TECHNICAL MANUAL

WESTERBEKE

20B TWO

30B THREE

MARINE DIESEL

PROPULSION ENGINE

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WESTERBEKE CORPORATION • MYLES STANDISH INDUSTRIAL PARK
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SAFETY PRECAUTIONS

The following symbols appear in this manual to call attention to and emphasize conditions potentially dangerous to the operator.

WARNING

The above symbol is used in the manual to warn of possible serious personal injury or loss of life.

CAUTION

The above symbol is used in the manual to caution personnel of possible damage to equipment.

Read the manual carefully and thoroughly before attempting to operate the equipment. Know when dangerous conditions can exist and take necessary precautions to protect personnel and equipment.

Fuels, exhaust gases, batteries, electrical equipment, and moving and hot parts are potential hazards that could result in serious personal injury or death. Follow recommended procedures carefully.

Always operate bilge blowers for at least five minutes before starting a gasoline-fueled engine; ensure no gasoline fumes are present before starting.

- Prevent Electric Shock

  Shut off electric power before accessing electrical equipment.

  Use insulated mats whenever working on electrical equipment.

  Make sure your clothing is dry, not damp (particularly shoes), and keep your skin surfaces dry when handling electrical equipment.

  Remove wristwatch and jewelry when working on electrical equipment.

  Do not connect utility shore power to vessel's AC circuits, except through a ship-to-shore double-throw transfer switch. Damage to vessel's AC generator may result if this is not done.

  Be extremely careful when working on electrical components. High voltage can cause injury or death.

- Exhaust Gases Are Toxic

  Ensure that the exhaust system is adequate to expel gases discharged from the engine. Check exhaust system regularly for leaks and make sure the exhaust manifolds are securely attached and no warping exists.

  Be sure the unit and its surroundings are well-ventilated.

- Use Extreme Care When Handling Engine Fuel (A constant danger of explosion or fire exists)

  Do not fill fuel tank(s) while the engine is running.

  Do not smoke or use an open flame near the engine or the fuel tank.

- Do Not Alter or Modify the Fuel System

  Be sure all fuel supplies have a positive shut-off valve.

  Be certain fuel line fittings are adequately tightened and free of leaks.

  Make sure a fire extinguisher is installed nearby and is properly maintained. Be familiar with its proper use. Extinguishers rated ABC by the NFPA are appropriate for all applications encountered in this environment.

- Use Extreme Care When Servicing Batteries

  Wear rubber gloves, a rubber apron, and eye protection when servicing batteries.

  Lead acid batteries emit hydrogen, a highly-explosive gas, which can be ignited by electrical arcing or by a lighted cigarette, cigar, or pipe. Do not smoke or allow an open flame near the battery being serviced. Shut off all electrical equipment in the vicinity to prevent electrical arcing during servicing.

- Avoid Moving Parts

  Do not service the unit while the unit is running; if a situation arises in which it is absolutely necessary to make operating adjustments, use extreme care to avoid moving parts and hot exhaust system components.

  Do not wear loose clothing or jewelry when servicing equipment; avoid wearing loose jackets, shirts or sleeves, rings, necklaces, or bracelets that might be caught in moving parts.

  Make sure all attaching hardware is properly tightened. Keep protective shields and guards in their respective place at all times.

  Do not check fluid levels or the drive-belt's tension while the unit is operating.

  Do not work on the equipment when mentally or physically incapacitated by fatigue.

IMPORTANT

PRODUCT SOFTWARE DISCLAIMER

Product software of all kinds, such as brochures, drawings, technical data, operator's and workshop manuals, parts lists and parts price lists, and other information, instructions and specifications provided from sources other than Westerbeke, is not within Westerbeke's control and; accordingly, is provided to Westerbeke customers only as a courtesy and service. **Westerbeke cannot be responsible for the content of such software, makes no warranties or representations with respect thereto, including the accuracy, timeliness or completeness thereof, and will in no event be liable for any type of damages or injury incurred in connection with, or arising out of, the furnishing or use of such software.**

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In summation, product software provided with Westerbeke products, whether from Westerbeke or other suppliers, must not and cannot be relied upon exclusively as the definitive authority on the respective product. It not only makes good sense but is imperative that appropriate representatives of Westerbeke or the supplier in question be consulted to determine the accuracy and currency of the product software being consulted by the customer.

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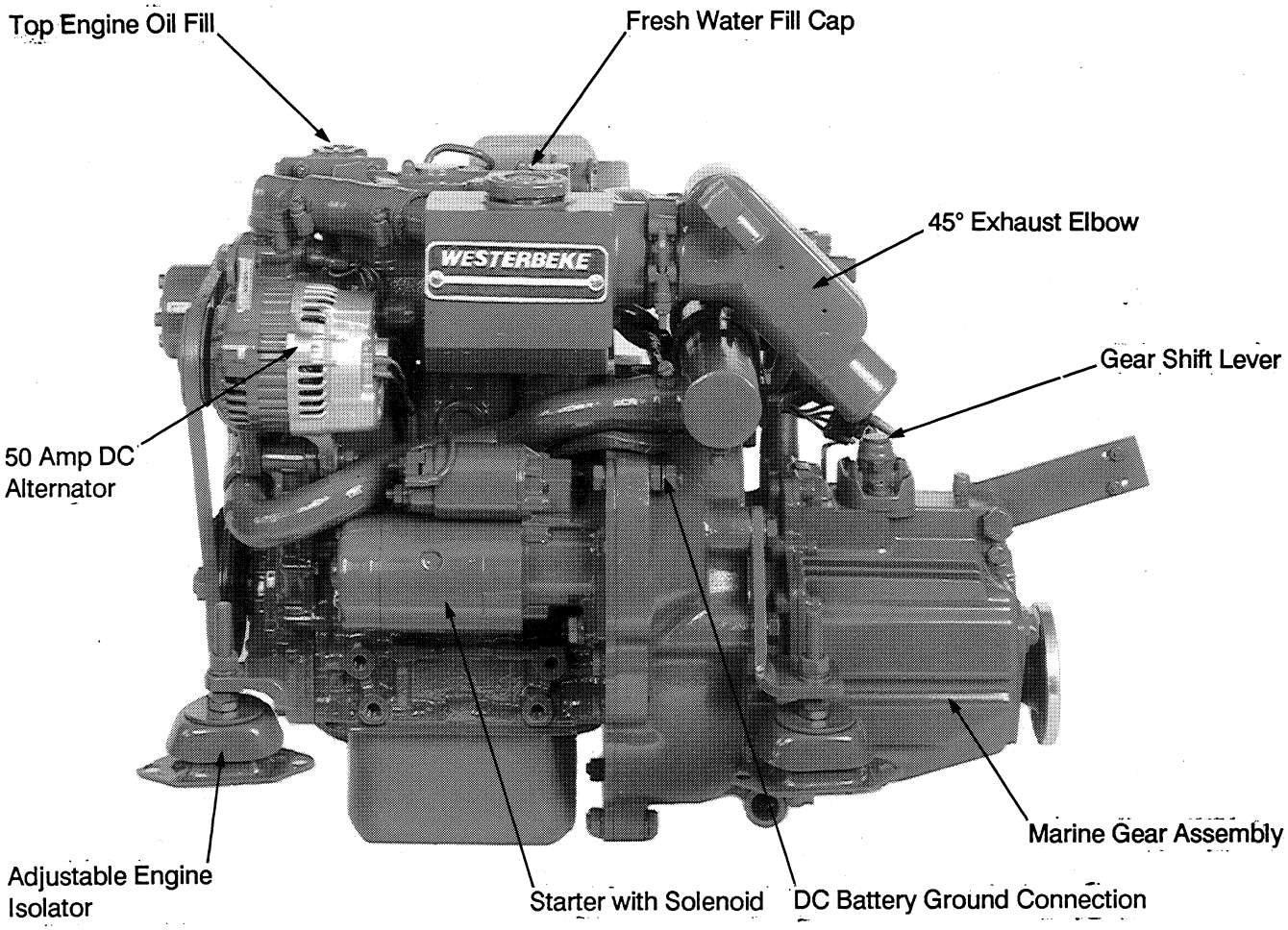
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Fresh Water Fill Cap
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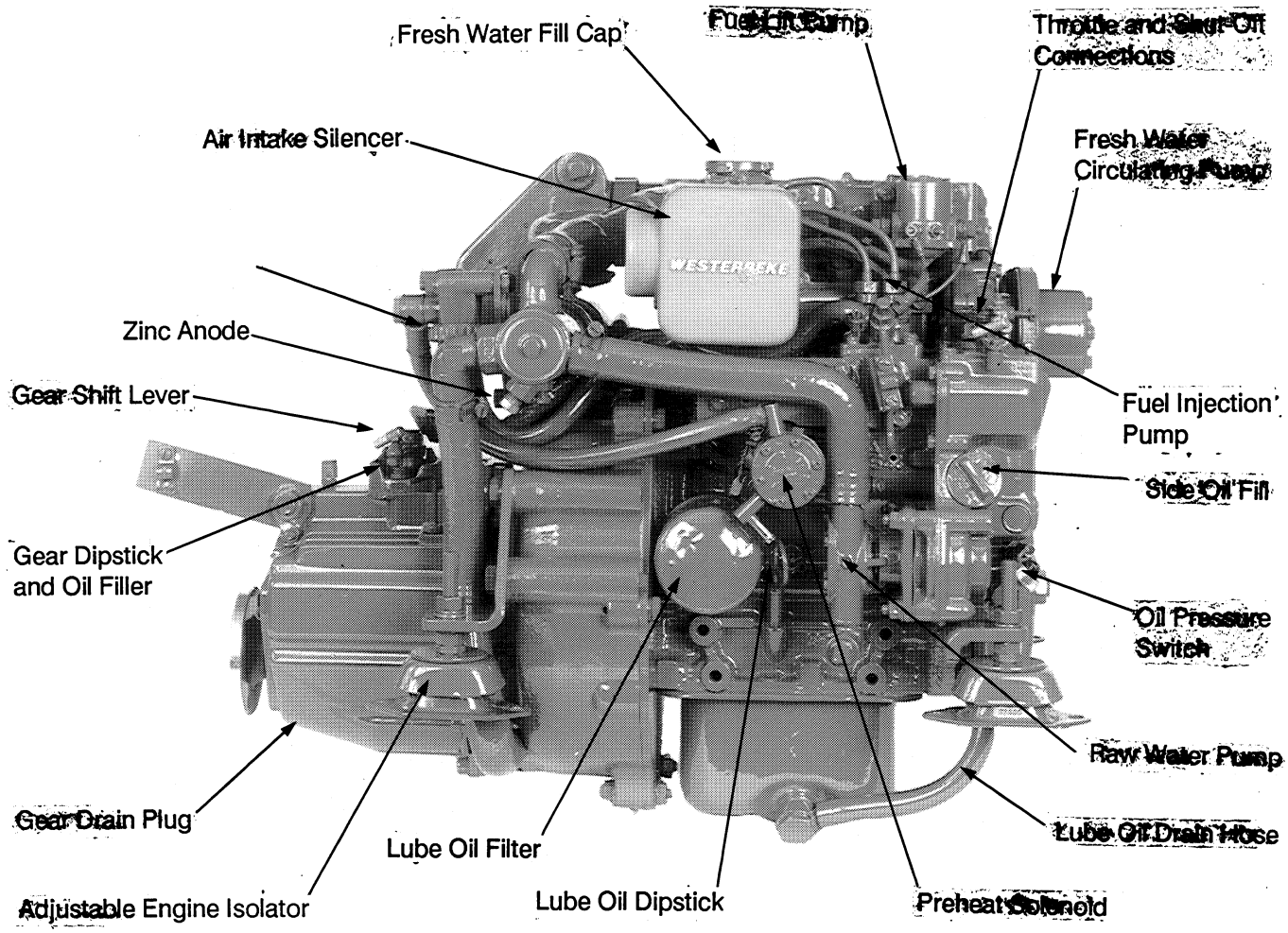
Gear Shift Lever
50 Amp DC Alternator
Marine Gear Assembly
Adjustable Engine Isolator
Starter with Solenoid
DC Battery Ground Connection
WESTERBEKE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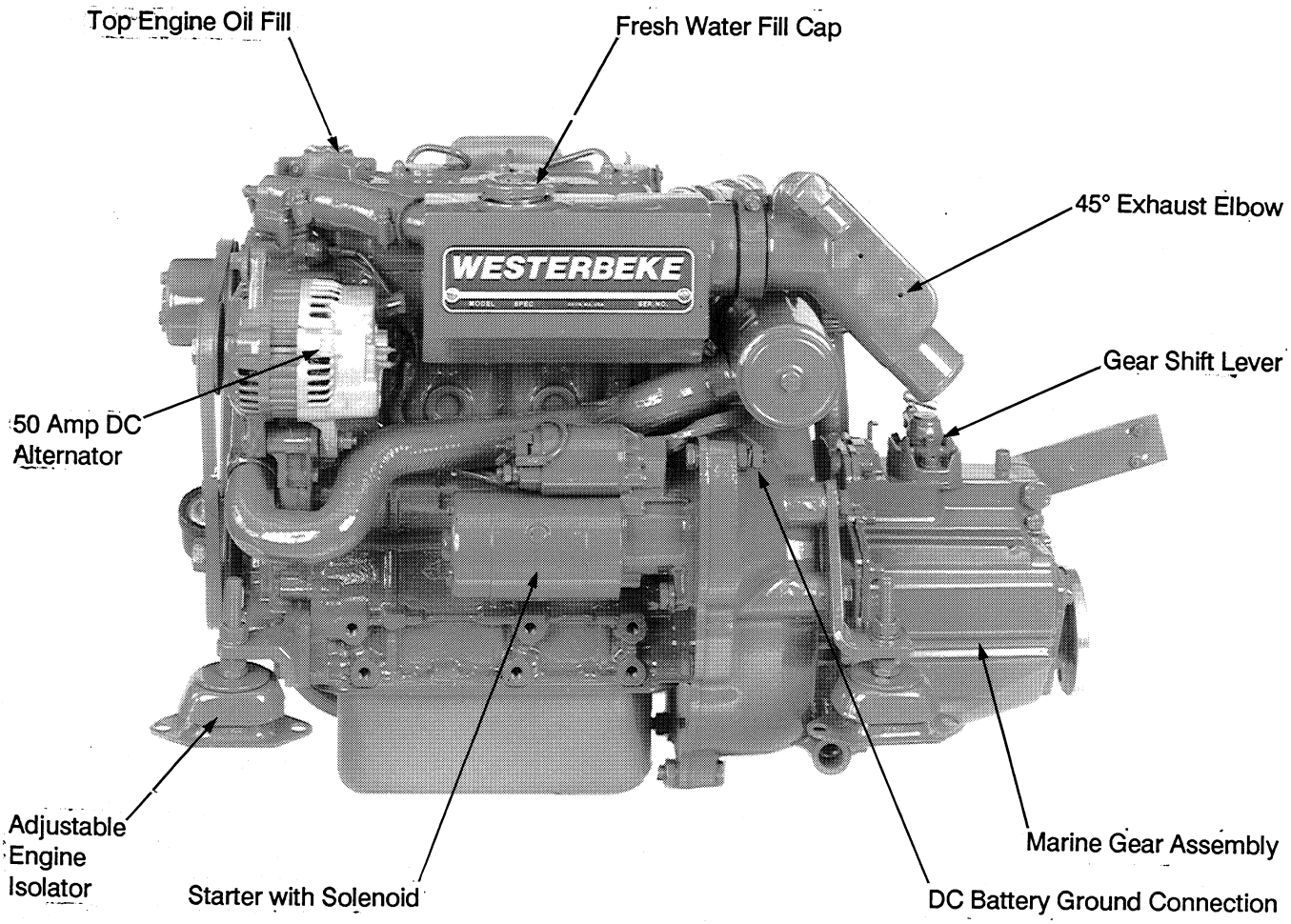
Fuel Lift Pump
Throttle and Gear Cut Connections
Air Intake Silencer
Fresh Water Circulating Pump
Zinc Anode
Gear Shift Lever
Fuel Injection Pump
Side Oil Fill
Gear Dipstick and Oil Filler
Oil Pressure Switch
Raw Water Pump
Gear Drain Plug
Lube Oil Filter
Lube Oil Drain Hose
Adjustable Engine Isolator
Lube Oil Dipstick
Preheat Solenoid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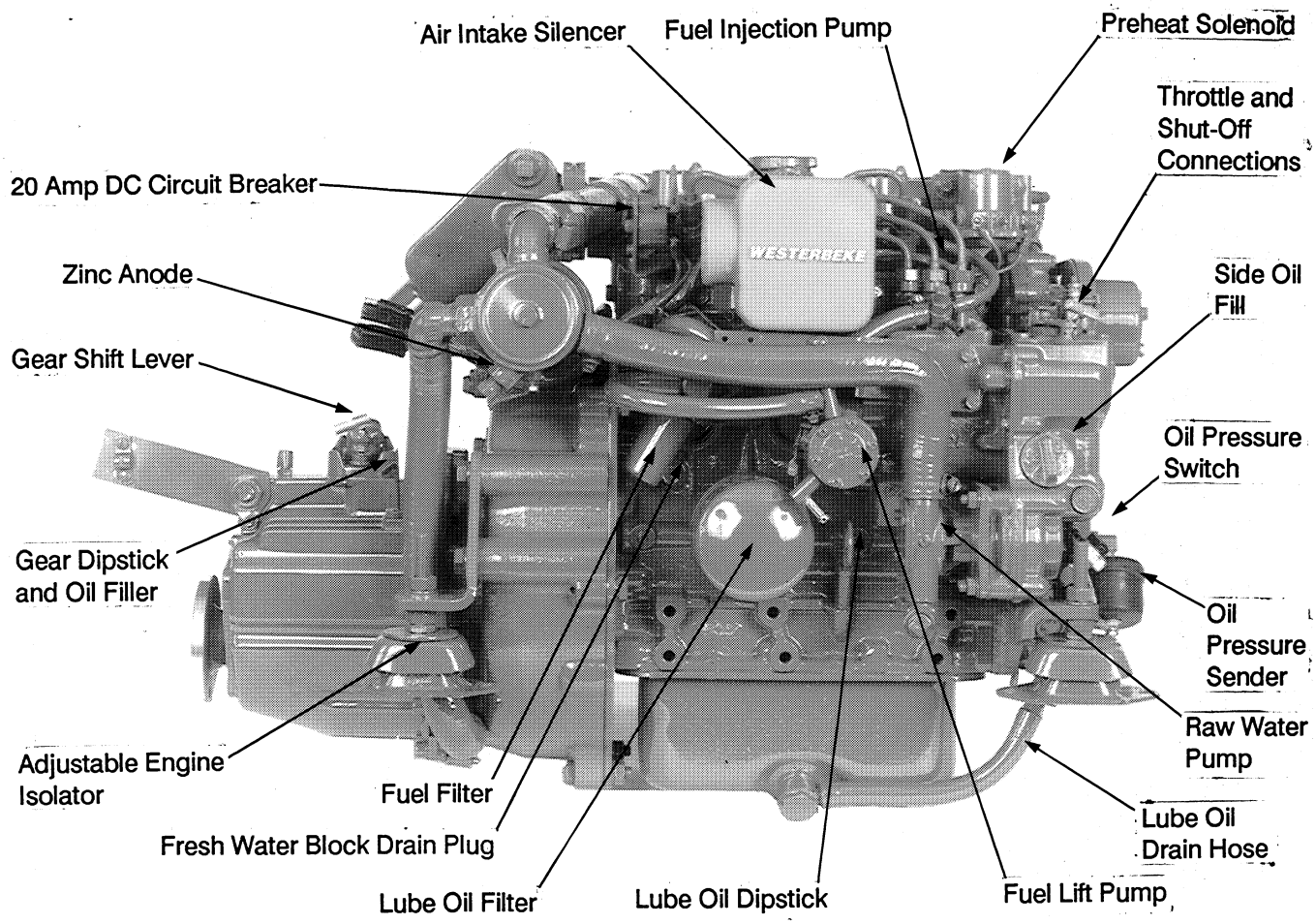
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Fuel Injection Pump
Preheat Solenoid
Throttle and Shut-Off Connections
20 Amp DC Circuit Breaker
Zinc Anode
Side Oil Fill
Gear Shift Lever
Oil Pressure Switch
Gear Dipstick and Oil Filler
Oil Pressure Sender
Raw Water Pump
Adjustable Engine Isolator
Fuel Filter
Fresh Water Block Drain Plug
Lube Oil Drain Hose
Lube Oil Filter
Lube Oil Dipstick
Fuel Lift Pump

UNIT I.D. PLATES

20B TWO UNIT I.D. PLATE

30B THREE UNIT I.D. PLATE

The unit I.D. plate is attached to the exhaust manifold of the engine. These illustrations are provided so that the owner/operator may transcribe the specifications and serial number from the I.D. plate on the engine to one of the illustrations above. This will allow for easy reference when seeking parts, service or technical needs.

20B TWO MARINE DIESEL ENGINE
GENERAL SPECIFICATIONS

Engine Type	Diesel, four-cycle, two-cylinder, fresh water-cooled. Vertical, in-line, overhead valve mechanism (18 hp at 3600 rpm maximum).
Governor	Mechanical, centrifugal weight type.
Combustion Chamber	Swirl type.
Bore & Stroke	2.99 x 2.76 inches (76 x 70 mm)
Piston Displacement	38.75 cubic inches (0.635 liters)
Firing Order	1 - 2
Direction of Rotation	Clockwise, when viewed from the front.
Maximum Torque (at 2200 rpm)	30 lb-ft (4.15 kg-m)
Compression Ratio	23:1
Compression Pressure	398 psi (28 kg/cm^2) at 280 rpm
Valve Timing	Intake Opens BTDC Intake Closes ABDC Exhaust Opens BBDC Exhaust Closes ATDC
Valve Seat Angle	Intake & Exhaust 45°
Valve Clearance (engine cold)	Intake 0.010 inches (0.25 mm) Exhaust 0.010 inches (0.25 mm)
Dimensions	Length: 25.87 inches (657.10 mm) Width: 16.00 inches (406.40 mm) Height: 19.75 inches (501.65 mm)
Inclination	Continuous 15° Temporary 25° (not to exceed 30 min.)
Weight	228 lbs (103.4 kgs)
Fuel Consumption (propeller allowing rated rpm)	0.7 U.S. gph (2.65 lph) running at 2500 rpm (approximate).
Idle Speed	1000 - 1200 rpm
Cruise rpm	2500 - 3000 rpm

20B TWO MARINE DIESEL SYSTEM SPECIFICATIONS

FUEL SYSTEM

General	Open flow - totally self-bleeding, manual priming.
Fuel	No. 2 Diesel (cetane # 45 or better).
Injector Pump	In-line plunger type (Bosch type).
Engine Timing (spill timing)	19° ±1° BTDC Static
Injector Pressure	1991 psi (140 kg/cm^2)
Nozzle	Throttle type.
Lift Pump PN 037818	12-volt DC; lift capacity 5 ft (1.5 m)
Air cleaner	Plastic screen type - cleanable.
Air Flow (engine combustion)	40.6 cfm (1.1 cmm)

COOLING SYSTEM

General	Fresh water-cooled block, thermostatically-controlled with heat exchanger.
Operating Temperature	170 - 190° F (77 - 88° C)
Fresh Water Pump PN 037015	Centrifugal type, metal impeller, belt-driven.
Raw Water Pump PN 033636	Positive displacement, rubber impeller, mechanically-driven.
Raw Water Flow, at 3600 rpm (measured before discharging into exhaust elbow)	11.1 U.S. gpm (42 lpm) approximate.
System Capacity (fresh water)	2.9 qts (2.7 liters)

LUBRICATION SYSTEM

General	Pressure type by Trochoid pump, gear-driven, with external pressure relief valve.

Oil Filter PN 036918	Full flow, paper element, spin-on type.
Sump Capacity (including filter)	3.0 U.S. qts (2.9 liters)
Operating Oil Pressure (engine hot)	15 - 45 psi (1.0 - 3.1 kg/cm^2)
Oil Grade	API SPECIFICATION OF **CF** OR **CG-4**

ELECTRICAL SYSTEM

Starting Battery	12-volt, 26 A-H, (-) negative ground (recommended) (35 A-H in cold areas)
Battery Capacity	90 - 125 (ampere-hours)
Starter PN 034552	12-volt, 1.2 KW, reduction type, solenoid-mounted.
DC No-Load Current	100 amp (max.) at 11.5 volts (3000 rpm, min.).
DC Cranking Current	125 amps at 10 volts (805 rpm, min.) (engine cold).
DC Alternator PN 030594	12 volt DC, 50 amps

TRANSMISSION

General (JS Transmission)	Case hardened helical gears with an intermediate reverse gear. Reversing out by a servo double disc system.
Standard Gear Ratio	2.47:1
Propeller Shaft Direction of Rotation	Right handed - standard transmission.
Propeller Recommendations (using JS transmission 2.47:1 reduction)	15 D x 10 P - 2 blade or 15 D x 8 P - 3 blade. Propeller should allow the engine to reach its full rated rpm (3600 + 000 - 100) at full open throttle while underway.
Lubricating Oil Grade	API SPECIFICATION OF **CF** OR **CG-4**
SAE Grade	SAE 20W/20 or SAE 30 exclusively. (**Do not** mix grades of oil or use multigrade oils!)
Transmission Sump Capacity	1 qt (1 liter)

30B THREE MARINE DIESEL ENGINE
GENERAL SPECIFICATIONS

Engine Type	Diesel, four-cycle, three-cylinder, fresh water-cooled. Vertical, in-line, overhead valve mechanism (27 hp at 3600 rpm maximum).
Governor	Mechanical, centrifugal weight type.
Combustion Chamber	Swirl type.
Bore & Stroke	2.99 x 2.76 inches (76 x 70 mm)
Piston Displacement	59.09 cubic inches (0.952 liters)
Firing Order	1 - 3 - 2
Direction of Rotation	Clockwise, when viewed from the front.
Maximum Torque (at 2200 rpm)	43 lb-ft (5.9 kg-m)
Compression Ratio	23:1
Compression Pressure	398 psi (28 kg/cm^2) at 280 rpm
Valve Timing	Intake Opens BTDC Intake Closes ABDC Exhaust Opens BBDC Exhaust Closes ATDC
Valve Seat Angle	Intake & Exhaust 45°
Valve Clearance (engine cold)	Intake 0.010 inches (0.25 mm) Exhaust 0.010 inches (0.25 mm)
Dimensions	Length: 28.81 inches (731.77 mm) Width: 16.00 inches (406.40 mm) Height: 19.75 inches (501.65 mm)
Inclination	Continuous 15° Temporary 25° (not to exceed 30 min.)
Weight	272 lbs (123.3 kgs)
Fuel Consumption (propeller allowing rated rpm)	1.0 U.S. gph (3.78 lph) running at 2500 rpm (approximate).
Idle Speed	1000 - 1200 rpm
Cruise rpm	2500 - 3000 rpm

30B THREE MARINE DIESEL SYSTEM SPECIFICATIONS

FUEL SYSTEM

General	Open flow - totally self-bleeding, manual priming.
Fuel	No. 2 Diesel (cetane # 45 or better).
Injector Pump	In-line plunger type (Bosch type).
Engine Timing (spill timing)	19° ±1° BTDC Static
Injector Pressure	1991 psi (140 kg/cm^2)
Nozzle	Throttle type.
Lift Pump PN 037818	12-volt DC; lift capacity 5 ft (1.5 m)
Air cleaner	Plastic screen type - cleanable.
Air Flow (engine combustion)	60.4 cfm (1.7 cmm)

COOLING SYSTEM

General	Fresh water-cooled block, thermostatically-controlled with heat exchanger.
Operating Temperature	170 - 190° F (77 - 88° C)
Fresh Water Pump PN 037015	Centrifugal type, metal impeller, belt-driven.
Raw Water Pump PN 033636	Positive displacement, rubber impeller, mechanically-driven.
Raw Water Flow, at 3600 rpm (measured before discharging into exhaust elbow)	11.1 U.S. gpm (42 lpm) approximate.
System Capacity (fresh water)	4 qts (3.8 liters)

LUBRICATION SYSTEM

General	Pressure type by Trochoid pump, gear-driven, with external pressure relief valve.

Oil Filter PN 036920	Full flow, paper element, spin-on type.
Sump Capacity (including filter)	3.7 U.S. qts (3.5 liters)
Operating Oil Pressure (engine hot)	15 - 45 psi (1.0 - 3.1 kg/cm^2)
Oil Grade	API SPECIFICATION OF **CF** OR **CG-4**

ELECTRICAL SYSTEM

Starting Battery	12-volt, 26 A-H, (-) negative ground (recommended) (35 A-H in cold areas)
Battery Capacity	90 - 125 (ampere-hours)
Starter PN 034552	12-volt, 1.2 KW, reduction type, solenoid-mounted.
DC No-Load Current	100 amp (max.) at 11.5 volts (3000 rpm, min.).
DC Cranking Current	190 amps at 10 volts (805 rpm, min.) (engine cold).
DC Alternator PN 030594	12 volt DC, 50 amps

TRANSMISSION

General (JS Transmission)	Case hardened helical gears with an intermediate reverse gear. Reversing out by a servo double disc system.
Standard Gear Ratio	2.47:1
Propeller Shaft Direction of Rotation	Right handed - standard transmission.
Propeller Recommendations (using JS transmission 2.47:1 reduction)	16 D x 10 P - 2 blade or 16 D x 8 P - 3 blade. Propeller should allow the engine to reach its full rated rpm (3600 + 000 - 100) at full open throttle while underway.
Lubricating Oil Grade	API SPECIFICATION OF **CF** OR **CG-4**
SAE Grade	SAE 20W/20 or SAE 30 exclusively. (**Do not** mix grades of oil or use multigrade oils!)
Transmission Sump Capacity	1 qt (1 liter)

20B TWO AND 30B THREE ENGINE SERVICE SPECIFICATIONS

NOTE: All dimensions and specifications contained in this section are given in inches then millimeters unless otherwise stated. For example, 0.002 (0.5 mm).

