

MITSUBISHI MARINE ENGINE

S6R-T2MPTK

for Mitsubishi Heavy Industries Engine System Asia Pte. Ltd.

OPERATION & MAINTENANCE MANUAL

Issued: March 2024

Pub. No. 292T1-40720

Revision: 3

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**

Contact Us for MHIET Engine Parts

According to the contents of the inquiry, we may share personal information including your name, address, telephone number, e-mail address and contents of the inquiry with our group companies. In this case, MHI take responsibility for managing personal information and will not use such information for purposes other than responding to your inquiry.

<http://www.mhiet.co.jp/en/products/contact/index.html>



Request & Inquiry About Maintenance

According to the contents of the inquiry, we may share personal information including your name, address, telephone number, e-mail address and contents of the inquiry with our group companies. In this case, MHI take responsibility for managing personal information and will not use such information for purposes other than responding to your inquiry.

<http://www.mhiet.co.jp/en/products/engine/service/maintenance/consulting/index.html>



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

Mitsubishi Heavy Industries Engine & Turbocharger, Ltd. will repair or replace the product, which returned to us during the warranty period, when we judge that the product or a part of the products is defective in material and/or workmanship after conducting inspection. 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.

♦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.

♦MHIET Ltd. will not be liable for any damages or personal injuries resulting from any modification, without our written permission, of the engine and devices supplied from 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 operation 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 part 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 aspect 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.
- ♦MHIET 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.
- ♦This manual has been prepared for people whose native language is English. When the engine is used by individuals whose native language is not English, the engine owner is requested to provide thorough safety guidance to the operators. Also attach safety, caution and operating signs 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 in this manual may differ from the engine you have purchased.
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.
- ♦Make sure that all warning/caution/emission labels are legible. Clean or replace the labels when the description and/or illustration are not clear to read.
 - ♦Illegible labels fail to alert people, which may cause personal injury, environmental pollution, and damage to the engine.
 - ♦For cleaning the labels, use a cloth and soapy water. DO NOT USE CLEANING SOLVENTS, GASOLINE, OR OTHER CHEMICALS THAT MAY ERASE THE PRINT OR CAUSE PEELING OFF OF THE LABEL. If the labels are damaged, replace them with new ones.
- ♦When replacing a part that has a label attached, attach the new label to the new part so that it is in the same state as before replacement.
- ♦New labels are available at your MHIET dealer, MHIET group company, or MHIET.

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.

Units 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 = ASTM International
- ♦CARB = California Air Resources Board
- ♦CCS = Cold Cranking Simulator
- ♦EPA = United States Environmental Protection Agency
- ♦FED = Federal Specifications and Standards
- ♦ISO = International Organization for Standardization
- ♦JIS = Japanese Industrial Standards
- ♦JPI = Japan Petroleum Institute
- ♦LLC = Long Life Coolant
- ♦MHIET = Mitsubishi Heavy Industries Engine & Turbocharger, Ltd.
- ♦MRV = Mini - Rotary Viscometer
- ♦OSHA = Occupational Safety and Health Administration
- ♦SAE = Society of Automotive Engineers
- ♦SDS = Safety Data Sheet

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 NOx 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 NOx regulations. EIAPP-certificate and Technical File must be kept onboard 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)

NOx 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.

Chapter 1

BASIC SAFETY PRECAUTIONS

Fire and Explosion Protection.....	1-1
Keep Flames Away	1-1
Keep Engine Surrounding Area Tidy and Clean ...	1-1
Pay Attention to Engine Room Ventilation	1-1
Do Not Open Side Covers Until Engine Has Cooled	1-1
Be Alert for Leaking Fuel, Oil, or Exhaust Gas	1-1
Use Explosion-Proof Light.....	1-1
Prevention of Electric Short Circuit	1-1
Keep Fire Extinguishers and First-Aid Kit Handy ...	1-1
Stay Away From Rotating and Moving Parts.....	1-2
Keep Rotating Parts Covered for Safety	1-2
Checking Safety Around Engine Before Starting ...	1-2
Stay Away From Rotating Parts During Operation	1-2
Lockout and Tagout	1-2
Be Sure to Stop Engine Before Inspection/ Maintenance Work	1-2
Always Put Turning Tool Back in Place After Use.....	1-2
Prevention of Exhaust Gas Poisoning... ..	1-3
Pay Attention to Ventilation When Operating Engine	1-3
Prevention of Hearing Loss	1-3
Be Sure to Wear Ear Plugs	1-3
Fall Prevention.....	1-3
Lift Engine Carefully.....	1-3
Do Not Climb Onto the Engine.....	1-3
Always Use a Stable Foothold During Maintenance.....	1-3
Burn Protection.....	1-4
Do Not Touch Engine During or Immediately After Operation.....	1-4
Add Coolant Only After Coolant Temperature Dropped	1-4
Do Not Remove Heat Shields	1-4
Burn Prevention When Changing Oil	1-4
Be Careful When Handling Fuel, Engine Oil, and Coolant (LLC)	1-4
Use Specified Fuel, Engine Oil, and LLC Only ...	1-4
Handle LLC Carefully	1-4
Proper Disposal of Waste Oil, LLC, and Coolant	1-4

When Abnormality Occurs	1-5
Stop Operation Immediately If You Notice Any Abnormality	1-5
Do Not Add Coolant Immediately After Stopping Due to Overheating	1-5
Be Careful When Starting After an Abnormal Stop	1-5
Stop Engine Immediately When Engine Oil Pressure Has Dropped	1-5
If Belt Breaks, Stop Engine Immediately	1-5
Battery Safety Precautions	1-5
Be Careful When Handling Battery	1-5
Other Precautions	1-6
Do Not Tamper.....	1-6
Observe Safety Rules at Work Site	1-6
Wear Proper Work Clothing and Protective Gears	1-6
Never Break the Seals	1-6
Performance of Pre-Operation Inspection and Periodic Inspections	1-6
Engine Break-in.....	1-6
Warming Up Engine First.....	1-6
Cool Down the Engine Before Stopping.....	1-6
Prohibition of Overloaded Operation	1-7
Limitation of Continuous Under Light Load Operation	1-7
Do Not Splash Water on Engine	1-7
Pay Attention to Pre-cleaner Maintenance	1-7
Use Proper Tools for Maintenance Work	1-7
Do Not Operate Starter for a Long Duration ...	1-7
Do Not Turn Off the Battery Switch During Operation	1-7
Engine Transportation Precautions	1-7
Do not turn engine to reverse direction	1-7
Warning/Caution Labels.....	1-8
Maintenance of Warning/Caution Labels	1-8

Chapter 2

NAME OF PARTS

Engine External Views	2-1
Front View	2-1
Rear View	2-1
Left View	2-2
Right View	2-2

Operating Devices	2-3
Speed Control Knob.....	2-3
Manual Stop Lever	2-3
Stop Solenoid	2-4
Operating Position Selector Switch.....	2-4
Transmitters for Instruments	2-4
Engine Protection Devices	2-5
Oil Pressure Switch.....	2-5
Thermo Switch	2-5
Rotation Detection Pickup	2-5
Instrument Panel	2-6
Trip Panel	2-8
Using Manual Turning Gear	2-9

Chapter 3 OPERATION

Preparation for Operation of New or Overhauled Engine	3-1
Preparation of Fuel System	3-1
Preparation of Lubrication System	3-4
Preparation of Cooling System	3-5
Preparation of Electrical System	3-6
Test Operation	3-7
Normal Engine Operation	3-8
Pre-operation Inspection	3-8
Engine Exterior - Inspect	3-8
Fuel Tank Oil Level - Check.....	3-9
Oil-Water Separator - Drain Water.....	3-9
Fuel Control Link - Check.....	3-10
Engine Oil Level - Check.....	3-11
Coolant Level - Check.....	3-11
Warning Indicator Light - Operation Check....	3-12
Start-up.....	3-12
Cautions When Starting	3-12
Starting Procedures	3-13
Warm-up Operation	3-14
Engine Oil Pressure - Check	3-14
Engine - Walk Around Check	3-14
Operation	3-15
Precautions in Engine Operation	3-15
Inspection During Operation	3-15
Stopping	3-16
Cautions When Stopping	3-16
Stopping Procedure	3-16

Chapter 4 FUEL

Recommended Fuel	4-1
Handling Fuel	4-1
Fuel Quality Standard	4-2

Chapter 5 ENGINE OIL

Use Recommended Engine Oil Only ...	5-1
Genuine MHIET Engine Oil.....	5-1
Other Commercial Engine Oils	5-1
Handling Engine Oil	5-5
Service Limits for Engine Oil	5-5
Definition of Property Limit of Engine Oil	5-6
Kinetic Viscosity	5-6
Base Number	5-6
Acid Number	5-6
Water Content	5-6
Flash Point	5-6
Insolubles	5-6
Engine Oil Analysis Service	5-7

Chapter 6 COOLANT

Recommended Water for Coolant	6-1
Long Life Coolant (LLC)	6-1
Genuine MHIET LLC	6-1
Other Commercial LLCs	6-2
Requirements for Other Commercial LLCs	6-2
General Quality Requirements for LLC	6-2
LLC Quality Standard	6-3
Maintenance of LLC	6-6
Replacement Intervals of LLC.....	6-6
LLC Concentration (GLASSY and PG GLASSY).....	6-6
Necessity of LLC	6-7
Characteristics of LLC Additives	6-7
Examples of Abnormalities Caused by Amine Type LLC	6-7
Pitting of Iron Parts	6-7
Corrosion of Aluminum Parts	6-7
Pitting and Clogging of Heat Exchanger	6-7

Chapter 7

MAINTENANCE SCHEDULE

How to Use the Periodic

Maintenance Schedule 7-1

Periodic Maintenance Schedule 7-2

Chapter 8

PERIODIC INSPECTION AND MAINTENANCE PROCEDURES

Engine 8-1

Engine Exterior - Inspect 8-1

Belt and Belt Tension - Inspect and Adjust 8-2

Damper - Inspect..... 8-3

Fuel System.....8-4

Fuel System - Inspect 8-4

Fuel Tank - Clean..... 8-4

Fuel Tank - Drain Water..... 8-4

Oil-Water Separator - Drain Water..... 8-5

Oil-Water Separator Element - Replace..... 8-5

Gauze Filter - Clean..... 8-6

Fuel Filter - Replace..... 8-7

Fuel Filter - Replace While Engine is Running... 8-8

Fuel Control Link Ball Joint - Inspect..... 8-8

Fuel Pipe - Inspect 8-9

Lubrication System.....8-10

Engine Oil, Oil Filter, and Bypass Oil Filter -
Replace 8-10

Ingress of Fuel and Water In Engine Oil -
Inspect 8-13

Governor Oil Filter - Replace 8-13

Cooling System 8-14

Coolant - Change 8-14

Zinc Rod - Inspect..... 8-16

Inlet and Exhaust Systems 8-17

Turbocharger - Inspect..... 8-17

Pre-Cleaner - Clean, Inspect, and Replace ... 8-18

Electrical System.....8-19

Starter - Inspect..... 8-20

Alternator - Inspect..... 8-20

Chapter 9

LONG-TERM STORAGE

Storing Engine in an Inoperable

Condition for 3 Months up to 1 Year ... 9-1

Preparation for Storage 9-1

Maintenance During Storage 9-1

When Using Engine After Storage 9-2

Storing Engine in an Operable

Condition 9-2

Operation for Maintenance Purpose 9-2

Chapter 10

TRANSPORTATION

Lifting Engine 10-1

Chapter 11

TROUBLESHOOTING

General Precautions 11-1

Contact Your MHIET Dealer for Repair

Service 11-1

Considerations Before Proceeding with

Corrective Action 11-1

Cautions Against Contamination 11-1

Cautions for Parts Handling 11-1

Safety Working Practices 11-1

Problems, Probable Causes,
and Solutions 11-2

The Starter Does not Crank or Cranks

Slowly, Resulting in Start Failure..... 11-2

Starter Cranks, but Engine Does Not Start 11-3

Insufficient Output 11-4

Exhaust Smoke is White or Blue 11-5

Exhaust Smoke is Black or Gray..... 11-6

Excessive Fuel Consumption 11-7

Excessive Engine Oil Consumption 11-8

Overheating..... 11-8

Engine Oil Pressure Drop 11-9

When Fuel has Run Out 11-9

Chapter 12

MAIN SPECIFICATIONS

Main Specifications 12-1

Chapter 13

ELECTRICAL WIRING DIAGRAM

REVISION HISTORY

List of Illustrations

Fig. 1-1	Warning/Caution Labels	1-8
Fig. 2-1	Engine Front View	2-1
Fig. 2-2	Engine Rear View	2-1
Fig. 2-3	Engine Left-Side View	2-2
Fig. 2-4	Engine Right-Side View.....	2-2
Fig. 2-5	Speed Control Knob	2-3
Fig. 2-6	Manual Stop Lever	2-3
Fig. 2-7	Stop Solenoid	2-4
Fig. 2-8	Operating Position Selector Switch	2-4
Fig. 2-9	Rotation Detection Pickup	2-4
Fig. 2-10	Oil Pressure Switch	2-5
Fig. 2-11	Thermo Switch	2-5
Fig. 2-12	Rotation Detection Pickup	2-5
Fig. 2-13	Instrument Panel	2-6
Fig. 2-14	Stop Panel.....	2-8
Fig. 2-15	Manual Turning Gear Position (During Operation)	2-9
Fig. 2-16	Manual Turning Gear Position (Pushed-In)	2-9
Fig. 2-17	Manual Turning Gear Position (When Turning Shaft)	2-9
Fig. 3-1	Priming Pump Comparison	3-1
Fig. 3-2	A-type Priming Pump - Operation	3-2
Fig. 3-3	B-type Priming Pump - Operation	3-2
Fig. 3-4	Fuel Filter - Bleed Air	3-2
Fig. 3-5	Fuel Injection Pump - Bleed Air	3-2
Fig. 3-6	A-type Priming Pump Tightening Method	3-3
Fig. 3-7	A-type Priming Pump Head Packing	3-3
Fig. 3-8	Oil Filler and Oil Level Gauge	3-4
Fig. 3-9	Coolant Drain Cock (Engine Body)	3-5
Fig. 3-10	Coolant Drain Cock (Water Pump).....	3-5

Fig. 3-11	Coolant Drain Cock (Exhaust Manifold Pipe)	3-5
Fig. 3-12	Battery Fluid Level - Check	3-6
Fig. 3-13	Valve Open/Closed Position - Check	3-8
Fig. 3-14	Oil-Water Separator - Drain Water	3-9
Fig. 3-15	Fuel Control Link - Check.....	3-10
Fig. 3-16	Fuel Non-Injection Position	3-10
Fig. 3-17	Oil Filler and Oil Level Gauge	3-11
Fig. 3-18	Warning Indicator Light - Operation Check	3-12
Fig. 3-19	Battery Switch "ON"	3-13
Fig. 3-20	Starter Switch "START".....	3-13
Fig. 3-21	Starter Switch "ON"	3-13
Fig. 3-22	Oil Pressure Gauge.....	3-14
Fig. 3-23	Engine Stop Button	3-16
Fig. 3-24	Starter Switch "OFF"	3-16
Fig. 3-25	Battery Switch "OFF".....	3-16
Fig. 5-1	MITSUBISHI DIESEL ENGINE OIL	5-1
Fig. 5-2	Engine Oil Grade.....	5-1
Fig. 5-3	Selection of Oil Viscosity.....	5-4
Fig. 6-1	GLASSY - LLC	6-1
Fig. 6-2	Coolant Freezing Temperature (GLASSY and PG GLASSY).....	6-6
Fig. 8-1	Valve Open/Closed Position - Check	8-1
Fig. 8-2	Belt Tension - Adjust	8-2
Fig. 8-3	Damper - Check Visually.....	8-3
Fig. 8-4	Damper Temperature Control	8-3
Fig. 8-5	Fuel Tank - Drain Water	8-4
Fig. 8-6	Oil-Water Separator - Drain Water	8-5
Fig. 8-7	Oil-Water Separator Element - Replace...	8-5
Fig. 8-8	Gauze Filter - Clean	8-6
Fig. 8-9	Fuel Filter - Replace.....	8-7
Fig. 8-10	Fuel Filter	8-7
Fig. 8-11	Fuel Filter Switchover Cock.....	8-8
Fig. 8-12	Ball Joint - Check for Looseness	8-8
Fig. 8-13	Fuel Control Link - Remove.....	8-8
Fig. 8-14	High-Pressure Fuel Injection Pipe and Clamp Seat - Inspect and Replace	8-9
Fig. 8-15	Low-Pressure Fuel Pipe, Oil Pipe, and Clip - Inspect and Replace	8-9

Fig. 8-16	Oil Filter and Bypass Oil Filter - Replace	8-10
Fig. 8-17	Oil Filter	8-10
Fig. 8-18	Oil Filter - Replace While Engine is Running	8-11
Fig. 8-19	Oil Filler and Oil Level Gauge	8-12
Fig. 8-20	Governor Oil - Drain	8-13
Fig. 8-21	Governor Oil Filter - Replace.....	8-13
Fig. 8-22	Coolant Drain Cock (Engine Body) ...	8-14
Fig. 8-23	Coolant Drain Cock (Water-Cooled Exhaust Pipe).....	8-14
Fig. 8-24	Coolant Drain Cock (Water Pump).....	8-15
Fig. 8-25	Zinc Rod - Judge	8-16
Fig. 8-26	Zinc Rod Mounting Location (Heat Exchanger)	8-16
Fig. 8-27	Zinc Rod Mounting Location (Air Cooler)	8-16
Fig. 8-28	Turbocharger - Inspect.....	8-17
Fig. 8-29	Pre-Cleaner - Wash.....	8-18
Fig. 8-30	Battery Fluid Level - Check	8-19
Fig. 8-31	Specific Gravity of Battery Electrolyte - Check	8-20
Fig. 8-32	Starter - Inspect.....	8-20
Fig. 8-33	Alternator - Inspect.....	8-20
Fig. 10-1	Lifting Hangers	10-1
Fig. 13-1	Electric Wiring Diagram 1/2.....	13-1
Fig. 13-2	Electric Wiring Diagram 2/2.....	13-2

List of Tables

Table 2-1	Instrument Panel	2-6
Table 2-2	About Stop Panel.....	2-8
Table 3-1	Standard Values at Rated Speed	3-15
Table 4-1	Recommended Fuel	4-1
Table 4-2	Recommended Limit and Use Limit for Fuel Properties	4-2
Table 5-1	Engine Oil Quality Standards (Grade CF SAE 30)	5-2
Table 5-2	Engine Oil Quality Standards (Grade CF SAE 15W-40).....	5-3
Table 5-3	Engine Oil Quality Standards (Grade CH-4 SAE 15W-40).....	5-4
Table 5-4	Engine Oil Properties.....	5-5
Table 6-1	Water Quality Standard	6-1
Table 6-2	LLC Quality Standard	6-3
Table 6-3	Recommended LLC Concentration	6-6
Table 7-1	PERIODIC MAINTENANCE CHART	7-2
Table 8-1	Types of Thermo Labels.....	8-3
Table 8-2	Specific Gravity of Battery Electrolyte	8-20
Table 9-1	Recommended Rust-Preventive Oil and Corrosion Inhibitor	9-1
Table 11-1	The Starter Does not Crank or Cranks Slowly, Resulting in Start Failure	11-2
Table 11-2	Starter Cranks, but Engine Does Not Start	11-3
Table 11-3	Insufficient Output.....	11-4
Table 11-4	Exhaust Smoke is White or Blue	11-5
Table 11-5	Exhaust Smoke is Black or Gray	11-6
Table 11-6	Excessive Fuel Consumption	11-7
Table 11-7	Excessive Engine Oil Consumption.....	11-8
Table 11-8	Overheating	11-8
Table 11-9	Engine Oil Pressure Drop.....	11-9
Table 12-1	Main Specifications.....	12-1

Chapter 1 BASIC SAFETY PRECAUTIONS

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 Has Cooled

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.

Checking Safety Around Engine 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 Rotating 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 Work

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.



Prevention of Hearing Loss

WARNING

Be Sure to 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 temperature of the engine with the gauge if the engine has cooled sufficiently.



Add Coolant Only After 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 fuel, oil, or coolant (LLC) other than the specified one, or improper handling may cause various engine problems 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 MHJET dealer. Continuous operation neglecting an unusual symptom could cause serious or fatal accident.

Do Not Add Coolant Immediately After Stopping 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, etc. 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 start the engine immediately after an abnormal stop. If the engine stops or is brought to a stop due an abnormality, find out the cause, and repair failed parts before starting the engine again. 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

If engine oil pressure has dropped abnormally, stop the engine immediately, and inspect every part of 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 has broken, stop the engine immediately and replace the belt. Continued use of the engine without any remedy could cause charging or cooling failure, and result in serious engine failure.

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 terminals, always remove the negative (-) terminal first. When connecting, always connect 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 conducting any electrical work or electrical welding, place the battery switch in the [Open/OFF] position or remove the battery 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 the battery).
- If battery fluid is spilled onto your skin or clothing, immediately wash it away with lots of water. Use soap to clean thoroughly.
- The battery fluid can cause a 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.

