OPERATION & MAINTENANCE MANUAL

MITSUBISHI DIESEL ENGINE

S12A2

MITSUBISHI HEAVY INDUSTRIES, LTD.

INTRODUCTION

Thank you for purchasing the Mitsubishi S12A2 diesel engine.
This manual contains operation instructions, and lubrication and maintenance information for Mitsubishi S12A2 diesel engine.
We suggest that you carefully read and understand the instructions in the manual before operating or performing lubrication and maintenance on the engine.
Whenever a question arises regarding your engine, this publication, or maintenance to be performed on the engine, consult your Mitsubishi dealer for the latest available information.

⚠ WARNING

Most accidents involving operation and maintenance are caused by a failure to follow fundamental safety rules and precautions.
Read these operation instructions carefully before operating or performing lubrication and maintenance on the engine.
Do not operate the engine unless you have read and understood the instructions in this manual.

- Keep this manual handy for ready reference.
- If this manual is damaged, missing or cannot be read, consult your Mitsubishi dealer for a replacement manual.
- Read and understand basic safety precautions listed in the SAFETY section before operating or performing lubrication, maintenance and repair on this engine.

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Warning Signs

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

⚠ DANGER — Indicates the most serious specific potential hazard resulting in serious bodily injury or death.

⚠ WARNING — Indicates a specific potential hazard resulting in bodily injury.

⚠ CAUTION — Indicates operating procedures, practices, etc., resulting in personal injury or damage to or destruction of engine.

Some **CAUTION** items also indicate a specific potential hazard resulting in serious bodily injury or death. In any case, please observe every safety instruction.

Symbols

✔ ---------- Indicates a proper action or "DO."

⊘ ---------- Indicates a prohibited action or "DON'T."

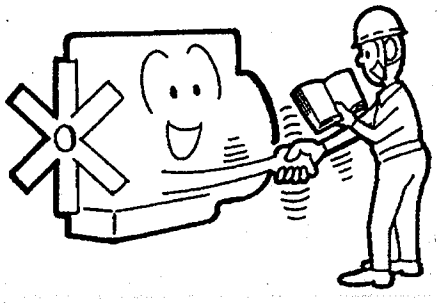
Others

P ---------- Indicates a page number to be referred to.

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:

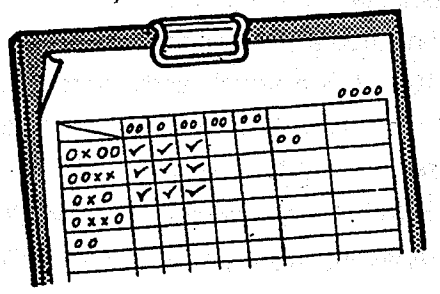
- Effective troubleshooting (to help a serviceman of your Mitsubishi dealer pin-point a problem).
- Quick servicing and less downtime (to help a serviceman of your Mitsubishi dealer save time and cost for servicing).
- Grasp of operating conditions (to help you recognize conditions, signs or indications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



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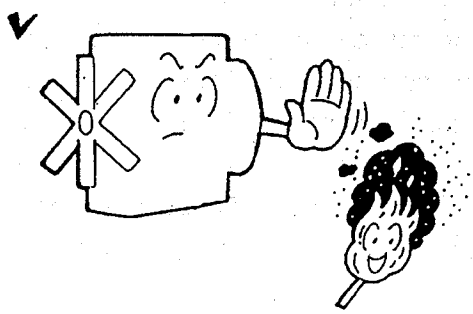
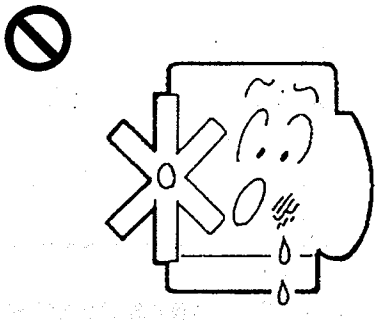
DANGER Fire or Explosion Prevention

Fire hazards!
Do not use fire near flammable materials such as fuel, oil, and some coolant mixtures. Do not spill fuel or oil on hot surfaces. Clean up any spillage soon. Do not smoke, create a spark or light a match near flammable materials.



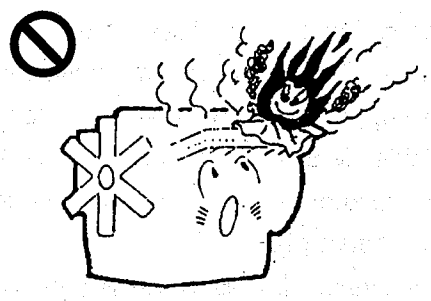
Do not fill fuel tank while engine is running!
Shut off the engine when fueling — and use extra caution if engine is hot.



Always look out for oil leakage!
If you find any oil leakage, immediately take necessary measures for stopping it. Oil spilled on hot surfaces is a fire hazard.

WARNING Fire Prevention

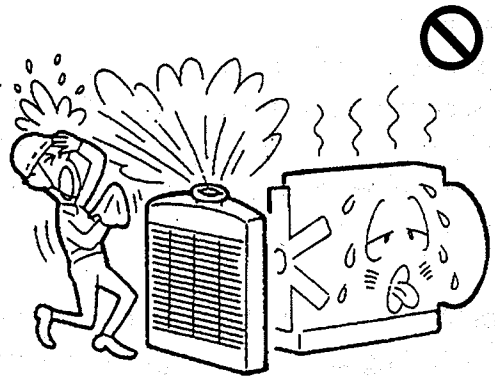
Keep flammable materials away from engine!
Keep any flammable and hazardous materials away from the engine, such as oil, fuel, wastepaper, or gunpowder. Remove them completely. The surface of the engine becomes very hot because of the heat of exhaust pipe or exhaust gas. Any flammable materials on/near the pipe can cause fire.
Install the engine at least one meter [3.3 ft] away from the engine room or shelter walls, or from other equipment.



WARNING

Burn Prevention

Remove radiator filler cap carefully!
At operating temperature, engine coolant is hot and under pressure. Steam can cause personal injury. 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.

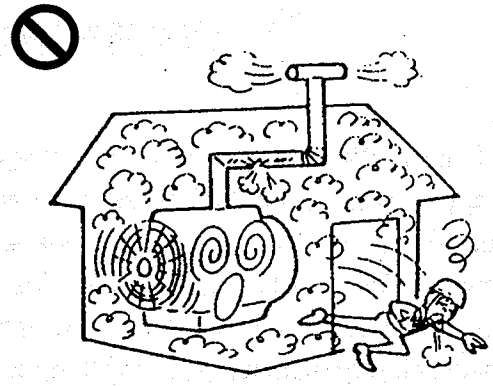


WARNING

Exhaust Fumes

Operate engine only in a well-ventilated area!
Exhaust fumes may cause injury or death if inhaled.

- Start and operate the engine in a well-ventilated area only. Do not operate it in an enclosed area (warehouse or tunnel) to avoid gas poisoning.
- If operating in an enclosed area cannot be avoided, provide adequate ventilation and take measures to vent exhaust fumes to the outside. Make sure that no exhaust gas leaks into the engine room from the joint portions of the exhaust pipe.
- Vent exhaust fumes to the outside in a manner that it is not objectionable or dangerous to surrounding plants and animals.



WARNING

Stay clear of all rotating and moving parts
The output shaft, flywheel, drive belts and pulleys, for instance, of the engine in operation are dangerous rotating parts. Stay clear of them during operation to prevent from getting entangled.

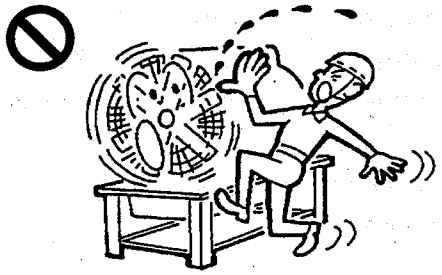
Perform service safely!
Before performing any service on the engine, place the operation mode of the generator in manual mode, press the emergency stop button, and turn OFF the battery switch. Attach a "Do not operate" or similar warning tag to the starter switch. It is very dangerous if the engine starts to operate during maintenance.
In case of pneumatic starting, close the prime valve of the air tank and affix a label indicating "DO NOT OPEN," etc., to the valve.

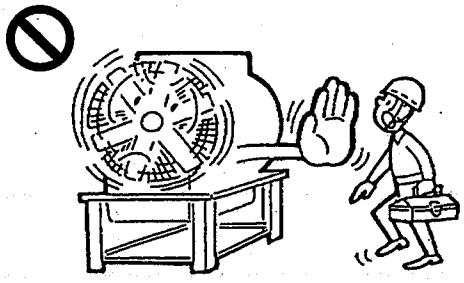
Start engine safely!
Before starting the engine, clear all personnel from the engine and area. Keep the engine free of foreign materials such as debris, oil, tools and other items that are not part of the engine.

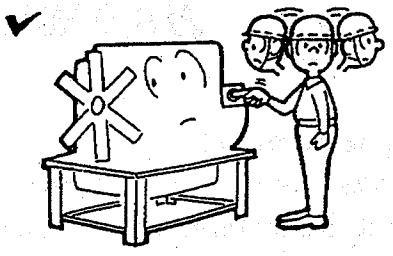
Install protective covers!
Make sure all protective covers and guards are installed to drive belts and couplings to avoid personal injury. It is very dangerous if the engine starts to operate accidentally during maintenance.

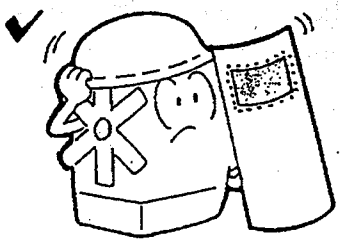
Remove turning tool after use.
Remove the turning tool after use. Starting or operating the engine with the turning tool in position can cause engine damage and personal injury.

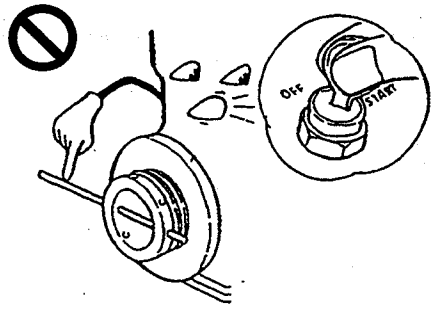
Cutting Prevention









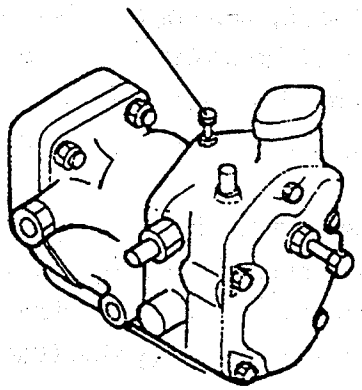


WARNING

Do not change the speed settings !
Hydraulic governor has speed set bolts that have been set at the factory and sealed. Never attempt to break seals and never reset them in the field. Resetting can cause overspeeding, resulting in serious troubles.

Governor Sealing

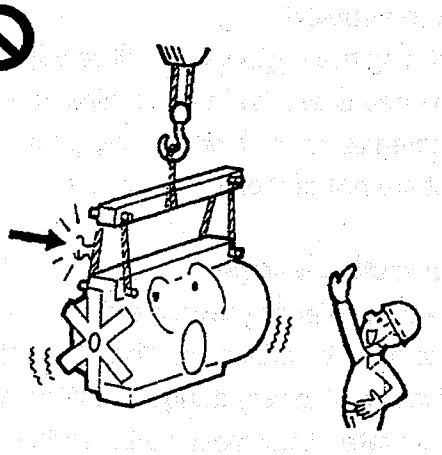
High-speed set bolt sealed



WARNING

Lift engine carefully !
Never allow anyone to walk or stand underneath a suspended engine. Do not give shocks to the engine. Operate the hoist carefully without jerking it. Otherwise, serious accidents can result.

Lifting Precautions



WARNING

Service the batteries carefully!
Storage batteries generate hydrogen when charging. Hydrogen and air is a very explosive mixture.

(1) Wear safety glasses and rubber gloves when working with batteries.

(2) Never allow sparks or open flame near batteries.

(3) Stop the engine and turn OFF the battery switch before inspecting or servicing batteries.

(4) Do not short across battery terminals. Spark could ignite battery gas.

(5) When you remove a battery, disconnect ground (negative) clamp first. When installing a battery, always connect ground clamp last.

(6) Charge batteries in well ventilated areas, with all plugs removed.

(7) When installing a battery, tighten clamps securely. A loose clamp can cause sparks, or, worse, explosion.

(8) When servicing any electrical component, or when welding on the engine, turn OFF the battery switch or disconnect ground clamp.

Be careful of damp ground and wet hands!
Do not touch electric circuits with wet hands, standing on damp ground.

Servicing Batteries

Handle electrolyte carefully!
Battery acid will burn skin, eat holes in clothing and causes blindness if splashed into eyes.

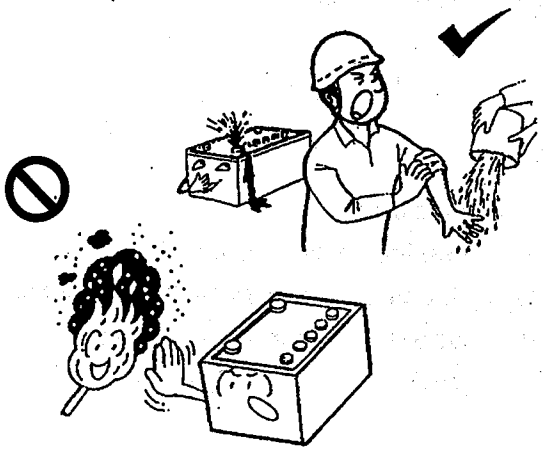
(1) When servicing batteries, consult your foreman for specific instructions on the job and safety equipment required.

(2) Do not use a battery in which electrolyte is below minimum level. Low electrolyte level could cause explosion.

(3) If you spill electrolyte on yourself, flush skin immediately with lots of water. Apply baking soda to help neutralize the acid.

(4) If electrolyte gets in your eyes, flush them immediately with large amounts of water and see a doctor at once.

(5) Should you drink by mistake electrolyte, gargle with water over and over again and drink as much water as you can and then consult a doctor at once.



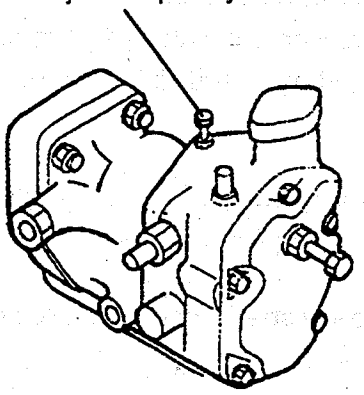
CAUTION Operating Precautions

Do not break seals for settings!

Never attempt to break seals of hydraulic governor, linkages and electric governor actuators for injection quantity and minimum and maximum speed settings. Breaking these seals and varying settings could result in:

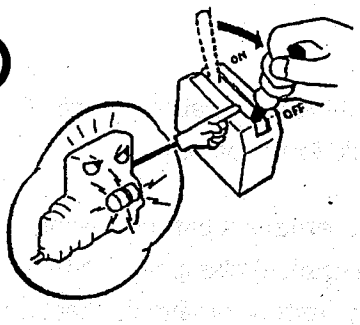
- Accelerated wear of engine components
- Seizure or damage of engine components
- Increase in fuel and oil consumption
- Maladjusted injection quantity and poor engine performance

Maximum injection quantity set bolt



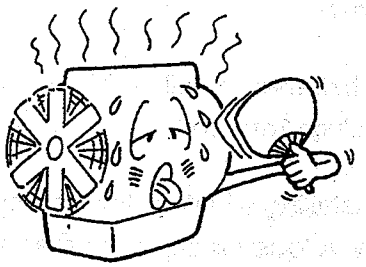
Do not turn OFF battery switch during operation!

Do not turn OFF the battery switch when the engine is running to avoid damage to alternator diodes and transistors. This also results in a failure of instruments to work properly.



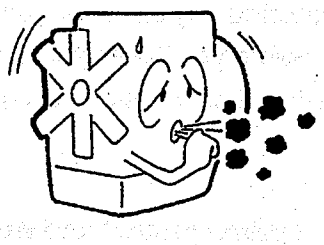
Always keep engine room well ventilated!

Unless the engine room is properly ventilated, air supply will be inadequate, resulting in lack of air for fuel combustion and loss of power.



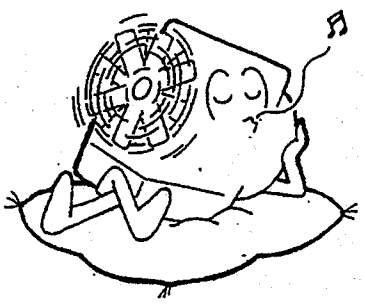
Avoid overloading!

This can cause incomplete combustion often indicated by black smoke, high fuel consumption and carbon deposits in combustion chambers, affecting engine life.

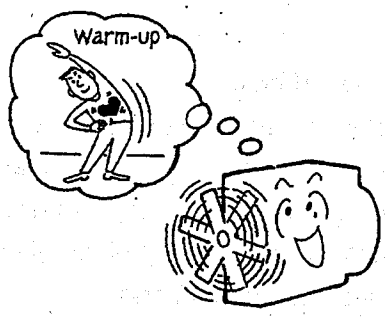


CAUTION Operating Precautions

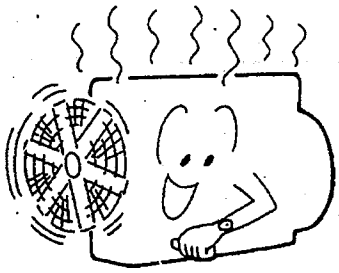
Be sure to break-in engine!
During the first 50 hours of operation, break-in the engine with lighter load and lower speeds than normal. Proper break-in contributes to maximum service life of engine.



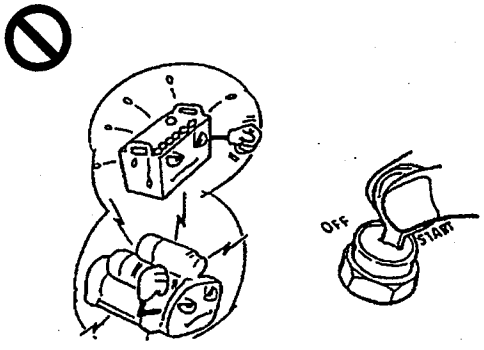
Warm-up engine before operation!
For maximum engine life, warm the engine up after starting it, and run it in idle at low speed for 5 to 10 minutes before operating under full load.
Notice: Long periods of warming up the engine is not recommended. This can deposit carbon in cylinders and cause incomplete fuel combustion.



Stop engine after cooling!
Stopping engine immediately after it has been working under load can result in overheating and accelerated wear of engine components. Before stopping the engine, run it in idle at low speed for 3 minutes. This allows hot areas in the engine to cool gradually, extending engine life. With the engine running, make a walk-around inspection to check abnormality.



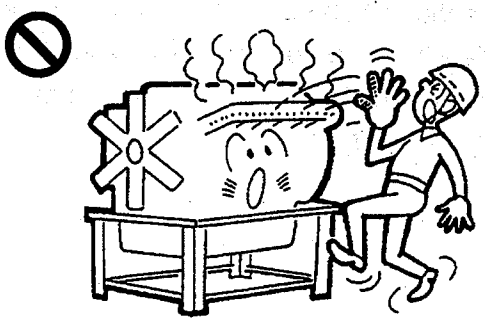
Use starting motor correctly!
Do not use the starting motor longer than 10 seconds. If the engine does not crank with one operation, wait for 30 seconds before cranking it again. If the starting motor is used successively, it will be damaged and the battery will be dead.



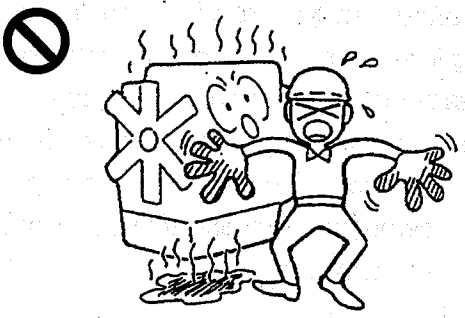
CAUTION

Burn Prevention

Do not touch hot components!
At operating temperature, engine components are very hot. Avoid any contact during operation. Service the engine only after the engine has been stopped and components are cool enough to touch them with your bare hands.

