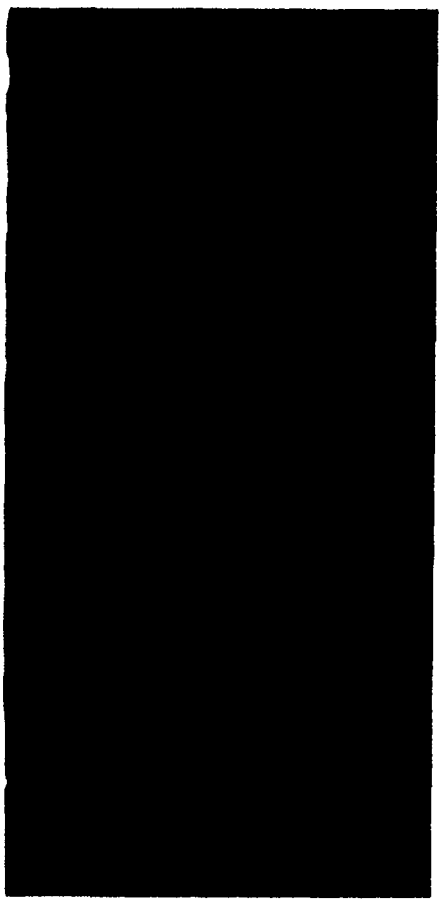
OPERATION & MAINTENANCE MANUAL



MITSUBISHI DIESEL ENGINE

S12A2

800KW

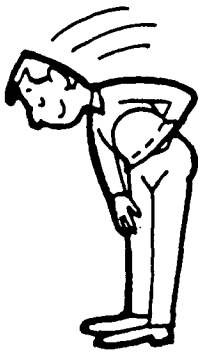
APPLICATIONS

- Generator drive
- General mechanical drive
- Locomotive drive
- Marine generator drive
- Marine general mechanical drive

MITSUBISHI HEAVY INDUSTRIES, LTD.

WE WELCOME YOU TO THE GROWING LIST OF PEOPLE WHO OWN AND USE OUR DIESEL ENGINE

S12A2



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This manual is written to familiarize you with the operation and maintenance of your S12A2 diesel engine, and provide important safety information. We suggest that you carefully read this manual to learn about your new engine.

After reading this manual, be sure to keep it near your engine as a ready reference when you need it. See your Mitsubishi dealer for any further information you feel you need. He will be glad to help you and answer any questions you may have about handling of your new engine.

The engine described in this manual is for industrial drive and marine auxiliary drive (such as generator drive).

The descriptions, illustrations and specifications contained in this manual were in effect at the time it was approved for printing. Mitsubishi reserves the right to change specifications or design without notice and without incurring obligation.

TABLE OF CONTENTS

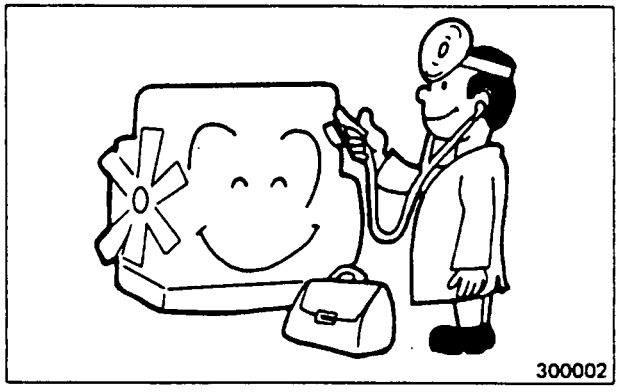
YOUR ENGINE AND MITSUBISHI

SERVICE ASSISTANCE

Your Mitsubishi dealer is vitally interested in your complete satisfaction with the Mitsubishi engine you purchased from him. He is anxious to know that all of your service needs are quickly and courteously filled.

Mitsubishi has established district and regional offices throughout the world to help each dealer make himself more helpful to you. Should you feel that you require service assistance beyond that which your dealer is providing, the Mitsubishi office in your area will be pleased to work with you and your dealer.

If your engine is transferred to elsewhere from the original place of use registered with Mitsubishi, be sure to have the registration changed. Consult your Mitsubishi dealer for the necessary procedure.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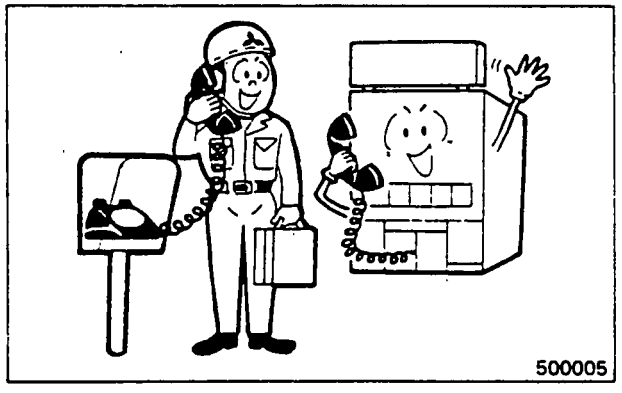
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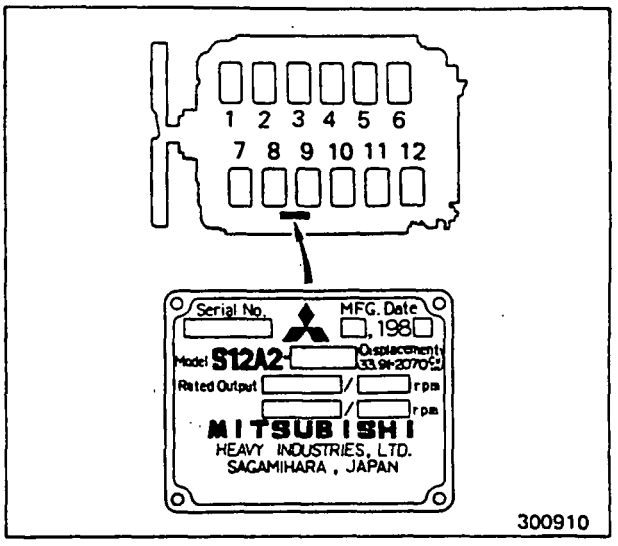
LOCATION OF ENGINE SERIAL NUMBER

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

Example

Model	Serial number
S12A2	20001

On the nameplate are also stamped the output and rated speed. The numbers in the illustrations show cylinder numbers.



ENGINE MODEL AND APPLICATION CODES

S□□2-□T "T" stands for turbocharged unit.
S□□2-□TA "TA" stands for turbocharged, aftercooled unit.
S□□2-□TK "TK" stands for turbocharged, intercooled unit.

Application code
- P : Generator drive and general mechanical drive
- L : Locomotive drive
- MP : Marine generator drive and marine general mechanical drive

Series code

No.-of-cylinders code

Sagamihara Machinery Works

SAFETY – IT'S UP TO YOU

WARNINGS, CAUTIONS and NOTES are used in this manual to emphasize important and critical instructions. They are used for the following conditions:

⚠ WARNING ..... Operating procedures, practices, etc., which if not correctly followed, will result in personal injury or loss of life.

⚠ CAUTION ..... Operating procedures, practices, etc., which if not strictly observed, will result in damage to or destruction of engine.

NOTE ..... An operating procedure, condition, etc., which is essential to highlight.

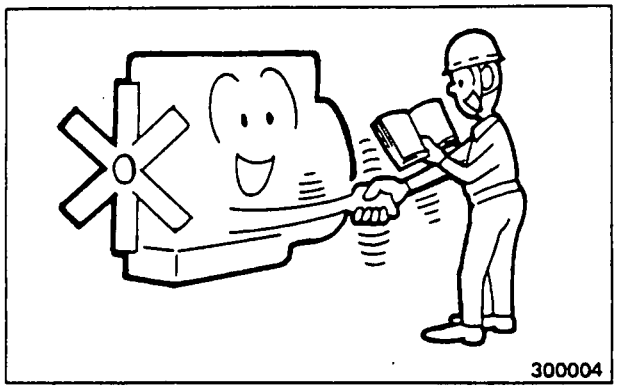
✓ ..... Right or normal

× ..... Wrong or abnormal (service needed)

Recommendation of daily operation record

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 pin-point the trouble)
- Quick servicing and less downtime (to help him save time for servicing)
- Grasp of operating conditions (to help you recognize conditions, signs or indications of approaching trouble)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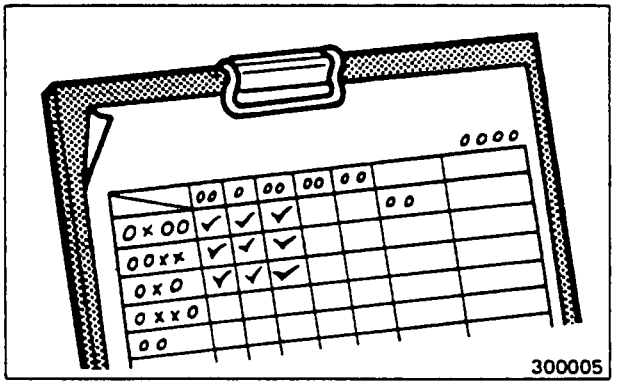
Items to be recorded

The following items are recommended to be recorded as "daily readings":

1. Operating hours (service meter reading)
2. Quantities of engine oil, fuel oil and water (coolant) used for refilling.
3. Engine oil and coolant change periods
4. Engine oil pressure, exhaust temperature and supply air pressure
5. Parts serviced, kinds of service (adjustment, repair or replacement) and results of service
6. Changes in operating conditions (for example, "Exhaust smoke turned black")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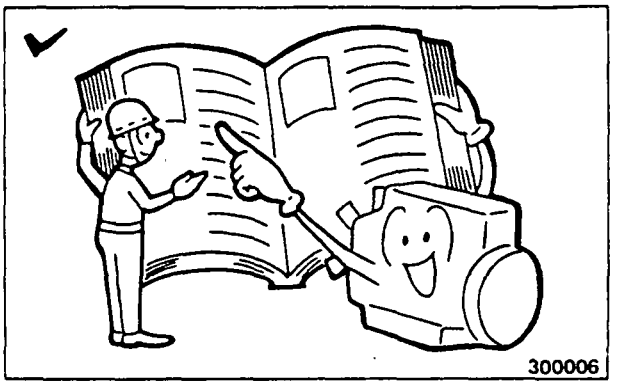
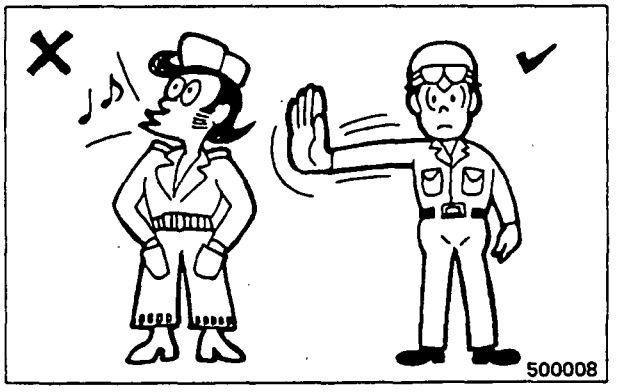
⚠ Study OPERATION & MAINTENANCE MANUAL to become thoroughly familiar with all engine controls and instruments – and service procedures.

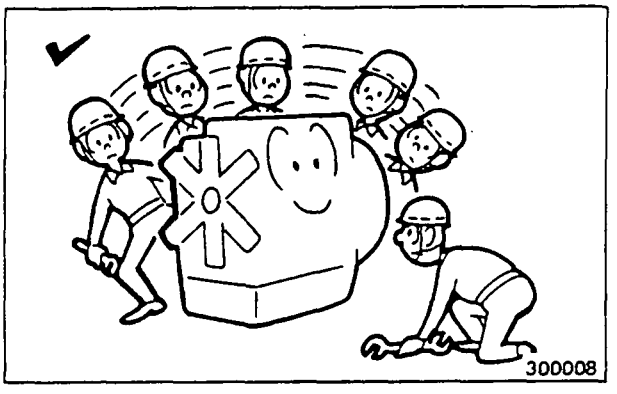


⚠ Wear hard hat and safety shoes – and, if job conditions require, safety goggles, heavy gloves, car protectors, respirators, etc.

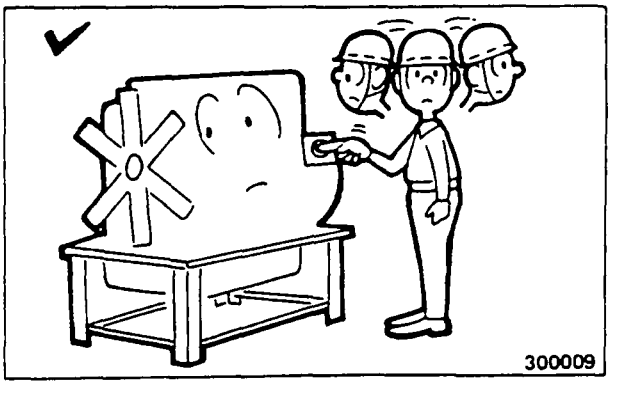


Before operation

Before starting and during warm up period, check under and around engine for visual defects – leaks of fuel, oil and coolant, loose or missing part.

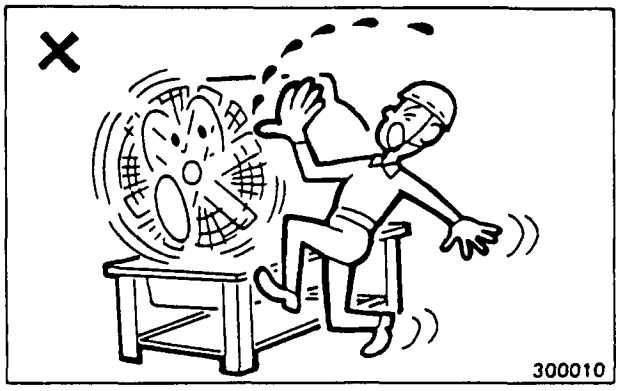


⚠ When starting engine, walk around it once more – open eyes and be alert to people and obstacles that may be within operating range.

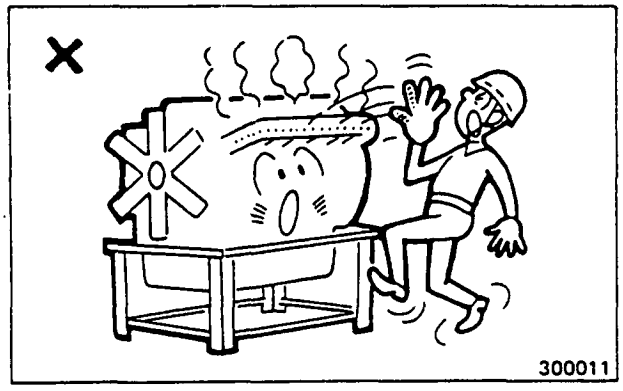


During operation

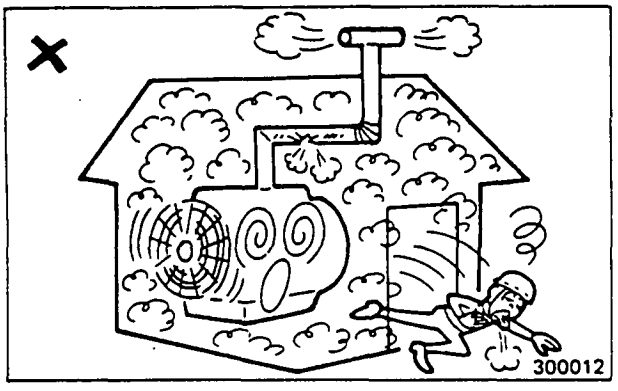
⚠ Do not touch any moving part of a running engine, or clothing or hair can be caught in moving parts, resulting in personal injury or loss of life.



⚠ Keep hands off hot parts – turbocharger, exhaust pipe, etc. – during operation or immediately after shutting off engine.



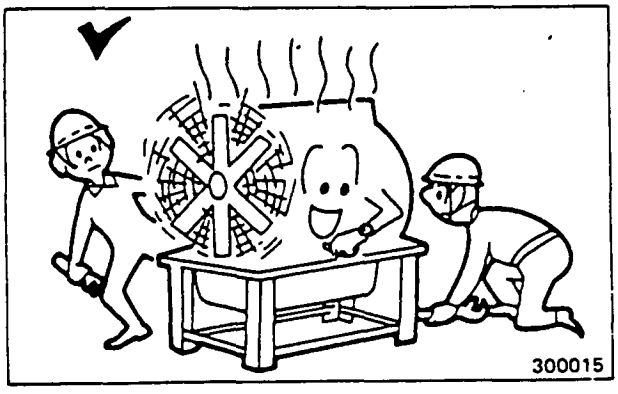
⚠ If necessary to operate engine within an enclosed area, provide adequate ventilation – and pay attention to exhaust piping and exhaust gas leaks.



Idling operation for engine cooling

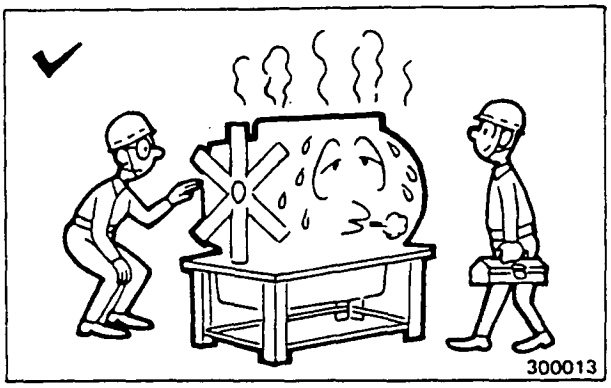
After the load is removed, allow the engine to low idle for about 5 to 6 minutes and, during this period, check the engine for any defects.

Shutting off the engine immediately after removing the load is very hard on the engine parts.



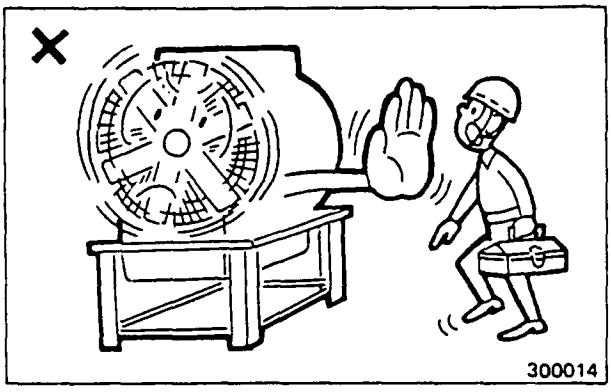
After operation

At end of operating period, walk around engine to check for any defects, and make repairs to prepare for the next day.

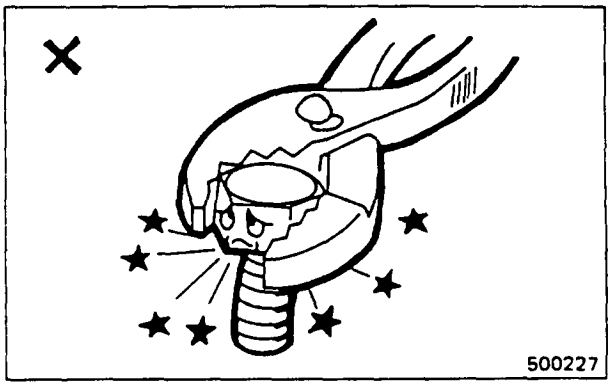


Maintenance

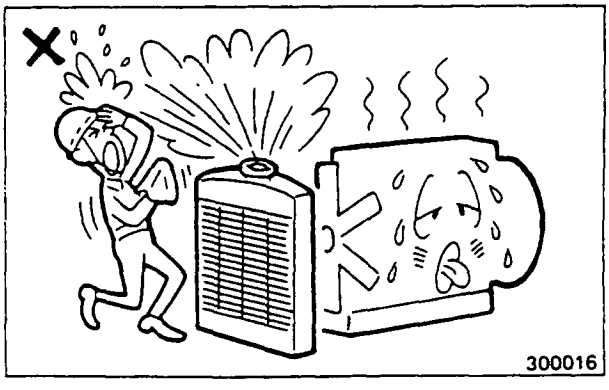
⚠ Be sure to shut off engine, and turn off battery main switch (or close air tank valve) before servicing engine. If necessary to crank engine for inspection, signal to other man before cranking. After cranking, be sure to remove cranking bar.



⚠ Use right tools correctly. Thoughtless use of tools including use of a wrong tool can cause personal injury and damage to engine.

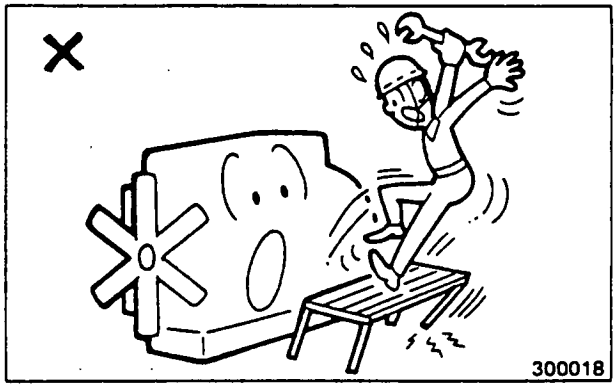


⚠ When removing radiator filler cap immediately after shutting off engine, be sure to release pressure to avoid having scalding by hot water or steam spouted out from radiator.



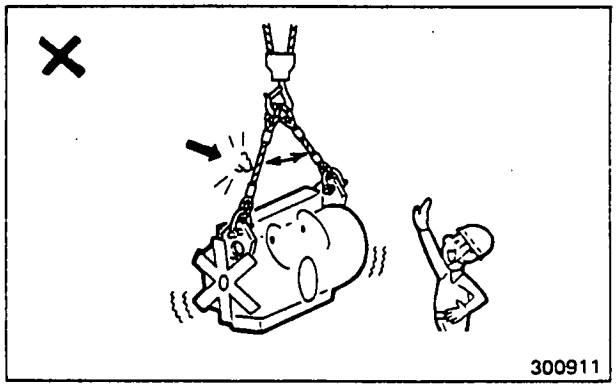
⚠ Do not smoke while handling highly flammable materials. Do not use open cans of gasoline or diesel fuel for cleaning parts near any open flame. Good commercial, nonflammable solvents are preferred.

⚠ Do not attempt to "climb up" engine for access to upper parts. Use a safe footstool for maintenance without accidents.



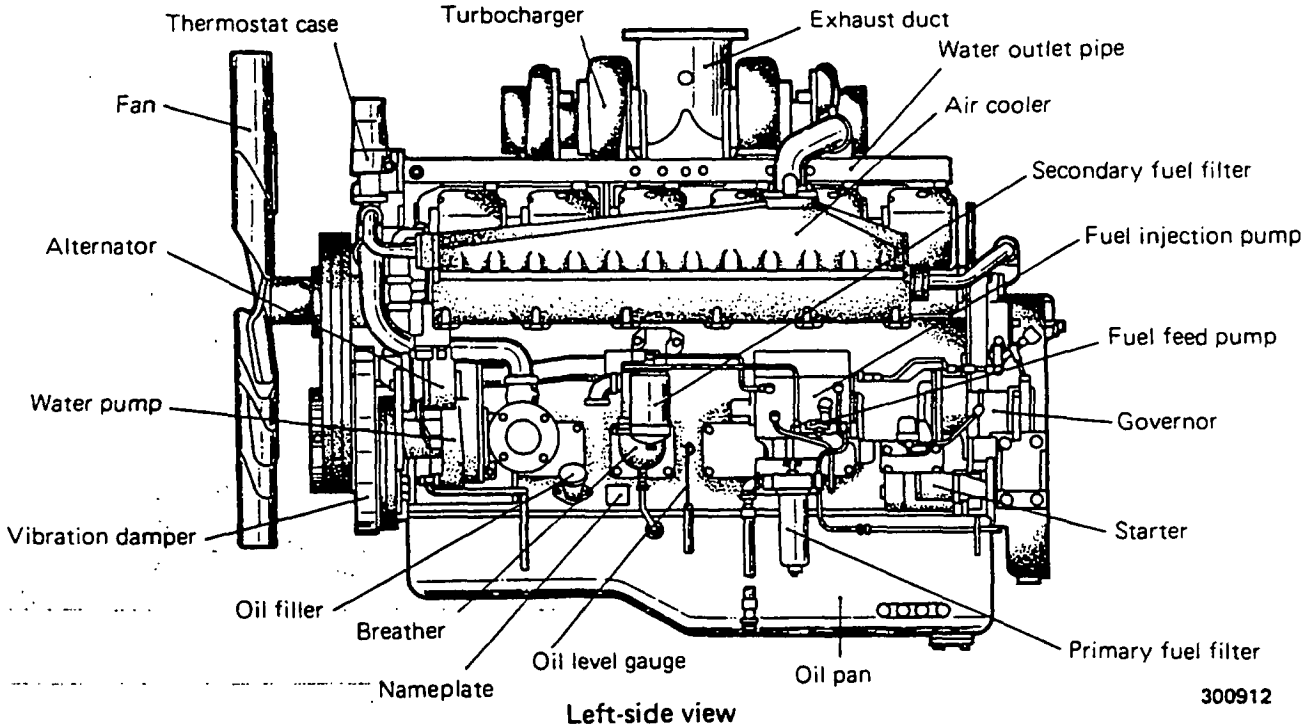
⚠ When lifting engine, use slings free of broken strands. Be sure that the crane has enough capacity for engine to be lifted. Make use of hangers provided on engine, and lift it carefully.

