MITSUBISHI
DIESEL ENGINE

S12R

OPERATION & MAINTENANCE MANUAL

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CAUTION

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

MITSUBISHI HEAVY INDUSTRIES (SHANGHAI) CO., LTD.

- Company names or product names described this Operation & Maintenance Manual are generally trademarks or registered trademarks of each company.

FOREWORD

This Operation & Maintenance Manual describes information and basic points required to use the Mitsubishi Diesel Engine (hereinafter called the "engine") correctly and effectively.

Please read this manual before using the engine.

In addition, operation, inspection and maintenance of the engine must be limited to the persons who understand the contents of this manual sufficiently.

IMPORTANT INFORMATION

Intended Purpose and Use

This engine is a general purpose engine, which is suitable for the following purposes in an industrial power generator:

Continuous use engine:

It can be used as the main engine of a power generator, whose base load is kept constant by, for an example, combination with commercial power supply.
Or, it can be used in a power generator which is used in place of commercial power supply and the load generally fluctuates throughout a day.

Emergency use engine:

It can be used for an emergency power generator which supplies electricity in case of power failure of the main or commercial power supply.
However, its operation is regulated in terms of the annual operating time.
Please check the rating definitions "Rating Definition" (→ Page 114).

Do not use this engine for other purposes and applications other than those above-mentioned.

General

- This engine must be operated, inspected and maintained only by qualified persons who have thorough knowledge of engines and their dangers, and also have received risk avoidance training.
- Be sure to read and understand this manual before operating, inspecting, and maintaining the engine. Working with insufficient understanding could cause personal injury or damage to the devices due to unexpected operation of them.
- Inadequate operation or maintenance will cause unexpected damage to the device due to accumulated engine damage if not cause immediate failure.
  Carefully perform engine operation and maintenance.
- Be sure to obey the applicable laws and regulations of the national government and other local municipalities.
- When disposing this engine, follow the method defined by the national government or other local municipalities.
- When discarding fuel, engine oil, or coolant, follow the method defined by the national government or other local municipalities.
- The devices covered by the recycle law and those for which recycling requirements are stipulated shall be disposed in accordance with the corresponding laws and regulations.
- Install an hour meter on the engine so that you can find the exact engine operating time, thereby performing the specified maintenance at the appropriate time in accordance the Scheduled Maintenance as described herein.

Important Tips for Safety of Work

- To avoid a potential risk, you must thoroughly understand the functions of this engine.
- All involved personnel should actively participate, recognize their roles, and organize themselves and their work to ensure a safe environment.
- To prevent injury, fatal accident or damage to this engine, you must obey the cautions, compliance rules and normal directions of use described in this manual while giving the highest priority to safety. If you do not obey them,
  - (a) it could result in death in the worst case.
  - (b) it could threaten your health.
  - (c) it may cause damage to this engine or the devices.
- 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, inspecting, and maintaining the engine.
- The design incorporated measures evaluated by the risk analysis and the risks which cannot be eliminated by the protection devices are described as warnings in this manual.
- Descriptions about devices and facilities outside the scope of our supply are included in this manual.
  For the devices and facilities outside the scope of our supply, refer to the corresponding manual of the generator and the supplier's operation manual and obey the descriptions.
- Electrical instruments must be inspected or maintained by a person who has received education and training for handling and avoiding risks about the electrical instruments on the machine, in addition to general knowledge needed for electric construction work.

To the User Company

The user company must obey the following points and ensure safety management thoroughly.

General

- When modifying this engine, changing the specifications, and disassembling it, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8). If the customer modifies the engine or changes the specifications, it could become impossible to ensure safety.
- Mitsubishi Heavy Industries (Shanghai) Co., Ltd. (MHISH) 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.
- For the devices and facilities outside the scope of our supply, provide the corresponding manuals as "Usage Information" to the operators and let them obey the descriptions. MHISH will not bear a responsibility for damage or injury caused by the devices and facilities outside the scope of our supply.
- In some countries or regions, this engine cannot be used depending on the laws, regulations and installation environment. When transferring this engine to a third party, check the regional conditions of them and contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).

Important Tips for Managing Safety of Work

- You must prepare a "Safety Manual", which describes your management criteria and operation rules. The supervisor must have the operators understand the "Safety Manual" preliminarily.
  In addition, keep the manual at hand so the operator can read it whenever necessary.
- In order to prevent a disaster, the accident prevention measures must be suitable for the functions and specifications of this engine.
- The accident prevention activities must be as the occupational safety and health management system planned and performed organizationally and continuously. This occupational safety and health management system must include the following points:
  (a) Proper location of this engine
  (b) Instructions concerning maintenance and usage of the operators' personal protective equipment
  (c) Organization of the operation management system such as preparation of operation standards, clarification of the operation command system, etc.
  (d) Education and training of the operators
- Important purposes of the safety measures are to prevent personal injuries, protect the environment, and protect the engine.
  Always consider environmental protection.
- Mitsubishi Heavy Industries (Shanghai) Co., Ltd. (MHISH) shall accept no responsibility for loss or injury resulting from not observing instructions in this manual, or not paying attention to commonly required precautions when operating, inspecting or maintaining this engine.

About This Manual

- This manual is intended for native speakers of the language in which the manual is written. If the operator of this engine is not a native speaker of the language used in this manual, the owner of the engine is requested to provide thorough safety guidance to the operator. Also prepare and affix warning labels written in the native language of the operators.
- MHISH possesses the copyright of this manual. All rights reserved. No part of this manual, including illustrations and technical descriptions, may be photocopied, translated, or reproduced, in whole or in part, in any electronic medium or machine readable form without prior written consent from MHISH.
- Illustrations in this manual may differ from the engine you have purchased. Covers can be omitted from illustrations to provide a better view of the inside.
- The contents of this manual are subject to change without any notice.
- When transferring this engine to a third party, make sure to attach this manual.
- Keep this manual in the usual place so that it can be used any time.
- If you need more information or if you have any questions, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).

WARRANTY PROVISIONS

1. Mitsubishi Heavy Industries (Shanghai) Co., Ltd. (hereinafter referred to as MHISH) shall make a repair or replacement of a failure or damage at no charge, only when the said failure or damage occurs during the warranty period (refer to the individual contract) of this engine, and MHISH admits that its cause arises from the material, a problem of production, or a problem concerning our construction work within the scope of the contract specifications. The above-mentioned warranty period of this engine is not updated or prolonged by the said repair.

2. The above-mentioned warranty is the only one provided by MHISH concerning this engine.
   No new contracts or warranties arise from this manual.
   MHISH will not bear a responsibility for any loss (including, but not limited to direct loss, indirect loss, lost profits, operating losses, down time loss, etc.) caused by any reason, regardless of whether the warranty period is expired or not.

3. The warranty coverage is effective for the original purchaser only. Those to whom ownership is later transferred are not provided with the warranty.

4. We may deny the warranty coverage regardless of the warranty period if fault or damage has been caused to the engine by any reason mentioned below:
   - Fault or damage caused by operation or maintenance deviated from the instructions or cautions described in this manual
   - Fault or damage caused by being repaired or modified by other than us/Mitsubishi dealer, or by illegal act
   - Fault or damage caused by abuse, misuse, incorrect operation or misapplication
   - Fault or damage caused by operation or maintenance beyond the specification limit
   - Fault or damage caused by use of spare parts, optional parts or consumables (including engine oil, LLC and fuel) that MHISH do not recommend
   - Operation with BDF which blending rate exceeds the required specification in Chapter 4 FUEL. (The warranty for any material or workmanship failure is subject to the deliberation of Mitsubishi Heavy Industries (Shanghai) Co., Ltd.)
   - Fault or damage caused by a natural disaster (earthquake, typhoon, flood, seismic sea waves, volcanic eruption, etc.) fire, war, terrorism, or other abnormal operational conditions which MHISH cannot bear responsibility
   - Fault or damage caused by the location of this engine (for example, electromagnetic environment stress)
   - Fault or damage caused by resale or relocation
   - Fault or damage caused by consumption or age deterioration
   - Fault or damage caused by other reasons which MHISH cannot bear responsibility

CONTACT LIST

■ Europe

Netherland	Mitsubishi Turbocharger and Engine Europe B.V. (MTEE)	Damsluisweg 2, 1332 EC, Almere the Netherlands TEL 31-36-5388-311 FAX 31-36-5388-200

■ North America

USA	Mitsubishi Turbocharger and Engine America, Inc. (MTEA)	Two Pierce Place, 11th Floor, Itasca, IL 60143 U.S.A. TEL 1-630-268-0750 FAX 1-630-268-9293

■ South America

Brasil	MHI Sul Americana Distribuidora de Motores Ltda. (MSA)	Avenida Paulista, 1274-8°. Conj. 23, Sala C, Cep 01310-100, São Paulo, SP, Brasil TEL 55-11-3515-7890 FAX 55-11-3515-7899

■ Asia

Singapore	Mitsubishi Heavy Industries Engine System Asia Pte. Ltd. (MHIES-A)	No.3, Tuas Avenue 12, Singapore 639024 Republic of Singapore TEL 65-6862-2202 FAX 65-6862-5728
Vietnam	MHI Engine System Vietnam Co., Ltd. (MHIES-V)	39 Dai Lo Huu Nghi, Vietnam-Singapore Industrial Park, Thuan An, District, Binh Duong Province Socialist Republic of Vietnam TEL 84-650-3769251 FAX 84-650-3769262
Philippines	MHI Engine System Philippines, Inc. (MHIES-P)	Warehouse 4C. Sunblest Compound, KM23 West Service Road, Barangay Cupang, Muntinlupa City, Metro Manila Philippines TEL 63-2-775-0209 FAX 63-2-775-0310
Indonesia	PT. MHI Engine System Indonesia (MHIES-I)	#302 Bld. Cilandak Commercial Estate P.O. Box 7510 CCE, Cilandak, Jakarta, Indonesia TEL 62-21-7890-191 FAX 62-21-7890-279
UAE	MHI Engine System Middle East FZE (MHIES-ME)	Q4-44, Sharjah Airport International Free Zone (SAIF ZONE) P.O. Box 121801, Sharjah, UAE TEL 971-6-548-9295 FAX 971-6-548-9294

■ China

China	Mitsubishi Heavy Industries (Shanghai) Co., Ltd. (MHISH)	26th Floor, HSBC Tower, 1000 Lujiazui Ring Road, Pudong New Area, Shanghai, 200120, China. TEL 86-21-6841-3030 FAX 86-21-6841-5222

MODEL NAME

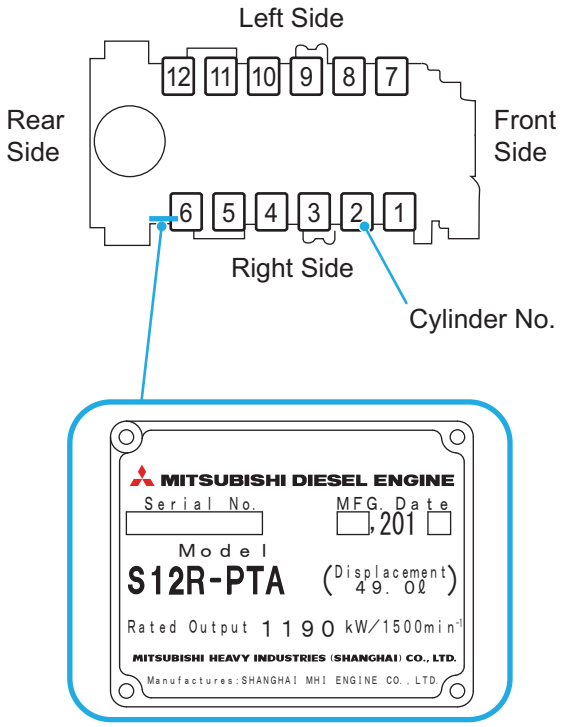
In this manual, different models of the same series are described. Please check the model name and other details with the nameplate on this engine, and fill in "SPECIFICATIONS - CHECK" (→ Page 10).

■ Location of Nameplate

The name plate is located on the lateral side of the engine, and indicates the following information:

- Serial number
- Manufactured date
- Model name
- Rated output
- Rated speed

<Engine top view>



*Adove illustration shows S12R-PTA nameplate.

Fig. 1 Location of Nameplate

SPECIFICATIONS - CHECK

Main Specifications

Table 1 Main Specifications

Engine model	S12R
Type	Water-cooled, 4-cycle stroke, turbocharged, with air cooler
No. of cylinders - Arrangement	12-V
Cylinder bore x stroke	170 × 180 mm [6.69 × 7.09 in.]
Total displacement	49.03 L [2992.45 cu in.]
Combustion system	Direct injection system
Compression ratio	13.5 : 1, 14.0 : 1, 14.5 : 1, 15.5 : 1
Firing order	1 - 12 - 5 - 8 - 3 - 10 - 6 - 7 - 2 - 11 - 4 - 9
Direction of rotation	Counterclockwise as viewed from flywheel side
Damper	Double damper, damper with spacer
Fuel injection pump	Mitsubishi PS6 type
Fuel injection nozzle	Hole type
Fuel injection starting pressure	34.3 MPa {349.76 kgf/cm^2} [4974.80 psi]
Fuel filter	Paper element type
Lubricating method	Forced lubrication (pressure feed by oil pump)
Oil filter	Paper element type
Oil cooler	Water-cooled, multi-plate type
Cooling method	Forced water cooling

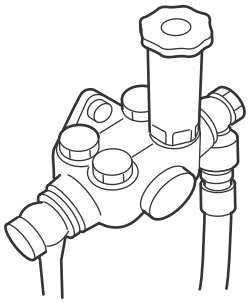
Detailed Specifications

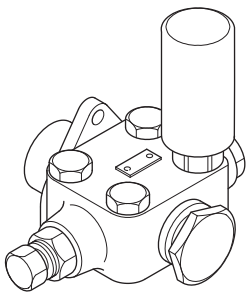
The detailed specifications varies depending on your devices. Refer to the specification sheet prepared by the generator supplier, and fill in below.

- Mark ✓ into ☐ of the corresponding item.
- If there is not an item to be selected, enter into ☐ or a blank directly.

