OPERATION & MAINTENANCE MANUAL

MITSUBISHI DIESEL ENGINE

S12H

FEBRUARY 2001

MITSUBISHI HEAVY INDUSTRIES, LTD.

INTRODUCTION

Thank you for purchasing the S12H diesel engine.
This manual contains operation instructions as well as maintenance and inspection information.
We suggest that you carefully read and understand the information in this manual before operation to bring out the maximum performance from the engine and to ensure safety.
Do not hesitate to consult your Mitsubishi dealer should a question arise regarding the engine or the engine fail to operate properly.

Failure to follow the instructions and cautions in this manual can result in a serious accident.
Users and supervisors should read the manual carefully before operating the engine or conducting maintenance and inspection.
Do not operate the engine unless you have read and understood the instructions in this manual.

- Keep this manual readily available for easy reference.
- If this manual is damaged or misplaced, obtain a new copy immediately from your Mitsubishi dealer.
- Read and understand the basic items described in the SAFETY section before operating the engine or conducting maintenance and inspection.

Pub. No. 99260-03110

■ WARNING SIGNS

The following safety related signs are used in this manual to emphasize important and critical instructions.

⚠ DANGER — DANGER indicates an immediately hazardous situation which, if not avoided, will result in death or serious injury.

⚠ WARNING — WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION — CAUTION indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury and also property damage.

All safety items listed in this manual are important and should be observed closely.

■ Meaning of Symbols

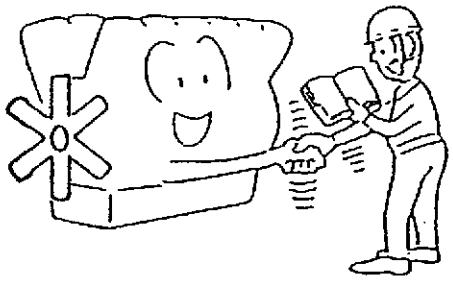
✓ ---------- Indicates a proper action.

⊘ ---------- Indicates a prohibited action.

■ Recommendation of Daily Operation Records

It is recommended to keep daily operation records every day. Daily recording is a preventive maintenance program and will serve as a guide for:

- Effective troubleshooting (to help a serviceman of your Mitsubishi dealer pin-point a problem).
- Quick servicing and less downtime (to help a serviceman of your Mitsubishi dealer save time and cost for servicing).
- Grasp of operating conditions (to help you recognize conditions, signs or indications of approaching trouble)



■ Items to be Recorded

The following items are recommended to be recorded once a day:

1. Operating hours (service hour meter reading)
2. The amount of oil and coolant (fresh water) required for refilling
3. Oil and coolant (fresh water) change intervals
4. Engine oil pressure, exhaust temperature, coolant temperature, and intake air pressure
5. Parts serviced, kinds of service (adjustment, repairs, or replacement) and results of service
6. Change in operating conditions (for example, "Exhaust smoke turned black," etc.)

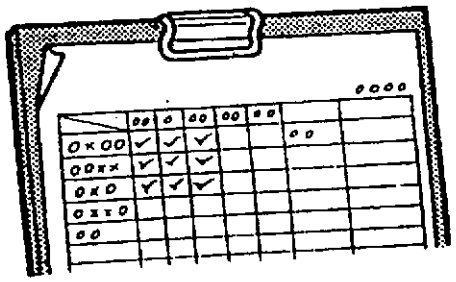


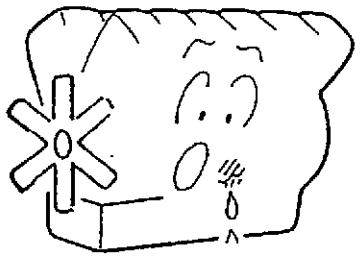
TABLE OF CONTENTS

DANGER Fire and Explosion Hazard

Keep flames away!
Do not use flames or smoke cigarettes at a site where fuel or oil is handled or a cleaning solvent is used for washing parts. Use drip pan to receive drained fuel and oil. Spilled fuel and oil should be wiped thoroughly. Do not use flames near the battery since it releases hydrogen gas which can ignite and explode.

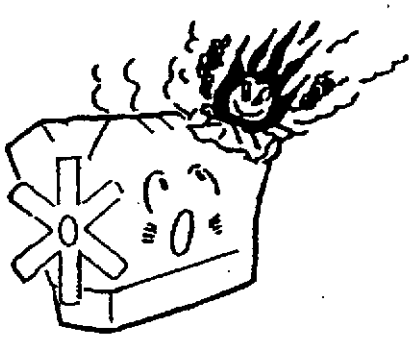
Do not refill fuel tank while engine is operating!
Stop the engine before adding fuel; otherwise it may cause a fire.

Check for fuel and oil leaks!
Regularly inspect fuel and oil pipes for damage and looseness. If a fuel or oil leak is found, repair the leakage immediately. Fuel or oil spilled on a hot surface of the engine can cause a fire and lead to personal injuries and equipment damage.



DANGER Fire Hazard

Keep flammable materials away!
The engine, muffler and exhaust gas become very hot. Keep flammable materials (oil, paper, explosive substances, etc.) away from the engine to prevent a fire.
The engine must be positioned at least 1 m [3.3 feet] away from buildings and other equipment to prevent a possible fire cause by engine heat.

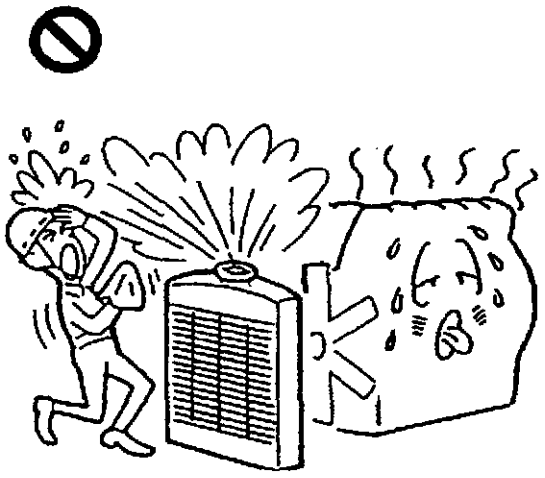


WARNING Burn Hazard

Remove radiator filler cap carefully!

Never open the radiator filler cap while the engine is operating or immediately after the engine is stopped.

The engine coolant is hot during engine operation and immediately after operation. If the radiator filler cap is opened when the coolant is at operating temperature, steam and hot coolant gushes out and can cause burns. Check coolant level only after engine has been stopped and filler cap is cool enough to touch with your bare hand. Muffle the cap with cloth and remove it slowly to relieve pressure. Also be sure to tighten the cap securely.

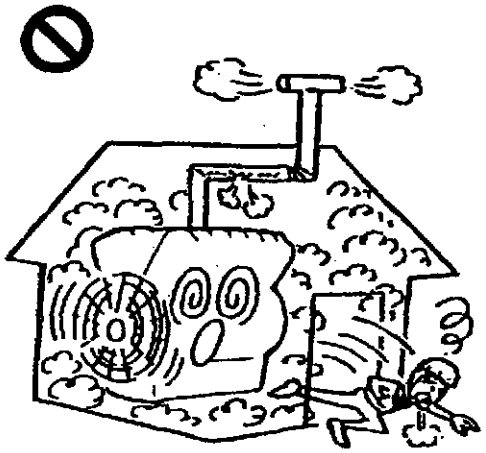


WARNING Exhaust Gas Poisoning

Operate engine only in a well-ventilated area!

Exhaust fumes contain carbon monoxide and other harmful substances.

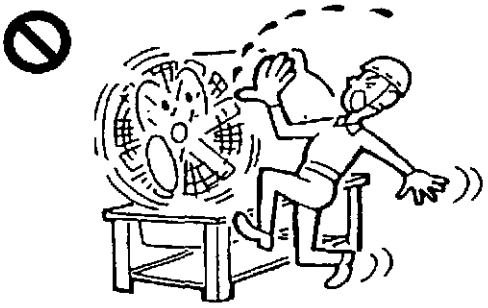
- Exhaust fumes can cause gas poisoning if the engine is operated in an enclosed area (inside a warehouse, tunnel, etc.) or in a site where all sides are blocked.
- If the engine must be operated in an enclosed area, provide adequate ventilation. When an exhaust duct is connected to the exhaust pipe to lead exhaust fumes to the outside, make sure exhaust gas does not leak from the duct joints.
- Make sure exhaust gas does not blow in the direction of plants or animals.



WARNING Injuries Hazard Moving Parts

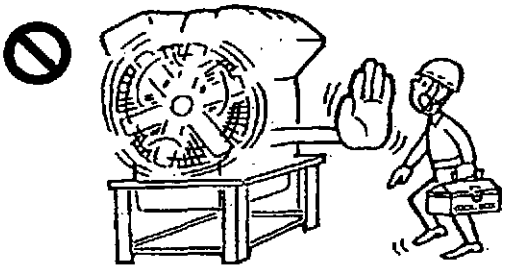
Stay clear of all rotating and moving parts while engine is operating!

Do not approach rotating and moving parts output shaft, flywheel, fan belts and pulleys of the engine while in operation. Entanglement by rotating parts can cause serious injury.



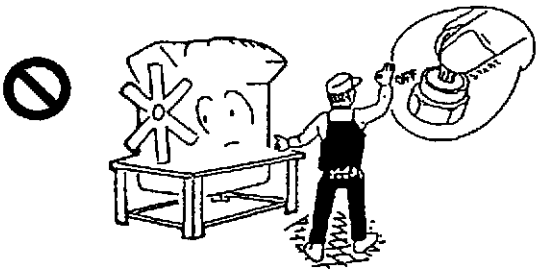
Preparations before maintenance and inspection!

Before conducting maintenance and inspection, remove the key from the starter switch and turn off the battery switch. Also attach a "Do Not Operate" sign or similar warning tag to the starter switch. Accidental operation of the engine while someone is conducting inspection or maintenance is extremely dangerous.



Check surrounding area for safety!

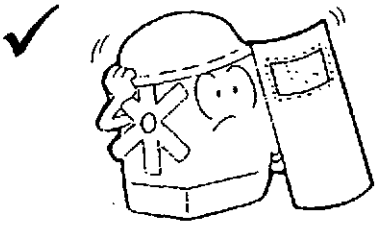
Before starting the engine, check to make sure no one is near the engine and tools are not left on or near the engine. In a loud voice, notify people in the area when starting the engine.



Install covers on rotating parts!

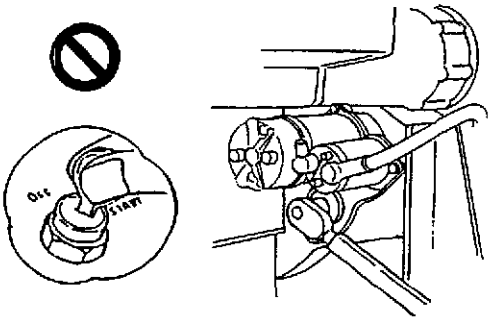
When the engine is coupled to equipment, install protective covers on the connecting belt and coupling.

Accidental operation of the engine while someone is conducting inspection or maintenance is extremely dangerous.



Remove turning tool after use!

Be sure to remove the turning tool used in maintenance and inspection. Starting the engine with the turning tool in position can cause personal injury and engine damage.

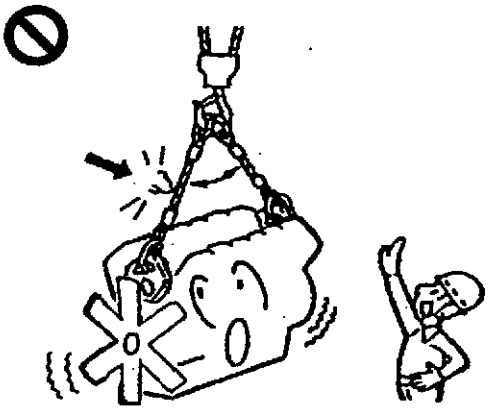


WARNING Lifting Precautions

Lift engine carefully!

To lift the engine with a crane, attach appropriate slings to the hangers provided on the engine. Never allow anyone to walk or stand under the suspended engine. Operate the crane slowly to prevent jerking. Exercise caution to prevent accidents.

Engine dry mass: Approx. 3900 kg [8598 lb]



CAUTION Cautions Regarding Battery

Service battery carefully!

Batteries release flammable hydrogen gas and oxygen. Never use flames near the battery since flames can cause an explosion.

- Wear safety goggles and rubber gloves when working with the battery (replenishment of fluid, charging, etc.)
- Do not use flames, smoke cigarettes or generate sparks near the battery.
- Before inspecting or servicing the battery, stop the engine and turn off the battery switch.
- Do not short the battery terminals with a tool or other metal object.
- When disconnecting battery cables, disconnect the cable from the negative (–) terminal first. When reconnecting cables, connect the cable to the positive (+) terminal first.
- Charge the battery in a well-ventilated area, with all 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, turn the battery switch to OFF or remove the cable from the negative (–) battery terminal to cut off the electric current.

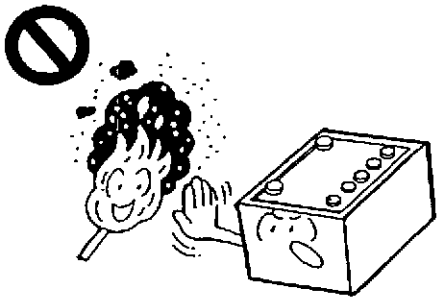
Be careful of damp ground and wet hands

Do not touch electric circuits with wet hand on damp ground.

Handle electrolyte (battery fluid) carefully!

Electrolytic contains dilute sulfuric acid. Careless handling of the battery can cause loss of sight and burns.

- The battery must be serviced under the guidance of a specialist or a person experienced in handling batteries.
- Do not use the battery when the fluid surface is lower than the minimum level. Using a battery with a low electrolyte level can result in an explosion.
- If electrolyte is spilled on skin or clothes, wash immediately with lots of water. Then, use soap to clean thoroughly.
- If electrolyte gets into your eyes, flush immediately with lots of fresh water and consult a physician as soon as possible.
- Should you accidentally swallow electrolyte, gargle with plenty of water, then drink lots of water. Consult a physician immediately.

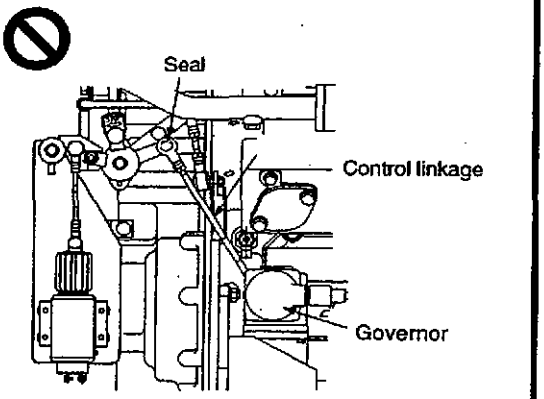


CAUTION Operating Precautions

Never break seals!

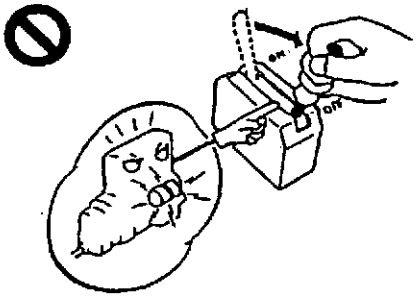
To ensure proper engine operation, the fuel control linkage is attached with seals that prevent an accidental change of the fuel injection volume and rotation speed control. Operating the engine without these seals in place can result in a serious equipment failure such as seizing and other engine damage.

- Early wear of moving or rotating parts
- Seizure of engine parts, breakage, or other damage
- High fuel or oil consumption
- Degradation in engine performance caused by improper balance between fuel-injection quantity and the governor



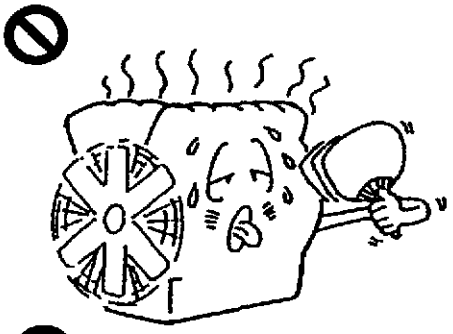
Do not turn off battery switch while engine is operating!

Do not turn off the battery switch when the engine is in operation. Turning off the battery switch while the engine is in operation not only causes malfunctioning of instruments but also deteriorates the diodes and transistors in the alternator.



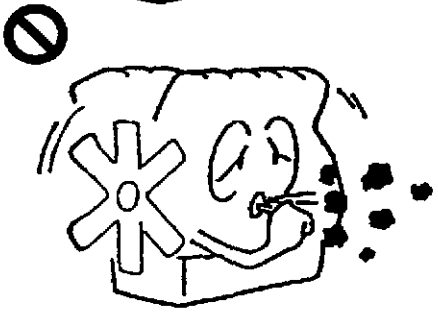
Always keep engine room well ventilated!

Provide adequate ventilation in the engine room. If air supplied to the engine room is restricted, the room temperature increases and can affect engine output and performance.



Never operate engine under overload condition!

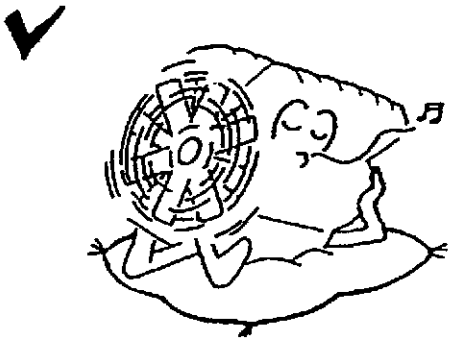
Do not operate the engine if exhaust smoke is black. Overloading the engine (indicated by black smoke) not only causes high fuel consumption but also excessive carbon deposits inside the engine, thus it can reduce the service life of the engine.



CAUTION Operating Precautions

Be sure to break in engine!

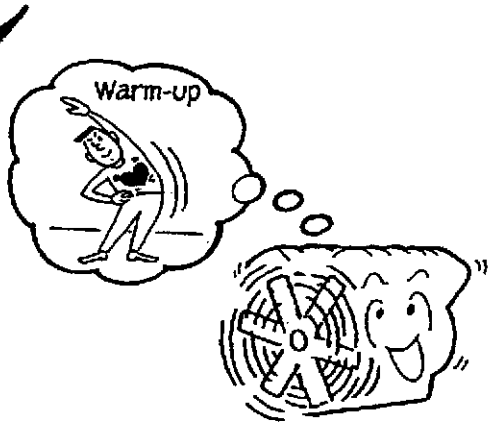
During the first 50 hours of operation, break in the engine by operating it with light load and at lower speed than normal.
Operating the engine under high load or severe conditions during the break-in period can shorten the service life of the engine.



Warm up engine before use!

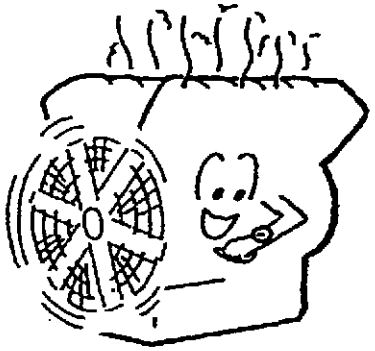
Let the engine idle for 5 to 10 minutes before using the engine for work.
Warm-up operation circulates lubricants in the engine and contributes to a longer service life and economical operation.

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



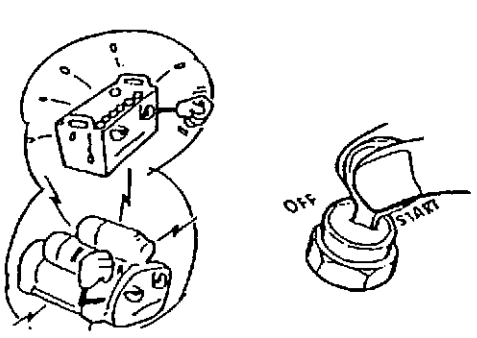
Stop engine after cooling operation!

Before stopping the engine, let it operate at low idle speed for 5 to 6 minutes for cooling operation.
Stopping the engine immediately after operation under overload operation can cause engine parts to heat up and cause adverse effects on a longer service life.
During cooling operation, check the engine for abnormalities.



Do not operate starter for prolonged time!

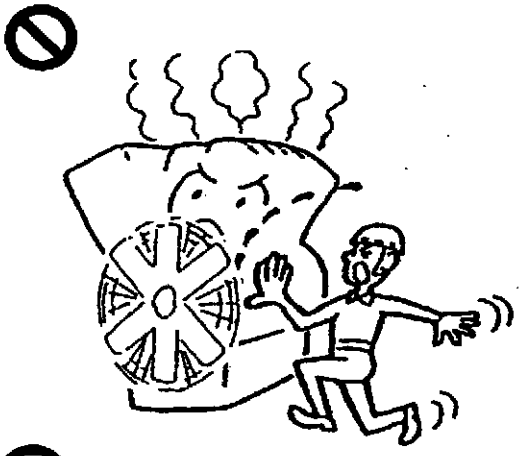
Do not use the starter for more than 10 seconds at a time. When the engine does not start, wait for more than 30 seconds before cranking again. A long and continuous operation of the starter drains the battery power, and it can also burn the starter.



CAUTION Operating Precautions

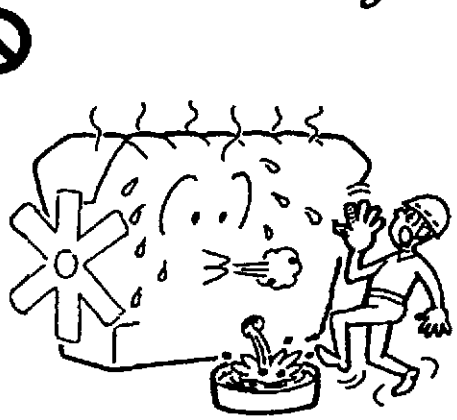
Do not touch engine during operation or immediately after operation!

Do not touch any part of the engine while it is operating or immediately after it is stopped. A hot engine can cause burns.
When conducting maintenance and inspection, wait until the engine cools.



Stay clear of spurting fuel!

Fuel is pressurized in pipes. If you touch spurting fuel, it can penetrate your skin and cause serious injury. To search for suspected fuel leaks, which are sometimes hard to see, use cardboard or wooden board, instead of hands.

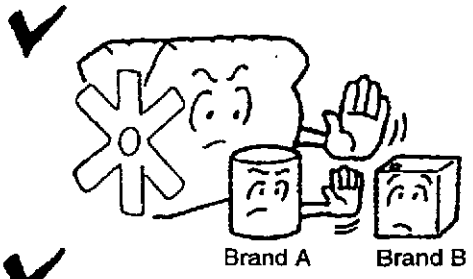


Wear ear plugs!

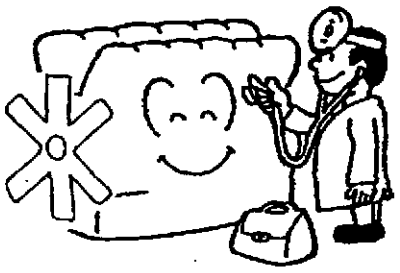
When entering into the engine room, make sure to wear ear plugs to protect your ear from engine noise that may be injurious to hearing.

CAUTION Maintenance Precautions

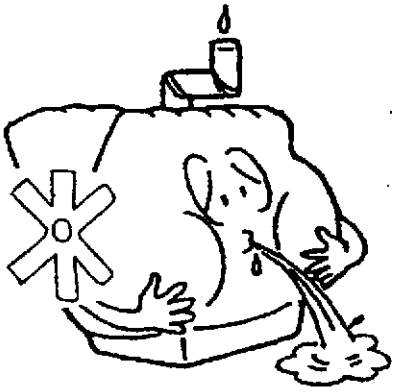
Use only recommended fuel, oil and coolant!
Use fuel, oil and coolant specified in this manual, and handle them carefully. Use of any other fuel, oil or coolant and improper handling can cause various engine problems as well as serious accidents.



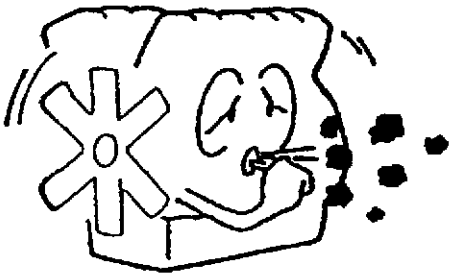
Perform all specified pre-start inspection and periodic inspection!
Conduct the pre-start inspection and periodic inspection as specified in this manual. Failure to conduct an inspection can cause various engine problems and parts damage as well as serious accidents.

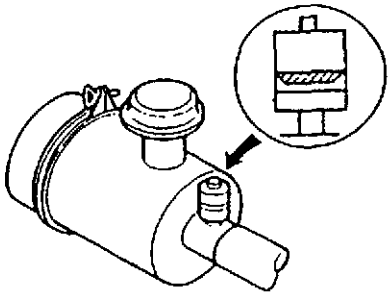


Keep water out of engine!
Do not allow rain or other water to enter the engine through the air inlet and exhaust openings. Do not wash the engine while it is operating, since the operating engine can suck water or a cleaning agent. If the engine is started with water inside the combustion chambers, water hammer action can damage the engine and result in serious accidents.



