FOREWORD

This service manual is written to familiarize you with the maintenance of your S4Q, S4Q2 Diesel Engine. If the engine is carefully maintained it will deliver a long productive life and efficient performance marked by power and economy.

Before you attempt to inspect, disassemble, or repair the engine, read this manual carefully to learn more about the engine and how to care for it properly. All descriptions, illustrations, specifications, and serial numbers in this manual are effective as of the date printing of this manual.

The information contained in this manual applies to the engine model produced at the time of publication.

It should be noted that specifications and design may change due to improvements made thereafter.

Service Manual Mitsubishi SQ-Series diesel engines Version 08/2004 Copyright © 2004 MHI Equipment Europe B.V.

How to use this manual

Following is a brief summary of the system used in compiling this service manual.

- The sections of the manual and their contents are listed in the index furnished at the beginning of the manual. 1. The contents of each section are listed in the index furnished at the beginning of the section.
- 2. The parts read in the texts or shown in the disassembled views are numbered in the disassembly sequence.
- 3.
- What to be inspected for during disassembly are indicated in _____ in the disassembled views. The maintenance standards or specifications to be referred to for inspection and repair are indicated in easy-torefer passages of the texts and also in Section 11 in a tabulated form.
- 5. The following symbols are used in this manual to emphasize important and critical instructions:



An operating procedure, condition, etc. that will help you work more efficiently.



Indicates operating procedure, practice, etc., resulting in personal injury or damage to or destruction of engine.



Indicates a specific potential hazard resulting in bodily injury.

The following terms are used in the dimensional and other specifications:

Nominal Value Indicates the standard dimension of a part.

Indicates the dimension of a part, the dimension to be attained at the time of reassembly Assembly Standard

or the standard performance. The value is rounded to the nearest whole number needed

for inspection and is different from the design value.

Standard Clearance Indicates the clearance to be obtained between mating parts at reassembly.

Repair Limit A part which has reached this limit must be repaired. Service Limit A part which has reached this limit must be replaced.

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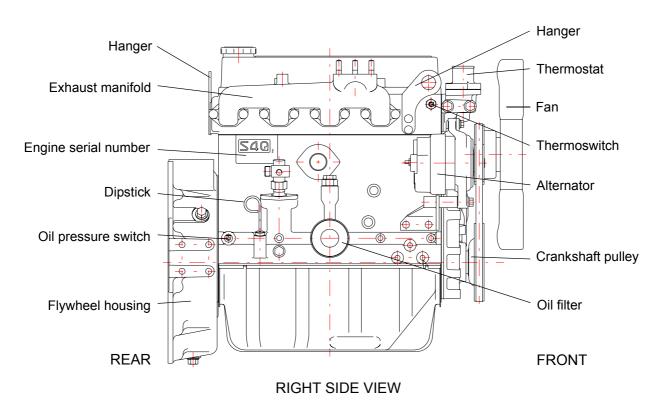
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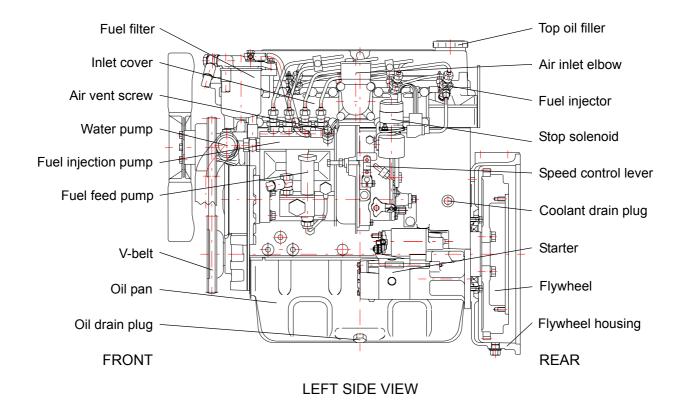
GENERAL

OUTLINE GENERAL

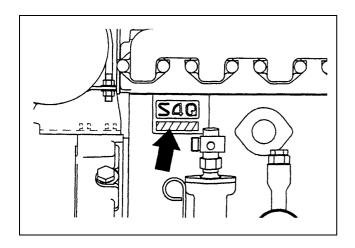
1 OUTLINE

1.1 External View





GENERAL OUTLINE



Note

Rotation of crankshaft is counterclockwise when seen from flywheel end.

1.2 Engine Serial Number Location

The engine serial number is located on the side of the crankcase.

1.3 Engine Model and Application Codes

e.g. S 4 Q

- S Initial of "Sagamihara Machinery Works"
- 4 Number-of-cylinders
- Q Series code

SPECIFICATIONS GENERAL

2 SPECIFICATIONS

	Engine model	S4Q	S4Q2	
	Туре	In-line, water-cooled, 4-stroke cycle		
	Firing order	1-3-4-2		
	Compression ratio	22		
0	Combustion chamber type	Swirl chamber type		
General	Weight (dry) kg [lb]	195	[430]	
	Number of cylinders	4	4	
	Bore x stroke mm [in.]	88 x 95 [3.46 x 3.74]	88 x 103 [3.46 x 4.06]	
	Displacement liter [cu in.]	2.311 [141]	2.505 [153]	
	ssible working angles for oil pickup ongitudinal and lateral	10°		
	Injection pump, type	Bosch A		
Fuel system	Injection nozzle, type	Bosch	throttle	
	Fuel filter, type	Spir	n-on	
	Туре	Force	e feed	
Lubrication	Oil filter, type	Spin-on cartridge of paper-element		
system	Capacity liter [U.S. gal.]	Oil pan: 5.5 [1.5], approx. Crankcase: 6.5 [1.7], approx.		
	Starter V-kW	12	2-2	
Electrical system	Alternator V-A	12	-50	
,	Battery recommended	12V-	92Ah	

GENERAL INSTRUCTIONS

3 DETERMINATION OF OVERHAUL TIMING

In most cases the engine should be overhauled when the engine's compression pressure is low. Other factors that indicated the necessity of engine overhaul are as follows:

- 1. Decreased power.
- 2. Increased fuel consumption.
- 3. Increased engine oil consumption.
- 4. Increased blow-by gas volume through the breather due to abrasion at the cylinder liner and the piston ring.
- Gas leakage due to poor seating of the inlet and the exhaust valves.
- 6. Starting problems.
- 7. Increased noise from engine parts.

Any one or a combination of these symptoms may indicate that engine overhaul is required. Of the items listed above some are not directly related to the necessity of engine overhaul. Items (2) and (6) are more likely to be affected substantially by

- Injection volume of the fuel injection pump
- Fuel injection timing
- Wear of injection-pump plunger
- Fitting of the injection nozzle
- Condition of electrical equipment: battery, starter, or alternator

Item (4) above, however, requires special consideration because decreased pressure due to wear at the cylinder liner and the piston ring is one of the most obvious signs that the engine requires overhauling.

The most effective way to make a decision is by testing the compression pressure; other factors are to be considered secondarily.

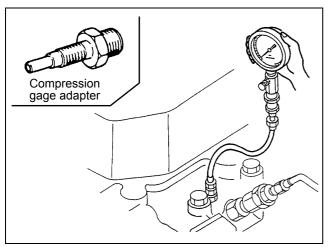


Figure 1 Measuring compression pressure

4 TESTING THE COMPRESSION PRESSURE

Start by:

- a. Make sure the engine oil, air cleaner, starter and battery are normal
- b. Start the engine and allow it to warm up thoroughly
- 1. Move the stop lever to the stop position.
- Remove the glow plugs from all cylinder heads. Connect compression gage (33391-02100) to the cylinder on which the compression is to be measured with compression gage adaptor (30691-21100).
- Crank the engine with the starter, then read the compression gage indication while the engine is running at the specified speed.
- 4. If the compression pressure is lower than the repair limit, overhaul the engine.



- a. Measure the compression pressure on all cylinders.
- Compression pressure varies with the engine speed. Check the engine speed when measuring the compression pressure.

Unit: MPa (kgf/cm²) [psi]

Item	Assembly Standard	Repair Limit	
Compression pressure	2.94 (30) [427]	2.55 (26) [370]	

NOTE

Meaure the compression pressure with the engine running at 150 to 200 rpm

$oldsymbol{\Lambda}$ CAUTION

- a. Measure the compression pressure at regular intervals to obtain correct data.
- b. The compression pressure will be slightly higher in a new or overhauled engine due to new piston rings, valve seats, etc. Pressure will drop gradually by the wear of parts.

5 TIPS ON DISASSEMBLY AND REASSEMBLY

This service manual covers recommended procedures to be followed when servicing diesel engines. It also contains information on special tools required and basic safety precautions.

It is the responsibility of service personnel to be familiar with these requirements, precautions and potential hazards and to discuss these points with their foreman or supervisor.

Study this manual carefully and observe the following general precautions to prevent serious personal injury and to avoid damage to the engine, equipment and parts.

5.1 Disassembly

- 1. Use the correct tools and instruments. Serious injury or damage to the engine can result from using the wrong tools and instruments.
- Use an overhaul stand or a work bench if necessary. Also, use assembly bins to keep the engine parts in order of removal.
- 3. Lay down the disassembled or cleaned parts in the order in which they were removed. This will save you time at reassembly.
- Pay attention to the marks on assemblies, components and parts for positions or directions. Put on your own marks, if necessary, to aid reassembly.
- Carefully check each part for faults during removal or cleaning. Signs of abnormal wear will tell if parts or assemblies are functioning improperly.
- When lifting or carrying heavy parts, get someone to help you if the part is too awkward for one person to handle. Use jacks and chain blocks when necessary.

5.2 Reassembly

- Wash all parts, except for oil seals, O-rings, rubber seals, etc., in cleaning solvent and dry them with compressed air.
- Always use tools that are in good condition and be sure you understand how to use them before performing any service work.
- 3. Use only good quality lubricating oils and greases. Be sure to apply a coat of oil, grease or sealant to parts as specified.
- 4. Use a torque wrench to tighten parts when specified tightening torques are required.
- 5. Replace all gaskets and packing.

6 PRECAUTIONS FOR DISASSEMBLY AND REASSEMBLY

6.1 Oil Seals

When installing oil seals, carefully observe the following points.

6.1.1 Driving oil seals into housings

- 1. Check the seal lip for damage, and be sure to position correctly in the housing.
- 2. Apply a smear of grease to the surface of the oil seal (to be fitted into the housing bore).
- Using an oil seal driver shown to guide the seal lip and drive the outer diameter squarely. To avoid damage to the oil seal and leaking, never hammer on it directly.

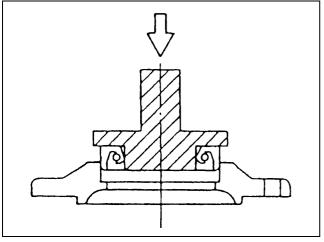


Figure 2 Oil seal installer

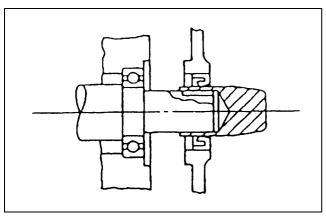


Figure 3 Oil seal guide

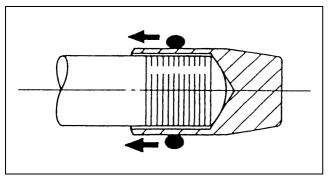


Figure 4 O-ring guide

6.1.2 Driving oil seals onto shafts

- 1. Apply a smear of grease to the oil seal lip.
- 2. Use an oil seal guide of the type shown when driving the oil seal over the stepped portion, splines, threads, or key way to prevent damage to the oil seal lip.

6.2 O-rings

Use an O-ring guide to install an O-ring over stepped parts, splines, threads, or key way to prevent damage to the ring. Apply a smear of grease to the O-ring before installation.

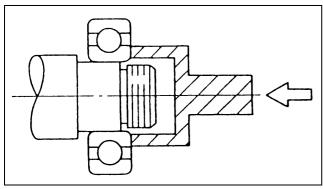


Figure 5 Bearing driver

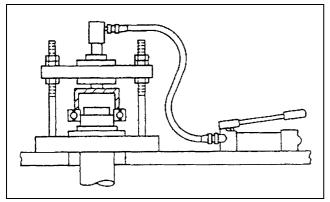


Figure 6 Installing a bearing with a press

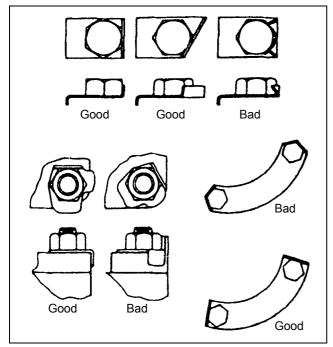


Figure 7 Bending lock plates

6.3 Bearings

1. When installing a rolling bearing, be sure to push the inner or outer race by which the bearing is fitted. Be sure to use a bearing driver like the one shown.

2. Whenever possible, use a press to minimize shock to the bearing and to assure proper installation.

6.4 Lock Plates

Bend lock plates against the flats of the nuts or bolt heads as shown.

6.5 Split Pins and Spring Pins

Generally, split pins are to be replaced once disturbed. Insert the pin fully and spread it properly. Drive each spring pin into position to hold it in place after later installation of parts has been completed.

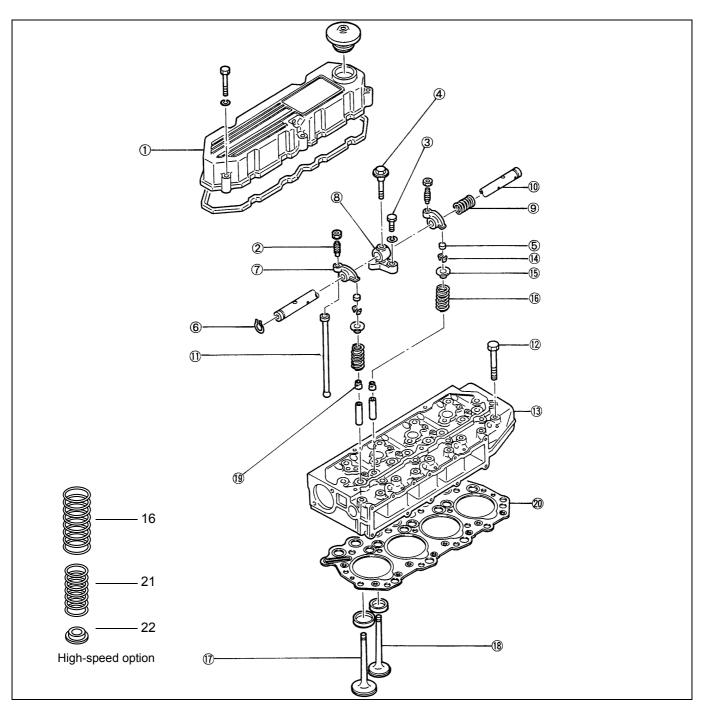
PRECAUTIONS FOR DISASSEMBLY AND REASSEMBLY

GENERAL INSTRUCTIONS

ENGINE MAIN PARTS

7 CYLINDER HEADS AND VALVE MECHANISM

7.1 Disassembly



- 1. Rocker cover
- 2. Adjusting screw
- 3. Bolt (short)
- 4. Bolt (long)
- 5. Valve cap
- 6. Snap ring
- 7. Rocker arm
- 8. Rocker shaft bracket

- 9. Rocker shaft spring
- 10. Rocker shaft
- 11. Valve pushrod
- 12. Cylinder head bolt
- 13. Cylinder head
- 14. Valve cotters
- 15. Upper valve retainer
- 16. Valve spring
- 17. Valve (inlet)
- 18. Valve (exhaust)
- 19. Valve stem seal
- 20. Cylinder head gasket
- 21. Inner valve spring
- 22. Lower valve spring

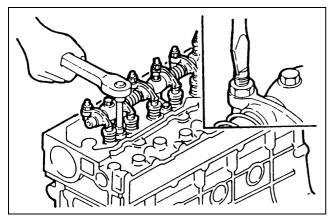


Figure 8 Removing rocker shaft assembly

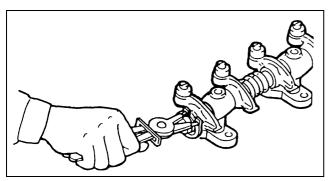


Figure 9 Disassembling rocker shaft assembly

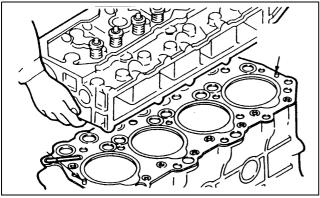


Figure 10 Removing cylinder head

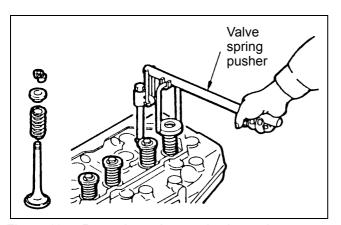


Figure 11 Removing valves and valve springs

7.1.1 Removing rocker shaft assembly

- 1) Loosen the adjusting screw one turn.
- 2) Loosen the bolts, long and short, that hold the rocker shaft bracket to the cylinder head. Be sure to loosen the short bolt first. Remove the rocker shaft assembly from the cylinder head.

⚠ CAUTION

If the long bolt is loosened first, the rocker shaft bracket might suffer damage.

7.1.2 Disassembling rocker shaft assembly

Arrange the disassembled rockers in the order removed, so you can install them in that order at reassembly. This will ensure the same rockershaft clearance as before.

7.1.3 Removing cylinder head

Remove the cylinder head bolts. Lift the head off the crankcase.

NOTE

If any parts of the cylinder head are faulty, check the cylinder head bolts for torque with a torque wrench before removing them.

7.1.4 Removing valves and valve springs

Use valve spring pusher (30691-04500) to compress the valve spring squarely, then remove the valve cotters.

NOTE

If the existing valves are to be reused, put a mark on each valve for its location.

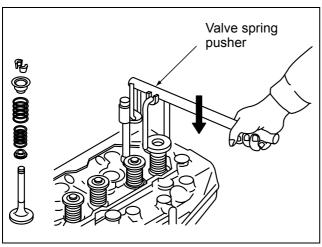


Figure 12 Removing valves and valve springs (high speed option)

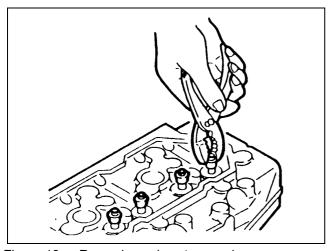


Figure 13 Removing valve stem seals

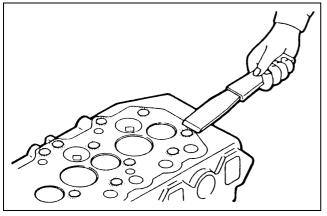


Figure 14 Cleaning cylinder head

7.1.5 Removing valve stem seals

Remove the stem seals with a pliers, as shown in the illustration.

NOTE

Do not reuse the stem seals.

7.1.6 Cleaning cylinder head

Clean the machined surface of the cylinder head that makes contact with the gasket.

NOTE

Remove the gasket with a scraper, then clean the machined surface with an oilstone and engine oil.

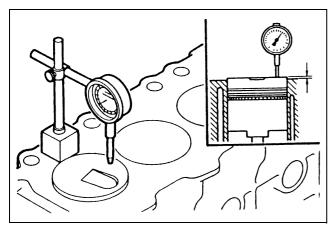


Figure 15 Measuring piston protrusion

7.1.7 Measuring piston protrusion

- Determine the top dead center of the piston with a dial indicator.
- 2) Install a dial indicator on the crankcase with its point on the top of the piston. Set the indicator to read 0 (zero).
- 3) Check the piston protrusion at three points on the top of the piston, as shown in the illustration, and average the three measurements to determine the protrusion. Subtract the projection from the compressed thickness of the gasket to determine the clearance between the piston top and the cylinder head.

If the piston protrusion is not correct, check the various parts for clearance.

Unit: mm [in.]

Item	Assembly Standard
Piston protrusion	0.13 to 0.60 [0.0051 to 0.0236]
Compressed thickness of gasket	1.27 to 1.35 [0.0500 to 0.0531]



Incorrect piston protrusion affects engine performance and causes valve interference with piston.

7.2 Inspection

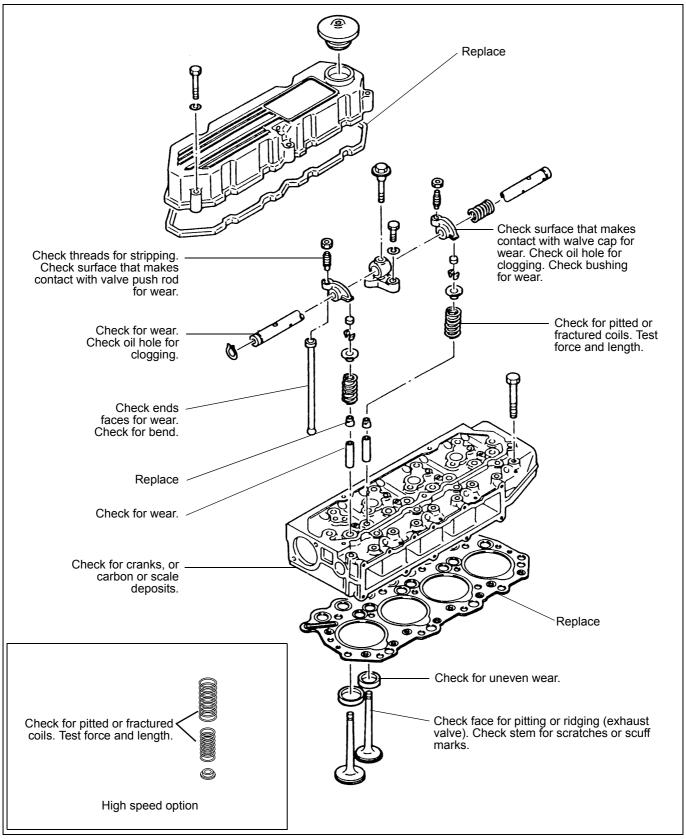


Figure 16 Inspection points

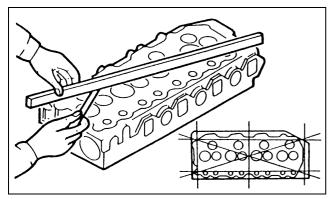


Figure 17 Checking cylinder head for warpage

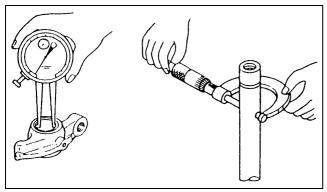


Figure 18 Measuring rocker arm bushing and rocker shaft

7.2.1 Cylinder head

Using a heavy accurate straight edge and a feeler gage, check for warpage in three positions lengthwise, two crosswise and two widthwise, as shown in the illustration. If warpage exceeds the repair limit, reface the head with a surface grinder.

Unit: mm [in.]

Item	Assembly Standard	Repair Limit	
Warpage of bottom face	0.05 [0.0020] or less	0.20 [0.0079]	

7.2.2 Rocker arms and rocker shafts

1. Measuring rocker arm bushing and rocker shaft

Measure the inside diameter of the rocker arm (bushing bore) and the diameter of the rocker shaft, as shown in the illustration, to check the clearance between the rocker arm and shaft. If the clearance is not correct, within the repair limit, replace the rocker arm. If it exceeds the repair limit, replace both rocker arm and bushing.

Unit: mm [in.]

Item	Nominal Value	Assembly Standard	Repair Limit
Inside diameter of rocker arm bushing	19 [0.75]	19.010 to 19.030 [0.7484 to 0.7492]	
Diameter of rocker shaft	19 [0.75]	18.980 to 19.000 [0.7472 to 0.7480]	_
Clearance between rocker bushing and shaft	_	0.010 to 0.050 [0.0004 to 0.0020]	0.070 [0.0028]

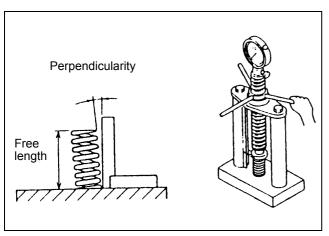


Figure 19 Measuring valve spring perpendicularity and free length

Measuring valve spring perpendicularity and free length

Measure the free length and perpendicularity of each valve spring. If the free length or perpendicularity exceeds the service limit, replace the spring.

Unit: mm [in.]

Item	Assembly Standard	Service Limit
Free length	48.85 [1.92]	47.60 [1.87]
Perpendicularity	1.5° or less	
Set force N (kgf) [lbf]	177 to 196 (18 to 20) [40 to 44]	147 (15) [33]

Inner valve spring (high-speed option)

Unit: mm [in.]

Item	Item Assembly Standard	
Free length	50.0 [1.9685]	49.0 [1.9291]
Perpendicularity	1.5° or less	_
Set force N (kgf) [lbf]	56.9 (5.8) [12.8]	48.1 (4.9) [10.8]

Figure 20 Measuring valve pushrod runout

7.2.3 Valve pushrods

Using V-blocks and a dial indicator, check for runout, as shown in the illustration. If runout exceeds the assembly standard, replace the pushrod.

Unit: mm [in.]

Item	Assembly Standard	
Pushrod runout	0.3 [0.012] or less	

NOTE

Assembly standards refer to dial gage readings.

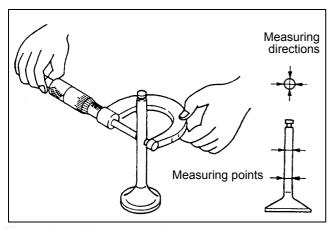


Figure 21 Measuring valve stem

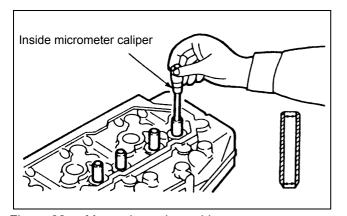


Figure 22 Measuring valve guide

7.2.4 Valves, valve guides and valve seats

1. Measuring valve stem

Measure the diameter of the valve stem, as shown in the illustration. If the service limit is exceeded, replace the valve.

Unit: mm [in.]

Item		Nominal Value	Assembly Standard	Service Limit
Valve stem	Inlet valves	8 [0.315]	7.940 to 7.955 [0.3126 to 0.3132]	7.900 [0.3110]
diameter	Exhaust valves	8 [0.315]	7.920 to 7.940 [0.3118 to 0.3126]	7.850 [0.3091]

2. Checking clearance between valve stem and guide

The valve guide wears more rapidly at its both ends than at any other parts. Measure the inside diameter of the valve guide at its ends, as shown in the illustration, to check the clearance. If the clearance exceeds the service limit, replace the guide or valve whichever is badly worn.

Unit: mm [in.]

Item		Nominal Value	Assembly Standard	Repair Limit
Clearance between valve	Inlet valves		0.065 to 0.095 [0.0026 to 0.0037]	0.200
stem and guide	Exhaust valves		0.080 to 0.115 [0.0032 to 0.0045]	[0.0079]
Height to top of valve guide		15.5 [0.61]	15.1 to 15.6 [0.5945 to 0.6142]	_

NOTE

Before measuring the valve guides, clean the guides, removing lacquer or other deposits by running wire brush through them.

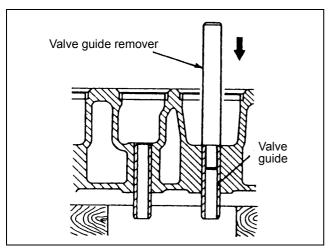


Figure 23 Replacing valve guide

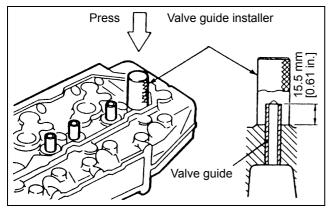


Figure 24 Installing valve guide

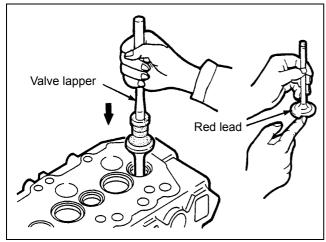


Figure 25 Inspecting valve face

3. Replacing valve guide

- 1) To remove the valve guide for replacement, use valve guide remover (32A91-00300).
- 2) To install a replacement valve guide, use valve guide installer (32A91-00100) and a press.

$oldsymbol{\Delta}$ CAUTION

The height to top of valve guide is specified; be sure to use the valve guide installer to insure the correct height.

- 3) Insert a new valve into the guide just installed to check how the valve slides in the guide.
- 4) After replacing the valve guides, check the valve contact with the seats.

4. Inspecting valve face

Coat the valve face lightly with red lead. Use the Valve lapper to inspect the valve contacts with its seat. If the contact is not uniform, or if the valve is defective or if the service limit is exceeded, repair or replace the valve and valve seat.

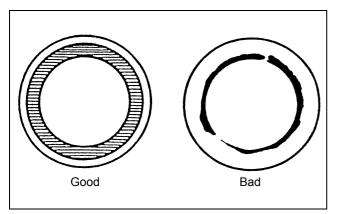


Figure 26 Valve contact pattern

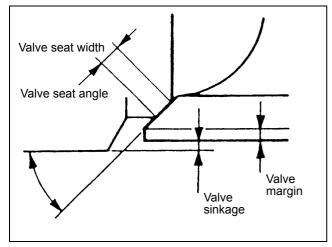


Figure 27 Valve contact with valve seat

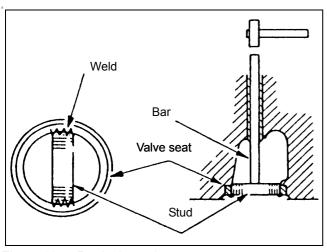


Figure 28 Replacing valve seat

NOTE

- a Check the valve contact after checking or replacing the valve guides.
- b Do not rotate the valve when holding it against the seat for checking the contact.
- c After refacing or replacing the valve or valve seat, lap the valve in the seat. (See (8) Lapping valves.)

