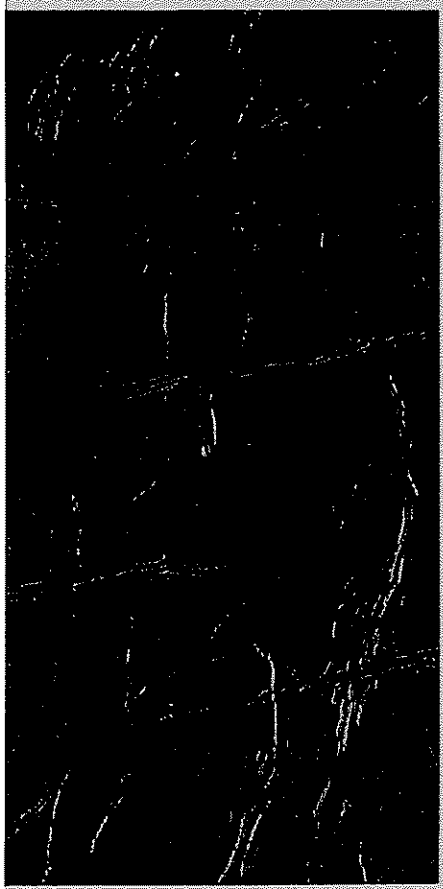
OPERATION & MAINTENANCE MANUAL



MITSUBISHI DIESEL ENGINES

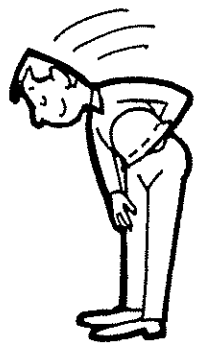
S12N
S16N

APPLICATIONS

- Generator drive
- General mechanical drive
- Locomotive drive
- Construction machinery 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



S12N · S16N

This manual is written to familiarize you with the operation and maintenance of your S12N and S16N diesel engines, and provide important safety information. We suggest that you carefully read this manual to learn about your new engines.

After reading this manual, be sure to keep it near your engines 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 engines.

The engines described in this manual are 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

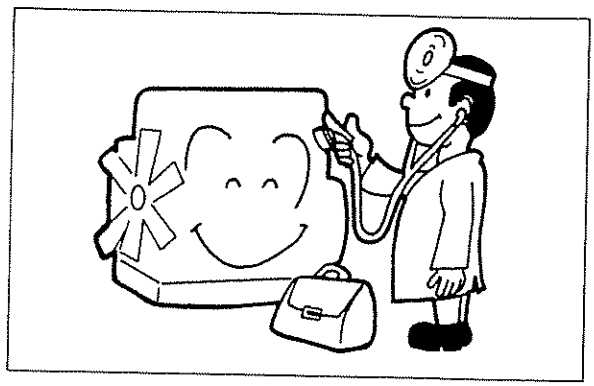
YOUR ENGINE AND MITSUBISHI

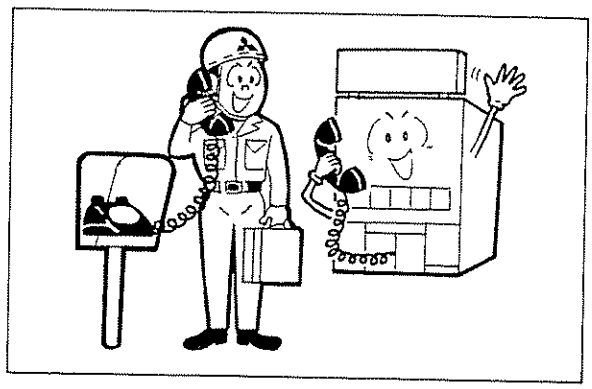
SERVICE ASSISTANCE

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.





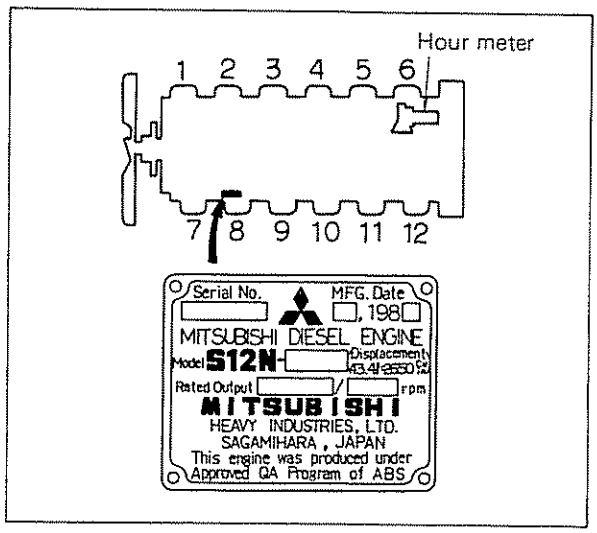
LOCATION OF ENGINE SERIAL NUMBER

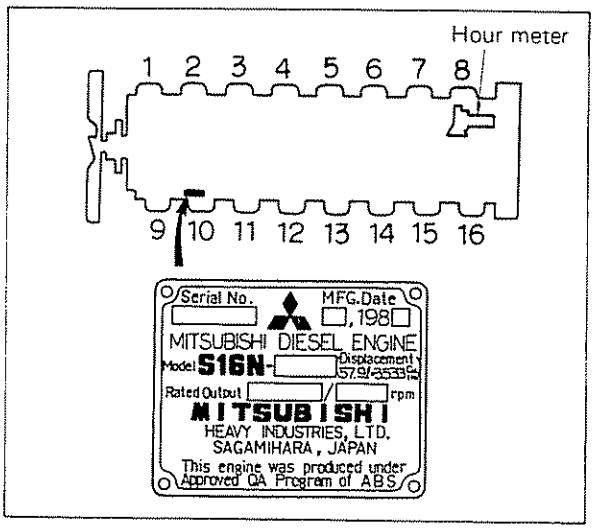
The engine serial number is stamped on the nameplate attached to the left front side of the engine.

Example

Model	Serial number
S12N	00012

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

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

Series code — B, A and N

No.-of-cylinders code — 6, 8, 12 and 16

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.

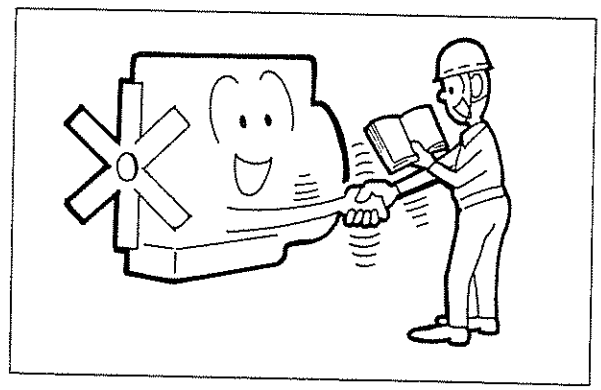
✓ ..... Right or normal

× ..... 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:

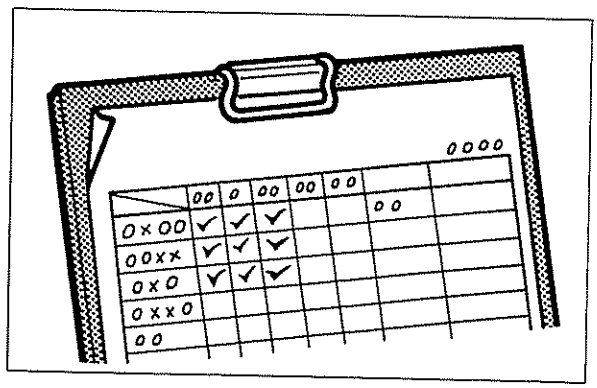
- Effective troubleshooting (to help a serviceman of your Mitsubishi pin-point the trouble)
- Quick servicing and less downtime (to help him save time for servicing)
- Grasp of operating conditions (to help you recognize conditions, signs or indications of approaching trouble)



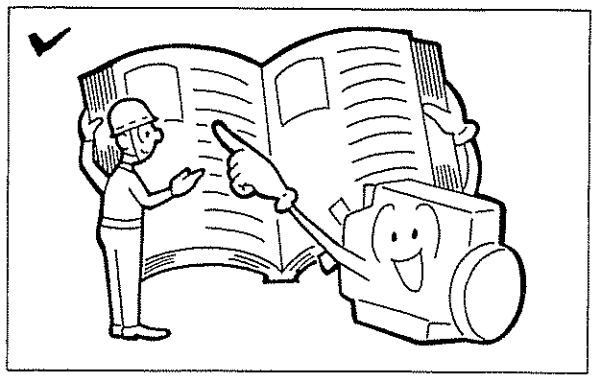
Items to be recorded

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

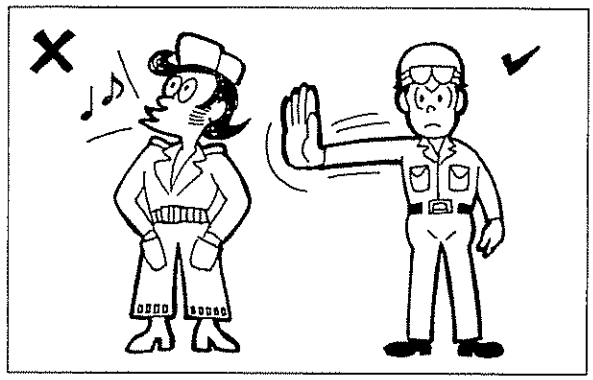
1. Operating hours (hour meter reading)
2. Quantities of engine oil, fuel oil and water (coolant) used for refilling.
3. Engine oil and coolant change periods
4. Engine oil pressure, exhaust temperature and supply air pressure
5. Parts serviced, kinds of service (adjustment, repair or replacement) and results of service
6. Changes in operating conditions (for example, "Exhaust smoke turned black")



Study OPERATION & MAINTENANCE MANUAL to become thoroughly familiar with all engine controls and instruments – and service procedures.

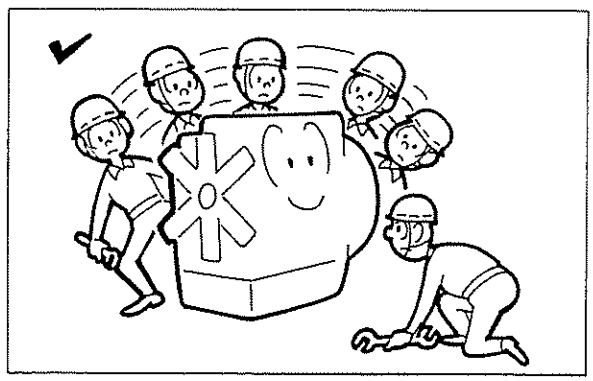


Wear hard hat and safety shoes – and, if job conditions require, safety goggles, heavy gloves, ear protectors, respirators, etc.

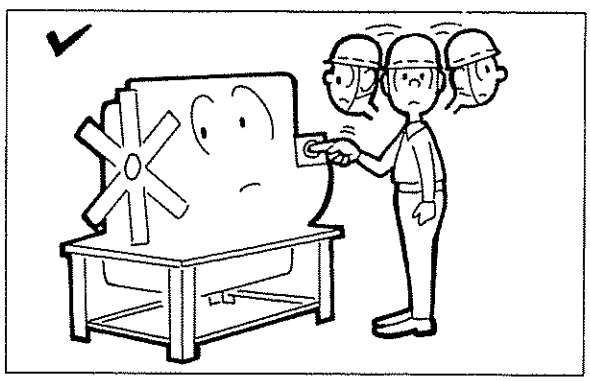


Before operation

⚠ 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.

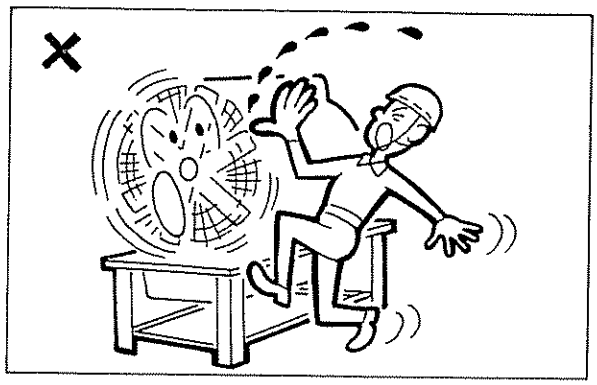


⚠ When starting engine, walk around it once more – open eyes and be alert to people and obstacles that may be within operating range.

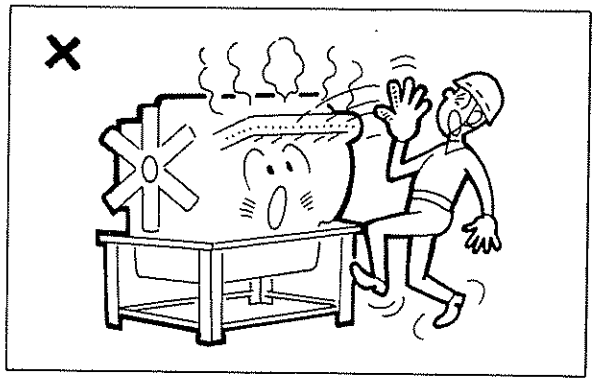


During operation

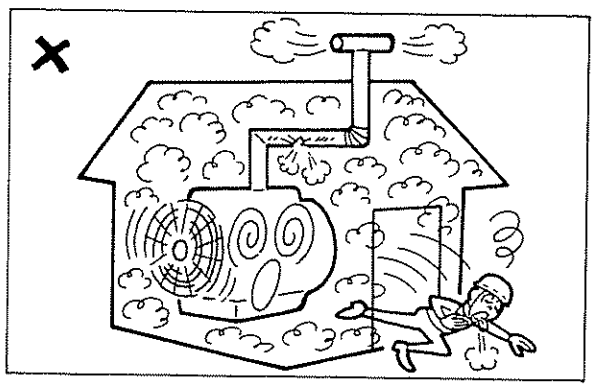
⚠ Do not touch any moving part of a running engine, for clothing or hair can be caught in moving parts, resulting in personal injury or loss of life.



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

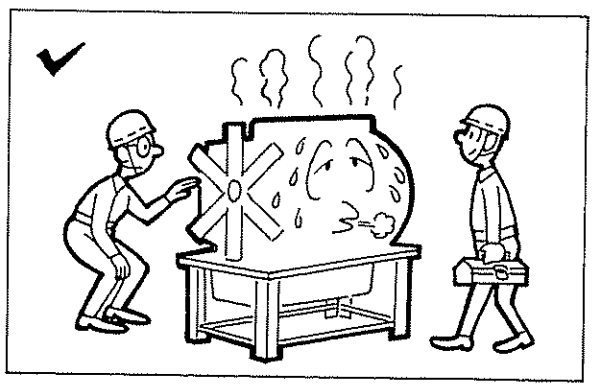


⚠ If necessary to operate engine within an enclosed area, provide adequate ventilation – and pay attention to exhaust piping and exhaust gas leaks.



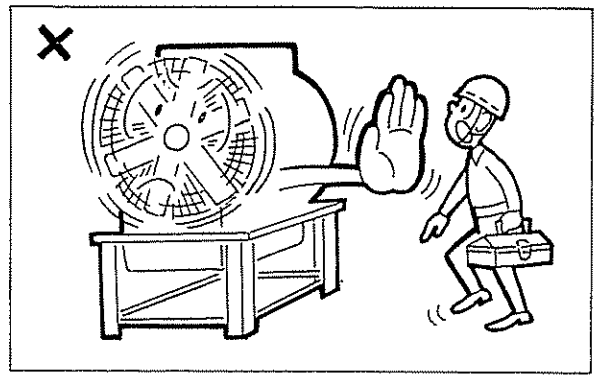
After operation

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

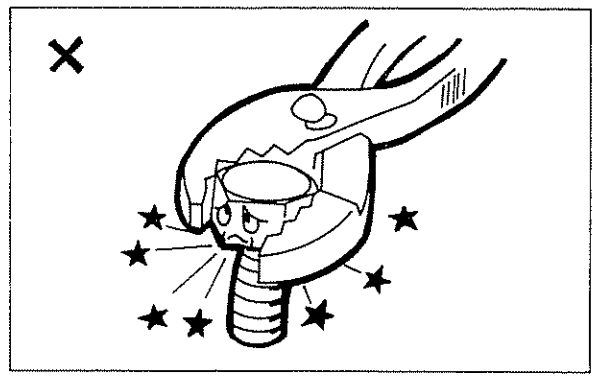


Maintenance

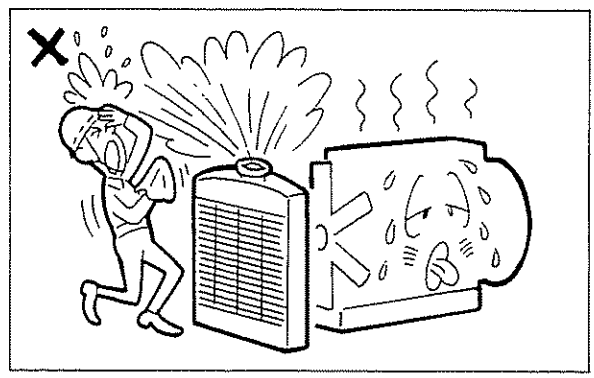
⚠ Be sure to shut off engine, and turn off battery main switch (or close air tank valve) before servicing engine. If necessary to crank engine for inspection, signal to other man and remove cranking bar.



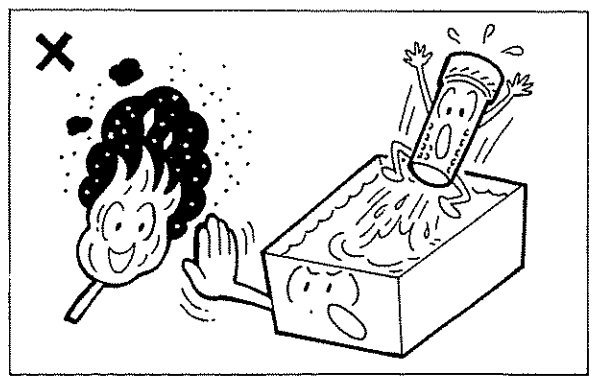
⚠ Use right tools correctly. Thoughtless use of tools including use of a wrong tool can cause personal injury and damage to engine.



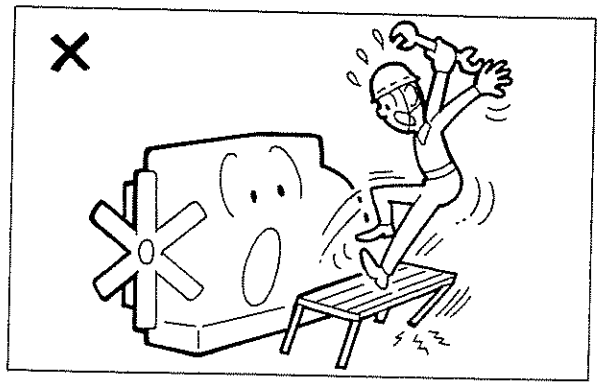
⚠ When removing radiator filler cap immediately after shutting off engine, be sure to release pressure to avoid having scalding by hot water or steam spouted out from radiator.



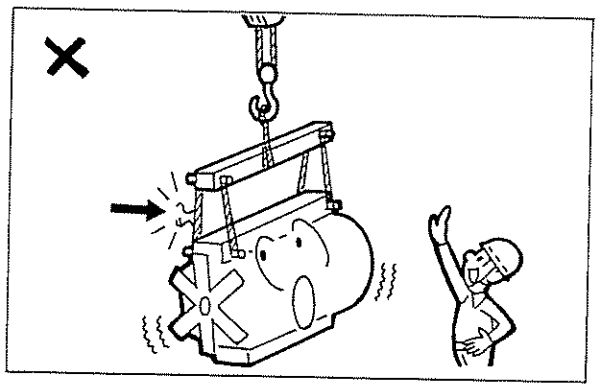
⚠ Do not smoke while handling highly flammable materials. Do not use open cans of gasoline or diesel fuel for cleaning parts. Good commercial, nonflammable solvents are preferred.



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

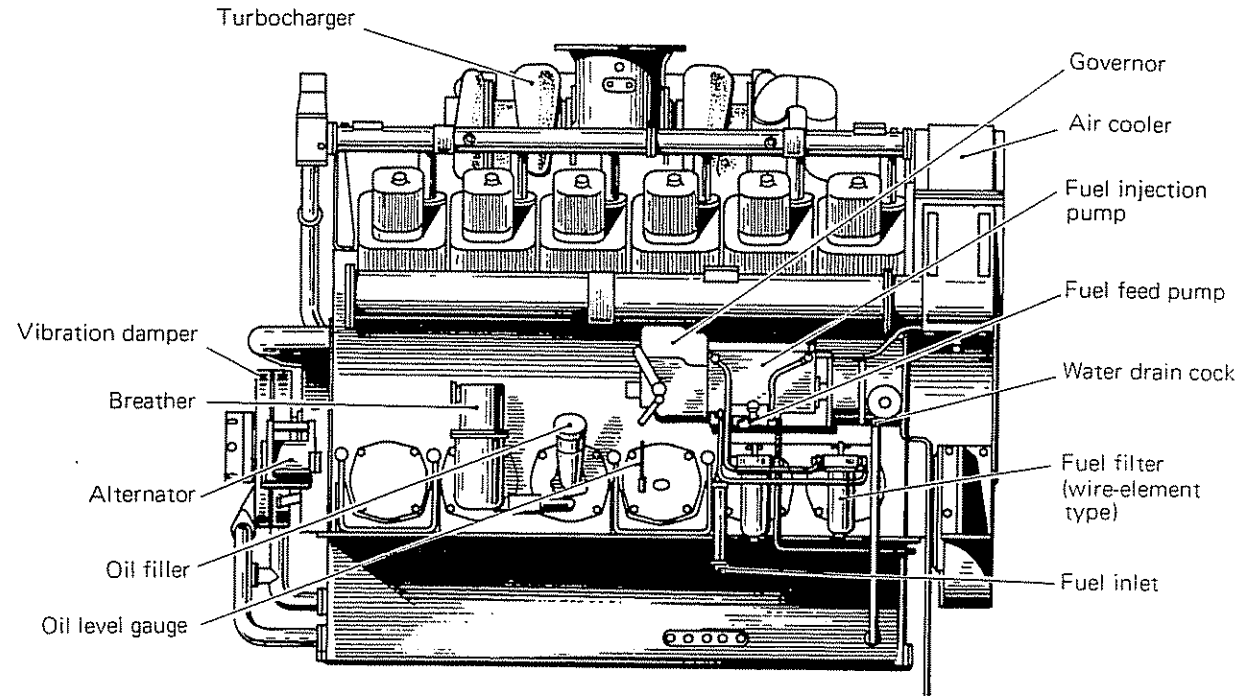


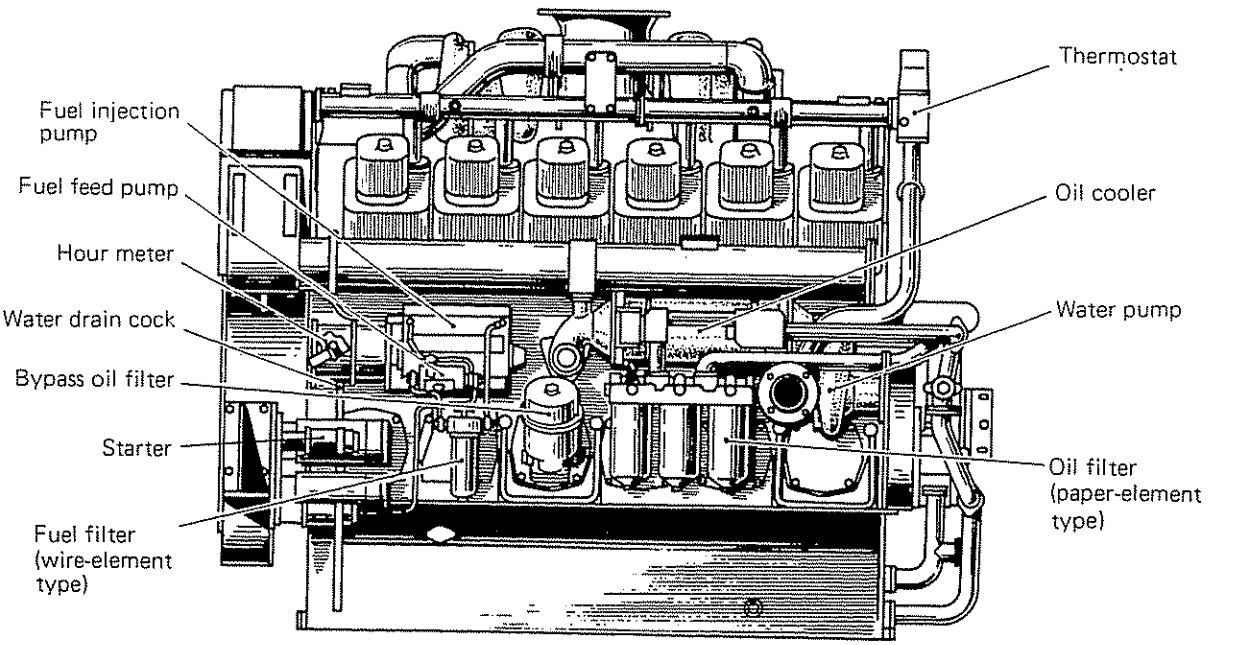
⚠ When lifting engine, use slings free of broken strands. Be sure that the crane has enough capacity for engine to be lifted. Make use of hangers provided on engine, and lift it carefully.



