

ENGINE BASE

SERVICE MANUAL

**MITSUBISHI
S4S, S6S**

REFERENCE ONLY

- EXCAVATOR(16-18TON, -7SERIES)
- FORK LIFT(HDF35-70, -7SERIES)

MANUAL

INTRODUCTION

This service manual describes the specifications of the Mitsubishi Diesel Engine and the maintenance and adjustment procedures.

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 reassembling, 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

In this service manual, the Mitsubishi Diesel Engine (standard model for land use) specifications, maintenance standards and adjustment procedure as well as service procedures such as disassembly, inspection, repair and reassembly are arranged in groups for quick reference. There are separate manuals for the fuel injection pump, governor and turbocharger.

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

Regarding engine operation and periodical maintenance, refer to the Operation & Maintenance Manual. For component parts and ordering of service parts, refer to the Parts Catalogue. Structure and function of the engine are described in various training manuals.

1. Methods of Indication

- (1) Parts shown in illustrations and described in text are numbered to correspond with the sequence of disassembly.
- (2) Inspections to be conducted during disassembly are indicated in a box in disassembled views.
- (3) Maintenance standards for inspection and repair are described in text where they are relevant, are also listed in Group 1 in the General Contents.
- (4) The sequence in which parts are to be assembled is summarized below each assembled view.
Such as: ⑤→②→④→③→①.
- (5) The following marks are used in this manual to emphasize important safety cautions.



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



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



.... Indicates a potentially hazardous situation which, if not avoided, can 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 which is useful for engine operation or maintenance.

- (6) Tightening torque under wet conditions is indicated as "[Wet]." When so indicated, apply engine oil to the threaded portion of the fastener. Unless indicated as such, the tightening torque is to be assumed in the dry condition.

2. Terms Used in This Manual

Nominal value •••• Indicates the standard dimension of a part to be measured.

Standard •••••••• Indicates the dimension of a part, the clearance between parts, or the standard performance. Since the value is indicated in a range needed for inspection, it is different from the design value.

Limit •••••••••• A part must be repaired or replaced with a new part when it reaches the limit value.

3. Abbreviations, Standards, Etc.

- BTDC = Before Top Dead Center
- ATDC = After Top Dead Center
- BBDC = Before Bottom Dead Center
- ABDC = After Bottom Dead Center
- TIR = Total Indicated Reading
- 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.)

4. 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: 1 min⁻¹ = 1 rpm

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 **WARNING** Danger of Fire and Explosion

● **Keep flames away**

Do not use flames or smoke at a site where fuel or engine oil is handled or cleaning solvent is used for washing parts.

Flames can ignite such materials and result in a dangerous situation.

Spilled fuel and oil should be wiped immediately and thoroughly. Spilled fuel and oil can ignite and cause fire.

When storing fuel or engine oil, make sure that the storage area is well ventilated and the caps of containers are tightly closed.



● **Keep surrounding area neat and clean**

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

Remove dust, dirt and other foreign materials accumulated on or near the engine. They can cause fire or engine overheating. Be sure to remove dust from the top side of the battery after maintenance. Dust can cause a short-circuit.

The engine must be positioned at least 1 m [3.28 ft] away from buildings and other equipment to prevent possible fire caused by engine heat.

● **Do not open crankcase until engine cools**

After the engine stops operation, let the engine cool for at least 10 minutes before opening the side cover of the crankcase.

Inflow of fresh air into the crankcase of a hot engine can cause oil mist to ignite and explode.

● **Check for fuel and oil leaks**

When fuel or oil leaks are found, repair the leakage immediately.

Fuel or engine oil spilled on a hot surface of the engine can cause fire and result in personal injury or equipment damage.

● **Use shatterproof light**

Use a shatterproof light when inspecting the fuel system, lubrication system, cooling system or battery fluid level.

A non-shatterproof light may catch fire and explode.

● **Do not short-circuit electrical wires**

Do not inspect or repair the electrical system with the battery cables connected to the battery, since it can cause accidental short-circuiting and lead to fire. Be sure to disconnect the negative (-) battery cable from the battery before conducting work.

Loose terminals and damaged cables/wires can result in a short-circuit and cause fire. Inspect the terminals, cables and wires before servicing, and repair or replace when damage is found.

● **Keep fire extinguishers and first aid kit nearby**

Always keep fire extinguishers nearby, and be familiarized with their usage.

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

Also, establish emergency response procedures to follow in the event of a fire or accident, and post emergency contact locations and contact methods.



WARNING Danger of Entanglement

● Install protective covers on rotating parts

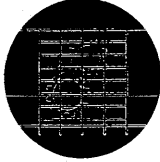
Make sure the protective covers of the engine are installed correctly at rotating parts.

If protective covers are loose or damaged, repair.

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

When the engine is coupled to other equipment or connected to a radiator, be sure to install covers on the exposed connecting belt and coupling.

Never remove protective covers.



● Check surrounding area for safety before starting engine

Before starting the engine, check to make sure no one is near the generator and tools are not left on or near the engine. Always verbally notify people within the immediate area when starting the engine.

When the starter switch is posted with a sign that prohibits startup operation, do not operate the engine.

● Stay clear of rotating parts while engine is in operation

Do not approach rotating parts while the engine is in operation.

Keep items that can be easily entangled away from rotating parts.

Rotating parts can entangle a persons' body or tools to cause serious.



● Lock out and tag out

Be sure to lock out and tag out before starting inspection and maintenance.