If you need to modify the engine, contact your MHIET dealer.

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 awareness may cause improper operation that could result in accidents. When working in a team for two or more people, use specified hand signals to communicate among workers.

Wear Proper Work Clothing and Protective Gears

Wear a hard-hat, face shield, safety shoes, dust mask, gloves, ear plugs, and other protective gears as needed. When handling compressed air, be sure to 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

When the engine has started, run the engine at a low idling speed until the coolant temperature reaches approximately 50°C [122°F] before starting any actual work.

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.

Prohibition of Overloaded Operation

If symptoms of overload such as black exhaust smoke is observed, reduce the load immediately and confirm 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.

Pay Attention to Pre-cleaner Maintenance

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

- ♦ Wash pre-cleaner periodically. If 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 objects 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, etc. 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.

Warning/Caution Labels



Maintenance of Warning/Caution Labels

Make sure that all warning/caution labels are legible. Clean or replace the labels when the description and/or illustration are not clear to read.

- Illegible labels fail to alert people, which may cause personal injury, environmental pollution, and damage to the engine.
- For cleaning the labels, use a cloth and soapy water. **DO NOT USE CLEANING SOLVENTS, GASOLINE, OR OTHER CHEMICALS THAT MAY ERASE THE PRINT OR CAUSE PEELING OFF OF THE LABEL.** If the labels are damaged, replace them with new ones.
- When replacing a part that has a label attached, attach the new label to the new part so that it is in the same state as before replacement.
- New labels are available at your MHIET dealer, MHIET group company, or MHIET.

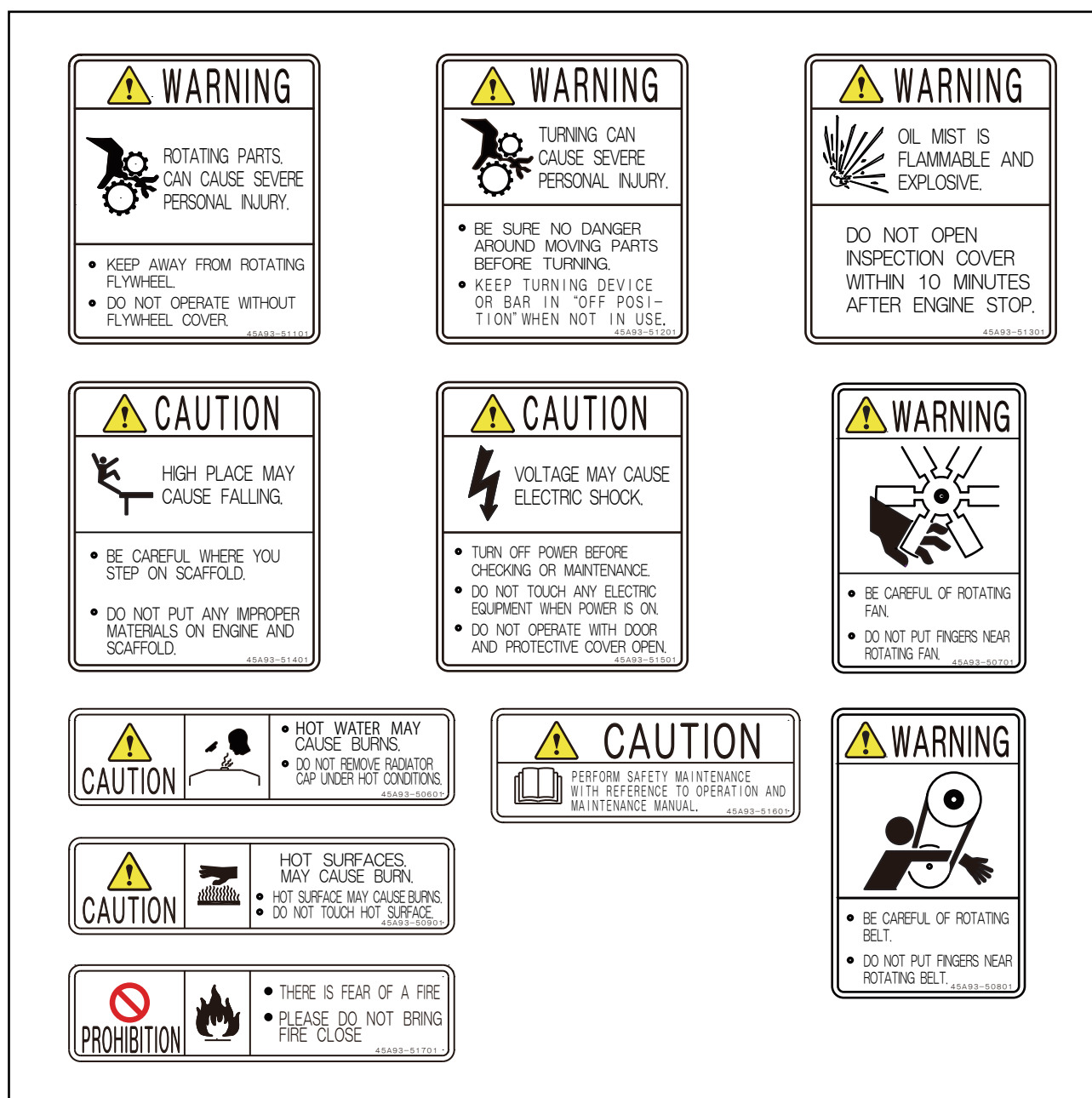


Fig. 1-1 Warning/Caution Labels

Chapter 2 NAME OF PARTS

Engine External Views

This external diagram shows the standard type of the engine. The type and shape of each equipment may vary depending on the specifications.

Front View

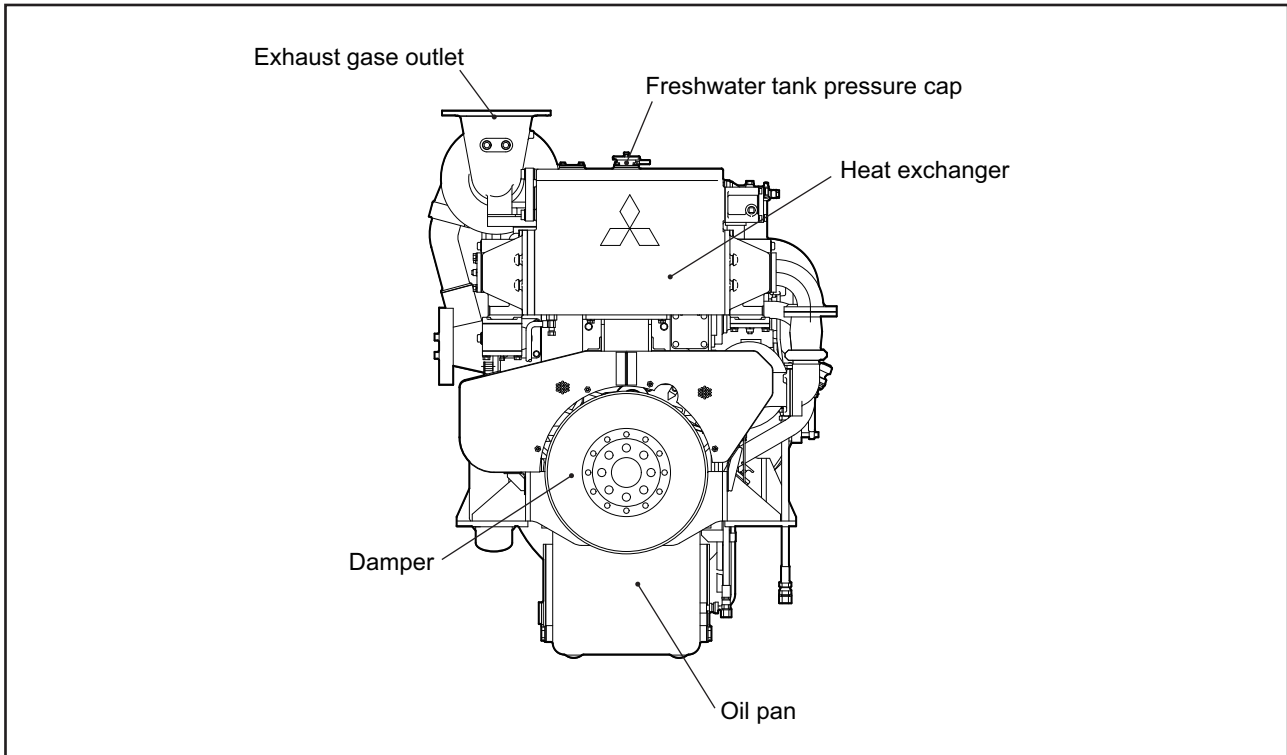


Fig. 2-1 Engine Front View

Rear View

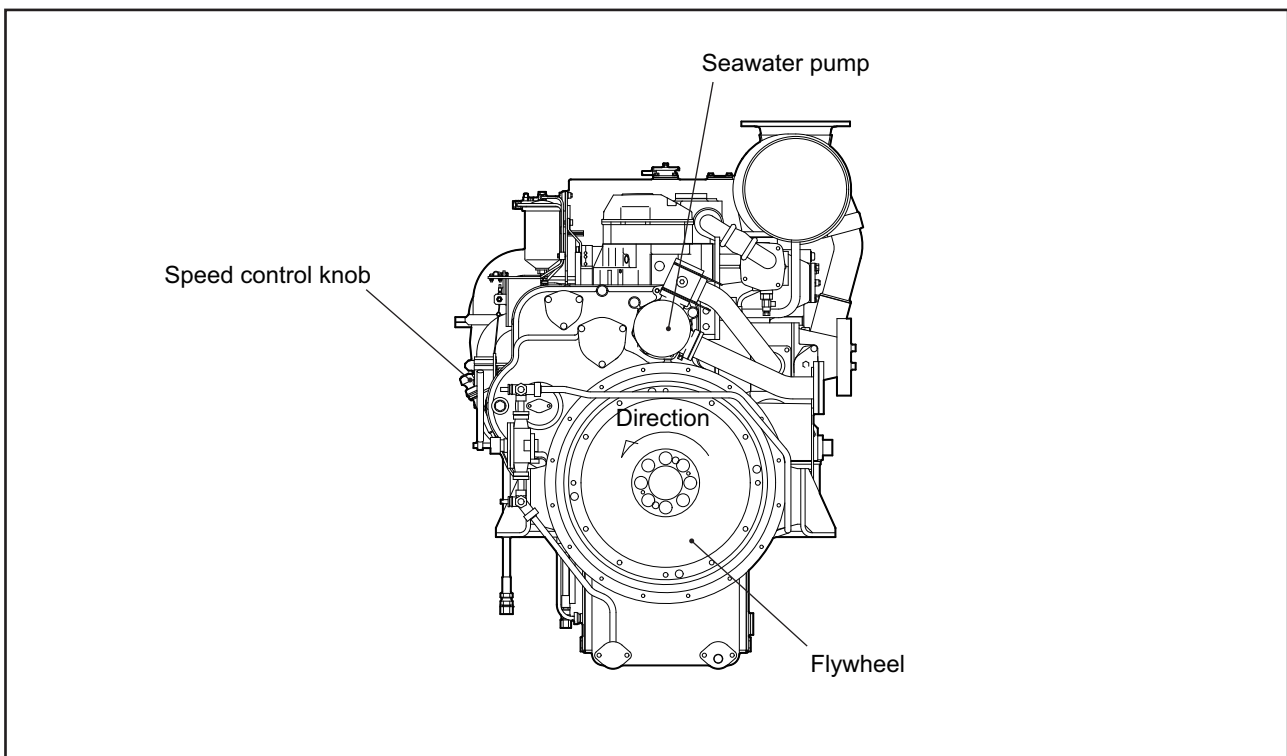


Fig. 2-2 Engine Rear View

Left View

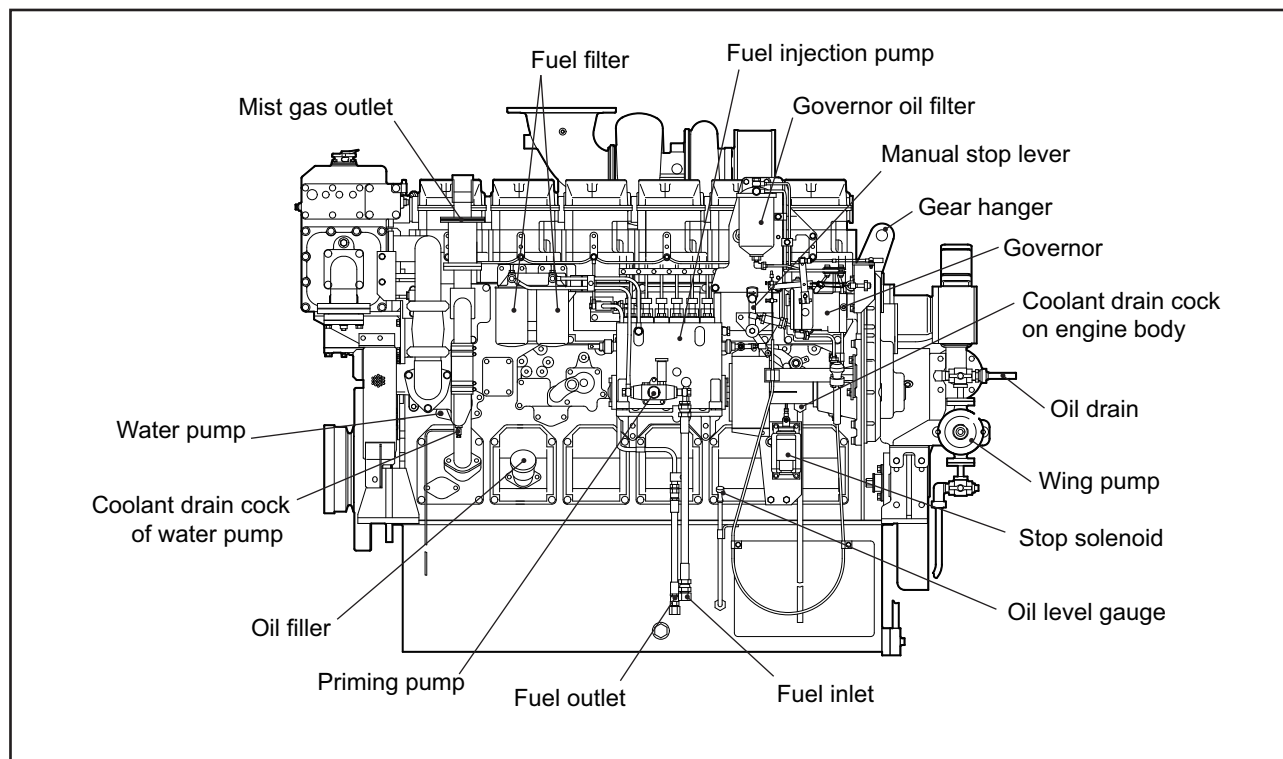


Fig. 2-3 Engine Left-Side View

Right View

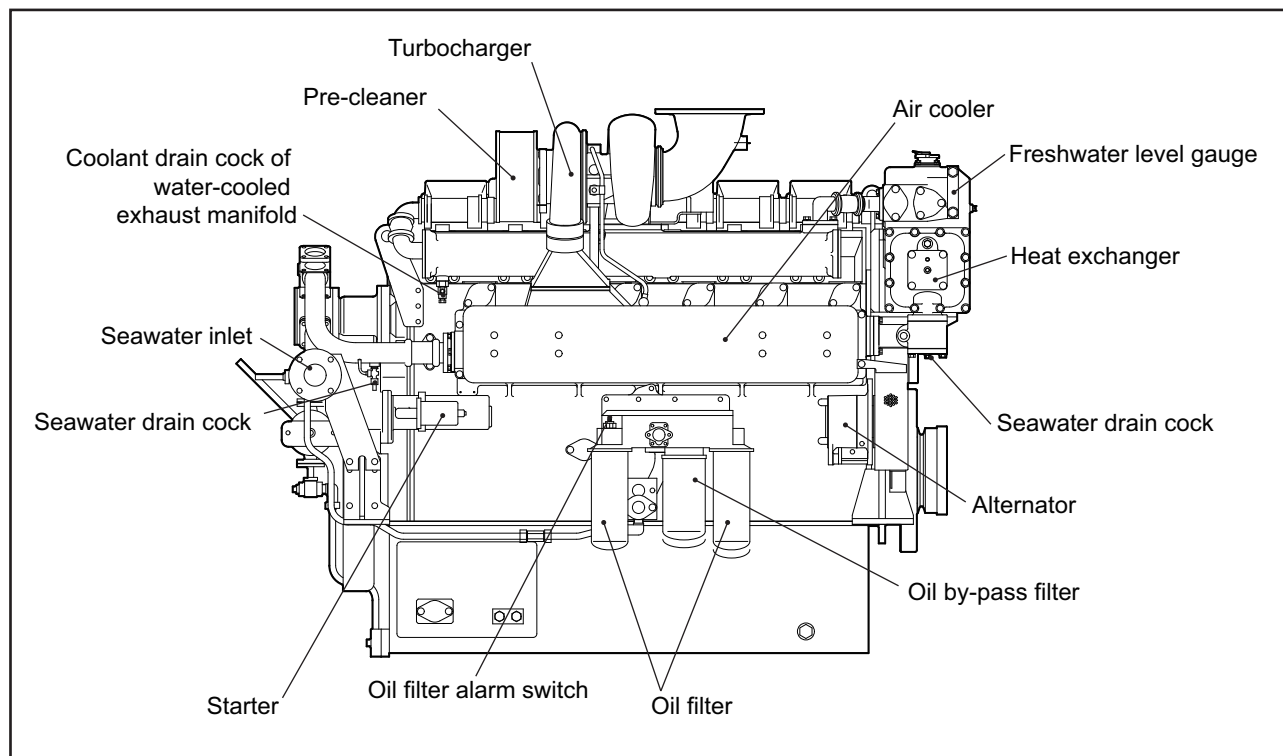


Fig. 2-4 Engine Right-Side View

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 bottom 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.

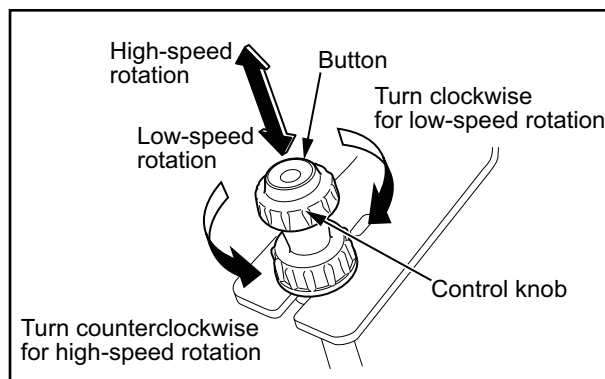


Fig. 2-5 Speed Control Knob

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.

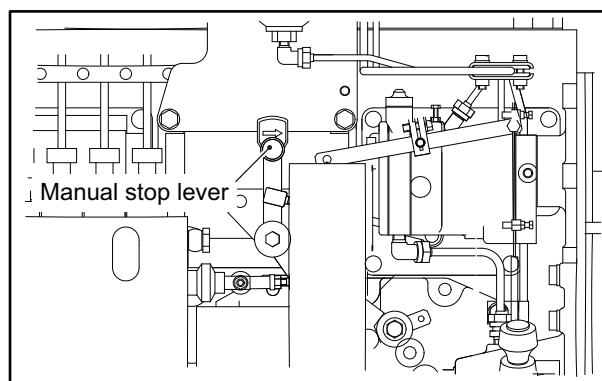


Fig. 2-6 Manual Stop Lever

Stop Solenoid

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

The stop solenoid moves the rack of fuel injection pump to the no-fuel position to stop the engine.

This engine is equipped with the RUN OFF type stop solenoid. The stop solenoid is not energized while the engine is running. It is energized by a stop signal to stop the engine.

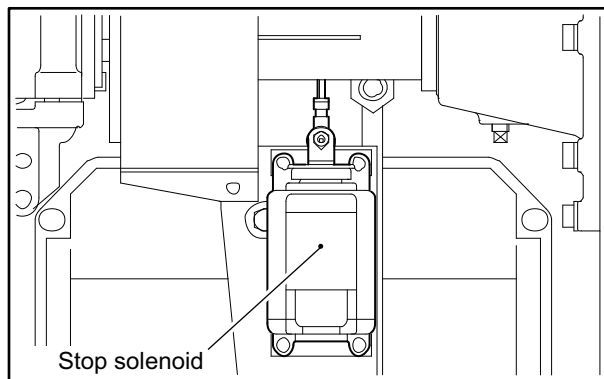


Fig. 2-7 Stop Solenoid

Operating Position Selector Switch

This switch is used to choose operating position, either in the engine room or wheel house.