Exercise caution during maintenance of air cleaner!
Excessive wear of engine parts is caused primarily by dust entering with air. Worn parts can cause increased oil consumption, reduced output and difficulty in startup. To ensure proper dust removing performance of the filter, observe the following cautions during the maintenance of the air cleaner.
Do not conduct maintenance on the air cleaner while the engine is operating.
When removing the air cleaner element, be careful not to allow dust on the filter element to enter the air clear outlet.
If a dust indicator is provided, conduct maintenance only when the indicator shows clogging. Conducting unnecessary maintenance can increase the chance of dust entering the engine during the removal and reinstallation of the filter element and also the possibility of damaging or deforming the element.

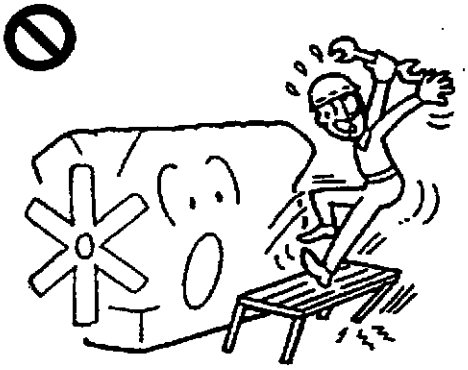




CAUTION · Maintenance Precautions

Always watch your footing!

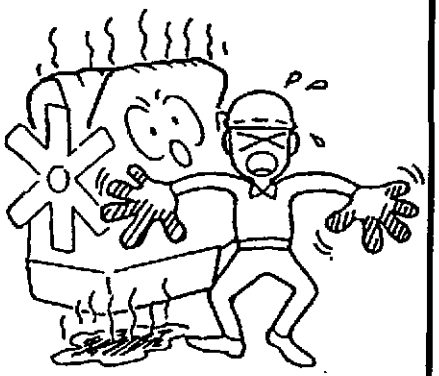
Use a stable work platform to work on the upper part of the engine and other hard-to-reach places. Standing on an old unused stand or parts box can cause personal injury.



Do not touch engine during operation or immediately after operation!

Do not touch any part of the engine while it is operating or immediately after it is shut down. A hot engine can cause burns.

When conducting maintenance and inspection, wait until the engine cools.

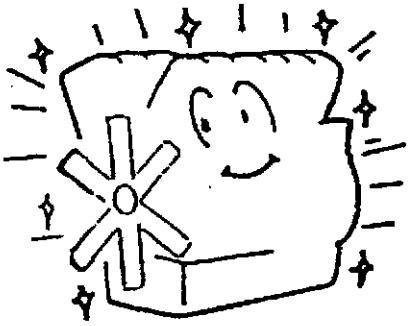


Do not short electrical wires!

- Disconnect the ground cable from the negative (–) battery terminal before inspecting or servicing any electrical component to prevent short-circuit.
- Loose or damaged cables and wires can cause shorting that may lead to a fire. Inspect cables and wires before operating the engine. Repair or replace damaged cables and wires. Also remove dust buildup from terminals and connections.

Keep engine and surrounding area clean!

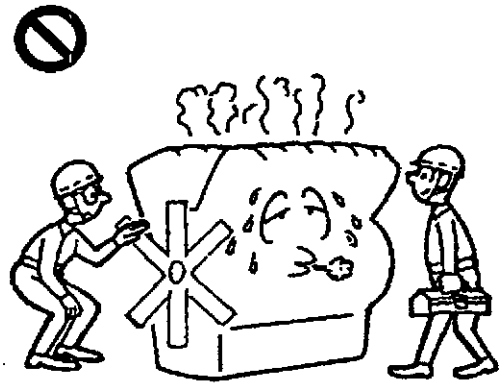
Keep the engine free of dust, dirt and foreign materials, since they can cause a fire or engine overheating.



CAUTION Maintenance Precautions

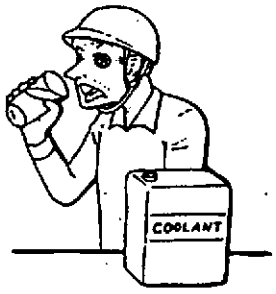
Cautions in checking and adding oil, fuel and coolant!

Be sure to stop the engine before adding or changing oil, coolant or fuel. Check or add coolant after the engine cools. The coolant is hot immediately after the engine stops.
Do not attempt to adjust the V-belts tension while the engine is operating.
Make sure not to take the above mentioned transactions, if not avoided, will results in fire, burn or serious injury caused by entanglement of rotating parts.



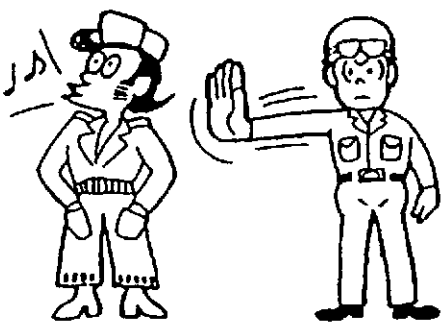
Handle antifreeze with caution!

- Antifreeze contains alkali. Avoid accidentally swallow the coolant or contact with eyes to prevent personal injury.
- Drain coolant only after the engine has been stopped and the drain plug is cool enough to touch with your hand.
- Dispose of drained material according to local regulations. For disposal, consult your dealer.



Wear protective gear!

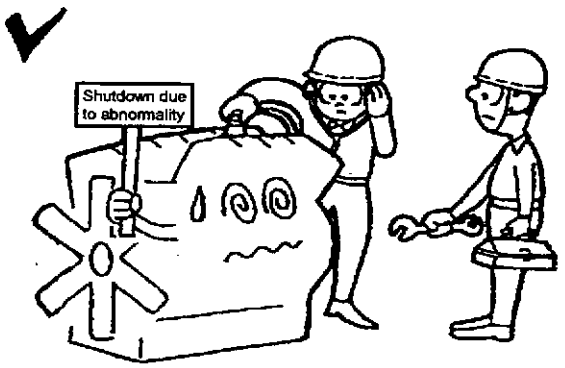
Wear protective gear such as a hard hat, face shield, work clothes, safety shoes, dust protective mask. Be sure to wear safety goggles and other protective devices when handling compressed air which can be a cause personal injury.



CAUTION Cautions Regarding Equipments Problems

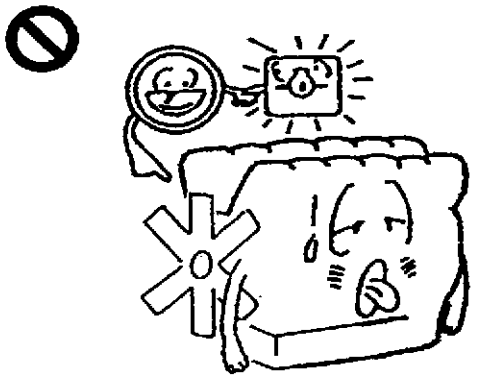
If engine stops due to an abnormality, exercise caution when restarting!

Do not restart the engine immediately after it stops due to an abnormality. If an alarm is generated when the engine stops, find out the cause of the problem and correct the problem before restarting the engine.
Continuing engine operation without correcting the problem can result in a serious problem.



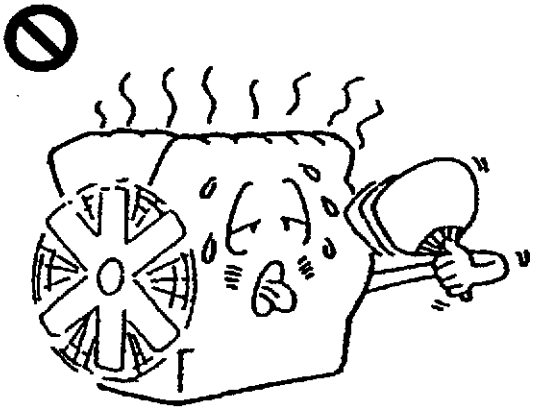
If oil pressure drops!

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



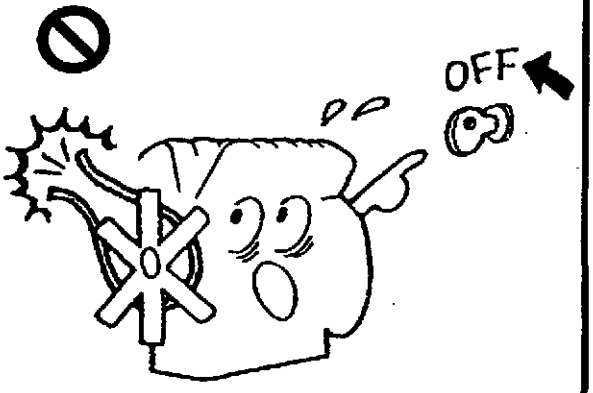
If engine overheats!

If the engine overheats, do not stop the engine immediately. Stopping an overheated engine suddenly can result in a rise of the coolant temperature that may cause seizing of moving parts. If the engine overheats, operate it at low idle speed for a while to cool the engine before shutting down.
Do not add coolant immediately after stopping the engine. Adding coolant to a hot engine can cause cylinder head damage due to a sudden change in temperature. Add coolant gradually after the engine reaches room temperature.

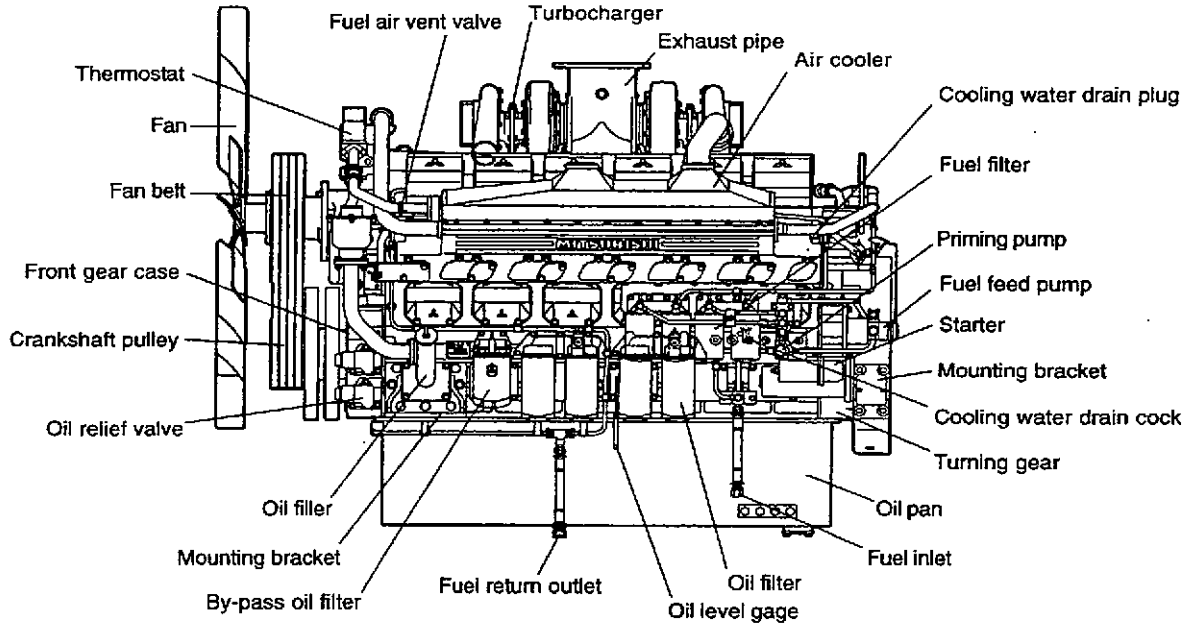


If the V-belt breaks!

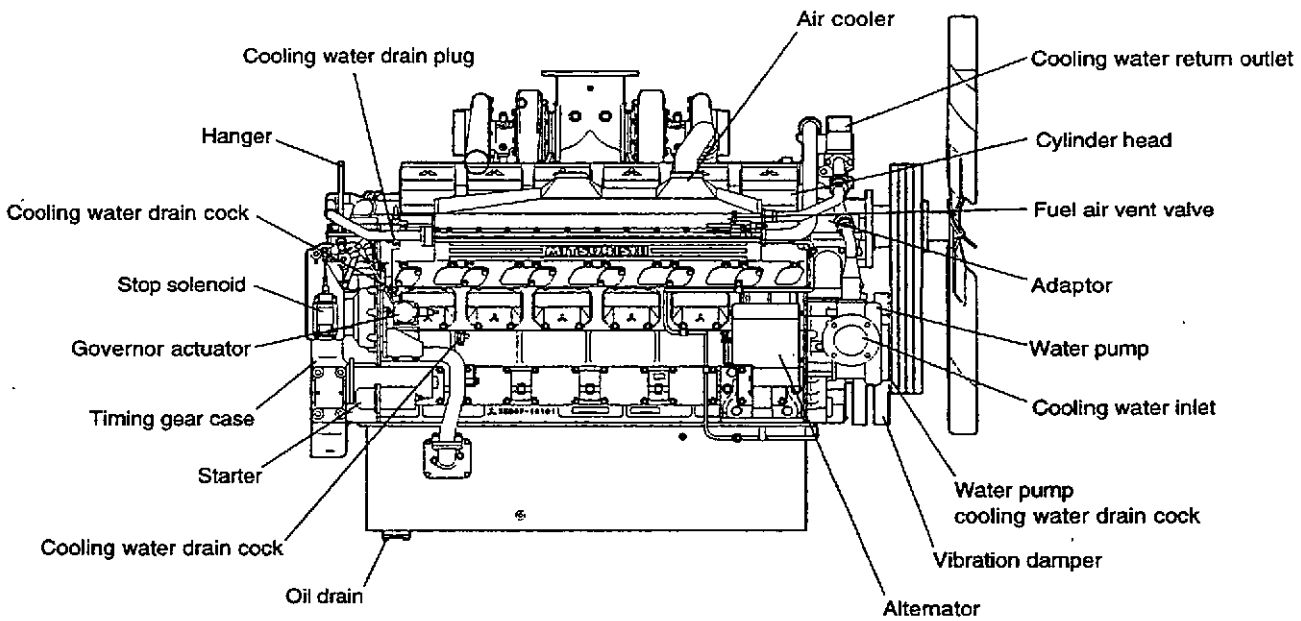
If the V-belt breaks, stop the engine immediately. Continuing engine operation without the V-belt can cause vaporized coolant to gush out from the reservoir and radiator, thus causing engine overheating as well as burns.



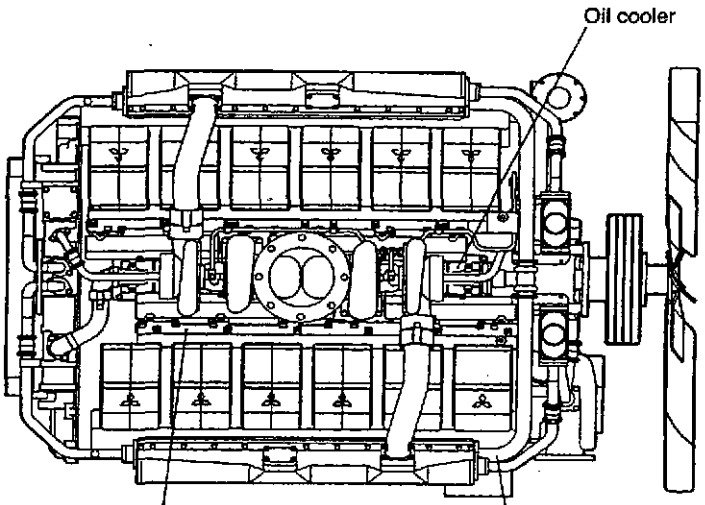
NAME OF PARTS



Left view



Right view



Top view

[Starting and Shutdown Devices]

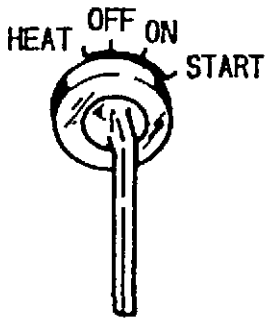
Starter Switch

HEAT (Preheating) — When the ambient temperature is low, turn the key to the HEAT position to preheat the air heater for easy engine startup. (Air-heater-equipped starting system)

OFF — Turn the key to the OFF position when removing the key. When the switch is in this position, the entire electrical system is turned off. To stop engine operation, turn the key to this position.

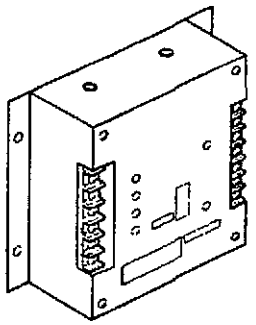
ON — Set the switch to this position, after the engine starts.

START — When the key is turned to the START position, the engine cranks and starts. When the key is released, the switch automatically returns to the ON position.



Speed Controller (Electrical Governor)

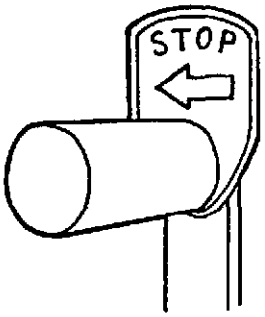
(The engine rotating speed is properly adjusted at the factory, then adjustment of the speed controller dial should be handled only by your dealer.)



Manual Stop Lever

By pulling the lever in the "STOP" direction, you can stop the engine. Use this lever in an emergency. If you cannot stop the engine with the starter switch, use this lever to stop the engine.

Notice: If the engine cannot be stopped with this lever, shut off the supply of fuel.

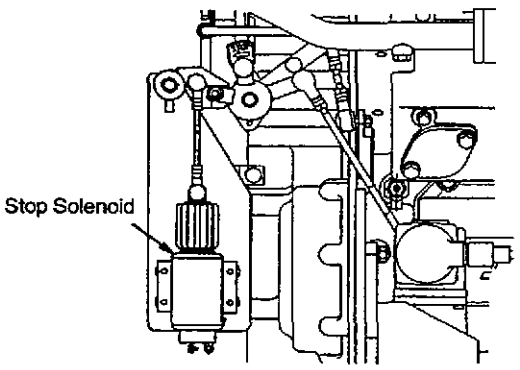


Stop Solenoid

The stop solenoid moves the rack of the fuel-injection pump to the non-injection position to stop the engine.

The stop solenoid, when de-energized, stops the engine.

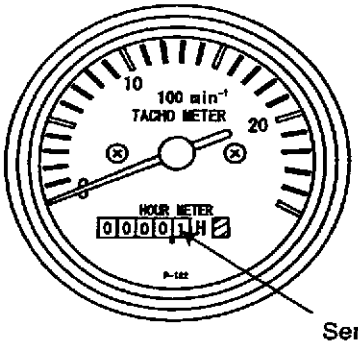
To stop the engine, press the stop button or turn the starter switch to the "OFF" position.



[Instruments]

The instruments monitor the status of the engine during operation. Check each reading during normal operating conditions. If a reading significantly deviates from the normal position, an unusual event may have occurred.

Tachometer

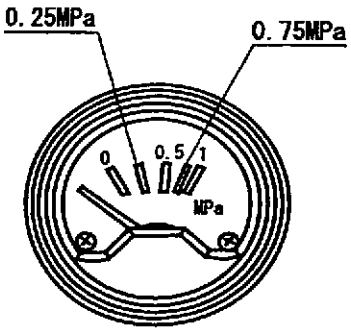


Tachometer
This indicates the engine speed.

Service Meter
This indicator shows cumulative engine operating hours.
Use the meter indication as a guideline for determining the need for regular inspection and servicing.

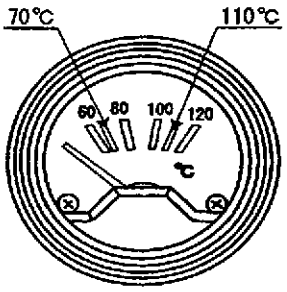
Oil Pressure Gage
This indicates the engine oil pressure.
The reading will be maximum immediately after the engine starts.
After the engine has been warmed up, the reading will be 0.39 to 0.69 MPa (4 to 7 kgf/cm²) [57 to 100 psi]. (When using oil with a viscosity rating of SAE30.)
The reading will be lower at low-idle speed than at the rated speed.
If the reading is lower than 0.29 MPa (3 kgf/cm²) [43 psi] at the rated speed, or if it is lower than 0.10 MPa (1 kgf/cm²) [14 psi] at low-idle speed, stop the engine and check for the cause. Make sure to complete necessary repairs before starting the engine again.

Oil pressure gage



Coolant Temperature Gage
This indicates the temperature of the coolant.
Normally, the reading will be 70 to 90°C [158 to 194°F] at an ambient temperature of 20 to 30°C [68 to 86°F].

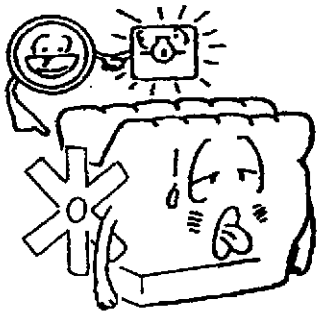
Coolant temperature gage



[Protective Devices]

Low Oil Pressure Alarm Light

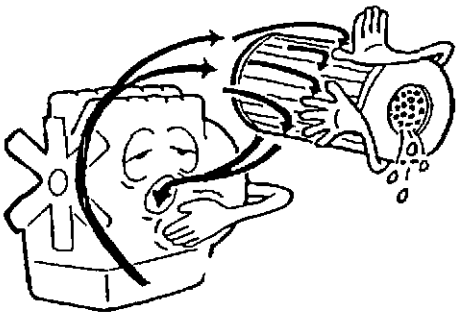
This alarm sounds when the oil pressure is lower than 0.29 MPa (3 kgf/cm²) [43 psi] at an engine speed higher than 1500 min⁻¹. In the entire speed range, the alarm sounds when the oil pressure is lower than 0.15±0.02 MPa (1.5±0.2 kgf/cm²) [21±2.8 psi].
The engine will come to a stop on some models.



Oil Filter Alarm Light

This light comes ON when the difference in pressure across the oil filter is greater than $0.15^{+0.03}_{0}$ MPa ($1.5^{+0.3}_{0}$ kgf/cm²) [21^{+4}_{0} psi]. When the light comes ON, immediately replace the oil filter.

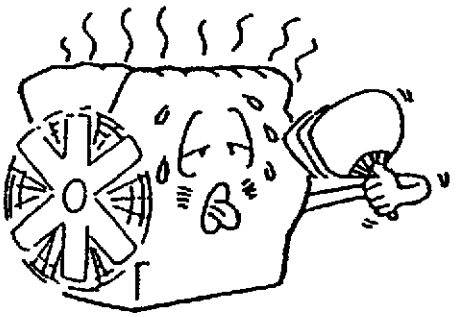
Notice: Change the engine oil when replacing the oil filter.



High Coolant Temperature Alarm Light

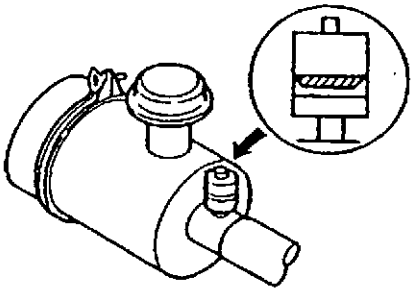
When the coolant temperature increases to 101°C [213.8°F] at the inlet side of the radiator, this alarm will light on. If the alarm system is turned on, run the engine for 5 to 6 minutes at low idle to let it cool gradually, and then stop the engine to check the cooling system.

Notice: The setting value varies depending on the specification of the engine.



Air Cleaner Indicator

If the air cleaner becomes clogged, the indicator shows a red signal (at indicator differential pressure of 84 kPa (635 mmH₂O)). When this signal appears, clean the air cleaner element immediately.
After installation of the cleaned element, press the button at the top of the indicator to reset the piston in the indicator.



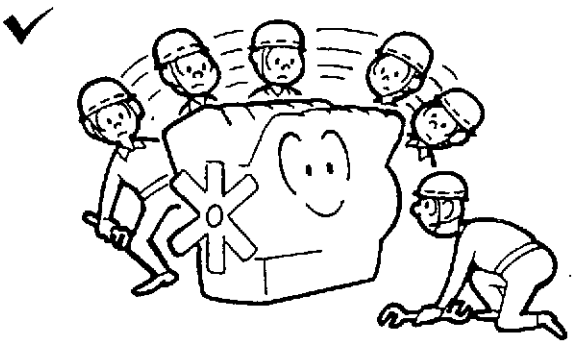
[New Engine Initial Service]

Before starting for the first time a new or reconditioned engine or an engine that has been stored or left standing for any length of time, give it an initial inspection for your own safety and maximum service life of the engine. When operating the engine for the second time or thereafter, give it an inspection as outlined under the topic **[Pre-Start Inspection]**.

External Inspection

Check points mentioned below from external inspection.