	Specified Value/Standard	Repair Limit
Cylinder Compression Pressure	398.16 psi (at 280 rpm) (28 kg/cm^2)	355.5 psi (25 kg/cm^2)
Difference Between Cylinders (maximum)	35.55 psi (2.5 kg/cm^2)	
Fuel Injection Order		
20B Two	1 - 2	
30B Three	1 - 3 - 2	
Injection Timing at BTDC on Compression Stroke		
Spill timing (static)	19° ±1.5	19° ±2
Cylinder Head		
Bottom surface distortion	Within 0.002 (0.05 mm)	0.004 (0.1 mm)
Valve guide I.D. (IN & EX)	0.260 (6.6 mm)	
Valve seat angle (IN & EX)	45°	
Valve seat width (IN & EX)	0.051 - 0.071 (1.3 - 1.8 mm)	0.098 (2.5 mm)
Valve seat sinkage		-0.039 (Service limit) (-1 mm)
Valve Clearance (IN and EX)	0.010 (cold) 0.25	

	Specified Value/Standard	Repair Limit
Valves		
Valve clearance (IN & EX)	0.010 (cold) (0.25 mm)	
Valve head dia. (IN)	1.051 (26.7 mm)	
(EX)	0.972 (24.7 mm)	
Overall length	3.701 (94 mm)	
Stem O.D.	0.260 (6.6 mm)	
Stem to guide clearance (IN)		1.051 (Service limit) (26.7 mm)
(EX)		0.972 (Service limit) (24.7 mm)
Valve face angle	45°	
Valve head thickness (margin width)	0.039 (1.0 mm)	
Valve head sinkage (From cylinder head to bottom face)	0.020 0.5 mm	
Valve Spring		
Free length	1.595 (40.5 mm)	1.547 (39.3 mm)
Preload/installed length	13.095 lbs/1.398 in (5.94 kg/35.5 mm)	
	32.716 lbs/1.102 in (14.84 kg/28 mm)	
Squareness	2°	

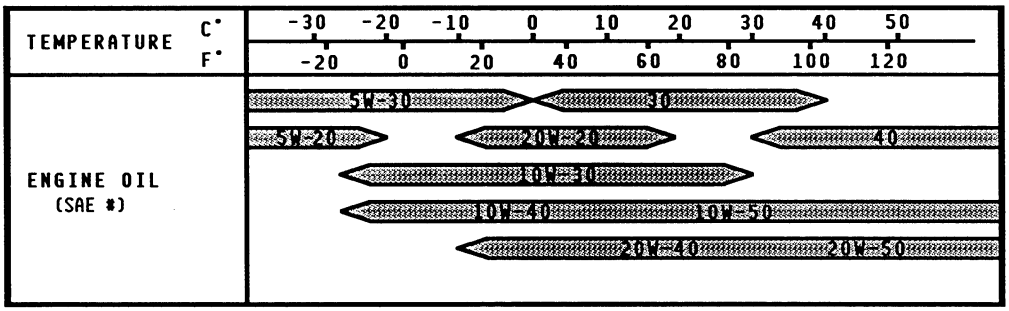
	Specified Value/Standard	Repair Limit
Rocker Arm		
Rocker arm I.D.	0.472 (12 mm)	
Rocker arm to shaft clearance		-0.008 (Service limit) (-0.2 mm)
Cylinder Block		
Camshaft hole dia.		
Front	1.654 Ball bearing hole (42 mm)	
No. 2	1.339 (34 mm)	
No. 3 (30B Three only)	1.299 (33 mm)	
Rear	1.299 (33 mm)	
Cylinder Bore		
Bore size	2.992 (76 mm)	+0.008 (+0.2 mm)
Oversize finish tolerance	0 - 0.001 for each oversize (0 - 0.03 mm)	
Cylindricity	Within 0.0004 (0.01 mm)	
Gasket fitting/surface distortion	Within 0.0020 (0.05 mm)	0.004 (0.1 mm)
Piston		
Type	Solid type	
Material	Aluminum alloy	
O.D. (skirt end)	2.992 (76 mm)	
Clearance to cylinder		0.001 (Service limit) (0.3 mm)

	Specified Value/Standard	Repair Limit
Piston (continued)		
Oversize	0.01, 0.02, 0.03 (0.25, 0.50, 0.75 mm)	
Protrusion from cylinder block top surface	0.035 (0.9 mm)	
Piston Pin		
Type	Semi-floating type	
O.D.	0.709 (18 mm)	
Piston pin to piston clearance		0.003 (Service limit) (0.08 mm)
Piston pin to connecting rod clearance	Press-fit load: 2204.6 ±1102.3 lbs. (1000 ±500 kg)	
Piston Rings		
Number of rings		
Compression (2)	No. 1: Chrome plated, semi-keystone type No. 2: Tapered	
Oil (1)	Chrome plated ring with coil expander	
Ring width		
Compression (No. 2)	0.079 (2 mm)	
Oil	0.118 (3 mm)	
Ring side clearance		
Compression No. 1		
No. 2	0.002 - 0.004 (0.05 - 0.09 mm)	0.008 (0.2 mm)
Oil ring	0.001 - 0.003 (0.03 - 0.07 mm)	
Ring gap	0.006 - 0.016 (0.15 - 0.40 mm)	

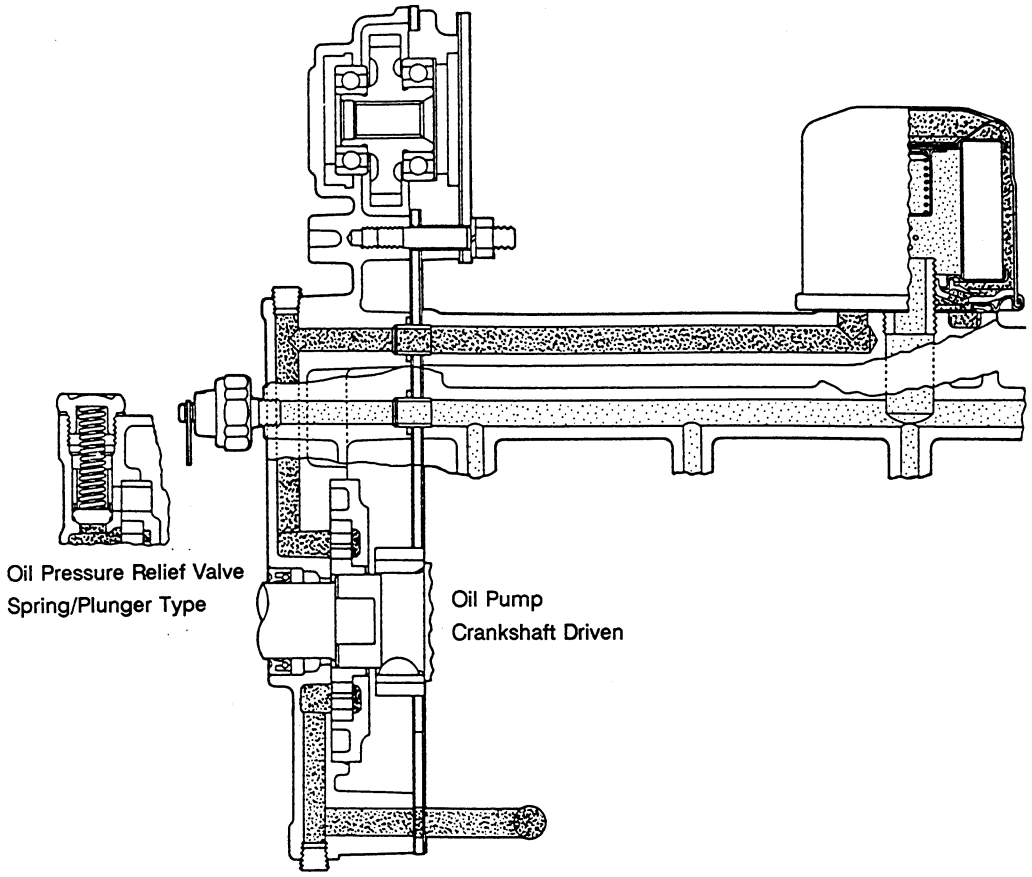
	Specified Value/Standard	Repair Limit
Connecting Rod		
Type	Forged I-beam	
Bend and twist	Within 0.002 (0.05 mm)	
Big end thrust clearance	0.004 - 0.014 (0.1 - 0.35 mm)	
Connecting Rod Bearing		
Type	Aluminum metal with back metal	
Oil clearance		0.006 (Service limit) (0.15 mm)
Under size	0.01, 0.02 (0.25, 0.50 mm)	
Crankshaft		
Type	Fully counterbalanced	
Bend	Within 0.001 (0.03 mm)	
End play	0.002 - 0.007 (0.05 - 0.175 mm)	
Journal O.D.	1.693 (43 mm)	-0.006 (-0.15 mm)
Pin O.D.	1.575 (40 mm)	-0.006 (-0.15 mm)
Under size finishing Journal U.S.		
0.25	1.6817 - 1.6823 (42.715 - 42.730 mm)	
0.50	1.6719 - 1.6724 (42.465 - 42.480 mm)	
Pin U.S. 0.25	1.5636 - 1.5642 (39.715 - 39.730 mm)	
0.50	1.5537 - 1.5543 (39.465 - 39.480 mm)	

	Specified Value/Standard	Repair Limit
Main Bearing		
Type	Aluminum metal with back metal	
Oil clearance	(No. 2: Flanged metal)	
Under size	0.01, 0.02 (0.25, 0.50 mm)	
Camshaft		
Driving method	Gear drive	
Front journal	Ball bearing	
Journal to cylinder block hole clearance		0.006 (Service limit) (0.15 mm)
Major diameter of cam (IN and EX)	1.078 (27.37 mm)	
Oil clearance		0.006 (Service limit) (0.15 mm)
Injection Pump Camshaft		
Driving method	Gear drive	
Bearing	Ball bearing (front and rear)	
Major diameter of cam	1.18 (30 mm)	
Tappet		
O.D.	0.75 (19 mm)	
Tappet to cylinder block clearance		0.006 (Service limit) (0.15 mm)
Push Rod		
Bend	Within 0.0118 (0.3 mm)	

Oil Specification



NOTE: API SPECIFICATION OF CF OR CG-4 IN ACCORDANCE WITH THE THERMAL ENVIRONMENT (SEE TABLE).



Oil Pump and Oil Filter

NOTES

ENGINE OVERHAUL

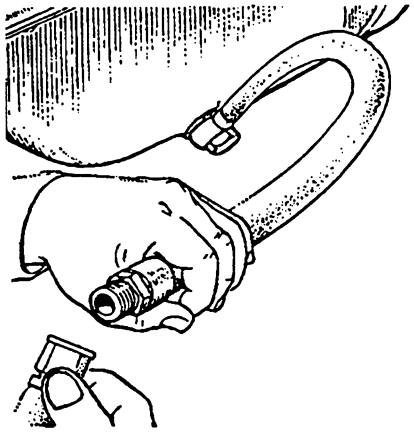
PREPARATIONS FOR OVERHAUL

1. Shut off and disconnect all fuel lines, raw water and exhaust connections.

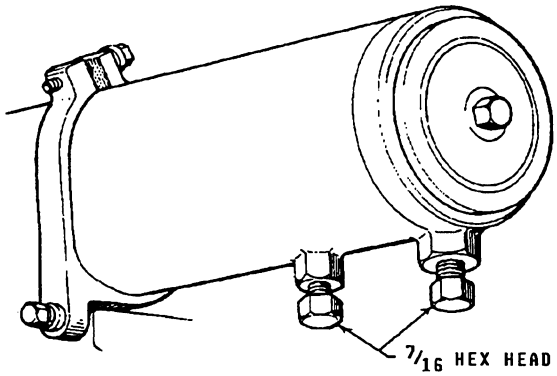
2. Unbolt the engine and carefully move it to the overhaul shop.

3. Once at the overhaul shop, drain all lubricating oil and coolant from the engine and exchanger system.

4. Clean the engine's exterior of all dirt and oil deposits.



Oil Sump Drain



Heat Exchanger Drains

ENGINE DISASSEMBLY

This section describes the disassembly of the engine when performing a complete overhaul of the unit. The procedures which follow include the disassembly of subassemblies, inspection of their components parts, repair or replacement of these parts (if necessary), and the reassembly of the subassemblies.

Removal of External Parts and Subassemblies

1. Remove the exhaust manifold and related hoses as a unit. Disassemble and inspect these parts.

2. Remove the heat exchanger and its related hoses and mounts from the front of the engine. Have the heat exchanger cleaned and tested at a local automotive radiator repair shop or replace it if necessary.

3. Remove the starter motor and circuit breaker assembly. Examine the starter and have it repaired or replaced if necessary.

4. Remove the intake silencer, fuel lines, fuel pump and fuel filter with bracket assembly from its attachment on the bellhousing.

5. Remove the high pressure injector lines from between the injection pump and injectors. Note the location of each line.

6. Remove the transmission bellhousing assembly.

7. Remove the raw water pump from its mounting point on the engine.

8. Remove the alternator, the fresh water pump's drive belt, and the alternator's mounting bracket.

9. Remove the fresh water circulating pump's pulley and remove the fresh water pump.

10. Remove the engine's backplate.

11 Remove the water temperature switch and the water temperature sender.

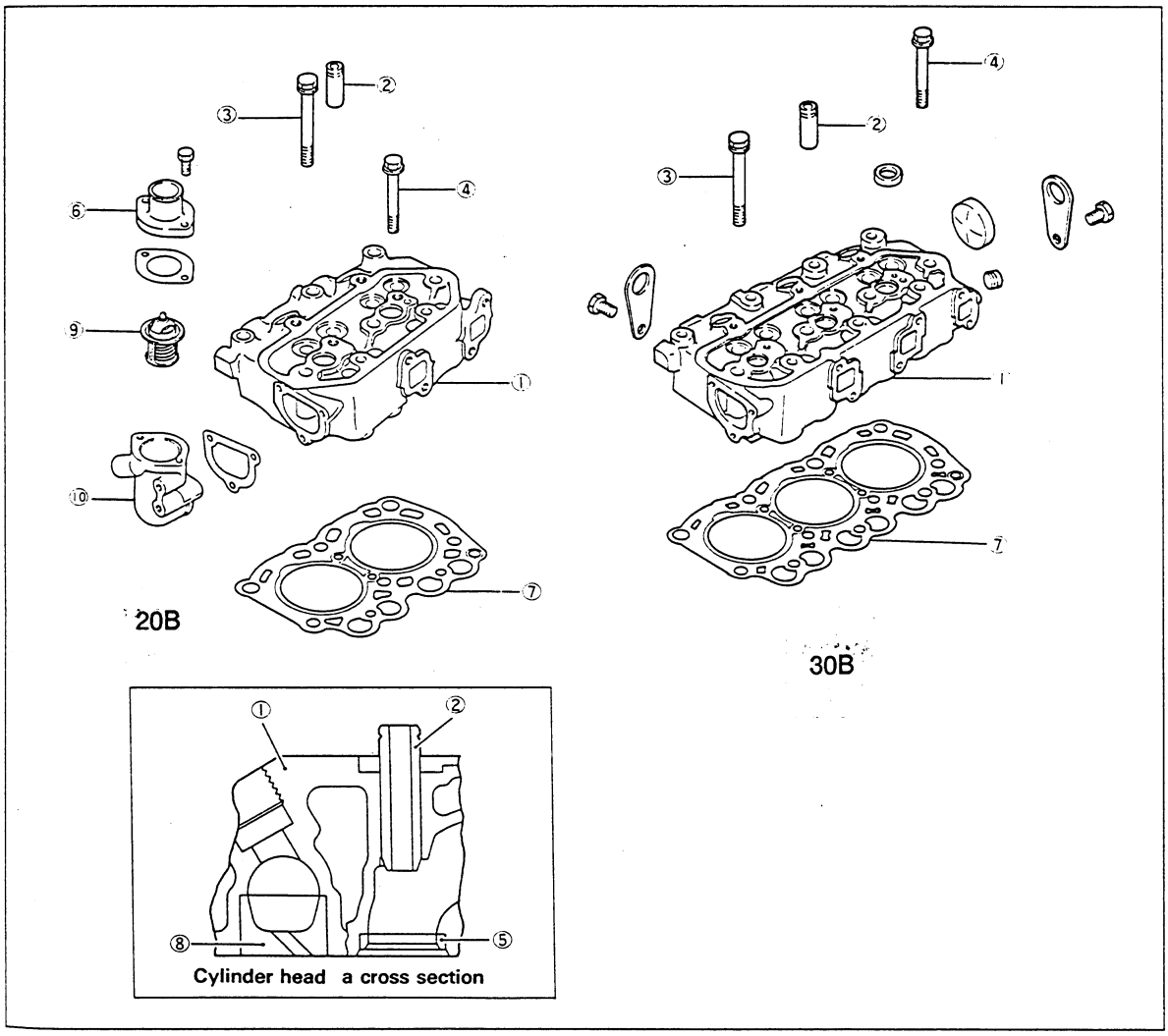
12. Remove the oil pressure switch, the oil pressure sender, and the oil filter.

13. Remove the thermostat housing and the thermostat.

14. Remove the crankshaft pulley from the crankshaft.

The basic engine assembly is now ready for disassembly, cleaning, inspection, and repair if necessary.

CYLINDER HEAD CONSTRUCTION AND SERVICING



CYLINDER HEAD COMPONENT PARTS

1. Cylinder head.
2. Valve guide.
3. Cylinder head bolt (main bolt).
4. Cylinder head bolt (sub-bolt).
5. Seat ring (3600 rpm specification engine).
6. Water outlet fitting.
7. Cylinder head gasket.
8. Mouth piece.
9. Thermostat.
10. Thermostat fitting.

Cylinder Head Removal

1. Remove the high pressure injection line assembly.

CAUTION

When disconnecting each injection line from the injection pump side delivery valve holder, grasp the holder with a wrench to prevent it from loosening. After removing the pipe assembly, plug the nozzle holders and delivery valve holders to prevent intrusion of dust.

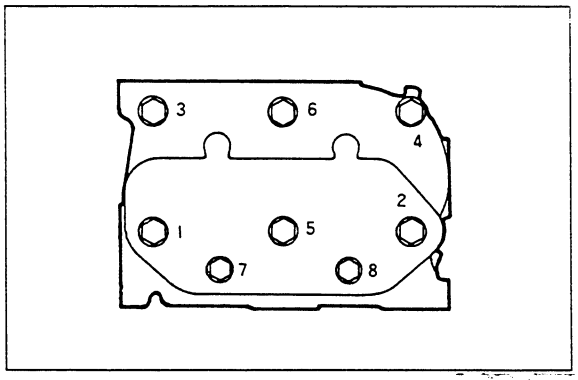
2. Disconnect the glow plug lead wire.

3. Disconnect the air breather hose.

4. Remove the rocker cover.

5. Remove the rocker shaft assembly.

6. Loosen the cylinder head mounting bolts in the numerical order as illustrated and remove the cylinder head assembly (including the intake and exhaust manifold).



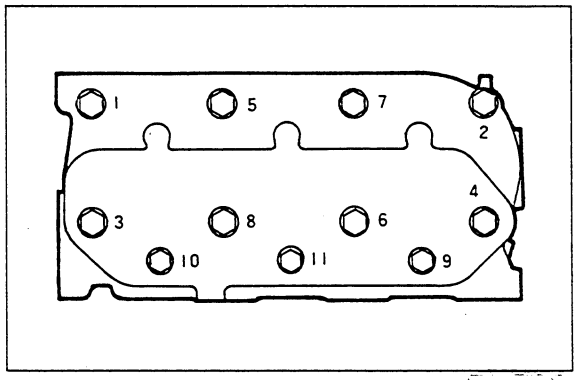
Sequence for Loosening Cylinder Head Bolts 20B

7. Remove the cylinder head gasket. Clean the cylinder head and the cylinder block surface from which the gasket has been removed.

8. Remove the injector assemblies and glow plugs from the cylinder head.

9. Remove the intake manifold from the cylinder head.

10. Remove the valve retainers, valve springs and valves from the cylinder head.



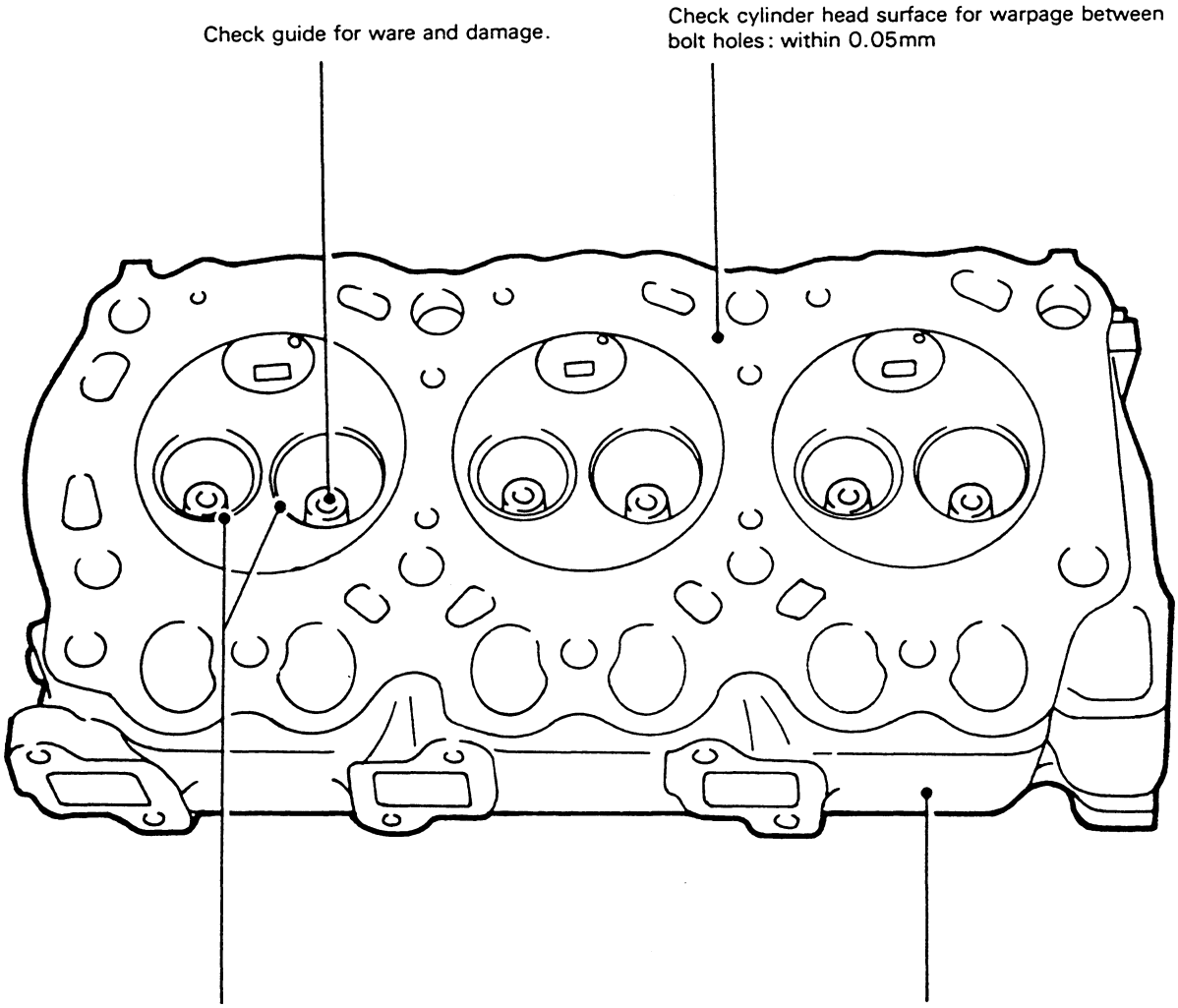
Sequence for Loosening Cylinder Head Bolts 30B

CAUTION

When removing each valve retainer, depress the retainer against the valve spring and remove the retainer lock. Identify each valve by putting a mark indicating the number of the cylinder from which the valve is removed.

11. Remove the valve stem seals.

Cylinder Head Inspection and Repair

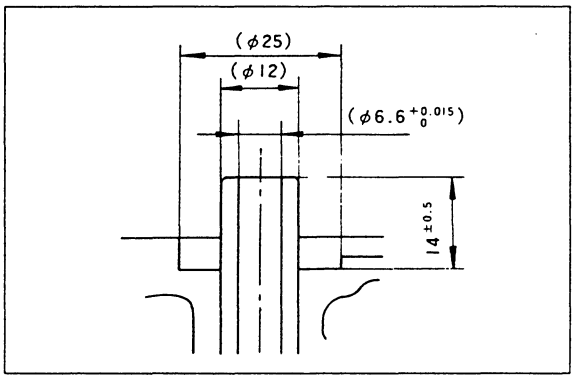


Valve Guide Replacement

If a valve guide is found defective, replace it.

1. Remove the valve guide by pressing at its upper end and pull it out to the valve seat side.

2. Install the valve guide by press fitting the guide from the upper side of the cylinder head to a height of 14 ± 0.5 mm from the valve spring seat face.

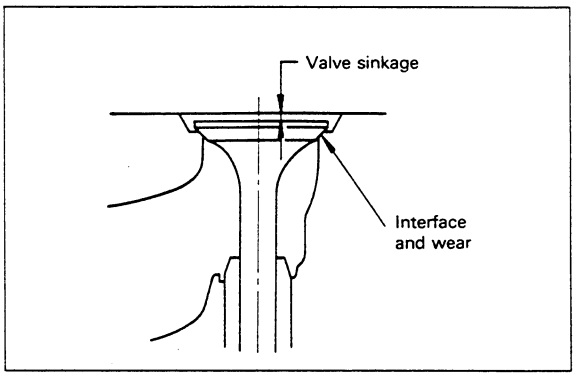


Press-fitting Valve Guide

Valve Seat Repair

If a valve seat is found defective, reface it or replace the cylinder head.

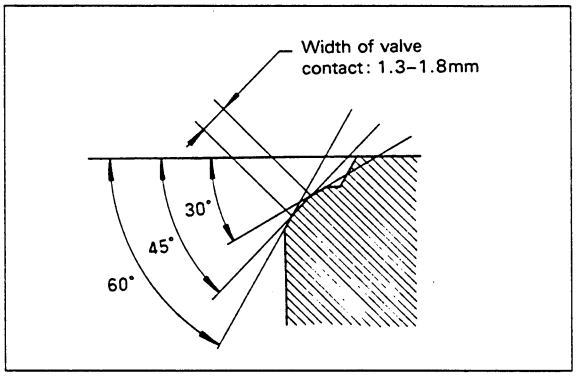
Sinkage of valve	
Standard	Service limit
0.5 mm	1.5 mm



Checking Valve Sinkage

CAUTION

When checking valve sinkage, the valve guide must be in normal condition. Resurface the valve seat so that it contacts the mid-portion of the valve face.



Resurfacing Valve Seat (Common to intake and exhaust valves)

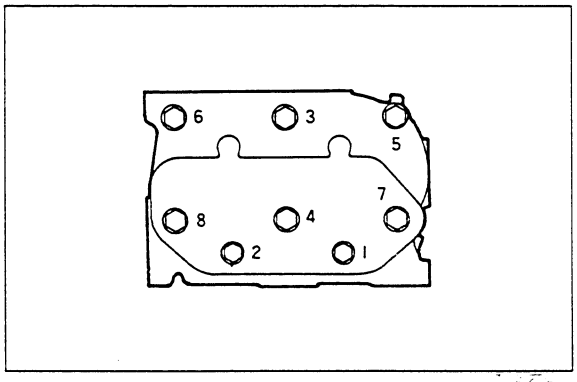
Valve Seat Installation

Installation of the cylinder head is in the reverse order of removal. Pay attention to the following.

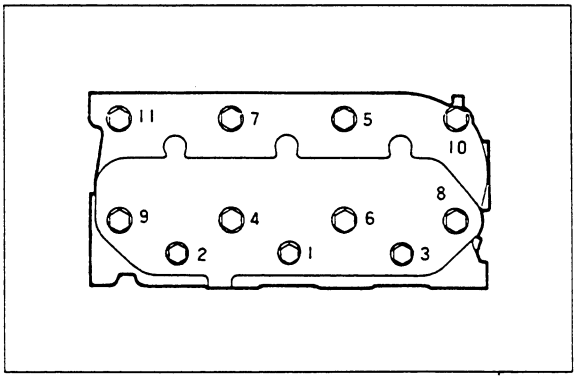
1. Renew the cylinder head gasket. No application of sealant is necessary. On the upper front of the gasket is engine model to which that gasket is applicable. Be careful not to confuse it with a gasket for another engine model.

2. Tighten the cylinder head bolts in the numerical order shown in the figure at right, going through that order two or three times. Tighten each bolt a little at a time until all are tightened to the specified torque.