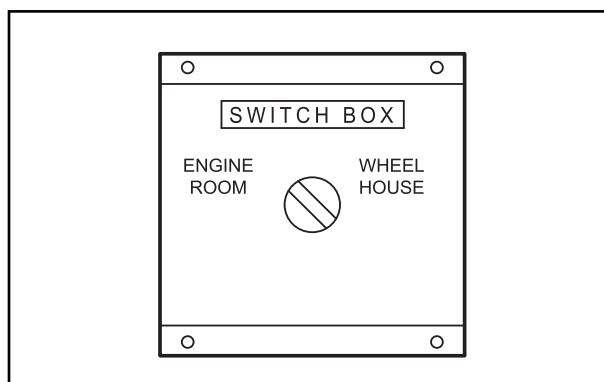


Fig. 2-8 Operating Position Selector Switch

Transmitters for Instruments

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

Rotation Detection Pickup

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

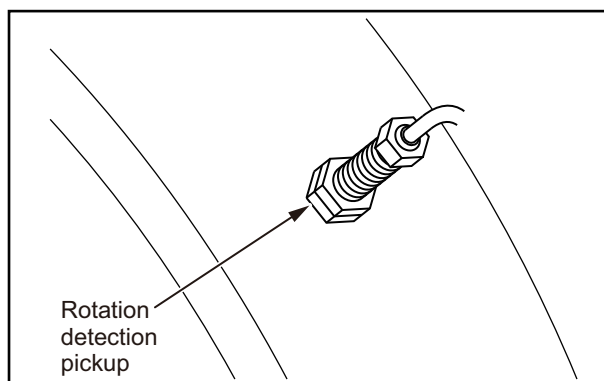


Fig. 2-9 Rotation Detection Pickup

Engine Protection Devices

The engine protection devices activate an alarm when an abnormality occurs in the engine to prevent the engine from serious failures and accidents. When a protection device is activated, stop the engine, inspect the causes of the abnormality, and take corrective measures. If you cannot find the cause, contact your MHIET dealer.

Oil Pressure Switch

The oil pressure switch stops the engine when the engine oil pressure reaches the lower limit of pressure.

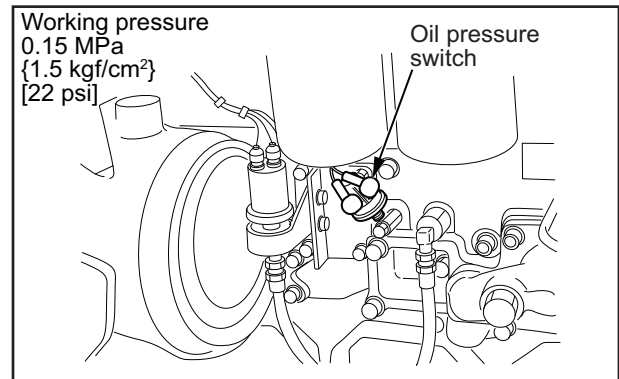


Fig. 2-10 Oil Pressure Switch

Thermo Switch

When the engine coolant temperature rises to the set temperature, the thermo switch is activated to stop the engine.

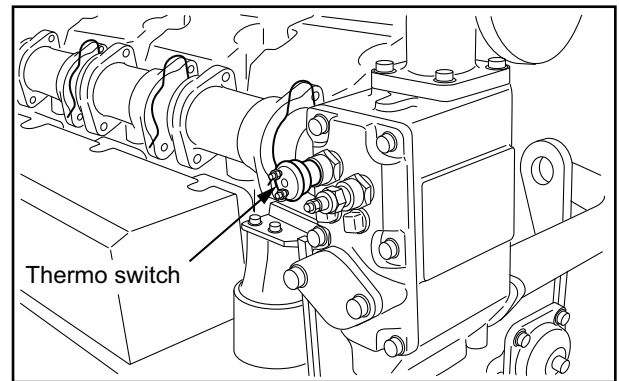


Fig. 2-11 Thermo Switch

Rotation Detection Pickup

Alarm is activated when the engine rotational speed reaches the higher limit of rotational speed.

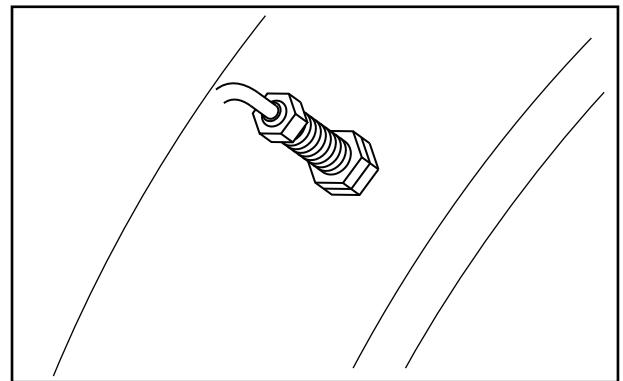


Fig. 2-12 Rotation Detection Pickup

Instrument Panel

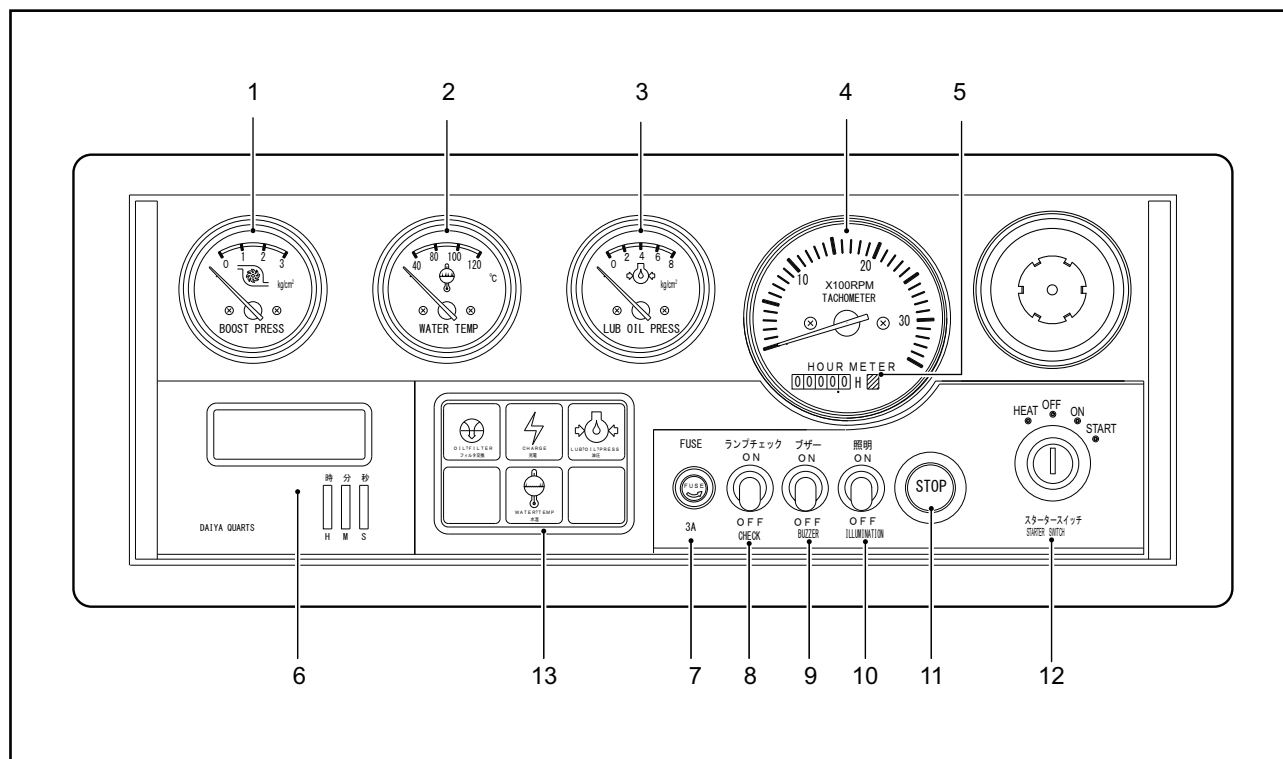


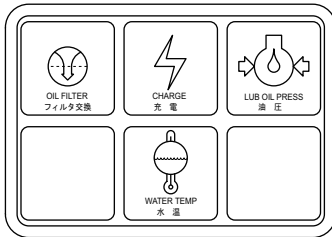
Fig. 2-13 Instrument Panel

Table 2-1 Instrument Panel

No.	Name	Function
1	Manifold pressure gauge	Indicates manifold air pressure in the engine.
2	Coolant temperature gauge	Indicates the temperature of the engine coolant (freshwater). (Standard temperature at rated speed: 70 to 80°C [158 to 176°F]) If the gauge indicates 92°C [197°F] or above, the engine is overheating.
3	Lubricating oil pressure gauge	Indicates engine oil pressure. (Standard pressure at rated speed: 0.44 to 0.59 MPa {4.49 to 6.02 kgf/cm ² } [63.8 to 85.6 psi])
4	Engine speed meter (Tachometer)	Indicates the rotational speed of engine (RPM).
5	Accumulated operating hour meter (Hour Meter)	Indicates the operating time of engine. Maintenance can be scheduled by reading this meter. Note that hour meter adds hours if the starter switch is in "ON" position when the engine is stopped. Be sure to turn the starter switch to "OFF" position when the engine is stopped.
6	Time display and adjustment buttons	Always displays the clock time since it is battery-powered type. (Battery: alkaline button cell battery LR44) Set the clock time using adjustment buttons. "Hour" button: one press advances one hour, continuous press to advance faster. "Minutes" button: one press advances one minute, and continuous press to advance faster. "Second" button: to set clock time (minutes) accurately, use this button. When pressing buttons, use a coin or something smooth. Do not use anything with a sharp edge like a screwdriver.
7	Fuse	There is barrel type 3A fuse inside the cap. If warning lamp does not glow when the starter switch is turned to "ON", the fuse may have blown. Check the fuse, and if it has blown, replace it.

Table 2-1 Instrument Panel

No.	Name	Function
8	Light check switch	When the starter switch is in "ON" position, turn this switch to make sure the warming lights will glow. Check this during start-up inspection.
9	Buzzer stop switch	When the warning buzzer goes off, turn this switch "OFF" to stop the buzzer. Always keep this switch in "ON" position during operation.
10	Illumination switch	Turn this switch "ON" to illuminate gauges.
11	Engine stop button	Press this button to stop the engine. When the button is pressed, stop solenoid will be energized for about ten seconds. During this period, the engine cannot be restarted.
12	Starter switch	HEAT (Preheat): Unused OFF (Switch Off): Return the key to OFF position when the engine is stopped. The key can be removed or inserted in this position since electrical circuits of gauges are disconnected. ON (Switch ON): Place the key in this position after the engine has started (during operation). Electricity flows through the electrical circuits of gauges and warming indicators/lamps. START (Start-up): Turn the key to "START" position to start the engine. Release your hand from the key when the engine has started. The key returns to "ON" position automatically.
13	Warning light	Filter warning light (oil filter clogging warning light) The light comes on when oil filter is clogged. Replace oil filter when the light comes on. (Oil filter alarm switch ON: Pressure difference across the oil filter is 0.15 MPa {1.53 kgf/cm²} [21.76 psi]) Charge warning light (battery charge fault light) The light comes on when there is a fault in charging system. Check the charging system when the light comes on. Note: Note that this light normally illuminates for several seconds immediately after starting the engine. Oil pressure warning light (lubricating oil pressure drop warning light) The light comes one when the lubricating oil (engine oil) pressure drops abnormally. Stop the engine at once, and check the lubricating system. (Oil pressure that triggers the switch: 0.15MPa {1.53 kgf/cm²}[21.76 psi]) Water temperature warning light (coolant temperature rise warning light) The light comes on when the coolant (freshwater) temperature rises abnormally. If this light comes on, run the engine at no load, minimum idling speed, and then stop the engine. Check the cooling system after the engine has cooled down. (Temperature at which thermo switch turns ON: 92°C [197°F]) Note: The warning buzzer will goes off when the oil pressure warning light or water temperature warning light comes on.



Trip Panel

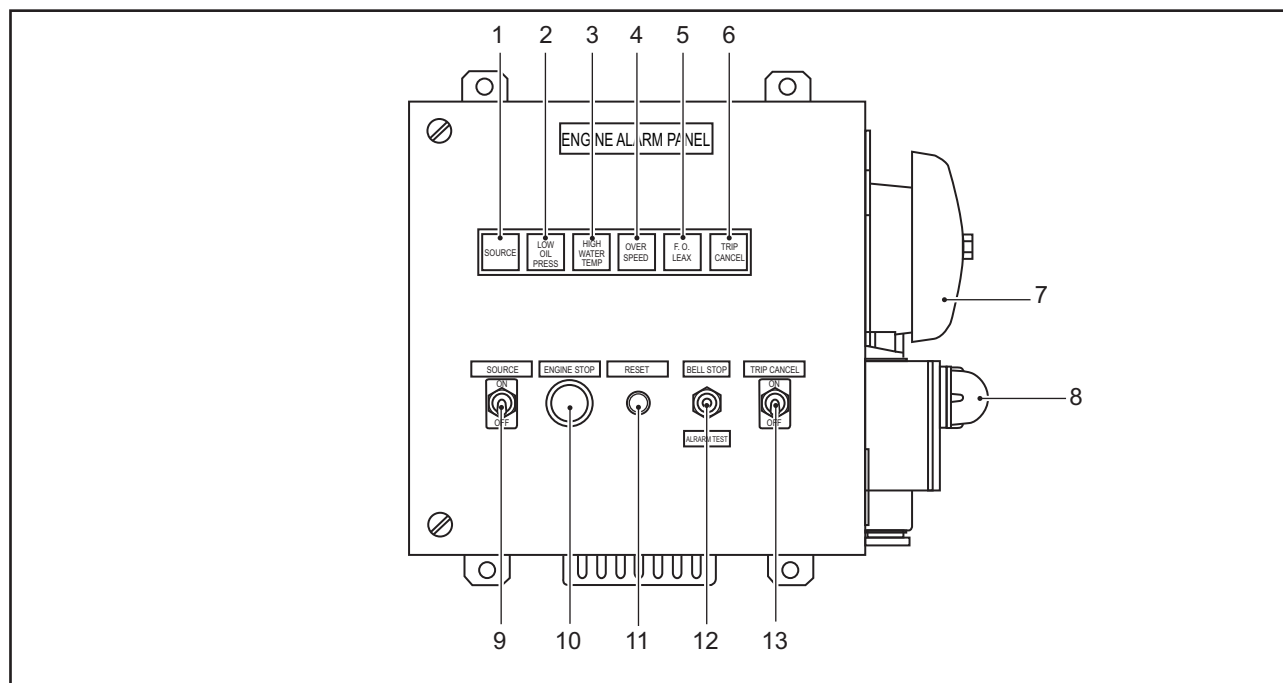


Fig. 2-14 Stop Panel
Table 2-2 About Stop Panel

No.	Name	Function
1	SOURCE light	The light comes on when the instrument panel power is turned on.
2	LOW OIL PRESS light	Engine stops and light comes on when there is abnormal engine oil pressure drop. (Oil pressure that triggers the switch: 0.2 MPa {2.04 kgf/cm ² } [29.01 psi])
3	HIGH WATER TEMP light	Engine stops and light comes on when the coolant temperature rises abnormally. (Temperature at which thermo switch turns ON: 95°C [203°F])
4	OVER SPEED light	Engine stops and light comes on when the engine is overspeeded. (2124 min ⁻¹)
5	F.O. LEAK light	The light comes on when fuel leak occurs.
6	TRIP CANCEL light	The light comes on when the trip function is cancelled.
7	Warning bell	This warning bell goes off when an abnormal condition occurs.
8	Warning light	This warning light will come on when an abnormal condition occurs.
9	SOURCE switch	Turn this switch to the ON position to activate the instrument panel.
10	ENGINE STOP button	To stop the engine, push this button.
11	RESET button	Press "RESET" button to start the engine again after an abnormal stop.
12	BELL STOP / ALARM TEST button	To check operation of stop panel, press down this lever while the starter switch is ON. All warning lights will glow. Check this during start-up inspection. When the warning bell goes off, raise the lever to stop the bell ringing.
13	TRIP CANCEL switch	TRIP function can be cancelled temporarily by turning this switch to ON position.

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.

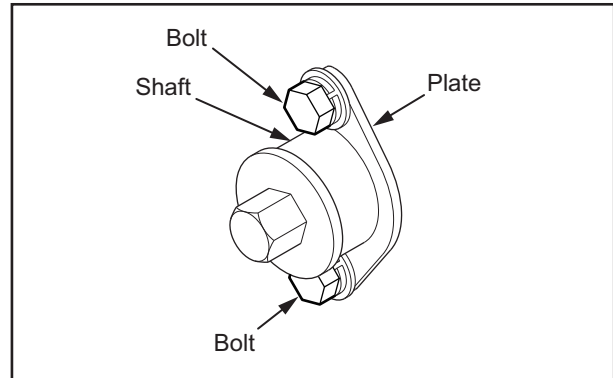


Fig. 2-15 Manual Turning Gear Position (During Operation)

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

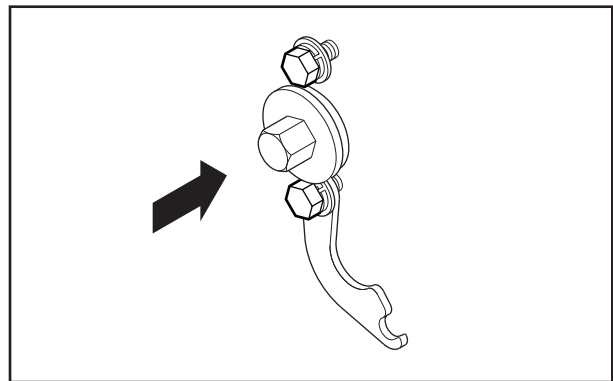


Fig. 2-16 Manual Turning Gear Position (Pushed-In)

3. Using a socket wrench and ratchet handle, turn the shaft.
4. After the 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.

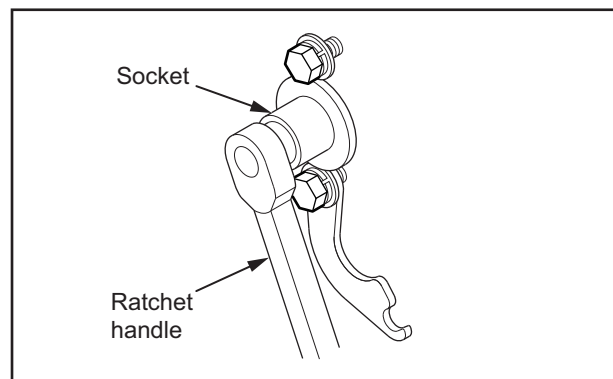


Fig. 2-17 Manual Turning Gear Position (When Turning Shaft)

Preparation for Operation of New or Overhauled Engine

Before proceeding with operation of a new or overhauled engine, conduct the inspections as instructed herein. Note that, for second and subsequent operation, 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. It can cause a fire.

After bleeding air, lock the A-type priming pump securely. If the lock is loose, the priming pump may get damaged, resulting in a fuel leak, and increasing the risk of a fire.

Note: There are two different types of priming pumps, type "A" and type "B". Operation varies depending on the type. Be sure to check the type before operation.

While feeding fuel with the priming pump, bleed air from the location closest to the fuel tank, that is, in the order of the oil-water separator, fuel filter, and fuel return pipe.

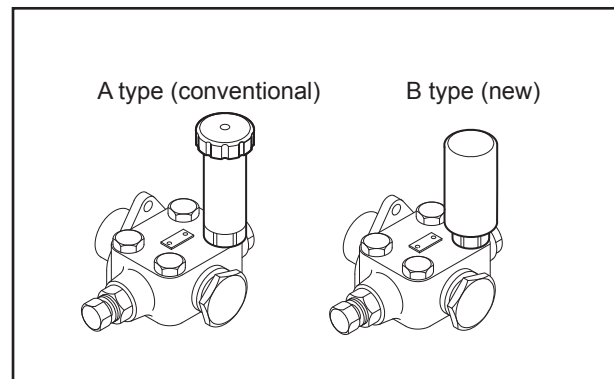


Fig. 3-1 Priming Pump Comparison

A-type Priming Pump - Operation

1. Turn the priming pump cap counterclockwise to unlock.
2. Push the priming pump cap several times to feed fuel to bleed air.
3. After bleeding air, turn the priming pump cap clockwise while pushing. Be sure to lock securely.

B-type Priming Pump - Operation

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

Note: Since there is no locking mechanism, you do not need lock and unlock the pump handle before and after air bleeding.