Unit: mm [in.]

Item		Nominal Value	Assembly Standard	Repair Limit
Valve seat	Angle	30°		
	Width	1.18 [0.05]	1.04 to 1.32 [0.0409 to 0.0520]	1.6 [0.0630]
	Valve sinkage	0.8 [0.03]	0.7 to 0.9 [0.0276 to 0.0354]	1.3 [0.0512]
Valve margin		1.70 [0.07]		1.20 [0.0472]

5. Replacing valve seat

 Weld a stud to the valve seat. Insert a shaft through the valve guide from the upper side of the cylinder head to put its end on the stud, as shown in the illustration. Then, drive the seat off from the cylinder head.

NOTE

When welding the stud to the valve seat, avoid contact of any spatter with the machined surface of the cylinder head.

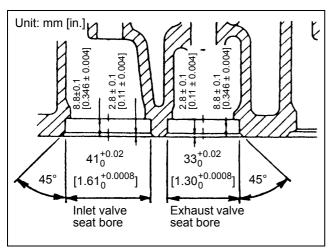


Figure 29 Valve seat bore dimensions

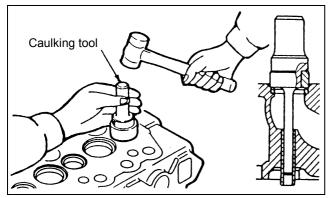


Figure 30 Installing valve seat

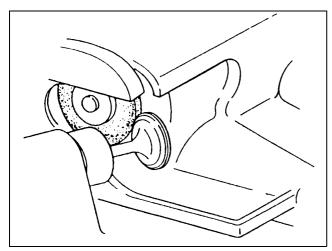


Figure 31 Refacing valve face

- Before inserting a new valve seat, measure the bores in the cylinder head for the valve seats to make sure they are correct in dimension.
- 3) Chill the valve seat in liquid nitrogen (about 170°C [–274°F]) for more than 4 minutes with the cylinder head kept at normal temperature, or heat the cylinder head to 80 to 100°C [176 to 212°F] with the valve seat chilled in ether or alcohol containing dry ice.
- 4) Use the caulking tool to install the valve seat.

Tools needed

	Part number
Caulking tool (for inlet valve seat)	30691-02700
Caulking tool (for exhaust valve seat)	30691-02800

Refacing valve face

If the valve face is badly worn, reface it with a valve refacer.

NOTE

- a Set a valve refacer at an angle of 30°.
- b Grind the valve as little as possible. If the margin seems to exceed the repair limit as a result of grinding, replace the valve.

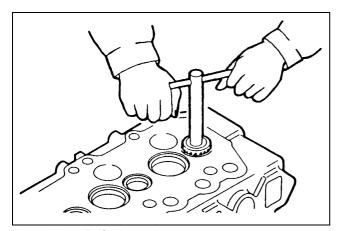


Figure 32 Refacing valve seat

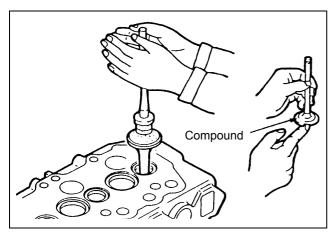


Figure 33 Lapping valve in valve seat

7. Refacing valve seat

Use the Valve seat cutter or valve seat grinder to reface the valve seat. After refacing, grind the seat lightly using #400 grade sandpaper inserted between the cutter and valve seat.

NOTE

- Cut or grind the valve seat only as needed for refacing.
- b Replace the valve seat if the seat width is more than the repair limit as a result of wear or cutting.
- 8. Lapping valve in valve seat

Be sure to lap the valve in the valve seat after the seat has been replaced.

 Coat the valve face lightly with a lapping compound.

NOTE

- a Do not permit the compound to come in contact with the valve stem.
- b Use a compound of 120 to 150 mesh for initial lapping and the compound finer than 200 mesh for finish lapping.
- c Mixing the compound with a small amount of engine oil will facilitate coating.
- Use the Valve lapper to lap the valve in the seat. To lap, raise the valve off the seat, then rotate the valve only a partial turn and strike it against the seat.
- 3) Wash off the compound with diesel fuel.
- 4) Coat the valve face with engine oil, and again lap the valve.
- 5) Check the valve face for contact.

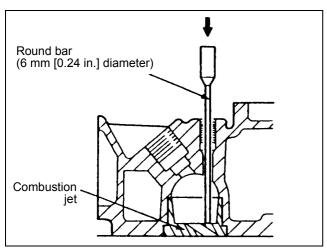


Figure 34 Removing combustion jet

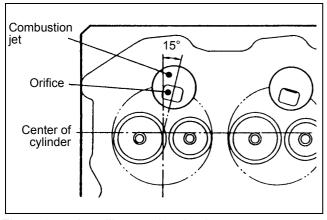


Figure 35 Installing combustion jet

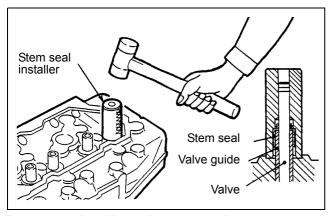


Figure 36 Installing valve stem seal

7.2.5 Replacing combustion jets

Replace the combustion jets when they are cracked or otherwise faulty.

- 1) To remove the combustion jet, tap the jet off the cylinder head with a 6 mm [0.24 in.] diameter round bar inserted through the glow plug hole, as shown in the illustration.
- To install a replacement jet, position the jet so that the orifice is toward the center of the cylinder and drive it into position with a plastic hammer.

7.3 Reassembly

- 1. Installing valve stem seal
 - 1) Apply engine oil to the valve stem and put the valve in the valve guide.
 - 2) Put a new stem seal on the valve guide.
 - 3) Using stem seal installer (32A91–00200), install the stem seal to the valve guide, making use of the valve stem as a guide.

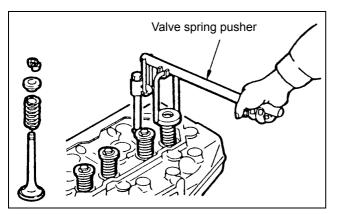


Figure 37 Installing valve and valve spring

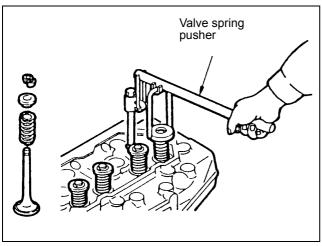


Figure 38 Installing valve and valve spring (highspeed option)

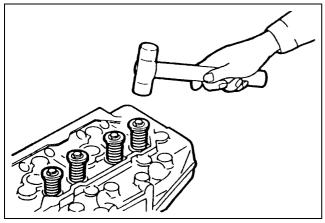


Figure 39 Testing valve cotter installation

- 2. Installing valve and valve spring
 - 1) Put the valve spring and retainer on the valve guide. Using valve spring pusher (30691–04500), compress the valve spring and install the valve cotters to the valve.



Compressing the valve spring excessively will cause the retainer to make contact and damage the stem seal.

2) Tap the top of the valve with a soft faced hammer several times to make sure the valve spring and valve cotters are properly installed.

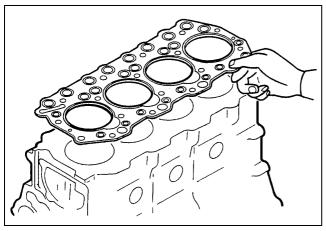


Figure 40 Installing cylinder head gasket

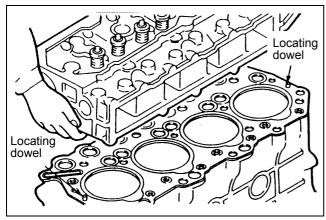


Figure 41 Installing cylinder head

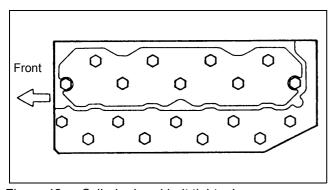


Figure 42 Cylinder head bolt tightening sequence

3. Installing cylinder head gasket

- Make sure the machined surface of the crankcase and the top of the pistons are clean.
- 2) Put a new gasket on the crankcase with "UP" mark side up. Make sure the locating dowels enter their holes in the gasket.



Do not use any sealant.

4. Installing cylinder head

Put the cylinder head on the crankcase. Make sure the locating dowels enter their holes in the cylinder head.

5. Tightening cylinder head bolt

Tighten the cylinder head bolts to the specified torque in the sequence shown.

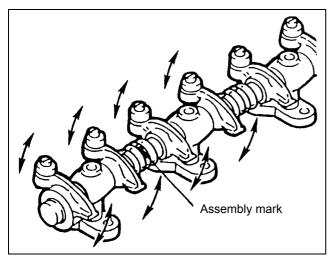


Figure 43 Assembling rocker arms and rocker shaft

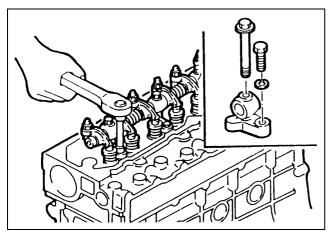


Figure 44 Installing rocker shaft assembly

6. Assembling rocker arms and rocker shaft

When installing the rocker arms to the rocker shaft, position the arms with their assembly marks pointing forward. After installing the arms, make sure they move smoothly.

- 7. Installing valve pushrod
 - Insert the pushrod into position through the pushrod hole in the cylinder head.
 - 2) Make sure the ball end of each pushrod rests securely on the curved surface (R section) of the tappet.
- 8. Installation of rocker shaft assembly
 - 1) Install valve caps.
 - 2) When installing rocker shaft brackets, tighten the long bolts first, then tighten the short bolts (reversal of removal sequence).

Tightening	Long bolts	$15 \pm 2 \text{ N·m}$ (1.5 ± 0.2 kgf·m) [11 ± 1 lbf·ft]
torque	Short bolts	12 ± 1 N·m (1.2 ± 0.1 kgf·m) [9 ± 1 lbf·ft]

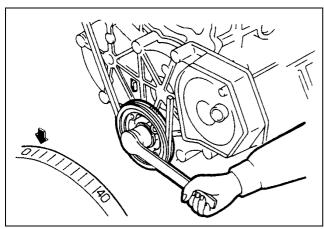


Figure 45 Finding top dead center on compression stroke for No. 1 piston — 1

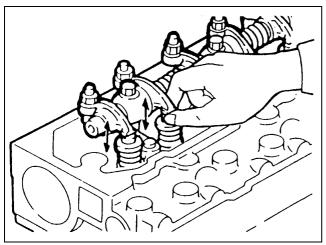


Figure 46 Finding top dead center on compression stroke for No. 1 piston — 2

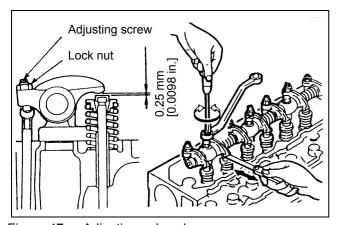


Figure 47 Adjusting valve clearance

7.4 Valve Clearance Adjustment

- 1. Find the top dead center on the compression stroke for No.1 piston as outlined below:
 - 1) Using the turning handle (30691–21800), turn the nut on the crankshaft pulley in the engine's forward rotating direction (clockwise when viewed from the front of the engine).
 - 2) Stop turning when the stamped "0" line on the periphery of the crankshaft pulley aligns with the pointer on the turning gear case.
 - 3) Try to move up and down the inlet and exhaust valve rocker arms of the No.1 cylinder to make sure they are not being pushed up by the pushrods. The No.1 piston is at the top dead center on the compression stroke when the rocker arms are not being pushed up by the pushrods. If the rocker arms are being pushed up, turn the crankshaft one turn.

2. Insert a 0.25 mm [0.0098 in.] feeler gage into between the rocker arm and valve cap.

Unit: mm [in.]

Item		Assembly Standard
Valve clearance (cold	Inlet valves	0.13 to 0.60 [0.0051 to 0.0236]
setting)	Exhaust valves	1.27 to 1.35 [0.0500 to 0.0531]

- 3. Loosen the lock nut for the adjusting screw and turn the adjusting screw in either direction until the feeler gage is slightly gripped between the rocker arm and valve cap.
- 4. After adjusting, tighten the lock nut and recheck the clearance.

5. Adjust the valve clearance on the remaining cylinders by turning the crankshaft 180° at a time, in the firing order.

Sequence (cylinder No.)	Turning angle	
1–3–4–2	180°	



After adjusting the valve clearance on all cylinders, turn the crankshaft two or three turns and recheck the clearance.

FLYWHEEL 8

Disassembly 8.1

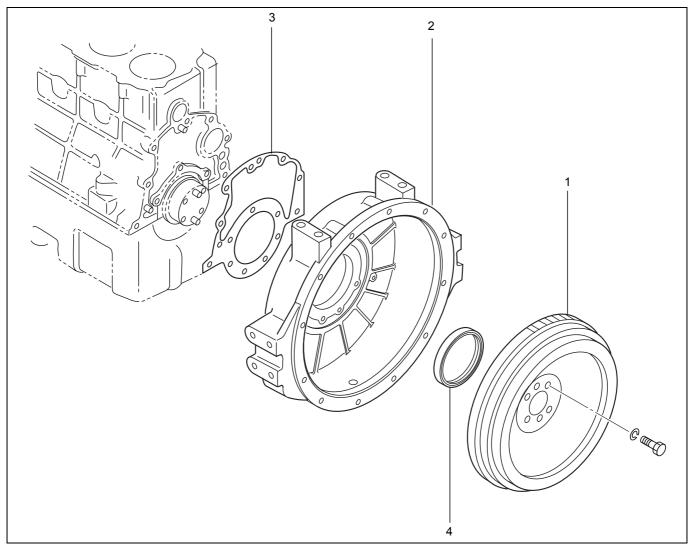


Figure 48 Disassembly sequence

- 1.
- Flywheel Flywheel housing Gasket 2.
- 3.
- Oil seal

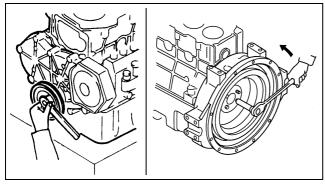


Figure 49 Removing flywheel

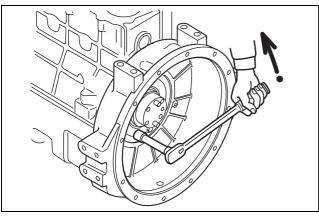


Figure 50 Removing flywheel housing

1. Removing flywheel

- 1) Have someone hold the crankshaft pulley with a wrench to prevent the flywheel from turning during removal.
- 2) Remove one of the bolts that hold the flywheel.

$oldsymbol{\Delta}$ CAUTION

During removal, signal each other to avoid personal injury.

- 3) Screw safety bar (M12 x 1.25 mm [0.47 x 0.049 in.]) in the bolt hole and remove the remaining bolts.
- 4) Remove the flywheel from the crankshaft by pulling it straight.

$oldsymbol{\Delta}$ CAUTION

When removing the flywheel, wear heavy gloves to protect your hands.

2. Removing flywheel housing

The flywheel housing is doweled. To remove the housing, pull it as straight as possible.

8.2 Inspection

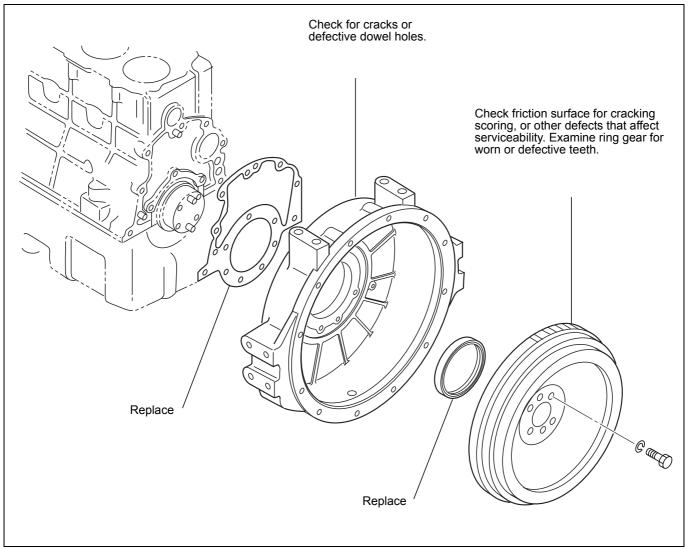


Figure 51 Inspection points

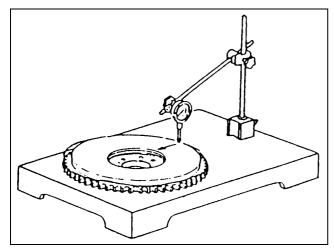


Figure 52 Checking flywheel

8.2.1 Flywheel and ring gear

1. Flatness of flywheel

Put the flywheel on the surface plate. Set a dial indicator at one side of the friction surface and move it over to the opposite side of the surface, as shown in the illustration. If the friction surface is not flat over the repair limit, regrind it.

Item	Assembly Standard	Repair Limit
Flatness of flywheel	0.15 [0.0059] of less	0.50 [0.0197]

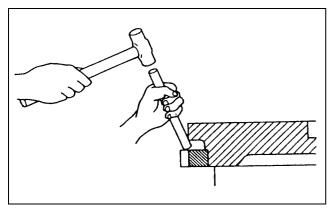


Figure 53 Removing ring gear

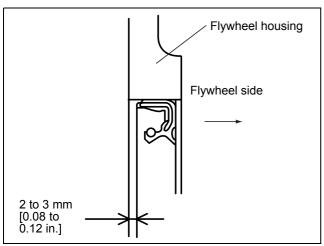


Figure 54 Installing oil seal

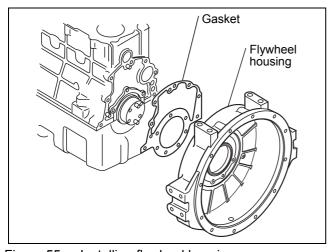


Figure 55 Installing flywheel housing

2. Replacing ring gear

(Removal)

- Heat the ring gear evenly with an acetylene torch.
- 2) Tap the ring gear all the way around with a bar and a hammer to remove it from the flywheel.

(Installation)

Heat a replacement ring gear up to 150°C [302°F] with a piston heater and install it to the flywheel with the unchamfered side of the gear teeth foremost.

8.3 Reassembly

1. Installing oil seal

Apply a small amount of grease to new oil seal and drive the oil seal to flywheel housing by using installer.

Be sure oil seal faces to the correct direction.

NOTE

Replace, if oil seal sleave running surface of crankshaft is badly worn.

2. Installing flywheel housing

- Apply THREEBOND 1104 on the mounting surfaces of both crankcase and flywheel housing.
- Install the gasket and flywheel housing on the crankcase by aligning the holes on the flywheel with the dowel pins on the crankcase.
- 3) Tighten the flywheel mounting bolts to the specified torque.

	60 ± 6 N·m
Tightening torque	(6.1 ± 0.6 kgf·m)
	[44 ± 4 lbf·ft]

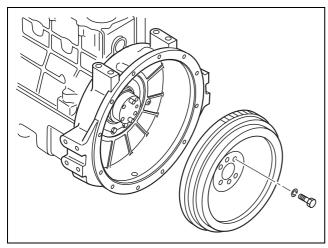


Figure 56 Installing flywheel

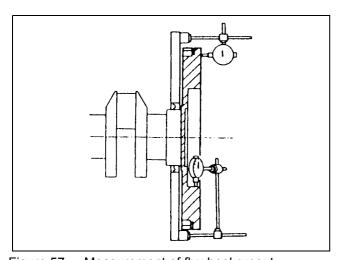


Figure 57 Measurement of flywheel runout

3. Installing flywheel

- 1) Install the flywheel in place by using the dowel pins on the crankshaft for alignment.
- 2) Install the washers and bolts, and tighten the bolts to the specified torque.

83 ± 5 N·m (8.5 ± 0.5 kgf·m)
[61 ± 4 lbf·ft]

4. Measurement of flywheel runout

Measure the amount of runout of the installed flywheel. If the measured value exceeds the standard value, check the bolts for tightening condition and the mounting face for foreign particles.

Item	Assembly Standard	Repair Limit
Flywheel runout	0.15 [0.059] or less	0.50 [0.0197]

TIMING GEARS, 9 **CAMSHAFT AND OIL PAN**

9.1 **Disassembly**

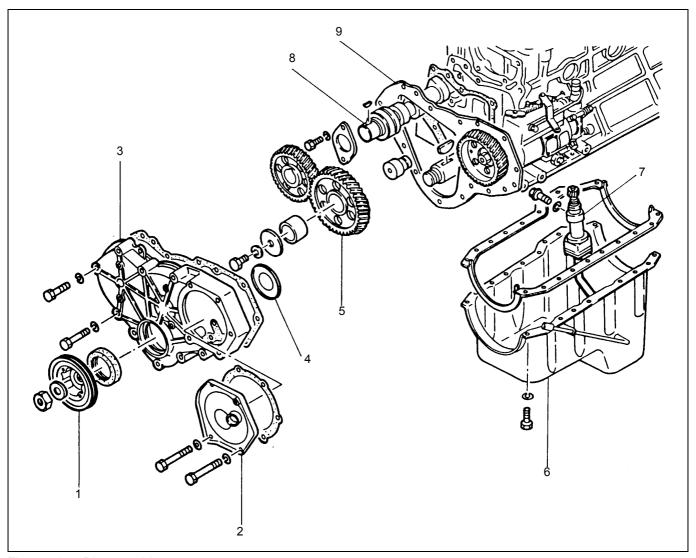


Figure 58 Disassembly sequence

- 1. Crankshaft pulley
- Cover
- Timing gear case Baffle plate 3.
- ldler gear
- 6. Oil pan
- 7. Oil pump
- 8. Camshaft
- Front end plate

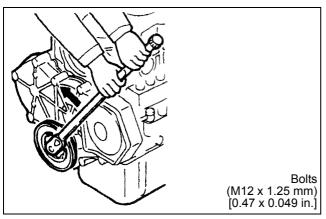


Figure 59 Removing crankshaft pulley

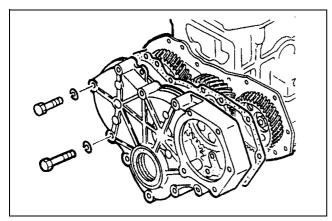


Figure 60 Removing timing gear case

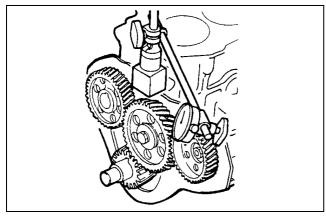


Figure 61 Measuring timing gear backlash

1. Removing crankshaft pulley

- 1) Install two bolts (M12 x 1.25 mm [0.47 x 0.049 in.]) to the rear end of the crankshaft and put a bar between the bolts to hold the crankshaft, as shown in the illustration.
- 2) Remove the pulley from the crankshaft.

⚠ CAUTION

Make sure the bar will not come off when removing the pulley.

2. Removing timing gear case

Remove the timing gear case with the oil pump drive gear and idler gear from the crankcase. Pull the case straight off the locating dowels.

$oldsymbol{\Delta}$ CAUTION

The front plate is bolted inside the gear case. Do not attempt to remove the plate with the case by tapping.

3. Measuring timing gear backlash

Measure the backlash betw een the gears and make a record of the measurements to be referred to at the time of assembly. If the backlash exceeds the service limit, replace the gears.

Item	Assembly Standard	Service Limit
Backlash between crankshaft gear and idler gear	0.05 to 0.15	
Backlash between idler gear and camshaft gear	[0.0020 to 0.0059]	0.25 [0.0098]
Backlash between injection pump drive gear and idler gear	0.04 to 0.16 [0.0016 to 0.0063]	

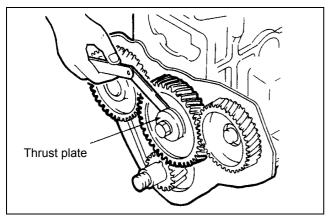


Figure 62 Measuring idler gear end play

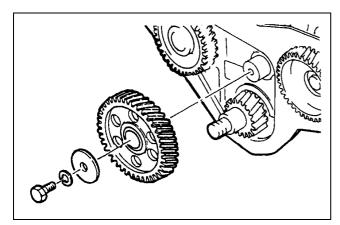


Figure 63 Removing idler gear

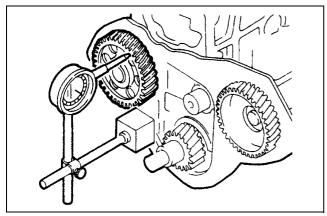


Figure 64 Measuring camshaft end play

4. Measuring idler gear end play

Measure the end play with feeler gages or a dial gage. If the end play exceeds the repair limit, replace the thrust plate.

Unit: mm [in.]

ltem	Assembly Standard	Service Limit
End play of idler gear	0.05 to 0.20 [0.0020 to 0.0079]	0.35 [0.0138]

5. Removing idler gear

Unscrew the bolt and washer and remove the idler gear.

6. Measuring camshaft end play

Use a dial gage to measure the end play of the camshaft to which the camshaft gear is installed. If the end play exceeds the service limit, replace the thrust plate.

ltem	Assembly Standard	Service Limit
End play of camshaft	0.10 to 0.25 [0.0039 to 0.0098]	0.30 [0.0118]

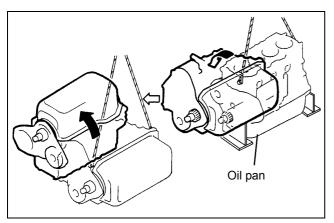


Figure 65 Turning crankcase upside down

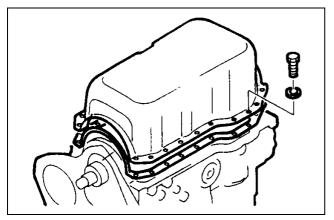


Figure 66 Removing oil pan and gasket

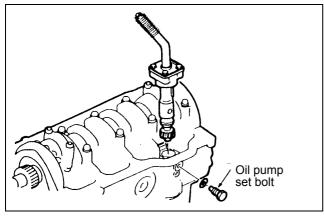


Figure 67 Removing oil pump

7. Turning crankcase upside down

1) Turn the crankcase upside down.



To prevent damage to the oil pan, do not place the engine on the floor with the oil pan facing down.

- 2) Unscrew the bolts that hold the oil pan to the crankcase. Remove the oil pan.
- 3) Remove the gasket.

8. Removing oil pump

Unscrew the set bolt and remove the oil pump from the crankcase.

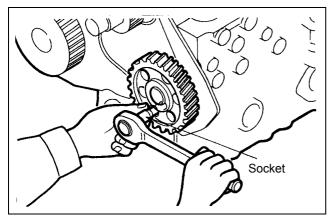


Figure 68 Removing cramshaft

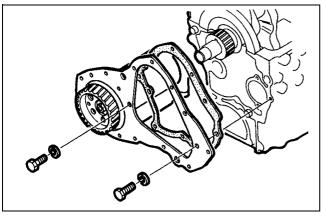


Figure 69 Removing front plate

9. Removing camshaft

- 1) Position the camshaft gear so that its lightening holes are on the top and bottom sides. Unscrew the bolts that hold the thrust plate with socket (34491–00300).
- 2) Pull the camshaft from the crankcase.



Do not cause damage to the lobes or bushing journals when removing the camshaft.

10. Removing front plate

Unscrew the bolts that hold the front plate to the crankcase. Remove the plate (with the injection pump) from the crankcase.

9.2 Inspection

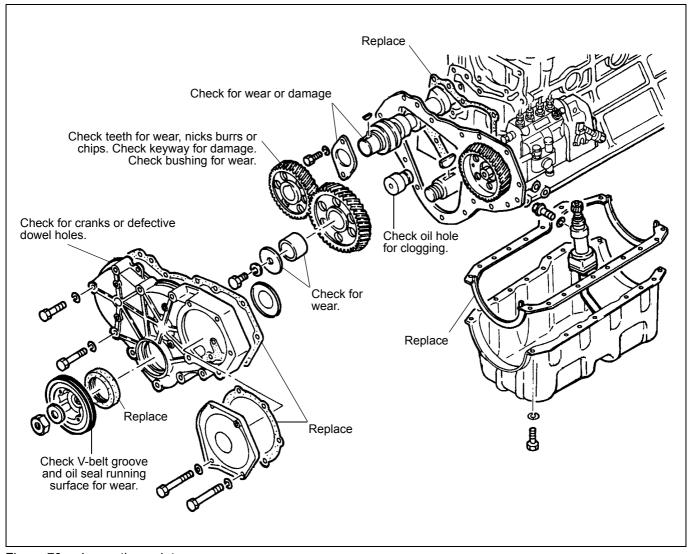


Figure 70 Inspection points

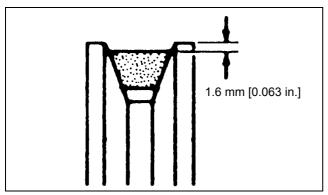


Figure 71 Wear limit of V-belt groove of pulley

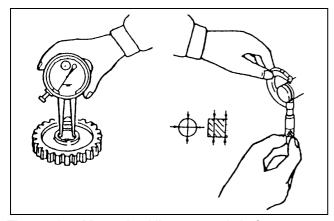


Figure 72 Measuring idler gear and shaft

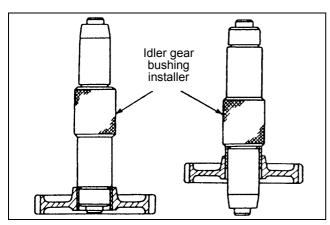


Figure 73 Replacing idler gear bushing

9.2.1 Crankshaft pulley

Check the V-belt groove for wear. Wrap a new belt around the pulley, pressing it in the groove as far as it goes, and see if the top surface of the belt is above the top of the pulley.

If the top surface of the belt (or the belts for the pulleys having two or more grooves) is uniformly above the top of the pulley all the way around, it is not necessary to replace the pulley.