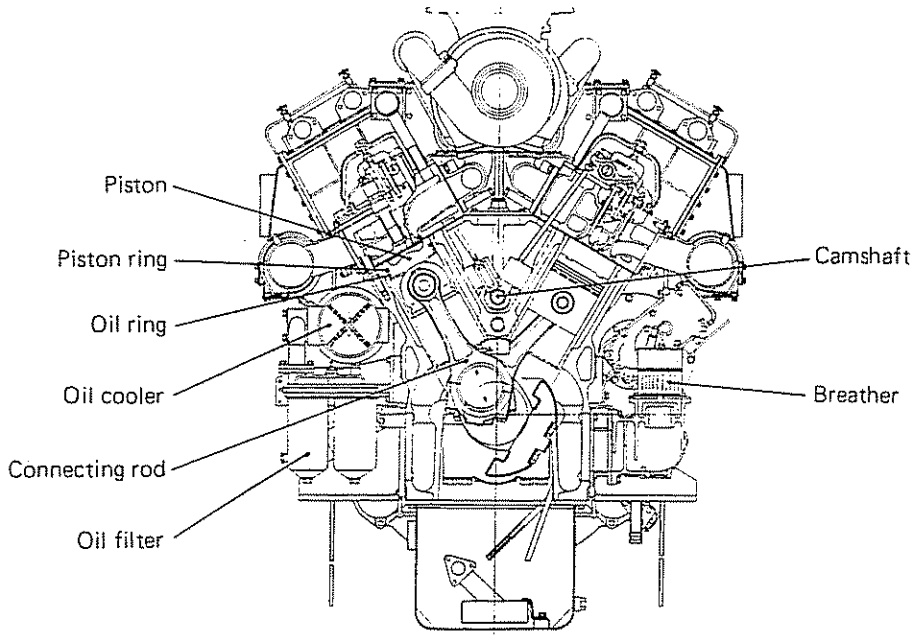
MAJOR COMPONENTS

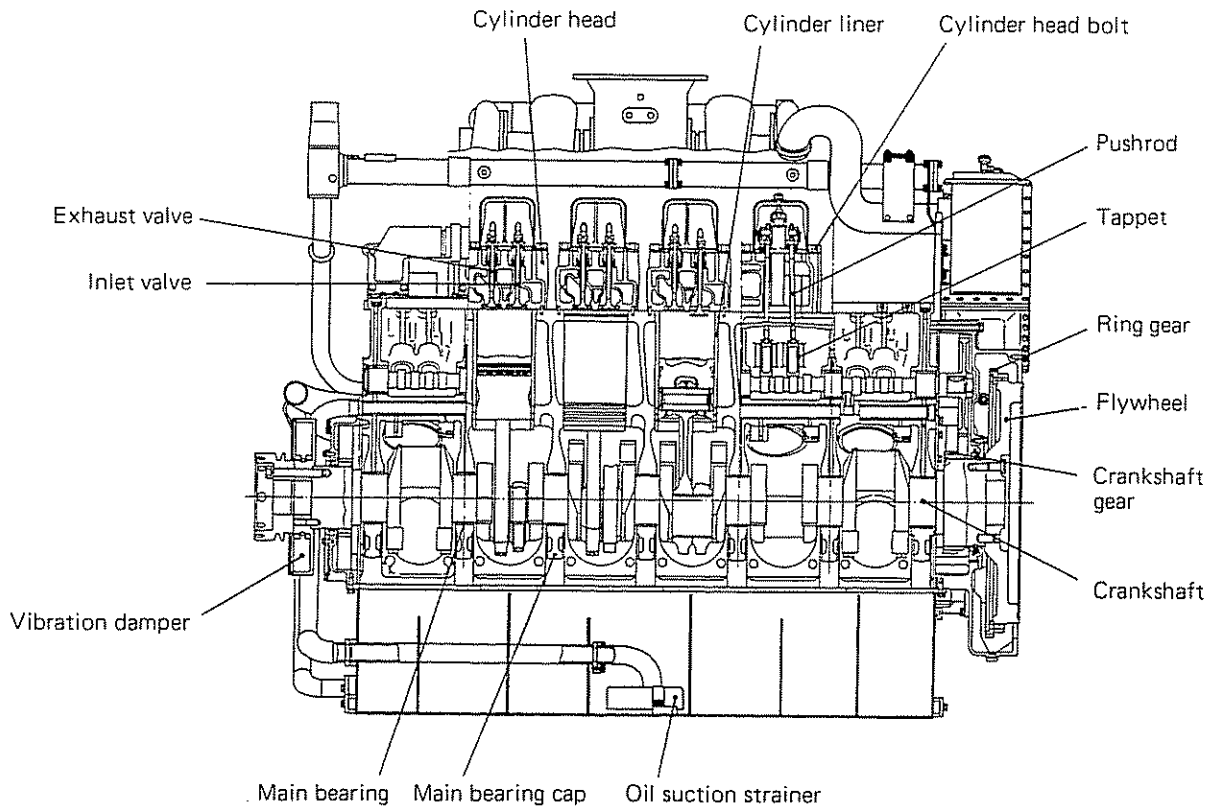
S12N diesel engine – External views



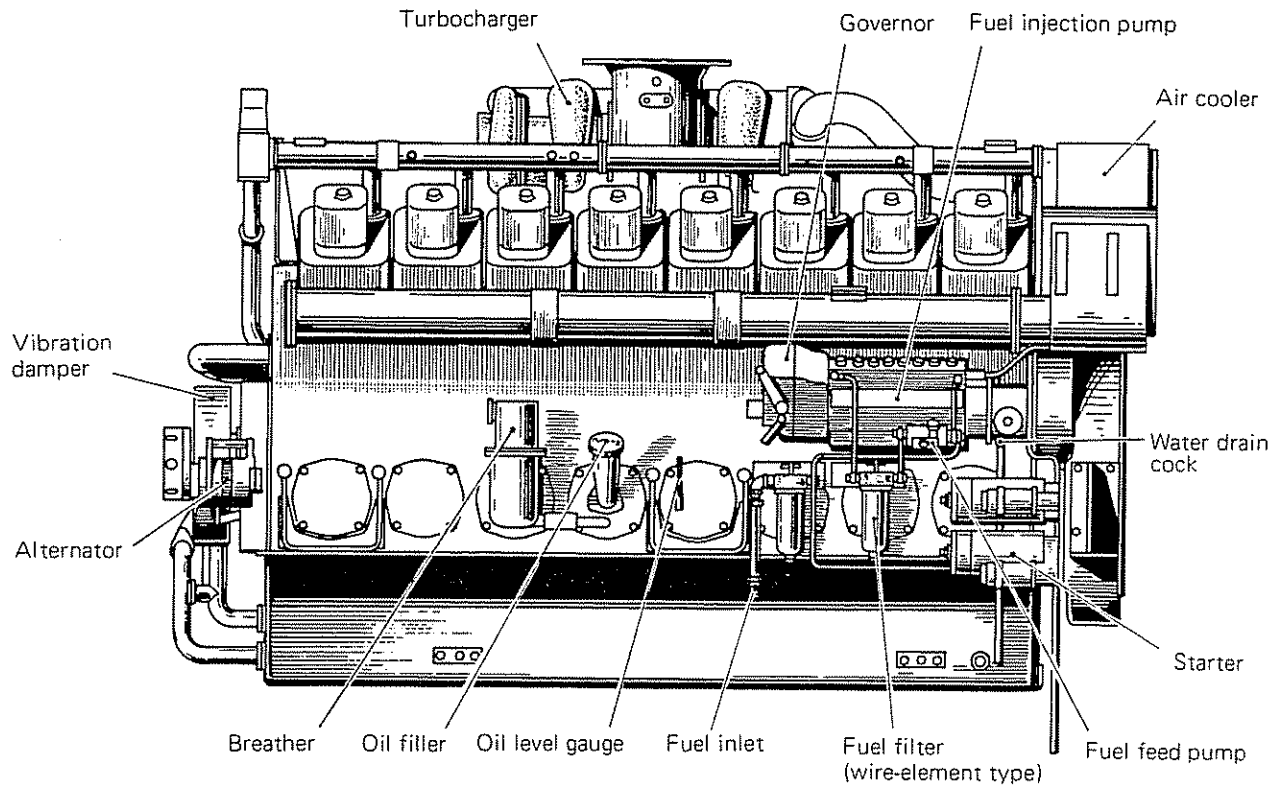


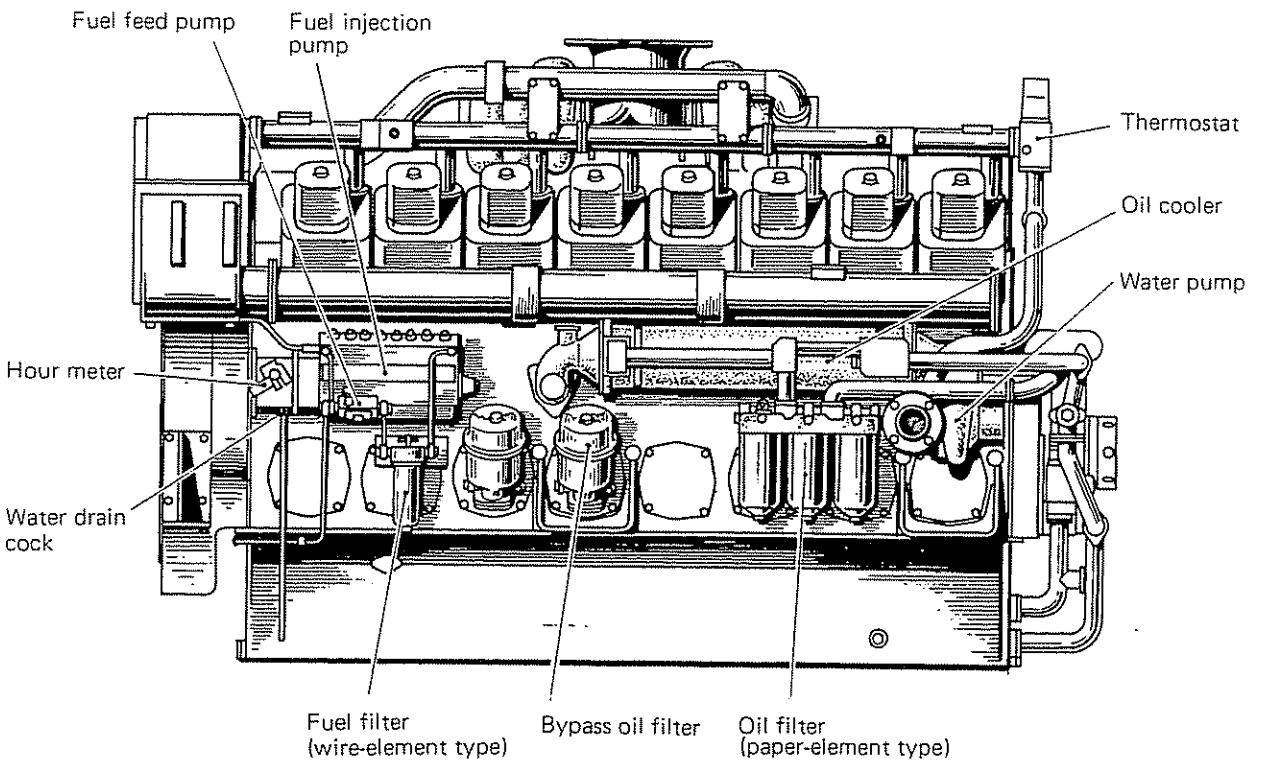
S12N diesel engine – Sectional views



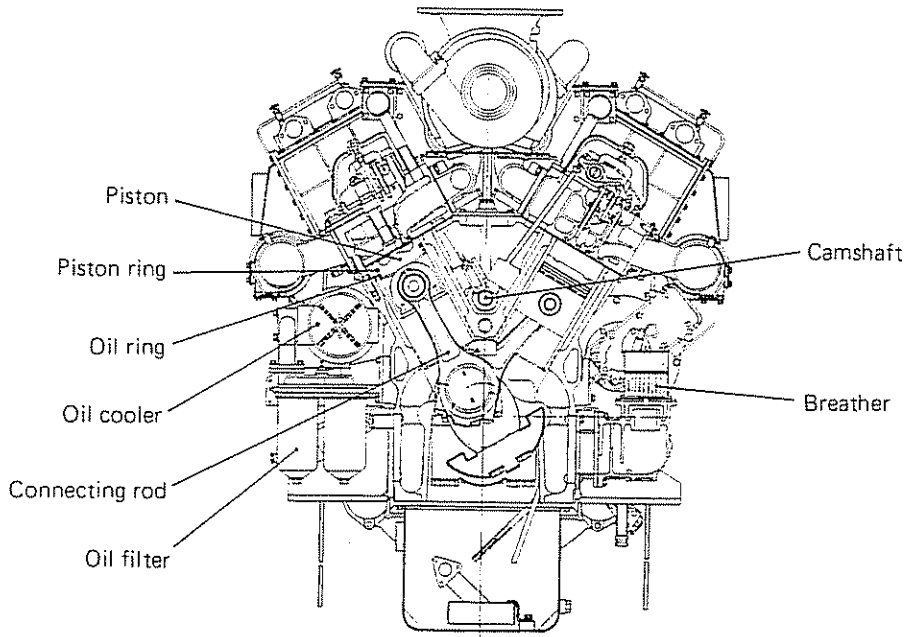


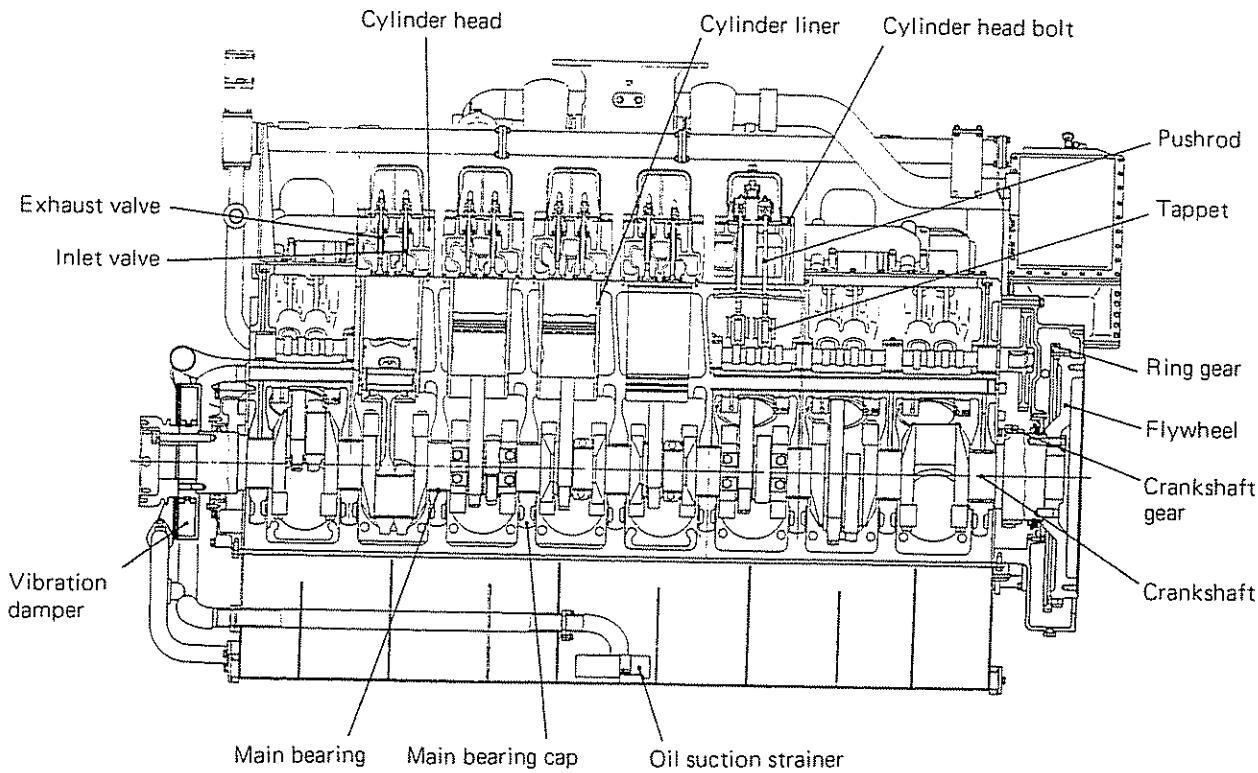
S16N diesel engine – External views





S16N diesel engine – Sectional views

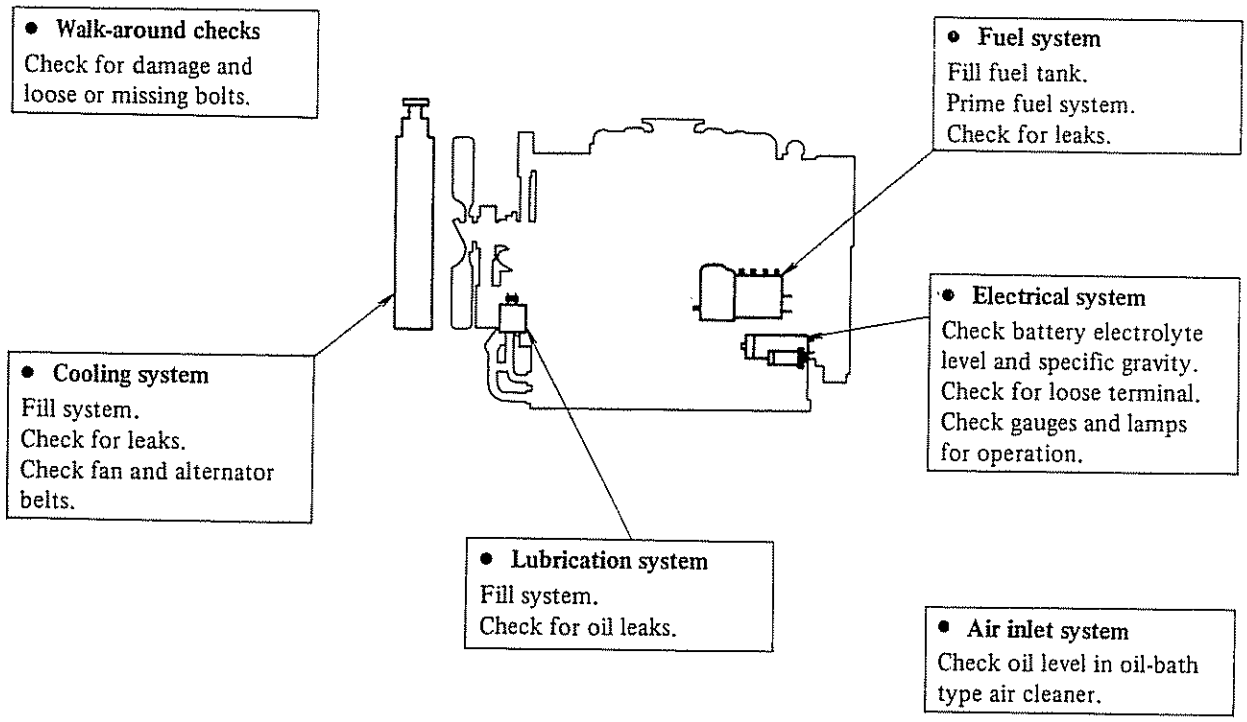




NEW ENGINE INITIAL SERVICE

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 element
- Adjustment of valve clearance
- Retightening of bolts and nuts

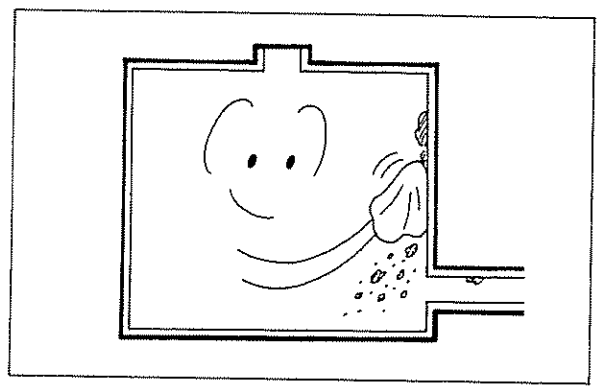
NOTE

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
  - Timing gear case
  - Crankshaft pulley
  - Fuel injection pump couplings and drive shafts
  - Mounting brackets
  - Turbochargers
  - Exhaust pipe

FUEL SYSTEM



Filling the fuel tank

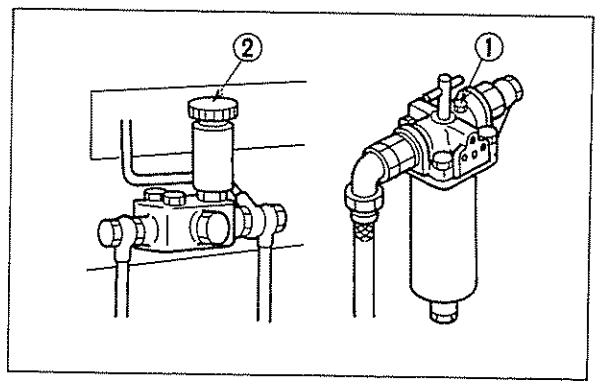
Before filling the fuel tank, check to be sure that the tank and pipes are free of dirt, water or other foreign substances. After filling, check the oil level in the tank with the level gauge.

