



HINSHI-H10-001-1

**SERVICE MANUAL**

**MARINE DIESEL ENGINE**

**6LP Series**

6LP-DT (Z) E (1)

6LP-ST (Z) E (1)

---

2000. 3. 13

---

# **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.**

Publication No.	HINSHI-H10-001-1
-----------------	------------------

<b>History of Revision</b>				Page No.	1
----------------------------	--	--	--	----------	---

Manual Name	Yanmar Service Manual for Marine Diesel Engine				
-------------	--	--	--	--	--

Engine Model:	6LP-DTE/DTZE/DTZE1, 6LP-STE/STZE/STZE1				
---------------	--	--	--	--	--

Number of revision	Date of revision	Reason for correction	Outline of correction	Correction item No.(page)	Corrected by
--------------------	------------------	-----------------------	-----------------------	---------------------------	--------------

- |   |                     |            |   |  |  |
|---|---------------------|------------|---|--|--|
| ● | New edition         | July 1998  |   |  |  |
| ● | 1st revised edition | April 1999 | (Publication No. HINSHI-H10-001-1)<br>6LP-DTZE1, 6LP-STZE1 (less power steering oil pump) added |  |  |


# FOREWORD

*This manual describes the service procedures for the 6LP 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.*



These products have been developed, designed, and manufactured in the facilities certified by the Standards for Quality Systems of ISO 9001

The contents of this service manual may not be copied or reproduced without permission.

# CONTENTS

<b>1. For Safe Operation</b> .....	1-1
<b>1.1 Warning Symbols</b> .....	1-1
<b>1.2 Precautions for Safe Servicing</b> .....	1-2
<b>1.3 Location for Product Safety Labels</b> .....	1-6
<b>2. General</b> .....	2-1
<b>2.1 Specifications</b> .....	2-1
<b>2.2 External Views</b> .....	2-2
<b>2.3 Piping Diagram</b> .....	2-4
<b>2.4 Performance Curves</b> .....	2-6
<b>2.5 Front Power Take-Off (PTO) Output</b> .....	2-8
<b>2.6 Fuel Oil</b> .....	2-10
<b>2.7 Lube Oil</b> .....	2-11
<b>2.8 Cooling Water</b> .....	2-11
<b>2.9 Location of Senders and Warning Switches</b> .....	2-12
<b>3. Engine Overhaul</b> .....	3-1
<b>3.1 Cylinder Head</b> .....	3-1
<b>3.1.1 Components</b> .....	3-1
<b>3.1.2 Removal of Cylinder Head</b> .....	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

<b>3.1.3</b>	<b>Disassembly of Cylinder Head</b> .....	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
<b>3.1.4</b>	<b>Inspection and Servicing of Cylinder Head Components</b> .....	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
<b>3.1.5</b>	<b>Replacement of Oil Seal for Camshaft</b> .....	3-16
<b>3.1.6</b>	<b>Assembly of Cylinder Head</b> .....	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
<b>3.1.7</b>	<b>Installation of Cylinder Head</b> .....	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
<b>3.2</b>	<b>Cylinder Block</b> .....	3-25
<b>3.2.1</b>	<b>Components</b> .....	3-25
<b>3.2.2</b>	<b>Preparation for Disassembly</b> .....	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
<b>3.2.3</b>	<b>Disassembly of Cylinder Block .....</b>	<b>3-27</b>
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
<b>3.2.4</b>	<b>Inspection of Cylinder Block .....</b>	<b>3-32</b>
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
<b>3.2.5</b>	<b>Disassembly of Piston and Connecting Rod.....</b>	<b>3-34</b>
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
<b>3.2.6</b>	<b>Inspection of Piston and Connecting Rod.....</b>	<b>3-35</b>
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
<b>3.2.7</b>	<b>Inspection and Servicing of Crankshaft .....</b>	<b>3-39</b>
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
<b>3.2.8</b>	<b>Replacement of Oil Seal for Crankshaft .....</b>	<b>3-40</b>
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
<b>3.2.9</b>	<b>Assembly of Piston and Connecting Rod.....</b>	<b>3-40</b>
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

<b>3.2.10</b>	<b>Assembly of Cylinder Block</b> .....	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
<b>3.2.11</b>	<b>Next Assembly</b> .....	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
<b>3.3</b>	<b>Timing Belt</b> .....	3-48
<b>3.3.1</b>	<b>Components</b> .....	3-48
<b>3.3.2</b>	<b>Removal of Timing Belt</b> .....	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
<b>3.3.3</b>	<b>Checking of Timing Belt</b> .....	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