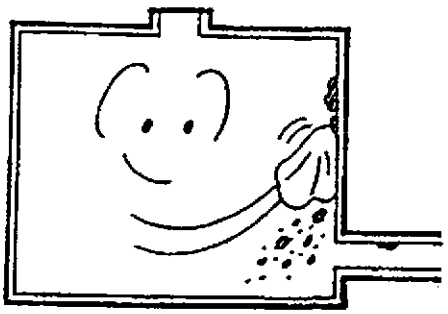
- Check the electrical system for loose terminals.
- Check defects of engine parts.
- Check the following components for loose bolts or nuts:
  - Crankshaft pulley and damper
  - Mounting brackets
  - Fuel control link
  - Cylinder heads
  - Exhaust manifolds
  - Turbocharger
  - Timing gear case
  - Front Gear Case
  - Adaptor



Fuel System

Fill the fuel tank

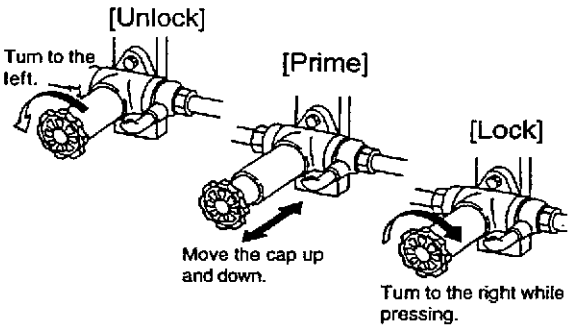
Before filling the fuel tank, put some amount of fuel in the tank, and disconnect the fuel pipe from the engine inlet and remove the drain plug from the tank to drain off the fuel. Check the drained fuel for dirt or water. After making sure the tank is clean, connect the fuel pipe and tighten the drain plug and fill the tank properly.



Prime the fuel system

⚠ WARNING

- **Thoroughly wipe overflowing fuel from the air vent plug with a cloth, since spilled fuel can cause a fire.**
- **After the priming, lock the priming pump cap securely. If the cap is not locked properly, the pump may suffer damage and leak fuel. Fuel leakage is a fire hazard. Be sure to lock the cap according to the procedures outlined on the next page.**



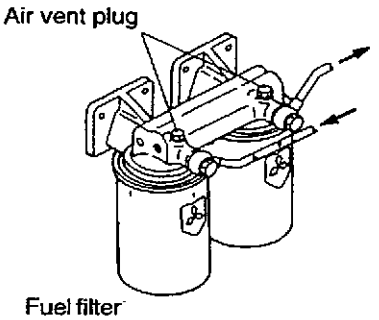
Priming pump

Prime the fuel filters and fuel return pipe in the following sequence.

- **Fuel filter**

1. Loosen the air vent plug on the fuel filter about 1.5 turns.
2. Turn the priming pump plunger to the left to unlock it, and move it up and down.
3. Operate the plunger until the fuel flows free of bubbles from the vent. Tighten the air-vent plug.
4. Prime both the right and left fuel filter simultaneously.

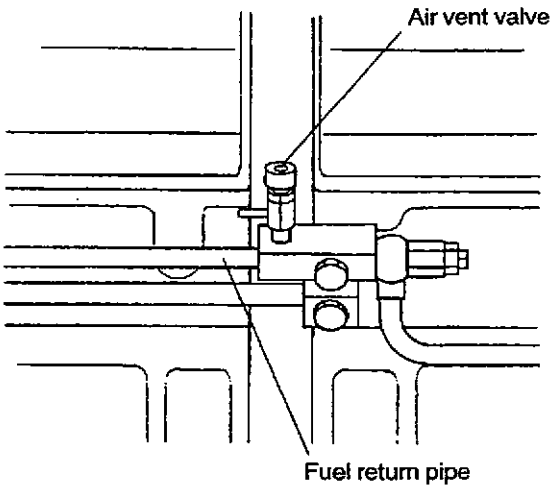
Notice: Prime the dual-cartridge-type fuel filter according to the instruction on the caution plate.



- **Fuel return pipe**

1. Loosen the air vent cock on the fuel injection pump about 1.5 turns (Installed lock nut).
2. Move the priming pump cap up and down.
3. After fuel showing no visible bubbles come out from the air vent cock, tighten the cock. Just before tightening the air vent cock, lock the priming pump cap while holding it down.
4. Then, tighten the air vent cock.

Notice: There are two air vent plugs for the fuel return pipes, one on the front side and the other on the rear side of each bank.



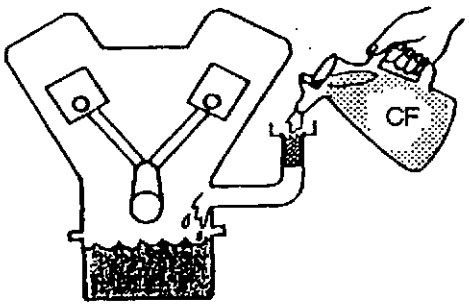
Lubrication System

Fill the oil pan

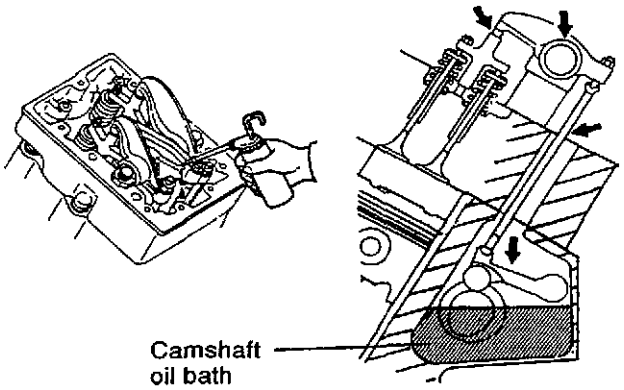
1. Remove the crankcase filler cap and fill with recommended oil.

Refill capacity, oil pan (whole engine)	**Standard engine** Approx. 180 liters [48 U.S. gallons] Whole engine: approx. 200 liters [53 U.S. gallons]
Recommended oil	Oils that meet Engine Service Classification CF (API Service Classification)

(API: American Petroleum Institute)



2. Remove the rocker cover. Lubricate the valve mechanism and fill the camshaft oil bath from the cylinder head. (Approx. 800cm^3 to each cylinder)



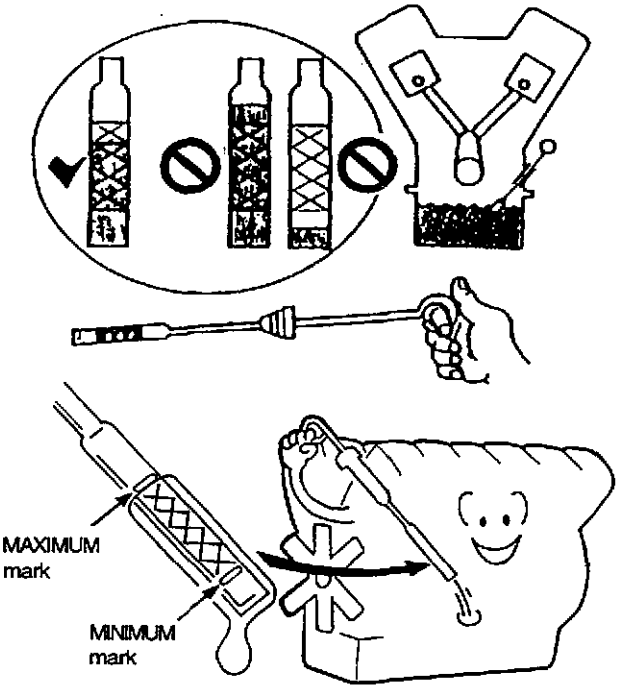
3. Check the oil level in the oil pan with an oil level gage. The oil level should be between the MAXIMUM and MINIMUM marks on the dipstick. Add oil if necessary.

4. Check the oil pan and related parts for oil leaks.

5. Crank the engine with the fuel supply shut off to make sure the oil pressure rises properly.

Notice: Crank the engine for 10 seconds. If the pressure does not rise within 10 seconds, wait one minute before cranking it again. When cranking or operating the engine, see the topic, "Cooling System" which comes in the following page.

6. Start the engine and operate it for about 10 minutes. Stop the engine and add oil until the oil level reaches to the MAXIMUM mark.

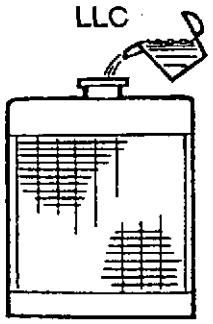


Cooling System

Fill the radiator

1. Close the engine and water pump drain cocks and tighten the radiator drain plug.
2. Remove the cap from the radiator tank and pour in pure, undiluted LLC.

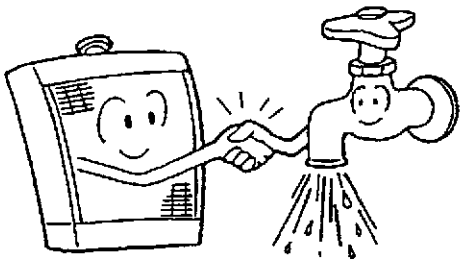
For concentration of LLC, see the chart below.



Recommended LLC Concentrations

Ambient temperature °C [°F]	-10 [14]	-20 [-4]	-30 [-22]	-40 [-40]
LLC concentration %	30	40	50	60

3. Add water (which is soft, or as free as possible from scale-forming minerals) to the radiator slowly to avoid trapped air in the cooling system.

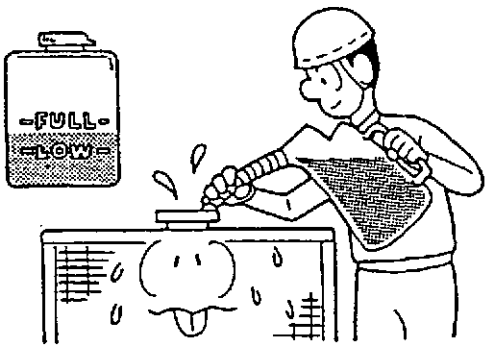


4. After filling up the tank, tighten the radiator tank cap securely. Crank the engine with the starter several times, for 10 seconds each time, at intervals of about one minute, to bleed air out of the fresh water pump.

⚠ CAUTION

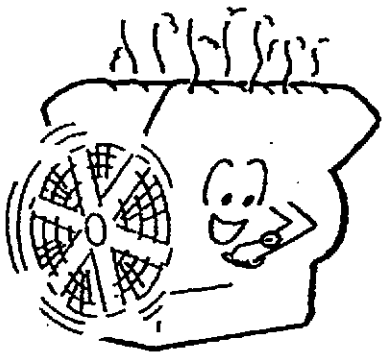
With the fuel supply shut off (the manual stop lever being pulled), crank the engine with the starter.

Notice: When cranking or operating the engine, see the topic, "Lubricant System" which is in the previous page.



5. Check the coolant level in the radiator and add coolant if necessary. If a reserve tank is equipped, add same concentration of coolant (a mixture of fresh water and LLC) to it up to the FULL mark level.

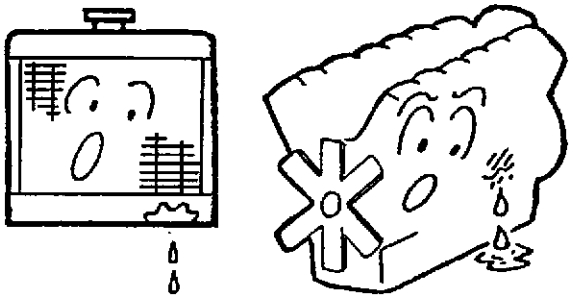
6. Start the engine and run it under light load until the thermostat valve-opening temperature is reached to mix LLC with water in the system.



7. Stop the engine and check the coolant level in the radiator tank. If the level is low, add coolant until the tank is full.

Notice: When adding coolant, maintain the specified concentration of LLC.

8. Check the hose joints to make sure they are free of coolant leaks.



Electrical System

Inspection of battery fluid level and specific gravity

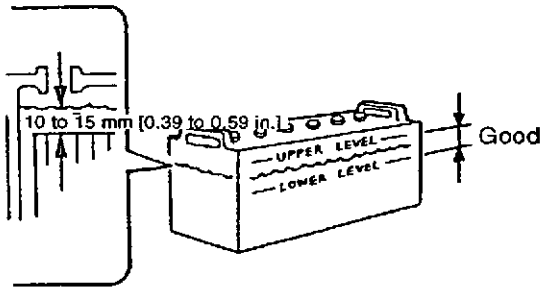
⚠ WARNING

- **If battery fluid splashes on the eyes, skin or clothes, wash immediately with plenty of water. If battery fluid enters the eyes, wash immediately with water and see a physician.**
- **Do not bring flames near the battery. When handling the battery, be careful of sparks generated by accidental shorting.**

● Battery fluid level

Battery fluid evaporates during use and the fluid level gradually decreases. The fluid surface should be between the LOWER LEVEL and UPPER LEVEL lines. If there are no level lines on the battery, make sure that the fluid surface is about 10 to 15 mm [0.39 to 0.59 in.] above the top edges of the plates. If the fluid level is lower, remove the caps and add distilled water to the proper level.

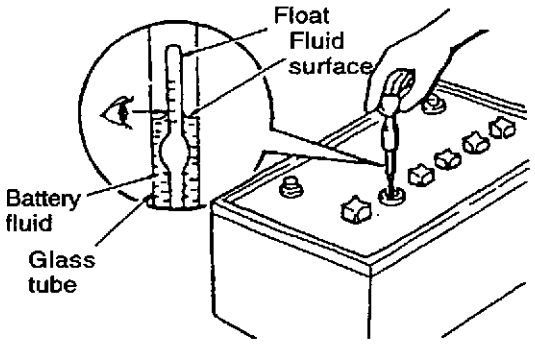
Notice: When pouring fresh battery fluid, pour the fluid carefully.



● Specific gravity of battery fluid

Check the specific gravity of the battery fluid. If the specific gravity measured at 20°C [68°F] is lower than 1.22, then charge the battery.

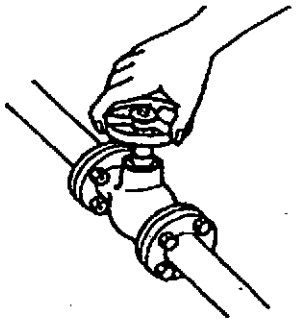
Specific gravity (at 20°C [68°F])	Condition	Remedy
From 1.26 to 1.28	Fully charged	—
From 1.22 to 1.25	Charged	Charge
Less than 1.22	Discharged	Charge



Valves and Plugs

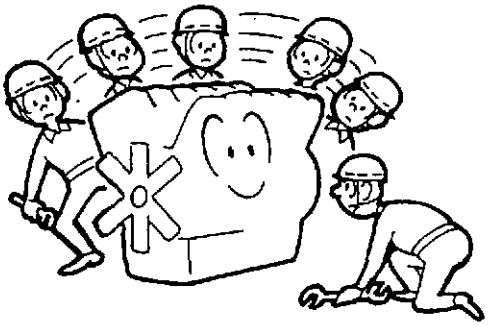
Make sure the following valves and plugs are open or closed properly:

Fuel supply valve ..... Open
Coolant drain plug (radiator) ..... Closed
Coolant drain plug (engine) ..... Closed
Coolant drain cock (water pump) ..... Closed
Oil drain plug ..... Closed
Air supply valve (air tank) ..... Open



Electrical Wiring

Check for loose or damaged terminals or connectors.

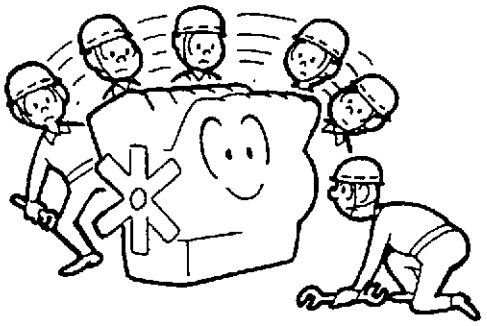


[Preparations before Operation (Pre-start Inspection)]

External Inspection

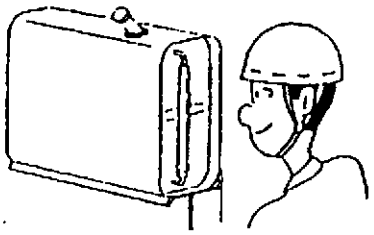
Look around and under the engine for:

- Loose bolts or nuts
- Fuel, oil, coolant, or air leaks
- Faulty electrical wiring or loose pipe connection
- Properly functioning of the instruments



Checking Fuel Level

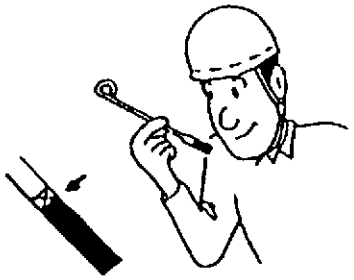
Make sure the fuel tank is full.



Checking Engine Oil Level

When the oil on the oil level gage is between the MAXIMUM and MINIMUM lines, the oil volume is normal. If the oil level is below the MINIMUM line, add specified oil.

Notice: Wipe oil from the oil level gage and insert the gage again to check the oil level.



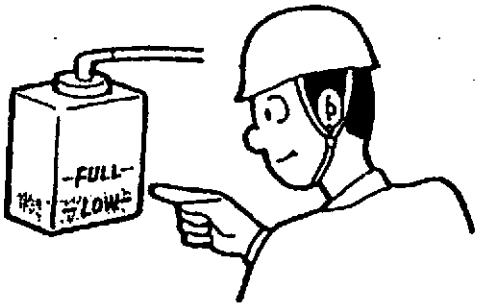
Checking Coolant Level

⚠ WARNING

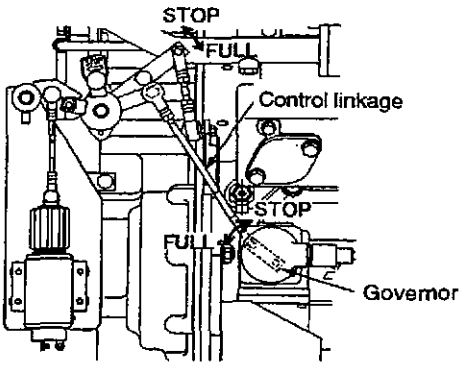
Check the coolant level only after the engine has been stopped and the radiator filler cap is cool enough to touch with your bare hand. Otherwise, hot water will blow out and burn you.

Remove the radiator filler cap and make sure the coolant surface is up to the filler mouth. If the engine is equipped with a reservoir, make sure the coolant surface is close to the FULL line.
If the coolant level is low, add coolant to the FULL line.

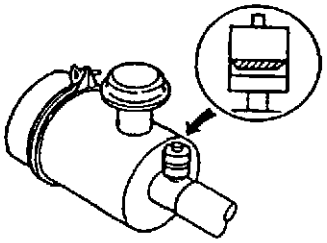
Notice: Coolant to be added should have the same LLC concentration as the coolant in the engine. Do not add plain water.



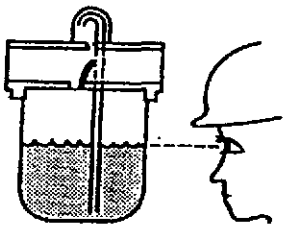
Checking the Fuel-Control Linkage
Make sure that the fuel-control linkage moves smoothly.
Check for slack or looseness in the ball joint.



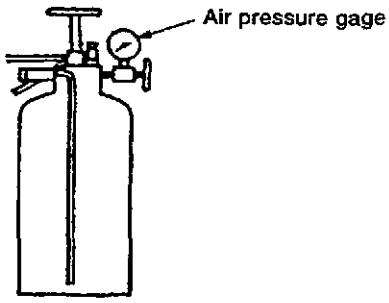
Checking the Air Cleaner Indicator
If a red signal appears during operation, clean the air cleaner element.



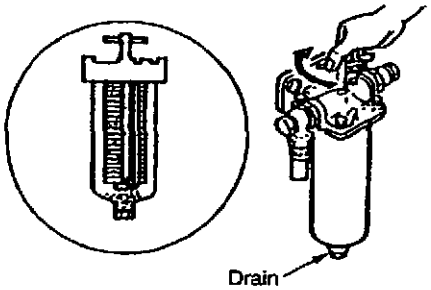
Checking Oil Level in the Oiler (Air Motor System)
Check to make sure the oil surface is at the UPPER LEVEL line. If the level is low, add turbine oil (viscosity: ISO VG32).



Checking Air Pressure of the Air Tank (Air Motor System)
Before starting the engine, make sure that the air pressure gage is at the specified pressure.
Air pressure: 0.98 MPa (10 kgf/cm^2) [142.3 psi]
Notice: Make sure not to exceed 1.03 MPa (10.5 kgf/cm^2) [149.4 psi], for the safety of Air Starter.



Turning of the primary fuel filter
Turn the handle for 4-5 rounds (clockwise) to clean the element.
Remove a drain plug at bottom of a case for draining water from the filter.



[Starting]

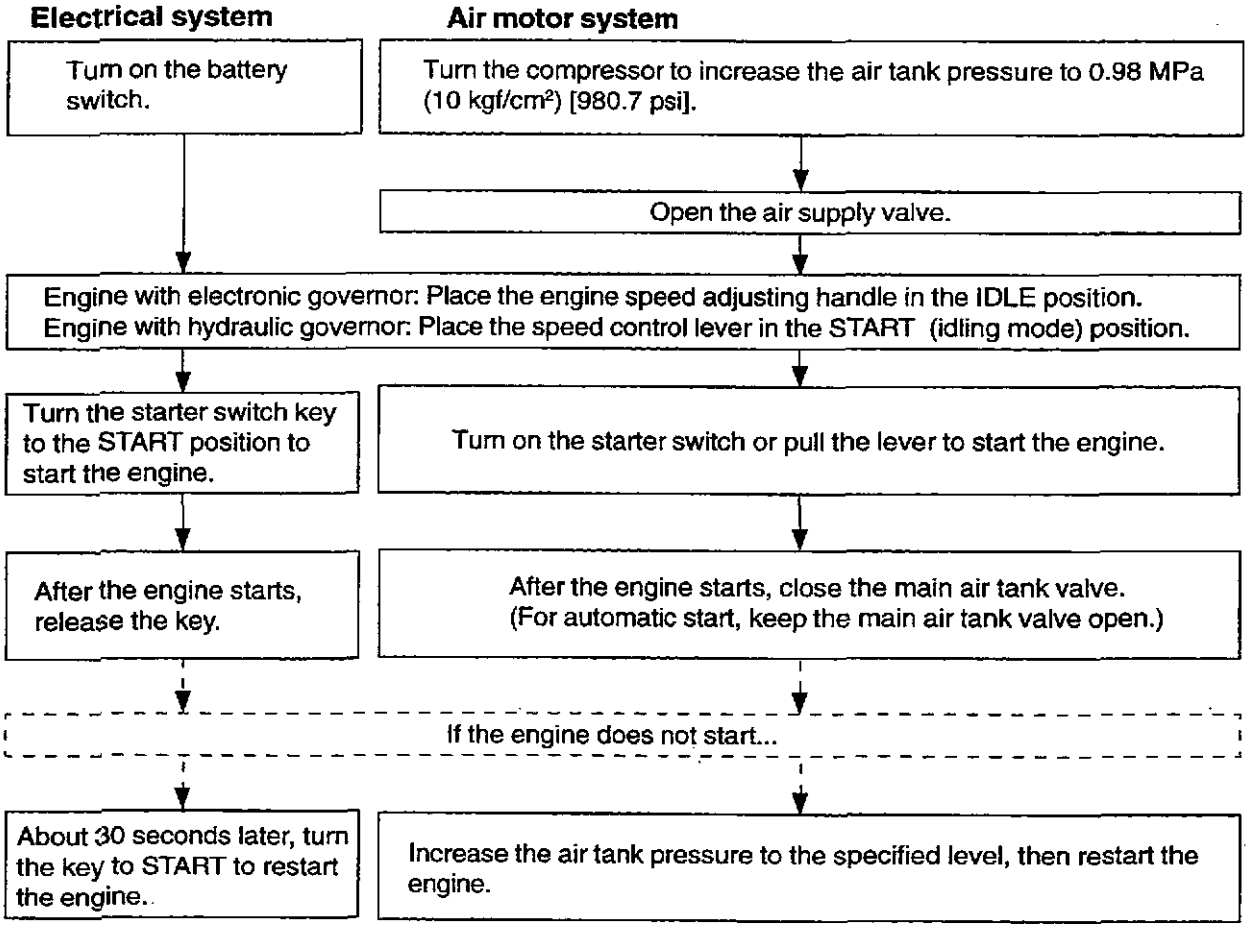
⚠ WARNING

Before starting the engine, make sure no one is near the engine and tools are not left on or near the engine. In a loud voice, notify people in the area when starting the engine.

