Not regulated
Variable speed engine	20/15/50 or less

(2) California ARB Emission Regulation

The ARB emission standard is based on that of the EPA.

1.6.2 Engine identification

(1) Emission control labels of US EPA

EPA label for constant speed engines

EPA label for variable speed engines

(2) Emission control label for both EPA and ARB

1.6.3 Guarantee Conditions for the EPA Emission Standard

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

(1) Requirement on engine installation condition

(a) Intake air depression

kPa(mmAq)

Initial	Permissible
<= 2.9(300)	<= 6.23 (635)

(b) Exhaust gas back pressure

kPa (mmAq)

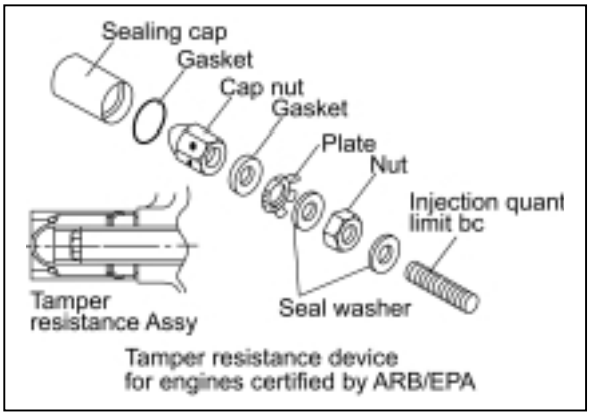
Engine type	Initial	Permissible
Naturally aspirated engines	<= 12.7(1300)	<= 15.3(1560)
4IRI8T	<= 9.8(1000)	<= 11.7(1200)

(2) Fuel oil and lubricating oil

(a) Fuel: The diesel fuel oil [ISO 8217 DMA, BS 2869 A1 or A2 (Cetane No.45 min.)]

(b) Lube oil: API grade, class CD or CF

(3) Do not remove the seals restricting injection quantity and engine speed.



Tamper resistance device for engines certified by ARB/EPA

(4) Perform maintenance without fail.

Note**:** Inspections to be carried out by the user and by the maker are divided and set down in the “List of Periodic Inspections” and should be checked carefully.

(5) Maintenance period and Quality guarantee period for exhaust emission related parts

The maintenance of the parts related to the exhaust emission must be carried out in the maintenance period as shown in the below table.

A guarantee period is that either the operation hours or years shown in the table come first in the condition that the maintenance inspection was carried out based on the “List of Periodic Inspections”.

	Maintenance period		Quality Guarantee Period
Parts Power Rating	Fuel nozzle cleaning	Adjustment, cleaning, repairs for fuel nozzle, fuel pump, turbocharger, electronic control unit etc.	For nozzle, fuel pump, turbocharger
37 <= kW < 130	Every 1500 hours (applied from Tier 2)	Every 3000 hours (applied from Tier 2)	3000 hours / 5 years
19 <= kW < 37 except constant speed engines >= 3000min^{-1}	Every 1500 hours	Every 3000 hours	3000 hours / 5 years
KW < 19 And constant speed engines beyond 3000min^{-1} under 37kW	Every 1500 hours	Every 3000 hours	3000 hours / 2 years

2. Inspection and Adjustment

2.1 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.

○: User-maintenance ◎: Parts replacement ●: Shop-inspection

Classification	Item	Daily	Maintenance period				
			Every 50 hours	Every 250 hours or 3 months	Every 500 hours or 6 months	Every 1000 hours or one year	Every 2000 hours or two years
Whole	Visual inspection of engine outside	○					
Fuel oil system	Fuel tank level check and fuel supply	○					
	Fuel tank draining		○				
	Water separator (Option) draining		○				
	Water separator cleaning				○		
	Fuel filter element replacement				◎		
Lubricating oil system	Lube oil level check	○					
	Lube oil replacement		◎ 1st time	◎ 2nd time and thereafter			
	Lube oil filter replacement						
Cooling water system	Cooling water level check and replenish	○					
	Radiator fin cleaning			○			
	Cooling fan V-belt tension check		○ 1st time	○ 2nd time and thereafter			
	Cooling water replacement					◎	
	Cooling water path flushing and maintenance						●
Rubber house	Fuel pipe and cooling water pipe inspection and maintenance	○					●
Governor	Inspection and adjustment of governor lever and accelerator	○		○			
Air intake system	Air cleaner cleaning and element replacement			○	◎		
	Turbocharger blower cleaning*					●*1	
Electrical system	Warning lamp & instruments function check	○					
	Battery electrolyte level check and battery recharging		○				
Cylinder head	Intake/exhaust valve head clearance adjustment					●	
	Intake/exhaust valve seat lapping						●
Fuel injection pump and nozzle	Fuel injection nozzle pressure inspection					●*1	
	Fuel injection timing inspection						●*1

2.2 Periodic Inspection and Maintenance Procedure

2.2.1 Check before Daily Operation

Be sure to check the following points before starting an engine every day.

No.	Inspection Item
(1)	Visual inspection of engine outside
(2)	Fuel Inspection
(3)	Oil Inspection
(4)	Cooling Water Inspection
(5)	Accelerator
(6)	Alarm device and Panel

(1) Visual check around engine.

If any problem is found, do not use before the engine repairs have been completed.

- Oil leak from the lubrication system
- Fuel leak from the fuel system
- Cooling water leak from the cooling water system
- Damaged parts
- Loosened or lost bolts
- Fuel, radiator rubber hoses, V belt cracked, loosened clamp

(2) Checking and refueling

Check the remaining fuel oil level in the fuel tank and refuel the recommended fuel if necessary. (Refer to 1.3.(1))

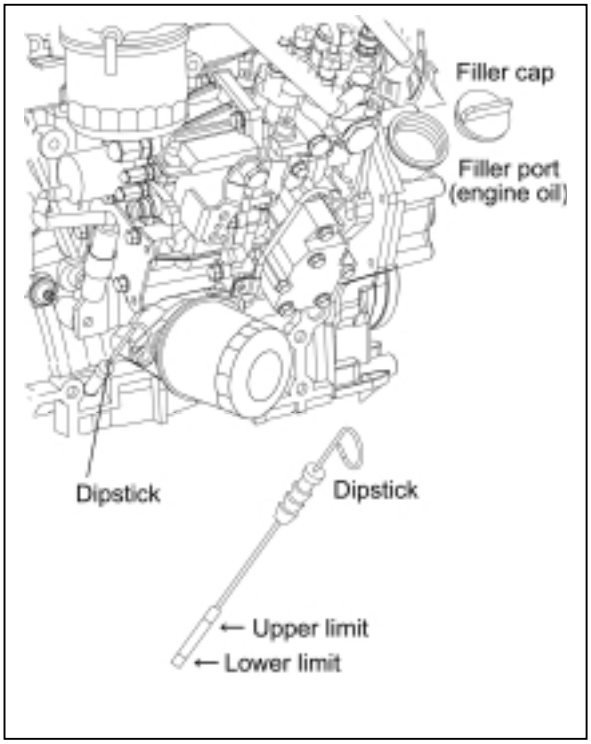
(3) Checking oil level and replenishing with engine oil

(a) Checking oil level

Check the engine oil level with the dipstick, after adjusting the posture of the machine unit so that an engine may become horizontally. Insert the dipstick fully and check the oil level. The oil shall not be contaminated heavily and have appropriate viscosity. No cooling water or diesel gas oil shall be mixed.
If, check the oil level after about 10 minutes passes after the engine shutdown so that oil inside the engine may be returned in the oil pan when oil is supplied after the engine running.

Standard

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



(Unit: liter)

Model	Total volume (L)	Effective volume (L)
3IRH2N	5.5	1.9
3IRH8N	6.7	2.8
4IRH8N	7.4	3.4
4IRI8N	10.5	4.5

Engine oil capacity may differ from the above volume depending on an engine installed on a machine unit.

(b) Replenishing oil pan with engine oil

If the remaining engine oil level is low, fill the oil pan with the specified engine oil to the specified level through the filler port.

[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. If engine oil is put in an engine too much, especially, a naturally-aspirated engine may intake engine oil in the combustion chamber during the operation, and white smoke, oil hummer or urgent rotation may occur, because the blow-by gas is reduced in the suction air flow.

(4) Cooling Water Inspection

Daily inspection of cooling water should be done only by sub-tank.

- Never open the radiator filler cap while the engine and radiator are still hot. Steam and hot water will spurt out and seriously burn you. Wait until the radiator is cooled down after the engine has stopped, wrap the filler cap with a rag piece and turn the cap slowly to gently release the pressure inside the radiator.
- Securely tighten the filler cap after checking the radiator. Steam can spurt out during operation, if the cap is tightened loosely.

(a) Checking cooling water volume

Check the cooling water level in the sub-tank. If the water level is close to the LOW mark, open the sub-tank cap and replenish the sub-tank with clean soft water to the FULL mark.

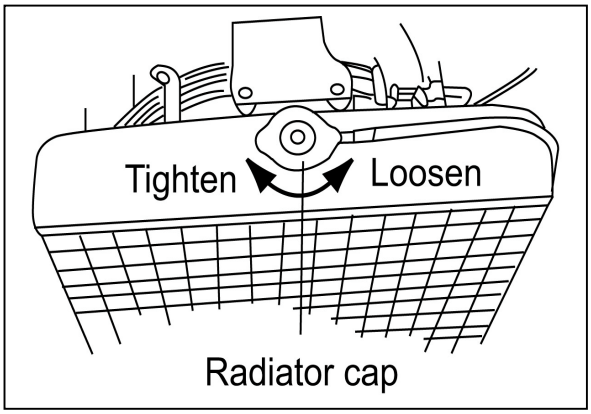
Standard

The water level of the sub-tank shall be between the upper and lower limit lines.

(b) Replenishing engine with water

If the sub-tank water level is lower than the LOW mark, open the radiator cap and check the cooling water level in the radiator. Replenish the radiator with the cooling water, if the level is low.

- Check the cooling water level while the engine is cool.
  Checking when the engine is hot is dangerous. And the water volume is expanded due to the heat.
- Daily cooling water level check and replenishing shall be done only at the sub-tank. Usually do not open the radiator cap to check or replenish.



IMPORTANT:

If the cooling water runs short quickly or when the radiator runs short of water with the sub-tank level unchanged, water may be leaking or the air tightness may be lost. Increase in the sub-tank water level during operation is not abnormal.

The increased water in the sub-tank returns to the radiator when the engine is cooled down.

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.

Standard

Engine: The radiator shall be filled up.

(Unit: liter)

Model	Cooling water volume In an engine
3IRH2N	1.8
3IRH8N	2.0
4IRH8N	2.7
4IRI8T	4.2

Engine cooling water capacity may differ from the above volume depending on an engine installed on a machine unit.

(5) Checking accelerator operation

Make sure the accelerator of the machine unit can be operated smoothly before starting the engine. If it feels heavy to manipulate, lubricate the accelerator cable joints and pivots. Adjust the accelerator cable if there is a dislocation or excessive play between the accelerator and the governor lever. Refer to 3.2.3.

(6) Checking alarm operation

Before and after starting the engine, check to see that the alarm function normally. Failure of alarm cannot warn the lack of the engine oil or the cooling water. Make it a rule to check the alarm operation before and after starting engine every day. Refer to each manual for machine units in details.

2.2.2 inspection after initi al 50 hours operation

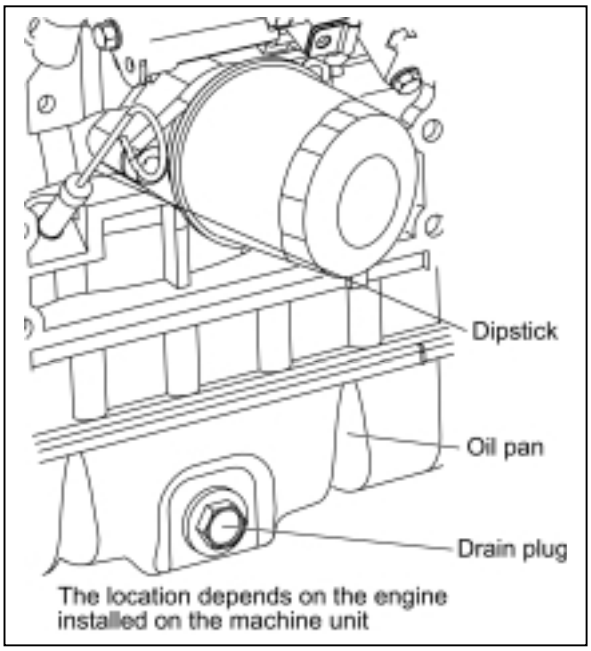
Be sure to check the following points after initial 50 hours operation,therafter every 250 hours operation.

No.	Inspection Item
(1)	Oil and filter replacement
(2)	Checking and adjusting radiator fan V-belt

(1) Replacing the engine oil and engine oil filter (1st time)

When an engine is still hot, be careful with a splash of engine oil which may cause burns. Replace engine oil after the engine oil becomes warm. It is most effective to drain the engine oil while the engine is still warm.

In early period of use, the engine oil gets dirty rapidly because of the initial wear of internal parts. Replace the engine oil earlier.
Engine oil filter should also be replaced when the engine oil is replaced.
Engine oil and engine oil filter replacing procedures are as follows.
Remove the oil filler cap to drain easily while draining the engine oil.



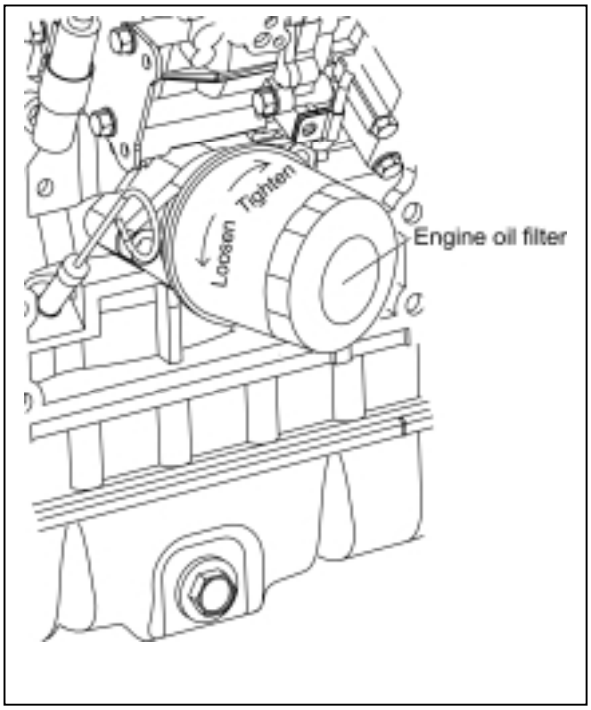
(a) Drain engine oil

- Prepare a waste oil container collecting waste oil.
- Loosen the drain plug using a wrench (customer procured) to drain the engine oil.
- Securely tighten the drain plug after draining the engine oil.

(b) Replacing oil filter

- Turn the engine oil filter counter-clockwise using a filter wrench (customer procured) to remove it.
- Clean the mounting face of the oil filter.
- Moisten the new oil filter gasket with the engine oil and install the new engine oil filter manually turning it clockwise until it comes into contact with the mounting surface, and tighten it further to 3/4 of a turn with the filter wrench.

  Tightening torque: 19.6～23.5N·m (2.0～2.4kgf·m)



Model	Applicable oil filter Part No.
3IRH2N～4IRI8T	22226351

(c) Filling oil and inspection

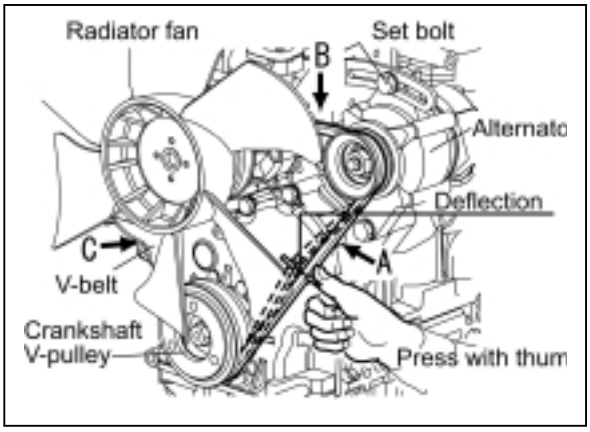
- Fill with new engine oil until it reaches the specified level.

IMPORTANT:
Do not overfill the oil pan with engine oil.
Be sure to keep the specified level between upper and lower limit on the dipstick.

- Warm up the engine by running for 5 minutes while checking any oil leakage
- Stop the engine after warming up and leave it stopping for about 10 minute to recheck the engine oil level with dipstick and replenish the engine oil. If any oil is spilled, wipe it away with a clean cloth.

(2) Checking and adjusting radiator fan V-belt

When there is not enough tension in the V-belt, the V-belt will slip making it impossible for the alternator to generate power and cooling water pump and cooling fan will not work causing the engine to overheat.
Check and adjust the V-belt tension (deflection) in the following manner.



1) Press the V-belt with your thumb [approx. 98N(10kgf)] at the middle of the V-belt span to check the tension (deflection).
Available positions to check and adjust the V-belt tension (deflection) are at the A, B or C direction as shown in the illustration right.
You may choose a position whichever you can easily carry out the check and adjustment on the machine unit.

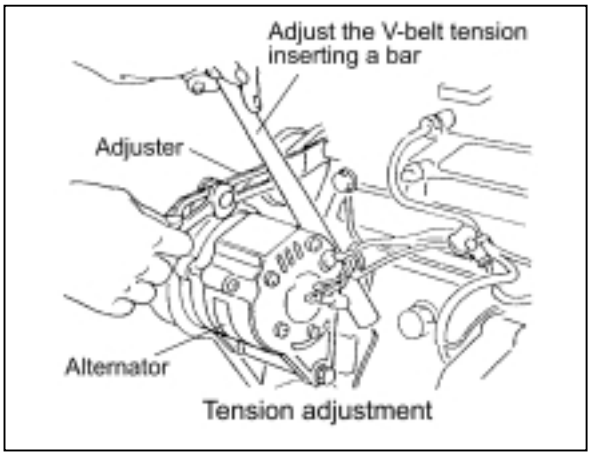
- "New V-belt" refers to a V-belt, which has been used less than 5 minutes on a running engine.
- "Used V-belt" refers to a V-belt, which has been used on a running engine for 5 minutes or more.

The specified deflection to be measured at each position should be as follows.

(Unit: mm)

Direction	A	B	C
For used V-belt	10～14	7～10	9～13
For new V-belt	8～12	5～8	7～11

2) If necessary, adjust the V-belt tension (deflection). To adjust the V-belt tension, loosen the set bolt and move the alternator to tighten the V-belt.
After replacing with a new V-belt and adjusting it, run the engine for 5 minutes and readjust the deflection to the value in the table above.



3) Visually check the V-belt for cracks, oiliness or wear. If any, replace the V-belt with new one.

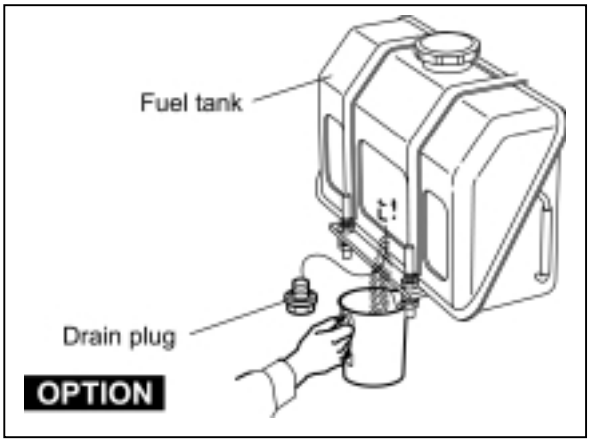
2.2.3 Inspection every 50 hours

Be sure to check the following points every 50 hours operation.

No.	Inspection Item
(1)	Draining of the fuel tank
(2)	Draining of the oil/water separator
(3)	Bleeding the fuel system
(4)	Battery Inspection

(1) Draining of the fuel tank

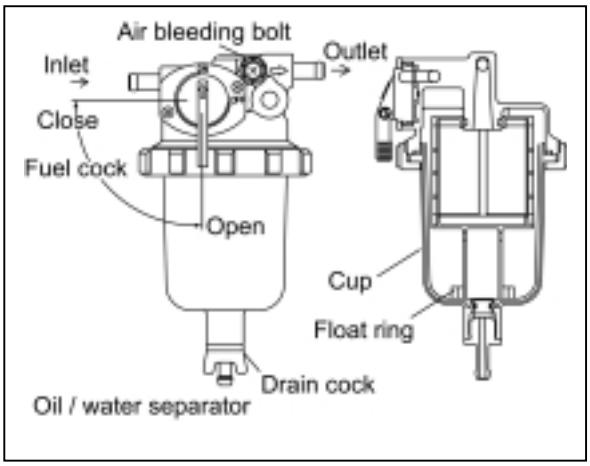
1) Prepare a waste oil container.
2) Remove the drain plug of the fuel tank to drain (water, dust, etc.) from the fuel tank bottom.
3) Drain until fuel with no water and dust flow out. Then tighten the drain plug firmly.



(2) Draining of the oil/water separator

Drain off the oil/water separator whenever there is a lot of drain collected in the oil/water separator at the bottom of the cup even if not the time for periodic inspection hour. The cup of the oil/water separator is made from semi-transparency material and in the cup, the red colored float ring, which rises on the surface of the drain, is installed to visualize the amount of drain. Also, the oil/water separator with sensor to detect the drain for warning device on a control panel is provided as the optional. Drain off the oil/water separator in the following manner.

1) Prepare a waste oil container.
2) Close the fuel cock.
3) Loosen the drain cock at the bottom of the oil/water separator, and drain off any water collected inside.
4) Tighten the drain cock with hand.
5) Be sure to bleed air in the fuel system.



NOTE:
If no drain drips when the drain cock is opened, loosen the air bleeding bolt on the top of the oil / water separator by turning counter-clockwise 2∼3 times using screw driver.
(This may occur in case of the oil/water separator position is higher than the fuel oil level in the fuel tank).
After draining, be sure to tighten the air bleeding bolt.

(3) Bleeding the fuel system

Bleed the fuel system according to the following procedures. When there is air in the fuel system, the fuel injection pump will not be able to function.

1) Check the fuel oil level in the fuel tank. Refuel if insufficient.

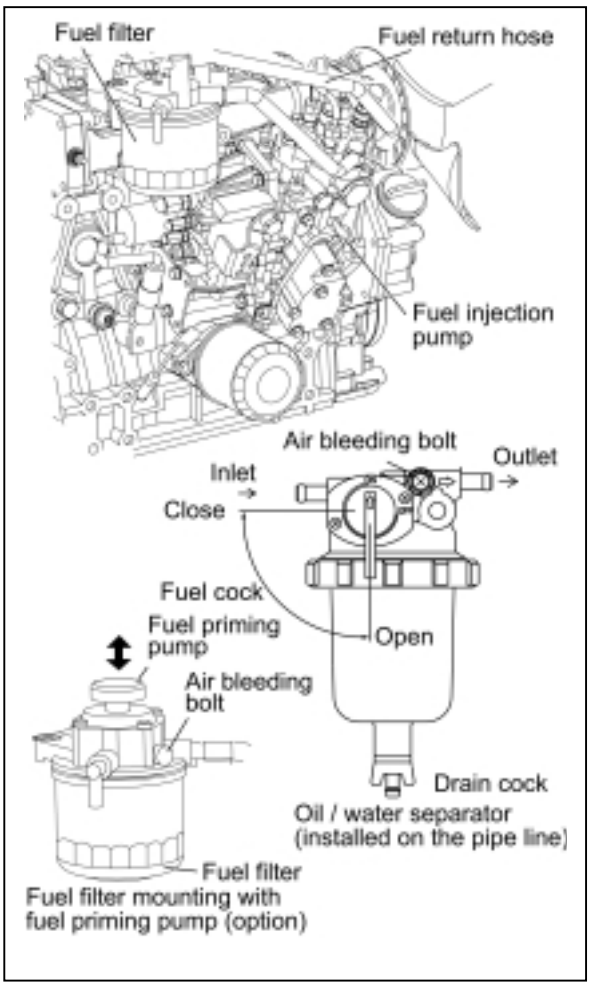
2) Open the cock of the oil / water separator.

3) Loosen the air bleeding bolt on the oil /water separator by turning 2~3 times to the counter-clockwise using screwdriver or spanner.

4) When the fuel coming out is clear and not mixed with any bubble, tighten the air bleeding bolt.

5) Feed the fuel with the fuel-priming pump or electromagnetic fuel feed pump.

- In case of the engine using the electro-magnetic fuel feed pump.
  Turn the starter switch to the ON position and hold it in the position for 10~15 seconds to operate the fuel feed pump.
- In case of the engine installed the fuel filter mounting with the fuel-priming pump.
  The priming pump is on the top of the fuel filter mounting. Move the priming pump up and down to feed fuel until feel your hand slightly heavy.



(4) Battery Inspection

⚠ WARNING

Fire due to electric short-circuit

- Make sure to turn off the battery switch or disconnect the negative cable (-) before inspecting the electrical system. Failure to do so could cause short-circuiting and fires.
- Always disconnect the (-) Negative battery cable first before disconnecting the battery cables from battery. An accidental "Short circuit" may cause damage, fire and or personal injury.
  And remember to connect the (-) Negative battery cable (back onto the battery) LAST.

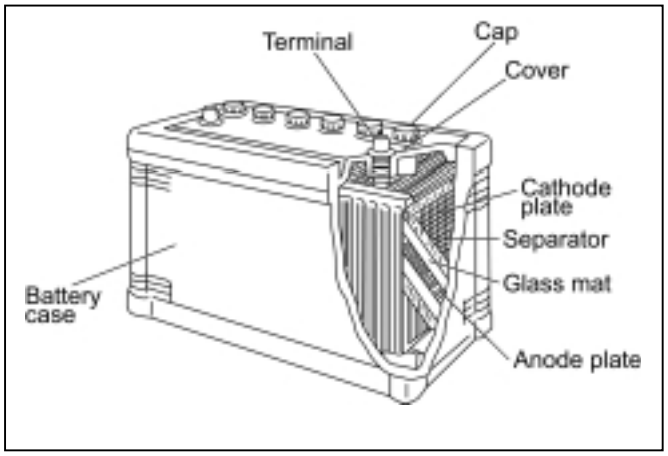
Proper ventilation of the battery area

Keep the area around the battery well ventilated, paying attention to keep away any fire source. During operation or charging, hydrogen gas is generated from the battery and can be easily ignited.

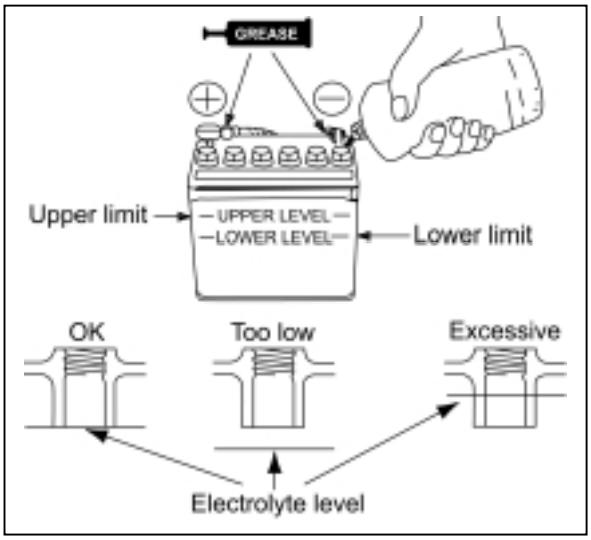
Do not come in contact with battery electrolyte

Pay sufficient attention to avoid your eyes or skin from being in contact with the fluid. The battery electrolyte is dilute sulfuric acid and causes burns. Wash it off immediately with a large amount of fresh water if you get any on you.

Battery structure



(1) Electrolyte level



- Check the level of fluid in the battery. When the amount of fluid nears the lower limit, fill with battery fluid (available in the market) to the upper limit. If operation continues with insufficient battery fluid, the battery life is shortened, and the battery may overheat and explode.
- Battery fluid tends to evaporate more quickly in the summer, and the fluid level should be checked earlier than the specified times.
- If the engine cranking speed is so slow that the engine does not start up, recharge the battery.
- If the engine still will not start after charging, replace the battery.
- Remove the battery from the battery mounting of the machine unit after daily use if letting the machine unit leave in the place that the ambient temperature could drop at -15°C or less. And store the battery in a warm place until the next use the unit to start the engine easily at low ambient temperature.

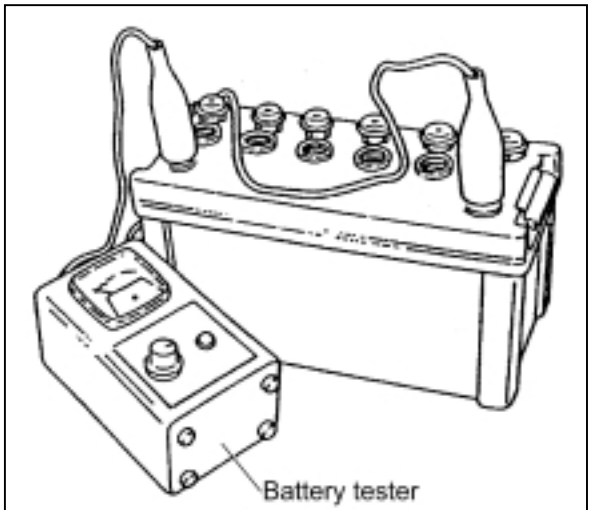
(2) Battery charge

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

(a) 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



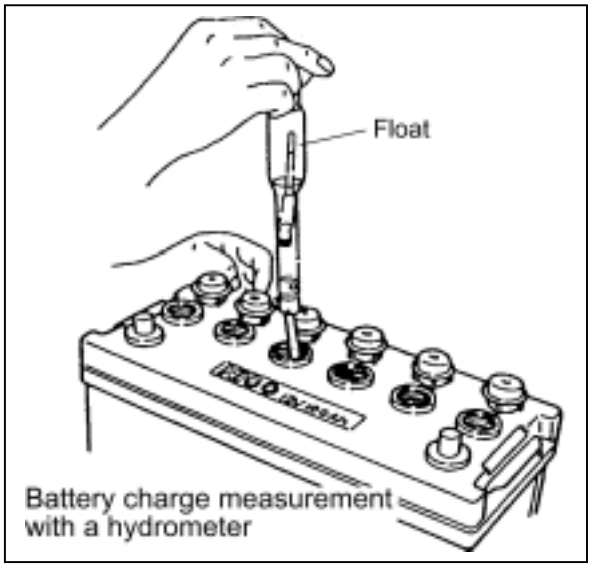
Battery charge measurement with battery tester

(b) 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.

$$S20 = St + 0.007(t-20)$$

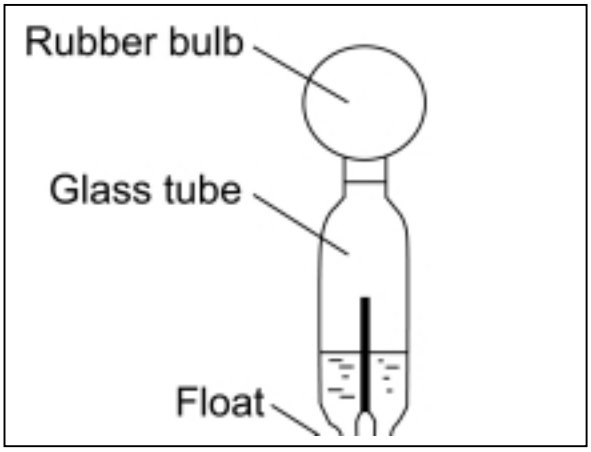
- St: Specific gravity at measurement
- t: Electrolyte temperature at measurement
- S20: Converted specific gravity at 20°C



Battery charge measurement with a hydrometer

(c) Specific gravity and remaining battery charge

Specific gravity (20°C)	Discharged quantity of electricity (%)	Remaining charge (%)
1.28	0	100
1.26	10	90
1.24	20	80
1.23	25	75



(d) Terminals

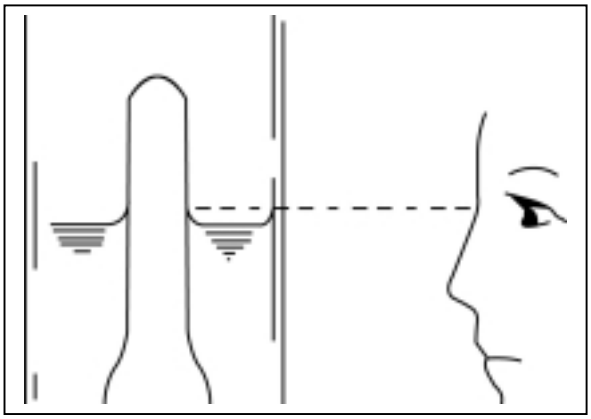
Clean if corroded or soiled.

(e) Mounting bracket

Repair or replace it if corroded.
Retighten if loosened.

(f) Battery appearance

Replace the battery if cracked or deformed.
Clean with fresh water if contaminated.



2.2.4 Inspection every 250 hours or 3 months

Be sure to check the following points every 250 hours or 3 months operation, whichever comes first.

No.	Inspection Item
(1)	Oil and filter replacement
(2)	Inspection and cleaning of radiator fin
(3)	Adjustment of governor lever and accelerator device
(4)	Air cleaner element cleaning
(5)	Fan belt tension inspection and adjustment

(1) Oil and filter replacement (The second replacement and after)

Replace the engine oil every 250 hours operation from 2nd time and on. Replace the engine oil filter at the same time. Refer to 2.2.1.(1).

(2) Inspection and cleaning of radiator fin

Beware of dirt from air blowing

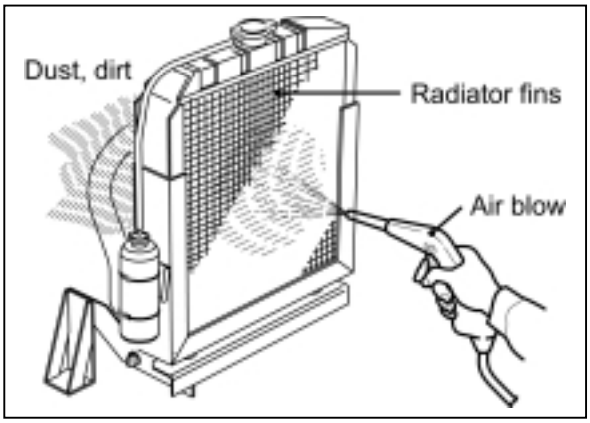
Wear protective equipment such as goggles to protect your eyes when blowing compressed air. Dust or flying debris can hurt eyes.

Dirt and dust adhering on the radiator fins reduce the cooling performance, causing overheating. Make it a rule to check the radiator fins daily and clean as needed.

- Blow off dirt and dust from fins and periphery with compressed air [0.19MPa (2kgf/cm^2) or less] not to damage the fins with compressed air.
- If contaminated heavily, apply detergent, thoroughly clean and rinse with tap water shower.

IMPORTANT:

Never use high-pressure water or air from close by fins or never attempt to clean using a wire brush. Radiator fins can be damaged.



(3) Adjustment of governor lever and accelerator device

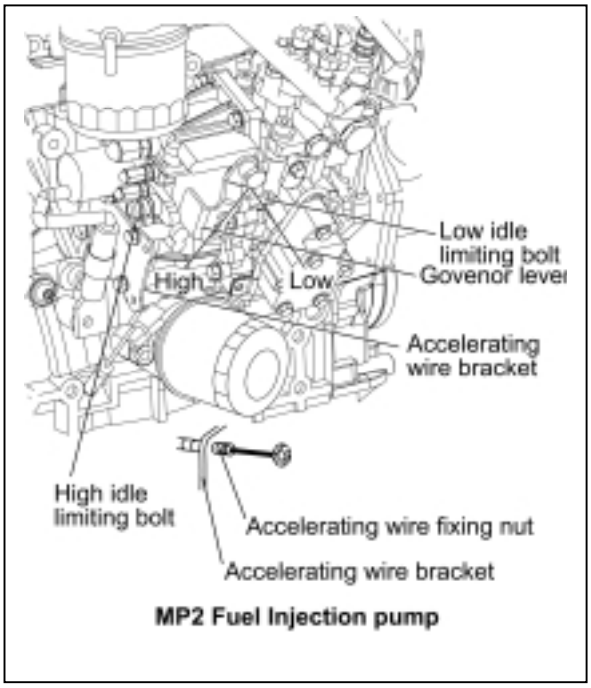
The governor lever and accelerating devices (accelerating lever, pedal, etc.) of the machine unit are connected by an accelerating wire or rod. If the wire becomes stretched or the connections loose, the deviation in the position may result and make operation unsafe. Check the wire periodically and adjust if necessary.

Do not strongly move the accelerating wire or accelerating pedal. It may deform the governor lever or stretch the wire to cause irregular engine speed control.

Checking and adjusting procedure are as follows.

1) Check that the governor lever of the engine makes uniform contact with the high idling and low idling limiting bolt when the accelerating devices is in the high idling speed or low idling speed position.

2) If either the high or the low idling speed side does not make contact with the limiting bolt, adjust the accelerating wire.
Loosen the accelerating wire fixing nut and adjust the wire to contact with the limiting bolt.



