

HINSHI-H10-001-2

SERVICE MANUAL

MARINE DIESEL ENGINE

6LP-DTE/-DTZE(1)

6LPA-DTP/-DTZP

6LP-STE/-STZE(1)

6LPA-STP/-STZP

2001.6

YANMAR

SERVICE MANUAL

MARINE DIESEL ENGINE

MODEL **6LP-DTE/-DTZE(1)**
 6LPA-DTP/-DTZP
 6LP-STE/-STZE(1)
 6LPA-STP/-STZP



YANMAR DIESEL ENGINE CO., LTD.

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FOREWORD

This manual describes the service procedures for the 6LP and 6LPA series marine diesel engine.

Please use this manual for accurate, quick and safe servicing of the respective engine. Since the explanation herein assumes the standard type engine, the specifications and components may partially be different from the engine installed on each boat. Please also refer to the service manual for each boat for details.

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

California

Proposition 65 Warning

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

California

Proposition 65 Warning

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

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CONTENTS

Notice: The descriptions for the 6LP-DTE series also apply to 6LPA-DTP series. The descriptions for the 6LP-STE series also apply to 6LPA-STP series.

1. For Safe Operation	1-1
1.1 Warning Symbols	1-1
1.2 Precautions for Safe Servicing	1-2
1.3 Location for Product Safety Labels	1-6
2. General	2-1
2.1 Specifications	2-1
2.2 External Views	2-2
2.3 Piping Diagram	2-4
2.4 Performance Curves	2-6
2.5 Front Power Take-Off (PTO) Output	2-8
2.6 Fuel Oil	2-10
2.7 Lube Oil	2-11
2.8 Cooling Water	2-11
2.9 Location of Senders and Warning Switches	2-12
3. Engine Overhaul	3-1
3.1 Cylinder Head	3-1
3.1.1 Components	3-1
3.1.2 Removal of Cylinder Head	3-4
3.1.2.1 Drain the engine cooling water.	3-4
3.1.2.2 Remove the turbocharger	3-4
3.1.2.3 Remove the fresh water tank.....	3-4
3.1.2.4 Remove the fuel filter.....	3-4
3.1.2.5 Remove the intake manifold and intercooler.....	3-4
3.1.2.6 Remove the fuel injection pipe and fuel injection nozzle (For 6LP-DTE series).	3-4
3.1.2.7 Remove the bonnet.	3-5
3.1.2.8 Remove the semi-circular plug	3-5
3.1.2.9 Remove the timing belt and pulley	3-5
3.1.2.10 Remove the camshaft oil seal retainer.....	3-5
3.1.2.11 Remove the fuel injection nozzle (6LP-STE series)	3-5

3.1.2.12	Remove the camshaft (6LP-STE series)	3-5
3.1.2.13	Remove the cylinder head assy.....	3-5
3.1.3	Disassembly of Cylinder Head	3-7
3.1.3.1	Remove the valve lifter and shim (6LP-DTE series only)	3-7
3.1.3.2	Remove the valve bridge (6LP-STE series only)	3-7
3.1.3.3	Remove the intake and exhaust valves	3-7
3.1.4	Inspection and Servicing of Cylinder Head Components	3-7
3.1.4.1	Clean the piston and cylinder block top surfaces	3-7
3.1.4.2	Clean the cylinder head	3-8
3.1.4.3	Inspect the cylinder head.....	3-9
3.1.4.4	Clean the intake and exhaust valves	3-9
3.1.4.5	Inspection of valve stem and valve guide	3-9
3.1.4.6	Inspect and lap the intake and exhaust valves.....	3-10
3.1.4.7	Inspect and clean the valve seat.....	3-11
3.1.4.8	Check the valve spring	3-12
3.1.4.9	Check the valve rocker arm and shaft (For 6LP-STE series only)	3-13
3.1.4.10	Check the camshaft and bearing	3-14
3.1.5	Replacement of Oil Seal for Camshaft.....	3-16
3.1.6	Assembly of Cylinder Head	3-17
3.1.6.1	Install the intake and exhaust valves	3-17
3.1.6.2	Install the valve bridge (6LP-STE series)	3-18
3.1.6.3	Install the valve lifter and shim (6LP-DTE series only)	3-18
3.1.7	Installation of Cylinder Head	3-19
3.1.7.1	Measure protrusion of piston head for top surface of cylinder block to determine an appropriate cylinder head gasket	3-19
3.1.7.2	Set cylinder No.1 at the bottom dead center	3-20
3.1.7.3	Install the cylinder head	3-21
3.1.7.4	Install the camshaft	3-22
3.1.7.5	Install the fuel injection nozzle	3-23
3.1.7.6	Install the camshaft oil seal retainer.....	3-23
3.1.7.7	Install the pulley and timing belt.....	3-24
3.1.7.8	Check and adjust the valve clearance	3-24
3.1.7.9	Install the semi-circular plug	3-24
3.1.7.10	Install the bonnet	3-24
3.2	Cylinder Block	3-25
3.2.1	Components	3-25
3.2.2	Preparation for Disassembly	3-26

3.2.2.1	Remove the flywheel	3-26
3.2.2.2	Install the engine on the engine stand for disassembling it.....	3-26
3.2.2.3	Remove the timing belt and pulley.....	3-26
3.2.2.4	Remove the cylinder head	3-26
3.2.2.5	Remove the fresh water pump and sea water pump.....	3-26
3.2.2.6	Remove the alternator	3-26
3.2.2.7	Remove the timing gear	3-26
3.2.2.8	Remove the fuel injection pump	3-26
3.2.2.9	Remove the oil pan and timing gear case.....	3-26
3.2.2.10	Remove the oil cooler.....	3-26
3.2.2.11	Remove the engine mount.....	3-26
3.2.3	Disassembly of Cylinder Block	3-27
3.2.3.1	Remove the rear oil seal case	3-27
3.2.3.2	Check the connecting rod thrust clearance.....	3-27
3.2.3.3	Remove the connecting rod cap and check oil clearance	3-27
3.2.3.4	Remove the piston and connecting rod assembly.....	3-29
3.2.3.5	Inspect the thrust clearance of the crankshaft	3-29
3.2.3.6	Remove the main bearing cap and inspect the oil clearance	3-29
3.2.3.7	Remove the crankshaft.....	3-32
3.2.3.8	Remove the check valve and oil nozzle (for piston cooling)	3-32
3.2.4	Inspection of Cylinder Block	3-32
3.2.4.1	Clean the cylinder block.....	3-32
3.2.4.2	Measure warpage of the top surface of cylinder block	3-32
3.2.4.3	Visually check scratches of the cylinder in the vertical direction	3-32
3.2.4.4	Measure the cylinder bore diameter	3-32
3.2.4.5	Clean the cylinder ridge	3-33
3.2.4.6	Inspect the main bearing cap bolt.....	3-33
3.2.5	Disassembly of Piston and Connecting Rod.....	3-34
3.2.5.1	Check fitting between the piston and piston pin.....	3-34
3.2.5.2	Remove the piston ring.....	3-34
3.2.5.3	Remove the connecting rod from the piston	3-34
3.2.6	Inspection of Piston and Connecting Rod	3-35
3.2.6.1	Clean the piston.....	3-35
3.2.6.2	Inspect the piston and piston ring	3-35
3.2.6.3	Inspect the piston pin fit.....	3-37
3.2.6.4	Inspect the connecting rod	3-37
3.2.7	Inspection and Servicing of Crankshaft	3-39
3.2.7.1	Measure circle runout of the crankshaft.....	3-39
3.2.7.2	Inspect the crank journal and crank pin	3-39
3.2.8	Replacement of Oil Seal for Crankshaft	3-40
3.2.8.1	When the rear oil seal case has been removed from the cylinder block.....	3-40
3.2.8.2	When the rear oil seal case is installed to the cylinder block	3-40

3.2.9	Assembly of Piston and Connecting Rod	3-40
3.2.9.1	Assemble the piston and connecting rod	3-40
3.2.9.2	Install the piston ring.....	3-41
3.2.9.3	Install the crank pin bearing.....	3-42
3.2.10	Assembly of Cylinder Block	3-42
3.2.10.1	Install the oil nozzle and check valve for the piston cooling	3-42
3.2.10.2	Install the main bearing	3-42
3.2.10.3	Place the crankshaft on the cylinder block.....	3-43
3.2.10.4	Install the thrust bearing	3-43
3.2.10.5	Install the main bearing cap.....	3-43
3.2.10.6	Inspect the thrust clearance of the crankshaft	3-44
3.2.10.7	Install the piston and connecting rod assembly	3-44
3.2.10.8	Install the connecting rod cap	3-45
3.2.10.9	Check the connecting rod thrust clearance.....	3-45
3.2.10.10	Install the rear oil seal case	3-46
3.2.11	Next Assembly	3-47
3.2.11.1	Install the engine mounting bracket	3-47
3.2.11.2	Install the timing gear case	3-47
3.2.11.3	Install the oil pan.....	3-47
3.2.11.4	Install the rear end plate	3-47
3.2.11.5	Install the flywheel	3-47
3.2.11.6	Install the flywheel housing by tightening the set bolts.....	3-47
3.2.11.7	Upside down the engine and place it on the engine stand	3-47
3.2.11.8	Install the thermostat	3-47
3.2.11.9	Install the alternator and bracket assembly.....	3-47
3.2.11.10	Install the fresh water pump.....	3-47
3.2.11.11	Install the cylinder head	3-47
3.2.11.12	Install the timing belt and pulley.....	3-47
3.2.11.13	Remove the engine from the engine stand	3-47
3.2.11.14	Install the turbocharger oil pipe.....	3-47
3.2.11.15	Install the oil cooler assembly, oil dipstick and guide	3-47
3.2.11.16	Install the sender units and warning switches	3-47
3.2.11.17	Install the fuel injection pump	3-47
3.2.11.18	Install the sea water pump.....	3-47
3.2.11.19	Install the lube oil filter	3-47
3.3	Timing Belt	3-48
3.3.1	Components	3-48
3.3.2	Removal of Timing Belt	3-49
3.3.2.1	Remove the timing belt cover	3-49
3.3.2.2	Set the No.1 cylinder at the bottom dead center (BDC)	3-49
3.3.2.3	Remove the timing belt.....	3-49
3.3.2.4	Remove the idler pulley	3-50
3.3.2.5	Remove No.2 camshaft timing pulley	3-50
3.3.2.6	Remove the bonnet	3-50

3.3.2.7	Remove No.1 camshaft timing pulley	3-50
3.3.3	Checking of Timing Belt	3-50
3.3.3.1	Checking the timing belt	3-50
3.3.3.2	Inspect the idler pulley	3-52
3.3.3.3	Inspect the tension spring and tensioner	3-52
3.3.4	Installation of Timing Belt	3-53
3.3.4.1	Install No.1 camshaft timing pulley	3-53
3.3.4.2	Install the bonnet	3-53
3.3.4.3	Install No.2 camshaft timing pulley	3-53
3.3.4.4	Install the idler pulley	3-54
3.3.4.5	Set the No.1 cylinder to the bottom dead center (BDC)	3-54
3.3.4.6	Install the timing belt.....	3-54
3.3.4.7	Install the tension spring (6LP-DTE series).....	3-55
3.3.4.8	Install the timing belt tensioner (6LP-STE series)	3-55
3.3.4.9	Inspect the valve timing	3-55
3.3.4.10	Install the timing belt cover	3-56
3.4	Timing Gear	3-57
3.4.1	Components	3-57
3.4.2	Removal of Timing Gear	3-58
3.4.2.1	Remove the V-belt for driving the fresh water pump and alternator	3-58
3.4.2.2	Loosen the crankshaft pulley	3-58
3.4.2.3	Remove the timing belt and pulley.....	3-58
3.4.2.4	Remove the camshaft oil seal retainer.....	3-58
3.4.2.5	Remove the crankshaft pulley	3-58
3.4.2.6	Remove the alternator adjusting bar.....	3-58
3.4.2.7	Remove the timing gear cover	3-58
3.4.2.8	Remove the oil pump drive shaft gear	3-58
3.4.2.9	Inspect thrust clearance of the idler gear.....	3-59
3.4.2.10	Remove the idler gear	3-59
3.4.2.11	Remove the fuel injection pump drive gear.....	3-59
3.4.2.12	Remove the crankshaft timing gear	3-59
3.4.3	Inspection of Timing Gear	3-60
3.4.2.1	Check the idler gear	3-60
3.4.3.2	Check the fuel injection pump drive gear bearing	3-60
3.4.3.3	Replace the fuel injection pump drive gear bearing, as needed.....	3-60
3.4.3.4	Inspect backlash of the timing gear	3-61
3.4.4	Replacement of Crankshaft Front Oil Seal	3-61
3.4.4.1	Replace the crankshaft front oil seal.....	3-61
3.4.5	Replacement of Fuel Injection Pump Drive Gear Oil Seal	3-62
3.4.5.1	Replace the fuel injection pump drive gear oil seal	3-62
3.4.6	Installation of Timing Gear	3-63
3.4.6.1	Install the crankshaft timing gear	3-63
3.4.6.2	Install the fuel injection pump drive gear.....	3-63

3.4.6.3	Install the idler gear	3-63
3.4.6.4	Install the oil pump drive shaft gear	3-64
3.4.6.5	Install the timing gear cover.....	3-64
3.4.6.6	Install the alternator adjusting bar.....	3-64
3.4.6.7	Install the crankshaft pulley	3-65
3.4.6.8	Install camshaft oil seal retainer	3-65
3.4.6.9	Install timing pulleys and timing belt	3-65
3.4.6.10	Tighten crankshaft pulley bolt	3-65
3.4.6.11	Install the V-belt for driving the fresh water pump and alternator	3-65
3.5	Valve Clearance Inspection and Adjustment	3-66
3.5.1	Inspection of Valve Clearance.....	3-66
3.5.1.1	Remove the bonnet	3-66
3.5.1.2	Set No.1 cylinder to the top dead center (TDC)	3-66
3.5.1.3	Inspect the valve clearance	3-66
3.5.2	Adjustment of Valve Clearance	3-67
3.5.2.1	Adjust the valve clearance.....	3-67
3.5.2.2	Install the bonnet.....	3-68
3.6	Inspection and Adjustment of Injection Timing	3-69
3.6.1	Inspection of Injection Timing.....	3-69
3.6.1.1	Set the No.1 or No.6 cylinder at the top dead center (TDC) /compression	3-69
3.6.1.2	Install the plunger stroke measuring tool and dial indicator	3-69
3.6.1.3	Inspect the injection timing	3-69
3.6.2	Adjustment of Injection Timing	3-70
3.6.2.1	Adjust the injection timing.....	3-70
3.6.2.2	Tighten union nuts for the fuel injection pipe	3-70
3.6.2.3	Start the engine and check for fuel oil leakage.....	3-70
3.7	Service Specifications	3-71
3.7.1	Engine Adjusting Standards.....	3-71
3.7.2	Service Standards	3-72
3.7.3	Nut and Bolt Tightening Torque.....	3-75
3.8	Turbocharger.....	3-76
3.8.1	Construction and Function.....	3-76
3.8.1.1	Overview of construction and function	3-76
3.8.1.1.1	Turbine	3-76
3.8.1.1.2	Blower.....	3-76
3.8.1.1.3	Bearing	3-76
3.8.1.1.4	Sealing structure at blower side	3-76
3.8.2	Components (RHE6W Turbocharger)	3-78
3.8.3	Service Specifications	3-79
3.8.3.1	Service standards.....	3-79

3.8.3.2	Nut and bolt tightening torque.....	3-80
3.8.4	Periodic Inspection Procedure.....	3-81
3.8.4.1	Periodic inspection intervals	3-81
3.8.4.2	Inspection procedure	3-81
3.8.4.2.1	Running of turbine shaft.....	3-81
3.8.4.2.2	Inspection of turbine shaft play	3-82
3.8.5	Disassembly Procedure.....	3-83
3.8.5.1	Preparation for disassembly	3-83
3.8.5.2	Inspection before disassembly	3-84
3.8.5.2.1	Check the turbine and compressor impellers for interference. Also, check that the turbine shaft rotates smoothly.....	3-84
3.8.5.2.2	Measure the turbine shaft play.....	3-84
3.8.5.3	Disassembly	3-84
3.8.5.3.1	Remove the boost hose	3-84
3.8.5.3.2	Remove the compressor housing	3-84
3.8.5.3.3	Remove the compressor impeller	3-84
3.8.5.3.4	Remove the seal plate	3-85
3.8.5.3.5	Remove the turbine housing	3-85
3.8.5.3.6	Pull off the turbine shaft.....	3-85
3.8.5.3.7	Remove the thrust bearing and thrust bushing	3-85
3.8.5.3.8	Remove the floating bearing	3-85
3.8.5.3.9	Remove the seal ring.....	3-85
3.8.6	Cleaning and Checking Procedures	3-86
3.8.6.1	Cleaning	3-86
3.8.6.1.1	Checking before cleaning	3-86
3.8.6.1.2	Cleaning procedure	3-87
3.8.6.2	Inspection procedure	3-88
3.8.6.2.1	Compressor housing ③①	3-88
3.8.6.2.2	Turbine housing ④①	3-88
3.8.6.2.3	Compressor impeller ⑧	3-88
3.8.6.2.4	Turbine shaft ①	3-88
3.8.6.2.5	Thermal insulation plate ④②	3-88
3.8.6.2.6	Thrust bushing ②, oil thrower ③ and thrust bearing ②②.....	3-89
3.8.6.2.7	Floating bearing ②①	3-89
3.8.6.2.8	Bearing housing ⑤①	3-90
3.8.6.2.9	Seal plate ①①	3-90
3.8.6.2.10	Seal rings ④ and ⑥	3-90
3.8.6.2.11	Check bolts, etc. for deformation	3-90
3.8.7	Reassembly Procedure.....	3-91
3.8.7.1	Preparation for reassembly.....	3-91
3.8.7.1.1	Prepare tools	3-91
3.8.7.1.2	Replace the parts.....	3-91
3.8.7.2	Reassembly.....	3-91
3.8.7.2.1	Installation of floating bearing	3-91
3.8.7.2.2	Installation of turbine shaft.....	3-91

3.8.7.2.3	Installation of thrust bearing	3-91
3.8.7.2.4	Installation of turbine housing	3-92
3.8.7.2.5	Installation of seal plate	3-92
3.8.7.2.6	Installation of compressor impeller.....	3-92
3.8.7.2.7	Installation of compressor housing.....	3-93
3.8.7.2.8	Installation of boost hose	3-93
3.8.7.2.9	Measurement of turbine shaft play.....	3-93
3.8.8	Handling after Disassembly and Reassembly.....	3-94
3.8.8.1	Instructions for turbocharger installation	3-94
3.8.8.1.1	Lubrication path	3-94
3.8.8.1.2	Intake path.....	3-94
3.8.8.1.3	Exhaust path.....	3-94
3.8.9	Troubleshooting.....	3-95
3.8.9.1	Excessively dense exhaust smoke	3-95
3.8.9.2	White exhaust gas color	3-96
3.8.9.3	Excessive engine oil consumption	3-96
3.8.9.4	Engine output drop	3-96
3.8.9.5	Poor (slow) response (starting) of turbocharger.....	3-96
3.8.9.6	Abnormal sound or vibration	3-97
3.9	Fuel Filter Replacement.....	3-98
3.9.1	Removal of Fuel Filter.....	3-98
3.9.1.1	Disconnect the connector of the water alarm switch of the fuel filter.....	3-98
3.9.1.2	Drain fuel from the fuel filter	3-98
3.9.1.3	Fuel filter removal.....	3-98
3.9.1.4	Remove the water alarm switch from the fuel filter	3-98
3.9.2	Installation of Fuel Filter.....	3-98
3.9.2.1	Install the water alarm switch to the new fuel filter	3-98
3.9.2.2	Install the new fuel filter	3-98
3.9.2.3	Install the water alarm switch connector of the fuel filter.....	3-98
3.9.2.4	Fill fuel to the fuel filter.....	3-98
3.9.2.5	Start the engine to check for fuel leakage	3-98
3.10	Fuel Injection Nozzle.....	3-99
3.10.1	Components	3-99
3.10.2	Removal of Fuel Injection Nozzle.....	3-100
3.10.3	Testing the Fuel Injection Nozzle.....	3-102
3.10.3.1	Leak test.....	3-102
3.10.3.2	Testing the spray condition.....	3-102
3.10.4	Components of Fuel Injection Nozzle.....	3-103
3.10.5	Disassembly of Fuel Injection Nozzle	3-104
3.10.5.1	Disassemble the fuel injection nozzle	3-104
3.10.6	Cleaning and Inspection of Fuel Injection Nozzle.....	3-104
3.10.6.1	Cleaning the nozzle	3-104

3.10.6.2	Inspection of nozzle assembly	3-105
3.10.7	Adjustment of Fuel Injection Nozzle	3-105
3.10.7.1	Adjust the needle lift and pre-lift	3-105
3.10.7.2	For 6LP-DTE series	3-105
3.10.7.3	For 6LP-STE series	3-108
3.10.8	Checking No.2 Opening Pressure	3-112
3.10.9	Adjusting No.1 Opening Pressure	3-114
3.10.10	Installation of Fuel Injection Nozzle	3-116
3.10.10.1	Install the fuel injection nozzle	3-116
3.10.10.2	Install the nozzle holder seal	3-116
3.10.10.3	Install the fuel injection pipe	3-116
3.10.10.4	Install the fuel return pipe	3-117
3.10.10.5	Install the bonnet	3-117
3.10.10.6	Start the engine and check for fuel leakage	3-117
3.11	Fuel Injection Pump	3-118
3.11.1	Removal of Fuel Injection Pump	3-119
3.11.1.1	Drain cooling water from the engine and disconnect the cooling pipe	3-119
3.11.1.2	Remove the timing belt	3-119
3.11.1.3	Remove the No.2 camshaft timing pulley	3-119
3.11.1.4	Remove the fuel injection pipe	3-119
3.11.1.5	Disconnect the boost compensator hose	3-119
3.11.1.6	Remove the fuel injection pump	3-119
3.11.2	Components	3-121
3.11.3	Installation of Fuel Injection Pump	3-123
3.11.3.1	Install the fuel injection pump	3-123
3.11.3.2	Connect boost compensator hose	3-124
3.11.3.3	Install the No.2 camshaft timing pulley	3-124
3.11.3.4	Install the timing belt	3-124
3.11.3.5	Check the injection timing	3-124
3.11.3.6	Install the fuel injection pipe	3-124
3.11.3.7	Fill with engine coolant (fresh water line)	3-124
3.11.3.8	Start the engine and check for fuel leakage	3-124
3.12	Fuel System Service Specifications	3-125
3.12.1	Service Standards	3-125
3.12.2	Nut and Bolt Tightening Torque	3-126
3.12.3	Specifications of Fuel Injection Pump	3-127
3.13	Fresh Water Pump	3-129
3.13.1	Removal of Fresh Water Pump	3-129
3.13.1.1	Drain engine cooling water	3-129
3.13.1.2	Remove the drive belt, viscous damper and fresh water pump pulley	3-129

3.13.1.3	Remove the timing belt.....	3-129
3.13.1.4	Remove the idler pulley	3-129
3.13.1.5	Remove No.1 camshaft timing pulley	3-130
3.13.1.6	Remove the camshaft oil seal retainer.....	3-130
3.13.1.7	Remove the fresh water pump.....	3-130
3.13.2	Inspection of Fresh Water Pump	3-130
3.13.2.1	Check the fresh water pump.....	3-130
3.13.3	Installation of Fresh Water Pump	3-130
3.13.3.1	Install the fresh water pump.....	3-130
3.13.3.2	Install the camshaft oil seal retainer.....	3-130
3.13.3.3	Install No.1 camshaft timing pulley	3-130
3.13.3.4	Install the idler pulley	3-131
3.13.3.5	Install the timing belt.....	3-131
3.13.3.6	Install the fresh water pump pulley, drive belt and viscous damper	3-131
3.13.3.7	Fill with engine coolant (fresh water)	3-131
3.13.3.8	Start the engine and check for water leakage.....	3-131
3.14	Sea Water Pump.....	3-132
3.14.1	Disassembly of Sea Water Pump.....	3-132
3.14.2	Inspection of Sea Water Pump.....	3-132
3.14.3	Reassembly of Sea Water Pump	3-132
3.15	Thermostat	3-133
3.15.1	Removal of Thermostat.....	3-133
3.15.2	Inspection of Thermostat.....	3-134
3.15.3	Installation of Thermostat	3-134
3.15.3.1	Install the thermostat on the cylinder block	3-134
3.15.3.2	Install the thermostat cover.....	3-134
3.15.3.3	Fill with engine coolant (fresh water)	3-134
3.15.3.4	Start the engine and check for water leakage.....	3-134
3.16	Components Related to Cooling System	3-135
3.16.1	Fresh Water Tank	3-135
3.16.1.1	Remove the pressure cap.....	3-135
3.16.1.2	Check the pressure cap.....	3-135
3.16.1.3	Check for fresh water leakage	3-135
3.16.1.4	Reinstall the pressure cap	3-135
3.16.2	Fresh Water Cooler	3-136
3.16.3	Subtank.....	3-136
3.16.3.1	Install the subtank	3-136
3.16.3.2	Subtank operational precautions	3-137
3.16.4	Kingston Cock (Optional)	3-137

3.17	Lubrication	3-138
3.17.1	Inspection of Oil Pressure	3-138
3.17.1.1	Check the lube oil quality	3-138
3.17.1.2	Check the lube oil level	3-138
3.17.1.3	Remove the oil pressure sender unit	3-138
3.17.1.4	Attach the oil pressure gauge	3-138
3.17.1.5	Warm up the engine	3-138
3.17.1.6	Check the oil pressure	3-138
3.17.1.7	Remove the oil pressure gauge	3-138
3.17.1.8	Install the oil pressure sender unit	3-138
3.17.1.9	Start the engine and check for oil leakage	3-138
3.17.2	Replacement of Lube Oil and Oil Filter	3-139
3.17.2.1	Drain the lube oil	3-139
3.17.2.2	Replace the lube oil filter	3-139
3.17.2.3	Fill with lube oil	3-139
3.17.2.4	Start the engine and check for oil leakage	3-139
3.17.2.5	Check the lube oil level again and replenish as needed	3-139
3.18	Oil Pump	3-140
3.18.1	Removal of Oil Pump	3-141
3.18.1.1	Drain the engine cooling fresh water	3-141
3.18.1.2	Drain the lube oil	3-141
3.18.1.3	Remove the timing gear	3-141
3.18.1.4	Remove the oil pan	3-141
3.18.1.5	Remove the oil pump (timing gear case)	3-141
3.18.1.6	Remove the oil strainer	3-141
3.18.2	Disassembly of Oil Pump	3-142
3.18.2.1	Remove the driven rotor	3-142
3.18.2.2	Remove the relief valve	3-142
3.18.3	Inspection of Oil Pump	3-142
3.18.3.1	Check the relief valve	3-142
3.18.3.2	Check the drive shaft	3-142
3.18.3.3	Check the drive and driven rotors	3-142
3.18.4	Reassembly of Oil Pump	3-143
3.18.4.1	Install the relief valve	3-143
3.18.4.2	Install the drive and driven rotors	3-143
3.18.5	Installation of Oil Pump	3-143
3.18.5.1	Install the oil strainer	3-143
3.18.5.2	Install the oil pump (timing gear case)	3-143
3.18.5.3	Pour lube oil into the oil pump	3-144
3.18.5.4	Install the oil pan	3-145
3.18.5.5	Install the timing gear	3-145
3.18.5.6	Fill with lube oil	3-145
3.18.5.7	Fill with engine coolant (fresh water)	3-145

3.18.5.8	Start the engine and check for oil leakage.....	3-145
3.18.5.9	Check the lube oil level again and, if needed, replenish up to the upper limit of the oil dipstick	3-145
3.19	Oil Cooler (Cooling by Fresh Water).....	3-146
3.19.1	Removal of Oil Cooler.....	3-147
3.19.1.1	Drain the engine coolant (fresh water).....	3-147
3.19.1.2	Remove the timing belt.....	3-147
3.19.1.3	Remove No.2 camshaft timing pulley	3-147
3.19.1.4	Remove the fuel injection pipe.....	3-147
3.19.1.5	Remove the fuel injection pump	3-147
3.19.1.6	Remove the oil filter.....	3-147
3.19.1.7	Remove the relief valve	3-147
3.19.1.8	Remove the check valve.....	3-147
3.19.1.9	Remove the oil cooler and cover assembly.....	3-147
3.19.1.10	Remove the oil cooler from the oil cooler cover	3-147
3.19.2	Inspection of Oil Cooler and Relief Valve.....	3-147
3.19.2.1	Check the relief valve	3-147
3.19.2.2	Check the check valve.....	3-148
3.19.2.3	Check the oil cooler	3-148
3.19.3	Installation of Oil Cooler.....	3-148
3.19.3.1	Install the oil cooler to the oil cooler cover	3-148
3.19.3.2	Install the oil cooler and cover assembly	3-148
3.19.3.3	Install the relief valve	3-149
3.19.3.4	Install the check valve	3-149
3.19.3.5	Install the oil filter.....	3-149
3.19.3.6	Install the fuel injection pump	3-149
3.19.3.7	Install the fuel injection pipe.....	3-149
3.19.3.8	Install No.2 camshaft timing pulley	3-149
3.19.3.9	Install the timing belt.....	3-149
3.19.3.10	Fill with engine coolant (fresh water)	3-149
3.19.3.11	Start the engine and check for oil leakage.....	3-149
3.19.3.12	Check the lube oil level again and, if needed, replenish up to the upper limit of the oil dipstick	3-149
3.20	Piston Cooling Oil Nozzle.....	3-150
3.20.1	Disassembly of Oil Nozzle.....	3-150
3.20.1.1	Remove the oil pan.....	3-150
3.20.1.2	Remove the check valve and oil nozzle	3-150
3.20.2	Inspection of Oil Nozzle.....	3-150
3.20.2.1	Check the check valve.....	3-150
3.20.2.2	Inspect the oil nozzle	3-151
3.20.3	Installation of Oil Nozzle.....	3-151
3.20.3.1	Install the oil nozzle and check valve	3-151
3.20.3.2	Install the oil pan.....	3-151

3.21	Service Specifications	3-151
3.21.1	Service Standards	3-151
3.21.2	Nut and bolt tightening torque	3-151
3.22	Starter	3-152
3.22.1	Components	3-152
3.22.2	Disassembly of Starter	3-152
3.22.2.1	Remove the field frame and lead wire with armature from the magnetic switch	3-152
3.22.2.2	Remove the starter housing, clutch assembly and gear	3-153
3.22.2.3	Remove the steel ball	3-153
3.22.2.4	Remove the brush holder	3-154
3.22.2.5	Remove the armature from the field frame	3-154
3.22.3	Inspection and Repair of Starter	3-154
3.22.3.1	Armature coil	3-154
3.22.3.1.1	Check the commutator for open circuit	3-154
3.22.3.1.2	Check grounding of the commutator	3-154
3.22.3.2	Commutator.....	3-154
3.22.3.2.1	Check the commutator surface for dirt and burning	3-154
3.22.3.2.2	Check the commutator for circle runout	3-154
3.22.3.2.3	Check the commutator diameter	3-155
3.22.3.2.4	Check the undercut depth.....	3-155
3.22.3.3	Field frame (Field coil)	3-155
3.22.3.3.1	Check open circuit of the field coil.....	3-155
3.22.3.3.2	Check grounding of the field coil.....	3-155
3.22.3.4	Brush.....	3-156
3.22.3.4.1	Check the brush length.....	3-156
3.22.3.5	Brush spring	3-156
3.22.3.5.1	Check the brush spring load	3-156
3.22.3.6	Brush holder	3-156
3.22.3.6.1	Check the insulation status of the brush holder	3-156
3.22.3.7	Clutch and gear	3-156
3.22.3.7.1	Check the gear tooth surfaces	3-156
3.22.3.7.2	Check the clutch pinion gear.....	3-157
3.22.3.7.3	Replace the clutch assembly if needed.....	3-157
3.22.3.8	Bearing.....	3-158
3.22.3.8.1	Check the bearing.....	3-158
3.22.3.8.2	Replace the bearing, if needed	3-159
3.22.3.9	Magnetic switch	3-159
3.22.3.9.1	Check continuity of the pull-in coil circuit.....	3-159
3.22.3.9.2	Check continuity of the hold-in coil circuit	3-159
3.22.3.10	Reassembly of starter.....	3-159
3.22.3.10.1	Fit the armature in the field frame	3-159
3.22.3.10.2	Install the brush holder.....	3-160

3.22.3.10.3	Insert the steel ball into the clutch shaft hole	3-160
3.22.3.10.4	Install the starter housing, clutch assembly and gear.....	3-160
3.22.3.10.5	Install the field frame, armature assembly and lead wire to the magnetic switch	3-161
3.22.3.11	Starter performance test.....	3-162
3.22.3.11.1	Pull-in test.....	3-162
3.22.3.11.2	Hold-in test	3-162
3.22.3.11.3	Check return of the clutch pinion gear	3-162
3.22.3.11.4	No-load performance test	3-162
3.22.4	Service Standard	3-163
3.23	Charging System.....	3-164
3.23.1	Preparation and Inspection	3-164
3.23.1.1	Inspect the drive belt	3-164
3.23.1.2	Visually check the alternator wiring and check for abnormal sounds	3-164
3.23.1.3	Check the discharge warning light circuit.....	3-164
3.23.1.4	Check the charging circuit at no load.....	3-165
3.23.1.5	Check the charging circuit at on load (Reference)	3-165
3.23.2	Alternator	3-166
3.23.3	Disassembly of Alternator	3-166
3.23.3.1	Remove the rear end cover	3-166
3.23.3.2	Remove the brush holder and IC regulator	3-167
3.23.3.3	Remove the rectifier holder.....	3-167
3.23.3.4	Remove the pulley	3-168
3.23.3.5	Remove the rectifier end frame	3-168
3.23.3.6	Remove the rotor from the drive end frame	3-169
3.23.4	Inspection and Repair of Alternator.....	3-169
3.23.4.1	Check continuity of the rotor circuit.....	3-169
3.23.4.2	Check the rotor grounding	3-169
3.23.4.3	Check the slip ring	3-169
3.23.4.4	Drive end frame (stator).....	3-169
3.23.4.4.1	Check continuity of the drive end frame circuit.....	3-169
3.23.4.4.2	Check grounding of the drive end frame	3-170
3.23.4.5	Brush.....	3-170
3.23.4.5.1	Check the exposed brush length.....	3-170
3.23.4.6	Rectifier (rectifier holder)	3-170
3.23.4.6.1	Check the positive rectifier	3-170
3.23.4.6.2	Check the negative rectifier	3-170
3.23.4.7	Bearing.....	3-170
3.23.4.7.1	Check the front bearing	3-170
3.23.4.7.2	Replace the front bearing when needed	3-171
3.23.4.7.3	Check the rear bearing	3-171
3.23.4.7.4	Replace the rear bearing when needed	3-171

3.23.5 Reassembly of Alternator	3-172
3.23.5.1 Locate the rectifier end frame on the pulley	3-172
3.23.5.2 Install the rotor to the rectifier end frame	3-172
3.23.5.3 Install the rectifier end frame	3-172
3.23.5.4 Install the pulley	3-173
3.23.5.5 Install the rectifier holder	3-173
3.23.5.6 Install the IC regulator and brush holder	3-174
3.23.5.7 Install the rear end cover	3-174
3.23.5.8 Check that the rotor rotates smoothly	3-174
3.23.6 Service Standards	3-175
3.24.1 Crankshaft Bearing Selecting TABLE (additional)	3-176
4. Troubleshooting	4-1
4.1 Does not Start or Difficult to Start	4-1
4.2 Unsmooth Running	4-2
4.3 Sudden Engine Stop	4-3
4.4 Poor Exhaust Gas Color	4-4
4.5 Insufficient Output	4-5
4.6 Ununiformity Output for Each Cylinder	4-6
4.7 Knocking	4-7
4.8 Trouble Related to Turbocharger	4-8
4.9 Other Malfunctions	4-9
5. Instrument Panel (Optional)	5-1
6. Electric Wiring Diagram	6-1
7. Tools	7-1
7.1 Special Tools	7-1
7.2 Special Tools (Local Supply)	7-3
7.3 Recommended Tools (Local Supply)	7-8
7.4 Equipment (Local Supply)	7-8
7.5 Service Special Materials (Local Supply)	7-10
7.6 Other Service Materials for Reference	7-11

1. For Safe Operation

1.1 Warning Symbols

- Most accidents are caused by negligence of basic safety rules and precautions. For accident prevention, it is important to avoid such causes before development to accidents. Please read this manual carefully before starting repair or maintenance to fully understand safety precautions and appropriate inspection and maintenance procedures. Attempting a repair or maintenance job without sufficient knowledge may cause an unexpected accident.
- It is impossible to cover every possible danger in repair or maintenance in the manual. Sufficient consideration for safety is required in addition to the matters marked **▲ CAUTION**. Especially for safety precautions in a repair or maintenance job not described in this manual, receive instructions from a knowledgeable leader.
- Warning Symbols used in this manual and their meanings are as follows:



DANGER - Indicates an imminently hazardous situation which, if not avoided, **WILL** result in death or serious injury.



WARNING - Indicates a potentially hazardous situation which, if not avoided, **COULD** result in death or serious injury.



CAUTION - Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

- Any matter marked [NOTICE] in this manual is especially important in serving. If not observed, the product performance and quality may not be guaranteed.

1.2 Precautions for Safe Servicing

(1) Service Shop (Place)

⚠ WARNING



● **Place allowing sufficient ventilation**

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

[Otherwise]

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

⚠ CAUTION

● **Sufficiently wide and flat place**

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

[Otherwise]

An accident such as a violent fall may be caused.

⚠ CAUTION

● **Clean, orderly arranged place**

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

[Otherwise]

An unexpected accident may be caused.

⚠ CAUTION



● **Bright, safety illuminated place**

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

[Otherwise]

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


⚠ CAUTION



● **Place equipped with a fire extinguisher**

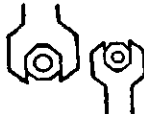
Keep a first aid kit and fire extinguisher close at hand in preparation for an emergency of fire.

(2) Working Wear


⚠ CAUTION	● Wears for safe operation
	Wear a helmet, working clothes, safety shoes and other safety protectors matching each job. Especially, wear well-fitting working clothes.
	[Otherwise]
	A serious accident such as trapping by a machine may arise.

(3) Tools to Be Used


⚠ WARNING	● Appropriate holding and lifting
	Never operate when the engine is supported with blocks or wooden pieces or only with a jack. To lift and hold the engine, always use a crane with a sufficient allowance in limit load or a rigid jack.
	[Otherwise]
	A serious accident may arise.

⚠ WARNING	● Use of appropriate tools
	Use tools matching the jobs to be done. Use a correctly sized tool for loosening or tightening a machine part.
	[Otherwise]
	A serious injury or engine damage may arise.

(4) Use of Genuine parts, Oil and Grease

⚠ CAUTION	● Always use genuine product
	[Otherwise] Shortening of engine life or an unexpected accident may arise.

(5) Bolt and Nut Tightening Torques

⚠ WARNING	● Always tighten to the specified torque if designated in the manual
	[Otherwise] Loosening or falling may cause parts damage or an injury.

(6) Handling Of Product

▲ WARNING



● **Pay attention to hot portions**

Do not touch the engine during running or immediately after it is stopped.

[Otherwise]

Scalding may be caused by a high temperature.

▲ WARNING



● **Pay attention to the rotating part**

Never bring clothes or a tool close to the rotating part during engine running.

[Otherwise]

Injury may be caused by entraping.

▲ WARNING



● **Harness short-circuit**

Disconnect the battery negative (-) terminal before starting the service job.

[Otherwise]

Shorting of a harness may occur to start a fire.

▲ WARNING



● **Battery charging**

Since flammable gas is generated during battery charging, keep any fire source away.

[Otherwise]

Explosion may arise.

▲ WARNING



● **Battery electrolyte**

Since the electrolyte is diluted sulfuric acid, do not let it be splashed onto clothes or skin.

[Otherwise]

The clothes or skin may be burnt.

(7) Waste Disposal

⚠ CAUTION

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

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

(8) Safety Label Check

⚠ CAUTION

- Pay attention to the product safety label.

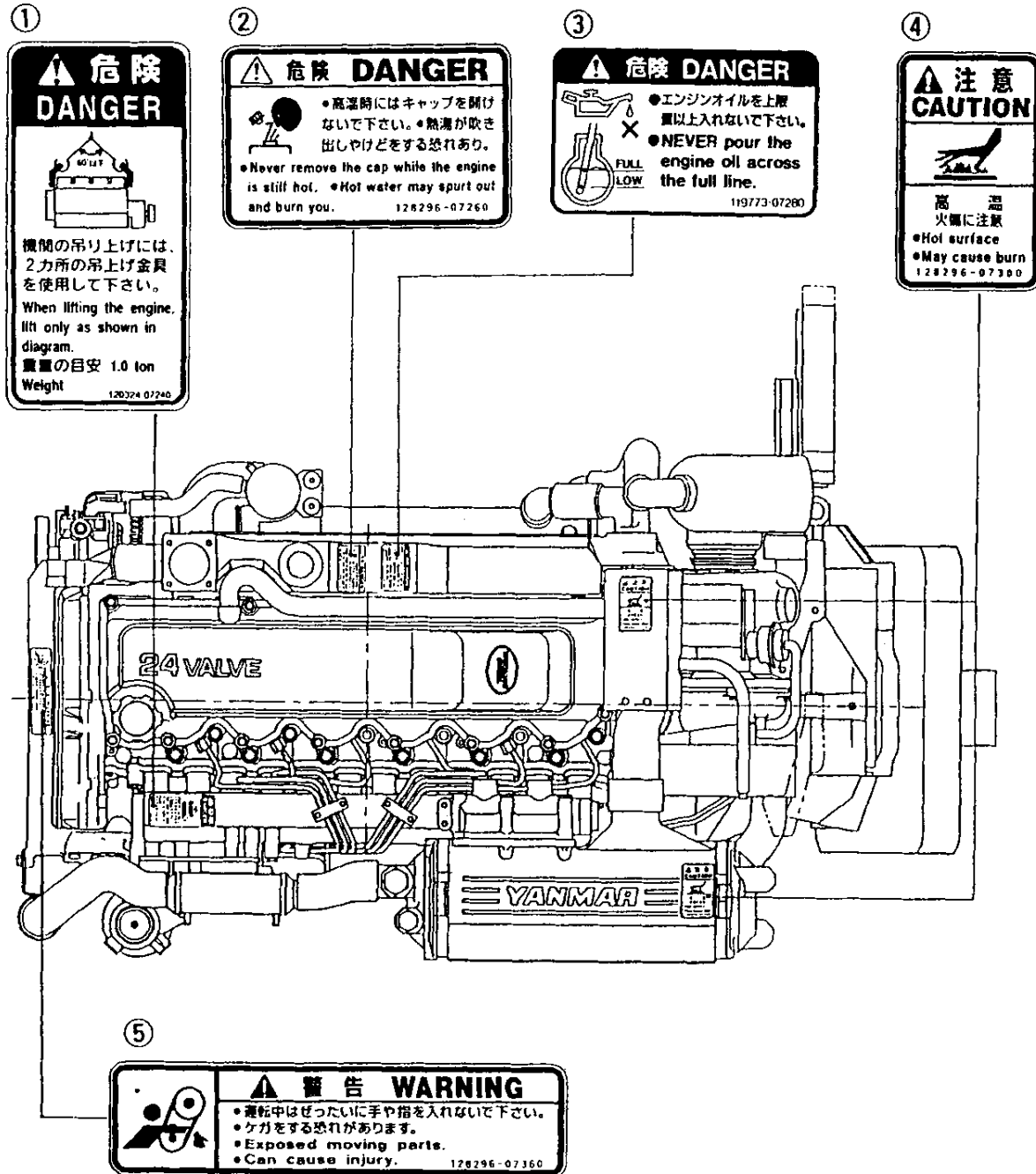
A safety label (caution plate) is affixed on the product for calling special attention to safety.

If it is missing or illegible, always affix a new one.

1.3 Location for Product Safety Labels

To insure safe operation, product safety labels have been attached. Their location is shown in the diagram below. Keep the labels from becoming dirty or torn and replace them if they are lost or damaged. Also replace labels when parts are replaced, ordering them in the same way parts are ordered.

Product Safety Labels, Parts Code Numbers	
①	120324-07240
②	128296-07260
③	119773-07280
④	128296-07300
⑤	128296-07360



The above diagram shows an overhead view of the engine.

2. General

2.1 Specifications

Engine model		6LP-DTE	6LP-STE	6LP-DTZE (1)	6LP-STZE (1)		
Type	Vertical water-cooled 4-cycle diesel engine						
Number of cylinders – Bore × stroke	mm	6 – φ 94 × 100					
Displacement	ℓ	4.163					
Aspiration system	Turbocharger, intercooler						
Cont. rating output	kW{hp}/rpm (Output/Flywheel)	154 {210}/3600	188 {255}/3600	154 {210}/3600	188 {255}/3600		
Max. output	kW{hp}/rpm (Output/Flywheel)	184 {250}/3800	221 {300}/3800	184 {250}/3800	221 {300}/3800		
High idling	(rpm)	4200 ± 25					
Low idling	(rpm)	750 ± 25					
Combustion system	Direct injection						
Starting system	Electric starting						
Cooling system	Constant high temperature fresh water cooling (2 cooling systems: seawater & fresh water)						
Lubrication system	Forced lubrication system with gear pump						
Direction of rotation	(Crankshaft)	Clockwise when viewed from stern side					
Fuel injection pump	BOSCH-distributor type Model VE6 (DENSO Co.)						
Fuel injection nozzle	Dual spring type Pinhole injection nozzle 6LP-DTE/-DTZE/-DTZE1: DLLA141P678 (5-0.30 × 140°) 6LP-STE/-STZE/-STZE1: DLLA141P677 (5-0.32 × 141°)						
Turbocharger	RHE62W(IHI)Water cooling and forced lubrication system with waste gate						
Elec. devices	Starter	DC12V - 2.5kW					
	Alternator	DC12V - 80A					
Lube oil capacity	ℓ	10.0	10.5	10.0	10.5		
Cooling water capacity	ℓ	13.5					
	Subtank	1.6					
Dimensions (L × W × H)	mm	1065 × 671 × 729	1065 × 671 × 729	1145 × 699 × 729	1145 × 699 × 729		
Dry weight (engine only)	kg (N)	380 (3724)	408 (3998)	400 (3920)	428 (4194)		
On-board marine drive	Maker	[Note] Marine drive with SAE#3 structure can be used. Example : HURTH (Italy) HSW630A1 Marine gear			MERCUISER (USA)		
	Type				BRAVO-1	BRAVO-2	BRAVO-3
	Speed ratio Ahead/Astern				1.36	1.50	1.36
		1.50	1.65	1.50			
		1.50	1.81	1.65	1.81		
Engine installation style	Rubber vibro-isolating mount						
Recommended battery capacity	12V-80Ah(5HR) or greater						
Recommended engine room ventilator	20m ³ / min. or greater						

※ -DTZE1/-STZE1 : less power steering oil pump (Engine name designated by the engine manufacturer)
(Shown as 6LP-DTZE/STZE in the name plate)

2. General

Engine model		6LPA-DTP	6LPA-DTZP
Type		Vertical water-cooled 4-cycle diesel engine	
Number of cylinders – Bore × stroke	mm	6– φ 94 × 100	
Displacement	ℓ	4.164	
Fuel stop power at crankshaft kW{hp}/rpm		*191 {260} / 3800 **182 {248} / 3800	
Cont. power at crankshaft kW{hp}/rpm		154 {210} / 3600	
High idling	(rpm)	4200 ± 25	
Low idling	(rpm)	750 ± 25	
Combustion system		Direct injection	
Starting system		Electric starting (12V-2.5kW)	
Charging system		Regulator built in Alternator DC12V-80A	
Cooling system		Constant high temperature fresh water cooling (2 systems: sea & fresh water)	
Lubrication system		Forced lubrication system with trochoidal gear pump	
Direction of rotation	(Crankshaft)	Counter-clockwise (Viewed from flywheel side)	
Lube oil capacity	All	ℓ	
	Oil pan	ℓ	
Cooling water capacity	ℓ	13.5 (Engine), 1.6 (Sub-tank)	
Turbocharger	Model	RHE62W (IHI made)	
	Type	Water cooled turbine housing	
Dimensions (L × W × H) (gear less)	mm	1065 × 671 × 729	1145 × 752 × 799
Dry mass (gear less)	kg	380	400
Recommended battery capacity		12V × 120Ah	
Recommended type of remote control handle		Single lever type only	
Engine installation style		On the flexible engine mount	

(Note) 1. Rating condition: ISO 3046-1, 8665 2. 1hp=0.7355 kW
3. Fuel condition: Density at 15°C=0.860, Fuel oil temperature *: 25°C at the fuel injection pump inlet
**: ISO 8665 (Fuel oil temp. 40°C at the fuel injection pump inlet)

● Marine gear (Option)

Model	HURTH HSW630A1	MERCUISER		
		Bravo X-1	Bravo X-2	Bravo X-3
Type	8° down Hydraulic	Stern drive		
Available engine	6LPA-DTP	6LPA-DTZP		
Reduction ratio HSW630A: Ahead/Astem Bravo X-1, 2, 3: Both Ahead and Astem	1.22/1.21	1.36	1.50	1.36
	1.56/1.58	1.50	1.65	1.50
	2.04/2.10	1.65	1.81	1.65
	2.52/2.53		2.00	1.81
			2.20	2.00
For further detail, refer to the maker's manual				

Engine model		6LPA-STP	6LPA-STZP
Type		Vertical water-cooled 4-cycle diesel engine	
Number of cylinders – Bore × stroke mm		6– φ 94 × 100	
Displacement ℓ		4.164	
Fuel stop power at crankshaft kW{hp}/rpm		*232 {315} / 3800 **222 {301} / 3800	
Cont. power at crankshaft kW{hp}/rpm		188 {255} / 3600	
High idling (rpm)		4200 ± 25	
Low idling (rpm)		750 ± 25	
Combustion system		Direct injection	
Starting system		Electric starting (12V-2.5kW)	
Charging system		Regulator built in Alternator DC12V-80A	
Cooling system		Constant high temperature fresh water cooling (2 systems: sea & fresh water)	
Lubrication system		Forced lubrication system with trochoidal gear pump	
Direction of rotation (Crankshaft)		Counter-clockwise (Viewed from flywheel side)	
Lube oil capacity	All ℓ	10.5	
	Oil pan ℓ	8.4	
Cooling water capacity ℓ		13.5 (Engine), 1.6 (Sub-tank)	
Turbocharger	Model	RHE62W (IHI made)	
	Type	Water cooled turbine housing	
Dimensions (L × W × H) (gear less) mm		1065 × 671 × 729	1145 × 752 × 799
Dry mass (gear less) kg		408	428
Recommended battery capacity		12V × 120Ah	
Recommended type of remote control handle		Single lever type only	
Engine installation style		On the flexible engine mount	

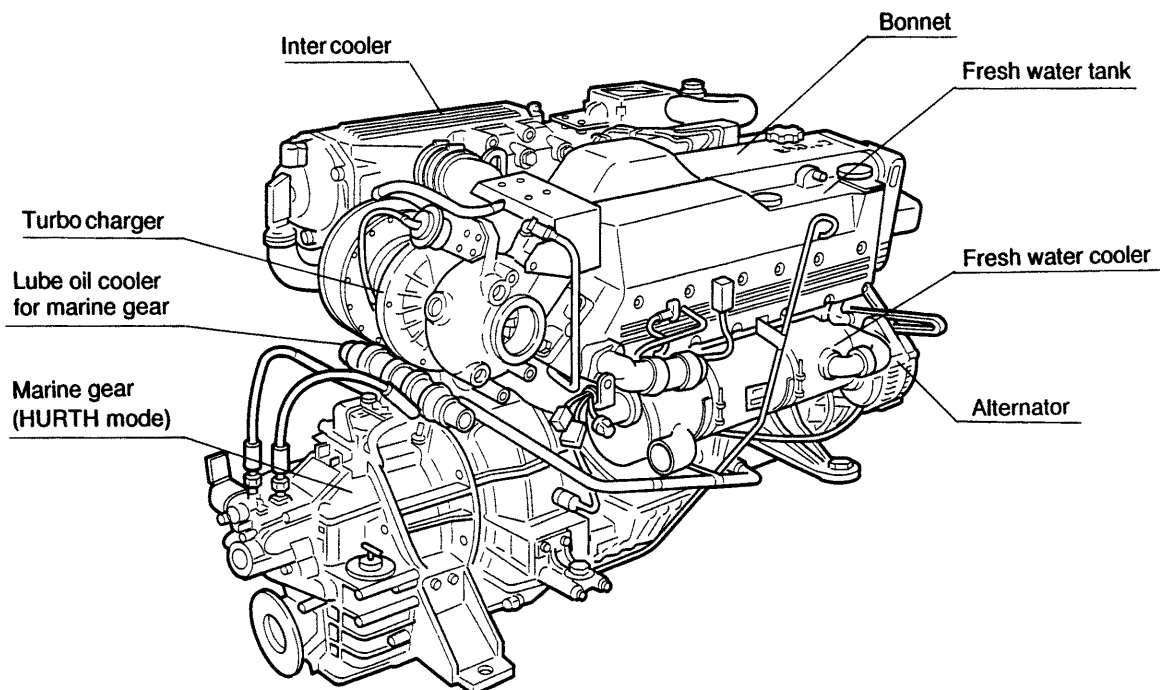
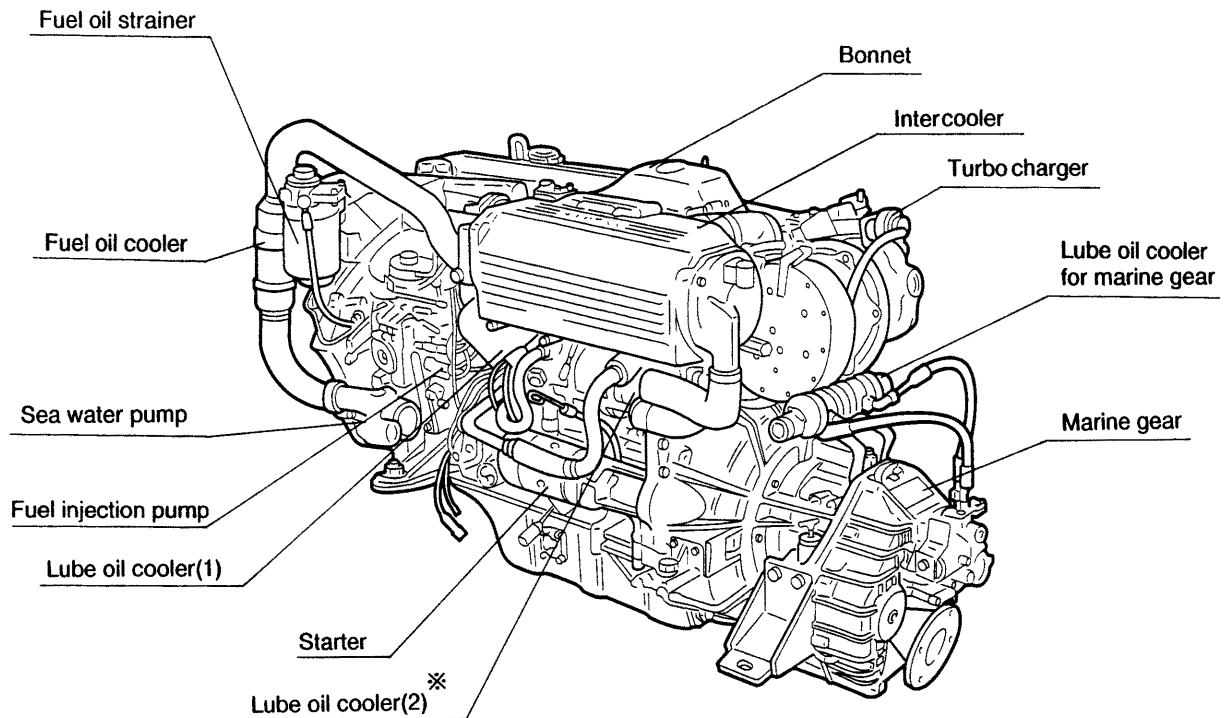
(Note) 1. Rating condition: ISO 3046-1, 8665 2. 1hp=0.7355 kW
3. Fuel condition: Density at 15°C=0.860, Fuel oil temperature *: 25°C at the fuel injection pump inlet
**: ISO 8665 (Fuel oil temp. 40°C at the fuel injection pump inlet)

● Marine gear (Option)

Model	HURTH HSW630A1	MERCUISER		
		Bravo X-1	Bravo X-2	Bravo X-3
Type	8° down Hydraulic	Stern drive		
Available engine	6LPA-STP	6LPA-STZP		
Reduction ratio HSW630A1: Ahead/Astem Bravo X-1, 2, 3: Both Ahead and Astern	1.22/1.21	1.36	1.50	1.36
	1.56/1.58	1.50	1.65	1.50
	2.04/2.10		1.81	1.65
	2.52/2.53		2.00	1.81
For further detail, refer to the maker's manual				

2.2 External Views

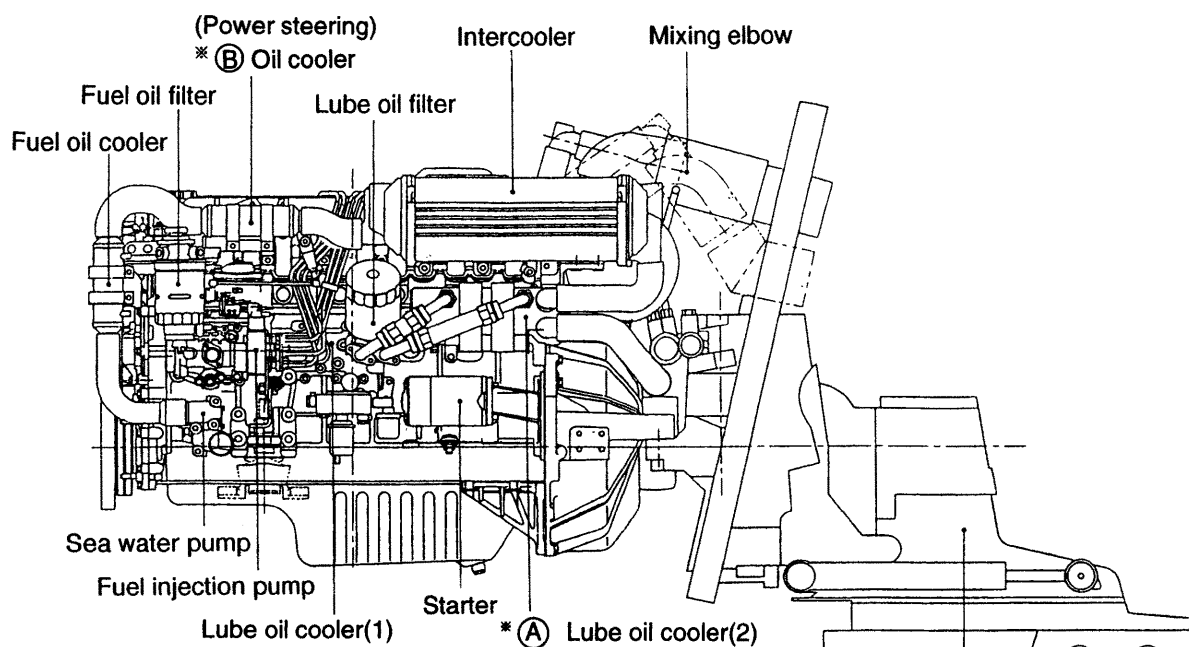
- 6LP-DTE/-STE, 6LPA-DTP/-STP



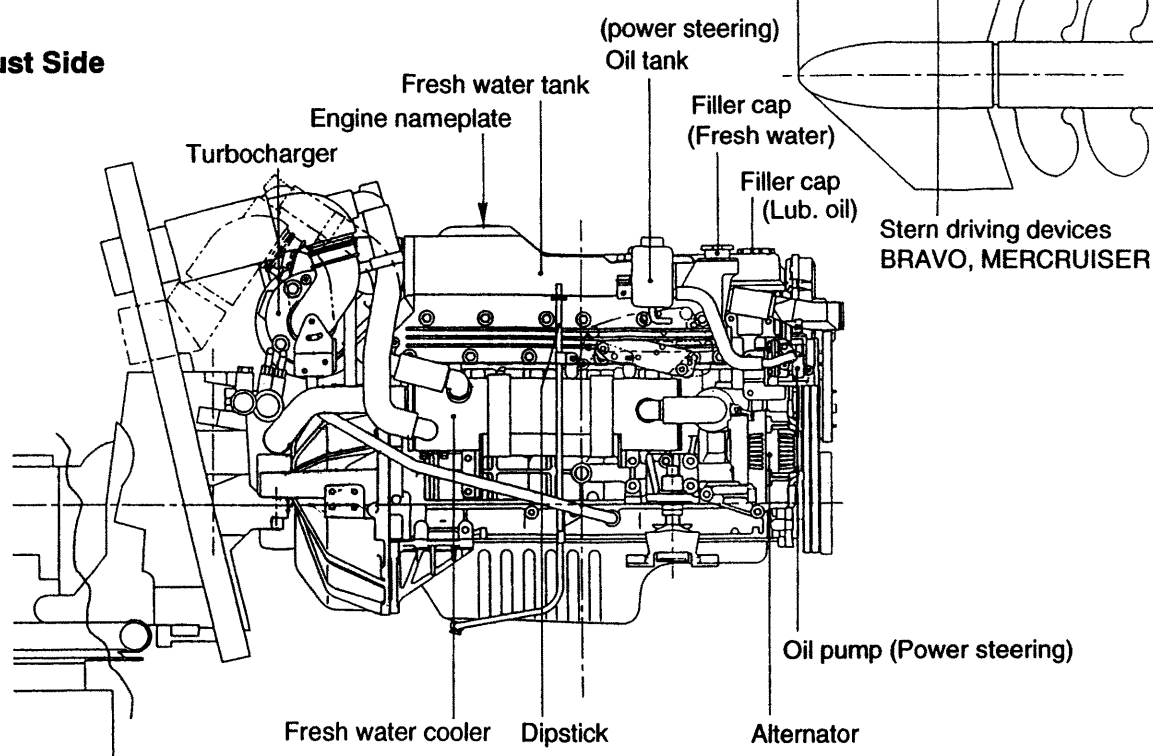
Note: 6LP-DTE has almost same external shape as 6LP-STE but it does not include a lube oil cooler(2).
(* mark) The above illustrations show the 6LP-STE attaching the HURTH marine gear.
The external shape of the 6LPA-DTP/-STP is identical with that of 6LP-DTE/-STE.

• 6LP-DTZE/-DTZE1/-STZE/-STZE1, 6LPA-DTZP/STZP

F.I. Pump Side



Exhaust Side



Note: The 6LP-STZE engine (stern driving device : BRAVO, MERCURISER) is used as the example for the above drawings.

※ (A) (indicated) oil cooler (2) is for the 6LP-STZE/-STZE1, 6LPA-STZP engines.

6LP-DTZE/-DTZE1, 6LPA-DTZP engines do not have one.

※ (B) (indicated) power steering oil pump, oil tank, oil cooler are parts for 6LP-DTZE/-STZE, 6LPA-DTZP/-STZP engines.

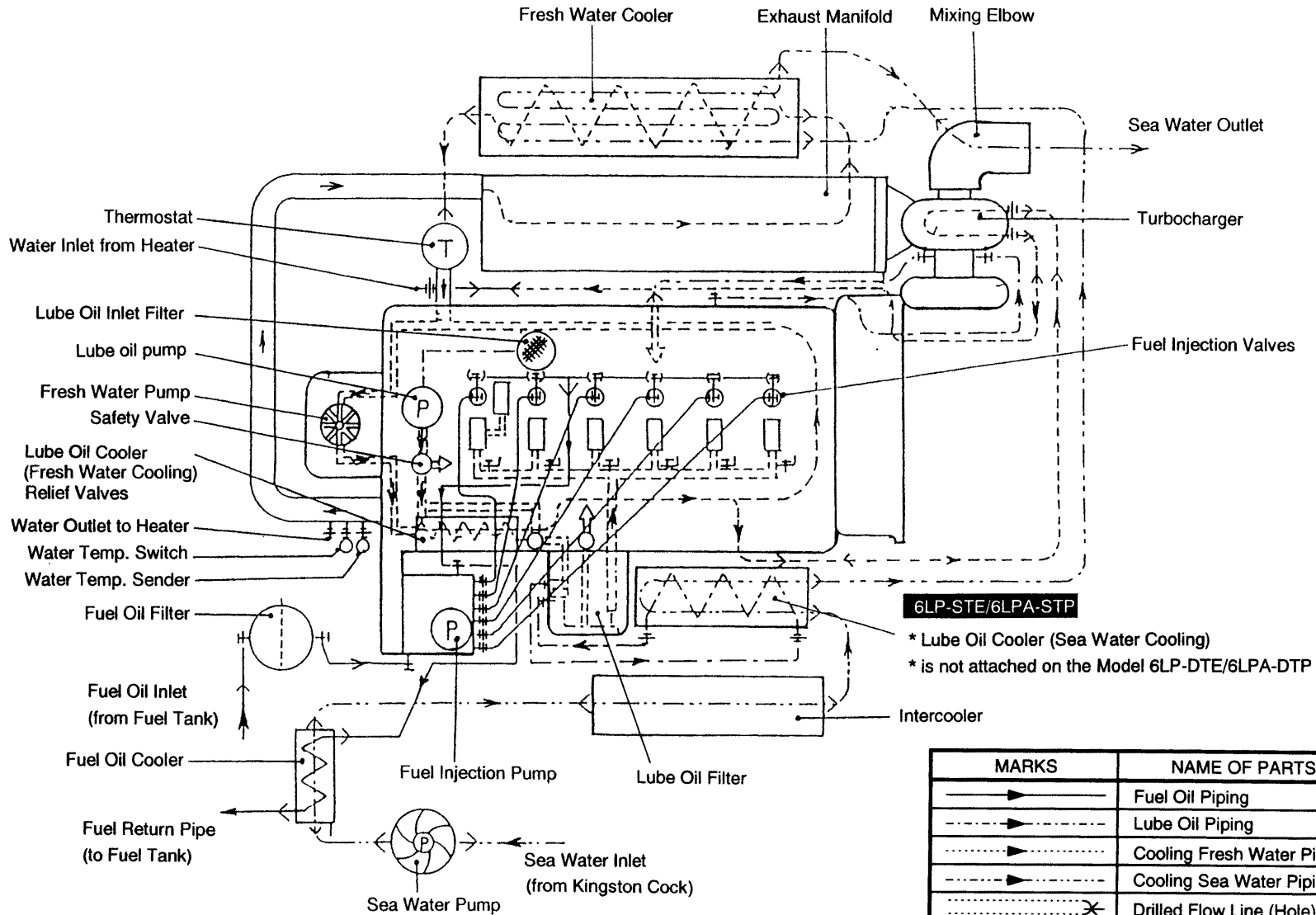
6LP-DTZE1/-STZE1 engines do not have these.

6LP-DTZE and 6LP-STZE are the same outline as 6LPA-DTZP and 6LPA-STZP respectively.

6LP-DTZE1/-STZE1 are the name designated by the engine manufacturer to identify the less power steering engine. (6LP-DTZE, 6LP-STZE in the nameplate)

2.3 Piping Diagram

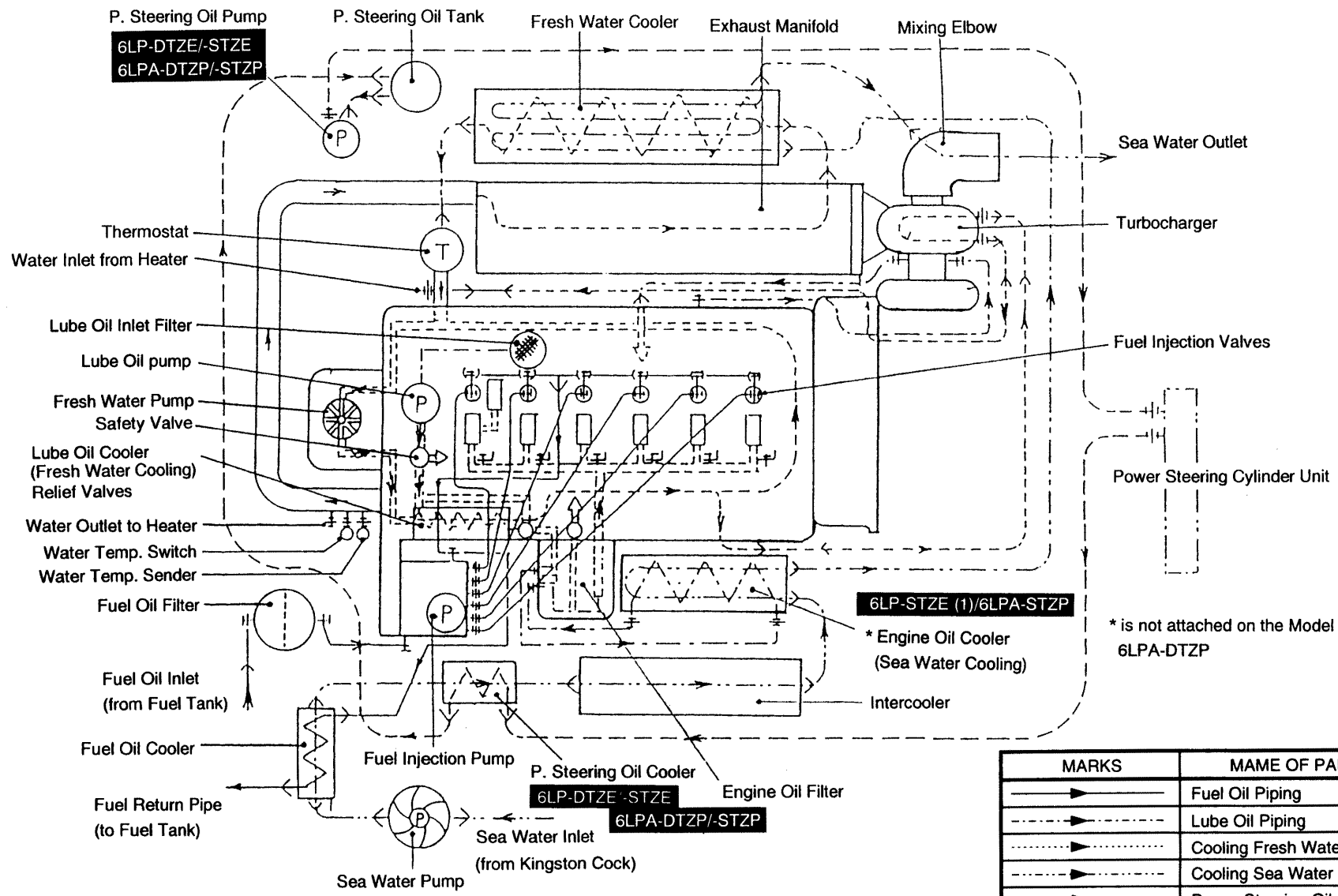
• 6LP-DTE/-STE, 6LPA-DTP/-STP



6LP-STE/6LPA-STP
 * Lube Oil Cooler (Sea Water Cooling)
 * is not attached on the Model 6LP-DTE/6LPA-DTP

MARKS	NAME OF PARTS
—▶—	Fuel Oil Piping
- - -▶-	Lube Oil Piping
⋯▶⋯	Cooling Fresh Water Piping
- · - ·▶	Cooling Sea Water Piping
⋯▶⋯ X	Drilled Flow Line (Hole)
→←	Inserted Pipe Coupling
┴	Eye type Pipe Coupling
	Screwed type Pipe Coupling
	Flanged type Pipe Coupling

• 6LP-DTZE/-DTZE1/-STZE/-STZE1, 6LPA-DTZE/-STZE

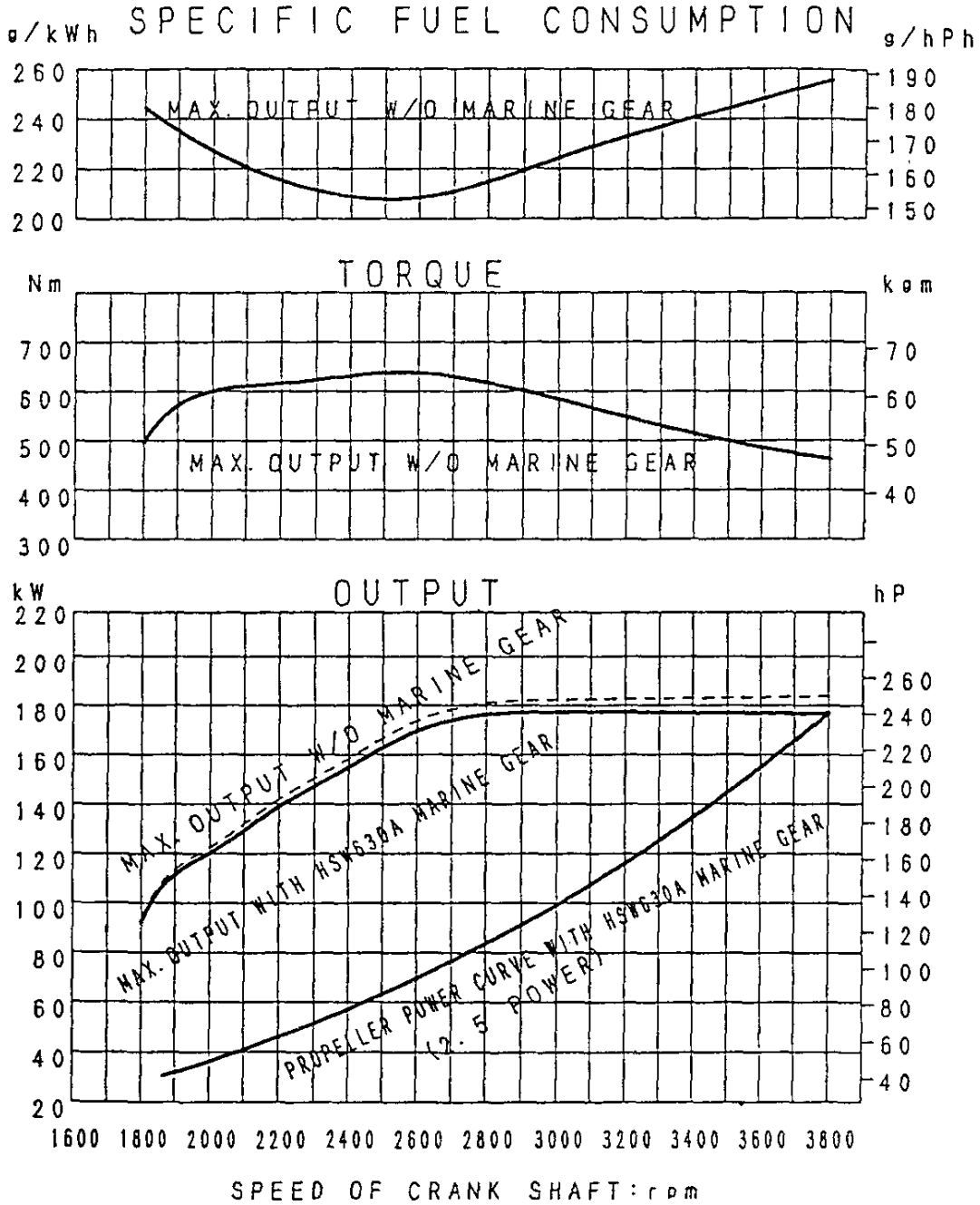


* is not attached on the Model 6LP-DTZE, 6LPA-DTZE

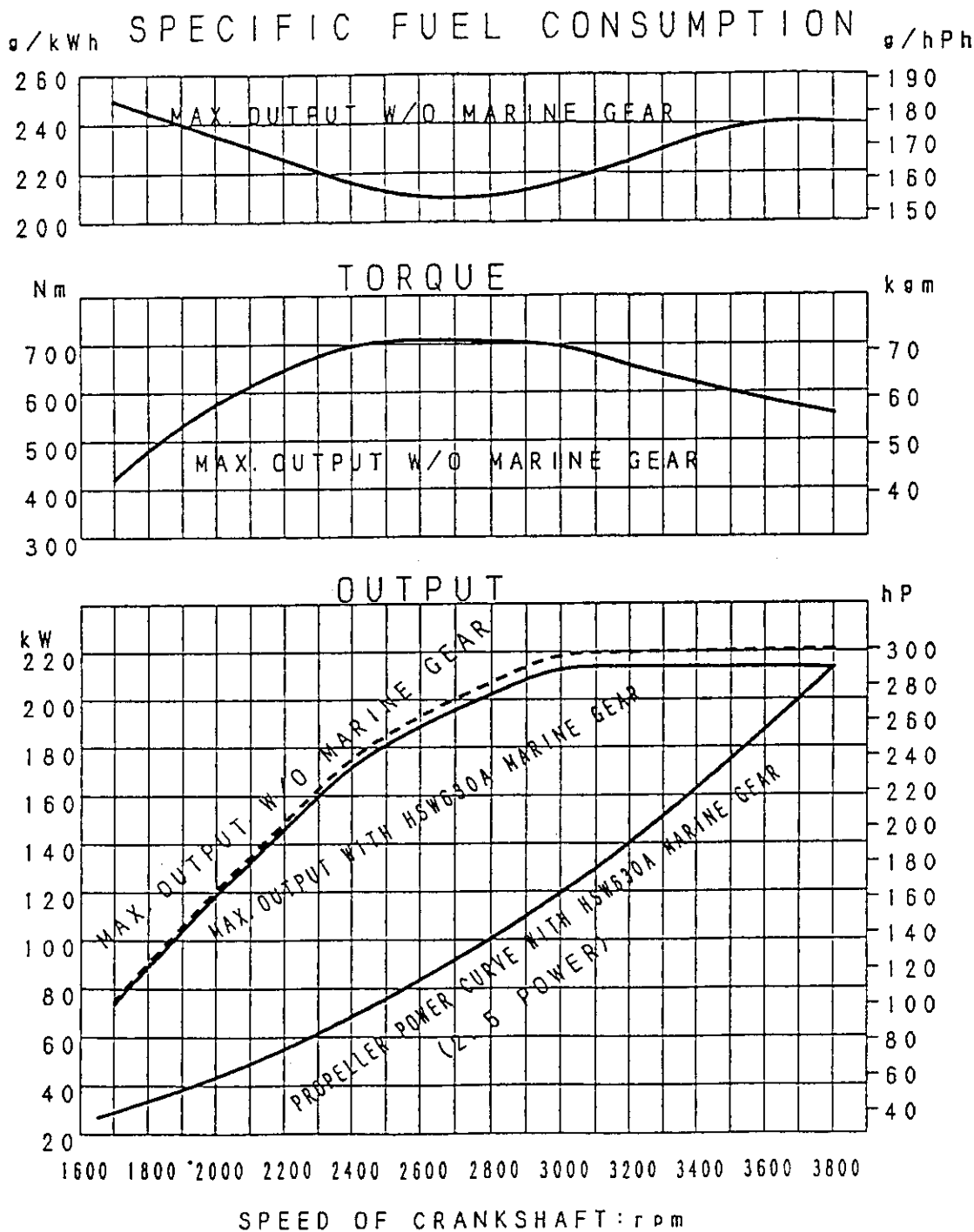
MARKS	MAME OF PARTS
—▶—	Fuel Oil Piping
- - -▶-	Lube Oil Piping
.....▶.....	Cooling Fresh Water Piping
- - -▶-	Cooling Sea Water Piping
- - -▶-	Power Steering Oil Piping
.....✕.....	Drilled Flow Line (Hole)
▶—←	Inserted Pipe Coupling
┌—┐	Eye type Pipe Coupling
┌—┐	Screwed type Pipe Coupling
┌—┐	Flanged type Pipe Coupling

2.4 Performance Curves

- 6LP-DT(Z)E/-DTZE1 (Max. output : 184 kW/3800 rpm)

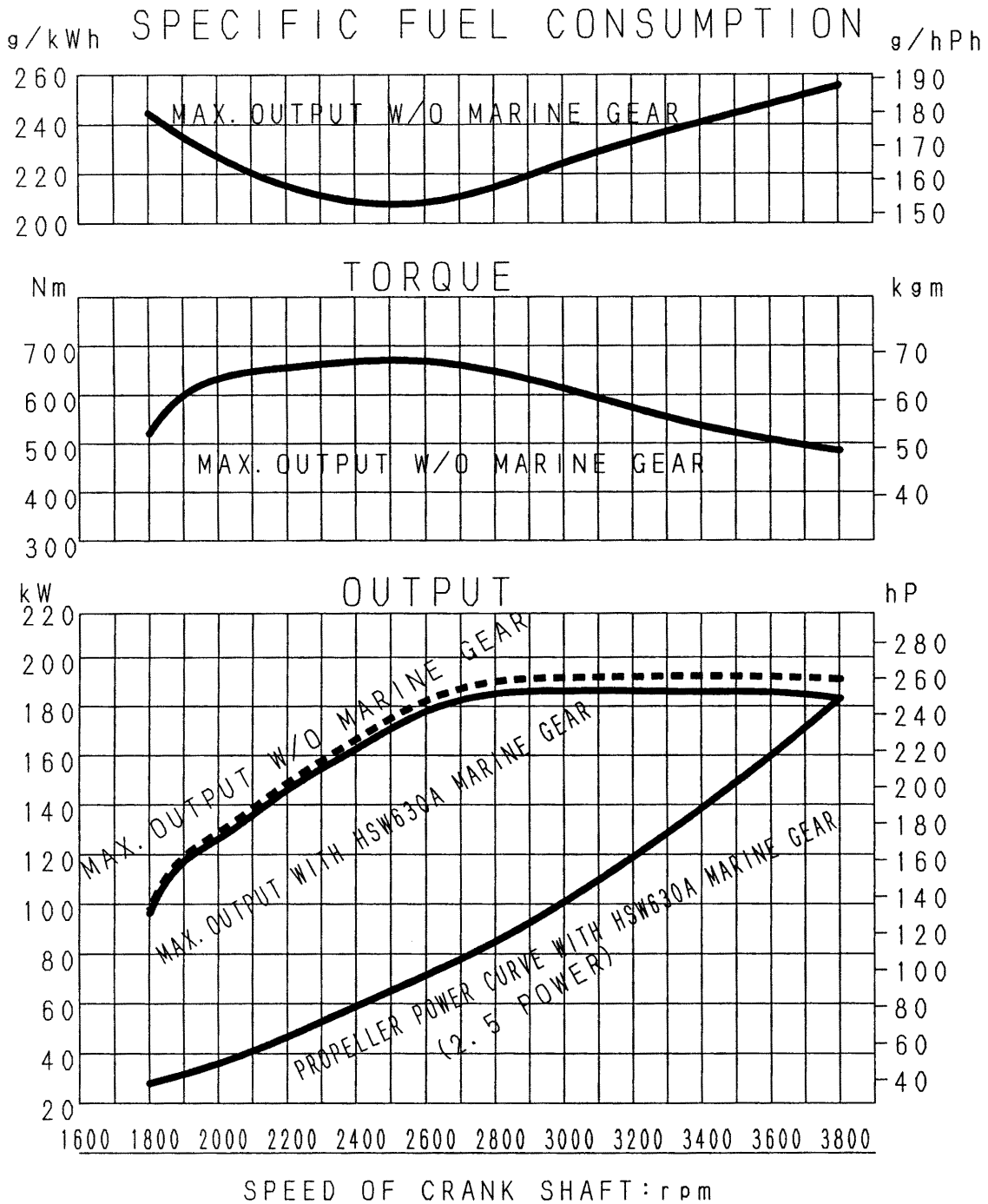


- 6LP-ST(Z)E/-STZE1 (Max. output : 221 kW/3800 rpm)

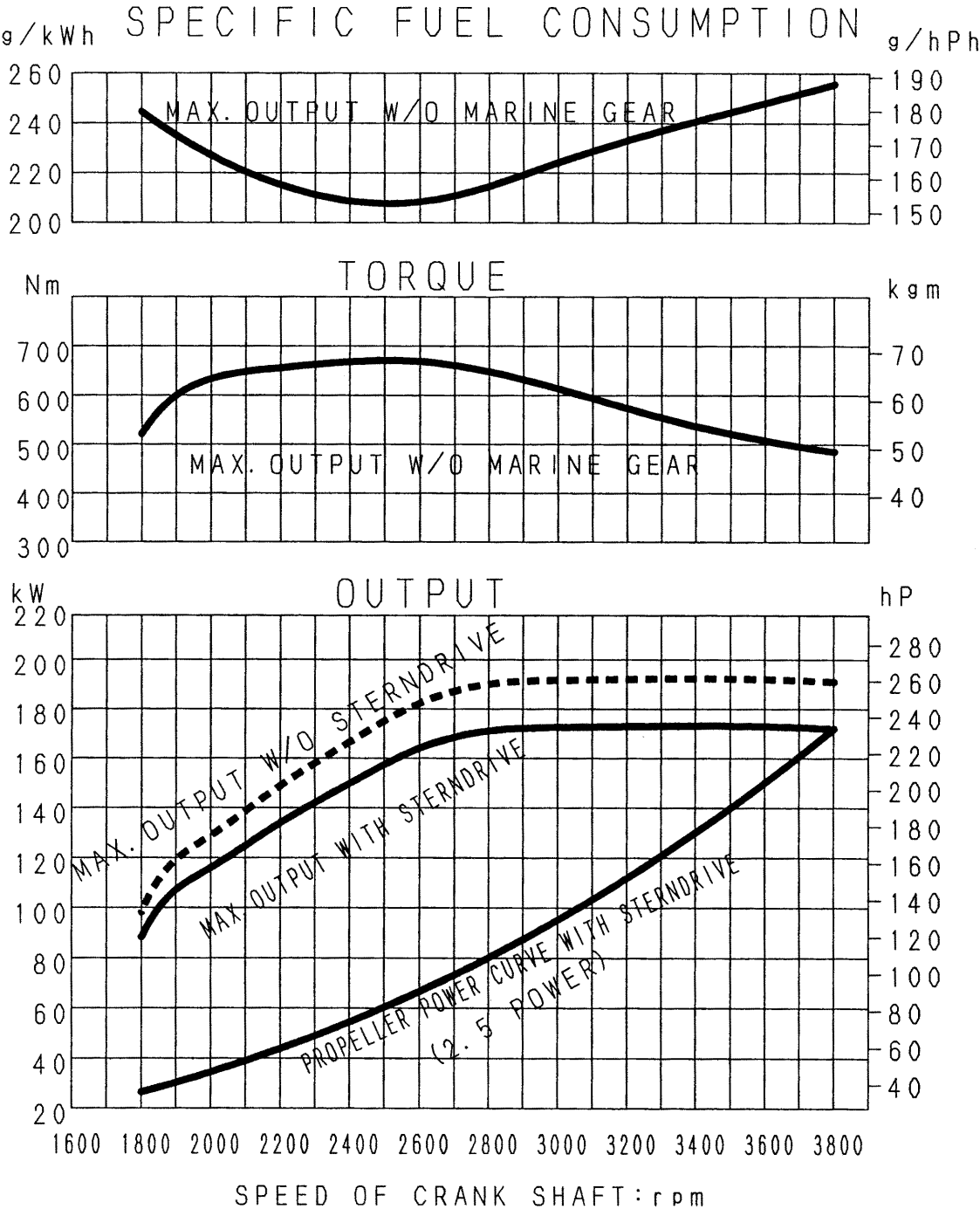


2. General

- 6LPA-DTP (Fuel stop power : 191 kW/3800 rpm)

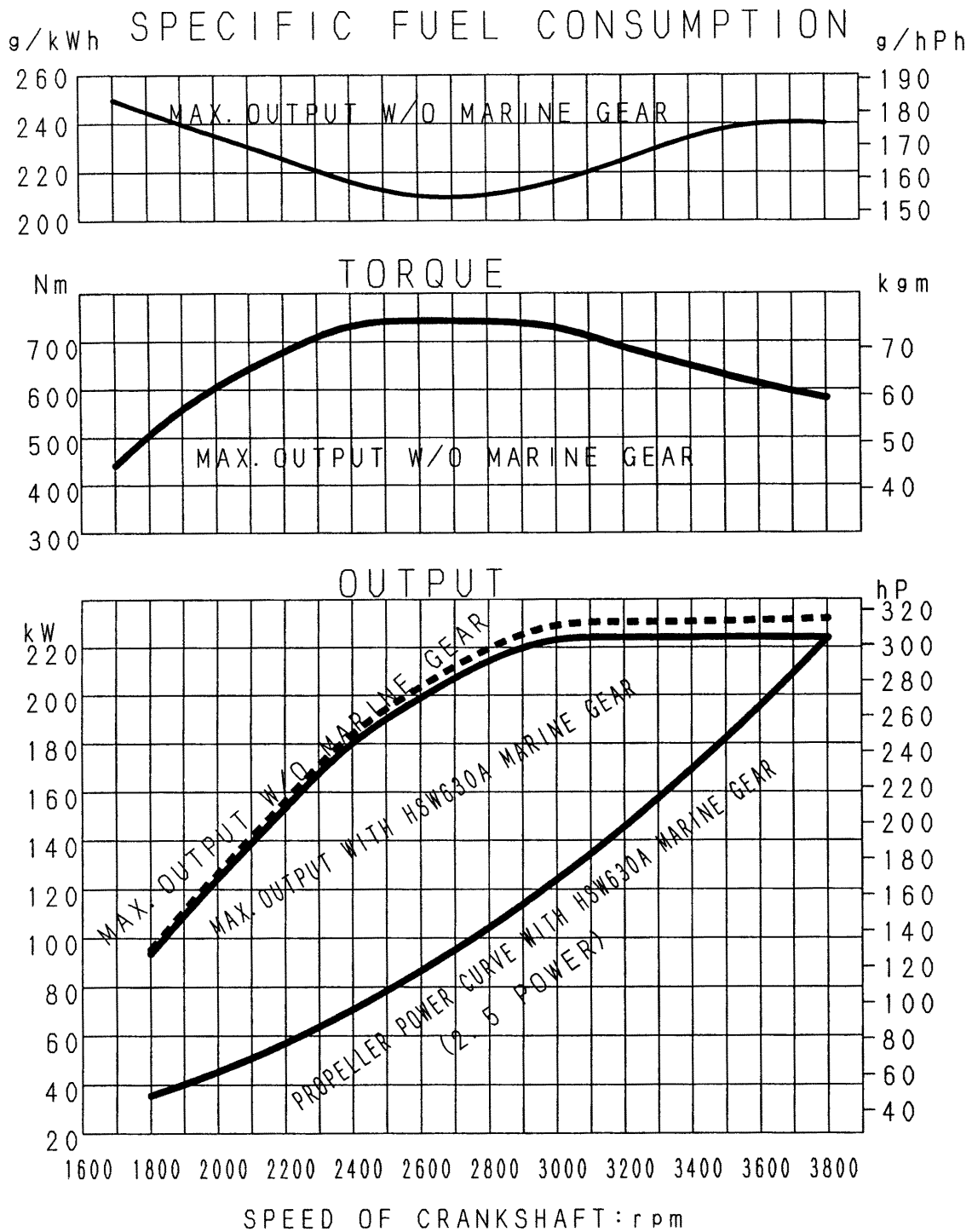


• 6LPA-DTZP (Fuel stop power : 191 kW/3800 rpm)

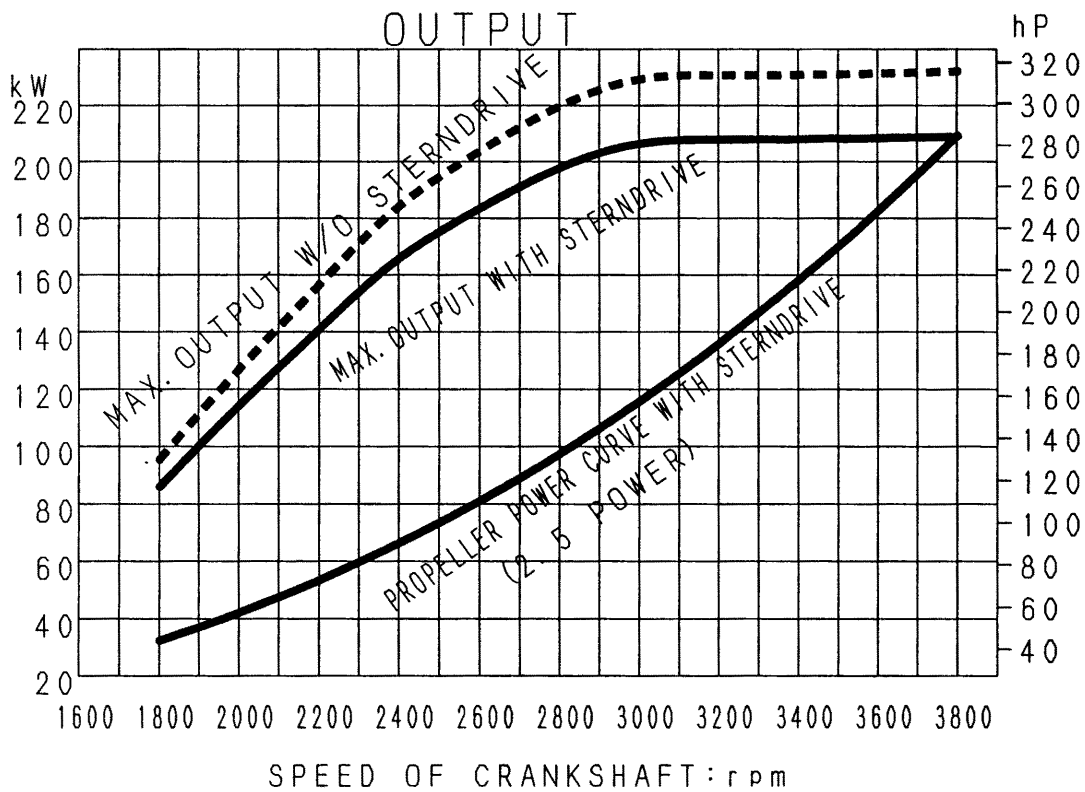
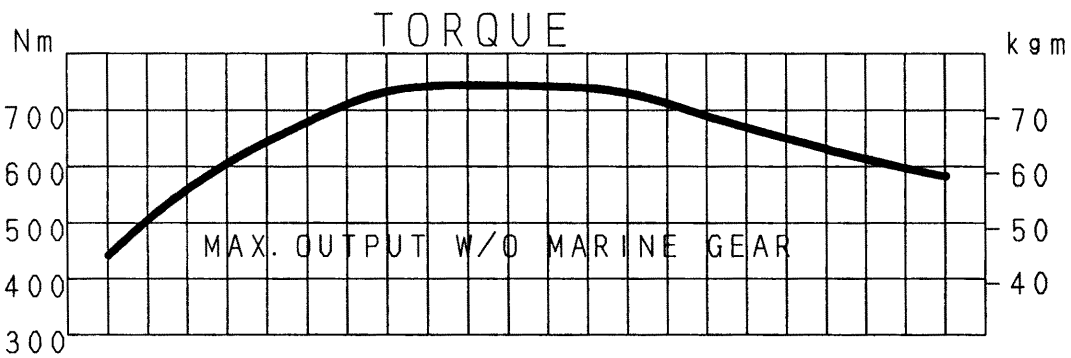
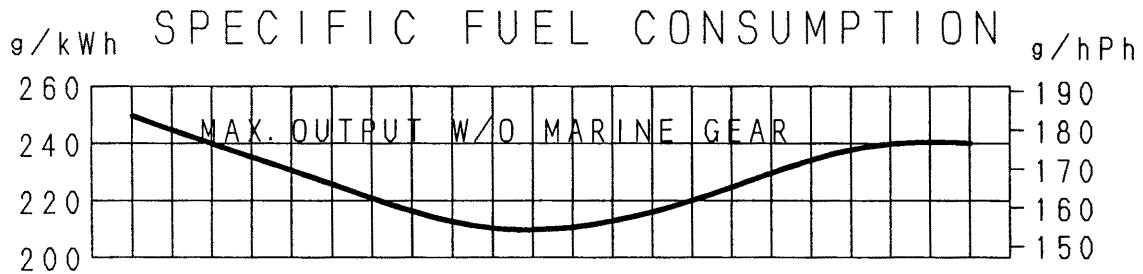


2. General

- 6LPA-STP (Fuel stop power : 232 kW/3800 rpm)

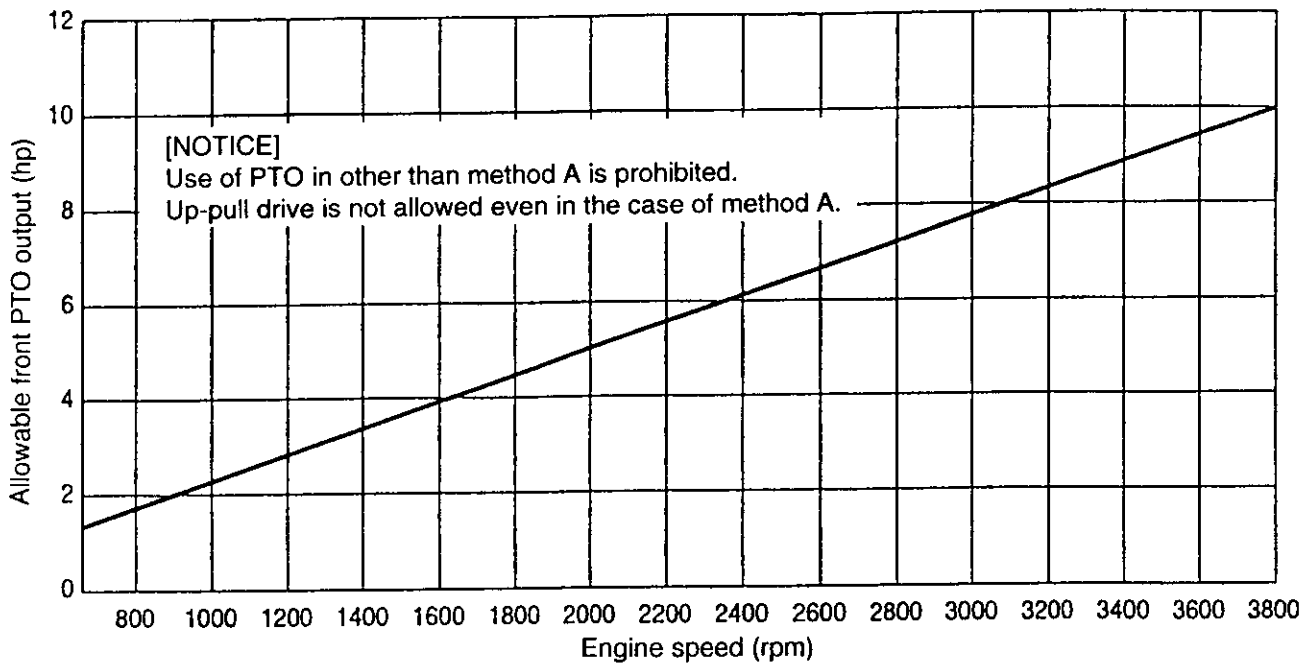


• 6LPA-STZP (Fuel stop power : 232 kW/3800 rpm)



2.5 Front Power Take-Off (PTO) Output

- Front PTO diagram

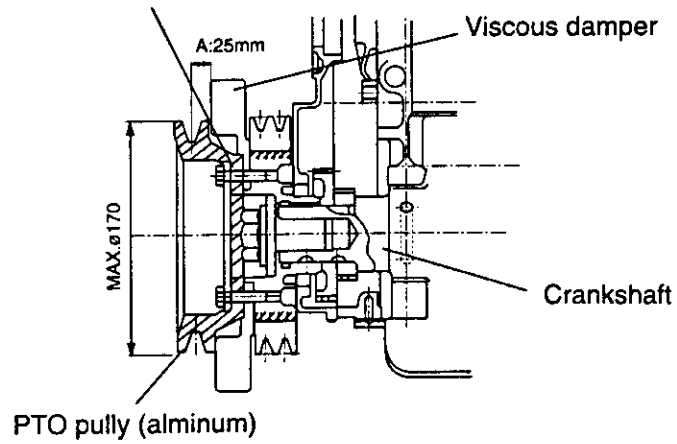


[Method for Front PTO]

- (1) Use type A (Belt drive with no outside bearing). Do not use other types of PTO.
- (2) Do not employ the up-pull drive. Use the side pull belt drive.
- (3) Use a single V-drive, type A.
- (4) The PTO pulley should be aluminum. The outside diameter should be max. $\phi 170$ mm and the overhang within 25 mm.
- (5) Install the pulley to the exterior of the viscous damper and tighten the pulley and damper with the damper fixing bolts (M8 \times 6 pcs.) and the washers.
(Tightening torque: 3.8 ± 0.2 kg-m (37.27 ± 1.96 N·m))

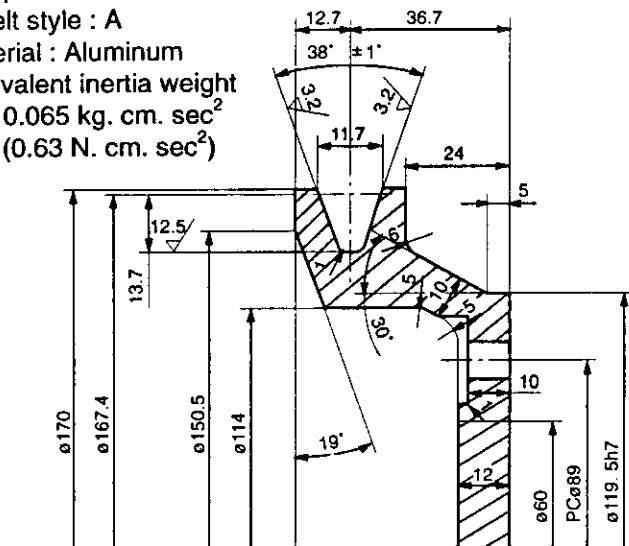
Please note that the crankshaft may break if the front PTO output exceeds the allowable output.

