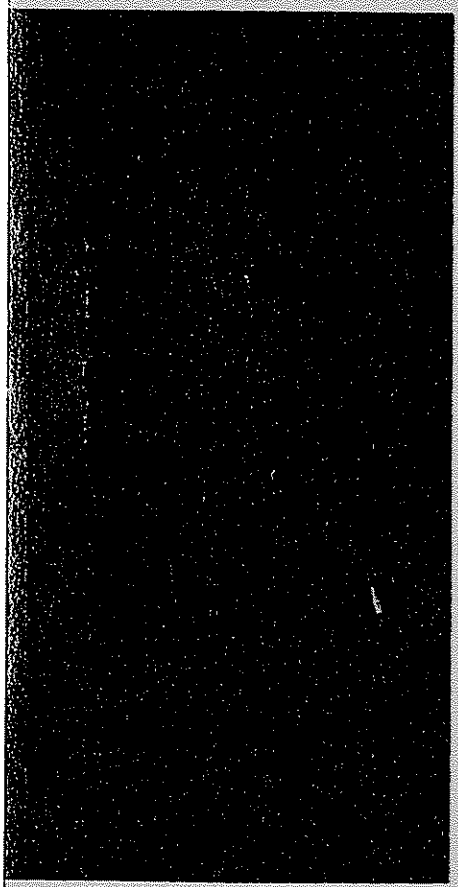
OPERATION & MAINTENANCE MANUAL



MITSUBISHI DIESEL ENGINES

S12H

MITSUBISHI
HEAVY INDUSTRIES, LTD.

INTRODUCTION

This manual contains operation instructions, and lubrication and maintenance information for Mitsubishi S12H 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 understand 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. 99260-03100

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

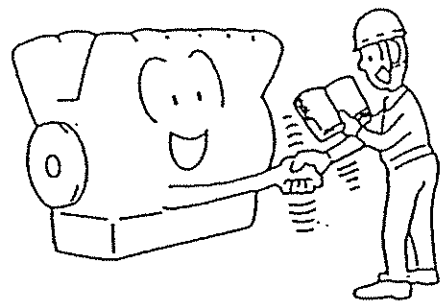
✓ ..... Indicates a proper action or "DO."

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

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:

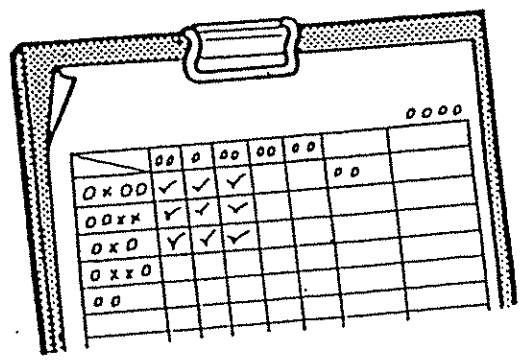
- Effective troubleshooting (to help a serviceman of your Mitsubishi dealer pin-point a trouble).
- Quick servicing and less downtime (to help a serviceman of your Mitsubishi dealer save time (cost) for servicing)
- Grasp of operating conditions (to help you recognize conditions, signs or indications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



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DANGER Fire or Explosion Prevention

Fire hazards!

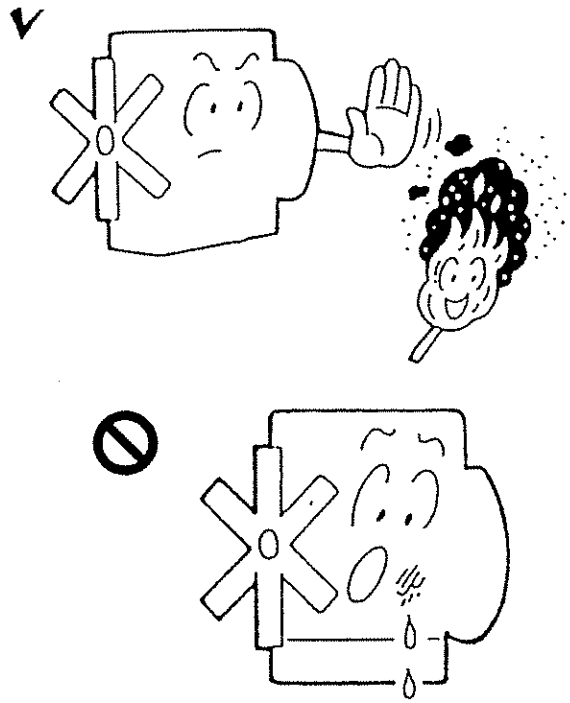
Do not smoke while fueling, or when handling fuel containers. Do not use gasoline or diesel fuel for cleaning parts. Good commercial, non-flammable and non-toxic solvents are recommended. Do not spill fuel on hot surfaces. Clean up any spillage soon.

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!

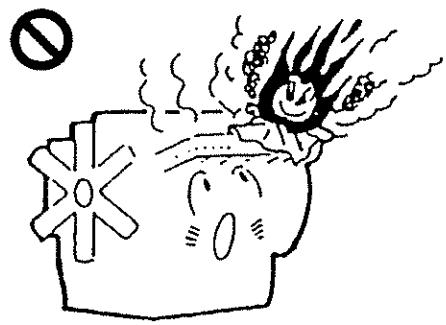
Leaks can cause fires and personal injury. If your check uncovers any leakage, report it now.



WARNING Fire Prevention

Keep flammable materials away!

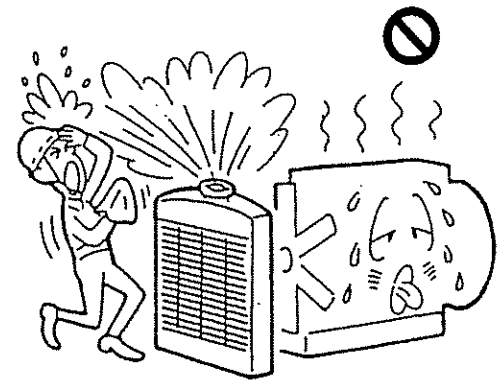
Remove all flammable materials such as fuel, oil and other debris before they accumulate on engine. Keep engine at least 1 meter [3.3 ft] apart from surrounding structures and other equipment to avoid fires.



⚠ 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.

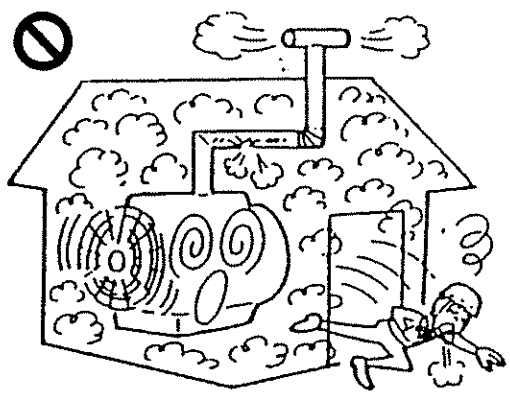


⚠ WARNING — Exhaust Fumes

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

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. Attach a "DO NOT OPEN" or similar warning tag to air tank valve in case of air-start engine.

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.

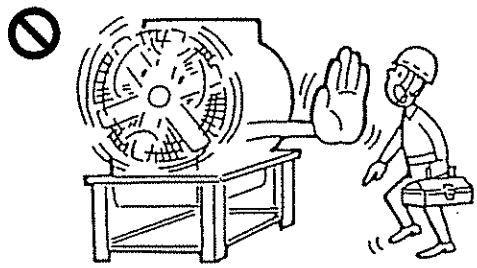
Install protective covers!

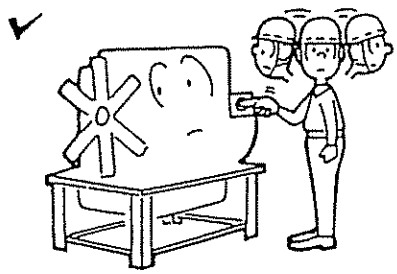
Make sure all protective covers and guards are installed to drive belts, couplings, etc. to prevent personal injury.

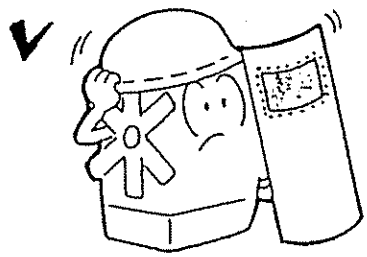
Keep turning gear disengaged when not in use!

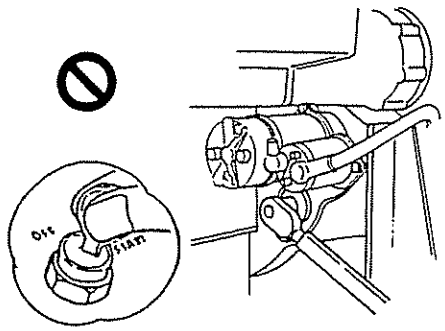
Lock the turning gear in disengaged position properly when not in use. Failure to follow this recommendation can cause personal injury and engine damage.

Cutting Prevention



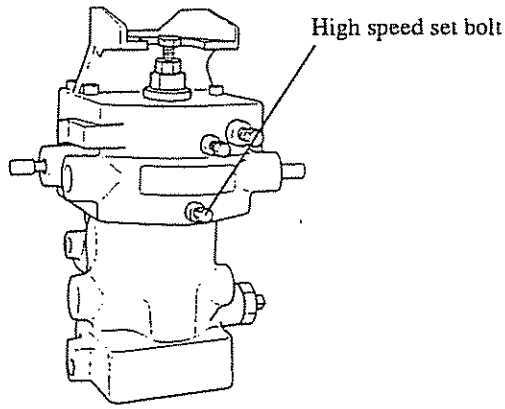






⚠ WARNING Governor Sealing

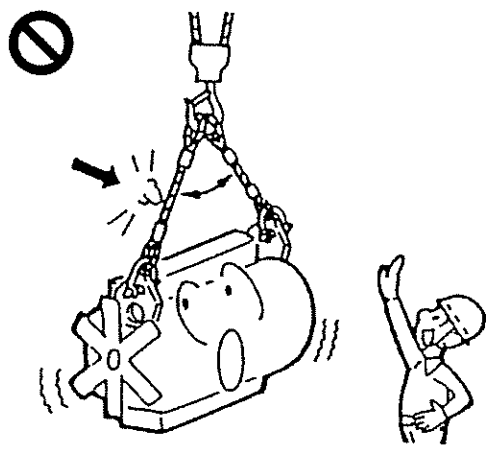
Hydraulic governor has speed set bolts which have been properly set at factory and sealed. Never attempt to break seals and reset them in field. Resetting can cause overspeeding, resulting in serious troubles.



⚠ WARNING Lifting Precautions

Lift engine carefully!

When lifting engine, attach 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 engine that is lifted.



⚠ 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.

Handle electrolyte carefully!

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

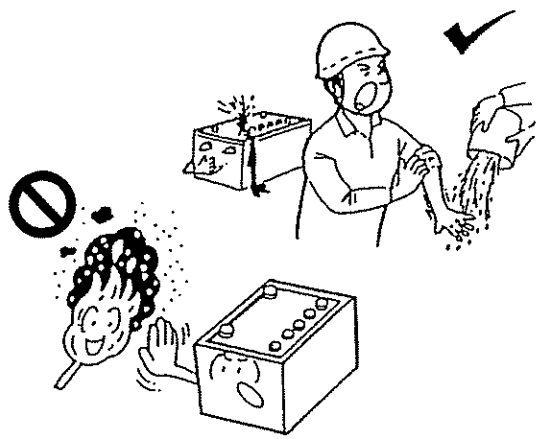
(1) When servicing batteries, consult your foreman for specific instructions on a job and safety equipment required.

(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.

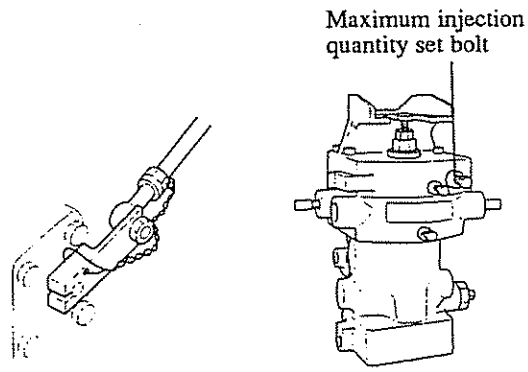


⚠ CAUTION Operating Precautions

Do not break seals for settings!

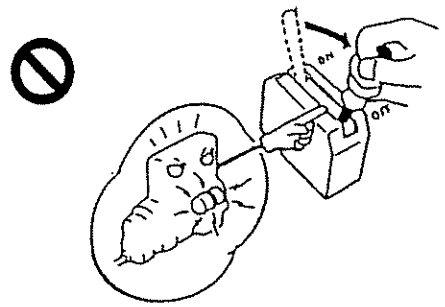
Never attempt to break seals of hydraulic governor linkages or electronic governor actuators for injection quantity and minimum and maximum speed settings. Breaking these seals and varying settings could result in:

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



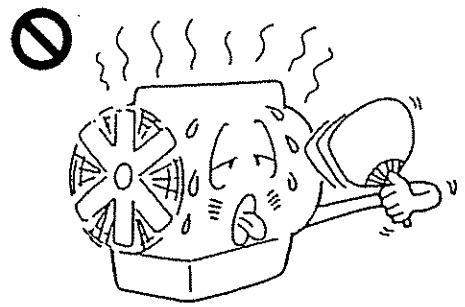
Do not turn OFF battery switch during operation!

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.



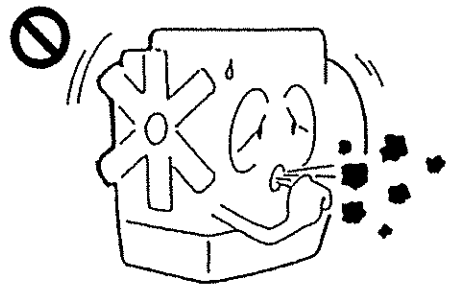
Always keep engine room well ventilated!

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!

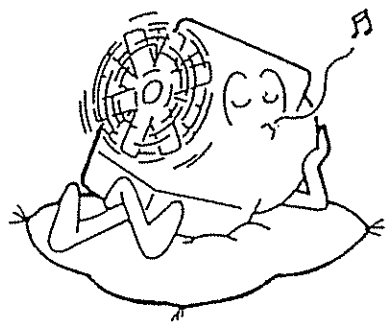
This can cause incomplete combustion often indicated by black smoke, high fuel consumption and carbon deposits in combustion chambers, affecting engine life.



⚠ CAUTION Operating Precautions

Be sure to break-in engine!

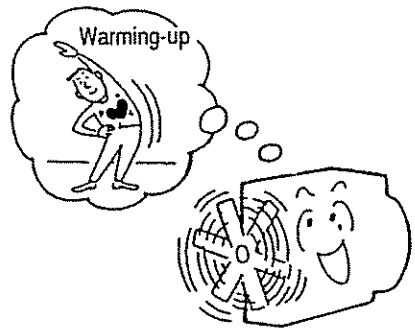
During first 50 hours of operation, break-in engine with lighter load and lower speeds than normal. Proper break-in contributes to maximum service life of engine.



Warm-up engine before operation!

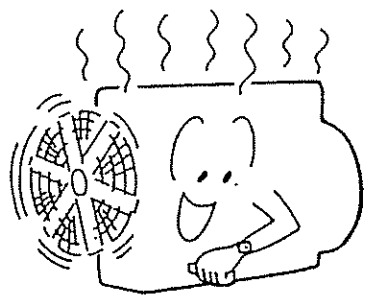
After starting engine, warm it at low idle for 5 to 10 minutes before operating under full load, for maximum engine life.

NOTICE: Long periods of warming up the engine is not recommended. This can deposit carbon in cylinders and cause incomplete fuel combustion.



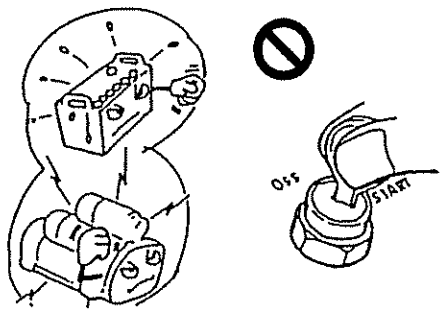
Stop engine after cooling!

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 at low idle for 5 to 10 minutes. This allows hot areas in engine to cool gradually, extending engine life. With engine running. make a walk-around inspection, checking for any abnormality.



Use starting motor correctly!

When starting engine, do not crank it for more than 10 seconds at a time. After every 10 seconds of engine cranking, allow 30 seconds for starting motor to cool before cranking again.

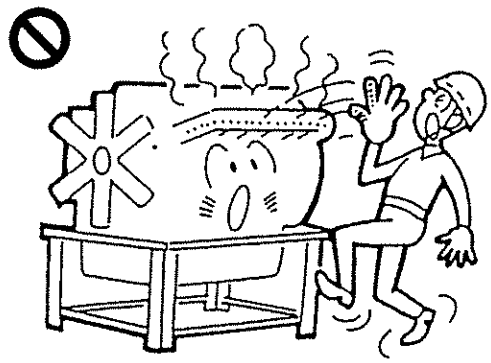


⚠ CAUTION

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.



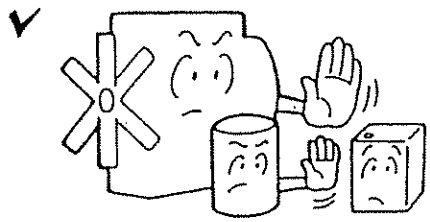
Stay clear of hot oil!