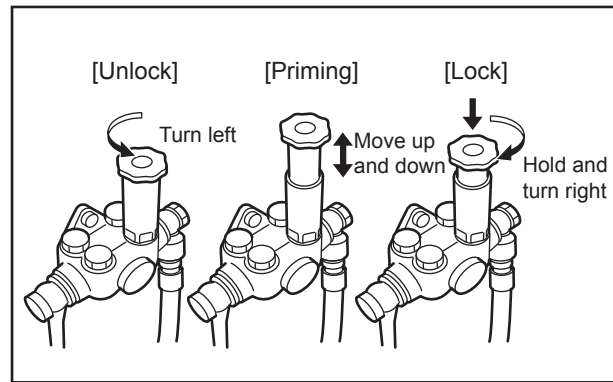


Fig. 3-2 A-type Priming Pump - Operation

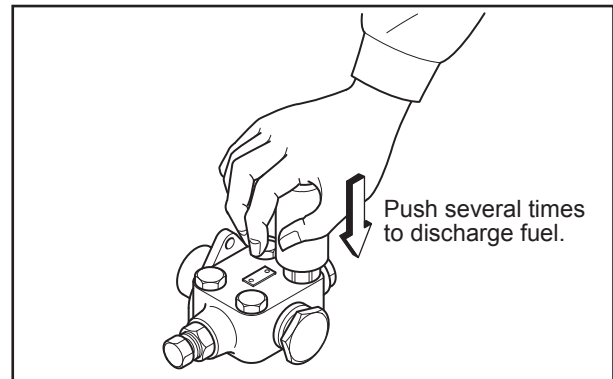


Fig. 3-3 B-type Priming Pump - Operation

Fuel Filter - Bleed Air

CAUTION

If the air vent plugs, the thread portion of the bracket, or sealing washers are damaged, replace them with new ones.

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.

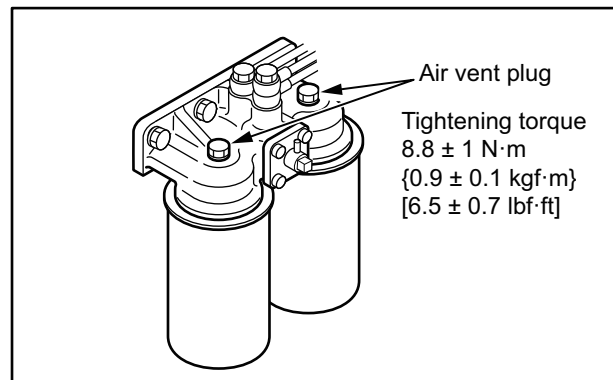


Fig. 3-4 Fuel Filter - Bleed Air

Fuel Injection Pump - Bleed Air

1. Loosen the air vent plug on the fuel injection pump about 1.5 turns.
2. Move the priming pump up and down. When the fuel flow from the air vent plug becomes free of bubbles, for the A-type priming pump, lock the priming pump cap by turning clockwise while pushing.
3. Tighten the air vent plug on the fuel injection pump.

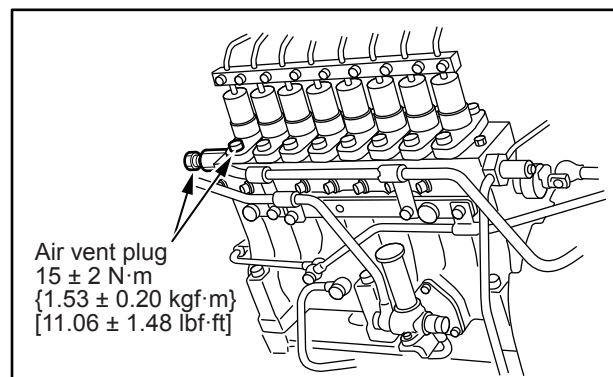


Fig. 3-5 Fuel Injection Pump - Bleed Air

Priming Pump Tightening Method

CAUTION

Securely tighten the A-type priming pump. If the priming pump is not firmly tightened, the internal threads will be worn due to engine vibration, and the priming pump may pop out, causing fuel to flow out. Or if the priming pump is excessively tightened, the head of the priming pump can be damaged. Be sure to tighten the pump by the correct angle.

1. Gently tighten the priming pump by hand, and put a mark that shows the seating position.
2. Using a wrench or another appropriate tool, further tighten the priming pump by 90 ± 10 degrees.
3. Check the mounting position of head packing.

Note: If the head packing has abnormality such as deformation or scratches, the priming pump must be replaced. Consult with your MHIET dealer.

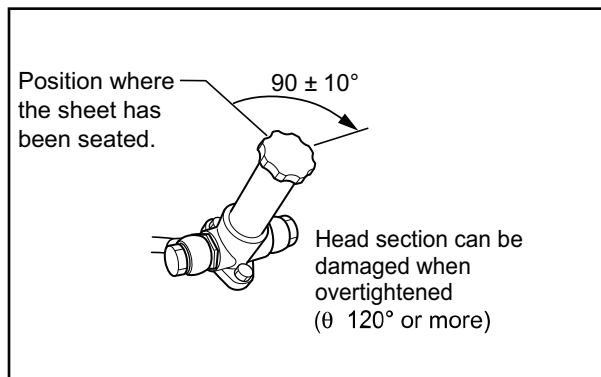


Fig. 3-6 A-type Priming Pump Tightening Method

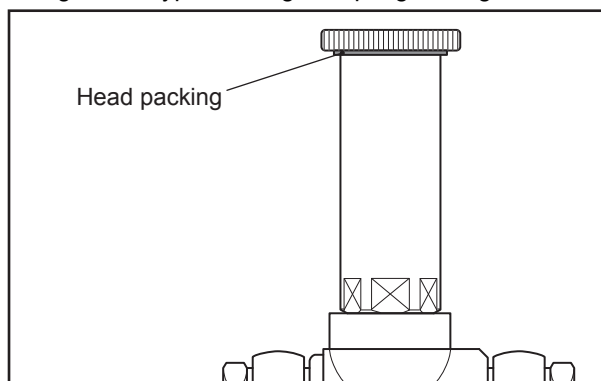


Fig. 3-7 A-type Priming Pump Head Packing

Preparation of Lubrication System

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 SPECIFICATIONS" (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 oil drain valve.
If the engine oil level is low, add the specified engine oil.
7. Check the oil pan, etc., for oil leaks. Repair if there is an oil leak.
8. With the manual stop lever placed in pulled position, rotate the engine with starter for approximately 10 seconds to circulate oil to the engine thoroughly. Stop for 1 minute, and then repeat this operation 2 or 3 times to circulate oil to all parts of the engine.

Note: Also, perform the items described under the Preparation of Cooling System.

9. Start the engine and run at no-load and low-idle speed for 5 to 10 minutes.
10. Stop the engine 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).

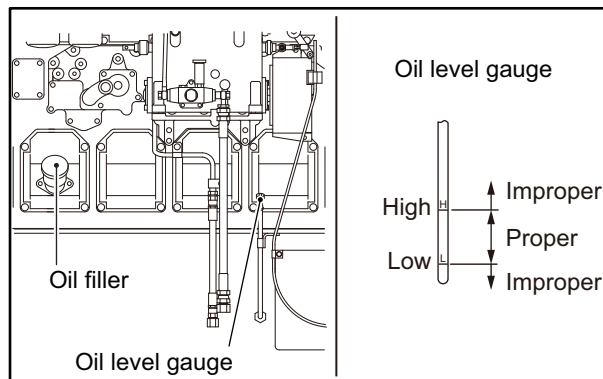


Fig. 3-8 Oil Filler and Oil Level Gauge

Preparation of Cooling System

Coolant - Refill

CAUTION

To add coolant, use the same LLC concentration coolant that is currently in the cooling system.

1. Close the coolant drain cocks firmly.
2. Open the coolant filler port and add a mixture of water and coolant (LLC) having the specified concentration.

Note: 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 SPECIFICATIONS" (12-1).

3. Check the heat exchanger, etc. for coolant leaks. Repair if a leak is found.
4. When the coolant reaches the specified level, securely close the coolant fill port.
5. With the manual stop lever placed in the pulled position, crank the engine for approximately 10 seconds using the starter. Stop for approximately 1 minute, and then repeat the cranking 2 or 3 times to bleed air from the cooling system.

Note: Also, perform the items described under the Preparation of Lubrication System.

6. Check the coolant level.

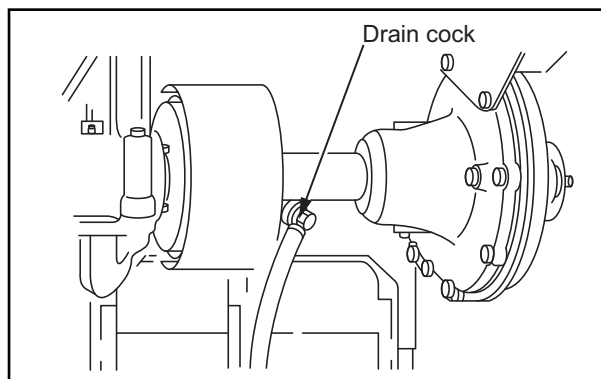


Fig. 3-9 Coolant Drain Cock (Engine Body)

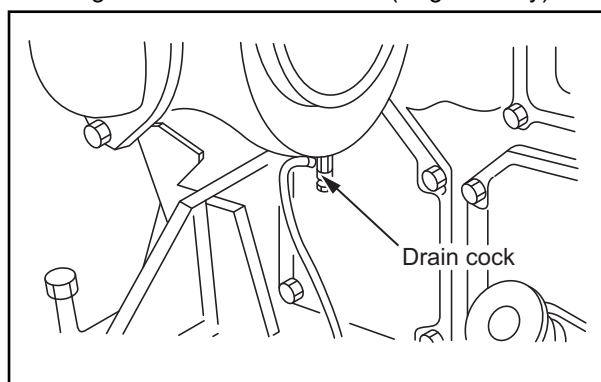


Fig. 3-10 Coolant Drain Cock (Water Pump)

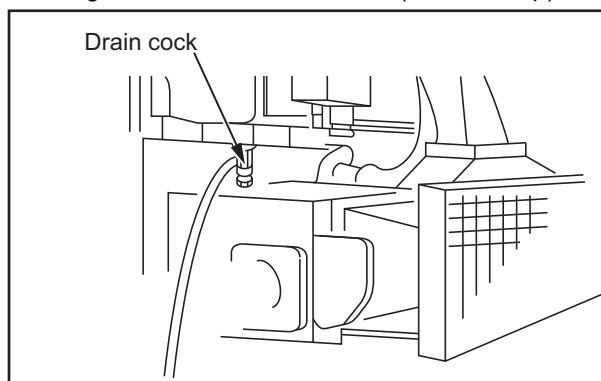


Fig. 3-11 Coolant Drain Cock (Exhaust Manifold Pipe)

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 conducting any electrical work or electrical welding, place the battery switch in the [Open/OFF] position or remove the battery 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 the battery).

If battery fluid is spilled onto your 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, 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.

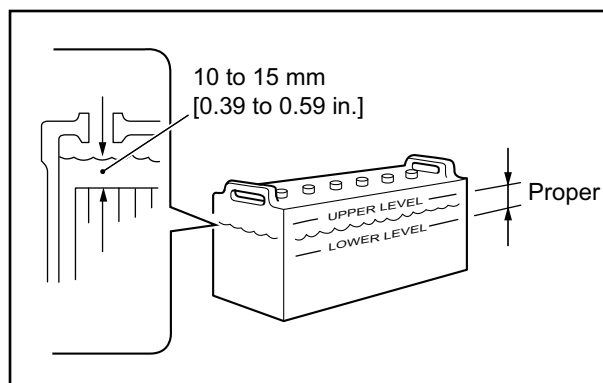


Fig. 3-12 Battery Fluid Level - Check

Test Operation

To conduct a 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 idle speed and no load for 5 to 10 minutes for warm-up.
Remove JK (exciting circuit) if necessary, and proceed with test run.

At low idle	(700 to 750min ⁻¹)	5 minutes
No-load	750 to 900min ⁻¹	5 minutes
No-load	900 to 1050min ⁻¹	5 minutes
No-load	1050 to 1200min ⁻¹	5 minutes
No-load	1200 to 1350min ⁻¹	5 minutes
No-load	1350 to 1500min ⁻¹	5 minutes
No-load	1500 to 1650min ⁻¹	5 minutes
No-load	1650 to 1800min ⁻¹ (Connect JK at this time)	5 minutes
Load operation	25%	20 minutes
Load operation	50%	20 minutes
Load operation	75%	20 minutes
Load operation	100%	20 minutes

3. Stop the engine.

Inspection

CAUTION

To add 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.
6. If the coolant level is low, add coolant to the specified level.

Normal Engine Operation

This section covers the operating procedures for the engine which is in normal operating status.

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

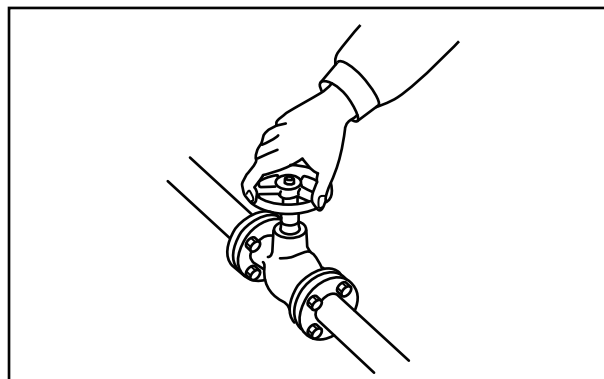


Fig. 3-13 Valve Open/Closed Position - Check

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.

Oil-Water Separator - Drain Water

WARNING

From water drain valve, fuel is discharged together with water. Wipe off any spilled fuel completely.

1. Turn the 3-way cock of oil-water separator to the "drain" position.
2. Loosen the air vent plug.
3. Open the water drain valve, and drain the water from oil-water separator.
4. Turn the 3-way cock of oil-water separator on the inlet side to the "run" position.
5. Close the water drain valve.
6. Bleed air from the oil-water separator.
7. Turn the 3-way cock of oil-water separator on the outlet side to the "run" position.

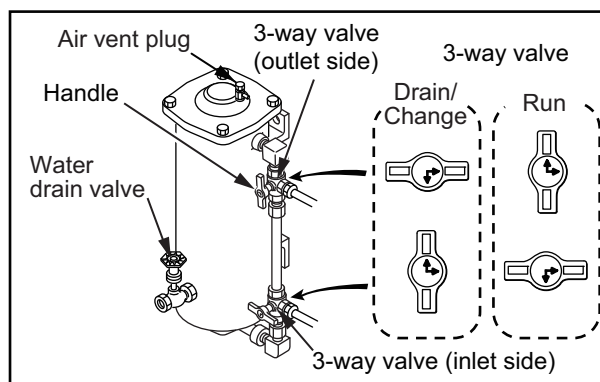


Fig. 3-14 Oil-Water Separator - Drain Water

Fuel Control Link - Check

Check the fuel control link for smooth movement.
Check the rack cancel spring for smooth movement by pushing the manual stop lever to the fuel increase direction. Then gradually release the manual stop lever to make sure that the stop lever will return to the Fuel non-injection position smoothly. Also check all ball joints for looseness and play.

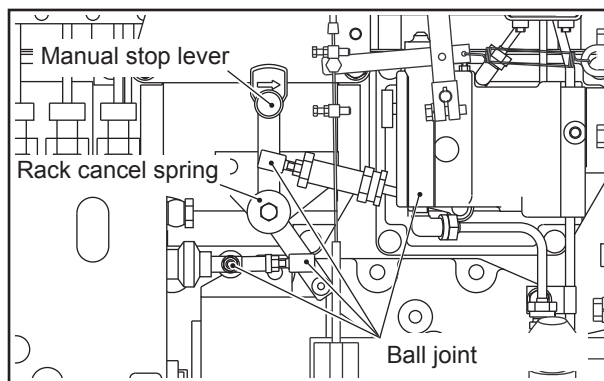


Fig. 3-15 Fuel Control Link - Check

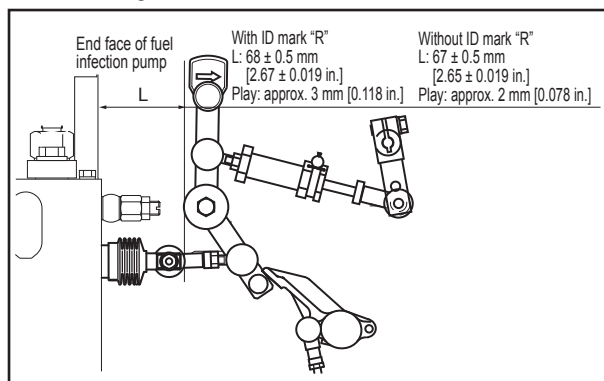


Fig. 3-16 Fuel Non-Injection Position

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" \(8-12\)](#).

5. Install the oil filler cap after engine oil is refilled.

Note: (a) Before installing the oil filler cap, wipe off engine oil on the oil filler cap and pipe.

(b) Overtightening the oil filler cap may cause damage.

Tighten the oil filler cap for two and a half to three turns after the rubber part contacts the inner surface of the pipe.

6. Check the oil pan, etc., for oil leaks.

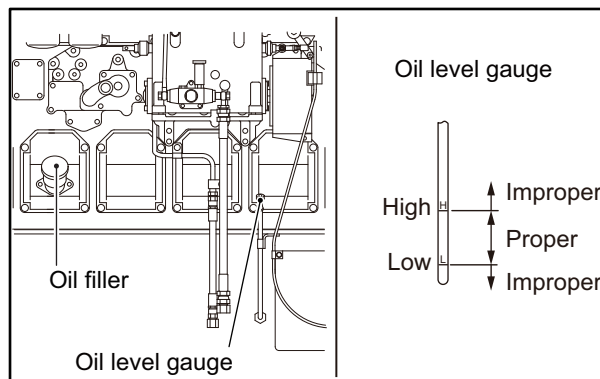


Fig. 3-17 Oil Filler and Oil Level Gauge

Coolant Level - Check

CAUTION

To add coolant, use the same LLC concentration coolant that is currently in the cooling system.

If the coolant level is low, add coolant to the specified level.

Note: 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 SPECIFICATIONS" \(12-1\)](#).

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.

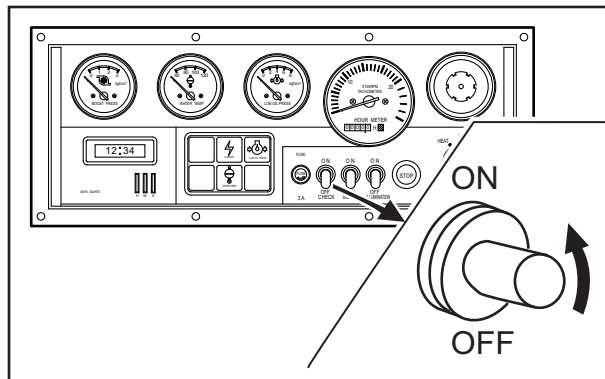


Fig. 3-18 Warning Indicator Light - Operation Check

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. In a loud voice, notify 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 30 seconds before cranking again.

Restart the engine after it stops completely.

Check fuel system if the engine cannot be started by trying three to five times.

Do not use the starter while the engine is running.

When the engine is not operated for a long time (one week or more), rotate the crankshaft three times at 30 seconds interval to circulate engine oil while pulling the manual stop lever for 10 seconds.

Starting Procedures

1. Open the Kingston valve.
2. Place the battery switch in the "ON" position.

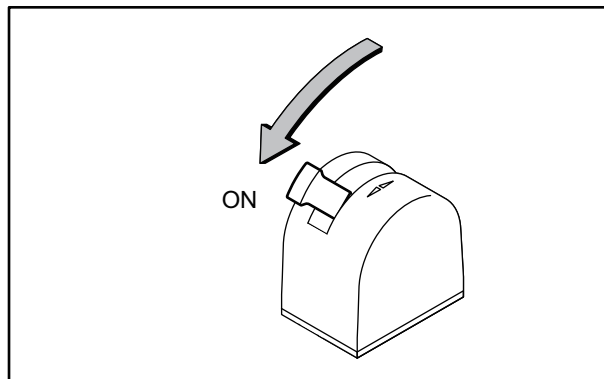


Fig. 3-19 Battery Switch "ON"

3. Turn the starter switch key to the "START" position to start the engine.

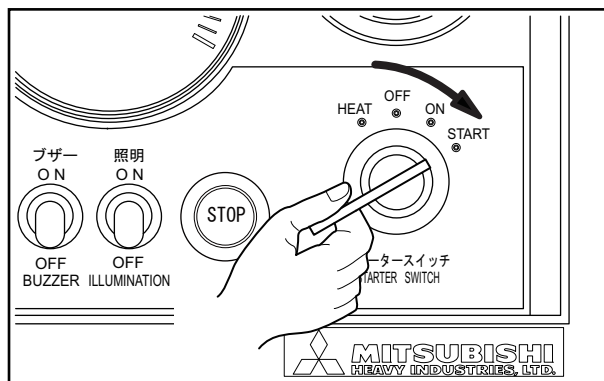


Fig. 3-20 Starter Switch "START"

4. Release your hand from the key when the engine has started. The key returns to "ON" position automatically.

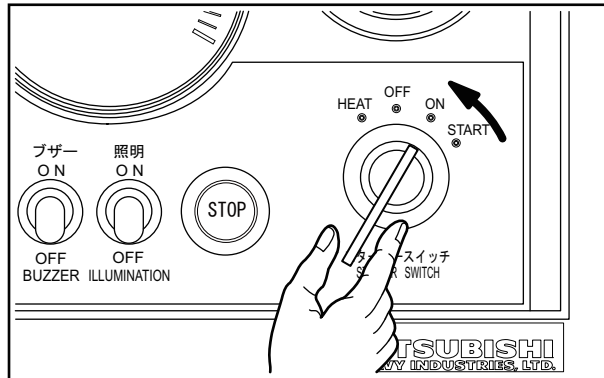


Fig. 3-21 Starter Switch "ON"

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.