The pulley thickness should be 10 mm.



V-pulley overhang

A-Type
 V-Belt style : A
 Material : Aluminum
 Equivalent inertia weight
 : 0.065 kg. cm. sec²
 (0.63 N. cm. sec²)



V-pulley drawing

2.6 Fuel Oil

(1) Selection of Fuel Oil

Use the following diesel fuels and select fuels of a higher quality for best engine performance.

[Diesel fuel standard for various countries]

- ISO 8217 DMA
- JIS K2204 Grade No.2, No.3 or special-No.3
- BS 2869 Part-1 class-A1 or A2

At low temperatures, fuel oil becomes difficult to ignite and will not flow easily, making starting difficult. Select fuel oil of a cetane number of 45 or greater to insure ignitability, and use the outside temperature as a guide for selecting the proper grade to insure fluidity.

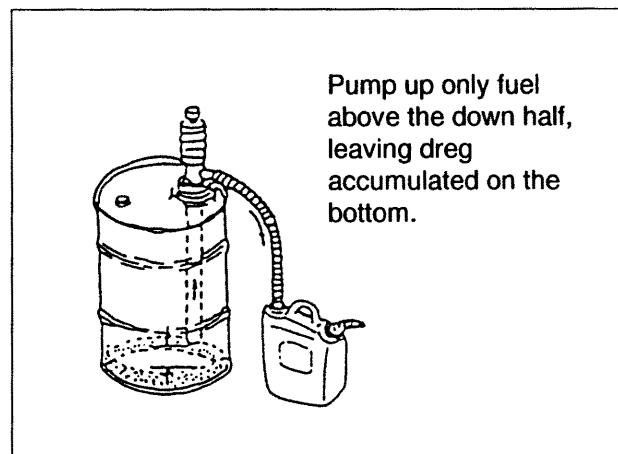
[NOTICE]

When other than the specified fuel oil is used, the engine will not perform to full capacity and parts may be damaged.

Sample for recommended fuel oil	
Standard for fuel oil	JIS K2204
Pour point (Temperature)	
-7.5°C or greater	Grade No.2
-20°C or greater	Grade No.3
-30°C or greater	Grade No.3-Sp.
Cetane fuel number	45 or greater

(2) Handling of Fuel Oil

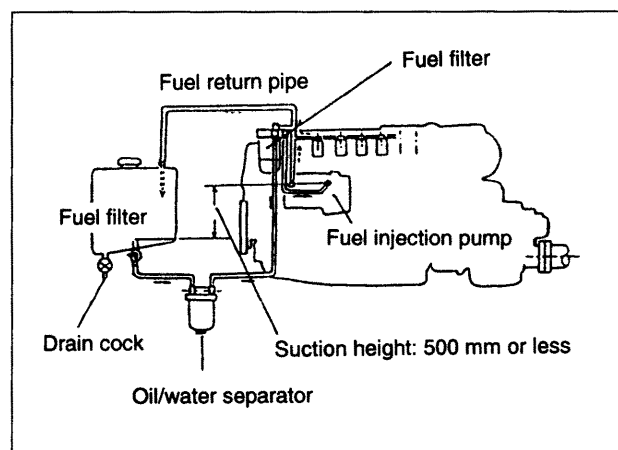
- Keep the fuel oil in a clean container. Store the container in a place away from rain and dirt as water and dust mixed in with the fuel cause engine failure.
- Keep the fuel container stationary for several hours to allow any dirt or water to settle to the bottom. Use a pump to extract the clear, filtered fuel from the top of the container for use.



(3) Fuel Piping

Install the fuel pipe from the fuel tank to the fuel pump in accordance with the diagram to the right. Be sure to attach a drain cock to the fuel tank to enable dirt and water which have settled at the bottom of the tank to be drained off.

The oil/water separator (optional) is placed at the center section of the line.



2.7 Lube Oil

(1) Selection of Engine Lube Oil

Use the following lube oil:

- *API Classification CD
(Standards of America Petroleum Institute)
- *SAE Viscosity 15W40
(Standards of Society of Automotive Engineering)

[NOTICE]

Using other than the specified lube oil will lead to seizure of parts inside the engine and gear device, abnormal wear, and shorten engine life. It will also affect the starting ability and power output.

(2) Selection of Marine Drive Oil

Refer to the operation manual for the marine drive unit for the selection of the proper lube oil.

- For **MERCUISER's** stern-driven (**BRAVO**) use the following lube oil.

6LP-DTZE (1)

6LP-STZE (1)

6LPA-DTZP

6LPA-STZP

System Oil	Specified lube oil
Drive oil	Quicksilver High Performance Gear Lube
Power steering oil ※	Quicksilver Power Trim and Steering Fluid or Dexlone- II
Power trim oil	Quicksilver Power Trim and Steering Fluid or SAE 10W-30 or 10W-40 engine oil

※ for 6LP-DTZE/-STZE, 6LPA-DTZP/-STZP

(3) Handling the Lube Oil

- When handling and storing lube oil, be careful not to allow dust and water to enter the lube oil. Clean around the filter post before refilling.
- Do not mix lube oils of different types or brands. Mixing may reduce the lubricating performance. Different oils are used for the engine and the marine drive unit. Be careful to use the correct oil for each one and store in separate clearly labeled containers.

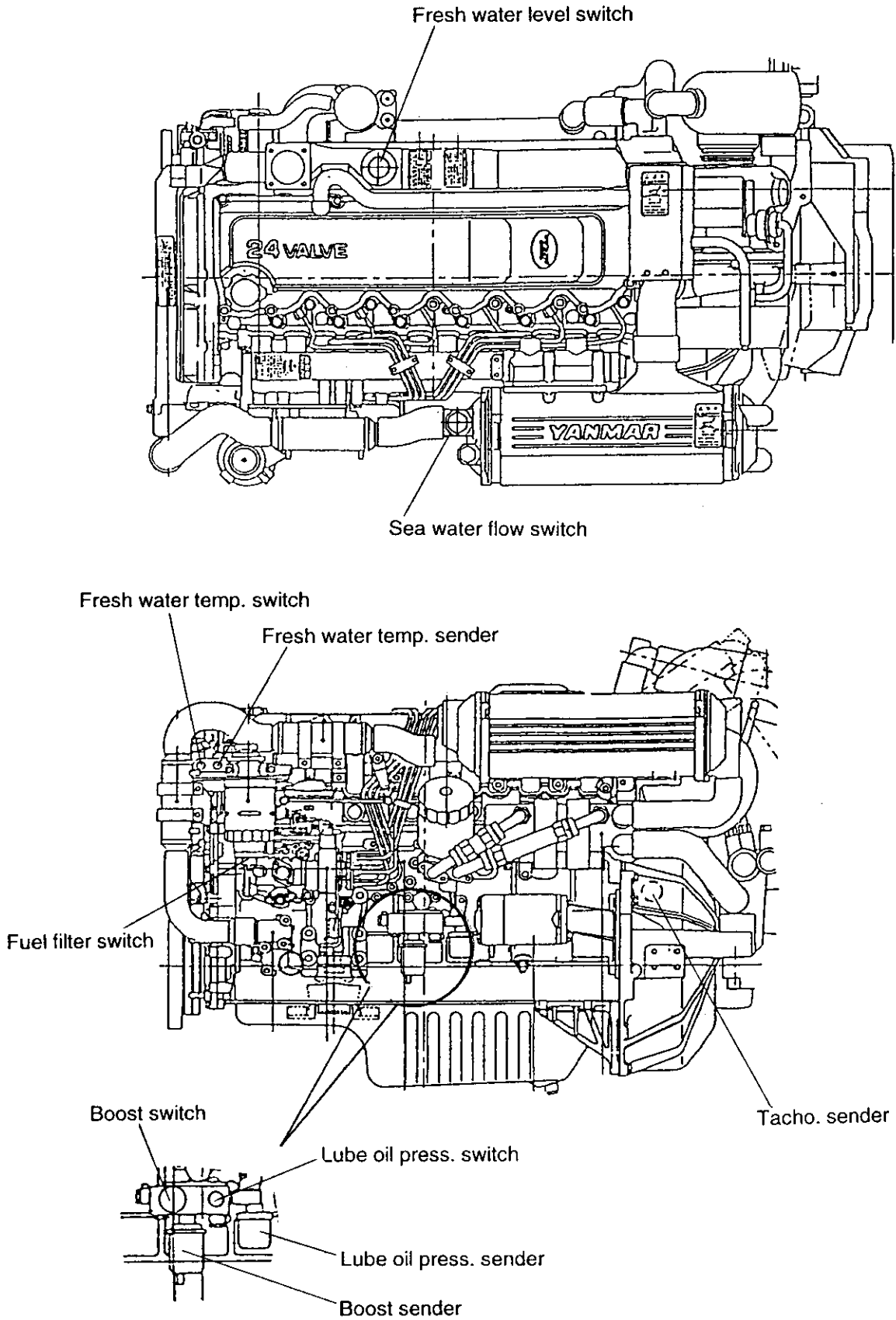
2.8 Cooling Water

- Always use soft water (tap water) for the fresh water. Never use dirty water or hard water. Impurities in the cooling water cause scale and rust to build up in the cooling system reducing cooling efficiency and causing the engine to overheat.
- During the cold season, add antifreeze to the cooling water to prevent freezing. Failure to add antifreeze will result in damage to various parts in the cooling water system.
- Consult your Yanmar dealer or distributor on the use of antifreeze, anti-rust, and detergents.

[NOTICE]

- **Refer to the instructions accompanying the antifreeze for the proper mixing ratio. Select the ratio for the lowest temperature of the cold season. If the mixture is too thick, the cooling efficiency will be reduced.**
- **Do not mix different brands of antifreeze or anti-rust. Mixing reduces cooling efficiency and leads to parts damage.**
- **When the amount of cooling water is too low, refill with fresh water only.**

2.9 Location of Senders and Warning Switches



3. Engine Overhaul

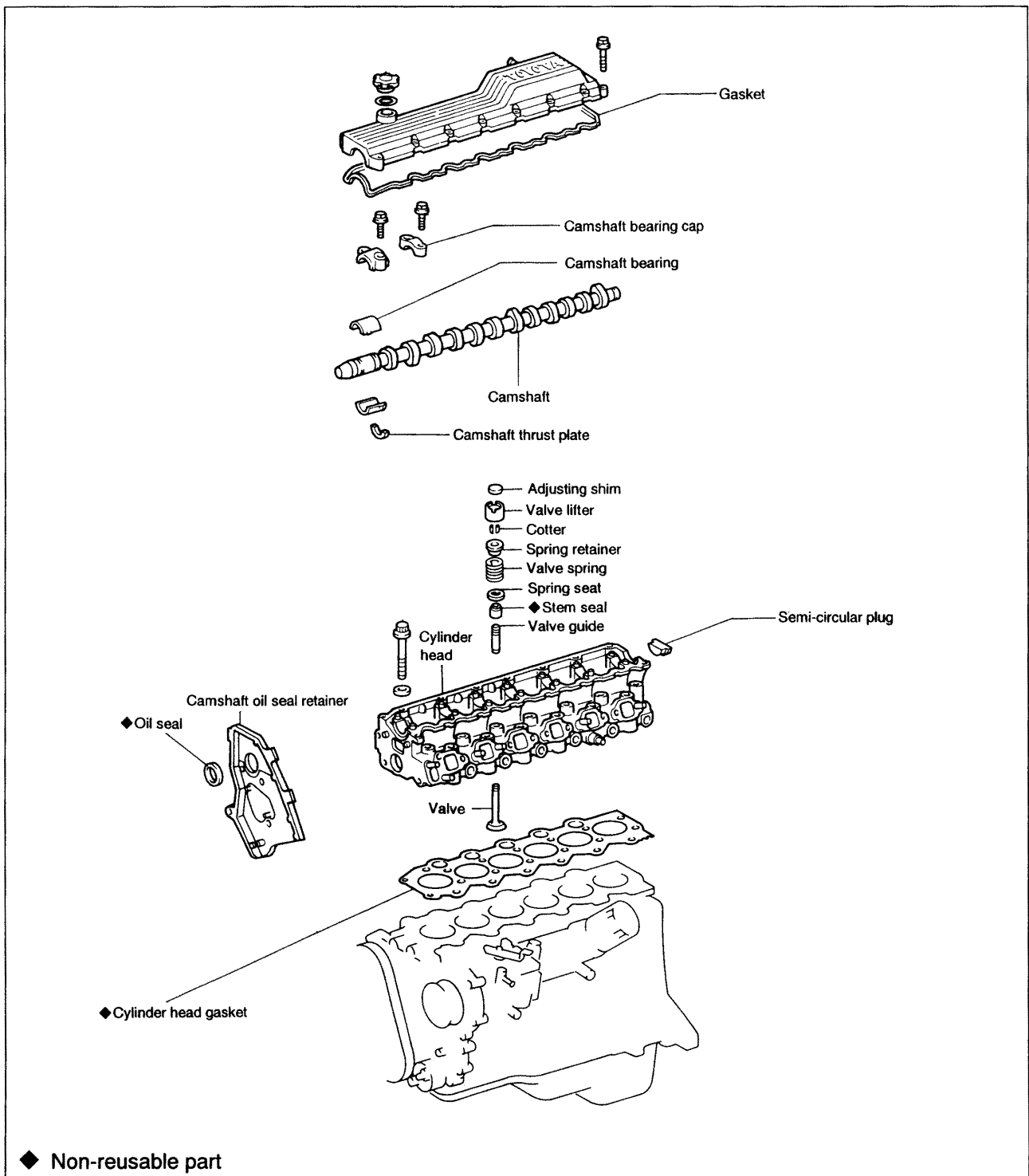
3.1 Cylinder Head

3.1.1 Components

[NOTICE]

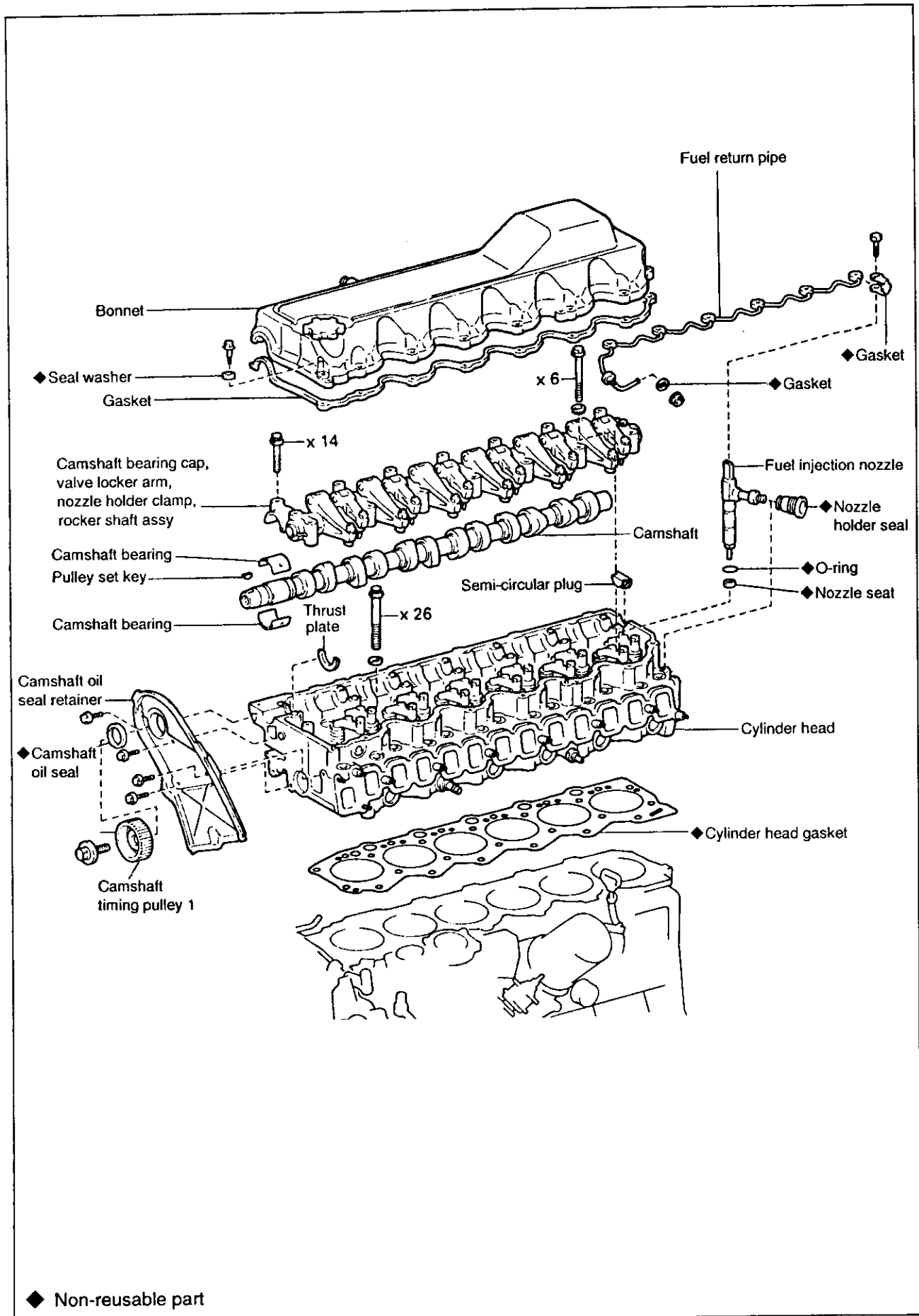
- *Cylinder numbers No.1, No.2 and on are allocated starting from the gear case side.*
- *Avoid placing the engine body directly on the floor. Otherwise, the oil pan may be bent.*
- *6LP-DTE series or 6LP-DTE series only includes 6LPA-DTP series.*
- *6LP-STE series or 6LP-STE series only includes 6LPA-STP series in this descriptions.*

(1) 6LP-DTE series



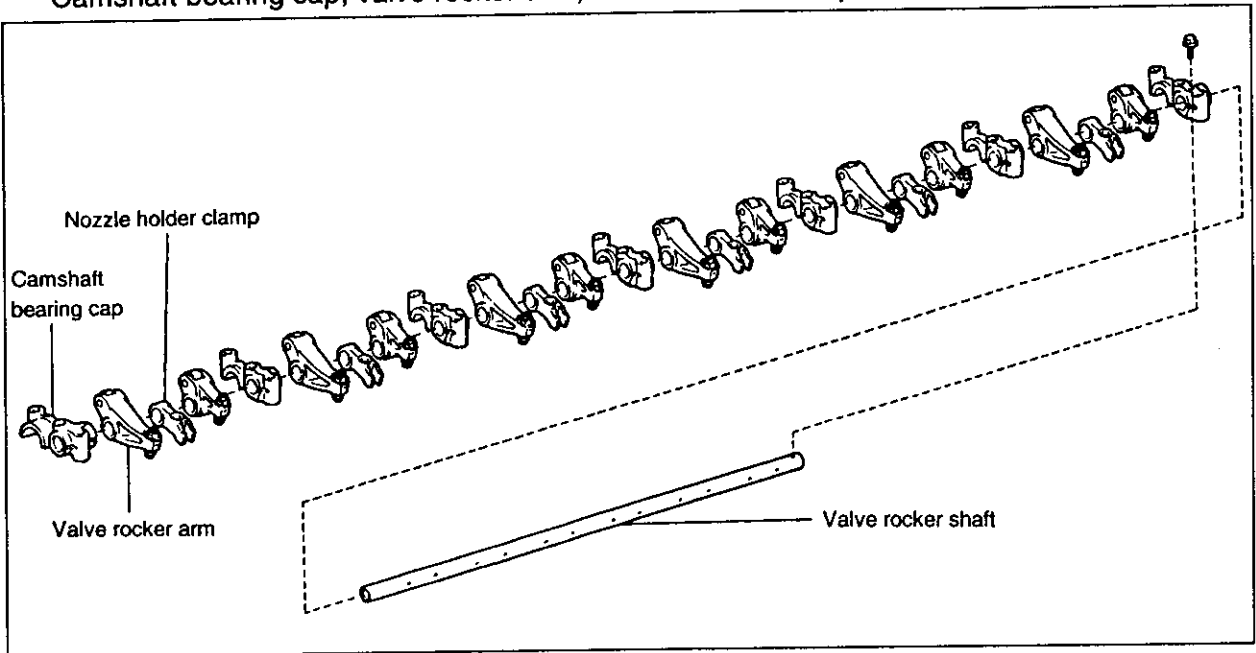
3. Engine Overhaul

(2) 6LP-STE series



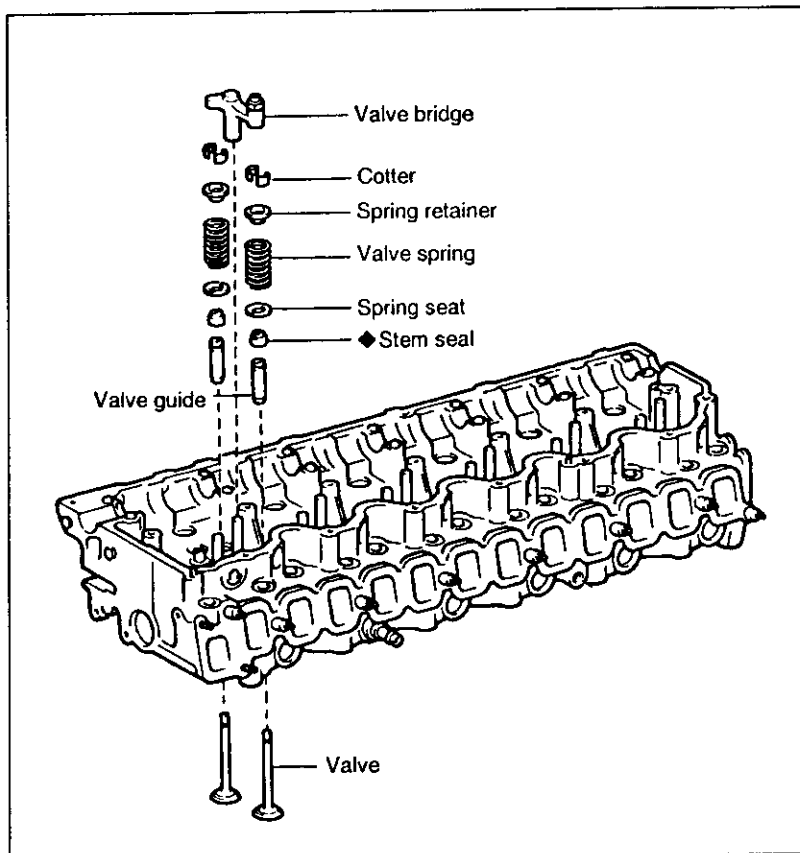
● 6LP-STE series

Camshaft bearing cap, valve rocker arm, nozzle holder clamp and rocker shaft assy



● 6LP-STE series

Cylinder head assy



◆ Non-reusable part

3. Engine Overhaul

3.1.2 Removal of Cylinder Head

3.1.2.1 Drain the engine cooling water

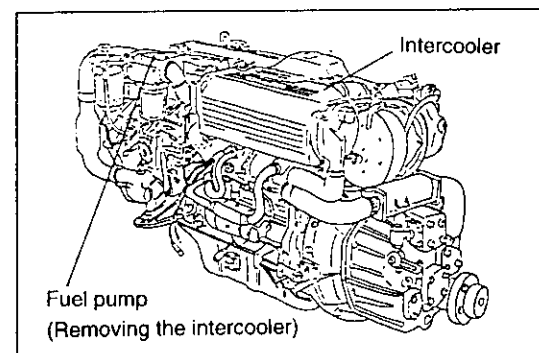
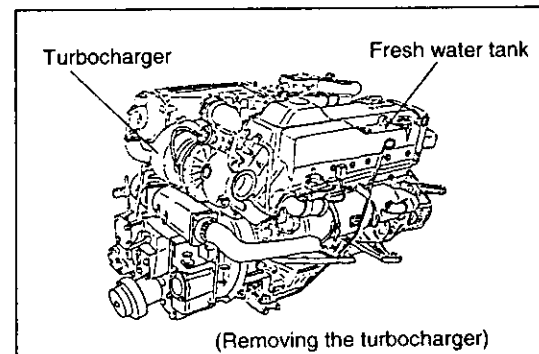
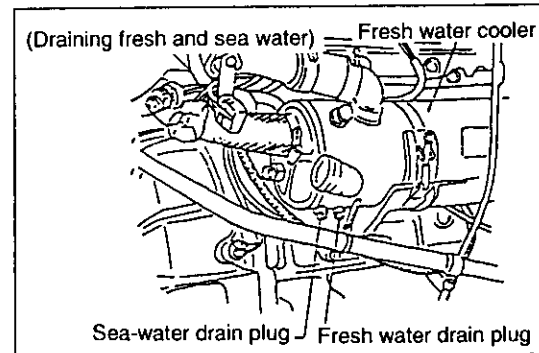
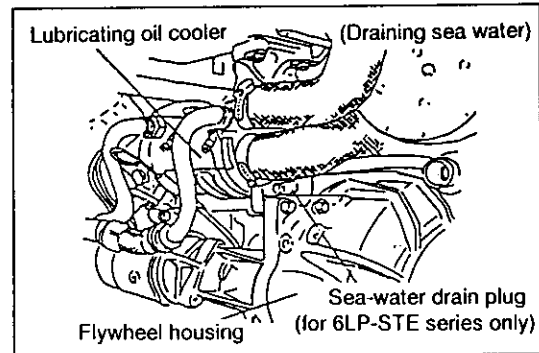
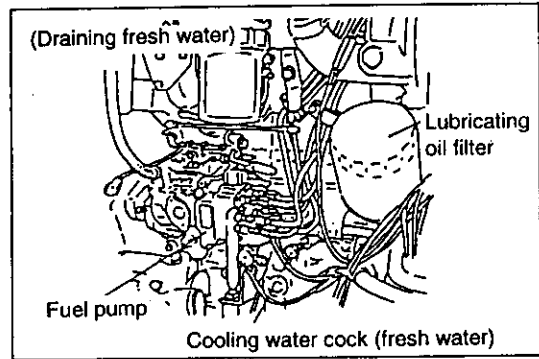
Make sure to drain cooling water from the fresh water and sea water systems.

- (1) Open the cooling water drain cock as shown and drain the cooling water.
- (2) After drain, close the drain cock.

Number of drain cocks

Model	Fresh water system	Sea water system
6LP-DTE series	2	1
6LP-STE series	2	2

- ★ Drain the engine oil.
Remove the joint bolt under the oil pan to drain the oil. At the same time, remove the oil dipstick.



3.1.2.2 Remove the turbocharger

3.1.2.3 Remove the fresh water tank

3.1.2.4 Remove the fuel filter

3.1.2.5 Remove the intake manifold and intercooler

3.1.2.6 Remove the fuel injection pipe and fuel injection nozzle (For 6LP-DTE series) (See 3.10.2 Removal of Fuel Injection nozzle)

3.1.2.7 Remove the bonnet

Remove 12 bolts and 12 seal washers, and then the bonnet and gasket.

3.1.2.8 Remove the semi-circular plug
(See the component illustration.)**3.1.2.9 Remove the timing belt and pulley**
(See 3.3.2 of Removal of Timing Belt.)**3.1.2.10 Remove the camshaft oil seal retainer**

- (1) Remove 4 bolts.
- (2) Pry out the oil seal retainer to remove.

3.1.2.11 Remove the fuel injection nozzle
(6LP-STE series)
(See 3.10.2 of Removal of Fuel Injection nozzle)**3.1.2.12 Remove the camshaft**
(6LP-STE series)

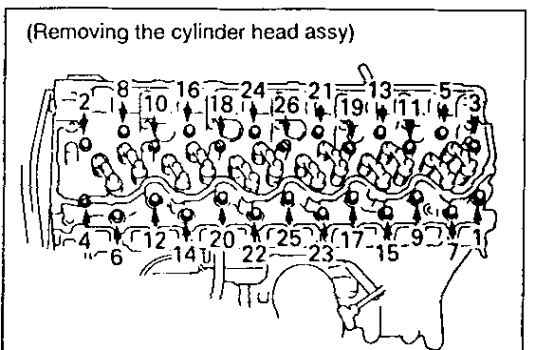
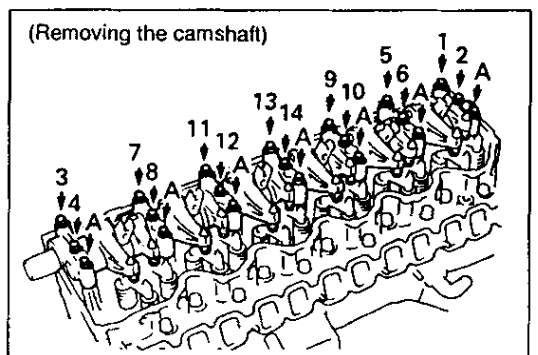
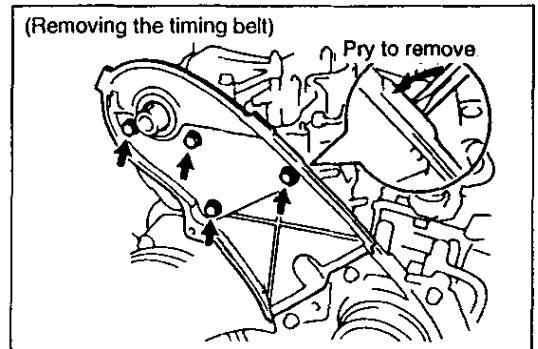
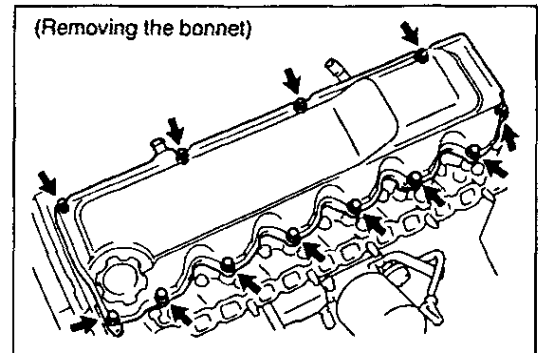
- (1) Remove 7 bolts (A).
- (2) Loosen other 14 bolts uniformly at several passes in the sequence shown in the illustration to remove them.
- (3) Remove 7 bearing caps, 12 rocker arms, 6 holder clamps, rocker shaft assy and 7 upper camshaft bearings.
 - Keep the bearing caps, rocker arms and nozzle holder clamps installed with the rocker shaft.
 - Keep the bearings as they are inserted in the bearing caps.
- (4) Remove the camshaft, thrust plate and 7 lower camshaft bearings.
 - Keep the bearings in an orderly manner so that they will be reassembled in the original positions.

3.1.2.13 Remove the cylinder head assy

- (1) Loosen 26 bolts uniformly at several passes in the sequence shown in the illustration to remove them.

[NOTICE]

If bolts are removed at random, the head may be warped or cracked.



3. Engine Overhaul

- (2) Lift the cylinder head from the cylinder block and put the head on a wooden block or bench.
 - If the cylinder head is too tight to lift, pry the head by inserting a screwdriver between the head and block.

[NOTICE]

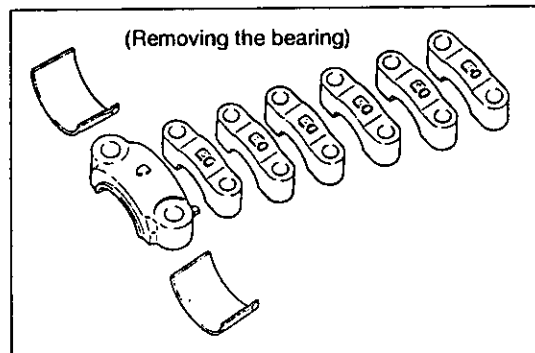
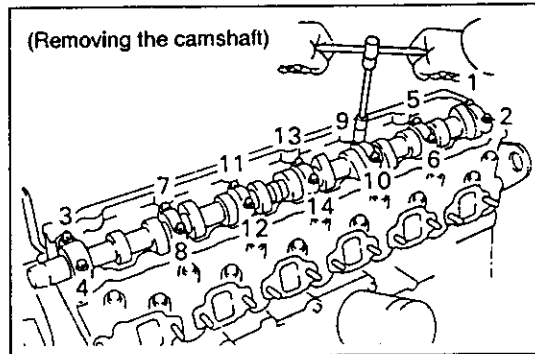
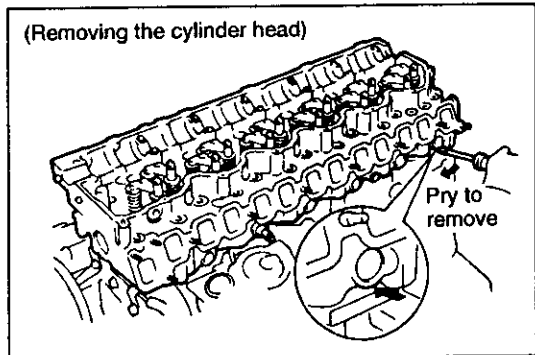
Pay attention so as not to damage the contact surfaces of the cylinder head and the cylinder block.

[6LP-DTE series]

- (1) Loosen 14 bearing cap bolts uniformly at several times in the order shown in the illustration to remove them.
- (2) Remove 7 bearing caps and the camshaft.
- (3) Remove 2 bearings from the No.1 bearing cap and No.1 journal of the cylinder head.
- (4) Remove the camshaft thrust plate.

[NOTICE]

Keep the bearings and bearing caps in the correct order so that they will be reassembled in the original positions.

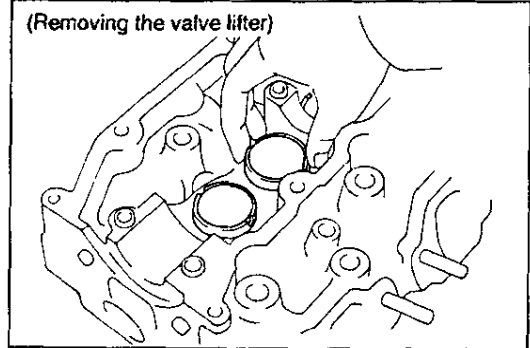


3.1.3 Disassembly of Cylinder Head

3.1.3.1 Remove the valve lifter and shim (6LP-DTE series only)

[NOTICE]

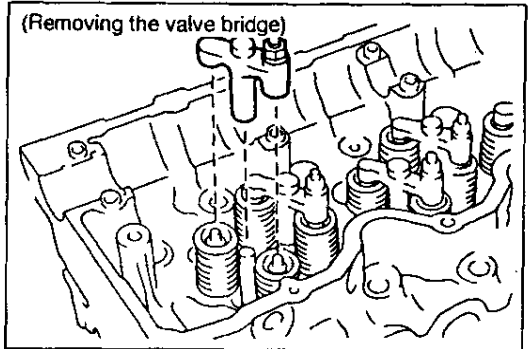
Keep the valve lifter and shim in the correct order so that they will be reassembled in the original positions.



3.1.3.2 Remove the valve bridge (6LP-STE series only)

[NOTICE]

Keep the valve bridges in the correct order and correct directions, identifying by the cylinder numbers and intake/exhaust sides.

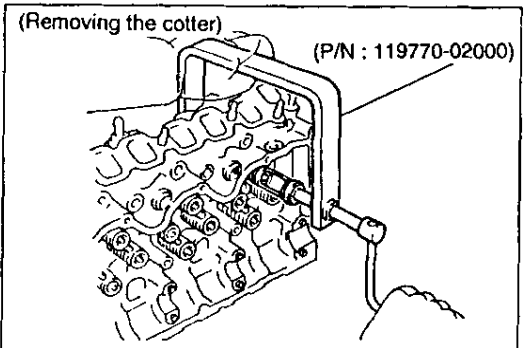


3.1.3.3 Remove the intake and exhaust valves

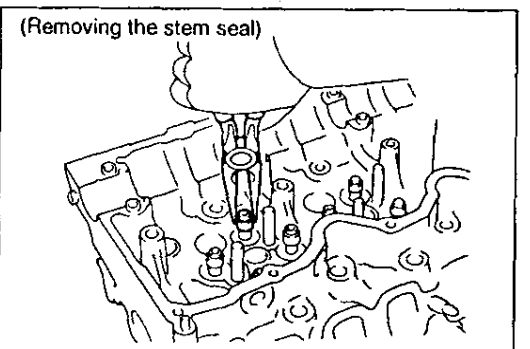
- (1) Compress the valve spring and remove 2 cotters.
- (2) Remove the spring retainer, valve spring, valve, and spring seat.

[NOTICE]

Keep the valve, valve spring, spring seat and spring retainer in the correct order so that they will be reassembled in the original positions.



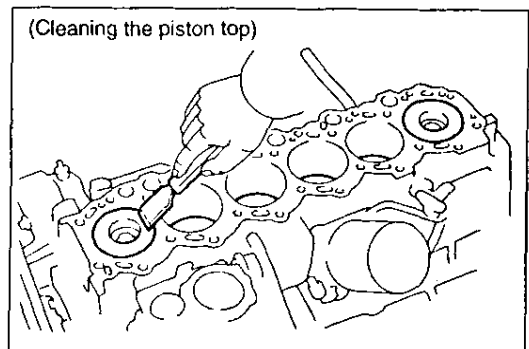
- (3) Remove the stem seal using nose pliers.



3.1.4 Inspection and Servicing of Cylinder Head Components

3.1.4.1 Clean the piston and cylinder block top surfaces

- (1) Turn the crankshaft to bring each piston to the top dead center. Remove carbon deposits completely from the piston top surface using a scraper.



3. Engine Overhaul

- (2) Completely remove the gasket materials remaining on the top surface of cylinder block.

[NOTICE]

Pay attention so as not to damage the cylinder block top surface.

- (3) Blow off carbon deposits and oil from the bolt holes using compressed air.

▲ WARNING

Wear protective goggles when using compressed air. Otherwise, your eyes may be contaminated by foreign matter.

3.1.4.2 Clean the cylinder head

- (1) **Remove the gasket materials**

Completely remove gasket materials remaining on the cylinder block contacting surface, using a scraper.

[NOTICE]

Pay attention so as not to damage the cylinder head surface.

- (2) **Clean the intake and exhaust valve seats**

Completely remove carbon deposits from the intake and exhaust valve seats, using a wire brush.

[NOTICE]

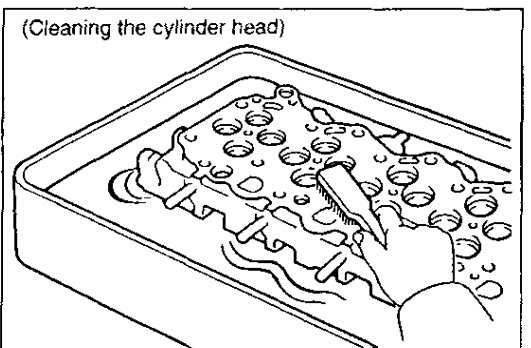
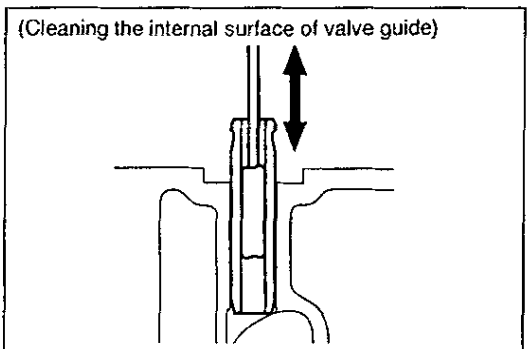
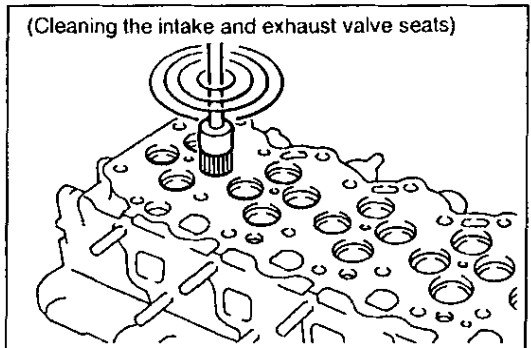
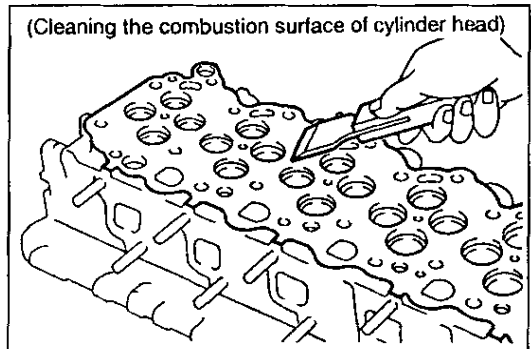
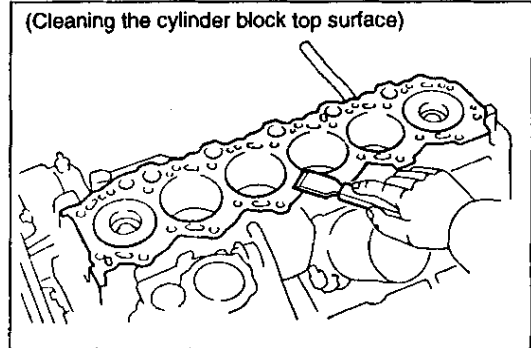
Pay attention so as not to damage the valve contacting surfaces.

- (3) **Clean the valve guide**

Clean the entire valve guide internal surfaces using a brush and solvent.

- (4) **Clean the cylinder head**

Thoroughly clean the cylinder block contacting surface of cylinder head using a soft brush and solvent.



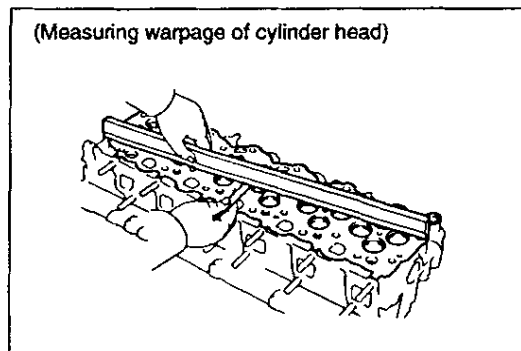
3.1.4.3 Inspect the cylinder head

(1) Inspect the flatness

Measure the cylinder block contacting surface using a straight edge and feeler gauge in order to check warpage of the surface.

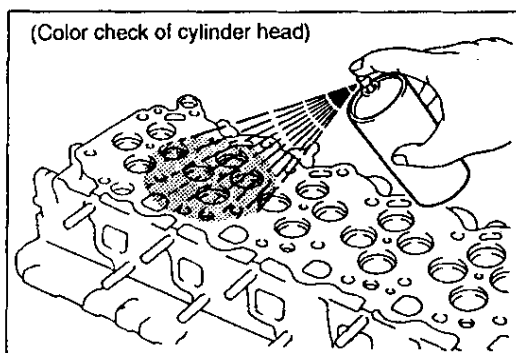
Maximum warpage: 0.20 mm

If the measured warpage exceeds the specified maximum, replace the cylinder head.



(2) Inspect for cracks

Check the intake and exhaust ports and cylinder block contacting surfaces for cracks, using the color check agent. If any cracks are discovered, replace the cylinder head.



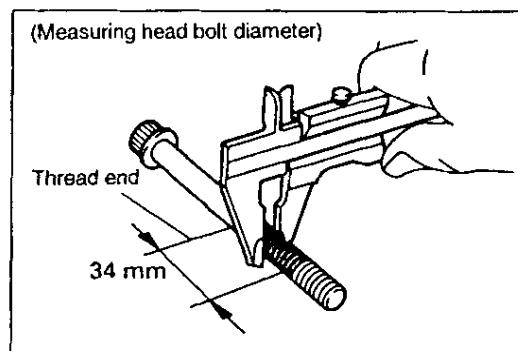
(3) Inspection of cylinder head bolt

Measure the minimum outside diameter of thread using calipers. Also, check for damaged and seized threads.

Standard outside diameter: 10.80 to 11.00 mm

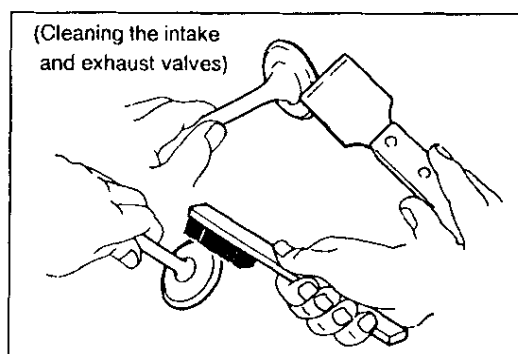
Minimum outside diameter: 10.55 mm

If the measured value is less than the minimum outside diameter, replace the bolt.



3.1.4.4 Clean the intake and exhaust valves

- (1) Remove the carbon deposits adhering on the valve head, using a scraper.
- (2) Thoroughly clean the valve using a wire brush.



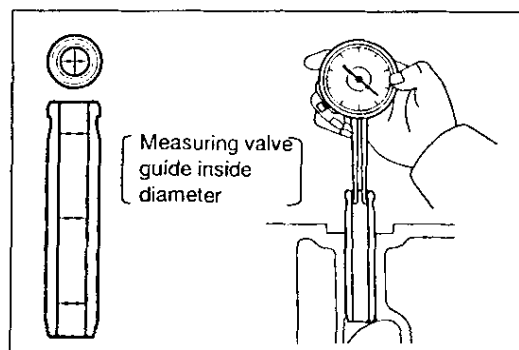
3.1.4.5 Inspection of valve stem and valve guide

- (1) Measure the inside diameter of valve guide using a caliper gauge.

Valve guide inside diameter:

6LP-DTE series: 8.010 to 8.030 mm

6LP-STE series: 7.010 to 7.030 mm



3. Engine Overhaul

- (2) Measure the diameter of the valve stem using a micrometer.

Valve stem diameter:

6LP-DTE series:

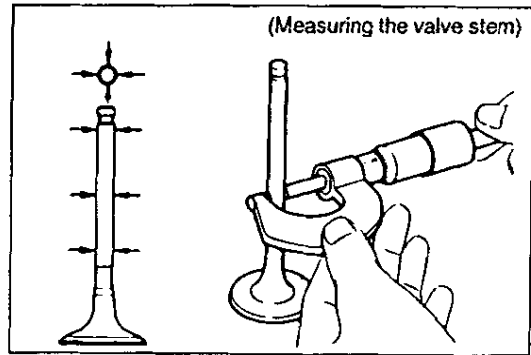
Intake valve: 7.975 to 7.990 mm

Exhaust valve: 7.960 to 7.975 mm

6LP-STE series:

Intake valve: 6.970 to 6.985 mm

Exhaust valve: 6.960 to 6.975 mm



- (3) Subtract the valve stem diameter from the measured valve guide inner diameter.

Standard oil clearance:

6LP-DTE series:

Intake valve: 0.020 to 0.055 mm

Exhaust valve: 0.035 to 0.070 mm

6LP-STE series:

Intake valve: 0.025 to 0.060 mm

Exhaust valve: 0.035 to 0.070 mm

Maximum oil clearance:

Intake valve: 0.08 mm

Exhaust valve: 0.10 mm

If the measured clearance exceeds the specified maximum, replace the valve and cylinder head assy.

3.1.4.6 Inspect and lap the intake and exhaust valves

- (1) Check the valve face for wear. If so, replace the worn valve.
- (2) Check the margin thickness of valve head.

6LP-DTE series:

Standard margin thickness:

Intake valve: 1.6 mm

Exhaust valve: 1.7 mm

Minimum margin thickness:

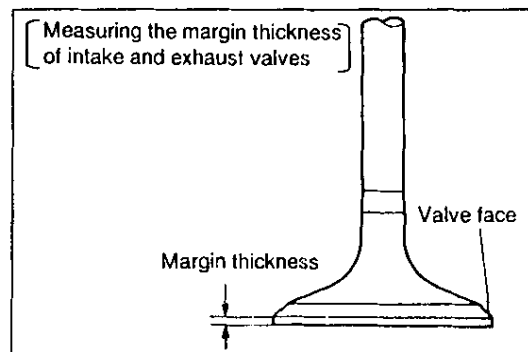
Intake valve: 1.1 mm

Exhaust valve: 1.2 mm

6LP-STE series:

Standard margin thickness: 1.00 mm

Minimum margin thickness: 0.83 mm



If the measured margin thickness is below the specified minimum, replace the valve.

- (3) Check the overall length of the intake and exhaust valves.

6LP-DTE series:

Standard overall length:

Intake valve: 103.29 to 103.69 mm

Exhaust valve: 103.14 to 103.54 mm

Minimum overall length:

Intake valve: 102.79 mm

Exhaust valve: 102.64 mm

6LP-STE series:

Standard overall length:

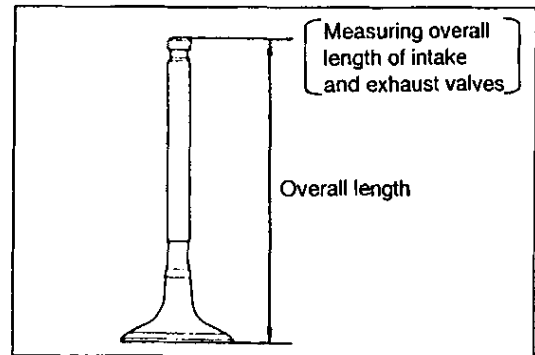
Intake valve: 126.85 to 127.45 mm

Exhaust valve: 126.43 to 127.03 mm

Minimum overall length:

Intake valve: 126.85 mm

Exhaust valve: 126.43 mm

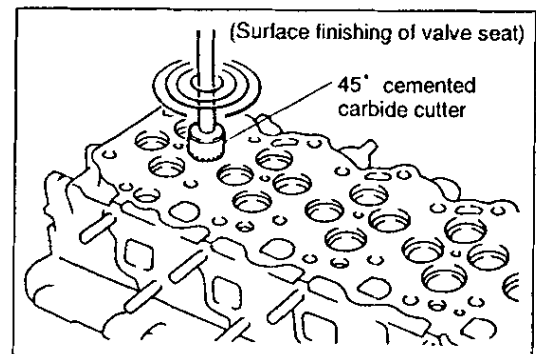


If the measured overall length is smaller than the specified minimum, replace the valve. Check the tip of valve stem for wear. If so, replace the valve.

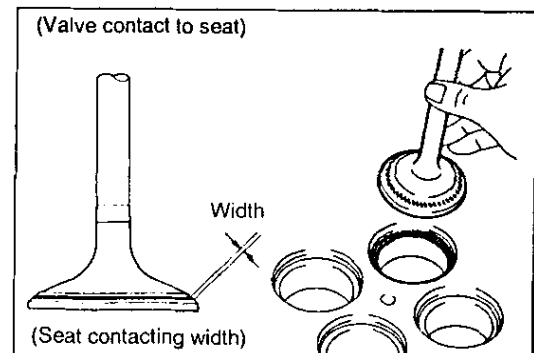
3.1.4.7 Inspect and clean the valve seat

- (1) Finish the valve seat surface using a 45° cemented carbide cutter. Cut the metal by the minimum depth necessary for cleaning.

- (2) Check the valve seat for poor contact. Apply a light coat of prussian blue (or white lead) on the valve face. Lightly press the valve onto the seat, without rotating the valve.



- (3) Check the valve face and seat as follows:
- If the blue color adheres around 360° of the valve seat, the valve is concentric. If not concentric, replace the valve.
 - If the blue color adheres around 360° of the valve seat, the guide and face are concentric. If the color fails to adhere around 360°, carry out the surface finishing of the seat.
 - Check if the seat contacts at the following width and within the middle of valve face.



3. Engine Overhaul

6LP-DTE series:

Intake valve: 1.5 to 1.9 mm

Exhaust valve: 1.8 to 2.2 mm

6LP-STE series:

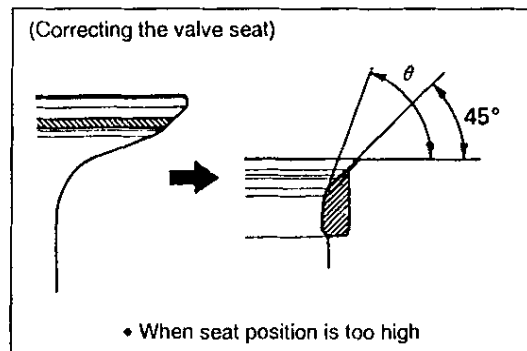
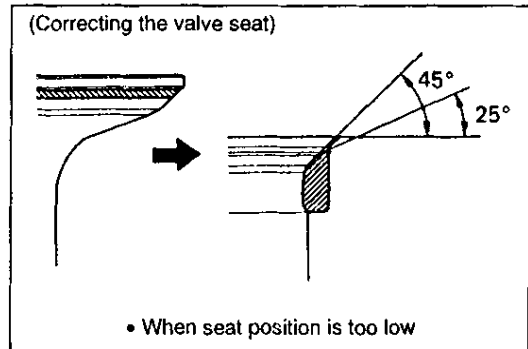
Intake valve: 1.4 to 1.8 mm

Exhaust valve: 1.6 to 2.0 mm

If not at the middle, correct the valve seat as follows.

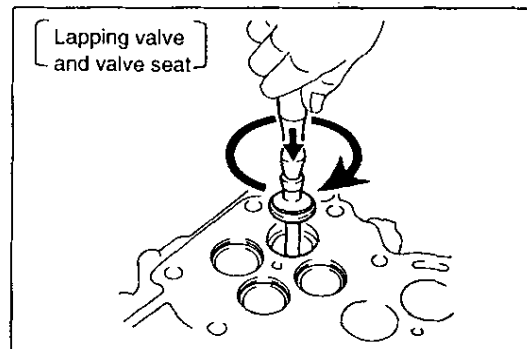
- If the seat position on the valve face is too low, correct the seat using 25° and 45° cutters.
- If the seat position on the valve face is too high, correct the valve seat using cutters having angles listed below and a 45° cutter.

θ	Intake	Exhaust
6LP-DTE series	70°	60°
6LP-STE series	70°	65°



(4) Hand-lap the valve and valve seat using the abrasive compound.

(5) After lapping, clean the valve and valve seat.

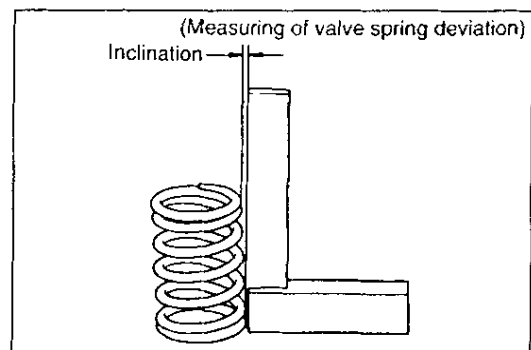


3.1.4.8 Check the valve spring

(1) Measure the deviation of the valve spring using a square.

Maximum deviation: 2.0 mm

If the measured deviation exceeds the specified maximum, replace the valve spring.

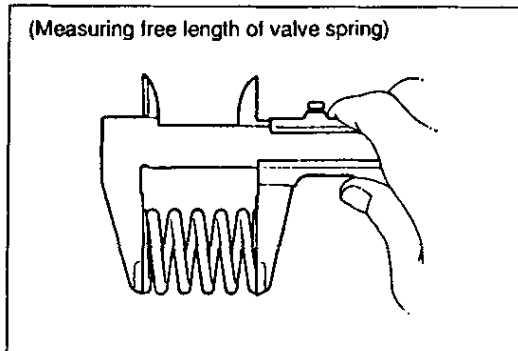


- (2) Measure free length of the valve spring using calipers.

Free length:

	6LP-DTE series	6LP-STE series
Yellow mark	46.20 mm	49.6 mm
Blue mark	49.14 mm	

If the measured free length is out of the specification, replace the valve spring.



- (3) Measure spring force after installing the spring at the specified length, using the spring tester.

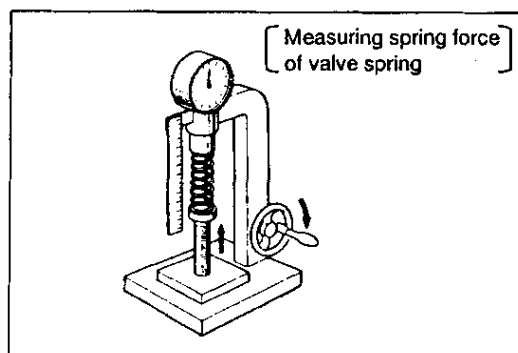
For 6LP-DTE series:

30.7 to 33.9 kgf (301.06 to 332.45 N)
at 37.0-mm position

For 6LP-STE series:

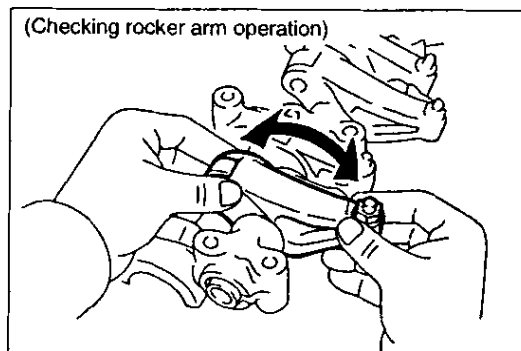
24.2 to 26.8 kgf (237.32 to 262.82 N)
at 39.5-mm position

If the spring force is out of the specified range, replace the valve spring.



3.1.4.9 Check the valve rocker arm and shaft (For 6LP-STE series only)

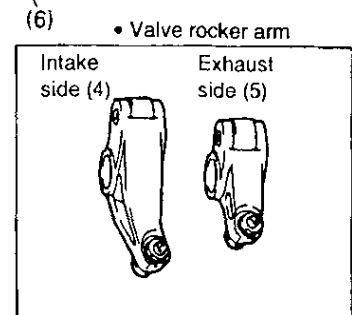
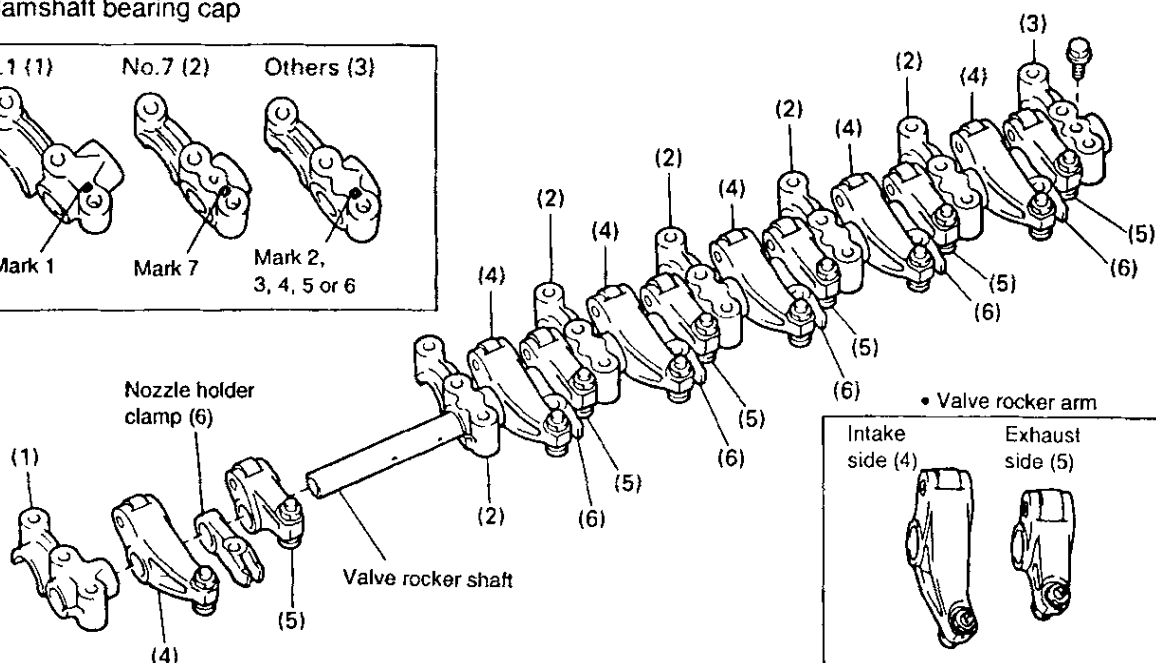
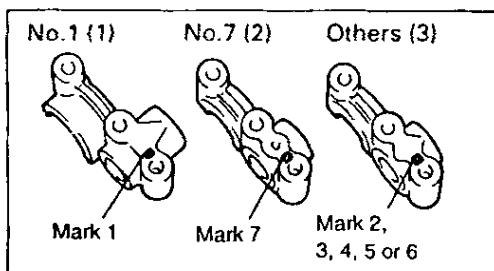
- Check that the rocker arms rotate smoothly. If hooking is felt, disassemble and inspect.
- Remove bolts and disassemble the parts.



[NOTICE]

Keep disassembled parts in an orderly manner.

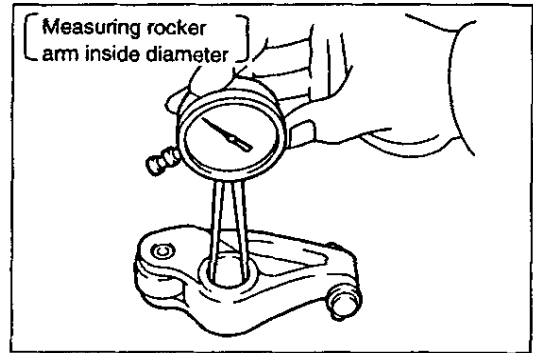
• Camshaft bearing cap



3. Engine Overhaul

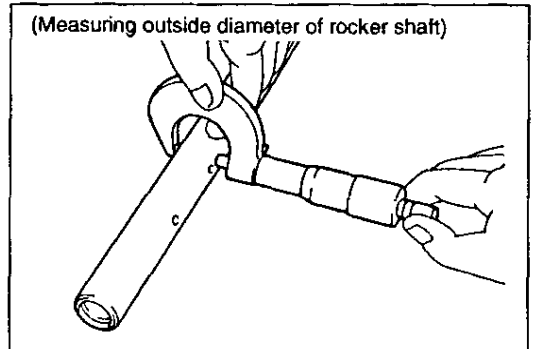
- (3) Measure inside diameter of the rocker arm using a caliper gauge.

Rocker arm inside diameter:
20.012 to 20.033 mm



- (4) Measure the rocker arm shaft diameter using a micrometer.

Shaft outside diameter:
19.972 to 19.993 mm



- (5) Subtract the rocker arm shaft diameter from the inside diameter of the rocker arm.

Standard oil clearance: 0.019 to 0.061 mm

Maximum oil clearance: 0.10 mm

If the measured oil clearance exceeds the specified maximum, replace the rocker arm shaft and rocker arm.

- (6) Assemble the parts as shown in the illustration.
(See step (2) above.)

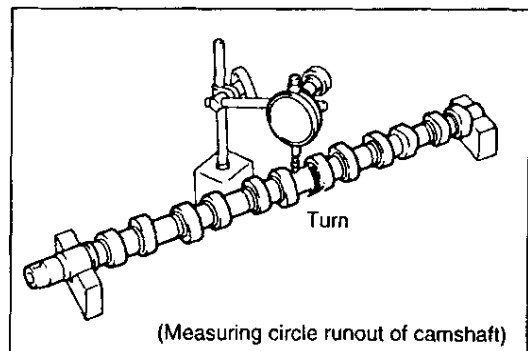
3.1.4.10 Check the camshaft and bearing

- (1) Check the camshaft for circle runout

- 1) Install the camshaft on the V-block.
- 2) Measure circle runout on the center journal, using a dial indicator.

Maximum circle runout: 0.10 mm

If the measured circle runout exceeds the specified maximum, replace the camshaft.



- (2) Check the cam lobe height

Measure the cam lobe height using a micrometer.

6LP-DTE series:

Standard cam lobe height:

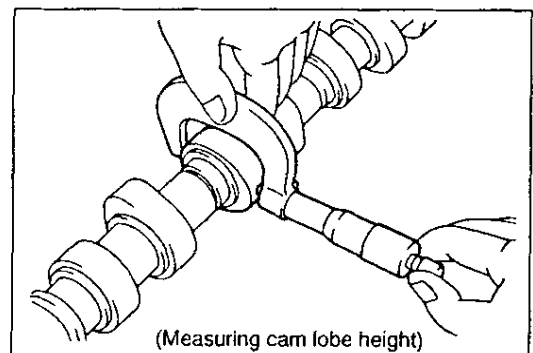
Intake side: 54.440 to 54.460 mm

Exhaust side: 55.940 to 55.960 mm

Minimum cam lobe height:

Intake side: 53.94 mm

Exhaust side: 55.44 mm



6LP-STE series:

Standard cam lobe height:

Intake side: 48.498 to 48.598 mm

Exhaust side: 50.734 to 50.834 mm

Minimum cam lobe height:

Intake side: 47.998 mm

Exhaust side: 50.234 mm

If the measured cam lobe height is smaller than the specified minimum, replace the camshaft.

(3) Inspect the camshaft journal

Measure diameter of the journal using a micrometer.

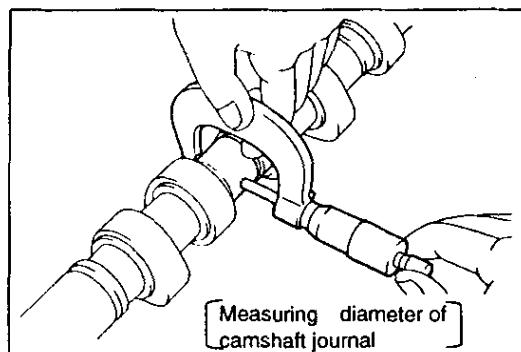
Journal diameter:

No.1: 34.969 to 34.985 mm

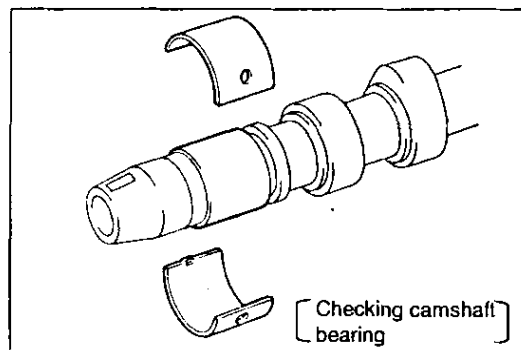
Others:

27.986 to 27.998 mm

If the journal diameter is out of the specified range, check the oil clearance.

**(4) Check the camshaft bearing**

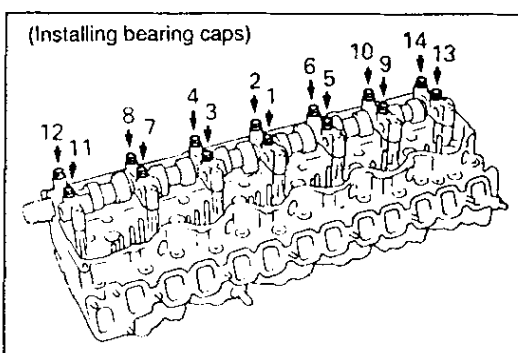
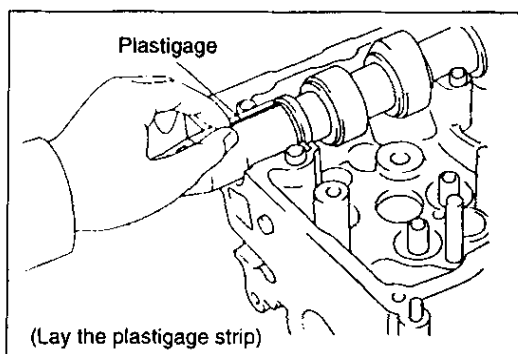
Check the camshaft bearings for flaking (peeling off) or score (scratches). If the bearing is damaged, replace the bearing cap and cylinder head at the same time.

**(5) Inspect oil clearance of the camshaft journal**

- 1) Remove the 7 bearing caps from the camshaft or valve rocker shaft.
- 2) Clean the bearing caps and camshaft journals.
- 3) Install the camshaft to the cylinder head.
- 4) Lay the plastigage strips across the camshaft journals.
- 5) Install 7 bearing caps with the 14 bolts. Tighten 14 bolts uniformly at several times in the order shown in the illustration.

Tightening torque:

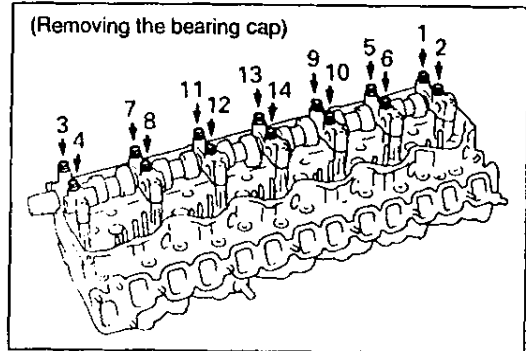
250 kgf·cm (24.52 N·m)

**[NOTICE]**

Do not turn the camshaft during tightening.

3. Engine Overhaul

- 6) Loosen the 14 bolts uniformly at several times in the order shown in the illustration to remove them.
- 7) Remove the 7 bearing caps.



- 8) Measure the plastigages at the widest point.

Standard oil clearance:

No.1: 0.022 to 0.074 mm

Others:

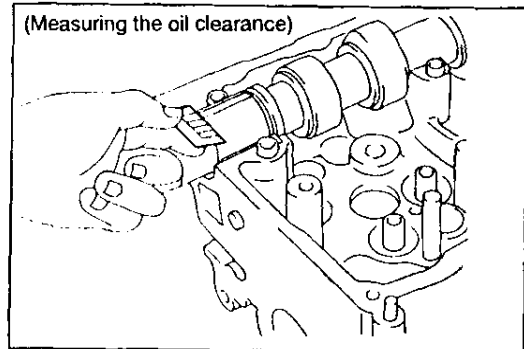
0.023 to 0.075 mm

Maximum oil clearance:

0.10 mm

If the measured oil clearance is greater than the specified maximum, replace the camshaft. Also, replace the bearing caps and cylinder head as needed.

- 9) Completely remove the plastigages.
- 10) Install the 7 bearing caps to the valve rocker shaft. (See 3.1.4.9 (2).)



(6) Inspect the camshaft thrust clearance.

- 1) Install the camshaft.
(See the procedure in (5) above.)
- 2) Measure the thrust clearance using the dial gauge while moving the camshaft longitudinally.

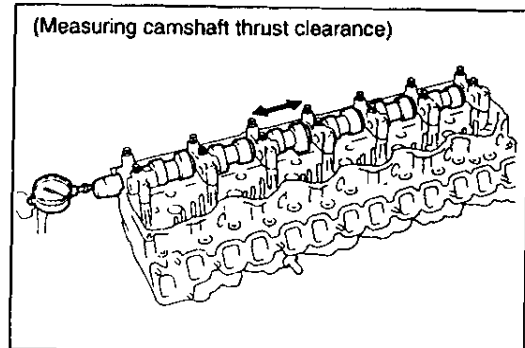
Standard thrust clearance:

0.100 to 0.200 mm

Maximum thrust clearance:

0.30 mm

If the measured thrust clearance exceeds the maximum, replace the thrust plate. Replace the camshaft or the bearing cap and cylinder head as a set, as needed.

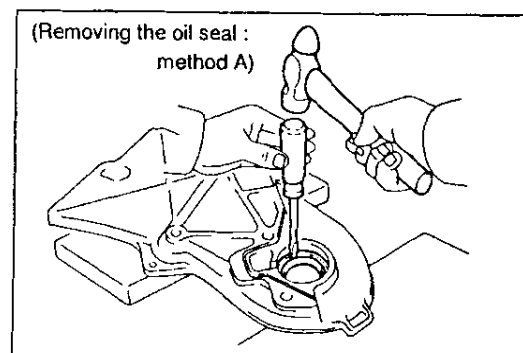


3.1.5 Replacement of Oil Seal for Camshaft

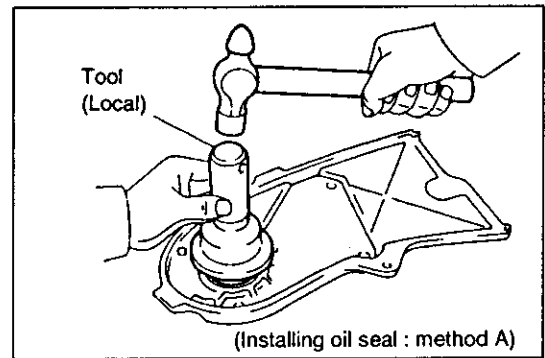
There are two methods (A and B) for replacing the oil seal.

- (A) When the camshaft oil seal retainer has been removed from the cylinder head

- 1) Tap out the oil seal using a screwdriver and a hammer as shown.



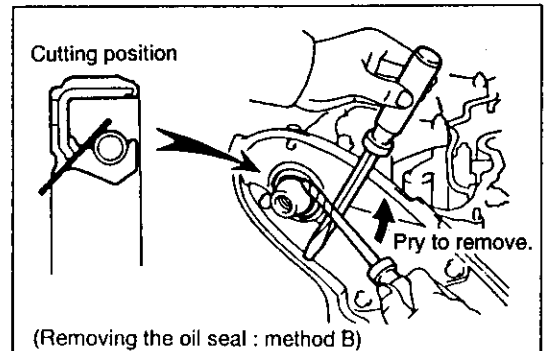
- 2) Apply the grease to the oil seal lip.
- 3) Tap in a new oil seal to install in position until its surface is level with the end surface of oil seal retainer.



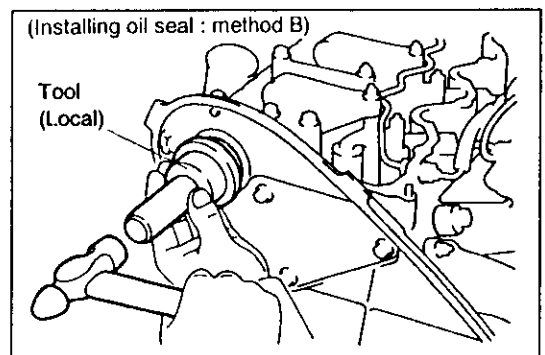
- (B) When the camshaft oil seal retainer is installed to the cylinder head
- 1) Cut off the oil seal lip using a knife.
 - 2) Remove the oil seal using two screwdrivers as the lever.

[NOTICE]

***Be careful so as not to damage the camshaft.
Tape the screwdrivers tip.***



- 3) Apply the grease to the new oil seal lip.
- 4) Tap in a new oil seal to install in position until its surface is level with the end surface of oil seal retainer.



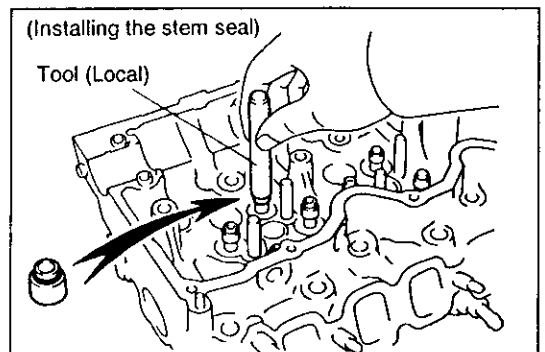
3.1.6 Assembly of Cylinder Head

[NOTICE]

Clean all parts to be assembled. Apply new engine oil to all sliding and rotating surfaces before assembling parts. Replace all gaskets and oil seals to new ones.

3.1.6.1 Install the intake and exhaust valves

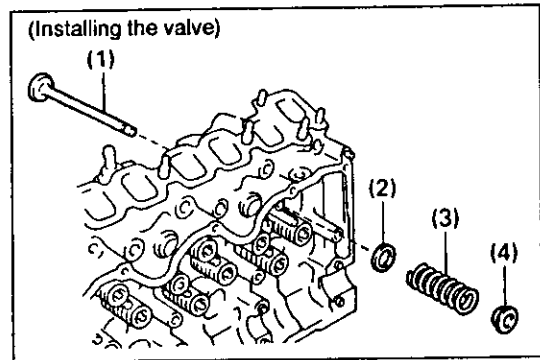
- (1) Press in the new stem seal into the valve guide.



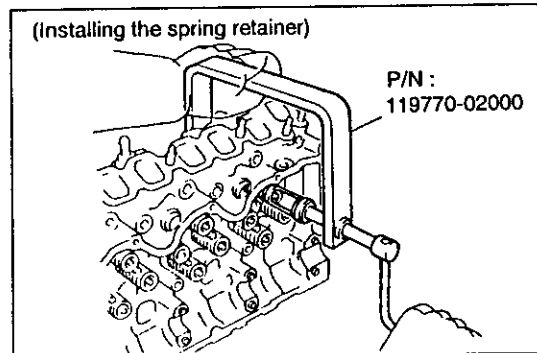
3. Engine Overhaul

(2) Install the following parts:

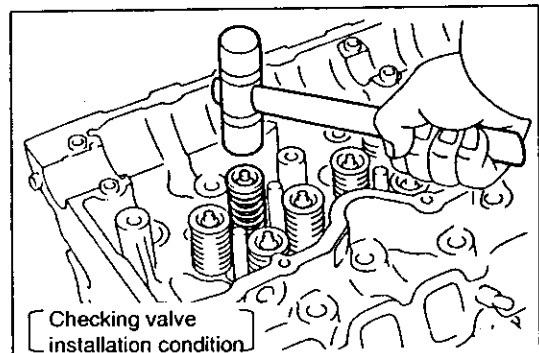
- 1) Valve
- 2) Spring seat
- 3) Valve spring
- 4) Spring retainer



(3) Compress the valve spring and install the spring retainer.

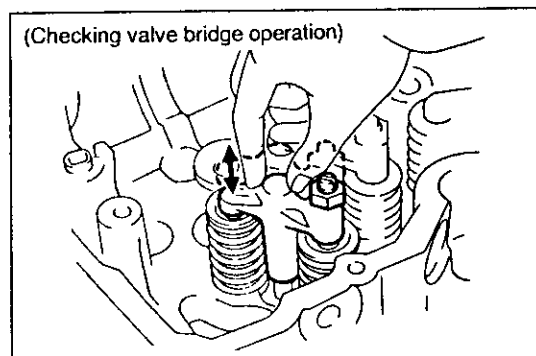


(4) Tap the tip of the valve stem with a plastic hammer to check that it is fit in position.



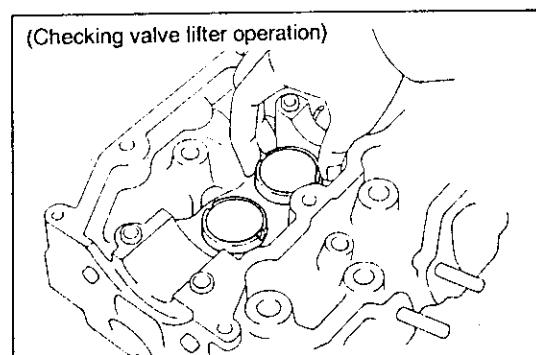
3.1.6.2 Install the valve bridge (6LP-STE series)

- (1) Install the valve bridge.
- (2) Check that the valve bridge operates smoothly.



3.1.6.3 Install the valve lifter and shim (6LP-DTE series only)

Manually turn the valve lifter to check if it rotates smoothly.



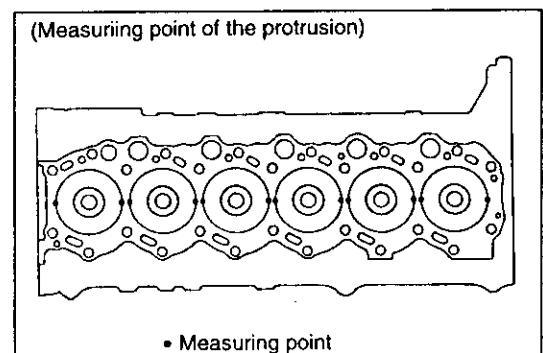
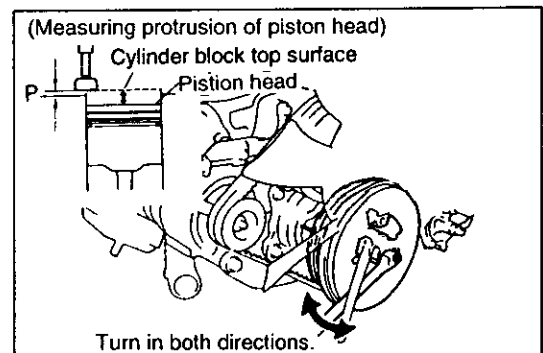
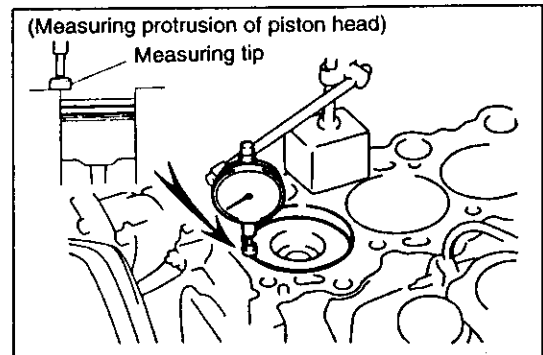
3.1.7 Installation of Cylinder Head

3.1.7.1 Measure protrusion of piston head for top surface of cylinder block to determine an appropriate cylinder head gasket

- (1) Measure protrusion of piston head for each cylinder.
 - 1) Clean the top surface of cylinder block with solvent.
 - 2) Set the piston of the cylinder for measurement at slightly before the top dead center.
 - 3) Put a dial indicator on the cylinder block and adjust the dial indicator to 0 mm.

[NOTICE]

- Use a dial indicator measuring tip as shown.
- Always check that the measuring tip is parallel to the cylinder block gasket mounting surface and the piston head before reading the dial indicator.



- 4) Determine the position where the piston head is at the upper-most position (maximum protrusion) by slowly turning the crankshaft clockwise and/or counter-clockwise.
- 5) Measure at two points for each cylinder, a total of 12 points as shown in the illustration.
- 6) Measure at two points for each cylinder and obtain their average as the measured protrusion of piston head for each cylinder.

Piston protrusion (P):

6LP-DTE series: 0.475 to 0.725 mm

6LP-STE series: 0.175 to 0.425 mm

If the measured value is out of the specified range, remove the piston and connecting rod assy, and then reassemble and measure again.

(See 3.2.3 Disassembly of Cylinder Block.)

3. Engine Overhaul

- (2) Select a new cylinder head gasket to be installed. There are three types of service parts (mark Nos. 1, 3 and 5). Select an appropriate gasket from the following three types.

Thickness of newly installed cylinder head gasket:

6LP-DTE series

Mark No. "1": 1.15 to 1.25 mm

Mark No. "3": 1.25 to 1.35 mm

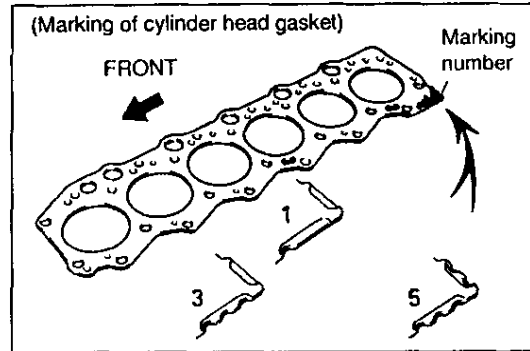
Mark No. "5": 1.35 to 1.45 mm

6LP-STE series

Mark No. "1": 0.85 to 0.95 mm

Mark No. "3": 0.95 to 1.05 mm

Mark No. "5": 1.05 to 1.15 mm



Select an appropriate gasket based on the measurement.

6LP-DTE series

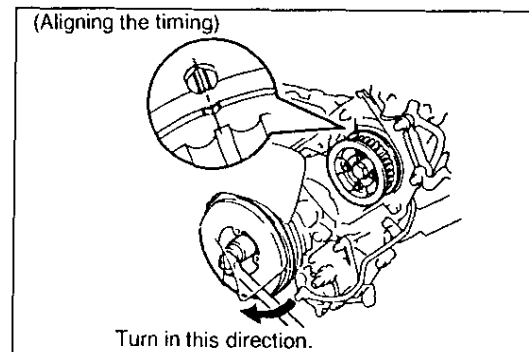
Piston protrusion (P)	Gasket size	Gasket P/N
0.525 mm or less	Use gasket "1".	119770-00930
0.526 to 0.625 mm	Use gasket "3".	119770-00940
0.626 or more	Use gasket "5".	119770-00950

6LP-STE series

Piston protrusion (P)	Gasket size	Gasket P/N
0.225 mm or less	Use gasket "1".	119771-00401
0.226 to 0.325 mm	Use gasket "3".	119771-00411
0.326 or more	Use gasket "5".	119771-00421

3.1.7.2 Set cylinder No.1 at the bottom dead center

Turn the crankshaft pulley to align to the timing mark of No.2 camshaft timing pulley, using the bottom dead center (BDC) mark of the timing gear cover.



3.1.7.3 Install the cylinder head

(1) Install the cylinder head on the cylinder block.

- 1) Install a new cylinder head gasket in position on the cylinder block.

[NOTICE]

Install the gasket in the right way round.

- 2) Install the cylinder head correctly on the cylinder head gasket.

(2) Install the cylinder head bolt.

[NOTICE]

- ***Gradually tighten the cylinder head bolt in 3 steps.***
- ***If the bolt is damaged or deformed, replace with a new one.***

- 1) Lightly apply the engine oil to the thread and cylinder head bolt seat.
- 2) Tighten the 26 cylinder head bolts uniformly at several times in the order shown in the illustration.

Tightening torque:

700 kgf·cm (68.65 N·m)

Bolt length (6LP-STE series only)

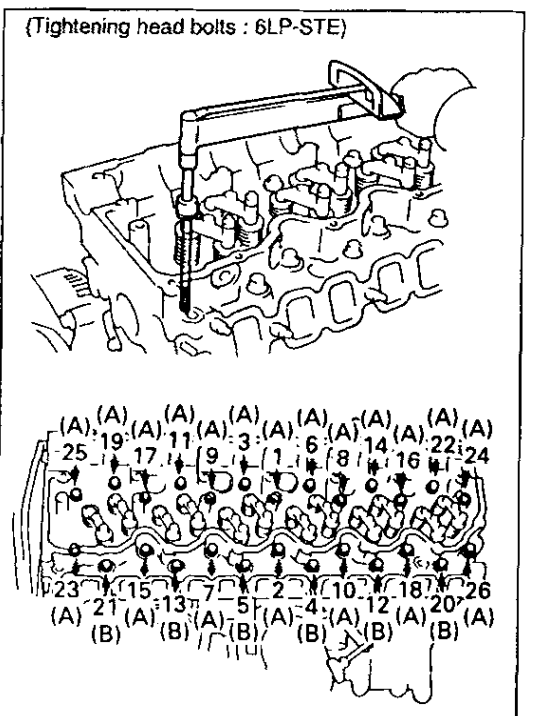
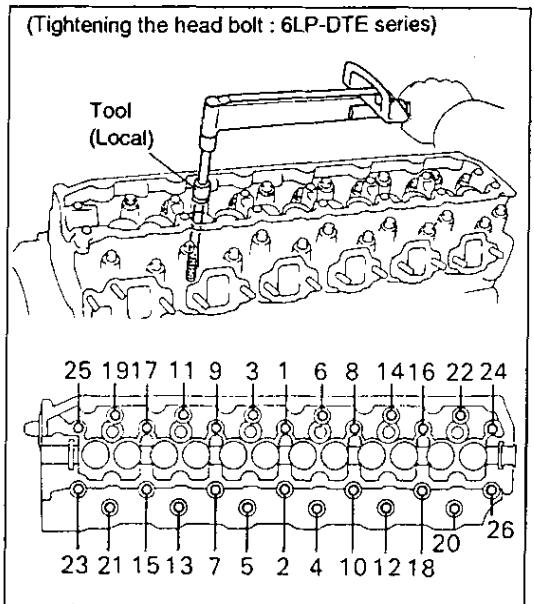
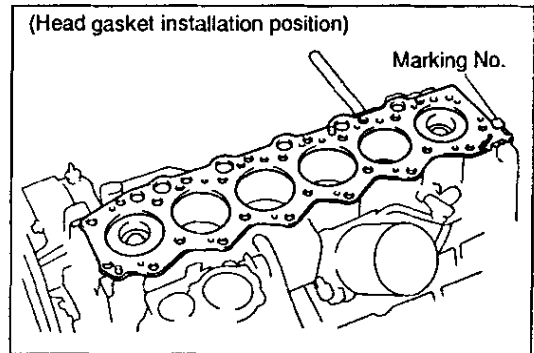
A: 121.5 mm

B: 133.5 mm

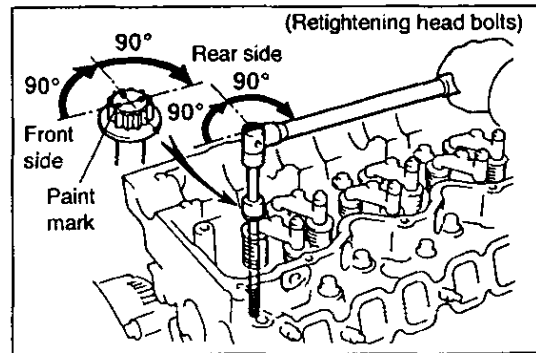
[NOTICE]

If any one of the cylinder head bolt does not satisfy the specified torque, replace that bolt.

- 3) Mark the front side of each cylinder head bolt by paint.
- 4) Retighten the cylinder head bolts by 90° in the order shown in the illustration.
- 5) Retighten the cylinder head bolts further by 90°.
- 6) Check that the painted marks face rearwards.

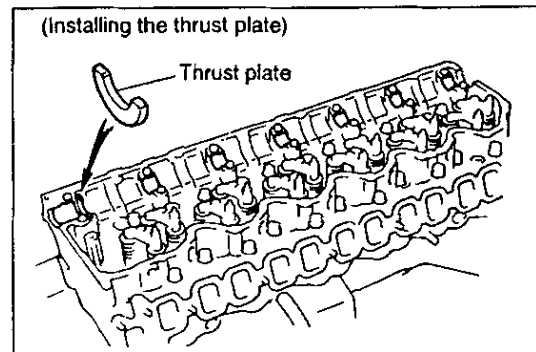


3. Engine Overhaul



3.1.7.4 Install the camshaft

(1) Install the thrust plate .



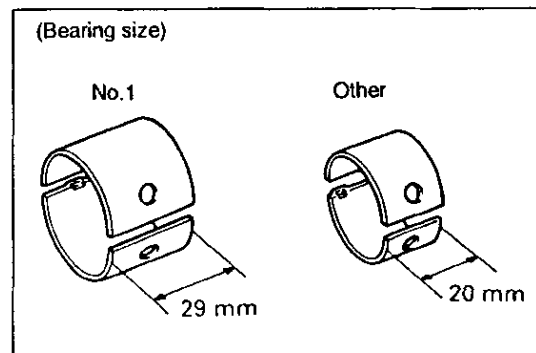
(2) Install the lower camshaft bearing.

For 6LP-DTE series:

Install the No.1 lower camshaft bearing.

For 6LP-STE series:

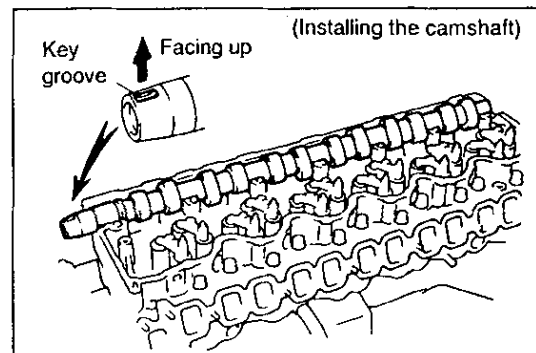
Install the 7 lower camshaft bearings.