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

To lock out and tag out, pull out the key from the starter switch, turn off the battery switch, and post a "Do Not Operate" tag or a similar sign on the starter switch.

The starter switch key should be kept by the person performing the inspection and maintenance.

If the engine is installed with an air starter system, close the main valve of the air tank, and post a "Do Not Open" tag on the main valve.

● Always stop engine before inspection and maintenance

Before inspection and maintenance, be sure to stop the engine. Never attempt to adjust the belt tension while the engine is operating. Operating belt can entangle your body and result in serious injury.

● Always return turning tools to original position after use

Be sure to remove all turning tools used in inspection and maintenance. Return the turning gear in the original position before starting the engine.

Starting the engine with the turning tools inserted or turning gear engaged may not only cause engine damage but personal injury as well.

⚠ WARNING Danger of Burns

- Do not touch engine in operation or immediately after operation

Do not touch any part of the engine while the engine is operating or immediately after it stops operation. Touching the engine in operation or immediately after operation can cause burns.



When conducting inspection and maintenance, check the water temperature gage to make sure the engine has cooled sufficiently.

- Open radiator filler cap carefully

Never open the radiator filler cap while the engine is operating or immediately after it stops operation. Open the cap only after the engine stops and the coolant temperature drops sufficiently.

When opening the cap, slowly turn the cap to release internal pressure. To prevent burns caused by spurting steam, wear thick rubber gloves or cover the cap with a cloth.

When closing the cap, make sure to tighten it securely. If the radiator filler cap is opened when the coolant is at operating temperature, steam and hot coolant may blow out, causing skin burns as a result.

- Add coolant after coolant temperature drops sufficiently

Do not add coolant immediately after the engine stops, wait until the coolant temperature drops sufficiently. Otherwise, it will result to burns.

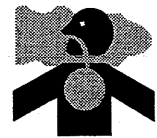
- Do not remove heat shields

The exhaust system, which becomes extremely hot while the engine is operating, is installed with heat shields. Never remove these heat shields. If they must be removed for inspection and maintenance, be sure to reinstall the heat shields after inspection and maintenance.

⚠ WARNING Beware of Exhaust Gas Poisoning

- Operate engine in well-ventilated area

If the engine is installed in an enclosed area and an exhaust duct is used to discharge the exhaust gas to the outside, inspect the duct joints to make sure there is no exhaust gas leak from duct joints.



When the engine is used as a movable generator, do not use the engine in an enclosed area (inside a warehouse, tunnel, etc.) or at a site where all sides are blocked for poor ventilation. If the engine must be operated in an enclosed area, discharge the exhaust gas to the outside and provide adequate ventilation. Make sure the exhaust gas does not blow in the direction of plants or animals.

Exhaust gas from the engine contains carbon monoxide and other harmful substances. Operating the engine in an ill-ventilated area can cause gas poisoning.

⚠ WARNING Danger of Hearing Problems

- 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 Beware of Falling Equipment

● Lift engine carefully

When lifting the engine, use wire ropes capable of supporting the entire weight of the engine.

Attach appropriate slings to the hangers provided on the engine to lift the engine.

Keep the engine balanced during lifting by considering center of gravity of the engine.

Keep the angle formed by wire ropes within 60°. If the angle exceeds this limit, excessive load is applied on the hangers and may damage the hangers.

If wire ropes contact the engine directly, place a cloth or other soft padding to prevent damage to the engine and wire ropes.



● Do not climb onto engine

Do not climb onto the engine, or set a foot on any part located on the side of the engine.

To work on parts located on the upper section, use a ladder, stand, etc., and be careful not to fall.

Climbing on the engine can damage engine parts, and a person may fall and get injured.

● Watch footing when conducting maintenance

When working on the upper part of the engine and other hard-to-reach places, use a stable work platform.

Standing on a decrepit stand or parts box may result in personal injury.

Do not place any item on a work platform.



CAUTION Cautions Regarding Engine Oil and LLC

● Use only specified fuel, engine oil and coolant

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

Use of other fuel, oil or coolant, and improper handling may cause various engine problems and malfunctions.

Obtain the MSDSs (Material Safety Data Sheets) issued by the fuel, oil and coolant manufacturers, and follow the directions on the MSDSs for proper handling.

● Handle LLC (long life coolant) carefully

LLC contains strong alkali. Do not swallow or allow it to contact eyes.


Since drained coolant (containing LLC) is harmful, do not dispose of it into conventional sewage. Abide by the applicable law and regulations when discarding drained coolant.

● Properly disposed of drained oil and coolant

Do not dispose of drained engine oil or coolant into conventional sewage.

Laws and regulations prohibit disposal of oil and coolant into ordinary sewage systems.

When disposing oil waste, coolant and other environmentally hazardous waste, abide by the law and regulations.

 **CAUTION Cautions Regarding Battery**

● **Handle battery carefully**

- Never use flames or allow sparks near the battery. The battery releases flammable hydrogen gas and oxygen gas. These gases can be ignited by flames and cause an explosion.
- Do not use the battery when the fluid surface is lower than the minimum level. Using a battery with a low electrolytic level can 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 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, do not swallow electrolyte.
- Wear protective goggles and rubber gloves when maintaining and inspecting the battery (when adding water, charging, etc.).
- If electrolyte is spilled onto the skin or clothes, immediately wash with lots of water and thoroughly clean with soap.
- If electrolyte gets into eyes, immediately flush with lots of clean fresh water, and seek immediate medical attention.
- Should accidentally swallow electrolyte, gargle with plenty of water, then drink lots of water, and seek immediate medical attention.