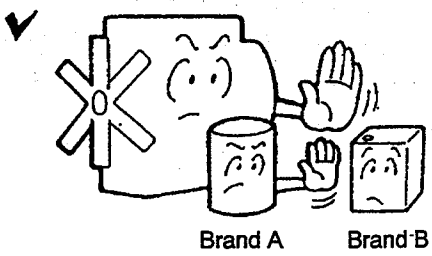


Stay clear of hot oil!
High pressure and hot oil can be dangerous. Pressurized oil can penetrate skin and cause serious injury. Oil escaping from a small hole can be almost invisible. Use a piece of cardboard or wood, instead of your hands, to search for suspected leaks.

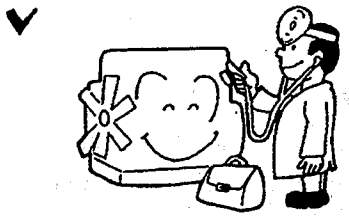


CAUTION Maintenance Precautions

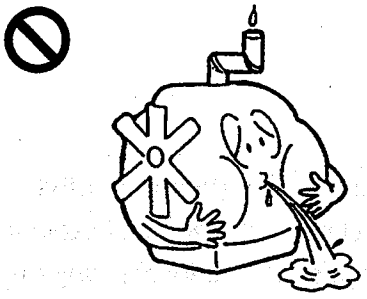
Use recommended fuel, oil and coolant!
Use of any other fuel, oil or coolant can cause engine damage and reduced engine service life.



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

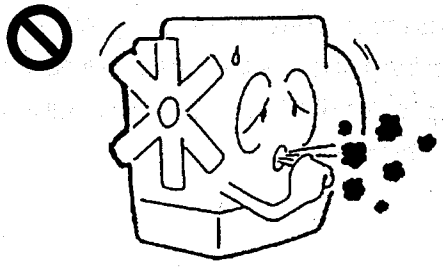


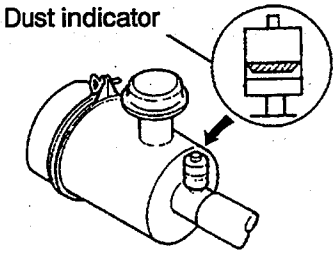
Keep water out of engine!
When washing the engine, cover the air inlet and exhaust opening with tape to prevent water or cleaning agent from getting inside the engine. Do not wash the engine when it is running. If water or cleaning agent gets inside combustion chambers, hammering action of water can damage the engine.



Service the air cleaner properly!
Dust or dirt entering the engine will cause early wear of moving parts and result in a loss of power, high oil consumption, starting problems and other failures. To keep dust and grit-laden air out of the engine, service the air cleaner properly, as instructed below.

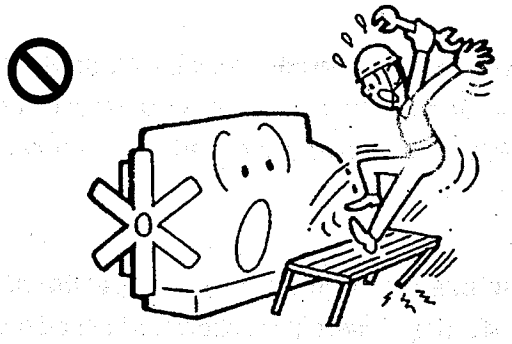
- Do not service the air cleaner while the engine is running.
- When removing the air cleaner, prevent dust from entering the air cleaner inlet.
- If the dust indicator is equipped, service the cleaner only when the clog-warning light comes on. Over-frequent service could cause damage to the element, and dust or dirt could enter the element when removing or installing it.



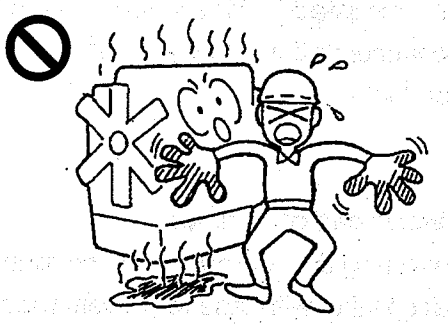


CAUTION Maintenance Precautions

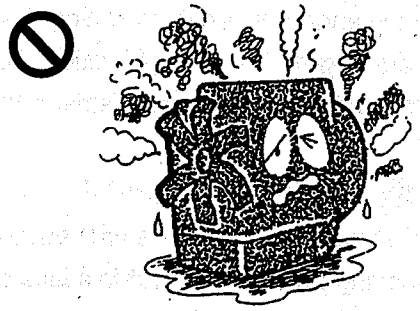
Always watch your footing!
Do not climb on engine for access to certain parts. Be sure to use a rigid step stool for maintenance without accidents.



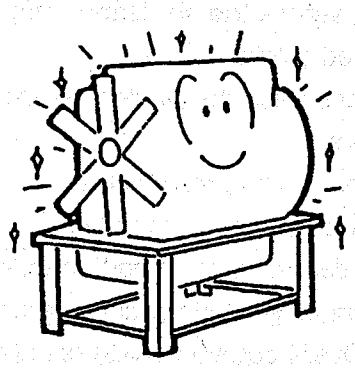
Avoid burns!
When changing oil or coolant, do not allow hot oil or coolant to contact the skin. Do not change oil filter with bare hands.



Service electrical system carefully!
- Disconnect ground (negative) cable from battery before inspecting or servicing any electrical component.
- Loose or damaged terminals and cables can cause fires. Before operating the engine, check terminals and cables and make needed repairs. Inspect for dirt build-up on terminals and connections.



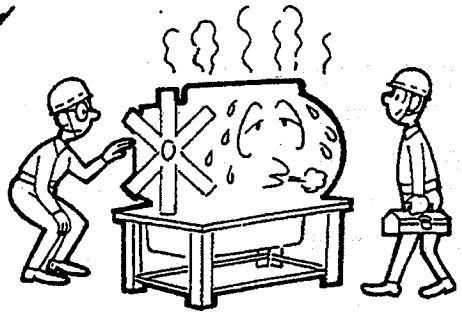
Keep engine and area clean!
Remove all flammable materials such as fuel, oil and other debris, before they accumulate on the engine.



CAUTION Maintenance Precautions

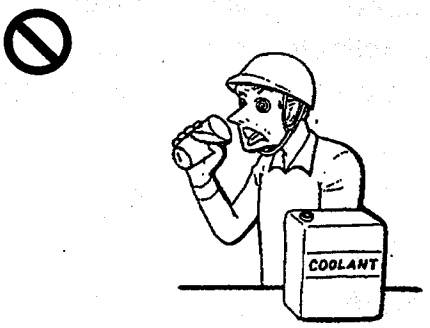
Stop engine before servicing!

Be sure to stop the engine before adding or changing oil, coolant or fuel. Check coolant level only after engine has been stopped and radiator filler cap is cool enough to remove with bare hands. Never attempt to adjust the fan belt when the engine is running.



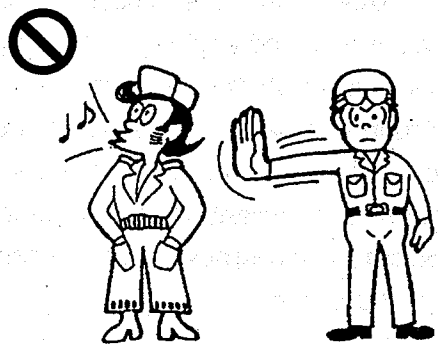
Handle antifreeze carefully!

- Antifreeze contains alkali. Avoid contact with skin and 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 Mitsubishi dealer.



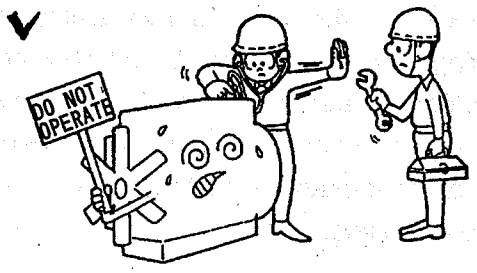
Dress properly for the job!

You may need any number of special items — hard hat, face shield, safety shoes, goggles, heavy gloves, ear protector, etc. — for your own protection.

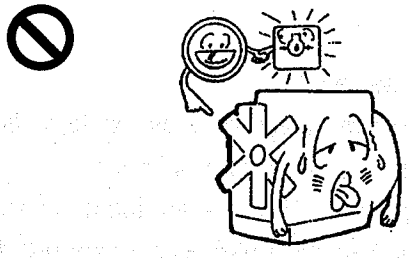


CAUTION If Any Trouble Should Occur

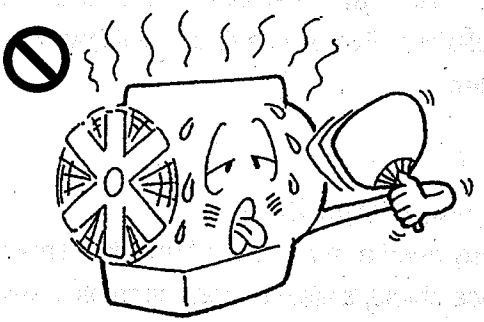
If engine stops abnormally!
Do not restart the engine immediately after it has stopped abnormally. If the engine stops abnormally, check for the cause and make needed repairs before starting it again.



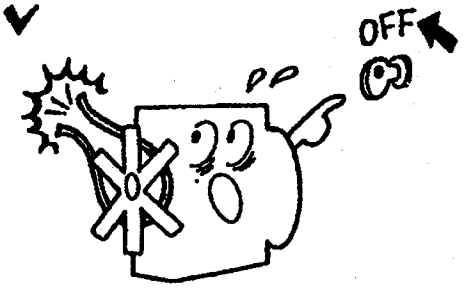
If engine oil pressure is low!
Stop the engine immediately and check lubrication system. Operating the engine with low oil pressure can cause seizure of bearings and other parts.

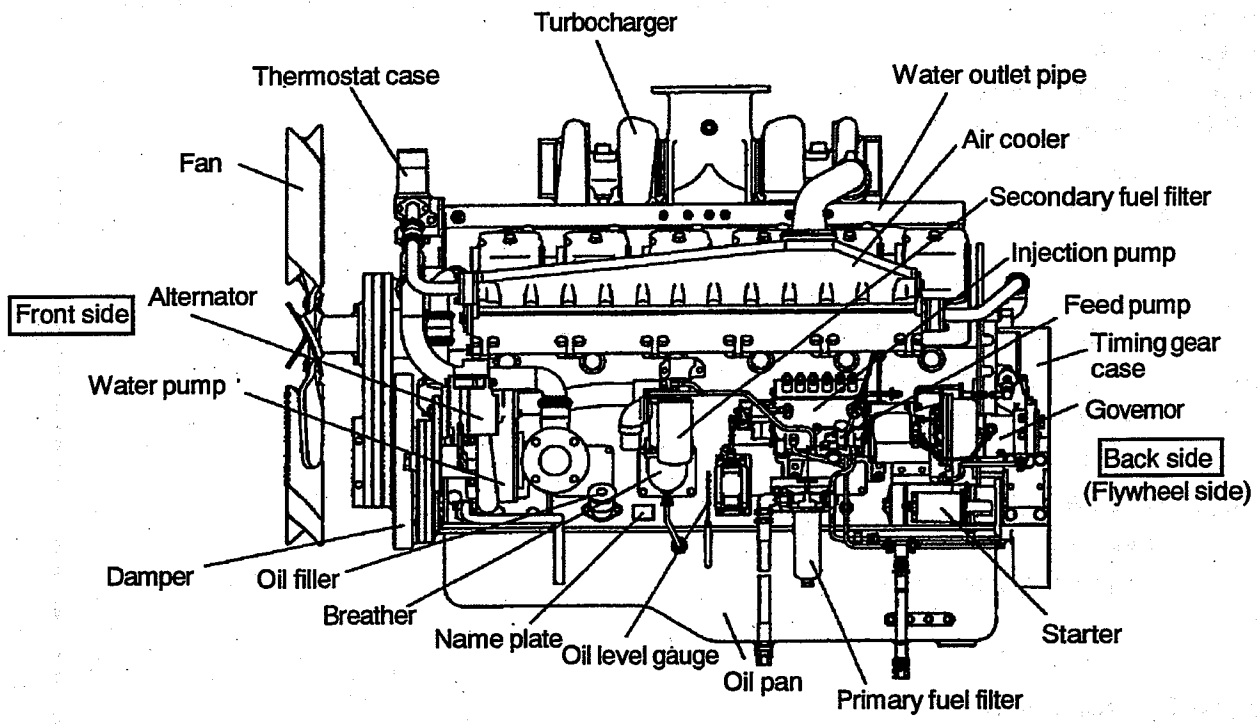


If engine overheats!
If the engine overheats, never stop it immediately. Stopping an overheated engine immediately can result in sudden coolant temperature rise and seizure of running parts. Operate the engine at low idle to allow hot areas in the engine to cool gradually, then add coolant gradually. Remember, adding coolant to an overheated engine can cause cylinder head damage.

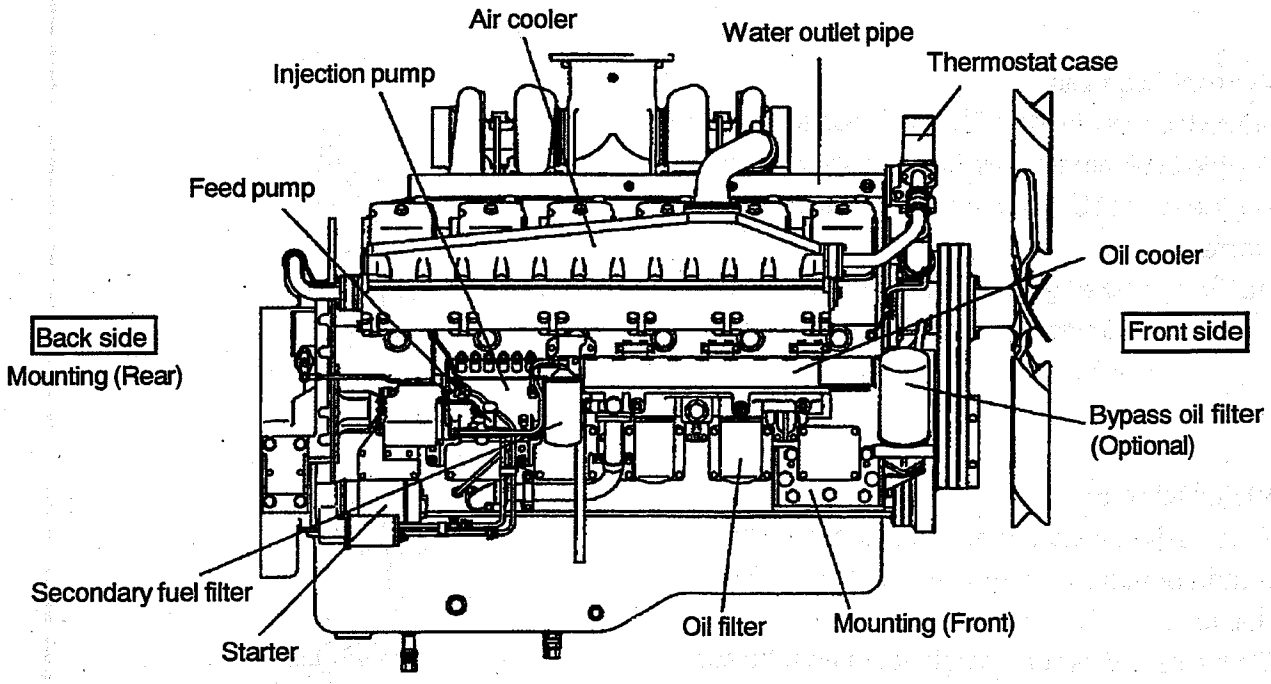


If the fan belt breaks!
If the fan belt breaks, stop the engine immediately. If you continue running the engine, hot coolant or steam will blow off from the reserve tank and the radiator, resulting in engine overheating. Contact with either of these parts can cause serious burns.





Left side



Right side

INSTRUMENTS AND INDICATORS

[START/STOP CONTROLS]

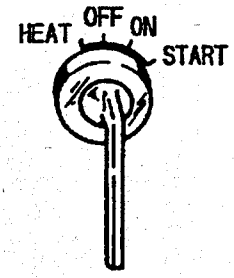
Starter Switch

HEAT (Preheating) During cold seasons, turn the key to this position to preheat the air heater. This facilitates engine start (starting with the air heater).

OFF Turn the key to the OFF position to stop the engine. All electrical circuits are OFF. Insert or remove the key.

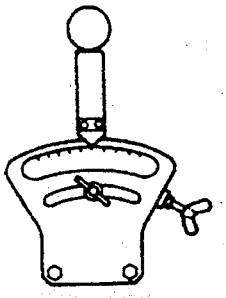
ON The key will return to the ON position when released from the START position.

START Turn the key to the START position to crank the engine. Release the key as soon as the engine starts.



Speed Control Lever

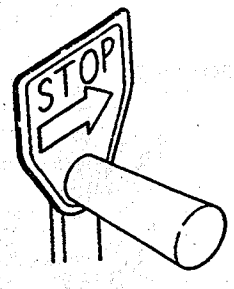
Controls the engine speed.



Manual Stop Lever

Move the lever in the STOP direction to stop the engine in an emergency. Use this lever if the engine cannot be stopped by means of the starter switch.

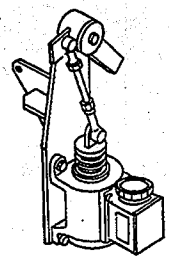
Notice: If the engine does not stop even when this lever is operated, shut off fuel supply.



Stop Solenoid

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

This solenoid, when energized, moves the rack of the fuel injection pump to the non-injection position to stop the engine.

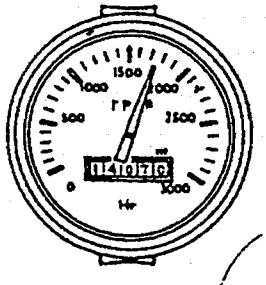


[INSTRUMENTS]

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.

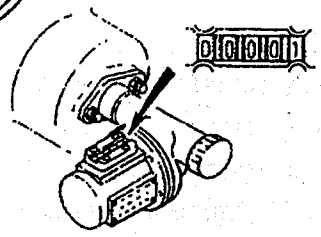
Tachometer
Indicates the engine speed.

Tachometer



Service Hour Meter
Indicates the total number of hours the engine has operated. Use this meter to determine service intervals.
The service hour meter is built into the tachometer.
Notice: Service hour meters come in separate and built-in (the tachometer) types.

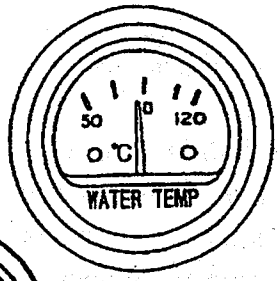
Service Hour Meter



Oil Pressure Gauge
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 0.59 MPa (4 to 6 kgf/cm²) [57 to 85 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 needed repairs before starting the engine again.

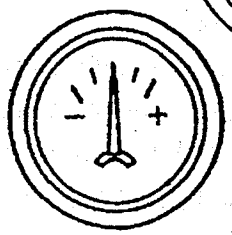
Oil Pressure Gauge

Coolant Temperature Gauge



Coolant Temperature Gauge
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].

Ammeter

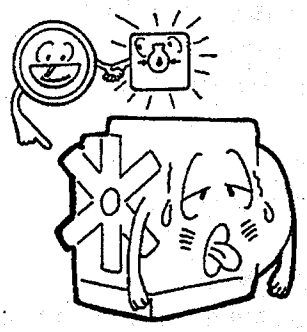


Ammeter
Indicates the amount the battery is being charged or discharged. The pointer is normally in the charging range (on the + side of center) when the battery is being charged. It will remain slightly in the charging range when the battery is fully charged.

[PROTECTIVE DEVICES]

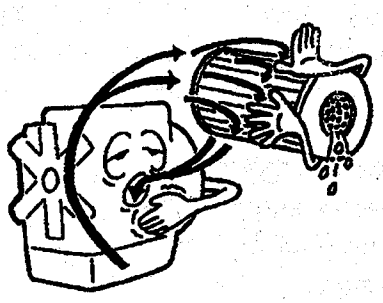
Low Oil Pressure Alarm Light

This alarm sounds when the oil pressure is lower than 0.29 or 0.39 MPa (3 or 4 kgf/cm²) [43 or 57 psi] at an engine speed higher than 1,500 rpm. 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.
Notice: The setting value varies depending on the specification.



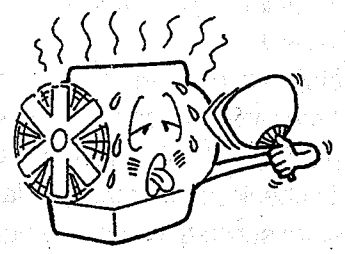
Oil Filter Alarm Light

This light comes ON when the difference in pressure across the oil filter is greater than 0.15 MPa (1.5 kgf/cm²) [21 psi]. When the light comes ON, immediately replace the oil filter.
Notice: Change the engine oil when replacing the oil filter.