⚠ CAUTION

- **Do not turn the starter switch key to the START position for more than 10 seconds, which can drain the battery power or give damage to the battery.**
- **Keep the starter switch in the [ON] position during operation. Never set the starter switch and battery switch to the [OFF] position.**
- **In the case of the air motor system, open the drain cock of the air tank once every 50 service hours or every month to remove water.**
- **During startup, do not apply load to the engine. (If the engine is equipped with a clutch, disengage the clutch.)**

There are two methods to start up the engine, one is electrical system and the other is air motor system.
After finishing the pre-start inspection, perform the "starting procedure" as shown in the chart below

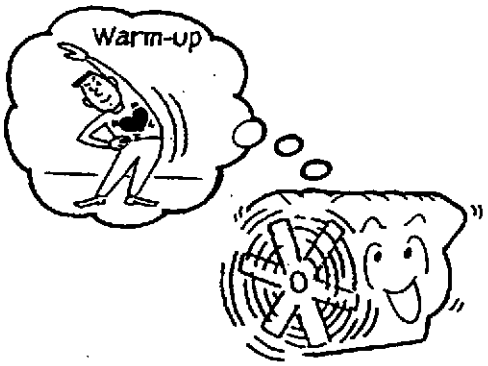


[Warming-up]

⚠ WARNING

- **Do not conduct warm-up operation for an extended period of time. Prolonged warm-up operation causes carbon buildup in the cylinders that leads to incomplete combustion.**
- **Warm-up operation is not necessary for emergency-application engines, since they are designed to start up immediately. However, all items on the maintenance chart must be checked.**

- Operate at low idle speed for 5 to 10 minutes to warm up.
- If the ambient temperature is lower than 5°C [41°F], install an auxiliary device that keeps the temperatures of the cooling water and oil at 5°C [41°F] or higher.
- The oil pressure will be 0.20 to 0.29 MPa (2 to 3 kgf/cm²) [28 to 43 psi] after the warm-up run. If the engine speed is increased immediately after it has been started, the oil pressure would be higher than the normal level — 0.39 to 0.69 MPa (4 to 7 kgf/cm²) [57 to 100 psi] but it will restore to the normal level as the oil temperature rises.



[Operation]

⚠ WARNING

Stay clear of all rotating and moving parts during operation.

⚠ CAUTION

- **At operating temperature, the engine components are hot. Any contact can cause severe burns.**
- **Always keep the engine room well ventilated. Unless it is properly ventilated, the air supply will be inadequate, resulting in lack of air for fuel combustion and loss of power.**
- **During the first 50 hours of operation, operate the engine under a lighter load and lower speeds than normal for break-in. Proper break-in contributes to maximum service life of the engine.**
- **Avoid overloading. This can cause incomplete fuel combustion often indicated by black exhaust, high fuel consumption and carbon deposits in combustion chambers, affecting engine life.**
- **Do not turn OFF the battery switch when the engine is running to avoid damage to the alternator.**
- **Do not turn the starter switch key to the START position when the engine is running to avoid damage to the starter.**

Starting the Load

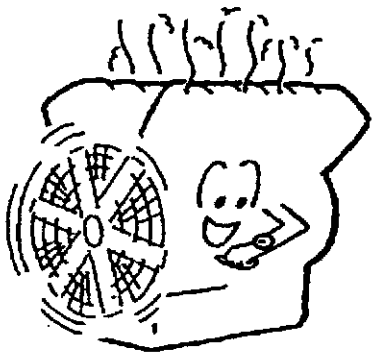
When the engine has run long enough to warm up, bring the engine to operating speed and apply the load. During load operation, check to be sure:

1. No alarms lamps are lit.
2. The engine is free from fuel, oil, coolant or exhaust leaks.
3. The engine is free from abnormal noise and vibration.
4. Exhaust smoke is normal.
5. Breather mist is normal in quantity and color.
6. All measuring instruments are in normal condition.
   - Tachometer (engine speed meter)
   - Oil pressure gage: 0.39 to 0.69MPa (4 to 7 kgf/cm²) [57 to 100 psi]
   - Coolant temperature gage: 65 to 85°C [149 to 185°F]
   - Ammeter (+) side
   - Engine oil temperature gage: 70 to 110°C [158 to 230°F]
   - Oil filter alarm (pilot lamp): OFF

[Stopping]

⚠ CAUTION

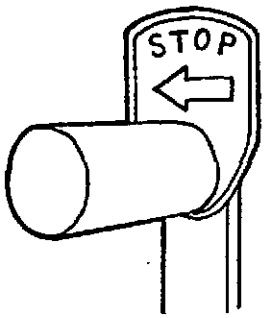
- **Stopping the engine abruptly while engine parts are hot due to high-speed operation can shorten the service life of the engine. Be sure to operate the engine at low idle speed for 5 or 6 minutes before stopping the engine. With the engine cooling, check for problems.**
- **Do not stop the engine abruptly while operating at high speed. This can result in sectional overheating and reduce the service life. While the engine is in a cooling operation, check the engine for abnormalities.**
- **Do not rev up the engine just before stopping it.**
- **If the engine abnormally stops, try to find a problem and its source, then make needed repairs before starting again. After starting the engine, check to be sure the engine has no problem.**
- **When stopping the engine by pulling the stop lever, continue to pull the lever until the engine comes to complete stop, otherwise the engine can be restarted.**



For the cooling operation, operate the engine at low idle speed for 5 to 6 minutes.

When equipped with speed control lever	When equipped with stop lever
Move the speed control lever to the STOP position.	Move the stop lever linked to the governor in the direction of STOP.

Turn the starter switch to the "OFF" position and remove the key then turn the battery switch to the "OFF" position. (Electrical system)



MAINTENANCE CHART

- Regular maintenance is important to prolong the service life of the engine and to ensure safety.
  Be sure to conduct inspections according to the maintenance chart.
- The maintenance chart shows the standard service intervals. When you think the engine should be serviced more frequently due to particular operating conditions, adjust the intervals accordingly.

Notice: Appropriate service intervals vary depending on the usage and operating conditions as well as the fuel, oil and coolant used. Check the operating record of the engine to determine the most appropriate service intervals.
(Do not hesitate to consult your Mitsubishi dealer.)

- Perform service items with shorter intervals that correspond to the interval of the service being conducted.
  (Example) During inspection conducted at "Every 2000 Service Hours," also include service items listed under "Every 250 Service Hours" and "Every 1000 Service Hours."
- Items marked with an asterisk (*) require special tools and large equipment. For inspection of these items, consult Mitsubishi your dealer.
- For items whose "Page" column is blank, refer to the SERVICE MANUAL for details.
- Select servicing intervals according to application or duty of the engine.
  - When the engine is constantly operated (for constant power supply or as movable generator), conduct regular inspection and servicing according to the maintenance chart for standard-use engine.
  - When the engine is used as an emergency power supply (as emergency power generator), conduct regular inspection and servicing according to the maintenance chart for emergency engine.
    Due to the nature of the application, emergency engines must start up quickly to supply power as soon as possible, and this causes severe conditions for the engines. Moreover, emergency engines are required to provide reliable operation and function. Therefore, be sure to conduct regular inspection and servicing, and also conduct the following engine maintenance operation.
    Once every week: Run the engine under no load (for 5 to 10 minutes)
    (When operating the engine for the adjustment of peripheral devices, limit the operating time to 30 minutes.)
    Once every month: Run the engine under load (for 15 to 30 minutes with more than 1/2 load)
    If the engine cannot be operated under load every month, run the engine under no load for 1 hour every year. Then, operate the engine under load (40% load) for more than 2 hours.
    During engine maintenance operation, check the ease of startup, oil pressure, exhaust color and vibration.
  - When the engine is used for a purpose other than the above, conduct inspection and servicing according to the maintenance chart for general-purpose power supply engine.

[Maintenace Chart for Standard-Use Engine]

Interval	Service item	Page
Every 50 Service Hours or Every Month	Fuel tank drain water	44
(First 50 Service Hour of New or Reconditioned Engine)	Re-tighten external bolts and nuts	42
	Engine oil change (It is recommended to analyze engine oil properties at the same time.)	52
	Change oil filters	52
(First 250 Service Hours of New or Reconditioned Engine)	Inspection & adjustment of valve clearance	39
	Inspection and adjustment of fuel injection timing	49
Every 500 Service Hours	Clean engine breather inside	–
Every 500 Service Hours or one year	Engine oil change (It is recommended to analyze engine oil properties at the same time.)	52
	Change oil filters (Change oil filters whenever the filter alarm turns on.)	52
	Change bypass oil filter	52
	Changing hydraulic governor oil filter	53
	Checking and adjusting V-belt tension	55
Every 1000 Service Hours	Change 2ndry fuel filter (cartridge type)	43
	* Check LLC concentration level of the coolant by optical density meter	–
	Valve clearance inspection and adjustment (Inspect valve mechanisms at the same time.)	39
	Inspection and adjustment of the fuel injection timing	49
Every 2000 Service Hours	Check the rack movement of the unit injector (including governor) while the engine is in operation	–
	* Replacement of fuel injection nozzle tips	51
	* Replacement of ball joints in fuel control links	51
	Replacement of V-belt	55
	Replacing the air cleaner element	60
	Inspect parts related to valve mechanisms	39
	Inspect crank case	–
	Vibration damper inspection	41
Every 4000 Hours	* Overhaul the top end of the engine Remove cylinders, inspect and service the combustion chambers. • Inspect connecting rod • Visually inspect top surface of each piston • Inspect cylinder liner surface	–
	* Replacement of unit seals, oil seal in water pump	–
	* Inspect fuel feed pump and drive linkage	–
	Inspect and service for oil relief valve	
	Inspect turbocharger shaft thrust with turning by hand	59
	Starter and alternator inspection	61
	* Inspect and service oil pump	–
	* Inspect operation of the protection devices High water temperature, low oil pressure, over speed , startup congestion, cooling water cut-off, low voltage, over voltage, over current, low water level in cooling water tank, low level in fuel tank, etc.	61

Items with an asterisk (*) require special tools and large equipment. For inspection of these items, consult your dealer.

Interval	Service item	Page
Every 8000 Hours	* Major overhaul Disassembling & cleaning major parts of engine and inspection, replacement	–
	Parts to be changed Inlet and exhaust valve seats, inlet and exhaust valves, valve rotators, valve cotters, rocker arm adjusting screws, valve push rods, bridge caps, injector rocker bushings, injector rocker pieces, cancel rod pins, main bearings, cylinder liners, piston rings, connecting rod bearings, vibration damper, thrust plate, and expendable items (gasket, oil seals, O-rings, etc.) etc. Replace following parts in addition to the parts listed above for 2nd overhaul Cylinder head bolts, valve guides, valve bridge guides, valve bridges, rocker bushings, pistons, piston pins, camshaft bushings, connecting rod bolts, nozzle holder assembly, roller tappets, valve springs, camshaft thrust plates, connecting rod bushings, main bearing cap bolts and washers, etc.	
	* Disassembly, service and test for unit injectors and if necessary, replace those parts	–
	* Disassembly and service for governor and if necessary replace those parts	–
	* Repair or replace auxiliary equipment Water heater, oil heater, oil priming pump, fuel feed pump, governor motor	–
	Disassembly and service for oil cooler, gear train inspection, disassembly and service for cylinder head, disassembly and service for accessory drive, replacement of damper, changing coolant, camshaft inspection, disassembly and service for turbo charger, rocker arm inspection.	–
Every 2 Years	Changing coolant	57
When Required	Inspecting and cleaning radiator fins	56
	Cleaning the pre-cleaner	59
	Clean the air cleaner element, replace if necessary	60
	Prime the fuel system	19
	* Inspection and replacement of stop solenoid	–
	* Inspection and replacement of vibration-isolating rubber	–
	* Inspection and replacement of coupling	–

Items with an asterisk (*) require special tools and large equipment. For inspection of these items, consult your dealer.

[Maintenace Chart for Emergency Engine]

Interval		Service item	Page
Every Week		External inspection of the engine (leakage of fuel, oil, coolant etc.)	25
		Checking engine oil level	25
		Checking fuel level in tank	25
		Checking coolant level	25
		Checking air pressure of the air tank	26
		Checking air cooler for water leakage	–
		Conduct engine maintenance operation (under no load: 5 to 10 minutes), checking ease of startup engine, exhaust color, abnormal vibration, smell Checking instrument indications (oil pressure, water temperature, oil temperature, exhaust temperature, tachometer, etc.)	–
Every Month		Checking battery fluid level	23
		Checking fuel-control linkage	26
		Checking engine oil for contamination of fuel and water	54
		Draining water from air tank	62
		Checking air compressor for oil level and adding oil	–
		Cleaning 1st fuel filter (wire element type), rotate handle one or two turns	26
		Conduct engine maintenance operation (under load: 15 to 30 minutes with more than 1/2 load), checking ease of startup engine, exhaust color, abnormal vibration & noise, smell Checking instrument indications (oil pressure, water temperature, oil temperature, exhaust temperature, tachometer, etc.) Check unit injector and rack movement of unit injector (hydraulic governor)	–
Every 6 Months		* Checking LLC concentration level	–
		Clean the inside of cooling water tank	–
Every Year	Engine Unit	Inspection and adjustment of valve clearance (Inspect valve mechanisms at the same time)	39
		Vibration damper inspection	41
		Checking and adjusting V-belt tension	55
		Re-tighten external bolts and nuts	42
		* Inspection and replacement of vibration-isolating rubber	–
		* Inspect foundation bolts	–
		* Inspection of coupling	–
	Fuel System	Fuel tank drain water	43
		Inspecting and adjusting spray condition & pressure of fuel injection nozzles	–
		Inspection and adjustment of fuel injection timing	49
		Draining water from 1st fuel filter (wire element type)	26
	Lubrication System	* Analyze engine oil properties	–
		Inspection and adjustment of the engine oil pressure (during engine maintenance operation in running)	–

Items with an asterisk (*) require special tools and large equipment. For inspection of these items, consult your dealer.

Interval	Service item		Page
Every Year	Cooling System	Inspection of water pump	–
		* Inspection, disassembly and cleaning for solenoid valve and pressure reducing valve	–
		Inspection, disassembly and cleaning of strainer (with ball tap)	–
		* Analyze properties cooling water (soft water only)(change cooling water based on analysis results)	–
	Intake System	Checking air cleaner indicator	26
		Inspecting and cleaning pre-cleaner	59
		Inspecting and cleaning air cleaner element	60
	Electrical system	Checking specific gravity of battery fluid	23
		Starter inspection	61
		Alternator inspection	61
		Air heater inspection	–
	Air starter system	Inspecting and draining water from air filter	62
		Checking air tank safety valve operation	62
		* Inspecting starter valve	–
		* Inspecting distributor valve	–
		* Inspecting and cleaning of solenoid valve	–
		Checking air compressor valve tension	–
	* Inspect operation of the protection devices High water temperature, low oil pressure, over speed, startup congestion, cooling water cut-off, low voltage, over voltage, over current, low water level in cooling water tank, low level in fuel tank, low air tank pressure, etc.		61
	Check auxiliary equipment operation Engine control devices, fuel feed pump, governor motor, room ventilation fan, solenoid, water pump, water tank ball tap, water heater, oil heater, oil priming pump, etc.		–
Every 2 Years	Changing fuel filters (cartridge type)		43
	* Replacement of ball joints in fuel control link		51
	Changing coolant		57
	Inspect turbocharger shaft thrust with turning by hand		59
	Checking exhaust muffler and drain water		59
	Engine oil changing (It is recommended to analyze engine oil properties at the same time)		52
	Change oil filters (Whenever oil filter alarms turns on, change oil filters.)		52
	Changing bypass oil filter		52
	* Thermostat inspection		–
	* Air compressor overhaul		–

Items with an asterisk (*) require special tools and large equipment. For inspection of these items, consult your dealer.

MAINTENANCE CHART

Interval	Service item	Page
Every 4 Years	Replacement of V-belt	55
	Changing hydraulic governor oil filter	53
	Inspecting and cleaning radiator fins	56
	Replacing air cleaner element	60
	* Cleaning fuel tank	–
	* Service and test for unit injectors and if necessary replace parts	–
	* Service for governor and if necessary replace parts	–
	* Checking oil cooler for dirtiness, clogs and water leakage	–
	* Checking oil pump for discoloration and external appearance	–
	Replacing rubber hose	–
	Replacing pre-cleaner	–
	* Service or replacing gages and indicators Oil pressure gage, water temperature indicator, oil temperature indicator, exhaust temperature indicator, tachometer	–
Every 8 Years	* Replacement of fuel injection nozzle tips	51
	* Inspecting and replacing major engine parts Inlet and exhaust valve seats (lapping), valve guide, pistons, piston rings, connecting rod bearings, connecting rod bushings, cylinder liners, crank shaft (When abnormalities are found on cylinder No.1 and No.2, check all of cylinders.)	–
	* Replacement of vibration damper	–
	* Repairing or replacing oil pump	–
	* Replacement of unit seals, oil seals in water pump	–
	* Disassembly and inspecting turbocharger	–
	* Disassembly and inspecting air cooler	–
	* Repairing or replacing vibration-isolating rubber	–
	* Repairing or replacing of coupling	–
	* Repairing or replacing governor motor	–
	* Repairing or replacing room ventilation fan	–
	* Repairing or replacing stop solenoid	–
	* Repairing or replacing water tank ball tap	–
	* Repairing or replacing rubber parts and O-rings	–
	* Replace other expendable parts	–

Items with an asterisk (*) require special tools and large equipment. For inspection of these items, consult your dealer.

[Maintenace Chart for General-Purpose Power Supply Engine]

Interval	Service item	Page
Every 50 Service Hours or Every Day	Fuel tank drain water	43
	Draining water from air filter	62
	Draining water from air tank	62
(First 50 Service Hour of New Engine)	Engine oil change	52
	Change oil filters	52
	Re-tighten external bolts and nuts	42
(First 250 Service Hour of New Engine)	Inspection & adjustment of valve clearance	39
	Inspection and adjustment of fuel injection timing	49
Every 500 Hours or Every Year	Engine oil change (It is recommended to analyze engine oil properties at the same time)	52
	Change oil filters (Change the oil filters whenever the filter alarm turns on)	52
	Change the bypass oil filter	52
	Change the hydraulic governor oil filter	53
	Inspecting and cleaning radiator fins	56
	Exhaust muffler drain water	59
	Checking air tank safety valve operation	62
	Checking and adjusting V-belt tension	55
Every 1000 Hours or Every 1 Year	Changing fuel filters (cartridge type)	43
	Replacing zinc rod	56
	Cleaning of air filter	62
Every 2000 Hours or Every 3 Year	Inspect and adjust valve clearance (Inspect valve mechanisms at the same time)	39
	Re-tighten external bolts and nuts (for tightening torque, refer Service Manual)	42
	Replacement of V-belt	55
	* Replace the fuel injection nozzle tips	51
	* Inspect operation of the protection devices (High water temperature, low oil pressure, over speed, etc.)	61
Every 4000 Hours or Every 5 Years	Vibration damper inspection	41
	* Replace ball joints of fuel control links	51
	* Cleaning of air cooler	59
	* Cleaning of heat exchanger	56
Every Major Overhaul (Every 8000 to 12000 Service Hours)	* The same service items as listed in maintenance chart for standard use engine	–
Every 2 Years	Changing coolant	57
When Required	Priming air from fuel system	19
	Cleaning and replacing pre-cleaner	59
	Cleaning and replacing of air cleaner element	60

Items with an asterisk (*) require special tools and large equipment. For inspection of these items, consult your dealer.

⚠ WARNING

Be sure to stop the engine!
Be sure to stop the engine before adding or changing oil, coolant or fuel. Check or add coolant after the engine becomes cool, the coolant is hot immediately after the engine stops. Never attempt to adjust the V-belts tension while the engine is operating. If not avoided, those can be a cause of fire or burns, and you can be entangled by rotating parts.

Handle electrolyte (battery fluid) carefully!
If electrolyte is spilled on skin or clothes, wash immediately and thoroughly with lots of water. If electrolyte gets into your eyes, flush immediately with lots of water and consult a physician as soon as possible.

Handle antifreeze carefully!
Antifreeze contains alkali. Should antifreeze be accidentally swallowed, induce vomiting immediately and seek medical attention immediately. If antifreeze gets into your eyes, flush immediately with lots of water, and see a physician once.

Dress properly for the job!
Wear protective devices — hard hat, ear protectors, face shield, work clothes, dust protective mask, etc.
Be sure to wear goggles whenever you handle compressed air for own safety, since it often can be a cause of serious injury.

⚠ CAUTION

Use recommended fuel, oil and coolant!
Use of any other fuel, oil or coolant can cause engine damage and serious accidents.

Perform all recommended inspections!
Perform pre-start inspection and periodic inspection on items listed in this manual. Failure to follow this recommendation can cause serious engine damage and accident.

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 an increase of oil consumption, output decrease and starting difficulties. Conduct maintenance of the air cleaner according to the following directions to ensure proper dust filtering performance.

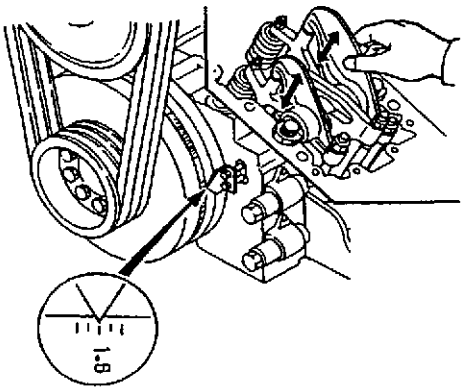
- Do not conduct maintenance of the air cleaner while the engine is running.
- When removing the air cleaner element, do not allow dust attached on the element to fall into the air cleaner outlet side.
- When a dust indicator is provided, conduct maintenance only when the clog warning sign appears. Unnecessary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

[Main Parts]

Valve Clearance
Check and adjust the valve clearance when the engine is cold.

Confirm top dead center on compression stroke

1. Turn the engine in the normal direction to align the timing mark [1.6] on the damper with the pointer as shown.
2. Remove the rocker cover of a cylinder on which the valve clearance is to be checked and adjusted, and make sure the inlet and exhaust valves have some clearance.
3. (Example) If the timing mark [1.6] is aligned with the pointer, either the No. 1 or No. 6 piston is at top dead center on the compression stroke.



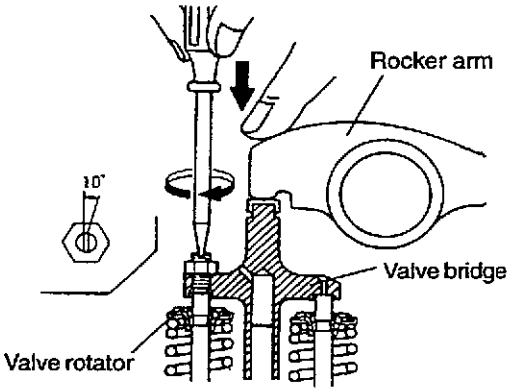
Adjust the height of valves

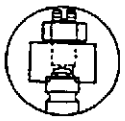
⚠ CAUTION

Make sure the clearance between the valve bridge and valve rotator is 1.5 mm [0.059 in.] or more; if not, interference will occur between the bridge and rotator to cause the valve cotters to get out of the place. If the clearance is less than 1.5 mm [0.059 in.] after the height of valves has been adjusted, consult your Mitsubishi dealer.

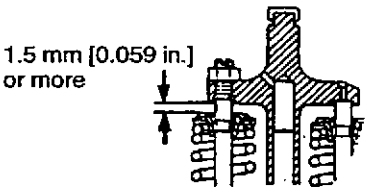
Before inspecting the valve clearance, adjust the height of two valves (bring the bridge into contact with the valves) by means of the valve-bridge adjusting screw so that there is no difference in height between the two valves. If the valve seats are worn, one valve differs from another in height, producing some clearance between the valve stem and bridge, resulting in a change in valve clearance.

1. Loosen the lock nut of the valve-bridge adjusting screw and turn in the adjusting screw.
2. Hold the rocker arm by finger to push down on the bridge and turn in the adjusting screw slowly.
3. While observing the adjusting screw through the inspection hole, turn in the screw until contacting to the top of valve stem. From that position, turn in the screw approximately, 10°more and tighten the lock nut.
4. Check to confirm if there is 1.5 mm [0.059 in.] of clearance or more between valve-bridge and valve-rotator.





Observation



[Main Parts] - continued

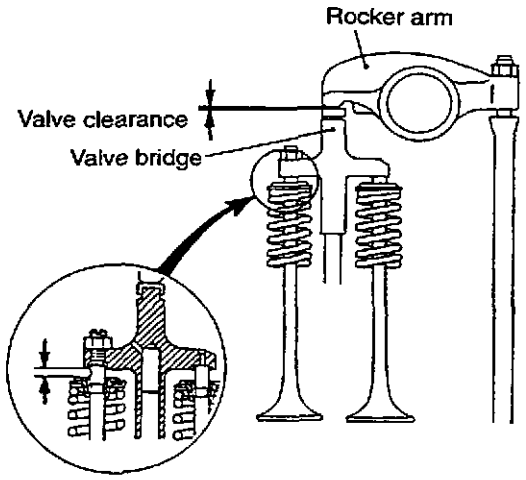
Valve Clearance Inspection

After adjusting the height of the front and rear valves using the valve bridge, check the valve clearances.

1. Check the valve clearance with feeler gages inserted between the rocker arm and bridge cap.

Valve clearance	Inlet valve	0.4 mm [0.016 in.]
	Exhaust valve	0.5 mm [0.020 in.]