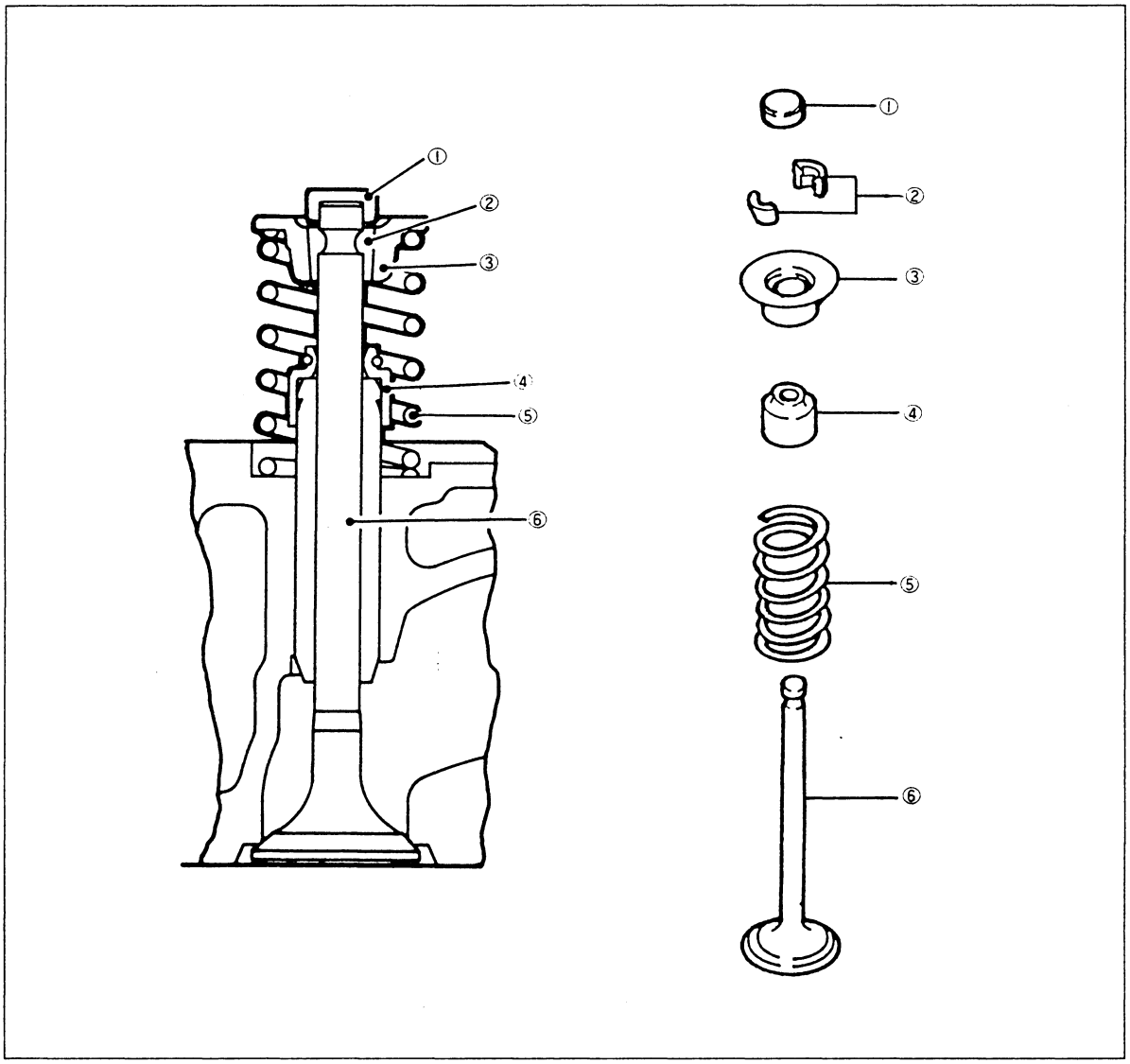
3. When connecting the injector line assembly, loosen the pipe clamp. When tightening the nut at each end of the pipe, grip the nozzle holder or delivery valve holder with a wrench to prevent it from being turned together with the nut. Also, take care not to allow dust to enter the fuel line.



Sequence for Tightening Cylinder Head Bolts 20B



Sequence for Tightening Cylinder Head Bolts



VALVE SYSTEM COMPONENT PARTS

1. Valve stem cap.
2. Retainer lock.
3. Valve spring retainer.
4. Valve stem seal.
5. Valve spring.
6. Valve.

Valve Removal

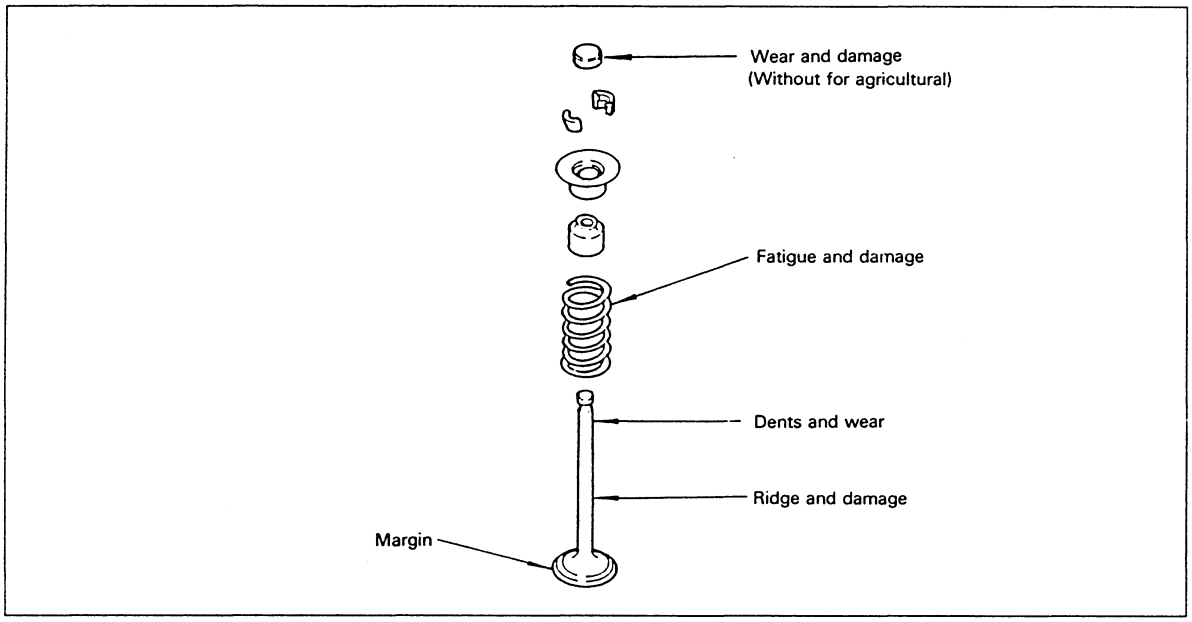
1. Dismount the cylinder head assembly.

2. Depress the valve retainer (to compress the valve spring) and remove the retainer lock.

3. Remove the valve.

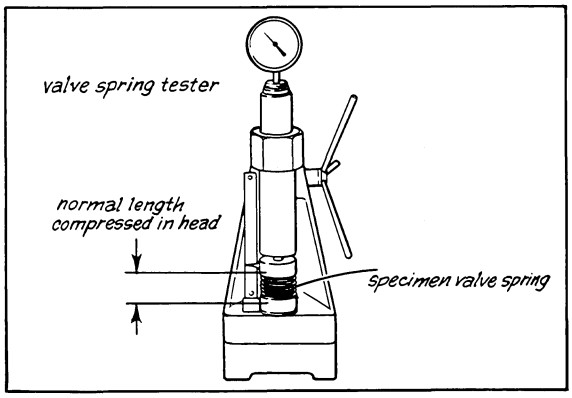
Valve Inspection and Repair

If any parts are found defective, repair or replace them.



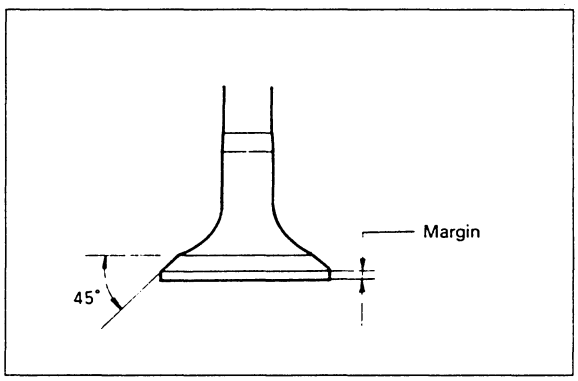
Inspection of Valve and Valve Spring

Valve fatigue and damage		
Inspection item	Standard	Service limit
Free length (mm)	40.5	−1
Load (kg/mm)	5.94/35.5	−15%
Squareness	2°	3°
Margin (mm)	1.0	0.5



1. If the valve face is found worn down, resurface it with a valve refacer. If the margin of the resurfaced valve exceeds the service limit, replace the valve.

2. If the valve stem end has been indented by wear, flatten it with an oil stone.



Inspecting Valve

Valve and Valve Spring Installation

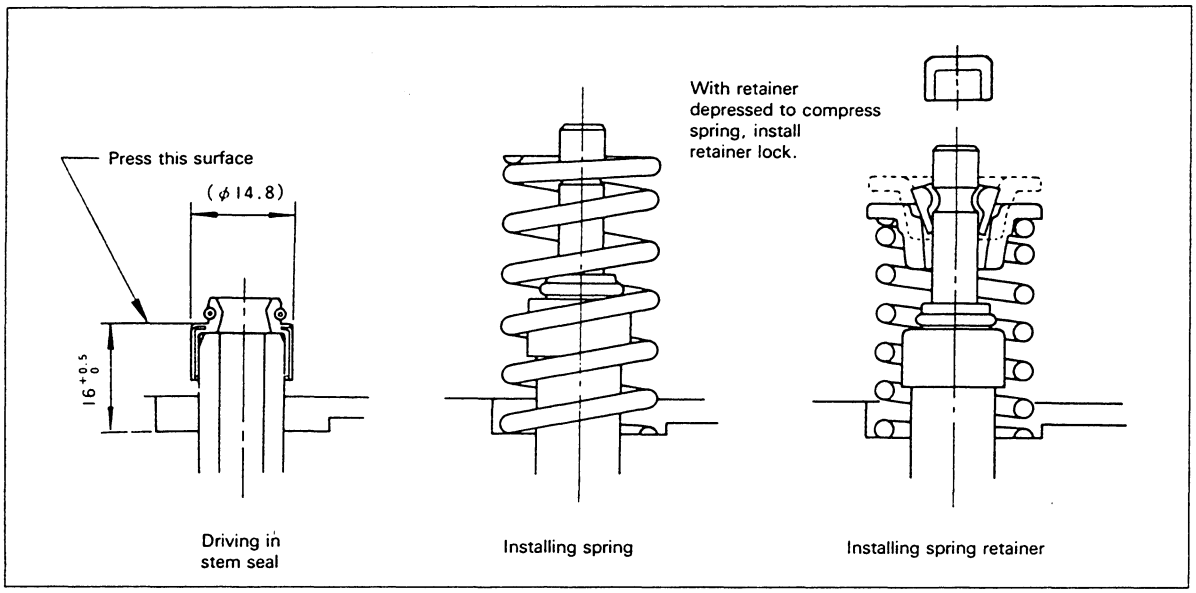
1. Install the valves and valve springs, referring to notes shown in the figure below.

2. Mount the cylinder head assembly.

3. Adjust the valve clearances.

CAUTION

Be careful not to damage the spring and stem seal by excessively compressing the spring when installing the valve spring.



Installation of Valve Spring

Valve Clearance Adjustment

Cylinder head bolts *must* be retightened before adjusting the valve clearance. When retightening the cylinder head bolts, draw out coolant, loosen the bolts slightly, and then retighten the bolts to the specified torque in the numerical order illustrated at right.

Tightening torque: M10 bolt 54.2 - 61.5 lb-ft (7.5 - 8.5 kg-m)

M8 bolt 10.8 - 15.9 lb-ft (2.0 - 3.0 kg-m)

The rocker assembly (the rocker arms, shaft, and stays) is to be kept removed when the cylinder head bolts are retightened.

Rocker stay tightening torque: M8 bolt 10.8 - 15.9 lb-ft (1.5 - 2.2 kg-m)

1. Set the cylinder to be adjusted to the top dead center of the compression stroke.

   Valve clearance: 0.0098 in. (0.25 mm) (cold) for both intake and exhaust valves.

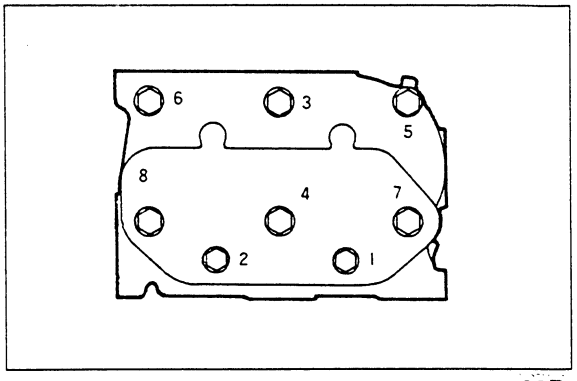
2. The top dead center of the compression stroke can be obtained by aligning the T.D.C. (Top Dead Center) mark (notch) on the crankshaft pulley with the mark on the gear case.

3. First align the T.D.C. mark for the No. 1 cylinder. Confirm that the valves do not move up and down when the crankshaft is turned about 20° in the normal direction of rotation and in the reverse direction.

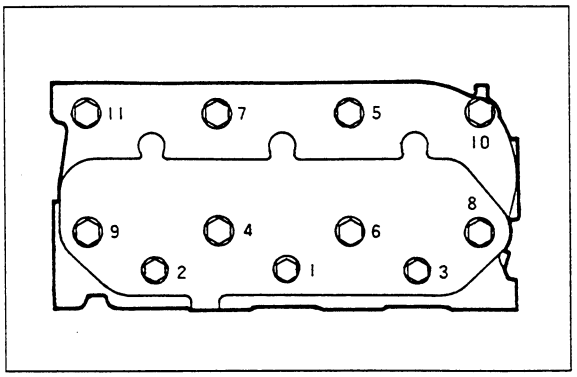
4. When setting the top dead center for the 3 cylinder engine, perform as follows:

   a. *Two Cylinder Engine* From T.D.C. for the No. 1 cylinder, turn the crankshaft 180° clockwise and the No. 2 cylinder is set to T.D.C.

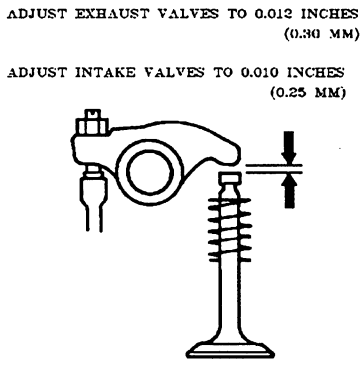
   b. *Three Cylinder Engine* From the T.D.C. for the No. 1 cylinder, turn the crankshaft 240° clockwise to set the No. 3 cylinder T.D.C. Further, turn the crankshaft 240° clockwise, and the No. 2 cylinder is set to T.D.C.

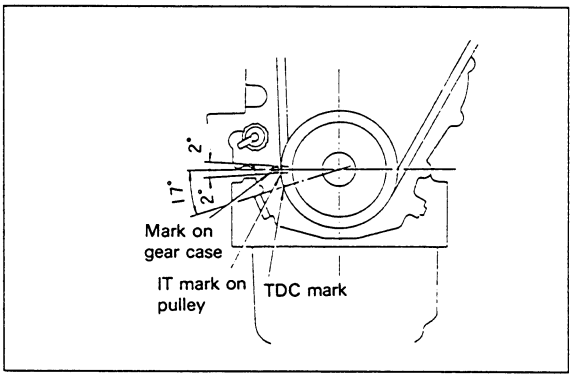


Cylinder Head Bolt Tightening Sequence 20B



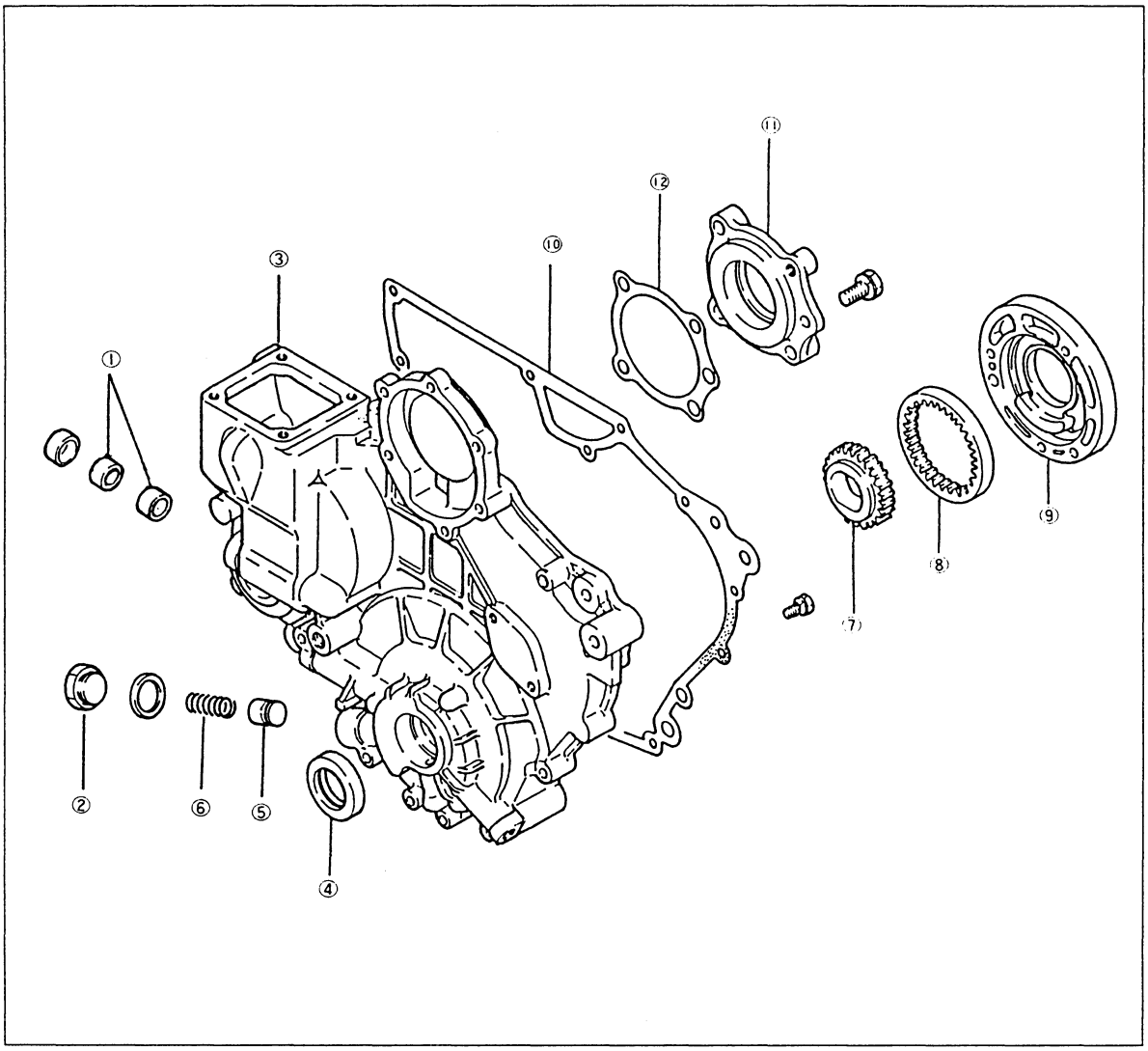
Cylinder Head Bolt Tightening Sequence 30B





Injection Timing Mark

GEAR CASE AND OIL PUMP



GEAR CASE COMPONENT PARTS

1. Bushings.
2. Plug.
3. Gear case.
4. Front oil seal.
5. Relief plunger.
6. Relief spring.
7. Oil pump inner gear.
8. Oil pump outer gear.
9. Oil pump housing.
10. Gear case gasket.
11. High-pressure pump gear housing.
12. Housing gasket.

Gear Case and Oil Pump Removal and Inspection

1. Remove the crankshaft pulley.

2. Remove the fan and fan belt.

3. Remove the tie-rod cover from the side face of the injection pump.

4. Remove the tie rod and tie rod spring. Be careful not to let the spring fall into the case.

5. Remove the governor cover assembly.

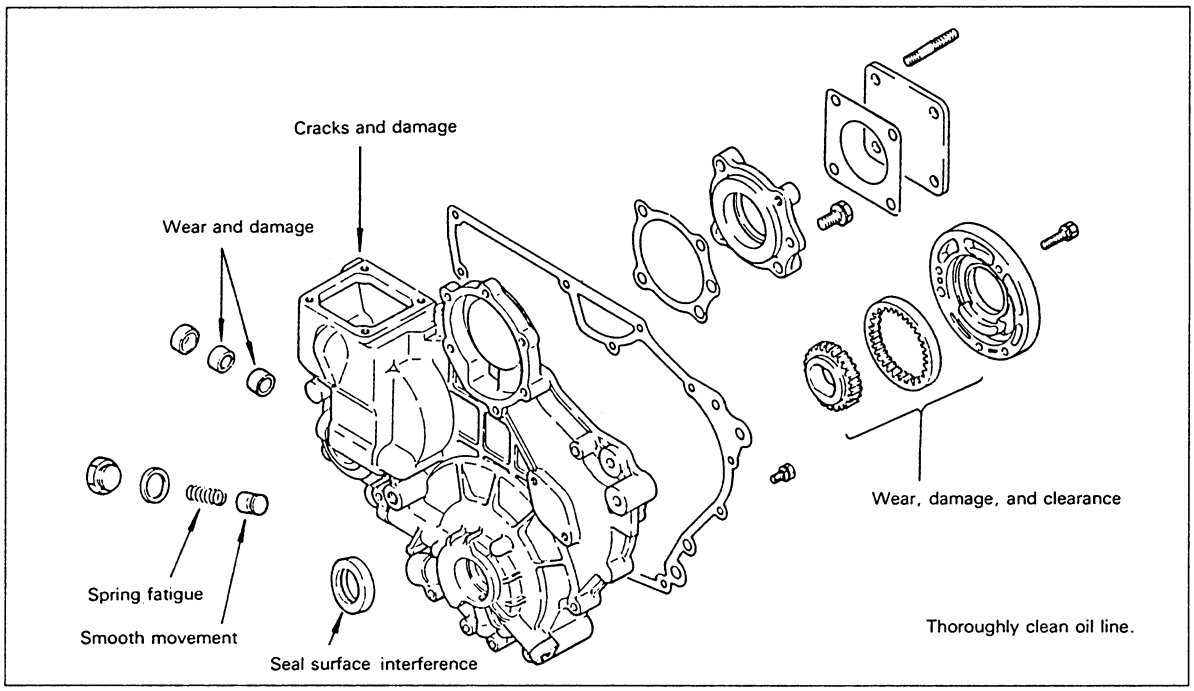
6. Remove the water pump assembly.

7. Remove the alternator.

8. Remove the pump housing.

9. Remove the gear case assembly.

Check the removed parts. If any parts are found defective, repair or replace them.



Inspection of Gear Case and Oil Pump

Front Oil Seal Replacement

1. Remove the front oil seal.

2. Press-fit the new front oil seal.

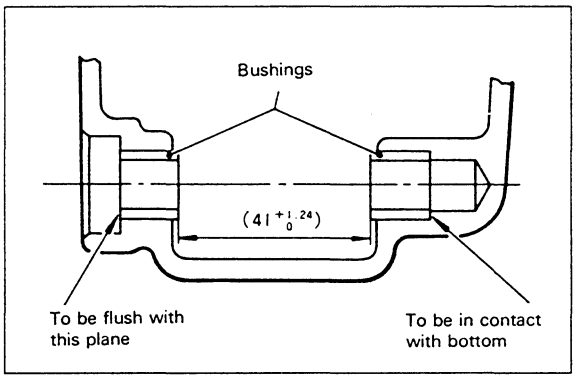
CAUTION

Apply a thin coat of engine oil to the circumference and lip of the oil seal.

Governor Shaft Bushings' Replacement

1. Remove the expansion plug and draw the bushings out.

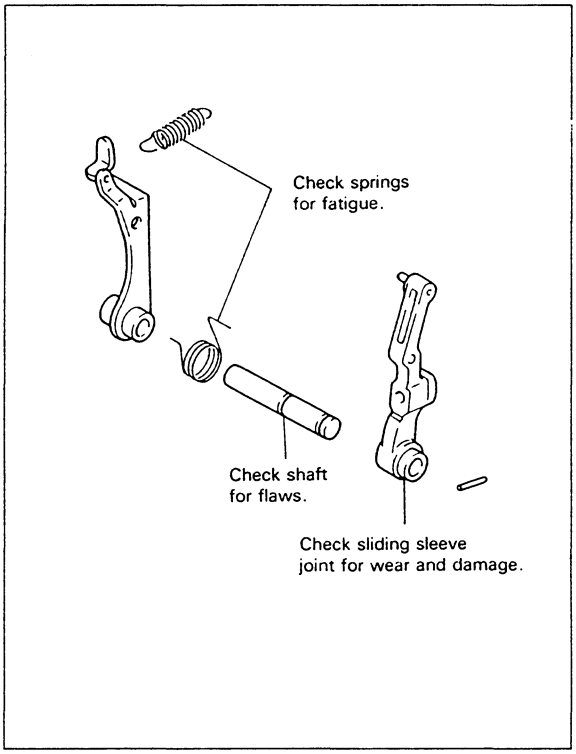
2. Press-fit the new bushings into positions shown in the figure at right.



Press-fitting Governor Shaft Bushing

Governor System Inspection

Check the governor system parts. If any parts are found defective, repair or replace them.



Check weight for wear and damage.

Governor Levers' Disassembly and Reassembly

1. Removal of the shaft.

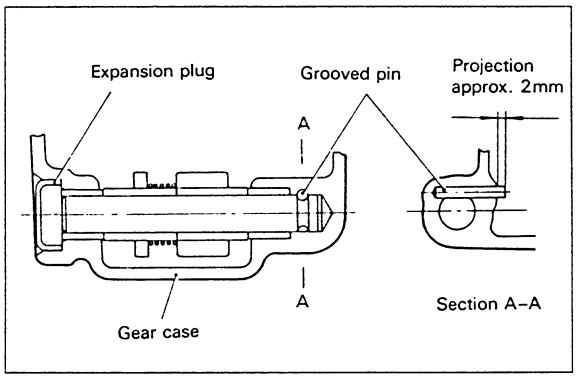
   a. Remove the expansion plug, taking care not to scratch the gear case.

   b. Pull out the grooved pin.

2. Installation of the shaft.

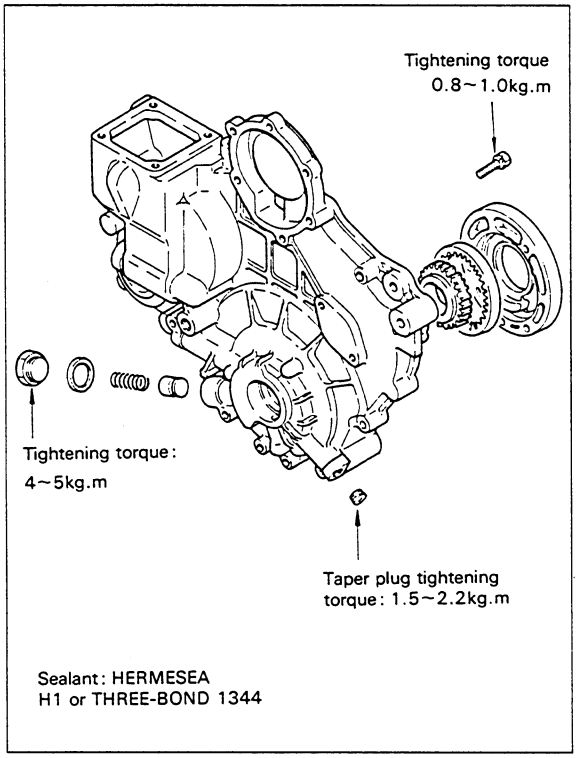
   a. Install the shaft in the reverse order of removal.

   b. After installing the shaft, press-fit the expansion plug into the shaft hole in the gear case.

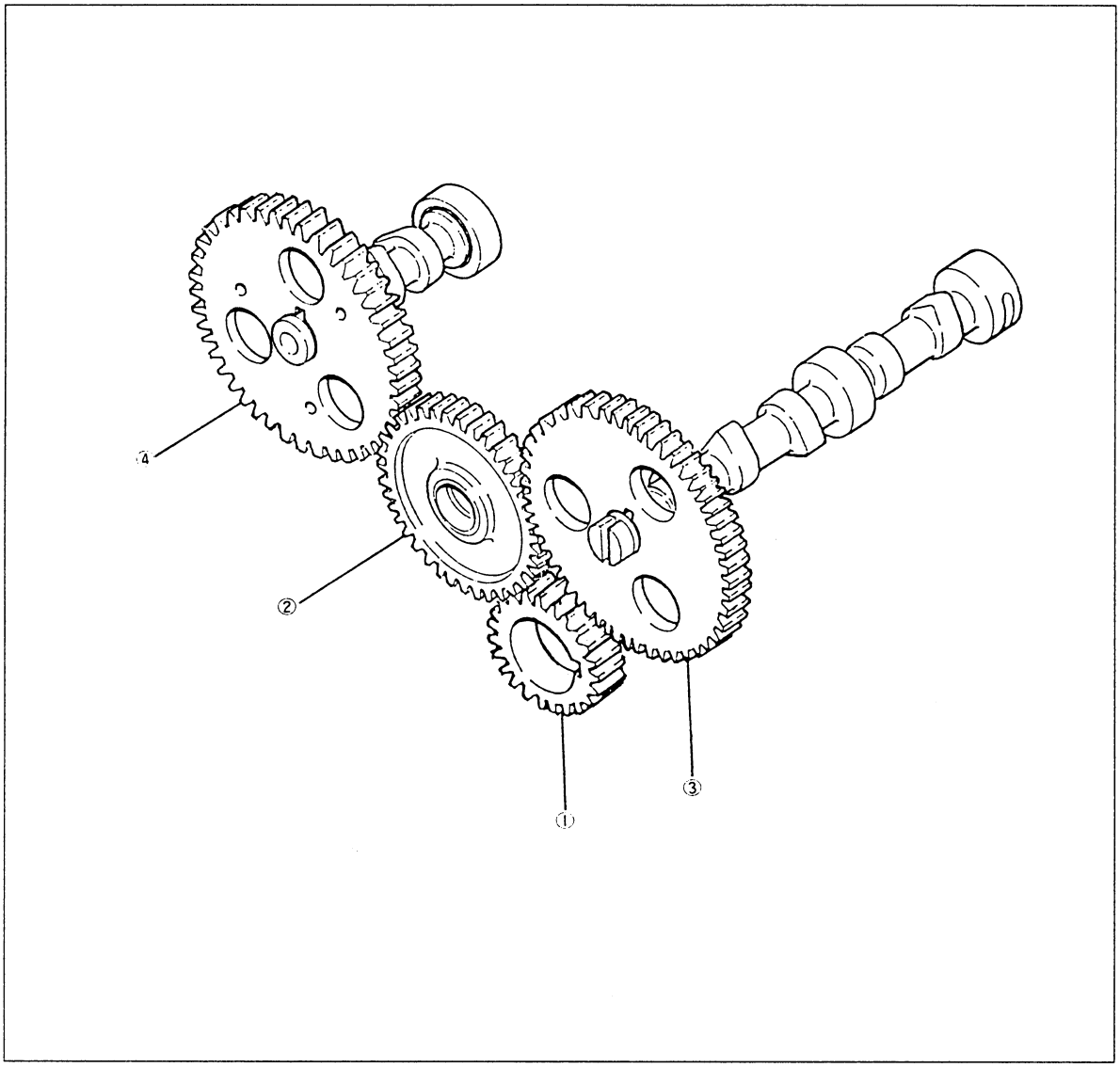


Installing Governor Shaft

Gear Case Installation



Gear Case Assembly



TIMING GEAR COMPONENT PARTS

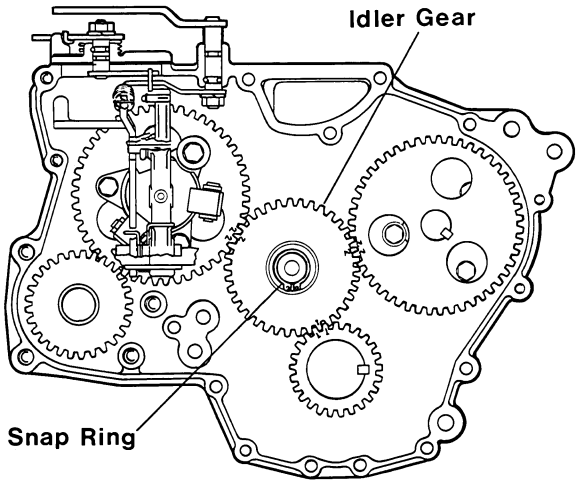
1. Crankshaft gear.
2. Idle gear.
3. Camshaft gear.
4. Injection pump camshaft gear.