Priming the fuel system

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

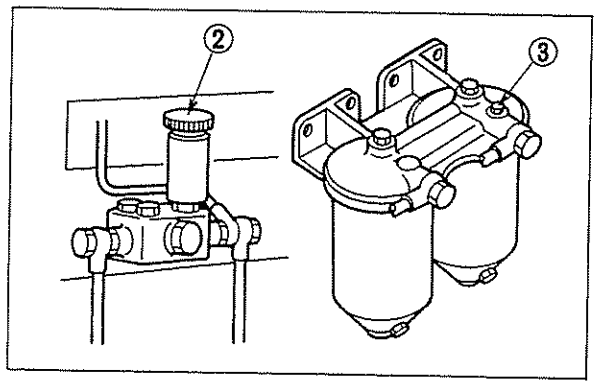
- **Fuel filters (wire-element type)**

1. Loosen air vent plug (1) of fuel 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.



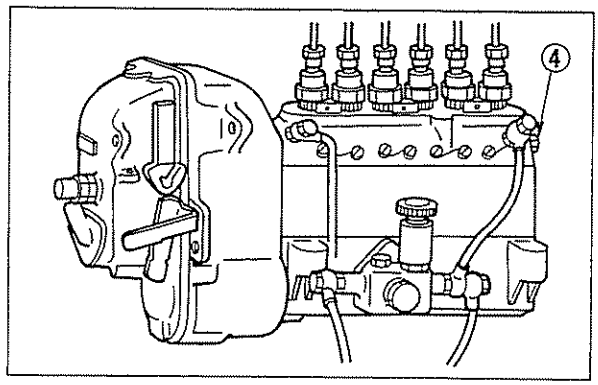
- **Fuel filters (paper-element type)**

1. Loosen air vent plug (3) of fuel 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 (4) of injection pump.
2. Operate the priming pump until the flow of fuel at the plugs is free of air bubbles. Lock the priming pump by twisting it clockwise while depressing it before tightening the last vent plug.



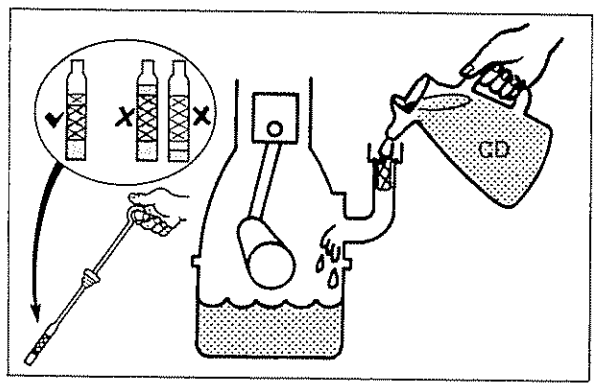
NOTE

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 between the two marks 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.



COOLING SYSTEM

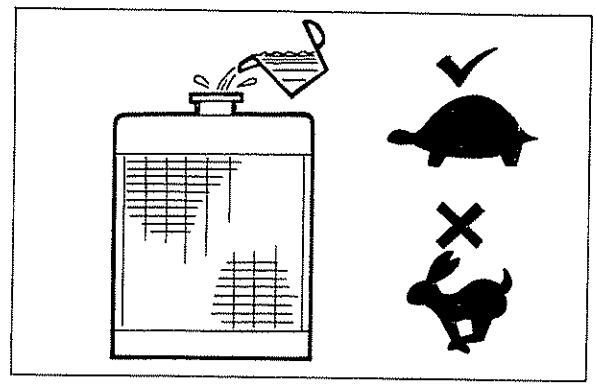
Filling the cooling system

1. Tighten the engine drain cock and oil cooler (or radiator) drain cock. (The engine is shipped from the factory with the cooling system drained.)
2. Use soft water, with rust inhibitor. The use of rust inhibitor will prevent rust formation. It will also retard, and in some cases, completely eliminate mineral deposits within the cooling system.

NOTE

Use anti-freeze solution if temperatures below freezing are likely to be encountered.

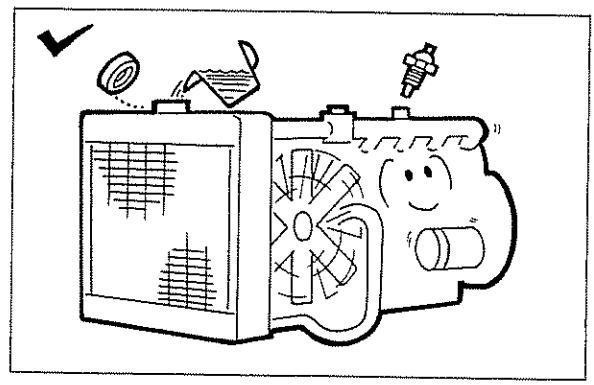
3. To fill the cooling system of a radiator-cooled engine for the first time, or to change the coolant in such an engine, proceed as follows:



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 engine outlet pipe.

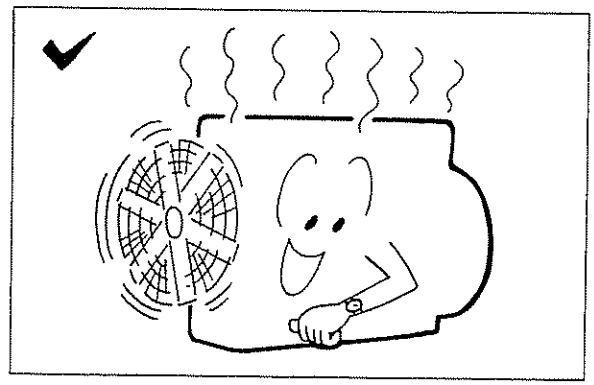


b) With the radiator filler cap and thermo sensor removed, crank the engine with the starter three times, for 5 to 6 seconds each time, at intervals of about 20 seconds, in order to bleed air out of the water pump.

NOTE

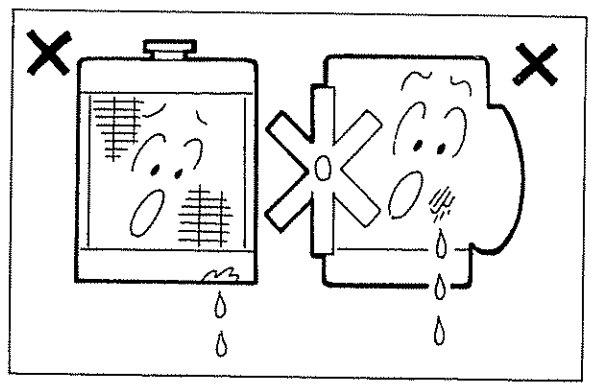
To crank the engine for air bleeding, keep the stop lever in STOP position.

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, allow 1 minute intermission before cranking it again.

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



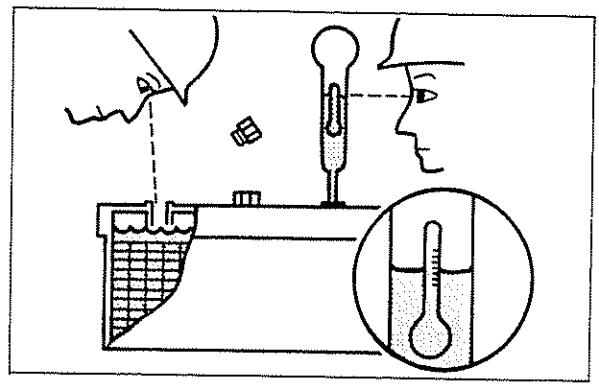
f) Stop the engine, and check the coolant level in the radiator again. If the level is low, refill the radiator fully, and install the cap.

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 1.20 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.

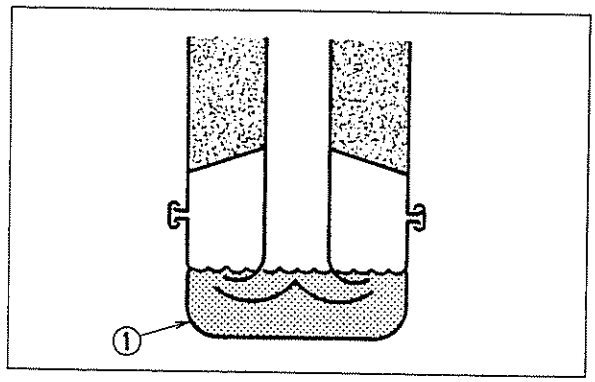
AIR INLET SYSTEM

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

OPERATING THE ENGINE

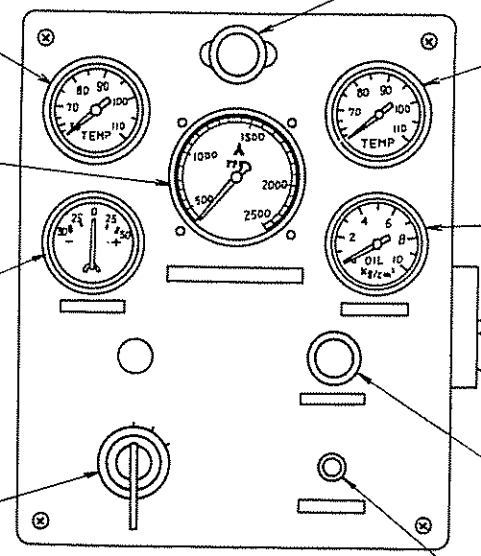
Controls and instruments

- **Water temperature gauge**
  Indicates temperature of engine coolant.
  Normal range:
  75 ~ 85°C
  (167 ~ 185°F)

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

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

- **Starter switch**
  OFF: Insert and pull out key. All electrical circuits are OFF.
  ON: Keep engine running. All electrical circuits are ON.
  START: Start engine. Key will return to ON when released.



- **Instrument panel lamp**

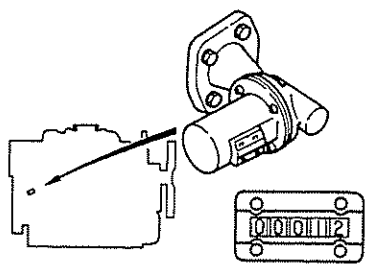
- **Oil temperature gauge**
  Indicates temperature of engine lubricating oil.
  Normal range:
  70 ~ 110°C
  (158 ~ 230°F)

- **Oil pressure gauge**
  Indicates pressure of lubricating oil.
  Normal range:
  5 ~ 6.5 kgf/cm²
  (71 ~ 92 psi)

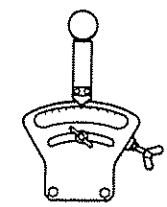
- **Fuse box**

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

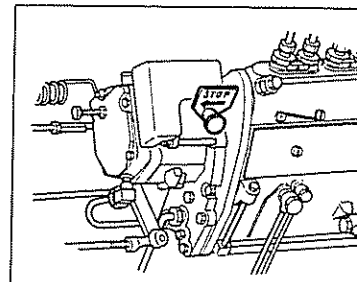
- **Instrument panel lamp switch**
  Pull the switch to turn on lamp; push it to turn off lamp.



- **Hour meter**
  Rely on hour meter to check, service or lubricate engine.



- **Fuel control lever**
  Use the lever to control engine speed. Pull it to stop engine.

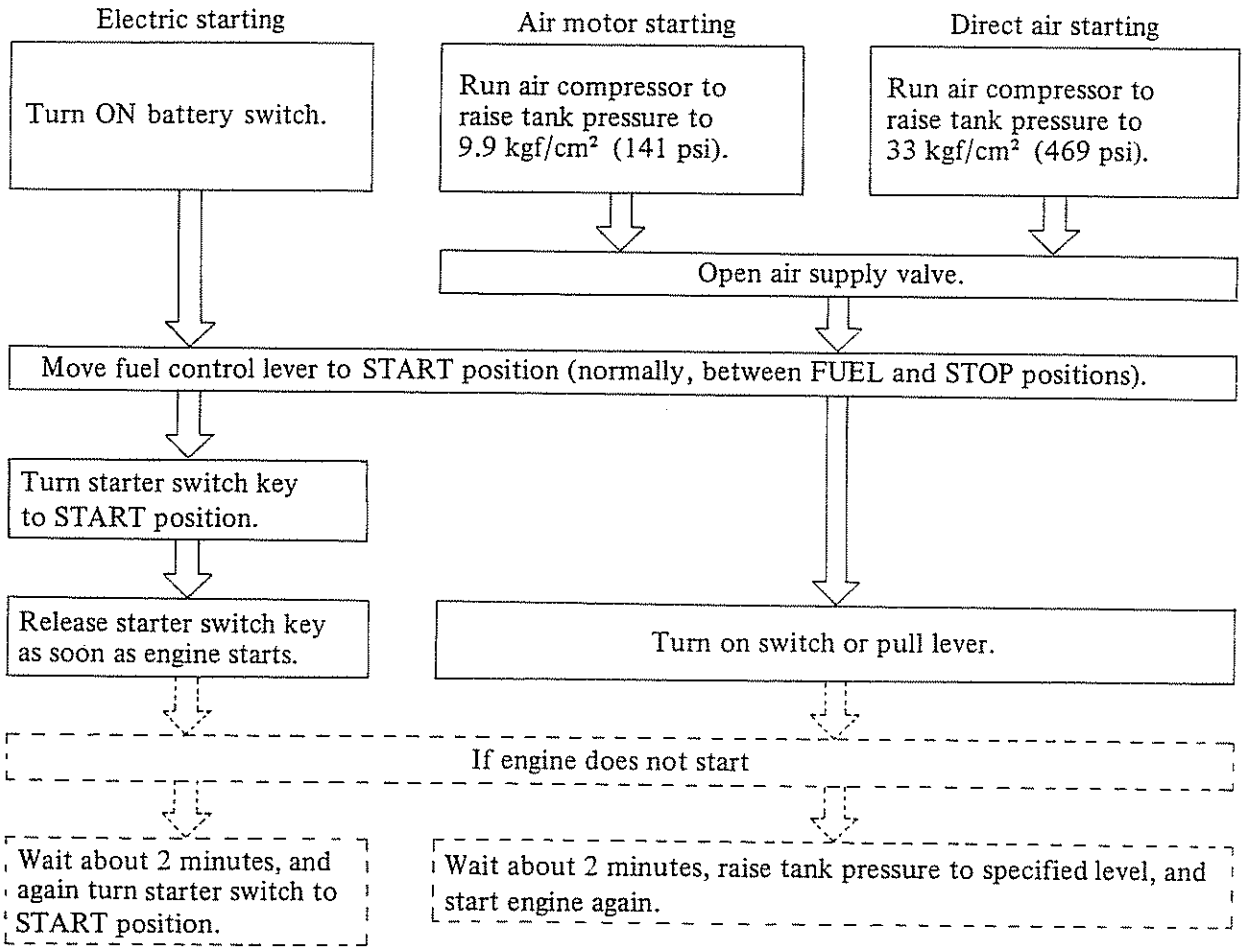


- **Stop lever**
  Pull the lever to stop engine in case of emergency.

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.



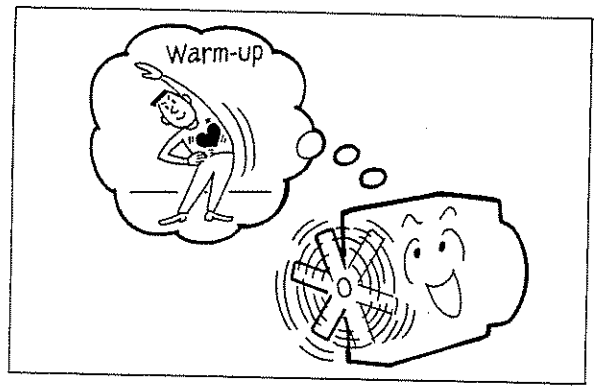
⚠ CAUTION

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

1) Do not run the starter for more than 30 seconds at a time. Then allow 2 minutes for cooling before using it again.
2) When re-cranking the engine, stop crankshaft rotation to prevent it from turning in reverse direction.
3) Keep the starter switch in ON position during operation. Never move it to START or OFF position.

WARMING UP

After starting up, allow the engine to idle for 10 minutes to warm it up. During this warm-up period, check to be sure that oil pressure rises properly. The pressure will be a little higher by 2 ~ 3 kgf/cm² (28 ~ 43 psi) during low idling.



⚠ CAUTION

1) Do not warm up the engine for more than 15 minutes.

2) It is not necessary to warm up the engine if it is used as a stand-by engine, but as a periodical testing item as in Maintenance Instructions, page 22, warming-up is necessary.

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 ~ 6.5 kgf/cm² (71 ~ 92 psi)
- o Water temperature gauge 75° ~ 85°C (167° ~ 185°F)
- o Ammeter (+) side
- o Engine oil temperature gauge 70° ~ 110°C (158° ~ 230°F)
- o Oil filter alarm lamp – OFF

STOPPING

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

⚠ CAUTION

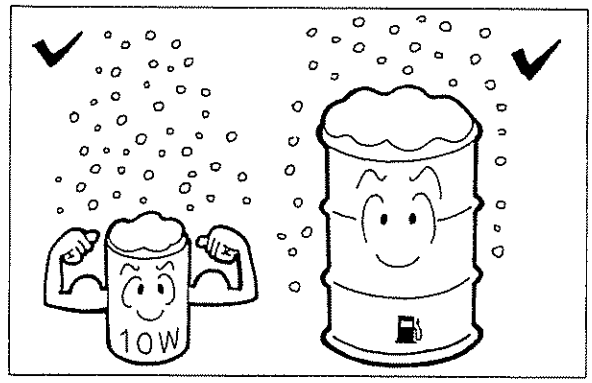
Keep on pulling the stop lever until the engine comes to a complete stop. Do not release the lever before the engine stops to prevent it from turning in reverse direction.

Engine equipped with fuel control lever	Engine equipped with stop lever
Move fuel control lever to STOP position.	Pull stop lever on governor to STOP position.

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

OPERATION UNDER EXTREME WEATHERS

COLD WEATHER PRECAUTIONS

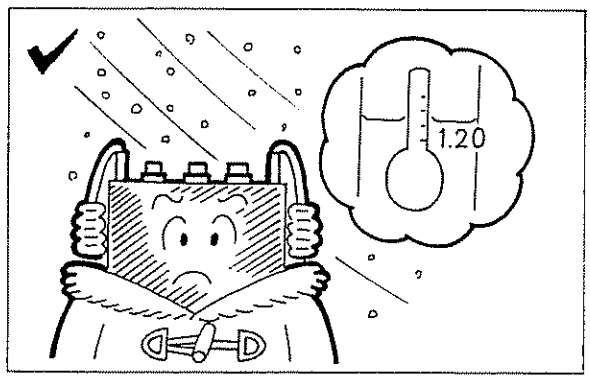


Engine oil and fuel

1. Use engine oil of lower S.A.E. viscosity grade in cold weather.
2. Use fuel oil of lower pour point.

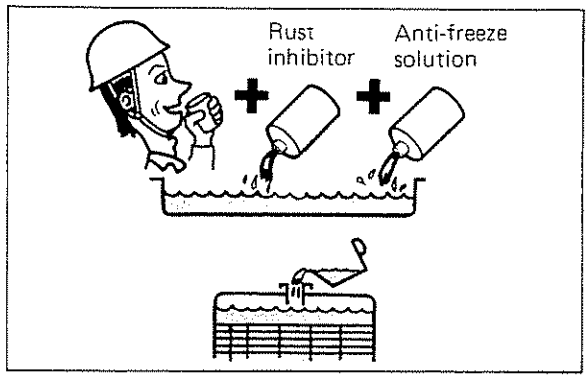
Battery

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 1.26 or over.
3. The lower the temperature, the smaller the capacity of the battery. Try to draw energy from the battery as sparingly as possible, and make necessary provisions for protecting the battery from the deadly chill of the night. A battery with its electrolyte frozen is done with.



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

Percent of solution and coolant freezing point (reference)

Anti-freeze solution	0	10	20	30	40	50	60
Freezing point °C (°F)	0 (32)	−4 (24.8)	−9 (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.

in a container, and pour the mixture into radiator.

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 about 2 minutes before cranking the engine again.
2. After starting the engine, warm it up thoroughly before applying the load.

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.

HOT WEATHER PRECAUTIONS

Engine oil

Use engine oil of higher S.A.E. viscosity grade in hot weather.

Battery

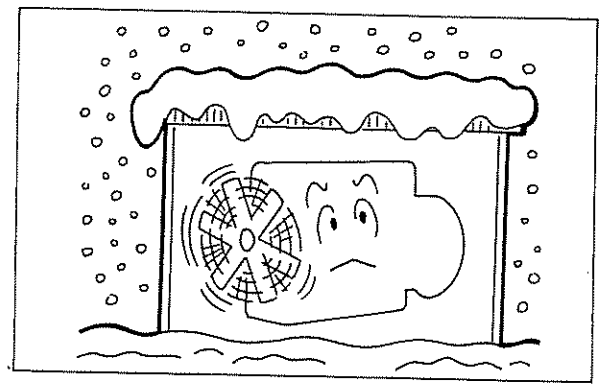
At higher temperatures, the battery is likely to lose its energy by "self-discharging." Remove the battery from the engine, and store it in a cool place.

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.