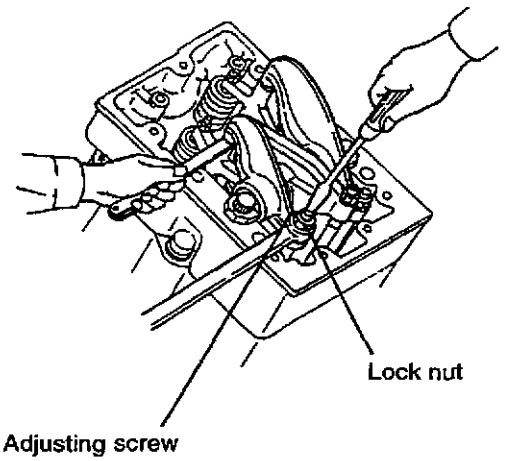
2. When feeler gages snuggly fit between the rocker arm and bridge cap, the clearance is correct. If the feeler does not fit into the clearance, perform adjustments as described below.



Clearance between bridge and valve rotator

Valve Clearance Adjustment

1. Loosen the lock nut of the adjusting screw.
2. Turn in the adjusting screw so that feeler gages is snuggly fit between the rocker arm and bridge cap.
3. After adjusting the clearance, tighten the lock nut of the adjusting screw.



Check and Adjust Order

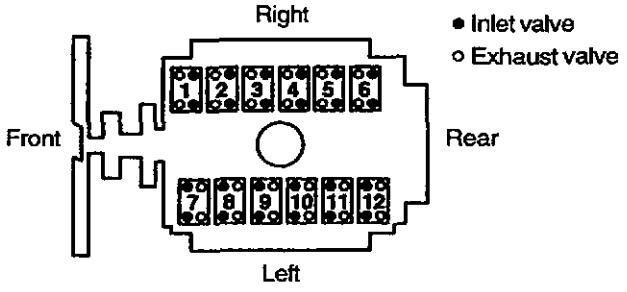
Conduct the above inspection and adjustment with each cylinder at the top dead center in firing order (injection sequence).

	Cylinder No.
Firing order (injection sequence)	1-12-5-8-3-10-6-7-2-11-4-9

(Example): After checking and adjusting the cylinder No.1, turn the engine for 60° and then adjust cylinder No. 12.

- **Placement of valves**

In the side view of the engine, location of inlet valve is always at left side of the cylinder, and exhaust valve at right side.



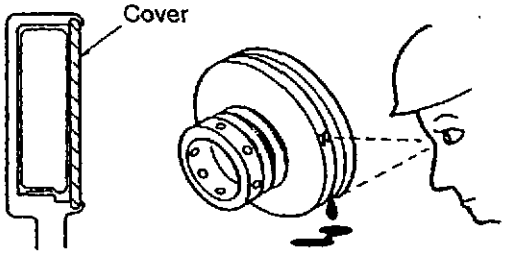
[Main Parts] - continued

Vibration Damper Inspection

⚠ CAUTION

When installing a damper protective cover to the engine, do not use a cover enclosing the damper.

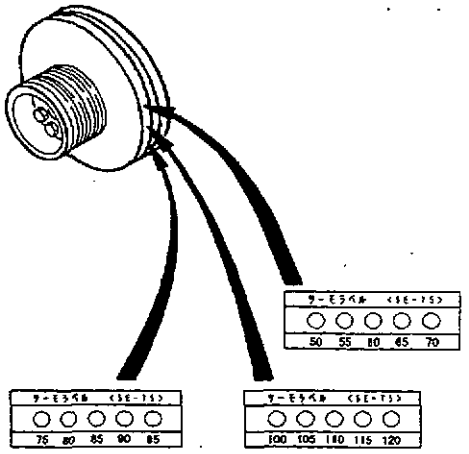
Visually check for fluid leaks, flaws, distortion, or discoloration or flaking of painted surfaces. Also check for deformation of the cover (measuring by a scale), and fluid leaks from shim, discoloration or flaking of painting by the engine heat as well.



Vibration Damper Temperature Control

For proper operation, heat of the vibration damper must be taken out from its surface to prevent excessive damper heating. Mitsubishi inspects each engine before shipment to ensure proper operating temperature of the vibration damper in normal. However, the vibration damper temperature varies depending on ambient conditions. Therefore, observe the followings to provide sufficient ventilation for the vibration damper and equipment.

1. In the case of viscous damper, make sure the temperature of the outside damper surface does not exceed 100°C [212°F] in emergency use and 90°C [194°F] in normal use after the engine is operated at the rated output for one hour. In the case of viscous rubber damper, make sure the temperature does not exceed 90°C [194°F] in emergency use and 80°C [176°F] in normal use. It is recommended to use the thermal label for temperature management of the vibration damper.



Thermal label

Parts name	Temperature measuring range	Parts No.
Thermal label 75-95	75 to 95°C [167 to 203°F]	32522-04100
Thermal label 100-120	100 to 120°C [212 to 248°F]	32522-04200
Thermal label 50-70	50 to 70°C [122 to 158°F]	32522-04300

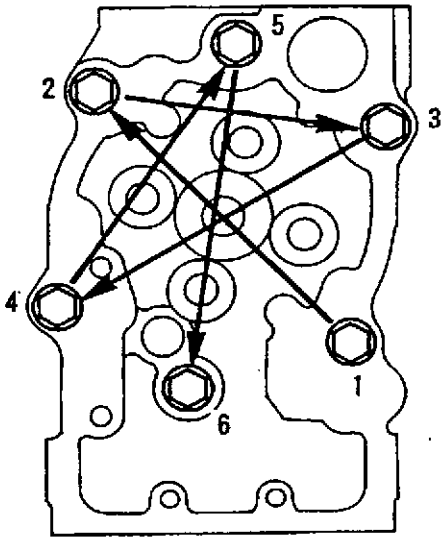
2. When installing a safety cover over the vibration damper, check ventilation carefully and make sure the damper temperature remains below the above temperature with the cover in place.

[Main Parts] - continued

Re-tighten Bolts and Nuts

Re-tighten the bolts and nuts on the following components:

- Timing gear case
- Crankshaft pulley
- Mounting brackets
- Exhaust manifold
- Turbocharger
- Cylinder heads

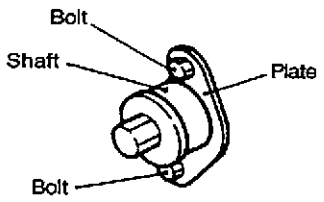


Check the cylinder head bolts and re-tighten them in number sequence (1-2-3-4-5-6) if necessary.

Notice: For tightening torque, refer to the SERVICE MANUAL.

How to Use Turning Gear

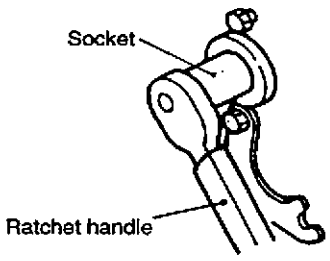
1. Loosen the bolts securing the shaft lock plate and disengage the plate from the shaft. Then, push in the shaft all the way to the TURN position.
2. Put a socket to the shaft and turn the shaft with a ratchet handle for turning.
3. After turning the engine, pull the shaft back to RUN position, engage the plate with the shaft and tighten the plate bolts. Make sure the plate is engaged properly.



Run position

⚠ CAUTION

Before starting the engine, make sure the turning gear is in the RUN position.

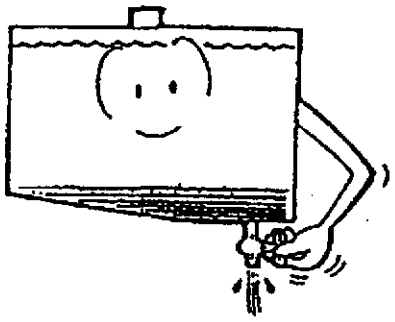


Turning position

[Fuel System]

⚠ DANGER

- **Keep maintenance area is safe — no fire hazards.**
- **Wipe off any spilled fuel thoroughly. Spilled fuel can be a fire hazard.**



Fuel Tank Drain Water and Sediment

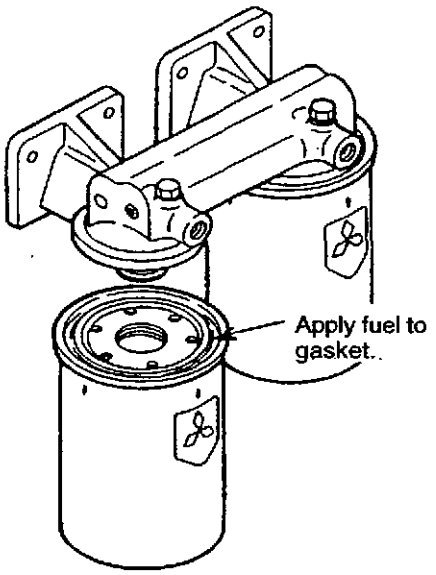
Open the fuel tank drain valve and allow water and sediment to drain in a drip pan. Drain at least 1 to 2 liters [0.3 to 0.5 U.S. gallons] of fuel to remove water and sediment.

Change the Fuel Filter (Cartridge Type)

1. Clean the outside of the fuel filter.
2. Place a drip pan under the fuel filter.
3. Using a filter wrench, remove the used filter.

Notice: When removing the filter, be careful not to damage the cartridge.

4. Clean the gasket of a new filter.
5. Coat the gasket of the new filter with clean diesel fuel.
6. Clean the filter base of the fuel filter bracket. Install the new filter.
7. When the gasket contacts the base, turn the gasket 1/2-3/4, and then tighten it by hand to avoid damage to the cartridge.



⚠ CAUTION

When installing fuel filter, be sure not to use filter wrench but tighten it by hand. There is a risk of damaging the fuel filter when it is over tightened.

8. Prime the fuel filter after replacement.
9. Start the engine and run it at low idle for several minutes. Check the filter base for leaks. If any leakage is found, stop the engine and loosen the filter and check the gasket for damage. Then, retighten the filter as described in step 6.

[Fuel System] - continued

Replacement of unit injectors

⚠ DANGER

- **Cover the openings in the fuel system with rubber caps to prevent dust from entering.**
- **Be sure to install the unit injector puller (special tool) to the injector body before removing the gland. If the gland is removed prior to the unit injector puller installation, the unit injector may eject.**

Name of special tool	Part No.
Unit injector puller	35C91-11400

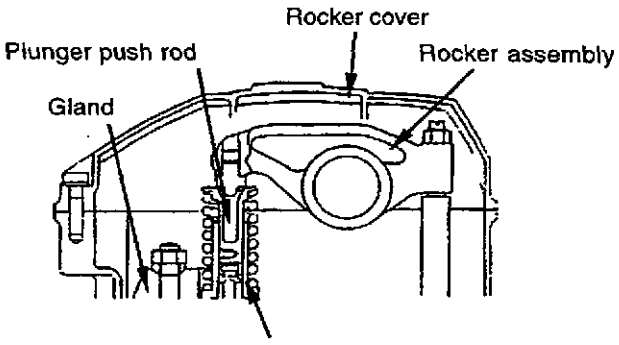
Removing unit injectors

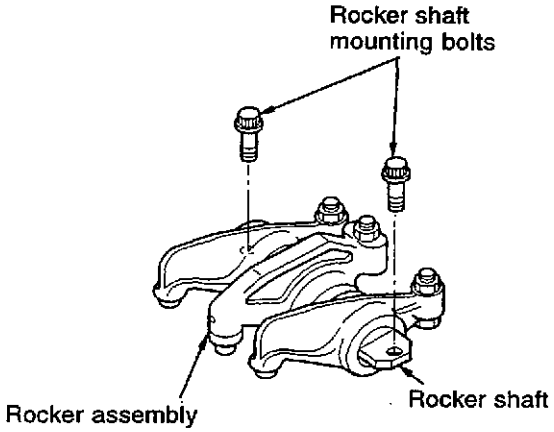
1. Close the valve on the fuel passage.
2. Remove the rocker cover.
3. Turn the engine until the piston reaches the top dead center in compression stroke. With the piston in that position, the intake and exhaust valves should have clearances.
4. Unscrew the rocker shaft mounting bolts, and remove the rocker shaft and rocker assembly. The plunger push rod may be stuck to the rocker shaft assembly due to the adhesive force of engine oil. When this happens, keep the plunger push rod attached to the injector tappet.

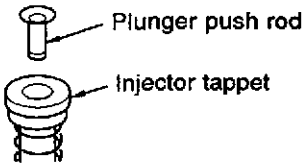
Notice: Use cloths to prevent parts from falling into the cam compartment.

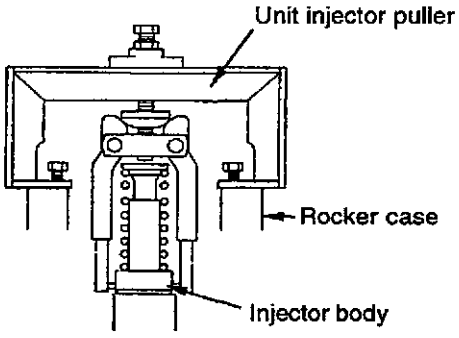
5. Remove the plunger push rod from the injector tappet.
6. Install the unit injector puller (special tool) to the rocker case, and hook the claws of the puller onto the injector body.

Notice: Check the unit injector puller (special tool) for external damage and loose joints.



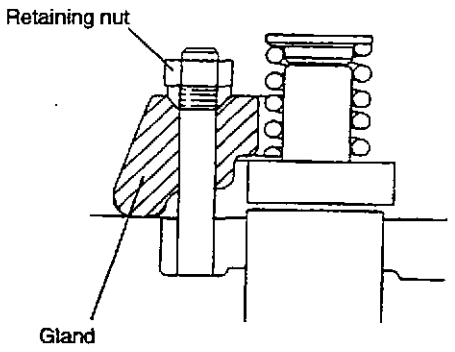


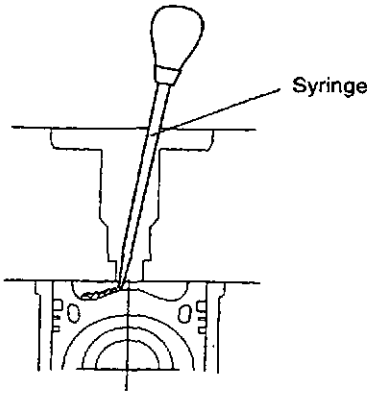




[Fuel System] - continued

7. Unscrew the gland retaining nut, and remove the gland.
8. Using the unit injector puller, pull out the unit injector.
9. After removing the unit injector, suck spilled fuel from the cylinder (combustion chamber) by using a syringe.
   (The oil sampling pump (36291-09100) is recommended.)
10. Thoroughly remove carbon deposits from the unit injector mounting hole in the cylinder head.



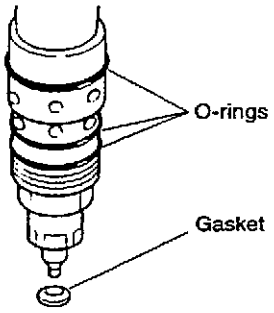


[Fuel System] - continued

Reinstalling unit injectors

1. Apply grease to the gasket, and install the gasket to the unit injector.
2. Clean the area around the unit injector mounting hole in the cylinder head to remove dust and other foreign particles. If dust is not completely removed, gas and fuel leakage can result.
3. Apply grease, silicon oil or lubricating oil to the O-rings on the unit injector.

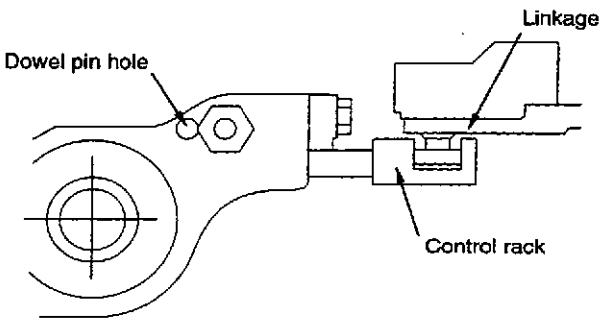
Notice: Be careful not to allow dust to adhere on the unit injector. Also handle with care to prevent damage to the O-rings.

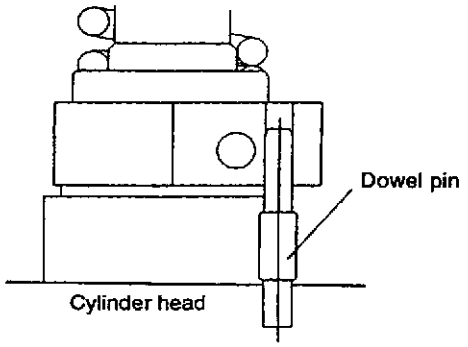


4. Insert the unit injector into the cylinder head. Press firmly by hand to make sure the dowel pin hole, rack and linkage align properly.
5. Install the gland, and tighten the retaining screw by hand.

In this step, make sure that:

- the unit injector is fully inserted;
- the dowel pin is in place;
- the gland is not extended over the unit injector; and
- the control rack is engaged with the bearing of the link.



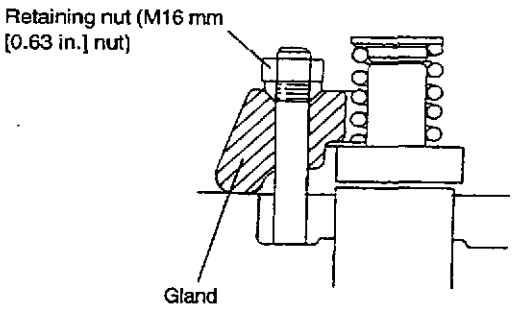


[Fuel System] - continued

6. Tighten the retaining nut to the specified torque (127.5±5 N·m (13±0.5 kgf·m) [94.0±3.6 lbf·ft]).
7. Adjust the linkage of the unit injector.

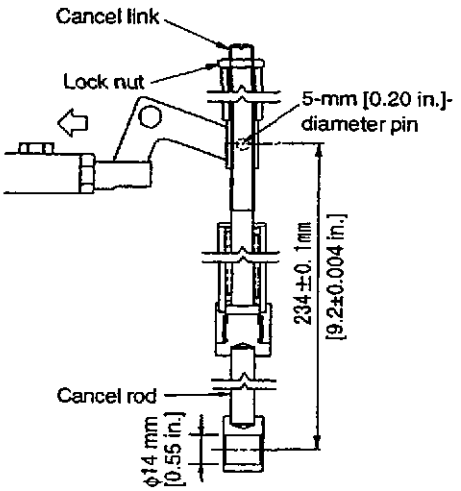
(1) With the rack of the unit injector pressed against the rack stopper (fully moved to the non-injecting side), adjust the cancel link so there is no play in each linkage.

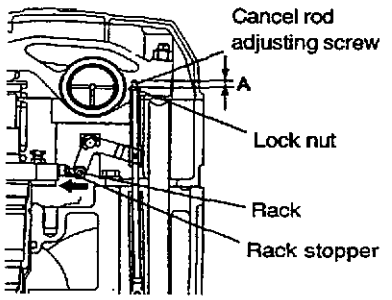
Notice: Adjust the distance between the center of the 14-mm [0.55 in.]-diameter hole in the cancel rod and the center of the 5-mm [0.20 in.]-diameter pin to 234±0.1 mm [9.21±0.004 in.]. Then, tighten the lock nut. If this dimension cannot be achieved, remove the linkage adjusting turnbuckle on the right side, then repeat the above step (1), then conduct steps (2) through (4).



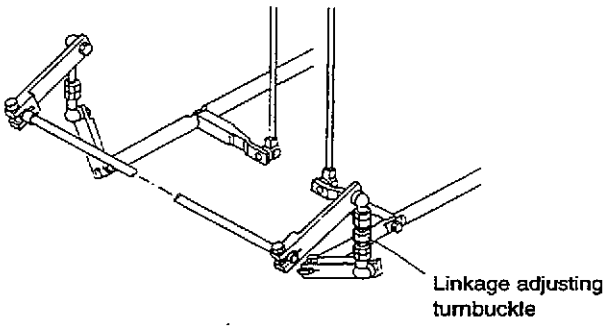
(2) Conduct the following steps (3) through (5) only when parts other than the lock nut of the cancel link are removed. In normal service operation, these steps do not need to be conducted. The following steps eliminate the looseness in the right and left links and lock the links in position.

Notice: When conducting steps (2) and (3), make sure the rack is in contact with the rack stopper on the unit injector (the rack is normally in the non-injecting side due to the weight of the link).



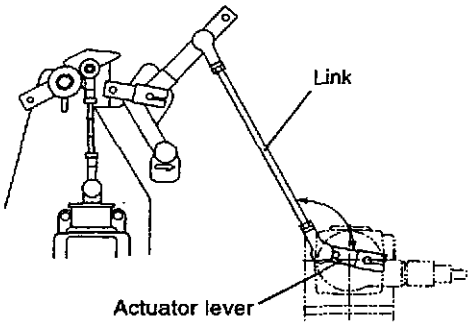


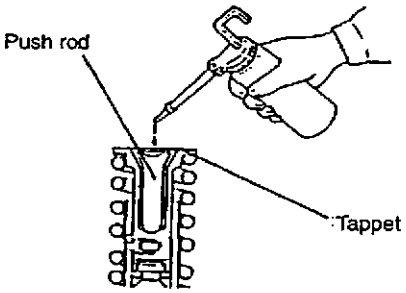
(3) Make sure the racks of the unit injectors of all cylinders are in contact with the rack stoppers (non-injecting position). If any of the racks is not contacting the rack stopper, repeat step (2) for readjustment.



[Fuel System] - continued

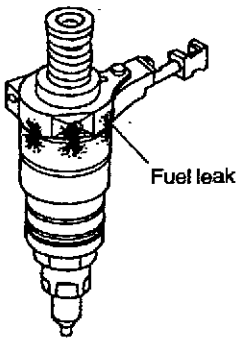
(4) After completing steps (1) through (3), make sure the angle between the electronic governor actuator lever and link is 100 to 115° with the rack resting on the rack stopper.
(5) Move the linkage to make sure it moves smoothly.
8. Pour lubricating oil on the sliding surfaces (tappet and rack) of the unit injector.
9. Insert push rod into the tappet, and supply oil to the indentation on the top face of the push rod.
10. After assembling the parts on all cylinders, move the levers to make sure the racks of all cylinders move smoothly and there is no looseness in the linkages.
(Each link must operate smoothly with a force of 19.6 N (2.0 kgf) [14.5 lbf] or less applied to the hole where the governor is connected.)
11. Bleed the fuel system, and also make sure that fuel does not leak from the unit injectors.





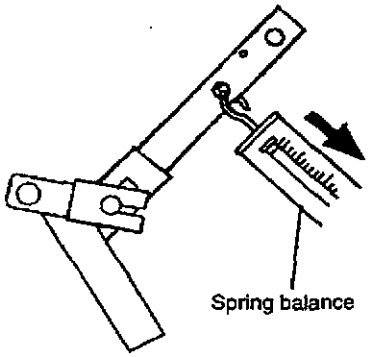
⚠ CAUTION

Use the priming pump for bleeding the fuel system. Using the starter for bleeding can cause the fuel feed pump to seize.



12. Install the rocker shaft and rocker assembly on each cylinder, and adjust valve clearances and fuel injection timing.
Specified torque: 167 N·m (17 kgf·m) [123 lbf·ft]

Notice: Assemble and adjust the rocker shaft assembly for each cylinder. Be sure to turn the engine before adjustment.
If the engine is turned after adjustment, the plunger of the injector protrudes and can cause sticking of the unit injector.
When turning the engine, check to make sure the rocker arm, injector tappet and push rod do not interfere with each other.



[Fuel System] - continued

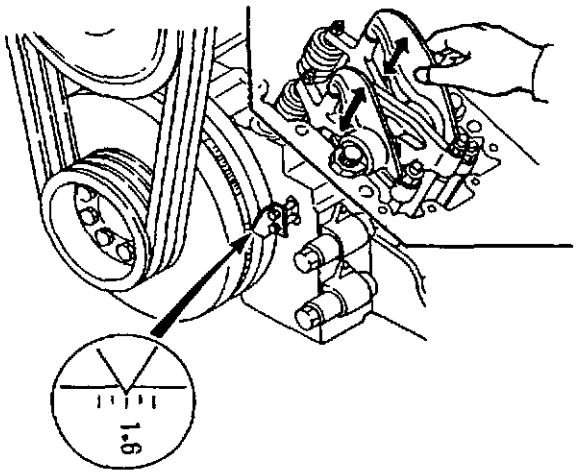
Inspection and adjustment of fuel injection timing

Inspecting fuel injection timing

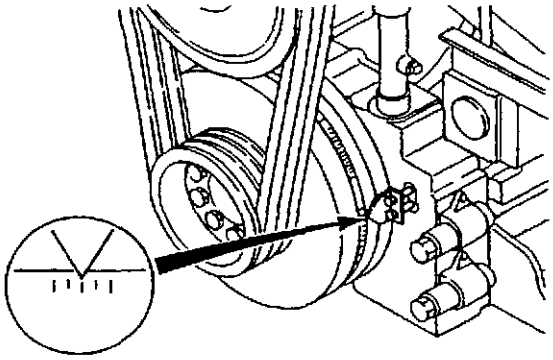
1. The fuel injection timing specification is stamped on the caution plate located on rocker cover No. 1. Check the indication before inspection.
2. Turn the engine and bring the piston in cylinder No. 1 to the top dead center in compression stroke.