Attach each sling to engine at an angle of less than 60°. Put wads to sling contacting surfaces of engine to protect both slings and engine.

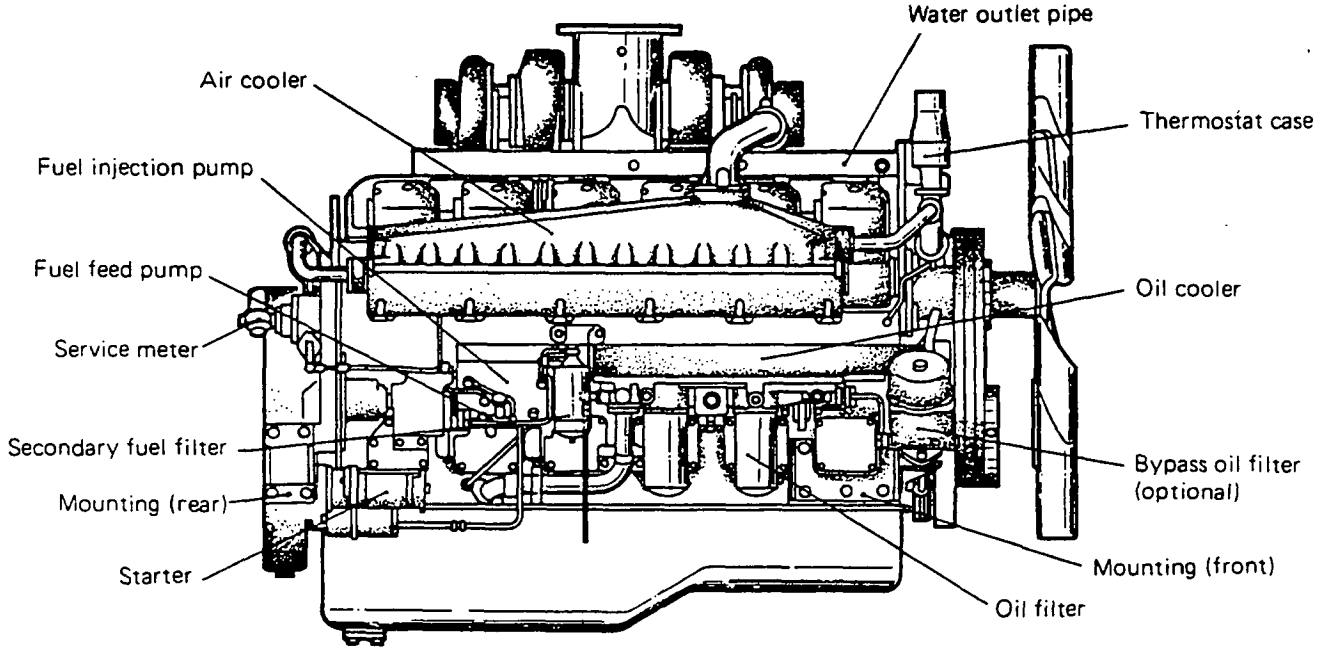


MAJOR COMPONENTS

S12A2 diesel engine – External views



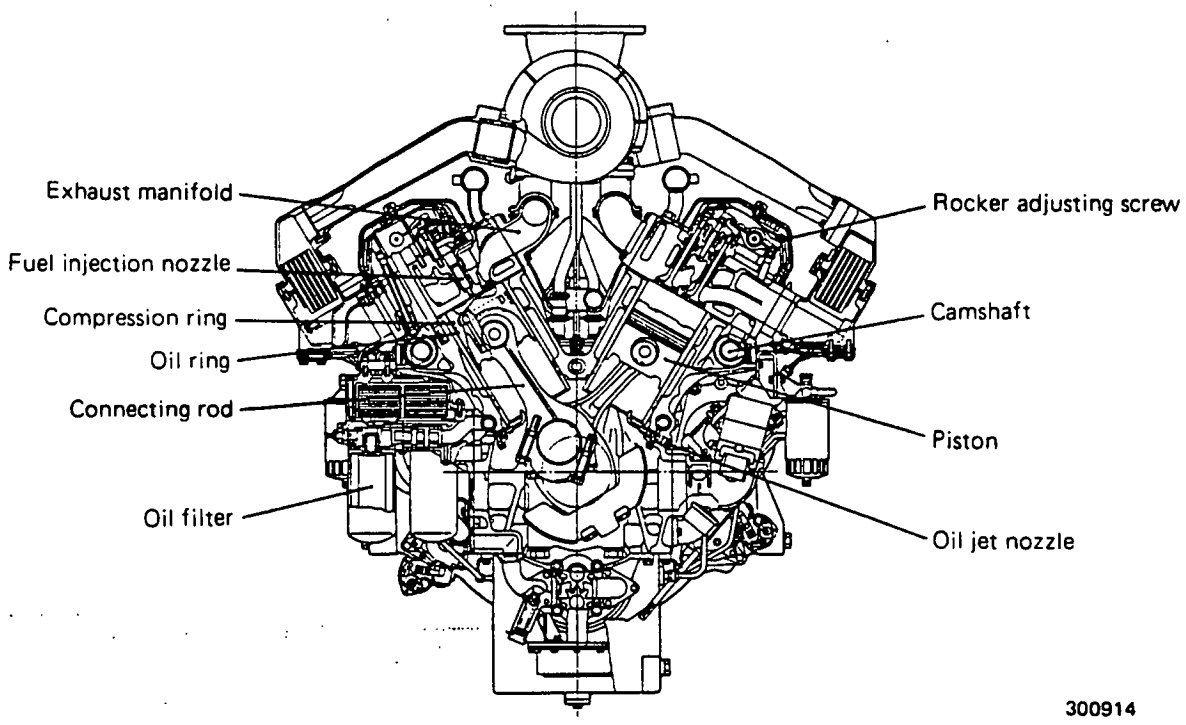
Left-side view



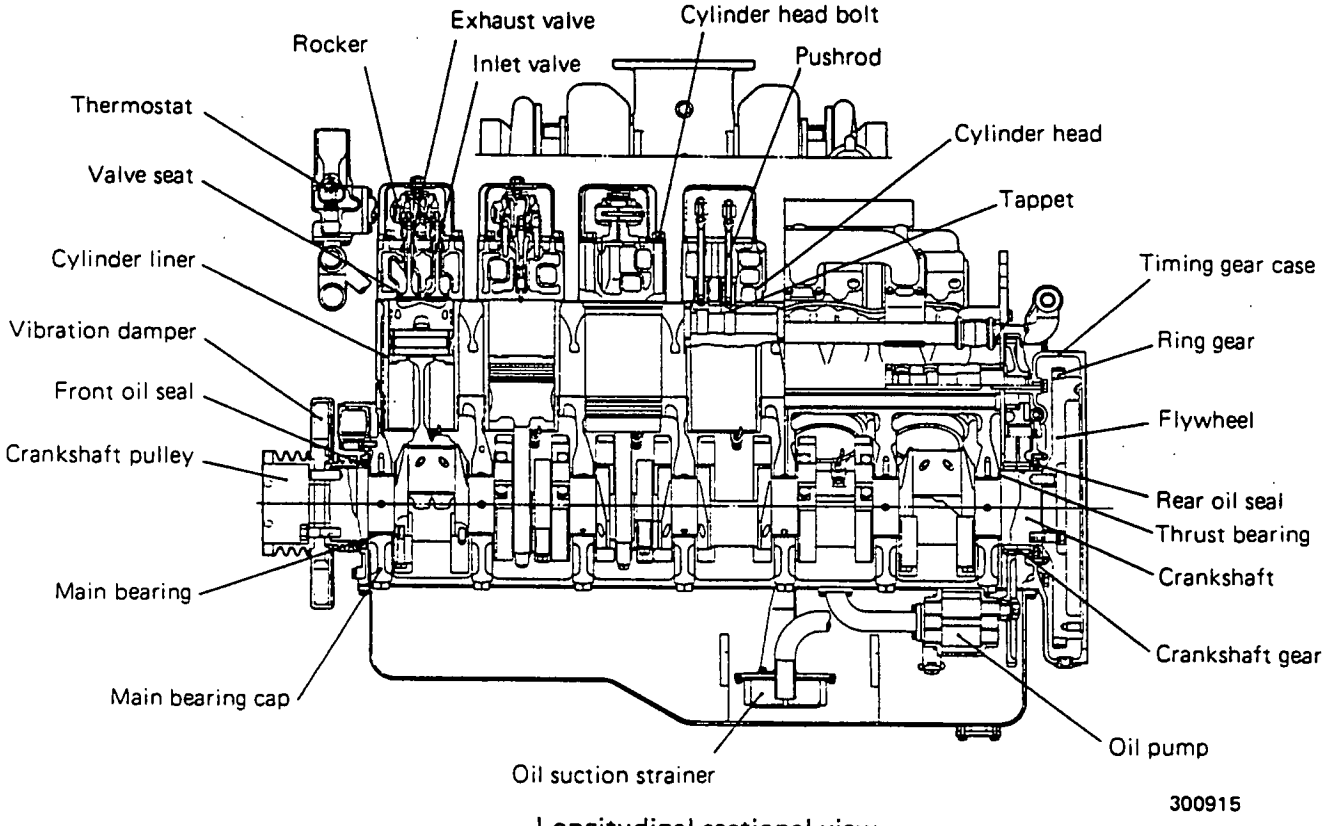
Right-side view

NOTE: Direction of rotation of this engine is counterclockwise as viewed from flywheel side.

S12A2 diesel engine – Sectional views



Transverse sectional view

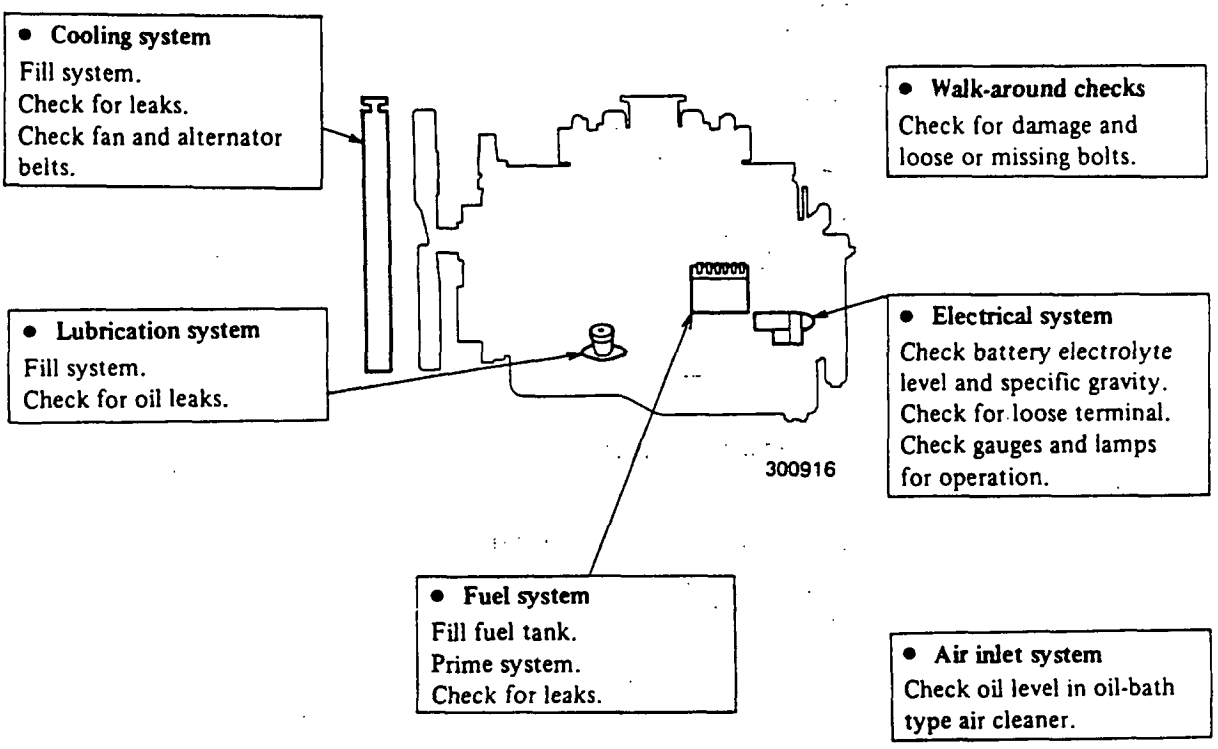


Longitudinal sectional view

NEW ENGINE INITIAL SERVICE

Before operation

Anyone charged with the care and operation of the engine is responsible for "new engine initial service" – service for a new or reconditioned engine or an engine which has been stored for any length of time. Check the following points before starting the engine for the first time. For the second and subsequent services, refer to Maintenance Schedule.



After initial 50 service hours, perform the following services:

- Change of engine oil
- Change of oil filter paper element
- Adjustment of valve clearance
- Retightening of bolts and nuts

NOTE

During break-in period of a new or reconditioned engine, avoid sudden application of load and high-speed operation for engine life.

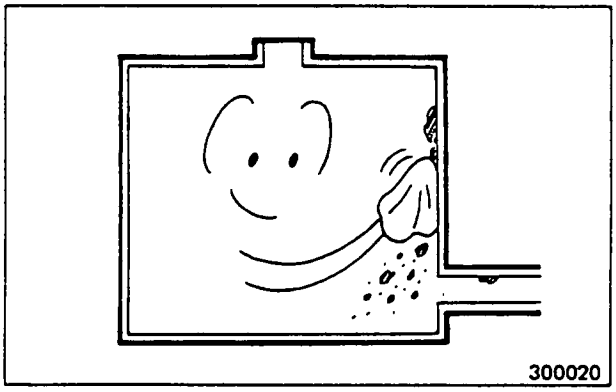
WALK-AROUND CHECKS

- Damage or missing parts — Engine
- Loose bolts and nuts — Cylinder heads
  - Crankshaft pulley
  - Fuel injection pump coupling and drive shaft
  - Mounting brackets
  - Turbocharger
  - Exhaust pipe

FUEL SYSTEM

Filling the fuel tank

Before filling the fuel tank, check to be sure that the tank and pipes are free of dirt, water or other foreign substances. After filling, check to make sure that the tank is filled up to FULL mark on the level gauge.

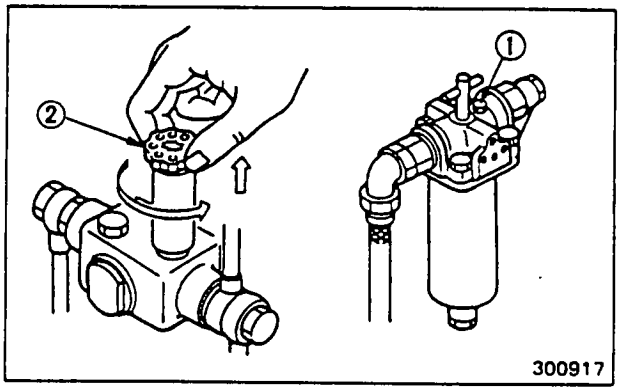


Priming the fuel system

Prime the fuel filters and injection pumps in that order – that is, from the fuel tank side.

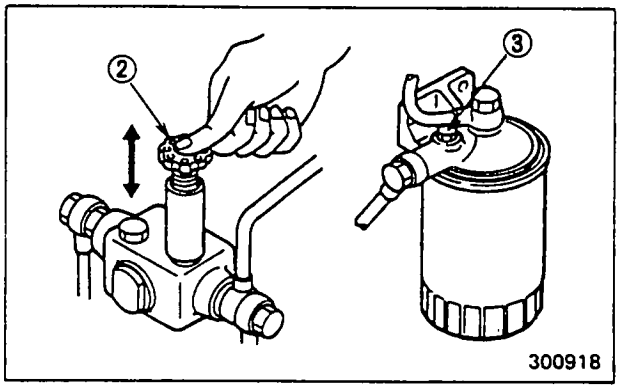
- **Primary fuel filter (wire-element type)**

1. Loosen air vent plug (1) about 1-1/2 turns on the filter.
2. Unlock priming pump handle (2) of fuel feed pump by twisting it counterclockwise, and operate.
3. Tighten plug (1) when the flow of fuel at the plug is free of air bubbles.



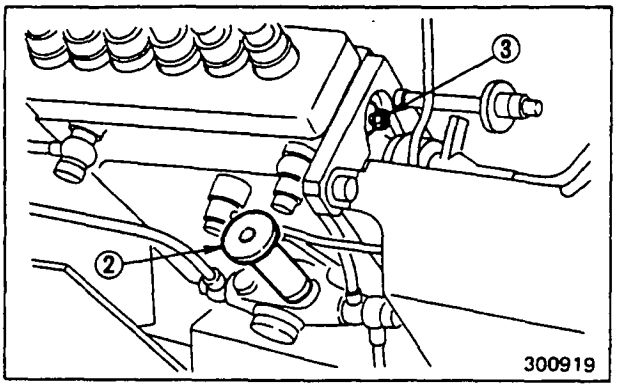
- **Secondary fuel filters (paper-element type)**

1. Loosen air vent plug (3) about 1-1/2 turns on the filter.
2. Operate the priming pump handle (2).
3. Tighten plug (3) when the flow of fuel at the plug is free of air bubbles.



- **Fuel injection pumps**

1. Loosen air vent plug (3) about 1-1/2 turns on the injection pump.
2. Operate priming pump (2) until the flow of fuel at the plug is free of air bubbles. Lock the priming pump by twisting it clockwise while depressing it, and then tighten vent plug (3).



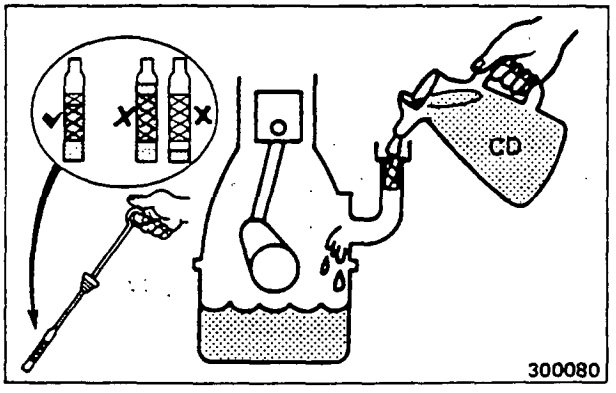
⚠ CAUTION

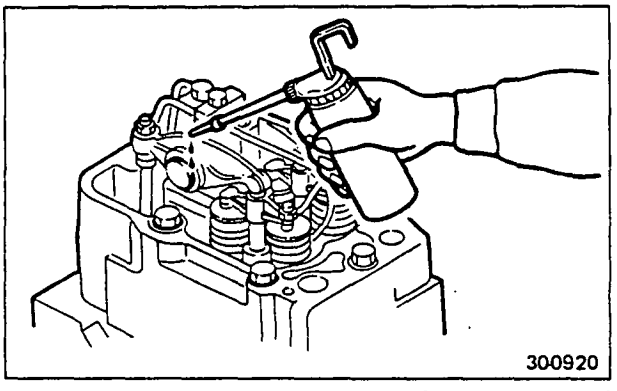
1) If all vent plugs are tightened before priming pump is locked, pressure acts on feed pump, making it difficult to lock the priming pump.
2) Wipe off fuel spilled out of each vent plug hole with wiping rag.

LUBRICATION SYSTEM

Filling the oil pan

1. Use a clean jug to pour oil into the oil pan. Use engine oil of API service classification "CD."
2. After filling, check the oil level with the level gauge. The level should be within the operating range on the gauge.
3. Remove the rocker cover, and apply oil to the valve mechanism.
4. Check the oil pan and other parts for oil leaks.
5. Start and run the engine for a while. Stop the engine and, after waiting for about 10 minutes, add oil up to the level specified in step 2 above.





COOLING SYSTEM

Filling the cooling system

1. Tighten the oil cooler, water pump and air cooler (TA, TK) drain cocks (or the radiator drain plug on a radiator-cooled engine). The engine is shipped from the factory with its cooling system drained.
2. Use clean water that is low in scale forming mineral. Remember, some waters pumped out of ground in a mining or hot-spring area contain active impurities harmful to the metal of cylinder liners.

NOTE

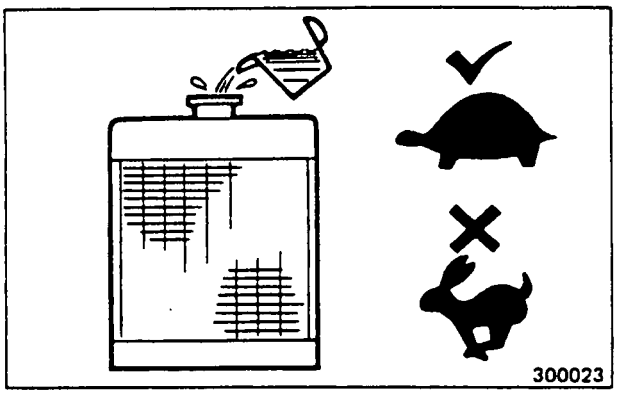
Use rust inhibitor in the cooling system at all times. Use anti-freeze solution when the temperature is below freezing.

3. To fill the cooling system of a radiator-cooled engine for the first time, or to change the coolant in such an engine, proceed as follows:

a) Remove the radiator filler cap, and slowly fill the radiator until it is full. Pour water at a rate of 10 liters (2.6 U.S. gal) per minute.

NOTE

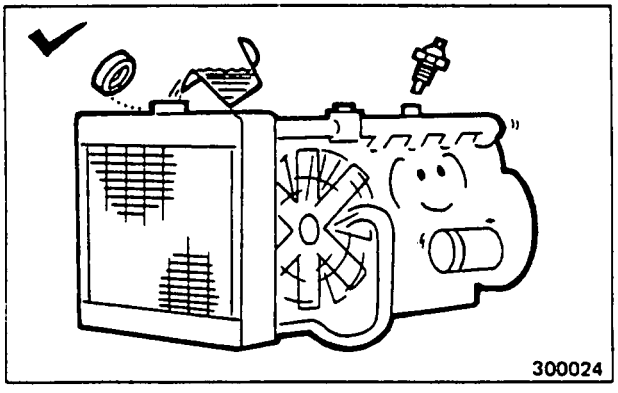
To bleed air out of the cooling system, loosen the thermo sensor at the water outlet pipe.



b) With the radiator filler cap removed, crank the engine with the starter three times, for 5 to 6 seconds each time, at intervals of about 20 seconds, in order to bleed air out of the water pump.