If the top surface of the belt sinks into the groove more than 1.6 mm [0.063 in.], replace the pulley.

9.2.2 Idler gear

1. Checking clearance between idler gear and shaft

Measure the inside diameter of the idler gear and the diameter of the shaft, as shown in the illustration, to check the clearance. If the clearance exceeds the service limit, replace the gear or shaft whichever is badly worn.

Item	Assembly Standard	Service Limit
Clearance between idler gear and shaft	0.025 to 0.075 [0.0010 to 0.0030]	0.100 [0.0039]

- 2. Replacing idler gear bushing
 - 1) To replace the bushing, use idler gear bushing installer (30691–51900).
 - When installing a replacement bushing, press it into position until its end is flush with the end of the gear boss.
 - 3) After installing the bushing, finish its inside diameter to 36 (1.42) $H7_0^{+0.025} \binom{+0.0098}{0}$ 0.8 Ra.

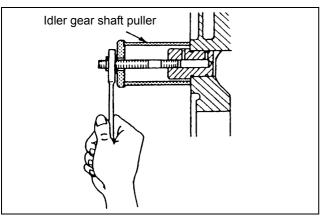


Figure 74 Replacing idler gear shaft

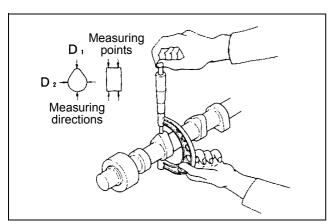
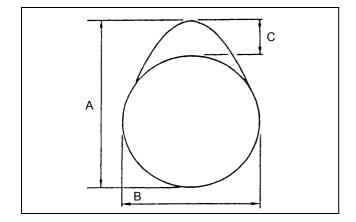


Figure 75 Measuring cam lift



3. Replacing idler gear shaft

To remove the shaft for replacement, use idler gear shaft puller (MH061077).

NOTE

When installing a replacement shaft to the crankcase, make sure the oil hole in the shaft points upward.

9.2.3 Camshaft

1. Checking lobe lift

To fine the lobe lift, use the procedure that follows:

- 1) Measure lobe height (A).
- 2) Measure base circle (B).
- 3) Subtract base circle (B) from lobe height (A). The difference is lobe lift (C). If the lobe lift is less than the service limit, replace the camshaft.

I	ltem	Nominal Value	Assembly Standard	Service Limit
Lobe	Inlet valve	A= 46.916 ^{+0.1} [1.84709] [lobe height]	C= 6.684 [0.2631]	C= 6.184 [0.2435]
lift	Exhaust valve	A= 45.944 ^{+0.1} [1.80882] [lobe height]	C= 7.344 [0.2891]	C= 6.844 [0.2694]

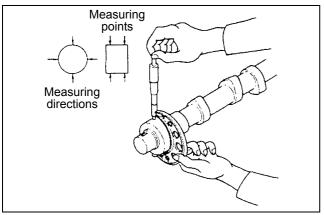


Figure 76 Measuring camshaft journal

2. Checking clearance between camshaft journal and bore in crankcase (or bushing)

Measure the diameter of the camshaft journal and the inside diameter of the bore in the crankcase (or bushing) for camshaft, as shown in the illustration, to check the clearance. If the clearance exceeds the service limit, replace the camshaft.

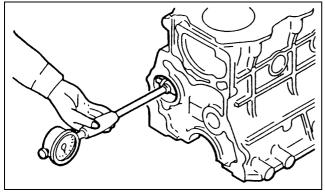


Figure 77 Measuring bore in crankcase (bushing) for camshaft

Item	1	Nominal Value	Assembly Standard	Service Limit
Diameter of	No. 1 and No.2	54 [2.13]	53.94 to 53.96 [2.1236 to 2.1244]	53.90 [2.1220]
camshaft journal	No. 3	53 [2.09]	52.94 to 52.96 [2.0843 to 2.0850]	52.90 [2.0827]
Clearance be camshaft jou and bore in crankcase (or bushing) for camshaft	urnal	ı	0.07 to 0.11 [0.0028 to 0.0043]	0.15 [0.0059]
Inside diameter of bushing	No. 1 (61GT only)	54 [2.13]	54.030 to 54.050 [2.1272 to 2.1280]	_
Inside diameter	No. 1 and No. 2	54 [2.13]	54.030 to 54.050 [2.1272 to 2.1280]	_
of bore for camshaft	No. 3	53 [2.09]	53.030 to 53.050 [2.0878 to 2.0886]	_

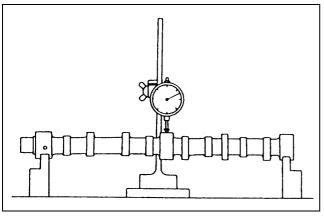


Figure 78 Measuring camshaft deflection

3. Measuring camshaft deflection

If the deflection exceeds the repair limit, straighten the camshaft with a press, or replace it with a new one.

$oldsymbol{\Delta}$ CAUTION

Set up a dial gage on the camshaft, then turn the camshaft. Take one half (1/2) of the gage indication as the deflection.

Unit: mm [in.]

Item	Assembly Standard	Service Limit
Camshaft deflection	0.02 [0.0008] or less	0.05 [0.0020]

4. Removing camshaft gear

To remove the camshaft gear, use a hydraulic press.

NOTE

Do not remove the camshaft, thrust plate or gear unless it requires replacement.

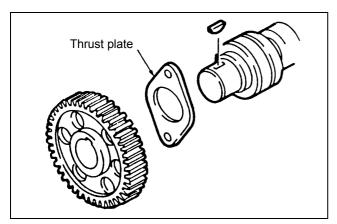


Figure 79 Removing camshaft gear

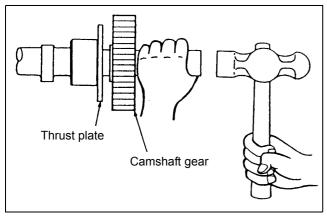


Figure 80 Installing camshaft gear and thrust plate

- 5. Installing camshaft gear and thrust plate
 - Install the key and thrust plate to the camshaft.
 - 2) Heat the gear up to a temperature of 250°C [482°F].
 - 3) Drive the gear onto the camshaft.

NOTE

Install the thrust plate before installing the gear to the camshaft.

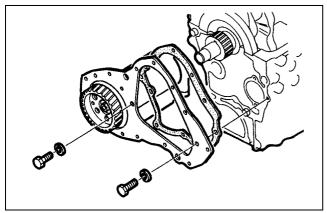


Figure 81 Installing front end plate

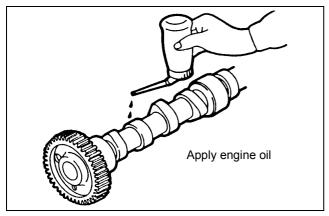


Figure 82 Applying engine oil to camshaft

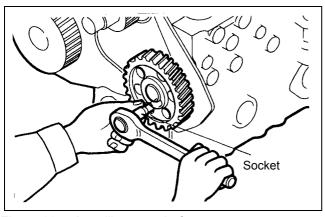


Figure 83 Installing camshaft

9.3 Reassembly

- 1. Installing front end plate
 - Put the front end plate and gasket on the front face of the crankcase. Make sure the locating dowels enter their holes in the plate and gasket.
 - 2) Tighten two bolts to the specified torque.

	12 ± 1 N·m
Tightening torque	(1.2 ± 0.1 kgf·m)
	[9 ± 1 lbf·ft]

- 2. Installing camshaft
 - Apply engine oil to the journals and lobes of the camshaft.

2) Install the camshaft (with gear) in the crankcase.

NOTE

Do not cause damage to the journals and lobes.

3) Tighten the thrust plate bolts to the specified torque with a torque wrench and socket (34491–00300).

Tightening torque	12 ± 1 N·m (1.2 ± 0.1 kgf·m) [9 ± 1 lbf·ft]
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 Make sure the camshaft rotates smoothly.
 Move the camshaft back and forth in the axial direction to make sure it has correct end play.

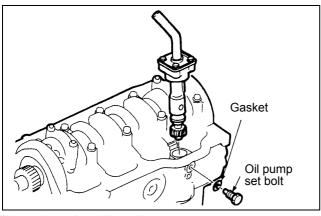


Figure 84 Installing oil pump

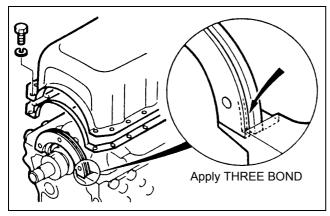


Figure 85 Installing oil pan

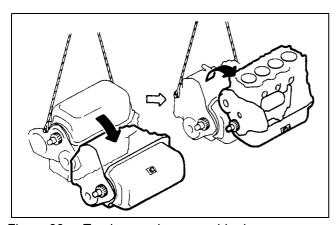


Figure 86 Turning crankcase upside down

3. Installing oil pump

- Install the oil pump in position in the crankcase. Make sure the oil pump gear is meshing with the oil pump drive gear of the camshaft.
- 2) Install the oil pump set bolt with gasket and tighten it to the specified torque.

Tightening torque	34 ± 4 N·m (3.5 ± 0.4 kgf·m)
rigitiening torque	[25 ± 3 lbf·ft]

4. Installing oil pan

- Apply THREE BOND 1207C or 1211, or equivalent, to the seats formed of the crankcase for the No.1 and No.5 main bearing caps just enough to be forced out of the seats when the oil pan gasket is installed.
- 2) Install the oil pan gasket to the bottom of the crankcase by fitting it into the grooves in the main bearing caps and into the seats to which THREE BOND was applied in Step (a), as shown in the illustration.
- 3) Tighten the oil pan bolts to the specified torque.

	7.8 ± 1 N·m
Tightening torque	(0.8 ± 0.1 kgf·m)
	[5.8 ± 1 lbf·ft]

Turn the crankcase upside down for the steps that follow.



To prevent damage to the oil pan, do not place the engine on the floor with the oil pan facing down.

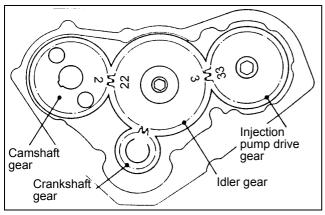


Figure 87 Marks on timing gears

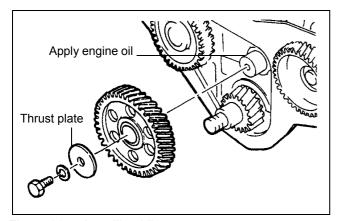


Figure 88 Installing idler gear

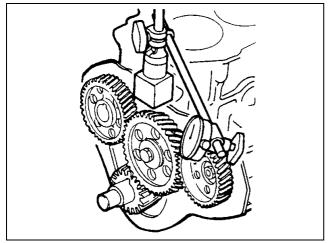


Figure 89 Checking timing gear backlash

6. Installing idler gear

- 1) Apply engine oil to the idler gear shaft.
- 2) Install the idler gear with its marks in alignment with the marks on the injection pump drive gear, camshaft gear and crankshaft gear, as shown in the illustration.

- 3) Put the thrust plate on the idler gear and tighten the bolt with washer to the specified torque.
- 4) Move the idler gear back and forth in the axial direction to make sure it has correct end play.

7. Checking timing gear backlash

After installing the timing gears, check them for backlash, as shown in the illustration.

Item	Assembly Standard	Service Limit
Backlash between crankshaft gear and idler gear	0.05 to 0.15 [0.0020 to	
Backlash between idler gear and camshaft gear	0.0059]	0.25 [0.0098]
Backlash between injection pump drive gear and idler gear	0.04 to 0.16 [0.0016 to 0.0063]	

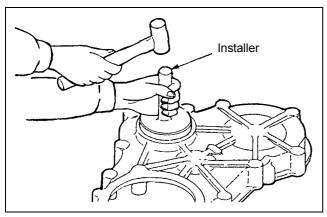


Figure 90 Installing oil seal

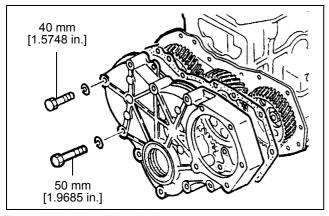


Figure 91 Installing timing gear case

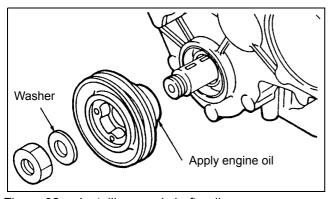


Figure 92 Installing crankshaft pulley

8. Installing oil seal

Using an installer, install a new oil seal to the timing gear case until it is flush with the end face of the case, as shown in the illustration. The lip of the seal must be toward the inside of the gear case.

Installing timing gear case

- Install the oil pump drive gear and idler gear to the timing gear case. Install the cover in position.
- 2) Install the baffle plate to the crankshaft.
- Install the timing gear case and gasket to the front face of the crankcase. Make sure the locating dowels enter their holes in the case and gasket.
- 4) Install the eight long bolts (M8 x 1.25 mm [0.315 x 0.049 in.], 1=50 mm [1.9685 in.]) and one short bolt (M8 x 1.25 mm [0.315 x 0.049 in.], 1=40 mm [1.5748 in.]), and tighten to the specified torque.

Tightening torque	12 ± 1 N·m (1.2 ± 0.1 kgf·m) [9 ± 1 lbf·ft]
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10. Installing crankshaft pulley

- Apply engine oil to the oil seal running surface of the pulley.
- Push the pulley on to the crankshaft in alignment with the keys.
- Install two lock bolts (M12 x 1.25 mm [0.47 x 0.049 in.]) to the rear end of the crankshaft and insert a bar between the bolts to hold the crankshaft.
- 4) Tighten the nut with washer to the specified torque.

$392 \pm 10 \text{ N} \cdot \text{m}$ (40 ± 1 kgf·m) [289 ± 7 lbf·ft]

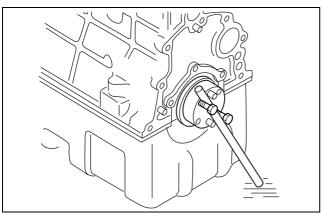


Figure 93 Crankshaft rotation stopper

⚠ CAUTION

To ensure safety, make sure the bar and bolt used to prevent the crankshaft from turning have sufficient strength.

10 PISTONS, CONNECTING RODS, CRANKSHAFT AND CRANKCASE

10.1 Disassembly

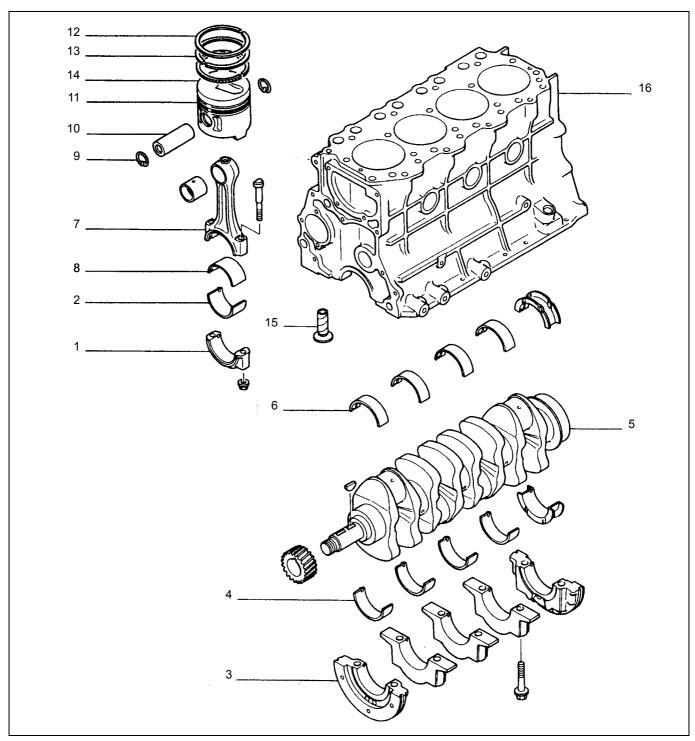


Figure 94 Disassembly sequence

- Connecting rod cap
- 2. Connecting rod bearing (lower half)
- 3. Main bearing cap
- Main bearing (lower half)
- 5. Crankshaft
- Main bearing (upper half)
- Connecting rod
- 7. 8. Connecting rod bearing (upper half)
- 9. Snap ring
- 10. Piston pin
- 11. Piston
- 12. No.1 ring
- 13. No.2 ring
- 14. Oil ring
- 15. Tappet
- 16. Crankcase

NOTE

When replacing the crankcase, carefully remove the parts (such as the relief valve, etc.) from the crankcase to reuse them at the time of reassembly.

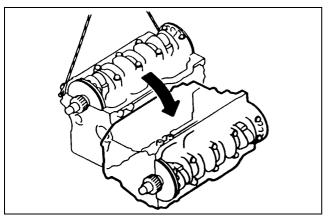


Figure 95 Laying crankcase on its side

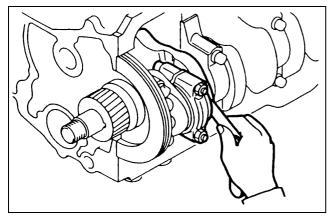


Figure 96 Checking thrust clearance of connecting rod big-end

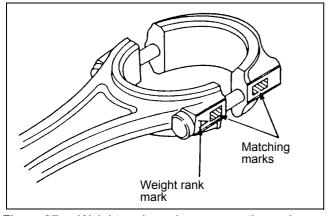


Figure 97 Weight rank mark on connecting rod

- 1. Laying crankcase on its side
 - Carefully lay the crankcase on its side.

- Checking thrust clearance of connecting rod bigend
 - 1) Check the clearance between the connecting rod big-end and the crankpin with a feeler gage, as shown in the illustration.
 - 2) If the thrust clearance exceeds the service limit, replace the connecting rod.

Unit: mm [in.]

Item	Assembly Standard	Service Limit
Thrust clearance of connecting rod big-end (End play)	0.15 to 0.35 [0.0059 to 0.0138]	0.50 [0.0197]

3. Maximum permissible difference between average weight of all connecting rod assemblies in one engine

When replacing the connecting rods, select new connecting rods having the same weight rank marks so that the difference between average weight of all connecting rod assemblies in one engine does not exceeds the maximum permissible limit.

Maximum permissible difference between average weight of all connecting rod assemblies in one engine	10 g [0.35 oz]
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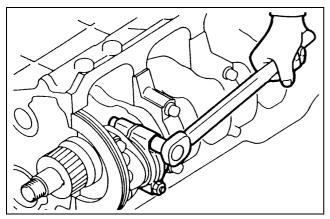


Figure 98 Removing connecting rod caps

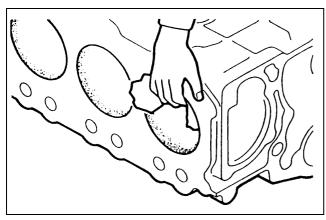


Figure 99 Removing carbon from cylinders

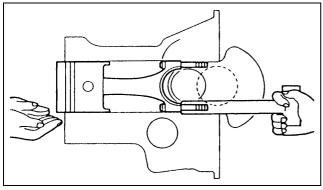


Figure 100 Removing piston and connecting rod

4. Removing connecting rod caps

- Put a mark on each cap so it can be installed in the same position from which it was removed.
- 2) Remove the caps and the lower halves of the connecting rod bearings.
- Put a mark on each connecting rod bearing (lower half) so it can be installed in the same position from which it was removed.

NOTE

Be careful not to cause damage to the bearings. Arrange the removed bearings in a proper order so that they can be reinstalled in their original positions during reassembly.

5. Removing carbon from cylinders

Use a cloth or sandpaper to remove all carbon deposits from the upper areas of the cylinder liner. If any carbon deposits are present, this will make it difficult to pull a piston upward.

6. Removing piston and connecting rod

- Turn the crankshaft to bring the piston to the top dead center.
- 2) Push the piston and connecting rod away from the crankshaft with the handle of a hammer until the piston rings are above the cylinder. Then remove the piston and connecting rod from the crankcase.

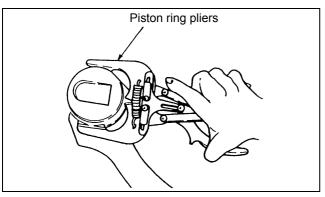


Figure 101 Removing piston rings

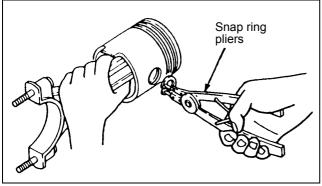


Figure 102 Removing piston pins

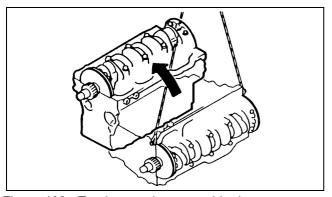


Figure 103 Turning crankcase upside down

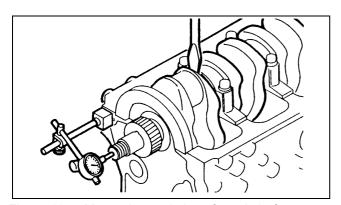


Figure 104 Measuring end play of crankshaft

7. Removing piston rings

Remove the piston rings with piston ring pliers (31391–12900).

8. Removing piston pins

Using ring pliers, remove the snap rings. Remove the piston pin to separate the piston from the connecting rod.

If it is difficult to pull out the pin, heat the piston with a piston heater or in hot water to expand the pin bore.

9. Turning crankcase upside down

Turn the crankcase upside down with the oil pan side up.

10. Measuring end play of crankshaft

- With a dial indicator at the end of the crankshaft, check the end play, as shown in the illustration.
- 2) If the end play exceeds the service limit, replace the thrust bearing.

Item	Assembly Standard	Service Limit
End play of crankshaft	0.10 to 0.20 [0.0039 to 0.0080]	0.30 [0.0118]

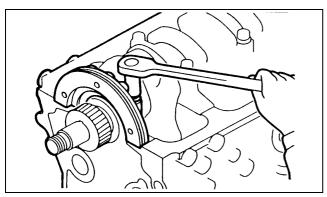


Figure 105 Removing main bearing caps

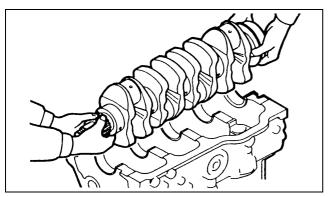


Figure 106 Removing crankshaft

11. Removing main bearing caps

Remove the main bearing caps with lower halves of the main bearings.

NOTE

Be careful not to cause damage to the main bearings. Put a mark on each bearing cap so it can be installed in the same position from which it was removed.

12. Removing crankshaft

Carefully remove the crankshaft.

NOTE

Be careful not to cause damage to the main journals and crankpins. Put a mark on each bearing.

13. Orderly arrangement of bearings

If bearings scatter during disassembly, they cannot be reinstalled in their original positions. Be sure to arrange the removed bearings in a proper order so that they can be reinstalled in their original positions.

10.2 Inspection

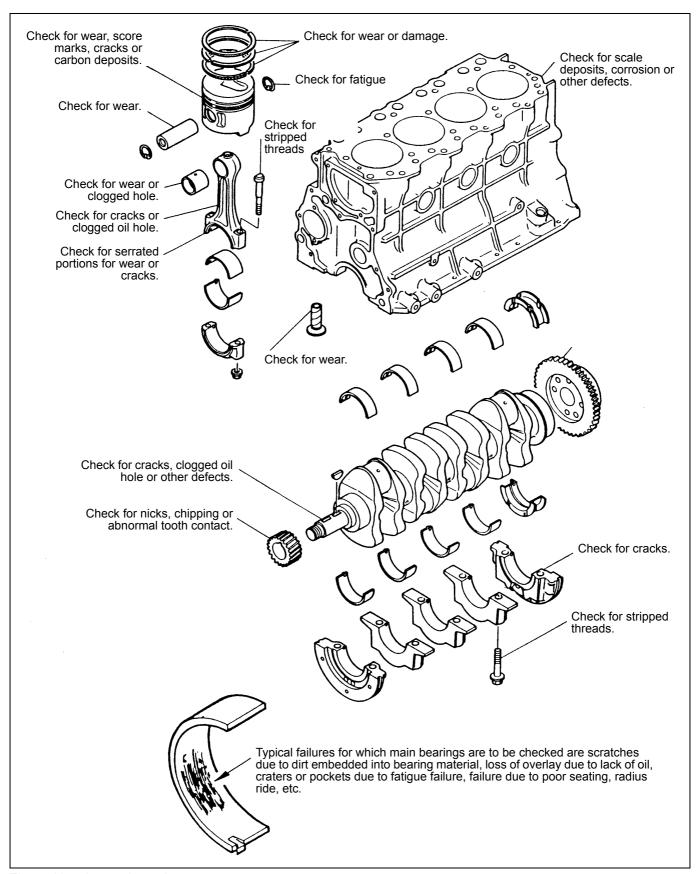


Figure 107 Inspection points

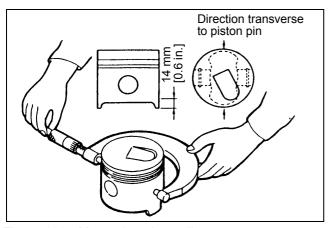


Figure 108 Measuring piston diameter

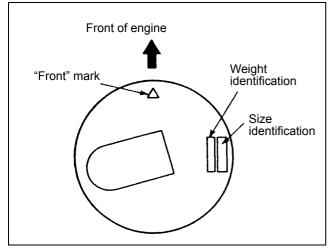


Figure 109 Identification on top of piston

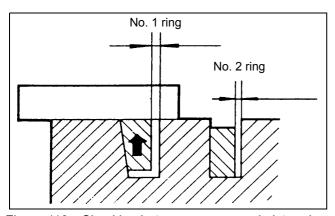


Figure 110 Checking between groove and piston ring

10.2.1 Pistons, piston rings and piston pins

- 1. Measuring piston diameter
 - Using a micrometer, measure the diameter of each piston perpendicular to the piston pin (at the position shown). If the diameter exceeds the service limit, replace the piston. If any pistons have to be replaced, select new pistons so the weight difference in an engine is within assembly standards.

Unit: mm [in.]

	Item	Nominal Value	Assembly Standard	Service Limit
J.	Standard 87.970 [3.4634]		87.955 to 87.985 [3.4628 to 3.4640]	87.770 [3.4555]
Piston diameter	0.25 [0.0098] oversize	88.220 [3.4732]	88.205 to 88.235 [3.4726 to 3.4738]	88.020 [3.4654]
<u>a</u>	0.50 [0.0197] oversize	88.470 [3.4831]	88.455 to 88.485 [3.4825 to 3.4837	88.270 [3.4752]
	Weight difference in one engine		5 g [0.2 oz] or less	_

- 2) The weight of the piston is stamped on the top of the piston.
- 2. Checking piston and piston ring
 - Check the clearance between the groove and the piston ring with a feeler gage, as shown in the illustration. If the clearance exceeds the service limit, replace the piston ring.

Item		Assembly Standard	Service Limit
Clearance	No. 1	0.060 to 0.100	0.200
	ring	[0.0024 to 0.0039]	[0.0079]
between	No.2	0.045 to 0.080	0.150
groove and	ring	[0.0018 to 0.0032]	
piston ring	Oil ring	0.025 to 0.065 [0.0010 to 0.0026]	[0.0059]

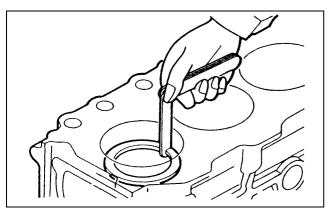


Figure 111 Checking clearance between ends of piston ring

- Install a new piston rings and recheck the clearance. If the clearance still exceeds the service limit, replace the piston.
- 3. Checking clearance between ends of piston ring

Install the piston ring in a new cylinder or a gage and measure the clearance between the ends of the ring with a feeler gage. If the clearance exceeds the service limit, replace all piston rings.

Inside diameters of gages

Standard gage:

$$88_0^{+0.035}$$
 mm [3.46₀^{+0.0014} in.]

0.25 mm (0.0098 in.) oversize gage:

$$88.25_0^{+0.035}$$
 mm [3.4744 $_0^{+0.0014}$ in.]

0.50 mm [0.0197 in.] oversize gage:

$$88.50_0^{+0.035}$$
 mm [3.4843 $_0^{+0.0014}$ in.]

NOTE

Use a piston to place the piston ring in the liner by pushing it squarely.

Unit: mm [in.]

Item		Assembly Standard	Service Limit
Clearance between	No. 1, No. 2 ring	0.25 to 0.40 [0.00984 to 0.0157]	0.150
ends of piston ring	Oil ring	0.30 to 0.50 [0.0118 to 0.0197]	[0.0059]

4. Checking clearance between piston pin and bore

Measure the inside diameter of the pin bore of the piston and the diameter of the pin, as shown in the illustration, to check the clearance. If the clearance exceeds the service limit, replace the parts.

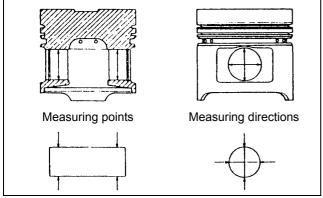


Figure 112 Measuring piston pin and bore

Unit: mm [in.]

Item	Nominal Value	Assembly Standard	Service Limit
Diameter of piston pin	28 [1.10]	27.994 to 28.0000 [1.1021 to 1.1024]	
Clearance between piston pin and bore	_	0.000 to 0.016 [0.0000 to 0.0006]	0.050 [0.0020]

Checking clearance between connecting rod bushing and piston pin

Measure the inside diameter of the connecting rod bushing bore and the diameter of the piston pin, as shown in the illustration, to check the clearance. If the clearance exceeds the service limit, replace the parts.