(1) Turn the engine until a [1·6] indication on the damper periphery aligns with the pointer.

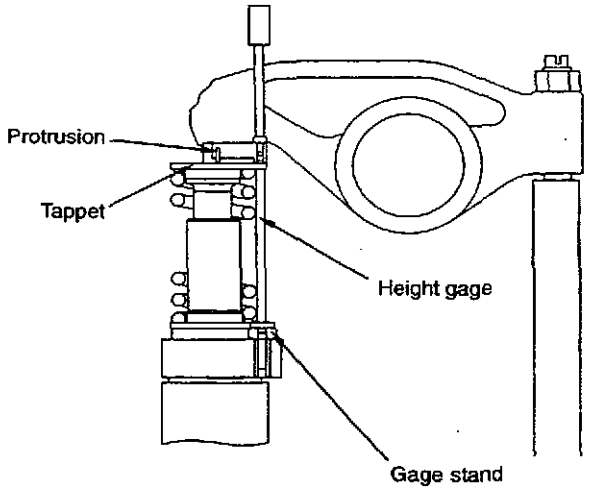
(2) Remove the rocker cover of cylinder No. 1, and check intake and exhaust valve clearances.
If there are valve clearances, the piston is at the top dead center in compression stroke. If there are no valve clearances, turn the engine again until a [1·6] indication on the damper periphery aligns with the pointer.



Notice: Be sure to check valve clearances; otherwise, the piston in cylinder No. 6 may be at the top dead center, instead of the piston in cylinder No. 1.



3. Turn the engine about 60° in a reverse direction, then turn it slowly in a forward direction until the fuel injection timing mark (number indicated on the caution plate) on the damper periphery aligns with the pointer. In this process, insert the height gage (special tool) in the gage stand of the injector body, and make sure the tappet top face aligns with the protrusion on the gage. Conduct this inspection for all cylinders. If the tappet top face does not align with the protrusion on the gage, make the following adjustment.



Name of special tool	Part No.
Height gage	35C91-11100

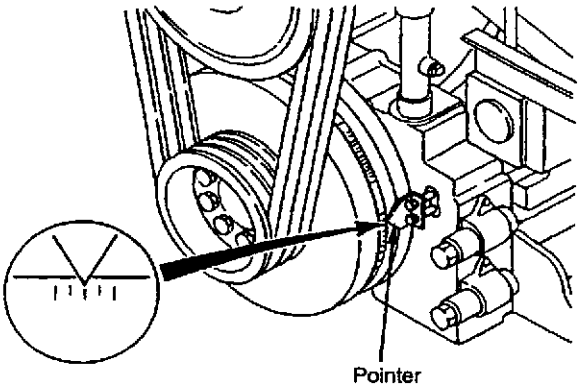
[Fuel System] - continued

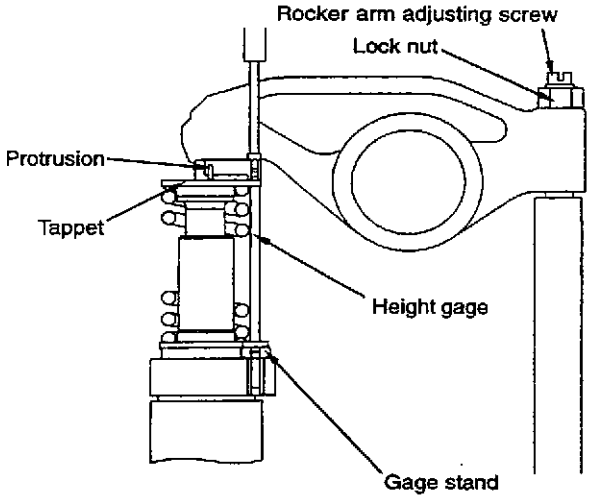
Adjusting fuel injection timing

⚠ CAUTION

To adjust the fuel injection timing of unit injectors, start from cylinder No. 1, and conduct the inspection for all unit injectors.

1. With the piston in cylinder No. 1 at the top dead center in compression stroke, check to make sure the fuel injection timing mark (number indicated on the caution plate) on the damper periphery is aligned with the pointer.
2. Loosen the lock nut on the rocker arm adjusting screw.
3. Insert the height gage (special tool) in the gage stand of the injection body. Tighten or loosen the rocker arm adjusting screw until the tappet top face aligns with the protrusion on the height gage.
4. After the adjustment, secure the rocker arm adjusting screw in place by tightening the lock nut.
5. Repeat the adjustment procedure for cylinder No. 2 and all others.
6. For reconfirmation, rotate the engine (2 turns) and check the fuel injection timing again.





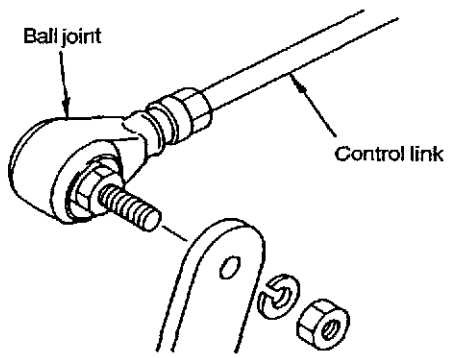
[Fuel System] - continued

Replacement of ball joints of fuel control links

Replace the ball joints of the fuel control links with new parts.

When installing new ball joints, be sure to tighten the nuts firmly.

Notice: When the ball joint is integrated in the control link, replace the control link assembly.



Replacement of fuel injection nozzle tips

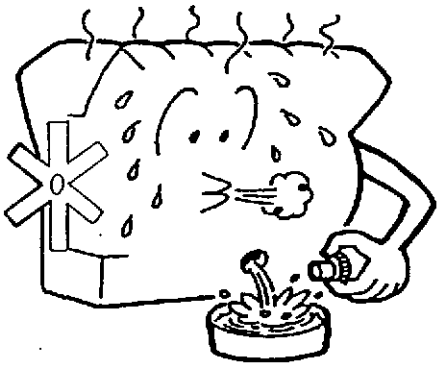
For replacement of nozzle tips, consult your Mitsubishi dealer.

[Lubrication System]

Engine Oil Change

⚠ CAUTION

Hot oil and components can cause personal injury. Do not allow hot oil or components to contact skin.



After the engine has been stopped, remove the drain plug from the oil pan and drain the engine oil while the oil is warm.

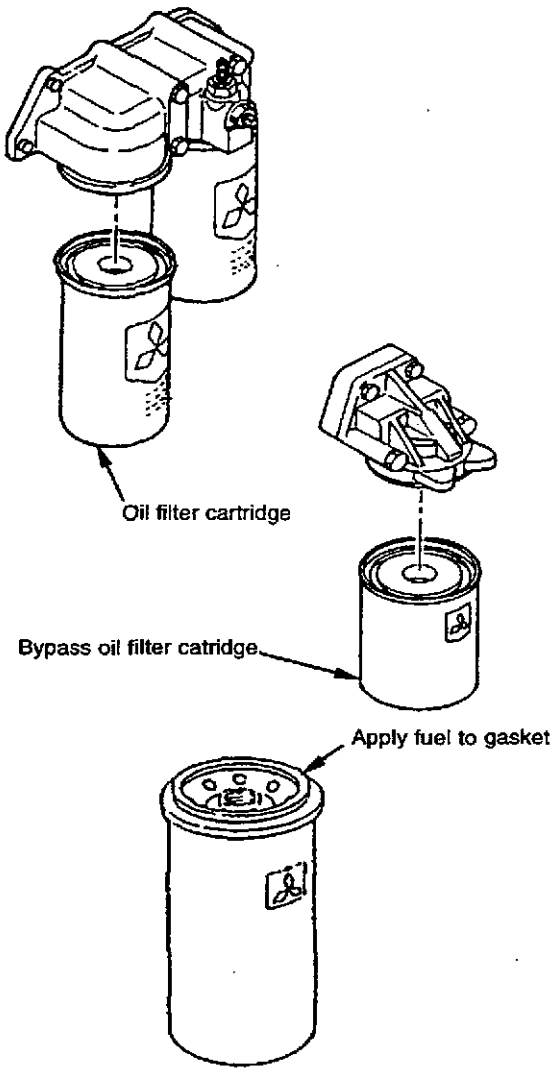
Notice: Avoid using a vacuum suction.

Change the Oil Filters and Bypass Oil Filter

1. Clean the dirt and dust off the surface of the fuel filter.
2. Place a drip pan under the oil filter.
3. Using a filter wrench, remove the used oil-filter cartridge.

Notice: Check the used oil-filter element for debris. Metal debris can indicate a possible failure. Consult your dealer whenever you notice Metal debris in the oil filter. In addition to the periodic check, change the filter when the indicator light comes ON.

4. Clean the filter base of the oil-filter bracket with a clean cloth.
5. Check a new filter to be sure the packing is properly installed in the groove.
6. Coat the gasket of the new filter with clean engine oil.
7. Install the new oil filter cartridge by hand. When the packing contacts the base, tighten 3/4 to 1 turn more. Do not damage the cartridge.



⚠ CAUTION

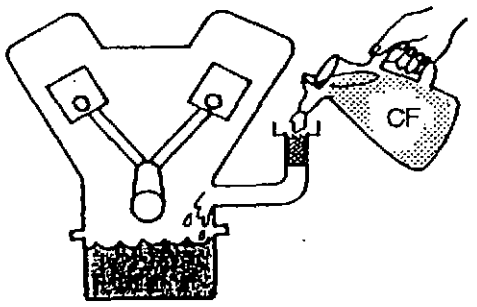
When installing oil filter cartridge, be sure not to use filter wrench. There is a risk of damaging the cartridge when it is over tightened.

[Lubrication System] - continued

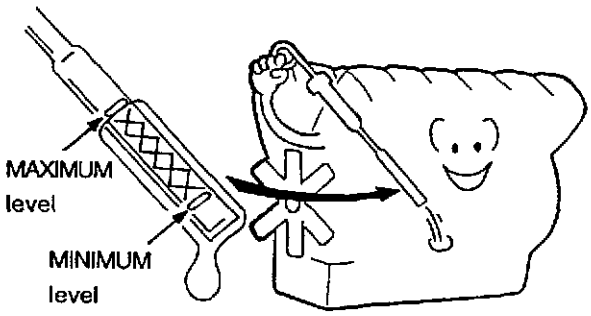
Fill the Oil Pan

1. Install the drain plug.
2. Remove the crankcase filler cap and fill with recommended oil.

Refill capacity, oil pan (whole engine)	Approx. 180 liters [48 U.S. gallons] (Approx. 200 liters [53 U.S. gallons])
Recommended oil	Oils that meet Engine Service Classification CF (API Service Classification)

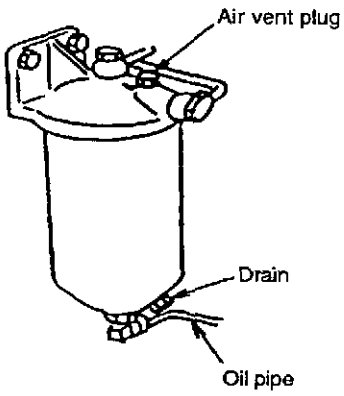


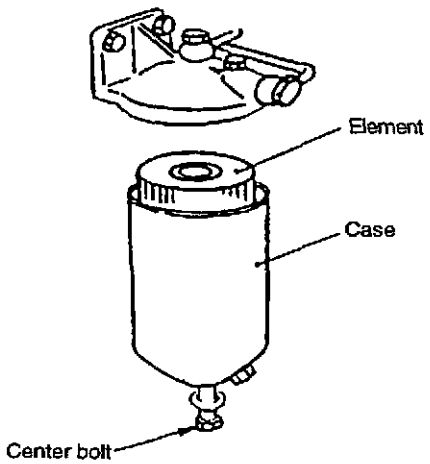
3. Start the engine and run it at low idle for several minutes. Check around the filter cartridges for oil leaks. If oil leakage is found, re-tighten the cartridges.
4. Stop the engine and wait for about 10 minutes. Then, check the oil level in the oil pan with a oil level gage. The oil level should be between the MAXIMUM and MINIMUM marks on the oil level gage. Add oil if necessary.



Changing the Hydraulic Governor Oil Filter (Hydraulic Governor)

1. Prepare a pan to receive drained oil, and position it below the governor oil filter.
2. Loosen the air vent plug and remove the drain plug to drain the oil into pan.
3. Remove the oil pipe from the center bolt.
4. Remove the center bolt and remove the case from the bracket. Remove the used element from the case.
5. By using the center bolt, put a new element in the case.
6. Install the case with new element inside to bracket and tighten the center bolt.
7. Install the oil pipe to the center bolt.
8. Install the drain plug.
9. Remove the air vent plug and fill up the filter with engine oil, and install the air vent plug.

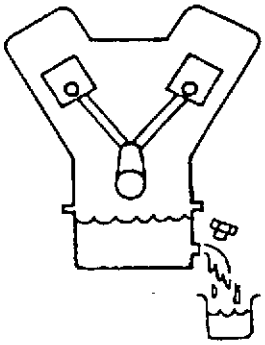




[Lubrication System] - continued

Check the Oil for Contamination of Fuel and Water

Drain 1 to 2 liters [0.3 to 0.5 U.S. gallons] of oil in a jar, and smell it and visually check for fuel and water in the oil. The oil contaminated by fuel smells like fuel and the emulsified oil is an evidence of water contamination.

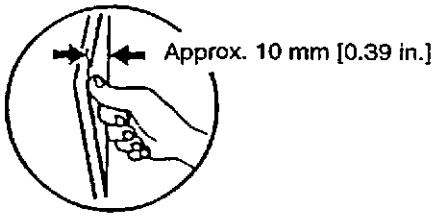


[Cooling System]

Checking and Adjusting V-Belt Tension, Replacement.

⚠ CAUTION

- **Change the belt if cracked, frayed or cut.**
- **Always keep the belts clear of oil or grease. Oil or grease can cause the belt to slip, which might shorten belt life.**
- **If the belts are too taut, excessive load applied by the tight belts can shorten the service life of the alternator bearing. Be sure to follow the procedures described below to adjust the belt tension properly.**



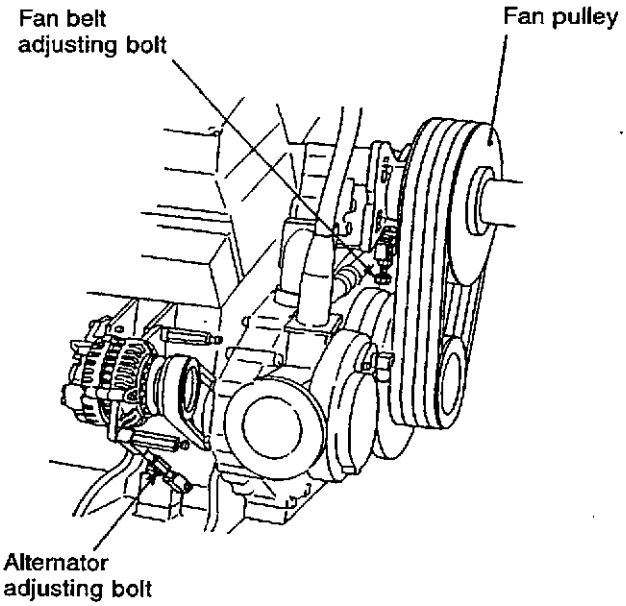
Apply force (approx. 98 N (10 kgf) [22 lb]) in the center section of the V-belt and if the belt deflects 10 mm [0.39 in.], the tension is appropriate.

Alternator side [for all engines]

1. Remove the belt cover.
2. Loosen all alternator mounting bolts.
3. Loosen the lock nut on adjusting rod, and adjust V-belt tension by moving the rod.
4. While keeping the alternator in above position, tighten the lock nut first and then tighten the alternator mounting bolts.

Fan side

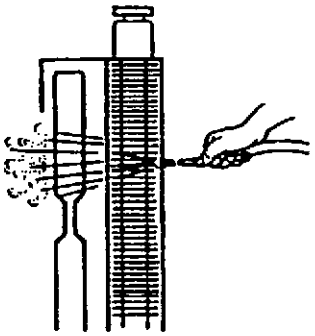
1. Loosen the tension pulley mounting bolts.
2. Loosen the lock nut on the adjusting bolt, then tighten the bolt and adjust the belt tension.
3. With the bolt in that position, tighten the lock nut and bracket mounting bolt.



[Cooling System]- continued

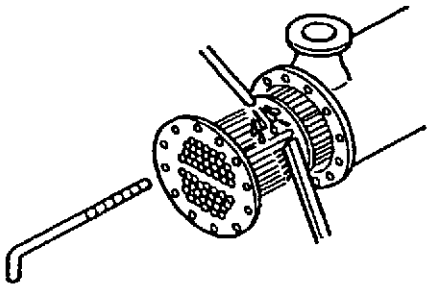
Inspecting and Cleaning Radiator Fins

Check radiator fins for holes and cracks.
To clean radiator fins, blow compressed air in the direction opposite to normal air flow.



Cleaning the Heat Exchanger

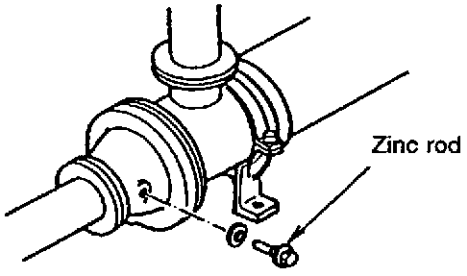
Clean the outside of the pipe by pouring clean water and using a wire brush. To clean the inside of the pipe, insert a rod to remove internal deposits.

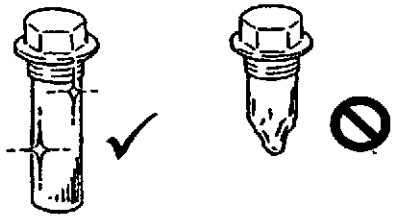


Inspecting and Replacing the Zinc Rod

Zinc rods (zinc electrodes) are installed at various sections of the sea water passages to prevent corrosion caused by sea water.

1. Remove each zinc rod and remove deposits (scale) from the surface.
2. If the zinc rod has worn to half the original size, replace it with a new zinc rod.
   If the zinc rod is larger than half the original size, reinstall it.

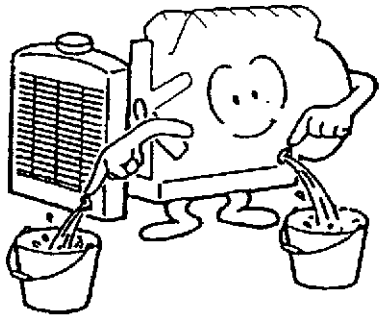




[Cooling System] - continued

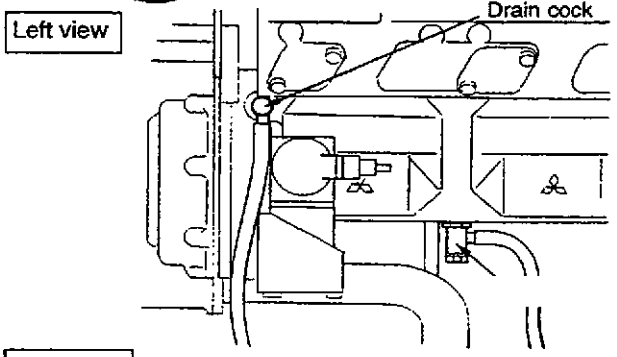
Changing Coolant

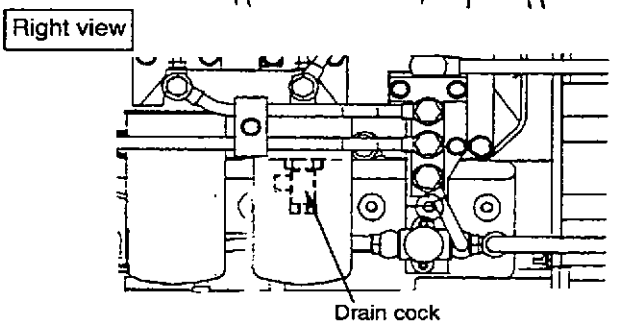
LLC used in the cooling system retains its efficacy for two years. Be sure to change the coolant every 2 years.



- **Draining Coolant**

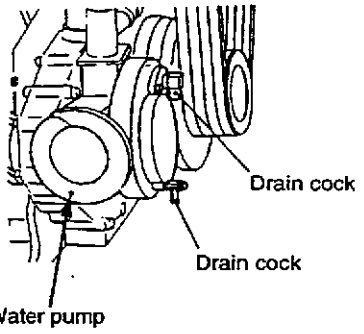
1. Start the engine and operate it until the coolant temperature increases up to 70 to 80°C [158 to 176°F].
2. Allow the engine to cool to room temperature and lift the radiator-cap lever to relieve pressure. Then remove the radiator cap.
3. Open the drain cocks of the engine block, water pump, and radiator, and allow the coolant to drain in a container.
4. Remove the drain plugs (one on each side) of the air cooler pipes and allow the coolant to drain.



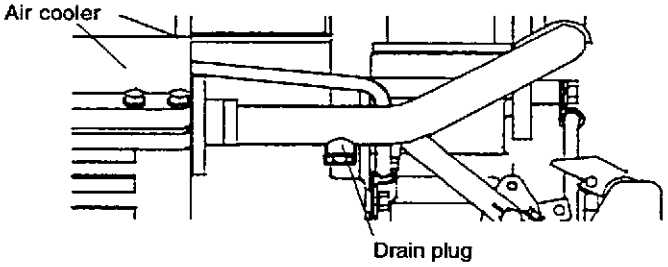


- **Flushing the cooling system**

1. Tighten all the drain cocks of the engine block, water pump and radiator.
2. Fill the cooling system with cleaning solution (which does not chemically attack rubber and metal surfaces). Start and operate the engine at 800 to 900 min^{-1} for about 15 minutes. Stop the engine and open the drain cocks to allow the solution to drain.
3. Close the drain cocks tightly.
4. Fill the cooling system with clean water and operate the engine at 800 to 900 min^{-1} for about 10 minutes.



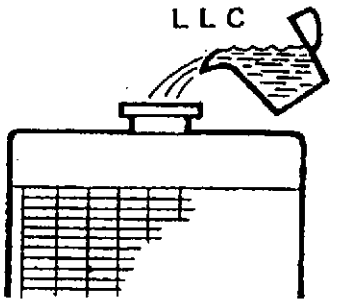
Continue to flush the cooling system in the above manner until the draining water is clear.



[Cooling System] - continued

- **Fill the radiator**

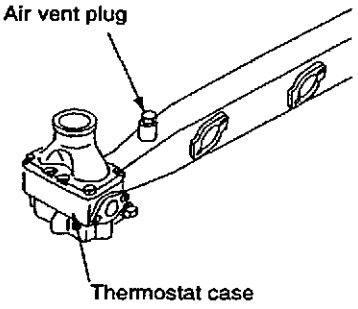
1. Tighten the drain plugs of the cylinder block, the water pump, and the radiator.
2. Remove the air vent plug at the top of the thermostat. This will help prevent trapped air in the system.
3. Remove the radiator filler cap and pour pure, undiluted LLC into the radiator.



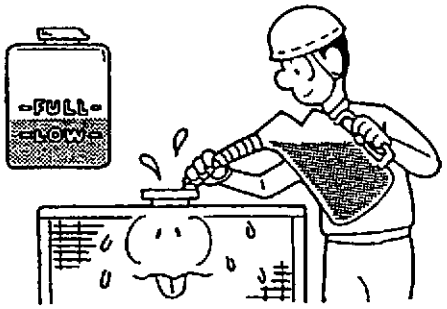
For concentration of LLC, see the chart below:

Recommended LLC Concentrations

Ambient temperature °C [°F]	-10 [14]	-20 [-4]	-30 [-22]	-45 [-49]
LLC concentration %	30	40	50	60



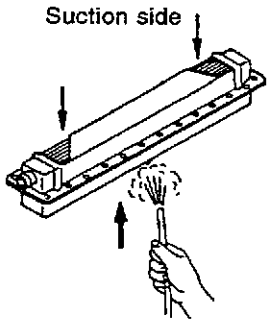
4. Add water (which is soft, or as free as possible from scale-forming minerals) to the radiator slowly to help avoid air pockets in the system.
5. When the tank is full, tighten the radiator cap securely.
6. Crank the engine with the starter several times, for 10 seconds each time, at intervals of one minute, to bleed air out of the water pump.
7. Operate the engine until the coolant temperature is 70°C to 80°C [158°F to 176°F]. Stop the engine.
8. Check the coolant level in the tank and add if necessary. If a reserve tank is equipped, the coolant level in the reserve tank should be near the FULL mark when the engine is cold.



[Air Inlet and Exhaust Systems]

Cleaning the Air Cooler

Remove the air cooler, and blow compressed air in the direction opposite to normal air flow.



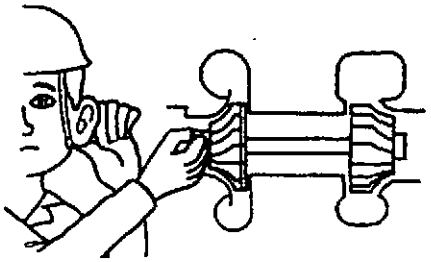
Turbocharger Inspection

⚠ CAUTION

Check the turbocharger only when the engine is cool and the compressor wheel is not running.