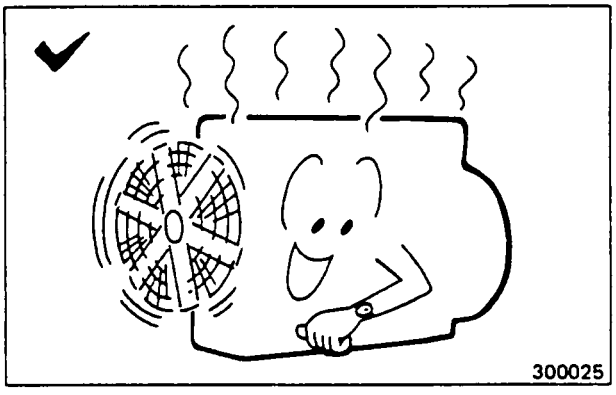
⚠ CAUTION

To crank the engine for air bleeding, keep the stop lever in STOP position.



c) Check the coolant level in the radiator, and add water if necessary.

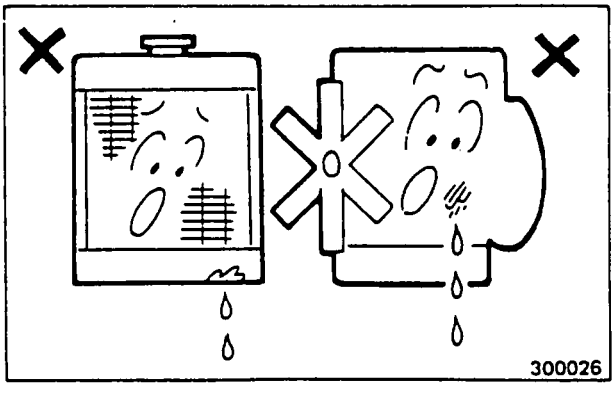
d) Crank the engine with the fuel supply shut off for 30 seconds to make sure that the oil pressure rises normally. If the pressure does not rise in 30 seconds, wait for about 1 minute, and crank it again.



e) Start the engine, and run it at 600 to 700 rpm for 3 to 5 minutes.

f) Stop the engine, and check the coolant level in the radiator again. If the level is low, refill the radiator fully, and install the cap.

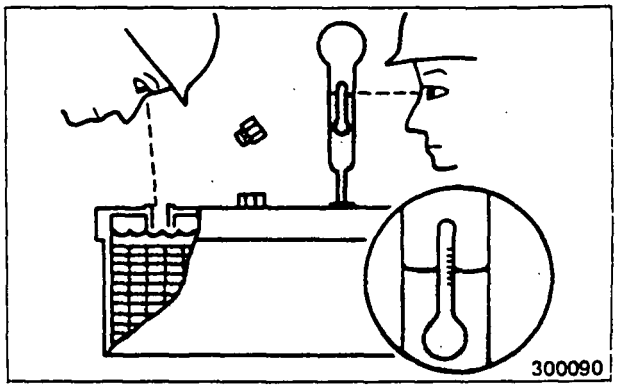
g) Check the hose joints for coolant leaks.



ELECTRICAL SYSTEM

Battery electrolyte level and specific gravity

1. Remove the filler caps, and check the electrolyte level in each cell. It should be 1 cm (3/8 in.) above the cell plates.
2. When filling the cells of the battery for the first time, slowly pour dilute sulfuric acid (electrolyte) in the cells.
3. If the battery is already in service, check the electrolyte level and, if the level is low, add distilled water.
4. Check the specific gravity of electrolyte. If the SG is below 1.22 at 20°C (68°F), recharge the battery.



⚠ WARNING

1) Electrolyte, sulfuric acid, is very corrosive. If you drip it on your skin or clothing, flush it off at once with water.
2) Do not allow sparks or open flame near the battery.

Circuits

Check each circuit for loose terminals.

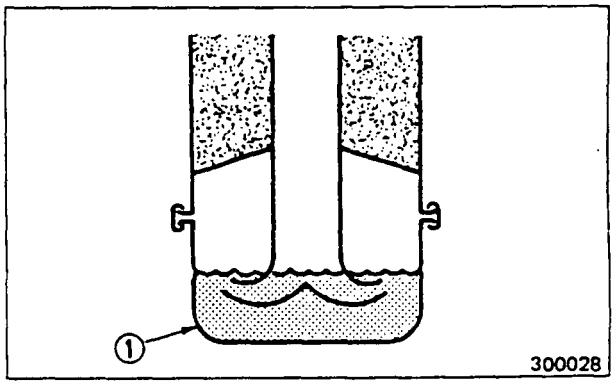
AIR INLET SYSTEM

Checking the oil level in oil-bath type air cleaner:

1. Remove the lower tank (1).
2. Check the oil level in the tank, and add engine oil if necessary.

⚠ CAUTION

Do not overfill the air cleaner tank or the oil is drawn into the engine, causing it to overrun.



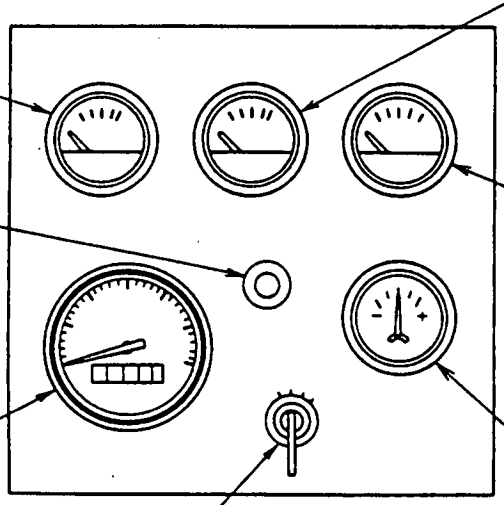
OTHERS

Check the following valves and cocks to make sure they are opened or closed properly:

- Fuel supply valve . . . . . Opened
- Coolant drain plug (radiator) . . . . Closed
- Coolant drain cocks (engine) . . . . Closed
- Oil drain valve . . . . . Closed
- Air supply valve (air tank) . . . . . Opened

OPERATING THE ENGINE

Controls and instruments



- **Water temperature gauge**
  Indicates temperature of engine coolant.
  Normal range:
  70 – 90°C
  (158 – 194°F)

- **Oil temperature gauge**
  Indicates temperature of engine lubricating oil.
  Normal range:
  70 – 110°C
  (158 – 230°F)

- **Oil filter alarm lamp (pilot lamp)**
  Glows when paper-element type oil filter is clogged.

- **Oil pressure gauge**
  Indicates pressure of lubricating oil.
  Normal range:
  5 – 6 kgf/cm^2
  (71 – 85.3 psi)
  [0.5 – 0.6 MPa]

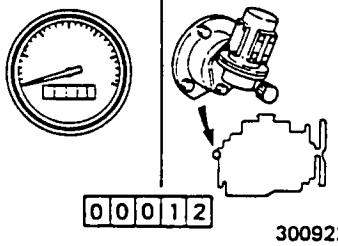
- **Tachometer**
  Indicates engine speed in rpm (revolutions per minute).

- **Ammeter**
  Indicates battery charging current.
  Normal indication: (+) side

- **Starter switch**
  HEAT: Operates air heater to start engine easily in cold weather. (air-heater model)
  OFF: Insert and pull out key. All electrical circuits are OFF.
  ON: Keep engine running. Charging and lamp circuits are ON.
  START: Start engine. Key will return to ON when released.

- **Service meter**

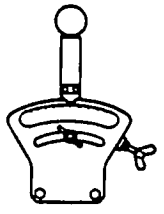
Incorporated in tachometer | Attached to engine proper



300922

Rely on this meter to check, service or lubricate engine. Dial advances one number when engine is operated for 1 hour at 1500 rpm.

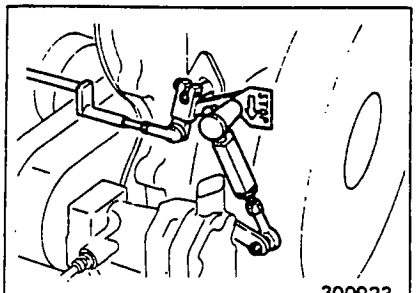
- **Speed control lever**



300082

Use the lever to control engine speed. Pull it to stop engine.

- **Stop lever**



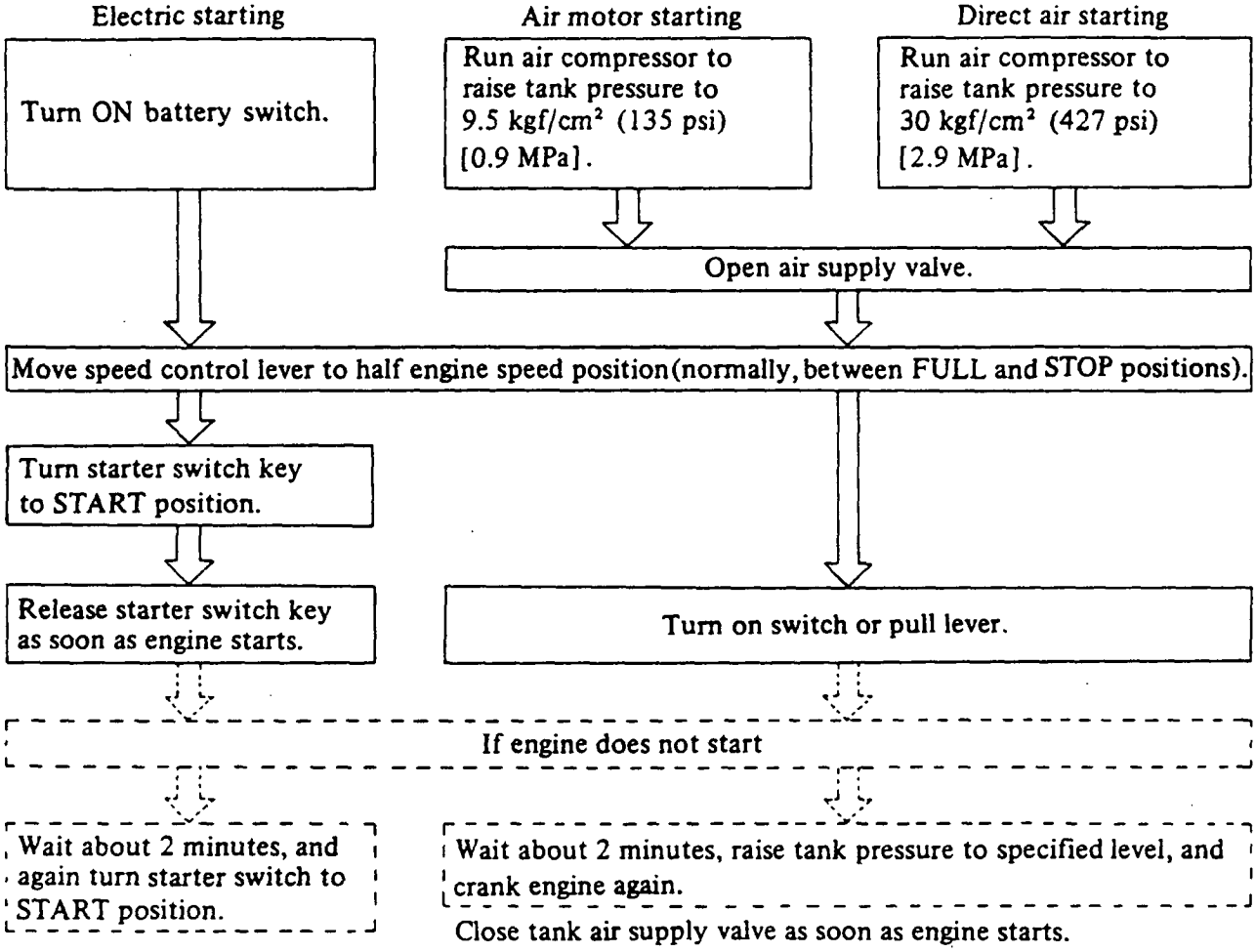
300923

Push the lever to stop a generator drive engine in case of emergency.

After performing daily (10-hour) servicing, operate the engine as follows:

STARTING

There are three methods available for starting the engine – electric starting, air motor starting and direct air starting. Disengage the clutch (if equipped) or remove any load possible from the engine.



Close tank air supply valve as soon as engine starts.

NOTE

* Keep the tank air supply valve always opened for automatic starting.

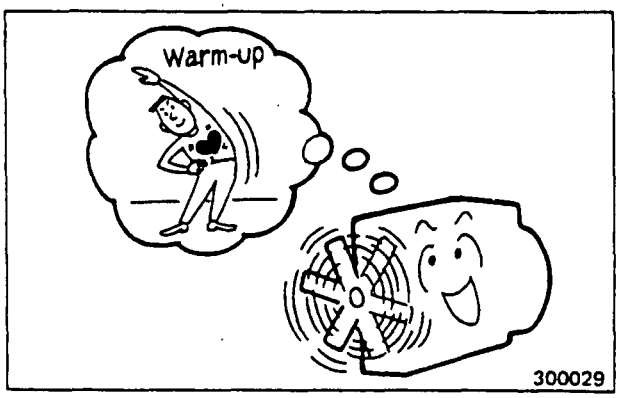
⚠ CAUTION

Give particular attention to the following rules when using the electric starting:

- Do not run the starter for more than 30 seconds at a time. Prolonged starter operation discharges battery, resulting in hard starting.
- When cranking the engine again, wait until the starter stops rotating and the engine stops "rocking" to prevent it from turning in reverse direction.
- Keep the starter switch in ON position during operation. Never move battery switch and starter switch to OFF position.
- On air-motor or direct-air starting engine, open the air tank drain cock and drain water every 50 hours or monthly.

WARMING UP

After starting up, allow the engine to idle at about 1000 rpm for 5 minutes to warm it up. During this warm-up period, check to be sure that oil pressure rises properly. After warm-up operation, the 2 to 3 kgf/cm² (28 to 43 psi) [0.2 to 0.3 MPa] during low idling.



⚠ CAUTION

- It is not necessary to warm up a stand-by engine. Instead, be sure to perform periodical testing items described in "Maintenance Instructions."

STARTING THE LOAD

After warming up the engine, apply the load. During the operation, check to be sure –

1. The engine makes no abnormal sound and vibration.
2. Exhaust smoke color is normal.
3. Meters and gauges are indicating normally.

- o Tachometer
- o Engine oil pressure gauge
  5 – 6 kgf/cm² (71 – 85 psi) [0.5 – 0.6 MPa]
- o Water temperature gauge
  70 – 90°C (158 – 194°F)
- o Ammeter
  (+) side
- o Engine oil temperature gauge
  70 – 110°C (158 – 230°F)
- o Oil filter alarm lamp (pilot lamp) – OFF

STOPPING

1. After the load is removed, allow the engine to idle for about 5 minutes.
2. Shutting off the engine immediately after removing the load is very hard on the engine parts.

⚠ CAUTION

Keep on pushing the stop lever until the engine comes to a complete stop. Do not release the lever before the engine stops to prevent it from turning in reverse direction.

Engine equipped with speed control lever	Engine equipped with stop lever
Move speed control lever to STOP position.	Push stop lever on governor to STOP position.

Turn starter switch to OFF position, pull out key, and turn OFF battery switch (electric starting).

OPERATION UNDER EXTREME WEATHERS

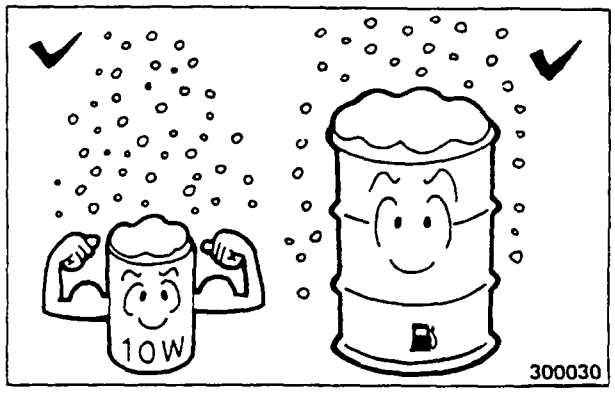
COLD WEATHER PRECAUTIONS

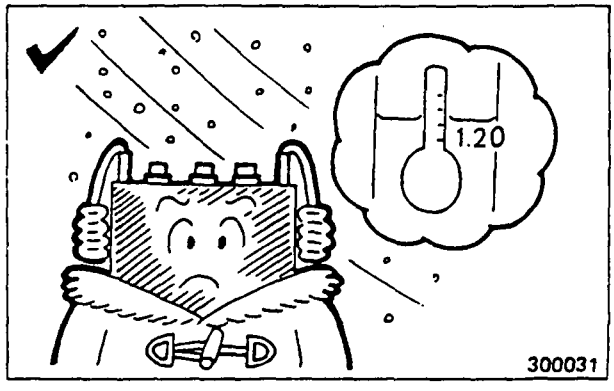
Engine oil and fuel

1. Use engine oil of lower S.A.E. viscosity grade in cold weather. (See page 44.)
2. Use fuel oil of lower pour point.(See page 41.)

Battery

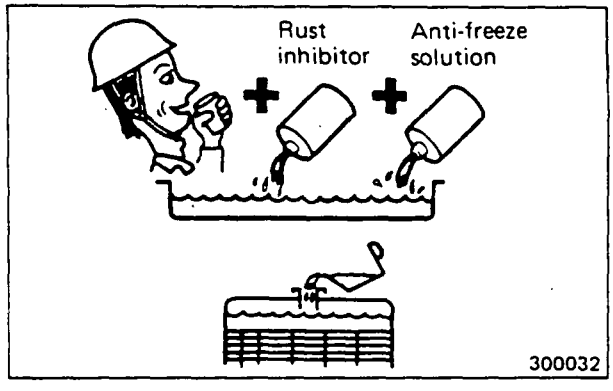
1. Add distilled water to the battery before starting the engine to prevent electrolyte from freezing.
2. The specific gravity of electrolyte rises as the battery becomes increasingly charged. An electrolyte with S.G. of 1.20 or under freezes at −20°C (−4°F) or so. To avoid such a freeze-up, be sure to keep the battery fully charged at all times, so that the electrolyte S.G. will be 1.28 or over.
3. The lower the temperature, the smaller the capacity of the battery. Try to keep the battery as warm as possible, and make necessary provisions for protecting the battery from the deadly chill of the night.





Cooling water

1. When the temperature is below freezing, use an anti-freeze solution in the cooling system.
2. The larger the proportion of the solution, the lower is the freezing point of the mixture.
3. A commercial anti-freeze solution comes with printed directions. Read them carefully and prepare the mixture in proportions (water and solution) necessary for the lowest freezing temperature expected. This chart will serve as a rough guide for determining the percent proportion of the solution for the mixture:



- **Anti-freeze solution**

a. Use a permanent-type anti-freeze solution.

b. When using anti-freeze solution, mix fresh water, anti-freeze solution and rust inhibitor in a container, and pour the mixture into radiator.

Percent of solution and coolant freezing point (reference)

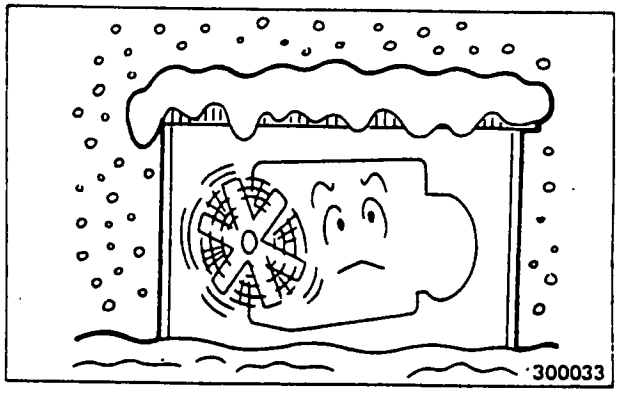
Anti-freeze solution	20	30	40	50	60
Freezing point °C (°F)	0 – −9 (32 – 15.8)	−16 (3.2)	−24 (−11.2)	−36 (−32.8)	−45 (−49.0)

⚠ WARNING

The anti-freeze solution is inflammable. Be sure to handle it carefully.

c. Before filling up the cooling system with the anti-freeze coolant, flush the system clean.

d. After the cold season, drain and flush the cooling system and fill it with soft water.



Operating in cold weather

1. During cold weather, the battery is weak, often resulting in hard starting. If the engine fails to start within 30 seconds, wait for about 2 minutes to allow the battery to recover strength, before cranking the engine again.
2. When starting the engine equipped with an air heater in temperatures below -5°C (23°F), or when the engine is hard to start, turn the starter switch to HEAT position for the length of time indicated below to preheat the engine. (See page 15.)

Starting temperature	-5 – -15°C (23 – 5°F)	-15 – -30°C (5 – -22°F)
Heating time	20 – 40 seconds	40 – 60 seconds

NOTE

Cold starting aids are available from your Mitsubishi dealer.

3. After starting the engine, warm it up thoroughly before applying the load.

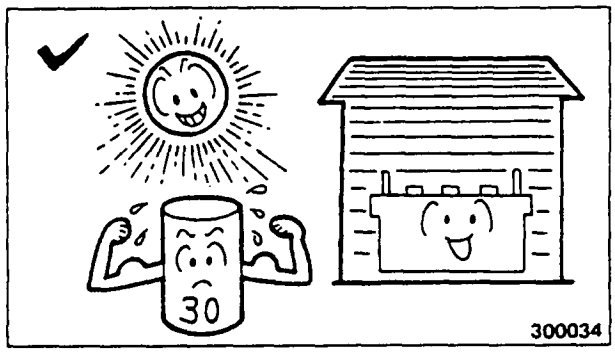
NOTE

The oil pressure gauge will indicate high pressure when the oil temperature is low immediately after the engine is started. In such a case, keep on idling the engine without increasing engine speed. The oil pressure will drop to the normal level as the oil temperature rises.

At end of operating period

1. Drain out water and sediment that has accumulated in fuel system to prevent freezing.
2. Fill the fuel tank fully to drive out moisture-laden air for preventing condensation.
3. In case of the TK type engine, drain coolant from the air cooler to prevent freezing.

HOT WEATHER PRECAUTIONS



Engine oil

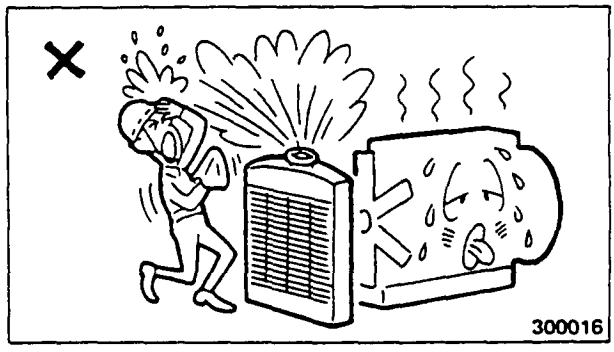
Use engine oil of higher S.A.E. viscosity grade in hot weather. (See page 44.)

Battery

At higher temperatures, the battery is likely to lose its energy by "self-discharging." Remove the battery from the engine, and store it in a cool place.

Cooling water

Keep the cooling system filled up at all times. Repair any leaking point upon discovery of such a point. Maintain the water pump, fresh-water cooler and thermostat in the best operable condition.



Operating in hot weather

Give particular attention to overheating of the engine by observing the water temperature gauge, oil pressure gauge and alarms. When the engine is overheated, remove the load rather slowly, and allow the engine to idle for gradual cooling.

WARNING

Do not attempt to pour cold water into the radiator of an overheated engine: you will have scalding hot coolant or steam spouted out from the radiator.

MAINTENANCE INSTRUCTIONS

1. Use service-meter or calendar intervals whichever occur first.
2. The maintenance schedule, which follows, is for a fully equipped engine.
3. The established intervals in the schedule are for an average job application. Service the engine earlier than scheduled intervals if necessary. (Service intervals depends on application, operating conditions, fuel oil and lubricating oil used in the engine. Adjust the service intervals to meet the actual operating conditions.)
4. Perform previous interval items at multiples of the original requirement.