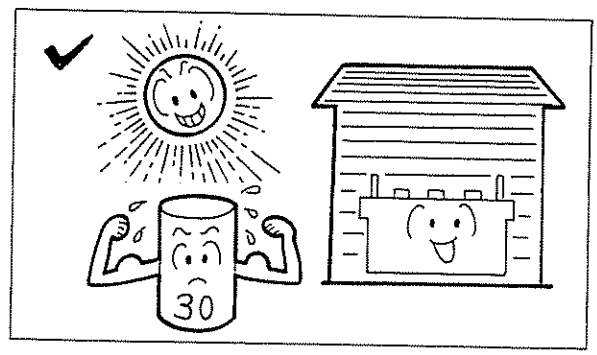
Operating in hot weather

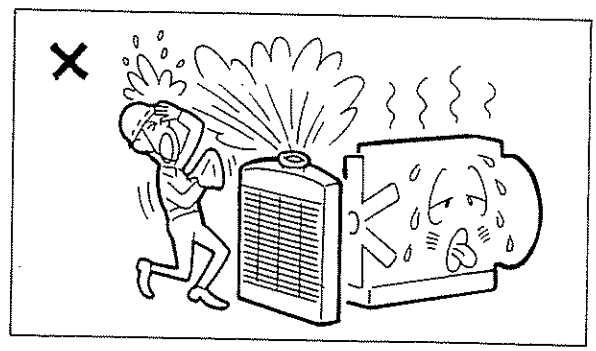
Give particular attention to overheating of the engine by observing the water temperature gauge and oil pressure gauge. When the engine is overheated, remove the load rather slowly, and allow the engine to idle for gradual cooling.



NOTE

As starting aids, an oil pan heater, a water heater and a starting burner are available from your Mitsubishi dealer.





CAUTION

Shutting off an overheated engine is a dangerous practice. Equally dangerous is an attempt to pour cold water into the radiator: you will have scalding hot coolant or steam spouted out from the radiator.

MAINTENANCE INSTRUCTIONS

1. Use hour-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."

Periodical testing

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

Where the engine is used for stand-by duty, it 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 no-load condition, as follows:

○ Check, clean, wash
● Change
* Item to be performed after initial 50 operating hours of a new or reconditioned engine or placed in service after a long storage

MAINTENANCE SCHEDULE

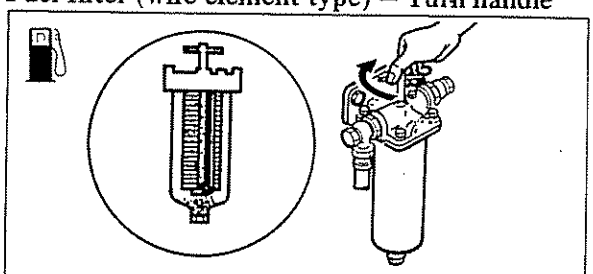
Group	Service		Service intervals						Remarks
			Every 10 hours or daily	Every 50 hours or monthly	Every 250 hours or 1 year	Every 500 hours or 2 years	Every 1000 hours or 3 years	Every 2000 hours or 5 years	
Engine	Valve clearance	Check		*			○		
	Bolts and nuts	Retighten		*			○		
	Walk-around checks		○						
Lubrication system	Oil pan	Check oil level	○						
		Check for water or fuel in oil		○					
		Change		*	●				
	Oil filter (paper-element type)	Change element		*	●				
	Oil filter (notched wire type)	Wash element		*	○				
	Bypass oil filter	Wash			○				
	Woodward governor oil filter	Change element				●			
Fuel system	Fuel tank	Check oil level	○						
		Drain water		○					
	Fuel filter (paper-element type)	Drain water		○					
		Change element					●		
	Fuel filter (wire-element type)	Turn handle	○						
		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/alternator drive belts	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	Fan drive	Lubricate			○				
	Heat exchanger	Wash						○	
	Zinc rods	Change				●			
Air inlet and exhaust systems	Air cleaner (paper-element type)	Check indicator	○						
		Clean			○				
		Change element					●		
	Air cleaner (oil-bath type)	Change oil			●				
		Wash element			○				
	Air cleaner (silencer type)	Clean			○				
	Muffler	Drain water			○				
	Air coolers	Clean						○	
	Turbo-chargers	Check						○	
	Air cooler	Drain water							To be kept opened
Starting system	Electric starting: Battery	Check electrolyte level/ specific gravity	○						Check specific gravity from time to time
	Electric starting: Alter-nator	Check						○	
	Electric starting: Starters	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 engine for stand-by every year.)
	Engine oil pressure drop [1.5 ± 0.2 kg/cm² (21 ± 2.8 psi)]								
	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			○				Ⓢ

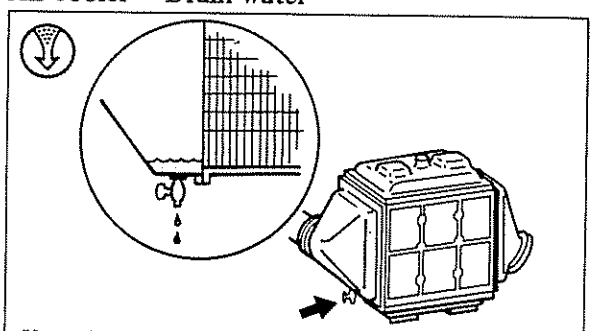
EVERY 10 HOURS OR DAILY

Fuel filter (wire-element type) – Turn handle



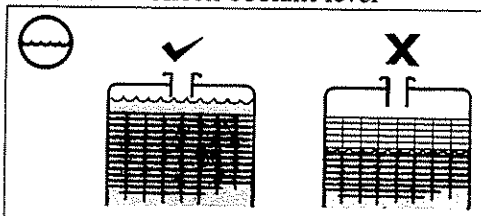
Turn handle 1 or 2 times in direction of arrow.

Air cooler – Drain water



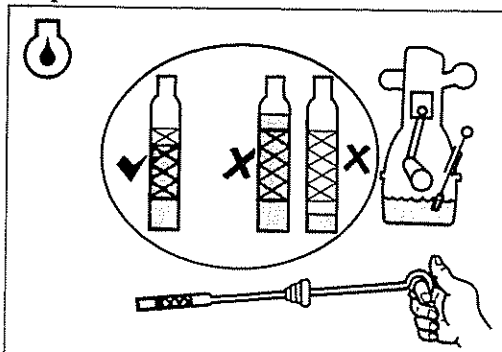
Keep drain cock opened.

Radiator – Check coolant level



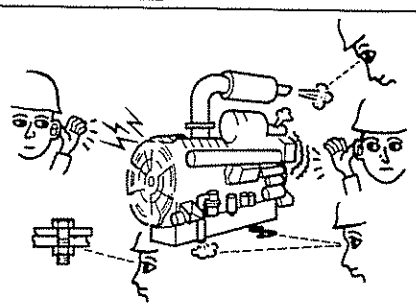
Remove radiator filler cap and check.
Coolant should be visible in filler neck.
Check level in sight gauge on expansion tank.

Oil pan – Check oil level



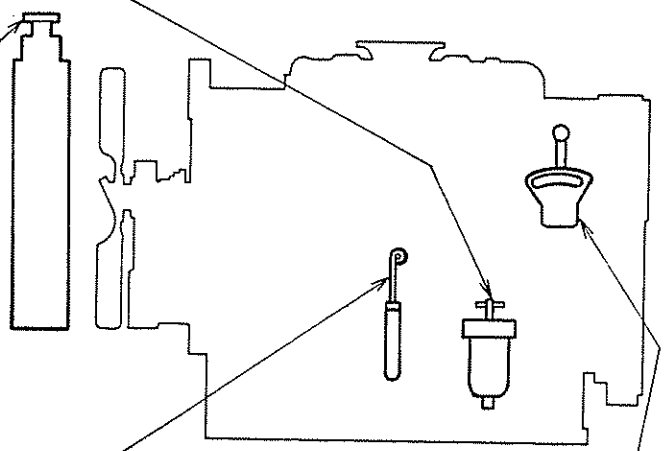
Maintain oil level in correct range.

Walk-around checks

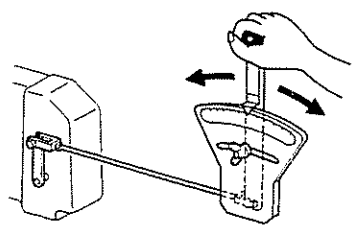


Check for:

- 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

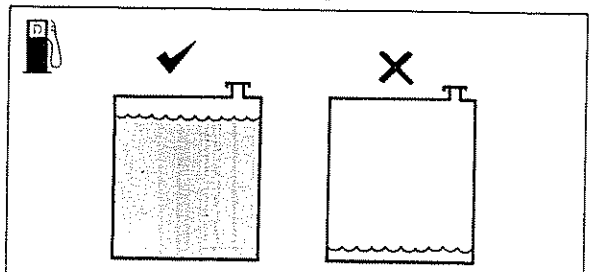


Fuel control lever – Check



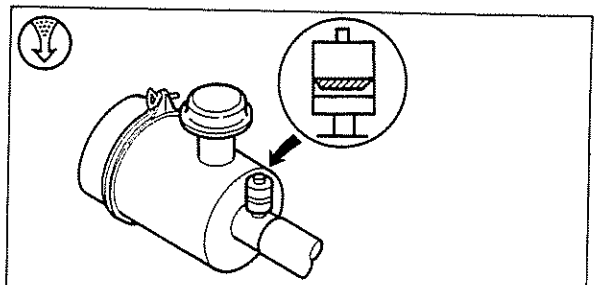
Check to be sure linkage moves smoothly without any sign of interference.

Fuel tank – Check oil level

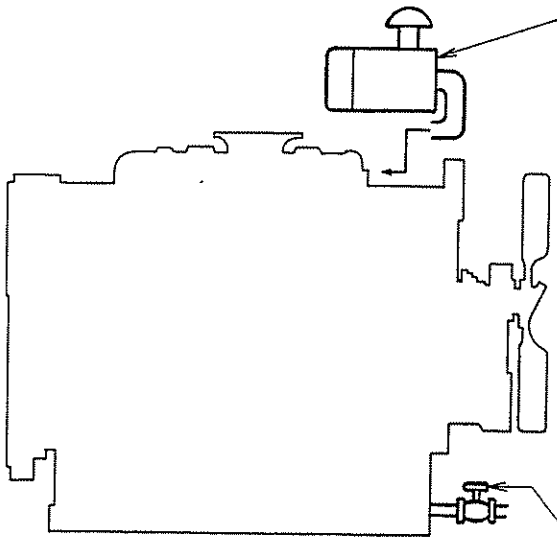


Be sure to fill at end of operating period.

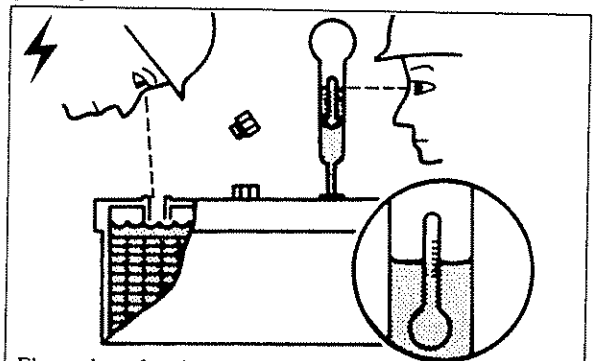
Air cleaner indicator (paper-element type) – Check



Clean element when indicator shows RED.

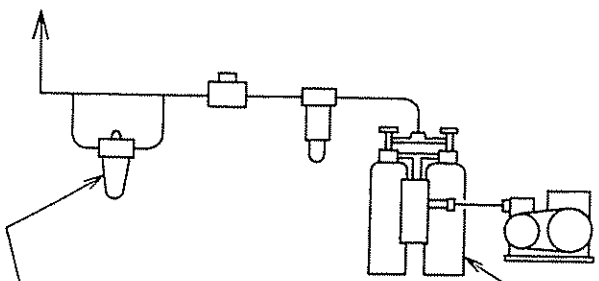


Battery – Check electrolyte level/specific gravity

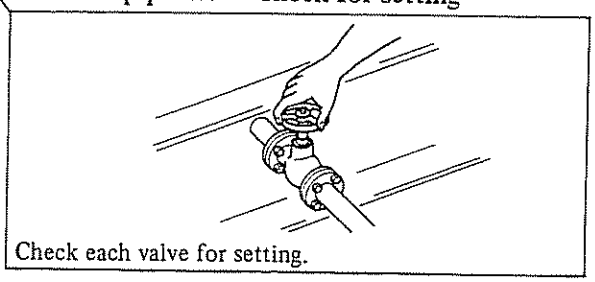


Electrolyte level should be 1 cm (3/8 in.) above cell plates.

Check specific gravity from time to time, and recharge before it drops to 1.20.

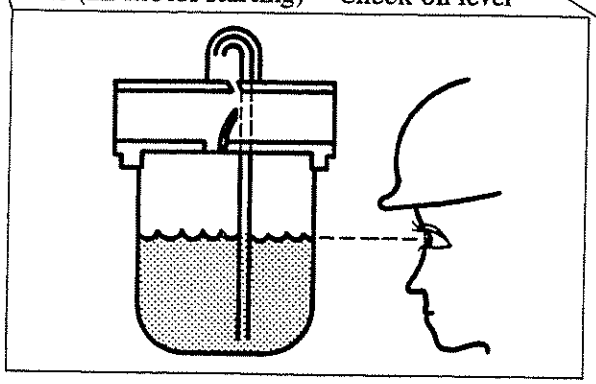


Valves in pipeline – Check for setting

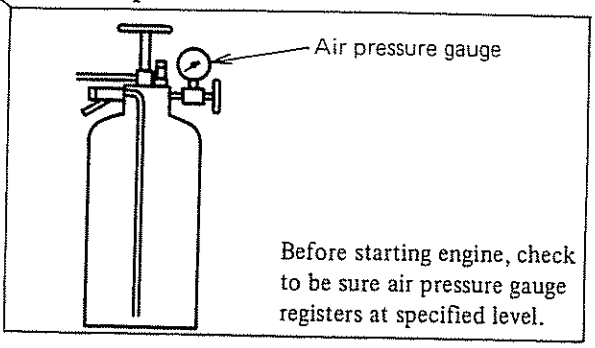


Check each valve for setting.

Oiler (air-motor starting) – Check oil level



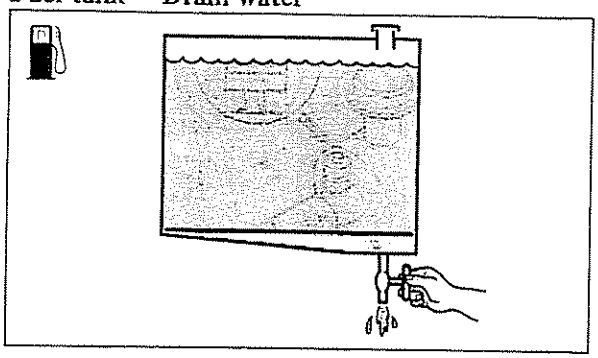
Air tank (air-motor/direct-air starting) – Check air pressure



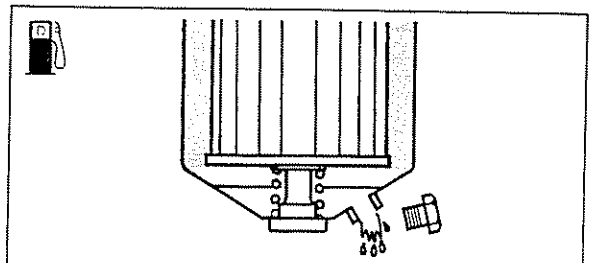
Before starting engine, check to be sure air pressure gauge registers at specified level.

EVERY 50 HOURS OR MONTHLY

Fuel tank – Drain water

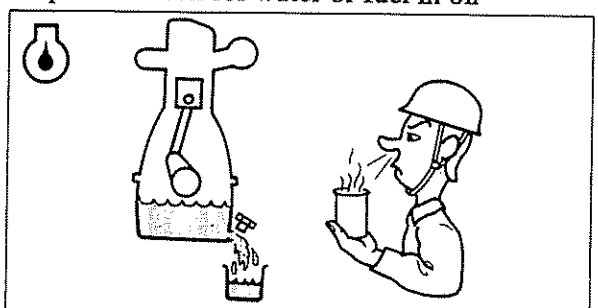


Fuel filter (paper-element/wire-element type) – Drain water

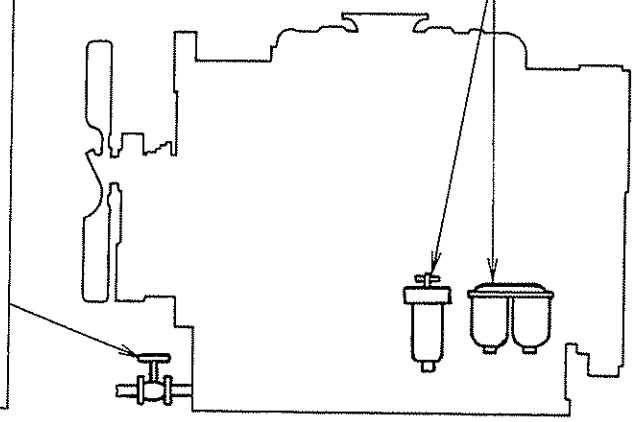


Before draining, close fuel supply cock.
After draining, prime filter.

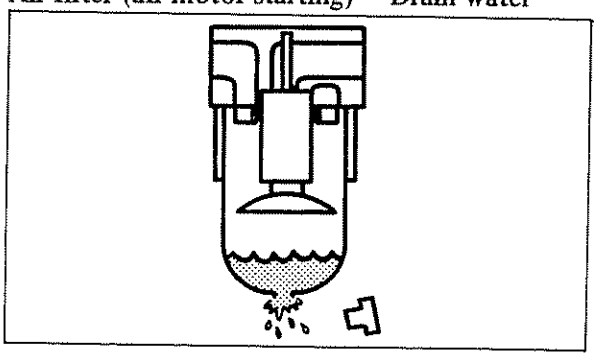
Oil pan – Check for water or fuel in oil

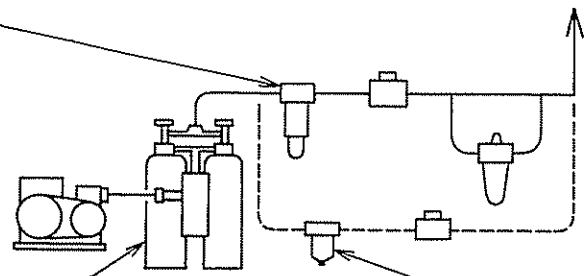


Catch a little of oil in a can, and smell or visually check for presence of fuel or water. Fuel smells as such if present. Water leakage is often evidenced by emulsified oil.

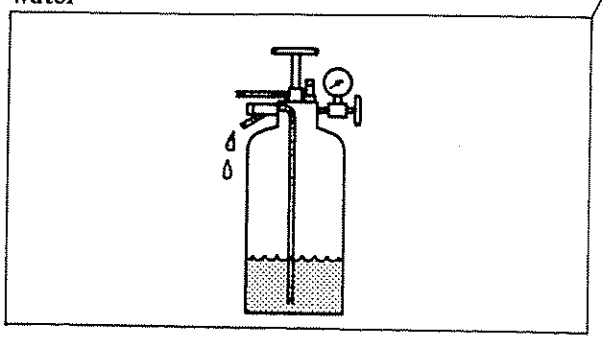


Air filter (air-motor starting) – Drain water

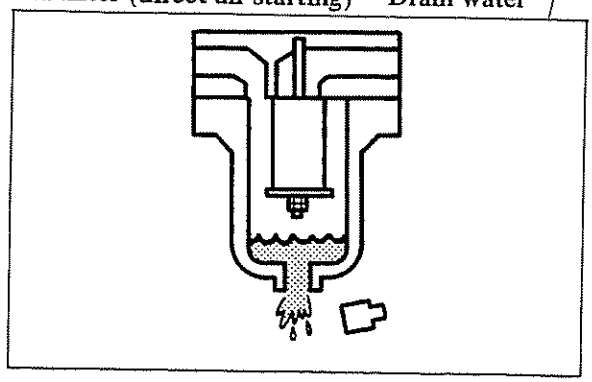




Air tank (air-motor/direct-air starting) – Drain water

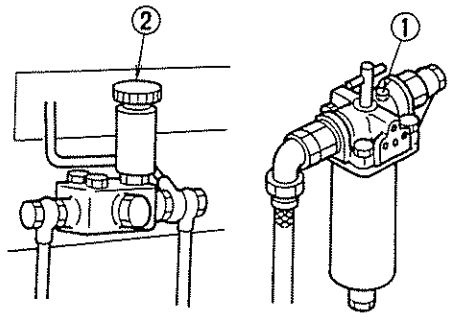


Air filter (direct-air starting) – Drain water



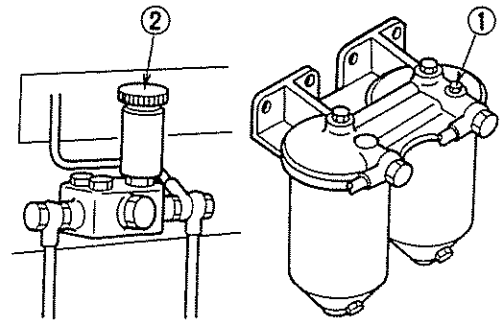
Priming the fuel system

- **Fuel filter (wire-element type)**

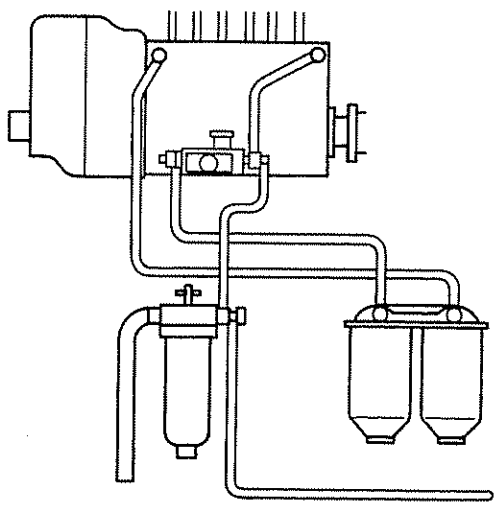


1. Loosen air vent plug (1) on fuel filter.
2. Unlock priming pump handle (2) by twisting it to left, and operate it.
3. Tighten air vent plug when flow of fuel at vent plug hole is free of air bubbles.

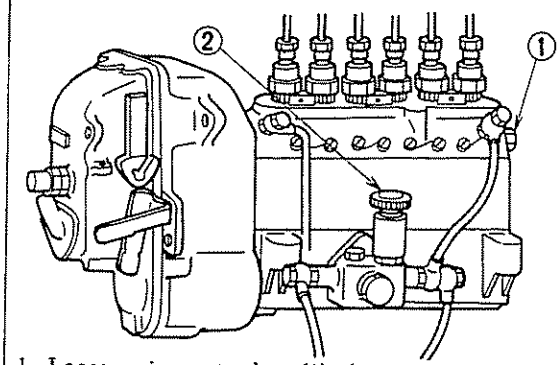
- **Fuel filter (paper-element type)**



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.