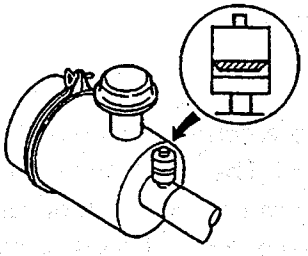
High Coolant Temperature Alarm Light

When the coolant temperature increases to 92°C [198°F] or 98°C [208°F] at the inlet side of the radiator, the coolant temperature alarm light comes on.
If the alarm system is tripped, run the engine at low idle to let it cool gradually, and then stop the engine and check the cooling system.
Some engine models will come to a stop depending on the specification.
Notice: The setting value varies depending on the specification.



Air Cleaner Dust Indicator

The indicator shows red when the air cleaner element is clogged when the difference in pressure across the element is greater than 6.23 kPa {635 mmH2O}. If it shows red, immediately clean the element. After installing the cleaned element, reset the indicator by pressing the button on top of the indicator.

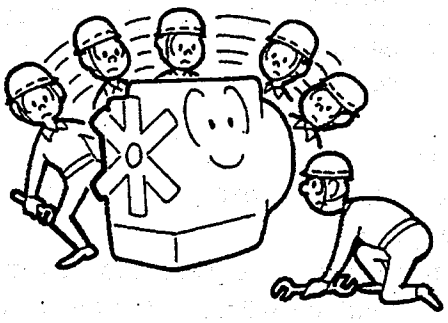


[NEW ENGINE INITIAL SERVICE]

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]**.

Walk-Around Inspection

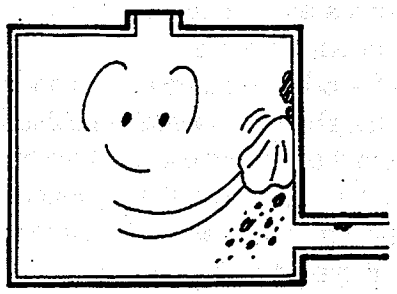
1. Check the electrical system for loose terminals
2. Check defects of engine parts.
3. Check the following components for loose bolts or nuts:
   - Plugs and covers of fuel system, lubrication system and cooling system
   - Coupling of fuel injection pump and shaft
   - Crankshaft pulley and damper
   - Mounting brackets
   - Fuel control link
   - Turbochargers
   - Timing gear case
   - Exhaust manifolds
   - Cylinder heads



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 drain plug and fill the tank properly.

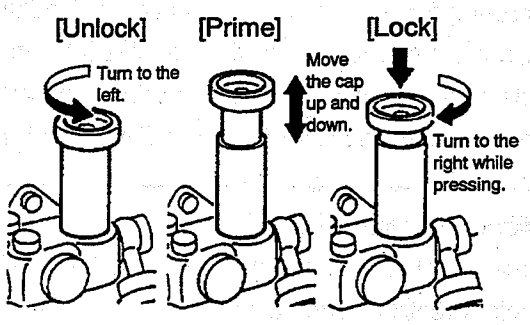


Prime the fuel system

⚠ WARNING

- **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.**

Prime the fuel filters and fuel injection pump in that sequence.

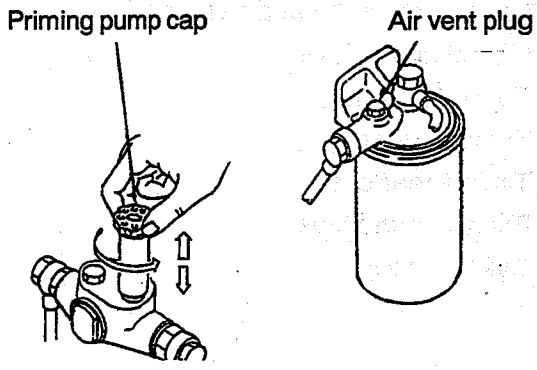


Priming pump

Fuel filter

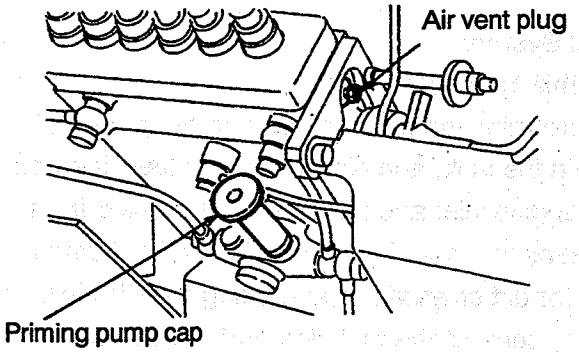
1. Loosen the air vent plug on the fuel filter about 1.5 turns.
2. Turn the priming pump plunger to the left to unlock it, and move it up and down. Operate the plunger until the fuel flows free of bubbles from the vent. Tighten the air-vent plug.
3. Prime both the right and left fuel filters simultaneously.

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



Fuel injection pump

1. Loosen the air vent cap on the fuel injection pump about 1.5 turns.
2. Move the priming pump cap up and down. After fuel showing no visible bubbles comes out from the air vent plug, tighten the plug. Just before tightening the air vent plug, lock the priming pump cap while holding it down. Then, tighten the air vent plug.
3. Prime both the right and left fuel-injection pumps simultaneously.



Fuel injection pump

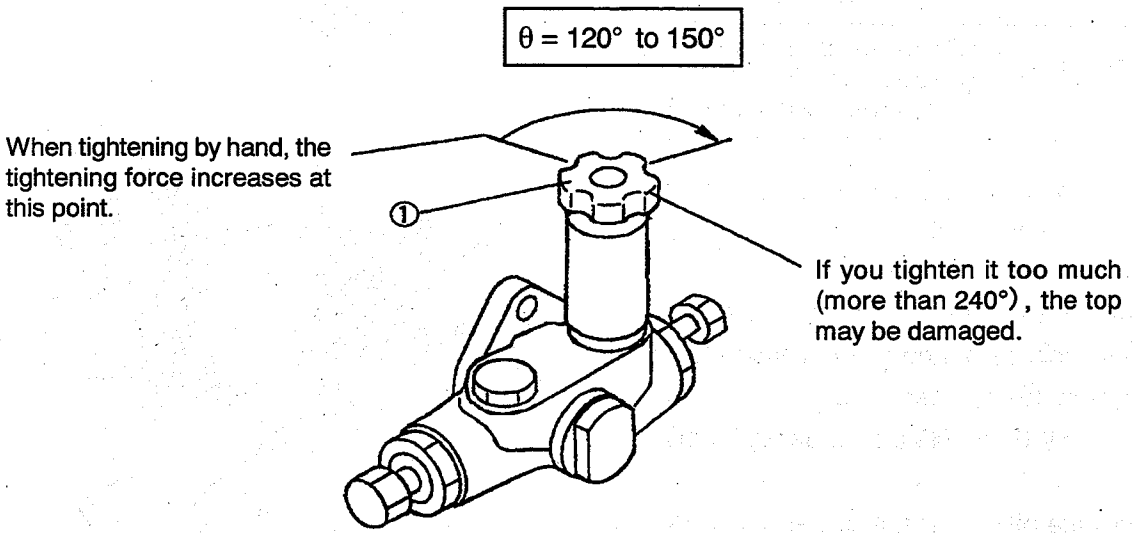
⚠ CAUTION

- **Be sure to lock the priming pump cap before tightening all the air vent plugs. Otherwise, the cap does not return to the original position due to the pressure in the priming pump.**

Method for tightening the priming pump cap

1. Tighten the priming pump cap by hand until the tightening force increases
   Notice: Mark this position on the priming pump cap so as to make item 2 work more easily.

2. In addition to item 1, tighten the priming pump cap by wrench 120° to 150°.
   Notice: In addition to item 1, it is generally tightened 70° to 90° by hand.



⚠ WARNING

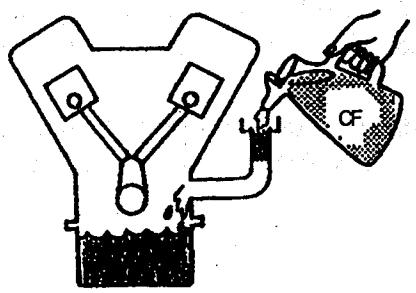
- **Looseness of the priming pump cap and engine vibration may cause wear to the inside screws, the priming pump cap to be shaken off and fuel leakage.**
- **If you tighten it too much (θ = 240° or more), the top of the priming pump may be damaged. Tighten it at the proper angle of 120° to 150°.**

Lubrication System

Fill the oil pan

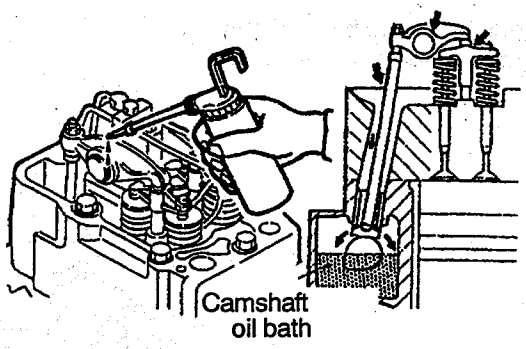
1. Remove the crankcase filler cap and fill with recommended oil.

Refill capacity	Oil pan: 100 or 170 liters [26.4 or 44.9 U.S. gallons] Whole engine: 120 or 190 liters [31.7 or 50.1 U.S. gallons]
Recommended oil	Oils that meet Engine Service Classification CF (API Service Classification)

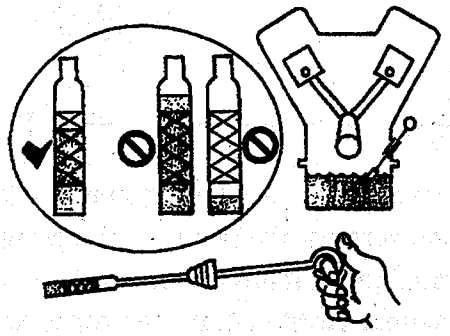


Notice: The oil capacity varies depending on the specification.

2. Remove the rocker cover. Lubricate the valve mechanism and fill the camshaft oil bath from the cylinder head. (approx. 800 cm^3 [49 cu in.] per cylinder).



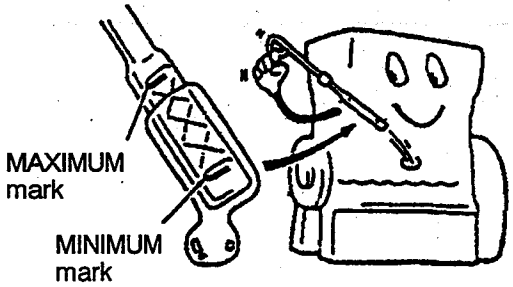
3. Check the oil level in the oil pan with a dipstick. The oil level should be between the MAXIMUM and MINIMUM marks on the dipstick. Add oil if necessary.



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

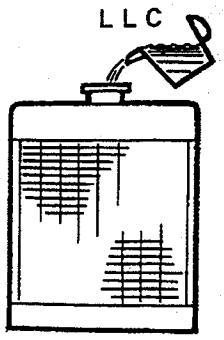
5. Crank the engine with the fuel supply shut off to make sure the oil pressure rises properly.

6. Start the engine and operate it for about 10 minutes. Stop the engine and add oil until the condition of item 3 is satisfied.



Cooling System

Fill the radiator



1. Close the drain plugs and drain cocks of the basic block and the water pump and tighten the radiator drain plug.

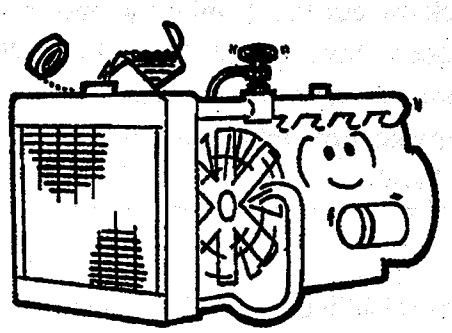
2. Remove the cap from the radiator tank and pour in pure, undiluted LLC.

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. For concentration of LLC, see the chart below.

Recommended LLC Concentrations

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

Notice: To remove air completely effectively, loosen the air vent plug on the top of the thermostat.



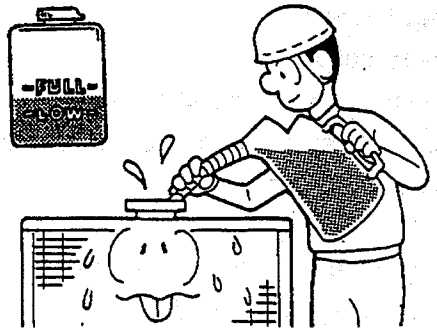
4. When the tank is full, tighten the radiator cap securely. To bleed air out of the water pump, crank the engine with the starter several times, for 10 seconds each time, at intervals of about one minute.

⚠ CAUTION

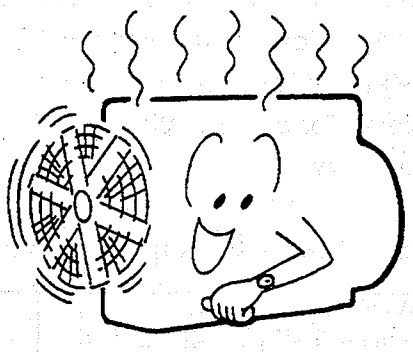
With the fuel supply shut off, crank the engine with the starter.

Notice: When cranking or operating the engine, see the topic Lubrication System.

5. Check the coolant level in the radiator and add coolant if necessary. If a reserve tank is equipped, add coolant 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.

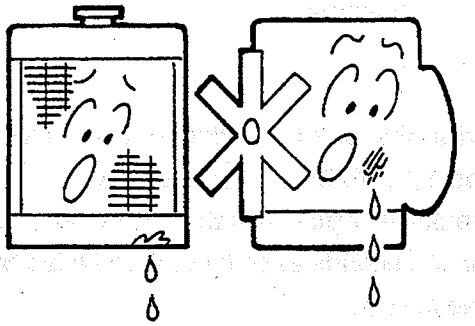


7. Stop the engine and check the coolant level in the radiator tank. If the level is low, add coolant until the tank is full.

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

⚠ 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 your hand.



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

Electrical System

Batteries

⚠ WARNING

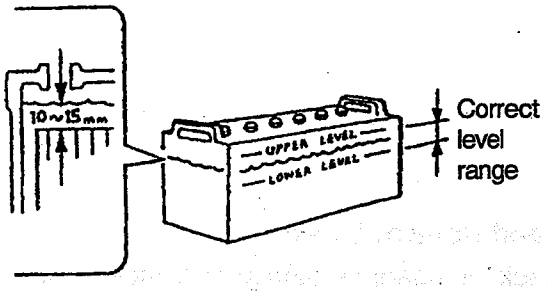
- **If electrolyte gets in your eyes, flush them immediately with large amounts of water and see a doctor at once.**
- **Never allow open flame near batteries. Do not short across battery terminals. Spark could ignite battery gas.**

Check the electrolyte level

The amount of electrolyte will decrease by vaporization.

The electrolyte level should be between the UPPER LEVEL and LOWER LEVEL marks on the battery case. If the battery case is not transparent and the inside cannot be seen, remove the vent caps and check the electrolyte level in the cells. The electrolyte should be 10 to 15 mm [0.4 to 0.6 in.] above the plates in the cells. Add distilled water if necessary.

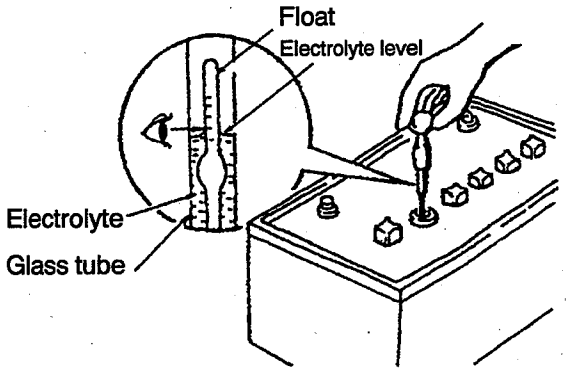
Notice: When adding the new electrolyte, add it gently.



Check the electrolyte specific gravity

Charge the battery if the specific gravity of electrolyte is below 1.22 at 20℃ [68°F].

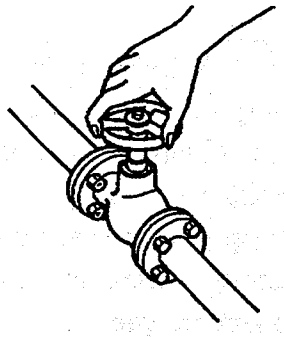
Specific gravity at 20℃ [68°F]	State of charge	Correction
1.26 - 1.28	Fully charged	——
1.22 - 1.26	3/4 charged	Recharge
Below 1.22	Discharged	Recharge



Valves and Plugs

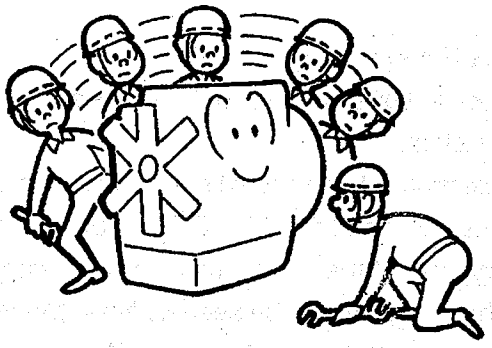
Make sure the following valves and plugs are open or closed properly:

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



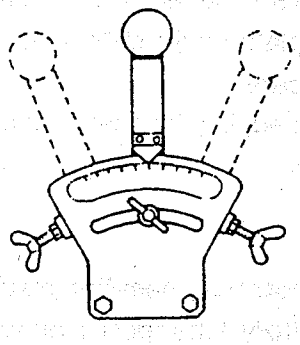
Electrical Wiring

Check for loose or damaged terminals or connectors.



Speed Control Lever

Check for looseness and interference in the linkage, and make sure that the lever moves smoothly.

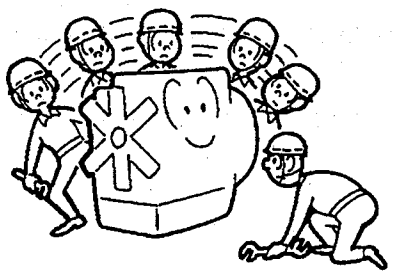


[PRE-START INSPECTION]

Walk-Around Inspection

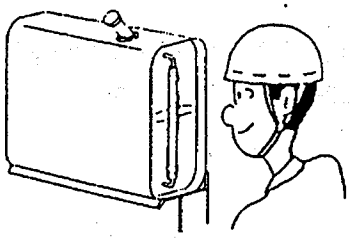
Look around and under the engine for:

- Loose bolts or nuts
- Fuel, oil, coolant, or air leaks
- Faulty electrical wiring or loose pipe connection



Check the Fuel Level

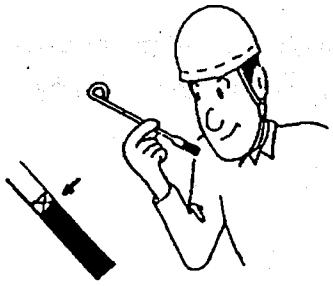
Make sure the fuel tank is full.



Check the Oil Level

The oil level should be between the MAXIMUM and MINIMUM marks on the dipstick. Add oil if necessary.

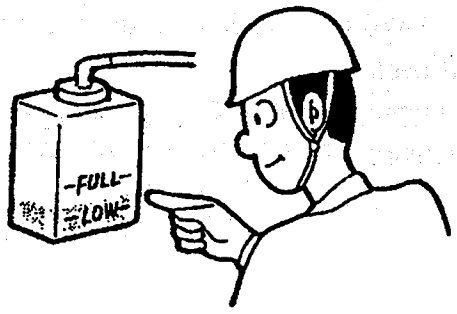
Notice: To check the oil level, the dipstick should be withdrawn, wiped clean, reinserted, and again withdrawn so that the oil level on the dipstick can be seen.



Check the 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 your hand.



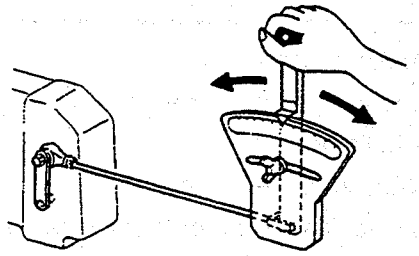
Check the coolant level in the radiator tank by removing the radiator cap. The coolant in the radiator tank should be filled up to the rim of the inlet. If a reserve tank is equipped, the coolant level in the reserve tank should be near the FULL mark. If insufficient, add coolant up to the FULL mark level.

Notice: When adding coolant, maintain the specified concentration of LLC. Never add water only.

