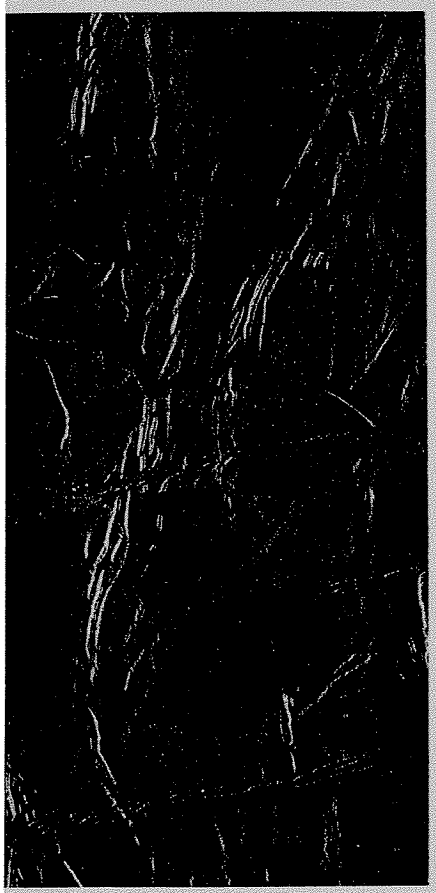
OPERATION & MAINTENANCE MANUAL



MITSUBISHI DIESEL ENGINE

S6R, S6R2

MITSUBISHI HEAVY INDUSTRIES, LTD.

INTRODUCTION

This manual contains operation instructions, and lubrication and maintenance information for Mitsubishi S6R· S6R2 diesel engine.
We suggest that you carefully read and understand the instructions in this manual before operating or performing lubrication and maintenance on the engine.
When performing lubrication, maintenance and repair on the engine, be sure to consult your Mitsubishi dealer for correct procedures.

⚠ WARNING

Most accidents involving operation and maintenance are caused by a failure to follow fundamental safety rules and precautions.

- Do not operate the engine unless you have read and understood the instructions in this manual.
- Keep this manual in the engine as a 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.
- A careful operator is the best insurance against an accident.

Pub.No.99410-12100

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 of **CAUTION** also indicate a specific potential hazard resulting in serious bodily injury or death.

Symbols

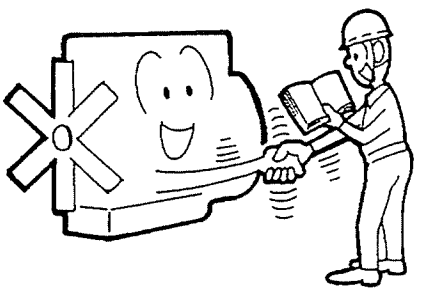
✔ ---------- Indicates a proper action or "DO."

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

Others

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

Recommendation of Daily Operation Records

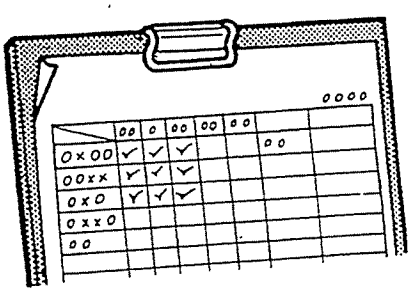


It is obvious to every engine user and operator that an engine should not be run to destruction. Daily recording is a preventive maintenance program and will serve as a guide for:

- Effective troubleshooting (to help a serviceman of your Mitsubishi dealer pin-point a trouble).
- Quick servicing and less downtime (to help a serviceman of your Mitsubishi dealer save time (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:

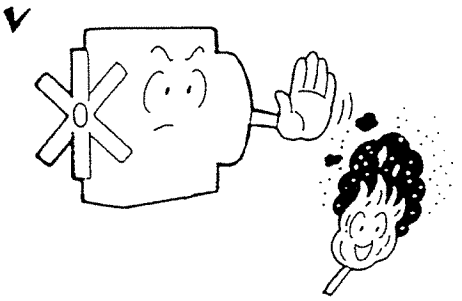


1. Operating hours (service hour meter reading)
2. The amount of oil, fuel and coolant (soft water) required for refilling
3. Oil and coolant change intervals
4. Engine oil pressure, exhaust temperature, coolant temperature and inlet air temperature
5. Parts serviced, kinds of service (adjustment, repairs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

TABLE OF CONTENTS

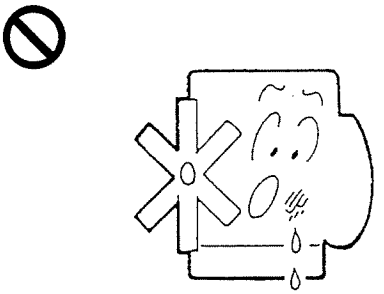
DANGER Fire or Explosion Prevention

Fire hazards!
Do not smoke while fueling, or when handling fuel containers. Do not use gasoline or diesel fuel for cleaning parts. Good commercial, non-flammable and non-toxic solvents are recommended. Do not spill fuel on hot surfaces. Clean up any spillage soon.



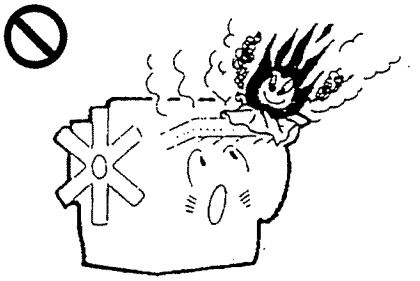
Do not fill fuel tank while engine is running!
Shut off engine when fueling — and use extra caution if engine is hot.

Always watch for fuel or oil leaks!
Leaks can cause fires and personal injury. If your check uncovers any leakage, report it now.



WARNING Fire Prevention

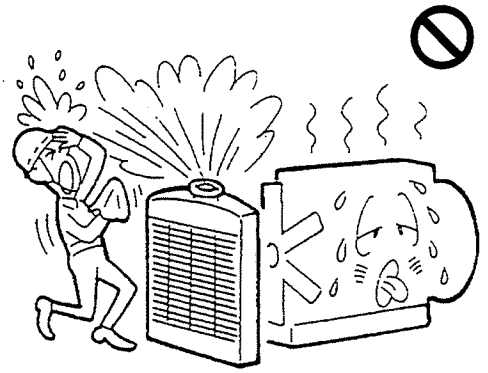
Keep flammable materials away!
Remove all flammable materials such as fuel, oil and other debris before they accumulate on engine. Keep engine at least 1 meter [3.3 ft] apart from surrounding structures and other equipment to avoid fires.



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 cap with cloth and remove it slowly to relieve pressure.

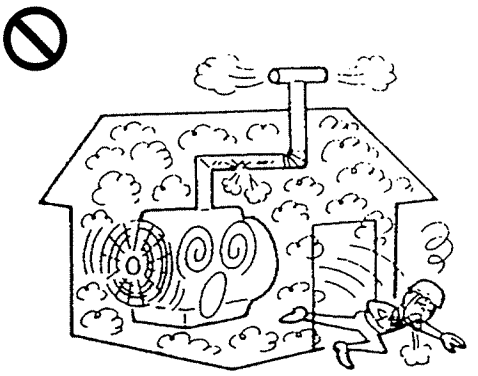


WARNING

Exhaust Fumes

Operate engine only in safe area!
Exhaust fumes may cause injury or death if inhaled.

- Do not operate engine in an enclosed area.
- If necessary to operate engine in an enclosed area, provide adequate ventilation and take measures to vent exhaust fumes to the outside. Exhaust line should be free of exhaust fumes leaking into the engine room.
- Vent exhaust to the outside in a manner that is not objectionable or dangerous to engine operator or area residents. Exhaust system must also be consistent with applicable environmental regulations and building codes.

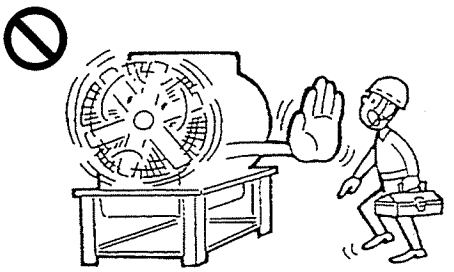


WARNING

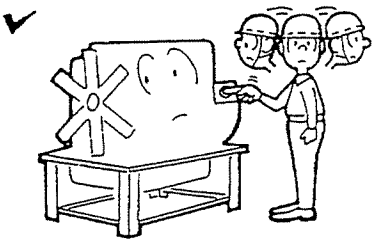
Cutting Prevention

Stay clear of all rotating and moving parts!
The drive belts, pulleys and fan, for instance, of the engine are dangerous rotating parts. Always stay clear of them during operation.

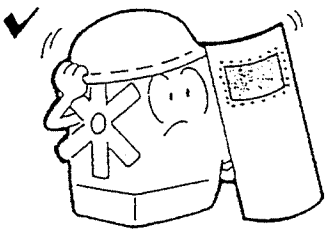
Check and service carefully!
Before performing maintenance, pull off the starter switch key and turn OFF the battery switch. Attach a "DO NOT OPERATE" or similar warning tag to starter switch.
In case of pneumatic starting, close the prime valve of the air tank and affix a label indicating "DO NOT OPEN", etc., to the valve.



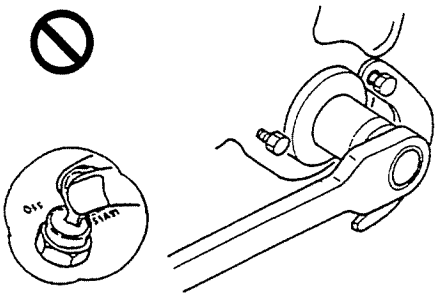
Prepare to operate engine!
Clear all personnel from engine and area. Keep engine free of foreign material, such as debris, oil, tools and other items which are not part of engine.



Install protective covers!
Make sure all protective covers and guards are installed to drive belts, couplings, etc. to prevent personal injury.



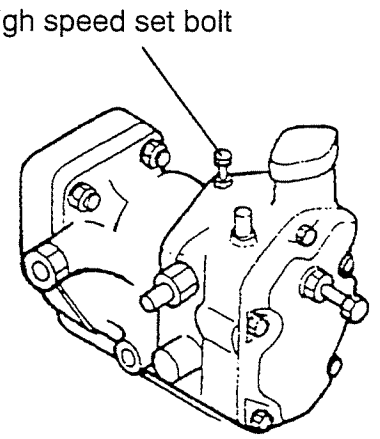
Keep turning gear disengaged when not in use!
Lock the turning gear in disengaged position properly when not in use. Failure to follow this recommendation can cause personal injury and engine damage.



WARNING

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

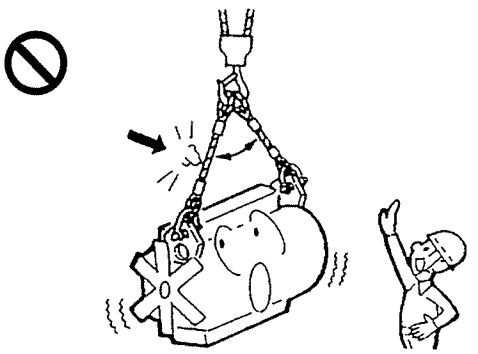
Governor Sealing



WARNING

Lift engine carefully !
When lifting an engine, attsch specified slings and shackles to engine hangers properly . Operate a hoist carefully to take up slack slowly. Do not jerk. Remember, sudden impact of load can cause serious accidents. Never allow anyone to walk or stand under the engine that is lifted.

Lifting Precautions



WARNING

Servicing Batteries

Service 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 engine and turn OFF 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, for worse, explosion.

(8) When servicing any electrical component, or when welding on engine, turn OFF 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.

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

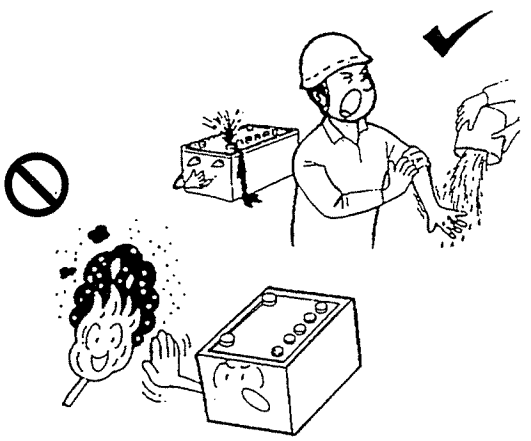
(1) When servicing batteries, consult your foreman for specific instructions on a job and safety equipment required.

(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 again and drink as much water as you can and then consult a doctor at once.



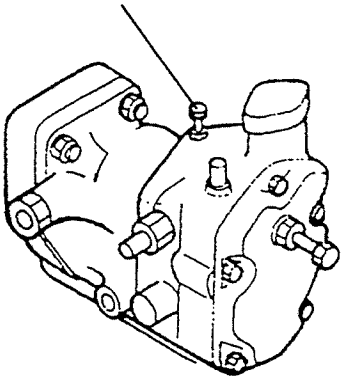
CAUTION Operating Precautions

Do not break seals for settings!

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

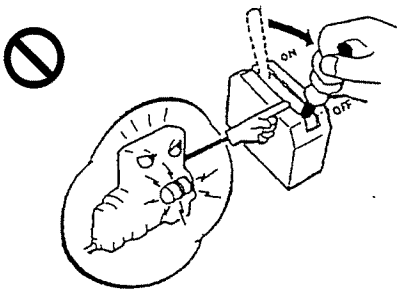
- Accelerated wear of engine components
- Seizure or damage of engine components
- Increase in fuel and oil consumption
- Maladjusted injection quantity and poor engine performance

Maximum injection quantity set bolt



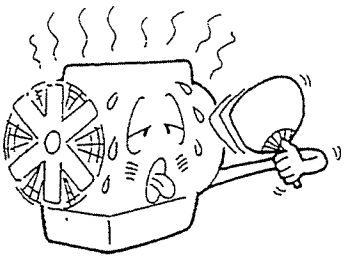
Do not turn OFF battery switch during operation!

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



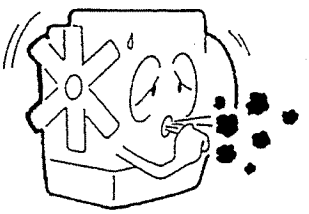
Always keep engine room well ventilated!

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



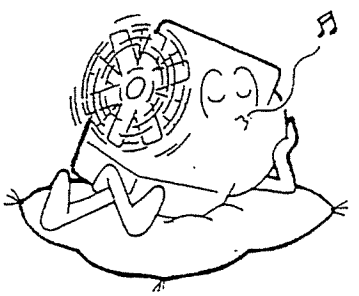
Avoid overloading!

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

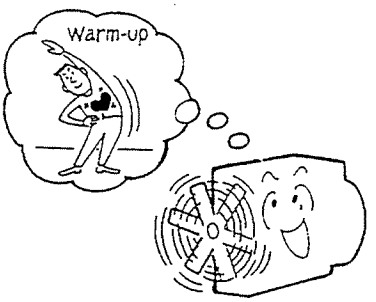


CAUTION Operating Precautions

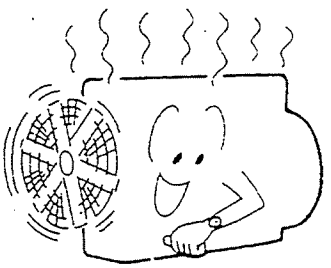
Be sure to break-in engine!
During first 50 hours of operation, break-in engine with lighter load and lower speeds than normal. Proper break-in contributes to maximum service life of engine.



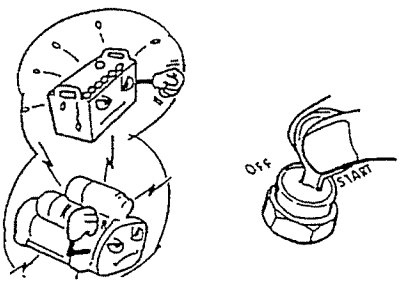
Warm-up engine before operation!
For maximum engine life, warm the engine up after starting it, and run it in idle at low speed for 3 minutes before operating under full load.
Notice: Long periods of warming up the engine is not recommended. This can deposit carbon in cylinders and cause incomplete fuel 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 engine, run it in idle at low speed for 3 minutes. This allows hot areas in engine to cool gradually, extending engine life. With 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.

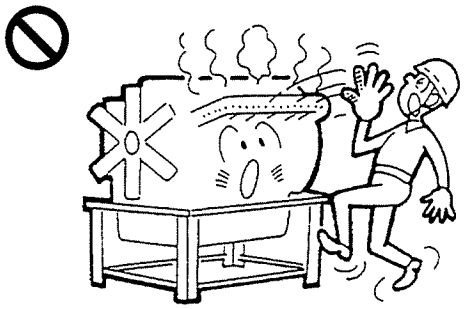


CAUTION

Burn Prevention

Do not touch hot components!

At operating temperature, engine components are very hot. Avoid any contact during operation. Service engine only after engine has been stopped and components are cool enough to touch them with your bare hand.

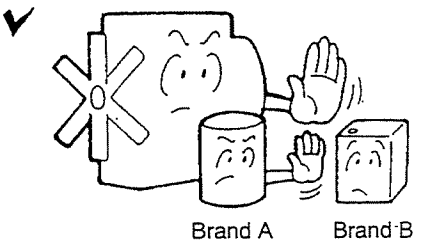


Stay clear of hot oil!

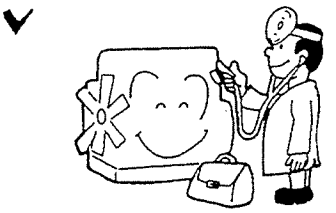
High pressure and hot oil can be dangerous. Pressurized oil can penetrate skin and cause serious injury. Oil escaping from a small hole can be almost invisible. Use a piece of cardboard or wood, instead of your hands, to search for suspected leaks.

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.