- **Fuel injection pump**



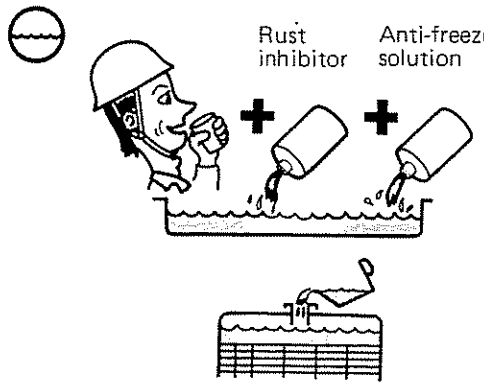
1. Loosen air vent plug (1) (on opposite side to governor).
2. Unlock priming pump handle (2) by twisting it to left, and operate it.
3. Stop priming when flow of fuel at vent plug hole is free of air bubbles.

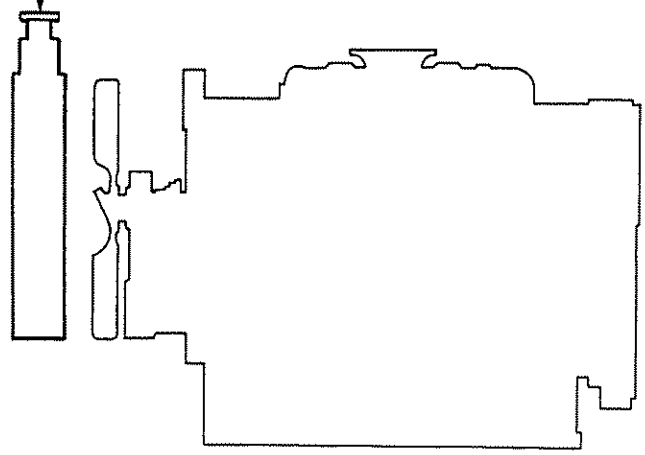
   Lock priming pump handle by twisting it to right while depressing it before tightening the last vent plug.

⚠ 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.

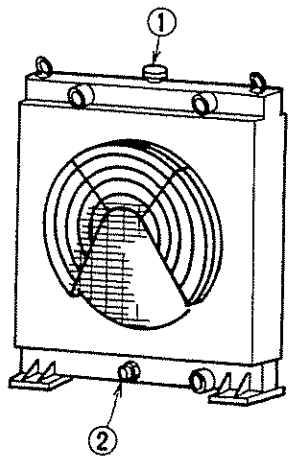
Changing the coolant (spring and autumn)

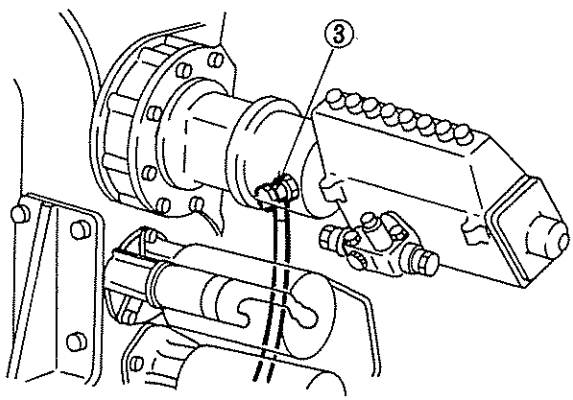




Normally, change coolant twice a year. Use only water that is soft or as free from scale forming minerals as possible. Use anti-freeze solution and rust inhibitor in advance (in autumn, for example) when temperature is expected to be below freezing in winter. After cold season, drain and flush cooling system and fill it with soft water and rust inhibitor.

When temperature is expected to be above freezing all the year around, change coolant once a year.





Procedure

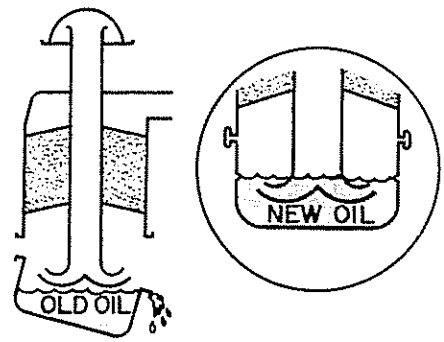
1. Start engine, and run it until water temperature is 75° ~ 85°C (167° ~ 185°F).
2. Raise lever at radiator filler cap (1) to relieve pressure, and remove cap.
3. Open drain cock (2) (radiator) and drain cock (3) (engine), and drain coolant.
4. Close drain cocks, and fill cooling system with flushing solvent (which will not attack rubber and metal). Run engine at 800 ~ 900 rpm for about 15 minutes, and drain.
5. Stop engine, and drain flushing solution. Rinse system with clean water until draining water is clean. Run engine at 800 ~ 900 rpm for about 10 minutes for this rinsing.
6. Close drain cocks, and fill system with soft water up to level.

⚠ CAUTION

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

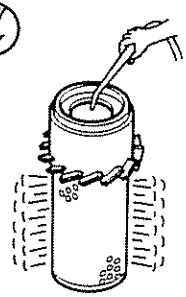
EVERY 250 HOURS OR 1 YEAR

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



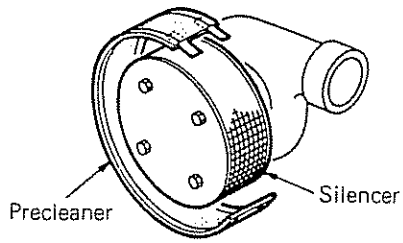
Drain old oil, wash element with diesel fuel, and refill with new oil up to level.

Air cleaner (paper-element type) – Clean

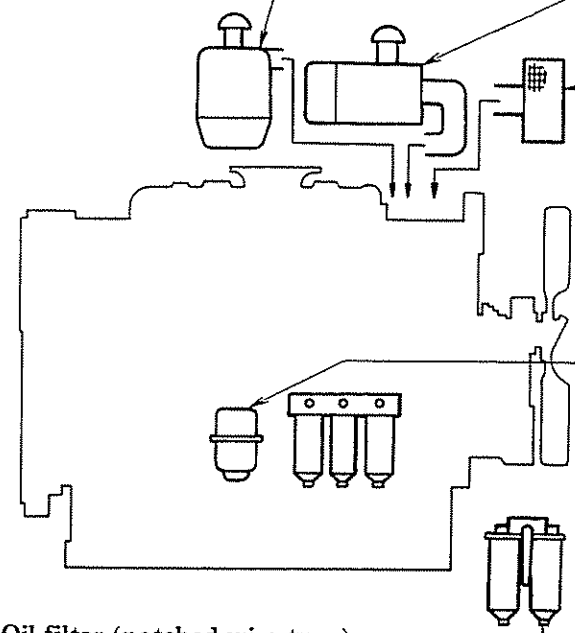


Use pressure air – 7 kgf/cm² (99.5 psi) maximum. Insert light inside clean, dry element and check. Replace element if pinholes or tears are found. Clean air cleaner case.

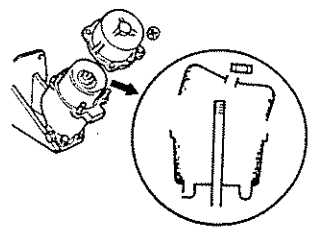
Air cleaner (silencer type) – Clean



Remove precleaner, and wash it with neutral cleaning solvent.



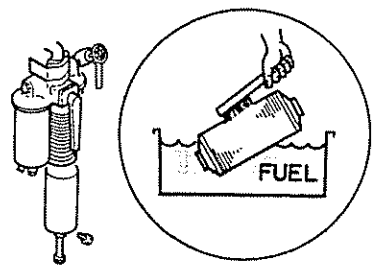
Bypass oil filter – Wash



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

Oil filter (notched-wire type) – Wash element

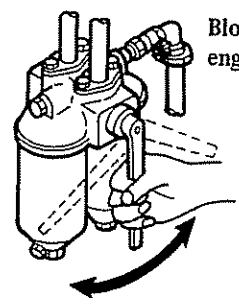
Remove and wash (with engine stopped)



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

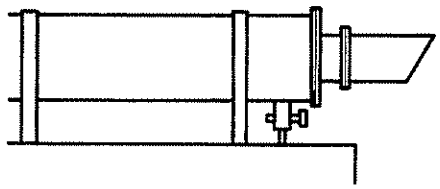
Wash element in diesel fuel by using a soft brush.

Blow-off (with engine running)

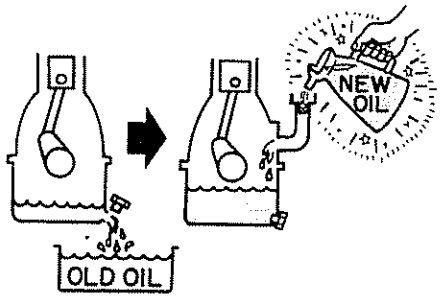


Clean by flowing oil in reverse direction (blowing off) during operation. Turn handle to blow-off position for 2 ~ 3 seconds on each side, 2 ~ 3 times.

Exhaust muffler – Drain water

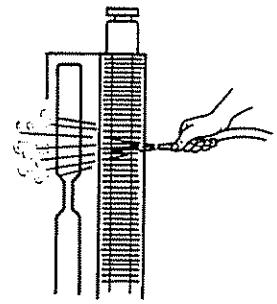


Oil pan – Change oil

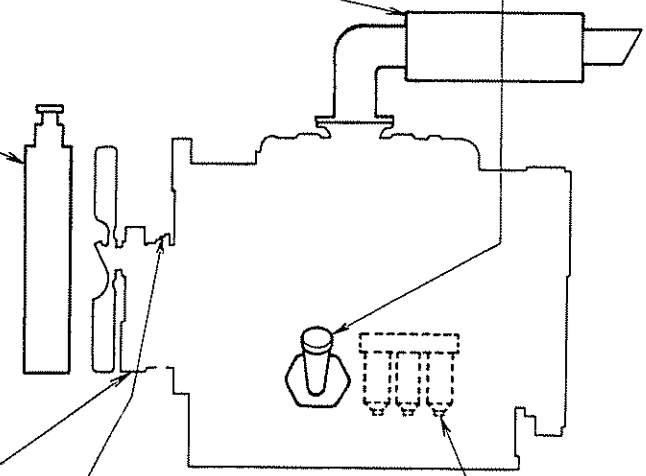


Drain out oil when engine is still hot after operation. Use engine oil of API service classification "CD" (for high-speed, high-load, turbocharged diesel engines).

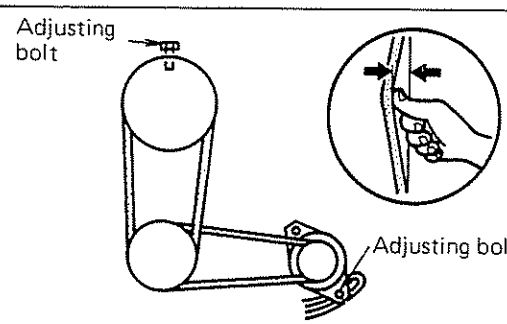
Radiator fins – Clean



Direct pressure air in direction opposite to air flow.

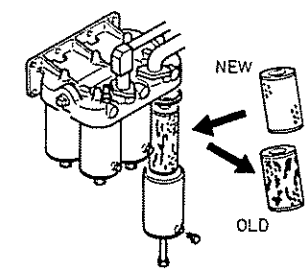


Fan/alternator drive belts – Check tension



Push belt inward between pulleys with a thumb. Belt should deflect 20 ~ 25 mm (3/4 ~ 1 in.).
Adjust tension with adjusting bolt, each.

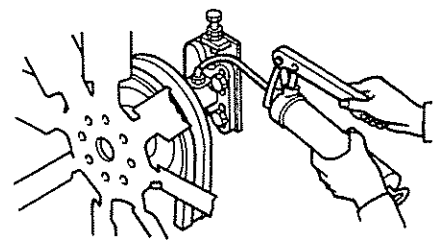
Oil filter (paper-element type) – Change element



Check for metal particles collected on it. If such particles are found, consult your Mitsubishi dealer for seizure or abnormal wear of moving parts.

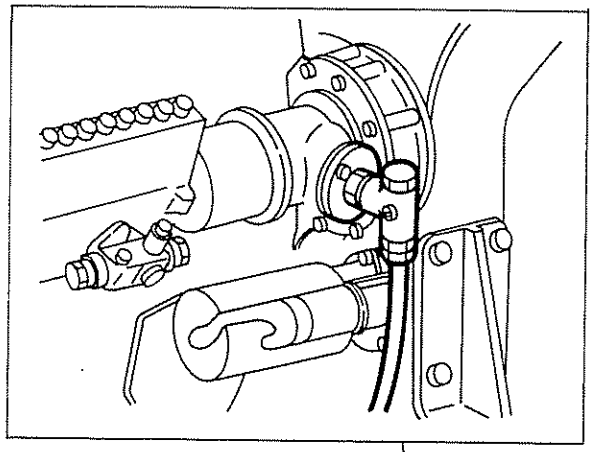
Do not reuse element by washing.

Fan drive (grease-lubricated type) – Lubricate

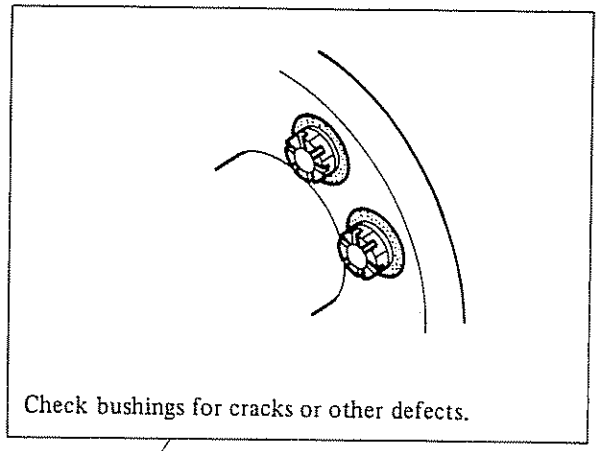


Clean grease fitting, and lubricate fitting with a grease gun.

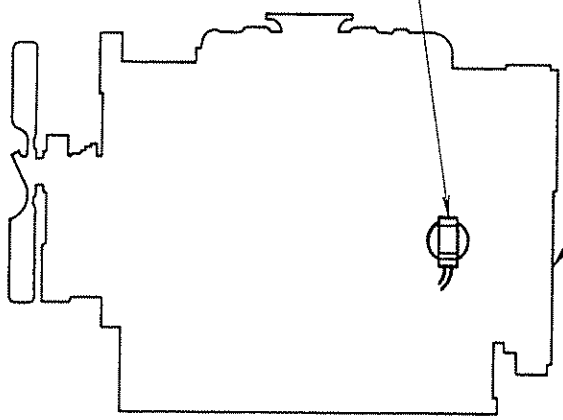
Tachometer drive L joint – Lubricate

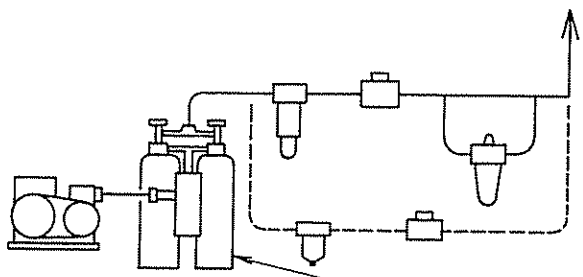


Coupling (rubber-bushing type) – Check

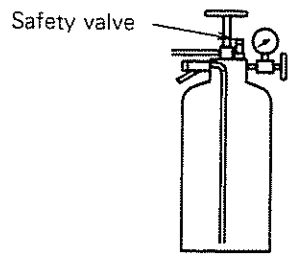


Check bushings for cracks or other defects.





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

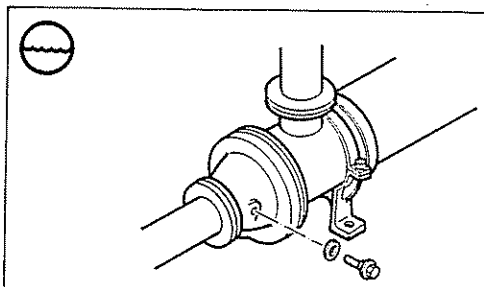


Make sure that safety valve opens when air pressure rises higher than limit.

Air motor: 9.9 kgf/cm^2 (141 psi)
Direct air starting: 33 kgf/cm^2 (469 psi)

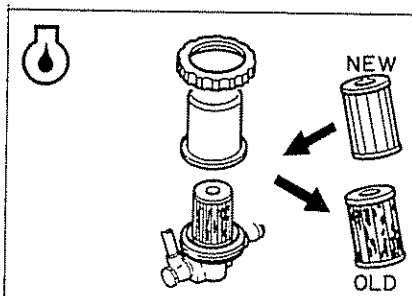
EVERY 500 HOURS OR 2 YEARS

Zinc rods (sea-water cooling) – Change

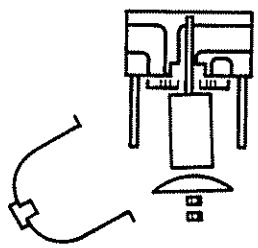


Change zinc rods of heat exchanger, air coolers, etc.

Governor oil filter (Woodward type) – Change element

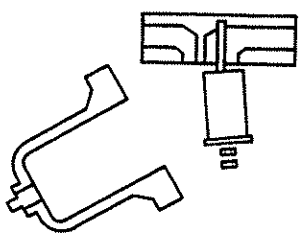


Air filter (air-motor starting) – Wash element



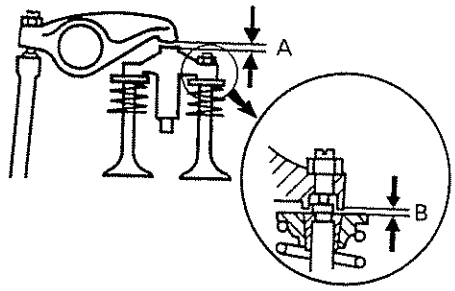
Wash element with diesel fuel.

Air filter (direct-air starting) – Wash element



Wash element with diesel fuel.

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



Check valve clearance in order shown below. Turn crankshaft by fitting turning gear (optional) to crankshaft pulley or rotating turning gear with a wrench.

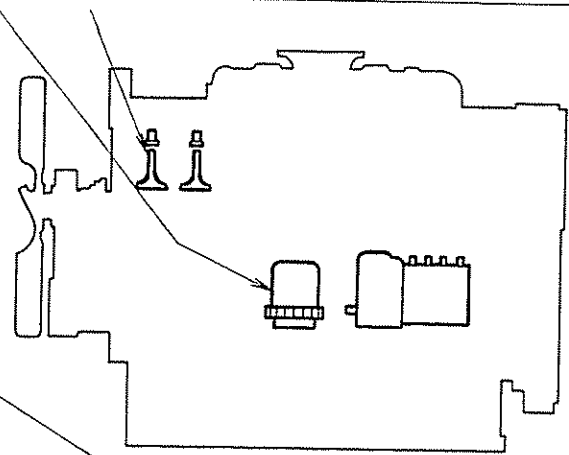
Inspection order

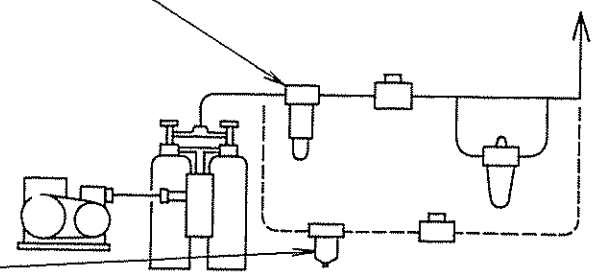
S12N	1-12-5-8-3-10-6-7-2-11-4-9
S16N	1-9-6-14-2-10-4-12-8-16-3-11-7-15-5-13

Unit: mm (in.)

	Valve clearance (A)		Bridge-to-retainer clearance (B)
	Cold	Hot	
Inlet & exhaust	0.25 (0.010)	0.2 (0.008)	0.5 (0.020), min.

Adjust clearance if necessary.





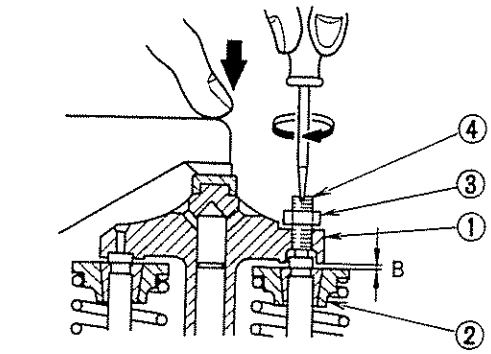
Valve clearance – Adjust (EVERY 1000 HOURS OR 3 YEARS)

Bridges and valve retainers – adjust

1. Before adjusting valve clearance, check and adjust clearance (B) between bridge (1) and valve retainer (2). If valve seat is worn, this clearance changes, resulting in maladjusted valve clearance.
2. To adjust, loosen lock nut (3), and turn out adjusting screw (4).
3. Hold rocker arm with finger, and slowly turn in adjusting screw (4) until it touches valve stem top. From this position, further turn it in about 10 degrees, and tighten lock nut to secure adjusting screw.

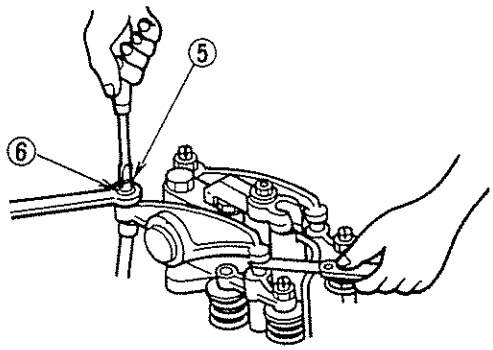
NOTE

Be sure to adjust clearance (B) as prescribed. If it reaches less than 0.5 mm (0.020 in.), valve cotter 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, turn adjusting screw (5) in either direction to adjust valve clearance.
3. After adjusting, tighten lock nut (6) to secure adjusting screw (5).

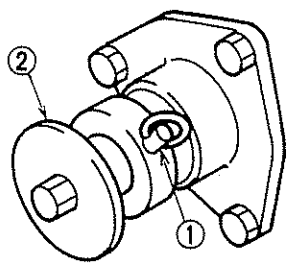


How to use turning gear (optional)

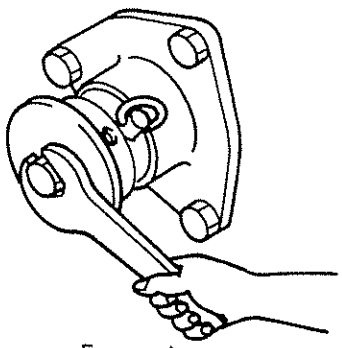
1. Remove eye bolt (1).
2. Push shaft (2) all the way, and insert eye bolt into pin hole in case.
3. Grip hexagonal end of shaft with a wrench, and crank engine.
4. After cranking engine, remove eye bolt and, after making sure that shaft returns, restore eye bolt to original position.

⚠ CAUTION

Be sure to return turning gear to original position when starting engine.