Timing Gears' Removal

1. Pry the snap ring out and remove the idle gear.

2. Remove the valve camshaft and injection pump camshaft on which the respective gears are press-fitted. Remove the gears from the shafts.

3. Remove the crankshaft. Remove the gear from the crankshaft.

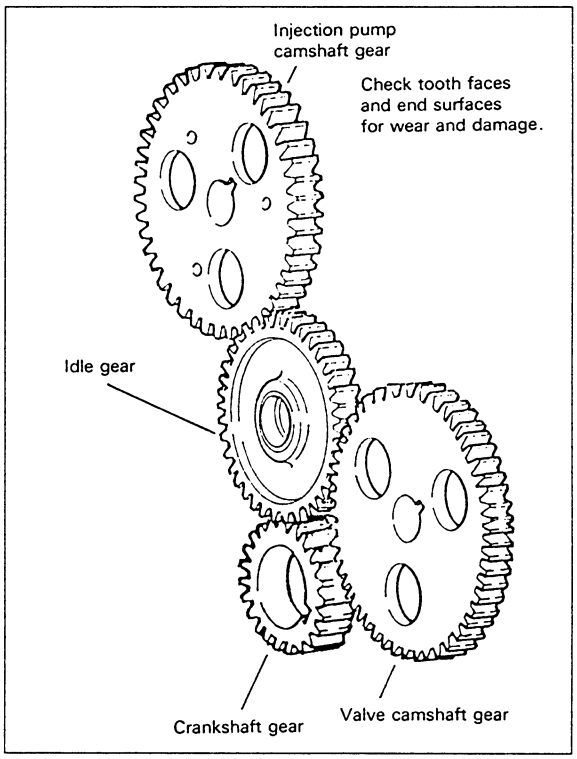


Timing Gears' Inspection

Check the removed gears. If any gear is found defective, replace it.

Idle gear bushing		
Description	Standard value	Service limit
Clearance between bushing and shaft	0.03 – 0.07	0.2

Backlash between gears in mesh		
Description	Standard value	Service limit
Crankshaft-Idle	0.01 – 0.14	0.3
Idle-Camshaft		
Idle-Fuel pump Gear		



Inspecting Timing Gears

Timing Gears' Installation

1. Press-fit the crankshaft gear onto the shaft.

2. Press-fit the valve camshaft gear and injection pump camshaft gear onto the respective shafts.

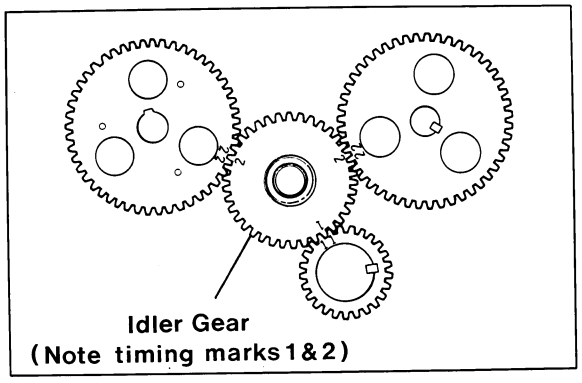
3. Install the gears in the following sequence.

   a. Turn the crankshaft to set the No. 1 cylinder to top dead center on compression stroke.

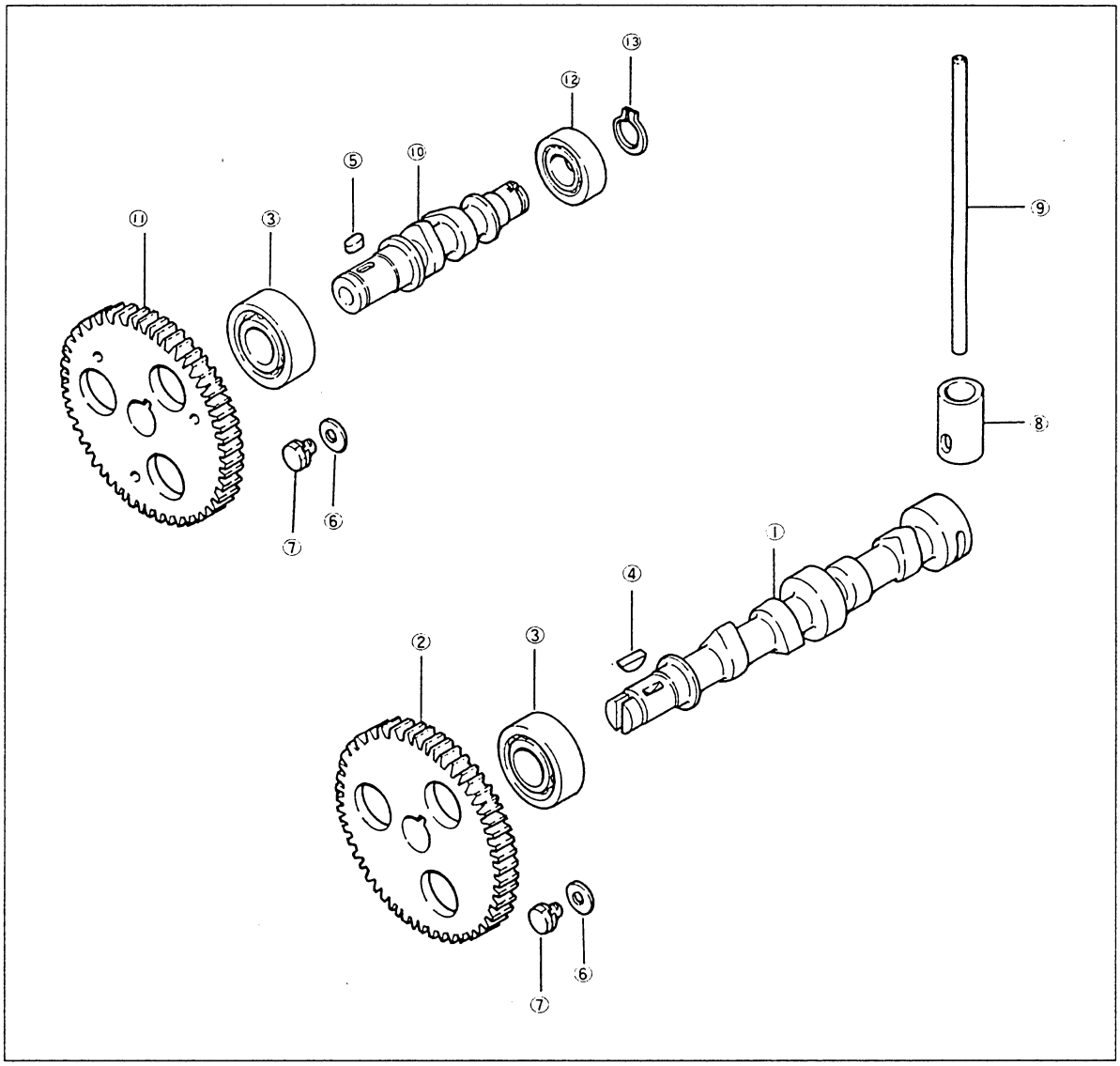
   b. Install the valve camshaft and injection pump camshaft.

   c. Install the idle gear so that timing marks on it are in alignment with marks on the other gears.

   d. Confirm that timing gears are in alignment with each other.



CAMSHAFTS (Valve and Pump)



CAMSHAFT COMPONENT PARTS

1. Camshaft (valve).
2. Camshaft gear.
3. Ball bearing.
4. Woodruff key.
5. Sunk key.
6. Camshaft stopper.
8. Tappet.
9. Push rod.
10. Camshaft (injection pump).
11. Camshaft gear.
12. Ball bearing (rear).
13. Snap ring.

Valve Camshaft Removal

1. When it is necessary to remove only the valve camshaft, use the following procedure.

   a. Dismount the cylinder head assembly.

   b. Pull out the push rods.

   c. Pull out the tappets.

   d. Remove the gear case assembly.

   e. Remove the camshaft stopper bolt.

   f. Draw the camshaft assembly out.

2. Removal of the injection pump camshaft.

   a. Disconnect the injector lines.

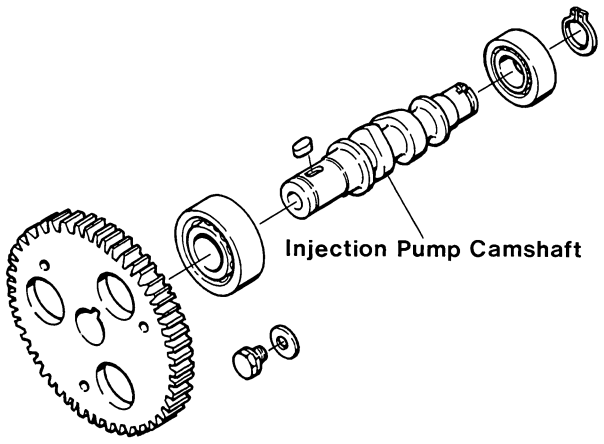
   b. Remove the injection pump assembly.

   c. Remove the gear case assembly.

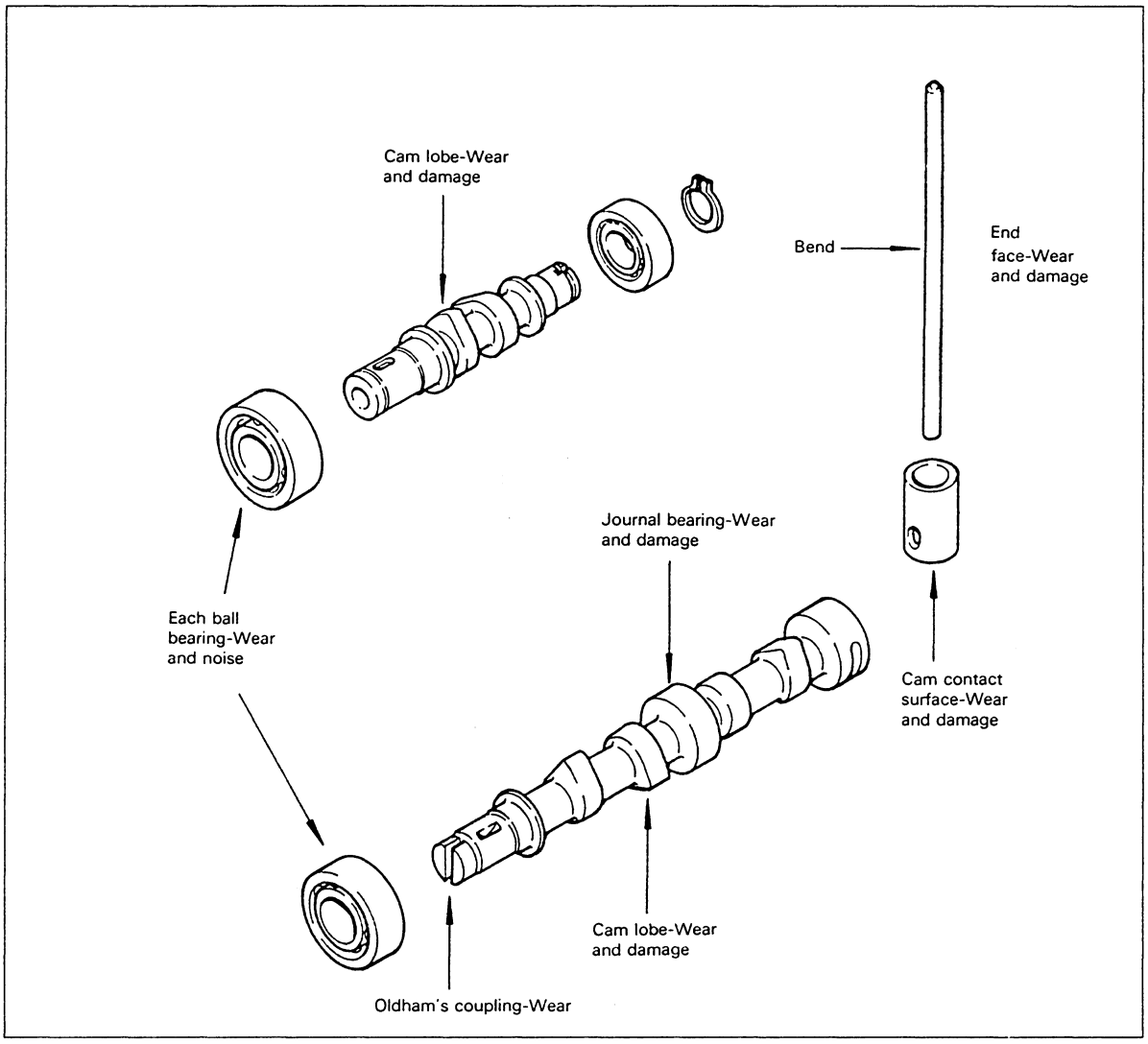
   d. Remove the shaft rear cover.

   e. Remove the stopper bolt.

   f. Remove the shaft from the front of the engine.



Camshafts' Inspection



Inspection of Camshafts

Major diameter of injection pump cam	
Standard value	30
Service limit	−0.7

Major diameter of valve cam	
Standard value	27.37
Service limit	−1.0

Camshafts' Installation

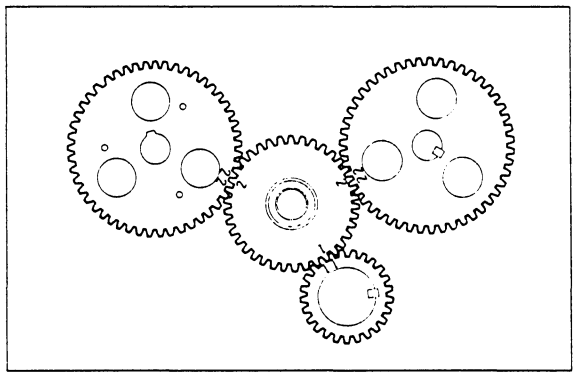
When installing the camshafts, give care to the following.

1. Coat the bearings and cam lobes with oil.

2. Install the camshafts in the reverse order of removal.

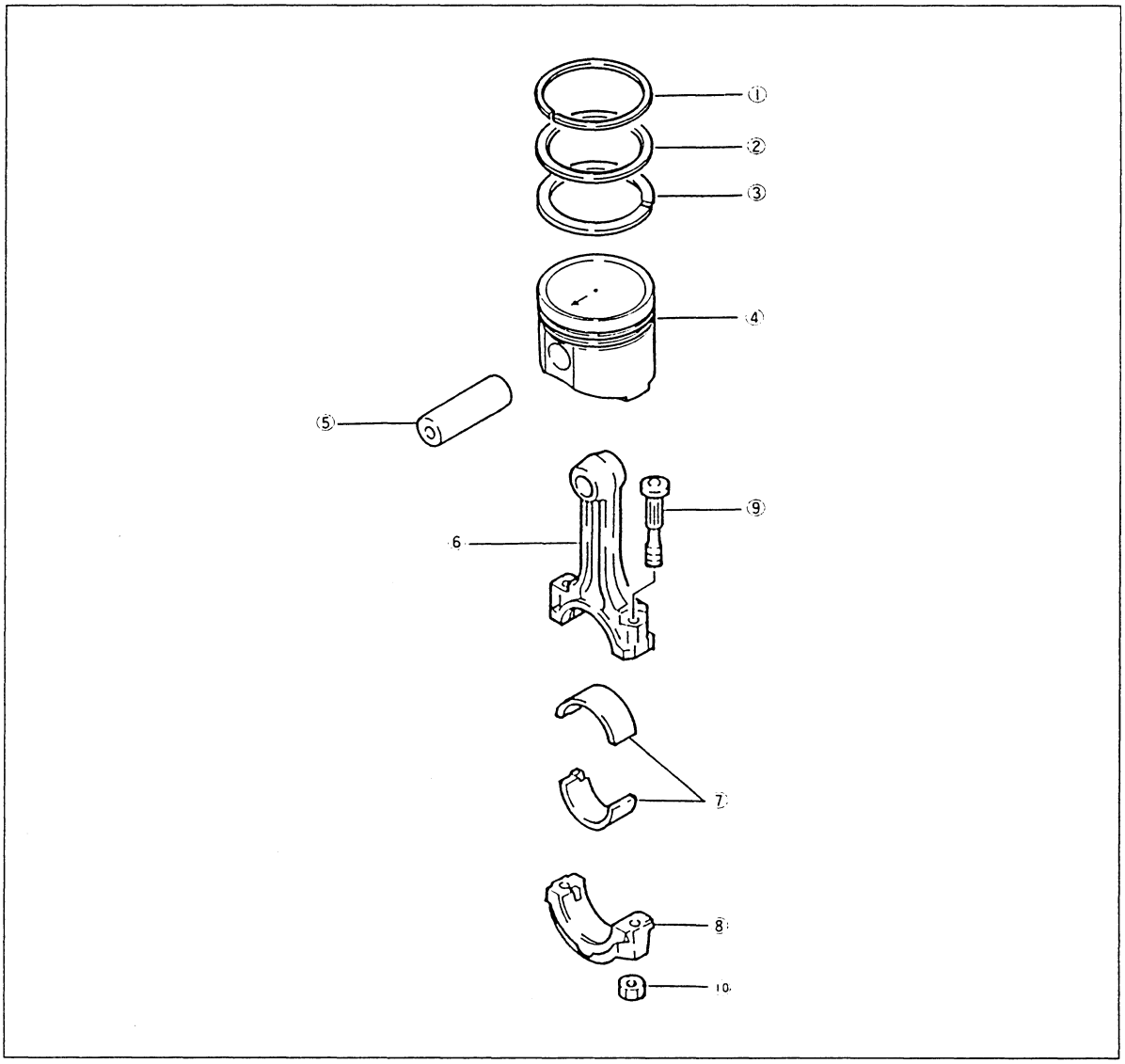
3. Position the timing marks on the gears in alignment with the marks on the idler gear.

4. After installation, check and adjust fuel injection timing and valve clearances.



Timing Gears in Alignment with Each Other

PISTON AND CONNECTING ROD



PISTON AND CONNECTING ROD COMPONENT PARTS

1. Piston ring No. 1.
2. Piston ring No. 2.
3. Oil ring.
4. Piston.
5. Piston pin.
6. Connecting rod.
7. Connecting rod bearing.
8. Connecting rod cap.
9. Connecting rod bolt.
10. Connecting rod nut.

Piston and Connecting Rod Removal

1. Remove the cylinder head assembly.

2. Remove the oil pan.

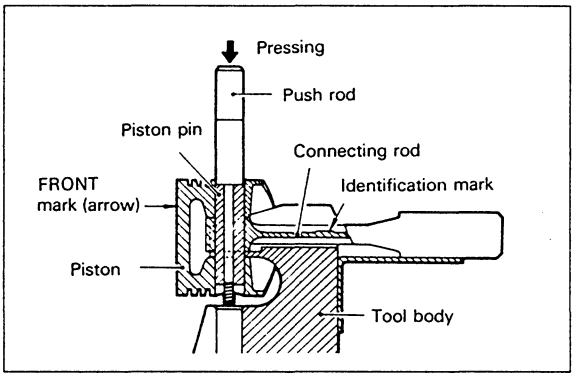
3. Remove the oil screen.

4. Chalk the cylinder number on the side face of the big end of each connecting rod to prevent confusion of connecting rods.

5. Remove the connecting rod cap from each piston and rod assembly and draw the assembly upward from the cylinder. Take care not to allow the connecting rod to scratch the crankshaft pin and cylinder. Keep the removed parts (connecting rod, rod cap, piston etc.) classified by cylinders.

6. Remove the rings from each piston with the piston ring pliers.

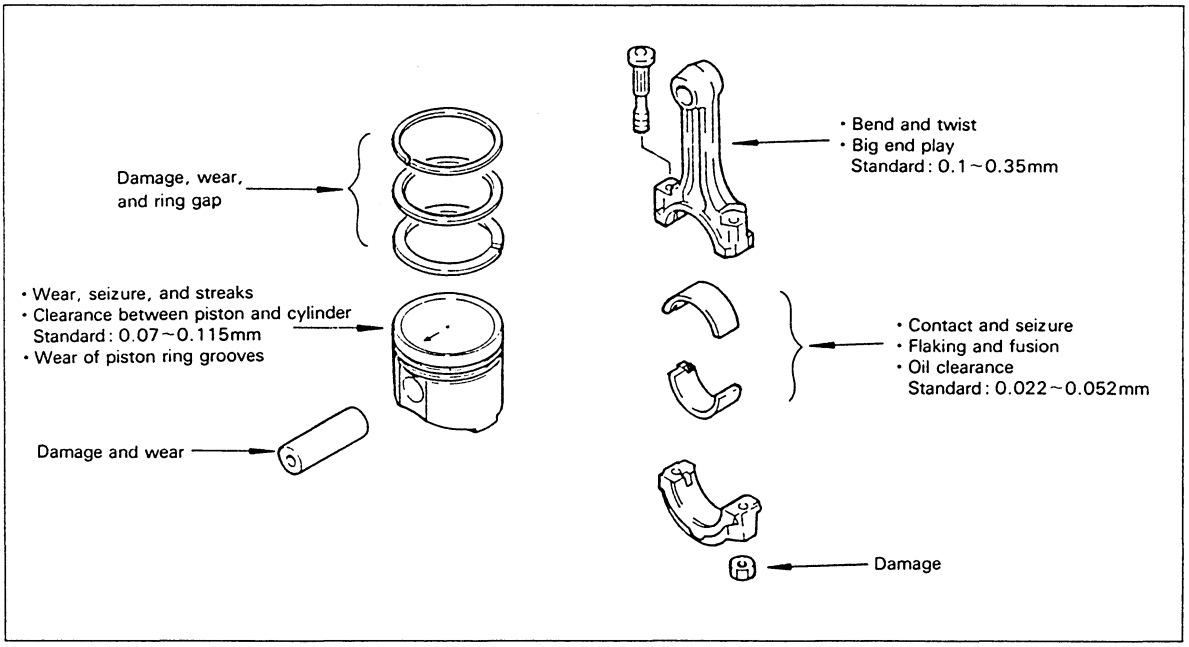
7. Using the piston setting tool, pull out the piston pin from each piston.



Removing Piston Pin

Piston and Connecting Rod Inspection

Inspect the removed parts. If any parts are found defective, replace or repair them.

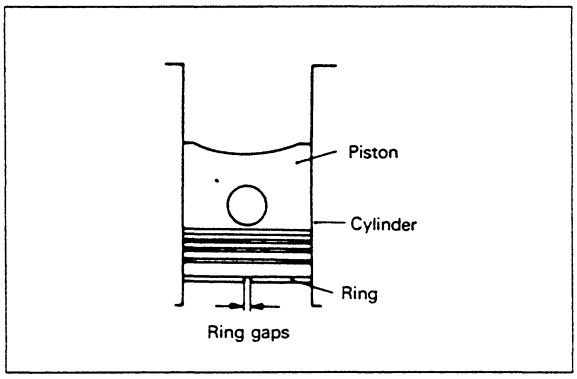


Inspection of Piston and Connecting Rod

Inspection of piston ring gaps. Put each piston ring into the cylinder bore and push the ring with the piston to position the ring on square with the cylinder wall. Measure the ring gap with a feeler gauge. If the measurement exceeds the service limit, replace that piston ring.

CAUTION

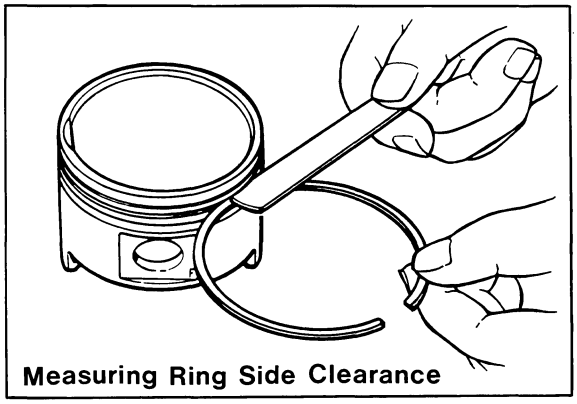
When only the replacement of rings is to be made, without reboring (honing) of the cylinder, position the ring to be measured at the least worn place of the cylinder skirt. Install the new rings having the same size as the piston. Piston rings available for servicing are sized into three classes: STD, 0.25 OS, and 0.50 OS.



Measuring Ring Gap

Ring	Standard	Service limit
All rings	0.15~0.40	1.5

Inspection of ring groove in piston. Measure the side clearance for each piston ring set in the ring groove in the piston. If the service limit is exceeded, replace the ring with a new one.


Measuring Ring Side Clearance

Ring	Standard	Service limit
No. 1	–	0.3
No. 2	0.05~0.09	0.2
Oil	0.03~0.07	0.2

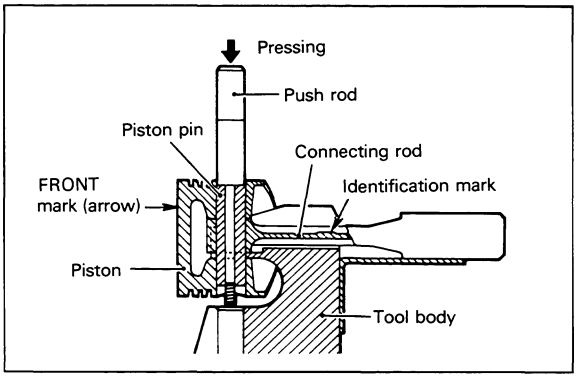
Note : No. 1 ring is of the semi-key stone type.

Piston and Connecting Rod Installation

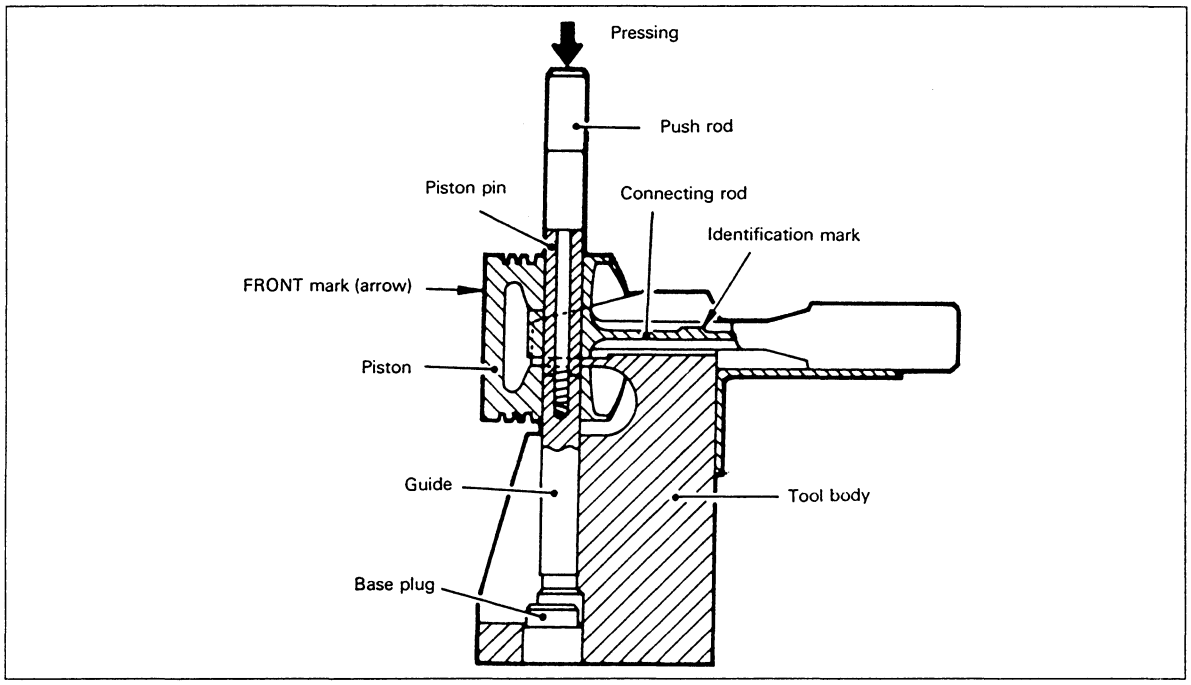
When reassembling the piston and connecting rod and installing the piston and rod assemblies in the cylinder block, pay attention to the following.

