

SERVICE MANUAL

MITSUBISHI DIESEL ENGINE

L3E

for KOBELCO CONSTRUCTION MACHINERY CO.,LTD.

August 2006



INTRODUCTION

This service manual describes the specifications, maintenance and service procedures for Mitsubishi Diesel Engine.

To maintain the performance of the engine for many years and to ensure safe operation, it is important to use the engine correctly and conduct regular inspection and maintenance, and also to take necessary measures which involves the disassembly, inspection, repair and reassembly of the engine and engine parts.

Read this manual carefully and understand the work procedures fully before disassembling, inspecting, repairing or reassembling the engine.

The contents of the manual are based on the engine models that are being produced at the time of publication. Due to improvements made thereafter, the actual engine that you work on may differ partially from the one described in this manual.

How to use this manual

This service manual consists of several Groups, which are arranged so as to allow you to make reference quickly to specifications, maintenance standards, adjustment procedures and service procedures including methods for disassembly, inspection, repair and reassembly of the Mitsubishi Diesel Engine (standard model for land use).

A short summary describing the content of each Group is given in the General Contents page, and there is also a detailed table of contents at the beginning of each Group.

Regarding the procedures for operation and periodical maintenance of the engine, refer to the Operation and Maintenance Manual. For information on the engine components and ordering of service parts, refer to the Parts Catalogue. Structure and function of the engine are described in the relevant training manuals.

Methods of presentation

- (1) Index numbers allotted to parts in exploded views are not only a call-out of part names listed in the text but also an indication of the sequence of disassembly.
- (2) Inspections to be conducted during disassembly process are indicated in boxes in the relevant exploded views.
- (3) Maintenance standards required for inspection and repair works are indicated in the appropriate positions in the text. They are also collectively indicated in Group 2, the General Contents group.
- (4) Fasteners to be tightened in "wet" condition, or with engine oil applied, are identified by [Wet] placed after tightening torque values. If no such indication is suffixed, the fastener should be tightened in "dry" condition, or without lubricating with engine oil.
- (5) In this manual, important safety or other cautionary instructions are emphasized with the following marks headed.



Indicates an immediately hazardous situation which, if not avoided, will result in death or serious injury.



Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.



Indicates an immediately hazardous situation which, if not avoided, may result in minor or moderate injury.



Indicates a potentially hazardous situation which, if not avoided, can result in property damage.

Note:

Indicates important information or information useful for operation or maintenance of the engine.

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Terms Used in This Manual

Nominal

means the rated (design) size or magnitude of a part to be measured.

Standard

means the quantitative requirement for dimension of a part, clearance between parts and performance. This is given in a form of tolerance. Therefore, the values shown are not in agreement with the design values.

Limit

means that, if this value is reached, the part must be repaired or replaced with a new part.

Abbreviations

- BTDC: Before Top Dead Center
- ATDC: After Top Dead Center
- BBDC: Before Bottom Dead Center
- ABDC: After Bottom Dead Center
- TIR: Total Indicated Runout
- API: American Petroleum Institute
- ASTM: American Society for Testing and Materials
- JIS: Japanese Industrial Standards
- LLC: Long Life Coolant
- MIL: Military Specifications and Standards (U.S.)
- MSDS: Material Safety Data Sheet
- SAE: Society of Automotive Engineers (U.S.)

Units of Measurement

Measurements are based on the International System of Units (SI), and their converted metric values are indicated in parentheses {}. For metric conversion, the following rates are used.

- Pressure: 1 MPa = 10.197 kgf/cm²
- Torque: 1 N·m = 0.10197 kgf·m
- Force: 1 N = 0.10197 kgf
- Horsepower: 1 kW = 1.341 HP = 1.3596 PS
- Meter of mercury: 1 kPa = 0.7 cmHg
- Meter of water: 1 kPa = 10.197 cmH₂O (cmAq)
- Rotational speed: 1min⁻¹ = 1 rpm

Safety Cautions

 **WARNING**

Fire and explosion

Keep flames away

Store fuel and engine oil in a well-ventilated designated area.

Make sure that the caps of fuel and engine oil containers are tightly closed.

Do not use flames, do not smoke, or do not work near heater or other fire hazards where fuel or oil is handled or when cleaning solvent is being used for washing parts.

Wipe off spilled fuel, oil and LLC immediately and thoroughly. Spilled fuel, oil and LLC may ignite and cause a fire.



Keep surrounding area neat and clean

Do not leave combustible or explosive materials, such as fuel, engine oil and LLC, near the engine. Such substances can cause fire or explosion.

Remove dust, dirt and other foreign materials accumulated on the engine and surrounding parts thoroughly. Such materials can cause fire or the engine to overheat. In particular, clean the top surface of the battery thoroughly. Dust can cause a short-circuit.

Always operate the engine at a position at least 1 m [3.28 ft.] away from buildings and other equipment to prevent possible fire caused by engine heat.

Care about fuel, oil and exhaust gas leakage

If any fuel, oil or exhaust gas leakage is found, immediately take corrective measures to stop it.

Such leakages, if left uncorrected, can cause fuel or engine oil to reach hot engine surfaces or hot exhaust gas to contact flammable materials, possibly leading to personal injury and/or damage to equipment.

Use explosion-proof lighting apparatus

When inspecting fuel, engine oil, coolant, battery electrolyte, etc., use a flameproof light. An ordinary light, if it accidentally broken, may ignite and cause an explosion.

Prevent electrical wires from short-circuiting

Avoid inspecting or servicing the electrical system with the ground cable connected to the battery. Otherwise, a fire could result from short-circuiting. Be sure to disconnect the battery cable from the negative (-) terminal before beginning with the work procedure.

Short-circuits, possibly resulting in fire, may be caused by a loose terminal or damaged cable/wire. Inspect the terminals, cables and wires, and repair or replace the faulty parts before beginning with the service procedure.

Keep fire extinguishers and first-aid kit handy

Keep a fire extinguisher handy and be familiarized with their usage.

Keep a first-aid kit at a designated place, and make sure it is easily accessible whenever needed.

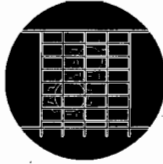
Establish emergency procedures to follow in the event of fire or accident, and keep the personnel informed of emergency contact locations and contact methods.



Stay clear of all rotating and moving parts

Install protective covers on rotating parts

Make sure the protective covers for engine rotating parts are properly installed as intended. Repair loose or damaged protective covers as necessary.



Never remove the covers guarding personnel from rotating parts, such as the camshaft covers and rocker covers, when the engine is operating.

When combining the engine with the engine-driven machine or radiator, always provide a cover on every exposed moving part such as driving belt and coupling.

Never remove protective covers.

Ensure safety of neighboring people before starting engine

Before starting the engine, ensure that there is nobody in the neighborhood and no tools are left on or near the engine. Be sure to give a sign with a shout when starting the engine.

When a tag saying "Do not operate" is attached on or near the starter switch, never start the engine.

Stay clear of moving parts during engine running

Do not approach rotating or sliding parts of the engine when the engine is in operation.

Keep objects likely to be caught by rotating parts away from such parts. If any part of the clothing or outfitting is caught by a rotating part, serious bodily injuries could result.



Lockout and Tagout

Be sure to lockout and tagout before starting inspection and maintenance.

Lockout and tagout are effective methods of cutting off machines and equipment from energy sources.

To accomplish the lockout/tagout, remove the starter switch key, set the battery switch to OFF and attach a "Do Not Run" or similar caution tag to the starter switch. The starter switch key must be kept by the person who performs inspection and maintenance during the work. In the case of pneumatic starting type, close the main valve of the air tank and post a tag saying "Do Not Open the Valve" or the like.

