

MITSUBISHI MARINE ENGINE S6R2-T2MTK3M

OPERATION & MAINTENANCE MANUAL

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CAUTION

- Read this Operation & Maintenance Manual, and conduct the engine operation, inspection and maintenance only after sufficiently understanding the description.
- Please keep this Operation & Maintenance Manual with related manuals at a suitable place for quick reference when needed.



**MITSUBISHI HEAVY INDUSTRIES
ENGINE & TURBOCHARGER**

Foreword

This operation and maintenance manual contains detailed operation, inspection and maintenance information for engines from Mitsubishi Heavy Industries Engine & Turbocharger, Ltd.

Please be noticed that some contents are repeated among chapters for better understanding.

Please read and understand this manual thoroughly before proceeding with operation, inspection, and maintenance work.

Failure to follow instructions in this manual may result in serious accidents.

Please observe the laws and regulations in the country or region where the engine is used.

■ California, U.S.A.- Proposition 65 warning statement



WARNING: Breathing diesel engine exhaust exposes you to chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

- Always start and operate the engine in a well-ventilated area.
- If in an enclosed area, vent the exhaust to the outside.
- Do not modify or tamper with the exhaust system.
- Do not idle the engine except as necessary.

For more information go to www.P65warnings.ca.gov/diesel.

Limited Warranty

During the warranty period, Mitsubishi Heavy Industries Engine & Turbocharger, Ltd.(MHIET) will repair and replace any defective products, which are returned, if such defective are found to be manufacturing defects by investigation. For warranty period, contact your MHIET dealer.

Mitsubishi Heavy Industries Engine & Turbocharger, Ltd.(MHIET) warranty is limited to the compensation work of repair or replacement of parts.

The warranty coverage is effective for the original purchaser only. Those to whom ownership is later transferred are not provided with the warranty. However, the warranty coverage is effective for the ultimate purchaser and each subsequent purchaser for emission-related parts.

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- ♦Mitsubishi Heavy Industries Engine & Turbocharger, Ltd.makes no warranties, either expressed or implied, except as provided in this manual, including, but not limited to, warranties as to marketability, merchantability, fitness for a particular purpose or use, or against infringement of any patent.
 - ♦Mitsubishi Heavy Industries Engine & Turbocharger, Ltd.will not be liable for any damages or consequential damages, including, but not limited to, damages or other costs resulting from any abuse, misuse, misapplication of the engine and devices which supplied by us.
 - ♦Mitsubishi Heavy Industries Engine & Turbocharger, Ltd.will not be liable for any damages or personal injuries resulting from any modification, without our written permission, of the engine and devices which supplied by us.
 - ♦Mitsubishi Heavy Industries Engine & Turbocharger, Ltd.will not be liable for any damages or production losses caused by the use of fuel, engine oil and/or long life coolant (LLC) that we are not recommended.
 - ♦The owner of the engine is responsible for performing regular maintenance described in this manual.

When performing the maintenance, follow the instructions in the service manual published by Mitsubishi Heavy Industries Engine & Turbocharger, Ltd.

Mitsubishi Heavy Industries Engine & Turbocharger, Ltd.may deny the warranty coverage if the engine or a part of the engine has failed due to inadequate or improper maintenance.

Important Information

- ♦To avoid the potential hazard, accident prevention activities must be planned methodically and conducted continually by considering all aspects of engine operation, maintenance, and inspection. All involved personnel, including managers and supervisors, should actively participate, recognize their roles, and organize themselves and their work to ensure a safe environment.
- ♦The foremost safety objective is to prevent accidents which may result in injury or death, or equipment damage.
- ♦Always observe laws and regulations of the local or federal/national government.
- ♦Mitsubishi Heavy Industries Engine & Turbocharger, Ltd. cannot foresee all potential dangers of the engine, potential dangers resulting from human error and other causes, or a danger caused by a specific environment in which the engine is used. Since there are many actions that cannot be performed or must not be performed, it is impossible to indicate every caution in this manual or on warning labels. As such, it is extremely important to follow instructions in this manual and also to take general safety measures when operating, maintaining, and inspecting the engine.
- ♦When the engine is used by individuals whose native language is not English, the engine owner must provide thorough safety guidance to the operators. Also, attach the warning and operational decals that describe the original warning label statements in the native language of the operators.
- ♦The engine must be operated, maintained, and inspected only by qualified persons who have thorough knowledge of engines and their dangers, and also have received risk avoidance training.
- ♦To prevent an accident, do not attempt to carry out any operation other than those described in this manual, and do not use the engine for any unapproved purpose.
- ♦When the ownership of the engine is transferred, be sure to give this manual to the new owner although the warranty does not transfer to the new owner. Also, inform MHIET of the name and address of the new owner of the engine.
- ♦This manual is copyrighted and all rights are reserved. No part of this manual, including illustrations and technical references, may be photocopied, translated, or reproduced in any electronic medium or machine readable form without prior written consent from Mitsubishi Heavy Industries Engine & Turbocharger, Ltd.
- ♦For improvement of the engine, the contents in this manual are subject to change at any time without notice.
- ♦Pictures or illustrations of the product in this manual may differ from those of the product you have. Please note that, depending on specifications, the items described in this manual may differ from those on your engine in shape, or may not be installed on your engine.
- ♦Please contact your MHIET dealer if you need more information or if you have any questions.
- ♦If the manual is lost or damaged, please obtain a new copy at your MHIET dealer without delay.
- ♦Knowing the exact running time of the engine is very important. For safety operation, be sure to install the engine hour meter so that you know the exact running time and can conduct a timely maintenance that is described in this manual.

Warning Indication

The following signs and symbols are used to call attention of the operators and maintenance personnel to potential dangers of the engine.

- ♦Warning Statements in This Manual
- ♦Warning Labels Attached on the Engine

Warning Statements

The warning statements in this manual describe potential danger in operation, inspection, and maintenance of the engine, using the five symbols below to indicate the degree of potential hazard.

Failure to follow these directions could lead to serious accidents which could result in personal injury, or death in the worst case.

Please understand the instructions described in this manual well, and handle the engine according to the instructions.



Indicates an immediately hazardous situation which, if not avoided, will result in death or serious injury.



Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.



Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.



Indicates a potentially hazardous situation which, if not avoided, may result in property damage.

Note: Indicates important or useful information related to the operation and maintenance of the engine.

Unit of Measurement

Measurements are based on the International System of Units (SI), and they are converted to the metric system units shown in { } in this manual. Conversion rates are as follows:

- ♦Pressure: 1 MPa = 10.197 kgf/cm²
- ♦Torque: 1 N•m = 0.10197 kgf•m
- ♦Force: 1 N = 0.10197 kgf
- ♦Power, output: 1 kW = 1.341 HP = 1.3596 PS
- ♦Rotational speed: 1 min⁻¹ = 1 rpm
- ♦Kinetic viscosity: 1 mm²/s = 1 cSt

Abbreviations, Standards and Others

- ♦API = American Petroleum Institute
- ♦ASTM = American Society for Testing and Materials
- ♦ISO = International Organization for Standardization
- ♦JIS = Japanese Industrial Standards
- ♦LLC = Long Life Coolant
- ♦MIL = Military Specifications and Standards
- ♦SDS = Safety Data Sheet
- ♦SAE = Society of Automotive Engineers

Regulation for the Prevention of Air Pollution From Ships

Engine International Air Pollution Prevention Certificate and Technical File

The engine you have purchased is provided with "Engine International Air Pollution Certificate" (EIAPP-certificate) which proves the NO_x regulation compliance of MARPOL 73/78 Annex VI, regulation for the Prevention of Air Pollution from Ships, and "Technical File." The ship which is built after 1 January 2000 must be equipped with the marine use engine that complies with the NO_x regulations. EIAPP-certificate and Technical File must be kept on board all the time. If you fail to do so, you may receive penalties for violations.

Owner's Responsibilities Confirming the Engine Maintenance Description (With Signature)

NO_x regulation approval engine conditions such as part names and adjustment values are described in the Technical File. When you repair the engine or do maintenance work (part replacement, adjustment), you must follow the instructions described in the Technical File and perform the repair or maintenance work properly. Ship-owner, captain, and chief engineers have a responsibility to verify the work that has been done, and record every detail of work on "Maintenance Records for Parameters" in the Technical File with signatures.

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Chapter 1 SAFETY CAUTIONS

Fire and Explosion Protection



WARNING

Keep Flames Away

Do not use flames near the engine (in the engine room). Fuel gas vapor or other gas can catch fire and produces hazardous situations.



Wipe off spilled fuel, oil, and LLC immediately and thoroughly. Spilled fuel, oil, and LLC may ignite and cause a fire. Store the fuel and engine oil in a well-ventilated area. Make sure that the caps of fuel and engine oil containers are tightly closed.

Keep Engine Surrounding Area Tidy and Clean

Do not leave combustible or explosive materials such as fuel, engine oil, and LLC near the engine. It can cause a fire or explosion. Remove dust, dirt, and other foreign substances accumulated on the engine and surrounding area. Such materials can cause a fire or overheating. In particular, clean the top surface of the battery after maintenance work is completed. Dust can cause a short-circuit.

Pay Attention to Engine Room Ventilation

Always keep the engine room well ventilated. Insufficient air in the room can cause an increase in the engine temperature and a decrease in the output power and performance. Prior to installation of the engine, it is recommended to provide an adequate ventilation system by calculating the proper amount of supply air needed for the engine.

Do Not Open Side Covers Until Engine Cools

Do not attempt to open the side cover of the crankcase before the engine cools down. Wait at least 10 minutes after stopping the engine. If fresh air flows into the crankcase while the engine is overheating, oil mist can be ignited and exploded.

Be Alert for Leaking Fuel, Oil, or Exhaust Gas

If any fuel, oil, or exhaust gas leak is found, immediately stop the engine. After the engine has completely cooled down, repair the leak.

If oil/fuel splashes or leaks on the hot surfaces of the engine, or if exhaust gas comes in contact with flammable materials, it can cause property damage or personal injury.

Use Explosion-Proof Light

When inspecting fuel, engine oil, cooling water, battery electrolyte, etc., use a flameproof light. An ordinary lighting apparatus may ignite gas and cause an explosion.

Prevention of Electric Short Circuit

Do not inspect or repair the electrical system with the ground cable connected to the battery. Otherwise, a fire could result from short-circuit. Be sure to disconnect the battery cable from the negative (-) terminal before proceeding with any work.

Short-circuit, which may result in fire, is caused by a loose terminal or damaged cable/wire. Inspect terminals, cables, and wires, and repair or replace faulty parts before proceeding with any work.

Keep Fire Extinguishers and First-Aid Kit Handy

Keep fire extinguishers handy and become familiar with the usage. Keep a first-aid kit at the designated place where it is easily accessible by anyone at any time.



Prepare an emergency action plan in the event of fire or accident. Provide an emergency evacuation route and contact points and means of communication in case of emergency.

Stay Away From Rotating and Moving Parts



WARNING

Keep Rotating Parts Covered for Safety

Make sure the protective covers attached to the engine rotating parts are correctly installed. Repair any damaged or loose covers. During operation, never remove protective covers such as the front cover, fuel injection pump coupling cover, and alternator cover that enclose rotating parts.



When the engine is coupled to the driven equipment, be sure to provide protective covers over the parts such as the connecting belts and couplings that are exposed.

Never remove the protective covers.

Check Work Area for Safety Before Starting

Before starting the engine, make sure no one is near the engine and no tools are left on or near the engine. Alert people in the area when starting the engine. When the starter device is posted with a sign that prohibits startup operation, do not operate the engine.

Stay Away From Moving Parts During Operation

Stay away from rotating parts of the engine while the engine is running. Do not place any objects which might be easily entangled near the rotating parts.



If any part of the clothing or tool is caught in rotating parts, it could result in serious injury or death.

Lockout and Tagout

Be sure to lockout/tagout before starting inspection and maintenance work.

Lockout and tagout are effective methods of cutting off machines and equipment from energy sources.

To accomplish the lockout/tagout, remove the starter switch key, place the battery switch to the OFF position and attach a "DO NOT OPERATE" or similar caution sign to the starter switch.

The starter switch key must be kept by the person who performs inspection and maintenance work.

Be Sure to Stop Engine Before Inspection/Maintenance

Be sure to stop the engine before proceeding with any inspection and maintenance work. Never attempt to make any adjustments on the engine parts while the engine is running.

Entanglement in rotating parts can result in serious injury or death.

Always Put Turning Tool Back in Place After Use

Be sure to remove all turning tools that are used during maintenance and inspection work. Be sure to pull out the manual turning gear shaft before starting the engine.

Starting the engine with the turning tool inserted or with the turning gear engaged can lead to not only engine damage but also personal injuries.

Prevention of Exhaust Gas Poisoning

WARNING

Pay Attention to Ventilation When Operating Engine

Check exhaust pipes and pipe joints for gas leaks.

Exhaust gas from the engine may contain harmful substances to human body. Operating the engine in a poorly-ventilated area can cause gas poisoning.



California, U.S.A-Proposition 65 Warning Statement

WARNING

The engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects or other reproductive harm.

Prevention of Hearing Loss

WARNING

Wear Ear Plugs

Always wear ear plugs when entering the machine room (engine room). Combustion sound and mechanical noise generated by the engine can cause hearing problems.



Fall Prevention

WARNING

Lift Engine Carefully

To lift the engine, use slings strong enough to support the weight of the engine.

Attach proper slings to the hangers provided on the engine to lift the engine.

During the lifting process, keep the engine in a well-balanced position by paying attention to the center of gravity of the engine.

The hangers attached to the engine are designed to lift the engine only. When the engine is equipped with marine gear, take care so that extra load will not impose on the engine hangers.

Keep the angle formed by slings that are attached to hangers within 60 degrees. If the angle exceeds this limit, an excessive load could be imposed on the hangers and this could damage the hangers and result in a serious accident.

Attach wire ropes to the hangers after removing the pipe near the hanger.

If the sling contacts the engine parts directly, place a cloth or other soft padding to avoid damage to the engine parts and sling. If necessary, remove the engine parts.



Do Not Climb Onto the Engine

Do not climb onto the engine, nor step on any engine parts, which located on the engine sides.

When working in a high place such as the upper part of engine, use a step, or work platform, and be careful not to fall off.

Climbing on the engine may not only damage engine parts but also cause a falling-down accident which can result in a personal injury.

Always Use a Stable Foothold During Maintenance

When working on the upper part of the engine and other hard-to-reach places, use a stable work platform.

Do not stand on a decrepit stool or parts box. Otherwise, it may result in personal injury.

Do not put any unnecessary objects on a work platform.



Burn Protection



CAUTION

Do Not Touch Engine During or Immediately After Operation

Do not touch any part of the engine during or immediately after operation. A hot engine can cause burns.

Before conducting maintenance and inspection work, check the water temperature gauge to see if the engine has cooled sufficiently.



Be Careful When Opening and Closing of Fresh Water Tank Cap

Never open the fresh water tank cap while the engine is running or immediately after stopping. Stop the engine, and then open the cap after the coolant temperature has dropped sufficiently.

To open the fresh water tank cap, open slowly to release the pressure in the tank.

The coolant is hot while the engine is running and immediately after stopping. If the fresh water tank cap is opened while the coolant is hot, steam and hot water may blow out and it may result in burns. To avoid the risk of getting scalded by steam, wear thick rubber gloves or wrap a cloth around the cap.

When fastening the fresh water tank cap, be sure to tighten securely.

Refill Coolant Only After the Coolant Temperature Dropped

Before adding coolant, check the coolant temperature with the gauge if it is lowered to the normal temperature. Adding coolant immediately after engine shutdown may result in burns.

Do Not Remove Heat Shields

The inlet and exhaust systems are provided with various heat shields because they become extremely hot while the engine is running. Do not remove these heat shields. If any of these heat shields have been removed due to unavoidable circumstances for the work, be sure to install them after the work is completed.

Burn Prevention When Changing Oil

Before draining oil or changing oil filters, wear leather gloves or be sure to check the engine has cooled down. Hot oil or hot parts can cause burns if touched.

Be Careful When Handling Fuel, Engine Oil, and Coolant (LLC)



CAUTION

Use Specified Fuel, Engine Oil, and LLC Only

Use fuel, oil, and coolant (LLC) specified in this manual, and handle them carefully.

Use of any other fuel, oil, or coolant (LLC) than the specified one, or improper handling may cause various engine defects and failures.

Obtain the SDS issued by the oil and LLC suppliers, and follow the instructions in the SDS for proper handling.

Handle LLC Carefully

When handling LLC, always wear rubber gloves, a protective face mask, and protective eyeglasses. If LLC or cooling water containing LLC comes into contact with your skin or eyes, or if it is ingested, you would suffer from damage of your skin or eyes, or poisoning.

If coolant (LLC) is accidentally swallowed, induce vomiting immediately, and seek medical attention. If coolant (LLC) gets in your eyes, flush them immediately with plenty of water and seek medical attention. If coolant (LLC) splashes onto your skin or clothing, wash it away immediately with plenty of water.

Keep flames away from LLC. LLC is highly flammable and can easily catch a fire if exposed to a flame.

Proper Disposal of Waste Oil, LLC, and Coolant

Do not dump waste engine oil, LLC, and coolant into sewerage, river, lake, or other similar places. Such a way of disposal is strictly prohibited by laws and regulations.

Be sure to dispose of waste oil, LLC, coolant, and other environmentally hazardous waste in accordance with the applicable laws and regulations.

When Abnormality Occurs

CAUTION

Stop Operation Immediately If You Notice Any Abnormality

Stop the operation immediately if you notice any unusual noise, odor, or vibration during operation. When an emergency occurs, press the emergency stop button to stop the engine. If the cause of problem cannot be located after stopping, contact your MHIET dealer. Continuous operation neglecting an unusual symptom could cause serious or fatal accident.

Do Not Add Coolant Immediately After a Sudden Stop Due to Overheating

If the engine stops suddenly or if you have no choice but stop the engine suddenly due to overheating, do not add coolant immediately.

Adding coolant while the engine is hot may cause damage to cylinder heads and others due to a sudden drop of temperature. Add coolant gradually after the engine has completely cooled.

Be Careful When Starting After an Abnormal Stop

Do not restart immediately after an abnormal stop. If the engine stops or is brought to a stopped condition with an abnormality, find out the cause, repair the troubled part, and then restart the engine. Continued operation of the engine without proper repairs and maintenance could result in serious engine failure.

Stop Engine Immediately When Engine Oil Pressure Has Dropped

When abnormal engine oil pressure drop is observed, stop the engine immediately, and inspect the lubrication system to locate the cause. Continued engine operation could cause bearings and other parts to seize.

If Belt Breaks, Stop Engine Immediately

If the belt breaks, stop the engine immediately and replace the belt. Continued use of the engine without any remedy could cause charging failure or cooling failure, and result in serious engine problems.

Battery Safety Precautions

CAUTION

Be Careful When Handling Battery

•Never use flames or allow sparks near the battery. The battery releases flammable hydrogen gas and oxygen gas. Any flames or sparks in the vicinity of battery could cause an explosion.



- Do not use the battery when the battery fluid level is below the "LOWER LEVEL" mark. It may result in an explosion.
- Do not short the battery terminals with a tool or other metal object.
- When removing battery, always remove the plug from the negative (-) terminal first. When connecting battery, always connect the plug to the positive (+) terminal first.
- Before charging the battery, remove all battery cables, and then charge the battery in a well ventilated area.
- Make sure the cable clamps are securely attached to the battery terminals. A loose cable clamp can cause sparks, which may result in an explosion.
- Before servicing electrical components or conducting electric welding, set the battery switch to the [Open/OFF] position or remove the plug from the negative (-) terminal to cut off the electrical current.
- Battery fluid contains dilute sulfuric acid. Careless handling of the battery can lead to sight loss and/or skin burns. Also, do not swallow the battery fluid.
- Wear protective goggles and rubber gloves when working with the battery (e.g. when adding water or charging battery).
- If battery fluid is spilled onto the skin or clothing, immediately wash it away with lots of water. Use soap to clean thoroughly.
- The battery fluid can cause sight loss if splashing into your eyes. If it gets into your eyes, immediately flush it away with plenty of clean water, and seek immediate medical attention.
- If you accidentally swallow battery fluid, gargle with plenty of water and then drink lots of water, and seek immediate medical attention.
- If the battery does not fully recover after charging for 24 hours or more, do not use the battery.

Other Precautions


CAUTION

Do Not Tamper

Unauthorized modification of the engine will void your warranty.

Modification of the engine may not only cause damage to the engine but also may result in personal injury.

Always Use Mitsubishi Genuine Parts

Be sure to use Mitsubishi genuine parts for Mitsubishi engines. DO NOT use imitation parts.

Also, be sure to use fuel, engine oil, and LLD which recommended in this manual.

Observe Safety Rules at Work Site

Observe the safety rules established at your workplace.

Do not operate the engine if you are not feeling well. Inform your supervisor of your condition. Operation of the engine with reduced attentiveness may cause improper operation that could result in accidents.

When working in a team of two or more people, use specified hand signals to communicate among workers.

Wear Proper Work Clothing and Protective Gears

Wear a hard-hat, a face shield, safety shoes, a dust mask, gloves, ear plugs, and other protective gears as needed. When handling compressed air, wear safety goggles, a hard-hat, gloves, and other necessary protective gears. Working without wearing proper protective gears could result in serious injury.

Never Break the Seals

To ensure proper engine operation, the fuel control links are sealed to prevent the injection volume and rotational speed settings from tampering. Removing these seals of the engine will void the warranty. The following problems may occur if these seals are removed.

- ♦Rapid wear of moving and rotating parts
- ♦Failures such as seizure and damage of engine parts
- ♦Sudden increase of fuel and lubricating oil consumption
- ♦Poor engine performance due to improper balance between fuel injection volume and governor control, or a serious accident due to overrunning of the engine

Performance of Pre-Operation Inspection and Periodic Inspections

Be sure to perform the pre-operation inspection and periodic inspection as instructed in this manual.

Failure to conduct specified the pre-operation inspection or periodic inspection may cause various engine problems and damage to parts, which may result in serious accidents.

Engine Break-in

For the first 50 hours of operation of a new engine or the engine that has been overhauled, operate the engine under a light load for break-in.

Operating a new engine or an engine that has been overhauled under a severe condition during break-in will shorten the service life of the engine, because the engine parts are not well lubricated and warmed up yet.

Warming Up Engine First

After starting the engine, run the engine at a low idling speed until the coolant temperature reaches approx. 50°C [122°F]. Start the actual engine operation after warming up operation is completed. (Except for the emergency generator which requires a rapid starting. Refer to the technical manual of auxiliary devices for rapid starting.)

The warm-up operation circulates lube oil through the engine and contributes to a longer service life and economical operation.

However, do not perform the warm-up operation for longer than necessary. It may cause accumulation of carbon in the cylinder, and cause faulty combustion.

Cool Down the Engine Before Stopping

Before stopping the engine, operate the engine at a low idle speed for 5 to 6 minutes to cool down.

Stopping the engine immediately after high-load operation will cause engine parts to heat up, and shorten the service life of the engine.

During cooling operation, check the engine for abnormalities.

Do Not Operate the Engine in an Overloaded Condition

If overload symptoms such as black exhaust smoke is observed, reduce the load immediately and assure the proper output and load.

Overloaded operation will cause not only excessive fuel consumption but also excessive carbon deposits. Carbon deposits cause various problems, and will shorten the service life of the engine.

Limitation of Continuous Under Light Load Operation

Allowable minimum load during continuous operation: Operate with 30% or more of the rated output.

Allowable continuous operation time with a load factor of 30% or less of the rated output: Limit the operation within one hour.

Operate with a load factor of 50% or more for 30 minutes or more after continuous operation with 30% or less of the rated output is conducted.

The following problems may occur when light load operation is conducted beyond the above allowable range:

- ♦ Fuel and/or oil leak from the exhaust system
- ♦ Carbon build-up on the cylinder head and exhaust pipe
- ♦ Sulfuric acid corrosion
- ♦ Dilution
- ♦ Generation of blue-white smoke (mainly during low idle operation)

Do Not Splash Water on Engine

Do not allow water or rainwater to enter the engine through the air inlet or exhaust opening.

Do not wash the engine during operation. Cleaning fluid (water) can be sucked into the engine.

If the water enters into the combustion chambers, the internal engine may be damaged due to water hammer, and result in a serious accident.

Pre-cleaner Maintenance Precautions

For the maintenance of engine equipped with pre-cleaner, be sure to observe the instructions below:

- ♦ Wash the pre-cleaner periodically. If the pre-cleaner is clogged, exhaust temperature will increase because sufficient intake air for combustion is not supplied, and as a result, a failure may occur.
- ♦ Never service the pre-cleaner during engine operation. The turbocharger may suck foreign substances into the engine, and could result in serious accidents.
- ♦ When removing the pre-cleaner, take care so that foreign substances accumulated on the pre-cleaner will not enter the inside of the engine. When the pre-cleaner is removed, immediately cover the air inlet with a plastic film and others to prevent foreign substances from entering the engine.

Use Proper Tools for Maintenance Work

Always keep in mind to select most appropriate tools for the work, and use them correctly. If a tool is damaged, replace it with a new one.

Do Not Operate Starter for a Long Duration

Do not operate the starter for more than 10 seconds at a time. If the engine does not start, wait for at least 1 minute before cranking again.

Continuous operation of the starter will drain the battery power or cause the starter to seize.

Do Not Turn Off the Battery Switch During Operation

Do not turn off the battery switch during operation.

If the battery switch is turned OFF when the engine is running, it stops the operation of meters and also may deteriorate alternator diode and transistor.

Engine Transportation Precautions

When transporting the engine on a truck, consider the engine weight, width, and height to ensure safety.

Abide by the road traffic law, road vehicles act, vehicle restriction ordinance, and other pertinent laws.

Do Not Turn Engine to Reverse Direction

When rotating the engine by hands, be sure to rotate the engine in its normal rotation direction. If the engine is rotated in the opposite direction, the seawater pump impeller will be broken.

Operate Clutch at Low Idling Speed

Changing direction with the clutch selector, between neutral and forward, or between neutral and reverse, must be always done at 50% rated engine speed or lower. If clutch operation is conducted during high speed rotation, it could cause damage to the marine gear.

Shift Clutch Properly

When shifting the clutch, be sure to securely place the clutch in position, F (Forward), R (Reverse) or N (Neutral). If the clutch lever is not firmly engaged in one of these positions, there is a risk for wearing or burning of clutch plates by slipping.

Warning Labels



Maintenance of Warning Labels

Make sure all warning/caution labels are legible.

Clean or replace the warning/caution labels when the description and/or illustration are not clear to read.

For cleaning the warning/caution labels, use a cloth, water and soap. Do not use cleaning solvents, gasoline or other chemicals to prevent the letters from getting blurred or the adhesion from being weakened.

Replace damaged or fractured labels with new ones.

If any engine part on which a warning label is attached is replaced with a new one, attach a new identical warning label to the new part.

To obtain new warning labels, contact your MHIET dealer.



