MITSUBISHI DIESEL ENGINE

OPERATION MANUAL

SL-SERIES

S3L,S3L2
S4L,S4L2

Sep. '97

This manual contains operation instructions, and lubrication and maintenance information.

OPERATION section is a reference for the new operator and a refresher for the experienced one. Read — study — and keep it handy. Illustrations guide the operator through correct procedures of checking, starting, operating and stopping the engine. Operating techniques outlined in this manual are basic. Skill and techniques develops as the operator gains knowledge of the engine.

MAINTENANCE section is a guide to engine care. The illustrated, step-by-step instructions are grouped by service intervals. Items without specific intervals are listed under "When Required." Items in the Lubrication and Maintenance Chart are referred to the detailed instructions which follow.

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

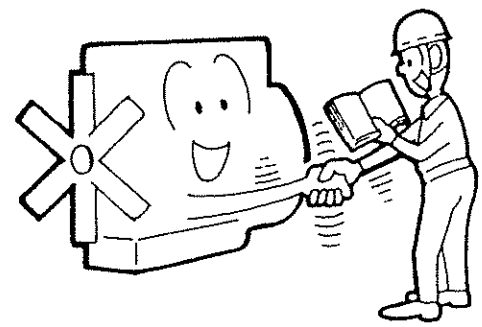
✓ ..... Indicates a proper action or "DO."

⊘ ..... 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:

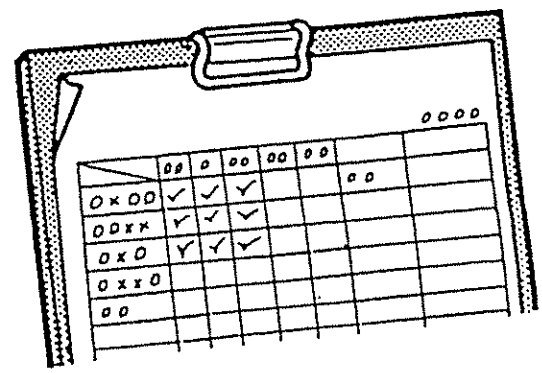
- Effective troubleshooting (to help a serviceman of your Mitsubishi dealer pin-point a trouble).
- Quick servicing and less downtime (to help a serviceman of your Mitsubishi dealer save time (cost) for servicing)
- Grasp of operating conditions (to help you recognize conditions, signs or indications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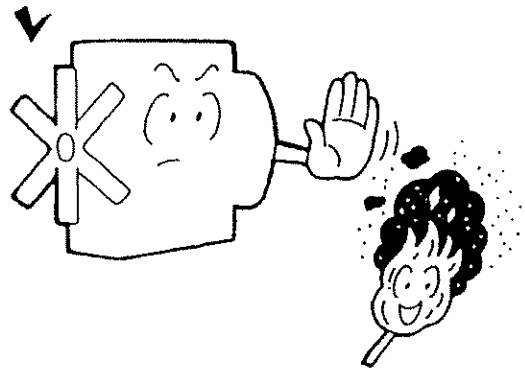
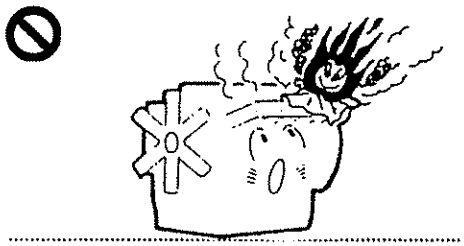
⚠ DANGER Prevention of Fire and Explosion

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

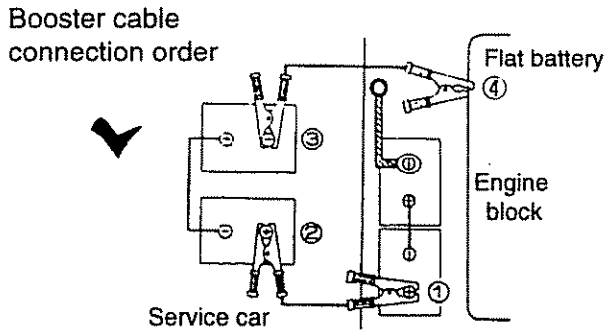


⚠Do not fill fuel tank while engine is running!
Shut off the engine when fueling, and use extra caution if the engine is hot.

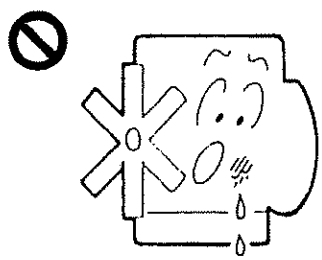
⚠Do not bring close to flammable materials!
Do not put flammable materials on hot parts of the exhaust pipe. Keep them away from the pipe. In addition, do not operate the engine in areas where flammable materials are present.



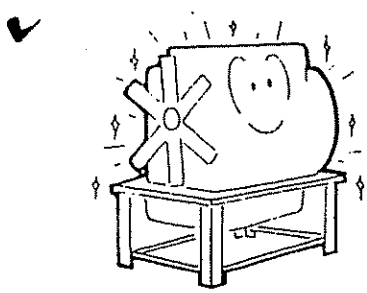
⚠Connect the battery earth cable carefully!
When starting the engine using another battery, connect the earth cable (negative terminal) last to the engine block. If it is accidentally connected to the negative terminal of the mounted battery, a spark may occur, igniting the explosive gas produced by the battery. After starting the engine, disconnect the earth cable first.



⚠Always watch out for fuel or oil leaks!
If your checks uncover any leaks, take corrective measures immediately. If fuel or oil spills on the hot the engine, fire may occur, resulting in personal injury or damage to equipment.

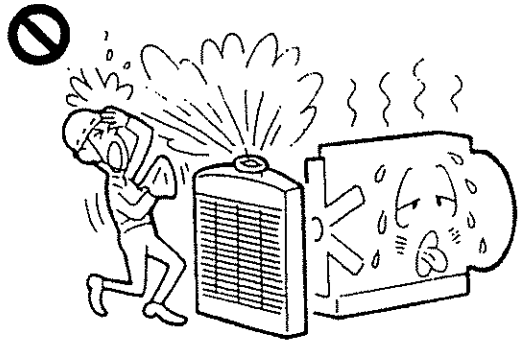


⚠Keep the engine and its compartment clean!
Remove all flammable materials such as fuel, oil, and other debris, before they accumulate on the engine.

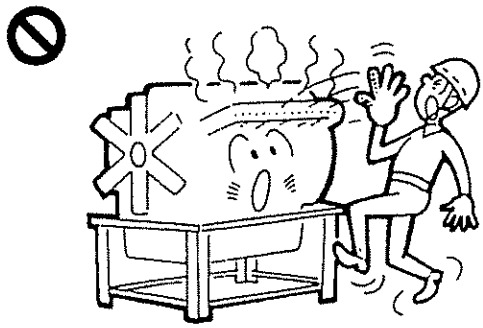


⚠ DANGER Burn Prevention

⚠Remove the radiator filler cap carefully!
At operating temperatures, 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 filler cap is cool enough to touch with the bare hands. Grip the cap with a cloth and remove it slowly to relieve the pressure gradually.

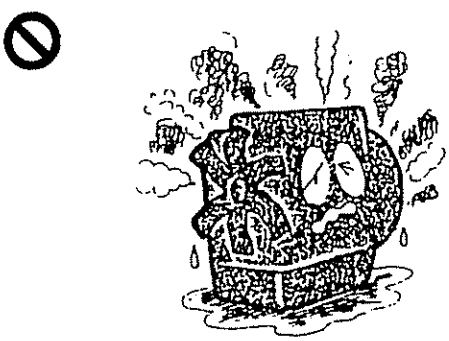


⚠Do not touch hot components!
At operating temperature, the engine components become very hot. Avoid any contact during operation. Service the engine only after it has been stopped and components are cool enough to touch with the bare hand.



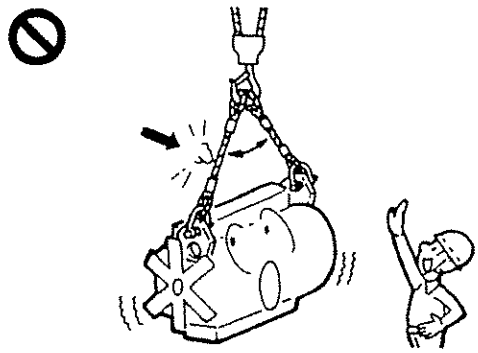
⚠Avoid burns!
Do not change oil or coolant immediately after completing operations. Hot oil or coolant may burn the skin. Allow the engine to cool to room temperature before replacement.

⚠Turn off the battery switch before servicing!
Be sure to turn OFF the battery switch before servicing.
If electrical equipment, including the starter or alternator, is serviced with the battery switch turned ON, it may be shortcircuited by current from the battery's positive terminal, resulting in burns or fire.



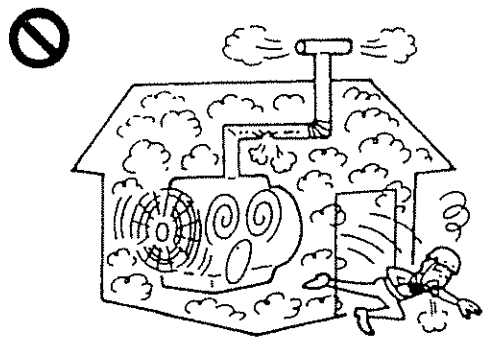
⚠ DANGER  Lifting Precautions

⚠Lift the engine carefully!
Never allow anyone to walk or stand underneath a suspended engine.
Operate the hoist carefully without jerking it.
Remember, sudden impact of loads can cause serious accidents.

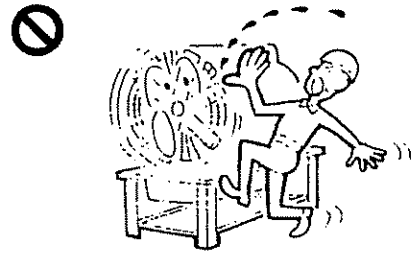


⚠ WARNING  Exhaust Fumes

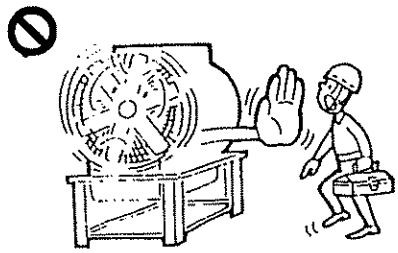
⚠Exhaust Fumes
Operate the engine only in safe areas!
Operate the engine in a well ventilated area. Never operate it in an enclosed area. In particular, do not operate it near an exhaust port on the downwind side.



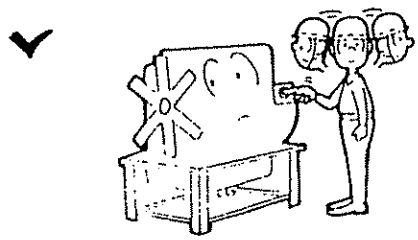
⚠WARNING Prevention of Cuts and Other Injuries



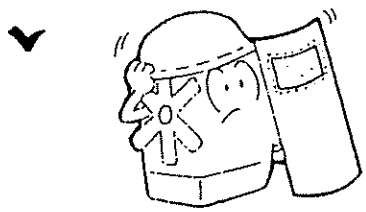
⚠Stay clear of all rotating and moving parts!
The rotating parts of the engine are dangerous. Always stay clear of them during operation.