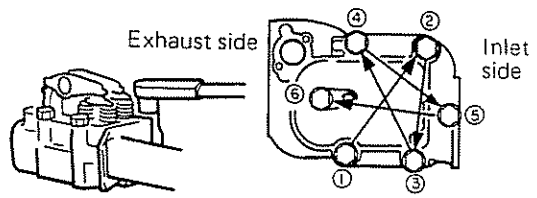
For operation



For turning

EVERY 1000 HOURS OR 3 YEARS

Bolts and nuts – Retighten

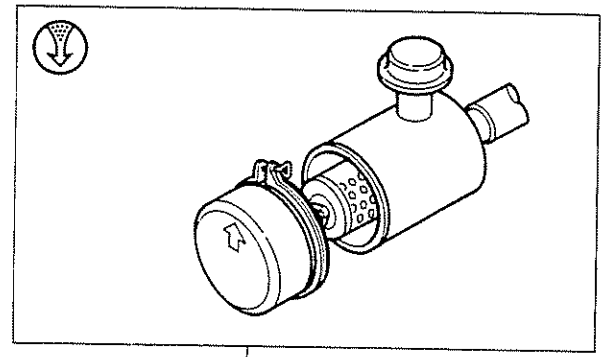


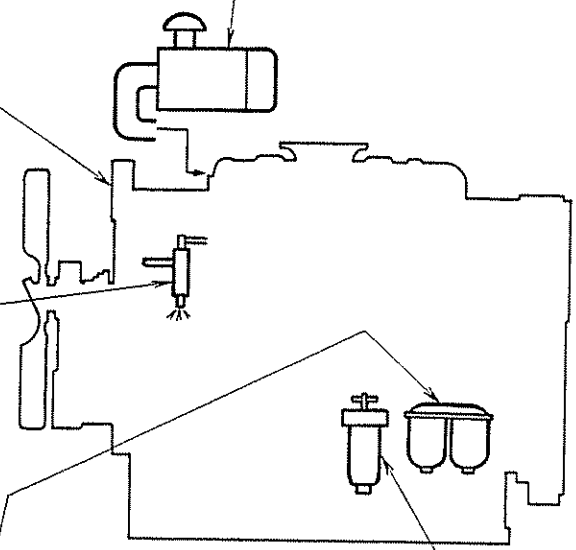
Retighten bolts and nuts on:

- Cylinder heads
- Timing gear case
- Crankshaft pulley
- Injection pump couplings and shafts
- Mounting brackets
- Exhaust manifolds
- Turbochargers

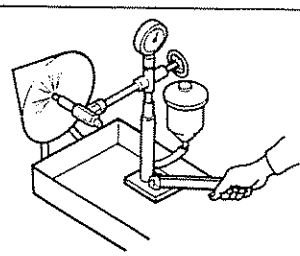
Retighten cylinder head bolts in sequence shown above.

Air cleaner (paper-element type) – Change element





Fuel injection nozzles – Check



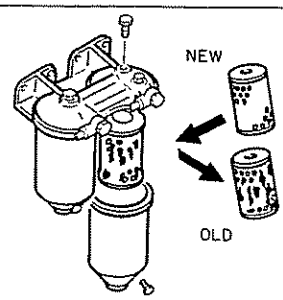
Standard injection pressure: 350 kgf/cm² (4977 psi)

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

NOTE

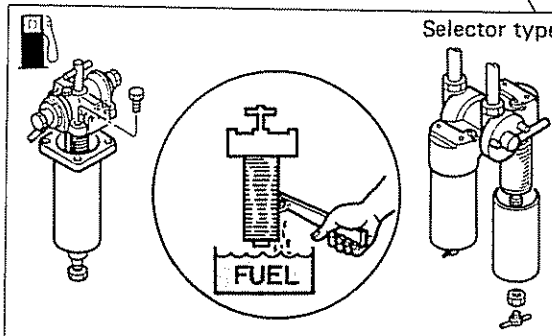
If exhaust smoke is abnormal, check nozzles for spray pattern. See Fuel Injection Nozzles – Check and adjust, page 38.

Fuel filter (paper-element type) – Change element



Do not reuse element by washing.

Fuel filter (wire-element type) – Wash element



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

Turn handle to side of element to be washed before removing case (selector type).

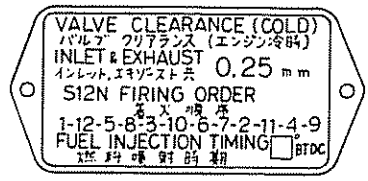
Injection timing – Check and adjust

To adjust injection timing, proceed as follows:

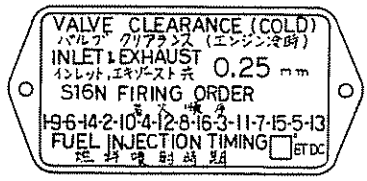
- Right-hand side injection pump

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

S12N



S16N



2. Using a turning bar or gripping turning gear (optional) with a wrench, turn crankshaft in normal direction (clockwise as viewed from front side), bringing timing pointer into alignment with 1.6 (S12N) or 1.8 (S16N) index number mark punched on damper. This crank position corresponds to top dead center on compression stroke in No. 1 cylinder.

NOTE

Be careful not to confuse No. 1 cylinder with No. 6 (S12N) or No. 8 (S16N). When No. 1 is in the above-mentioned position, its inlet and exhaust valves are both fully seated, presenting valve clearance.

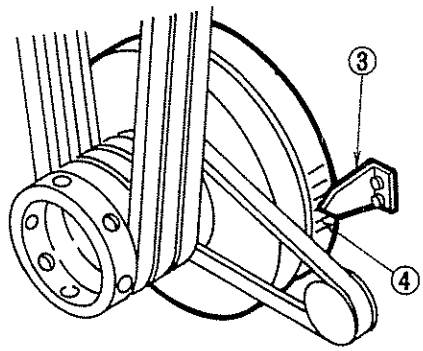
3. Turn back crankshaft about 60°, and turn it forward slowly until timing mark (2) on pump drive coupling aligns to pointer (1) on end face of pump case. In this position of crankshaft, read degrees of angle (injection timing) on scale (4) provided on damper, indicated by pointer (3). Minus (–) mark on scale (4) means BEFORE top dead center.

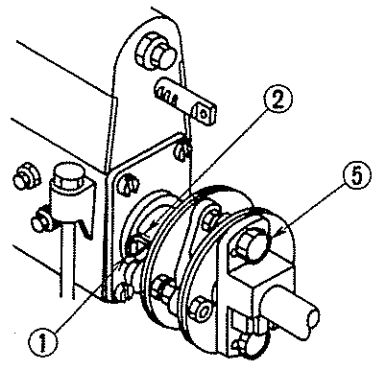
4. Injection timing specifications are as follows:

Model	S12N	S16N
BTDC	30°	34°

5. 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 on pump case with timing mark (2) on coupling. Then, tighten one bolt and, after turning crankshaft, tighten another. Again check injection timing by cranking engine.





- Left-hand side injection pump

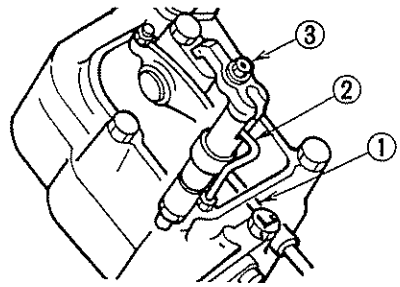
On left-hand injection pump, the position where pointer aligns to index number – 7, 12 (S12N) or 9, 16 (S16N) – on damper is top dead center on compression stroke of No. 7 (S12N) or No. 9 (S16N) cylinder. At this position, both inlet and exhaust valves of that cylinder must have clearance as specified. After this, follow procedure outlined for right-hand side injection pump.

★ The timing varies according to output, speed and specifications of the engine. Be sure to check the timing indicated on caution plate attached to No. 1 rocker cover when setting the timing on each engine.

Fuel injection nozzles – Check and adjust

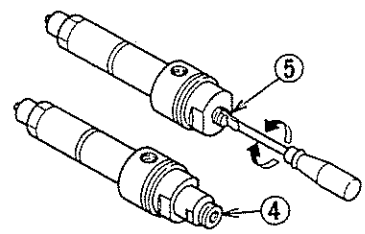
- Removal

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.



- Injection pressure adjustment

1. Mount injection nozzle in a tester. Push down tester lever gently to pressurize. See if fuel spray begins at 350 kgf/cm^2 (4977 psi).
2. Remove cap nut (4) on nozzle holder, and tighten or loosen adjusting screw (5). Tightening screw will increase pressure, and vice versa.



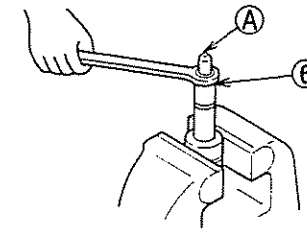
3. After adjusting, put back on cap nut (4) and tighten it to 4 ~ 5 kgf-m (29 ~ 36 lb-ft) [39 ~ 49 N·m].

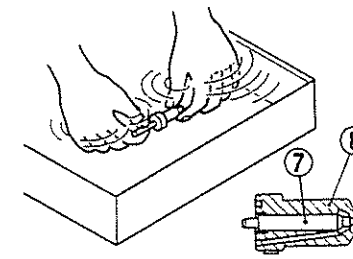
- Fuel spray pattern

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 noted to be poor, remove nozzle tip by loosening cap nut (6), and needle valve (7) and body (8).

NOTE

When taking out nozzle tip, be careful not to damage tip (A).





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

CAUTION

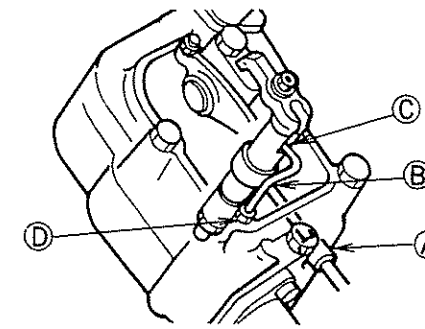
Needle valve and body are selectively fitted: never change this combination by replacing either part.

4. Tighten cap nut (6) to 18 ~ 20 kgf-m (130 ~ 145 lb-ft) [176 ~ 196 N·m].
5. If the foregoing adjustment and cleaning do not improve spray pattern, replace nozzle tip.

- Installation

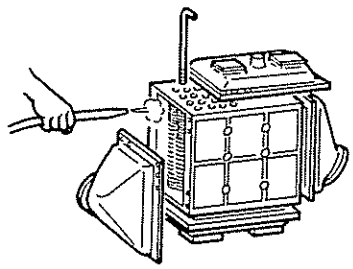
To install use reverse of removal procedure. After installing nozzle, check each fuel pipe joints for fuel leaks.

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.



EVERY 2000 HOURS OR 5 YEARS

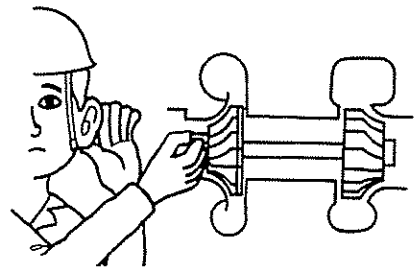
Air coolers – Clean



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

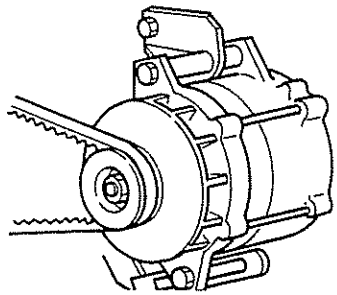
- Remove scale from inside of fresh-water or sea-water pipes by inserting a bar.

Turbochargers – Check



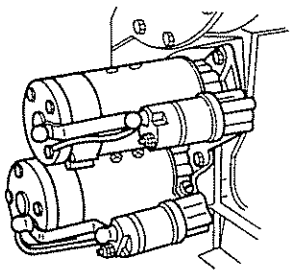
Turn compressor wheel by hand to listen for abnormal noise. If wheel is noisy, replace bearings.

Alternator – Check

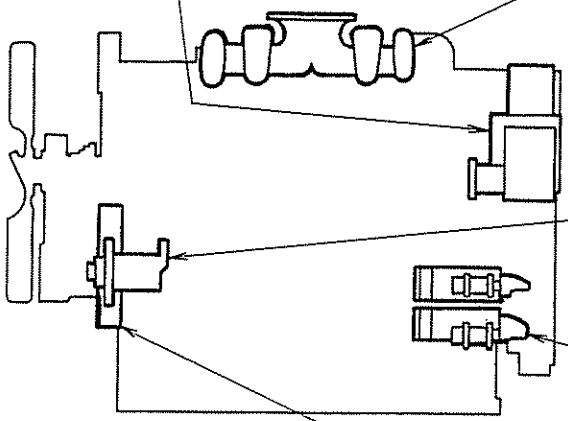


Visually check for any defects. Check for abnormal rotation.

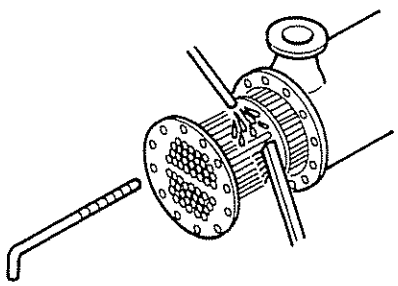
Starters – Check



Check for leaks of silicone oil or other defects.



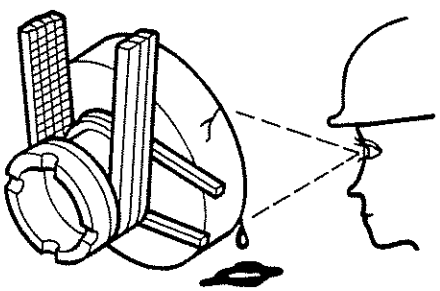
Heat exchanger – Wash



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

Remove scale from inside of pipes by inserting a bar.

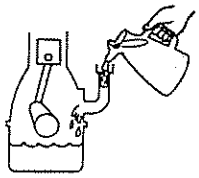
Vibration damper – Check



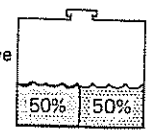
STORAGE

Preparation for storage extending over 3 months

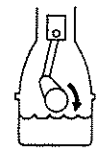
Drain out engine oil, and fill in anticorrosive oil such as "P-10."



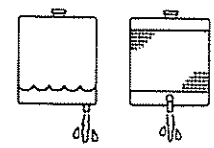
Use a mixture of "P-9" anticorrosive oil and fuel oil in 50-to-50 ratio.



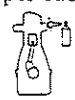
Run engine at 800 ~ 1000 rpm for 5 ~ 10 minutes under no-load condition.



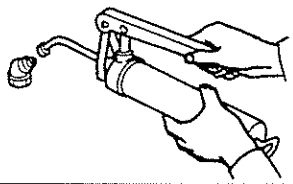
After stopping engine, drain out fuel and coolant.



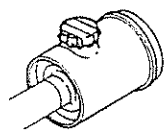
Put volatile anticorrosive compound in air inlet and exhaust system in amount of 3 ~ 5 g (0.1 ~ 0.2 oz) of the compound per cubic foot.



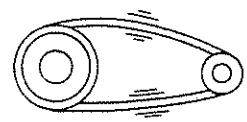
Apply grease to fitting or linkage for protection.



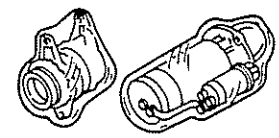
Cover up air cleaners, air inlet pipe, exhaust pipe, breather and turbocharger with adhesive tapes.



Loosen V-belts.

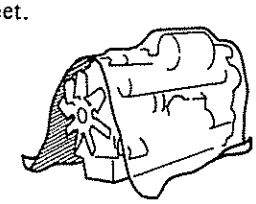


Cover up starter and alternator with polyethylene sheet.



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

Cover engine with an awning sheet.



⚠ CAUTION

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

NOTE

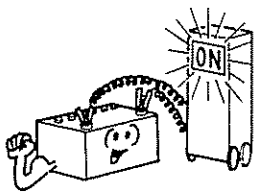
It is not necessary to change engine oil if storage period is shorter than 6 months.

Recommended anticorrosive oils

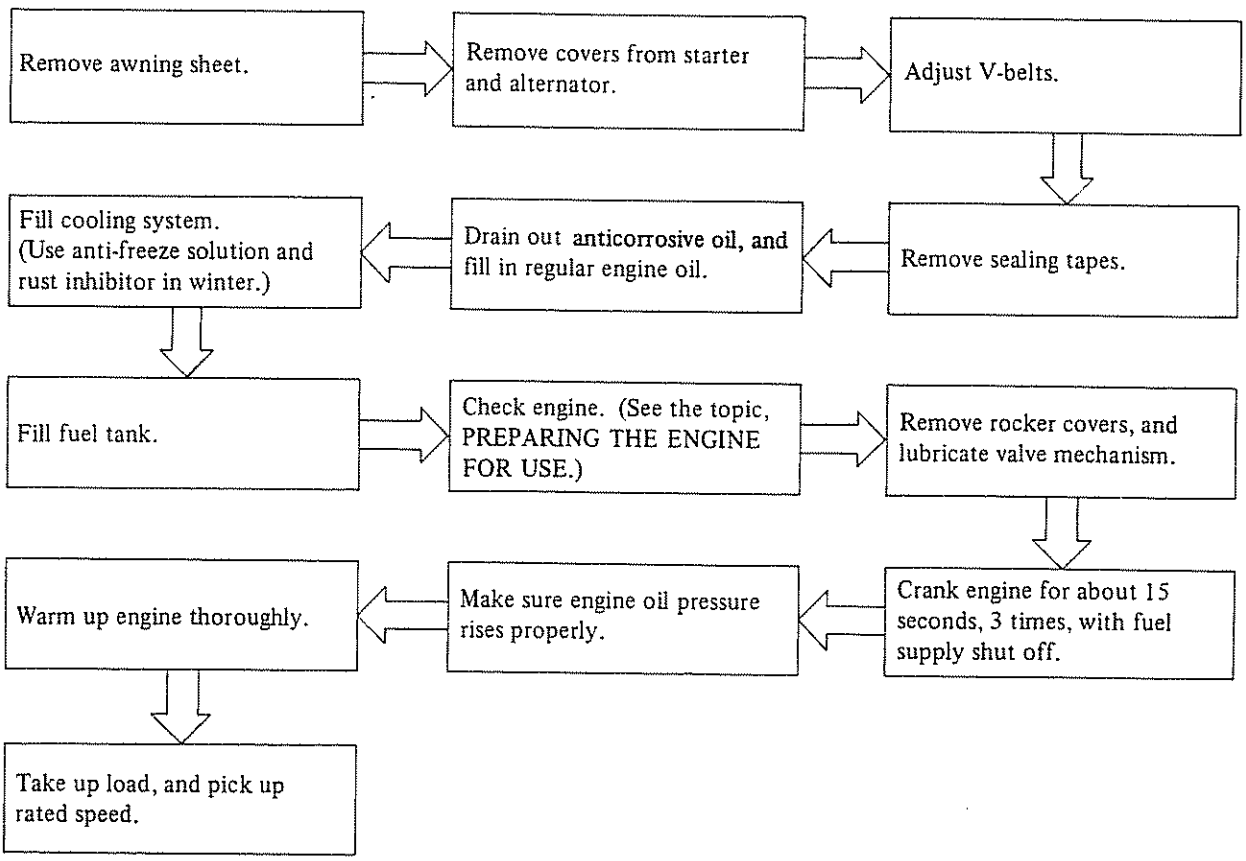
Specification	Brand name
P – 9	US Horton Rustbet Cosmolin
P – 10	US Horton Rustbet Cosmolin 1051, 1049

Service during storage

Recharge batteries at least once a month.



Placing engine in service after storage



DIESEL FUELS, COOLING WATER AND LUBRICANTS

DIESEL FUEL

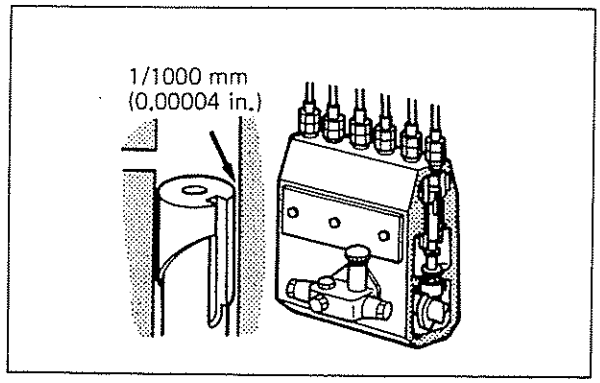
Mitsubishi diesel engines are designed to use diesel fuel oil meeting the requirements of JIS (Japanese Industrial Standard K2204). JIS K2204 diesel fuel oil nearly corresponds to Class 2-D fuel oil specified by ASTM (American Society for Testing and Materials) D975. For pour point, refer to the following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

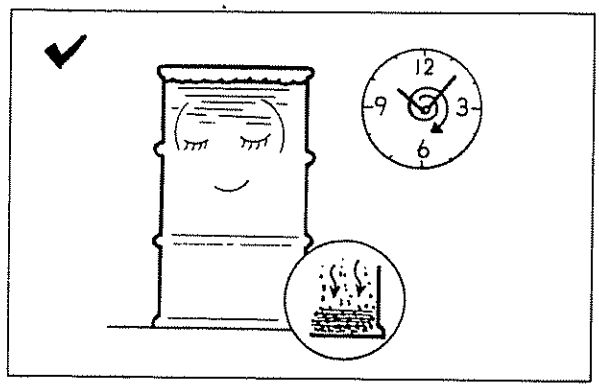
JIS K2204 diesel fuel oil	Above 10°C (50°F)	10~0°C (50~32°F)	0~-5°C (32~23°F)	-5~-15°C (23~5°F)	-15~-30°C (5~-22°F)
	No.1 special	No.1	No.2	No.3	No.3 special

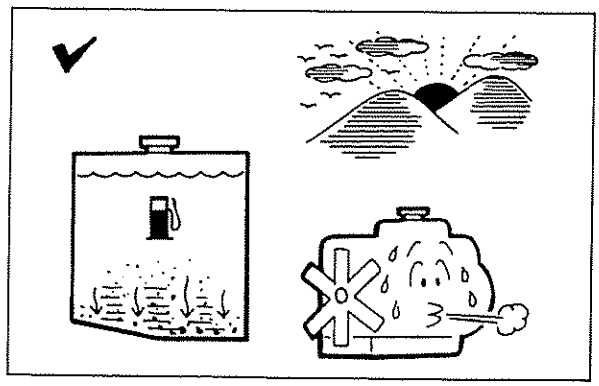
Too much emphasis cannot be placed on the importance of using only clean diesel fuel. The clearance between the plunger and barrel of fuel injection pump and that between needle valve and body of injection nozzle are very small. This makes it evident that invisible particles of dirt which might pass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

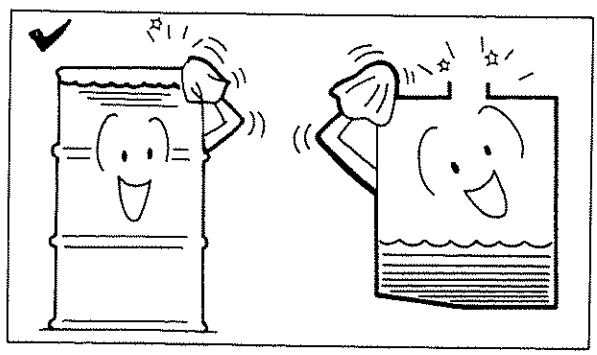
Care of the fuel supply

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.