Checking the Fuel-Control Linkage

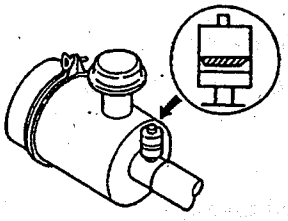
Make sure that the fuel-control linkage moves smoothly.

Check for slack or looseness in the ball joint.



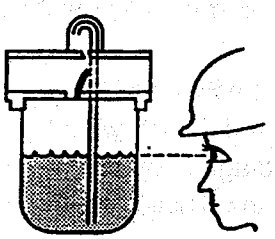
Checking the Air-cleaner Indicator (paper element)

When the red light comes on during operation, clean the element in the air cleaner.



Checking the Oil Level in the Oiler (Air-motor Type)

The oil in the oiler should be filled up to the upper line. Use turbine oil with a viscosity rating of ISO VG32.

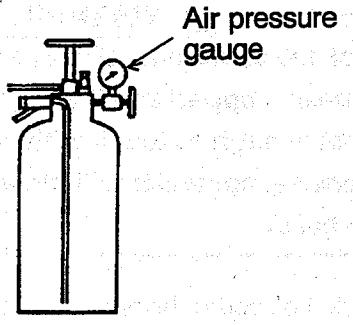


Checking the Air Pressure in the Air Tank (Air-motor or Direct-air Type)

Before starting the engine, check the pressure gauge to make sure the air pressure reaches the specified level.

Air-motor type: 0.97 MPa (9.9 kgf/cm^2) [141 psi]

Direct-air type: 2.94 MPa (30 kgf/cm^2) [427 psi]



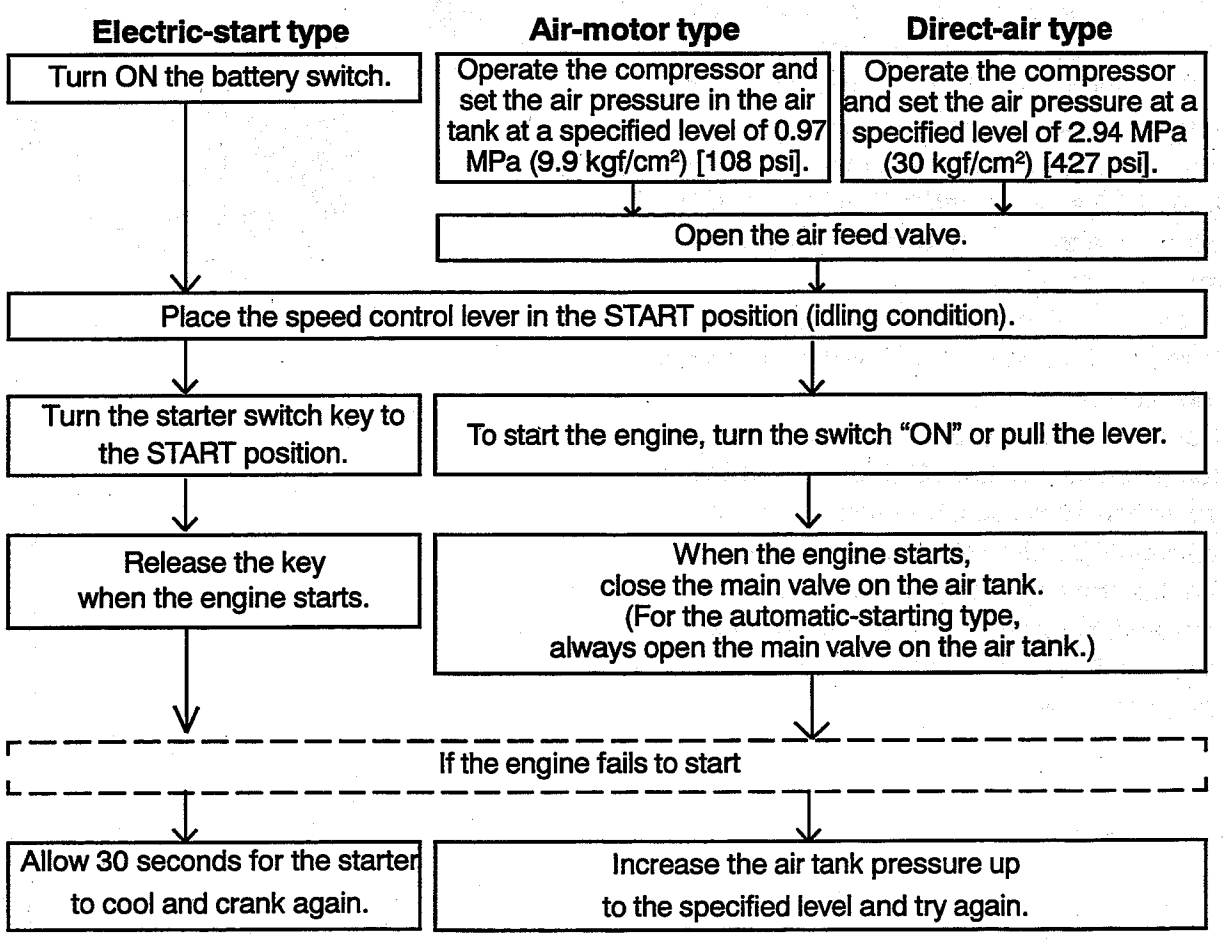
[STARTING]

⚠ WARNING

Make sure no one is working on, or close to, the engine before starting it. Keep the engine free of foreign material such as debris, oil, tools and other items that are not part of the engine.

⚠ CAUTION

- **Do not turn the starter switch key to the START position for more than 10 seconds.**
- **Keep the starter switch in the [ON] position during operation. Never set the starter switch and battery switch to the [OFF] position.**
- **For the air-motor-type or direct-air-type starting system, drain water from the air tank by opening the drain cock, once every 50 service hours or once a month.**
- **Do not apply loads to the engine when cracking the engine for starting. (Disengage the clutch if equipped.)**

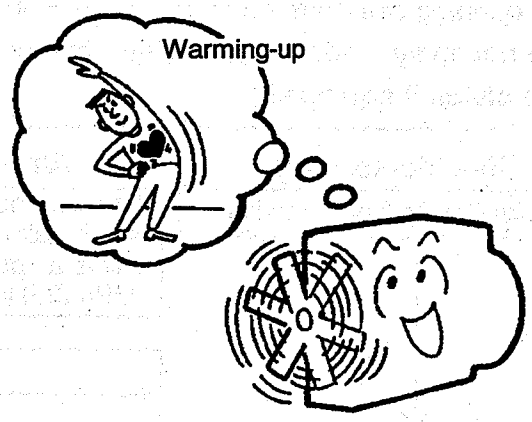


[WARMING-UP]

⚠ WARNING

- **Long periods of warming up are not recommended. This can cause carbon deposits in the cylinders, resulting in incomplete fuel combustion.**
- **In case of the standby engine, it is not necessary to warm it up. However, be sure to perform service on specified items.**

- Warm-up the engine at low idle speed for 5 to 10 minutes.
- In temperatures below 5°C [41°F], use a starting aid to keep the coolant and oil temperatures above 5°C [41°F].
- 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 — 0.3 to 0.59 MPa (4 to 6 kgf/cm²) [57 to 85 psi] but it will restore to the normal level as the oil temperature rises.
  In the case of the standby engine, no warm-up is required, because the coolant is warmed by the water heater.
- For the direct-air type, when the outside air temperature is below 10°C [50°F], use the water heater to keep the water temperature above 40°C before starting the engine.
- For the standby engine, no warm-up is required, but keep the water temperature above 40°C before starting the engine by using the water heater.



[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 are raised.
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 gauge: 0.39 to 0.59 MPa {4 to 6 kgf/cm²} [57 to 85 psi]
- Coolant temperature gauge: 70 to 90°C [158 to 194°F]
- Ammeter: (+) side
- Oil temperature gauge: 70 to 110°C [158 to 230°F]
- Oil filter alarm (pilot lamp): the light is out.

[STOPPING]

⚠ CAUTION

- **Stopping the engine immediately after it has been working under load can result in over-heating and accelerated wear of the engine components. Before stopping the engine, operate it at low idle for 5 to 6 minutes to allow hot areas in it to cool gradually. With the engine cooling, check for problems.**
- **Do not rev up the engine just before stopping it.**
- **If the engine stops abnormally, 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 stops "rocking."**

Before stopping the engine, operate it at low idle for 5 to 6 minutes to allow hot areas to cool gradually.

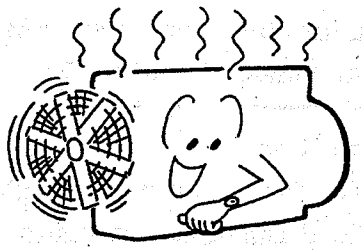
If a speed control lever is equipped:

Place the speed control lever in the "STOP" position.

If a stop lever is equipped:

Place the stop lever connected to the governor in the "STOP" direction.

Turn the starter switch key to the "OFF" position and remove it. Then turn the battery switch to the "OFF" position (electric type).



MAINTENANCE CHART

- For your own safety and maximum service life of the engine, perform recommended service according to the "Maintenance Chart."

- Under extremely severe, dusty or wet operating conditions, more frequent service than is specified in the "Maintenance Chart" may be necessary.
  Notice: The servicing intervals vary according to application or operating conditions of the engine, fuel or oil used, coolant, etc. For adjustment of the intervals, consult your Mitsubishi dealer.

- Perform service on items at multiples of the original requirements.
  For example, at Every 2000 Service Hours, also service those items listed under Every 1000 Service Hours and Every 250 Service Hours or Monthly.

- For items marked with an asterisk (*) in the "Maintenance Chart," rely on the knowledge of the servicemen, and the service facilities at your Mitsubishi 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.

- Where the engine is used to provide prime power for generator sets, perform service at intervals specified in [Maintenance Chart for Prime-power Engine].

- Where the engine is used for standby duty, perform service at intervals specified in [Maintenance Chart for Standby-Duty Engine]. Where the engine is used for standby duty, it must be thoroughly serviced and kept in perfectly operable condition at all times. This is because it has to start and run under severe operating conditions and is expected to provide emergency standby power when it is put in operation. Also perform maintenance runs as follows:

  Once a week, run the engine under no-load conditions for 5 to 10 minutes.
  (When running it to adjust the peripheral devices, it is limited to 30 minutes.)

  Once a month, run the engine with more than 1/2 load for 15 to 30 minutes.
  If you cannot run it with load once a month, run it under no-load conditions for an hour, and then run it with 40% load for more than 2 hours once a year.

  During maintenance runs, check for ease of starting, lube oil pressure, color of exhaust smoke, abnormal vibration, etc.

- Where the engine is used for any other duty, perform service at intervals specified in the [Maintenance Chart for General Duty Engine].

[MAINTENANCE CHART FOR PRIME-POWER ENGINE]

Interval	Service	Page
Every 50 service hours or monthly	Drain water and sediment from fuel tank.	43
(The first 50 service hours of new or reconditioned engine)	Check for loose bolts and nuts.	-
	Change oil.	50
	Change oil filter. (Change filters also when the filter alarm light comes on.)	50
Every 250 service hours or yearly	Change oil. (Oil analysis is recommended.)	50
	Change oil filter. (Change filters also when the filter alarm light comes on.)	50
	Change bypass oil filter.	50
	Change hydraulic governor oil filter.	51
(The first 250 service hours of a new or reconditioned engine)	* Check valve clearance — adjust.	39
Every 1,000 service hours	Change fuel filter (cartridge type)	43
	Check V-belts — adjust.	59
Every 2,000 service hours	Check valve clearance — adjust. (Check valve mechanism.)	39
	Check fuel injection pump (governor) rack movement (during operation).	-
	* Change injection nozzle tips. (Adjust injection pressure after replacement.)	44
	* Check injection timing — adjust.	47
	Check fuel control link ball joints. (Change parts if necessary.)	49
	Change V-belts.	59
Every Top overhaul (Every 4,000 to 6000 service hours)	Top overhaul Remove cylinder heads and check around combustion chambers. · Disassemble and check cylinder heads. · Check inlet and exhaust valves and valve seats — lap. · Visually check piston top. · Check cylinder liner inside surfaces.	-
	* Change water pump unit seals and oil seals.	-
	* Check LLC concentration in coolant.	-
	Check turbocharger shaft.	56
	Check starter and alternator.	58
	Check vibration damper.	41
	* Check protective devices. Increase in coolant temperature, decrease in oil pressure, overspeed, starting failure, coolant cutoff, undervoltage, overvoltage, overcurrent, decrease in water tank level, decrease in fuel tank level, etc.	58

* Special tools or heavy maintenance are needed. Make requests with your Mitsubishi dealer.

Interval	Service	Page
Every Major overhaul (Every 8,000 to 12,000 service hours)	*Major overhaul Disassembling engine — clean, check and change major parts. **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, camshaft bushings, camshaft expansion plugs, main metals, cylinder liners, main metal cap bolts and washers, piston rings, connecting rod metals, vibration damper and consumable items (gaskets, oil seals, O-rings, etc.) **In the second overhaul, replace the following parts in addition to the parts listed above:** Cylinder head bolts, valve guides, valve bridge guides, valve bridges, valve springs, tappets, camshaft thrust plates, rocker bushings, thrust plates, pistons, piston pins, connecting rod bolts, connecting rod bushings, etc.	-
	* Test fuel injection pumps. (Change parts if necessary.)	-
	* Test governor. (Change parts if necessary.)	-
	* Check auxiliary equipment operations. Water heater, oil heater, oil-priming pump, fuel transfer pump, governor motor, etc.	-
	* Check protective devices — repair or change. Increase in coolant temperature, decrease in engine oil pressure, overspeed, starting failure, coolant cutoff, undervoltage, overcurrent, overvoltage, decrease in water tank level, decrease in fuel tank level, etc.	-
Every 2 years	Change coolant.	54
When required	Check radiator fins — clean.	53
	Wash precleaner.	56
	Clean or change the air-cleaner element.	57
	Clean engine breather inside.	-
	Prime fuel system.	18
	* Check stop solenoid — change.	-
	* Check rubber mounts — change.	-
	* Check coupling — change.	-

* For items with an asterisk (*), special tools and large-scale facilities are required. Consult your Mitsubishi dealer.

[MAINTENANCE CHART FOR STANDBY ENGINE]

Interval		Service	Page
Weekly		Walk-around inspection (for fuel, oil or coolant leaks, etc.)	25
		Check oil level.	25
		Check fuel level.	25
		Check coolant level.	25
		Check the air tank pressure.	26
		Check air cooler for water leaks.	-
		Maintenance run (5 to 10 minutes under no-load conditions) Check for ease of starting, color of exhaust smoke, abnormal vibration, abnormal noise, abnormal smell and gauge indication (oil pressure gauge, coolant temperature gauge, oil temperature gauge, exhaust temperature gauge, tachometer, etc.).	-
Monthly		Check for fuel or water in oil.	52
		Clean fuel filter (wire-element type) — turn handle one or two times.	-
		Check fuel control link.	26
		Check battery electrolyte level.	23
		Check the air tank pressure — feed fuel.	-
		Check air cooler for water leaks.	60
		Maintenance run (15 to 30 minutes under more than a 1/2 load) Check for ease of starting, color of exhaust smoke, abnormal vibration, abnormal noise, abnormal smell and gauge indication (oil pressure gauge, coolant temperature gauge, oil temperature gauge, exhaust temperature gauge, tachometer, etc.). Check fuel injection pump and hydraulic and electronic governor rack movement.	-
Every 6 months		* Check LLC concentration in coolant.	-
		Wash coolant tank inside.	-
Every 1 year	Basic block	Check V-belts — adjust.	59
		Check valve clearance — adjust. (Check valve mechanism.)	39
		Check for loose bolts and nuts.	-
		Check vibration damper.	41
		* Check rubber mounts.	-
		* Check foundation bolts.	-
		* Check coupling.	-
	Fuel system	Drain water and sediment from fuel tank.	43
		Drain water from fuel filter (wire element type).	-
		* Check injection nozzle discharge pattern and injection pressure — adjust.	45
		* Check injection timing — adjust.	47
	Lubrication system	* Oil analysis	-
		Check oil pressure — adjust (during maintenance run).	-
	Cooling system	Check water pump.	-
		* Check, disassemble, and clean the solenoid valve and pressure-reducing valve.	-
		Check, disassemble, and clean the strainer (including a ball-tap-equipped type).	-
		* Analyze coolant — change.	-
	Air inlet system	Check the air-cleaner indicator.	26
		Check and clean the air-cleaner element.	57
		Check precleaner — wash.	56

* Special tools or heavy maintenance are needed. Make requests with your Mitsubishi dealer.

Interval	Service		Page
Every 1 year	Electrical system	Check starter.	58
		Check alternator.	58
		Check the air heater.	-
		Check battery electrolyte specific gravity.	23
	Air-starting system	Check the starter valve.	-
		Check the distributing valve.	-
		Check the air filter — drain water.	60
		Check the solenoid valve — clean.	-
		Check the air-compressor belt tension.	-
		Check the proper operation of the air-tank safety valve.	60
	* Check protective devices. High coolant temperature, low oil pressure, overspeeding, starting failure, coolant cutoff, undervoltage, overvoltage, overcurrent, decrease in water tank level, decrease in fuel tank level, decrease in air tank pressure, etc.		58
	* Check auxiliary equipment. Engine control, fuel transfer pump, governor motor, indoor ventilation fan, solenoid, pumping system, water-tank ball tap, water heater, oil heater, oil priming pump, etc.		-
Every 2 years	Change oil. (Oil analysis is recommended.)		50
	Change oil filter. (Change filters when the oil filter alarm light comes on.)		50
	Change bypass oil filter.		50
	Change fuel filter (cartridge type).		43
	Change fuel control link ball joints.		49
	* Check thermostat.		-
	Change coolant.		54
	Check turbocharger shaft.		56
	Check muffler — drain water.		56
	* Overhaul the air compressor.		-
Every 4 years	* Check oil cooler for dirt build-up, clogging and/or water leaks.		-
	* Visually check oil pump for discoloration.		-
	Change hydraulic governor oil filter.		51
	Wash fuel tank.		-
	* Test fuel injection pump. (Change parts if necessary.)		-
	* Test governor. (Change parts if necessary.)		-
	Check radiator fins — clean.		53
	Change rubber hoses.		-
	Change the air-cleaner element.		57
	Change precleaner.		-
	* Check instruments — change.		-
Every 8 years	* Check major running parts — change. Inlet and exhaust valves and valve seats (lapping), valve guides, pistons, piston rings, connecting rod metals, connecting rod bushings, cylinder liners and crankshaft. (If the parts for No. 1 and No. 2 cylinders are found defective, change the parts for all cylinders.)		-
	* Change vibration damper.		-
	* Check oil pump — change.		-
	* Change fuel injection nozzle tips.		44

* Special tools or heavy maintenance are needed. Make requests with your Mitsubishi dealer.

MAINTENANCE CHART

Interval	Service	Page
Every 8 years	* Change water pump unit seals and oil seals.	-
	* Disassemble and check turbocharger.	-
	* Disassemble and clean air cooler.	-
	* Check rubber mounts — change.	-
	* Check coupling — change.	-
	* Check governor motor — change.	-
	* Check the indoor ventilation fan — change.	-
	* Check stop solenoid — change.	-
	* Check the water-tank ball tap — change.	-
	* Change rubber parts and O-rings.	-
	* Change consumable items.	-

* Special tools or heavy maintenance are needed. Make requests with your Mitsubishi dealer.

[MAINTENANCE CHART FOR GENERAL DUTY ENGINE]

Interval	Service Item	Page
Every 50 Service Hours or Every day	Drain water from the fuel tank.	43
	Drain water from the air filter.	60
	Drain water from the air tank.	60
(First 50 Service Hours of New or Reconditioned Engine)	Check bolts and nuts for looseness.	-
	Change the engine oil.	50
	Change the oil filters.	50
Every 250 Service Hours or Every Year	Change the engine oil. (It is recommended to check the engine oil characteristics at the same time.)	50
	Change the oil filters. (Change filters also when the oil filter alarm works.)	50
	Change the bypass oil filter.	50
	Change the hydraulic governor oil filter	51
	Check and adjust V-belt tension.	59
	Clean the radiator fins.	53
	Drain water from the exhaust muffler.	56
	Check the proper operation of the air-tank safety valve.	60
(First 250 Service Hours of New or Reconditioned Engine)	Check and adjust valve clearance.	39
Every 1,000 Service Hours or Every 2 Years	Clean the air filter	60
	Change the zinc rod.	53
	Change the fuel filters (cartridge type).	43
Every 2,000 Service Hours or Every 3 Years	* Check and adjust valve clearance. (Check valve mechanism at the same time.)	39
	Retighten the bolts and nuts. (For tightening torque, see the service manual.)	42
	* Change the tip of the fuel-injection nozzle. (Check the spray condition and adjust the fuel-injection pressure after replacement.)	44
	* Check and adjust fuel-injection timing.	47
	* Check protective units. (Increase in coolant temperature, decrease in oil pressure, overspeed, etc.)	58
Every 4,000 Service Hours or Every 5 Years	* Change fuel-control-linkage ball joint.	49
	* Clean the air cooler.	56
	Check the vibration damper.	41
	* Clean the heat exchanger.	53
Every major overhaul (Every 8,000 to 12,000 service	* As specified in the "Maintenance Chart for Prime-power Engine."	-
Every 2 years	Change the coolant.	54
When required	Prime the fuel system.	18
	Clean or change the air-cleaner element.	57
	Clean or change the precleaner.	56

* Special tools or heavy maintenance are needed. Make requests with your Mitsubishi dealer.