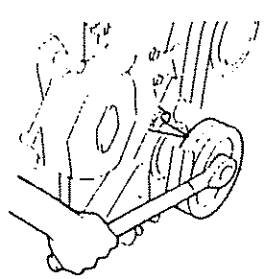
⚠Use care during checking and servicing!
Before performing maintenance, remove the starter switch key and turn OFF the battery switch. Attach a "DO NOT OPERATE" or similar warning tag to the starter switch.



⚠Ensure that everything is in order before restarting the engine!
Clear all personnel from the engine and area. Remove all foreign material from the engine, such as debris, oil, tools and other items which are not part of the engine.



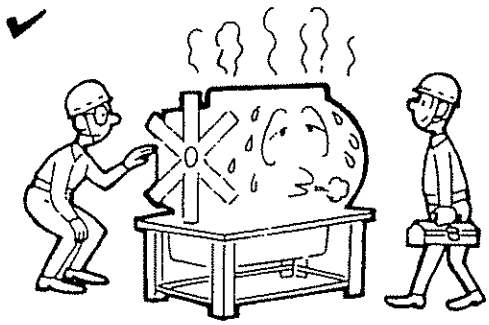
⚠Install the protective covers!
Make sure all protective covers and guards are installed over rotating parts to prevent personal injury.



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

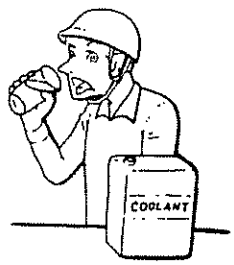
⚠ WARNING Maintenance Precautions

⚠Stop the engine before servicing it!
Always stop the engine before adding or changing oil, coolant, or fuel. Check the coolant level only after the engine has been stopped and the radiator filler cap is cool enough to remove with the bare hands. Never attempt to adjust the fan belt while the engine is running.



⚠Handle battery electrolyte carefully!
If battery electrolyte contacts the eyes or skin, wash clean immediately using plenty of water. If it contacts the eyes, wash immediately and then see a doctor.

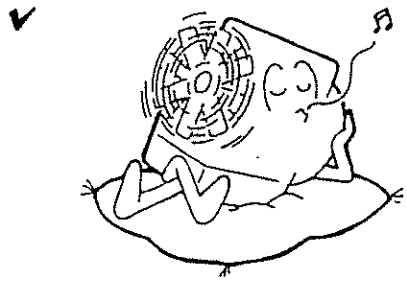
⚠Handle antifreeze carefully!
If you accidentally drink antifreeze, make yourself vomit and see a doctor immediately. If antifreeze contacts the eyes, wash clean immediately using plenty of water, and then see a doctor.



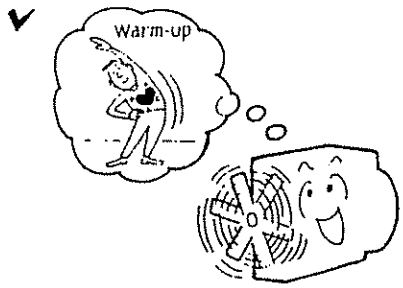
⚠Dress properly for the job!
You may need any number of special items - hard hat, face shield, safety shoes, goggles, heavy gloves, ear protectors, etc. - for your own protection.

⚠ CAUTION Operating Precaution

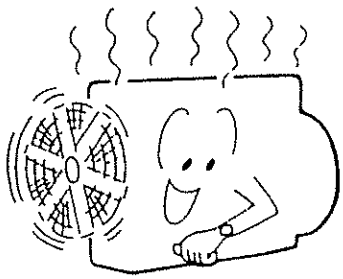
⚠Be sure to break in the engine!
During the first 50 hours of operation, break in the engine by using lighter loads and lower speeds than normal. Proper break-in contributes to the maximum service life of the engine.



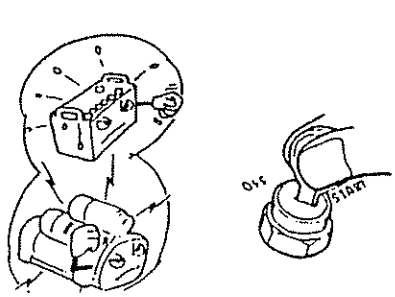
⚠Warm up the engine before operation!
After starting the engine, warm it up at low idle for 5 to 10 minutes before operating under full load, for maximum engine life.
NOTE: Long periods of warming up the engine are not recommended. This can deposit carbon in cylinders and cause incomplete fuel consumption.



⚠Stop the engine only after cooling it down!
Stopping the engine immediately after it has been working under load can result in overheating and accelerated wear of engine components. Before stopping the engine, run it at low idle for 5 to 10 minutes. This allows the hot areas in the engine to cool gradually, extending engine life. With the engine running, make a walk-around inspection, checking for any abnormality.



⚠Use the starting motor correctly!
When the starting the engine, do not crank it for more than 10 seconds at a time. After each 30 seconds of engine cranking, allow 30 seconds for the starting motor to cool before cranking again.

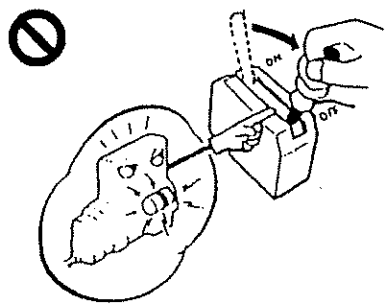


⚠ CAUTION Operating Precaution

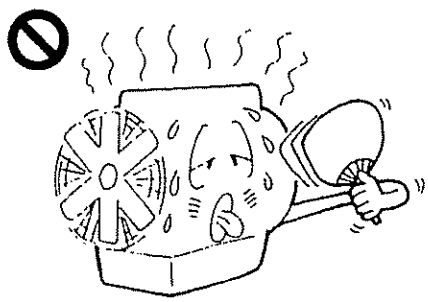
⚠Do not break seals for settings!
Never attempt to break the seals of the fuel injection pumps (governors) controlling injection quantity and minimum and maximum speed settings. Breaking these seals and varying settings could result in:

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

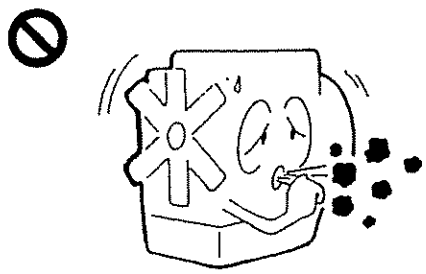
⚠Do not turn OFF battery switch during operation!
Do not turn OFF battery switch when the engine is running to avoid damage to alternator diodes and transistors. This could also result in failure of instruments to work properly.



⚠Always keep the engine compartment well ventilated!
Unless the engine compartment is properly ventilated, the air supply will be inadequate, resulting in shortage of air for fuel combustion and loss of power.



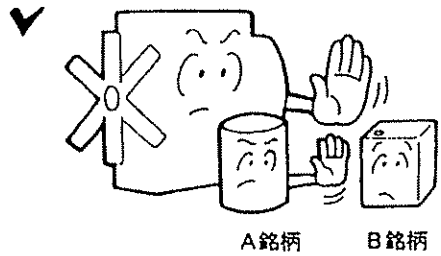
⚠Avoid overloading!
This can cause incomplete combustion, often indicated by black smoke, high fuel consumption and carbon deposits in the combustion chambers, adversely affecting engine life.



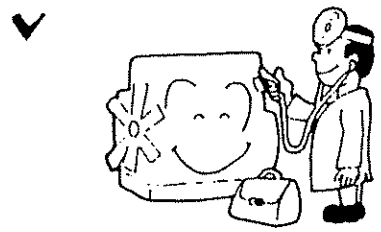
⚠ CAUTION Maintenance Precautions

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

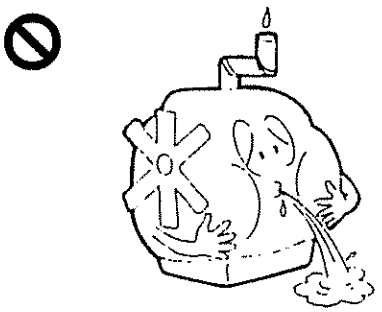
Brand A Brand B



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

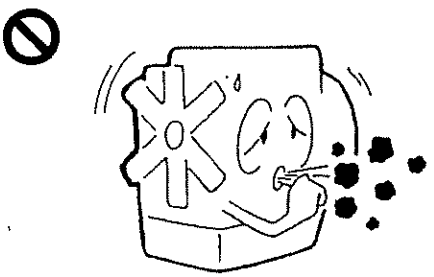


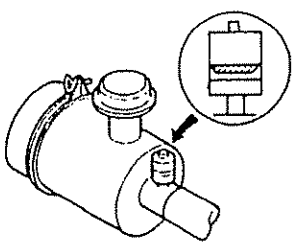
⚠Keep water out of the engine!
When washing the engine, cover the air inlet and exhaust opening with tape to prevent water or cleaning agent from getting inside the engine. Do not wash the engine while it is running. If water or cleaning agent get inside the combustion chambers, the hammering action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



⚠Keep grit-laden air out of the engine!
Dust and dirt entering the engine will cause early wear of moving parts with a resultant loss of power, high oil consumption, problems starting and other failures. Service the air filter as instructed.

1. Do not service the air filter while the engine is running.
2. When removing the air filter element for servicing, prevent dust from entering the air intake to the cylinders.
3. For air filters equipped with a dust indicator, service the part only when the indicator shows red. Over-frequent servicing can cause damage.

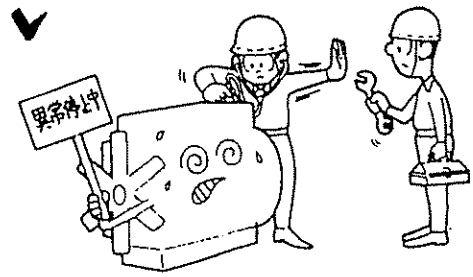




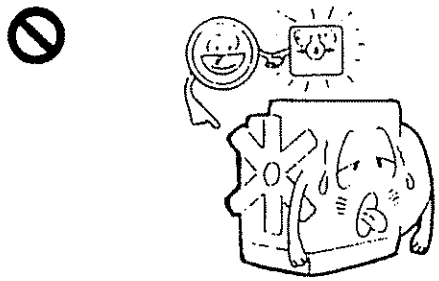
⚠ CAUTION If Any Trouble Should Occur

⚠If the engine stops unexpectedly:
Do not restart the engine immediately after it has stopped unexpectedly. Check for the cause and make needed repairs before restarting. Failure to follow this precaution can cause serious engine problems.