1. Reassemble the piston and connecting rod, using the Piston Pin Setting Tool, by pressing the piston pin in to the set position.

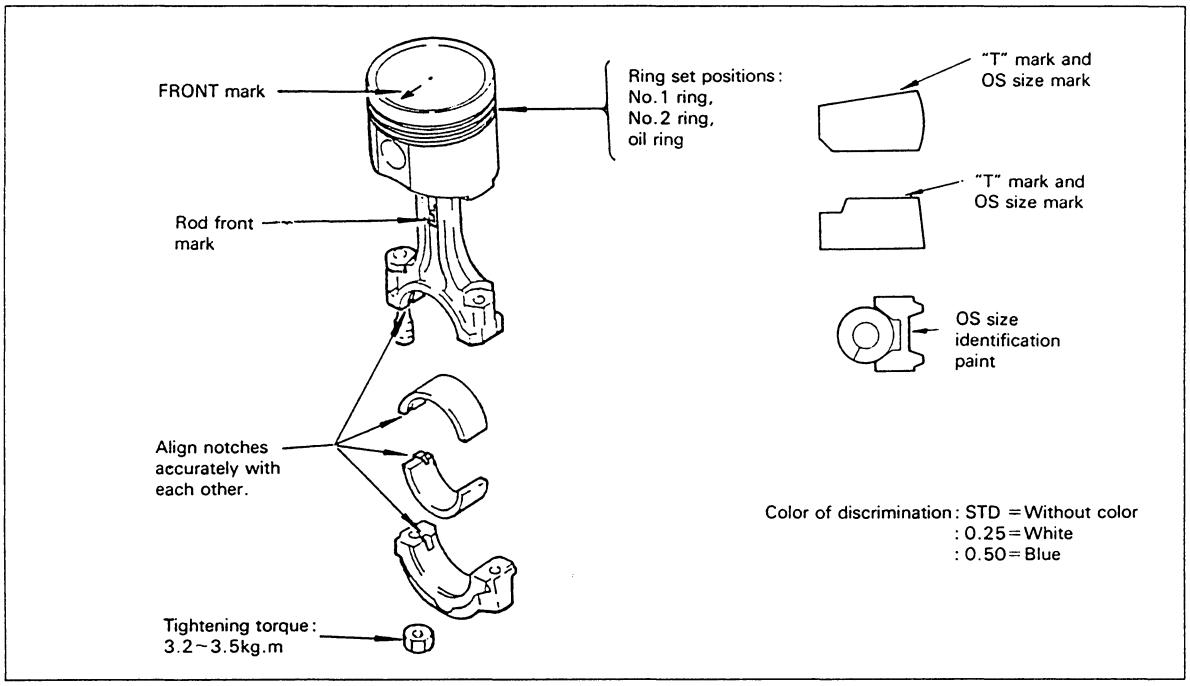
Description	Standard
Pin press-fitting force (at a normal temperature)	1000±500kg



Installation of Piston and Connecting Rod

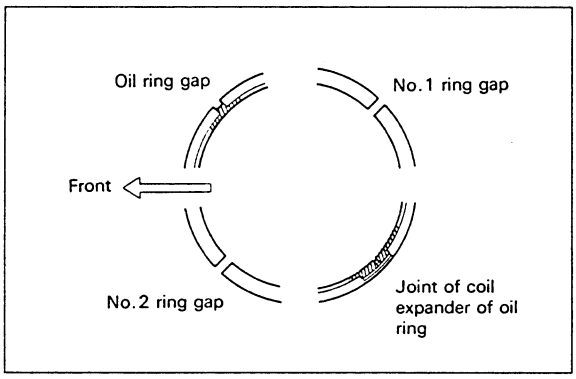


2. Installation of piston rings.



Installation of Piston Rings and Connecting Rod Cap

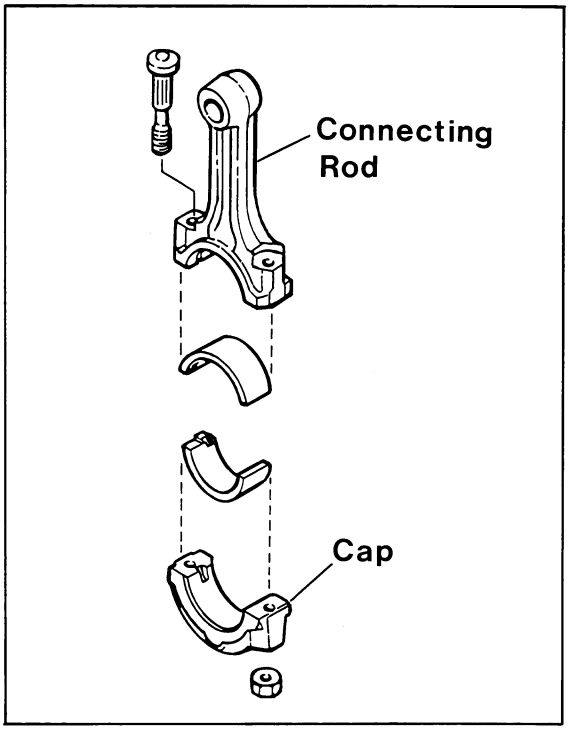
3. Set the piston ring gaps to the proper positions as shown in the figure at right. Coat the rings and cylinder wall with oil.

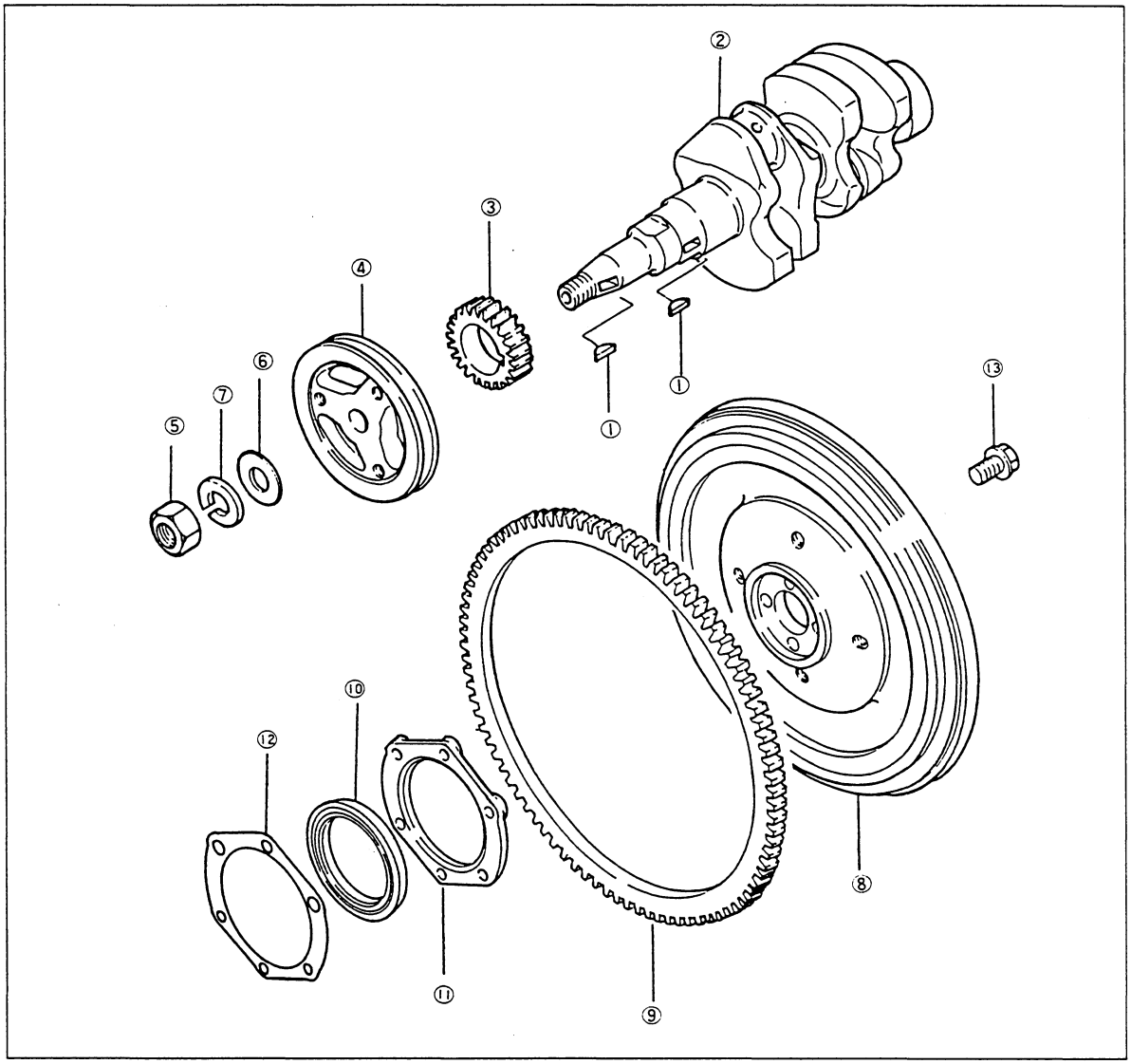


Proper Arrangement of Ring Gaps

4. Using a piston ring compressor to compress the rings into the grooves, push the piston and rod assembly down into the cylinder. Be careful not to break the rings by excessively knocking the head of the piston. Note that the front marks on the piston and connecting rod are toward the engine front.

5. Coat the bearing surface of the connecting rod caps with engine oil. Fit each cap to the connecting rod using match marks put before removal as a guide. In the case of a new rod which does not have a mark, position the notches (provided for preventing the bearing from rotating) on the same side.





CRANKSHAFT COMPONENT PARTS

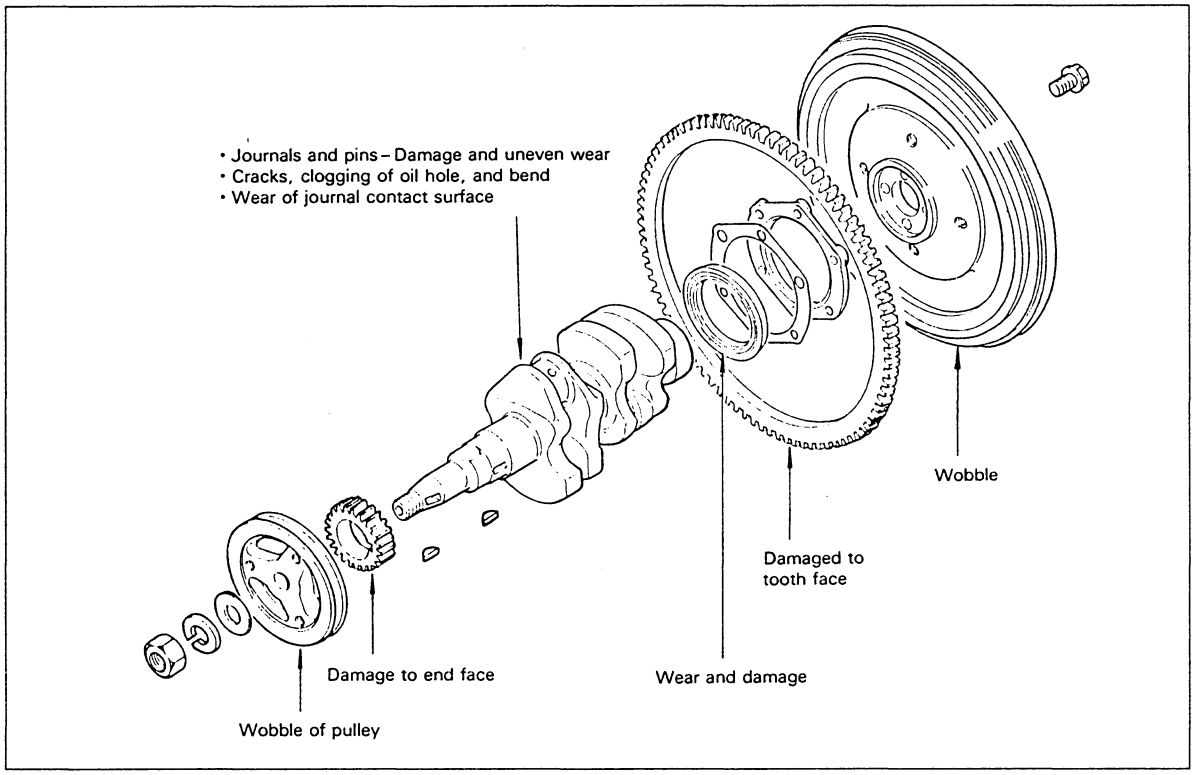
1. Key.
2. Crankshaft.
3. Crankshaft gear.
4. Crankshaft pulley.
5. Nut.
6. Washer.
7. Spring washer.
8. Flywheel.
9. Ring gear.
10. Rear oil seal.
11. Rear oil seal case.
12. Gasket.
13. Flywheel bolt.

Crankshaft Removal

1. Loosen the flywheel bolts and remove the flywheel.
2. Loosen the crankshaft pulley nut and remove the pulley.
3. Remove the rear oil seal case assembly.
4. Remove the main bearing caps.
5. Take out the crankshaft.

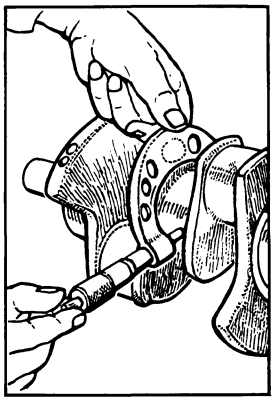
Crankshaft Inspection

Inspect the removed parts. If any parts are found defective, repair or replace them.



Inspection of Crankshaft and Flywheel

Checking the crankshaft for wear. To check the crankpins and main journals for tapering wear and out-of-round wear, the diameter of each crankpin or main journal should be measured at two places along the crankpin or main journal, in two directions "A" and "B" each place, as shown in the figure at right. If necessary, regrind the crankpins and main journals to the next under size. If any crankpin or main journal has been worn out beyond the service limit, replace the crankshaft.

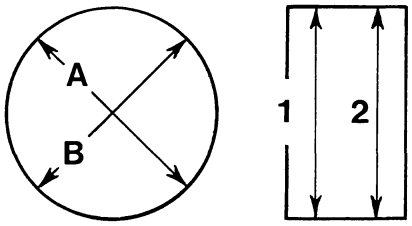


Checking Crankshaft for Wear

Diameter of crankpin and main journal (mm)		
Description	Standard	Service limit
Main journal dia.	43	−0.70
Crankpin dia.	40	−0.70

Under-size diameters (mm)		
Description	Main journal	Crankpin
0.25 US	42.715~42.730	39.715~39.730
0.50 US	42.465~42.480	39.465~39.480

Inspection of the crankshaft oil clearance. Oil clearance is calculated by subtracting the diameter of main journal or crankpin from the inside diameter of the main bearing or rod bearing. To check the main bearings and rod bearings for tapering wear and out-of-round wear, the inside diameter of each main bearing or rod bearing should be measured, after its bearing cap is fastened to the specified torque, at two places along the bearing, and in two directions "A" and "B", each place as shown in the figure at right. If necessary, replace the worn bearing with a new one. If the oil clearance still exceeds the service limit, regrind the crankshaft to the next under size and replace the bearing with one of the corresponding under sizes.



Measuring Main Bearing I.D.

CAUTION

A crankshaft which has been sized cannot be reground to any under size.

Tightening torque (kgm)	
Description	Standard
Main bearing cap bolt	5.0~5.5
Rod bearing cap nut	3.2~3.5

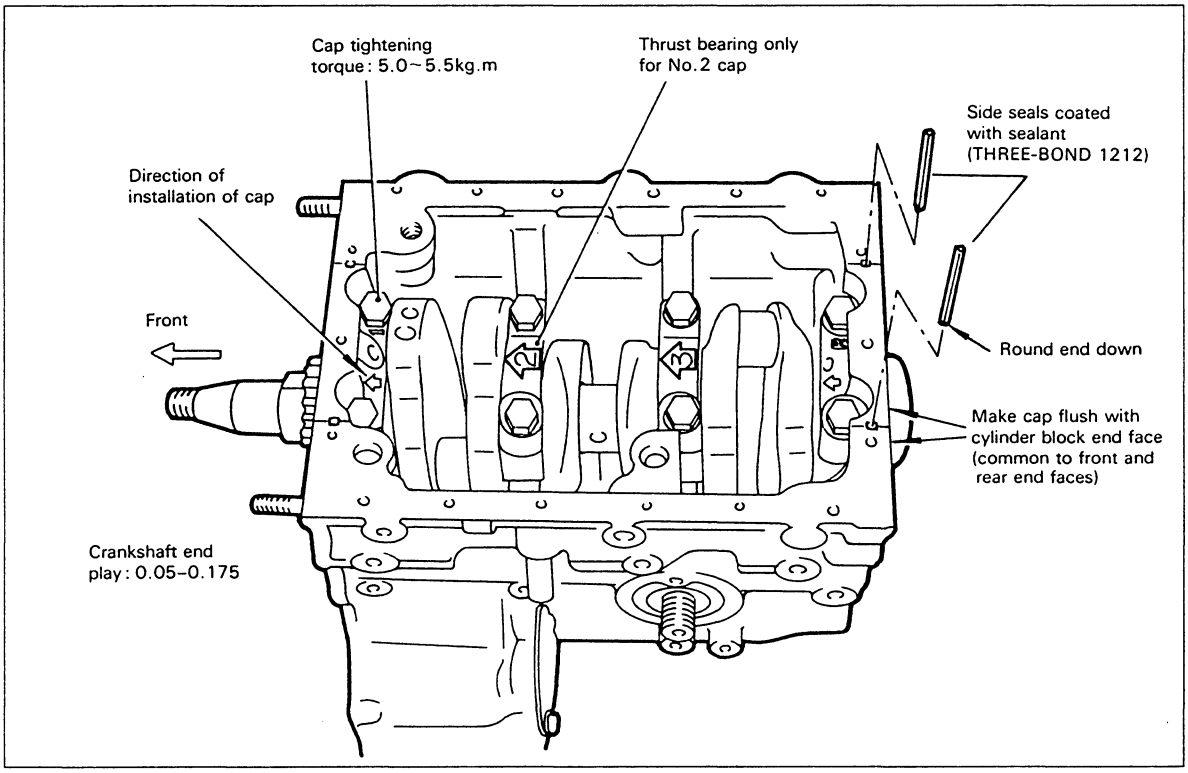
Oil clearance (mm)	
Description	Service limit
Main bearing	0.10
Rod bearing	0.15

Crankshaft Rear Oil Seal Replacement

1. Pry the oil seal out with a screwdriver.

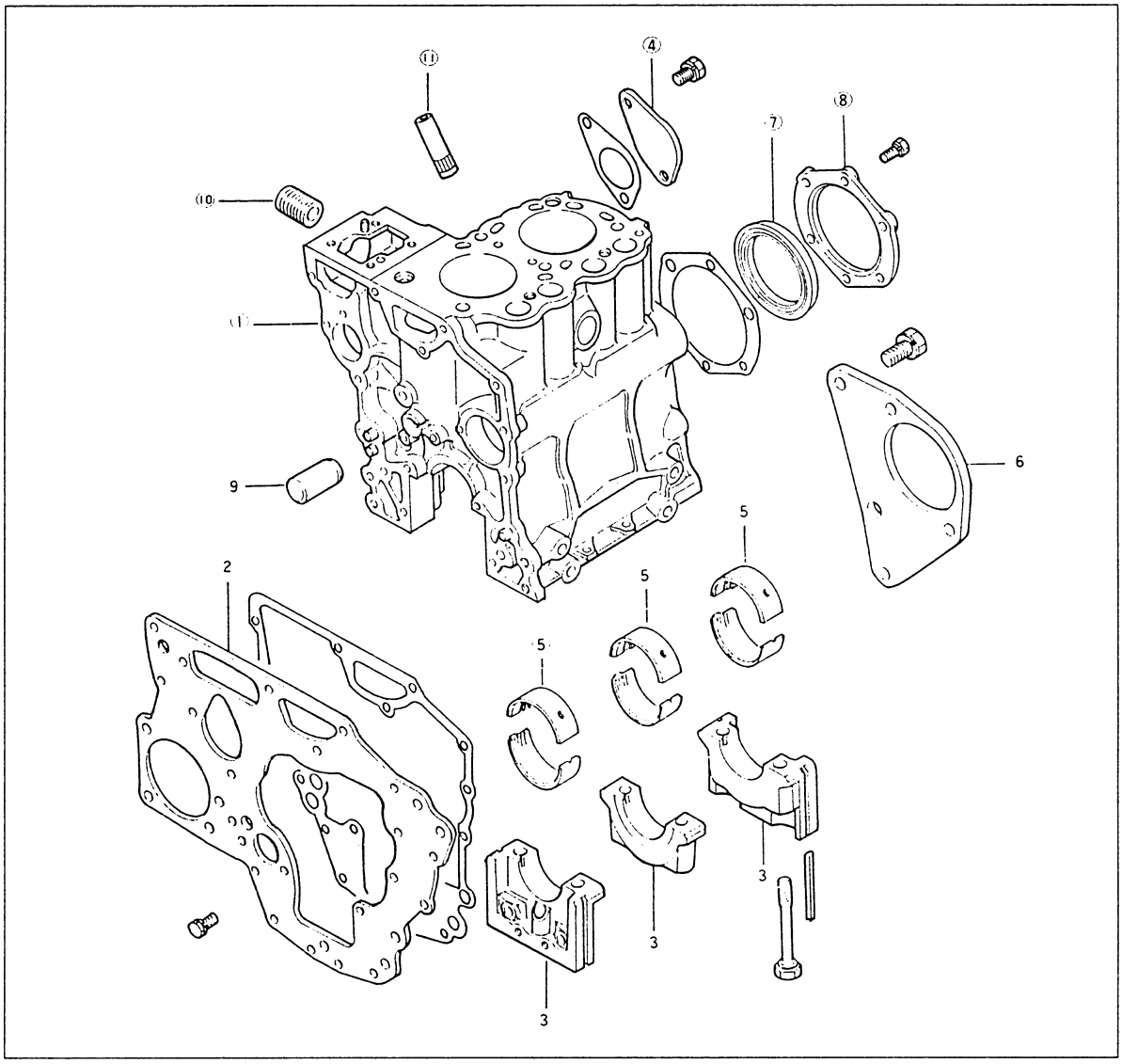
2. Drive in a new oil seal to the oil seal case.

When installing the crankshaft, pay attention to the notes given in the figure below.



Installation of Crankshaft

CYLINDER BLOCK



CYLINDER BLOCK COMPONENT PARTS

1. Cylinder block.
2. Front plate.
3. Bearing cap.
4. Cover.
5. Main bearing.
6. Starter bracket.
7. Rear oil seal.
8. Oil seal case.
9. Idler gear shaft.
10. Oil filter shaft.
11. Oil level gauge guide.

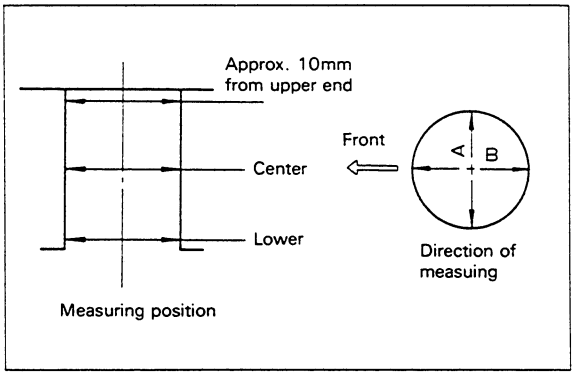
Cylinder Block Inspection

Inspect the cylinder block. If it is found defective, repair or replace the block.

Cylinder Bore (mm):

Model	Standard
20B	76 +0.03 -0.0
30B	76 +0.03 -0.0

Wear Limit Before Rebore: +0.02 mm



Cylinder Bore Measuring Positions

Cylinder Reboring

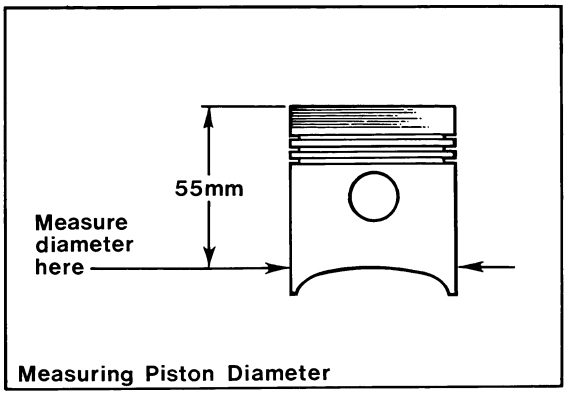
When reboring a cylinder, use the following procedure.

1. Select a piston size: 0.25 OS or 0.50 OS.

2. Measure the piston diameter.

3. Reboring finish dimension = [piston OD] + [clearance] - [honing allowance (0.2 mm)]

   Clearance (between piston and cylinder)
   Standard: 0.071 - 0.084 mm (A-D)

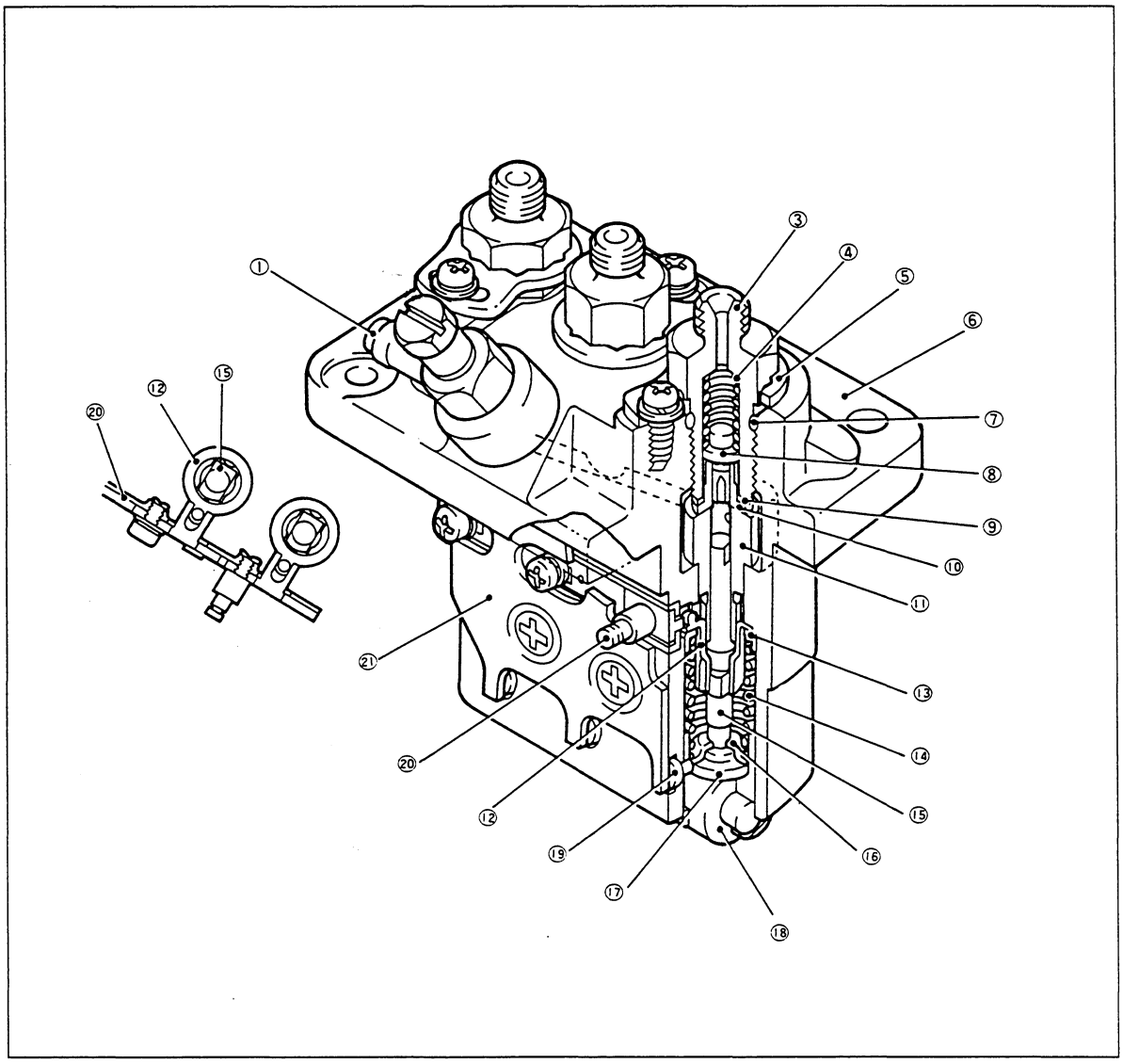


Measuring Piston Diameter

CAUTION

When it is necessary for a cylinder to be rebored to the next over size, the remainders must also be rebored to the same over size.

FUEL INJECTION PUMP



INJECTION PUMP COMPONENT PARTS

1. Union collar.	8. Delivery valve.	15. Plunger.
	9. Gasket.	16. Lower seat.
3. Delivery valve holder.	10. Seat valve.	17. Adjusting shim.
4. Valve spring.	11. Plunger barrel.	18. Tappet roller.
5. Holder stopper.	12. Sleeve.	19. Pin.
6. Housing.	13. Upper seat.	20. Control rack.
7. O-ring.	14. Plunger spring.	21. Stop wire bracket.

Injection Pump Inspection while on the Engine

Never attempt to disassemble the pump unless it is necessary. If the pump is assumed defective, it is recommended to replace the pump assembly.