MP2 Fuel Injection pump

⚠ CAUTION

Never release the limiting bolts. It will impair the safety and performance of the product and functions and result in shorter engine life.

(4) air cleaner element cleaning

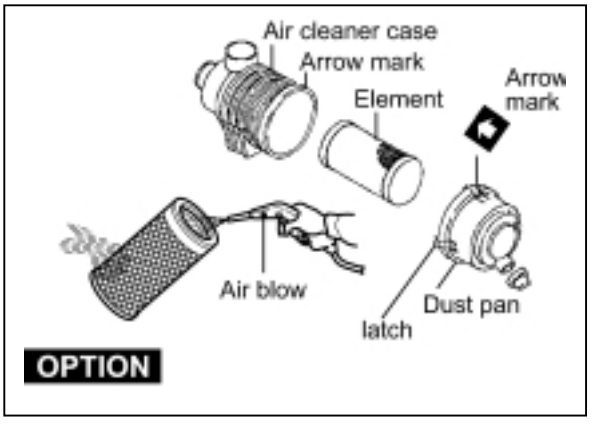
Beware of dirt from air blowing

Wear protective equipment such as goggles to protect your eyes when blowing compressed air. Dust or flying debris can hurt eyes.

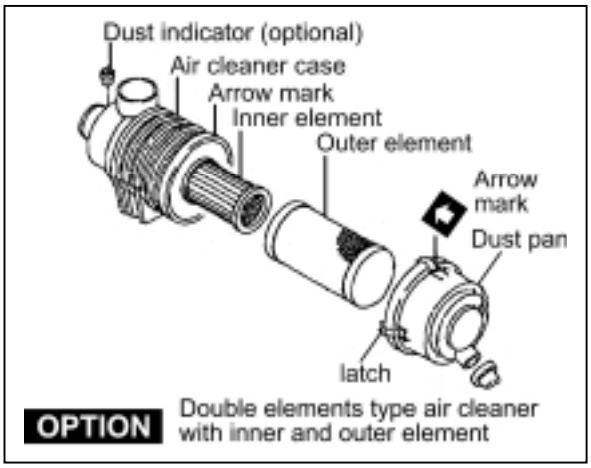
The engine performance is adversely affected when the air cleaner element is clogged by dust. So periodical cleaning after disassembly is needed.

1) Undo the clamps on the dustpan and remove the dustpan.

2) Loosen the wing bolt on the element and pull out the element.



3) Blow air [0.29∼0.49MPa (3.0∼5.0kgf/cm^2)] from inside the element to blow dust off as shown in the illustration right.
Apply the air blowing pressure as low as possible so as not to damage the element.
If having the air cleaner with double elements, never remove and clean the inner element.
The aim of installing the inner element is for back up protecting from intaking dust during engine running when leaving the outer element to reinstall after removing it or when damaging the outer element unexpectedly during engine running.



4) Replace the element with new one, If the element is damaged, excessively dirty or oily.
5) Remove the inside dust cover of the dustpan, and clean inside of the dustpan.
6) Reinstall the element with the wing bolt. (do not leave the gasket.) Reattach the inside dust cover to the dust pan and install the dust pan to the air cleaner case placing the TOP mark upward.

IMPORTANT:

- When the engine is operated in dusty conditions, clean the element more frequently.
- Do not run the engine with removed air cleaner or element, as this may cause foreign material to enter and damage the engine.

(5) Fan Belt Tension Inspection and Adjustment (The second time and after)

Check and adjust the cooling fan V-belt tension. Refer to 2.2.2(2)

2.2.5 Inspection every 500 hours or 6 months

Be sure to check the following points every 500 hours or 6 months operation, whichever comes first.

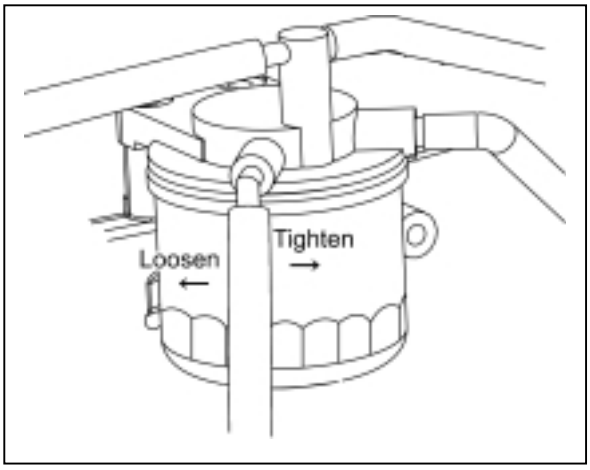
No.	Inspection Item
(1)	Air cleaner element replacement
(2)	Fuel filter replacement
(3)	Cleaning oil/water separator

(1) Air cleaner element replacement

Replace the air cleaner element periodically even if it is not damaged or dirty.
When replacing the element, clean inside of the dustpan at the time.
If having the air cleaner with double elements, do not remove the inner element. If the engine output is still not recover (or the dust indicator still actuates if having the air cleaner with a dust indicator) even though the outer element has replaced with new one, replace the inner element with new one.

(2) Fuel filter replacement

Replace the fuel filter at specified intervals before, it is clogged with dust to adversely affect the fuel flow. Also, replace the fuel filter after the engine has fully been cooled.



1) Close the fuel cock of the oil / water separator.

2) Remove the fuel filter using a filter wrench (customer procured). When removing the fuel filter, hold the bottom of the fuel filter with a piece of rag to prevent the fuel oil from dropping. If you spill fuel, wipe such spillage carefully.

3) Clean the filter-mounting surface and slightly apply fuel oil to the gasket of the new fuel filter.

4) Install the new fuel filter manually turning until it comes into contact with the mounting surface, and tighten it further to 1/2 of a turn using a filter wrench.

Tightening torque for 3IRH2N to 4IRI8T:
20～24Nm(2.0～2.4kgfm)

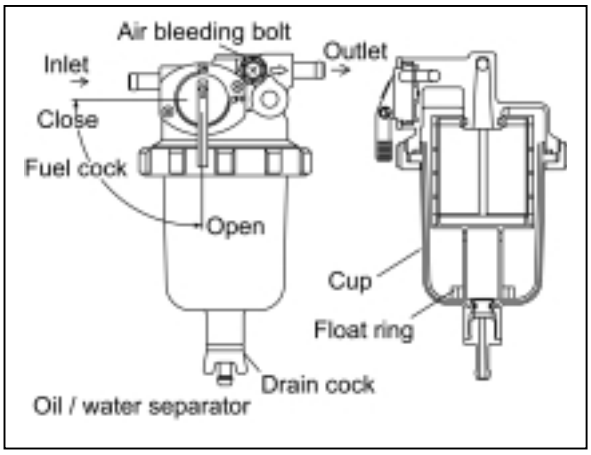
Model	Applicable fuel filter Part No.
3IRH2N～ 4IRH8N	22226369
4IRI8T	22226377

5) Bleed the fuel system. Refer to 2.2.3.(3)

IMPORTANT:
Be sure to use genuine Ingersoll-Rand part (super fine mesh filter). Otherwise, it results in engine damage, uneven engine performance and shortens engine life.

(3) Cleaning oil/water separator

Periodically wash the oil / water separator element and inside cup with clean fuel oil.



1) Prepare a waste oil container.

2) Close the fuel cock.

3) Loosen the drain cock and drain.
Refer to 2.2.3.(2)

4) Turn the retaining ring counter-clockwise and remove the cup.
(Disconnect the coupler of the lead wire for drain sensor before removing the cup if it is with drain sensor).

5) Wash the element and inside cup with clean fuel oil. Replace the element with new one if any damaged.

Model	Applicable element Part No.
3IRH2N～ 4IRI8T	54468178

6) Insert the element to the bracket (O-ring) and after putting the float ring in the cup, install it to the bracket by tightening the retaining ring clockwise.

Tightening torque: 15～20Nm (1.5～2.0kgf-m)

7) Close the drain cock (connect the coupler if with drain sensor).

8) Bleed the fuel system. Refer to 2.2.3.(3)

2.2.6 Inspection every 1,000 hours or one year

Be sure to check the following points every 1,000 hours or one year operation, whichever comes first.

No.	Inspection Item
(1)	Replacing cooling water
(2)	Washing turbocharger blower
(3)	Injection pressure and spray pattern of fuel injection valve
(4)	Measuring and adjusting Valve Clearance

(1) Replacing cooling water

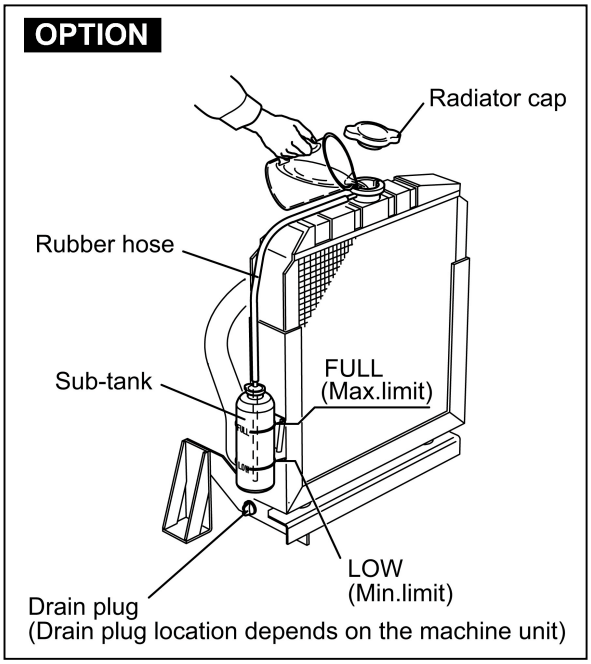
Cooling water contaminated with rust or water scale reduces the cooling effect. Even when antifreeze agent (LLC) is mixed, the cooling water gets contaminated due to deteriorated ingredients. Replace the cooling water at least once a year.

1) Remove the radiator cap.

2) Loosen the drain plug at the lower portion of the radiator and drain the cooling water.

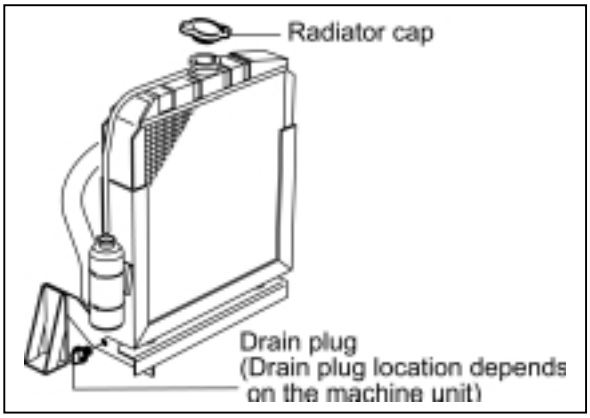
3) After draining the cooling water, tighten the drain plug.

4) Fill radiator and engine with cooling water. Refer to 3.4



Beware of scalding by hot water

Wait until the temperature goes down before draining the cooling water. Otherwise, hot water may splash to cause scalding.



(2) Washing turbocharger blower

When engine speed seems sluggish or the exhaust color looks poor, the blades of the turbocharger-blower may be dirty.
Wash the turbine blower in such a case.

(a) General items

1) As for washing, use washing liquid and clear water.

2) Washing time is the time when about 10% of the boost pressure decreases more than that of usual operation state as a standard.

3) Disassemble and clean a turbocharger periodically because the whole of the turbocharger can't be cleaned in this method.

(b) Washing point

1) A specified quantity of washing liquid/water is poured with filler (ex. Oil sprayer) from the air inlet of the blower gradually (about then seconds) at the normal load (3/4-4/4) of an engine.
And, perform this work at no-load after load running of the engine, if it is difficult to pour the liquid into the blower at load running.

Specified quantity of washing liquid/water

Turbocharger model	RHB31, RHB51
Injection amount, one time	20 cc

⚠ CAUTION

It causes an accident when large quantity of washing liquid is poured rapidly into a turbocharger.

2) Pour the same amount of clear water as washing liquid/water into the blower about 3-5 minutes later after the washing liquid/water injection and wash it.

⚠ CAUTION

It causes an accident when large quantity of water is poured rapidly into a turbocharger.

3) Repeat the washing after then minutes when there is no change with the boost pressure or the exhaust gas temperature after washing.
When there is no change at all even if it repeats 3-4 times, disassemble and maintain the turbocharger because of the cruel dirt of the blower or other causes.

4) Operate the engine at load for at least 15 minutes after washing, and dry.

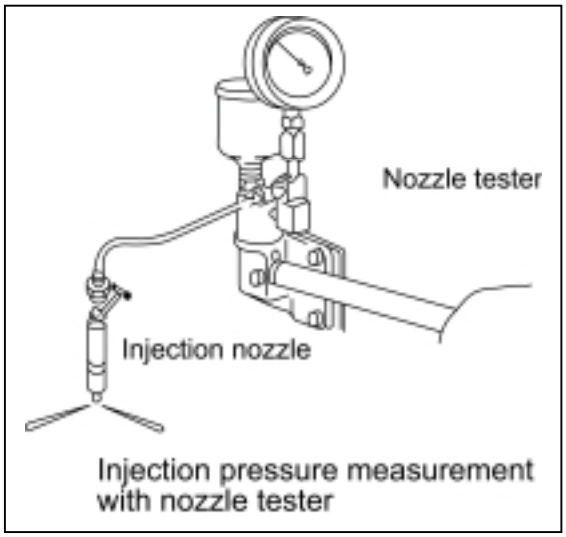
(3) Inspection and adjustment: Injection Pressure and Spray Pattern of Fuel Injection Valve

⚠ 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.

(a) Injection pressure measurement

Model	Standard Mpa(kgf/cm^2)
3IRH2N～3IRH8N (CL)	19.6-20.6 (200-210)
3IRH2N～3IRH8N (VM)	21.6-22.6 (220-230)
4IRI8T	



Injection pressure measurement with nozzle tester

[NOTICE]

As for the opening pressure of the brand-new fuel nozzle, about 0.5Mpa(5kgf/cm) declines by the engine operation for about 5 hours because of the initial wear-out of a spring etc. Therefore, adjust 0.5MPa(5kgf/cm) higher than the standard value of the above table when adjusting a new fuel nozzle of a spare part.

Remove carbon deposit at the nozzle hole thoroughly before measurement.

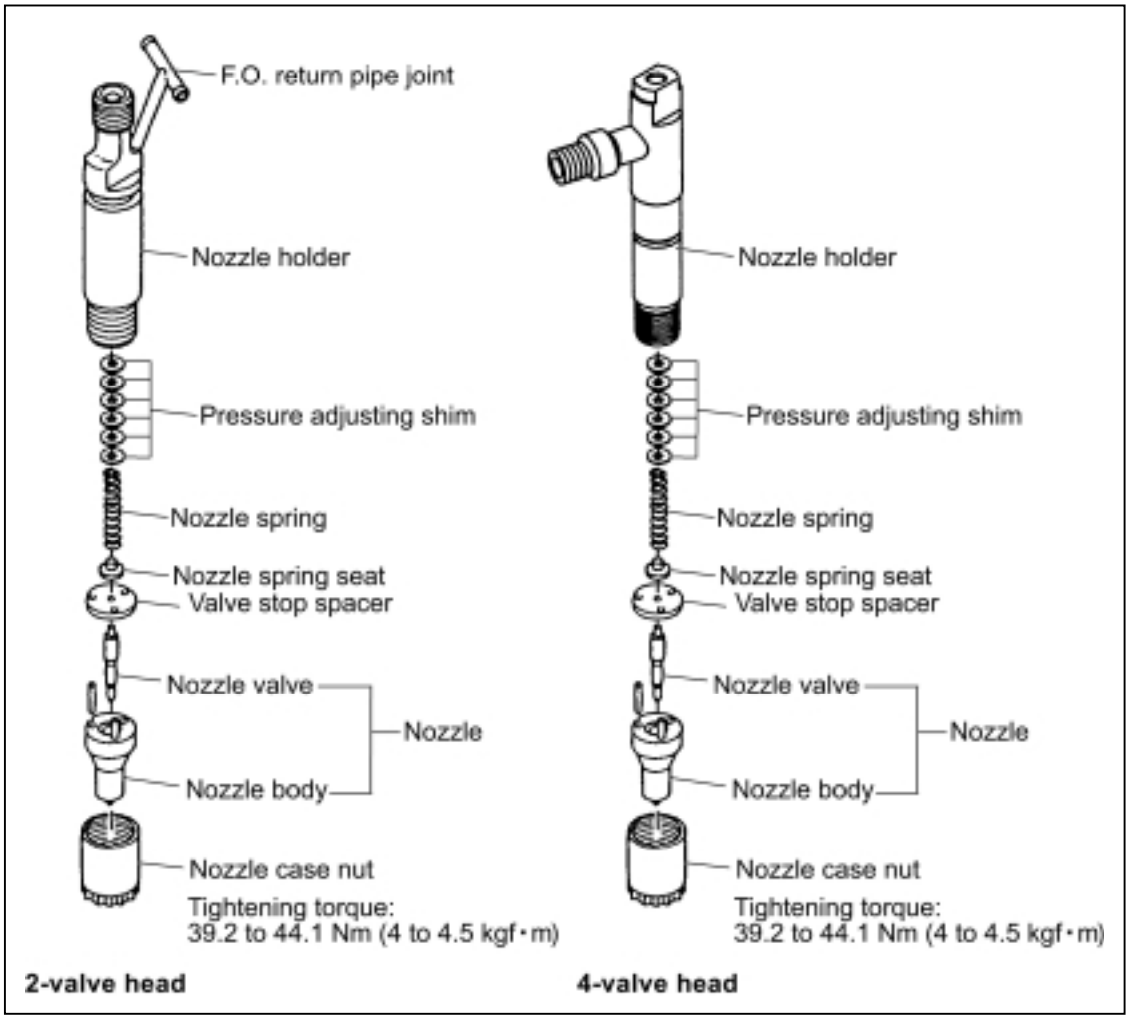
1) Connect the fuel injection valve to the high-pressure pipe of the nozzle tester.

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.

Thickness of pressure adjusting shims mm	Injection pressure adjustment
0.13, 0.15, 0.18, 0.4, 0.5, 0.8	The injection pressure is increased by approx. l.9 MPa(l9 kgf/cm^2), when the adjusting shim thickness is increased by 0.l mm.

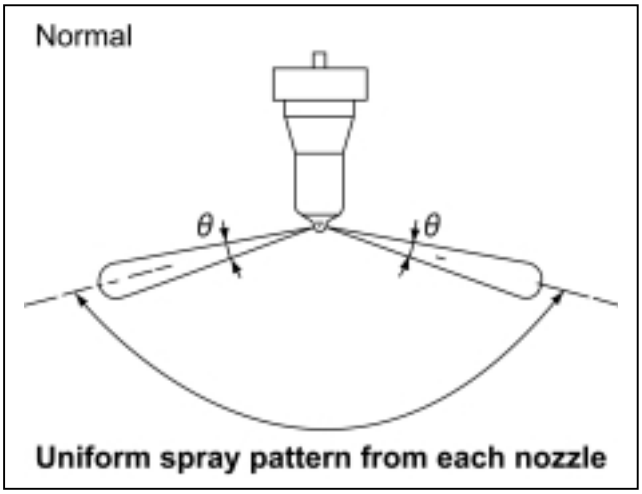
[Informative: Fuel injection valve structure]



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

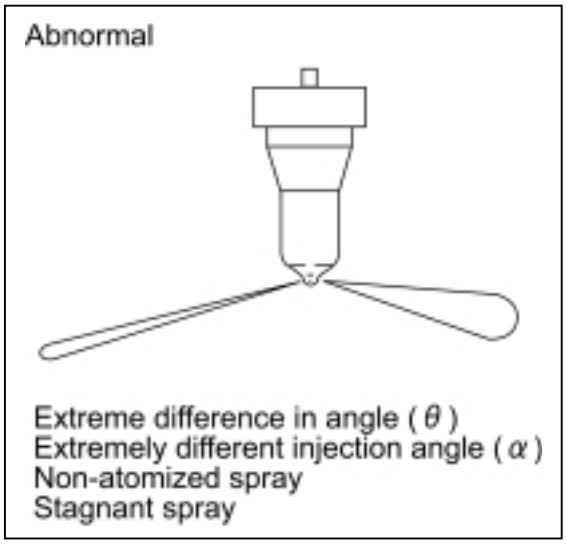
Seat oil tightness check

- 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(20kgf/cm^2), 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.



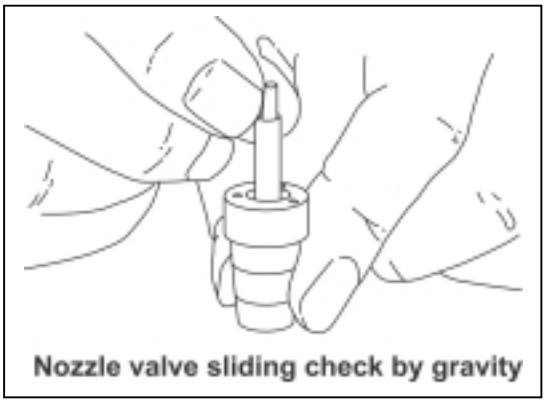
Spray and injection states

- 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

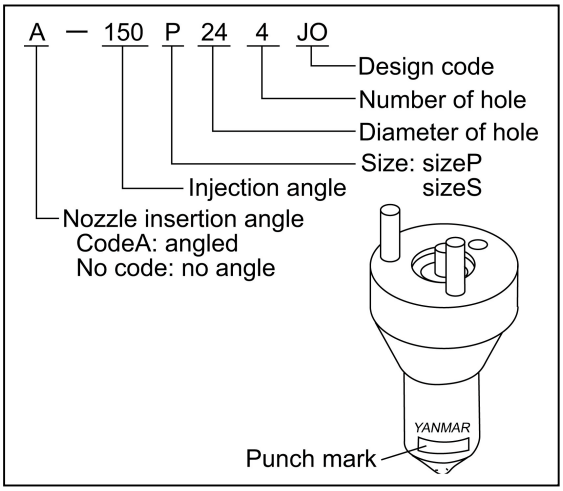


(c) Nozzle valve sliding test

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.



(d) Nozzle punch mark



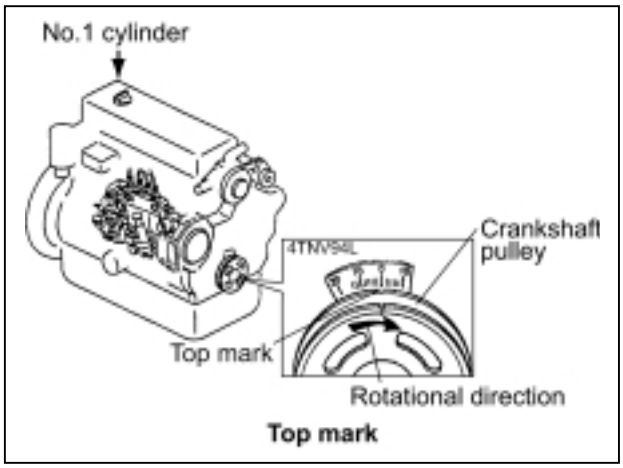
(4) Measuring and adjusting Valve Clearance

Make measurement and adjustment while the engine is cold.

(a) Valve clearance measurement

1) Remove the bonnet above cylinder head.

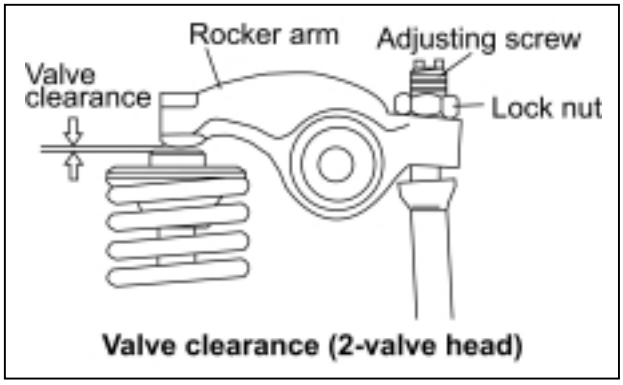
2) Set the No.1 cylinder in the compression TDC
Turn the crankshaft to bring the piston of the No.1 cylinder to its compression top dead center while watching the rocker arm motion, timing scale and the top mark position of the crankshaft pulley.
(Position where both the intake and exhaust valves are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



Top mark

Notes:

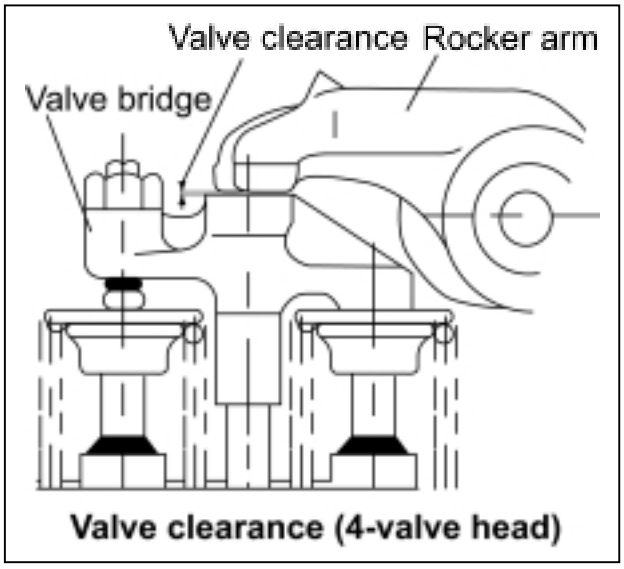
- The crankshaft shall be turned clockwise as seen from the radiator side.
- The No.1 cylinder position is on the opposite side of the radiator and the ignition order shall be 1-3-4-2-1 at 180° intervals.
- Since the intake and exhaust valve rocker arms are operated the same and there is a clearance 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 (2-valve head)

3) Valve clearance measurement
In case of 2-valve cylinder head insert a thickness gage between the rocker arm and valve cap, and record the measured valve clearance.
In case of 4-valve head insert a thickness gage between the rocker arm and the valve bridge, and record the measured valve clearance.
(Use it as the data for estimating the wear state.)

4) Adjusting other cylinders
In case of 4-cylinder engines, turn the crankshaft 180° 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.



Valve clearance (4-valve head)

In case of 3-cylinder engines, turn the crankshaft 240° and make adjustment for the No.3 cylinder. Then adjust the No.2 cylinder 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 240° each time.

The adjustment method of reducing the flywheel turning numbers (for reference):
For 3 cylinder engines
Set No.1 cylinder to the compression T.D.C.and adjust the clearance of the ● mark of the below table. Next, turn the flywheel once (the suction / exhaust valve of No.1 cylinder is in the position of the overlap T.D.C. at this time), and adjust the clearance of the ○ mark.

Ignition order of 3 cylinder engines: 1⟶3⟶2

Cylinder No.	1		2		3		
Valve	Suction	Exhaust	Suction	Exhaust	Suction	Exhaust	
No.1 compression T.D.C	●	●	●			●	The first time
No.1 overlap T.D.C				○	○		The second time

For 4 cylinder engines
Set No.1 cylinder to the compression T.D.C. and adjust the clearance of the ● mark of the bottom table. Next, turn the flywheel once, and adjust the clearance of the ○ mark.

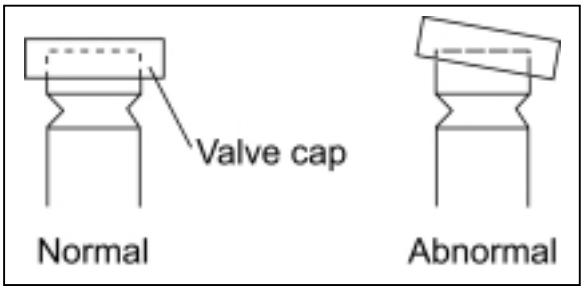
Ignition order of 3 cylinder engines: 1⟶3⟶4⟶2

Cylinder No.	1		2		3		4		
Valve	Suction	Exhaust	Suction	Exhaust	Suction	Exhaust	Suction	Exhaust	
No.1 compression T.D.C	●	●	●			●			The first time
No.4 compression T.D.C				○	○		○	○	The second time

(b) Valve clearance inspection and adjustment

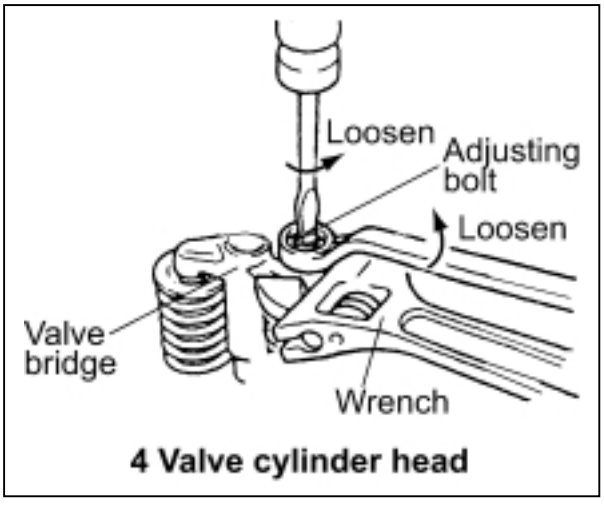
1) Loosen adjusting bolts

In case of 2-valve cylinder head loosen the lock nut and adjusting screw, and check the valve for any inclination of valve cap, entrance of dirt or wear.



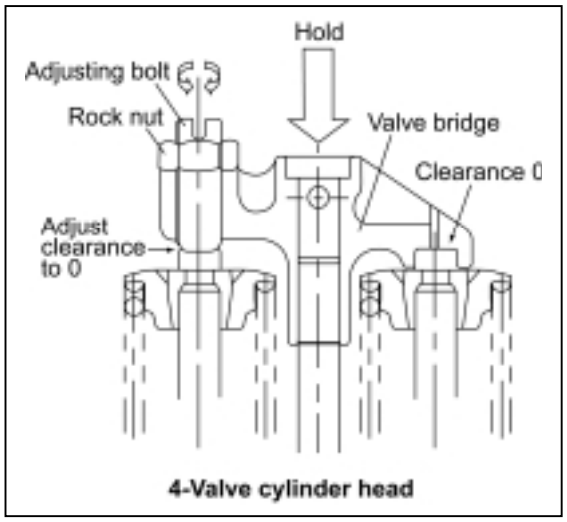
In case of 4-valve cylinder head loosen the lock nut and adjusting screw of rocker arm. Be careful that excessive tension isn't applied to the Valve Bridge, and loosen a locknut of Valve Bridge.

[NOTICE]
When loosening a locknut of a valve bridge, loosen the locknut while fixing the valve bridge with a wrench so that the valve may not lean.



4 Valve cylinder head

Push the bridge head so that a valve bridge and two valve stem heads may contact each other uniformly, and adjust an adjusting bolt so that a gap of the valve stem head may become 0. Tighten a locknut after a valve bridge is fixed with a wrench.

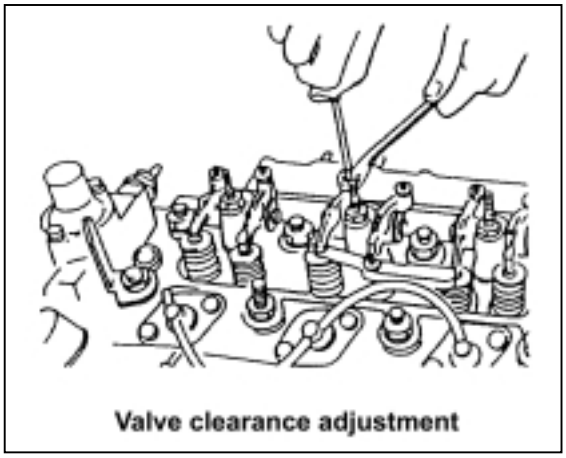


4-Valve cylinder head

2) Measuring valve clearance
Insert a 0.2 or 0.3 mm thickness gage between the rocker arm and valve cap / valve bridge, and adjust the valve clearance. Tighten the adjusting screw.

mm

Model	Standard valve clearance
3IRH2N∼8N	0.15∼0.25
4IRI8T	0.25∼0.35


Valve clearance adjustment

[NOTICE]
When tightening a valve bridge locknut of 4-valve head, tighten a locknut after fixing a valve bridge with a wrench so that a bridge may not rotate and a valve may not lean.

3) Apply oil to the contact surface between adjusting screw and push rod.

4) Adjusting other cylinders
In case of 4-cylinder engines 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.

In case of 3-cylinder engines turn the crankshaft 240° then and make adjustment for the No.3 cylinder. Then adjust the No.2 cylinder 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 240° each time.

2.2.7 Inspection every 2000 hours or 2 years

Be sure to check the following points every 2,000 hours or two years operation, whichever comes first.

No.	Inspection Item
(1)	Cleaning of cooling water system, inspection of parts and maintenance
(2)	Inspection and replacement of fuel pipe and cooling water pipe
(3)	Lapping the intake and exhaust valves
(4)	Fuel injection timing inspection and adjustment

(1) Cleaning of cooling water system, inspection of parts and maintenance

Rust and water scale will accumulate in the cooling system through many hours of operation. This lowers the engine cooling effect. Oil coolers (attached to turbocharged engines and some of naturally aspirated engines) guickly deteriorate the engine oil. The cleaning and maintenance of the following parts are necessary in accordance with the cooling water replacement.
Cooling system parts: radiator, cooling water pump, thermostat, cylinder block, cylinder head, oil cooler.

(2) Inspection and replacement of fuel pipe and cooling water pipe

Regularly check the rubber hoses of the fuel system and cooling water system for prevention of fuel or water leak. If cracked or degraded, replace them with new one. Replace the rubber hoses at least every 2 years.

(3) Lapping the intake and exhaust valves

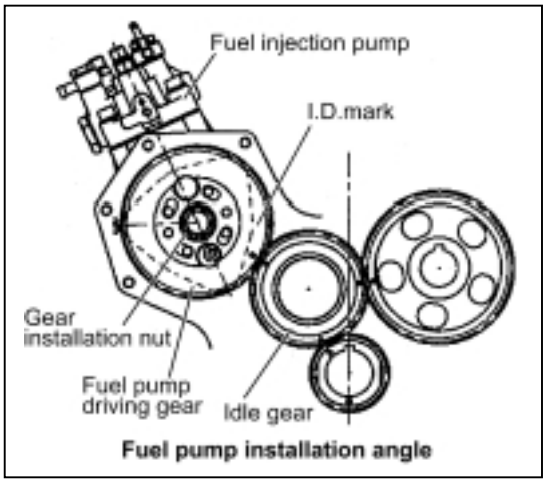
The adjustment is necessary to maintain proper contact of the valves and seats.

(4) Fuel injection timing inspection and adjustment

The fuel injection timing is adjusted so that engine performance may become the best condition.

As for the engine which adopts a MP type fuel injection pump, the fuel injection angle (Note1) is adjusted for the fuel injection timing adjustment, because the adjusting method of fuel injection timing like an inline fuel pump can't be applied.

Note1) A fuel injection angle θ_L (cam angle) is defined as the difference in position of a flange angle fixation from the position of FIR when dynamic injection timing FIR is measured with an actual fuel pump, and it is the value, which depends on pump specifications.
Fuel injection angle $\theta_L = (\mathrm{FIT}(2.5) - \mathrm{FIR})/2$
FIT(2.5) is the crank angle when the plunger lift of the fuel pump is 2.5mm, and is the specified crank angle to install a fuel pump.
And, as for the actual fuel injection angle θ_L, the measured value is recorded in the pump by each every fuel pump.



Fuel pump installation angle

The adjustment of fuel injection angle θ_L

In case that a gear case cover and a fuel pump are removed, and reassembled, the procedure of fuel injection angle adjustment is as follows.

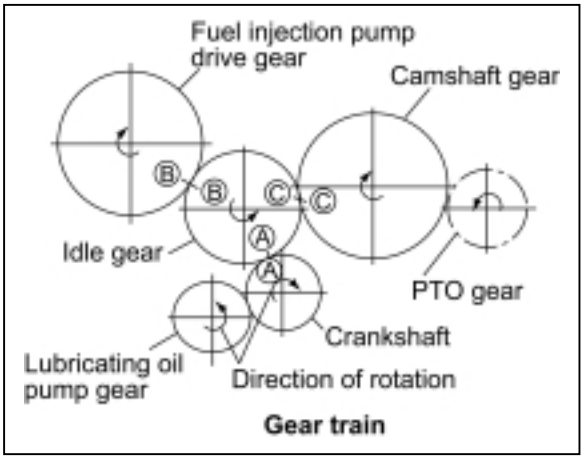
[NOTICE]

1) Never loosen four flange bolts, which fasten a pump flange and a fuel pump drive gear at the time of the removal of the fuel pump. When it is loosened, the adjustment of the fuel injection timing becomes very difficult.

2) Record the position relations of the mark-off lines of the fuel pump and the gear case precisely at the time of the removal of the fuel pump.

(a) Positioning of the piston

Turn the crankshaft and set the piston of a gear case side cylinder (No.4 cylinder for 4 cylinder engine and No.3 cylinder for 3 cylinder engine.) to the compression T.D.C., then fasten the nuts of fuel pump tentatively on the gear case and install a fuel pump drive gear on the pump cam shaft, and temporarily tighten a nut for the fuel pump drive gear. See that the timing marks on the gear train are aligned. If not, align them.



Gear train

(b) Adjustment of fuel injection angle (Positioning of fuel pump)

Read the fuel injection angle recorded on the fuel pump, which is reassembled, and calculate the difference of the fuel injection angles from the disassembled fuel pump.