MAINTENANCE

⚠ WARNING

Avoid burns and crushing or cutting!

At operating temperature, the engine coolant is hot and under pressure. Steam can cause personal injury. Check the coolant level only after the engine has been stopped and the radiator filler cap is cool enough to touch with your hand. Never adjust the V-belts while the engine is running.

Service batteries carefully!

If you spill electrolyte on yourself, flush skin immediately with lots of water. Apply baking soda to help neutralize the acid. If electrolyte gets in your eyes, flush them immediately with large amounts of water and see a doctor at once.

Handle antifreeze carefully!

Antifreeze contains alkali. Avoid contact with skin and eyes to prevent personal injury. Dispose of drained antifreeze coolant according to local regulations. For disposal, consult your Mitsubishi dealer.

Dress properly for the job!

Wear protective devices — hard hat, face shield, safety shoes, goggles, heavy gloves, ear protectors, etc. — for your own safety.

⚠ CAUTION

Use recommended fuel, oil and coolant!

Use of any other fuel, oil or coolant can cause engine damage and reduced engine service life.

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.

Service the air-cleaner properly!

Dust or dirt entering the engine will cause early wear of moving parts and result in a loss of power, high oil consumption, starting problems and other failures. To keep dust and grit-laden air out of the engine, service the air-cleaner properly as instructed below:

- Do not service the air-cleaner while the engine is running.
- When removing the air-cleaner element, prevent dust from entering the air-cleaner inlet.
- If the dust indicator is equipped, service the cleaner only when the clog-warning light comes on. Over-frequent service could cause damage to the element, and dust or dirt could enter the element when removing or installing it.

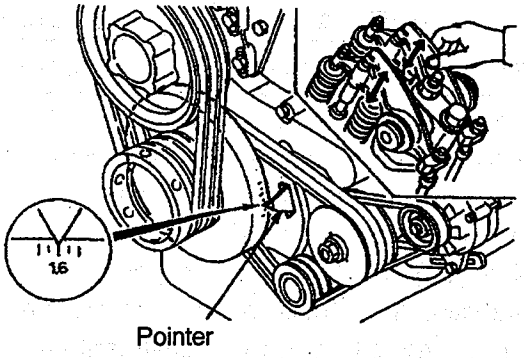
[MAIN PARTS]

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], [2.5] or [4.3] 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.

(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.



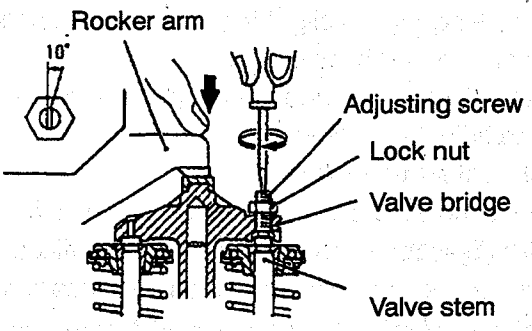
Adjust the height of valves

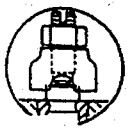
⚠ CAUTION

Make sure the clearance between the valve bridge and valve rotator is more than 1.5 mm [0.059 in.]; if not, interference will occur between the bridge and rotator to cause the valve cotters to get out of 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.

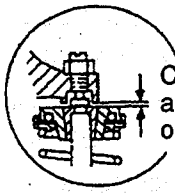
Before inspecting the valve clearance, adjust the height of two valves (bring the bridge into contact with the valves) by means of the valve-bridge adjusting screw so that there is no difference in height between the two valves. If the valve seats are worn, one valve differs from another in height, producing 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 back the screw off.
2. Hold the rocker arm by finger in such a manner as 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 it touches the valve stem. From that position, turn in the screw approximately, 10°more and tighten the lock nut.





Observation



Clearance between bridge and value rotator 1.5 mm or more

[MAIN PARTS] - continued

Inspect

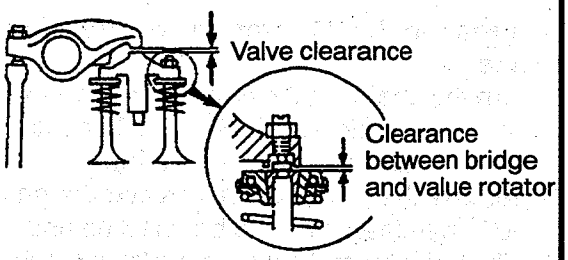
1. Check the valve clearance with a feeler gauge inserted between the rocker arm and bridge cap.

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

Valve clearances will vary depending on the specification. To confirm the valve clearance of each engine, refer to the caution plate.

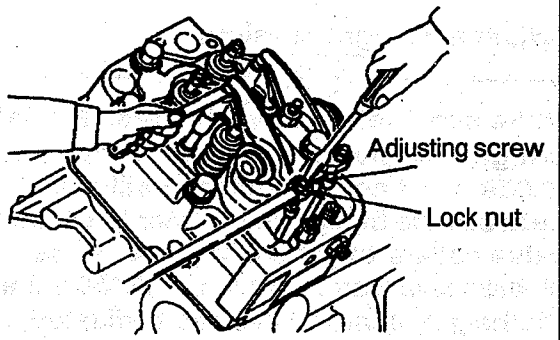
2. The clearance is correct if the feeler gauge is slightly gripped between the rocker arm and bridge cap. If the feeler does not fit into the clearance exactly, perform adjustments as described below.

Notice: Facing the cylinder head on the engine side, the inlet valve is on the left side and the exhaust valve is on the right side.



Adjust

1. Loosen the lock nut of the rocker arm-adjusting screw.
2. Turn in or back off the adjusting screw so that the feeler gauge is slightly gripped between the rocker arm and bridge cap.
3. After adjusting the clearance, tighten the lock nut of the adjusting screw.



Check and Adjust Order

Check and adjust the valve clearance in firing-order (injection sequence), with each cylinder piston at the top dead center on compression stroke, by turning the engine in 60° increments.

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

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

Injection Timing

Cylinder No.	1	12	5	8	3	10	6	7	2	11	4	9
Timing (°)	0	60	120	180	240	300	360	420	480	540	600	660

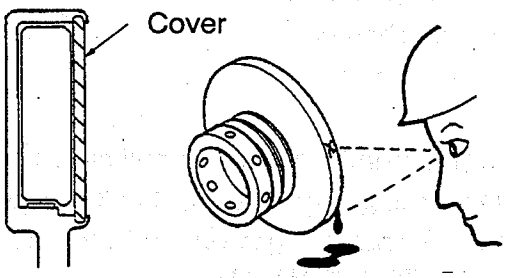
[MAIN PARTS] - continued

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 swelling (by measuring with a scale) and fluid leaks past staked portions.

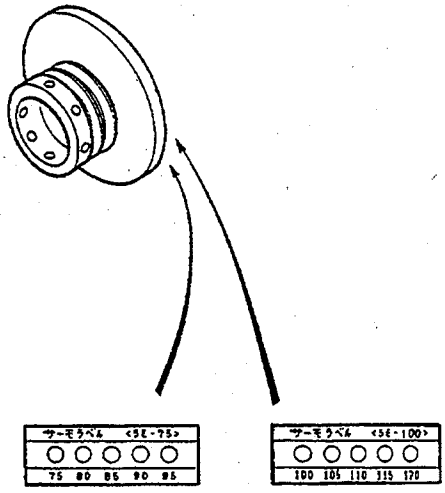


Damper operating temperature

Proper heat dissipation from damper surfaces is essential to damper function. When each engine is shipped from the factory, its damper is verified to be free from abnormal temperature rise. However, damper temperature would rise abnormally in some operating conditions. Make sure the engine operating area is well ventilated.

1. In case of a viscous damper, its surface temperature should not exceed 100℃ [212°F] on a standby-duty engine or 90℃ [194°F] on a prime-power engine after operation for one hour. In case of a viscous-rubber damper, it should not exceed 90℃ [194°F] on a standby-duty engine or 80℃ [176°F] on a prime-power engine. Use of Thermo Labels is recommended to check the damper temperature on a generator-set prime-power engine.

Part name	Measuring range	Part number
Thermo Label 75-95	75℃ to 95℃ [167°F to 203°F]	32522-04100
Thermo Label 100-120	100℃ to 120℃ [212°F to 248°F]	32522-04200



Thermo Labels

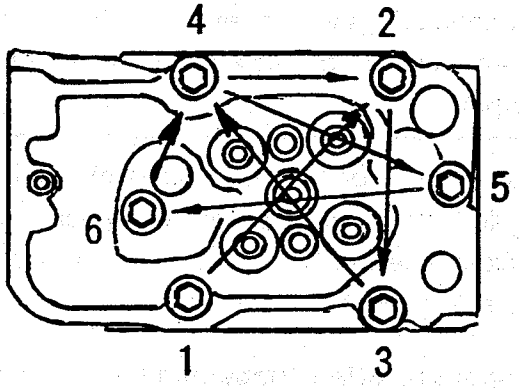
2. When installing a protective cover on the damper, select a cover that does not cause damper temperature to rise abnormally.

[MAIN PARTS] - continued

Re-tighten Bolts and Nuts

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

- Timing gear case
- Crankshaft pulley
- Coupling of fuel injection pump and shaft
- Mounting brackets
- Exhaust manifolds
- Turbocharger
- Cylinder head



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

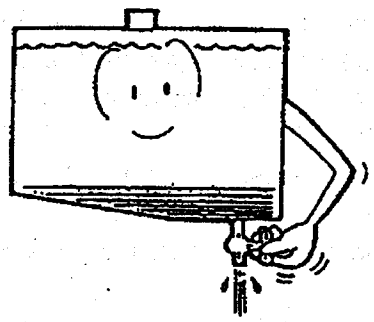
Notice: For tightening torque, refer to the SERVICE MANUAL.

[FUEL SYSTEM]

Fuel Tank Drain water and sediment

⚠ DANGER

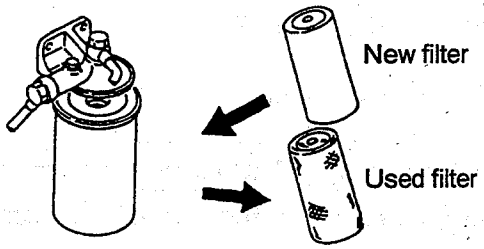
- **Keep maintenance area is safe — no fire hazards.**
- **Completely wipe off any spilled fuel. Spilled fuel is a fire hazard.**

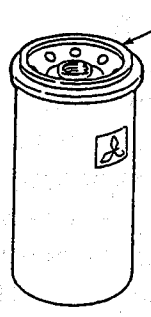


Open the fuel tank drain valve and allow water and sediment to drain in a drip pan. Drain at least 1 to 2 liters [0.3 to 0.5 U.S. gallons] of fuel to remove water and sediment.

Change the Fuel Filter (Cartridge Type)

1. Clean the dirt and dust off the surface of the fuel filter.
2. Place a drip pan under the fuel filter.
3. Using a filter wrench, remove the used filter.
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. When the gasket contacts the base, tighten 3/4 to one turn more. Tighten it by hand to avoid damage to the cartridge. Do not use a filter wrench.
7. Prime the fuel filter after replacement.
8. 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 Item 6.



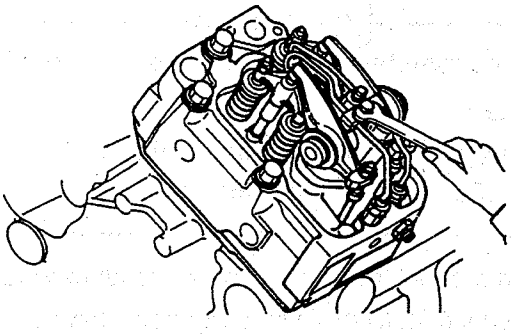


[FUEL SYSTEM] - continued

Fuel Injection Nozzle Tip Change

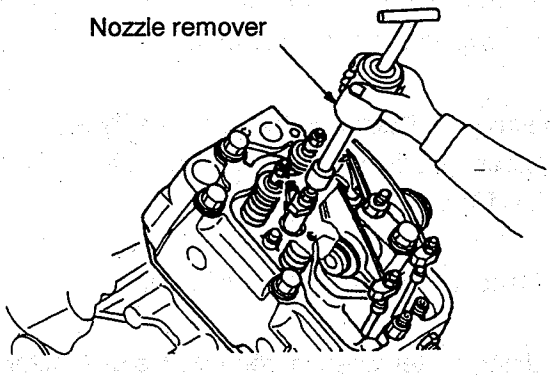
⚠ CAUTION

To keep dirt out, cover the fuel injection port on a fuel injection pipe, and on the intake opening of a fuel injection nozzle.



Remove the fuel injection nozzle

1. Remove the rocker cover.
2. Remove the cramp from the fuel injection pipe.
3. Remove the fuel injection pipe and fuel leak-off pipe from the fuel injection nozzle.
4. Remove the nozzle gland nut to take off the nozzle gland.
5. Pull out the fuel injection nozzle using a nozzle remover (36291-00900).



Remove the nozzle tip

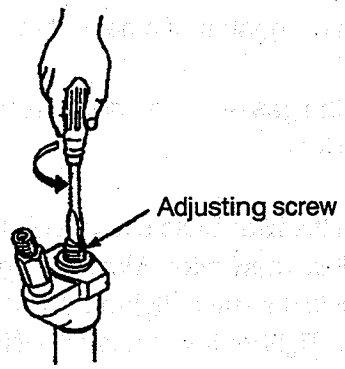
⚠ CAUTION

Do not give shock to the end of the nozzle tip.

1. Secure the fuel injection nozzle using a vice.
2. Remove the cap nut and loosen the adjusting screw using a screw driver.

Notice: This operation is required to release spring pressure applied to the nozzle tip. When spring pressure is applied, it is hard to loosen the retaining nut.

3. Remove the retaining nut and take the nozzle tip off.

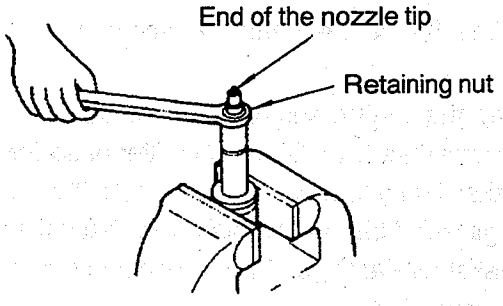


Install the nozzle tip

1. Install the nozzle tip according to the pin on the nozzle.
2. Tighten the retaining nut by applying the specified torque 59 to 78 N·m (6 ± 8 kgf·m) [43 ± 58 lbf·ft]. (Apply oil to the nut.)

Notice: Do not use Moly Disulfide.

3. Adjust the fuel injection start pressure and check spray conditions.

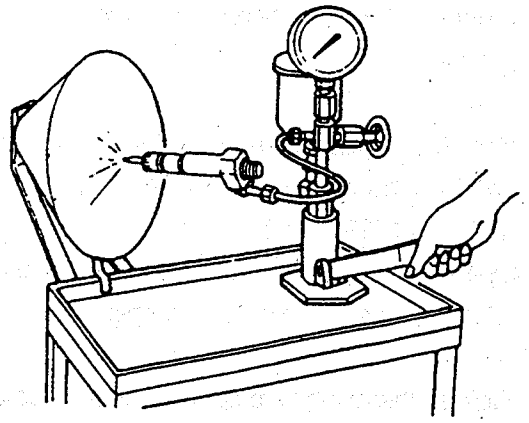


[FUEL SYSTEM] - continued

Check the fuel injection start pressure

⚠ WARNING

Do not allow the fuel injected from a nozzle to contact the skin or body when inspecting the nozzle using a nozzle tester.
The fuel injected from the nozzle has an extremely high pressure with power strong enough to penetrate skin, causing serious injury.



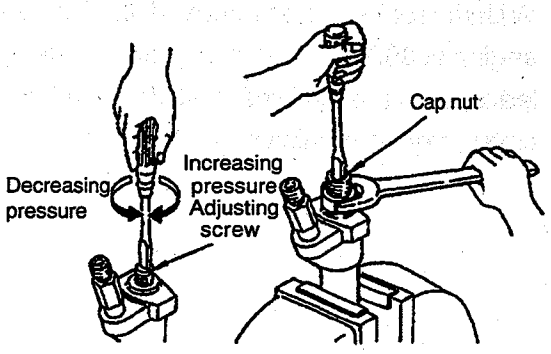
1. Attach the fuel injection nozzle to the nozzle tester.
2. While watching the pressure gauge of the nozzle tester, push the handle down slowly.

Notice: If fuel drips from the end of the nozzle tip, the tip is faulty.

3. When the handle is being pressed down, the fuel is injected, and the needle of the pressure gauge decreases suddenly. The pressure value indicated at this point is the fuel injection start pressure.

Fuel injection start pressure standard value
21.57 MPa {220 kgf/cm²} [3,130 psi]

If the fuel injection pressure goes out of the standard value, adjust the pressure in the following manner.



Adjust the fuel injection pressure

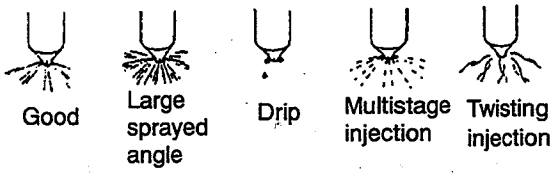
1. Turn the adjusting screw to the standard value. To increase the injection pressure, tighten the screw. To decrease the injection pressure, loosen the screw.
2. When the pressure meets the standard value, secure the cap nut by applying the specified torque (44±5 N·m {4.5±0.5 kgf·m} [32.5±3.6 lbf·ft]).

Check spray conditions of a fuel injection nozzle

Check spray conditions when checking fuel injection pressure. Good spray conditions are as follows:

- Fuel is injected from all nozzle holes.
- The fuel is sprayed in a conical shape.
- No big particles but fine ones.
- No oil drip is left after injection.

If the nozzle fails to spray fuel properly, replace with a new one.



[FUEL SYSTEM] - continued

Installing a fuel injection nozzle

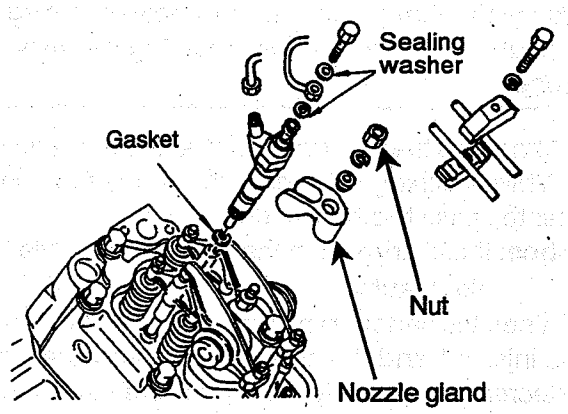
1. Attach a nozzle gasket to the fuel injection nozzle.

2. Insert the fuel injection nozzle into the cylinder head.

3. Install the nozzle gland and tighten the nut by applying the specified torque (78 N • m {8 kgf • m} [58 lbf·ft]).
   Use sealing washers when securing the fuel injection pipe and fuel leak-off pipe.

4. Tighten the eyebolt to secure the fuel leak-off pipe by applying the specified torque (15 to 20 N • m {1.5 to 2 kgf • m} [10.8 to 14.5 lbf·ft]).

5. With the rocker cover removed, operate the engine at 600 rpm and check for any fuel leakage from each joint. Install the rocker cover after confirming no fuel leakage.



[FUEL SYSTEM] - continued

Injection Timing Inspection

1. The injection timing is indicated on the caution plate attached to the No. 1 rocker cover. Check it before inspection.