Fig. 1-1 Warning Labels

Chapter 2 NAMES OF PARTS

Engine External Views

Front View

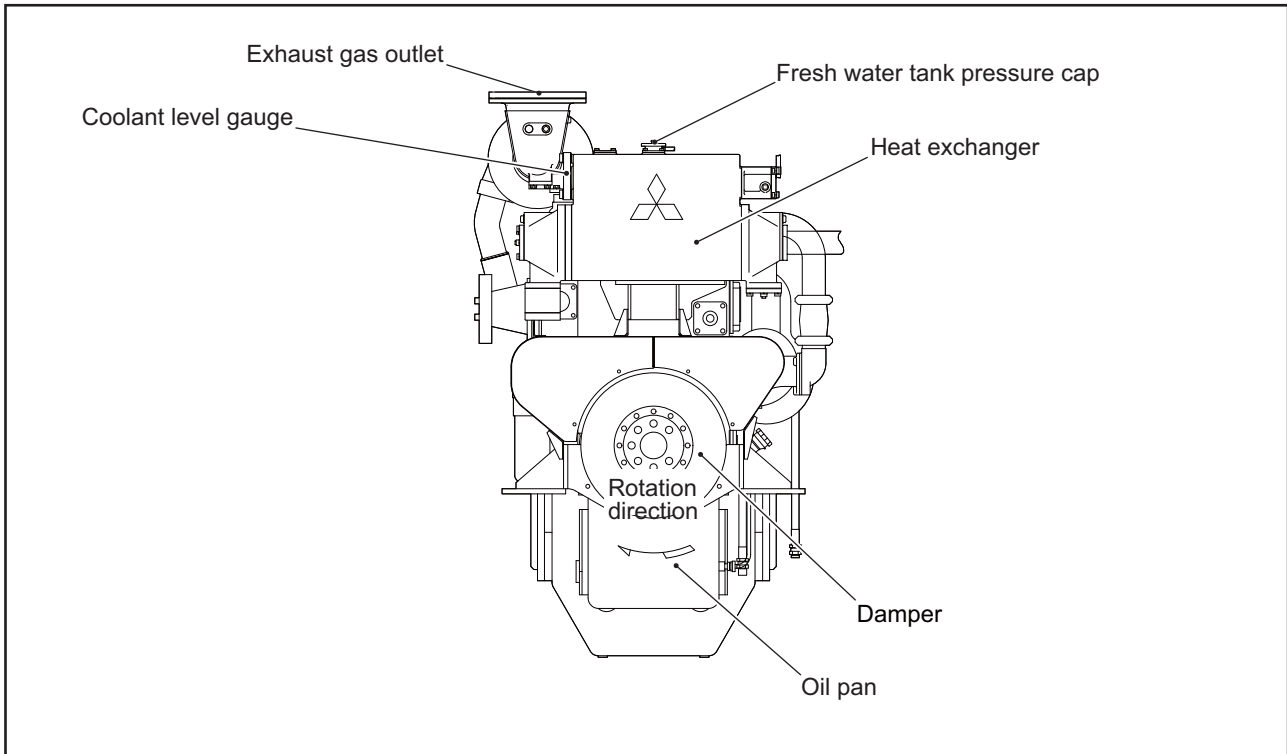


Fig. 2-1 Engine Front View

Rear View

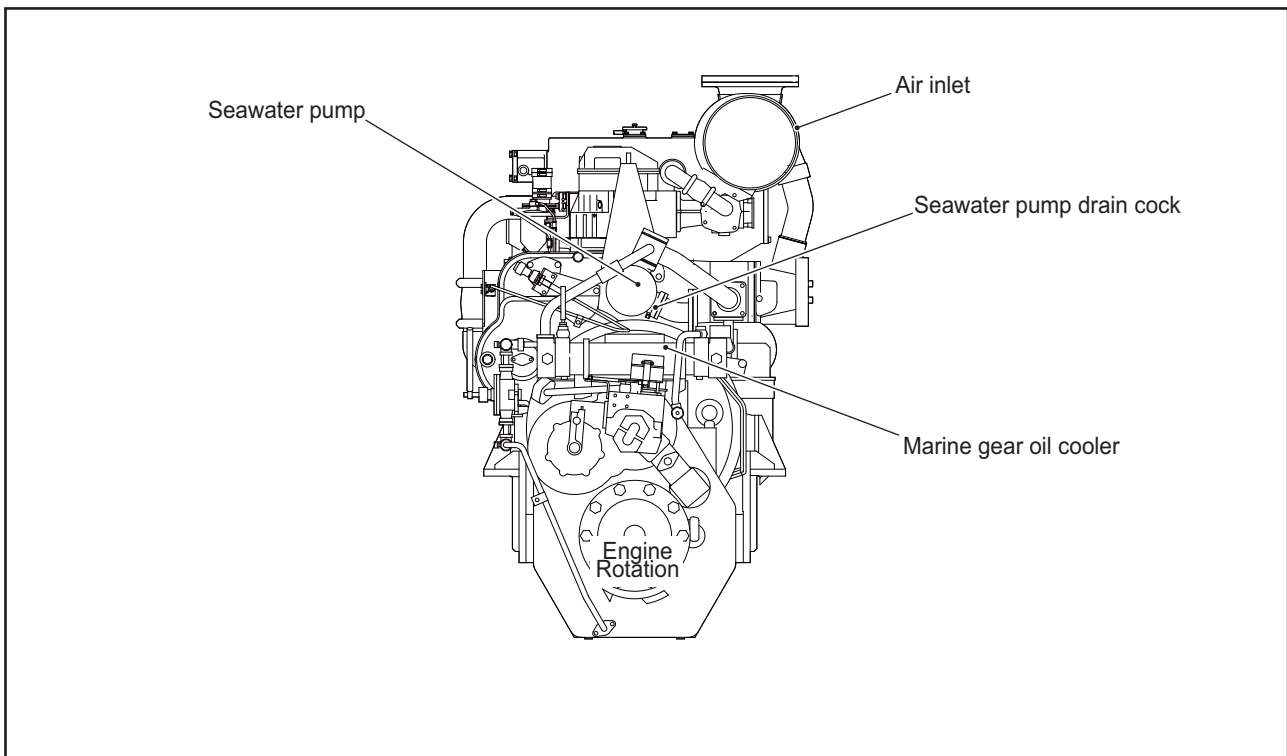


Fig. 2-2 Engine Rear View

Left View

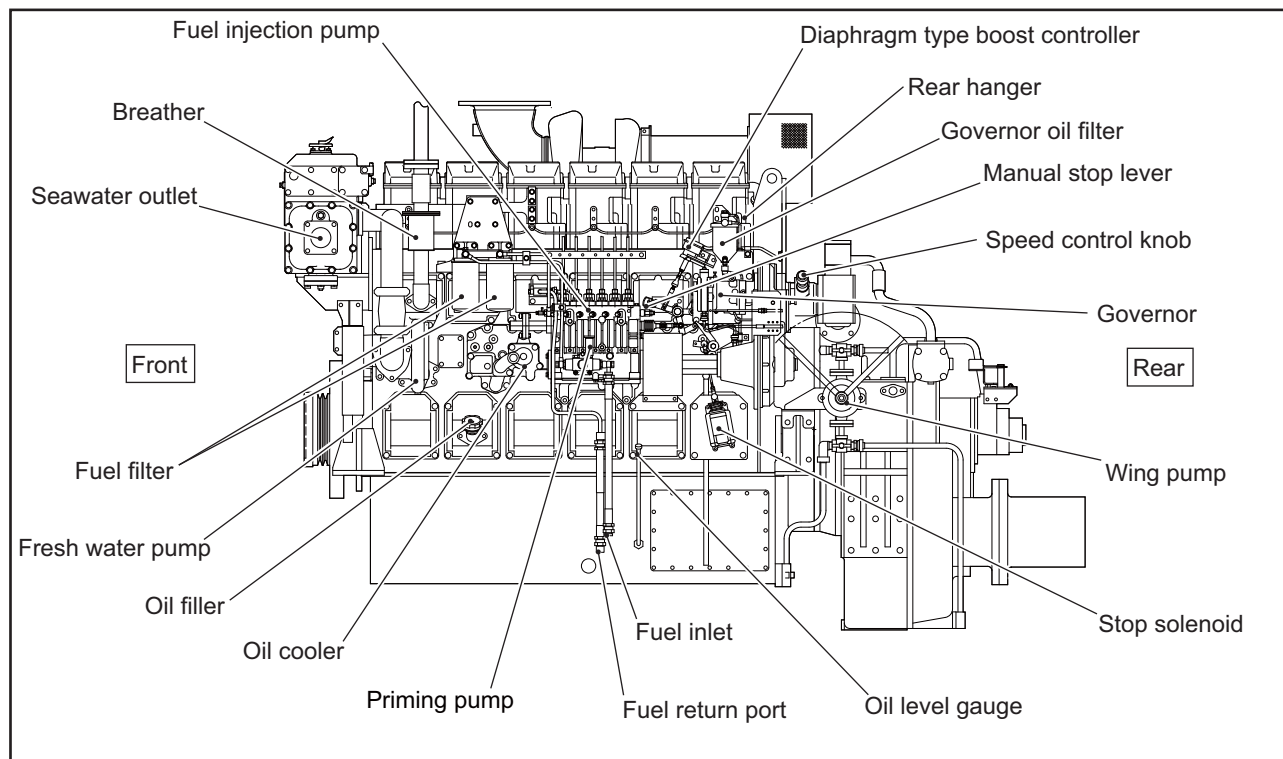


Fig. 2-3 Engine Left-Side View

Right View

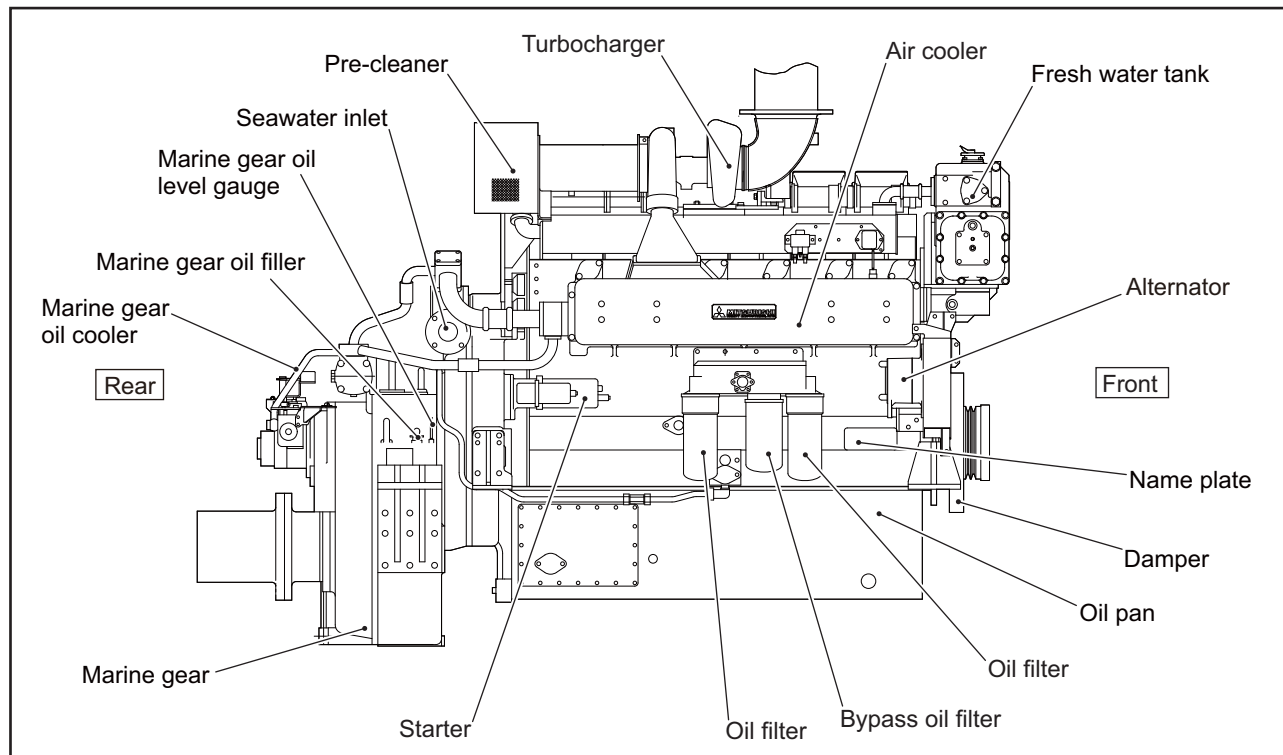


Fig. 2-4 Engine Right-Side View

Operating Devices

Speed Control Knob

You can adjust the engine speed in the engine room. Turn the knob for fine adjustment of rotating speed. Turn the knob counterclockwise for high-speed rotation, and turn it clockwise for low-speed rotation. Push the button to unlock the knob. Rotation speed can be adjusted by moving the knob. Pull the knob for high-speed rotation and push it for low-speed rotation.

Note: (a) To change the rotation speed by pushing the button, slowly operate so as to avoid rapid speed changes.

(b) After the condition of the engine is checked by changing the rotation speed using this knob, place the knob in the fully pushed down position (minimum speed). If you try to lower the engine speed to the minimum using the speed control lever in the wheel house, the speed will not go lower than the preset value of the knob. Be sure to push down the knob fully after checking.

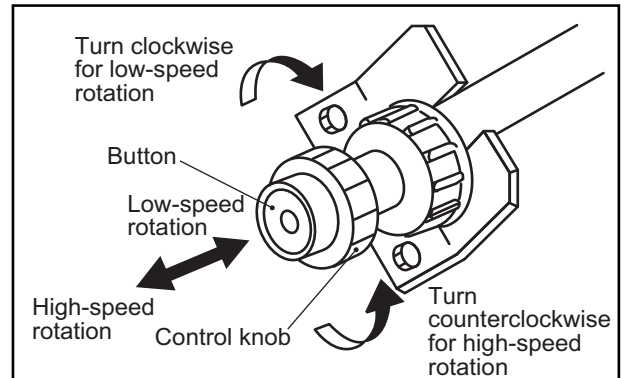


Fig. 2-5 Speed Control Knob

Manual Stop Lever

The manual stop lever is provided to stop the engine in the event of an emergency and also when the engine will not stop with the stop button.

The manual stop lever is mounted on the fuel control link unit. You can stop the engine by operating this lever in the "STOP" direction.

If the engine will not stop even after operating the lever in the "STOP" position, cut off the fuel supply to the engine.

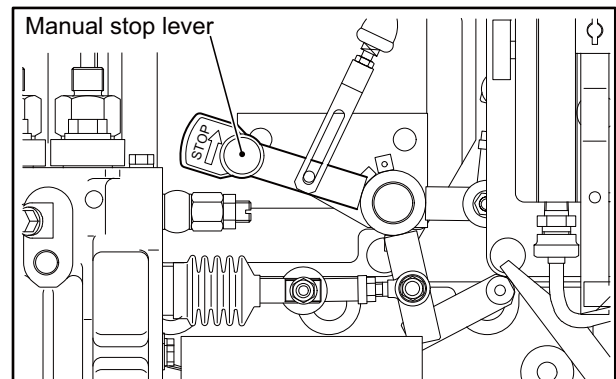


Fig. 2-6 Manual Stop Lever

Stop Solenoid

The stop solenoid is used for normal shutdown of engine operation.

The stop solenoid moves the rack of the fuel injection pump to stop fuel injection, thus shutting down the engine.

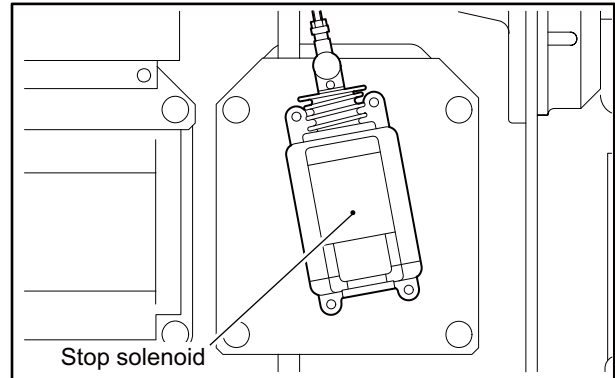


Fig. 2-7 Stop Solenoid

Diaphragm Type Boost Controller

Fuel rank is limited until turbo boost pressure is increased to reduce the black smoke during rapid acceleration.

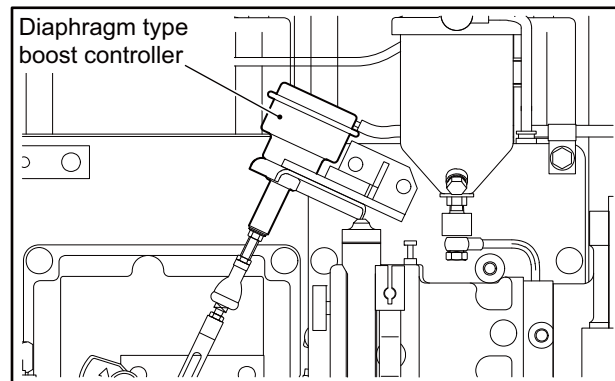


Fig. 2-8 Diaphragm type boost controller

Transmitters for Instruments

The engine is equipped with the devices which transmit signals to instruments and equipment for operation. Be sure to understand the role of these devices.

Oil Pressure Unit

Detects the oil pressure.

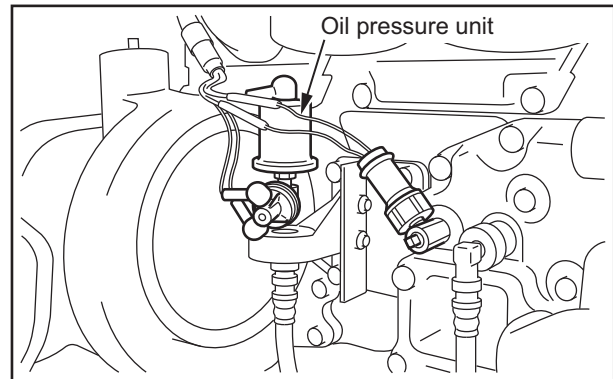


Fig. 2-9 Oil Pressure Unit

Thermo Unit

Detects the engine coolant temperature.

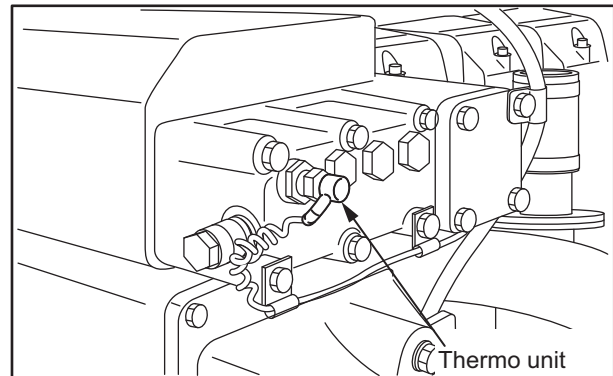


Fig. 2-10 Thermo Unit

Rotation Detection Pickup

The pickup device is mounted on the timing gear case to detect engine speed.

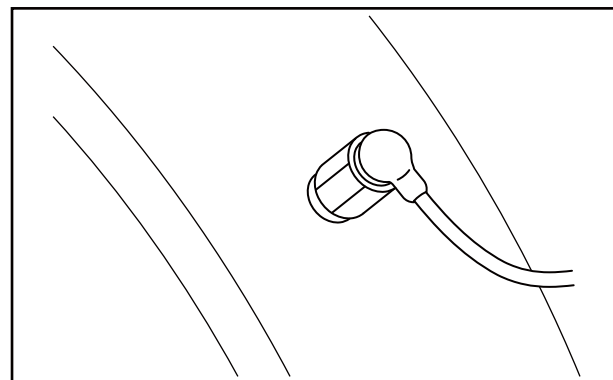


Fig. 2-11 Rotation Detection Pickup

Intake Pressure Sensor

The engine is equipped with the intake pressure sensor to detect intake pressure.

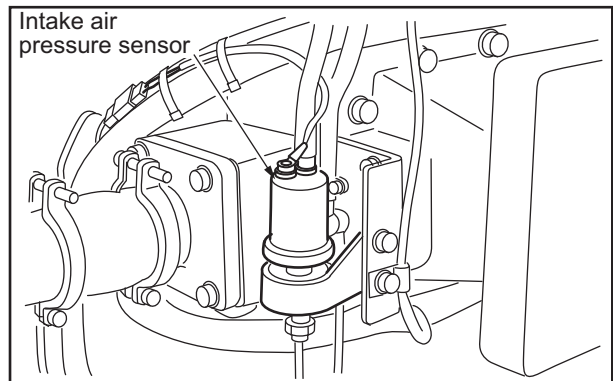


Fig. 2-12 Intake Pressure Sensor

Exhaust Gas Temperature Sensor

Detects the engine exhaust gas temperature.

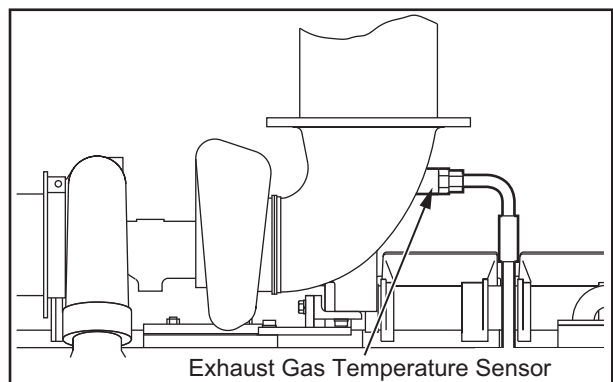


Fig. 2-13 Exhaust Gas Temperature Sensor

Clutch position detector switch

Clutch position detector switch is equipped to detect the position of the clutch (forward, neutral, reverse).

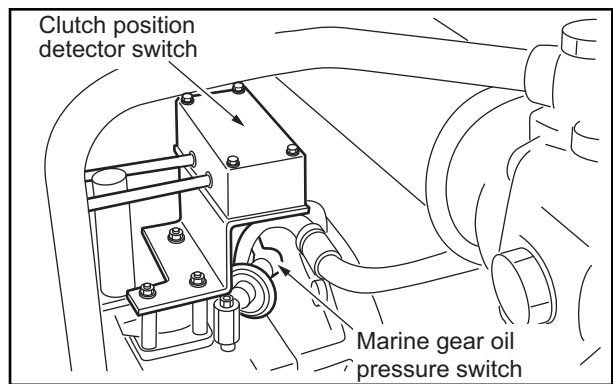


Fig. 2-14 Clutch position detector switch

Engine Protection Devices

Oil Pressure Switch

The oil pressure switch activates an alarm when the engine oil pressure reaches the lower limit of pressure.

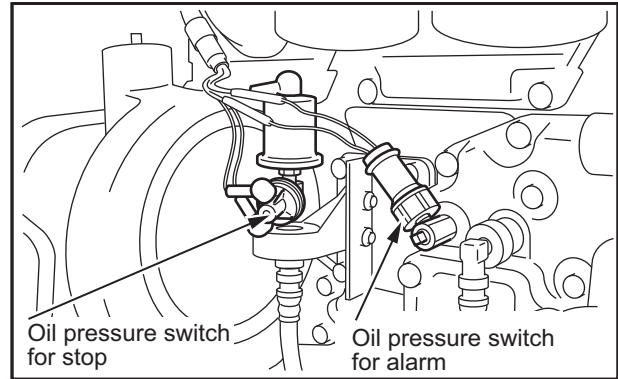


Fig. 2-15 Oil Pressure Switch

Thermo Switch

Thermo switch activates an alarm when the engine coolant temperature reaches the higher limit of temperature.

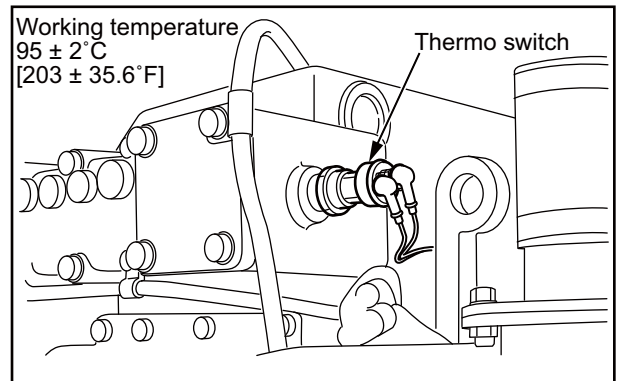


Fig. 2-16 Thermo Switch

Marine gear oil pressure switch

Marine gear oil pressure switch is equipped to prevent malfunction of clutch and damage of gear when the pressure of marine gear oil decreases. The marine gear oil pressure switch is set to issue an alarm when the marine gear oil pressure is 0.03 MPa{0.3 kgf/cm²}.

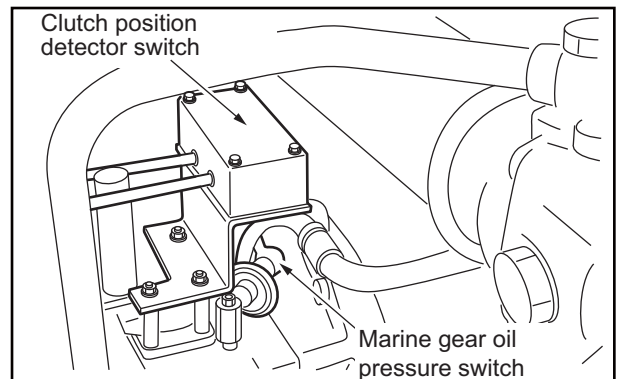


Fig. 2-17 Marine gear oil pressure switch

Wheel House Indicator and Alarm Panel

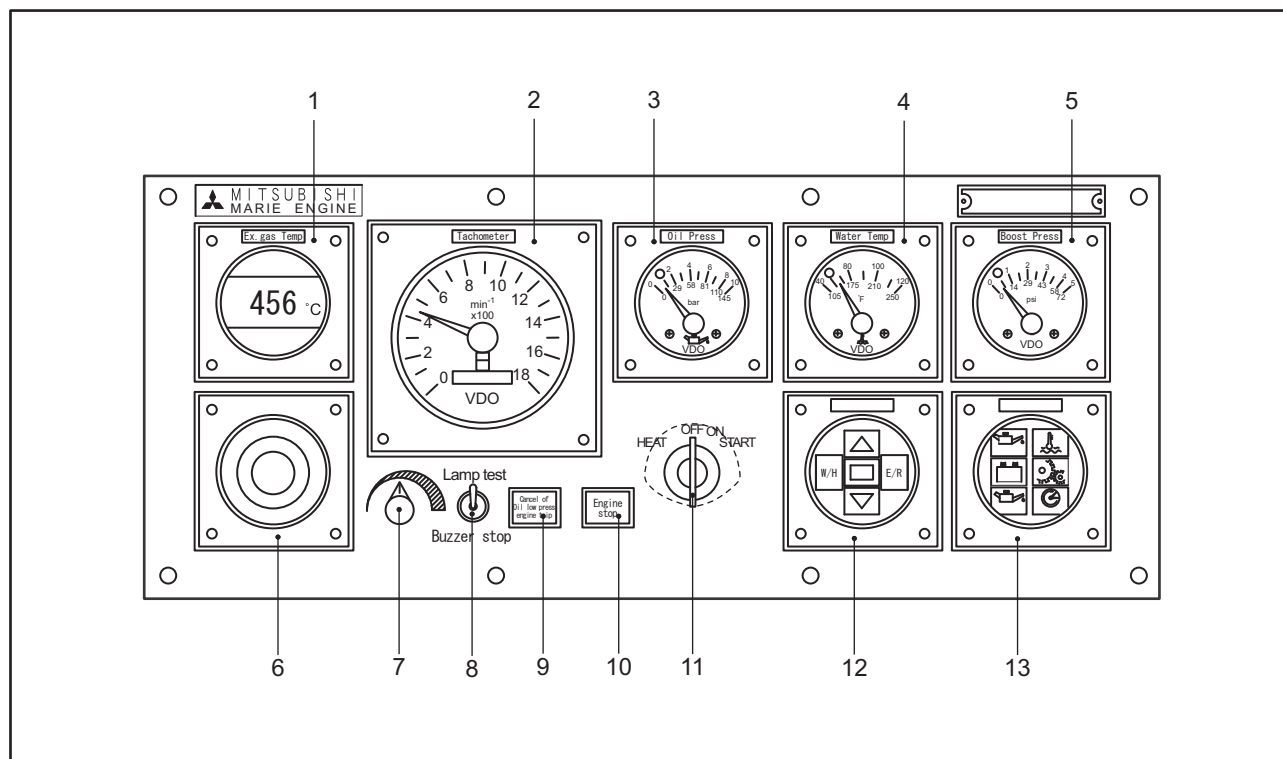


Fig. 2-18 Steering room instrument panel
Table 2-1 About steering room instrument panel

No.	Name	Function
1	Exhaust gas thermometer	Indicates the exhaust gas temperature of the engine.
2	Engine speedometer (tachometer)	Indicates the rotational speed of engine (RPM). (Continuous rated rotation speed: 1406 min ⁻¹ , minimum no-load rotational speed 500 min ⁻¹)
3	Lubricating oil pressure gauge	Indicates engine oil pressure. (Standard rated rotational speed : 0.49 to 0.64 MPa {5 to 6.5 kgf/cm ² }) If abnormally lowered, take appropriate measures according to "When the engine oil pressure is abnormal" on page 11-2.
4	Coolant temperature gauge	Indicates the temperature of engine coolant (freshwater). (Standard temperature: 70 to 80°C) If the gauge indicates 95°C [203° F] or above, the engine is overheating. Take appropriate measures according to "When the engine is overheating" on page 11-2.
5	Manifold pressure gauge	Indicates manifold air pressure in the engine.
6	Alarm buzzer	If a fault occurs, this alarm buzzer starts sounding at the same time the alarm lamp lights up.
7	Dimmer	Used to adjust the brightness of displays, lighting etc.
8	Lamp test, buzzer stop switch	Raise the lever when the starter switch is "ON" to check the operation. Check this during start-up inspection. To stop the alarm buzzer sounding, lower the lever.
9	Engine stop cancellation indicator lamp	When you set the engine stop cancellation switch of engine room instrument warning panel "OFF", this indicator lamp lights up if the engine oil pressure decreases.
10	Engine stop button	Pushing this button activates the stop solenoid to stop the engine.

Table 2-1 About steering room instrument panel

No.	Name	Function	
11	Starter switch	OFF (Shut off)	When stopping the engine, return the key to this position. you can insert and remove the key in this position as the the electric supply to instruments is disconnected.
		ON (Turn on)	Return the key in this position after the engine has started (during operation). Electricity flows in the electric circuits of instruments and alarms.
		START (Starting)	Turn the key to the "START" position to start the engine. Release the key when the engine has started. The key automatically returns to the "ON" position.
		HEAT (Pre-heat)	To make starting easier during cold season, turn the key to the "HEAT" position before turning to the "START" position to warm the air heater.
12	Clutch position indicator lamp	Indicates the position of clutch (forward, neutral or reverse).	
	Starting location indicator lamp	Lights up to indicate the starting location. The engine can be started only at the location where the lamp grows. Wen the starting location indicator lamp indicates the engine room, you can not start in the steering room. Be sure to check this indicator lamp at startup.	

Table 2-1 About steering room instrument panel

No.	Name	Function
13	Alarm lamp	1. Engine oil pressure drop lamp Lights up when oil pressure decreases. Stop the engine immediately, and check the lubrication system. (Page 11-2) (Oil pressure switch operating pressure: 0.15 MPa{1.5 kgf/cm²}) 2. Coolant temperature rise lamp Lights up when the coolant (freshwater) temperature rises abnormally. If the lamp lights up, stop the engine after idling operation and take appropriate measures. (Thermo switch operating temperature: 98±2°C) 3. Charge warning lamp Lights up when there is abnormality in the charging system. Check the charging system if this lamp lights up. NOTE: This light normally illuminates for several seconds immediately after starting the engine. 4. Clutch oil pressure drop lamp Lights up when the clutch oil drops abnormally. Stop the engine immediately, and check the lubrication system. (Page 11-3) (Marine gear oil pressure switch operating pressure: 0.03 MPa {0.3 kgf/cm²}) 5. Oil pressure drop engine stop lamp When the engine oil pressure drops abnormally, the engine stops and the lamp lights up. (Oil pressure switch operating pressure: 0.10 MPa {1 kgf/cm²}) 6. Overspeed engine stop lamp When the engine overspeeds, the engine stops and the lamp lights up. (Overspeed trip set value: 1700 min⁻¹)

Engine Room Indicator and Alarm Panel

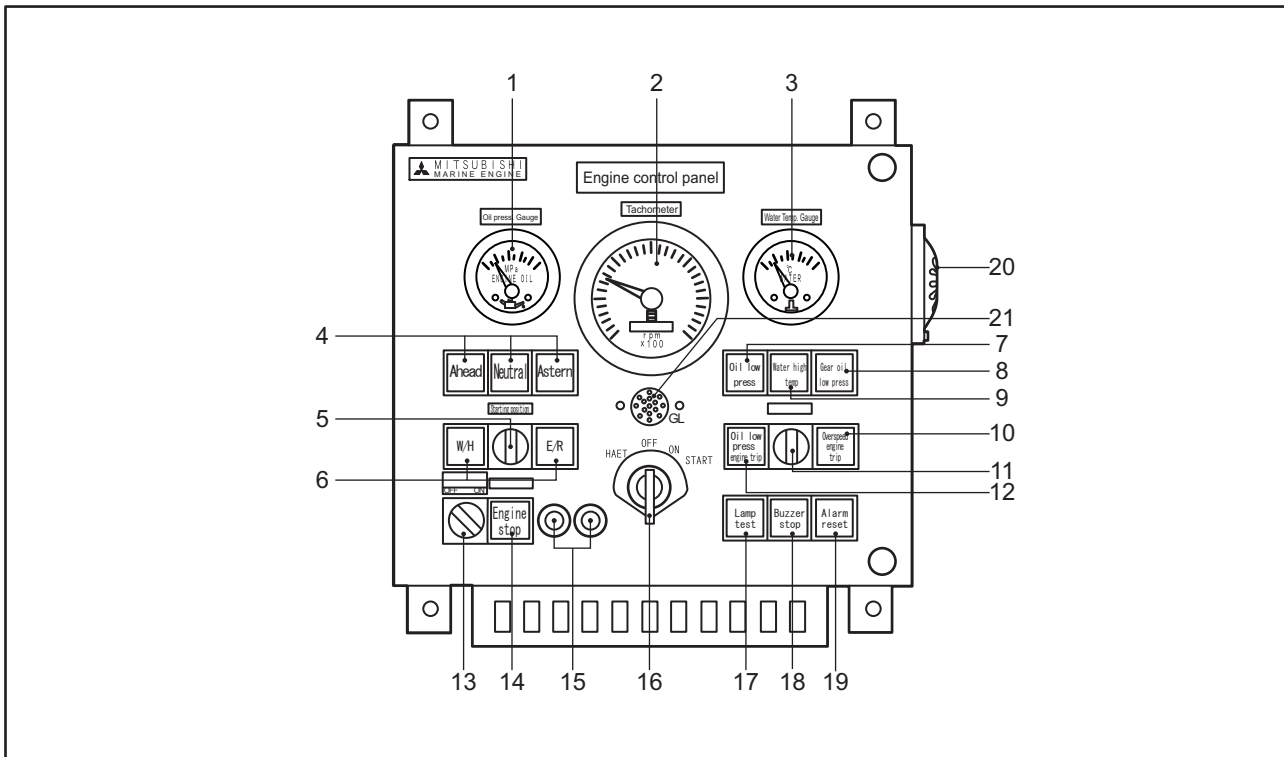


Fig. 2-19 Engine room instrument warning panel
Table 2-2 About engine room instrument warning panel

No	Name	Function
1	Lubricating oil pressure gauge	Indicates engine oil pressure.
2	Engine speedometer (tachometer)	Indicates the rotational speed of engine (RPM).
3	Coolant temperature gauge	Indicates the temperature of engine coolant (freshwater).
4	Clutch position indicator lamp	Indicates the position of clutch (forward, neutral or reverse).
5	Starting location selector switch	You can switch the location where you start the engine.
6	Starting location indicator lamp	Indicates the location (engine room or steering room) at engine start.
7	Engine oil pressure drop lamp	Same function as the alarm lamp on the steering room instrument panel.
8	Clutch oil pressure drop lamp	Same function as the alarm lamp on the steering room instrument panel.
9	High coolant temperature lamp	Same function as the alarm lamp on the steering room instrument panel.
10	Overspeed engine stop lamp	When the engine overspeeds, the engine stops and the lamp lights up.
11	Control power switch	By turning "ON", the power supply turns on and the engine room instrument panel functions.
12	Oil pressure drop engine stop lamp	When the engine oil pressure drops abnormally, the engine stops and the lamp lights up.
13	Engine stop cancellation switch	When set to "ON", the engine stops automatically when engine oil pressure decreases. When set to "OFF", the engine stop cancellation indicator lamp in the steering room instrument alarm panel lights up.
14	Engine stop button	Press this button to stop the engine.
15	Fuse	This is a fuse (10A) for control power supply circuit.