 **CAUTION Response to Abnormalities**

● **If engine overheats, conduct heating operation before stopping engine**

If the engine overheats, do not stop the engine immediately. Abruptly stopping an overheated engine may cause the coolant temperature to rise, resulting in seizing of the engine. If the engine overheats, operate 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 may cause damage to the cylinder heads due to sudden change in temperature. Add coolant after the engine cools to room temperature.

● **If engine stops due to abnormality, exercise caution when restarting**

If the engine stops due to an abnormality, do not restart the engine immediately. If the engine stops with an alarm, check and correct the cause of the problem before restarting. Operating the engine without correcting the problem may result in serious engine problems.

● **If oil pressure drops, stop engine immediately**

If the engine oil pressure decreases, stop the engine immediately, and inspect the lubrication system. Operating the engine with low oil pressure may cause seizing of the bearings and other parts.

● **If fan belt breaks, stop engine immediately**

If the fan belt breaks, stop the engine immediately. Continued operation of the engine without the fan belt causes coolant to change into steam and blow out from the reservoir and radiator, thus resulting in burns.

CAUTION Other Cautions

● Never modify engine

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

Modification of the engine may not only cause engine damage but also result in personal injury.

● Never break seals

To ensure proper engine operation, the fuel control link is attached with seals that prevent change of the fuel injection volume and rotation speed settings. Operating the engine without these seals in place can result in the following problems, and also invalidates the warranty.

- Rapid wear of moving and rotating parts
- Engine malfunctions including engine damage and seizing of engine parts
- Increased consumption of fuel and lubricating oil
- Degradation of engine performance due to improper balance between fuel injection volume and governor operation

● Always perform specified pre-operation inspections and periodic inspections

Conduct the pre-operation inspections and periodic inspections as described in this manual.

Failure to conduct the specified pre-operation inspections or periodic inspections may cause various engine problems and damage to parts, as well as serious accidents.

● Break in new engine

Break in a new engine by operating it with a light load during the first 50 hours of operation. Operating a new engine under high load or severe condition during the break-in period can shorten the service life of the engine.

● Conduct warm-up operation

After the engine starts, let it idle at low speed for 5 to 10 minutes before using the engine for work.

Warm-up operation circulates lubricants in the engine, thus prolonging the service life and contributing to high-performance and economical operation.

Do not conduct warm-up operation for an extended period of time. Prolonged warm-up operation causes carbon build-up in the cylinders that leads to incomplete combustion.

● Never operate engine under overload condition

Do not operate the engine if the exhaust smoke is black.

Overloading the engine (indicated by black smoke) causes not only high fuel consumption but also excessive carbon deposits inside the engine that leads to engine problems and shortens the service life of the engine.

● Conduct cooling operation before stopping engine

Before stopping the engine, conduct cooling operation (operating at low speed) for 5 to 6 minutes.

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.

● Do not splash water on engine

Do not allow rain water 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.

If water enters the combustion chambers of the engine, starting the engine can cause water hammer action, and may result in internal engine damage and serious accidents.

● Conduct proper maintenance of air cleaner

The major cause of abnormal wear on engine parts is dust entering with intake air. Worn parts result in 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 directions.

- Do not conduct maintenance of the air cleaner while the engine is operating.
- When removing the air cleaner, do not allow dust attached on the air clear to fall into the outlet side of the air cleaner.
- If equipped with a dust indicator, conduct maintenance only when the clog warning sign appears. Unnecessary maintenance may cause dust to enter the engine when removing the filter element, or result in element damage or deformation.

● Observe safety rules at workplace

Observe the safety rules established at workplace when operating and maintaining the engine.

When feeling ill, do not operate the engine, and inform supervisor of condition.

Operation of the engine with reduced awareness may cause operation errors that may result in accidents.

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

● Wear proper work clothes and protective gear

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

When handling compressed air, wear safety goggles, hardhat, gloves and other necessary protective gear. Conducting work without proper protective gear may result in serious injury.

● Use appropriate tools for maintenance work

To conduct maintenance work, use tools appropriate for the type of work to be performed, and use them correctly.

If tools are damaged, replace with new tools.

● Do not operate starter for prolonged time

Do not operate the starter for more than 10 seconds at a time if the engine does not start and wait for at least 30 seconds before cranking again.

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

● Do not turn off battery switch while engine is operating

Do not turn off the batter switch while the engine is in operation.

Turning off the battery switch while the engine is in operation not only stops the instrument operations but also damages the diodes and transistors inside the alternator.

● Cautions in transporting engine

When transporting the engine on a truck, consider the generator weight, width and height to ensure safety, and also abide by the traffic law, road trucking vehicle law, vehicle restriction ordinance and other pertinent laws.