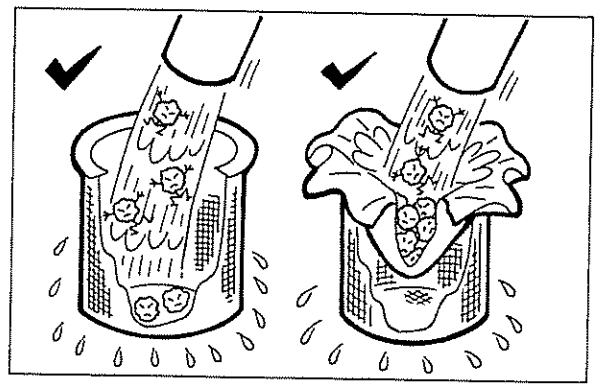




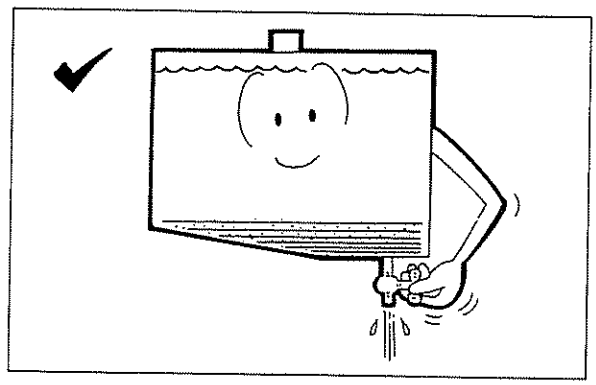




4. Be sure to pour fuel through strainer in the filler opening. Use of a lint-free cheese cloth is a good practice for keeping dirt out.

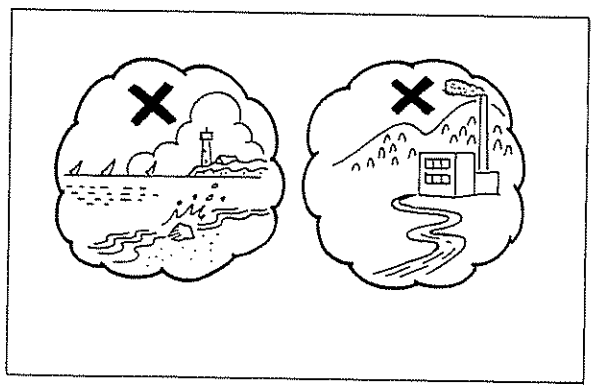


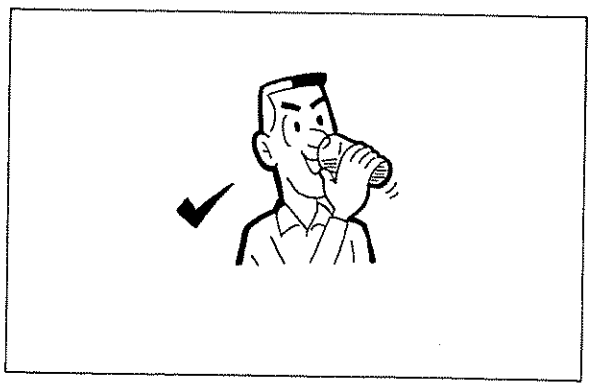
5. Occasionally, open the drain cock of the storage and diesel fuel tank to drain off any water or sediment that may have accumulated. Even clean top portion of fuel oil contains more or less dirt and water. Such dirt and water should be removed before they get inside the engine. This method of cleaning fuel oil is called "draining."



COOLING WATER

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.

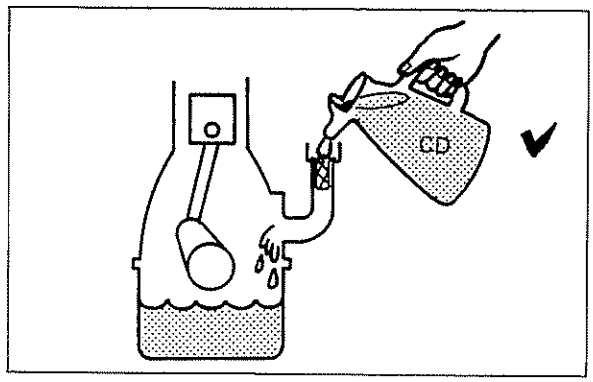




LUBRICANTS

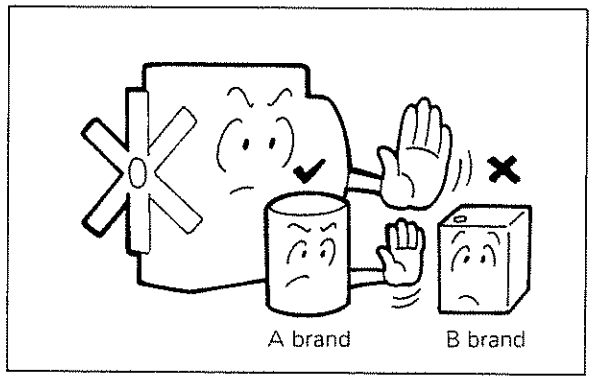
Engine oil

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.

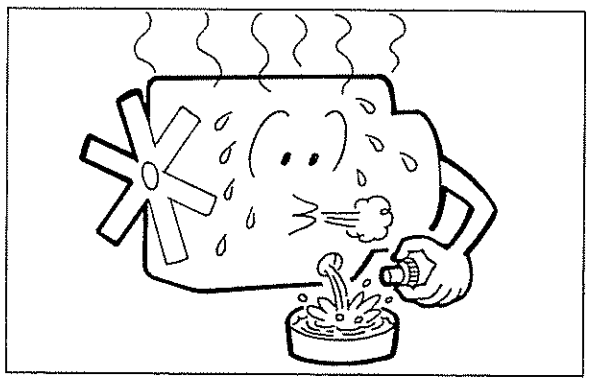


1. Be sure to use engine oil of the API (American Petroleum Institute) service classification "CD."

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. 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, it is recommended to idle the engine for about 5 minutes with a flushing oil in the oil pan and to refill with fresh oil upon draining the flushing oil.



Grease

Use clean multi-purpose grease for your engine.

NOTE

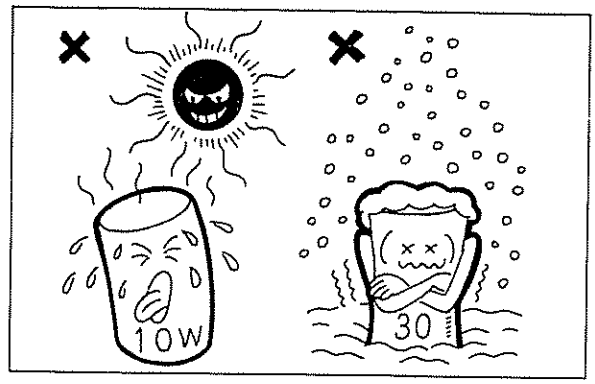
Cleanliness is important for handling the engine oil and grease. Use clean handling tools; wipe the filler cap, grease fittings and plugs clean; and handle them in a dust-free condition.

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 10W−30				SAE 30			SAE 40
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
Kyoseki	Kyodo 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
Shell	Shell Rimula Z Oil	10W, 20W/20, 30, 40, 50
Showa	White Parrot Super S-3	10W, 20W/20, 30, 40
Taikyo	Pioneer Diesel S-3	10W, 20, 30, 40

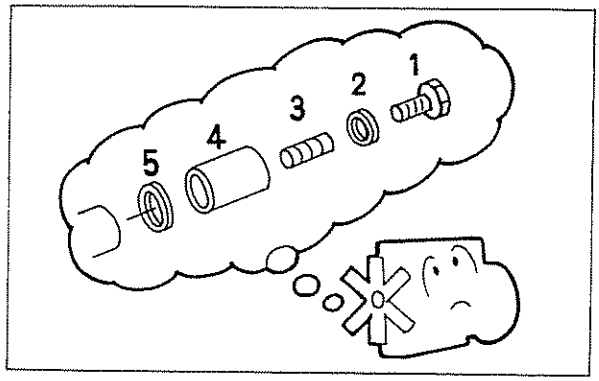
These recommended oils should be in API service classification "CD" and meet the requirements of MIL-L-2104C.

TROUBLESHOOTING

General instructions

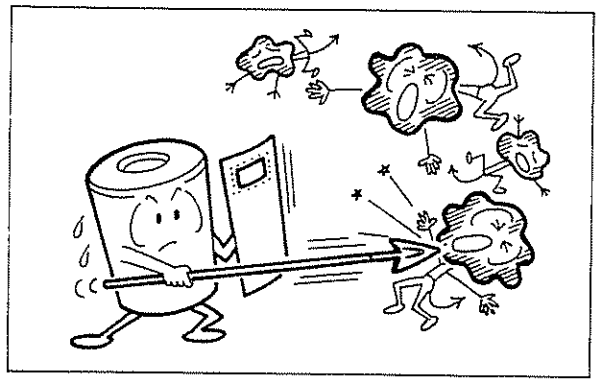
(1) Think before acting

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.



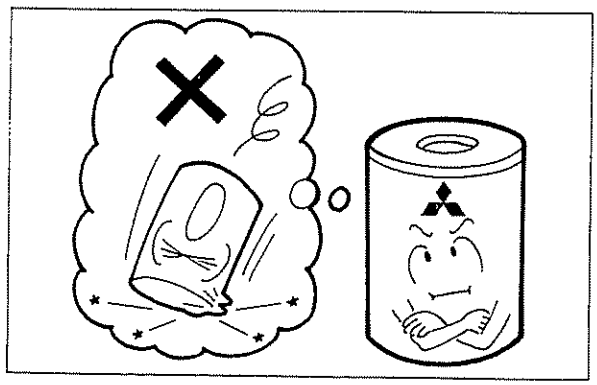
(2) Dust and dirt are often the ultimate causes.

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



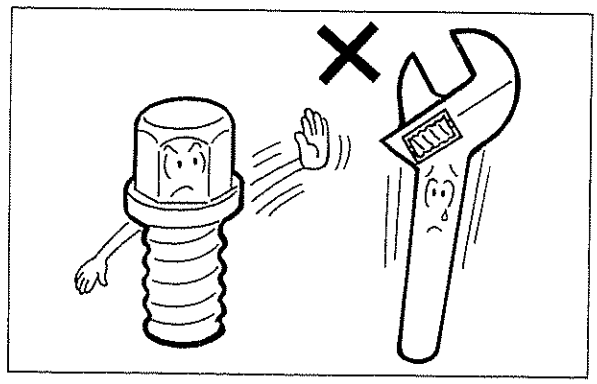
(3) Use genuine Mitsubishi parts.

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.

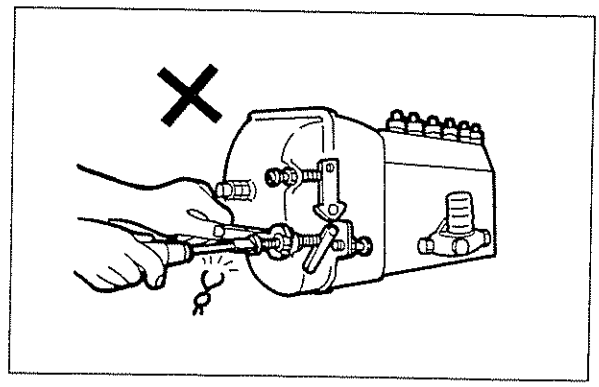
Use the right kind of hand tool to carry on each working step in repair work. Avoid injury to yourself and damage to the parts by using improper tool. When lifting or carrying a part too heavy for one person to handle, get another person's help and, if necessary, use a jack or a chain block to avoid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



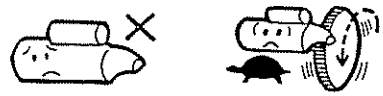
CAUTION

1) Never attempt to break the seals of the governor for maximum speed setting and maximum injection quantity setting.

2) 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.

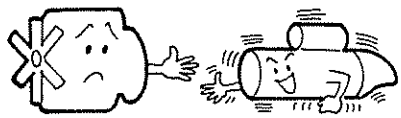


Electric-starting engine



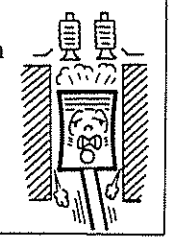
Starter will not crank engine or cranks slowly, resulting in a failure of engine to start

- 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
  - → Starter, 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



Starter will crank engine, but engine will not start

- Fuel system → Fuel tank
  - O.K. → Electrical system → Battery specific gravity low
    - Recharge
    - Adjust alternator drive belt
    - Circuit defective → Repair or replace
  - Empty → Refuel
    - *Fuel leaks from pipe connection → Consult Mitsubishi dealer
  - Filled
    - Wrong type of fuel → Refill with correct type of fuel
    - Dirt or water in fuel → Remove dirt or drain
    - Fuel filter clogged → Clean (wire-element type) Change (paper-element type)
    - Fuel pipe clogged or leaky → Clean or repair
    - *Injection pump defective → Consult Mitsubishi dealer
- O.K. → Air inlet system → Air cleaner clogged → Clean element → Change element
- O.K. → Engine proper
  - * Compression pressure low
  - * Cylinders, pistons and piston rings worn
  - * Valve springs broken



→ Consult Mitsubishi dealer

Air-starting engines

- **Air-motor starting**

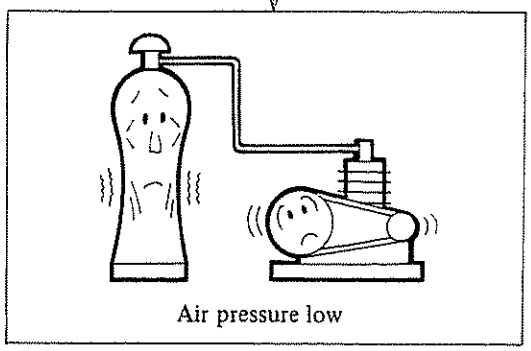
Starter will not crank engine

- 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



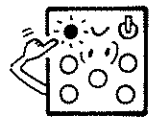
Air pressure low → Run air compressor to increase air pressure

- **Direct-air starting**

Engine will not crank

- 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 	◦ Incorrect grade of oil	◦ Use recommended type and SAE number of oil.
	◦ Wrong type of fuel	◦ Change.
	◦ Air cleaner clogged	◦ Clean or change element.
	◦ Engine overcooled	◦ Use radiator cover, or clean, test and replace thermostat.
	◦ Engine overheating	◦ Check coolant level, adding water if necessary.
	◦ Valve clearance incorrect	◦ Readjust.
	◦ Injection pump defective	◦ *Readjust or replace.
	◦ Injection nozzles defective	◦ *Readjust or replace.
	◦ Injection timing incorrect	◦ *Retime.
	◦ Poor compression pressure (due to worn cylinders and pistons)	◦ *Overhaul.
White or blue exhaust smoke 	◦ 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.
	◦ Injection timing incorrect	◦ *Retime.
	◦ Poor compression pressure	◦ *Overhaul.
Black or gray exhaust smoke 	◦ Wrong type of fuel	◦ Refill with correct type of fuel
	◦ Valve clearance incorrect	◦ Readjust.
	◦ Injection pump defective	◦ *Readjust or replace.
	◦ Compression pressure low	◦ *Overhaul.
	◦ Insufficient air (air cleaner clogged)	◦ Clean or change element.
High fuel consumption 	◦ Injection pump defective	◦ *Readjust or replace.
	◦ Injection nozzles defective	◦ *Readjust or replace.
	◦ Injection timing incorrect	◦ *Retime.
	◦ Wrong type of fuel	◦ Refill with correct type of fuel.
	◦ Compression pressure low	◦ *Overhaul.
	◦ Insufficient air	◦ Clean or change air cleaner element. Check turbocharger.
High oil consumption 	◦ Too high oil level in crankcase	◦ Maintain oil level between marks on gauge.
	◦ Incorrect grade of oil	◦ Use recommended type and SAE number of oil.
	◦ Oil leaks	◦ Locate and repair.
	◦ Cylinders and piston rings worn	◦ *Replace.

Complaint	Possible causes	Remedy
Engine overheats 	◦ Fan belt loose ◦ Lack of coolant ◦ Too low oil level ◦ Water pump defective ◦ Thermostat defective	◦ Readjust. ◦ Refill. ◦ Maintain oil level between marks on gauge. ◦ *Replace. ◦ *Replace.
Low oil pressure (Oil pressure alarm lamp glows) 	◦ Lack of oil ◦ Oil viscosity too low ◦ Oil filter clogged ◦ Oil pump defective ◦ Oil pressure regulating valve defective	◦ Refill up to level. ◦ Refill with correct viscosity of oil. ◦ Replace element. ◦ *Readjust or replace. ◦ *Readjust or replace.

NOTE

Most of the possible causes listed in the troubleshooting procedures can be coped with by the user; but those marked with asterisk (*) demand specialized skill and equipment which are usually not available in the user's outfit. An example is an injection pump in trouble; if the cause of trouble is ascertained to be in this pump, the remedial job should be farmed out to the Mitsubishi-authorized service shop through the dealer or distributor. As a matter of general policy, the user is advised to consult your dealer or distributor for the job involved in remedying a cause indicated by an asterisk (*).

When communicating with your dealer or distributor in regard to replacement part supply or any other services, be sure to cite the model designation, serial number and hour meter reading of your engine.

SPECIFICATIONS

Model designation		S12N			S16N		
		T	TA	TK	T	TA	TK
Type		Water-cooled, 4-stroke cycle, turbocharged					
			With after-cooler	With inter-cooler		With after-cooler	With inter-cooler
No. of cylinders — arrangement		12 – V			16 – V		
Bore X stroke		160 mm X 180 mm (6.299 in. X 7.087 in.)					
Piston displacement		43.4 liters (2650 cu in.)			57.9 liters (3533 cu in.)		
Fuel injection system		Direct-injection					
Compression ratio		13.5 : 1					
Firing order		1–12–5–8–3–10–6–7–2–11–4–9			1–9–6–14–2–10–4–12–8–16–3–11–7–15–5–13		
Rotation		Counterclockwise as viewed from flywheel side					
Dimensions	Length	2241 mm (88.2 in.)	2433 mm (95.8 in.) with fan	2262 mm (89.1 in.)	2771 mm (109.1 in.)	3186 mm (125.4 in.) with fan	2864 mm (112.8 in.)
	Width	1406 mm (55.4 in.)				1524 mm (60.0 in.)	1406 mm (55.4 in.)
	Height	1804 mm (71.0 in.)					
Dry weight		4550 kg (10033 lb)	4800 kg (10584 lb)	4700 kg (10364 lb)	5750 kg (12679 lb)	6050 kg (13340 lb)	5900 kg (13010 lb)
Fuel system	Fuel	Diesel fuel oil – light or heavy A					
	Injection pump	Bosch Z type					
	Governor	Mechanical or hydraulic					
	Filter	Wire-element type or paper-element type					
	Injection nozzles	Hole type					
	Injection pressure	350 kgf/cm² (4977psi)					
Lubrication system	Type	Pressure feed by gear pump					
	Oil	API CD class					
	Capacity (engine)	220 liters (58.1 U.S. gal)			290 liters (76.6 U.S. gal)		
	Oil filter	Paper-element or notched-wire type and centrifugal type					
	Oil cooler	Fresh water-cooled multi-tube type					
Cooling system	Type	Fresh water-cooling					
	Capacity (engine)	170 liters (44.9 U.S.gal)	190 liters (50.2 U.S.gal)	190 liters (50.2 U.S.gal)	220 liters (58.1 U.S.gal)	250 liters (66 U.S. gal)	250 liters (66 U.S. gal)
	Water pump	Centrifugal type					
Starter		Electric starter (24 V, 7.5 kW X 2) or air starter (air motor or direct air)					
Alternator		24 V, 25 A					
Turbocharger		5MF X 2			TC15 X 2 or 5MF X 2		

TIGHTENING TORQUE

Important bolts and nuts

Torque values shown in [ ] are for early type.