Keep engine stopped during servicing

Be sure to stop the engine before proceeding to inspection and service procedure. Never attempt to make adjustments on the engine parts while the engine is running. Rotating parts such as belt can entangle your body and cause serious injuries.

Always restore engine turning tools after use

Do not forget to remove the tools which have been used for turning the engine during inspection or servicing, after the procedure is finished. Remember also that the turning gear must be returned to the operating condition before starting the engine.

Starting the engine with the turning tools inserted or with the turning gear in engagement can lead to not only engine damage but also personal injuries.

WARNING

Be careful of burns

Do not touch engine during or immediately after operation

Do not touch the engine during or immediately after operation to avoid risk of burns.

To conduct maintenance and inspection work, wait until the engine has cooled sufficiently, checking the temperature gauge.



Slowly and carefully open radiator cap

Never attempt to open the radiator cap while the engine is running or immediately after the engine stops. Give a sufficient cooling time to the engine coolant before opening the cap.

When opening the radiator cap, slowly turn the cap to release internal pressure. To prevent scalds with steam gushing out, wear thick rubber gloves or cover the cap with a cloth.

Close the radiator cap tightly without fail.

The coolant is very hot and under pressure during engine running or just after the engine stops. If the radiator cap is not closed tightly, steam and hot coolant may gush out and can cause scalds.

Add coolant only after coolant temperature dropped

Do not add coolant immediately after the engine stops. Wait until the coolant temperature lowers sufficiently to avoid a risk of burns.

Never remove heat shields

The exhaust system, which becomes extremely hot while the engine is operating, is provided with various heat shields. Do not remove these heat shields. If any of these heat shields have been removed owing to unavoidable circumstances during the work, be sure to re-store them after the work is completed.

WARNING

Protect ears from noises

Wear ear plugs

Always wear ear plugs when entering the machine room (engine room). Combustion sound and mechanical noise generated by the engine can cause hearing problems.



⚠ WARNING

Be careful of falling down

Lift engine correctly

For lifting the engine, always use a correct wire rope capable of withstanding the engine weight.

Also, attach the wire rope to the correct lifting hangers originally fitted on the engine using a correct sling.

During lifting process, keep the engine in a well-balanced position by taking the center of gravity of the engine into consideration.

During lifting process, keep the engine in a well-balanced position by taking the center of gravity of the engine into consideration.

If the wire rope contacts the engine directly, place a cloth or other soft padding between them to prevent damage to the engine and wire rope.

Do not get on engine

Do not get on top of the engine, nor step on any engine parts located on the lateral sides.

To work on parts located on the upper section of engine, use a ladder, stool, etc., firmly secured not to fall down.

Falling down of such footholds could result in not only to damage of the engine parts but also personal injuries.



⚠ CAUTION

Be careful of handling fuel, engine oil and LLC

Use only specified gas engine oil and coolant (LLC)

Use fuel, oil and LLC specified in this manual, and handle them carefully.

Use of any other fuel, oil or LLC, and improper handling may cause various engine problems and malfunctions. Obtain the MSDSs issued by the fuel, oil and LLC suppliers, and follow the directions in the MSDSs for proper handling.

Handle LLC (long life coolant) carefully

When handling LLC, always wear rubber gloves and protective face mask. If LLC or cooling water containing LLC comes into contact with your skin or eyes, or if it is swallowed, you would suffer from inflammation, irritation or poisoning.

Should LLC be accidentally swallowed, induce vomiting immediately and seek medical attention. Should LLC enter your eyes, flush them immediately with plenty of water and seek medical attention. If LLC splashes onto your skin or clothing, wash it away immediately with plenty of water.

Keep flames away from LLC. The LLC can catch flames, causing a fire.

Drained coolant (containing LLC) is harmful. Do not dispose of it in unauthorized manner. Abide by the applicable law and regulations when discarding drained coolant.

Proper disposal of waste oil and coolant (LLC)

Do not discharge waste engine oil or coolant into sewerage, river, lake or other similar places. Such a way of disposal is strictly prohibited by laws and regulations.

Dispose of waste oil, coolant and other environmentally hazardous waste in accordance with the applicable law and regulations, or consult a Mitsubishi dealer.

CAUTION

Service battery

Handle battery correctly

- Never use flames or allow sparks to generate near the battery. The battery releases flammable hydrogen gas and oxygen gas. Any flames or sparks in the vicinity could cause an explosion.
- Do not use the battery the fluid level of which is lowered below the lower limit line. Sustained use of the battery could result in an explosion.
- Do not short the battery terminals with a tool or other metal object.
- When disconnecting battery cables, always remove the cable from the negative (-) terminal first. When reconnecting the cables, attach the cable to the positive (+) terminal first.
- Charge the battery in a well-ventilated area, with all filling hole plugs removed.
- Make sure the cable clamps are securely installed on the battery terminals. A loose cable clamp can cause sparks that may result in an explosion.
- Before servicing electrical components or conducting electric welding, set the battery switch to the [Open/OFF] position or disconnect the cable from the negative (-) battery terminal to cut off the electrical current.
- Electrolyte (battery fluid) contains dilute sulfuric acid. Careless handling of the battery can lead to the loss of sight and/or skin burns. Also, keep the battery fluid off the mouth.
- Wear protective goggles and rubber gloves when working with the battery (when adding water, charging, etc.).
- If electrolyte is spilled onto the skin or clothing, immediately wash it away with lots of water. Use soap to thoroughly clean.
- The battery fluid can cause blindness if splashing into eyes. If it gets into eyes, immediately flush it away with plenty of clean fresh water, and seek immediate medical attention.
- If the battery fluid is accidentally swallowed, gargle with plenty of water, then drink lots of water, and seek immediate medical attention.



CAUTION

When abnormality occurs

Stop overheated engine after cooling run

Even if the engine comes to overheat, do not stop the engine immediately. Abrupt stopping of an overheated engine can cause the coolant temperature to rise, resulting in seized engine parts. If the engine comes to overheat, run the engine at low idling speed (cooling operation), and stop the engine after the coolant temperature lowers sufficiently.

Do not add coolant immediately after stopping the engine. Adding coolant to a hot engine can cause the cylinder heads to crack due to sudden change in temperature. Add coolant little by little after the engine cools down to room temperature.

Avoid immediate restart after abnormal stop

If the engine stops abnormally, do not restart the engine immediately. If the engine stops with an alarm, check and remedy the cause of the problem before restarting. Sustained use of the engine without any remedy could result in serious engine problems.

Avoid continued engine operation with too low oil pressure

If an abnormal engine oil pressure drop is indicated, stop the engine as immediately as possible, and inspect the lubrication system to locate the cause. Continuing to operate the engine with low oil pressure may cause seizure of the bearings and other parts.

Stop the engine immediately if fan belt is broken

If the fan belt is broken, stop the engine immediately. Continued operation of the engine with the fan belt broken could cause the engine to overheat and thereby the coolant to boil into steam, which may gush out from the reserve tank or radiator, and cause personal injuries.

Other cautions

Modification of engine prohibited

Unauthorized modification of the engine will void the manufacturer's warranty.

Modification of the engine may not only cause engine damage but also produce personal injuries.

Never break seals

To ensure proper engine operation, the fuel control link is provided with seals that protect the fuel injection volume and rotation speed settings against tampering. If these seals are broken and the settings are changed, proper operation of the engine will no longer be guaranteed, and the following problems will be expected to occur.