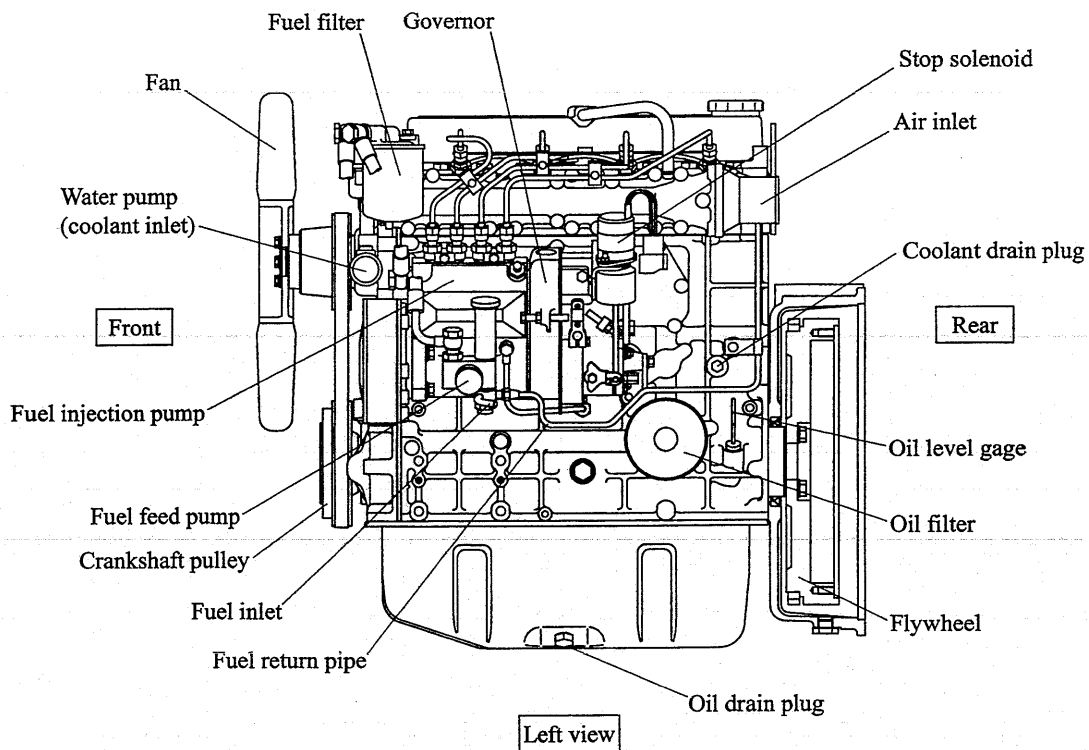
GENERAL

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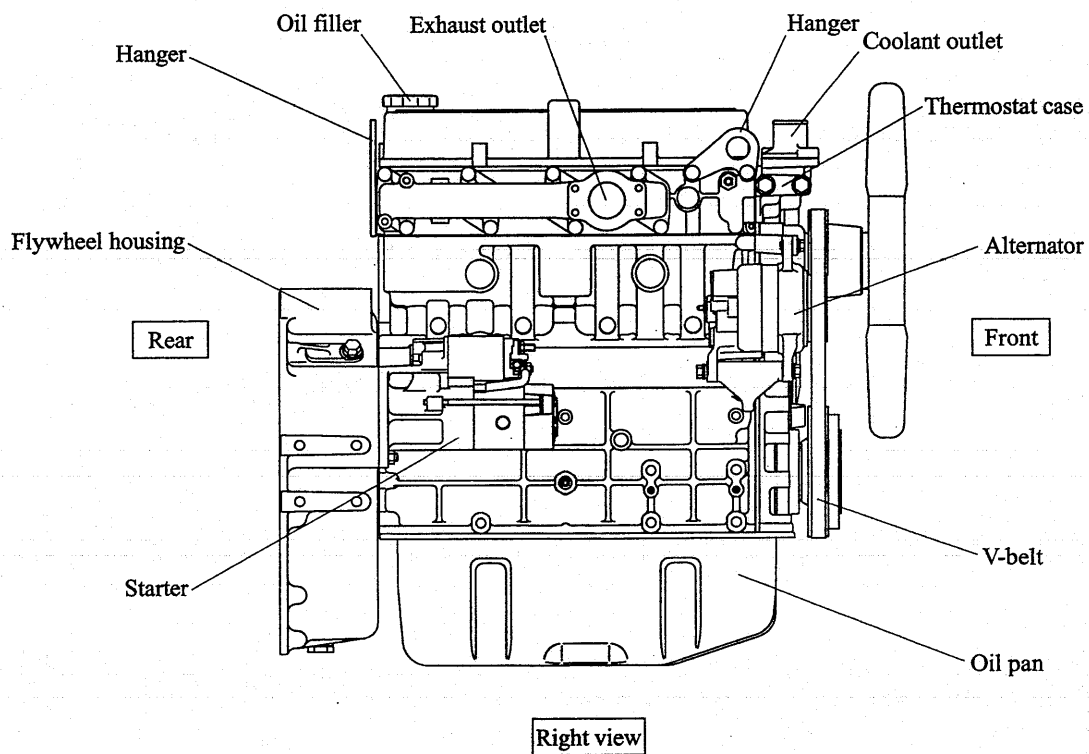
1. Outline