Specifications of Engine Body

- **Model name** ☐
- **Serial number** ☐
- **Manufacturing date** ☐
- **Dimensions (L x W x H)** ☐☐☐☐ mm x ☐☐☐☐ mm x ☐☐☐☐ mm
- **Dry weight** ☐☐☐☐ kg
- **Purpose and intended use** ☐ Continuous use engine ☐ Emergency use engine
- **Rated output** ☐☐☐☐ kW
- **Rated speed** ☐☐☐☐ min^{-1}
- **Generator frequency** ☐☐☐☐ Hz
- **Installation situation** ☐ Stationary ☐ Cubicle (bonnet type)
- **Starting system** ☐ Self Starter Motor Starting ☐ Air Direct Admission Starting ☐ Air Motor Starting
- **Fuel** ☐ Diesel fuel
- **Priming pump type** ☐ Type A (with locking mechanism) ☐ Type B (without locking mechanism)





- **Governor** ☐ Mechanical/hydraulic type ☐ Electric type
- **Oil pan** ☐ Standard type ☐ Large type
- **Engine oil capacity** ☐☐☐ L (Oil pan capacity) ☐☐☐ L (Engine total)
- **Engine oil grade** ☐ Grade
- **Coolant capacity** ☐☐☐☐ L

Additional Equipment of Generator

- **Fuel system**
  - ☐ Fuel day tank
  - ☐ Water separator
- **Lubrication system**
  - ☐ Oil tank
  - ☐ Oil Level Regulator
  - ☐ Priming pump
  - ☐ Mist separator
- **Cooling system**
  - ☐ Expansion tank
  - ☐ Radiator
  - ☐ Reserve tank
  - ☐ Heat exchanger
  - ☐ Water heater
- **Air Intake System**
  - ☐ Air cleaner
  - ☐ Silencer. pre-cleaner
  - ☐ Air heater
- **Exhaust system**
  - ☐ Flue piping, external smoke equipment
  - ☐ Muffler, silencer
- **Air starter system**
  - ☐ Air tank
  - ☐ Air compressor
  - ☐ Air filter
  - ☐ Air motor
- **Electrical system**
  - ☐ Control panel, operation panel, instrument panel
  - ☐ Battery, Battery switch
- **Protection devices**
  - ☐ Oil pressure switch
  - ☐ Oil filter alarm switch
  - ☐ Thermo switch
  - ☐ Rotation detection pickup

Protection Devices Added During Manufacturing the Generator

Please compile the information about the protection devices added during manufacturing the generator and attach it on this page.

DEFINITION OF INTENDED PERSONS

We have defined and classified the persons related to this engine for the safety as follows:

■ "User company or supervisor":

Means a person, who maintains and manages this engine, conducts safety management for operators, prevents emergency situation (fire, etc.), and takes actions in the event of emergency to minimize damage.
The user company or supervisor prepares the "Safety Manual", and then performs periodic safety guidance to the operators and management of the safety tools and jigs accordingly.

■ "Operator":

Means a person, who has sufficient knowledge about this engine, and the technique of operation, inspection and maintenance.
The operator is allowed to perform a simple troubleshooting of this engine and scheduled maintenance in addition to operation works. The operator is allowed to bring this engine to an emergency stop, when he/she has found critical situation.
Before working, the operator must read the "Safety Manual" and this manual thoroughly to understand the special features of this engine and all the details of works sufficiently.

■ "Customers":

Means the user company, supervisor and operator mentioned above.

■ "Service personnel or Mitsubishi dealer":

Means a person who is certified by our service personnel or us, and who gives guidance and performs the commissioning test as a site manager of installation, a test run and others of this engine, and after installation and commissioning test, also gives operating guidance to the customers, operating instructions, maintenance, overhaul and other works.

■ "Installation contractor or generator supplier":

Means a person to whom this engine is supplied by MHISH, and who manufactures and sells the generator.

This manual is intended for use by the user company, supervisor and operator.
For other service documents, refer to "STRUCTURE OF SERVICE DOCUMENTS" (→ Page 15).

STRUCTURE OF SERVICE DOCUMENTS

The service documents concerning this engine is structured as follows.

Please use the required service documents in accordance with your situation.

To acquire the service documents, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).

Please use this engine referring to the completion book of the generator in addition to them.

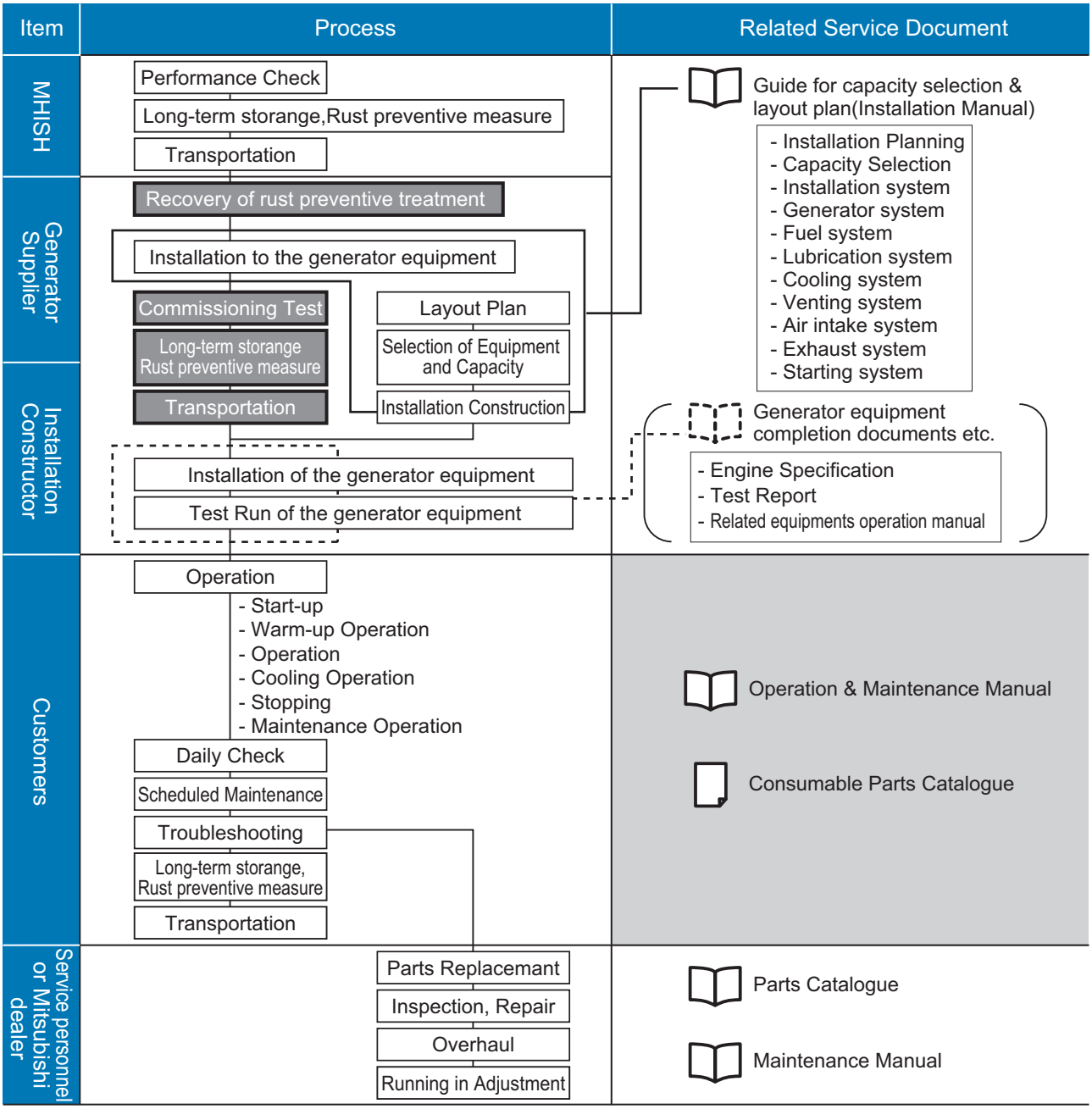


Fig. 1 Structure of Service Documents

STRUCTURE OF THIS MANUAL

This manual is constructed as follows:

LIST OF MODELS

The following models are covered in this manual.

Check the model name.

For the “models conforming to the exhaust gas standards”, see corresponding items.

Table 1 List of Models

Model name		intended use	Supercharging method	Cooling method
S12R	PTA	Generaor	Turbocharging	Aftercooler
	PTA2	Generaor	Turbocharging	Aftercooler
	PTAA2	Generaor	Turbocharging	Air-to air intercooler

UNIT OF MEASUREMENT

In this manual, the SI System (International Unit System) is basically used for the units of measurement. The conversion rates between the SI system and other conventional systems are given below.

[Pressure] 1 MPa = 10.197 kgf/cm^2

[Torque] 1 N ·m = 0.10197 kgf ·m

[Force] 1 N = 0.10197kgf

[Horsepower] 1 kW = 1.341 HP = 1.3596 PS

[Pressure (meter of mercury)] 1 kPa = 0.75 cmHg

[Pressure (meter of water)] 1 kPa = 10.197 cmH_2O (cmAq)

[Rotating speed] 1 min^{-1}= 1 rpm

[Kinetic viscosity] 1 mm^2/s = 1 cSt

ABBREVIATIONS AND STANDARDS

- API = American Petroleum Institute
- ASTM = American Society for Testing and Materials
- ISO = International Organization for Standardization
- JIS = Japanese Industrial Standards
- LLC = Long Life Coolant
- MHI = Mitsubishi Heavy Industries, Ltd.
- MHISH = Mitsubishi Heavy Industries (Shanghai) Co., Ltd.
- OSHA = Occupational Safety and Health Administration
- SAE = Society of Automotive Engineers
- SDS = Safety Data Sheet

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1 SAFETY

This chapter describes the required safety instructions for handling the engine.

General Information

The safety instructions given here provide operators with guidelines for preventing personal injury.

In order to operate this engine according to your own Occupational Safety and health Management System, not only the information for safety, operation, inspection and maintenance work described in this manual but also use them in combination with the regular safety education and training.

Warnings

In order to call the attention to the operator's risks, the following two options are reserved in this engine.

- Warning descriptions in this Operation & Maintenance Manual
- Warning labels on the engine and the devices

Read carefully all the safety-related warnings described in this Operation & Maintenance Manual. Before operating the engine, make sure of the locations and contents of all the warning labels affixed to the engine and the devices.

In order to ensure safety and prevent damage to the machine, the categories (DANGER, WARNING, CAUTION, and Note) explained in "Types and Meanings of Warning Terms" (→ Page 26) and their text are described in this Operation & Maintenance Manual.

Understand and obey the details of warnings for each operation.

In addition to "Matters to be Obeyed and Matters Prohibited" (→ Page 29), these warnings present important information for each operation.

Types and Meanings of Warning Terms

■ Marking description

"Warning labels" and "warning texts" in this Operation & Maintenance Manual warn you of the dangerous situations expected during operation in addition to the "warning terms" indicated with the categories mentioned below.

Disregarding the content of the warnings could result in an accident according to the "warning terms" accompanying the text. In extreme case, it could lead to a fatal accident or damage to important parts of the machine and additional equipment.

Table 1-1 Types and meanings of warning terms

Types of warning terms	Meanings
⚠ DANGER	Indicates an immediately hazardous situation which, if not avoided, will result in death or serious injury, serious fault or environmental destruction.
⚠ WARNING	Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury, serious fault or environmental destruction.
⚠ CAUTION	Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.
Note	Indicates particularly a caution or information to be emphasized.

■ Meanings of symbols

Cautions and markings for danger are indicated by 3 types of symbols as mentioned below:

Table 1-2 Meanings of symbols

Mark	Meanings
 (Prohibition)	Indicates prohibition of a dangerous action.
 (General Instruction)	Indicates an operating instruction. In order to avoid a danger, it is necessary to take this action
 (General Caution)	Indicates warning for a dangerous place and action, as well as a possibility that danger may occur due to negligence of safety duties or carelessness.

Warning Labels

⚠ WARNING

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

* Unreadable warning labels cannot be noticed and they may cause to personal injury, environmental pollution, and damage to engine.
* For cleaning the warning labels, use a cloth, water and soap. Do not use cleaning solvents, gasoline or other chemicals to prevent damage to the print or peeling off of the label.
* If any engine part on which a warning label is attached is replaced with a new one, purchase a new identical warning label from your Mitsubishi dealer and attach it to the new part.

■ Precautions concerning handling

(a) Keep in mind to understand the meanings of the warning labels throughly to conduct work on the engine more safely without causing any faults.

(b) Never operate the engine until you understand the meanings of the warning labels throughly.

(c) Always obey the detailed descriptions of the warning labels and the warning texts described in this Operation & Maintenance Manual to work on accordingly.

(d) Do not tear or damage warning labels, nor wipe them with solvent.

(e) Do not paint the warning labels when repainting the engine.

(f) In case a warning label affixed to the engine becomes unreadable, damaged or peeled off, purchase a new label from your Mitsubishi dealer "CONTACT LIST" (→ Page 8) and replace it.

(g) After replacing an old part bearing a warning label with a new part, affix a new warning label in the same way as before.

■ Warning Labels and Their Locations (Examples)

Examples of locations of the warning labels are indicated on the next page.
Before using the engine, check the locations of the warning labels, since they differ according to the specifications of the devices and the construction work carried out by the generator suppliers.