(Installation Procedure)

There are two types of camshaft bearings, one having a 20 mm width and the other, 29 mm. Install the 29 mm bearing together with the camshaft bearing cap at the position of cylinder head journal No.1. Install the 20 mm bearing at the other position.

(3) Install the camshaft on the cylinder head in a way the key groove faces upwards.



(4) Install the upper camshaft bearing to the bearing cap.

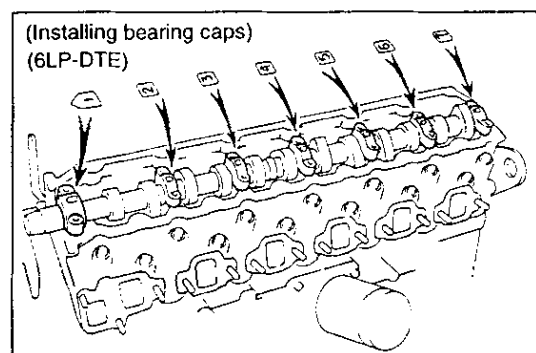
(5) Install the bearing cap and other parts.

For 6LP-DTE series:

Install the 7 bearing caps in their proper locations.

For 6LP-STE series:

Install 7 bearing caps, 12 rocker arms, 6 holder clamps and the rocker shaft assembly.



- (6) Uniformly tighten the 14 bearing cap bolts in the order shown in the illustration, at several times.

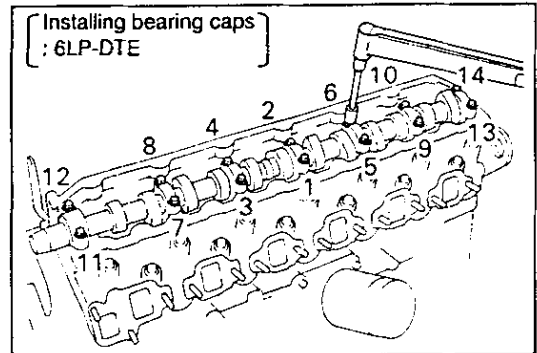
For 6LP-DTE series:

Tightening torque (No.1 journal):

250 kgf·cm (24.50 N·m)

(Others):

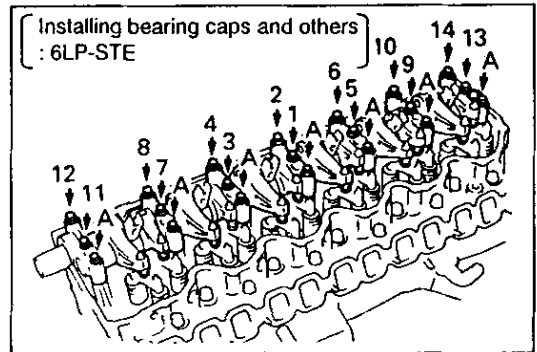
185 kgf·cm (18.13 N·m)



For 6LP-STE series:

Tightening torque (bearing cap, others A):

250 kgf·cm (24.50 N·m)



3.1.7.5 Install the fuel injection nozzle

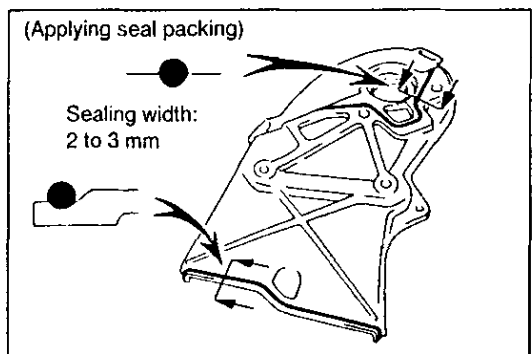
3.1.7.6 Install the camshaft oil seal retainer

- (1) Remove the adhering packing material.

[NOTICE]

Pay attention so that the oil seal retainer and cylinder head contacting surfaces are not contaminated by oil.

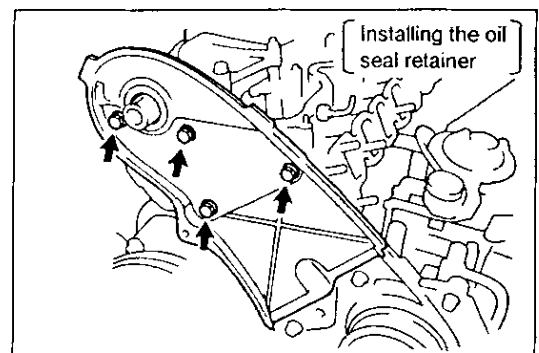
- Completely remove the packing material remaining on the gasket surface and sealing groove using a razor and gasket scraper.
 - Clean all parts to thoroughly remove foreign matter.
 - Clean both seal surfaces using solvent.



- (2) Apply the seal packing to the oil seal retainer as shown.

- Use a nozzle being cut to a sealing width of 2 to 3 mm.
- Parts must be assembled within 5 minutes after seal packing is applied. Otherwise, the packing material must be removed and applied again.
- Disconnect the nozzle from the tube immediately after use and protect it by a cap.

(Seal packing: TOYOTA P/N 08826-00080 or equivalent)



3. Engine Overhaul

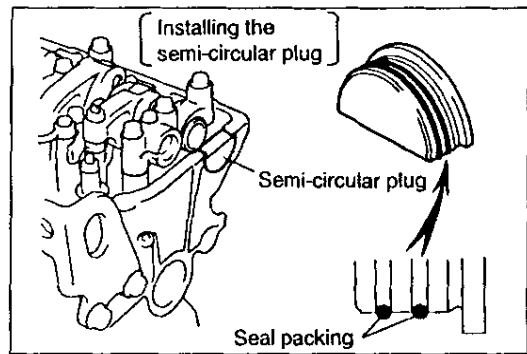
- (3) Install the oil seal retainer using 4 bolts.
Tighten bolts uniformly at several times.
Tightening torque: 200 kgf·cm (19.61 N·m)

3.1.7.7 Install the pulley and timing belt

3.1.7.8 Check and adjust the valve clearance

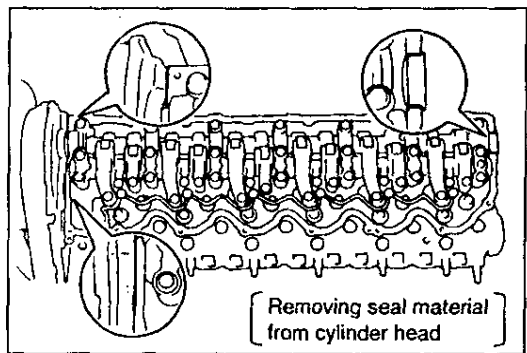
3.1.7.9 Install the semi-circular plug

- (1) Completely remove the adhering packing material.
- (2) Apply the seal packing to the semi-circular plug as shown.
(Seal packing: TOYOTA P/N 08826-00080 or equivalent)
- (3) Install the semi-circular plug to the cylinder head.



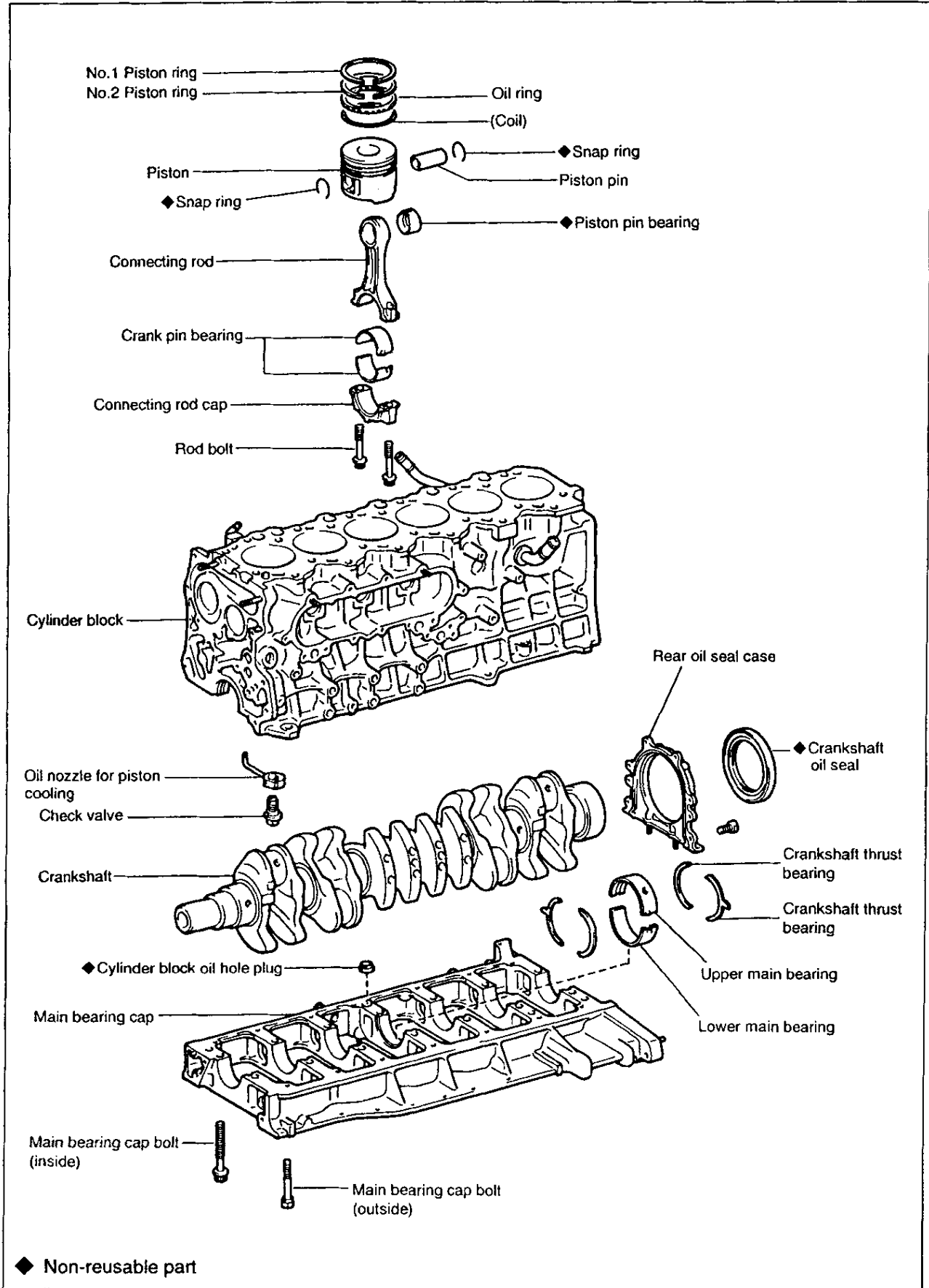
3.1.7.10 Install the bonnet

- (1) Completely remove the adhering packing material.
- (2) Apply the seal packing to the cylinder head as shown.
(Seal packing: TOYOTA P/N 08826-00080 or equivalent)
- (3) Install the gasket to the bonnet.
- (4) Install the bonnet using 12 new seal washers and 12 bolts. Uniformly tighten the bolts in several passes.
Tightening torque: 65 kgf·cm (6.37 N·m)



3.2 Cylinder Block

3.2.1 Components



3.2.2 Preparation for Disassembly

3.2.2.1 Remove the flywheel

3.2.2.2 Install the engine on the engine stand for disassembling it

3.2.2.3 Remove the timing belt and pulley

(See 3.3.2 Removal of Timing Belt)

3.2.2.4 Remove the cylinder head

(See 3.1.2 Removal of Cylinder Head)

3.2.2.5 Remove the fresh water pump and sea water pump

(See 3.13.1 Removal of Fresh Water Pump)

3.2.2.6 Remove the alternator

3.2.2.7 Remove the timing gear

(See 3.4.2 Removal of Timing Gear)

3.2.2.8 Remove the fuel injection pump

(See 3.11.1 Removal of Fuel Injection Pump)

3.2.2.9 Remove the oil pan and timing gear case

(See 3.18.1 Removal of Oil Pump)

3.2.2.10 Remove the oil cooler

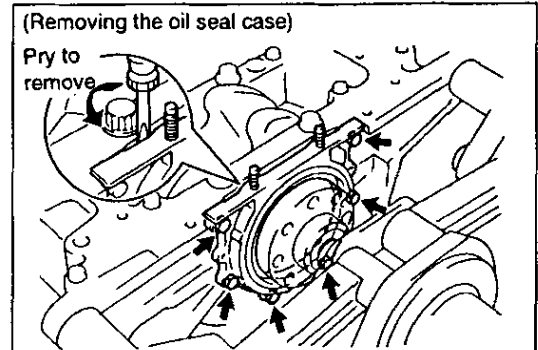
(See 3.19.1 Removal of Oil Cooler)

3.2.2.11 Remove the engine mount

3.2.3 Disassembly of Cylinder Block

3.2.3.1 Remove the rear oil seal case

- (1) Remove the 6 bolts.
- (2) Insert a screwdriver between the oil seal case and main bearing cap and pry to remove the oil seal case.



3.2.3.2 Check the connecting rod thrust clearance

Move the connecting rod back and forth, and measure thrust clearance using a dial gauge.

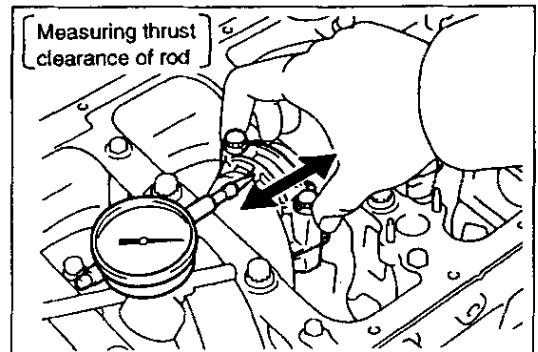
Standard thrust clearance:

0.100 to 0.200 mm

Maximum thrust clearance:

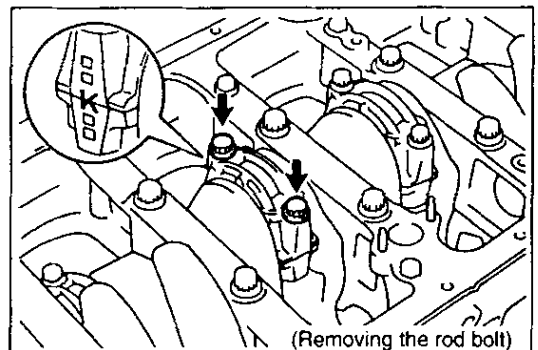
0.30 mm

If the measured value exceeds the specified maximum, replace the connecting rod assembly. Also, replace the crankshaft if needed.



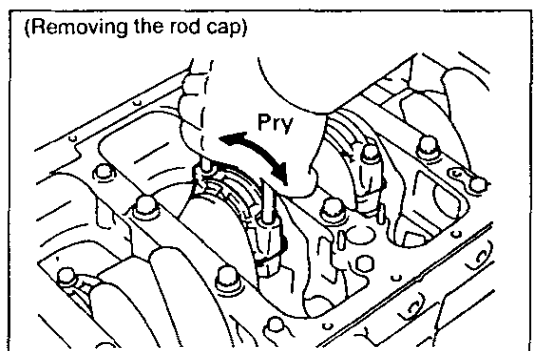
3.2.3.3 Remove the connecting rod cap and check oil clearance

- (1) Check the match marks on the connecting rod and the cap to confirm that they will be able to reassemble correctly.
- (2) Remove two connecting rod cap bolts.

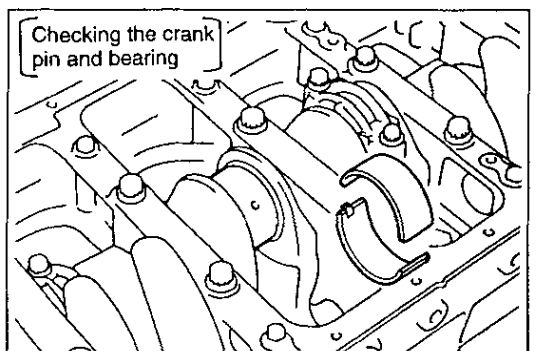


- (3) Move the connecting rod cap transversely using the two removed connecting rod cap bolts, to remove the connecting rod cap.

- Insert the lower bearing to the connecting rod cap as preparation for reassembly.

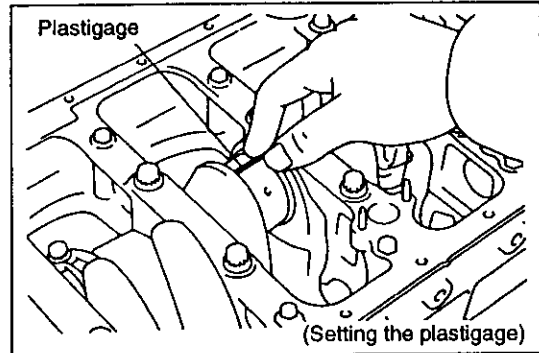


- (4) Clean the crank pin and bearing.
- (5) Check the crank pin and bearing for corrosion and scratches. If so, replace the bearing. Grind or replace the crankshaft, as needed.



3. Engine Overhaul

(6) Attach the strip of the plastigage to the crank pin.

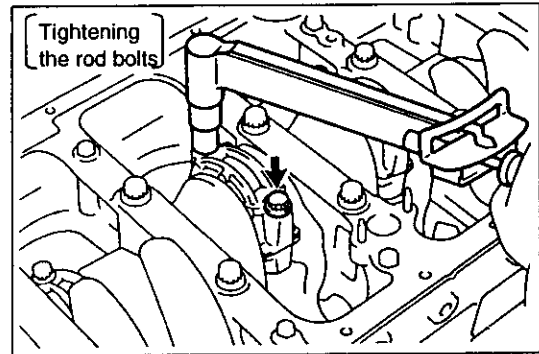


(7) Install the connecting rod cap with the 2 bolts.
(See 3.2.10.8 Install the connecting rod cap)

Tightening torque:

First tightening: 375 kgf·cm (37 N·m)

Second tightening: Turn by 90-deg



[NOTICE]

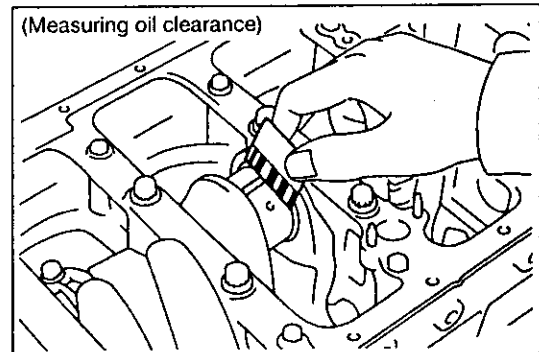
Do not turn the crankshaft.

(8) Remove the 2 bolts, connecting rod cap and lower bearing.

(9) Measure the plastigage at the widest position.

Standard oil clearance: 0.036 to 0.054 mm

Maximum oil clearance: 0.10 mm



If the measured value exceeds the specified maximum, replace the bearing. Grind or replace the crankshaft as needed.

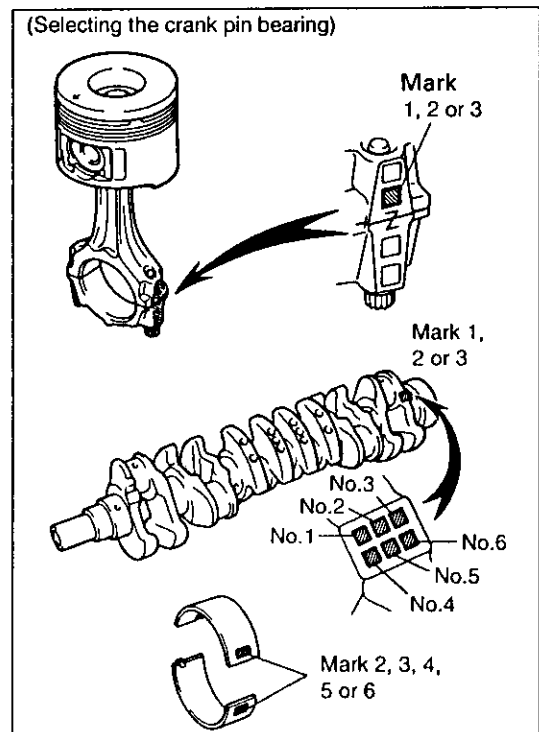
- Always replace bearings with those having the same number. If the bearing number is unknown, add numbers indicated on the crankshaft and connecting rod and select a bearing having a number equal to that obtained by addition.

There are five types of standard bearings, which are identified by marks "2", "3", "4", "5" and "6".

• **Crank pin bearing selection table**

Connecting rod	Mark No.								
	1			2			3		
Crankshaft	1	2	3	1	2	3	1	2	3
Bearing	2	3	4	3	4	5	4	5	6

Example: Assume that indications on connecting rod and crankshaft are "2" and "1", select bearing "3" ("2"+"1"="3").



Reference:

Inside diameter of larger end of connecting rod

(mm)

Mark "1"	62.014 to 62.020
Mark "2"	62.020 to 62.026
Mark "3"	62.026 to 62.032

Diameter of crankshaft crank pin

(mm)

Mark "1"	58.994 to 59.000
Mark "2"	58.988 to 58.994
Mark "3"	58.982 to 58.988

Bearing thickness

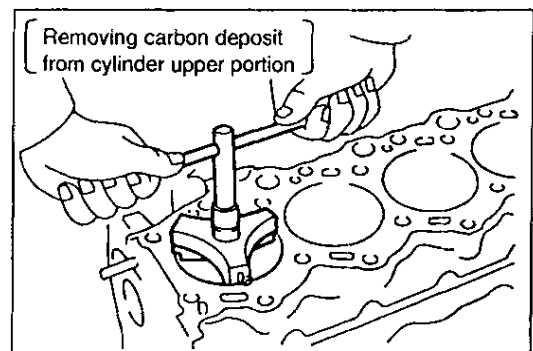
(mm)

Mark "2"	1.486 to 1.489	P/N: 119770-00260
Mark "3"	1.489 to 1.492	119770-01010
Mark "4"	1.492 to 1.495	119770-01020
Mark "5"	1.495 to 1.498	119770-01030
Mark "6"	1.498 to 1.501	119770-01040

(10) Completely remove the T gage.

3.2.3.4 Remove the piston and connecting rod assembly

- (1) Thoroughly remove the carbon deposits from the cylinder upper portion.
- (2) Push out the piston and connecting rod assembly from under the cylinder block.
 - Store the bearing, connecting rod and cap as a set.
 - Store pistons and connecting rod assemblies in an orderly manner according to cylinder numbers, so that they will be reassembled at original positions.



3.2.3.5 Inspect the thrust clearance of the crankshaft

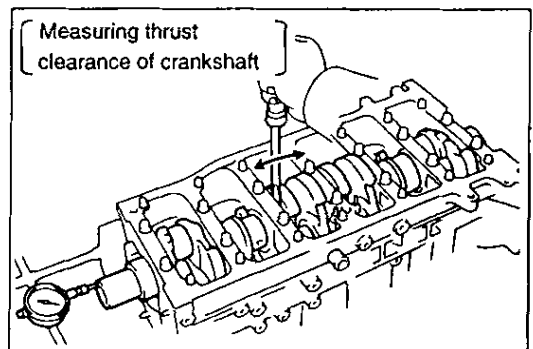
Measure thrust clearance using a dial indicator by moving the crankshaft back and forth using a screwdriver.

Standard thrust clearance: 0.040 to 0.240 mm

Maximum thrust clearance: 0.30 mm

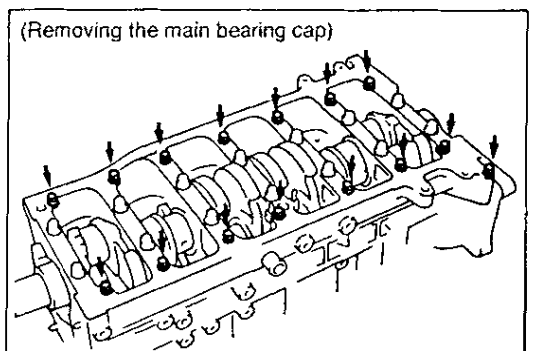
If the measured value exceeds the specified maximum, replace the thrust bearing as a set.

Thrust bearing thickness: 2.930 to 2.980 mm



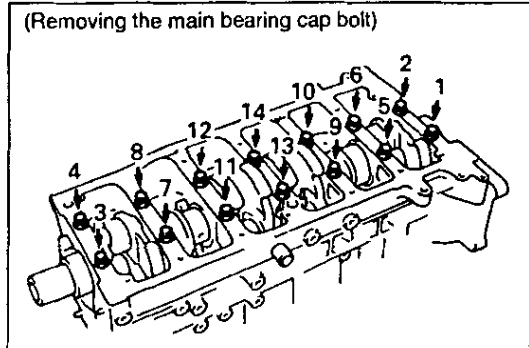
3.2.3.6 Remove the main bearing cap and inspect the oil clearance

- 1) Remove 15 main metal cap bolts (6 pointed head).

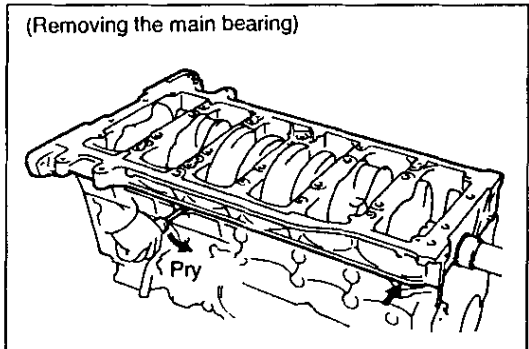


3. Engine Overhaul

- (2) Uniformly loosen at several times and remove the 14 main bearing cap bolts (12 pointed head) in the order shown in the illustration.



- (3) Insert the tip of a screwdriver between the main bearing cap and cylinder block and pry out the main bearing cap.

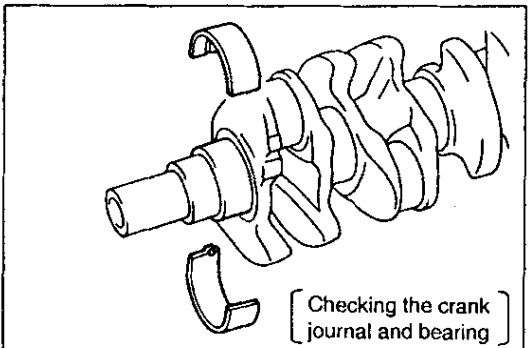


[NOTICE]

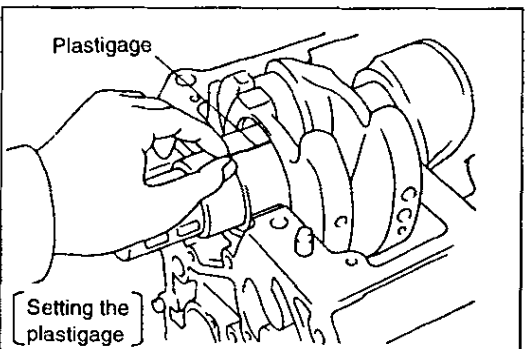
Pay attention so as not to damage the contact surfaces of the main bearing cap and cylinder block.

- Insert the lower bearing to the main bearing cap as preparation for reassembly.

- (4) Lift and remove the crankshaft.
- Insert the upper bearing to the cylinder block as preparation for reassembly.
 - Keep the thrust bearings in the correct order.
- (5) Clean main journals and bearings.
- (6) Check main journals and bearings for damages. If damaged, replace the bearing. Grind or replace the crankshaft, as needed.



- (7) Locate the crankshaft on the cylinder block.
- (8) Attach the strip of plastigage to each journal.



- (9) Install the main bearing cap with the 14 bolts (12 pointed head).

(See 3.2.10.5 Install the main bearing cap)

Tightening torque:

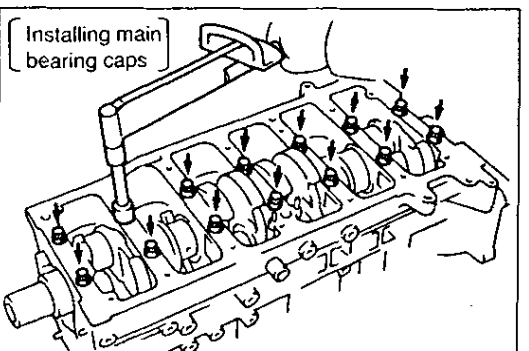
First tightening: 1050 kgf·cm (102.90 N·m)

Second tightening: Turn by 90°

[NOTICE]

Do not turn the crankshaft.

- (10) Remove the 14 bolts and main bearing cap.



- (11) Measure the plastigage at the widest point.
 Standard clearance: 0.036 to 0.054 mm
 Maximum clearance: 0.10 mm

If the measured oil clearance exceeds the specified maximum, replace the bearing. Grind or replace the crankshaft as needed.

- Always replace bearings with those having the same number. If the bearing number is unknown, add numbers indicated on the main bearing cap and crankshaft and select a bearing having a number equal to that obtained by addition. There are five types of standard bearings, which are identified by marks "2", "3", "4", "5" and "6".

• Crank journal bearing selection table

Main bearing cap	Mark No.								
	1			2			3		
Crankshaft	1	2	3	1	2	3	1	2	3
Bearing	2	3	4	3	4	5	4	5	6

Example: Assume that indications on main bearing cap and crankshaft are "2" and "1", select bearing "3" ("2"+"1"="3").

Reference:

Cylinder block journal bore diameter (mm)

Mark "1"	71.000 to 71.006
Mark "2"	71.006 to 71.012
Mark "3"	71.012 to 71.018

Crankshaft journal diameter (mm)

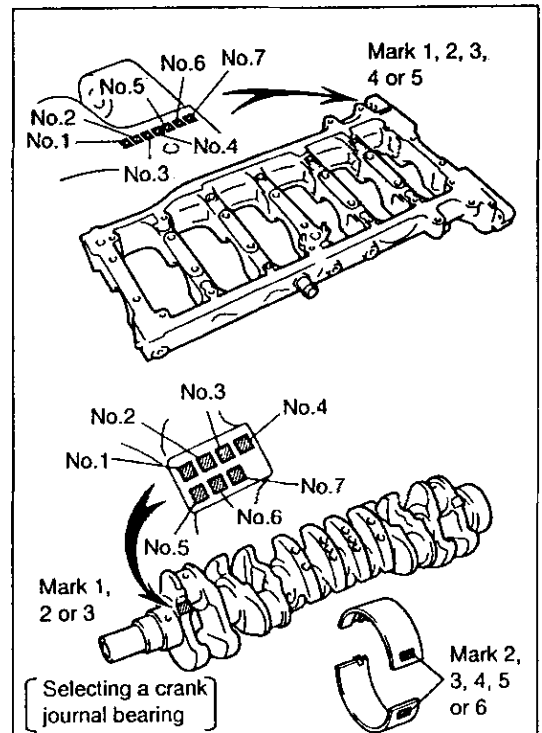
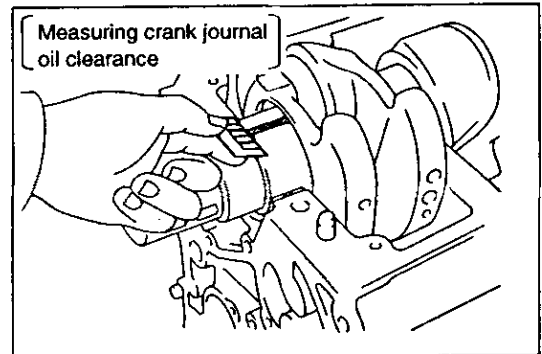
Mark "1"	66.994 to 67.000
Mark "2"	66.988 to 66.994
Mark "3"	66.982 to 66.988

Crank journal bearing thickness and P/N (mm)

Mark "2"	1.979 to 1.982	—
Mark "3"	1.982 to 1.985	P/N: 119770-00961
Mark "4"	1.985 to 1.988	119770-00971
Mark "5"	1.988 to 1.991	119770-00981
Mark "6"	1.991 to 1.994	119770-00991
Mark "7"	1.994 to 1.997	119770-01001
Mark "8"	1.997 to 2.000	119770-01170

(Refer to 3.24.1)

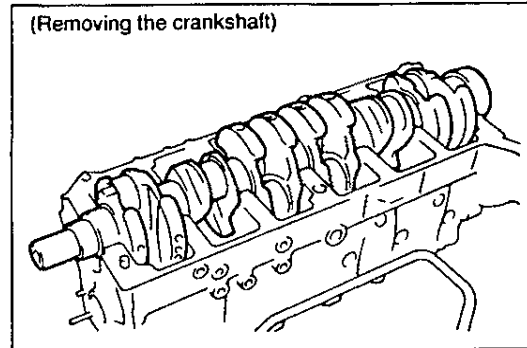
- (12) Completely remove the plastigage.



3. Engine Overhaul

3.2.3.7 Remove the crankshaft

- (1) Lift and remove the crankshaft.
- (2) Remove the upper bearing and thrust bearing from the cylinder block.
 - Keep the main bearing and thrust bearing after assembling them in correct order.

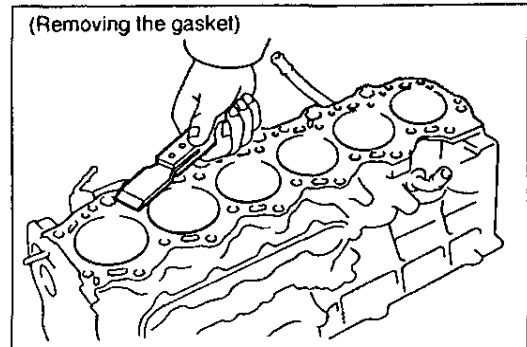


3.2.3.8 Remove the check valve and oil nozzle (for piston cooling) (See 3.20.1 Disassembly of Oil Nozzle)

3.2.4 Inspection of Cylinder Block

3.2.4.1 Clean the cylinder block

- (1) Completely remove the gasket material remaining on the top surface of cylinder block using a scraper.
- (2) Thoroughly clean the cylinder block using a soft brush and solvent.

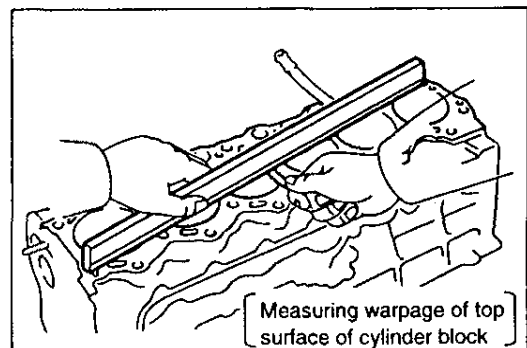


3.2.4.2 Measure warpage of the top surface of cylinder block

Measure warpage of the top surface of cylinder block using a precision straight edge and feeler gauge.

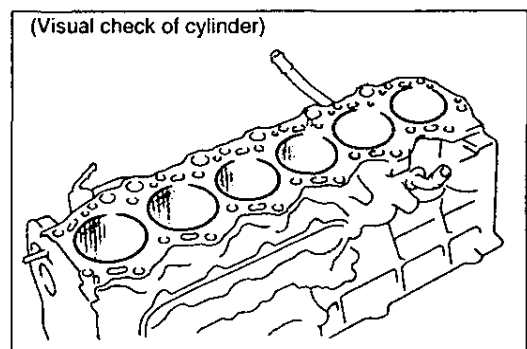
Maximum warpage: 0.20 mm

If the measured warpage exceeds the maximum, replace the cylinder block.



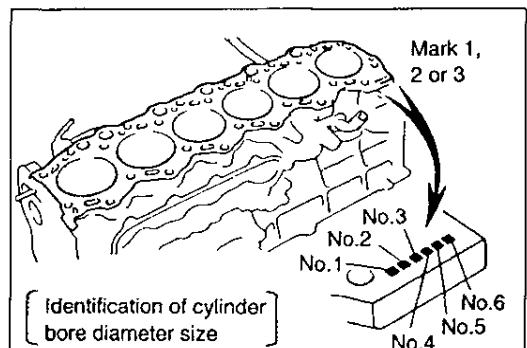
3.2.4.3 Visually check scratches of the cylinder in the vertical direction

Visually check the cylinder for vertical scratches. If deep scratches are discovered, rebores for the cylinder or replace as needed.



3.2.4.4 Measure the cylinder bore diameter

- There are three types of cylinders having different bore diameters, which are identified by markings of "1", "2" and "3" in the upper portion of the cylinder block.



Measure the cylinder bore diameter at points A, B and C in the thrust and axial directions, using a cylinder gauge.

Standard bore diameter:

Mark "1": 94.000 to 94.010 mm

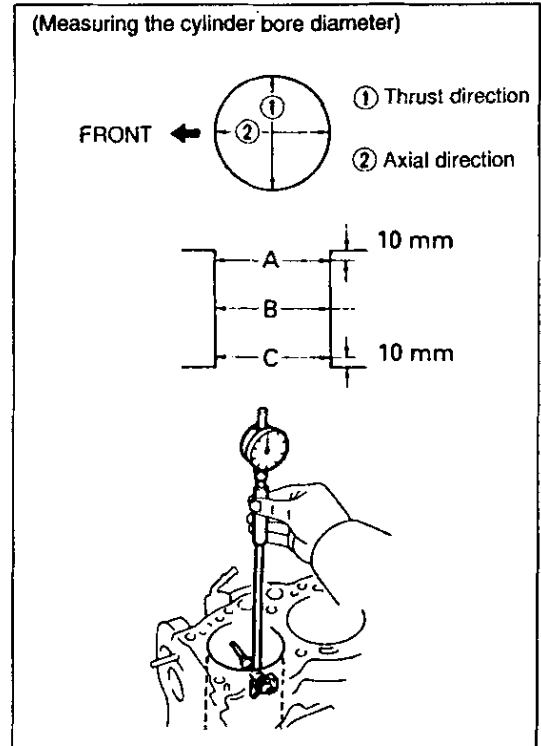
Mark "2": 94.010 to 94.020 mm

Mark "3": 94.020 to 94.030 mm

Maximum bore diameter:

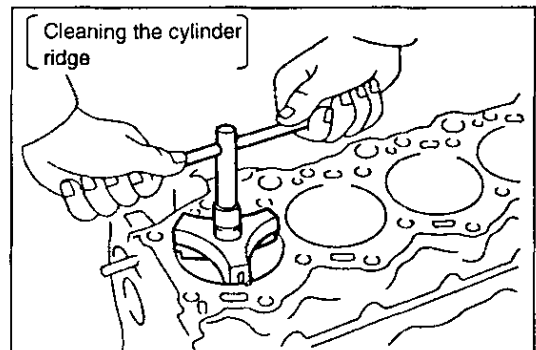
94.23 mm

If the measured bore diameter exceeds the specified maximum, rebore the cylinders, or replace as needed.



3.2.4.5 Clean the cylinder ridge

If the wear is less than 0.2 mm, using a ridge reamer, grind the cylinder upper portion.



3.2.4.6 Inspect the main bearing cap bolt

Measure outside diameter of the thread using calipers. Check for damaged or seized thread.

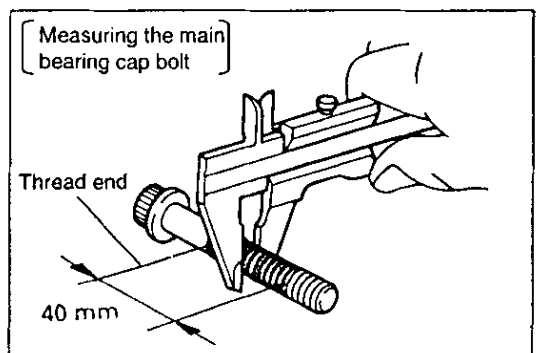
Standard outside diameter:

11.800 to 12.000 mm

Minimum outside diameter:

11.50 mm

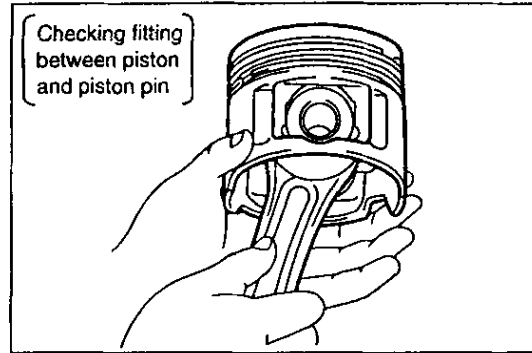
If the measured outside diameter is below the specified minimum, replace the bolt.



3.2.5 Disassembly of Piston and Connecting Rod

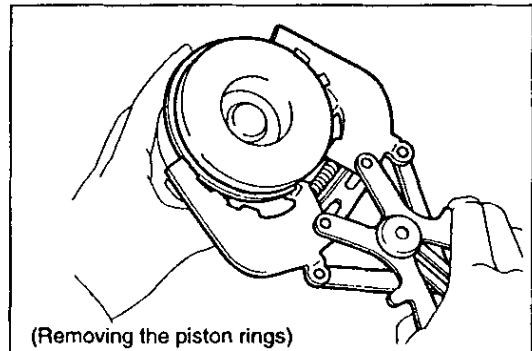
3.2.5.1 Check fitting between the piston and piston pin

Move the piston on the piston pin back and forth. If any movement is felt, replace the piston and piston pin as a set.



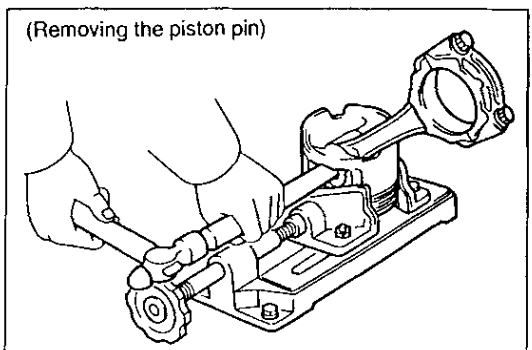
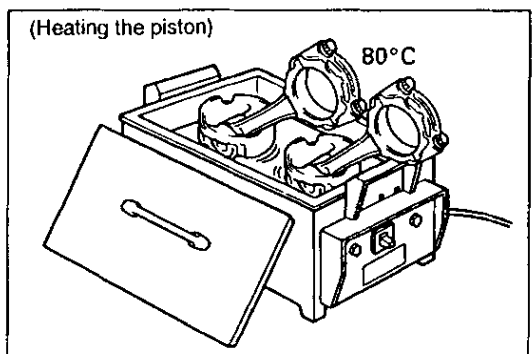
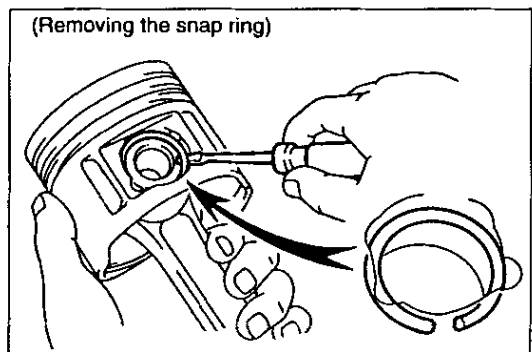
3.2.5.2 Remove the piston ring

- (1) Remove the piston rings using the piston ring expander.
- (2) Manually remove the coil for oil ring.
 - Store rings in a way their corresponding cylinders can be identified easily.



3.2.5.3 Remove the connecting rod from the piston

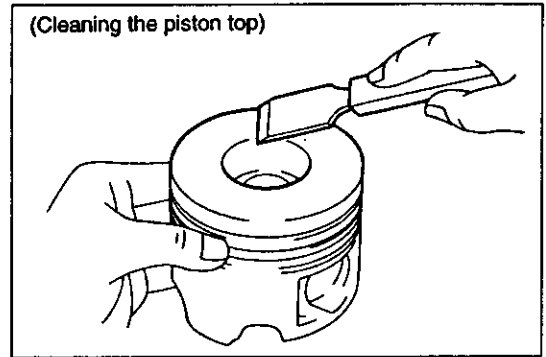
- (1) Pry out the snap ring using a small screwdriver to remove it from the piston.
- (2) Slowly heat the piston to about 80°C
- (3) Lightly tap out the piston pin using a plastic hammer and copper bar to disconnect the connecting rod.
 - Store the piston and pin as a set.
 - Store pistons, pins, rings and connecting rods in a way their corresponding cylinders can be identified easily.



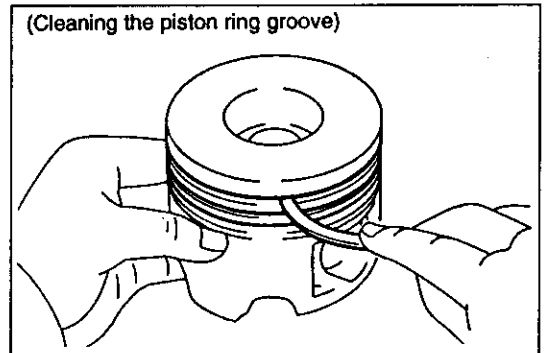
3.2.6 Inspection of Piston and Connecting Rod

3.2.6.1 Clean the piston

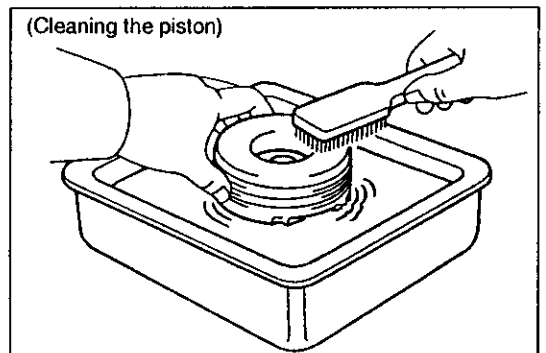
(1) Clean the carbon deposits off the piston top using a scraper.



(2) Clean the piston ring groove using the groove cleaning tool or a damaged ring.



(3) Completely clean the piston using a brush and solvent.



[NOTICE]

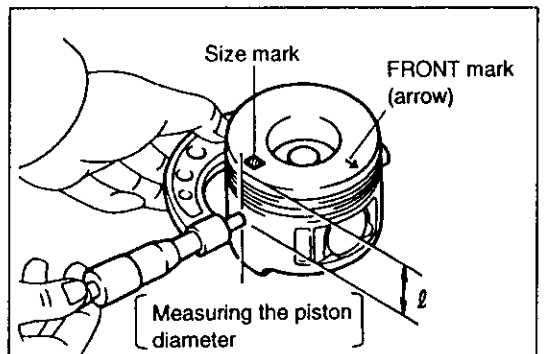
Do not use a wire brush.

3.2.6.2 Inspect the piston and piston ring

(1) Measure piston diameter and oil clearance.

- There are three types of pistons having different piston diameters, which are identified by marks "1", "2" and "3". The mark is stamped on the piston top.

1) Measure the piston diameter at right angle to the piston pin at an "ℓ" position from the piston top, using a micrometer.



• **Piston diameter**

	6LP-DTE series	6LP-STE series
Measurement position "ℓ"	65.7mm	66.4mm
Mark "1"	93.95 to 93.96 mm	93.835 to 93.845 mm
Mark "2"	93.96 to 93.97 mm	93.845 to 93.855 mm
Mark "3"	93.97 to 93.98 mm	93.855 to 93.865 mm

3. Engine Overhaul

- 2) Measure the cylinder bore diameter in the thrust direction. (See 3.2.4.3 Measure the cylinder bore diameter)
- 3) Subtract the piston diameter from the cylinder bore diameter.

6LP-DTE series

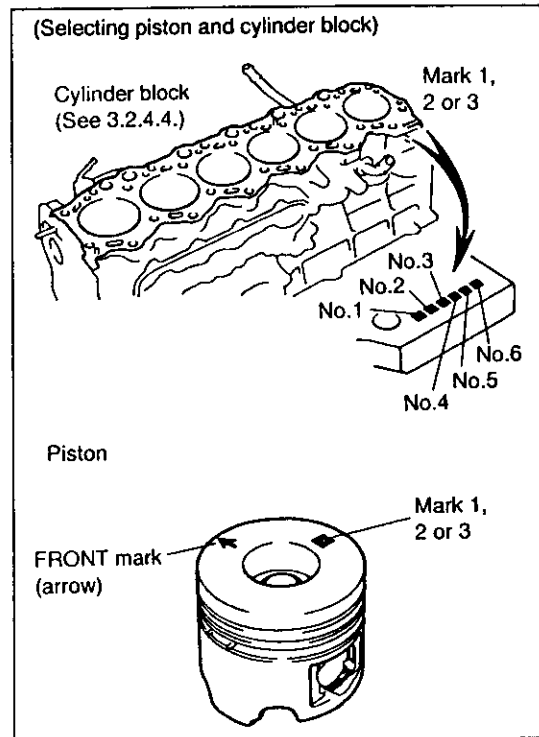
Standard oil clearance: 0.04 to 0.06 mm
Maximum oil clearance: 0.14 mm

6LP-STE series

Standard oil clearance: 0.145 to 0.165 mm
Maximum oil clearance: 0.215 mm

If the obtained oil clearance exceeds the specified maximum, replace all six pistons and carry out all six cylinders reboring. Or, replace faulty cylinder blocks as needed.

- Use a piston having the same mark number with that marked on the cylinder block whenever a new cylinder block is used.



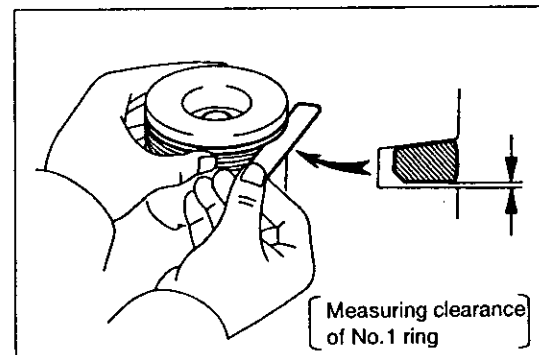
- (2) Measure clearance of the piston ring.

No.1 ring (top ring):

Install a new piston ring to the piston. Measure clearance between the piston ring and ring groove using the thickness gauge.

Standard clearance: 0.050 to 0.095 mm
Maximum clearance: 0.20 mm

If the measured clearance exceeds the specified maximum, replace the piston.

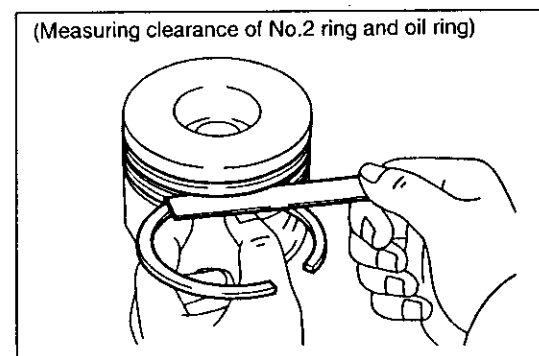


No.2 ring (second ring) and oil ring:

Measure clearance between the new piston ring and ring groove using a thickness gauge.

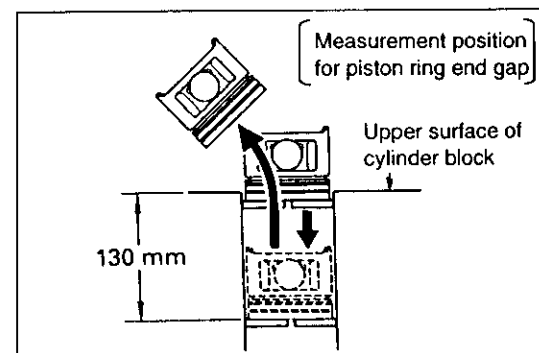
Standard clearance:
No.2 ring: 0.060 to 0.100 mm
Oil ring: 0.030 to 0.070 mm
Maximum clearance: 0.20 mm

If the measured clearance exceeds the specified maximum, replace the piston.



- (3) Measure the piston ring end gap.

- 1) Insert the piston ring in the cylinder.
- 2) Press in the piston ring to a position 130 mm from the cylinder block top surface, using the piston.



- 3) Measure the end gap using a thickness gauge.

Standard end gap:

- No.1 ring: 0.270 to 0.470 mm
- No.2 ring: 0.400 to 0.650 mm
- Oil ring: 0.200 to 0.500 mm

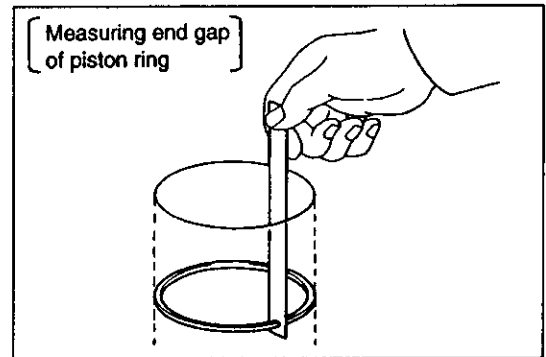
Maximum end gap:

6LP-DTE series:

- No.1 ring: 1.34 mm
- No.2 ring: 1.42 mm
- Oil ring: 1.32 mm

6LP-STE series:

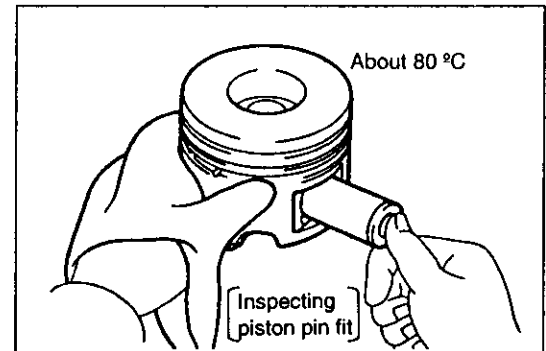
- No.1 ring: 0.85 mm
- No.2 ring: 0.90 mm
- Oil ring: 0.88 mm



If the end gap exceeds the specified maximum, replace the piston ring. If the end gap still exceeds the maximum even when a new piston ring is used, rebore all the six cylinders or replace the cylinder block.

3.2.6.3 Inspect the piston pin fit

The piston is acceptable if the piston pin can be pressed into the piston with your thumb after heating the piston to about 80°C.



3.2.6.4 Inspect the connecting rod

- (1) Measure the alignment of the connecting rod using rod aligner and thickness gauge.

- Measure bend of the connecting rod.

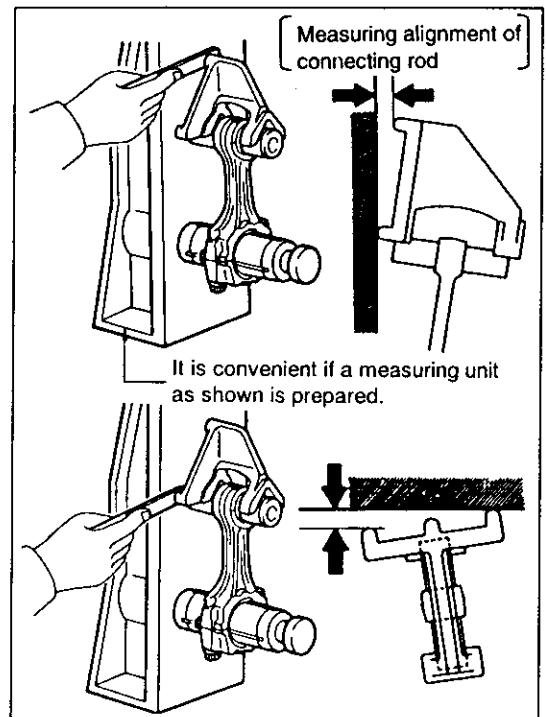
Maximum bend: 0.03 mm per 100 mm

If the measured bend exceeds the specified maximum, replace the connecting rod assy.

- Measure the twist of the connecting rod.

Maximum twist: 0.15 mm per 100 mm

If the measured twist exceeds the specified maximum, replace the connecting rod assy.



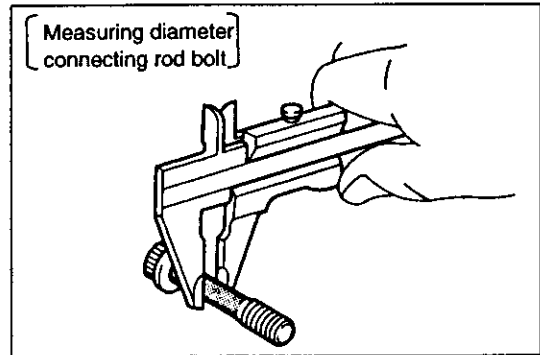
3. Engine Overhaul

- (2) Inspect the connecting rod bolt.
Measure the tension portion diameter using calipers.

Standard diameter: 8.300 to 8.400 mm

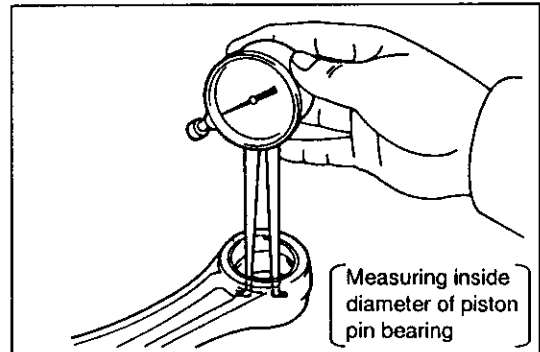
Minimum diameter: 7.95 mm

If the measured diameter is smaller than the specified minimum, replace the connecting rod bolt.



- (3) Inspect the oil clearance of the piston pin.
1) Measure inside diameter of the piston pin bearing using caliper gauge.

Inside diameter of piston pin bearing:
33.008 to 33.020 mm

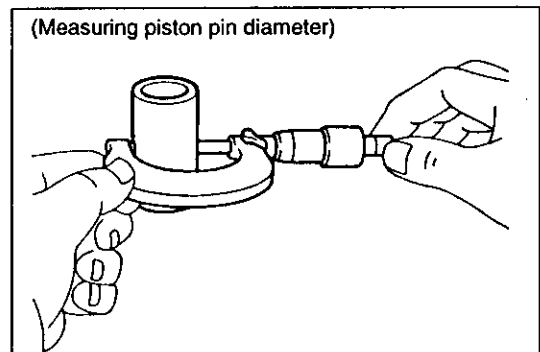


- 2) Measure the piston pin diameter using micrometer.

Piston pin diameter:
33.000 to 33.012 mm

- 3) Subtract the measured piston pin diameter from the measured inside diameter of the piston pin bearing.

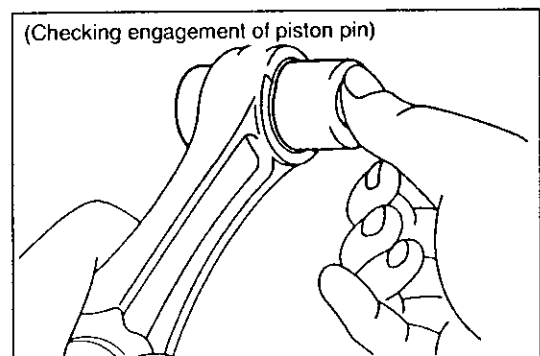
Standard oil clearance: 0.004 to 0.020 mm
Maximum oil clearance: 0.03 mm



If the measured oil clearance exceeds the specified maximum, replace the piston pin bearing. When necessary, replace the piston and piston pin as an assembly.

- (4) If the piston pin bearing needs to be replaced, replace by the connecting rod assembly.

- 1) Check the piston pin engagement at the normal temperature. Apply engine oil to the piston pin and press it into the connecting rod with your thumb.



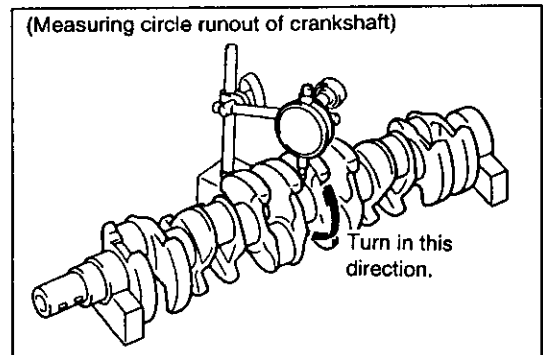
3.2.7 Inspection and Servicing of Crankshaft

3.2.7.1 Measure circle runout of the crankshaft

- (1) Set the crankshaft on a V-block.
- (2) Measure circle runout of the center journal using a dial indicator.

Maximum circle runout: 0.06 mm

If the circle runout exceeds the specified maximum, replace the crankshaft.



3.2.7.2 Inspect the crank journal and crank pin

- (1) Measure diameters of each crank journal and crank pin using a micrometer.

Standard crank journal diameter :

66.982 to 67.000 mm

Standard crank pin diameter :

58.982 to 59.000 mm

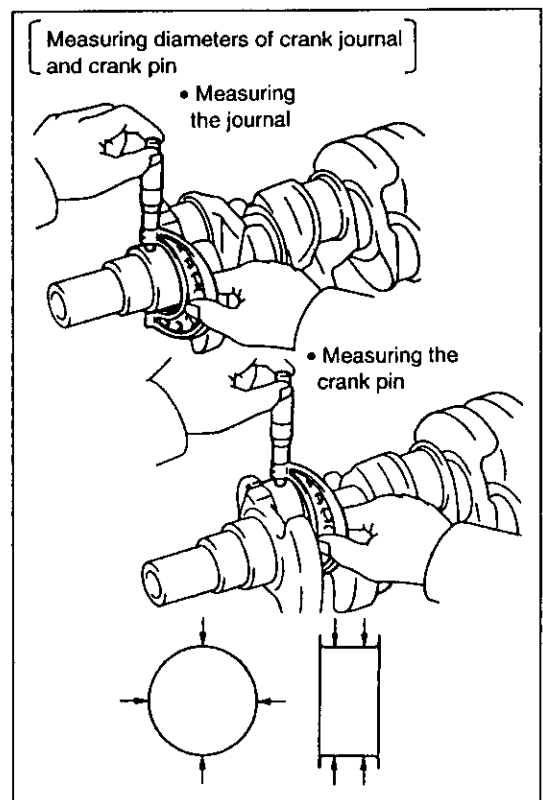
If the measured diameter is out of the specified range, check the oil clearance. Grind or replace the crankshaft as needed.

(See 3.2.3 Disassembly of Cylinder Block)

- (2) Measure the taper and out-of-round of the crank journal and crank pin.

Maximum taper and out-of-round: 0.020 mm

If the measured taper or out-of-round exceeds the specified maximum, replace the crankshaft.

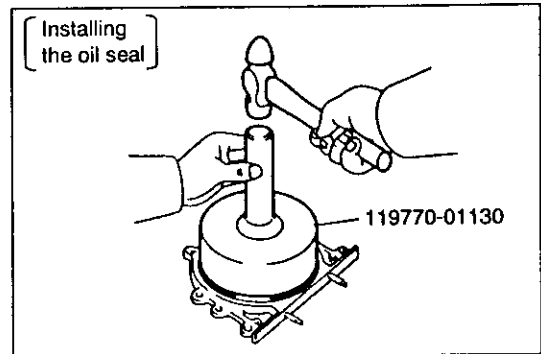
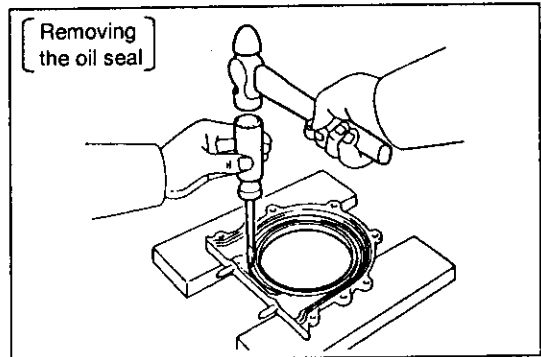


3.2.8 Replacement of Oil Seal for Crankshaft

- There are two oil seal replacement procedures as instructed in 3.2.8.1 and 3.2.8.2.

3.2.8.1 When the rear oil seal case has been removed from the cylinder block

- (1) Tap out the oil seal using a screwdriver and hammer.
- (2) Install a new oil seal by tapping it until its surface is level with that of the rear oil seal case.
- (3) Apply grease to the oil seal lip.

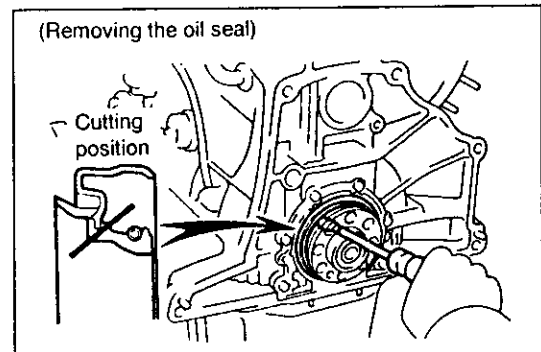


3.2.8.2 When the rear oil seal case is installed to the cylinder block

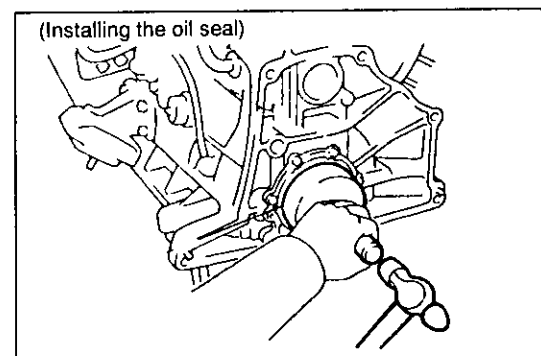
- (1) Cut off the oil seal lip using a knife.
- (2) Pry out the oil seal using a screwdriver.

[NOTICE]

***Be careful so as not to damage the crankshaft.
Tape the screwdriver tip.***



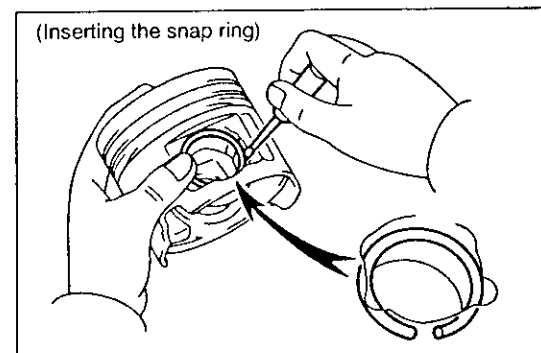
- (3) Apply grease to the new oil seal lip.
- (4) Tap in the oil seal until its surface is level with that of the rear oil seal case.



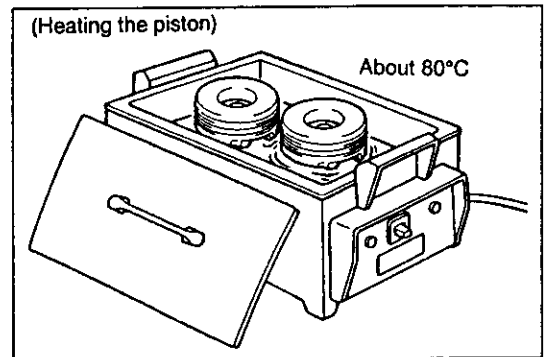
3.2.9 Assembly of Piston and Connecting Rod

3.2.9.1 Assemble the piston and connecting rod

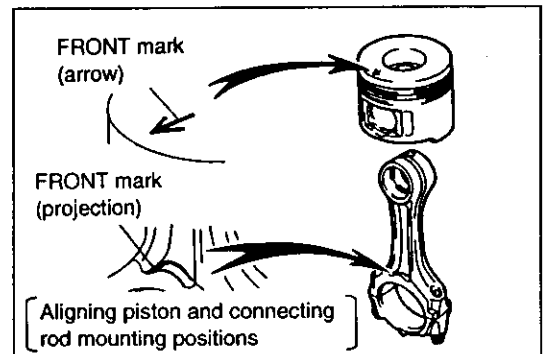
- (1) Install a new snap ring to one of the piston pin holes.



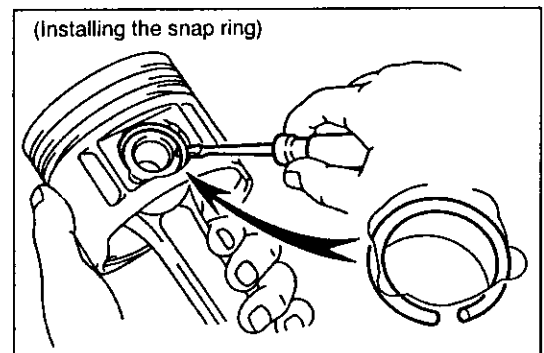
- (2) Slowly heat the piston to about 80°C.



- (3) Apply engine oil to the piston pin.
- (4) Align front marks of the piston and connecting rod and press in the piston pin by the thumb.

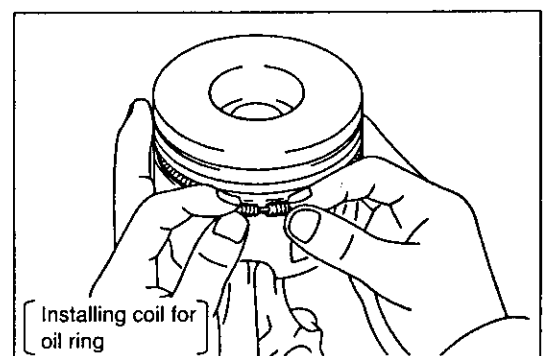


- (5) Install a new snap ring to the piston pin hole on the opposite side.

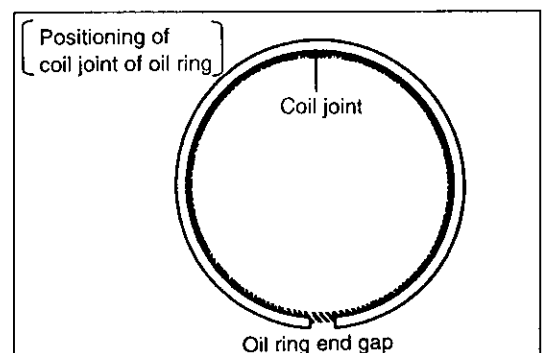


3.2.9.2 Install the piston ring

- (1) Manually install the coil for oil ring
- (2) Using the piston ring expander, install the oil ring.



- Install the oil ring so that the ring end faces the opposite side of the coil joint.



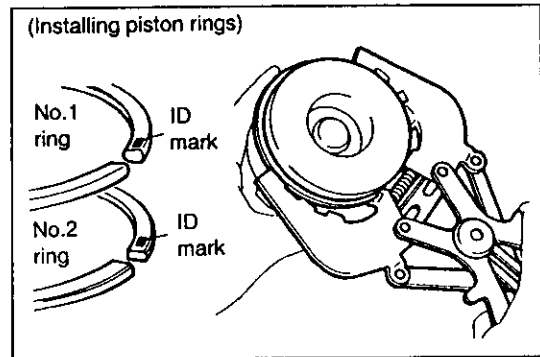
3. Engine Overhaul

- (3) Install the piston ring using the piston ring expander, in a way that the identification mark faces up.

ID mark:

No.1 ring: T1

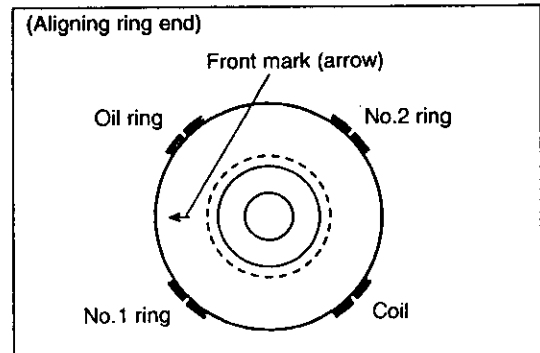
No.2 ring: 2T



- (4) Install the piston rings so that their ring ends are located as shown in the figure.

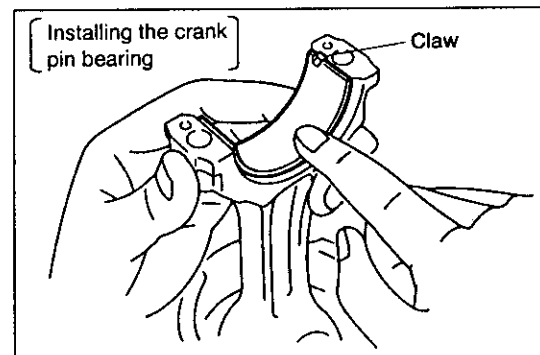
[NOTICE]

Pay attention so that ring ends are not overlapped at the same position.



3.2.9.3 Install the crank pin bearing

- (1) Align the bearing claw with the groove in connecting rod or connecting rod cap.
- (2) Install the bearing to the connecting rod and connecting rod cap.



3.2.10 Assembly of Cylinder Block

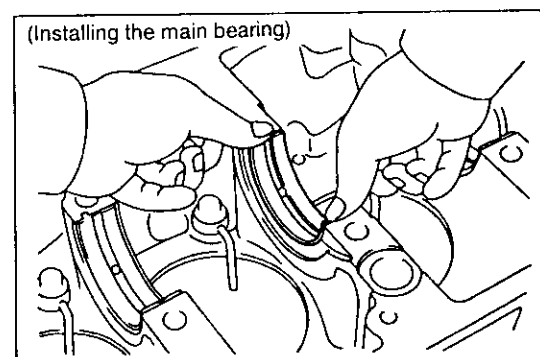
- Clean all parts before assembly.
- Apply new engine oil to all sliding and rotating surfaces before beginning assembly.
- Replace all gaskets, O-rings and oil seals with new ones.

3.2.10.1 Install the oil nozzle and check valve for the piston cooling (See 3.20.3 Installation of Oil Nozzle)

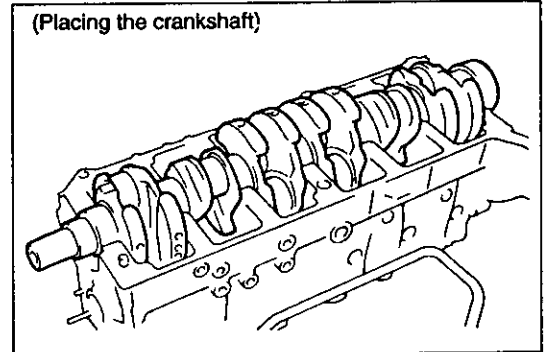
3.2.10.2 Install the main bearing

The oil groove and hole are provided to the upper bearing, which are not provided to the lower bearing.

- (1) Align the bearing claws with the groove in the cylinder block and press in seven upper bearings.
- (2) Align the bearing claws with the groove in the main bearing cap and press in seven lower bearings.

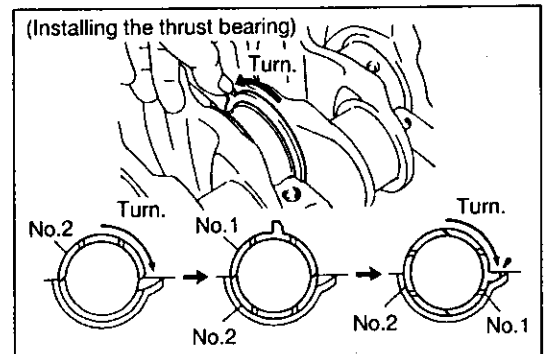


3.2.10.3 Place the crankshaft on the cylinder block



3.2.10.4 Install the thrust bearing

- (1) Push the crankshaft towards the front or rear.
- (2) Install four thrust bearings to journal No.4 of the cylinder block in a way the oil groove faces outwards.



3.2.10.5 Install the main bearing cap

- (1) Place the main bearing cap on the cylinder block.
 - 1) Completely remove the adhering packing material.

[NOTICE]

Pay attention so as not to contaminate with any oil the contact surfaces of the main bearing cap and cylinder block.

- Clean all components and remove foreign matter completely.
- Clean the sealing surface using clean solvent.

- 2) Apply the seal packing to the cylinder block as shown.

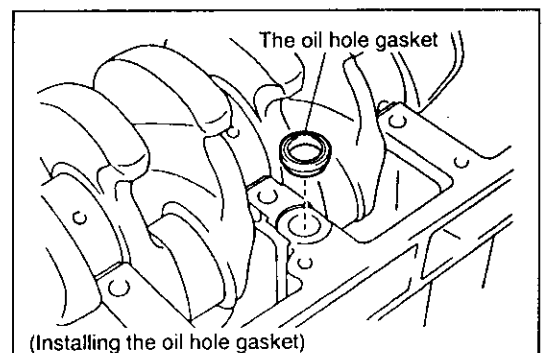
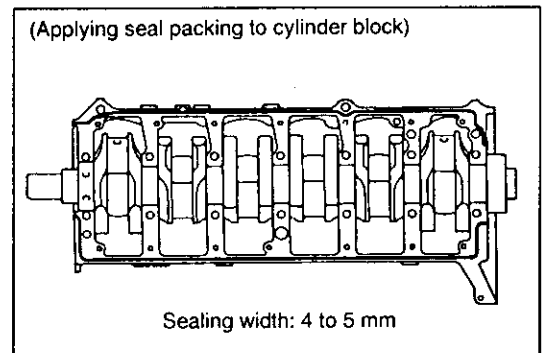
- Use a nozzle cut to a sealing width of 4 to 5 mm for applying the seal packing.
- Parts must be assembled within 5 minutes after the seal packing is applied. Otherwise, the packing material must be removed and then applied again.
- Disconnect the nozzle from the tube immediately after use and protect by the cap.

(Seal packing: TOYOTA P/N 08826-00080
or equivalent)

- 3) Install a new oil hole gasket.
- 4) Place the main bearing cap on the cylinder block.

- (2) Install the main bearing cap bolt (12 pointed head).

- Tighten the main bearing cap bolts in two steps.
- If any one of main bearing cap bolts is broken or deformed, replace it.



3. Engine Overhaul

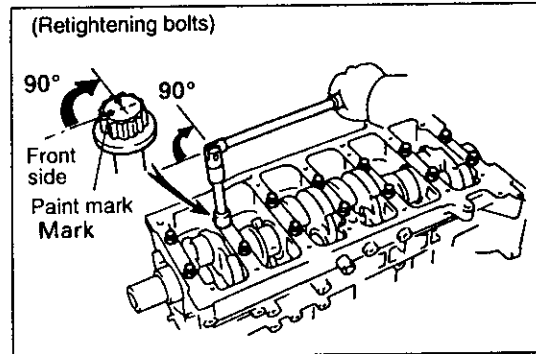
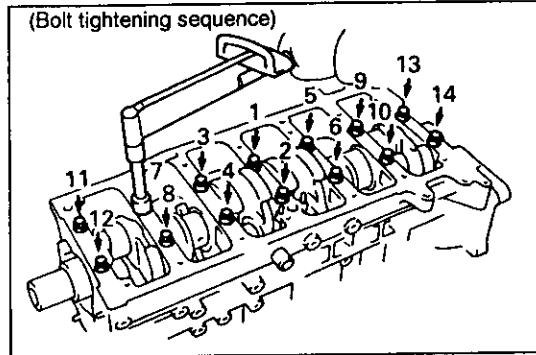
- 1) Apply engine oil to the threaded portion and seat surface of the main bearing cap bolts.
- 2) Install the 14 main bearing cap bolts as instructed below, and uniformly tighten them in several passes in the sequence shown.

Tightening torque:

1050 kgf·cm (102.90 N·m)

If any one of main bearing cap bolts fails to satisfy the torque specification, replace the main bearing cap bolts.

- 3) Paint marks on the front of main bearing cap bolt heads.
- 4) Retighten all bolts by 90° in the numerical order shown in the figure.
- 5) Check that all paint marks are facing at 90° to the front direction.
- 6) Check that the crankshaft rotates smoothly.

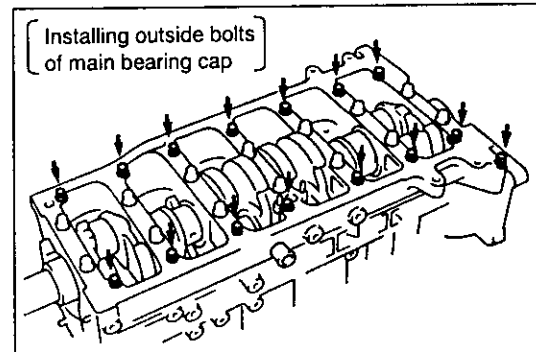


- (3) Install the outside main bearing cap bolts (6 pointed head), totaling 15 bolts.

Tightening torque: 185 kgf·cm (18.13 N·m)

3.2.10.6 Inspect the thrust clearance of the crankshaft

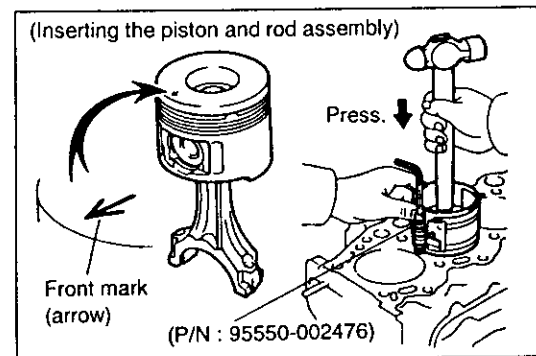
(See 3.2.3.5 Inspect the thrust clearance of the crankshaft)



3.2.10.7 Install the piston and connecting rod assembly

Press in the piston and connecting rod assembly, corresponding to each cylinder, using the piston ring compressor (YANMAR P/N: 95550-002476) so that the front mark of the piston faces to the front.

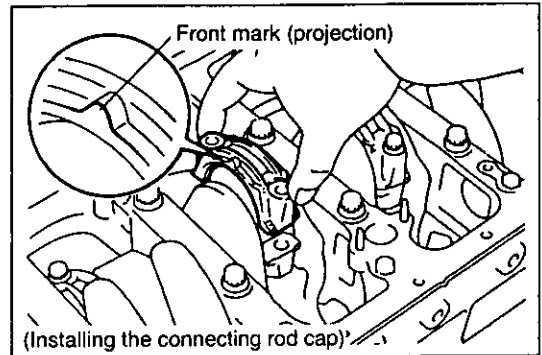
Note: Place the cylinder block horizontally to easily install piston and connecting rod assembly. Install the crankshaft pulley temporarily so as not to rotate crankshaft freely. (Use tool P/N 119770-01090, - 01120)



Over size piston	719773-22100	Piston 0.5 mm over size CMP	Ring set	6LP-DTE series
	719775-22100	Piston 0.5 mm over size CMP	Ring set	6LP-STE series

3.2.10.8 Install the connecting rod cap

- (1) Install the connecting rod cap to each connecting rod.
- 1) Make sure to use the connecting rod cap corresponding to each cylinder.
 - 2) Install in a way the front mark of the connecting rod cap faces to the front.



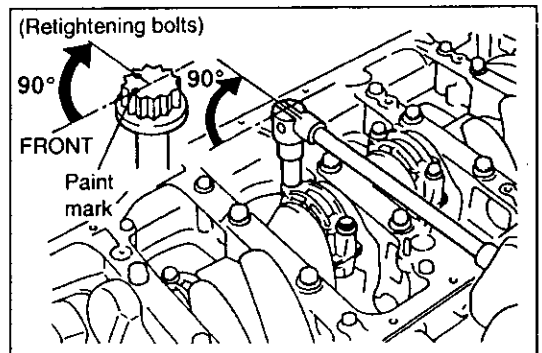
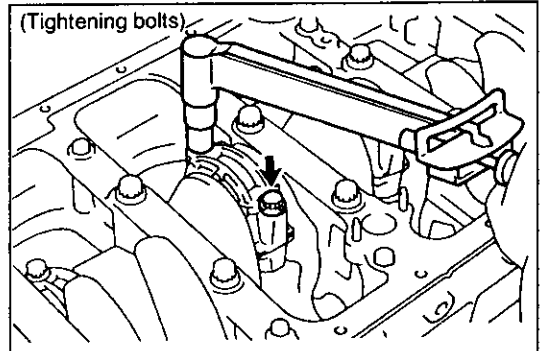
- (2) Install the connecting rod cap bolt.
- Install connecting rod cap bolts in two steps.
 - If only one of main bearing cap bolts is broken or deformed, replace it.
- 1) Apply engine oil to threaded portions and seats of connecting rod cap bolts.
 - 2) Install connecting rod cap bolts and tighten them alternately in several passes.

Tightening torque:

375 kgf·cm (36.77 N·m)

If any one of connecting rod cap bolts fails to satisfy the torque specification, replace the cap bolt.

- 3) Mark with a paint at the front side of the connecting rod cap bolt head.
- 4) Retighten the connecting rod cap bolt by 90° as shown.
- 5) Check that the paint mark is at a right angle to the front.
- 6) Check that the crankshaft rotates smoothly.

**3.2.10.9 Check the connecting rod thrust clearance**

(See 3.2.3.2 Check the connecting rod thrust clearance)

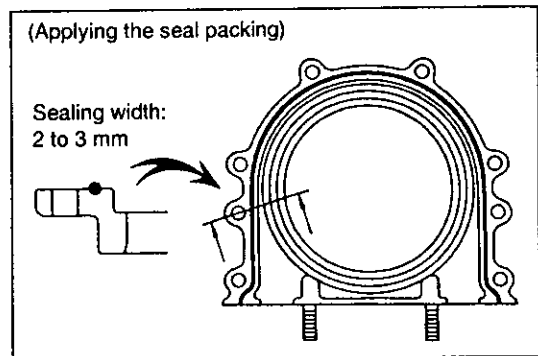
3.2.10.10 Install the rear oil seal case

- 1) Completely remove the adhering packing material.

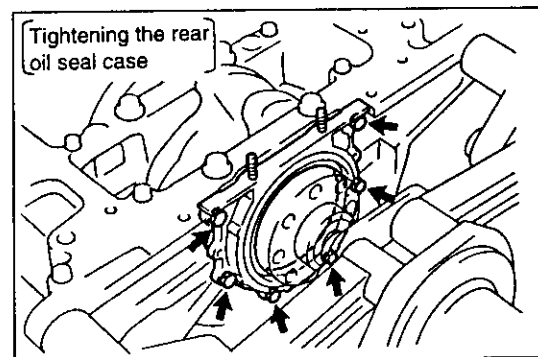
[NOTICE]

Pay attention so as not to contaminate with any oil the contact surface of the seal case and cylinder block.

- Completely remove the packing material from the case surface and seal groove using a razor blade and gasket scraper.
- Clean all components and remove all foreign matter.
- Clean the both sealing surfaces using solvent.
(Seal packing: TOYOTA P/N 08826-00080 or equivalent)



- 2) Apply the seal packing to the case as shown.
 - Use a nozzle cut to a sealing width of 2 to 3 mm for applying the seal packing.
 - Avoid supplying excessive amount of seal packing to the surface.
 - Parts must be assembled within 5 minutes after the seal packing is applied. Otherwise, the packing material must be removed and then applied again.



- Disconnect the nozzle from the tube immediately after use and protect by the cap.
- 3) Install the case using 6 bolts.
Tightening torque: 65 kgf·cm (6.37 N·m)

3.2.11 Next Assembly**3.2.11.1 Install the engine mounting bracket**

Tightening torque: 700 kgf·cm (68.65 N·m) (M12), 500 kgf·cm (49.10 N·m) (M10)

3.2.11.2 Install the timing gear case

(See 3.18.4 Reassembly of Oil Pump, 3.18.5 Installation of Oil Pump)

3.2.11.3 Install the oil pan

(See 3.18.5.4 Install the oil pan)

3.2.11.4 Install the rear end plate

Tightening torque: 185 kgf·cm
(18.14 N·m)

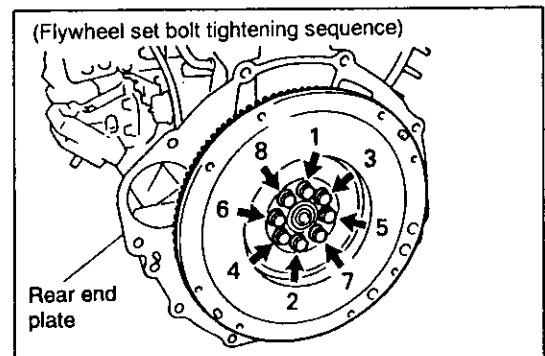
3.2.11.5 Install the flywheel

Tighten the bolts uniformly in several passes,
in the sequence shown.

Tightening torque: 1300 kgf·cm (127.40 N·m)

**3.2.11.6 Install the flywheel housing
by tightening the set bolts**

Tightening torque: 185 kgf·cm (18.13 N·m)

**3.2.11.7 Upside down the engine and place
it on the engine stand****3.2.11.8 Install the thermostat**

(See 3.15.3 Installation of Thermostat)

3.2.11.9 Install the alternator and bracket assembly

Tightening torque: 700 kgf·cm (68.60 N·m)

3.2.11.10 Install the fresh water pump

(See 3.13.3 Installation of Fresh Water Pump)

3.2.11.11 Install the cylinder head

(See 3.1.7 Installation of Cylinder Head)

3.2.11.12 Install the timing belt and pulley

(See 3.3.4 Installation of Timing Belt)

3.2.11.13 Remove the engine from the engine stand**3.2.11.14 Install the turbocharger oil pipe****3.2.11.15 Install the oil cooler assembly, oil dipstick and guide**

(See 3.19.3 Installation of Oil Cooler)

3.2.11.16 Install the sender units and warning switches**3.2.11.17 Install the fuel injection pump**

(See 3.11.3 Installation of Fuel Injection Pump)

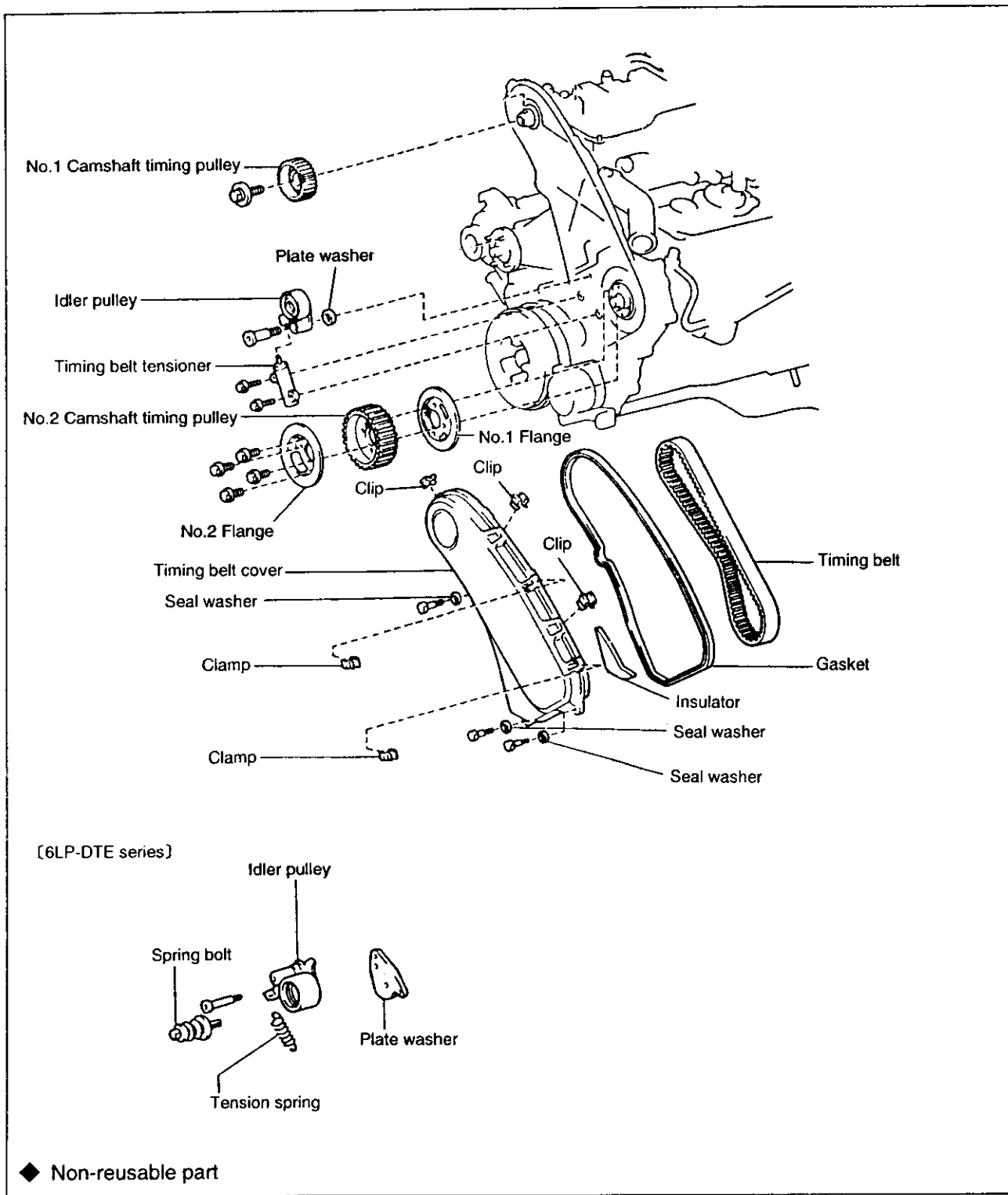
3.2.11.18 Install the sea water pump

(See 3.14 Sea Water Pump)

3.2.11.19 Install the lube oil filter

3.3 Timing Belt

3.3.1 Components



3.3.2 Removal of Timing Belt

3.3.2.1 Remove the timing belt cover

- (1) Remove the 3 clips.
- (2) Remove the 3 bolts, 3 seal washers, timing belt cover, gasket and insulator.

3.3.2.2 Set the No.1 cylinder at the bottom dead center (BDC)

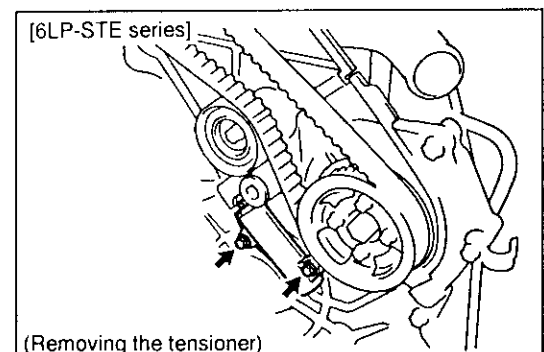
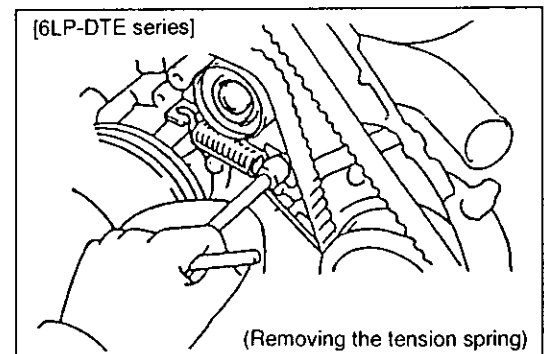
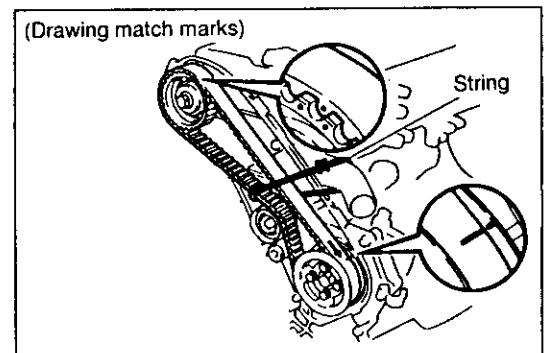
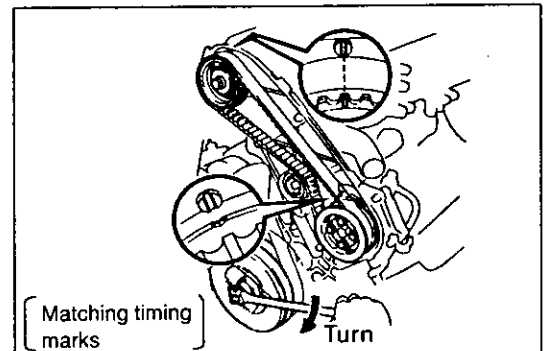
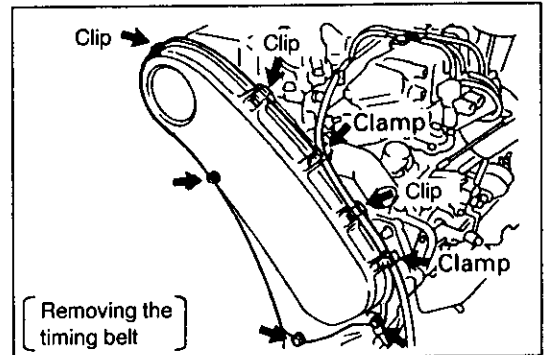
Turn the crankshaft pulley clockwise to align timing marks of camshaft timing pulleys No.1 and No.2 with the BDC mark.

[NOTICE]

If the timing belt is disengaged, the angle of crankshaft pulley becomes improper and, as a result, the piston head and intake/exhaust valve heads may be damaged because of interference during removal of the camshaft timing pulley. Make sure to always set the crankshaft pulley at the correct angle.