1.1 External View (In-line Fuel Injection Pump and Distributor-type Fuel Injection Pump)

(1) S4S in-line fuel injection pump specification

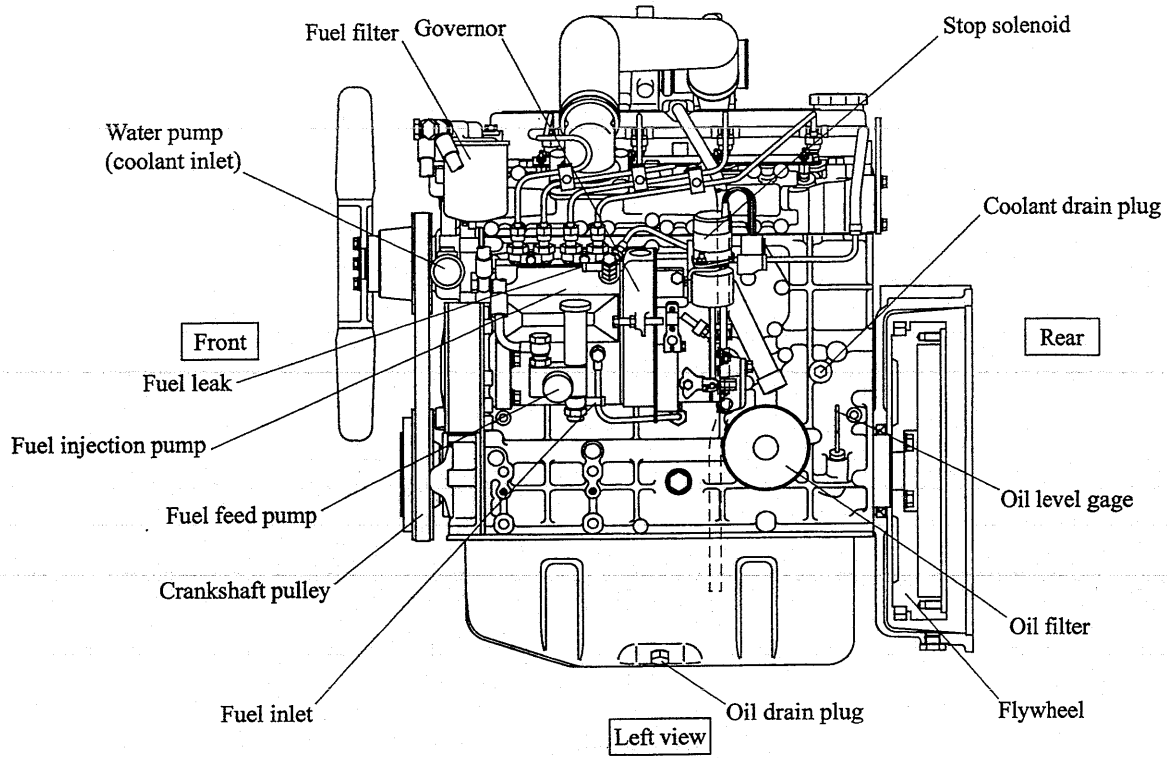


Left view of engine

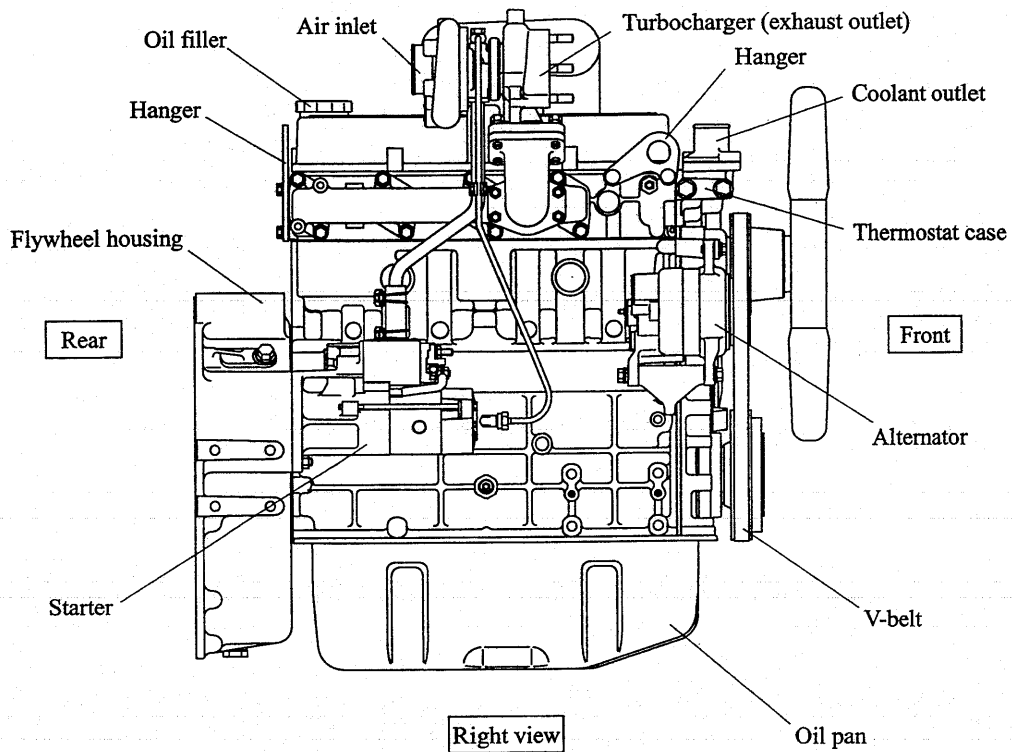