- Rapid wear of moving and rotating parts
- Engine troubles such as damage and seizure of engine parts
- Increased consumption of fuel and lubricating oil
- Deterioration of engine performance due to poorly balanced fuel injection volume and governor operation

Pre-operational check and periodic inspection/maintenance

Be sure to perform the pre-operational checks and periodic inspection/maintenance as described in this manual.

Neglecting the pre-operational check or periodic inspection/maintenance can arouse various engine troubles such as damage to parts, eventually leading to serious accidents.

Break-in operation

A new engine needs to be broken in for the first 50 hours of operation. During this period, do not subject the engine to heavy loads.

Operating a new engine under high loads or severe conditions during the break-in period can shorten the service life of the engine.

Warming-up operation

After starting the engine, run the engine at low idling speeds for 5 to 10 minutes for warming-up. Start the work after this operation is completed.

Warm-up operation circulates the lubricant through the engine. Therefore, individual engine parts are well lubricated before they are subjected to heavy loads. This is very important for longer service life, high-performance and economical operation.

Do not conduct warm-up operation for a longer time than necessary. Prolonged warm-up operation causes carbon build-up in the cylinders that leads to incomplete combustion.

Avoid engine operations under overload condition

If the engine is considered to be in an overloaded condition which is identified by too much black smoke, etc., immediately reduce the load on the engine such that the correct output and load conditions may be achieved. Overloading the engine causes not only high fuel consumption but also excessive carbon deposits inside the engine. Excessive carbon deposits can cause various engine problems and shorten the service life of the engine remarkably.

Cooling operation before stopping engine

Always conduct the cooling operation (low speed idling) for 5 to 6 minutes before stopping the engine. Abruptly stopping the engine immediately after high-load operation can cause partial overheating and shorten the service life of the engine.

During cooling operation, check the engine for abnormalities.

Protection of engine against water entry

Do not allow rainwater, etc. to enter the engine through the air inlet or exhaust openings.

Do not wash the engine while it is operating. Cleaning fluid (water) can be sucked into the engine.

Starting the engine with water inside the combustion chambers can cause the water hammer action which may result in internal engine damage and serious accidents.

Maintenance of air cleaner or pre-cleaner

The major cause of abnormal wear on engine parts is dust entering with intake air. Worn parts produce many problems such as an increase of oil consumption, decrease of output, and starting difficulties. For effective removal of dust from intake air, conduct maintenance of the air cleaner according to the following instructions.

- Do not conduct maintenance of the air cleaner/pre-cleaner while the engine is operating. Engine operation without the air cleaner/pre-cleaner in place allows foreign matters to enter the turbocharger, causing it to damage seriously.
- Remove the air cleaner/pre-cleaner slowly to prevent dust accumulated on the element from falling off. After removing the air cleaner or pre-cleaner, immediately cover the opening (inlet port in case of air cleaner; port in body in case of pre-cleaner) with plastic sheet or similar means to prevent dust from entering the engine.
- Air cleaners equipped with a dust indicator will issue an alarm if the element gets clogged. Service the cleaner as soon as possible if an alarm is issued.

Safety rules at work site

When operating or servicing the engine, always observe the applicable safety rules established at each work site.

If you are feeling ill, do not operate the machine, but inform the supervisor of your condition.

Unsatisfactory physical condition reduces the concentration. Operation of the machine with reduced concentration may cause operation errors that may result in accidents.

When working in a group, use specified hand signals to communicate among the workers.

Work clothing and protective gear

Wear a hardhat, face shield, safety shoes, dust mask, gloves and other protective gear as needed.

When handling compressed air, wear safety goggles, hardhat, gloves and other necessary protective gear. Works without wearing proper protective gear could result in serious injuries.

Use of tools optimum for each work

Always keep in mind to select most appropriate tools for the work to be performed and use them correctly. If tools are damaged, replace with new tools.

Avoidance of prolonged time of starter operation

Do not operate the starter for more than 10 seconds at a time even if the engine does not start. Wait for at least 30 seconds before next engine cranking.

Continuous operation of the starter will drain the battery power and cause seizing of the starter.

Do not turn off battery switch during operation

If the battery switch is turned OFF when the engine is running, not only various meters will stop working but also the alternator may have its diode and transistor deteriorated.

Cautionary instructions for transporting engine

When transporting the engine on a truck, consider the engine weight, width and height to ensure safety. Abide by road traffic law, road vehicles act, vehicle restriction ordinance and other pertinent laws.

Avoid continuous engine operation under low load conditions

Do not operate the engine continuously for more than 10 minutes with a load of less than 30%. Engine operation under low load conditions increases the emission of unburned fuel. Therefore, a prolonged time of engine operation under low load conditions increases the quantity of unburned fuel adhering to engine parts, provoking the possibility of engine malfunctioning and shortening the service life of the engine.

Ventilation of engine room

Always keep the engine room well-ventilated. Insufficient amount of intake air causes the operating temperature to rise, resulting in poor output and lowered performance.

It is highly recommended to calculate the required amount of air supply to the engine and install an adequate ventilation system before putting the engine to use.

Avoid contact with high-pressured fuel

Should fuel leak from a fuel injection pipe, do not touch the spouting fuel directly.

Fuel in the fuel injection pipes is under high pressure. If high-pressured fuel contacts you skin, it penetrates through the skin and may result in gangrene.

CAUTION

About warning labels

Maintenance of warning labels

Make sure all warning/caution labels are legible.

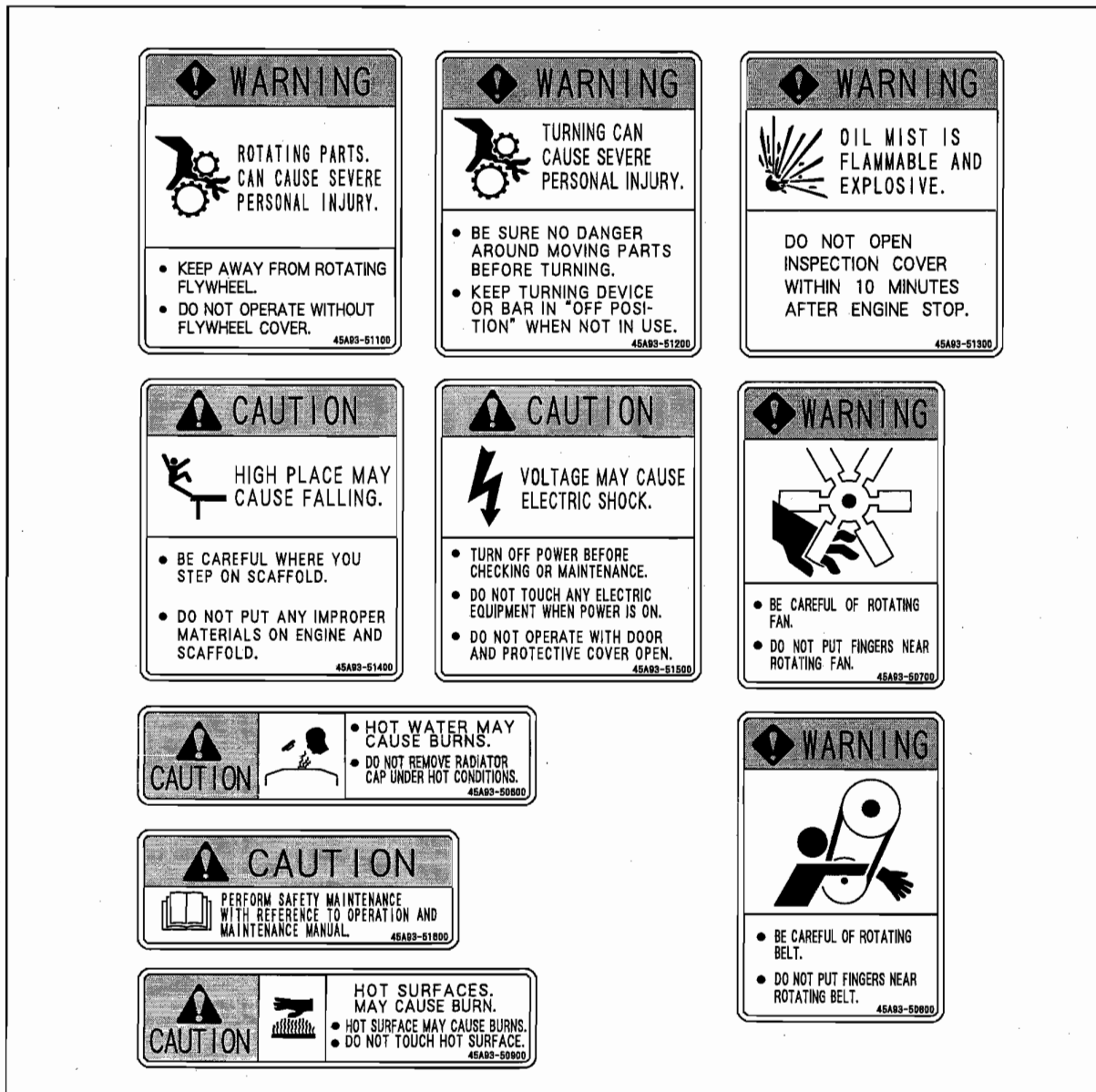
Clean or replace the warning/caution labels the description and/or illustration of which cannot be seen clearly.