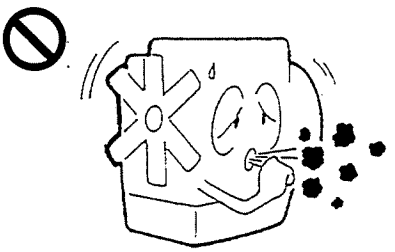
Perform all recommended inspection!
Perform pre-start inspection and periodic inspection on items listed in this manual. Failure to follow this recommendation can cause engine damage, or injury or death.

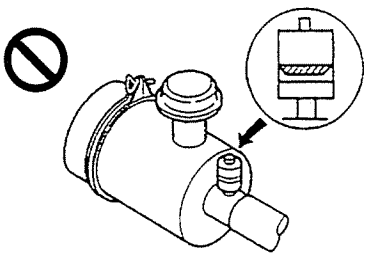


Keep water out of engine!
When washing engine, cover air inlet and exhaust opening with tape to prevent water or cleaning agent from getting inside engine. Do not wash engine when it is running. If water or cleaning agent gets inside combustion chambers, hammering action of water can damage engine.

Keep grit-laden air out of engine!
Dust and dirt entering engine will cause early wear of running parts with a resultant loss of power, high oil consumption, hard starting and other failures.
Service air cleaner properly.

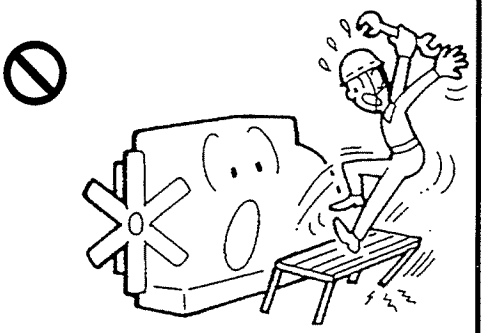
1. Do not service air cleaner when engine is running.
2. When removing air cleaner element for servicing, prevent dust from entering air passage to cylinders.
3. In case of air cleaner equipped with a dust indicator, service element only when the indicator shows red. Frequent servicing can cause element damage.



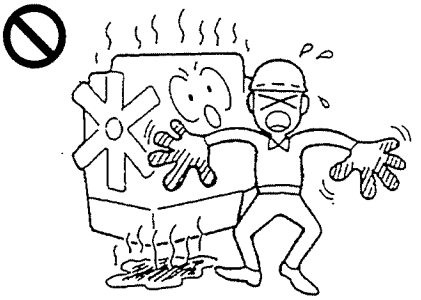


CAUTION Maintenance Precautions

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.

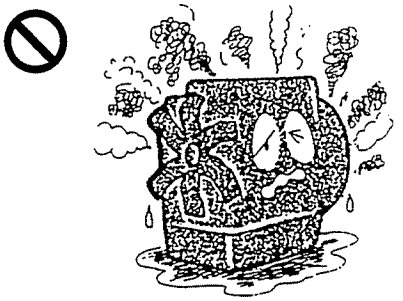


Avoid burns!
When changing oil or coolant, do not allow hot oil or coolant to contact skin. Do not change oil filter with bare hands.

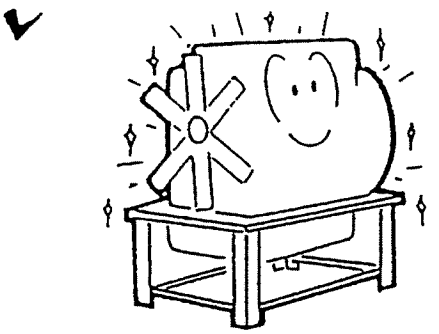


Service electrical system carefully!

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



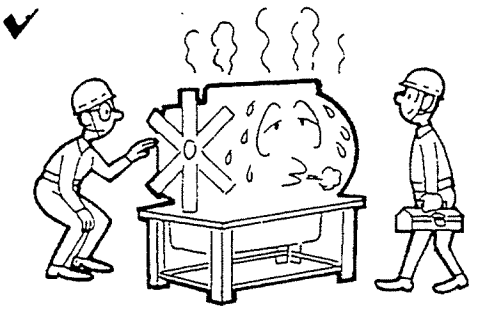
Keep engine and area clean!
Remove all flammable materials such as fuel, oil and other debris, before they accumulate on engine.



CAUTION Maintenance Precautions

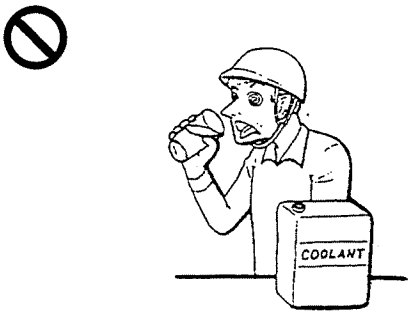
Stop engine before servicing!

Be sure to stop 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 hand. Never attempt to adjust fan belt when engine is running.



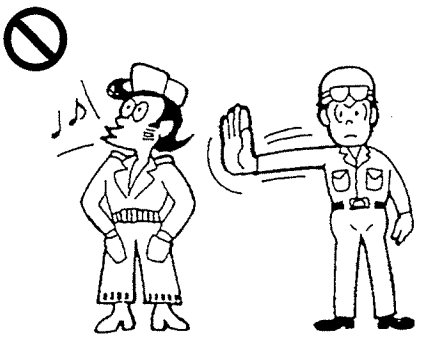
Handle antifreeze carefully!

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



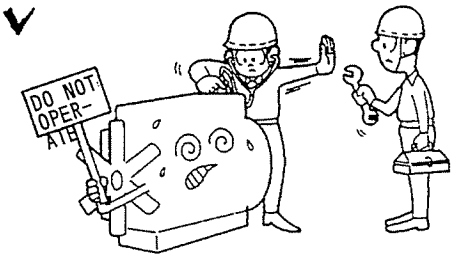
Dress properly for the job!

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

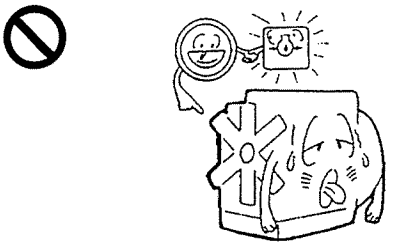


CAUTION If Any Trouble Should Occur

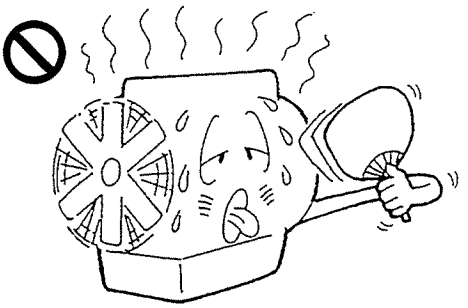
If engine stops abnormally!
Do not restart engine immediately after it has stopped abnormally. If engine stops abnormally, check for the cause and make needed repairs before starting it again.



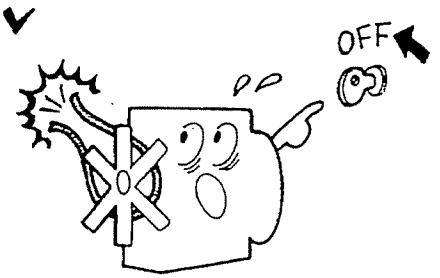
If engine oil pressure is low!
Stop engine immediately and check lubrication system. Operating engine with low oil pressure can cause seizure of bearings and other parts.

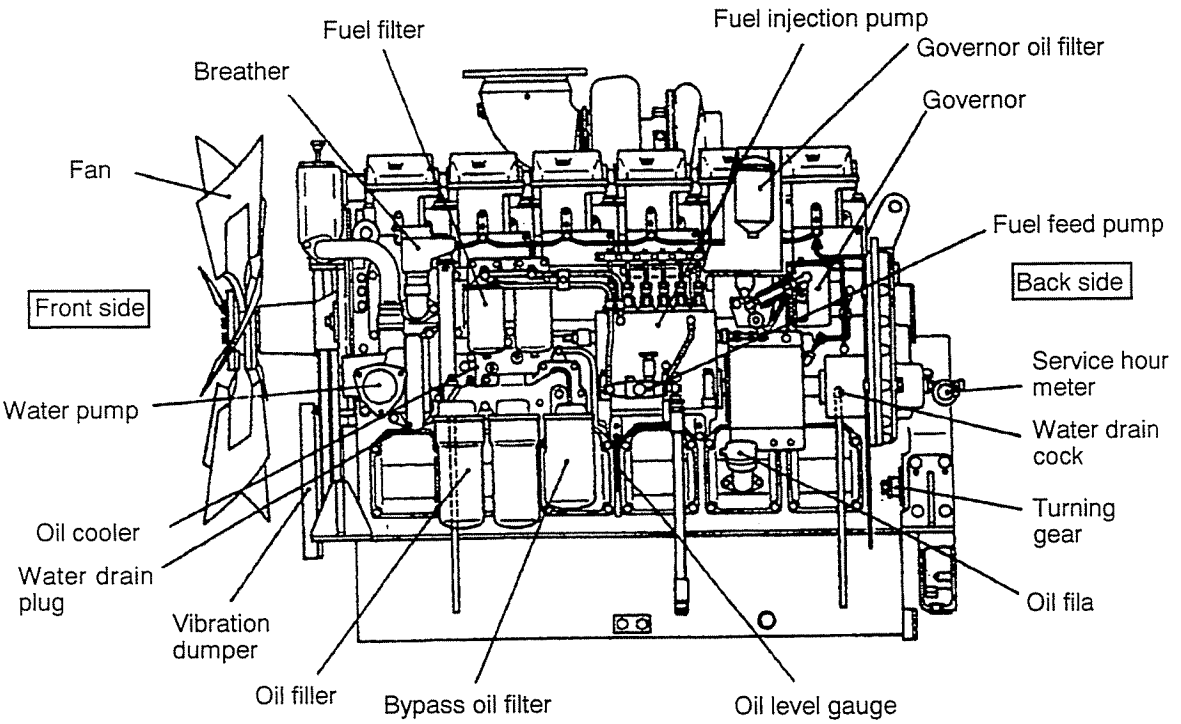


If engine overheats!
If engine overheats, never stop it immediately. Stopping an overheated engine immediately can result in sudden coolant temperature rise and seizure of running parts. Operate engine at low idle to allow hot areas in engine to cool gradually, then add coolant gradually. Remember, adding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

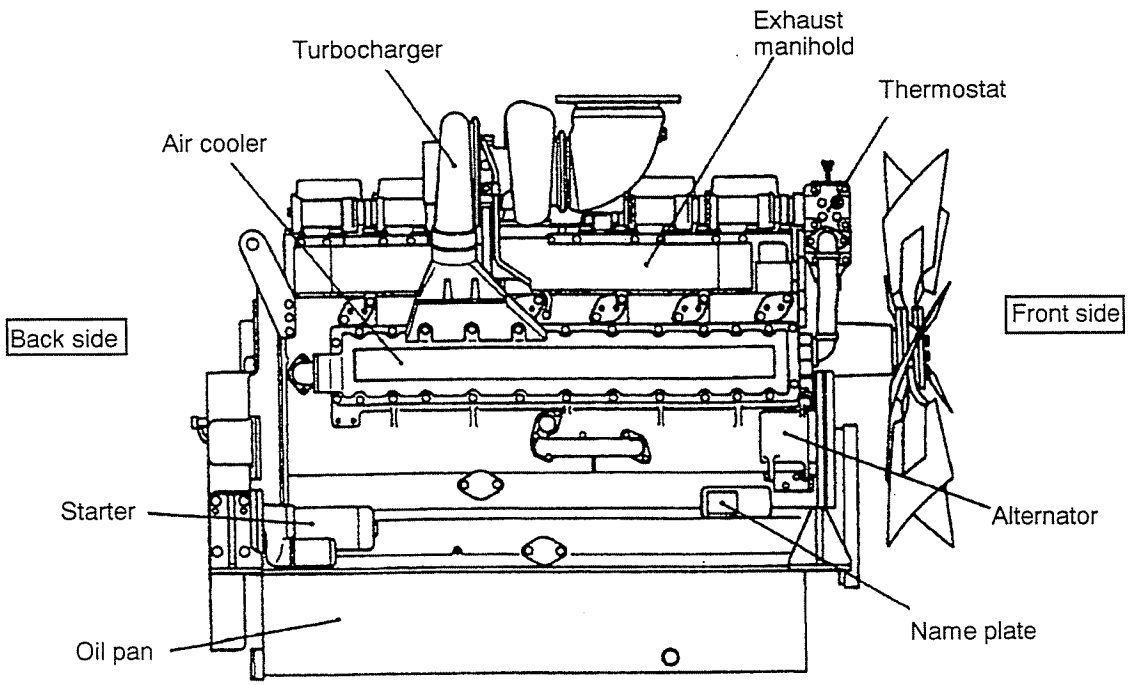


If fan belt is broken!
Stop engine immediately. Operating engine with broken fan belt can cause coolant to spout out of reserve tank and radiator, resulting in engine overheating.





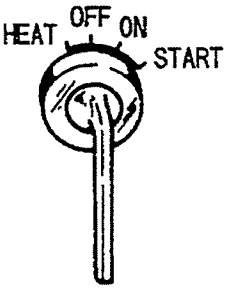
Left side



Right side

[START/STOP CONTROLS]

Starter Switch

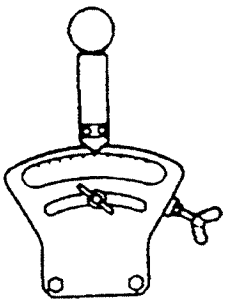


HEAT Turn the starter switch key to the HEAT position to heat the engine (with an air heater) when the engine is hard to start in cold weather.

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

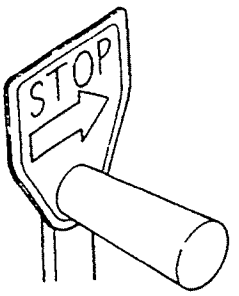
ON The key will return to the ON position when released from the START position.

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.



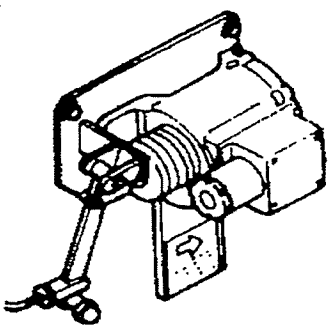
Manual Stop Lever

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 key.

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

Stop Solenoid

Press the stop button or turn OFF the starter switch to stop the engine. This solenoid, when energized, moves the rack of the fuel injection pump to the non-injection position to stop the engine.



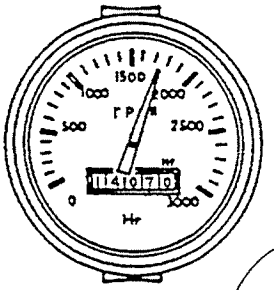
[INSTRUMENTS]

Learn the location and purpose of all instruments before operating the engine.

Tachometer

Measures engine speed (revolutions per minute or angular speed).

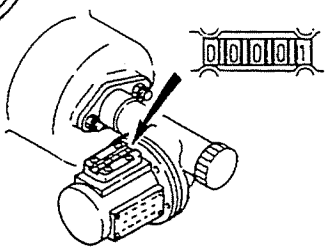
Tachometer



Service Hour Meter

Indicates the total number of hours the engine has operated. Use this meter to determine service intervals.

Service Hour Meter

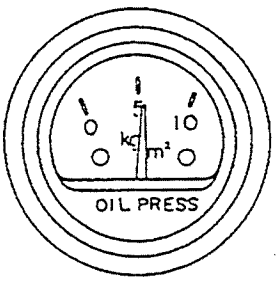


Notice: There are two types of service hour meters; the single unit type and the built-in type.

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 should be 0.39 to 0.64 MPa (4 to 6.5 kgf/cm^2) [57 to 92 psi] (when SAE 30 engine oil is used). The reading will be lower at low idle speed than at rated speed. If the reading is lower than 0.29 MPa (3 kgf/cm^2) [43 psi] at rated speed, or if it is lower than 0.10 MPa (1 kgf/cm^2) [14 psi] at low idle speed, immediately stop the engine. Check for the cause and make needed repairs before starting the engine again.

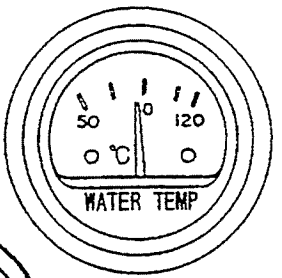
Oil Pressure Gauge



Coolant Temperature Gauge

Indicates the temperature of coolant. Normally, the reading will be 65℃ to 85℃ [149°F to 185°F] at an ambient temperature of 20℃ to 30℃ [68°F to 86°F].

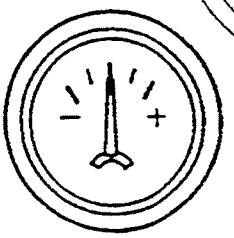
Coolant Temperature Gauge



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.

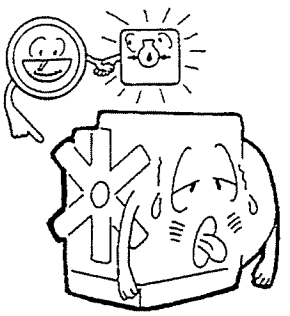
Ammeter



[PROTECTIVE DEVICES]

Low Oil Pressure Indicator Light

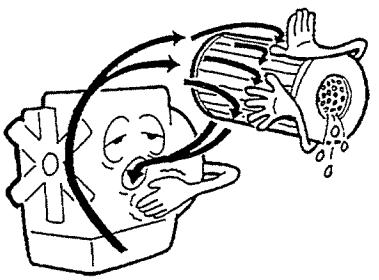
Comes ON when the oil pressure is lower than 0.29 $^{0}_{-0.03}$ MPa (3 $^{0}_{-0.3}$ kgf/cm²) [43 $^{0}_{-4.3}$ psi] at engie speed higher than 1500 rpm. It comes ON when the oil pressure is lower than 0.15 ± 0.02 MPa (1.5 ± 0.2 kgf/cm²) [21 ± 2.8 psi] in the entire speed range.