   Example: At 250 hours or 1 year, also perform those items listed in "10 hours or daily" and "50 hours or monthly."
5. The engine used for stand-by duty must be thoroughly checked and kept in perfectly operable condition at all times. This is because it has to be started and run under severe conditions and is expected to give full performance no matter when it is put in operation. Test the engine periodically by running it in the following conditions:

Periodical testing

Test run	Once-a-week no-load test run for 5 to 10 minutes	Check for: Ease of starting Lube oil pressure Color of exhaust smoke Abnormal vibration and others
	Once-a-month load test run for 15 to 30 minutes (Operate at half the full load, min.)	

○ Check, clean, wash, adjust.
● Change.
Ⓢ Rely on your Mitsubishi dealer if necessary.
* Item to be performed after initial 50 hours of operation of a reconditioned or long-stored engine.

MAINTENANCE SCHEDULE

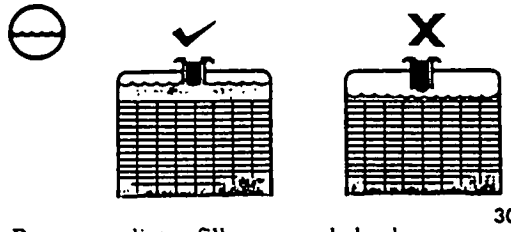
Group	Service		Service intervals						Remarks
			Every 10 hours or daily	Every 50 hours or monthly	Every 250 hours or 1 year	Every 500 hours or 2 years	Every 1000 hours or 3 years	Every 2000 hours or 5 years	
Engine proper	Valve clearance	Check		*			○		Ⓢ
	Bolts and nuts	Retighten		*			○		Ⓢ
	Walk-around checks		○						
Lubrication system	Oil pan	Check oil level	○						
		Check for water or fuel in oil		○					
		Change oil		*	●				Ⓢ
	Oil filter (paper-element type)	Change element		*	●				Change element when alarm lamp glows.
	Bypass oil filter	Wash			○				Ⓢ
	Woodward governor oil filter	Change element				●			
Fuel system	Fuel tank	Check level	○						
		Drain water		○					
	Secondary fuel filter (paper-element type)	Drain water		○					
		Change cartridge					●		
	Primary fuel filter (wire-element type)	Turn	○						
		Drain water		○					
		Wash element					○		Ⓢ
	Injection nozzles	Check and adjust					○		Ⓢ
	Injection timing	Check and adjust					○		Ⓢ
Cooling system	Coolant	Check level	○						
		Change	Change coolant twice a year. Use rust inhibitor. Use anti-freeze solution in autumn if freezing temperatures are expected in winter. In spring, drain anti-freeze coolant and refill with soft water.						
	Radiator fins	Clean			○				Ⓢ
	Fan/water pump drive belt	Check tension			○				

Group	Service		Service intervals						Remarks
			Every 10 hours or daily	Every 50 hours or monthly	Every 250 hours or 1 year	Every 500 hours or 2 years	Every 1000 hours or 3 years	Every 2000 hours or 5 years	
Cooling system cont'd	Water pump tension pulley	Lubricate			○				
	Heat exchanger	Wash						○	Ⓢ
	Zinc rods	Change				◐			Ⓢ
Air inlet and exhaust systems	Air cleaner (paper-element type)	Check indicator	○						
		Clean element			○				Ⓢ
		Change element					●		
	Air cleaner (oil-bath type)	Change oil			●				
		Wash element			○				Ⓢ
	Air cleaner (silencer type)	Clean			○				Ⓢ
	Exhaust muffler	Drain water			○				
	Air cooler	Clean						○	Ⓢ
	Turbo-charger	Check						○	Ⓢ
Starting system	Electric starting: Battery	Check electrolyte level/ specific gravity	○						Check specific gravity from time to time
	Electric starting: Alter-nator	Check						○	Ⓢ
	Electric starting: Starter	Check						○	Ⓢ
	Air starting: Oiler	Check oil level	○						
	Air starting: Air filter (air-motor starting)	Drain water		○					
		Wash element				○			Ⓢ
	Air starting: Air filter (direct-air starting)	Drain water		○					
		Wash element				○			Ⓢ
	Air starting: Air tank	Check air pressure	○						Before starting
		Drain water		○					
		Check safety valve for operation			○				Ⓢ

Group	Service		Service intervals						Remarks
			Every 10 hours or daily	Every 50 hours or monthly	Every 250 hours or 1 year	Every 500 hours or 2 years	Every 1000 hours or 3 years	Every 2000 hours or 5 years	
Protective devices operation	Water temperature rise [95 ± 2°C (203 ± 3.6°F)]						○		Ⓢ Check when malfunction is suspected (Check standby engine every year.)
	Engine oil pressure drop 1.5 ± 0.15 kgf/cm² (21 ± 2.1 psi) [0.15 ± 0.015 MPa]								
	Overspeeding (112 – 115%)								
Others	Vibration damper	Check						○	Leaks, cracks in rubber or flaw
		Change							Every 8000 hours
	Coupling (rubber bushings)	Check			○				Ⓢ Cracks or other defects
	Valves in pipeline	Check for setting	○						
	Speed control lever	Check	○						
	Tachometer drive L joint	Lubricate			○				Ⓢ

EVERY 10 HOURS OR DAILY

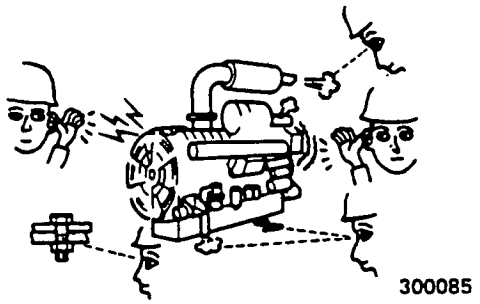
Radiator – Check coolant level



300160

Remove radiator filler cap and check.
Coolant should be visible in filler neck.
Check level in sight gauge on expansion tank.

Walk-around checks

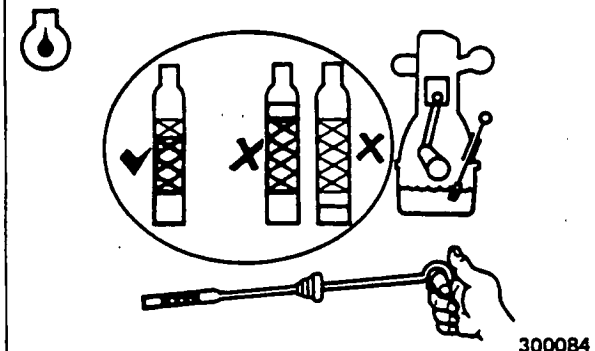


300085

Check for:

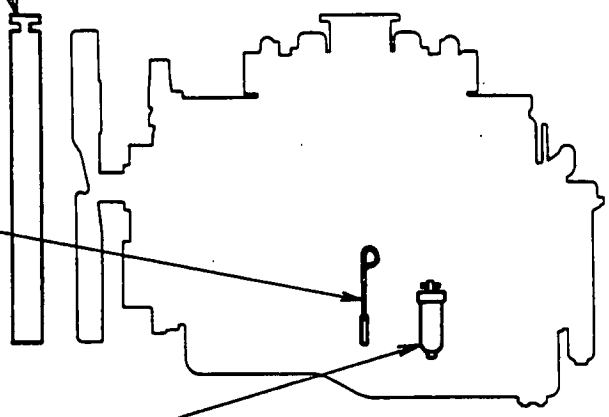
- Loose or missing bolts and nuts
- Abnormal vibration, noise and exhaust color
- Water, oil and air leaks
- Broken electric wire and loose terminals
- Loose pipe joints
- Excessive mist from breather

Oil pan – Check oil level



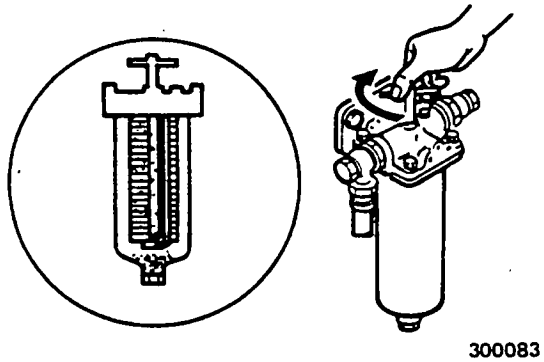
300084

Maintain oil level in operating range.



300924

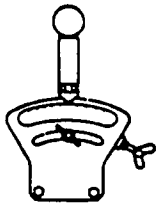
Primary fuel filter (wire-element type) – Turn



300083

Turn handle 1 to 2 rotations in direction of arrow (clockwise).

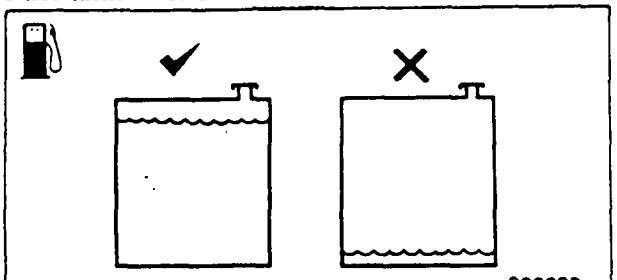
Speed control lever – Check



300082

Check to be sure linkage moves smoothly without any sign of interference.

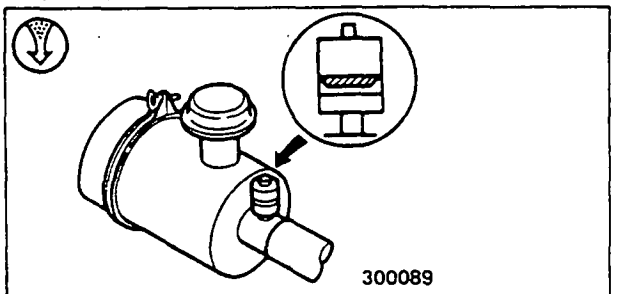
Fuel tank – Check level



300087

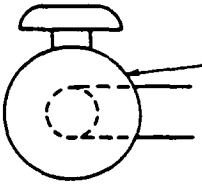
Be sure to fill at end of operating period.

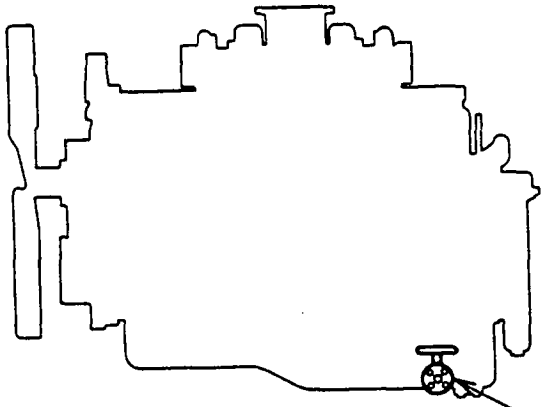
Air cleaner indicator (paper-element type) – Check



300089

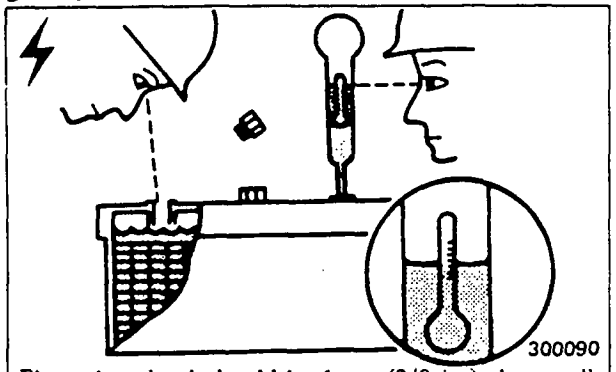
Clean element when indicator shows RED.





300925

Battery – Check electrolyte level/specific gravity

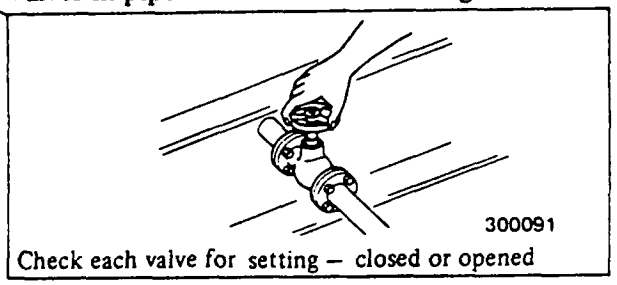


300090

Electrolyte level should be 1 cm (3/8 in.) above cell plates.

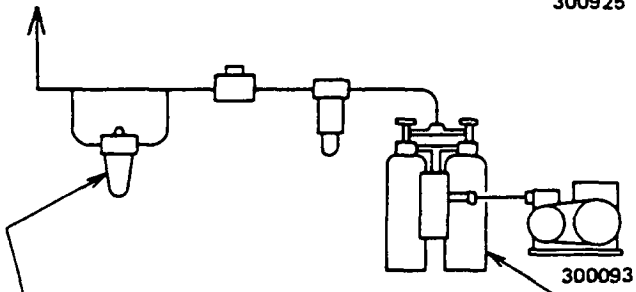
Check specific gravity from time to time, and recharge before it drops to 1.22.

Valves in pipeline – Check for setting



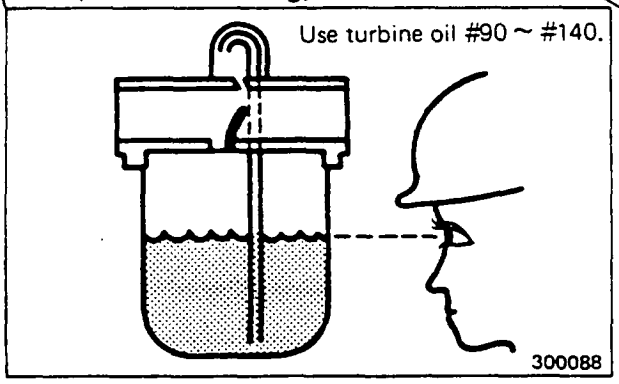
300091

Check each valve for setting – closed or opened



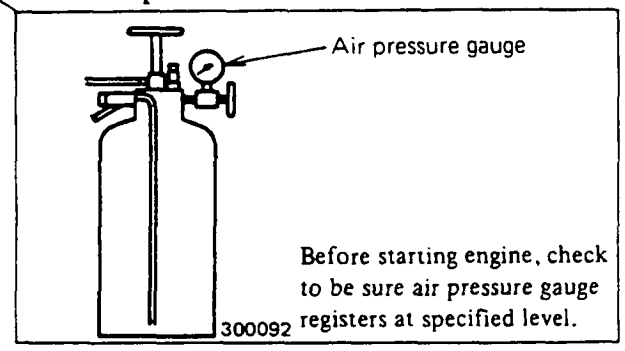
300093

Oiler (air-motor starting) – Check oil level



300088

Air tank (air-motor/direct-air starting) – Check air pressure

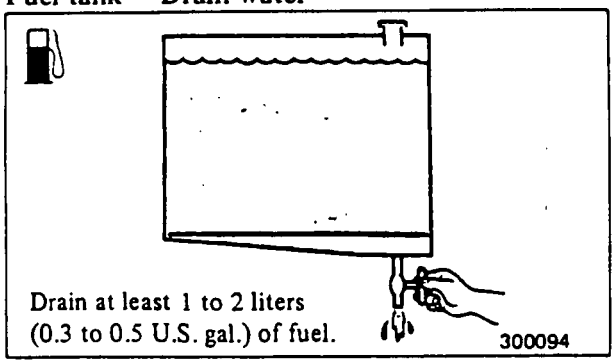


300092

Before starting engine, check to be sure air pressure gauge registers at specified level.

EVERY 50 HOURS OR MONTHLY

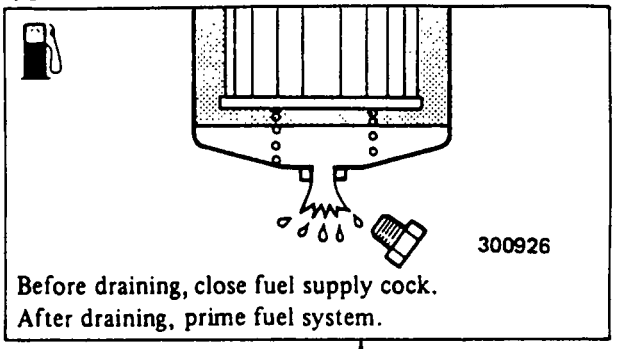
Fuel tank – Drain water



Drain at least 1 to 2 liters (0.3 to 0.5 U.S. gal.) of fuel.

300094

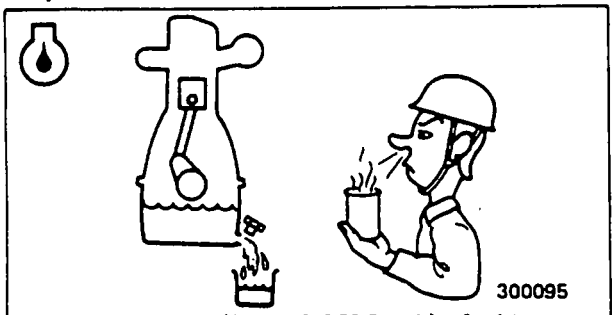
Fuel filter (paper-element/wire-element type) – Drain water



300926

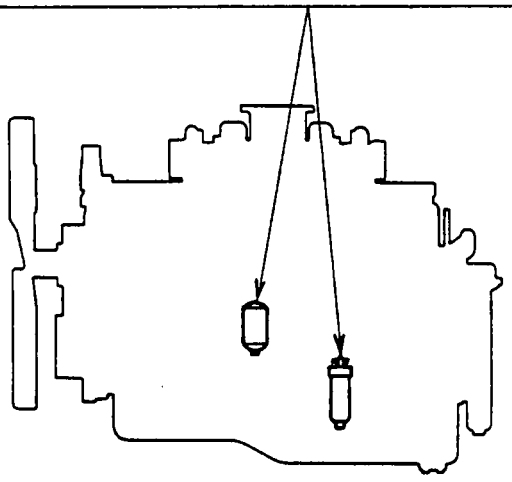
Before draining, close fuel supply cock.
After draining, prime fuel system.

Oil pan – Check for water or fuel in oil



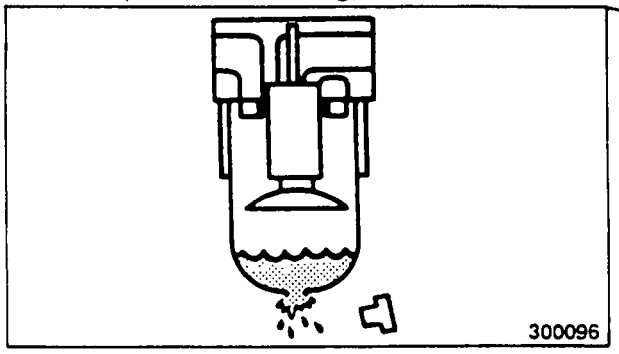
300095

Catch 1 to 2 liters (0.3 to 0.5 U.S. gal.) of oil in a can, and smell or visually check for presence of fuel or water. Fuel smells as such if present. Water leakage is often evidenced by emulsified oil.

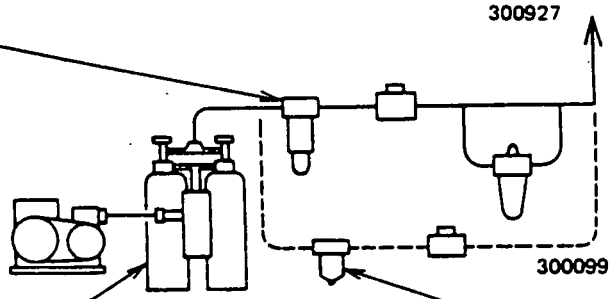


300927

Air filter (air-motor starting) – Drain water

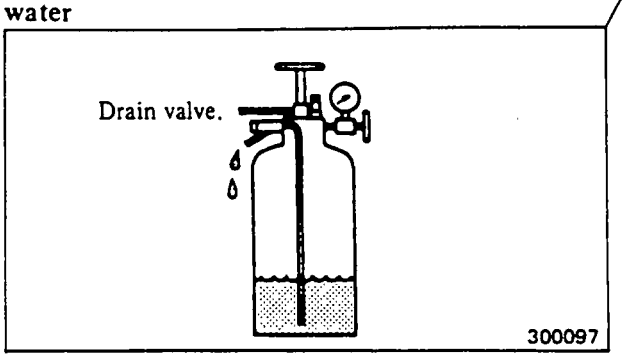


300096



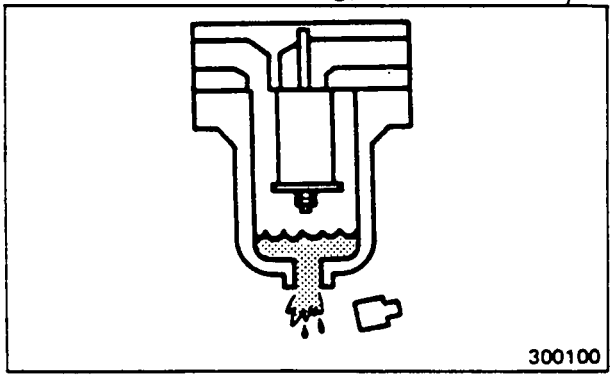
300099

Air tank (air-motor/direct-air starting) – Drain water



300097

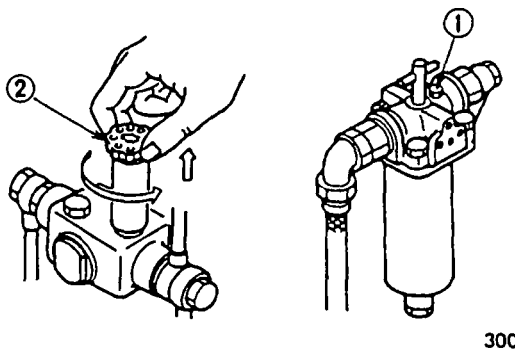
Air filter (direct-air starting) – Drain water



300100

Priming the fuel system

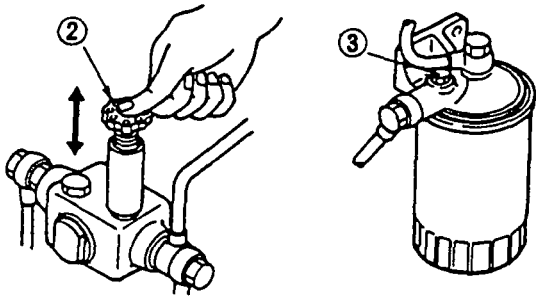
- **Primary fuel filter (wire-element type)**



300917

1. Loosen air vent plug (1) on fuel filter.
2. Unlock priming pump handle (2) by twisting it to left, and operate it.
3. Tighten air vent plug when flow of fuel at vent plug hole is free of air bubbles.

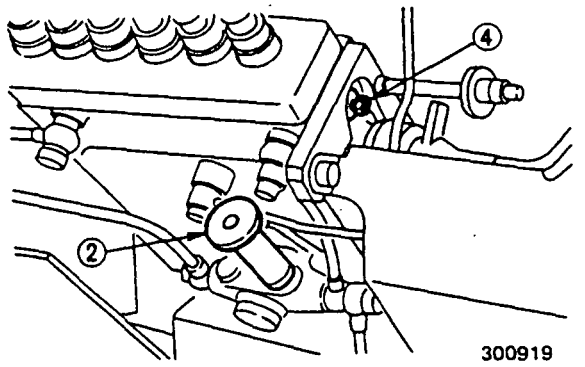
- **Secondary fuel filters (paper-element type)**



300918

1. Loosen air vent plug (3) on fuel filter.
2. Unlock priming pump handle (2) by twisting it to left, and operate it.
3. Tighten air vent plug when flow of fuel at vent plug hole is free of air bubbles.