Item	Nominal Value	Assembly Standard	Service Limit
Inside diameter of bushing	28 [1.10]	28.020 to 28.045 [1.1031 to 1.1041]	
Clearance between bushing and piston pin	_	0.020 to 0.051 [0.0008 to 0.0020]	0.080 [0.0032]



- 1) Use a connecting rod bushing puller to replace the connecting rod bushings.
- 2) When installing a new bushing, align the oil holes in the bushing and connecting rod. Position the ends of the bushing at the location shown in the illustration.
- 3) After installing the bushing, insert the piston pin into position and make sure it rotates smoothly.

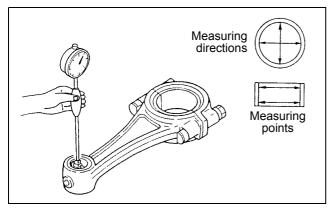


Figure 113 Measuring connecting rod bushing

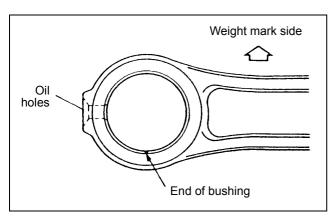


Figure 114 Installing connecting rod bushing

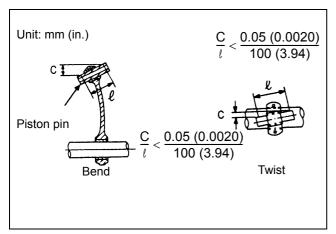


Figure 115 Inspecting connecting rod

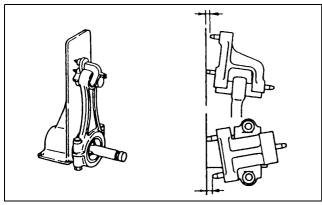


Figure 116 Checking connecting rod with a connecting rod aligner

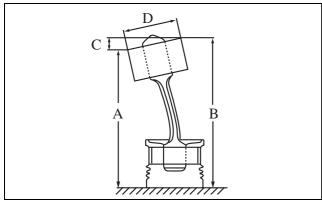


Figure 117 Checking connecting rod with a dial indicator

10.2.2 Connecting rods

1. Measure "C" and " ℓ ". If the measurement at C is larger than 0.05 mm [0.0020 in.] per 100 mm [3.94 in.] of ℓ , straighten the rod with a press.

Unit: mm (in.)

Item	Nominal Value	Assembly Standard
Connecting rod bend and twist	0.05/100 [0.0020/3.94] or less	0.15/100 [0.059/3.94]

2. A connecting rod aligner is generally used for checking the connecting rod for twist and bend.

NOTE

To check the connecting rod for bend, install the cap to the rod and tighten the cap nuts to the specified torque.

 When the measurement is taken with the piston installed to the connecting rod, place the piston upside down on a surface plate, insert a round bar having the same diameter as the crank pin, and measure the height of the round bar using a dial gage.

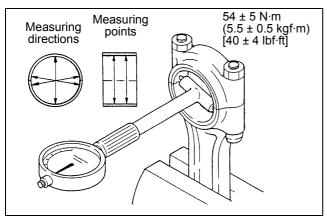


Figure 118 Measuring connecting rod bearing

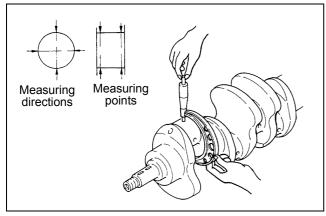


Figure 119 Measuring crankpin

10.2.3 Crankshaft

- 1. Checking oil clearance of connecting rod bearing
 - Install the upper and lower halves of the bearing and the cap to the connecting rod, and tighten the cap nuts to the specified torque. Measure the inside diameter of the bearing, as shown in the illustration.

	54 ± 5 N·m
Tightening torque	(5.5 ± 0.5 kgf·m)
	[40 ± 4 lbf·ft]

2) Measure the diameter of the crankpin of the crankshaft, as shown in the illustration, and subtract the diameter of the crankpin from the inside diameter of the bearing (Step (1)). The difference is the oil clearance of the connecting rod bearing.

Unit: mm [in.]

Item	Nominal Value	Assembly Standard	Repair Limit
Diameter of crankpin (standard)	58 [2.28]	57.955 to 57.970 [2.2817 to 2.2823]	
Oil clearance	_	0.03 to 0.09 [0.0012 to 0.0035]	0.20 [0.0079]

- If the oil clearance exceeds the repair limit, replace the bearing and recheck the oil clearance.
- 4) If the oil clearance still exceeds the repair limit, use 0.25 mm [0.0098 in.], 0.50 mm [0.0197 in.] or 0.75 mm [0.0295 in.] undersize bearings. When using undersize bearings, refinish the crankpins to any of the undersizes listed below.

		Finishing dimension
Undersize of crankpin	0.25 [0.0098]	57.75 ^{-0.030} _{-0.045} [2.2736 ^{-0.0012} _{-0.0018}]
	0.50 [0.0197]	57.50 ^{-0.030} _{-0.045} [2.2638 ^{-0.0012} _{-0.0018}]
	0.75 [0.0295]	57.25 ^{-0.030} _{-0.045} [2.2539 ^{-0.0012} _{-0.0018}]

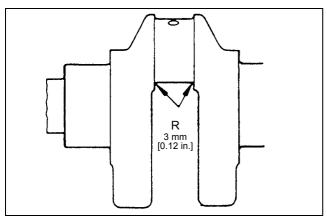


Figure 120 Fillet radius

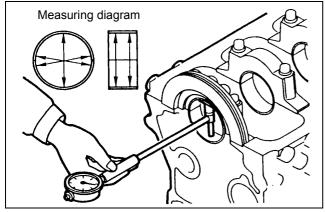


Figure 121 Measuring main bearing

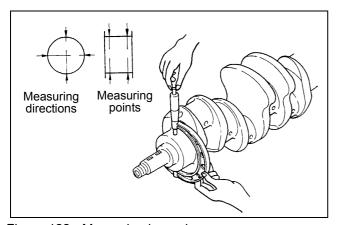


Figure 122 Measuring journal

NOTE

- a Grind all crankpins to the same undersize.
- b Finish the fillet radius to 3 mm [0.12 in.]

- 2. Checking oil clearance of main bearing
 - Install the upper and lower halves of the bearing and the cap to the crankcase, and tighten the cap nuts to the specified torque. Measure the inside diameter of the bearing, as shown in the illustration.

	83 ± 5 N·m
Tightening torque	(8.5 ± 0.5 kgf·m)
	[61 ± 4 lbf·ft]

2) Measure the diameter of the journal of the crankshaft, as shown in the illustration, and subtract the diameter of the journal from the inside diameter of the bearing (Step (1)). The difference is the oil clearance of the main bearing.

Item	Nominal Value	Assembly Standard	Repair Limit
Diameter of journal (standard)	65 [2.56]	64.965 to 64.985 [2.5577 to 2.5585]	_
Oil clearance	_	0.035 to 0.100 [0.0014 to 0.0039]	0.200 [0.0079]

- If the oil clearance exceeds the repair limit, replace the bearing and recheck the oil clearance.
- 4) If the oil clearance still exceeds the repair limit, use 0.25 mm [0.0098 in.], 0.50 mm [0.0197 in.] or 0.75 mm [0.0295 in.] undersize bearings. When using undersize bearings,

refinish the journals to any of the undersizes listed below.

Unit: mm [in.]

		Finishing dimension
Undersize of journal	0.25 [0.0098]	64.75 ^{-0.015} _{-0.035} [2.5492 ^{-0.0006} _{-0.0014}]
	0.50 [0.0197]	64.50 ^{-0.015} _{-0.035} [2.5394 ^{-0.0006} _{-0.0014}]
	0.75 [0.0295]	64.25 ^{-0.015} _{-0.035} [2.5295 ^{-0.0006} _{-0.0014}]

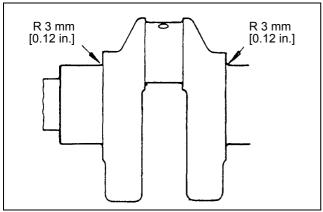


Figure 123 Fillet radius

Flywheel housing Oil seal running surface Oil seal sleeve

Figure 124 Checking oil seal running surface

NOTE

- a Grind all crankpins to the same undersize.
- b Finish the fillet radius to 3 mm [0.12 in.]

3. Checking oil seal running surface

Check the oil seal sleeve running surface of the crankshaft rear-end. If the sleeve is badly worn by the oil seal, replace the oil seal sleeve.

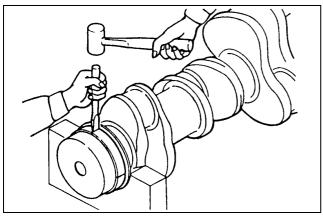


Figure 125 Removing oil seal sleeve

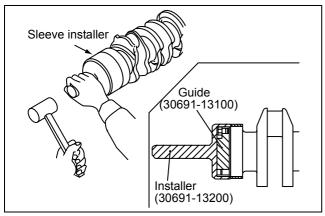


Figure 126 Installing oil seal sleeve

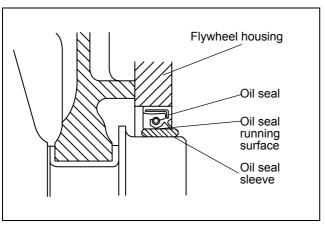


Figure 127 Checking oil seal running surface

1) Removing oil seal sleeve

Hold a flat cold chisel at right angles to the sleeve and cut the sleeve at three places to loosen it, as shown in the illustration. If it is impossible to remove the sleeve in this method, hold the chisel in the axial direction and lightly tap the sleeve to loosen it.

△ CAUTION

Be extra careful not to cause damage to the crankshaft when removing the sleeve.

2) Installing oil seal sleeve

Apply oil to the inside of an oil seal sleeve and, using crankshaft sleeve installer set (30691–13010), install the sleeve in position, as shown in the illustration.

$oldsymbol{\Delta}$ CAUTION

Be extra careful not to cause damage to the sleeve when installing it.

When the oil seal sleeve is worn after the engine has been operated, replace both oil seal and oil seal sleeve.

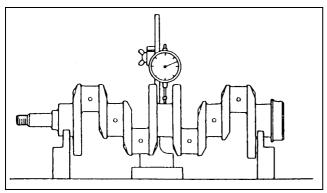


Figure 128 Checking crankshaft deflection

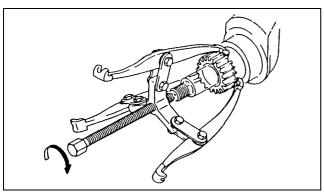


Figure 129 Removing crankshaft gear

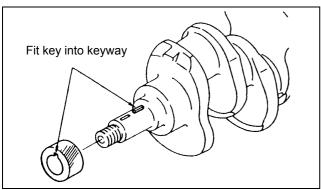


Figure 130 Installing crankshaft gear

4. Checking crankshaft deflection

Support the crankshaft on its front and rear journals in V-blocks. With the dial indicator set at 0.00 mm [0.0000 in.] at the center journal, turn the camshaft full one revolution and read the indicator, as shown in the illustration. If deflection is out of the assembly standard but does not exceed the repair limit, repair the crankshaft by grinding. If deflection exceeds the repair limit, repair the crankshaft by cold working. Replace the crankshaft if runout exceeds the repair limit excessively.

Unit: mm [in.]

Item	Assembly Standard	Repair Limit
Crankshaft deflection	0.02 [0.0008] or less	0.05 [0.0020]

5. Removing crankshaft gear

Remove the crankshaft gear with a gear puller, as shown in the illustration.

NOTE

Do not remove the gear unless it requires replacement.

6. Installing crankshaft gear

- 1) Heat the gear in an oven to a temperature of 100°C to 150°C [212°F to 302°F].
- 2) Install the key to the crankshaft.
- 3) Install the gear by fitting the key into the keyway in the gear.

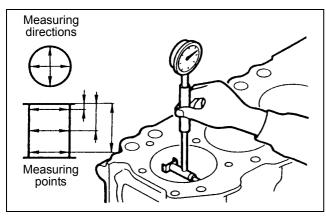


Figure 131 Checking crankcase bore

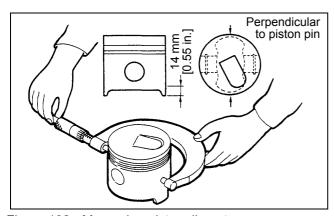


Figure 132 Measuring piston diameter

10.2.4 Crankcase

- 1. Checking crankcase bore
 - Measure the entire bore with a cylinder bore gage having a dial indicator. Take measurements at A, B and C positions in the bore on axes 90° apart, as shown in the illustration, to check the diameter, out-ofround and taper. If the bores exceeds the service limit for diameter, out-of-round and taper, increase them for oversize pistons.

Unit: mm [in.]

Piston available		Bore Diameter	
Size	Size Code	Assembly Standard	Service Limit
Standard	STD	88 ₀ ^{+0.035} [3.46 ₀ ^{+0.0014}]	
0.25 [0.0098] oversize	25	88.25 ^{+0.035} ₀ [3.4744 ^{+0.0014} ₀]	+0.2 [+0.008]
0.50 [0.0197] oversize	50	88.50 ^{+0.035} ₀ [3.4842 ^{+0.0014} ₀]	
Out-of-rou taper of bo		0.015 [0.0006] or less	_

- 2) Boring of cylinders
- a There are two piston oversizes (0.25 mm [0.0098 in.] and 0.50 mm [0.0197 in.] over standard size) as listed above. Determine the piston size to be used based on the largest bore diameter of the cylinders.
- b Measure the outside diameter of the piston to be used.
- c Based on the measurement of the piston outside diameter, calculate the finishing dimension to be achieved by boring.
 - A : Measured piston outside diameter selected oversized piston) mm
 - B : Clearance between piston and cylinder (standard value) 0.03 mm [0.0012 in.]
 - C : Honing allowance 0.04 mm [0.0016 in.] or less

Finishing dimension = A + B - C

d Bore the cylinders to the calculated dimension.

CAUTION

Before the cylinders in the order of the cylinder numbers to prevent distortion due to the heat generated by the boring operation.

- Hone the cylinders to the final dimension (piston outside diameter + cylinder clearance).
- Checking crankcase top face

Check the top face for warpage, using an accurate straight edge and a feeler gage, in three positions lengthwise, two crosswise and two widthwise, as shown in the illustration. If warpage exceeds the repair limit, grind the crankcase.

Unit: mm [in.]

Item	Assembly Standard	Repair Limit
Warpage of crankcase top face	0.05 [0.0020] or less	0.20 [0.0079]



NOTE

The maximum limit of stock to be removed from the crankcase and cylinder head for grinding is 0.2 mm [0.0079 in.] in all.

10.2.5 Tappets

Checking for wear

Check the cam contact face of each tappet for wear. Replace badly worn tappets if any.

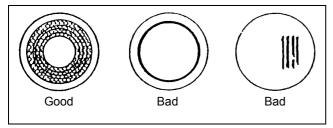


Figure 134 Cam contact face of tappet

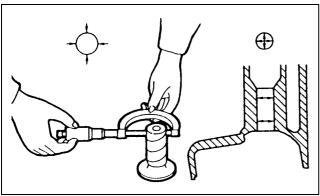


Figure 135 Checking clearance between tappet and bore

2. Checking clearance between tappet and bore

Measure the diameter of the tappet and the inside diameter of the bore in the crankcase for the tappet, as shown in the illustration, to check the clearance. If the clearance exceeds the service limit, replace the tappets.

Unit: mm [in.]

Item	Nominal Value	Assembly Standard	Repair Limit
Inside diameter of bore for tappet	14 [0.55]	14.000 to 14.018 [0.5512 to 0.5519]	14.100 [0.5551]
Clearance between tappet and bore	_	0.016 to 0.052 [0.0006 to 0.0021]	0.080 [0.0032]

NOTE

If the bores are worn beyond the service limit, replace the crankcase.

10.3 Reassembly

- 1. Installing tappet
 - 1) Apply engine oil to the tappets and install them in the bores in the crankcase.
 - 2) Make sure the tappets rotate smoothly.

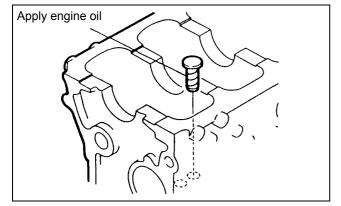


Figure 136 Installing tappet

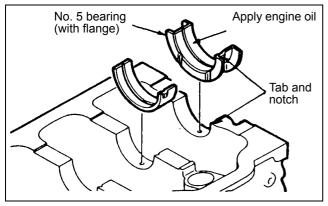


Figure 137 Installing main bearings

2. Installing main bearings

 Install the lower halves of the main bearings in the main bearing caps. Install the upper halves of the main bearings in the crankcase.

NOTE

- a Make sure the upper and lower halves of the main bearings are installed so the bearing tabs fit into the notch in the crankcase and main bearing caps.
- b Only the upper halves of the main bearings to be installed in the crankcases has an oil groove.

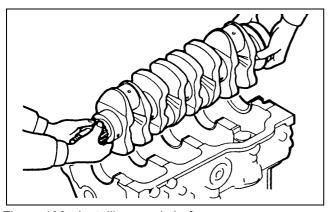


Figure 138 Installing crankshaft

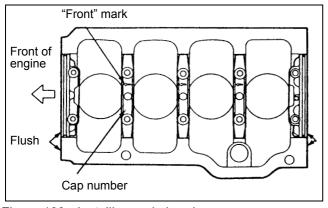


Figure 139 Installing main bearing caps

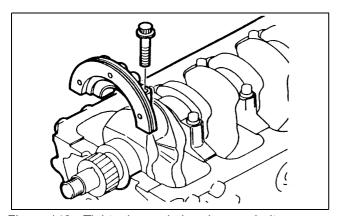


Figure 140 Tightening main bearing cap bolts

Install the upper and lower halves of the main bearing having flanges in the crankcase and main bearing cap for No.5 journal of the crankshaft.

3) Lightly coat the inside surface of the shells with engine oil.

3. Installing crankshaft

- Wash the crankshaft with cleaning solvent and blow dry with compressed air. Make sure all oil holes in the crankshaft are clean. Check the oil holes for condition.
- Hold the crankshaft in a horizontal position by using a hoist, and carefully put it in the crankcase.
- 3) Lightly coat the journals with engine oil.

4. Installing main bearing caps

Install the main bearing caps in position so the "front" mark (arrow) on the cap is toward the front of the engine and the number on the cap is the same as the number on the crankcase on the left side of each main bearing cap.

NOTE

The end faces of No.1 and No.5 bearing caps must be flush with the end faces of the crankcase.

5. Tightening main bearing cap bolts

Tighten the main bearing cap bolts evenly to the specified torque.

	83 ± 5 N·m
Tightening torque	(8.5 ± 0.5 kgf·m)
	[61 ± 4 lbf·ft]

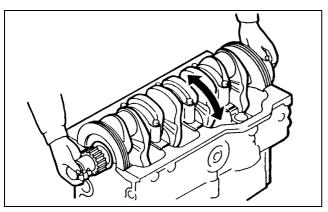


Figure 141 Checking crankshaft for rotation

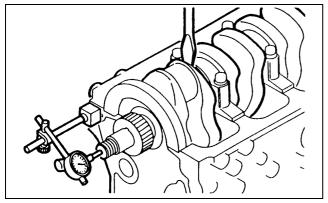


Figure 142 Measuring crankshaft end play

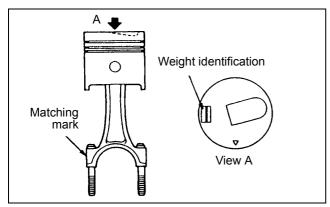


Figure 143 Reassembling piston (1)

6. Checking crankshaft for rotation

Make sure the crankshaft rotates smoothly.

- 7. Measuring crankshaft end play
 - Check the crankshaft end play with a dial indicator, as shown in the illustration.

Unit: mm [in.]

Item	Assembly Standard	Repair Limit
End play of crankshaft	0.10 to 0.20 [0.0039 to 0.0080]	0.30 [0.0020]

- If the end play is less than the assembly standard, retighten the main bearing cap bolts.
- 3) If it exceeds the service limit, replace the flanged bearings.
- 8. Reassembling piston and connecting rod
 - 1) Put the connecting rod in position in the piston with the matching mark of the rod on the same side as the weight identification on the top of the piston.
 - Apply engine oil to the piston pin and install it in position.

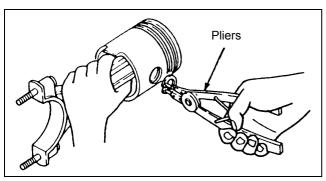


Figure 144 Reassembling piston (2)

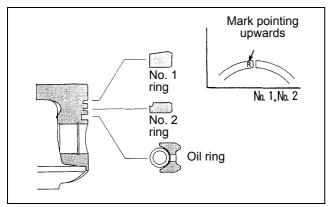


Figure 145 Piston and piston rings

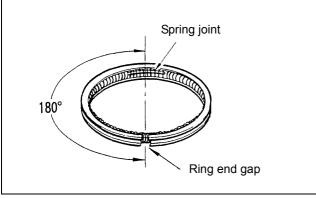


Figure 146 Oil ring end gap and spring joint

3) Install the snap rings in the grooves in the piston with a pliers. Make sure the snap rings fit in the grooves properly.

NOTE

The snap ring ends must be toward the bottom of the piston.

9. Installing piston rings

Using piston ring pliers (31391–12900), install the compression (No.1 and No.2) rings and oil ring on the piston with the mark "R" toward the top of the piston.

NOTE

The oil ring must be installed on the piston with the ring end gap 180° from the coil spring joint.

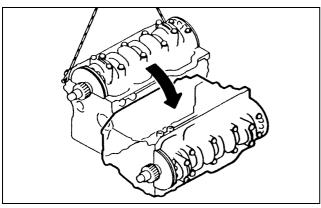


Figure 147 Laying crankcase on its side

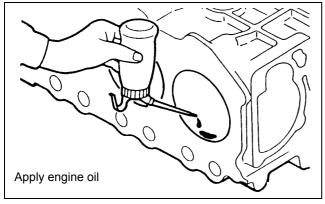


Figure 148 Apply engine oil to bores

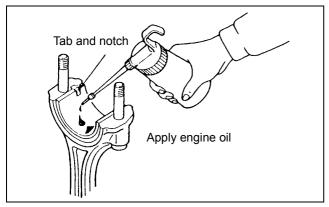


Figure 149 Installing connecting rod bearing

10. Laying crankcase on its side

Lay the crankcase on its side.

11. Apply engine oil to bores

Clean the bores with a clean rag and apply engine oil to the bores.

12. Installing connecting rod bearing

- Install the connecting rod cap bolts in the bigend of the connecting rod so the flats of their heads fit on the connecting rod properly.
- Install the tipper half of the connecting rod bearing in the big-end of the connecting rod. Make sure the tab on the back of the bearing is in the notch of the connecting rod.

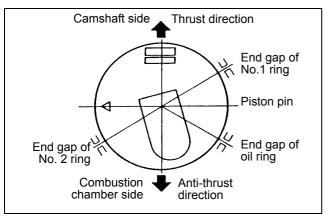


Figure 150 Installing piston assembly (1)

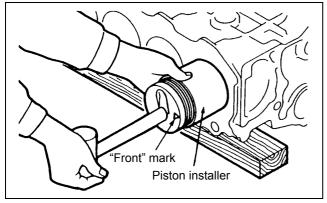


Figure 151 Installing piston assembly (2)

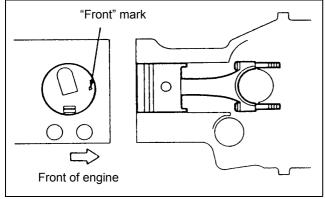


Figure 152 Installing piston assembly (3)

13. Installing piston assembly

- 1) Apply engine oil to the piston rings.
- 2) Make sure the piston ring end gaps are arranged on the piston, as shown in the illustration.

- 3) Turn the crankshaft to bring the No.1 (or No. 4) crankpin to the top center.
- 4) Put piston installer (30691–58100) on the top of the crankcase in alignment with the bore center. Hold the installer in position by one hand.
- 5) Put the piston assembly in the crankcase through the installer. Make sure the "front" mark on the top of the piston is toward the front of the engine.

NOTE

Make sure the big-end of the connecting rod fits on the crankpin properly.

6) Lightly tap the top of the piston with the handle of a hammer to put the big-end of the connecting rod on the crankpin.



Be careful not to cause damage to the crankpin when putting the connecting rod on the crankpin.

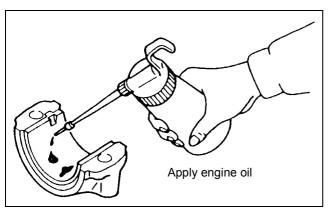


Figure 153 Installing connecting rod cap (1)

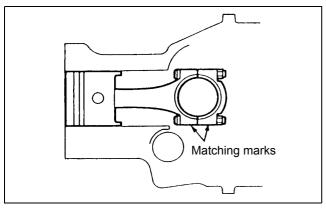


Figure 154 Installing connecting rod cap (2)

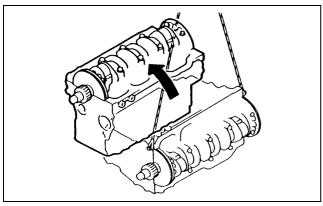


Figure 155 Raising crankcase

14. Installing connecting rod cap

- Install the lower half of the connecting rod bearing in the connecting rod cap. Make sure the tab on the back of the bearing is in the notch of the connecting rod cap. Apply engine oil to the inside of the bearing.
- 2) Install the connecting rod cap (with the bearing) to the connecting rod (over the crankpin) with the matching mark of the cap on the same side as the mark of the rod.
- 3) Tighten the connecting rod cap nuts finger tight.

NOTE

Steps (a) through (c) are for the installation of the piston assemblies in the No.1 and No.4 cylinders. Turn the crankshaft 180° and install the piston assemblies in the No.2 and No.3 cylinders.

4) Tighten the connecting rod cap nuts evenly to the specified torque with a torque wrench.

	54 ± 5 N⋅m
Tightening torque	(5.5 ± 0.5 kgf·m)
	[40 ± 4 lbf·ft]

 Check the thrust clearance of the connecting rod big-end. If the thrust clearance is less than the assembly standard, retighten the cap nuts.

15. Raising crankcase

Raise up the crankcase with the oil pan side up.

Make sure the crankshaft rotates smoothly.

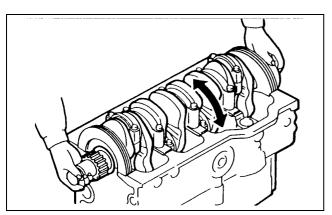
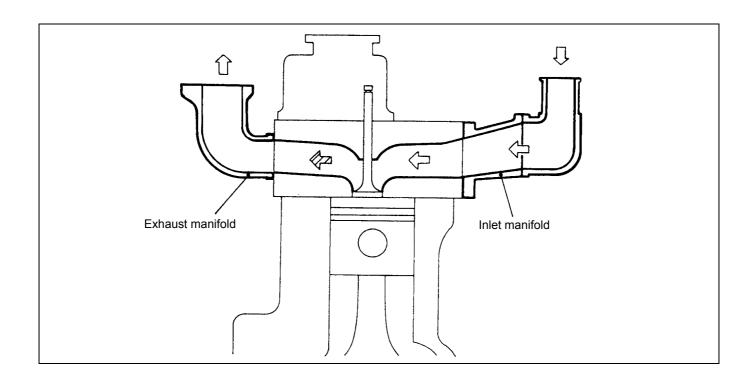


Figure 156 Checking crankshaft rotation

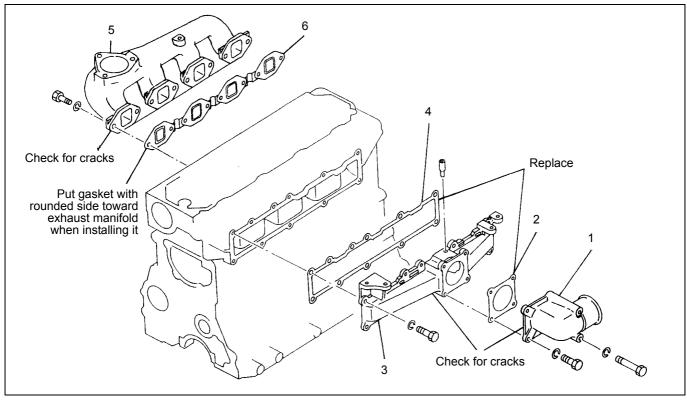
16. Checking crankshaft rotation

INLET AND EXHAUST SYSTEM

11 DESCRIPTION



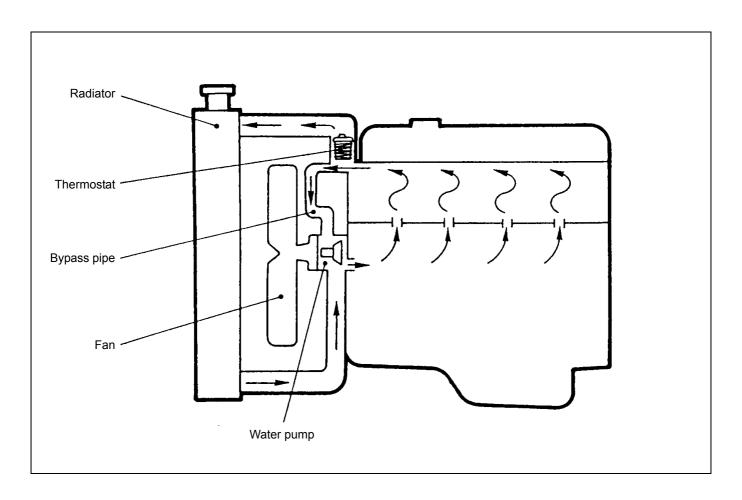
12 DISASSEMBLY, INSPECTION AND REASSEMBLY



- 1. Air inlet elbow
- 2. Gasket
- 3. Inlet manifold
- 4. Gasket
- 5. Exhaust manifold
- Gasket

COOLING SYSTEM

13 DESCRIPTION



14 WATER PUMP, FAN

14.1 Inspection

Visually check the water pump and replace it as an assembly if any defect is found.