[NOTICE]

Ask Ingersoll-Rand about the fuel Injection angle by offering the fuel pump number when the fuel injection angle on the fuel pump is hard to read.

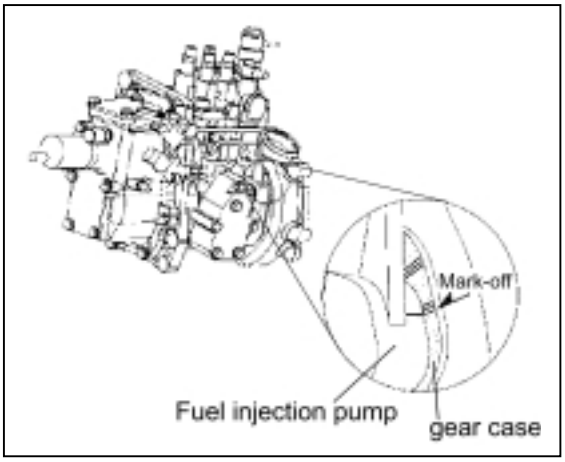
Fuel injection angle difference (cam angle) = (the fuel injection angle of a reassembled fuel pump) - (the fuel injection angle of a disassembled previous fuel pump)

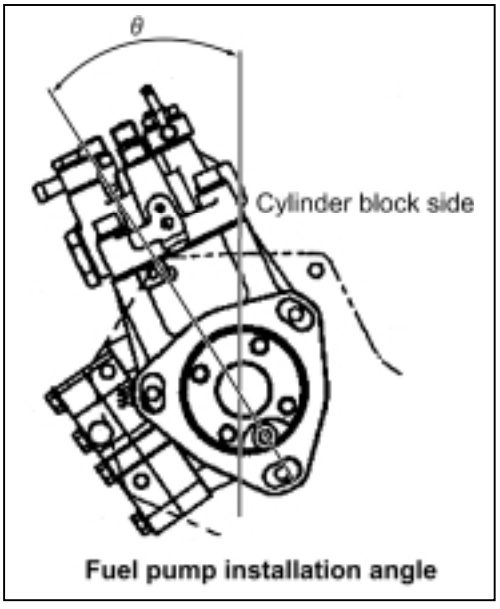
When there is no difference in fuel injection angle, install the pump precisely on the position where the mark-off lines of the fuel pump and the gear case was met together, and fasten pump installation nuts. Distinguish the line to check with every model because there are some lines on the gear case.

[NOTICE]

When a difference in fuel injection angle is +1 degree, turn the fuel injection pump in the outside direction of the cylinder block at 1 degree. When a difference in fuel injection angle is –1 degree, turn it in the cylinder block direction at 1 degree.

Model	Installation angle θ (deg.)	Mark-off line on a gear case
3IRH2N∼8N	25	The third line from the bottom,
4IRI8N	13	The bottom line
4IRI8T	11.5	The second line from the bottom,

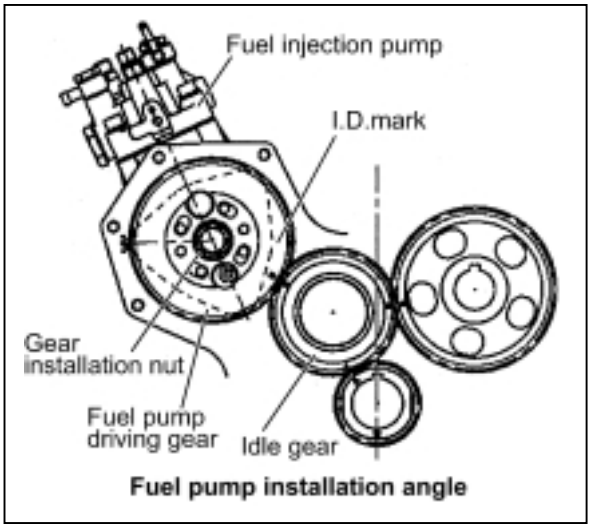




Fuel pump installation angle

(c) Tighten the installation nut of a pump drive gear.

Model	Tightening torque Nm(kgf m)	Lubricating oil application (thread portion, and seat surface)
3IRH2N∼8N	78∼88 (8∼9)	Not applied
4IRI8N-8T	113∼123 (11.5∼12.5)	

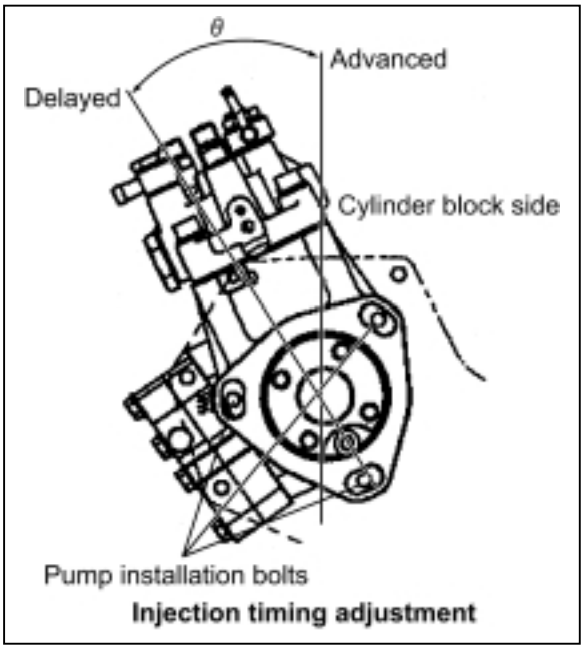


Fuel pump installation angle

(Footnote)

Fuel injection timing is adjusted by changing the installation angle of the fuel pump.

When the fuel injection timing is advanced for example at 2 degree, loosen the nuts, which fasten a fuel pump on the gear case, and turn a fuel pump body at 1 degree to the outside direction of the cylinder block. Then tighten pump installation nuts. And, slant a pump to that reverse direction when the fuel injection timing is delayed.



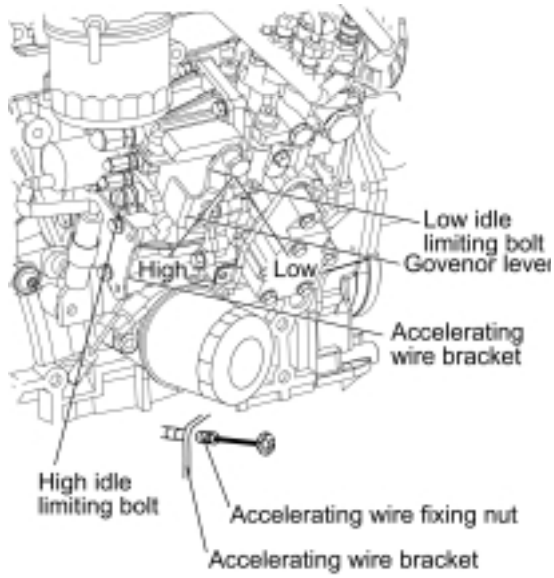
Injection timing adjustment

2.3 Adjusting the no-load maximum or minimum speed

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 out of the standard, adjust it by turning the high idle limiting bolt.

3) Then set the no-load minimum speed by adjusting the low idle limiting bolt.



MP2 Fuel Injection pump

Standards (Unit: min^{-1})

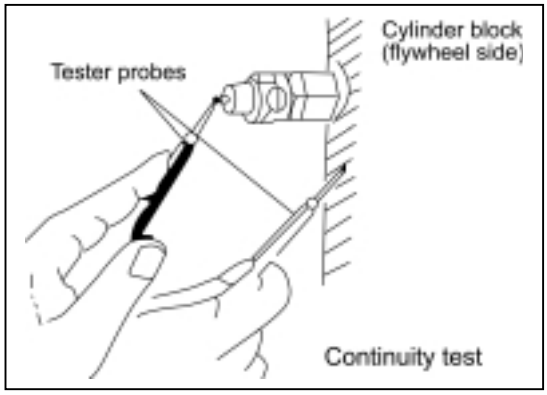
Engine application class	Rating speed	No-load maximum	No-load minimum
CL	1500	1575∼1625	1200 or more
	1800	1870∼1920	
VM	2000	2180∼2230	800 or more
	2200	2395∼2445	
	2400	2590∼2640	
	2500	2700∼2750	
	2600	2785∼2835	
	2800	2970∼3020	
	3000	3185∼3235	

Note) The engine speed may differ from the above standard depending on an engine installed on a machine unit.

2.4 Sensor Inspection

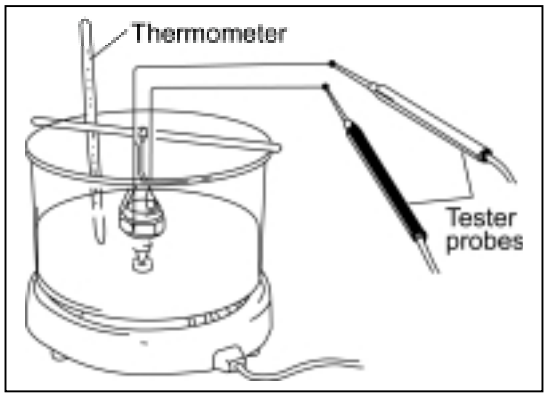
2.4.1Oil pressure switch

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. If is abnormal if circuit is closed.



2.4.2 Thermo switch

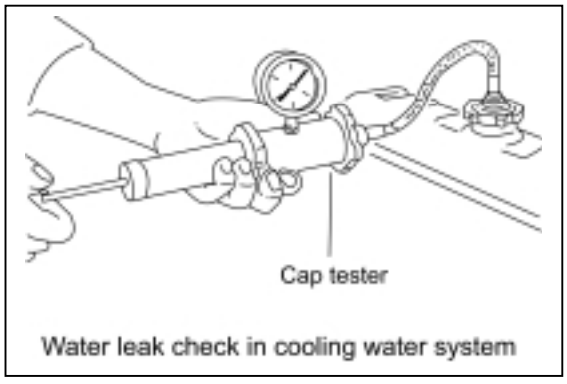
Place the thermo switch in a container filled with antifreeze or oil. Heat it while measuring the fluid temperature. The switch is normal if the voltammeter shows continuity when the fluid temperature is 107∼113 deg C.



2.5 Water leak check in cooling water system

Check cooling water leakage from the cooling water system visually. If any problem is found, Inspect as follows.

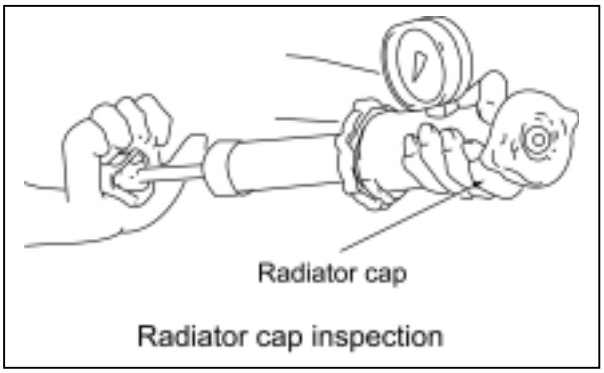
1) Fill cooling water to the normal level in the radiator, and install the cap tester on the radiator.
2) Operate the manual pump to set the pressure to 0.09±0.015MPa (0.9±0.15kgf/cm^2). If the cap tester pressure gage reading drops then, water is leaking from the cooling water system. Check the water leaking point.



Water leak check in cooling water system

2.6 Radiator cap inspection

Install the radiator cap on the cap tester. Set the tester pressure to 0.09±0.015Mpa (0.9±0.15kgf/cm^2) and see that the cap is opened. If the cap does not open, replace the cap since it is abnormal.



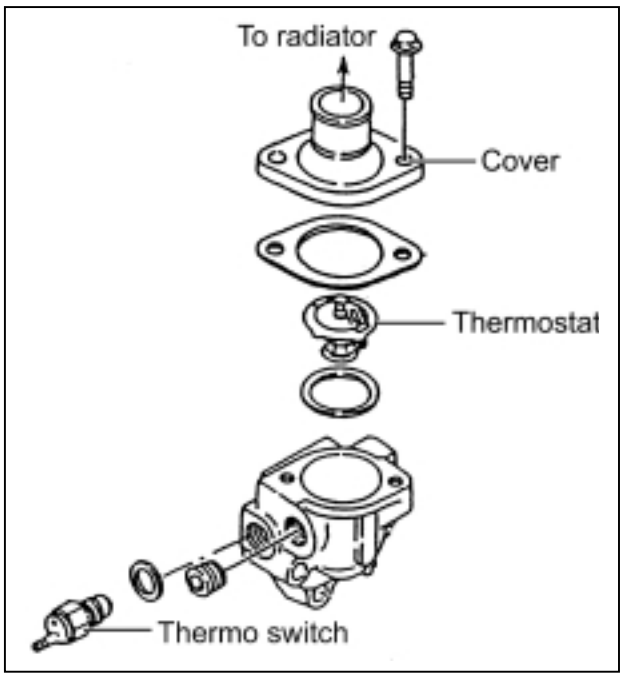
Radiator cap inspection

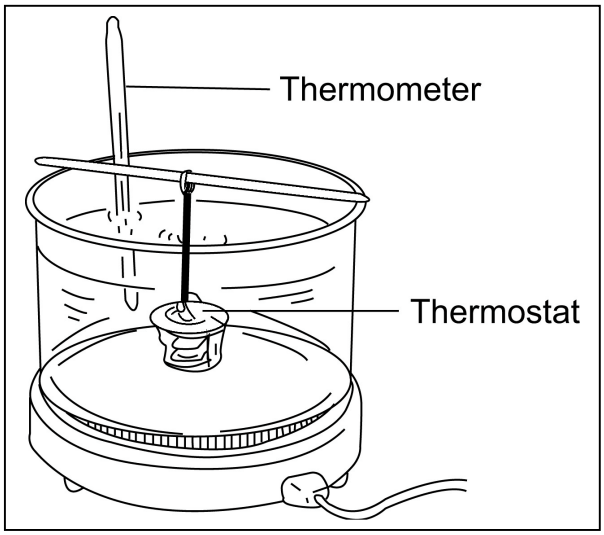
2.7 Thermostat Inspection

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.

Model	Valve opening Temperature (deg C)*	Full open lift (Temperature) (mm)
All models	69.5∼72.5	8 or more (85deg C)

- Valve opening temperature is carved on the flange.





2.8 Adjusting Operation

Perform the adjusting operation of a engine 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.

2.9 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
a) Remove the radiator cap.
b) Loosen the water draining cock under the radiator to drain water from the inside.
c) Loosen the drain cock on the side surface of the cylinder to drain water from the inside.
d) 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. TROUBLESHOOTING

3.1 Preparation before troubleshooting

If the signs of a trouble appear, it is important to lecture on the countermeasure and treatment before becoming a big accident not to shorten the engine life.

When the signs of a trouble appear in the engine or a trouble occurs, grasp the trouble conditions fully by the next point and find out the cause of sincerity according to the troubleshooting. Then repair the trouble, and prevent the recurrence of the trouble.

1) What's the occurrence phenomenon or the trouble situation? -----(e.g. Poor exhaust color)

2) Investigation of the past records of the engine
Check a client control ledger, and examine the history of the engine.

- Investigate the engine model name and the engine number. (Mentioned in the engine label.)
  Examine the machine unit name and its number in the same way.
- When was the engine maintained last time?
- How much period and/or time has it been used after it was maintained last time?
- What kind of problem was there on the engine last time, and what kind of maintenance was dane?

3) Hear the occurrence phenomenon from the operator of the engine in detail.

5W1H of the occurrence phenomenon : the investigation of when (when), where (where), who (who), what (what), why (why) and how (how)

- When did the trouble happen at what kind of time?
- Was there anything changed before the trouble?
- Did the trouble occur suddenly, or was there what or a sign?
- Was there any related phenomenon.
  ----.(e.g. Poor exhaust color and starting failure at the same time)

4) After presuming a probable cause based on the above investigation, investigate a cause systematically by the next troubleshooting guide, and find out the cause of sincerity.

3.2 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 becomes a serious problem so as not to shorten the engine service life.

Cause	Trouble symptom	Starting failure: Engine does not start.	Starting failure: Engine starts but stops soon. – Exhaust smoke: None	Starting failure: Engine starts but stops soon. – Exhaust smoke: Little	Starting failure: Engine starts but stops soon. – Exhaust smoke: Much	Insufficient engine output – Exhaust color: Ordinary	Insufficient engine output – Exhaust color: White	Insufficient engine output – Exhaust color: Black	Poor exhaust color – During work: White	Poor exhaust color – During work: Black	High knocking sound during combustion	Abnormal engine sound	Uneven combustion sound	Hunting: During idling	Hunting: During work	Large engine vibration	Difficulty in returning to low speed	Excessive fuel consumption	Lubricating oil: Excessive consumption	Lubricating oil: Dilution by fuel oil	Lubricating oil: Mixture with water	Lubricating oil: Low L.O. pressure	Much blow-by gas	Cooling water: Overheat	Cooling water: Low water temperature	Air intake: Pressure drop	Air intake: Pressure rise	Exhaust temperature rise	Corrective action
Engine system	Improper clearance of intake/exhaust valve	○	○			○						○														○		○	Adjust the valve clearance. (See 2.2.6 in Chapter2.)
	Compression leakage from valve seat					○		○		○		○					○					○			○		○	Lap the valve seat. (See 4.2.6 in Chapter4.)
	Seizure of intake/exhaust valve	○			○	○		○		○		○		○	○				○			○			○			Correct or replace.
	Blowout from cylinder head gasket					○														○			○					Replace the gasket. (See 4.2.2-11) in Chapter4.)
	Seized or broken piston ring	○			○		○		○			○		○		○			○	○			○	○				○	Replace the piston ring. (See 4.2.2-5)10) in Chapter4.)
	Worn piston ring, piston or cylinder	○			○		○		○										○	○			○						Perform honing and use oversize parts. (See 4.4.5-1)4) and 4.4.6 in Chapter4.)
	Seized crankpin metal or bearing	○	○									○		○	○	○							○						Repair or replace.
	Improper arrangement of piston ring joints		○				○												○				○						Correct the ring joint positions. (See 4.4.4-6 in Chapter4.)
	Reverse assembly of piston rings						○		○										○				○						Reassemble correctly. (See 4.4.4-6 in Chapter4.)
	Worn crankpin and journal bearing					○						○		○	○	○						○							Measure and replace. (See 4.4.5-2) in Chapter4.)
	Loosened connecting rod bolt											○				○						○							Tighten to the specified torque. (See 4.4.4-2 in Chapter4.)
	Foreign matter trapped in combustion chamber	○										○							○				○						Disassemble and repair.
	Excessive gear backlash											○																	Adjust gear meshing. (See 4.3.4-2 in Chapter4.)
	Worn intake/exhaust valve guide						○												○				○						Measure and replace. (See 4.2.5-2) and 4.2.7 in Chapter4.)
	Defective governor		○											○	○	○	○												Make adjustment.
	Improper open/close timing of intake/exhaust valves	○					○	○	○	○		○																	Adjust the valve clearance. (See 2.2.6-3) in Chapter2.)
Turbocharger	Fouled blower							○		○																			Wash the blower.
	Waste gate malfunction							○		○																			Disassemble and inspect.
	Worn floating bearing						○		○																				Disassemble and inspect.

Cause		Starting failure				Insufficient engine output			Poor exhaust color		High knocking sound during combustion	Abnormal engine sound	Uneven combustion sound	Hunting		Large engine vibration	Difficulty in returning to low speed	Excessive fuel consumption	Lubricating oil				Much blow-by gas	Cooling water		Air intake		Exhaust temperature rise	Corrective action
			Engine starts but stops soon.			Exhaust color			During work																				
		Engine does not start.	Exhaust smoke																Excessive consumption	Dilution by fuel oil	Mixture with water	Low L.O. pressure		Overheat	Low water temperature	Pressure drop	Pressure rise		
			None	Little	Much	Ordinary	White	Black	White	Black				During idling	During work														
Cooling Water System	Excessive cooling effect of radiator								○									○							○				Defective thermostat (kept closed) (See 2.2.7 in Chapter2.)
	Insufficient cooling effect of radiator							○																○				○	Defective thermostat (kept opened)(See 2.2.7 in Chapter2.) or slipping fan belt (See 2.2.2-2) in Chapter2.)
	Insufficient cooling water level							○																○				○	Check water leakage from cooling water system. (See 2.2.1-4) in Chapter2.)
	Cracked water jacket																				○	○		○					Repair or replace.
	Slackened fan belt							○																○				○	Adjust the belt tension. (See 2.2.2-2) in Chapter2.)
	Defective thermostat							○	○															○	○				Check or replace. (See 2.2.7 in Chapter2.)
Lubricating System	Improper properties of lubricating oil	○	○			○													○			○	○						Use proper lubricating oil. (See 1.3.2 in Chapter1.)
	Leakage from lubricating oil piping system																		○			○							Repair.
	Insufficient delivery capacity of trochoid pump																					○							Check and repair. (See 5.5 in Chapter5.)
	Clogged lubricating oil filter																					○	○						Clean or replace.
	Defective pressure regulating valve																					○							Clean, adjust or replace.
	Insufficient lubricating oil level		○																			○							Add proper lubricating oil. (See 2.2.1-3) in Chapter2.)
Fuel system	Too early timing of fuel injection pump								○	○	○					○													Check and adjust. (See 2.2.7-4) in Chapter2.)
	Too late timing of fuel injection pump						○	○	○	○								○										○	Check and adjust. (See 2.2.7-4) in Chapter2.)
	Improper properties of fuel oil					○	○	○	○	○			○																Use proper fuel oil. (See 1.3.1 in Chapter1.)
	Water entrance in fuel system	○			○		○		○				○	○	○														Perform draining from the fuel filter. (See 2.2.3 and 2.2.5 in Chapter2.)
	Clogged fuel filter	○	○			○																							Clean or replace. (See 2.2.5 in Chapter2.)
	Air entrance in fuel system	○	○			○																							Perform air bleeding. (See 2.2.3 in Chapter2.)
	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.
	Excessive fuel injection volume									○								○	○				○	○			○	○	Check and adjust.
	Poor spray pattern from fuel injection nozzle						○	○	○	○			○	○	○	○		○											Check and adjust. (See 2.2.6 in Chapter2.)
	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		High knocking sound during combustion	Abnormal engine sound	Uneven combustion sound	Hunting		Large engine vibration	Difficulty in returning to low speed	Excessive fuel consumption	Lubricating oil				Much blow-by gas	Cooling water		Air intake		Exhaust temperature rise	Corrective action
		Engine does not start.	Engine starts but stops soon.			Exhaust color			During work					During idling	During work				Excessive consumption	Dilution by fuel oil	Mixture with water	Low L.O. pressure		Overheat	Low water temperature	Pressure drop	Pressure rise		
			Exhaust smoke																										
			None	Little	Much	Ordinary	White	Black	White	Black																				
Air/Exhaust Gas System	Clogged air filter				○			○		○			○													○			Clean. (See 2.2.4 in Chapter2.)
	Engine used at high temperatures or at high altitude							○		○								○						○		○			Study output drop and load matching.
	Clogged exhaust pipe							○		○			○															○	Clean.
Electrical System	Starting motor defect	○																											Repair or replace. (See Chapter8.)
	Alternator defect	○																											Repair or replace. (See Chapter9.)
	Open-circuit in wiring	○																											Repair. (See Chapter10.)
	Battery voltage drop	○																											Inspect and change the battery. (See 2.2.3 in Chapter2.)

3.3 Troubleshooting by measuring Compression Pressure

Compression pressure drop is one of major causes of increasing blow-by 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.

(5) Compression pressure measurement method

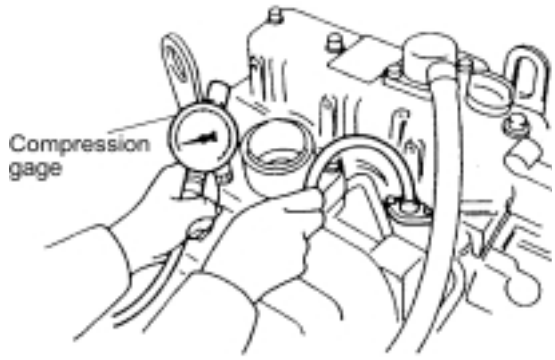
1) After warming up the engine, remove the fuel injection pipe and valves from the cylinder to be measured.

2) Crank the engine before installing the compression gage adapter.

*1) Perform cranking with the stop handle at the stop position (no injection state).
*2) See 12.2-18 in Chapter 12 for the compression gage and compression gage adapter.

3) Install the compression gage and compression gage adapter at the cylinder to be measured.
*1)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 starter motor until the compression gage reading is stabilized.



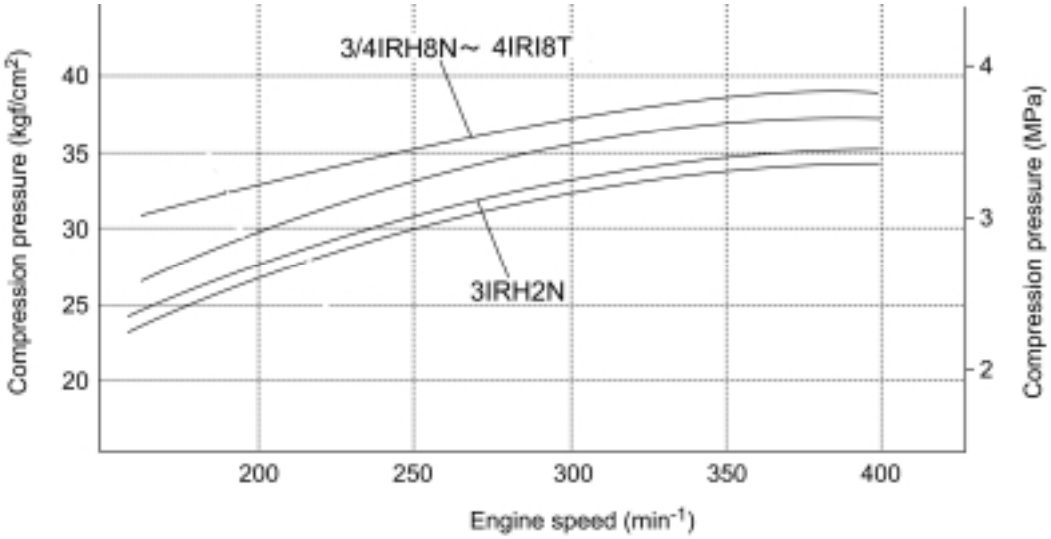
Measurement of the compression pressure

(6) Standard compression pressure

Engine compression pressure list (reference value)

Engine mode	Compression pressure at 250 min^{-1} MPa (kgf/cm^2)		Deviation among cylinders MPa (kgf/cm^2)
	Standard	Limit	
IRH2N∼8N	2.94±0.1 (30±1)	2.35 (24)	0.2∼0.3 (2∼3)

(7) Engine speed and compression pressure (for reference)



(8) 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	● Air cleaner element	● Clogged element ● Broken element ● Defect at element seal portion	● Clean the element. ● Replace the element.
2	● Valve clearance	● Excessive or no clearance	● Adjust the valve clearance. (See 3.5 in Chapter 3.)
3	● valve timing	● Incorrect valve clearance	● Adjust the valve clearance. (See 3.5 in Chapter 3.)
4	● Cylinder head gasket	● Gas leak from gasket	● Replace the gasket. ● Retighten the cylinder head bolts to the specified torque. (See 4.2(2)12) in Chapter 4.)
5	● Intake/exhaust vale ● Valve seat	● Gas leak due to worn valve seat or foreign matter trapping ● Sticking valve	● Lap the valve seat. (See 4.2(6) in Chapter 4.) ● Replace the intake/exhaust valve.
6	● Piston ● Piston ring ● Cylinder	● Gas leak due to scratching or wear	● Perform honing and use an oversized part. (See 4.4(5)-(5-1), (5-4) and (6) in Chapter 4.)

4. Disassembly, Inspection and Reassembly of Engines

4.1 Complete disassembly and reassembly

4.1.1 Introduction

Make preparation as follows before starting engine inspection and service:

1) Fix the engine on a horizontal base.

⚠ WARNING

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 to prevent any foreign matter from entering the engine.

⚠ WARNING

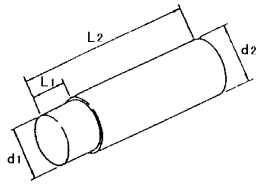
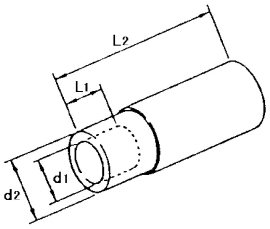
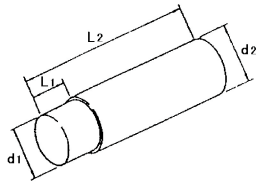
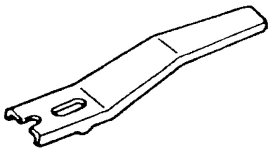
Always wear glasses or other protectors when using compressed air or steam to prevent any foreign matter from getting in the eyes.

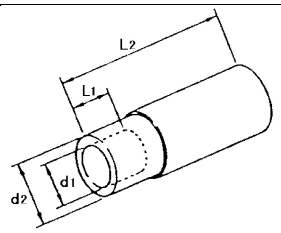
[NOTICE]

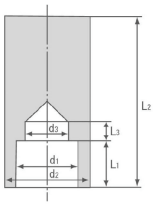
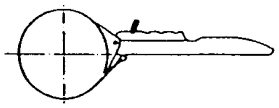
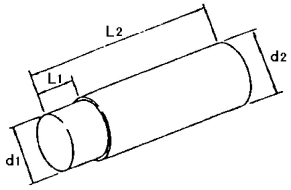
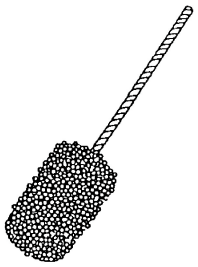
- Any part which is found defective as a result of inspection or any part whose measured value does not satisfy the standard or limit shall be replaced.
- Any part predicted to dissatisfy the standard or limit before the next service as estimated from the state of use should be replaced even when the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

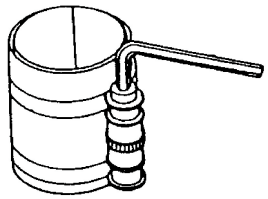
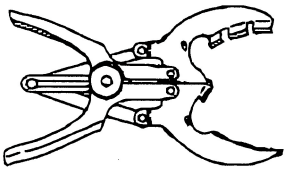
4.1.2 Special service tools

(9) Special Tools

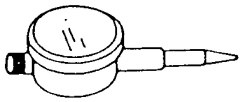
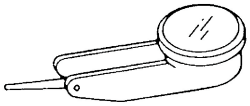
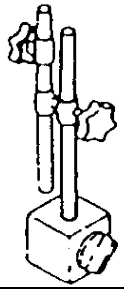
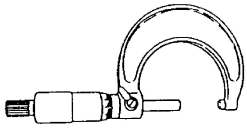
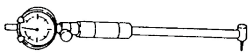
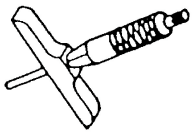
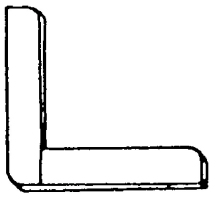
No.	Tool name	Applicable model and tool size mm					Illustration
1	Valve guide tool (for extracting valve guide)	**Model**	**L1**	**L2**	**D1**	**D2**	
		3IRH2N 4IRI8N (8T)	20	75	6.5	10	
		3/4IRH8N	20	75	7.5	11	
2	Valve guide tool (for inserting valve guide)	**Model**	**L1**	**L2**	**D1**	**D2**	
		3IRH2N	12	60	13	19	
		3/4IRH8N	15	65	14	20	
		4IRI8T	7	60	13	16	
3	Connecting rod bushing replacer (for removal / installation of connecting rod bushing)	**Model**	**L1**	**L2**	**D1**	**D2**	
		3IRH2N	25	85	23	26	
		3/4IRH8N	20	100	26	29	
		4IRI8N	20	100	30	33	
4	Valve spring compressor (for removal / installation of valve spring)	Available on the market					

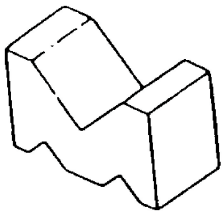
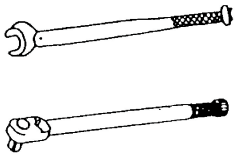
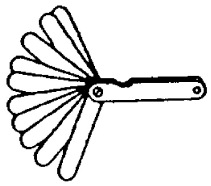
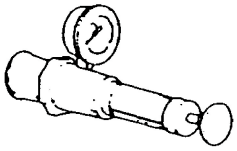
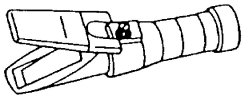
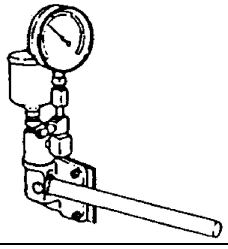
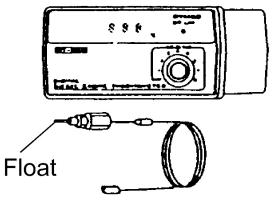
<table>
<tr><th>No.</th><th>Tool name</th><th>Applicable model and tool size mm</th><th>Illustration</th></tr>
<tr><td rowspan="3">5</td><td rowspan="3">Stem seal inserter
(for inserting stem seal)</td><td>
<table>
<tr><th>Model</th><th>D1</th><th>D2</th><th>D3</th><th>L1</th><th>L2</th><th>L3</th></tr>
<tr><td>3IRH2N</td><td>15.1</td><td>21</td><td>12</td><td>15.8</td><td>65</td><td>4</td></tr>
<tr><td>4IRH8N</td><td>16.2</td><td>22</td><td>13.5</td><td>18.8</td><td>65</td><td>4</td></tr>
</table>
</td><td> 

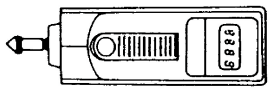
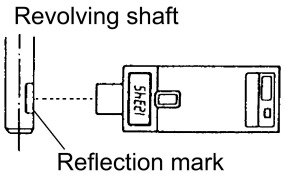
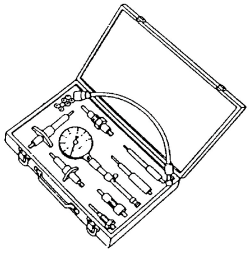

</td></tr>
<tr><td>6</td><td>Filter wrench
(for removal / installation of L.O. filter)</td><td>Available on the market</td><td>  </td></tr>
<tr><td>7</td><td>Camshaft bushing tool
(for extracting camshaft bushing)</td><td>
<table>
<tr><th>Model</th><th>L1</th><th>L2</th><th>D1</th><th>D2</th></tr>
<tr><td>3/4IRH2N (8N)</td><td>18</td><td>70</td><td>45</td><td>48</td></tr>
<tr><td>4IRI8N</td><td>18</td><td>70</td><td>50</td><td>53</td></tr>
</table>
</td><td> 
</td></tr>
<tr><td>8</td><td>Flex-Hone
(For re-honing of cylinder liner)</td><td>
<table>
<tr><th>Model</th><th>Part No.</th><th>Cylinder Bore (mm)</th></tr>
<tr><td>3IRH2N</td><td></td><td>78-84</td></tr>
<tr><td>33/4IRH8N</td><td></td><td>83-95</td></tr>
<tr><td>4IRI8N</td><td></td><td>89-101</td></tr>
</table>
</td><td>  </td></tr>
</table>

No.	Tool name	Applicable model and tool size	Illustration
9	Piston insertion tool (for inserting piston)	*The above piston insertion tool is applicable to 60-125 mm diameter pistons.	
10	Piston ring replacer (for removal / installation of piston ring)	Available on the market	

(10) 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	

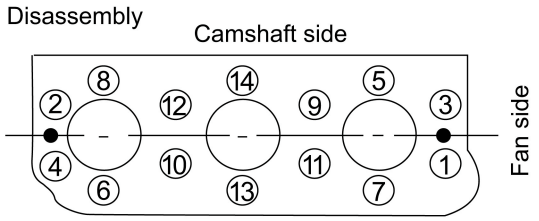
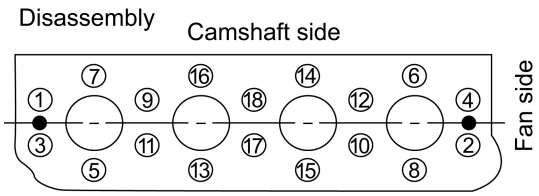
No.	Instrument name	Application	Illustration
9	V-block	For measuring shaft bend	
10	Torque wrench	For tightening nuts and bolts to the specified torque	
11	Thickness gage	For measuring gaps between ring and ring groove, and shaft joints during assembly	
12	Cap tester	For checking water leakage	
13	Battery 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	

No.	Instrument name		Application	Illustration
16	Speedometer	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	
17	Circuit tester		For measuring resistance, voltage and continuity of electrical circuits	
18	Compression gage kit		For measuring compression pressure	

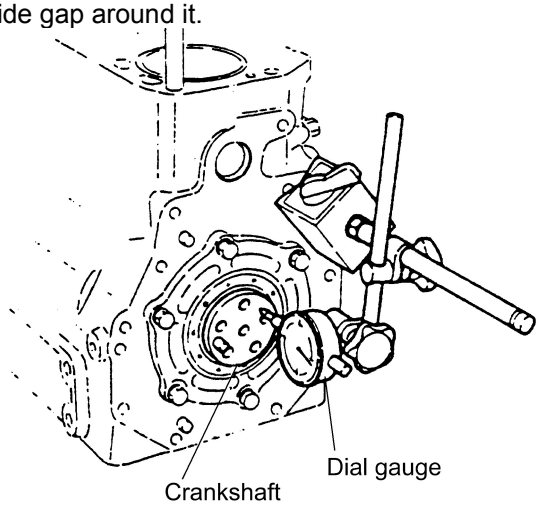
4.1.3 Complete disassembly

Peripheral parts such as air cleaner, muffler and radiator differ in installation and types for each application. Therefore, description in this Chapter is started with the steps to be taken just after the peripheral parts have been removed.