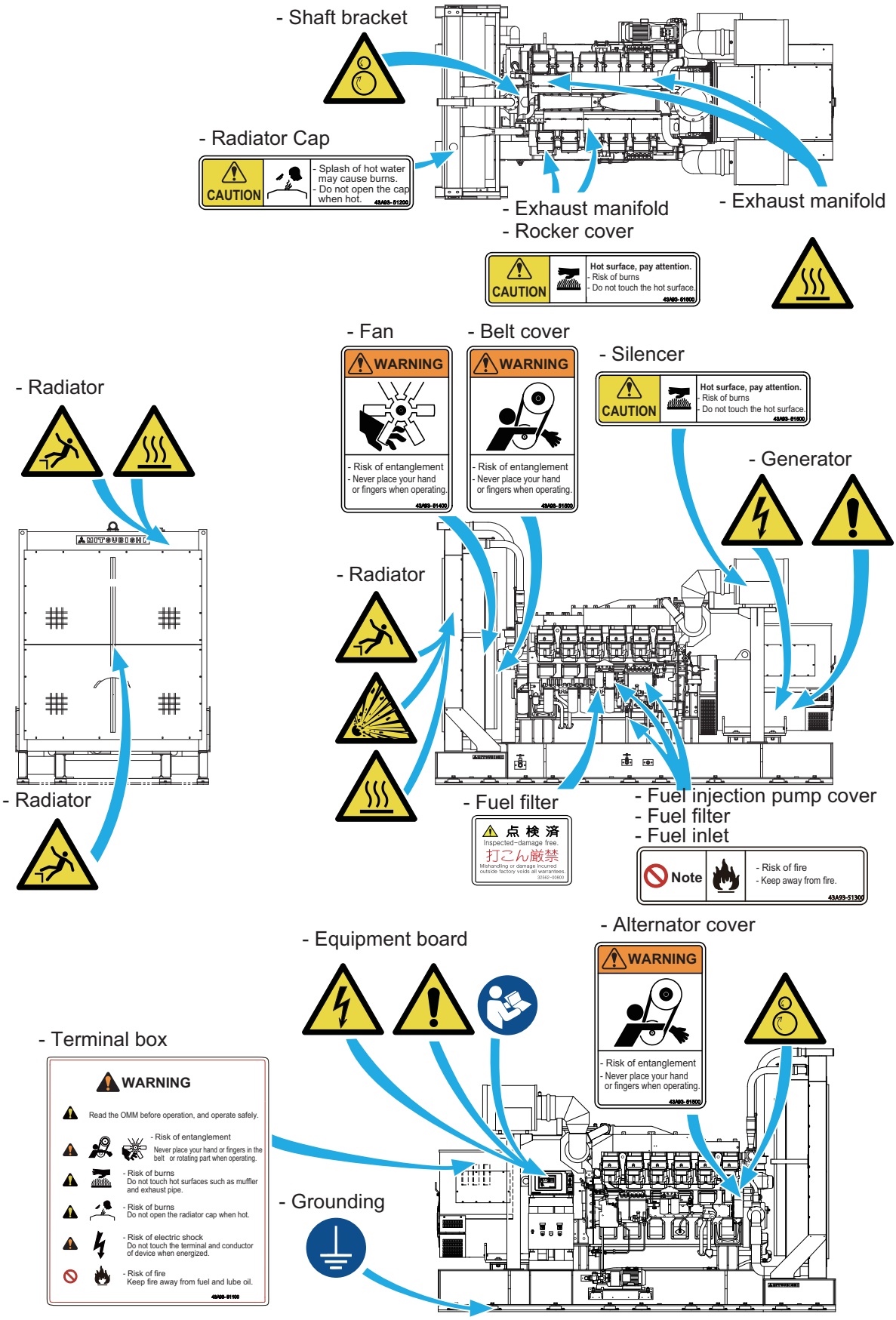


Fig. 1-1 Warning Labels and Their Locations (Examples)

Matters to be Obeyed and Matters Prohibited

The matters to be obeyed and matters prohibited as described herein are intended to be guidelines for preventing personal injuries, accidents causing property damages, and environmental pollution.
If these matters to be obeyed and matters prohibited are not obeyed, a serious injury to the operator, damage to the engine or environmental pollution could occur. Before handling the engine, be sure to understand the described details.

Safety Cautions

⚠CAUTION

Do not operate the engine if you are not feeling well.

* Operating the engine with reduced attentiveness could cause improper operation that could result in accidents or damage to the devices.

Be sure to obey the safety rules established at the workplace when operating, inspecting or maintaining the engine.

* Operating the engine with reduced attentiveness could cause improper operation that could result in accidents or damage to the devices.

Preparation for Emergencies

⚠WARNING

Prepare fire-fighting equipments and fire extinguishers. If you are obliged to prepare fire extinguishers by various laws and regulations, be sure to place them.

* In case of a fire, delay in fire suppression will result in expansion of damage.
* To extinguish engine fire, it is recommended to use an ABC dry-powder fire extinguisher which has the effect of suppressing of both of oil and electrical fires.

To extinguish the oil fire or an electrical fire, use an extinguisher suitable for the type of fire.

* If you try to use water to extinguish the oil fire, the fire will get worse.
* To extinguish engine fire, it is recommended to use an ABC dry-powder fire extinguisher which has the effect of suppressing of both of oil and electrical fires.

Prepare first-aid kits and first aid tools.

* Otherwise, in case of personal injury, first aid treatment can be delayed, which may cause death in the worst case.

Prepare an emergency action plan in the event of emergency (fire, accidents, etc.) including emergency contact points and means of communication.

* Delay in action will result in expansion of damage.

Precautions for Covers

⚠ WARNING

Do not attempt to open the side cover of the crankcase before the engine surface cools down to room temperature.

* Opening the cover when the engine is hot allows fresh air to flow into the crankcase, which could cause oil mist to ignite and explode.

Do not remove the heat shields (laggings) from the intake and exhaust systems.

* If you touch it, you could get burned by heat.
* If any of these heat shields (laggings) have been removed to perform inspection and maintenance, be sure to install them after the work is completed.

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

* Otherwise, belts and devices could fly apart and result in a serious personal injury.

Before starting the engine, make sure the protective covers of the engine are correctly installed.

* If you are caught in rotating parts, you could be seriously injured.

Precautions for Fire Sources

⚠ WARNING

Do not use flames near the engine.

* They could cause a fire.

When working with flammable substances such as fuel, engine oil, coolant (LLC), grease, rust preventive oil, anti-corrosive agent, etc., use explosion-proof lighting equipment without fire.

* Otherwise, they could catch fire and cause an explosion.

Precautions Regarding the Environment

⚠ WARNING

Do not operate the engine in a poorly ventilated place.

* Otherwise, it could cause carbon monoxide intoxication and lead to death at the worst.

Clean the engine and the surrounding area to remove dust, dirt and other foreign substances.

* Otherwise, foreign objects could be caught in the engine, which could cause a fire or failure.

Precautions for Personal Protective Equipment

⚠ WARNING

When draining oil or replacing oil filters, be sure to wear working gloves.

* Hot engine oil and parts could cause burns.

When working by using compressed air, wear protective glasses.

* Not wearing or not properly wearing personal protective equipment may result in serious personal injury.

Wear suitable personal protective equipment according to the workplace or the kind of work.

- **When operating, inspecting or maintaining the engine, wear a hard hat, a face shield, safety shoes, a dust mask, gloves, ear plugs and other personal protective equipment as needed.**

* Not wearing or not properly wearing personal protective equipment may result in serious personal injury.

⚠ CAUTION

Always wear ear plugs when entering the machine room (engine room).

* Otherwise, noise could cause a hearing loss.

Precautions for Protection Devices

⚠ WARNING

Do not remove any circuits of the protection device.

* Otherwise, the protection device could not work in the event of an abnormality, which could cause personal injury or damage to the devices.

If a protection device activates, inspect the cause of the abnormality.

* If the cause cannot be determined, contact your Mitsubishi dealer.

Precautions for Battery

⚠ WARNING

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

* Otherwise, degradation of the inner metal parts or lowering of the battery fluid level will be accelerated, which could cause an explosion or a fire.
* Replace the battery with a new one.

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

* A short circuit may cause explosion, fire, electric shock or fusing of the terminals.

When working with the battery, obey the manufacturer's operation manual or SDS.

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

Remove water or debris on the top of the battery.

* Otherwise, a short circuit may occur, which could cause a fire.

When disconnecting battery terminals, always remove the negative (-) terminal first. When connecting the battery, always connect the positive (+) terminal first.

* Otherwise, a short circuit may occur, which could cause an electric shock or fusing of the terminals.

Charge the battery in a well-ventilated area.

* Charging the battery in a poor ventilated area could let hydrogen gas accumulate, which could cause a fire.

Precautions for Warning Labels

⚠ WARNING

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

* Unreadable warning labels cannot be noticed and they may cause to personal injury, environmental pollution, and damage to engine.
* For cleaning the warning labels, use a cloth, water and soap. Do not use cleaning solvents, gasoline or other chemicals to prevent damage to the print or peeling off of the label.
* If any engine part on which a warning label is attached is replaced with a new one, purchase a new identical warning label from your Mitsubishi dealer and attach it to the new part.

Other Precautions

⚠ WARNING

Never cut the seal of the fuel control link.

* If you cut the seal, damage to the engine or deterioration in the exhaust gas properties could occur.
* In case that the seal is cut, warranty will become invalid.

Never peel off the label at the fuel inlet or other labels that are not allowed to remove.

* Doing so may be against the law or regulations.

Precautions for Auxiliary Facilities of the Generator

■ Water heater

⚠ WARNING

Do not touch the water heater even after stopping of the engine.

* Even after stopping, water heater is at high temperature and touching it may cause burns.

For the generator with a water heater, connect the wiring of the water heater correctly.

* Otherwise, flue explosion may occur, which could cause serious personal injury or damage to the devices.

For the generator with a water heater, always set the water heater switch to "ON".

* If you start up the engine when the water heater switch is "OFF", incomplete combustion may occur, which could result in flue explosion or deterioration in the exhaust gas properties.

OPERATION

■ Daily Check

<Operational Environment - Check>

⚠ WARNING

Do not operate in an environment below the lower limit of the ambient temperature specified in the specifications sheet.

* Otherwise, flue explosion may occur, which could cause serious personal injury or damage to the devices.
* When operating in an environment below the lower limit of the ambient temperature, it is necessary to install an additional water heater.

Do not operate in an environment above the upper limit of the ambient temperature specified in the specifications sheet.

* A violation of the law related to the devices could result.
* Damage to the engine due to overheat or worsen exhaust values will result.
* When operating in an environment above the upper limit of the ambient temperature, it is necessary to reexamine the operating conditions and operating time.

Keep away from fire, when working with flammable substances such as fuel, engine oil, coolant (LLC), grease, rust preventive oil and anti-corrosive agent.

* They could cause a fire.

Do not place flammable substances such as fuel and engine oil around the engine.

* They could cause a fire.

Make sure that there is no water (especially, seawater or rain water) seeped in the air intake and exhaust ports.

* Piston scuffing (contact of the piston with the cylinder inner wall) and damage to the devices could result.

Make sure that no foreign particles get into the air inlet.

* They could cause damage to the turbocharger and lead to serious problems in the engine.

⚠ WARNING

Make sure that there is no contamination of water into the fuel, engine oil, air inlet and exhaust systems and combustion chambers.

* Flue explosion, deterioration in the exhaust gas properties or damage to the devices could result.

Make sure that there is no clogging in the air cleaner or pre-cleaner.

* Otherwise, the engine stopping device will work to stop the engine suddenly and cause deterioration in the exhaust gas properties.

Make sure that there is no clogging in the air cleaner element or pre-cleaner element.

* The thermal load could increase excessively and will cause piston scuffing.

Before maintaining electrical components, place the battery switch to the OFF position or disconnect the battery negative (-) terminal.

* Electric shock could result when electricity flows through the circuit.

Be sure to operate the engine in an environment of appropriate humidity.

* High humidity, inrush of rain water, or water condensation in the combustion chamber may cause falling off of valves or water hammering and lead to damage to the devices.

⚠ CAUTION

Before starting the engine, check that there are no bolts, nuts, tools, etc. around the rotating parts.

* When the rotating parts work, the above objects can fly and cause personal injury or damage to the surrounding.
* Entanglement in rotating parts could cause machine damage.

Check that the terminals and connectors of the electrical system are connected correctly.

* Otherwise, starting failure or overrun due to inability to stop the engine could occur.

<Engine Exterior - Check>

⚠ WARNING

Make sure that any accumulation of flammables, fuel leaks, engine oil leaks, moisture, etc. are not found around the hot parts of the engine (exhaust manifold) and the battery.

* They could cause a fire.

Make sure that a coolant leak from any part of the engine is not found.

* Coolant will flow out.

Make sure that the open/close conditions of the valves, plugs and cocks on each line are normal.

* Otherwise, the engine may seize.

Make sure that the open/close condition of the coolant drain cock on the water pump is normal.

* Otherwise, insufficient cooling could occur and it could cause serious damage to the devices.

Make sure that the engine oil leak from any part of the engine is not found.

* If engine oil gets in your eyes, it will cause pain and lead to sight loss at the worst.

⚠ CAUTION

Before stating the engine, check the battery and cable terminals for corrosion. In addition, check the connections for looseness.

* Defective contact or short circuit could cause damage to the devices.

■ Pre-operation Check

⚠ WARNING

Be sure to perform the pre-operation check and scheduled maintenance as instructed in this Operation & Maintenance Manual.

* Failure to perform the pre-operation check and scheduled maintenance may cause various engine problems and breakage to parts, which may result in serious accidents.

Before starting the engine, make sure the protective covers of the engine are correctly installed.

* If you are caught in rotating parts, you could be seriously injured.

<Fuel Tank Oil Level - Check>

⚠ WARNING

When discarding a waste cloth used to wipe off combustible material, put it into a lidded can and obey the Waste Management and Public Cleansing Act to handle it as a special industrial waste.

* It may cause a fire.
* It could lead to environmental pollution.
* If you violate rules, you may be subject to penalties.

Before handling fuel, remove static electricity.

* Otherwise, the fuel could be ignited.
* Ground the fuel tank.

⚠ CAUTION

Do not remove the strainer while filling the fuel tank.

* Otherwise, foreign particles could enter and cause damage to the fuel pump.

<Coolant Level - Check>

DANGER

Use the genuine LLC specified in this Operation & Maintenance Manual.

* Otherwise, the devices could be damaged.

Keep LLC to be the specified concentration.

* If LLC concentration is low, it could cause corrosion of the radiator or heat exchanger.
* If LLC concentration is high, it may cause damage to the devices or overheat due to the seized engine parts.

WARNING

Do not open the radiator cap or coolant tank cap while the engine is hot.

* Otherwise, you could get burns by steam or water splashing out.

Tighten the drain cock on the water pump properly.

* Insufficient tightening may cause a coolant leak.

When handling coolant (LLC), always wear suitable personal protective equipment such as rubber gloves and protective eyeglasses.

* If LLC comes into contact with your eyes, it will result in sight loss at the worst.
* If LLC comes into contact with your skin while the engine is hot, you could get burned by heat.

Maintain the coolant level properly.

* If the coolant level is low, overheat or cavitation in the engine could occur.

<Battery - Check>

WARNING

Do not short the battery terminals.

* Otherwise, sparks could occur and cause a fire or an explosion.

Do not touch battery terminal with a wet hand.

* There are possibilities to get an electric shock.

When checking and servicing the battery, wear suitable personal protective equipment such as protective eyeglasses, rubber gloves, working clothes with long sleeves and long trousers.

* If battery fluid comes into contact with your eyes or skin, it may result in sight loss or burns.

<Pre-cleaner - Check for Clogging>

WARNING

Make sure that the pre-cleaner is free from clogging.

* Insufficient intake air could result in loss of power, incomplete combustion, exhaust gas temperature rise, and overspeed of the turbocharger.

<Air Cleaner - Check for Clogging>

WARNING

Make sure that the air cleaner is free from clogging.

* Insufficient intake air could result in loss of power, incomplete combustion, exhaust gas temperature rise, and overspeed of the turbocharger.

<Damper Temperature - Check>

WARNING

Make sure that the damper temperature is within the permissible range (for continuous use: 90°C [194°F] or lower; for emergency use: 100°C [212°F] or lower).

* Degradation of silicone oil could result in a loss of damping and breakage of the crankshaft.

<Manual Turning Gear - Check>

DANGER

Before starting the engine, pull out the manual turning gear shaft.

* Starting the engine while the turning gear is engaged with the ring gear could result in serious personal injury or destruction of the engine.

WARNING

Make sure that the plate of the manual turning gear is securely engaged in the shaft groove.

* Otherwise, the devices could be damaged.