<b>3.3.4</b>	<b>Installation of Timing Belt.....</b>	<b>3-53</b>
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
<b>3.4</b>	<b>Timing Gear .....</b>	<b>3-57</b>
<b>3.4.1</b>	<b>Components .....</b>	<b>3-57</b>
<b>3.4.2</b>	<b>Removal of Timing Gear .....</b>	<b>3-58</b>
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
<b>3.4.3</b>	<b>Inspection of Timing Gear .....</b>	<b>3-60</b>
3.4.3.1	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
<b>3.4.4</b>	<b>Replacement of Crankshaft Front Oil Seal .....</b>	<b>3-61</b>
3.4.4.1	Replace the crankshaft front oil seal .....	3-61
<b>3.4.5</b>	<b>Replacement of Fuel Injection Pump Drive Gear Oil Seal .....</b>	<b>3-62</b>
3.4.5.1	Replace the fuel injection pump drive gear oil seal .....	3-62
<b>3.4.6</b>	<b>Installation of Timing Gear .....</b>	<b>3-63</b>
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
<b>3.5</b>	<b>Valve Clearance Inspection and Adjustment .....</b>	<b>3-66</b>
<b>3.5.1</b>	<b>Inspection of Valve Clearance.....</b>	<b>3-66</b>
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
<b>3.5.2</b>	<b>Adjustment of Valve Clearance .....</b>	<b>3-67</b>
3.5.2.1	Adjust the valve clearance .....	3-67
3.5.2.2	Install the bonnet .....	3-68
<b>3.6</b>	<b>Inspection and Adjustment of Injection Timing.....</b>	<b>3-69</b>
<b>3.6.1</b>	<b>Inspection of Injection Timing.....</b>	<b>3-69</b>
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
<b>3.6.2</b>	<b>Adjustment of Injection Timing.....</b>	<b>3-70</b>
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
<b>3.7</b>	<b>Service Specifications .....</b>	<b>3-71</b>
<b>3.7.1</b>	<b>Engine Adjusting Standards.....</b>	<b>3-71</b>
<b>3.7.2</b>	<b>Service Standards .....</b>	<b>3-72</b>
<b>3.7.3</b>	<b>Nut and Bolt Tightening Torque.....</b>	<b>3-75</b>
<b>3.8</b>	<b>Turbocharger .....</b>	<b>3-76</b>
<b>3.8.1</b>	<b>Construction and Function.....</b>	<b>3-76</b>
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
<b>3.8.2</b>	<b>Components (RHE6W Turbocharger) .....</b>	<b>3-78</b>
<b>3.8.3</b>	<b>Service Specifications .....</b>	<b>3-79</b>
3.8.3.1	Service standards .....	3-79
3.8.3.2	Nut and bolt tightening torque.....	3-80
<b>3.8.4</b>	<b>Periodic Inspection Procedure.....</b>	<b>3-81</b>
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

<b>3.8.5</b>	<b>Disassembly Procedure</b> .....	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
<b>3.8.6</b>	<b>Cleaning and Checking Procedures</b> .....	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
<b>3.8.7</b>	<b>Reassembly Procedure</b> .....	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

<b>3.8.8</b>	<b>Handling after Disassembly and Reassembly</b> .....	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
<b>3.8.9</b>	<b>Troubleshooting</b> .....	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
<b>3.9</b>	<b>Fuel Filter Replacement</b> .....	3-98
<b>3.9.1</b>	<b>Removal of Fuel Filter</b> .....	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
<b>3.9.2</b>	<b>Installation of Fuel Filter</b> .....	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
<b>3.10</b>	<b>Fuel Injection Nozzle</b> .....	3-99
<b>3.10.1</b>	<b>Components</b> .....	3-99
<b>3.10.2</b>	<b>Removal of Fuel Injection Nozzle</b> .....	3-100
<b>3.10.3</b>	<b>Testing the Fuel Injection Nozzle</b> .....	3-102
3.10.3.1	Leak test.....	3-102
3.10.3.2	Testing the spray condition .....	3-102
<b>3.10.4</b>	<b>Components of Fuel Injection Nozzle</b> .....	3-103
<b>3.10.5</b>	<b>Disassembly of Fuel Injection Nozzle</b> .....	3-104
3.10.5.1	Disassemble the fuel injection nozzle .....	3-104
<b>3.10.6</b>	<b>Cleaning and Inspection of Fuel Injection Nozzle</b> .....	3-104
3.10.6.1	Cleaning the nozzle .....	3-104
3.10.6.2	Inspection of nozzle assembly .....	3-105
<b>3.10.7</b>	<b>Adjustment of Fuel Injection Nozzle</b> .....	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
<b>3.10.8</b>	<b>Checking No.2 Opening Pressure</b> .....	3-112