Injection Pump Removal

1. Disconnect the fuel injection pipes.
2. Remove the tie-rod clip cover.
3. Remove the tie-rod clip and tie-rod.

Injection Pump Disassembly

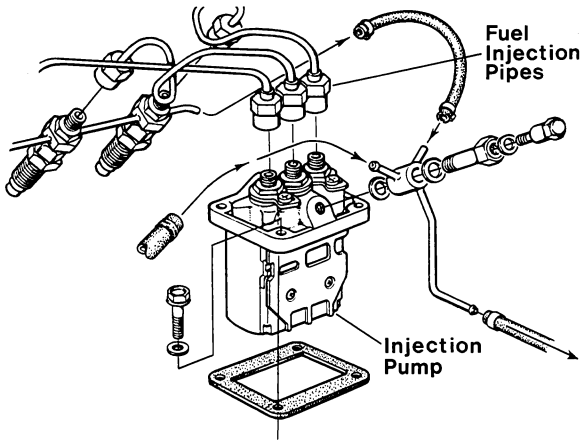
1. Remove the stopper plate.
2. Unscrew the delivery holder. Take out the delivery valve and valve spring.
3. Remove the tappet roller and stopper pin.
4. Remove the tappet, plunger spring, etc.

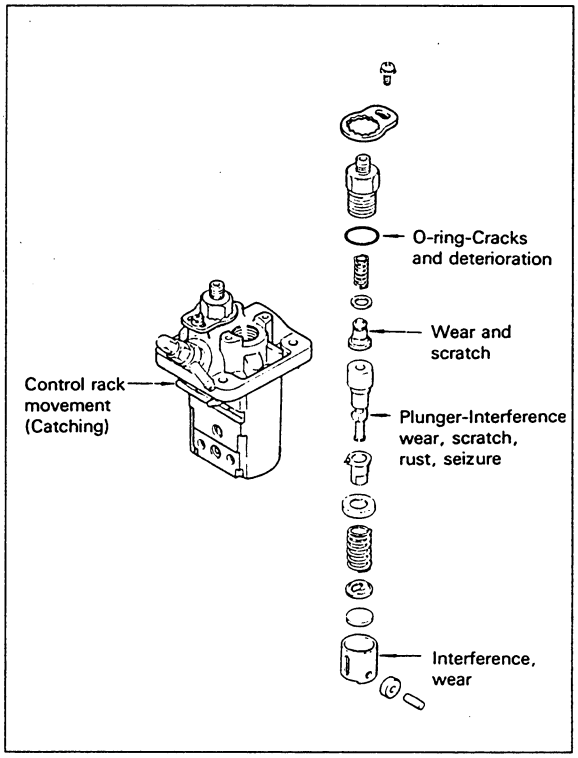
CAUTION

When replacing the plunger barrel, delivery valve, etc., do not loosen the adjusting screw and plate for each cylinder. When those parts have been replaced, it is necessary to measure fuel injection quantity by utilizing a pump tester and cam box. All parts removed from the pump should be kept classified by cylinders and immersed in clean fuel.

Injection Pump Inspection

Inspection	Inspection procedure	Criterial
Idling speed	Measure engine speed.	900^{+50}_{0}rpm
Exhaust smoke color	1) Quickly accelerate engine without load. 2) Apply load to engine	No remarkably black-smoke exhaust permitted.
Fuel cut-off solenoid	Turn ignition switch to OFF from ON.	A solenoid acting sound.





Inspection of Injection Pump

Injection Pump Assembly

1. Insert the plunger barrel into the housing.

2. Install the delivery valve and valve spring. Temporarily tighten the holder.

3. Insert the control rack.

4. Insert the control pinion. Align the matchmark on the rack with that on the pinion.

5. Install the spring upper seat.

6. Insert the plunger spring.

7. Fit the lower seat to the plunger. Insert the plunger into the barrel side.

8. Depress the tappet roller assembly and install the stopper pin.

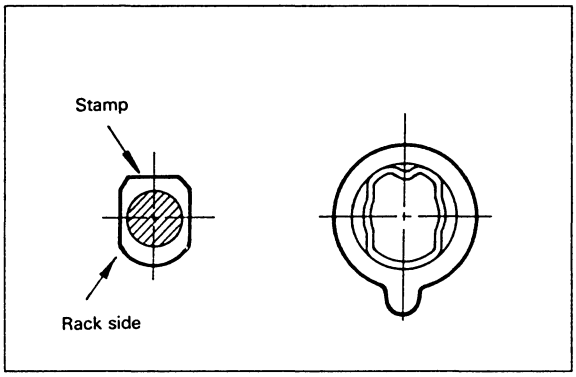
9. Tighten the delivery holder.
   Tightening torque: 3.5 - 3.9 kgm

Injection Pump Installation

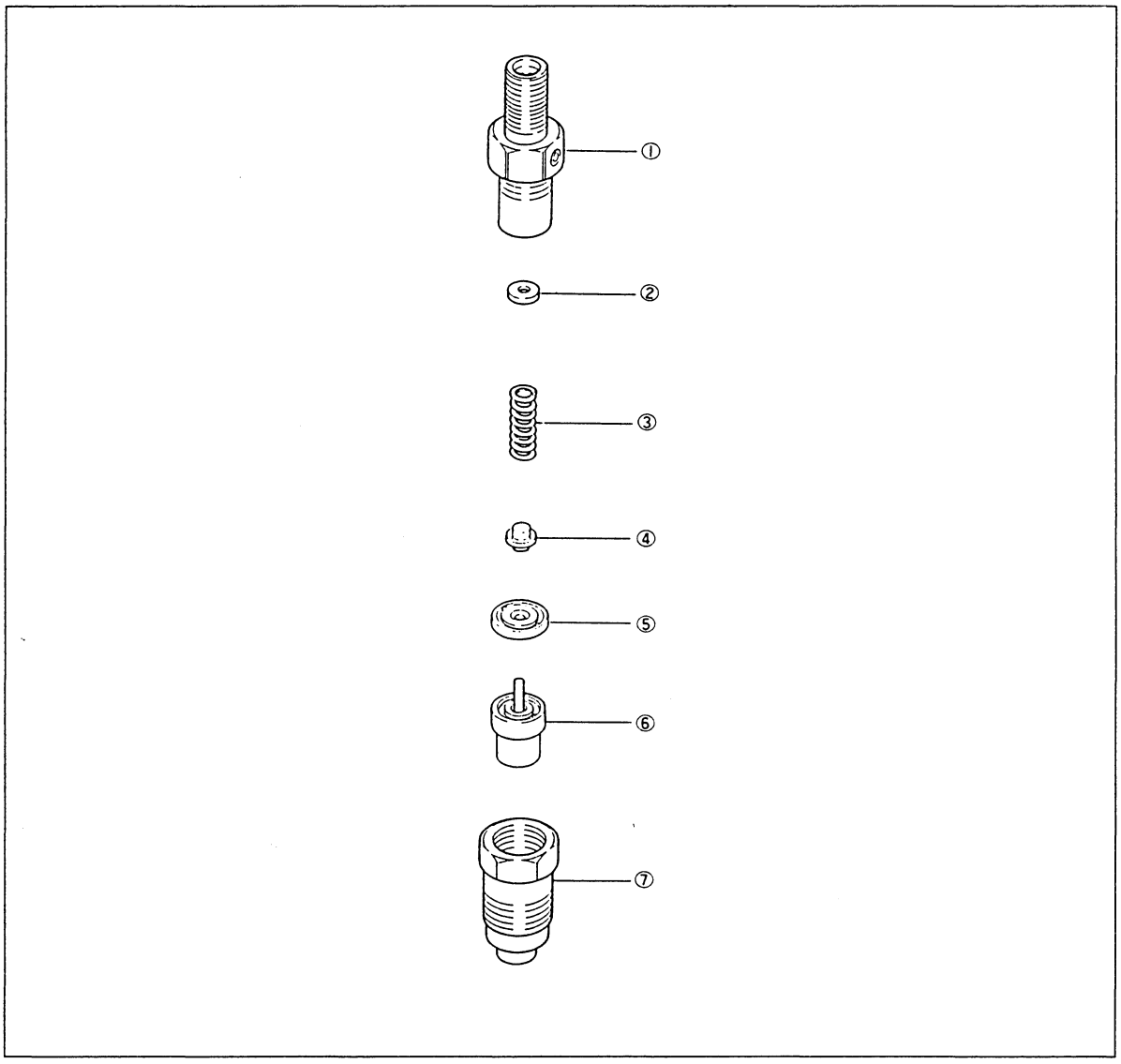
Install the injection pump assembly in the reverse order of removal.

CAUTION

When installing the plunger barrel, engage the dowel pin on the housing side with the groove in the barrel. Position the plunger so that the part number stamp on its flange faces the direction opposite to the rack side. (Engage the feed hole with the plunger lead.) After installation, check for proper injection timing.



Direction of Installation of Plunger



NOZZLE HOLDER ASSEMBLY COMPONENT PARTS

1. Body subassembly.
2. Shim washer.
3. Pressure spring.
4. Pin.
5. Distance piece.
6. Nozzle assembly.
7. Retaining nut.

Injection Nozzle Removal

1. Disconnect the injection pipe and fuel return pipe.

2. Remove the injection nozzle assembly from the cylinder head.

CAUTION

Attach an identification number tag to the removed injection nozzle. Plug the openings from which the pipes are disconnected and the nozzle is removed to prevent intrusion of dust, water, and other foreign particles into the pipes and combustion chamber.

Injection Nozzle Disassembly

If the removed nozzle assembly is assumed defective, disassemble the assembly and repair or replace the faulty parts.

1. Grip the nozzle holder body in a vise. Loosen the retaining nut. Never vise the retaining nut to prevent deformation.

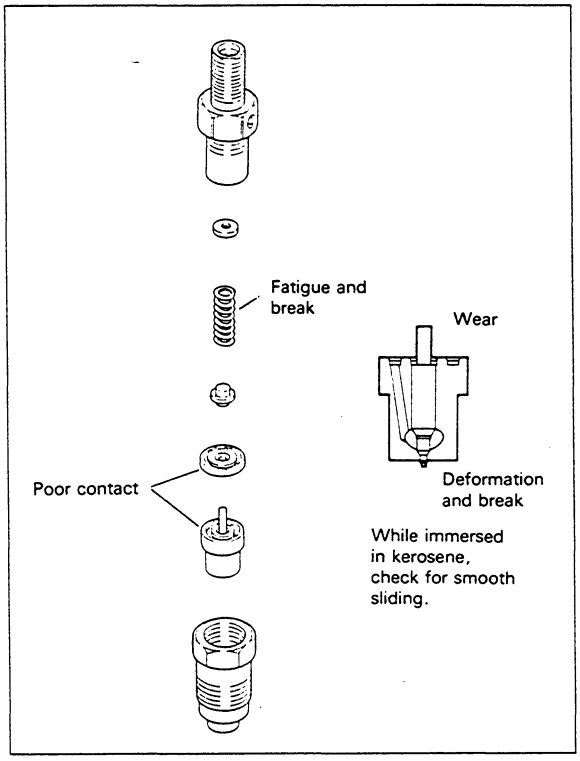
2. Take out the shim washer, pressure spring, distance piece, and nozzle assembly.

CAUTION

Scrape off carbon deposits with a wooden spatula. Keep the removed parts immersed in washing oil (kerosene). Take special care not to scratch the needle valve in the nozzle assembly.

Injection Nozzle Inspection

Inspect the removed parts. If any part is found defective, replace it.



Inspecting Nozzle

Injection Nozzle Assembly

1. Insert the nozzle assembly into the retaining nut so that the nozzle is perfectly seated in the nut.

2. Place the distance piece, retaining pin, pressure spring, and shim washer on the nozzle assembly.

3. Tighten the nozzle holder body fully by hand.

4. Grip the nozzle holder in a vise. Tighten the retaining nut to the specified torque.

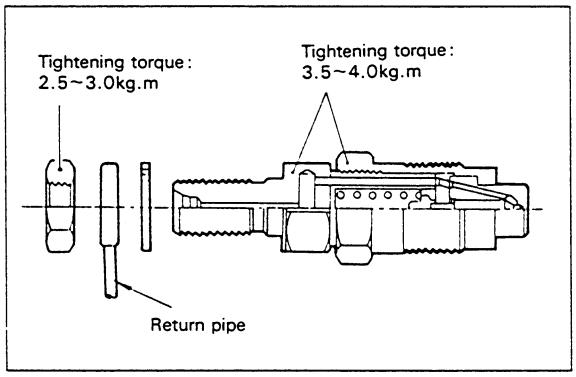
Tightening torque: 3.5 - 4.0 kgm

Injection Nozzle Adjustment

Adjust injection start pressure by increasing or decreasing the thickness of the shim washer to be inserted. Varying shim thickness by 0.1 mm causes injection start pressure to change 10 kg/cm.

10 kinds of shims available from 1.25 mm to 1.7 mm in thickness, 0.05 mm step.

Injection start pressure	
Standard	140^{+10}_{0} kg/cm²
Allowable limit	130 kg/cm² or less



Assembling the Nozzle

Injection Nozzle Installation

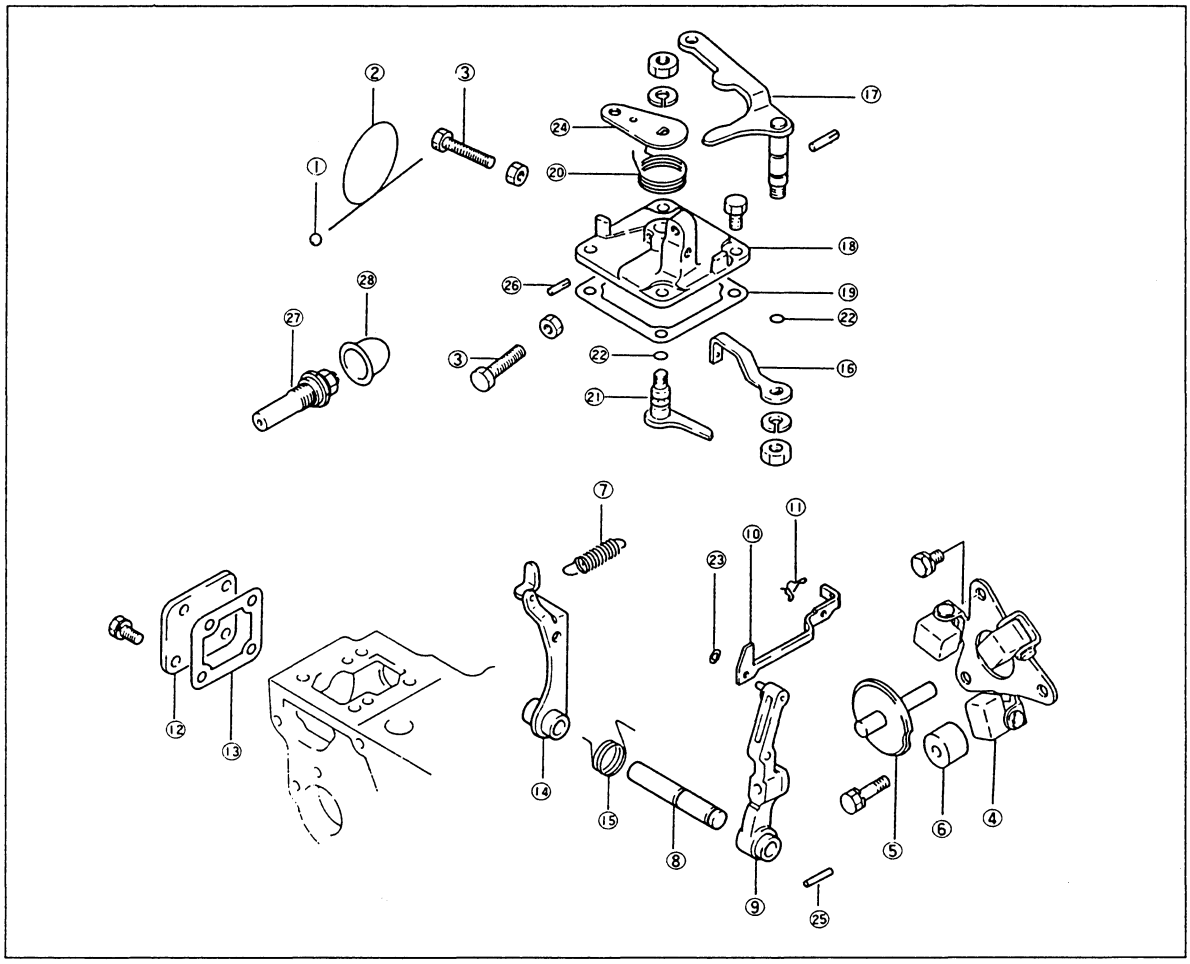
1. Clean the nozzle holder fitting surface of the cylinder head. Install the nozzle holder with a gasket interposed.

   Tightening torque: 5.0 - 6.0 kgm

2. Connect the fuel return pipe and injection pipe.

   Tightening torque:
   Injection pipe 2.5 - 3.5 kgm
   Fuel return pipe 2.5 - 3.0 kgm

GOVERNOR SYSTEM



GOVERNOR SYSTEM COMPONENT PARTS

1. Sealing metal.
2. Sealing wire.
3. Low and high speed.
4. Governor spring.
5. Sliding shaft.
6. Stopper
7. Governor spring.
8. Governor shaft.
9. Governor lever.
10. Tie-rod.
11. Tie-rod clip.
12. Tie-rod cover.
13. Tie-rod cover gasket.
14. Tension lever
15. Start spring.
16. Governor spring lever.
17. Speed control lever assembly.
18. Cover assembly.
19. Governor cover gasket.
20. Return spring.
21. Stop lever assembly.
22. O-ring.
23. Snap ring.
24. Stop lever.
25. Grooved pin (3 x 20).
26. Grooved pin (3 x 14).
27. Torque spring test.
28. Sealing cap.

Torque Spring Set Installation

Install and adjust the torque spring set using the following procedure:

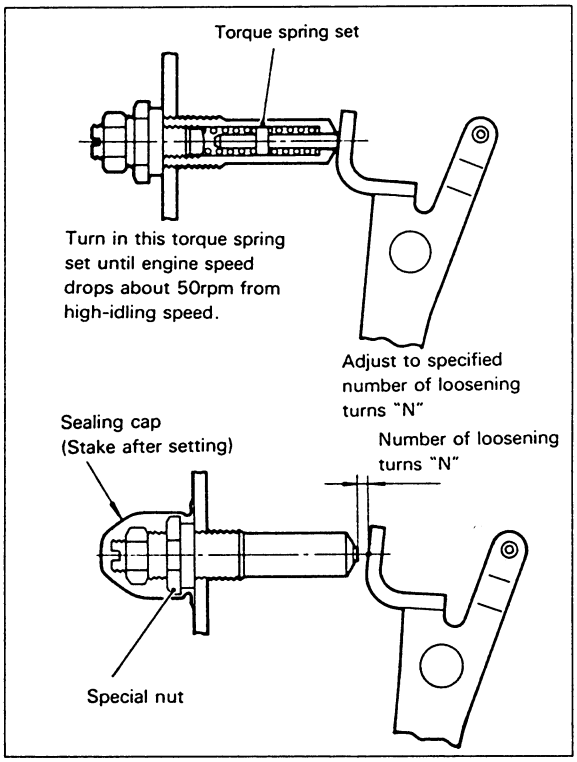
1. Set the speed control lever to the high idling speed position by adjusting the high speed set bolt.

2. Turn in the torque spring set until engine speed drops about 50 rpm from high idling speed.

3. From this position, turn back the torque spring set by the specified number of turns (N). Lock the torque spring set at that position with the special nut.

4. Install the torque spring set sealing cap and stake the cap to prevent loosening.

Model	Number of loosening turns (N)
20B Two & 30B Three	2.2



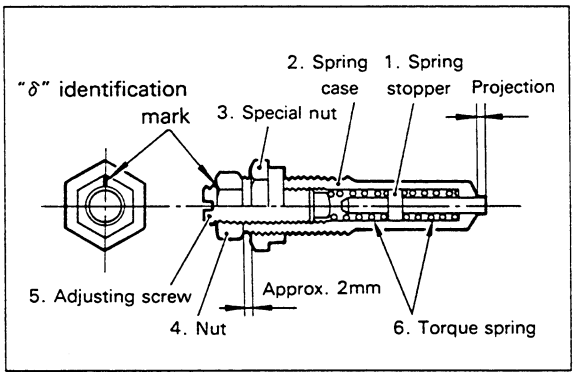
Torque spring set

Torque Spring Set Assembly

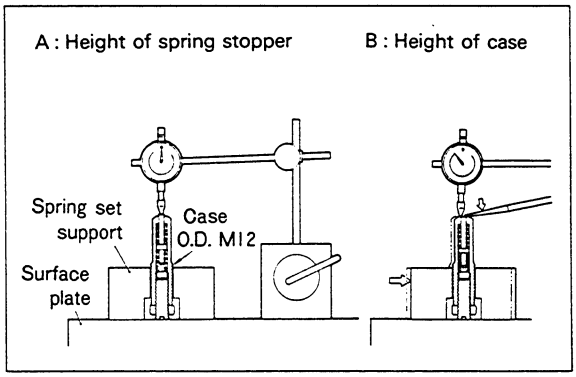
When the torque spring set has been disassembled or its component parts have been replaced, reassemble and adjust the torque spring set using the following procedure:

1. Assemble the torque spring set as shown in the figure. Using the adjusting screw (5), adjust the projection (8) of the torque spring stopper (1) from the spring case (2) to get the specified projection.

2. To measure the projection (8), keep the torque spring set in vertical position as illustrated. Put the dial gauge probe against the spring stopper (1) at the center of its end face using a small dial gauge (having the sensitive probe which does not compress the torque spring when pushed against the spring stopper end).



Assembling torque spring set



Measuring spring stopper projection (δ)

3. Leaving the dial gauge set condition unvaried, depress the spring stopper (1) and slide the torque spring set support spring case (2). Read the deflection of dial gauge which corresponds to the projection of the spring stopper from the spring case. (Measurement should be made two or three times repeatedly to make sure of accurate measure.) For the models which do not require any torque spring action, set the projection (8) to a value in the range of 0 to -0.4.

4. After adjustment, tighten nut (4) to a torque of 0.8 to 1.2 kgm.

5. Check to see that the spring stopper (1) can be depressed smoothly and that the end face of the stopper (1) can become flush with the end face of the spring case (2).

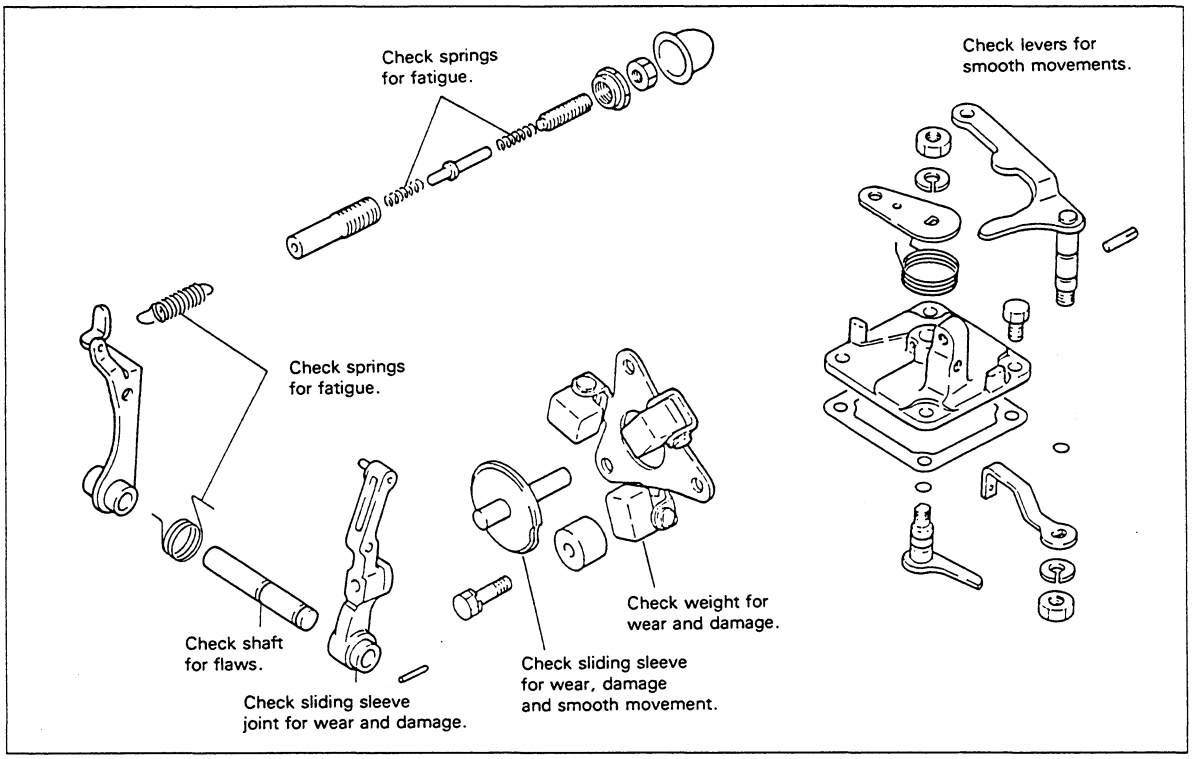
6. For the purpose of identification of projection (8), apply paint of the color specified to the surface shown in the figure at the right of paragraph (1).

Model	Projection 8 mm	Identification color
20B Two & 30B Three	0 ~ -0.4	Red

Replace the gear case and inspect the governor. When removing the gear case, be sure to remove the tie-rod cover by the side of the fuel pump and disconnect the tie-rod from the rack. If any parts are found defective, replace them.

CAUTION

If the governor is assumed to be malfunctioning, check the bearing on the gear case side, too.



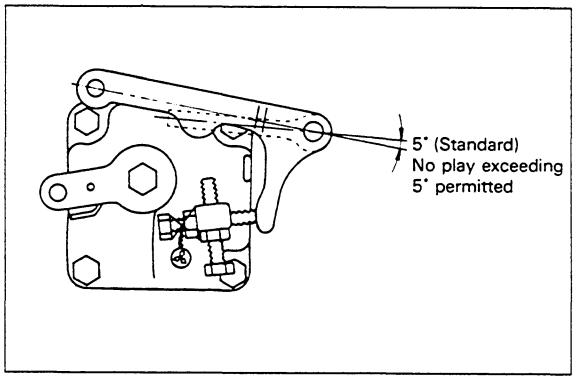
Inspection Governor System Parts

Governor Removal and Installation

To remove the levers, pull out the grooved pins which have been driven into the governor lever, stop lever, and speed control lever. Loosen the bolts fastening the levers and shafts.

Install the levers and shafts, one after another, checking for proper functioning.

After press-fitting each grooved pin, check the shaft for smooth rotation. Coat the O-rings with oil before installing them. No deflection exceeding 20 mm is permitted for the governor spring installed. Install the governor spring lever and speed control lever so that the play of angle between levers (standard: 5°) is minimized.

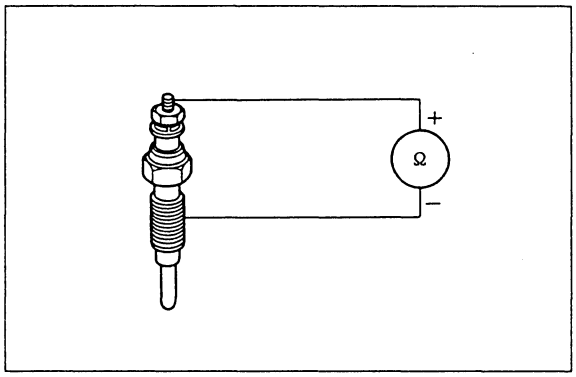


Instaling Speed Control Lever

Glow Plug Inspection

Check for conduction between the glow plug terminal and body. If the plug is not conductive at all or shows a large resistance, replace the plug.

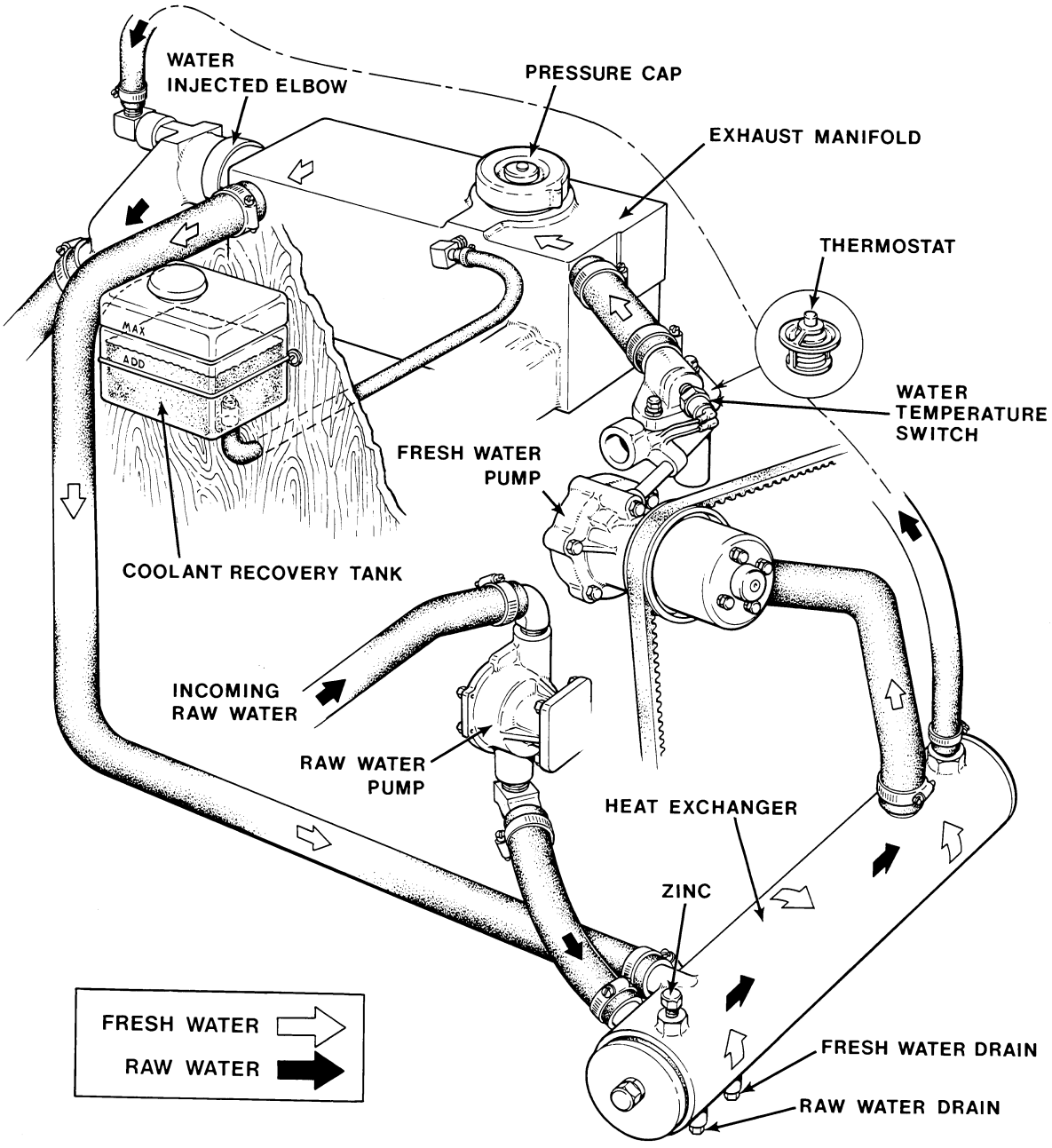
Glow plug tightening torque: 1.5 - 2.0 kgm.