Table 2-2 About engine room instrument warning panel

No	Name	Function
16	Starter switch	Same function as the steering wheel instrument panel.
17	Lamp test, buzzer stop switch	Press to check that the alarm lamp lights up.
18	Buzzer stop switch	To stop the alarm buzzer sounding, press this switch.
19	Reset switch	Press "RESET" to start the engine again after an abnormal stop.
20	Buzzer	If a fault occurs, this alarm buzzer starts sounding at the same time the alarm lamp lights up.
21	Glow sign	Turn the starter switch to HEAT. When the air heater is heated, red glow sign is issued.

Using Manual Turning Gear



WARNING

Before starting the engine, make sure that the turning gear is pulled out. If the engine is started with the turning gear pushed-in, it not only damages the ring gear but also may result in personal injury.

1. Loosen two bolts, and remove the plate from the shaft groove.

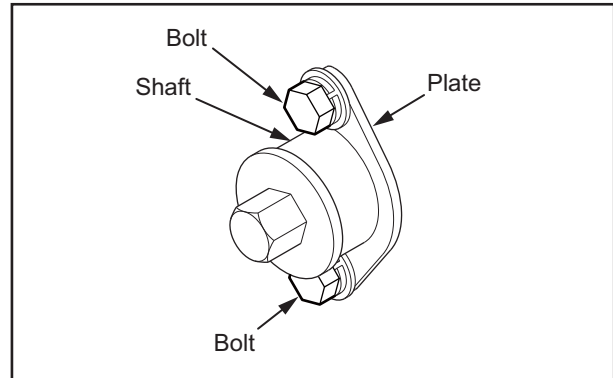


Fig. 2-20 Manual Turning Gear Position (During Operation)

2. Push the shaft fully to engage it with the ring gear.

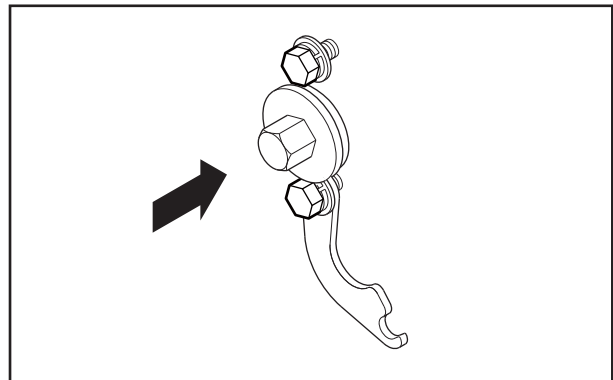


Fig. 2-21 Manual Turning Gear Position (When Pushing-In)

3. Using a socket wrench and a ratchet handle, turn the shaft.
4. After turning, pull out the shaft, insert the plate in the shaft groove, and tighten the bolts.



CAUTION

Make sure the plate is securely engaged in the shaft groove.

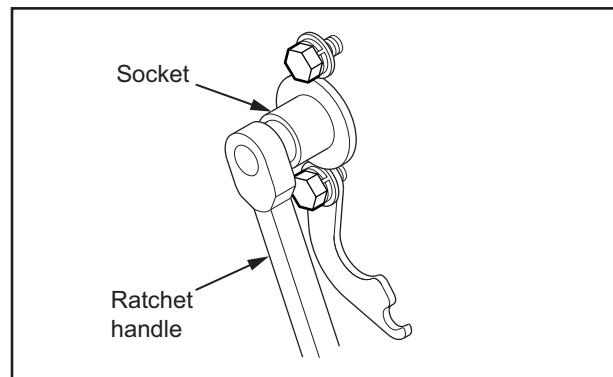


Fig. 2-22 Manual Turning Gear Position (When Turning Shaft)

Preparation for Operation of New or Overhauled Engine

Before proceeding with operation of a new or overhauled engine, conduct the inspections described in this section. Note that, for second operation onward, follow the instructions described in the "Normal Engine Operation" (3-8).

Preparation of Fuel System

⚠ CAUTION

When handling fuel, make sure there are no open flames or other fire hazards near the engine.
Wipe off any spilled fuel completely. It can cause a fire.

CAUTION

Do not remove the strainer during fuel tank filling.
For the fuel to be used, refer to "FUEL" (4-1).

1. Make sure the inside of the fuel tank and the fuel feed pipe to the engine are thoroughly clean.
2. Close the fuel tank drain valve.
3. Fill the fuel tank with fuel.
4. Remove the fuel feed pipe and check the discharged fuel for foreign substances such as dust.
5. Install the fuel feed pipe to the engine fuel inlet port.

Priming the Fuel System

⚠ WARNING

If fuel overflows from the air vent plug, wipe thoroughly with a cloth. Failure to do so may cause fire.

To bleed the fuel system, start from a position close to the fuel tank, that is, from the oil-water separator to fuel filter to fuel return pipe by feeding fuel using the priming pump.

Priming Pump - Operate

Move the priming pump handle up and down several times to feed fuel.

Note: Since there is no locking mechanism, it is not necessary to lock or unlock before and after bleeding.

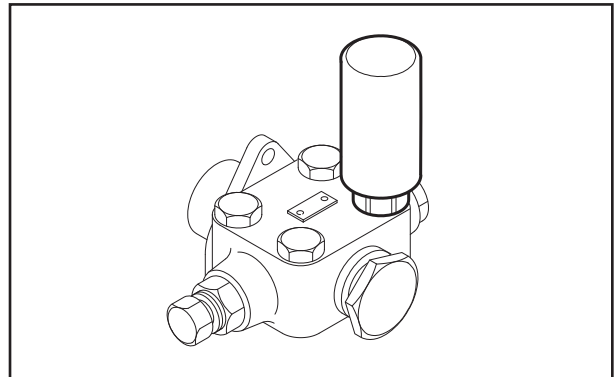


Fig. 3-1 Priming Pump

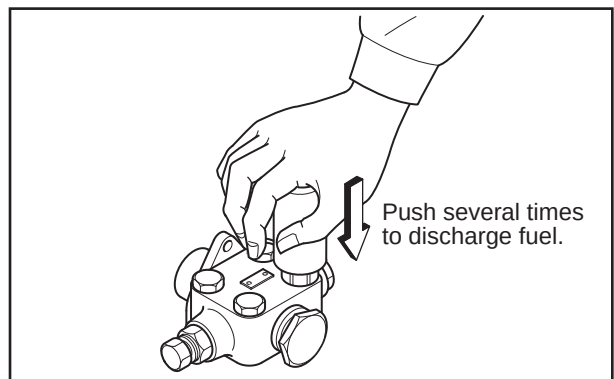


Fig. 3-2 Priming Pump - Operate

Fuel Filter - Bleed Air

CAUTION

If the air vent plug, thread of the bracket, or sealing washer is damaged, replace it with a new one.

1. Loosen the air vent plug of the fuel filter about 1.5 turns.
2. Move the priming pump up and down to feed fuel.
3. When the fuel from the air vent plug becomes free from air bubbles, stop priming and tighten the air vent plug to the specified torque.

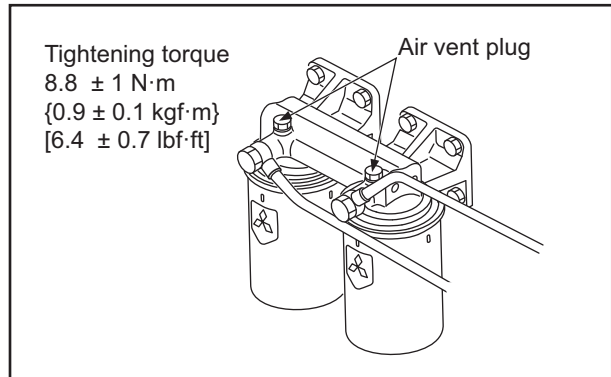


Fig. 3-3 Fuel Filter - Bleed Air

Fuel Injection Pump - Bleed Air

1. Loosen the air vent plug on the fuel injection pump by rotating about 1.5 turns.
2. Move the priming pump up and down. When the fuel from the air vent plug becomes free from air bubbles, stop priming and tighten the air vent plug.

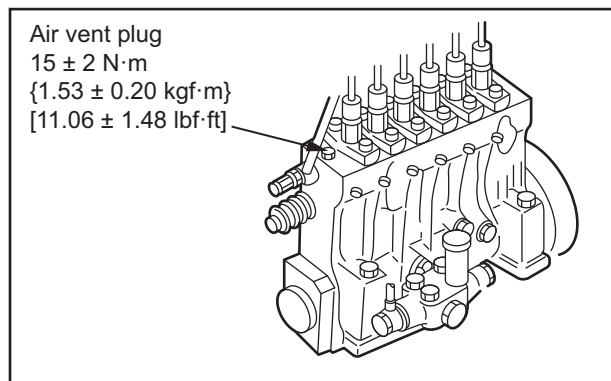


Fig. 3-4 Fuel Injection Pump - Bleed Air

Preparation of Lubrication System

Engine Oil - Filling

CAUTION

Refill the engine with the specified engine oil to the specified level. If the oil level is higher than the maximum mark on the level gauge, engine oil may blow out during operation. Also, the increase of oil temperature could adversely affect engine components.

1. Remove the oil filler cap.
2. Add the specified engine oil to the specified level.
Note: For engine oil, refer to **"ENGINE OIL" (5-1)**. For engine oil capacity, refer to **"MAIN SPECIFICATION" (12-1)**.

3. Remove the rocker cover of every cylinder, and pour engine oil to the valve mechanism and camshaft oil bath. Pour engine oil to the camshaft oil bath from cylinder head side.

Oil capacity per cylinder: 0.8 L [0.21 U.S. gal.]

4. Reinstall the rocker covers.
5. Check the oil level in oil pan as follows:
6. Pull out the oil level gauge and wipe it clean with a cloth.
7. Insert the oil level gauge fully into the oil level gauge guide and then pull it out again.
8. The oil level should be between the maximum and minimum marks on the oil level gauge. If the oil level is low, add the specified engine oil.
9. Check the oil pan, etc., for oil leaks. Repair if there is oil leak.
10. With the stop knob placed in pulled position, rotate the engine with starter for approx. 10 seconds to circulate oil to the whole engine. Stop the rotation for 1 minute, then, repeat the rotation two or three times to circulate the engine oil to each engine parts.

Note: Also perform the Preparation of Cooling System described below.

11. Start the engine and run under no-load and low-idling condition for 5 to 10 minutes.
12. Stop the engine, and after 30 minutes or more has elapsed, check the oil level with the oil level gauge again and add oil to the specified level.

For details, refer to **"Test Operation" (3-7)**.

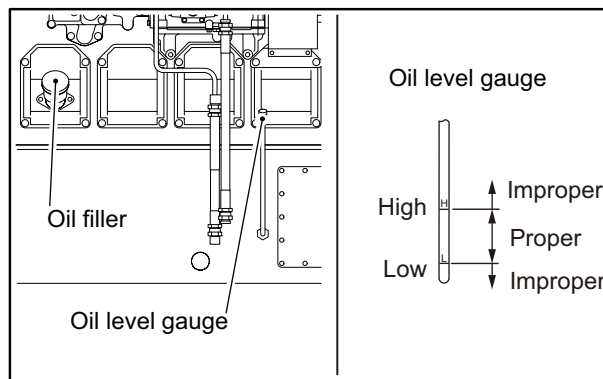


Fig. 3-5 Oil Filler and Oil Level Gauge

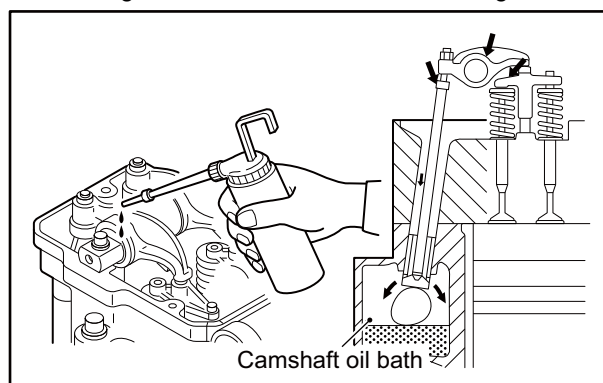


Fig. 3-6 Lubricating Valve and Cam Oil Bath

Preparation of Cooling System

Fresh Water Tank Cap - Open/Close

⚠ CAUTION

Never open the fresh water tank cap during the operation or immediately after stopping. Stop the engine and, after coolant has sufficiently cooled down, open the cap.

When opening the fresh water tank cap, raise the lever to the upright position to release internal pressure.

Do not open the fresh water tank cap when the engine is running or immediately after stopping. You can get burn yourself due to hot steam. To avoid a steam burn, wear thick rubber gloves or wrap a cloth around the cap.

When fastening the fresh water tank cap, be sure to tighten securely.

Stand the lever to the upright position to relieve pressure.

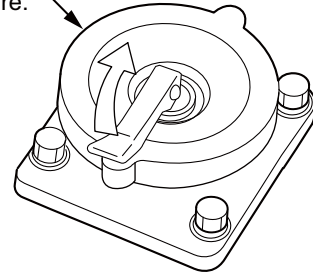


Fig. 3-7 Fresh Water Tank Cap

Coolant - Refill

CAUTION

When adding coolant, use the same LLC concentration coolant that is currently in the cooling system.

1. Close every coolant drain cock securely.
2. Open the coolant filler port and add a mixture of water and coolant having the specified concentration.

Note: (a) Determine the quantity of LLC based on the coolant capacity and the LLC concentration chart.

For the coolant, refer to "COOLANT" (6-1).

For the coolant capacity, refer to "MAIN SPECIFICATION" (12-1).

(b) For complete air bleeding, loosen the air vent plug on the upper section of thermostat.

3. Check the heat exchanger, etc. for coolant leaks. Repair if a leak is found.
4. When coolant reaches the specified level, close the fresh water tank cap securely.
5. With the manual stop lever placed in the pulled position, crank the engine for approx. 10 seconds using the starter. Stop for approx. 1 minute, then, repeat the cranking two or three times to bleed the cooling system.

Note: Perform this procedure after the preparation work for the lubrication and cooling systems have finished.

6. Check the coolant level.

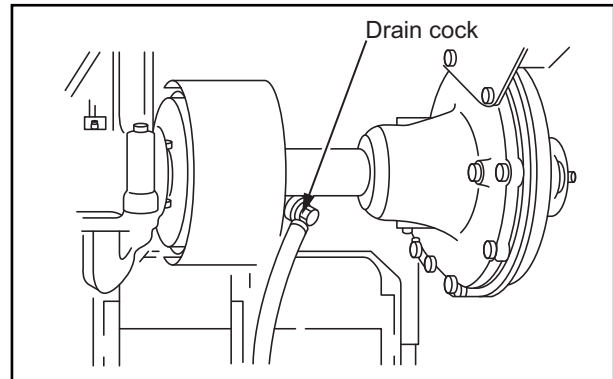


Fig. 3-8 Coolant Drain Cock (Engine Body)

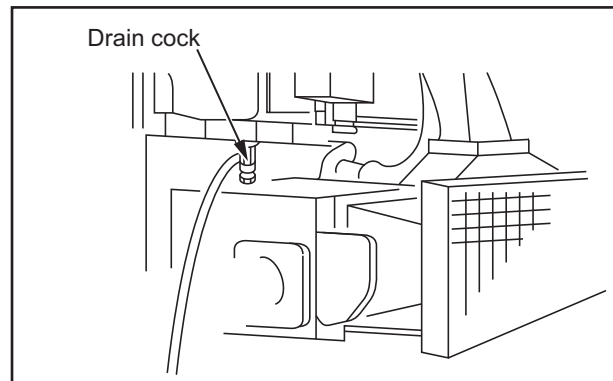


Fig. 3-9 Coolant Drain Cock (Fresh Water Tank)

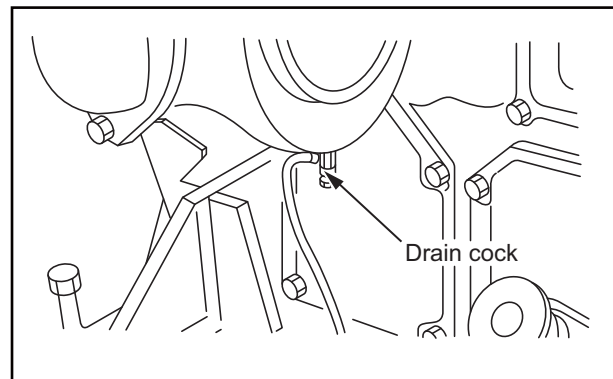


Fig. 3-10 Coolant Drain Cock (Water Pump)

Preparation of Electrical System

Battery - Check

⚠ CAUTION

Never use flames or allow sparks near the battery. The battery releases flammable hydrogen gas and oxygen gas. Any flames or sparks in the vicinity of battery could cause an explosion.

Do not use the battery when the battery fluid level is below the "LOWER LEVEL" mark. It may explode.

Do not short the battery terminals with a tool or other metal object.

When removing battery, always remove the plug from the negative (-) terminal first. When connecting battery, always connect the plug to the positive (+) terminal first.

Before charging the battery, remove all battery cables, and then charge the battery in a well ventilated area.

Make sure the cable clamps are securely attached to the battery terminals. A loose cable clamp can cause sparks, and it could result in an explosion.

Before servicing electrical components or conducting electric welding, set the battery switch to the [Open/OFF] position or remove the plug from the negative (-) terminal to cut off the electrical current.

Battery fluid contains dilute sulfuric acid. Careless handling of the battery may cause a sight loss and/or skin burns. Also, do not swallow the battery fluid.

Wear protective goggles and rubber gloves when working with the battery (e.g. when adding water or charging battery).

If battery fluid is spilled onto the skin or clothing, immediately wash it away with lots of water. Use soap to clean thoroughly.

The battery fluid can cause sight loss if splashing into the your eyes. If it gets into your eyes, immediately flush it away with plenty of clean water, and seek immediate medical attention.

If you accidentally swallow battery fluid, gargle with plenty of water and then drink lots of water, and seek immediate medical attention.

If the battery does not fully recover after charging for 24 hours or more, do not use the battery.

Note: If the specification of battery differs from those of this operation manual, follow the battery manufacturer's operation manual.

Battery Fluid Level - Check

The battery fluid evaporates during the use, and the fluid level gradually decreases. The proper fluid level is between the LOWER LEVEL (Lower limit) and UPPER LEVEL (Upper limit) marks.

For the battery without level marks, the proper fluid level is about 10 to 15 mm [0.39 to 0.59 in.] above the top face of the polar plates.

If the battery fluid level is low, remove the cap, and add distilled water to the proper level.

Note: When adding distilled water, add little by little.

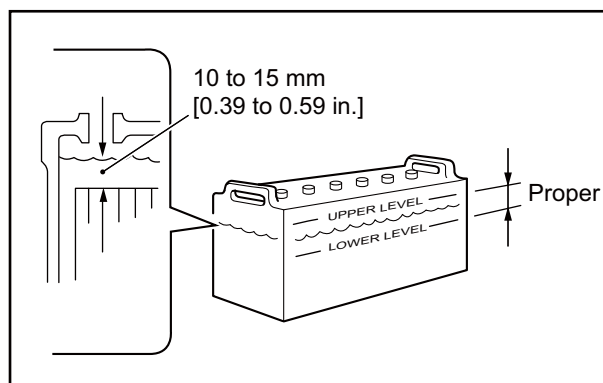


Fig. 3-11 Battery Fluid Level - Check

Test Operation

To conduct the test operation, follow the procedures below.

Note: For engine operation, refer to "Normal Engine Operation" (3-8).

Start and Stop

1. Start the engine.
2. Operate the engine at a low idling speed under no load for 5 to 10 minutes for warm-up.
3. Stop the engine.

Inspection

CAUTION

Never open the fresh water tank cap during the operation or immediately after stopping. Stop the engine and after coolant has sufficiently cooled down, open the cap.

When opening the fresh water tank cap, raise the lever to the upright position to release internal pressure.

Do not open the fresh water tank cap when the engine is running or immediately after stopping. You can get burn yourself due to hot steam. To prevent burn injuries from hot steam, wear thick rubber gloves or wrap a cloth around the cap.

When fastening the fresh water tank cap, be sure to tighten securely.

CAUTION

When adding coolant, use the same LLC concentration coolant that is currently in the cooling system.

1. Stop the engine for about 30 minutes.
2. During this period, walk around the engine to check for leaks of fluids such as fuel, engine oil, or coolant.
3. When 30 minutes has passed since the engine stop, check the oil level with the oil level gauge.
4. If the oil level is low, add engine oil from the oil filler port. Be sure to use the engine oil of the same brand and type.
5. Check the coolant level in the coolant expansion tank with the level gauge.
6. If the coolant level is low, add coolant to the specified level.

Normal Engine Operation

This section covers the procedures for the engine operation in normal condition.

CAUTION

If an engine abnormality is observed during operation, stop the engine and correct the problem, or contact your MHIET dealer.

Pre-operation Inspection

Always conduct daily pre-operation inspection before starting the engine for the day.

Engine Exterior - Inspect

CAUTION

Check external parts of the engine, particularly hot parts (exhaust manifold and others), or the battery for accumulation of flammable materials. Also, check leaks of fuel and engine oil. Remove dust from the top surface of the battery. If hot parts have a problem, it may cause a fire. If any abnormality is found, be sure to repair or contact your MHIET dealer.

Inspect the engine exterior as instructed below:

1. Make sure there is no combustible material near the engine or battery. Also, check to make sure that the engine and battery are clean. If combustible materials or dust are found near the engine or battery, remove them.
2. Make sure fluids, such as fuel, oil, and coolant, are not leaking from the engine. If a leak is found, repair the leak, or contact your MHIET dealer.
3. Walk around the engine and check bolts and nuts for looseness.
4. Check electric wiring for disconnection, looseness, cuts, or rubbing.
5. Make sure the following valves, plugs, or cocks are properly positioned as indicated below:
 - Fuel feed valve: open
 - Coolant drain cock (valve): closed
 - Engine oil drain plug: closed

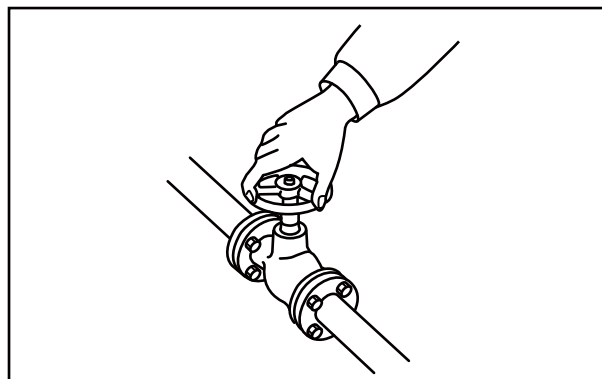


Fig. 3-12 Valve Open/Closed Position - Check

Fuel Tank Oil Level - Check



WARNING

Make sure that there is no open flame in the vicinity before handling fuel.

Wipe off any spilled fuel completely. It can cause a fire.

CAUTION

Do not remove the strainer during fuel tank filling.

For the fuel to be used, refer to ["FUEL" \(4-1\)](#).

Make sure that the fuel tank is filled to the specified level.

If the fuel level is low, add fuel to the "FULL" level.

Note: If the specification of fuel tank differs from the contents in this operation manual, follow the fuel tank manufacturer's operation manual.

Fuel Control Link - Check

Push the manual stop lever to the direction of fuel increase, and make sure that the fuel control link moves smoothly. Then, gradually loosen the lever, and make sure the manual stop lever returns smoothly to the engine stop position (fuel non-injection position).

Also, check all ball joints for looseness and play.

Engine Oil Level - Check

CAUTION

Refill the engine with oil to the specified level. If the oil level is higher than the maximum mark on the level gauge, engine oil may blow out during operation. Also, the rise of oil temperature could adversely affect engine components.

When adding engine oil, use the same oil that is used in the engine.

1. Stop the engine and leave it for 30 minutes or more.
2. Pull out the oil level gauge and wipe oil off from the oil level gauge using a clean waste cloth.
3. Insert the oil level gauge fully into the oil level gauge guide and then pull it out again.
4. The oil level should be between the maximum and minimum marks on the oil level gauge. If the engine oil level is higher than the high mark on the oil level gauge, drain the oil. If the oil level is low, add the specified engine oil.

For draining engine oil, refer to "Engine Oil - Drain" (8-10). For refilling engine oil, refer to "Engine Oil - Refill" (8-11).

5. Install the oil filler cap after engine oil is refilled.
6. Check the oil pan and others for oil leaks.

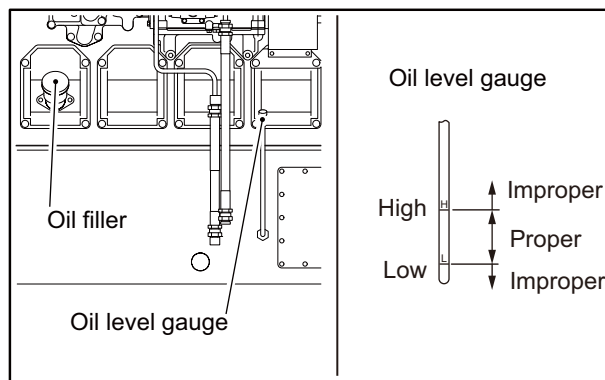


Fig. 3-13 Oil Filler and Oil Level Gauge

Coolant Level - Check



WARNING

Never open the fresh water tank cap during the operation or immediately after stopping. Stop the engine and after coolant has sufficiently cooled down, open the cap.

When opening the fresh water tank cap, raise the lever to the upright position to release internal pressure.

The coolant is hot while the engine is running and immediately after the engine stops. Do not open the cap when the coolant is hot to prevent accidental burns due to hot steam and boiling water. To prevent burn injuries from hot steam, wear thick rubber gloves or wrap a cloth around the cap.

When fastening the fresh water tank cap, be sure to tighten securely.

CAUTION

When adding coolant, use the same LLC concentration coolant that is currently in the cooling system.

1. Check the coolant level in the fresh water tank with the level gauge.
2. If the coolant level is low, add coolant to the specified level.

Note: (a) Determine the quantity of LLC based on the coolant capacity and the LLC concentration chart.

(b) For coolant, refer to ["COOLANT" \(6-1\)](#).

Stand the lever to the upright position to relieve pressure.

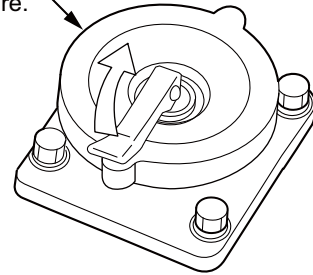


Fig. 3-14 Fresh Water Tank Cap

Coolant level gauge (Should be full level.)

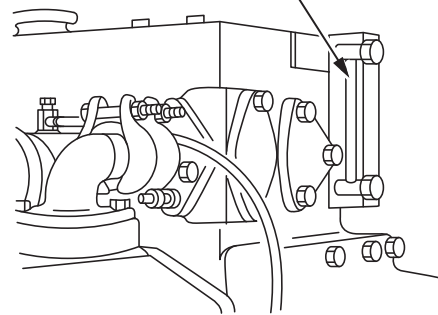


Fig. 3-15 Coolant Level - Check

Warning Indicator Light - Operation Check

1. Turn the starter switch to the "ON" position.
2. Turn the light test switch to "ON" position.
3. Make sure the lights come on. If any of the lights does not come on, check the light bulbs, etc. on the instrument panel.

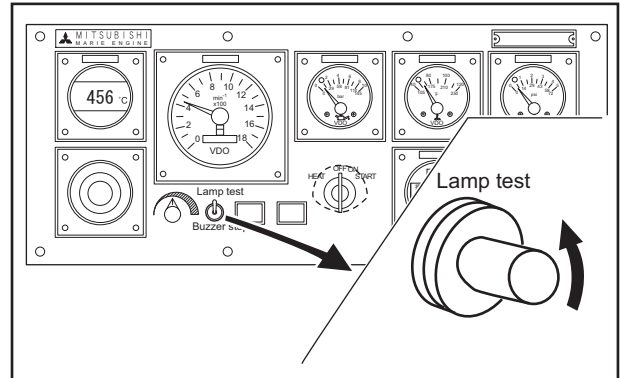


Fig. 3-16 Warning Indicator Light - Operation Check

Control Cable - Check

Check the visual appearance of control cable for flaws, deformation, discoloration, abnormal rust, etc.