Oil Filter Indicator 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 this light comes ON, immediately replace the oil filter,

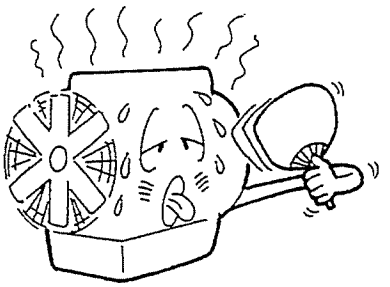
Notice:Change engine oil when replacing the oil filter.



High Coolant Temperature Indicator Light

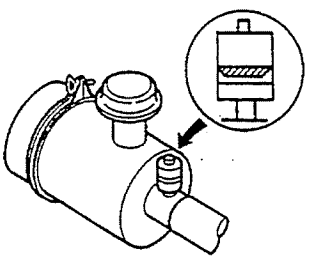
Comes ON when the coolant temperature (at radiator inlet) is higher than 95 ± 2℃ [203 ± 36°F]. If this indicator light comes ON, run the engine at low idle speed to let it cool gradually. Then, stop the engine and check the cooling system .

Notice:The coolant temperature at which the indicator light comes ON differs from one specification of the engine to another.



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 635 mmH_2O [25 in.H_2O]. Immediately clean the element if the indicator shows red. After installing cleaned element, reset the indicator by pressing the button at the top of the indicator.

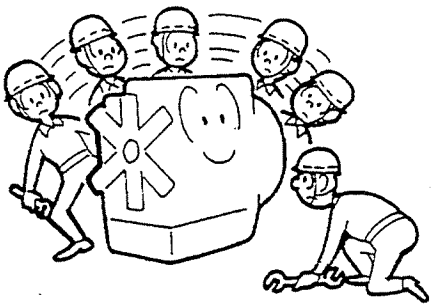


[NEW ENGINE INITIAL SERVICE]

Before starting a new or reconditioned engine or an engine which has been stored or left standing for any length of time for the first 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

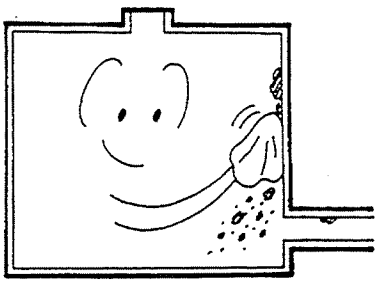
1. Check the electrical system for loose terminals or other defects.
2. Check the following components for loose bolts or nuts:
   - Plugs and covers of fuel system, lubrication system and cooling system
   - Coupling of fuel injection pump and shaft
   - Crankshaft pulley and damper
   - Mounting brackets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



Fuel System

Fill the fuel tank

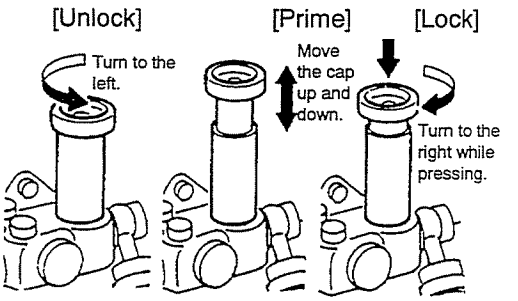
Before filling the fuel tank, put some amount of fuel in the tank, and disconnect the fuel pipe from the engine inlet and remove the drain plug from the tank to drain off the fuel. Check the drained fuel for dirt or water. After making sure the tank is clean, connect the fuel pipe and drain plug and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



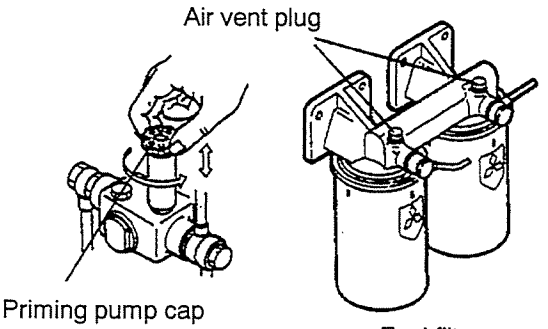
Priming pump

Prime the fuel filters and fuel return pipes in that sequence.

Fuel filter

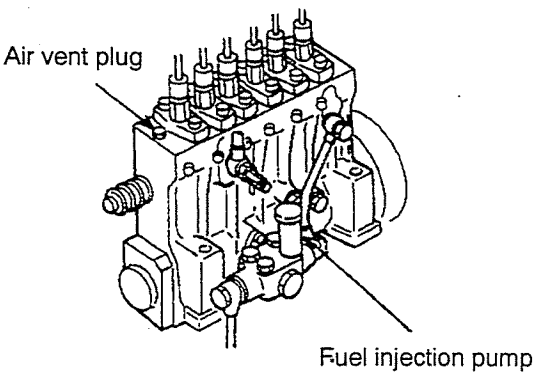
1. Loosen the air vent plug on the fuel filter about 1.5 turns.
2. Turn the priming pump cap to the left to unlock and move it up and down.
3. After fuel showing no visible bubbles come out from the air vent plug, tighten the air vent cap.

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.
3. After fuel showing no visible bubbles come out from the air vent plug, tighten the air vent cap. Just before the final tightening of the air vent plug while holding it down. Then, tighten the air vent plug.



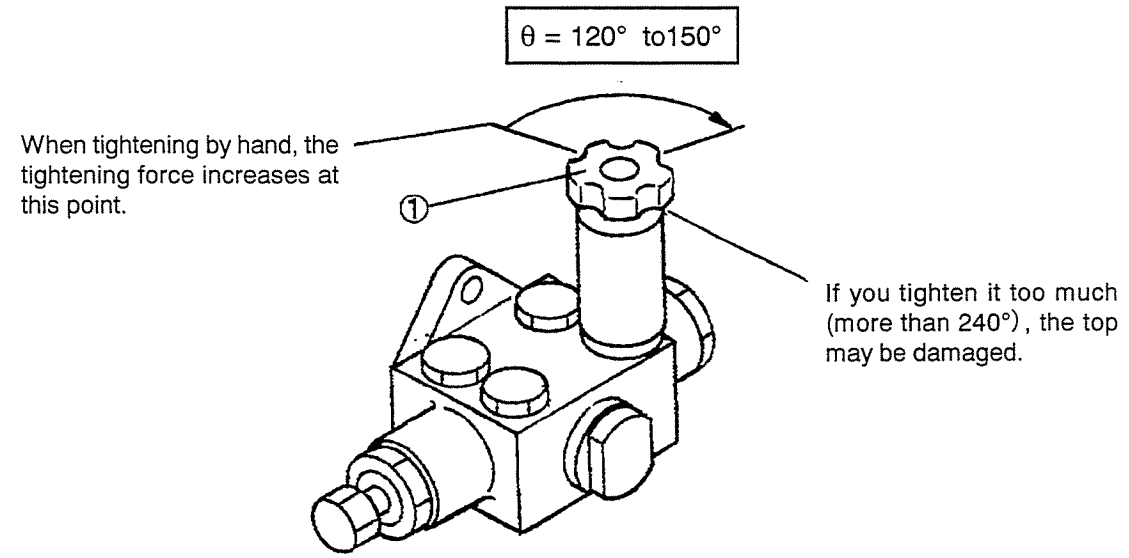
⚠ CAUTION

- **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.**
- **Be sure to wipe the fuel from the vent thoroughly with a cloth.**

• 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 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

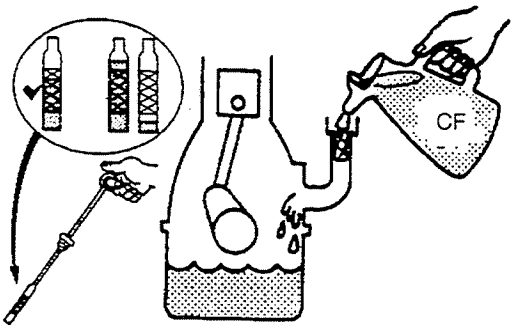
- **Looseness of the priming pump cap and engine vibration may cause wear to the inside screws, the priming pump cap to be shaken off and the fuel leakage.**
- **If you tighten it too much (θ = 240° or more), top of the priming pump may be damaged. Tighten it at the proper angle 120° to 150°.**

Lubrication System

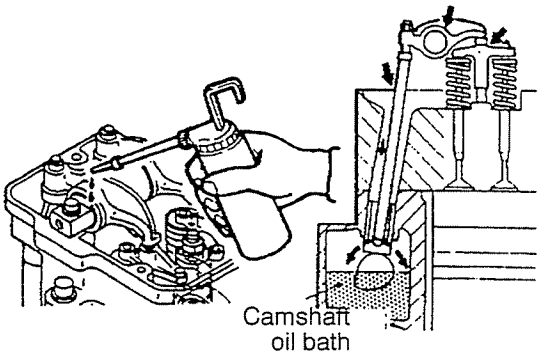
Fill the oil pan

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

Refill capacity (approximate)	Oil pan: 82 liters [22 U.S. gallons] Whole engine: 92 liters [24.3 U.S. gallons]
Recommended oil	Oils that meet Engine Service Classification CF



2. Remove the rocker cover. Lubricate the valve mechanism and fill the camshaft oil bath from the cylinder head.

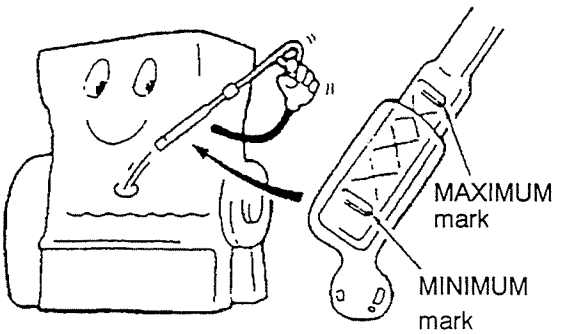


3. Check the oil level in the oil pan with a dip-stick. The oil level should be between the MAXIMUM and MINIMUM marks on the dipstick. Add oil if necessary.

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.

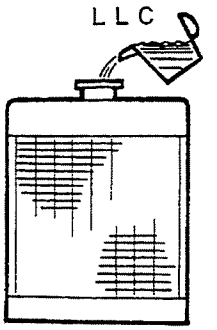
6. Start the engine and operate it for about 10 minutes. Stop the engine and add oil until the condition of item 2 is satisfied.



Cooling System

Fill the radiator

1. Close the engine and water pump drain cocks and tighten the radiator drain plug.
2. Remove the radiator filler cap and pour pure, undiluted LLC into the radiator.
   For concentration of LLC, see the chart below:

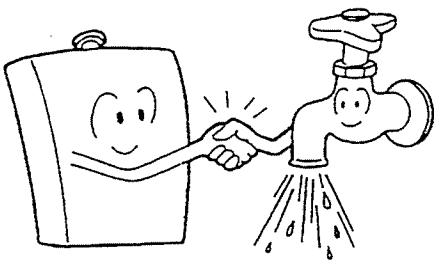


Recommended LLC Concentrations

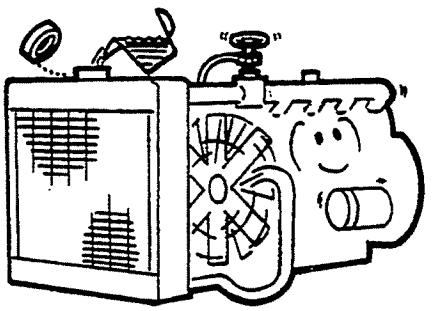
Ambient temperature ℃ [°F]	-10 [14]	-20 [-4]	-30 [-22]	-45 [-49]
LLC concentration, %	30	40	50	60

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

Notice: To bleed air effectively, loosen the air vent on the top of the thermostat.



4. When the radiator is full, install the filler cap. Crank the engine with the starter several times, for 10 seconds each time, at intervals of about 1 minute, to bleed air out of the water pump.

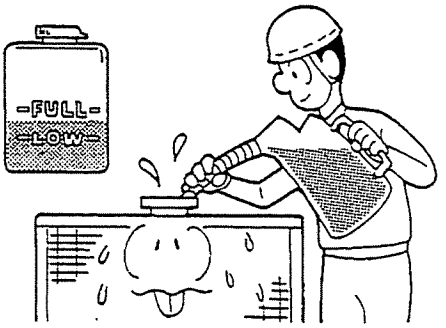


⚠ CAUTION

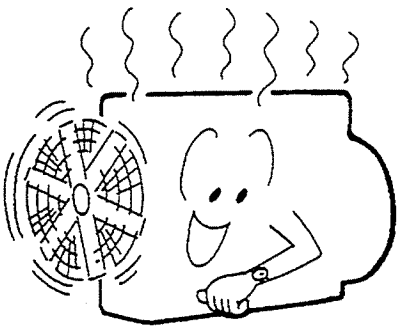
With the fuel supply shut off, crank the engine with the starter.

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. On cooling system with a reserve tank, also fill the reserve tank up to the FULL mark.



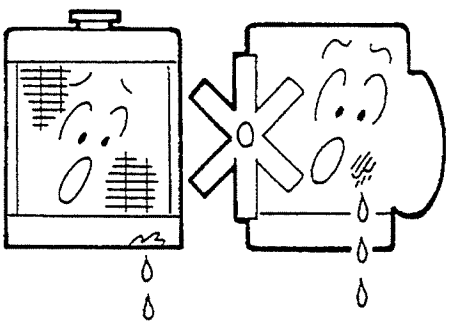
6. Start the engine and run it under light load until the thermostat valve opening temperature is reached to mix LLC with water in the system.



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

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

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



Electrical System

Batteries

⚠ WARNING

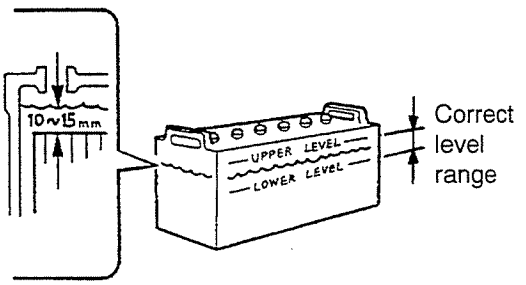
- **If electrolyte gets in your eyes, flush them immediately with large amounts of water and see a doctor at once.**
- **Never allow open flame near batteries. Do not short across battery terminals. Spark could ignite battery gas.**

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.

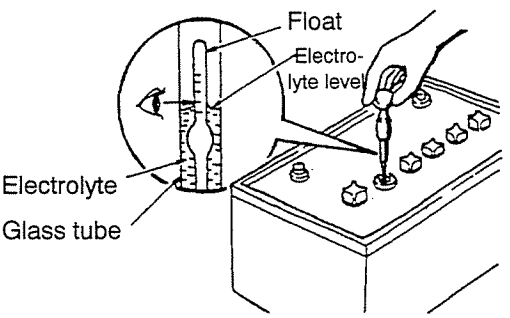
Notice: When adding the new electrolyte, add it gently.



Check the electrolyte specific gravity

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

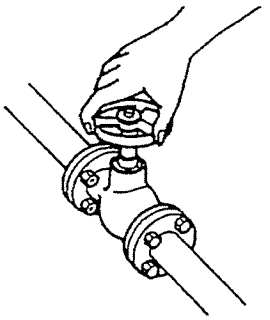
Specific gravity at 20℃ [68°F]	State of charge	Correction
1.26 - 1.28	Fully charged	——
1.22 - 1.26	3/4 charged	Recharge.
Below 1.22	Discharged	Recharge.



Valves and Plugs

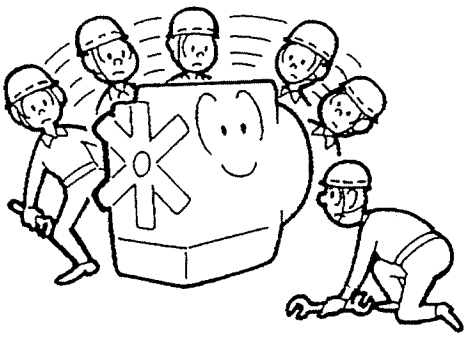
Make sure the following valves and plugs are open or closed properly:

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



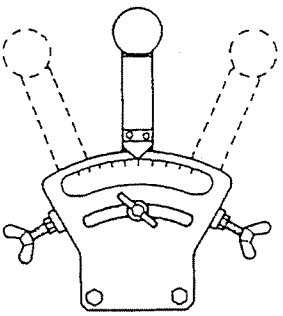
Electrical Wiring

Check for loose or damaged terminals or connectors.



Speed Control Lever

Check for looseness or interference in the linkage, and make sure its smooth movement.

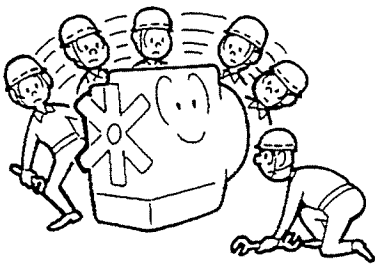


[PRE-START INSPECTION]

Walk-Around Inspection

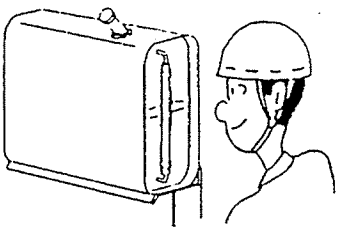
Look around and under the engine for:

- Loose bolts or nuts
- Fuel, oil, coolant, or air leaks
- Vibration, noise, or exhaust color
- The amount of mists from the breather
- Faulty electrical wiring or loose pipe connection



Check the Fuel Level

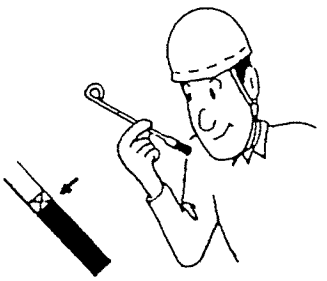
Make sure the fuel tank is full.



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.