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!

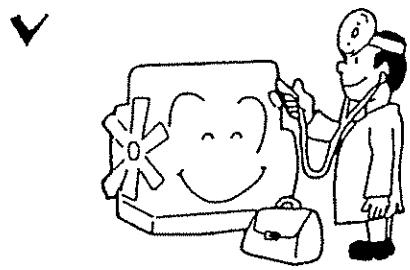
Use of any other fuel, oil or coolant can cause engine damage and reduced engine service life.



Brand A Brand B

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.



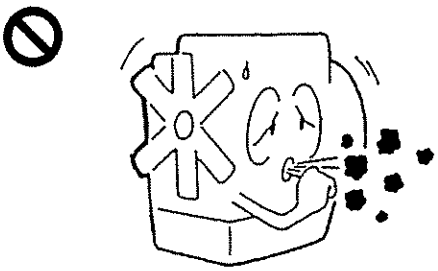
Keep water out of engine!

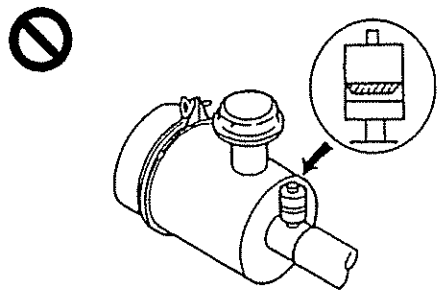
When washing engine, cover air inlet and exhaust opening with tape to prevent water or cleaning agent from getting inside engine. Do not wash engine when it is running. If water or cleaning agent gets inside combustion chambers, hammering action of water can damage engine.

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.

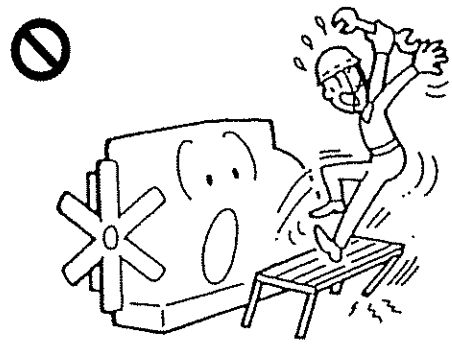




⚠ CAUTION Maintenance Precautions

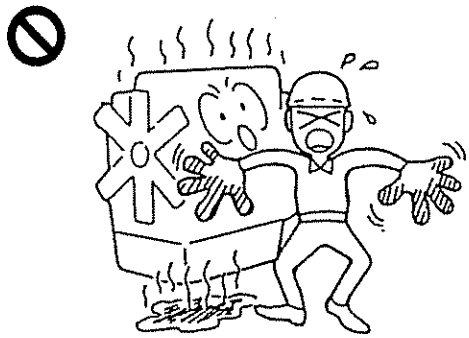
Always watch your footing!

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



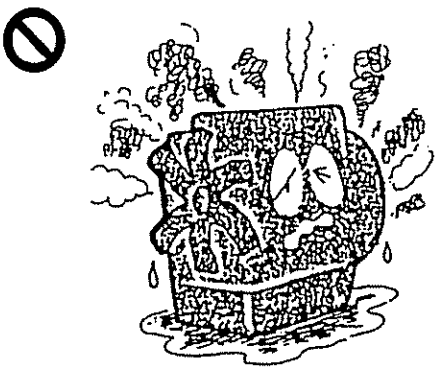
Avoid burns!

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



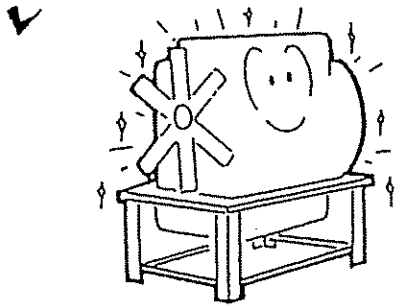
Service electrical system carefully!

- 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!

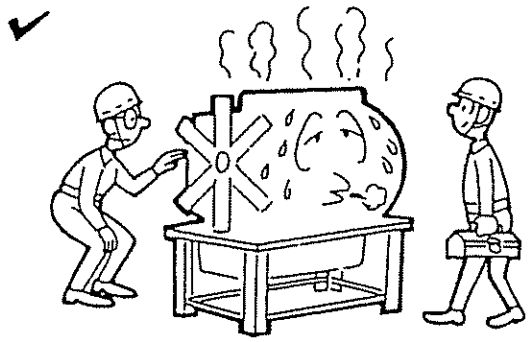
Remove all flammable materials such as fuel, oil and other debris, before they accumulate on engine.



⚠ CAUTION Maintenance Precautions

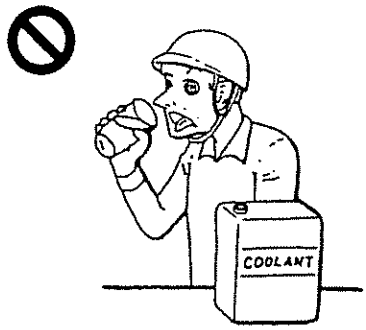
Stop engine before servicing!

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.



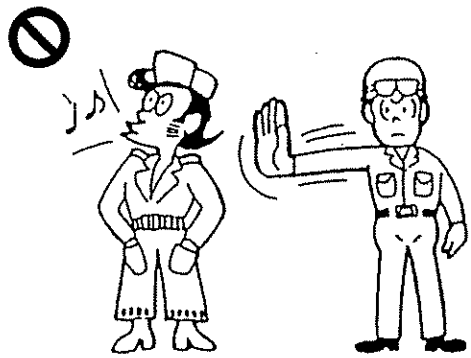
Handle antifreeze carefully!

- 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!

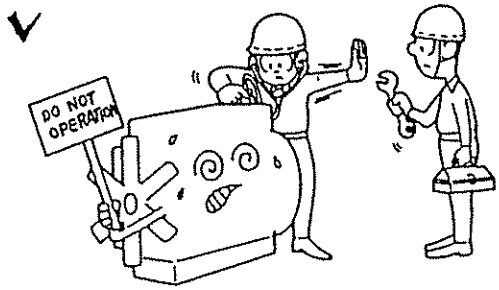
You may need any number of special items — hard hat, face shield, safety shoes, goggles, heavy gloves, ear protector, etc. — for your own protection.



⚠ CAUTION If Any Trouble Should Occur

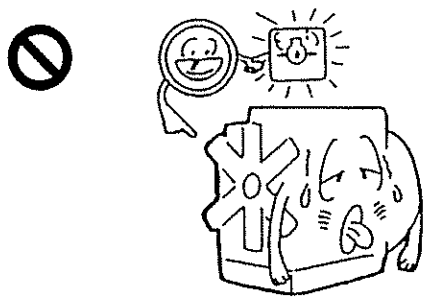
If engine stops abnormally

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. Failure to follow this precaution can cause serious engine trouble.



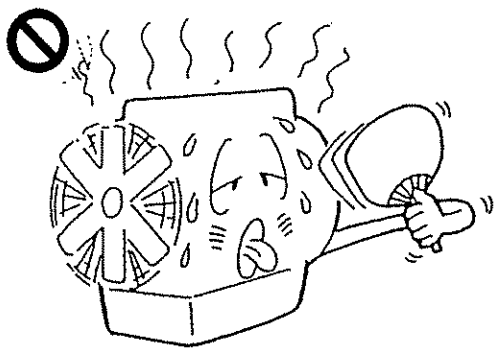
If engine oil pressure is low

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



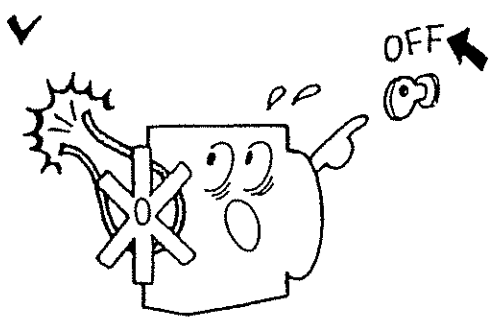
If engine overheats

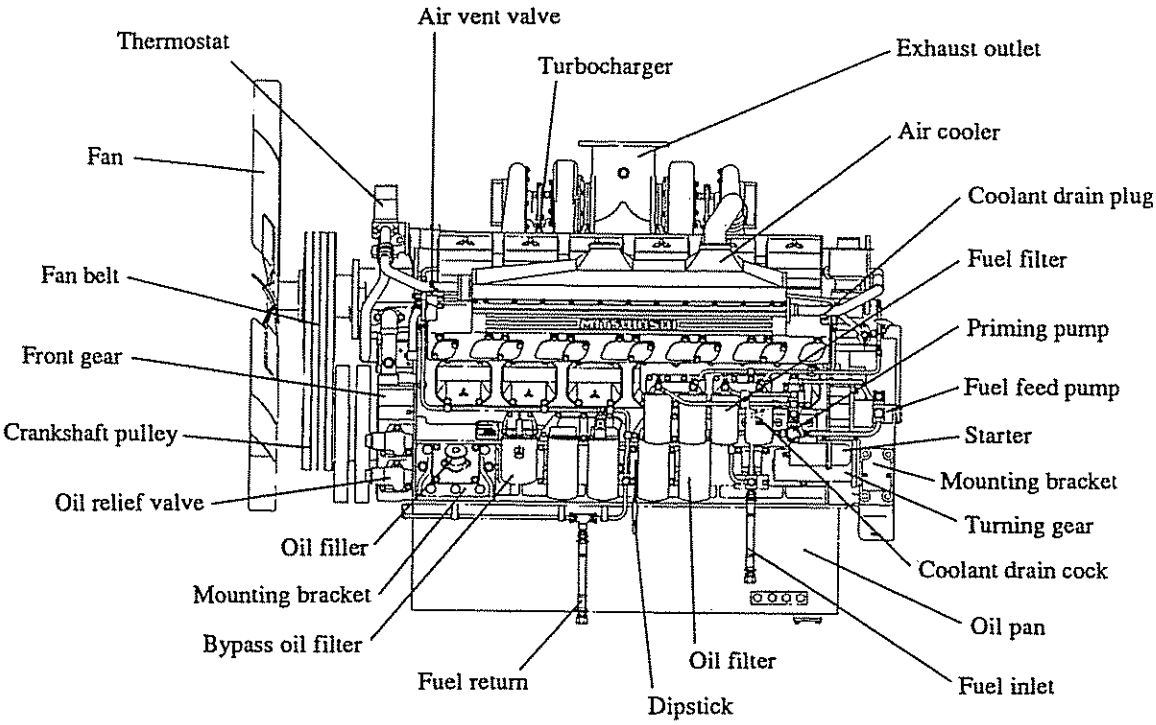
If engine overheats, never stop it immediately. Stopping an overheated engine immediately can result in sudden coolant temperature rise and seizure of running parts. Operate engine at low idle to allow hot areas in engine to cool gradually, then add coolant gradually. Remember, adding coolant to an overheated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



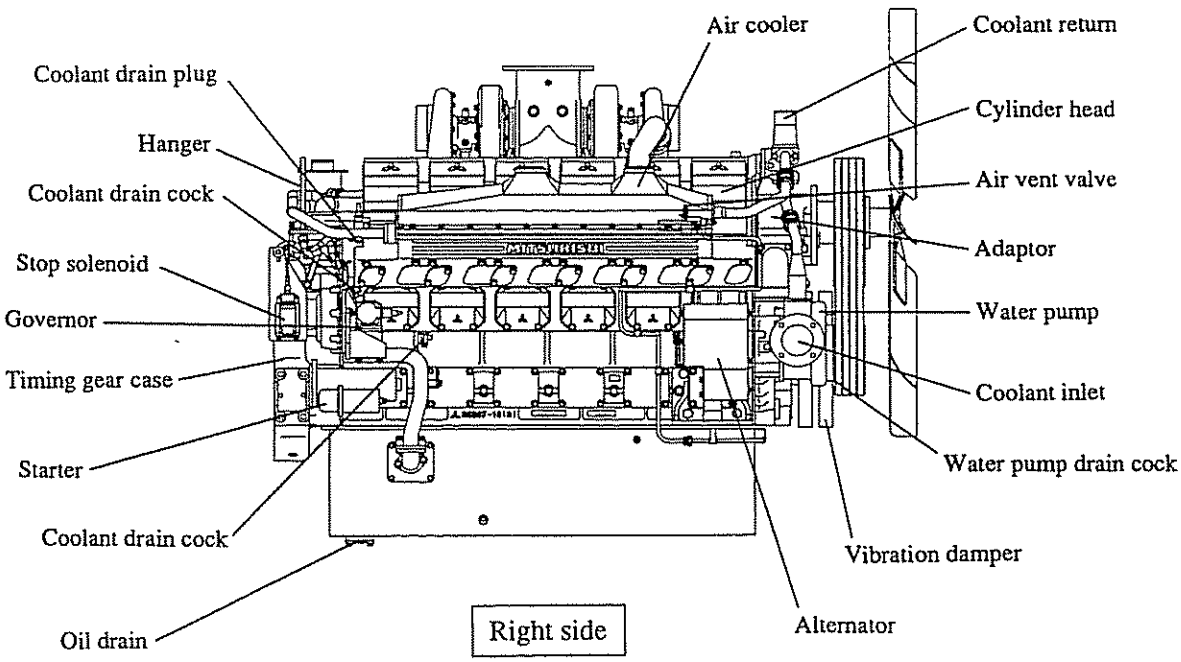
If fan belt is broken

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

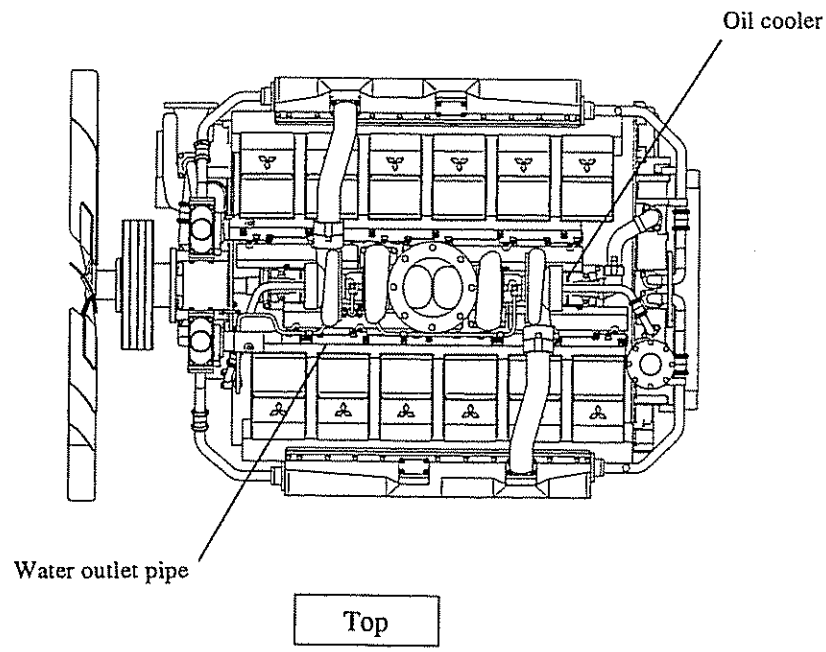




Left side



Right side


Oil cooler
Water outlet pipe
Top

[START/STOP CONTROLS]

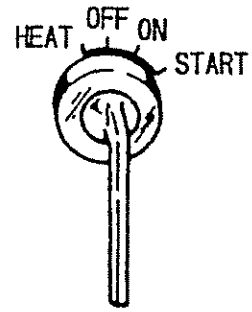
Starter Switch

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.

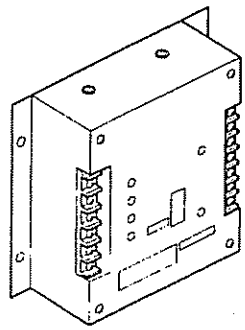
ON The key will return to the ON position when released from the START position.

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



Speed Controller (Electronic Governor)

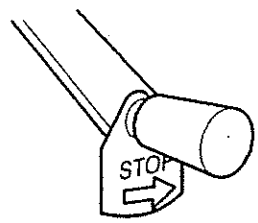
Controls the engine speed.



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.

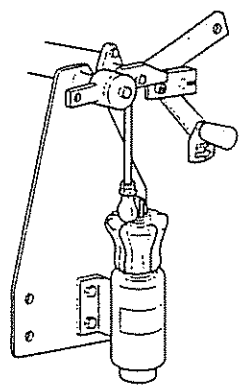
NOTICE: If the engine does not stop even when this lever is operated, shut off fuel supply.



Stop Solenoid

Press the stop button to stop the engine in the "RUN OFF" state. Turn the starter switch key to the OFF position to stop the engine in the "RUN ON" state.

This solenoid, when energized, moves the unit injector rack to the non-injection position to stop the engine.



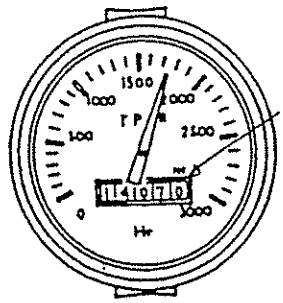
[INSTRUMENTS]

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

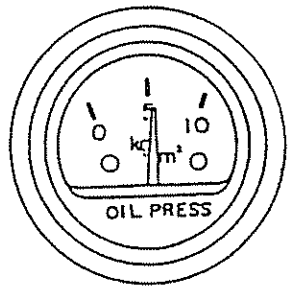
Indicates the total number of hours the engine has operated. Use this meter to determine service intervals.

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 0.67 MPa (4 to 7 kgf/cm^2) [57 to 100 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.