- **Fuel injection pump**



300919

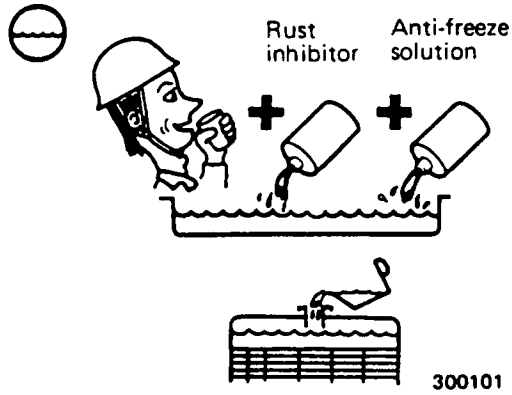
1. Loosen air vent plug (4) on injection pump.
2. Unlock priming pump handle (2) by twisting it to left, and operate it.
3. Stop priming when flow of fuel at vent plug hole is free of air bubbles.

   Lock priming pump handle by twisting it to right while depressing it before tightening the last vent plug.

⚠ CAUTION

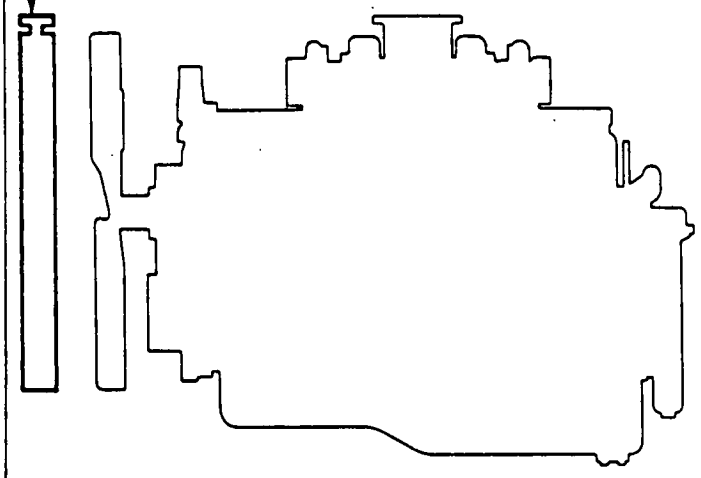
1) Priming pump handle might be unable to restore to its locked position if all air vent plugs are tightened in advance.
2) Wipe off fuel spilled out of each vent plug hole.
3) Prime fuel filters and injection pumps in that order, beginning on component closer to fuel tank.

Changing the coolant (spring and autumn)

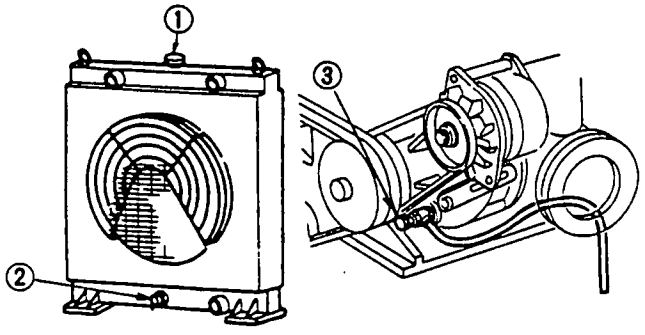


300101

1. Normally, change coolant twice a year.
2. Use clean water that is low in scale forming mineral – such as "city" water.
3. Use anti-freeze solution with rust inhibitor before cold season (in autumn, for example) in an area where freezing temperatures are expected in winter. After cold season (in spring, for example), change coolant with clean water (described in 2 above) containing rust inhibitor.
4. In an area where freezing temperatures are not expected, change coolant once a year.

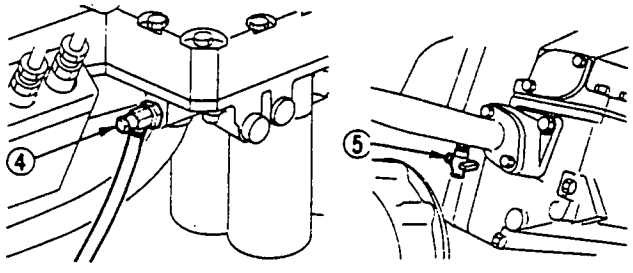


300930



300102

300928



300929

Procedure

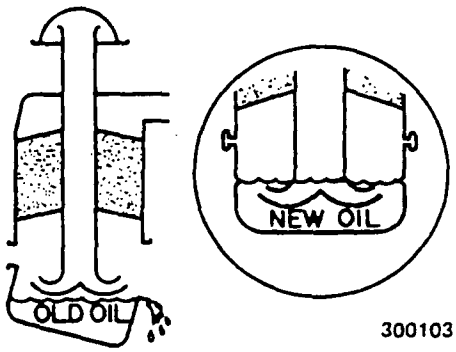
1. Start engine, and run it until water temperature is 70 to 90°C (158 to 194°F).
2. Raise lever at radiator filler cap (1) to relieve pressure, and remove cap.
3. Open radiator drain plug (2), water pump drain plug (3), oil cooler drain plug (4) and air cooler drain cock (5) (TA, TK), and allow coolant to drain.
4. Close drain plug and cocks, and fill cooling system with flushing solvent (which does not attack rubber and metal). Run engine at 800 to 900 rpm for about 15 minutes. Stop engine, and drain flushing solvent.
5. Close drain plug and cocks, fill cooling system with clean water and run engine at 800 to 900 rpm for about 10 minutes.
6. Stop engine, and open drain plug and cocks. Rinse cooling system with clean water until water flowing out of system is clean.
7. Close drain plug and cocks, and fill system with soft water up to specified level.

⚠ CAUTION

When using anti-freeze solution, mix fresh water, anti-freeze solution and rust inhibitor thoroughly in a container, and pour the mixture into radiator.

EVERY 250 HOURS OR 1 YEAR

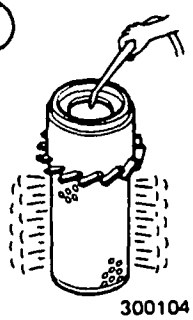
Air cleaner (oil-bath type) – Change oil and wash element



300103

Drain old oil, wash element with diesel fuel, and refill with new oil up to level.

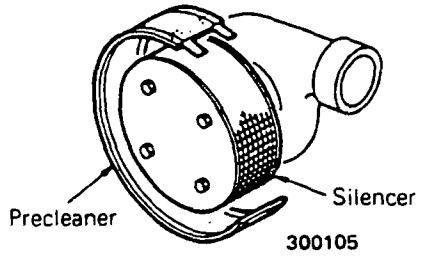
Air cleaner (paper-element type) – Clean element



300104

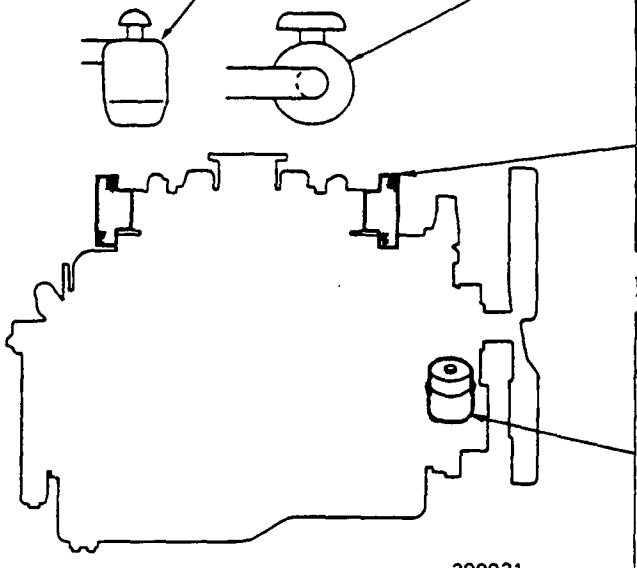
Use pressure air – 7 kgf/cm² (99.5 psi) [0.7 MPa] maximum. Insert light inside clean, dry element and check. Replace element if pinholes or tears are found. Clean air cleaner case.

Air cleaner (silencer type) – Clean



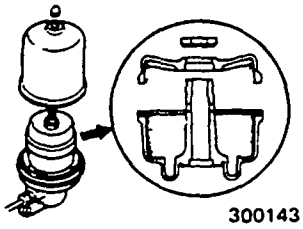
300105

Remove precleaner, and wash it with neutral cleaning solvent.



300931

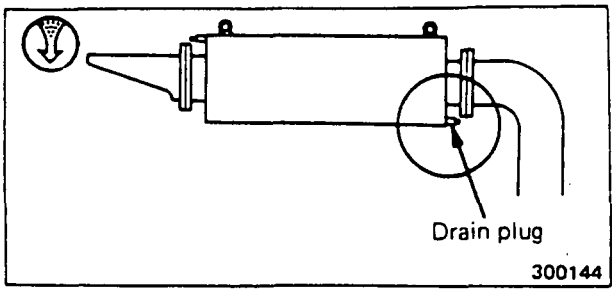
Bypass oil filter – Wash



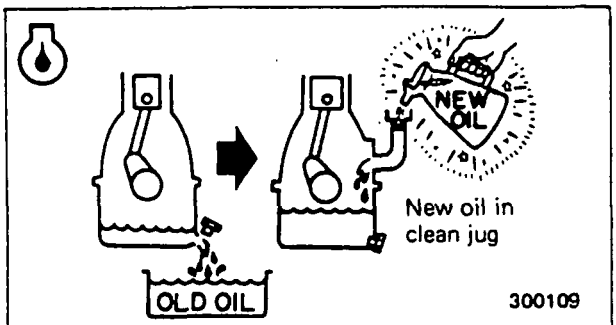
300143

Remove cover, remove sludge accumulated in filter cover and rotor, and wash cover and rotor with diesel fuel.

Exhaust muffler – Drain water

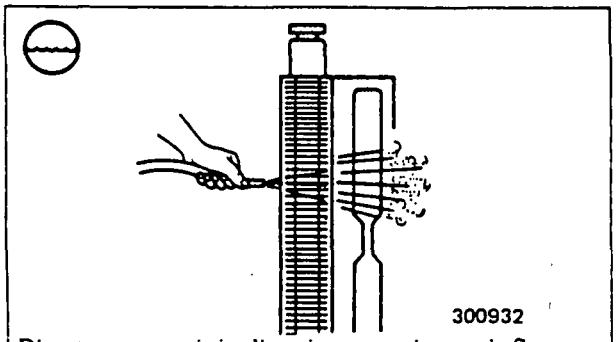


Oil pan – Change oil

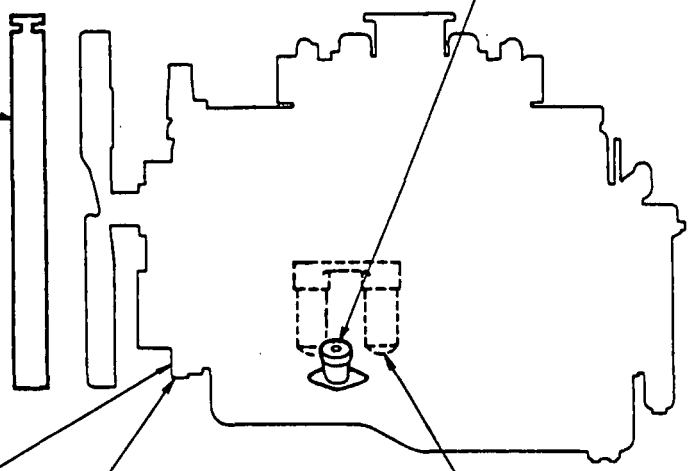


Drain out oil when engine is still hot after operation. Use engine oil of API service classification "CD" (for high-speed, high-load, turbocharged diesel engines).

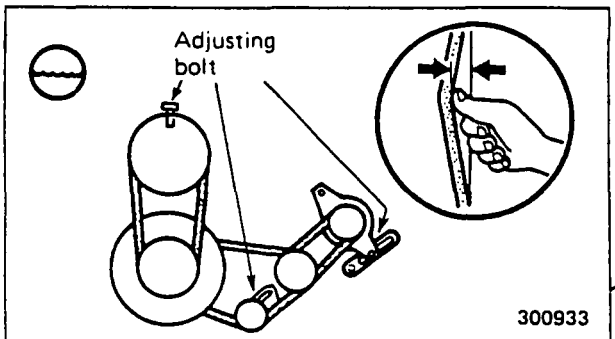
Radiator fins – Clean



Direct pressure air in direction opposite to air flow.

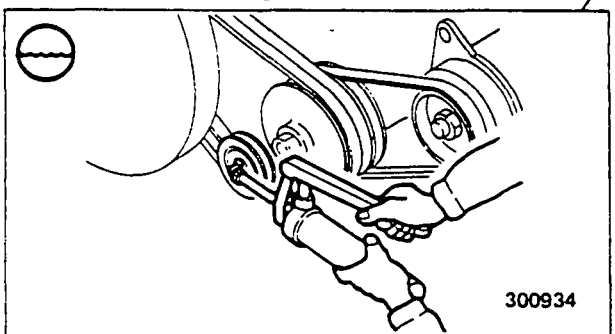


Fan/water pump/alternator drive belts – Check tension



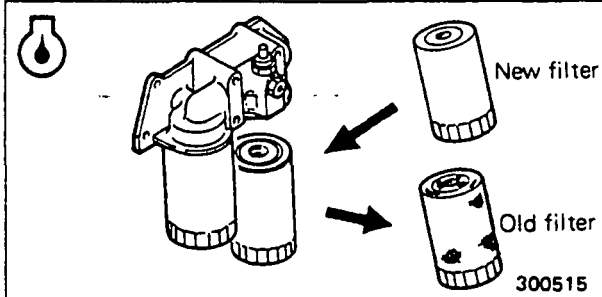
Push belt inward between pulleys with a thumb. Belt should deflect 10 to 15 mm (3/8 to 5/8 in.).
Adjust tension with adjusting bolt.

Water pump tension pulley – Lubricate



Clean grease fitting, and lubricate fitting with a grease gun.

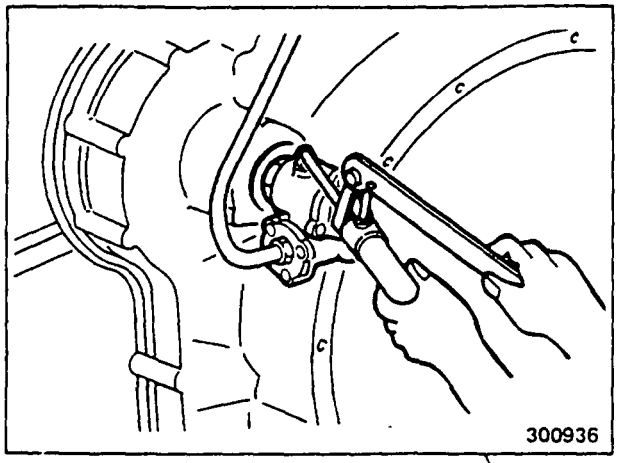
Oil filter (paper-element type) – Change element



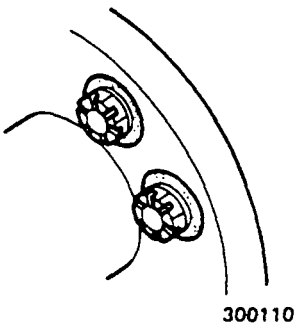
Disassemble element and check for metal particles trapped in it. If such particles are found, consult your Mitsubishi dealer for seizure or abnormal wear of moving parts.

NOTE: Change element when oil filter alarm lamp glows, regardless of recommended service interval.

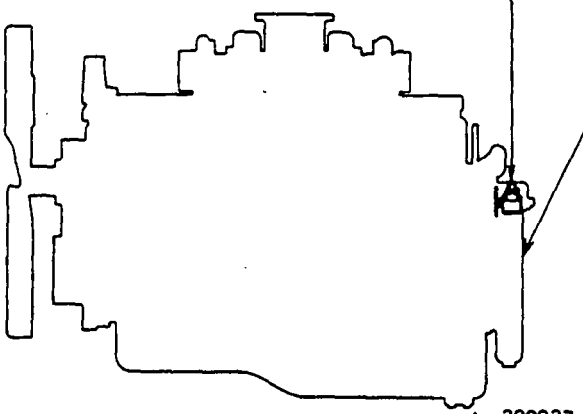
Tachometer drive L joint – Lubricate



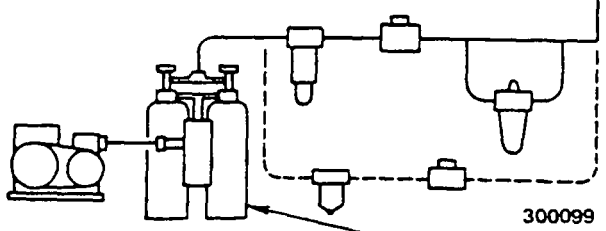
Coupling (rubber-bushing type) – Check

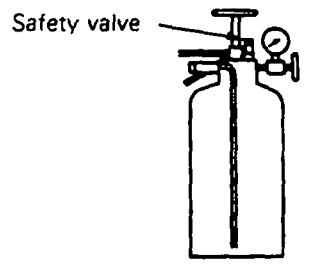


Check bushings for cracks or other defects.



Air tank (air-motor/direct-air starting) – Check safety valve for operation



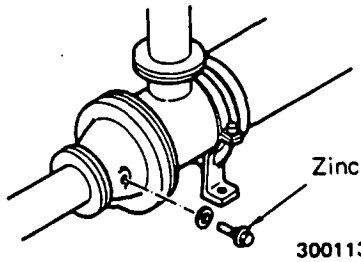


Make sure that safety valve opens when air pressure rises higher than limit.

Air motor: 9.5 kgf/cm^2 (135 psi) [0.9 MPa]
Direct air starting: 30 kgf/cm^2 (427 psi) [2.9 MPa]

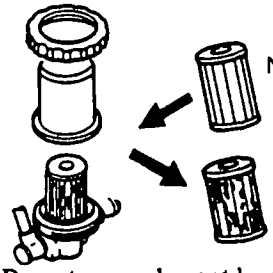
EVERY 500 HOURS OR 2 YEARS

Zinc rods (sea-water cooling) – Change



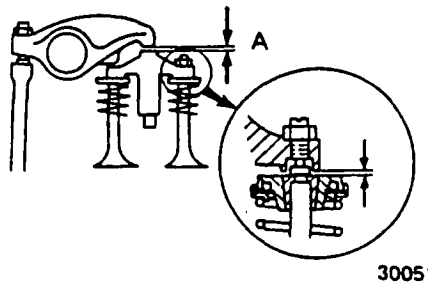
Change zinc rods of heat exchanger, air cooler, etc.

Governor oil filter (Woodward type) – Change element



Do not reuse element by washing.

Valve clearance – Check (EVERY 1000 HOURS OR 3 YEARS)



Check valve clearance in order shown below. Turn crankshaft by fitting turning bar to crankshaft pulley.

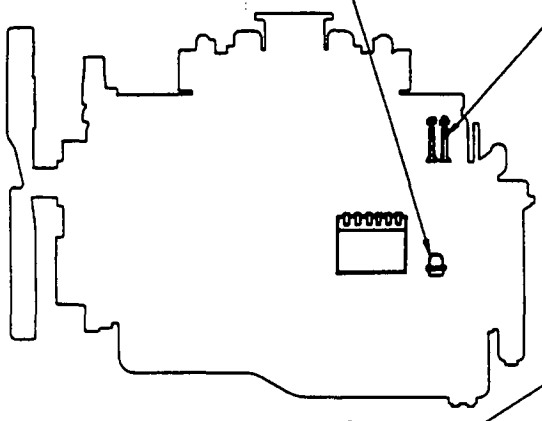
Inspection order

S12A2	1-12-5-8-3-10-6-7-2-11-4-9

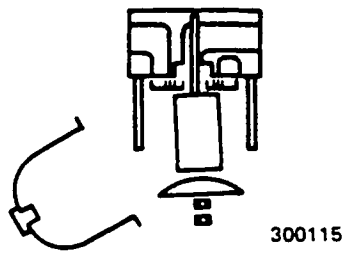
Unit: mm (in.)

	Valve clearance (A) at cold	Bridge-to-rotator clearance (B)
Inlet	0.4 (0.016)	0.5 (0.020 in.), min
Exhaust	0.5 (0.020)	

Adjust clearance if necessary.

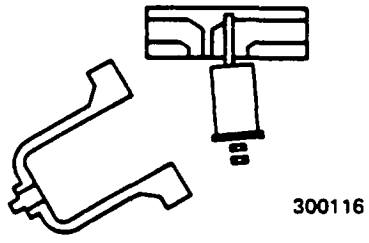


Air filter (air-motor starting) – Wash element

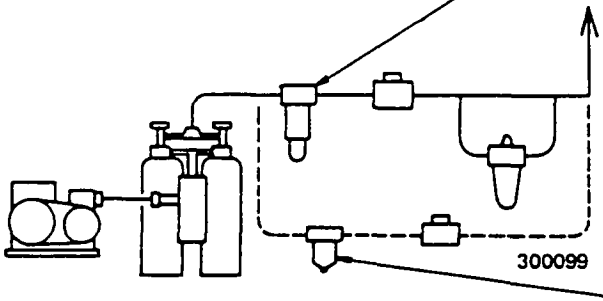


Wash element with diesel fuel.

Air filter (direct-air starting) – Wash element



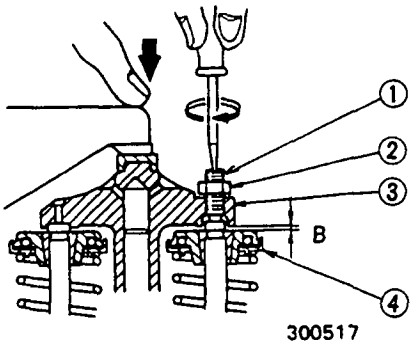
Wash element with diesel fuel.



Valve clearance – Adjust (EVERY 1000 HOURS OR 3 YEARS)

Valve bridges and valve stem top - adjust

1. Before adjusting valve clearance, check and adjust bridge (3). Adjust height of valves, front and rear, by means of adjusting screw (1). Normally there is no need of adjusting valve height but, if two valves become unequal in height as the result of valve seat wear, valve clearance changes, making it necessary to adjust this height.
2. To adjust, loosen lock nut (2), and back off adjusting screw (1).
3. Hold rocker arm with finger, and slowly turn in adjusting screw (1) until it touches valve stem top. From this position, further turn it in about 10 degrees, and tighten lock nut (2) to secure adjusting screw.



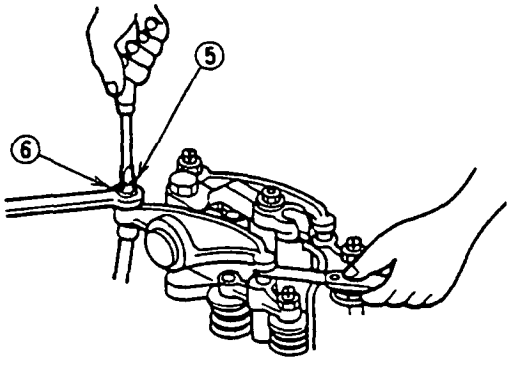
300517

NOTE

Be sure to adjust clearance (B) between bridge (3) and valve rotator (4) as prescribed. If this clearance is less than 0.5 mm (0.020 in.), valve cotters may come off.

Valve clearance – adjust

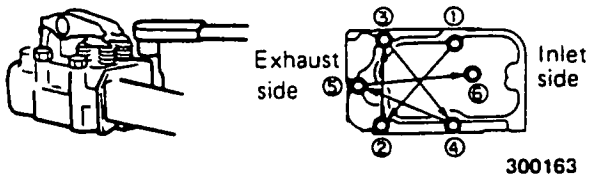
1. Loosen lock nut (6) of adjusting screw (5) on pushrod side of each rocker.
2. While measuring clearance with a feeler gauge, turn adjusting screw (5) in either direction to adjust valve clearance.
3. After adjusting, tighten lock nut (6) to secure adjusting screw (5).