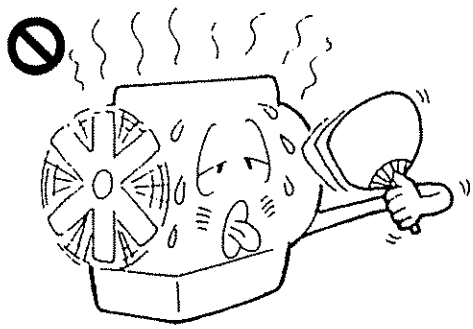
ABNORMAL STOP



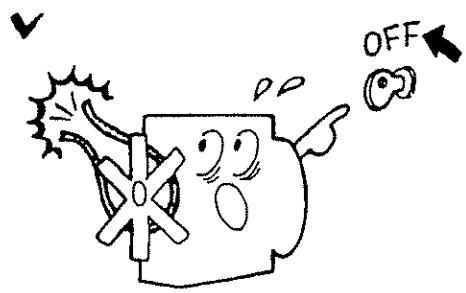
⚠If engine oil pressure is low:
Stop the engine immediately and check the lubrication system. Operating the engine with low oil pressure can cause seizure of bearings and other parts.



⚠If the engine overheats:
If the engine overheats, do not stop it suddenly. Stopping an overheated the engine suddenly can result in steep rise in coolant temperature and seizure of running parts. First operate the engine at low idle to allow the hot areas in the engine to cool slowly, then gradually add coolant. Remember, adding coolant to an overheated engine can cause cylinder head damage.



⚠If fan belt is broken:
Stop the engine immediately. Operating the engine with a broken fan belt can cause coolant to burst out of the reserve tank and radiator (condenser), resulting in engine overheating.



Operating Engine Properly

1. Never attempt to break the seals of the injection pump governor for maximum speed and maximum injection quantity settings. Breaking these seals and varying the settings could result in —

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

2. 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.
3. Start the engine properly. After every 10 seconds of engine cranking, allow 30 seconds for the starting motor to cool before cranking again.
4. After starting the engine, warm it at slow idle for five to 10 minutes before operating under full load, for maximum engine life.

NOTE

Long periods of warming up the engine is not recommended. This can result in carbon deposits in the combustion chambers and incomplete fuel combustion.

5. Do not turn OFF the battery switch when the engine is running to avoid damage to alternator.
6. Avoid overloading. This can cause incomplete combustion often indicated by black exhaust, high fuel consumption and carbon deposits in the combustion chambers, affecting engine life.
7. During the first 50 hours of operation, break-in the engine under a lighter load and lower speeds than normal. Proper break-in contributes to maximum service life of the engine.
8. Stopping the engine immediately after it has been working under load can result in accelerated wear of the engine components. Before stopping, operate the engine at low idle for five minutes. This allows hot areas in the engine to cool gradually, extending engine life. With the engine so running, make a walk-around inspection, checking for oil, fuel or coolant leaks.

Servicing Engine Properly

1. Use the recommended fuel, oil and coolant listed in this manual. Use of any other fuel, oil or coolant can result in higher maintenance costs and reduced engine service life.
2. Be sure to perform pre-start inspection and periodic service on items specified in this manual. Improper performance of inspection or service is dangerous and could result in damage to the engine, or injury or death.
3. At the end of each day of operation, check the engine for broken, defective or missing parts. If your daily check uncovers any item that needs attention — repair, replacement or adjustment, report it soon. Remember, the most minor defect could result in more serious trouble.
4. When washing the engine, cover the air inlet and exhaust openings with tape to prevent water or cleaning agent from getting inside the engine. Do not attempt to wash the engine when it is running. If water or cleaning agent gets inside the combustion chambers, hammering action of water can cause damage to the engine.
5. Service the air cleaner properly to keep dust and grit-laden air out of the engine because clean air is essential to satisfactory engine operation and long engine life. Dust and dirt entering the engine will cause rapid wear of piston rings, cylinders and pistons with a resultant loss of power and high oil consumption. Also, dust and dirt allowed to build-up in the air cleaner passages will eventually restrict the air supply to the engine and result in heavy carbon deposits on the pistons and valves due to incomplete combustion.

(1) Do not service the air cleaner element when the engine is running.

(2) When removing the air cleaner from the engine for servicing, prevent dust from entering the air passage to the cylinders.

(3) Service the air cleaner element at reasonable intervals, or when the signal of the indicator is visible (if equipped).

(4) Do not use the element if any tears, rips or damage is evident.

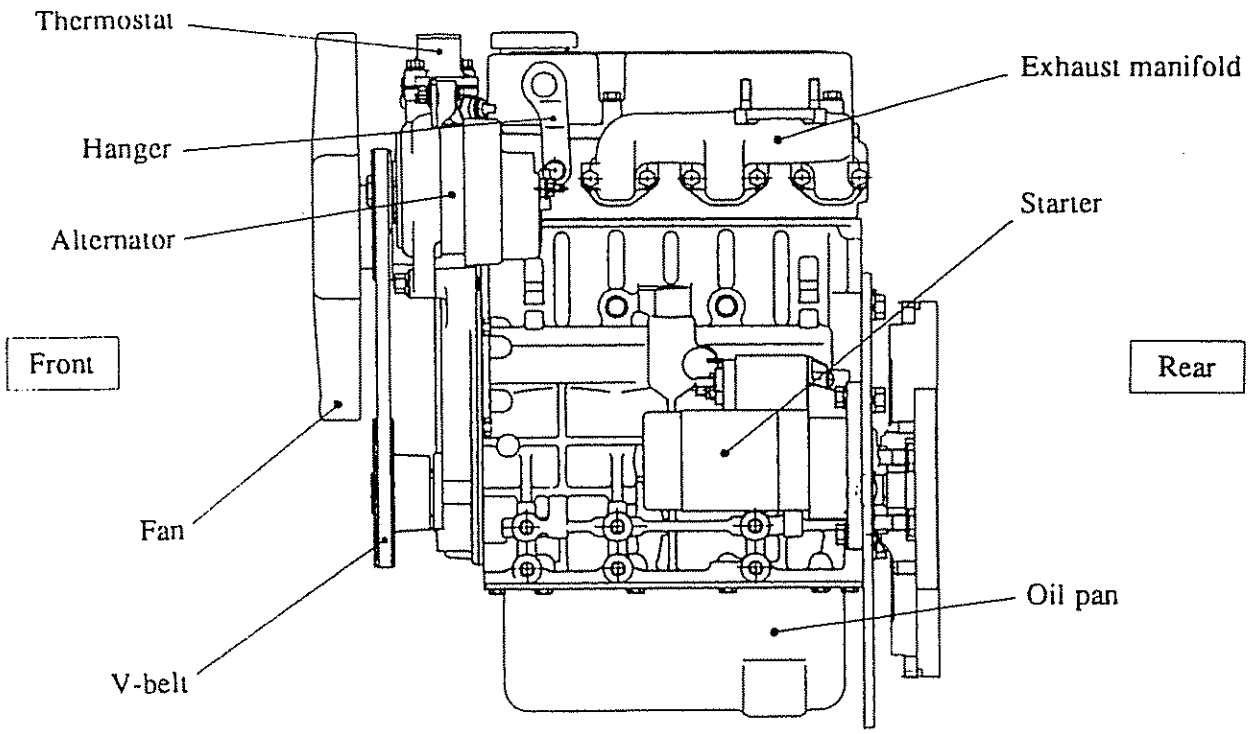
If Any Trouble Should Occur

1. If the engine stops abnormally, try to find a problem and its source, then make the necessary repair, before starting the engine again.
2. If the engine overheats, the warning light comes on and, at the same time, the engine will stop. When this happens, never add coolant to an overheated engine; allow the engine cool first, then add coolant gradually.
3. If the engine oil pressure becomes low, stop the engine and check for the cause. Operating the engine with low oil pressure can cause seizure of the bearings and other parts.

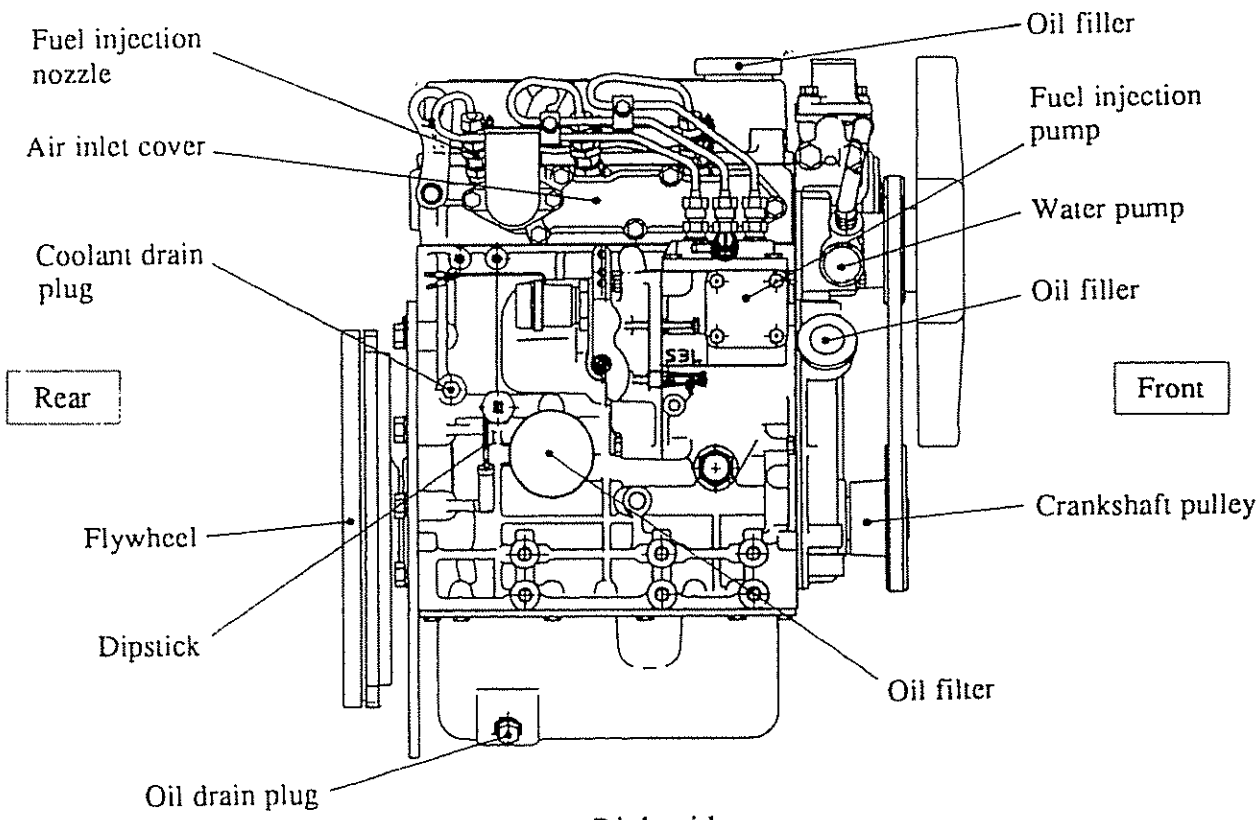
SPECIFICATIONS

Engine model		S3L	S3L2	S4L	S4L2
Type		Water-cooled, 4-stroke cycle, in-line diesel engine			
Firing order (injection sequence)		1 – 3 – 2		1 – 3 – 4 – 2	
Compression ratio		22			
Combustion chamber, type		Swirl			
Weight, kg (lb)		125 (276)		150 (331)	
No. of cylinders		3		4	
Bore x Stroke, mm (in.)		78 x 78.5 (3.07 x 3.09)	78 x 92 (3.07 x 3.62)	78 x 78.5 (3.07 x 3.09)	78 x 92 (3.07 x 3.62)
Displacement, liter (cu in.)		1.125 (68.7)	1.318 (80.4)	1.500 (91.5)	1.758 (107.3)
Fuel system	Injection pump, type	Bosch M			
	Injection nozzle, type	Throttle			
	Governor, type	Centrifugal flyweight			
	Fuel	ASTM No. 2-D			
Lubrication system	Type	Force feed (by trochoid pump)			
	Engine oil	API Service Classification CC			
	Oil filter	Paper-element (full-flow)			
	Capacity (high level excl. 0.5 liter (0.13 U.S. gal) of oil in oil filter), liter (U.S. gal)	5.7 (1.5) (with deep oil pan) 3.7 (1.0) (with standard oil pan)		7.7 (2.0) (with deep oil pan) 5.4 (1.4) (with standard oil pan)	
Cooling system	Type	Forced cooling			
	Capacity (approximate), liter (U.S. gal)	1.8 (0.5)		2.5 (0.7)	
Starter, V – kW		12 – 1.6		12 – 2.0	
Alternator, V – A		12 – 50			