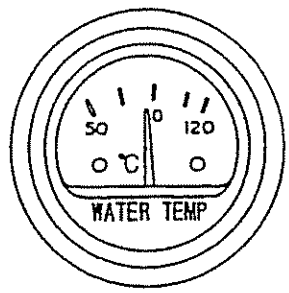
Oil pressure gauge



Coolant Temperature Gauge

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

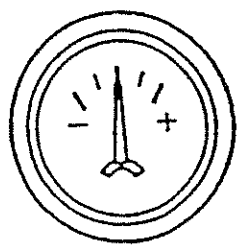
Coolant temperature gauge



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.

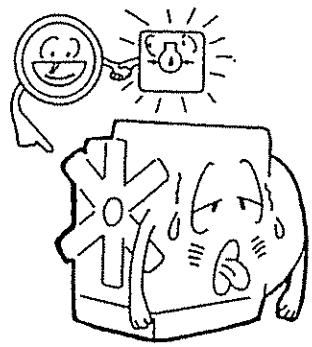
Ammeter



[PROTECTIVE DEVICES]

Low Oil Pressure Indicator Light

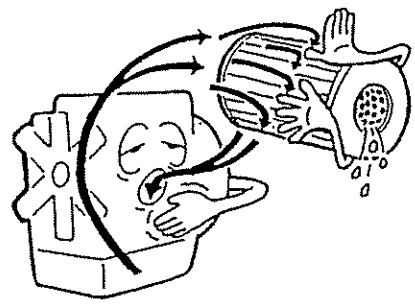
Comes ON when the oil pressure is lower than $0.29^{0}_{-0.03}$ MPa ($3^{0}_{-0.3}$ kgf/cm²) [$43^{0}_{-4.3}$ psi] at engie speed higher than 1 500 rpm. It comes ON when the oil pressure is lower than 0.15 ± 0.02 MPa (1.5 ± 0.2 kgf/cm²) [21 ± 2.8 psi] in the entire speed range.



Oil Filter Indicator Light

Comes ON when the difference in pressure across the oil filter is greater then 0.15 MPa (1.5 kgf/cm²) [21 psi]. When this light comes ON, immediately replace the oil filter.

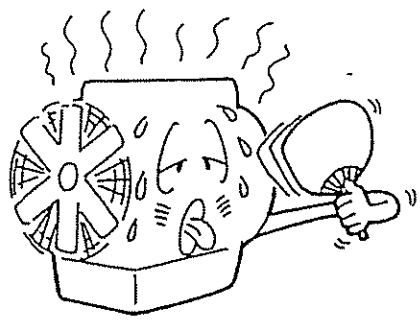
NOTICE: Change engine oil when replacing the oil filter.



High Coolant Temperature Indicator Light

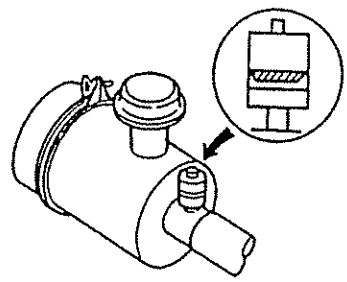
Comes ON when the coolant temperature (at radiator inlet) is higher than 95 ± 2°C [203 ± 3.6°F]. If this indicator light comes ON, run the engine at low idle speed to let it cool gradually. Then, stop the engine and check the cooling system.

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.

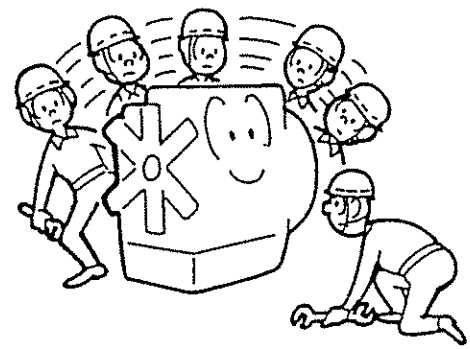


[NEW ENGINE INITIAL SERVICE]

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

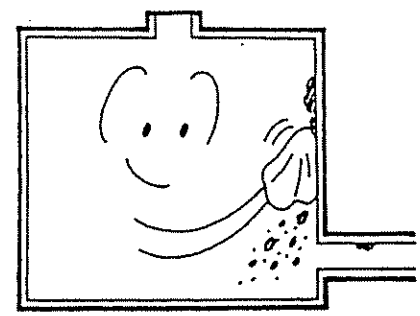
1. Check the electrical system for loose terminals or other defects.
2. Check the following components for loose bolts or nuts:
   - Plugs and covers of fuel system, lubrication system and cooling system
   - Crankshaft pulley and damper
   - Mounting brackets
   - Fuel control linkage
   - Cylinder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



Fuel System

Fill the fuel tank

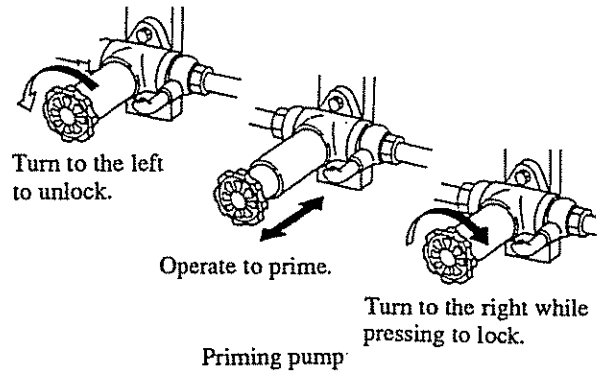
Before filling the fuel tank, put some amount of fuel in the tank, and disconnect the fuel pipe from the engine inlet and remove the drain plug from the tank to drain off the fuel. Check the drained fuel for dirt or water. After making sure the tank is clean, connect the fuel pipe and drain plug and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



Prime the fuel system

⚠ WARNING

- **Clean up fuel spilled onto surfaces around air vent plugs. Spillage is a fire hazard.**
- **After priming, lock the priming pump plunger securely. If the plunger is not locked properly, the pump will suffer damage to leak fuel. Fuel leakage is a fire hazard. Be sure to lock the plunger by hand. Use of any tool can damage the pump.**

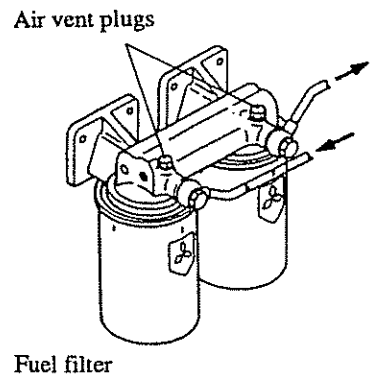


Prime the fuel filters and fuel return pipes in that sequence.

Fuel filter

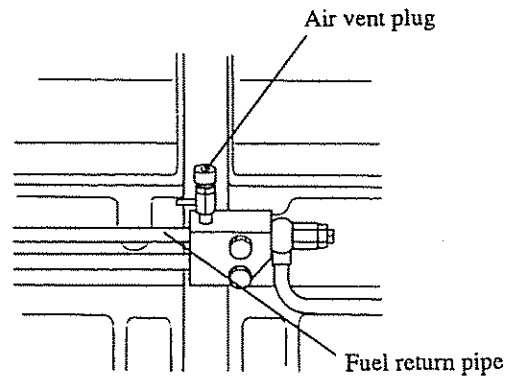
1. Loosen the air vent plug on the left-hand fuel filter about 1.5 turns with a wrench.
2. Turn the priming pump plunger to the left to unlock.
3. Operate the plunger until the fuel flows free of bubbles from the vent. Tighten the air vent plug.
4. Similarly prime the right-hand fuel filter.

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



Fuel return pipes

1. Loosen the air vent plug (with lock nut) on each fuel return pipe about 1.5 turns with a wrench.
2. Turn the priming pump plunger to the left to unlock.
3. Operate the plunger until the fuel flows free of bubbles from the vent. Turn the plunger to the right while pressing to lock.
4. Tighten the air vent plug.



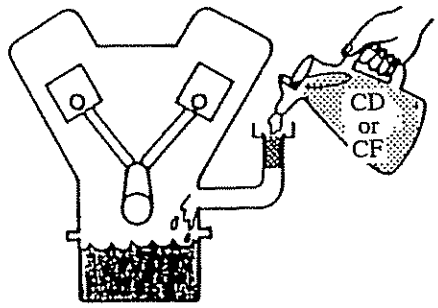
NOTICE: There are two air vent plugs for the fuel return pipes, one on the front side and the other on the rear side of each bank.

Lubrication System

Fill the oil pan

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

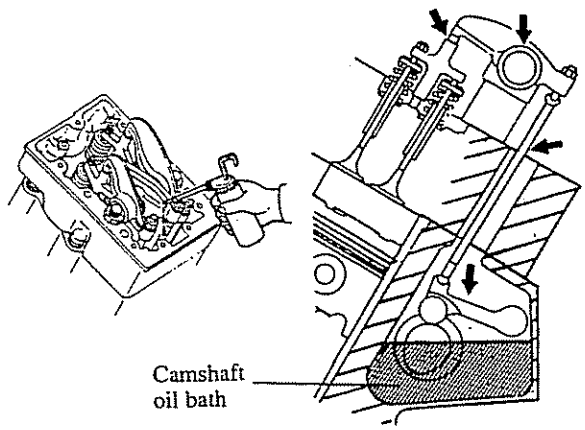
Refill capacity (approximate)	Oil pan: 180 liters [48 U.S. gallons] Engine: 200 liters [53 U.S. gallons]
Recommended oil	Oils that meet Engine Service Classification CD or CF

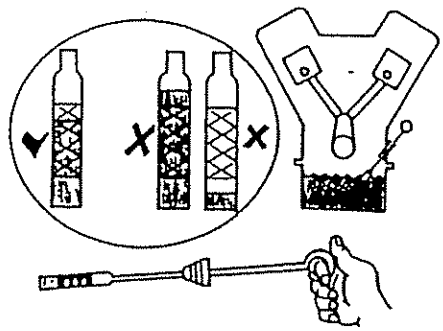


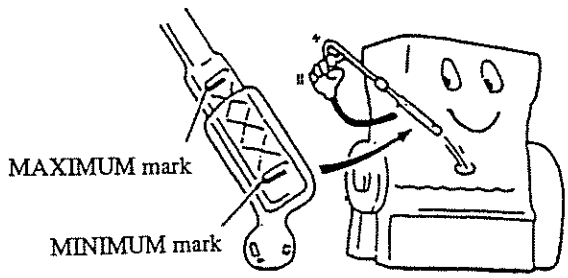
2. Remove the rocker cover. Lubricate the valve mechanism and fill the camshaft oil bath from the cylinder head side. (The approximate capacity of the oil bath is 800 cm^3 [49 cu in.] per cylinder.)
3. Check the oil level in the oil pan with a dipstick. The oil level should be between the MAXIMUM and MINIMUM marks on the dipstick. Add oil if necessary.
4. Check the oil pan and related parts for oil leaks.
5. Crank the engine with the fuel supply shut off to make sure the oil pressure rises properly.

NOTICE: Crank the engine for 10 seconds. If the pressure does not rise within 10 seconds, wait one minute before cranking it again. When cranking or operating the engine, see the topic, Cooling System, which follows.

6. Start the engine and operate it for about 10 minutes. Stop the engine and add oil up to the MAXIMUM mark on the dipstick.







Cooling System

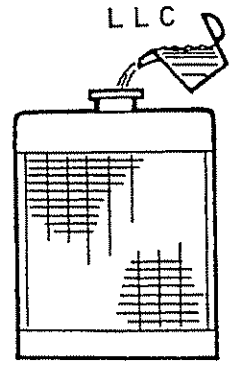
Fill the radiator

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.

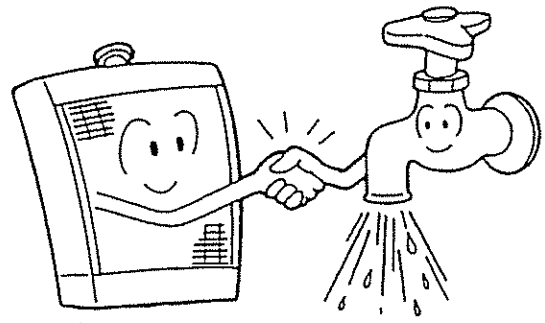
   For concentration of LLC, see the chart below:

Recommended LLC Concentrations (Reference)

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



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

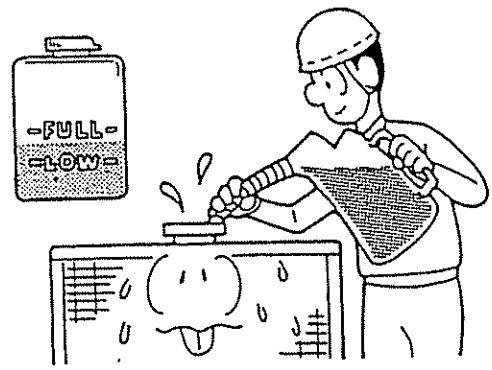


⚠CAUTION

To crank the engine for bleeding, keep the manual stop lever in STOP position (with the fuel supply shut off).

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

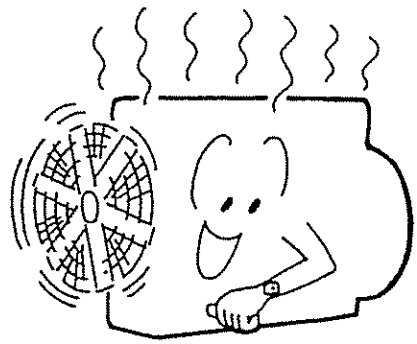
5. Check the coolant level in the radiator and add coolant if necessary. On cooling system with a reserve tank, also fill the reserve tank up to the FULL mark.

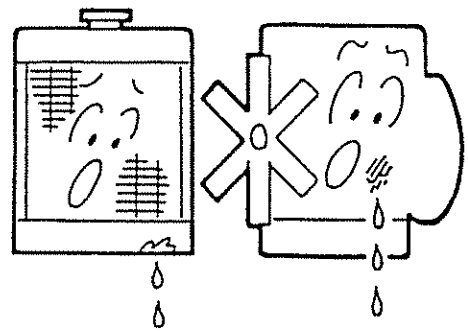


6. Start the engine and run it under light load until the thermostat valve opening temperature is reached to mix LLC with water in the system.
7. Stop the engine and check the coolant level in the radiator or the reserve tank. If the level is low, add coolant.

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

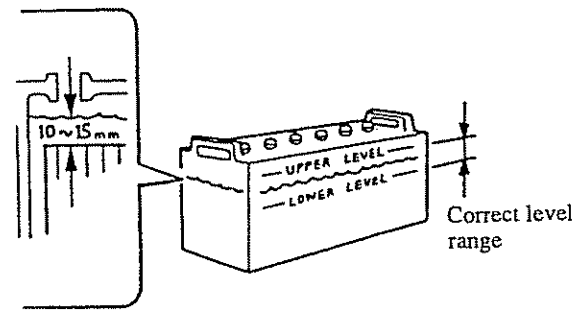
Batteries

⚠ 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

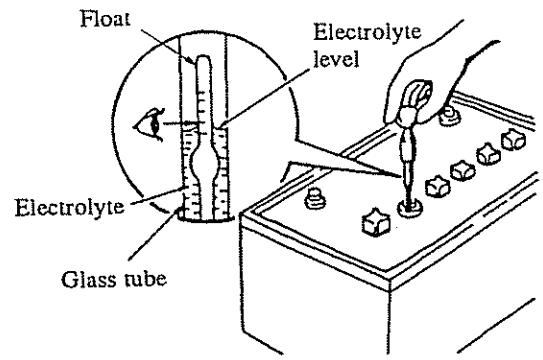
The electrolyte level should be between the UPPER LEVEL and LOWER LEVEL marks on the battery case. If the battery case is not transparent and the inside cannot be seen, remove the vent caps and check the electrolyte level in the cells. The electrolyte should be 10 to 15 mm [0.4 to 0.6 in.] above the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



Check the electrolyte specific gravity

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

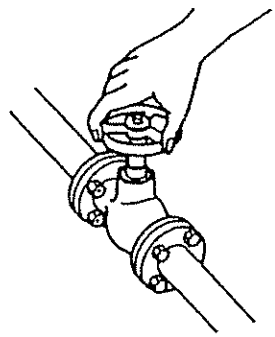
Specific gravity at 20°C [68°F]	State of charge	Correction
1.26 – 1.28	Fully charge	—
1.22 – 1.26	3/4 charged	Recharge.
Below 1.22	Discharged	Recharge.



Valves and Plugs

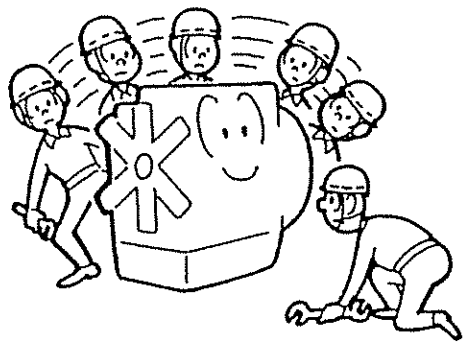
Make sure the following valves and plugs are open or closed properly:

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



Electrical Wiring

Check for loose or damaged terminals or connectors.