<Air Direct Admission Starting - Check>

Starting Air Tank - Check

⚠ WARNING

Be sure to drain water from the starting air tank.

* Otherwise, water could enter the cylinders when starting the engine.

<Air Motor Starting - Check>

Starting Air Tank - Check

⚠ WARNING

Make sure that the air pressure in the starting air tank satisfies the specification.

* If starting is attempted several times in a row, the air motor could get damaged.

⚠ CAUTION

Be sure to drain water from the starting air tank.

* Otherwise, water could enter the air motor when starting the engine.

■ Engine Start-up

⚠ WARNING

Do not apply load to the engine at startup.

* Otherwise, the devices could be damaged.

Do not use the starter continuously for 10 seconds or longer. In case that the engine does not start after three consecutive trials, contact your Mitsubishi dealer.

* Otherwise, flue explosion due to the accumulation of unburnt fuel or burn-damage to the starter may occur.

While a warning sign such as "DO NOT OPERATE" is hanged out on the starting system, do not start the engine.

* Otherwise, serious personal injury, environmental pollution or damage to the devices could occur.

Do not start the engine with water inside its combustion chamber.

* Otherwise, water hammering could cause damage to the engine inner parts and a serious accident.

Before starting the engine, make sure there is no one in the vicinity of the engine.

* Otherwise, he/she may be caught in the rotating parts and get seriously injured or suffer noise-induced hearing loss.

■ Warm-up Operation

⚠ WARNING

Stay away from rotating parts during operation.

* Otherwise you may get caught in the rotating parts and seriously injured.

Do not apply excessive load when the engine is cold.

* Otherwise, it could cause a failure.
* If the engine is driven at an idle speed in the low load range for a prolonged period of time, unburnt fuel may accumulate in the flue and explode.

When operating at low load (less than 30%), limit the operation to an hour or less.

* Prolonged warm-up operation causes carbon build-up in the cylinders that leads to incomplete combustion.
* After one hour operation at a low load, operate the engine at 50% or more of rated load for 30 minutes or longer to prevent the formation of carbon deposits.

While the engine is warming up, check the connections for leak (fuel, engine oil, coolant and exhaust gas). If an abnormality is found, stop the engine immediately.

* Otherwise, a fire or damage to the devices may occur.
* It could lead to carbon monoxide intoxication or environmental pollution.

■ Operation

⚠ WARNING

Stay away from rotating parts during operation.

* Otherwise you may get caught in the rotating parts and seriously injured.

Do not approach the engine side without care during operation.

* Serious injury may result due to unexpected device operation.

Do not touch any part of the engine (other than the manual stop lever) during or immediately after operation and immediately after stopping.

* If you touch, you could get burned by heat.
* Before starting the inspection and maintenance work, make sure that the engine is cooled down.

Do not turn off the battery switch during operation.

* Otherwise, the instruments will become inoperable, damage to the devices due to operation at low oil pressure may occur, the engine may be forcibly stopped by the solenoids, or the engine may become unable to stop.
* It may also cause degradation of the diodes and transistors in the alternator.

Never turn the key to the "START" position during operation.

* Otherwise, the starter could be damaged.

Do not remove the protective covers during operation.

* If you are caught in rotating parts, you could be seriously injured.

Do not perform the inspection and maintenance work during operation.

* Unexpected activation of the devices could cause serious personal injury or damage to the devices.

Do not clean the engine during operation.

* Otherwise, water or cleaning solution could enter the engine, and will cause piston scuffing and damage to the devices.

Do not operate the engine at no load or low load for a prolonged period of time.

* Otherwise, it could cause deterioration in the exhaust gas properties.

⚠ WARNING

Do not operate the engine at a load exceeding the specified value or for a prolonged period of time.

* Otherwise, the main bearing or connecting rod bearing could seize.
* The thermal load could increase excessively and will cause piston scuffing.
* Otherwise, the crankshaft stress could become too large, and the crankshaft could crack or break.

Do not approach near the breather or breather gas.

* The breather releases breather gas in the air. Contacting the breather gas may cause burns.

Ventilate the machine room (engine room) sufficiently.

* Otherwise, deterioration in the exhaust gas properties and damage to the devices could occur due to insufficient air intake.

When operating at low load (less than 30%), limit the operation to an hour or less.

* Prolonged warm-up operation causes carbon build-up in the cylinders that leads to incomplete combustion.
* After one hour operation at a low load, operate the engine at 50% or more of rated load for 30 minutes or longer to prevent the formation of carbon deposits.

<Checking During Operation>

⚠ WARNING

If an engine abnormality is observed during operation, stop the engine immediately.

* Sustained use of the engine without any remedy could cause serious personal injury or damage to the devices.
* Investigate the cause of abnormality, correct the defect, then restart the engine.
* If the cause of problem cannot be located, contact your Mitsubishi dealer.

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

* Overload could not only cause increase in fuel consumption but also lead to malfunction and environmental pollution (outbreak of the black smoke) due to carbon deposits.

⚠ WARNING

Check exhaust pipes and pipe joints for exhaust gas leaks.

* Otherwise, it may cause carbon monoxide intoxication and lead to death at the worst.
* If an exhaust leak is found, contact your Mitsubishi dealer.

If an abnormal engine oil pressure drop is observed, stop the engine immediately, and check the engine oil system to locate the cause.

* Sustained use of the engine without any remedy could cause seizure of the bearings and lead to serious damage to the devices.
* If the cause of problem cannot be located, contact your Mitsubishi dealer.

If a belt breaks, stop the engine immediately and replace the belt.

* Sustained use of the engine without any remedy could cause defective battery charge and cooling fault, and result in serious engine problems.

⚠ CAUTION

Keep the intake air temperature at the specified level.

* If the intake air temperature is higher than the specified level, the engine stopping device may work due to the increased exhaust temperature and stop the engine suddenly.
* The thermal load could increase excessively and will cause piston scuffing.
* If the intake air temperature cannot be kept at the specified level, reconsider the operating conditions and operating time.

Keep the engine oil and coolant temperatures at the specified level.

* If the engine oil or coolant temperatures is increased, the engine stopping device may work due to the increased exhaust temperature and stop the engine suddenly.

■ Cooling Operation

⚠ WARNING

Except in a time of emergency, operate the engine at low idle for 5 to 6 minutes to cool down before stopping the engine.

* If the engine is stopped without cooling down, the devices could be damaged.

⚠ CAUTION

Do not stop the engine suddenly at high speed.

* It could cause damage to the devices due to degradation of the damper or stopped circulation of the engine oil to the turbocharger.

■ Stopping

⚠ WARNING

Do not restart the engine immediately after an abnormal stop.

* Investigate the cause of abnormality, correct the defect, then restart the engine.

Do not race the engine immediately before shutting it down.

* Otherwise, the devices could be damaged.

FUEL

■ Fuel

⚠ WARNING

Do not refill the fuel tank more than the specified level.

* Otherwise, fuel will leak out and may cause a fire.

Do not mix and use fuels of different types and/or manufacturers.

* Otherwise, damage to the fuel supply pump or deterioration in the exhaust gas properties may occur.

Do not use fuel after the recommended storage expiration date.

* Otherwise, incomplete combustion may occur, which could result in flue explosion or deterioration in the exhaust gas properties.

Use only the fuel that meets our fuel quality standards specified in this Operation & Maintenance Manual.

* Otherwise, damage to the fuel supply pump or deterioration in the exhaust gas properties may occur.
* Using a fuel with low cetane number (lower than 45) may result in flue explosion.

Change the fuel remained in the tank or the pipelines over the period recommended by the manufacturer with new fuel.

* Otherwise, deterioration in the components may cause clogged pipe lines, which could result in starting failure.

■ Fuel - Handling

⚠ WARNING

Do not discard waste oil into sewerage, river, lake or other similar places.

* Be sure to discard waste oil in accordance with the applicable laws and regulations.

Do not store fuel in a poorly ventilated place.

* Otherwise, vaporized fuel may build up, which could cause an explosion or a fire on exposure to a flame.

Before handling fuel, remove static electricity.

* Otherwise, the fuel could be ignited.
* Ground the fuel tank.

When working with fuel, wear suitable personal protective equipment such as protective mask, protective eyeglasses, rubber gloves, working clothes with long sleeves and long trousers.

* If fuel comes into contact with your eyes, mouth or skin, it will cause irritation or disorders.

Do not breathe in vaporized fuel.

* Otherwise, it could be hazardous to your health.

When storing fuel in the container, close its cap tightly.

* Otherwise, vaporized fuel may build up, which could cause an explosion or a fire on exposure to a flame.

<Fuel - Refill>

⚠ WARNING

Be sure to drain water from fuel, and pay attention that coolant or other water will not get mixed with fuel.

* Otherwise, rust could form on the plunger, which could interfere engine stopping or cause flue explosion, dilution, or water hammering.

⚠ CAUTION

Do not remove the strainer while filling the fuel tank.

* Otherwise, foreign particles could enter and cause damage to the fuel pump.

When using fuel from a storage tank, leave it to sit for more than 24 hours so that dust and water can settle at the bottom. Then, use the upper clean fuel.

* Otherwise, clogging of the filter may occur, which could cause decrease in the output power.
* Depending on the specification of the tank, prolonged sedimentation time may be required.

ENGINE OIL

■ Engine oil

⚠ WARNING

Refer to the Engine Oil Properties table in this Operation & Maintenance Manual, and even if one item exceeds the limit, the engine oil must not be used.

* Otherwise, seizure of the sliding parts may occur, which could cause serious damage to the devices.

Use the genuine engine oil specified in this Operation & Maintenance Manual.

* Otherwise, seizure of bearings, breakage of a valve, sticking of a piston ring, seizure between a ring and a cylinder, premature wear of bearings and sliding parts may occur, which could shorten the service life of the engine.

Conduct analysis of the engine oil periodically and check to make sure that the engine oil does not show milky color.

* If the engine oil shows milky color, water may be mixed into the engine oil system due to coolant leak or a damaged cylinder liner O-ring. Sustained use of the engine without any remedy could cause seizure of the crankshaft and lead to serious damage to the devices.

Keep the quantity and properties (viscosity) of the engine oil at the specified level.

* If the supply or kinematic viscosity of engine oil is too low, insufficient lubrication of the bearing could occur, which could cause seizure of the crankshaft.
* If kinematic viscosity of engine oil increases, fuel consumption will increase.

■ Handling Engine Oil

⚠ WARNING

Keep away from fire, when working with flammable substances such as engine oil.

* They may cause a fire.

Do not operate the engine with fuel or water mixed in the engine oil.

* Otherwise, viscosity of engine oil could decrease, which could cause seizure of the bearings or other serious accidents.

Do not store engine oil in a poorly ventilated place.

* Otherwise, vaporized engine oil may build up, which could cause an explosion or a fire on exposure to a flame.

Wipe off spilled flammable substances such as engine oil thoroughly with a waste cloth.

* They may cause a fire.

When discarding a waste cloth used to wipe off combustible material, put it into a lidded can and obey the Waste Management and Public Cleansing Act to handle it as a special industrial waste.

* It may cause a fire.
* It could lead to environmental pollution.
* If you violate rules, you may be subject to penalties.

When handling engine oil, obey the manufacturer's SDS.

* If engine oil gets in your eyes, it will cause pain and lead to sight loss at the worst.

Do not breathe in vaporized engine oil.

* Otherwise, it could be hazardous to your health.

When storing engine oil in the container, be sure to close the cap.

* Otherwise, vaporized engine oil may build up, which could cause an explosion or a fire on exposure to a flame.

COOLANT

■ Water to Be Used

⚠ WARNING

When you add water to coolant, use only the water that meets the water quality standard specified in this Operation & Maintenance Manual.

* Otherwise, premature corrosion or overheating in the engine parts may occur.

■ LLC to Be Used

⚠ DANGER

Use the genuine LLC specified in this Operation & Maintenance Manual.

* Otherwise, the devices could be damaged.

■ Coolant (LLC) - Handling

⚠ WARNING

Keep away from fire, when working with flammable substances such as coolant (LLC).

* They may cause a fire.

Wipe off spilled flammable substances such as coolant (LLC) thoroughly with a waste cloth.

* They may cause a fire.

When discarding a waste cloth used to wipe off combustible material, put it into a lidded can and obey the Waste Management and Public Cleansing Act to handle it as a special industrial waste.

* It may cause a fire.
* It could lead to environmental pollution.
* If you violate rules, you may be subject to penalties.

Use care not to let oil mixed with coolant.

* Otherwise, cooling fault could occur, which could cause overheating.

⚠ WARNING

When handling coolant (LLC), always wear suitable personal protective equipment such as rubber gloves and protective eyeglasses.

* If LLC comes into contact with your eyes, it will result in sight loss at the worst.
* If LLC comes into contact with your skin while the engine is hot, you could get burned by heat.

■ Maintenance of LLC

<Replacement Period>

⚠ DANGER

Do not use LLC after the recommended storage expiration date.

* Otherwise, the devices could be damaged.

■ LLC Concentration

⚠ DANGER

Keep LLC to be the specified concentration.

* If LLC concentration is low, it could cause corrosion of the radiator or heat exchanger.
* If LLC concentration is high, it may cause damage to the devices or overheat due to the seized engine parts.

SCHEDULED MAINTENANCE

⚠ WARNING

Do not take actions for items indicated as "Contact your Mitsubishi dealer" in the measure column in the Scheduled Maintenance.

* Otherwise, serious accident, environmental pollution or damage to the devices may occur. Be sure to contact your Mitsubishi dealer.

Be sure to perform the pre-operation check and scheduled maintenance as instructed in this Operation & Maintenance Manual.

* Failure to perform the pre-operation check and scheduled maintenance may cause various engine problems and breakage to parts, which may result in serious accidents.

INSPECTION AND MAINTENANCE

■ Precautions for General Inspection and Maintenance

⚠ DANGER

Before starting the engine, pull out the manual turning gear shaft.

* Starting the engine while the turning gear is engaged with the ring gear could result in serious personal injury or destruction of the engine.

Before inspecting and maintaining the engine, read this Operation & Maintenance Manual thoroughly to understand the construction and the required work to service the corresponding part. In addition, conduct the work after fully studying the procedure

* In case of conducting the work without studying enough, an accident or damage due to wrong installation, or deterioration in the exhaust gas properties may occur.

⚠ WARNING

Do not make any modifications to the engine without our previous written agreement.

* Otherwise, damage to the devices or significant environmental pollution may occur.
* In such a case, the whole warranty will become invalid.

Do not work while standing on the engine.

* Otherwise, you may slip and fall by accident, and get injured.
* In addition, the devices or pipes may be damaged.

Do not disconnect the fuel or engine oil piping while the engine is operating or at high temperature.

* Otherwise, fuel could come in contact with the engine, which could cause a fire.