Step	Removal Parts	Remarks
1	1) Thoroughly remove sand, dust, dirt and soil from the surface of the engine. 2) Drain cooling water and lubricating oil from the engine.	
2	1) Remove turbocharger and exhaust manifold. 2) Remove intake manifold and surge tank.	
3	1) Close the fuel cock valve of the fuel tank. 2) Remove high-pressure fuel pipe. 3) Remove fuel return pipe. 4) Loosen the tightening nut on fuel injection nozzle retainer and extract the retainer and fuel injection nozzle. *) Fuel injection nozzle for Indirect injection system is screwed type.	1) If nozzle seat is left on the cylinder head, remove the cylinder head before extracting nozzle seat. 2) To prevent dust from entering fuel injection nozzle, fuel injection pump and high-pressure fuel pipe, seal their respective threads with a tape or the like. 3) Whenever extracting fuel injection nozzle, replace nozzle protector with a new one.
4	1)Remove bonnet assembly.	
5	1) Remove valve rocker arm shaft assembly. 2) Remove push rod.	1) Attach a tag to push rod for each cylinder No. to put the push rod in order. 2) Remove valve cap from the intake/exhaust valve head. 3) Note that tappet of the indirect injection system can be removed at the same time when push rod is extracted. 4) Attach a tag to tappet for each cylinder No. to put the tappet in order.
6	1) Remove fan mounting bolt, and then remove fan. 2) Loosen adjusting bolt for the V-belt adjuster, and then remove V-belt. 3) Remove alternator. 4) Remove the spacer for cooling fan and V-pulley.	1) Never turn down alternator vigorously toward the cylinder block. Otherwise, your finger may be nipped and alternator broken.
7	1) Remove lubricating oil filter assembly. 2) Extract dipstick form the oil dip-stick hole.	
8	1) Disconnect fuel return pipes to. 2) Remove fuel filter.	

Step	Removal Parts	Remarks
9	1) Disconnect cooling water pipe from the cooling water pump. 2) Remove thermostat assembly. 3) Remove cooling water pump.	
10	1) Remove cylinder head tightening bolt. 2) Remove cylinder head assembly. 3) Remove cylinder head gasket.	1) Lay a cardboard or the like on the floor and place cylinder head assembly on it so as not to damage the combustion surface. 2) Order of loosening the cylinder head tightening bolts.  Head bolt disassembly order 3 cylinder head  Head bolt disassembly order 4 cylinder head 3) To remove the intake/exhaust valves from cylinder head assembly, take the following steps. a) Using a valve spring compressor (see Chapter 5, 5-1), compress valve spring and remove valve cotter. b) Remove valve retainer and valve spring. c) Remove intake valve and exhaust valve.
11	1) Remove crankshaft V-pulley clamping bolt. 2) Using a puller, extract crankshaft V-pulley.	1) Extract crankshaft V-pulley by hitting the bolt of the puller using a plastic hammer or the like.
12	1) Remove oil pan mounting bolt under gear case. 2) Remove gear case mounting bolt. 3) Remove gear case.	1) Never fail to removes stiffner bolt at the center of the gear case. 2) When removing the gear case, carefully protect oil seal from damage.
13	1) Remove the nut from fuel injection pump drive gear. Extract fuel injection pump drive gear using a puller.	1) Before removing fuel injection pump, make sure of the position of the arrow of the pump body for adjusting fuel injection timing as well as the position of the scribed line of the gear case flange. (Applies only to direct injection system.)

Step	Removal Parts	Remarks
14	1) Remove lubricating oil pump.	
15	1) Remove starting motor from flywheel housing sing.	
16	1) Remove flywheel mounting bolt. 2) Remove flywheel.	1) Carefully protect the ring gear from damage mage.
17	1) Remove flywheel housing. 2) Remove oil seal case with a screwdriver or the like by utilizing grooves on both sides of oil seal case.	1) Carefully protect the oil seal from damage.
18	1) Remove oil pan and spacer.	1) Put the cylinder block with the attaching surface of the cylinder head facing down. 2) Carefully protect the combustion surface of the cylinder block from damage. 3) For indirect injection system, be careful to the possibility of the tapped to drop off when the cylinder block is turned upside down, because the tappet is cylindrical in shape.
19	1) Remove idle gear shaft, and then remove idle gear. 2) Remove mounting bolt of thrust bearing through the hole of the camshaft gear. Remove camshaft assembly.	1) Turn the cylinder block aside and carefully prevent tappet from jamming on the cam. 2) Preheat camshaft gear and camshaft assembly to 180°∼200° which are shrink fitted, before removing them.
20	1) Remove gear case flange.	
21	1) Remove lubricating oil strainer.	
22	1) Remove crankpin side cap of the connecting rod. While turning crankshaft, place piston in the bottom dead center (BDC).	1) Before extracting piston, remove carbon deposits from the upper wall of the cylinder using fine sandpaper, while taking care not to damage the inner surface of the cylinder. 2) Make sure than cap No. of connecting rod agrees with cylinder No. 3) Take care not to let crankpin metal fall when removing connecting rod crankpin side cap.

Step	Removal Parts	Remarks
23	1) Remove main bearing cap bolt. While shaking main bearing cap, remove main bearing cap together with lower main bearing metal. 2) Extract crankshaft, taking care not to damage it. 3) Remove upper main bearing metal.	1) Before extracting crankshaft, measure the side gap around it.  Apply a dial gauge to the end of crankshaft. Force the crankshaft on both sides in the axial direction to measure the thrust gap. Alternatively, insert a thickness gauge directly between the base thrust metal and the thrust surface of the crankshaft to measure the gap. If the limit size is exceeded, replace the thrust metal with a new one. Thrust gap (All models) 2) Notice on the removal of thrust metal. a) When removing thrust metal, ascertain the position and direction where thrust metal is installed in relation to the cap. b) Make sure that the thrust metal groove is outward in relation to the cap.
24	1) Remove piston and connecting rod assembly.	1) To selectively remove a desired piston and connecting rod assembly without extracting crankshaft, take the steps itemized below: a) Remove carbon deposits from the upper wall of the cylinder using fine sandpaper, taking care not to damage the inner surface of the cylinder. b) While turning the crankshaft, with the connecting rod cap removed, raise the piston up to the top dead center (TDC). c) Extract the piston/connecting rod assembly while tapping the connecting rod at the large end with the handle of a plastic hammer or the like.
25	2) Remove tappet.	

4.1.4 Precautions before and during reassembly

To reassemble engine components, reverse the procedure of disassembly. However, follow the precautions below and the precautions from in chapter 4 to in chapter 7 particularly before and during reassembly.

(11) Cleaning the component

Use particular care to clean the cylinder block, cylinder head, crankshaft, and camshaft. Ensure that they are free from chips, dust, sand, and other foreign matter.

(12) Parts to be replaced during reassembly

Be sure to replace the following parts with new ones during assembly.

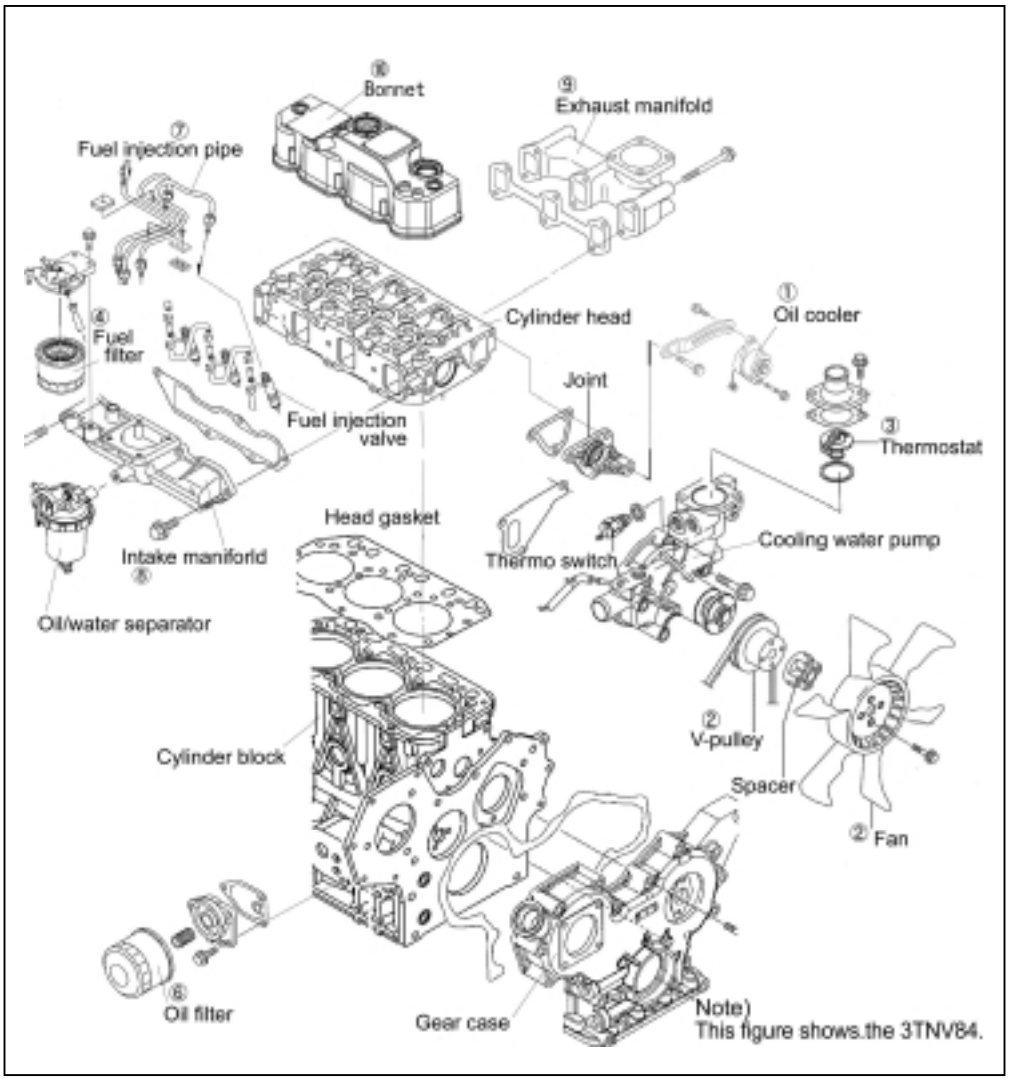
- Valve stem seal
- Head gasket packing
- Nozzle protector and nozzle seat of the fuel injection valve
- Various copper packing, O-rings and gasket packing.

4.1.5 Adjusting operation

Make sure to perform adjusting operation after completing reassembly. Refer to section 2.5 in chapter 2 for the operation procedure.

4.2 Cylinder Head: Disassembly, Inspection and Reassembly

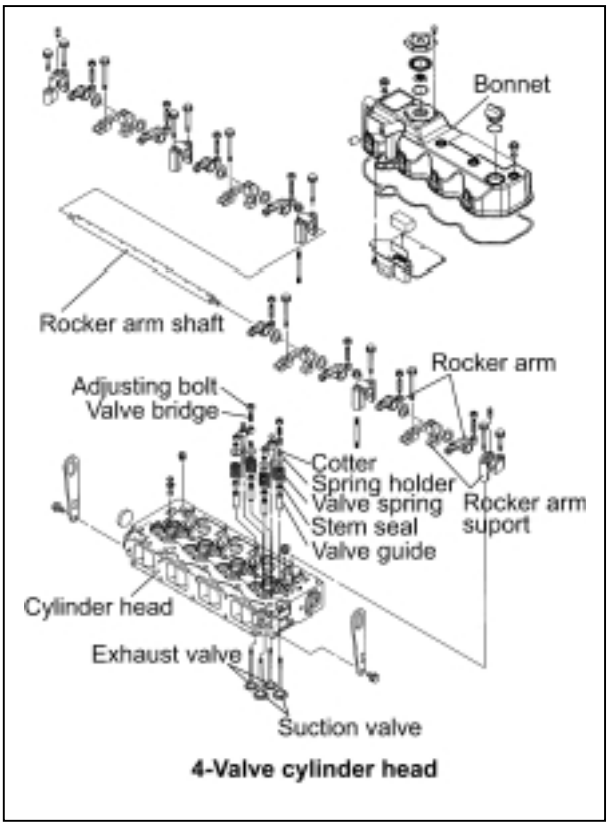
4.2.1 Components (2-valve cylinder head)



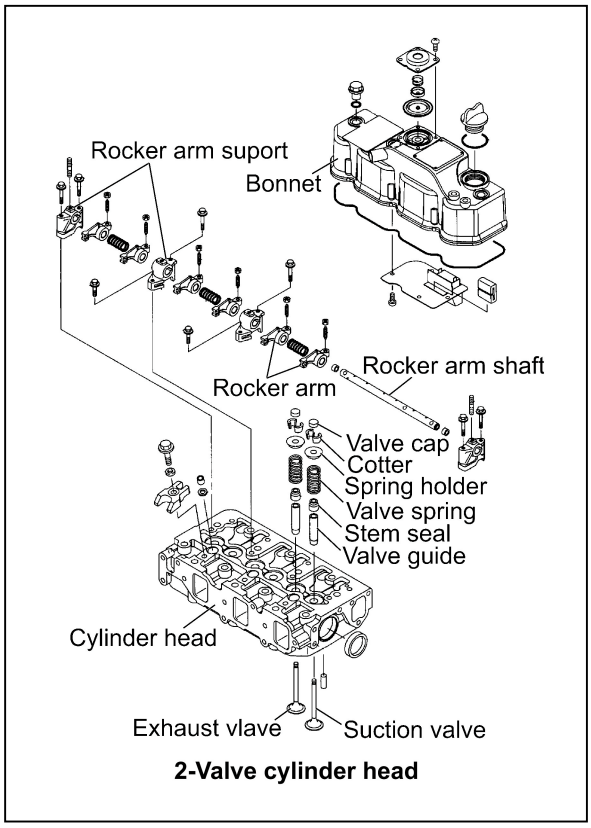
4.2.2Disassembly procedure:

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

1) Remove the alternator assy. (Point1)
2) Remove the fan, pulley and V belt.
3) Remove the thermostat case. (Point2)
4) Remove the fuel filter and fuel oil piping. (Point3)
5) Remove the oil level gage assy.
6) Remove the oil filter. (Point4)
7) Remove the fuel injection pipes. (Point5)
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. (Point6)
12) Remove the cylinder head assy and head gasket. (Point7)
13) Remove the fuel injection valves and fuel return pipe. (Point8)
14) Remove the intake/exhaust valves, stem seals and valve springs. (Point9)
15) Remove the rocker arms from the rocker shaft.



4-Valve cylinder head



2-Valve cylinder head

4.2.3Reassembly procedure:

Reverse order of the disassembly procedure.

4.2.4Servicing points

Point 1

[Disassemble]

- Loosen the mounting bolt while supporting the alternator.

⚠ CAUTION

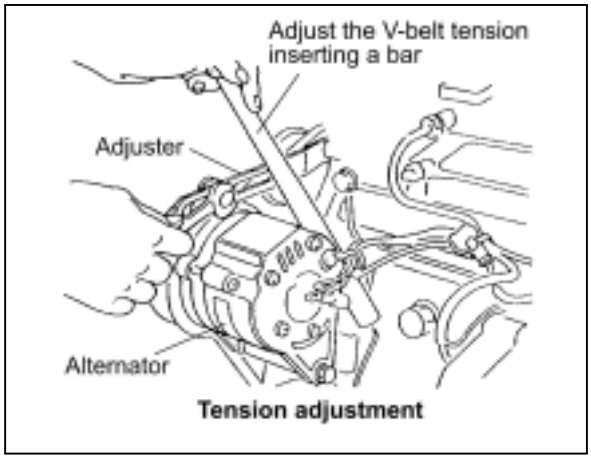
Do not tilt the alternator toward the cylinder block in haste since it may damage the alternator or pinch a finger.

[Reassemble]

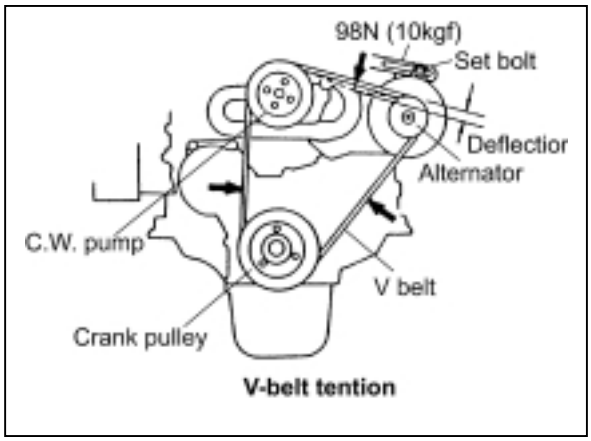
- The belt deflection shall be checked according to 2.2.2. in Chapter2.

[Reassemble]

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



Tension adjustment



V-belt tention

Point 2

[Reassemble]

- Check the thermostat function. (See3.9 in Chapter 3 for the check procedure.)

Pont 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.

Point 6

A point in case of 4 valve head is mentioned.

[Disassemble]

- Take off a bonnet in case of 4 valve head after removing fuel injection pipes and pipe seals.

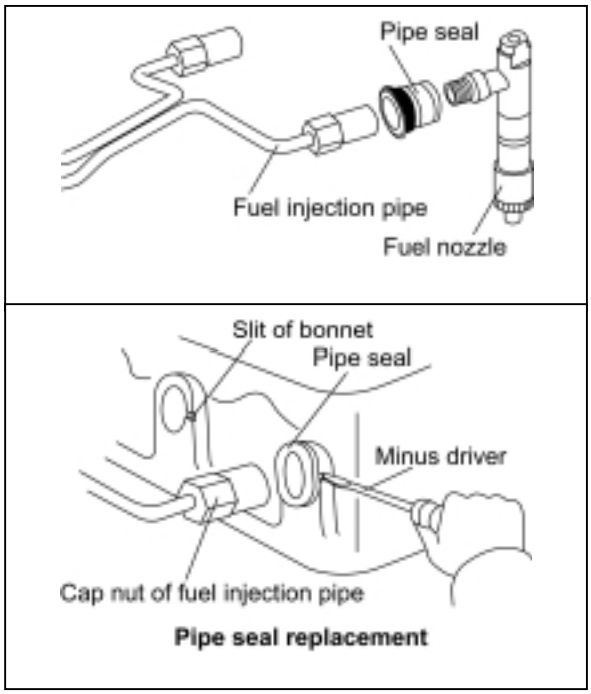
[NOTICE]

Attention is necessary because a fuel nozzle is caught in a pipe seal and the pipe seal is damaged when a bonnet is lifted with a pipe seal sticking to the bonnet.

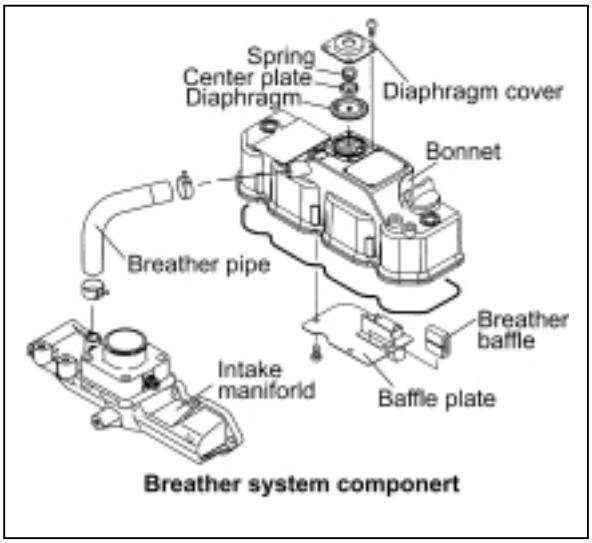
- Insert a minus driver in the slit part of the bonnet, and remove it when removing a pipe seal.

[Reassemble]

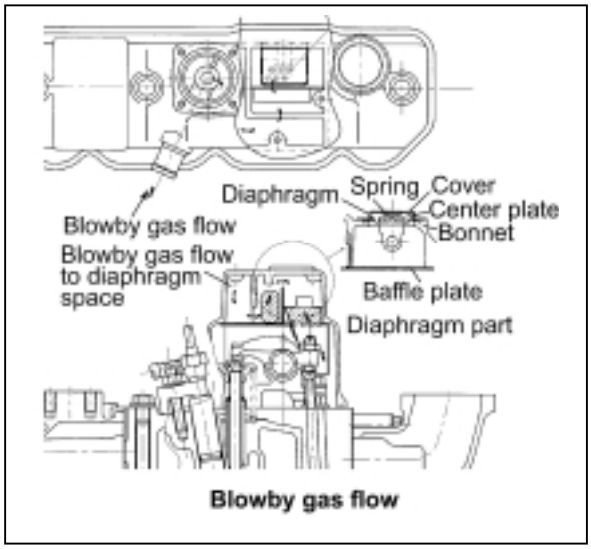
- Replace the used pipe seal with a new one when removing a pipe seal.



Pipe seal replacement



Breather system componert



Blowby gas flow

Point 7

[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 clearance adjusting screws.

Point 8

[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.

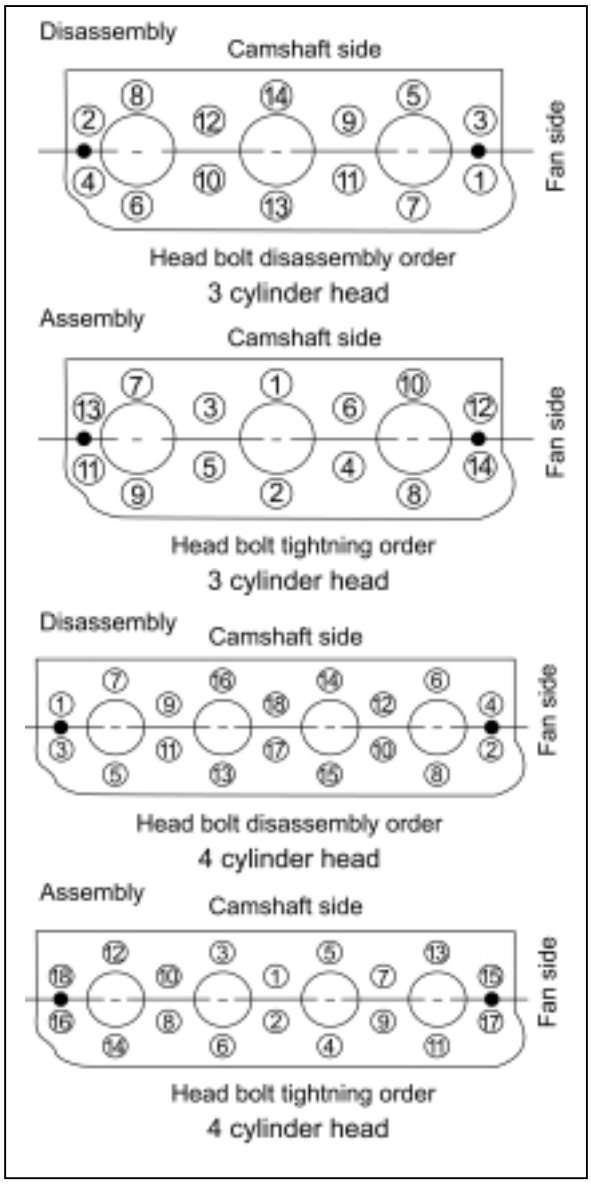
[Reassemble]

- 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

Nm(kgf･m)

	3IRH2N	3/4IRH8N
First step	30.0～34.0 (3.1～3.5)	41.1～46.9 (4.2～4.8)
Second step	61.7～65.7 (6.3～6.7)	85.3～91.1 (8.7～9.3)

	4IRI8N	
First step	49.0～58.8 (5.0～6.0)	
Second step	103.1～112.9 (10.5～11.5)	



Point 9

[Disassemble]

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

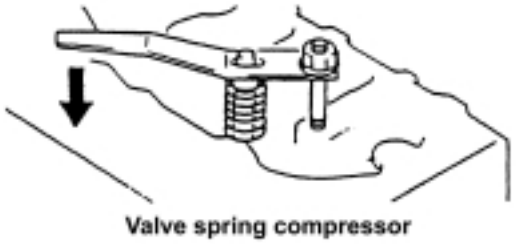
[Reassemble]

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

Point 10

[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 oilstone and extract the valve from the cylinder head.



Valve spring compressor

[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.

4.2.5 Parts Inspection and measurement

(13) Cylinder head

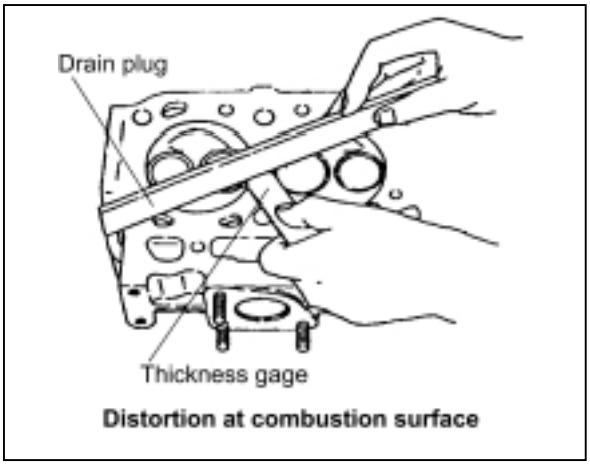
Clean the cylinder head, mainly the combustion surface, valve seats and intake/exhaust ports, remove carbon deposit and bonding agent, and check the surface state.

(a) Appearance check

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

(b) Combustion surface distortion

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



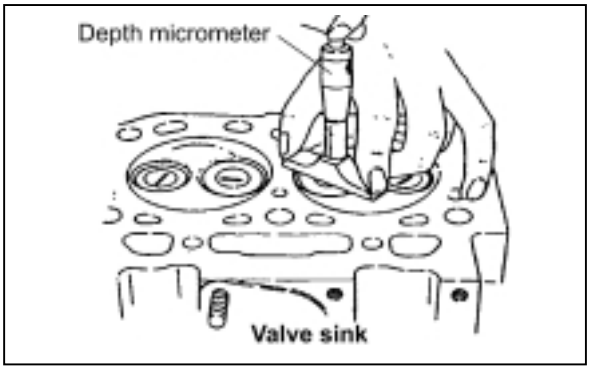
Distortion at combustion surface

mm

	Standard	Limit
Distortion	0.05 or less	0.15

(c) Valve sink

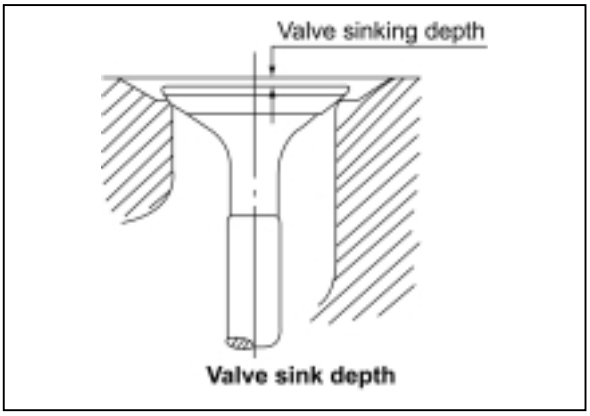
Measure with the valve inserted to the cylinder head.



Valve sink

mm

		Standard	Limit
3IRH2N (2-valve head)	Intake	0.35∼0.55	0.8
	Exhaust	0.30∼0.50	0.8
3IRH8N 4IRH8N (2-valve head)	Intake	0.30∼0.50	0.8
	Exhaust	0.30∼0.50	0.8
4IRI8N 4IRI8T (4-valve head)	Intake	0.36∼0.56	0.8
	Exhaust	0.35∼0.55	0.8

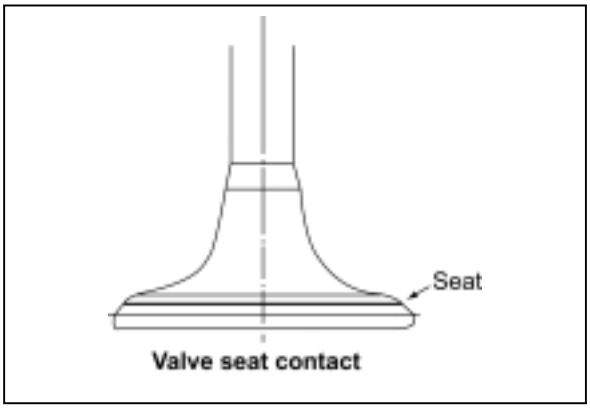


Valve sink depth

(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

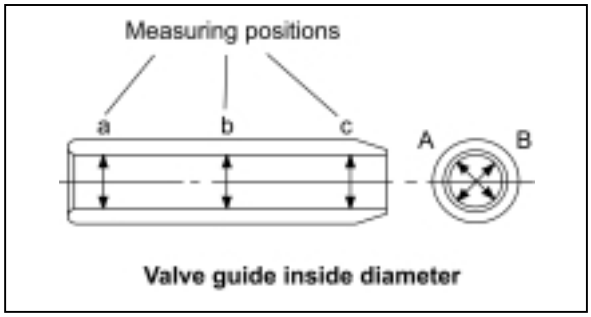


Valve seat contact

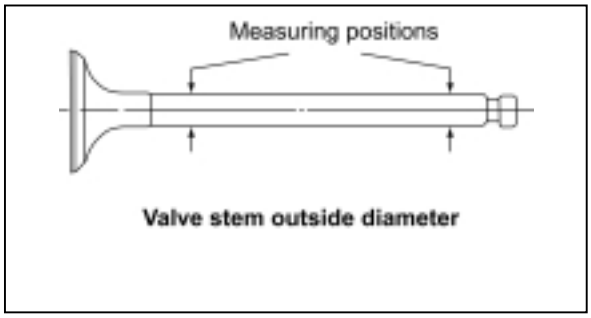
(14) Valve guide

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

Model		Service part code
3IRH2N (2-valve)	Suction	124060-11800
	Exhaust	119802-11810
3/4IRH8N (2-valve)	Suction	120130-11860
	Exhaust	129150-11810
4IRI8T (4-valve)	Suc./Exh.	129907-11800



Valve guide inside diameter



Valve stem outside diameter

Valve stem clearance

Model	Part name	Place	Standard	Limit
3IRH2N (2-valve head)	Intake value	Guide I.D.	7.000~7.015	7.08
		Stem O.D.	6.945~6.960	6.90
		Clearance	0.040~0.070	0.18
	Exhaust value	Guide I.D.	7.000~7.015	7.08
		Stem O.D.	6.940~6.955	6.90
		Clearance	0.045~0.075	0.18
3/4IRH8N (2-valve head)	Intake value	Guide I.D.	8.010~8.025	8.10
		Stem O.D.	7.955~7.975	7.90
		Clearance	0.035~0.070	0.18
	Exhaust value	Guide I.D.	8.015~8.030	8.10
		Stem O.D.	7.955~7.970	7.90
		Clearance	0.045~0.075	0.18
4IRI8T (4-valve head)	Intake value	Guide I.D.	7.000~7.015	7.08
		Stem O.D.	6.945~6.960	6.90
		Clearance	0.040~0.070	0.17
	Exhaust value	Guide I.D.	7.000~7.015	7.08
		Stem O.D.	6.940~6.955	6.90
		Clearance	0.045~0.075	0.17

(15) Intake/exhaust valve

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

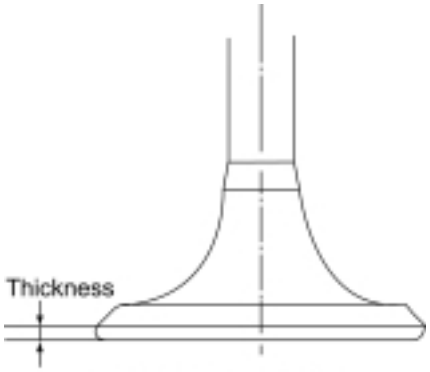
(a) Seat contact: See (1)-(d) above.

(b) Stem outside diameter: See (2) above.

(c) Valve head thickness

mm

Model	Part	Standard	Limit
3/4IRH2N-8N	Intake	1.34	0.50
	Exhaust	1.45	0.50

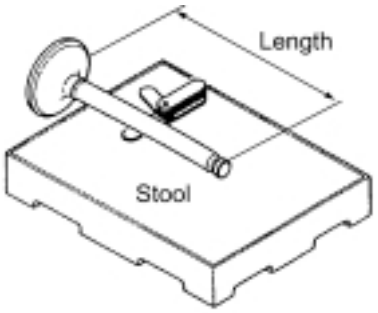


Valve head thickness

(d) Valve stem bend

mm

Limit	0.01



Valve bend and length

(e) Overall length

mm

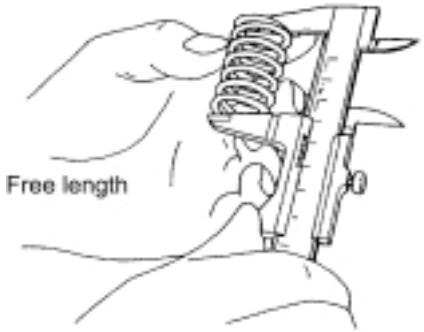
		Standard	Limit
3IRH2N	Intake/Exhaust	?	
3/4IRH8N	Intake/Exhaust		
4IRI8N	Intake/Exhaust	115	114.5

(16) Valve spring

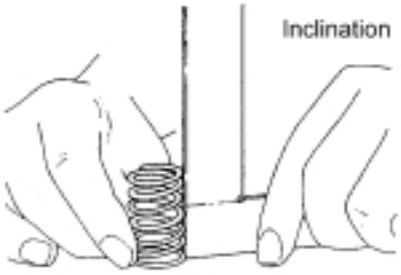
Mainly inspect damage and corrosion.

mm

	Free length standard	Inclination limit
3IRH2N	44.4?	1.2
3/4IRH8N	42.0?	
4IRI8N	47.5	1.2



Valve spring



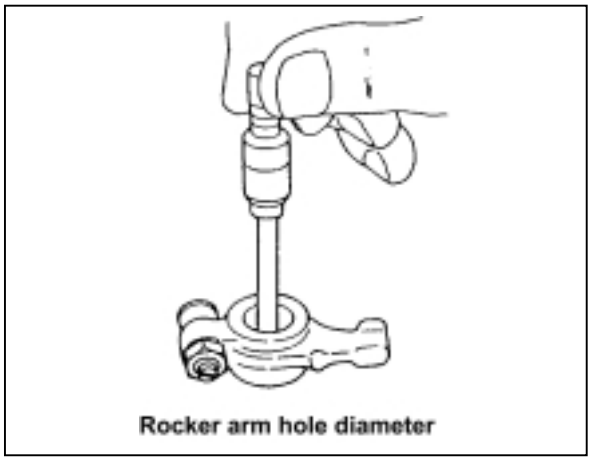
Valve spring

(17) 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

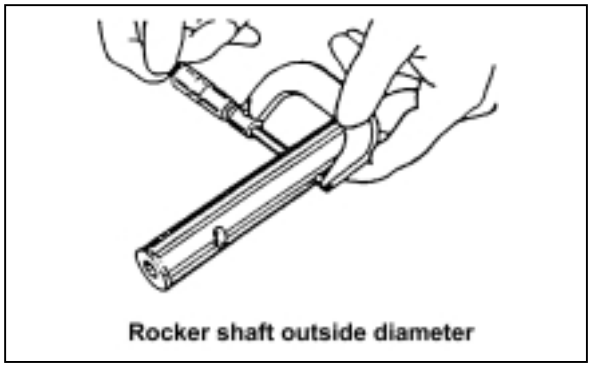
Model	Items	Standard	Limit
3/4IRH2N-8N	Arm hole diameter	16.00～16.02	16.07
	Shaft O.D.	15.97～15.98	15.94
	Clearance	0.016～0.054	0.13
4IRI8T	Arm hole diameter	18.50～18.52	18.57
	Shaft O.D.	18.47～18.49	18.44
	Clearance	0.01～0.05	0.13



Rocker arm hole diameter

(18) 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.