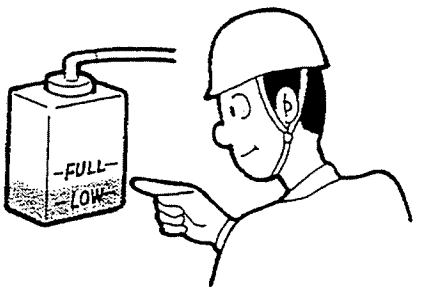
Check the Coolant Level

⚠ 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.

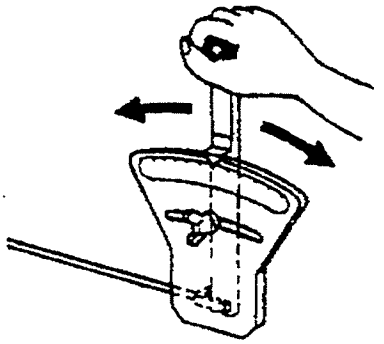
Remove the filler cap to check the coolant level. The coolant should be visible in the filler neck. If not, replenish coolant up to the FULL level.

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



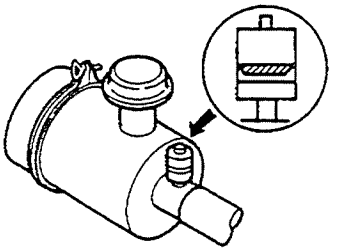
Check the Fuel Control Link

Check the link to make sure it moves smoothly.
Check for play and looseness in the ball joint.



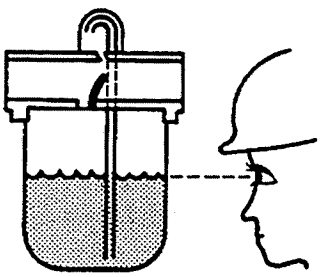
Check the Air Cleaner Dust Indicator (paper element type)

Service the element if the indicator shows red.



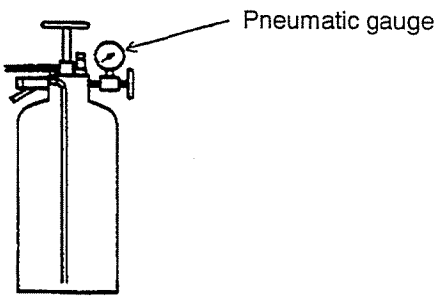
Check Oil Level in the Oiler (air-motor type)

Maintain the oil level to the FULL mark. Add turbine oil (ISO VS32) if necessary to maintain the correct level.



Check Air Pressure in the Air Tank (air motor type or direct air type)

Before starting the engine, look at the pressure gauge to make sure the air pressure is correct.
Air pressure: 2.94 MPa (30 kgf/cm^2) [427 psi]



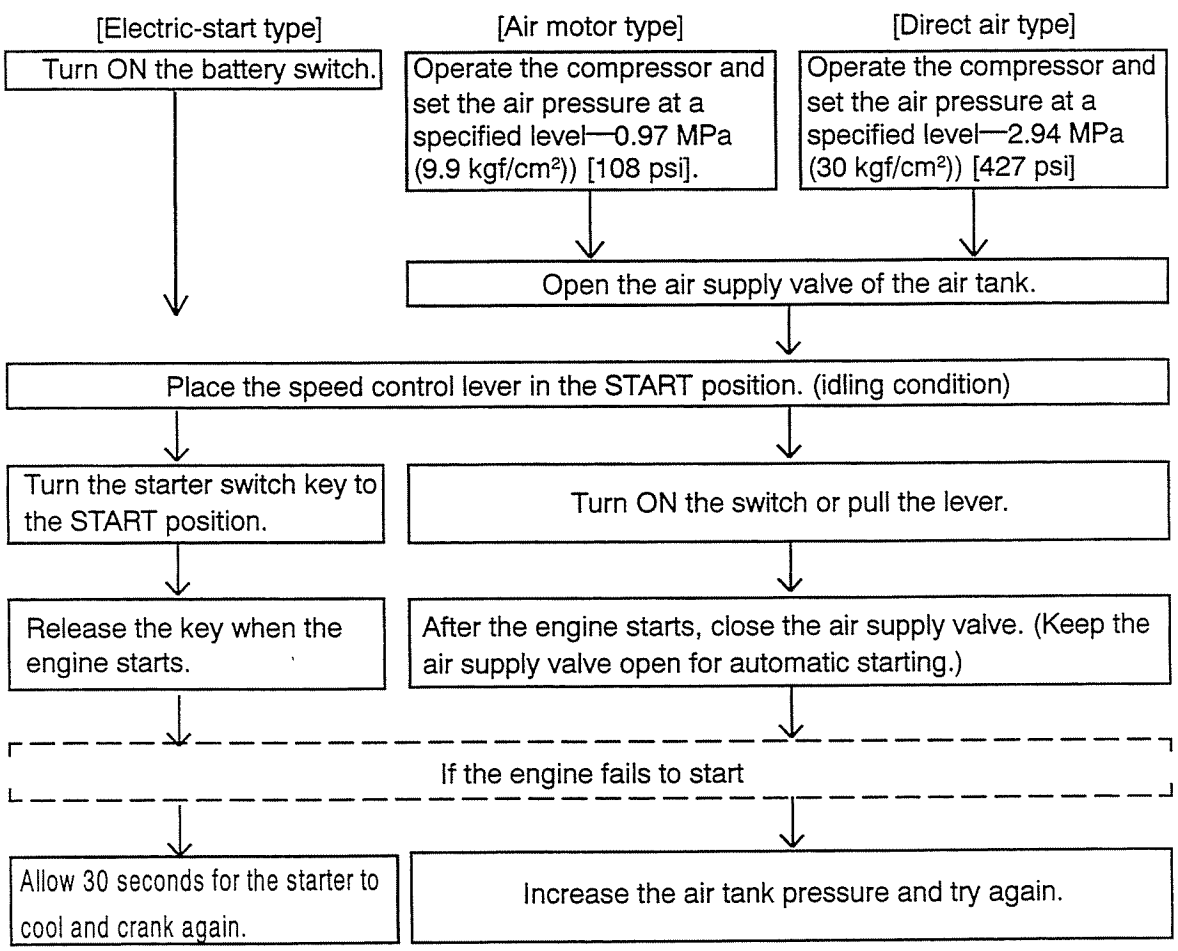
[STARTING]

⚠ 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 which 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.**
- **When you use air motor type or direct air type, drain the water from the air tank every 50 hours or once a week by opening the drain cock.**
- **Do not apply load to the engine (disengage the clutch if so equipped) when cranking the engine.**

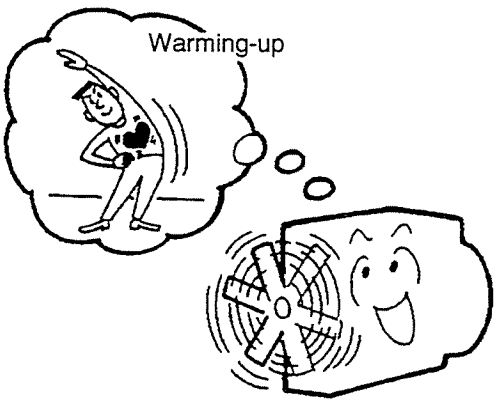


[WARMING-UP]

⚠ WARNING

- **Long periods of warming up is 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.
- When starting the engine at temperatures below 5°C [41°F], use an auxiliary device to keep coolant and oil temperatures above 5°C [41°F].
  When the engine has an air heater, energize the air heater for 30 seconds before starting the engine.
- When starting the engine at temperatures above 5°C [41°F], warm it up at low idle at least for 30 seconds.
- The oil pressure will be 0.20 to 0.29 MPa (2 to 3 kgf/cm^2) [28 to 43 psi] after warm-up run. If the engine speed is increased immediately after it has been started, the oil pressure would be higher than the normal level — 0.39 to 0.64 MPa (4 to 6.5 kgf/cm^2) [57 to 92 psi] but it will restore to the normal level as the oil temperature rises.
- But when using the direct-air type at temperatures below 10°C [51°F], keep coolant temperatures above 40°C [104°F] by using the water heater and start the engine. In the case of the standby engine, it is not necessary to warm it up, however, keep coolant temperatures above 40°C [104°F] by using the water heater and start the engine.



[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. All indicator lights are OFF.
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 is in normal condition.
   - Tachometer (engine speed meter)
   - Oil pressure gauge: 0.39 to 0.64 MPa {4 to 6.5 kgf/cm^2} [57 to 92 psi]
   - Coolant temperature gauge: 65 to 85°C [149 to 185°F]
   - Ammeter: (+) side
   - Oil temperature gauge: 70 to 110°C [158 to 230°F]
   - Oil filter alarm (Pilot lamp): Lights out

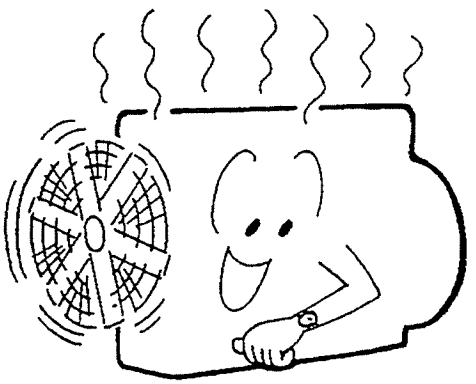
[STOPPING]

⚠ 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 idle for 3 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 more than 3 minutes for gradual cooling.

Engine with speed control lever	**Engine with stop lever**
Move the speed control lever to the STOP position.	Move the stop lever (connected to the governor) in the STOP direction.
↓	↓
Turn the starter switch key to the OFF position and remove it. Turn OFF the battery switch. (Electric-start engine)	



- For your own safety and maximum service life of the engine, perform recommended service according to the "Lubrication and Maintenance Chart."
- Under extremely severe, dusty or wet operating conditions, more frequent service than is specified in the "Lubrication and 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, Every 250 Service Hours and Every 50 Service Hours or Monthly.
- For items marked with asterisk (*), 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 provides prime power for generator sets, perform service at intervals specified in [Maintenance Chart for Generator Set Prime Power] .
- 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 run as follows:
  Once a week, run the engine under no-load condition 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 run, check for ease of starting, lube oil pressure, color of exhaust smoke, abnormal vibration and others.
- Where the engine is used for any other duty, perform service at intervals specified in [Maintenance Chart for General Duty Engine].

[MAINTENANCE CHART FOR GENERATOR SET PRIME POWER]

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 full-flow filter and bypass filter.	50
Every 250 service hours	Change oil. (Oil analysis is recommended.)	50
	Change full-flow filter and bypass filter. (The filters must also be changed when oil filter indicator light comes ON.)	50
	Change bypass oil filter.	50
	Change hydraulic governor oil filter.	51
(The first 250 service hours of new or reconditioned engine)	* Check valve clearance — adjust.	39
Every 1000 service hours	Change fuel filter (cartridge type)	43
	Check V-belts — adjust.	59
Every 2000 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 if necessary.)	49
	Change V-belts.	59
Every Top overhaul (Every 4000 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 thrust by turning by hand.	56
	Check starter and alternator.	58
	Check vibration damper.	41
	* Check protective devices. High coolant temperature, low oil pressure, overspeeding, starting failure, water supply failure, undervoltage, overvoltage, overcurrent, low coolant level in tank, low fuel level in tank, etc.	58

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

Interval	Service	Page
Every Major overhaul (Every 8000 to 12000 service hours)	* Major overhaul Disassembling engine — wash, 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, liners, main metal cap bolts and washers, piston rings, connecting rod metals, vibration damper and consumable items (gaskets, oil seals, O-rings, etc.) In 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. High coolant temperature, low oil pressure, overspeeding, starting failure, water supply failure, undervoltage, overvoltage, overcurrent. low coolant level in tank, low fuel level in tank, low air pressure in tank, etc.	-
Every 2 years	Change coolant.	54
When required	Check radiator fins — clean.	53
	Wash precleaner.	56
	Clean or change air cleaner element.	57
	Clean engine breather inside.	-
	Prime fuel system.	18
	* Check stop solenoid — change.	-
	* Check rubber mounts — change.	-
	* Check coupling — change.	-

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

[MAINTENANCE CHART FOR STANDBY-DUTY 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 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 oil level in air compressor — add oil.	-
		Drain water from air tank.	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).	-

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

Interval	Service		Page
Every 1 year	Cooling system	Check water pump.	-
		* Check solenoid valve and pressure reducing valve — disassemble and clean.	-
		Check strainer (including ball tap) — disassemble and clean.	-
		* Analyze coolant — change.	-
	Air inlet system	Check air cleaner indicator.	26
		Check air cleaner element — clean.	57
		Check precleaner — wash.	56
	Electrical system	Check starter.	58
		Check alternator.	58
		Check air heater.	-
		Check battery electrolyte specific gravity.	23
	Air-start system	* Check starter valve.	-
		* Check distributor valve.	-
		Check air filter — drain water.	60
		* Check solenoid valve — clean.	-
		Check air compressor drive belt.	-
		* Check air tank safety valve operation.	60
	* Check protective devices. High coolant temperature, low oil pressure, overspeeding, starting failure, water supply failure, undervoltage, overvoltage, overcurrent, low coolant level in tank, low fuel level in tank, low air pressure in tank, etc.		58
	* Check auxiliary equipment. Engine control, fuel transfer pump, governor motor, room ventilating fan, solenoid, storage pump, water tank ball tap, water heater, oil heater, oil priming pump, etc.		-
Every 2 years	Change oil. (Oil analysis is recommended.)		50
	Change full-flow filter and bypass filter. (The filters must also be changed when oil filter indicator light comes ON.)		50
	Change bypass oil filter.		50
	Clean fuel filter (wire element type).		-
	Change fuel filter (cartridge type).		43
	Change fuel control link ball joints.		49
	* Check thermostat.		-
	Change coolant.		54
	Check turbocharger shaft thrust by turning by hand.		56
	Check muffler — drain water.		56
	* Overhaul air compressor.		-

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

Interval	Service	Page
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 air cleaner element.	57
	Change precleaner.	-
	* Check instruments — change. Oil pressure gauge, coolant temperature gauge, oil temperature gauge and tachometer.	-
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
	* 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 room ventilating fan — change.	-
	* Check stop solenoid — change.	-
	* Check 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	Page
Every 50 service hours or monthly	Drain water and sediment from fuel tank.	43
	Drain water from air filter.	60
	Drain water from air tank.	60
(The first 50 service hours of new or reconditioned engine)	Check for loose bolts and nuts.	-
	Change oil.	50
	Change full-flow filter and bypass filter.	50
Every 250 service hours or 1 year	Change oil. (Oil analysis is recommended.)	50
	Change full-flow filter and bypass filter. (The filters must also be changed when oil filter indicator light comes ON.)	50
	Change bypass filter	50
	Change hydraulic governor oil filter.	51
	Check V-belt — adjust.	59
	Check radiator fins — clean.	53
	Drain water form muffler.	56
	Check air tank safety valve.	60
(The first 250 service hours of new or reconditioned engine)	* Check valve clearance — adjust.	39
Every 1000 service hours or 2 years	Wash air filter.	60
	Change zinc rods.	53
Every 2,000 service hours or 3 years	Change fuel filter (cartridge type).	43
	* Check valve clearance — adjust. (Check valve mechanism.)	39
	Retighten bolts and nuts. (Refer to the SERVICE MANUAL for tightening torques.)	42
	* Change fuel injection nozzle tips. (Check discharge pattern and injection pressure after replacement — adjust.)	44
	* Check fuel injection timing — adjust.	47
	* Check protective devices (high coolant temperature, low oil pressure, overspeeding, etc.)	58
Every 4,000 service hours or 5 years	* Change fuel control link ball joints.	49
	* Clean air cooler.	56
	Check vibration damper.	41
	* Wash heat exchanger.	53
Every Major overhaul (Every 8,000 to 12,000 service hours)	* Major overhaul Refer to [Maintenance Chart for Generator Set Prime Power].	-
Every 2 years	Change coolant.	54
When required	Prime fuel system.	18
	Clean air cleaner element.	57
	Wash precleaner — change.	56

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

⚠ 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 regulation. For disposal, consult your Mitsubishi dealer.

Dress proper 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.

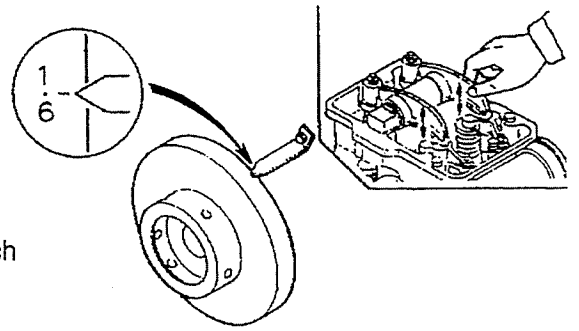
Perform all recommended inspection!
Perform pre-start inspection and periodic inspection on items listed in this manual. Failure to follow this recommendation can cause engine damage, or injury or death.

Service air cleaner properly!
Dust and dirt entering engine will cause early wear of running parts with a resultant loss of power, high oil consumption, hard starting and other failures. Service air cleaner properly.
1. Do not service air cleaner while engine is running.
2. When removing air cleaner element for servicing, prevent dust from entering air passage to cylinders.
3. In case of air cleaner equipped with a dust indicator, service element only when the indicator shows red. Frequent servicing can cause element damage.

[BASIC BLOCK]

Valve Clearance

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



Confirm top dead center on compression stroke

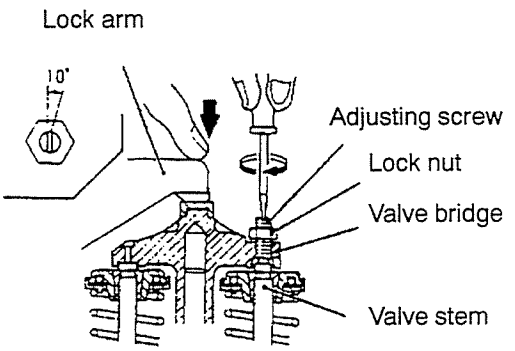
1. Turn the engine in normal direction to align the timing mark [1.6] on the damper with the pointer as shown.
2. Remove the rocker cover of a cylinder on which the valve clearance is to be checked and adjusted, and make sure the inlet and exhaust valves have some clearance.