Do not disconnect the pipes immediately after the engine is stopped.

* Otherwise, you could get burned by hot engine oil or coolant splashing out.

⚠ WARNING

Do not touch any part of the engine (other than the manual stop lever) during or immediately after operation and immediately after stopping.

* If you touch, you could get burned by heat.
* Before starting the inspection and maintenance work, make sure that the engine is cooled down.

Only the genuine parts are recommended to use.

* Using non-genuine parts could cause deterioration in the exhaust gas properties and damage to the devices.
* Faults or damages caused by using non-genuine parts will be outside the scope of the warranty.

While washing the engine, pay attention that water or foreign particles will not enter the engine.

* Otherwise, the devices could be damaged.

After washing the engine, blow off water around the terminals by using compressed air.

* Otherwise, it may cause damage to the devices due to short circuit.

Before maintaining electrical components, place the battery switch to the OFF position or disconnect the battery negative (-) terminal.

* Electric shock could result when electricity flows through the circuit.

Wipe off spilled flammable substances such as fuel, engine oil, coolant (LLC), grease, rust preventive oil and anti-corrosive agent.

* They may cause a fire.

When discarding a waste cloth used to wipe off combustible material, put it into a lidded can and obey the Waste Management and Public Cleansing Act to handle it as a special industrial waste.

* It may cause a fire.
* It could lead to environmental pollution.
* If you violate rules, you may be subject to penalties.

⚠ WARNING

Make sure that dripped oil, parts, tools or other things are not left on the floor around the engine. Always maintain cleanliness and tidiness.

* Otherwise, a tumbling accident may occur.
* Wear proper personal protective equipment for the work.

Watch your step during inspection and maintenance work.

* Otherwise, a tumbling accident or a falling accident may occur while working on the floor panel or other high positions.
* The floor could be extremely slippery due to spilt oil. Thoroughly wipe off oil on the floor and the sole of your shoes.
* Install a stable scaffold as required.

Cover the disconnected pipes or joints and their openings properly so that dusts or other foreign objects will not enter into them.

* Otherwise, the devices may be damaged.

The engine must be inspected and maintained only by qualified persons who have received a required training or on-site instructions, or done so under the mentorship of a person who have completed our training course.

* Otherwise, serious personal injury or damage to the devices may occur.

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

* Do not stand on an old stool or parts box. Otherwise, it may result in personal injury. In addition, do not put any unnecessary objects on a work platform.

⚠ CAUTION

While inspecting and maintaining, do not put your hand in a gap between the connecting rod, crankshaft, timing gear or others and the crankcase.

* Otherwise, you may be stuck and injured.

While operating the engine, stay away from the moving parts.

* Otherwise, you may cut your hand by the rotating parts, or be caught in them and injured.

■ Inspection and Maintenance - Prepare

⚠ WARNING

Make sure that the tools to be used are not damaged.

* Using a damaged tool or a wrong-size tool may cause personal injury or damage to the devices.

Check and calibrate measurement equipment periodically.

* Using uncalibrated measurement equipment may cause damage to the devices or performance degradation of them.

<Inspection and Maintenance - Prepare (with Engine Switched OFF)>

⚠ WARNING

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

* Unexpected startup of the engine could cause serious personal injury or damage to the devices.

Be sure to establish zero energy state before starting inspection and maintenance work.

* Unexpected activation of the devices could cause serious personal injury or damage to the devices.

■ Engine Body - Check

<Belt -Check>

⚠ WARNING

Stay away from rotating parts during operation.

* Otherwise you may get caught in the rotating parts and seriously injured.

⚠ CAUTION

Keep the belt for the crankshaft pulley or alternator free from oil and grease.

* Otherwise, a slip could occur, which will shorten the service life of the belt.

⚠CAUTION

Check each belt status (tension, damage and the like) of the crankshaft pulley or alternator.

* If the belt has been stretched, the battery cannot be cahrged and DC power supply will be lost.

<Belt Tension (Alternator) - Adjust>

⚠WARNING

Stay away from rotating parts during operation.

* Otherwise you may get caught in the rotating parts and seriously injured.

Adjust the belt tension properly in accordance with the procedures recommended by MHISH.

* Otherwise, the service life of the alternator, bearing or belt could be shortened.
* After you replaced the belt with a new one, check the tension again after the initial stretch of the belt is settled.

⚠CAUTION

Keep the belt for the crankshaft pulley or alternator free from oil and grease.

* Otherwise, a slip could occur, which will shorten the service life of the belt.

<Damper - Check>

⚠WARNING

Install a protective cover which can dissipate heat.

* Otherwise, the damper could be enclosed and degenerated due to poor heat dissipation and ventilation, and which may cause breakage of the crankshaft.

■ Fuel System - Check

⚠WARNING

Keep away from fire, when working with flammable substances such as fuel.

* They may cause a fire.

If fuel leaks or splashes out from the high pressure injection pipe, do not touch the fuel.

* The fuel injection pipe delivers high pressure fuel. If the fuel contacts your skin, it goes into deep skin tissues and may result in gangrene.

Wipe off spilled flammable substances such as fuel thoroughly with a waste cloth.

* They may cause a fire.

When discarding a waste cloth used to wipe off combustible material, put it into a lidded can and obey the Waste Management and Public Cleansing Act to handle it as a special industrial waste.

* It may cause a fire.
* It could lead to environmental pollution.
* If you violate rules, you may be subject to penalties.

<Fuel Tank -Check and Service>

Fuel Tank - Clean

⚠WARNING

Tighten the fuel supply valve to the engine firmly.

* Otherwise, fuel may leak out, which could cause a fire.

⚠CAUTION

After cleaning the fuel tank, do not leave the used waste cloth in the fuel tank.

* Otherwise, it may cause damage to the devices in the fuel system.

When draining fuel through the drain cock, always use a container which can accept all the fuel in the tank.

* Otherwise, the drained fuel will overflow from the container and may run to outside of the facility.
* The fuel drained into the container shall be discarded in accordance with the local laws and regulations as well as the manufacturer's SDS.

Fuel Tank - Drain Water

⚠CAUTION

When draining water from the fuel tank, always use a container which is suitable for the water quantity.

* Otherwise, the drained water will overflow from the container and may run to outside of the facility.
* The water drained into the container is contaminated with fuel. Discard the water in accordance with the local laws and regulations as well as the manufacturer's SDS.

Drain water properly from the fuel tank.

* If water, dust or other foreign particles are left, they may mix with fuel, which could cause low output power or damage to the devices in the fuel system.

< Fuel System - Bleed Air>

⚠WARNING

Bleed air sufficiently from the fuel system.

* Otherwise, starting failure may occur.

After bleeding, tighten the priming pump firmly.

* If the tightening torque is too weak, fuel leak may occur.
* If the tightening torque is too strong, the priming pump could be damaged.

<Water Separator - Check and Service>

Water Separator - Drain Water

⚠CAUTION

When draining water from the water separator, always use a container which is suitable for the water quantity.

* Otherwise, the drained water will overflow from the container and may run to outside of the facility.
* The water drained into the container is contaminated with waste oil. Discard the water in accordance with the local laws and regulations as well as the manufacturer's SDS.

Drain water properly from the water separator.

* If draining the water separator is insufficient, water may enter into the fuel system, which could cause damage to the devices.

Water Separator Element - Replace

⚠WARNING

Open the inlet valve of the water separator slowly to prevent fuel in the water separator from spilling out. Wrap a cloth around the water separator.

* Otherwise, spilled fuel may be ignited, which could cause a fire.

⚠CAUTION

Tighten the cover and cock on the water separator appropriately.

* If the tightening torque is too weak, fuel may leak, causing a fire or fuel flow-out, which could lead to environmental pollution.

<Gauze filter - Clean>

⚠WARNING

Clean the gauze filter properly.

* A clogged gauze filter may result in insufficient fuel supply, low power output, or engine stall during operation.

⚠CAUTION

When replacing the gauze filter, tighten the new one under the same condition as the old one was installed.

* If the tightening torque is too weak, fuel may leak, causing a fire or fuel flow-out, which could lead to environmental pollution.

<Fuel Filter - Replace>

⚠WARNING

Do not pour fuel into the fuel filter before installing it.

* Otherwise, it may cause serious personal injury, environmental pollution due to fuel running to outside of the facility, or damage to the devices.
* Follow the installation procedure described in this Operation & Maintenance Manual.

Use a genuine fuel filter.

* If a non-genuine filter is used, , deterioration in the exhaust gas properties and damage to the devices could occur due to insufficient air intake.
* Faults or damages caused by using non-genuine parts will be outside the scope of the warranty.

⚠CAUTION

Do not use a fuel filter with a scratch or dent.

* Otherwise, damage to the filter or fuel leak may occur, which could cause a fire or environmental pollution due to fuel running to outside of the facility.

Do not use a filter wrench when installing the fuel filter.

* It may cause a dent or damage to the fuel filter.

If fuel spills out while removing the fuel filter, wipe off with a waste cloth.

* Otherwise, it may cause a fire or environmental pollution due to fuel running to outside of the facility.
* The waste cloth used to wipe off fuel shall be discarded in according with the local laws and regulations as well as the manufacturer's SDS.

Check the specification of the fuel filter when installing it.

* The fuel filter of which specification does not apply to the fuel may cause damage to the devices.

<Fuel Control Link - Check>

⚠WARNING

Never cut the seal of the fuel control link.

* If you cut the seal, damage to the engine or deterioration in the exhaust gas properties could occur.
* In case that the seal is cut, warranty will become invalid.

Make sure there is no looseness or play at the fuel control link.

* Otherwise, the engine may overrun.

⚠CAUTION

When checking the fuel control link, do not insert your finger into the moving parts.

* Otherwise, you may get injured.

<Fuel Pipe - Check>

⚠WARNING

Check the clamp for the high pressure fuel injection pipe for looseness.

* If looseness or play is detected at the clamp for the high pressure fuel injection pipe, damage to the pipe may occur, which could cause a fire.

Install the clamp for the high pressure fuel injection pipe at the correct position.

* If it is installed at a wrong position, the pipe could be damaged, which could cause a fire.

■ Engine Oil System - Check

⚠WARNING

Do not touch hot engine oil or parts.

* Otherwise, you could get burned.

Do not discard waste oil into sewerage, river, lake or other similar places.

* Be sure to discard waste oil in accordance with the applicable laws and regulations.

<Engine Oil - Change>

Engine Oil - Check

⚠WARNING

Conduct analysis of the engine oil periodically and check to make sure that the engine oil does not show milky color.

* If the engine oil shows milky color, water may be mixed into the engine oil system due to coolant leak or a damaged cylinder liner O-ring. Sustained use of the engine without any remedy could cause seizure of the crankshaft and lead to serious damage to the devices.

Engine Oil - Refill

⚠ WARNING

Be sure to install the oil filler cap after engine oil is refilled.

* Otherwise, seizure due to insufficient oil or environmental pollution due to engine oil running out from the facility may occur.

Make sure that engine oil is not leaking from the oil pan. When checking the engine oil level, wear protective glasses to prevent engine oil from getting in your eyes.

* If engine oil gets in your eyes, it will cause pain and lead to sight loss at the worst.

Refill engine oil enough to raise the level to within the specified range (between the highest line {H} and the lowest line {L}).

* If the engine oil level exceeds the upper limit, the oil pan may crack or oil may splash out from the breather.
* If the engine oil level is too low, seizure of the bearings could occur.

Keep the quantity and properties (viscosity) of the engine oil at the specified level.

* If the supply or kinematic viscosity of engine oil is too low, insufficient lubrication of the bearing could occur, which could cause seizure of the crankshaft.
* If kinematic viscosity of engine oil increases, fuel consumption will increase.

Engine Oil Level - Check

⚠ WARNING

Keep away from fire, when checking the engine oil level.

* It may cause a fire.

<Oil Filter - Replace>

⚠ WARNING

When replacing the oil filter, do not pour the remaining engine oil in the old filter into the new filter.

* Otherwise, foreign particles could enter the engine oil system, which could cause damage to the devices.

Before replacing the oil filter, make sure that the engine has cooled down to the normal temperature.

* Otherwise, you could get burned by heat.

Use a genuine oil filter.

* Using non-genuine parts could cause damage to the devices or degradation in the performance.
* Faults or damages caused by using non-genuine parts will be outside the scope of the warranty.

If paint or other matter is adhering around the sealing surface, remove them before assembling.

* If paint or other matter is stuck on the sealing surface, fuel could leak through the gap, which could cause a fire.

If engine oil spills out while removing the oil filter, wipe off with a waste cloth.

* Otherwise, it may cause a fire or environmental pollution due to fuel running to outside of the facility.
* The waste cloth used to wipe off engine oil shall be discarded in according with the local laws and regulations as well as the manufacturer's SDS.

⚠ CAUTION

Do not use the oil filter with a scratch or dent.

* Otherwise, damage to the filter or oil leak may occur, which could cause a fire or environmental pollution due to fuel running to outside of the facility.

Do not use a filter wrench when installing the oil filter.

* It may cause a dent or damage to the oil filter.

When replacing the oil filter, set the gasket into the groove properly.

* Otherwise, engine oil leak could occur, which could cause a fire or environmental pollution due to oil running to outside of the facility.
* Follow the replacing procedure described in this Operation & Maintenance Manual.

<Governor Oil Filter - Replace
(Hydraulic governor spec)>

⚠ WARNING

Do not touch hot engine oil or parts.
* Otherwise, you could get burned.

■ Cooling System - Check

⚠ WARNING

Do not continue to operate the engine with engine oil mixed in coolant.
* Otherwise, cooling fault may occur, which could cause damage to the engine.

Do not open the radiator cap or coolant tank cap while the engine is hot.
* Otherwise, you could get burns by steam or water splashing out.

Tighten the drain cock on the water pump properly.
* Insufficient tightening may cause a coolant leak.

⚠ CAUTION

Follow the coolant draining procedure described in this Operation & Maintenance Manual.
* Draining in the incorrect procedure may cause burns or environmental pollution due to coolant running to outside of the facility.

When handling cleaning solution for washing the cooling system, obey the manufacturer's SDS.
* Improper wearing or using of personal protective equipment may cause personal injury.

<Cooling System - Clean>

⚠ CAUTION

When handling cleaning solution for washing the cooling system, obey the manufacturer's SDS.
* Improper wearing or using of personal protective equipment may cause personal injury.

<Cooling System - Bleed Air>

⚠ WARNING

Bleed air sufficiently from the cooling system.
* If air remains in the coolant, cooling performance may decrease, and seizure of the engine or piston scuffing may occur.

<Radiator Fins - Check and Clean
(Radiator Specification)>

⚠ WARNING

When working by using compressed air, wear protective glasses.
* Not wearing or not properly wearing personal protective equipment may result in serious personal injury.