Warm-up the engine at low idle with no load until the coolant temperature reaches approximately 50°C [122°F].

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.

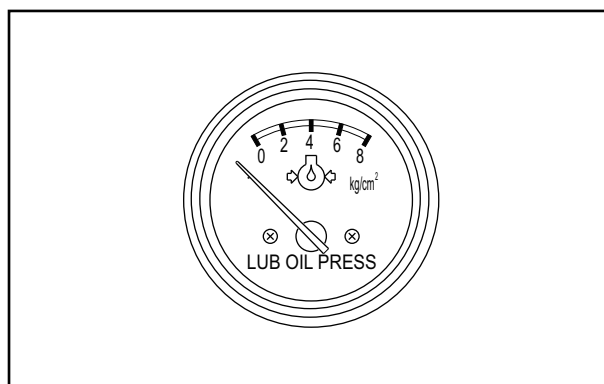


Fig. 3-22 Oil Pressure Gauge

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.

Operation

Precautions in Engine Operation



WARNING

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



CAUTION

During operation, do not touch hot parts such as exhaust pipes. You can get burned.

CAUTION

Always keep the engine room well ventilated. The room temperature will increase if air ventilation in the engine room is not sufficient, which may result in decrease in engine output and performance.

For break-in of a new or overhauled engine, operate the engine at a light load for first 50 hours of operation. The new engine components are not well lubricated and fitted in each other. Thus, if operated under heavy load or severe conditions during the break-in period, it will shorten the service life of the engine. Do not turn the battery switch OFF during operation. If the battery switch is turned off during operation, it will not only stop the operation of instruments but also deteriorate the alternator diode and transistor. Never turn the key to the "START" position during operation. Otherwise, damage to the starter may result.

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)

Inspection During Operation

Carefully check the exterior of engine such as pipe joints for leaks during operation.

Check the engine for abnormal noise, odor, or vibration.

Check to make sure that the mist coming from the breather is normal.

Check exhaust gas color from the exhaust muffler. Make sure the instrument and gauge readings are normal.

Make sure the damper temperature is 90°C [194°F] or lower.

Table 3-1 Standard Values at Rated Speed

Item	Reference value	
Engine oil pressure	0.5 to 0.64 MPa {5.10 to 6.53 kgf/cm ² } [72.52 to 92.82 psi] or more	
Coolant temperature in engine	80 to 95°C [176 to 203°F]	
Coolant temperature in air cooler Inlet temperature	Seawater indirect cooling	32.0°C [89.6°F] or lower
Engine oil temperature (oil pan)	110.0°C [230°F] or lower	
Maximum intake air pressure	0.392 MPa {3.997 kgf/cm ² } [56.85 psi] or lower	

Note: (a) When the oil pressure drops below 0.29 MPa {2.96 kgf/cm²} [42.06 psi] in normal operation, or below 0.10 MPa {1.02 kgf/cm²} [14.50 psi] at low idling, stop the engine immediately.

Be sure to find the cause and repair the problem before starting the engine again.

(b) When the thermo switch is activated during normal operation, run the engine at a low idle speed for 5 to 6 minutes to cool down the engine, and then stop the engine. Be sure to find the cause and repair the problem before starting the engine again.

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.

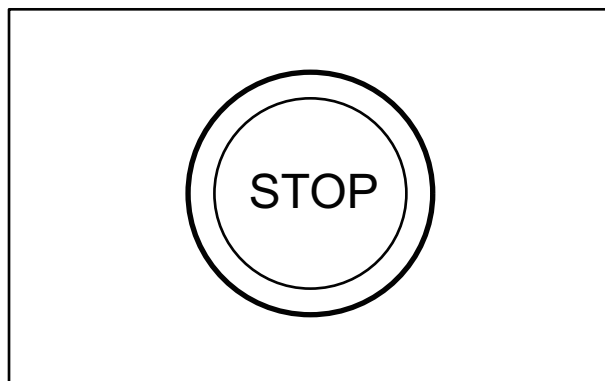


Fig. 3-23 Engine Stop Button

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

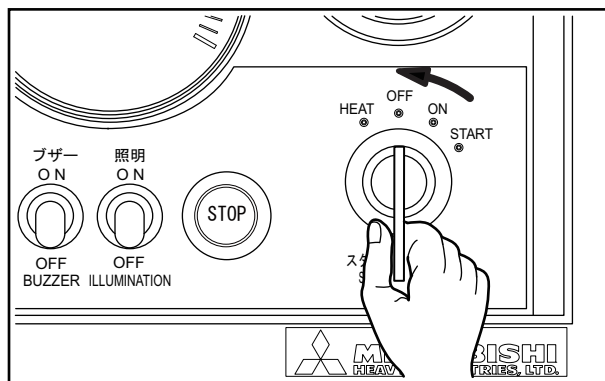


Fig. 3-24 Starter Switch "OFF"

5. Turn the battery switch to the "OFF" position.
6. Close the Kingston valve.

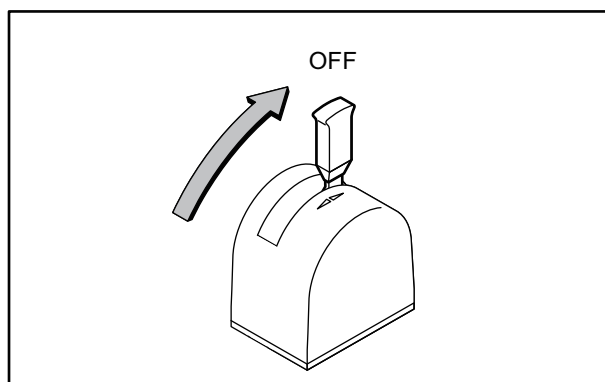


Fig. 3-25 Battery Switch "OFF"

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"Recommended Fuel"](#) and [Table 4-2"Recommended Limit and Use Limit for Fuel Properties"](#)

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

- (a) 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.
- (b) When using the engine for propulsion use, be sure to mount oil-water separator on the engine.

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. For a complete filtration, it is recommended to use a clean lint-free cloth together with the strainer.

Fuel Quality Standard

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

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

Item		Recommended limit	Use limit	Test standard
Flash point		50°C [122°F] or more (In accordance with the regulation)		JIS K 2265: 2007 ISO 3769 ISO 2719
Distillation	Initial boiling point	170°C [338°F] or more		JIS K 2254: 1998 ISO 3405
	90% distillation temperature	330 to 380°C [626 to 716°F]		
Pour point (PP)		Lower than ambient temperature by 6°C [10.8°F] or more		JIS K 2269: 1987 ISO 3016
Cloud point (CP)		Below ambient temperature		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 mass% or lower	1.0 mass% or lower	JIS K 2270: 2000 ISO 6615 ISO 10370
Cetane number		45 or more		JIS K 2280: 1996 ISO 5165
Cetane index (new way)		45 or more		JIS K 2280: 1996 ISO/DIS 4264
Kinetic viscosity		2.0 mm²/s [0.0031 in²/s] or more at 30°C [86°F] 8.0 mm²/s [0.0124 in²/s] or less at 30°C [86°F]		JIS K 2283: 2000 ISO 3104
Sulfur content		0.2 mass% or lower	1.0 mass% or lower (Shorten engine oil change intervals)	JIS K 2541: 2000 Content as low as the diesel fuel is desirable. ISO 4260 ISO 8754
Water and sediments		0.1 volume % or less		JIS K 2275: 1996 ISO 3733
Ash content		0.01 mass% or lower	0.03 mass% or lower	JIS K 2272: 1998 ISO 6245
Copper corrosion (3 hrs at 50°C [122°F])		Class 3 or lower (Dark tarnished)		JIS K 2513: 2000 ISO 2160
Density at 15°C [59°F]		0.83 to 0.87 g/cm³ [51.8169 to 54.3123 lb/ft³]		JIS K 2249: 1995 ISO 3675
Coking	250°C [482°F] × 24 hrs	Carbonization 75% or less	Carbonization 80% or less	Fed 791B
	230°C [446°F] × 24 hrs	Carbonization 55% or less	-	
	180°C [356°F] × 48 hrs	Tar-free	-	
Aromatics substances (by HPLC)		38% by volume or less (total of aroma)		JIS K 2536: 2003 ISO 3837
Polycyclic aromatic content		8 volume % or less		
Asphaltene		0.1 mass% or lower		-
Fine foreign substances (foreign substances at fuel inlet)		10 mg/liter or less		JIS B 9931: 2000 ISO 4405

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

Item	Recommended limit	Use limit	Test standard
Lubricity: MWSD (Measured mean Wear Scar Diameter) by HFRR wear test when fuel temperature is 60°C [140°F]	460 µm [1811 µin.] or less (calculated wear scar diameter at WS 1.4 kPa {0.0143 kgf/cm ² } [0.2031 psi])	-	ISO 12156-1

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

MHIET have developed from the various test results to offer "MITSUBISHI DIESEL ENGINE OIL CH-4 15W-40" as the most suitable engine oil for our marine engine.

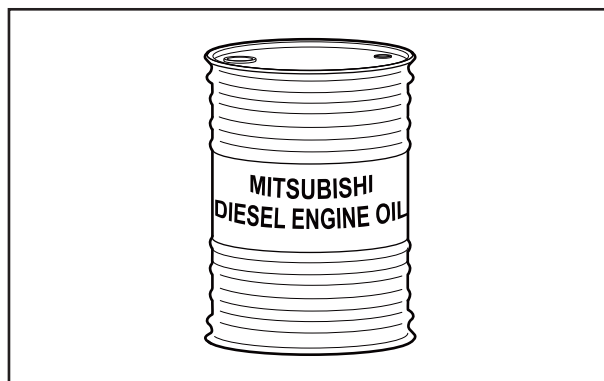


Fig. 5-1 MITSUBISHI DIESEL ENGINE OIL

Other Commercial Engine Oils

CAUTION

Never mix different brands of engine oil with genuine MHIET oil. When engine oils of different brands are mixed and used, the additives in the engine oils may chemically change and the performance of the engine oil may deteriorate. Several types of diesel engine oil are specified, but among them, use CF or CH-4 category for our engine, which is suitable for high supercharging and heavy load. 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 "Engine Oil Quality Standard" (5-2). If the fuel with 0.2% or less sulfur content is used in the engine, CF or CH-4 grade oil can be used. However, the oil must have base value of 8.0 mgKOH/g or higher by Hydrochloric acid method. If measured by the perchloric acid method, the total base value must be 11.0 mgKOH/g or more.

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.

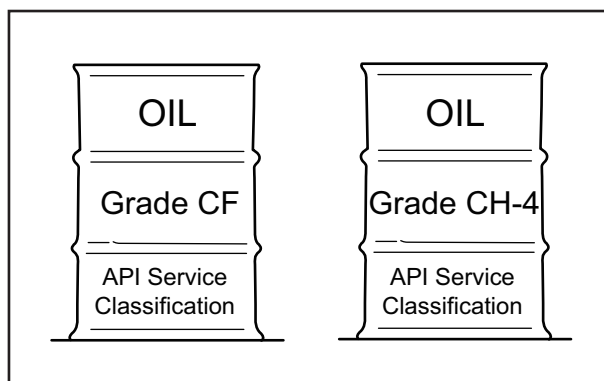


Fig. 5-2 Engine Oil Grade

Engine Oil Quality Standard

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

Table 5-1 Engine Oil Quality Standards (Grade CF SAE 30)

Item				Unit	Recommended property value	Test method
ASTM Color				-	L3.0	JIS K 2580
Density		15°C [59°F]		g/cm³	0.87 to 0.90	JIS K 2249
Kinetic viscosity		40°C [104°F]		mm²/s	95.0 to 110	JIS K 2283
		100°C [212°F]			11.0 to 12.5	
Flash point				°C [°F]	200 [392] or more	JIS K 2265
Base number	Hydrochloric acid method	Sulfur content in fuel	1.0 mass% or less	mgKOH/g	10 or more (up to 13)	JIS K 2501
			0.2 mass% or less		8.0 or more (up to 13)	
	Perchloric acid method		1.0 mass% or less		13 or more (up to 16)	
			0.2 mass% or less		11 or more (up to 16)	
Acid number				mgKOH/g	1.8 or less	JIS K 2501
Sulfur content				%	0.7 or less	JIS K 2541
Sulfuric acid ash				mass%	2.0 or less	JIS K 2272
Carbon residue content				%	2.0 or less	JIS K 2270
High temperature shear viscosity		150°C [302°F]		mPa·S	2.9 or more	JPI-5S-36-91
Pour point				°C [°F]	-12.5 [9.5] or less	JIS K 2269
Additives		Ca		mass%	0.40 to 0.48	JIS K 0116
		P			0.037 to 0.050	
		Zn			0.042 to 0.055	
		B			0.010 or less	
		Si			0.005 or less	
		N		0.060 or less	JIS K 2609	
Bubbling test		I		mL	10/0 or less	JIS K 2518
		II			30/0 or less	
		III			10/0 or less	
Panel coking test*		300°C [572°F]		-	40 or less	FED791-3462
		325°C [617°F]			300 or less	

*: Temperature of aluminum panel: 300°C [572°F] and 325°C [617°F], Temperature of engine oil: 100°C [212°F], Splatter time: 15 seconds, Downtime: 45 seconds, Test time: 8 hours. The properties are the weight of solid product accumulated on the panel.

Table 5-2 Engine Oil Quality Standards (Grade CF SAE 15W-40)

Item				Unit	Recommended property value	Test method
ASTM Color				-	L4.0	JIS K 2580
Density		15°C [59°F]		g/cm³	0.87 to 0.90	JIS K 2249
Kinetic viscosity		40°C [104°F]		mm²/s	100 to 110	JIS K 2283
		100°C [212°F]			13.5 to 15.5	
Flash point				°C [°F]	225 to 250 [437 to 482]	JIS K 2265
Base number	Hydrochloric acid method	Sulfur content in fuel	1.0 mass% or less	mgKOH/g	10 or more (up to 13)	JIS K 2501
			0.2 mass% or less		8.0 or more (up to 13)	
	Perchloric acid method		1.0 mass% or less		13 or more (up to 16)	
			0.2 mass% or less		11 or more (up to 16)	
Acid number				mgKOH/g	15 to 2.0	JIS K 2501
Sulfur content				%	0.5 or less	JIS K 2541
Sulfuric acid ash				mass%	2.0 or less	JIS K 2272
Carbon residue content				%	2.0 or less	JIS K 2270
High temperature shear viscosity		150°C [302°F]		mPa·S	3.7 or more	JPI-5S-36-91
Pour point				°C [°F]	-25 [-13] or less	JIS K 2269
Additives		Ca		mass%	0.480 to 0.570	JIS K 0116
		P			0.050 to 0.070	
		Zn			0.060 to 0.080	
		B			0.010 or less	
		Si			0.001 or less	
		N		0.030 to 0.060	JIS K 2609	
Bubbling test		I		mL	10/0 or less	JIS K 2518
		II			30/0 or less	
		III			10/0 or less	
Panel coking test*		300°C [572°F]		-	140 or less	FED791-3462
		325°C [617°F]			300 or less	

*: Temperature of aluminum panel: 300°C [572°F] and 325°C [617°F], Temperature of engine oil: 100°C [212°F], Splatter time: 15 seconds, Downtime: 45 seconds, Test time: 8 hours. The properties are the weight of solid product accumulated on the panel.

Table 5-3 Engine Oil Quality Standards (Grade CH-4 SAE 15W-40)

Item		Unit	Recommended property value	Test method
ASTM Color		-	L4.0	ASTM D 1500
Flash point		°C [°F]	200 [392] or more	ASTM D 92
Kinetic viscosity	40°C [104°F]	mm ² /s	100 to 120	ASTM D 445 ASTM D 7042
	100°C [212°F]		13.00 to 15.00	
CCS Viscosity	-20°C [-4°F]	mPa·S	7000 or less	ASTM D 5293
MRV Viscosity	-25°C [-13°F]	mPa·S	60000 or less	ASTM D 4684
Sulfuric acid ash		mass%	2.0 or less	ASTM D 874
Acid number		mgKOH/g	4.0 or less	ASTM D 664
Base number	Hydrochloric acid method	mgKOH/g	8.0 or more	ASTM D 2896
	Perchloric acid method	mgKOH/g	11 or more	
Pour point		°C [°F]	-25 [-13] or less	ASTM D 7346 ASTM D 6749/97
Bubbling test	I	mL	10/0 or less	ASTM D 892
	II		20/0 or less	
	III		10/0 or less	
Additives	Ca	mass%	0.38 to 0.48	ASTM D 5185 ASTM D 4951 ASTM D 6481
	P		0.11 to 0.15	
	Zn		0.12 to 0.17	
	S		0.5 or less	
NOACK (evaporability)		mass%	18 or less	ASTM D 5800
High temperature shear viscosity	150°C [302°F]	mPa·S	3.7 or more	ASTM D 4741
Carbon residue content		-	2.0 or less	
Hot tube test *		-	4.0 or more	

*300°C [572°F], 16 hours

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.

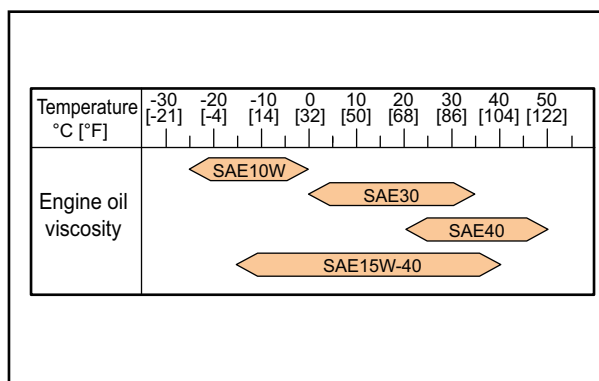


Fig. 5-3 Selection of Oil Viscosity

Handling Engine Oil

WARNING

Before filling the engine with engine oil, stop the engine and make sure there is no open flame nearby. If oil is spilled or leaked on hot surfaces or electrical components, it may 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 perform the work 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.

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 degradation of the engine oil. Change the engine oil in accordance with [Chapter 7 MAINTENANCE SCHEDULE](#). The recommended oil change interval is 50 hours for the first time. And, the intervals after the first change is every 250 hours. However, only if engine oil analyze result allows, the oil change interval may 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 5-4 Engine Oil Properties

Properties		Standard value		Test standard
Kinetic viscosity	mm ² /s [in ² /s] @100°C [212°F]	For main engine/ main generator	+30% or less rate of change from new oil 10 [0.39] or more	JIS K 2283: 2007 ISO 3107 ISO 2909
		Emergency use Generator use	+30% or less rate of change from new oil -20% or more rate of change from new oil	
Base number	mgKOH/g	2.0 or more by hydrochloric acid (HCL) method 1/2 of new oil or more by the 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	Vol%	0.2 or less		JIS K 2275: 1996 ISO 9029
Flash point (open cup)	°C [°F]	180 [356] or more		JIS K 2265: 2007 ISO 3769 ISO 2719
Pentane insolubles	mass%	0.5 or less		Compliant to ASTM D 893
Coagulated pentane insolubles	mass%	3.0 or less		Compliant to 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

The total base number represents the ability to neutralize organic acids generated by the oxidation of engine oil and sulfurous acid and sulfuric acid by burning sulfur compounds 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 total acid number in the oil increases due to the formation of organic acids by the oxidation of engine oil, the formation of sulfurous acid and sulfuric acid by the combustion of sulfur compounds in the fuel, and the incomplete 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 dispersant 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 [77°F])	-	-	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. (MHIET) 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 malfunctions 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. Be sure to use our Genuine LLC.