For cleaning the warning/caution labels, use a cloth, water and soap. Do not use cleaning solvents, gasoline or other chemicals to prevent the letters from getting blurred or the adhesion from being weakened.

Replace damaged or fractured labels with new ones.

If any engine part on which a warning label is attached is replaced with a new one, attach a new identical warning label to the new part.

To obtain replacement warning labels, contact a Mitsubishi dealer.



Warning labels

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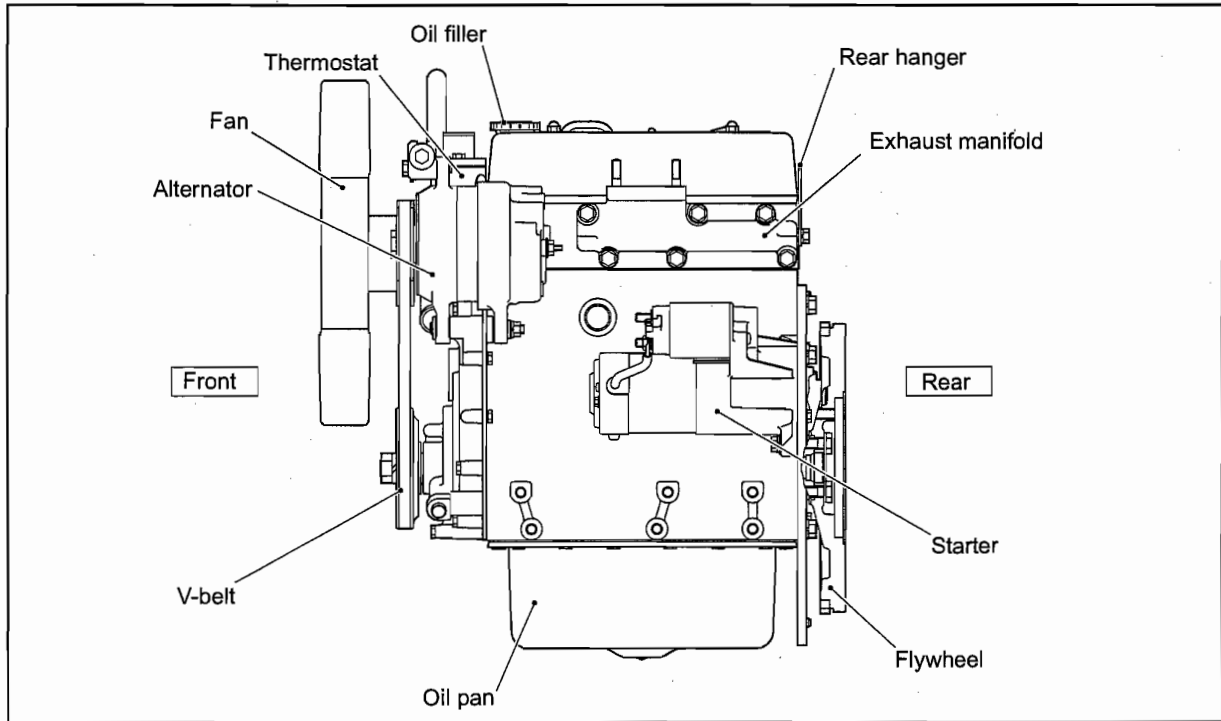
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GENERAL

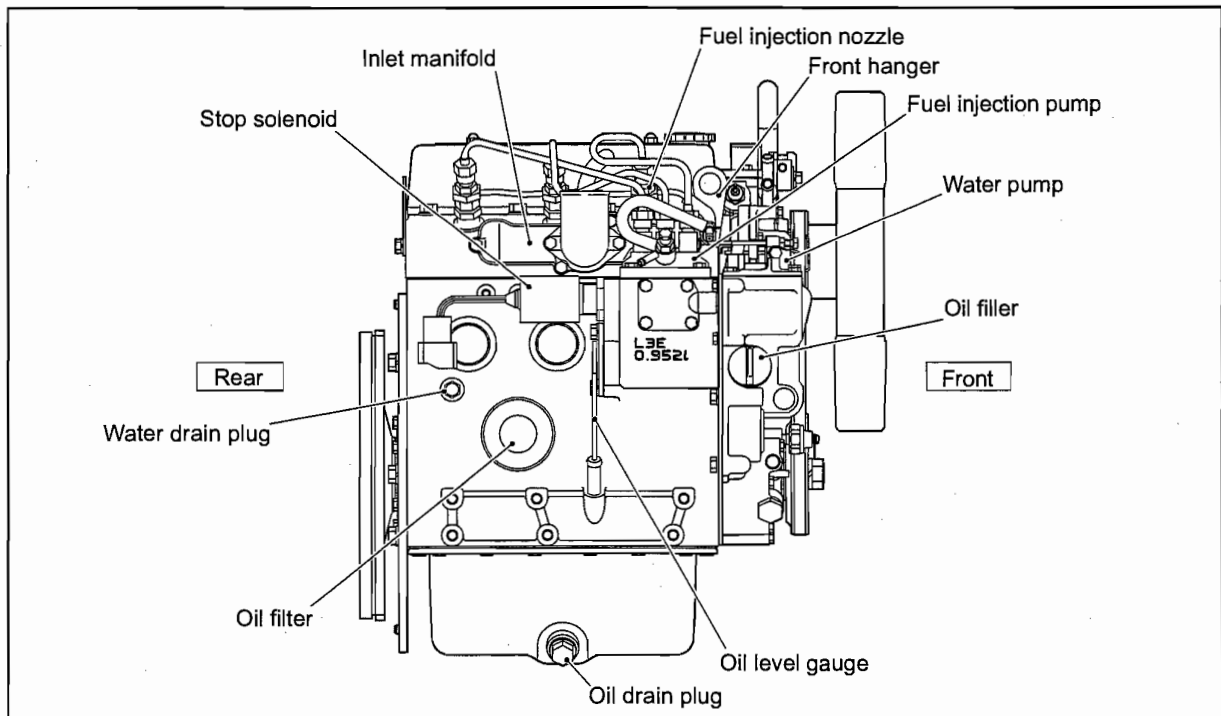
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1. Outside drawing