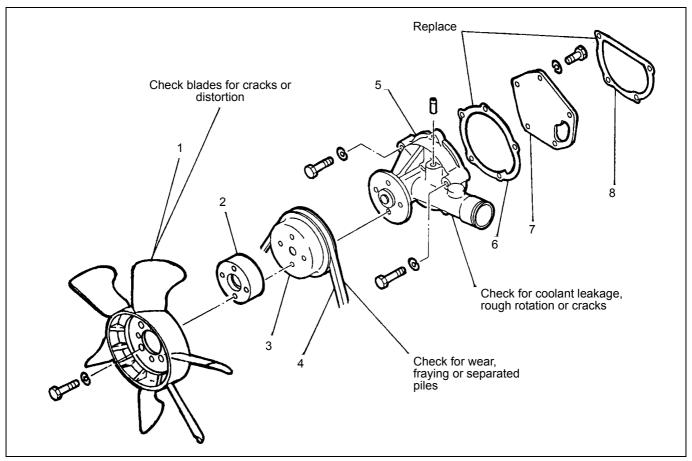


Figure 157 Disassembly sequence

- 1. Fan
- Spacer
- 3. Pulley
- 4. V-belt
- 5. Water Pump assembly
- 6. Gasket
- 7. Plate
- 8. Gasket

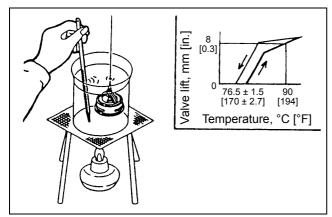


Figure 158 Testing thermostat

15 **THERMOSTAT**

15.1 Inspection

Put each thermostat in a glass jar filled with water, and test it for thermostatic action by heating the jar to raise the water temperature. In the test, measure the temperature at which the valve starts opening and that at which the valve lift is more than 8 mm [0.3 in.]. If these measurement are out of the assembly standard, replace the thermostat.

Unit: mm [in.]

Item	Assembly Standard
Temperature at which valve starts opening	76.5 ± 1.5°C [170 ± 2.7°F]
Temperature at which valve lift exceeds 8 mm [0.3 in.]	90°C [194°F]



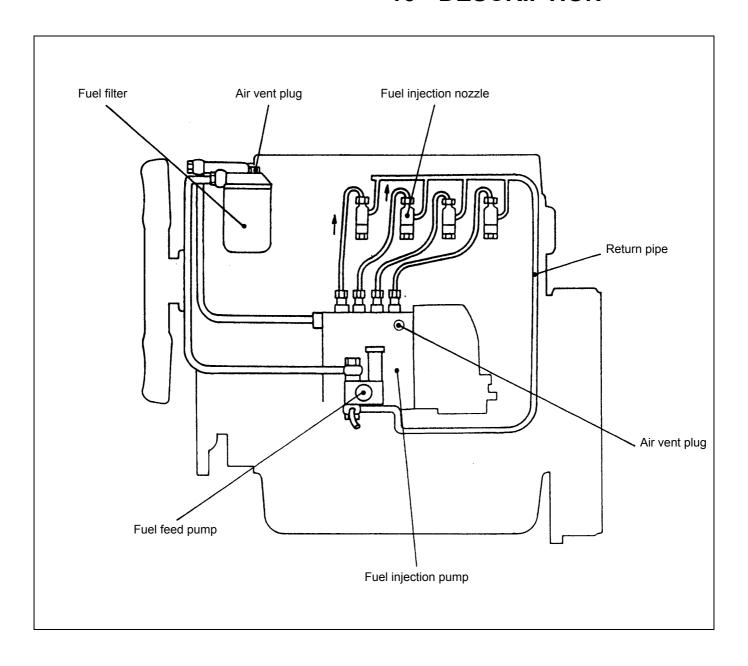
⚠ CAUTION

- Stir up the water with a stick to keep the temperature uniform.
- Install the thermostat with its air vent hole up.

FUEL SYSTEM

DESCRIPTION FUEL SYSTEM

16 DESCRIPTION



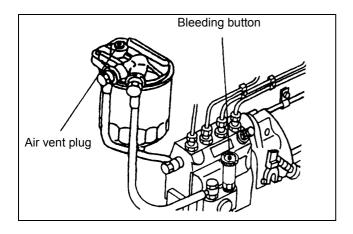
17 FUEL SYSTEM BLEEDING

1. Fuel filter

- 1) Loosen air vent plug on the fuel filter (by turning it 1.5 turns).
- 2) Unlock bleeding pump plunger by turning it to the left, and operate the pump.
- 3) Tighten the air vent plug when the fuel flows free of bubbles.

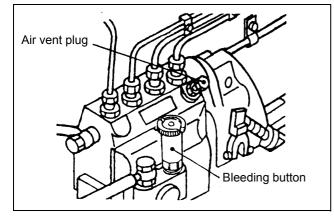
2. Fuel injection pump

- 1) Loosen air vent plug on the injection pump (by turning it 1.5 turns).
- 2) Unlock bleeding pump plunger by turning it to the left, and operate the pump.
- 3) Tighten the air vent plug when the fuel flows free of bubbles.



NOTE

- a If the vent plug is tightened before the bleeding pump plunger is locked, fuel pressure acts on the feed pump, making it difficult to restore the plunger.
- b Clean up fuel spillage.



DISASSEMBLY FUEL SYSTEM

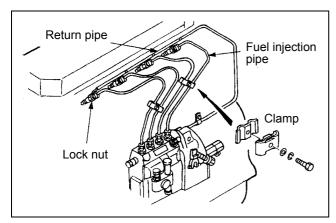


Figure 159 Disconnecting fuel pipes

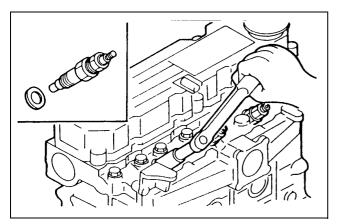


Figure 160 Removing fuel injection nozzles

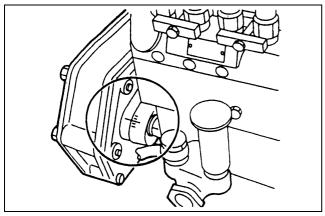


Figure 161 Removing fuel injection pump (1)

18 DISASSEMBLY

1. Disconnecting fuel pipes

Remove the pipe clamp from the injection pipes. Disconnect the injection pipes at the injection pump and at the injection nozzles. Disconnect the leak-off pipes from the nozzles by loosening the lock nuts.

$oldsymbol{\Delta}$ CAUTION

Put protection caps on the pump and nozzles to keep dirt and foreign material out of the fuel system.

2. Removing fuel injection nozzles

Using a box wrench, remove the fuel injection nozzles with gaskets from the engine.

NOTE

Remove the nozzle gaskets from the cylinder head, if any, with a wire or a screwdriver and discard them.

- 3. Removing fuel injection pump
 - Check the alignment of the mark on the fuel injection pump with the mark on the flange plate.

FUEL SYSTEM DISASSEMBLY

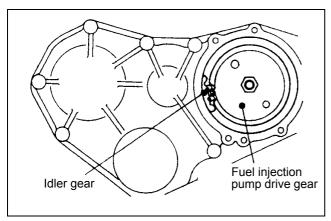


Figure 162 Removing fuel injection pump (2)

- Remove the front end cover from the engine.
- Put marks on the fuel injection pump drive
- gear and idler gear.
 Unscrew the bolts that hold the fuel injection pump flange to the front end plate and remove the pump and flange from the end plate.

NOTE

- Do not attempt to turn the engine after removing the injection pump from the
- To remove the fuel injection pump drive gear, loosen its nut with the pump on the engine.

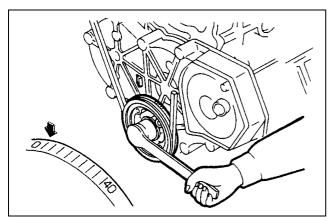


Figure 163 Finding top dead center on compression stroke

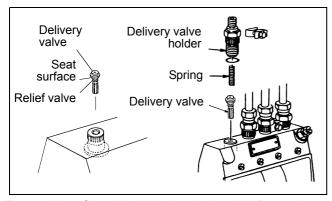


Figure 164 Checking injection timing (1) (Removing delivery valve)

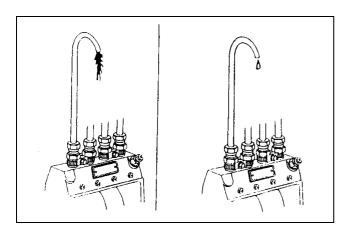


Figure 165 Checking injection timing (2)

19 FUEL INJECTION TIMING CHECK

The injection timing varies according to the output, rpm and specifications of the engine. Be sure to verify the timing by referring to the specifications.

- 1. Bringing the No.1 cylinder piston to the top dead center on compression stroke
 - Put socket (30691–21800) on the crankshaft pulley nut and turn the crankshaft in the normal direction (clockwise as seen from the front end).
 - 2) Stop turning the crankshaft when the timing mark "0" on the crankshaft pulley is aligned with the pointer.
 - Push down on the inlet and exhaust valve rocker arms for the No.1 cylinder to make sure they are not being pushed up by the pushrods (the inlet and exhaust valves have some clearance).

2. Checking injection timing

- Remove delivery valve holder from the No.1 plunger of the injection pump. Remove delivery valve and spring from the holder, restore the holder to the pump.
- Connect a spare injection pipe to the No.1 plunger, with its free end held downward so that you can observe the fuel flow from that end.
- 3) Turn the crankshaft to bring the No.1 piston to 60° position before top dead center on compression stroke.
- 4) While operating the priming pump to allow the fuel to flow from the injection pipe, slowly turn the crankshaft in the normal direction. Stop turning the crankshaft when the fuel flow stops.
- 5) Make sure the timing mark on the crankshaft pulley is aligned with the pointer.

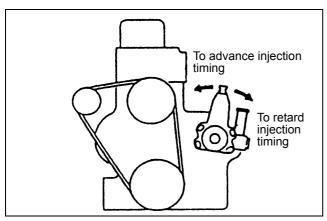


Figure 166 Adjusting injection timing (1)

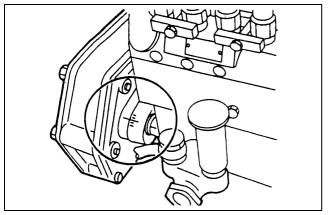


Figure 167 Adjusting injection timing (2)

3. Adjusting injection timing

 If the injection timing is retarded, move the injection pump toward the crankcase. If the timing is advanced, move the pump away from the crankcase.

 One graduation of the scale on the injection pump coupling changes the timing by 6° in terms of crank angle.

20 FUEL FILTER (PAPER-ELEMENT CARTRIDGE TYPE)

20.1 Disassembly and Inspection

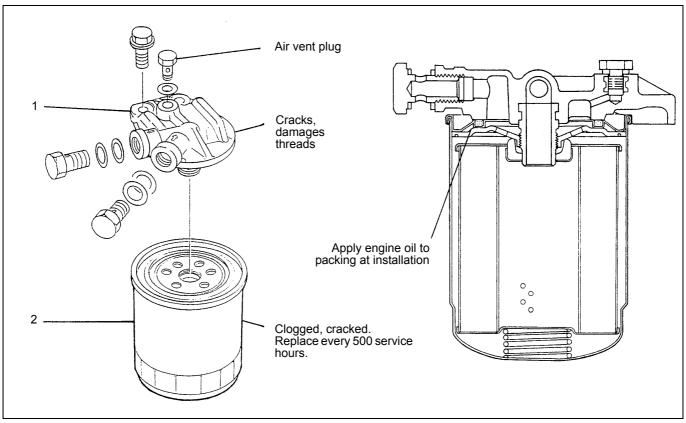


Figure 168 Disassembly sequence

- 1. Element assembly
- 2. Bracket

21 FUEL INJECTION NOZZLES

21.1 Disassembly

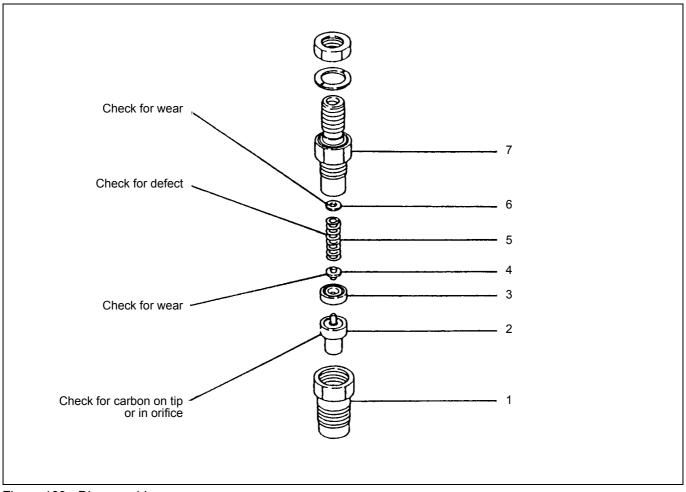


Figure 169 Disassembly sequence

- 1. Retaining nut
- 2. Nozzle tip assembly
- 3. Piece
- 4. Pin
- 5. Spring
- 6. Washer
- 7. Nozzle body

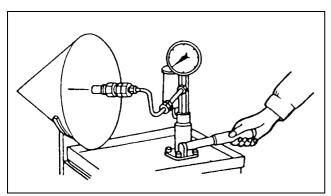


Figure 170 Testing fuel injection nozzle

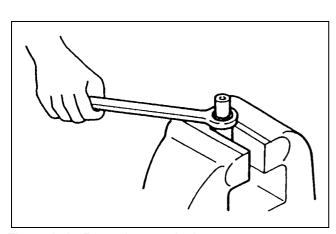


Figure 171 Removing nozzle tip

21.2 Testing

- 1. Injection pressure (valve opening pressure)
 - Install the injection nozzle on the tester. Slowly operate the tester handle full strokes to bleed (remove) air from the pipe and nozzle.
 - Make a slow increase in pressure by operating the tester handle at a speed of more than one stroke per second while observing the pressure gage.
 - 3) The pressure gage reading will slowly increase and, when the nozzle starts discharging fuel, it will go down fast. Take the gage reading right then as the injection pressure.

Unit: MPa (kgf/cm²) [psi]

Item	Assembly Standard
Injection pressure	$14.22_0^{+0.78} $ $(145_0^{+8}) $ $[2063_0^{+113}]$



When testing the injection nozzle, keep its tip pointed away from the operator. Fuel from the orifices in the tip of the nozzle is under high pressure and can cause injury to the operator.

 If the injection pressure is not correct, make an adjustment of the nozzle by adding or removing the shims inside the nozzle holder.

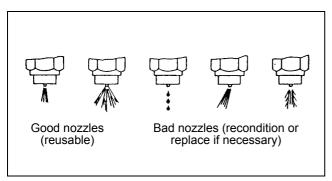


Figure 172 Possible spray pattern

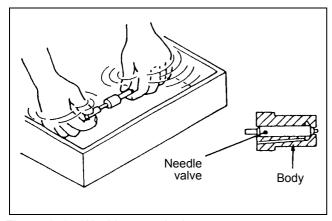


Figure 173 Washing nozzle tip

2. Spray pattern

- Operate the tester handle at a speed of one stroke per second and look at the spray pattern (shape of discharge) when fluid begins to flow through the fuel injection nozzle. The discharge must be 0°. Any change is an indication of a bad nozzle.
- 2) If the nozzle is bad, loosen the retaining nut and remove the tip from the nozzle. Wash the tip needle valve and body in clean diesel fuel. After washing, put the needle valve in the body in clean diesel fuel.

\triangle CAUTION

Be careful not to cause damage to the tip when removing it from the nozzle body.

3) After cleaning the nozzle tip, install it to the nozzle body and tighten the retaining nut to the specified torque.

	37 ± 2.5 N⋅m
Tightening torque	(3.77 ± 0.25 kgf·m)
	[27 ± 1.8 lbf·ft]

4) If the discharge pattern (nozzle) is still bad after the nozzle tip has been washed, replace the tip.

NOTE

- a Do not touch the sliding surface of the needle valve.
- b When installing a new nozzle tip, remove resin film from the tip and slide the needle valve in the body in clean diesel fuel to wash off inhibitor completely.

21.3 Reassembly

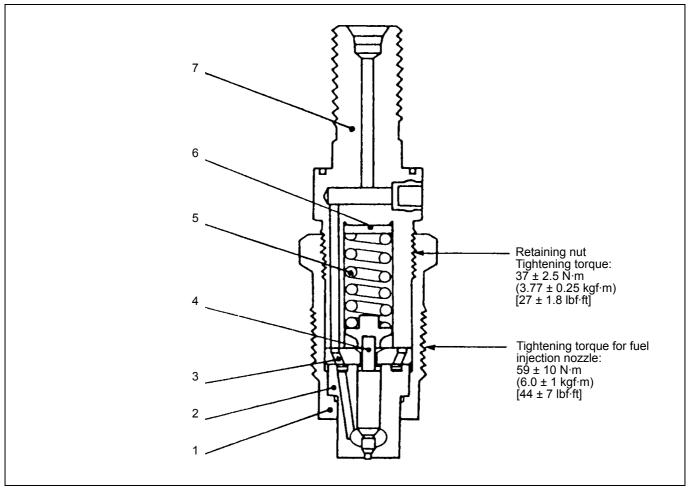
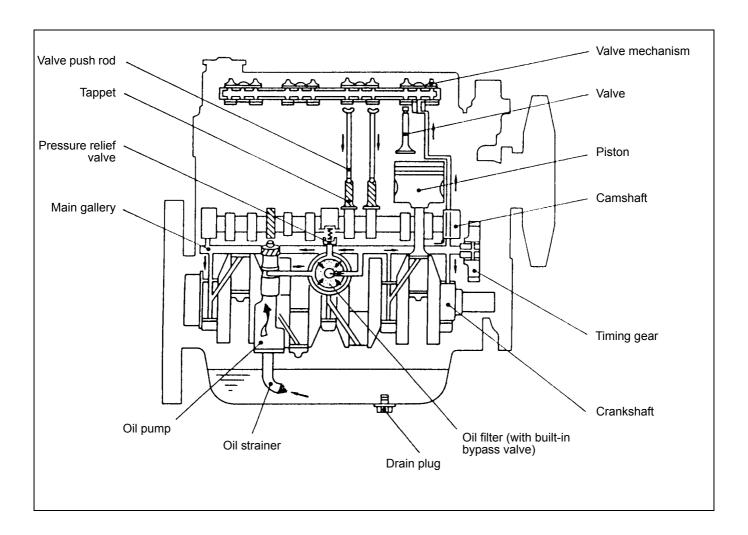


Figure 174 Ressembly sequence

$$7 \rightarrow 6 \rightarrow 5 \rightarrow 4 \rightarrow 3 \rightarrow 2 \rightarrow 1$$

LUBRICATION SYSTEM

22 DESCRIPTION



23 OIL PUMP

23.1 Disassembly

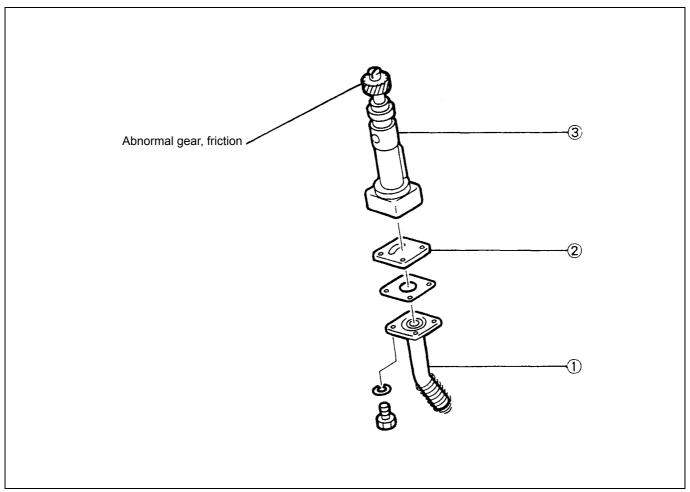


Figure 175 Disassembly sequence

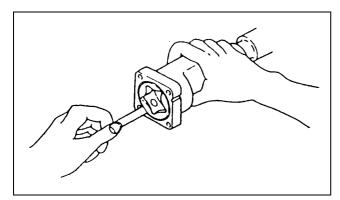


Figure 176 Checking clearance between outer rotor and inner rotor

- 1. Oil strainer
- 2. Cover
- 3. Oil pump

23.2 Inspection

Checking clearance between outer rotor and inner rotor

Check the clearance with a feeler gage, as shown in the illustration. If the clearance exceeds the service limit, replace the pump assembly.

Unit: mm [in.]

Item	Assembly Standard	Service Limit
Clearance between outer rotor and inner rotor	0.13 to 0.15 [0.0051 to 0.0059]	0.20 [0.0079]

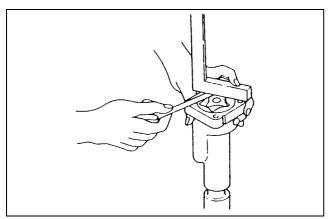


Figure 177 Checking clearance between rotors and cover

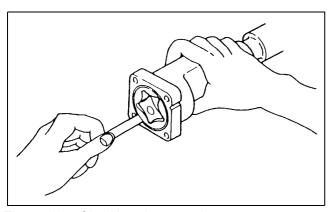


Figure 178 Checking clearance between outer rotor and case

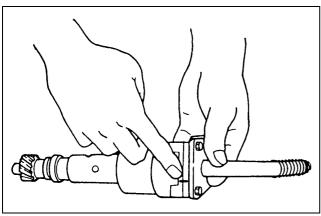


Figure 179 Marks on cover and case

2. Checking clearance between rotors and cover

Check the clearance with a feeler gage and straight edge, as shown in the illustration. If the clearance exceeds the service limit, replace the pump assembly.

Unit: mm [in.]

Item	Assembly Standard	Service Limit
Clearance between rotors and cover	0.04 to 0.09 [0.0016 to 0.0035]	0.15 [0.0059]

3. Checking clearance between outer rotor and case

Check the clearance with a feeler gage, as shown in the illustration. If the clearance exceeds the service limit, replace the pump assembly.

Unit: mm [in.]

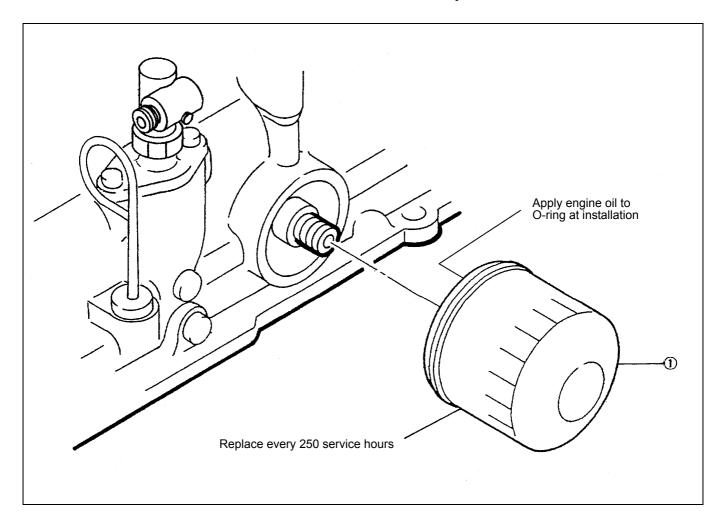
Item	Assembly Standard	Service Limit
Clearance between outer rotor and case	0.200 to 0.275 [0.0079 to 0.0108]	0.500 [0.0197]

23.3 Reassembly

Put the outer rotor in the case. Make sure the mark on the case is in alignment with the mark on the cover and tighten the bolts that hold the cover.

24 OIL FILTER

24.1 Inspection



1. Oil filter

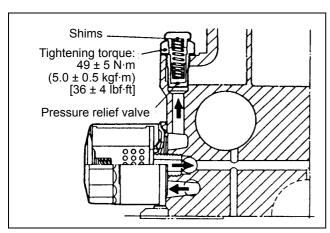


Figure 180 Pressure relief valve

25 PRESSURE RELIEF VALVE

25.1 Inspection

- 1. Check the valve and valve seat for condition. Also, check the spring for damage.
- Check the valve opening pressure (the oil pressure when the engine is running at the rated rpm). If the pressure is not correct, make an adjustment by adding or removing shim. The pressure tap (RP 1/8 thread (PS 1/8)) is located near the oil filter.

Unit: kPa (kgf/cm²) [psi]

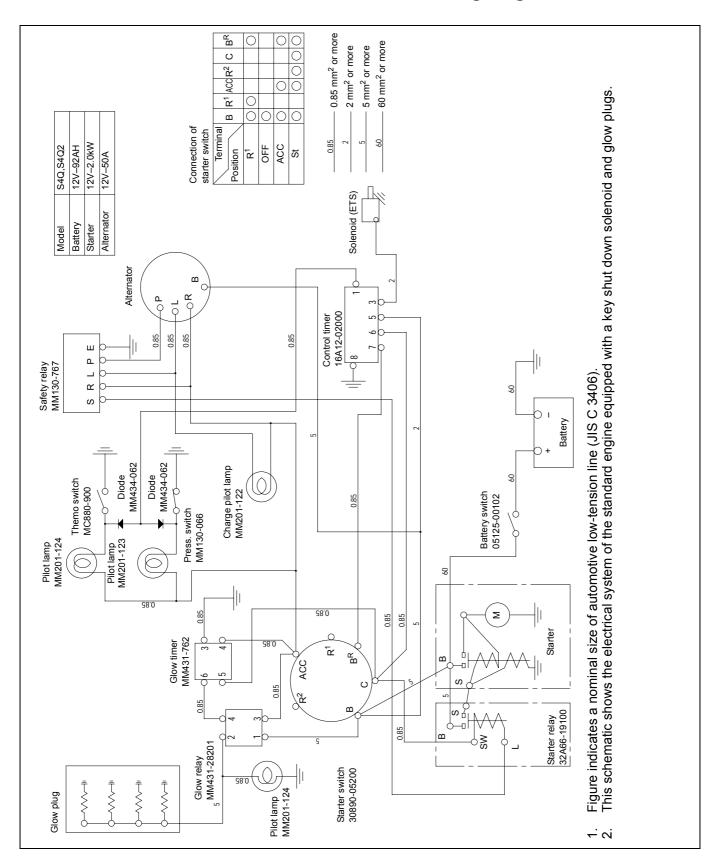
Item	Assembly Standard
Valve opening pressure	343 ± 49 (3.5 ± 0.5) [50 ± 7]

ELECTRICAL SYSTEM

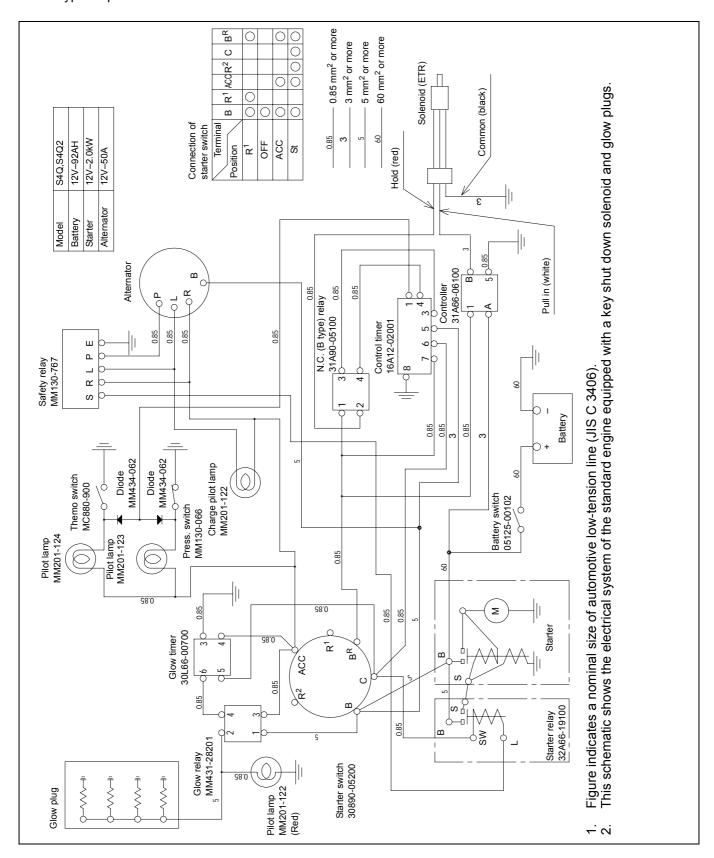
26 GENERAL

< ETS type stop solenoid >

26.1 Wiring diagrams



< ETR type stop solenoid >



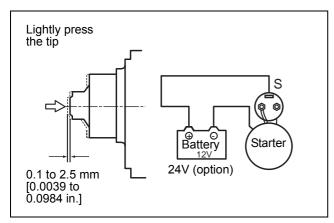


Figure 181 Inspection of pinion gap

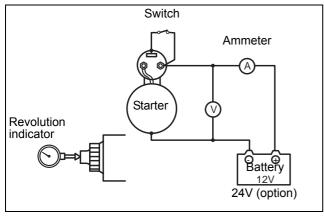


Figure 182 No-load test

27 STARTER

27.1 Inspection before disassembly (inspection of assembly)

If an abnormality is found, disassemble and repair.

Pinion gap

 Connect the positive (+) cable of the battery to terminal S of the starter and the negative (-) cable to the starter body to extend the pinion.