2. Bring the piston for No. 1 cylinder to top dead center on compression stroke as follows:

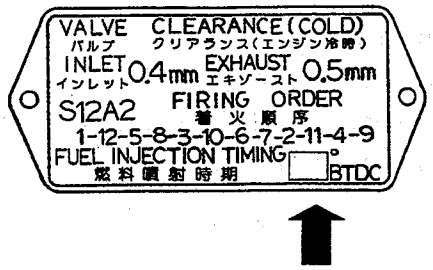
(1) Turn the engine in the normal direction to align the timing mark [1.6] on the damper with the pointer as shown.

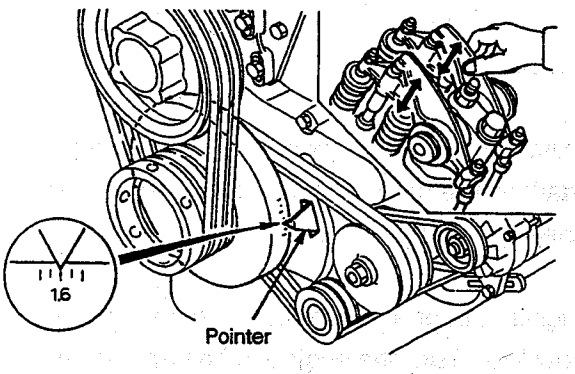
(2) Remove the No. 1 rocker cover and make sure the inlet and exhaust valves for No. 1 cylinder have some clearance. If these valves have no clearance, turn the engine once again to align the timing mark [1.6].

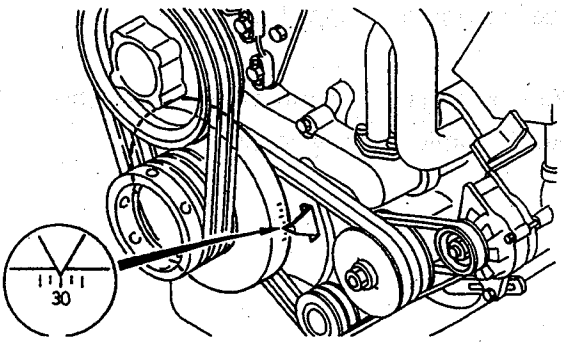
Notice: Do not confuse the No. 1 cylinder with No. 6. When the piston for the No. 1 cylinder is in the above-mentioned position, its inlet and exhaust valve are seated, presenting some clearance.

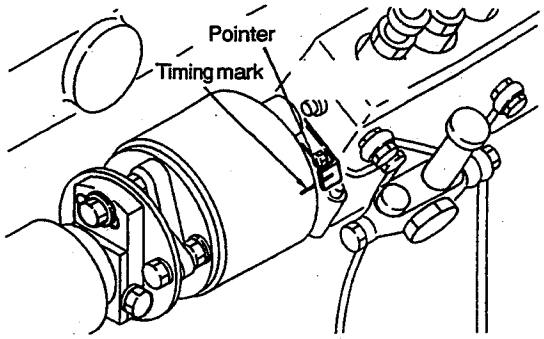
3. Turn back the engine approximately 60° ~~once~~, and turn it in the normal direction slowly until the timing mark (indicated on the caution plate) aligns with the pointer. To ensure proper injection timing, make sure that the timing mark on the timer of the fuel injection pump lines up with the pointer. If not, make an adjustment as follows:

Caution plate





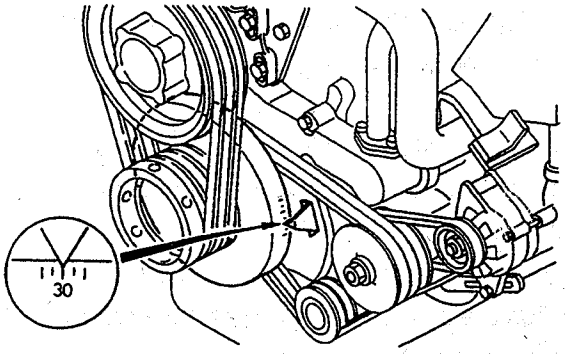




[FUEL SYSTEM] - continued

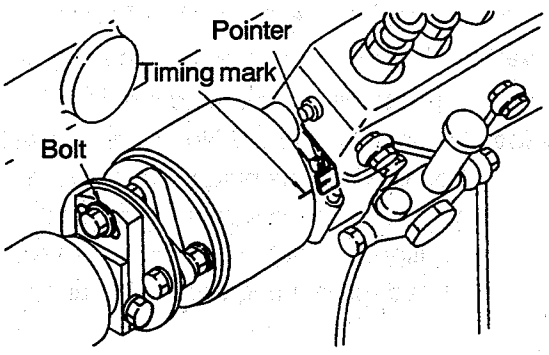
Adjust fuel injection timing

1. Make sure the timing mark (indicated on the caution plate) is aligned with the pointer, with the piston for the cylinder at top dead center on compression stroke.



2. Loosen two bolts for the fuel injection pump coupling.

3. Turn the coupling flywheel until the timing mark on the timer of the fuel-injection pump lines up with the pointer.



4. Tighten the one bolt for fuel injection pump coupling. Turn the engine to tighten the other side bolt and the opposite side nut.

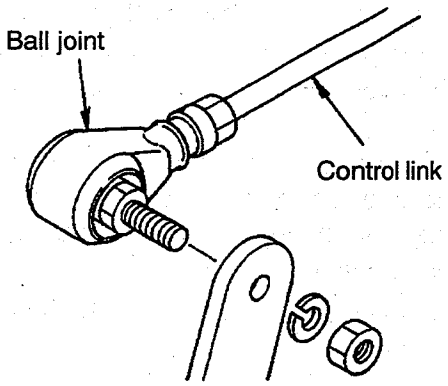
5. Turn the engine (two turns) to recheck the injection timing for verification.

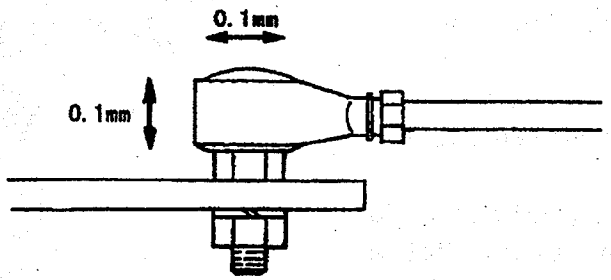
[FUEL SYSTEM] - continued

Fuel Control Link Ball Joints Inspection

Check the ball joints for play. If there is more than 0.1 mm play, change the ball joints with new ones.

Notice: In case of a control link having a ball joint that is an integral part of the link, change the link as an assembly.



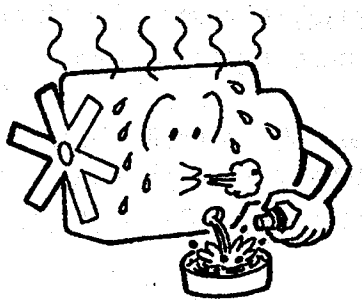


[LUBRICATION SYSTEM]

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: Do not remove the oil by suction whenever possible.

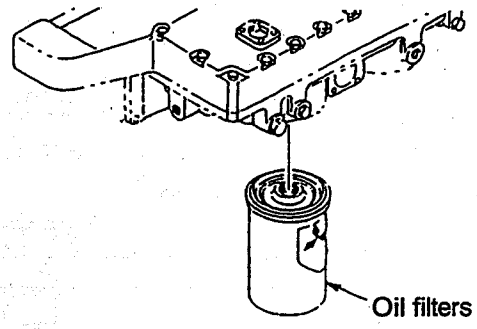
Change the Oil Filters and Bypass Oil Filter

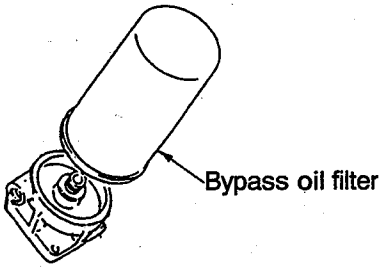
1. Clean the dirt and dust off the surface of the fuel filter.
2. Place a container under the oil filter.
3. Using a filter wrench, remove the used oil-filter cartridge.

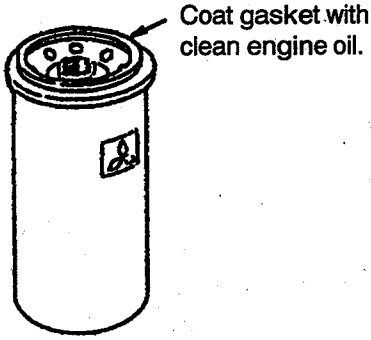
Notice: Check the used oil-filter element for debris. Metal debris can indicate a possible failure. Consult your Mitsubishi dealer. In addition to the periodic check, change the filter when the indicator light comes ON.

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 packing of the new filter with clean engine oil.
7. Install the new filter in the filter-bracket base. When the packing contacts the base, tighten 3/4 to 1 turn more. Be careful not to dent or scratch the surface of the oil-filter cartridge.

Notice: Tighten the cartridge by hand. Do not use a filter wrench.





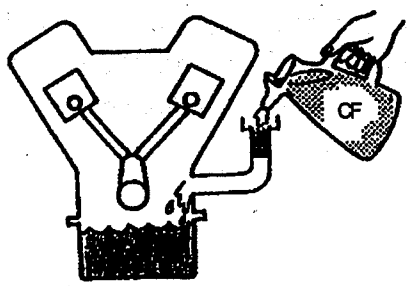


[LUBRICATION SYSTEM] - continued

Fill the oil pan

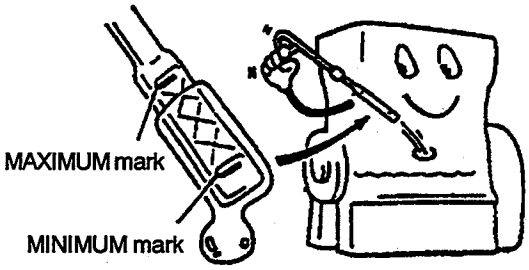
1. Clean and install the drain plug.
2. Remove the crankcase filler cap and fill with recommended oil.

Refill capacity	Oil pan: 100 or 170 liters [26.4 or 44.9 U.S. gallons] Whole engine: 120 or 190 liters [31.7 or 50.1 U.S. gallons]
Recommended oil	Oils that meet Engine Service Classification CF (API Service Classification)



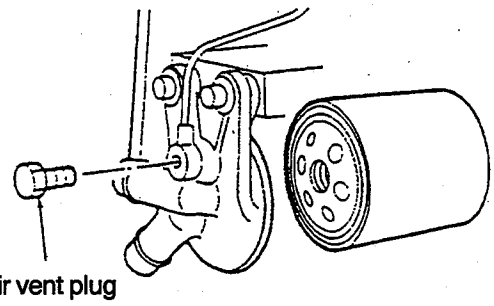
Notice: The engine oil capacity varies depending on the specification.

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 dipstick. The oil level should be between the MAXIMUM and MINIMUM marks on the dipstick. Add oil if necessary.



Change the Hydraulic Governor Oil Filter

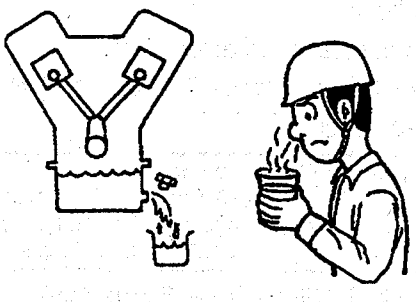
1. Place a container under the governor oil filter and allow the oil to drain in it.
2. Remove the governor oil filter using a filter wrench.
3. Prepare a new governor oil filter and clean the gasket.
4. Coat the gasket with clean engine oil.
5. Securely screw the governor oil filter in the filter bracket by hand.
6. Remove the plug from the filter bracket and fill up the filter with engine oil. When the filter becomes full, replace the plug.
7. Operate the priming pump or wing pump to circulate the engine oil. Check for any oil leakage from the filter base. If found, tighten the filter again.



[LUBRICATION SYSTEM] - continued

Check the Oil

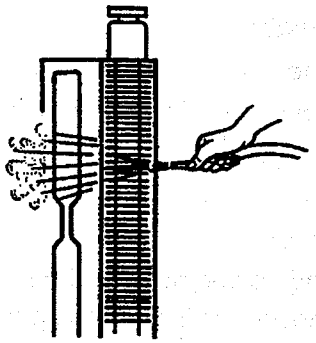
Drain 1 to 2 liters [0.3 to 0.5 U.S. gallons] of oil in a jar, and smell it and visually check it for the presence of fuel and water. Water leakage is often evidenced by emulsified oil.



[COOLING SYSTEM]

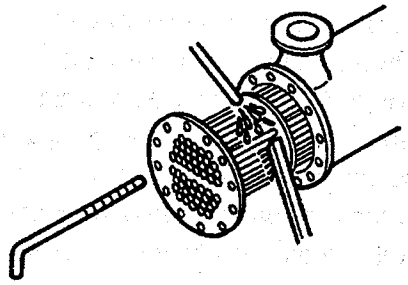
Radiator fins Check/clean

Check the fins for cracks or other defects.
To clean the fins, direct air pressure along the length of fins in the direction opposite to the air flow.



Heat Exchanger Wash

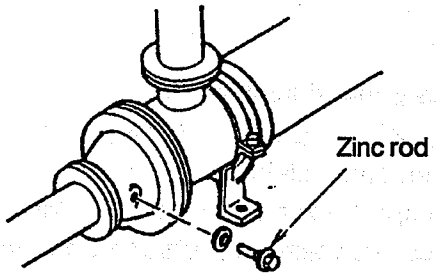
Wash the outside of the pipes with a wire brush by directing fresh water along them.

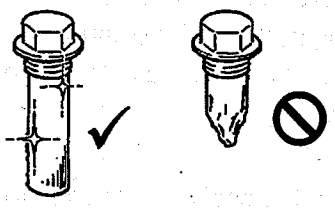


Zinc Rods Check/change

Zinc rods (zinc electrodes) are installed in the sea-water cooling system to prevent corrosion of the components.

1. Remove the zinc rods and scrape off scales.
2. Change the rods if they have been worn out by more than half.
   Reuse the rods if they have been left by more than half.

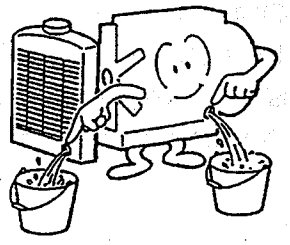




[COOLING SYSTEM] - continued

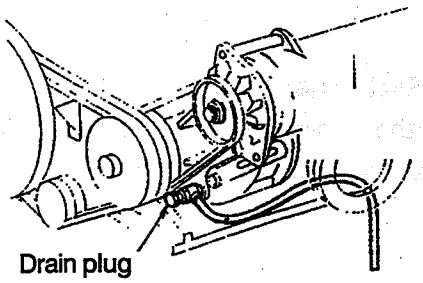
Changing Coolant

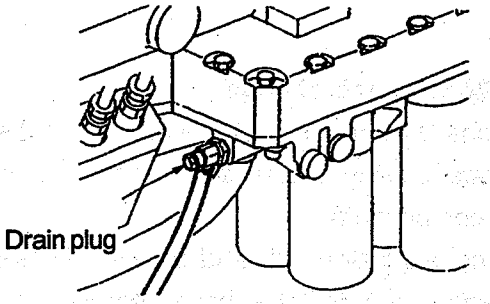
LLC used in the cooling system retains its efficacy for two years. Be sure to change the coolant every 2 years.



Draining Coolant

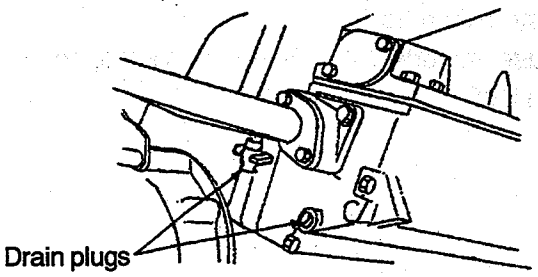
1. Start the engine and operate it until the coolant temperature increases up to 70 to 80℃ [158 to 176°F].
2. Allow the engine to cool to room temperature and lift the radiator-cap lever to relieve pressure. Then remove the radiator cap.
3. Loosen the engine and water pump drain plugs and remove the radiator drain plug, 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.



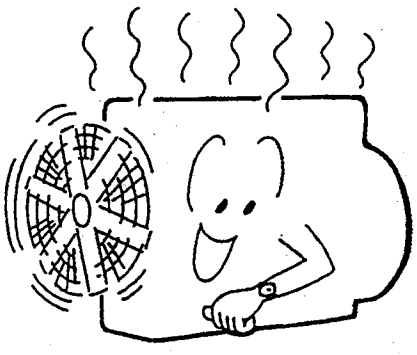


Flushing the cooling system

1. Close the drain plugs 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 rpm for about 15 minutes. Stop the engine and open the drain plugs to allow the solution to drain.
3. Tighten the drain cocks securely.
4. Fill the cooling system with clean water and operate the engine at 800 to 900 rpm for about 10 minutes.



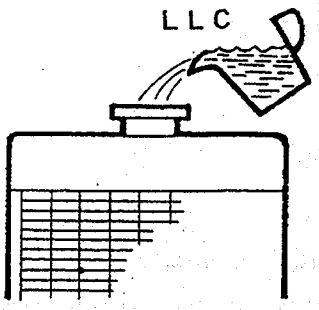
Continue to flush the cooling system in the above manner until the draining water is clear.



[COOLING SYSTEM] - continued

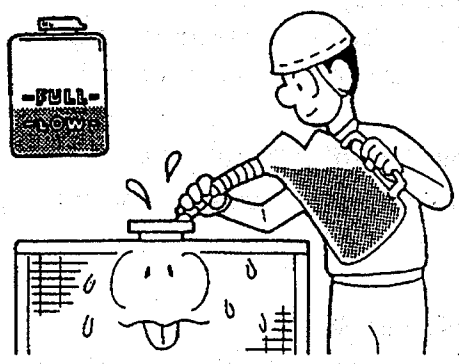
Fill the radiator

1. Tighten the drain plugs of the cylinder block, fresh 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.
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. For concentration of LLC, see the chart below:



Recommended LLC Concentrations

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

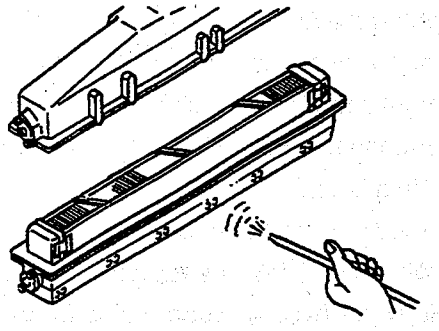


5. When the tank is full, tighten the radiator cap securely.
6. Crank the engine with the starter several times, for 10 seconds each time, at intervals of one minute, to bleed air out of the water pump.
7. Operate the engine until the coolant temperature is 70℃ to 80℃ [158°F to 176°F]. Stop the engine.
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]

Air Cooler Clean

Remove the air cooler and direct pressure air along the length of element in the direction opposite to the air flow.



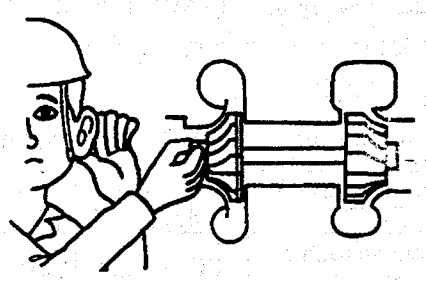
Turbocharger Inspection

⚠ CAUTION

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

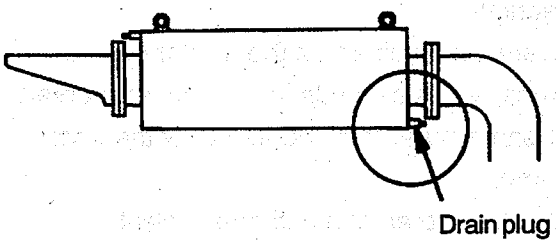
Take a hold of the compressor wheel nut and turn the wheel to feel for rattle and listen for abnormal noise. Replace the bearings if the wheel is noisy or rattles.

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



Exhaust Muffler Drain water

Remove the drain plug and allow water to drain.

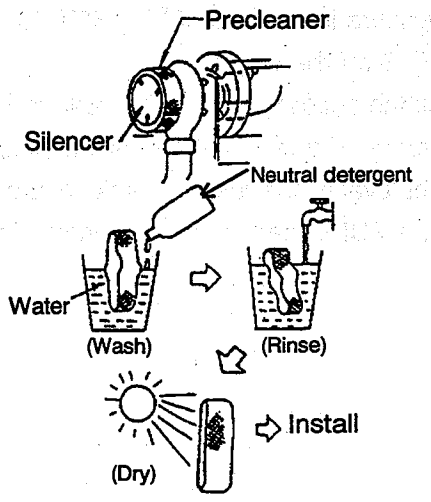


Precleaner Wash

The precleaner of the silencer built in the turbo-charger functions to furnish clean air required for combustion of the fuel. Keep the precleaner clean at all times by servicing it properly.