(Example) If the timing mark [1.6] is aligned with the pointer, either No. 1 or No. 6 piston is at top dead center on compression stroke.

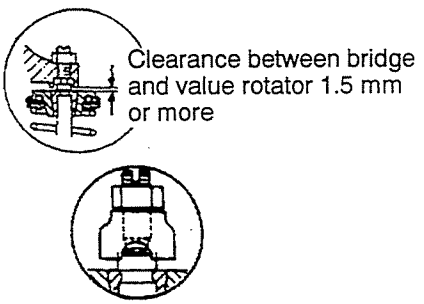
Adjust the height of valves

⚠ 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 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 change in valve clearance.



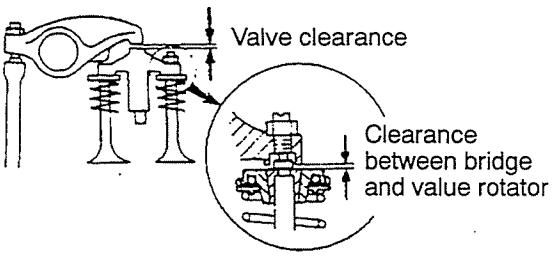
1. Loosen the lock nut of the valve bridge adjusting screw and back the screw off.
2. Hold the rocker arm by finger in such a manner as to push down on the bridge and turn in the adjusting screw slowly.
3. While observing the adjusting screw through inspection hole, turn in the screw until it touches the valve stem. From that position, turn in the screw approximately, 10°more and tighten the lock nut.

[BASIC BLOCK] - continued

Inspect

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

Valve clearance	Inlet valve	0.6 mm [0.024 in.]
	Exhaust valve	0.8 mm [0.031 in.]



- The valve clearance is subject to change depending on the specifications. Please refer to the caution plate.

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.

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

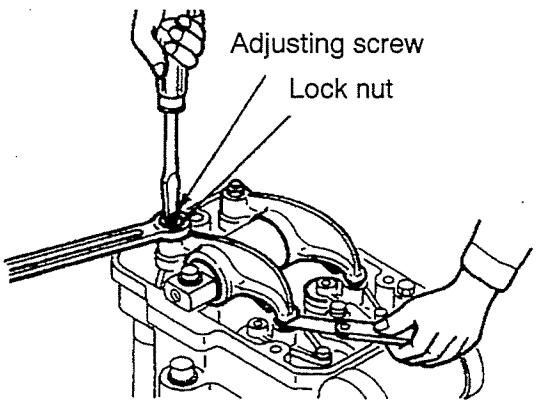
Adjust

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 the injection order, turning the engine with each cylinder piston at the top dead center on the compression stroke.

	Cylinder No.
Firing order (injection sequence)	1-5-3-6-2-4



(Example): After checking and adjusting the cylinder No.1, turn the engine 120° and check and adjust the cylinder No.5.

Ignition timing

Cylinder No.	1	5	3	6	2	4
Timing (°)	0	120	240	360	480	600

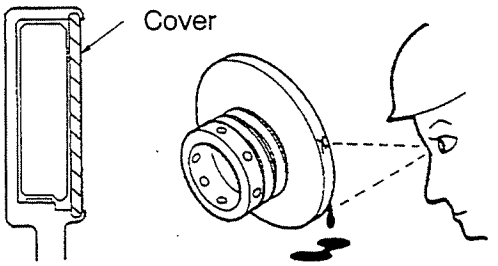
[BASIC BLOCK] - continued

Vibration Damper

Inspect

⚠ CAUTION

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



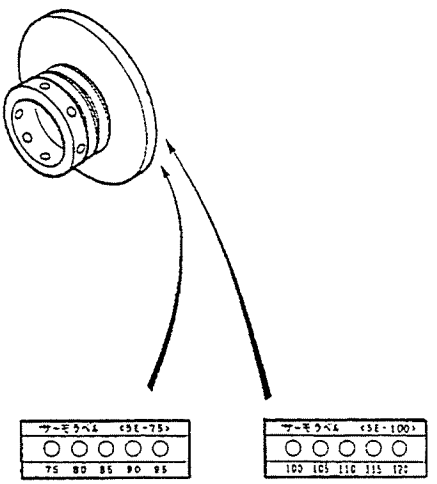
Visually check for fluid leaks, flaws, distortion, or discoloration or flaking of painted surfaces. Also check for swelling (by measuring with a scale), fluid leaks past staked portions.

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 generator set prime power 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 generator set prime power. Use of Thermo Labels is recommended to check the damper temperature on a generator set prime power. For Thermo Labels, consult your Mitsubishi dealer.

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 to the damper, select a cover which does not cause damper temperature to rise abnormally.

[BASIC BLOCK] - continued

Bolts and Nuts

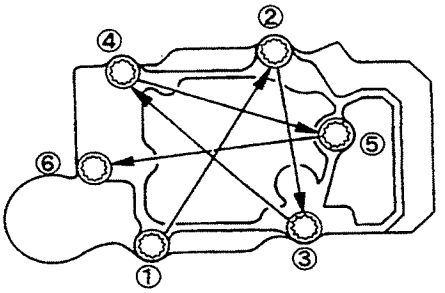
Retighten

Retighten the bolts and nuts on the following components:

- Timing gear case
- Crankshaft pulley
- Mounting brackets
- Exhaust manifolds
- Turbocharger
- Cylinder head

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

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

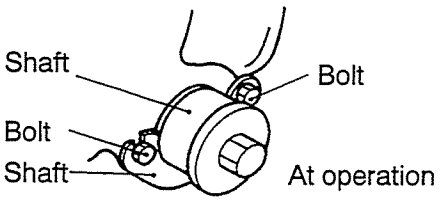


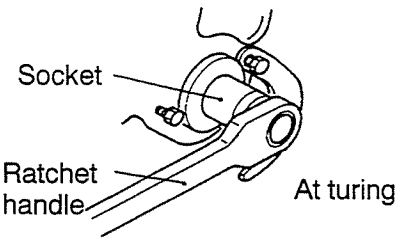
How to Use Turning Gear

1. Loosen the two bolts securing the shaft lock plate and remove the plate from the shaft (groove). Then, push in the shaft all the way to the TURN position.
2. Put a socket to the hexagonal end of the shaft and turn the shaft with a ratchet handle for turning.
3. After turning the engine, pull the shaft back to the RUN position, secure the plate with the shaft and tighten the plate bolts. Make sure the plate is secured properly.

⚠ CAUTION

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





[FUEL SYSTEM]

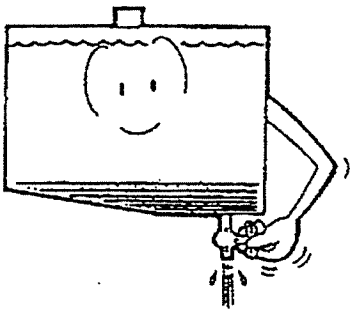
Fuel Tank

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.**

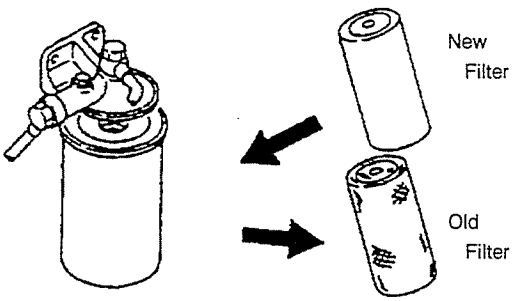
Open the fuel tank drain valve and allow water and sediment to drain in a container. Drain at least 1 to 2 liters [0.3 to 0.5 U.S. gallons] of fuel to remove water and sediment.

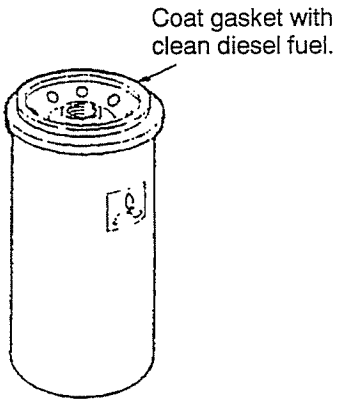


Fuel Filter (Cartridge Type)

Change

1. Clean the area to keep the dirt out of the filter base.
2. Allow the fuel to drain in a container.
3. Using a filter wrench, remove the used filter.
4. Clean the gasket of a new filter.
5. Coat the gasket of a new filter with clean diesel fuel.
6. Clean the filter base. Install the new filter by hand. When the gasket contacts the base, tighten 3/4 to 1 turn more by hand. Do not use the filter wrench in order to avoid damaging the cartridge.
7. Prime the fuel filter.
8. Start the engine and run it at low idle for several minutes. Check the filter base for leaks. If leakage is found, loosen the filter and check the gasket for scratches and re-tighten it as described in item 6 above.





[FUEL SYSTEM] - continued

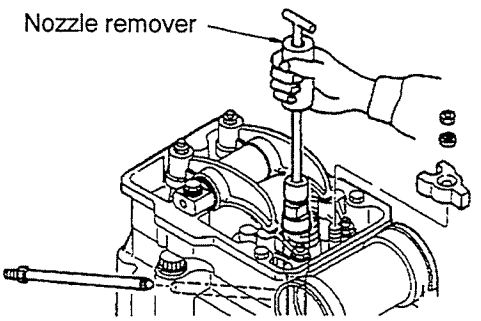
Fuel Injection Nozzle Tip Change

⚠ CAUTION

To keep dirt out, install a rubber cap on 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 from the fuel injection nozzle.
4. Remove the nozzle inlet connector.
5. Remove the nozzle gland nut to take off the nozzle gland.
6. Pull out the fuel injection nozzle using a nozzle remover (33591-10101).



Remove the nozzle tip

⚠ CAUTION

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

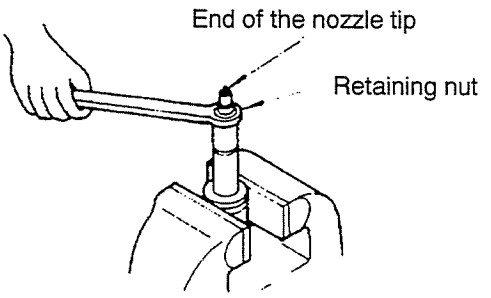
1. Secure the fuel injection nozzle using a vice.
2. Remove the cap nut and loosen the adjusting screw using a driver.

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 186 ± 10 N·m (19 ± 1 kgf·m) [137 ± 7.2 lbf·ft]. (Apply oil to the nut.)



Notice: Do not use Mori Coat.

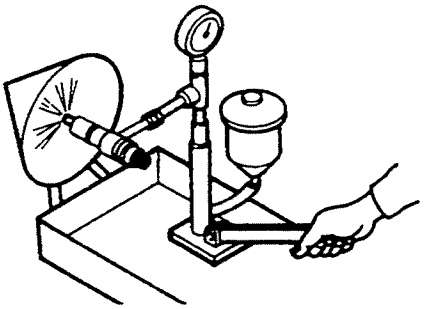
3. Adjust the fuel injection start pressure and check spray conditions.

[FUEL SYSTEM] - continued

Check the fuel injection start pressure.

⚠ WARNING

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



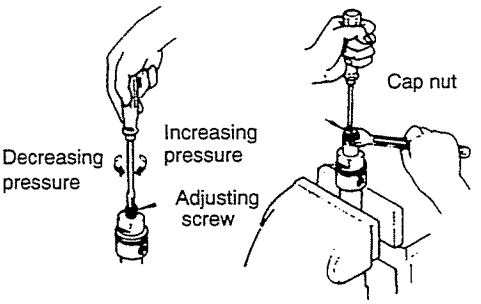
1. Attach the fuel injection nozzle to the nozzle tester.
2. While watching the pressure gauge of the nozzle tester, push the handle down slowly.

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

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

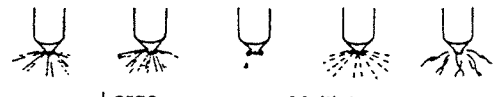
Fuel injection start pressure standard value
34.32 MPa {350 kgf/cm²} [4,979 psi]

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



Adjust an fuel injection pressure

1. Turn the adjusting screw to the standard value. Tightening the screw increases the pressure, and loosening it decreases the pressure.
2. When the pressure meets the standard value, secure the cap nut by applying a specified torque 74±5 N·m {7.5 ± 0.5 kgf·m} [54.2 ± 3.6 lbf·ft]. Then, secure the set screw by a specified torque 39±5 N·m {4 ± 0.5 kgf·m} [28.9 ± 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 conical shape.
- No big particles but fine ones.
- No oil drip is left after injection.

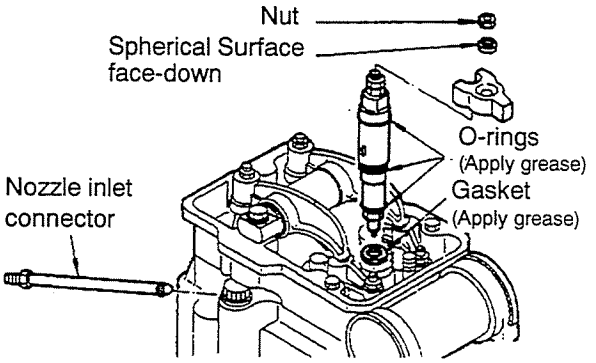
If the nozzle fails to spray fuel properly, replace with a new one.

[FUEL SYSTEM] - continued

Installing a fuel injection nozzle

Installing the fuel injection nozzle

1. Remove the nozzle inlet connector from the fuel injection nozzle.
2. Attach three O-rings to the nozzle and grease them.
3. Apply a small amount of grease to a gasket and attach the nozzle.
4. Insert the nozzle into the cylinder head while looking at the center of the nozzle inlet connector securing hole.
5. Attach the nozzle inlet connector to the nozzle by applying the specified torque (69 ± 5 N·m {7 ± 0.5 kgf·m} [50.6 ± 3.6 lbf]).
6. Attach the nozzle gland and tighten the nut at the specified torque 98 ± 5N·m {10 ± 0.5 kgf·m} [72 ± 3.6 lbf·ft]).
7. Attach the fuel injection pipe and fuel leak-off pipe.
8. When the rock cover is taken off, operate the engine at approx. 600 rpm and check for any fuel leakage from each joint. Install the rocker cover after confirming no fuel leakage.



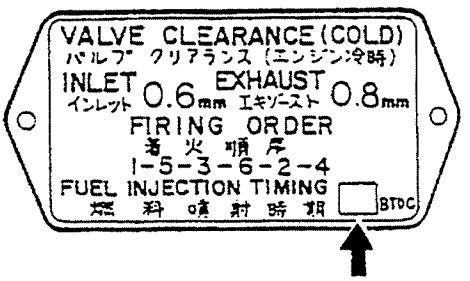
[FUEL SYSTEM] - continued

Injection Timing

Inspect

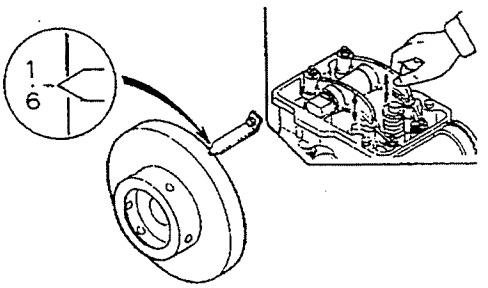
1. The injection timing is indicated on the caution plate attached to the No. 1 rocker cover. Check it before inspection.

Caution plate



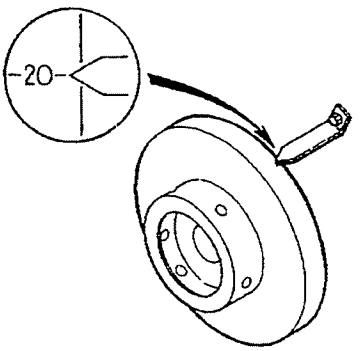
2. Bring the piston for No. 1 cylinder to top dead center on compression stroke as follows:

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

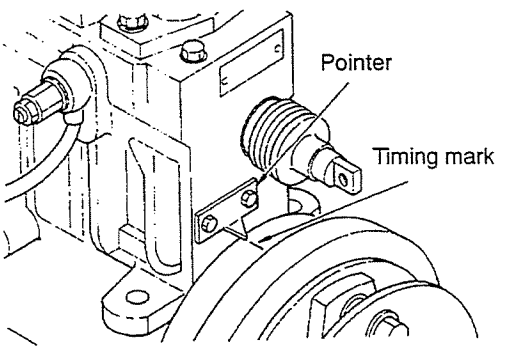


(2) Remove the No. 1 rocker cover and make sure the inlet and exhaust valves for No. 1 cylinder have some clearance. If these valves have no clearance, turn the engine once again to align the timing mark.

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

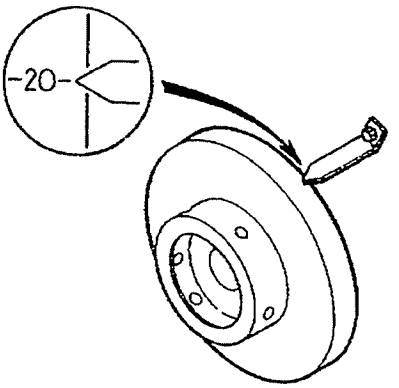


3. Turn back the engine approximately 60° once, and turn it in normal direction slowly until the timing mark (indicated on the caution plate) aligns with the pointer. To ensure proper injection timing, make sure that the timing mark on the coupling flywheel is even with the pointer on the fuel injection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



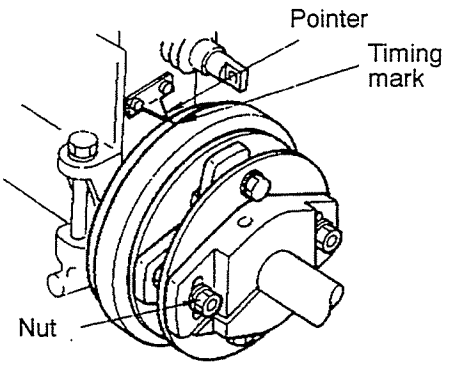
[FUEL SYSTEM] - continued

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 fuel injection pump coupling.
3. Turn the coupling flywheel until the timing mark on the coupling flywheel aligns with the pointer on the fuel injection pump.
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.