S3L/S3L2

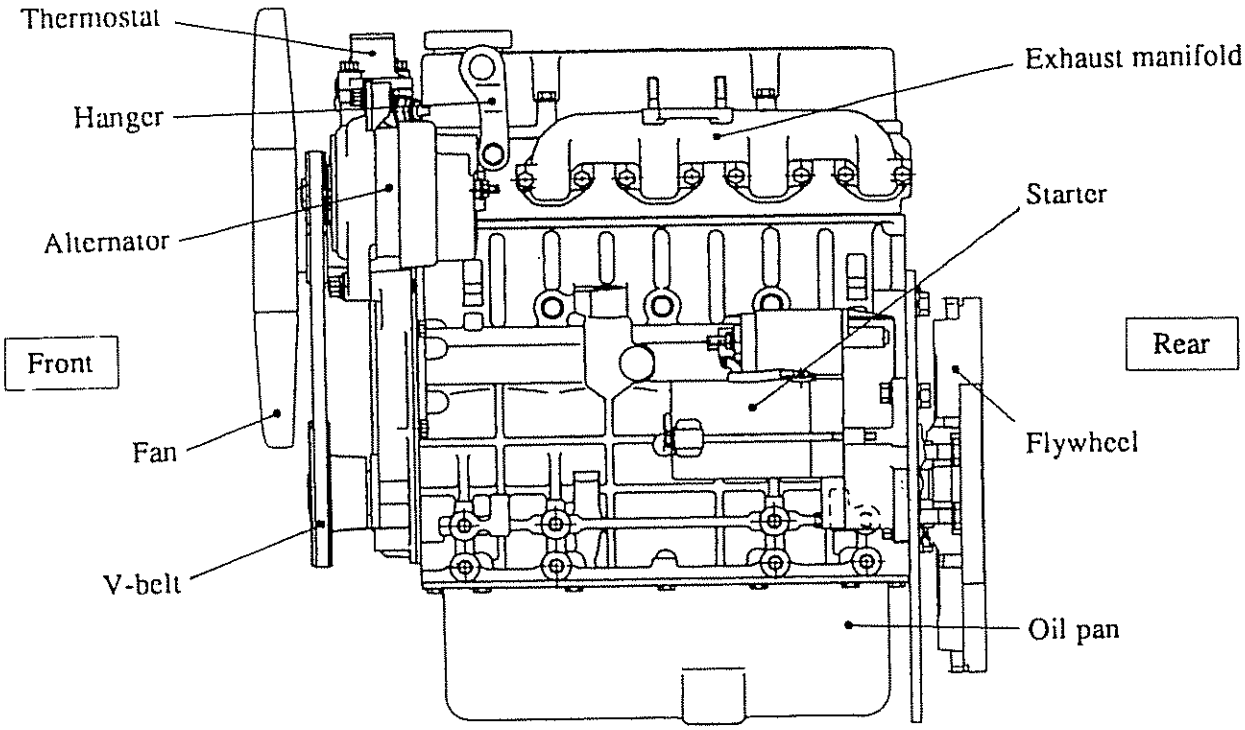


Left side



Right side

S4L/S4L2



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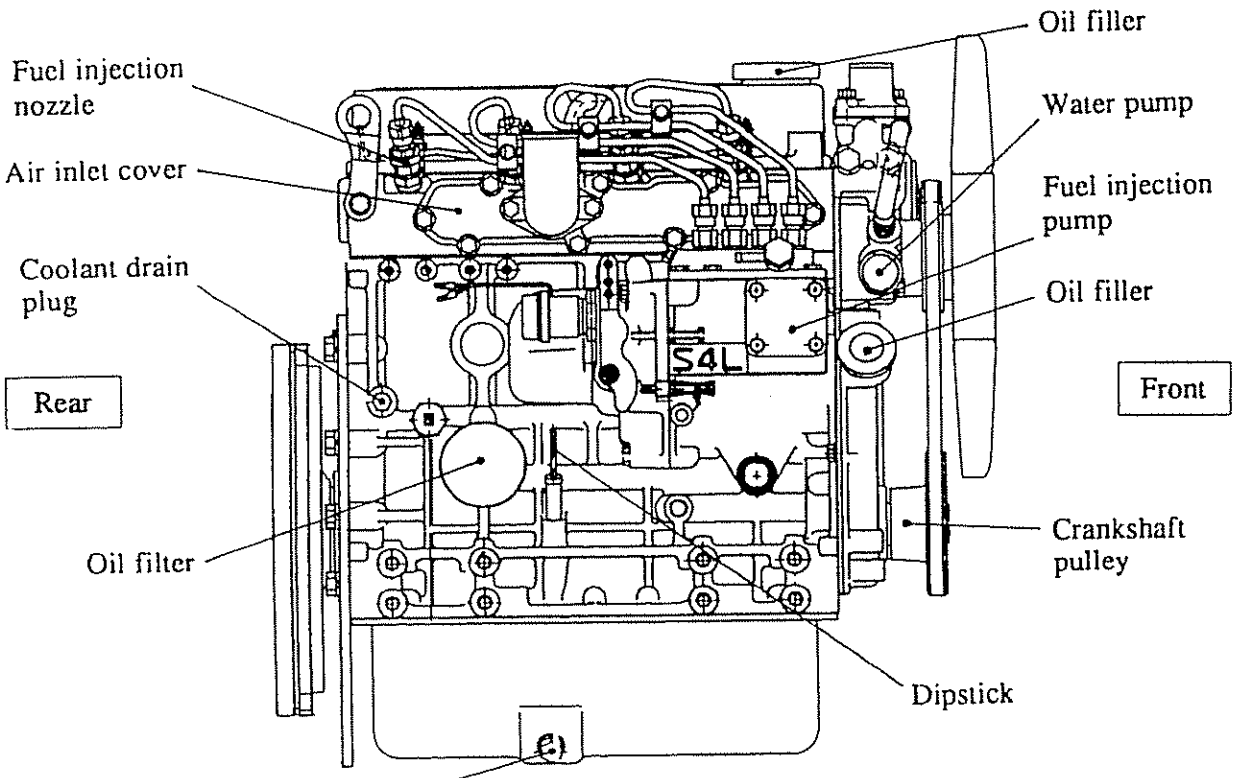
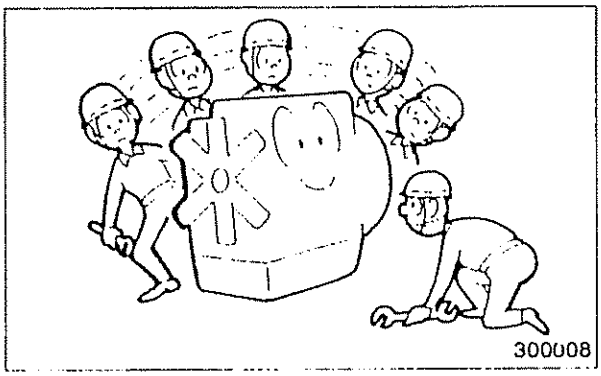


Right side

PRE-START INSPECTION

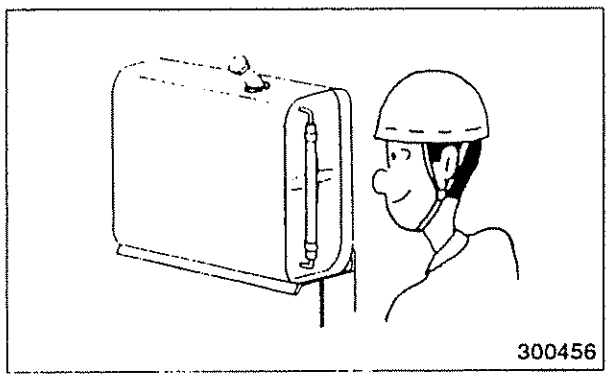
Walk-Around Inspection

Look around for such items as loose bolts, debris build-up, oil, fuel or coolant leaks, broken or worn parts.



Check Fuel Level

Make sure the fuel level is at FULL mark in the sight gauge.

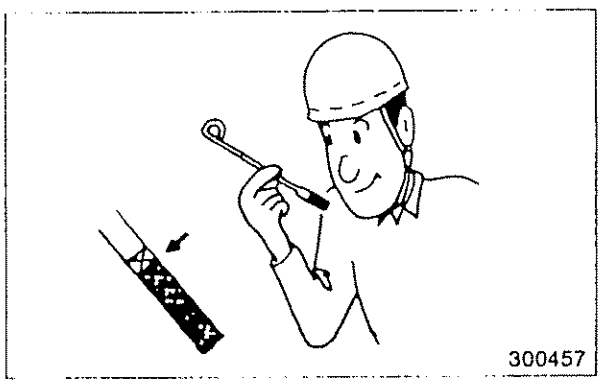


Check Engine Oil Level

Maintain the engine oil level between MAX and MIN marks on the dipstick. Add oil if necessary. (See page 28)

NOTE

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 Coolant Level

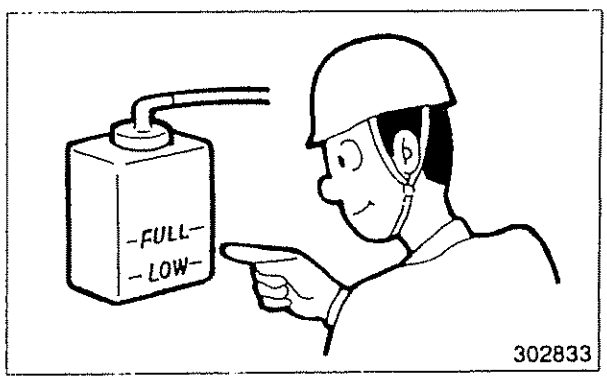
Maintain the coolant level to FULL mark on the reserve tank (when the engine is cold). Add coolant if necessary.