Checking Glow Plug

COOLING SYSTEM

Illustrated below is a typical Westerbeke engine cooling system. Both fresh water and raw water flow through their independent cooling circuits. Refer to your generator's Parts List for part numbers and part descriptions if you need to order cooling system parts for your engine.



Typical Cooling System

Fresh Water Pump Drive Belt Tension

Generator models come equipped with belt guards that cover over the belt(s) on the front of the engine. ("Out of sight-out of mind." The belt guard is not installed for that purpose.) Operators are advised that the inspection, service, and maintenance spoken of below should be followed.

WARNING

Never attempt to adjust the drive belt's tension while the engine is in operation.

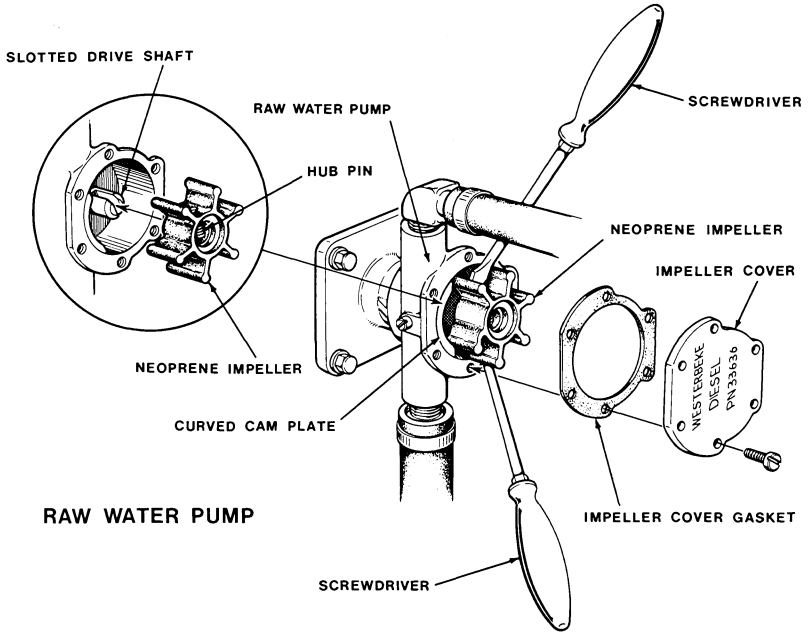
CAUTION

Excessive water pump drive belt tension can cause rapid wear of the belt and reduce the service life of the fresh water pump's bearings. Excessive slack or the presence of oil on the belt can cause belt slipping, resulting in high operating temperatures.

The water pump drive belt is properly adjusted if the belt can be deflected no less than 3/8 inch and no more than 1/2 inch (10 mm, 12 mm) as the belt is depressed with the thumb at the midpoint between the two pulleys on the longest span of the belt. A spare drive belt should be carried on board.

Raw Water Pump

The raw water pump is a self-priming, gear-driven, rotary pump with a non-ferrous housing and a neoprene impeller. The impeller has flexible vanes which wipe against a curved cam plate within the impeller housing, producing the pumping action. **On no account should this pump be run dry.** There should always be a spare impeller and impeller cover gasket aboard (an impeller kit). Impeller failures occur when lubricant (raw water) is not present. Such failures are **not** warrantable and the operator's are cautioned to make sure raw water flow is present at start-up. Know your pump, know its location on the engine and know how to change the impeller in it.



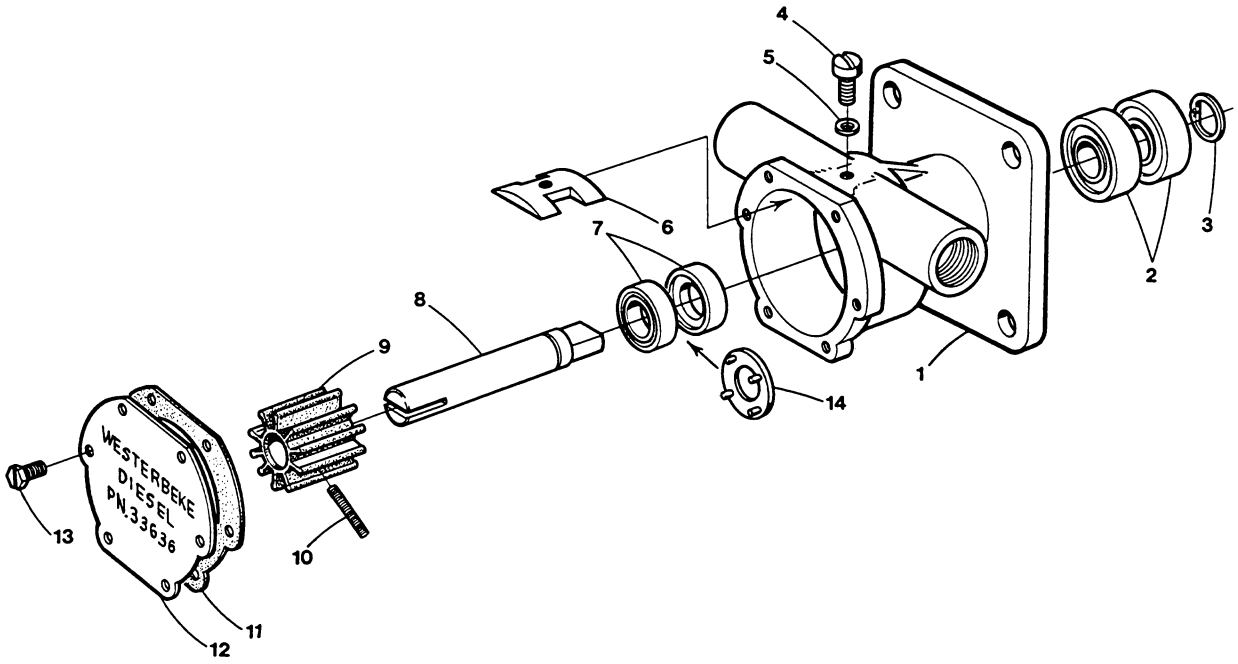
RAW WATER PUMP

Remove the impeller with the aid of two small screwdrivers, as illustrated, and carefully pry the impeller out of the pump. Install the impeller by positioning the hub pin to align with the slot in the drive shaft. Move the blades to conform to the curved cam plate and push the impeller into the pump's housing.

Raw Water Pump Overhaul

Raw water pump #033636 repair instructions are as follows:

Disassembly
The pump, as removed from the engine, will have hose attachment nipples threaded into the its inlet and outlet port. They may be left in place or removed if they interfere with the pump disassembly. Note the port location and positioning if removed.



a. Remove the six cover plate screws (ref 13), cover plate (ref 12) and the cover plate gasket (ref 11).

NOTE: Screw material should be stainless steel part number 034463. Also, replacement of the cover plate gasket is recommended; however, if you are going to reuse it, keep the gasket submerged in water until the pump is reassembled. If it's allowed to dry, the gasket will shrink and not be reusable

b. Remove the impeller (ref 9) with its drive screw (ref 10) from the pump housing.

c. Remove the screw (ref 4) and sealing washer (ref 5) and draw the cam (ref 6) from the pump housing.

d. Remove the circlip (ref 3).

e. Support the pump housing, at the mounting flange end, on an arbor press and, with a drift, press out the shaft (ref 8) and bearings (ref 2) from the pump housing from the impeller end.

f. With the pump housing supported, push the seals (ref 7) out of the pump housing. Push the impeller side seal out that side and then lift the spacer (ref 14) out. Then, push the bearing side seal out that side.

g. Supporting the bearings inner face (ref 2), push the shaft (ref 8) out of the bearings.

NOTE: Inspect all parts and replace those showing wear or corrosion.

Assembly

a. Install the seals (ref 7) and spacer (ref 14) in the pump housing. Push the impeller side seal into the housing. Rotate the pump and install the spacer (ref 14) against the seal face. Push the bearing side seal into the housing from the bearing side.

NOTE: The seal's flat surfaces, having printing and numbers, face towards each other.

b. Install shaft (ref 8) into bearings. Support bearings (ref 2) at their center race. Push the shaft into the bearings, pushing at the impeller drive slot end using the base of the drive slot. Push the shaft through both of the bearings, flush against each other so the flat sided end of the shaft extends beyond the second bearing center race 15 mm (19/32 in.) ±.5 mm (1/32 in.).

c. Support the pump housing at the impeller side. Apply a small amount of petroleum jelly to the seal's (ref 7) inner lips and to impeller shaft (ref 8). Carefully, install the shaft rotating it through the seals till the bearings contact the housing from the bearing end. Use a pushing tool that will push this shaft and bearing assembly into the pump housing by applying pressure against the outer bearing race. Push the assembly into the housing until the bearings seat fully in the housing. Install the circlip (ref 3).

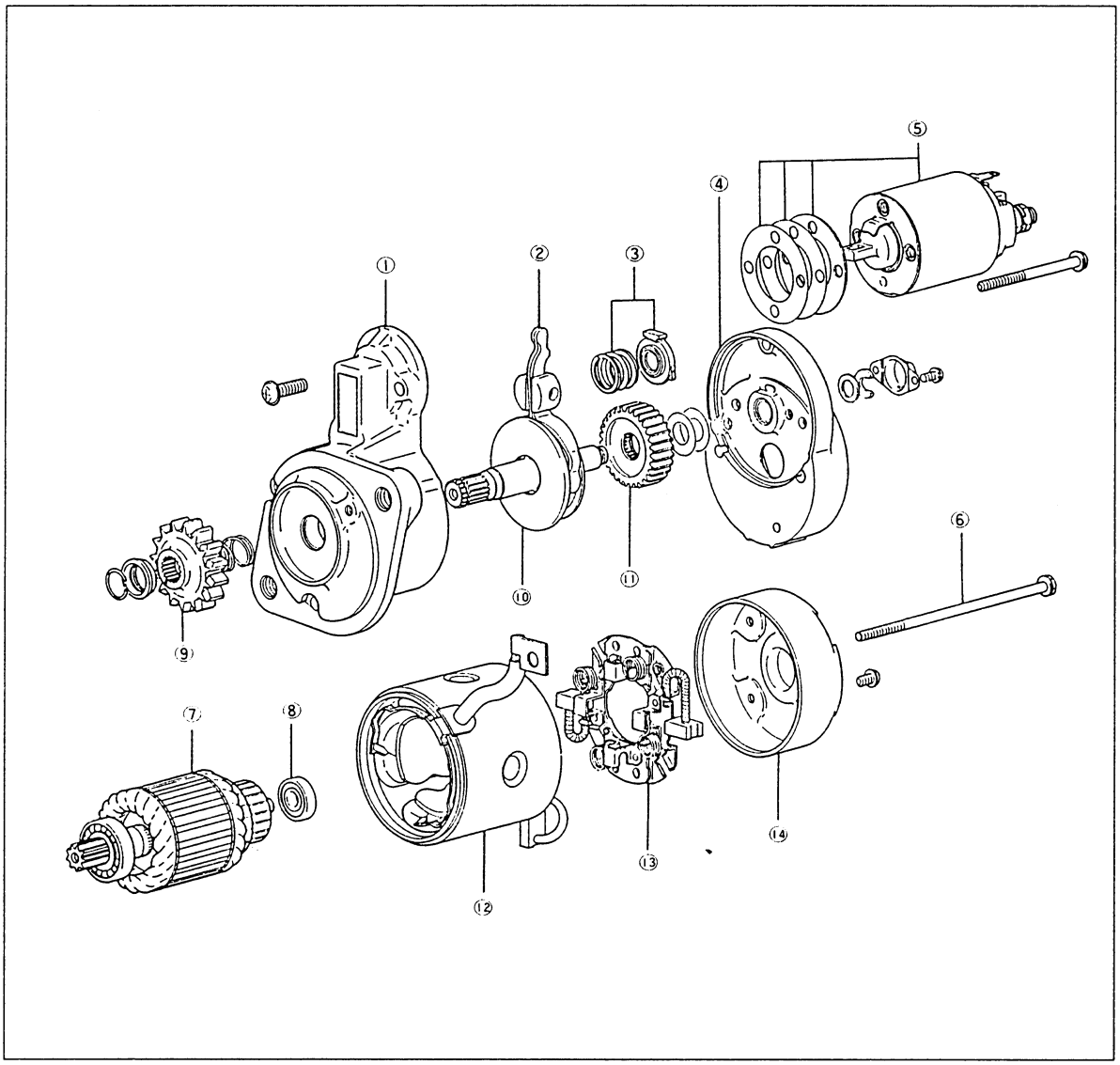
d. Position the cam (ref 6) in the housing and secure it in place with the screw (ref 4) and sealing washer (ref 5).

NOTE: Use a small amount of Permatex #1 on the inner cam surface and screw threads. Remove any excess from the impeller housing.

e. Apply a light film of silicone or petroleum jelly to the inner surface of the housing for the impeller.

NOTE: Just coat the surface, do not over apply. Install the impeller with the drive screw (ref 9 and 10). Push the assembly into the housing with the drive screw mating in the slot of the drive shaft.

f. Install the cover gasket (ref 11), cover (ref 12), and secure them with the six cover screws (ref 13).



STARTER COMPONENT PARTS

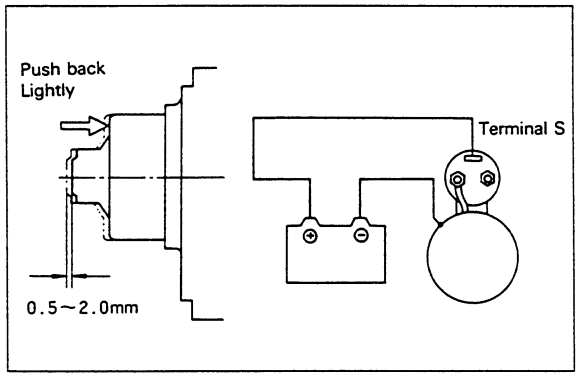
1. Front bracket assembly.
2. Lever assembly.
3. Spring set.
4. Center bracket assembly.
5. Switch assembly.
6. Through bolt.
7. Armature.
8. Rear bearing.
9. Pinion.
10. Pinion shaft assembly.
11. Gear.
12. Yoke assembly.
13. Brush holder assembly.
14. Rear bracket.

Starter Adjustment and Repair

If any abnormality is assumed by the following tests, adjust the starter or disassemble and repair it.

1. Pinion gap inspection.

   a. Interpose a battery (12 V) between the starter terminal "S" and the starter body, and the pinion will protrude and stop.



Inspecting Pinion Gap

CAUTION

Never apply battery voltage for over 10 seconds continuously.

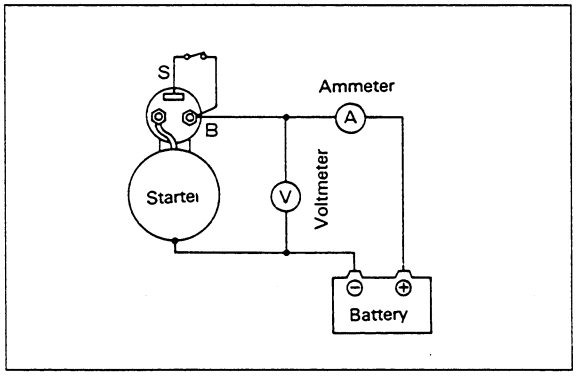
   b. Lightly push the pinion back and measure the return stroke (called pinion gap).

   c. If the pinion gap is not within the standard range, (0.5 to 2.0 mm), adjust it by increasing or decreasing the number of packings on the magnetic switch. The gap is decreased as the number of packings increases.

2. No-load test.

   a. Connect the ammeter, voltmeter, and battery to the starter as illustrated.

   b. When the switch is closed, the pinion must protrude and the starter must run smoothly (at 3000 rpm or more). If the current or starter speed is out of specification, disassemble the starter and repair it.



No-load Test

CAUTION

Use thick wires as much as possible and tighten every terminal securely. This is a solenoid shift type starter which makes a rotating sound larger than that of a direct-drive type starter. When detecting starter rotation at the pinion tip, take care of protrusion of the pinion.

3. Magnetic switch.

Perform the following tests. If any test result is not satisfactory, replace the magnetic switch assembly.

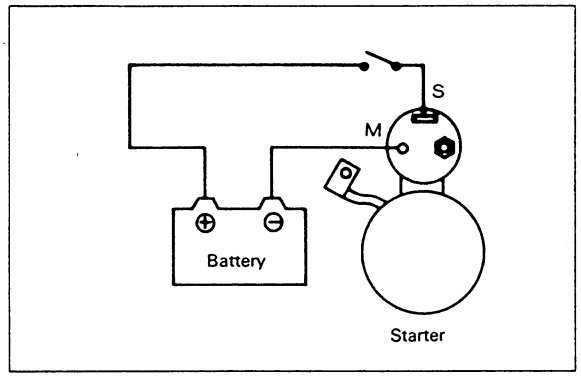
a. Disconnect the wire from terminal "M."

b. Attraction test.

Connect a battery to the magnetic switch terminals S and M. The pinion must protrude.

CAUTION

Do not apply battery current for more than 10 seconds.



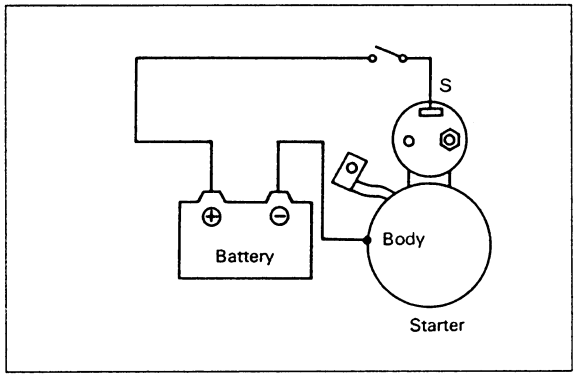
Attraction Test

c. Holding test.

With a battery connected to the magnetic switch terminal "S" and to the starter body, manually pull out the pinion fully. The pinion must remain at that position even when released from holding by hand.

CAUTION

Do not apply battery current for more than 10 seconds.



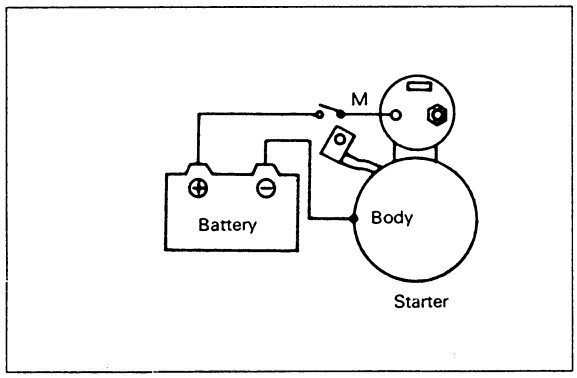
Holding Test

d. Return test.

With a battery connected to the magnetic switch terminal "M" and to the starter body, manually pull out the pinion fully. The pinion must return to its original position when released from holding by hand.

CAUTION

Do not apply battery current for more than 10 seconds.



Return Test

Starter Disassembly

1. Disconnect the wire from the magnetic switch terminal "M."

2. Loosen the two screws fastening the magnetic switch. Remove the magnetic switch assembly.

3. Remove the two through bolts and two screws fastening the brush holder. Remove the rear bracket.

4. With two brushes brought in a floating state, remove the yoke and brush holder assembly. Then, pull the armature out.

5. Remove the cover, pry the snap ring out, and remove the washer.

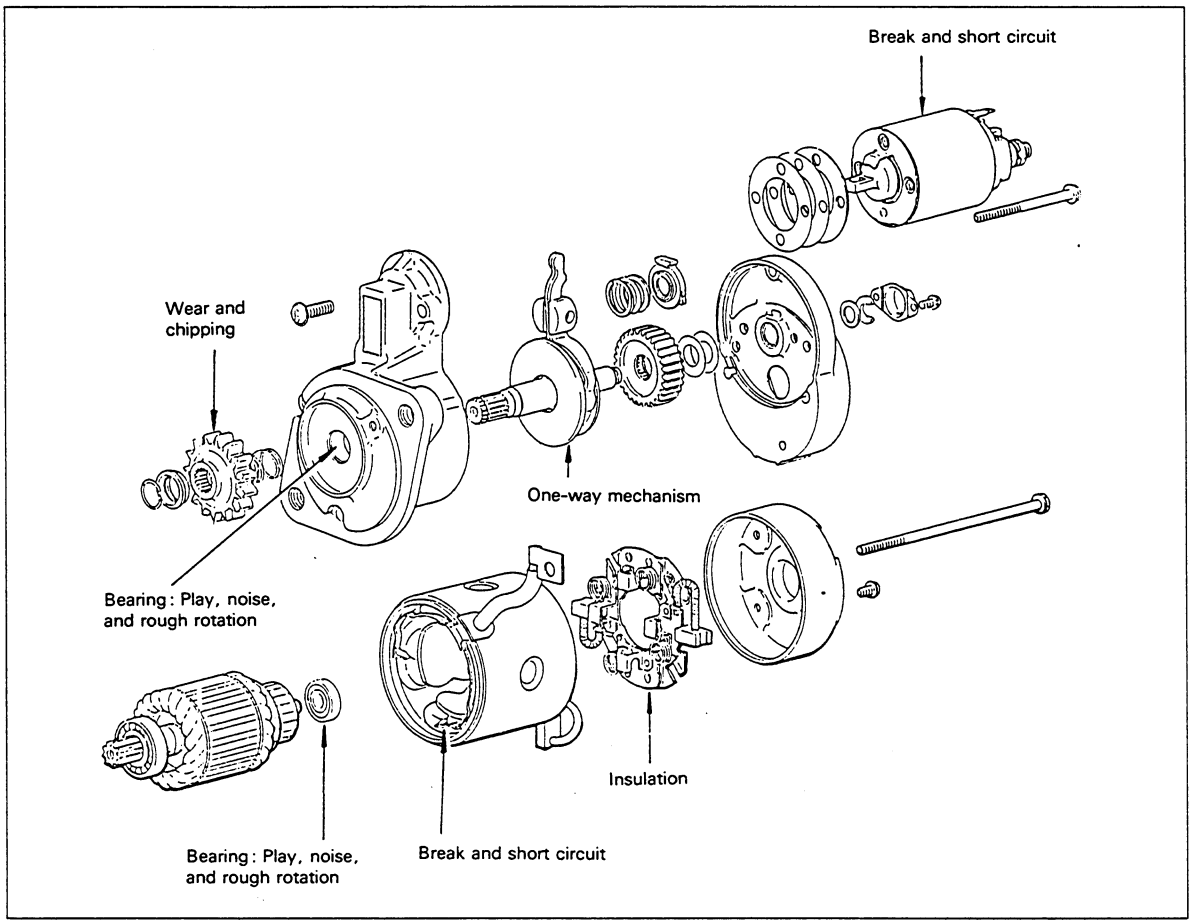
6. Unscrew the bolts and remove the center bracket. At the same time, washers for pinion shaft end play adjustment will come off.

7. Pull out the reduction gear lever and lever spring from the front bracket.

8. On the pinion side, pry the snap ring out, and pull out the pinion and pinion shaft.

9. At each end of the armature, remove the ball bearing with a bearing puller. It is impossible to replace the ball bearing press-fitted in the front bracket. If that bearing has worn off, replace the front bracket assembly.

Starter Inspection

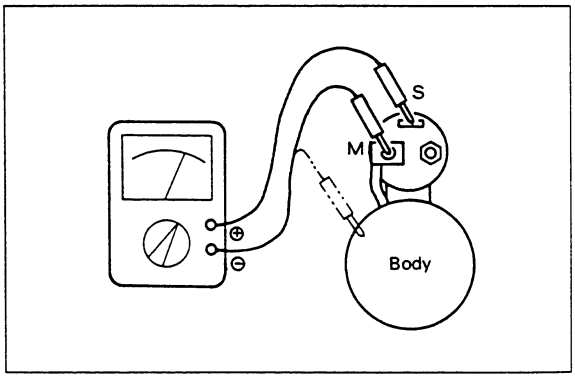


Inspect about the following :

Description	Standard	Service limit
Depth of under cut	0.5 mm	0.2 mm
Commutator O. D.	38.7 mm	−1.0 mm

Description	Standard	Service limit
Height of brush	17 mm	6 mm
Spring pressure	3 kg	

1. Inspect the magnetic switch for conduction between terminals S and M and between terminals S and body. There should be a low resistance found 1 - 2 ohms. If no resistance is found the circuit is open. The solenoid should be replaced.

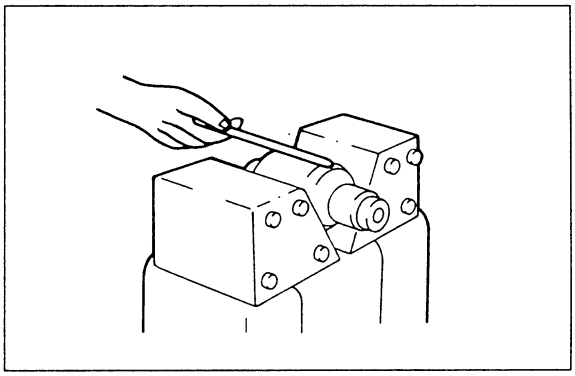


Checking Magnetic Switch

2. Inspecting the armature.

   a. Check the armature with a growler tester. If it's short circuited, replace the armature. Also, check for insulation between the commutator and its shaft. If poorly insulated, replace the armature.

   b. Measure the commutator O.D. and the depth of undercut. Repair or replace it if the service limit is exceeded. Also, check the commutator outside surface for dirtiness and roughness. If rough, polish the commutator with fine-grain sandpaper.



Checking Armature Coil

3. Brush holder inspection.

   a. Check the brushes. If worn out beyond the service limit, replace the brushes.

   b. Check the brush spring tension. If decreased beyond the service limit, replace the springs.

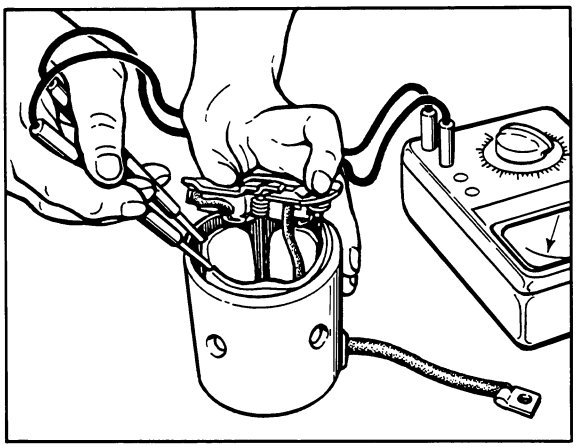
   c. Check for insulation between the positive brush holder and holder base. If poorly insulated, replace the holder assembly. Also, check the brush holders for proper staking.

4. Field coil inspection.

   a. Check for insulation between one end (brush) of coil and yoke.

   b. Check for conduction between both ends (brushes) of coil.

   c. Check the poles and coil for tightness.



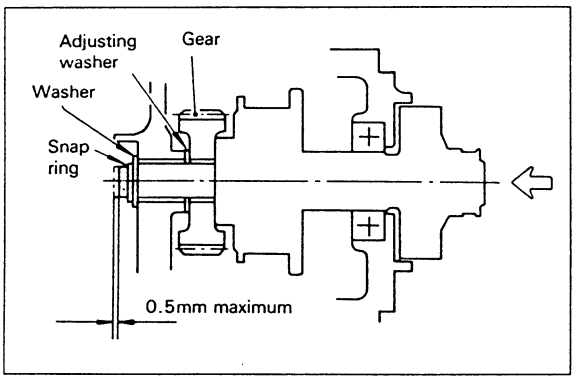
Checking Field Coil

Starter Adjustment and Assembly

Reassembly the starter assembly in the reverse order of disassembly, giving care to the following:

1. Pinion shaft end play adjustment. Set the end play (thrust gap) to 0.5 mm or less by inserting an adjusting washer between the center bracket and reduction gear.

   a. Fit the pinion shaft, reduction gear washer and snap ring to the center bracket.



Adjusting Pinion Shaft End Play

b. Measure end play by moving the pinion shaft in the axial direction. If the end play exceeds 0.5 mm, increase the number of adjusting washers inserted.