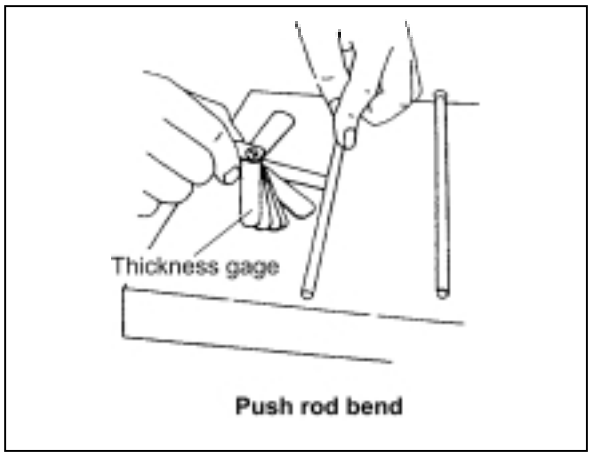


Rocker shaft outside diameter

(19) Push rod

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

Bend limit	0.03mm or less



Push rod bend

(20) Valve clearance adjusting screw

Mainly inspect the surface in contact with the push rod.
Slight defects shall be corrected with an oilstone.

(21) Rocker arm spring

Mainly inspect surface defects and corrosion.

4.2.6 Valve seat correction

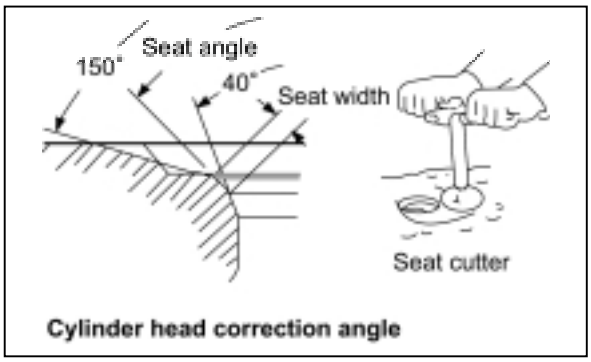
[NOTICE]

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.

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

[B]: Lap with engine oil only.



Cylinder head correction angle

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]**.

	intake	Exhaust
Seat cutter angle	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]**.

Grinding wheel angle	$\theta 1$	$\theta 2$
	40	150

4.2.7 Valve guide replacement

1) Use a valve guide extraction tool(12.1-1 in Chapter 12) 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 (Refer to No.2 of 4.1.2 in Chapter 4).

⚠ CAUTION

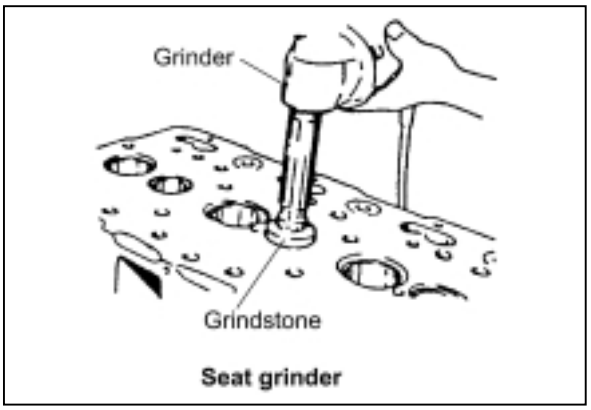
Do not touch the cooled valve guide with bare hands to avoid skin damage.

3) Check the inside diameter and finish to the standard inside diameter as required with a reamer.

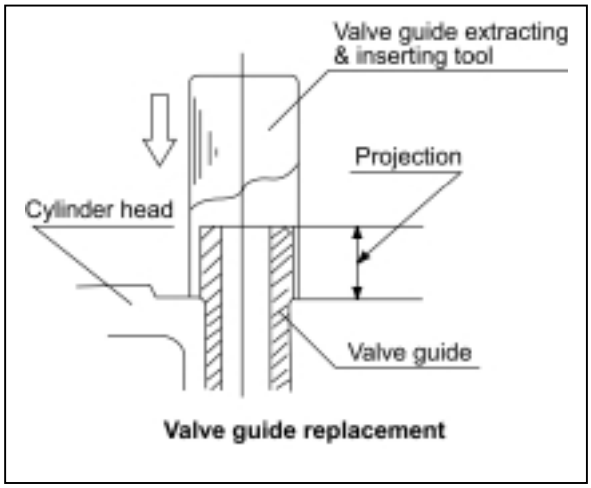
4) Check the projection from the cylinder head.

mm

Model	Number of valves	Projection
3IRH2N	2 valves	11.7∼12.0
4IRH8N		14.7∼15.0
4IRI8T		9.7∼10.



Seat grinder



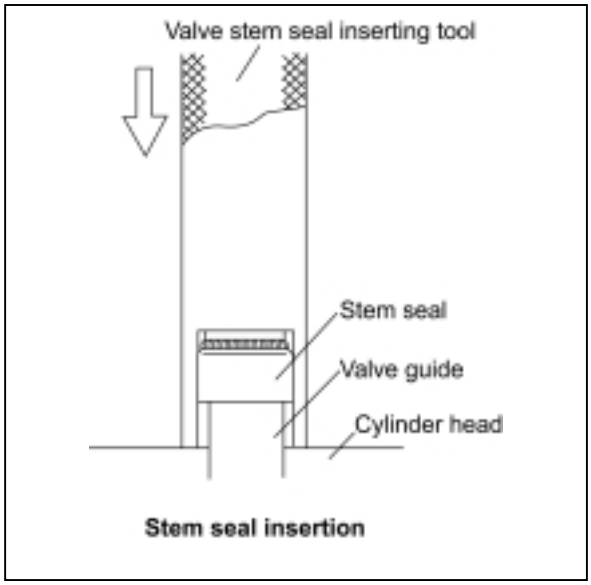
Valve guide replacement

4.2.8 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 (Refer to No.5 of 4.1.2 in Chapter 4) for installation.

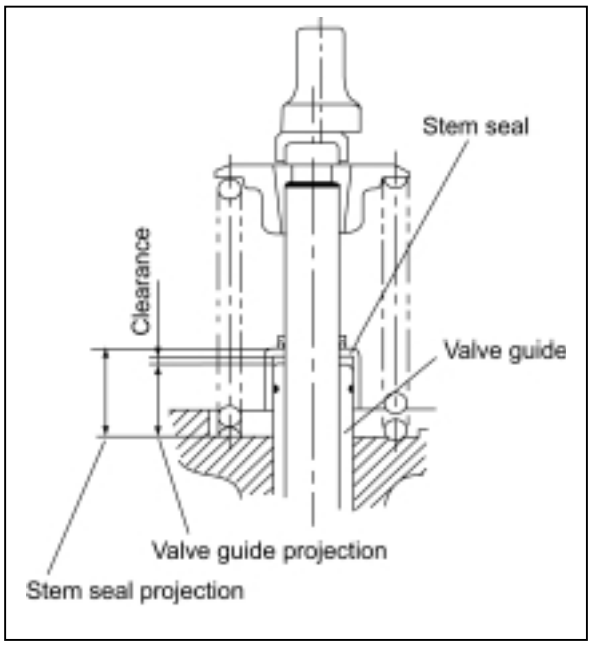


Stem seal insertion

Measure and check the projection of valve stem seal to keep proper clearance between valve guide and stem seal.

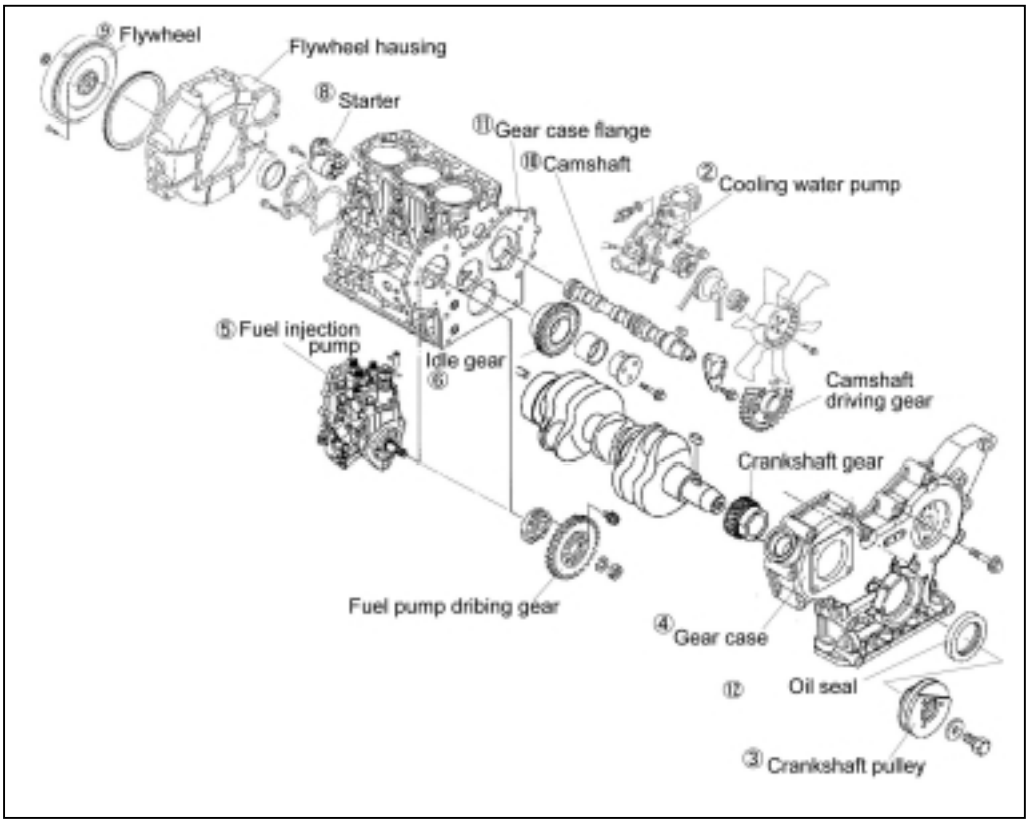
mm

Model	Number of valves	Projection
3IRH2N	2 valves	15.7∼16.0
4IRH8N		18.7∼19.0
4IRI8T		11.7∼12.0



4.3 Gear Train and Camshaft

4.3.1 Components



4.3.2 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 starting motor.
9) Remove the flywheel. (**Point 6**)
10) Remove the camshaft assy. (**Point 7**)
11) Remove the gear case. (**Point 8**)
12) Remove the oil seal from the gear case cover. (**Point 9**)

4.3.3 Reassembly procedure:

Reverse of the disassembly procedure.

4.3.4 Servicing points

Point 1

[Disassemble]

- Remove the crankshaft pulley using a gear puller after removing the crankshaft pulley set bolt. When removing the pulley using 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]

- Apply lithium grease to the oil seal lips. For the oil seal with double lips dust seal, further slightly apply engine oil on the lips so as not to damage them.
- Clean by wiping off any oil on both taper surfaces using detergent.
- Be sure to use the crankshaft pulley installing tool so as not to damage the oil seal lips. (See 4.3(6) Oil seal replacement)
- When installing the crankshaft pulley, apply lube oil to the set bolt to tighten and carefully assemble so as not to damage the oil seal.

N·m(kgf-m)

Model	Tightening torque
3IRH2N∼8N	112.7∼122.7 (11.5∼12.5)
4IRI8N-8T	107.9∼127.5 (11.0∼13.0)

Point 2

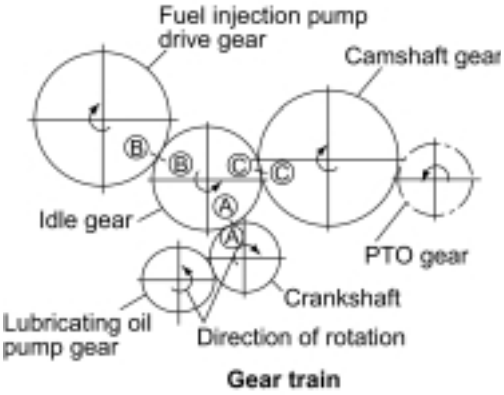
[Reassemble]

- 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

3IRH2N∼8N	Standard	Limit
Crankshaft gear, Camshaft gear, Fuel injection pump gear, Idle gear, PTO gear,	0.07∼0.15	0.17
Lubricating oil pump gear	0.11∼0.19	0.21

4IRI8N-8T	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



Gear train

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

Point 3: (Refer to 7.2.5 in chapter 7)

[Disassemble]

- Remove the mounting nut of the fuel injection pump drive gear, 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]

- Tightening torque for fuel pump drive gear nut (without lube. Oil)

N·m(kgf-m)

Model	Tightening torque
3/4IRH2N-8N	78～88 (8.0～9.0)
4IRI8N-8T	113～123 (11.5～12.5)

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 : apply lube oil

N·m(kgf-m)

Model	Tightening torque
3IRH2N～8N	83.3～88.2 (8.5～9.0)
4IRI8N-8T	186.2～205.8 (19.0～21.0)

Point 7

[Disassemble]

- Measure the camshaft side gap.

mm

Item	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℃～200℃ 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 of slipping when raising the engine vertically or returning it to the horizontal position. Proceed carefully so as not to lose balance.

Point 8: Gear case

[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 pints.

Point 9

[Reassemble]

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

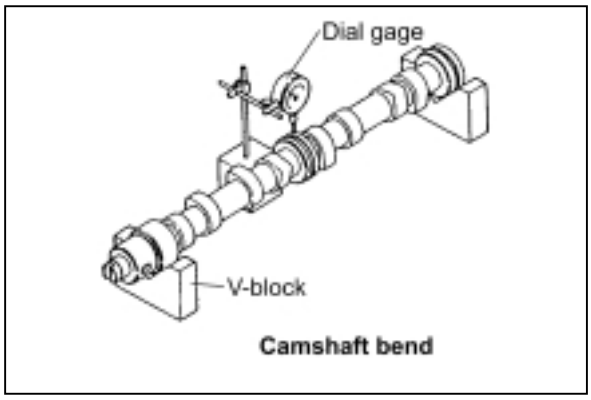
4.3.5 Parts inspection and measurement

(22) Camshaft

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

(a) 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.



Camshaft bend

mm

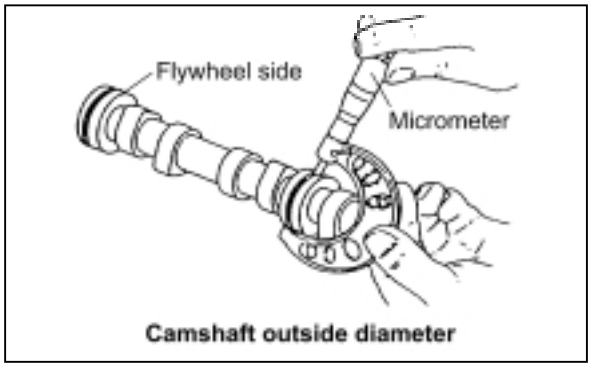
Item	Standard	Limit
Bend	0∼0.02	0.05

(b) Intake/exhaust cam height measurement

mm

Model	Standard	Limit
3IRH2N∼8N	38.600∼38.800	38.350
4IRI8N	43.400∼43.600	43.150

(c) 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.



Camshaft outside diameter

mm

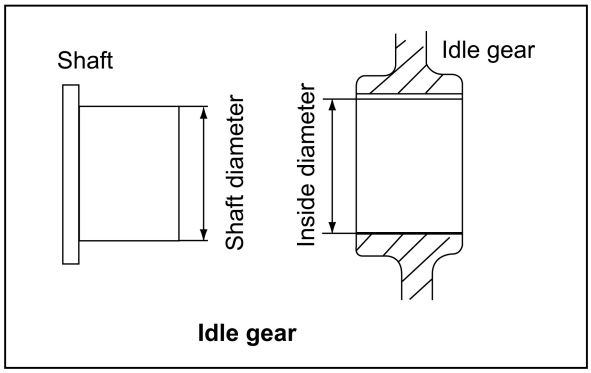
Model	Place	Item	Standard	Limit
3IRH2N～8N	Gear side	Bushing I.D.	44.990～45.055	45.130
		Camshaft O.D.	44.925～44.950	44.890
		Oil clearance	0.040～0.130	0.240
	Intermediate position	Bushing I.D.	45.000～45.025	45.100
		Camshaft O.D.	44.910～44.935	44.875
		Oil clearance	0.065～0.115	0.225
	Wheel side	Bushing I.D.	45.000～45.025	45.100
		Camshaft O.D.	44.925～44.950	44.890
		Oil clearance	0.050～0.100	0.210
4IRI8N-8T	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
	Intermediate position	Bushing 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	Bushing I.D.	50.000～50.025	50.100
		Camshaft O.D.	49.925～49.950	49.890
		Oil clearance	0.05～0.100	0.210

(23) Idle gear

Mainly check the bushing seizure and wear, and gear damage.
Shaft outside diameter and bushing inside diameter measurement

mm

Item	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



Idle gear

(24) PTO drive gear

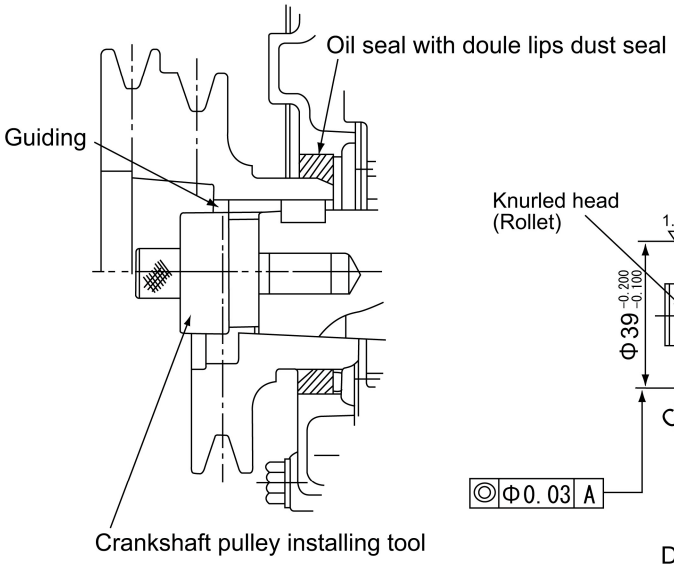
Mainly check sticking of bearings on both sides, gear damage and looseness, and gear shaft damage and wear.

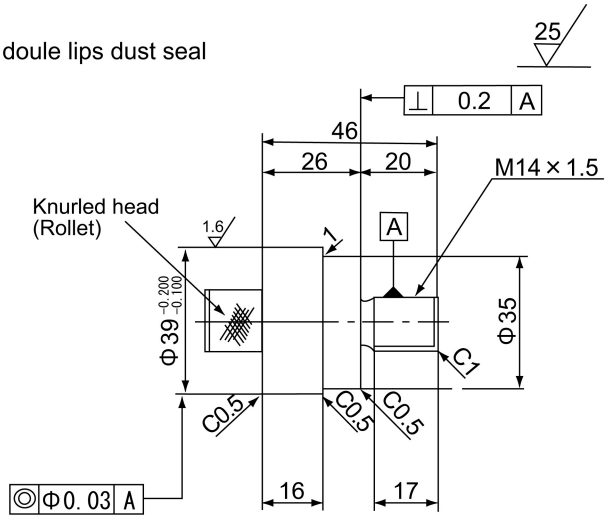
4.3.6 Oil seal replacement

1) Replace the oil seal with a new one when the gear case cover is disassembled.
   Extract the used oil seal.
2) Insert a new oil seal.
3) Apply lithium grease to the oil seal tips. For the oil seal with double lips dust seal, further, slightly apply engine oil on the oil seal lip so as not to damage them, when installing the pulley.

   [NOTICE]
   Pay attention not to drop any oil on the taper surface of the crankshaft. If dropped, clean by wiping off using detergent.

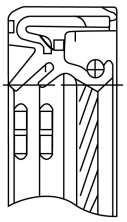
4) Carefully install the crankshaft pulley so as not to damage the oil seal lips. Especially for the engine installed the oil seal with double lips dust seal, be sure to use the crankshaft pulley-installing tool.





Detail of crankshaft pulley installing tool (Scale: free)
(Local supply)

For 4TNV94L engine installed the oil seal with double lips dust seal



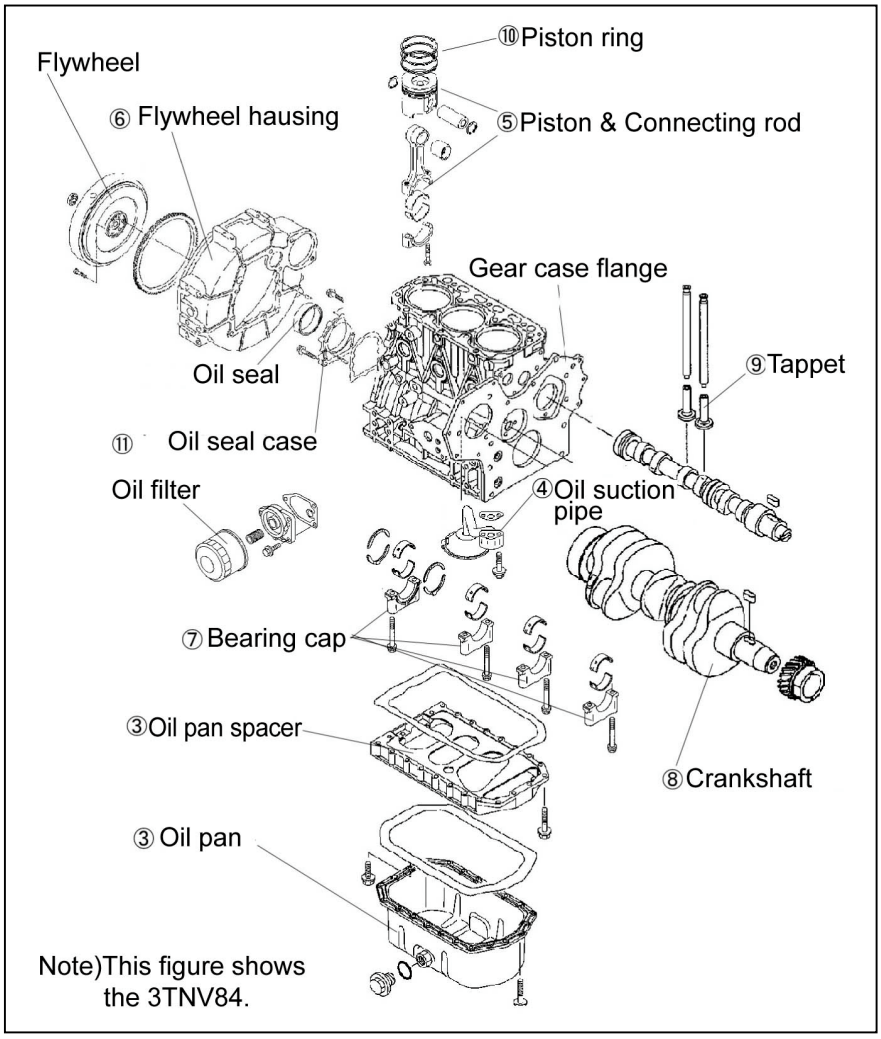
Oil seal with double lips dust seal

4.3.7 Camshaft bushing replacement

Replace the bushing using the special service tool (Refer to No.7 of 4.1.2 in Chapter 4).

4.4 Cylinder Block

4.4.1 Components



4.4.2 Disassembly procedure:

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

4.4.3 Reassembly procedure:

Reverse of the disassembly procedure.

4.4.4 Servicing points

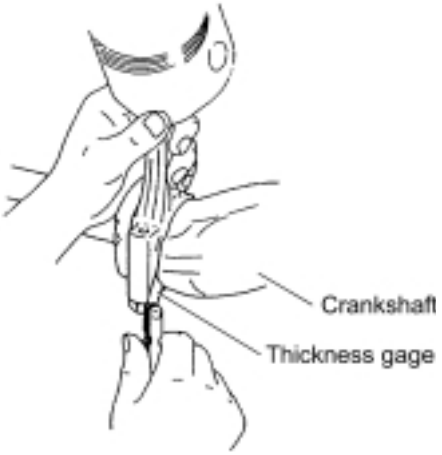
Point 1: Oil pan

[Disassemble]

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

[Reassemble]

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



Connecting rod side gap

Point 2: Piston w/rod

[Disassemble]

- Measure the connecting rod side gap.

mm

Standard	0.20～0.40

- 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 12.1-9 in Chapter 12) to insert each piston w/rod in the cylinder block and install the bearing metal cap.

Rod bolt tightening torque N·m(kgf-m)

Model	Standard (apply lube oil)
3IRH2N	37.2～41.2 (3.8～4.2)
3/4IRH8N	44.1～49.0 (4.5～5.0)
4IRI8N	53.9～58.8 (5.5～6.0)

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

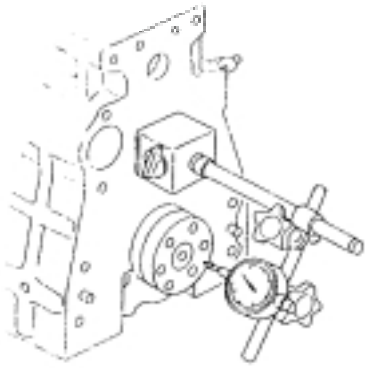
Unforeseen injury may arise due to falling of slipping when raising or reversing the engine. Carefully operate so as not to lose balance.

Point 4: Journal bearing cap

[Disassemble]

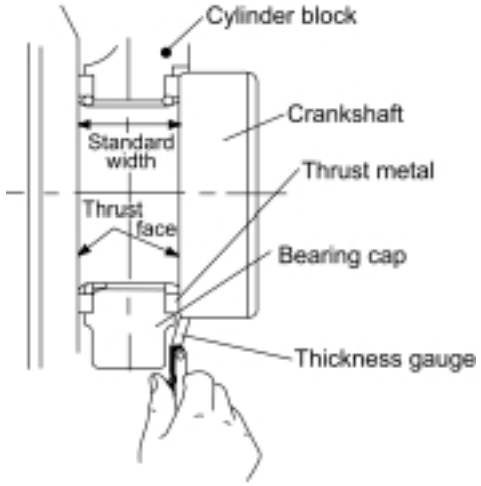
- Before removing the journal bearing, measure the crankshaft side gap. Measure it in either method because there are the next two methods.

1) Install a dial gage on the cylinder block, and move a crankshaft in front and back, and measure the side gap as shown in the right figure.



Side gap measurement 1

2) Put a thickness gauge in the clearance between thrust metal and crankshaft directly, and measure it.



Side gap measurement 2

Side gap standard mm

Model	Standard	Limit
All models	0.13～0.23	0.28

[Reassemble]

- If the side gap exceeds the standard, replace the thrust metal with an oversize one.
  Machine the standard width of the crankshaft thrust part into the dimension of the below table at the same time.
  Refer to a parts catalog when ordering the part.

  The surface finishing precision (refer to 4.4.5(2) in Chapter4): 1.6

0.25mm Oversized thrust metal (0.25DS) mm

0.25DS	Thrust metal assy code	Standard thickness
3IRH2N	119810-02940	2.055～2.105
3/4IRH8N	129150-02940	2.055～2.105
4IRI8N	129900-02940	2.055～2.105

The standard width of the crankshaft thrust part

mm

Model	Standard thickness
3IRH2N	25.250～25.271
3/4IRH8N	28.250～28.271
4IRI8N	32.250～32.275

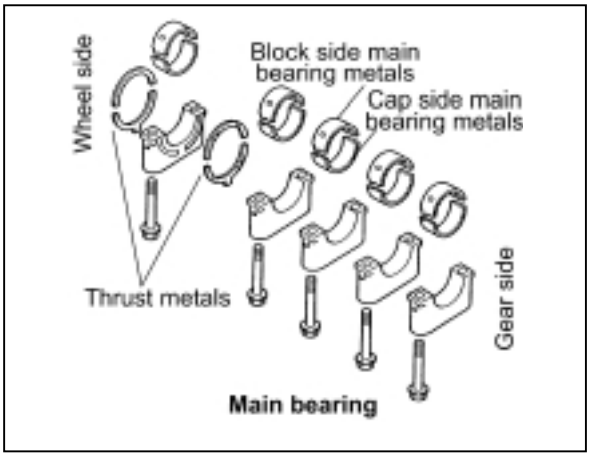
[Disassemble]

- 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.

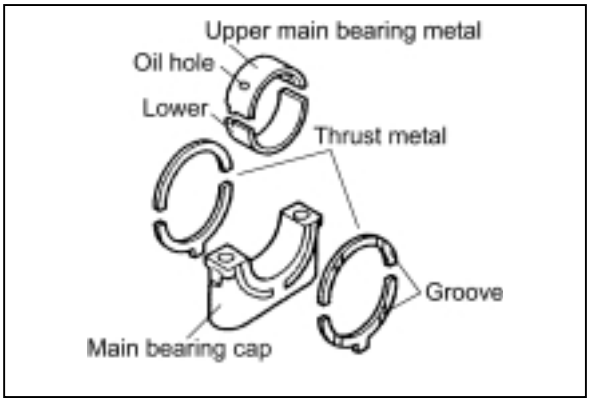
Main bearing cap bolt tightening torque
(apply lube oil)

Nm(kgf m)

Model	Standard
3IRH2N	76.4～80.4 (7.8～8.2)
3/4IRH8N	93.2～98.1(9.5～10.5)
4IRI8N	108.1～117.9 (11.0～12.0)



Main bearing



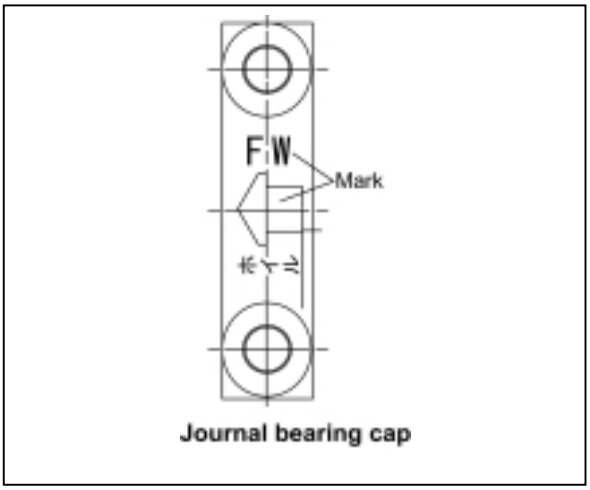
Point 5: Crankshaft

[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.



Journal bearing cap

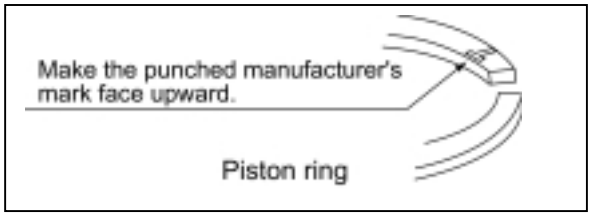
Point 6: Piston pin and rings

[Disassemble]

- Using the piston ring replacer (see 4.1.2 in Chapter 4), remove the piston rings.
- Remove the circlip and remove the piston pin by pushing it out.

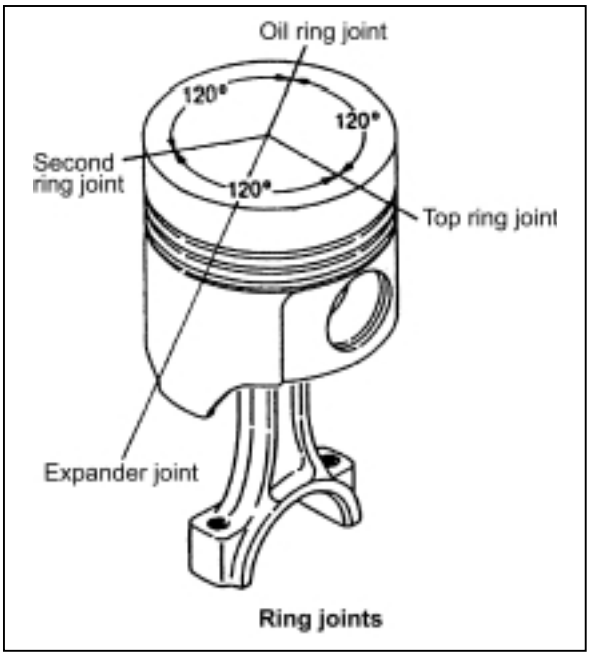
[Reassemble]

- 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.



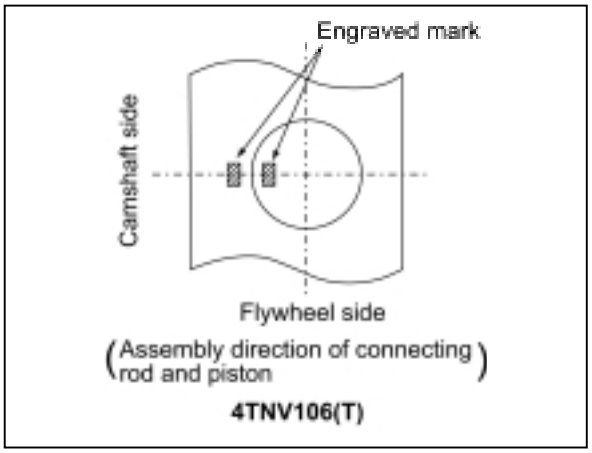
Ring joints

[Reassemble]

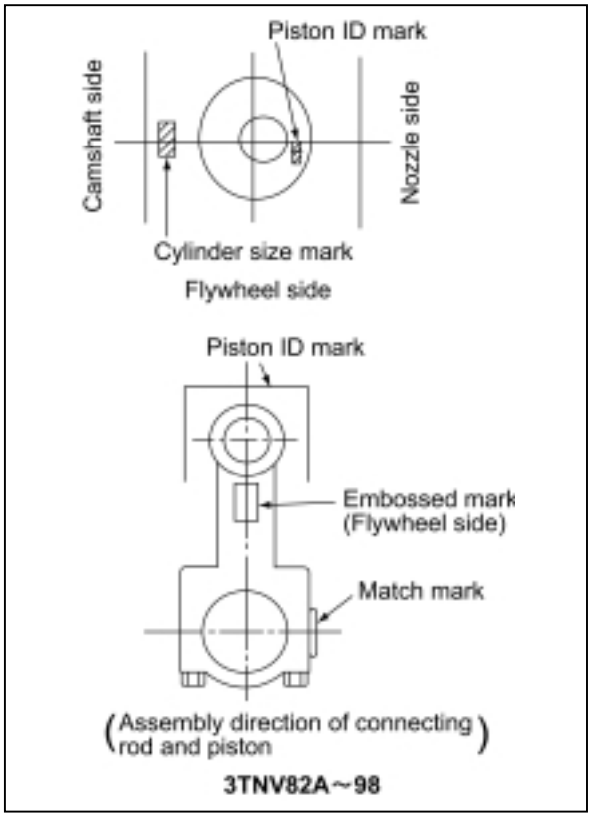
- When installing the piston pin to the rod and piston, the punched match mark on the big end of
- the connecting rod shal be opposite to the size mark on the piston top.

[Reassemble]

- Install the piston in the cylinder clock 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.)



4TNV106(T)



3TNV82A～98

Point 7: Oil seal

[Reassemble]

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

4.4.5 Parts inspection and measurement

(25) Cylinder block

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

(a) 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.

(b) 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:

Roundness is found as follows though it is the simple method. Measure cylinder diameters of the A direction and the B direction on each section of a, b and c.

Roundness is the maximum value among those difference values.

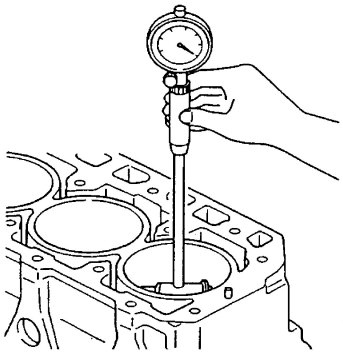
Cylindricity:

Cylindricity is found as follows though it is the simple method.

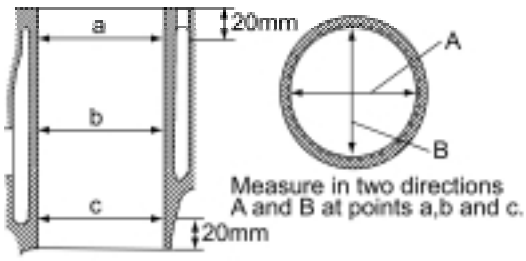
Measure cylinder diameters of a, b and c sections in the A direction, and calculate the difference in maximum value and minimum value of the measured diameters.

In the same way measure and calculate the difference in the B direction.

Cylindrically is the maximum value between those difference values.



Cylinder bore



Cylinder bore measurement positions

mm

Item		Model	Standard	Limit
Cylinder inside diameter		3IRH2N	82.000～82.030	82.200
		3/4IRH8N	88.000～88.030	88.200
		4IRI8N	98.000～98.030	98.130
Cylinder bore	Roundness	all IRH/IRI	0.01 or less	0.03
	Cylindrically			

(c) 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, with piston rings)

Model	Code No.	Standard (mm)
3IRH2N	719802-22900	82.250
3/4IRH8N	129005-22900	88.250
4IRI8N	129902-22700	98.250

Piston ring assy for oversized (0.25mm)

Model	Piston ring code No.
3IRH2N	719802-22950
3/4IRH8N	129005-22950
4IRI8N	729907-22950

Cylinder dimension after boring and honing

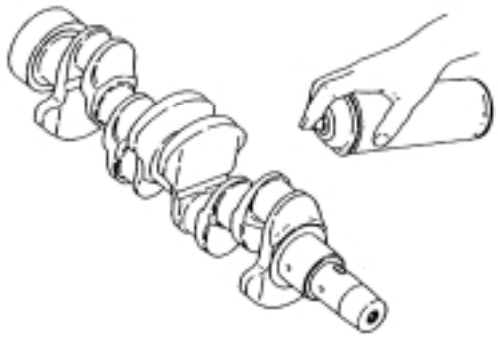
Model	Cylinder dimension (mm)	Honing angle (deg.)	Surface roughness	Roundness/Cylindricity (mm)
3IRH2N	82.250～82.280	30～40 deg.	R_{max} 1.0～3.5S	0.01 or less
3/4IRH8N	88.250～88.280			
4IRI8N	98.250～98.280			

(26) Crankshaft

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

(a) 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.