NOTE

When adding coolant, maintain the recommended concentration of Long Life Coolant. (See page 31.) Do not add water only. This dilutes Long Life Coolant and adversely affects freeze protection.

⚠ CAUTION

Check the coolant level only when the engine is cold.



STARTING THE ENGINE

[Engine with automatic glow plugs]

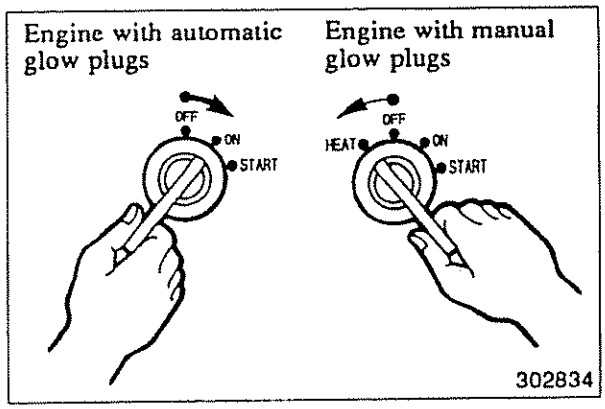
1. Turn the starter switch key to ON position, and make sure the oil pressure, coolant temperature and glow plug indicators come on. See Starting Aid Chart for heating time.

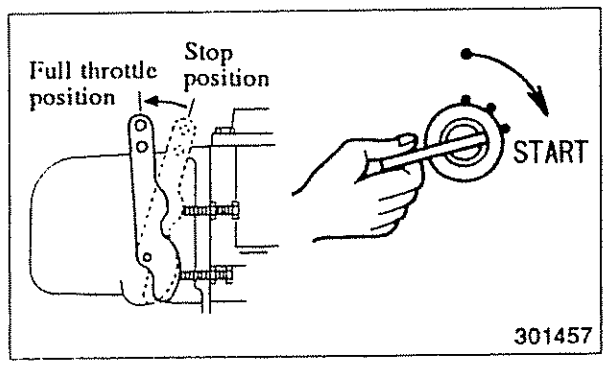
Starting Aid Chart

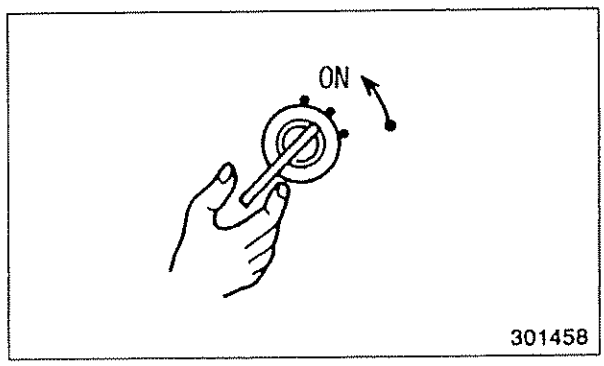
Coolant temperature		Heating time
Quick-heating type	Below 5°C (41°F)	About 3 seconds
	Above 5°C (41°F)	About 1 second
Standard type	Normally	About 6 seconds

[Engine with manual glow plugs]

1. Turn the starter switch key to HEAT position and continue to hold it there for about 20 seconds. Do not use the glow plugs for more than 1 minute at a time.
2. When the glow plug indicator goes off, move the speed control lever to FULL THROTTLE position and turn the key to START position. The glow plug indicator will also come on when the key is in START position.
3. Release the key when the engine starts. The key will return to ON position when released.







⚠ 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 parts of the engine.

⚠ CAUTION

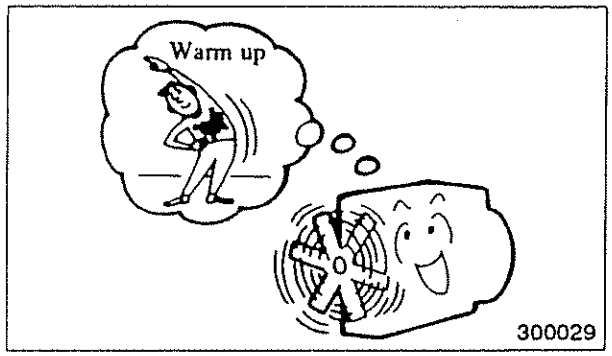
- After every 10 seconds of engine cranking, allow 30 seconds for the starting motor to cool before cranking again.
- Do not turn the starter switch key to START position when the engine is running to avoid damage to the starter.
- Do not apply the load to the engine (disengage the clutch if equipped) when cranking the engine for starting.

WARMING UP THE ENGINE

Allow the engine to warm up at low idle for five to 10 minutes. Proper warm-up is absolutely essential to maximum service life, performance and economy of the engine.

NOTE

Long periods of warming up the engine is not recommended. This can result in carbon deposits in the combustion chambers and incomplete fuel combustion.



STARTING THE LOAD

When the engine has run long enough to warm up, apply the load. During operation, check to be sure —

1. All indicators are OFF.
2. The engine is free from abnormal noise and vibration.
3. Exhaust smoke is normal.

⚠ WARNING

- **Stay clear of all rotating and moving parts during operation.**
- **At operating temperature, the engine is hot. Any contact can cause severe burns.**

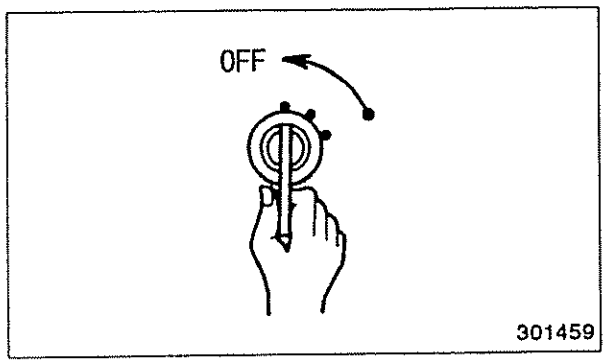
⚠ CAUTION

- 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. Proper break-in contributes to maximum service life of the engine.
- Avoid overloading. This can cause incomplete combustion often indicated by black exhaust smoke, high fuel consumption and carbon deposits in the combustion chambers, affecting engine life.
- Do not turn OFF the battery switch when the engine is running to avoid damage to alternator.
- Do not turn the starter switch key to START position when the engine is running to avoid damage to the starter.

STOPPING THE ENGINE

[Engine with Keystop Device]

Turn the starter switch key to OFF position. The engine will take about 5 seconds to stop after the key has been turned to OFF position.



⚠ CAUTION

- Operate the engine at low idle for five minutes. This allows hot areas in the engine to cool gradually, extending engine life. With the engine so running, make a walk-around inspection, checking for oil, fuel or coolant leaks.
- If the engine stops abnormally, try to find a problem and its source, then make the necessary repair, before starting it again. After starting the engine, check to be sure the engine has no problem.
- Remove the key from the starter switch. Leaving it in ON position after the engine has stopped can cause the battery to discharge.

1. Service the engine in accordance with the "Lubrication and Maintenance Chart." Under extremely severe or dusty operating conditions, service it more frequently than is specified in the "Lubrication and Maintenance Chart."
2. Perform service on items at multiples of the original requirement. For example, at Every 500 Service Hours, also service those items listed under Every 100 Service Hours, Every 50 Service Hours and Every 10 Service Hours [pre-start inspection].
3. For special items with asterisk (*), rely on the expert knowledge of the servicemen, and the service facilities at your Mitsubishi dealer.

LUBRICATION AND MAINTENANCE CHART

	Item	Remarks (specifications)	Page
Every 10 Service Hours [Pre-Start Inspection]	Walk-around inspection		15
	Check engine oil level.		15
	Check fuel level.		15
	Check coolant level.		15
Every 50 Service Hours	Drain water and sediment from fuel tank.		20
	Check battery electrolyte level and specific gravity.		20
First 50 Service Hours of New or Reconditioned Engine	Change engine oil.	See SPECIFICATIONS.	21
	Change oil filter.		21
	Retighten bolts and nuts.		*
Every 100 Service Hours	Change engine oil.	See SPECIFICATIONS.	21
	Change oil filter.		21
	Clean fuel filter element.	After cleaning, prime (page 26).	22
	Clean radiator fins.		*
Every 500 Service Hours	Check and adjust valve clearance.	0.25 mm (0.0098 in.) for both inlet and exhaust valves	*
	Change fuel filter element.	After changing, prime (page 26).	23
	Check and adjust injection pressure.	140 kgf/cm² (1 991 psi) [13 729 kPa]	*
	Check and adjust fan belt.	Deflection: 13 mm (0.5 in.)	23
	Check glow plugs.		*
Every 1000 Service Hours	Retighten bolts and nuts.		*
	Check starter.		24
	Check alternator.		24
Every 2 Years	Change coolant.	See SPECIFICATIONS.	25
When Required	Prime fuel system.		26
	Clean air cleaner element.		26
	Change air cleaner element.		26

EVERY 50 SERVICE HOURS

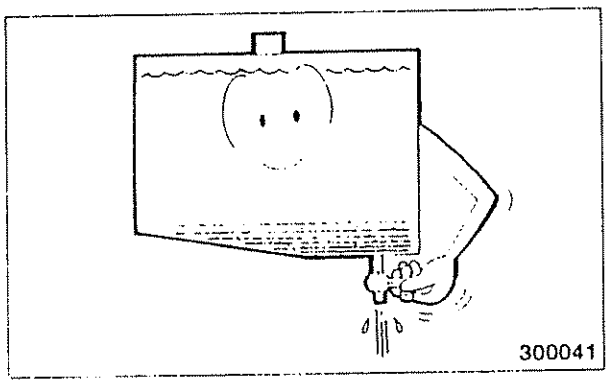
Drain Water and Sediment from Fuel Tank

Remove the drain plug and allow water and sediment to drain. Drain at least one to two liters (0.3 to 0.5 U.S. gal) of fuel to remove water and sediment.

It is evident that invisible particles of dirt in sediment which might pass through the filter can damage the finely finished parts of the fuel injection system.

⚠ DANGER

Do not smoke while draining off water and sediment. Keep flames and sparking devices away. Clean up any spillage before starting the engine.



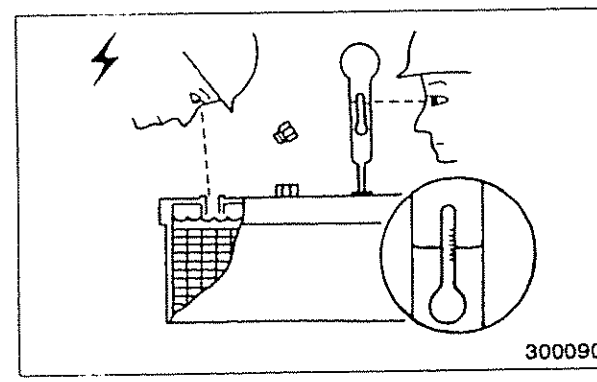
Check Battery Electrolyte Level and Specific Gravity

1. Maintain the electrolyte level between UPPER and LOWER marks on the case. In a battery without level marks, maintain the level 10 to 15 mm (0.4 to 0.6 in.) above the cells. Remove the filler caps and add distilled water if necessary.
2. Test the specific gravity of battery electrolyte with a battery hydrometer. The following chart of specific-gravity reading gives a general idea of battery condition.