3.3.2.3 Remove the timing belt

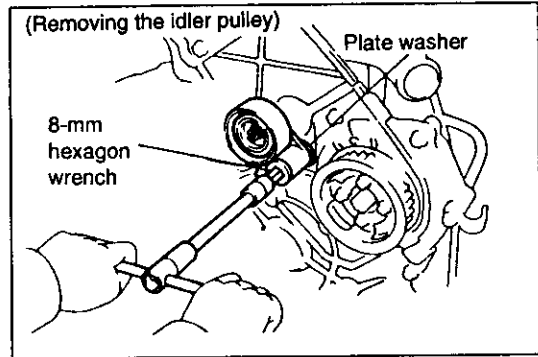
- **When the timing belt is reused**
Draw an arrow mark on the timing belt, indicating the operation direction (engine revolution direction) and then match marks both on the timing pulley and timing belt.
 - **When replacing the timing belt tensioner only (6LP-STE series)**
Secure the belt by string so that the engagement between the timing pulley and timing belt will not be disconnected.
- (1) Alternately loosen the two bolts to remove them, and then remove the timing belt tensioner.
 - (2) Remove the timing belt.



3. Engine Overhaul

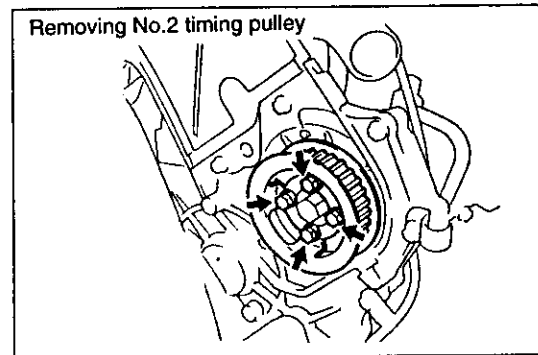
3.3.2.4 Remove the idler pulley

Remove the pivot bolt, idler pulley and plate washer using an 8 mm hexagon wrench.



3.3.2.5 Remove No.2 camshaft timing pulley

Remove the four bolts, No.2 flange, timing pulley and No.1 flange.

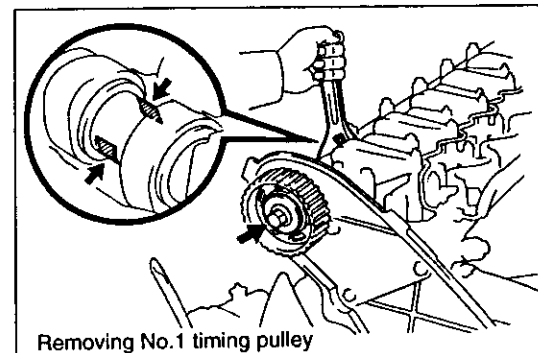


3.3.2.6 Remove the bonnet

(See 3.1.2.7 Remove the bonnet)

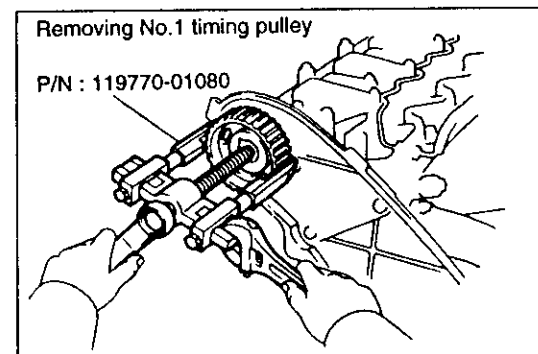
3.3.2.7 Remove No.1 camshaft timing pulley

(1) Slightly turn the camshaft timing pulley counter-clockwise and hold the hexagon wrench head portion of the camshaft with a wrench, and remove the bolt and timing pulley.



(2) Remove No.1 timing pulley using the gear puller.

(3) Remove the set key.

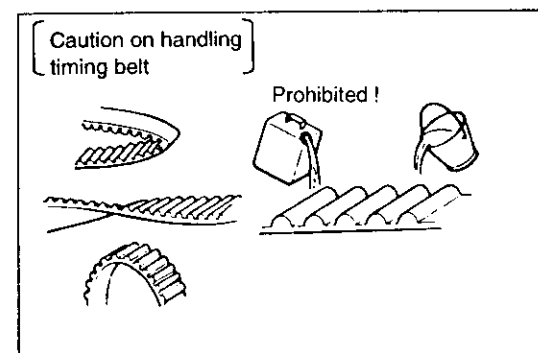


3.3.3 Checking of Timing Belt

3.3.3.1 Check the timing belt

[NOTICE]

- Do not bend, twist or turn the timing belt inside out.
- Do not contaminate the timing belt with oil, water or steam.



If defects as shown in the figure are discovered, take the necessary action as instructed below.

- (1) When the joint is premature parting
 - Check the timing belt cover and gasket for damage. Also, check if they are installed correctly.

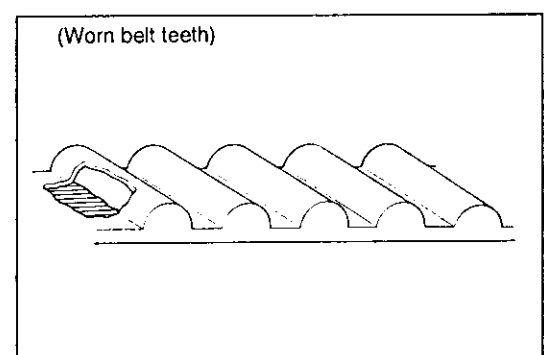
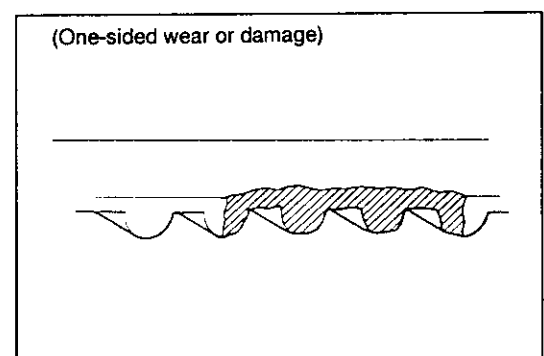
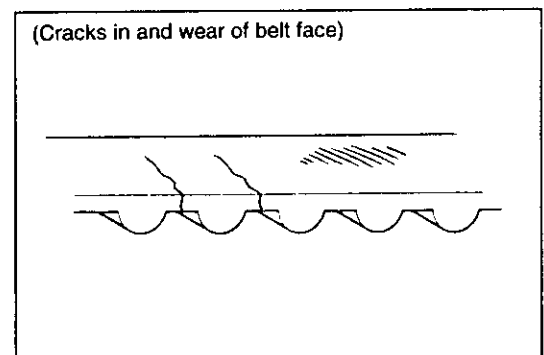
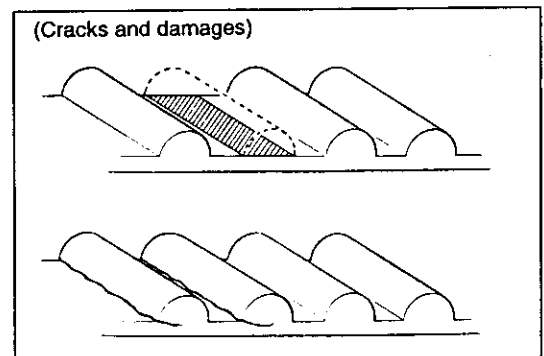
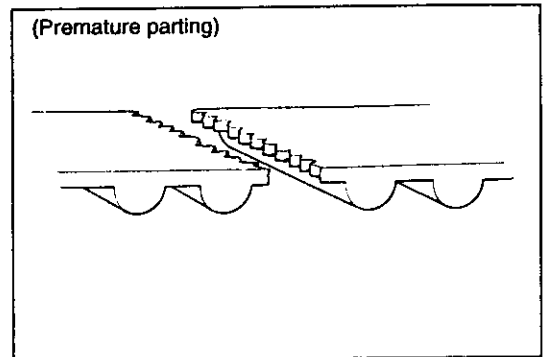
- (2) If the belt teeth are cracked or damaged, check for locked camshaft.

- (3) If the belt face is cracked or worn, check the idler pulley for nicks on the side.

- (4) If only one side of the belt is worn or damaged, check each timing pulley for center deviation, inclination or deviation in the axial direction.

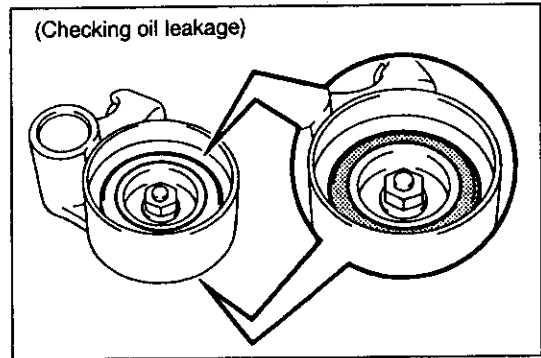
- (5) If the belt teeth are worn, check the timing belt cover for damage. Also, check if the gasket is installed correctly. Further, check pulley teeth for contamination with dust.

If needed, replace the timing belt.

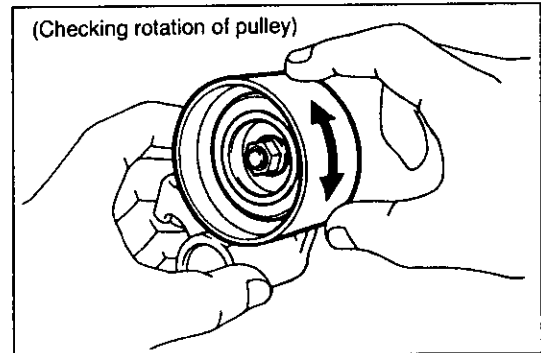


3.3.3.2 Inspect the idler pulley

- (1) Visually check the seal portion. If oil leakage is found, replace the idler pulley.



- (2) Check if the idler pulley rotates smoothly. If needed, replace the idler pulley.



3.3.3.3 Inspect the tension spring and tensioner

[For 6LP-DTE series]

- (1) Measure free length of the tension spring.

Free length: 72.7 mm

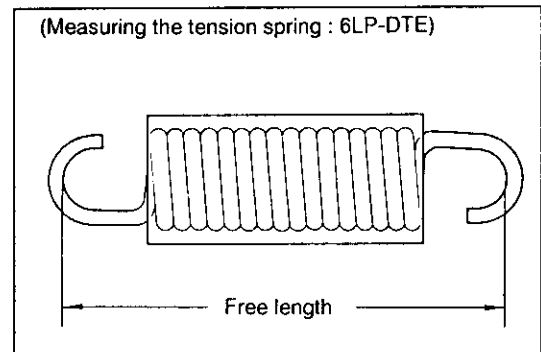
If the free length does not satisfy the specification, replace the tension spring.

- (2) Install the spring at the specified length and measure tension of the tension spring.

Tension upon mounting:

23 to 28 kgf (225.40 to 274.40 N) at 90.1 mm

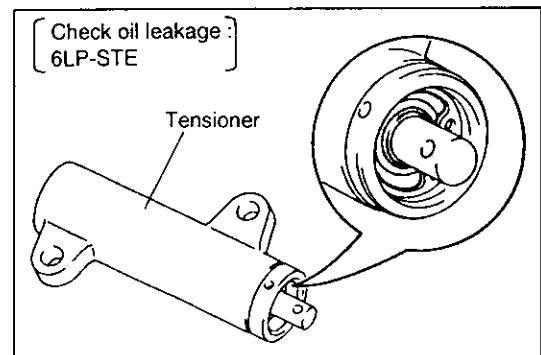
If the tension upon mounting does not satisfy the specification, replace the tension spring.



[For 6LP-STE series]

- (1) Visually check the tensioner seal portion for oil leak.

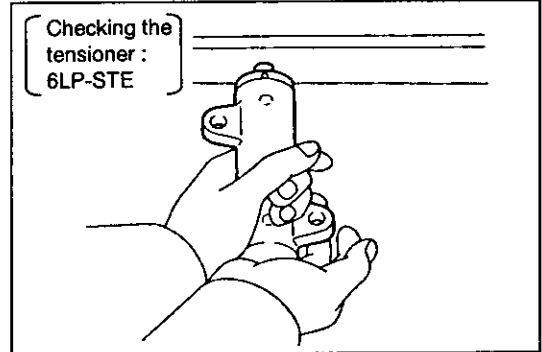
- If no trace of oil leak is discovered at all on the push rod side of the oil seal, the tensioner is normal.
- If oil leak is discovered, replace the tensioner.



- (2) Hold the tensioner by both hands and strongly push the push rod to check that it does not move. If it moves, replace the tensioner.

[NOTICE]

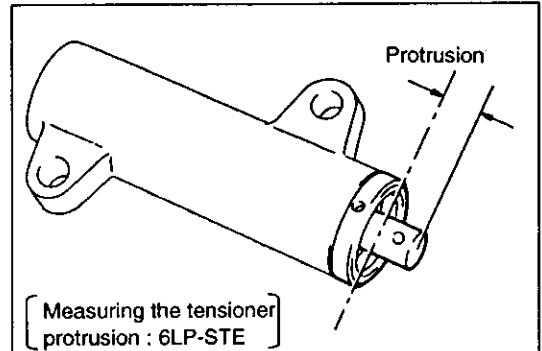
Never hold the tensioner push rod in the downwards direction.



- (3) Measure the push rod protrusion from the end of housing.

Protrusion: 9.0 to 9.8 mm

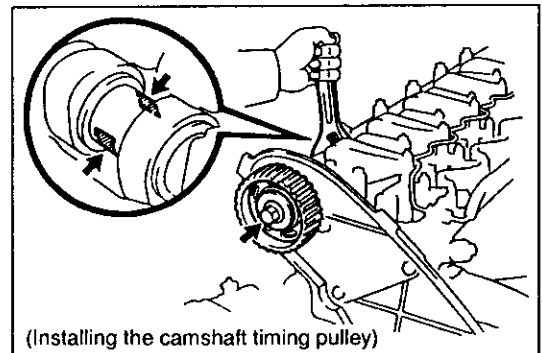
If the measured value does not fall in the specified range, replace the tensioner.



3.3.4 Installation of Timing Belt

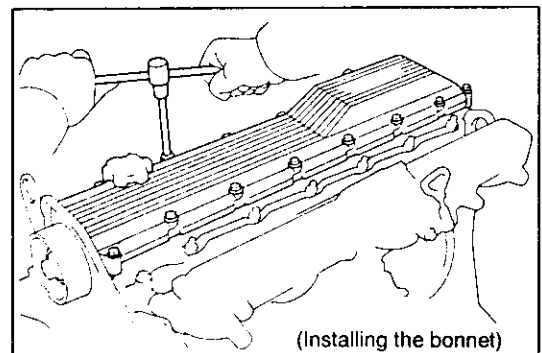
3.3.4.1 Install No.1 camshaft timing pulley

- (1) Install the set key to the key groove in the camshaft.
- (2) Press in the timing pulley, aligning to the key groove.
- (3) Temporarily tighten the pulley bolt.
- (4) Secure the hexagon wrench head portion of camshaft by a wrench and tighten the pulley bolt.
Tightening torque: 1000 kgf·cm (98.00 N·m)



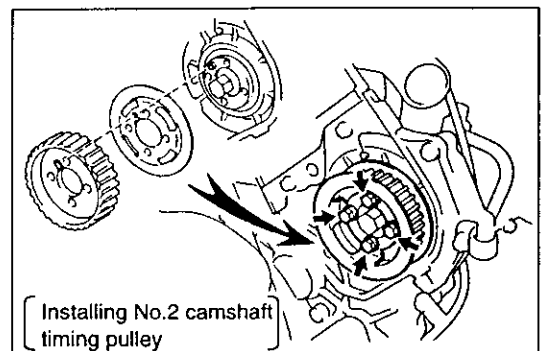
3.3.4.2 Install the bonnet

- (1) Completely remove adhering packing material.
- (2) Apply the seal packing to 3 positions of the cylinder head.
(See 3.1.7.10 Install the bonnet)
- (3) Install the gasket to the cylinder head cover.
- (4) Install the bonnet using new seal washers and bolts. Uniformly tighten the bolts in several passes.
Tightening torque: 65 kgf·cm (6.37 N·m)



3.3.4.3 Install No.2 camshaft timing pulley

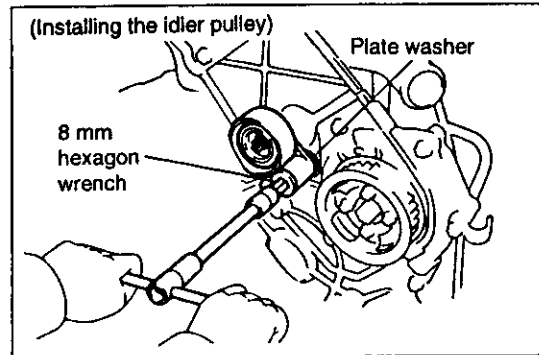
- (1) Align the knock pin on the injection pump drive gear with the knock pin hole of No.1 flange and that of the timing pulley.
- (2) Install the No.1 flange, timing pulley and No.2 flange using four bolts.
Tightening torque: 315 kgf·cm (30.87 N·m)



3. Engine Overhaul

3.3.4.4 Install the idler pulley

- (1) Install the plate washer and idler pulley by the pivot bolt, using an 8 mm hexagon wrench.
 - Tightening torque
 - 6LP-DTE series: 270 kgf·cm (26.48 N·m)
 - 6LP-STE series: 350 kgf·cm (34.32 N·m)
- (2) Check that the pulley bracket moves smoothly.

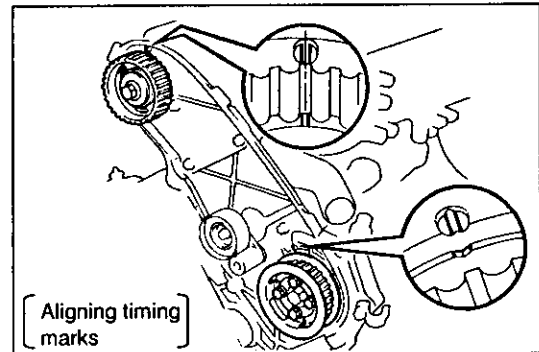


3.3.4.5 Set the No.1 cylinder to the bottom dead center (BDC)

- (1) Check that the timing mark of No.2 camshaft timing pulley matches with the bottom dead center (BDC) mark.

[NOTICE]

Do not turn the camshaft pulley. Otherwise, the valve head will interfere with the piston top.



- (2) Align the timing mark of No.1 camshaft timing pulley to the bottom dead center (BDC) mark.

3.3.4.6 Install the timing belt

[NOTICE]

Install when the engine is cooled down.

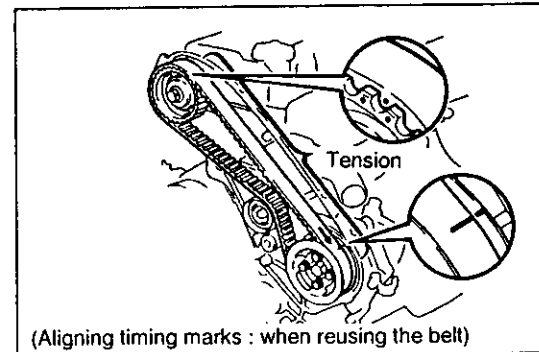
When reusing the timing belt:

Install the timing belt by aligning the mark marked before removal and the arrow mark to the engine revolution direction.

- (1) Clean by wiping oil and water off the pulley.

[NOTICE]

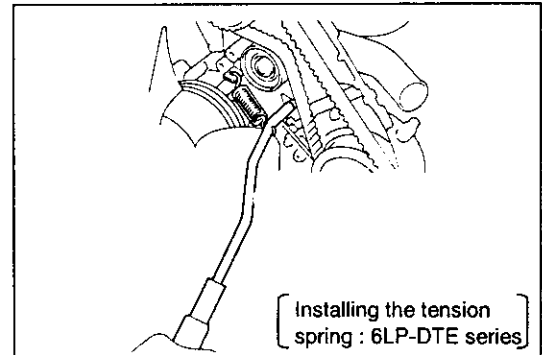
Clean merely by wiping without using detergent.



- (2) Install the idler pulley between No.1 and No.2 camshaft timing pulleys.

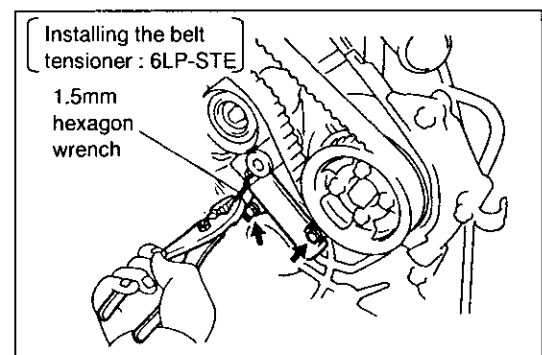
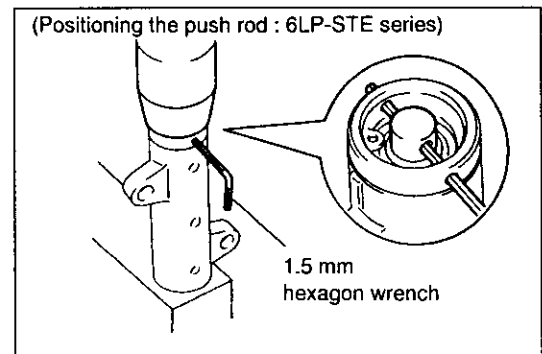
3.3.4.7 Install the tension spring (6LP-DTE series)

- (1) Install the tension spring.
- (2) Install the spring bolt of the idler pulley.
Tightening torque: 270 kgf·cm (26.48 N·m)



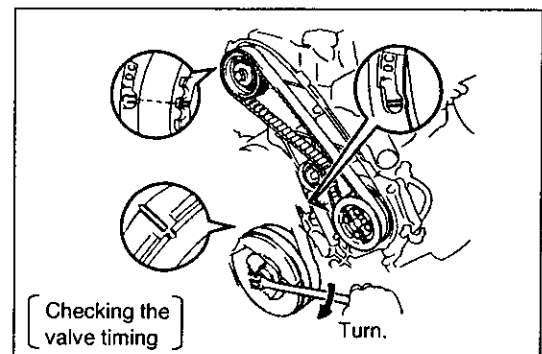
3.3.4.8 Install the timing belt tensioner (6LP-STE series)

- (1) Using a press, slowly press in by applying 100 to 1,000 kgf (980.67 to 9806.65 N) force to the push rod.
- (2) Align the push rod to the hole in the housing and carry out positioning of the push rod by passing a 1.5 mm hexagon wrench through the hole.
- (3) Release the force.
- (4) Temporarily secure the timing belt tensioner using 2 bolts, while pressing the idler pulley onto the timing belt.
- (5) Alternately tighten the two bolts.
Tightening torque: 130 kgf·cm (12.74 N·m)
- (6) Disconnect the 1.5 mm hexagon wrench from the tensioner.



3.3.4.9 Inspect the valve timing

Turn the crankshaft pulley clockwise to check if each pulley timing mark matches with the top dead center (TDC) mark. If not, disconnect the timing belt and reinstall it.

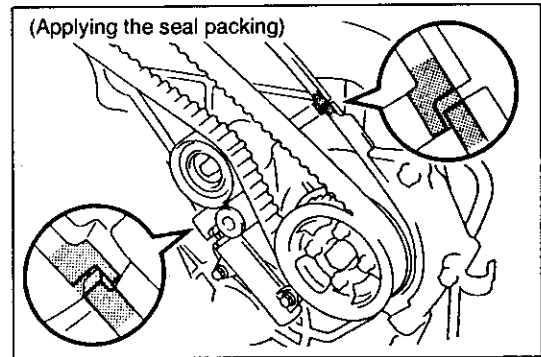


3. Engine Overhaul

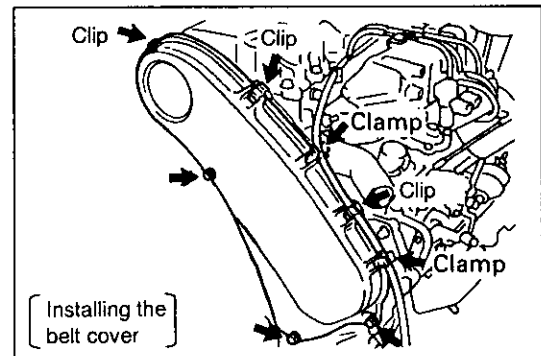
3.3.4.10 Install the timing belt cover

- (1) Completely remove adhering packing material.
- (2) Apply the seal packing to the camshaft oil seal retainer and timing belt cover as shown.

(Seal packing: TOYOTA P/N 08826-00080
or equivalent)

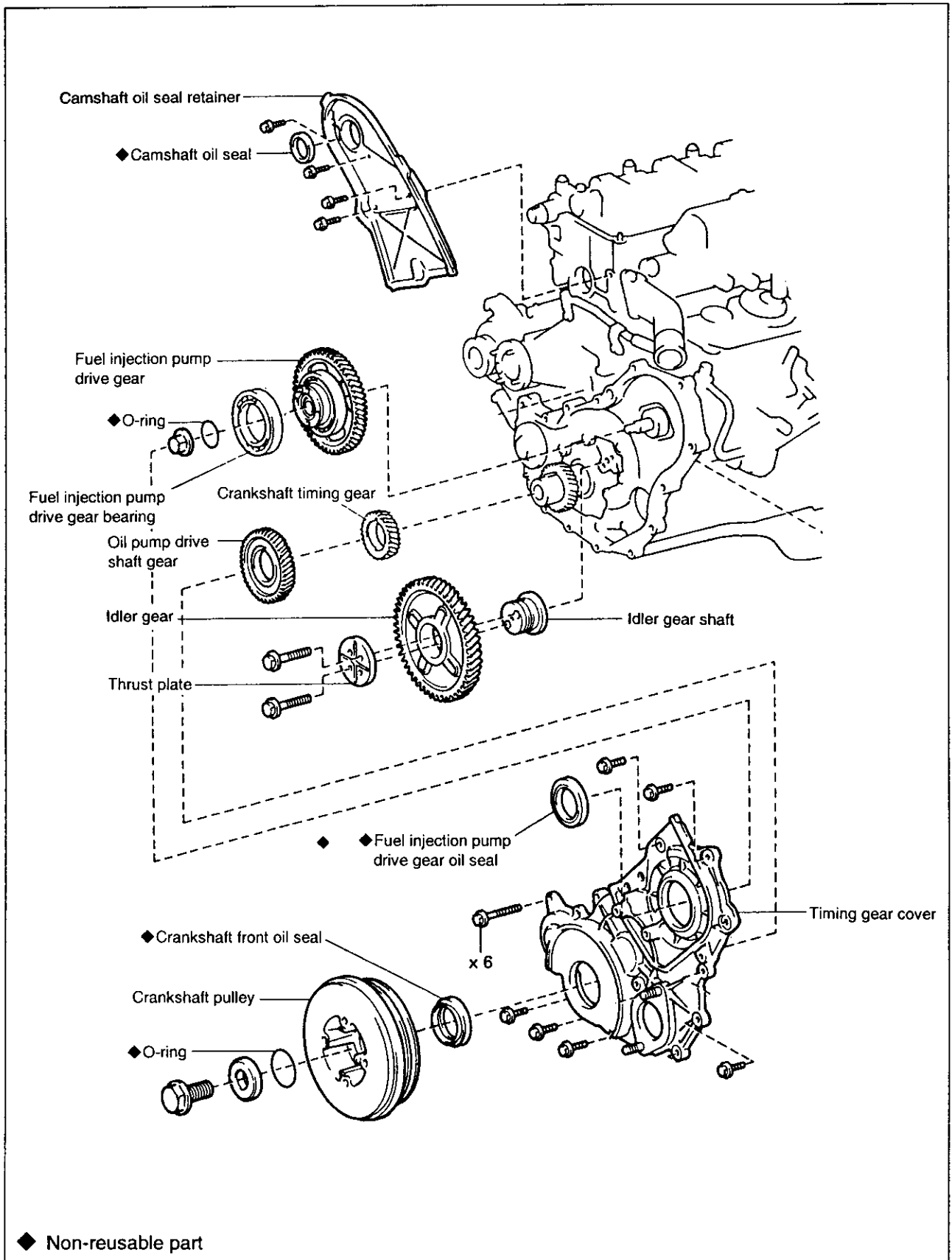


- (3) Install the insulator to the timing belt cover.
- (4) Install the gasket to the timing belt cover.
- (5) Install the timing belt cover by 3 seal washers, 3 belts and 3 clips.



3.4 Timing Gear

3.4.1 Components



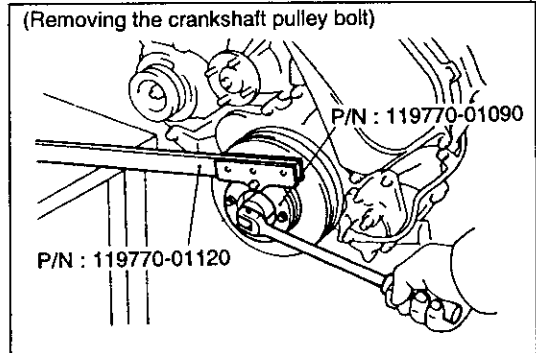
3. Engine Overhaul

3.4.2 Removal of Timing Gear

3.4.2.1 Remove the V-belt for driving the fresh water pump and alternator
(See 3.13.1.7 Remove the fresh water pump)

3.4.2.2 Loosen the crankshaft pulley

Loosen the pulley bolt.



[NOTICE]

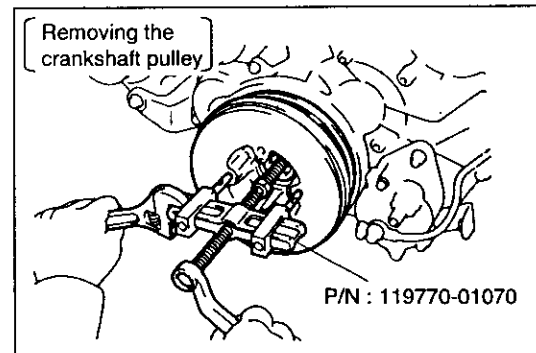
If the timing belt is disengaged, the crankshaft angle becomes inappropriate, making it possible to damage the piston head and valve head by contacting with each other when removing the camshaft timing pulley.

Pay full attention to secure the bolt when removing the crank pulley bolt, since it was tightened to a large tightening torque of 50 kgf·m (490.33 N·m) for the DTE series or 44 kgf·m (431.50 N·m) for the STE series

3.4.2.3 Remove the timing belt and pulley
(See 3.3.2 Removal of Timing Belt)

3.4.2.4 Remove the camshaft oil seal retainer
(See 3.1.2.10 Remove the camshaft oil seal retainer)

- Remove the viscous damper.
- Remove the fresh water pump pulley.



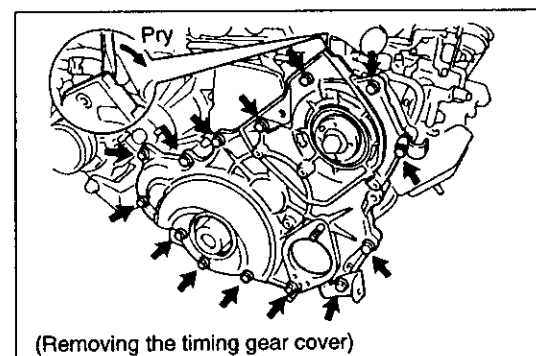
3.4.2.5 Remove the crankshaft pulley

(1) Remove the pulley bolt and plate washer.

[NOTICE]

Do not turn the crankshaft pulley. Otherwise, the valve heads may contact with the piston

- (2) Remove the crankshaft pulley.
(3) Remove the O-ring from the crankshaft pulley.



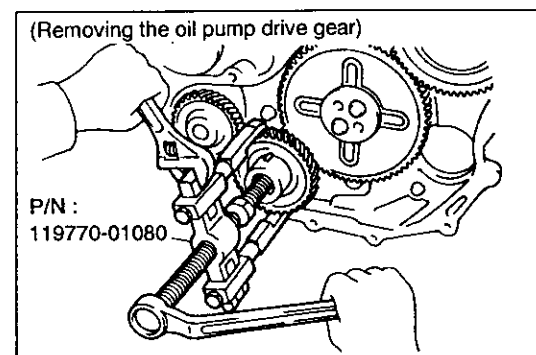
3.4.2.6 Remove the alternator adjusting bar

3.4.2.7 Remove the timing gear cover

- (1) Remove 14 bolts.
(2) Pry out the timing gear cover.

3.4.2.8 Remove the oil pump drive shaft gear

Remove the drive shaft gear from the crankshaft.



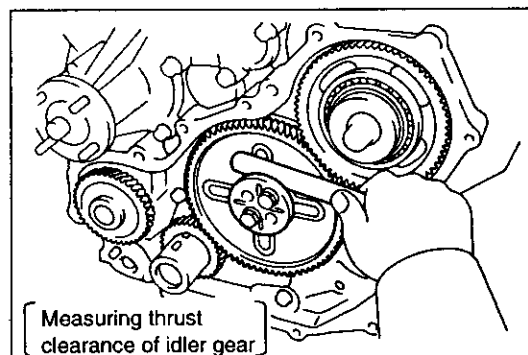
3.4.2.9 Inspect thrust clearance of the idler gear

Measure the thrust clearance using a feeler gauge .

Standard thrust clearance: 0.05 to 0.15 mm

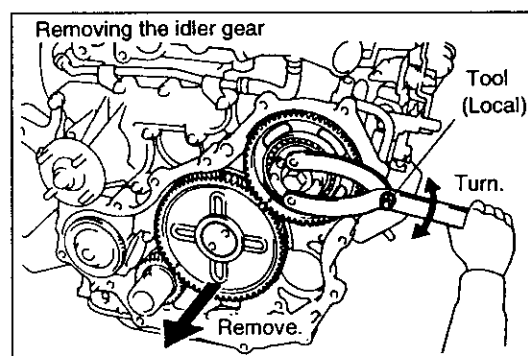
Maximum thrust clearance: 0.30 mm

If the measured thrust clearance exceeds the specified maximum, replace the thrust plate. Also, replace the idler gear and idler gear shaft as needed.



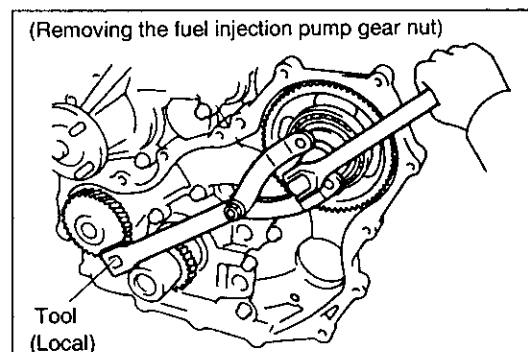
3.4.2.10 Remove the idler gear

- (1) Remove the 2 bolts and the thrust plate.
- (2) Turn the fuel injection pump drive gear in both directions to remove the idler gear.
- (3) Remove the idler gear shaft.

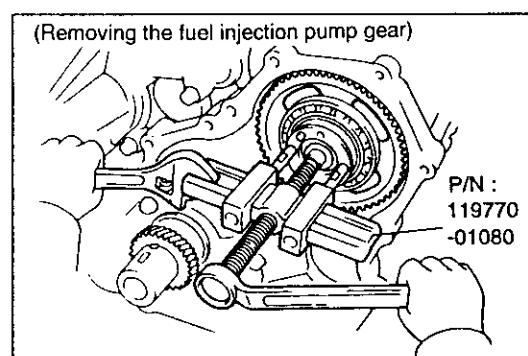


3.4.2.11 Remove the fuel injection pump drive gear

- (1) Loosen the gear nut.
- (2) Remove the gear nut together with the O-ring.

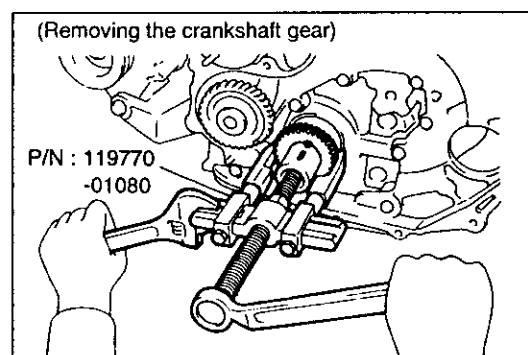


- (3) Remove the drive gear using the gear puller.



3.4.2.12 Remove the crankshaft timing gear

Remove the timing gear using the gear puller.



3.4.3 Inspection of Timing Gear

3.4.2.1 Check the idler gear

- (1) Measure inside diameter of the idler gear using the cylinder gauge.

Inside diameter of idler gear:
45.000 to 45.025 mm

- (2) Measure outside diameter of the idle gear shaft using a micrometer.

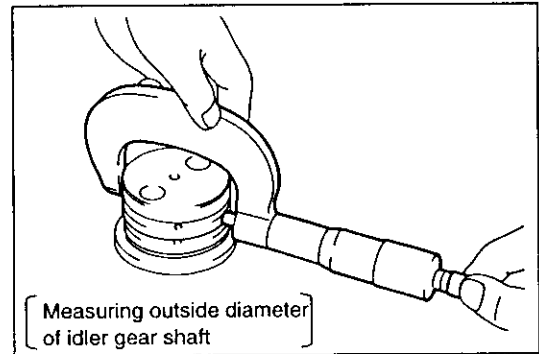
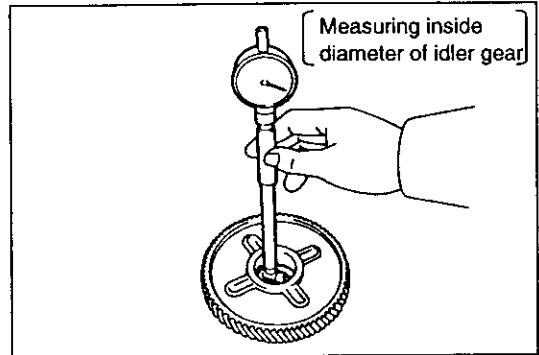
Outside diameter of idle gear shaft:
44.950 to 44.975 mm

- (3) Subtract the outside diameter of idler gear shaft from the measured inside diameter of idle gear.

Standard oil clearance: 0.025 to 0.075 mm

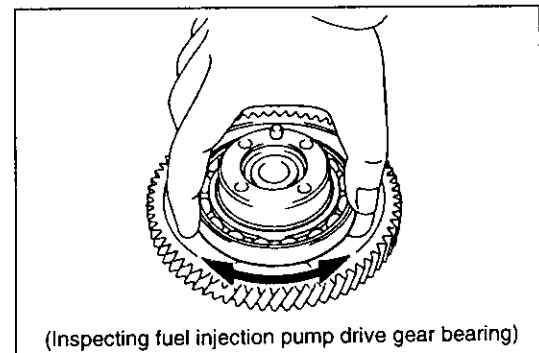
Maximum oil clearance: 0.20 mm

If the measured value exceeds the specified maximum, replace the gear and shaft.



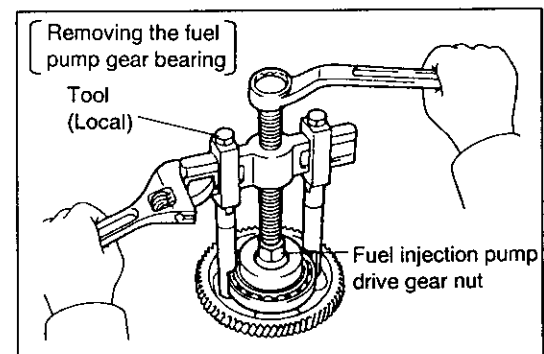
3.4.3.2 Check the fuel injection pump drive gear bearing

Check the bearing for wear and the gear bearing for play.

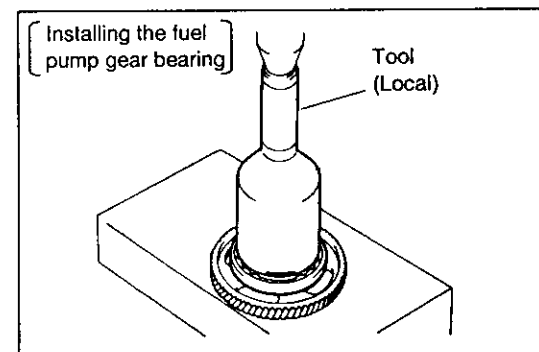


3.4.3.3 Replace the fuel injection pump drive gear bearing, as needed

1. Remove the bearing.



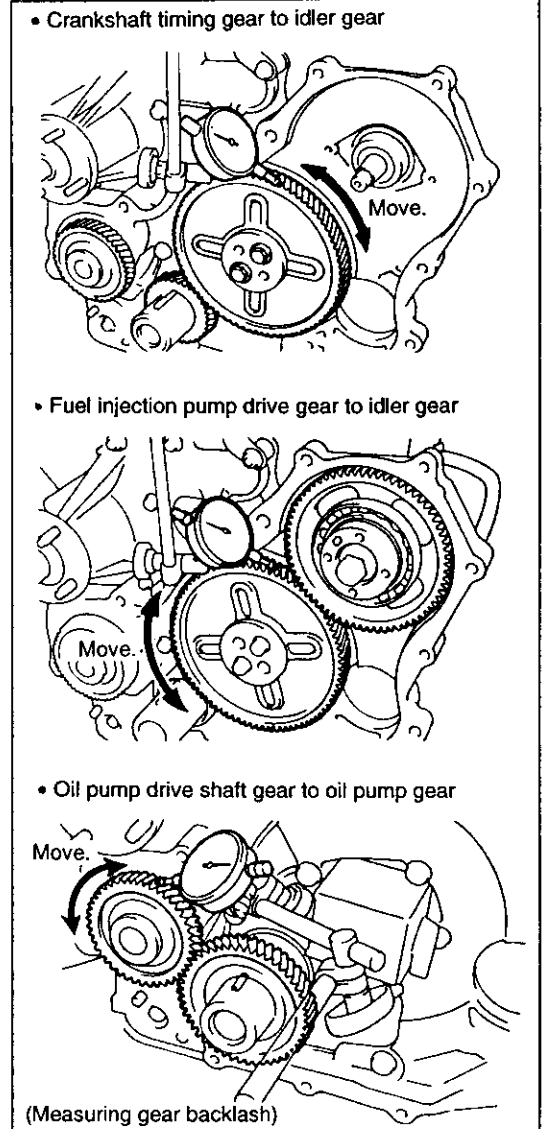
2. Install the bearing.
Press in a new bearing to install.



3.4.3.4 Inspect backlash of the timing gear

- (1) Install the timing gears.
- (2) Measure the backlash using a dial indicator.
 - Standard gear backlash: 0.05 to 0.15 mm
 - Maximum gear backlash: 0.30 mm

If the measured gear backlash exceeds the specified maximum, replace gears as a set.
- (3) Remove the timing gears.



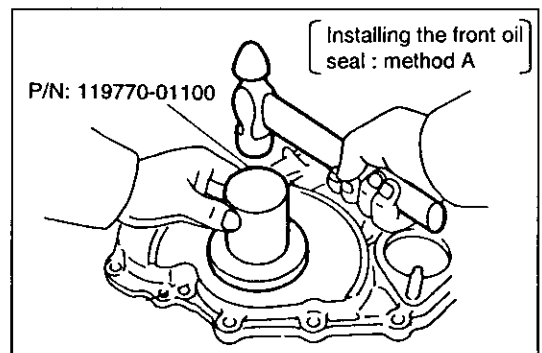
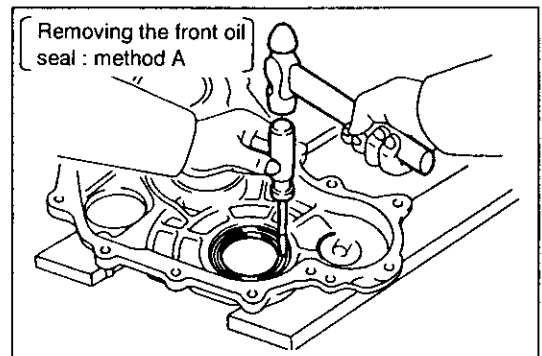
3.4.4 Replacement of Crankshaft Front Oil Seal

- There are the following two oil seal replacement methods (A and B).

3.4.4.1 Replace the crankshaft front oil seal

A. When the timing gear cover has been removed from the cylinder block

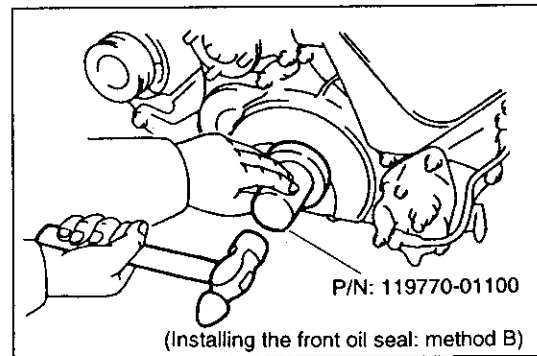
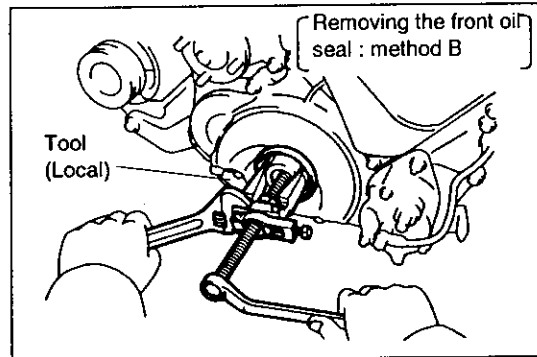
- (1) Tap out the oil seal using a screwdriver and hammer.
- (2) Tap in a new oil seal to install, until the surface is level with that of the timing gear cover.
- (3) Apply grease to the oil seal lip.



3. Engine Overhaul

B. When the timing gear cover is installed to the cylinder block

- (1) Remove the oil seal.
- (2) Apply grease to the lip of a new oil seal.
- (3) Tap in the oil seal to install, until its surface is level with that of the timing gear cover.



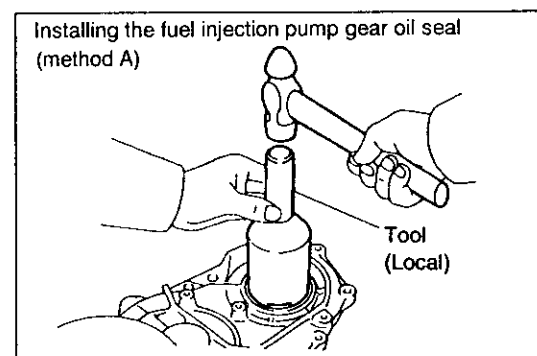
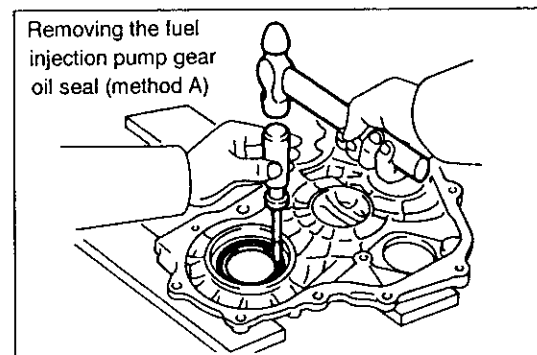
3.4.5 Replacement of Fuel Injection Pump Drive Gear Oil Seal

- There are the following two oil seal replacement methods (A and B).

3.4.5.1 Replace the fuel injection pump drive gear oil seal

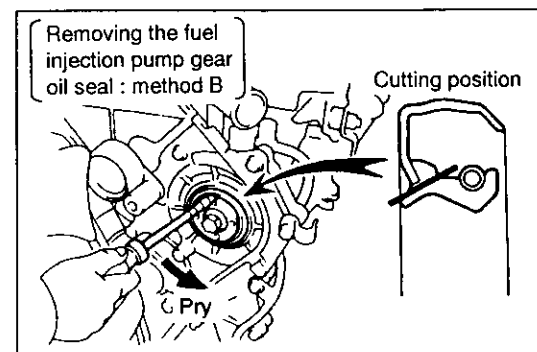
A. When the timing gear cover has been removed from the cylinder block

- (1) Tap out the oil seal using a screwdriver and hammer.
- (2) Tap in a new oil seal to install, until the surface is level with that of the timing gear cover.
- (3) Apply grease to the oil seal lip.



B. When the timing gear cover is installed to the cylinder block

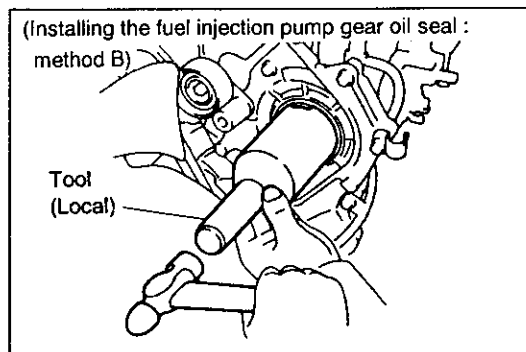
- (1) Cut off the oil seal lip using a knife.
- (2) Pry the oil seal using a screwdriver, to remove.



[NOTICE]

Pay attention so as not to damage the fuel injection pump drive gear. Tape the screwdriver tip.

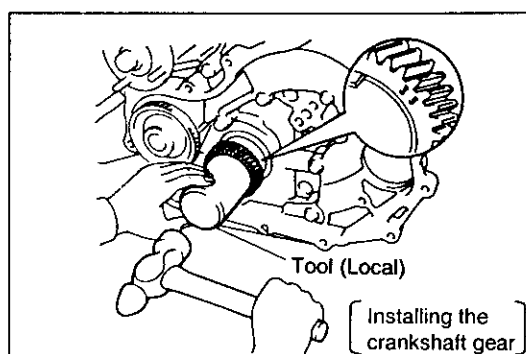
- (3) Apply grease to the lip of a new oil seal.
- (4) Tap in the new oil seal to install, until its surface is level with that of the timing gear cover.



3.4.6 Installation of Timing Gear

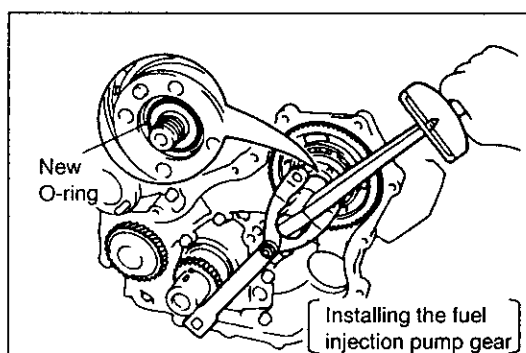
3.4.6.1 Install the crankshaft timing gear

- (1) Install the timing gear with its timing mark facing to the front.
- (2) Align the set key on the crankshaft to the key groove of timing gear.
- (3) Tap in the timing gear to install.



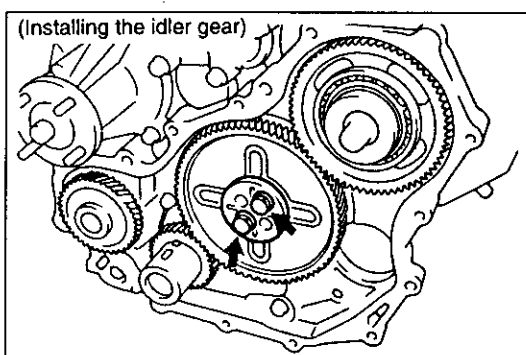
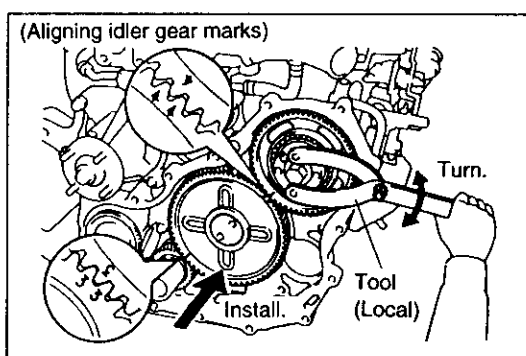
3.4.6.2 Install the fuel injection pump drive gear

- (1) Install the drive gear, aligning the set key on the drive shaft to the key groove of the drive gear.
- (2) Install a new O-ring to the drive gear groove.
- (3) Install the gear nut.
- (4) Tighten the gear nut.
Tightening torque: 1,000 kgf·cm (98.07 N·m)



3.4.6.3 Install the idler gear

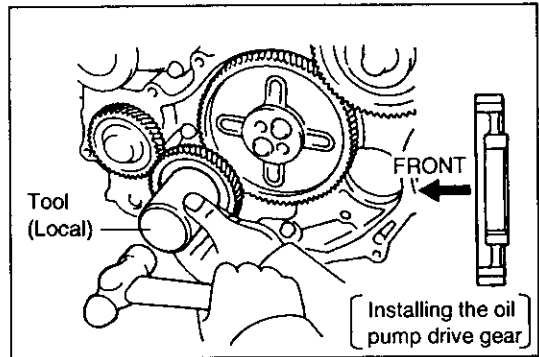
- (1) Install the idler gear shaft by aligning the bolt holes of the idler gear shaft to the bolt holes of the cylinder block.
- (2) Align timing marks 3 and 4 of the idler gear to timing mark 3 of the crankshaft timing gear and timing mark 4 of the fuel injection pump drive gear respectively by turning the fuel injection pump drive gear to the right or left and engage the gears.
- (3) Install the thrust plate using 2 bolts.
Tightening torque: 694 kgf·cm (68.06 N·m)



3. Engine Overhaul

3.4.6.4 Install the oil pump drive shaft gear

- (1) Align the set key on the crankshaft to the key groove in the drive shaft gear.
- (2) Tap in the drive shaft gear to install.



3.4.6.5 Install the timing gear cover

- (1) Remove adhering packing material.

[NOTICE]

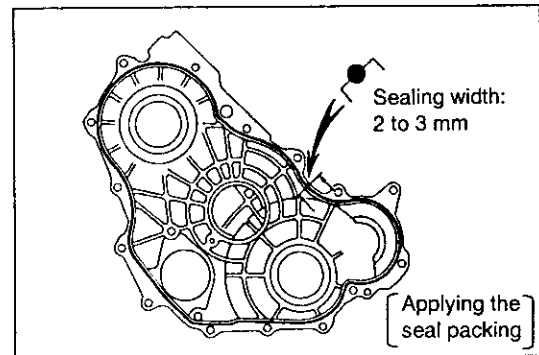
Be careful not to contaminate the timing gear cover and cylinder block mounting surfaces by oil.

- Completely remove the packing material remaining on the sealing surface and sealing groove.
- Clean all parts.
- Clean both sealing surfaces using solvent.

- (2) Apply the seal packing to the timing gear cover as shown.

- Attach a nozzle cut to a sealing width of 2 to 3 mm.
- Parts must be assembled within 5 minutes after seal packing is applied. Otherwise, the seal material must be removed and applied again.
- Disconnect the nozzle from the tube immediately after use and protect it by a cap.

(Seal packing: TOYOTA P/N 08826-00080)
or equivalent

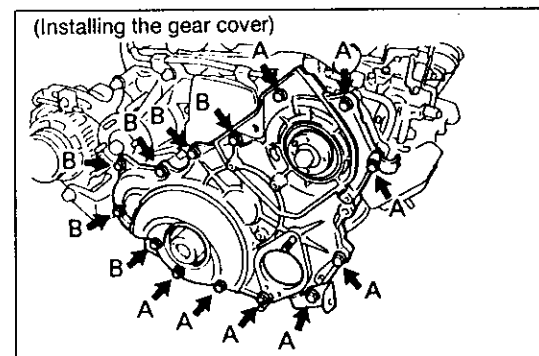


- (3) Install the timing gear cover by 14 bolts.
Tightening torque: 200 kgf·cm (19.61 N·m)

Note) Use bolts whose lengths are as shown in the illustration.

Bolt length:

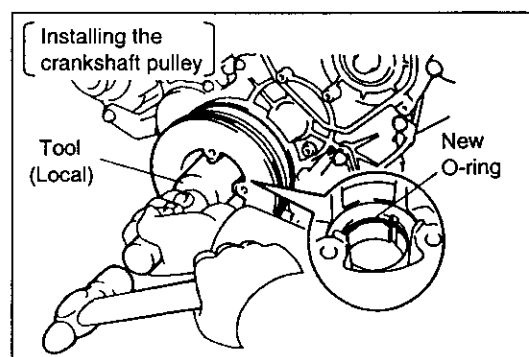
- A: 25 mm
- B: 50 mm



3.4.6.6 Install the alternator adjusting bar

3.4.6.7 Install the crankshaft pulley

- (1) Install a new O-ring in the crankshaft pulley groove.
- (2) Align the set key on the crankshaft to the key groove of the crankshaft pulley.
- (3) Tap in the crankshaft pulley to install.
- (4) Temporarily tighten the plate washer and pulley nut.

**[NOTICE]**

Do not turn the crankshaft pulley. Otherwise, the valve heads and piston top may be damaged by contacting each other.

3.4.6.8 Install camshaft oil seal retainer

(See 3.1.7.6 Install the camshaft oil seal retainer)

3.4.6.9 Install timing pulleys and timing belt

(See 3.3.4 Installation of Timing Belt)

3.4.6.10 Tighten crankshaft pulley bolt

Tightening torque: 50 kgf·m (490.33 N·m) for DTE series

44 kgf·m (431.50 N·m) for STE series

(See 3.4.2.2 Loosen the crankshaft pulley)

- **Install the fresh water pump pulley and viscous damper**

Tightening torque: 380 kgf·m (37.27 N·m) for viscous damper

3.4.6.11 Install the V-belt for driving the fresh water pump and alternator

3.5 Valve Clearance Inspection and Adjustment

- Check and adjust the valve clearance when the engine is cooled down.

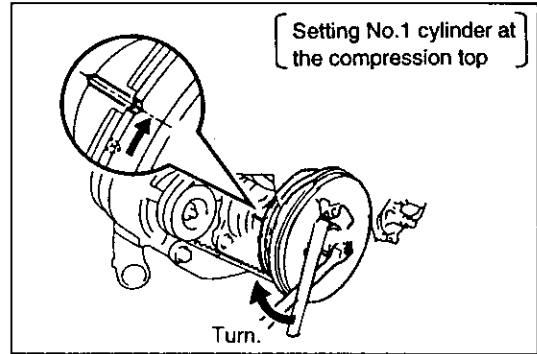
3.5.1 Inspection of Valve Clearance

3.5.1.1 Remove the bonnet

(See 3.1.2.7 Remove the bonnet)

3.5.1.2 Set No.1 cylinder to the top dead center (TDC)

- (1) Turn the crankshaft pulley clockwise to align its groove to that of the timing gear cover and set No.1 cylinder at the compression top position.
- (2) Check that the intake and exhaust valve rocker arm does not move when the crankshaft pulley is turned in the both directions (about 90°). If not, turn the crankshaft once (360°) and position the mark as shown.

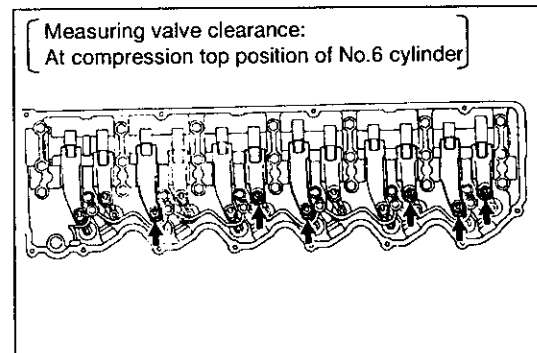
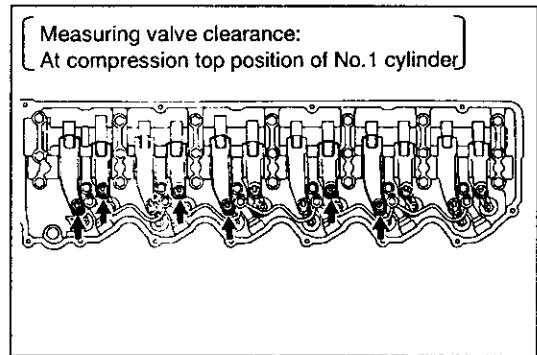


3.5.1.3 Inspect the valve clearance

- (1) Check only the valves indicated by arrow in the illustration.
 - Measure clearance between the adjusting screw on the valve rocker arm and valve bridge for the 6LP-STE or between the rocker arm and camshaft for the 6LP-DTE, using a feeler gauge.
 - Record the measured valve clearance.
 - **Valve clearance (at cooled down condition)**

	6LP-DTE series	6LP-STE series
Intake	0.15 to 0.25mm	0.17 to 0.23 mm
Exhaust	0.35 to 0.45 mm	0.47 to 0.53 mm

- (2) Turn the crankshaft pulley once (360°) and locate the mark as described above.
- (3) Check only the valves indicated by arrow in the illustration.
 - Measure the valve clearance and record it.



3.5.2 Adjustment of Valve Clearance

3.5.2.1 Adjust the valve clearance

[For 6LP-STE series]

- (1) Loosen the lock nut on the valve bridge and adjust the adjusting screw so that the two bridge heads come into contact with two valve stem heads.

[NOTICE]

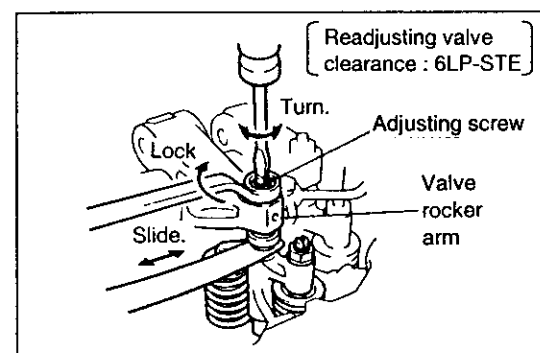
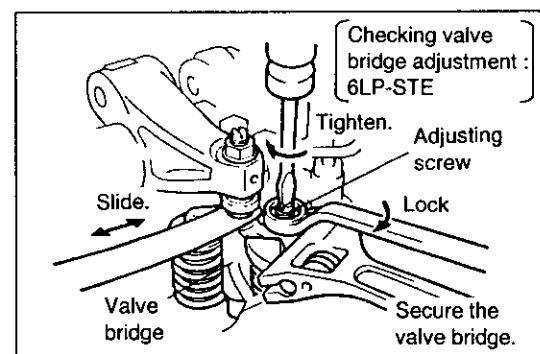
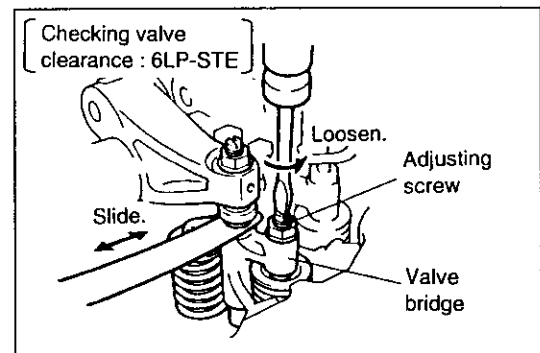
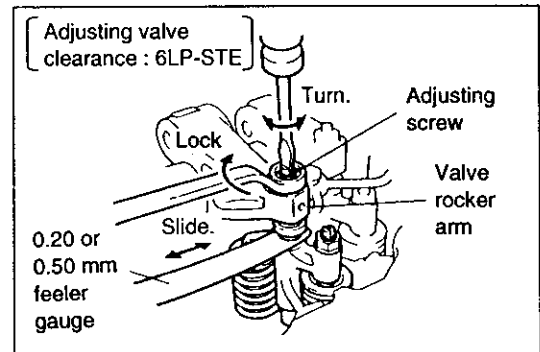
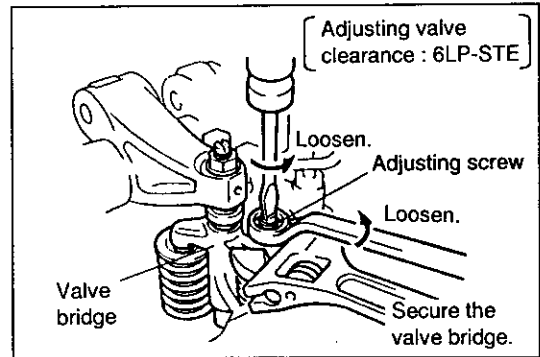
Secure the valve bridge by a wrench and loosen the lock nut. Do not apply any torque to the valve bridge.

- (2) Loosen the lock nut on the valve rocker arm and then the adjusting screw.
- (3) Insert a 0.20 mm feeler gauge between the adjusting screw on the valve rocker arm and the valve bridge for the intake side and a 0.50 mm feeler gauge for the exhaust side.
- (4) Turn the adjusting screw on the valve rocker arm, slightly slide the feeler gauge, and lock the adjusting screw by the lock nut.
- (5) Check that the resistance of the feeler gauge is the same when the feeler gauge is inserted and the adjusting screw on the valve bridge is loosened.
If not, readjust using the procedure in steps (7) to (9).
- (6) Tighten the adjusting screw on the valve bridge and lock the adjusting screw by the lock nut when resistance of the feeler gauge begins to increase.

[NOTICE]

Secure the valve bridge by a wrench and lock the adjusting screw by the lock nut. Do not apply any torque to the valve bridge.

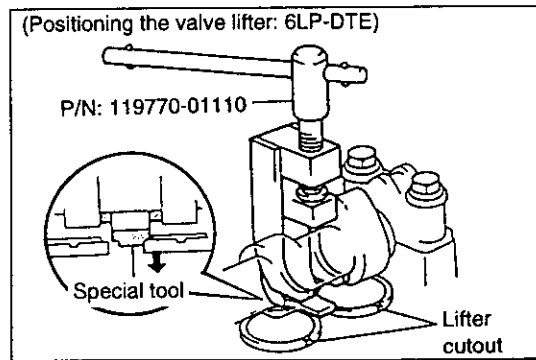
- (7) Loosen the lock nut on the valve rocker arm.
- (8) Turn the adjusting screw on the valve rocker arm, slightly slide the feeler gauge and lock the adjusting screw by the lock nut.



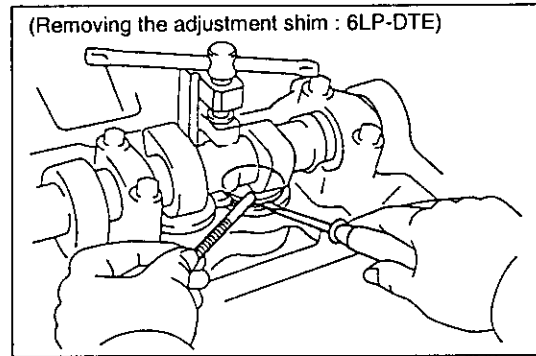
3. Engine Overhaul

[For 6LP-DTE series]

- (1) Direct the cam lobe top for the valve to adjust the valve clearance just upwardly, turning the crankshaft.
- (2) Locate the cutout of the lifter as shown in the illustration.
- (3) Press down the valve lifter using the special tool.
(P/N: 119770-01110)



- (4) Lift the adjusting shim from the cutout of the valve lifter using a small screwdriver, and remove the adjusting shim using a magnetic finger.
- (5) Measure thickness of the removed adjusting shim using a micrometer.
- (6) Select an appropriate adjusting shim.



$$\text{Shim} = \text{Thickness of removed shim} + \{(\text{measured valve clearance}) - (\text{standard valve clearance})\}$$

Specified valve clearance:

Intake 0.17 to 0.23 mm

Exhaust 0.47 to 0.53 mm

Shim type : There are 17 sizes shims ranging thickness from 2.35 to 3.15 mm in 0.05 mm steps.

- (7) Install the selected shim and measure the valve clearance.

• Adjusting shim

P/N: 119770-00520	Shim, Valve Adjusting		T = 2.40	6LP-DTE series
119770-00530	Shim, Valve Adjusting		T = 2.50	
119770-00540	Shim, Valve Adjusting		T = 2.60	
119770-00550	Shim, Valve Adjusting		T = 2.70	
119770-00560	Shim, Valve Adjusting		T = 2.80	
119770-00570	Shim, Valve Adjusting		T = 2.90	
119770-00580	Shim, Valve Adjusting		T = 3.00	
119770-00590	Shim, Valve Adjusting		T = 3.10	
119770-00600	Shim, Valve Adjusting		T = 3.20	
119770-00610	Shim, Valve Adjusting		T = 3.30	

3.5.2.2 Install the bonnet

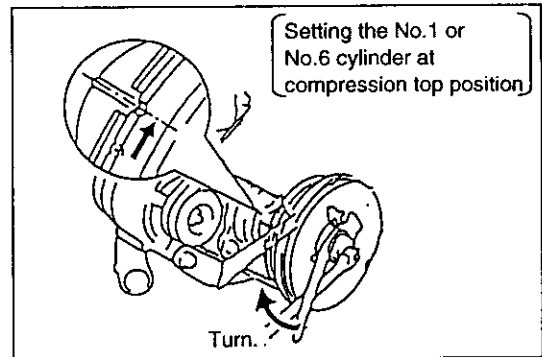
(See 3.3.4.2 Install the bonnet)

3.6 Inspection and Adjustment of Injection Timing

3.6.1 Inspection of Injection Timing

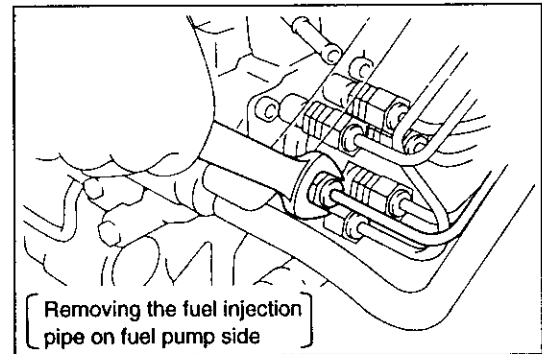
3.6.1.1 Set the No.1 or No.6 cylinder at the top dead center (TDC)/compression

Turn the crankshaft pulley clockwise to align its groove to that of the timing gear cover.

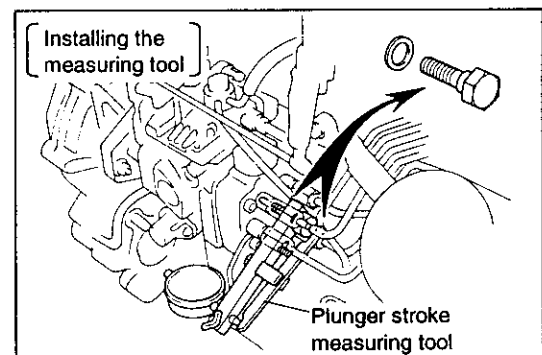


3.6.1.2 Install the plunger stroke measuring tool and dial indicator

- (1) Loosen the two union nuts securing the fuel injection pump to No.1 and No.5 fuel injection pipes and slide them backwards.

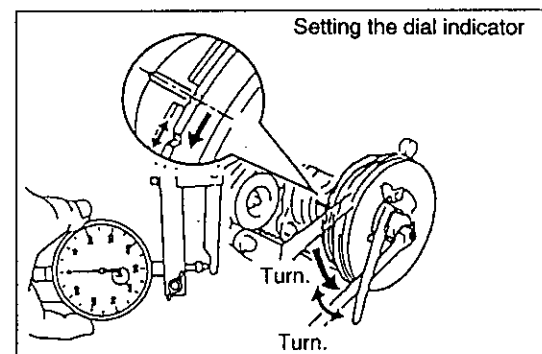


- (2) Remove the plug bolt and gasket from the distribution head plug of the fuel injection pump.
- (3) Install the plunger stroke measuring tool and dial indicator to the plug bolt hole of the distribution head plug.



3.6.1.3 Inspect the injection timing

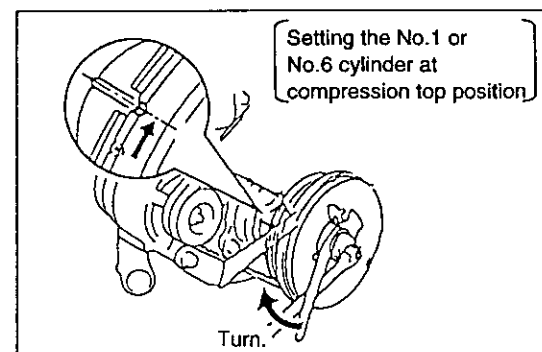
- (1) Slowly turn the crankshaft pulley counter-clockwise and adjust the dial indicator to 0 mm when the dial indicator reading is the minimum.
- (2) Turn the crankshaft clockwise and counter-clockwise and check that the dial indicator reads the minimum.



[NOTICE]

Check that the minimum reading is 0 mm.

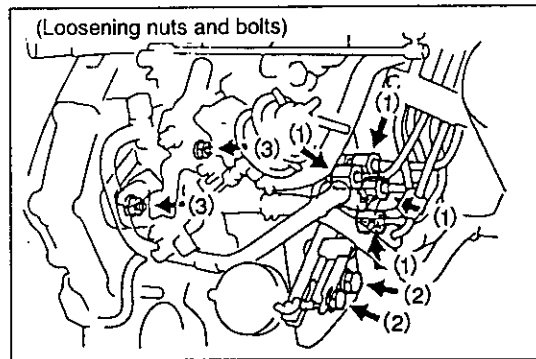
- (3) Slowly turn the crankshaft pulley clockwise to align its groove to that of the timing gear cover.
- (4) Measure the plunger stroke by the dial indicator.
Plunger stroke: 1.6 to 1.8 mm



3.6.2 Adjustment of Injection Timing

3.6.2.1 Adjust the injection timing

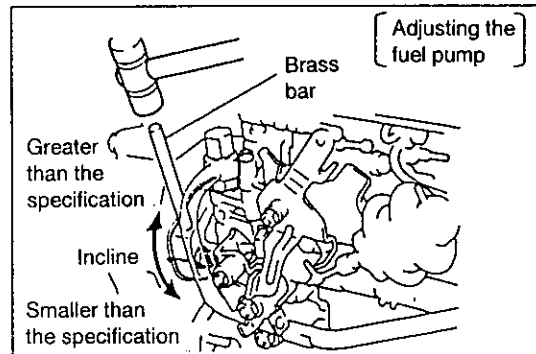
- (1) Loosen the following nuts and bolts
 - 1) Remaining four union nuts securing the fuel injection pipe to the fuel injection pump
 - 2) Two bolts securing the fuel injection pump to the fuel injection pump stay
 - 3) Two nut securing the fuel injection pump to the timing gear case



[NOTICE]

Do not loosen nuts over 90°.

- (2) Slightly incline the injection pump to adjust the plunger stroke. If the stroke is smaller than the specification, incline the pump towards the engine. If it is greater than the specification, incline the pump in the opposite direction to the engine.



- If the stroke is smaller than the specification, move the injection pump towards the engine.
- Adjust gradually by tapping the pump flange using a brass bar and plastic hammer.

- (3) Tighten the following nuts and bolts:
 - Two nuts securing the fuel injection pump to the timing gear case
Tightening torque:
185 kgf·cm (18.14 N·m)
 - Two bolts securing the fuel injection pump to the fuel injection pump stay
Tightening torque:
700 kgf·cm (68.65 N·m)

- (4) Check the plunger stroke again using the dial indicator.

3.6.2.2 Tighten union nuts for the fuel injection pipe

Tightening torque:
250 kgf·cm (24.52 N·m)

3.6.2.3 Start the engine and check for fuel oil leakage

3.7 Service Specifications

3.7.1 Engine Adjusting Standards

No.	Item		Standard		Remarks
			6LP-DTE series	6LP-STE series	
1	Fuel injection timing	mm	Plunger stroke : 1.7 ±0.1		FID 13.5 ±1° bTDC
2	Fuel injection pressure	kgf/cm ² (Mpa)	250 ⁺¹⁰ / 300 ⁺¹⁰ (24.52 ^{+0.1} / 29.42 ^{+0.1})		1st/2nd stage
3	Valve clearance	Intake	0.15 to 0.25	0.17 to 0.23	in cold condition
		mm	Exhaust	0.35 to 0.45	
4	Low idling		700±25 rpm		
5	High idling		4200±25 rpm		
6	Valve timing	Intake	Open	bTDC:8	bTDC:12
			Close	aBDC:29	aBDC:32
		Exhaust	Open	bBDC:51	bBDC:54
			Close	aTDC:5	bTDC:12
7	Fire order		120° 120° 120° 120° 120° 120° 1 → 4 → 2 → 6 → 3 → 5 → 1		Opposite the flywheel is the No.1 cylinder side.
8	Setting oil pressure	kgf/cm ² (Mpa)	4.5 (0.44)		At 3800 rpm engine speed
9	Lube oil capacity(oil pan)	ℓ	8.4/1.4 (Full / Effective)		Capacity in oil path 6LP-DTE series: 1.6 6LP-STE series: 2.1
10	Fresh water capacity	ℓ	13.5		
11	Fresh water thermostat	Valve opening temp. °C	70±2		
		Lift at full open mm	10 or more		
12	Delivery capa. of sea water pump	ℓ	135 or more		Pump shelf speed: At 3800 rpm Total head: 10 mAq (98 kPa)

3.7.2 Service Standards

(Unit: mm)

Item	Description	6LP-DTE series	6LP-STE series	
Injection timing	Plunger stroke	1.60 to 1.80		
Timing gear	Idler gear thrust clearance	Standard	0.05 to 0.15	
		Limit	0.30	
	Idler gear inside diameter	45.000 to 45.025		
	Idler gear shaft diameter	44.950 to 44.975		
	Idler gear oil clearance	Standard	0.025 to 0.075	
		Limit	0.20	
	Gear backlash	Standard	0.05 to 0.15	
		Limit	0.30	
Cylinder head	Combustion surface warpage	Limit	0.20	
	Valve seat Refacing angle	Intake	25°, 45°, 70°	
		Exhaust	25°, 45°, 65°	
	Contacting angle		45°	
	Contacting width	Intake	1.5 to 1.9	1.4 to 1.8
Exhaust		1.8 to 2.2	1.6 to 2.0	
Head bolt thread diameter	Standard	10.800 to 11.000		
	Limit	10.55		
Valve guide	Inside diameter	8.010 to 8.030	7.010 to 7.030	
Valve	Valve overall length	Standard: Intake	103.29 to 103.69	126.85 to 127.45
		Exhaust	103.14 to 103.54	126.43 to 127.03
	Limit: Intake	102.79	126.85	
		Exhaust	102.64	126.43
	Stem diameter	Intake	7.975 to 7.990	6.975 to 7.985
Exhaust		7.960 to 7.975	6.960 to 6.975	
Stem oil clearance	Standard: Intake	0.020 to 0.055	0.020 to 0.055	
	Exhaust	0.035 to 0.070	0.020 to 0.055	
Limit: Intake	0.08	0.08		
	Exhaust	0.10	0.10	
Margin thickness	Standard: Intake	1.6	1.00	
		Exhaust	1.7	1.00
	Limit: Intake	1.1	0.83	
		Exhaust	1.2	0.83
Valve spring	Deviation	Limit	2.0	2.0
	Free length	Yellow paint mark	46.20	49.6
Blue paint mark		49.14		

(Unit: mm)

Item	Description	6LP-DTE series	6LP-STE series	
Valve rocker arm and shaft	Valve rocker arm inside diameter	20.012 to 20.033		
	Valve rocker arm shaft diameter	19.972 to 19.993		
	Oil clearance	Standard Limit	0.019 to 0.061 0.10	
Camshaft	Thrust clearance	Standard Limit	0.100 to 0.200 0.30	
	Journal oil clearance	Standard 1 Others Limit	0.022 to 0.074 0.030 to 0.066 0.10	
	Journal diameter	1 Others	34.969 to 34.985 27.986 to 27.998	
	Circle runout	Limit	0.10	
	Cam lobe height	Standard: Intake Exhaust Limit: Intake Exhaust	54.440 to 54.460 55.940 to 55.960 53.94 55.44	48.498 to 48.598 50.734 to 50.834 47.998 50.234
Cylinder block	Cylinder top surface warpage	Maximum	0.20	
	Cylinder bore diameter	Standard: Mark 1 Mark 2 Mark 3 Limit	94.000 to 94.010 94.010 to 94.020 94.020 to 94.030 94.23	
	Main bearing cap bolt thread	Standard	11.800 to 12.000	
	outside diameter	Minimum	11.50	
Piston and piston ring	Piston diameter	Standard: Mark 1 Mark 2 Mark 3	93.95 to 93.96 93.96 to 93.97 93.97 to 93.98	93.835 to 93.845 93.845 to 93.855 93.855 to 93.865
	Piston oil clearance	Standard Limit	0.04 to 0.06 0.14	0.145 to 0.165 0.215
	Piston ring groove clearance	Standard: No.1 No.2 Oil Limit	0.050 to 0.095 0.060 to 0.100 0.030 to 0.070 0.20	
	Piston ring end gap	Standard: No.1 No.2 Oil	0.270 to 0.470 0.400 to 0.650 0.200 to 0.500	
		Standard: No.1 No.2 Oil	1.34 1.42 1.32	0.85 0.90 0.88

3. Engine Overhaul

(Unit: mm)

Item	Description	6LP-DTE series	6LP-STE series
Connecting rod	Thrust clearance	Standard	0.100 to 0.200
		Limit	0.30
	Oil clearance	Standard	0.036 to 0.054
		Limit	0.10
	Crank pin bearing wall thickness (Reference)	Standard: Mark 2	1.486 to 1.489
		Mark 3	1.489 to 1.492
		Mark 4	1.492 to 1.495
		Mark 5	1.495 to 1.498
		Mark 6	1.498 to 1.501
	Rod bend	Limit/100 mm	0.03
Rod twist	Limit/100 mm	0.15	
Piston pin bearing inside diameter		33.008 to 33.020	
Piston pin diameter		33.000 to 33.012	
Piston pin bearing oil clearance	Standard	0.004 to 0.012	
	Limit	0.03	
Connecting rod bolt diameter of tension portion	Standard	8.300 to 8.400	
	Limit	7.95	
Crankshaft	Thrust clearance	Standard	0.040 to 0.240
		Limit	0.30
	Thrust bearing thickness		2.930 to 2.980
	Crank journal oil clearance	Standard	0.036 to 0.054
		Limit	0.10
	Crank journal diameter	Standard: Mark 1	66.994 to 67.000
		Mark 2	66.988 to 66.994
		Mark 3	66.982 to 66.988
	Crank journal bearing thickness	Standard: Mark 2	1.979 to 1.982
		Mark 3	1.982 to 1.985
Mark 4		1.985 to 1.988	
Mark 5		1.988 to 1.991	
Mark 6		1.991 to 1.994	
Crank pin diameter	Standard: Mark 1	58.994 to 59.000	
	Mark 2	58.988 to 58.994	
	Mark 3	58.982 to 58.988	
Circle runout	Limit	0.06	
Journal taper and out-of-round	Limit	0.02	
Crank pin taper and out-of-round	Limit	0.02	

3.7.3 Nut and Bolt Tightening Torque

(Unit: kgf·cm (N·m))

Tightening parts	6LP-DTE series	6LP-STE series
	6LPA-DTP	6LPA-STP
Fuel injection pump × Timing gear case	185 (18.14)	
Fuel injection pump × Fuel injection pump stay	700 (68.65)	
Fuel injection pump drive gear × Fuel injection pump	1000 (98.07)	
Fuel injection pump stay × Cylinder block	700 (68.65)	
Fuel injection nozzle mounting bolt × Cylinder head	400 (39.23)	255 (25.01)
No.1 Camshaft timing pulley × Camshaft	1000 (98.07)	
No.2 Camshaft timing pulley × Fuel injection pump drive gear	315 (30.89)	
Idler pulley × Timing gear cover	270 (26.48)	350 (34.32)
Timing belt tensioner × Timing gear cover	—	130 (12.75)
Idler gear × Cylinder block	400 (39.23)	694 (68.06)
Timing gear cover, cylinder block × Timing gear case	200 (19.61)	
Camshaft bearing cap × Cylinder head	No.1:250 (24.52) Others: 185 (18.14)	250 (24.52)
Camshaft oil seal retainer × Cylinder head	200 (19.61)	
Main bearing cap × Cylinder block	(12 pointed head)※ (6 pointed head)	1050(102.97)→90° (Retightening) 185 (18.14)
Crankshaft pulley × Crankshaft	5000 (490.33)	4400 (431.50)
Flywheel × Crankshaft	1300 (127.50)	
Viscous damper × Crankshaft pulley	380 (37.27)	
Input shaft joint (rubber block) × Flywheel	400 (39.23)	
Connecting rod cap × Connecting rod	※	375 (36.77)→90° (Retightening)
Cylinder head × Cylinder block	※	700 (68.65)→90°→90° (Retightening)
Bonnet × Cylinder head	65 (6.37)	
Intake manifold × Cylinder head	200 (19.61)	
Alternator bracket × Cylinder block	700 (68.65)	
Rear end plate × Cylinder block	185 (18.14)	
Engine mounting bracket × Cylinder block	700 (68.65)	
Rear oil seal case × Cylinder block	65 (6.37)	

Note) For ※ marked tightening bolts, apply oil to their thread and seat before tightening.

3.8 Turbocharger

3.8.1 Construction and Function

3.8.1.1 Overview of construction and function

3.8.1.1.1 Turbine

The exhaust gas coming out of the engine is accelerated by its flowing speed through the nozzle of the turbine housing and blown against the turbine wheel to give the torque to the turbine shaft. This is called the turbine, in which the seal rings and thermal insulation plate are built in to prevent adverse influence to the bearings by the gas.

3.8.1.1.2 Blower

The compressor impeller mounted on the turbine shaft receives torque from the turbine shaft, sucks the air and compresses it to be fed to the air intake pipe. This is called the compressor or blower.

3.8.1.1.3 Bearing

(1) Thrust bearing

Since thrust force is continuously applied to the turbine shaft, it is designed to prevent the shaft from movement by the thrust.

(2) Radial bearing

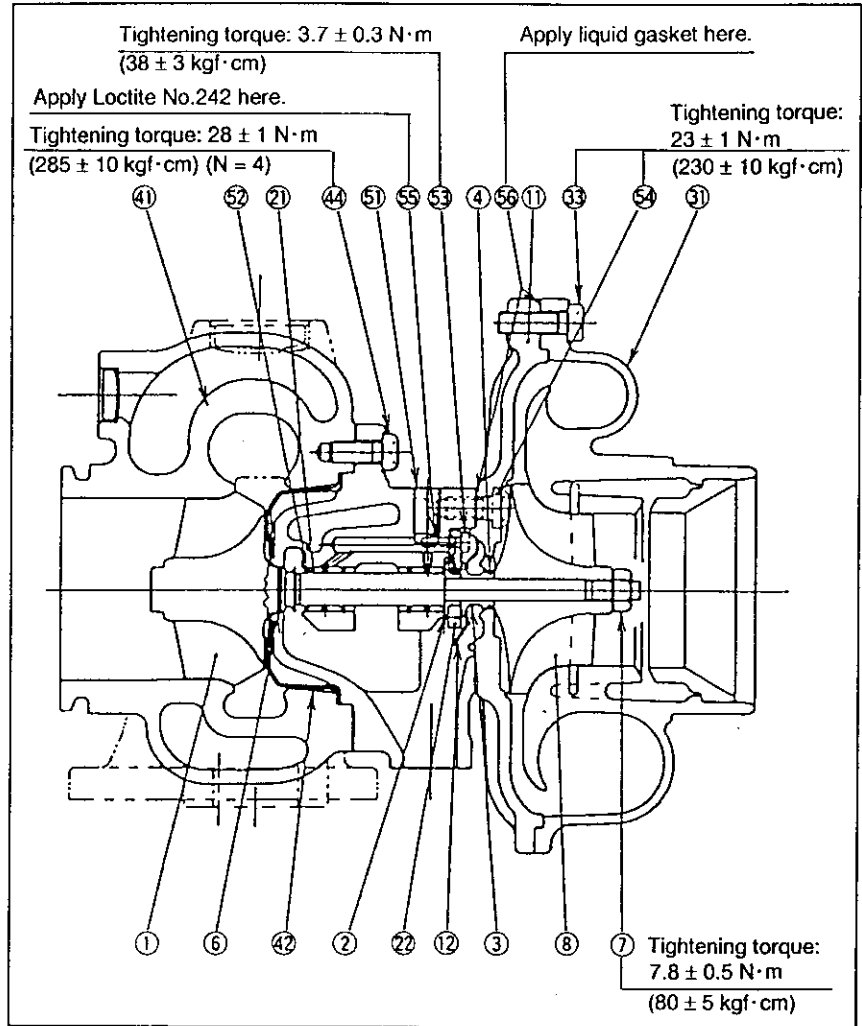
The floating bearing type is adopted. Since this type has double oil film layers at inside and outside surfaces of the bearing, causing the bearing itself to rotate together with the shaft, the slippage speed of bearing is lower than the turbine shaft revolution, thereby, the dynamic stability is improved, when compared with the normal type bearing.

3.8.1.1.4 Sealing structure at blower side

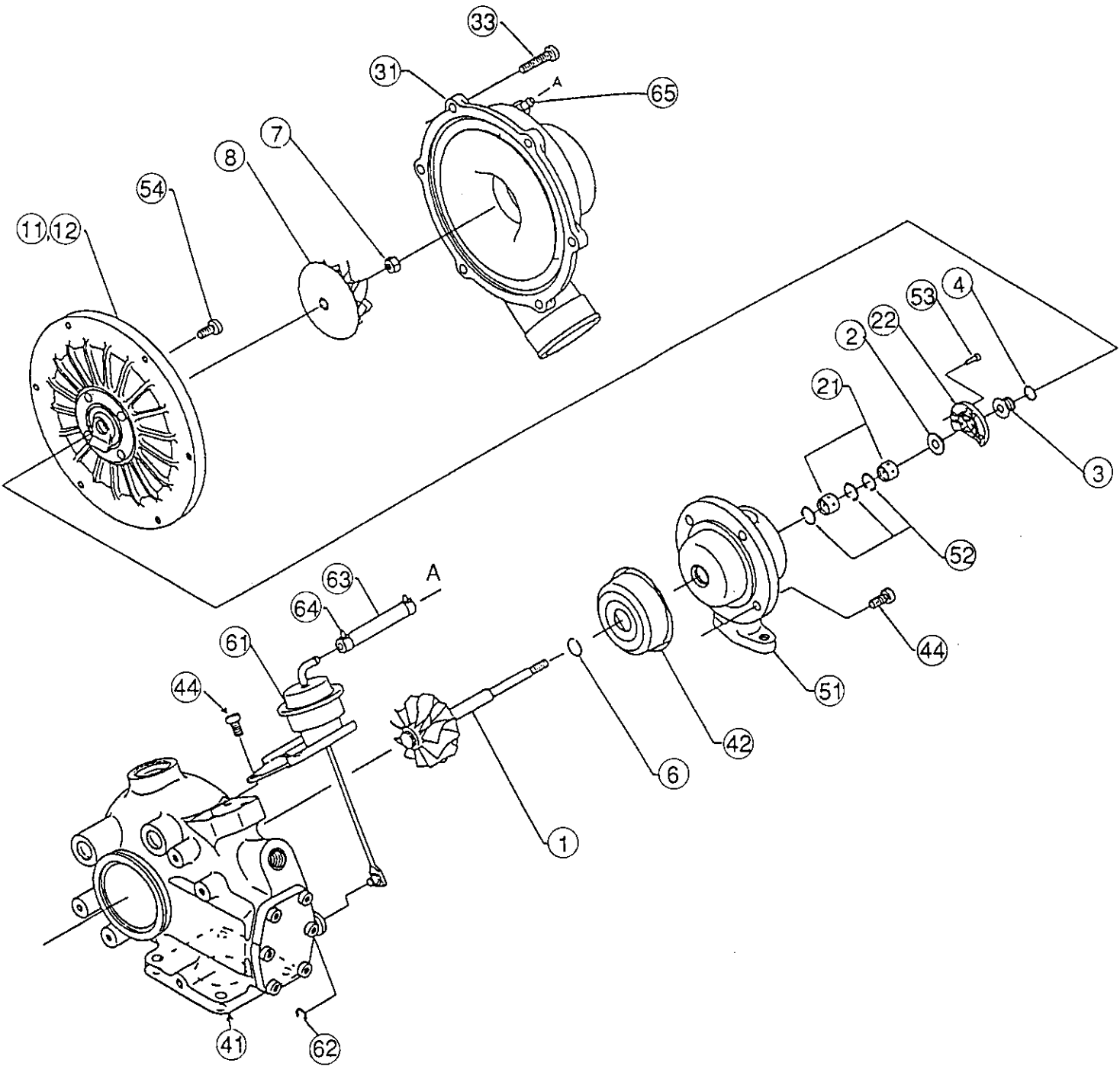
The dual-wall structure is adopted for the rear of compressor housing for preventing leakage of intake air and oil. Further, seal ring and oil defensive plate are provided.

Sectional View (RHE6W model)

No.	Components	Qty
①	Turbine shaft	1
②	Thrust bushing	1
③	Oil thrower	1
④	Compressor side seal ring	1
⑥	Turbine side seal ring	1
⑦	Shaft end nut	1
⑧	Compressor impeller	1
⑪	Seal plate	1
⑫	Oil defensive plate	1
⑳	Floating bearing	2
㉑	Thrust bearing	1
㉓	Compressor housing	1
㉔	TORX T screw bolt	6
㉖	Turbine housing	1
㉗	Thermal insulation plate	1
㉙	TORX T screw bolt	13
㉚	Bearing housing	1
㉛	Retaining ring	3
㉜	TORX T screw bolt	3
㉝	TORX T screw bolt	4
㉞	Liquid gasket	-
㉟	Liquid gasket	-
㊱	Waste gate actuator	1
㊲	E-type retaining ring	1
㊳	Boost hose	1
㊴	Hose clip	2
㊵	Boost pipe	1

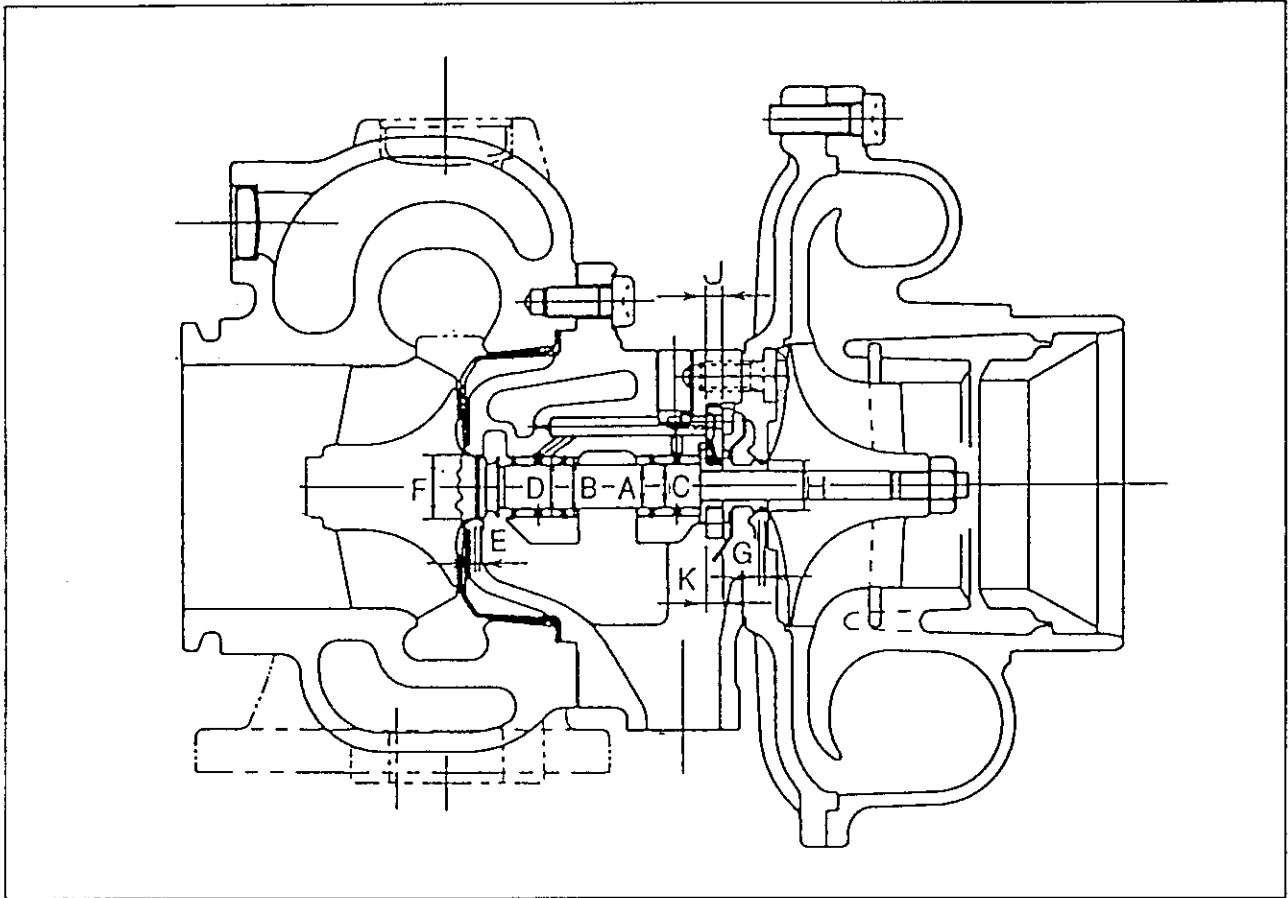


3.8.2 Components (RHE6W Turbocharger)



3.8.3 Service Specifications

3.8.3.1 Service standards



(Unit: mm)

	Inspection item	Usable limit	Remarks
Turbine shaft	Turbine shaft journal outside diameter (A)	11.380	
	Turbine side seal ring groove width (E)	1.330	
	Compressor side seal ring groove width (G)	1.520	
	Turbine shaft runout	0.011	
Bearing	Floating bearing inside diameter (C)	11.460	
	Floating bearing outside diameter (D)	15.980	
	Bearing case inside diameter (B)	16.110	
Thrust bearing	Thrust bearing width (J)	4.280	
	Thrust bushing groove to groove distance (K)	4.480	
Seal ring inserting area	Turbine side (bearing wheel chamber) (F)	17.030	
	Compressor side (seal plate) (H)	14.050	
	Turbine shaft play in axial direction	0.110	Service standard: 0.06 to 0.09
	Turbine shaft play in radial direction	0.205	Service standard: 0.10 to 0.17

3. Engine Overhaul

3.8.3.2 Nut and bolt tightening torque

Tightening parts	kgf·cm	N·m
Turbine housing set bolt (M8)	285 ± 10	28 ± 1
Compressor housing set bolt (M8)	230 ± 10	23 ± 1
Thrust bearing set bolt (M4)	38 ± 3	3.7 ± 0.3
Seal plate set bolt (M8)	230 ± 10	23 ± 1
Compressor impeller set nut (M7) (left-handed thread)	80 ± 5	7.8 ± 0.5
Actuator set bolt (M8)	285 ± 10	28 ± 1
Valve case cover set bolt (M8)	285 ± 10	28 ± 1

3.8.4 Periodic Inspection Procedure

3.8.4.1 Periodic inspection intervals

Periodically inspect the turbocharger for the overall conditions and fouling. The checking interval varies with the operating conditions, but refer to the table below as guideline.