Control Lever - Operation Check

Operate each lever and make sure that levers move smoothly without any looseness or restriction.

Operate the speed control lever from L (low-speed rotation) to H (high-speed rotation) and to L (low-speed rotation) position to make sure the operation of lever.

Operate the direction lever, and make sure the position of marine gear for "Forward", "Neutral," and "Reverse."

Start-up

Cautions When Starting

WARNING

Before starting the engine, check to make sure no one is near the engine and that tools are not left on or near the engine. Also alert people in the area when starting the engine.

CAUTION

Continuous operation of the starter will drain the battery power and cause the starter to seize. Do not use the starter for more than 10 seconds at a time. When the engine does not start, wait for more than 1 minute before cranking again.

Restart the engine after it stops completely.

Check fuel system if the engine will not start after repeating above step three to five times.

DO NOT turn the switch to "START" or "OFF" position during operation.

When the engine is not operated for a long time (one week or more), rotate the crankshaft for 10 seconds with the starter while pulling the manual stop lever. Repeat this three times with 30-second intervals between each rotation to circulate oil through the engine.

Pre-heating during cold weather should be performed within the specified time given below.

If pre-heating specified time is exceeded, it could decrease battery capacity faster, or shorten the life of air heater.

Table 3-1 Pre-heating Time in Cold Climates (Air Heater)

Ambient temperature	Preheating time
-5°C to -15°C [23°F to 5°F]	20 to 40 seconds
-15 °C to -30°C [5°F to -22°F]	40 to 60 seconds

Starting Procedures

CAUTION

For engine oil to be used, refer to "ENGINE OIL" (5-1).

1. Pull out the oil level gauge and wipe it clean using a cloth.
2. Insert the oil level gauge fully into the oil level gauge guide, then pull out the gauge again.
3. The correct oil level is between the MAXIMUM and MINIMUM marks on the oil level gauge.
4. If the oil level is low, remove the oil filler cap and add engine oil of the specified type to the MAXIMUM level.
5. Refasten the oil filler cap after refilling.
6. Check the oil pan and other area for oil leaks.

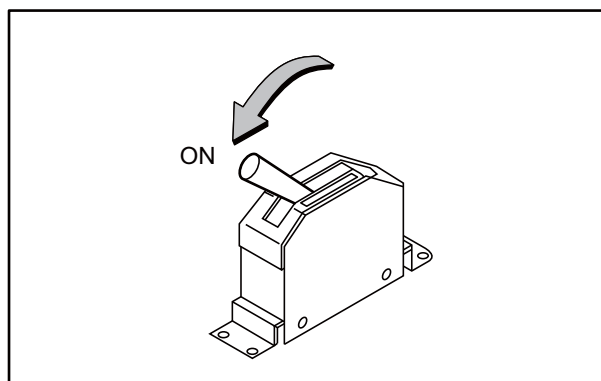


Fig. 3-17 Oil filler and oil level gauge

Warm-up Operation

WARNING

Stay away from rotating parts during operation. If you are caught in rotating parts, you can be seriously injured.

CAUTION

Do not conduct warm-up operation for extended periods of time. Carbon deposits accumulate in the cylinder and may cause faulty combustion.

During warm-up operation, avoid an overload operation (if overloaded, black smoke is exhausted). Overload operation causes not only excessive fuel consumption but also excessive carbon deposits inside the engine. Carbon deposits cause various problems and will shorten the service life of the engine.

Engine Oil Pressure - Check

During warm-up operation, make sure the engine oil pressure is within the specified range.

Also, make sure the oil pressure gauge is working properly.

Note: The oil pressure gauge reading may be higher than normal immediately after the engine starts due to the low oil temperature. The pressure gradually lowers to the normal level as the oil temperature rises.

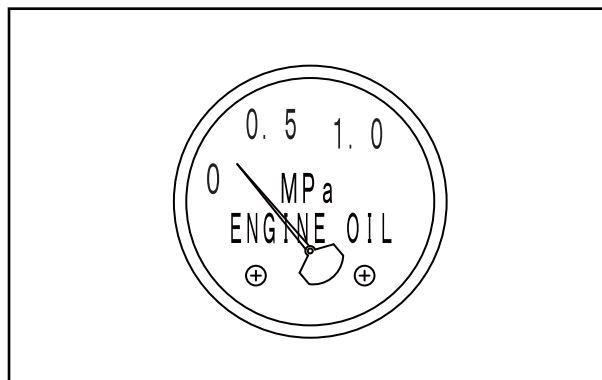


Fig. 3-18 Oil Pressure Gauge

Engine - Walk Around Check

Visually inspect the engine for external damage, abnormal noise, odor, vibration, and exhaust gas color, and then inspect for fuel, engine oil, coolant, or exhaust gas leaks from joints during warm-up operation.

Marine Gear Oil Level - Check

1. Pull out the oil level gauge during low idle operation, and wipe the gauge with a clean cloth.
2. Insert the oil level gauge fully into the oil level gauge guide and then pull it out again.
3. The oil level shall be between the maximum and minimum marks on the oil level gauge.
4. If the oil level is low, stop the engine, remove the filler cap, and add the specified oil to the specified level.
5. Check oil leaks from marine gears, etc.

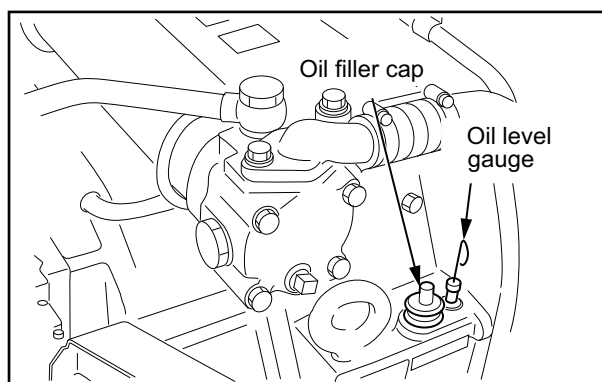


Fig. 3-19 Marine Gear Oil Filler Cap and Oil Level Gauge

Operation

Precautions in Engine Operation

Operate the Clutch Carefully

CAUTION

When shifting (operating clutch) between neutral and forward, and between neutral and reverse, make sure the engine speed is at a lower speed.

The marine clutch can be damaged if the gear (clutch) is shifted between forward and reverse while the engine is operating at high speed.

Do Not Leave the Clutch in a Half-Engaged Position

CAUTION

When shifting the marine gear clutch, be sure to securely place the clutch in the correct position, either F (Forward), R (Reverse) or N (Neutral). If the clutch lever is not firmly engaged in one of those positions, there is a risk for wearing or burning of clutch plates by slipping.

Pay Attention to Gauges and Warning Lights

CAUTION

If a gauge shows an abnormal indication or a warning light illuminates (buzzer is also activated), run the engine at idling speed, then stop the engine. After the engine stops, inspect the engine for abnormalities.

Pay Attention to Abnormal Noise

CAUTION

If the engine produces an abnormal sound during operation, stop the engine and check for the cause of noise. Continued operation can result in an unexpected accident.

Pay Attention to Exhaust Color

CAUTION

If the exhaust gas shows an abnormal color, there is a problem in the engine. Stop the engine and inspect the engine by referring to the TROUBLESHOOTING section to locate, and correct the problem.

Avoid Operating the Engine at a Speed Which Causes Resonance

CAUTION

Depending on various factors such as the ship structure, engine frame rigidity, and propeller shaft length, the engine can cause amplified vibrations. Do not operate the engine at a resonance-generating speed.

Pay Attention to Seawater Discharging Volume

CAUTION

If seawater does not circulate properly, overheating and other problems can occur. Record the amount of seawater discharged in normal operation, and regularly check the amount of discharged seawater to judge if it is normal.

Check to see if the kingston valve, seawater strainer, etc. are clogged with dust or plastic particles.

Check to see if the seawater pump impeller is damaged.

Limitation of Continuous Under Light Load Operation

CAUTION

Allowable minimum load during continuous operation: Operate with 30% or more of the rated output. Allowable continuous operation time with a load factor of 30% or less of the rated output: Limit the operation within one hour. Operate with a load factor of 50% or more for 30 minutes or more after continuous operation with 30% or less of the rated output is conducted.

The following problems may occur when light load operation is conducted beyond the above allowable range:

- Fuel and/or oil leak from the exhaust system
- Carbon build-up on the cylinder head and exhaust pipe
- Sulfuric acid corrosion
- Dilution
- Generation of blue-white smoke (mainly during low idle operation)

Stopping

Cautions When Stopping

CAUTION

Do not stop the engine abruptly during high-speed operation or while engine is hot. Otherwise, the engine life will be shortened. Except in a case of emergency, operate the engine at low idle speed for 5 to 6 minutes to cool the engine before stopping. Then check the engine for abnormalities.

Do not race the engine immediately before shutdown.

Do not start the engine immediately after abnormal stop. If the engine stops with a warning buzzer, be sure to locate causes of problem and correct the problem before starting the engine again. After starting operation, check the engine for abnormalities again. If an abnormality is found, repair it immediately.

When stopping the engine by pushing the stop button, keep pushing the button until the engine stops completely. If not, the engine may start again.

Stopping Procedure

1. Place the direction lever in the neutral "N" position.
2. Before stopping, run the engine at low idle for 5 to 6 minutes to cool the engine.
3. Press the engine stop button on the instrument panel to stop the engine.

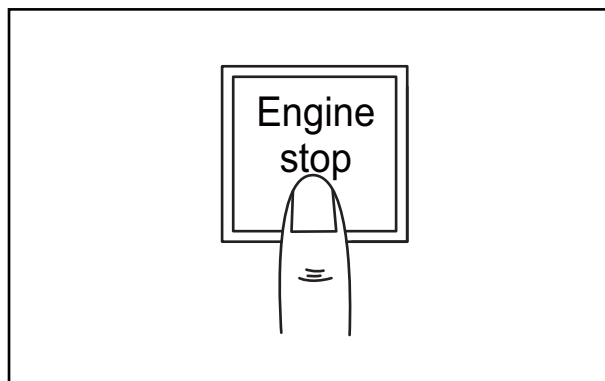


Fig. 3-20 Engine Stop Button

4. Turn the starter switch to the "OFF" position.

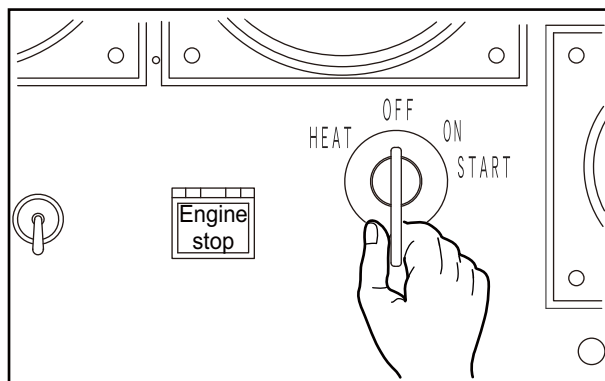


Fig. 3-21 Starter Switch "OFF"

5. The stop solenoid is placed in "OFF" position, then turn the battery switch to the "OFF" position.
6. Close the Kingston valve.

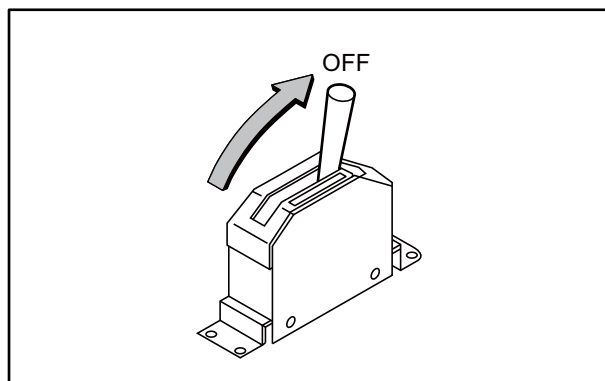


Fig. 3-22 Battery Switch "OFF"

Trolling Operation

Conditions of Use for Trolling Operation

The oil sampling pump is reusable, but oil sampling bottle and suction pipe must be replaced each time.

For replacing tools, order them through the regular part supply system. The analysis fee is included in the price of the sampling bottle.

Therefore, if you sample the oil in other bottles, you will not receive our analysis service.

Also, note that optional analysis requires additional charge.

Table 3-2 Rotational Speed Control Range
(Marine Gear MGN90BLX)

Specified engine rotational speed (min ⁻¹)	Reduction ratio	Rotational speed control range (min ⁻¹)
600	2.51	50 to 210
	3.06	50 to 175
	3.48	50 to 155
	3.93	50 to 135

Trolling Operations



CAUTION

Be sure to conduct trolling operation once per day. If not used for extended period of time, malfunction may occur due to clogging of trolling hydraulic circuit.

After required speed is obtained by trolling operation, lock the trolling lever to prevent it from moving due to vibration.

When Trolling Device is Not Used

The trolling lever is fixed securely at the factory. Keep it as it is.

Recommended Fuel



WARNING

Use the fuel specified in this manual only. Also, do not refill the fuel tank more than the specified level. It could lead to a fire.

Use a fuel that meets the requirements in the following [Table 4-1](#) of [Recommended Fuel](#) and [Table 4-2](#) of [Recommended Limit and Service Limit for Fuel Properties](#).

It is necessary to use fuel that has a pour point suitable for the ambient temperature.

Note: Please use the fuel that meets the laws and regulations of the country or region where the engine is used, if the laws and regulations are applied.

Table 4-1 Recommended Fuel

Standard	Classification
ISO 8217	DMX-CLASS
ASTM D975	No. 1-D, No. 2-D
BS 2869	CLASS A1, CLASS A2
DIN 51601	DIESEL-FUEL
JIS K2204	TYPE 1, TYPE 2, TYPE 3
EN 590	DIESEL-FUEL

Handling Fuel

When using fuel that is stored in a storage tank, leave it for more than 24 hours to settle dust and water at the bottom, and drain them. Use the upper clean fuel.

Fill up the fuel tank or service tank at the end of each operation.

This prevents water from mixing with fuel in the tank, and also gives time for dust and water to separate and settle at the bottom of the tank.

When refilling, clean the areas around the caps of drum and tank thoroughly before removing the caps. Also clean your hands and the hose before refueling. When using a hand-operated pump, be careful not to pump water or sediment accumulated at the bottom of the storage tank.

Be sure to use a strainer when filling the fuel tank. Use clean cloth to filtrate the fuel to reduce the contaminants such as dust.

Fuel Quality Standard

Use a fuel which meets the requirements specified in the table below.

Table 4-2 Recommended Limit and Service Limit for Fuel Properties

Item		Recommended limit	Service limit	Test standard
Flash point		Diesel fuel 50°C[122°F] or higher (Base on fuel handling regulations.)		JIS K2204 JIS K 2205 JIS K 2265: 2007 ISO 3679 ISO 2719
Distillation properties	Initial boiling point	170°C [338 °F] or higher		JIS K 2254: 1998 ISO 3405
	90 % distillation temperature	330 to 380°C [626 to 716°F]		
Pour point (PP)		Lower than the ambient temperature by 6°C[10.8°F] or more		JIS K 2269: 1987 ISO 3016
Cloud point (CP)		Ambient temperature or below		JIS K 2269: 1987 ISO 3015
Cold filter plugging point (CFPP)		Lower than ambient temperature by 3°C [5.4°F] or more		JIS K 2288: 2000 IP 309/96
Carbon residue (10 % residual oil)		0.4% or lower by weight	1.0% or lower by weight	JIS K 2270: 2000 ISO 6615, ISO 10370
Cetane number		45 or more *1	45 or more	JIS K 2280: 1996 ISO 5165
Cetane index (new method)		45 or more		JIS K 2280: 1996 ISO/DIS 4264
Kinetic viscosity		2.0 mm ² /s or higher (30°C)8.0 mm ² /s or lower (50°C)		JIS K 2283: 2000 ISO 3104
Sulfur content		0.2% or lower by weight	1.0% or lower by weight (Shorten the engine oil change intervals.) *2	JIS K 2541: 2000 ISO 4260, ISO 8754. It is preferable that sulfur contents is as low as diesel fuel.
Water content and sediments		0.1% or less by volume		JIS K 2275: 1996 ISO 3733
Ash content		0.01% by weight or lower	0.03% by weight or lower	JIS K 2272: 1998 ISO 6245
Copper corrosion (3 hrs at 50 °C [122 °F])		Discoloration = Copper plate No. 3 or less (deep discoloration)		JIS K 2513: 2000 ISO 2160
Density at 15 °C [59 °F]		0.83 to 0.87 g/cm ³ [51.82 to 54.31 lb/ft3]	0.80 to 0.87 g/cm ³ [49.94 to 54.31 lb/ft3]	JIS K 2249: 1995 ISO 3675
Caulking	24 hrs at 250°C[482°F]	Carbonization 75% or less	Carbonization 80% or less	Fed 791B
	24 hrs at 230°C [446°F]	Carbonization 55% or less	-	
	48 hrs at 180°C [356°F]	Tar-free	-	
Aromatics substances (by HPLC)		38% by volume or less (total of aroma)		JIS K 2536: 2003 ISO 3837
Polycyclic aromatic content		8% or lower by volume		
Asphaltene		0.1% by weight or lower		-
Fine foreign substances (foreign substances at fuel inlet)		10 mg/L or less		JIS B 9931: 2000 ISO 4405

Table 4-2 Recommended Limit and Service Limit for Fuel Properties

Item	Recommended limit	Service limit	Test standard
Lubricity: MWSD (Measured mean Wear Scar Diameter) by HFRR wear test at 60 °C [140 °F] fuel temperature	460 µm or less (calculated wear scar diameter at WS 1.4 kPa {0.0143 kgf/cm ² } [0.2031 psi])	-	ISO 12156-1
BDF: Biodiesel fuel (FAME: Fatty Acid Methyl Ester)	BDF quality shall meet JIS K 2390, EN14214, or ASTM-D6751 5% or lower by weight	-	JIS K 2390:2008 (FAME standard for mixing) ASTM D 6751

*1: Cetane index (JIS K 2280) substitutes. When the fuel which satisfies the service limit of cetane number is not available with some inevitable reasons, the use of cetane booster is allowed. However, this is allowed only for the period before getting the fuel which satisfies the service limit after consulting with the fuel supplier and the manufacturer of cetane booster, and at the customer's own risk.

The additive rate of 0.5% or less of cetane booster, and the lube oil analysis at every 125 hours are recommended.

High concentration of additive may cause metal elusion, rubber material infiltration, increased load in high-load operation, and acceleration of lube oil deterioration.

- Brand examples of cetane number improver HITEC 4105K (Made by Afton Chemical)

*2: If the sulfur content of using fuel is higher than 0.2% by weight, use the engine oil specified in "5 ENGINE OIL".

Use Recommended Engine Oil Only

CAUTION

Use the engine oil recommended in this manual only. Do not use any other oil.

The use of inappropriate or inferior oils will result in sticking of piston rings, seizure between piston and cylinder, or premature wear of bearings and moving parts, and significantly shorten the service life of the engine.

Use only MHIET genuine engine oil for the engine. If you have to use an oil other than MHIET genuine oil, check the engine oil grade, and use only the oil that meets our quality standard. Furthermore, conduct the analysis of oil to review the oil replacement intervals. MHIET disclaims the warranty claim for malfunctions due to the use of engine oil that does not meet our quality standard.

Genuine MHIET Engine Oil

Mitsubishi Heavy Industries Engine & Turbocharger, Ltd. offers the best suited oils, which yielded from many test, to Mitsubishi marine engines. We highly recommend the use of our genuine engine oil. For marine engine, "JUKOIL New Mariner 15W-40 or 30" are available.

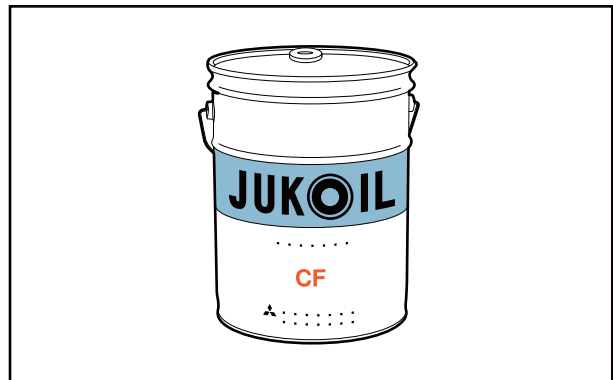


Fig. 5-1 JUKOIL New Mariner

Other Commercial Engine Oils

CAUTION

Never mix different brands of engine oil with genuine MHIET oil. Mixing different brands of engine oil may cause a chemical reaction of additives in the engine oil that could degrade the engine oil quality.

For the engine oil quality, there are oil standards that are established through special engine tests based on the engine specifications and operating conditions. Among those standards, API (American Petroleum Institute) service classifications are mostly used to classify engine oils. The SAE standard specifies the viscosity only, while the API service classification indicates the quality level of engine oil.

Several kinds of diesel engine oils are specified. The recommended oils are API service classification CF or CH-4 grade oils which are suitable for highly super-charged and loaded engines.

When using the CF grade engine oil, the certified year must be the year of 2009 or before and the oil must meet the requirements listed in the Table 5-1, Recommended Limit of Engine Oil Properties.

If 0.2% or less sulfur content fuel is used in the engine, CF or CH-4 grade oil can be used. However, the oil must have base value of 8.0 mg KOH/g or higher by Hydrochloric acid method.

If measured by the perchloric acid method, the total base value must be 11.0 mg KOH/g or more.

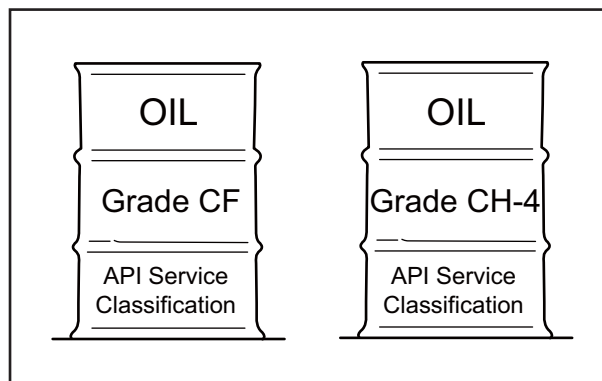


Fig. 5-2 Engine Oil Grade

Engine Oil Quality Standard

Use engine oil that meets the requirements specified in the table below.

Table 5-1 Recommended Limits for Engine Oil Properties

Item			Unit	Recommended property value	Test method	
API/JASO standards				Grade CF *1	-	
SAE viscosity			-	15W-40	-	
ASTM Color			-	L4.0	JIS K 2580 ISO 2049	
Density		15°C [59°F]	g/cm ³	0.87 to 0.90 [54.3123 to 56.187]	JIS K 2249 ISO 3675 ISO 3838 ISO 649-4 ISO 91-1	
Kinetic viscosity		40°C [104°F]	mm ² /s	100 to 110 [3.94 to 4.33]	JIS K 2283 ISO 3107 ISO 2904	
		100°C [212°F]		13.5 to 15.5 [0.532 to 0.610]		
Viscosity index			-	-	JIS K 2283 ISO 3107 ISO 2904	
Flash point			°C	225 to 250 [437 to 482]	JIS K 2265 ISO 3679 ISO 2719 ISO 2592	
Base number	Hydrochloric acid method	Sulfur content in fuel	1.0% by weight or lower	mg KOH/g	10 or higher (up to 13)	JIS K 2501 ISO 3771 ISO 6618 ISO 6619 ISO 7537
			0.2% by weight or lower		8 or higher (up to 13)	
	Perchloric acid method	Sulfur content in fuel	1.0% by weight or lower	mg KOH/g	13 or higher (up to 16)	
			0.2% by weight or lower		11 or higher (up to 16)	
Acid number			mg KOH/g	1.5 to 2.0	JIS K 2501 ISO 3771 ISO 6618 ISO 6619 ISO 7537	
Sulfur content			%	0.5 or less	JIS K 2541 ISO 4260 ISO 8754	
Sulfuric acid ash			%	2.0 or less	JIS K 2272 ISO 3987 ISO 6245	
Carbon residue content			%	2.0 or less	JIS K 2270 ISO 10370 ISO 6615	
High temperature shear viscosity		150°C[302°F]	mPa·S	3.7 or more	JPI-5S-36-91	
Pour point			°C	-25 or lower	JIS K 2269 ISO 3015 ISO 3016	

Table 5-1 Recommended Limits for Engine Oil Properties

Item		Unit	Recommended property value	Test method
Bubbling test *2	I	mL	10/0	JIS K 2518 ISO 6247
	II		30/0	
	III		10/0	
Panel coking test *3	300°C [572°F]	mg	140 or less	FED791-3462
	325°C [617°F]		300 or less	

*1: API CF grade oil certified in the year of 2009 or before.

*2: I test temp. (24°C [75°F]), II test temp. (93.5°C [200°F]), III test temp. (24°C [75°F] after 93.5°C [200°F])

*3: Aluminum panel temp = 300°C [572°F] and 325°C [617°F], lubrication oil temp = 100°C [212°F], splashing time = 15 seconds,

Interval = 45 seconds, test time = 8 hours, and the property is the solid mass accumulated on the panel.

Selection of Oil Viscosity

Use the chart on the right to select the appropriate oil viscosity according to the ambient temperature.

Excessively high oil viscosity causes power loss and an abnormal rise of oil temperature, while excessively low oil viscosity accelerates wear and causes gas leak from the cylinder due to inadequate lubrication, and also causes a decrease in engine output.

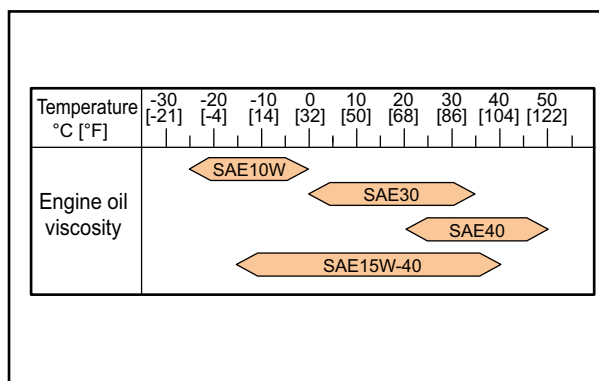


Fig. 5-3 Selection of Oil Viscosity

Handling Engine Oil

WARNING

Before filling the engine with engine oil, stop the engine and make sure there is no open flame in the vicinity. If oil is spilled or leaked on hot surfaces or electrical components, it could cause a fire. Wipe off any spilled oil immediately and thoroughly. After filling oil, securely close the filler cap.

When handling a large amount of engine oil more than the legally specified quantities, be sure to have the work performed in a service station operated under the provision of the law. When draining oil from the engine or oil can, be sure to use an oil pump.

Tighten the oil can cap securely.

Store the oil can in a well-ventilated place and out of direct sunlight.

Be sure to obtain the SDS of the engine oil and follow the instructions in the SDS.

Marine Gear Oil

CAUTION

For marine gear oil, use SAE 30 single grade oil. Do not use multi-grade oil.

The use of multi-grade oil results in harmful effect on marine gears.

The marine gear oil serves as lubricant as well as clutch hydraulic oil. Use the oil that has high stability against temperature changes, acid resistance, and excellent water resistance. Also the oil must have no harmful effect on the materials of gears and clutch plates.

Use SAE 30 single grade oil as marine gear oil. Do not use multi-grade oil. The additive contained in the multi-grade oil reduces friction characteristics of the clutch plate.

Tighten the cap of marine gear oil can firmly.

Store the oil can in a well-ventilated place and out of direct sunlight.

Be sure to obtain the SDS (Safety Data Sheet) of the marine gear oil and follow the instructions of the SDS.

Service Limits for Engine Oil

Engine oil degrades through the use and by the lapse of time. The quality of engine oil and the operating condition of the engine have influence on deterioration of the engine oil. Change the engine oil in accordance with Chapter 7 PERIODIC MAINTENANCE CHART. However, only when the engine oil analysis result allows, the oil change intervals can be extended. The limit of extended oil change interval is 500 hours. For the determination of engine oil properties degradation, see the table below. If any of oil properties exceeds the limit, change the engine oil with new oil.

Table 5-2 Engine Oil Properties

Properties		Standard value		Test standard
Kinetic viscosity	mm ² /s@100°C	For main engine/main generator	+30% or less rate of change from new oil 10 mm ² /s or more	JIS K 2283:2007 ISO 3107 ISO 2909
		For emergency generator	+30% or less rate of change from new oil -20% or less rate of change from new oil	
Base number	mgKOH/g	2.0 or more with hydrochloric acid (HCL) method 1/2 of new oil or more by perchloric acid (PCA) method		JIS K 2501: 2003 ISO 3771
Acid number	mgKOH/g	+3.0 or less of new oil		JIS K 2501: 2003 ISO 3771
Water content	% by volume	0.2 or less		JIS K 2275: 1996 ISO 9029
Flash point (open cup)	°C	180 or higher		JIS K 2265:2007 ISO 3679 ISO 2719
Pentane insolubles	% by weight	0.5 or less		Based on ASTM D 893
Coagulated pentane insolubles	% by weight	3.0 or less		Based on ASTM D 893

Definition of Property Limit of Engine Oil

Kinetic viscosity

Kinetic viscosity is a basic physical property of engine oil and is considered as the most important factor when evaluating oil.

The kinetic viscosity increases by contamination with blow-by gas and degradation of oil. Also, the viscosity decreases by contamination with fuel and molecular disconnection of the viscosity index improver. The former will cause oil filter clogging and sludge accumulation in the engine, while the latter will cause poor lubrication and wear.

Base number

Base number shows the ability to neutralize acids such as organic acid due to engine oil oxidation, and sulfurous or sulfuric acid due to the combustion of sulfur content in fuel.

Because the base number indicates the amount of dispersant detergent in oil, it can be used to estimate the consumption of basic dispersant detergent. The ability to disperse sludge declines as the dispersant detergent is consumed. Thus, the base number is often used as an indication of cleaning capability decline.

Acid number

The acid number in oil increases as the organic acid is being derived by the engine oil oxidation, or sulfurous acid or sulfuric acid derived by the combustion of sulfur content of fuel, or the oil becomes contaminated with imperfect combustion products.

An increase in the acid number will result in corrosion or wear of the inner parts of the engine (such as cylinder liner and bearing) due to sulfur content, and the piston ring seizure due to sludge.

Water content

Water in oil promotes corrosion/wear, and decreases lubricity between sliding parts.

Flash point

The flash point is lowered by contamination with fuel. Flash point is used to check the fuel dilution of oil. The dilution of oil reduces oil film, and causes insufficient lubrication that will cause friction or wear of engine parts.

Insolubles

Insolubles include acid products of engine oil, imperfect combustion products, sludge or soot, worn metal particles and dust. Insolubles value is an indication of degradation/contamination of oil.