1.1 Outside drawing of L3E



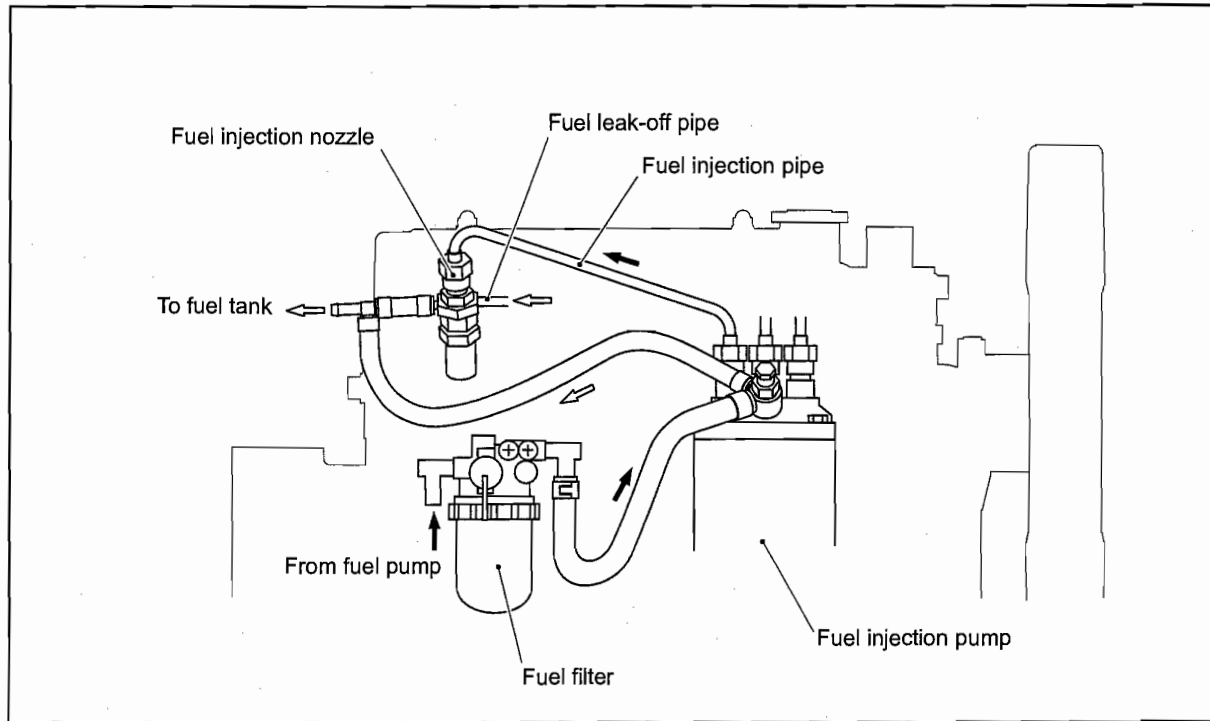
Left side view of engine



Right side view of engine

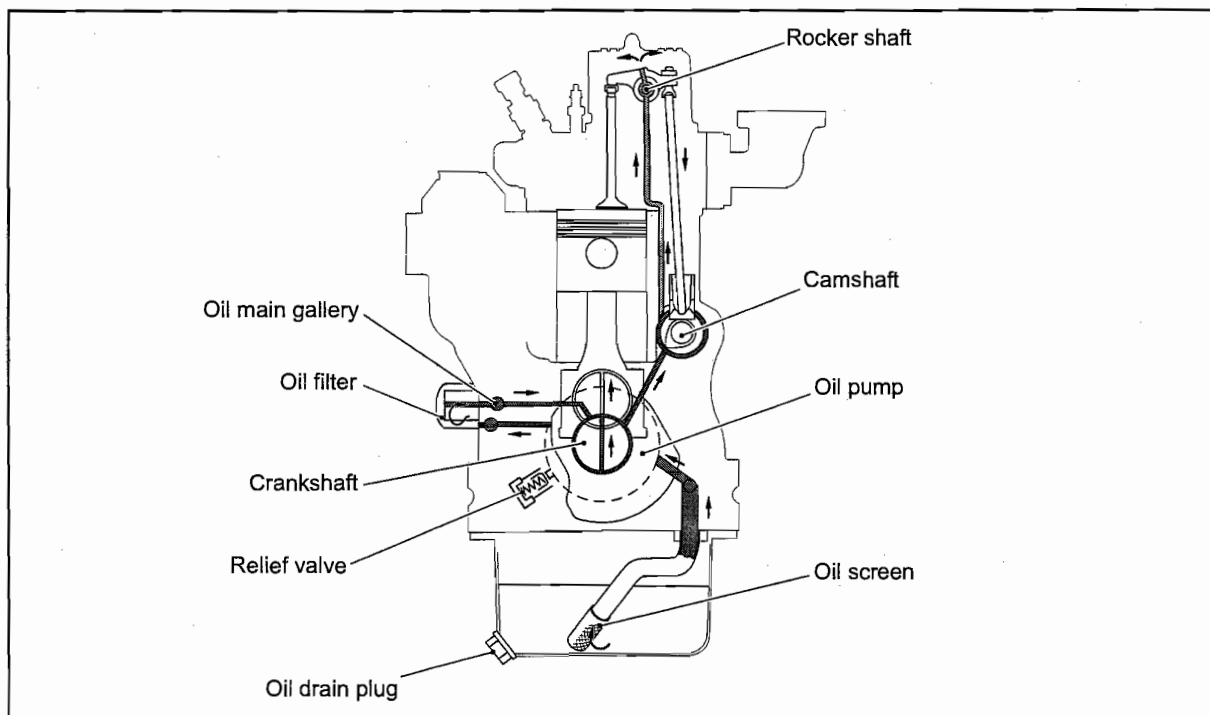
2. Outline of systems

2.1 Outline of fuel system



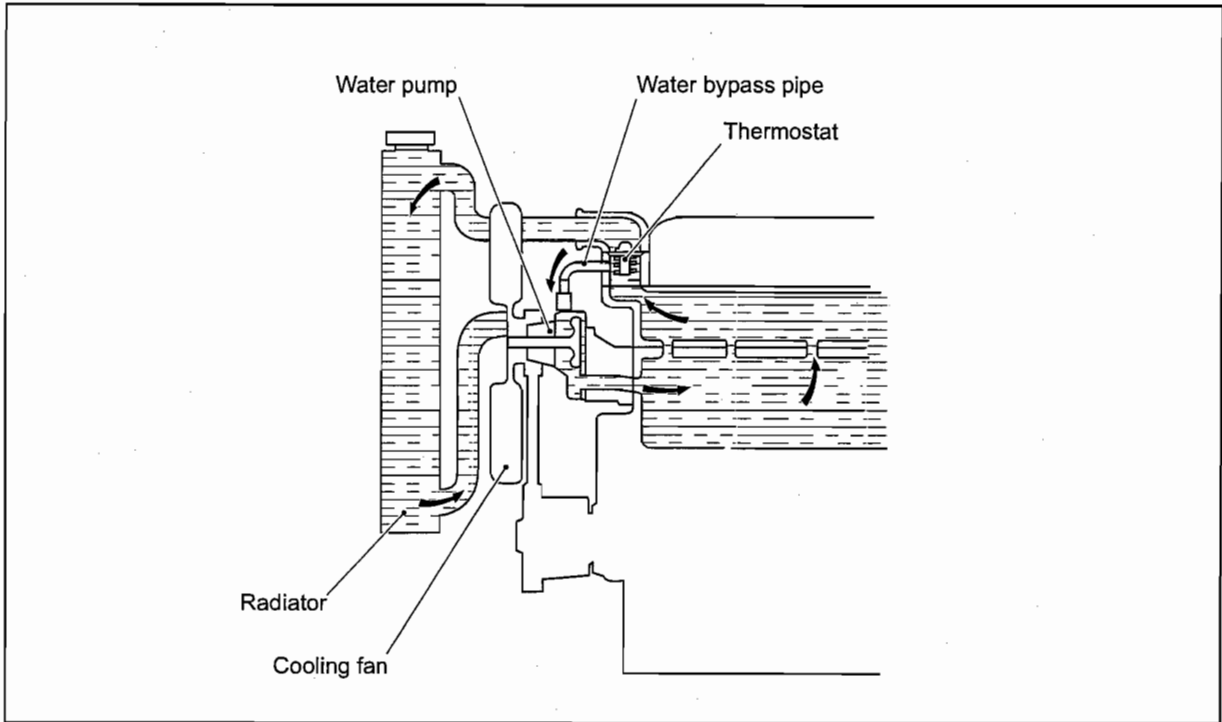
Outline of fuel system

2.2 Outline of lubrication system



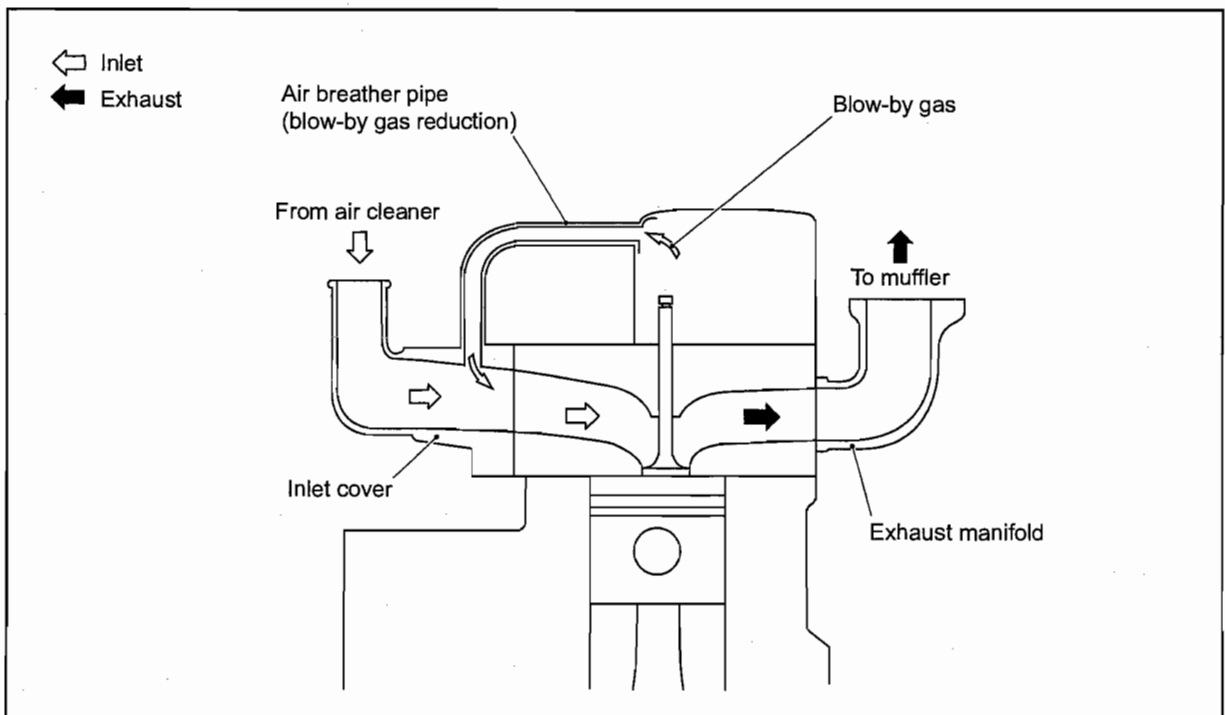
Outline of lubrication system

2.3 Outline of cooling system



Outline of cooling system

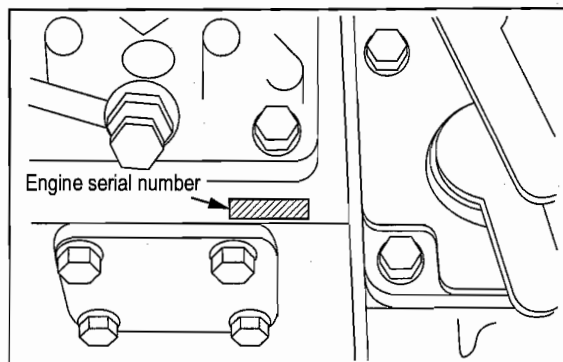
2.4 Outline of inlet and exhaust systems



Outline of inlet and exhaust systems

3. Engine serial number location

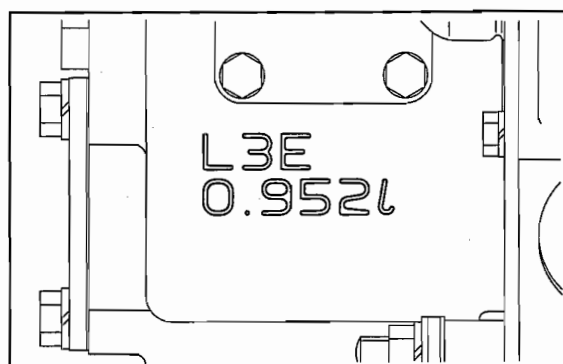
The engine serial number is stamped on the injection pump mount (upper side of tie rod cover) of the cylinder block.



Stamping position of engine serial number

4. Indication of engine model and total displacement

The engine type and displacement are stamped on the side of the injection pump mount of the cylinder block.



Engine model and cylinder capacity

5. Specifications

5.1 Specifications of L3E

Table 1-1 Specifications of L3E (1 / 2)

Engine model			L3E	
Main specifications	Type		In-line, water cooled, 4-cycle diesel engine	