— Inspection item	Inspection interval		
	Every 6 months or 1,500 hours	Every 12 months or 3,000 hours	Every 24 months or 6,000 hours
Rotation of turbine shaft	○		
Play of turbine shaft		○	
Overhaul and inspection			○

3.8.4.2 Inspection procedure

3.8.4.2.1 Running of turbine shaft

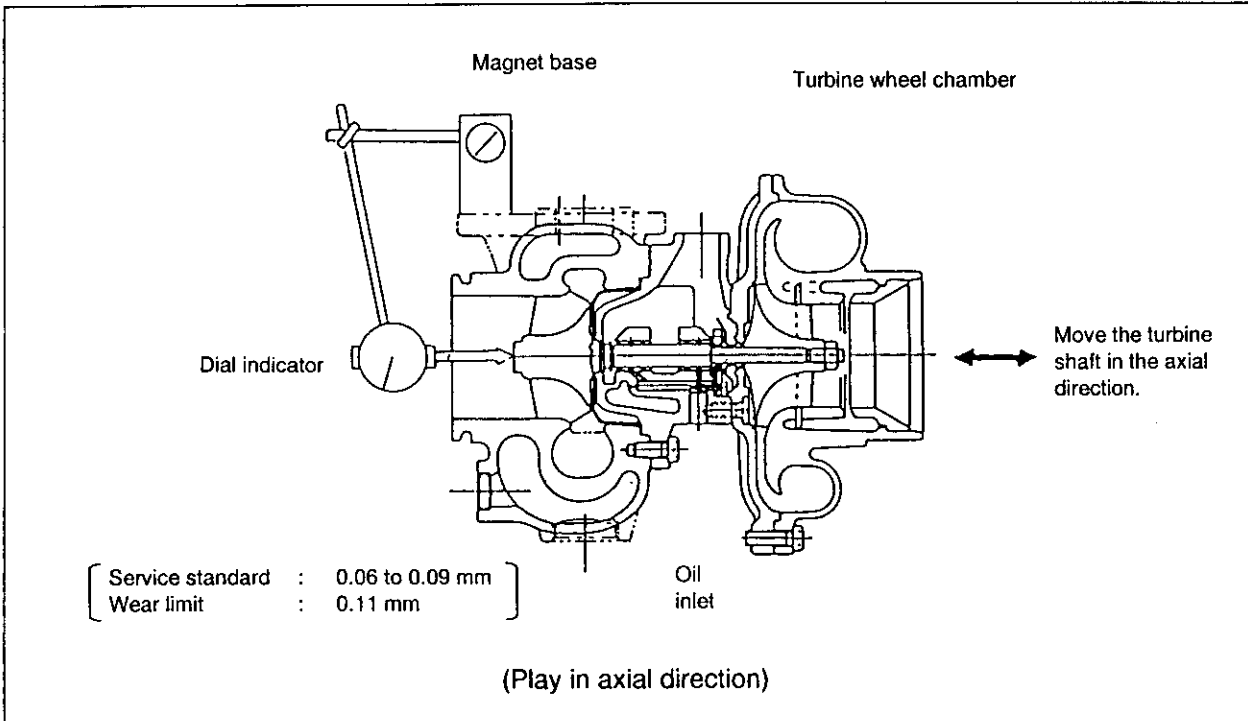
Inspect the turbine shaft operation by listening to any abnormal sounds during running. For inspection using a listening bar, bring the tip end of the bar into strong contact with the turbocharger case and raise the engine speed gradually. If any high pitch sounds are generated at intervals of 2 to 3 seconds, the rotation is abnormal. Since the bearing or rotor may be defective in this case, either replace or overhaul the turbocharger.

3.8.4.2.2 Inspection of turbine shaft play

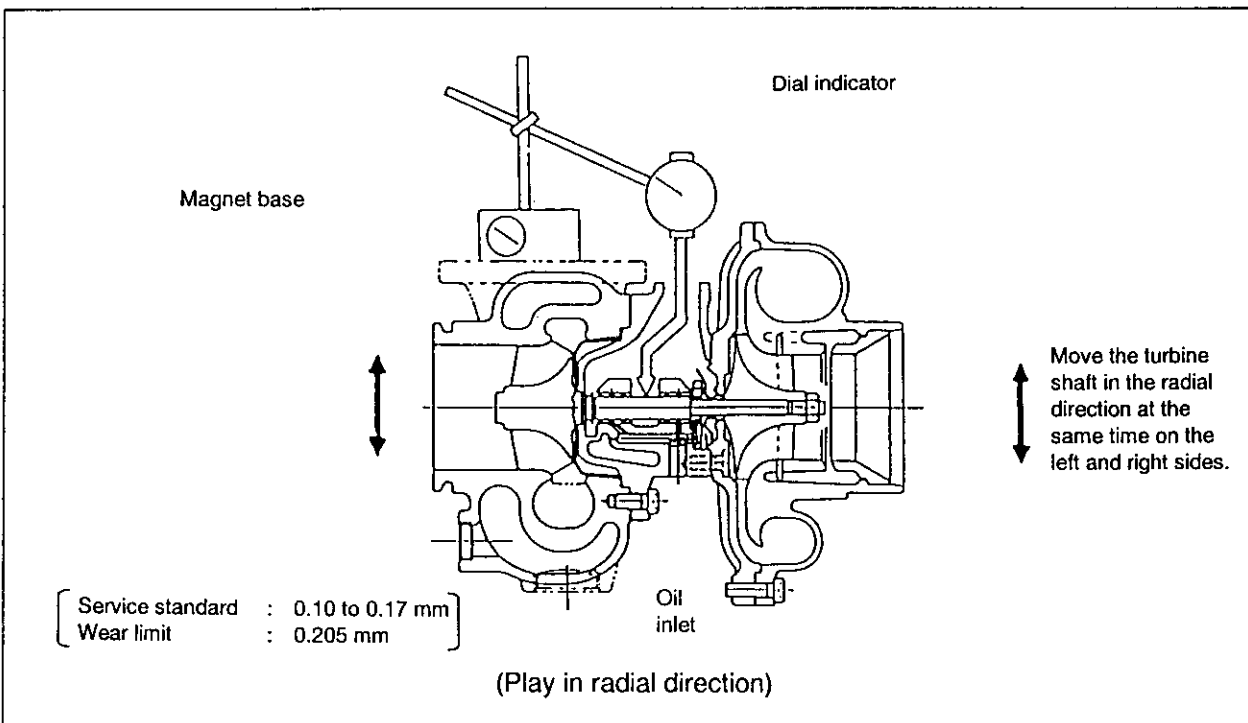
Remove the turbocharger from the engine and inspect the turbine shaft play in the axial and radial directions according to the procedures below.

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

1) Turbine shaft play in axial direction



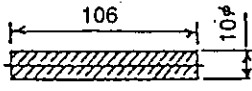
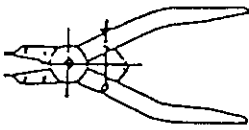
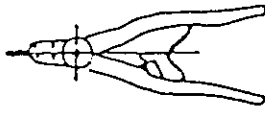

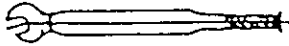
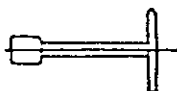
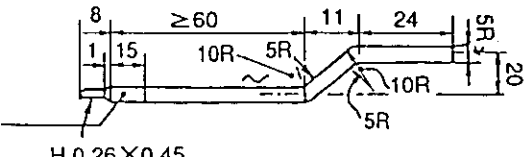
2) Turbine shaft play in radial direction



3.8.5 Disassembly Procedure

3.8.5.1 Preparation for disassembly

In addition to the general tools, the following special tools are required for disassembling and reassembling the turbocharger.

Tool name	Use	Illustration
Bar	For removing thrust bearing and thrust bushing	 <p>Material: Copper or brass</p>
Pliers	For removing and installing floating bearing retaining ring	
Pliers	For removing and installing seal ring	
Torque screwdriver for TORX bolt (Universal type) 5 to 50kgf·cm (0.49 to 4.90 N·m)	For installing thrust bearing, for M4 (13 kgf·cm (1.27 ±0.1 N·m))	<p>Available in the market</p>  <p>(Type: TORX TT20 or equivalent)</p>
Torque wrench for TORX bolt (Universal type)	<p>For installing turbine housing, for M8 (285 kgf·cm (28 ±1 N·m))</p> <p>For installing compressor housing, for M8 (230 kgf·cm (23 ±1 N·m))</p> <p>For installing seal plate, for M8 (230 kgf·cm (23 ±1 N·m))</p>	<p>Available in the market</p> <p>(Type: TORX TT40 or equivalent)</p>
Torque wrench (single purpose type)	For tightening shaft end nut, for M7 (80 kgf·cm (7.84 N·m))	
Box spanner	For fixing turbine shaft (14mm × 12 pointed head)	 <p>Box part alone may be used.</p>
Probe	<p>For measuring play in axial and radial directions</p> <p>To be knurled here (rolette)</p>	<p>To be attached to a dial indicator</p> 

3.8.5.2 Inspection before disassembly

3.8.5.2.1 Check the turbine and compressor impellers for interference with their housings. Also, check that the turbine shaft rotates smoothly.

3.8.5.2.2 Measure the turbine shaft play

(See 3.8.4.2.2 Inspection of turbine shaft play)

- (1) Turbine shaft axial play
Wear limit: 0.110 mm
- (2) Turbine shaft radial play
Wear limit: 0.205 mm

3.8.5.3 Disassembly

[NOTICE]

As mounting angles of the turbine housing, bearing housing and compressor housing of the turbocharger are determined according to their mounting status on the engine, put match marks before beginning disassembly.

3.8.5.3.1 Remove the boost hose

- (1) Move the hose clip ⑥4 to the center of boost hose ⑥3.
- (2) Disconnect boost hose ⑥3 from compressor housing ③1 and waste gate actuator ⑥1.

3.8.5.3.2 Remove the compressor housing

- (1) Remove the M8 TORX T screw bolt ③3 using the torque wrench (TT40).
- (2) Remove compressor housing ③1.

Note 1: The liquid gasket is applied to the compressor housing ③1 and seal plate ① mounting surfaces.

Note 2: Pay attention so as not to damage the compressor impellers when disassembling the compressor housing.

3.8.5.3.3 Remove the compressor impeller

- 1) Attach the box spanner (14 mm) to the shaft end of turbine shaft ① on the turbine side and remove the shaft end nut ⑦.

[NOTICE]

Pay attention to the loosening direction as the shaft end nut has left-handed thread.

- 2) Remove compressor impeller ⑧.

3.8.5.3.4 Remove the seal plate

- (1) Loosen M8 TORX T screw bolt ⑤④ securing the seal plate, using the torque wrench (TT40).
- (2) Remove seal plate ①①.
Note: Lightly tap the bearing housing side of the seal plate by a wooden hammer.
Note: The liquid gasket is applied to the seal plate and bearing wheel mounting surfaces.
- (3) Remove oil thrower ③ from the seal plate.

3.8.5.3.5 Remove the turbine housing

- (1) Remove M8 TORX T screw bolt ④④ using the torque wrench (TT40).
- (2) Remove turbine housing ④①.

3.8.5.3.6 Pull off the turbine shaft

- (1) Lightly and manually secure heat insulation plate ④② and pull off turbine shaft ①.
Note: If the turbine shaft is too tight, lightly tap the shaft end on the blower side by a wooden hammer.
- (2) Remove heat insulation plate ④②.

3.8.5.3.7 Remove the thrust bearing and thrust bushing

- (1) Loosen M4 TORX T screw bolt ⑤③ securing the thrust bearing, using the screwdriver (TT20).
- (2) Remove thrust bearing ②② and thrust bushing ② using a bar (copper).

3.8.5.3.8 Remove the floating bearing

- (1) Remove floating bearing ②① on the compressor side from bearing housing ⑤①.
- (2) Remove retaining ring ⑤② on the turbine side from bearing housing ⑤①, using the retaining ring pliers.
- (3) Remove floating bearing ②① on the turbine side from bearing housing ⑤①.
- (4) Remove far-side retaining rings ⑤② of turbine and compressor sides from bearing housing ⑤①, using the retaining ring pliers.

3.8.5.3.9 Remove the seal ring

- (1) Remove seal ring ⑥ on the turbine side from turbine shaft ①.
- (2) Remove seal ring ④ on the compressor side from oil thrower ③.

3.8.6 Cleaning and Checking Procedures

3.8.6.1 Cleaning

3.8.6.1.1 Checking before cleaning

Before cleaning, visually check each part for any trace of seizure, wear, foreign matter or carbon deposits. When parts are disassembled because of any trouble, carefully check for identifying the cause of trouble at this stage.

<Major checking items>

Check item	Position to be checked
Carbon deposits	1) Turbine side seal ring of turbine shaft ① and turbine wheel backside 2) Mounting portions for bearing housing⑤ and thermal insulation plate 42 and inner wall of bearing housing
Lubrication status (wear, seizure, discoloration, etc.)	1) Journal of turbine shaft ①, thrust bushing ② and oil thrower ③ 2) Floating bearing② and thrust bearing② 3) Internal circumference of bearing case of bearing housing⑤
Oil leakage	1) Inner wall of turbine housing④ 2) Outer surface of bearing housing⑤ and thermal insulation plate 42 mounting area 3) Turbine side seal ring ⑥ of turbine shaft ① and turbine wheel backside 4) Inner wall of compressor housing③ 5) Backside of compressor impeller ⑧ 6) Surface of seal plate ① and seal ring ④ inserting area

3.8.6.1.2 Cleaning procedure

Part	Tools and detergent	Cleaning procedure
(1) Turbine shaft	<ol style="list-style-type: none"> 1. Tools <ol style="list-style-type: none"> 1) Washing bucket (500 × 500) 2) Heat source: Steam or gas burner 3) Brush 2. Detergent General carbon removing agent available in the market 	<ol style="list-style-type: none"> 1) Immerse the turbine shaft in the washing bucket filled with detergent and warm up. Do not strike the blade to remove the carbon. 2) Immerse in the detergent until the carbon and other deposits are softened. 3) Use a plastic scraper or hard hair brush to remove the softened deposits. 4) Pay full attention so as not to damage the bearing surface and seal ring groove of the turbine shaft. 5) Any deposit remaining on the turbine shaft due to improper washing may cause unbalancing. Be sure to remove thoroughly. Never use a wire brush.
(2) Turbine housing	<ol style="list-style-type: none"> 1. Tools Same as those for turbine shaft 2. Detergent Same as that for turbine shaft 	<ol style="list-style-type: none"> 1) Immerse the turbine housing in the washing bucket filled with detergent and warm up. Do not strike the blade to remove the carbon. 2) Immerse in the detergent until the carbon and other deposits are softened. 3) Use a plastic scraper or hard hair brush to remove the softened deposits.
(3) Blower impeller and housing	<ol style="list-style-type: none"> 1. Tools <ol style="list-style-type: none"> 1) Washing bucket (500 × 500) 2) Brush 2. Detergent 	<ol style="list-style-type: none"> 1) Immerse in the detergent filled in the washing bucket until the deposit is softened. 2) Use a plastic scraper or hard hair brush to remove the softened deposits. Never use a wire brush.
(4) Others	<ol style="list-style-type: none"> (1) Wash all other parts with diesel oil. (2) Clean all lubricating oil paths by blowing with compressed air. (3) Be especially careful so as not to damage and get them rusted. 	

3.8.6.2 Inspection procedure

3.8.6.2.1 Compressor housing⁽³¹⁾

Check the compressor housing for any contact traces with the compressor impeller and defect, dent or cracks at joint surfaces, and replace if it is defective.

3.8.6.2.2 Turbine housing⁽⁴¹⁾

Check for any contact traces with the turbine wheel, separation due to degradation by oxidation of the case surface, thermal deformation or cracks. Replace with a new one if defective.

3.8.6.2.3 Compressor impeller⁽⁸⁾

Check for any contact traces, chipping, corrosion or deformation. Replace with a new one if defective.

3.8.6.2.4 Turbine shaft⁽¹⁾

- (1) Check for any contact traces, chipping, thermal discoloration or deformation at the turbine wheel. Check the shaft portion for bend, the journal portion for thermal discoloration or abnormal wear, and the seal ring groove for surface defect or wear. Replace with a new one if defective.
- (2) Measure the outside diameter (A) and seal ring groove width (E) of the turbine shaft journal. Replace with a new turbine shaft if beyond the wear limit.
Wear limit of journal outside diameter (A):
11.38 mm
Wear limit of seal ring groove width (E):
1.33 mm
- (3) Measure runout of the turbine shaft. Replace with a new one if measured runout exceeds 0.011 mm.

3.8.6.2.5 Thermal insulation plate⁽⁴²⁾

Check the thermal insulation plate for any contact traces, thermal deformation or corrosion. Replace with a new one if defective.

3.8.6.2.6 Thrust bushing ②, oil thrower ③ and thrust bearing ②②

Check each part for wear, surface defect and discoloration. Replace with a new one if defective even if dimensions G and K are within the wear limit.

(1) Thrust bushing ②

Measure the seal ring groove width (K) of the thrust bushing. Replace with a new one if the measured value exceeds the wear limit.

Wear limit: 4.48 mm

(2) Oil thrower ③

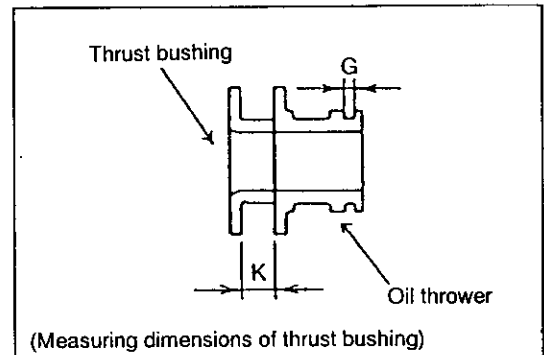
Measure the seal ring groove width (G). Replace with a new one if the measured value exceeds the wear limit.

Wear limit: 1.52 mm

(3) Thrust bearing ②②

Measure the thrust bearing width (J). Replace with a new one if the measured value exceeds the wear limit.

Wear limit: 4.28 mm



3.8.6.2.7 Floating bearing ②①

(1) Check the floating bearing for abnormal wear, discoloration or surface defect. Replace with a new one if defective.

(2) Measure inside diameter (C) and outside diameter (D) of the bearing. If it exceeds the wear limit, replace.

Wear limit

Outside diameter: 15.98 mm

Inside diameter: 11.46 mm

3. Engine Overhaul

3.8.6.2.8 Bearing housing ⑤①

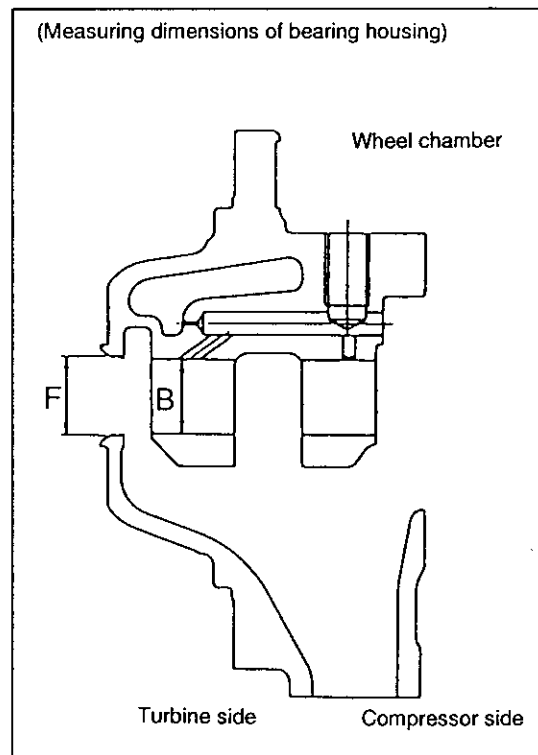
- (1) Check the castings surface for separation, dents and cracks caused by oxidation degradation. Replace faulty parts with new ones.
- (2) Check the retaining ring ⑤② for breakage and cracks. Replace with a new one if defective.
- (3) Measure dimensions (B) and (F) of the bearing housing shown in the illustration. Replace if either measured value exceeds the wear limit.

Bearing housing inside diameter (B)

Wear limit: 16.11 mm

Seal ring insertion hole on turbine side (F)

Wear limit: 17.03 mm



3.8.6.2.9 Seal plate ⑩

- (1) Check the seal plate for any contact traces and defect, dent or cracks of the joint surfaces. Replace with a new one if defective.
- (2) Measure the seal ring insertion hole (H) on the compressor side. Replace the seal ring with a new one if the measured value exceeds the wear limit.

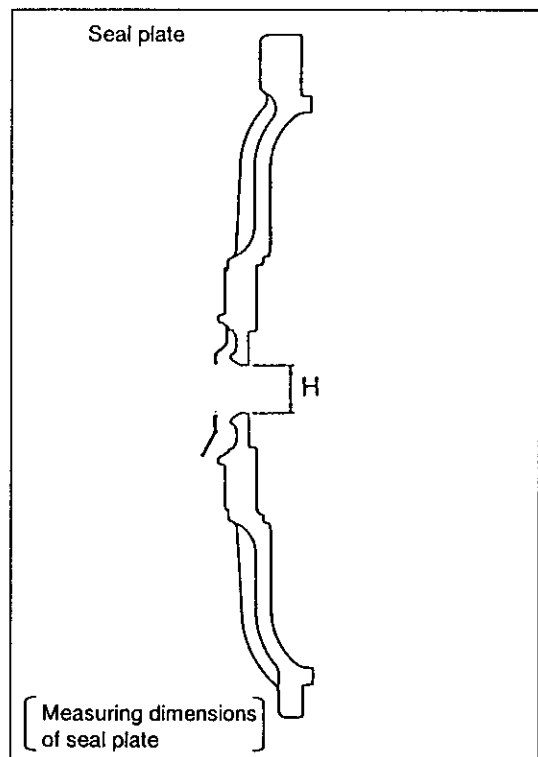
Wear limit: 14.05 mm

3.8.6.2.10 Seal rings ④ and ⑥

Replace seal rings with new ones.

3.8.6.2.11 Check bolts, etc. for deformation.

Replace with new ones if defective. Also, replace the M4 and M8 TORX T screw bolt ⑤④ and ⑤③ with new ones.



3.8.7 Reassembly Procedure

3.8.7.1 Preparation for reassembly

3.8.7.1.1 Prepare tools

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

3.8.7.1.2 Replace the parts

Always replace the following parts with new ones:

- Turbine side seal ring ⑥ (1 pc.)
- Compressor side seal ring ④ (1 pc.)
- M4 pan head small screw ⑤③ (3 pcs.)
- M8 pan head small screw ⑤④ (4 pcs.)

3.8.7.2 Reassembly

3.8.7.2.1 Installation of floating bearing

- (1) Install retaining rings ⑤② to bearing housing ⑤① using the retaining ring pliers.
- (2) Install the turbine side floating bearing ②① to bearing housing ⑤①.
- (3) Install the turbine side retaining ring ⑤② to bearing housing ⑤① using the retaining ring pliers.
- (4) Install the compressor side floating bearing ②① to bearing housing ⑤①.

[NOTICE]

- ***The rounded surface of retaining ring faces to the bearing.***
- ***Apply engine oil to the floating bearing before reassembly.***

3.8.7.2.2 Installation of turbine shaft

- (1) Fit seal ring ⑥ onto turbine shaft ①.
- (2) Install thermal insulation plate ④② to bearing housing ⑤① on the turbine side.
- (3) Apply engine oil to the journal portion of the turbine shaft and insert the shaft from the turbine side of bearing housing ⑤①.

[NOTICE]

***Pay sufficient attention so as not to damage the floating bearing by the turbine shaft.
Position the seal ring end on the lube oil inlet side after centering with the turbine shaft.***

3.8.7.2.3 Installation of thrust bearing

- (1) Fit thrust bushing ② on turbine shaft ①.
- (2) Apply engine oil to the bearing portion of thrust bearing ②② and install it in bearing housing ⑤①.
- (3) Apply Loctite on the threaded portion of M4 TORX T screw bolt ⑤③ used for mounting thrust bearing and install it to the specified torque using the TORX torque screwdriver.

Tightening torque:

$38 \pm 3 \text{ kgf} \cdot \text{cm} (3.73 \pm 0.3 \text{ N} \cdot \text{m})$

3.8.7.2.4 Installation of turbine housing

- (1) Install bearing housing ⑤① to turbine housing ④①, aligning match marks marked before disassembly.

[NOTICE]

If the parts are replaced, install while confirming the oil inlet and outlet positions and the exhaust gas inlet position.

- (2) Tighten M8 TORX bolt ④④ using the TORX torque wrench.

Tightening torque:

$285 \pm 10 \text{ kgf}\cdot\text{cm}$ ($27.95 \pm 1 \text{ N}\cdot\text{m}$)

3.8.7.2.5 Installation of seal plate

- (1) Fit seal ring ④ to oil thrower ③.
- (2) Insert oil thrower ③ into seal plate ①①.
Note: Position the seal ring end on the oil inlet side.
- (3) Apply the liquid gasket (Three Bond No.1207) on the flange surface of seal plate ①① on the turbine side.

Note: See the figure on the right for the applying position.

Liquid gasket thickness: 0.1 to 0.2 mm

- (4) Install seal plate ①① to bearing housing ⑤①.
- (5) Apply Loctite on the threaded portion of M8 TORX bolt ⑤④ for seal plate mounting, and tighten it with the torque wrench.

Tightening torque:

$230 \pm 10 \text{ kgf}\cdot\text{cm}$ ($22.56 \pm 1 \text{ N}\cdot\text{m}$)

3.8.7.2.6 Installation of compressor impeller

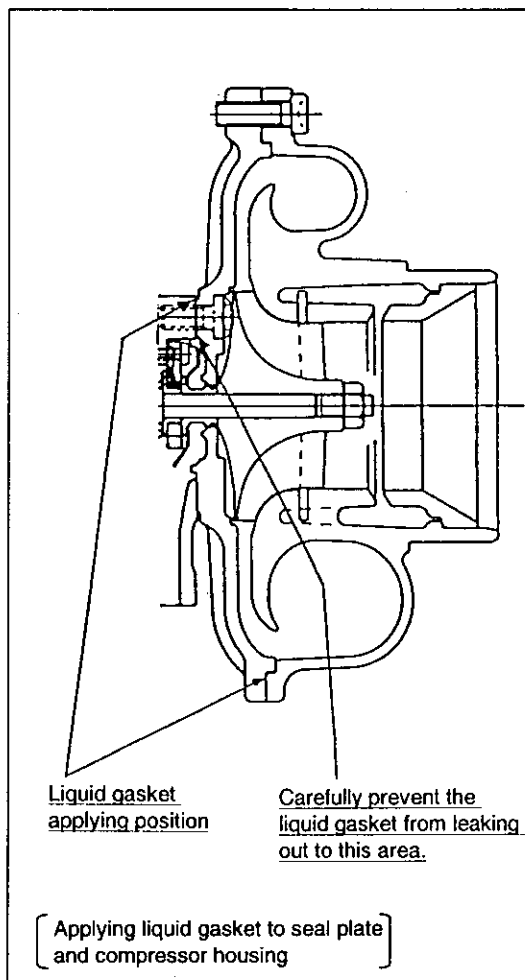
- (1) Fit compressor impeller onto turbine shaft ①.
- (2) Set a box spanner (14 mm) on the turbine side end of turbine shaft ① and tighten shaft end nut ⑦.

[NOTICE]

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

Tightening torque:

$80 \pm 5 \text{ kgf}\cdot\text{cm}$ ($7.84 \pm 0.5 \text{ N}\cdot\text{m}$)



3.8.7.2.7 Installation of compressor housing

- (1) Apply the liquid gasket (Three Bond No.1207) to the compressor side flange surface of seal plate ①.

Note: For the applying position, see 3.8.7.2.5.
Liquid gasket thickness: 0.1 to 0.2 mm

- (2) Assemble compressor housing ③① to bearing housing ⑤①, aligning match marks marked before disassembly.

[NOTICE]

If the parts are replaced, install while confirming the oil inlet and outlet positions and the exhaust gas inlet position.

- (3) Tighten M8 TORX bolt ③③ using the TORX torque wrench.
Tightening torque:
230 ± 10 kgf·cm (22.56 ± 1 N·m)

3.8.7.2.8 Installation of boost hose

- (1) Place hose clip ⑥④ on the center of boost hose ⑥③.
- (2) Fit boost hose ⑥③ to compressor housing ③① and waste gate actuator ⑥①.
- (3) Move hose clip ⑥④ to the nipple portion of compressor housing ③① and waste gate actuator ⑥①, to prevent boost hose ⑥③ from disconnection.

3.8.7.2.9 Measurement of turbine shaft play

See the inspection procedure in section 3.8.4.2.2 for the measurement method.

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

- (1) Turbine shaft play in axial direction
Service standard: 0.06 to 0.09 mm
- (2) Turbine shaft play in radial direction
Service standard: 0.10 to 0.17 mm

3.8.8 Handling after Disassembly and Reassembly

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

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

3.8.8.1 Instructions for turbocharger installation

3.8.8.1.1 Lubrication path

- (1) Add new engine oil through the oil inlet port before installation on the engine, and manually turn the turbine shaft to lubricate the floating and thrust bearings.
- (2) Flush the oil inlet pipe from the engine and outlet pipe, and check for crushed pipe and dirt or foreign matter remaining in the pipes.
- (3) Connect the pipes securely so as to ensure no oil leak from joints.

3.8.8.1.2 Intake path

- (1) Check the intake line for foreign matter or dirt.
- (2) Connect securely to prevent any air leak from joints with the intake duct and air cleaner.

3.8.8.1.3 Exhaust path

- (1) Check the exhaust system for dirt and foreign matter.
- (2) Since heat resistant steel nuts and bolts are used for the installation, do not use ordinary nuts and bolts for other use. Always apply anti-seizure agent on set nuts and bolts at tightening. (Use heat resistant bolts for the turbine housing.)
- (3) Connect exhaust pipes securely to prevent gas leak from each pipe joint.

3.8.9 Troubleshooting

Sufficient turbocharger performance and required engine output cannot be obtained if there is any fault. In such a case, first check each engine part to see if there is any fault. Then, inspect the turbocharger for troubleshooting according to the procedure shown below.

3.8.9.1 Excessively dense exhaust smoke

<Insufficient intake air amount>

Possible cause	Corrective action
1) Clogged air cleaner element	Replace or wash the element.
2) Blocked air intake port	Remove obstruction.
3) Leak from a joint in intake line	Inspect and repair.

<Turbocharger operation failure>

Possible cause	Corrective action
1) Deposit of impurities in oil sticking on the turbine side seal portion to hamper smooth turbine shaft rotation	<ul style="list-style-type: none"> • Turbocharger overhaul (disassembly and washing) and engine oil replacement
2) Bearing seizure <ul style="list-style-type: none"> • Insufficient lubrication or clogged lubrication piping • Excessively high oil temperature • Unbalanced rotating part • Insufficient warming up or sudden stop from loaded operation (no-load operation) 	<ul style="list-style-type: none"> • Turbocharger overhaul (disassembly and repair) Inspect the oil system of the engine and repair faulty parts and replace the engine oil. • Replace or wash the faulty rotating part. • Strictly observe instructions in the operation manual.
3) Contact or breakdown of turbine wheel or compressor impeller <ul style="list-style-type: none"> • Over speed • Excessive exhaust temperature rise • Foreign matter invasion • Worn bearing • Faulty assembly 	<ul style="list-style-type: none"> • Inspect and repair faulty engine parts. • Completely remove foreign matter after disassembling. Inspect the air cleaner and engine parts and repair as needed. • Disassemble turbocharger for repair. • Reassemble.

<Influence of exhaust resistance >

Possible cause	Corrective action
1) Exhaust gas leak before the turbocharger to decrease its speed	<ul style="list-style-type: none"> • Check the mounting portions and repair as needed. • Repair the pipe to the normal operating condition.
2) Since exhaust piping is deformed or clogged, turbocharger speed does not increase.	

3.8.9.2 White exhaust gas color

Possible cause	Corrective action
1) Oil flows to the compressor or turbine side due to clogged oil return pipe.	<ul style="list-style-type: none"> • Repair or replace the piping. • Disassemble and repair the turbocharger.
2) Abnormal wear or breakage of seal ring by excessive wear of bearing	

3.8.9.3 Excessive engine oil consumption

Possible cause	Corrective action
1) Abnormal wear or breakage of seal ring by excessive wear of bearing	<ul style="list-style-type: none"> • Disassemble and repair the turbocharger.

3.8.9.4 Engine output drop

Possible cause	Corrective action
1) Gas leak at exhaust system	<ul style="list-style-type: none"> • Check for faulty part and repair. • Wash or replace the element. • Disassemble and repair or replace the turbocharger.
2) Air leak from discharge side of compressor	
3) Clogged air cleaner element	
4) Dirty or damaged turbocharger	

3.8.9.5 Poor (slow) response (starting) of turbocharger

Possible cause	Corrective action
1) Hard carbon deposits on the turbine side (wheel sealing) to hamper turbine shaft smooth rotation	<ul style="list-style-type: none"> • Replace engine oil and wash the turbocharger after disassembly. • Check the engine combustion system and take corrective action to obtain good combustion.
2) Incomplete combustion	

3.8.9.6 Abnormal sound or vibration

<Abnormal sound>

Possible cause	Corrective action
1) Excessively narrowed gas path due to clogged nozzle in turbine housing or reverse flow of blower discharge during acceleration (generally called surging)	• Disassemble and wash the turbocharger.
2) Contacting rotating parts	• Disassemble and repair or replace the turbocharger.

<Abnormal vibration>

Possible cause	Corrective action
1) Loose intake, exhaust or oil pipe connection with the turbocharger	• Check pipe connections of the turbocharger and repair as needed.
2) Chipping of turbine wheel or compressor impeller caused by contacting between rotating part and adjacent parts due to damaged bearing or invasion by foreign matter	• Disassemble and repair or replace the turbocharger. If foreign matter has invaded, completely remove it.
3) Unbalanced rotating part	• Repair or replace the rotating part.

3.9 Fuel Filter Replacement

3.9.1 Removal of Fuel Filter

3.9.1.1 Disconnect the connector of the water alarm switch of the fuel filter

3.9.1.2 Drain fuel from the fuel filter

- (1) Close the cocks of fuel tank, etc.
- (2) Connect a vinyl hose to the filter drain cock and the other end of the hose to an oil container.
- (3) Loosen the drain plug to drain the fuel.

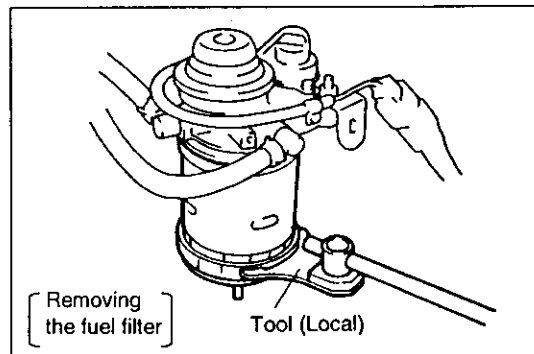
3.9.1.3 Fuel filter removal

Remove the fuel filter.

3.9.1.4 Remove the water alarm switch from the fuel filter

Remove the alarm switch and O-ring using pliers.

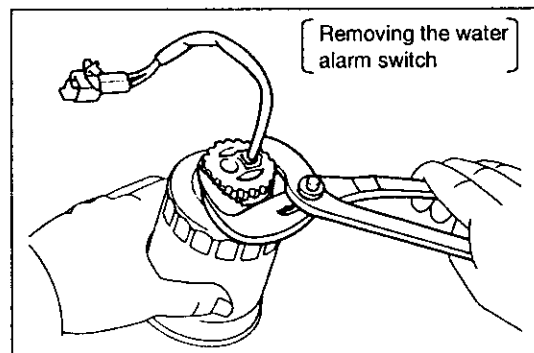
Note: Pay attention so as not to damage the alarm switch.



3.9.2 Installation of Fuel Filter

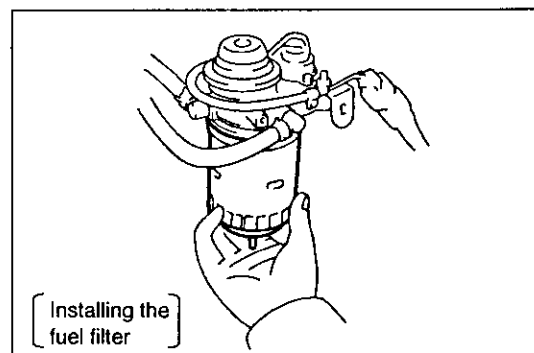
3.9.2.1 Install the water alarm switch to the new fuel filter

- (1) Install a new O-ring to the alarm switch.
- (2) Apply fuel to the O-ring of the alarm switch.
- (3) Manually install the alarm switch to the new fuel filter.



3.9.2.2 Install the new fuel filter

- (1) Check and clean the fuel filter mounting surface.
- (2) Apply fuel to the gasket of the new fuel filter.
- (3) Lightly screw in the fuel filter in position and tighten it until the gasket comes into contact with the seat.
- (4) Manually retighten the filter by a 3/4 turn.
Tightening torque:
150 to 200 kgf·cm (14.71 to 19.61 N·m)

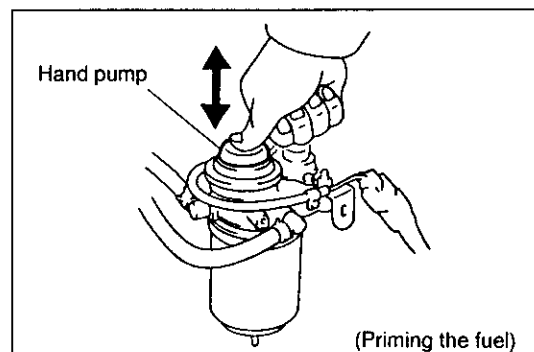


3.9.2.3 Install the water alarm switch connector of the fuel filter

3.9.2.4 Fill fuel to the fuel filter

- (1) Open the fuel tank cock and operate the hand pump to add fuel.
- (2) Operate the hand pump until further operation is felt heavy.

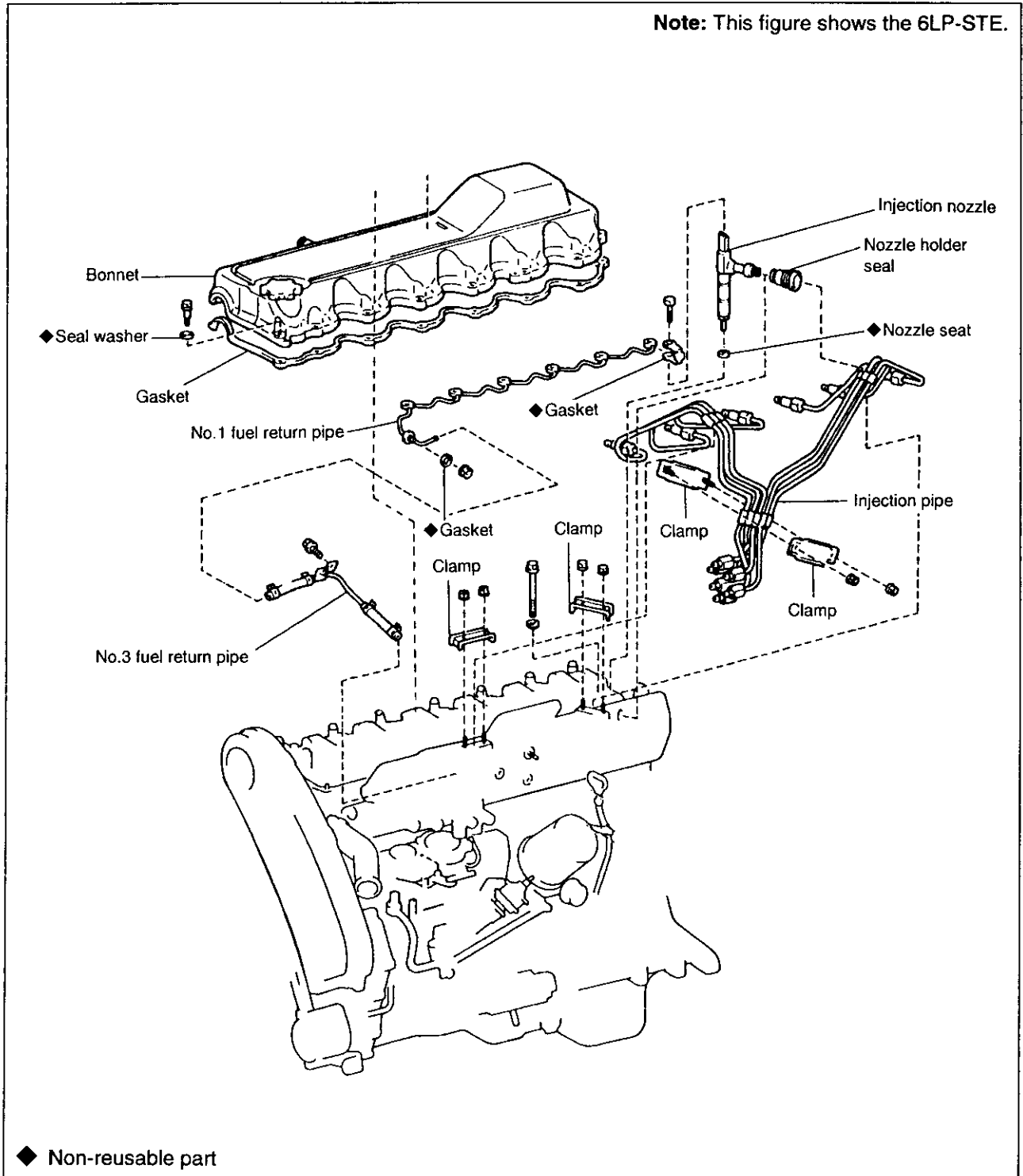
3.9.2.5 Start the engine to check for fuel leakage



As for servicing of the fuel injection pump and fuel injection nozzle, consult the DENSO Serviceshop. Here, the servicing procedure is described for your reference.

3.10 Fuel Injection Nozzle

3.10.1 Components

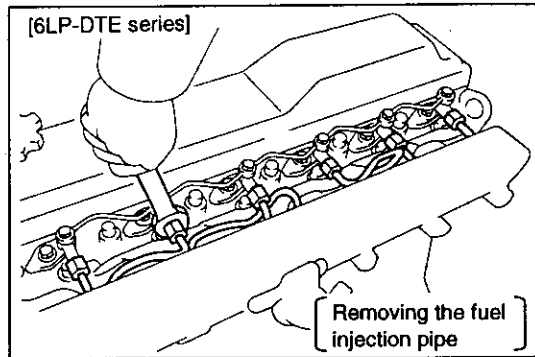


3.10.2 Removal of Fuel Injection Nozzle

[6LP-DTE series]

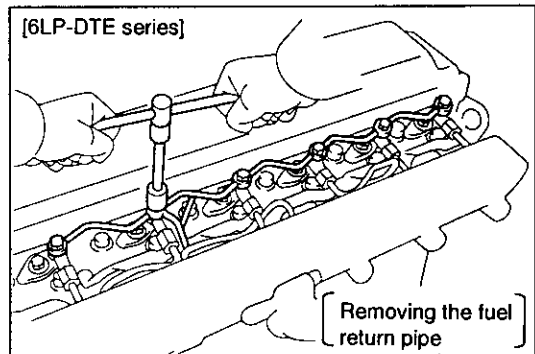
(1) Remove the fuel injection pipe.

Remove the fuel injection pipe nut from the fuel injection nozzle.



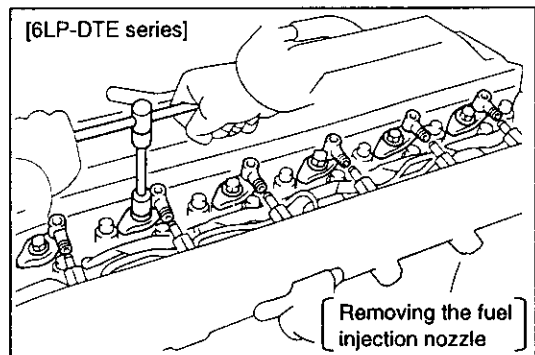
(2) Remove the fuel return pipe.

- ① Disconnect the fuel hose from the fuel return pipe.
- ② Remove the six joint bolts, fuel return pipe and 12 gaskets.



(3) Remove the fuel injection nozzle.

- ① Remove the bolt, washer, nozzle holder clamp, fuel injection nozzle and seat.
- ② Remove the O-ring from the fuel injection nozzle.



[6LP-STE series]

(1) Remove the bonnet

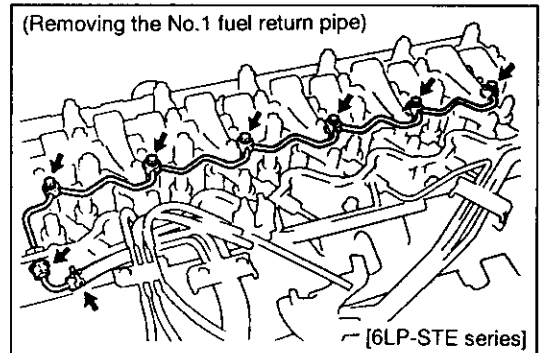
(See 3.1.2.7 Remove the bonnet.)

(2) Remove the link unit from the fuel injection pump and intake manifold

(3) Remove the No.1 fuel return pipe

① Remove the No.1 fuel return pipe from the cylinder head.

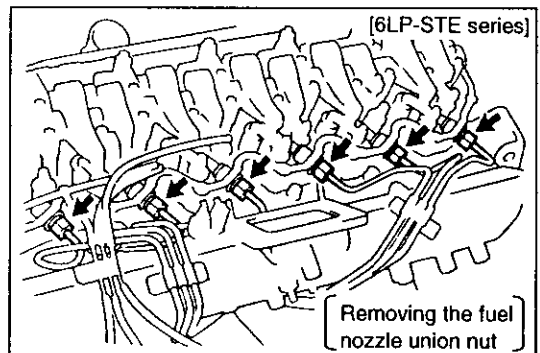
- Remove six joint bolts, a nut, seven gaskets and No.1 fuel return pipe.
- Disconnect the fuel return hose from the No.1 return pipe.



(4) Remove the fuel injection pipe

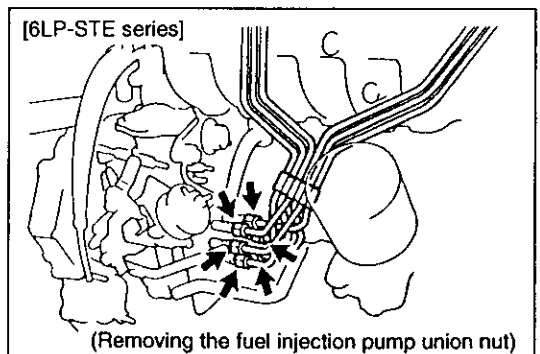
① Remove the 4 nuts and 2 clamps from the intake manifold.

② Remove the 4 nuts and 2 clamps.

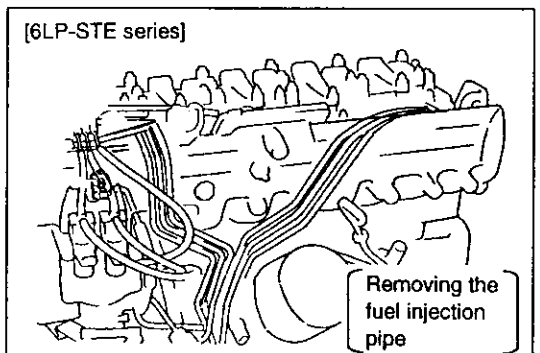


③ Remove the union nut of the fuel injection pipe from the fuel injection nozzle.

④ Remove the union nut of the fuel injection pipe from the fuel injection pump.



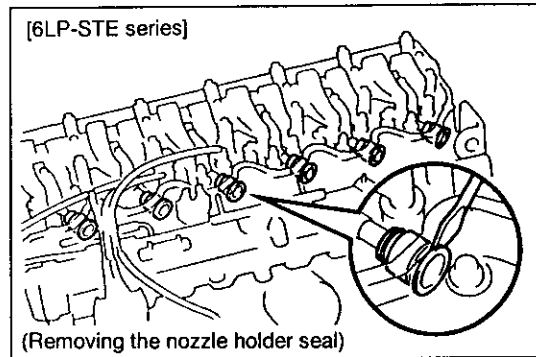
⑤ Remove the fuel injection pipe.



3. Engine Overhaul

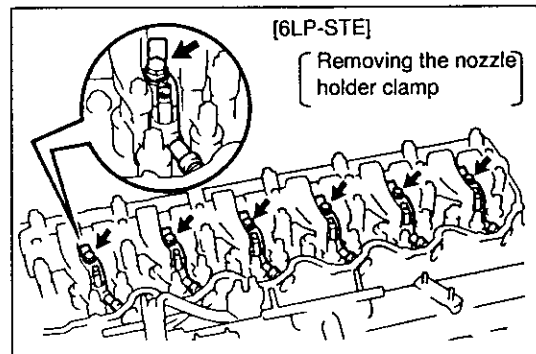
(5) Remove the nozzle holder seal

Pry out the nozzle holder seal using a screwdriver from the cylinder head.



(6) Remove the fuel injection nozzle

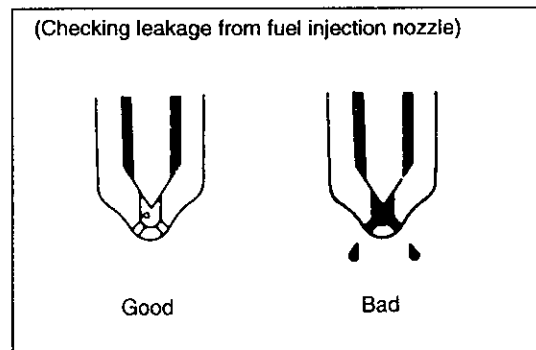
- ① Remove the nozzle holder clamp from the cylinder head.
- ② Remove the fuel injection nozzle and seat from the cylinder head.
- ③ Remove the O-ring from the fuel injection nozzle.
 - Store fuel injection nozzle in orderly manner so that they will be reassembled to corresponding cylinders.



3.10.3 Testing the Fuel Injection Nozzle

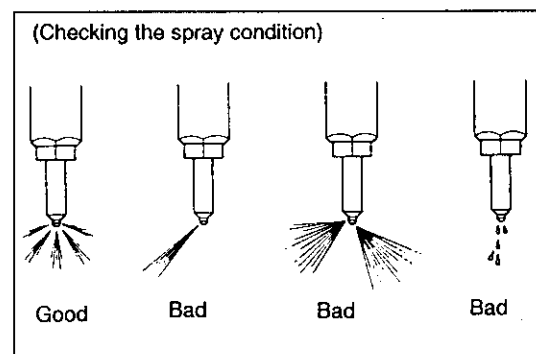
3.10.3.1 Leak test

Increase the pressure to near the specified injection pressure of 10 to 20 kgf/cm² (0.98 to 1.96 MPa). Check for oil leakage from the injection hole and around the retaining nut. If leakage occurs from the nozzle, replace, clean or overhaul the nozzle.

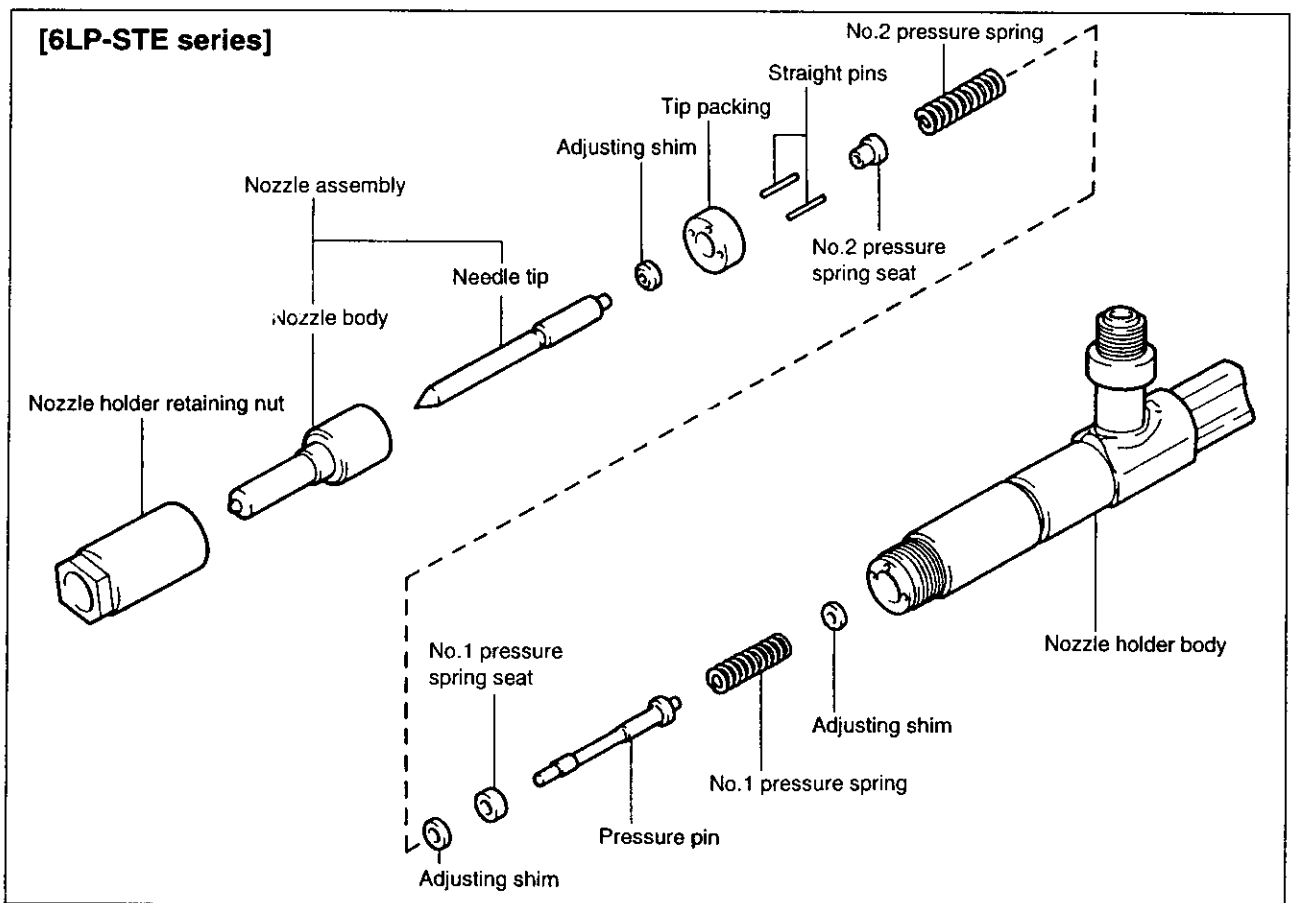
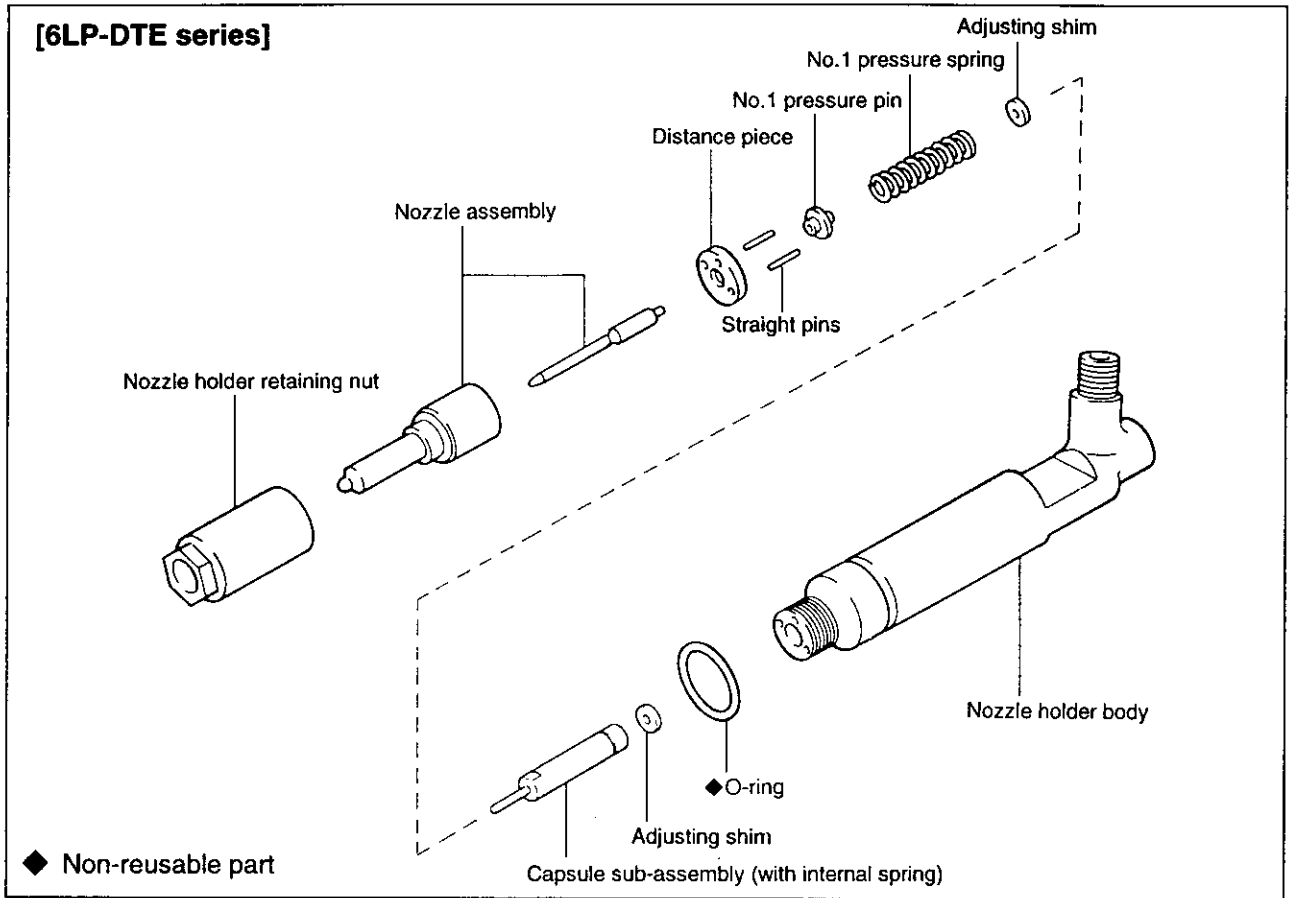


3.10.3.2 Testing the spray condition

Check the spray condition. If the spray condition is improper, replace or clean the nozzle.



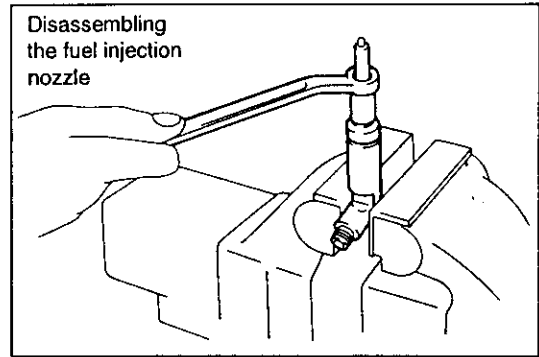
3.10.4 Components of Fuel Injection Nozzle



3.10.5 Disassembly of Fuel Injection Nozzle

3.10.5.1 Disassemble the fuel injection nozzle

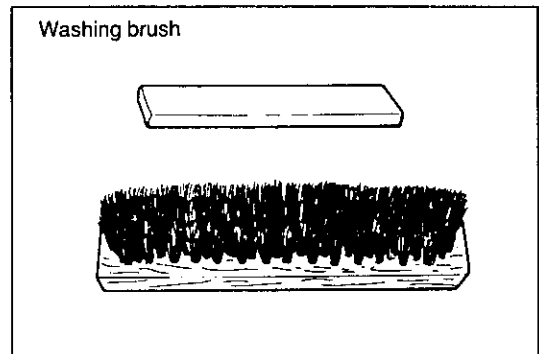
- (1) Remove the nozzle holder retaining nut.
 - Be careful not to drop internal parts when disassembling the nozzle.
- (2) Disassemble the fuel injection nozzle.



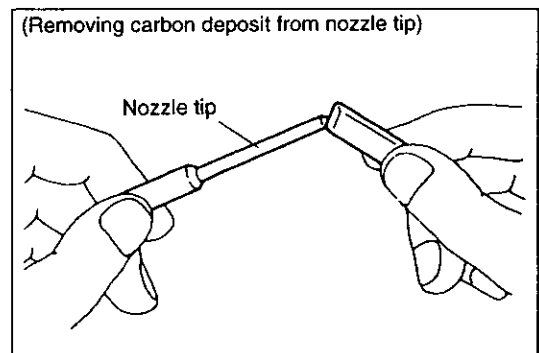
3.10.6 Cleaning and Inspection of Fuel Injection Nozzle

3.10.6.1 Cleaning the nozzle

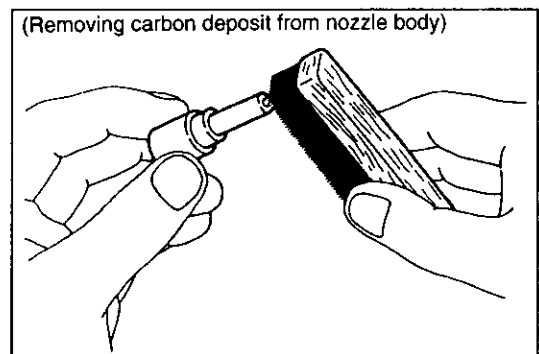
- (1) Prepare a wooden stick and soft (brass) brush when washing the nozzle. Wash the nozzle with clean diesel oil.
 - Do not touch the nozzle mating surfaces with bare fingers.



- (2) Remove carbon deposits from the nozzle tip, using a wooden stick.

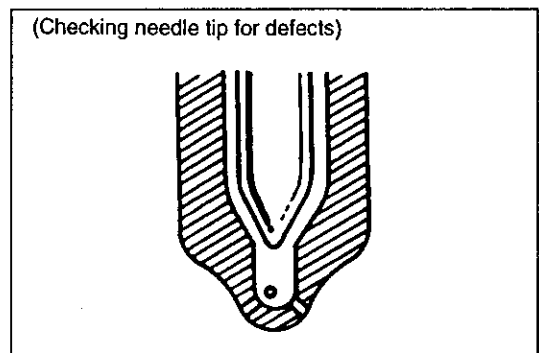


- (3) Remove carbon deposits from the outside surface of nozzle body using a soft (brass) brush (except the lapped surface).



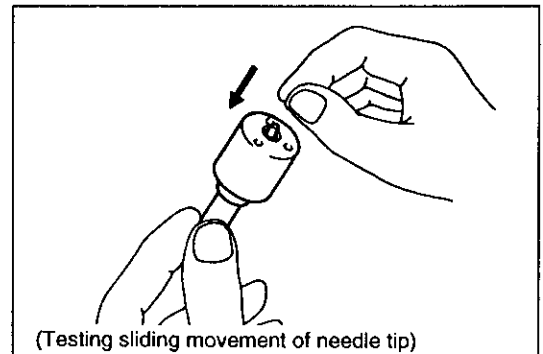
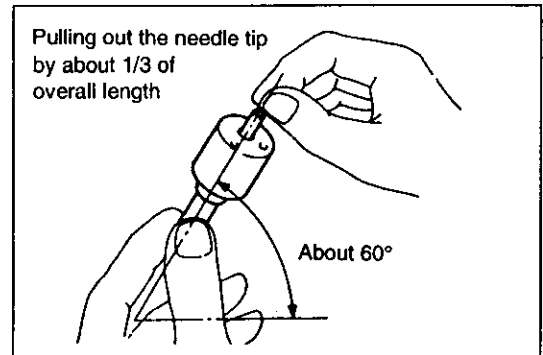
- (4) Check the nozzle body seat for damages and corrosion.

- (5) Check the needle tip for damages and corrosion. If any of these conditions is discovered, replace the nozzle assembly.



3.10.6.2 Inspection of nozzle assembly

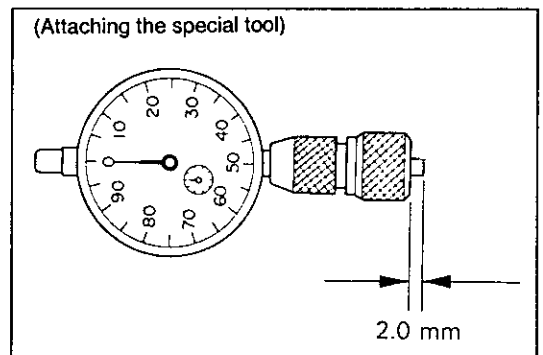
- (1) Wash the nozzle in clean diesel oil.
 - Do not touch the nozzle mating surfaces with bare hands.
- (2) Incline the nozzle body by about 60° and pull out the needle tip by about 1/3 of its overall length.
- (3) Check that the needle tip returns smoothly into the body by its own weight.
- (4) Repeat the above test several times after turning the needle tip. If the needle tip fails to return smoothly, replace the nozzle assembly.



3.10.7 Adjustment of Fuel Injection Nozzle

3.10.7.1 Adjust the needle lift and pre-lift

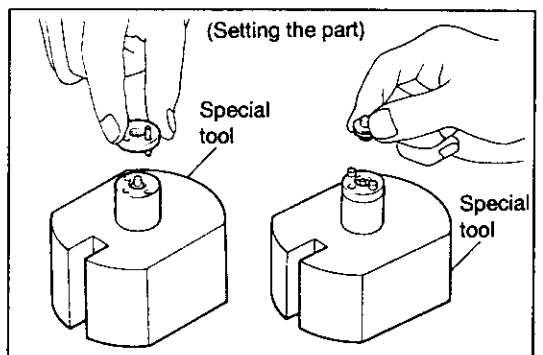
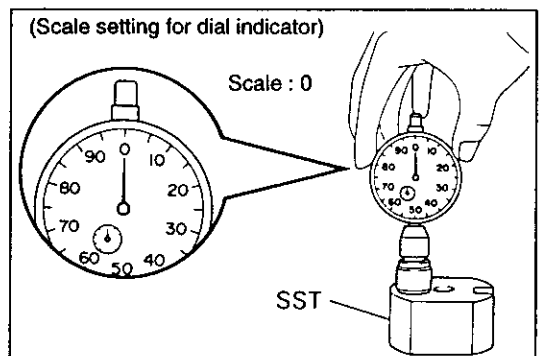
- High precision is required for needle lift and pre-lift measurements. So, thoroughly clean the parts and tools before measurements and prevent invasion by foreign matter.



3.10.7.2 For 6LP-DTE series

1. Adjust the pre-lift

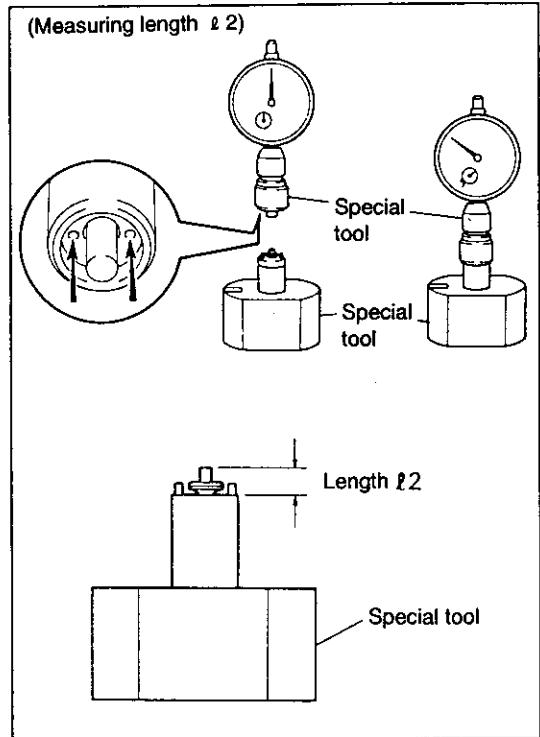
- (1) Attach the special tool to the dial indicator and adjust the protrusion shown in the figure to 2.0 mm or less.
- (2) Adjust the dial indicator reading on the special tool or square block to 0 mm, using the special tool.
- (3) Locate the nozzle assembly, distance piece, straight pins and No.1 pressure pin on the special tool shown in the figure.



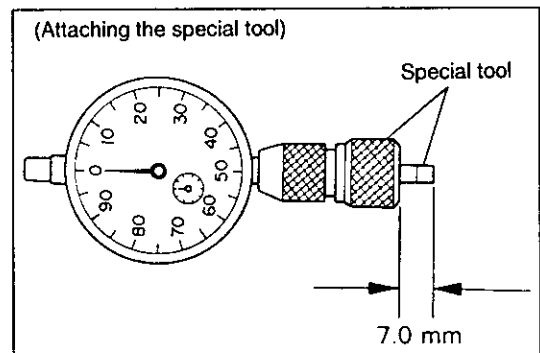
3. Engine Overhaul

- (4) Fit the holes in the special tool to the straight pins and measure length $\ell 2$.

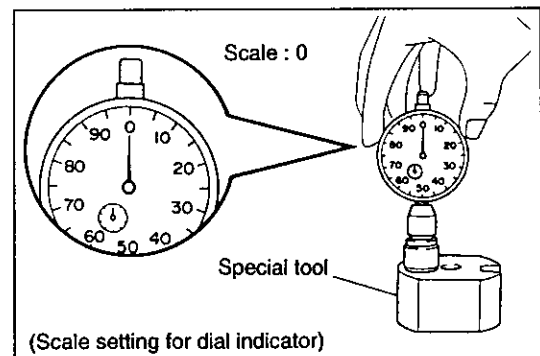
Length $\ell 2$ (standard): 4.70 mm



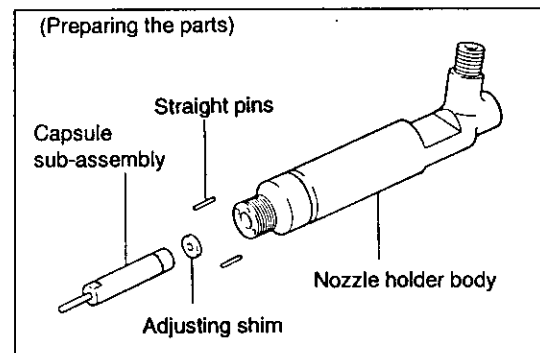
- (5) Attach the special tool to the dial indicator and adjust the protrusion shown in the figure to 7.0 mm or less.



- (6) Adjust the dial indicator reading to 0 mm on the special tool or square block.

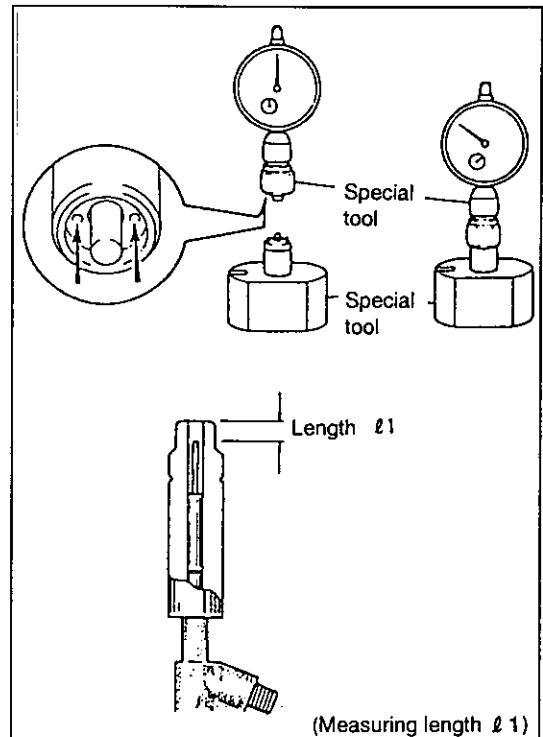


- (7) Locate the adjusting shim, capsule sub-assembly and straight pins on the nozzle holder body as shown.



- (8) Fit the holes in the special tool to the straight pins and measure length $\ell 1$.

Length $\ell 1$ (standard): 4.79 mm

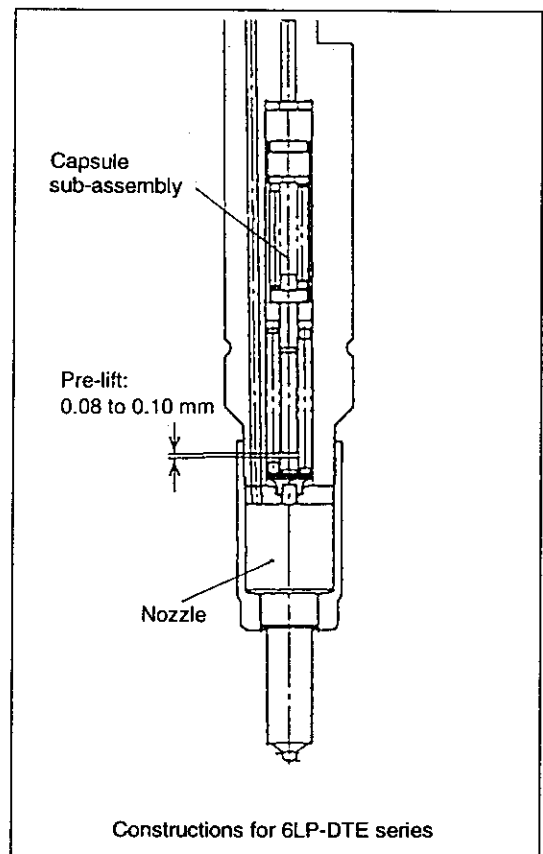


- (9) Subtract length $\ell 2$ from length $\ell 1$.

Pre-lift: 0.08 to 0.10 mm

If the obtained pre-lift is not within the specified range, select a suitable adjusting shim, installed at the upper portion of capsule sub-assembly, from those listed below.

Adjusting shim thickness			mm
0.700	1.310	1.520	
0.750	1.320	1.530	
0.800	1.330	1.540	
0.850	1.340	1.550	
0.900	1.350	1.560	
0.950	1.360	1.570	
0.975	1.370	1.580	
1.000	1.380	1.590	
1.025	1.390	1.600	
1.050	1.400	1.610	
1.075	1.410	1.620	
1.100	1.420	1.630	
1.125	1.430	1.640	
1.150	1.440	1.650	
1.175	1.450	1.660	
1.200	1.460	1.670	
1.225	1.470	1.680	
1.250	1.480	1.690	
1.280	1.490	1.700	
1.290	1.500	1.750	
1.300	1.510	1.800	

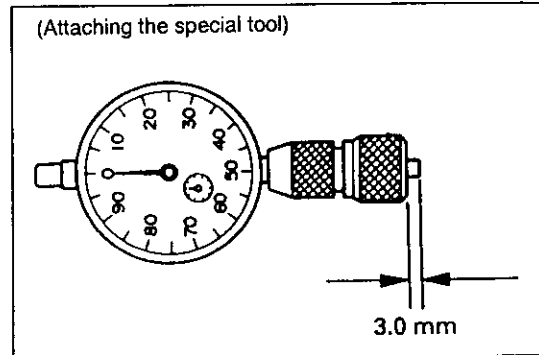


3. Engine Overhaul

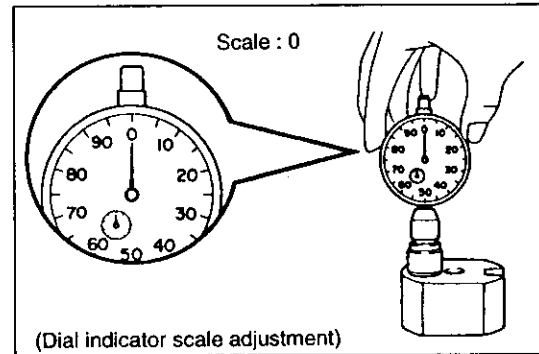
3.10.7.3 For 6LP-STE series

1. Adjust the Needle-lift

(1) Attach the special tool to the dial indicator and adjust the protrusion length shown in the figure to 3.0 mm or less.



(2) Adjust the dial indicator reading to 0 mm on the special tool or square block, using the special tool.



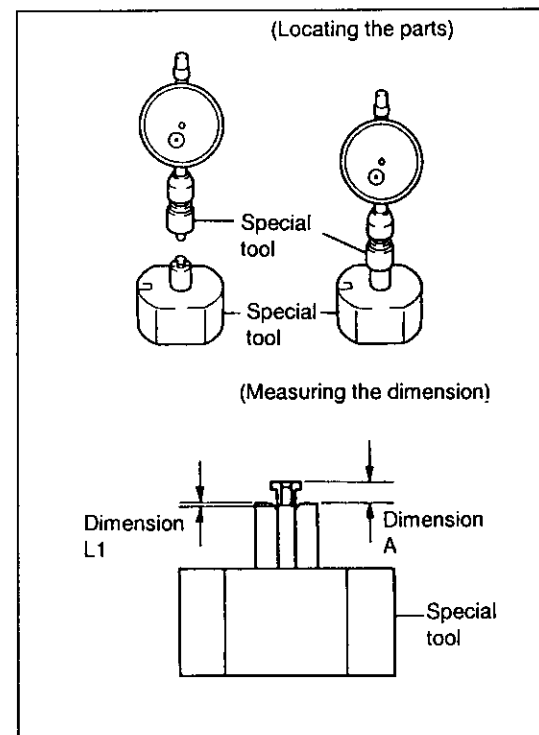
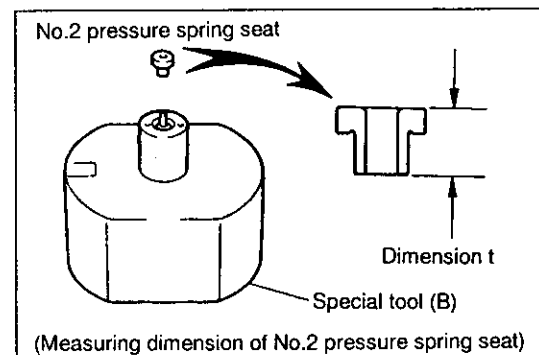
(3) Measure dimension t of the No.2 pressure spring seat using a micrometer.

(4) Locate the nozzle assembly and No.2 pressure spring seat on the special tool (B) as shown.

(5) Set the special tool on the nozzle and measure dimension A.

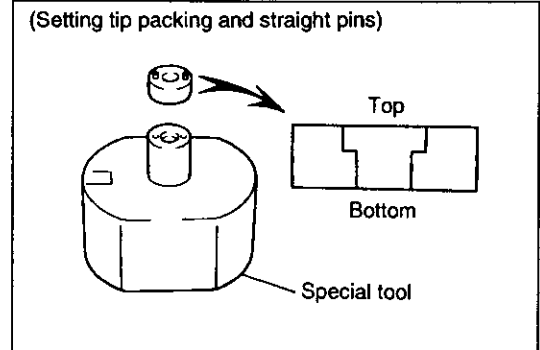
$$\text{Dimension L1} = t - A$$

(6) Remove the special tool and needle tip from the nozzle body.



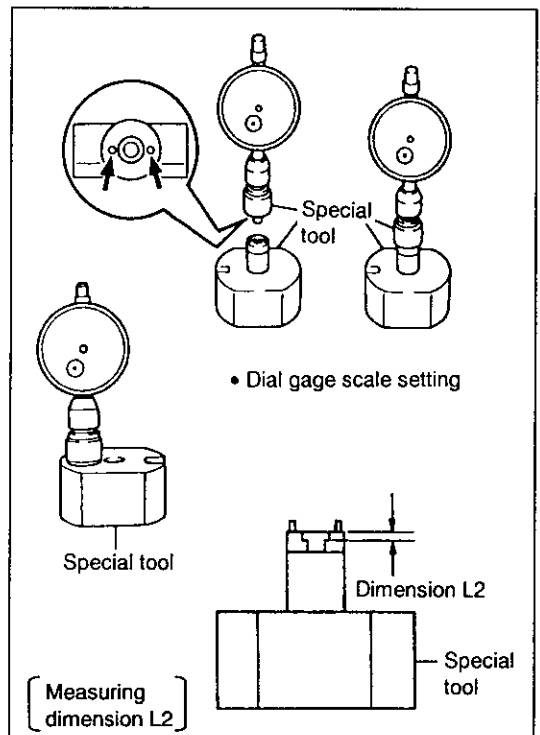
- (7) Locate the tip packing and straight pins as shown.

Note: Place the tip packing on the nozzle body in the direction shown in the figure.



- (8) Adjust the dial indicator reading to 0 mm on the special tool or square block, using the special tool.

- (9) Fit the straight pins into the tip packing and then fit the holes in the special tool to the straight pins. Measure dimension L2.



- (10) Measure dimension L3 of the adjusting shim, using a micrometer.

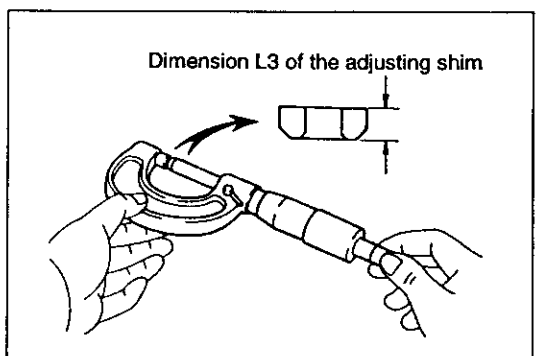
$$\text{Needle lift} = (L1+L2) - L3$$

Needle lift: 0.26 to 0.31 mm

If the obtained needle lift is out of the specified range, change the adjusting shim.

Thickness of the adjusting shims (mm)

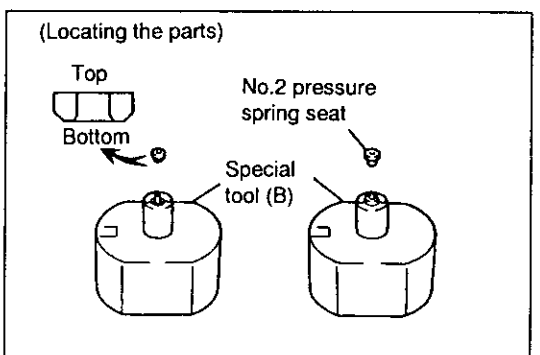
1.900	1.925	1.950
1.975	2.000	-



- Increasing the shim thickness reduces the needle lift.

2. Adjust the pre-lift

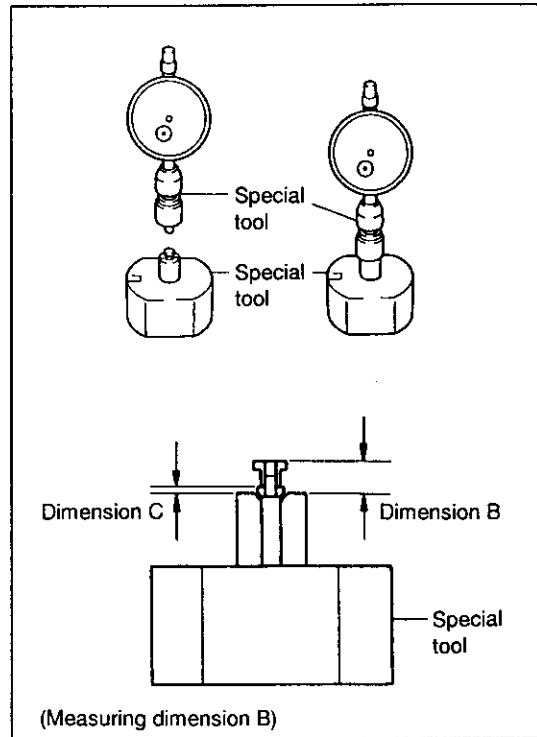
- (1) Locate the nozzle assembly, adjusting shim selected in step 1 above and No.2 pressure spring seat on the special tool (B) as shown, using the special tool.



3. Engine Overhaul

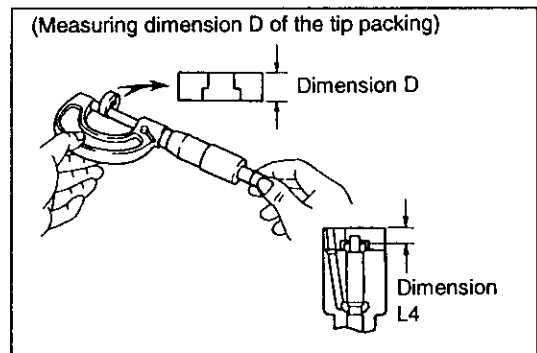
- (2) Set the special tool on the nozzle and measure dimension B.

$$\text{Dimension C} = \text{B} - t$$



- (3) Measure dimension D of the tip packing using a micrometer.

$$\text{Dimension L4} = \text{D} - \text{C}$$



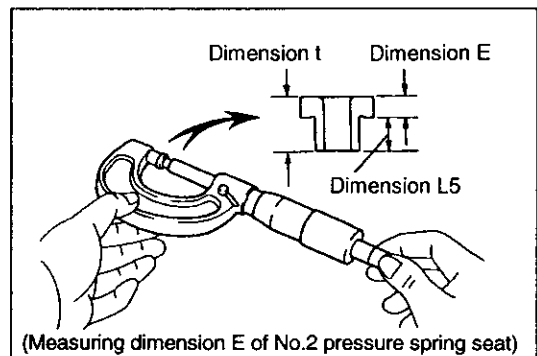
- (4) Measure dimension E of No.2 pressure spring seat, using a micrometer.

$$\text{Dimension L5} = t - E$$

$$\text{Pre-lift} = \text{L4} - \text{L5}$$

Pre-lift standard: 0.08 to 0.10 mm

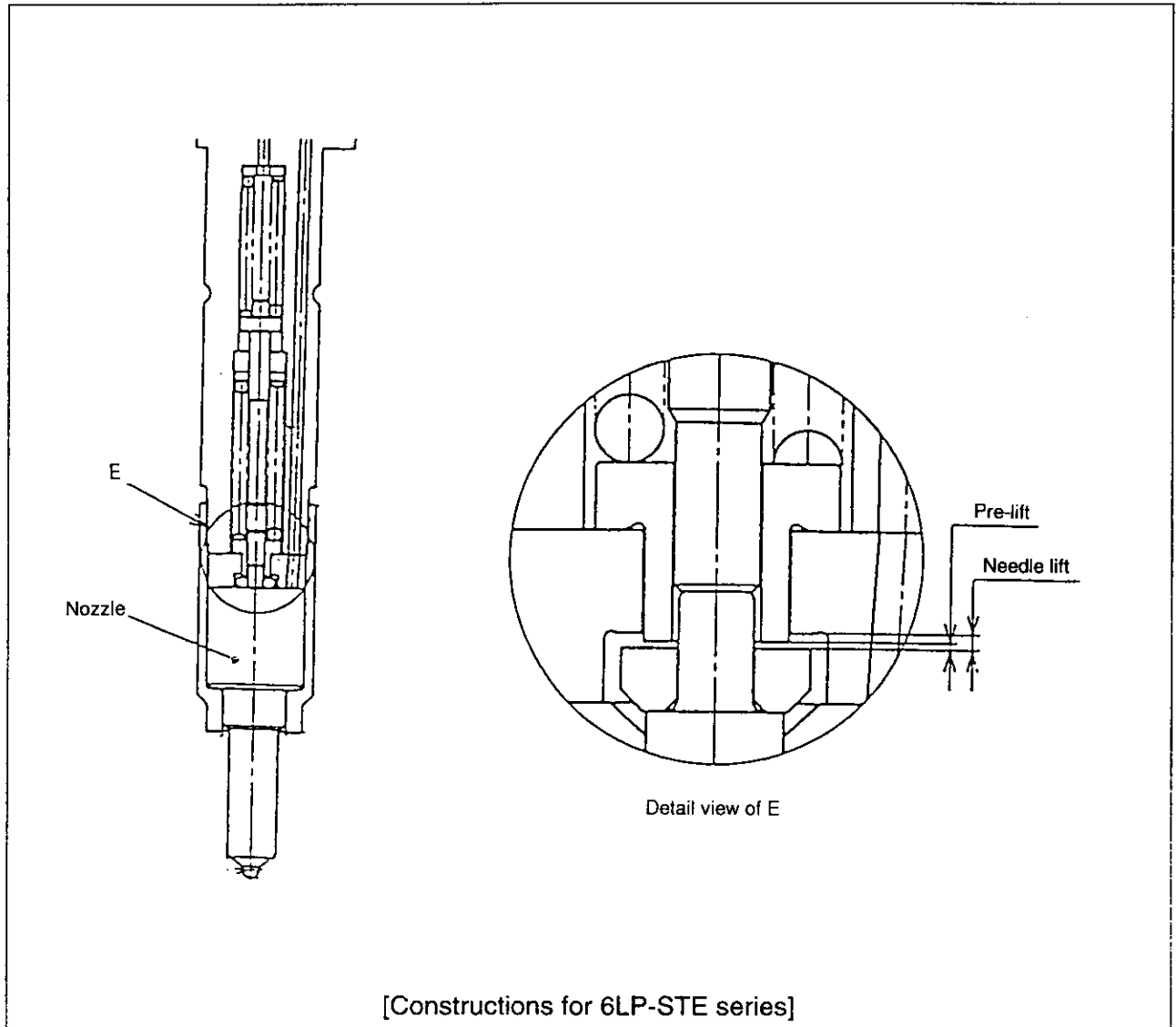
If the pre-lift length is out of the specified range, select a No.2 pressure spring seat from those listed below.



Thickness of No.2 pressure spring seat (t) (mm)

3.09	3.12	3.15
3.18	3.21	3.24
3.27	—	—

- Increasing the seat thickness reduces the pre-lift.



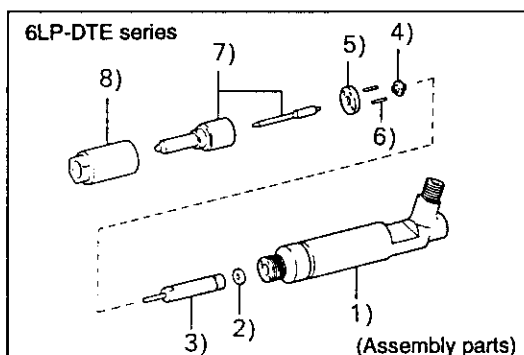
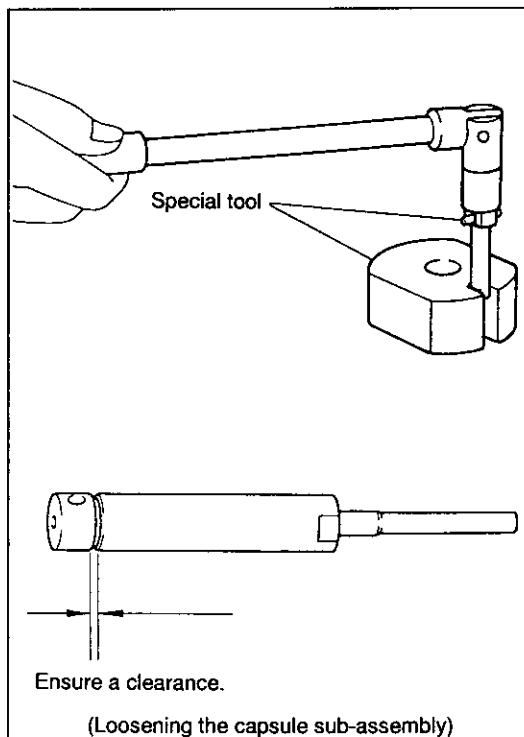
3.10.8 Checking No.2 Opening Pressure

[For 6LP-DTE series]

- (1) Loosen the plug screw of the capsule sub-assembly by 1 or 2 turns using the special tool.
 - Loosening the plug screw by 1 or 2 turns sets the pre-lift to 0 mm.

Assemble the following parts:

- 1) Nozzle holder body
 - 2) Adjusting shim
 - 3) Capsule sub-assembly
 - 4) No.1 pressure pin
 - 5) Distance piece
 - 6) Straight pins
 - 7) Nozzle assembly
 - 8) Nozzle holder retaining nut
- Exclude the No.1 pressure spring and adjusting shim.

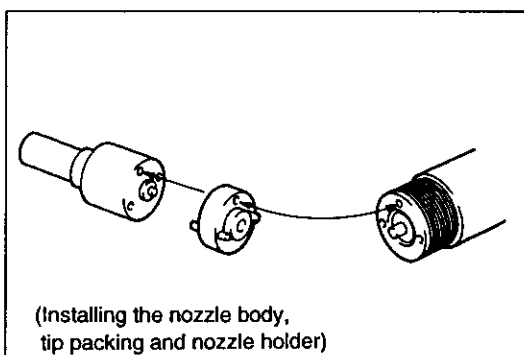
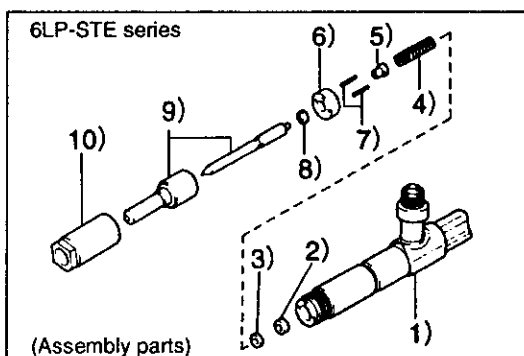


[For 6LP-STE series]

- (1) Assemble the following parts:

- 1) Nozzle holder body
- 2) No.1 pressure spring seat
- 3) Adjusting shim
- 4) No.2 pressure spring
- 5) No.2 pressure spring seat
- 6) Tip packing
- 7) Straight pins
- 8) Lift adjusting shim
- 9) Nozzle assembly
- 10) Nozzle holder retaining nut

- Exclude the No.1 pressure spring, adjusting shim and pressure pin.
- Align holes of the nozzle body, tip packing and nozzle holder body.



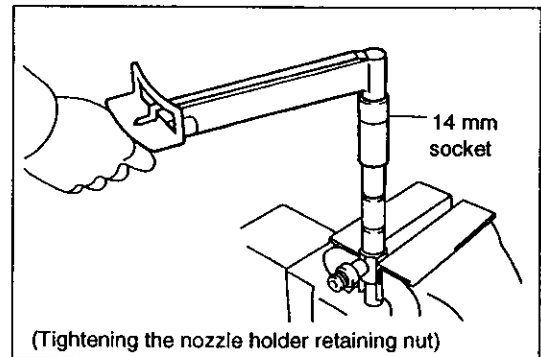
- (2) Tighten the nozzle holder retaining nut to the specified torque, using the 14 mm socket wrench.

Tightening torque

6LP-DTE series: 350 kgf·cm (34.32 N·m)

6LP-STE series: 300 kgf·cm (29.42 N·m)

Note: Do not tighten excessively. Otherwise, deformation, adhesion or other defects may occur.