Check the radiator fins for holes and cracks.
* Otherwise, overheating, damage to the devices, or performance degradation may occur.

■ Intake and Exhaust Systems - Check

<Turbocharger - Check>

⚠ WARNING

Before checking the turbocharger, make sure that the engine has cooled down to normal temperature. Before checking, make sure that the compressor wheel is not rotating.
* Otherwise, you could get burned.
* If you are caught in a rotating compressor wheel, you will suffer laceration.

Make sure that there is no intake air leak in the piping to the compressor of the turbocharger.
* If there is intake air leak, insufficient boost pressure could occur, which could cause deterioration in the exhaust gas properties.

⚠ CAUTION

Check that the compressor or turbine of the turbocharger is not dirty.
* If the compressor or turbine of the turbocharger is dirty, performance degradation of the turbocharger may occur, which could cause power reduction.

<Exhaust Muffler - Drain Water>

⚠ WARNING

Do not touch the exhaust muffler immediately after the engine is stopped.

- Make sure that the engine is cooled down to the normal temperature.

* Otherwise, you could get burned.

<Pre-cleaner - Check and Service>

⚠ WARNING

Do not check, maintain or remove the pre-cleaner during operation.

* Otherwise, dust or other foreign particles may enter the engine, which could accelerate wear of the parts or cause damage to the devices including the turbocharger.

Take care that parts will not fall down and get caught in the fuel control link.

* If parts are caught in the fuel control rack, the engine will become out of control.

Pre-cleaner - Check for Clogging

⚠ WARNING

Make sure that the pre-cleaner is free from clogging.

* Insufficient intake air could result in loss of power, incomplete combustion, exhaust gas temperature rise, and overspeed of the turbocharger.

<Air Cleaner - Check and Service>

Air Cleaner - Check for Clogging

⚠ WARNING

Make sure that the air cleaner is free from clogging.

* Insufficient intake air could result in loss of power, incomplete combustion, exhaust gas temperature rise, and overspeed of the turbocharger.

■ Electrical System - Check

<Battery - Check>

⚠ WARNING

Do not short the battery terminals.

* Otherwise, sparks could occur and cause a fire or an explosion.

Do not touch battery terminal with a wet hand.

* There are possibilities to get an electric shock.

When checking and servicing the battery, wear suitable personal protective equipment such as protective eyeglasses, rubber gloves, working clothes with long sleeves and long trousers.

* If battery fluid comes into contact with your eyes or skin, it may result in sight loss or burns.

<Starter - Check (Self Starter Motor Starting)>

⚠ CAUTION

Check that there is no damage to the pinion gear of the starter.

* Otherwise, a spark or damage to the devices could occur.

<Alternator - Check>

⚠ CAUTION

Do not touch the rotating part of the alternator.

* Otherwise, you may get caught in the rotating part and suffer an injury or damage to the devices could occur.

■ Air Direct Admission Starting, Air Motor Starting - Check

<Air strainer - Drain water and clean>

⚠ WARNING

When working by using compressed air, wear protective glasses.

* Not wearing or not properly wearing personal protective equipment may result in serious personal injury.

⚠ CAUTION

Before draining or cleaning the starting air strainer, bleed air completely. In addition, check the pressure reduction with the pressure gauge.

* If high pressure air remains in the pipe, the drain valve may blow off, which could cause personal injury or damage to the devices.

<Starting air tank - Check and Service>

⚠ WARNING

Be sure to drain water from the starting air tank.

* Otherwise, water could enter the cylinders when starting the engine.

Make sure that the safety valve on the starting air tank is not malfunctioning.

* If the safety valve is out of order, improper operation could occur, which could result in explosion of the starting air tank.

⚠ CAUTION

Be sure to drain water from the starting air tank.

* Otherwise, water could enter the air motor when starting the engine.

LONG-TERM STORAGE

■ Storing Engine in Inoperable Condition

<Storage - Prepare (Rust-preventive Measure)>

⚠ WARNING

Keep away from fire, when working with flammable substances such as volatile corrosion inhibitor or rust preventive oil.

* They may cause a fire.

Keep away from fire, when working with flammable substances such as grease.

* They may cause a fire.
* When handling grease, obey the manufacturer's SDS.

If the engine is stored for 3 month or longer (up to 1 year), apply rust-preventive measure properly.

* Otherwise, the internal engine parts and/or sliding parts may be rusted, which could cause damage to the devices.
* Follow the storage procedure described in this Operation & Maintenance Manual.

Use volatile corrosion inhibitor and rust preventive oil recommended by us.

* If a product other than the recommendation is used, the internal engine parts may be rusted due to insufficient anti-rust effect.

Use new (immediately after opened) desiccant.

* If you use a product which has been unused for a long time since its package was opened, moisture absorbency may be weakened, and may cause the internal engine parts and/or sliding parts to rust.

After stopping the engine, spray volatile corrosion inhibitor while cranking the engine for at least 2 times.

* Otherwise, anti-corrosive agent may accumulate and harden on the piston, which could block turning.

⚠CAUTION

When handling volatile corrosion inhibitor or rust preventive oil, wear personal protective equipment such as protective mask or protective glasses, and obey the manufacturer's SDS.

* If such products are breathed in or comes in contact with the skin, serious personal injury may occur.

When working with grease, wear suitable personal protective equipment such as protective eyeglasses, rubber gloves, working clothes with long sleeves and long trousers.

* If grease comes into contact with your eyes, it will cause irritations.
* When handling grease, obey the manufacturer's SDS.

<Maintenance During Storage>

⚠WARNING

Do not short the battery terminals.

* Otherwise, sparks could occur and cause a fire or an explosion.

When checking and servicing the battery, wear suitable personal protective equipment such as protective eyeglasses, rubber gloves, working clothes with long sleeves and long trousers.

* If battery fluid comes into contact with your eyes or skin, it may result in sight loss or burns.

TRANSPORTATION

■ Precautions on Transportation

⚠WARNING

When transporting the engine on a truck, consider the engine weight, width and height to ensure safety. Abide by road traffic law, road vehicles act, vehicle restriction ordinance and other pertinent laws.

* Operation of the truck disregarding the laws and regulations may cause traffic accident or damage to the devices.

Be extremely careful when transporting the engine on rough roads.

* Otherwise, a traffic accident such as rollover or damage to the devices may occur.

■ Engine - Lift

⚠ WARNING

When lifting up the engine, do not allow the operators to stay under the engine.

* Otherwise, if the wire breaks, the engine may fall down, which could cause serious personal injury.

The engine must be lifted only by an operator who is qualified for a crane and slinging works and also well skilled.

* Otherwise, the engine may fall by an operation error, which could cause serious personal injury or damage to the devices.

To lift the engine, take the mass of the engine and that of water remained in the engine into account, and use wire ropes, shackles, and slings which are strong enough to support the weight.

* Otherwise, the engine may slip down, which could cause serious personnel injury or damage to the devices.
* Check the contract specifications for engine dry mass.

Use sling/hoisting tools in accordance with their instruction manual.

* Otherwise, the engine may slip down, which could cause serious personnel injury or damage to the devices.

Use the hangers of the engine only for lifting the engine unit.

* If you use them when the engine is assembled with the generator and additional devices, the hanger may not be able to endure the mass and may break. If the engine falls, serious personnel injury or damage to the devices will occur.

Before lifting the engine, drain fuel, engine oil and coolant.

* Otherwise, the hanger may not be able to endure the mass and break. If the engine falls, serious personnel injury or damage to the devices may occur.

Lift the slings while keeping the angle formed by the slings attached to the hangers within 60°.

* If the angle is too large, excessive weight will be imposed on the hanger, which could cause damage to the hanger.

TROUBLESHOOTING

■ Precautions on Troubleshooting

⚠ DANGER

Before inspecting and maintaining the engine, read this Operation & Maintenance Manual thoroughly to understand the construction and the required work to service the corresponding part. In addition, conduct the work after fully studying the procedure

* In case of conducting the work without studying enough, an accident or damage due to wrong installation, or deterioration in the exhaust gas properties may occur.

⚠ WARNING

Do not take actions for items indicated as "Contact your Mitsubishi dealer" in the measure column in the Scheduled Maintenance.

* Otherwise, serious accident, environmental pollution or damage to the devices may occur. Be sure to contact your Mitsubishi dealer.

Do not disconnect the pipes immediately after the engine is stopped.

* Otherwise, you could get burned by hot engine oil or coolant splashing out.

When lifting a part or tool, check its weight and lift it slowly.

* If you lift it carelessly, you may hurt your back or get injured by dropping the part.

Make sure that dripped oil, parts, tools or other things are not left on the floor around the engine. Always maintain cleanliness and tidiness.

* Otherwise, a tumbling accident may occur.
* Wear proper personal protective equipment for the work.

Make sure that the tools to be used are not damaged.

* Using a damaged tool or a wrong-size tool may cause personal injury or damage to the devices.

Check and calibrate measurement equipment periodically.

* Using uncalibrated measurement equipment may cause damage to the devices or performance degradation of them.

⚠ WARNING

Watch your step during inspection and maintenance work.

* Otherwise, a tumbling accident or a falling accident may occur while working on the floor panel or other high positions.
* The floor could be extremely slippery due to spilt oil. Thoroughly wipe off oil on the floor and the sole of your shoes.
* Install a stable scaffold as required.

Before maintaining electrical components, place the battery switch to the OFF position or disconnect the battery negative (-) terminal.

* Electric shock could result when electricity flows through the circuit.

Cover the disconnected pipes or joints and their openings properly so that dusts or other foreign objects will not enter into them.

* Otherwise, the devices could be damaged.

DISPOSAL

■ Disposal Precautions

<Fuel - Drain>

⚠ WARNING

Do not discard waste oil into sewerage, river, lake or other similar places.

* Be sure to discard waste oil in accordance with the applicable laws and regulations.

Keep away from fire, when working with flammable substances such as fuel.

* They may cause a fire.

When working with fuel, wear suitable personal protective equipment such as protective mask, protective eyeglasses, rubber gloves, working clothes with long sleeves and long trousers.

* If fuel comes into contact with your eyes, mouth or skin, it will cause irritation or disorders.

Wipe off spilled flammable substances such as fuel thoroughly with a waste cloth.

* They may cause a fire.

When discarding a waste cloth used to wipe off combustible material, put it into a lidded can and obey the Waste Management and Public Cleansing Act to handle it as a special industrial waste.

* It may cause a fire.
* It could lead to environmental pollution.
* If you violate rules, you may be subject to penalties.

<Engine Oil - Drain>

⚠ WARNING

Do not discard waste oil into sewerage, river, lake or other similar places.

* Be sure to discard waste oil in accordance with the applicable laws and regulations.

Keep away from fire, when working with flammable substances such as engine oil.

* They may cause a fire.

When handling engine oil, obey the manufacturer's SDS.

* If engine oil gets in your eyes, it will cause pain and lead to sight loss at the worst.

Wipe off spilled flammable substances such as engine oil thoroughly with a waste cloth.

* They may cause a fire.

When discarding a waste cloth used to wipe off combustible material, put it into a lidded can and obey the Waste Management and Public Cleansing Act to handle it as a special industrial waste.

* It may cause a fire.
* It could lead to environmental pollution.
* If you violate rules, you may be subject to penalties.

<Coolant (LLC) - Drain>

⚠ WARNING

Do not discard coolant (LLC) into sewerage, river, lake or other similar places.

* Be sure to discard coolant (LLC) in accordance with the applicable laws and regulations.

Keep away from fire, when working with flammable substances such as coolant (LLC).

* They may cause a fire.

When handling coolant (LLC), always wear suitable personal protective equipment such as rubber gloves and protective eyeglasses.

* If LLC comes into contact with your eyes, it will result in sight loss at the worst.
* If LLC comes into contact with your skin while the engine is hot, you could get burned by heat.

Wipe off spilled flammable substances such as coolant (LLC) thoroughly with a waste cloth.

* They may cause a fire.

When discarding a waste cloth used to wipe off combustible material, put it into a lidded can and obey the Waste Management and Public Cleansing Act to handle it as a special industrial waste.

* It may cause a fire.
* It could lead to environmental pollution.
* If you violate rules, you may be subject to penalties.

<Anti-corrosive Agent, Rust Preventive Oil, Rust-preventive Fuel - Drain>

⚠ WARNING

Do not discard waste oil into sewerage, river, lake or other similar places.

* Be sure to discard waste oil in accordance with the applicable laws and regulations.

Keep away from fire, when working with flammable substances such as volatile corrosion inhibitor or rust preventive oil.

* They may cause a fire.

⚠ CAUTION

When handling volatile corrosion inhibitor or rust preventive oil, wear personal protective equipment such as protective mask or protective glasses, and obey the manufacturer's SDS.

* If such products are breathed in or comes in contact with the skin, serious personal injury may occur.

<Battery Fluid (Dilute Sulfuric Acid) - Drain>

⚠ WARNING

Do not discard battery fluid (dilute sulfuric acid) into sewerage, river, lake, or other similar places.

* Be sure to discard battery fluid (dilute sulfuric acid) in accordance with the applicable laws and regulations.

Never use flames or allow sparks near the battery.

* An explosion due to catching flame or a fire may occur.

When checking and servicing the battery, wear suitable personal protective equipment such as protective eyeglasses, rubber gloves, working clothes with long sleeves and long trousers.

* If battery fluid comes into contact with your eyes or skin, it may result in sight loss or burns.

<Engine Body - Disposal>

⚠ WARNING

In case that you have to discard the engine body, contact your Mitsubishi dealer.

* You must deal with it as a special industrial waste in accordance with the laws and regulations of the national government and other local municipalities.

Asbestos was used in the parts of the engines that were manufactured in 2005 or earlier. Therefore, when discarding them, obey the "Waste Management and Public Cleansing Act".

* If you violate rules, you may be subject to penalties.

⚠ CAUTION

While discarding the engine body, be sure to wear the appropriate personal protective equipment.

* Without wearing or not properly wearing personal protective equipment, serious personal injury may occur.

<Other Disposal>

⚠ WARNING

When discarding a waste cloth used to wipe off combustible materials such as fuel, the engine oil, and coolant (LLC), put it into a lidded can and obey the Waste Management and Public Cleansing Act to handle it as a special industrial waste.

* It may cause a fire.
* It could lead to environmental pollution.
* If you violate rules, you may be subject to penalties.

⚠ CAUTION

Lift and transport an engine or a heavy object such as tank filled with waste oil or fluid with a forklift only by the qualified operator.

* Otherwise, the heavy object may fall due to improper transportation, and the operator may get injured.
* And the waste oil or fluid leak may occur, which could cause environmental pollution.