<b>3.10.9</b>	<b>Adjusting No.1 Opening Pressure</b> .....	3-114
<b>3.10.10</b>	<b>Installation of Fuel Injection Nozzle</b> .....	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
<b>3.11</b>	<b>Fuel Injection Pump</b> .....	3-118
<b>3.11.1</b>	<b>Removal of Fuel Injection Pump</b> .....	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
<b>3.11.2</b>	<b>Components</b> .....	3-121
<b>3.11.3</b>	<b>Installation of Fuel Injection Pump</b> .....	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
<b>3.12</b>	<b>Fuel System Service Specifications</b> .....	3-125
<b>3.12.1</b>	<b>Service Standards</b> .....	3-125
<b>3.12.2</b>	<b>Nut and Bolt Tightening Torque</b> .....	3-126
<b>3.12.3</b>	<b>Specifications of Fuel Injection Pump</b> .....	3-127
<b>3.13</b>	<b>Fresh Water Pump</b> .....	3-129
<b>3.13.1</b>	<b>Removal of Fresh Water Pump</b> .....	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
<b>3.13.2</b>	<b>Inspection of Fresh Water Pump</b> .....	3-130
3.13.2.1	Check the fresh water pump.....	3-130

<b>3.13.3</b>	<b>Installation of Fresh Water Pump</b> .....	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
<b>3.14</b>	<b>Sea Water Pump</b> .....	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
<b>3.15</b>	<b>Thermostat</b> .....	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
<b>3.16</b>	<b>Components Related to Cooling System</b> .....	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
<b>3.17</b>	<b>Lubrication</b> .....	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
<b>3.17.2</b>	<b>Replacement of Lube Oil and Oil Filter</b> .....	<b>3-139</b>
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
<b>3.18</b>	<b>Oil Pump</b> .....	<b>3-140</b>
<b>3.18.1</b>	<b>Removal of Oil Pump</b> .....	<b>3-141</b>
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
<b>3.18.2</b>	<b>Disassembly of Oil Pump</b> .....	<b>3-142</b>
3.18.2.1	Remove the driven rotor .....	3-142
3.18.2.2	Remove the relief valve. ....	3-142
<b>3.18.3</b>	<b>Inspection of Oil Pump</b> .....	<b>3-142</b>
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
<b>3.18.4</b>	<b>Reassembly of Oil Pump</b> .....	<b>3-143</b>
3.18.4.1	Install the relief valve .....	3-143
3.18.4.2	Install the drive and driven rotors.....	3-143
<b>3.18.5</b>	<b>Installation of Oil Pump</b> .....	<b>3-143</b>
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
<b>3.19</b>	<b>Oil Cooler (Cooling by Fresh Water)</b> .....	<b>3-146</b>
<b>3.19.1</b>	<b>Removal of Oil Cooler</b> .....	<b>3-147</b>
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
<b>3.19.2</b>	<b>Inspection of Oil Cooler and Relief Valve.....</b>	<b>3-147</b>
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
<b>3.19.3</b>	<b>Installation of Oil Cooler.....</b>	<b>3-148</b>
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
<b>3.20</b>	<b>Piston Cooling Oil Nozzle.....</b>	<b>3-150</b>
<b>3.20.1</b>	<b>Disassembly of Oil Nozzle.....</b>	<b>3-150</b>
3.20.1.1	Remove the oil pan.....	3-150
3.20.1.2	Remove the check valve and oil nozzle.....	3-150
<b>3.20.2</b>	<b>Inspection of Oil Nozzle.....</b>	<b>3-150</b>
3.20.2.1	Check the check valve.....	3-150
3.20.2.2	Inspect the oil nozzle.....	3-151
<b>3.20.3</b>	<b>Installation of Oil Nozzle.....</b>	<b>3-151</b>
3.20.3.1	Install the oil nozzle and check valve.....	3-151
3.20.3.2	Install the oil pan.....	3-151
<b>3.21</b>	<b>Service Specifications.....</b>	<b>3-151</b>
<b>3.21.1</b>	<b>Service Standards.....</b>	<b>3-151</b>
<b>3.21.2</b>	<b>Nut and bolt tightening torque.....</b>	<b>3-151</b>
<b>3.22</b>	<b>Starter.....</b>	<b>3-152</b>
<b>3.22.1</b>	<b>Components.....</b>	<b>3-152</b>



<b>3.22.2 Disassembly of Starter</b> .....	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
<b>3.22.3 Inspection and Repair of Starter</b> .....	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
<b>3.22.4</b>	<b>Service Standard</b> .....	<b>3-163</b>
<b>3.23</b>	<b>Charging System</b> .....	<b>3-164</b>
<b>3.23.1</b>	<b>Preparation and Inspection</b> .....	<b>3-164</b>
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
<b>3.23.2</b>	<b>Alternator</b> .....	<b>3-166</b>
<b>3.23.3</b>	<b>Disassembly of Alternator</b> .....	<b>3-166</b>
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
<b>3.23.4</b>	<b>Inspection and Repair of Alternator</b> .....	<b>3-169</b>
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
<b>3.23.5</b>	<b>Reassembly of Alternator</b> .....	<b>3-172</b>
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
<b>4.</b>	<b>Troubleshooting</b> .....	<b>4-1</b>
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
<b>5.</b>	<b>Instrument Panel (Optional)</b> .....	<b>5-1</b>
<b>6.</b>	<b>Electric Wiring Diagram</b> .....	<b>6-1</b>
<b>7.</b>	<b>Tools</b> .....	<b>7-1</b>
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.