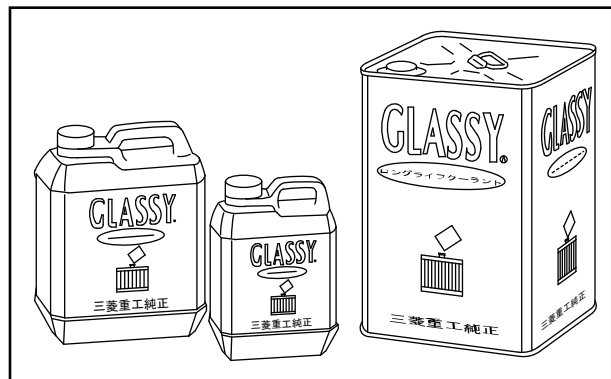


Fig. 6-1 GLASSY - LLC

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 malfunctions 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) [20/68°F] (undiluted solution)
Water content				5.0 weight % or lower (undiluted solution)
Freezing temperature	30 volumetric % water solution			-14.5°C [5.9°F] or lower
	50 volumetric % water solution			-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 volumetric % water solution			4.0 ml [0.0008 gal] or less
	33 ¹ / ₃ vol % water solution			150 ml [0.032 gal] 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 Hr, 30 volumetric% water solution (ethylene glycol), 50 volumetric% 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		Except the contact between the test piece and spacer, any corrosion should not be observed. 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 volumetric % water solution 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 Hr, 30 volumetric% water solution (ethylene glycol), 50 volumetric% 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		Except the contact between the test piece and spacer, any corrosion should not be observed. 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 volumetric % water solution 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 Hr, 30 volumetric% 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		Except the contact between the test piece and spacer, any corrosion should not be observed. 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 vol % water solution, 115°C [239°F], 360 Hr)	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%
	Nitril 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	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 (volumetric % water solution) (30 volumetric % water solution, room temp, 6 hrs)			0.3 or less

Maintenance of LLC

CAUTION

Should coolant or LLC be accidentally swallowed, induce vomiting immediately and seek medical attention. If LLC should enter eyes, flush immediately with plenty of water and seek medical attention.

LLC is toxic. Never dispose of coolant containing LLC drained from engine into regular sewage. For disposal of used coolant, consult LLC distributor.

Replacement Intervals of LLC

CAUTION

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

Failure to renew 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		to -10°C [14°F]	to -20°C [-4°F]	to -30°C [-22°F]	to -45°C [-49°F]
LLC Con- centration	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 be lowered, or the cooling water temperature will be increased due to the lowered specific heat.
4. Coolant temperature will increase by approximately 1.5°C [2.7°F] for 60% concentration of GLASSY (ethylene glycol) and approximately 3°C [5.4°F] for 90% concentration of PG GLASSY (propylene glycol). Confirm the heat exchanger capacity of the cooling system to avoid overheating.

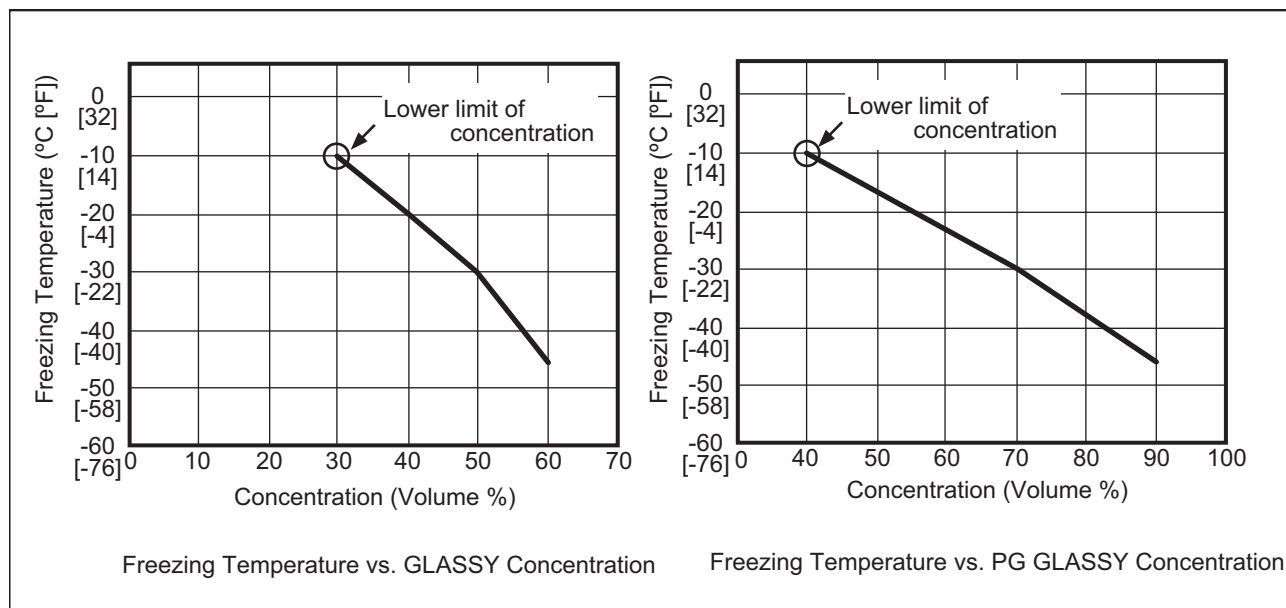


Fig. 6-2 Coolant Freezing Temperature (GLASSY and PG GLASSY)

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. 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, resulting in the corrosion of metals. Brass and solder tend to corrode faster than other metals, and corrosion of these metals is said to cause water leaks or clogging. Example: holes and clogging in heat exchanger.

Chapter 7 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 work according to the "Periodic Maintenance Schedule".

Basically, obey the standard service intervals specified in the "Periodic Maintenance Schedule". However, if you notice any abnormalities such as abnormal noise, black exhaust smoke, white exhaust smoke, extremely high temperature of exhaust gas, abnormal vibration, and fuel, oil or exhaust gas leakage, be sure to conduct the inspection and maintenance work regardless of recommended service intervals in the "Periodic Maintenance Schedule".

Note: Appropriate service intervals vary with usage and operating conditions as well as conditions of fuel, oil, and coolant. Check the operating record of the engine to determine the most appropriate service intervals. (Feel free to consult your MHIET dealer regarding service intervals.)

Be sure to inspect the items which are included in the applicable interval and shorter intervals. For example, in the 2000 hour maintenance, also inspect those items listed in every 50, 250, 500, and 1000 hours.

Periodic Maintenance Schedule

Table 7-1 PERIODIC MAINTENANCE CHART

Service interval	Service Items	Page
First 100 hours of operation (Only once)	Engine Oil, Oil Filter, and Bypass Oil Filter - Replace	8-10
	Fuel Filter - Replace	8-7
	Valve Clearance - Inspect and Adjust	*
	Engine Exterior - Inspect	8-1
	Oil-Water Separator - Inspect	-
Every 250 hours	Engine Oil, Oil Filter, and Bypass Oil Filter - Replace	8-10
	Belt and Belt Tension - Inspect and Adjust	8-2
	Pre-Cleaner - Clean, Inspect, and Replace	8-18
Every 500 hours	Items included in the intervals of every 100 and 250 hours	-
	Zinc Rod - Inspect	8-16
	Gauze Filter - Clean	8-6
	Governor Oil Filter - Replace	8-13
Every 1000 hours	Items included in the intervals of 100, 250 and 500 hours	-
	Oil-Water Separator Element - Replace	-
	Fuel Filter - Replace	8-7
	Turbocharger Rotor Movement and Looseness - Inspect	*
	Valve Clearance - Inspect and Adjust	*
	Fuel Injection Nozzle - Inspect and Adjust	*
Every 2000 hours or every year	Items included in the intervals of every 500, 100, 250 and 1000 hours.	-
	High-Pressure Fuel Injection Pipe and Clamp Seat - Inspect and Replace	8-9
	Low-Pressure Fuel Pipe, Oil Pipe, and Clip - Inspect and Replace	8-9
	Fuel Injection Nozzle Tip, Spacer, and Nozzle Spring - Replace	*
	Seawater Pump Impeller - Replace	*
	Bolts and Nuts on Exhaust and Air Inlet Pipes - Retighten	*
	Damaged Harness and Loose Terminal - Inspect	*

Table 7-1 PERIODIC MAINTENANCE CHART

Service interval	Service Items		Page
Every 4000 service hours or every 2.5 years	Items included in the intervals of every 100, 250, 500, 1000 and 2000 hours.		-
	Engine Overhaul	Cylinder Head - Disassembly and Inspect Valve Mechanism - Inspect Cylinder Liner Inside Surface - Inspect	*
	Belt - Replace		*
	Damper - Inspect		8-3
	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		*
	Air Cooler Element - Clean		*
	Starter - Inspect		8-20
	Alternator - Inspect		-
	Protection System Operation - Inspect		*
	Coolant - Change (Every 2 Years)		8-14

Table 7-1 PERIODIC MAINTENANCE CHART

Service interval	Service Items		Page
Every 8000 hours or every 5 years	Items included in the intervals of every 100, 250, 500, 1000, 2000, and 4000 hours		-
	Engine overhaul	Piston - Check Piston Cooling Nozzle - Inspect Crankshaft - Inspect Main bearing - Replace Thrust Plate - Replace Connecting Rod Bearing - Replace Camshaft Bushing - Inspect Cylinder Liners - 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)		*
	Governor - Inspect and Test (Replace parts as needed)		*
	Clamp Seat for High-Pressure Fuel Injection Pipe - Replace		*
	Oil Cooler - Clean		*
	Fresh Water Pump Unit Seal and Ball Bearing - Replace		*
	Seawater Pump Unit Seal and Ball Bearing - Replace		*
	Tension Pulley Bearing - Replace		*
	Thermostat - Replace		*
	Coolant Hose - Replace		*
	Fresh Water Tank Cap - Replace		*
	Turbocharger - Overhaul		*
	Electrical Components - Inspect		*
	Relays - Replace		*
Every 16000 hours or every 10 years	Items included in the intervals of every 100, 250, 500, 1000, 2000, 4000, and 8000 hours		-
	Replace the following parts with new ones: Piston, connecting rod bushing, piston pin, rocker bush, gear bushing, tappet, valve guide, valve spring, connection 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) Items marked with * in the maintenance schedule require special tools and specialized maintenance service. Please contact a dealer of MHIET for maintenance of those items.

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

Chapter 8 PERIODIC INSPECTION AND MAINTENANCE PROCEDURES

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

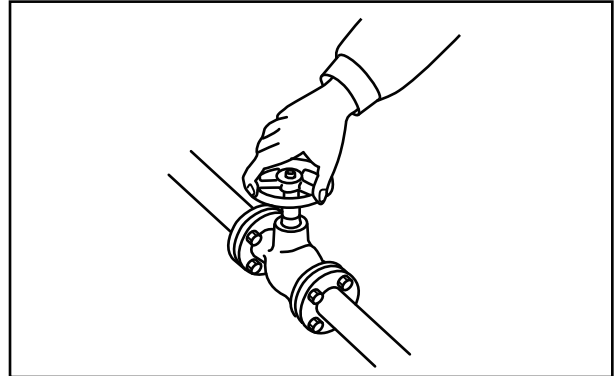


Fig. 8-1 Valve Open/Closed Position - Check

Belt and Belt Tension - Inspect and Adjust

CAUTION

If defects such as cuts or surface separations are found by 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 instructions 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 [0.39 to 0.59 in.], the tension is correct.
Belt pushing force: approx. 98 to 147 N {9.99 to 14.99 kgf} [22.03 to 33.05 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.

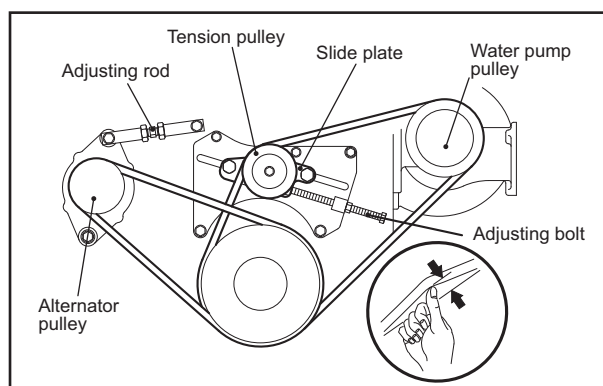


Fig. 8-2 Belt Tension - Adjust

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.

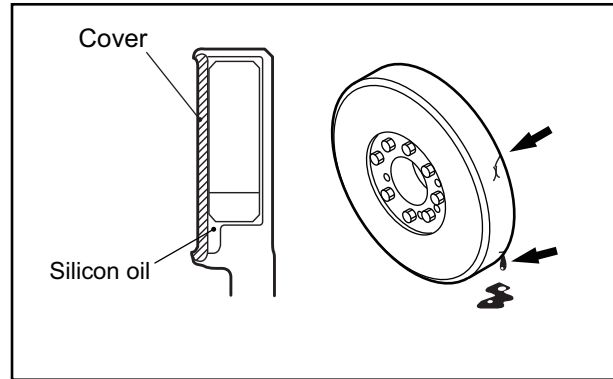


Fig. 8-3 Damper - Check Visually

Damper Temperature Control

To ensure the proper function of damper, heat must be dissipated from its surface to prevent excessive heating. MHIET inspects each engine before shipment to make sure that the temperature of damper does not excessively rise. However, the damper temperature varies depending on ambient conditions. Thus, follow the instructions below, paying attention to ventilation around the damper and facility.

1. Make sure the temperature of the damper outer surface will not exceed 90°C [194°F] when operating the engine at rated power for an hour.
2. When installing a protective cover on the damper, provide adequate ventilation so that the damper temperature is maintained at 90°C [194°F] or below.
3. MHIET recommends the use of thermo label for temperature control.

Thermo Label - Use

When the thermo label reaches the specified temperature, the white heat-sensitive portion turns into black color.

Note: Once the heat-sensitive area turns its color, it will never return to the original color again. Thus, even when the temperature of damper has dropped after the stop of engine, the thermo label still indicates the highest temperature when engine was running.

1. Attach the thermo label to the damper outer circumference or front end near the outside diameter.
2. Record the highest temperature by checking the thermo label heat-sensitive portion when engine is not running. Record the temperature regularly so that you can tell if there is any abnormal temperature change.

Note: (a) When an increase in thermo label temperature is observed, look for the abnormality of engine or other causes. And then replace the thermo label with new one, and check the temperature changes again.

(b) If the temperature indication of thermo label comes close to the limit temperature of damper, or if there is an abnormal temperature change, contact your MHIET dealer.

(c) For damper temperature limit, refer to "Damper Temperature Control" (8-3).

Table 8-1 Types of Thermo Labels

Part name	Part number	Measurable temperature range
Thermo label 100-120	32522-04211	100 to 120°C [212 to 248°F]
Thermo label 75-95	32522-04111	75 to 95°C [167 to 203°F]
Thermo label 50-70	32522-04311	50 to 70°C [122 to 158°F]

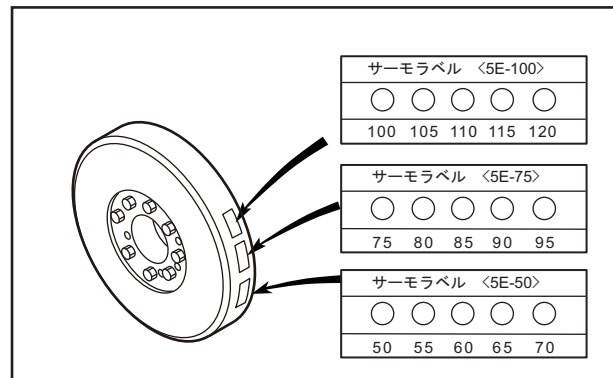


Fig. 8-4 Damper Temperature Control

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 pan under the drain cock.
3. Drain all fuel in the tank from the drain cock located at the bottom of fuel tank.
4. Clean the inside of fuel tank.
5. Add fuel in the fuel tank.
6. Open the fuel feed valve of the engine.

Note: If the specification of fuel tank differs from the contents in this operation manual, follow the fuel 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 pan (capacity of 2 L [0.53 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 L [0.26 to 0.53 U.S. gal.].
3. After making sure water and foreign material has been discharged together with fuel, close the drain cock.

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

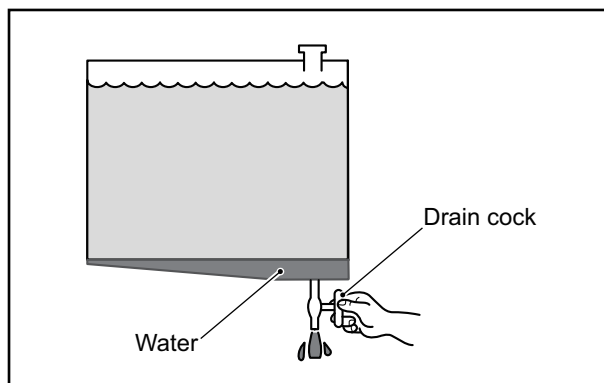


Fig. 8-5 Fuel Tank - Drain Water

Oil-Water Separator - Drain Water

WARNING

From water drain valve, fuel is discharged together with water. Wipe off any spilled fuel completely.

1. Turn the 3-way cock of oil-water separator to the "drain" position with the handle attached to it.
2. Loosen the air vent plug.
3. Open the water drain valve, and drain the water from oil-water separator.
4. Turn the 3-way cock of oil-water separator on the inlet side to the "run" position.
5. Close the water drain valve.
6. Bleed air from the oil-water separator.
7. Turn the 3-way cock of oil-water separator on the outlet side to the "run" position.

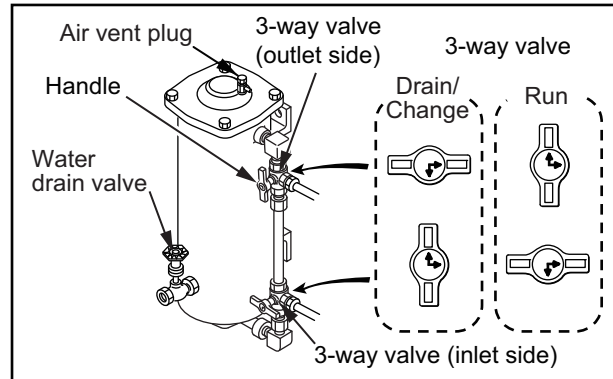


Fig. 8-6 Oil-Water Separator - Drain Water

Oil-Water Separator Element - Replace

1. Place a pan under the oil-water separator to catch fuel.
2. Turn the 3-way cock of oil-water separator to the "Change" position with the handle.
3. Loosen the air vent plug.
4. Open the drain valve, and drain fuel from oil-water separator.
5. Remove the cover mounting bolts and remove the cover.
6. Replace the element with a new one.
7. After confirming that O-ring and spring are attached to the cover, install the cover.

Note: Be sure to use a new O-ring.

8. Close the drain valve.
9. Bleed air from the oil-water separator.
10. Turn the 3-way cock to "run" position.
11. Be sure to bleed air from fuel system after replacement of element.

Note: (a) If the specification of water separator differs from the contents of this operation manual, follow the manufacturer's operation manual.

(b) For bleeding air from fuel system, refer to ["Priming the Fuel System" \(3-1\)](#).

(c) During engine operation, check for fuel leaks from the cover mounting portion. If fuel leaks, retighten the cover mounting bolts.

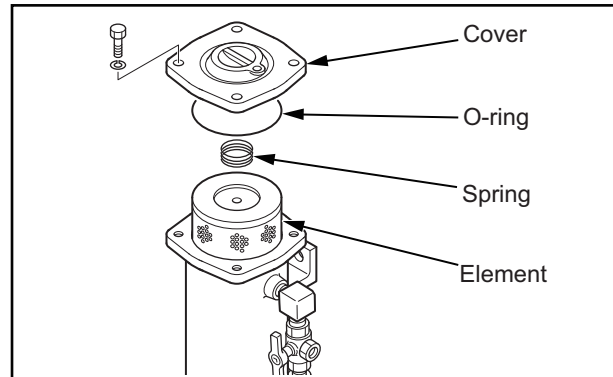


Fig. 8-7 Oil-Water Separator Element - Replace

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 in the fuel feed pump.
7. Bleed air from the fuel filter.

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

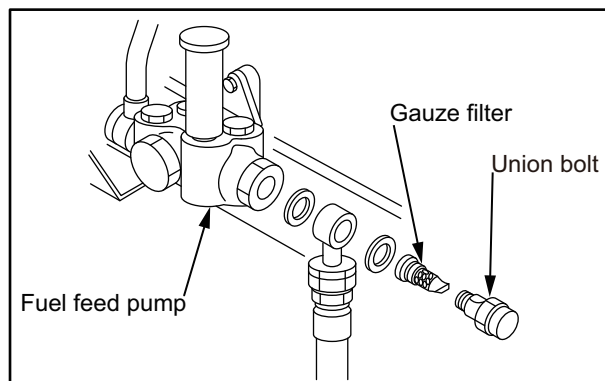


Fig. 8-8 Gauze Filter - Clean

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 engaged in the groove.



WARNING

If the filter case is dented, do not use the filter. Filter 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 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, retighten the fuel filter.