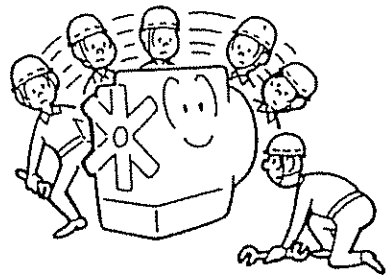


[PRE-START INSPECTION]

Walk-Around Inspection

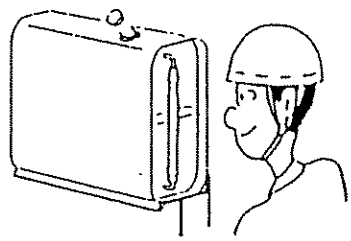
Look around and under the engine for:

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



Check the Fuel Level

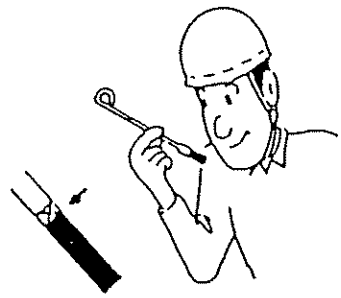
Make sure the fuel tank is full.



Check the Oil Level

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

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



Check the Coolant Level

⚠ WARNING

Check the coolant level only after the engine has been stopped and the radiator filler cap is cool enough to touch with your bare hand.

Remove the filler cap to check the coolant level. The coolant should be visible in the filler neck. On cooling system with a reserve tank, maintain the coolant level up to the FULL mark.

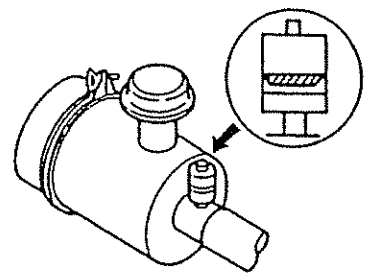
NOTICE: When adding coolant, maintain the specified concentration of LLC. Never add water only.

Check the Fuel Control Link

Check the link to make sure it moves smoothly. Check the ball joints for rattle.

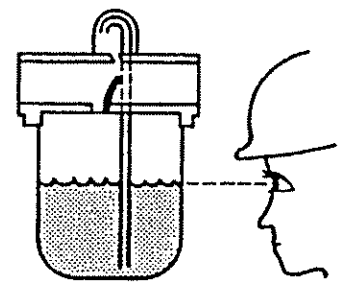
Check the Air Cleaner Dust Indicator

Service the element if the indicator shows red.



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

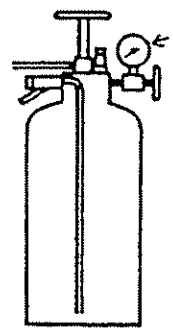
Maintain the oil level to the FULL mark. Add turbine oil (ISO VS32) if necessary to maintain the correct level.



Check Air Pressure in the Air Tank (air-motor type)

Before starting the engine, look at the pressure gauge to make sure the air pressure is correct.

Air pressure: 2.49 MPa (30 kgf/cm^2) [427 psi]



[STARTING]

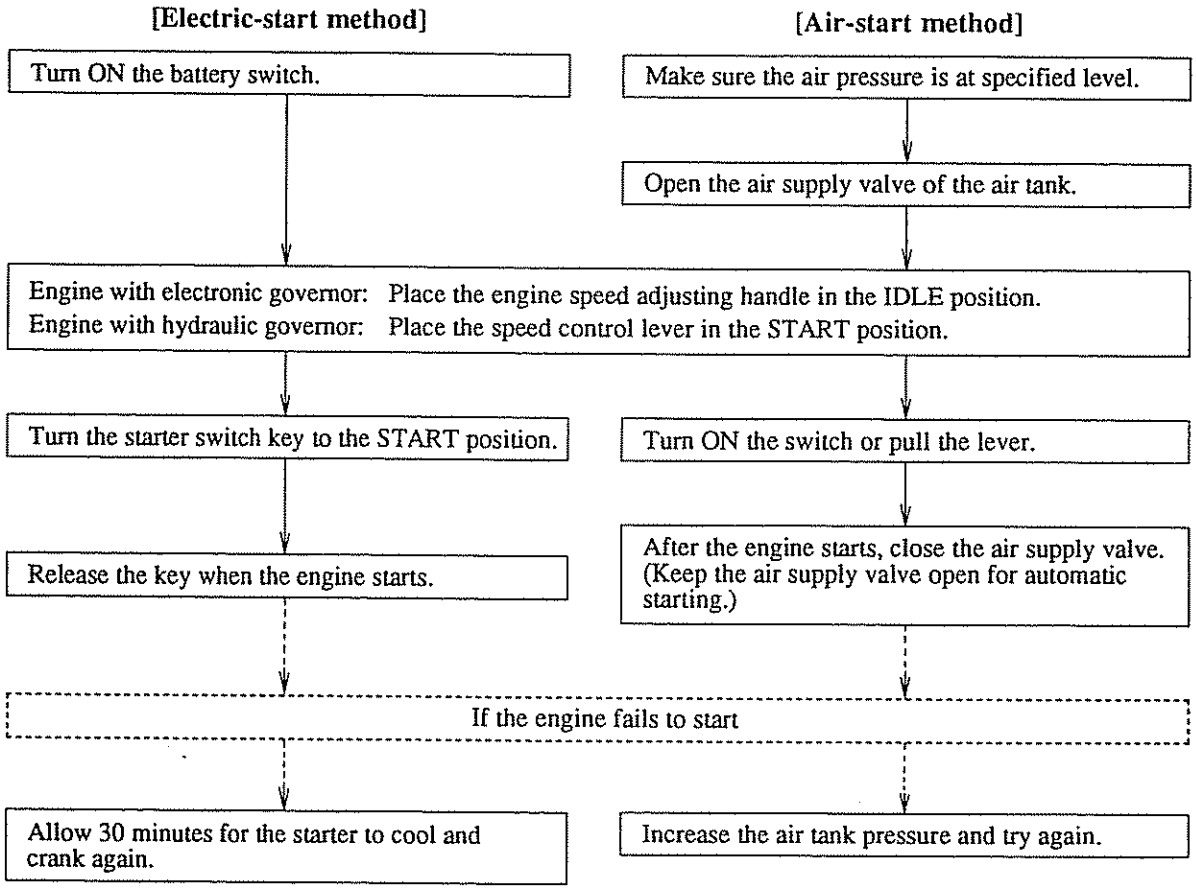
⚠ WARNING

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.**
- **Do not apply load to the engine (disengage the clutch if so equipped) when cranking the engine.**

Two methods of starting the engine, electric-start method and air-start method, are available.

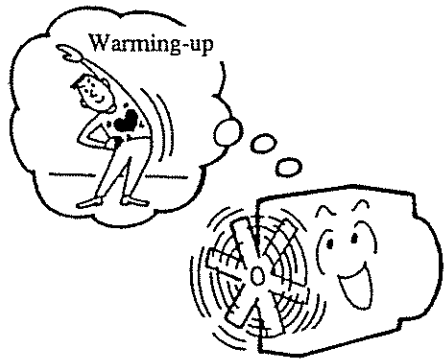


[WARMING-UP]

⚠ CAUTION

- **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.**

- When starting the engine at temperatures below 5°C [41°F], warm it up at low idle speed for 5 to 10 minutes.
- If the engine is started at temperatures below 5°C [41°F] but it cannot be warmed up for 5 to 10 minutes, use an auxiliary device to keep coolant and oil temperatures above 5°C [41°F].
- 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 0.67 MPa (4 to 7 kgf/cm^2) [57 to 100 psi] but it will restore to the normal level as the oil temperature rises.



[OPERATION]

⚠ WARNING

Stay clear of all rotating and moving parts during operation.

⚠ CAUTION

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

Starting the Load

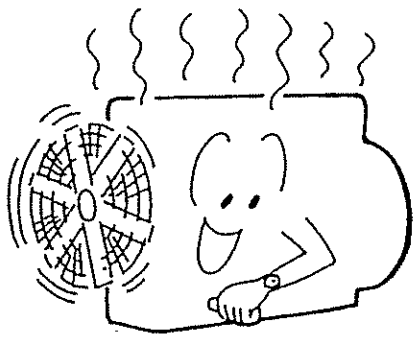
When the engine has run long enough to warm up, bring the engine to operating speed and apply the load. During load operation, check to be sure:

1. 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.

[STOPPING]

⚠ CAUTION

- **Stopping the engine immediately after it has been working under load can result in overheating and accelerated wear of the engine components. Before stopping the engine, operate it at low idle 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 30 seconds 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 lift 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.

  Once a month, run the engine with more than 1/2 load for 15 to 30 minutes.

  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.	44
(The first 50 service hours of new or reconditioned engine)	Check for loose bolts and nuts.	—
	Change oil.	53
	Change full-flow filter and bypass filter.	53
Every 250 service hours	Change oil. (Oil analysis is recommended.)	53
	Change full-flow filter and bypass filter. (The filters must also be changed when oil filter indicator light comes ON.)	53
	Change bypass oil filter.	53
	Change hydraulic governor oil filter.	54
(The first 250 service hours of new or reconditioned engine)	Check valve clearance — adjust.	40
Every 1000 service hours	Change fuel filter (cartridge type)	44
	Check V-belts — adjust.	56
Every 2000 service hours	Check valve clearance — adjust. (Check valve mechanism.)	40
	Check unit injector (governor) rack movement (during operation).	—
	* Change injection nozzle tips.	—
	Check injection timing — adjust.	50
	Change fuel control link ball joints.	52
	Change V-belts.	56
Every 4000 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 fuel feed pump and its drive.	—
	Check turbocharger shaft thrust by turning by hand.	60
	Check starter and alternator.	62
	Check vibration damper.	42
	* 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.	62

Interval	Service	Page
Every 8000 service hours	* Major overhaul Disassemble 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, cylinder liners, main metal cap bolts and washers, piston rings, connecting rod metals, vibration damper and consumable items (gaskets, oil seals, O-rings, etc.) In 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 and connecting rod bushings	—
	* Test unit injections. (Change parts if necessary.)	—
	* Test governor. (Change parts if necessary.)	—
	* Check auxiliary equipment — repair or change. Water heater, oil heater, oil priming pump, fuel transfer pump and governor motor	—
	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.	58
When required	Check radiator fins — clean.	57
	Wash precleaner.	60
	Clean or change air cleaner element.	61
	Clean engine breather inside.	—
	Prime fuel system.	19
	* Check stop solenoid — change.	—
	* Check rubber mounts — change.	—
	* Check coupling — change.	—

[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 (3 to 5 minutes under 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.)	—
Monthly		Check for fuel or water in oil.	—
		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.	—
		Maintenance run (3 to 5 minutes under 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 unit injectors 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.	—
		Check valve clearance — adjust. (Check valve mechanism.)	—
		Check for loose bolts and nuts.	—
		Check vibration damper.	—
		* Check rubber mounts.	—
		* Check foundation bolts	—
		* Check coupling.	—

Interval		Service	Page
Every 1 year	Fuel system	Drain water and sediment from fuel tank.	44
		Drain water from fuel filter (wire element type).	—
		* Check injection nozzle discharge pattern and injection pressure — adjust.	—
		Check injection timing — adjust.	—
	Lubrication system	Oil analysis	—
		Check oil pressure — adjust (during maintenance run).	—
	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.	61
		Check precleaner — wash.	60
	Electrical system	Check starter.	62
		Check alternator.	62
		Check air heater.	—
		* Check battery electrolyte specific gravity.	23
	Air-start system	* Check starter valve.	—
		Check distributor valve.	—
		Check air filter — drain water.	63
		Check solenoid valve — clean.	—
		Check air compressor drive belt.	—
		* Check air tank safety valve operation.	—
	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.		—
	* 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.		—

Interval	Service	Page
Every 2 years	Change oil. (Oil analysis is recommended.)	53
	Change full-flow filter and bypass filter. (The filters must also be changed when oil filter indicator light comes ON.)	53
	Change bypass oil filter.	53
	Change fuel filter (cartridge type).	44
	Change fuel control link ball joints.	52
	* Check thermostat.	—
	Change coolant.	58
	Check turbocharger shaft thrust by turning by hand.	60
	Check muffler — drain water.	60
	* Overhaul air compressor.	—
Every 4 years	* Check oil cooler for dirt build-up, clogging and/or water leaks.	—
	* Visually check oil pump for discoloration.	—
	Change hydraulic governor oil filter.	54
	Wash fuel tank.	—
	* Test unit injectors. (Change parts if necessary.)	—
	* Test governor. (Change parts if necessary.)	—
	Check radiator fins — clean.	57
	Change rubber hoses.	—
	Change air cleaner element.	61
	Change precleaner.	—
	* Check instruments — change. Oil pressure gauge, coolant temperature gauge, oil temperature gauge and tachometer.	—

Interval	Service	Page
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.	—
	* 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.	—

[MAINTENANCE CHART FOR GENERAL DUTY ENGINE]

Interval	Service	Page
Every 50 service hours or monthly	Drain water and sediment from fuel tank.	44
	Drain water from air filter.	63
	Drain water from air tank.	63
(The first 50 service hours of new or reconditioned engine)	Check for loose bolts and nuts.	—
	Change oil.	53
	Change full-flow filter and bypass filter.	53
Every 250 service hours or 1 year	Change oil. (Oil analysis is recommended.)	53
	Change full-flow filter and bypass filter. (The filters must also be changed when oil filter indicator light comes ON.)	53
	Change bypass oil filter.	53
	Change hydraulic governor oil filter.	54
	Check V-belt — adjust.	56
	Check radiator fins — clean.	57
	Drain water from muffler.	60
	Check air tank safety valve.	63
(The first 250 service hours of new or reconditioned engine)	Check valve clearance — adjust.	40
Every 500 service hours or 2 years	Wash air filter.	63
	Change zinc rods.	57
Every 1000 service hours or 3 years	Change fuel filter (cartridge type).	44
	Check valve clearance — adjust. (Check valve mechanism.)	40
	Retighten bolts and nuts. (Refer to the SERVICE MANUAL for tightening torques.)	43
	* Change fuel injection nozzle tips. (Check discharge pattern and injection pressure after replacement — adjust.)	—
	Check fuel injection timing — adjust.	50
	* Check protective devices (high coolant temperature, low oil pressure, overspeeding, etc.)	62
Every 2000 service hours or 5 years	Change fuel control link ball joints.	52
	* Clean air cooler.	60
	Check vibration damper.	42
	* Wash heat exchanger.	57
Every 4000 service hours	* Top overhaul (refer to [Maintenance Chart for Generator Set Prime Power].)	—
Every 8000 service hours	* Major overhaul (refer to [Maintenance Chart for Generator Set Prime Power].)	—
Every 2 years	* Change coolant.	58
When required	Prime fuel system.	19
	Clean air cleaner element.	61
	Wash precleaner — change.	60

⚠ 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]

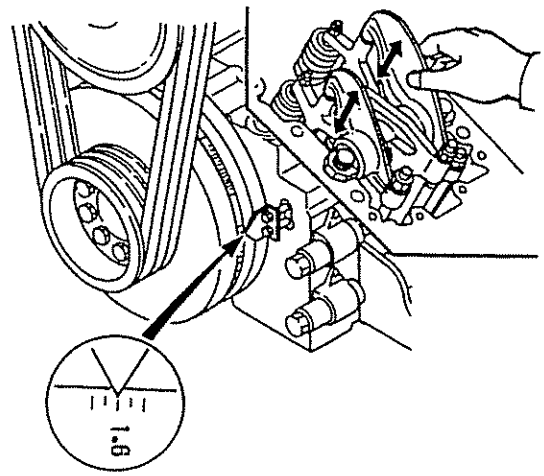
Valve Clearance

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.



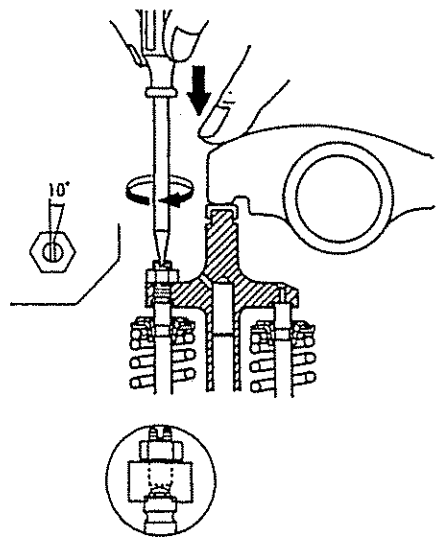
Adjust the height of valves

⚠ WARNING

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

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



Inspection hole

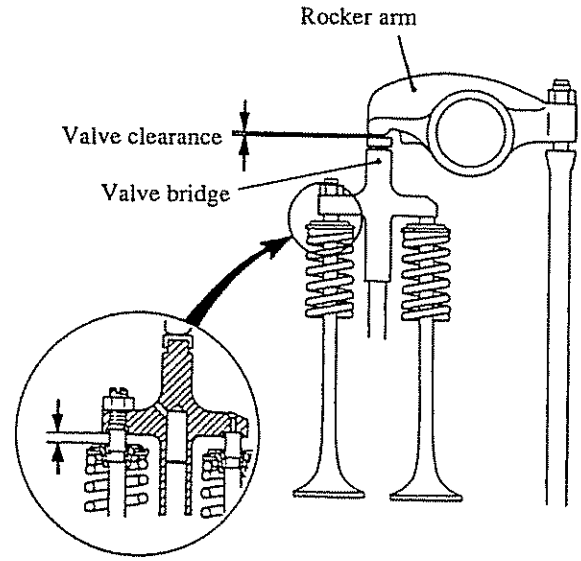
[BASIC BLOCK]— continued

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.]