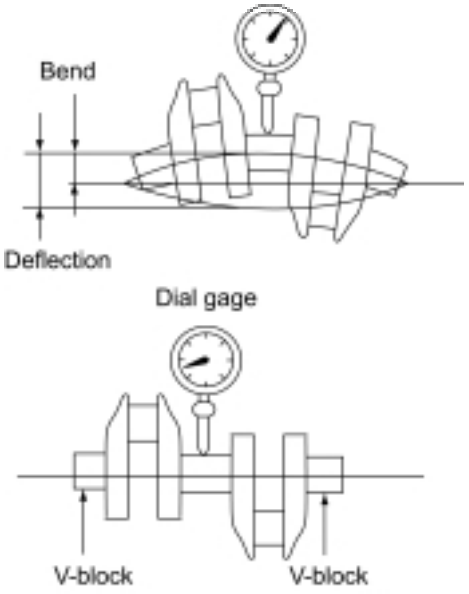


Inspection by color check

(b) 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.

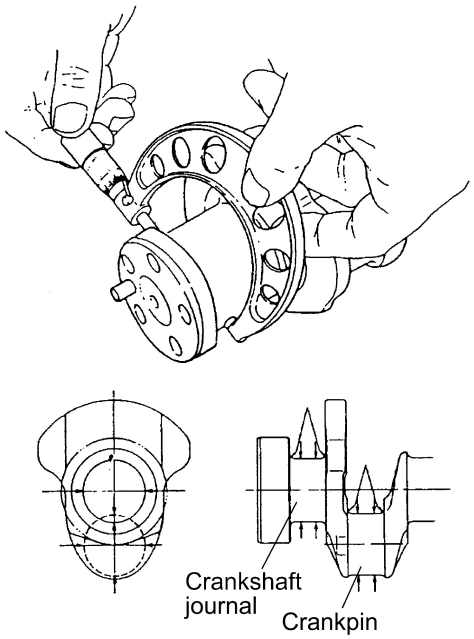
Limit	0.02mm or less



Crankshaft bend measurement

(c) Crankpin and journal measurement

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



Measuring position of the crankpin and crank journal

Crankpin mm

Model & Item		Standard	Limit
3IRH2N	Pin outside diameter	42.952～42.962	42.902
	Metal thickness	1.487～1.500	-
	Oil clearance	0.038～0.090	0.150
3/4IRH8N	Pin outside diameter	47.952～47.962	47.902
	Metal thickness	1.492～1.500	-
	Oil clearance	0.038～0.074	0.150
4IRI8N	Pin outside diameter	57.952～57.962	57.902
	Metal thickness	1.492～1.500	-
	Oil clearance	0.038～0.074	0.150

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

Undersized crankpin bearing (0.25 mm)

Model	Code No.	Standard thickness (mm)
3IRH2N	119810-23610	1.612～1.625
3/4IRH8N	129150-23610	1.617～1.625
4IRI8N	129900-23610	1.617～1.625

Pin machining dimension

Model	Pin machining dimension (mm)
3IRH2N	ϕ42.702～42.712
3/4IRH8N	ϕ47.702～47.712
4IRI8N	ϕ57.702～57.712

Crank journal mm

Model	Item	Standard	Limit
3IRH2N	Journal O.D.	46.952～46.962	46.902
	Metal thickness	1.987～2.000	-
	Oil clearance	0.038～0.080	0.150
3/4IRH8N (Selective assembly)	Journal O.D.	53.952～53.962	53.902
	Metal thickness	1.995～1.990	-
	Oil clearance	0.038～0.068	0.150
4IRI8N (Selective assembly)	Journal O.D.	64.952～64.962	64.902
	Metal thickness	1.995～2.010	-
	Oil clearance	0.038～0.068	0.150

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

Undersized bearing (0.25mm)

Model	Code No.	Standard thickness (mm)
3IRH2N	119810-02870	2.112～2.125
3/4IRH8N	129150-02870	2.112～2.125
4IRI8N	129900-02340	2.112～2.125

Crankshaft Journal machining dimension

Model	Journal machining dimension (mm)
3IRH2N	ϕ46.702～46.712
3/4IRH8N	ϕ53.702～53.712
4IRI8N	ϕ64.702～64.712

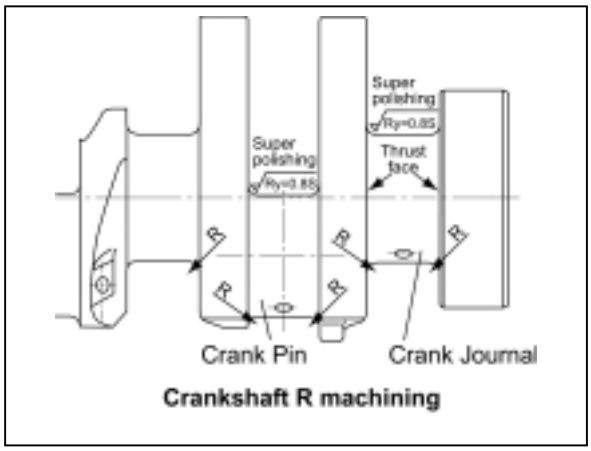
- Dimension R and finishing precision of crankshaft journal and pin

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

  Surface finishing precision standard on journal and pin:

  Ry=0.8S super polishing

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



Crankshaft R machining

mm

Model	Finishing precision standard of dimension R
3/4IRH2N-8N	3.5 +0.3/ 0
4IRI8T	4.0 +0.3/ 0

[NOTICE]

1) If the oil clearance is excessive though the thicknesses of the iournal 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.

(27) Thrust metal inspection

(a) Inspect any damage or wear.

(b) Measure side gap and thrust metal thickness

Side gap and thrust metal thickness mm

Model	Side gap		Thrust metal thickness	
	Standard	Limit	Standard	Limit
3/4IRH8N	0.14∼0.22	-	1.930∼1.980	1.850
4IRI8N	0.13∼0.23	-	1.930∼1.980	1.850

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

Oversized metal (0.25mm)

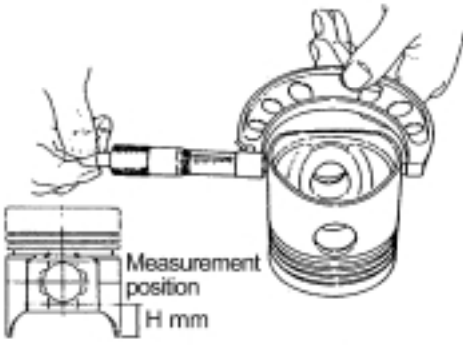
-	Code No.		Standard thickness (mm)
	Upper	Lower	
3IRH2N	???119810-02940 (Up-down combination)		2.15
3/4IRH8N	129150-02940 (Up-down combination)		2.15
4IRI8N	129900-02370	129900-02360	2.055∼2.105

(28) 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.

(a) 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

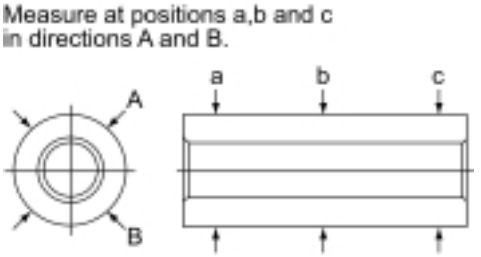
Piston outside diameter mm

Model	Outside diameter Standard	Limit	Clearance between piston and cylinder	Measurement position (H)
3IRH2N	81.950∼81.980	81.905	0.035∼0.065	22∼25
3/4IRH8N	87.945∼87.975	87.900		
4IRI8T	97.940∼97.950	97.895		22

If the clearance between piston and cylinder exceeds the limit, use an oversized piston. (Refer to the tables of oversized pistons, oversized piston rings and cylinder boring dimension on 4.4.5(1)(c) in chapter 4.)

(b) Piston pin hole measurement

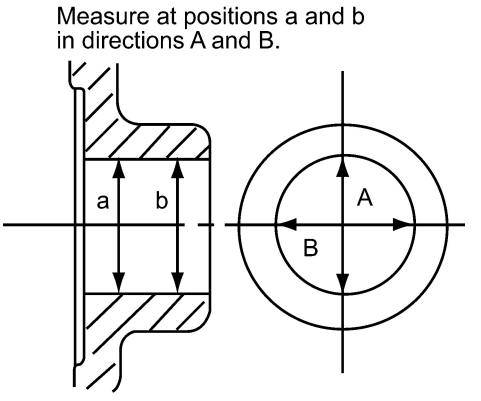
Measure the outside diameter of piston pin and the inside diameter of piston pin hole. Calculate the clearance between piston pin and piston pin hole. If any data exceeds the limit, replace the part with a new one.



Piston pin outside diameter

mm

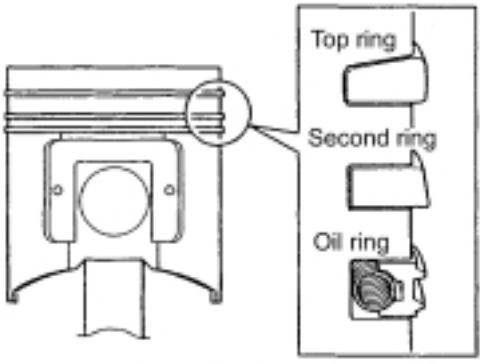
Model	Item	Standard	Limit
3IRH2N	Pin I.D.	23.000∼23.009	23.039
	Pin O.D.	22.995∼23.000	22.965
	Clearance	0.000∼0.014	0.074
3/4IRH8N	Pin I.D.	26.000∼26.009	26.039
	Pin O.D.	25.995∼26.000	25.965
	Clearance	0.000∼0.014	0.074
4IRI8T	Pin I.D.	30.000∼30.009	30.039
	Pin O.D.	29.989∼30.000	29.959
	Clearance	0.000∼0.020	0.080



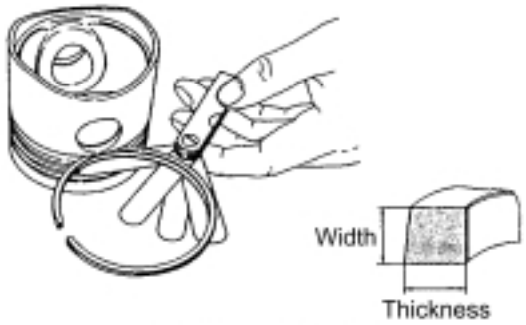
Piston pin hole

(c) Piston ring, ring groove and end clearance measurement

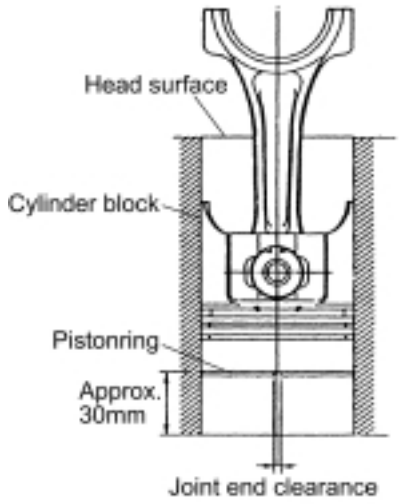
- Except for the top ring, to measure the piston ring groove width, first measure the width of the piston ring. Then insert the piston ring into the ring. Then insert the piston ring into the ring groove. Insert a thickness gage in between the piston ring and groove to measure the gap between them. Obtain 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.



Ring components



Measuring side clearance



Ring joint end clearance measurement

Piston ring dimension mm

Model	Part	Item	Standard	Limit
3IRH2N	Top ring	Ring groove width	2.065~2.080	-
		Ring width	1.970~1.990	1.950
		Side clearance	0.075~0.110	-
		End clearance	0.200~0.400	0.490
	Second ring	Ring groove width	2.035~2.050	2.150
		Ring width	1.970~1.990	1.950
		Side clearance	0.045~0.080	0.200
		End clearance	0.200~0.400	0.490
	Oil ring	Ring groove width	4.015~4.030	4.130
		Ring width	3.970~3.990	3.950
		Side clearance	0.025~0.060	0.180
		End clearance	0.200~0.400	0.490
3/4IRH8N	Top ring	Ring groove width	2.060~2.075	-
		Ring width	1.970~1.990	1.950
		Side clearance	0.070~0.105	-
		End clearance	0.200~0.400	0.490
	Second ring	Ring groove width	2.025~2.040	2.140
		Ring width	1.970~1.990	1.950
		Side clearance	0.035~0.070	0.190
		End clearance	0.200~0.400	0.490
	Oil ring	Ring groove width	4.015~4.030	4.130
		Ring width	3.970~3.990	3.950
		Side clearance	0.025~0.060	0.180
		End clearance	0.200~0.400	0.490
4IRI8N	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

(29) Connecting rod

(a) Appearance inspection

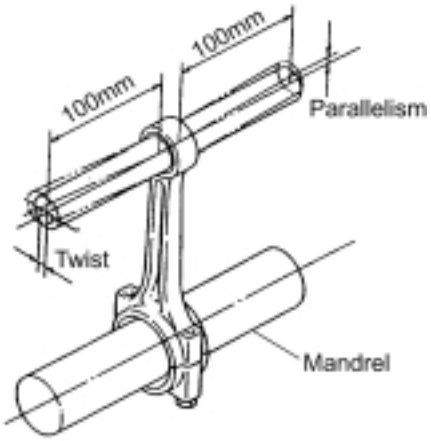
Inspect the portion near the boundary of the chamfered portion and I-beam section of the big and small ends of the connecting rod as well as the portion near the oil hole of the bushing at the small end for cracks, deformation, and discoloration.

(b) Twist and parallelism measurement

Use a connecting rod aligner and measure the twist and bend.

mm

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



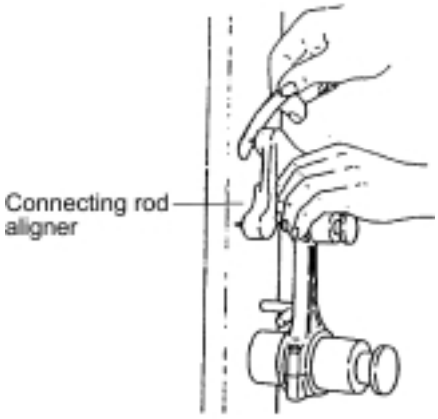
Twist and parallelism measurement

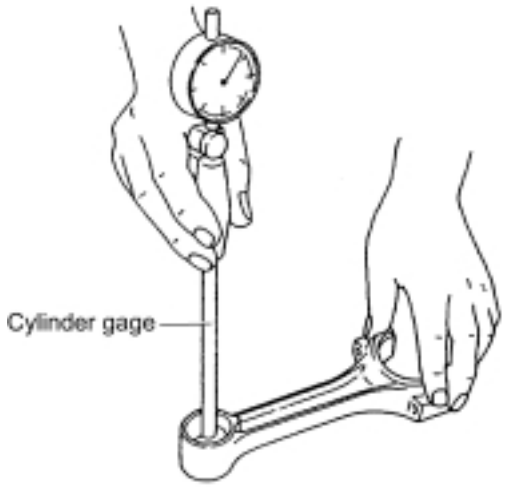
(c) Rod small end measurement

Measure the pin outside diameter according to 4.4.5.(4)(a) described above.

mm

Model	Item	Standard	Limit
3IRH2N	Piston pin I.D. bushing	23.025～23.038	23.068
	Pin O.D.	22.995～23.000	22.967
	Clearance	0.025～0.043	0.101
3/4IRH8N	Piston pin I.D. bushing	26.025～26.038	26.068
	Pin O.D.	25.995～26.000	25.967
	Clearance	0.025～0.043	0.101
4IRI8N	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





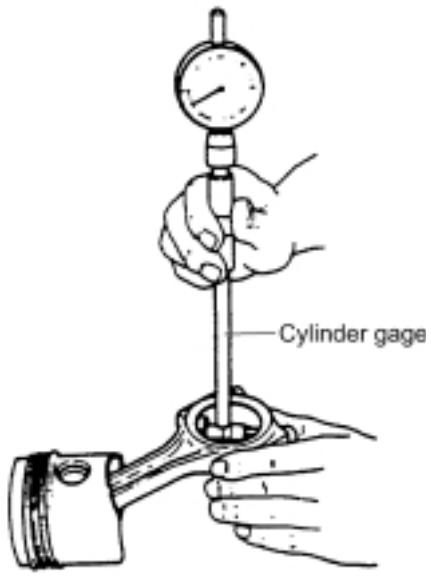
Connecting rod small end

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

Model	Service part code
3IRH2N	119810-23910
3/4IRH8N	129100-23910
4IRI8T	129900-23910

(d) Rod big end measurement
Measure the crankpin and bushing according to 4.4.5.(2)(c) described above.
Calculate the oil clearance of a crank pin metal and a crank pin from the measured values of the crank pin metal inner diameter and the crank pin outside diameter.
Replace a crank pin metal if the oil clearance becomes about the limit dimension of the below table.
Correct by grinding if unevenly wear, roundness exceeding the limit or insufficient outside diameter is found. Also use an undersized metal. (Refer to the above (2) c.)

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



Rod bushing I.D. measurement

Tightening torque of rod bolt

Model	Tightening torque Nm(kgf-m)	Lubricating oil application (threaded portion, and bearing seat surface)
3IRH2N	37.2∼41.2 (3.8∼4.2)	Lube. oil applied
3/4IRH8N	44.1∼49.0 (4.5∼5.0)	
4IRI8N	53.9∼58.8 (5.5∼6.0)	

Standard of rod big end mm

Model	Item	Standard	Limit
3IRH2N	Rod I.D. bushing	42.952∼42.962	42.902
	Crankpin O.D.	43.000∼43.042	-
	Metal thickness	1.487∼1.500	-
	Clearance	0.038∼0.090	0.150
3/4IRH8N	Rod I.D. bushing	47.952∼47.962	47.902
	Crankpin O.D.	48.000∼48.026	-
	Metal thickness	1.492∼1.500	-
	Clearance	0.038∼0.074	0.150
4IRI8N	Rod I.D. bushing	57.952∼57.962	57.902
	Crankpin O.D.	58.000∼58.026	-
	Metal thickness	1.492∼1.500	-
	Clearance	0.038∼0.074	0.150

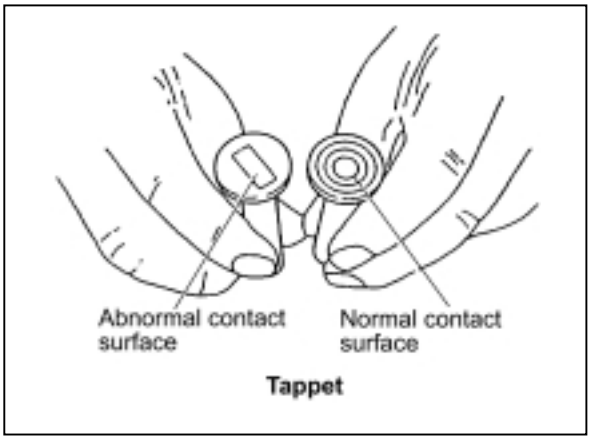
(30) Tappet

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

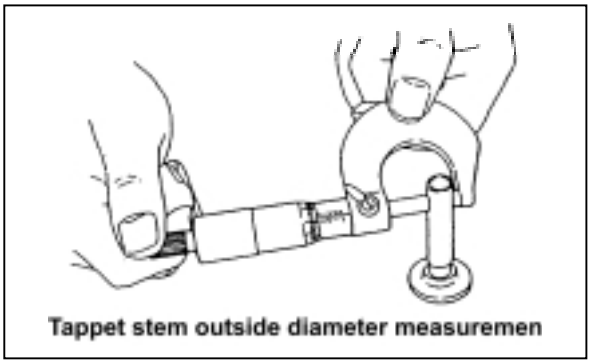
(a) Tappet stem outside diameter measurement

mm

Model	Item	Standard	Limit
3/4IRH8N	Tappet hole I.D.	12.000～12.025	12.045
	Stem O.D.	11.975～11.990	11.955
	Clearance	0.010～0.050	0.090
4IRI8N	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



Tappet

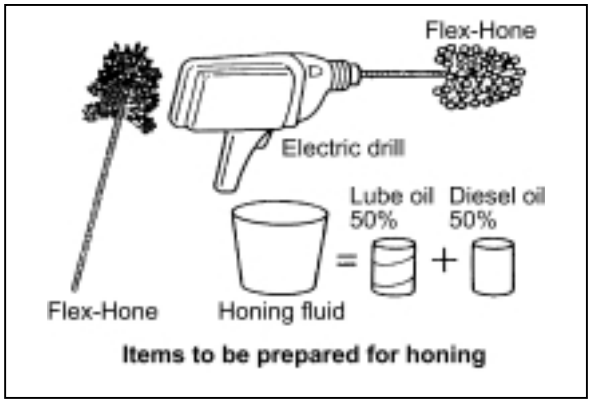

Tappet stem outside diameter measuremen

4.4.6 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 4.4.5.(1)(c) for the boring dimension.

2) Items to be prepared for honing

- Flex-Hone
  (see No.8 of 4.1.2 in Chapter 4)
- Electric drill
- Honing fluid
  (50:50 mixture of lube oil and diesel oil)



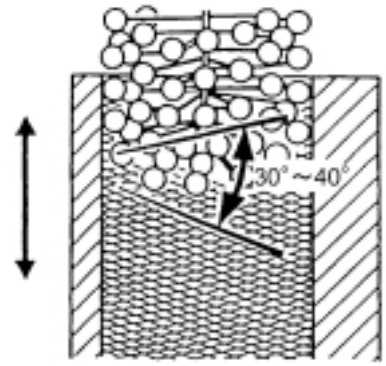
Items to be prepared for honing

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°.

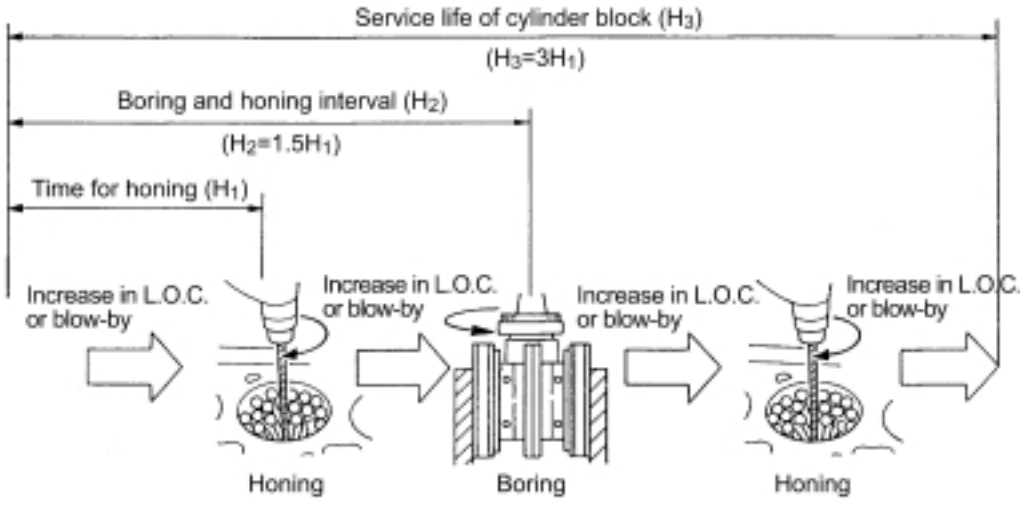
[NOTICE]

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.



Honing cross hatch



Study if an oversized piston or piston ring is usable

4.4.7 Piston pin bushing replacement

Replace bushing by using the special service tool (see 4.1.2 No.3 in Chapter 4).

4.4.8 Oil seal replacement

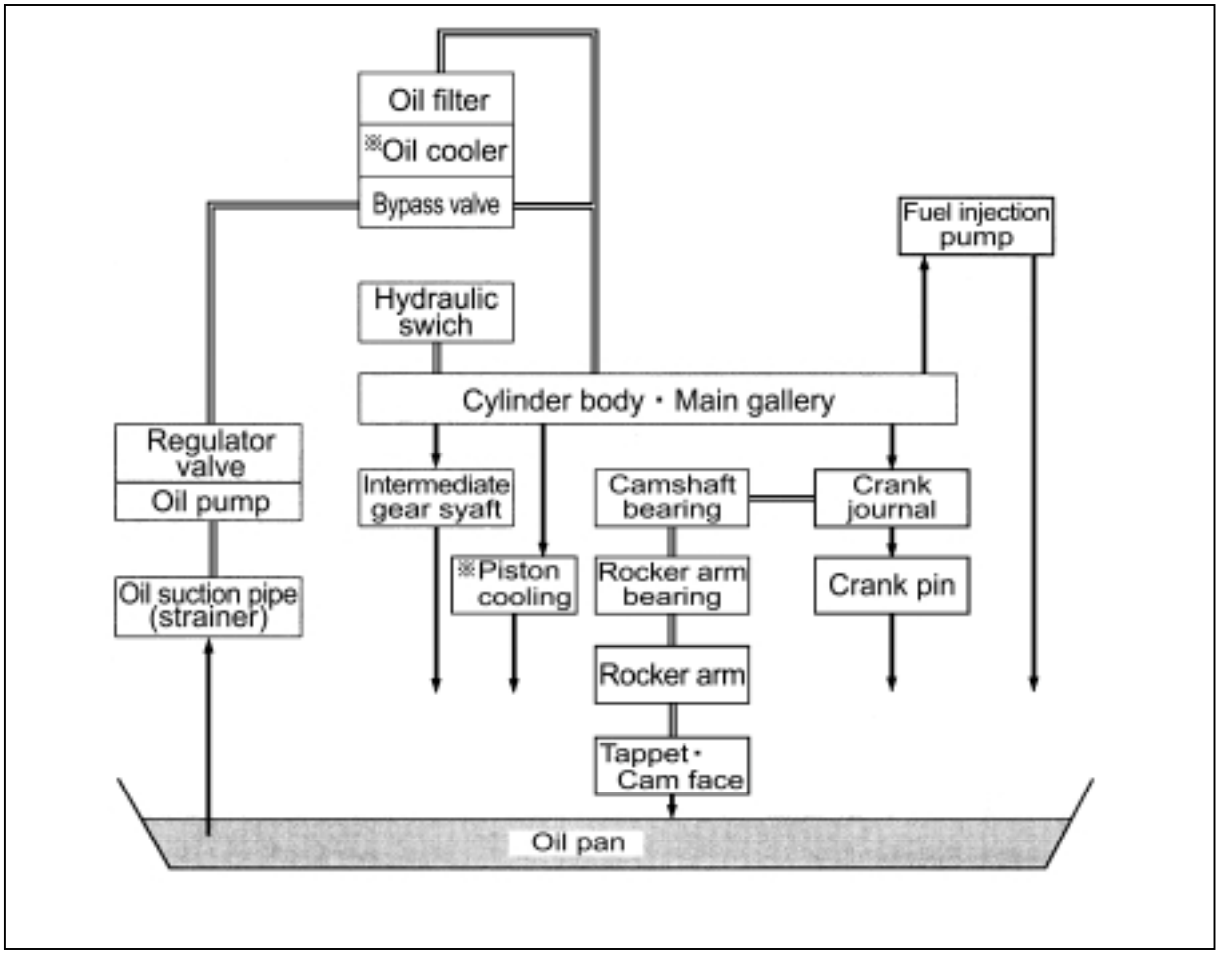
1) Replace oil seal, when mounting flange is removed. Extract the used oil seal.

2) Insert a new oil seal with the oil seal insertion tool.

3) Apply lithium grease.

5. LUBRICATION SYSTEM

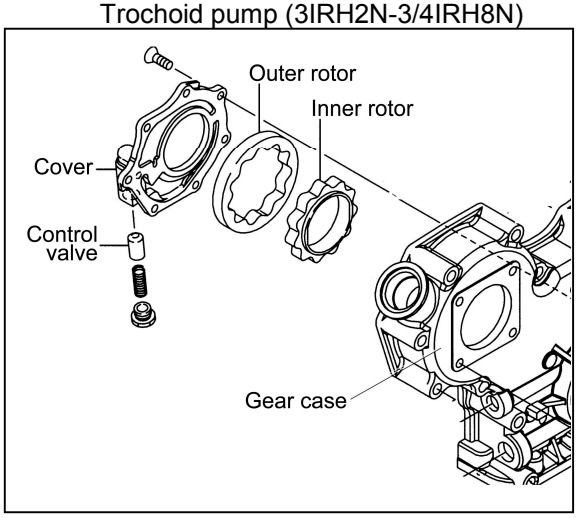
5.1 Lubrication System Diagram



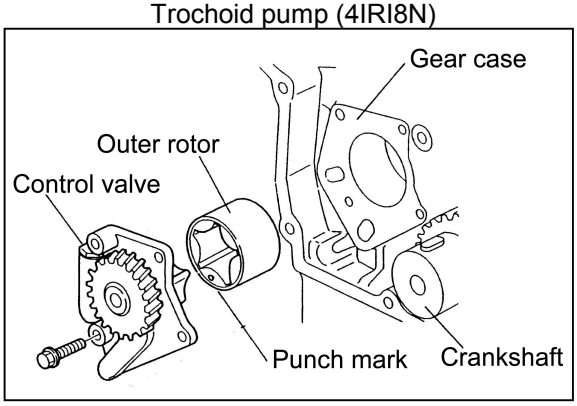
Note: It varies in the specifications of each model whether Oil cooler and Piston cooling of the * mark are attached.

5.2 Trochoid Pump Components

Trochoid pump (3IRH2N-3/4IRH8N)



Trochoid pump (4IRI8N)



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]

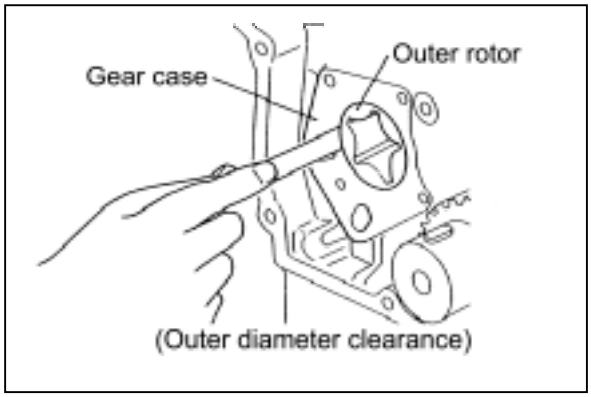
- Only wash the pressure regulating valve. Disassembly is unnecessary unless any abnormality in operation is detected.

5.5 Parts Inspection and Measurement

5.5.1 Trochoid pump inspection and measurement

(31) Outside clearance and side clearance of outer rotor

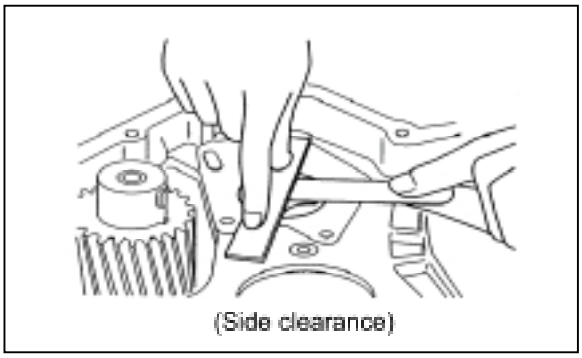
Insert a gap gage between a outer rotor and a pump body, and measure the clearance.



Outside clearance mm

Model	Standard	Limit
3IRH2N 3/4IRH8N	0.12∼0.21	0.30
4IRI8N	0.100∼0.155	0.25

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



Side clearance mm

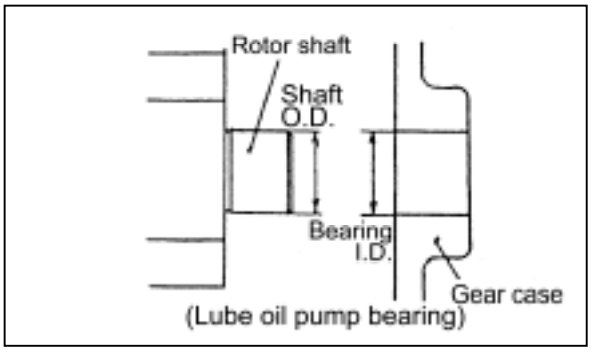
Model	Standard	Limit
3IRH2N 3/4IRH8N	0.02∼0.07	0.12
4IRI8N	0.05∼0.10	0.15

(32) Inner rotor clearance (3IRH2N-4IRH8N)

Item	Part	Standard dimension (mm)	Standard clearance (mm)	Standard clearance limit (mm)
Inside clearance of inner rotor	Gear boss diameter	53.05∼53.15	0.3∼0.5	0.6
	Rotor inner diameter	53.45∼53.55		
Width across flat clearance of inner rotor	Gear boss width across flat	49.45∼49.75	0.2∼0.6	0.7
	Rotor width across flat	49.95∼50.05		

(33) Rotor shaft clearance

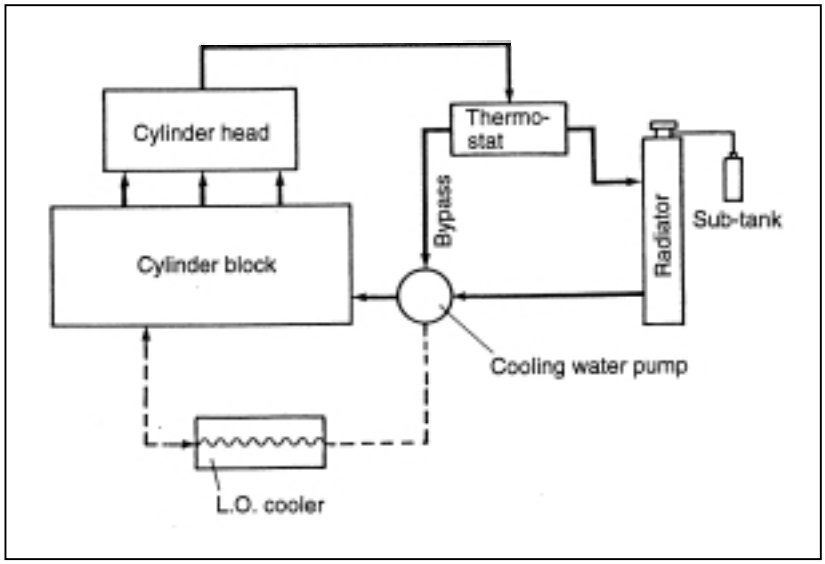
Measure the outside diameter of rotor shaft and the shaft hole diameter of gear case. Calculate the clearance from that difference.



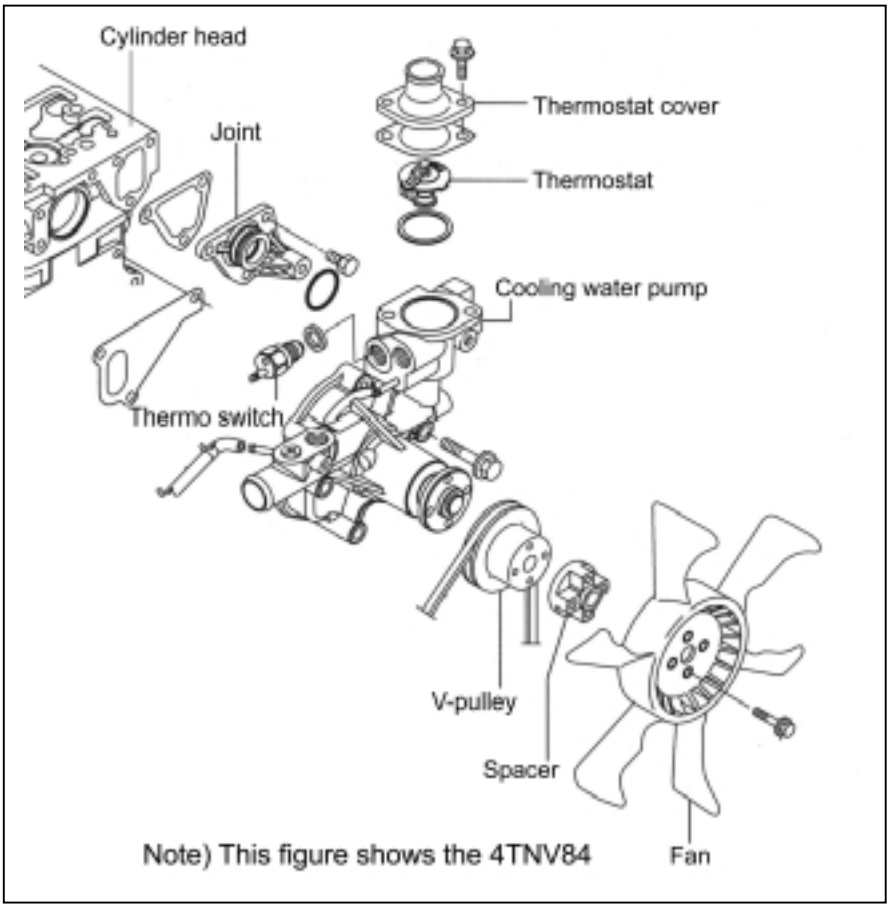
Model	Inspection item	Standard	Limit
4IRI8N	Gear case bearing I.D.	13.0～13.02	13.05
	Rotor shaft O.D.	12.955～12.965	12.955
	Rotor clearance	0.035～0.065	0.105

6. COOLING SYSTEM

6.1 Cooling Water System



6.2 Cooling Water Pump Components



6.3 Disassembly (Reverse the procedure below for assembly)

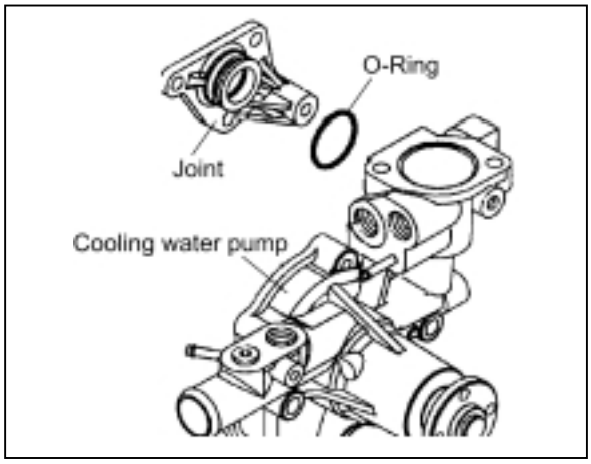
1) Remove the alternator. See 4.2.2. 1) in Chapter 4.
2) Remove the fan, V-belt and pulley. See 4.2.2. 2) in Chapter 4.
3) Remove the cooling water pump. (Point 1, in below 6.4)
4) Remove the thermostat. (Point 2 in below 6.4)

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.