	No. of cylinders		3	
	Combustion type		Swirl chamber type	
	Valve mechanism		Overhead valve type	
	Cylinder bore × stroke		76 × 70 mm [2.99 × 2.76 in.]	
	Total displacement		0.952 L [0.251 U.S. gal.]	
	Compression ratio		23 : 1	
	Fuel used		Diesel oil (JIS K2204 Special No. 1 - Special No. 3)	
	Order of ignition		1-3-2	
	Direction of rotation		Counterclockwise as viewed from flywheel side	
	Dry mass		71 kg [157 lb.]	
Main unit of engine	Piston ring	Number	Compression ring : 2 Oil rings (with expander) : 1	
	Valve timing (when warm)	Inlet valve	Open	BTDC 18°
			Close	ABDC 46°
		Exhaust valve	Open	BBDC 46°
			Close	ATDC 18°
Starting system		Electric starting		
Fuel system	Fuel injection pump	Type	Bosch NC type	
		Manufacturer	DENSO CORPORATION	
		Plunger diameter	∅ 5.5 mm [0.217 in.]	
		Cam lift	6 mm [0.24 in.]	
	Governor	Speed governing type	Centrifugal weight system	
	Fuel injection nozzle	Type	Throttle type	
		Manufacturer	DENSO CORPORATION	
		Spray angle	15°	
		Valve opening pressure	13.73 MPa {140 kgf/cm ² } [1992 psi]	
	Fuel filter	Type	Paper-element switch cock	
	Fuel pump	Type	Solenoid fuel pump (compact type)	
		Discharge rate	0.4 L [0.11 U.S. gal.]/min or more (at 12 V-1.5 A)	