2. The clearance is correct if the feeler gauge is slightly gripped between the rocker arm and bridge cap. If the clearance is incorrect, adjust it as follows:



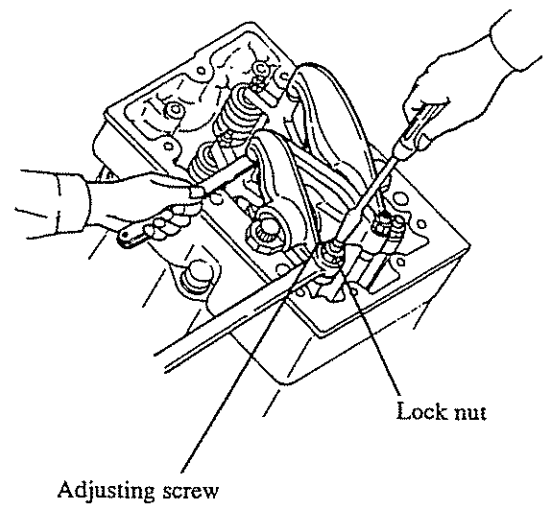
Clearance between bridge and valve rotator

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 the valve clearance in firing-order (injection sequence), with each cylinder piston at top dead center on compression stroke.

Firing order (injection sequence)	1–12–5–8–3–10–6–7–2–11–4–9



[BASIC BLOCK] — continued

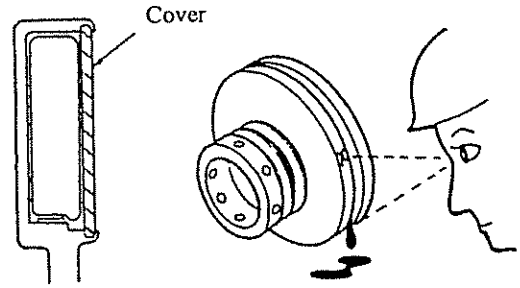
Vibration Damper

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

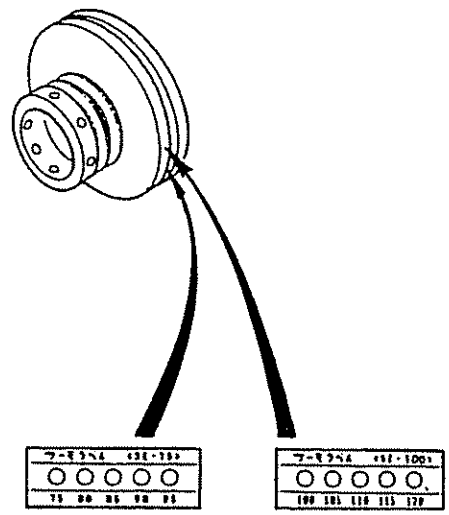
Proper heat dissipation from damper surfaces is essential to damper function. When each engine is shipped from the factory, its damper is verified to be free from abnormal temperature rise. However, damper temperature would rise abnormally in some operating conditions. Make sure the engine operating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

1. In case of a viscous damper, its surface temperature should not exceed 100°C [212°F] on a standby-duty engine or 90°C [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°C [194°F] on a standby-duty engine or 80°C [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°C to 95°C [167°F to 203°F]	32522-04100
Thermo Label 100-120	100°C to 120°C [212°F to 248°F]	32522-04200

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



Thermo Labels

[BASIC BLOCK] — continued

Bolts and Nuts

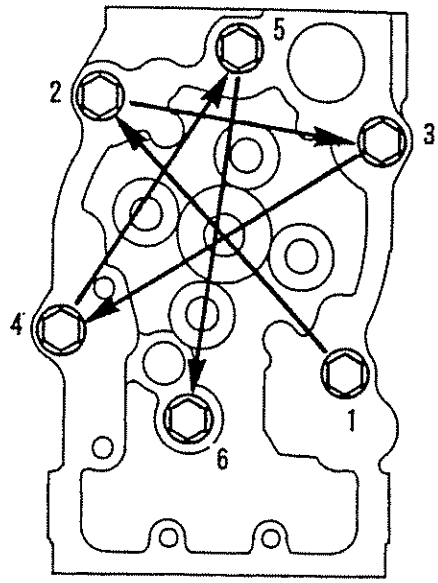
Retighten

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 torques, refer to the SERVICE MANUAL.

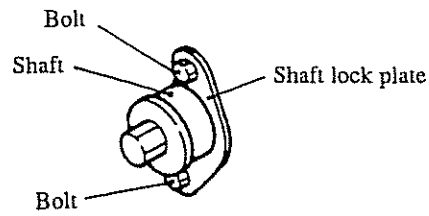


How to Use Turning Gear

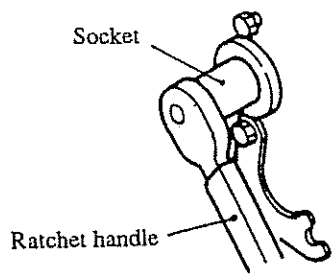
1. Loosen the bolts securing the shaft lock plate and disengage the plate from the shaft (groove). Then, push in the shaft all the way to the TURN position.
2. Put a socket to the hexagonal end of the shaft and turn the shaft with a ratchet handle for turning.
3. After turning the engine, pull the shaft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

⚠ CAUTION

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



Turning gear in RUN position



Turning gear in TURN position

[FUEL SYSTEM]

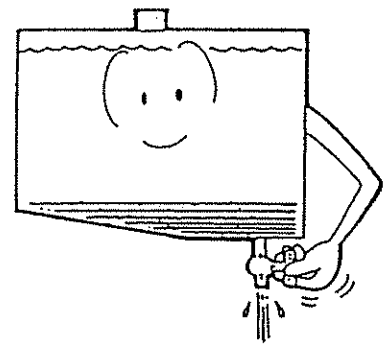
Fuel Tank

Drain water and sediment

⚠ WARNING

- **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.



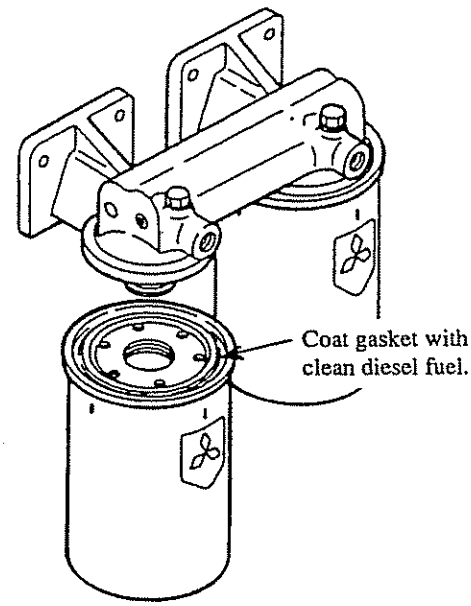
Fuel Filter (Cartridge Type)

Change

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

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

4. Clean the gasket of a new filter.
5. Coat the gasket of 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 1/2 to 3/4 turn more. Be careful not to damage 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. Retighten the filter if leakage is found.



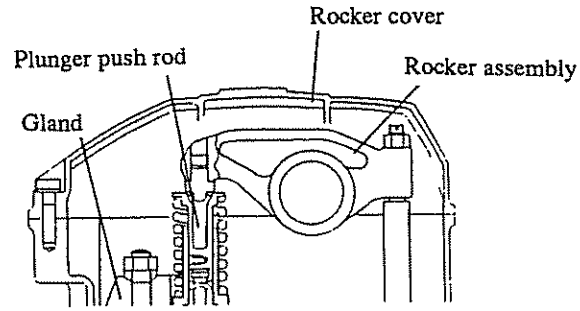
[FUEL SYSTEM] — continued

Unit Injectors

Change

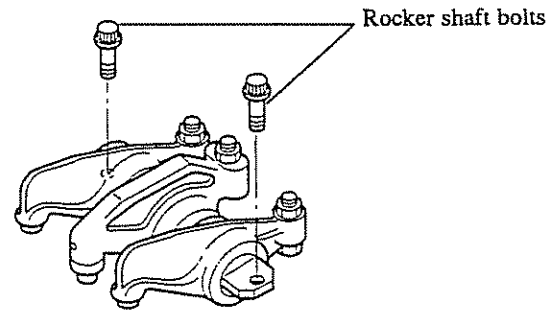
⚠ CAUTION

- **Install a rubber cap to the disconnected end of each fuel pipe to keep dirt out.**
- **Before removing the gland, attach the unit injector puller to the injector body. If the gland is removed before the puller is installed, the injector would jump off.**

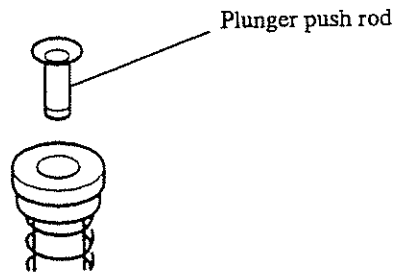


Remove the used injectors

1. Close the fuel supply valve.
2. Remove the rocker cover.
3. Turn the engine to bring the piston of the cylinder on which the injector is to be removed to top dead center on compression stroke. With the piston so positioned, the inlet and exhaust valve rocker arms will not being pushed up by the push rods.
4. Loosen the bolts securing the rocker shaft and remove the rocker shaft assembly. The plunger push rod would sometimes be sticking to the rocker shaft assembly with engine oil. Be sure to remove the rocker shaft assembly, leaving the push rod behind on the injector tappet.

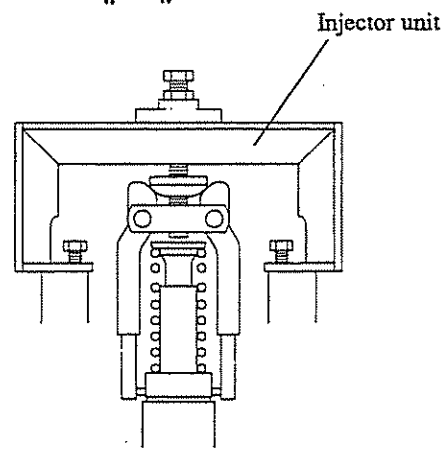


NOTICE: Cover the injector mounting hole in the cylinder head with cloth to prevent parts from falling into the camshaft chambers.



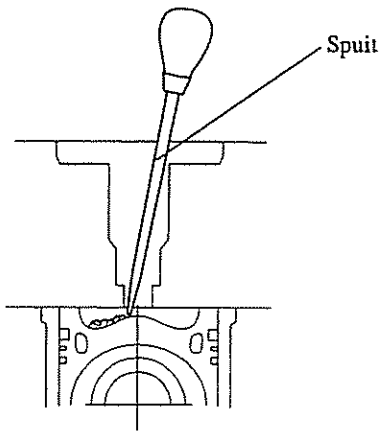
5. Remove the push rod from the injector.
6. Install the puller to the rocker case, gripping the injector body with its jaws.

NOTICE: Check the unit injector puller (35C91-11400) to be sure it is safe to use.



[FUEL SYSTEM] — continued

7. Remove the nut securing the gland and remove the gland.
8. Remove the injector with the puller.
9. After removing the injector, remove the fuel spilled into the combustion chamber with a spuit. (Oil sampling pump (36291-09100) is convenient for removing the fuel.)
10. Remove carbon deposits from the injector mounting hole in the cylinder head.



[FUEL SYSTEM] — continued

Install new injectors

1. Coat the gasket with grease and put it on the injector.

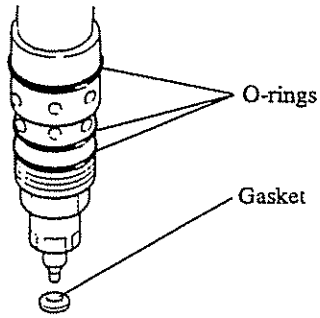
2. Clean the area to keep dirt out of the injector mounting hole in the cylinder head. Dirty mounting hole can cause gas or fuel leaks.

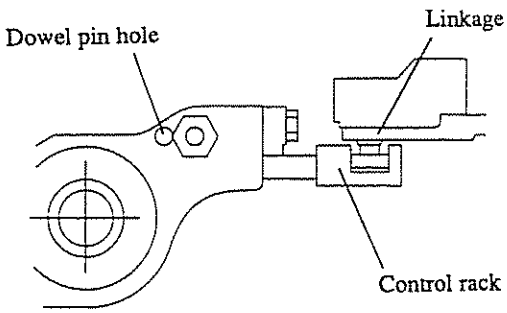
3. Coat the O-rings of the injector with grease or silicone oil.

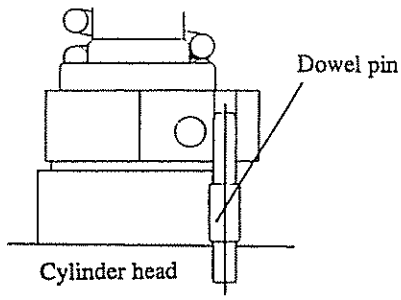
NOTICE: Keep the injector clean. Do not damage the O-rings.

4. Put the injector in the cylinder head, making sure the dowel pin hole, rack and linkage are in alignment.

5. Install the gland and tighten the nut by hand. Make sure the injector is inserted properly — the dowel pin is in position — the gland does not interfere with the injector — and the control rack is properly engaged with the bearing of the link.





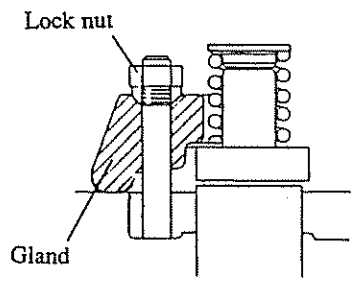


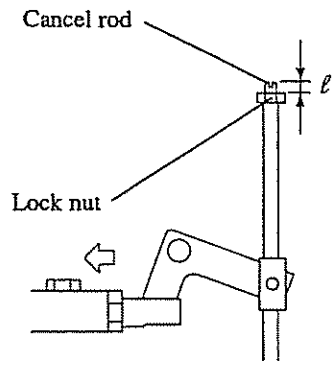
[FUEL SYSTEM] — continued

6. Tighten the lock nut to 98 ± 5 N·m (10 ± 0.5 kgf·m) [72 ± 4 lbf·ft].
7. Adjust the injector linkage as follows:

(1) With the injector rack pressed against the rack stopper (kept in the non-injection position), make an adjustment to the cancel rod to take up free movement in each linkage.

NOTICE: Adjust the exposed length of thread (dimension "ℓ") of the cancel rod within a range of 7 ± 1.5 mm [0.3 ± 0.06 in.]. (Normally, the adjustment can be made within this range.) If the adjustment cannot be made within this range, disconnect the turnbuckle (right-hand only) and do Step (1) above and Steps (2) through (4) below.

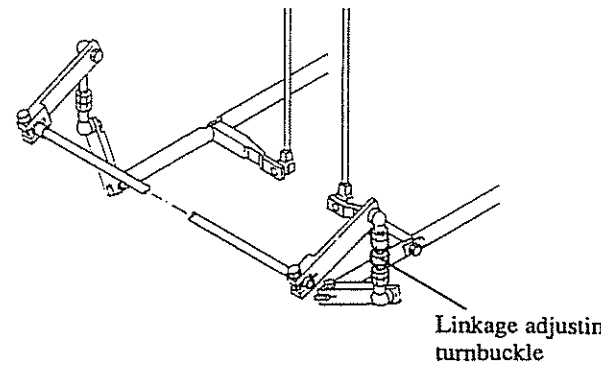




(2) If any part other than the cancel rod lock nut is removed, do Steps (3) through (5) below. Make an adjustment to take up free movement in the left-hand and right-hand linkages and tighten the lock nut.

NOTICE: Do Step (2) above or (3) below with the rack in touch with the stopper. (The rack will move to the non-injection position under its weight.)

(3) Again make sure the racks of the injectors for all cylinders are in touch with the stoppers (in the non-injection position). If there is any rack not in touch with the stopper, do Step (2) above again.



[FUEL SYSTEM] — continued

(4) After doing Steps (1) through (3) above, make sure the electronic governor actuator lever is at an angle of 100 to 115 degrees to the link with the rack in touch with the stopper.

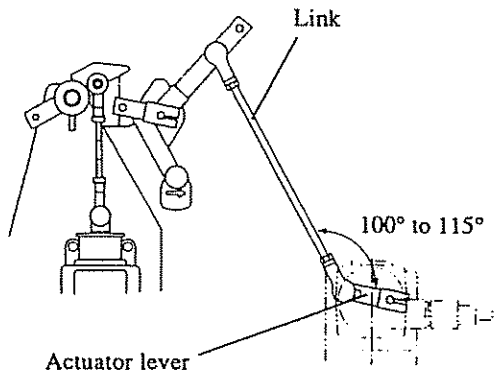
(5) Move the linkage to make sure it is moves smoothly.

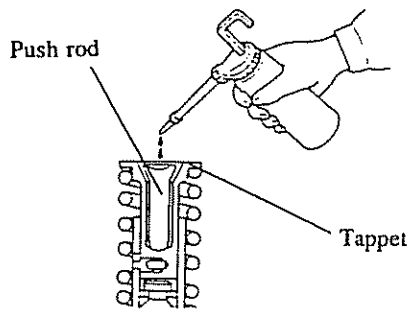
8. Lubricate the moving parts (tappets and racks) of the injectors.
9. Put the push rod in position in the tappet and lubricate the concave end of the rod.
10. After installing all injectors, move the lever to make sure the racks for all injectors move smoothly. (The lever operating effort should be less than 20 N (2.0 kgf) [4.4 lbf].)
11. Prime the fuel system and check the injectors for fuel leaks.
12. Install the rocker shafts and rocker assembly, and adjust the valve clearance and injection timing.