300204

EVERY 1000 HOURS OR 3 YEARS

Bolts and nuts – Retighten

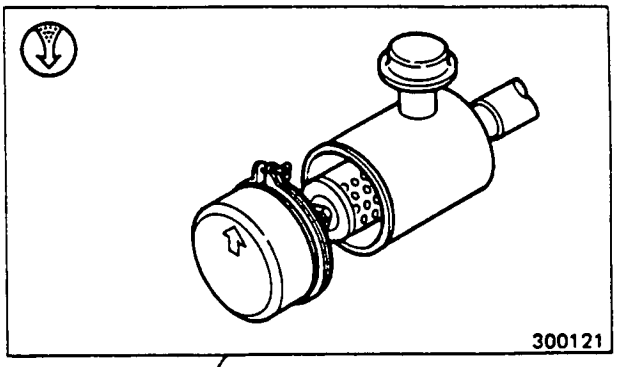


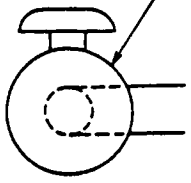
Retighten bolts and nuts on:

- Cylinder heads
- Crankshaft pulley
- Injection pump coupling and shaft
- Mounting brackets
- Exhaust manifolds
- Turbocharger

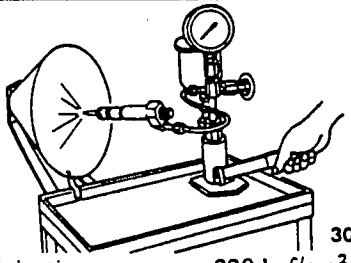
Retighten cylinder head bolts in sequence shown above.

Air cleaner (paper-element type) – Change element





Fuel injection nozzles – Check

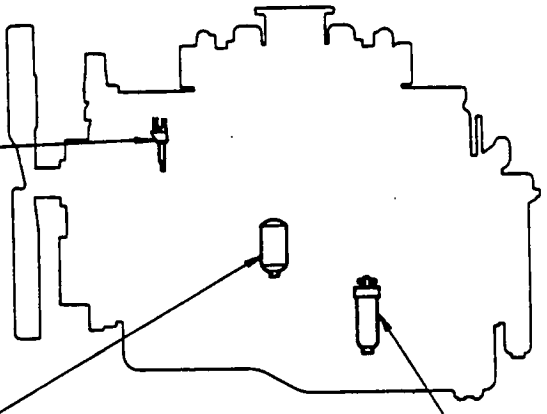


Standard injection pressure: 220 kgf/cm² (3128 psi) [21.6 MPa]

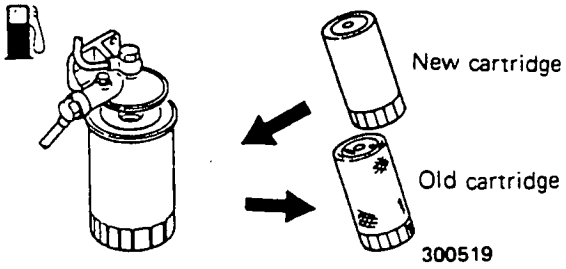
Make sure spray occurs from all eight orifices at the same time.

NOTE

If exhaust smoke is abnormal, check nozzles for spray pattern. See Fuel Injection Nozzles – Check and adjust, pages 36, 37.

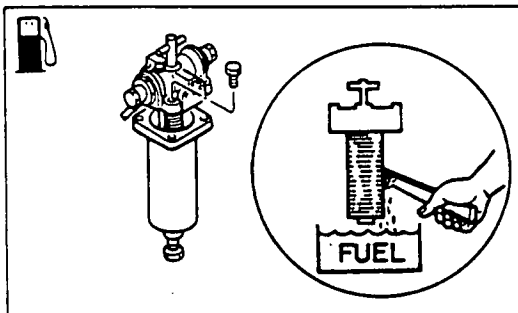


Secondary fuel filter (paper-element type) – Change cartridge



Apply oil to gasket of a new cartridge. Bring gasket into contact with sealing face of bracket, and tighten cartridge 1/2 to 3/4 rotation by hands.

Primary fuel filter (wire-element type) – Wash element

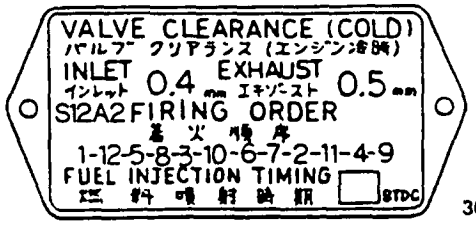


Remove case, and wash dust particles off element with a soft brush and diesel fuel.

Injection timing – Check and adjust

To adjust injection timing, proceed as follows:

1. Injection timing is indicated on caution plate attached to rocker cover.



300940

2. Using a turning bar, turn crankshaft in normal direction (clockwise as viewed from front side), bringing timing pointer into alignment with 1.6 index number mark punched on damper. This crank position corresponds to top dead center on compression stroke in No. 1 cylinder.

⚠ CAUTION

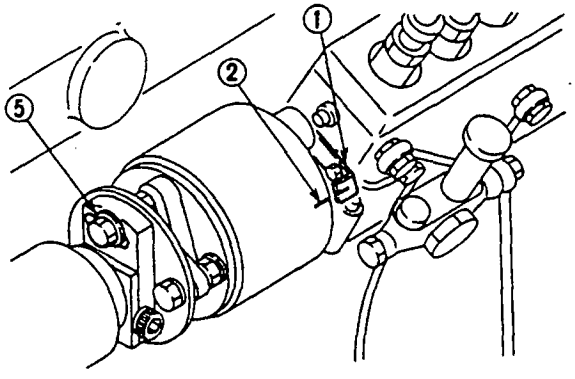
Be careful not to confuse No. 1 cylinder with No. 6. When No. 1 is in the above-mentioned position, its inlet and exhaust valves are both fully seated, presenting valve clearance.

3. Turn back crankshaft about 60°, and turn it forward slowly until timing mark (2) on auto-timer is aligned with pointer (1) on end face of pump case. In this position of crankshaft, read degrees of angle (injection timing) on scale (4) provided on damper, indicated by pointer (3). Minus (-) mark on scale and caution plate means BEFORE top dead center.

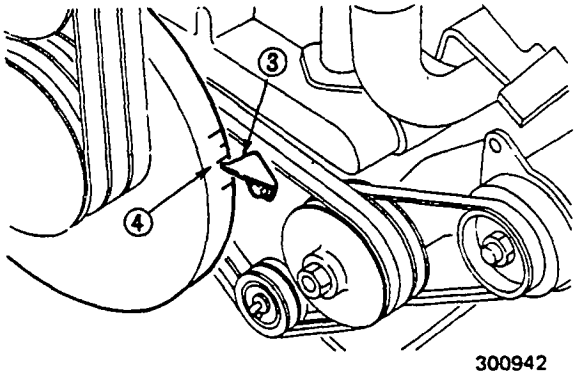
4. To adjust injection timing, proceed as follows:

   Make sure that pointer is aligned with injection timing mark for No. 1 cylinder on damper, displace injection pump by loosening two coupling bolts (5) to align pointer (1) on pump case with timing mark (2) on auto-timer. Then, tighten one bolt and, after turning crankshaft, tighten another. Again check injection timing by cranking engine.

5. In case of injection pump on left side, the position where pointer is aligned with index number 7, 12 on damper is top dead center on compression stroke of No. 7 cylinder. At this position, both inlet and exhaust valves of that cylinder must have clearance as specified. After this, follow procedure mentioned for injection pump on right side.



300941

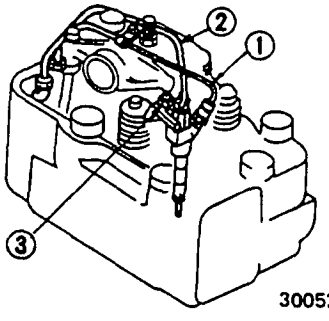


300942

Fuel injection nozzles – Check and adjust

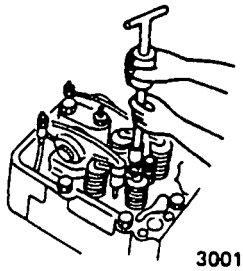
- Removal

1. Disconnect injection pipe (1) inside the rocker cover from nozzle by loosening securing nut. Also disconnect leak-off pipe (2).
2. Unscrew gland nut (3) and, after taking off gland and spacer, remove nozzle from cylinder head.



300523

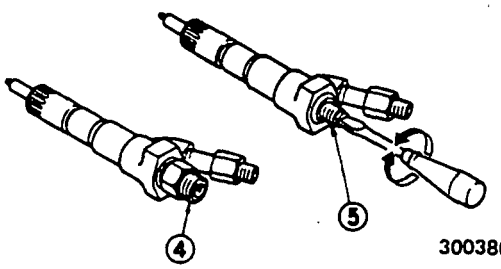
3. To remove nozzle, use nozzle remover (32591-00201).



300165

- Injection pressure adjustment

1. Mount injection nozzle in a tester. Push down tester lever gently to pressurize. See if fuel spray begins at 220 kgf/cm^2 (3128 psi) [21.6 MPa].
2. Remove cap nut (4) on nozzle holder, and tighten or loosen adjusting screw (5). Tightening screw will increase pressure, and vice versa.



300386

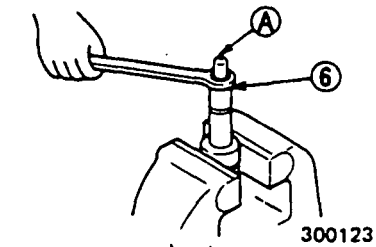
3. After adjusting, put back on cap nut (4) and tighten it to 4 to 5 kgf·m (29 to 36 lbf·ft) [39 to 49 N·m].

- Fuel spray pattern

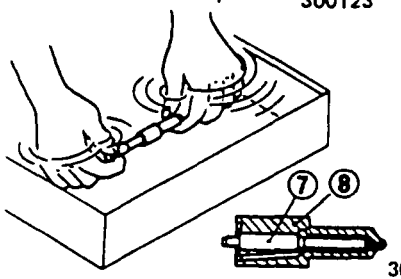
1. Push down tester lever forcefully to let nozzle spray fuel. Spray should occur from all of the eight orifices at the same time, taking a cone shape with an angle of 155 degrees and consisting of finely and uniformly atomized fuel particles. Nozzle should terminate each spray without any after-dribble.
2. If spray pattern is poor, remove nozzle tip. To remove the tip, remove cap nut, loosen adjusting screw with a screwdriver, and loosen retaining nut (6). Be sure to follow these steps in order because the tip is spring-loaded.
3. Wash needle valve (7) and body (8).

⚠ CAUTION

When removing nozzle tip, be careful not to tap part (A) of the tip.



300123



300337

4. For cleaning fluid, use clean gasoline. After cleaning, assemble needle valve (7) and body (8) in clean diesel fuel.

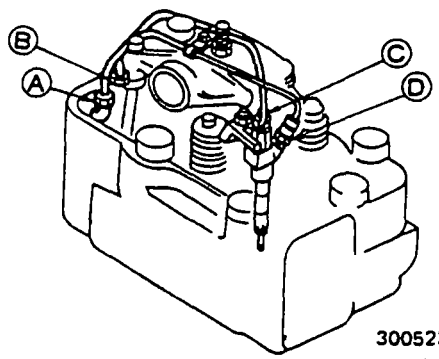
⚠ CAUTION

Needle valve and body are selectively fitted: never change this combination by replacing either part.

5. Tighten cap nut (6) to 6 to 8 kgf·m (43.4 to 57.9 lbf·ft) [58.8 to 78.5 N·m].
6. If the foregoing adjustment and cleaning do not improve spray pattern, replace nozzle tip.

- Installation

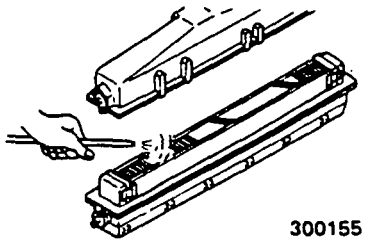
1. To install, use reverse of removal procedure. To install nozzle, tighten nut to 8 kgf·m (57.9 lbf·ft) [78.5 N·m] while keeping the gap between nozzle body and valve spring equally. After installing nozzle, check each fuel pipe joints for fuel leaks.
2. Remove rocker cover, and run engine at about 600 rpm. Under this condition, check to be sure that no fuel leaks at points (A), (B), (C) and (D). Then, stop engine, and install rocker cover.



300523

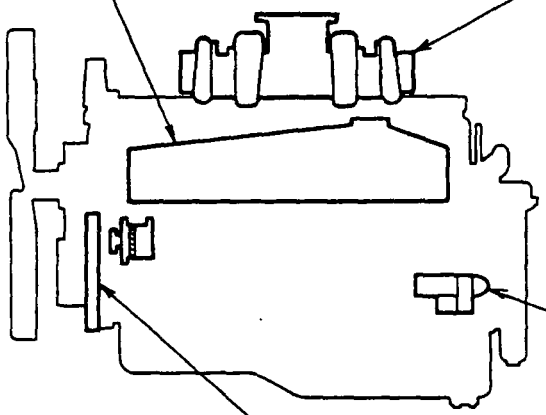
EVERY 2000 HOURS OR 5 YEARS

Air cooler – Clean

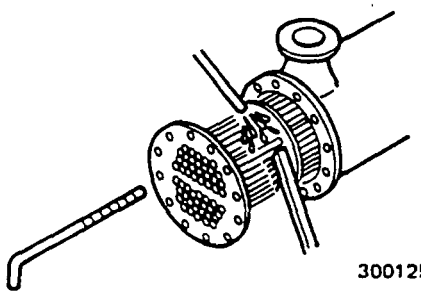


Remove air cooler, and direct pressure air in direction opposite to air flow.

- Remove scale from inside of fresh-water pipes by inserting a bar.



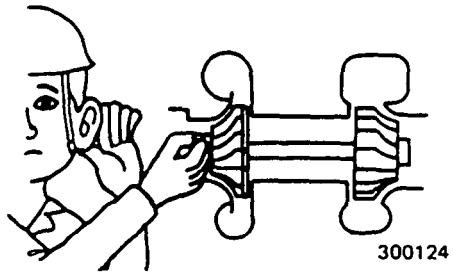
Heat exchanger – Wash



Wash outside surfaces of pipes with a brush by dashing fresh water over them.

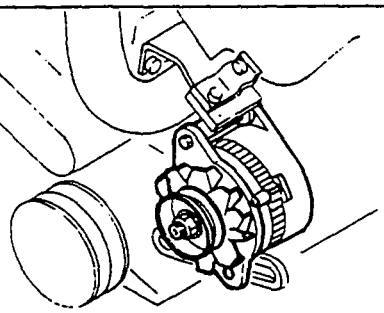
Remove scale from inside of pipes by inserting a bar.

Turbochargers – Check



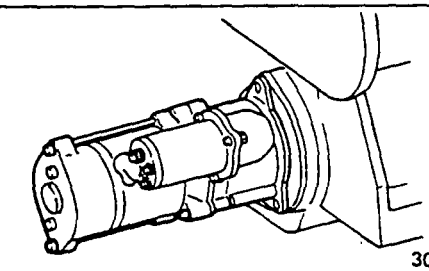
Turn compressor wheel by hand to listen for abnormal noise. If wheel is noisy, replace bearings.

Alternator – Check



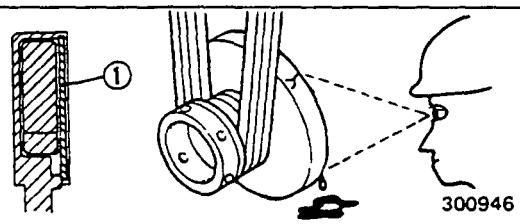
Visually check for any defects. Check for abnormal rotation with belt removed.

Starters – Check



Visually check for any defects. Check pinion for operation.

Vibration damper – Check

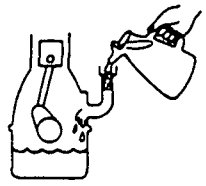


Check for fluid leaks, flaws, distortion, cracks in rubber and discoloration of paint. In case of viscous damper, carefully check for swelling of cover (1) (by touching), fluid leaks from joint, discoloration of paint due to heating and flaking.

STORAGE

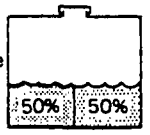
Preparation for long-term storage (3 months or more)

Drain out engine oil, and fill in anticorrosive oil such as "P-10."



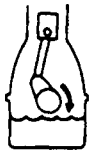
300127

Use a mixture of "P-9" anticorrosive oil and fuel oil in 50-to-50 ratio.



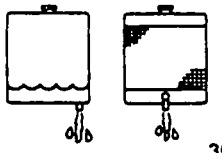
300128

Run engine at 800 to 1000 rpm for 5 to 10 minutes under no-load condition.



300129

After stopping engine, drain out fuel and coolant.

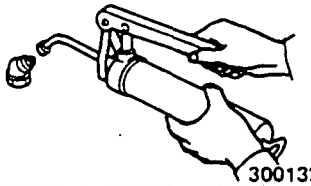


300130

Put volatile anticorrosive compound in air inlet and exhaust systems in amount of 3 to 5 g (0.1 to 0.2 oz) of the compound per 28 liters (7.4 U.S. gal.).

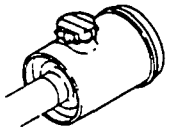
300131

Lubricate fitting or linkage of tension pulley, etc.



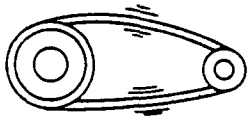
300132

Cover up air cleaners, air inlet pipes, exhaust pipes, breather and turbochargers with adhesive tapes.



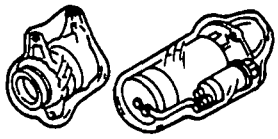
300133

Loosen V-belts.



300134

Cover up starters and alternator with polyethylene sheet.



300135

CAUTION

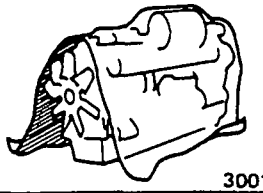
1) When storing engine, keep it indoors whenever possible.
2) Do not use a vinyl sheet for covering purposes.
3) Attach caution tags reading "Anticorrosive oil in engine," and "Before placing engine in service, fill in coolant and fuel."

Add distilled water and recharge batteries. Remove batteries, clean terminals and keep batteries in a dry, cool place.

NOTE

It is not necessary to change engine oil if storage period is shorter than 6 months.

Cover engine with an awning sheet.



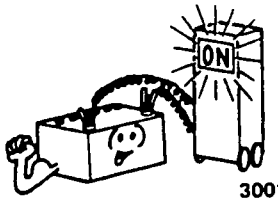
300136

Recommended anticorrosive oils

Specification	Brand name
P – 9	US Horton Rustbet Cosmolin
P – 10	US Horton Rustbet Cosmolin 1051, 1049

Service during storage

Recharge batteries at least once a month.



300137

Preparing a stored engine for service

Remove awning sheet from engine.

Remove covers from starters and alternator.

Adjust V-belts.

Remove sealing tapes.

Drain out anticorrosive oil, and fill in regular engine oil.

Fill cooling system.
(Use anti-freeze solution with rust inhibitor in winter.)

Fill fuel tank.
Prime fuel system.

Check engine. (See the topic, NEW ENGINE INITIAL SERVICE.)

Remove rocker covers, and lubricate valve mechanism.

Crank engine 3 times, about 15 seconds each time.

Make sure engine oil pressure rises properly.

Warm up engine thoroughly.

Apply load, and pick up rated speed.

DIESEL FUEL

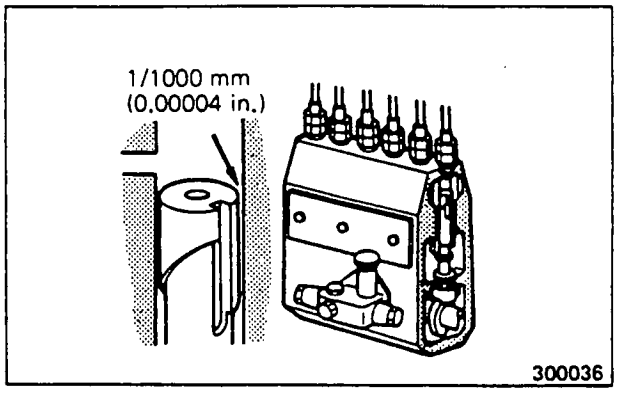
Mitsubishi diesel engines are designed to use diesel fuel oil meeting the requirements of JIS (Japanese Industrial Standard) K2204. JIS K2204 diesel fuel oil nearly corresponds to Class 2-D fuel oil specified by ASTM (American Society for Testing and Materials) D975. For pour point, refer to the following chart:

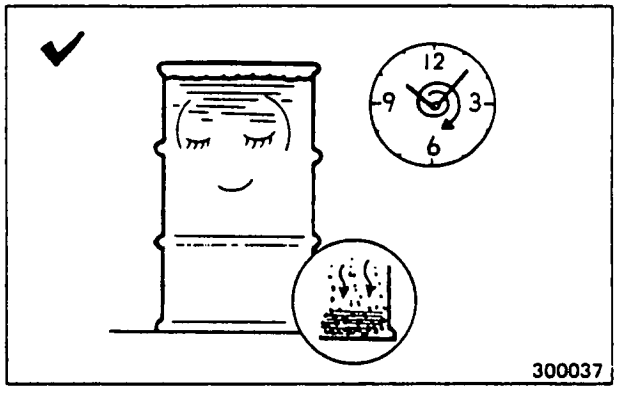
JIS K2204 diesel fuel oil	Above 10°C (50°F)	10~0°C (50~32°F)	0~-5°C (32~23°F)	-5~-15°C (23~5°F)	-15~-30°C (5~-22°F)
	No.1 special	No.1	No.2	No.3	No.3 special

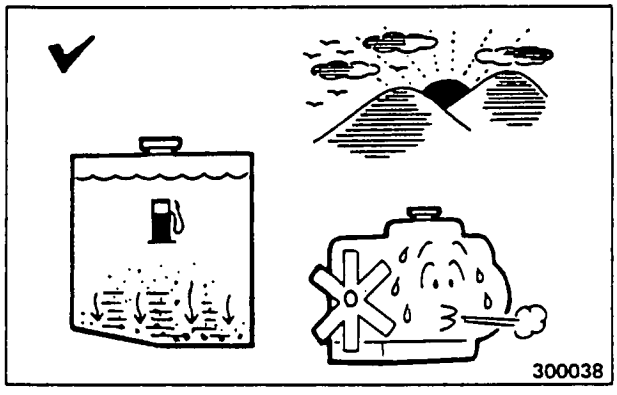
Too much emphasis cannot be placed on the importance of using only clean diesel fuel. The clearance between the plunger and barrel of fuel injection pump and that between needle valve and body of injection nozzle are very small. This makes it evident that invisible particles of dirt which might pass through the filter can damage these finely finished parts.

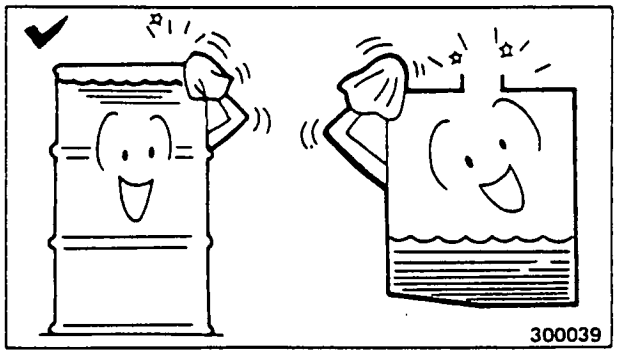
Care of the fuel supply

1. Use a storage tank, and allow fuel to stand at least 24 hours in this tank before pumping it to the diesel fuel tank. Be sure to drain all water and sediment that has settled to the bottom of the storage tank before the diesel fuel tank is refilled.
2. Fill the diesel fuel tank at the end of the day. This will drive out moisture-laden air and prevent condensation.
3. 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.