Protection Devices

Protection Devices on the Engine

On this engine, protection devices are incorporated in order to ensure the operators' safety and prevent personal injury and damage to the engine.
The protection devices incorporated in the engine will not function by themselves. Affix the information (types, location, functions, etc.) of the protection devices added at the time of the generator's production onto "Protection Devices Added During Manufacturing the Generator" (→ Page 13) as "Usage Information" for the operator.
It is very important for ensuring safety to maintain these functions in order. Therefore, conduct the scheduled maintenance.

Note

- **The functional check of the protection devices must be conducted properly in conformity to the operation status of this engine. Schedule functional checks of the protection devices.**
- **Follow the working methods and procedures while taking advantage of the permanently-installed protection devices. Never deactivate the protection devices.**
- **The location of the protection devices varies depending on the specification of the engine. Refer to "Protection System - Location" (→ Page 78).**
- **Equipped or not equipped, type, setting value and figure of each protection device vary depending on the equipment and specifications. Check the protection devices of your engine at first.**

■ Oil Pressure Switch

The oil pressure switch will send a signal when the engine oil pressure has dropped and reached the specified pressure.

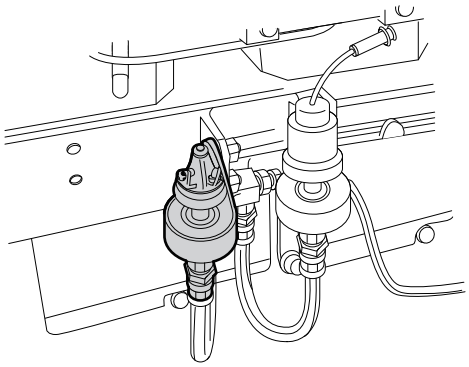


Fig. 1-2 Oil Pressure Switch

■ Thermo Switch

The thermo switch will send a signal when the engine coolant temperature becomes high and reaches the specified temperature.

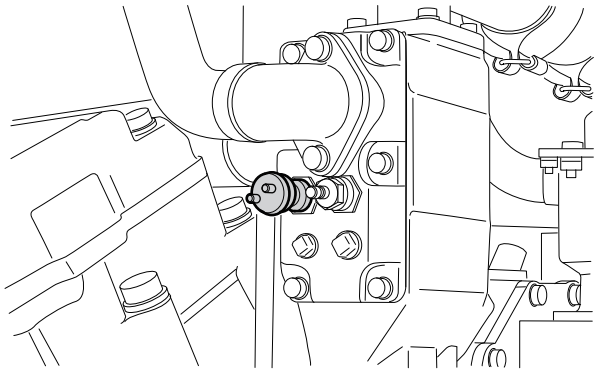


Fig. 1-3 Thermo Switch

■ Oil Filter Alarm Switch

The oil filter alarm switch will send a signal when the difference in pressure across the filter reaches the specified value due to clogged oil filter.

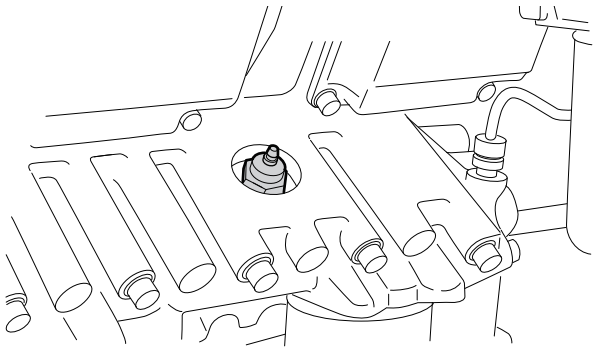


Fig. 1-4 Oil Filter Alarm Switch

■ Rotation Detection Pickup

The pickup will send a signal when the engine speed becomes high and reaches the specified engine speed.

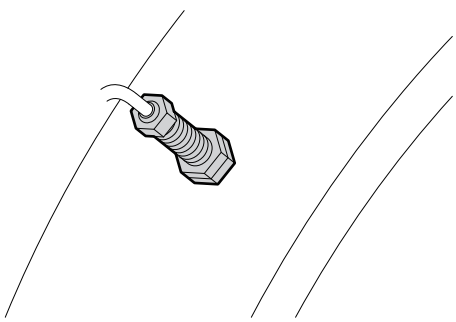


Fig. 1-5 Rotation Detection Pickup

Lockout/Tagout

Lockout/tagout is a measure to avoid other personnel to get injured by mistakenly switching ON the power source during the work conducted by multiple operators, and it is very effective for ensuring safety.

In Japan, the Ordinance on Industrial Safety and Health, Article 107 "Stoppage of Operation etc., in the Case of Cleaning, etc." requires to lockout/tagout.

Details of implementation and management of lockout/tagout are described in OSHA§1910.147 issued by the Occupational Safety and Health Administration. OSHA§1910.147 can be browsed at the Internet website of OSHA.

Note

- **The customer is required to prepare the tags.**
- **Prepare tags of the expected numbers of operators if plural operators are to work in a dangerous area.**

Lockout

Lockout is intended for ensuring safety when the operators enter the dangerous area for maintenance work such as replacing parts.

- Shut off all the power source and set to Zero Energy State "Zero Energy State" (→ Page 59).
- Lock up the power source so that the other operators will not be able to switch on the power source.
- The operator in charge must hold the key so that other operators will not be able to open the lock.

Tagout

Tagout is to attach a tag onto the deactivated operating panel which indicates a warning to prohibit activating.

The name of the person in charge of management or the operator who attached the tag must be indicated on the tag.

After completing works, the operator must fill in the work completion date & time and his sign in the work management table, and report to the user company or supervisor.

The user company or supervisor must prepare a work management table in advance. If it is necessary to conduct tagouts to work, the user company or supervisor must record the working classification, person in charge, and tag number in a table, and keep the table.

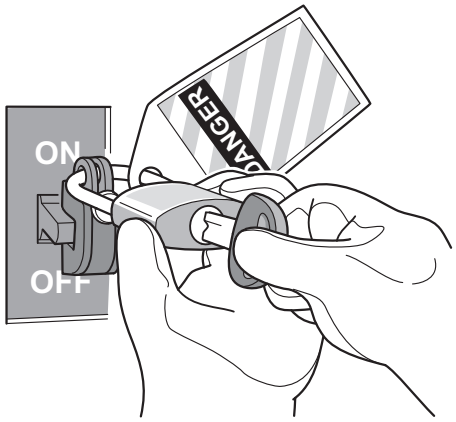


Fig. 1-6 Lockout/Tagout (Example)

Zero Energy State

"Zero Energy State" is to maintain the condition to inhibit unexpected energy releases or inputs during maintenance work. In other words, Zero Energy State is to prevent unexpected output or input of energy when the engine is not used, even if the potential energy is not zero.

Note

- **You must know how to set the engine to Zero Energy State.**
- **When setting the generator to Zero Energy State, refer to the corresponding manual of the generator.**

How to Set the Engine to Zero Energy State

1 **Operate the stop switch of the generator "Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81) to turn off the engine.**

2 **Make sure the engine has stopped.**

3 **Set the battery switch to "OFF", or disconnect the battery negative (-) terminal to isolate from main power source.**

4 **Disconnect the external equipment (set the relay of the generator "OFF", etc.).**

For engines with the air direct admission starting or air motor starting system, conduct the following operation in addition.

5 **Bleed air trapped in the air starter system (starting air tank, starting air compressor) to release the residual pressure.**

Working Procedure in Dangerous Areas

Works in Dangerous Areas

When you need to enter a dangerous area, for example, to solve a problem that has occurred during operation, follow the procedure shown below.

■ Works that require Lockout/tagout

Note

- **When you conduct a work which can not be done for a short time, for example, when replacing a part, conduct lockout/tagout for ensuring safety.**

1 **Operate the stop switch of the generator "Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81) to turn off the engine.**

2 **Lock the starting switch of the generator "Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81) with a key and hang a tag, as necessary.**

Note

- **A tag must be hanged, as necessary, by considering the number of the operators, difficulties to check the presence of each other, or the working times.**

3 **Conduct the works.**

After completing the works, restore the condition as follows.

1 **Inform the other operators that the works have been completed.**

2 **Remove the key and tag from the starting switch of the generator.**

3 **Check for any operators remaining in the dangerous area.**

4 **Inform the user company or supervisor that the works have been completed.**

5 **Start up the engine by the normal operation procedure.**

Body Protection

When working on this engine, obey the requirements below in order to protect the operator.

Clothing

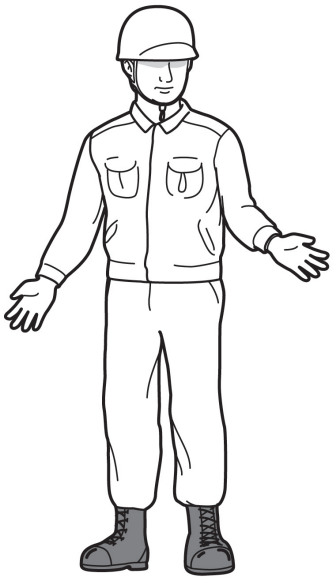


Fig. 1-7 Clothing

Be sure to wear the appropriate protective clothing to work.

- Wear tight clothing and fasten cuffs firmly.
- Proper work clothing is valuable protection against electrical shock.
- If you work while wearing a short sleeved shirt or short-pants, you may get injured when you come into contact with something.

Note

- **For handling fuel, the engine oil, coolant, and anti-corrosive agent, refer to SDS "Dangerous and Hazardous Chemicals" (→ Page 69).**

Personal Protective Equipment

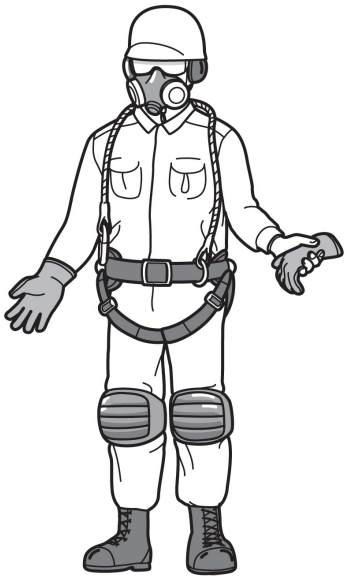


Fig. 1-8 Personal Protective Equipment

Note

- **Personal protective equipment vary depending on the working environment and works (operation, diagnosis, inspection and maintenance, and so on).**
  Specify the rules, and wear the required personal protective equipment.

<Personal protective equipment to be worn, in general>

- Working clothes
- Safety shoes
- Hard hat
- Protective glasses
- Protective mask (gas mask)

<Personal protective equipment to be added according to the working environment and works>

- Earplugs (hearing personal protective equipment)
- Plastic gloves (when handling the dangerous and toxic chemicals)
- Safety belt (when working at the high position)

Product-specific Precautions

Use of Chemicals

This engine uses fuel (diesel fuel), engine oil, coolant (LLC), grease, and anti-corrosive agent.
If these come into contact with your eyes or skin, they may cause skin burns or abnormal sight (sight loss at the worst).
To prevent an accident, take measures given below.

- When handling, wear proper personal protective equipment.
  (protective glasses, protective mask (gas mask), plastic gloves)
- Wear working clothes with long sleeves and trousers to protect the skin.

Surface Temperature

A surface of this engine during operation or immediately after operation is raised to high temperature (approx. 180°C [356°F]) by location, and therefore if you touch it, you could get burns. After making sure with the thermometer (thermo gun, etc.) that a surface of the engine is cooled down so that you can touch (approx. 40°C [104°F]), conduct the inspection and maintenance work.

Precautions on Additional Equipment

Water Heater

⚠ WARNING

Do not touch the water heater even after stopping of the engine.

* Even after stopping, water heater is at high temperature and touching it may cause burns.

For the generator with a water heater, connect the wiring of the water heater correctly.

* Otherwise, flue explosion may occur, which could cause serious personal injury or damage to the devices.

For the generator with a water heater, always set the water heater switch to "ON".

* If you start up the engine when the water heater switch is "OFF", incomplete combustion may occur, which could result in flue explosion or deterioration in the exhaust gas properties.

For generators for emergency use with a water heater, be sure to follow the instructions below:

Note

- **The water heater is outside the scope of our supply.**
  For the details, refer to the corresponding manual of the generator.

- Always place the water heater switch in the ON position to maintain the cooling water temperature to the proper value (35°C [95°F] or higher).
- If you had to set the water heater switch to "OFF" for inspection and maintenance, be sure to set the switch back to "ON" after completing the work.
  Start up the engine only after the coolant temperature reaches the proper temperature (35°C [95°F] or higher).

Develop the Action Procedure to Obey in the Event of Emergency

It is necessary to develop the action procedure to observe in the event of emergency so as to rescue and assist the operators involved in an accident.
Some items that are to be included in the action procedure are given below as a reference.

(a) Assign a liaison person as support staff of rescue works

(b) Include at least one rescue trained person in each work party

(c) Prepare the suitable tools and equipment required for rescue work.

⚠ WARNING

Prepare first-aid kits and first aid tools.

* Otherwise, in case of personal injury, first aid treatment can be delayed, which may cause death in the worst case.

Prepare an emergency action plan in the event of emergency (fire, accidents, etc.) including emergency contact points and means of communication.

* Delay in action will result in expansion of damage.

Keep Everyone Informed about the Emergency Stop Procedure

Compile the information about the protection devices, fuel, engine oil, pipings of the cooling and Inlet/exhaust system installed during manufacturing the generator and attach it on the next page.
Also ensure that their locations and function are instructed to, and understand by the operators in addition to the details of the "Safety Manual".

Measures in the Event of Emergency

Emergency Stop Procedure

Thoroughly understand the stopping procedure to be followed in the event of emergency.

1 **Use the emergency stopping devices of the generator "Emergency Stopping Devices Installed During Manufacturing the Generator" (→ Page 64).**

2 **If the engine will not stop, pull the manual stop lever of this engine in the direction of stopping and hold this position.**

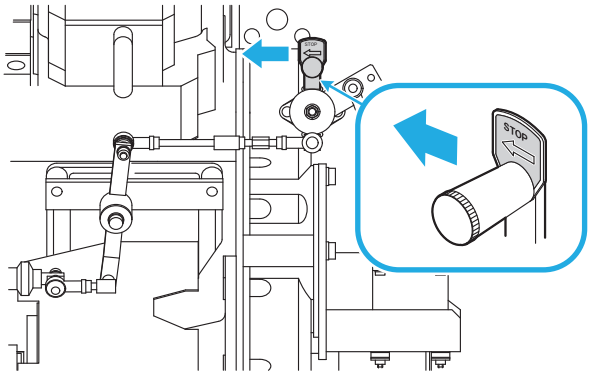


Fig. 1-9 Emergency Stop Procedure

Note

- **The location of the manual stop lever varies depending on the specification of the engine. Refer to "Protection System - Location" (→ Page 78).**

3 **After the engine has stopped completely, release the manual stop lever.**

⚠ WARNING

When stopping the engine by pulling the manual stop lever, keep pulling the lever until the engine stops completely.