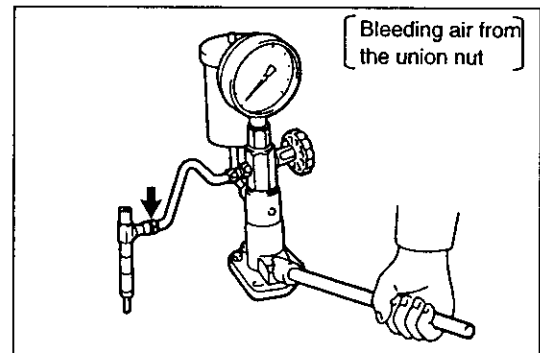


- (3) Install the fuel injection valve to the nozzle tester and bleed air from the union nut.

⚠ WARNING

Never put your hands to the nozzle injection hole.

Otherwise, your hands may be injured.



- (4) Pump the tester handle several times as quickly as possible to discharge foreign matter from the injection hole.

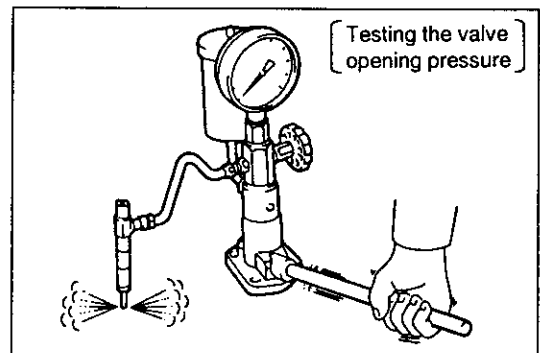
- (5) Slowly pump the tester handle and observe the pressure gauge.

- (6) Read the pressure gauge when the injection pressure begins to decrease.

No.2 opening pressure:

300 to 310 kgf/cm² (29.42 to 30.40 MPa)

- Judge if the nozzle operates normally or not by hearing the swishing sound.



[For 6LP-DTE series]

If No.2 opening pressure is out of the specified range, replace the capsule sub-assembly.

- No.2 opening pressure of a new capsule sub-assembly is already adjusted at shipment.

[For 6LP-STE series]

If No.2 opening pressure is out of the specified range, disassemble the nozzle and select a suitable adjusting shim located at the upper portion of the No.2 pressure spring from those listed below.

Thickness of adjusting shim (mm)

0.700	0.850	1.000
1.025	1.150	1.175
1.275	1.300	1.425
1.450	1.575	1.600
1.725	1.750	1.900
2.050	—	—

- Changing the adjusting shim thickness by 0.025 mm changes the injection pressure by approximately 3.8 kgf/cm² (0.37 MPa).
- Change only one adjusting shim (at the upper portion of No.2 pressure spring).

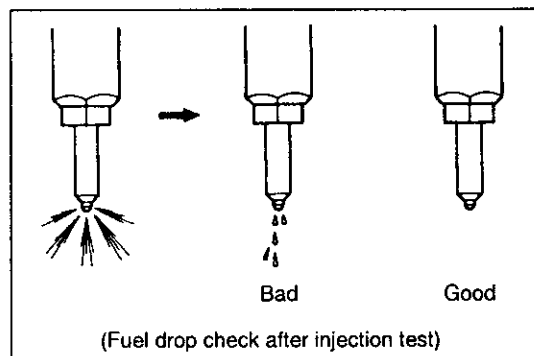
(7) After the injection test, check that no drops from the injection hole.

(8) Disassemble the nozzle after checking the No.2 opening pressure.

[For 6LP-DTE series]

Remove the capsule sub-assembly and tighten the plug screw.

Tightening torque: 25 kgf·cm (2.45 N·m)



3.10.9 Adjusting No.1 Opening Pressure

- (1) Reassemble the fuel injection nozzle assembly to the operating condition (as shown in the structural diagram in 3.10.4).
 - Align holes of the nozzle holder body, distance piece and nozzle holder body.
 - If the adjusting shim thickness originally used is unknown, use the shim with a 1.5mm thickness.
- (2) Install the assembly to the tester, carry out pumping and read the pressure gauge when the injection pressure begins to decrease.

No.1 opening pressure:

250 to 260 kgf/cm² (24.52 to 25.50 MPa)

- Judge if the nozzle operates normally or not by hearing the swishing sound. If the valve opening pressure is out of the specified range, disassemble the nozzle select a suitable adjusting shim at the upper portion of the capsule assembly (6LP-DTE) or at the upper portion of No.1 pressure spring (6LP-STE) from those listed below.

[For 6LP-DTE series]

Adjustment shim thickness			mm
0.700	1.310	1.520	
0.750	1.320	1.530	
0.800	1.330	1.540	
0.850	1.340	1.550	
0.900	1.350	1.560	
0.950	1.360	1.570	
0.975	1.370	1.580	
1.000	1.380	1.590	
1.025	1.390	1.600	
1.050	1.400	1.610	
1.075	1.410	1.620	
1.100	1.420	1.630	
1.125	1.430	1.640	
1.150	1.440	1.650	
1.175	1.450	1.660	
1.200	1.460	1.670	
1.225	1.470	1.680	
1.250	1.480	1.690	
1.280	1.490	1.700	
1.290	1.500	1.750	
1.300	1.510	1.800	

- Changing the adjusting shim thickness by 0.01 mm changes the valve opening pressure by approximately 1.5 kgf/cm² (0.15 MPa).
- Change only one adjusting shim (at the upper portion of No.1 pressure spring).

[For 6LP-STE series]**Adjusting shim thickness (mm)**

0.825	0.900	0.975
1.050	1.125	1.200
1.275	1.350	1.425
1.500	1.575	1.650
1.725	1.800	1.875
1.950	2.000	2.100
2.175	—	—

- Changing the adjusting shim thickness by 0.025 mm changes the valve opening pressure by approximately 3.8 kgf/cm² (0.37 MPa).
- Change only one adjusting shim (at the upper portion of No.1 pressure spring).

(3) After the injection test, check that no drops from the injection hole.

3.10.10 Installation of Fuel Injection Nozzle

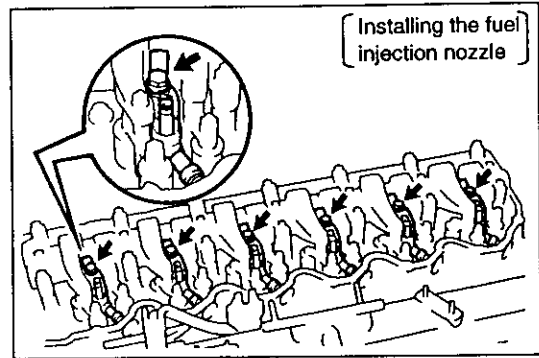
3.10.10.1 Install the fuel injection nozzle

- (1) Install a new O-ring to the fuel injection nozzle.
- (2) Insert a new nozzle seat in the hole in the fuel injection nozzle of the cylinder head.
- (3) Install the fuel injection nozzle to the cylinder head, using the nozzle holder clamp, washer and bolt.

Tightening torque

6LP-DTE series: 400 kgf·cm (39.23 N·m)

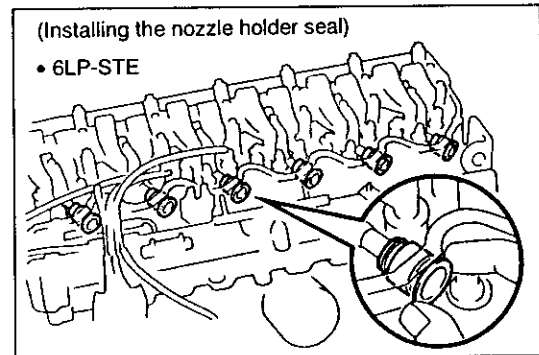
6LP-STE series: 255 kgf·cm (25.01 N·m)



3.10.10.2 Install the nozzle holder seal

[6LP-STE series]

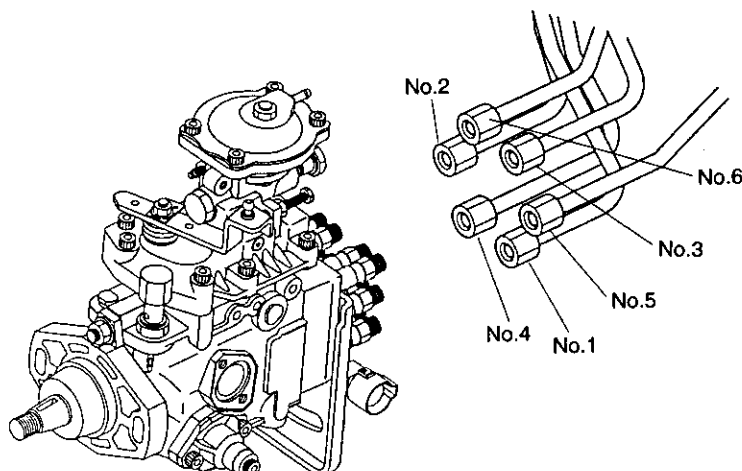
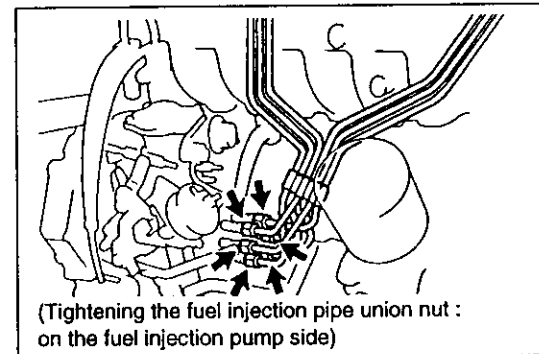
Manually install a new nozzle holder seal to the cylinder head.



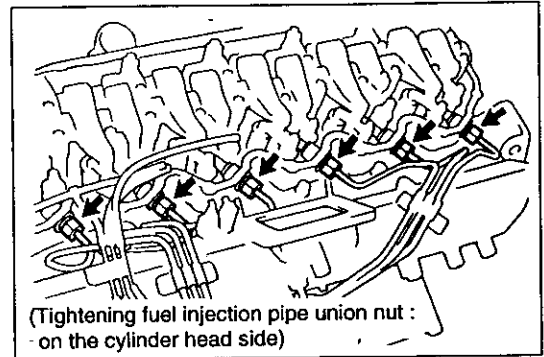
3.10.10.3 Install the fuel injection pipe

- (1) Install the fuel injection pipe to the fuel injection nozzle and fuel injection pump.
- (2) Tighten the union nut onto the fuel injection pump.

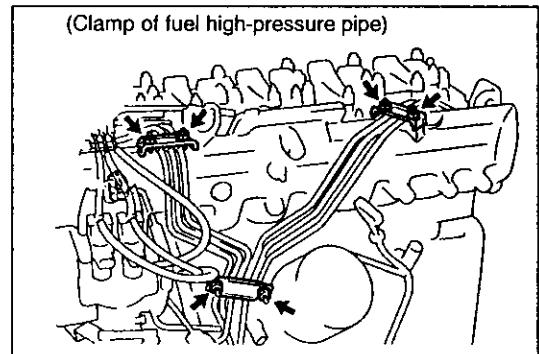
Tightening torque: 250 kgf·cm (24.52 N·m)



- (3) Tighten the union nut to the fuel injection nozzle.
Tightening torque: 250 kgf·cm (24.52 N·m)



- (4) Fix two clamps with 2 nuts.
Tightening torque: 65 kgf·cm (6.37 N·m)



- (5) Fix two clamps with 4 nuts to the intake manifold.

3.10.10.4 Install the fuel return pipe [6LP-STE series]

- (1) Fix seven new gaskets and No.1 fuel return pipe to the cylinder head and fuel injection nozzle, using six joint bolts and nuts.

Tightening torque:

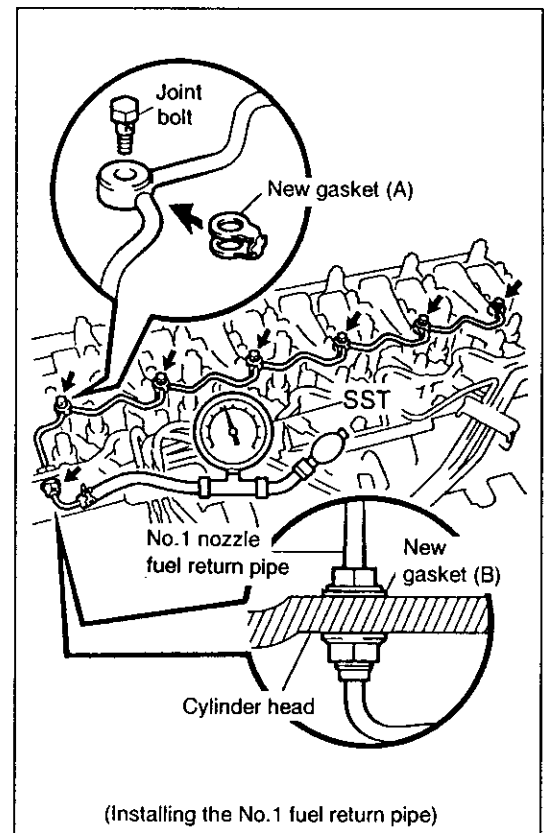
Joint bolt: 176 kgf·cm (17.26 N·m)

Nut: 186 kgf·cm (18.24 N·m)

- Install gasket (A) so that its joint is located between pipes, as shown in the illustration.

- (2) Use the turbocharger pressure gauge as the tool. Connect the pressure gauge to the fuel return side of the No.1 fuel return pipe, apply a 0.5 kgf/cm² (0.05 MPa) pressure continuously for 10 seconds and check for leakage.

- (3) Connect the fuel return hose to the No.1 fuel return pipe.



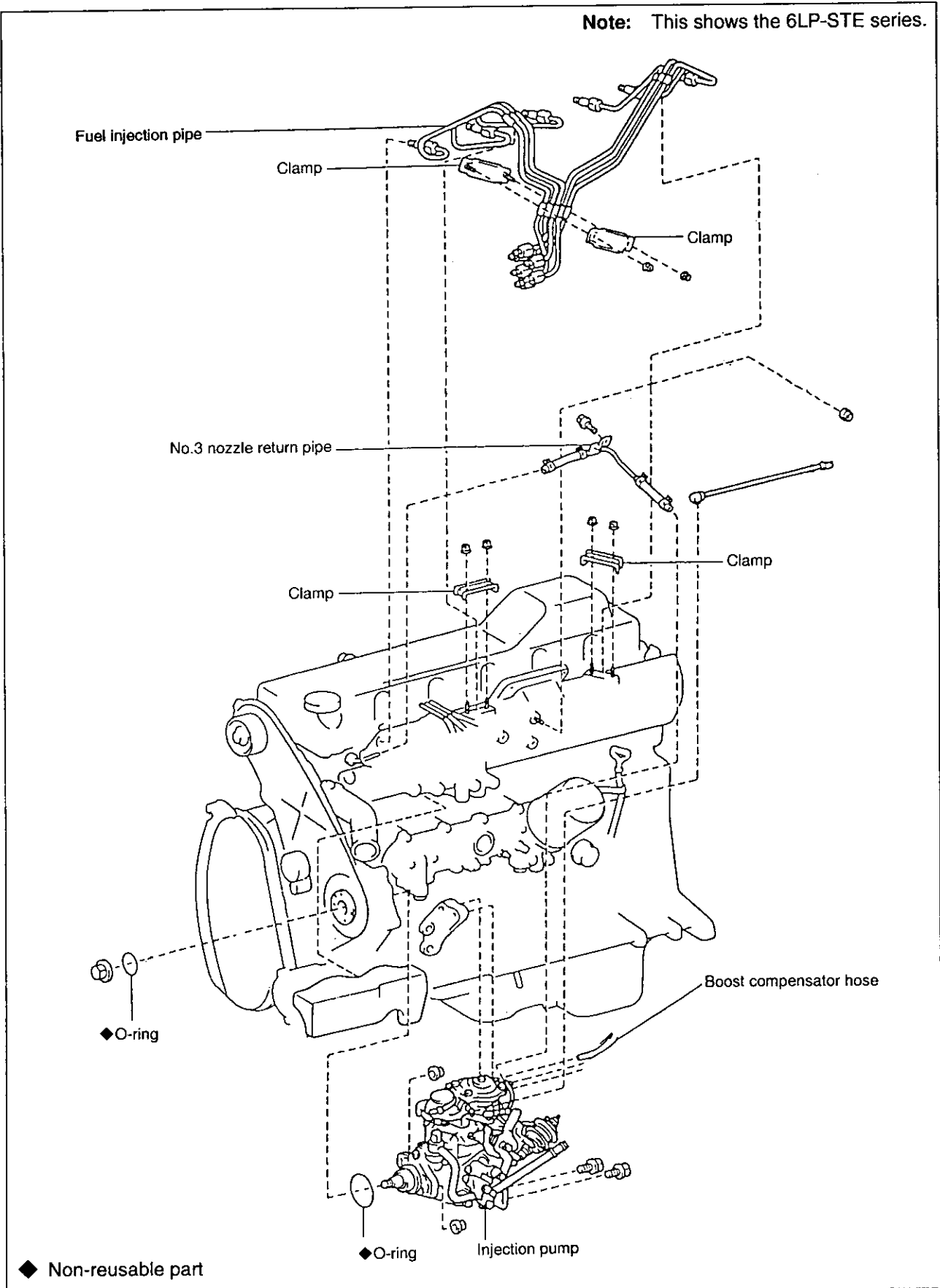
3.10.10.5 Install the bonnet

(See 3.1.7.10 Install the bonnet)

3.10.10.6 Start the engine and check for fuel leakage

3.11 Fuel Injection Pump

Fuel injection pump related components



3.11.1 Removal of Fuel Injection Pump

3.11.1.1 Drain cooling water from the engine and disconnect the cooling pipe

3.11.1.2 Remove the timing belt
(See 3.3.2 Removal of Timing Belt)

3.11.1.3 Remove the No.2 camshaft timing pulley
(See 3.3.2.5 Remove No.2 camshaft timing pulley)

3.11.1.4 Remove the fuel injection pipe
(See 3.10.2 Removal of Fuel Injection Nozzle)

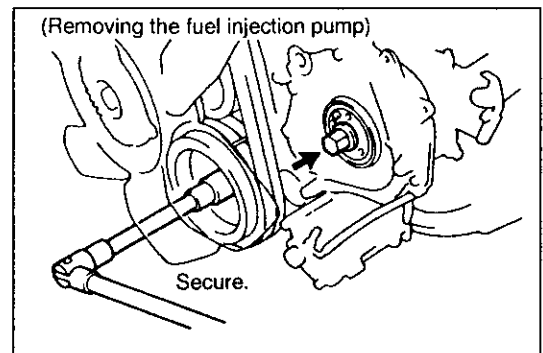
3.11.1.5 Disconnect the boost compensator hose

3.11.1.6 Remove the fuel injection pump

(1) Remove the fuel injection pump drive gear set nut while securing the crankshaft pulley.

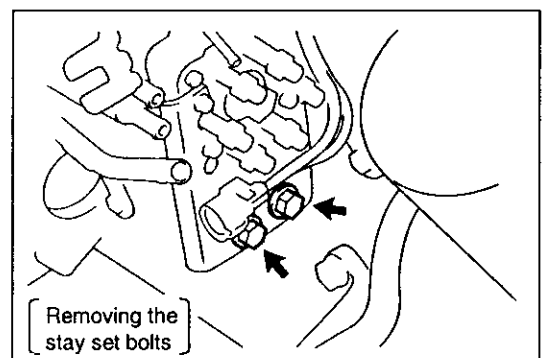
[NOTICE]

*Pay attention so that the crankshaft pulley will not turn.
Otherwise, the valve heads and piston top may be damaged by interference with each other.*



(2) Remove the O-ring from the fuel injection pump drive gear.

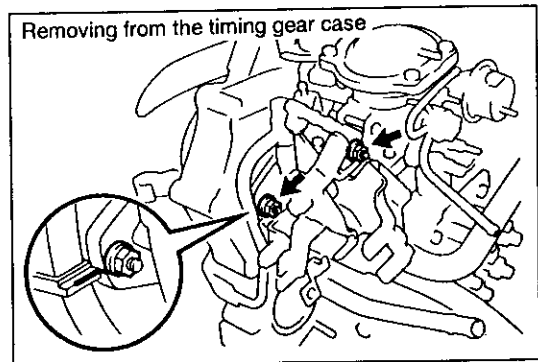
(3) Remove two fuel injection pump stay set bolts.



3. Engine Overhaul

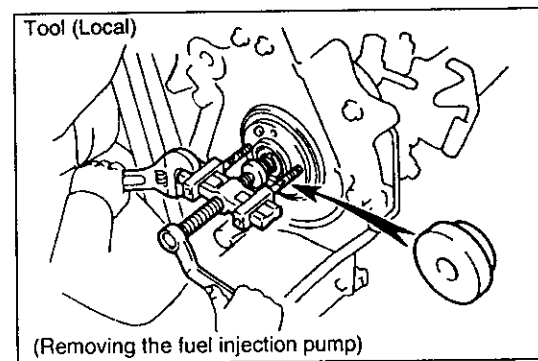
(4) Check that match marks align before removing the fuel injection pump.
If not, draw a new match marks for reassembly.

(5) Remove the two nuts securing the fuel injection pump to the timing gear case.



(6) Remove the fuel injection pump using the special tool.

- Tighten the two bolts over 8 mm.
- Set the special tool with balance.
- Never grasp the adjust lever for moving the fuel injection pump. Otherwise, the adjust lever may be damaged.
- Do not place the fuel injection pump at 45° or more from the level.

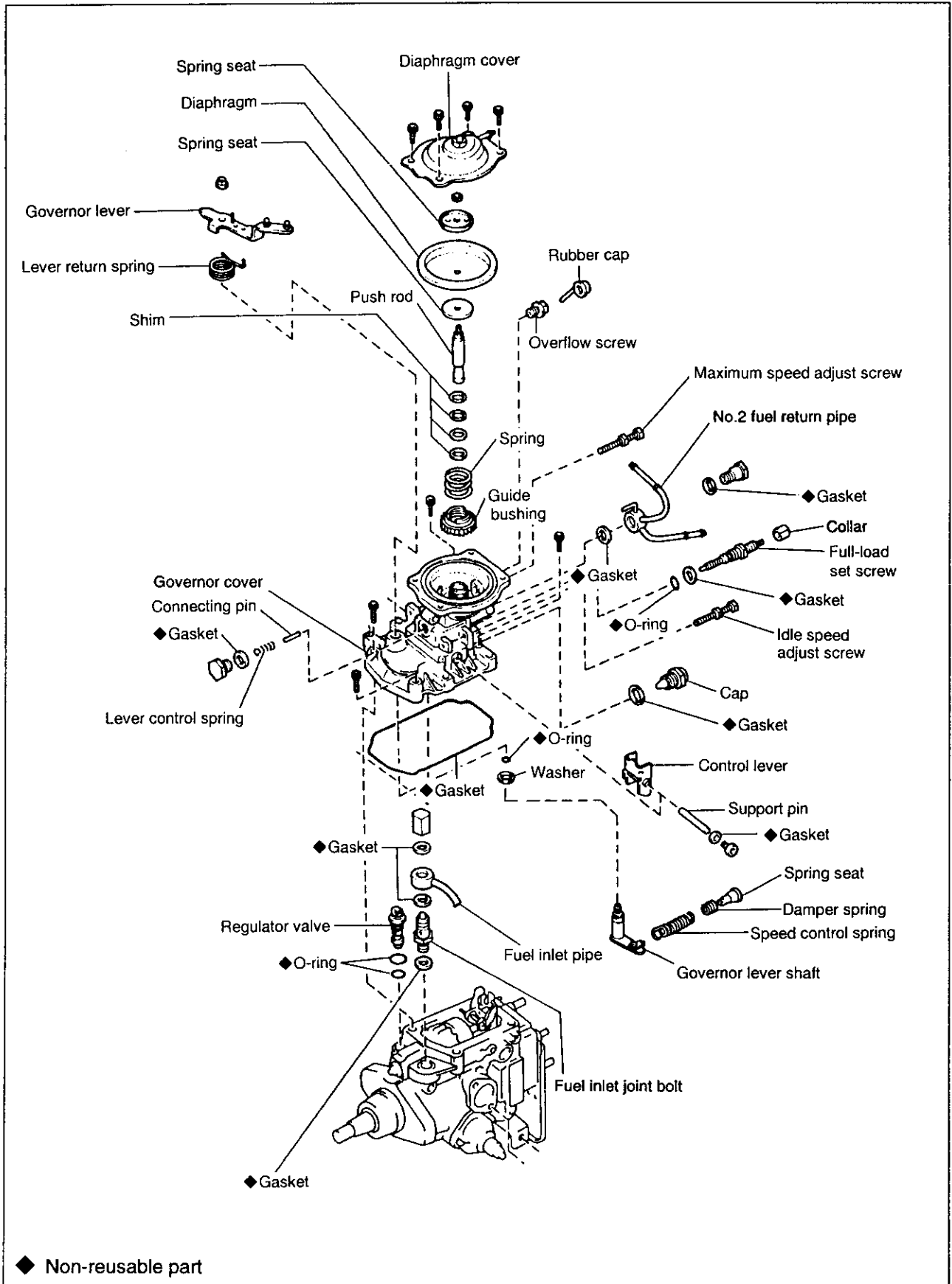


(7) Remove the O-ring from the fuel injection pump.

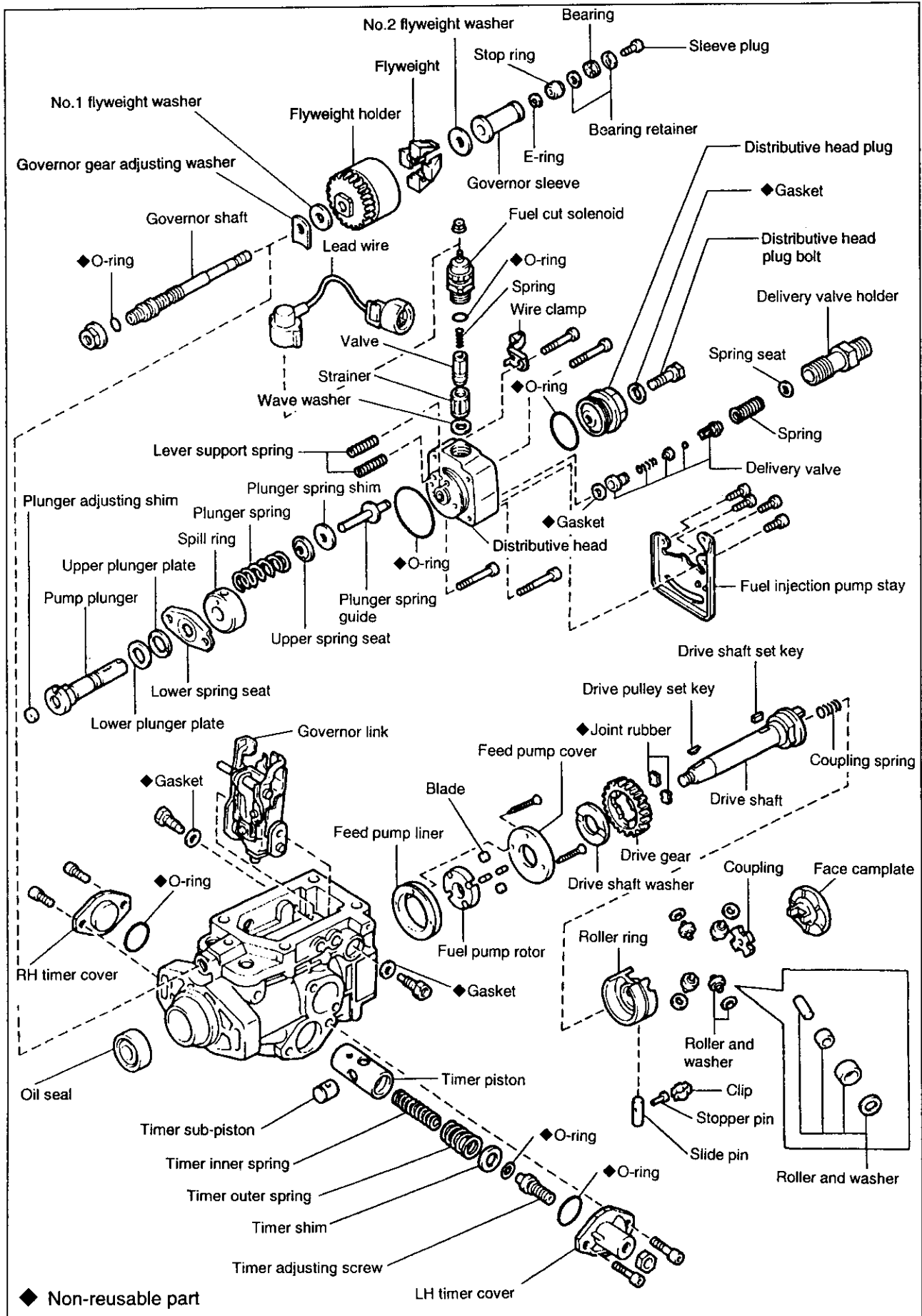
3.11.2 Components

Note: *Since professional knowledge and special equipment are required for disassembly and adjustment of the fuel injection pump, consult the DENSO.*

Components (to be continued)



Components (continued)

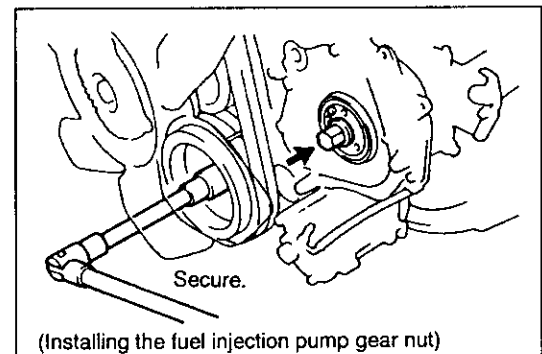
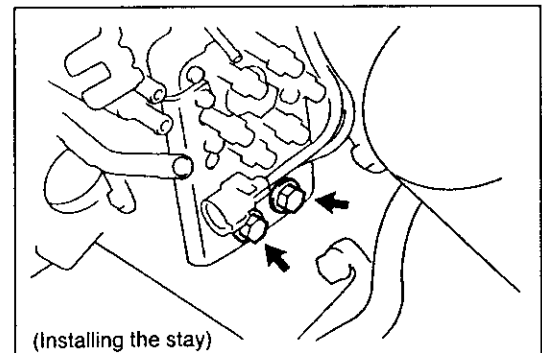
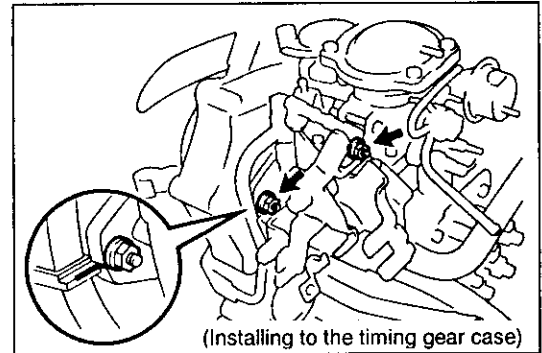
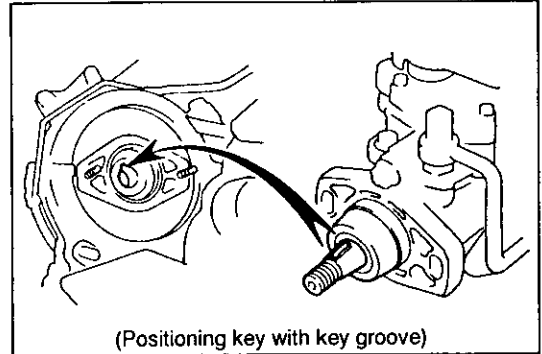


3.11.3 Installation of Fuel Injection Pump

3.11.3.1 Install the fuel injection pump

Note: Do not place the fuel injection pump at a position over 45° from the level.

- (1) Install a new O-ring to the pump.
- (2) Lightly apply engine oil to the O-ring.
- (3) Align the set key on the drive shaft with the groove in the fuel injection pump drive gear.
- (4) Align match marks of the fuel injection pump and timing gear case.
- (5) Install the two nut securing the fuel injection pump to the timing gear case.
Tightening torque: 185 kgf·cm (18.14 N·m)
- (6) Install the fuel injection pump stay using two bolts.
Tightening torque: 700 kgf·cm (68.65 N·m)
Note: Check that the pump stay is lifted to contact with the fuel injection pump before tightening to the specified torque. If there is a gap, loosen the bolt securing the pump stay to the cylinder block and lift the pump stay until it comes into contact with the fuel injection pump.
- (7) Install a new O-ring to the fuel injection pump drive gear.
- (8) Install the drive gear set nut of the fuel injection pump.
- (9) Tighten the set nut while securing the crankshaft pulley.
Tightening torque: 1050 kgf·cm (102.97 N·m)
Note: Do not turn the crankshaft pulley. Otherwise, the valve heads will contact with the piston top.
- (10) Check the thrust clearance of the fuel injection pump drive shaft.



3. Engine Overhaul

3.11.3.2 Connect boost compensator hose

Connect the boost compensator hose (1) to the fuel injection pump.

3.11.3.3 Install No.2 camshaft timing pulley

(See 3.3.4.3 Install No.2 camshaft timing pulley)

3.11.3.4 Install the timing belt

(See 3.3.4.6 Install the timing belt)

3.11.3.5 Check the injection timing

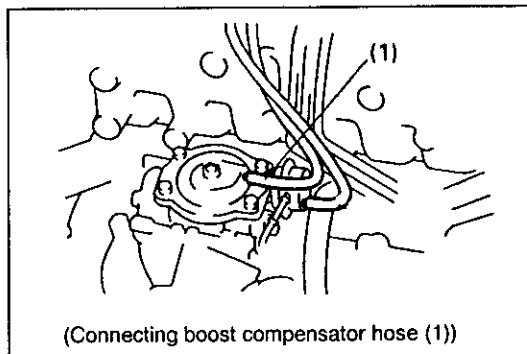
(See 3.6.2 Adjustment of Injection Timing)

3.11.3.6 Install the fuel injection pipe

(See 3.10.10.3 Install the fuel injection pipe)

3.11.3.7 Fill with engine coolant (fresh water line)

3.11.3.8 Start the engine and check for fuel leakage



3.12 Fuel System Service Specifications

3.12.1 Service Standards

(Unit: mm)

Part name	Item	6LP-DTE series	6LP-STE series	
Fuel injection nozzle	Nozzle type	DLLA141P677	DLLA140P678	
	Nozzle opening pressure	No. 1	250 to 260 kgf/cm ² (24.52 to 25.50 Mpa)	
		No. 2	300 to 310 kgf/cm ² (29.42 to 30.40 Mpa)	
	Needle lift	0.23 to 0.28	0.26 to 0.31	
	Adjusting shim thickness	—	1.900 to 2.000 (in 0.025 steps)	
	Pre-lift	0.08 to 0.10		
	No.2 pressure spring seat thickness	—	3.09 to 3.27 (in 0.03 steps)	
	No.2 opening pressure adjusting shim thickness	—	0.700	1.425
		0.850	1.450	
		1.000	1.575	
		1.025	1.600	
		1.150	1.725	
		1.175	1.750	
		1.275	1.900	
	1.300	2.050		
No.1 opening pressure adjusting shim thickness	0.70 to 0.95 (0.05 steps)	0.825 to 1.950 (0.075 steps)		
	0.975 to 1.250 (0.025 steps)	2.000 to 2.100		
	1.28 to 1.70 (0.01 steps)			
	1.75 to 1.80			
Fuel injection pump	Direction of rotation	Clockwise viewing from the drive side		
	Injection order	1-4-2-6-3-5 (A-B-C-D-E-F)		
	Delivery valve opening pressure	75 to 85 kgf/cm ² (7.36 to 8.34 Mpa)		
	Inclination of plunger spring	2.0		
	Spring free length	—		
		Delivery valve spring	12.6	
	Plunger spring	31.2		
	Boost compensator spring	19.2	19.0	
	Roller height variation	0.02		
	Timer adjusting screw protrusion presetting	7.5 to 8.0		
	Plunger spring shim thickness	0.5	0.8	
1.0		1.2		
1.5		1.8		
2.0				
Flyweight holder thrust clearance	0.15 to 0.35			
Governor gear adjusting washer thickness	1.05	1.25		
	1.45	1.65		
	1.85			

3. Engine Overhaul

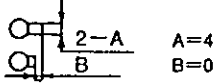
(Unit: mm)

Part name	Item	6LP-DTE series	6LP-STE series
Fuel injection pump	Governor shaft protrusion	0.5 to 2.0	
	Plunger pre-stroke Adjusting shim thickness	0.23 to 0.27 There are 131 types of shims having thickness from 1.90 to 3.20 mm in 0.01 mm steps.	
	Boost compensator diaphragm adjusting shim thickness	There are 12 types of shims having thickness from 1.1 to 3.3 mm in 0.2 mm steps.	

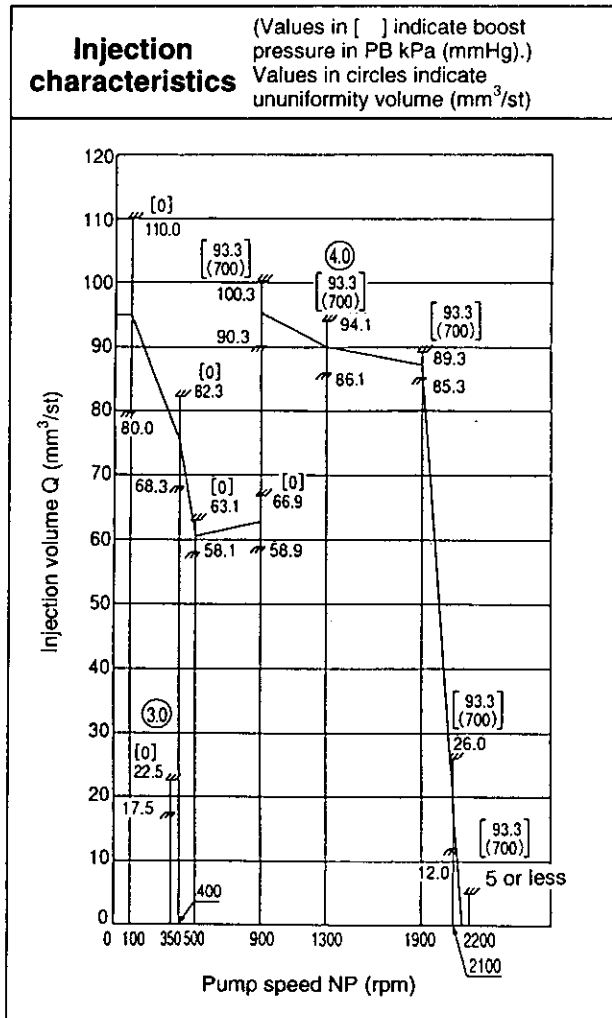
3.12.2 Nut and Bolt Tightening Torque

Tightening parts	Tightening torque: kgf·cm (N·m)
Fuel filter × fuel filter bracket	185 (18.14)
Fuel hose clamp × fuel filter bracket	120 (11.77)
Nozzle holder body × nozzle holder retaining nut	300 (29.42)
Injection nozzle × cylinder head	255 (25.01)
Injection pipe × injection nozzle and injection pump	250 (24.52)
Injection pipe clamp × intake manifold and injection pipe clamp	65 (6.37)
No.1 fuel return pipe × cylinder head	186 (18.24)
Delivery valve holder × distributive head	600 (58.84)
Fuel inlet joint bolt × injection pump body	375 (36.77)
Regulator valve × injection pump body	90 (8.83)
Feed pump cover × injection pump body	31 (3.04)
Timer cover and injection pump stay × injection pump body	85 (8.34)
Timer adjusting screw × timer cover	145 (14.22)
Governor link support × injection pump body	140 (13.73)
Distributive head × injection pump body	120 (11.77)
Governor shaft × injection pump body	275 (26.97)
Overflow screw × governor cover	250 (24.52)
Control lever × governor cover	70 (6.86)
Governor cover × injection pump body	85 (8.34)
Idle speed adjusting screw and lever × governor cover	70.4 (6.90)
Governor lever × governor cover	85 (8.34)
Distributive head plug × distributive head	900 (88.2)
Diaphragm × push rod	75 (7.35)
Diaphragm cover × governor cover	75 (7.35)
Lever control spring × governor cover	115 (11.28)
Fuel cut solenoid × distributive head	225 (22.06)
Lead wire × fuel cut solenoid	17 (1.67)
Cap × injection pump	115 (11.28)
No.2 fuel return pipe and fuel inlet pipe × injection pump	250 (24.52)
Fuel inlet pipe × bracket	200 (19.61)
Injection pump × timing gear case	185 (18.14)
Pump stay × injection pump	700 (68.05)
Injection pump drive gear × injection pump	1050 (102.97)

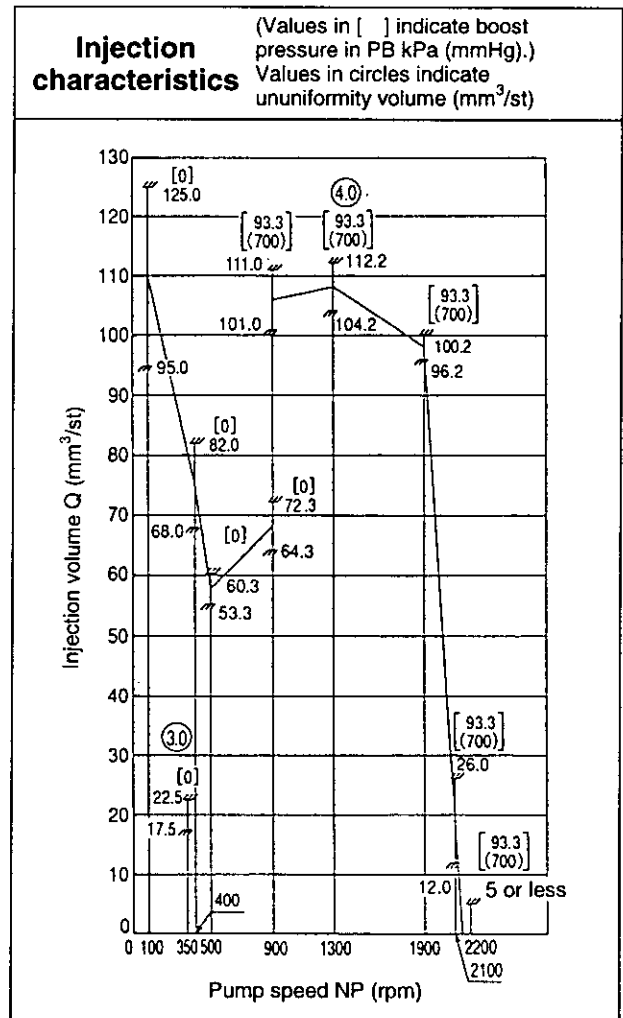
3.12.3 Specifications of Fuel Injection Pump

Pump specification	Plunger diameter	φ12mm
	Spill port shape	
	Cam profile	ND0283
	Cam lift	2.2 mm
	Statical fuel oil rate	18.6 mm ³ /deg
	Pre-stroke	0.25 mm
	Governor type	AS
	Governor link	NAR
	Injection order	A-B-C-D-E-F
	Direction of rotation	Clockwise viewing from drive side
	Valve	CPV
	Governor speed adjusting range	350 to 2100 rpm
Measurement conditions	Nozzle type	DN12SD12
	Opening pressure	150 kf/cm ² (14.71 MPa)
	Injection pipe spec.	φ2 × φ6 × 840 mm
	Fuel oil feed pressure	0.2 kgf/cm ² (0.02 Mpa)
	Test oil	JIS No.2 fuel oil
	Fuel oil temperature	40 °C (at overflow portion)

6LP-DTE series

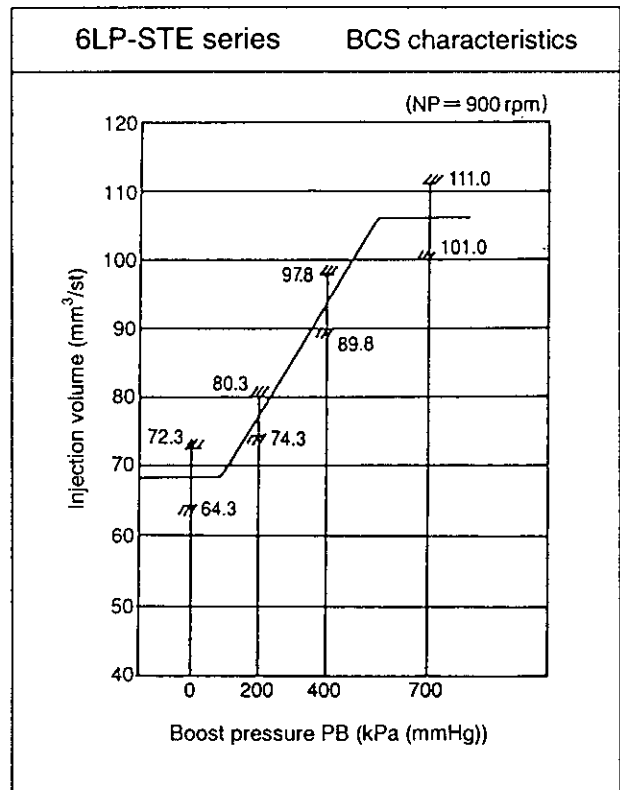
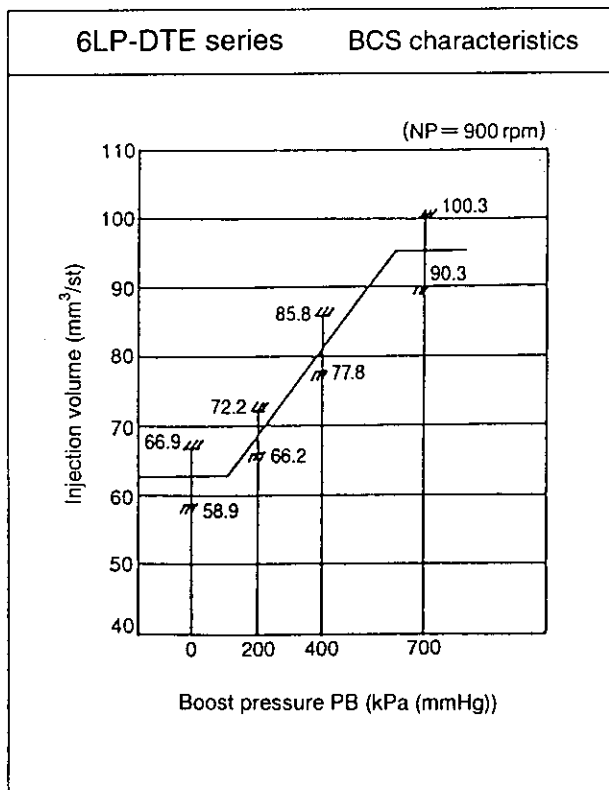
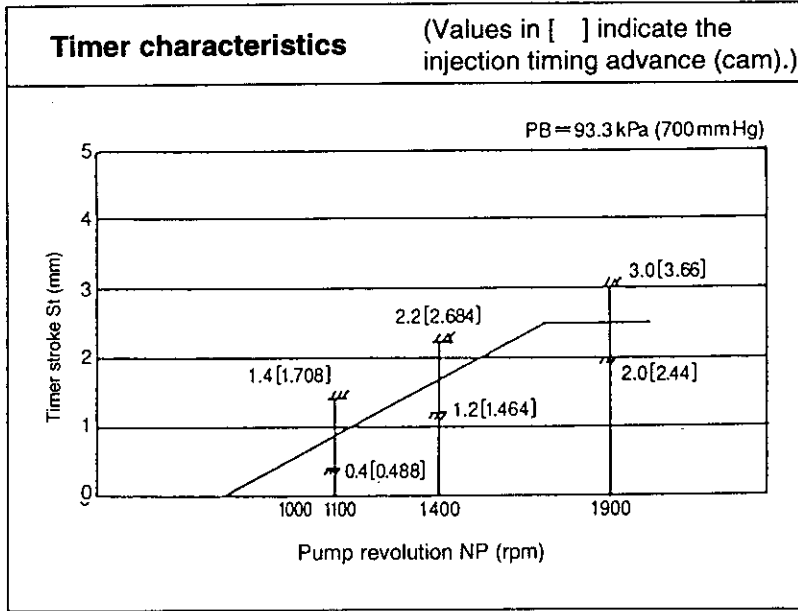


6LP-STE series



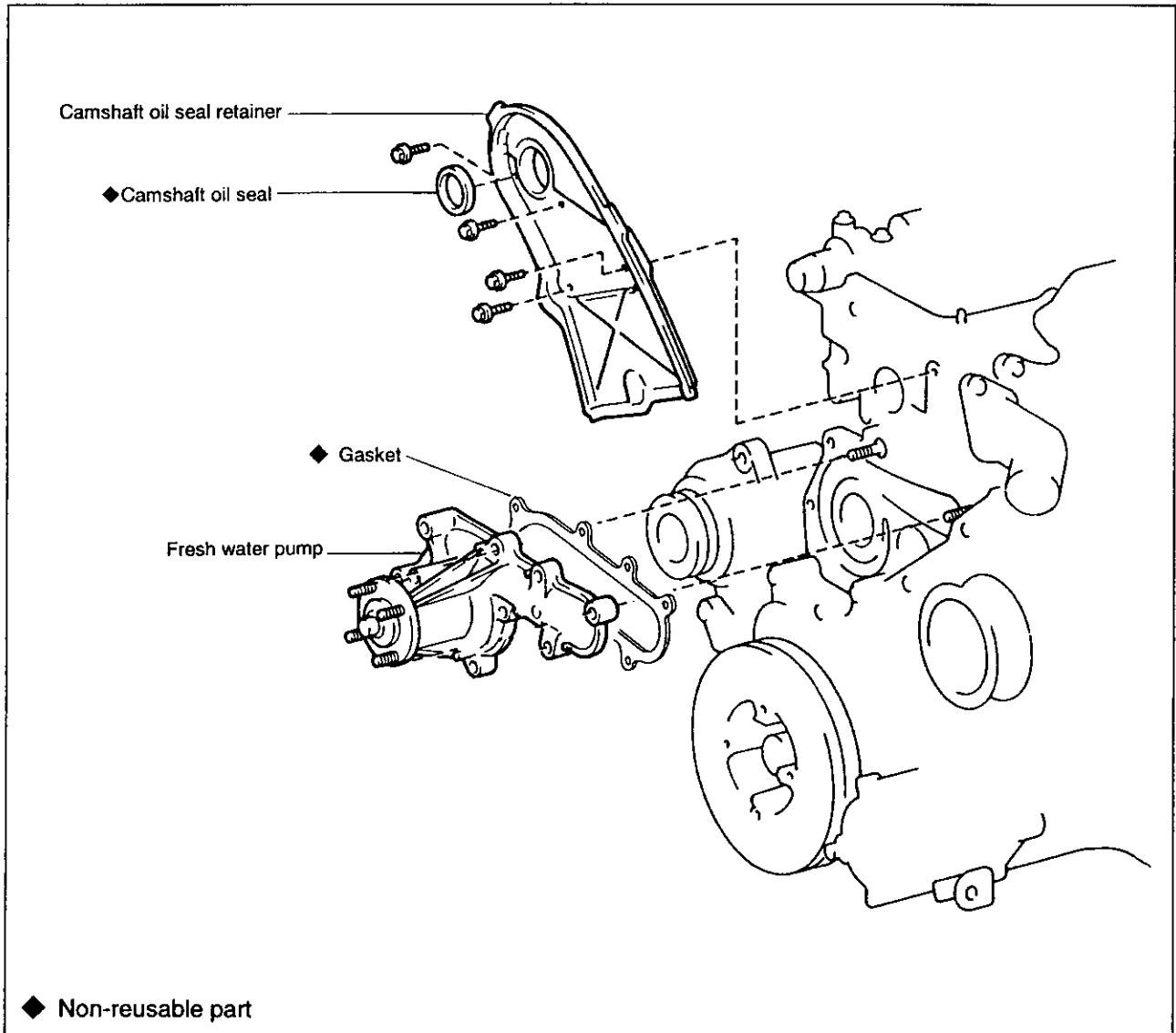
3. Engine Overhaul

6LP-DTE, 6LP-STE series



3.13 Fresh Water Pump

Fresh water pump related components

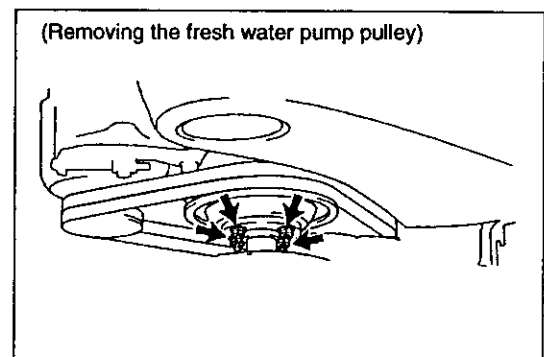


3.13.1 Removal of Fresh Water Pump

3.13.1.1 Drain engine cooling water

3.13.1.2 Remove the drive belt, viscous damper and fresh water pump pulley

- (1) Loosen six bolt for viscous damper.
- (2) Loosen four fresh water pump pulley nuts.
- (3) Loosen the alternator pivot bolt and adjust lock bolt.
- (4) Loosen adjust bolts and remove the two drive belts.



3.13.1.3 Remove the timing belt

(See 3.3.2 Removal of Timing Belt)

3.13.1.4 Remove the idler pulley

(See 3.3.2.4 Remove the idler pulley)

3.13.1.5 Remove No.1 camshaft timing pulley

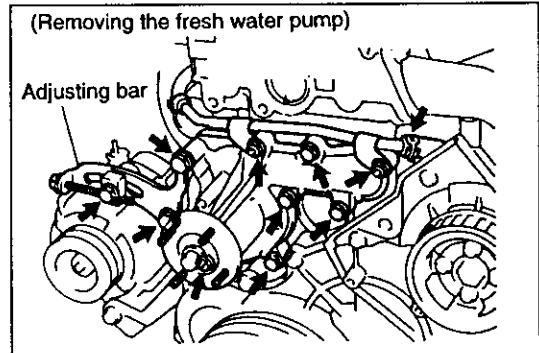
(See 3.3.2.7 Remove No.1 camshaft timing pulley)

3.13.1.6 Remove the camshaft oil seal retainer

(See 3.1.2.10 Remove the camshaft oil seal retainer)

3.13.1.7 Remove the fresh water pump

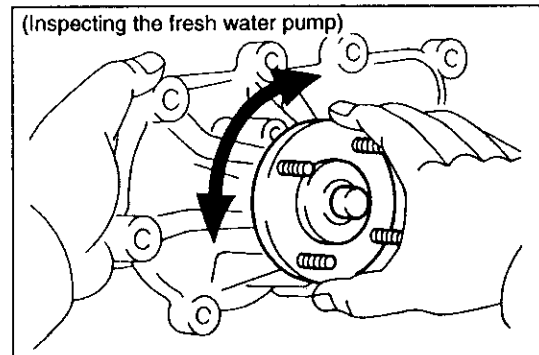
- (1) Remove the three bolts and alternator adjusting bar.
- (2) Remove the six bolts, two nuts, fresh water pump and gasket.



3.13.2 Inspection of Fresh Water Pump

3.13.2.1 Check the fresh water pump

Turn the pulley and check that the fresh water pump rotates smoothly and the bearing has no play. Replace the fresh water pump as needed.



3.13.3 Installation of Fresh Water Pump

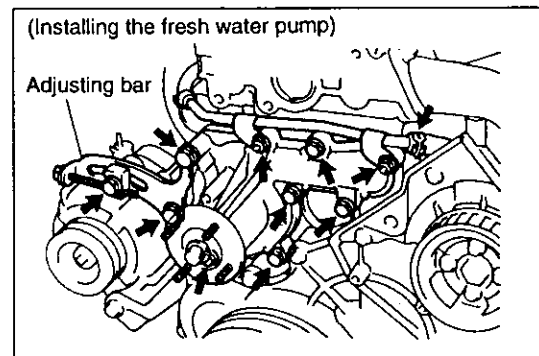
3.13.3.1 Install the fresh water pump

- (1) Temporarily secure a new gasket and pump using six bolts and two nuts.
- (2) Temporarily tighten the 3 bolts securing the alternator.
- (3) Uniformly tighten 7 bolts and 2 nuts securing the fresh water pump to the cylinder block.

Tightening torque:

12mm bolt head: 200 kgf·cm (19.61 N·m)

14mm bolt head: 400 kgf·cm (39.23 N·m)



3.13.3.2 Install the camshaft oil seal retainer

(See 3.1.7.6 Install the camshaft oil seal retainer)

3.13.3.3 Install No.1 camshaft timing pulley

(See 3.3.4.1 Install No.1 camshaft timing pulley)

3.13.3.4 Install the idler pulley
(See 3.3.4.4. Install the idler pulley)

3.13.3.5 Install the timing belt
(See 3.3.4.6. Install the timing belt)

**3.13.3.6 Install the fresh water pump pulley,
drive belt and viscous damper**

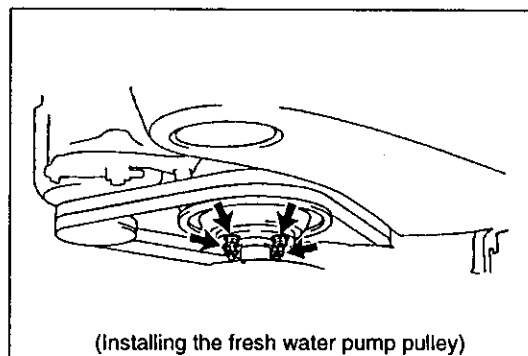
Tightening torque: 65 kgf·cm (6.37 N·m)

Install and adjust the drive belt.

Tighten four fresh water pump pulley nuts.

Tightening torque: 200 kgf·cm (19.61 N·m)

Tightening torque: 380 kgf·cm (37.27 N·m)
for viscous damper



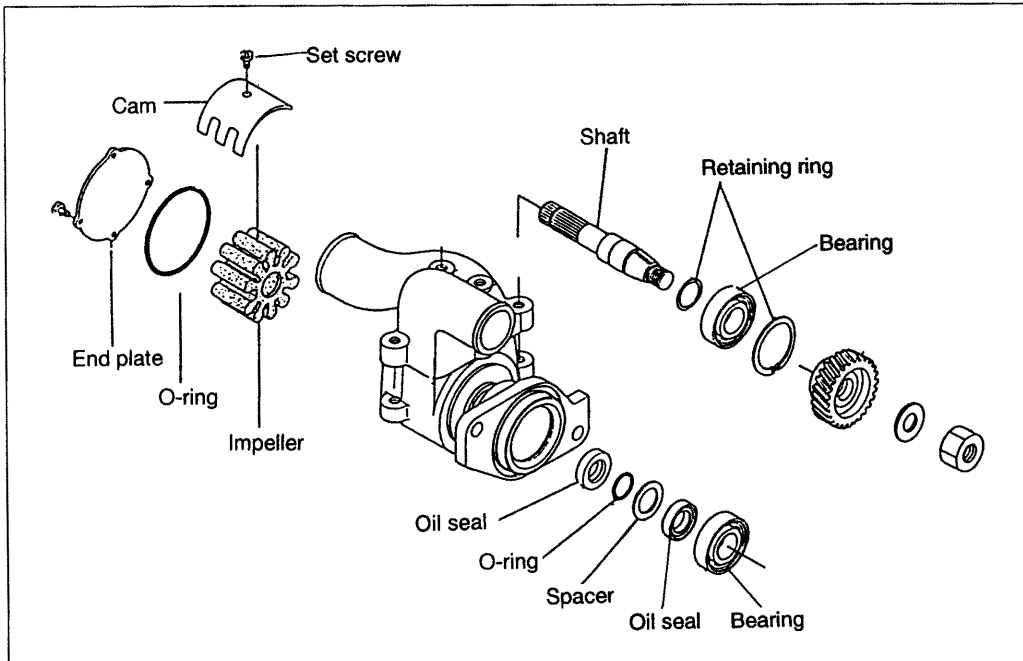
(Installing the fresh water pump pulley)

3.13.3.7 Fill with engine coolant (fresh water)

3.13.3.8 Start the engine and check for water leakage

3.14 Sea Water Pump

• Components



3.14.1 Disassembly of Sea Water Pump

- (1) Disconnect the hose joint and remove the sea water pump.
- (2) Remove the end plate and pull out the impeller.
 - The cam can be removed after removing the set screw.
- (3) Loosen the M16 nut on the drive side and pull out the gear.
- (4) Remove retaining ring and pull out the shaft.

3.14.2 Inspection of Sea Water Pump

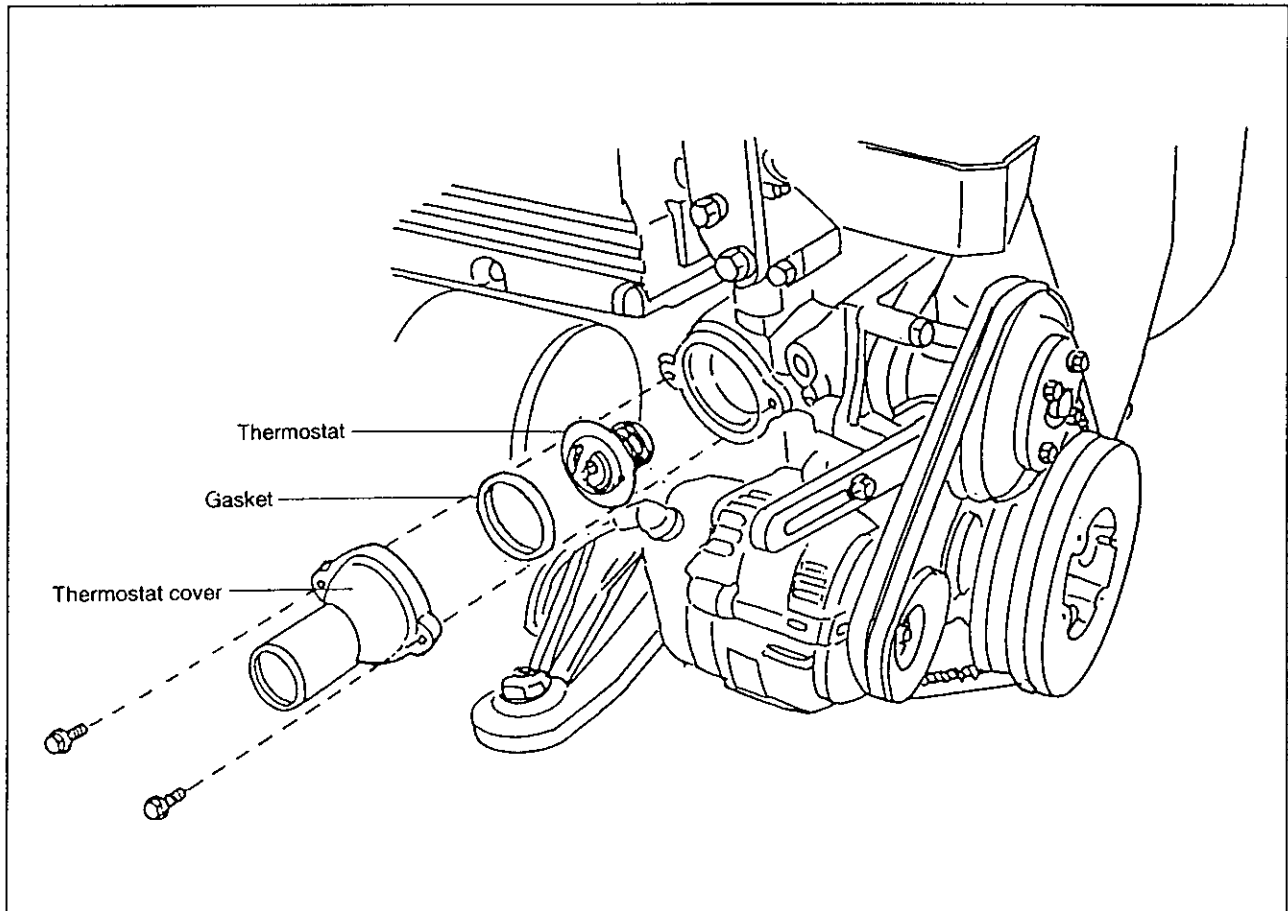
- (1) Check the impeller for damages.
- (2) Check the inner sliding surface of the pump housing and the cam for excessive wear and damage.
- (3) Turn the shaft to check that it turns smoothly. Also, check the bearing for play.
- (4) If oil or water leak is discovered at the hole of the pump bottom, replace the oil seal.

3.14.3 Reassembly of Sea Water Pump

- (1) Apply grease to the oil seal and bearing.
- (2) Insert the impeller while turning it in the operating direction (clockwise).

3.15 Thermostat

- Components

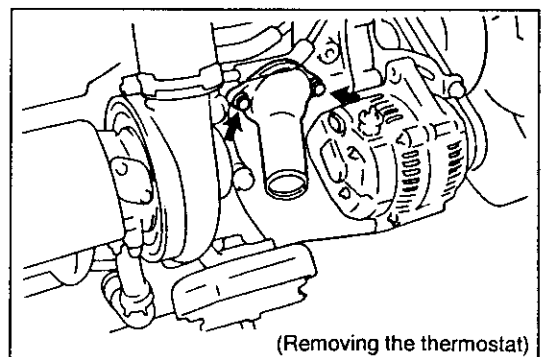


3.15.1 Removal of Thermostat

[NOTICE]

Never remove the thermostat. If the engine is operated with the thermostat removed, the engine is over heated.

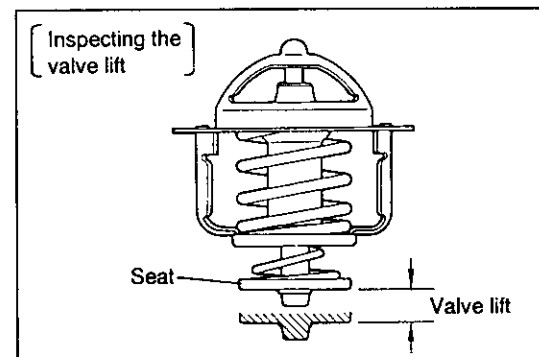
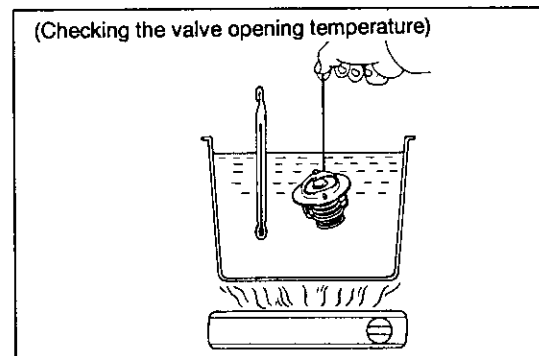
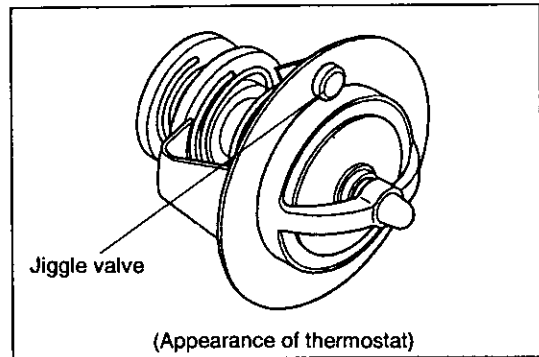
- (1) Drain the fresh water from the fresh water cooler.
- (2) Remove the thermostat cover and thermostat.
 - a) Remove the rubber hose and hose band.
 - b) Remove the thermostat.
 - c) Remove the gasket from the thermostat.



3.15.2 Inspection of Thermostat

Inspect the thermostat

- The valve opening temperature is indicated on the thermostat.
- (1) Immerse the thermostat in water and slowly heat it.
 - (2) Check the valve opening temperature.
Valve opening temperature: 68 to 72 °C
If the valve opening temperature does not satisfy the specification, replace the thermostat.
 - (3) Check the valve lift.
Valve lift: 10 mm or more at 90 °C
If the valve lift does not satisfy the specification, replace the thermostat.
 - (4) Check that the valve spring strongly presses the seat when the thermostat is closed completely.
If not, replace the thermostat.



3.15.3 Installation of Thermostat

3.15.3.1 Install the thermostat on the cylinder block

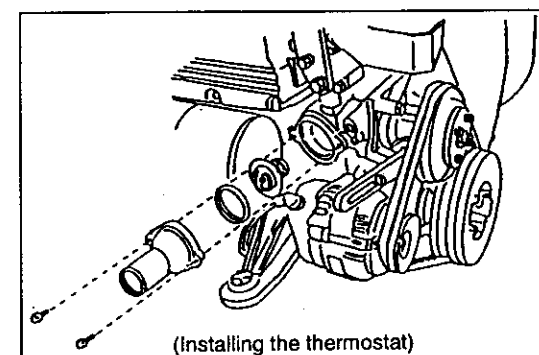
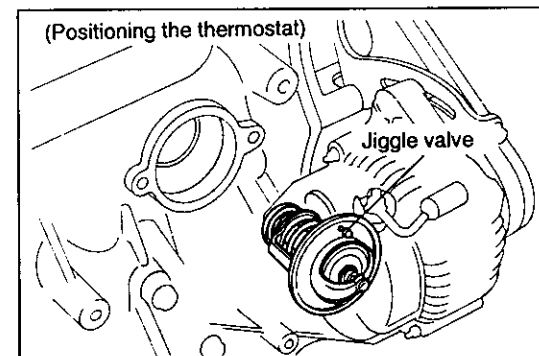
- Install a new gasket to the thermostat.
(P/N 119773-49570)
- Install with the jiggle valve facing upwards.

3.15.3.2 Install the thermostat cover

- Secure the rubber hose by the hose band.

3.15.3.3 Fill with engine coolant (fresh water)

3.15.3.4 Start the engine and check for water leakage



3.16 Components Related to Cooling System

3.16.1 Fresh Water Tank

3.16.1.1 Remove the pressure cap

⚠ WARNING

Never remove the pressure cap while the engine and fresh water tank are hot. Otherwise, you will be burnt by hot water and steam.

3.16.1.2 Check the pressure cap

Note: If the pressure cap is contaminated by foreign matter, wash with water.

Measure the valve opening pressure by applying pressure to the tester, using the pressure cap tester.

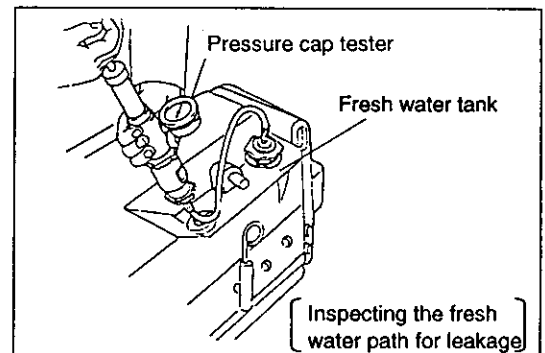
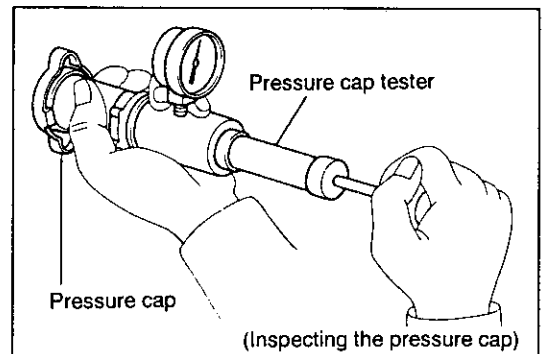
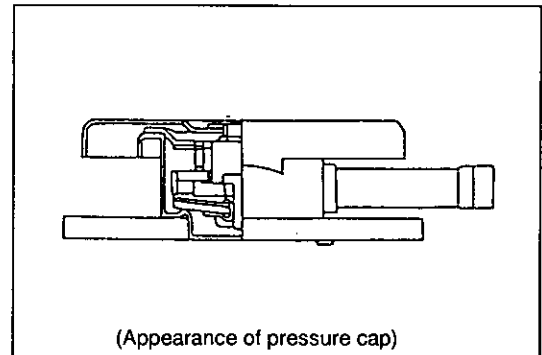
Standard valve opening pressure:

0.75 to 1.05 kgf/cm² (0.07 to 0.10 MPa)

Minimum valve opening pressure:

0.6 kgf/cm² (0.06 MPa)

- Use the maximum reading of the tester as the valve opening pressure. If the measured value is less than the specified minimum valve opening pressure, replace the pressure cap.



3.16.1.3 Check for the fresh water leakage

- (1) Fill the fresh water tank and engine with fresh water and bleed air from the fresh water path.
- (2) Attach the cap tester to the water filler.
- (3) Increase the pressure to 1.2 kgf/cm² by the pressure cap tester and check that the pressure does not drop. If it does, check the hose, fresh water tank, cooler and fresh water pump for leakage.

If no leakage is discovered from the outside, check the cylinder block and cylinder head.

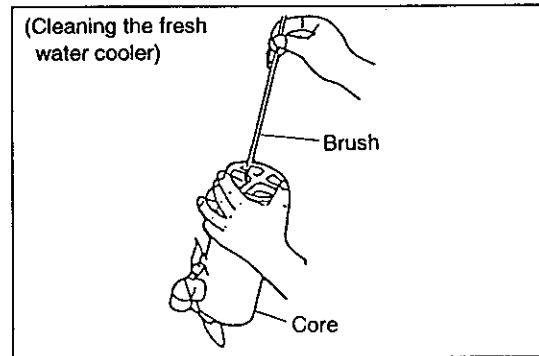
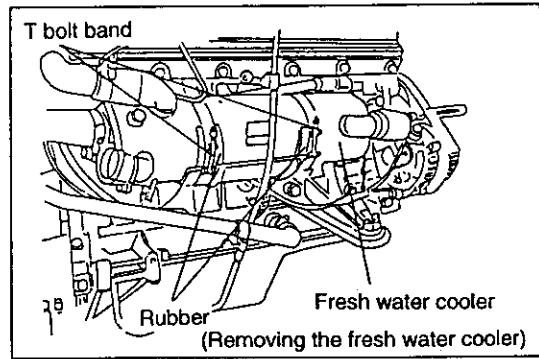
3.16.1.4 Reinstall the pressure cap

3.16.2 Fresh Water Cooler

The fresh water cooler is the multi-pipe core type. The sea water flows inside the core while the fresh water flows outside the core to be cooled by the sea water. Disconnect the rubber hose connected to the fresh water cooler.

Remove the fresh water cooler in a way not to apply shocks. Frequently check the rubber seat holding the fresh water cooler for collapse and cracks. Replace it before failures occur. Check the hose band for damaged screw and nut and the plate portion for damage. Replace it at an early stage.

Remove the side cover from the fresh water cooler. Check the core for contamination by dust and foreign matter. If so, clean the core using a soft brush available in the market.

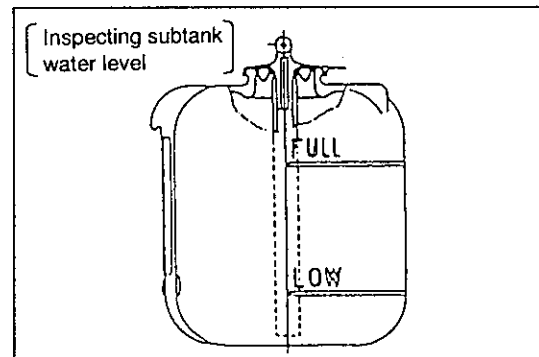


3.16.3 Subtank

When the engine is operated, the fresh water temperature increases and fresh water expands to increase the fresh water tank pressure. When the pressure in the fresh water tank exceeds 0.9 kgf/cm² (0.09 MPa), the pressure cap valve opens to release steam. If this steam is discharged to the atmosphere, the fresh water is consumed. In order to prevent the fresh water consumption, steam is discharged into the subtank. Steam discharged into the subtank condenses in the water, thus preventing discharge of fresh water to the atmosphere.

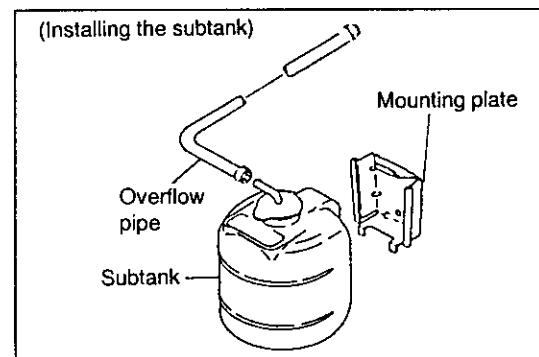
When the engine stops, the fresh water temperature decreases to drop the pressure in the fresh water tank. When the pressure in the fresh water tank drops, the negative pressure valve of the pressure cap activates to return the water from the subtank to the fresh water tank.

The water level in the subtank rises during the operation (hot state) or lowers during stopping (cold state).



3.16.3.1 Install the subtank

- (1) Carry out the daily check of the fresh water level on the subtank. It is not required to remove the pressure cap.
- (2) Install the overflow pipe at a length shorter than 1000 mm and without bending or extreme short curving.



3.16.3.2 Subtank operational precautions

- (1) Check the fresh water level in the subtank after the engine is cooled down. Replenish fresh water as needed to maintain the fresh water level between the LOW and FULL marks.
- (2) Check the overflow pipe and, if cracks are discovered, replace. If it is clogged, wash it. Also, check for disconnected or loose pipe joint. If the air tightness is lost, the subtank will not function correctly.

3.16.4 Kingston Cock (Optional)

(1) Construction

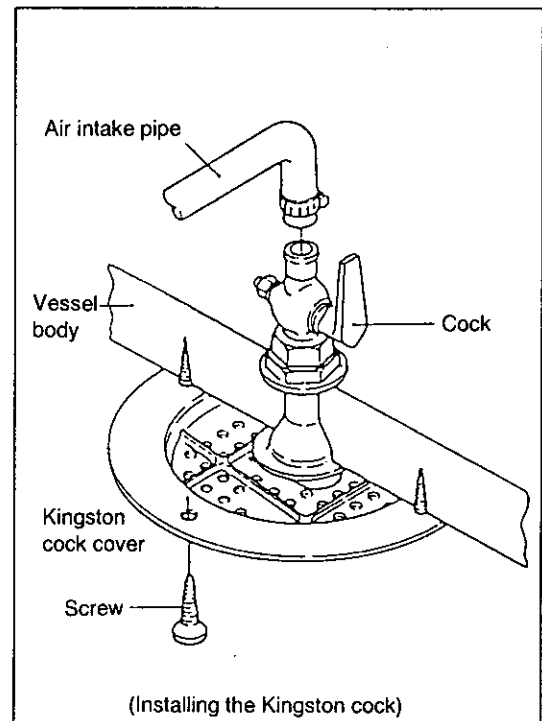
The Kingston cock located at the hull bottom suctions the engine cooling sea water. In the scoop strainer are vast number of holes which prevent suctioning of vinyl and other foreign matter.

(2) Handling notice

Instruct the user to close the Kingston cock after daily work and check that it is open before beginning work. If the Kingston cock is open when the boat is not operated and if a problem occurs to the sea water path, the sea water invades into the boat. On the other hand, if the boat is operated with the Kingston cock closed, no sea water is fed to the engine and pump, causing them to break down.

(3) Inspection

When the sea water delivery dropped, check the sea water pump. If it is normal, lift the boat above the sea water and check the Kingston cock for clogging. If sea water is leaking from the cock, remove the cock and check for wear. If so, repair or replace the cock.



3.17 Lubrication

3.17.1 Inspection of Oil Pressure

3.17.1.1 Check the lube oil quality

Visually check the oil for deterioration, mixture of water, discoloration or poor quality. If needed, replace the oil.

- Oil grade: Grade CD of API classification
- SAE viscosity: 15W40

3.17.1.2 Check the lube oil level

The oil level must be between the lower and upper limits of the oil dipstick. If it is lower than the lower limit, check for oil leak and then replenish the oil to the upper limit.

[NOTICE]

- *Never add oil exceeding the FULL mark.*
- *The standard oil level is measured when the engine is located horizontally.*

3.17.1.3 Remove the oil pressure sender unit

3.17.1.4 Attach the oil pressure gauge

3.17.1.5 Warm up the engine

Warm up the engine to the normal operating temperature.

3.17.1.6 Check the oil pressure

Oil pressure at idling:

0.3 kgf/cm² (0.03 MPa) or more

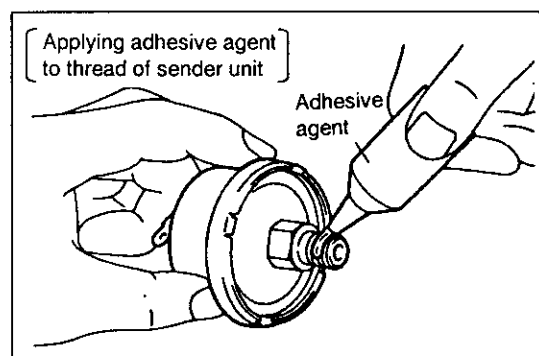
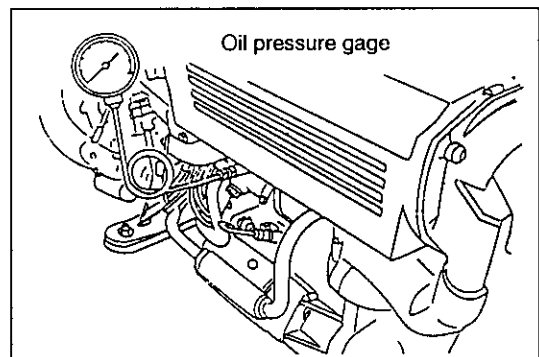
Oil pressure at 3800 rpm:

4.5 kgf/cm² (0.44 MPa)

3.17.1.7 Remove the oil pressure gauge

3.17.1.8 Install the oil pressure sender unit

- (1) Apply adhesive agent to the threaded portion (2 to 3 threads) of the hydraulic sender unit. (THREE BOND 1344, LOCTITE 242 or equivalent)
- (2) Install the sender unit.



3.17.1.9 Start the engine and check for oil leakage

3.17.2 Replacement of Lube Oil and Oil Filter

⚠ CAUTION

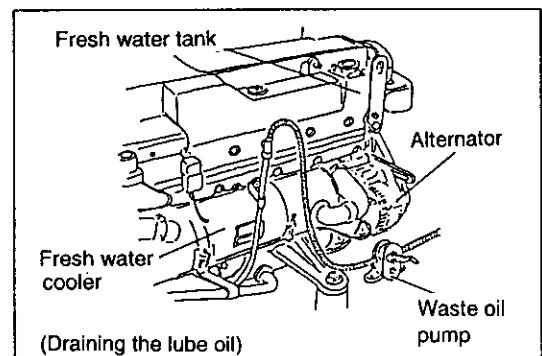
If your hands are contaminated by oil, promptly and thoroughly wash by water and detergent or hand cleanser. Otherwise, your skin may be damaged.

⚠ CAUTION

Dispose the used oil and oil filter observing the applicable laws and regulations to prevent environmental pollution.

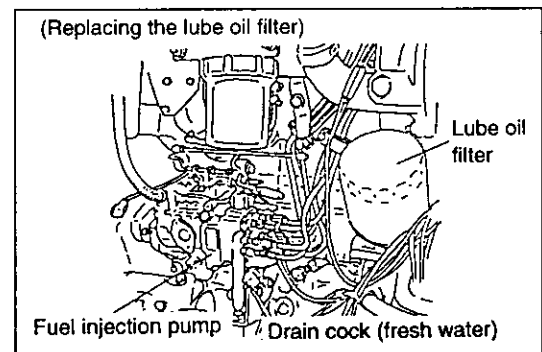
3.17.2.1 Drain the lube oil

- (1) Remove the engine oil cap.
- (2) Drain the waste oil from the oil dipstick guide using a waste oil pump.



3.17.2.2 Replace the lube oil filter

- (1) Remove the lube oil filter.
- (2) Clean the lube oil filter mounting surface on the lube oil filter mounting.
- (3) Apply clean lube oil to the O-ring of a new filter.
- (4) Manually tighten the new lube oil filter.



3.17.2.3 Fill with lube oil

- (1) Add new lube oil up to the upper limit of the oil dipstick.

Lube oil capacity:

- 10 liters (6LP-DTE series)
- 10.5 liters (6LP-STE series)
- 8.4 liters (oil pan) (both series)

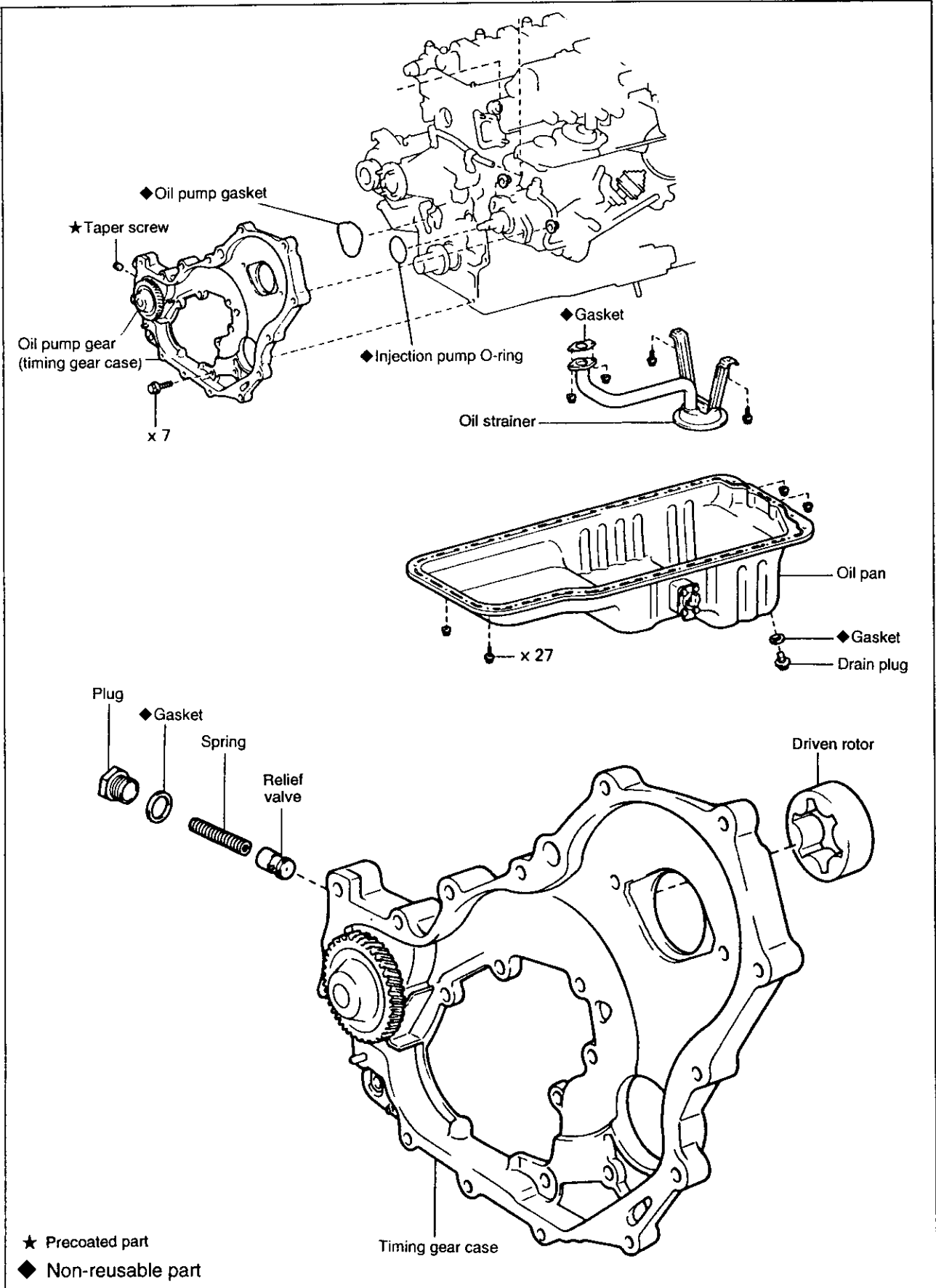
- (2) Install the oil filler cap.
- (3) Thoroughly clean any spilled lube oil.

3.17.2.4 Start the engine and check for oil leakage

3.17.2.5 Check the lube oil level again and replenish as needed

3.18 Oil Pump

• Disassembly and Reassembly of Components



3.18.1 Removal of Oil Pump

Remove and clean the oil pan and oil strainer when repairing the oil pump.

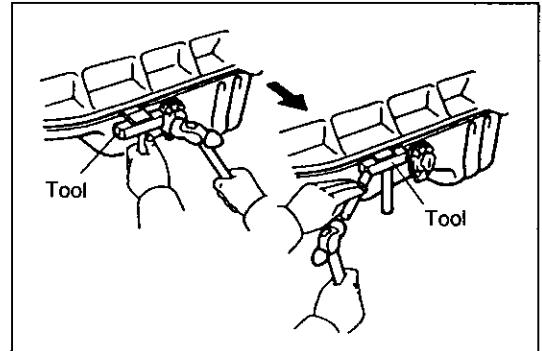
3.18.1.1 Drain the engine cooling fresh water

3.18.1.2 Drain the lube oil

3.18.1.3 Remove the timing gear (See 3.4.2 Removal of Timing Gear)

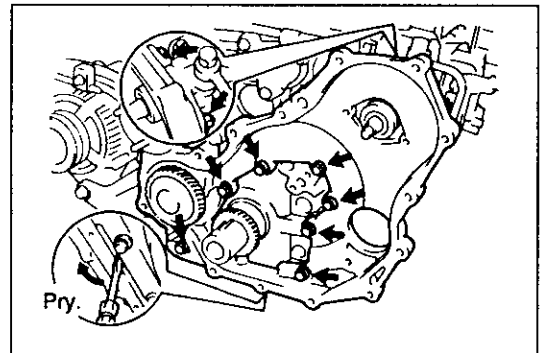
3.18.1.4 Remove the oil pan

- (1) Remove 27 nuts and bolts.
- (2) Insert the tool between the cylinder block and oil pan to cut off the seal and then remove the oil pan.
 - Pay attention so as not to damage the oil pan flange.



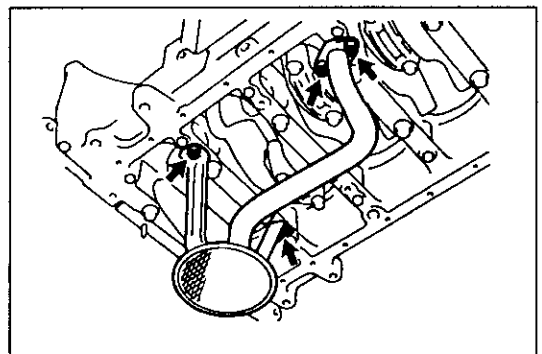
3.18.1.5 Remove the oil pump (timing gear case)

- (1) Remove the two nuts securing the fuel injection pump to the timing gear case.
- (2) Remove the seven bolts securing the timing gear case to the cylinder block.
- (3) Insert a screwdriver between the oil pump and cylinder block and pry to remove the oil pump.
- (4) Remove the gasket and O-ring.



3.18.1.6 Remove the oil strainer

Remove the two bolts and nuts, and then the oil strainer and gasket.

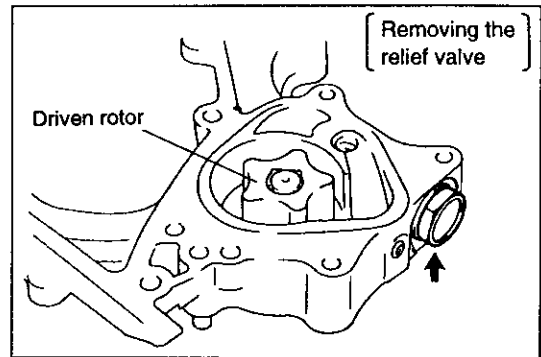


3.18.2 Disassembly of Oil Pump

3.18.2.1 Remove the driven rotor

3.18.2.2 Remove the relief valve

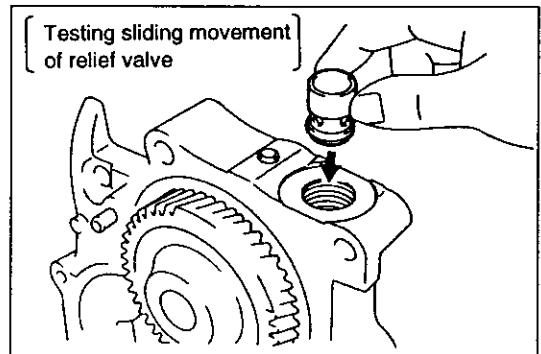
Remove the plug, gasket, spring and relief valve.



3.18.3 Inspection of Oil Pump

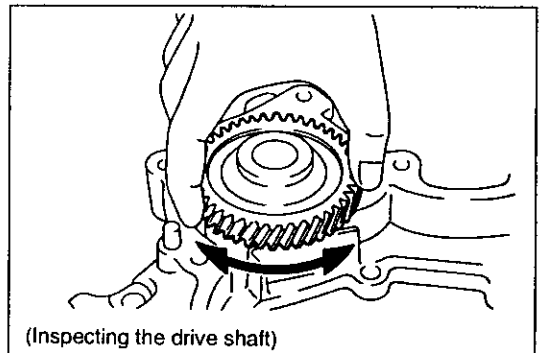
3.18.3.1 Check the relief valve

Apply engine oil to the valve and check if it falls into the valve hole smoothly by its own weight. If not, replace the relief valve. If needed, replace the oil pump assembly.



3.18.3.2 Check the drive shaft

Turn the gear and check if the drive shaft turns smoothly and the bearing has no play. If needed, replace the oil pump assembly.



3.18.3.3 Check the drive and driven rotors

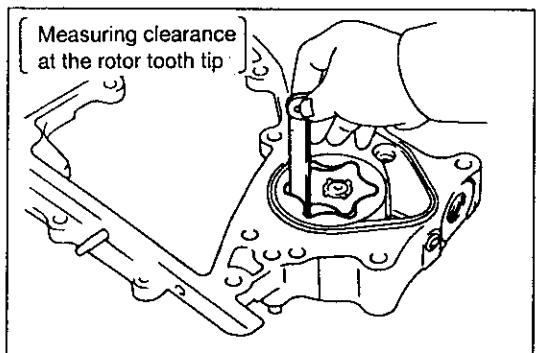
(1) Check clearance at the rotor tooth tip

Measure clearance at the tips of drive and driven rotors using feeler gauges.

Standard clearance: 0.080 to 0.160 mm

Maximum clearance: 0.21 mm

If the measured clearance exceeds the specified maximum, replace the oil pump assembly.



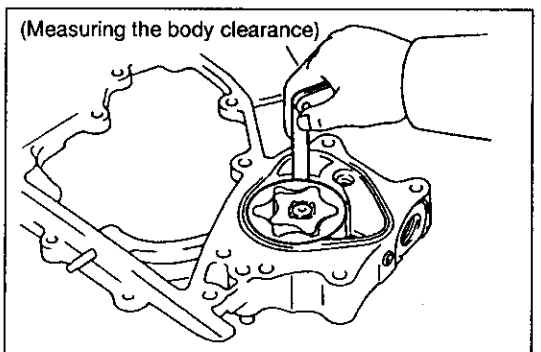
(2) Check clearance of the rotor body

Measure clearance between the driven rotor and rotor body using feeler gauges.

Standard clearance: 0.100 to 0.170 mm

Maximum clearance: 0.20 mm

If the measured clearance exceeds the specified maximum, replace the oil pump assembly.



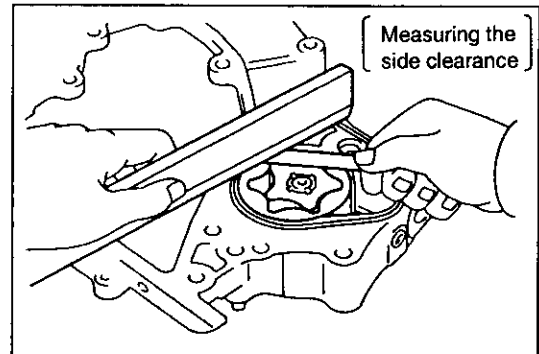
(3) Check clearance of the rotor assembly

Measure the clearance between the rotor and body end surface using feeler gauges and a straight edge.