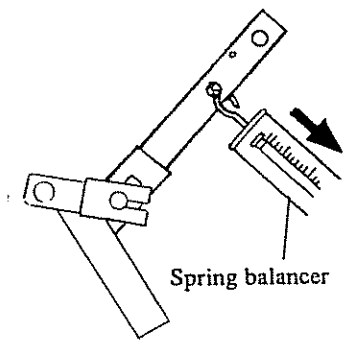
Tightening torque for rocker shaft and rocker assembly bolts	167 N·m (17 kgf·m) [123 lbf·ft]

NOTICE: 1) Be sure to install and adjust one rocker shaft assembly at a time and, after completing the adjustment, turn the engine for the next rocker shaft assembly. If the engine is turned before adjusting, the injector plunger will be pushed up, resulting in sticking of the injector.

2) When turning the engine, make sure the rocker arm does not interfere with the injector tappet or push rod.





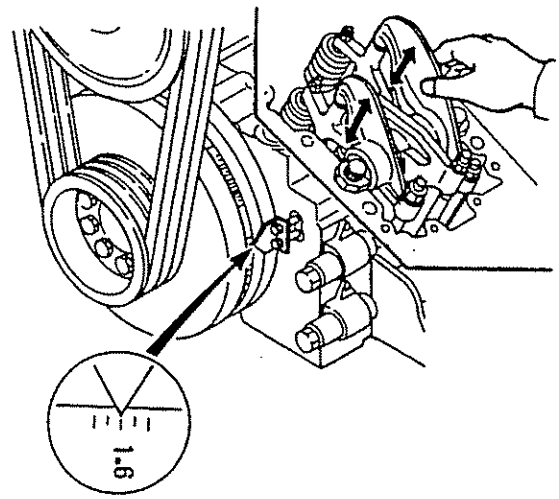


[FUEL SYSTEM] — continued

Injection Timing

Inspect

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

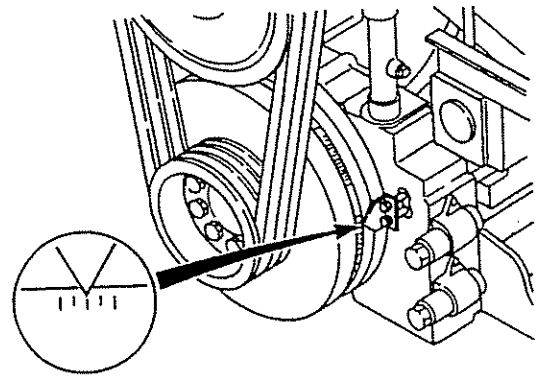


2. Bring the piston for No. 1 cylinder to top dead center on compression stroke as follows:

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

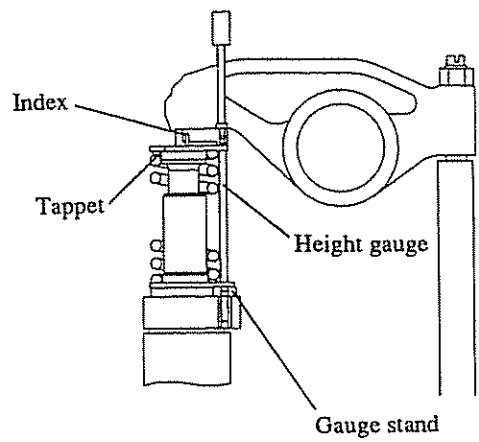
(2) Remove the No. 1 rocker cover and make sure the inlet and exhaust valves for No. 1 cylinder have some clearance. If these valves have no clearance, turn the engine once again to align the timing mark.

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. Insert the height gauge (35C91-01100) into the gauge stand of the injector body and make sure the top of the injector tappet is even with the index of the gauge. Make this inspection on all cylinders.

   If the height gauge is not even with the tappet, make an adjustment as follows:



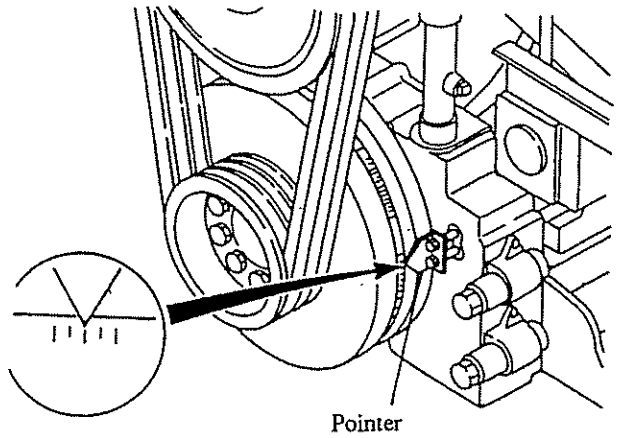
[FUEL SYSTEM] — continued

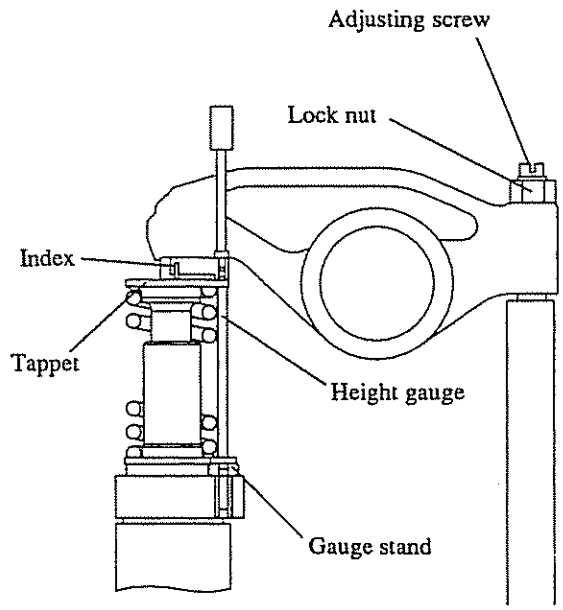
Adjust

⚠CAUTION

Adjust the injection timing of the unit injectors on all cylinders, beginning with the injector for No. 1 cylinder.

1. Make sure the timing mark (indicated on the caution plate) is aligned with the pointer, with the piston for No. 1 cylinder at top dead center on compression stroke.
2. Loosen the lock nut for the rocker arm adjusting screw.
3. With the height gauge (35C91-01100) inserted into the gauge stand of the injector body, turn in or back off the adjusting screw until the height gauge index is even with the top of the tappet.
4. Tighten the lock nut to lock the adjusting screw.
5. Follow Steps 1 through 4 above for remainder of the injectors.
6. Turn the engine (two turns) to recheck the injection timing for verification.





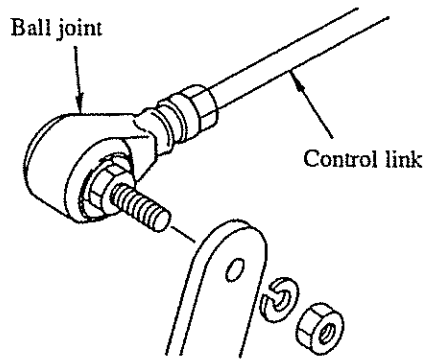
[FUEL SYSTEM] — continued

Fuel Control Link Ball Joints

Change

Change the ball joints with new ones. When installing new ball joints, tighten the nuts securely.

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.



Injection Nozzle Tips

Change

Consult your Mitsubishi dealer.

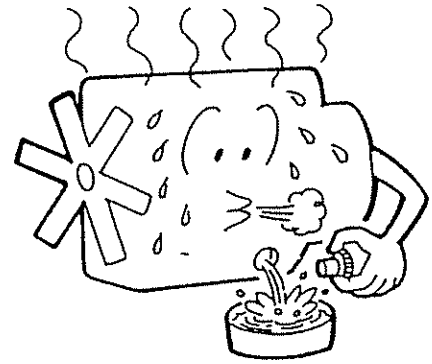
[LUBRICATION SYSTEM]

Engine Oil

Change

⚠CAUTION

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



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.

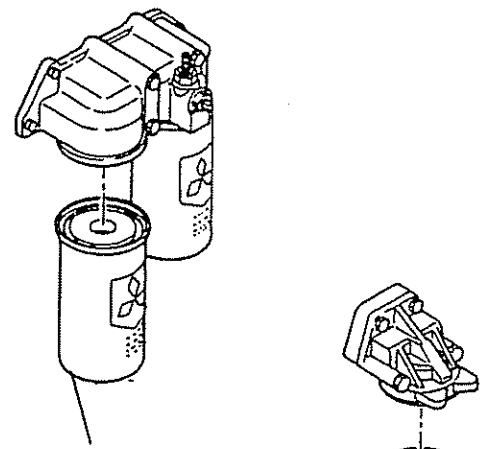
Full-Flow Filter and Bypass Filter

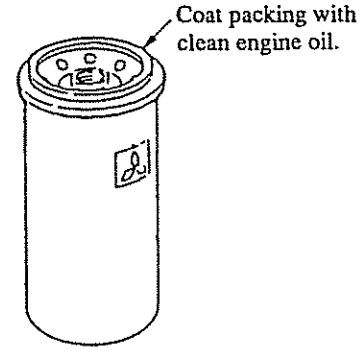
Change

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.



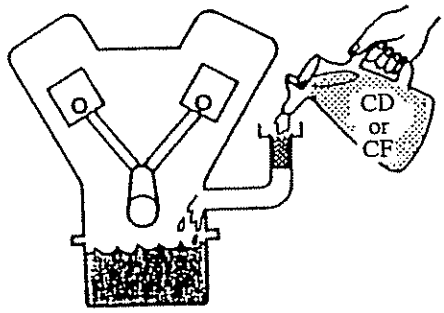


[LUBRICATION SYSTEM] — continued

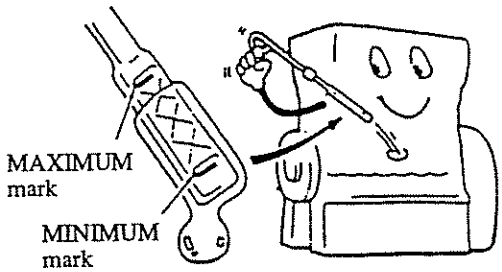
Fill the oil pan

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

Refill capacity (approximate)	Oil pan: 180 liters [48 U.S. gallons] Engine: 200 liters [53 U.S. gallons]
Recommended oil	Oils that meet Engine Service Classification CD or CF



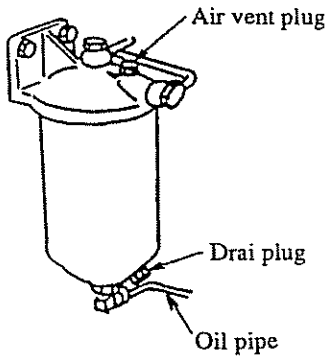
3. Start the engine and run it at low idle for several minutes. Check around the filter cartridges for oil leaks. If oil leakage is found, retighten the cartridges.
4. Stop the engine and wait for about 30 minutes. Then, check the oil level in the oil pan with a dipstick. The oil level should be between the MAXIMUM and MINIMUM marks on the dipstick. Add oil if necessary.

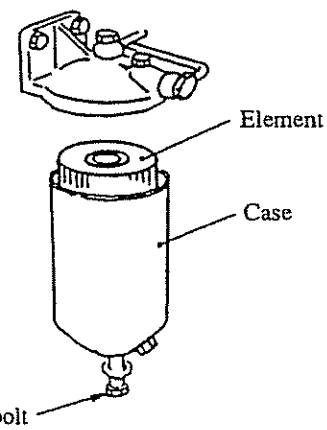


Hydraulic Governor Oil Filter

Change

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

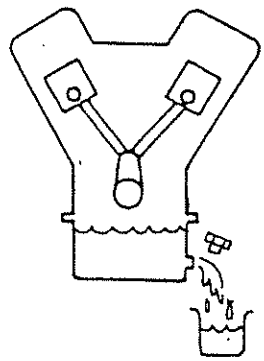




[LUBRICATION SYSTEM] — continued

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]

V-Belts

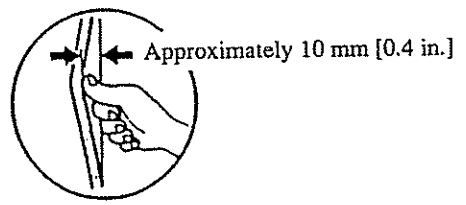
Measure the deflection

⚠ 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.**

Measure the deflection of the belts. Apply approximately 98 N (10 kgf) [22 lbf] force midway between the pulleys. The deflection should be approximately 10 mm [0.4 in.].

Adjust the belts if the deflection is not correct.

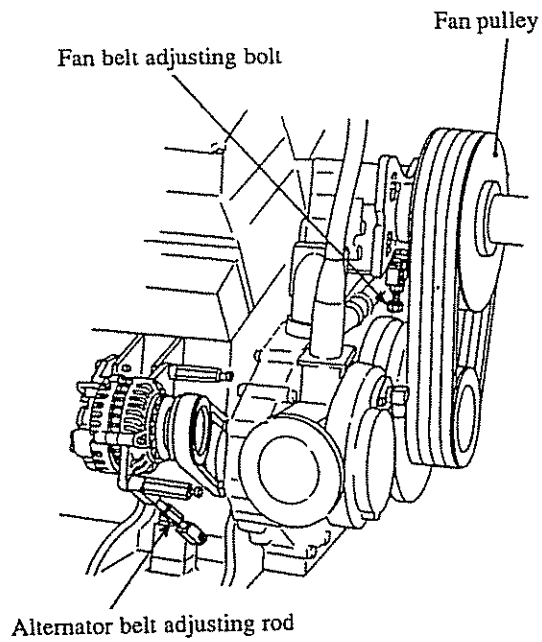


Adjust the alternator drive belt

1. Remove the belt cover.
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.

Adjust the fan drive belts

1. Loosen the fan pulley bracket mounting bolts.
2. Loosen the lock nut of the adjusting bolt, and turn it in or back off to obtain the required belt deflection.
3. Tighten the lock nut and bracket mounting bolts.



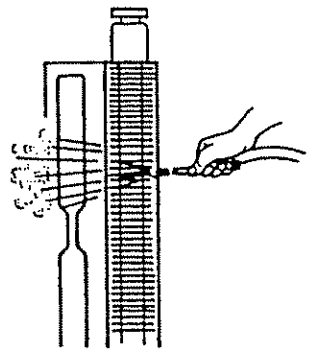
[COOLING SYSTEM] — continued

Radiator

Check/clean the fins

Check the fins for cracks or other defects.

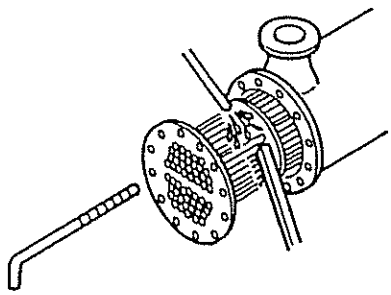
To clean the fins, direct pressure air along the length of fins in the direction opposite to the air flow.



Heat Exchanger

Wash

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

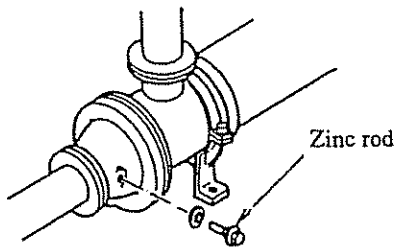


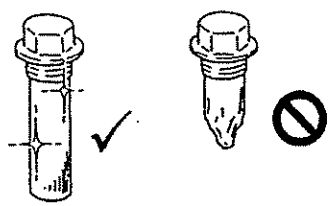
Zinc Rods

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.



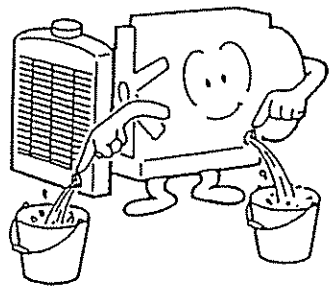


[COOLING SYSTEM] — continued

Coolant

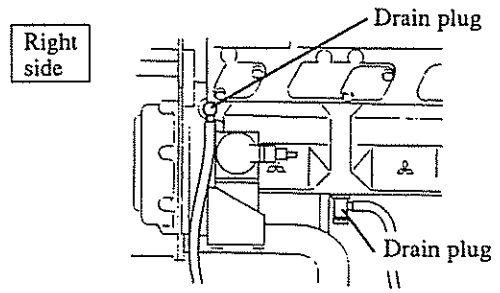
Change

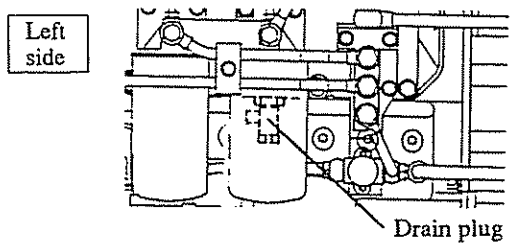
LLC used in the cooling system retains its efficacy for 2 years. Be sure to change the coolant every 2 years.



Drain the coolant

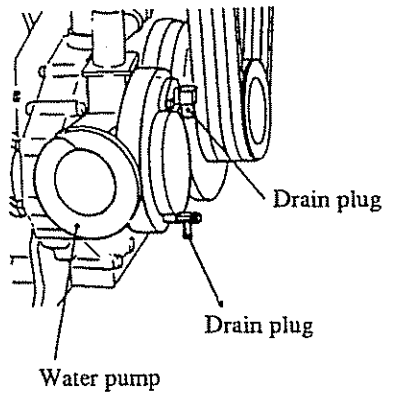
1. Start the engine and operate it until the coolant temperature is 70°C to 80°C [158°F to 176°F]. Stop the engine.
2. Remove the radiator filler cap only after the engine has been stopped and the cap is cool enough to remove with your bare hand.
3. Loosen the engine and water pump drain plugs and remove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

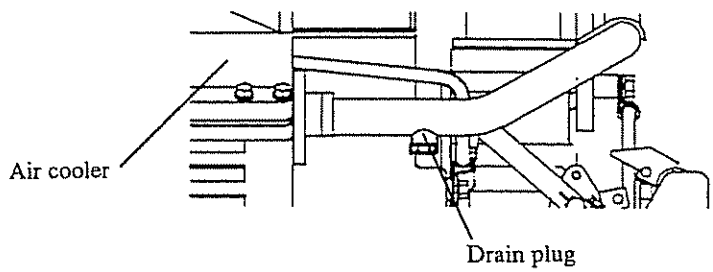




Flush the cooling system

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.