1. Remove the precleaner from the silencer and wash it in warm water and non-sudsing household detergent.
2. Rinse with clean water.
3. Dry thoroughly and install.

Notice: Do not use damaged precleaner.



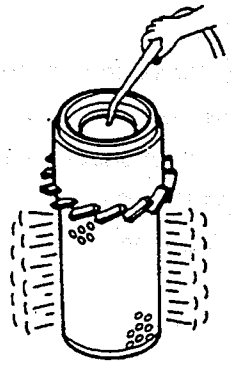
[AIR INLET AND EXHAUST SYSTEMS] - continued

Cleaning the Air Cleaner

⚠ CAUTION

- **When using pressurized air for cleaning, wear a protective face shield, goggles, and protective clothing.**
- **Never service the air cleaner when the engine is running. This can cause dirt to be drawn into the engine, which might accelerate wear of engine components and shorten engine life.**
- **Do not clean the element by bumping or tapping.**

1. Direct the pressurized air inside the element along the length of pleats. The maximum air pressure is 0.69 MPa (7 kgf/cm²) [100 psi].
2. Insert a light inside clean, dry element and inspect. Discard the element if rips or tears are found. If the dust indicator still shows red shortly after the installation of the clean element, change the used element.

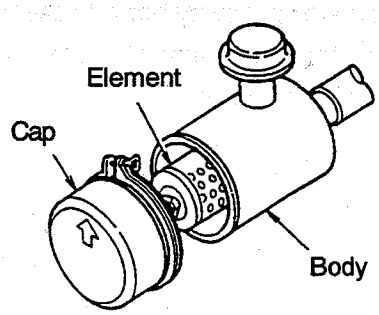


Changing the Air Cleaner Element

⚠ CAUTION

Never service the air cleaner when the engine is running. This can cause dirt to be drawn into the engine, which might accelerate wear of engine components and shorten engine life.

1. Remove the cap from the air cleaner body.
2. Remove the wing nut securing the element. Remove the used element from the body and discard. Install a new element.



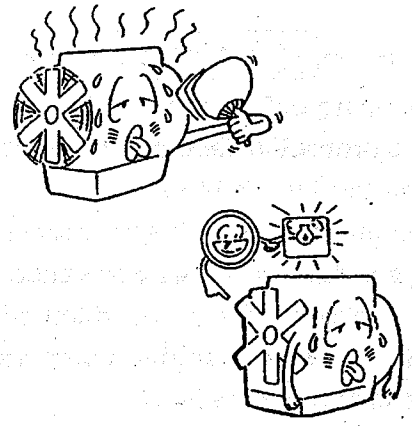
[ELECTRICAL SYSTEM]

Protective Devices Inspection

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

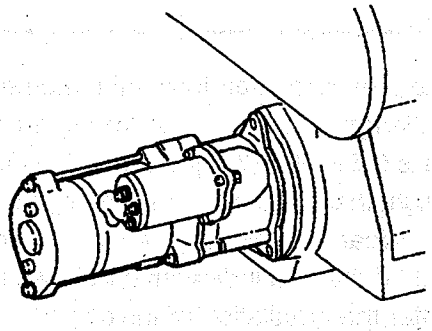
Notice: If the device has a defect, check the level (temperature or pressure) at which it operates.

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



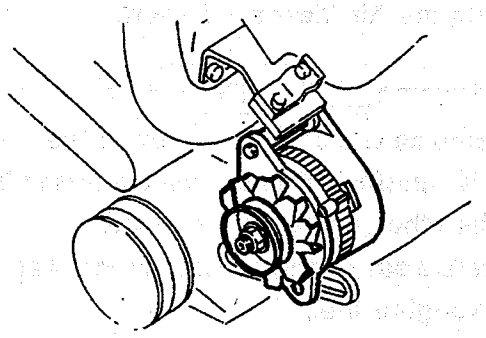
Starter Inspection

1. Visually check for loose bolts, dirt build-up, broken or worn parts, etc. Blow dirt, 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 loose bolts, dirt build-up, broken or worn parts, etc. Blow dirt off, 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.

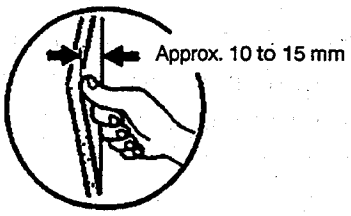


[ELECTRICAL SYSTEM] - continued

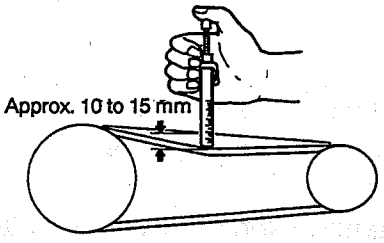
V-Belts Deflection Measurement

⚠ CAUTION

- **Change the belts if cracked, frayed or cut.**
- **Always keep the belts clear of oil or grease. Oil or grease can cause the belts to slip, which might shorten belt life.**
- **If the belts are too tight, unnecessary stresses are placed on the alternator bearings and belts, which might shorten the life of both. Adjust the belts correctly by the following method.**



Measure the deflection of the belts. Apply approximately 98 to 147 N (10 to 15 kgf) [22 to 33 lbf] force midway between the pulleys. The deflection should be approximately 10 to 15 mm [0.4 to 0.6 in.]. Adjust the belts if the deflection is not correct.
When belt tension (deflection) is measured by a tension gauge, use the special V-belt gauge (32591-09100).



Adjusting the fan-belt tension

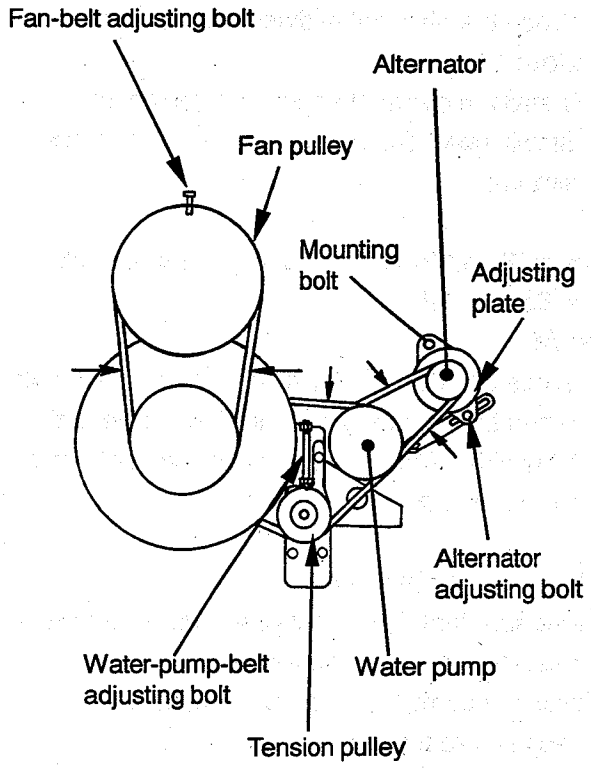
1. Remove the belt cover that covers the fan belt.
2. Loosen all the fan-bracket mounting bolts.
3. Turn the adjusting rod to adjust the belt tension.
4. While maintaining this condition, tighten all the mounting bolts to secure the fan bracket.

Adjusting the water-pump tension

1. Remove the belt cover that covers the water-pump belt.
2. Loosen all the tension-bracket mounting bolts.
3. Turn the tension bolt to adjust the belt tension.
4. While maintaining this condition, tighten all the mounting bolts to secure the tension bracket.

Adjusting the alternator tension

1. Remove the belt cover that covers the alternator.
2. Loosen the alternator and all the alternator mounting bolts.
3. Turn the adjusting rod to adjust the belt tension.
4. While maintaining this condition, tighten all the mounting bolts to secure the alternator.



[AIR STARTING SYSTEM]

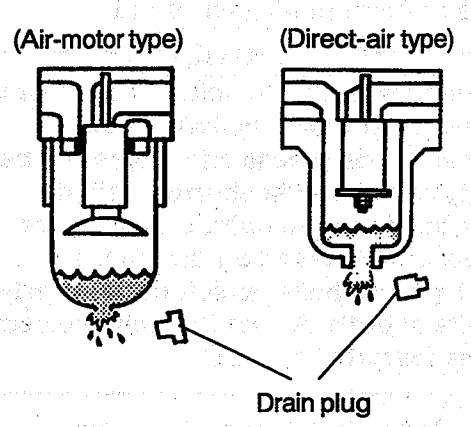
Drain Water from the Air Filter and Clean the Element

⚠ CAUTION

Slowly open the starting-valve handle of the air tank. Otherwise, the engine could start suddenly, resulting in serious troubles.

Drain

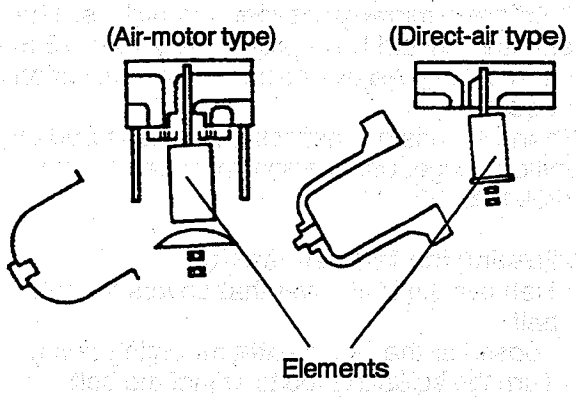
1. Close the starting-valve handle of the air tank.
2. Remove the drain plug from the bottom of the air tank, and allow water to drain from the air filter.



Clean

If the air filter is clogged, an engine start failure will be caused. Be sure to clean the filter periodically.

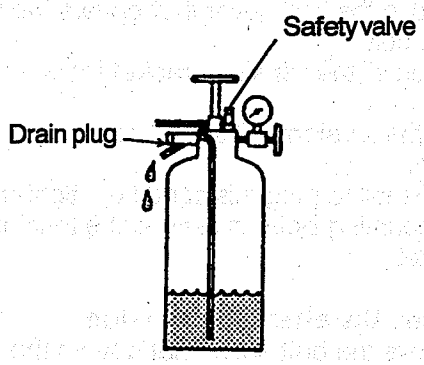
1. Close the starting-valve handle of the air tank.
2. Remove the cover from the air filter, and take the element out of the body.
3. Wash the element in diesel fuel, and dry it by blowing air.
4. Install the element and attach the cover.
5. Slowly open the starting-valve handle of the air tank.



Drain Water from the Air Tank and Check the Safety Valve

Drain

1. Close the starting-valve handle of the air tank.
2. Open the handle under the drain valve at the front side of the tank, and allow water to drain from the tank.



Check the safety valve

Make sure that the safety valve opens to relieve pressure when the air pressure in the tank increases up to the specified pressure.

Specified pressure:

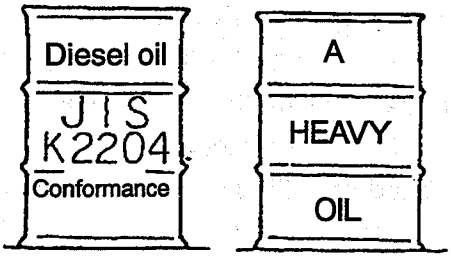
Air-motor type: 0.97 MPa (9.9 kgf/cm2) [141 psi]

Direct-air type: 3.14 MPa (32 kgf/cm2) [455 psi]

Recommended Types of Fuels

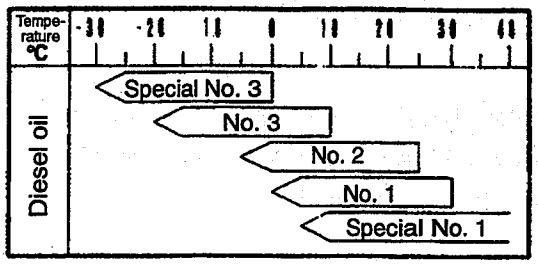
⚠ CAUTION

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 2204) or recommended brands of "A" heavy oils for internal combustion engines (see the "Recommended Brands of Oils" chart).

Notuce: Some "A" heavy oils cannot be used for this engine. 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.

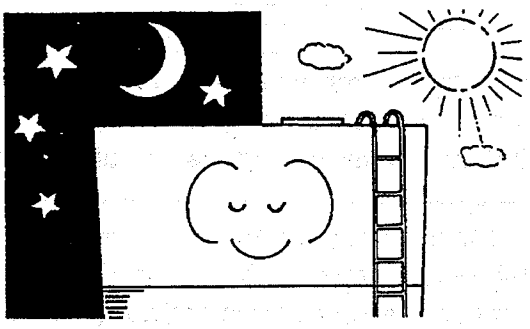
Fuel use limit table

Property		New use limit	Current use limit	Note
Flash point		As stipulated by regulation	As stipulated by regulation	JIS K2204, 2205 Diesel oil: 50°C [122°F] or more "A" heavy oil: 60°C [140°F] or more
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] or lower	
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 cSt or more (30°C) [86°F] 8.0 cSt or lower (50°C) [122°F] 10.5 cSt or lower (40°C) [104°F] 16.0 cSt or lower (30°C) [86°F]	2.0 cSt or more (30°C) [86°F] 8.0 cSt or more (50°C) [122°F] 10.5 cSt or more (40°C) [104°F] 16.0 cSt or more (30°C) [86°F]	
Sulfur content		0.2 weight % or lower	1.0 weight % or lower	Desirable value: 0.05 weight % or lower as seen in diesel oil
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		

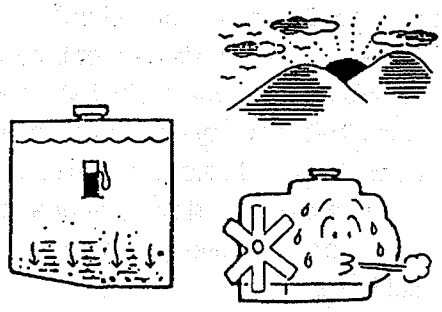
Care of Fuel Supply

⚠ WARNING

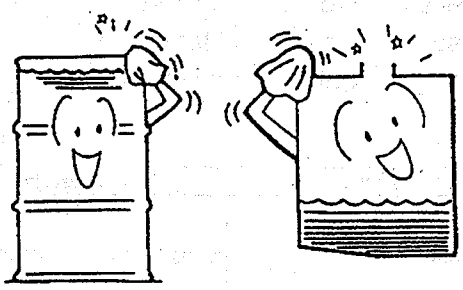
- **Shut down the engine when fueling. Do not smoke while fueling — or when handling fuel containers.**
- **Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire.**
- **After fueling, secure filler cap.**



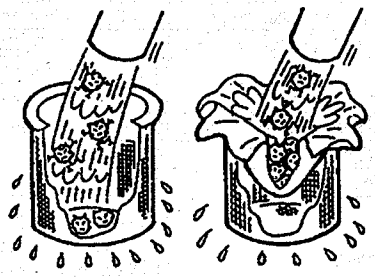
1. Fill the diesel fuel tank at the end of the day. This will drive out moisture-laden air and prevent condensation.

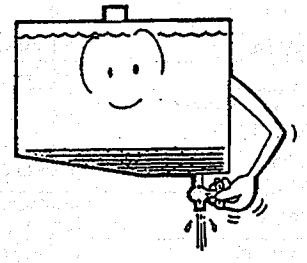


2. When refilling the diesel fuel tank, use clean tools, such as a hand pump, funnel, container, hose, etc. Wipe filler cap clean before removing it. When operating the hand pump, keep in mind that there could be water and sediment that has settled to the bottom of the storage tank; tap the needed amount of fuel from the clean top portion.



3. Be sure to pour fuel through the strainer in the filler opening. Use of a lint-free cheese cloth is a good practice for keeping dirt out.



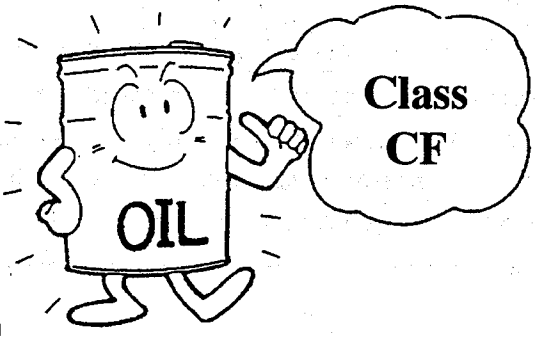


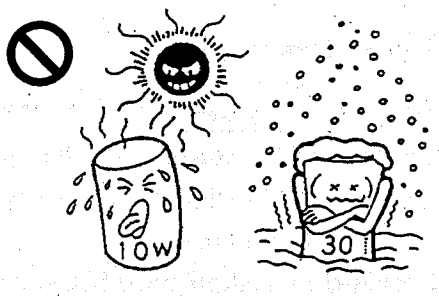
Recommended Types of Engine Oils

Use oils that meet the Engine Service Classification CF.

Do not use Class CE and CF-4 oils. The Class CE engine oil is formulated for use with diesel fuels having a sulfur content of 0.5% or lower; the Class CF-4 for use with diesel fuels having a sulfur content of 0.2% or lower. Some "A" heavy oils have a sulfur content of 0.5% or more, so avoid using Class CE and CF-4 oils.

Improper oil selection may result in congealed oil film on cylinder walls and bearing surfaces, which results in high friction loads and more cranking effort, thus preventing sufficient cranking speeds for reliable starting and affecting engine life.





Recommended Oil Viscosities

Two important considerations related to satisfactory engine operation under ambient temperature conditions—(1) the ability to crank the engine fast enough to assure starting, and (2) adequate lubrication of internal wearing surfaces during starting and warm-up.

Recommended oil viscosities are SAE15W-40 for all seasons, shown in the chart below:

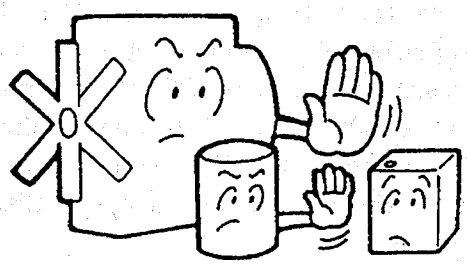
Recommended Oil Viscosities

Starting temperature ℃ [°F]	[-22] [-13] [-4] [5] [14] [23] [32] [41] [50] [59] [68] [77] [86] [95] [104] [113] [122] -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50
Oil viscosities	SAE30 SAE40 SAE15W-40 SAE10W-30 SAE5W-20

Recommended Brands of Oils

⚠ CAUTION

Avoid mixing oils of different brands. If different brands of oils are mixed, they may chemically affect each other and result in degradation of performance of the oils.



Oil A Oil B

Replenish Engine Oil

⚠ CAUTION

- **Shut down the engine when filling oil. Do not smoke while filling oil — or when handling oil containers.**
- **Oil leaked or spilled onto hot surfaces or electrical components can cause a fire.**
- **After filling oil, secure the filler cap.**

COOLANT AND ANTIFREEZE SPECIFICATIONS

Coolant Specifications

Water used in the engine cooling system must be soft, or as free from scale-forming minerals as possible and meet the requirements shown in the "Coolant Specifications" chart.

NOTICE: Basically, harmful chemical substances contained in water (as coolant) shoud not exceed the Mitsubishi limits, but they are tolerable up to the limits shown in the chart below:

Coolant Specifications

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

Notice: The values indicated in ( ) are the limits set forth by Mitsubishi. In addition to the items specified above, turbidity is specified to be below 15°.

Recommended Types of LLC

⚠ CAUTION

LLC is toxic and can cause personal injury if it contacts the skin or eyes. If LLC gets in your eyes, flush them immediately with water and see a doctor at once.

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

Recommended LLC Chart

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

Notice: When using an LLC other than the above, periodic inspection is required, because the service life may become shorter.

Features of recommended brands

- None of amines (methyl amines, ethyl amines, n-propyl amines, etc., all being derivatives of ammonia, NH_3) are contained.
- Silicate and borate are not contained.
- Close to neutral on the pH scale, and hence, slightly basic (alkaline).
- Balanced additive ingredients, some being substitutes for amines.
- Long life. (Coolant with 30% concentration, for example, retains its efficacy for a long time, not less than one year.)