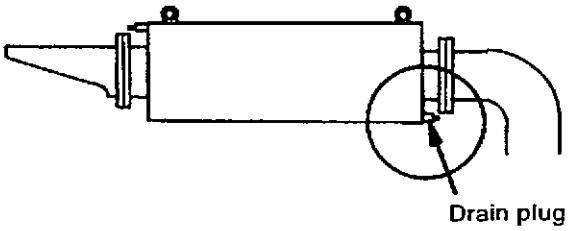
Take a hold of the compressor wheel nut and turn the wheel to feel for rattle and listen for abnormal noise. Replace the bearings if the wheel is noisy or rattles.

Notice: Also check the turbocharger when the exhaust color is abnormal.



Exhaust Muffler Drain water

Remove the drain plug and allow water to drain.

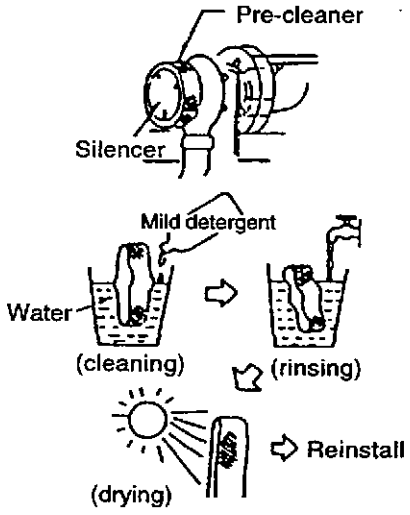


Cleaning the Pre-cleaner

Remove dust from the suction side of the pre-cleaner in the silencer of the turbocharger. Be sure to keep the pre-cleaner clean to ensure optimum engine performance.

1. Remove the pre-cleaner from the silencer, and hand-wash with a mild detergent.
2. Rinse the pre-cleaner with clean water.
3. After drying thoroughly, reinstall the pre-cleaner in the silencer.

Notice: If the pre-cleaner is cracked or damaged, replace.

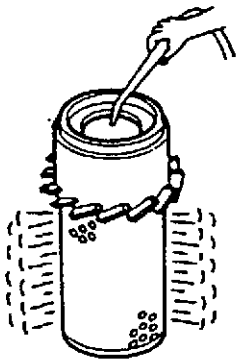


[Air Inlet and Exhaust Systems] - continued

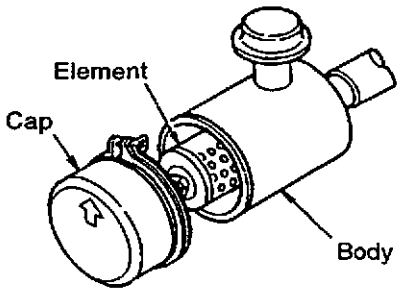
Clean the Air Cleaner Element

⚠ CAUTION

- **When using compressed air for cleaning, wear a protective face shield protective clothing and protective shoes.**
- **Do not service the air cleaner while the engine is running. Maintenance of the air cleaner while the engine is in operation can cause dust to enter the engine and result in rapid wear of parts, leading to a shorter service life.**
- **Do not clean the element by bumping or tapping.**



1. Blow compressed air to the inside of element along the length of pleats. The maximum air pressure is 0.69 MPa (7 kgf/cm^2) [100 psi].
2. Insert a light into cleaner element and inspect. Discard the element if rips or tears are found. If the indicator still shows RED shortly after the installation of the cleaner element, change the used element.



Replacing the Air Cleaner Element

⚠ CAUTION

Do not service the air cleaner while the engine is running. Maintenance of the air cleaner while the engine is in operation can cause dust to enter the engine and result in rapid wear of parts, leading to a shorter service life.

1. Remove the air cleaner cap.
2. Remove the wing nut securing the element in place. Pull out the element from the body, and install a new element.

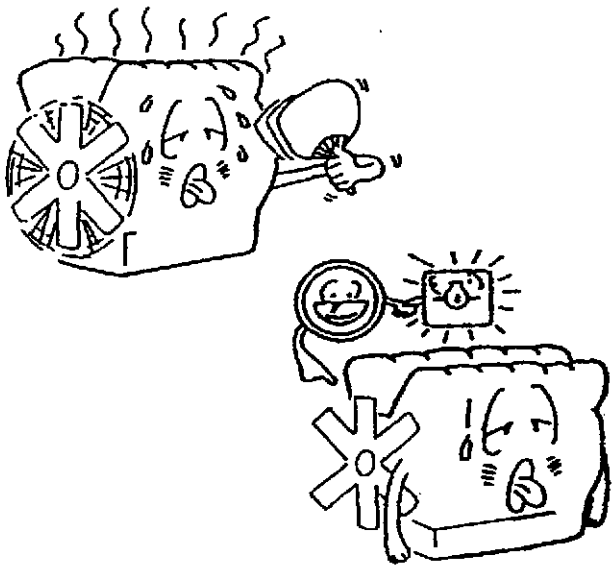
[Electrical System]

Protective Devices Inspection

Close the contactor of each device to check the stop solenoid for operation and the circuit for continuity.

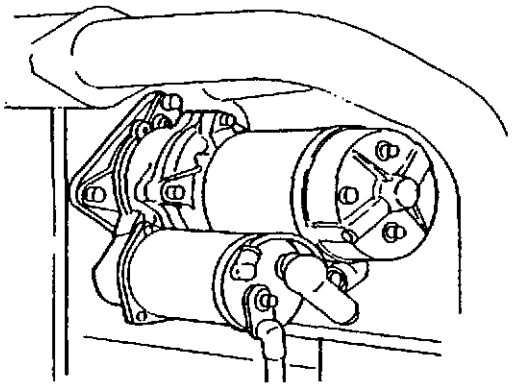
Notice: If the device has a defect, check the level (temperature or pressure) at which it operates.

- Thermo switch (high coolant temperature)
- Oil pressure switch (low oil pressure)
- Others



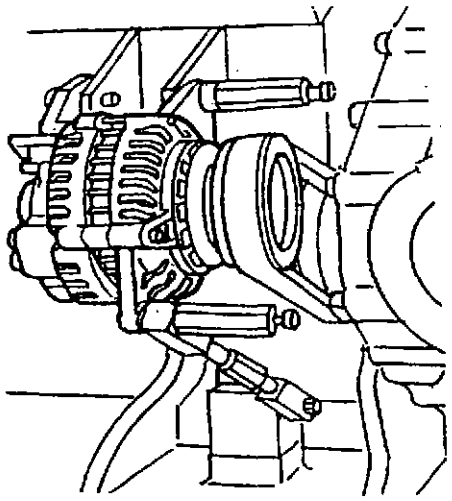
Starter Inspection

1. Visually check for abnormalities. Blow dirt build-up, if any.
2. Check the pinion for shifting and meshing action. If the starter has a defect, consult your Mitsubishi dealer.



Alternator Inspection

1. Visually check for abnormalities. Blow dirt build-up, if any.
2. Remove the V-belt from the alternator. Turn the alternator pulley by hand to check for rotation. If the alternator has a defect, consult your Mitsubishi dealer.

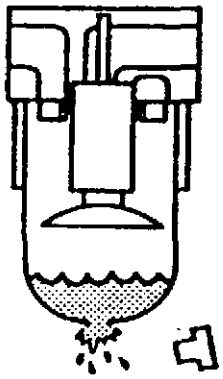


[Air Start System]

Draining Water from the Air Filter and Cleaning

⚠ CAUTION

Operate the starter valve handle of the air tank slowly when opening the valve. Otherwise, the engine may start operation abruptly and can cause a serious accident.



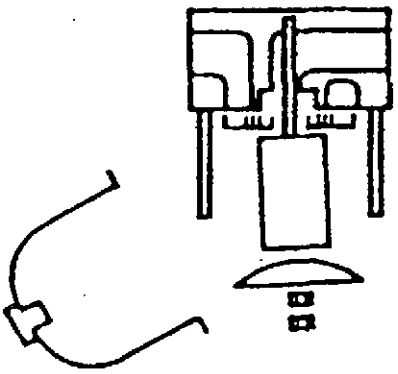
Draining water

1. Close the starter valve handle of the air tank.
2. Remove the drain plug located on the lower section of the air filter to drain water from the filter.

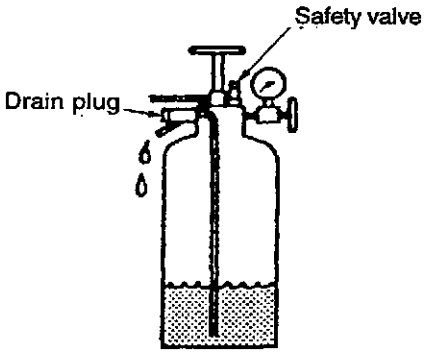
Cleaning

If the air filter is clogged, the engine becomes difficult to start. Be sure to clean the air filter regularly.

1. Close the starter valve handle of the air tank.
2. Remove the air filter cover, and take out the element.
3. Clean the element by immersing in cleaning oil, then blow compressed air to dry.
4. Reinstall the element and cover.
5. Open the starter valve handle of the air tank slowly.



Draining Water from the Air Tank and Checking Safety Valve Operation



Draining water

1. Close the starter valve handle of the air tank.
2. Open the handle located at the lower section of the drain valve on the front of the tank to drain water from the tank.

Checking safety valve operation

Test if the safety valve activates when the air tank pressure exceeds the specified pressure level.

Pressure level

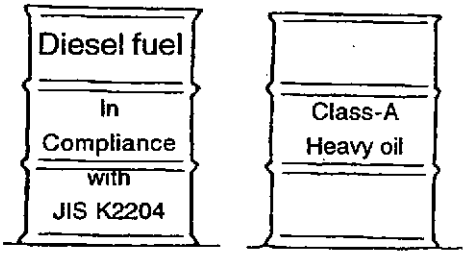
Air motor system: 0.93 MPa (9.5 kgf/cm^2) [135.1 psi]

FUEL

Recommended Types of Fuels

⚠ CAUTION

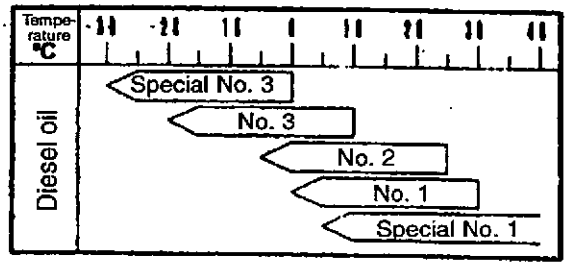
Use only recommended fuel oils. Do not pour in fuels more than necessary. Otherwise, a fire hazard may result.



Use commercially available diesel oils (JIS K2204).

Notice: Use fuels that meet the Use Limit Property Guideline on Diesel Fuel described below. For an engine that has been used heavily for a long period of time, refer to the new guideline.

It is necessary to use a fuel that has a pour point suitable for ambient temperature. Choose your fuel type from the chart at right.



Fuel use limit table

Property		New use limit	Present use limit	Remarks
Flash point		As stipulated by regulation	As stipulated by regulation	JIS K2204, 2205 Diesel fuel 50°C [122°F] or higher Class-A heavy oil 60°C [140°F] or higher
Distillation	First distillation point	170°C [338°F] or more		
	90% distillation point	330°C to 380°C [626°F to 716°F]	380°C [716°F] below	
Pour point		6°C below ambient temperature	6°C below ambient temperature	
Cloud point		Below ambient temperature	Below ambient temperature	
Carbon residue (10% residual oil)		0.4 weight % or lower	1.0 weight % or lower	
Cetane number		45 or more	45 or more	
Cetane index (new)		45 or more		JIS K2280-1996
Kinetic viscosity		2.0 mm^2/S or more (30°C) [86°F] 8.0 mm^2/S or lower (50°C) [122°F] 10.5 mm^2/S or lower (40°C) [104°F] 16.0 mm^2/S or lower (30°C) [86°F]	2.0 mm^2/S or more (30°C) [86°F] 8.0 mm^2/S or lower (50°C) [122°F] 10.5 mm^2/S or lower (40°C) [104°F] 16.0 mm^2/S or lower (30°C) [86°F]	
Sulfur content		0.2 weight % or lower	1.0 weight % or lower	0.05 weight % or lower recommended
Water and sediment		0.1 volume % or lower	0.1 volume % or lower	
Ash		0.03 weight % or lower	0.03 weight % or lower	
Copper plate corrosion (100°C [212°F], 3h)		No. 3 or lower	No. 3 or lower	ASTM: No. 3 JIS K2513: Discoloration No. 3
Specific gravity (15°C /4°C) [59°F/39°F]		0.80 to 0.87	0.80 to 0.87	
Coking test		Not carbonized 100% at 250°C [482°F]		
Aromatics content		38 weight % or lower		
Particulate contaminant		5.0 mg/liter or lower		
Asphaltene		0.1 weight % or lower		

Handling Fuel

1. When using fuel kept in a storage tank, leave for more than 24 hours so dust and water settle at the bottom. Then, use clean fuel from the upper layer. This prevents moisture condensation inside the tank and allows dust and water to separate and settle at the bottom.

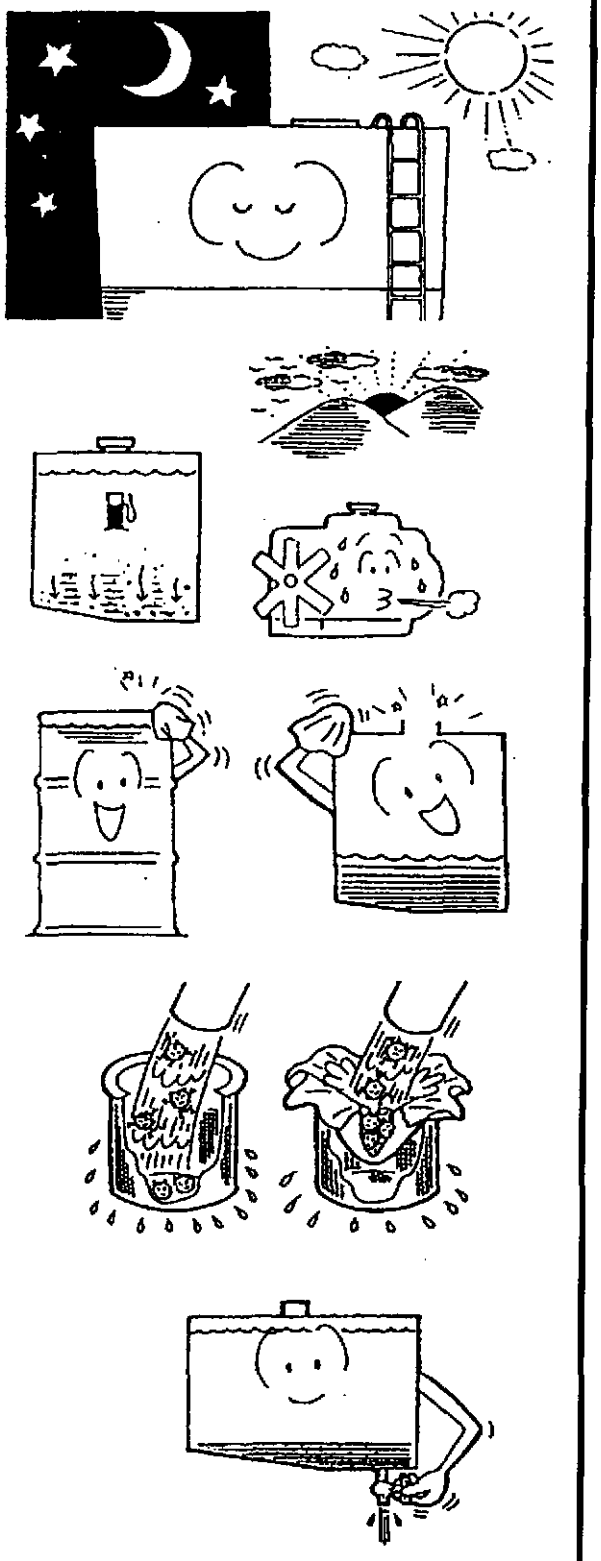
2. Fill the fuel tank or service tank after each work day. This prevents water from mixing with fuel in the tank and gives time for dust and water to separate and settle at the bottom of the tank.

3. Before removing the caps from the drum and tank, clean the areas around the caps thoroughly. Also clean your hands and the hose used for refueling. When a hand-operated pump is used, be careful not to pump water or sediment accumulated at the bottom of the storage tank.

4. Be sure to pour fuel through a strainer. Use of a clean lint-free cheese cloth is recommended.

5. Open the drain valves on the bottom surfaces of the storage tank, fuel tank and service tank regularly to remove (drain) sediments.

Notice: Even if fuel is obtained from the top layer in the drum, it still contains dust and water. To prevent them from entering the engine, it is important to use a strainer before pouring fuel into the fuel tank.

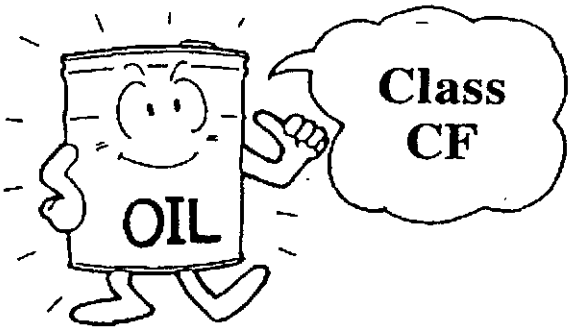


Recommended Types of Engine Oil

Class CF engine oil must be used.

Class CE and CF-4 engine oils are designed for diesel fuel with a sulfur content of less than 0.5% and less than 0.2%, respectively. Since the sulfur content of most Class-A heavy oil exceeds 0.5%, do not use Class CE or CF-4 engine oil when using Class-A heavy oil as fuel.

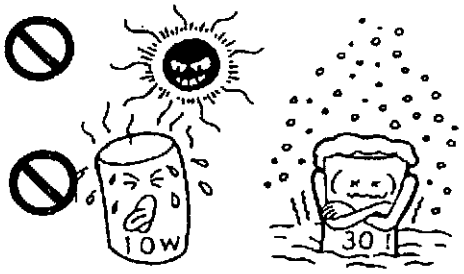
Use of improper or inferior oil can cause excessive wear of bearings and moving parts, thus shortening the engine life. It can also result in sticking of piston rings and seizing of pistons in the cylinders, thus causing major damage.



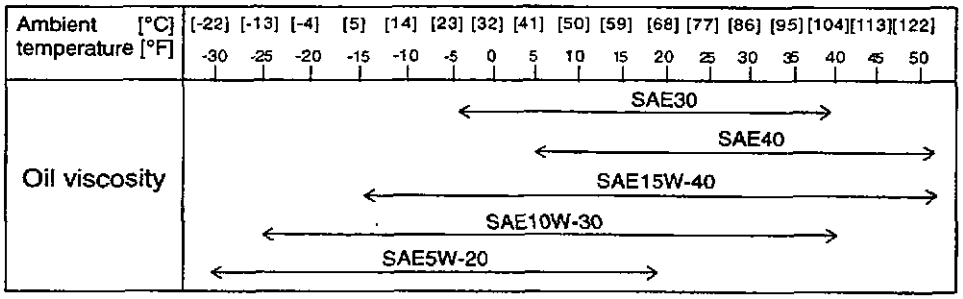
Selection of Oil Viscosity

Use the following chart to select appropriate oil viscosity according to the ambient temperature. Recommended oil viscosity is SAE 15W-40 for all seasons.

Excessively high oil viscosity causes power loss and higher oil temperature, while excessively low oil viscosity results in inadequate lubrication and leakage of combustion gas to cause increased wear and reduced output.



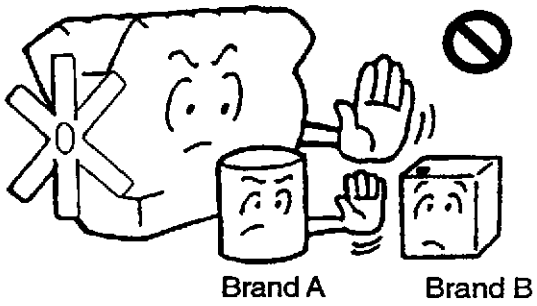
Recommended Oil Viscosities



Recommended Commercial Oil Brands

⚠ CAUTION

Avoid mixing oils of different brands. When oils of different brands are mixed, additives used in the oils can cause chemical reactions to degrade the oil performance.



Replenish Engine Oil

⚠ CAUTION

- **Stop the engine when filling oil. Do not smoke while filling — or when handling oil containers.**
- **Oil leaked or spilled onto hot surfaces or electrical components can cause a fire. Be sure to wipe immediately and thoroughly.**
- **After filling oil, secure filler cap.**

Coolant Specifications

Water used in the engine cooling system must be soft water (such as tap water) and meet the following requirements.

Notice: As a general rule, chemical substances contained in water should not exceed the standards, but they are tolerable up to the limits shown in the chart below.

Water quality standards

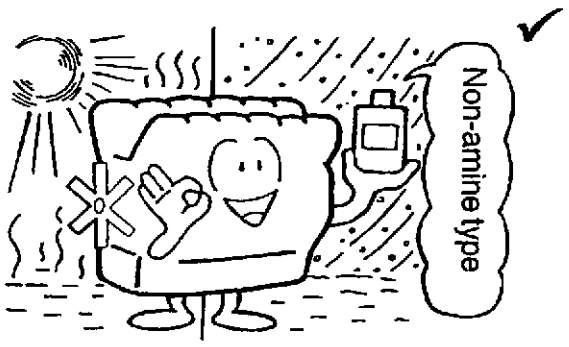
Item	Chemical symbol	Unit	Recommended limit	Main adverse effect	
				Corrosion and rust	Scale formation
pH (25°C) [77°F]	–	–	6.5-8.5 (6.5-8.0)	O	O
Electrical conductivity (25°C [77°F])	–	μ℧/cm	< 400 (< 250)	O	O
Total hardness	$CaCO_3$		< 100 (< 95)	–	O
M alkalinity	$CaCO_3$	ppm	< 150 (< 70)	–	O
Chlorine ion	Cl^-	ppm	< 100 (< 100)	O	–
Sulfuric acid ion	SO_4^{2-}	ppm	< 100 (< 50)	O	–
Total iron	Fe	ppm	< 1.0 (< 1.0)	–	O
Silica	SiO_2	ppm	< 50 (–)	–	O
Residue from evaporation	–	ppm	< 400 (< 250)	–	O

Notice: In addition to the items specified above, turbidity is specified to be below 15 mg/liter.

Recommended type of Antifreeze (LLC)

⚠ CAUTION

Should LLC be accidentally swallowed, induce vomiting immediately and seek medical attention immediately. If LLC gets into your eyes, flush immediately with lots of water, and see a physician at once.



Be sure to use Long Life Coolant (LLC) as an antifreeze, because it prevents not only freezing of cooling water from but also rusting of the cooling system. Use an all-season, non-amine type.

Recommended Commercial LLC Brands
Recommended brands of LLC are shown in the chart below.

Recommended brands of LLC

Manufacturer	Brand
Nippon Mitsubishi Oil	Diamond Diesel Coolant
Mitsubishi Motors	Fuso Diesel Long Life Coolant

Notice: When using an LLC other than the above, frequent inspections are required since the service life may be shorter.

Features and Performance of Recommended LLC

- Contains no amine.
  Contains no silicate or borate.
- Close to neutral on the pH scale (slightly alkaline).
- Contains balanced chemical additives as substitutes for amines.
- Offers long life. (Coolant with 30% LLC concentration, for example, retains its efficacy for more than one year).

LLC Maintenance

⚠ CAUTION

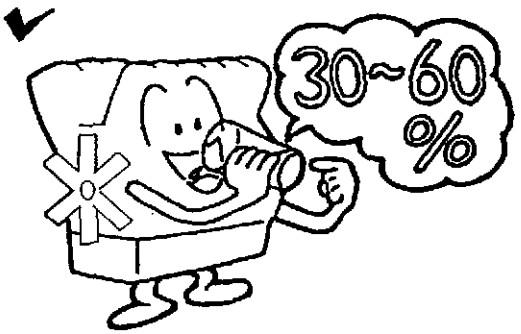
Coolant (containing LLC) drained during coolant change is toxic, and must not be disposed of into regular sewage.
For disposal of used coolant, consult your dealer.

Intervals of LLC (Coolant) Change

Coolant containing recommended LLC should be changed every two years.

- **LLC concentration**

When determining the LLC concentration, provide a margin of 5°C [41°F] lower than the expected lowest temperature in your region. Maintain the LLC concentration between 30 and 60% throughout the year. LLC of less than 30% concentration does not provide sufficient corrosion protection. If the LLC concentration is as low as several percent, it may promote corrosion. Concentrations over 60% adversely affect freeze protection and cause the engine to overheat easily.
When adding coolant, do not add plain water. Always use coolant having the same LLC concentration.



Recommended LLC Concentrations

Ambient temperature °C [°F]	-10 [14]	-20 [-4]	-30 [-22]	-45 [-49]
LLC concentration (vol. %)	30	40	50	60

Why LLC?