Dispersant detergent, which is an additive in engine oil, absorbs sludge particles, and disperses them as fine particles in oil. Total insoluble density and remaining dispersibility can be obtained by measuring insoluble and coagulated insoluble (chemical specialties which stop action of disperse detergent and collect the sludge dispersed in oil) to identify the engine oil contamination level, and thereby, the insoluble value can be a marker to prevent the piston ring from seizure or premature wear.

Engine Oil Analysis Service

For a long productive service life of engine, the use of engine oil analysis service is recommended.

By this service, the engine oil, extracted from the engine with a dedicated sampling tool, is analyzed to determine whether the oil being used is acceptable or not for the use.

The following information is obtained by the engine oil analysis service:

- ♦The amount of fine metal powder in engine oil due to abrasion is measured, by which, worn parts of the engine can be located.
- ♦Water, LLC, or salt that should not be in engine oil can be detected if presented.
- ♦Deteriorated condition of engine oil is shown. These will allow the planning of operational and maintenance counter-measures, and show the proper engine oil replacement intervals.

The engine oil analysis service can diagnose the internal condition of the engine without disassembling the engine.

It is highly recommended to take advantage of our engine oil analysis service so that you can find the engine condition before any malfunction occurs in the engine.

Note: In this operation manual, the word "coolant" denotes a mixture of water and LLC.

Recommended Water for Coolant

Use soft water (such as tap water) for the engine cooling system. The water quality must meet the requirements in the table below. Basically, the water quality should be within the range of the recommended values, however, up to the limit value is acceptable.

Table 6-1 Water Quality Standard

Item	Chemical symbol	Unit	Recommend value	Limit value	Main harm
pH (25 °C)	-	-	6.5 to 8.0	6.5 to 8.5	Corrosion and scale formation
Electrical conductivity (25°C [77°F])	-	mS/m	< 25	< 40	Corrosion and scale formation
Total hardness	CaCO ₃	mg/l	< 95	< 100	Scale formation
M alkalinity	CaCO ₃	mg/l	<70	< 150	Scale formation
Chlorine ion	Cl ⁻	mg/l	< 100	< 100	Corrosion
Sulphate ion	SO ₄ ²⁻	mg/l	< 50	< 100	Corrosion
Total iron	Fe	mg/l	< 1.0	< 1.0	Scale formation
Silica	SiO ₂	mg/l	< 30	< 50	Scale formation
Residue by evaporation	-	mg/l	< 250	< 400	Scale formation

Long Life Coolant (LLC)

⚠ CAUTION

If you swallow coolant or LLC accidentally, induce vomiting immediately and seek medical attention. If LLC gets in your eyes, flush immediately with plenty of water and seek medical attention.

Be sure to use Mitsubishi Heavy Industries Engine & Turbocharger, Ltd. genuine long life coolant (LLC), "GLASSY long life coolant (ethylene glycol type)" or "PG GLASSY long life coolant (propylene glycol type)." When using an LLC other than genuine MHIET long life coolant by necessity, be sure to use the non-amine type LLC that meets our requirements. Mitsubishi heavy industries Engine & Turbocharger, Ltd. disclaims the warranty claim for defects due to the use of LLC that does not meet our requirements.

Genuine MHIET LLC

Mitsubishi Heavy Industries Engine & Turbocharger, Ltd. recommends the use of our genuine long life coolant "GLASSY long life coolant (ethylene glycol type)" and eco-friendly product "PG GLASSY long life coolant (propylene glycol type)," which are most appropriate coolant for Mitsubishi diesel engines.

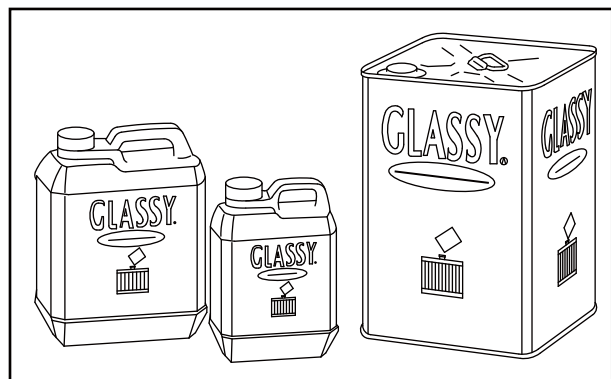


Fig. 6-1 GLASSY Long Life Coolant

Other Commercial LLCs

CAUTION

Never mix genuine MHIET LLC with other brand of LLCs. Mixing with other brand of LLCs degrades the performance of genuine MHIET LLC.

When using an LLC other than genuine MHIET long life coolant (LLC) "GLASSY long life coolant (ethylene glycol type)" or "PG GLASSY long life coolant (propylene glycol type)," be sure to use the LLC that meets our requirements.

The quality and performance of commercially available LLCs and their component variations are the responsibility of LLC suppliers.

Before purchasing a commercial LLC, be sure to discuss the suitability of LLC with the LLC supplier.

Use an all-season LLC (non-amine type) only. Do not use antifreeze alone instead of LLC.

Requirements for Other Commercial LLCs

If you must use other brand of LLCs, be sure to use the LLC that meets the requirements below. Mitsubishi Heavy Industries Engine & Turbocharger, Ltd. disclaims the warranty claim for defects caused by the use of LLC that does not meet our requirements.

General Quality Requirements for LLC

- LLC must be a homogeneous liquid without sediment.
- When the LLC is diluted to 30 to 60% density, the LLC shall not cause any problems such as corrosion and precipitation deposits in the engine cooling system.
- LLC shall be mixed well with other non-amine type LLC that meets this requirements and shall not separate elements included in the each product, and shall not decrease the performance of both products.
- LLC shall not corrode the container and shall not produce a precipitate when LLC is stored in the container for 6 months.
- LLC shall be free from any abnormalities such as precipitates when kept in -20 to -25 °C [-4 to -13 °F] temperature.
- The validity period for the quality requirements for products specified herein shall be 2 years after the delivery, provided that they are stored under indoor normal temperature.

LLC Quality Standard

LLC shall be tested in accordance with JIS K 2234, Section 7 "Test method," and satisfy the requirements. General matters and specimen sampling method shall comply with JIS K 2234.

Table 6-2 LLC Quality Standard

Test items				Standard value
Visual inspection				No precipitation
Specific gravity				Minimum 1.112 g/cm ³ [69.4199 lb/ft ³] (20/20 °C) [68/68 °F] (undiluted solution)
Water content				5.0 weight or lower (undiluted solution)
Freezing temperature	30% by volume in aqueous solutions			-14.5°C [5.9 °F] or lower
	50% by volume in aqueous solutions			-34.0°C [-29.2°F] or lower
Equilibrium reflex boiling point				155°C [311°F] or higher (undiluted solution)
pH				7.0 to 11.0 (30 volumetric water solution)
Bubbling character (ASTM D3306-01)	30% by volume in aqueous solutions			4.0 ml [0.0008 gal] or less
	33 ¹ / ₃ % by volume in aqueous solutions			150 ml or less, deforming time 5 sec. or less
Hard water compatibility				1.0 or less (50 volumetric water solution)
Metallic causticity (88±2°C [190.4±4°F], 336±2 Hrs, 30% by vol water solution (ethylene glycol), 50% by vol water solution (propylene glycol))	Metallic test piece	Mass change	Aluminum	±0.30 mg/cm ²
			Cast iron	±0.15 mg/cm ²
			Steel	±0.15 mg/cm ²
			Brass	±0.15 mg/cm ²
			Solder	±0.30 mg/cm ²
			Copper	±0.15 mg/cm ²
		Visual inspection of test piece after testing		Any corrosion should not be observed except for the contacting position of the test piece and spacer. Discoloration is allowed.
	Bubble formation during test			Bubble shall not overflow.
	Property of liquid after test	pH		6.5 to 11.0
		pH change		±1.0
		Precipitation		0.5% by volume in aqueous solutions or less
		Visual inspection of liquid		No significant discoloration. No significant changes such as separation and gel generation.

Table 6-2 LLC Quality Standard

Test items				Standard value
Circulating corrosion (98±2°C [208.4±4°F], 1000 Hrs, 30% by vol water solution (ethylene glycol), 50% by vol water solution (propylene glycol))	Metallic test piece	Mass change	Aluminum, cast iron, steel, brass, solder, and copper	±0.30 mg/cm ²
		Visual inspection of test piece after testing		Any corrosion should not be observed except for the contacting position of the test piece and spacer. Discoloration is allowed.
	Property of liquid after test	pH		7.0 to 9.0
		pH change		±1.0
		Reserve alkalinity change		±15%
		Precipitation		1.0% by volume in aqueous solutions or less
		Visual inspection of liquid		No significant discoloration. No significant changes such as separation and gel generation.
		Ion concentration	Iron, copper, aluminum, zinc, lead, and ammonium ion	10 ppm or less
Circulating corrosion (88±3°C [190.4±6°F], 1000±2 Hrs, 30% by vol water solution (ethylene glycol))	Metallic test piece	Mass change	Aluminum	±0.60 mg/cm ²
			Cast iron	±0.30 mg/cm ²
			Steel	±0.30 mg/cm ²
			Brass	±0.30 mg/cm ²
			Solder	±0.60 mg/cm ²
			Copper	±0.30 mg/cm ²
		Visual inspection of test piece after testing		Any corrosion should not be observed except for the contacting position of the test piece and spacer. Discoloration is allowed.
	Property of liquid after test	pH		6.5 to 11.0
		pH change		Maximum ±1.0
		Visual inspection of liquid		No significant discoloration. No significant changes such as separation and gel generation.
	Condition of parts	Pump seals		Free from any malfunction, liquid leak, and abnormal noise during operation.
		Pump case inner surfaces and blades		Free from significant corrosion.

Table 6-2 LLC Quality Standard

Test items			Standard value
Rubber adaptability (30% by vol water solution, 115°C [239°F], 360 Hrs)	Silicone	Tensile strength change rate	-60 to 0%
		Elongation change rate	-40 to +20%
		Volume change rate	0 to +40%
		Hardness change rate	-20 to +10%
	Nitrile rubber	Tensile strength change rate	0 to +10%
		Elongation change rate	-15 to +15%
		Volume change rate	0 to +40%
		Hardness change rate	-10 to 0%
	Ethylene pro- pylene diene monomer	Tensile strength change rate	0 to +10%
		Elongation change rate	-30 to 0%
		Volume change rate	0 to +10%
		Hardness change rate	-10 to 0%
Storage stability (% by vol water solution) (30% by volume in aqueous solutions, room temp. 6 Hrs)			0.3 or less

Maintenance of LLC

CAUTION

If you swallow coolant or LLC accidentally, induce vomiting immediately and seek medical attention. If LLC gets in your eyes, flush immediately with plenty of water and seek medical attention.

LLC is toxic. Do not dump coolant containing LLC drained from the engine casually into sewage. For disposal of used coolant, consult the LLC distributor.

Replacement Intervals of LLC

CAUTION

Be sure to renew LLC (coolant) at the intervals specified in the "Periodic Maintenance Schedule".

Failure to replace LLC may cause malfunctions due to rust prevention performance degradation and cavitations.

LLC Concentration (GLASSY and PG GLASSY)

1. To prevent cavitations of water pump and cylinder liners, LLC concentration must be at least 30% for GLASSY (ethylene glycol) and 40% for PG GLASSY (propylene glycol) by volume under any temperature conditions throughout the year.
2. Coolant anti-freeze concentration for the engine is determined by the ambient minimum temperature of the year. Maintain the coolant concentration in the range shown in the table below.

Table 6-3 Recommended LLC Concentration

Ambient temperature		Up to -10°C	Up to -20°C	Up to -30°C	Up to -45°C
LLC concentration	GLASSY (ethylene glycol)	30%	40%	50%	60%
	PG GLASSY (propylene glycol)	40%	55%	70%	90%

3. Concentration must be 60% at a maximum for GLASSY (ethylene glycol) and 90% for PG GLASSY (propylene glycol). If the concentration is higher than that, the antifreeze effect will decrease, or the cooling water temperature will increase due to the lowered specific heat.
4. Coolant temperature will increase by approx. 1.5°C for 60% concentration of GLASSY (ethylene glycol) and approx. 3°C for 90% concentration of PG GLASSY (propylene glycol). Check heat exchanger capacity of the cooling system to avoid overheating.

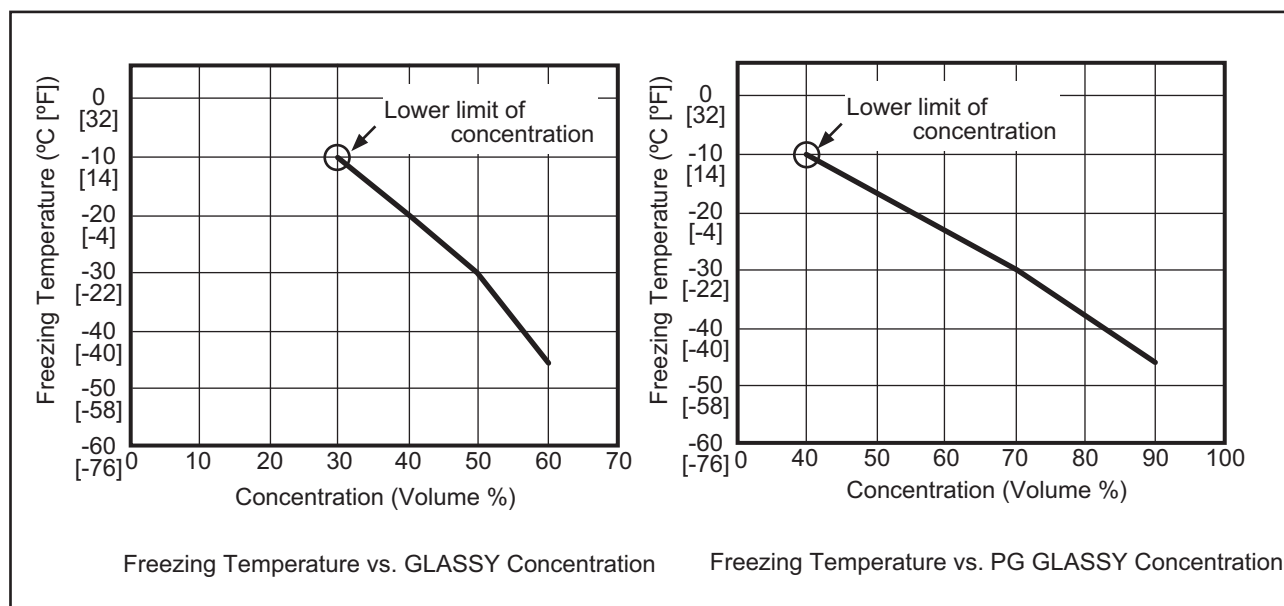


Fig. 6-2 Coolant Freezing Temperature (GLASSY and PG GLASSY)

LLC Concentration Measuring Method

Tool

Coolant tester

Part No. 37591-00100

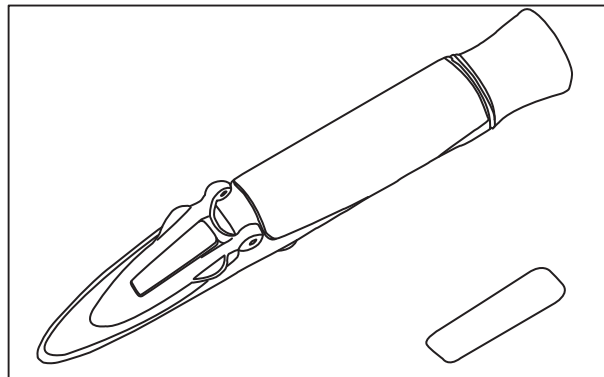


Fig. 6-3 Coolant Tester

Calibration

1. Place 1 or 2 drops of distilled or tap water on the prism.

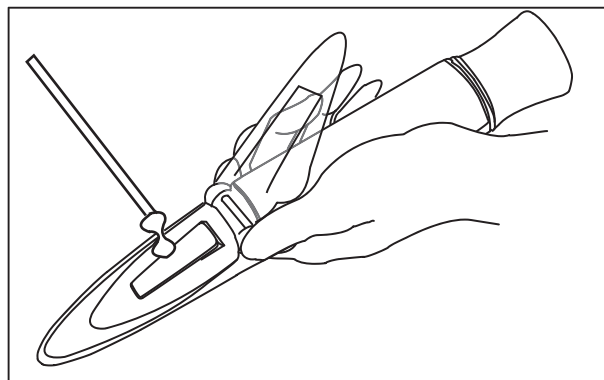


Fig. 6-4 Measuring Procedure 1

2. Close the daylight plate gently.

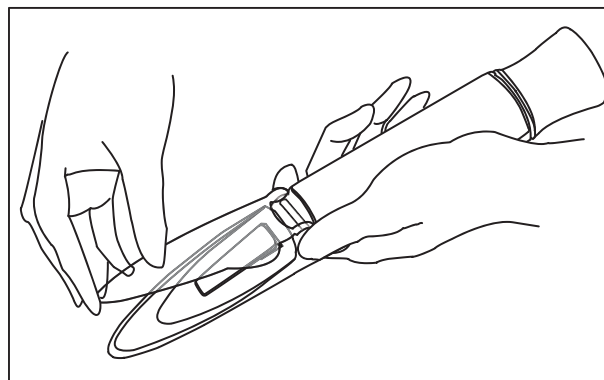


Fig. 6-5 Measuring Procedure 2

3. Spread the drop evenly on the prism surface. Do not allow bubbles staying on the surface.

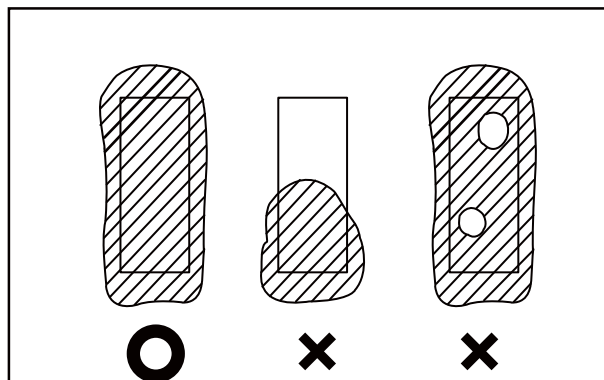


Fig. 6-6 Measuring Procedure 3

4. Read the scale through the eye piece. Turn the eye piece until the scale is clearly visible.

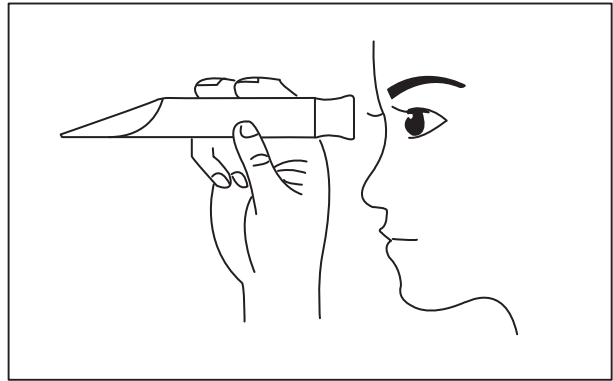


Fig. 6-7 Measuring Procedure 4

5. Verify the boundary line of blue color aligns with the 0% on the scale.

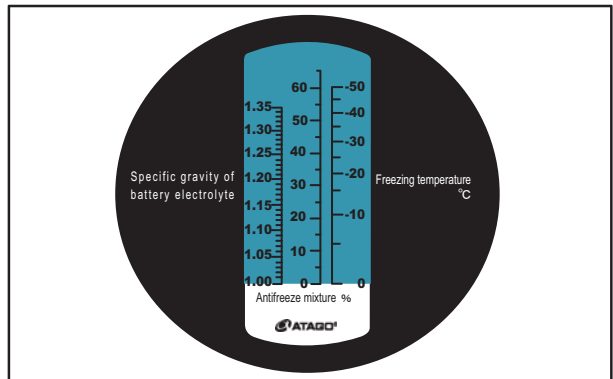


Fig. 6-8 Measuring Procedure 5

6. Adjust the scale calibration screw with the tool to align the boundary line and the 0% line if they are not aligned.

CAUTION

Do not rotate the calibration screw excessively. The refractometer may be damaged.

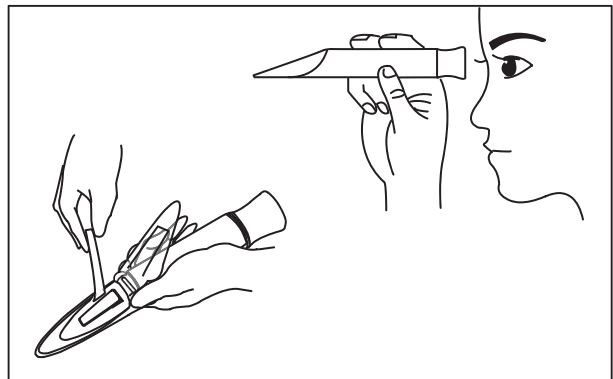


Fig. 6-9 Measuring Procedure 6

Measurement

1. Place 1 or 2 drops of specimen on the prism. (Figure 6-4)
2. Close the daylight plate gently. (Figure 6-5)
3. Spread the specimen evenly on the prism surface. Do not allow bubbles staying on the surface. (Figure 6-6)
4. Read the scale through the eye piece. Turn the eye piece until the scale is clearly visible. (Figure 6-7)
5. Read the measured value where the boundary line crosses the scale line.

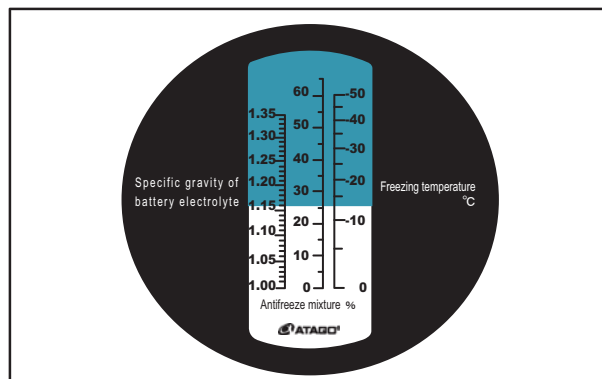


Fig. 6-10 Measuring Procedure 7

6. Wipe off the specimen with water-soaked soft facial tissue.

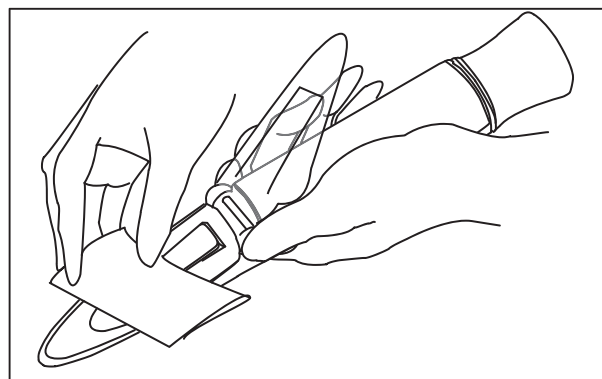


Fig. 6-11 Measuring Procedure 8

Necessity of LLC

Smaller and lighter engines are today's trend as they can offer greater output, lower fuel consumption, and lower exhaust emission levels.

Conditions to which engine coolant is subjected, therefore, are becoming severer due to longer operating hours, higher coolant temperature, and higher coolant circulating speed.

Furthermore, many different materials such as steel, aluminum, copper, solder, and rubber are used in the cooling system, and they are also subject to the severe conditions described above. Those materials have different ionization characteristics, and this difference accelerates corrosion through the medium of engine coolant. To prevent such a problem, it is necessary to use the LLC containing additives that prevent rust.

Characteristics of LLC Additives

LLC contains several chemicals in such proportions as to produce chemical reactions that suppress corrosion (ionization) of engine parts that contact with the coolant. LLC loses its effectiveness by hours of use as well as lapse of time.

Furthermore, if the chemicals are not well proportioned to match the metals used in the cooling system, certain chemicals in the LLC become rapidly used up, and it results in corrosion of metals to be protected. Consequently, other corrosion preventing chemicals react with dissolving metals, by which corrosion is accelerated. This condition generates more severe corrosion than when plain soft water is used. This is a typical problem caused by the use of inappropriate LLC.

Examples of Abnormalities Caused by Amine Type LLC

Pitting of Iron Parts

Amines are generally effective in suppressing the rusting of ferrous metals, but they are said to become corrosion promoter for copper parts.

Dissolved copper (copper corrosion) in the cooling system deposits on iron parts, and the copper deposits will cause corrosion and then pitting on iron parts that have a high ionization characteristics due to galvanic or local-cell action.

Corrosion of Aluminum Parts

Silicate is highly effective in protecting aluminum against rusting. However, it is unstable in a solution in which the pH is 9 or lower, and can turn to gel and precipitate in the solution. For this reason, the pH is usually specified to be about 10 to ensure a high alkaline level.

This means, after silicate is used up, the high alkalinity causes chemical attacks on aluminum. To prevent this problem, proper maintenance of the coolant is required. For example, rapid wear of water pump mechanical seal due to gelification of silicate salt has been observed.

Pitting and Clogging of Heat Exchanger

When LLC deteriorates or when its concentration in the coolant becomes low, the anti-corrosion performance of LLC lowers and it results in the corrosion of metals. Brass and solder tend to corrode faster than other metals, and corrosion of these metals is said to cause troubles such as water leak and clogging in the heat exchanger or radiator.

Chapter 7 PERIODIC MAINTENANCE SCHEDULE

How to Use the Periodic Maintenance Schedule

Periodic inspection and maintenance not only extends the service life of the engine but also serves to ensure the safe operation. Be sure to conduct the inspection and maintenance according to the "Periodic Maintenance Schedule".

Obey the standard service intervals specified in the "Periodic Maintenance Schedule". However, when you think the engine should need the inspection and maintenance earlier than the specified intervals in the "Periodic Maintenance Schedule", change the intervals accordingly.

Note: Appropriate service intervals vary with usage and operating conditions as well as conditions of fuel, oil, and coolant.

Be sure to inspect the items which are included in the applicable intervals and shorter intervals. For example, in the 2000 hour maintenance, also inspect those items listed in every 50, 250, 500, and 1000 hours. Be sure to conduct periodic inspection at specified intervals, either service hours or years, whichever comes first.

(Example) During the inspection conducted at "Every 4000 Hours," also inspect the items listed under "Every 2000 Hours" and "Every 1000 Hours."

Items marked with * in the "Periodic Maintenance Schedule" require special tools or large-scale maintenance. For those items, contact your MHIET dealer.

<Engine top overhaul>

On the top overhaul, the cylinder head is removed. The inspection and maintenance and part replacement are conducted for the cylinder head, combustion chamber, and other main components.

For details of top overhaul, contact your MHIET dealer.

<Engine major overhaul>

On the major overhaul, the engine is sent to the factory, and the complete disassembly is conducted for inspection, maintenance, and part replacement of major parts.

For details of major overhaul, contact your MHIET dealer.

Table 7-1 Diesel Engine Rating Definition

Designation of rated output	Warranty requirements (*1)					Operating hours/ year (Recommendation)
	Operation load/time duration (*2)		O/H interval (maximum) after delivery to customer		Annual operating time	
	Allowable ave.load factor/yr	Allowable ave.speed	Top	Major		
M output, Medium workload	83% or less	94% or less	6000 hrs	12000 hrs or 3 years whichever comes fast (recommended: 8000 hrs)	-	3000 hrs or less

(*1) Atmospheric conditions are according to ISO 15550: 2002 (JIS B 8003: 2005) (atmospheric pressure: 100 kPa, atmospheric temperature: 298 K, relative humidity: 30%).

(*2) The method of calculating the average load factor (day and year) depends on the calculation formula of ISO 8528: 2005 'average power output (Ppp)'.

Periodic Maintenance Schedule

Table 7-2 Periodic Inspection Chart for Marine Engine (with Marine Gear)

Service Intervals	Service Items	Referred page
First 100 hrs (only once)	Engine Oil, Oil Filter, and Bypass Oil Filter - Replace	8-9
	Marine gear oil - Change, Marine gear oil strainer - Clean, Marine gear cover oil filter - Replace	8-15
	Fuel Filter - Replace	8-6
	Valve Clearance - Inspect and Adjust	*
	Engine Externals - Inspect	8-1
Every 250 hours	Engine Oil, Oil Filter, and Bypass Oil Filter - Replace	8-9
	Belt and Belt Tension - Inspect and Adjust	8-2
	Pre-Cleaner - Clean, Inspect, and Replace	8-24
Every 500 hours	Also includes the items listed under every 100 and 250 hours.	-
	Zinc Rod - Inspect	8-22
	Gauze Filter - Clean	8-5
Every 1000 hours	Also includes items listed in every 100, 250 and 500 hours.	-
	Fuel Filter - Replace	8-6
	Marine gear oil - Change, Marine gear oil strainer - Clean, Marine gear cover oil filter - Replace	8-15
	Seawater Pump Impeller - Inspect	8-21
	Turbocharger Rotor - Inspect for Movement and Looseness	*
	Valve Clearance - Inspect and Adjust	*
	Fuel Injection Nozzle - Inspect and Adjust	*
Every 2000 hours or every year	Also includes the items listed under every 100, 250, 500 and 1000 hours.	-
	High-pressure Fuel Injection Pipe and Clamp Seat - Inspect and Replace	8-8
	Low-Pressure Fuel Pipe, Oil Pipe, and Clip - Inspect and Replace	8-8
	Fuel Injection Nozzle Tip, Nozzle Spring and Spacer - Replace(After replacement, inspect and adjust the spray/injection pressure)	*
	Fuel Control Link Ball Joint - Inspect	8-7
	Seawater Pump Impeller - Replace	*
	Bolts and Nuts on Exhaust and Air Inlet Pipes - Tighten	*
	Harnesses and Terminals - Inspect for Damage and Looseness	*

Table 7-2 Periodic Inspection Chart for Marine Engine (with Marine Gear)

Service Intervals	Service Items		Referred page
Top Overhaul Service intervals vary depending on usage conditions. For details, see the rating definition.	Includes items listed in every 100, 250, 500, 1000, and 2000 hours		-
	Engine Overhaul	Cylinder Head - Disassemble and Inspect, Valve System - Inspect, and Cylinder Liner - Inspect Inner Surface	*
	Belt - Replace		*
	Damper - Inspect		8-2
	Fuel Injection Timing - Inspect and Adjust		*
	Fuel Injection Pump Coupling Bolt and Laminated Plate - Inspect		*
	Fuel Link Ball Joints (for Stop Solenoid and Governor) - Replace		*
	Heat Exchanger - Clean		*
	Thermostat Operation - Check		*
	Inter Cooler Element - Clean		*
	Starter - Inspect		8-26
	Alternator - Inspect		8-26
	Marine gear oil cooler - Clean		*
	Protective Devices - Check Actuation		*
	Cooling Fresh Water - Change (Every 2 Years)		8-17

Table 7-2 Periodic Inspection Chart for Marine Engine (with Marine Gear)

Service Intervals	Service Items		Referred page
Major Overhaul Service intervals vary depending on usage conditions. For details, see the rating definition.	Includes items listed under 100, 250, 500, 1000, 2000, and 4000 hours.		-
	Engine Overhaul	Piston - Inspect, Piston cooling nozzle - Inspect, Crankshaft - Inspect, Main bearing - Replace, Thrust plate - Replace, Connecting rod bearing - Replace, Camshaft bushing - Inspect, Cylinder liner - Replace, Piston ring - Replace, Inlet and exhaust valves - Replace, Inlet and exhaust valve seats - Replace, Valve rotator - Replace, Damper - Replace	*
	Fuel Flexible Hose - Replace		*
	Fuel injection pump - Inspect and Test (replace parts as needed), Fuel injection pump lamination plate - Replace		*
	Governor - Inspect and Test (replace parts as needed)		*
	Clamp Seat for High-Pressure Fuel Injection Pipe - Replace		*
	Oil Cooler - Clean		*
	Freshwater Pump Unit Seal and Ball Bearing - Replace		*
	Seawater Pump Unit Seal and Ball Bearing - Replace		*
	Tension Pulley Bearing - Replace		*
	Thermostat - Replace		*
	Coolant Hose - Replace		*
	Cap of Fresh Water Tank - Replace		*
	Turbocharger - Major Overhaul		*
	Electrical Components - Inspect		*
	Relays - Replace		*
	Marine Gear - Overhaul, Marine Gear Periodic Replacement Parts - Replace		*
	Rubber Blocks - Replace		*
Second Major Overhaul Every 16000 hours or 10 years	Includes items listed in every 100, 250, 500, 1000, 2000, 4000, and 8000 hours		-
	Replace the following parts with new ones: Piston, piston pin, rocker bushing, gear bushing, tappet, valve guide, valve spring, connecting rod and connecting rod bolt, main bearing cap bolt, high-pressure fuel injection pipe, low-pressure fuel pipe, and oil pipe.		*
	Cylinder Head Bolt - Inspect		*

Note: (a) The table above also includes the parts that MHIET does not supply. For inspection and maintenance of the parts that are not supplied by MHIET, follow the instructions in the supplier's operation manual.