Right view of engine

(2) S4S-DT in-line fuel injection pump specification

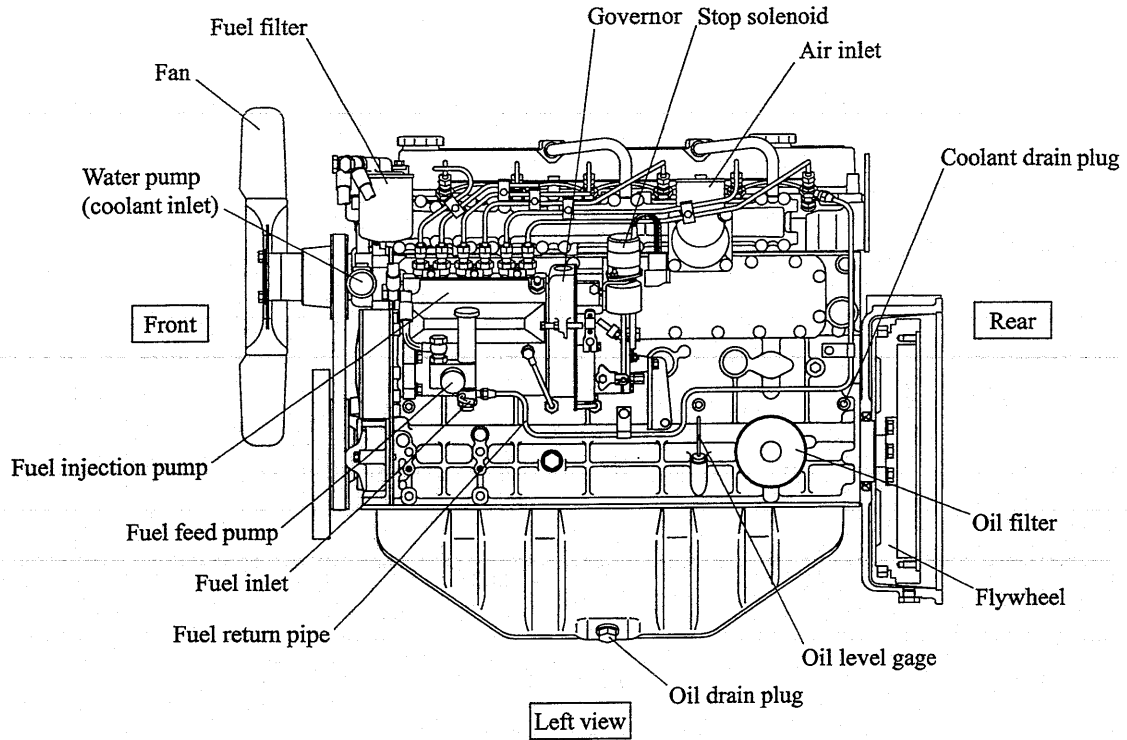


Left view of engine

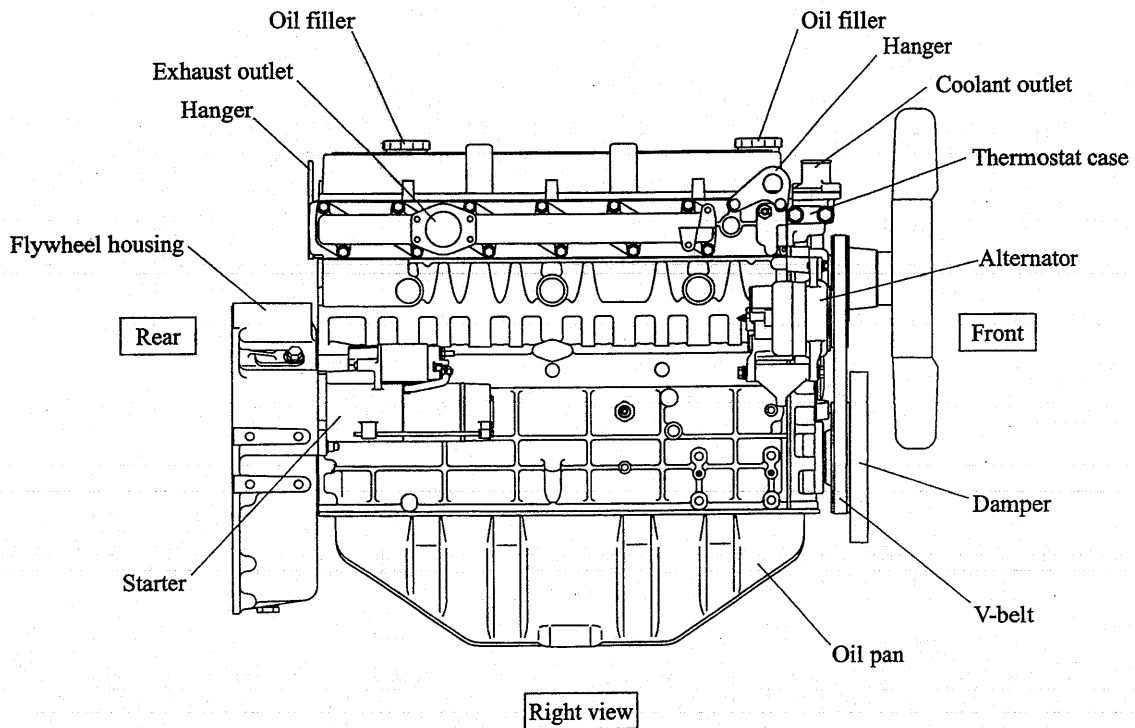


Right view of engine

(3) S6S in-line fuel injection pump specification