[NOTICE]
Replace the O-ring of the cooling water pump with new one when disassembling. And, be sure to use the special O-ring for each engine model, because the material is different, although the dimension is the same as a commercial part. (Refer to the right figure.)



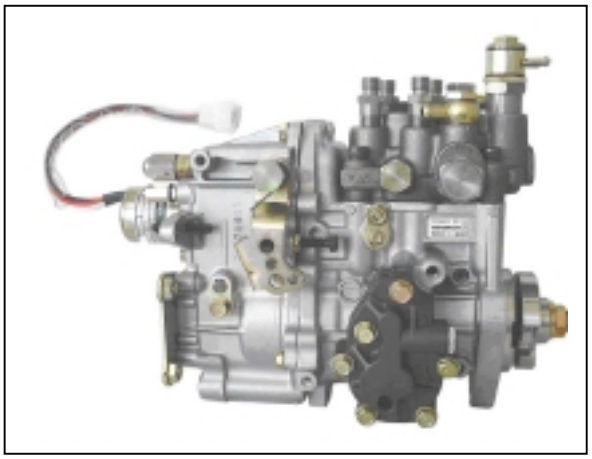
Point 2
Disassemble:

- Check the thermostat function. See 2.7 in Chapter 2 for the inspection method.

7. FUEL INJECTION PUMP/GOVERNOR

Only the outline of the MP fuel pump is explained in this chapter. Refer to the MP pump service manual of the separate volume for the disassembly and assembly.

7.1 Introduction



It is described about the features of the fuel injection pump, YDP-MP disassembly, and assembly and adjustment procedure.

Fuel injection pump is the most important equipment, which is enable to make the sensitive adjustment according to the variable load of the engine.

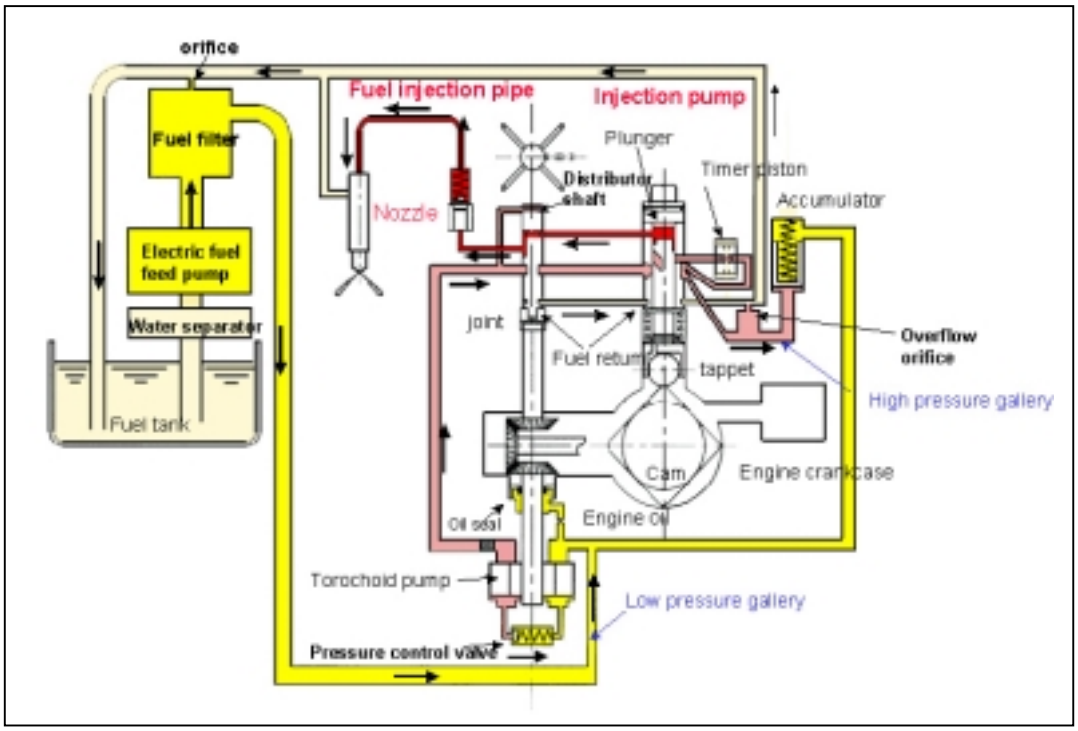
Therefore all of the parts are required not only very precise machining but also finest, assembling with top level.
The careful arrangement of keeping off the dust and the rust when disassemble, adjustment and reassemble of the fuel injection pump is made in the market.

The YDP-MP Pump is a distributor type pump which is unified of Mono-plunger, a distributing shaft, a hydraulic head which equipped the delivery valve for each cylinder, pump housing which has a cam shaft internally and governor.
The fuel, which is pressurized by the up and down movement of the plunger driven by the cam-rotation, is supplied through the distributor shaft, which is rotating accordingly.

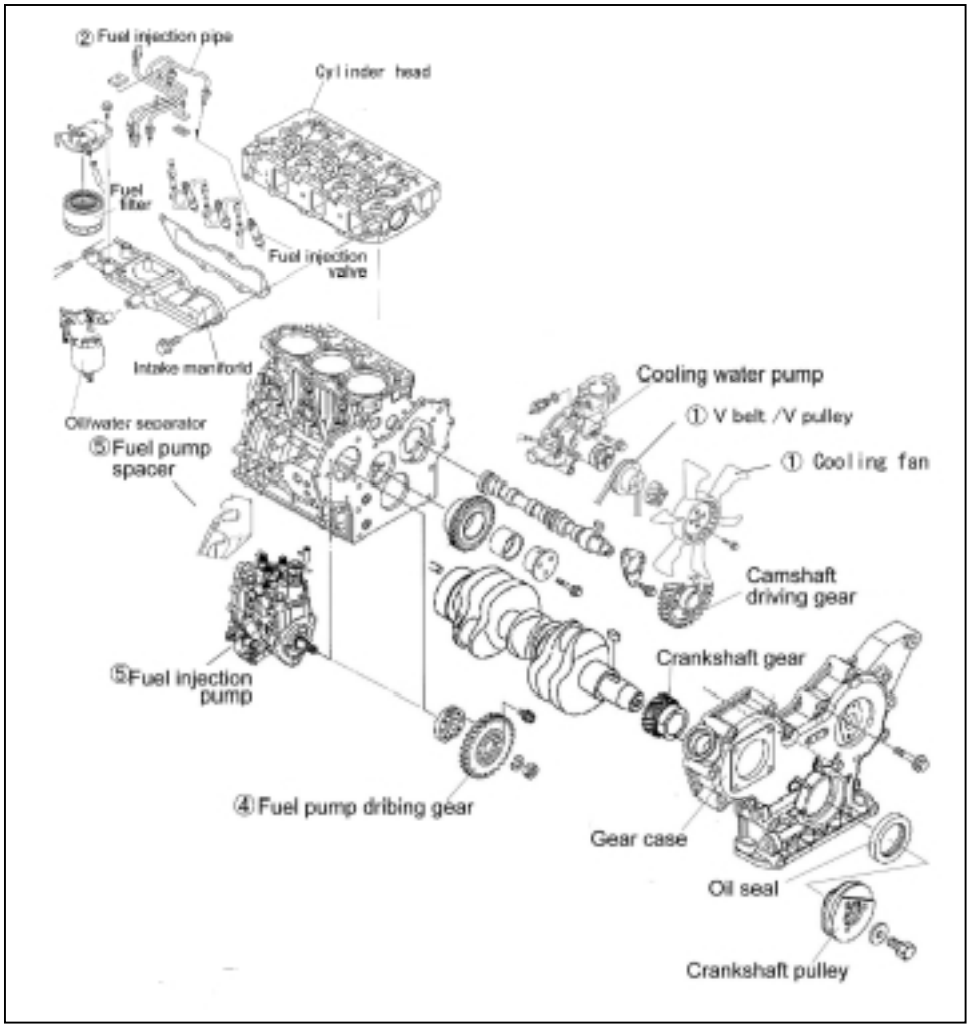
There are a model YDP-MP2 and a model YDP-MP4, and plunger diameter and fuel cam speed are different.

7.2 Fuel Injection Pump

7.2.1 Fuel system diagram



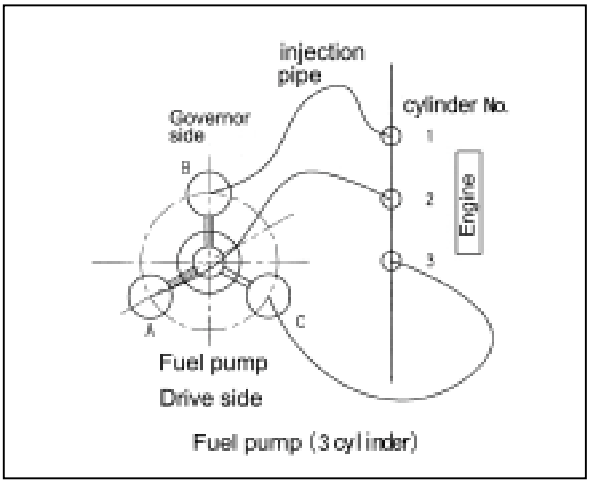
7.2.2 External view and components



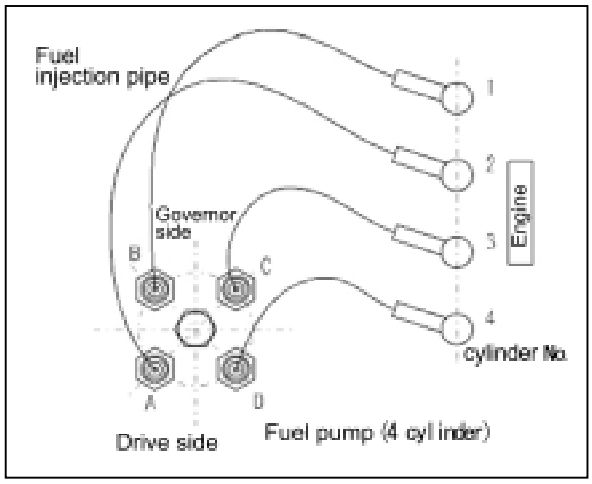
7.2.3Disassembly procedure:

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 point 1 of 7.2.5.
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 Point 2 of 7.2.5.
5) Remove the fuel injection pump. See Point 3 of 7.2.5.



Fuel pump (3 cylinder)



Fuel pump (4 cylinder)

7.2.4 Assembly procedure

Reverse the disassembly procedure.

7.2.5 Servicing points

Point 1

[Disassemble]

- Block an entrance with the tape so that trash may not enter the fuel injection pipe and the fuel injection pump.

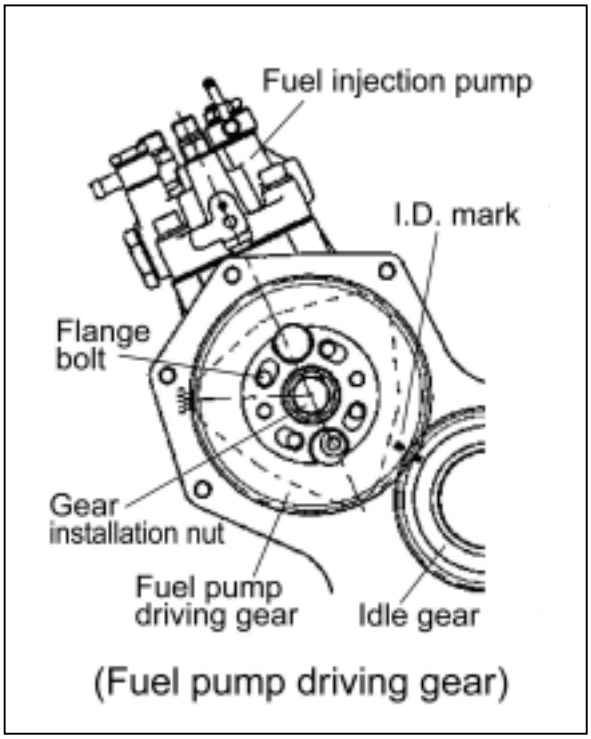
Point 2

[Disassemble]

- Remove the fuel injection pump drive gear and idle gear after putting the I.D. marks.

[NOTICE]

Don't remove four flange bolts.



(Fuel pump driving gear)

[Reassemble]

- Assemble the gears after checking those I.D.marks.

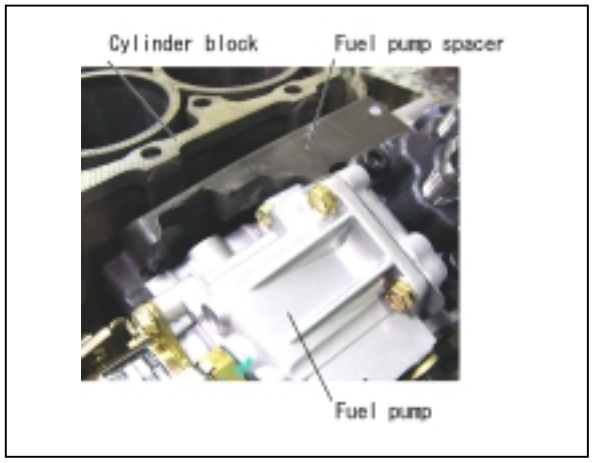
Tightening torque of the gear installation nut

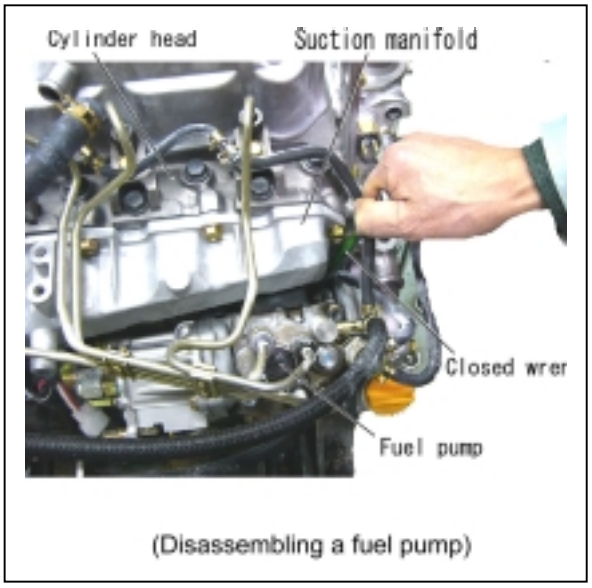
Model	N·m(kgf·m)	Lubricating oil application (thread portion, and seat surface)
3IRH2N 3/4IRH8N	78～88 (8～9)	Not applied

Point 3

[Disassemble]

There is an acoustic material part to name as fuel pump spacer between the fuel pump and the cylinder block. Loosen fuel pump installation bolts with a closed wrench when disassembling a fuel pump.





(Disassembling a fuel pump)

[Reassemble]

When installing a fuel pump on the gear case, put a fuel pump spacer between the cylinder blocks, and install it .

8. TURBOCHAGER: Disassembly, inspection and reassembly

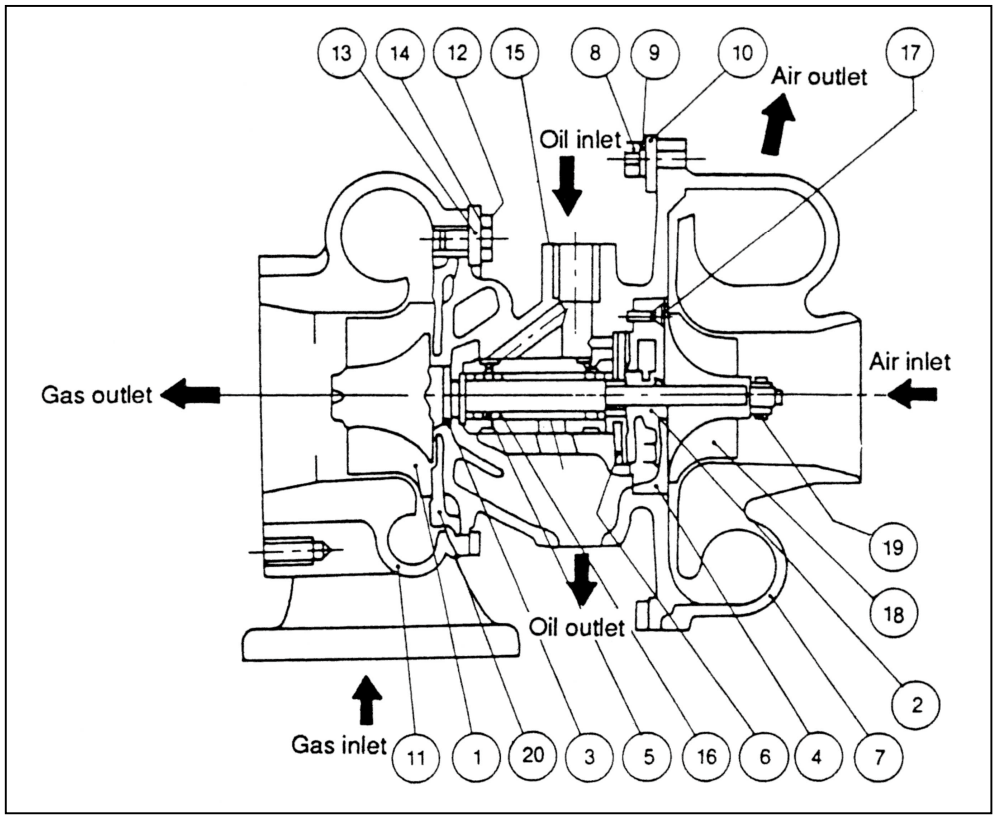
8.1 Structure and Functions

8.1.1 Main specifications

Applicable engine model (application)			4IRI8T(CL, VM)
Turbocharger model	RHB31	RHB51	RHF5
Turbocharger specification	Standard (w/waste gate)		
Turbine type	Radial flow		
Blower (compressor) type	Centrifugal		
Lubrication method	External lubrication		
Max. continuous allowable speed	250,000	180,000	
Max. continuous allowable gas inlet temperature	750		
Dry weight N(kgf)	24(2.4)	41(4.2)	46(4.7)

Note) VM application is provided with the waste gate.

8.1.2 Construction



8.1.3 Structural and functional outline

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

(34) 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.

(35) 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.

(36) 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.

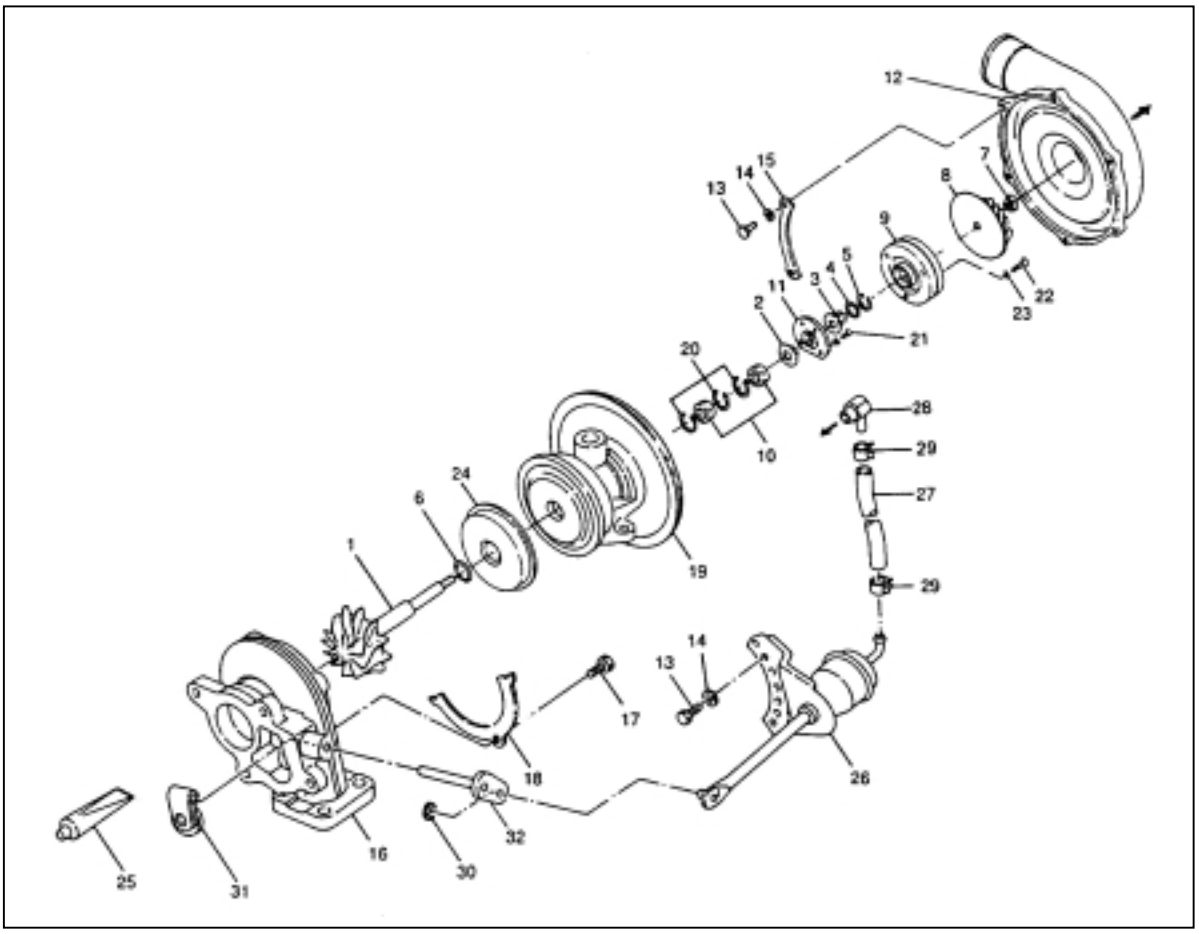
(37) Compressor side sealing mechanism

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

(38) 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.

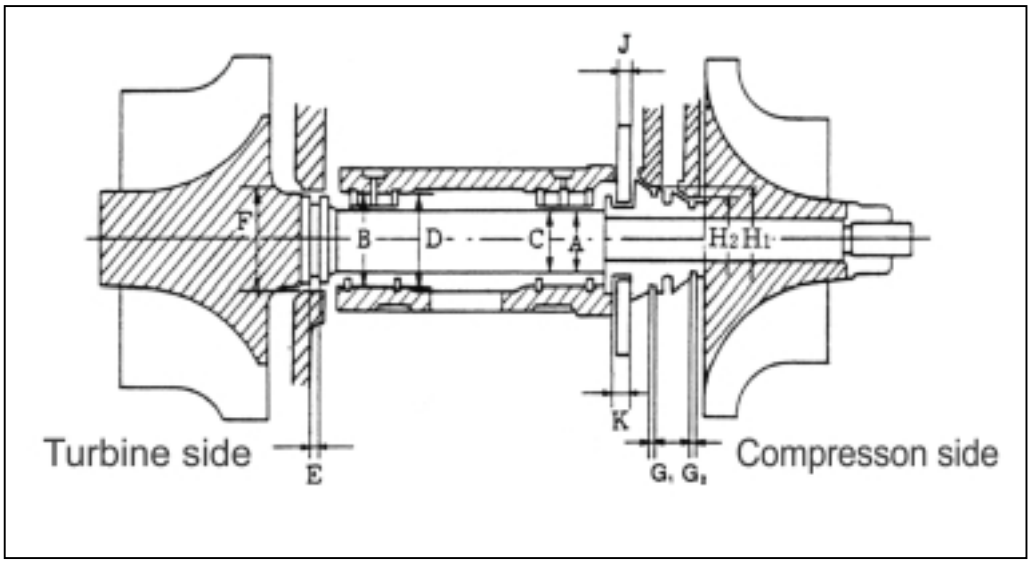
8.1.4 Components



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

8.2 Service Standards and Tightening Torque

8.2.1 Service standards



(39) RHF5 type

Unit: mm

		Standard dimension	Wear limit
Turbine shaft	Turbine shaft journal outside diameter (A)	7.99～8.00	7.98
	Turbine shaft seal ring groove width (E)	1.25～1.28	1.29
	Compressor side seal ring groove width (G1)	1.22～1.23	1.31
	Compressor side seal ring groove width (G2)	1.02～1.03	1.11
	Turbine shaft run-out	0.002	0.011
Bearing	Journal bearing inside diameter (C)	8.01～8.03	8.04
	Journal bearing outside diameter (D)	12.32～12.33	12.31
	Bearing housing inside diameter (B)	12.40～12.41	12.42
Thrust bearing	Thrust bearing width (J)	3.99～4.01	3.98
	Thrust bushing groove dimension (K)	4.04～4.05	4.07
Seal ring fixing area	Turbine side (bearing housing)(F)	15.00～15.02	15.05
	Compressor side (seal ring)(H1)	12.40～12.42	12.45
	Compressor side (seal ring)(H2)	10.00～10.02	10.05
Rotor play in axial direction		0.03～0.06	0.09
Rotor play in radial direction		0.08～0.13	0.17

(40) RHB31/RHB51 type

Unit: mm

		Standard dimension		Wear limit	
		RHB31	RHB51	RHB31	RHB51
Turbine shaft	Turbine shaft journal outside diameter (A)	6.257～6.263	7.99～8.00	6.25	7.98
	Turbine shaft seal ring groove width (E)	1.038～1.062	1.25～1.28	1.07	1.29
	Compressor side seal ring groove width (G1)	1.02～1.03	1.22～1.23	1.04	1.31
	Compressor side seal ring groove width (G2)	0.82～0.83	1.02～1.03	0.84	1.11
	Turbine shaft run-out	0.002	0.002	0.005	0.011
Bearing	Journal bearing inside diameter (C)	6.275～6.285	8.01～8.03	6.29	8.04
	Journal bearing outside diameter (D)	9.940～9.946	12.32～12.33	9.93	12.31
	Bearing housing inside diameter (B)	9.995～10.005	12.40～12.41	10.01	12.42
Thrust bearing	Thrust bearing width (J)	3.59～3.61	3.99～4.01	3.58	3.98
	Thrust bushing groove dimension (K)	3.632～3.642	4.04～4.05	3.65	4.07
Seal ring fixing area	Turbine side (bearing housing)(F)	11.00～11.018	15.00～15.02	11.03	15.05
	Compressor side (seal ring)(H1)	9.987～10.025	12.40～12.42	10.04	12.45
	Compressor side (seal ring)(H2)	7.968～8.00	10.00～10.02	8.01	10.05
Rotor play in axial direction		0.022～0.053	0.03～0.06	0.07	0.09
Rotor play in radial direction		0.061～0.093	0.08～0.13	0.12	0.17

8.2.2 Tightening torque

(41) RHF5 type

N·m(kgf·cm)

Part	Thread diameter	Tightening torque
Turbine housing set bolt	M8	27～29 (275～295)
Compressor housing set bolt	M5	4.2～5.2 (43～53)
Thrust bearing set screw	M3	1.2～1.4 (12～14)
Seal plate set screw	M3	1.2～1.4 (12～14)
Blower impeller set nut (left-handed screw)	M5	1.8～2.2 (18～22)

(42) RHB31/ RHB51 type

N·m(kgf·cm)

Part	Thread diameter	Tightening torque	
		RHB31	RHB51
Waste gate actuator set bolt	M5	3.9～4.9 (40～50)	3.9～4.9 (40～50)
Lock plate set bolt	M6	11.8～12.8 (120～130)	11.8～12.8 (120～130)
	M8	11.8～12.8 (120～130)	27.0～28.9 (275～295)
Thrust bearing set screw	M3	1.2～1.4 (12～14)	1.2～1.4 (12～14)
Seal plate set screw	M3	1.2～1.4 (12～14)	1.2～1.4 (12～14)
Blower impeller set nut (left-handed screw)	M5	0.9～1.1 (9～11)	1.8～2.2 (18～22)

8.3 Periodic Inspection Procedure

8.3.1 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 60,000km	Every 12 months or 150,000km	Every 24 months or 300,000km
For construction machinery	Every 6 months or 500hrs	Every 12 months or 1,000hrs	Every 24 months or 2,000hrs
For faming machinery	Every 6 months or 200hrs	Every 12 months or 400hrs	Every 24 months or 800hrs
For marine use	Every 6 months or 1,500hrs	Every 12 months or 3,000hrs	Every 24 months or 6,000hrs
Rotor rotation	○		
Rotor play		○	
Overhaul and overall inspection			○
Oil filter cleaning and inspection	Based on engine operation manual		
Engine oil replacement			

8.3.2 Inspection procedure

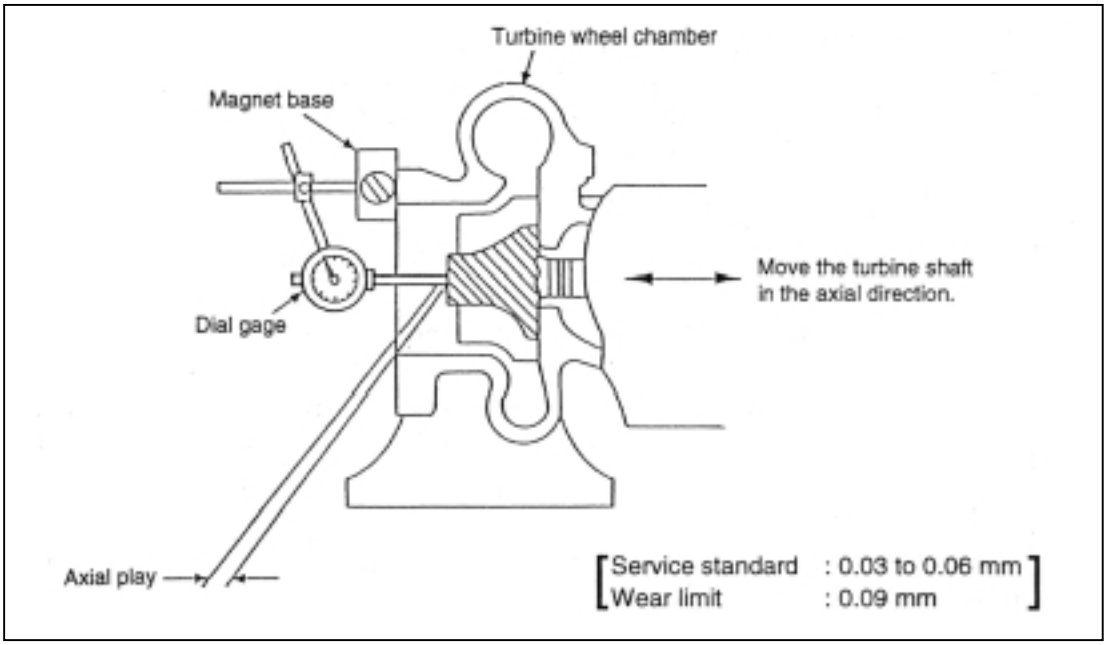
(43) Rotor rotation inspection

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.

(44) Rotor play inspection

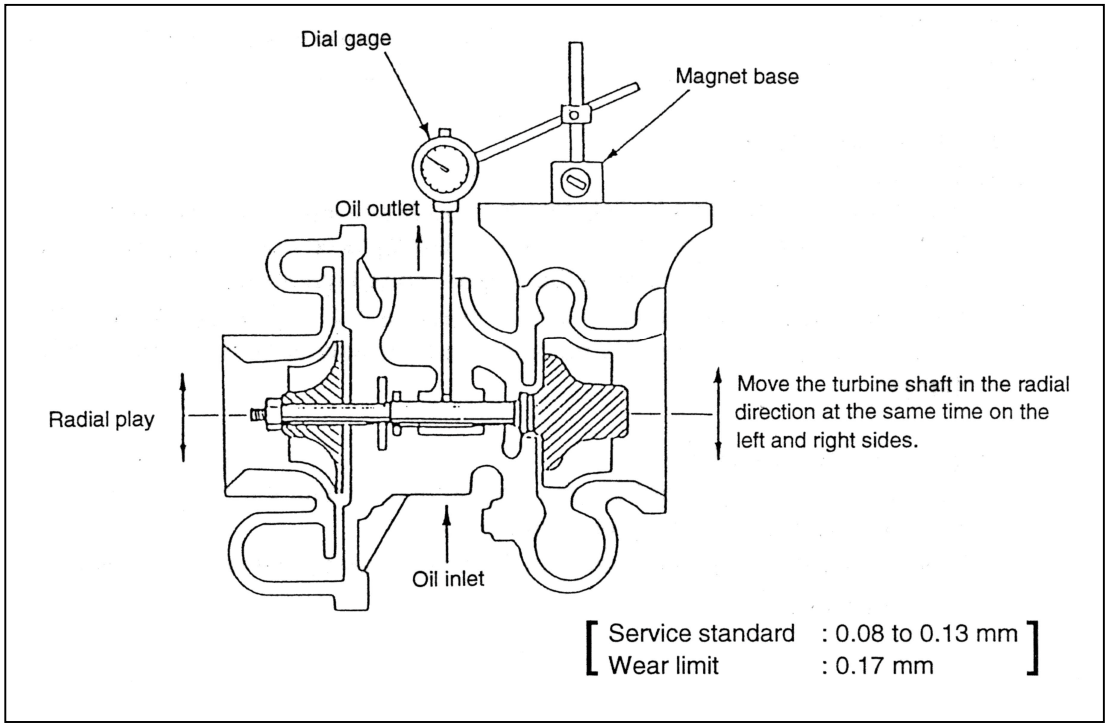
Remove the turbocharger from the engine and inspect the rotor play in the axial and radial directions according to the procedure below.
After removing the turbocharger from the engine, always bind the oil inlet and outlet holes with adhesive tape.

Rotor play in axial direction



8.3.3 Waste gate valve adjustment procedure

Rotor play in radial direction



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.

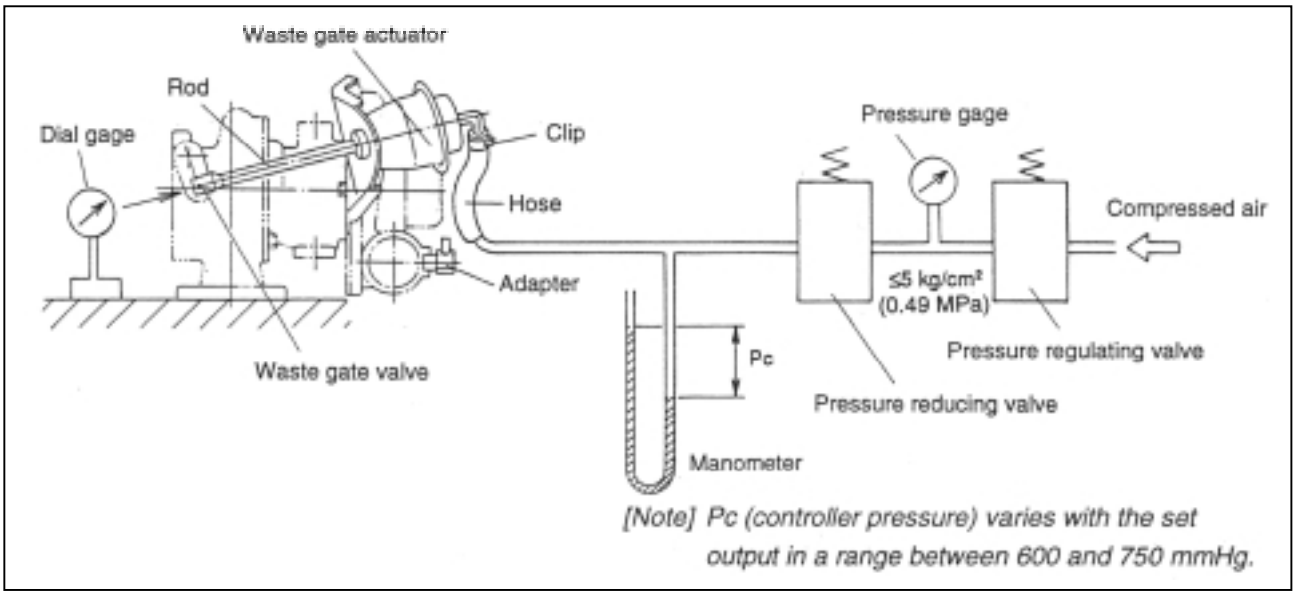
[NOTICE]
If the adjustment is impossible, give up overhaul but replace the whole turbocharger assembly.