(b) The items marked with an asterisk (*) will require special tools and specialized maintenance work. Please contact your local MHIET dealer for the maintenance of those items.

(c) Be sure to conduct periodic inspection at specified intervals, either service hours or years, whichever comes first.

(d) Under high temperature and or high humidity environment, the deterioration of engine oil and others could be accelerated. Conduct daily check, and perform the engine oil analysis or engine oil change if necessary.

Engine

Engine Exterior - Inspect

CAUTION

Check external parts of the engine, particularly hot parts (exhaust manifold and others), or the battery for accumulation of flammable materials. Also, check leaks of fuel and engine oil. Remove dust from the top surface of the battery. If hot parts have a problem, it may cause a fire. If any abnormality is found, be sure to repair or contact your MHIET dealer.

Inspect the engine exterior as instructed below:

1. Make sure there is no combustible material near the engine or battery. Also, check to make sure that the engine and battery are clean. If combustible materials or dust are found near the engine or battery, remove them.
2. Make sure fluids, such as fuel, oil, and coolant, are not leaking from the engine. If a leak is found, repair the leak, or contact your MHIET dealer.
3. Walk around the engine and check bolts and nuts for looseness.
4. Check electric wiring for disconnection, looseness, cuts, or rubbing.
5. Make sure the following valves, plugs, or cocks are properly positioned as indicated below:
 - Fuel feed valve: open
 - Coolant drain cock (valve): closed
 - Engine oil drain plug: closed

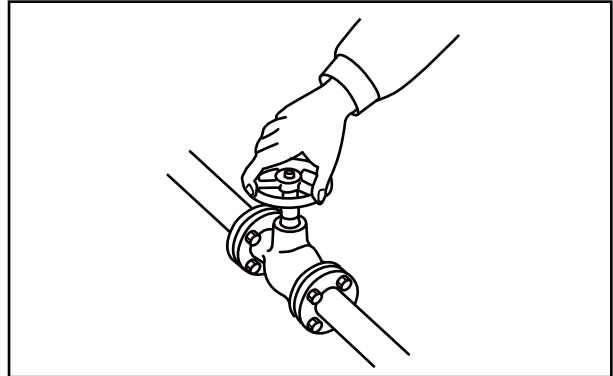


Fig. 8-1 Valve Open/Closed Position - Check

Belt and Belt Tension - Inspect and Adjust

CAUTION

If defects such as cuts or surface separations are found in the inspection, replace the belt.

Belts must be free from grease and oils. Grease and oils cause belts to slip and shorten their service life.

Excessive belt tension can cause rapid wear of the alternator bearing, and shorten the service life of the belt.

Adjust the belt tension properly by following the procedures below:

Belt - Inspect

1. Inspect the belt visually for peeling or breaks. If any abnormality is found, replace the belt with a new one.
2. Inspect the belt tension (deflection).
Push the belt strongly at the midway between pulleys. If the deflection is 10 to 15 mm [0.4 to 0.6 in.], the tension is correct.
Belt pushing force: approx. 98 to 147 N {10 to 15 kgf} [22 to 32.4 lbf]
If the belt deflection is not within the specified range, adjust the belt tension.

Belt Tension - Adjust

1. Remove the belt cover.
2. When adjusting the belt tension on the alternator side, loosen the alternator fixing bolt and the lock nut of turn buckle and then adjust the tension by rotating the turn buckle.
3. When adjusting the belt on fresh water pump side, loosen the fixing bolt of tension pulley first and loosen the lock nut of tension pulley. Then adjust the tension with the adjusting bolt.
4. Install the belt cover.

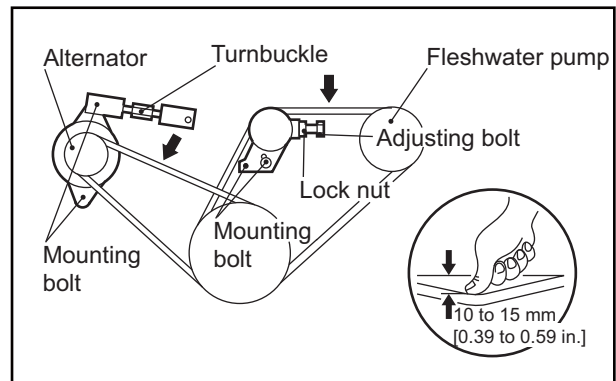


Fig. 8-2 Belt Tension - Adjust

Damper - Inspect

Damper - Check Visually

CAUTION

The protective cover for the damper should not be air-tight.

Installation of a closed cover can cause damage to the damper due to heat.

Visually check the damper for scratches, silicon oil leaks, and paint discoloration or peeling.

Note: If the damper is defective, contact your MHIET dealer.

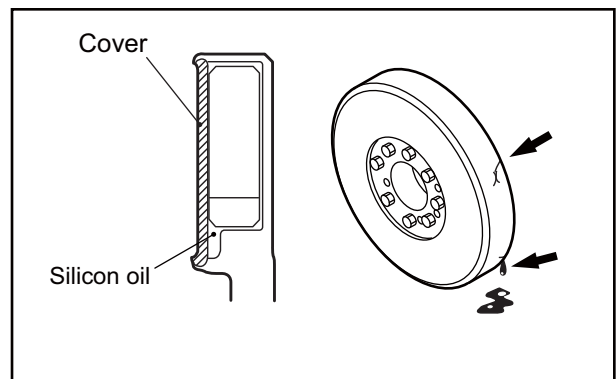


Fig. 8-3 Damper - Check Visually

Cold Weather Operations

In cold weather, engine oil gets thicker and the coolant can freeze. As a result, the engine fails to start, or the cylinder heads and heat exchanger may be damaged. To prevent such problems, follow the instructions given below.

Fuel



WARNING

When handling fuel, make sure there are no open flames or other fire hazards near the engine.

Wipe off any spilled fuel completely. Spilled fuel can be ignited and cause a fire.

Replace oil with a low viscosity oil.

Use fuel that has a pour point suitable for the ambient temperature.

Note: For fuel, refer to ["FUEL" \(4-1\)](#).

Engine Oil

Use engine oil suitable for the ambient temperature of the engine.

Note: For engine oil, refer to ["ENGINE OIL" \(5-1\)](#).

Coolant



CAUTION

Never open the fresh water tank cap during the operation or immediately after stopping. Stop the engine and, after coolant has sufficiently cooled down, open the cap.

When opening the fresh water tank cap, raise the lever to the upright position to release internal pressure.

The coolant is hot while the engine is running and immediately after stopping. If the cap is opened while the coolant is hot, hot coolant steam that can burn you will burst out. To avoid a steam burn, wear thick rubber gloves or wrap a cloth around the cap. When fastening the fresh water tank cap, be sure to tighten securely.

In cold weather the coolant can be frozen, and it may cause damage to the crankcase. Therefore, be sure to use an all-season long life coolant that has anti-freeze and anti-rust protection for the cooling system.

Note: For coolant and LLC, refer to ["COOLANT" \(6-1\)](#).

Maintenance After Cold Weather is Over

When a cold season ends, replace fuel, engine oil, and coolant with those of suitable for the outside temperature in accordance with the specifications in this manual.

Seawater - Drain

When the ambient temperature drops below 0°C [32°F], the seawater used to cool the engine can freeze and cause serious problems such as seawater pump damage. Drain seawater after engine operation.

Fuel system

Fuel System - Inspect

**WARNING**

When handling fuel, make sure there are no open flames or other fire hazards near the engine.

Wipe off any spilled fuel completely. It can cause a fire.

Fuel Tank - Clean

CAUTION

For the fuel to be used, refer to ["FUEL" \(4-1\)](#).

1. Close the fuel feed valve to cut off the fuel supply to the engine.
2. Place a drip pan under the drain cock.
3. Drain all fuel in the tank from drain cock located at the bottom of fuel tank.
4. Clean the inside of fuel tank.
5. Add fuel to the fuel tank.
6. Open the fuel feed valve of the engine.

Note: If the specifications of fuel tank differs from the contents in this operation manual, obey the tank manufacturer's operation manual.

Fuel Tank - Drain Water

If fuel is contaminated with foreign substances such as dust, dirt, or water, it can cause not only decrease of output but also malfunctions of the fuel system. To avoid such problems, drain water from the fuel tank as instructed below.

1. Place a drip pan (capacity of 2 L [0.5 U.S. gal.] or more) under the drain cock of fuel tank.
2. Open the drain cock of fuel tank and drain fuel at least 1 to 2 liters (0.26 to 0.53 US gal).
3. After making sure water and foreign material particles has been discharged together with fuel, close the drain cock.

Note: If the specifications of fuel tank differs from the contents in this operation manual, obey the tank manufacturer's operation manual.

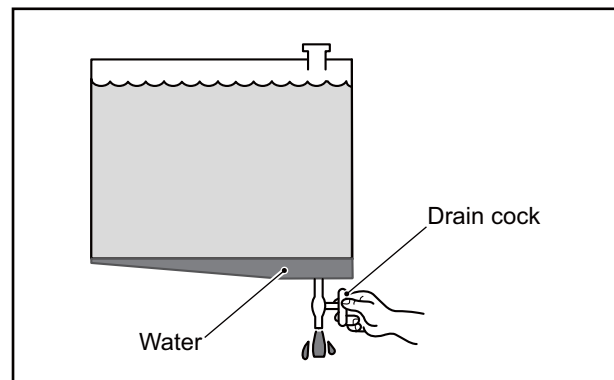


Fig. 8-4 Fuel Tank - Drain Water

Gauze Filter - Clean

If the gauze filter is clogged, the fuel supply becomes insufficient, resulting in decrease in power output or engine stall.

1. Remove the union bolt at the inlet port of fuel feed pump.
2. Using a screw driver, remove the gauze filter that is fitted inside the union bolt.
3. Soak the gauze filter in the fuel, and clean it with a brush.
4. Check the gauze filter for damage.
5. After cleaning, install the gauze filter into the union bolt using a screw driver.
6. Install the union bolt to the fuel feed pump.
7. Bleed air from the fuel filter.

Note: For bleeding the fuel filter, refer to ["Fuel Filter - Bleed Air" \(3-2\)](#).

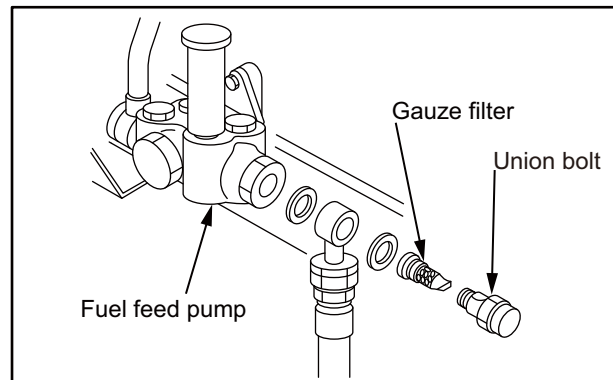


Fig. 8-5 Gauze Filter - Clean

Fuel Filter - Replace

1. Clean the area around the fuel filter.
2. Place a drip pan under the fuel filter.
3. Using a filter wrench, remove the fuel filter.
4. Wipe off fuel on the fuel filter cartridge mounting surface of the filter bracket with a waste cloth.
5. Prepare new fuel filter, and make sure that gasket is properly seated in the groove.



WARNING

If the filter case is dented, do not use the filter. The filter element in dented case may be damaged during operation, leading to fuel leaks, which eventually may result in a fire.

6. Apply clean fuel on the gasket of the new fuel filter.
7. Install the fuel filter on the filter bracket. When the gasket comes in contact with the mounting surface of the filter bracket, further rotate the filter by 3/4 to a full turn.

CAUTION

Hand tighten the fuel filter. Do not tighten with a filter wrench.

Be careful not to dent or scratch the fuel filter surfaces.

8. After the new fuel filter has been installed, bleed air from the fuel filter.

Note: To bleed air from the fuel filter, refer to "[Fuel Filter - Bleed Air](#)" (3-2).

9. Start the engine and run at an idle speed for several minutes.
10. Make sure that there is no fuel leak from the fuel filter mounting face. If the leak is found, loosen the fuel filter and check the gasket for damage. If there is no damage, tighten the fuel filter.

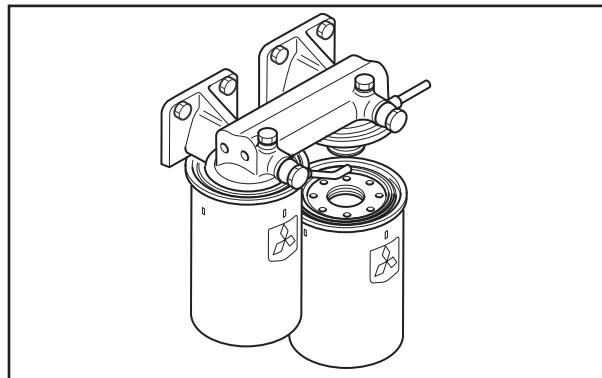


Fig. 8-6 Fuel Filter - Replace

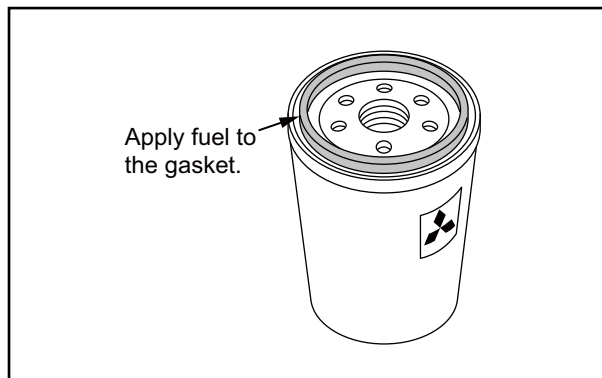


Fig. 8-7 Fuel Filter

Fuel Control Link Ball Joint - Inspect

Check the ball joint in the fuel control link for looseness or sluggish movement. If the amount of looseness is 0.1 mm [0.004 in.] or more, replace the ball joint with a new one.

CAUTION

If the sealed ball joints are found to be loosened, consult with your MHIET dealer. If the seal on the ball joint is broken, the engine is no longer covered under the warranty.

If the ball joint is integrated with the control link, replace the control link assembly. When installing the ball joint, be sure to tighten the nut firmly.

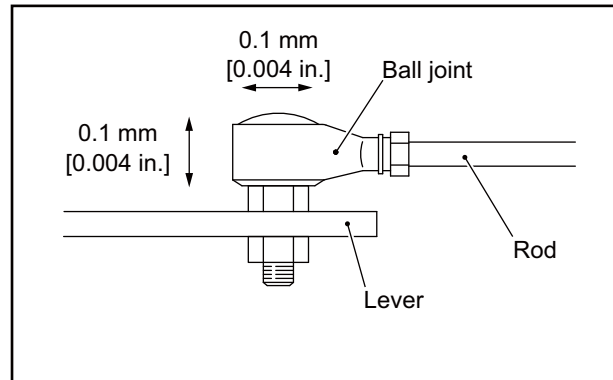


Fig. 8-8 Ball Joint - Check for Looseness

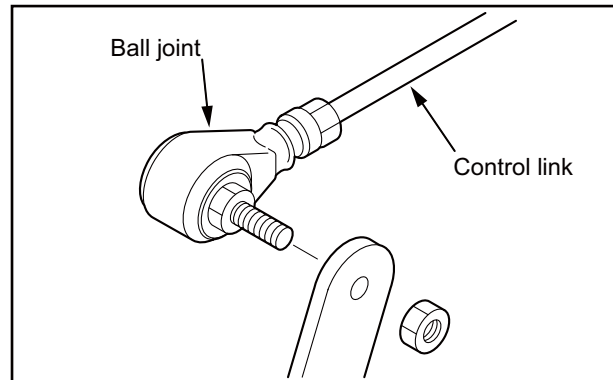


Fig. 8-9 Fuel Control Link - Remove

Fuel Pipe - Inspect

WARNING

Do not use any clamps such as harness for the high- and low-pressure pipes.

Also make sure the fuel pipe does not contact with other pipe and object.

If contacted, a fire disaster may occur due to a pipe hole made by abrasion between pipes.

High-Pressure Fuel Injection Pipe and Clamp Seat - Inspect and Replace

Visual Inspection

Check the clamp seat for crack and wear. Check the high-pressure fuel injection pipe for wear. If defective, replace the clamp seat with a new one. Replace the high-pressure fuel injection pipe with a new one if needed.

Every Major Overhaul

Replace the clamp seat with a new one. Also, check the high-pressure fuel injection pipe for wear. If defective, replace the high-pressure fuel injection pipe with a new one.

Every Other Major Overhaul

Replace all the high-pressure fuel injection pipes with new ones.

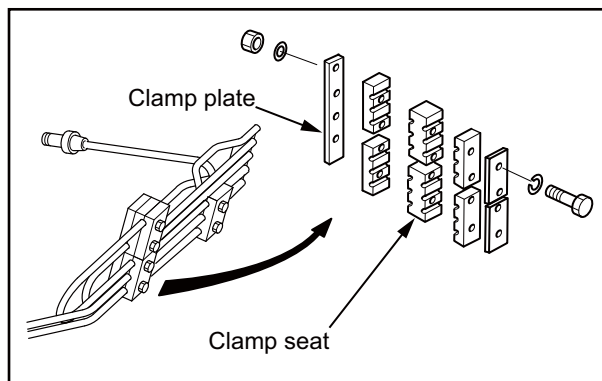


Fig. 8-10 High-pressure Fuel Injection Pipe and Clamp Seat - Inspect and Replace

Low-Pressure Fuel Pipe, Oil Pipe, and Clip - Inspect and Replace

Visual Inspection

Loosen clamp retaining bolts and check for clip wear and metal contact between pipe and clamp. If defective, replace the pipe assembly with a new one.

Every Other Major Overhaul

Replace the pipe assembly with a new one.

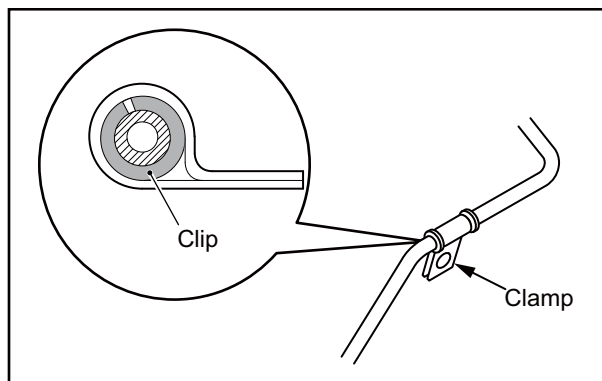


Fig. 8-11 Low-Pressure Fuel Pipe, Oil Pipe, and Clip - Inspect and Replace

Lubrication System

Engine Oil, Oil Filter, and Bypass Oil Filter - Replace

CAUTION

Before draining engine oil, make sure the oil has cooled down.

When draining oil or replacing oil filters, be sure to wear gloves. Hot engine oil and parts can cause burns.

CAUTION

Do not dump drain oil casually into the sewage. It is prohibited by the laws and regulations. For the disposal of drained oil, consult with your MHIET dealer.

Change the engine oil, oil filter, and bypass oil filter at a time.

Also, the engine oil analysis is recommended when you change the engine oil.

Do not reuse oil filter elements, as they are a paper type. When replacing filter elements, also replace gaskets with new ones.

Engine Oil - Drain

1. Place the 3-way cock of wing pump (inlet side) in the "From oil pan" position.
2. Place the 3-way cock of wing pump (outlet side) in the "Drain oil" position.
3. Move the wing pump handle right and left to drain engine oil from oil pan.

Note: Be careful when removing the oil filter, as there is the engine oil inside the oil filter, which is not discharged.

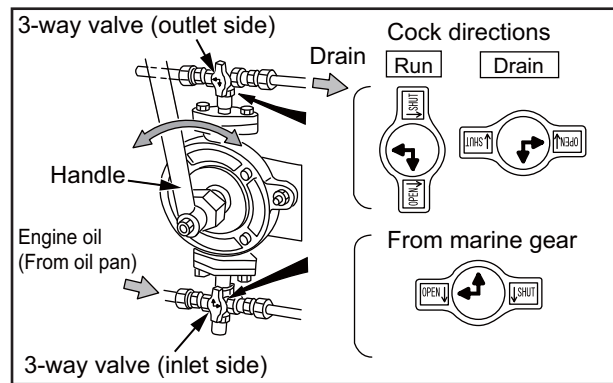


Fig. 8-12 Engine Oil - Drain

Oil Filter and Bypass Oil Filter - Replace



WARNING

If the filter case is dented, do not use the filter. Such filter may be damaged during operation and cause a fire due to oil leak.

CAUTION

Do not use a filter wrench to install the oil filter and bypass oil filter. Tighten the filter by hand. Be careful not to dent or scratch the oil filter surface.

1. Clean the area around the oil filter.
2. Prepare drip pans, and place them under oil filters and bypass oil filter.
3. Using a filter wrench, remove oil filters and bypass oil filter.

Note: Cut the removed oil filter and bypass oil filter elements, and check elements. Consult with your MHIET dealer, if metal particles are attached to the elements.

4. Thoroughly wipe off oil on the oil filter mounting surface of the filter bracket with a cloth.
5. Check the new oil filters and bypass filter to make sure the gasket is properly seated in the groove.
6. Apply clean engine oil to the gasket.
7. Install the oil filters and bypass oil filter to the filter bracket. When the gasket comes in contact with the mounting surface of the filter bracket, further rotate the filter by 3/4 to a full turn.

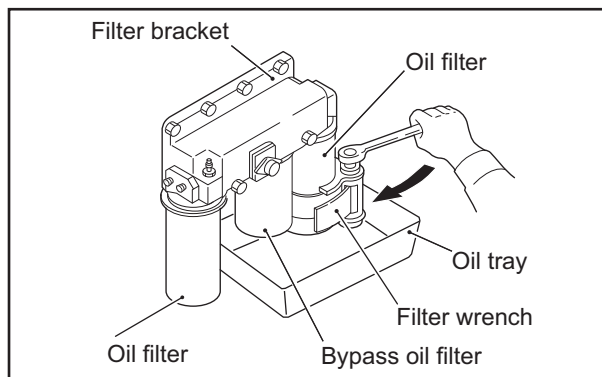


Fig. 8-13 Oil Filter and Bypass Oil Filter - Replace

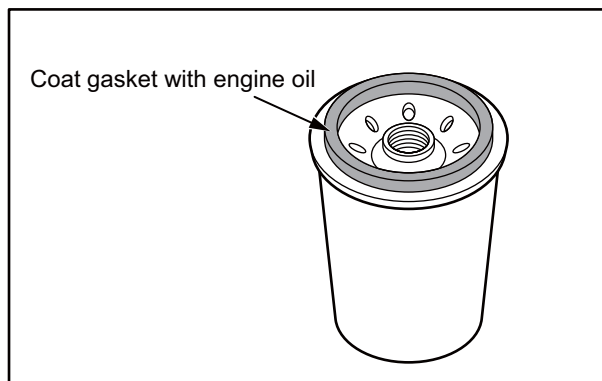


Fig. 8-14 Oil filter

Oil Filter - Replace While Engine is Running

CAUTION

When replacing oil filters during operation, be sure to decrease engine speed to low idle.

Do not replace two or more filters at the same time.

If the engine cannot be stopped when oil filter change interval has been reached, the oil filter can be replaced while the engine is running by turning the switchover cock located between the oil filters.

Note: (a) Normally, the engine must be stopped when replacing oil filters.

Only if the engine cannot be stopped at any cost, replace the oil filter by following the instructions below.

(b) Place a tray to catch oil flowing out during filter replacement, as a small amount of oil may leak from filter mounting portion on the stopped side.

1. Remove the switchover cock cover.
2. Turn the switchover cock so that the switchover cock pin faces to the filter replacement position (right side).
This stops the engine oil supply to the filter.
3. Replace the oil filter.
4. Place the switchover cock in the operating position.
5. Install the switchover cock cover.

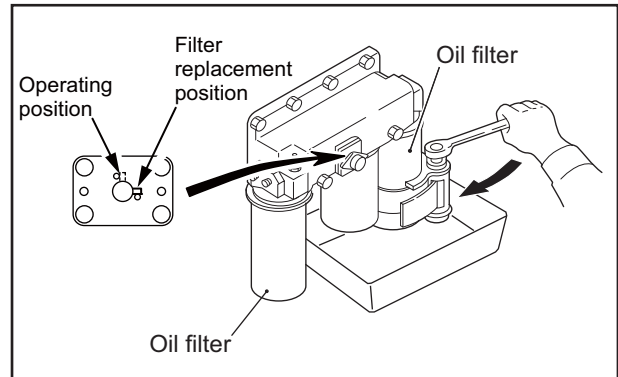


Fig. 8-15 Oil Filter - Replace While Engine is Running

Engine Oil - Refill

CAUTION

Fill the engine with the specified engine oil to the specified level. If the oil level is higher than the maximum mark on the level gauge, engine oil may blow out during operation. Also, the rise of oil temperature could adversely affect engine components.

1. Remove the oil filler cap.
2. Add the specified engine oil to the specified level.
Note: For engine oil, refer to ["ENGINE OIL" \(5-1\)](#). For engine oil capacity, refer to ["MAIN SPECIFICATION" \(12-1\)](#).
3. Check the oil level in oil pan.
4. Pull out the oil level gauge and wipe it clean with a cloth.
5. Insert the oil level gauge fully into the oil level gauge guide and then pull it out again.
6. The oil level should be between the maximum and minimum marks on the oil level gauge.
If the engine oil level is higher than the maximum mark on the oil level gauge, drain engine oil by opening the drain valve.
If the engine oil level is low, add the specified engine oil.
7. Check the oil pan and others for oil leaks. Repair if there is an oil leak.
8. With the manual stop lever placed in the pulled position, rotate the engine with starter for approx. 10 seconds to circulate oil to the engine thoroughly.
Stop for 1 minute, then, repeat this operation two or three times to circulate oil to all parts of the engine.
Note: Perform this procedure after the preparation work for the lubrication and cooling systems have been finished.
9. Start the engine and run at no-load and low-idling condition for 5 to 10 minutes.
10. Stop the engine and leave it for 30 minutes or more, and then, check the oil level with the oil level gauge again and add oil to the specified level.
For details, refer to ["Test Operation" \(3-7\)](#).

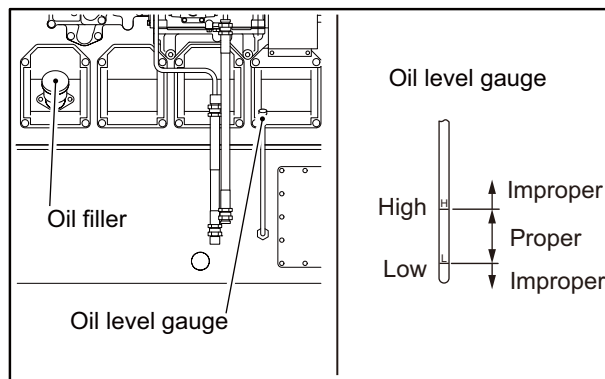


Fig. 8-16 Oil Filler and Oil Level Gauge

Ingress of Fuel and Water In Engine Oil - Inspect

CAUTION

If the engine operation is continued with fuel or water mixed in the engine oil, the engine oil viscosity will decrease and this can cause serious problems such as bearing seizure.

Extract 1 to 2 L [0.26 to 0.53 U.S. gal.] of engine oil, and check abnormal odor and discoloration to determine if the oil is contaminated with fuel or water.

If fuel is mixed, the oil will smell like fuel.

If water is mixed, oil may turn milky white.

If fuel or water is mixed with the engine oil, find the cause and repair. If the repair seems to be difficult, consult with your MHIET dealer.

If the coolant enters the engine oil during operation, moisture vapor is discharged from the breather. In such a case, locate the fuel or water leak, and repair properly.

Note: If oil leaks from oil cooler, oil will float in water in the freshwater tank. Also, LLC that is not mixed with oil will accumulate at the bottom of oil pan.

Governor Oil Filter - Replace

WARNING

When draining oil or replacing oil filters, be sure to wear gloves. Hot engine oil and parts can cause burns.

1. Prepare an oil catch pan and place it under the governor oil filter.
2. Using a filter wrench, remove the governor oil filter.
3. Prepare a new governor oil filter, and clean the gasket.
4. Apply clean engine oil on the gasket.
5. Screw the governor oil filter into the filter bracket by hand.
6. Remove the plug from filter bracket, and pour engine oil until the filter is filled up with engine oil.
7. Install the plug after the oil is filled.
8. Operate the priming pump or wing pump to circulate engine oil. Check to make sure oil does not leak from filter mounting surface. If oil leaks, tighten the filter again.