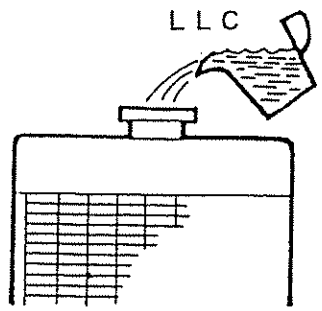


[COOLING SYSTEM] — continued

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.

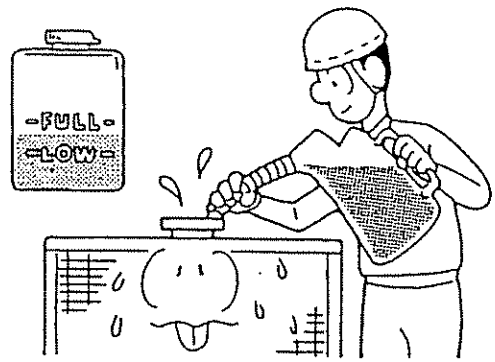
   For concentration of LLC, see the chart below:



Recommended LLC Concentrations (Reference)

Ambient temperature, °C [°F]	-10 (14)	-20 (-4)	-30 (-22)	-40 (-40)
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°C to 80°C [158°F to 176°F]. Stop the engine.
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.

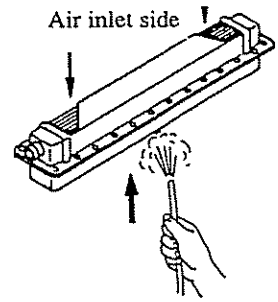


[AIR INLET AND EXHAUST SYSTEMS]

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

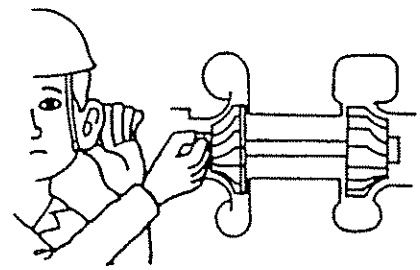
Inspect

⚠ 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.

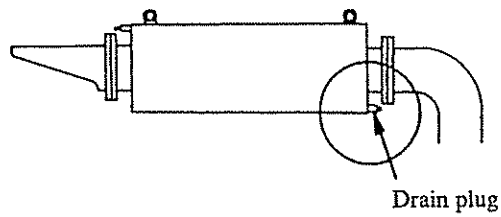
NOTICE: Also check the turbocharger when the exhaust color is abnormal.



Exhaust Muffler

Drain water

Remove the drain plug and allow water to drain.



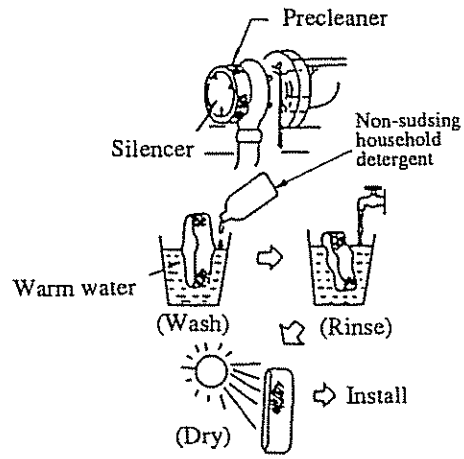
Precleaner

Wash

The precleaner of the silencer built in the turbocharger 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

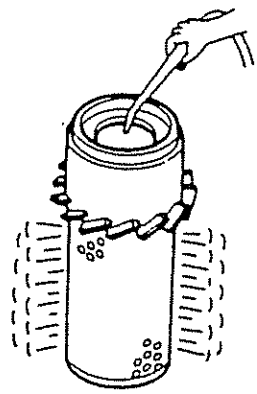
Air Cleaner

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/cm²) [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.



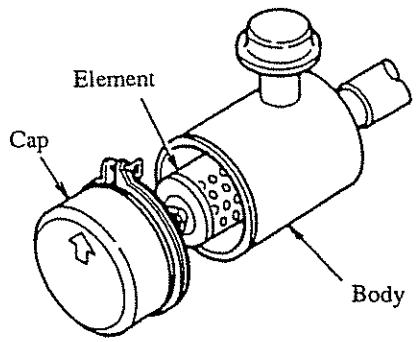
Change Element

⚠ CAUTION

Never service the air cleaner when the engine is running.

1. Remove the cap from the air cleaner body.

   Remove the wing nut securing the element. Remove the used element from the body and discard. Install a new element.



[ELECTRICAL SYSTEM]

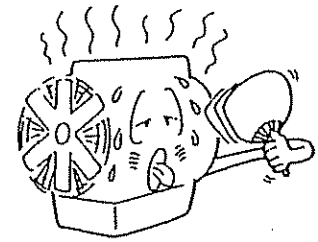
Protective Devices

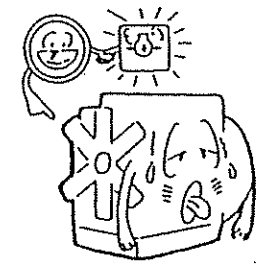
Inspect

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

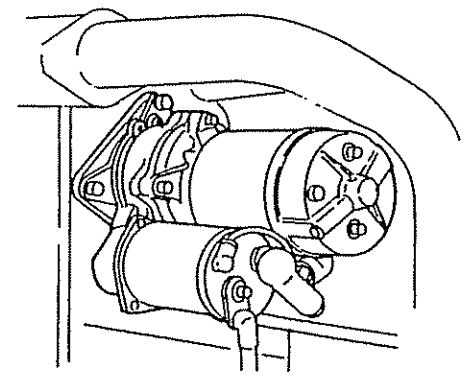




Starter

Inspect

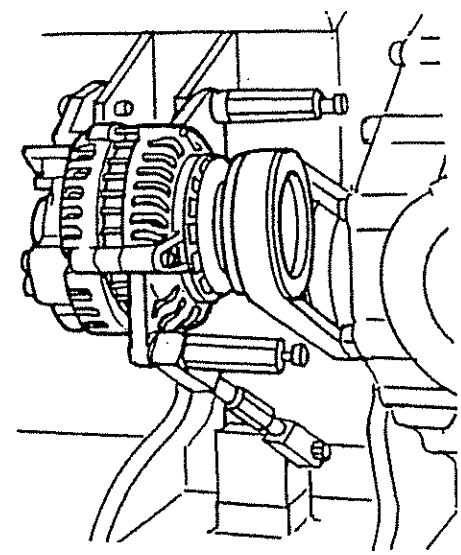
1. Visually check for loose bolts, dirt build-up, broken or worn parts, etc. Blow dirt, if any.
2. Check the pinion for shifting and meshing action. If the starter has a defect, consult your Mitsubishi dealer.



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.

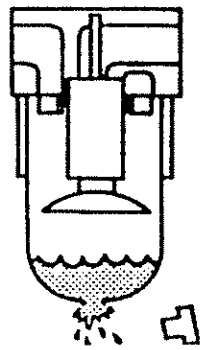


[AIR START SYSTEM]

Air Filter

⚠CAUTION

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



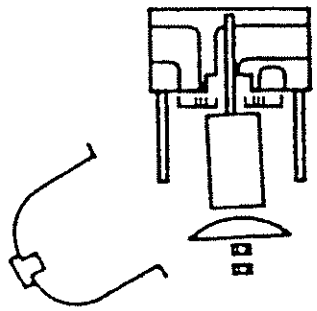
Drain water

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

Wash

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

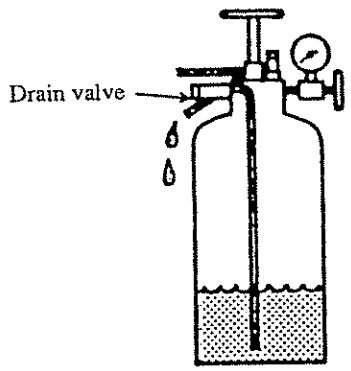
1. Close the starting valve.
2. Remove the cover from the filter. Remove the element from the filter.
3. Wash the element in approved commercial solvent and air dry.
4. Install the element and cover.
5. Open the starting valve by moving the handle slowly.



Air 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	0.93 MPa (9.5 kgf/cm²) [135 psi]

FUEL SPECIFICATIONS

Recommended Type of Fuel

⚠ WARNING

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.

The pour point of the fuel should be at least 6°C [11°F] below the lowest atmospheric temperature at which the engine must start and operate.

NOTICE: Some furnace oils marketed would not be suitable for Mitsubishi engines. In selecting a fuel, consult the "Limiting Requirements for Diesel Fuel Oils"

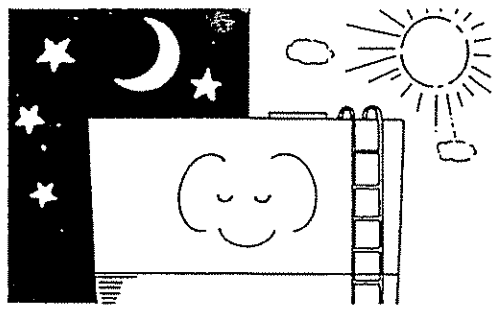
Limiting Requirements for Diesel Fuel Oils

Property	Limit	Remarks
Flash point, min.	Legal	JIS K 2204, 2205 Diesel fuel oil: 50°C [122°F] Furnace oil: 60°C [140°F]
Distillation temperature, 90% point	380°C [716°F], max.	
Pour point	6°C [11°F], min. below the lowest atmospheric temperature	
Cloud point	Below the lowest atmospheric temperature	
Carbon residue on 10% residuum, weight percent	1.0, max.	
Cetane number	45, min.	40, min. under special opening conditions
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, min. at 30°C [86°F]	
Sulfur, weight percent	1.0, max.	
Water and sediment, volume percent	0.1, max.	
Ash, weight percent	0.03, max.	
Copper strip corrosion, at 100°C [212°F], 3 hrs	No. 3, max.	ASTM: No. 3 JIS K 2513: Discoloration No. 3
Gravity, 15/4°C [39°F]	0.80 to 0.87	Reference

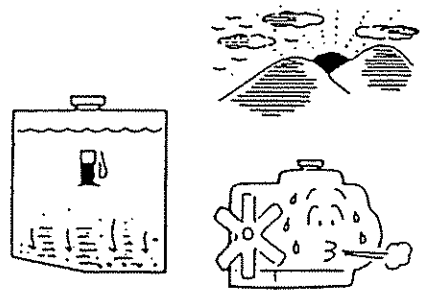
Care of Fuel Supply

⚠ WARNING

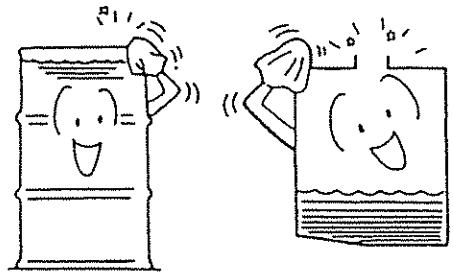
- **Shut down the engine when fueling. Do not smoke while fueling — or when handling fuel containers.**
- **Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire.**
- **After fueling, secure filler cap.**

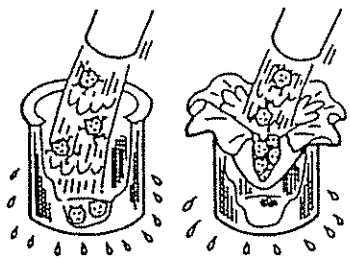


1. Fill the diesel fuel tank at the end of the day. This will drive out moisture-laden air and prevent condensation.

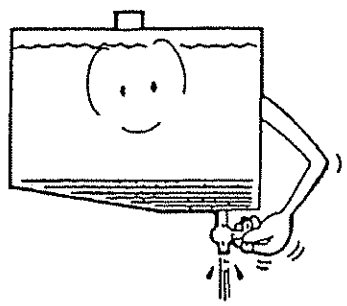


2. When refilling the diesel fuel tank, use clean tools, such as a hand pump, funnels, containers, hoses, etc. Wipe filler cap clean before removing it. When operating the hand pump, keep in mind that there could be water and sediment that has settled to the bottom of storage tank; tap the needed amount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





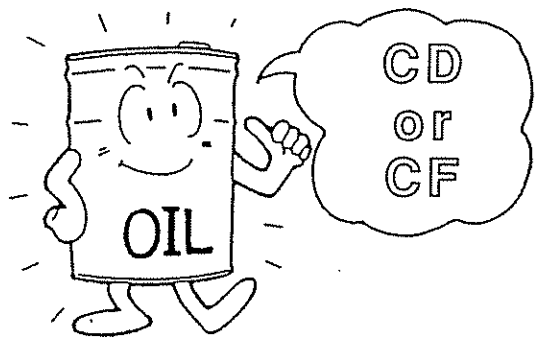
3. Be sure to pour fuel through strainer in the filler opening. Use of a lint-free cheese cloth is a good practice for keeping dirt out.



LUBRICANT SPECIFICATIONS

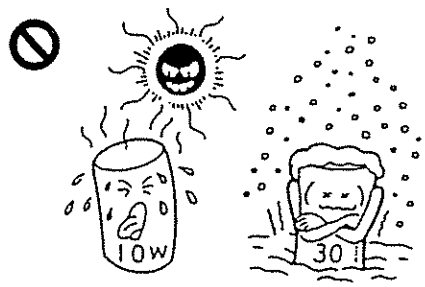
Recommended Types of Engine Oils

Use oils that meet the Engine Service Classification CD or CF. 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.

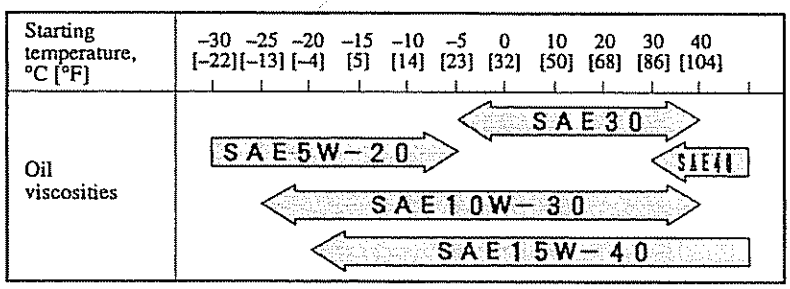


Recommended Oil Viscosities

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



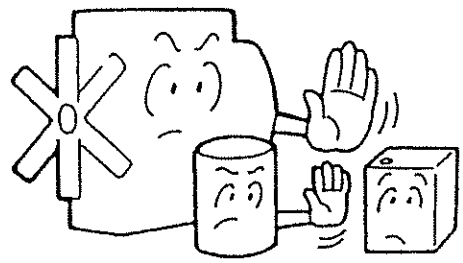
Mitsubishi recommends all-season type engine oil of SAE 10W-30.

Recommended Brands of Oils

Recommended brands of oil are shown in the chart below.

⚠ 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

Recommeded Brands of Oils (Reference)

Manufacturer	Brands
Mitsubishi Oil	Diamond HDS-3 Engine Oil
Shell	White Parrot Super S-3 Oil CD
Mobil	Mobil Delvac 1300
Exxon	Exxon D-3

⚠ 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 properties 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°C [77°F]	—	—	6.5 to 8.5 (6.5 to 8.0)	○	○
Electrical conductivity, 25°C [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

⚠ WARNING

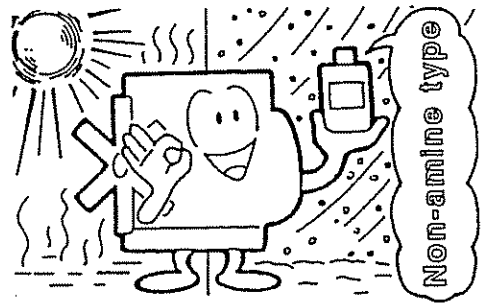
LLC is toxic and can cause personal injury if it contacts skin or eyes. If LLC gets in your eyes, flush them immediately with water and see a doctor at once.

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
Texaco Lub.	LLC Code 7998

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 2 years.)



How to use non-amine type LLC

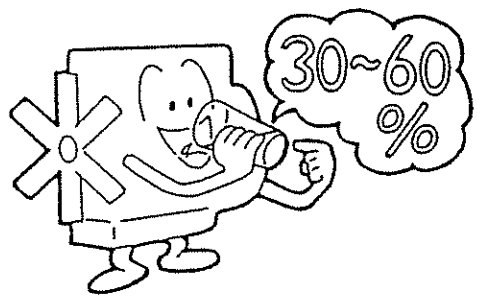
(1) The engine coolant with any of the recommended additives should be changed every two years.

NOTICE: When using any other LLC, refer to the coolant mixture chart on the container.

⚠ WARNING

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

(2) Proper concentration of LLC is from 30% to 60% year-round. Aim at a temperature level lower by 5°C [9°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, °C [°F]	–10 [14]	–20 [–4]	–30 [–22]	–45 [–49]
LLC concentration, %	30	40	50	60

Why LLC?