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

(a) Equipment
Prepare the equipment shown in the figure below.

(b) 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))



(c) Check method

1) Set the manometer control pressure (Pc) applied to the waste gate actuator to 0 and set the dial gage to the zero point.

2) Gradually open the pressure regulating valve and measure the Pc value when the actuator rod is operated by 2 mm.

3) 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 2mm 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 Pc by means of the pressure regulating valve shall be very slow near the measuring point. If the mm position is exceeded, restart from the beginning.
- Do not apply over 0.49 MPa (5 kgf/cm^2) to the actuator.

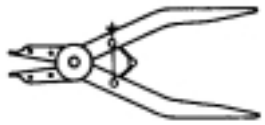
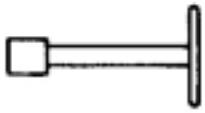
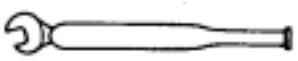
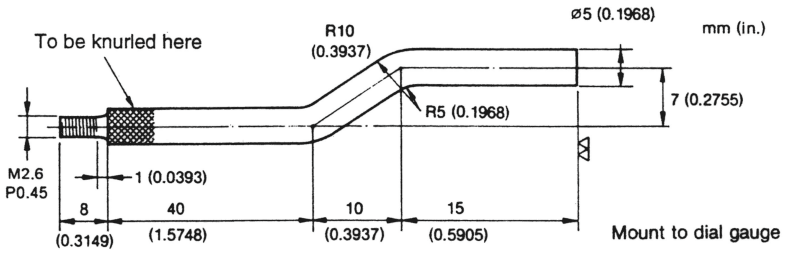
(46) Waste gate actuator leak test

Apply 0.12 Mpa (1.2kgf/cm^2) to the actuator and hold the state for minute. The actuator is good if the pressure then is 0.11 Mpa (1.1kgf/cm^2) or above.

8.4 Disassembly Procedure

8.4.1 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	 Material: Copper or brass
Pliers	For removing floating bearing circlip	
Pliers	For removing seal ring	
Torque driver for TORX bolt (multifunctional type) 0.5 to 4.9N-m (5 to 50 kgf-cm)	For thrust bearing installation (for M3):1.3 N-m (13 kgf-cm) For seal plate installation (for M3):1.3 N-m (13 kgf-cm)	Item sold on market  (Type: TORX TT20 or equivalent)
Box wrench	For fixing turbine shaft (mm×dodecagonal)	 Box only may be used.
Torque wrench (single purpose)	For following bolts and nuts: M8:mm, kgf-cm(N-m) M5:mm, kgf-cm(N-m) M5:mm, kgf-cm(N-m)	
Probe	For measuring play in axial and radial directions: To be installed on a dial gage	

8.4.2 Inspection before disassembly

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

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

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

8.4.3 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).

(47) Compressor housing removal

1) Remove flanged hexagon bolt 8 and compressor side keep plate 10.

Remove compressor housing 7.

Note:

Liquid gasket is applied on the surface of compressor housing 7 where bearing housing 15 is mounted. When disassembling compressor housing 7, carefully operate so as not to damage the compressor impeller.

(48) Compressor impeller removal

1) Set a box spanner (10mm) 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.

(49) Turbine housing removal

1) Remove hexagon nut 12 and turbine side keep plate 13.

2) Remove turbine housing 11.

(50) 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.

(51) 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.

(52) 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.

(53) 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.

(54) 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

8.5.1 Washing

(55) 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

(56) Washing procedure

Keep the following in mind when washing the parts.

Part	Tools and detergent	Procedure
a) Turbine s haft	● Tools 1) Bucket 2) Heat source: Steam or gas burner 3) Brush ● 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 hand 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.
b) Turbine wheel chamber	● Tools Same as for turbine shaft ● 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.
c) Blower blade and chamber	● Tools 1)Bucket 2)Brush ● 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.
d) 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.	

8.5.2 Inspection procedure

(57) 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.

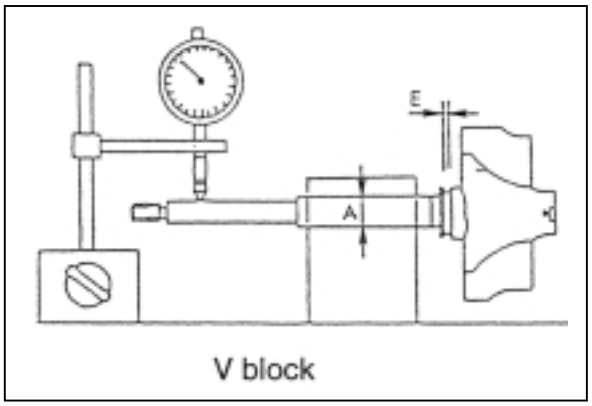
(58) Turbine housing 11
Inspect any trace of contact with the turbine wheel, exfoliation due to degradation by oxidation of the cast surface, thermal deformation or crack.
Replace with a new one of defective.

(59) Compressor impeller 18
Inspect any contact trace, chipping, corrosion or deformation.
Replace with a new one if defective.

(60) 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.



V block

Wear limit of journal outside diameter (A)
RHF5 ····· 7.98mm
RHB51 ····· 7.98mm
RHB31 ····· 6.25mm

Wear limit of ring groove width (E)
RHF5 ····· 1.29mm
RHB51 ····· 1.29mm
RHB31 ····· 1.07mm

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

(61) Heat insulating plate 20
Inspect the heat insulating plate for any contact trace, thermal deformation or corrosion Replace with a new one if defective.

(62) 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.

(a) Thrust bushing

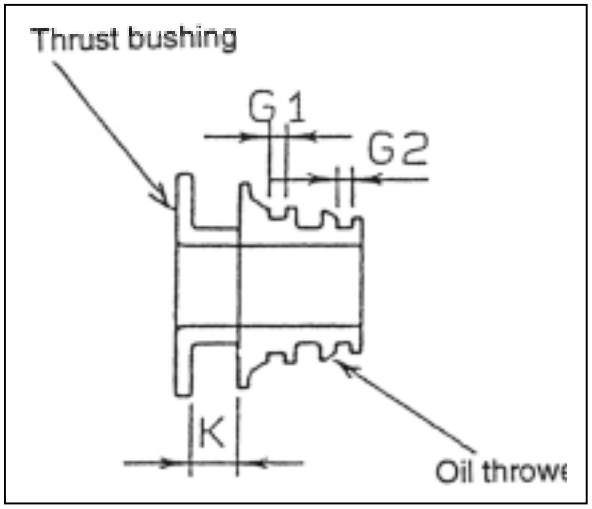
Measure the distance between grooves (K) of the thrust bushing, and replace with a new one if the wear limit is exceeded.

Wear limit

RHF5 ····· 4.07mm
RHB51 ····· 4.07mm
RHB31 ····· 3.65mm

(b) 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

RHF5--- G1: 1.31mm, G2: 1.11mm
RHB51--- G1: 1.31mm, G2: 1.11mm
RHB31--- G1: 1.04mm, G2: 0.84mm

(c) Thrust bearing 6

Measure the thrust bearing width (J), and replace with a new one if the wear limit is exceeded.

Wear limit

RHF5 ····· 3.98mm
RHB51 ····· 3.98mm
RHB31 ····· 3.58mm

(63) 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

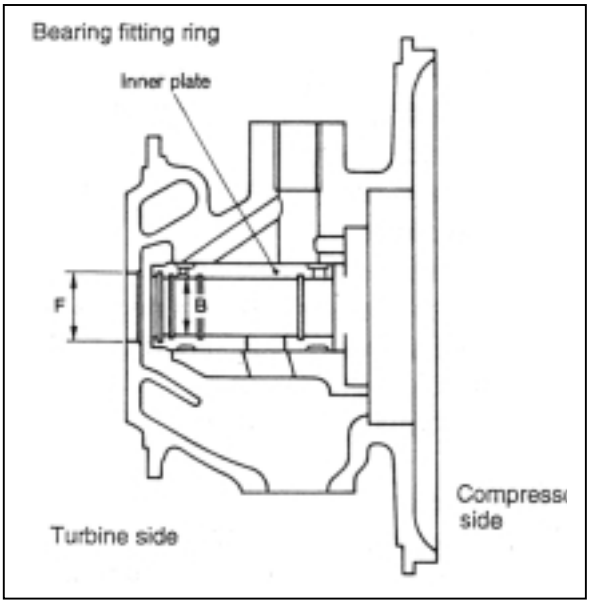
RHF5 ····· Outside diameter (D): 12.31mm,
Inside diameter (C): 8.04mm
RHB51 ····· Outside diameter (D): 12.31mm,
Inside diameter (C): 8.04mm
RHB31 ····· Outside diameter (D): 9.93mm,
Inside diameter (C): 6.29mm

(64) Bearing housing 15

1) Inspect the housing for cast surface exfoliation due to oxidation and degradation, dent or crack.

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.



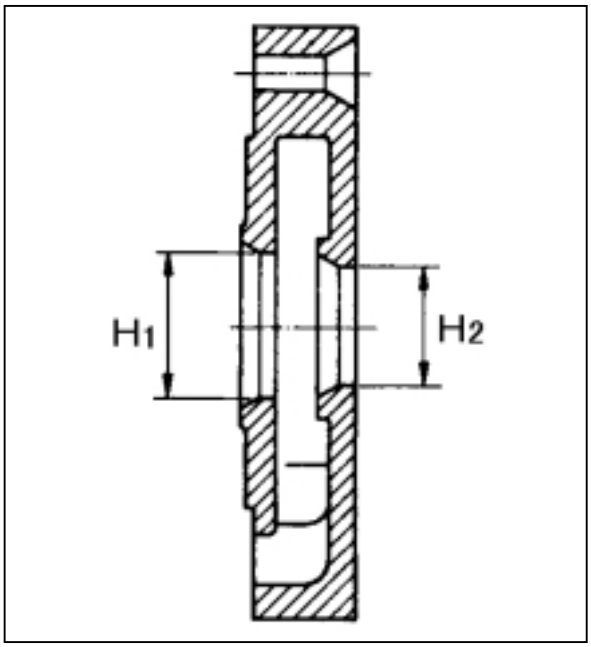
Wear limit of bearing housing inside diameter (B)
RHF5 ····· 12.42mm
RHB51 ····· 12.42mm
RHB31 ····· 10.01mm

Wear limit of turbine side seal ring inserting portion (F)
RHF5 ····· 15.05mm
RHB51 ····· 15.05mm
RHB31 ····· 11.03mm

(65) 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
RHF5 ····· H1: 12.45mm, H2: 10.05mm
RHB51 ····· H1: 12.45mm, H2: 10.05mm
RHB31 ····· H1: 10.04mm, H2: 8.01mm

(66) Seal rings
Replace seal rings with new ones.

(67) 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

8.6.1 Preparation for reassembly

1) Prepare general tools, special tools, liquid gasket (Three Bond No.1207) and Locktite No.242 before reassembling the turbocharger.

2) Always replace the following parts with new ones:

- Turbine side seal ring 1pc.
- Compressor side seal ring(large) 1pc.
- Compressor side seal ring(small) 1pc.
- M3 machine screws 3pcs.
- M3 machine screws 4pcs.

8.6.2 Reassembly

(68) Floating bearing installation

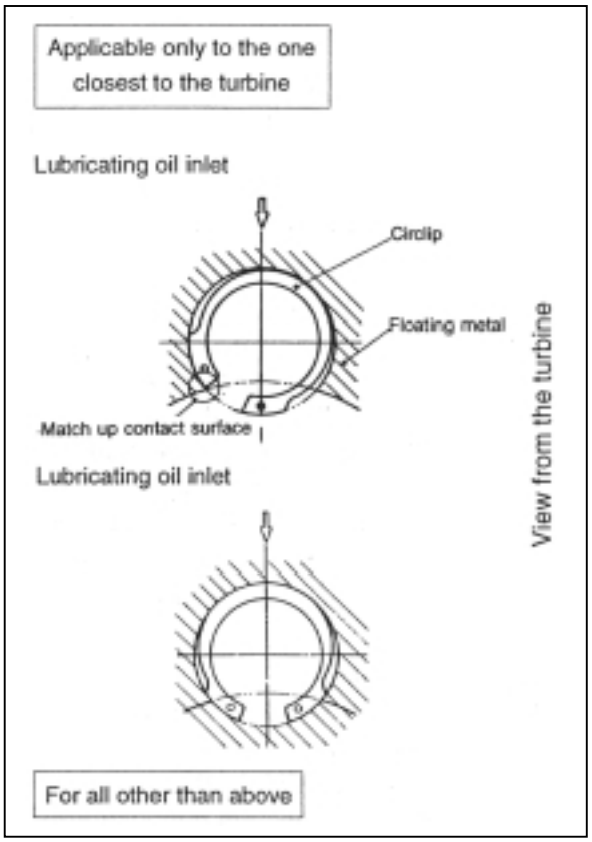
1) Use the snap ring pliers and install inner circlip 16 on bearing housing 15.

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



(69) 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.

(70) 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 Locktite 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: 1.3±0.1N-m (13±1kgf-cm)

(71) 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 at right.

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

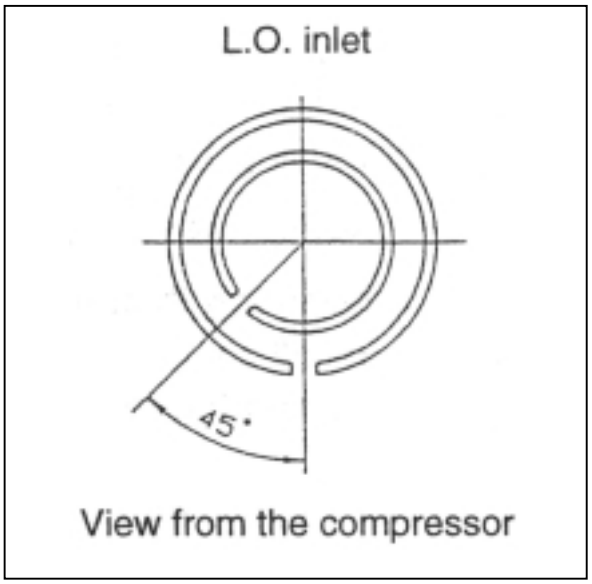
Note: See the illustration below for the applying position.

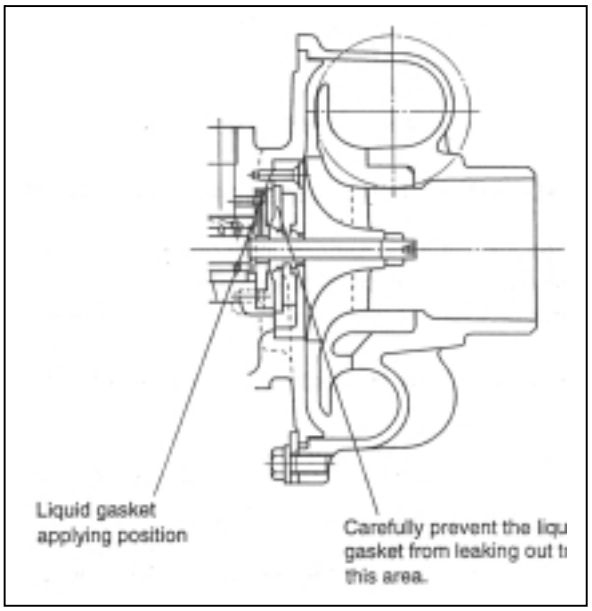
Applying thickness: 0.1∼0.2 mm

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: 1.3±0.1N-m (13±1kgf-cm)





(72) 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: 2.0±0.2N-m (20±2kgf-cm)

(73) 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±10N-m (28±1kgf-cm)

(74) Compressor housing installation

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

Note: See section (4)3) for the portion to be applied.

Applying thickness: 0.1∼0.2 mm

2) Check the mark and install the compressor housing 7 on the bearing housing 15.

Note: When a part is replaced, confirm a position of an oil entrance and a position of an air exit, and assemble it.

3) Install the keep plate 10 on compressor side, and tighten M8 hexagon bolt 8.

Tightening torque: 48±N-m (4.7±0.5kgf-cm)

(75) Rotor play measurement

See the inspection procedure in section 8.3.2 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.

Service standard of rotor play in axial direction

RHF5 ····· 0.03∼0.06mm
RHB51 ····· 0.03∼0.06mm
RHB31 ····· 0.022∼0.053mm

Service standard of rotor play in radial direction

RHF5 ····· 0.08∼0.13mm
RHB51 ····· 0.08∼0.13mm
RHB31 ····· 0.061∼0.093mm

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.

8.7.1 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.

8.8.1 Excessively exhaust smoke

(76) 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.

(77) 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	● Turbocharger overhaul (disassembly and repair)
● Insufficient lubrication or clogged lubrication piping	● Lubricating oil line inspection, repair of defective portion and lubricating oil replacement
● Excessively high oil temperature	● Rotating part replacement or washing
● Unbalanced rotating part	● Strict observance of instructions in operation manual
● Insufficient warming up or sudden stoop from loaded operation (no-load operation)	
3) Contact or breakdown of turbine wheel or blower vane	● Inspection and repair of each engine part
● Excessive revolution	● Perfect foreign matter elimination in disassembled state, followed by inspection and repair of individual air cleaner and engine components
● Excessive exhaust temperature rise	● turbocharger overhaul (disassembly and repair)
● Foreign matter invasion	● Reassembly
● worn bearing	
● Assembly defect	

(78) 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.

8.8.2 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

8.8.3 Sudden oil decrease

Cause	Corrective action
1) Excessive bearing wear causing abnormal wear or damage of seal ring	● Turbocharger disassembly and repair

8.8.4 Decrease in output

Cause	Corrective action
1) Gas leak from any part in exhaust piping	● Inspection and repair of defective portion
2) Air leak from discharge side of blower	
3) Clogged air cleaner element	● Element cleaning or replacement
4) Fouled or damaged turbocharger	● Turbocharger disassembly and repair or replacement

8.8.5 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	● Turbocharger disassembly and washing with lubricating oil replacement
2) Incomplete combustion	● Engine combustion state inspection, followed by improvement of combustion to normal state

8.8.6 Abnormal sound or vibration

(79) 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)	● Turbocharger disassembly and washing
2) Contact rotating part	● Turbocharger disassembly and repair or replacement

(80) Vibration

Cause	Corrective action
1) Loosened intake, exhaust or oil pipe connection with the turbocharger	● Turbocharger installation status check and repair of defective portion
2) Damaged bearing, contact between rotating part and adjacent part, or chipping of turbine wheel or blower vane due to foreign matter in vasion	● Turbocharger disassembly with repair or replacement, or perfect removal of foreign matters in case of foreign matter invasion
3) Unbalanced rotating part	● Repair or replacement of rotating part

9. SERVICE STANDARDS

9.1 Engine Tuning

No.	Inspection item			Standard		Limit	Reference page
1	Gap at intake/exhaust valve heads mm		3IRH2N 4IRI8N	0.15～0.25		-	2.2.6(4)
2	V-belt tension mm at 98N (10kgf)	Between alternator and crank pulley	Used part	10～14		-	2.2.2.(2)
			New part	8～12		-	
		Between alternator and radiator fan	Used part	7～10			
			New part	5～8			
		Between radiator fan and crank pulley	Used part	9～13			
			New part	7～11			
3	Fuel injection pressure MPa (kgf/cm^2)	3IRH2N～3/4IRH8N(VM)		21.57～22.55 (220～230)		-	2.2.6.(3)
		3IRH2N～3/4IRH8N(CL)		19.6～20.6 (200～210)			
4	Fuel injection timing FIT(2.5) degrees (bTDC)			Refer to 2.2.7 in chapter 2.		-	2.2.7.(4)
5	Compression pressure (at 250 min^{-1}) MPa (kgf/cm^2)	3IRH2N		3.16(31)±0.1(1)		2.45(25)±0.1(1)	3.3
		3/4IRH8N		3.43(35)±0.1(1)		2.75(28)±0.1(1)	
6	Cooling water Capacity (Only engine body) (Liter)	3IRH2N		1.8		-	2.2.1.(4)
		3IRH8N		2.0		-	
		4IRH8N		2.7		-	
		4IRI8T		4.2		-	
7	Lubricating oil capacity (oil pan) (Liter)			Full	Effective	-	2.2.1.(3)
		3IRH2N		5.5	1.9	-	
		3IRH8N		6.7	2.8	-	
		4IRH8N		7.4	3.4	-	
		4IRI8T		10.2	4.5	-	
8	Lubricating oil pressure MPa (kgf/cm^2)			at rated speed		at low idle speed	-
		3IRH2N～4IRI8N		0.29(3.0)～0.39(4.0)		0.06(0.6) or above	-
		4IRI8T (VM, WO balancer)		0.39(4.0)～0.49(5.0)			
9	Oil pressure switch operating pressure MPa (kgf/cm^2)			0.05±0.01 (0.5±0.1)		-	-
10	Thermostat			valve opening temperature deg. C		Full opening lift (mm) (temperature)	2.7
		All models		69.5～72.5		8 or above (85 deg.C)	
		All models option		80～84		10 or above (95 deg.C)	
11	Thermo switch actuating temperature (deg.C)			107～113		-	2.4.2

9.2 Engine Body

9.2.1Cylinder head

(1) Cylinder head

Inspection item			Standard	Limit	Reference page
Combustion surface distortion mm			0.05 or less	0.15	4.2.5.(1)
Valve sink mm	3IRH2N (2-valve head)	Intake	0.350.55	0.9	
		Exhaust	0.300.50	0.8	
	3/4IRH8N (2-valve head)	Intake	0.300.50	0.8	
		Exhaust	0.300.50	0.8	
	4IRI8T (4-valve head)	Intake	0.360.56	0.9	
		Exhaust	0.350.55	0.9	
Valve seat (2-valve, 4-valve)	Seat angle Deg.	Intake	120	-	4.2.6.
		Exhaust	90	-	
	Seat correction angle deg.		40, 150	-	

(2) Intake/exhaust valve and guide

mm

Inspection item			Standard	Limit	Reference page
3IRH2N (2-valve head)	Intake	Guide inside diameter	7.0007.015	7.08	4.2.5.(2)
		Valve stem outside diameter	6.9456.960	6.90	
		Clearance	0.0400.070	0.18	
	Exhaust	Guide inside diameter	7.0007.015	7.08	
		Valve stem outside diameter	6.9406.955	6.90	
		Clearance	0.0450.075	0.18	
3/4IRH8N (2-valve head)	Intake	Guide inside diameter	8.0108.025	8.10	
		Valve stem outside diameter	7.9557.975	7.90	
		Clearance	0.0350.070	0.18	
	Exhaust	Guide inside diameter	8.0158.030	8.10	
		Valve stem outside diameter	7.9557.960	7.90	
		Clearance	0.0450.075	0.18	
4IRI8T (4-valve head)	Intake	Guide inside diameter	7.0007.015	7.08	
		Valve stem outside diameter	6.9456.960	6.90	
		Clearance	0.0400.070	0.17	
	Exhaust	Guide inside diameter	7.0007.015	7.08	
		Valve stem outside diameter	6.9406.955	6.90	
		Clearance	0.0450.075	0.17	
Valve guide projection from cylinder head		3IRH2N	11.712.0	-	4.2.7.
		3/4IRH8N	14.715.0	-	
		4IRI8T	9.710.0	-	
Valve guide driving-in method			Cold-fitted	-	

(81) Valve spring

mm

Inspection item		Standard	Limit	Reference page
Free length	3IRH2N (2-valve)	44.4	43.9	4.2.5.(4)
	4IRH8N (2-valve)	42.0	41.5	
	4IRI8T, (4-valve)	39.7	39.2	
Inclination	3IRH2N (2-valve)	-	1.4	
	4IRH8N (2-valve)	-	1.4	
	4IRI8T, (4-valve)	-	1.4	

(82) Rocker arm and shaft

mm

Model	Inspection item	Standard	Limit	Reference page
3/4IRH2N-8N	Arm shaft hole diameter	16.00016.020	16.07	4.2.5.(5)
	Shaft outside diameter	15.96615.984	15.94	
	Clearance	0.0160.054	0.13	
4IRI8T	Arm shaft hole diameter	18.50018.520	18.57	
	Shaft outside diameter	18.47018.490	18.44	
	Clearance	0.0100.050	0.13	

(83) Push rod

mm

Inspection item	Standard	Limit	Reference page
Bend	-	0.03	4.2.5.(7)

9.2.2 Gear train and camshaft

(1) Camshaft

mm

Inspection item			Standard	Limit	Reference page
Side gap			0.050.20	0.30	4.3.4
Bending (1/2 the dial gage reading)			00.02	0.05	4.3.5(1)
Cam height		3IRH2N-3/4IRH8N	38.60038.800	38.350	
		4IRI8N	43.40043.600	43.150	
Shaft outside diameter / Metal inside diameter					
3/4IRH2N-8N	Gear side	Bushing inside diameter	44.99045.055	45.130	4.3.5(1)
		Camshaft outside diameter	44.92544.950	44.890	
		Clearance	0.0400.130	0.240	
	Intermediate	Bushing inside diameter	45.00045.025	45.100	
		Camshaft outside diameter	44.91044.935	44.875	
		Clearance	0.0650.115	0.225	
	Wheel side	Bushing inside diameter	45.00045.025	45.100	
		Camshaft outside diameter	44.92544.950	44.890	
		Clearance	0.0500.100	0.210	
4IRI8T	Gear side	Bushing inside diameter	49.99050.055	50.130	
		Camshaft outside diameter	49.92549.950	49.890	
		Clearance	0.0400.130	0.240	
	Intermediate	Bushing inside diameter	50.00050.025	50.100	
		Camshaft outside diameter	49.91049.935	49.875	
		Clearance	0.0650.115	0.225	
	Wheel side	Bushing inside diameter	50.00050.025	50.100	
		Camshaft outside diameter	49.92549.950	49.890	
		Clearance	0.050.100	0.210	

(2) Idle gear shaft and bushing

mm

Inspection item	Standard	Limit	Reference page
Shaft outside diameter	45.95049.975	45.900	4.3.5(2)
Bushing inside diameter	46.00046.025	46.075	
Clearance	0.0250.075	0.175	

(3) Backlash of each gear

mm

Model	Inspection item	Standard	Limit	Reference page
3IRH2N-8N	Crank gear, cam gear, idle gear, fuel injection pump gear and PTO gear	0.070.15	0.17	4.3.4.
4IRI8T	Crank gear, cam gear, idle gear, fuel injection pump gear and PTO gear	0.080.14	0.16	
	Lubricating oil pump gear	0.090.15	0.17	

9.2.3 Cylinder block

(1) Cylinder block

mm

Inspection item		Standard	Limit	Reference page
Cylinder inside diameter	3IRH2N	82.00082.030	82.130	4.4.5.(1)
	3/4IRH8N	88.00088.030	88.130	
	4IRI8T	98.00098.030	98.130	
Cylinder bore	Roundness	0.01 or less	0.03	
	Inclination			

(2) Crankshaft

mm

Inspection item			Standard	Limit	Reference page
Bending (1/2 the dial gauge reading)			-	0.02	4.4.5.(2)
Crank pin	3IRH2N	Pin outside diameter	42.95242.962	42.902	
		Metal inside diameter	43.00043.042	-	
		Metal thickness	1.4871.500	-	
		Clearance	0.0380.090	0.150	
	3/4IRH8N	Pin outside diameter	47.95247.962	47.902	
		Metal inside diameter	48.00048.026	-	
		Metal thickness	1.4921.500	-	
		Clearance	0.0380.074	0.150	
	4IRI8N	Pin outside diameter	57.95257.962	57.902	
		Metal inside diameter	58.00058.026		
		Metal thickness	1.4921.500	-	
		Clearance	0.0380.074	-	
Crank journal	3IRH2N	Journal outside diameter	46.95246.962	46.902	
		Metal inside diameter	47.00047.032	-	
		Metal thickness	1.9872.000	-	
		Clearance	0.0380.080	0.150	
	3/4IRH8N Selective pairing	Journal outside diameter	53.95253.962	53.902	
		Metal inside diameter	54.00054.020	-	
		Metal thickness	1.9951.990	-	
		Clearance	0.0380.068	0.150	
	4IRI8T Selective pairing	Journal outside diameter	64.95264.962	64.902	
		Metal inside diameter	65.00065.020	-	
		Metal thickness	1.9952.010	-	
		Clearance	0.0380.068	0.150	

(3) Thrust bearing

mm

Inspection item		Standard	Limit	Reference page
Crankshaft side gap	All models	0.130.23	0.28	4.4.4

(4) Piston and ring

Piston mm

Inspection item			Standard	Limit	Reference page
Piston outside diameter (Measure in the direction vertical to the piston pin.)		3IRH2N	81.95081.980	81.905	4.4.5.(4)
		3/4IRH8N	87.94587.975	87.900	
		4IRI8T	97.94097.950	97.895	
Piston diameter measure position (Upward from the bottom end of the piston)		3IRH2N	16	-	
		3/4IRH8N	24	-	
		4IRI8T	22	-	
Piston pin	3IRH2N	Hole inside diameter	23.00023.009	23.039	
		Pin outside diameter	22.99523.000	22.965	
		Clearance	0.0000.014	0.074	
	3/4IRH8N	Hole inside diameter	26.00026.009	26.039	
		Pin outside diameter	25.99526.000	25.965	
		Clearance	0.0000.014	0.074	
	4IRI8T	Hole inside diameter	30.00030.009	30.039	
		Pin outside diameter	29.98930.000	29.959	
		Clearance	0.0000.020	0.080	

Piston ring mm

Model	Inspection item		Standard	limit	Reference page
3IRH2N	Top ring	Ring groove width	2.0652.080	-	4.4.5.(4)
		Ring width	1.9701.990	1.950	
		Side clearance	0.0750.110	-	
		End clearance	0.2000.400	0.490	
	Second ring	Ring groove width	2.0352.050	2.150	
		Ring width	1.9701.990	1.950	
		Side clearance	0.0450.080	0.200	
		End clearance	0.2000.400	0.490	
	Oil ring	Ring groove width	4.0154.030	4.130	
		Ring width	3.9703.990	3.950	
		Side clearance	0.0250.060	0.180	
		End clearance	0.2000.400	0.490	
3/4IRH8N	Top ring	Ring groove width	2.0602.075	-	
		Ring width	1.9701.990	1.950	
		Side clearance	0.0700.105	-	
		End clearance	0.2000.400	0.490	
	Second ring	Ring groove width	2.0252.040	2.140	
		Ring width	1.9701.990	1.950	
		Side clearance	0.0350.070	0.190	
		End clearance	0.2000.400	0.490	
	Oil ring	Ring groove width	4.0154.030	4.130	
		Ring width	3.9703.990	3.950	
		Side clearance	0.0250.060	0.180	
		End clearance	0.2000.400	0.490	
4IRI8N	Top ring	Ring groove width	2.0402.060	-	4.4.5.(4)
		Ring width	1.9401.960	1.920	
		Side clearance	0.0800.120	-	
		End clearance	0.2500.450	0.540	
	Second ring	Ring groove width	2.0802.095	2.195	
		Ring width	1.9701.990	1.950	
		Side clearance	0.0900.125	0.245	
		End clearance	0.4500.650	0.730	
	Oil ring	Ring groove width	3.0153.030	3.130	
		Ring width	2.9702.990	2.950	
		Side clearance	0.0250.060	0.180	
		End clearance	0.2500.450	0.550	

(5) Connecting rod

mm

Inspection item	Standard	Limit	Reference page
Thrust clearance	0.20.4	-	4.4.4

Rod small end mm

Model	Item	Standard	Limit	Reference page
3IRH2N	Bushing inside diameter	23.02523.038	23.068	4.4.5.(5)
	Pin outside diameter	22.99523.000	22.967	
	Clearance	0.0250.043	0.101	
3/4IRH8N	Bushing inside diameter	26.02526.038	26.068	
	Pin outside diameter	25.99526.000	25.967	
	Clearance	0.0250.043	0.101	
4IRI8N	Bushing inside diameter	30.02530.038	30.068	
	Pin outside diameter	29.98730.000	29.959	
	Clearance	0.0250.051	0.109	

(84) Tappet

mm

Inspection item		Standard	Limit	Reference page
3/4IRH2N-8N	Tappet hole (block) inside diameter	12.00012.025	12.045	4.4.5.(6)
	Tappet stem outside diameter	11.97511.990	11.955	
	Clearance	0.0100.050	0.090	
4IRI8N	Tappet hole (block) inside diameter	12.00012.018	12.038	
	Tappet stem outside diameter	11.97511.990	11.955	
	Clearance	0.0100.043	0.083	

9.3 Lubricating Oil System (Trochoid Pump)

9.3.1Outside clearance of outer rotor

mm

Model	Standard	Limit	Reference page
3/4IRH2N-8N	0.120.21	0.30	5.5.1(1)
4IRI8N	0.1000.155	0.25	

9.3.2 Side clearance of outer rotor

mm

Model	Standard	Limit	Reference page
3IRH2N88	0.020.07	0.12	5.5.1(1)
4IRI8N	0.050.10	0.15	

9.3.3 Inside clearance of inner rotor

mm

Item	Parts	Standard	Standard	Limit	Reference page
Inside clearance of inner rotor	Gear boss diameter	53.0553.15	0.30.5	0.6	5.5.1(2)
	Rotor diameter	53.4553.55			
Width across flat clearance of inner rotor	Width across flat of Gear boss	49.4549.75	0.20.6	0.7	
	Width across flat of rotor	49.9550.05			

9.3.4 Rotor shaft clearance

mm

Model	Inspection item	Standard	Limit	Reference page
4IRI8N	Gear case bearing I.D.	13.013.02	13.05	5.5.1(3)
	Rotor shaft O.D.	12.95512.965	12.955	
	Rotor clearance	0.0350.065	0.105	

10. TIGHTENING TORQUE for BOLTS and NUTS

10.1 Tightening Torques for Main Bolts and Nuts

Part and engine model		Thread diameter ×pitch mm	Tightening torque Nm(kgf·m)	Lubricating oil application (thread portion, and seat surface)	Reference page
Cylinder head bolt	3IRH2N	M9×1.25	61.7～65.7 (6.3～6.7)	Applied	4.2.4
	3/4IRH8N	M10×1.25	85.3～91.1 (8.7～9.3)		
	4IRI8N	M11×1.25	103.1～112.9 (10.5～11.5)		
Connecting rod bolt	3IRH2N	M8×1.0	37.2～41.2 (3.8～4.2)	Applied	4.4.4
	3/4IRH8N	M9×1.0	44.1～49.0 (4.5～5.0)		
	4IRI8N	M10×1.0	53.9～58.8 (5.5～6.0)		
Flywheel set bolt	3/4IRH8N	M10×1.25	83.3～88.2 (8.5～9.0)	Applied	4.3.4
	4IRI8T	M14×1.5	2～205.8 (19～21)		
Bearing-cap set bolt	3IRH2N	M10×1.25	76.4～80.4 (7.8-8.2)	Applied	4.4.4
	4IRI8N	M11×1.25	108.1～117.9 (11.0～12.0)		
Crankshaft pulley set bolt	3/4IRH8N	M14×1.5	112.7～122.7 (11.5～12.5)	Applied	4.3.4
	4IRI8T	M14×1.5	107.9～127.5 (11.0～13.0)		
Fuel-nozzle set bolt	3/4IRH8N	M8×1.25	24.4～28.4 (2.5～2.9)	Not applied	-
	4IRI8T	M8×1.25	22.6～28.4 (2.3～2.9)		
Fuel pump drive gear set nut	3/4IRH8N	M14×1.5	78～88(8～9)	Not applied	4.3.4
	4IRI8T	M18×1.5	113～123 (11.5～12.5)		
Fuel injection pipe set bolt	3/4IRH8N	M12×1.5	29.4～34.3 (3.0～3.5)	Not applied	-
	4IRI8T	M12×1.5	19.6～24.5 (2.0～2.5)		
Fuel return pipe joint bolt	4IRI8T	M6×1.0	7.8～9.8 (0.8～1.0)	Not applied	-

10.2 Tightening Torques for Standard Bolts and Nuts

Item	Nominal thread diameter ×pitch	Tightening torque Nm(kgf-m)	Remarks
Hexagon bolt (7T) and nut	M6×1	9.8～11.8 (1.0～1.2)	Use 80% of the value at left when the tightening part is aluminum. Use 60% of the value at left for 4T bolts and lock nuts.
	M8×1.25	22.6～28.4 (2.3～2.9)	
	M10×1.5	44.1～53.9 (4.5～5.5)	
	M12×1.75	78.4～98.0 (8.0～10)	
	M14×1.5	127.5～147.1 (13～15)	
	M16×1.5	215.7～235.4 (22～24)	
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	M8	12.7～16.7 (1.3～1.7)	-
	M10	19.6～25.4 (2.0～2.6)	
	M12	24.5～34.3 (2.5～3.5)	
	M14	39.2～49.0 (4.0～5.0)	
	M16	49.0～58.8 (5.0～6.0)	

Note) Lubricating oil is not applied to threaded portion and seat surface.