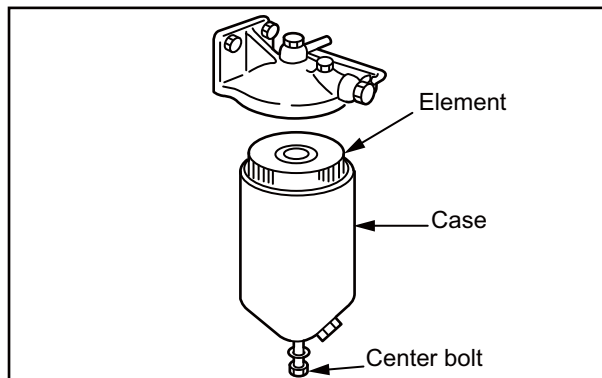


Fig. 8-17 Governor Oil Filter - Replace

Marine Gear Oil - Change, Marine Gear Oil Strainer - Clean, Marine Gear Cover Oil Filter - Replace

Marine Gear Oil - Drain

CAUTION

Wear gloves when draining oil. If hot oil or parts touch your skin, it could cause burns.

1. Place the 3-way cock of wing pump (inlet side) in the "From marine gear" position.
2. Place the 3-way cock of wing pump (outlet side) in the "Drain oil" position.
3. Move the wing pump handle right and left to drain engine oil inside the marine gears.

Note: The oil drain will be easier if it is conducted while the oil is still hot after stopping the engine.

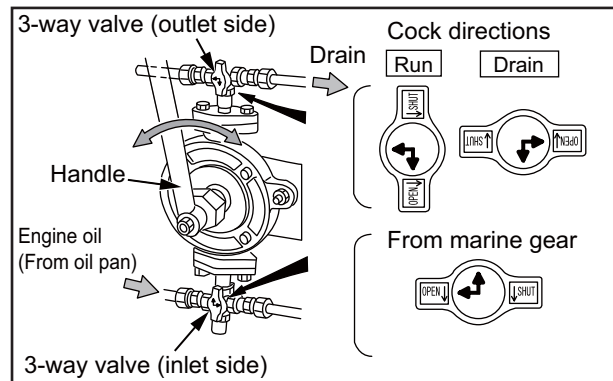


Fig. 8-18 Marine Gear Oil - Drain

Marine Gear Oil Strainer - Clean

1. Place a pan under the oil strainer to catch oil.
2. Remove the cover, and remove the element.
3. Soak the element in wash oil and remove foreign contamination attached to the outside with a soft brush.
4. Blow compressed air to the element and dry it thoroughly.
5. Install the element, and install the cover.

Note: If large amounts of iron are present in the strainer, contact our authorized dealer.

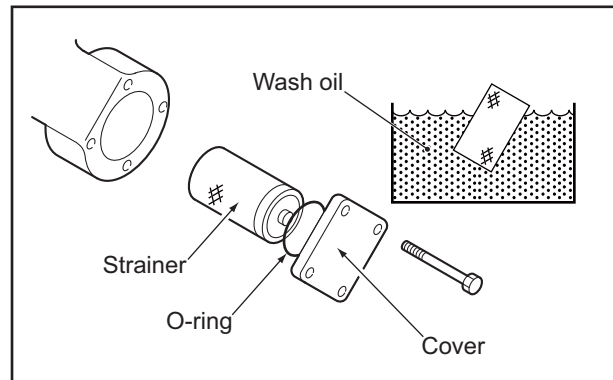


Fig. 8-19 Marine Gear Oil Strainer - Clean

Replace marine gear governor oil filter

1. Remove the center bolt, and remove the filter case, spring and element.
2. Install an O-ring to the new element, tighten it to the governor block with the center bolt and sealing washer, and fix.

Note: Do not reuse the element by cleaning. Be sure to replace with a new one.

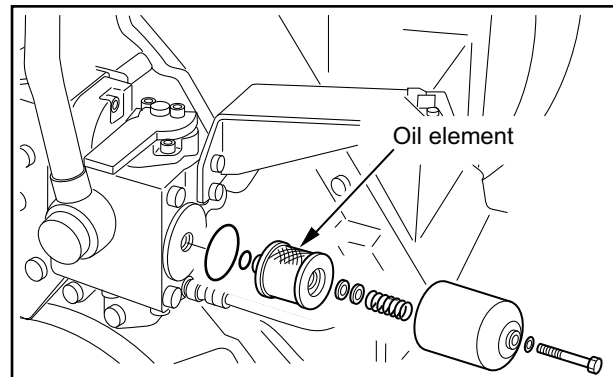


Fig. 8-20 Replace marine gear governor oil filter

Marine Gear Oil - Filling

1. Fill oil to the specified level from oil filler port.
Specified oil: CF class, single-grade oil (SAE 30 or equivalent)
2. Install the plug to the oil filler port.
3. Run the engine at idle speed for approx. 5 minutes, and check for oil leaks from marine gears.
4. Run the engine at low idle and check the oil level.
5. Make sure that oil level on the level gauge is between "maximum" and "minimum" lines.

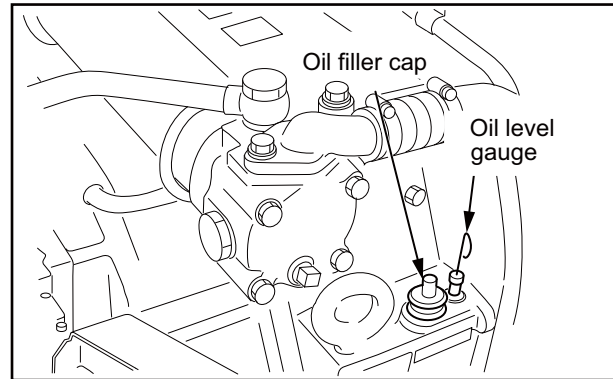


Fig. 8-21 Marine Gear Oil Filler Cap and Marine Gear Oil Level Gauge

Cooling system

Coolant (Fresh Water) - Change

CAUTION

When a coolant mixed with the LLC recommended by our company is used, replace coolant every 8000 hours or 2 years, whichever comes first.

Fresh Water Tank Cap - Open/Close

CAUTION

Never open the fresh water tank cap during the operation or immediately after stopping. Stop the engine and, after coolant has sufficiently cooled down, open the cap.

When opening the fresh water tank cap, raise the lever to the upright position to release internal pressure.

Do not open the fresh water tank cap when the engine is running or immediately after stopping. You can get burn yourself due to hot steam. To avoid a steam burn, wear thick rubber gloves or wrap a cloth around the cap.

When fastening the fresh water tank cap, be sure to tighten securely.

Stand the lever to the upright position to release pressure.

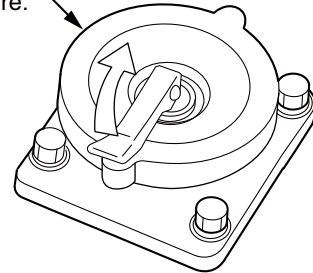


Fig. 8-22 Fresh Water Tank Cap

Coolant - Drain

1. After making sure the engine has cooled, open the fresh water tank cap.
2. Place coolant receiving cans under drain cocks. Open the drain cocks to drain coolant.

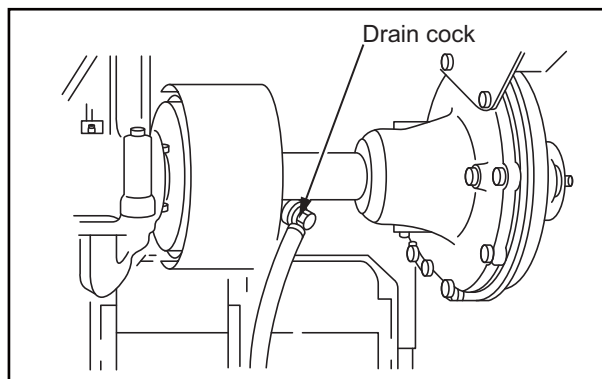


Fig. 8-23 Coolant Drain Cock (Engine Body)

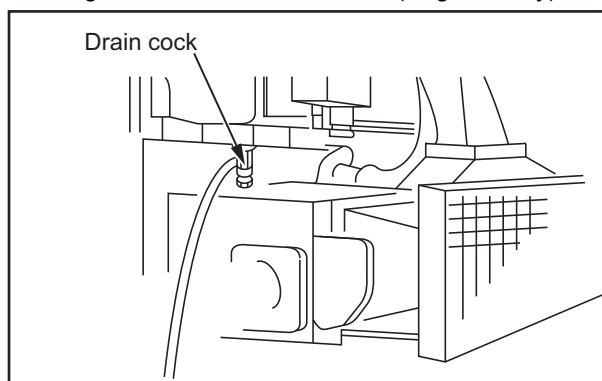


Fig. 8-24 Coolant Drain Cock (Water-Cooled Exhaust Pipe)

Cooling System - Clean

CAUTION

Wash the cooling system before operating the engine for the first time, or before starting the engine after it has been in storage under coolant drained condition.

1. Close coolant drain cocks and plugs.
2. Pour a cleaning solution (a solution that is non-corrosive to rubber and metals) into the cooling system, and operate the engine at 800 to 900 min⁻¹ for about 15 minutes, then drain the cleaning solution.
3. Close coolant drain cocks and plugs.
4. Add fresh water and operate the engine at 800 to 900 min⁻¹ for about 10 minutes.
Repeat the above rinsing steps until the draining water becomes clear and clean.

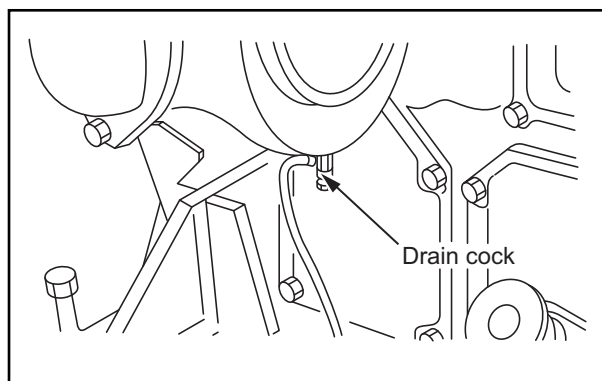


Fig. 8-25 Coolant Drain Cock (Water Pump)

Coolant - Refill



CAUTION

Never open the fresh water tank cap during the operation or immediately after stopping. Stop the engine and, after coolant has sufficiently cooled down, open the cap.

Place waste cloth over the fresh water tank cap, and loosen the cap about a quarter-turn to release the internal pressure.

The coolant is hot while engine is running and immediately after stopping. If the cap is opened while the coolant is hot, hot coolant steam that can burn you will burst out. To avoid a steam burn, wear thick rubber gloves or wrap a cloth around the cap.

When tightening the fresh water tank cap, be sure to tighten securely.

CAUTION

When adding coolant, use the same LLC concentration coolant that is currently in the cooling system.

1. Tighten the drain cocks and plugs firmly.
2. Remove the fresh water tank cap, and add a mixture of water and LLC of the specified concentration to the specified level.

Note: Determine the quantity of LLC using the LLC concentration chart. For the coolant, refer to ["COOLANT" \(6-1\)](#).

For the coolant capacity, refer to ["MAIN SPECIFICATION" \(12-1\)](#).

3. Check the fresh water tank, etc. for coolant leaks. If a leak is found, repair it.
4. When coolant reaches the specified level, tighten the fresh water tank cap firmly.
5. With the manual stop lever placed in the pulled position, crank the engine for approx 10 seconds using the starter. Stop the operation for 1 minute, then, repeat the above operation two or three times to bleed the cooling system.
6. Check the coolant level in the fresh water tank.
7. If a reserve tank is equipped, fill the reserve tank with coolant up to the "FULL" level line.

Seawater - Drain

When the ambient temperature drops below 0°C [32°F], the seawater used for cooling the engine can freeze and cause serious problems such as seawater pump damage. To prevent such problems, drain the seawater after using the engine by following the instructions below.

1. Make sure that the kingston valve is closed.
2. Open the seawater drain cock or remove the plug, and drain seawater.
3. Remove the seawater pump cover, and drain seawater from the seawater pump.

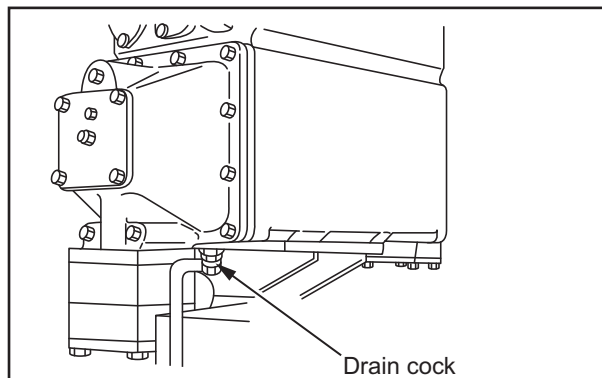


Fig. 8-26 Seawater Drain Cock (Heat Exchanger)

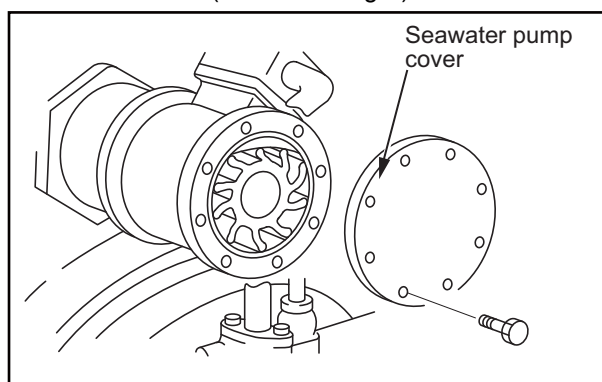


Fig. 8-27 Seawater Pump Cover

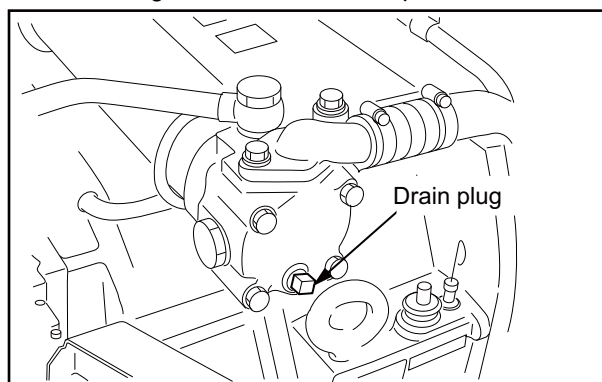


Fig. 8-28 Seawater Drain Plug (Marine Gear Oil Cooler)

Seawater Pump Impeller - Inspect

CAUTION

When installing the impeller, pay attention to the orientation of impeller blades. The impeller may be broken if it is incorrectly installed.

1. Remove the seawater pump cover.
2. Remove the impeller using a puller.
3. Check the impeller for damage, cracks, and if any defects are found, replace the impeller with a new one.
Check the inside the case, and if damaged, replace it with a new one.
Check the cam, and if damaged or worn, replace it with a new one.
4. While paying attention to the orientation of impeller, install the impeller to the seawater pump case.
5. Install the cover with O-ring to the pump case.

Note: Because of simple structure, the puller is not included in the special tools.

Please use commercially available puller or make it by yourself.

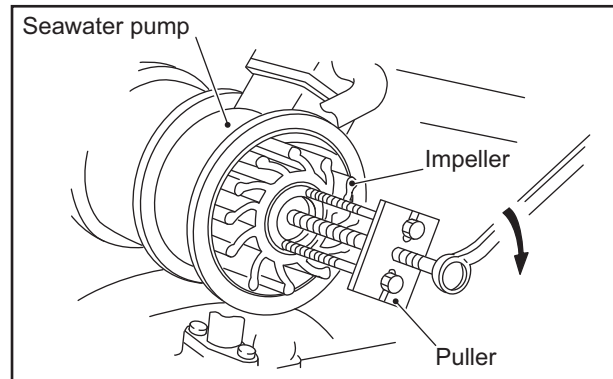


Fig. 8-29 Seawater Pump Impeller - Inspect

Zinc Rod - Inspect

Zinc rods (zinc electrodes) are installed at various sections of the seawater passage to prevent corrosion caused by seawater.

1. Remove each zinc rod and remove deposits (scale) from the surface of rod.
2. If the zinc rod has worn to half the original size, replace it with a new zinc rod. If the zinc rod is not less than half the original size, reinstall it. If zinc rods have completely disappeared, shorten the inspection intervals.

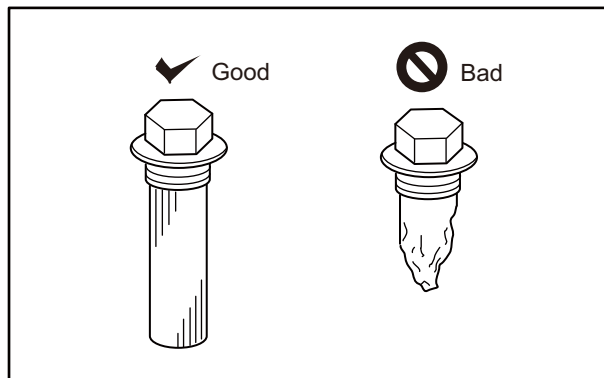


Fig. 8-30 Zinc Rod Condition, Good or Bad

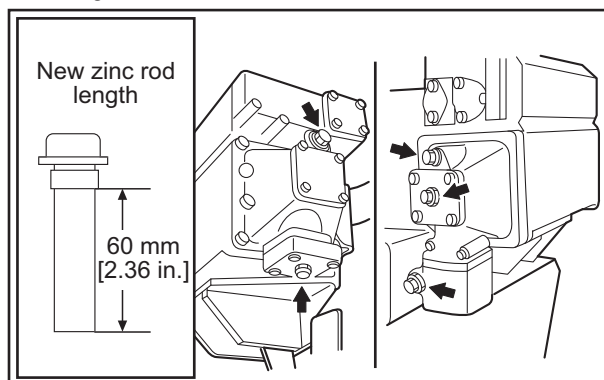


Fig. 8-31 Zinc Rod Mounting Location (Heat Exchanger)

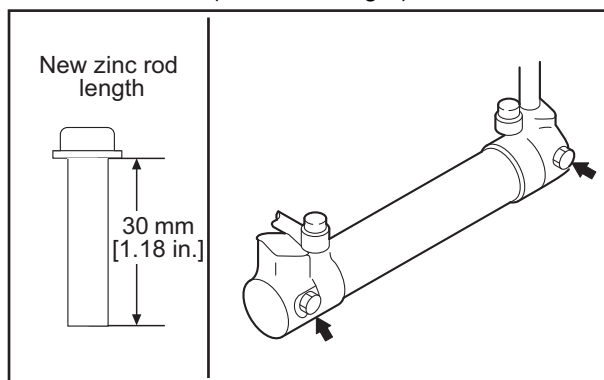


Fig. 8-32 Zinc Rod Mounting Location (Marine Gear Oil Cooler)

Inlet and exhaust systems

Turbocharger - Inspect

CAUTION

Inspect the turbocharger when the engine is cold. Before inspection, make sure that the compressor wheel is not rotating.

CAUTION

The turbocharger inspection should be also conducted if the color of the exhaust gas is abnormal. Do not allow foreign objects to enter the turbocharger.

Disconnect the pipe on the inlet side. Hold the compressor wheel nut by hand and move in the axis direction and from right to left and up and down to check for looseness or contact with surrounding parts. Turn the wheel to check if it rotates smoothly. Replace if defective.

Note: When the inspection requires the removal of turbocharger, contact your MHIET dealer. Also, check the compressor wheel fins for discoloration and breaks, and check for rubbing between compressor wheel and housing.

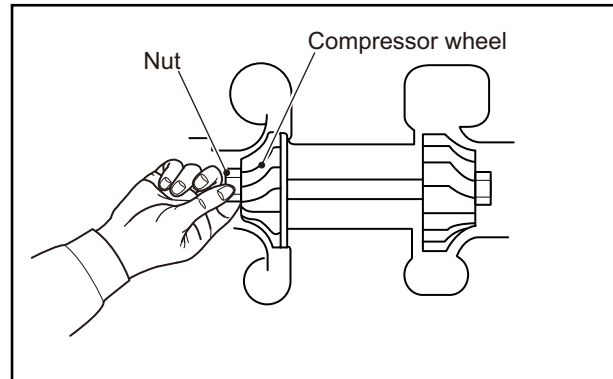


Fig. 8-33 Turbocharger - Check

Pre-Cleaner - Clean, Inspect, and Replace

CAUTION

Never conduct the maintenance of pre-cleaners during engine operation. If foreign particles enter the engine, it accelerates wear of parts and shortens the service life of the engine.

The pre-cleaner that is attached to the silencer of the turbocharger catches foreign particles included in intake air and keep the engine in clean condition for optimum performance. Always keep it clean as instructed below.

1. Remove the pre-cleaner from the silencer, and hand-wash the pre-cleaner with a mild detergent.
2. Rinse the pre-cleaner with fresh water.
3. After drying thoroughly, inspect the pre-cleaner for damage such as breaks. If breaks are found, replace the pre-cleaner with a new one.
4. After cleaning, inspection, or replacement, install the pre-cleaner to the silencer.

Note: If the pre-cleaner is torn, getting thinner or stretched due to cleaning, replace it with a new one.

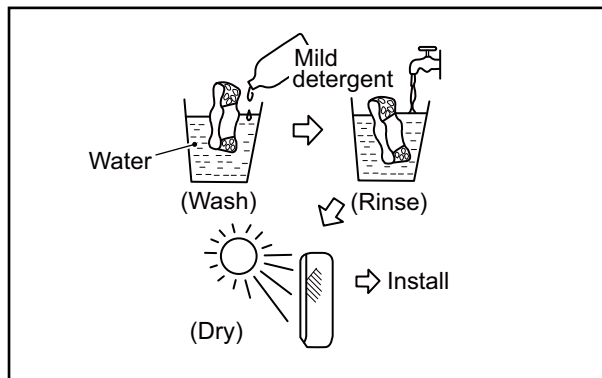


Fig. 8-34 Pre-Cleaner - Wash

Electrical System

Battery - Check

⚠ CAUTION

Never use flames or allow sparks near the battery. The battery releases flammable hydrogen gas and oxygen gas. Any flames or sparks in the vicinity of battery could cause an explosion.

Do not use the battery when the battery fluid level is below the "LOWER LEVEL" mark. It may explode.

Do not short the battery terminals with a tool or other metal object.

When removing battery, always remove the plug from the negative (-) terminal first. When connecting battery, always connect the plug to the positive (+) terminal first.

Before charging the battery, remove all battery cables, and then charge the battery in a well ventilated area.

Make sure the cable clamps are securely attached to the battery terminals. A loose cable clamp can cause sparks, and it could result in an explosion.

Before servicing electrical components or conducting electric welding, set the battery switch to the [Open/OFF] position or remove the plug from the negative (-) terminal to cut off the electrical current.

Battery fluid contains dilute sulfuric acid. Careless handling of the battery may cause a sight loss and/or skin burns. Also, do not swallow the battery fluid.

Wear protective goggles and rubber gloves when working with the battery (e.g. when adding water or charging battery).

If battery fluid is spilled onto the skin or clothing, immediately wash it away with lots of water. Use soap to clean thoroughly.

The battery fluid can cause sight loss if splashing into the your eyes. If it gets into your eyes, immediately flush it away with plenty of clean water, and seek immediate medical attention.

If you accidentally swallow battery fluid, gargle with plenty of water and then drink lots of water, and seek immediate medical attention.

If the battery does not fully recover after charging for 24 hours or more, do not use the battery.

Note: If the specification of battery differs from those of this operation manual, follow the battery manufacturer's operation manual.

Battery Fluid Level - Check

The battery fluid evaporates during the use, and the fluid level gradually decreases. The proper fluid level is between the LOWER LEVEL (Lower limit) and UPPER LEVEL (Upper limit) marks.

For the battery without level marks, the proper fluid level is about 10 to 15 mm [0.39 to 0.59 in.] above the top face of the polar plates.

If the battery fluid level is low, remove the cap, and add distilled water to the proper level.

Note: When adding distilled water, add little by little.

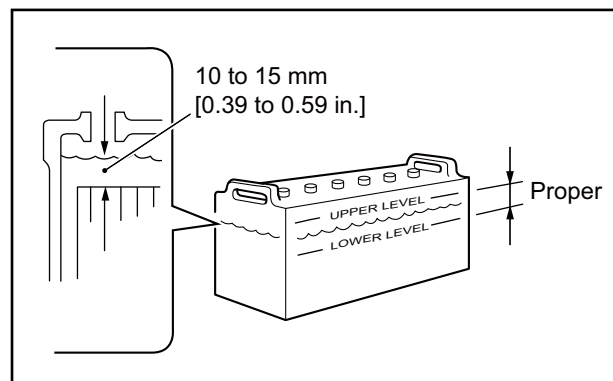


Fig. 8-35 Battery Fluid Level - Check

Specific Gravity of Battery Electrolyte - Check

If the specific gravity of battery fluid measured at 20 °C [68 °F] is lower than 1.22, charge the battery.

Table 8-1 Specific Gravity of Battery Electrolyte

Specific gravity at 20 °C [68 °F]	Condition	Remedy
From 1.26 to 1.28	Good	-
From 1.22 to 1.26	Almost good	Charge
1.22 or less	Not good	Charge

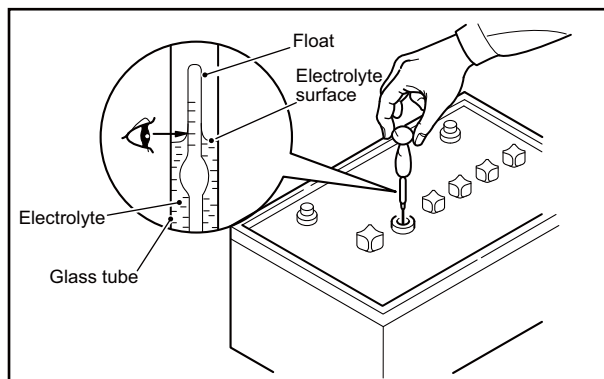


Fig. 8-36 Specific Gravity of Battery Electrolyte - Check

Starter - Inspect

Visually inspect the starter and ring gear for damage.

Note: If the starter is defective, contact your MHIET dealer.

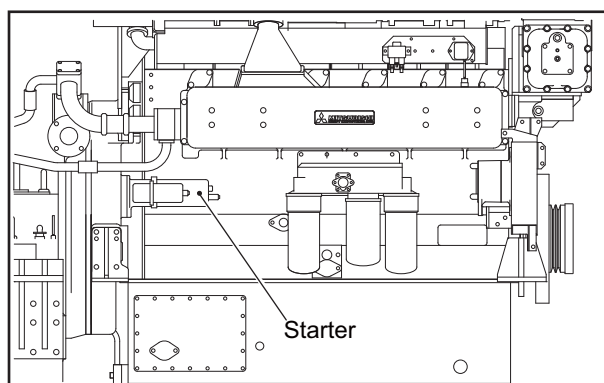


Fig. 8-37 Starter - Inspect

Alternator - Inspect

Visually inspect the alternator for damage.

Remove the belt and turn the pulley by hand to check the smooth rotation. Check the pulley for wear.

Also, visually inspect the inside of alternator for dust and salt accumulation since the alternator is an air cooling type.

Note: If the alternator is defective, contact your MHIET dealer.

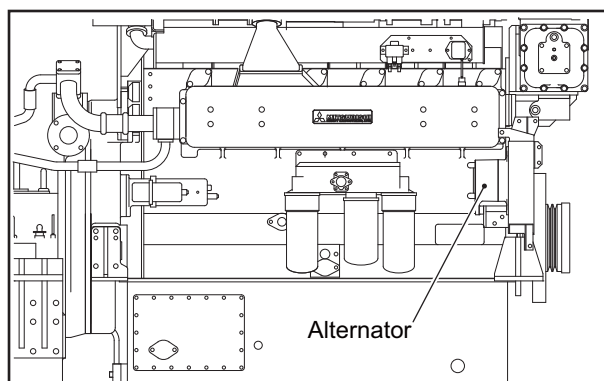


Fig. 8-38 Alternator - Inspect

Chapter 9 LONG-TERM STORAGE

CAUTION

If the engine is not in use for more than 3 months, the internal engine parts can rust, and it may cause damage to the engine.

For long-term engine storage, be sure to follow the instructions below.

Storing Engine in an Inoperable Condition for 3 Months up to 1 Year

Preparation for Storage

1. Drain engine oil, and fill the engine with new oil.
2. Prepare a fuel mixture containing 50% rust-preventive fuel (NP-9), and fill the fuel tank with it.
3. Run the engine at no load idle speed for 5 to 10 minutes.
4. Immediately before stopping the engine, spray volatile corrosion inhibitor (VCI) through the inlet port to prevent rust in the air intake system.
5. Stop the engine, and drain the mixed fuel from the fuel tank.
6. Fill the fuel tank with fuel to protect the fuel tank from rusting.
However, the FRP tank does not require any kind of corrosion protection.
7. Apply a sufficient quantity of ANTIRUST TERAMI SC (NP-3-2) on the exposed machined surfaces.
8. Cover the air inlet, exhaust outlet, breather, etc. with adhesive cloth tape or plastic film.
9. Loosen the belt.
10. Apply a thin coat of grease on the starter and alternator terminals and cover the openings. Also place desiccants inside the openings, and cover the openings with polyethylene sheet or processed polyethylene paper.
11. Disconnect the cables from the battery terminals, and charge the battery. Clean the terminals, apply a thin coat of grease on the terminals, and store the battery in a cool and dry room.
12. Cover the entire engine.

Note: (a) Store the engine in a well-ventilated and dried indoor area.

(b) It is not necessary to drain coolant since it contains LLC. (LLC must be the specified concentration. For the LLC concentration, refer to ["LLC Concentration \(GLASSY and PG GLASSY\)" \(6-6\)](#))

(c) Post a sign at an easily noticeable place to warn that the fuel tank must be filled before operation of the engine for the first time after storage.

Recommended Rust-Preventive Oil and Corrosion Inhibitor

Table 9-1 Table for Recommended Rust-Preventive Oil and Corrosion Inhibitor

JIS		Recommended product	Intended use
K 2246	NP-3-2	ANTIRUST TERAMI SC by JXTG Nippon Oil & Energy	Exposed machined surfaces
	NP-9	ANTIRUST TERAMI LN by JXTG Nippon Oil & Energy	Prevention of rust in fuel system
	NP-10-2	ANTIRUST P-230 by JXTG Nippon Oil & Energy	Prevention of rust in lubricating system
Z 1519	-	VCI Diana ND volatile corrosion inhibitor by Ryoko Chemical	Prevention of rust in air intake system

Maintenance During Storage

Charge the battery once a month. Check battery fluid level, and then charge the battery.