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

How LLC works

LLC contains several chemicals (ingredients) in such proportions as to produce chemical reactions that suppress corrosion of engine parts in contact with coolant. "Corrosion" is the result of a phenomenon called "ionization."

The power of LLC to defeat the ionic reaction is generally subject to wear and, in the engine coolant, becomes increasingly weak in time.

Moreover, if its chemicals are not well proportioned to match the circuit metals 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, brass and solder, the materials used in the cores of radiator, become

STORAGE

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.
4. Stop the engine. Spray volatile rust preservative (JIS Z1519 or equivalent) in the air inlet opening.
5. Drain the rust preservative-fuel mixture.
6. Apply a coat of rust preservative (JIS K2246 NP-3 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 "DO NOT OPERATE" 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.

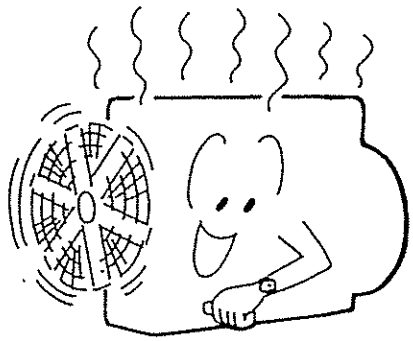
Service During Storage

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 at 800 rpm under no-load condition for 5 minutes.

(3) Operate the engine at 1000 to 2000 rpm under no-load condition for 10 minutes.



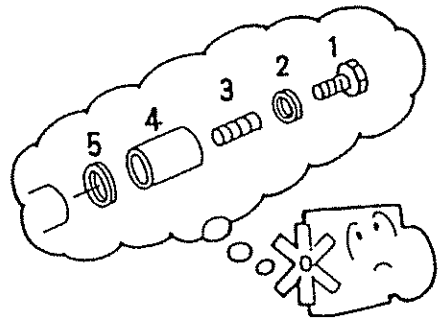
Remove the Engine from Storage

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.

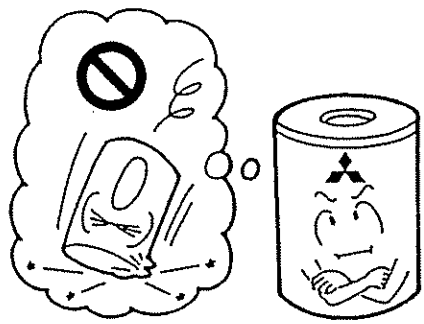


Beware of Dirt and Debris

"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.

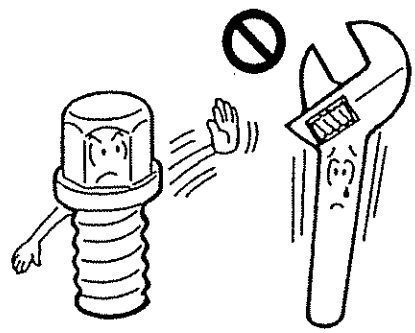
Use Genuine Mitsubishi Parts

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. Lifting eyes are not to be side loaded during a lifting operation.



Electric Start Engine

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

Electrical system

OK

Fuse blown → Replace.

Low oil pressure indicator light

- OFF
- ON → Battery–starter switch circuit open or shorted → Repair or replace.

Battery–starter switch circuit open or shorted → Repair or replace.

Battery discharged → Check alternator drive belt.

Starter or starter relay defective → Consult your Mitsubishi dealer.

Electrolyte specific gravity low → Recharge.

Battery "dead" → Change.

Lubrication system

OK

Oil viscosity too high → Change oil of proper viscosity.

Fuel system

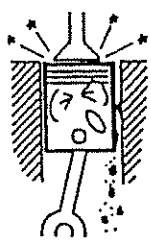
OK

- Air in system → Prime.
- No fuel → Refuel.
- Fuel filter clogged → Change.
- Fuel feed pump defective → Consult your Mitsubishi dealer.
- Unit injectors defective → Consult your Mitsubishi dealer.

Basic block

Running parts defective

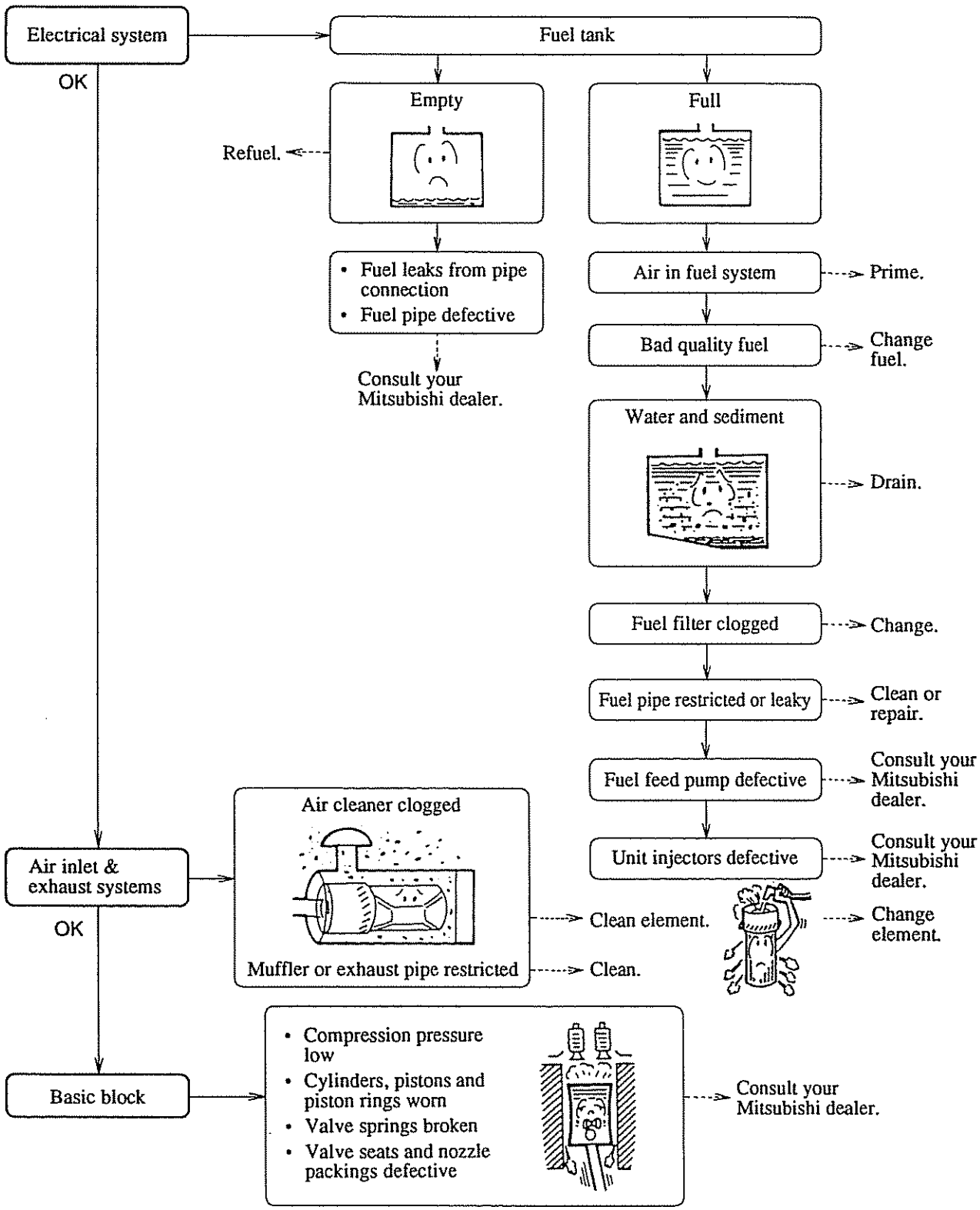
- Interference between pistons and valves
- Foreign matter in cylinders



→ Consult your Mitsubishi dealer.

Electric Start Engine — continued

Starter will crank engine, but engine will not start.



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.

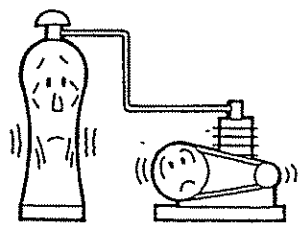
Magnetic valve defective ------> Repair or replace. ------> Consult your Mitsubishi dealer.

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

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

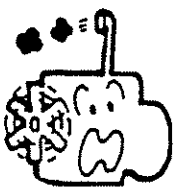
Pinion will engage with ring gear, but it will not run.

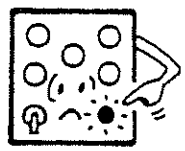
Air pressure low



---> Run air compressor to increase air pressure.

Other Problems

Problem	Cause	Correction
Engine lacks power 	Oil viscosity incorrect	Change oil. (Page 66)
	Bad quality fuel	Change fuel. (Page 64)
	Insufficient air (air cleaner element clogged)	Clean or change. (Page 61)
	Engine overcooled	Use radiator cover or consult your Mitsubishi dealer.
	Fuel filter clogged	Change. (Page 44)
	Engine overheats	Flush cooling system or consult your Mitsubishi dealer.
	Valve clearance incorrect	Readjust. (Page 40)
	Fuel feed pump defective	Consult your Mitsubishi dealer.
	Unit injectors defective	Consult your Mitsubishi dealer.
	Fuel discharge pattern improper	Consult your Mitsubishi dealer.
	Fuel injection timing incorrect	Readjust. (Page 50)
	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. (Page 25)
	Oil viscosity too low	Change oil. (Page 66)
	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. (Page 50)
	Compression pressure low (cylinder liners, piston rings, etc, worn)	Consult your Mitsubishi dealer.
	Bad quality fuel (low cetane number)	Change fuel. (Page 64)
Black or gray exhaust smoke 	Bad quality fuel	Change fuel. (Page 64)
	Valve clearance incorrect	Readjust. (Page 40)
	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. (Page 61)
	Fuel injection timing incorrect	Readjust. (Page 50)
	Fuel discharge pattern improper	Consult your Mitsubishi dealer.
	Unit injectors defective	Consult your Mitsubishi dealer.

Problem	Cause	Correction
High fuel consumption 	Fuel feed pump defective	Consult your Mitsubishi dealer.
	Unit injectors defective	Consult your Mitsubishi dealer.
	Fuel discharge pattern improper	Consult your Mitsubishi dealer.
	Fuel injection timing incorrect	Readjust. (Page 50)
	Bad quality fuel	Change fuel. (Page 64)
	Compression pressure low (cylinder liners, piston rings, etc, worn)	Consult your Mitsubishi dealer.
	Insufficient air (air cleaner element clogged)	Clean or change. (Page 61)
High oil consumption 	Too much oil in engine	Maintain correct oil level. (Page 25)
	Oil viscosity too low	Change oil. (Page 66)
	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. (Page 56)
	Not enough coolant in cooling system	Refill. (Page 25)
	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. (Page 25)
	Oil viscosity too low	Change oil. (Page 66)
	Oil filter clogged	Change. (Page 53)
	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.

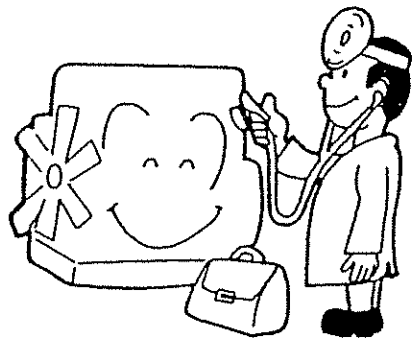
SPECIFICATIONS

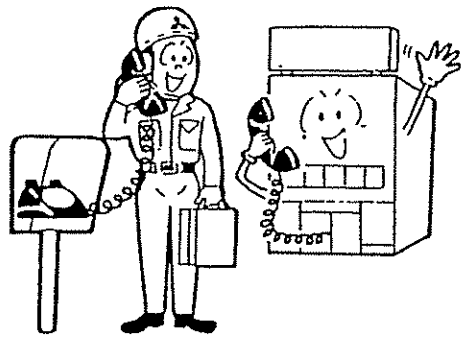
Engine model		S12H-TA	S12H-TK
Type		4-stroke cycle, water-cooled, turbocharged	
		With aftercooler	With intercooler
Number of cylinders – arrangement		12 – V	
Bore × stroke		150 mm × 175 mm [5.91 in. × 6.89 in.]	
Displacement		37.11 liters [2 265 cu in.]	
Fuel injection system		Direct injection	
Compression ratio		14.0 : 1	
Firing order (injection sequence)		1 – 12 – 5 – 8 – 3 – 10 – 6 – 7 – 2 – 11 – 4 – 9	
Rotation		Counterclockwise as seen from flywheel end	
Dimensions (length × width × height)		1 954 mm × 1 472 mm × 1 694 mm [76.93 in. × 57.95 in. × 66.69 in.]	
Dry weight (approximate)		3 900 kg [8 600 lb]	
Fuel system	Fuel	Diesel fuel or furnace oil	
	Fuel feed pump	Trochoid type	
	Fuel filter	Cartridge type paper element	
	Injector	Mitsubishi unit injector	
	Fuel injection nozzle	Hole type	
	Fuel injection pressure	29.42 MPa (300 kgf/cm²) [4 266 psi]	
Lubrication system	Type	Pressure feed	
	Oil	Engine Service Classification CD or CF	
	Capacity (approximate)	Oil pan: 180 liters [47.5 U.S. gallons] Whole system: 200 liters [52.8 U.S. gallons]	
	Oil filter	Cartridge type paper element	
	Oil cooler	Water cooled multi-plate	
Cooling system	Type	Forced water cooling	
	Coolant capacity (basic block) (approximate)	100 liters [26.4 U.S. gallons]	
Starting system	Type	Electric start or air start	
	Electric starter	24 V – 7.5 kW × 2	
Charging system	Alternator	24 V –30 A	
Turbocharger		Mitsubishi TD13-L	
Flywheel		SAE 18 in.	
Flywheel housing		SAE #0	

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.





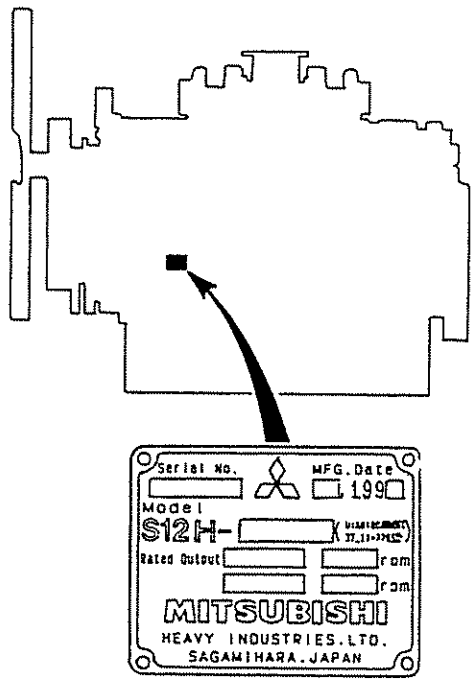
Location of Engine Serial Number

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

Example

Model: S12H
Serial number: 00012

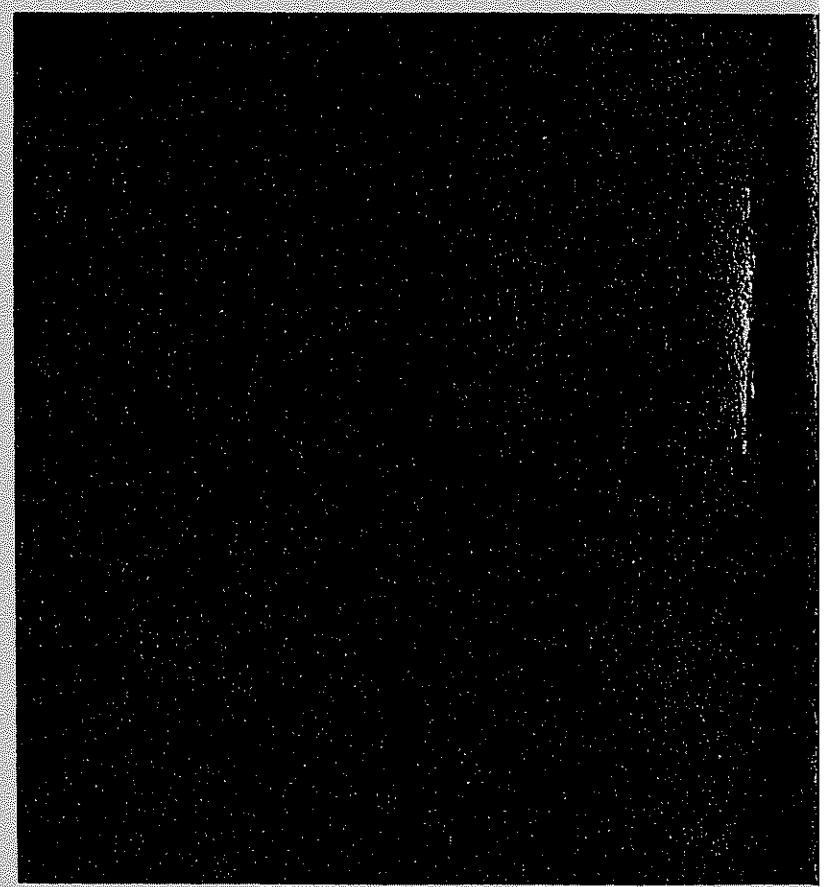
On the nameplate are also indicated the serial number, output, rated speed and other data of the engine.



Scheme of Designating Engine Model

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

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



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