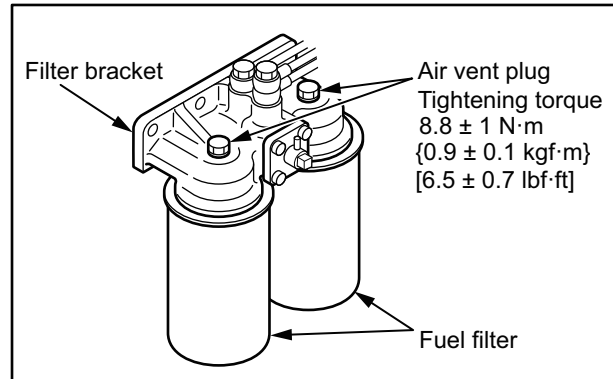


Fig. 8-9 Fuel Filter - Replace

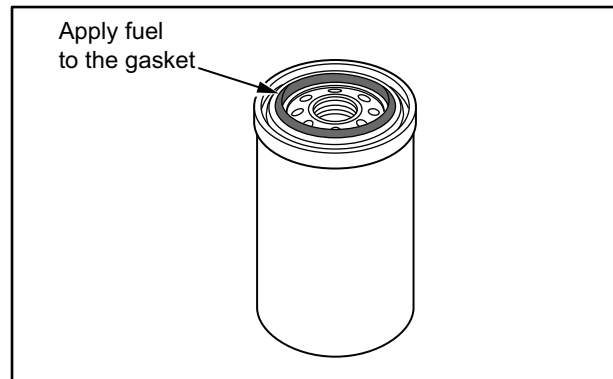


Fig. 8-10 Fuel Filter

Fuel Filter - Replace While Engine is Running

If the engine has to be operated continuously, you can replace fuel filters while the engine is running by turning the switchover cock located between the fuel filters.

Note: When changing the fuel filters using the switchover cock, be sure to decrease the engine speed and operate it at idle.

1. Turn the switchover cock and align the pin with the mark.

2. After the fuel filter is replaced, bleed the fuel filter.

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

3. Place the switchover cock in the operating position.
4. When replacing the fuel filters, oil may flow out from the filter mounting surface. Be sure to place a fuel tray under the oil filter.

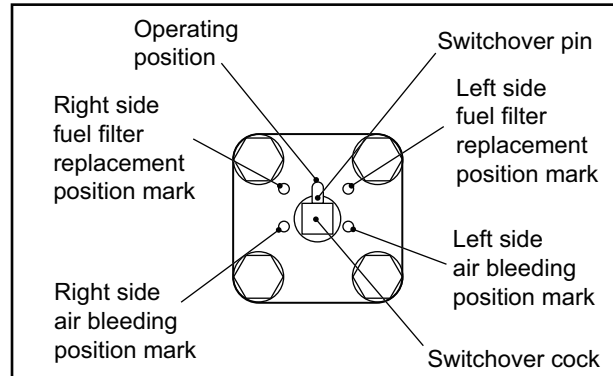


Fig. 8-11 Fuel Filter Switchover Cock

Fuel Control Link Ball Joint - Inspect

Check the ball joint of 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 the 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 warranty.

When the ball joints are integrated with the control link, replace the control link assembly. When installing ball joints, be sure to tighten the nuts firmly.

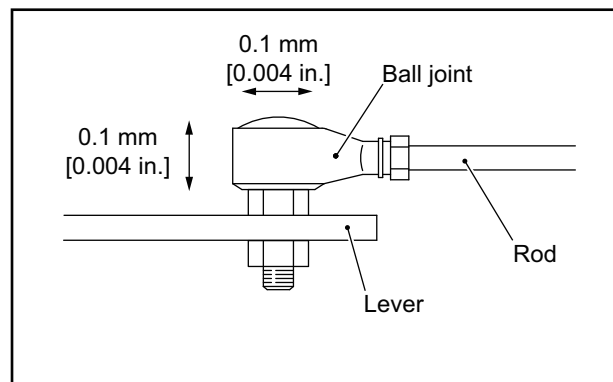


Fig. 8-12 Ball Joint - Check for Looseness

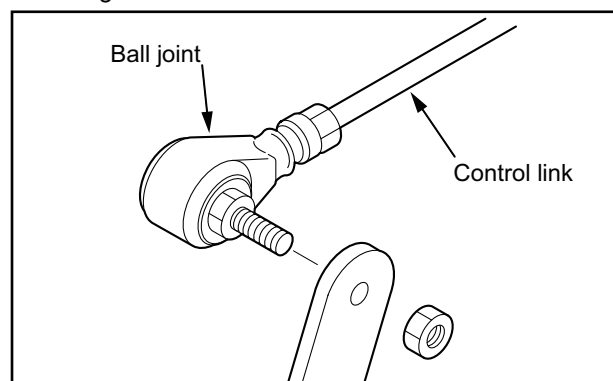


Fig. 8-13 Fuel Control Link - Remove

Fuel Pipe - Inspect



WARNING

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

Also, make sure the fuel pipes do not come in contact with other pipes and objects.

When contacted, a hole may open due to rubbing between pipes, and could result in a fire.

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

Visual Inspection

Check the clamp seat for cracks 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.

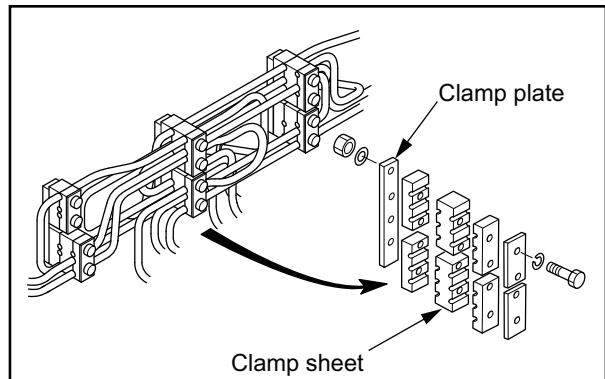


Fig. 8-14 High-Pressure Fuel Injection Pipe and Clamp Seat - Inspect and Replace

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.

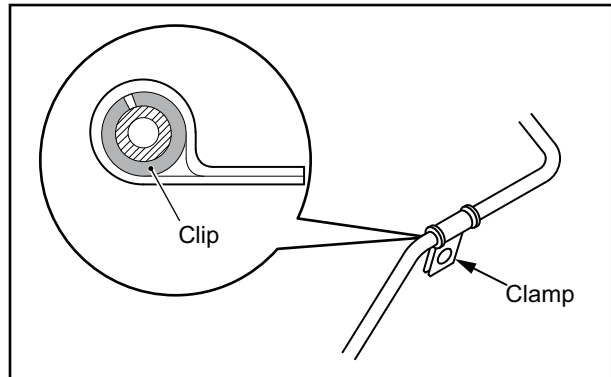


Fig. 8-15 Low-Pressure Fuel Pipe, Oil Pipe, and Clip - Inspect and Replace

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 down the drain. It is forbidden by the law. For the disposal of drained oil, consult with your MHIET dealer.

Engine oil, oil filter, and bypass oil filter should be changed at the same time.

Engine oil analysis is also recommended when changing 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

Drain engine oil from the drain port of oil pan after stopping the engine.

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, resulting in a fire due to oil leaks.

CAUTION

Do not use a filter wrench to install the oil filter and bypass oil filter. Tighten the filters by hand.

Be careful not to dent or scratch oil filter surfaces.

1. Clean the area around oil filters.
2. Place oil pans under oil filters and bypass oil filter.
3. Using a filter wrench, remove oil filters and bypass oil filter.
4. Thoroughly wipe off oil on the oil filter mounting surface of the filter bracket with a clean cloth.
5. Check new oil filters and bypass filter to make sure the gasket is properly engaged in the groove.
6. Apply clean engine oil on gasket.
7. Install oil filters and bypass oil filter on the filter bracket. When the gasket comes in contact with the mounting surface of the filter bracket, further rotate 3/4 to a full turn.

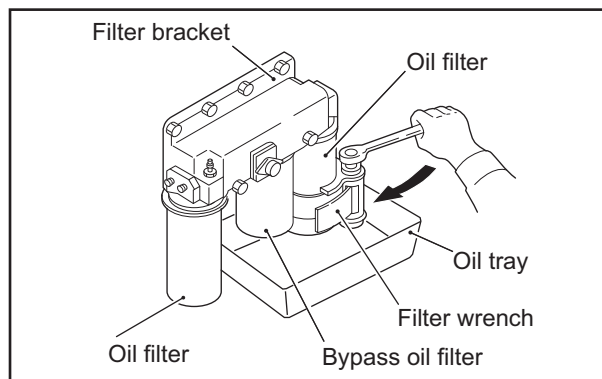


Fig. 8-16 Oil Filter and Bypass Oil Filter - Replace

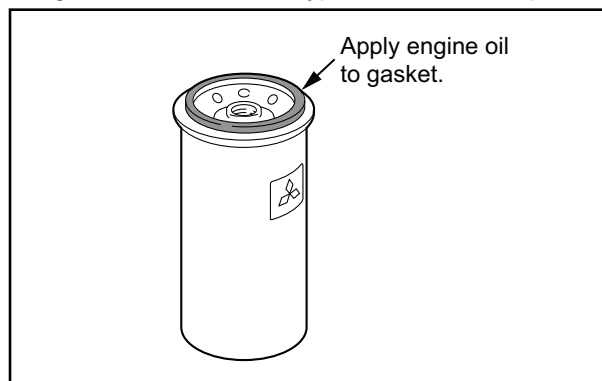


Fig. 8-17 Oil Filter

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.

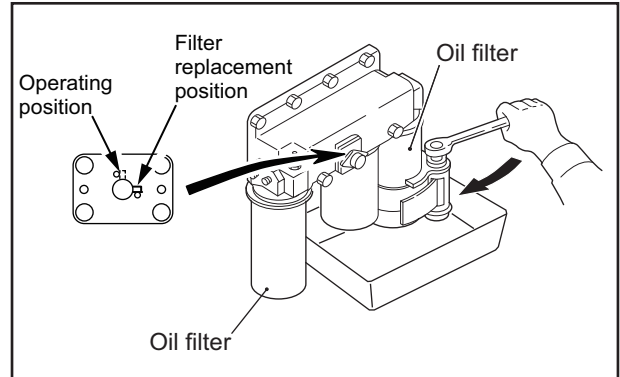


Fig. 8-18 Oil Filter - Replace While Engine is Running

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.

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

1. Stop the engine for about 30 minutes.
 2. Remove the oil filler cap.
 3. 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 SPECIFICATIONS" (12-1)**.

4. Check the oil level in oil pan.
5. Pull out the oil level gauge and wipe it clean with a cloth.
6. Insert the oil level gauge fully into the oil level gauge guide and then pull it out again.
7. 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.
8. Check the oil pan, etc., for oil leaks. Repair if there is an oil leak.
9. With the stop lever placed in pulled position, rotate the engine with starter for 10 seconds to feed oil to the 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 items described under the Preparation of Cooling System.

10. Check the oil level with the oil level gauge again, and add oil to the specified level.

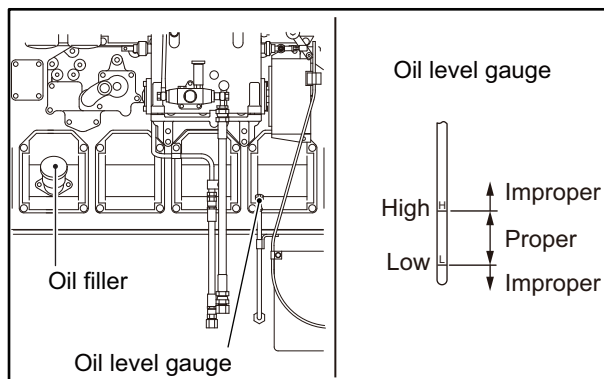


Fig. 8-19 Oil Filler and Oil Level Gauge

Ingress of Fuel and Water In Engine Oil - Inspect

CAUTION

Continuous operation with water or fuel mixed in the engine oil will decrease the engine oil viscosity, which can lead to serious problems such as bearing seizure.

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

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

If water is mixed, oil may turn milky white.

If the coolant gets into the engine oil during operation, moisture vapor is discharged from the breather.

If fuel or water is mixed with the engine oil, find the cause and repair. If the repair is not easy, consult with your MHIET dealer.

Note: If oil leaks from oil cooler, oil will float in fresh water in the coolant expansion tank. Also, LLC that is not miscible 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. Loosen the air vent plug and remove the drain plug. Drain oil from the filter into the drip pan.
3. Remove the oil pipe from the center bolt.
4. Remove the center bolt and remove the case from the bracket. Remove the used element from the case.
5. Install a new element in the case using the center bolt.
6. Install the case with the new filter on the filter bracket and tighten the center bolt to secure.
7. Install the oil pipe to the center bolt.
8. Tighten the drain plug.
9. Remove the air vent plug. Add engine oil until the filter is filled with oil.
10. After oil has been filled, install the air vent plug.

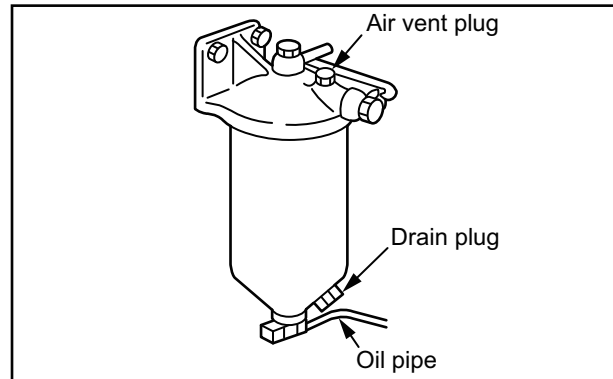


Fig. 8-20 Governor Oil - Drain

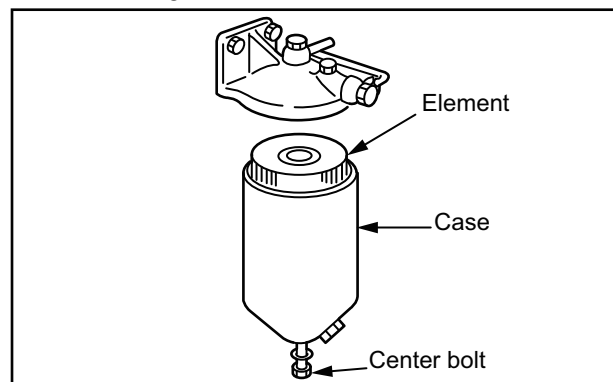


Fig. 8-21 Governor Oil Filter - Replace

Cooling System

Coolant - Change

CAUTION

Do not dump used coolant (containing LLC) down drains.

Such a way of disposal is strictly prohibited by laws and regulations.

Abide by the applicable laws and regulations for disposal of coolant.

CAUTION

The coolant mixed with the recommended LLC must be changed every 2 years.

Coolant - Drain

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

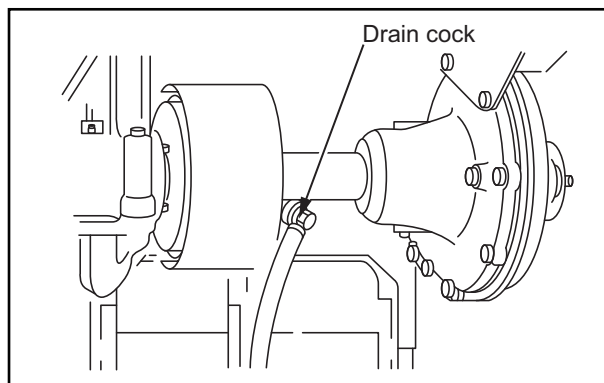


Fig. 8-22 Coolant Drain Cock (Engine Body)

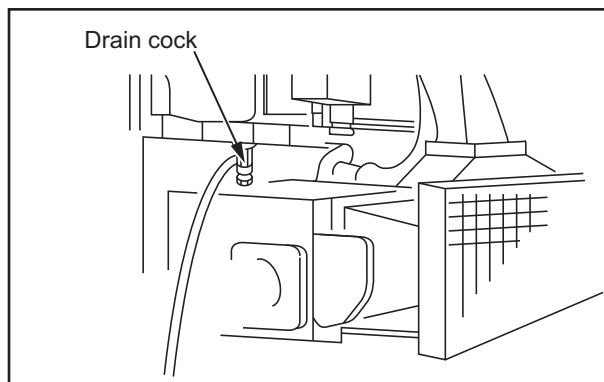


Fig. 8-23 Coolant Drain Cock (Water-Cooled Exhaust Pipe)

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.

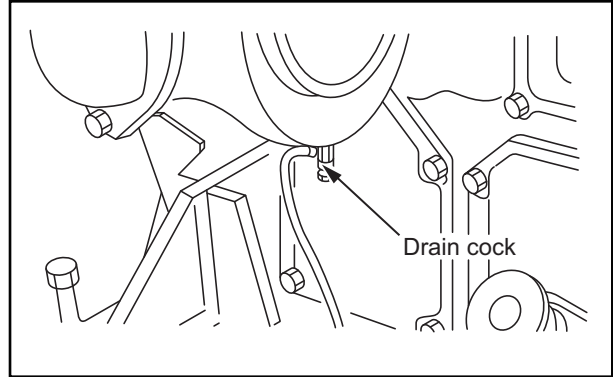


Fig. 8-24 Coolant Drain Cock (Water Pump)

Coolant - Refill

CAUTION

To add coolant, use the same LLC concentration coolant that is currently in the cooling system.

1. Close coolant drain cocks and plugs firmly.
2. Open the coolant filler port and add a mixture of water and coolant (LLC) having the specified concentration.
Note: Determine the amount of LLC using the LLC concentration chart.
For the coolant, refer to ["COOLANT" \(6-1\)](#). For the coolant capacity, refer to ["MAIN SPECIFICATIONS" \(12-1\)](#).
3. Check the heat exchanger, etc. for coolant leaks. If a leak is found, repair it.
4. When coolant reaches the full level, close the coolant filler securely.
5. With the manual stop lever placed in the pulled position, crank the engine for approximately 10 seconds using the starter. Stop for approximately 1 minute, and then repeat the cranking 2 or 3 times to bleed air from the cooling system.
Note: Also, perform the items described under the Preparation of Lubrication System.
6. Check the coolant level.

Zinc Rod - Inspect

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

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.

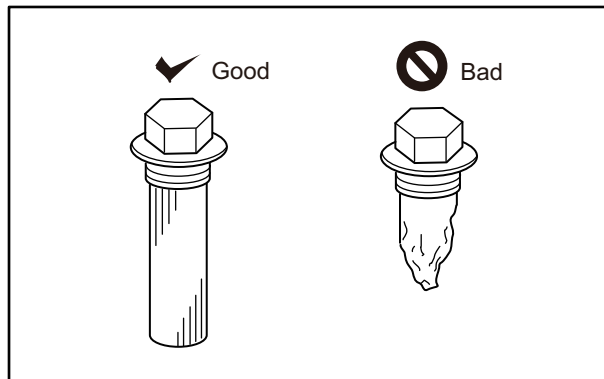


Fig. 8-25 Zinc Rod - Judge

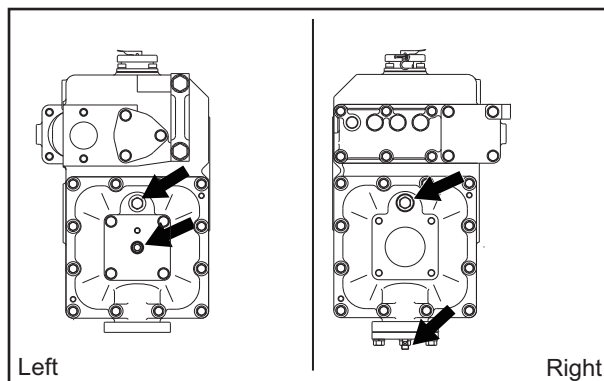


Fig. 8-26 Zinc Rod Mounting Location (Heat Exchanger)

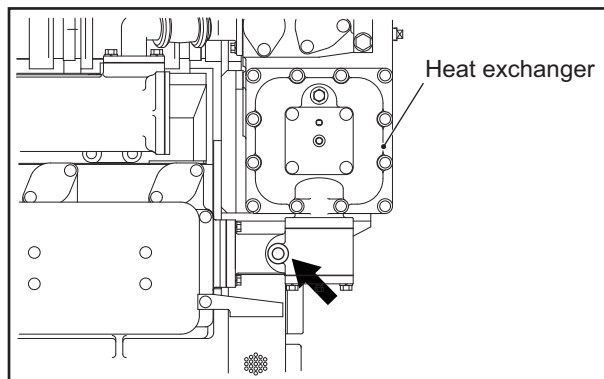


Fig. 8-27 Zinc Rod Mounting Location (Air Cooler)

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.

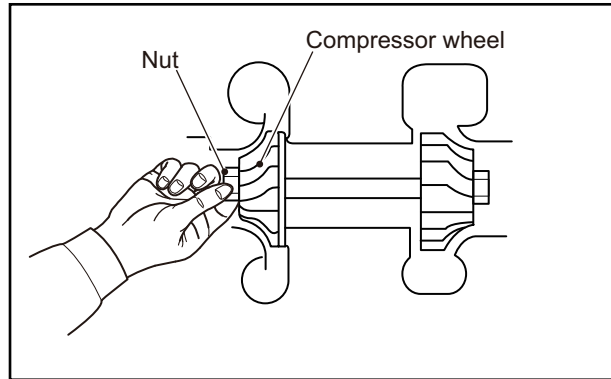


Fig. 8-28 Turbocharger - Inspect

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.