Parts attached	Thread Diam. – Pitch mm (in.)	Width across flats mm (in.)	Standard torque			Remarks
			kgf-m	lb-ft	N·m	
Cylinder heads	20 – 2.5 (0.79 – 0.098)	30 (1.18)	38	275	372	Apply oil to threads
Rocker shaft brackets	14 – 2.0 (0.55 – 0.079)	22 (0.87)	8	58	78	
Main bearing caps	22 – 2.5 (0.87 – 0.098)	32 (1.26)	50	360	490	Apply oil to threads
Timing gear case	16 – 1.5 (0.63 – 0.059)	24 (0.94)	15.8	114	155	
	12 – 1.75 (0.47 – 0.069)	17 (0.67)	6	43	59	
Oil pan	12 – 1.75 (0.47 – 0.069)	17 (0.67)	5	36	49	
Mounting brackets (rear)	20 – 2.5 (0.79 – 0.098)	30 (1.18)	30	220	294	
Mounting brackets (front, center)	20 – 1.5 (0.79 – 0.059)	30 (1.18)	48	347	470	
Connecting rod bearing caps	20 – 1.5 (0.79 – 0.059)	30 (1.18)	40	290	392	Apply oil to threads
Crankshaft pulley, damper	22 – 1.5 (0.87 – 0.059)	32 (1.26)	30	220	294	
Flywheel	22 – 1.5 (0.87 – 0.059)	32 (1.26)	60	435	588	Apply oil to threads
Idler gears	10 – 1.25 (0.39 – 0.049)	14 (0.55)	3	22	29	
Camshaft gears	42 – 1.5 (1.65 – 0.059)	65 (2.56)	60	435	588	
Injection pump gears	24 – 1.5 (0.94 – 0.059)	36 (1.42)	30	220	294	
	[30 – 1.5 (1.18 – 0.059)]	[46 (1.81)]	[40]	[290]	[392]	
Idler shafts	12 – 1.75 (0.47 – 0.069)	17 (0.67)	55	400	539	
Oil pump gear	27 – 1.5 (1.06 – 0.059)	41 (1.61)	30	220	294	
Water pump gear	20 – 1.5 (0.79 – 0.059)	30 (1.18)	20	145	196	
Water pump impeller	22 – 1.5 (0.87 – 0.059)	32 (1.26)	20	145	196	
Injection pump couplings	10 – 1.5 (0.39 – 0.059)	17 (0.67)	6 ~ 6.5	44 ~ 47	59 ~ 64	
Injection pump coupling shafts	12 – 1.75 (0.47 – 0.069)	19 (0.75)	7.5 ~ 8.5	55 ~ 60	74 ~ 83	

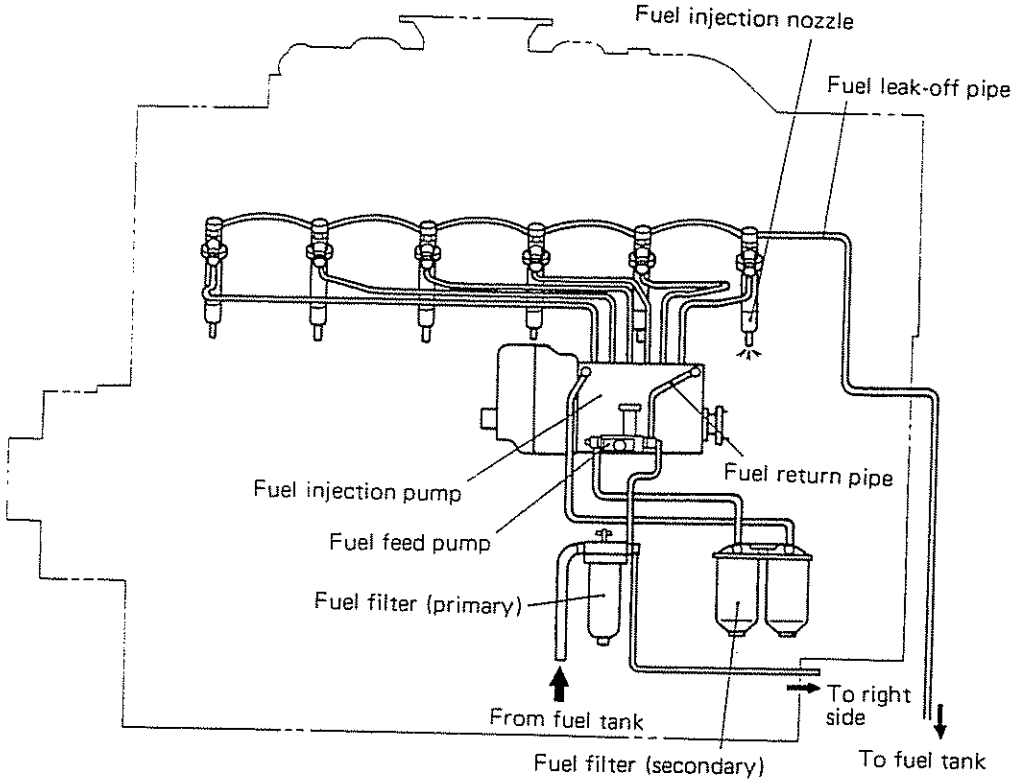
Parts attached	Thread Diam. – Pitch mm (in.)	Width across flats mm (in.)	Standard torque			Remarks
			kgf-m	lb-ft	N·m	
Injection nozzle inlet connectors	16 – 1.5 (0.63 – 0.059)	17 (0.67)	6.5 ~ 7.5	47 ~ 55	64 ~ 74	
Glands (nozzle holders)	14 – 1.5 (0.55 – 0.059)	22 (0.86)	10	70	98	
Nozzle holder set screw cap nuts	14 – 1.5 (0.55 – 0.059)	22 (0.86)	4 ~ 5	29 ~ 36	39 ~ 49	
Nozzle tip nuts	28 – 1.5 (1.10 – 0.059)	27 (1.06)	18 ~ 20	130 ~ 145	176 ~ 196	

General bolts and nuts

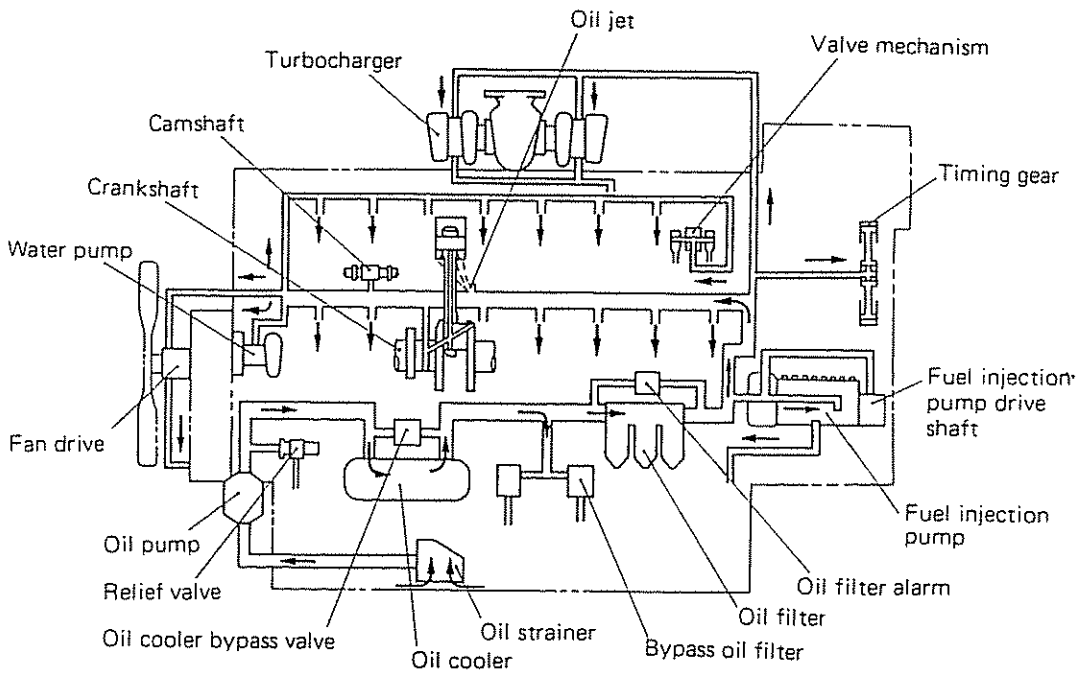
Screw thread mm (in.)		Standard torque					
Diam.	Pitch	w/spring washer			w/o spring washer		
		kgf-m	lb-ft	N·m	kgf-m	lb-ft	N·m
8 (0.31)	1.0 (0.039)	1.8	13	18	2.2	16	22
	1.25 (0.049)	1.8	13	18	2.1	15	21
10 (0.39)	1.25 (0.049)	3.6	26	35	4.2	30	41
	1.5 (0.059)	3.4	25	33	4.0	29	39
12 (0.47)	1.25 (0.049)	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

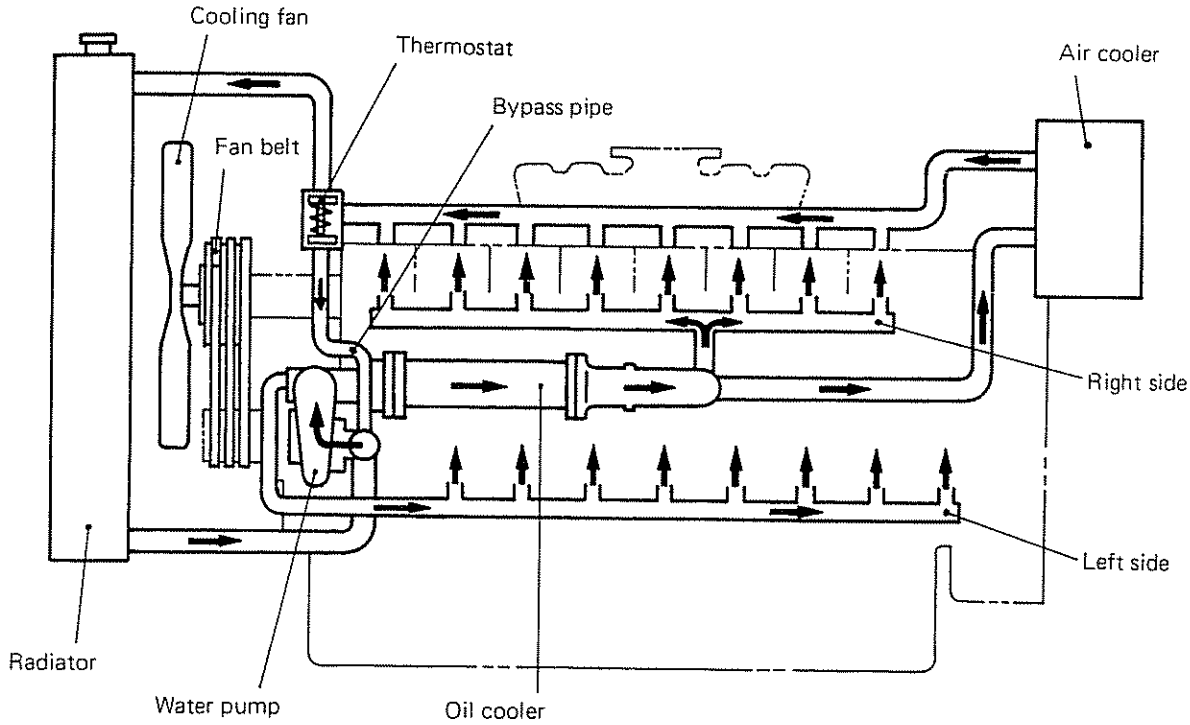


LUBRICATION SYSTEM

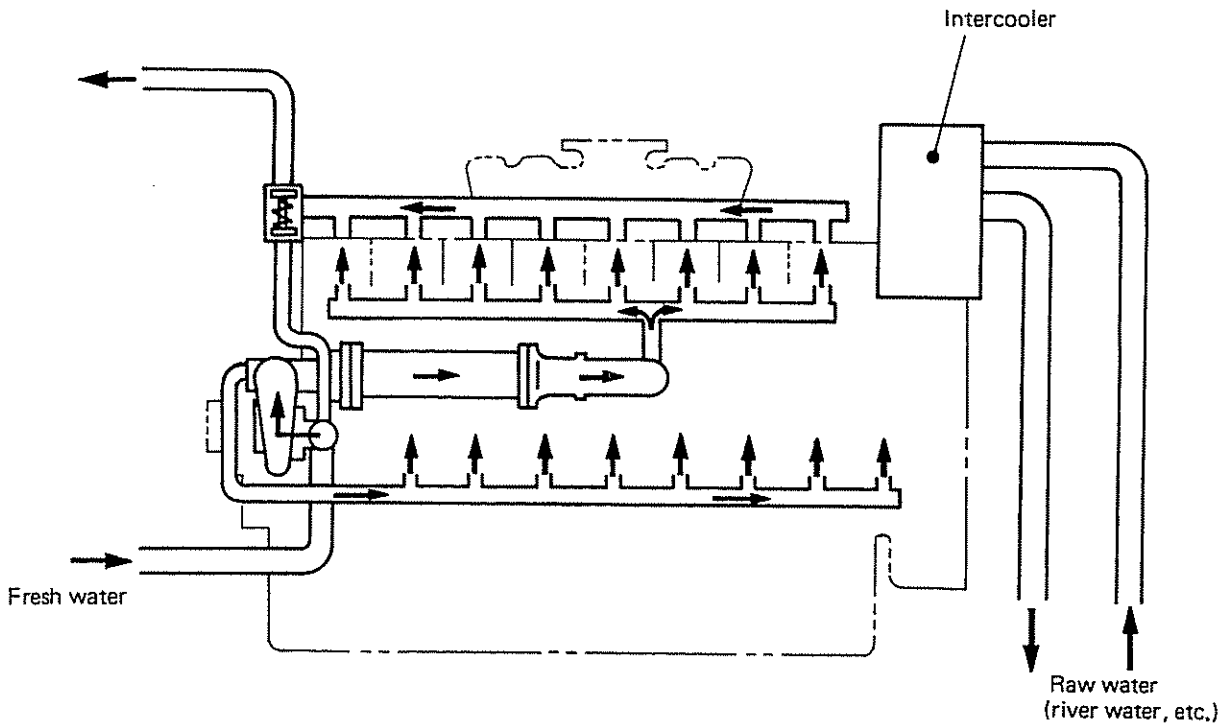


COOLING SYSTEM

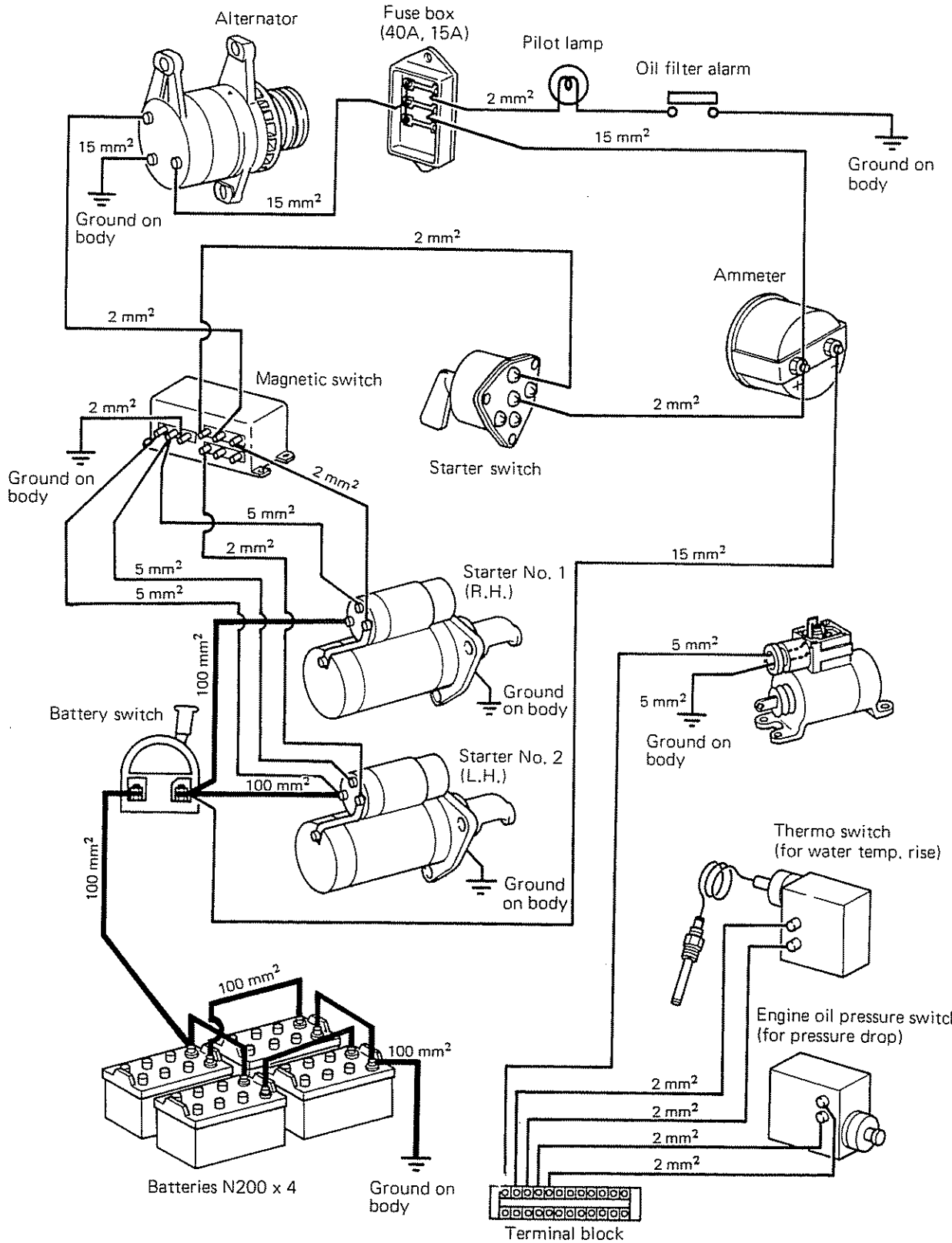
W/Radiator (PTA)



Dual cooling system (PTK)

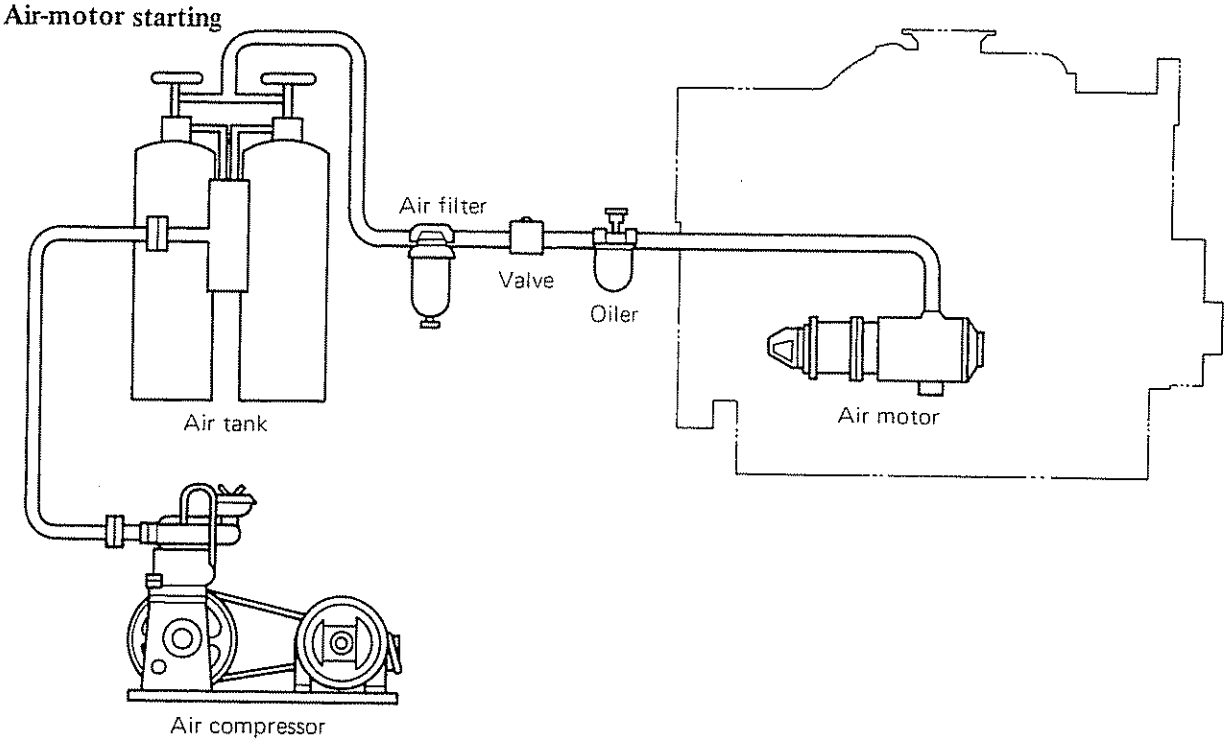


ELECTRICAL SYSTEM

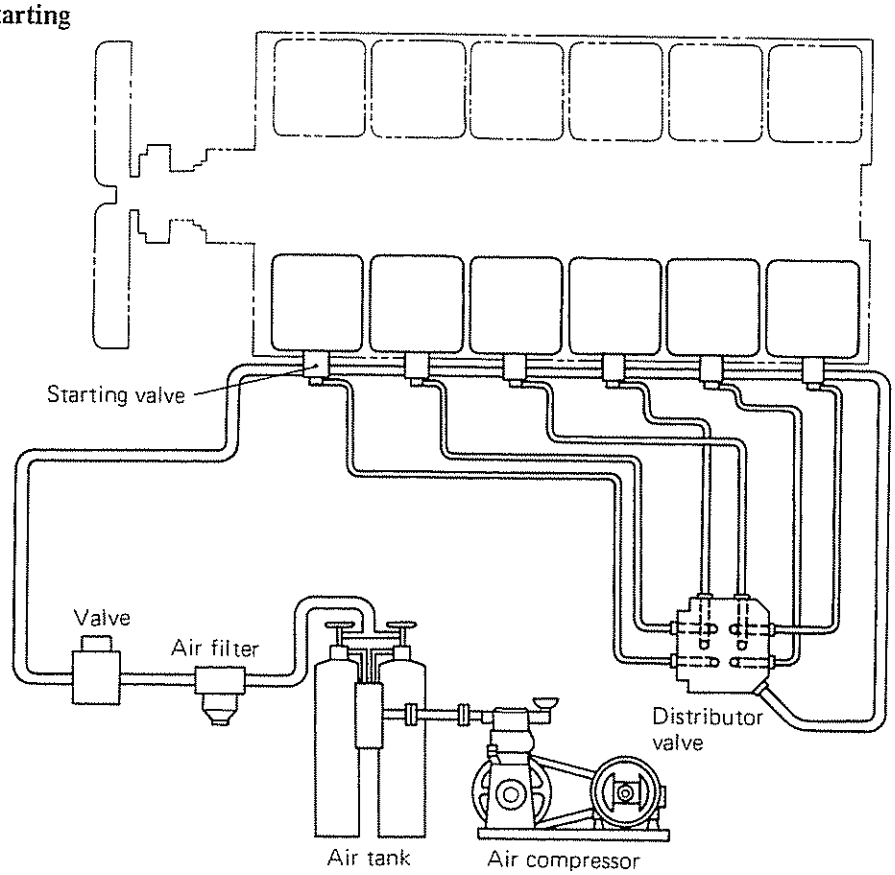


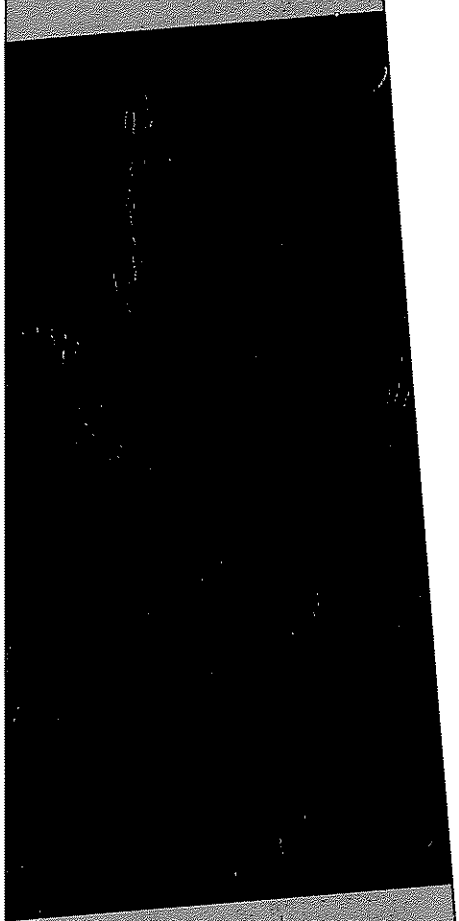
AIR-STARTING SYSTEMS

Air-motor starting



Direct-air starting





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