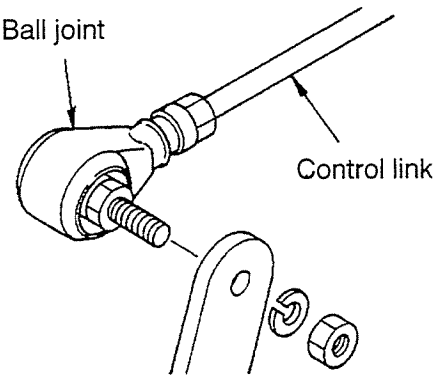
[FUEL SYSTEM] - continued

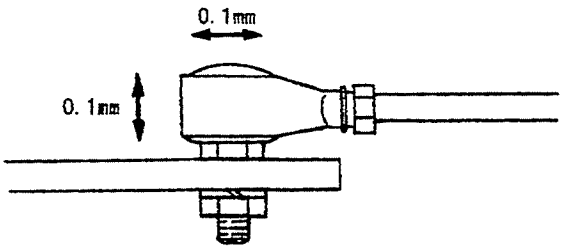
Fuel Control Link Ball Joints

Inspect

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 which is an integral part of the link, change the link as an assembly.



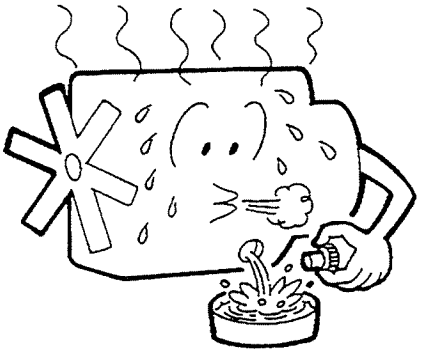


[LUBRICATION SYSTEM]

Engine Oil Change

⚠ CAUTION

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



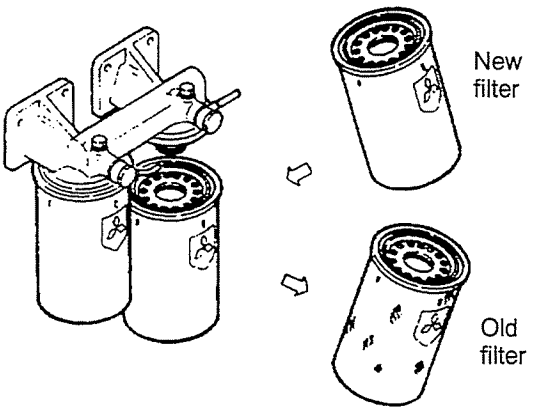
Remove the oil pan drain plug and allow oil to drain in a container immediately after the engine has been stopped (while the oil is hot).

Notice: Do not try to pump up the oil whenever possible.

Full-Flow Filter and Bypass Oil Filter Change

1. Clean the area to keep dirt out of the filter base.
2. Allow the oil to drain in a container.
3. Using a filter wrench, remove the used filter cartridge.

Notice: Check the used filter cartridge for debris. Cut the cartridge open and check for metal debris. Metal debris can indicate a possible failure. Consult your Mitsubishi dealer. Also change the filter cartridge when the indicator light comes ON.



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

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

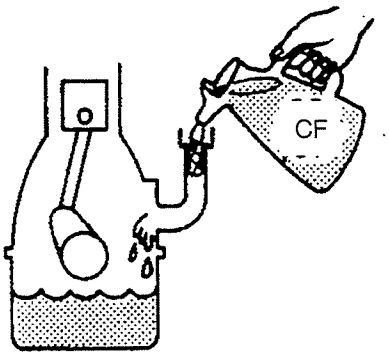
[LUBRICATION SYSTEM] - continued

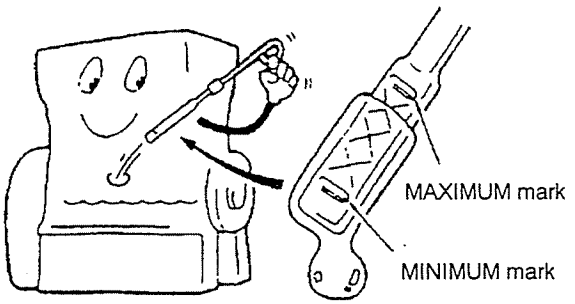
Fill the oil pan

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

Refill capacity (approximate)	Oil pan: 82 liters [22 U.S. gallons] Whole engine: 92 liters [24.3 U.S. gallons]
Recommended oil	Oils that meet Engine Service Classification CF

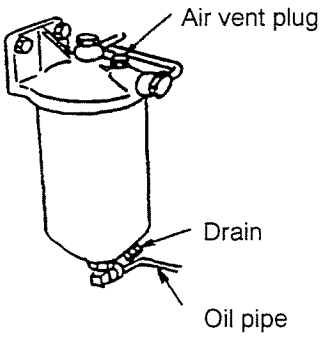
3. Start the engine and run it at low idle for several minutes. Check around the filter cartridges for oil leaks. If oil leakage is found, retighten the cartridges.
4. Stop the engine and wait for about 10 minutes. Then, check the oil level in the oil pan with a dipstick. The oil level should be between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

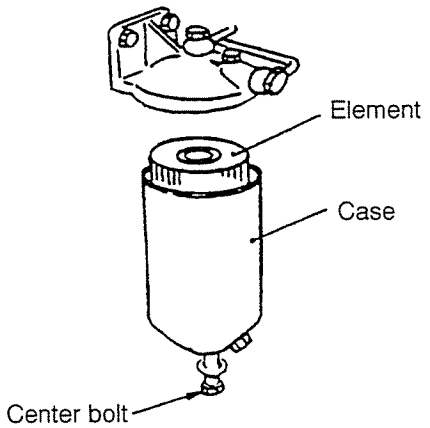




Hydraulic Governor Oil Filter Change

1. Place a container under the governor oil filter.
2. Loosen the air vent plug and remove the case from the bracket. Remove the used element from the case.
3. Remove the oil pipe from the center bolt.
4. Remove the center bolt and remove the case from the bracket. Remove the used element from the case.
5. Put a new element in the case.
6. Install the case to the bracket. Tighten the center bolt.
7. Install the oil pipe to the center bolt.
8. Install the drain plug.
9. Remove the air vent plug and fill up the filter with engine oil. Install the air vent plug.

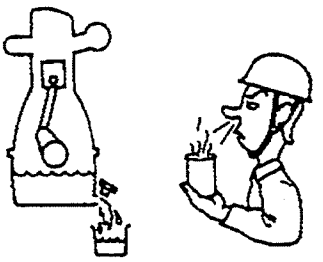




[LUBRICATION SYSTEM] - continued

Check the Oil

Drain 1 to 2 liters [0.3 to 0.5 U.S. gallons] of oil in a container, and smell or visually check for fuel or water in the oil. Fuel smells as such if present. Water leakage is often evidenced by emulsified oil.

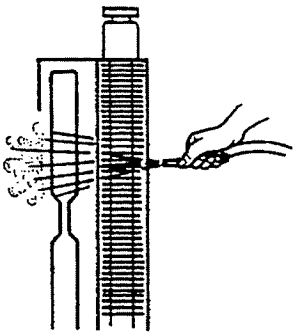


[COOLING SYSTEM] - continued

Radiator

Check/clean the fins

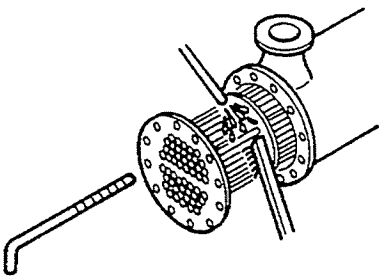
Check the fins for cracks or other defects.
To clean the fins, direct pressure air along the length of fins in the direction opposite to the air flow.



Heat Exchanger

Wash

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

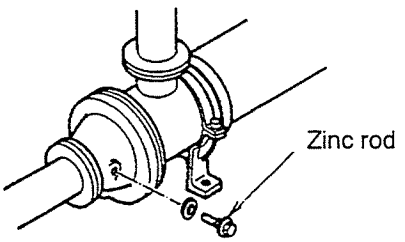


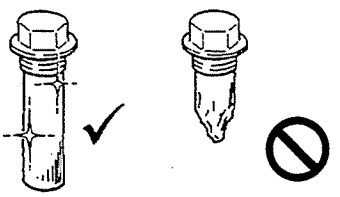
Zinc Rods

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 scale.
2. Change the rods if they have been worn out by more than half.



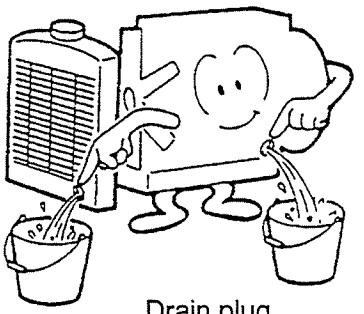


[COOLING SYSTEM] - continued

Coolant

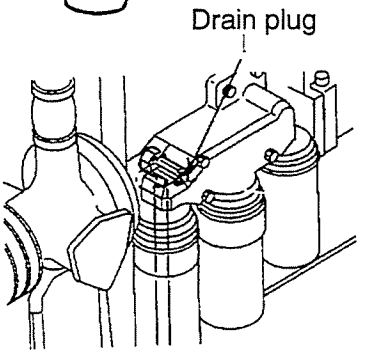
Change

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



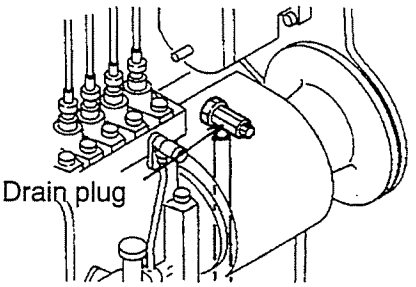
Drain the coolant

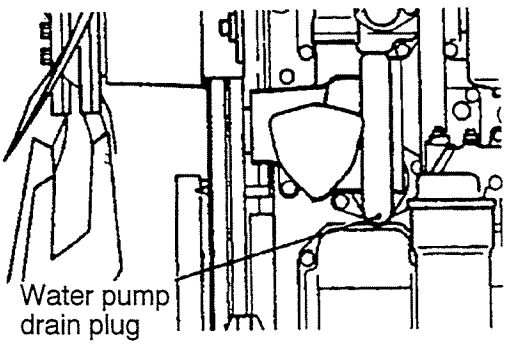
1. Start the engine and operate it until the coolant temperature is 70℃ to 80℃[158°F to 176°F]. Stop the engine.
2. Remove the radiator filler cap only after the engine has been stopped and the cap is cool enough to remove with your bare hand.
3. Loosen the engine and water pump drain plugs and remove 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.



Flush the cooling system

1. Tighten the engine and water pump drain plugs and install the radiator drain plug.
2. Fill the cooling system with cleaning solution which does not chemically attack rubber and metal surfaces. Start the engine and operate it at 800 to 900 rpm for about 15 minutes. Stop the engine. Loosen and remove the drain plugs to allow the solution to drain.
3. Tighten and install the drain plugs.
4. Fill the system with clean water and operate the engine at 800 to 900 rpm for about 10 minutes. Continue to flush the system until the draining water is clear.

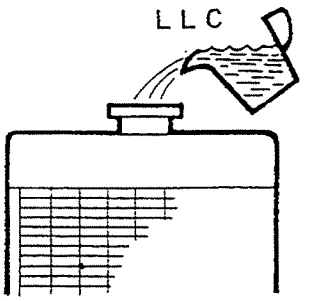




[COOLING SYSTEM] - continued

Fill the radiator

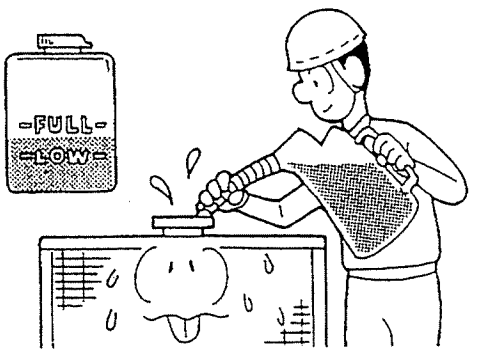
1. Tighten the engine and water pump drain plugs and install the radiator drain plug.
2. Remove the air vent plug at the top of the thermostat. This will help prevent air pockets in the system.
3. Remove the radiator filler cap and pour pure, undiluted LLC into the radiator. For concentration of LLC, see the chart below:



Recommended LLC Concentrations
(Reference)

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

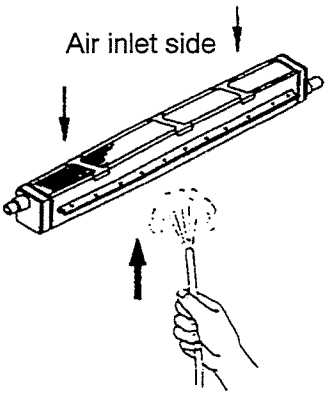
4. Add water (which is soft, or as free as possible from scale forming minerals) to the radiator slowly to help avoid air pockets in the system.
5. When the radiator is full, install the filler cap.
6. Crank the engine with the starter several times, for 10 seconds each time, at intervals of one minute, 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 radiator and add coolant if necessary. On cooling system with a reserve tank, also fill the reserve tank up to the FULL mark.



[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.

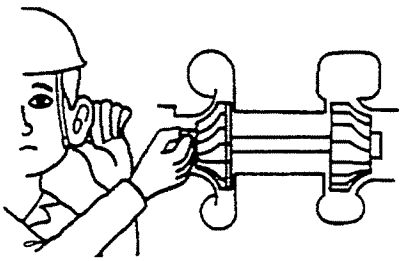


Turbocharger

Inspect

⚠ CAUTION

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



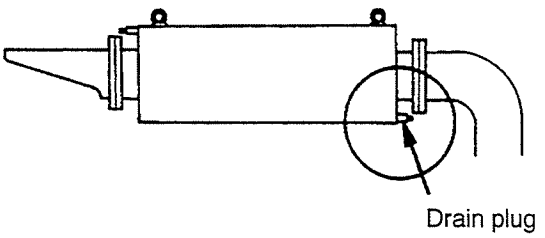
Take a hold of the compressor wheel nut and turn the wheel to feel for rattle and listen for abnormal noise. Replace the bearings if the wheel is noisy or rattles.

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

Exhaust Muffler

Drain water

Remove the drain plug and allow water to drain.



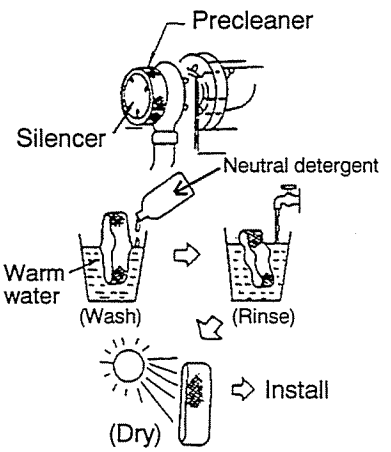
Precleaner

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

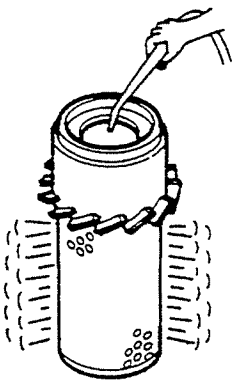
Air Cleaner

Clean element

⚠ CAUTION

- **When using pressure air for cleaning, wear a protective face shield, protective clothing and protective shoes.**
- **Never service the air cleaner when the engine is running.**
- **Do not clean the element by bumping or tapping.**

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

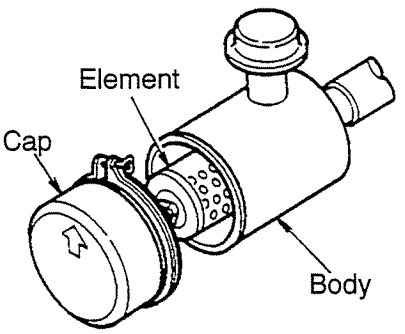


Change Element

⚠ CAUTION

Never service the air cleaner when the engine is running.

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]

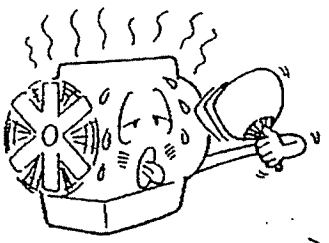
Inspecting Protective Devices

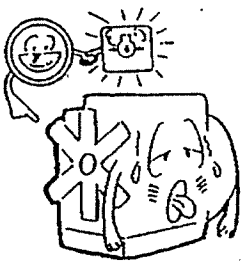
Inspect

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

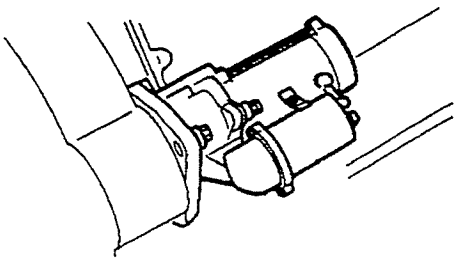




Starter

Inspect

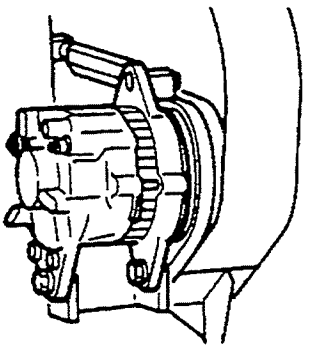
1. Visually check for loose bolts, dirt build-up, broken or worn parts, etc. Blow dirt, if any.
2. Check the pinion for shifting and meshing action. If the starter has a defect, consult your Mitsubishi dealer.