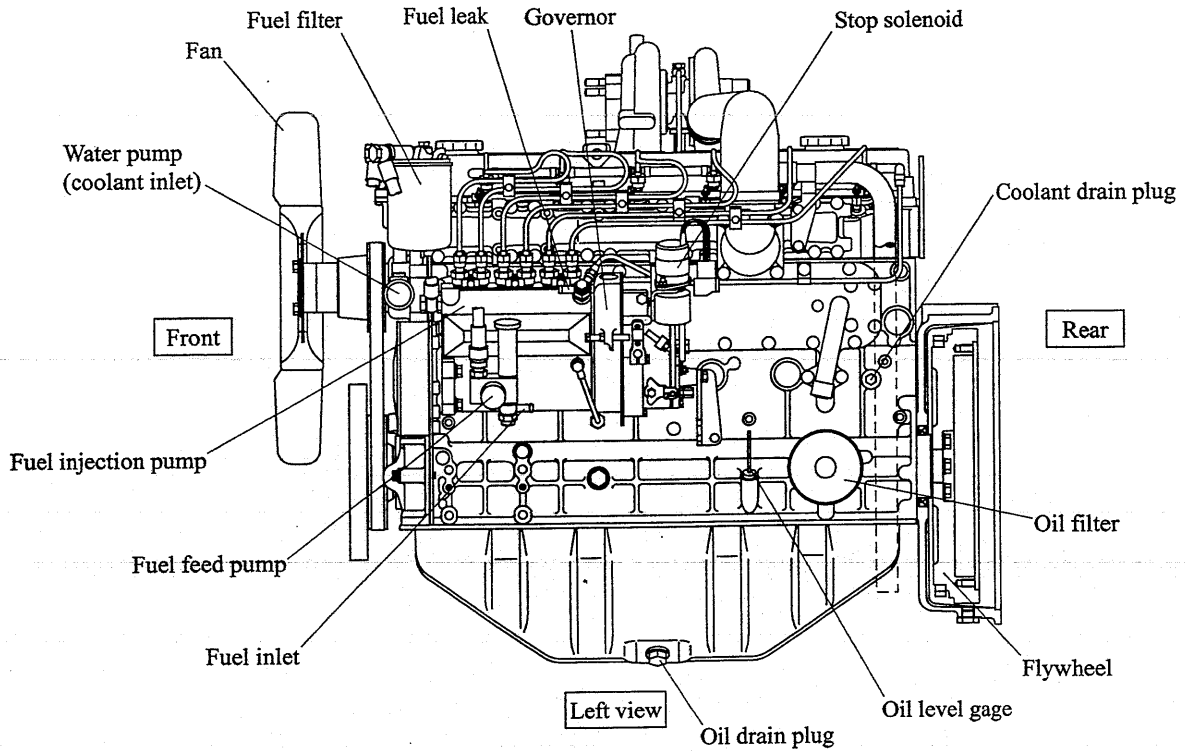


Left view of engine

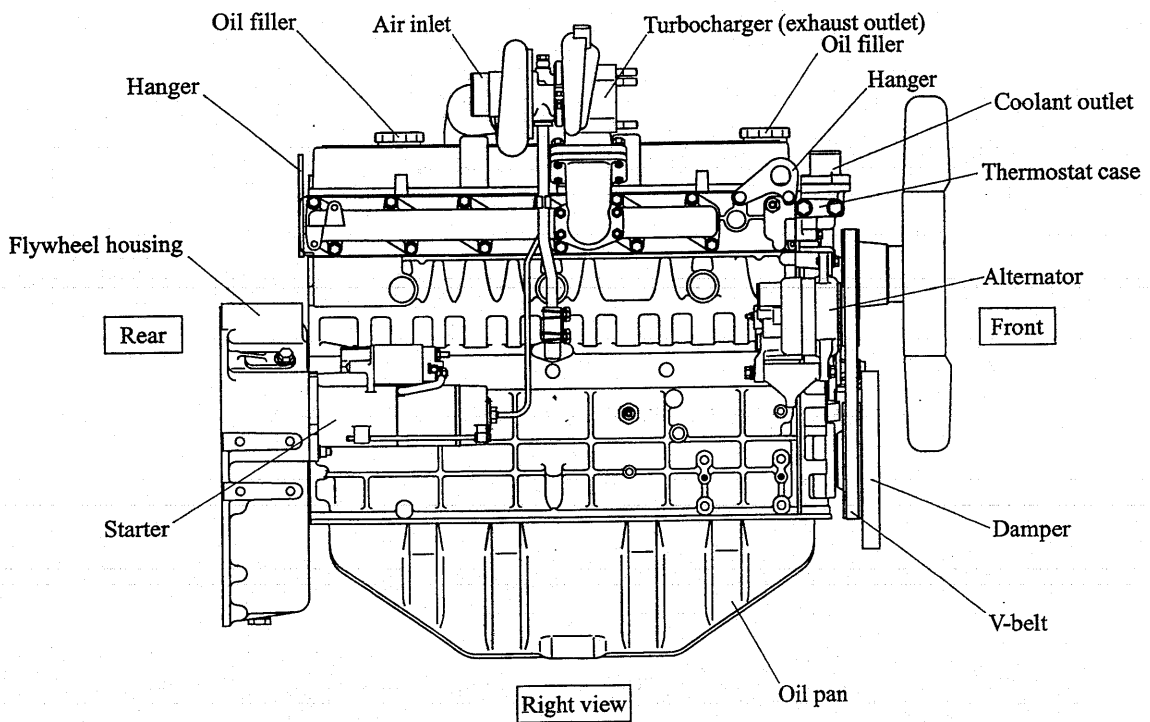


Right view of engine

(4) S6S-DT in-line fuel injection pump specification

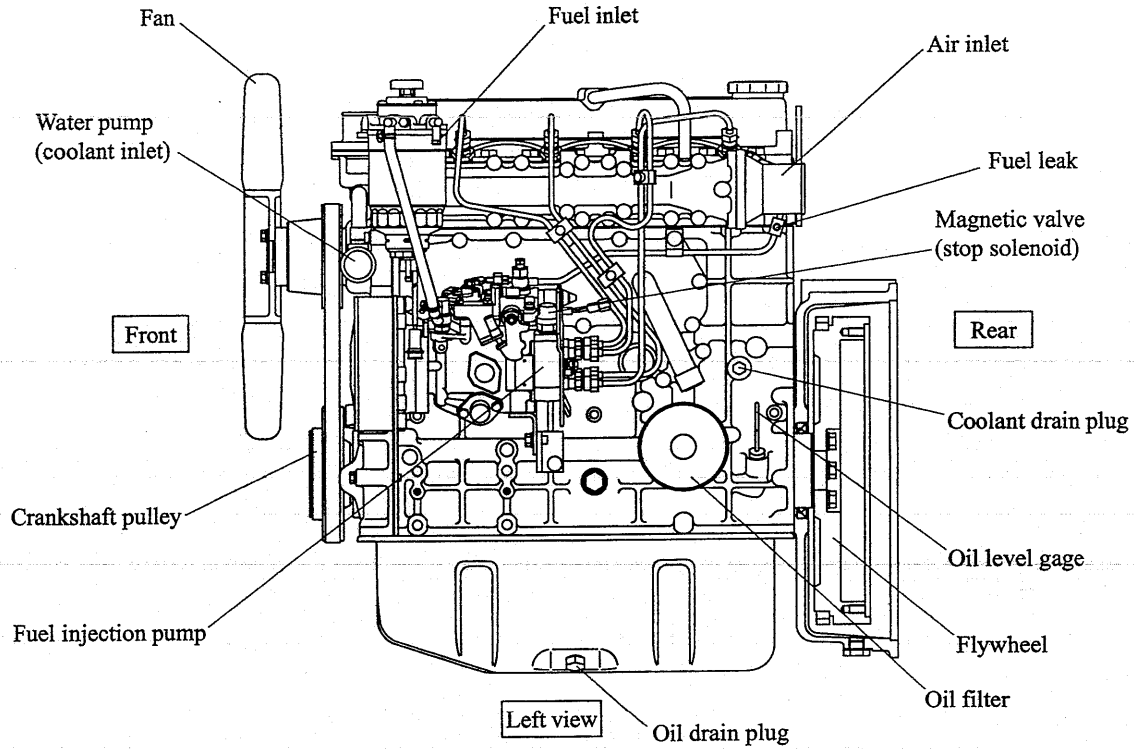