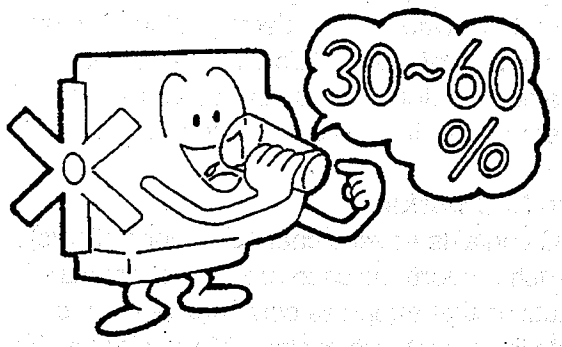
How to use non-amine type LLC

⚠ CAUTION

For disposal of a used coolant containing LLC, consult your Mitsubishi dealer.

(1) The engine coolant with any of the recommended additives should be changed every two years.

(2) Proper concentration of LLC is from 30% to 60% year-round. Consider a temperature level lower by 5℃ [41°F] than the expected lowest temperature. LLC of less than 30% concentration does not provide sufficient corrosion protection. Concentrations over 60% adversely affect freeze protection and heat transfer rates. When adding coolant, use LLC of the same concentration.



Recommended LLC Concentrations

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

Why LLC?
Today's full-blown 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 "ionization." The power of LLC to defeat the ionic reaction is generally subject 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 due to aging and allow some metals to precipitate into the coolant or to form 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 the 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 copper deposit introduces a localized galvanic cell which, by its ionic action, rapidly eats into the iron surface to result in a 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 exacerbation

[STORAGE OF ENGINE IN INOPERATIVE 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 (600 rpm) for 5 to 10 minutes.
4. Stop the engine. Spray volatile rust preservative in the silencer 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 the fan drive 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) Attach a "FILL THE FUEL" or similar warning tag to the starter switch or controls.
(4) New engine oil may be used instead of rust preservative (NP-10).

Rust Preservative Chart

JIS		Recommended brand	Application
K2246	NP-3	Diamond PA-3 (Nippon Mitsubishi Oil Co., Ltd.)	Exposed machined surfaces
	NP-9	Diamond PA90 (Nippon Mitsubishi Oil Co., Ltd.)	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.

Return the Engine to Service

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 the V-belts.
5. Remove all covering and taping.
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.

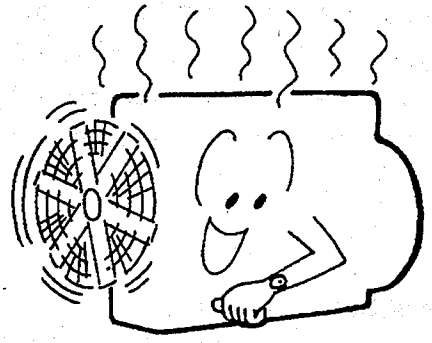
1. Crank the engine two times, with the starter at intervals of 15 seconds, with the fuel supply shut off.
2. Start and run the engine under no-load condition for 5 to 10 minutes.

[STORAGE DURING OFF-SEASON]

Preventive Maintenance

To prevent the formation of rust or oil starvation of moving parts, perform maintenance once a month in the following manner.

1. With the fuel supply shut off (with the engine stop button pressed and with no fuel injection), crank the engine two times with the starter, for 10 seconds each time. Check the oil pressure gauge to make sure that the oil pressure rises properly.
2. Start and operate the engine under no-load conditions for 5 to10 minutes.

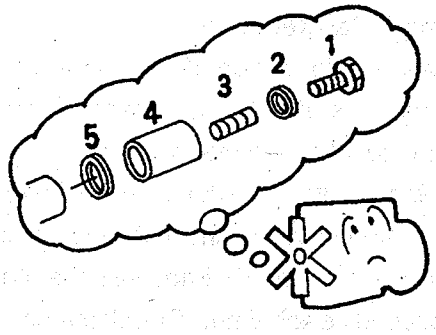


TROUBLESHOOTING

[GENERAL PRECAUTIONS]

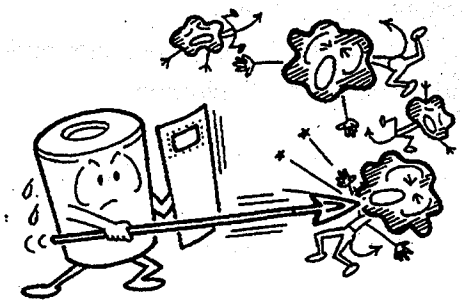
Think Before Acting

Upon facing a problem, recall what you did the last time when you experienced the same problem. If what you did was correct and successful, do the same. If a problem is new to you, think of possible causes in accordance with the troubleshooting.



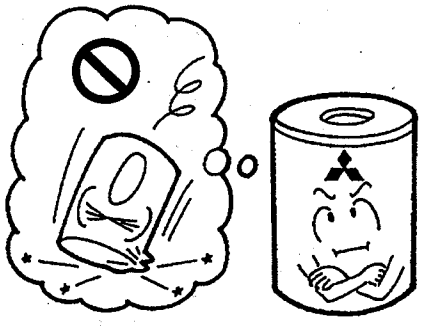
Beware of Dirt and Debris

"Wear" is usually a result of dirt and debris. When disconnecting or disassembling a part or component, be sure to keep off dirt and debris.



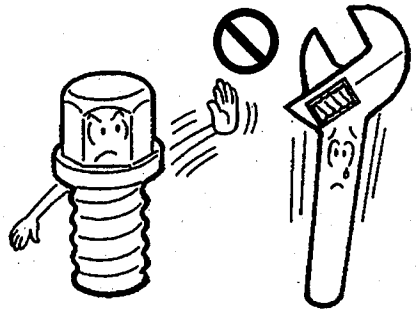
Use Genuine Mitsubishi Parts

Use only genuine parts to replace those that have failed or reached the service limit. When ordering parts, consult Mitsubishi Parts Catalogues.



Perform Service Safely

Use the right kind of tools. Many accidents and damage to parts result from using a tool to do something for which it was not intended. When lifting heavy components, use a hoist to avoid back injury. Make sure all chains, hooks. slings, etc., are in good condition and are in the correct capacity. Be sure hooks, are positioned correctly.



[HOW TO TROUBLESHOOT]

Electric Start Engine

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

Electric system
OK

Low oil pressure indicator light

Fuse blown

Replace.

Does not trip/ come on

Trips/Comes on

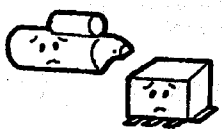
Battery-starter switch circuit open or shorted

Repair or replace.

Battery-starter switch circuit open or shorted.

Repair or replace.

Starter or starter relay defective



Consult your Mitsubishi dealer.

Battery discharged

Check alternator drive belt.

Electrolyte specific gravity low

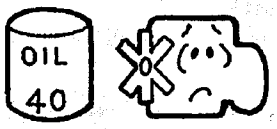
Recharge.

Battery "dead"

Change.

Lubrication system
OK

Oil viscosity too high



Change oil of proper viscosity.

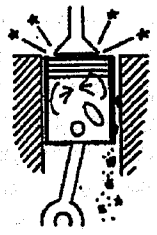
Fuel system
OK

- Air in system
- Insufficient fuel
- Fuel filter clogged
- Fuel feed pump defective
- Fuel injection pump defective

Prime.
Refuel.
Change.
Consult your Mitsubishi dealer.
Consult your Mitsubishi dealer.

Basic block

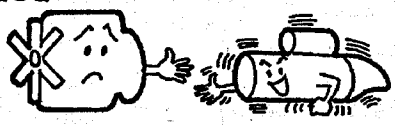
- Running parts defective
- Interference between pistons and valves
- Foreign matter in cylinders



Consult your Mitsubishi dealer.

[HOW TO TROUBLESHOOT]

Electric Start Engine—continued



Starter will crank engine, but engine will not start.

Electrical system
OK

Fuel tank

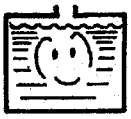
Empty

Refuel.

- Fuel leaks from pipe connection
- Fuel pipe defective

Consult your Mitsubishi dealer.

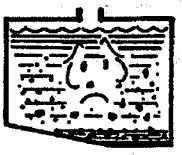
Full



Air in fuel system → Prime.

Bad quality fuel → Change fuel.

Water and sediment



→ Drain.

Fuel filter clogged → Clean or repair.

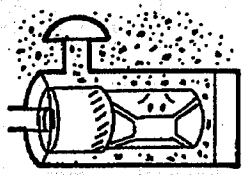
Fuel pipe restricted or leaky → Clean or repair.

Fuel feed pump defective → Consult your Mitsubishi dealer.

Fuel injection pump defective → Consult your Mitsubishi dealer.

Air inlet & exhaust systems
OK

Air cleaner clogged



→ Clean element.

→ Change element.

Muffler or exhaust pipe clogged

→ Clean.

Basic block

- Compression pressure low
- Cylinder liners, pistons and piston rings worn
- Valve springs broken
- Valve seats, nozzle packing seals defective

→ Consult your Miatsubishi dealer.

[HOW TO TROUBLESHOOT]

Air motor type

Air Start Engine

The air motor will not run.

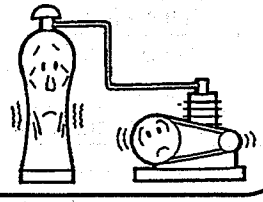
- Low air pressure → Operate the compressor to increase the pressure in the air tank.
- Defective starter switch, Defective magnetic valve → Repair broken wires or broken connections. → Consult your Mitsubishi dealer.

The air motor runs, but the pinion gear will not be engaged with the ring gear.

- Damaged ring gear or pinion gear → Consult your Mitsubishi dealer.

The pinion gear is engaged with the ring gear, but the ring gear will not rotate.

- Low air pressure



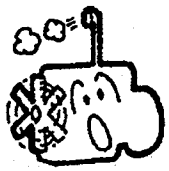
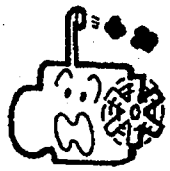
→ Run the compressor to increase the pressure in the air tank.

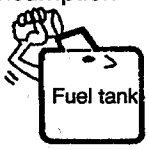
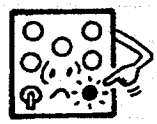
Direct air type

The engine will not run.

- Low air pressure → Operate the compressor to increase the pressure in the air tank.
- Clogged air filter → Clean or change the air filter.
- Seized starter valve → Consult your Mitsubishi dealer.

[Other Problems]

Problem	Cause	Correction
Engine lacks power 	Oil viscosity incorrect	Change oil.
	Bad quality fuel	Change fuel.
	Insufficient air (air cleaner element clogged)	Clean or change.
	Radiator overcooled	Use radiator cover or consult your Mitsubishi dealer.
	Fuel filter clogged	Change.
	Cooling performance of radiator insufficient (Engine overheating)	Flush cooling system or consult your Mitsubishi dealer.
	Valve clearance incorrect	Readjust.
	Fuel feed pump defective	Consult your Mitsubishi dealer.
	Fuel injection pump defective	Consult your Mitsubishi dealer.
	Fuel injection nozzle defective	Consult your Mitsubishi dealer.
	Fuel injection timing incorrect	Readjust.
	Compression pressure low (cylinder liners, piston rings, etc., worn)	Consult your Mitsubishi dealer.
White or blue exhaust smoke 	Too much oil in engine	Maintain correct oil level.
	Oil viscosity too low	Change oil.
	Radiator overcooled	Use radiator cover or consult your Mitsubishi dealer.
	Thermostat detective (no coolant temperature rise)	Consult your Mitsubishi dealer.
	Fuel injection nozzle defective	Consult your Mitsubishi dealer.
	Fuel injection timing incorrect	Readjust.
	Compression pressure low	Consult your Mitsubishi dealer.
	Bad quality fuel (low cetane number)	Change fuel.
Black or gray exhaust smoke 	Bad quality fuel	Change fuel.
	Valve clearance incorrect	Readjust.
	Compression pressure low	Consult your Mitsubishi dealer.
	Insufficient air (inadequate ventilation/air cleaner element clogged)	Clean or change.
	Fuel injection timing incorrect	Readjust.
	Fuel injection nozzle defective	Consult your Mitsubishi dealer.
	Fuel injection pump defective	Consult your Mitsubishi dealer.

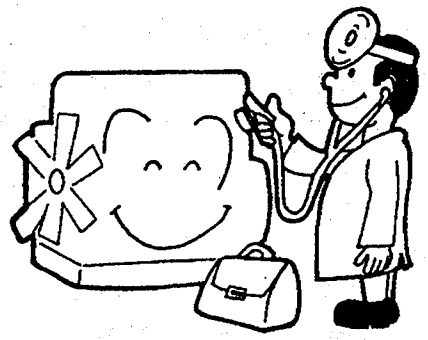
Problem	Cause	Correction
High fuel consumption 	Fuel injection pump defective	Consult your Mitsubishi dealer.
	Fuel injection timing incorrect	Readjust.
	Bad quality fuel	Change fuel.
	Compression pressure low	Consult your Mitsubishi dealer.
	Insufficient air (air cleaner element clogged)	Clean or change.
High oil consumption 	Too much oil in engine	Maintain correct oil level.
	Oil viscosity too low	Change oil.
	Oil leaks	Re-tighten or consult your Mitsubishi dealer.
	Cylinder liners, piston rings, etc., worn	Consult your Mitsubishi dealer.
	Valve stem seals worn	Consult your Mitsubishi dealer.
Engine overheats 	Radiator and or heat exchanger dirty	Clean heat exchanger or consult your Mitsubishi dealer.
	V-belts too loose	Readjust.
	Not enough coolant in cooling system	Refill.
	Water pump defective	Consult your Mitsubishi dealer.
	Thermostat defective	Consult your Mitsubishi dealer.
Low oil pressure 	Not enough oil in engine	Refill up to specified level.
	Oil viscosity too low	Change oil.
	Oil filter clogged	Change.
	Oil pump defective	Consult your Mitsubishi dealer.
	Relief valve defective	Consult your Mitsubishi dealer.
	Oil-pressure sensor defective	Consult your Mitsubishi dealer.

Remarks: • Consult your Mitsubishi dealer for any items other than those listed above.
• When ordering replacement parts, give the service-hour meter reading of your engine.

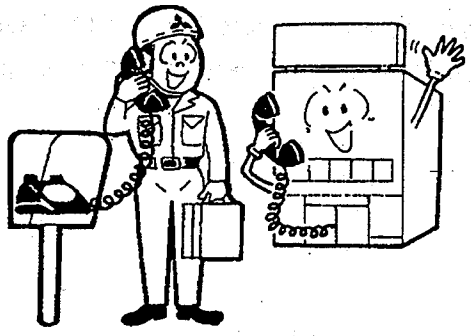
SPECIFICATIONS

Engine model			S12A2		
			T	TA	TK
Type			4cycle water cooled, turbocharged diesel engine		
			-	With after cooler	With inter cooler
Number of cylinders - arrangement			12-V		
Bore x stroke			φ150 mm x 160 mm [5.9 in. x 6.3 in.]		
Total Displacement			33.93 liters [2,070 cu in.]		
Combustion system			Direct injection system		
Compression ratio			14.5 : 1		
Firing order (injection sequence)			1 - 12 - 5 - 8 - 3 - 10 - 6 - 7 - 2 - 11 - 4 - 9		
Rotation			Counterclockwise as seen from flywheel end		
Dimensions (Over all length)			2,060 (mm) [81.1 (in.)]		1,948 (mm) [76.7 (in.)]
(Over all width)			1,382 (mm) [54.4 (in.)]		1,382 (mm) [54.4 (in.)]
(Over all height)			1,542 (mm) [60.7 (in.)]		1,542 (mm) [60.7 (in.)]
Dry weight			Approx. 2,840 kg [6,261 lb]	Approx. 2,920 kg [6,437 lb]	
Fuel system	Fuel oil		Diesel oil or A heavy oil		
	Fuel injection pump		Bosh P type		
	Fuel secondary filter		Paper element cartridge changeover-type		
	Fuel injection nozzle		Hole nozzle type		
	Initial fuel injection pressure		21.57 MPa {220 kgf/cm^2} [3,130 psi]		
Lubrication oil system	Type		Pressure feed		
	Lubricating oil	Standard type	Oil pan: 100 liters [26.4 U.S. gallons] Whole engine: 120 liters [31.7 U.S. gallons])		
		Large type	Oil pan: 170 liters [44.9 U.S. gallons] Whole engine: 190 liters [50.2 U.S. gallons])		
	Lub. Oil filter		Paper element cartridge changeover-type		
	Oil cooler		F.W cooling multi plate type area		
Cooling system	Type		Forced water cooling		
	Cooling fresh water		80 liters [21.1 U.S. gallons]	100 liters [26.4 U.S. gallons]	
Starting system	Type		Electric motor starting or Pneumatic starting (air motor/direct air type)		
	Starter (Electric motor)		24 V - 6 kW x 2		
	Generator (charging dynamo)		24 V - 30 A		
Turbocharger			Mitsubishi TD10 type or TD13 type		
Fly wheel			SAE. 18in.		
Fly wheel housing			SAE. #0		

Your Mitsubishi dealer is vitally interested in your complete satisfaction with the Mitsubishi engine you purchased from him. He is anxious to know that all of your service needs are properly filled. When consulting your Mitsubishi dealer for replacement parts or any other service, be sure to give the engine serial number and service-hour meter reading.



If your engine is transferred to elsewhere from the original place of use registered by your Mitsubishi dealer, be sure to have the registration changed. Consult your Mitsubishi dealer for the necessary procedures.



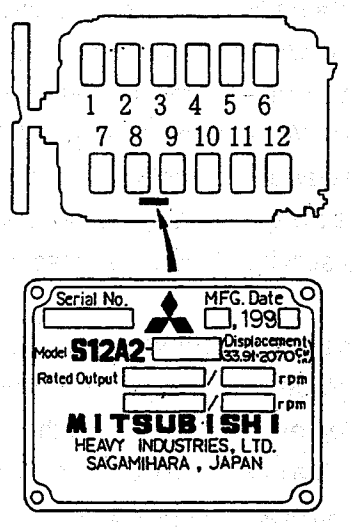
Location of Engine Serial Number

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

Example

Model: S12A2

Serial number: 00012



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

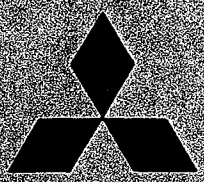
Scheme of Designating Engine Model

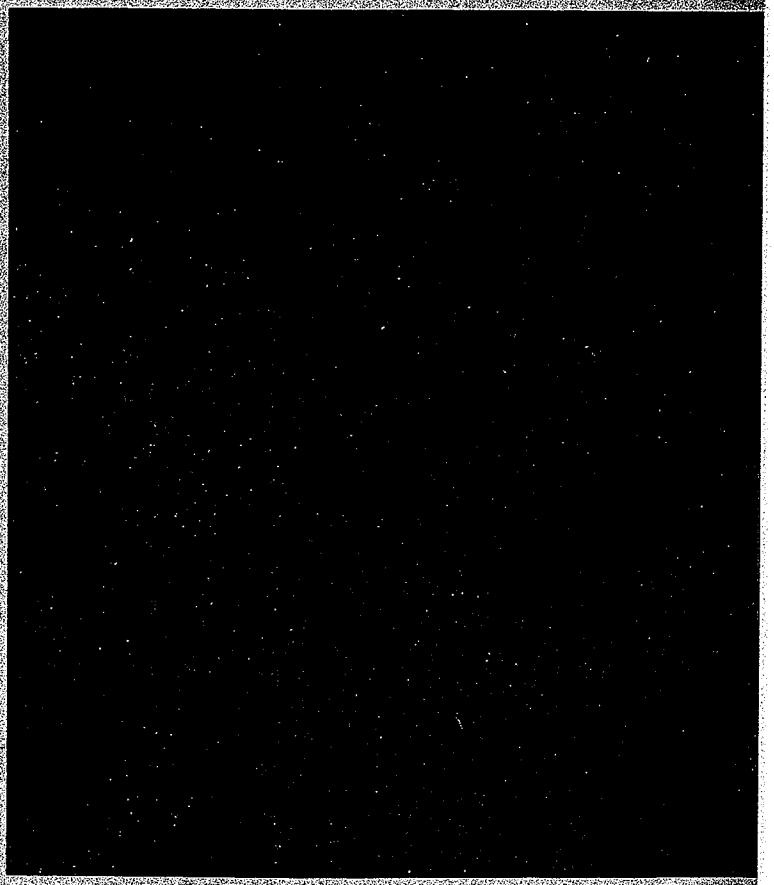
S □□ - □ T ..... With turbocharger

S □□ - □ TA ..... With aftercooler and turbocharger

S □□ - □ TK ..... With intercooler and turbocharger

- Application code
  - P ..... Generator sets and general prime power
  - L ..... Locomotives
  - MP .... Marine main and auxiliary machinery
- Series code
- Number-of-cylinders code
- Initial of SAGAMIHARA MACHINERY WORKS





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