Today's trend is toward smaller and more lightweight engines greater output, lower fuel consumption and lower exhaust emission levels. Engine application has also been expanded. In most applications, the engine coolant is compelled to withstand severe conditions, namely, continuous high-power operation with higher coolant temperature and higher speed of coolant recirculation in the cooling circuit. Many materials involved in the circuit (such as steel, aluminum, copper, solder and rubber) are also subjected to severe service. These materials differ in ionizing tendency and this difference promotes cavitation and deterioration through the medium of engine coolant. The job of breaking the link between cause and effect to preserve the circuit is undertaken by LLC.

How LLC works

LLC contains several chemicals (ingredients) in such proportions as to produce chemical reactions that suppress corrosion of engine parts in contact with coolant. "Corrosion" is the result of a phenomenon called "Corrosion" is the result of a phenomenon called "ionization." The power of LLC to defeat the ionic reaction is generally subjected to wear and, in the engine coolant, becomes increasingly weak in time. Moreover, if its chemicals are not well proportioned to match the circuit metals that they are meant to protect, they become rapidly used up to aging and allow some metals to precipitate into the coolant or to from new compounds that turn to rusty surface deposits. Some chemicals, calculated to inhibit this ionic reaction, might accelerate the reaction of those metals that have already begun reacting.

Far worse, the process of ionic reaction or corrosion will go on faster than when the coolant is straight water having no additives, if there is no good match between the chemical proportions and circuit metals.

Typical Reported Cases of circuit Trouble for Which Additive is Blamed

Case 1:

Amines are generally effective in suppressing the rusting of ferrous metals but are said to be problematic for copper and cupric metals because of copper involvement in pittings reported on ferrous metals. The mechanism of iron-surface pitting may be explained as that of galvanic or local-cell action. Suppose a cluster of copper molecules precipitates out and deposit itself on a surface of iron, a base metal relative to copper; the cooper deposit introduces a localized galvanic cell which, by its ionic action, rapidly eats into the iron surface to result in pit.

Case 2:

A silicate (there are several types of silicate) is highly effective in protecting aluminum against rusting. This compound of silicon is unstable in a solution whose pH is 9 or under: it is prone to turn to gel and settle down in the solution. For this reason, the pH is usually specified to be 10 or so. This means that the silicate has to be used in a high-alkalinity coolant. When the silicate is used up, the high alkalinity starts chemically attacking aluminum.

(Example)

The mechanical seal of the water pump may rapidly wear down as the secondary effect of silicate gel in the above context.

Case 3:

As the additive as a whole deteriorates or when its concentration in the coolant is too low, its anti-corrosion performance falls and consequently the circuit metals begin to corrode more than when the additive was active. Of those metals badly affected in such a condition, the deterioration of brass and solder is significant, causing water leakage or clogs.

(Example)

Hole in the radiator and clog can be resulted.

[Storage of Engine in Non-Operating Condition]

Preparation

1. Drain the oil from the engine and fill it with rust preservative (NP-10).
2. Make up a mixture of rust preservative (NP-9) and fuel of 1:1, and fill the fuel tank with the mixture.
3. Start the engine and operate it at low idle for 5 to 10 minutes (600 min^{-1}).
4. Stop the engine. Spray volatile rust preservative in the to prevent rust on the intake system.
5. Drain the rust preservative-fuel mixture.
6. Apply a coat of rust preservative (NP-3) to the exposed machined surfaces of the engine.
7. Cover the air inlet and exhaust openings and the breather with taping.
8. Loosen V-belt.
9. Tape the starter and alternator terminals and cover the starter and alternator with a polyethylene sheet. Put a desiccant inside the covering.

Notice: Do not use a vinyl sheet for the cover.

10. Remove the batteries and charge them. Clean the terminal posts and coat them with grease. Keep the batteries in a dry, cool place.
11. Cover the engine for weather protection.

Notice: (1) Store the engine in a well-ventilated room.
(2) It is not necessary to drain the coolant because it contains LLC (in 30% to 60% concentration).
(3) Post a warning sign for the next preservative in the engine must be replaced with the specified engine oil and the fuel tank be filled before starting the engine.
(4) New engine oil may be used instead of rust preservative (NP-10).

Rust Preservative Chart

JIS		Recommended brand	Application
K2246	NP-3 NP-9	Diamond PA-3 (Nippon Mitsubishi Oil Co., Ltd.) Diamond PA90 (Nippon Mitsubishi Oil Co., Ltd.)	Exposed machined surfaces Fuel system
	NP-10-1 NP-10-2 NP-10-3	Diamond PA-10 (Nippon Mitsubishi Oil Co., Ltd.)	Lubrication system
Z1519	—	V.C.I Volatile Rust Preservative Diana (Ryoko Chemical Co., Ltd.)	Intake system

Care During Storage

Recharge the battery at least once a month.

When Engine Returns From Storage

1. Remove the covering from the engine.
2. Connect well-charged batteries to the engine.
3. Remove the covering from the starter and alternator.
4. Adjust V-belts.
5. Remove all coverings and tapings.
6. Drain the rust preservative from the engine and fill the engine with recommended engine oil.
7. Fill the fuel tank and prime the fuel system.
8. Check under and around the engine for such items as loose or missing bolts, oil, fuel or coolant leaks.
9. Remove the rocker covers and lubricate the valve mechanism.
10. Crank the engine three times, 10 seconds each time, at intervals of one minute, with the fuel supply shut off, to make sure the oil pressure rises properly.
11. Check the engine oil pressure raising.
12. Start the engine.
13. Allow the engine to warm up at low idle.
14. When the engine has run long enough to warm up, apply the load and bring it to operating speed.

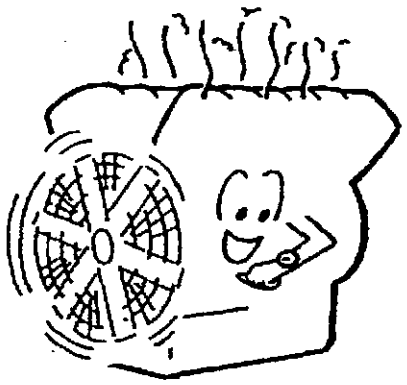
[Storage of Engine in Operating Condition]

Service the engine once a month in the following manner.

1. Crank the engine two times, for 10 seconds each time, with the starter at intervals of 30 seconds, with the fuel supply shut off.
2. Start and run the engine under no-load condition for 5 to 10 minutes.

[Off-Season Storage of Engine in Operating Condition]

Conducting Maintenance Operation



To prevent rust generation and keep rotating parts wet with oil, conduct a maintenance operation at least once every month.

1. With fuel supply cut off (press engine stop button to stop fuel injection), operate the starter twice for each 10 seconds in a 30-second interval, and check the oil pressure gage

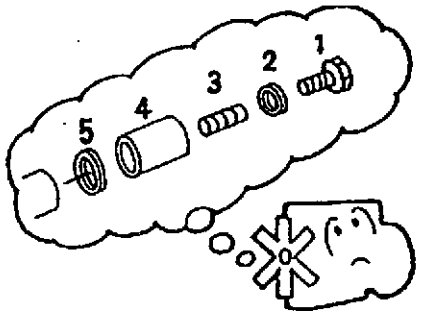
2. Start the engine, and run the engine under no load for 5 to 10 minutes.

TROUBLESHOOTING

[General Precautions]

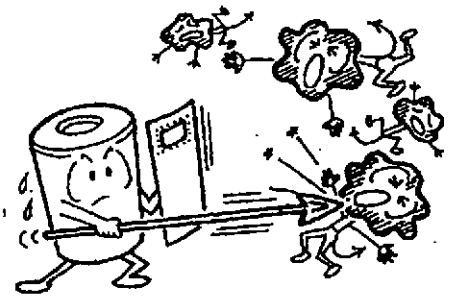
Think possible causes of the problem before conducting work

Before troubleshooting, think possible causes of the problem and try to see if the same problem has occurred in the past. Check the parts that may be causing the problem in the most efficient order. When disassembling a component, pay close attention to the disassembly sequence so that you can reassemble the component efficiently.



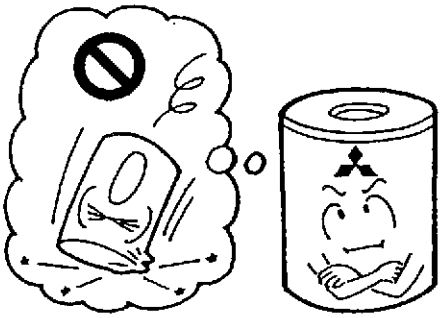
Beware of dirt and foreign particles

Dust and foreign particles are the most common cause of excessive wear of parts. When disassembling a component, take measures to prevent dust and foreign particles from entering the component being disassembled.



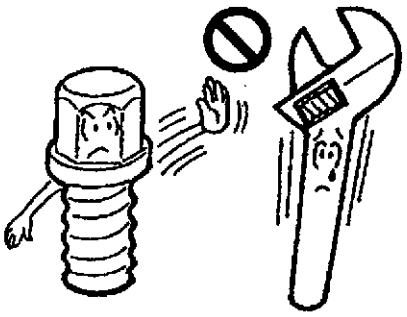
Handle parts with care

Handle parts carefully. When replacing parts, use only genuine parts by referring to the parts catalog.



Perform service safely

Use correct tools. For example, using a wrench of a wrong size not only damages the nut but can cause personal injury. It is important to perform work carefully to prevent accidents. Be sure to estimate the weight of the part being dismounted. If the removed part is too heavy, it may fall during lifting, causing damage to the part as well as personal injury.



[How to Troubleshoot]

Starter will not crank engine or cranks slowly, resulting in a failure to start.

Electrical system

OK

Fuse blown

Replace.

Low oil pressure indicator light

OFF

ON

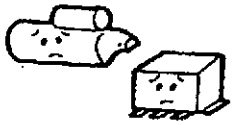
Battery-starter switch circuit open or shorted

⇨ Repair or replace.

Battery-starter switch circuit open or shorted.

⇨ Repair or replace.

Starter or starter relay defective



Consult your

Battery discharged

⇨ Check alternator drive belt.

Electrolyte specific gravity low ⇨ Recharge.

Battery "dead" ⇨ Change.

Lubrication system

OK

Oil viscosity too high

Change oil of proper viscosity.

Fuel system

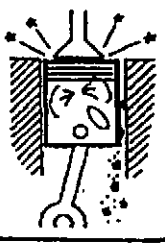
OK

- Air in system ⇨ Prime.
- Insufficient fuel ⇨ Refuel.
- Fuel filter clogged ⇨ Change.
- Fuel feed pump defective ⇨ Consult your dealer.
- Fuel injection pump defective ⇨ Consult your dealer.

Main parts

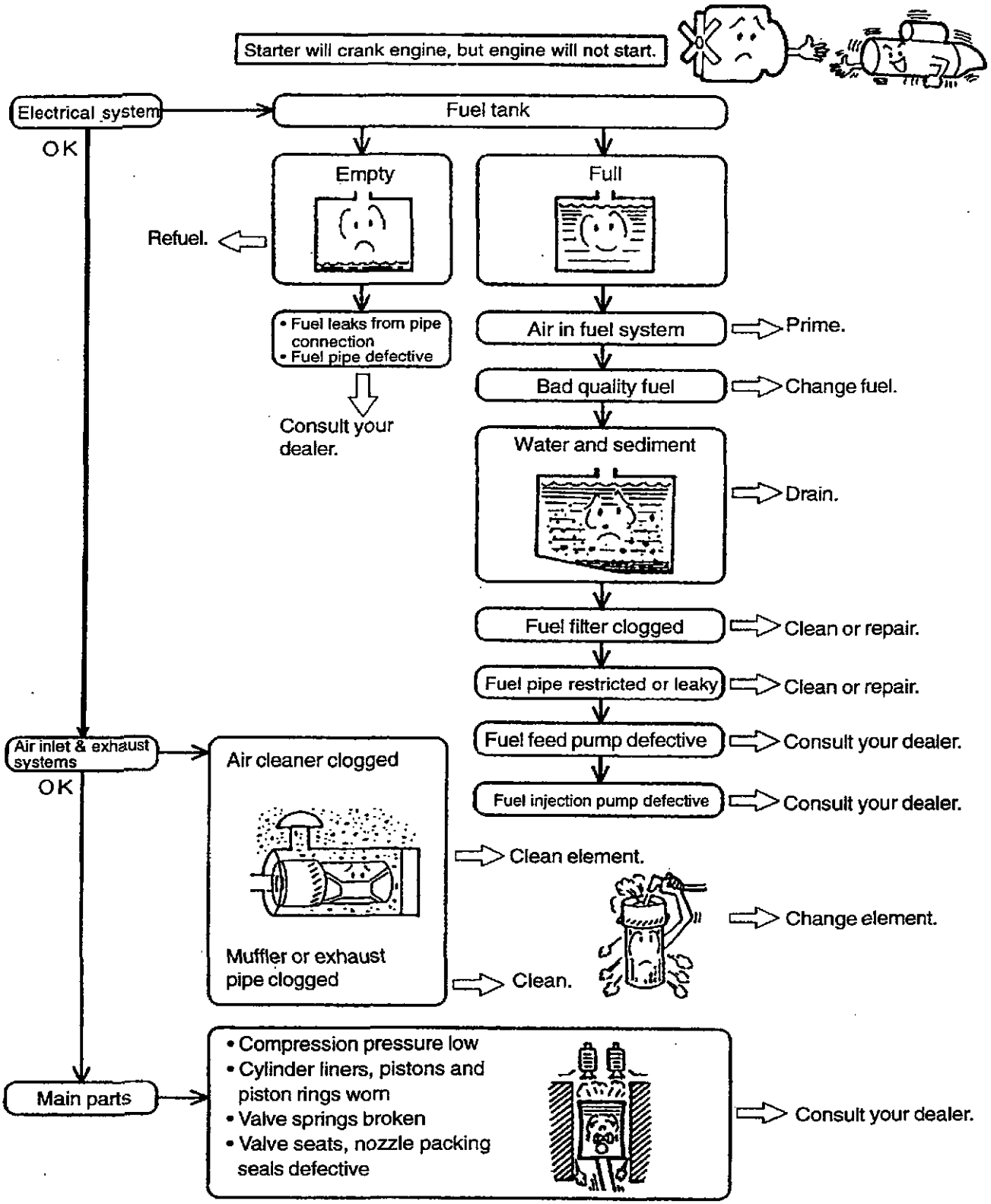
Moving parts defect

- Interference between pistons and valves
- Foreign matter in cylinders



⇨ Consult your dealer.

[How to Troubleshoot]



[Minor Problems and Countermeasures]

Air Starter

Air motor system

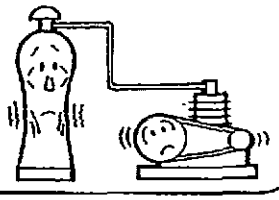
Air motor does not rotate.

Low air pressure	→ Operate compressor to increase air tank pressure.
Faulty starter switch Faulty magnetic valve	→ Correct short-circuit or open-circuit →Consult your Mitsubishi dealer.

Air motor rotates, but ring gear does not engage.

Damaged ring gear or pinion	→ Consult your Mitsubishi dealer.

Pinion engages with ring gear, but does not rotate.

Low air pressure 	→ Operate compressor to increase air tank pressure.

[Other Problems and Countermeasures]

Problem	Possible cause	Measure	Remedy
Engine lacks power 	• Improper engine oil viscosity	Inspection	Use engine oil of proper viscosity according to ambient temperature
	• Improper fuel	Inspection	Use recommended fuel.
	• Insufficient air intake (clogged air cleaner)	Cleaning	Change filter element if necessary.
	• Radiator overcooling	Inspection	Cover radiator or consult your Mitsubishi dealer. (parts change)
	• Clogged fuel filter	Inspection	Replace.
	• Insufficient cooling capacity of radiator (engine overheat)	–	Consult your Mitsubishi dealer. (parts change)
	• Incorrect valve clearance	–	Consult your Mitsubishi dealer. (adjustment)
	• Faulty fuel feed pump	–	Consult your Mitsubishi dealer. (parts change)
	• Faulty fuel injection pump	–	Consult your Mitsubishi dealer. (adjustment or parts change)
	• Faulty spraying of fuel injection nozzles	–	Consult your Mitsubishi dealer. (adjustment or parts change)
	• Incorrect fuel injection timing	–	Consult your Mitsubishi dealer. (adjustment)
	• Low compression pressure (worn cylinder liners, piston rings, etc.)	–	Consult your Mitsubishi dealer. (disassembly, repair, parts change)
Exhaust smoke is white or blue 	• Excessive amount of engine oil	Inspection	Maintain correct oil level
	• Low engine oil viscosity	Inspection	Use engine oil of proper viscosity according to ambient temperature.
	• Radiator overcooling	Inspection	Cover radiator or consult your Mitsubishi dealer. (parts change)
	• Faulty thermostat (no coolant temperature	–	Consult your Mitsubishi dealer. (parts change)
	• Faulty fuel injection nozzles (uneven injection among cylinders)	–	Consult your Mitsubishi dealer. (adjustment or parts change)
	• Incorrect fuel injection timing	–	Consult your Mitsubishi dealer. (adjustment)
	• Low compression pressure (worn cylinder liners, piston rings, etc.)	–	Consult your Mitsubishi dealer. (disassembly, repair, parts change)
	• Improper fuel (low cetane number)	Inspection	Use recommended fuel.
Exhaust smoke is black or dark gray 	• Improper fuel	Inspection	Use recommended fuel.
	• Incorrect valve clearance	–	Consult your Mitsubishi dealer. (adjustment)
	• Faulty fuel feed pump	–	Consult your Mitsubishi dealer. (parts change)
	• Low compression pressure (worn cylinder liners, piston rings, etc.)	–	Consult your Mitsubishi dealer. (disassembly, repair, parts change)
	• Insufficient air intake (insufficient ventilation, clogged air cleaner)	Cleaning	Replace filter element if necessary.
	• Incorrect fuel injection timing	–	Consult your Mitsubishi dealer. (adjustment)
	• Faulty fuel injection nozzles	–	Consult your Mitsubishi dealer. (adjustment or parts change)
	• Faulty fuel injection pump	–	Consult your Mitsubishi dealer. (adjustment or parts change)

Problem	Possible cause	Measure	Remedy
High fuel consumption 	• Faulty fuel feed pump	–	Consult your Mitsubishi dealer. (parts change)
	• Faulty fuel injection pump	–	Consult your Mitsubishi dealer. (adjustment or parts change)
	• Incorrect fuel injection timing	–	Consult your Mitsubishi dealer. (adjustment)
	• Improper fuel	Inspection	Use recommended fuel.
	• Low compression pressure (worn cylinder liners, piston rings, etc.)	–	Consult your Mitsubishi dealer. (disassembly, repair, parts change)
	• Insufficient air intake (clogged air cleaner)	Cleaning	Change filter element if necessary.
High oil consumption 	• Excessive amount of engine oil	Inspection	Maintain correct oil level.
	• Low engine oil viscosity	Inspection	Use engine oil of proper viscosity according to ambient temperature.
	• Engine oil leakage	Re-tightening	Consult your Mitsubishi dealer. (parts change)
	• Worn cylinder liners and piston rings	–	Consult your Mitsubishi dealer. (disassembly, repair, parts change)
	• Worn valve stem seals	–	Consult your Mitsubishi dealer. (parts change)
Engine overheats 	• Dirty radiator	Cleaning	Consult your Mitsubishi dealer.
	• Loose V-belts	Adjustment	
	• Low coolant level	Replenis-hment	
	• Faulty water pump	–	Consult your Mitsubishi dealer. (parts change)
Low oil pressure 	• Low engine oil level	Inspection	Add oil to specified level.
	• Low engine oil viscosity	Inspection	Use engine oil of proper viscosity according to ambient temperature.
	• Clogged oil filter	Replacement	
	• Faulty oil pump	–	Consult your Mitsubishi dealer. (cleaning, adjustment, parts change)
	• Faulty relief valve	–	Consult your Mitsubishi dealer. (cleaning, adjustment, parts change)
	• Faulty wiring of oil pressure sensor	–	Consult your Mitsubishi dealer. (repair)

Notice: • If the problem cannot be corrected easily or a problem other than those listed above occurs, consult your dealer.

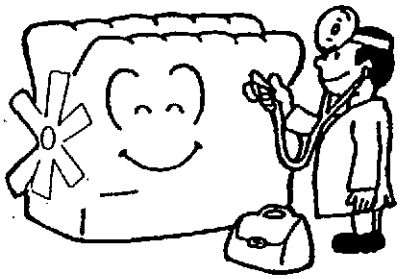
• When ordering replacement parts, provide the engine serial number. When requesting repair, provide the engine serial number and service-hour meter reading.

ENGINE SPECIFICATIONS

Engine model	S12H – TA	S12H – TK
Type	4-cycle water cooled diesel engine	
	Turbocharged with air-cooled after cooler	Turbocharged with air-cooled inter cooler
Number of cylinders, arrangement	12 V	
Bore × stroke (mm [in.])	ϕ150 × 175 [5.91 × 6.89]	
Total displacement (liter [U.S. gal.])	37.11 [9.80]	
Combustion type	Direct injection	
Compression ratio	14.0 : 1	
Firing order	1 – 12 – 5 – 8 – 3 – 10 – 6 – 7 – 2 – 11 – 4 – 9	
Rotation direction	Counterclockwise as viewed from flywheel side	
Dimensions (Length × Width × Height) (mm [in.])	1954 × 1472 × 1694 [76.9 × 58.0 × 66.7]	
Dry weight (kg [lb])	Approx. 3900 [8598]	
Fuel	Diesel fuel (JIS K2204) or Class-A heavy oil	
Fuel feed pump	Trochoid pump	
Fuel filter	Paper element cartridge type	
Injector	Mitsubishi unit injector	
Fuel injection nozzle	Hole nozzle type	
Initial fuel injection pressure (MPa (kgf/cm^2) [psi])	29.42 (300) [4268]	
Lubricating system	Forced lubrication (pressure feed by oil pump)	
Lubrication oil	Class CF (API Service Classification)	
Engine oil capacity oil pan (whole engine) (liter [U.S. gal.])	Approx. 180 [48] (Approx. 200 [53])	
Oil filter	Paper element cartridge type	
Oil cooler	Water cooling multi plate type	
Cooling system	Forced water cooling	
Cooling water capacity (liter [U.S. gal.])	Approx. 100 [26.4] (in engine only)	
Starting system	Electric motor starting or air starting	
Starter	12 V – 7.5 kW × 2 / 14.7 kW (air motor)	
Alternator	24 V – 30 A	
Turbocharger	Mitsubishi TD13 – L	
Flywheel	SAE 18 in.	
Flywheel housing	SAE # 0	

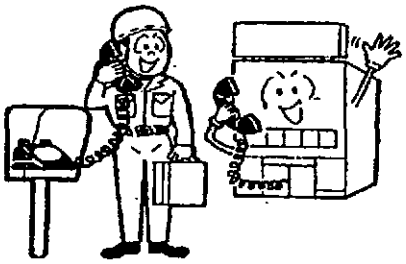
Requesting repair

Should the engine fail to operate properly, consult your Mitsubishi dealer. When requesting repair, check the engine serial number and service-hour meter reading, then explain the problem conditions in detail.



Relocating engine

When moving the engine to another location, consult your Mitsubishi dealer.



Location of Engine Serial Number

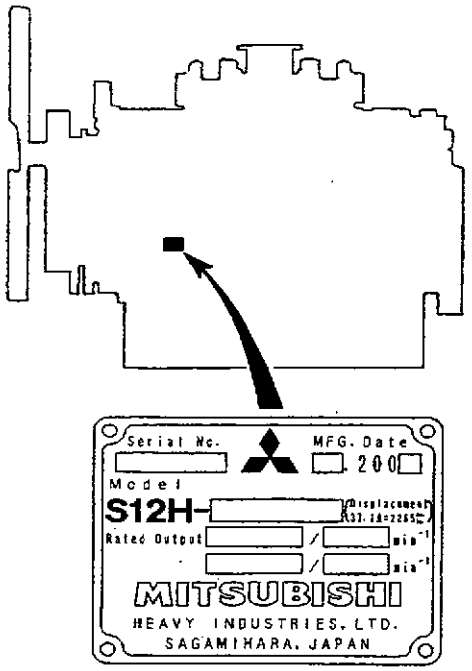
The engine serial number is indicated on the nameplate attached to the left side of the engine.

Example

Model: S12H

Serial number: 00012

On the nameplate are also indicated the serial number, output, rated speed and other engine data.



Scheme of Designating Engine Model

S□□-□TA ..... Turbocharged diesel engine with after cooler

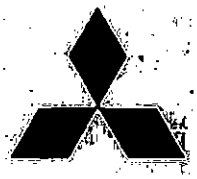
S□□-□TK ..... Turbocharged diesel engine with inter cooler

Application
- P ..... For Generator, general-purpose power supply engine
- L ..... For locomotive engine
- MP ..... For marine generator and marine propalsion

Series code

No. of cylinders code

Sagamihara Machinery Works



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