Left view of engine

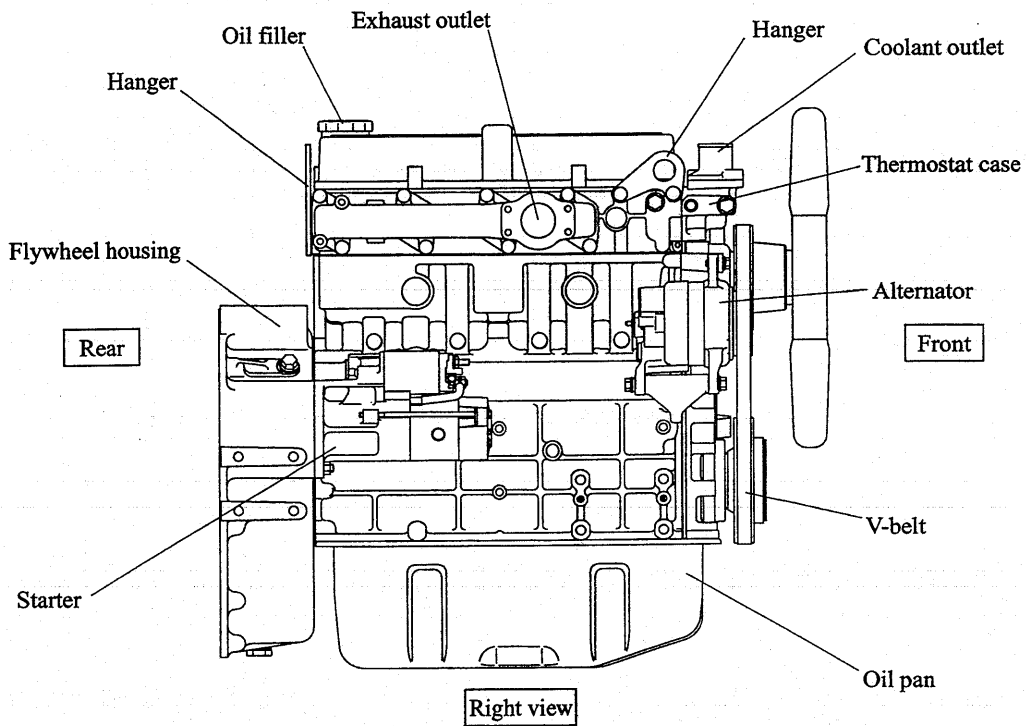


Right view of engine

(5) S4S distributor-type fuel injection pump specification



Left view of engine



Right view of engine

(6) S4S-DT distributor-type fuel injection pump specification