Standard clearance: 0.030 to 0.090 mm

Maximum clearance: 0.15 mm

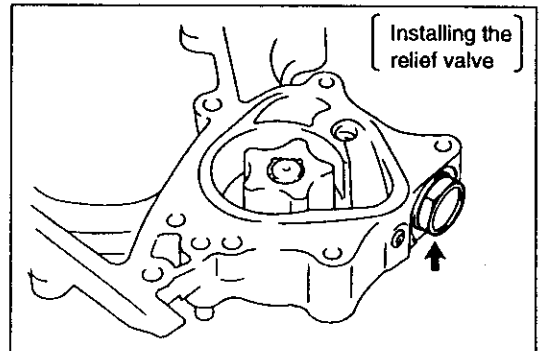
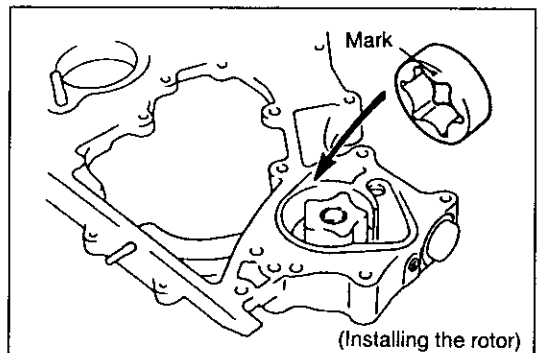
If the measured clearance exceeds the specified maximum, replace the oil pump assembly.

**3.18.4 Reassembly of Oil Pump****3.18.4.1 Install the relief valve**

(1) Fit the relief valve and spring to the mounting holes in the timing gear case.

(2) Install a new gasket and the plug.

Tightening torque: 425 kgf·cm (41.68 N·m)

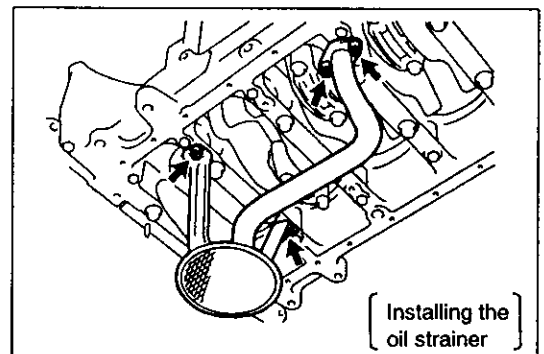
**3.18.4.2 Install the drive and driven rotors****3.18.5 Installation of Oil Pump****3.18.5.1 Install the oil strainer**

Install a new gasket and oil strainer by 2 nuts and bolts each.

Tightening torque: 90 kgf·cm (8.83 N·m)

3.18.5.2 Install the oil pump (timing gear case)

(1) Completely remove the adhering packing material.

**[NOTICE]**

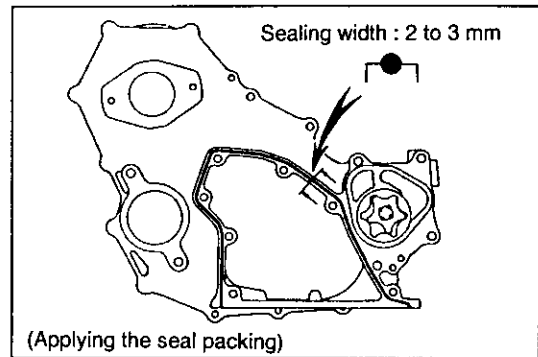
Pay attention so as not to contaminate the timing gear case and cylinder block mounting surfaces by oil.

- Remove old packing material from the gasket surface and seal groove using a razor and gasket scraper.
- Wash all parts and remove old packing material chips and other foreign matter.
- Wash the sealing surfaces with solvent.

3. Engine Overhaul

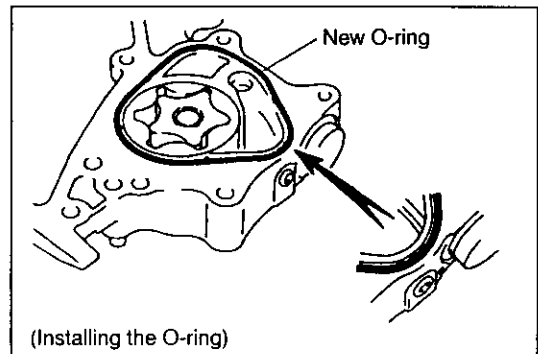
(2) Apply the seal packing to the timing gear case as shown.

- Attach a nozzle for 2 to 3 mm sealing width.
- All parts must be assembled within 5 minutes after the seal packing is applied. Otherwise, the seal packing must be removed and applied again.
- Remove the nozzle from the tube immediately after work and protect it by the cap.



(3) Install a new O-ring in the groove of the timing gear case as shown.

(Seal packing: TOYOTA P/N 08826-00080 or equivalent)



(4) Install a new O-ring to the fuel injection pump.

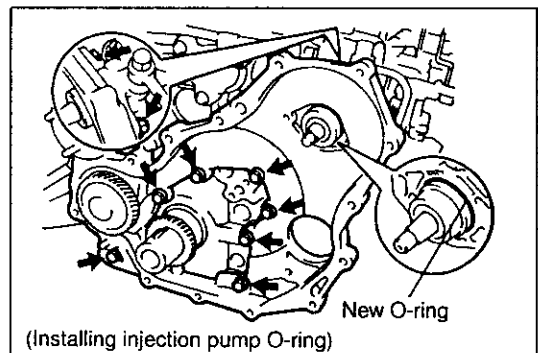
(5) Fix the timing gear case onto the cylinder block using 7 bolts.

Uniformly tighten bolts at several times.

Tightening torque: 200 kgf·cm (19.61 N·m)

(6) Install the two nuts securing the injection pump to the timing gear case.

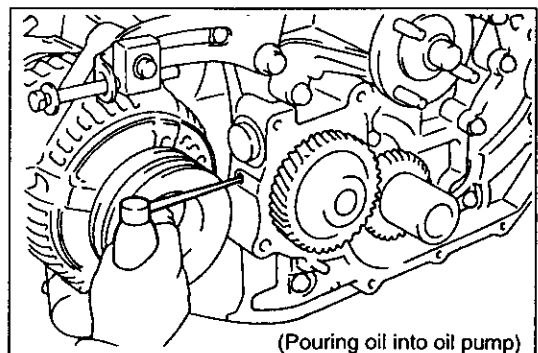
Tightening torque: 185 kgf·cm (18.14 N·m)



3.18.5.3 Pour lube oil into the oil pump

(1) Remove the taper screw plug using a 5-mm hexagon wrench.

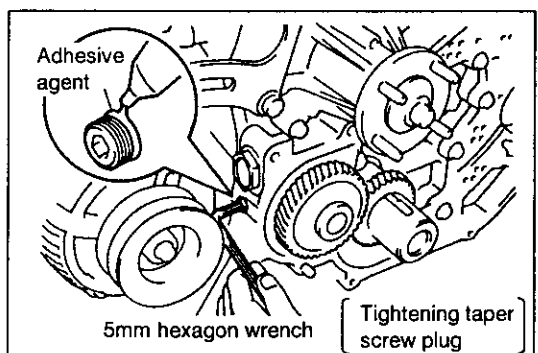
(2) Pour in approx. 10-cc lube oil into the oil pump.



(3) Apply adhesive agent to the threaded portion of taper screw plug (2 to 3 threads).

(4) Tighten the taper screw plug using a 5-mm hexagon wrench.

(Adhesive: TOYOTA P/N 08833-00070, THREE BOND 1344, LOCTITE 242 or equivalent)



3.18.5.4 Install the oil pan

- (1) Completely remove the adhering packing material.

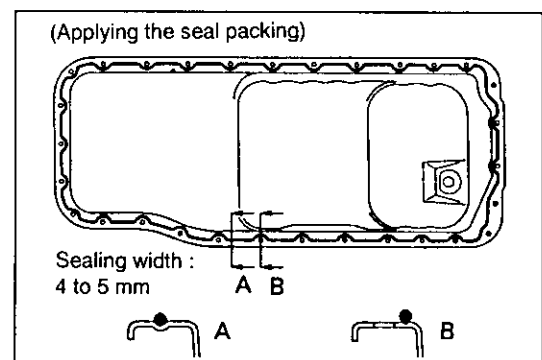
[NOTICE]

Pay attention so as not to contaminate the oil pan and cylinder block mounting surfaces by oil.

- Remove old packing material from the gasket surface and seal groove using a razor and gasket scraper.
- Wash all parts and remove old packing material chips and other foreign matter.
- Wash the both sealing surfaces with solvent.

Note: Do not use solvents which adversely affect the painted surfaces.

- (2) Apply the seal packing to the oil pan as shown.
- Attach a nozzle for 4 to 5 mm sealing width.
 - All parts must be assembled within 5 minutes after the seal packing is applied. Otherwise, the seal packing must be removed and applied again.
 - Remove the nozzle from the tube immediately after work and protect it by the cap.
- (Seal packing: TOYOTA P/N 08826-00080 or equivalent)



- (3) Install the oil pan using 27 bolts and 3 nuts. Uniformly tighten nuts and bolts at several times. Tightening torque: 100 kgf·cm (9.81 N·m)

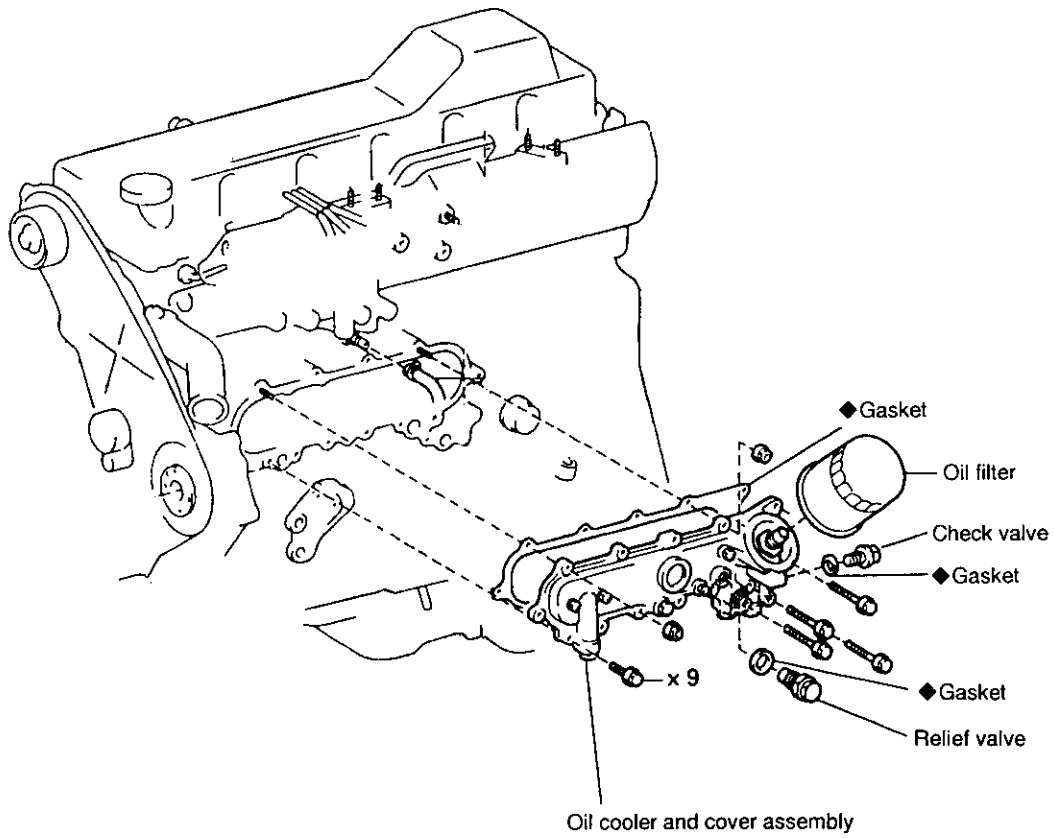
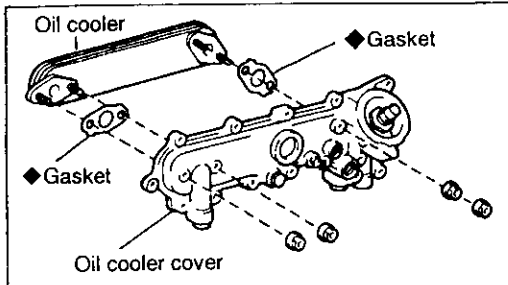
3.18.5.5 Install the timing gear
(See 3.4.6 Installation of Timing Gear)

3.18.5.6 Fill with lube oil**3.18.5.7 Fill with engine coolant (fresh water)****3.18.5.8 Start the engine and check for oil leakage****3.18.5.9 Check the lube oil level again and, if needed, replenish up to the upper limit of the oil dipstick**

3.19 Oil Cooler (Cooling by Fresh Water)

- Components

Oil cooler and cover assembly



◆ Non-reusable part

3.19.1 Removal of Oil Cooler

3.19.1.1 Drain the engine coolant (fresh water)
(See 3.1.2.1 Drain the engine cooling water)

3.19.1.2 Remove the timing belt
(See 3.3.2 Removal of Timing Belt)

3.19.1.3 Remove No.2 camshaft timing pulley
(See 3.3.2.5 Remove No.2 camshaft timing pulley)

3.19.1.4 Remove the fuel injection pipe
(See 3.10.2 Removal of Fuel Injection Nozzle)

3.19.1.5 Remove the fuel injection pump
(See 3.11.1 Removal of Fuel Injection Pump)

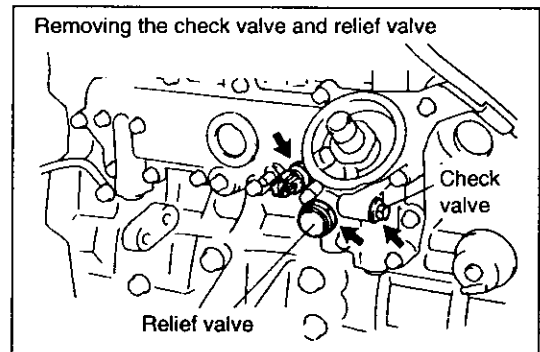
3.19.1.6 Remove the oil filter

3.19.1.7 Remove the relief valve

Remove the relief valve and gasket.

3.19.1.8 Remove the check valve

Remove the check valve and gasket.

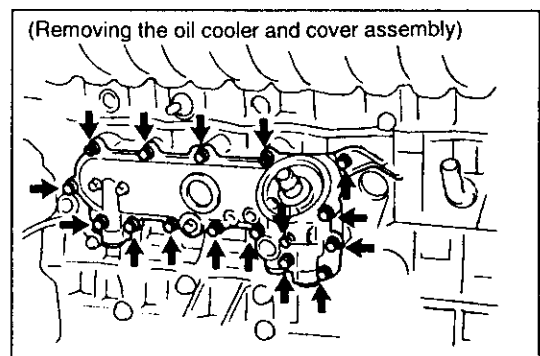


For 6LP-STE series

3.19.1.9 Remove the oil cooler and cover assembly

Remove the 13 bolts, 2 nuts, oil cooler, cover assembly and gasket.

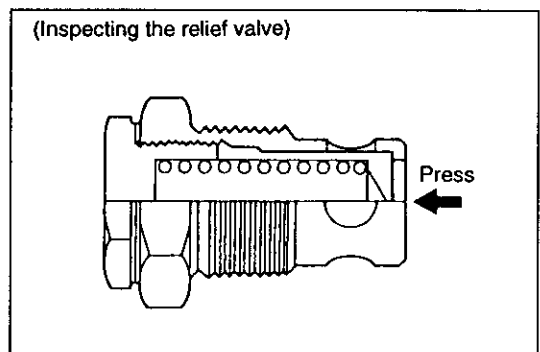
3.19.1.10 Remove the oil cooler from the oil cooler cover



3.19.2 Inspection of Oil Cooler and Relief Valve

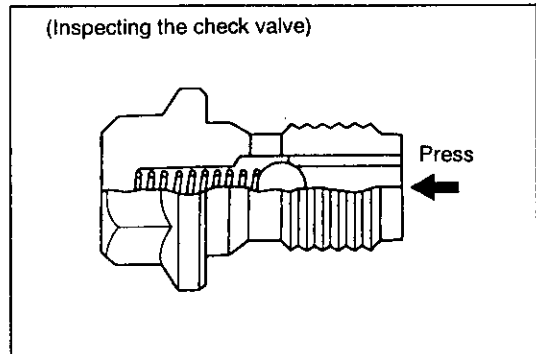
3.19.2.1 Check the relief valve

Press the valve by a wooden stick to check for sticking valve. If so, replace the relief valve.



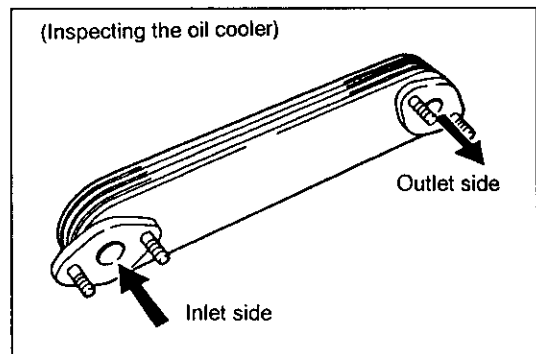
3.19.2.2 Check the check valve

Press the valve by a wooden bar to check for sticking valve. If so, replace the safety valve.



3.19.2.3 Check the oil cooler

Check the oil cooler for damage and clogging. If needed, replace the oil cooler.

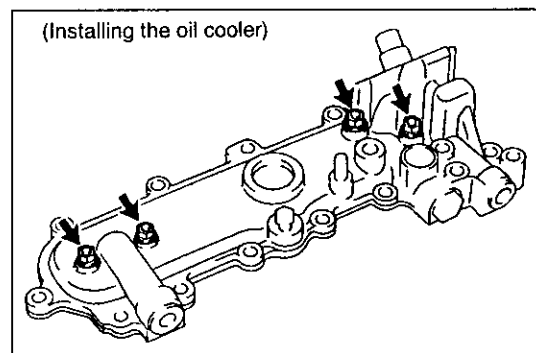


3.19.3 Installation of Oil Cooler

3.19.3.1 Install the oil cooler to the oil cooler cover

Install two new gasket and the oil cooler to the oil cooler cover, using 4 nuts.

Tightening torque: 160 kgf·cm (15.69 N·m)



3.19.3.2 Install the oil cooler and cover assembly

Install the new gasket, oil cooler and cover assembly using 13 bolts and 2 nuts. Tighten nuts and bolts uniformly at several times.

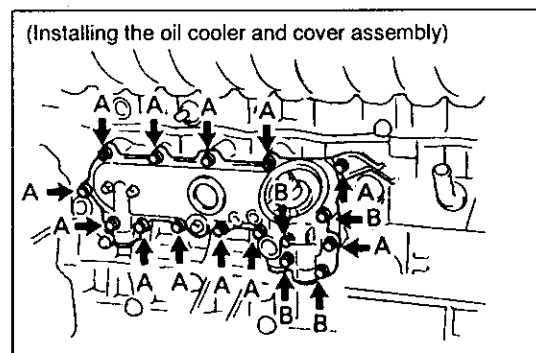
Tightening torque: 200 kgf·cm (19.61 N·m)

- Length of each bolt is shown in the figure.

Bolt length

A: 20 mm

B: 40 mm



3.19.3.3 Install the relief valve

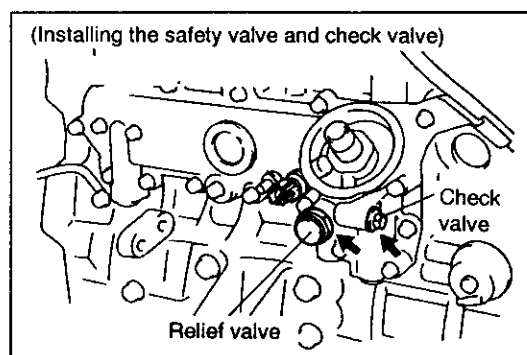
Install the new gasket and relief valve.

Tightening torque: 400 kgf·cm (39.23 N·m)

3.19.3.4 Install the check valve

Install the new gasket and check valve.

Tightening torque: 275 kgf·cm (26.97 N·m)



3.19.3.5 Install the oil filter

3.19.3.6 Install the fuel injection pump

(See 3.11.3 Installation of Fuel Injection Pump)

3.19.3.7 Install the fuel injection pipe

(See 3.10.10.3 Install the fuel injection pipe)

3.19.3.8 Install No.2 camshaft timing pulley

(See 3.3.4.3 Install No.2 camshaft timing pulley)

3.19.3.9 Install the timing belt

(See 3.3.4.6 Install the timing belt)

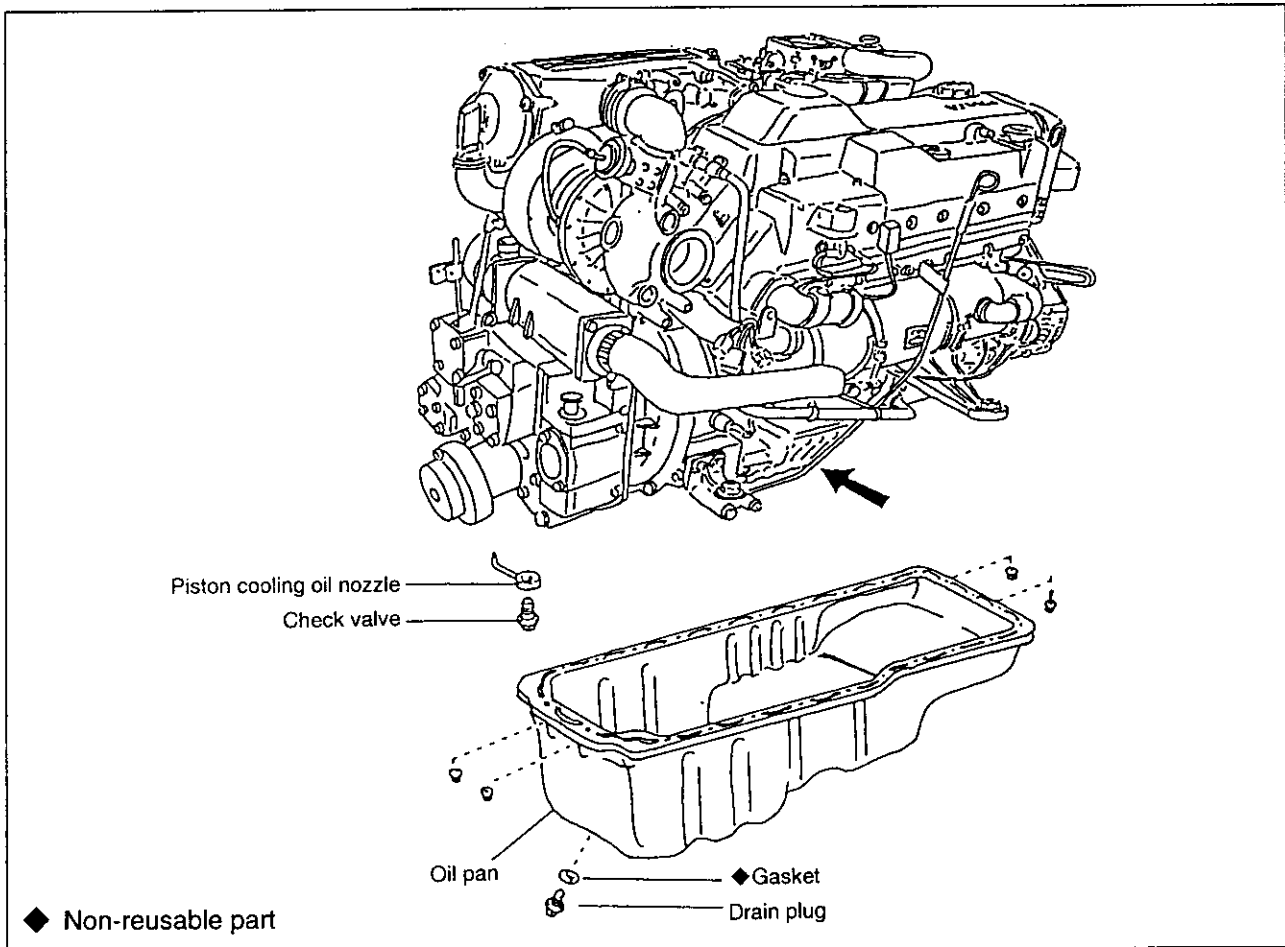
3.19.3.10 Fill with engine coolant (fresh water)

3.19.3.11 Start the engine and check for oil leakage

3.19.3.12 Check the lube oil level again and, if needed, replenish up to the upper limit of the oil dipstick

3.20 Piston Cooling Oil Nozzle

- Components

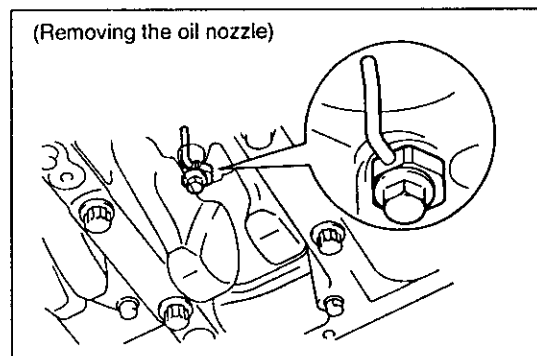


3.20.1 Disassembly of Oil Nozzle

3.20.1.1 Remove the oil pan
(See 3.18.1.4 Remove the oil pan)

3.20.1.2 Remove the check valve and oil nozzle

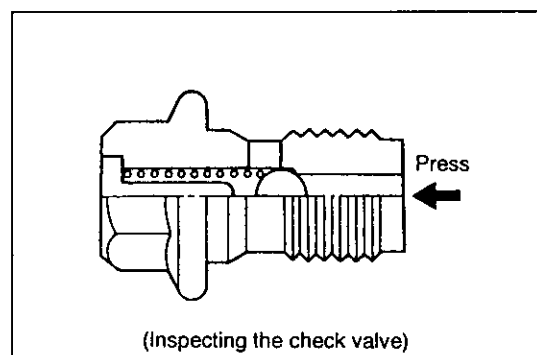
Remove the 6 check valves and 6 oil nozzles.



3.20.2 Inspection of Oil Nozzle

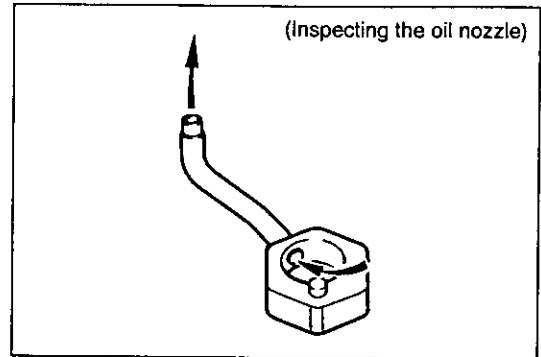
3.20.2.1 Check the check valve

Press the valve by a wooden stick and check for sticking valve. If so, replace the check valve.



3.20.2.2 Inspect the oil nozzle

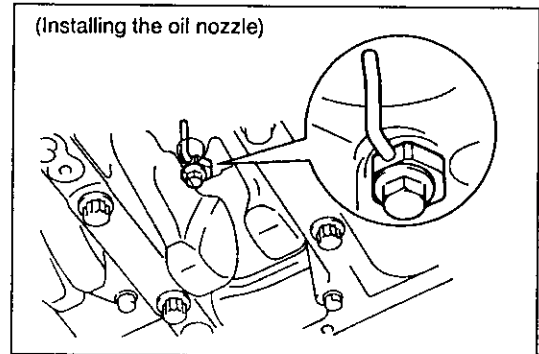
Check the oil nozzle for damage and clogging. If needed, replace the oil nozzle.



3.20.3 Installation of Oil Nozzle

3.20.3.1 Install the oil nozzle and check valve

- (1) Align the oil nozzle pin with the pin hole in the cylinder block.
- (2) Install the oil nozzle together with the check valve. Install each 6 oil nozzles and check valves.
Tightening torque: 175 kgf·cm (17.16 N·m)



3.20.3.2 Install the oil pan

(See 3.18.5.4 Install the oil pan)

3.21 Service Specifications

3.21.1 Service Standards

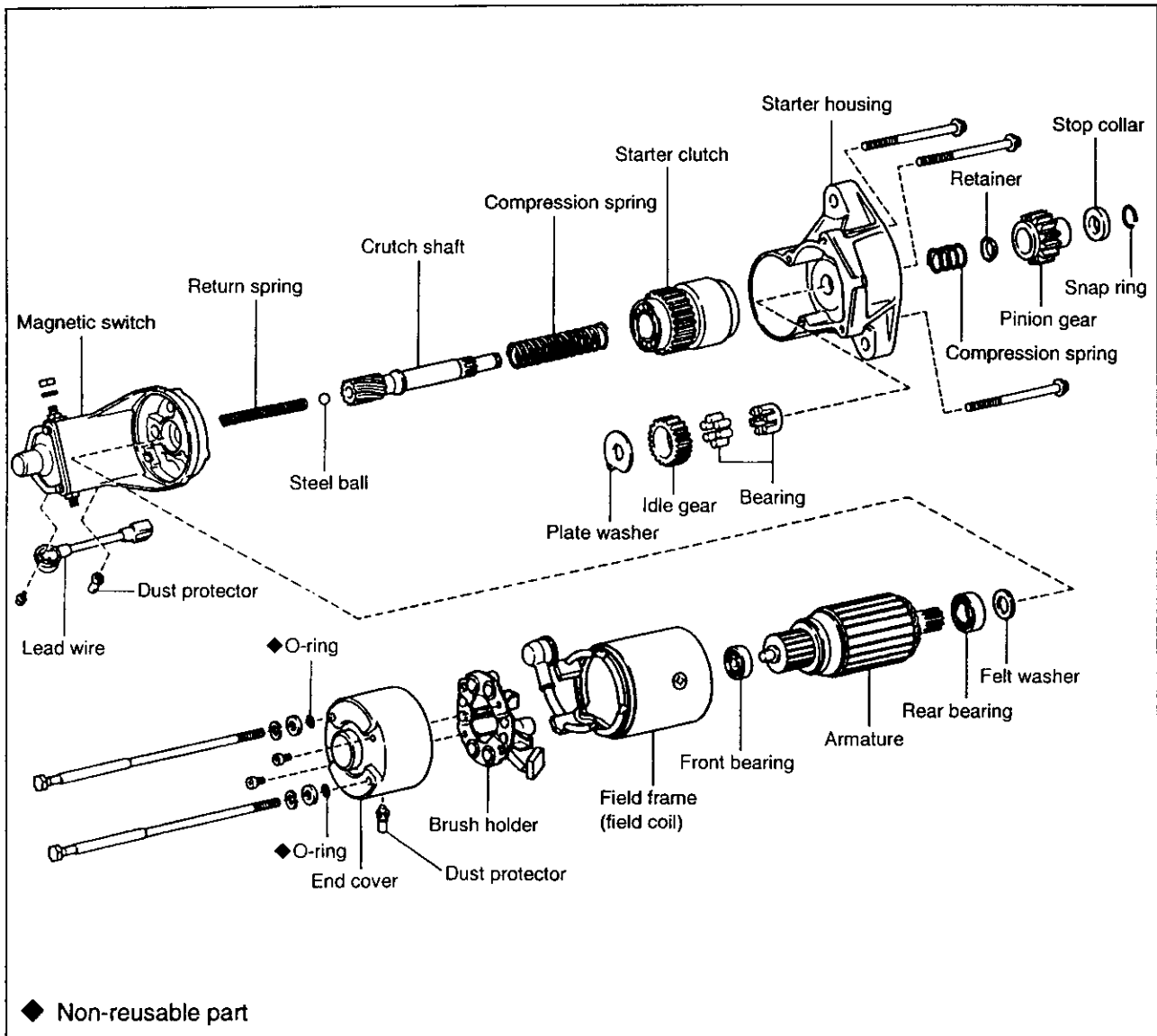
Oil pressure	Engine revolution:	800 rpm 3800 rpm	0.3 kgf/cm ² (0.03 MPa) or more 4.5 kgf/cm ² (0.44 Mpa)
Oil pump	Tooth tip clearance	Standard Maximum	0.80 to 0.160 mm 0.21 mm
	Body clearance	Standard Maximum	0.100 to 0.170 mm 0.20 mm
	Side clearance	Standard Maximum	0.030 to 0.090 mm 0.15 mm

3.21.2 Nut and bolt tightening torque

Tightening parts	kgf·cm (N·m)
Drain plug × oil pan	350 (34.32)
Relief valve × timing gear case	425 (41.68)
Oil filter × main bearing cap	90 (8.83)
Timing gear case × cylinder block and main bearing cap	200 (19.61)
Injection pump × timing gear case	185 (18.14)
Oil pan × main bearing cap, timing gear case and rear oil seal retainer	100 (9.81)
Oil cooler cover × oil cooler	160 (16.28)
Oil cooler cover and oil dipstick guide × cylinder block	200 (19.26)
Relief valve × oil cooler cover	400 (39.23)
Check valve × oil cooler cover	275 (26.97)
Oil nozzle × cylinder block	275 (26.97)

3.22 Starter

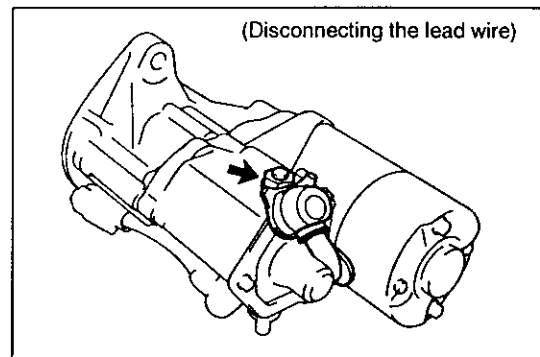
3.22.1 Components



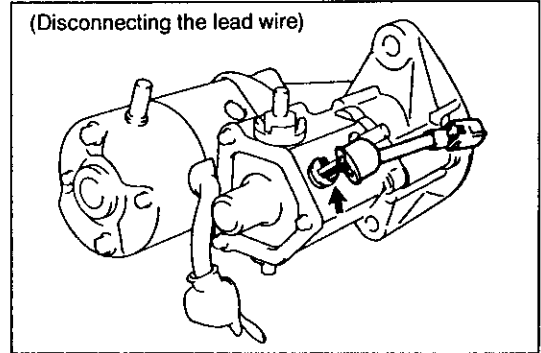
3.22.2 Disassembly of Starter

3.22.2.1 Remove the field frame and lead wire with armature from the magnetic switch

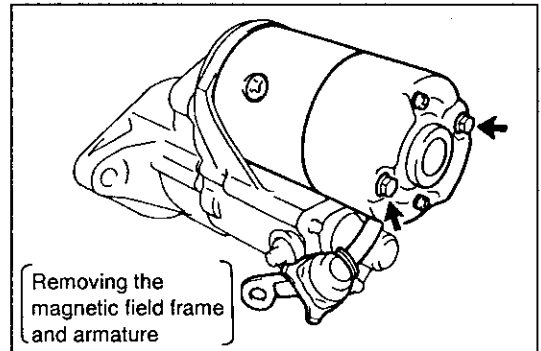
- (1) Remove the nut and disconnect the lead wire from the magnetic switch terminal.



- (2) Remove the screw, washer and lead wire from terminal 50.

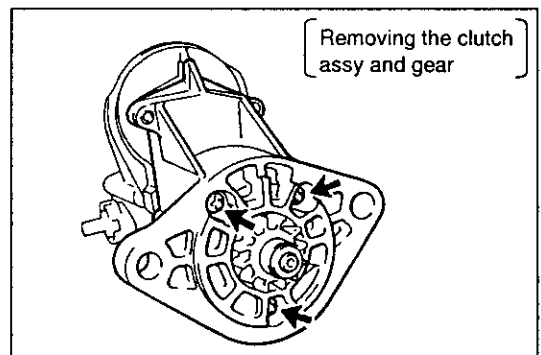


- (3) Remove the 2 through bolts and spring washers.
- (4) Pull out the field frame from the magnetic switch, together with the armature.
- (5) Remove the felt washer from the rear bearing.



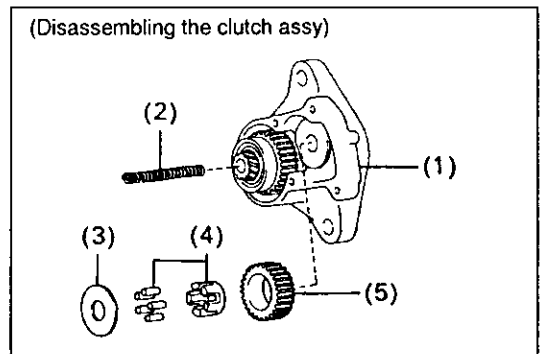
3.22.2.2 Remove the starter housing, clutch assembly and gear

- (1) Remove the 3 screws.



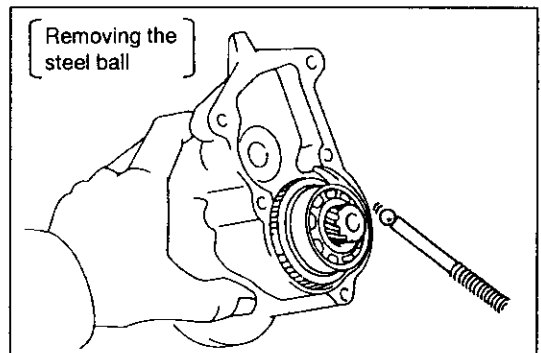
- (2) Remove the following parts from the magnetic switch assembly

- 1) Starter housing and clutch assembly
- 2) Return spring
- 3) Plate washer
- 4) Bearing
- 5) Idler gear



3.22.2.3 Remove the steel ball

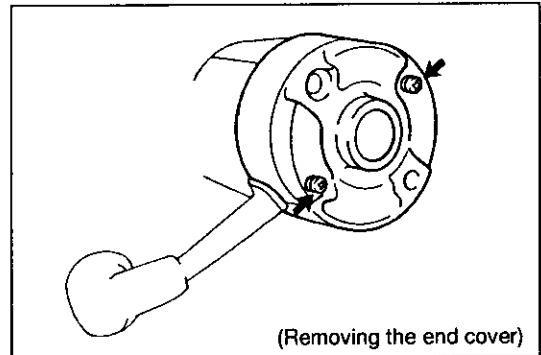
Remove the steel ball through the clutch shaft hole using a magnetic finger.



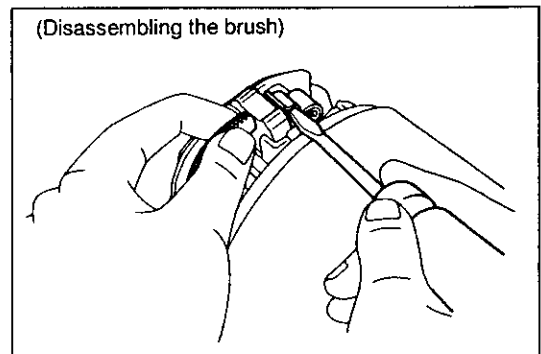
3. Engine Overhaul

3.22.2.4 Remove the brush holder

- (1) Remove the 2 screws and end cover from the field frame.



- (2) Secure the rear of the spring tank using a screwdriver and remove the brush from the brush holder.
- (3) Remove the 4 brushes and then the brush holder.



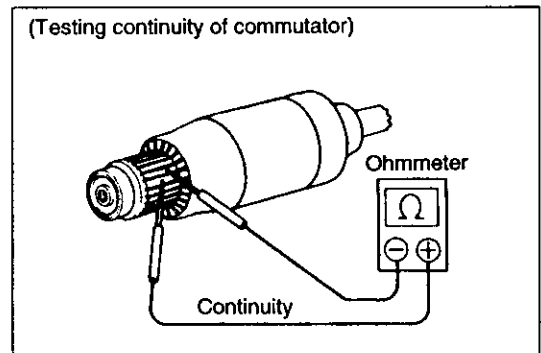
3.22.2.5 Remove the armature from the field frame

3.22.3 Inspection and Repair of Starter

3.22.3.1 Armature coil

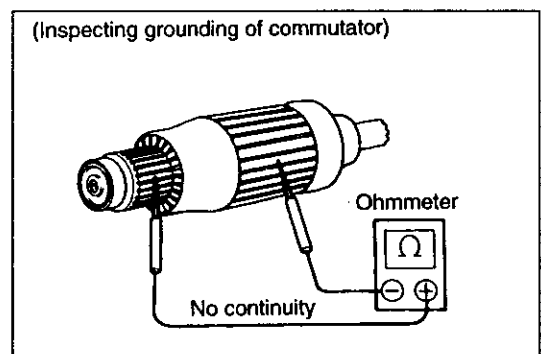
3.22.3.1.1 Check the commutator for open circuit

Check continuity between commutator segments using an ohmmeter. If segments are electrically open, replace the armature.



3.22.3.1.2 Check grounding of the commutator

Check that the circuit between the commutator and armature coil is no continuity using an ohmmeter. If it is continuity, replace the armature.



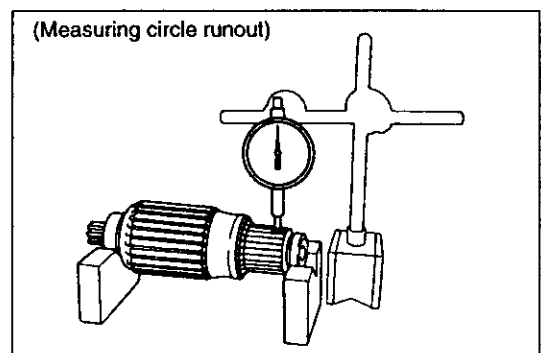
3.22.3.2 Commutator

3.22.3.2.1 Check the commutator surface for dirt and burning

If the commutator surface is dirty or burnt, correct with sandpaper (#400) or lathe.

3.22.3.2.2 Check the commutator for circle runout

- (1) Put the commutator on a V-block.
- (2) Measure circle runout using a dial indicator.
Maximum circle runout: 0.05 mm
If the measured value exceeds the specified maximum, correct using a lathe.



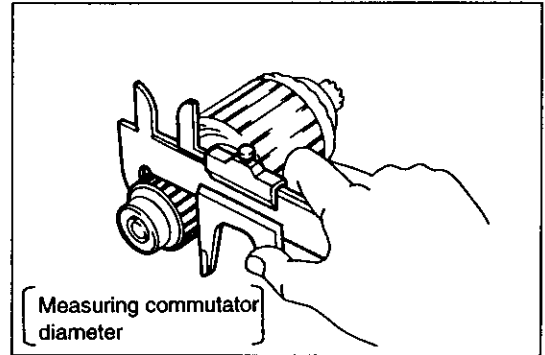
3.22.3.2.3 Check the commutator diameter

Measure commutator diameter using calipers.

Standard diameter: 36.0 mm

Minimum diameter: 35.0 mm

If the measured value is less than the specified minimum, replace the armature.



3.22.3.2.4 Check the undercut depth

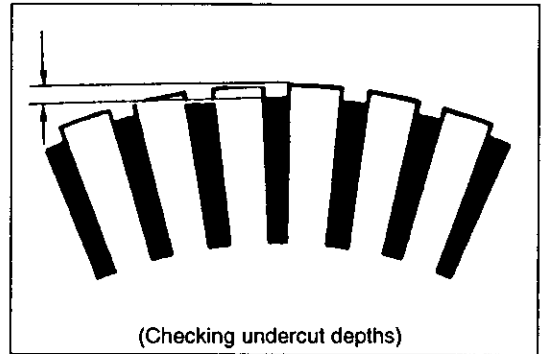
Check the undercut depth for entanglement of foreign matter.

Smooth the edges.

Standard undercut depth: 0.7 to 0.9 mm

Minimum undercut depth: 0.2 mm

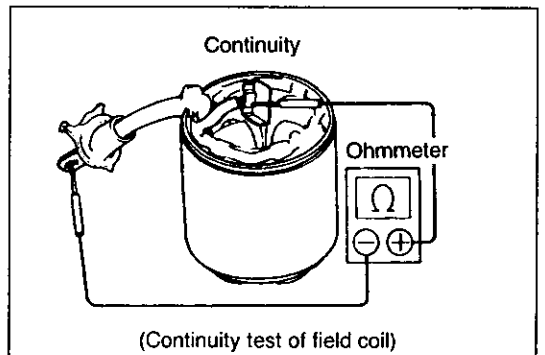
If the measured undercut depth is less than the specified minimum, correct it with hack saw blade.



3.22.3.3 Field frame (Field coil)

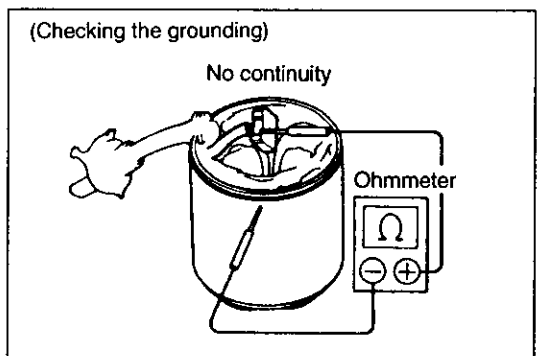
3.22.3.3.1 Check open circuit of the field coil

Check electrical continuity between the lead wire and field coil brush lead using an ohmmeter. If the circuit is open, replace the field frame.



3.22.3.3.2 Check grounding of the field coil

Check that the circuit between the field coil end and the field frame is no continuity using an ohmmeter. If it is continuity, repair or replace the field frame.



3.22.3.4 Brush

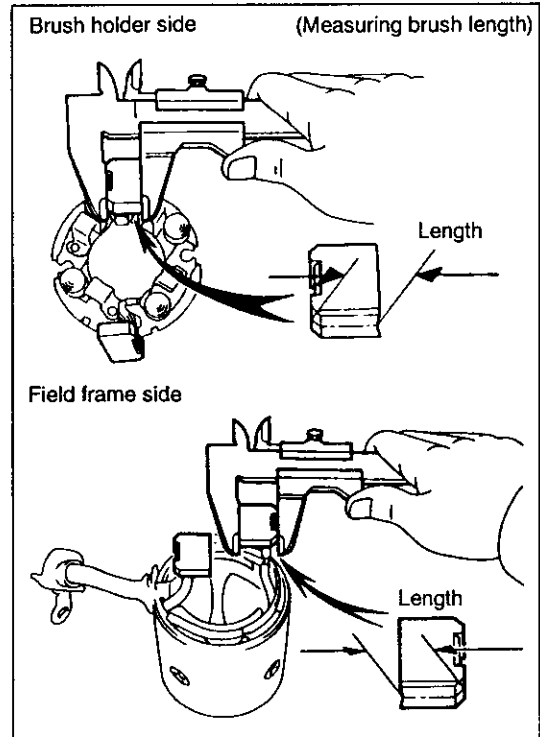
3.22.3.4.1 Check the brush length

Measure the brush length using calipers.

Standard length: 20.5 to 21.0 mm

Minimum length: 13.0 mm

If the measured value is less than the specified minimum, replace the brush holder and field frame.



3.22.3.5 Brush spring

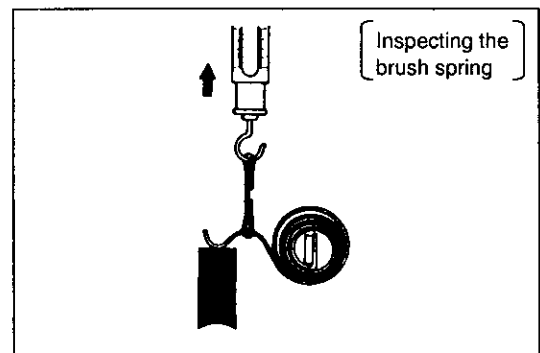
3.22.3.5.1 Check the brush spring load

Read the scale when the brush spring just leaves the brush.

Spring mounting load:

1.9 to 3.6 kgf (18.63 to 35.30 N·m)

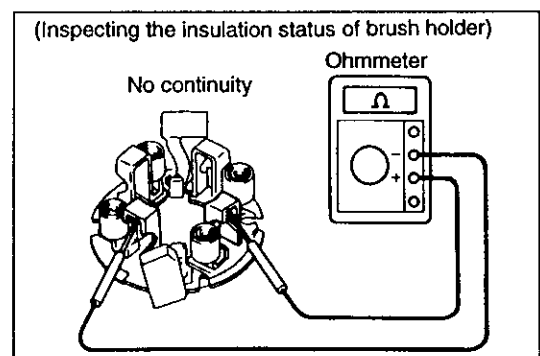
If the measured mounting load is out of the specified range, replace the brush spring.



3.22.3.6 Brush holder

3.22.3.6.1 Check the insulation status of the brush holder

Check that the circuit between the brush holder positive (+) and negative (-) is no continuity using an ohmmeter. If it is continuous, repair or replace the brush holder.



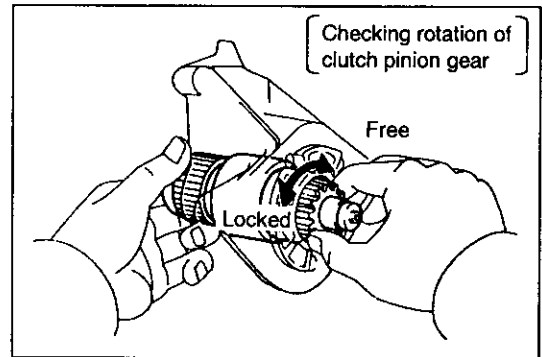
3.22.3.7 Clutch and gear

3.22.3.7.1 Check the gear tooth surfaces

Check the outside tooth surfaces of the pinion gear, idler gear and clutch for damage and wear. If they are faulty, replace the gear or clutch assembly. If any fault is discovered, also check the flywheel ring gear on the engine for damage.

3.22.3.7.2 Check the clutch pinion gear

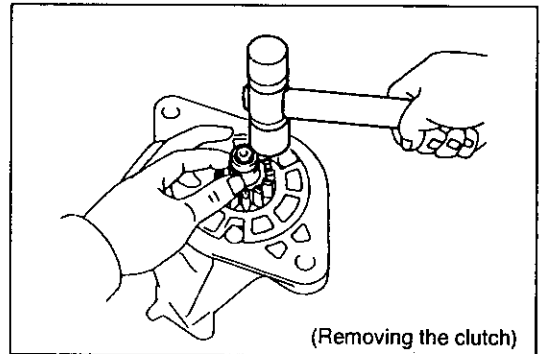
Secure the starter clutch and turn the pinion gear clockwise to check if it turns smoothly. Attempt to turn the pinion gear counterclockwise to check that it is locked. If needed, replace the clutch assembly.



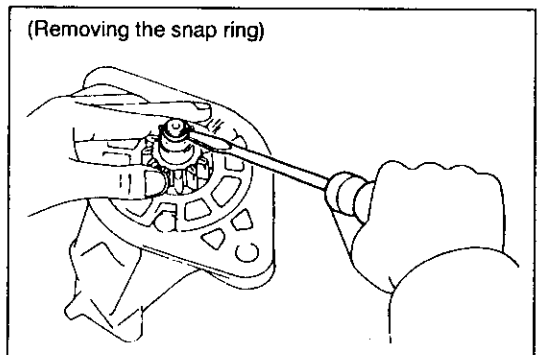
3.22.3.7.3 Replace the clutch assembly if needed

1. Disassemble the starter housing and clutch assembly

- (1) Press down the pinion gear and starter housing.
- (2) Tap in the stop collar with a plastic hammer.

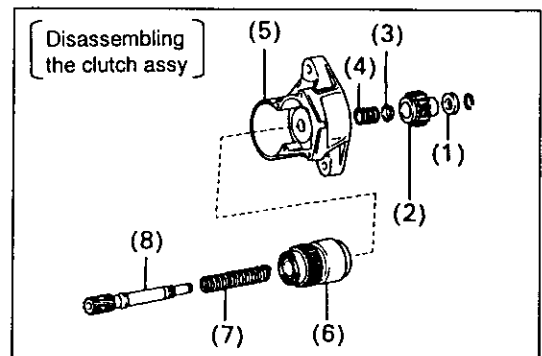


- (3) Pry the snap ring to remove using a screwdriver.



(4) Disassemble the following parts:

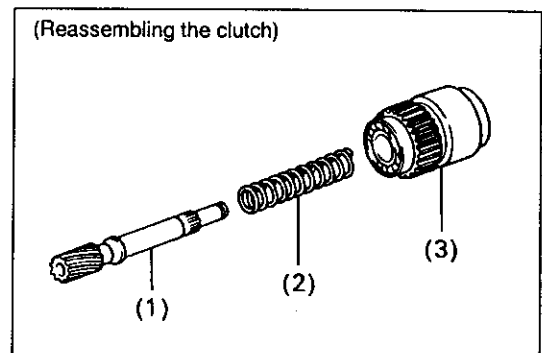
- 1) Stop collar
- 2) Pinion gear
- 3) Retainer
- 4) Spring
- 5) Starter housing
- 6) Starter clutch
- 7) Compression spring
- 8) Clutch shaft



2. Reassemble the starter housing and clutch assembly

(1) First, reassemble the following parts:

- 1) Clutch shaft
- 2) Spring
- 3) Starter clutch



3. Engine Overhaul

(2) Next, reassemble the following parts:

- 1) Clutch shaft and starter clutch assembly
- 2) Starter housing
- 3) Compression spring
- 4) Retainer
- 5) Pinion gear
- 6) Stop collar

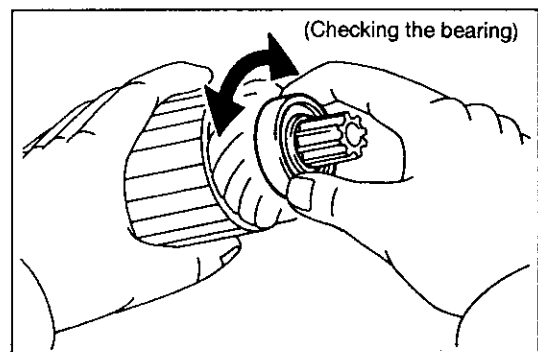
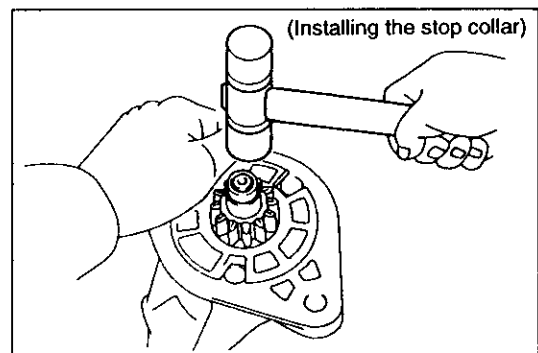
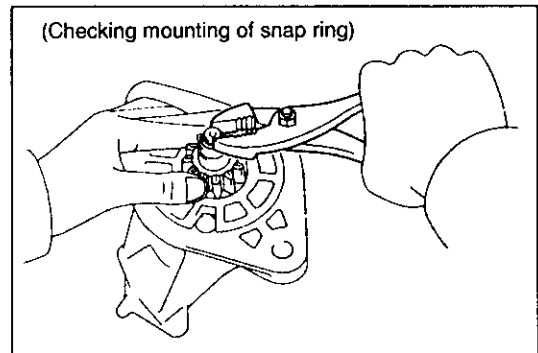
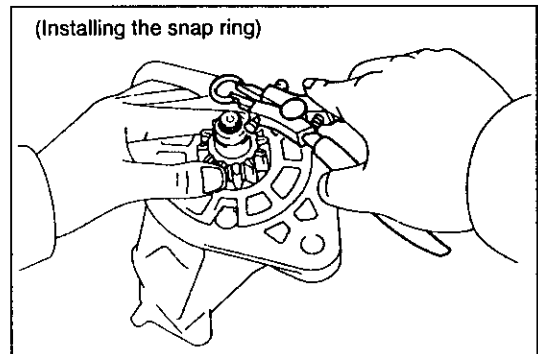
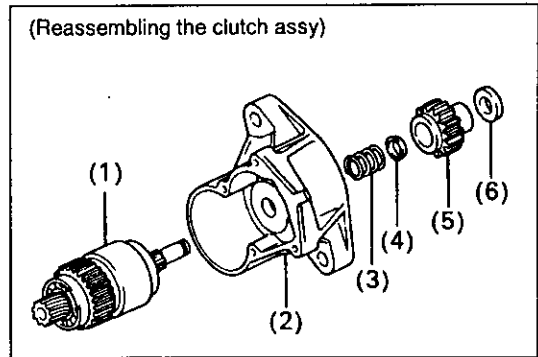
(3) Press down the pinion gear and starter housing.

(4) Install the new snap ring using the snap ring pliers.

(5) Compress the snap ring using pliers.

(6) Check that the snap ring is installed in position.

(7) Tap in the clutch shaft with a plastic hammer and install the stop collar onto the snap ring.



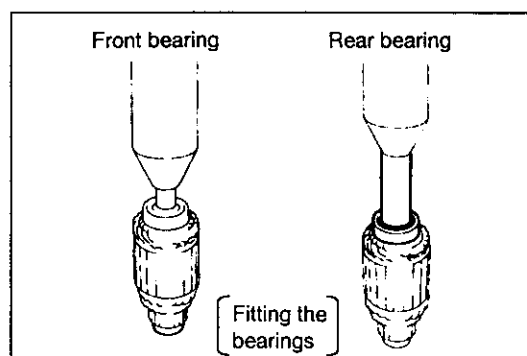
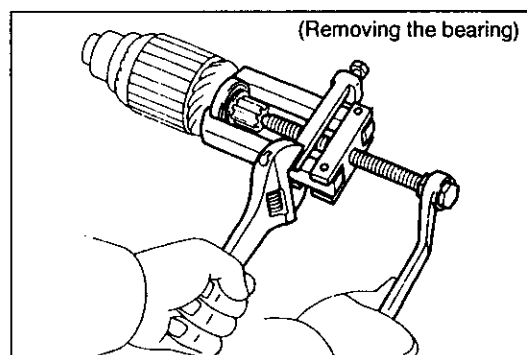
3.22.3.8 Bearing

3.22.3.8.1 Check the bearing

Manually turn the bearing while applying an inwards force. If you feel resistance or play to the bearing, replace the bearing.

3.22.3.8.2 Replace the bearing, if needed

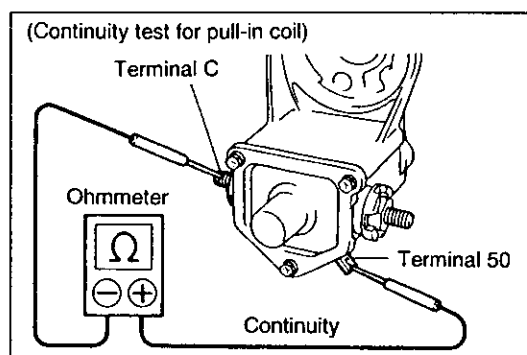
- (1) Remove the bearing.
- (2) Press in a new front bearing using the press.
- (3) Press in a new rear bearing.



3.22.3.9 Magnetic switch

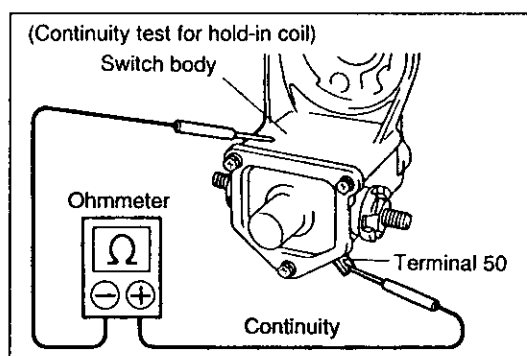
3.22.3.9.1 Check continuity of the pull-in coil circuit

Check electrical continuity between terminals 50 and C using an ohmmeter. If no continuity, replace the magnetic switch.



3.22.3.9.2 Check continuity of the hold-in coil circuit

Check electrical continuity between terminal 50 and the switch body using an ohmmeter. If no continuity, replace the magnetic switch.

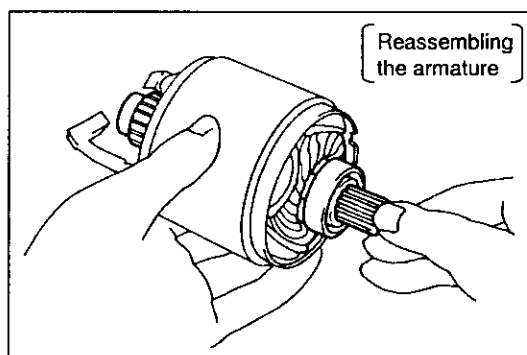


3.22.3.10 Reassembly of starter

Use high-temperature grease for lubrication of the bearing and gear when reassembling the starter.

3.22.3.10.1 Fit the armature in the field frame

Apply grease to the armature bearing and fit the armature in the field frame.

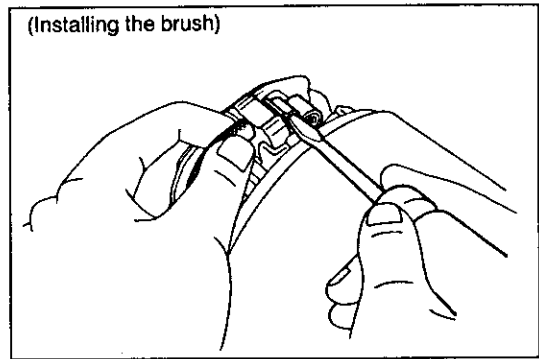


3.22.3.10.2 Install the brush holder

- (1) Install the brush holder to the armature.
- (2) Install the brush to the brush holder while securing the rear of the brush spring with a screwdriver. Connect four brushes in the same manner.

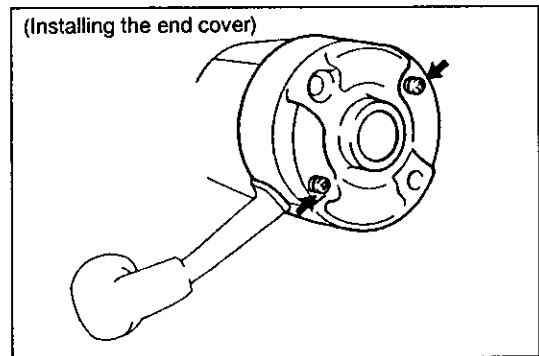
Note: Make sure that the positive (+) lead wire is not grounded.

- (3) Install the end cover to the field frame using two screws.



3.22.3.10.3 Insert the steel ball into the clutch shaft hole

- (1) Apply grease to the steel ball.
- (2) Insert the steel ball into the clutch shaft hole .

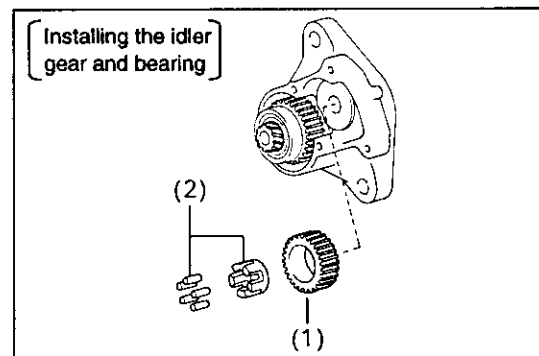
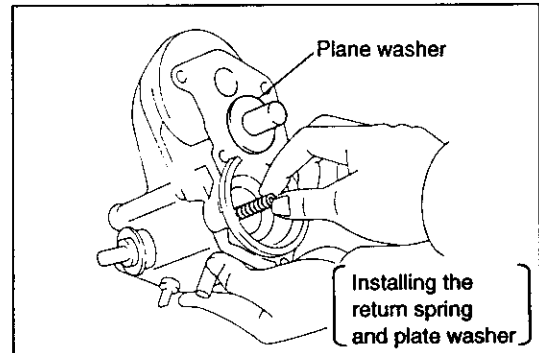


3.22.3.10.4 Install the starter housing, clutch assembly and gear

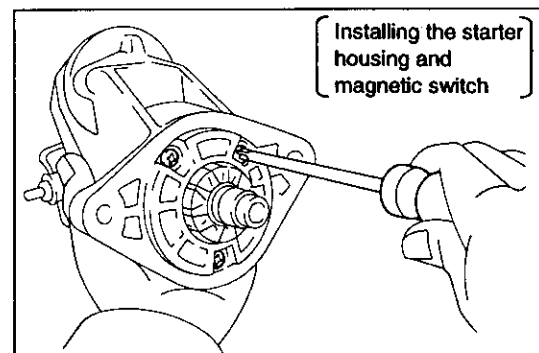
- (1) Apply grease to the return spring.
- (2) Insert the return spring into the magnetic switch hole.
- (3) Install the plate washer to the magnetic switch.

- (4) Install the following parts to the starter housing:

- 1) Idler gear
- 2) Bearing

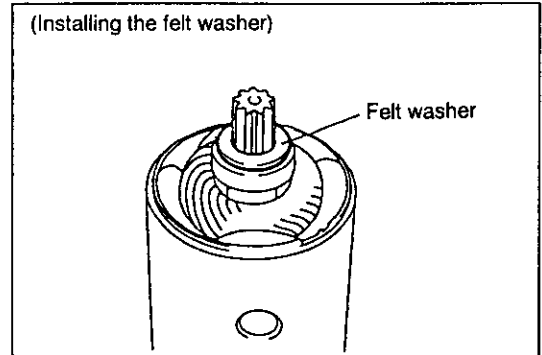


- (5) Assemble the starter housing and magnetic switch assembly, using three screws.

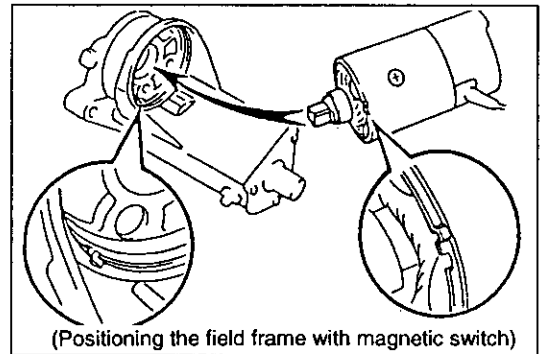


3.22.3.10.5 Install the field frame, armature assembly and lead wire to the magnetic switch

(1) Install a new felt washer to the armature.

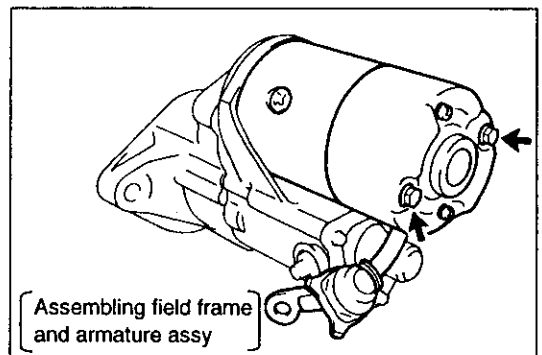


(2) Align the projection of the field frame with the cutout in the magnetic switch.



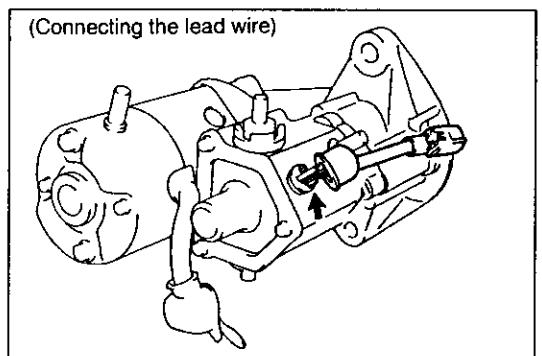
(3) Assemble the field frame and armature assembly using two through bolts.

Tightening torque: 95 kgf·cm (9.32 N·m)



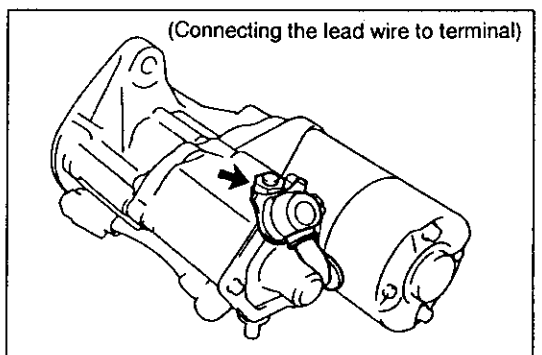
(4) Connect the lead wire to terminal 50 using a screw and washer.

Tightening torque: 41 kgf·cm (4.02 N·m)



(5) Connect the lead wire to terminal C and install the nut.

Tightening torque: 215 kgf·cm (21.08 N·m)



3. Engine Overhaul

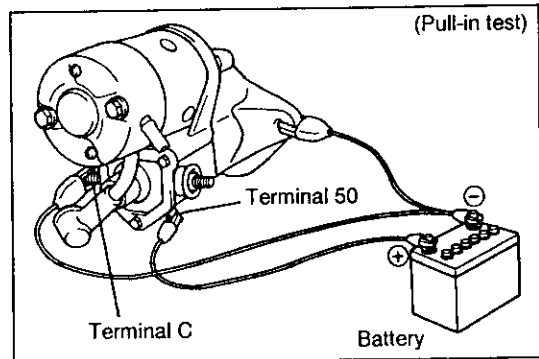
3.22.3.11 Starter performance test

[NOTICE]

Complete tests within 3 to 5 seconds in order to prevent burning of the coil.

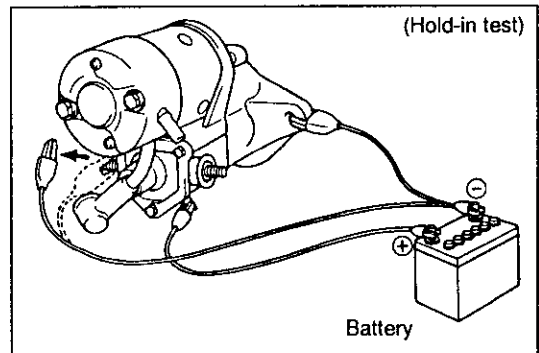
3.22.3.11.1 Pull-in test

- (1) Disconnect the field coil lead wire from terminal C.
- (2) Connect the battery to the magnetic switch as shown. Check that the clutch pinion gear moves outwards. If the clutch pinion gear does not move, replace the magnetic switch assembly.



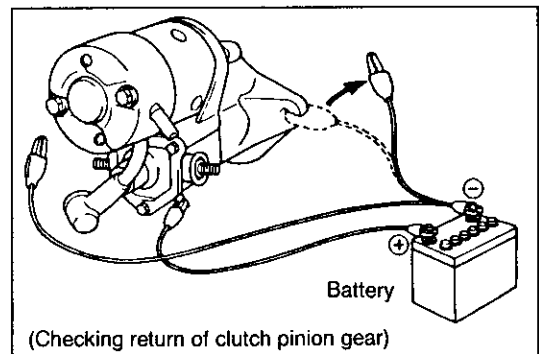
3.22.3.11.2 Hold-in test

Under the above condition where the clutch pinion gear is located outside and the battery is connected, disconnect the negative (-) lead from terminal C. Check that the pinion gear is at the outside. If it has return to the inside, replace the magnetic switch assembly.



3.22.3.11.3 Check return of the clutch pinion gear

Disconnect the negative (-) lead from the switch body. Check that the clutch pinion gear returns to the inside. If not, replace the magnetic switch assembly.



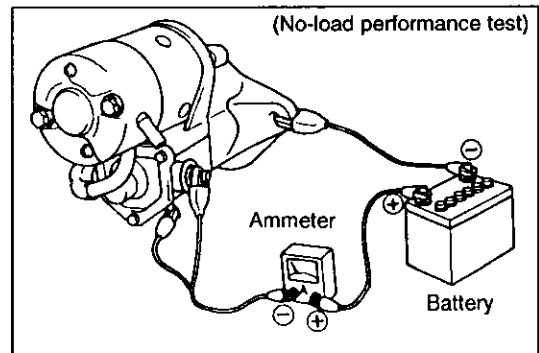
3.22.3.11.4 No-load performance test

- (1) Connect the battery and ammeter to the starter as shown.
- (2) Check that the starter rotates securely and smoothly and that the pinion gear moves outwards. Also, check that the ammeter reads a standard value.

Standard current

12V type: 180A or less at 11.0V

24V type: 90A or less at 24.0V



3.22.4 Service Standard

- Nut and bolt tightening torque

Tightening parts	kgf·cm (N·m)
Starter housing × magnetic switch	95 (9.32)
End cover × starter housing	95 (9.32)
Lead wire × terminal 50	41 (4.02)
Lead wire × terminal C	215 (21.08)

3.23 Charging System

3.23.1 Preparation and Inspection

1. Check that battery cables are connected to terminals correctly.
2. Disconnect the battery cables when charging the battery with other source for a quick charge.
3. Never use high voltage insulation resistance tester for tests.
4. Never disconnect the battery while the engine is running.

3.23.1.1 Inspect the drive belt

- (1) Visually check for cracks, oiliness and wear. Also, check that the belt does not contact the bottom of the pulley groove. If needed, replace the drive belt as a set.
- (2) Press down the belt at the position shown in the illustration, with a 10 kgf (98 N) force, and check the deflection of the drive belt.

Deflection of drive belt

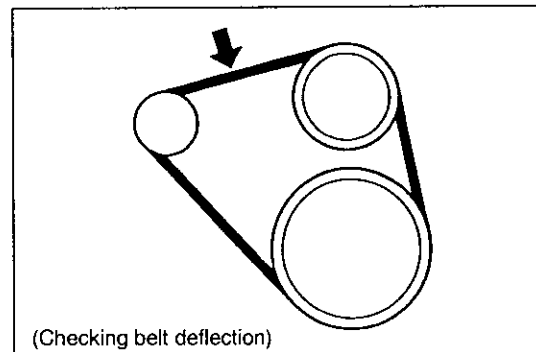
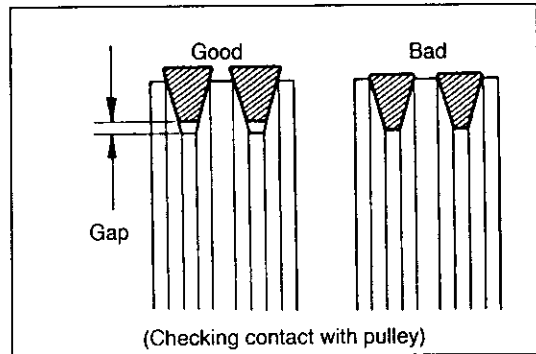
New belt: 6 to 8 mm

Used belt: 8 to 11 mm

Adjust the drive belt deflection as needed.

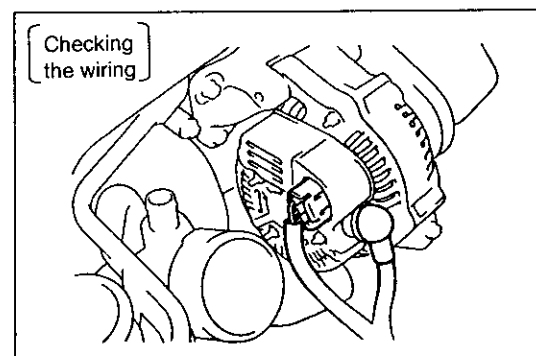
Note:

- A new belt is that used for less than 5 minutes on the running engine.
- Used belt is that used for over 5 minutes on the running engine.
- Install a new belt, operate the engine for 5 minutes and then check the deflection again.



3.23.1.2 Visually check the alternator wiring and check for abnormal sounds

- (1) Check if the wiring is correct and check for loose terminals.
- (2) Check for abnormal sounds generated from the alternator while the engine is running.



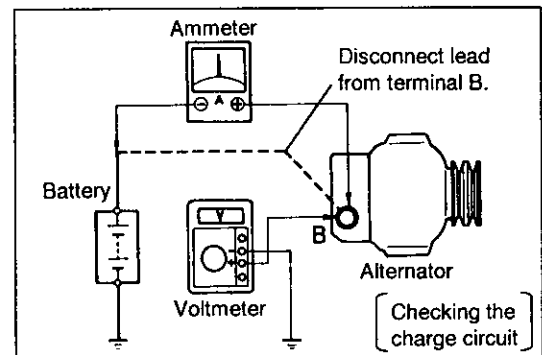
3.23.1.3 Check the discharge warning light circuit

- (1) Set the start switch to ON. Check that the discharge warning light turns on.
- (2) Start the engine. Check that the light turns off. If the light fails to operate as above, repair the circuit.

3.23.1.4 Check the charging circuit at no load

(1) Connect the voltmeter and ammeter to the charging circuit as instructed below.

- Disconnect the lead from alternator terminal B and connect to the negative (-) lead of ammeter.
- Connect the positive (+) lead of ammeter to the alternator terminal B.
- Connect the positive (+) lead of voltmeter to the alternator terminal B.
- Connect the negative (-) lead of voltmeter to the ground.



(2) Check the charging circuit as instructed below.

Start the engine, increase the engine speed up to 2,000 rpm from the idling, and read ammeter and voltmeter readings.

Standard current: 10A or less

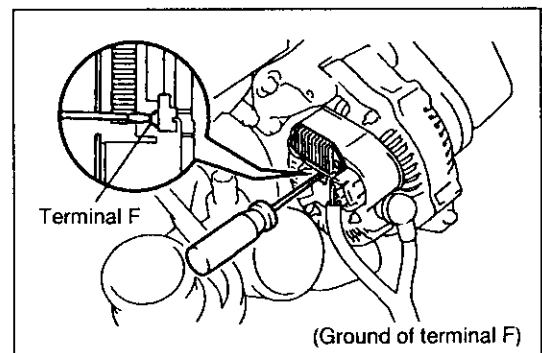
Standard voltage: 14.0 to 15.0 V at 25°C

13.5 to 14.3 V at 115°C

If the voltmeter reading exceeds the standard value, replace the IC regulator.

If the voltmeter reading is below the specified value, check the IC regulator and alternator as instructed below.

- Ground terminal F, start the engine and check the voltmeter reading at terminal B.
- If the voltmeter reading exceeds the standard value, replace the IC regulator.
- If the voltmeter reading is below the specified value, check the alternator.



3.23.1.5 Check the charging circuit at on load (Reference)

(1) Operate the engine speed at 2000 rpm, turn the high beam head light on and set the heater blower switch to HI.

(2) Check the ammeter reading.

Standard current

12V 80A type: 30 A or more

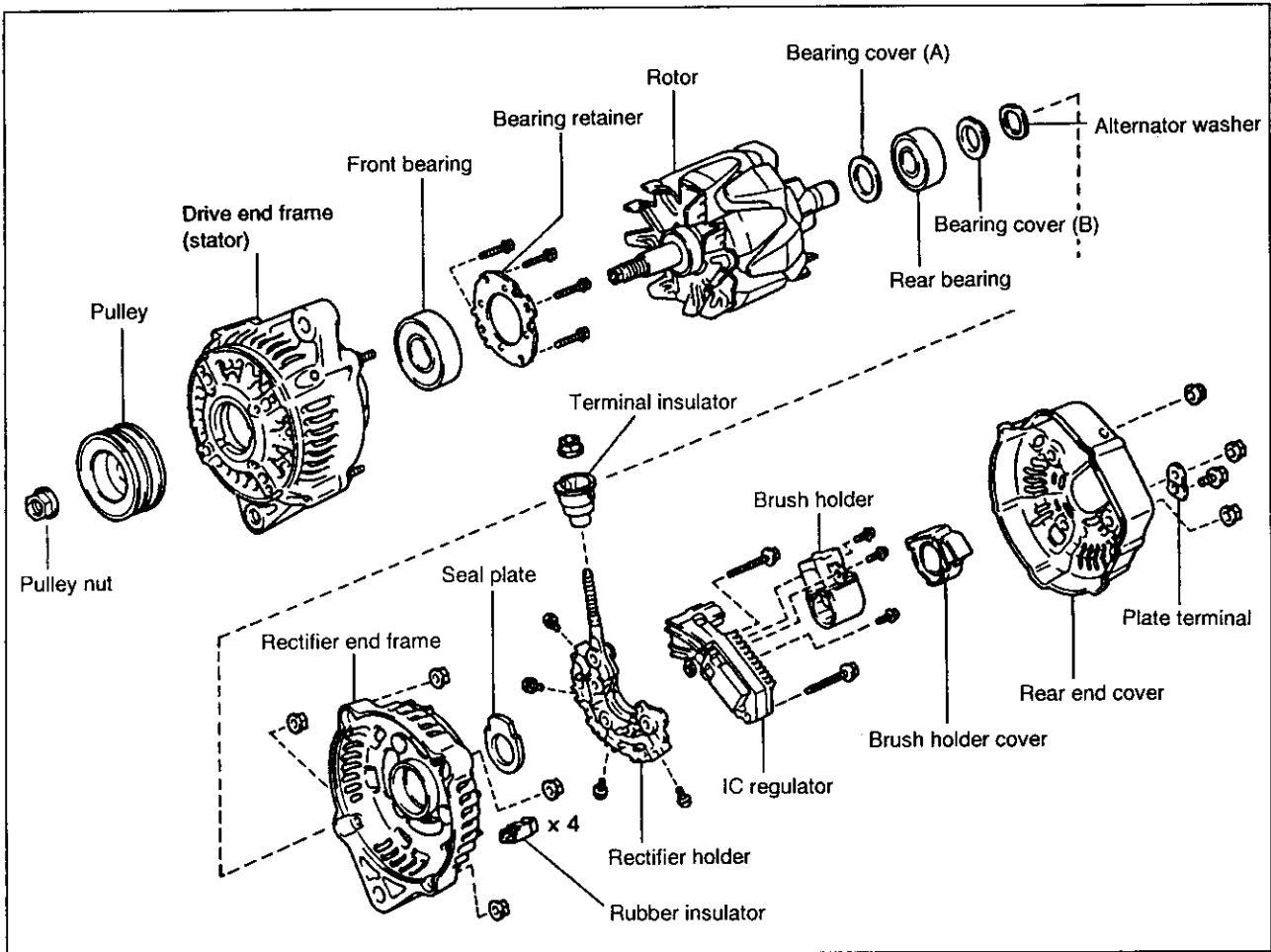
12V 100A type: 40 A or more

If the ammeter reading is below the specified value, repair the alternator.

- When the battery is in the fully charged state, the indication is below the standard value.

3.23.2 Alternator

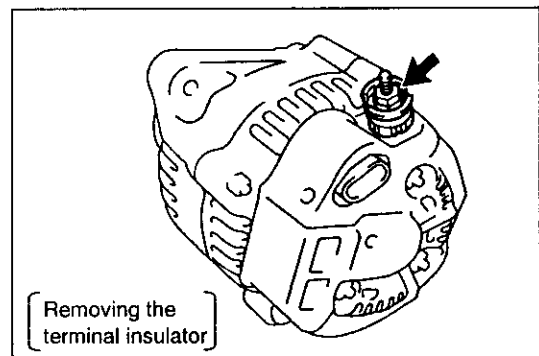
• Components



3.23.3 Disassembly of Alternator

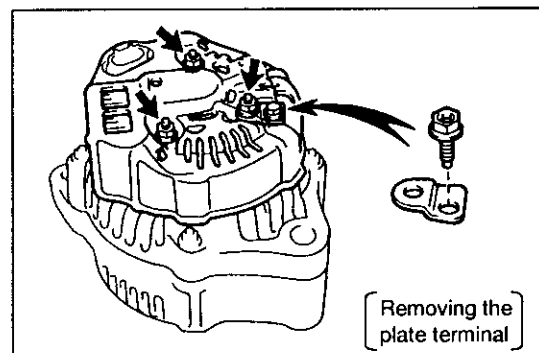
3.23.3.1 Remove the rear end cover

(1) Remove the nuts and terminal insulator.



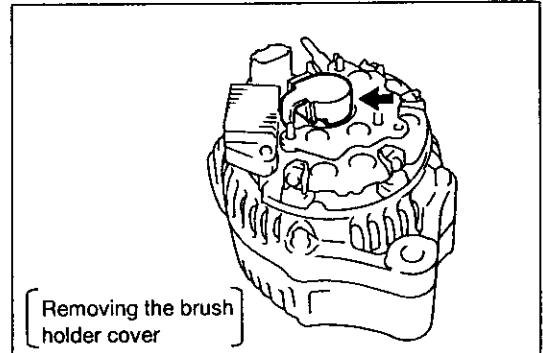
(2) Remove the 3 nuts, bolt and plate terminal.

(3) Remove the rear end cover.

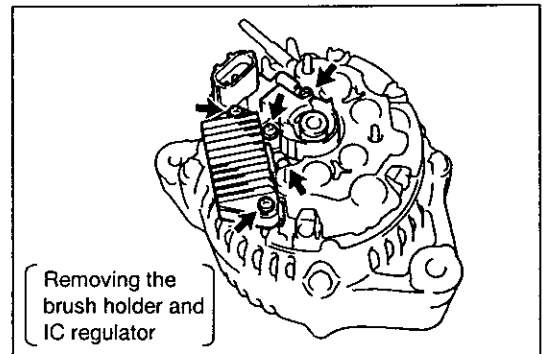


3.23.3.2 Remove the brush holder and IC regulator

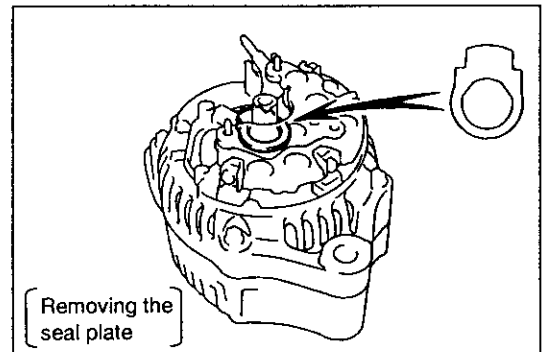
(1) Remove the brush holder cover from the brush holder.



(2) Remove the 5 screws, brush holder and IC regulator.

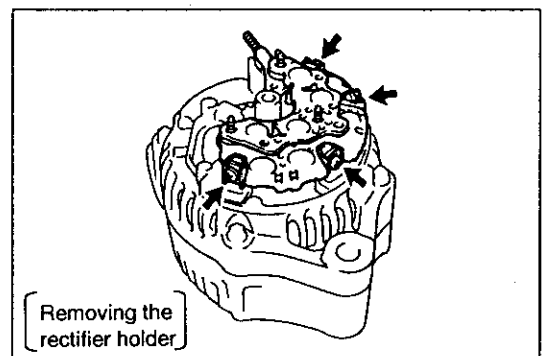


(3) Remove the seal plate from the rectifier end frame.

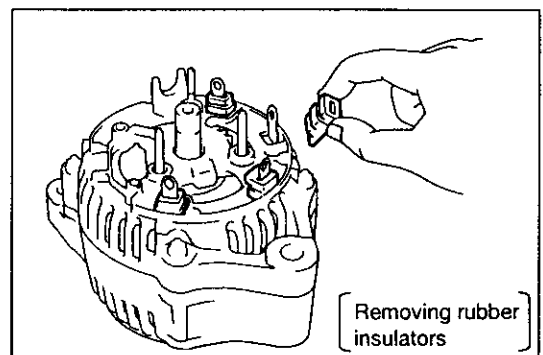


3.23.3.3 Remove the rectifier holder

(1) Remove the 4 screws and rectifier holder.



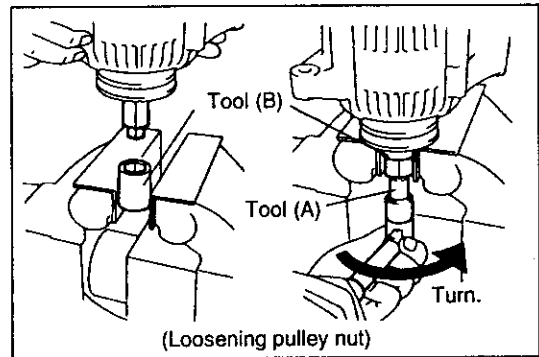
(2) Remove the 4 rubber insulators.



3. Engine Overhaul

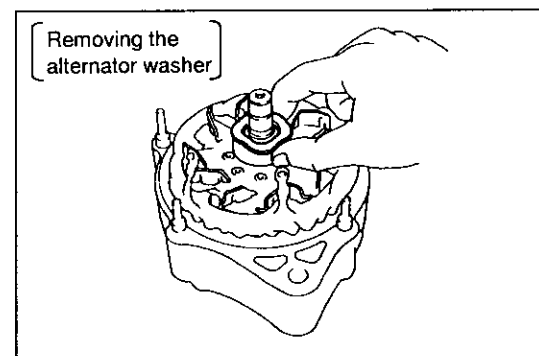
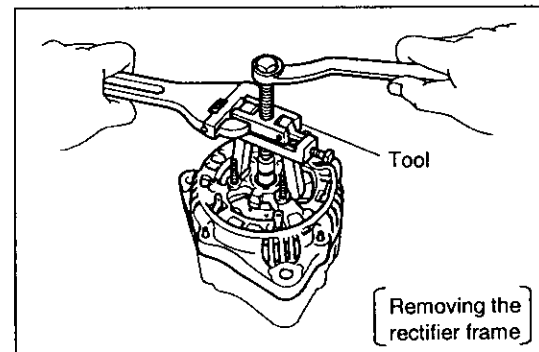
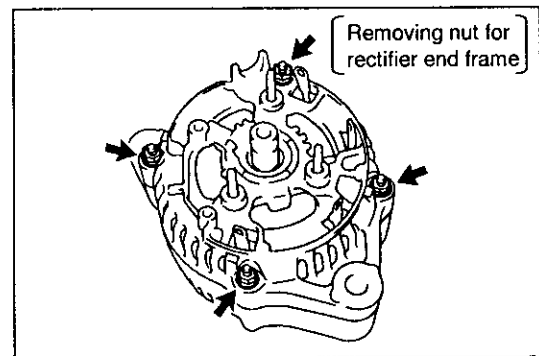
3.23.3.4 Remove the pulley

- (1) Fix the pulley nut tool (B) with a vice as shown and install the alternator to tool (B).
- (2) Turn the tool (A) for rotor shaft in the direction shown in the illustration, for loosening the pulley nut.
Note: Do not loose the rotor shaft over 1/4 of a turn to prevent damage to the rotor shaft.
- (3) Remove the alternator from tool (B).
- (4) Remove the pulley nut and then the pulley.

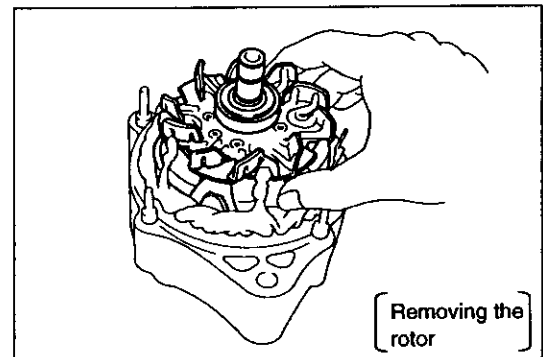


3.23.3.5 Remove the rectifier end frame

- (1) Remove the 4 nuts.
- (2) Remove the rectifier end frame.
- (3) Remove the alternator washer.



3.23.3.6 Remove the rotor from the drive end frame



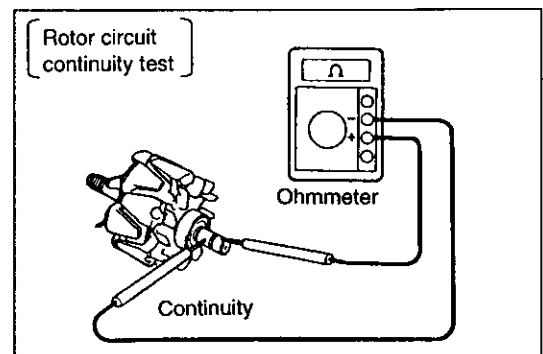
3.23.4 Inspection and Repair of Alternator

3.23.4.1 Check continuity of the rotor circuit

Check that the circuit between slip rings is continuity using an ohmmeter.

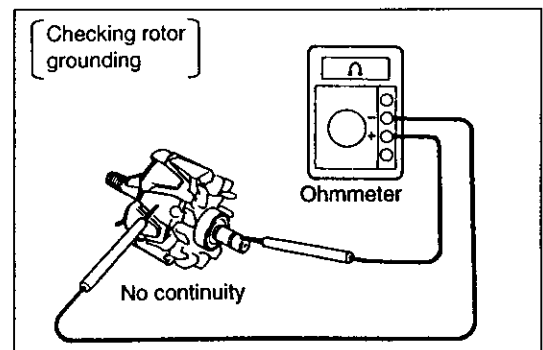
Standard resistance: 2.9Ω at 20°C

If it is not continuous, replace the rotor.



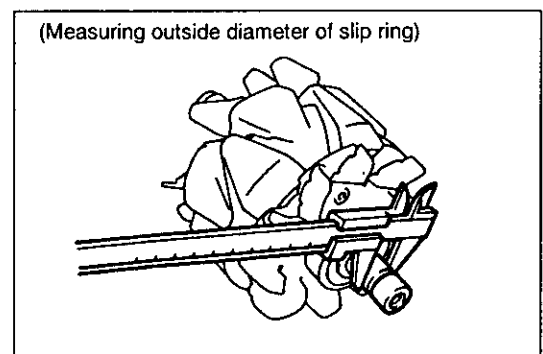
3.23.4.2 Check the rotor grounding

Check that the circuit between the slip ring and rotor is electrically no continuity using an ohmmeter. If continuity, replace the rotor.



3.23.4.3 Check the slip ring

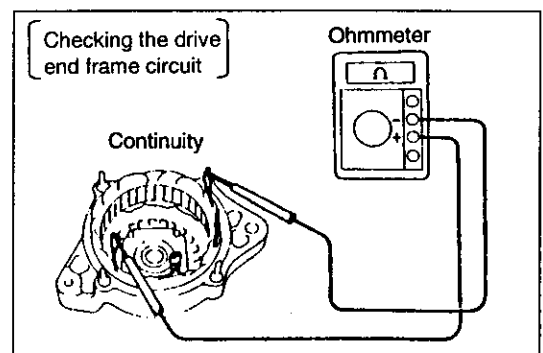
- (1) Check the slip ring for rough surface and scratches. If there is rough surface or scratches, replace the rotor.
- (2) Measure the slip ring diameter using calipers.
 - Standard diameter: 14.2 to 14.4 mm
 - Minimum diameter: 12.8 mm
 If the measured diameter is below the specified minimum, replace the rotor.



3.23.4.4 Drive end frame (stator)

3.23.4.4.1 Check continuity of the drive end frame circuit

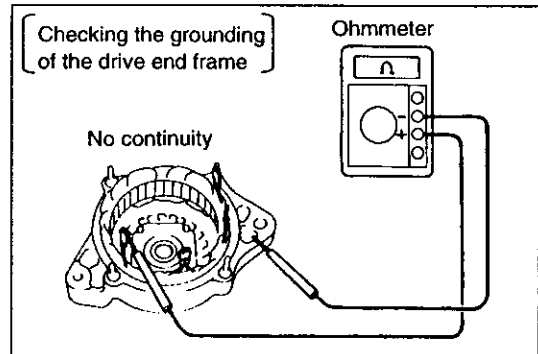
Check that it is electrically continuous between coil leads using an ohmmeter. If not continuity, replace the drive end frame assembly.



3. Engine Overhaul

3.23.4.4.2 Check grounding of the drive end frame

Check that the circuit between the coil lead and drive end frame is not continuity using an ohmmeter. If they are continuity, replace the drive end frame assembly.



3.23.4.5 Brush

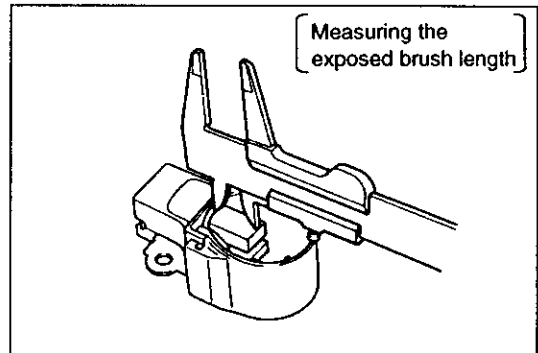
3.23.4.5.1 Check the exposed brush length

Check the exposed brush length using calipers.

Standard exposed length: 10.5 mm

Minimum exposed length: 1.5 mm

If the measured length is below the specified minimum, replace the brush holder.

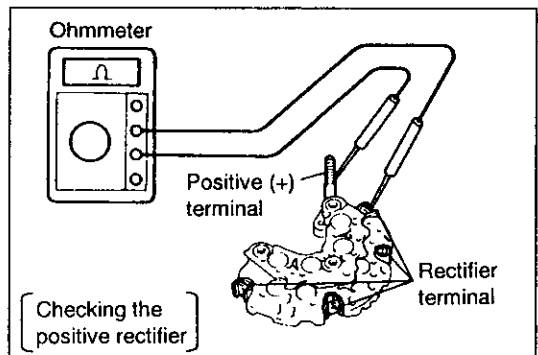


3.23.4.6 Rectifier (rectifier holder)

3.23.4.6.1 Check the positive rectifier

- (1) Connect one of tester probes of an ohmmeter to the positive (+) terminal and the other probe to the rectifier terminal.
- (2) Reverse polarities of the probes and repeat the procedure.
- (3) Check that one of continuity shows the state while the other connection results in no continuity state.