Table 1-1 Specifications of L3E (2 / 2)

Engine model		L3E	
Lubrication system	Lubrication system		Pressure feed, full flow filter system
	Engine oil	Speci fication	Class CD or above oil (API service classification)
		Capacity (engine total)	3.1 L [0.82 U.S. gal] (3.6 L [0.95 U.S. gal])
	Oil pump	Type	Gear type (internal and external teeth engagement), built into gear case
		Discharge rate	3 L [0.79 U.S. gal]/min or more (at 1000 min ⁻¹)
	Relief valve	Type	Plunger valve type
		Valve opening pressure	0.29 ± 0.029 MPa {3.0 ± 0.3 kgf/cm ² } [42.68 ± 4.3 psi] (1000 min ⁻¹)
Oil filter	Type	Paper-element cartridge	
Cooling system	Cooling system		Forced-feed circulation type
	Coolant capacity (main unit of engine)		1.8 L [0.48 U.S. gal]
	Water pump	Type	Centrifugal volute type
		Discharge rate	50 L [13.21 U.S. gal]/min (at pump rotation of 4500 min ⁻¹)
	Thermostat	Type	Wax pellet
		Valve opening pressure	76.5 ± 1.5°C [167.0 to 172.4°F]
	Cooling fan	Type	Push type
No. of blades/Outside diameter		5 equally spaced blades/310 mm [12.20 in.]	
Inlet system	Air cleaner	Type	Paper element
Electrical system	Voltage - polarity		12 V - negative (-) ground
	Starter	Type	M001T68381
		Manufacturer	Mitsubishi Electric Corporation
		Pinion engagement type	Pinion shift (reduction type)
		Output	12 V - 1.7 kW
		Number	1
		Pinion/ring gear ratio	14/106
	Alternator	Type number	A007TA0171B
		Type	Three-phase current generator, integral with IC regulator
		Manufacturer	Mitsubishi Electric Corporation
		Output	12 V - 40 A
		Rated voltage generating speed	5000 min ⁻¹ (at 13.5 V, 37 A, when hot)
		Regulator adjusting voltage	14.7 ± 0.3 V
	Glow plug	Type	Sheathed
		Rated voltage - current	11 V - 9.5 A ± 1.0 A (6-second duration)
	Stop solenoid	Working voltage	12 V - ETR: 8 V or less
		Insulation resistance	100 MΩ or more at DC 500 V megger (normal temperature, normal relative humidity)
		Stroke	13.5 ± 0.5 mm [0.532 ± 0.020 in.]
		Ambient temperature for use	-40 to 120°C [-40 to 248°F]

6. Tips on disassembling and reassembling

This service manual specifies the recommended procedures to be followed when servicing Mitsubishi engines. The manual also specifies the special tools that are required for the work, and the basic safety precautions to follow when working.

Note that this manual does not exhaustively cover potential hazards that could occur during maintenance, inspection and service work of engine.

When working on an engine, follow the relevant directions given in this manual and observe the following instructions:

6.1 Disassembling

- (1) Use correct tools and instruments. Serious injury or damage to the engine will result from using the wrong tools and instruments.
- (2) Use an overhaul stand or work bench if necessary, and follow the disassembling procedures described in this manual.
- (3) Keep the engine parts in order of removal to prevent losing them.
- (4) Pay attention to assembling marks. Put your marks on the parts, if necessary, to ensure correct reassembling.
- (5) Carefully check each part for defects during disassembling or cleaning. Do not miss symptoms which can not be detected after disassembling or cleaning.
- (6) When lifting or carrying heavy parts, exercise utmost caution to ensure safety. Pay attention to balance of heavy parts when handling. (Get help, and use jacks, chain blocks and guide bolts as necessary.)

6.2 Reassembling

- (1) Wash all engine parts, except such parts as oil seals, O-rings and rubber sheets, in cleaning oil and dry them with compressed air.
- (2) Use correct tools and instruments.
- (3) Use only high-quality lubricating oils and greases of appropriate types. Be sure to apply oil, grease or adhesive to the part wherever specified.
- (4) Use a torque wrench to tighten parts correctly when their tightening torques are specified.
Refer to "List of Tightening Torque."
- (5) Replace all gaskets and packings with new ones unless specified otherwise. Apply adhesive if necessary. Use only the proper amount of adhesive.

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SERVICE DATA

1. Maintenance service data

1.1 General

Table 2-1 Maintenance service data table - General

Unit: mm [in.]

Inspection point		Nominal	Standard	Limit	Remark
Maximum rotation speed (rated rotation speed used as reference)		2350 ⁺⁵⁰ / ₊₀ min ⁻¹			Adjust governor setting.
Minimum rotation speed					
Compression pressure (at 280 min ⁻¹)			2.7 MPa { 28 kgf/cm ² } [398 psi]	Not acceptable at or below 2.2 MPa { 22 kgf/cm ² } [313 psi]	When oil and water temperatures at 20 to 30 °C [68 to 86 °F]
Lubricating oil pressure	Rotated speed		0.29 to 0.39 MPa { 3 to 4 kgf/cm ² } [42.7 to 56.9 psi]		Oil temperature at 60 to 70 °C [140 to 158 °F]
	Low idling		0.10 MPa { 1.0 kgf/cm ² } [14.2 psi]		
Valve timing	Inlet	Open		BTDC 18°	Values for checking valve timing Different from actual valve opening and closing timing
	Inlet	Close		ABDC 46°	
	Exhaust	Open		BBDC 46°	
	Exhaust	Close		ATDC 18°	
Valve clearance	Inlet			0.25 [0.0098]	When engine is cold
	Exhaust			0.25 [0.0098]	
Fuel injection timing (before TDC)				BTDC 15°	

1.2 Engine main part

Table 2-2 Maintenance service data table - Engine main part (1 / 3)

Unit: mm [in.]

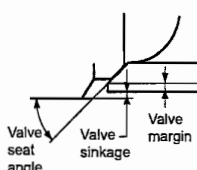

Inspection point		Nominal	Standard	Limit	Remark	
Rocker	Rocker arm inside diameter	∅ 12 [0.47]	12.013 to 12.035 [0.4730 to 0.4738]			
	Rocker shaft outside diameter	∅ 12 [0.47]	11.470 to 11.984 [0.4516 to 0.4718]			
	Clearance between rocker arm and rocker shaft		0.029 to 0.065 [0.0011 to 0.0026]	0.2 [0.0079]	Replace rocker arm	
Valve	Valve stem outside diameter	Inlet	∅ 6.6 [0.259]	6.565 to 6.580 [0.2587 to 0.2593]	6.500 [0.2561]	
		Exhaust	∅ 6.6 [0.259]	6.530 to 6.550 [0.2573 to 0.2581]	6.500 [0.2561]	
	Valve guide inside diameter	Inlet	∅ 6.6 [0.259]	6.600 to 6.615 [0.2601 to 0.2606]		
		Exhaust				
	Clearance between valve stem and valve guide	Inlet		0.020 to 0.050 [0.0008 to 0.0020]	0.10 [0.0040]	Replace valve and valve guide
		Exhaust		0.050 to 0.085 [0.0020 to 0.0034]	0.15 [0.0059]	
Valve seat and valve	Valve seat angle		44°			
	Valve sinkage	0.5 [0.020]	0.4 to 0.6 [0.016 to 0.024]			
	Valve margin		1.0 [0.040]	0.5 [0.020]		
	Valve guide mounting length	14 [0.55]	13.5 to 14.5 [0.532 to 0.552]			

Table 2-2 Maintenance service data table - Engine main part (2 / 3)

Unit: mm [in.]