When Using Engine After Storage

1. Remove the cover that has been placed over the entire engine.
2. Remove the cover from the starter and alternator.
3. Adjust the belt tension.

Note: Refer to "[Belt and Belt Tension - Inspect and Adjust](#)" (8-2) for the belt tension adjustment.

4. Remove sealing tapes that have been covered the openings of the engine.
5. Connect pipes and hoses.

Note: For engine oil, refer to "[ENGINE OIL](#)" (5-1).

6. Add fuel.
7. Inspect every part of the engine.
8. Remove the rocker covers, and lubricate the valve mechanisms.
9. Connect a fully charged battery.
10. Make sure the engine oil pressure rises.
11. Conduct a warm-up operation for a sufficient duration to fully lubricate all the components.

Note: For engine starting procedure, refer to "[Start-up](#)" (3-13).

12. Operate the engine under load.

Storing Engine in an Operable Condition

If the engine is not be used for an extended period of time, internal engine parts can rust and lose oil film. As a result, the engine may seize when it is started. To prevent such risks, the engine must be operated periodically.

Operation for Maintenance Purpose

Operate the engine at least once a month as instructed below:

1. With the manual stop lever placed in the pulled position, crank the engine for approx. 10 seconds using the starter. Stop the operation for approx. 1 minute, then, repeat the operation two or three times.
2. After starting, make sure the engine oil pressure rises.
3. Operate the engine about 5 to 10 minutes at no load.

Note: For engine starting procedure, refer to "[Start-up](#)" (3-13).

Lifting Engine

When using the crane to lift the engine, only the operators who have the crane operator license and also have a certificate of the crane operating skill training can operate the crane. Also when using a mobile crane, the person must have a certificate of mobile crane special training.

[Related laws and regulations]

- Occupational Health and Safety Law, Article 61
- Occupational Health and Safety Law, Regulations for Enforcement, Article 20
- Ordinance on Industrial Safety and Health
- The Safety Ordinance for Cranes



WARNING

To lift the engine, use wire ropes, shackles, and slings which are strong enough to support the weight of the engine. Attach slings to the hangers provided on the engine to lift the engine. Consider the engine's center of gravity, and maintain the balance during lifting. The hangers provided on the engine are designed for lifting the engine body only. When lifting the engine equipped with a marine gear, etc., take care so that the load is not imposed only on the hangers of the engine. Keep wire rope sling angles within 60 degrees. If the lifting angle exceeds this limit, excessive load will be imposed on the hangers and this could damage the hangers and result in a serious accident. Remove pipe covers and insulators located near the hangers, and then attach wire ropes to the hangers. To prevent damage to the engine and wire ropes, use a cloth or other soft padding so that the wire ropes will not come in contact with the engine.

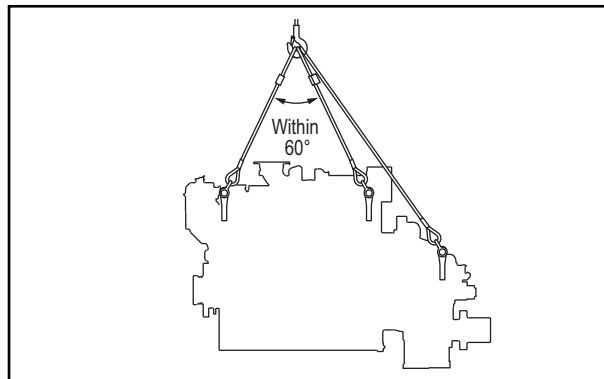


Fig. 10-1 Hitching Wire Ropes

Cautions at Transportation

CAUTION

When transporting the generator set on a truck, consider the weight of the generator set, width and height to ensure safety. Obey applicable laws and regulations such as road traffic laws, vehicle road acts, and vehicle restriction ordinances.

The height and width of the vehicle and cargo on board is established by law (3.5m or less).

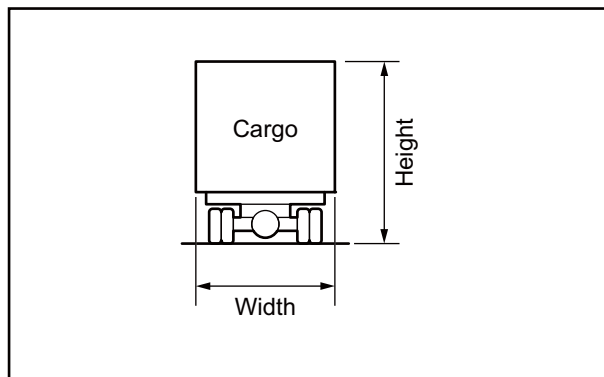


Fig. 10-2 Limitation of the height and width of vehicle and cargo on board

General Precautions

Contact Your MHIET Dealer for Repair Service

Except for relatively simple maintenance work such as changes and refilling of fuel, engine oil, and coolant, the repair work of the faulty engine may require special equipment or involves dangerous work. If the engine failed, contact your MHIET dealer.

Considerations Before Proceeding with Corrective Action

Before taking any actions, consider possible causes of the problem and try to find out if the same problem has occurred in the past.

Check the parts that may be causing the problem in the most efficient manner.

When disassembling any part of the engine, pay close attention to the disassembly sequence so that you can effectively assemble as they were.

Cautions Against Contamination

Dust and foreign materials are the most common cause of rapid wear of parts.

When disassembling any part of the engine, take measures to prevent dust and foreign materials from entering.

Cautions for Parts Handling

Handle parts carefully.

When replacing the part with a new one, order only the genuine MHIET part by referring to the parts catalogue.

Safety Working Practices

Be sure to use wrenches of the correct size. Using a wrench of the wrong size can cause damage to nuts and also may result in injury.

Use correct tools, and perform work with the utmost care.

Be sure to accurately estimate the weight of the part being dismantled. If the removed part is much heavier than you have estimated, it may fall off during lifting and can result in the damage to the parts or personal injury.

Troubleshooting

Tends To Overheat

CAUTION

Remove the fresh water tank cap only after the engine has cooled down sufficiently. To open the fresh water tank cap, open slowly to release pressure. Do not open the fresh water tank cap while the engine is hot to avoid burns due to hot steam and water.

Do not stop engine immediately after hard or extended operation. The engine may be seized due to the coolant temperature rise. Be sure to run the engine at a low idle speed to cool the engine.

Add coolant gradually after the engine has completely cooled. Do not add coolant while the engine is hot. Cylinder head, etc. could be damaged.

The coolant temperature rise warning light comes on (the warning buzzer also goes off) if the engine overheats. If you keep operating the engine uninterrupted with load, it will lead to problems such as knocking, lubrication failure, or seizure. Follow the instructions below when the engine overheats.

1. Stop sailing (or work) at once, and run the engine at a low idle to cool down the engine.
2. After stopping the engine, and only after the engine has completely cooled, add coolant up to the fresh water tank's neck.
3. Check the followings:
 - ♦Cooling freshwater capacity
 - ♦Leaks from cooling system
 - ♦Belt tension and damage
 - ♦Seawater pump impeller damage

If you have not found any problems after checking above, consult with your MHIET dealer.

When Engine Oil Pressure is Abnormal

If the engine continues to be operated under abnormal decrease in engine oil pressure, it could lead to bearing seizure, etc. If the lubrication oil pressure warning light glows with warning buzzer, stop the engine at once, and follow the instructions below.

Table 11-1 Procedures When Abnormal Decrease in Engine Oil Pressure Occurs

Inspection item	Remedy	Referred page
Engine oil level decrease	Refill	8-9
Oil viscosity is too low	Use engine oil of appropriate viscosity suitable to ambient temperature	5-5
Clogged oil filter	Oil Filter - Replace	8-10
Engine oil leaks	Contact your MHIET dealer.	
Lubricating oil pressure warning light failure		

Note: In general, immediately after starting the engine, oil pressure gauge reads higher the normal pressure because the oil temperature is low. The pressure will be back to the normal pressure as the temperature rises.

When Marine Gear Oil Pressure is Abnormal

If abnormal pressure decrease in marine gear oil occurs, do not keep operating the engine. Clutch malfunction or gear damage could occur.

If the clutch oil pressure warning light grows with warning buzzer, stop the engine at once, and follow the instructions below:

Table 11-2 Procedures When Abnormal Clutch (Marine Gear) Oil Pressure Occurs

Item to be Inspected	Remedy	Referred page
Decrease in marine gear oil	Refill	8-15
Oil viscosity is too low	Use engine oil of appropriate viscosity suitable to ambient temperature	5-5
Clogged oil strainer	Oil strainer - Clean	8-15
Clutch oil leaks	Contact your MHIET dealer.	
Clutch oil low pressure warning light failure		

While Being Towed or During Towing

If the ship is involved in a accident and has to be towed, it is not necessary to operate the engine, because the propeller drives the output shaft, thus, marine gear will be operated without lubrication. If the ship is going to be towed for more than one hour, secure the propeller shaft to prevent it from rotating, or pour the marine gear oil up to the center of input shaft.

Problems, Probable Causes, and Solutions

The Starter Does not Crank or Cranks Slowly, Resulting in Start Failure

Table 11-3 Starter Does Not Turn, or Turns Slowly and Engine Will Not Start

Possible cause		Solution
Electrical system	Faulty wire connection	♦Fuse - Inspect ♦Wiring connection of each relay between battery, starter, and starter switch - Inspect
	Battery charge failure	♦Alternator - Inspect (Refer to P8-26) ♦Belt - Inspect and Adjust (Refer to P8-2)
	Weak battery	♦Specific gravity of battery electrolyte - Check (Refer to P8-26) ♦Battery - Charge ♦Battery - Replace
	Faulty starter or faulty safety relay	♦Contact your MHIET dealer.
Lubricating system	Oil viscosity too high	♦Use appropriate engine oil. (Refer to P5-4)
	Excessive oil level	♦Engine oil level - Check (Refer to P3-10)
Engine	Sliding parts rapid wear or lock	♦Contact your MHIET dealer.

Note: The table above also includes the parts that MHIET does not supply. For inspection and maintenance of the parts that are not supplied by MHIET, follow the instructions in the supplier's operation manual.

Starter Cranks, but Engine Does Not Start

Table 11-4 Starter Turns, but Engine Will Not Start

Possible cause		Solution
Fuel system	Run out of fuel, blocked pipe	•Fuel Tank - Inspect, Refill, and Bleed Air (Refer to P8-4) •Fuel Pipes and Valves - Inspect
	Improper fuel properties	•Use appropriate fuel. (Refer to P4-1) •Dust, water, or impurities - Remove (Refer to P8-4)
	Fuel leaks from fuel line or injection pipe	•Fuel lines and injection pipes - Check and Tighten •Contact your MHIET dealer.
	Clogged fuel filter	•Fuel filter - Inspect and Replace (Refer to P8-6) •Gauze filter - Clean (Refer to P8-5)
	Fuel feed pump malfunction	•Contact your MHIET dealer.
	Fuel injection pump malfunction	•Fuel injection pump rack stroke - Inspect •Contact your MHIET dealer.
	Fuel injection nozzle malfunction	•Contact your MHIET dealer.
Air intake system	Insufficient amount of intake air	•Inlet system - Clean and Inspect •Contact your MHIET dealer.
Control system	Governor malfunction	•Fuel control link - Check (Refer to P8-7) •Contact your MHIET dealer.
Engine	Compression pressure drop	•Contact your MHIET dealer.

Note: The table above also includes the parts that MHIET does not supply. For inspection and maintenance of the parts that are not supplied by MHIET, follow the instructions in the supplier's operation manual.

Poor Output

Table 11-5 Poor Output

Possible cause		Solution
Fuel system	Improper fuel properties	•Use appropriate fuel. (Refer to P4-1)
	Clogged fuel filter	•Fuel filter - Inspect and Replace (Refer to P8-6) •Gauze filter - Clean (Refer to P8-5)
	Fuel feed pump malfunction	•Contact your MHIET dealer.
	Fuel injection pump malfunction	•Contact your MHIET dealer.
	Fuel injection nozzle malfunction	•Contact your MHIET dealer.
	Faulty fuel injection timing	•Fuel injection pump drive coupling - Inspect •Contact your MHIET dealer.
	Improper maximum injection volume	•Fuel injection pump rack stroke - Inspect •Contact your MHIET dealer.
Cooling system	Overheating or overcooling	•Belt - Inspect and Adjust Tension (Refer to P8-2) •Seawater pump impeller and drive shaft - Inspect (Refer to P8-21) •Heat exchanger - Inspect •Control system - Inspect •Contact your MHIET dealer.
Inlet and exhaust systems	Insufficient amount of intake air	•Turbocharger - Inspect (Refer to P8-23) •Pre-cleaner - Clean, Inspect, and Replace (Refer to P8-24) •Intake air pressure and intake air leaks - Inspect •Intake air temperature - Inspect •Contact your MHIET dealer.
	Increase of exhaust resistance	•Exhaust pipe - Inspect •Contact your MHIET dealer.
Engine	Compression pressure drop	•Contact your MHIET dealer.
	Faulty valve timing	•Contact your MHIET dealer.
	Rapid wear of sliding parts	•Contact your MHIET dealer.
Control system	Governor malfunction	•Contact your MHIET dealer.
Rig	Excessive load	•Propeller and propeller shaft - Inspect •Deposits - Remove

Note: The table above also includes the parts that MHIET does not supply. For inspection and maintenance of the parts that are not supplied by MHIET, follow the instructions in the supplier's operation manual.

Exhaust Smoke is White or Blue

Table 11-6 Exhaust Smoke is White or Blue

Possible cause		Solution
Fuel system	Improper fuel properties	•Check cetane index, and use appropriate fuel. (Refer to P4-1)
	Faulty fuel injection timing	•Fuel injection pump drive coupling - Inspect •Contact your MHIET dealer.
	Fuel injection nozzle malfunction	•Contact your MHIET dealer.
	Uneven volume of fuel injection	•Ignition noise and exhaust smoke temperature - Inspect •Contact your MHIET dealer.
	Incorrect fuel injection timing	•Contact your MHIET dealer.
Lubrication system	Combustion of engine oil	•Engine oil level - Check (Refer to P3-10) •Contact your MHIET dealer.
Cooling system	Overcooling	•Control system - Inspect •Thermostat - Inspect •Contact your MHIET dealer.
Engine	Faulty valve timing	•Contact your MHIET dealer.
	Compression pressure drop	•Contact your MHIET dealer.

Note: The table above also includes the parts that MHIET does not supply. For inspection and maintenance of the parts that are not supplied by MHIET, follow the instructions in the supplier's operation manual.

Exhaust Smoke is Black or Grey

Table 11-7 Exhaust Smoke is Black or Charcoal

Possible cause		Solution
Fuel system	Improper fuel properties	•Use appropriate fuel. (Refer to P4-1)
	Fuel feed pump malfunction	•Contact your MHIET dealer.
	Fuel injection pump malfunction	•Contact your MHIET dealer.
	Fuel injection nozzle malfunction	•Contact your MHIET dealer.
	Faulty fuel injection timing	•Fuel injection pump drive coupling - Inspect •Contact your MHIET dealer.
	Uneven volume of fuel injection	•Exhaust gas temperature - Check •Contact your MHIET dealer.
Inlet and exhaust systems	Insufficient amount of intake air	•Turbocharger - Inspect (Refer to P8-23) •Pre Cleaner - Clean, Inspect, and Replace (Refer to P8-24) •Intake air pressure and intake air leaks - Inspect •Intake air temperature and ventilation system - Inspect •Contact your MHIET dealer.
	Increase of exhaust resistance	•Turbocharger - Inspect (Refer to P8-23) •Exhaust pipe - Inspect •Contact your MHIET dealer.
Engine	Compression pressure drop	•Contact your MHIET dealer.
	Faulty valve timing	•Contact your MHIET dealer.
	Rapid wear of sliding parts	•Contact your MHIET dealer.
Load system	Excessive load	•Load system - Inspect •Contact your MHIET dealer.
Rig	Excessive load	•Propeller matching - Adjust

Note: The table above also includes the parts that MHIET does not supply. For inspection and maintenance of the parts that are not supplied by MHIET, follow the instructions in the supplier's operation manual.

Excessive Fuel Consumption

Table 11-8 Excessive Fuel Consumption

Possible cause		Solution
Fuel system	Fuel injection nozzle malfunction	•Contact your MHIET dealer.
	Faulty fuel injection timing	•Fuel injection pump drive coupling - Inspect •Contact your MHIET dealer.
	Improper fuel properties	•Use appropriate fuel. (Refer to P4-1)
	Fuel leaks from fuel line or injection pipe	•Fuel lines and injection pipes - Check and Tighten •Contact your MHIET dealer.
Cooling system	Overcooling	•Control system - Inspect •Thermostat - Inspect •Contact your MHIET dealer.
Inlet and exhaust systems	Insufficient amount of intake air	•Turbocharger - Inspect (Refer to P8-23) •Pre-cleaner - Clean, Inspect, and Replace(Refer to P8-24) •Intake air pressure and intake air leaks - Inspect •Intake air temperature and ventilation system - Inspect •Contact your MHIET dealer.
	Increase of exhaust resistance	•Turbocharger - Inspect (Refer to P8-23) •Exhaust pipe - Inspect •Contact your MHIET dealer.
Engine	Compression pressure drop	•Contact your MHIET dealer.
	Faulty valve timing	•Contact your MHIET dealer.
	Rapid wear of sliding parts	•Contact your MHIET dealer.
Rig	Excessive load	•Propeller matching - Adjust

Note: The table above also includes the parts that MHIET does not supply. For inspection and maintenance of the parts that are not supplied by MHIET, follow the instructions in the supplier's operation manual.

Excessive Engine Oil Consumption

Table 11-9 Excessive Engine Oil Consumption

Possible cause		Solution
Fuel system	Faulty fuel injection timing	•Fuel injection pump drive coupling - Inspect •Contact your MHIET dealer.
Lubrication system	Oil leaking on outside engine	•Oil leaks - Inspect •Contact your MHIET dealer.
	Engine oil viscosity too low	•Use the oil having appropriate viscosity. (Refer to P5-7)
	Excessive engine oil temperature	•Engine oil level - Check(Refer to P3-10) •Oil cooler and oil thermostat - Inspect •Contact your MHIET dealer.
Cooling system	Overheating	•Control system - Inspect •Thermostat - Inspect •Contact your MHIET dealer.
Inlet and exhaust systems	Oil entry to the air chamber	•Contact your MHIET dealer.
	Friction of valve train parts	•Contact your MHIET dealer.
Engine	Worn sliding parts	•Contact your MHIET dealer.
Load system	Excessive load	•Load system - Inspect •Contact your MHIET dealer.

Note: The table above also includes the parts that MHIET does not supply. For inspection and maintenance of the parts that are not supplied by MHIET, follow the instructions in the supplier's operation manual.

Overheating

Table 11-10 Overheating

Possible cause		Solution
Cooling system	Insufficient coolant level	•Coolant leaks - Inspect •Coolant level - Check (Refer to P3-11)
	Water Pump faulty operation	•Contact your MHIET dealer.
	Thermostat malfunction	•Contact your MHIET dealer.
Load system	Excessive load	•Load system - Inspect •Contact your MHIET dealer.
Engine	Rapid wear of sliding parts	•Contact your MHIET dealer.

Note: The table above also includes the parts that MHIET does not supply. For inspection and maintenance of the parts that are not supplied by MHIET, follow the instructions in the supplier's operation manual.

Engine Oil Pressure Drop

Table 11-11 Engine Oil Pressure Drop

Possible cause		Solution
Lubrication system	Low engine oil level	•Engine oil level - Check (Refer to P3-10)
	Faulty engine oil property (viscosity)	•Oil property analysis. Use appropriate engine oil. (Refer to P5-7)
	Oil temperature too high	•Cooling system - Check •Contact your MHIET dealer.
	Clogged oil filter	•Oil filter and bypass oil filter - Inspect and replace (Refer to P8-9)
	Faulty oil pump operation	•Contact your MHIET dealer.
	Faulty relief valve operation	•Contact your MHIET dealer.
Control system	Faulty pressure unit operation	•Control system and wiring - Inspect •Contact your MHIET dealer.
Engine	Rapid wear of sliding parts	•Contact your MHIET dealer.
	Increased clearance of sliding part	•Contact your MHIET dealer.
Load system	Excessive load	•Load system - Inspect •Contact your MHIET dealer.

Note: The table above also includes the parts that MHIET does not supply. For inspection and maintenance of the parts that are not supplied by MHIET, follow the instructions in the supplier's operation manual.

When Fuel has Run Out

When the engine stops due to fuel runout while engine is running, restart the engine as described below:

1. Turn the starter switch to the "OFF" position.
2. Add fuel to the fuel tank.
For refilling fuel tank, refer to ["Fuel Tank Oil Level - Check" \(3-9\)](#).
3. Bleed air from the fuel system.
To bleed air from the fuel system, refer to ["Priming the Fuel System" \(3-1\)](#).
4. Start the engine.
For engine starting procedure, refer to ["Start-up" \(3-13\)](#).

Chapter 12 MAIN SPECIFICATION

Table 12-1 Main Specifications

Item	Specifications
Engine model	S6R2-T2MTK3M
Continuous output	670 kW {911 PS} / 1406 min ⁻¹
Type	Vertical, Water-cooled, 4-stroke cycle, with Turbocharger and Intercooler
No. of cylinders - Arrange-ment	6 cylinders, in-line
Cylinder bore x stroke	φ170 x 220 mm [φ6.69 x 8.66 in.]
Displacement (declared value)	30.0 L
Combustion system	Direct injection system
Compression ratio	14.1 : 1
Firing order	1-5-3-6-2-4
Direction of rotation	Counterclockwise as viewed from the stern
Dimensions (L x W x H)	2700×1200×1900 mm [77.45×38.74×52.36 in.]
Dry weight	Approx. 4000 kg[14396 lb]
Fuel	Diesel fuel or A heavy oil (Representative engine test fuel oil: fuel composition DMX (diesel fuel))
Fuel injection pump	PS6 type
Fuel filter	Cartridge type paper-element
Fuel injection nozzle	Hole type
Fuel injection starting pressure	29.4 MPa {300 kgf/cm ² } [4263 psi]
Governor	Hydraulic type (all-speed control)
Lubricating method	Forced circulation (pressure feed by oil pump)
Lubrication oil	CF or CH-4 grade oil (API service classification)
Engine oil capacity	Oil pan: approx. 140 L, Engine: approx 150 L
Oil filter	Cartridge type paper-element
Oil cooler	Water-cooled, multi-plate type
Cooling method	Freshwater cooler directly connected to engine
Cooling freshwater capacity	Approx. 120 L [15.3 US gal]
Starting system	Self starter motor
Starter	DC24V - 7.5 kW
Alternator	DC24V - 35 A
Turbocharger	Mitsubishi TF15M
Marine gear type	Hydraulic parallel multi-pipes, MGN90BLX
Marine gear reduction ratio	2.51, 3.06, 3.48, 3.93
Marine gear oil capacity	21 L

Note: The specifications above are subject to change without notice.

Chapter 13 Electrical Wiring Diagram

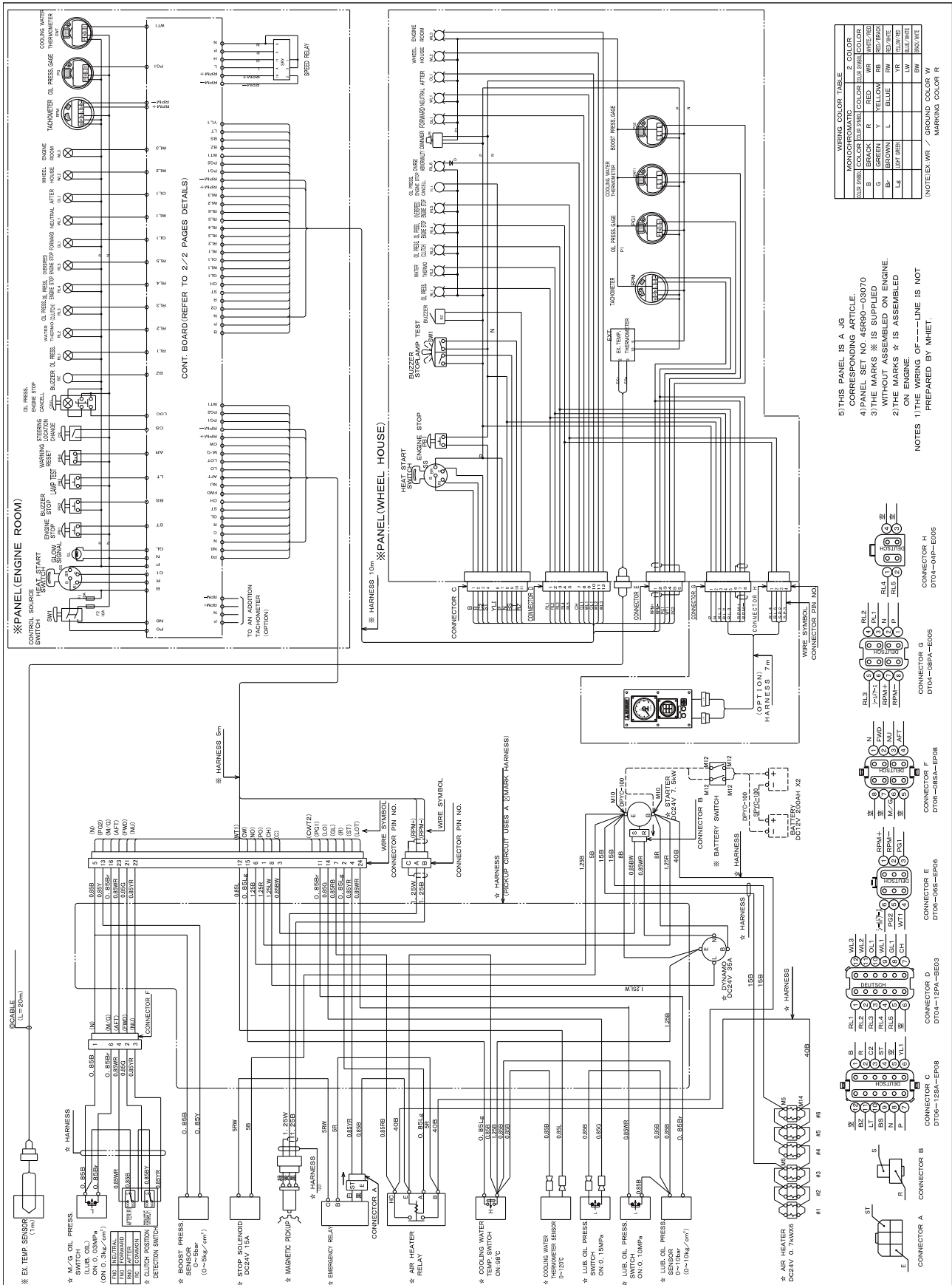


Fig. 13-1 Electric Wiring Diagram 1/2

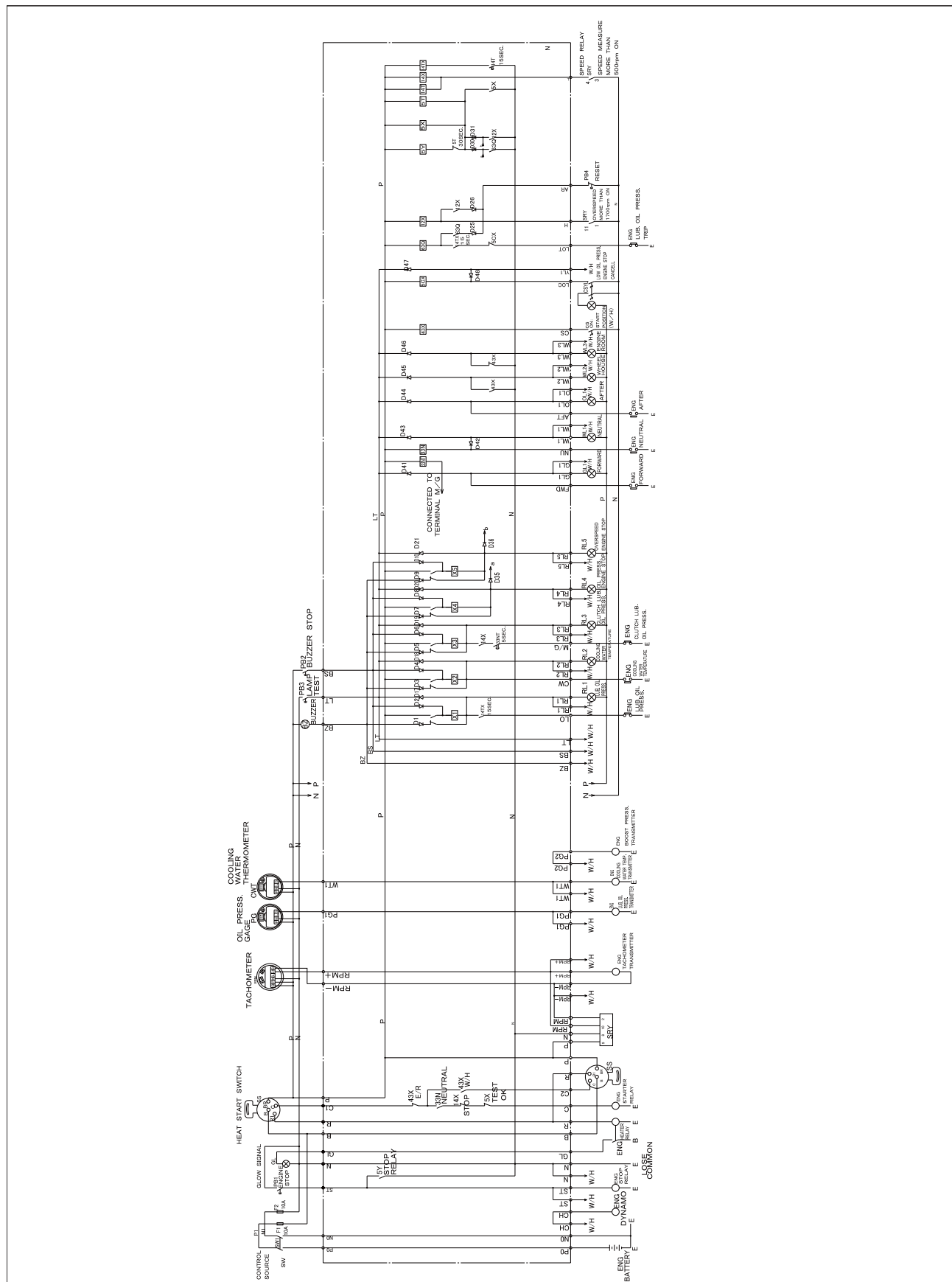


Fig. 13-2 Electric Wiring Diagram 2/2

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