$oldsymbol{\Delta}$ CAUTION

Do not supply electricity for more than 10 continuous seconds.

- Lightly press the tip of the extended pinion shaft with a finger, and measure the distance of the shaft movement.
- 3) If the measured value is not within a range of 0.1 to 2.5 mm [0.0039 to 0.0984 in.], increase or decrease the number of packings at the magnetic switch section for adjustment. An increase of packings results in a decrease of the pinion gap.

2. No-load test

- As shown in the diagram, connect an ammeter, voltmeter, revolution indicator and battery.
- Turning on the switch should extend the pinion and operate the starter at the specified speed or faster.

If the current or rotating speed does not conform to the standard value, disassemble the starter for inspection and repair.

ltem		Standard value
Starter model		M008T70371
Nominal output	V-kW	12-2.0
	Terminal voltage V	11
No-load characteristics	Current A	130 or lower
	Rotation speed rpm	3600 or higher

Option

Item		Standard value
Starter model		MT008T80772
Nominal output	V-kW	24-3.2
	Terminal voltage V	23
No-load characteristics	Current A	80 or lower
	Rotation speed rpm	3000 or higher



CAUTION

- a Use thick wires, and tighten the connections at the terminals.
- b It should be noted that the rotation sound is louder than the sound produced by a starter without a reduction gear mechanism.
- c When measuring the rotation speed at the tip of the pinion, be careful of the pinion extension at the start of operation.
- Inspection of magnetic switch
 Conduct the following inspection. If the magnetic switch is faulty, replace.
 - 1) Disconnect the wire from terminal M.
 - 2) Suction test
 Connect the battery to terminals S and M of the magnetic switch. The pinion should extend when the switch is turned on.

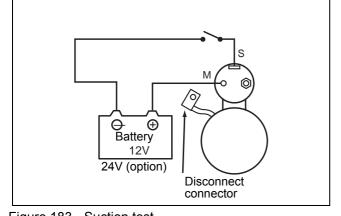


Figure 183 Suction test

⚠ CAUTION

Do not supply electricity for more than 10 continuous seconds.

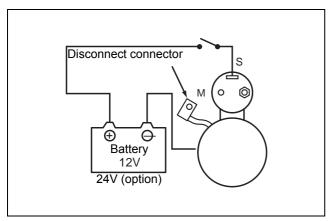


Figure 184 Holding test

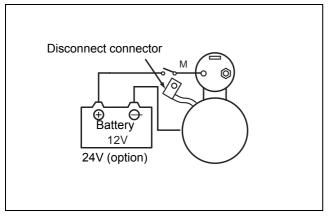


Figure 185 Return test

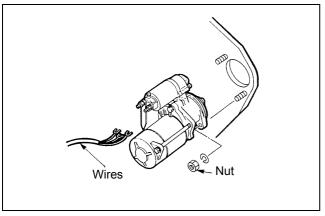


Figure 186 Removal of starter

Holding test
 With the battery connected to terminals S and
 the body of the magnetic switch, pull out the
 pinion fully with fingers. The pinion should not
 return to the original position when it is
 released.

⚠ CAUTION

Do not supply electricity for more than 10 continuous seconds.

4) Return test With the battery connected to terminals M and the body of the magnetic switch, pull out the pinion fully with fingers. The pinion should return immediately to the original position when it is released.

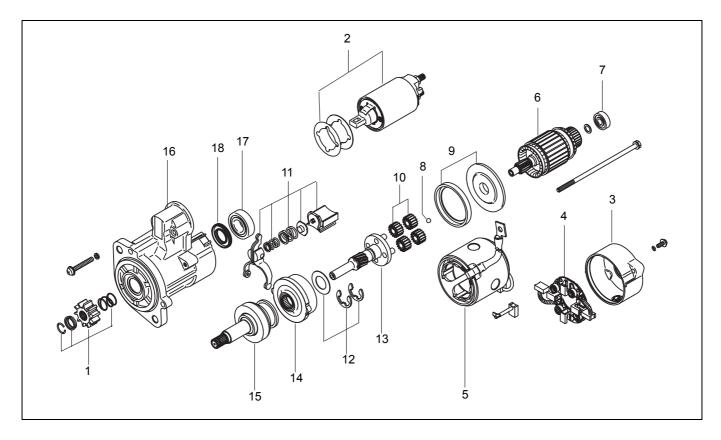


Do not supply electricity for more than 10 continuous seconds.

27.2 Removal

- 1. Disconnect the cables from the battery terminals. Be sure to disconnect the negative (-) cable first.
- 2. Disconnect the wires from the starter.
- Remove the two starter mounting nuts, and dismount the starter.

27.3 Disassembly



Disassembly sequence

- 1. Pinion set
- 2. Magnetic switch
- 3. Rear bracket
- 4. Brush holder
- 5. Yoke
- 6. Armature
- 7. Ball bearing
- 8. Ball
- 9. Packing set
- 10. Gear
- 11. Lever
- 12. Washer set
- 13. Gear shaft
- 14. Internal gear
- 15. Overrunning clutch
- 16. Front bracket
- 17. Bearing
- 18. Oil Seal

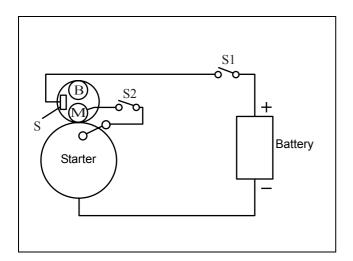


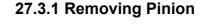
CAUTION

Before disassembling or replacing the following parts, remove the pinion.

Remove the pinion before disassembling:

- 1. Front bracket, or bracket bearing and oil seal
- 2. Reduction gears
- 3. Overrunning clutch





Supply electric current to the switch to set the pinion in the protruded condition. Remove the M-terminal connecttor, and connect the battery and starter, as shown in the diagram. Close swithes S1 and S2 to set the pinion in the protruded condition. Then, open switch S2 to stop the pinion rotation. Set a pipe-shape tool on the pinion stopper, and lightly tap the tool with a hammer to remove the pinion.

In some cases, the stopper does not dislodge from the position and the pinion retracts into the original position. When this happens, repeat the procedure.

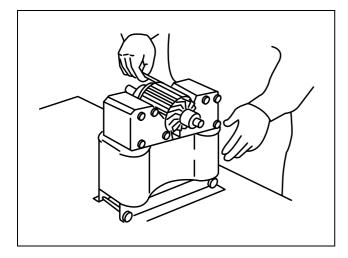
27.3.2 Ball

The ball serving as the bearing in the armature thrust direction may be stuck to grease on the tip of the shaft when the armature is removed. Do not loose this bearing ball.

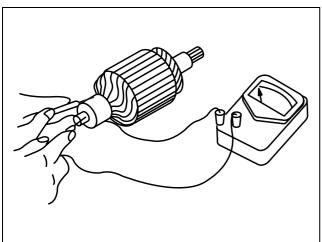


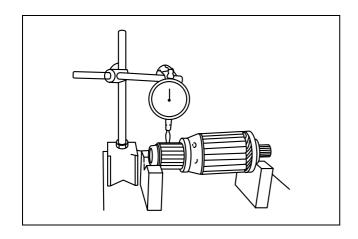
27.4.1 Armature

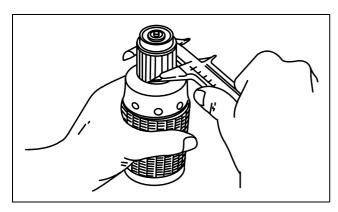
Testing for short circuits
 Place the armature on a growler, and slowly
 revolve it with a hacksaw blade held above the
 armature core. The hacksaw blade vibrates
 against the core when it is above a slot containing
 a shorted winding. Replace the armature if
 shorted.

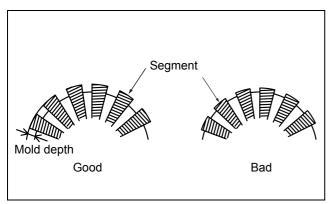


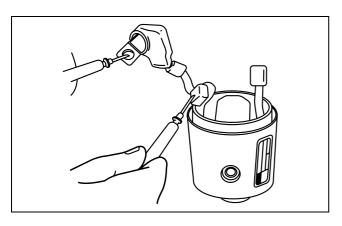
2. Testing for grounded circuits
If there is any continuity between the commutator
and shaft (or core), the armature is grounded and
should be replaced.











- 3. Inspecting commutator
 - 1) Support the armature in V-blocks and measure the runout of the commutator with a dial indicator. If the runout is near the service limit, recondition the commutator, making sure the commutator diameter does not exceed the service limit which is 31.4 mm [1.236 in.]. If the commutator surface is rough, smoothen it with a sandpaper of #300 to #500.

Unit: mm [in.]

Item	Service Limit
Runout of commutator	0.1 [0.004]

 Measure the diameter of commutator. If it is smaller than the service limit, replace the armature.

Unit: mm [in.]

Item	Normal Size	Service Limit
Diameter of commutator	32 [1.26]	31.4 [1.236]

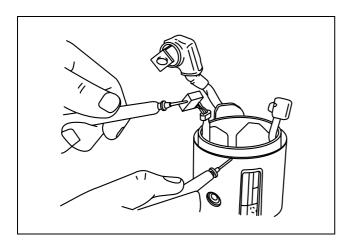
 Measure the depth of each mold between segments with a depth gauge. If the depth is less than the repair limit, recondition the mold.

Unit: mm [in.]

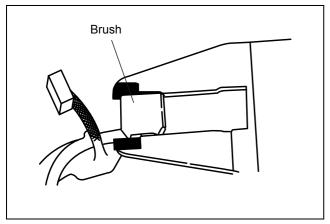
Item	Assembly Standard	Service Limit
Depth of commutator mold	0.4 to 0.6 [0.016 to 0.024]	0.2 [0.008] or less

27.4.2 Field Coil

Testing for open circuits
 If there is no continuity between the lead wire and positive (+) brush, the field coil is open and the yoke assembly should be replaced.



2. Testing for grounded circuits
If there is no continuity between the yoke and
positive (+) brush, the insulation and re-pair or
replace the yoke assembly.



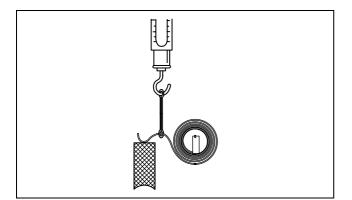
27.4.3 Brushed and holders

1. Wear of brushes

Measure the brush length and, if it is less than the service limit, replace the brushes. If the brushed are unevenly worn or rough, recondition them with a sandpaper of #300 to #500.

Unit: mm (in.)

Item	Assembly Standard	Service Limit
Length of brush	18 [0.71]	11 [0.43]

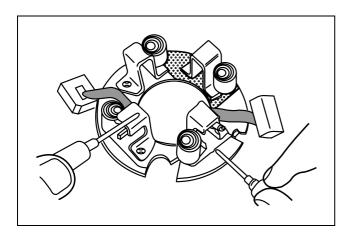


2. Brush spring force

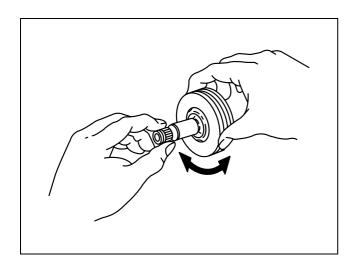
Test the spring force using a new brush. In the test, read the road at the instant the spring moves off the brush. If the force is less than the service limit, replace the spring.

Unit: N (kgf) [lbf]

Item	Assembly Standard	Service Limit
Force of brush spring	29 to 39 (3.0 to 4.0) [6.6 to 8.8]	19.6 (2.0) [4.4]



3. Testing brush holders insulation
If there is any continuity between the positive (+)
brush holder and negative (–) holder plate, replace
the brush holder assembly.

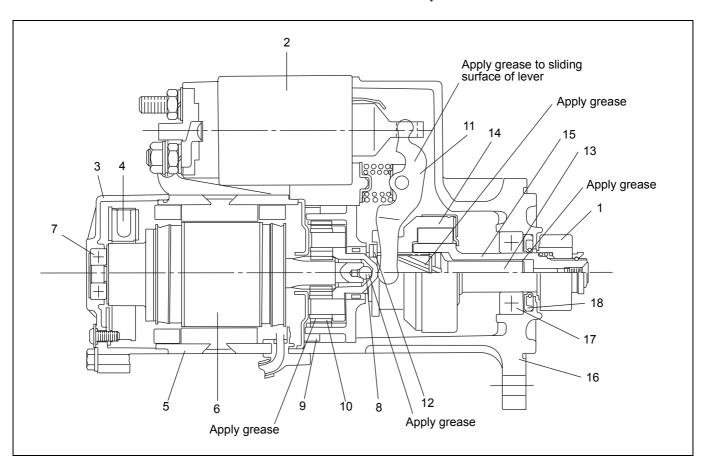


27.4.4 Overrunning Clutch

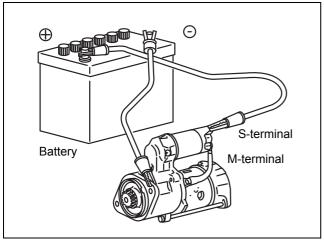
Make sure that the pinion shaft turns freely when turned in the direction of driving (clockwise) and it is locked when turned in the opposite direction. If not, replace the overrunning clutch.

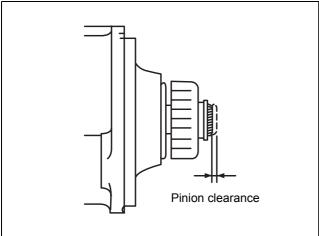
27.5 Reassembly

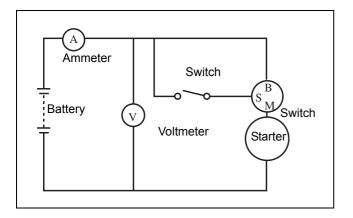
To reassemble, follow the disassembly sequence in reverse. Be sure to observe the following during reassembly.



Reassembly sequence $18 \rightarrow 17 \rightarrow 16 \rightarrow 12 \rightarrow 13 \rightarrow 14 \rightarrow 15 \rightarrow 1 \rightarrow 10 \rightarrow 11 \rightarrow 9 \rightarrow 8 \rightarrow 5 \rightarrow 6 \rightarrow 7 \rightarrow 4 \rightarrow 3 \rightarrow 2$







27.6 Inspection and testing after reassembly

27.6.1 Pinion clearance adjustment

- If the reassembled starter is wired as shown, the pinion will shift and turn slowly. Remove the connector from the M terminal to stop the pinion.
- 2. Under this condition, lightly push in the pinion toward the armature, and measure the movement (clearance) of the pinion.
- To adjust the clearance, increase or decrease the number of packings fitted to the magnetic switch. Increasing the number of packings decreases the pinion clearance.

Unit: mm [in.]

Item	Assembly Standard
Pinion clearance	0.5 to 2.0 [0.020 to 0.079]

NOTE

Do not test the starter continuously for more than 20 seconds to prevent the switch coil from overheating.

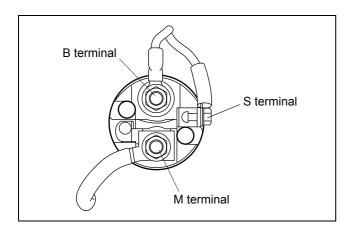
27.6.2 No-Load Test

After adjusting the pinion clearance, hook up the starter as shown, and test it for no-load characteristics.



Use wires as thick as possible and tighten each terminal securely.

Starter	Voltage, V	Current, A	Speed, rpm
No-Load	11	130 or less	4000 or less
characteristic	23 (Option)	80 or less	3000 or more



27.6.3 Magnetic switch

- Testing coil for open circuits
 If there is no continuity between S and M terminals and between S terminal and body (ground), replace the switch.
- Checking contactors for fusion
 If there is continuity between B and M terminals, replace the switch.
- Checking contactors for poor contact action Check for voltage drop. If voltage drop is excessive, the contactors are defective.

28 ALTERNATOR

If a problem occurs in the charge system, check the following abnormal conditions to locate the cause of the problem. Only when inspection cannot be conducted on the alternator installed on the engine, dismount the alternator for inspection and repair.

Overcharging	Voltage regulator adjustment value is high.
	Faulty battery.
	Voltage relay adjustment value is low.
	Faulty alternator output.
Overdischarging	Power consumption is extremely high.
	Special load is used.
	Faulty wiring.

28.1 On-vehicle inspection

28.1.1 Cautions in handling

Handle the alternator carefully. Incorrect handling can result in alternator damage and malfunctions.

- 1. Do not connect the battery cables in reverse. Note that the negative cable is a grounding wire.
- 2. Do not use a high-voltage tester such as a megger.
- 3. When charging the battery, disconnect the cables from the battery terminals.
- 4. Do not disconnect the lead wire from terminal B of the alternator while the engine is operating.
- Do not ground terminal B of the alternator since it is constantly applied with battery voltage.
- 6. Do not short or ground terminal L. (unit with integrated IC regulator)
- 7. When using a steam cleaner, do not allow steam to directly contact the alternator.

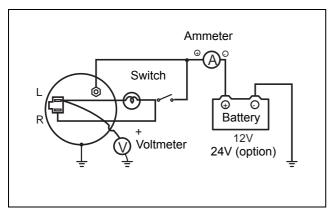


Figure 187 Inspection of adjustment voltage

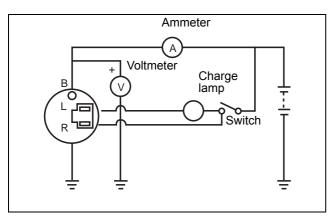


Figure 188 Wiring diagram for output test (unit with integrated IC regulator)

28.1.2 Inspection of adjustment voltage (unit with integrated IC regulator)

- 1. Disconnect the cable from the positive (+) terminal of the battery, and connect an ammeter between the terminal and cable.
- Connect a voltmeter between terminal L and ground.
- Make sure that the voltmeter indicates "0" when the starter switch is turned off.
 Make sure that the voltmeter indicates a voltage level sufficiently lower than the battery voltage when the starter switch is turned on (without starting the engine).
- 4. Short-circuit the terminal of the ammeter, and start the engine.
- 5. Read the indication (adjustment voltage) on the voltmeter with the ammeter indicating 5 A or lower, the engine operating at 1800 to 2500 rpm, and the lamp switches turned off.

Unit: V

Item	Standard Value	V-kW
	14.7 ± 0.5	12-50
Adjustment voltage at 20°C	Option 28.5 ± 0.5	Option 24-25 24.35

28.1.3 Inspection of output (unit with integrated IC regulator)

- 1. Disconnect the grounding cable from the battery.
- 2. Disconnect the wire from terminal B of the alternator, and connect an ammeter. Connect a voltmeter between terminal B and ground.
- 3. Connect the grounding cable to the battery.
- Start the engine.
- 5. Immediately after the engine starts, turn on all load devices such as lamps.
- Increase the engine speed. When the voltmeter indicates 27.0 V, read the maximum current at the specified alternator rotation speed. If the measured value conforms to the standard value, the alternator is normal.

Output characteristics:

		Standard Value		
Item	Model	Terminal voltage/ current	Rotation speed	
Option characteristic (when warm)	A7T02077C	13.5V/33A	2500 rpm	
		13.5V/47A	5000 rpm	
	A7TA8077 (option)	27.0V/18A	2500 rpm	
		27.0V/22A	5000 rpm	
	A3TN5776 (option)	27.0V/29A	2500 rpm	
		27.0V/33A	5000 rpm	

28.2 Removal

- 1. Disconect the battery cables.
- Disconnect the lead wire from terminal B located on the back side of the alternator.
- 3. Disconnect the alternator connector.
- 4. Unscrew the alternator brace bolt and support bolt, and push the alternator toward the engine, then remove the fan belt.
- 5. Dismount the alternator.

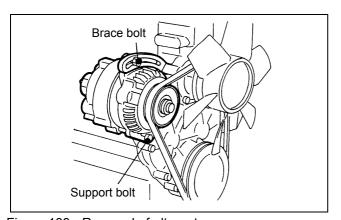
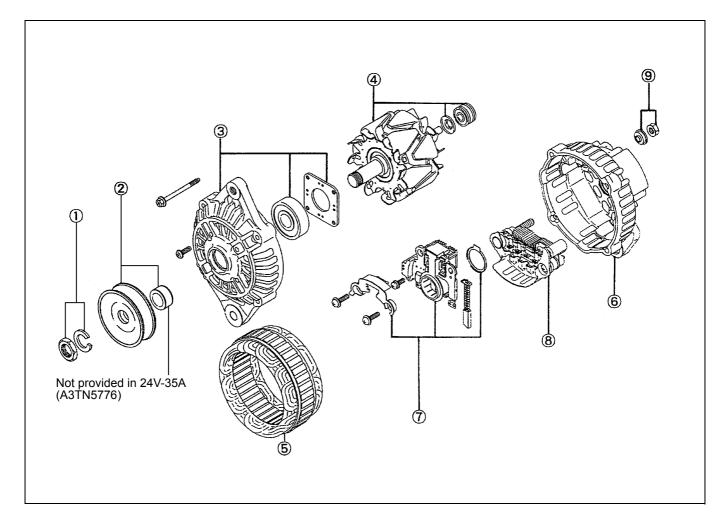


Figure 189 Removal of alternator

28.3 Disassembly



Disassembly sequence

- Nut and washer
- 2.
- Pulley and spacer Front bracket assembly 3.
- 4. Rotor assembly
- 5. Stator
- Rear bracket 6.
- Regulator assembly 7.
- 8. Rectifier assembly
- 9. Nut set

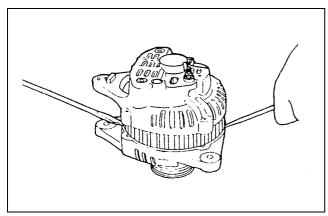


Figure 190 Disassembly of alternator

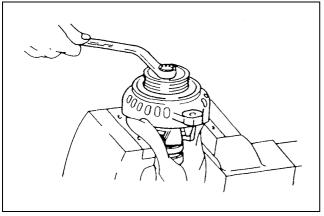


Figure 191 Removal of pulley

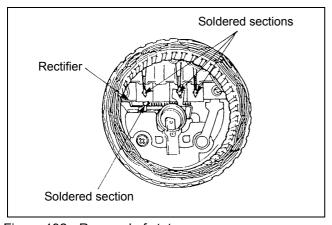


Figure 192 Removal of stator core

28.3.1 Key points in disassembly

- 1. Separation of front bracket from stator core.
 - Insert the tip of a slotted screwdriver into the gap between the stator core and front bracket, and pry open.



Do not insert the screwdriver too far into the assembly to prevent damage to the stator core.

2. Removal of pulley

- Wrap the rotor with a cloth for protection, and hold it with a vice. Unscrew the pulley nut, then remove the pulley and spacer.
- 2) Remove the rotor from the front bracket.

- 3. Removal of stator core and rectifier
 - Disconnect the lead wires from the stator core to the rectifier at the soldered sections. Then, remove the stator core.



Melt the soldered sections as quickly as possible. If heat is applied for an extended period of time, the diodes can be damaged.

 Unscrew the rectifier mounting screws, and dismount the rectifier.

28.4 Inspection

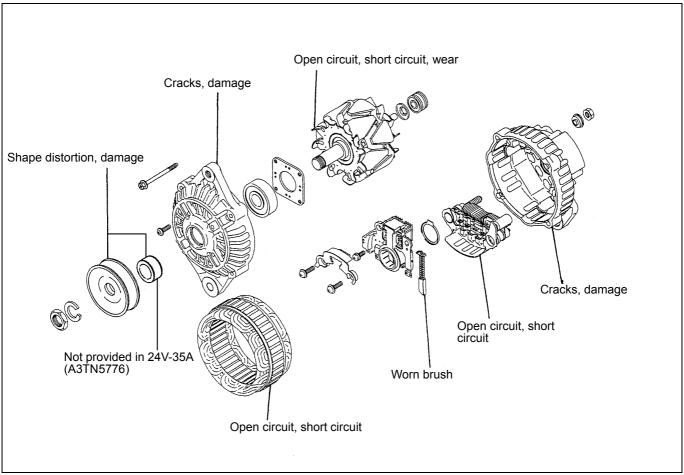


Figure 193 Inspection locations on alternator

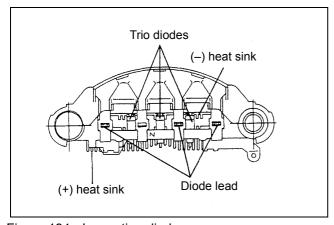


Figure 194 Inspecting diodes

28.4.1 Key points in inspection

1. Inspecting diodes

For inspection of individual diodes, check the resistance between each diode lead and heat sink. Take resistance measurements by connecting the positive (+) wire of a tester to the diode and also by connecting the negative (-) wire to the diode. If the resistance shows "infinite" in both measurements, there is an open circuit. If the resistance is close to 0 in both measurements, there is a short circuit. If there is an open or short circuit, the diode is faulty and the rectifier must be replaced.

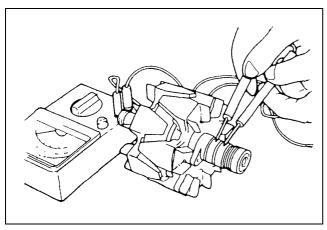


Figure 195 Field coil continuity

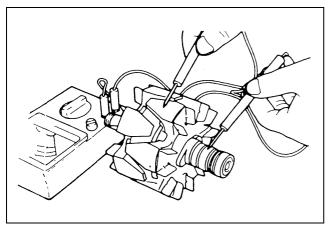


Figure 196 Field coil grounding test

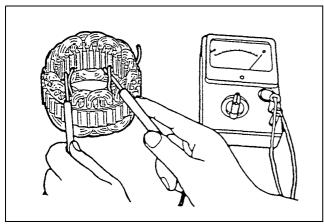


Figure 197 Stator core continuity test

2. Inspecting field coil

 Check the continuity between the slip rings. If there is no electric conduction, there is an open circuit: replace the field coil.

2) Check the continuity between the slip ring and shaft (or core).

If there is electric conduction, the field coil is grounded: replace the field coil.

3. Inspecting stator core

1) Check the continuity between the stator core and each lead wire.

If there is no electric conduction, there is an open circuit: replace the stator core.

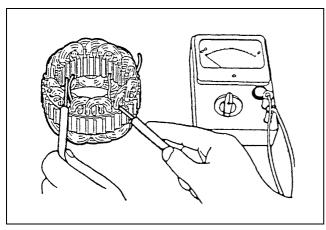


Figure 198 Stator core grounding test

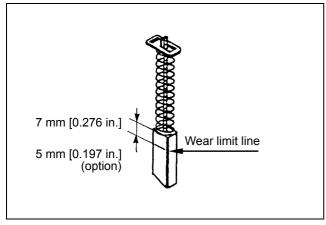


Figure 199 Inspecting brush

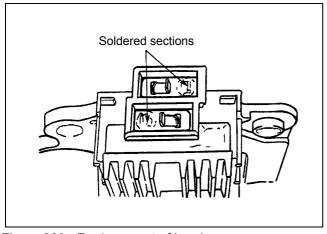


Figure 200 Replacement of brushes

 Check to make sure that there is no continuity between the lead wires and core.
 If there is continuity, the circuit is grounded: replace the stator.

4. Inspecting brushes

1) If the brushes are worn close to the wear limit line (service limit), replace the brushes.

Unit: mm [in.]

	Assembly Standard	Service Limit
Brush length		7 [0.276]
	18.5 [0.728]	5 [0.197] Option (A7TA80AA) (A3TN5776)

2) Disconnect the brush lead wires at the soldered sections to remove the brushes and springs.

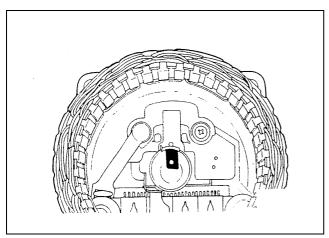


Figure 201 Replacement of brushes

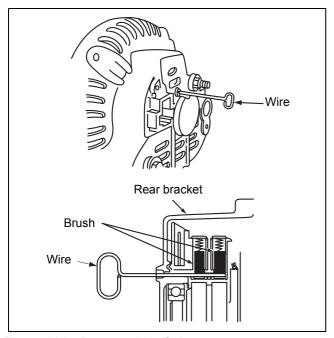


Figure 202 Reassembly of alternator

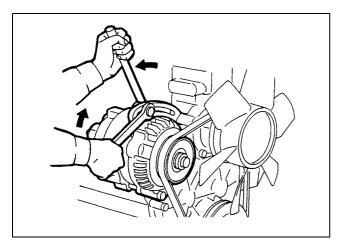


Figure 203 Installation of alternator

 To install new brushes, press them into the brush holders as shown in the diagram, then solder the lead wires.

28.5 Assembly

To reassemble, follow the disassembly sequence in reverse.

Be sure to observe the following during assembly.

28.5.1 Key points in reassembly

- 1. When press-fitting the rear bearing into the rear bracket, heat the rear bracket to 50 to 60°C [122 to 140°F].
- 2. The brushes must be raised before the rotor is installed to the rear bracket. To do so, put a wire through the small hole located on the rear bracket, then remove the wire after completing the reassembly.

28.6 Installation

- Install the fan belt on the alternator, and mount the alternator on the engine.
 Temporarily tighten all the bolts.
- Insert a bar between the alternator and crankcase.
 Using the bar as leverage, move the alternator and
 adjust the belt tension.
 While keeping the alternator at that position,
 tighten the bolt that secures the alternator to the
 adjusting plate.

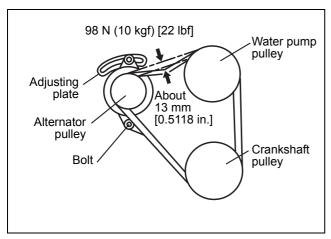


Figure 204 Inspection of belt tension

3. Check the belt tension. If the belt tension does not conform to the standard value, loosen the belt and repeat the above step (2).