Alternator

Inspect

1. Visually check for loose bolts, dirt build-up, broken or worn parts, etc. Blow dirt, if any.
2. Remove the 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]

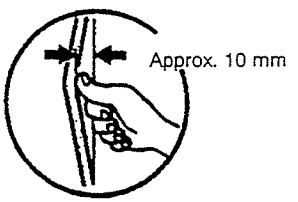
V-Belts

Measure the deflection

⚠ CAUTION

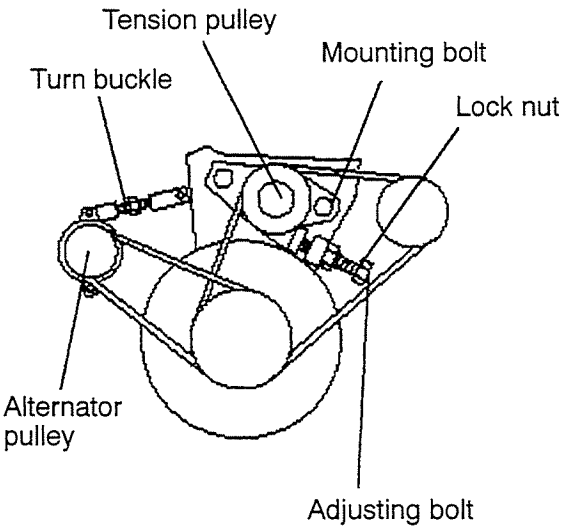
- **Change the belts if cracked, frayed or cut.**
- **Always keep the belts clear of oil or grease. Oil or grease can cause the belts to slip, which might shorten belt life.**
- **If the belts are too tight, unnecessary stresses are placed on the alternator bearings and belts, which might shorten the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



Adjust the alternator drive belt

1. Remove the belt cover of the alternator.
2. Loosen the alternator mounting bolts.
3. Turn the adjusting rod to move the alternator to obtain the required belt deflection.
4. Tighten the alternator mounting bolts.



[AIR START SYSTEM]

Air Filter

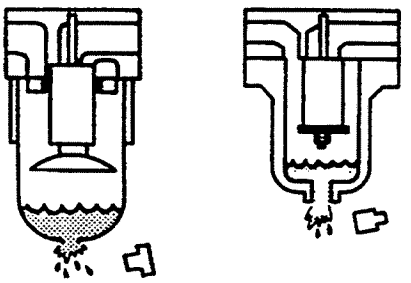
⚠ CAUTION

When opening the starting valve of the air tank, move the valve handle slowly. Suddenly and unexpected engine starting will occur if the handle is moved quickly. This can cause serious personal injury.

Drain water

1. Close the starting valve.
2. Remove the drain plug at the bottom of the air filter and allow water to drain.

(Air motor type) (Direct air type)

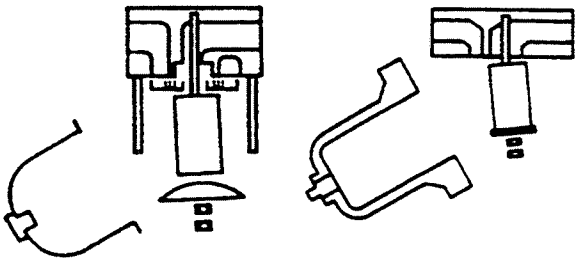


Wash

If the air filter is clogged, hard starting will occur. Wash the filter periodically.

1. Close the starting valve.
2. Remove the cover form the filter. Remove the element form the filter.
3. Wash the element in approved commercial solvent and air dry.
4. Install the element and cover.
5. Open the starting valve by moving the handle slowly.

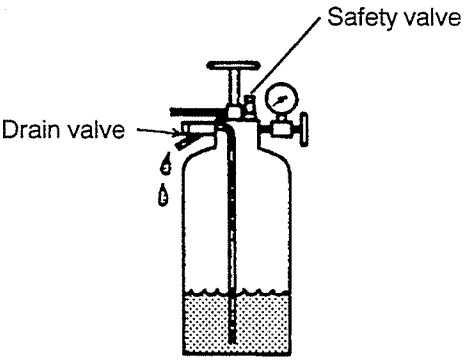
(Air motor type) (Direct air type)



Air Tank

Drain water

1. Close the starting valve.
2. Open the drain valve and allow water to drain.



Inspect safety valve

Check to make sure the safety valve opens to relieve pressure when the air pressure in the tank rises abnormally.

Safety valve opening pressure

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

Direct air type: 3.14 MPa (32 kgf/cm^2) [455 psi]

Recommended Type of Fuel

⚠ CAUTION

Use only fuel of recommended quality from an honest supplier. Overfilling can cause a fire.

The quality of fuel oil is a very important factor in obtaining satisfactory engine performance, long engine life, and acceptable exhaust emission levels.
This engine is designed to burn fuels marketed to meet the Limiting Requirements for Diesel Fuel Oils shown below. (for internal combustion engine)

NOTICE: Some furnace oils marketed would not be suitable for Mitsubishi engines. In selecting a fuel, consult the "Limiting Requirements for Diesel Fuel Oils"
For long term operation of the engine, the new limit is recommended.

The pour point of the fuel should be at least 6℃[43°F] below the lowest atmospheric temperature at which the engine must start and operate.

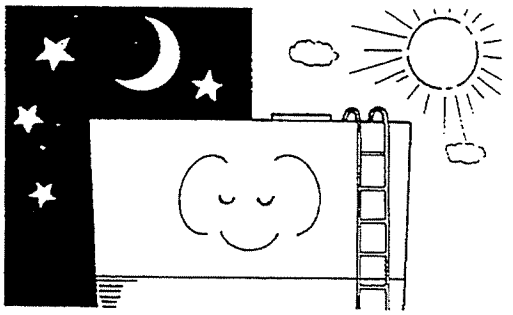
Limiting Requirements for Diesel Fuel Oils

Property		Limit (new)	Limit (conventional)	Remarks
Flash point, min.		Legal	Legal	JIS K 2204, 2205 Diesel fuel oil: 50°C [122°F] or higher Furnace oil: 60°C [140°F] or higher
Distillation temperature	First distillation point	170°C [338°F] or higher		
	90% point	330 to 380°C [626 to 716°F], max.	380°C [716°F], max.	
Pour point		6°C [11°F], min. below the lowest atmospheric temperature	6°C [11°F], min. below the lowest atmospheric temperature	
Cloud point		Below the lowest atmospheric temperature	Below the lowest atmospheric temperature	
Carbon residue on 10% residuum, weight percent		0.4, max.	1.0, max.	
Cetane number		45, min.	45, min.	
Cetane index (new method)		45, min.		JIS K 2280-1996
Kinematic viscosity		2.0 cSt, min. at 30°C [86°F] 8.0 cSt, min. at 50°C [122°F] 10.5 cSt, min, at 40°C [104°F] 16.0 cSt max. at 30°C [86°F]	2.0 cSt, min. at 30°C [86°F] 8.0 cSt, min. at 50°C [122°F] 10.5 cSt, min, at 40°C [104°F] 16.0 cSt max. at 30°C [86°F]	
Sulfur, weight percent		0.2, max.	1.0, max.	0.05 max. is proper as the same level for diesel fuel oil.
Water and sediment, volume percent		0.1, max.	0.1, max.	
Ash, weight percent		0.03, max.	0.03, max.	
Copper strip corrosion, at 100℃ [212°F], 3 hrs		No. 3, max.	No. 3, max.	ASTM: No. 3 JIS K 2213: Discoloration No. 3
Gravity, 15/4°C [39°F]		0.80 to 0.87	0.80 to 0.87	
Coking		not all carbonized at 250°C [482°F]		
		38, max.		
Particulate impurities		5.0 mg/l, max.		
Asphaltene		0.1, max.		

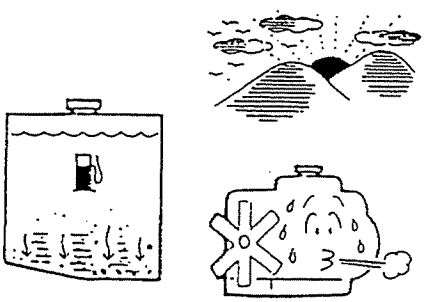
Care of Fuel Supply

⚠ WARNING

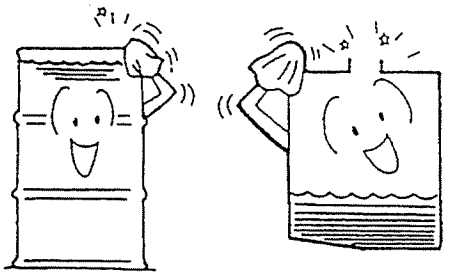
- **Shut down the engine when fueling. Do not smoke while fueling — or when handling fuel containers.**
- **Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire.**
- **After fueling, secure filler cap.**



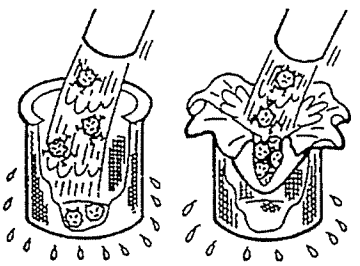
1. Fill the diesel fuel tank at the end of the day. This will drive out moisture-laden air and prevent condensation.

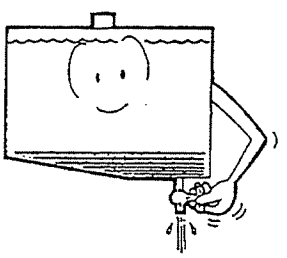


2. When refilling the diesel fuel tank, use clean tools, such as a hand pump, funnels, containers, hoses, etc. Wipe filler cap clean before removing it. When operating the hand pump, keep in mind that there could be water and sediment that has settled to the bottom of storage tank; tap the needed amount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



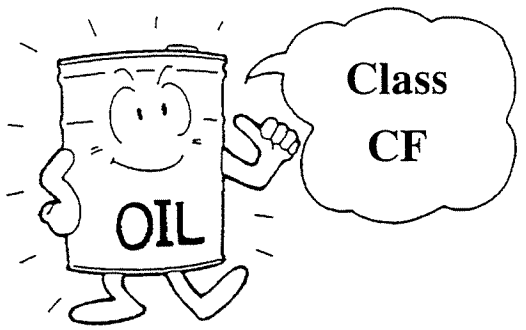
3. Be sure to pour fuel through strainer in the filler opening. Use of a lint-free cheese cloth is a good practice for keeping dirt out.





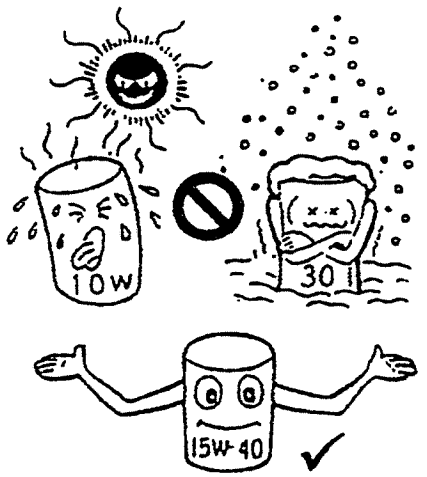
Recommended Types of Engine Oils

Use oils that meet the Engine Service Classification CF. However, do not use Class CF-4 when using heavy oil. Proper oil selection assures cranking ability by maintaining an oil film on cylinder walls and bearing surfaces in a condition which provides low friction, and therefore, less cranking effort to achieve cranking speeds necessary for reliable starting. Improper oil selection may result in congealed oil film on cylinder walls and bearing surfaces, which result in high friction loads and more cranking effort, thus preventing sufficient cranking speeds for reliable starting and affecting engine life.

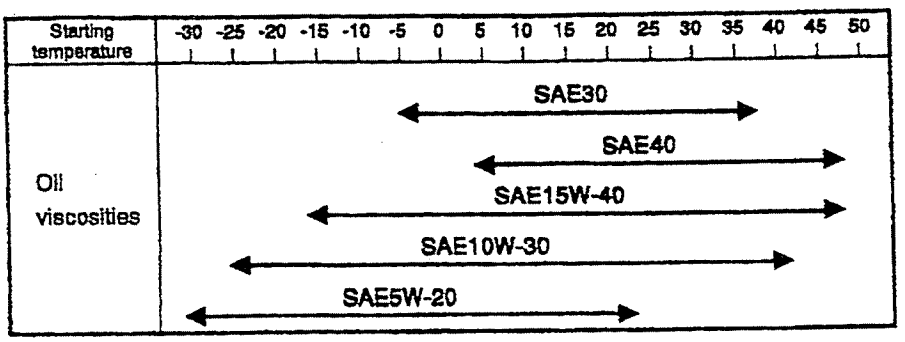


Recommended Oil Viscosities

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. These considerations can be adequately met through proper grade selection. Recommended oil viscosities are shown in the chart below:



Recommended Oil Viscosities

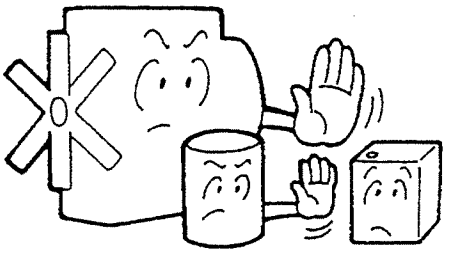


Mitsubishi recommends all-season type engine oil of SAE 15W-40.

Recommended Brands of Oils

⚠ CAUTION

Avoid mixing oils of different brands. In most cases, different brands are not compatible with each other and, when mixed, can seize parts such as piston rings, cylinders, etc. or abnormally wear moving parts. It is best to stick with one and the same brand of oil at successive service intervals.



A oil B oil

Replenish Engine Oil

⚠ CAUTION

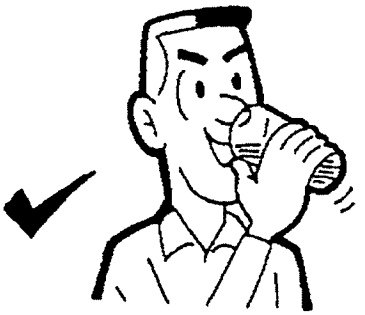
- **Shut down the engine when fueling. Do not smoke while fueling — or when handling fuel containers.**
- **Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire.**
- **After fueling, secure filler cap.**

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 proper-ties and substances contained in water (as coolant) must 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)	–	○

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

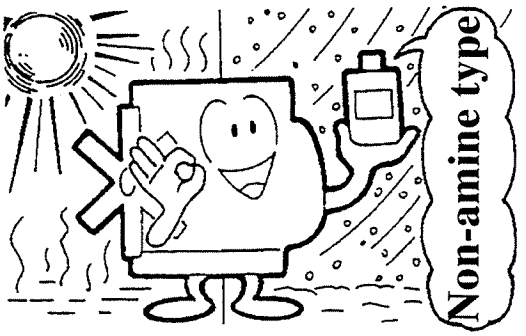
Recommended Types of LLC's

⚠ CAUTION

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

For Mitsubishi diesel engines, the following brands of all-season, non-amine type LLC's or equivalent are recommended:

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



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. (The coolant with 30% concentration, for example, retains its efficacy for long, not less than one year.)

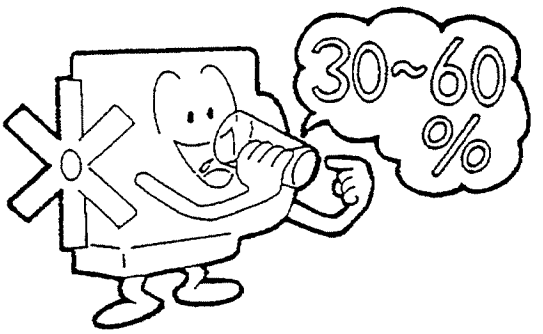
■ How to use non-amine type LLC

⚠ 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. Aim at 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
(Reference)

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 cool-ant, becomes increasingly weak in time. Moreover, if its chemicals are not well proportioned to match the circuit metals which they are mean to protect, they become rapidly used up due to aging and allow some metals to precipitate into the coolant or to form new compounds which 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.

For 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 Fe metals. The mechanism of Fe-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 Fe, a base metal relative to copper; the copper deposit introduces a localized galvanic cell which, by its ionic action, rapidly eats into the Fe 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 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

Preparation

1. Drain the oil from the engine and fill it with rust preservative (JIS K2246 NP-10 or equivalent).
2. Make up a mixture of rust preservative (JIS K2246 NP-9 or equivalent) and fuel, and fill the fuel tank with the mixture.
3. Start the engine and operate it at low idle for 5 to 10 minutes (800 to 1000 rpm).
4. Stop the engine. Spray volatile rust preservative in the silencer to prevent rust on the intake/exhaust systems.
5. Drain the rust preservative-fuel mixture.
6. Apply a coat of rust preservative (JIS K2246 NP-9 or equivalent) 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 polyethylene sheet. Put a desiccant inside the covering.
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.

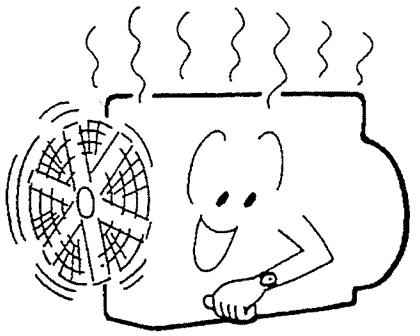
NOTICE: (1) Store the engine in a well-ventilated room.
(2) It is not necessary to drain the coolant if it contains LLC (in 30% to 60% concentration).
(3) Attach a "FILL THE FUEL" or similar warning tag to the starter switch or controls.
(4) New engine oil may be used instead of rust preservative JIS K2246 NP-10.