Specific gravity at 20°C (68°F)	Battery condition
1.26 to 1.28	Fully charged
1.22 to 1.26	Three-fourths charged (To be recharged)
Below 1.22	One-fourth charged (To be recharged)

⚠ WARNING

- **Battery gives off flammable fumes that can explode.**
- **Do not smoke when observing the battery electrolyte level.**
- **Electrolyte is an acid and can cause personal injury if it contacts skin or eyes.**
- **Always wear protective glasses when working with battery.**



EVERY 100 SERVICE HOURS

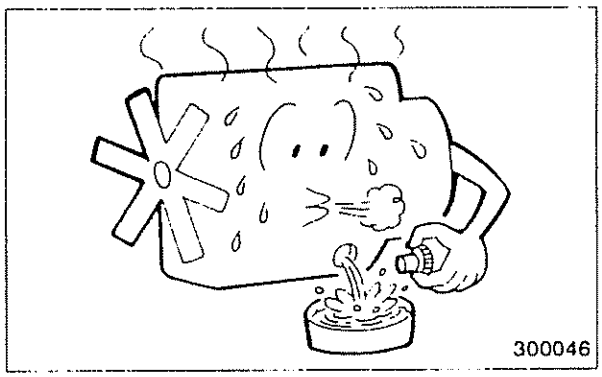
Change Engine Oil and Oil Filter

Draining oil

Immediately after shutting down the engine (when the oil is hot), remove the oil pan drain plug. Allow the oil to drain in a container.

⚠ DANGER

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



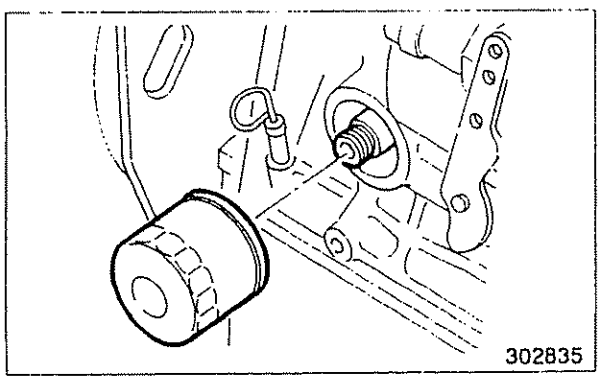
Changing oil filter

1. Remove the used oil filter with a filter wrench.

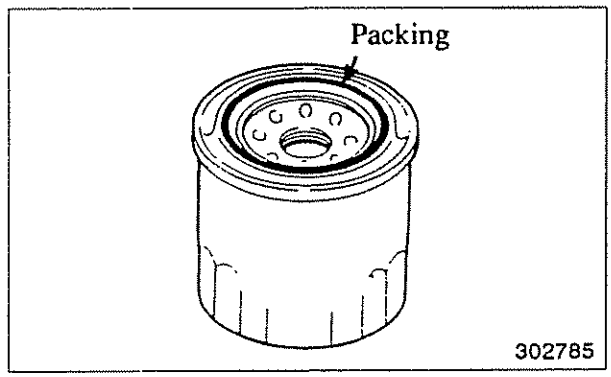
NOTE

Check particles collected in the used oil filter. If they are metallic particles, consult your Mitsubishi dealer.

2. Make sure all of the old filter packing is removed from the filter base and clean the base with a clean cloth.



3. Check the new oil filter to be sure the packing is fitted in the groove.
4. Apply a thin coat of engine oil to the packing on the new filter.
5. Install the filter by hand until its packing contacts the base. Tighten 3/4 to 1 turn more.



Filling with oil

1. Install the drain plug and tighten it to the specified torque.

Torque	4.5 ± 0.5 kgf·m (33 ± 4 lbf·ft) [44 ± 5 N·m]

2. Fill the crankcase with oil.

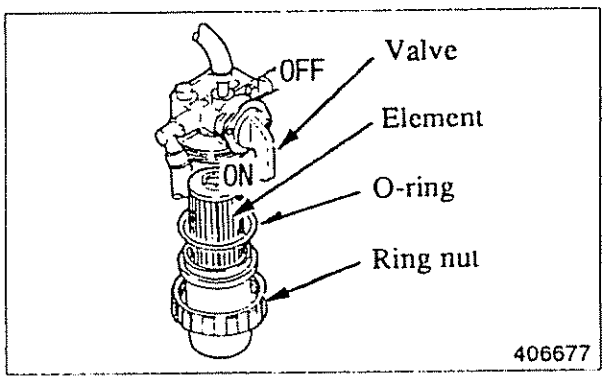
Refill capacity	See SPECIFICATIONS.
API Service Classification	CC

3. Start the engine and run it at low idle for a few minutes, and check for leaks. Retighten the filter if leakage is noticed.
4. Stop the engine and leave it standing for about 30 minutes. Check the oil level. Maintain the oil level between MAX and MIN marks on the dipstick. Add oil if necessary.

EVERY 100 SERVICE HOURS — Continued

Clean Fuel Filter Element

1. Turn the valve to OFF position.
2. Loosen the ring nut and remove the cup.
3. Wash the element in kerosene or diesel fuel.
4. Put the cleaned element in the cup and install the cup, making sure the O-ring is properly fitted in place. Tighten the ring nut.
5. Turn the valve to ON position and prime the fuel system.
(See page 20).

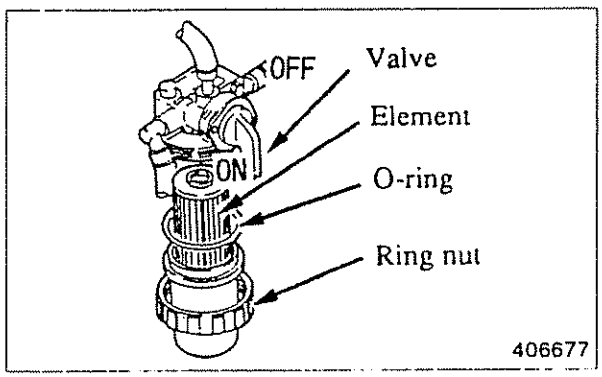


EVERY 500 SERVICE HOURS

Change Fuel Filter Element

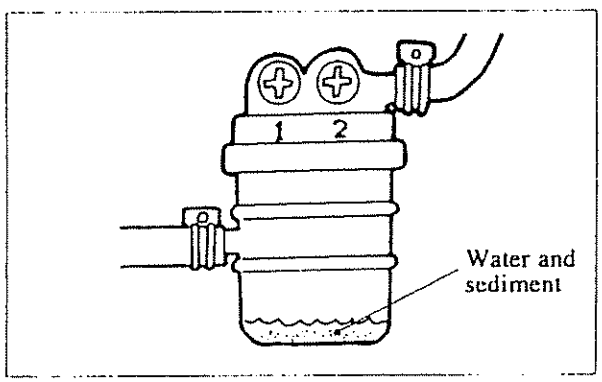
[Fuel filter with shutoff valve]

1. Turn the shutoff valve to OFF position.
2. Loosen the ring nut and remove the cup.
3. Remove and discard the filter element.
4. Put the new filter element in the cup and install the cup, making sure the O-ring is properly fitted in place. Tighten the ring nut.
5. Turn the shutoff valve to ON position and prime the fuel system.
   (See page 20 for priming).



[Cartridge type fuel filter]

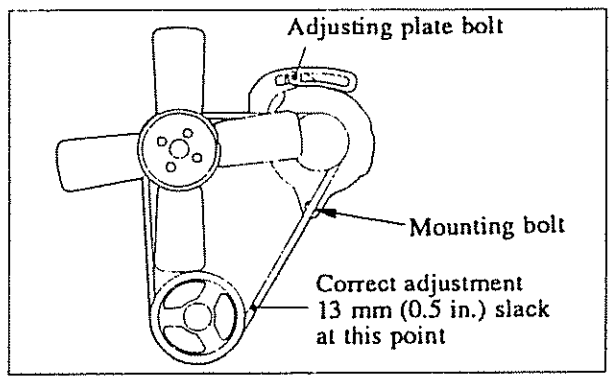
1. Change the filter if water and sediment have been collected in the filter.
2. After changing the filter, prime the fuel system. (See page 20 for priming.)



Check and Adjust Fan Belt

Checking

Correct adjustment exists when the belt can be pushed inward about 13 mm (0.5 in.) with 10 kg (22 lb) thumb pressure exerted midway between the alternator and crankshaft pulley as shown.

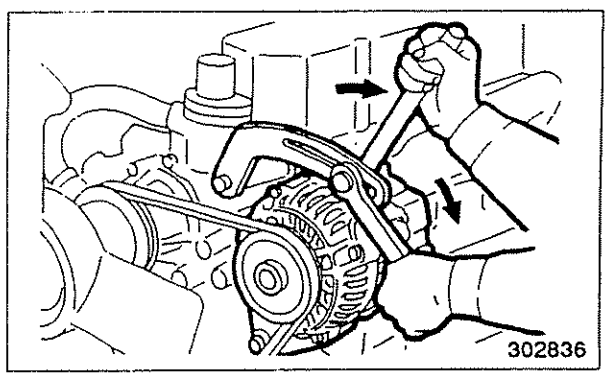


Adjusting

1. Loosen the adjusting plate bolt and mounting bolt.
2. Insert a pry bar between the alternator and cylinder block, to move the alternator to obtained the required belt deflection.
3. Tighten the mounting bolt and adjusting bolt.

⚠ CAUTION

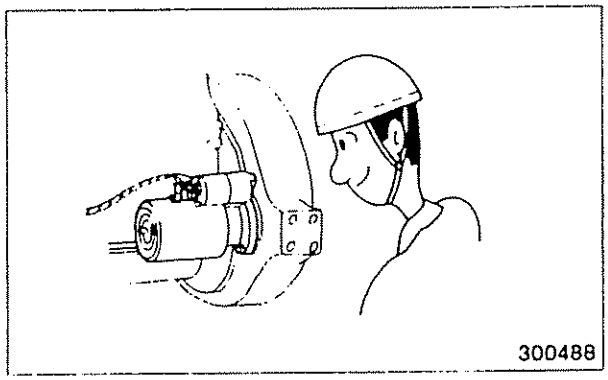
- If the fan belt is too tight, excessive stresses are placed upon the fan bearings and belt, which might shorten the life of both. If it is too loose, it will slap against the pulleys, causing unnecessary wear to the belt and possibly slipping to the extent that the engine will overheat.
- Keep the belt free from oil or grease.