Unit: mm [in.]

Item	Standard Value	
Belt tension (crankshaft pulley - alternator pulley)	Approx. 13 [0.5118] (when pressed with force of 98 N (10 kgf) [22 lbf])	

4. When the belt tension is properly adjusted, tighten all the bolts that secure the alternator in place.

29 ETR type stop solenoid

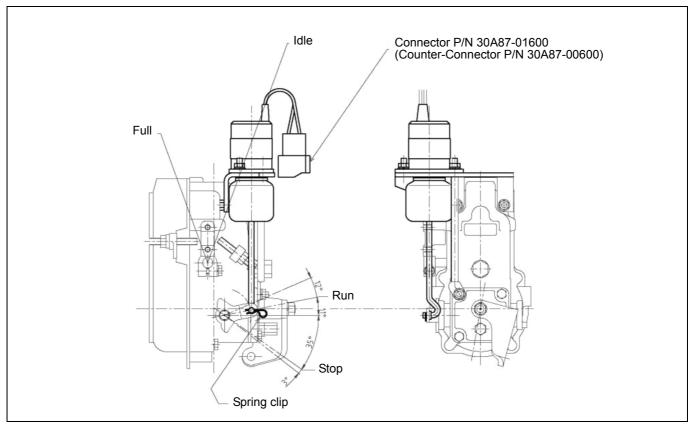


Figure 205

29.1 General

The energize-to-run (ETR) solenoid controlled engine shutdown system operates as follows:

When the starter switch is turned to the "ON" position, the hold coil and the pull coil are energized simultaneously, pulling the stop lever to the "RUN" position. However, the pull coils is energized only for about 1 second (maximum 3 seconds) by a special controller.

The hold coil of the solenoid remains energized in both the "ON" and "START" position of the starter switch, keeping the stop lever in the "RUN" position. When the current to the hold coil is interrupted, the hold coil is no longer energized causing that the stop lever immediately will be pushed to the no-injection position by the internal return spring force of the solenoid. The engine then stops.

This system is a safety device designed to stop the engine whenever the wiring is open or when the starter switch is turned "OFF".

NOTE

If the electrical system includes a control timer to stop the engine, the starter switch should be turned in the "OFF" position for at least 10 seconds before making another start attempt in order to reset the control timer automatically.

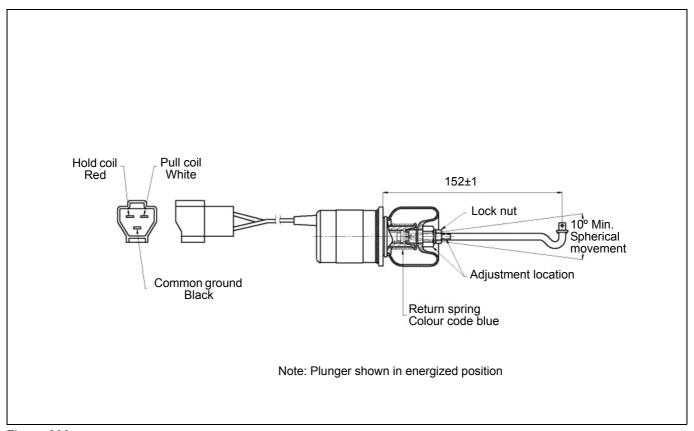


Figure 206

29.2 Solenoid specification

		current		resistance (+/-10%) at 20 °C	
connection	wire color	rated 12V	rated 24V	rated 12V	rated 24V
hold coil	red	55 A	29 A	11.15 Ω	41.35 Ω
pull coil	white	1.1 A	0.6 A	0.217 Ω	0.817 Ω
common ground	black			•	•

Notice that the housing is ungrounded.

Replace the complete solenoid if not within the above mentioned specification.

△ CAUTION

To avoid damage to the stop solenoid, do not energize the pull coil for more than 10 seconds. Allow the solenoid to cool down before energizing again.

29.3 Inspection

- 1. Check the spring: the coil ends should be squared and ground.
- Check the connecting rod spherical movement freely.
- 3. Check the rubber boot for any cracks or leaks.

Replace the complete solenoid assy if any failure at 1, 2 or 3.

- 4. The plunger and hub should be free of any wear, dirt or grease: clean if necessary. Install a tie rap to install the rubber boot.
- 5. Check the spring clip to secure well.

29.4 Connecting rod adjustment

- Check the connecting rod length and adjust to 152 +/- 1 mm if necessary (see Figure 206 on page 135).
- 2. Install the connecting rod from inside out to the stop lever and lock it by the spring clip (see Figure 205 on page 134).
- 3. Start and stop the engine to check proper operation of the shutdown system.



Wrong adjustment will cause that the engine can not run or can not be stopped. It is also possible that the engine can not reach its maximum output.

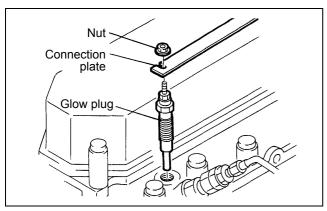


Figure 207 Removal of glow plug

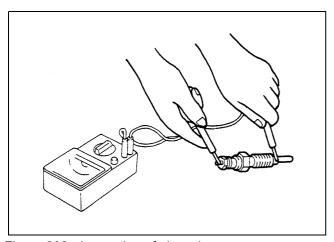


Figure 208 Inspection of glow plug

30 GLOW PLUGS

30.1 Removal

- 1. Unscrew the connection plate retaining nut, and remove the connection plate.
- 2. Remove the glow plug from the cylinder head.

△ CAUTION

After removing the glow plug, cover the glow plug mounting hole with tape to prevent dust from entering the cylinder head.

30.2 Inspection

As shown in the diagram, check the conductivity between the terminal and body. If there is no conductivity or if the resistance is high, replace the glow plug.

Unit: Ω

ltem	Assembly Standard	
Resistance	1.0	

30.3 Installation

1. Install the glow plug in the cylinder head by tightening to the specified torque.

Tightening torque	18 ± 2 N·m (1.8 ± 0.2 kgf·m) [13 ± 1 lbf·ft]
-------------------	--

2. Install the connection plate to the glow plug, and tighten the retaining nut to the specified torque.

Tightening torque	1.3 ± 0.2 N·m (0.13 ± 0.02 kgf·m) [0.96 ± 0.14 lbf·ft]
-------------------	--

TESTING AND ADJUSTING

31 BENCH TEST

An overhauled engine should be tested for performance on a dynamometer. This test is also for breaking in the major running parts of the engine, follow the procedures described below:

31.1 Starting Up

- Inspect the levels in the radiator, oil pan and fuel tank. Prime the fuel and cooling systems to bleed air out.
- Crank the engine with the starter for 15 seconds to permit lubricating oil to circulate through the engine. For this cranking, do not supply fuel to the engine.
- Move the speed control lever slightly in the direction of increasing the injection, and turn the starter switch to START to start the engine. Do not move the control lever to the "full fuel injection" positon.
- 4. After the engine starts, let it to idle under no load by operating the speed control lever.

31.2 Inspection after Starting Up

After starting up the engine, check the following points. If you find anything wrong, immediately stop the engine, then investigate for the cause.

- Lubricating oil pressure should be 0.2 to 0.4 MPa (2 to 4 kgf/cm²) [29 to 58 psi] at rated speed or over 0.1 MPa (1 kgf/cm²) [15 psi] at idling speed.
- 2. Coolant temperature should be 75°C to 85°C [167°F to 185°F].
- 3. Lube oil temperature should be 70°C to 90°C [158°F to 194°F].
- Check for leakage of oil, coolant, fuel.
- Knocking should die away as the coolant temperature increases. No other defective noise should be heard.
- 6. Check for exhaust color and abnormal odors.

31.3 Bench Testing (Dynamometer) Conditions

Here is a summary table of bench testing conditions.

Step	Speed (rpm)	Load (PS)	Time (min.)
1	1000	No-load	30
2	1500	25%	30
3	Ratted (varies according to specifications)	25%	10
4		50%	10
5		75%	30
6		100%	20

31.4 Inspection and Adjustment after Bench Testing

- 1) Adjusting valve clearance
- 2) Adjusting injection timing
- 3) Re-tightening external bolts and nuts

32 IDLING SPEED AND MAXIMUM SPEED SETTING INSPECTION AND ADJUSTMENT

$oldsymbol{\Delta}$ CAUTION

- a The idling speed (no-load) and maximum speed are set for each engine at factory bench testing, then the set bolts are sealed. These settings are to be inspected and adjusted at Mitsubishi service shops only.
- b After adjusting the governor be sure to seal the stopper.
- c The stoppers are specified to be sealed. Whether the seals are intact or not has importance bearing on the validity of claims under the warranty.
- d When inspecting and adjusting these settings, be ready to operate the engine stop lever manually against the engine overrunning.

NOTE

Prior to inspection and adjustment, warm up the engine until coolant and oil temperature rise to 70°C [158°F] or higher.

1. Starting the engine

- 1) Pull the speed control lever toward the HIGHS SPEED side, and operate the starter switch.
- 2) The engine ignites when the rotation speed reaches approximately 150 rpm. When the engine speed starts to increase, operate the speed control lever and maintain the engine speed between 800 and 1000 rpm.
- 3) After the engine speed stabilizes, return the speed control lever to the low idling position.

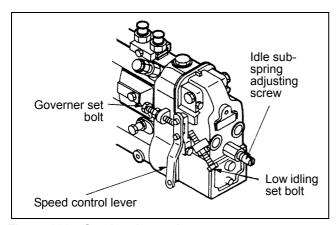


Figure 209 Starting the engine

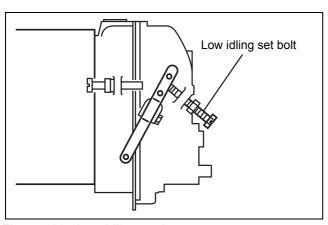


Figure 210 Low idling setting

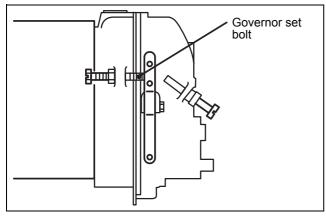


Figure 211 Governor setting

- 2. Low idling setting (no-load minimum rotation speed setting)
 - Set the speed control lever at the position of no-load minimum rotation speed, then secure the lever in that position using the low idling set bolt.

$oldsymbol{\Delta}$ CAUTION

If there is a speed range which causes dangerous torsional vibration, avoid setting the engine speed in that range.

- 3. Governor setting (maximum rotation speed setting)
 - 1) Keep the speed control lever at the position of the specified maximum rotation speed.
 - With the speed control lever held in that position, adjust and set the governor set bolt (maximum rotation speed set bolt) to the specified rotation speed.

33 PERFORMANCE TEST

There are various performance test procedures, and here the procedures for "Earth moving machinery Engines, Part 1: Test code of net power (JIS D 0006-1)" and "Earth moving machinery Engines, Part 2: standard format of specifications and tests methods of diesel engines (JIS D 0006-2)" are described. Other test items may be required on application. Engine performance is judged with integrated test results.

33.1 Engine Equipment Condition

Engine must be equipped with such standard auxiliaries as cooling fan, air cleaner and alternator.

33.2 Tests and Their Purposes

1. Operation load test

Conduct this test to evaluate engine output, torque, fuel consumption and governor performance under various load conditions.

Continuous load test

Operate the engine continuously for 10 hours at 90% load (continuous load application) of nominal net shaft output while engine speed is maintained at revolutions corresponding to the nominal shaft output. In this test, evaluate fuel consumption and operating condition and confirm continuous engine operation.

3. No-load minimum revolution test

Conduct this test to confirm that the engine can operate stably at the specified no-load minimum revolutions.

33.3 Other Inspections

During performance testing, inspect for leakage of gases, coolant, lubricating oil, or fuel, and for noise or hunting. Make adjustment, as needed.

33.4 Adjustment Engine Output

Diesel engine output is affected by atmospheric pressure, temperature, and humidity. Therefore, the engine output should be set for standard atmospheric conditions.

1. Standard atmospheric conditions

Temperature	298 K (25°C) [77°F]
Atmospheric pressure	100 kPa [750 mmHg]
Atmospheric vapor pressure	99 kPa [743 mmHg]

2. Calculation of corrected output value

Multiply the measured shaft output or torque by the calculated diesel engine correction factor (see below) to obtained a corrected value.

Corrected output = Correction factor (αc) x Measured shaft output

1) Atmospheric conditions for test

Temperature (T): 283 K (10°C) [50°F] \leq T \leq 313 K (40°C) [104°F]

Dry atmospheric pressure (Pd): 80 kPa (600 mmHg) \leq Pd \leq 110 kPa (825 mmHg)

3. Calculation of correction factor (α c)

$$\alpha c = (fa)^{fm}$$

fa: Atmospheric factor

fm: Engine factor

- 1) Calculation of atmospheric factor (fa)
- a Natural aspiration engine and engine with mechanically driven air charger

$$fa = (\frac{99}{Pd}) \cdot (\frac{T}{298})^{0.7}$$

b Turbocharged engine without air cooler (after cooler) or with air-to-air cooler

fa =
$$(\frac{99}{Pd})^{0.7} \cdot (\frac{T}{298})^{1.2}$$

c Turbocharged engine with air-to-liquid cooler

$$fa = (\frac{99}{Pd})^{0.7} \cdot (\frac{T}{298})^{0.7}$$

2) Calculation of engine factor (fm)

$$fm = 0.036 qc - 1.14$$

a qc (Corrected fuel supply volume) = $\frac{q}{r}$

$$q = \frac{(z) \times (\text{Fuel flow rate g/s})}{(\text{Stroke volume } l) \times (\text{Engine revolution rpm})}$$
$$z = 120000 \text{ (4-cycle engine)}$$

r: Ratio of pressure at turbocharger or air cooler to atmospheric pressure (r = 1 for natural aspiration engine)

b Applicable range of engine factor (fm)

 $37.2 \le qc \le 65 \text{ mg/(ℓ-cycle)}$

- $qc \le 37.2 \text{ mg/($\ell$-cycle)}$: fm = 0.2 (Constant)
- 65 mg/(ℓ-cycle) ≤ qc : fm = 1.2 (Constant)
- 3) Range of correction equation use

The range of correction factor (αc) use is as follows: $0.9 \le \alpha c \le 1.1$.

If this range is exceeded, indicate the corrected value and record the test conditions on the test record sheet.

TROUBLESHOOTING

34 CAUSES OF ENGINE PROBLEMS AND REMEDIES

	Problems/Symptoms		ı	Hard	starti	ng					t enoi		s	xhau: mok	е				Eng	
		Eng	jine tı	urns		doe	gine s not irn		ast		ke	ke		lı oper	n ation	pu		punos uo		
Pos	ssible causes	No exhaust smoke	Small amount of exhaust smoke	Large amount of exhaust smoke	Cranking speed low	Engine can be cranked manually	Engine can not be cranked manually	Glow plugs do not produce red heat	Glow plugs do produce red heat to fast	Small amount of exhaust smoke	Large amount of white exhaust smoke	Large amount of black exhaust smoke	At idling	White	Black	Engine produces loud knocking sound	Engine produces abnormal noice	Engine produces irregular combustion	At idling	In operation
	No fuel to injection pump	8	8	_	—	_	_	_	—	8		_	_	_	_	_	_	_	_	
	Greater variance of fuel injection quantity	—	—	8	—	-	_	_	1	—	—	\otimes	8	_	\otimes	\otimes	_	\otimes	\otimes	\otimes
	Injection pump oil seals defective	_	_	_	_	_		_	_	_	_	_	_	_	_	_	_	_	_	_
	Insufficient fuel injection volume	8	8	_	_	_	_	_		8	_				_		_		_	_
_	Excessive fuel injection volume	_	_	_	_		_	_			_	_	-	_	8	-	_	_	+	_
ster	Injection nozzle defective			8		_	_				_	8	8	8	8	8		\otimes	8	8
Fuel system	Excessive fuel return from injection nozzles	_	8	_	_	_	_	_	_	8	_	_		_	_	_	_	\otimes	\otimes	—
	Injection timing is too advanced	_		8	_	_	_	_			8			8	\otimes	\otimes	_		_	—
	Injection timing is too retarded		_	8	_	_	_	_	_		_	8	8	_	_	_	_	\otimes	8	
	Engine speed is too low		_	_	_		_	_	_		_	_		_	_	_	_	_	8	_
	Failure to stop		_	_	_	-	_	_				_	_	_	-	-	-	_	_	
	Improper fuel		_	8	_	_	_				\otimes	8	8	8	\otimes	\otimes		_		
	Fuel viscosity is too high	8	8	_	1	_	_	_	_	_	_	_	_	_			-	_		
	Improper oil quality		_	_	_			_	_	_	_	_	_	_	_	_	_	_	_	
	Oil viscosity is too high	_	_	_	_	\otimes	_	_			_	_		_	_	_	_	_	_	
Ee	Oil viscosity is too low	_	_	_	_	_		_	_	_	_	_	_	8	_	_	_	_	_	
syste	Oil pressure does not rise				_	_		_	_	_	_	_	_	_	_	_	_	_	_	
Lubricating system	Oil leaks	_	_	_	_	_	_	_	_					_	_	_	_	_	_	
Jpric	Excessive pumping up of oil		_		_	_	_		_					8	\otimes	\otimes	_	_		
	Clogged oil filter	_	_		_	_	_	_			_				_	_	_	_	_	
	Oil pressure switch or lamp defective								_							_		_	_	_

				stop							luk	ormal oricati systen	on	Abno coo tempe	lant	dofo	nator ctive	
Engine vibrates excessively	Engine stalls	Poor response for deceleration	Engine does not pick up speeds	Engine operates at high speeds and does not stop	Engine rotates in reverse direction	Fuel consumption is high	Oil consumption is high	Fuel mixes with oil	Water mixes with oil	Excessive blowby	Indicator does not light when engine is not operating	Indicator lights when engine operates at low speed	Indicator lights when engine operates at high speed	Overheating	Low	Indicator does not light when engine is not operating	Indicator lights when engine operates at high speed	Remedies
	8		—			—			_	_	_		—				_	•
8	\otimes	_	_	-	_	8	_	1	1	1	_	-	_			_	_	•
	_	_	_	_	_	_	_	8	_	_	_		-				_	If disassembled, replace parts.
_	\otimes	_	8	_	_	_	-	_		_	-	_	_	_	_	_	_	•
	_	_	_	_	_	8	_	8	_	_	_	-	-	8		_	-	•
\otimes	8		_			8	_	8	_	_	_	_	_	_		_	_	•
_	8	_	_	_	_	8		_		_	_	_	_	_	_	_	_	Replace nozzle tip(s).
8	\otimes	_	_	_	_	8		-		-	_	-	_	_	_	_	_	•
_	8		_	_	_	8	_		_	_	_			8	_		_	•
\otimes	8		_	_	_	_			_	_	_	8		_	_		_	
_	_		_	_	\otimes	_		_	_	_	_			_	_		_	
	8					8				_	_			_	_		_	•
			_		_		-	-			_	_	_		_			Use fuel designed for cold areas.
	_									_	_			_				Use high quality oil.
	_		_	_		_			_	_		_	8	_			_	Use oil of proper viscosity.
			_		_		8			\otimes	_	8		_			_	Use oil of proper viscosity.
_	_			_	_				_	_	_	8		_			_	•
		_	_	_	_	_	8	_			_	_	_	_	_	_	_	Tighten bolts and nuts. Replace packing(s) if necessary.
_	_	_	_	_	_		8		_	_	_			_			_	•
	_		_					_		_		_	8			_		Replace filter element and oil.
_	_								_	_	8	8						Replace filter element and oil.

	Problems/Symptoms		Н	lard s	tartin	g					t enoi		\$	xhau smok onorm	е			_	Eng	
		Eng	jine tu	ırns		do	gine es turn		ast		ke	ke			n ation	pu		punos uo		
Pos	ssible causes	No exhaust smoke	Small amount of exhaust smoke	Large amount of exhaust smoke	Cranking speed low	Engine can be cranked manually	Engine can not be cranked manually	Glow plugs do not produce red heat	Glow plugs do produce red heat to fast	Small amount of exhaust smoke	Large amount of white exhaust smoke	Large amount of black exhaust smoke	At idling	White	Black	Engine produces loud knocking sound	Engine produces abnormal noice	Engine produces irregular combustion sound	At idling	In operation
em	Insufficient intake air			\otimes		-	_	_			_	\otimes	_	-	\otimes		—		-	_
ce syst	Insufficient compression pressure			8	_			_			8	8	8	8	8	8	_	8	\otimes	8
Air intake system	Ambient temperature is too high, or ambient pressure is too low (high altitude)	_	_	_	_	-	_	_	_	_	_	8	_	_	8	_	_	_	_	_
	Engine is too cold	_	_	8	8	-	-		_	-	_	_	8	_	-	8	-	_	+	_
tem	Excessive cooling by radiator			—	—	—	_	_			\otimes		8	8		\otimes	—		-	_
sys	Insufficient coolant	_	_	—	—	_	_	_			_	8	_	_	\otimes		-		—	_
Cooling system	Excessive cooling by radiator			—	—	—	_	_			_	\otimes	_	-	\otimes		—		-	_
Coc	Water leakage from cylinder head gasket	_	_	_	_	_	_	_	—	—	8	_	8	8	-	_	_	8	_	
	Cracks in crankcase water jacket	_	_	_	_	_	_	_	—	—	_	_			_	_	_	—	_	_
	Starter switch defective			_	_	8		\otimes				_					_		_	
	Starter magnetic switch defective	_	_	_	_	8			—	-		_			-	—	_	-	_	
	Starter defective				\otimes	8		_			_		-	-			—		_	_
	Starter free wheel defective	_	_	_	8	8	—		—	—		_	—	—	—	—	—	—	_	
Electrical system	Flywheel ring gear and pinion defective	_	_	_	_	8	_	_	_	_		_	_	_	-	_	_	-	_	-
trical s	Battery voltage is too low			8	8	8	_	8		_		_					_		_	_
Elec	Open circuit in glow plug or pilot lamp			8	—	—		8		—	—	_				—	_			
	Short circuit in glow plug	_	_	\otimes	_	_	_	_	\otimes	_	_	_	_	_	_	_	_	_	_	
	Alternator malfunction	_	_		_	_	_	_	_	_	_	_	_	_					_	
	Relay defective	_	_	_	_	_	_	_	_		_	_	_	_			_		_	
	Wiring defective	_	_	8	8	8	_	_	8	_	_	_	_	_	_	_	_	_	_	

				t stop							lul	ormal oricati syster	on	Abno coo tempe	lant	dofo	nator ctive			
Engine vibrates excessively	Engine stalls	Poor response for deceleration	Engine does not pick up speeds	Engine operates at high speeds and does not stop	Engine rotates in reverse direction	Fuel consumption is high	Oil consumption is high	Fuel mixes with oil	Water mixes with oil	Excessive blowby	Indicator does not light when engine is not operating	Indicator lights when engine operates at low speed	Indicator lights when engine operates at high speed	Overheating	Гом	Indicator does not light when engine is not operating	Indicator lights when engine operates at high speed	Remedies		
	8	_	8			8	_		_	_		-	-	_				•		
-	\otimes	_	_			\otimes	_	—	_	—	_	—	—		—	_	_	•		
-	_	-	_	_	_	8	_	-	_	_	_	_	_	8	_	_	_	(Adjust full-load setting of governor.)		
-	_	8	_	_	_		+	-	_	_	_	_	_	8	_	_	_	Heat oil pan at starting. After starting warm up engine thoroughly.		
_	_	_	_		-	8	_	_	_	_	_	_	_	_	8	_		•		
	_	_	_			_	8	-	_	8	_	8		8	_			•		
	_	—				_	8			\otimes	_	\otimes		8	_	_	-	•		
-	_	_	_			_	_		8	—					-			If bolts must be tightened, replace gasket.		
_	_	_				-	_		\otimes	_				—				Disassemble and replace crankcase.		
-	_	_	_			_	_		_	—			—		_			Disassemble and repair. Replace part(s) if necessary.		
_	_	_	_		8	_	_		_	—								Repair or replace.		
_	—	_	_			—	—	—	—		_		_		_	_	_	Repair or replace.		
	_	_	_	-	-	_	_	_	_	_	_	-	_		—	_	_	Repair or replace starter if necessary.		
	_	_	_			-	_	_	_	_			_		—			Repair or replace ring gear. Replace pinion gear.		
_	_	_	_		8	_	_	_	_	_	8	-	-	—	—	8		Charge or replace battery. Heat it if necessary.		
_	-	_	_	—	_	_	_	_	_	_	_	_	—	—	_		_	Replace part(s).		
	_	_	_	_	_	_	_	_	_	_	_	_	_		_	_	_	Replace copper packing(s). Replace glow plug(s), if necessary.		
			_		_				_	_	_	_	_		_	_	8	Replace alternator if necessary.		
_	—	_	_		8	_	—	—	_	_	_	-	_	_	_	8	8	Adjust or replace.		
—	—		_			—			_	_	\otimes	—	—	_	_	\otimes	—	Connect wires properly.		

	Problems/Symptoms		Н	lard s	tartin	g					t enoi		\$	xhaus smoke onorm	Э			_	Eng	
		Eng	ine tu	ırns		do	gine es turn		ast		ke	ke		oper:	n ation	pu		ou sonuc		
Pos	Possible causes		Small amount of exhaust smoke	Large amount of exhaust smoke	Cranking speed low	Engine can be cranked manually	Engine can not be cranked manually	Glow plugs do not produce red heat	Glow plugs do produce red heat to fast	Small amount of exhaust smoke	Large amount of white exhaust smoke	Large amount of black exhaust smoke	At idling	White	Black	Engine produces loud knocking sound	Engine produces abnormal noice	Engine produces irregular combustion sound	At idling	In operation
	Seizing of moving parts	_	_	_	8	_	8	_	_	_		8	_	_	8	_	8	8	_	
	Worn cylinder(s), piston(s) or piston ring(s)	_	_	8	_	_	_	_	_	_	8	_	8	8	_	8	8			
	Worn piston ring(s)		_	8		_	_		_		8	_	8	8	-	8			1	_
sme	Excessive oil clearance	_	_	_	_	_	_	_	_	_	_	_	-	-	_	_	8			
proble	Loose connecting rod cap bolts	_		_	_		_	_				_		_	_		8	_	-	_
Mechanical problems	Interference between valve(s) and piston(s)						8	_				_	_	-	-		8	-	-	_
Mec	Damaged valve spring(s)	_	_	8	_	_	_	_			8	_	8	8	_	_	8	8	8	8
	Excessive valve clearance											8	_	_	8		8	8	\otimes	8
	Foreign item in cylinder(s)		_	_		_	8	_	_		_	_	_	_	_	_	8	_	_	_
	Excessive gear backlash	_		_			_	_	_			_		_	_	_	8	_	_	_

				t stop							lul	ormal oricati systen	on	Abno coo tempe	lant	Alter defe	nator ctive	
Engine vibrates excessively	Engine stalls	Poor response for deceleration	Engine does not pick up speeds	Engine operates at high speeds and does not stop	Engine rotates in reverse direction	Fuel consumption is high	Oil consumption is high	Fuel mixes with oil	Water mixes with oil	Excessive blowby	Indicator does not light when engine is not operating	Indicator lights when engine operates at low speed	Indicator lights when engine operates at high speed	Overheating	Low	Indicator does not light when engine is not operating	Indicator lights when engine operates at high speed	Remedies
_	8	_	8	_	_	8	8	_	_	8	_	_	_	8		_	_	•
_	8					8	8	\otimes		8								Den ein en mente er
		_	—								_			_				Repair or replace.
_	8					8	8	8		8		⊗	⊗		_		1	Repair or replace.
-	⊗ 			— —			⊗ —	⊗ —		⊗—	_ _	⊗—	⊗—					
+	⊗——						× —	⊗ 	_ _ _	⊗ 	_ 	⊗———	⊗———					Repair or replace. Check and replace bearings with
	⊗ 						× — — —	⊗ 	_ _ _ _	⊗——	_ _ _	⊗———	— ⊗ —					Repair or replace. Check and replace bearings with undersize ones if necessary.
							× — — — — —	×		×		- - -	- - -					Repair or replace. Check and replace bearings with undersize ones if necessary. Tighten. Reinstall timing gears or adjust
 &							×	⊗ 		× — — — — — — — — — — — — — — — — — — —		- ×	- - - - -					Repair or replace. Check and replace bearings with undersize ones if necessary. Tighten. Reinstall timing gears or adjust valve sinkage.
							× — — — — — — — — — — — — — — — — — — —			⊗ 			- - - - - -					Repair or replace. Check and replace bearings with undersize ones if necessary. Tighten. Reinstall timing gears or adjust valve sinkage. Replace part(s). Adjust valve clearance to 0.25

Causes	Details of Causes	Remedies
Fuel is not supplied to	Fuel tank supply valve is closed	Open the valve.
injection pumps properly	No fuel in tank	Add fuel.
	Fuel lines restricted	Repair or clean fuel pipes with compressed air.
	Air in fuel system	Tighten mounting sections or replace fuel pipes.
	Fuel leakage	Retighten connections.
	Fuel filter is clogged	Clean or replace filter element.
	Inadequate air bleeding	Conduct air bleeding.
Irregular injection pump	Sticking of plunger(s)	Disassemble and replace parts.
operation	Worn plunger(s)	Disassemble and replace parts.
	Worn bearing(s)	Disassemble and replace parts.
	Damaged plunger spring(s)	Disassemble and replace parts.
	Loose plunger pinion(s)	Reinstall by matching marks.
	Delivery valve(s) defective	Replace parts.
	Damaged delivery valve spring(s)	Replace parts.
Insufficient fuel injection	Catching of governor stop lever link	Repair link properly and set lever to neutral position.
volume (by injection pump)	Control rack does not move	Supply lubricant, or disassemble and repair.
	Seizing of plunger(s)	Disassemble and replace parts.
	Worn plunger(s)	Disassemble and replace parts.
	Worn bearing(s)	Disassemble and replace parts.
	Loose plunger pinion(s)	Reinstall by matching marks.
	Full-load setting of governor does not move	Readjust governor setting on bench.
Excessive fuel injection volume	Stop lever sticking in "increase" position	Repair link properly and set lever to neutral position.
volume	Full-load setting of governor improper	Adjust governor setting on bench.
	Loose plunger pinion(s)	Reinstall by matching marks.
Fuel injection nozzle(s) defective	Seizing of nozzle tip needle	Repair or replace.
delective	Nozzle tip seat(s) defective	Repair or replace.
	Damaged nozzle spring(s)	Replace parts.
	Fuel injection pressure is too low	Change adjusting shim and set standard injection start pressure using nozzle tester.
	Carbon deposits on packing at nozzle tip(s)	Remove carbon deposits.
Fuel injection timing is too advanced	Faulty mounting angle of injection pump	Tilt injection pump toward outside of engine and adjust timing.
	Timing gears incorrectly installed	Correct timing gear engagement.
Fuel injection timing is too retarded	Faulty mounting angle of injection pump	Tilt injection pump toward outside of engine and adjust timing.
	Timing gears incorrectly installed	Correct timing gear engagement.
	Worn fuel injection pump bearing	Replace parts.