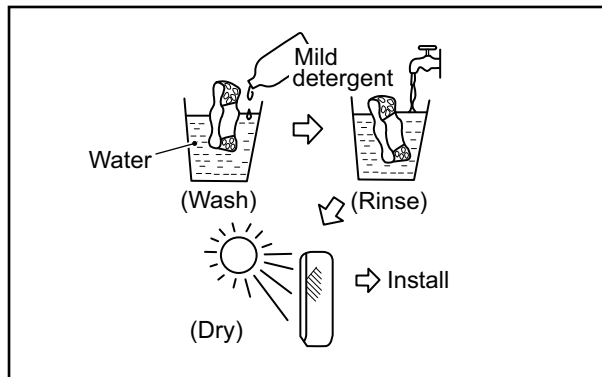


Fig. 8-29 Pre-Cleaner - Wash

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 conducting any electrical work or electrical welding, place the battery switch in the [Open/OFF] position or remove the battery 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 the battery).

If battery fluid is spilled onto your 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, 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.

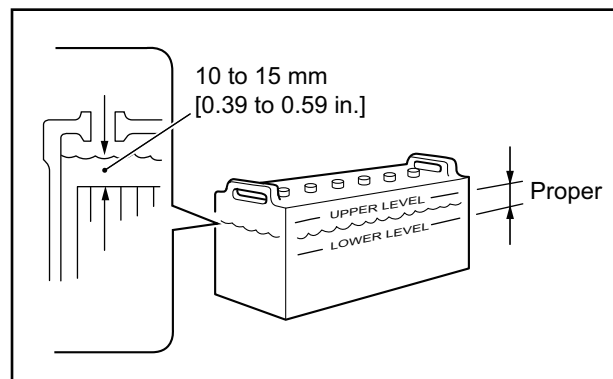


Fig. 8-30 Battery Fluid Level - Check

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 8-2 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	Bad	Charge

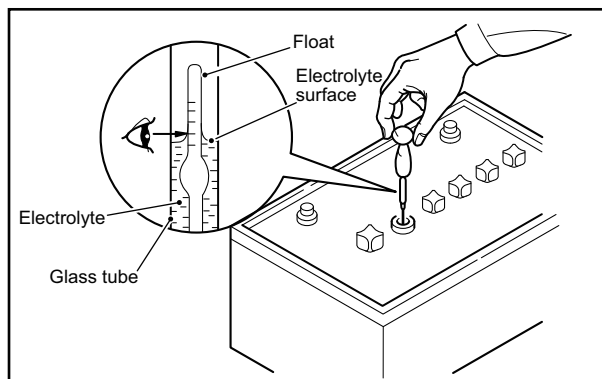


Fig. 8-31 Specific Gravity of Battery Electrolyte - Check

Starter - Inspect

Visually inspect the starter and ring gear for damage.

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

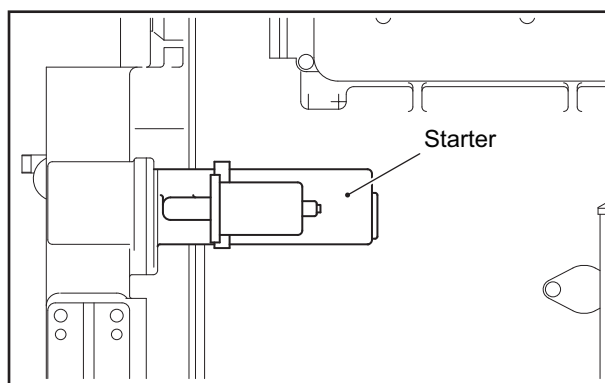


Fig. 8-32 Starter - Inspect

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.

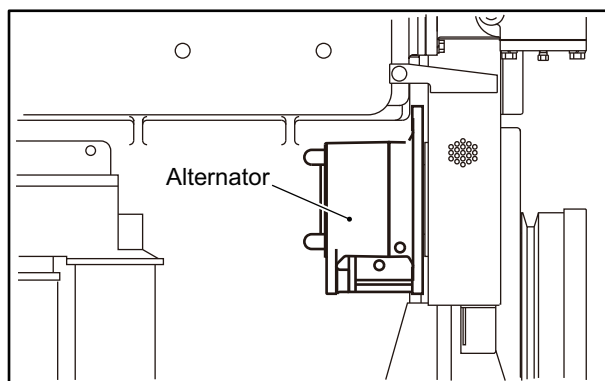


Fig. 8-33 Alternator - Inspect

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, gradually spray volatile corrosion inhibitor (VCI) about 1g (reference) 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, for FRP tanks, any kind of corrosion protection is not required.
7. Apply a sufficient quantity of anti-rust oil (NP-3-2) on the exposed machined surfaces.
8. Cover the air inlet, exhaust outlet, breather, etc., with an 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 in 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 terminals, and store 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 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 Recommended Rust-Preventive Oil and Corrosion Inhibitor

JIS		Recommended product	Intended use
K 2246	NP-3-2	ANTIRUST TERAMI SC by ENEOS Corporation	Exposed machined surfaces
	NP-9	ANTIRUST TERAMI LN by ENEOS Corporation	Prevention of rust in fuel system
	NP-10-2	ANTIRUST P-230 by ENEOS Corporation	Prevention of rust in lubricating system
Z 1519	-	VCI Diana ND volatile corrosion inhibitor by Mitsubishi Gas Chemical Trading, Inc.	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. Connect a fully charged battery.
3. Remove the cover from the starter and alternator.
4. Adjust the belt tension.

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

5. Remove sealing tapes that have been covered the openings of the engine.
6. Connect pipes and hoses.
7. Fill the fuel tank with fuel, and bleed air from the fuel system.

Note: To bleed air from the fuel system, refer to ["Priming the Fuel System" \(3-1\)](#).

8. Check the engine oil and coolant level.
9. Inspect every part of the engine.
10. Remove the rocker covers, and lubricate the valve mechanisms.
11. With the manual stop lever placed in the pulled position, crank the engine for approximately 10 seconds using the starter. Stop the operation for about 1 minute, and then repeat the operation two or three times.
12. After starting, make sure the engine oil pressure rises.
13. Conduct a warm-up operation for a sufficient duration to fully lubricate all the components.

Note: For engine starting procedure, refer to ["Start-up" \(3-12\)](#).

14. Apply load and increase the engine speed to the rated speed.

Storing Engine in an Operable Condition

If the engine is not be used for an extended period of time, the 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 approximately 10 seconds using the starter. Stop the operation for about 1 minute, and 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" \(3-12\)](#).

Lifting Engine



WARNING

To lift the engine, use wire ropes, shackles, and slings which is 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 attached to the engine are designed for lifting the engine only. For the engine coupled with a generator, use the special hangers provided on the common bed. Do not use hangers on the engine.

Keep wire rope sling angles within 60 degrees. If the angle exceeds this limit, excessive load will 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 pipe covers and insulators located near 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.

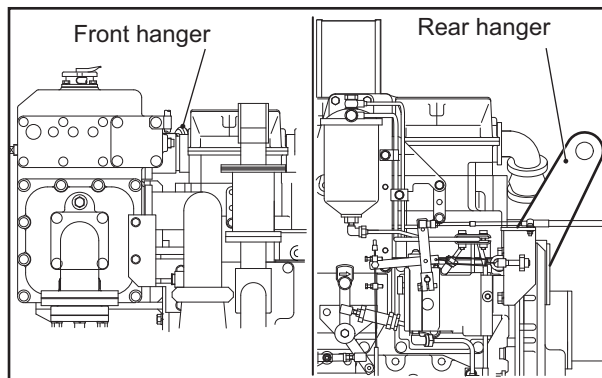


Fig. 10-1 Lifting Hangers

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 parts with new ones, order only genuine MHIET parts 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.

Problems, Probable Causes, and Solutions

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

Table 11-1 The Starter Does not Crank or Cranks Slowly, Resulting in Start Failure

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	•Belt - Inspect and Adjust (Refer to P8-2)
	Weak battery	•Specific gravity of battery electrolyte - Check (Refer to P8-20) •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 P5-1)
	Excessive oil level	•Engine oil level - Check (Refer to P3-11)
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 11-2 Starter Cranks, but Engine Does Not Start

Possible cause		Solution
Fuel system	Run out of fuel, blocked pipe	♦Fuel Tank - Inspect, Refill, and Air bleed (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 Retighten ♦Contact your MHIET dealer.
	Clogged fuel filter	♦Fuel filter - Inspect and Replace (Refer to P8-7) ♦Gauze filter - Clean (Refer to P8-6)
	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 - Inspect ♦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.

Insufficient Output

Table 11-3 Insufficient 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 P8-7) •Gauze filter - Clean (Refer to P8-6)
	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 •Heat exchanger - Inspect •Control system - Inspect •Contact your MHIET dealer.
Inlet and exhaust systems	Insufficient amount of intake air	•Turbocharger - Inspect (Refer to P8-17) •Pre-cleaner - Clean, Inspect and Replace (Refer to P8-18) •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.

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 11-4 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.
Lubricating system	Combustion of engine oil	•Engine oil level - Check (Refer to P3-11) •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 Gray

Table 11-5 Exhaust Smoke is Black or Gray

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	•Intake air pressure and intake air leaks - Inspect •Intake air temperature and ventilation system - 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	Excessive load	•Control 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.

Excessive Fuel Consumption

Table 11-6 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 Retighten •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	•Intake air pressure and intake air leaks - Inspect •Intake air temperature and ventilation system - 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.
Load	Excessive load	•Readjust digestion pump load.

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 11-7 Excessive Engine Oil Consumption

Possible cause		Solution
Fuel system	Faulty fuel injection timing	•Fuel injection pump drive coupling - Inspect •Contact your MHIET dealer.
Lubricating 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 P5-1)
	Excessive engine oil temperature	•Engine oil level - Check (Refer to P3-11) •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 11-8 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 11-9 Engine Oil Pressure Drop

Possible cause		Solution
Lubricating system	Low engine oil level	•Engine oil level - Check (Refer to P3-11)
	Faulty engine oil property (viscosity)	•Oil property analysis. Use appropriate engine oil. (Refer to P5-1)
	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 P8-10)
	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" \(3-12\)](#).

Chapter 12 MAIN SPECIFICATIONS

Main Specifications

Table 12-1 Main Specifications

Item	Specification
Engine model	S6R-T2MPTK
Type	Water-cooled 4-cycle engine with turbocharger and air cooler
No. of cylinders - Arrangement	6 cylinders, in-line
Cylinder bore × stroke	ø170 × 180 mm [6.69 × 7.09 in.]
Displacement (declared value)	24.51 L [1495.92 cu in.]
Combustion system	Direct injection system
Compression ratio	14.5 : 1
Firing order	1-5-3-6-2-4
Direction of rotation	Counterclockwise as viewed from flywheel side
Dimensions (L × W × H)	Approximately 2122 × 1201 × 1615 mm [83.54 × 47.28 × 63.58 in.]
Dry weight	Approximately 2950 kg [6504 lb]
Fuel	Diesel fuel
Fuel injection pump	PS6A
Fuel filter	Cartridge type paper-element
Fuel injection nozzle	Hole type
Fuel injection starting pressure	34.3 MPa {350 kgf/cm ² } [4978 psi]
Governor	Hydraulic type (all-speed control)
Lubrication method	Forced circulation (pressure feed by oil pump)
Lubrication oil	Grade CF or CH-4 oil (API service classification)
Engine oil capacity	Oil pan: approximately 140 L [36.99 US gal.], Whole engine: approximately 160 L [42.27 US gal.]
Oil filter	Cartridge type paper-element
Oil cooler	Water-cooled, multi-plate type
Cooling method	Seawater indirect cooling
Cooling freshwater capacity	Approximately 120 L [31.7 US gal.] (engine body)
Starting system	Electric start
Starter	DC 24V - 7.5 kW
Alternator	DC 24V - 35A
Turbocharger	Mitsubishi TF15M

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

Chapter 13 ELECTRICAL WIRING DIAGRAM

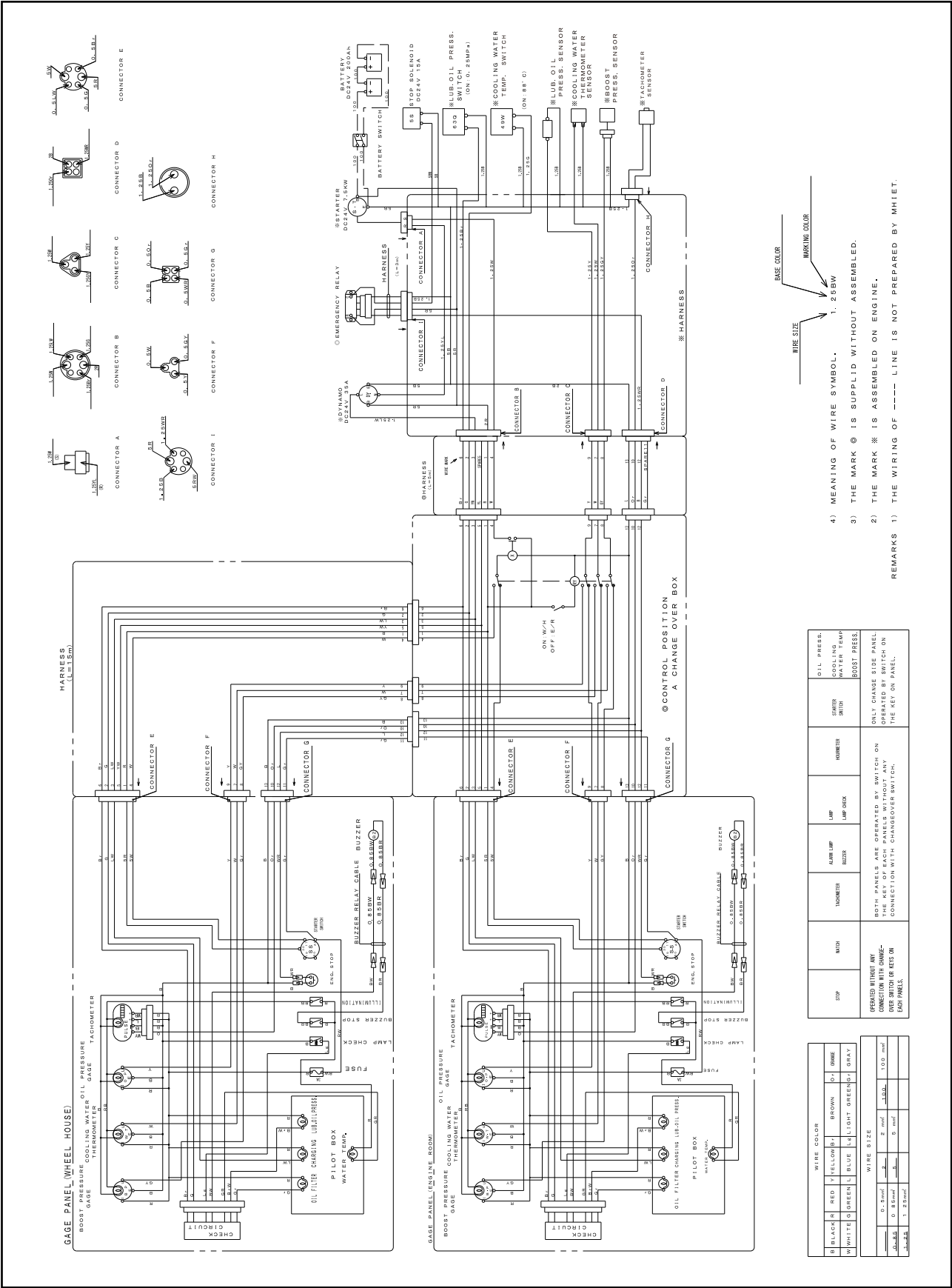
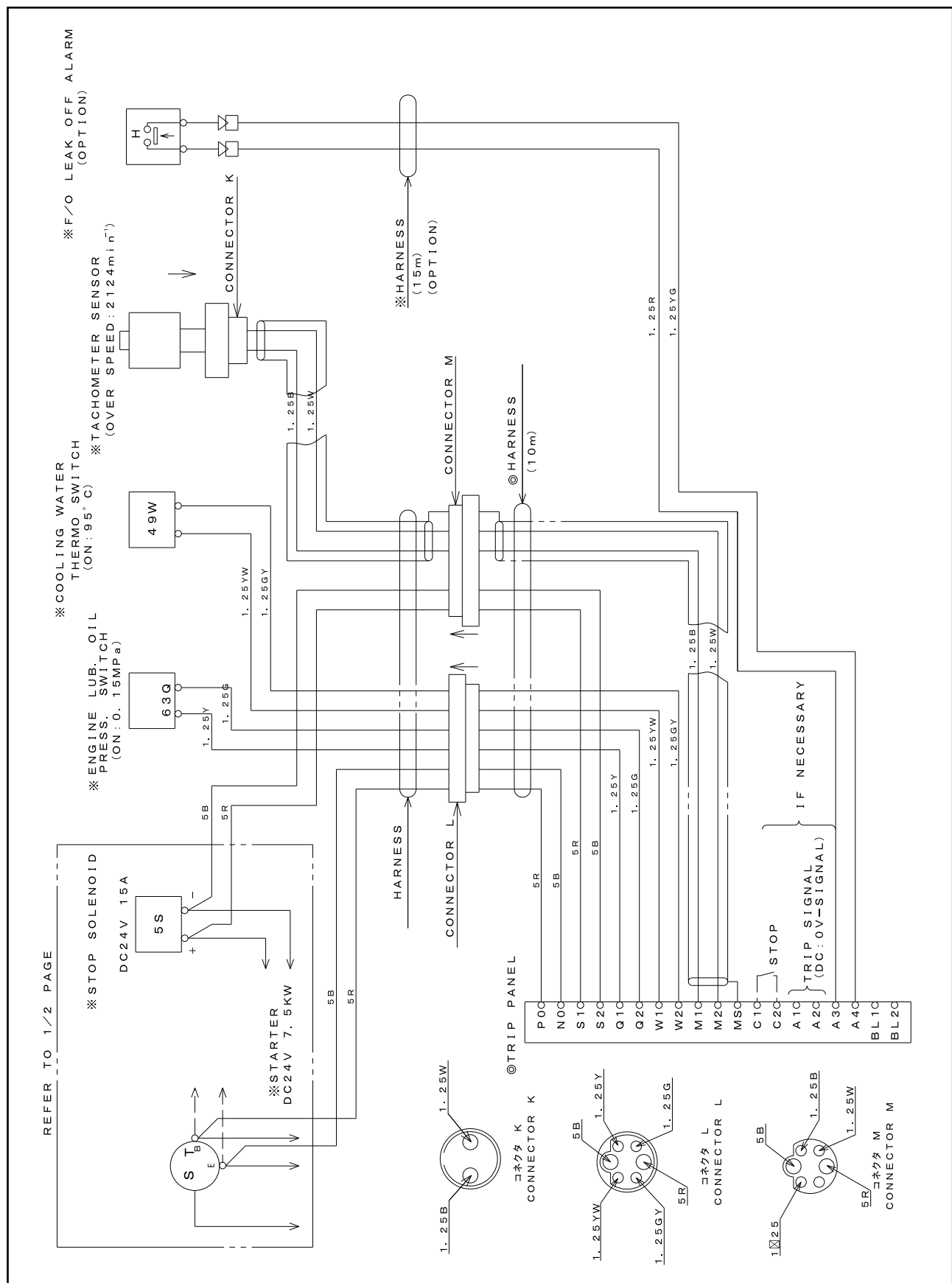


Fig. 13-1 Electric Wiring Diagram 1/2



Revision	Revision date	Revised content
-	March 2011	First edition issued.
-	June 2018	Changed the document number, cover Pub. No. 99410-38100 (issued in October 2014) and issued it as a new publication.
1	July 2020	Added precautionary text of "Limitation of Continuous Under Light Load Operation".
2	November 2020	• Add "QRcode" in Cover page. • Changed the recommended limit/Service limit value of Fine foreign substances (foreign substances at fuel inlet) in the Fuel Properties Table to "10mg/L or less".
3	March 2024	Important Information • Added a precaution regarding labels. Chapter 5 • Revised the recommended engine oil. • Updated the table of engine oil quality standards.

Mitsubishi Marine Engine S6R-T2MPTK OPERATION & MAINTENANCE MANUAL

Issued in March 2024

Pub. No. 292T1-40720 Revision: 3

Issued by Mitsubishi Heavy Industries Engine & Turbocharger, Ltd.
3000, Tana, Chuo-ku, Sagamihara, Kanagawa, 252-5293, Japan

Edited by MHI Sagami High-tech LTD.

Printed and bound by Fuji Film Service Link Co., Ltd.

-
- The manual with incorrect collating or missing pages is to be replaced.
 - Without written approval from the publisher, for all or some part of this manual, unauthorized reproduction, copy, reprinting in any way or method are prohibited.



March 2024

OPERATION & MAINTENANCE MANUAL S6R-T2MPTK for Mitsubishi Heavy Industries Engine System Asia Pte. Ltd.

Pub. No. 292T1-40720