Inspection point		Nominal	Standard	Limit	Remark	
Valve spring	Free length	40 [1.57]		38.8 [1.528]		
	Squareness		 $\theta = 2^\circ$ $\Delta = 1.4$ [0.055] $L_f = 40$ [1.57]	$\Delta = 2.0$ [0.079] over entire length		
	Mounting length/load		35.5/61.1 to 71.0 N {6.54 to 7.24 kgf} [1.40/47.30 to 52.37 lbf] 28/170.7 to 189.4 N {17.41 to 19.31 kgf} [1.10/38.38 to 42.57 lbf]	-15 %		
Cylinder	Pushrod	Runout	0.3 [0.012] or less	0.3 [0.012]	TIR, Replace	
	Cylinder head	Distortion of cylinder head bottom surface	0.05 [0.020] or less	0.10 [0.0039]	Repair	
		Distortion of block top surface	0.05 [0.020] or less	0.10 [0.0039]	Repair	
	Inside diameter		$\phi 76$ [2.99]	76.00 to 76.03 [2.9921 to 2.9933]	+0.7 [+0.027]	Repair limit is +0.2 [+0.0079]
	Cylindricity			0.01 [0.0004] or less		
Piston	Outside diameter	STD	$\phi 76$ [2.99]	75.906 to 75.926 [2.9884 to 2.9892]		
		0.25 OS	$\phi 76.25$ [3.0020]	76.156 to 76.176 [2.9983 to 2.9991]		
		0.50 OS	$\phi 76.50$ [3.0118]	76.406 to 76.426 [3.0081 to 3.0089]		
	Piston pin outside diameter		$\phi 21$ [0.83]	21.002 to 21.005 [0.8269 to 0.8270]		
	Clearance between piston pin bore and piston pin			0.007 to 0.015 [0.0003 to 0.0006]	0.08 [0.0031]	
	Clearance between piston and cylinder (clearance)			0.074 to 0.124 [0.0029 to 0.0049]	0.2 [0.008]	Repair to oversize or replace
Piston ring	Clearance between ring and ring groove	No.1 ring		—	0.3 [0.012]	Replace
		No.2 ring		0.05 to 0.09 [0.0020 to 0.0036]	0.2 [0.008]	
		Oil ring		0.03 to 0.07 [0.0012 to 0.0028]	0.2 [0.008]	
	Closed gap of ring	No.1 ring		0.15 to 0.30 [0.0059 to 0.0118]	1.5 [0.059]	Replace
		No.2 ring		0.15 to 0.30 [0.0059 to 0.0118]		
		Oil ring		0.15 to 0.35 [0.0059 to 0.0138]		
Connecting rod	Bend and torsion		0.05/100 [0.0197/3.94] or less	0.15/100 [0.0059/3.94]		
	End play		0.10 to 0.35 [0.0394 to 0.0138]	0.5 [0.020]		



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SERVICE DATA

Table 2-2 Maintenance service data table - Engine main part (3 / 3)

Unit: mm [in.]

Inspection point		Nominal	Standard	Limit	Remark
Crankshaft	Journal outside diameter (STD)	ø 43 [1.69]	42.965 to 42.980 [1.6915 to 1.6921]	-0.70 [-0.0276]	Repair limit is -0.15 [-0.0059]
	Pin outside diameter (STD)	ø 40 [1.57]	39.965 to 39.980 [1.5734 to 1.5740]		
	Runout		0.06 [0.0024] or less		TIR
	Clearance between main bearing and crankshaft		0.030 to 0.075 [0.0118 to 0.0030]	0.10 [0.0039]	
	Clearance between connecting rod bearings		0.028 to 0.071 [0.0011 to 0.0028]	0.150 [0.0059]	
	End play		0.050 to 0.175 [0.0020 to 0.0069]	0.500 [0.0197]	
Timing gear backlash	Between crank gear and idler gear		0.010 to 0.141 [0.0004 to 0.0056]	0.3 [0.012]	Replace
	Between idler gear and valve camshaft gear		0.010 to 0.136 [0.0004 to 0.0054]		
	Between idler gear and pump camshaft gear				
Cam height of camshaft (major axis)		27.37 [1.0776]	27.27 to 27.47 [1.0736 to 1.0815]	26.37 [1.0382]	
Cam height of fuel injection pump camshaft (major axis)		30 [1.18]	29.9 to 30.1 [1.177 to 1.185]	29 [1.14]	Replace
Flywheel flatness			0.08 [0.0032] or less		
Clearance between tappet and cylinder block bore			0.007 to 0.049 [0.0003 to 0.0019]	0.15 [0.0059]	Replace tappet.
Clearance between camshaft journal and cylinder block bore			0.050 to 0.100 [0.0020 to 0.0039]	0.15 [0.0059]	Replace camshaft or cylinder block
Clearance between idler gear bushing and idler shaft		ø 20 [0.79]	0.030 to 0.066 [0.0119 to 0.0026]	0.2 [0.008]	

1.3 Fuel system

Table 2-3 Maintenance service data table - Fuel system

Unit: mm [in.]

Inspection point	Nominal	Standard	Limit	Remark
Fuel injection nozzle pressure	13.73 MPa { 140 kgf/cm ² } [1992 psi]	13.73 to 14.73 MPa { 140 to 150 kgf/cm ² } [1992 to 2134 psi]		Adjust with washers.

1.4 Lubrication system

Table 2-4 Maintenance service data table - Lubrication system

Unit: mm [in.]

Inspection point	Nominal	Standard	Limit	Remark	
Oil pump	Clearance between oil pump housing inside diameter and oil pump outer gear outside diameter	∅ 75.5 [2.972]	0.100 to 0.196 [0.0039 to 0.0077]	0.3 [0.012]	Replace
	Clearance between oil pump outer gear width and oil pump housing	10 [0.04]	0.040 to 0.100 [0.0016 to 0.0039]	0.25 [0.0099]	Replace
Relief valve opening pressure (1000 min ⁻¹)		0.29 ± 0.029 MPa { 3.0 ± 0.3 kgf/cm ² } [43 ± 4.3 psi]		Replace	
Oil pressure at which oil pressure switch illuminates		0.05 ± 0.01 MPa { 0.5 ± 0.1 kgf/cm ² } [7 ± 0.7 psi]		Replace	

1.5 Cooling system

Table 2-5 Maintenance service data table - Cooling system

Unit: mm [in.]

Inspection point	Nominal	Standard	Limit	Remark
Thermostat	Temperature at which valve starts opening		76.5 ± 1.5 °C [167 to 172 °F]	Replace
	Temperature at which valve lift becomes 6 mm [0.24] or more		90 °C [194 °F]	
Thermoswitch	At 111 ± 3.5°C [225 to 238°F]		30 mΩ (in oil of 120 °C [248 °F])	
Deflection amount of belt (when it is pushed between crankshaft pulley and alternator pulley with a force of approx. 98 N { 10 kgf } [22.0459 lbf])			Approx. 10 [0.39]	

1.6 Inlet/Exhaust system

Table 2-6 Maintenance service data table - Inlet/Exhaust system

Unit: mm [in.]

Inspection point	Nominal	Standard	Limit	Remark
Distortion on mounting surfaces of intake cover and exhaust manifold			0.15 [0.0059]	Repair by grinding or replace

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