Causes	Details of Causes	Remedies
Improper fuel	Poor fuel quality	Drain fuel, and add high-quality fuel.
	Water is mixed with fuel	Drain fuel, and add high-quality fuel.
Low oil pressure	Insufficient amount of oil in oil pan	Add oil to specified level.
	Air in oil strainer	Correct damaged pipe and loose flange by replacing parts and tightening.
	Oil pump defective	Disassemble and repair.
	Oil lines restricted	Disassemble and clean.
	Relief valve defective	Disassemble and inspect for damaged spring, foreign particles on valve, and other abnormalities.
	Clogged oil filter	Replace filter element and oil.
	Leak in oil lines	Disassemble and repair.
Pumping up of oil	Too much oil in oil pan	Drain oil to specified level.
	Worn cylinder(s), piston(s) or piston ring(s)	Disassemble and repair. Replace parts.
	Seizing of piston ring(s)	Disassemble and repair. Replace parts.
	Worn valve guide(s)	Disassemble and repair. Replace parts.
	Engine operated too long under no load	Disassemble and repair if engine continues to produce smoke for a while or if large amount of oil is discharged from exhaust pipe.
Insufficient intake air	Clogged air cleaner	Clean or replace filter element.
	Clogged intake manifold	Inspect and clean.
Insufficient compression	Valve seat(s) defective	Disassemble and correct.
pressure	Seizing of valve stem(s)	Disassemble and correct.
	Valve is pressed down by rocker	Adjust valve clearance to 0.25 mm [0.0098 in.].
	Worn cylinder(s), piston(s) or piston ring(s)	Disassemble and repair. Replace parts.
	Seizing of piston ring(s)	Disassemble and repair. Replace parts.
	Gas leakage from cylinder heah gasket	Tighten. Replace gasket if necessary.
	Damaged valve spring(s)	Disassemble and replace parts.
	Insufficient starter speed (at startup)	Disassemble and replace parts.
Insufficient coolant	Overheating	Add coolant to specified level.
	Water leakage from unit seal of water pump	Disassemble and replace parts.
	Cracks in crankcase water jacket	Disassemble and replace parts.
	Water leakage from other part(s)	Disassemble and replace parts.
Insufficient cooling by radiator	Inadequate air bleeding of cooling system	Loosen air vent plug, drainage plug or hose clamp, and bleed air.
	Bust or water eagle accumulation inside redictor	Clean.
i	Rust or water scale accumulation inside radiator	
	Dust accumulation on radiator	Clean.
		Clean. Adjust belt tension.

Causes	Details of Causes	Remedies
Excessive cooling by	Ambient temperature is low	
radiator	Radiator is not covered	Cover radiator.
	Thermostat defective (stuck open)	Replace parts.
Seizing of moving parts	Seizing of cylinder(s), piston(s) or piston ring(s)	Disassemble and repair. Replace parts.
	Seizing of main or connecting rod bearing(s)	Disassemble and repair. Replace parts.
	Seizing of idler gear bushing	Disassemble and repair. Replace parts.

MAINTENANCE STANDARDS

35 MAINTENANCE STANDARDS TABLE

Unit: mm [in.]

Group	Ir	nspect	ion Point	Nominal Value	Assembly Standard (Standard Clearance)	Repair Limit (Clearance)	Service Limit (Clearance)	Remark
	Maximu	m speed	d, (no-load), rpm	Vary a	according to			Adjust asyonar acting
	Minimur	n speed	l, (no-load), rpm	spec	cifications			Adjust governor setting.
	Compre (kgf/cm ²	ssion pr ²) [psi]	essure, MPa	2.94 (30) [4	27] at 150 to 200 rpm	2.55 (26) [370]		Oil and water temp. 20 to 30°C [68 to 86°F]
	Engine (oil press	sure, MPa (kgf/		to 4) [28 to 57] at ted rpm	0.15 (1.5) [21.3]		Oil temperature 70 to 90°C
	cm ²) [ps	si]			or more at low idle speed	0.05 (0.5) [7]		[158 to 194°F]
General	Valve tir	ming		Inlet v Exhaus	valves open valves close t valves open valves closed	BTD0 ATD0 BTD0 ATD0 ±3° (crar	C 50° C 74° C 30°	
	Valve cl	earance	(cold)		0.25 [0.0098]			Bolt inlet and exhaust valves.
	Fuel inje	ection tir	ming		BTD	C 20°		Standard injection timing is indicated here. The timing for each model of engine varies according to its specification. Be sure to verify the timing by referring to the specifications of each model.
	Fan (wa drive be		p) and alternator n		13 [0.5], approx.			When belt is pushed inward with 98 N (22 lbf) [10 kgf] pressure exerted midway between crankshaft and alternator pulleys.
	Crankca	ase	Flatness of surface gasket		0.05 [0.0020] or less	0.20 [0.0079]		Regrind if warpage is minor.
			Inside diameter	88 [3.46]	88 ₀ ^{+0.035} [3.46 ₀ ^{+0.0014}]			
Parts	Cylinder	r	Circularity		0.01 [0.0004] or less			Increase bore to 0.25 [0.0098] or 0.50 [0.0197] oversize and use oversize piston.
Engine Main Parts			Cylindricity		0.015 [0.0006] or less			
Engin	ring	Bore for main bearing	Inside diameter	69 [2.72]	69 ₀ ^{+0.019} [2.72 ₀ ^{+0.0008}]			
	Main bearing	or main	Out-of-round		0.02 [0.0008] or less			With main bearing cap installed (bolts tightened).
	≥	Bore f	Concentricity		0.05 [0.0020] or less			

Group		Inspection I	Point	Nominal Value	Assembly Standard (Standard Clearance)	Repair Limit (Clearance)	Service Limit (Clearance)	Remark
	Main bearing	Oil clearance between crar journal and n bearing)	nkshaft		(0.035 to 0.100) ([0.0014 to 0.0039])		(0.200) ([0.0079])	
	Mair	Width of thru	st journals	23 [0.91]	22.979 to 23.000 [0.9047 to 0.9055]			
	Tappet bore	Inside diame	ter	14 [0.55]	14.000 to 14.018 [0.5512 to 0.5519]		14.100 [0.5551]	
	Тарре	Clearance be tappet and be			(0.016 to 0.052) ([0.0006 to 0.0021])		(0.080) ([0.0032])	
		Inside diame bushing (No.		54 [2.13]	54.030 to 54.050 [2.1272 to 2.1280]			61GT only
	amshaft	Inside diameter of	No. 1 and No. 2	54 [2.13]	54.030 to 54.050 [2.1272 to 2.1280]			
	case for	bores for camshaft	No. 3	53 [2.09]	53.030 to 53.050 [2.0878 to 2.0886]			
	crankca	Out-of-round			0.02 [0.0008] or less			
	Bore in	Concentricity	,		0.05 [0.0020] or less			
Engine Main Parts		Clearance be camshaft and			(0.07 to 0.11) ([0.0028 to 0.0043])		(0.15) ([0.0059])	
gine Ma	Cylinder head	Warpage of b	oottom face		0.05 [0.0020] or less	0.20 [0.0079]		Regrind if warpage is minor
E	Cylinde	Compressed of gasket	thickness	1.3 [0.05]	1.27 to 1.35 [0.0500 to 0.0531]			
	_	Valve stem	Inlet valve	8	7.940 to 7.955 [0.3126 to 0.3132]		7.900 [0.3110]	
	re guide	diameter	Exhaust valve	[0.315]	7.920 to 7.940 [0.3118 to 0.3126]		7.850 [0.3091]	
	Valves and valve guide	Clearance between	Inlet valve		(0.065 to 0.095) ([0.0026 to 0.0037])		(0.200)	
	Valves	stem and guide	Exhaust valve		(0.080 to 0.115) ([0.0032 to 0.0045])		([0.0079])	
		Height to top guide	of valve	15.5 [0.61]	15.1 to 15.6 [0.5945 to 0.6142]			
		Angle		30°				nid th
	eat	Valve sinkag	е	0.8 [0.03]	0.7 to 0.9 [0.0276 to 0.0354]		1.3 [0.0512]	sed with
	Valve seat	Width		1.18 [0.05]	1.04 to 1.32 [0.0409 to 0.0520]		1.6 [0.0630]	
		Valve margin	ı	1.70 [0.0669]			Up to 1.20 [0.0472] by refacing	Valve margin Valve seat sinkage angle

Group	Inspection Point		Nominal Value	Assembly Standard (Standard Clearance)	Repair Limit (Clearance)	Service Limit (Clearance)	Remark
		Free length		48.85 [1.92]		47.60 [1.87]	
	Valve spring	Perpendicularity (distortion)		1.5° or less			Squareness of ends with respect to center line
	Valve	Set length/set force N (kgf) [lbf]		43 [1.69]/ 177 to 196 (18 to 20) [40 to 44]		147 (15) [33]	
	(high-	Free length		50.0 [1.9685]		49.0 [1.9291]	
	e spring (Perpendicularity (distortion)		1.5° or less			Squareness of ends with respect to center line
	Inner valve spring (high- speed option)	Set length/set force N (kgf) [lbf]		38.5 [1.52]/ 56.9 (5.8) [12.8]		38.5 [1.52]/ 48.1 (4.9) [10.8]	
	u	Inside diameter of rocker arm (bushing)	19	19.010 to 19.030 [0.7484 to 0.7492]			
	Rocker arm	Diameter of rocker shaft	[0.75]	18.980 to 19.000 [0.7472 to 0.7480]			
ו Parts	R	Clearance between rocker arm and shaft		(0.010 to 0.050) ([0.0004 to 0.0020])	(0.070) ([0.0028])		
Engine Main Parts	Valve pushrod	Runout		0.3 [0.012] or less			Dial indicator reading
		Deflection		0.02 [0.0008] or less	0.05 [0.0020]		
		Diameter of journal	65 [2.56]	64.965 to 64.985 [2.5577 to 2.5585]			
		Diameter of crankpin	58 [2.28]	57.955 to 57.970 [2.2817 to 2.2823]			
	aft	Distance from center of journal to center of crankpin	47.5 [1.870]	47.46 to 47.54 [1.8685 to 1.8716]			
	Crankshaft	Parallelism between journal and crankpin		Runout: 0.01 [0.0004] or less			
		Out-of-round of journal and crankpin		0.01 [0.0004] or	0.03		
		Taper of journal and crankpin		less	[0.0012]		
		Fillet radius of journal and crankpin	3 [0.12]	±0.2 [±0.008]			
		End play		(0.10 to 0.20) ([0.0039 to 0.0080])		(0.30) ([0.0118])	

Group	ı	Inspection Point		Nominal Value	Assembly Standard (Standard Clearance)	Repair Limit (Clearance)	Service Limit (Clearance)	Remark
		r (at	Standard	87.970 [3.4634]	87.955 to 87.985 [3.4628 to 3.4640]		87.770 [3.4555]	
		Outside diameter (at skirt)	0.25 [0.0098] oversize	88.220 [3.4732]	88.205 to 88.235 [3.4726 to 3.4738]		88.020 [3.4654]	
	Piston	Outside	0.50 [0.0197] oversize	88.470 [3.4831]	88.455 to 88.485 [3.4825 to 3.4837]		88.270 [3.4752]	
		Protrus	ion		0.13 to 0.60 [0.0051 to 0.0236]			Check bearing clearance.
		Weight engine	difference in one		5 g [0.2 oz] or less			
		ween	No. 1 ring		(0.060 to 0.100) ([0.0024 to 0.0039])		(0.200) ([0.0079])	Danlace vistes visco if
		Clearance between groove and ring	No. 2 ring		(0.045 to 0.080) ([0.0018 to 0.0032])		(0.150)	Replace piston rings if service limit is not exceeded. Replace piston if
	ı ring	Cleara	Oil ring		(0.025 to 0.065) ([0.0010 to 0.0026])		([0.0059])	service limit is exceeded.
	Piston ring	between ston ring	No. 1, No. 2 ring		(0.25 to 0.40) ([0.0098 to 0.0157])		(1.50) ([0.0591])	
Engine Main Parts		Clearance between end of piston ring	O-ring		(0.30 to 0.50) ([0.0118 to 0.0197])		([0.0591])	
gine Ma		Diamet	er	28 [1.10]	27.994 to 28.000 [1.1021 to 1.1024]			
Eng	Piston pin	Clearar and bor	nce between pin re		0.000 to 0.016 [0.0000 to 0.0006]		0.050 [0.0020]	Replace pin if service limit is nog exceeded. Replace piston if service limit is exceeded.
		Clearar and bus	nce between pin shing		(0.020 to 0.051) ([0.0008 to 0.0020])		(0.080) ([0.0032])	Replace pin or bushing. Ream if necessary.
		Inside of	diameter of	28 [1.10]	28.020 to 28.045 [1.1031 to 1.1041]			
		Bend a	nd twist		0.05/100 [0.0020/ 3.94] or less	0.15/100 [0.0059/3.94]		
	Connecting rod	crankpi	ting rod bearing		(0.03 to 0.09) ([0.0012 to 0.0035])	(0.20) ([0.0079])		
	conne		Thrust clearance of connecting rod big-end (End play)		(0.15 to 0.35) ([0.0059 to 0.0138])		(0.50) ([0.020])	Replace connecting rod.
		Weight difference in one engine			10 g [0.35 oz] or less			
	leel	Flatnes	s		0.15 [0.0059] or less	0.50		
	Flywheel	Face ru	ınout		0.15 [0.0059] or less	[0.0197]		

Group	ı	Inspection Point		Nominal Value	Assembly Standard (Standard Clearance)	Repair Limit (Clearance)	Service Limit (Clearance)	Remark
		Deflection			0.02 [0.0008] or less	0.05 [0.0020]		Straighten by cold working or replace.
		lift C	Inlet valve	A= 46.916 ^{+0.1} [1.84709]	6.684 [0.2631]		6.184 [0.2435]	A C
	Camshaft	mshaft Lobe lift C	Exhaust valve	A= 45.944 ^{+0.1} [1.80882]	7.344 [0.2891]		6.844 [0.2694]	B
	O	Diameter of journals	No. 1, 2	54 [2.13]	53.94 to 53.96 [2.1236 to 2.1244]		53.90 [2.1220]	
arts		Diame	No. 3	53 [2.09]	52.94 to 52.96 [2.0843 to 2.0850]		52.90 [2.0827]	
Engine Main Parts		End pla	ау	5 [0.20]	(0.10 to 0.25) ([0.0039 to 0.0098])		(0.30) ([0.0118])	Replace thrust plate.
Engine			nce between nd bushing		(0.025 to 0.075) ([0.0010 to 0.0030])		(0.100) ([0.0039])	Replace bushing.
	ldler gear	End play			(0.05 to 0.20) ([0.0020 to 0.0079])		(0.35) ([0.0138])	Replace thrust plate.
	Þ	Fit (interference) of shaft in crankcase bore			(-0.039 to -0.076) ([-0.0015 to - 0.0030])			
	_	Cranks idler ge	haft gear and ear		(0.05 to 0.15)			
	Backlash	ldler ge gear	ear and camshaft		([0.0020 to 0.0059])		(0.25) ([0.0098])	Replace gears.
			n pump drive nd idler gear		(0.04 to 0.16) ([0.0016 to 0.0063])			
			nce between otor and inner		(0.13 to 0.15) ([0.0051 to 0.0059])		(0.20) ([0.0079])	
E			nce between and cover		(0.04 to 0.09) ([0.0016 to 0.0035])		(0.15) ([0.0059])	
ın syste	dwnd		nce between otor and case		(0.200 to 0.275) ([0.0079 to 0.0108])		(0.500) ([0.0197])	
Lubrication system	d lio	Shaft d	iameter	13 [0.51]	12.985 to 13.000 [0.5112 to 0.5118]			
וי			nce between nd case		(0.032 to 0.074) ([0.0013 to 0.0029])			
		Relief valve opening pressure, kPa (kgf/cm²) [psi]		343 (3.5) [50]	343 ± 49 (3.5 ± 0.5) [50 ± 7]			
system	ostat	Temp. a	at which valve pening		76.5 ± 1.5°C [170 ± 2.7°F]			
Cooling system	Thermostat		at which valve re than 8 [0.3]		90°C [194°F]			

Group	Inspection Point		ion Point	Nominal Value	Assembly Standard (Standard Clearance)	Repair Limit (Clearance)	Service Limit (Clearance)	Remark	
		Valve o MPa (k	pening pressure, gf/cm ²) [psi]	14.22 (145) [2063]	14.22 to 15.00 (145 to 153) [2063 to 2177]				
Fuel system	Injection nozzle	Spray cone angle		0°				Check nozzle with a hand tester (at fuel oil temperature 20°C [68°F]). Replace the nozzle tip if the spray pattern is still bad after washing in clean fuel oil.	
			tness of needle eat	MPa (40 ± 2. psi] with N2 (an oil tank (a for more than	re of 3.92 ± 0.25 5 kgf/cm ²) [569 ± 36 gas and submerge in t room temperature) 5 minutes. Check to ere is no leakage.			Wash or replace nozzle tip.	
		Commutator	Diameter	32 [1.26]			31.4 [1.24]		
		Comm	Runout		0.05 [0.0020]		0.10 [0.0039]		
		Commutator mica depth			0.4 to 0.6 [0.016 to 0.024]	0.2 [0.008]			
		ls h	Length	18 [0.71]			11 [0.43]		
		Brush	Spring tension, N (kgf) [lbf]		29 to 39 (3.0 to 4.0) [6.5 to 8.8]		19.6 (2.0) [4.4]		
	Starter	Pinion	clearance		0.5 to 2.0 [0.020 to 0.079]				
	Ste	For 12\	J						
stem			No-loa	ad character	istics	Magnetic switch operating voltage			
cal sy		V	oltage, V	Current, A	Speed, rpm	8 volts or less	, with pinion held	d at 2 mm [0.08 in.] position	
Electrical system			11	130 or less	4000 or more		from cranking	g position	
		For 24\	√ (Option)						
				ad character	istics	Magı	netic switch o	perating voltage	
		V	oltage, V	Current, A	Speed, rpm	16 volte or los	s with ninion hol	d at 2 mm [0.08 in.] position	
			23	80 or less	3000 or more	10 voits of less	from cranking	g position	
	Alternator	Brush I	ength		18.5 [0.728]		7 [0.276] 5 [0.197] Option (A7TA80AA) (A3TN5776)		
		Resista ring	ance between slip		3.4Ω			At 20°C [68°F]	

36 TIGHTENING TORQUES

36.1 Important Bolts and Nuts

D. C. C. L. C. C. C.	Thread Dia. x	Width across		Torque	
Parts to be fastened	Pitch, mm (M- thread)	flats, mm [in.]	N·m	kgf⋅m	lbf·ft
Cylinder head	M12 x 1.75	19 [0.75]	118 ± 5	12.0 ± 0.5	87 ± 4
Rock cover	M8 x 1.25	12 [0.47]	12 ± 1	1.2 ± 0.1	9 ± 1
Rocker shaft bracket (long bolt)	M8 x 1.25	12 [0.47]	15 ± 2	1.5 ± 0.2	11 ± 1
Main bearing cap	M12 x 1.75	12 [0.47]	83 ± 5	8.5 ± 0.5	61 ± 4
Connecting rod cap	M10 x 1	14 [0.55]	54 ± 5	5.5 ± 0.5	40 ± 4
Flywheel	M12 x 1.25	17 [0.67]	83 ± 5	8.5 ± 0.5	61 ± 4
Camshaft thrust plate	M8 x 1.25	12 [0.47]	12 ± 1	1.2 ± 0.1	9 ± 1
Front end plate	M8 x 1.25	12 [0.47]	12 ± 1	1.2 ± 0.1	9 ± 1
Timing gear case and cover	M8 x 1.25	12 [0.47]	12 ± 1	1.2 ± 0.1	9 ± 1
Crankshaft pulley	M24 x 1.5	34 [1.34]	392 ± 10	40 ± 1	289 ± 7
Flywheel housing	M10 x 1.25	14 [0.55]	60 ± 6	6.1 ± 0.6	44 ± 4
Oil pan	M8 x 1.25	12 [0.47]	7.8 ± 1	0.8 ± 0.1	5.8 ± 1
Oil pan drain plug	M14 x 1.5	22 [0.87]	39 ± 4	4.0 ± 0.4	29 ± 3
Oil filter shaft	M20 x 1.5		49 ± 5	5.0 ± 0.5	36 ± 4
Oil filter	M20 x 1.5	_	12 ± 1	1.2 ± 0.1	9 ± 1
Fuel injection nozzle	M20 x 1.5	21 [0.83]	59 ± 6	6.0 ± 0.6	43 ± 4
Fuel injection nozzle retaining nut	M16 x 0.75	21 [0.83]	37 ± 2.5	3.77 ± 0.25	27 ± 1.8
Fuel leak-off pipe	M12 x 1.5	17 [0.67]	23 ± 2	2.3 ± 0.2	17 ± 1
Fuel injection pump gear	M12 x 1.75	19 [0.75]	64 ± 5	6.5± 0.5	47 ± 4
B terminal of starter	M8 x 1.25	12 [0.47]	11 ± 1	1.1 ± 0.1	8 ± 1
Glow plug (body) Glow plug (terminal)	M10 x 1.25 M4 x 0.7	12 [0.47] 8 [0.31]	18 ± 2 1.3 ± 0.2	1.8 ± 0.2 0.13 ± 0.02	13 ± 1 0.94 ± 0.14
Exhaust manifold	M8 x 1.25	12 [0.47]	30 ± 2	3.1 ± 0.3	22 ± 2
Pressure relief valve	M22 x 1.5	27 [1.06]	49 ± 5	5.0 ± 0.5	36 ± 4
Coolant drain plug	1/4-18NPTF	14 [0.55]	39 ± 4	4.0 ± 0.4	29 ± 3
Fuel injection pipe	M12 x 1.5	19 [0.75]	29 ± 3	3.0 ± 0.3	22 ± 2
Fuel return pipe	M10 x 1.25	14 [0.55]	20 ± 2	2.0 ± 0.2	14 ± 1
Oil pump set bolt	M12 x 1.75	17 [0.67]	34 ± 4	3.5 ± 0.4	25 ± 3
Overheat warning unit (thermoswitch)	M16 x 1.5	19 [0.75]	23 ± 2	2.3 ± 0.2	17 ± 1
Drain plug	M16 x 1.5	24 [0.94]	44 ± 5	4.5 ± 0.5	33 ± 4

36.2 Standard Bolts

	Torque						
Thread Dia. x Pitch mm (M-thread)		4T		7T			
	N·m	kgf⋅m	lbf∙ft	N·m	kgf·m	lbf·ft	
M6 x 1.0	4 ± 1	0.4 ± 0.1	3 ± 1	9 ± 1	0.9 ± 0.1	7 ± 1	
M8 x 1.25	12 ± 1	1.2 ± 0.1	9 ± 1	18 ± 3	1.85 ± 0.35	13 ± 3	
M10 x 1.25	22 ± 3	2.2 ± 0.3	16 ± 2	35 ± 6	3.6 ± 0.6	26 ± 4	
M12 x 1.25	35 ± 6	3.6 ± 0.6	26 ± 4	64 ± 10	6.5 ± 1	47 ± 7	

36.3 Standard Studs

	Torque (tap end)							
Thread Dia. x Pitch mm (M-thread)	For driving	ı in aluminiur	n materials	For driving in ferrous materials				
	N·m	kgf·m	lbf·ft	N·m	kgf⋅m	lbf·ft		
M8 x 1.25	7.4 ± 0.8	0.75 ± 0.1	5.4 ± 0.6	13 ± 1	1.3 ± 0.1	9 ± 1		
M10 x 1.5	14 ± 1	1.4 ± 0.1	10 ± 1	24 ± 2	2.4 ± 0.2	17 ± 1		

36.4 Standard Plugs

	Torque						
Thread Dia. x Pitch	For a	luminium mat	terials	For ferrous materials			
	N·m	kgf·m	lbf∙ft	N·m	kgf⋅m	lbf·ft	
NPTF 1/16	6 ± 1.5	0.65 ± 0.15	4.7 ± 1	10 ± 2	1.0 ± 0.2	7 ± 1	
PT 1/8	10 ± 2	1.0 ± 0.2	7 ± 1	18 ± 3	1.85 ± 0.35	13 ± 3	
PT 1/8, NPTF 1/4	25 ± 5	2.5 ± 0.5	18 ± 4	39 ± 5	4.0 ± 0.5	29 ± 4	
PT 3/8	_	_	_	64 ± 10	6.5 ± 1	47 ± 7	

37 THREAD SEALANTS

Application Point	Mating Parts	Sealant	How to Use
Cylinder head coolant hole plug	Cylinder head	Three Bond 1386D	Apply to hole and install plug.
Crankcase coolant hole plug	Crankcase	Three Bond 1386D	Apply to hole and install plug.
Crankcase oil gallery plug	Crankcase	Three Bond 1386D	Apply to hole and install plug.
Crankcase oil return pipe	Crankcase	Three Bond 1344	Apply to pipe and tighten.
Crankcase No.1 and No.5 bearing cap grooves	Oil pan gasket and U-seal	Three Bond 1207C or 1211	See page 54.
Starter mounting stud	Rear plate	Three Bond 1344	Apply to stud and tighten.
Injection pump mounting stud	Flange plate	Three Bond 1344	Apply to stud and tighten.

38 MAINTENANCE SCHEDULE

- Use the service meter to determine servicing intervals.
- The servicing intervals in the schedule are for an average operating conditions. Service the engine earlier than the scheduled intervals if necessary. (The intervals depends on application, operating conditions and fuel oil and lube oil used in the engine. Adjust the intervals to meet the actual operating conditions.)
- Perform service on items at multiples of the original requirement. For example, at Every 250 service hours, also service those items listed under Every 50 service hours and Every 10 service hours.
- ⊗ Check, clean, wash or adjust.
- Change.
- S Rely on Mitsubishi dealer if necessary.
- * Items to be serviced after initial 50 hours of operation of a new, reconditioned or long-stored engine.

	ltem				Interval			
Group			Every 10 service hours	Every 50 service hours	Every 250 service hours	Every 500 service hours	Every 1000 service hours	Remarks
	Walk-around inspection	Check	8					
General	Valve clearance	Check				8		S
O	Boils and nuts (cylinder head bolts)	Retighten		*			8	S
tem	0.11	Check oil level	8					
on sys	Oil pan	Change oil		*	•			S
Lubrication system	Oil filter (cartridge)	Change		*	•			
	Fuel tank	Check oil level	8					
stem	ruei tank	Drain moisture		8				
Fuel system	Fuel filter	Change				•		
Fu	Injection nozzles	Check				8		S

				Interval					
Group	Ite	em	Every 10 service hours	Every 50 service hours	Every 250 service hours	Every 500 service hours	Every 1000 service hours	Remarks	
tem	Radiator	Check coolant level	8						
Cooling system		Change coolant		Every 2 years					
ooline	Radiator fins	Clean			8				
O	Fan belt	Check tension				8			
tem		Check indicator		8				S	
et syst	Air cleaner (paper-element	Clean element				8			
Air inlet system	type)	Change element					•		
Electrical system	Battery	Check electrolyte level and specific gravity		8				Check specific gravity from time to time	
ectrica	Alternator	Check					8	S	
i ii	Starter	Check					8	S	

SPECIAL TOOLS

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Tool name	Part No.	Shape	Use
Valve spring pusher	30691-04500		Valve spring removal/installation
Valve guide remover	32A91-00300		Valve guide removal
Valve guide installer	32A91-00100		Valve guide installation
Valve seat insert caulking tool	Intake 30691-02700 Exhaust 30691-02800		Valve seat installation
Idler gear bushing installer	30691-51900		Idler gear bushing removal/ installation
Idler gear shaft puller	MH061077		Idler gear shaft removal
Piston ring pliers	31391-12900		Piston ring removal/installation

Tool name	Part No.	Shape	Use
Crankcase oil seal sleeve installer set	30691-13010	6350	Crankshaft rear oil seal sleeve installation
Piston guide (installer)	30691-58100		Piston installation
Adaptor	30691-21100		Compression pressure testing
Compression gage	33391-02100		Compression pressure testing
Turning handle	30691-21800		Engine turning
Socket	34491-00300	6	Camshaft thrust plate and rocker shaft bracket installation
Stem seal installer	32A91-00200		Stem seal installation

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