2. Greasing.

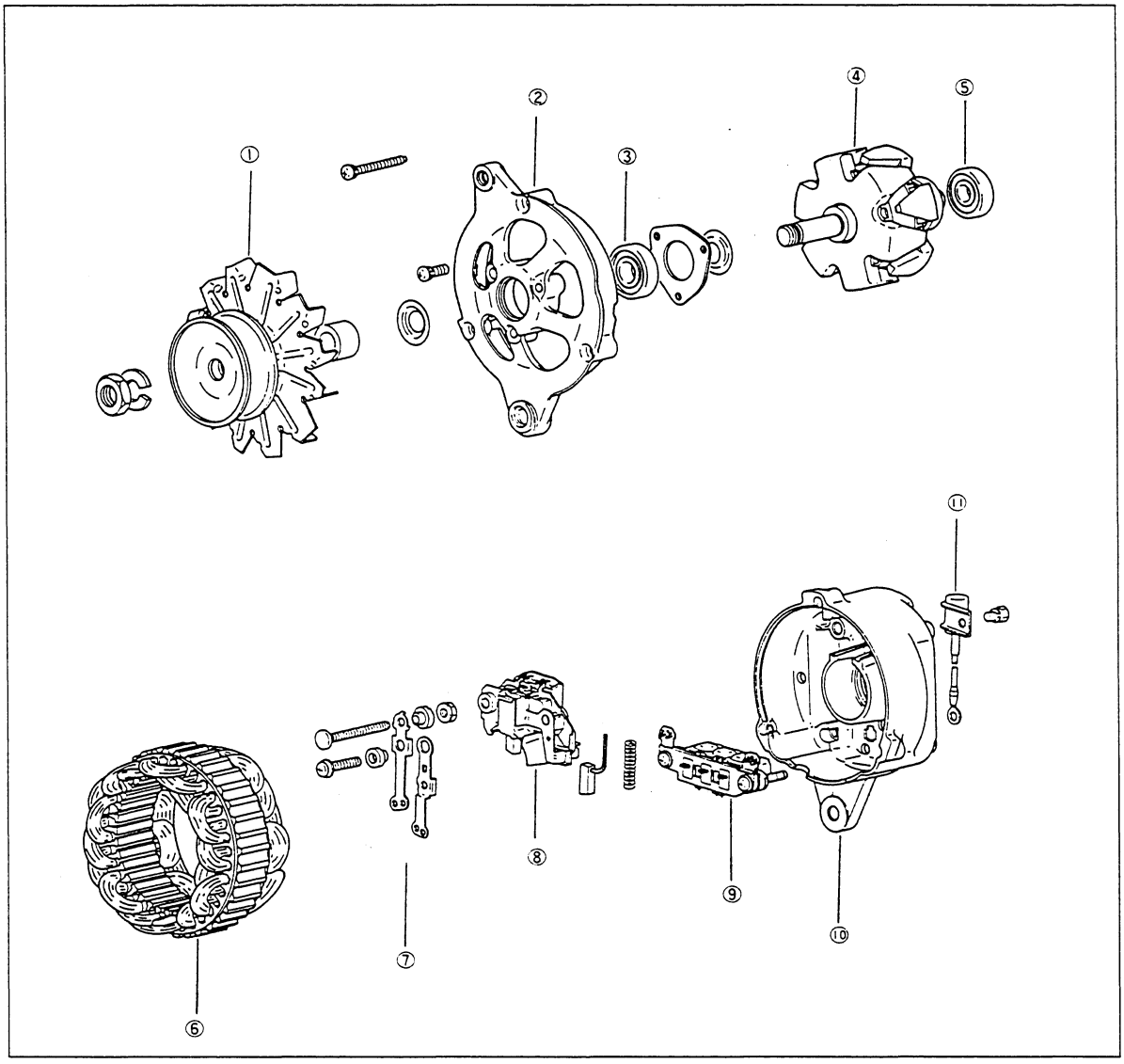
Whenever the starter has been overhauled, apply grease to the following parts:

1. Armature shaft gear and reduction gear.
2. All bearings.
3. Bearing shaft washers and snap rings.
4. Bearing sleeves.
5. Pinion.
6. Sliding portion of lever.

CAUTION

Never smear the starter fitting surface, terminals, brushes, or commutator with grease.

ALTERNATOR



ALTERNATOR COMPONENT PARTS

1. Pulley.
2. Front bracket assembly.
3. Front bearing.
4. Rotor assembly.
5. Rear bearing.
6. Stator.
7. Terminal set.
8. Regulator assembly.
9. Rectifier assembly.
10. Rear bracket assembly.
11. Condenser assembly.

Alternator On-Engine Inspection

1. Erroneous handling can cause damage to the charging circuit and other troubles so avoid the following:

   a. Never connect the battery in reverse.

   b. Do not use a megger and other high-voltage testers.

   c. When recharging the battery, disconnect the battery cable from the alternator.

   d. Never disconnect the lead wire from the alternator terminal B while the engine is running.

   e. Never ground the alternator terminal B to which battery voltage is always applied.

   f. Never short circuit or ground terminal L.

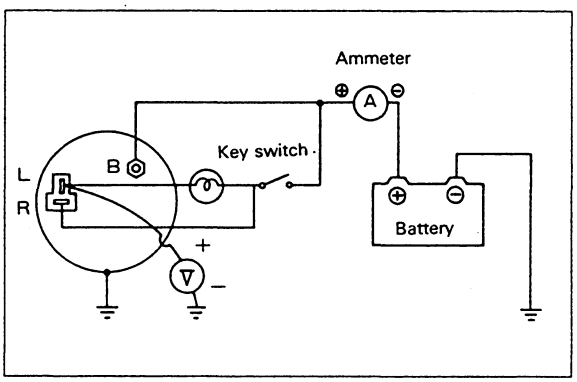
   g. When using a steam cleaner, be careful not to direct steam directly to the alternator.

2. Checking for regulated voltage.

   a. Interpose an ammeter between the positive terminal of the battery and terminal B or the alternator.

   b. Ground the alternator terminal "L" through a voltmeter.

   c. Note that the voltmeter indicates zero volts when the key switch is in the OFF position. The voltmeter will indicate a voltage considerably lower than battery voltage when the key switch is in the ON position (while the engine is stopped).



Checking for Regulated Voltage

   d. Short-circuit the ammeter and start the engine.

   e. Read the voltmeter indication (regulated voltage) under the following test conditions: Ammeter indication is below 5 A; engine speed is at 1800 rpm and 2500 rpm; and lamps are switched off. Regulated voltage shows a tendency to decrease as alternator temperature increases.

3. Output inspection.

   a. Disconnect the grounding cable from the battery.

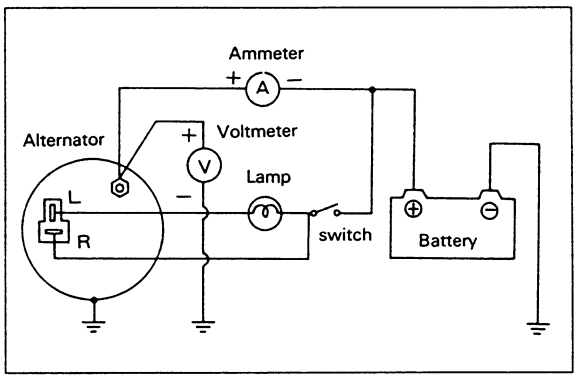
   b. Interpose an ammeter between the battery and alternator terminal "B." Ground the terminal "B" through a voltmeter.

   c. Connect the battery grounding cable.

   d. Start the engine.

e. Apply all load including the lamps.

f. Increase engine speed until normal alternator speed is attained. Read the maximum indication of the ammeter at 13.5 V of voltmeter indication. Output current must conform to the specification.



Checking for Output

Characteristic		Terminal voltage (V)	Current (A)	Speed (rpm)
No-load output	15A	14	0	1,300 maximum
	35A	14	8	1,300 maximum
	50A	13.5	24	1,300 maximum
Loaded output	15A	14	15 maximum	2,500 maximum
	35A	14	30 maximum	2,500 maximum
	50A	13.5	50 maximum	2,500 maximum

Alternator Removal

1. Disconnect the battery cable.

2. Disconnect the lead wire from terminal "B" on the back of the alternator.

3. Disconnect the alternator connector.

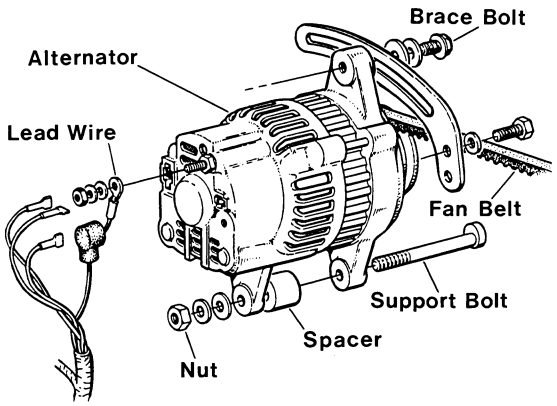
4. Loosen the alternator brace bolt and support bolt. Push the alternator toward the engine and remove the fan belt.

5. Dismount the alternator.

Alternator Disassembly

1. Remove the three through bolts.

2. Heat the rear bracket around the rear bearing up to 50 - 60° C (with a solder iron) and separate the bracket from the stator coil.



CAUTION

Pry open the alternator with a screwdriver blade inserted into the clearance between the stator core and front bracket. Be careful not to insert the blade too deep.

3. Grip the rotor in a vise, remove the pulley nut, and pull out the pulley, fan, and spacer.

4. Pull out the rotor assembly from the front bracket.

5. Unsolder the stator coil lead wires. Remove the stator assembly.

CAUTION

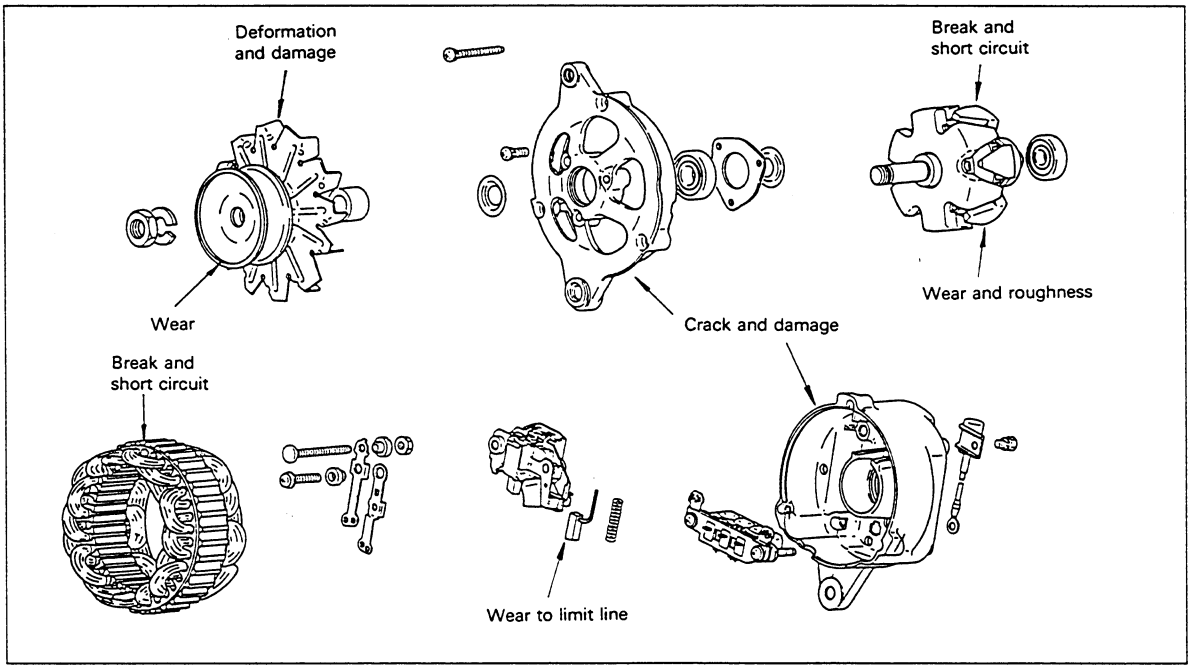
Never heat the lead wires long to prevent damage to diodes.

6. Disconnect the capacitor from terminal "B."

7. Loosen the screws fixing the rectifier and remove the rectifier.

Alternator Inspection

Inspect the disassembled parts, if any part is found defective, replace it.



Inspection of Alternator

1. Inspecting the diodes.

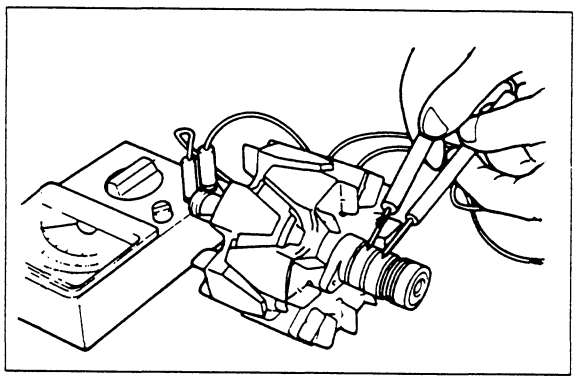
   a. Connect a circuit tester (ohmmeter) across the lead wire and case of the diode to be tested. The diode is considered normal if its resistance is large in either direction and small in the reverse direction.

   b. If there is equal resistance in both directions, the diode is suspected to be defective. Replace the rectifier assembly.

   c. Check every diode for conduction.

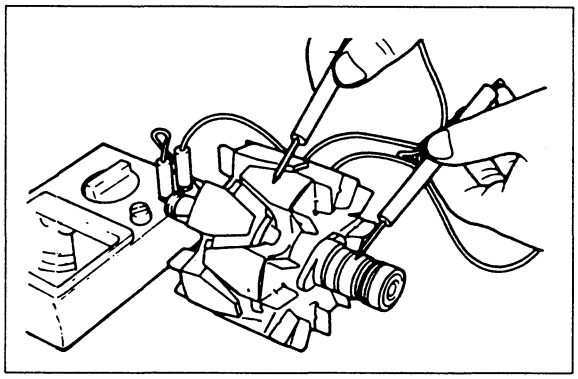
2. Inspecting the field coil.

a. Check for conduction between slip rings. If there is no conduction, the field coil is suspected to be broken. Replace the field coil.



Checking Field Coil for Conduction

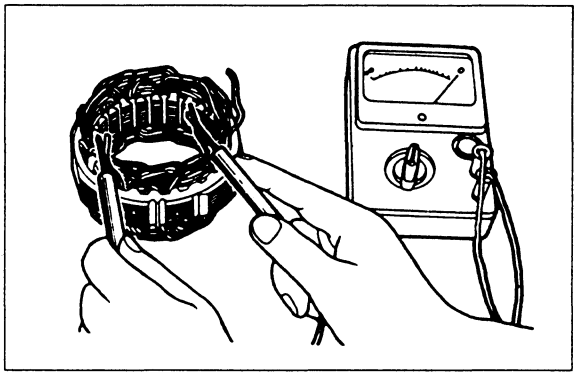
b. Check for conduction between a slip ring and shaft (or core). If any conduction is found, the field coil is suspected to be poor in insulation. Replace the field coil.



Checking Field Coil for Insulation

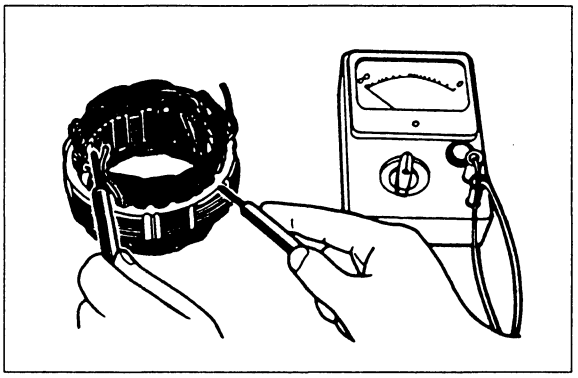
3. Inspecting the stator coil.

a. Check for conduction between lead wires of the stator coil. If there is no conduction, the stator coil is suspected to be broken. Replace the stator coil.



Checking Stator Coil for Conduction

b. Check for conduction between each lead wire and stator core. If any conduction is found, the stator coil is suspected to be poor in insulation. Replace the stator coil.



Checking Stator Coil for Insulation

Alternator Assembly

Reassemble the alternator assembly in the reverse order of disassembly giving care to the following:

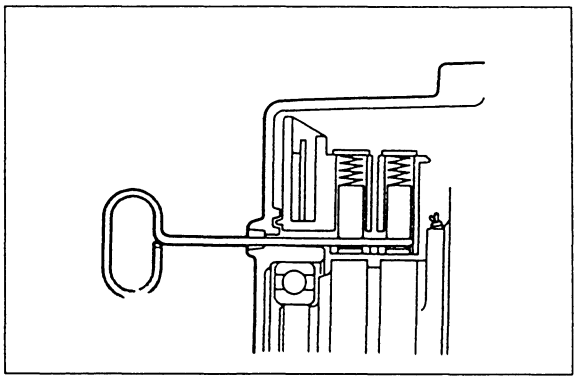
1. The rear bearing has an eccentric groove. Install the snap ring so that its projection fits in with the deepest part of the groove.

2. When installing a new rear bearing, press-fit the bearing with its groove facing the slip ring side.

3. When press fitting the rear bearing into the rear bracket, heat the bracket.

CAUTION

Pass a wire through the small hole in the rear bracket to lift the brushes before installing the rotor to the rear bracket. Remove the wire after the rotor is installed.



Lifting Brushes

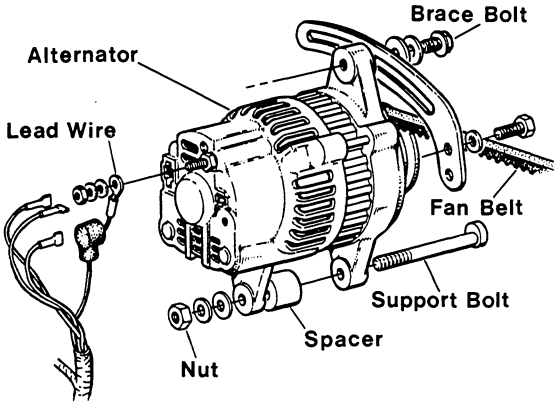
Alternator Installation

Install the alternator in the reverse order of removal.

1. When installing the support bolts, insert the spacer in place using the following procedure:

   a. Push in the support bolts to the normal position. (Leave the nuts removed from the bolts.)

   b. Push the alternator backward. Measure the clearance between the alternator rear bracket and gear case bracket to determine the number of spacers to be inserted into the clearance (0.2 mm maximum).



NOTES

ENGINE TROUBLESHOOTING

Fault	Possible Cause	Verification/Correction
Preheat is depressed: no preheat.	1. Connection or switch.	1. Check for 12 volts at the PREHEAT switch and at the **S** terminal on the preheat solenoid.
	2. Preheat solenoid.	2. No activation with 12 volts at the **S** terminal. Tap solenoid with a mallet to determine if it is stuck internally. Solenoid should produce a click when activated and deactivated.
	3. Glow plugs are faulty.	3. Twelve volts is present at the glow plugs. Remove each plug and check the resistance of the plugs with an ohmmeter. (1.5 - 2.2 ohm.)
Preheat is depressed: fuel pump does not operate.	1. Faulty connections or bad pump.	1. Check for 12 volts at the fuel pump connections. If 12 volts are present, the pump is possibly faulty. Tap pump with a mallet. Pump's plunger may be stuck. Check for contamination which will affect the pump.
Start is depressed: no fuel delivery to injectors.	1. Fuel solenoid or connections to it are faulty.	1. Check for 12 volts at lead positive terminal at the back of the fuel solenoid when the PREHEAT button is depressed. Twelve volts with no activation indicates a faulty solenoid.
	2. Voltage problem.	2. Less than 10 volts found at the lead terminal on the solenoid will not properly activate the solenoid and will cause a failure. Check for low batteries or voltage loss in small electrical wiring or corroded connections.
	3. Shut off lever.	3. Check that shut off lever is returned to the run position.

Fault	Possible Cause	Verification/Correction
START switch is depressed: no starter engagement. Engine does not crank.	1. Connection to starter solenoid faulty.	1. Check connection **S** at the starter solenoid for 12 volts with the switch depressed.
	2. Faulty start switch.	2. Check switch with an ohmmeter.
	3. Faulty preheat solenoid.	3. Twelve volts is present at the **S** terminal of the starter solenoid.
	4. Loose battery connection.	4. Check battery connections at both the + and - ground.
	5. Low batteries.	5. Check battery charge state. Low voltage at the solenoid's **S** terminal with no activation.
	6. Sea water in cylinders.	6. Remove exhaust hose at exhaust elbow and drain water. Correct the cause of sea water intrusion.
Engine cranks, but does not start.	1. Shut-off valve at fuel tank.	1. Return shut-off valve to its on position. Now bleed the fuel system.
	2. Faulty fueling system.	2. Check for fuel to engine.
	3. Air is in the fuel system.	3. Bleed the fuel system. Locate the leak and correct it. Check return fuel for no air present.
	4. Fuel pump is not operating.	4. Check pump operation. Check for 12 volts at pump.
	5. Fuel filters are clogged.	5. Clean/replace filters.
	6. Fuel solenoid not working (optional).	6. Check 12 volts present at solenoid.
Failure to stop.	1. Fuel solenoid faulty (optional).	1. Stop engine by manually shutting off fuel and air.
	2. Shut off cable.	2. Cable not operating shut off lever.

Fault	Possible Cause	Verification/Correction
Engine Stops.	1. Fuel starvation. Fuel shut-off is turned off.	1. Check to see that the shut-off valve at the fuel tank is on.
	2. Fuel pump is inoperative.	2. Inspect the fuel pump for 12 volts and see if it is pumping.
	3. Water is in the fuel.	3. Pump water out of the bottom of the fuel tank(s) and change the fuel filters and bleed the fuel system.
	4. Exhaust system is restricted.	4. Check exhaust system for some type of blockage such as carbon buildup at the exhaust elbow. Check for a fault in the muffler. Check for a collapsed exhaust hose.
Battery runs down.	1. DC charge circuit faulty.	1. Perform DC voltage check of charge circuit.
	2. Bad battery connections.	2. Connections are corroded or loose at the battery and/or at the engine.
Black exhaust smoke.	1. Engine is overloaded.	1. Check generator data plate for rating and monitor the load that is producing the black exhaust smoke.
	2. Poor fuel quality or incorrect fuel.	2. Check fuel filters. Make sure you are using #2 diesel fuel.
	3. Faulty injector(s).	3. Remove and test injectors.
	4. Lack of air.	4. Check air intake for restrictions. Make sure adequate combustion air is present.

MARINE TRANSMISSIONS

JS Gear
The standard transmission on the 20B Two and 30B Three is the JS Gear. Contact Westerbeke Corporation factory for overhaul information.

HURTH MARINE GEAR
ZF INDUSTRIES MARINE US HEADQUARTERS
3131 SW 42ND STREET
FORT LAUDERDALE, FL 33312

TEL. 954-581-4040
FAX 954-581-4077

BORG WARNER MARINE & INDUSTRIAL TRANSMISSIONS
200 THEODORE RICE BLVD
NEW BEDFORD, MA 02745

TEL. 508-979-4881
FAX 508-979-4826

TABLE OF STANDARD HARDWARE TIGHTENING TORQUES

Unless stated otherwise for a specific assembly, use the following torque values when tightening standard hardware.

	Pitch	lb-ft	kg-m
Grade 4T			
6mm bolt head/nut	1	2.9 - 5.1	0.4 - 0.7
8mm bolt head/nut	1.25	7.2 - 11.6	1.0 - 1.6
10mm bolt head/nut	1.25	13.7 - 22.4	1.9 - 3.1
10mm bolt head/nut	1.5	13.0 - 21.7	1.8 - 3.0
12mm bolt head/nut	1.25 (ISO)	25.3 - 39.8	3.5 - 5.5
12mm bolt head/nut	1.5	25.3 - 39.8	3.5 - 5.5
12mm bolt head/nut	1.75	21.7 - 36.2	3.0 - 5.0
13mm bolt head/nut	1.5	32.5 - 50.6	4.5 - 7.0
14mm bolt head/nut	1.5	36.2 - 57.9	5.0 - 8.0
14mm bolt head/nut	2	34.0 - 55.7	4.7 - 7.7
16mm bolt head/nut	1.5	54.2 - 79.6	7.5 -11.0
16mm bolt head/nut	2	51.4 - 76.7	7.1 -10.6
Grade 6T			
6mm bolt head/nut	1	4.3 - 6.5	0.6 - 0.9
8mm bolt head/nut	1.25	10.8 - 15.9	1.5 - 2.2
l0mm bolt head/nut	1.25	21.7 - 32.5	3.0 - 4.5
10mm bolt head/nut	1.5	19.5 - 30.4	2.7 - 4.2
12mm bolt head/nut	1.25 (ISO)	36.2 - 57.9	5.0 - 8.0
12mm bolt head/nut	1.5	36.2 - 50.6	5.0 - 7.0
12mm bolt head/nut	1.75	34.7 - 49.2	4.8 - 6.8
Grade 7T, 8T and 8.8			
6mm bolt head/nut	1	5.8 - 8.7	0.8 - 1.2
8mm bolt head/nut	1.25	14.5 - 21.7	2.0 - 3.0
10mm bolt head/nut	1.25	28.9 - 39.8	4.0 - 5.5
10mm bolt head/nut	1.5	26.8 - 37.6	3.7 - 5.2
12mm bolt head/nut	1.25 (ISO)	54.2 - 75.9	7.5 -10.5
12mm bolt head/nut	1.5	50.6 - 65.1	7.0 - 9.0
12mm bolt head/nut	1.75	43.4 - 61.5	6.0 - 8.5
13mm bolt head/nut	1.5	57.9 - 86.8	8.0 -12.0
14mm bolt head/nut	1.5	72.3 -108.5	10.0 -15.0
14mm bolt head/nut	2	68.7 -101.3	9.5 - 14.0
16mm bolt head/nut	1.5	108.5 - 166.4	15.0 - 23.0
16mm bolt head/nut	2	101.3 - 159.1	14.0 - 22.0
Grade 5 capscrew			
1/4 UNC		9 - 11	1.2 - 1.5
1/4 UNF		11 - 13	1.5 - 1.8
5/16 UNC		18 - 20	2.5 - 2.8
5/16 UNF		21 - 23	2.9 - 3.2
3/8 UNC		28 - 33	3.7 - 4.6
3/8 UNF		30 - 35	4.1 - 4.8
7/16 UNC		44 - 49	6.1 - 6.8
7/16 UNF		50 - 55	6.9 - 7.6
1/2 UNC		68 - 73	9.4 -10.1
1/2 UNF		73 - 80	10.1 -11.1

	Socket Size	Lb-ft	Kg-m
Cylinder head bolt	M 10 (14 mm)	54 - 61	7.5 - 8.5
	M 8 (12 mm)	14 - 22	2.0 - 3.0
Rocker shaft hold down bolts	M 8 (12 mm)	11 - 16	1.5 ~ 2.2
	(See the "Cylinder Head" section of this manual.)		
Crankshaft pulley nut 5.0 KW BCD	M 16 (24 mm)	72.3 - 86.7	10 - 12
Oil pan drain plug (All Models)	M 18	36.2 - 43.4	5.0 - 6.0
Oil filter (All Models)		8.0 - 9.4 (or tighten firmly by hand)	1.1 - 1.3
Delivery valve holder (injection pump) (All Models)	M 16 (17 mm)	25.3 - 28.2	3.5 - 3.9
Injector nozzle mounting (All Models) (To Engine)	M 20 (21 mm)	36.2 - 43.4	5.0 - 6.0
Fuel Solenoid Locknut	M 30 (36 mm)	28.9 - 36.2	4.0 - 5.0
Glow plug (All Models)	M 10 (12 mm)	10.8 - 14.5	1.5 - 2.0
Injector spray Pressure		140 ± 10/0 kg/cm^2 (1990 psi ± 140/0)	
Cylinder Compression Pressure		28 kg/m^2 at 280 rpm (398 psi)	
FLYWHEEL BOLTS	**M10(17 MM)**	**60 - 65**	**8.3 – 8.9**

Tightening Torque for Common Bolts and Nuts

Designation of screw thread	Head mark		
	4	7	10
M6	0.3~0.5	0.8~ 1.0	1.0~ 1.3
M8	1.0~1.3	1.5~ 2.2	2.5~ 3.5
M10	1.8~2.5	3.0~ 4.2	5.0~ 7.0
M12	3.0~4.2	5.5~ 7.5	9.5~12.0
M14	5.0~7.0	8.0~ 11.0	16.0~19.0

* NOTE: M8 indicates Metric, 8 mm thread diameter

SPARE PARTS

Since a possibility exists in which the engine may need to be serviced at sea or while in a port other than your home port, certain spare parts should be kept on board to help minimize delays in your voyage. Please refer to your engine's Parts List for part numbers when ordering spare parts. Listed below are those spare parts that should be carried on board at all times.

1. An impeller kit.
2. A fuel system hardware kit.
3. A secondary fuel filter element.
4. A water pump belt.
5. Hose clamps.
6. A spare oil filter with a spare quart of diesel service engine oil along with a gallon of premixed antifreeze.
7. A few zinc anodes and heat exchanger end plate gaskets.
8. An oil pressure switch.

Other parts (listed below), whose life expectancy cannot be accurately predetermined, should be carried on board (in addition to those listed above) especially if the vessel is to be taken on long ocean voyages.

1. Fuel injectors.
2. Glow plugs.
3. Cooling system hoses.
4. A starter.
5. A 20 amp DC circuit breaker.
6. An electric fuel pump.
7. A raw water pump.
8. Battery terminal connectors.
9. A fuel run solenoid (optional).

The spare parts listed directly above are those we *recommend* be carried on board during long ocean voyages. You may wish to ask other boat owners who have similar crafts and who have completed long ocean voyages as to what spare parts they carried on board and what parts were needed at specific times on the voyage. From the list provided directly above and from these inquiries, you can determine what spare parts may be needed. In addition, if you are planning a long ocean voyage, consult your local Westerbeke dealer for a listing of the Westerbeke dealers located on your route.

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