EVERY 1000 SERVICE HOURS

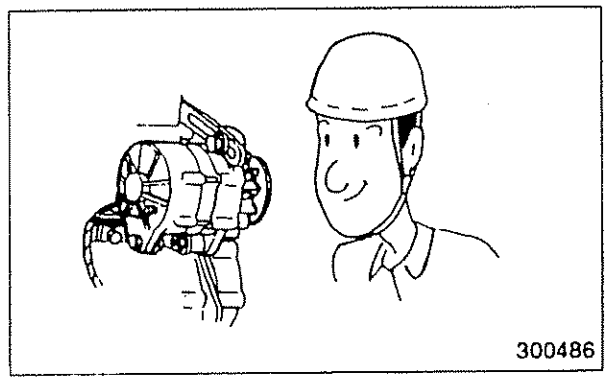
Check Starter

1. Visually check for defects.
2. Check to see if the pinion is shifted into mesh with the flywheel ring gear when the starter is energized. If the pinion does not shift properly, consult your Mitsubishi dealer.



Check Alternator

1. Visually check for defects.
2. Remove the belt from the alternator. Turn the pulley by hand to check the alternator for smooth rotation. If the alternator fails to rotate smoothly, consult your Mitsubishi dealer.



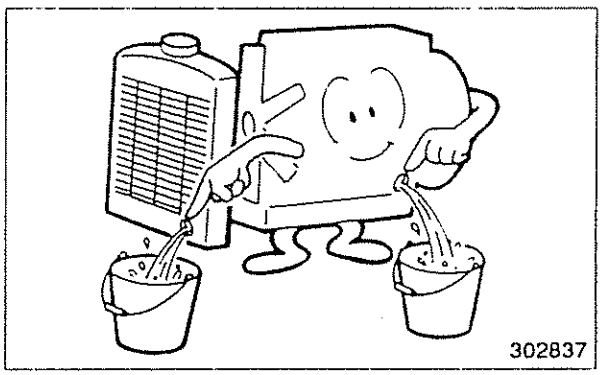
EVERY 2 YEARS

Change Coolant

Long Life Coolant (LLC) used in your engine retains its efficacy for two years. Be sure to change the coolant every two years.

Draining

1. Start and operate the engine until the coolant temperature is 70°C to 80°C (158°F to 176°F). Stop the engine.
2. Remove the filler cap only after the engine has been stopped and the cap is cool enough to remove with your bare hand.
3. Open the radiator drain valve and remove the engine drain plug and allow the coolant to drain into containers.



Flushing

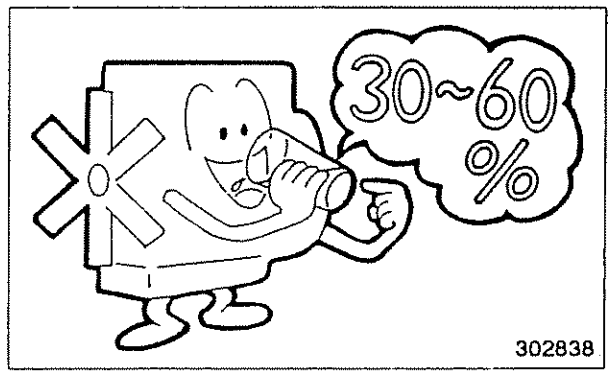
1. Close the radiator drain valve and install the engine drain plug.
2. Fill the cooling system with a cleaning solution which does not chemically attack rubber and metal surfaces. Start and operate the engine at 800 to 900 rpm for 15 minutes. Stop the engine and drain the cleaning solution.
3. Fill the system with clean water and operate the engine at 800 to 900 rpm for 10 minutes. Continue to flush the system until the draining water is clear.

Refilling

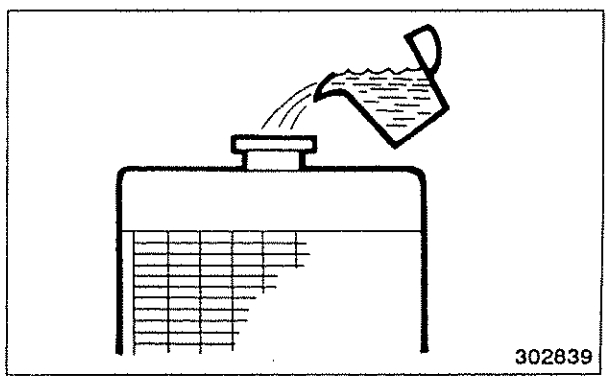
1. Tighten the radiator drain valve and engine drain plug.
2. Pour pure, undiluted LLC into the radiator. Recommended concentration of LLC is shown in the chart below:

Recommended LLC Concentrations (reference)

Ambient temperature, °C (°F)	–10 (14)	–20 (–4)	–30 (–22)	–45 (–49)
LLC concentration, %	30	40	50	60



3. Add water to the radiator slowly to help avoid air pockets in the system. See COOLANT AND ANTIFREEZE SPECIFICATIONS.



4. Start and 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 reserve tank. Add water if the level is low. Maintain the coolant level to FULL line on the tank when the engine is cold.

WHEN REQUIRED

Prime Fuel System

Air in the lines may cause the fuel system to become air bound, resulting in inability to start the engine or misfiring of one or more cylinders. Prime the fuel system —

1. After the engine has been fueled for the first time after installation.
2. After the engine has been refueled after running out of fuel.
3. After the fuel filter element has been cleaned or replaced.

Procedure

[Fuel filter with air valve]

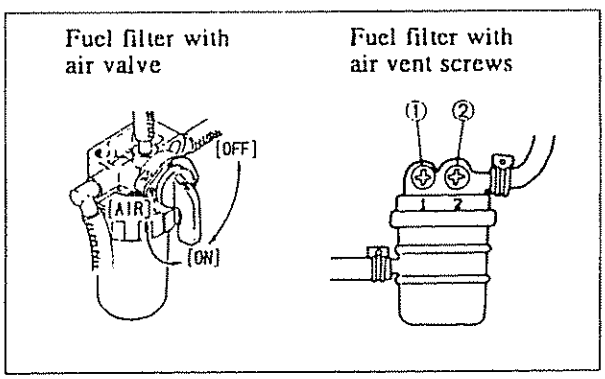
1. Turn the valve lever to AIR position and feed fuel.
2. Turn the valve lever to ON position when fuel flows free of bubbles from the overflow pipe.

[Fuel filter with air vent screws]

1. Loosen air vent screw (1). Tighten the screw when fuel flows free of bubbles.
2. Loosen air vent screw (2). Tighten the screw when fuel flows free of bubbles.

NOTE

The injection pipes and nozzles can be primed by cranking the engine. The fuel system of the engine equipped with an electric fuel pump can be primed by turning the starter switch key to ON position.

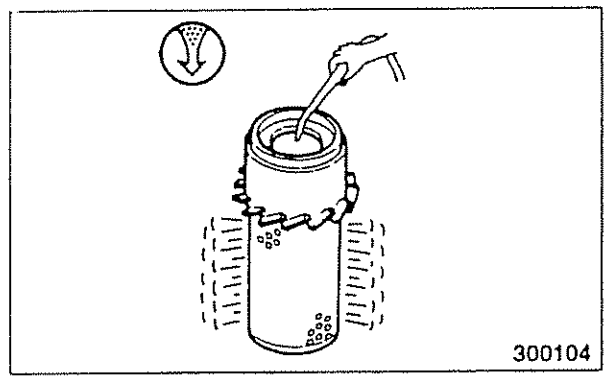


Clean/Change Air Cleaner Element

Service the air cleaner only as necessary, or when the dust indicator shows RED.

Cleaning

1. Direct air — 7 kgf/cm² (100 psi) [686 kPa] maximum — inside the element along the length of pleats.
2. Insert a light inside the clean element and check. Discard the element if rips or tears are found.



NOTE

Discard the element if it is excessively dirty.

⚠ CAUTION

- Never service the air cleaner when the engine is running. Without the air cleaner, dust and dirt enter the engine and can cause rapid wear of engine parts with a resultant loss of power and high oil consumption.
- Do not clean the element by bumping or tapping it.

⚠ WARNING

When using pressure air for cleaning. Wear a protective face shield, protective clothing and protective shoes.

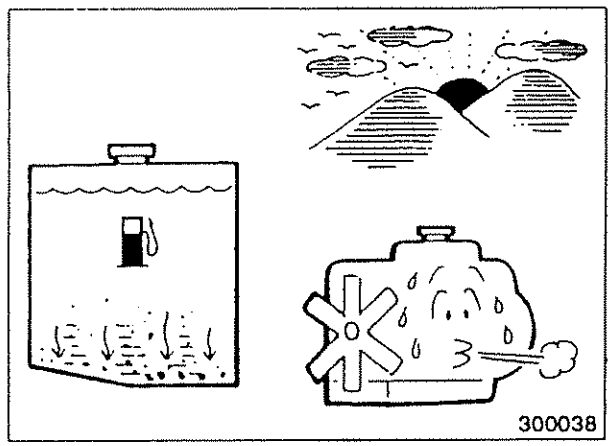
1. Recommended types of fuels

The quality of fuel 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 ASTM Designation D 975 (grade No. 2-D).

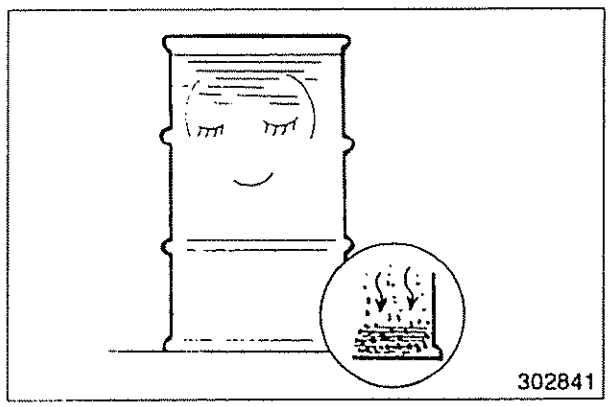
2. Care of diesel fuel tank

Fill the diesel fuel tank at the end of the day, because the incoming fuel will drive out the moisture-laden air and prevent condensation. Every 50 service hours before starting the engine, remove the drain plug and drain off any sediment or water which may have accumulated.



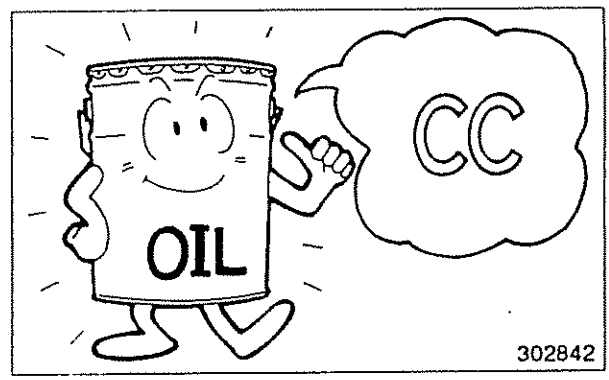
3. Care of fuel supply

It is important to buy clean fuel, and keep it clean. Natural settling is an effective method of cleaning fuel. Allow the fuel to stand at least for 10 days in the fuel storage tank after the tank has been filled before the fuel is transferred to the diesel fuel tank. Be sure to drain all water and sediment that has settled to the bottom of the tank before the tank is refilled. Occasionally, drain all of the fuel and clean the tank thoroughly.