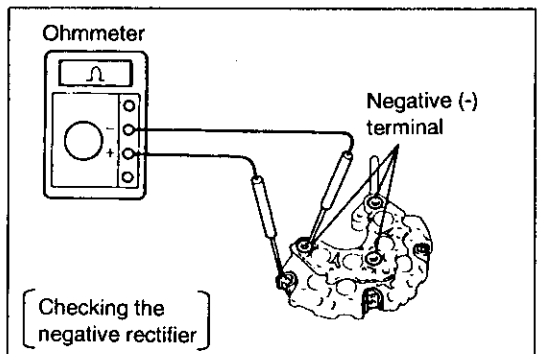
If the continuity check results are not as described above, replace the rectifier.



3.23.4.6.2 Check the negative rectifier

- (1) Connect one of tester probes of an ohmmeter to the negative (-) terminal and the other probe to the rectifier terminal.
- (2) Reverse polarities of the probes and repeat the procedure.
- (3) Check that one of connections shows the continuity state while the other connection results in no continuity state.

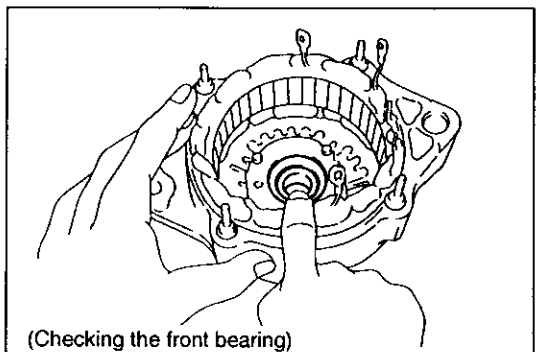
If the continuity check results are not as described above, replace the rectifier holder.



3.23.4.7 Bearing

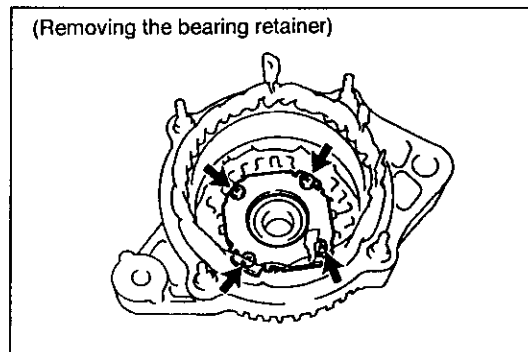
3.23.4.7.1 Check the front bearing

Check that the front bearing is not worn.

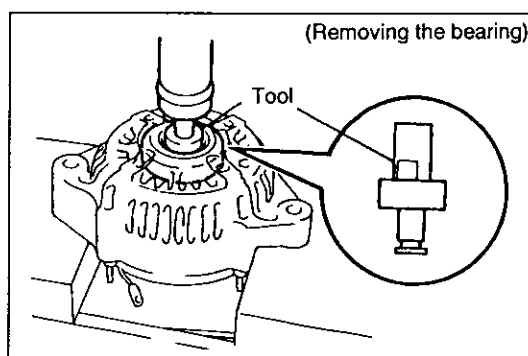


3.23.4.7.2 Replace the front bearing when needed

(1) Remove the 4 screws, bearing retainer and bearing.

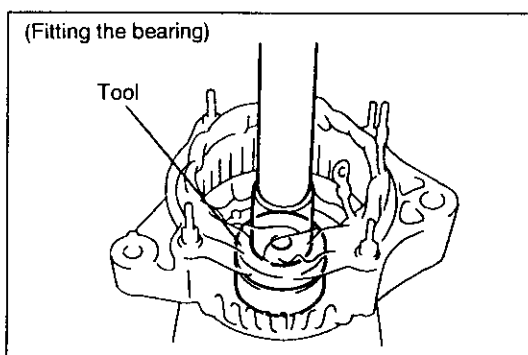


(2) Press out the bearing using the tool and press.



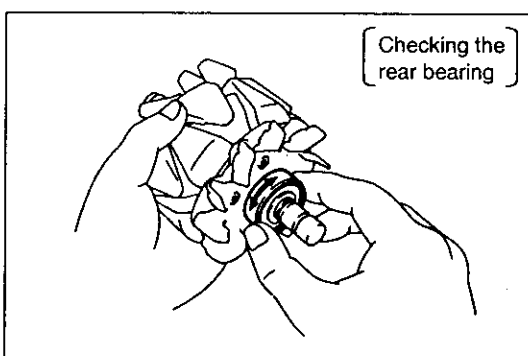
(3) Press in a new bearing using the tool and press.

(4) Install the bearing retainer using 4 screws.



3.23.4.7.3 Check the rear bearing

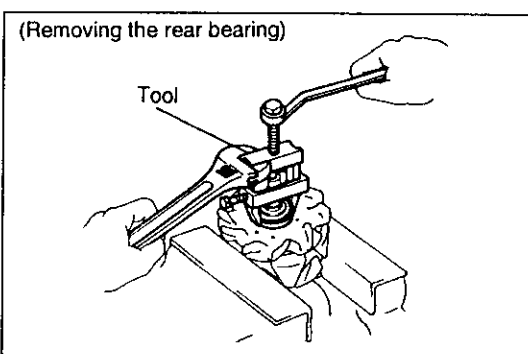
Check that the rear bearing is not worn.



3.23.4.7.4 Replace the rear bearing when needed

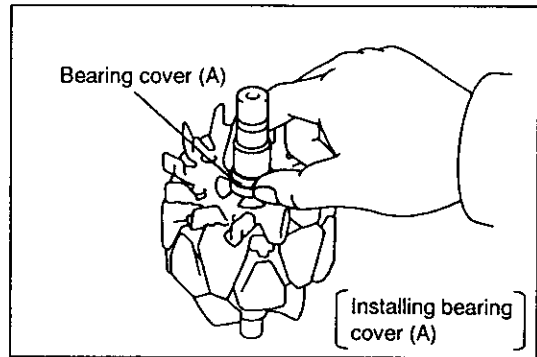
(1) Remove the bearing cover (B), bearing and bearing cover (A) using the tool.

Note: Pay attention so as not to damage the fan.

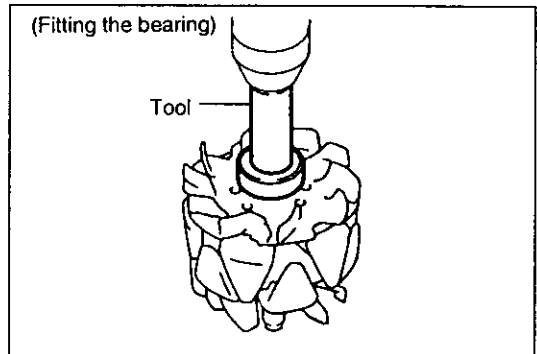


3. Engine Overhaul

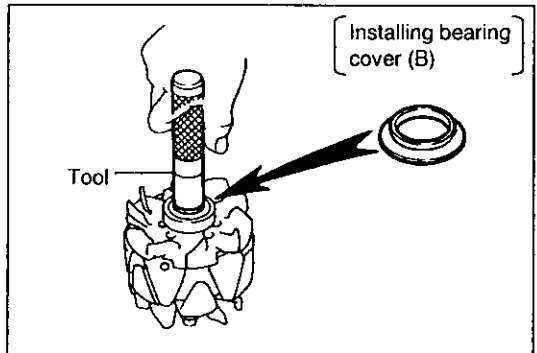
(2) Install bearing cover (A) above the rotor.



(3) Press in a new bearing using the tool and press.



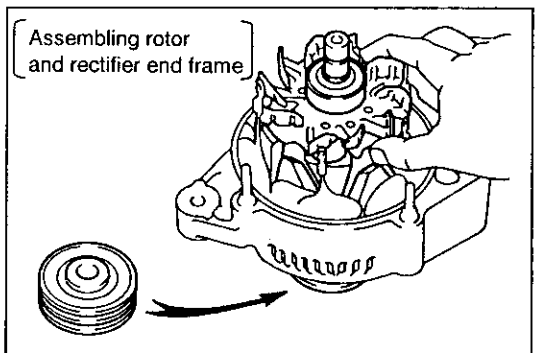
(4) Push in bearing cover (B) using the tool.



3.23.5 Reassembly of Alternator

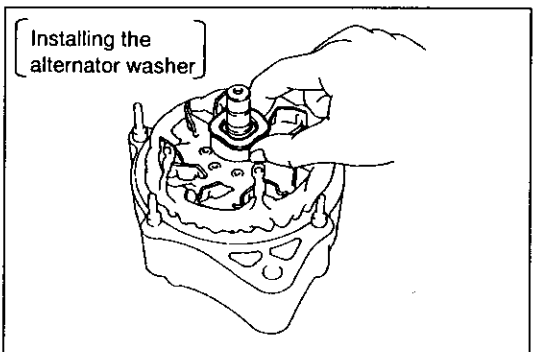
3.23.5.1 Locate the rectifier end frame on the pulley

3.23.5.2 Install the rotor to the rectifier end frame

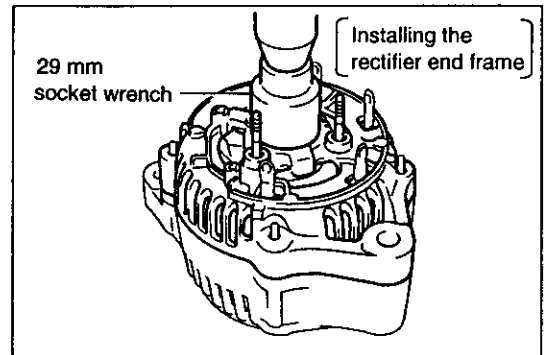


3.23.5.3 Install the rectifier end frame

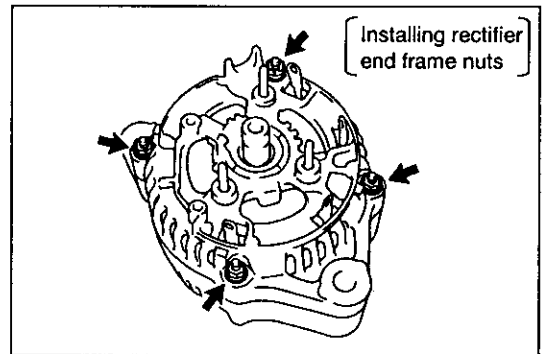
(1) Locate the alternator washer above the rotor.



- (2) Slowly press in the rectifier end frame using a 29 mm socket wrench and press.

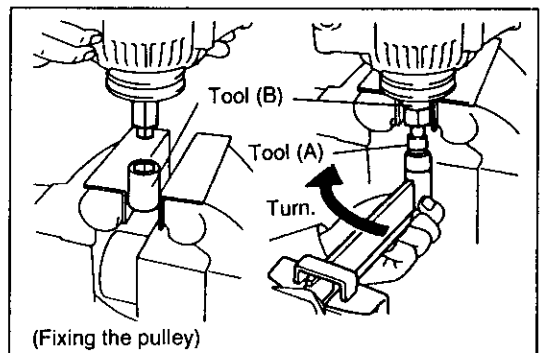


- (3) Install the 4 nuts.
Tightening torque: 46 kgf·cm (4.51 N·m)



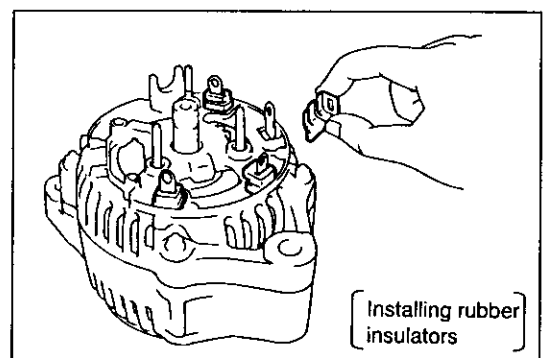
3.23.5.4 Install the pulley

- (1) Manually tighten the pulley nut to secure the pulley to the rotor shaft.
- (2) Fix tool (B) for pulley nut by a vice as shown and fix the alternator to tool (B).
- (3) Turn tool (A) for rotor shaft in the direction shown in the illustration, for tightening the pulley nut.
Tightening torque: 1,125 kgf·cm (110.32 N·m)
- (4) Remove the alternator from tool (B).



3.23.5.5 Install the rectifier holder

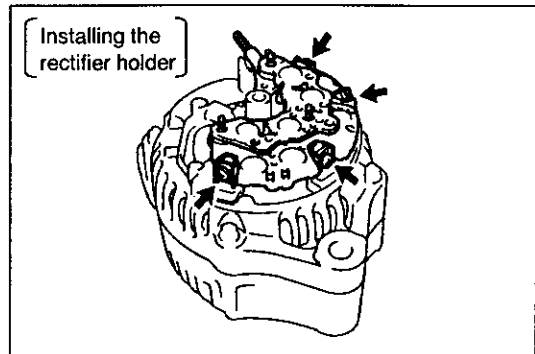
- (1) Install the 4 rubber insulators above lead wires.



3. Engine Overhaul

- (2) Fix the rectifier holder by 4 bolts while pushing it downwards.

Tightening torque: 30 kgf·cm (2.94 N·m)

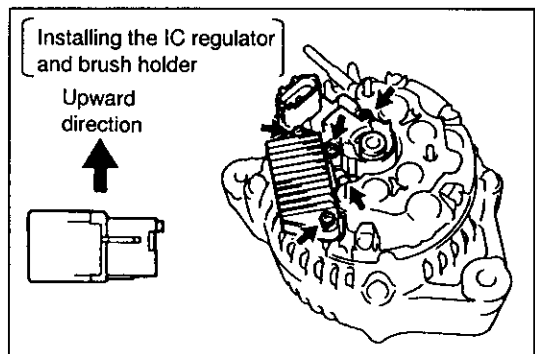


3.23.5.6 Install the IC regulator and brush holder

- (1) Locate the seal plate on the rectifier end frame.
- (2) Locate the IC regulator and brush holder on the rectifier end frame.

Note: Install the holder the right way direction.

- (3) Tighten the 5 bolts.
- (4) Locate the brush holder cover above the brush holder.



3.23.5.7 Install the rear end cover

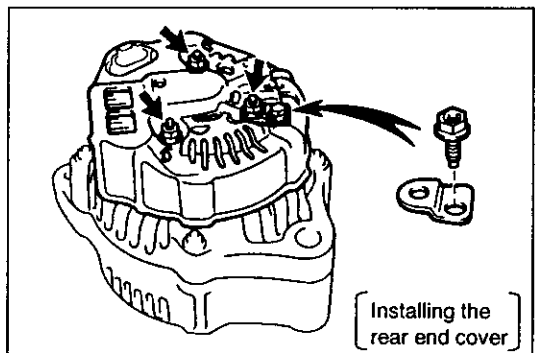
- (1) Fix the rear cover and plate terminal using 3 nuts and a bolt.

Tightening torque:

Bolt: 39 kgf·cm (3.82 N·m)

Nut: For 80A: 45 kgf·cm (4.41 N·m)

For 100A: 46 kgf·cm (4.51 N·m)

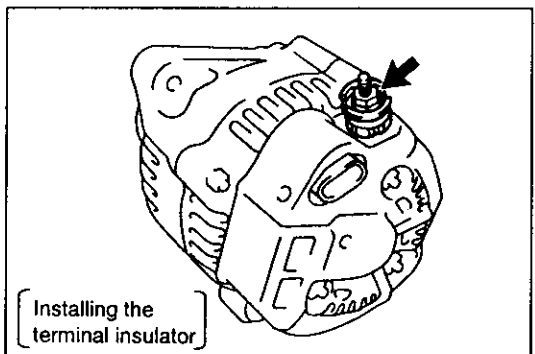


- (2) Install the terminal insulator using a nut.

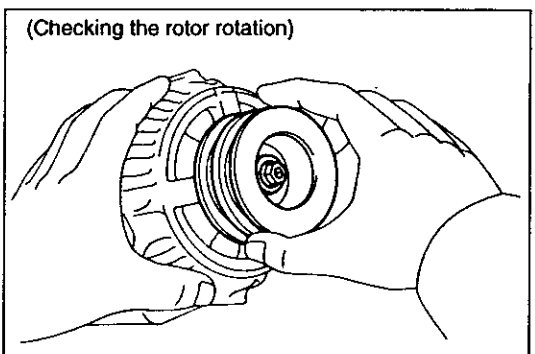
Tightening torque:

For 80A: 41.5 kgf·cm (4.07 N·m)

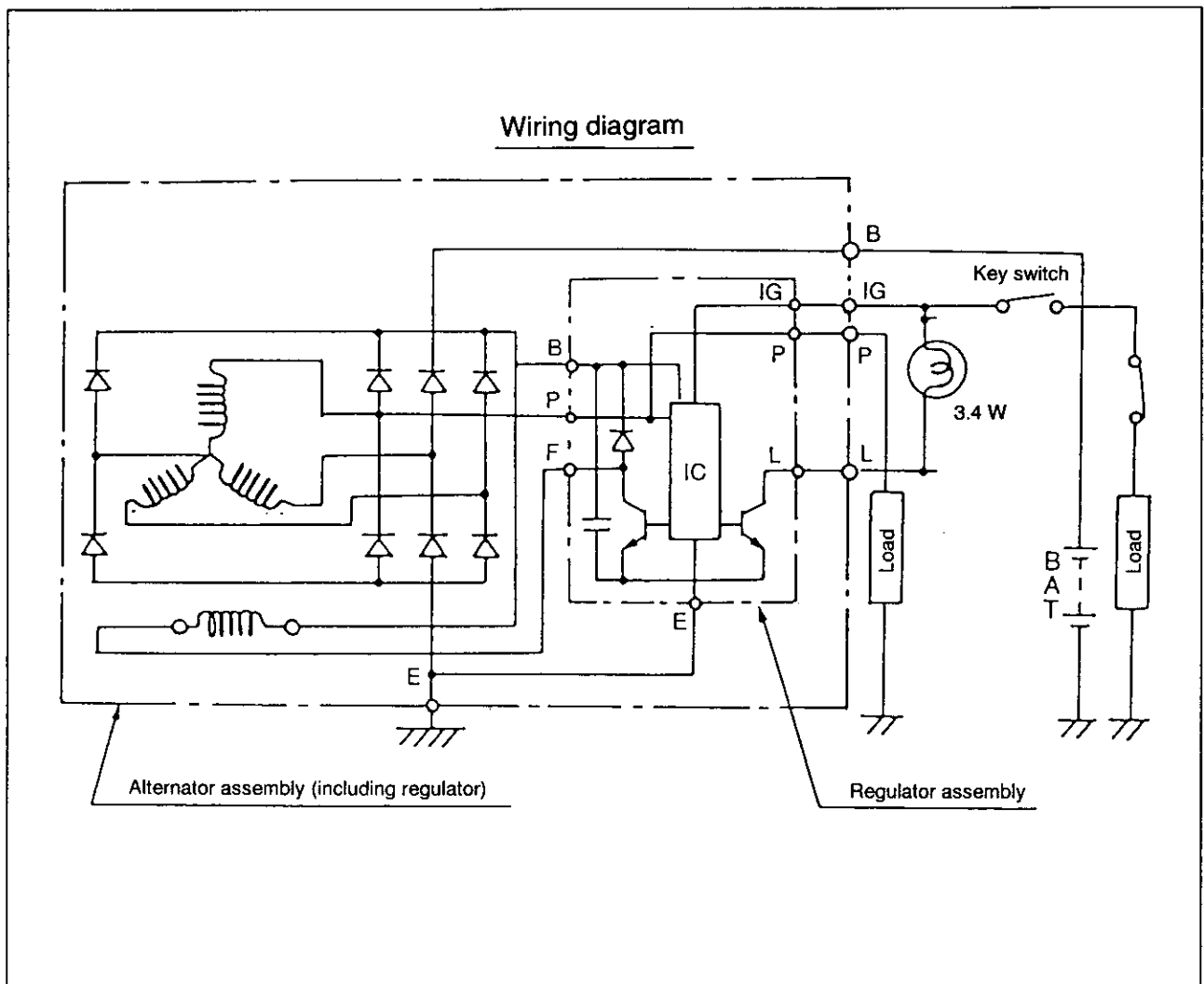
For 100A: 66 kgf·cm (6.47 N·m)



3.23.5.8 Check that the rotor rotates smoothly



3.23.6 Service Standards



Nut and bolt tightening torque

Tightening parts		kgf·cm (N·m)	
Rectifier end frame	× drive shaft end frame	46 (4.51)	
Alternator pulley	× rotor	1,125 (110.32)	
Rectifier holder	× coil lead on rectifier frame	30 (2.94)	
Plate terminal	× rectifier holder	39 (3.82)	
Rear end cover	× rectifier holder	For 80A	45 (4.41)
		For 100A	46 (4.51)
Terminal insulator	× rectifier holder	For 80A	41.5 (4.07)
		For 100A	66 (6.47)

3.24.1 Crankshaft Bearing Selecting TABLE (additional)

(Related to 3.2.3.6 Remove the main bearing cap and inspect the oil clearance)

Mark	Cylinder block main journal bore diameter
A	70.999~71.000
B	70.998~70.999
C	70.997~70.998
D	70.996~70.997
E	70.995~70.996
H	70.994~70.995
4	70.993~70.994
5	70.992~70.993
6	70.991~70.992
7	70.990~70.991
8	70.989~70.990
9	70.988~70.989
L	70.987~70.988
M	70.986~70.987
R	70.985~70.986
S	70.984~70.985
U	70.983~70.984
X	70.982~70.983

Mark	Crankshaft main journal diameter
A	66.999~67.000
B	66.998~66.999
C	66.997~66.998
D	66.996~66.997
E	66.995~66.996
H	66.994~66.995
4	66.993~66.994
5	66.992~66.993
6	66.991~66.992
7	66.990~66.991
8	66.989~66.990
9	66.988~66.989
L	66.987~66.988
M	66.986~66.987
R	66.985~66.986
S	66.984~66.985
U	66.983~66.984
X	66.982~66.983

		Crankshaft main journal MARK																	
		A	B	C	D	E	H	4	5	6	7	8	9	L	M	R	S	U	X
Cylinder block journal MARK	A	3	3	3	3	3	3	4	4	4	4	4	4	5	5	5	5	5	5
	B	3	3	3	3	3	4	4	4	4	4	4	5	5	5	5	5	5	6
	C	3	3	3	3	4	4	4	4	4	4	5	5	5	5	5	5	6	6
	D	3	3	3	4	4	4	4	4	4	5	5	5	5	5	5	6	6	6
	E	3	3	4	4	4	4	4	4	5	5	5	5	5	5	6	6	6	6
	H	3	4	4	4	4	4	4	5	5	6	5	5	5	6	6	6	6	6
	4	4	4	4	4	4	4	5	5	5	5	5	5	6	6	6	6	6	6
	5	4	4	4	4	4	5	5	5	5	5	5	6	6	6	6	6	6	7
	6	4	4	4	4	5	5	5	5	5	5	6	6	6	6	6	6	7	7
	7	4	4	4	5	5	5	5	5	5	6	6	6	6	6	6	7	7	7
	8	4	4	5	5	5	5	5	5	6	6	6	6	6	6	7	7	7	7
	9	4	5	5	5	5	5	5	6	6	6	6	6	6	7	7	7	7	7
	L	5	5	5	5	5	5	6	6	6	6	6	6	7	7	7	7	7	7
	M	5	5	5	5	5	6	6	6	6	6	6	7	7	7	7	7	7	8
R	5	5	5	5	6	6	6	6	6	6	7	7	7	7	7	8	8	8	
S	5	5	5	6	6	6	6	6	6	7	7	7	7	7	8	8	8	8	
U	5	5	6	6	6	6	6	6	7	7	7	7	7	7	8	8	8	8	
X	5	6	6	6	6	6	6	7	7	7	7	7	7	8	8	8	8	8	

4. Troubleshooting

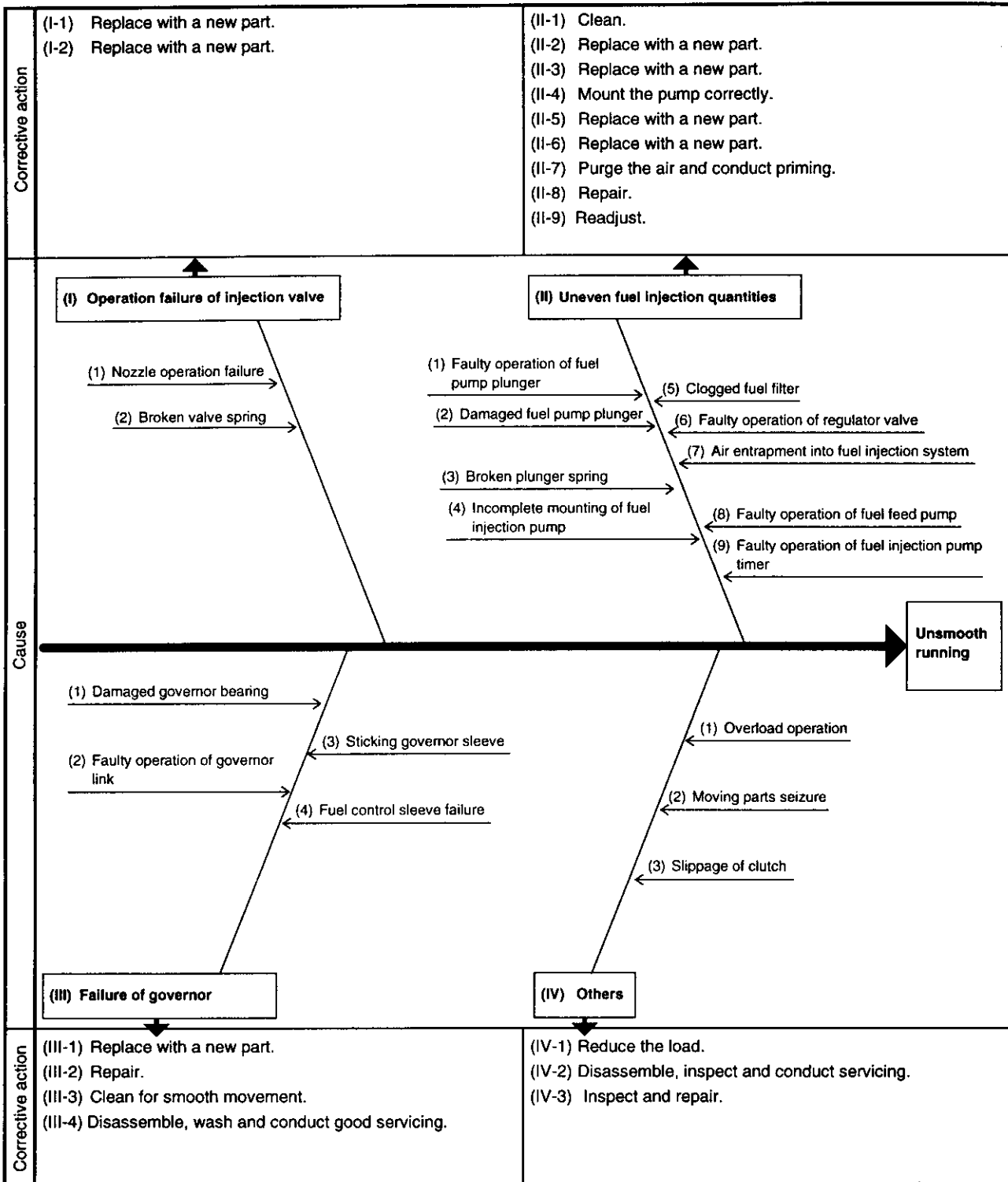
Note: Since fuel injection pump disassembly and adjustment requires special knowledge and equipment, please contact the DENSO service shop for the job.

4.1 Does not Start or Difficult to Start

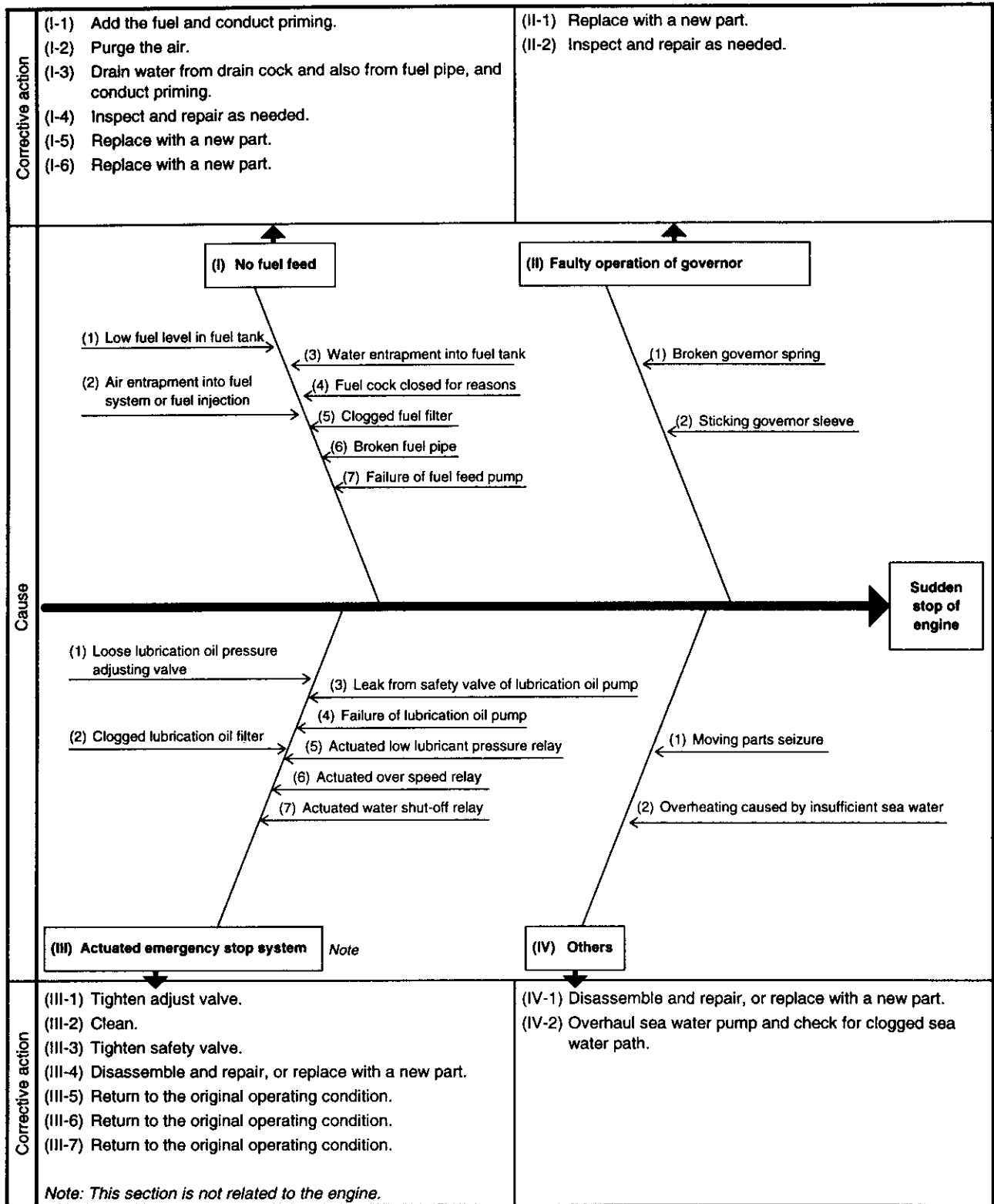
Corrective action	<p>(I-1) Tighten. (I-2) Correct with sandpaper or replace. (I-3) Replace. (I-4) Correct with sandpaper and apply grease. (I-5) Correct. (I-6) Correct. (I-7) Replace.</p>	<p>(II-1) Tighten. (II-2) Correct with sandpaper. (II-3) Replace. (II-4) Correct with sandpaper #500 to #600. (II-5) Replace. (II-6) Correct the under-cut or replace. (II-7) Replace. (II-8) Increase the cable size or shorten. (II-9) Charge.</p>	<p>(III-1) Carry out sufficient priming. (III-2) Readjust. (III-3) Replace with a new part. (III-4) Add fuel to the tank. (III-5) Open the cock. (III-6) Clean. (III-7) Overhaul or replace with a new part.</p>	<p>(IV-1) Replace with a new part. (IV-2) Replace with a new part. (IV-3) Replace with a new part. (IV-4) Replace with a new part. (IV-5) Readjust.</p>
Cause	<p>(I) No engagement of pinion gear</p> <p>(1) Loose terminal of battery/engage magnet (2) Poor contact of starting switch (3) Open coil of engage magnet (4) Unsmooth operation of shifter</p>	<p>(II) Although engaged with ring gear, no revolution of pinion gear</p> <p>(1) Loose battery/ starter terminal (2) Poor contact of engage magnet switch (3) Worn brush (4) Dirty or rough surface of rectifier</p>	<p>(III) No fuel injection</p> <p>(1) Incomplete priming of fuel system (2) Fuel shut-off by faulty speed adjusting system (3) Clogged fuel inlet filter (4) Low oil level of fuel tank (5) Closed cock of fuel tank (6) Clogged fuel pipe (7) Failure of fuel feed pump</p>	<p>(IV) Failure of fuel injection valve</p> <p>(1) Faulty valve seat (2) Sticking of nozzle (3) Worn nozzle (4) Clogged injection hole (5) Drop in injection pressure</p>
	<p>(V) Failure of fuel injection pump</p> <p>(1) Worn plunger (2) Broken plunger spring (3) Sticking plunger (4) Oil leak from delivery valve (5) Air entrapment into the pump (6) Broken delivery valve spring</p>	<p>(VI) Failure in fuel injection system</p> <p>(1) Deviated injection timing of fuel injection pump (2) Loose fuel injection pipe joint (3) Broken fuel injection pipe (4) Air entrapment into fuel injection pipe</p>	<p>(VII) Compressed air leak</p> <p>(1) Air leak from exhaust valve (2) No valve clearance (3) Faulty gasket/packing (4) Worn upper portion of cylinder liner (5) Worn piston ring (6) Sticking piston ring (7) Insufficient tightening of head bolt (8) Broken valve spring</p>	<p>(VIII) Others</p> <p>(1) Improper thickness of gasket/packing (2) Poor mounting of link or lever of speed control system (3) Location of speed control handle stopping position (4) Failure of engine starting system (5) Clogged intake or exhaust pipe</p>
Corrective action	<p>(V-1) Replace plunger and barrel with new ones, as a set. (V-2) Replace with a new part. (V-3) Overhaul or replace with a new part. (V-4) Carry out lapping of the valve. (V-5) Bleed the air. (V-6) Replace with a new part.</p>	<p>(VI-1) Readjust. (VI-2) Tighten firmly. (VI-3) Replace with a new part. (VI-4) Purge the air.</p>	<p>(VII-1) Carry out fitting of the valve and seat. (VII-2) Readjust. (VII-3), (VII-4) and (VII-5) Replace with a new part. (VII-6) Overhaul or replace with a new part. (VII-7) Retighten set bolts uniformly. (VII-8) Replace with a new part.</p>	<p>(VIII-1) Replace with a part of appropriate size. (VIII-2) Readjust. (VIII-3) Move the speed control handle towards higher speed. (VIII-4) Inspect and conduct servicing. (VIII-5) Clean.</p>

When does not start or difficult to start

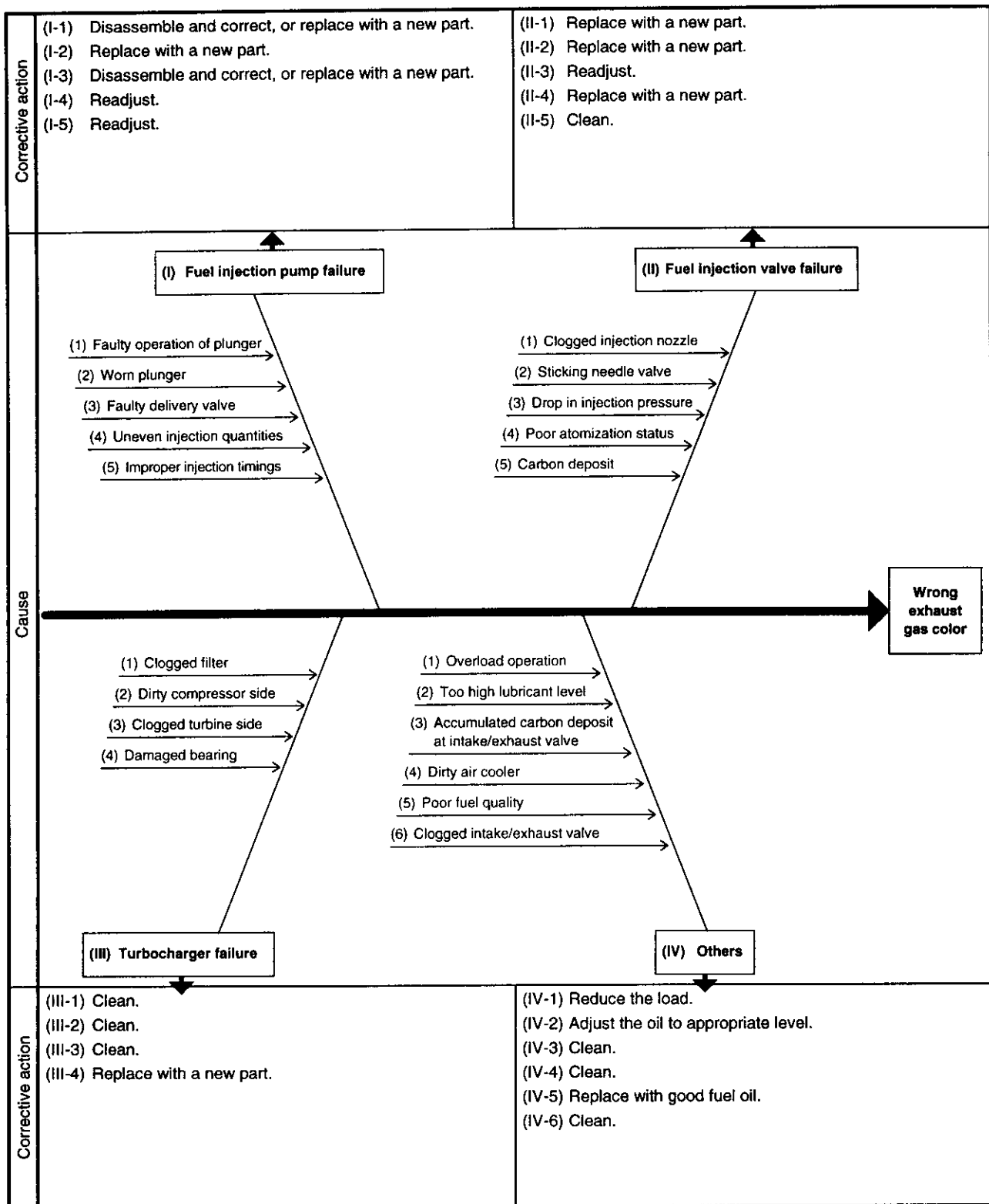
4.2 Unsmooth Running



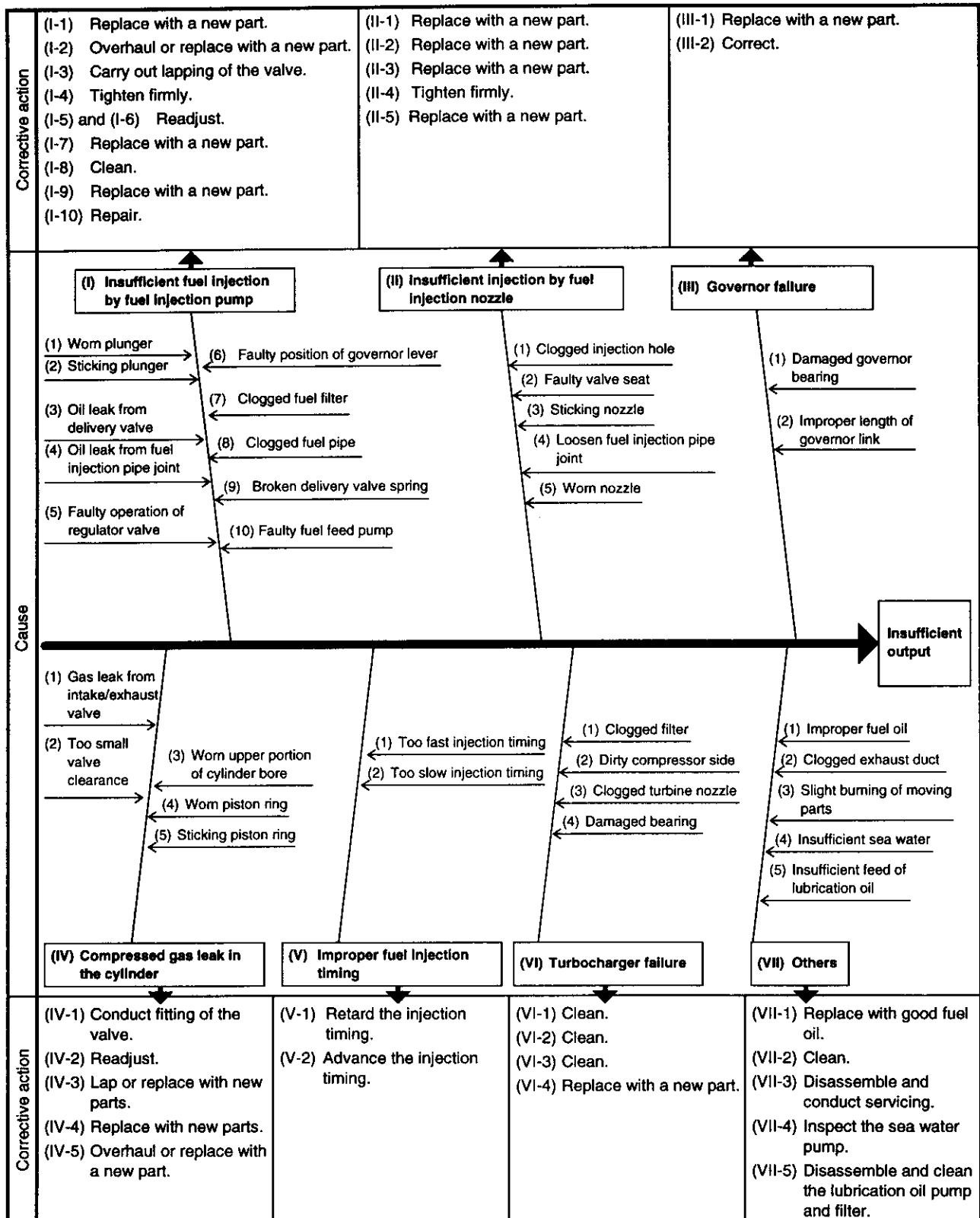
4.3 Sudden Engine Stop



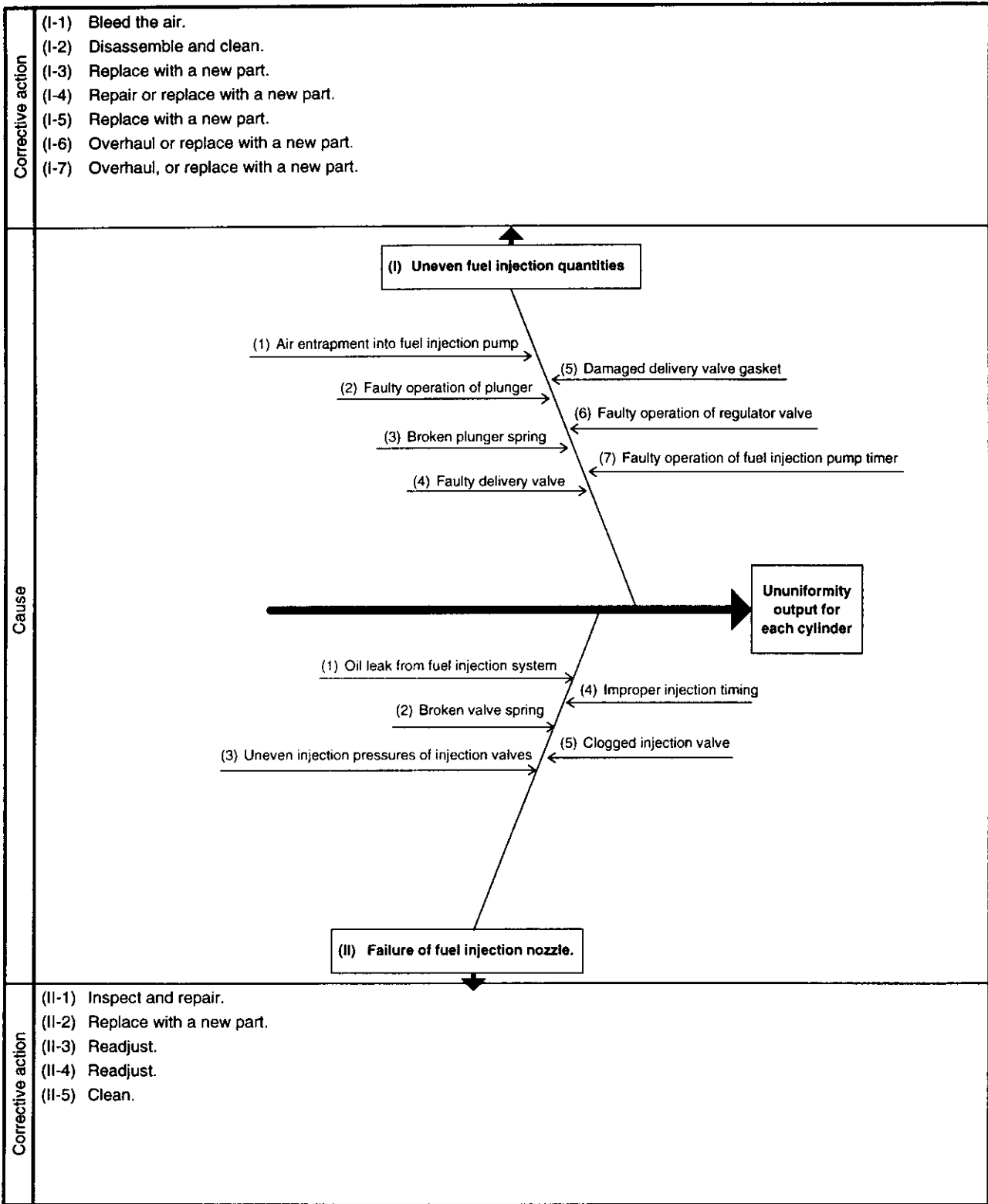
4.4 Poor Exhaust Gas Color



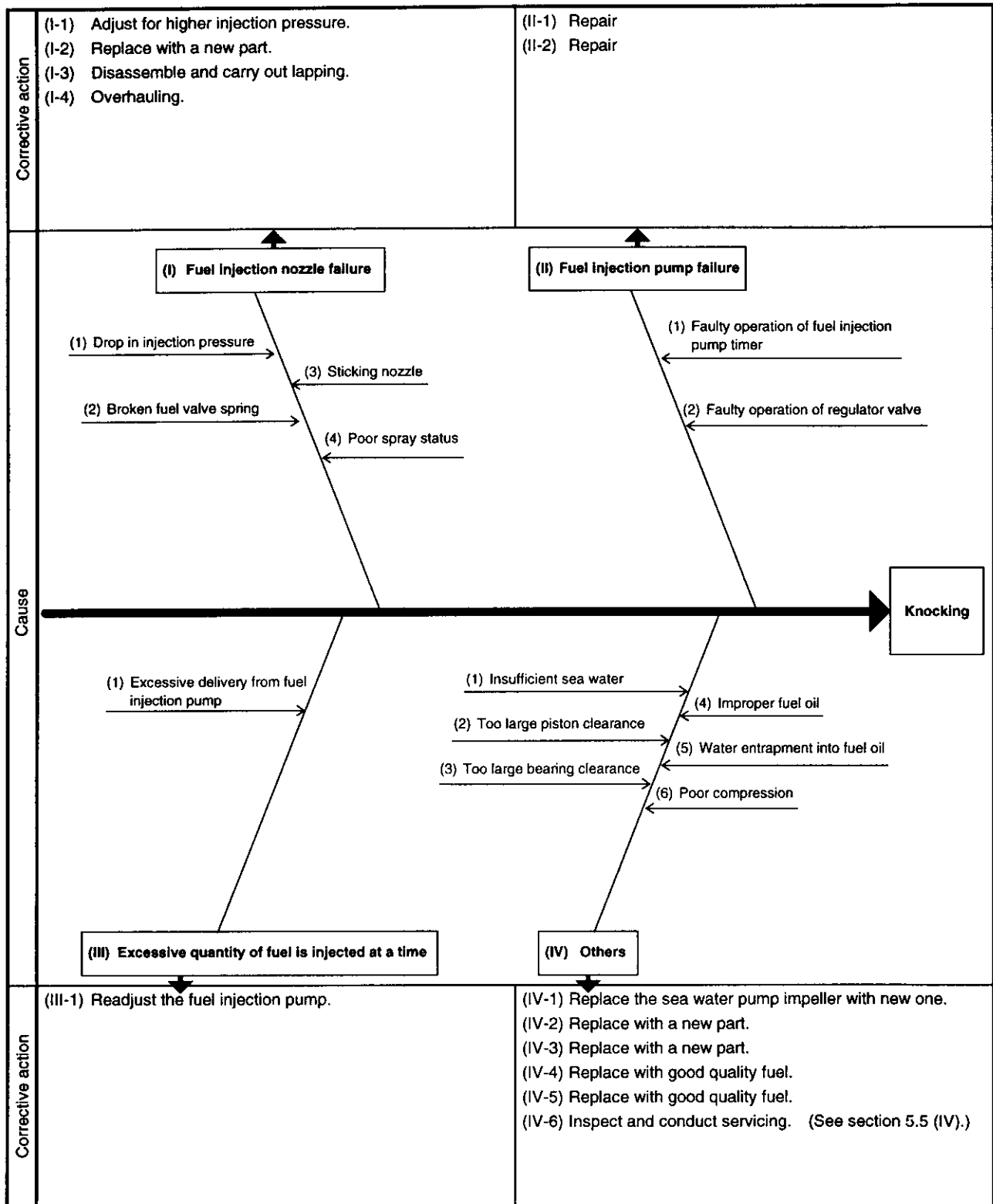
4.5 Insufficient Output



4.6 Ununiformity Output for Each Cylinder



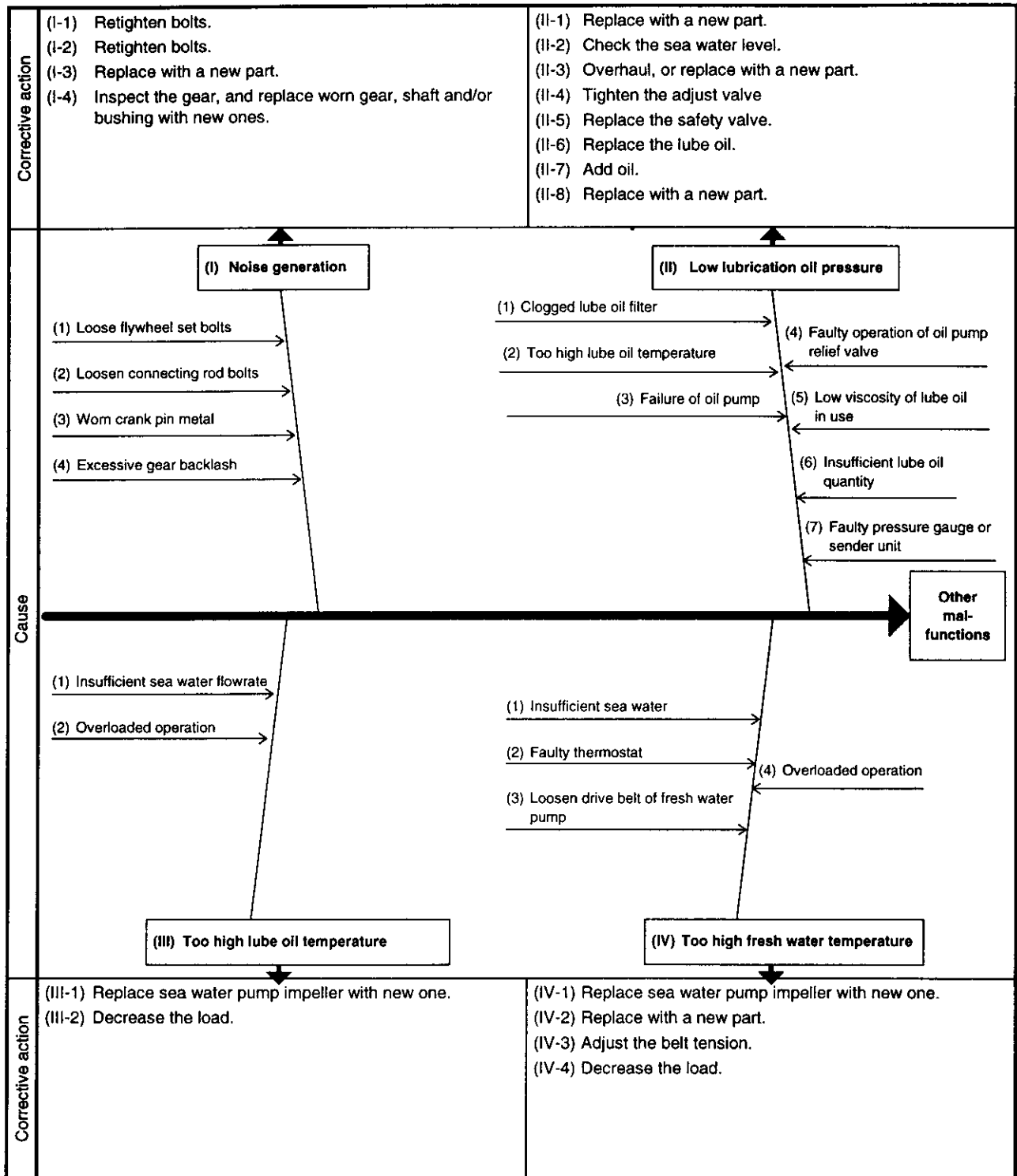
4.7 Knocking



4.8 Trouble Related to Turbocharger

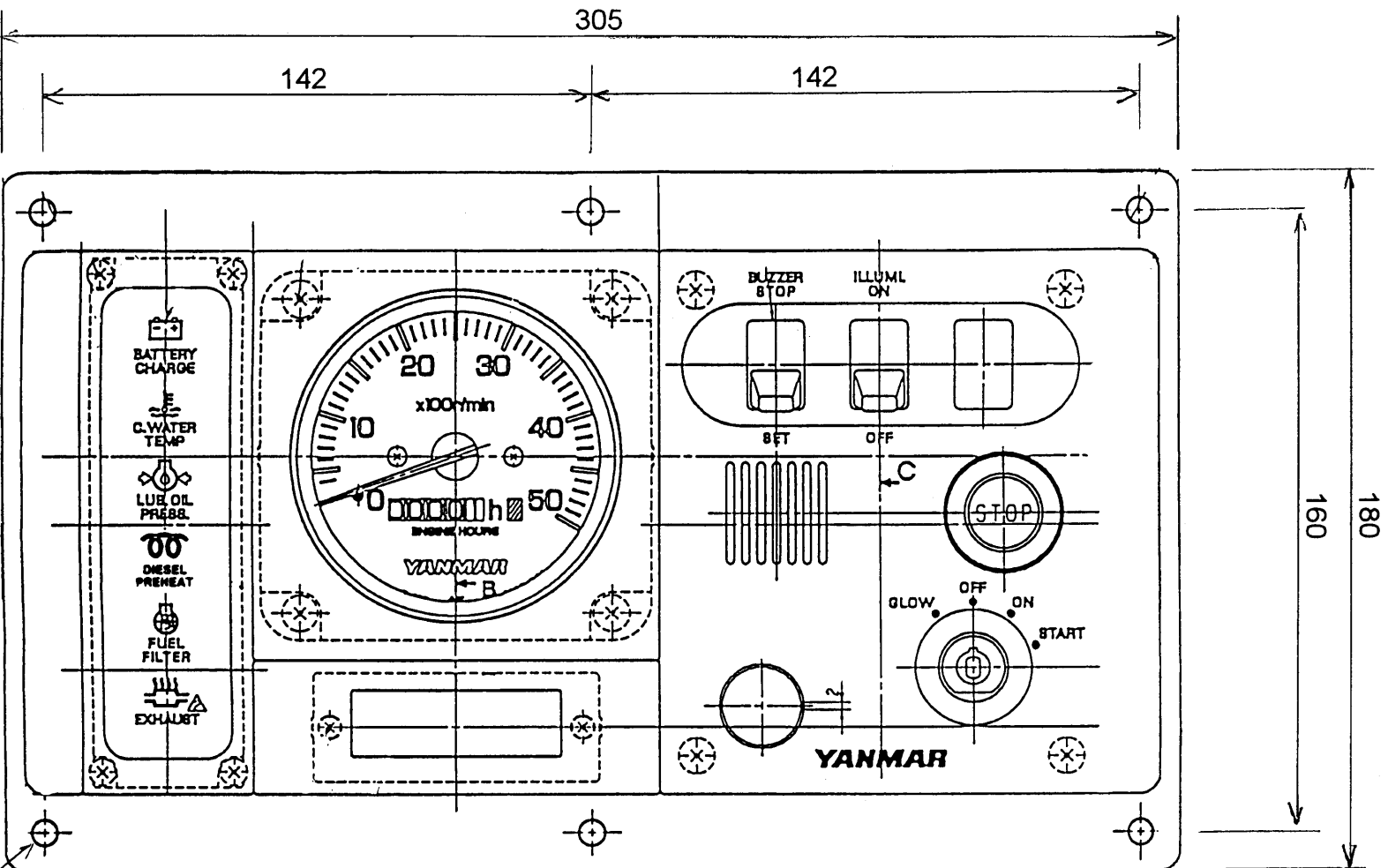
Corrective action	(I-1) Clean. (I-2) Clean. (I-3) Repair. (I-4) Repair. (I-5) (a) Make thermal insulation of exhaust pipe complete. (b) Intake the air from outside the combustion chamber. (c) Clean air cooler (I-6) Open the door or provide atmosphere intake duct. (I-7, 8 and 9) Replace. (I-10, 11 and 12) Clean. (I-13) Clean or change the piping. (I-14) Replace.	(II-1) Carry out remount of T/C. (II-2) (a) Inspect and adjust the injection timing. (b) Overhaul the injection pump, and repair or replace faulty parts. (c) Disassemble and inspect the injection valve, and repair or replace faulty parts. (II-3) Replace. (II-4) Clean. (II-5) Reduce the load. (II-6) Replace.	(III-1) Replace. (III-2) Replace. (III-3) Remove and repair or replace. (III-4) Replace. (III-5) Replace. (III-6) Tighten.	
Cause	<div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">(I) Drop in intake pressure</div> (1) Dirty filter (2) Dirty guide vane at outlet of compressor (3) Leak from intake piping (4) Leak of exhaust gas (5) High intake air temperature (6) Drop in air pressure in engine room (7) Broken seal ring (8) Broken turbine impeller (9) Broken nozzle ring (10) Dirty turbine impeller (11) Clogged nozzle (12) Clogged exhaust pipe (13) Too high back pressure (14) Wrong reading of pressure gage	<div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">(II) Increased intake pressure</div> (1) Exhaust gas leak (2) Failure in fuel injection system (3) Deformed turbine nozzle (4) Dirty turbine side (5) Increase in load (over loading) (6) Wrong reading of pressure gage	<div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">(III) Abnormal vibration</div> (1) Broken turbine impeller (2) Broken compressor impeller (3) Deposit of oxides on turbine (4) Broken bearing (5) Bent turbine shaft (6) Loose fixed parts	
Cause	<div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">(IV) Noise</div> (1) Damaged bearing (2) Contact by revolving parts (3) Dirty or carbon deposit on turbine and compressor (4) Entrapment of foreign matter (at turbine entrance) (5) Rapid change in load (surging)	<div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">(V) Quick contamination of lubrication oil</div> (1) Gas entrapment into bearing housing (2) Clogged seal air path (3) Damaged seal ring (4) Clogged pressure balance path	<div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">(VI) Pulsation of intake air pressure</div> (1) Uneven cylinder combustion (2) Rapid change in load (3) Excessively dirty compressor side (4) Too high intake air temperature	<div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">(VII) Others</div> (1) Bearing seizure (2) Water leak from exhaust opening (3) Corrosion in compressor/turbine impeller or bearing housing
Corrective action	(IV-1) Replace. (IV-2) Repair or replace. (IV-3) Clean. (IV-4) Repair or replace. (IV-5) Stabilize the load or replace turbine nozzle.	(V-1) Repair. (V-2) Clean. (V-3) Replace. (V-4) Clean.	(VI-1) Adjust for uniform combustion. (VI-2) Operate correctly. (VI-3) Clean. (VI-4) (a) Clean cooling fin. (b) Make thermal insulation of exhaust pipe complete. (c) Intake the air from outside of engine room.	(VII-1) Replace. (VII-2) Replace. (VII-3) Increase the coolant temperature.

4.9 Other Malfunctions



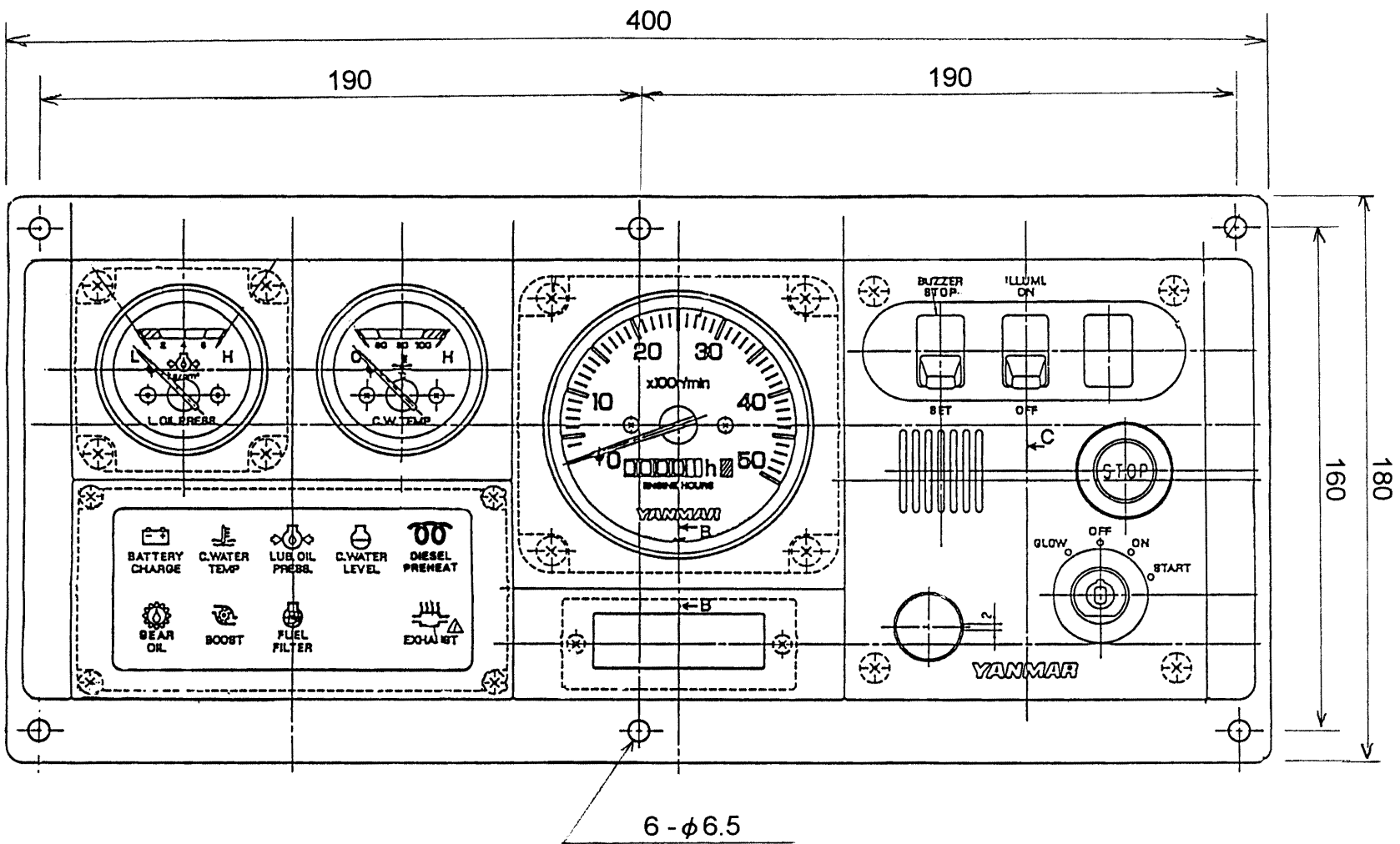
5. Instrument Panel (Optional)

- B-type Panel (119773-91131)

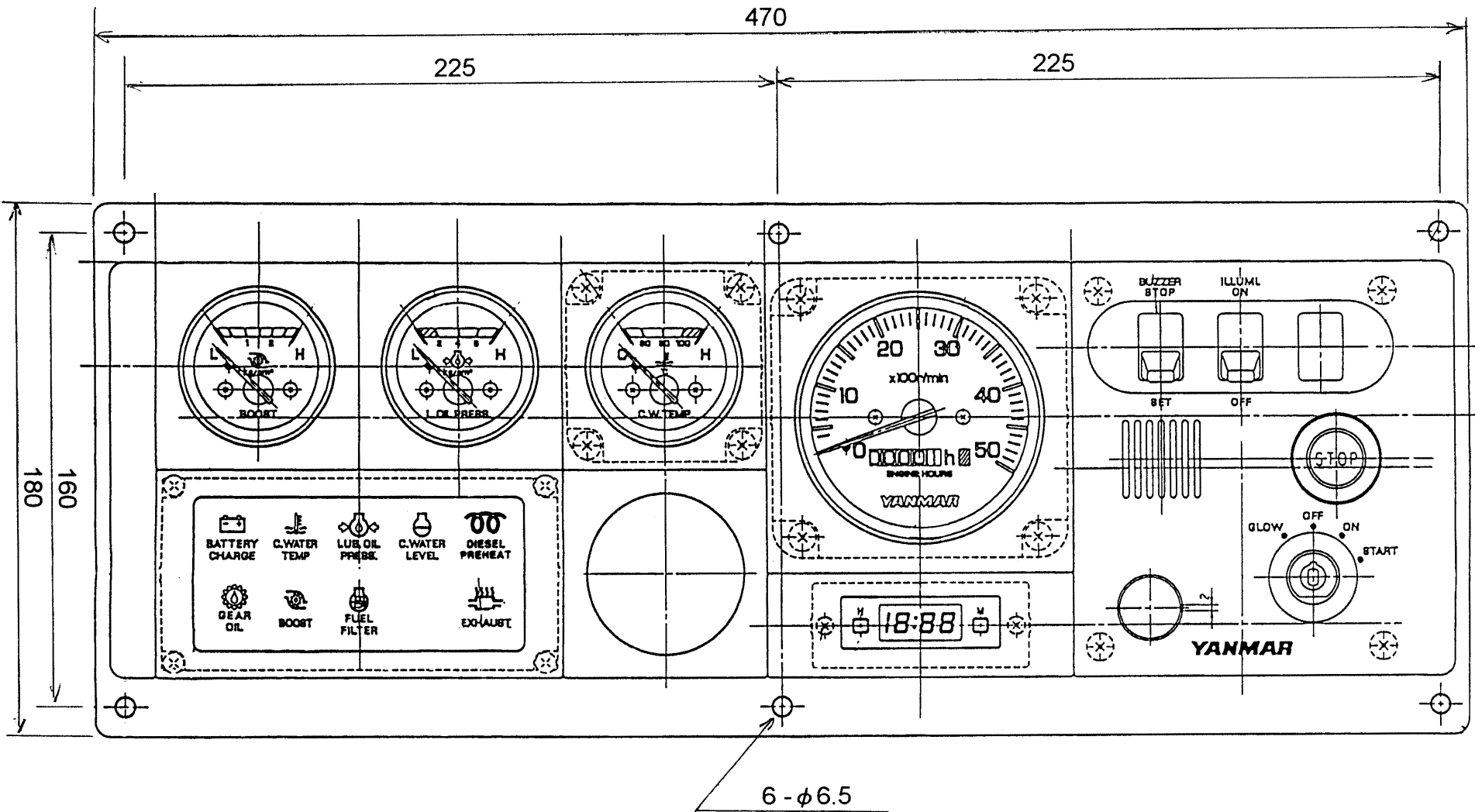


6-φ6.5

• C-type Panel (119773-91162)



• D-type Panel (119773-91192)



6. Electric Wiring Diagram

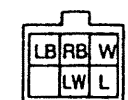
• For B-type Instrument Panel

Engine Harness

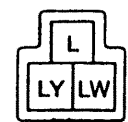
R	Red
B	Black
W	White
L	Blue
RB	Red / Black
LB	Blue / Black
YW	Yellow / White
YB	Yellow / Black
YG	Yellow / Green
WL	White / Blue
WB	White / Black
WR(RW)	White / Red (Red / White)
WG(GW)	White / Green (Green / White)
GB	Green / Black
YR	Yellow / Red
GR(RG)	Green / Red (Red / Green)
O	Orange
BrW	Brown / White
WBr	White / Brown
LW	Blue / White
Y	Yellow

Starter Switch

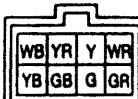
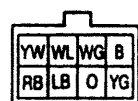
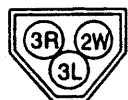
	30	AC	17	G1	G2	P1	P2	AR
GLOW	○			○		○	○	
OFF	○							○
ON	○	○						○
START	○	○	○					○



Details of coupler-D

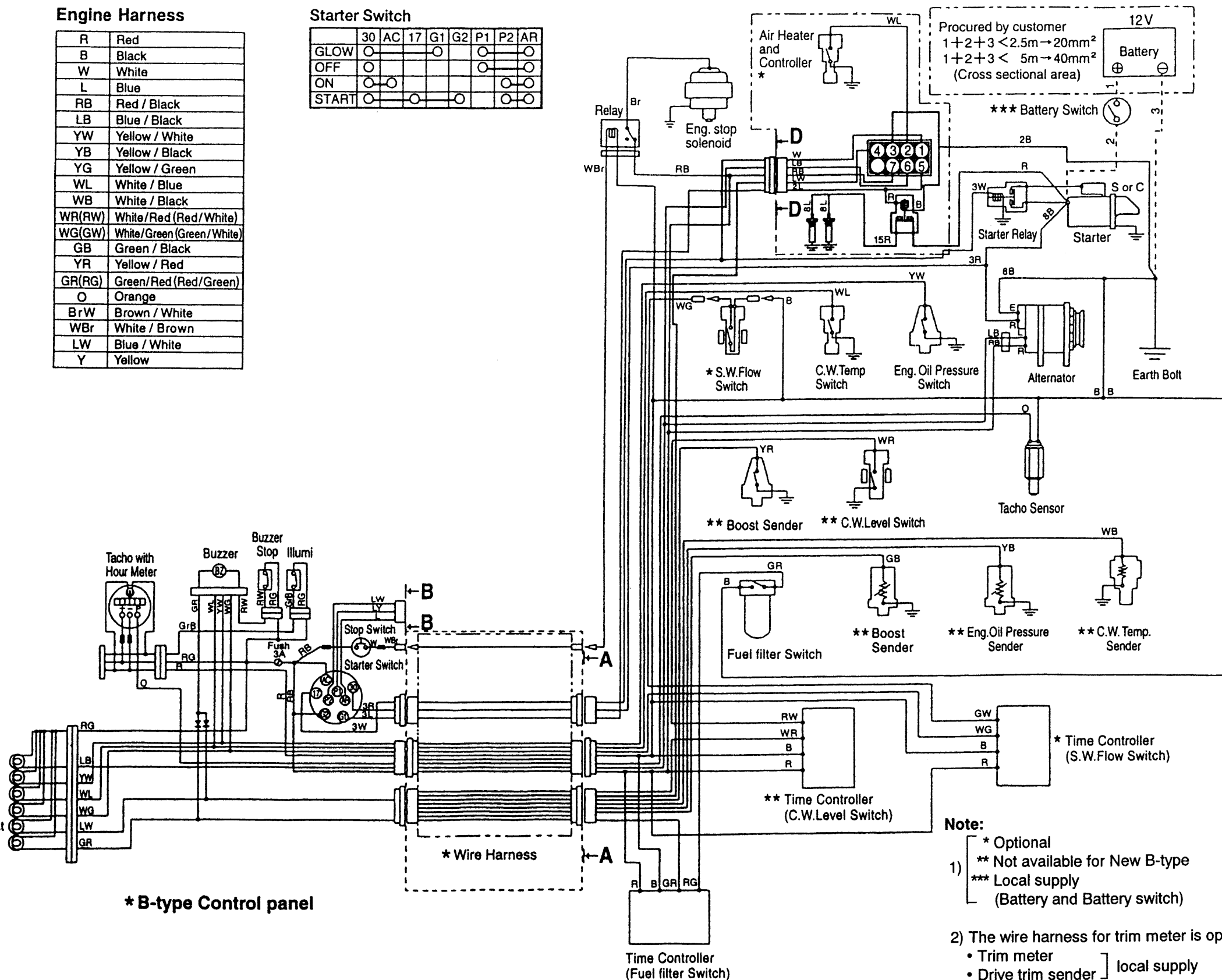


Details of coupler-B



Details of coupler-A

- Charge
- Eng. Oil P.
- C.W. Temp.
- Exhaust
- Diesel Preheat
- Fuel Filter

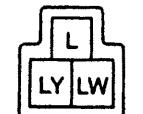
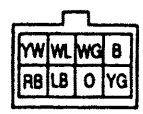
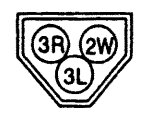
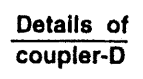
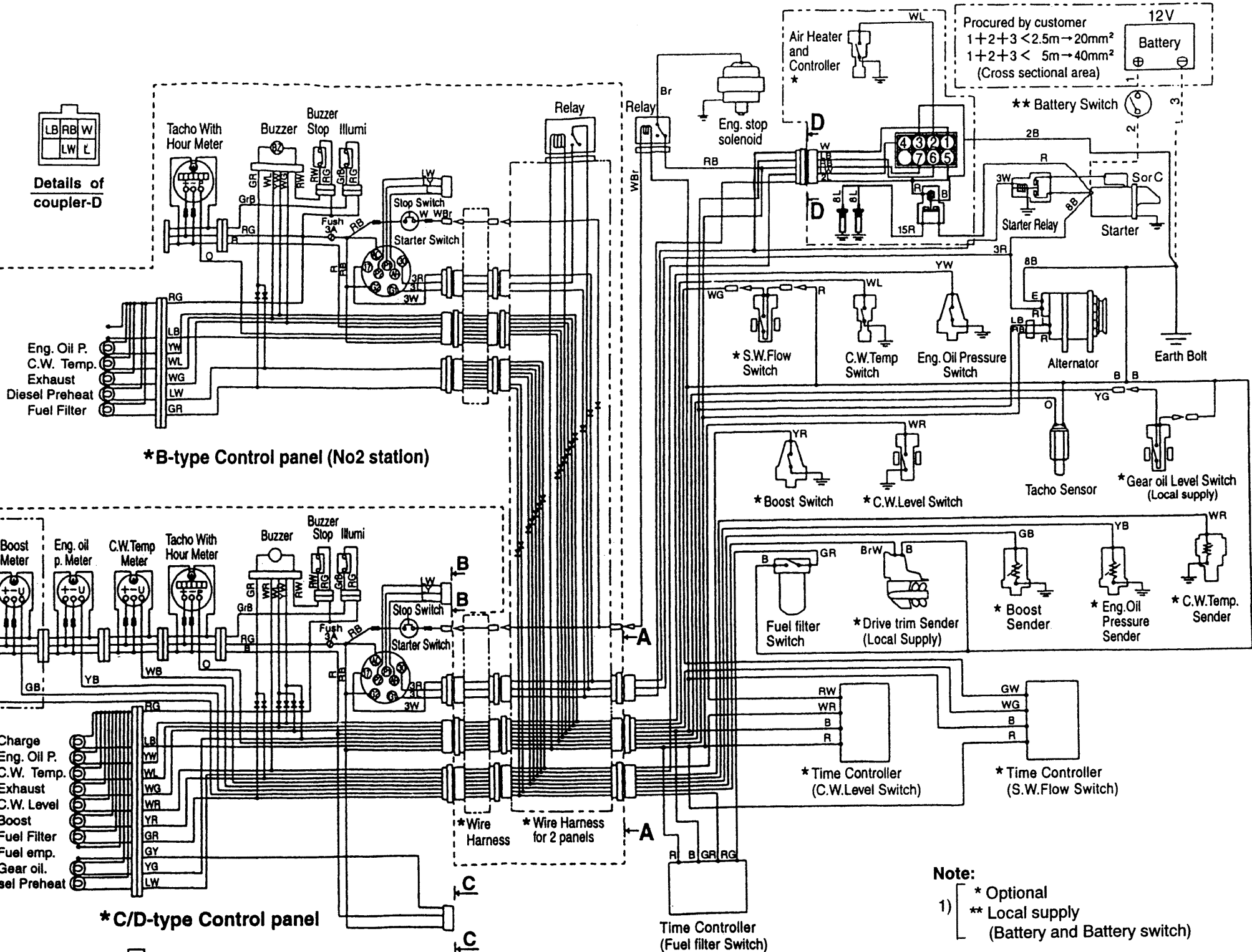


- Note:**
- * Optional
 - ** Not available for New B-type
 - *** Local supply (Battery and Battery switch)
- 1) [* Optional
** Not available for New B-type
*** Local supply (Battery and Battery switch)]
- 2) The wire harness for trim meter is optional
- Trim meter
 - Drive trim sender] local supply

• For C/D-type x B-type Instrument Panel

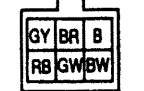
Engine Harness

R	Red
B	Black
W	White
L	Blue
RB	Red / Black
LB	Blue / Black
YW	Yellow / White
YB	Yellow / Black
YG	Yellow / Green
WL	White / Blue
WB	White / Black
WR(RW)	White/Red (Red/White)
WG(GW)	White/Green (Green/White)
GB	Green / Black
YR	Yellow / Red
GR(RG)	Green/Red (Red/Green)
O	Orange
BrW	Brown / White
WBr	White / Brown
LW	Blue / White
Y	Yellow



Starter Switch

	30	AC	17	G1	G2	P1	P2	AR
GLOW	○	○	○	○	○	○	○	○
OFF	○	○	○	○	○	○	○	○
ON	○	○	○	○	○	○	○	○
START	○	○	○	○	○	○	○	○



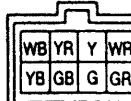
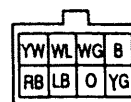
Note:

- * Optional
 ** Local supply (Battery and Battery switch)
- The wire harness for trim meter is optional
 - Trim meter
 - Drive trim sender
 local supply

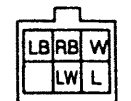
• For C/D-type x C-type Instrument Panel

Engine Harness

R	Red
B	Black
W	White
L	Blue
RB	Red / Black
LB	Blue / Black
YW	Yellow / White
YB	Yellow / Black
YG	Yellow / Green
WL	White / Blue
WB	White / Black
WR(RW)	White / Red (Red / White)
WG(GW)	White / Green (Green / White)
GB	Green / Black
YR	Yellow / Red
GR(RG)	Green / Red (Red / Green)
O	Orange
BrW	Brown / White
WBr	White / Brown
LW	Blue / White
Y	Yellow



Details of coupler-A



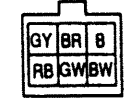
Details of coupler-D



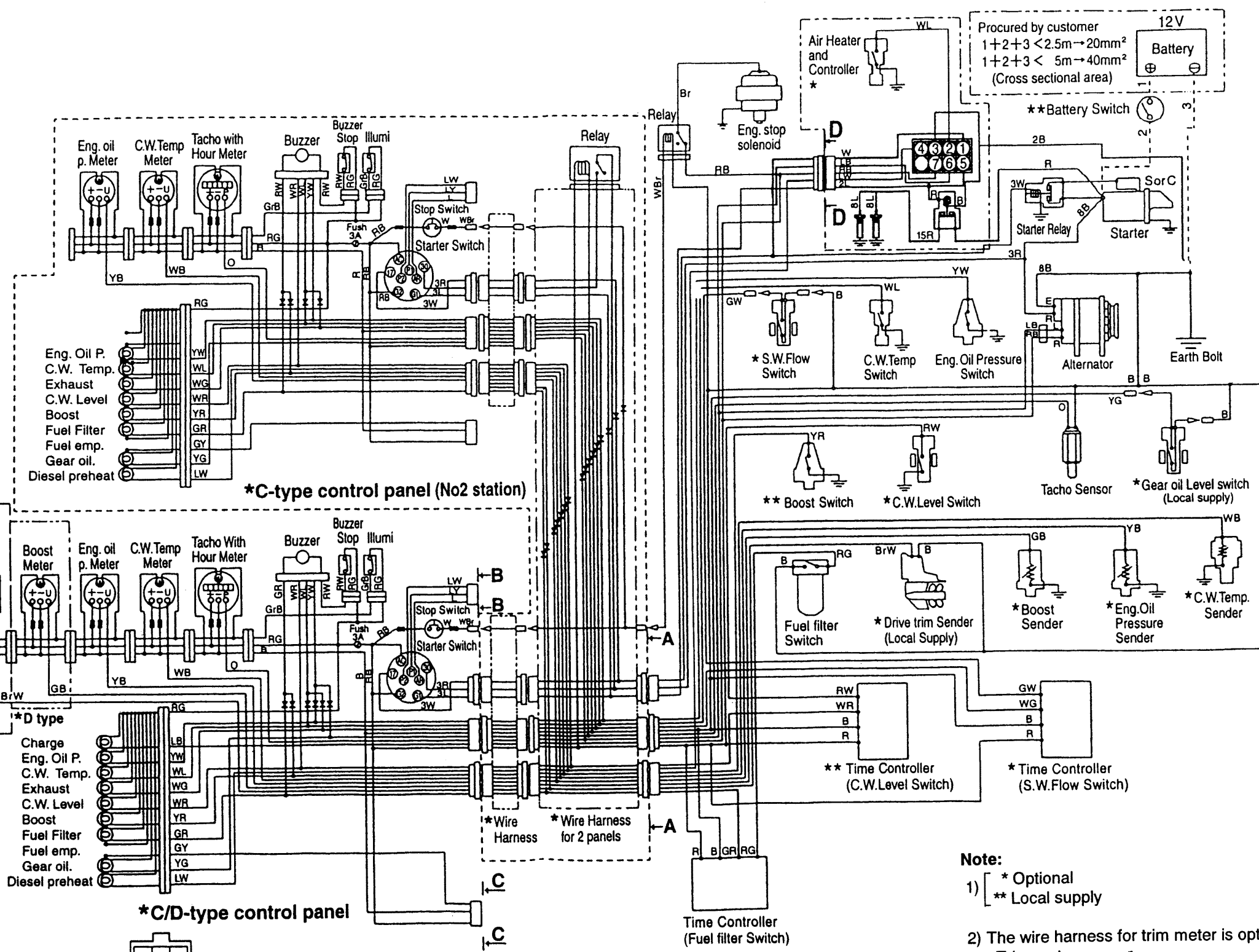
Details of coupler-B

Starter Switch

	30	AC	17	G1	G2	P1	P2	AR
GLOW	○	○	○	○	○	○	○	○
OFF	○	○	○	○	○	○	○	○
ON	○	○	○	○	○	○	○	○
START	○	○	○	○	○	○	○	○



Details of coupler-C


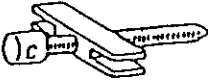




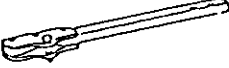
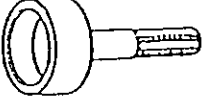
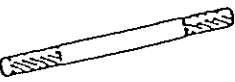


Note:

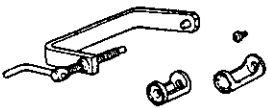
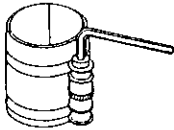
- 1) [* Optional
** Local supply
- 2) The wire harness for trim meter is optional
 - Trim meter
 - Drive trim sender] local supply

7. Special Tools (To be continued)

7.1 Special Tools

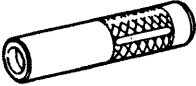
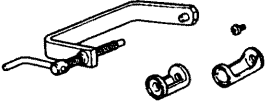
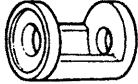
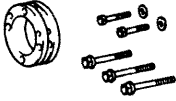






NO.	P/N	NAME		DESCRIPTION
1	119770-01060 (09032-00110)	SEAL CUTTER		FOR REMOVING OILPAN
2	119770-01070 (09213-00020)	PULLER		FOR REMOVING CRANKSHAFT PULLEY
3	119770-01080 (09213-36020)	REMOVER		FOR REMOVING DRIVE GEAR, OIL PUMP FOR REMOVING TIMING GEAR
4	119770-01090 (09213-58012)	TOOL		FOR SETTLING CRANKSHAFT PULLEY
5	119770-01100 (09223-78010)	REPLACER		FOR REPLACING THE ENGINE FRONT OIL SEAL
6	119770-01110 (09248-64011)	TOOL, VALVE		FOR ADJUSTING THE VALVE CLEARANCE (ONLY FOR 6LP-DTE, DTZE)
7	119770-01120 (09330-00021)	TOOL		FOR SETTLING CRANKSHAFT PULLEY
8	119770-01130 (09223-56010)	REPLACER, OIL SEAL		FOR REPLACING THE ENGINE REAR OIL SEAL
9	119770-01140 (09213-00030)	HANDLE		FOR REMOVING CRANKSHAFT PULLEY

7. Special Tools

NO.	P/N	NAME		DESCRIPTION
10	119770-02000 (09202-70020)	COMPRESSOR VALVE SPRING		FOR REMOVING VALVE SPRING (6LP-STE SERIES ONLY)
11	95550-002476	PISTON INSERTION		FOR COMPRESSING PISTON RING

(TOYOTA P/N)





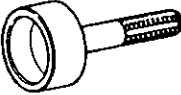

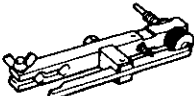

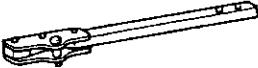

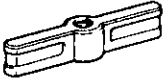
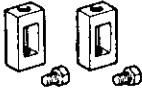


7.2 Special Tools (Local Supply)

	09201-41020	Valve Stem Oil Seal Replacer	
	09202-70020 ※ 119770-02000 09202-43013	Valve Spring Compressor (6LP-DTE series)	
	(09202-00010)	Attachment	
	09213-58012 ※ 119770-01090	Crankshaft Pulley Holding Tool	
	(90201-08131)	Washer	
	(91111-50845)	Bolt	
	09214-60010	Crankshaft Pulley & Gear Replacer	Crankshaft pulley
	09214-76011	Injection pump drive gear oil seal	Injection pump drive gear bearing Injection pump drive gear oil seal
	09222-17010	Connecting Rod Bushing Remover & Replacer	
	(09222-05020)	Remover & Replacer	

※: YANMAR P/N, Others: TOYOTA P/N


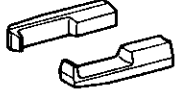
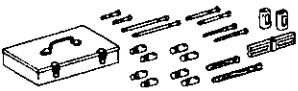
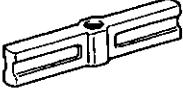
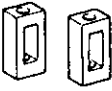


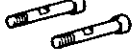






7. Special Tools

Special Tools (Local Supply)

	(09222-05030) Guide	
	(09222-05040) Base	
	09223-00010 Cover & Seal Replacer	Crankshaft timing gear Oil pump drive shaft gear
	09223-46011 Crankshaft Front Oil Seal Replacer	Camshaft oil seal
	09223-56010 Crankshaft Rear Oil Seal Replacer ※ 119770-01130	
	09223-78010 Crankshaft Oil Seal Replacer ※ 119770-01100	Crankshaft front oil seal
	09275-54011 Plunger Stroke Measuring Tool	
	09308-10010 Oil Seal Puller	Crankshaft front oil seal
	09330-00021 Companion Flange Holding Tool ※ 119770-01120	Crankshaft pulley
	09950-40010 Puller B Set	
	(09951-04010) Hanger 150	No.1 camshaft timing pulley Oil pump drive shaft gear Crankshaft timing gear Injection pump drive gear bearing
	(09952-04010) Slide Arm	No.1 camshaft timing pulley Oil pump drive shaft gear Crankshaft timing gear Injection pump drive gear bearing
	(09953-04010) Center Bolt 100	Oil pump drive shaft gear Crankshaft timing gear
	(09953-04020) Center Bolt 150	No.1 camshaft timing pulley Oil pump drive shaft gear Crankshaft timing gear Injection pump drive gear bearing

※: YANMAR P/N, Others: TOYOTA P/N



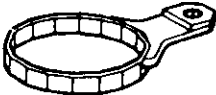



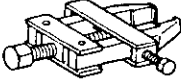

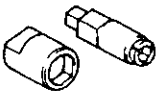
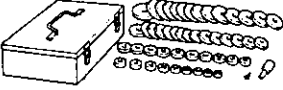


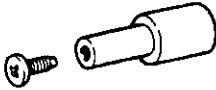
Special Tools (Local Supply)

	(09954-04010)	Arm 25	No.1 camshaft timing pulley Oil pump drive shaft gear Crankshaft timing gear Injection pump drive gear bearing
	(09955-04060)	Claw No.6	No.1 camshaft timing pulley Oil pump drive shaft gear Crankshaft timing gear Injection pump drive gear bearing
	09950-50010	Puller C Set	
	(09951-05010)	Hanger 150	Crankshaft pulley Injection pump drive gear
	(09952-05010)	Slide Arm	Crankshaft pulley Injection pump drive gear
	(09953-05010)	Center Bolt 100	Crankshaft pulley Injection pump drive gear
	(09953-05020)	Center Bolt 150	Crankshaft pulley
	(09954-05020)	Claw No.2	Crankshaft pulley Injection pump drive gear
	09950-70010	Handle Set	
	(09951-07100)	Handle 100	Valve guide bushing
	09960-10010	Variable Pin Wrench Set	
	(09962-01000)	Variable Pin Wrench Arm Assy	Injection pump drive gear
	(09963-00700)	Pin 7	Injection pump drive gear
	09992-00024	Cylinder Compression Check Gauge Set	

TOYOTA P/N














7. Special Tools

Special Tools (Local Supply)

	09032-00100 ※ 119770-01060	Oil pan Seal Cutter	
	09228-10002	Oil Filter Wrench	
	09228-64010	Fuel Filter Wrench	
	09236-00101	Water Pump Overhaul Tool Set	
	09285-76010	Injection Pump Camshaft Bearing Cone Replacer	Rotor rear bearing cover
	09286-46011	Injection Pump Spline Shaft Puller	Rectifier end frame
	09820-00021	Alternator Rear Bearing Puller	
	09820-00030	Alternator Rear Bearing Replacer	
	09820-63010	Alternator Pulley Set Nut Wrench Set	
	09950-60010	Replacer Set	Rotor front bearing
	(09951-00260)	Replacer 26	
	(09951-00500)	Replacer 50	
	(09952-06010)	Adapter	

※: YANMAR P/N, Others: TOYOTA P/N




Special Tools (Local Supply)

	(09992-00211) Gauge Assy	
	09992-00400 Attachment No.7	Cylinder compression check
	(09237-00070) Shaft "C"	Governor sleeve plug
	09241-76022 Injection Pump Stand Set	
	09245-54010 Injection Pump Stand Arm	
	09260-54012 Injection Pump Tool Set	
	(09262-54010) Distributor Head Plug Wrench	
	(09269-54020) Socket 14 mm	
	(09269-54030) Tweezers	
	(09269-54040) Governor Lever Support Bolt Wrench	
	(09262-54020) Regulator Valve Wrench	
	09268-17010 2 Spring Nozzle Tool set	
	(09957-04010) Attachment	Injection pump

TOYOTA P/N

7. Special Tools

7.3 Recommended Tools (Local Supply)

	09082-00050	TOYOTA Electrical Tester Set.	
	09200-00010	Engine Adjust Kit.	
	09258-00030	Hose Plug Set.	Plug for fuel hose

TOYOTA P/N

7.4 Equipment (Local supply)

Caliper gauge	
Connecting rod aligner	
Cylinder gauge	
Dial indicator	
Dye penetrant	
Engine tune-up tester	
Heater	
Micrometer	
Piston ring expander	
Plastigage	
Precision straight edge	
Soft brush	
Spring tester	Valve spring
Steel square	Valve spring

7. Special Tools

Thermometer	
Torque wrench	
Valve seat cutter	
V-block	
Vernier calipers	

For starter

Dial indicator	Commutator
Magnetic finger	
Pull scale	Brush spring
Sandpaper	Commutator
Torque wrench	
V-block	
Vernier calipers	Commutator, Brush

For lube oil pump

Oil pressure gauge	
Precision straight edge	
Torque wrench	

For fuel system

Angle gauge	
Brass brush	
Dial indicator with magnetic base	
Graduated cylinder	
Injection nozzle tester	

7. Special Tools

	For fuel system
Injection pump tester	
Inner pressure gauge	
Micrometer	
Steel square	
Timer measuring device	
Torque wrench	
Vernier calipers	
Wooden stick	

7.5 Service Special Materials (Local Supply)

08826-00080	Seal Packing Black or equivalent (FIPG)	Timing belt cover Timing gear cover Camshaft oil seal retainer Cylinder head semi-circular plug
08826-00080	Seal Packing Black or equivalent (FIPG)	Cylinder head cover Main bearing cover Rear oil seal retainer
08826-00100	Seal Packing 1282B, THREE BOND 1282B or equivalent (FIPG)	Water temperature sender gauge
08826-00080	Seal Packing Black or equivalent (FIPG)	Oil pump Oil pan
08833-00070	Adhesive 1344, THREE BOND 1344, LOCTITE 242 or equivalent	Oil pressure sender gauge Taper screw plug on timing gear case

TOYOTA P/N

FIPG: Formed In Placed Gasket.

7.6 Other Service Materials for Reference

Items		Usual Contents	Features and application
Liquid gasket	Three Bond No.1 TB1101	200 g (1 kg also available)	Non-drying liquid gasket; solventless type, easy to remove, superior in seawater resistance, applicable to various mating surfaces.
	Three Bond No.2 TB1102	200 g (1 kg also available)	Non-drying liquid gasket; easy to apply, superior in water resistance and oil resistance, especially superior in gasoline resistance.
	Three Bond No.3 TB1103	150 g	Drying film, low viscosity and forming of thin film, appropriate for mating surface of precision parts.
	Three Bond No.4 TB1104	200 g (1 kg also available)	Semi-drying viscoelastic material, applicable to non-flat surface having many indentations and protrusions, superior in heat resistance, water resistance, and oil resistance.
	Three Bond No.10 TB1211	100 g	Solventless type silicone-base sealant, applicable to high temperature areas. (-50°C to 250)
	Three Bond TB1212	100 g	Silicone-base, non-fluid type, thick application possible.
Adhesive	Loctite TB1401	200 g	Prevention of loose bolts, gas leakage, and corrosion. Torque required to loosen bolt: 10 to 20 % larger than tightening torque.
	Loctite SUPER TB1330B	50 g	Excellent adhesive strength locks bolt semipermanently.
Seal Tape		5 m round tape	Sealing material for threaded parts of various pipes. Ambient temperature range: -150°C to 200°C
O-ring kit		ϕ 1.92-m dia.:1 ϕ 2.42-m dia.:1 ϕ 3.12-m dia.:1 ϕ 3.52-m dia.:1 ϕ 5.72-m dia.:1	O-ring of any size can be prepared, whenever required. (Including adhesive, release agent, cutter, and jig)
EP lubricant (molybdenum disulfate)	Brand name (LOWCOL PASTE)	50 g	For assembly of engine cylinders, pistons, metals, shafts, etc. Spray type facilitates application work.
	Brand name (PASTE SPRAY)	330 g	
	Brand name (MOLYPASTE)	50 g	Prevention of seizure of threaded parts at high temperature. Applicable to intake and exhaust valves. (stem, guide, face)

Cautions:

It is recommended that the liquid gasket of Three Bond TB1212 should be used for service work. Before providing service, observe the cautions below:

- (1) Build up each gasket equally.
- (2) For a bolt hole, apply liquid gasket to the inside surface of the hole.
- (3) Conventionally, Three Bond TB1104 (gray) or Three Bond TB1102 (yellow) is used for paper packings though the use of only these bonds is not effective.
- (4) If conventional packings are used, do not use a liquid packing.

YANMAR MARINE DIESEL ENGINE

**MODEL 6LP-DTE/DTZE/DTZE1,
6LPA-DTP/DTZP,
6LP-STE/STZE/STZE1,
6LPA-STP/STZP**

SERVICE MANUAL

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