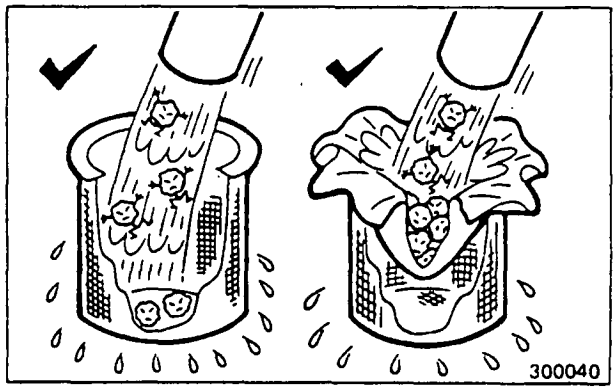








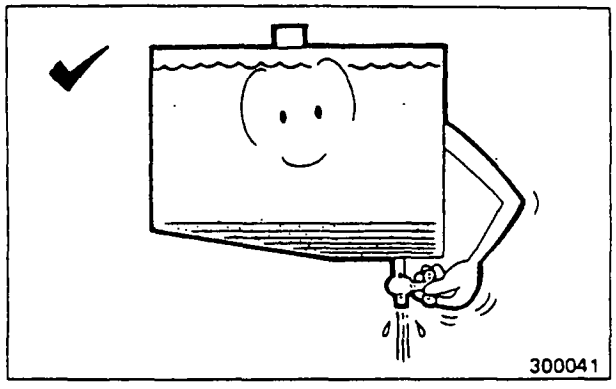
4. Be sure to pour fuel through strainer in the filler opening. Use of a lint-free cheese cloth is a good practice for keeping dirt out.



5. Occasionally, open the drain cock of the storage and diesel fuel tank to drain off any water or sediment that may have accumulated.

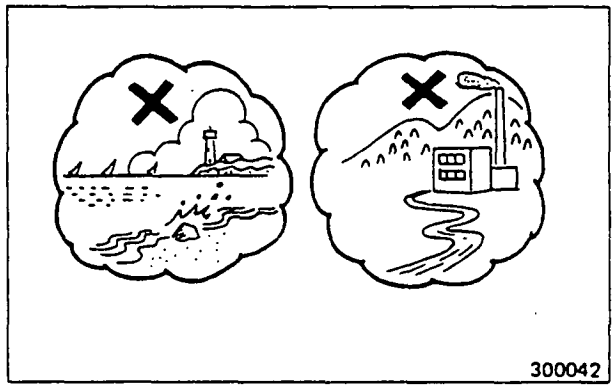
⚠ CAUTION

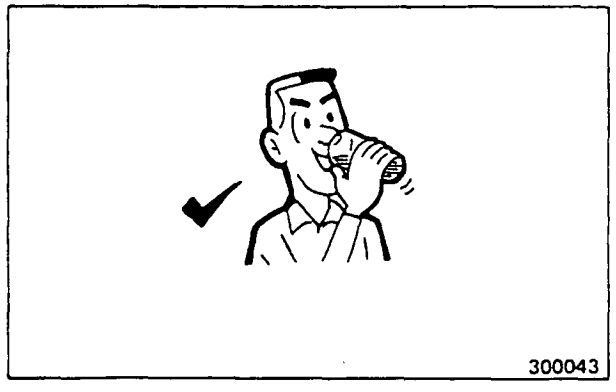
Even clean top portion of fuel oil contains more or less dirt and water. Such dirt and water should be removed before they get inside the engine. This method of cleaning fuel oil is called "draining."



COOLING WATER

1. Water used in the cooling system must be soft, or as free from scale forming minerals as possible. Water, such as is available from the city water supply, is generally soft enough for the engine. River water and well water are most likely to contain large amount of scale forming minerals and should not be used. Remember, some waters, particularly those pumped from ground in a mining or hot-spring area, contain active impurities harmful to cylinder liners of your engine.
2. Be sure to service zinc rods used in sea-water circuits of cooling system at recommended intervals.



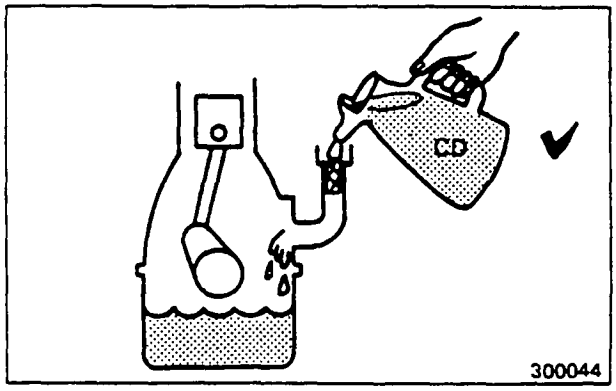


LUBRICANTS

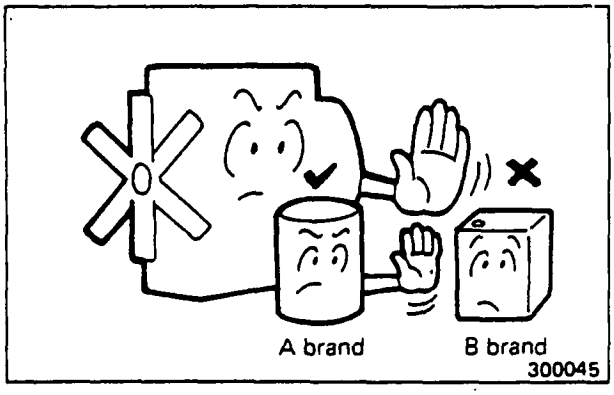
Engine oil

Careful attention to the following information on engine oil and its proper selection will add much to performance, economy and long life of your engine – a high-speed, high-load diesel engine.

1. Be sure to use engine oil of the API (American Petroleum Institute) service classification "CD."

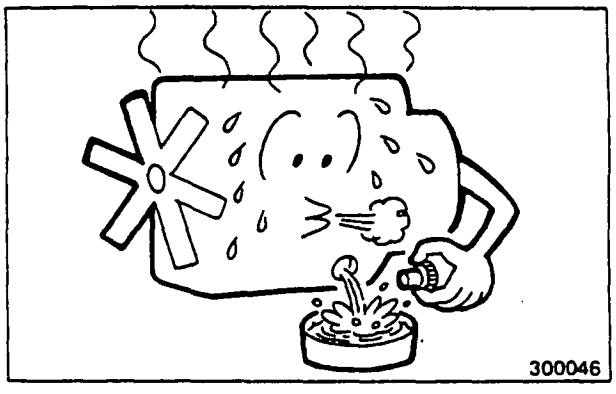


2. Avoid mixing engine oils of different brands. In some cases, different brands are not compatible with each other and, when mixed, can seize parts such as piston rings, cylinder liners, etc. or abnormally wear moving parts. It is best to stick with one and the same brand of engine oil at successive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



3. Draining and refilling

   To change the oil, drain it out while the engine is still hot after a duty operation: the oil is hot and will rush out, washing out the sludge. After draining, allow the engine to idle for about 5 minutes with a flushing oil in the oil pan and refill with fresh oil upon draining the flushing oil.



Grease

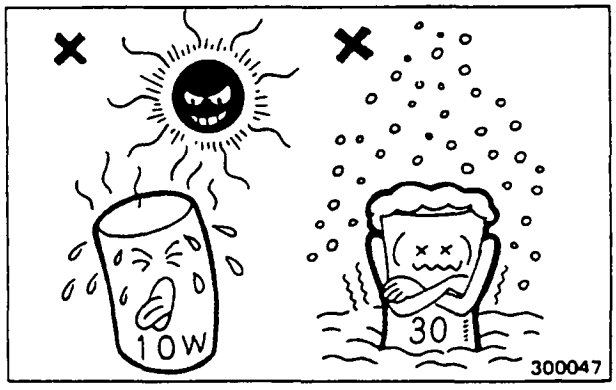
Use clean multi-purpose grease for your engine.

⚠ CAUTION

Cleanliness is important for handling the engine oil and grease. Use clean handling tools; wipe the filler cap, grease fittings and plugs clean; and handle them in a dust-free condition.

Selection

Refer to the following charts in selecting engine oil and grease:



Starting temperatures and grades of lubricants

Ambient temp. °C (°F)	−30 (−22)	−20 (4)	−10 (14)	0 (32)	10 (50)	20 (68)	30 (86)	40 (104)
Engine oil	SAE 10W			SAE 30				SAE40
	SAE 10W – 30							
Grease	NLGI No. 0, No. 1			NLGI No. 2				

Recommended engine oils

Manufacturer	Brand name	SAE viscosity number
Mitsubishi	Diamond HDS-3 Engine oil	10W, 20W, 30, 40, 50
Esso	Essolube D-3	10W, 20W, 30, 40, 50
General	General Gemico Super S-3	10W, 20W, 30, 40
Idemitsu	Apollo Oil Diesel Motive Custom	10W, 20, 30, 40
Kygnus	Mighty Oil S-3	10W, 20W/20, 30, 40, 50
Kyodo	Kyoseki Delmate D	10W, 20, 30, 40
Maruzen	Sawavis S-3	10W, 30, 40, 50
Mobil	Mobil Delvac 1300 series	10W/20, 30, 40
Nippon	High Diesel S-3	10W, 20W/20, 30, 40, 50
Showa Shell	Shell Rimula Z Oil	10W, 20W/20, 30, 40, 50
	White Parrot Super S-3	10W, 20W/20, 30, 40
Taikyo	Pioneer Diesel S-3	10W, 20, 30, 40

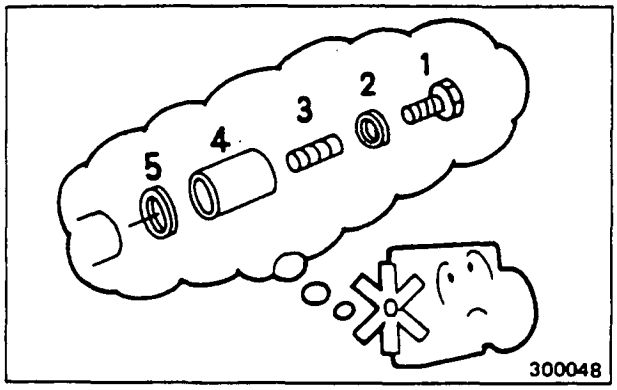
Oils other than these recommended above should be in API service classification "CD" and meet the requirements of MIL-L-2104C.

TROUBLESHOOTING

General instructions

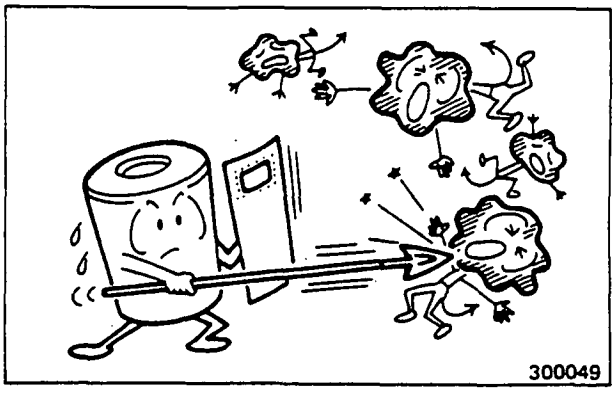
(1) Think before acting

Upon noting an abnormal symptom, recall what you did the last time when you ran across the same symptom. If what you did was correct and successful, do the same. If the symptom noted is new to you, think of possible causes in accordance with the troubleshooting procedure which follows.



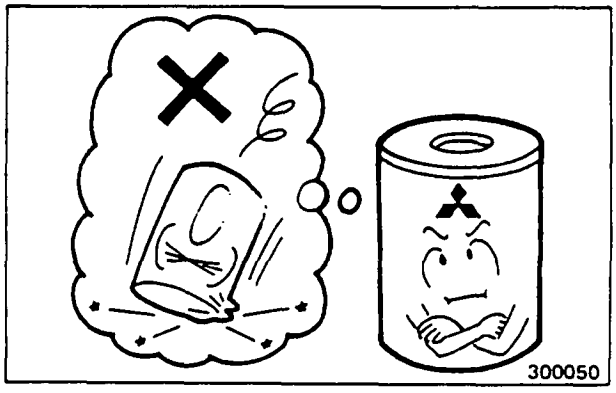
(2) Dust and dirt are often the ultimate causes.

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



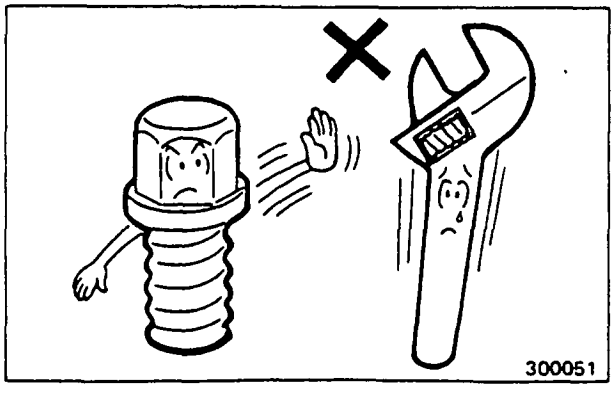
(3) Use genuine Mitsubishi parts.

Use only genuine parts to replace those that have failed or reached the service limit. When ordering, specify the needed replacement parts by referring to the Mitsubishi Parts Catalogues.



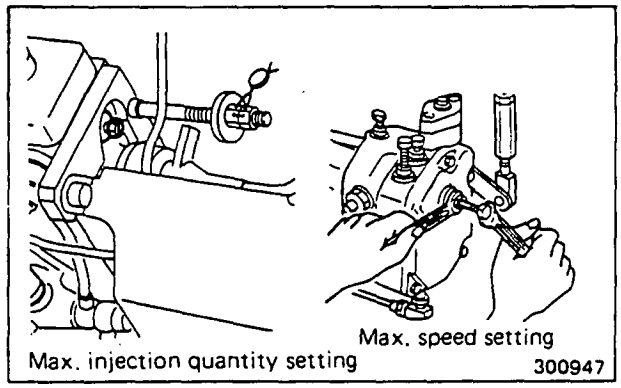
(4) Perform servicing work safely.

Use the right kind of hand tool to carry on each working step in repair work. Avoid injury to yourself and damage to the parts by using improper tool. When lifting or carrying a part too heavy for one person to handle, get another person's help and, if necessary, use a jack or a chain block to avoid personal injury.

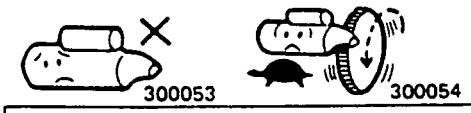


⚠ CAUTION

- Never attempt to break the seals of the governor for maximum speed setting and maximum injection quantity setting.
- The maximum injection quantity of injection pumps has been set on the basis of the output horsepower of each engine verified in the bench test. Never attempt to vary this injection quantity in field.

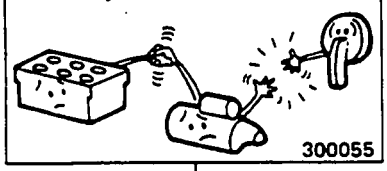


Electric-starting engine

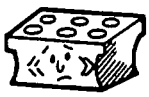


Starters will not crank engine or crank slowly, resulting in a failure of engine to start

- Electrical system
  - Battery – starter switch circuit open → Repair or replace
  - O.K.
    - Battery – starter – starter switch circuit open → Repair or replace

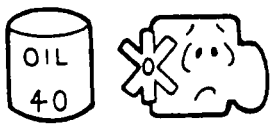


    - Battery weak → Adjust alternator drive belt

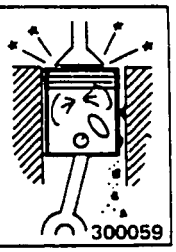


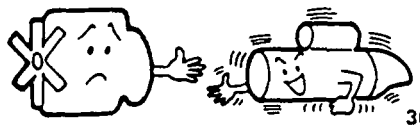
    - Starters, starter relay defective → Consult Mitsubishi dealer

    - Electrolyte specific gravity low → Recharge
    - Battery will not recover even if recharged → Replace
- Lubrication system
  - Engine oil viscosity too high → Refill with oil of proper viscosity



  - O.K.
    - Engine proper
      - Running parts defective
      - Interference between pistons and valves
      - Foreign matter in cylinder → Consult Mitsubishi dealer



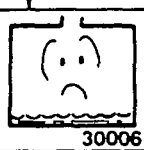

300060

Starter will crank engine, but engine will not start

Fuel system → Fuel tank

O.K.

Empty → Refuel


300061

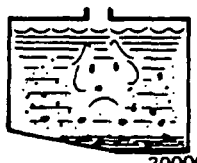
Filled


300062

Consult Mitsubishi dealer ← Fuel leaks from pipe connection

Wrong type of fuel → Refill with correct type of fuel

Dirt or water in fuel → Remove dirt or drain


300064

Electrical system

O.K.

Battery specific gravity low → Recharge


300063

Adjust alternator drive belt

Circuit defective → Repair or replace

Fuel filters clogged → Clean (wire-element type) Change (paper-element type)

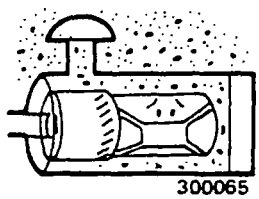
Fuel pipes clogged or leaky → Clean or repair

Injection pumps defective → Consult Mitsubishi dealer

Air inlet system

O.K.

Air cleaners clogged


300065

Clean element


300066

Change element

Engine proper

Compression pressure low
Cylinders, pistons and piston rings worn
Valve springs broken
Valve seats or injection nozzle packings defective


300067

Consult Mitsubishi dealer

Air-starting engines

- **Air-motor starting**

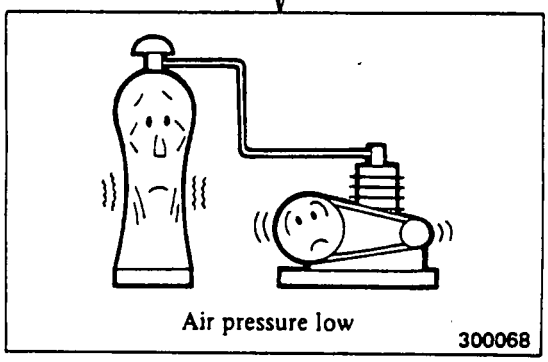
Starter will not crank engine

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

Starter will run, but starter pinion will not engage with flywheel ring gear

- Ring gear or pinion defective → Consult Mitsubishi dealer

Starter pinion engages with ring gear, but starter will not crank engine



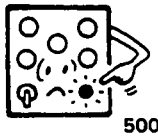
→ Run air compressor to increase air pressure

- **Direct-air starting**

Engine will not be cranked

- Air pressure low → Run air compressor to increase air pressure
- Air filter clogged → Clean or change
- Starter valve stuck → Consult Mitsubishi dealer

Complaint	Possible causes	Remedy
Engine lacks power  500040	• Incorrect grade of oil	• Use recommended type and SAE number of oil.
	• Wrong type of fuel	• Change.
	• Insufficient air (air cleaner clogged)	• Clean or change element.
	• Engine overcooled	• Use radiator cover, replace parts.
	• Engine overheating	• Flush cooling system or replace parts.
	• Valve clearance incorrect	• Readjust.
	• Injection pumps defective	* Readjust or replace.
	• Injection nozzles defective	* Readjust or replace.
	• Injection timing incorrect	* Readjust.
	• Compression pressure low (cylinders and pistons worn)	* Disassemble and replace parts.
White or blue exhaust smoke  500041	• Too much oil in crankcase	• Fill only to correct level on gauge.
	• Oil viscosity too low	• Refill with correct viscosity of oil.
	• Engine overcooled	• Use radiator cover, or clean, test and replace thermostat.
	• Thermostat defective (low water temperature)	* Replace.
	• Injection timing incorrect	* Readjust.
	• Compression pressure low	* Disassemble and replace parts.
	• Low cetane number of fuel	• Change.
Black or gray exhaust smoke  500042	• Wrong type of fuel	• Refill with correct type of fuel
	• Valve clearance incorrect	• Readjust.
	• Injection pumps defective	* Readjust or replace.
	• Compression pressure low	* Disassemble and replace parts.
	• Insufficient air (air cleaners clogged)	• Clean or change elements.
	• Turbocharger defective	* Disassemble and replace parts.
High fuel consumption  500043	• Injection pumps defective	* Readjust or replace.
	• Injection nozzles defective	* Readjust or replace.
	• Injection timing incorrect	* Readjust.
	• Wrong type of fuel	• Refill with correct type of fuel.
	• Compression pressure low	* Disassemble and replace parts.
	• Insufficient air	• Clean or change air cleaner elements. Check turbochargers.

Complaint	Possible causes	Remedy
High oil consumption  500044	• Too high oil level in crankcase	• Maintain oil level in operating range on gauge.
	• Incorrect grade of oil	• Use recommended type and SAE number of oil.
	• Oil leaks	• Retighten or replace.
	• Cylinders and piston rings worn	* Disassemble and replace parts.
Engine overheats  500047	• Radiator or heat exchanger dirty	• Wash.
	• Fan belt loose	• Readjust.
	• Lack of coolant	• Refill.
	• Too low oil level	• Maintain oil level in operating range on gauge.
	• Water pump defective	* Replace.
	• Thermostat defective	* Replace.
Low oil pressure  500045	• Lack of oil	• Refill up to level.
	• Oil viscosity too low	• Refill with correct viscosity of oil.
	• Oil filter clogged	• Replace element.
	• Oil pump defective	* Readjust or replace.
	• Oil pressure regulating valve defective	* Readjust or replace.
	• Oil pressure sensor improperly wired	* Replace.

NOTE

1. Consult your Mitsubishi dealer for items marked with asterisk (*).
2. Consult your Mitsubishi dealer for any item other than those listed above.
3. When communicating with your Mitsubishi dealer, give model designation, serial number and service meter reading of your engine.