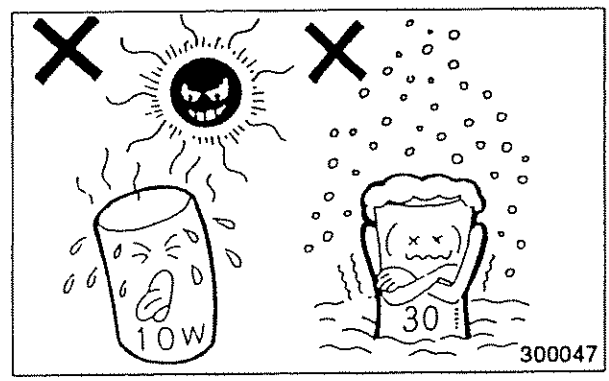
LUBRICANT SPECIFICATIONS

1. Recommended types of engine oils



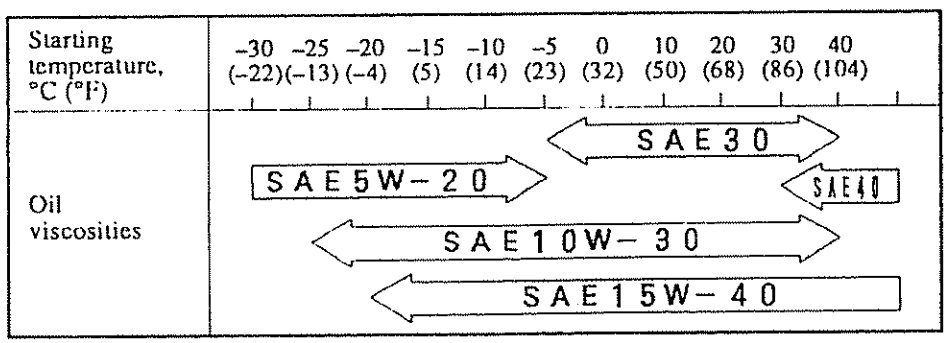
Use oils that meet the Engine Service Classification CC (MIL-L-2104C). Proper oil selection assures cranking ability by maintaining an oil film on cylinder walls and bearing surfaces in a condition which provides low friction, and therefore, less cranking effort to achieve cranking speeds necessary for 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.

2. 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:

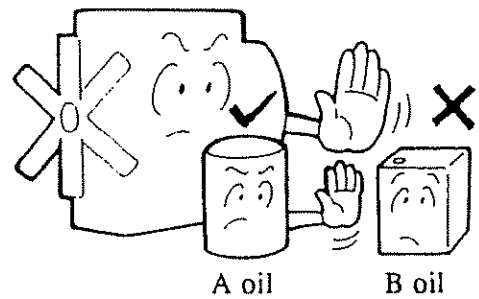
Recommended Oil Viscosities



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

⚠ 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.



3. Limiting requirements for engine oils

If a used oil analysis program is conducted in order to determine the condition of the oil, consult the chart below. Change the oil if any of these requirements is not met.

NOTE

- Oil change intervals depend to a great extent on fuel properties. Be sure to use only recommended fuels.
- The limit of total base number is 1/2 of that of a new oil in case of a perchloric-acid analysis method.

Limiting Requirements for Engine Oils

Property		Test method	Limit
Viscosity	cSt @ 100°C (212°F)	JIS K 2283	+30% −15%, max. of new oil
Total base number (Hcl)	mgKOH/g	JIS K 2501	2.0, min.
Total acid number	mgKOH/g		+3.0, max. of new oil
Water content	Vol%	JIS K 2275	0.2, max.
Flash point (coc)	°C (°F)	JIS K 2265	180 (356), min.
Pentane insolubles	Wt%	ASTM D 893	0.5, max.
Pentan insolubles coagulated	Wt%		3.0, max.

COOLANT AND ANTIFREEZE SPECIFICATIONS

1. 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.

NOTE

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)	–	○

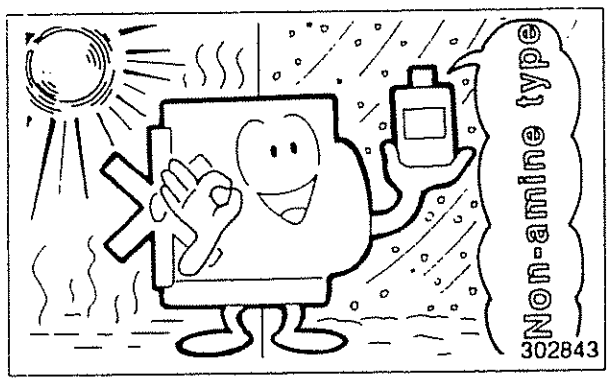
The values indicated in ( ) are the limits set forth by Mitsubishi. In addition to the items specified above, turbidity is specified to be above <15 deg.

2. Recommended types of LLC's

For Mitsubishi diesel engines, all-season, non-amine type LLC's or equivalent are recommended.

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.)



⚠ 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.

3. How to use non-amine type LLC

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

NOTE

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

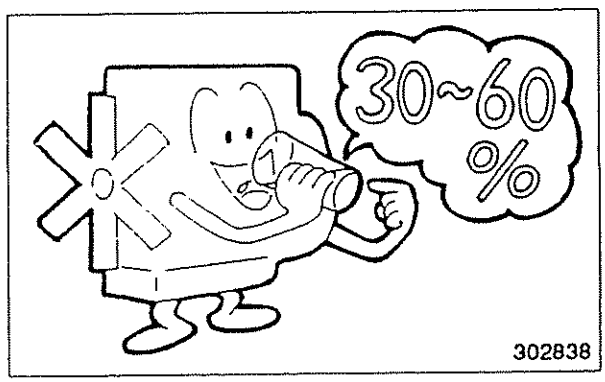
⚠ WARNING

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



4. 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.

5. 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.

6. 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 particularly victimized. The cause of coolant leakage from and clogging of the coolant circuit in the radiator are usually traceable to such a malcondition of the coolant.

Storage of Engine in Non-Operational Condition

Preparation

1. Drain the engine oil and put a preservative in the engine.
2. Make up a mixture of preservative and fuel oil in 50-to-50 ratio, and put the mixture in the fuel tank.
3. Start and operate the engine at low idle for five to 10 minutes.
4. Stop the engine and spray volatile preservative (VCI) in the air inlet opening.
5. Drain the preservative-fuel mixture.
6. Apply a coat of preservative 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 belt.
9. Tape the starter and alternator terminals. Cover the starter and alternator with polyethylene sheet and put a desiccant inside.
10. Disconnect the cables from the battery and charge the battery. Flush the top of the battery with clean water, and coat the parts with grease to retard further corrosion. Keep the battery in a cool, dry place.
11. Cover the engine to protect it against weather.

NOTE

- Store the engine in a well-ventilated room.
- It is not necessary to drain the coolant if it contains LLC.
- Attach "DO NOT OPERATE" or similar warning tag to the starter switch or any control.
- New engine oil may be used instead of preservative.

Service during storage

Charge the battery at least once a month.

Remove the engine from storage

1. Remove covering from the engine.
2. Connect a well-charged battery to the engine.
3. Remove covering from the starter and alternator.
4. Adjust the fan belt.
5. Remove covering and taping from the various ports.
6. Drain preservative and fill 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 cover 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.
11. Make sure the engine oil pressure rises properly.
12. Start the engine.
13. Allow the engine to warm up at low idle.
14. When the engine has run long enough to warm up, apply the load and bring it to operating speed.

Storage of Engine in Operational Condition

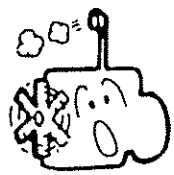
Do Steps 1 through 3 below once a month:

1. Crank the engine two times, for 10 seconds each time, with the starter at intervals of 30 seconds, with the fuel supply shut off.
2. Start and operate the engine at 800 rpm under no-load condition for five minutes.
3. Increase the engine speed to 1000 to 1200 rpm and operate the engine under no-load condition for 10 minutes.

TROUBLESHOOTING

For special servicing jobs on your engine, rely on the expert knowledge of the servicemen, and the service facilities at your Mitsubishi dealer.

Problem	Cause	Correction
Engine will not start.  302844	Fuse off	Replace.
	Defective starter switch	Repair or replace.
	Slow cranking speed	Recharge battery. Check and replace starter.
	Wrong viscosity grade of oil	Change oil.
	Seized running parts	Repair.
	Air in fuel system	Prime.
	No fuel in tank	Refuel.
	Bad quality fuel	Change fuel.
	Clogged fuel filter	Clean or replace.
	Defective fuel injection pump	Repair or replace.
	Defective control timer unit	Replace.
	Clogged air cleaner element	Clean or replace.
Not enough power  500040	Wrong viscosity grade of oil	Change oil.
	Clogged air cleaner element	Clean or replace.
	Clogged fuel filter	Clean or replace.
	Defective fuel injection pump	Repair or replace.
	Defective fuel injection nozzles	Repair or replace.
	Wrong injection timing	Adjust.
	Bad quality fuel	Change fuel.
	Overheating	Flush cooling system and replace parts.
	Wrong valve clearance	Adjust.
	Poor compression (cylinders, piston rings, etc. worn)	Repair or replace.

Problem	Cause	Correction
Overheating  500047	Not enough coolant in system	Add coolant.
	Leaks in cooling system	Retighten or repair.
	Loose fan belt	Adjust.
	Restriction to air flow through radiator	Remove restrictions.
	Defective water pump	Replace.
	Defective thermostat	Replace.
	Defective fan	Replace.
	High LLC concentration	Adjust LLC concentration.
Too much white or blue smoke  500041	Too much oil in engine	Fill only to correct level.
	Oil viscosity too low	Change oil.
	Defective thermostat (coolant temperature too low)	Replace.
	Defective fuel injection nozzles	Repair or replace.
	Wrong injection timing	Adjust.
	Wrong fuel cetane number	Change fuel.
	Poor compression (cylinders, piston rings, etc. worn)	Repair or replace.
Too much black or gray smoke  500042	Bad quality fuel	Change fuel.
	Defective fuel injection pump	Repair or replace.
	Defective fuel injection nozzles	Repair or replace.
	Wrong injection timing	Adjust.
	Clogged air cleaner element	Clean or replace.
	Wrong valve clearance	Adjust.
	Poor compression (cylinders, piston rings, etc. worn)	Repair or replace.

Problem	Cause	Correction
Fuel consumption too high  500043	Bad quality fuel	Change fuel.
	Defective fuel injection pump	Repair or replace.
	Defective fuel injection nozzles	Repair or replace.
	Wrong injection timing	Adjust.
	Clogged air cleaner element	Clean or replace.
	Poor compression (cylinders, piston rings, etc. worn)	Repair or replace.
Oil consumption too high  500044	Too much oil in engine	Fill only to correct level.
	Oil viscosity too low	Change oil.
	Leaks in lubrication system	Repair or replace.
	Worn cylinders and piston rings	Repair or replace.
	Worn valve stem seals	Replace.
Oil pressure too low  500045	Not enough oil in engine	Add oil.
	Oil viscosity too low	Change oil.
	Clogged oil filter	Replace.
	Defective oil pump	Repair or replace.
	Defective relief valve	Adjust or replace.
	Defective pressure switch	Replace.

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