Service During Storage

1. Recharge the battery at least once a month.
2. Perform maintenance run at least once a month as follows.

(1) Crank the engine two times, for 15 seconds each time, at intervals of one minute, with the fuel supply shut off (the stop button pushed).

(2) Start the engine and operate it under no-load conditions for 5 to 10 minutes.



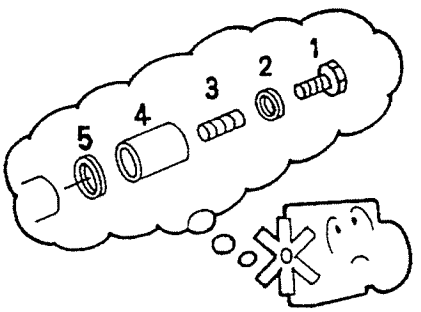
Remove the Engine from Storage

1. Remove the covering from the engine.
2. Connect well-charged batteries to the engine.
3. Remove the covering from the starter and alternator.
4. Adjust the fan drive belt.
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. Start the engine.
12. Allow the engine to warm up at low idle.
13. When the engine has run long enough to warm up, apply the load and bring it to operating speed.

[GENERAL PRECAUTIONS]

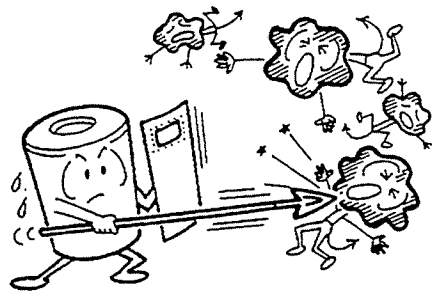
Think Before Acting

Upon noting a problem, recall what you did the last time when you ran across 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.



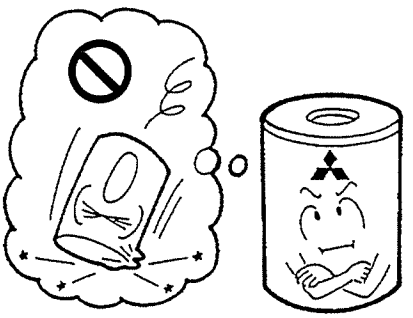
Beware of Dirt and Debris

"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.



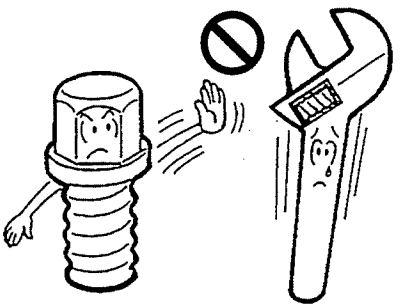
Use Genuine Mitsubishi Parts

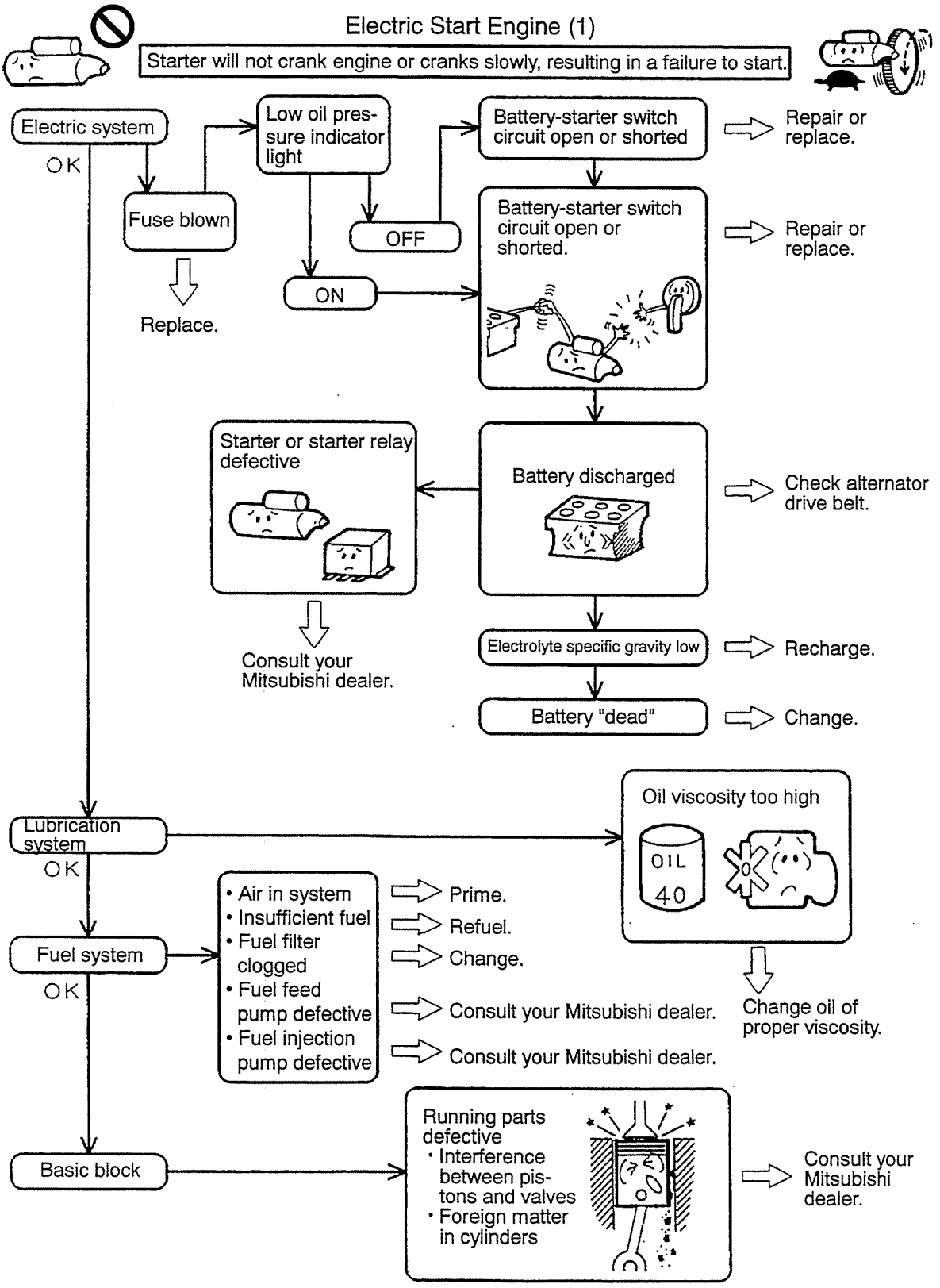
Use only genuine parts to replace those that have failed or reached the service limit. When ordering parts, consult Mitsubishi Parts Catalogues.



Perform Service Safely

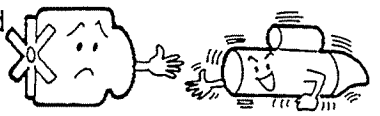
Use the right kind of tools. Many accidents and damage to parts result from using a tool to do something for which it was not intended. When lifting heavy components, use a hoist to avoid back injury. Make sure all chains, hooks. slings, etc. are in good condition and are in the correct capacity. Be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




Electric Start Engine (1)
Starter will not crank engine or cranks slowly, resulting in a failure to start.
Electric system
OK
Low oil pressure indicator light
Battery-starter switch circuit open or shorted
Repair or replace.
Fuse blown
Replace.
OFF
ON
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
OIL
40
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.

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

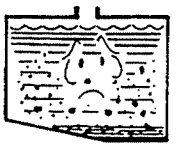
Consult your Mitsubishi dealer.

Full

Air in fuel system ⇨ Prime.

Bad quality fuel ⇨ Change fuel.

Water and sediment ⇨ Drain.



Fuel filter clogged ⇨ Change.

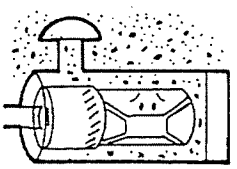
Fuel pipe restricted or leaky ⇨ Clean or repair.

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.

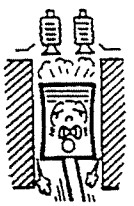
⇨ Change element.

Muffler or exhaust pipe restricted

⇨ Clean.

Basic block

- Compression pressure low
- Cylinders, pistons and piston rings worn
- Valve springs broken
- Valve seats and nozzle packing seal defective



⇨ Consult your Mitsubishi dealer.

Air Start Engine

Air motor type

Air motor will not crank engine.

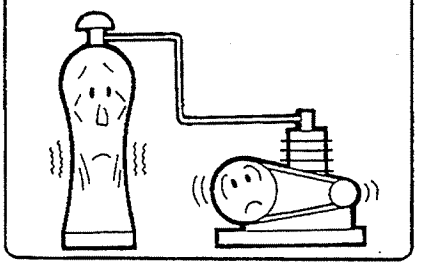
- Air pressure low ⇨ Run air compressor to increase air pressure.
- Starter switch defective ⇨ Repair or replace. ⇨ Consult your Mitsubishi dealer.
- Magnetic valve defective ⇨ Repair or replace. ⇨ Consult your Mitsubishi dealer.

Air motor will run, but it will not engage with flywheel ring gear.

- Ring gear or pinion defective ⇨ Consult your Mitsubishi dealer.

Pinion will engage with ring gear, but it will not run.

Air pressure low



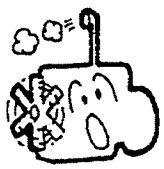
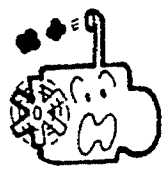
⇨ Run air compressor to increase air pressure.

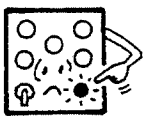
Direct air type

Engine will not run.

- Air pressure low ⇨ Run air compressor to increase air pressure.
- Air filter clogged ⇨ Clean the filter or change it.
- Starter valve stuck ⇨ 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.
	Engine overcooled	Use radiator cover or consult your Mitsubishi dealer.
	Fuel filter clogged	Change.
	Engine overheats	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 discharge pattern improper	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.
	Engine overcooled	Use radiator cover or consult your Mitsubishi dealer.
	Thermostat detective (no coolant temperature rise)	Consult your Mitsubishi dealer.
	Fuel discharge pattern improper	Consult your Mitsubishi dealer.
	Fuel injection timing incorrect	Readjust.
	Compression pressure low (cylinder liners, piston rings, etc., worn)	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.
	Fuel feed pump defective	Consult your Mitsubishi dealer.
	Compression pressure low (cylinder liners, piston rings, etc., worn)	Consult your Mitsubishi dealer.
	Insufficient air (air cleaner element clogged)	Clean or change.
	Fuel injection timing incorrect	Readjust.
	Fuel discharge pattern improper	Consult your Mitsubishi dealer.
	Fuel injection pump defective	Consult your Mitsubishi dealer.

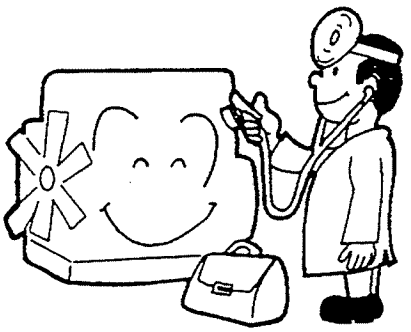
Problem	Cause	Correction
High fuel consumption 	Fuel feed pump defective	Consult your Mitsubishi dealer.
	Fuel injection pump defective	Consult your Mitsubishi dealer.
	Fuel injection timing incorrect	Readjust.
	Bad quality fuel	Change fuel.
	Compression pressure low	Consult your Mitsubishi dealer.
	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	Retighten 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 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 circuit defective	Consult your Mitsubishi dealer.

Remarks: (a) Consult your Mitsubishi dealer for any items other than those listed above.
(b) When ordering replacement parts, give service hour meter reading of your engine.

Engine model		S6R			S6R2		
		T	TA	TK	T	TA	TK
Type		4-stroke cycle, water-cooled, turbocharged					
		–	With aftercooler	With intercooler	–	With aftercooler	With intercooler
Number of cylinders - arrangement		6 — in-line					
Bore x stroke		ϕ170 mm x 180 mm [6.69 in. x 7.09 in.]			ϕ170 mm x 220 mm [6.69 in. x 8.66 in.]		
Displacement		24.5 liters [1,494 cu in.]			30.0 liters [1,831 cu in.]		
Fuel injection system		Direct injection					
Compression ratio		14.0 : 1					
Firing order (injection sequence)		1 - 5 - 3 - 6 - 2 - 4					
Rotation		Counterclockwise as seen from flywheel end					
Dimensions (length x width x height)		1,722 x 1,050 x 1,498 (mm) [67.8 x41.3 x 59.0 (in.)]			1,722 x 1,050 x 1,578 (mm) [67.8 x41.3 x 62.1 (in.)]		
Dry weight (approximate)		2,250 kg [4,960 lb]	2,300 kg [5,070 lb]		2,350 kg [5,180 lb]	2,400 kg [5,291 lb]	
Fuel system	Fuel	Diesel fuel or heavy oil					
	Fuel injection pump	Mitsubishi PS6					
	Governor	Woodword PSG hydraulic governor or electric governor					
	Fuel filter	Paper element (Cartridge type)					
	Fuel injection nozzle	Hole type					
	Initial fuel injection pressure	34.32 Mpa {350 kgf/cm^2} [4,978 psi]					
Lubrication system	Type	Pressure feed					
	Oil	Engine Service Classification CF					
	Capacity (approximate)	Oil pan: 82 liters [22 U.S. gallons] (Whole engine: 92 liters [24.3 U.S. gallons])					
	Oil filter	Paper element (equipped with bypass filter, cartridge type)					
	Oil cooler	Water cooled multi-plate (equipped with crank case)					
Cooling system	Type	Forced water cooling					
	Coolant capacity (basic block)	50 liters [13.21 U.S. gallons] (for whole engine only)			55 liters [14.53 U.S. gallons] (for whole engine only)		
	Radiator pump	Centrifugal pump					
Starting system	Type	Electric start or air start (air motor type or direct air type)					
	Electric starter	24 V - 7.5 kW					
	Alternator	24 V - 30 A					
Charging system		Mitsubishi TD13 or TD15					

PRODUCT SUPPORT

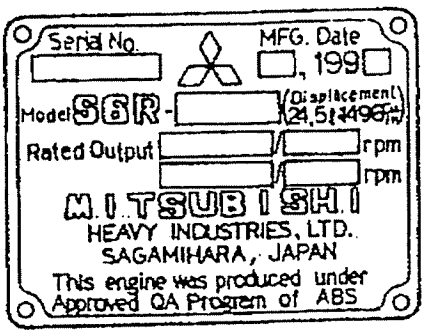
Your Mitsubishi dealer is vitally interested in your complete satisfaction with Mitsubishi engine you purchased from him. He is anxious to know that all of your service needs are properly filled. When consulting your Mitsubishi dealer for replacement parts supply or any other service, be sure to give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



If your engine is transferred to elsewhere from the original place of use registered with 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.

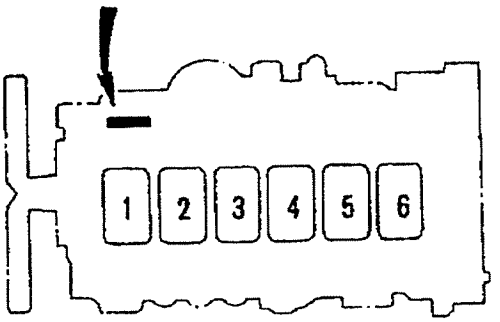


Example

Model: S6R

Serial number: 00012

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



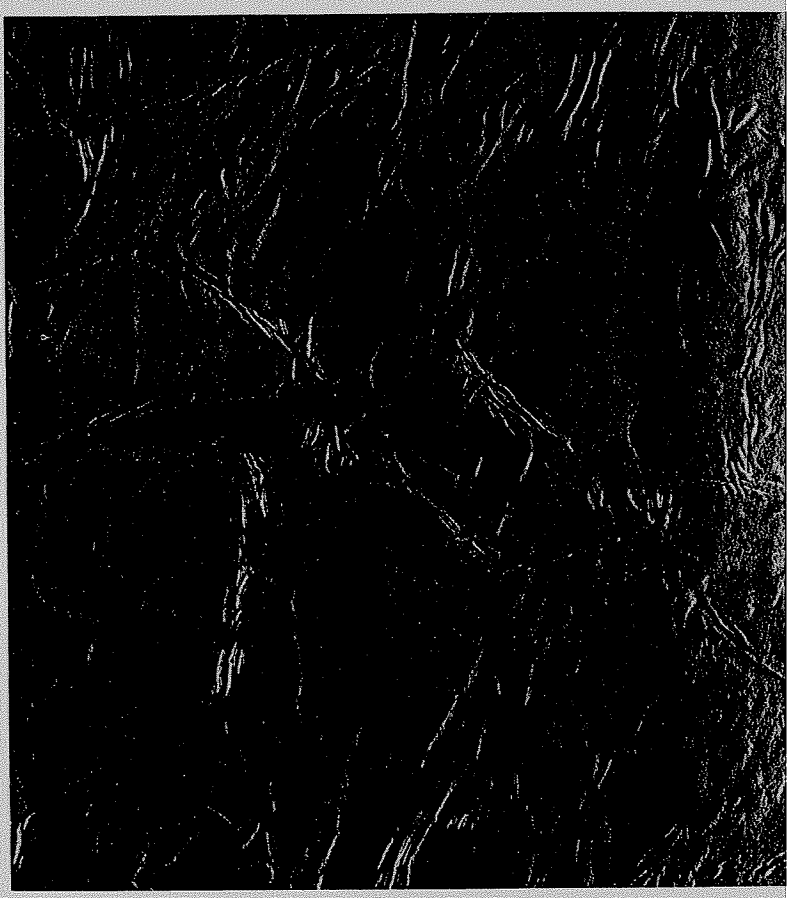
Scheme of Designating Engine Model

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
  - M : Marine ships
  - MP : Marine main and auxiliary machinery
- Series code
- Number-of-cylinders code
- Initial of SAGAMIHARA MACHINERY WORKS



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