SPECIFICATIONS

Model designation		S12A2		
		T	TA	TK
Type		Water-cooled, 4-stroke cycle, turbocharged		
			With aftercooler	With intercooler
Number of cylinders		12		
Bore X stroke		150 mm X 160 mm (5.906 in. X 6.299 in.)		
Piston displacement		33.929 liters (2071 cu in.)		
Fuel injection system		Direct-injection		
Compression ratio		14.5 : 1		
Firing order		1-12-5-8-3-10-6-7-2-11-4-9		
Rotation		Counterclockwise as viewed from flywheel side		
Dimensions (w/o fan)	Length	1808 mm (71.2 in.)		
	Width	1365 mm (53.7 in.)		
	Height	1562 mm (61.5 in.)		
Dry weight		2850 kg (6284 lb)	2920 kg (6439 lb)	
Fuel system	Fuel	Diesel fuel oil ASTM No. 2-D		
	Injection pump	Bosch P type		
	Governor	Woodward PSG		
	Filter	Wire-element type or paper-element type		
	Injection nozzles	Hole type		
	Injection pressure	220 kgf/cm^2 (3128 psi) [21.6 MPa]		
Lubrication system	Type	Pressure feed by gear pump		
	Oil	API CD class		
	Capacity (engine)	100 liters (26.4 U.S. gal.), approx.		
	Oil filter	Paper-element type		
	Oil cooler	Fresh water-cooled multi-plate type		
Cooling system	Type	Fresh water-cooling or seawater, raw water		
	Capacity (engine)	80 liters (21.1 U.S. gal.), approx.	100 liters (26.4 U.S. gal.), approx.	
	Water pump	Centrifugal type		
Starter		Electric starter (24 V, 6 kW X 2) or air starter (air motor or direct air)		
Alternator		24 V, 25 A		
Turbocharger		Mitsubishi turbocharger		

TIGHTENING TORQUE

Important bolts and nuts

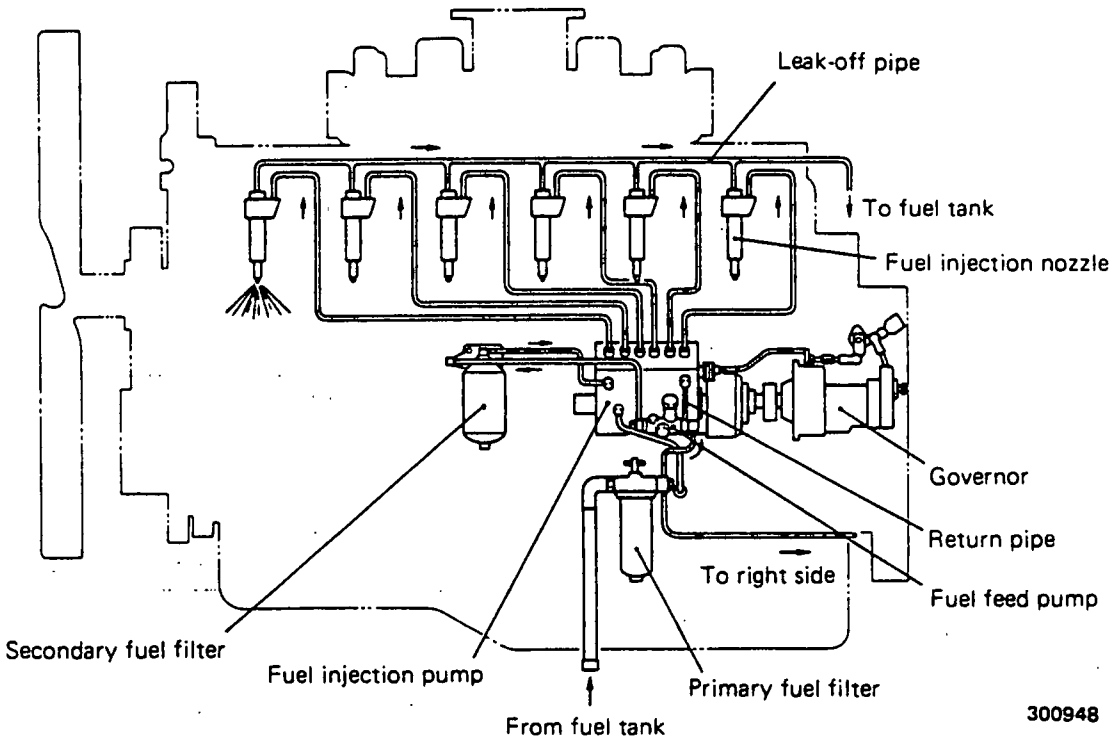
Parts attached	Thread Diam. – Pitch mm (in.)	Width across flats mm (in.)	Standard torque			Remarks
			kgf·m	lbf·ft	N·m	
Cylinder heads	20 – 2.5 (0.79 – 0.098)	30 (1.18)	40	290	392	Apply oil to threads
Rocker shaft brackets	12 – 1.75 (0.47 – 0.069)	17 (0.67)	5	36	49	
Main bearing caps	24 – 3 (0.94 – 0.118)	36 (1.42)	60	434	588	Apply oil to threads
Main bearing cap side bolts	16 – 2 (0.63 – 0.079)	22 (0.87)	15	108	147	Apply oil to threads
Timing gear case	12 – 1.75 (0.47 – 0.069)	17 (0.67)	15	108	147	
Oil pan	10 – 1.5 (0.39 – 0.059)	14 (0.55)	4	29	39	
Mounting brackets (front and rear)	18 – 2.5 (0.71 – 0.098)	24 (0.94)	25	181	245	
Connecting rod bearing caps	18 – 1.5 (0.71 – 0.059)	27 (1.06)	30	217	294	Apply oil to threads
Crankshaft pulley, damper	22 – 1.5 (0.87 – 0.059)	32 (1.26)	55	398	539	
Flywheel	22 – 1.5 (0.87 – 0.059)	32 (1.26)	55	398	539	Apply oil to threads
Exhaust manifolds	10 – 1.5 (0.39 – 0.059)	14 (0.55)	6 – 7	43 – 50	59 – 69	
Idler gears	10 – 1.25 (0.39 – 0.049)	14 (0.55)	4	29	39	
Camshaft gears	30 – 1.5 (1.18 – 0.059)	50 (1.97)	30	217	294	Left-hand thread
Injection pump gears	30 – 1.5 (1.18 – 0.059)	46 (1.81)	30	217	294	
Idler shafts	12 – 1.75 (0.47 – 0.069)	17 (0.67)	5.5	40	54	
Oil pump gear	27 – 1.5 (1.06 – 0.059)	41 (1.61)	30	217	294	
Water pump pulley	24 – 1.5 (0.94 – 0.059)	36 (1.42)	25	181	245	
Water pump impeller	22 – 1.5 (0.87 – 0.059)	–	20	145	196	
Injection pump couplings	12 – 1.75 (0.47 – 0.069)	19 (0.75)	8.5 – 9.5	60 – 69	83 – 93	
Injection pump coupling shafts	12 – 1.75 (0.47 – 0.069)	17 (0.67)	8.5 – 9.5	60 – 69	83 – 93	Hex socket
Glands (nozzle holders)	12 – 1.25 (0.47 – 0.049)	17 (0.67)	8	58	78	
Nozzle holder set screw cap nuts	16 – 1 (0.63 – 0.04)	22 (0.87)	4 – 5	29 – 36	39 – 49	
Nozzle tip nuts	19 – 1 (0.75 – 0.04)	19 (0.75)	6 – 8	43 – 58	59 – 78	

General bolts and nuts

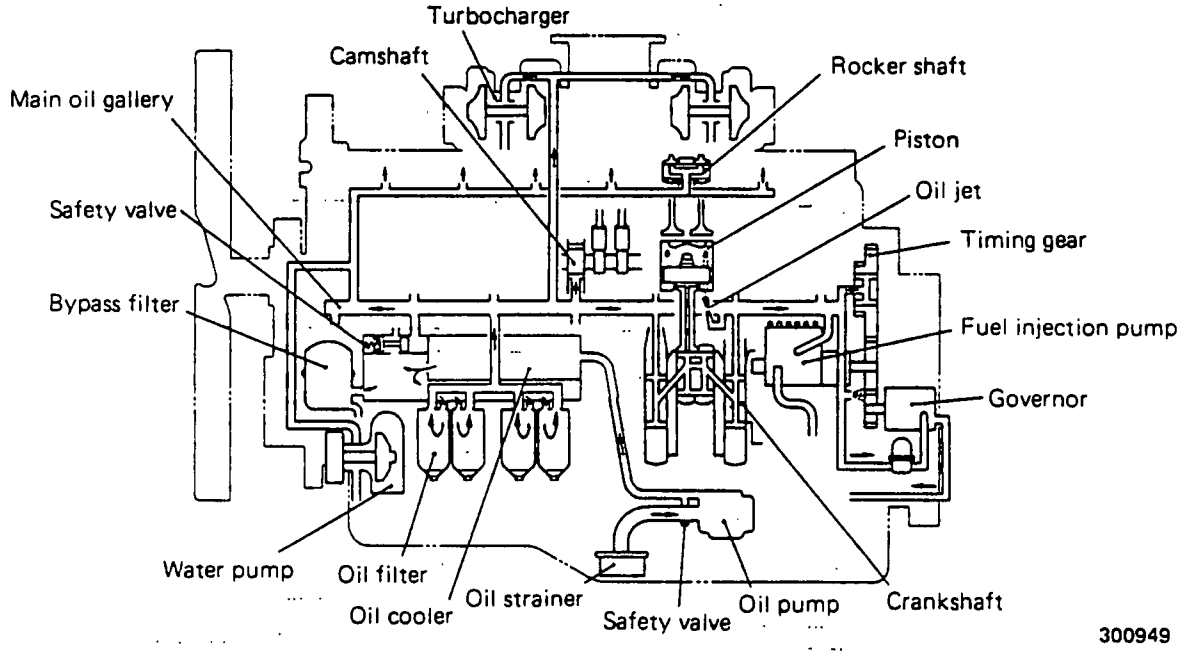
Screw thread mm (in.)		Standard torque					
Diam.	Pitch	w/spring washer			w/o spring washer		
		kgf·m	lbf·ft	N·m	kgf·m	lbf·ft	N·m
8 (0.31)	1.0 (0.039)	1.8	13	18	2.2	16	22
	1.25 (0.049)	1.8	13	18	2.1	15	21
10 (0.39)	1.25 (0.049)	3.6	26	35	4.2	30	41
	1.5 (0.059)	3.4	25	33	4.0	29	39
12 (0.47)	1.25 (0.049)	6.5	47	64	7.6	55	75
	1.75 (0.069)	6.0	43	59	7.1	51	70
14 (0.55)	1.5 (0.059)	10.4	75	102	12.2	88	120
	2.0 (0.079)	9.8	71	96	11.5	83	113
16 (0.63)	1.5 (0.059)	15.8	114	155	18.6	135	182
	2.0 (0.079)	15.0	108	147	17.6	127	173
18 (0.71)	1.5 (0.059)	22.9	166	225	26.9	195	264
	2.5 (0.098)	20.7	150	203	24.4	176	239

CIRCUIT DIAGRAMS

FUEL SYSTEM

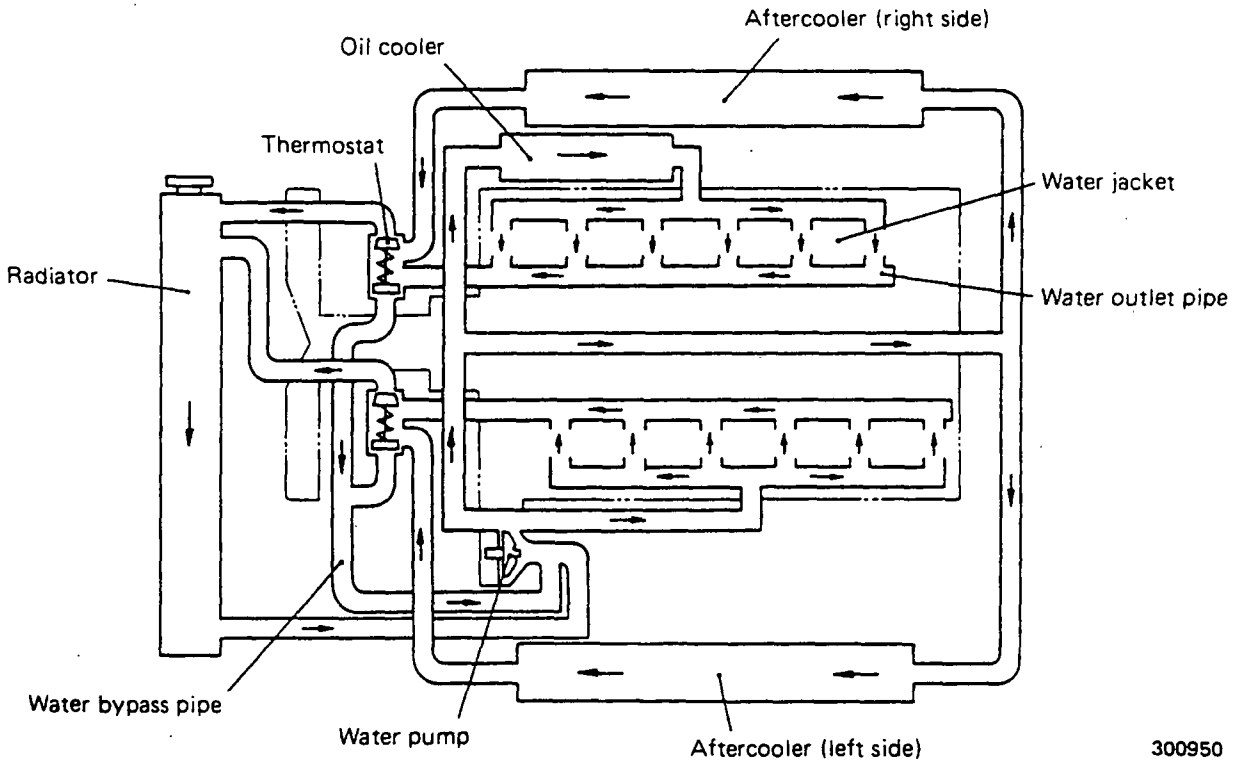


LUBRICATION SYSTEM

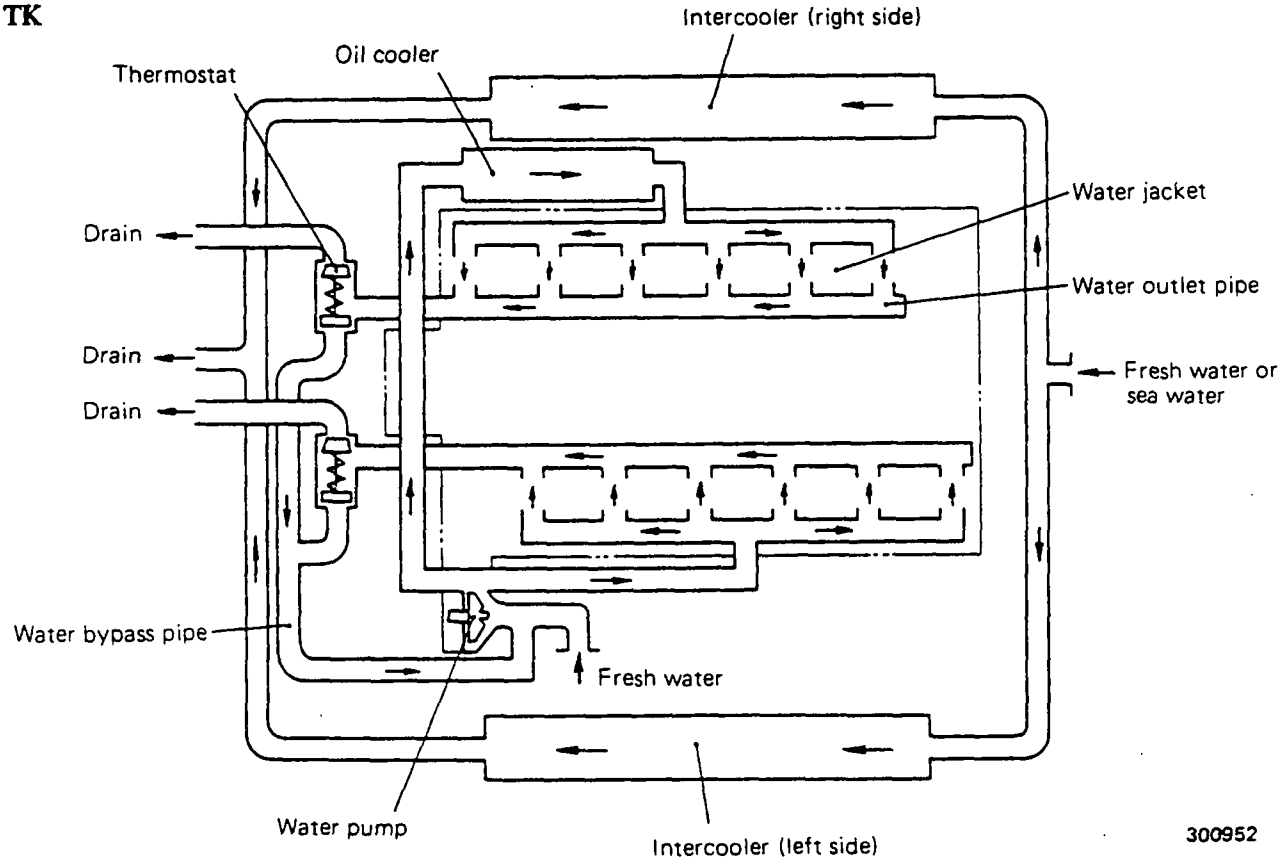


COOLING SYSTEM

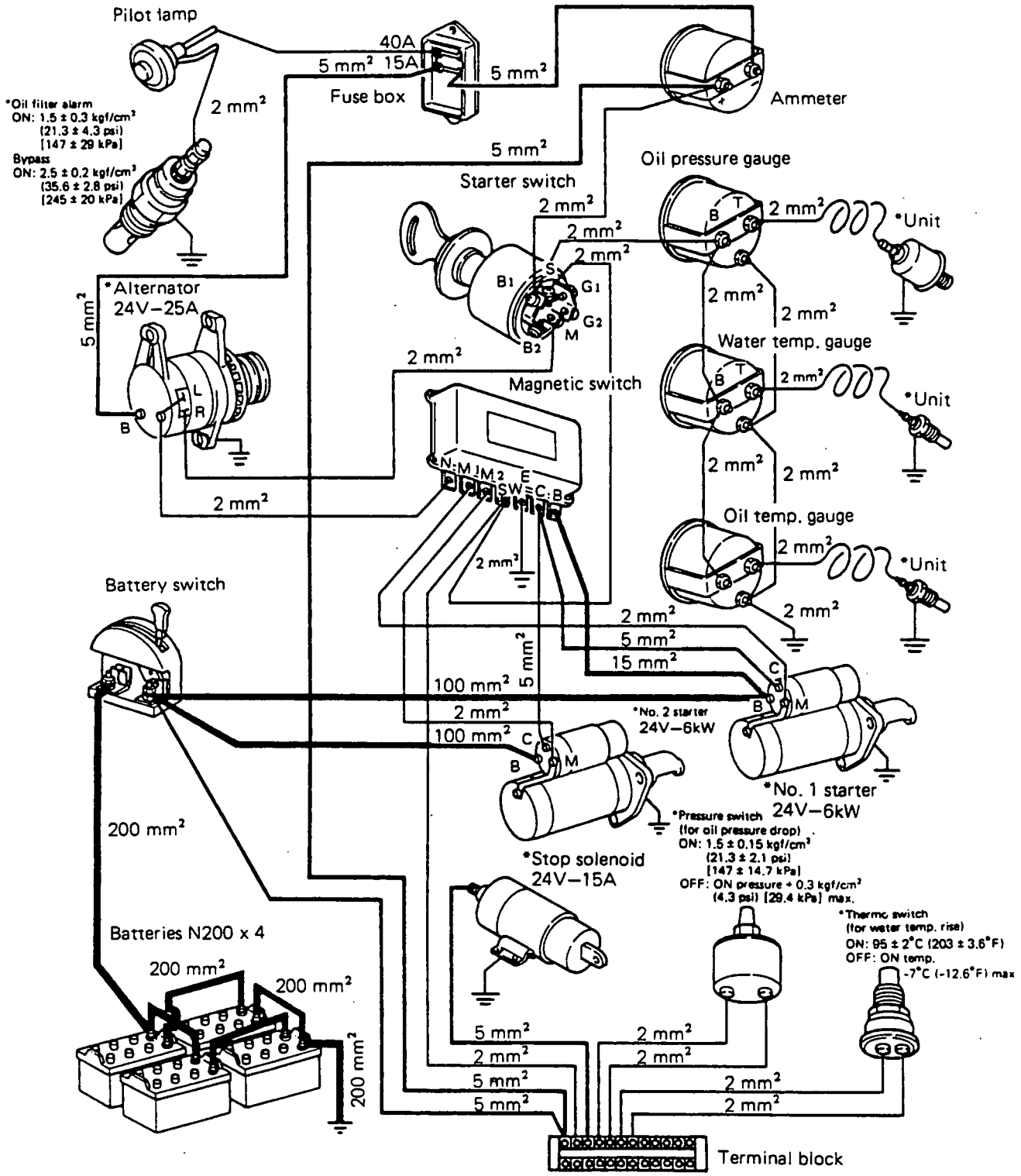
TA (radiator-cooled)



TK



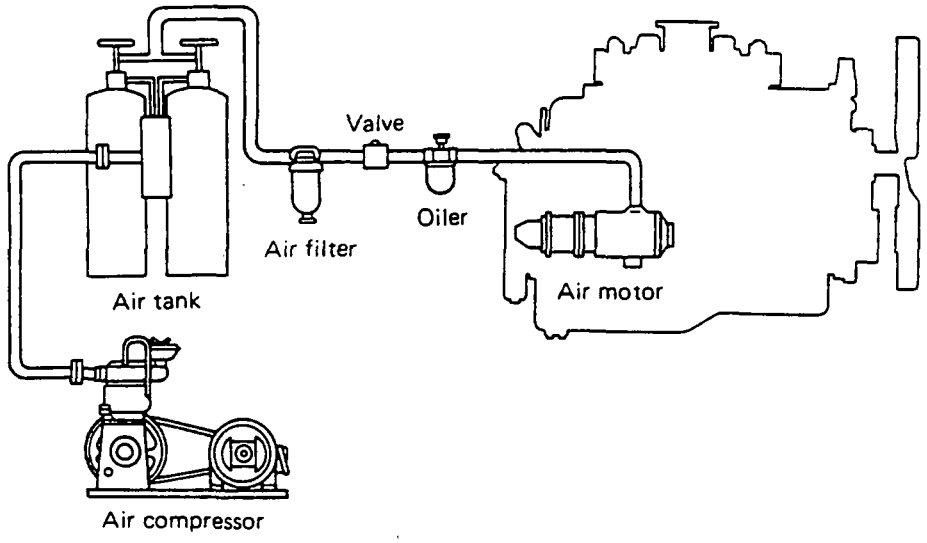
ELECTRICAL SYSTEM



Remarks:
1. The electrical system shown above is standard and is subject to change according to specifications.
2. Wiring material supply and wiring work are purchaser's responsibility.
3. Items (*) are furnished with the engine as accessories and other items are to be supplied on orders individually.

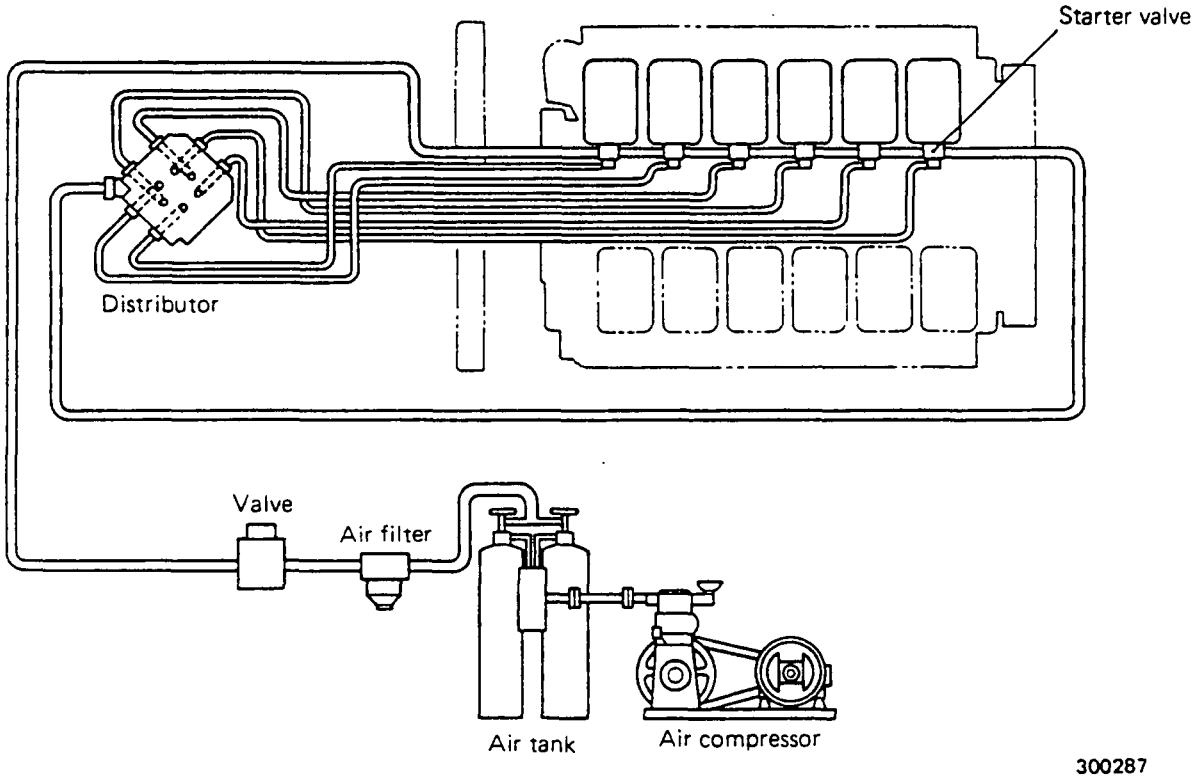
AIR-STARTING SYSTEM

Air-motor starting



300954

Direct-air starting



300287