* Otherwise, the engine may start again.

If the stop switch of the generator will not function and the engine will not stop by using the manual stop lever, shut off fuel supply.

* Otherwise, the extent of damage may increase.

Emergency Stopping Devices Installed During Manufacturing the Generator

The user company must compile the information about the emergency stopping devices installed during manufacturing the generator and attach it here.

Measures in the Event of Personal Injuries Resulting from This Engine

In case a personal injury occurs unfortunately, act in accordance with the following.

Fig. 1-10 Measures in the Event of Personal Injury

1 **Check your surroundings and save human lives.**

2 **Call for emergency services of the following organizations.**

(a) Fire department

(b) Supervisory authorities

3 **After conducting the emergency measures, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8) as soon as possible.**

Measures in the Event of Property Damaging Disasters

If the engine has been damaged due to a wrong handling during operation, act in accordance with the procedure shown below.

Fig. 1-11 Measures in the Event of Property Damaging Disasters

1 **Contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8) immediately.**

Note

- **If the engine has been damaged, exact damage situation cannot be judged only by visual check. Be sure to contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8), since their cooperation is essential for checking the damage situation.**

2 **In order to prevent the damage from spreading, stop the engine operation after the disaster occurred and follow the instruction by your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

Measures in the Event of Environmental Disaster

If waste oil have been mistakenly discharged through drain ditches, act in accordance with the procedure shown below.

Fig. 1-12 Measures in the Event of Environmental Disaster

1 **Call for emergency services of the following organizations.**

(a) Public agency, which performs local environment management

(b) Fire department

(c) Police department

(d) Fishermen's union

2 **Act as instructed by the public agency.**

Measures in the Event of a Fire Disaster Resulting from This Engine

If a fire has occurred during operation, act in accordance with the following procedure.

Fig. 1-13 Measures in the Event of a Fire Disaster

1 **The operator who has found a fire must inform the other people around him of it aloud immediately.**

2 **If there is any injured persons, take them to a safety place and perform proper emergency medical procedures.**

3 **Call the fire department.**

4 **Use a fire extinguisher which is suitable for the type of fire to extinguish the fire.**

⚠ WARNING

Prepare fire-fighting equipments and fire extinguishers. If you are obliged to prepare fire extinguishers by various laws and regulations, be sure to place them.

* In case of a fire, delay in fire suppression will result in expansion of damage.
* To extinguish engine fire, it is recommended to use an ABC dry-powder fire extinguisher which has the effect of suppressing of both of oil and electrical fires.

⚠ WARNING

To extinguish the oil fire or an electrical fire, use an extinguisher suitable for the type of fire.

* If you try to use water to extinguish the oil fire, the fire will get worse.
* To extinguish engine fire, it is recommended to use an ABC dry-powder fire extinguisher which has the effect of suppressing of both of oil and electrical fires.

5 The user company or supervisor must contact the Mitsubishi dealer "CONTACT LIST" (→ Page 8).

Note

- **Regardless of the size or cause of the accident, report the details to your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**
- **Place fire extinguishers at locations out of direct sunlight, with low humidity, kept out of rain, and conspicuous.**
- **Check the fire extinguishers for rust and deformation of the body once a year or more, and change the extinguishing agent approx. every 5 years.**
- **Escape from the scene immediately after extinguishing a fire with fire extinguishers including CO_2-agent.**

Measures in the Event of an Earthquake Disaster

If an earthquake has occurred during operation, act in accordance with the following procedure.

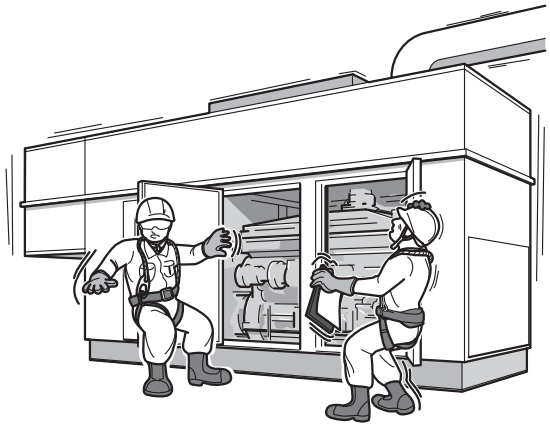


Fig. 1-14 Measures in the Event of an Earthquake Disaster

1 If there is any injured persons, take them to a safety place and perform proper emergency medical procedures.

2 The user company or supervisor must lead all the operators to a safe place in accordance with the company rules.

3 After confirming that there is not a possibility of earthquake recurrence, check the following points.

(a) Damage to the engine
(b) Falling objects near and inside of the engine
(c) Condition of pipings and wirings
(d) Abnormality of electric power

Note

- **If any abnormalities are found, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

Occupational Health and Safety Management

The following is a summary of the Occupational Health and Safety Management that you have to conduct.

For the operations concerning this engine, develop the "Safety and Health Planning" on the basis of the "Guidelines for Occupational Safety and Health Management System" (ILO-OSH2001), and observe it to conduct them.

In addition to the requirements of the national government and other local municipalities as well as your original safety management rules, use this to prevent accident to a human casualties, property damage and environmental accident.

Operation & Maintenance Manual - Understand and Obey

Let the operators thoroughly understand the details described in this Operation & Maintenance Manual, and conduct the training to prevent risks at the actual engine.

Fig. 1-15 Operation & Maintenance Manual - Understand and Obey

Education and Training for Safety

Safety skills of the personnel can be improved by teaching as with skills of the other works. Be sure to include the points concerning safety in your education and training.

The safety measures for specific works can be instructed in our operation training of the engine, however these are not enough.

It is necessary for the customer to recognize potential risks and have a sense of alertness. In addition, you must improve your awareness of safety so as to respond sensitively to danger and conform the established procedure.

If awareness of safety is boosted, you can judge situations, and avoid dangerous actions and dangerous places by yourself, or exclude potential dangers so as to act behaviors to safeguard yourself.

Fig. 1-16 Education and Training for Safety

Dangerous and Hazardous Chemicals

Being exposed to chemicals causes significant health problems, for example, heart disease, damage to kidneys and lungs, sterility, carcinoma, burns and rash.

Some chemicals have a risk which causes a fire, an explosion, or other serious accidents by inappropriate handling.

When purchasing dangerous and hazardous chemicals, get the SDS from the manufacturers and decide the storage location where you can access as soon as you want, and store them accordingly.

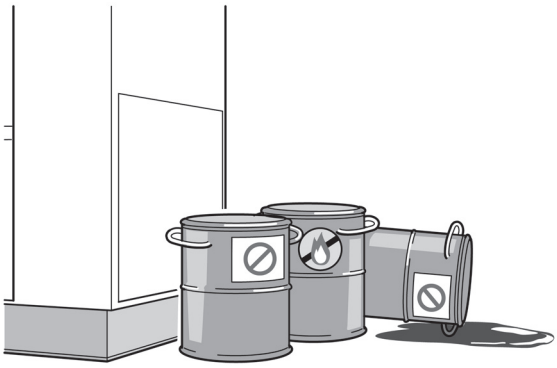


Fig. 1-17 Dangerous and Hazardous Chemicals

If you consult a physician due to the influence to your health by using dangerous and hazardous chemicals, hand in the SDS to the doctor.

For handling these dangerous and hazardous chemicals, distributing information, education and training to the operators in accordance with JIS Z 7253, ISO 11014 are needed.

According to the following precautions, conduct transmitting information, education and training to the chemicals handlers.

(a) In the area where dangerous and hazardous materials are used, proper ventilation must be ensured.

(b) For handling and storing dangerous and hazardous materials, follow the manufacturer's recommended handling procedures.

(c) Stick labels on to the containers of dangerous and hazardous materials, and handle them according to the manufacturer's instruction. Keep the chemicals from hot places, spark of flame, and store them in a dry and cool environment.

(d) Before handling dangerous and hazardous materials, check the manufacturer's SDS, and follow their handling procedures.

(e) When handling dangerous and hazardous materials, make the operators wear personal protective equipment in accordance with handling procedures of SDS prepared by the manufacturers.

(f) If injuring eyes by dangerous and hazardous materials is expected, inform the operators of the locations of the eye washer and its using procedure in advance.

(g) The operators who handle dangerous and hazardous materials handling operators must wash their hands before drinking and eating.

■ Treatment of the Waste Oil, Waste Fluid, Waste Materials

When discarding chemicals such as solvents which are used in the machines or waste cloths with which you have wiped off the chemicals, many restrictions are set on it.

Managing according to the requirements of the national government and other local municipalities as well as your original restrictions are required.

The company certified according to ISO-14001 must obey the procedure specified by itself.

■ Details of SDS (Safety Data Sheet)

In the SDS, details of dangerous points for health and safety, influence to environment, safety handling procedure, measures in an emergency are described.

Noise

In a environment at dangerous noise levels, the operators could suffer permanent auditory disorder. Therefore, noise is an important element for the health and safety management in the factory. Auditory disorder occurs by the following unsafe behaviors.

- Entering a dangerous area without wearing earplugs (hearing personal protective equipment).
- Staying in a dangerous area without earplugs (hearing personal protective equipment) or with improper personal protective equipment for a long time.

The noise level near the engine exceeds 85 dB during operation. Therefore, do not stay in a dangerous area without wearing earplugs (hearing personal protective equipment) for a long time.

Preparation of facilities such as a cubicle (bonnet) is recommended.

Fig. 1-18 Noise

Note

- **For the noise level, refer to the factory test results statement held by the generator supplier.**

■ Noise Level during Operation

The actual measured value of the engine at maximum speed during operation is 115 dB.

Note

- **Measured at the point 1 m [39.37 in.] away from the engine.**
- **Wear earplugs (hearing personal protective equipment) during engine operation.**
- **This is a result which was measured in our factory. The actual noise level varies depending on the environment. (Ceiling height, size of the engine installation space, facilities of the generator)**

Vibration

- Some problematic vibrations may occur in association of business actions in the factory or workplace. In an engine, vibration occurs by the rotation.
- Vibration may shake buildings and cause damage to properties and personnel.

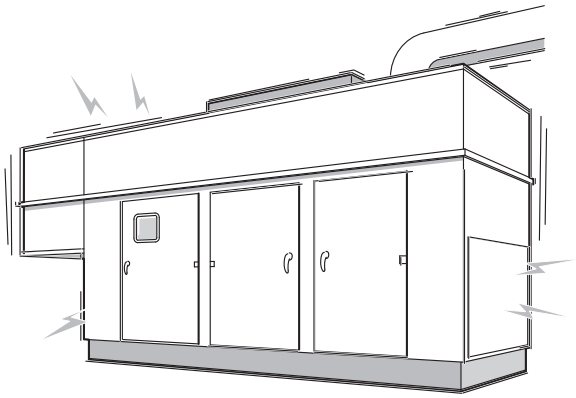


Fig. 1-19 Vibration

Note

- **For the vibration level, refer to the factory test results statement held by the generator supplier.**

To Maintain Cleanliness and Tidiness

Without keeping in mind to maintain cleanliness and tidiness, you are in danger of stumbling over an obstacle or falling over. In addition, maintaining cleanliness and tidiness has a significant influence on the operations.

Sufficiently maintaining cleanliness and tidiness will increase the working efficiency and decrease the possibility of accidents.

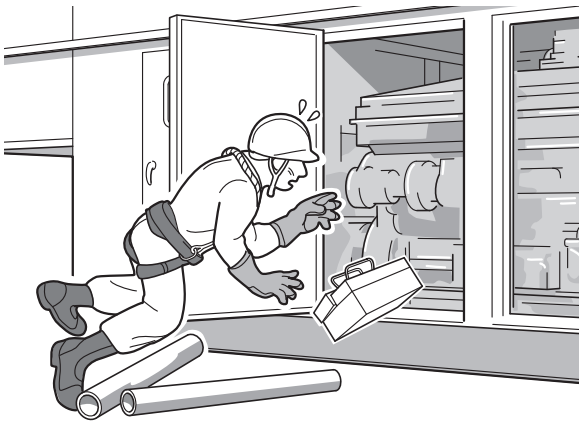


Fig. 1-20 To Maintain Cleanliness and Tidiness

Risk of Fire

Making efforts to prevent fire is by all means important, but it is necessary to train the procedures to follow in an event of a fire on a routine basis.

The following is a general fire prevention measures.

- Do not leave combustible materials near the fire-using area.
- If you have to use a flame temporarily, obtain permission from the user company or supervisor before conducting the corresponding work.
- When conducting welding or gas cutting works, cover with an incombustible sheet and prevent a flame.
- While using a flame, prepare fire extinguishers.
- After using a flame, clean up the site.
- Prepare fire extinguishers and fire hydrants, and replace them with new ones periodically.
- If the insulation of an electrical wiring is damaged, repair or replace it immediately.
- To prevent a fire due to old and deteriorated wiring, check and replace deteriorated wiring.
- Control build up of static electricity.

In addition to these, always conduct the measures for preventing a fire.

Fig. 1-21 Risk of Fire

Communication with MHISH

Please inform MHISH about the points you have noticed about safety when contracting and having the engine delivered, or while operating the engine. MHISH is willing to have sufficient communication with the customer.

Fig. 1-22 Communication with MHISH

Note

- **For the details described in this Operation & Maintenance Manual, if you want to have more detailed information or questions, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8)**
- **If you establish the protection measures, use this Operation & Maintenance Manual and warning labels on this engine and each device as "Usage Information".**

2 ENGINE - OUTLINE

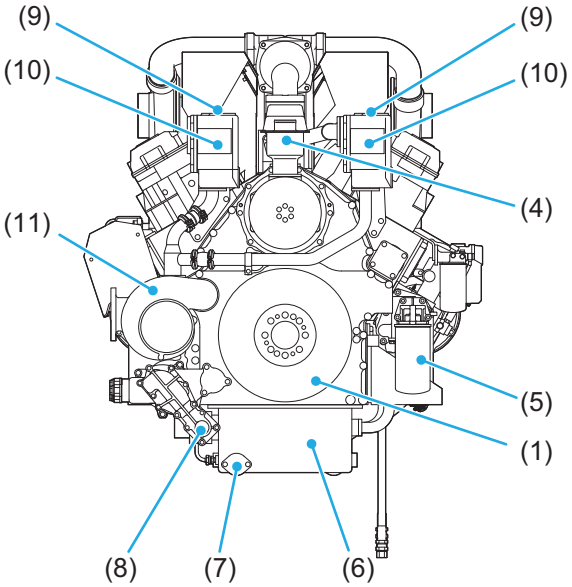
This chapter describes the engine parts and the location of protection devices.
The descriptions are based on the standard data of an engine built as a unit, which may become altered depending on the specifications of your devices or the construction work made by the generator supplier.

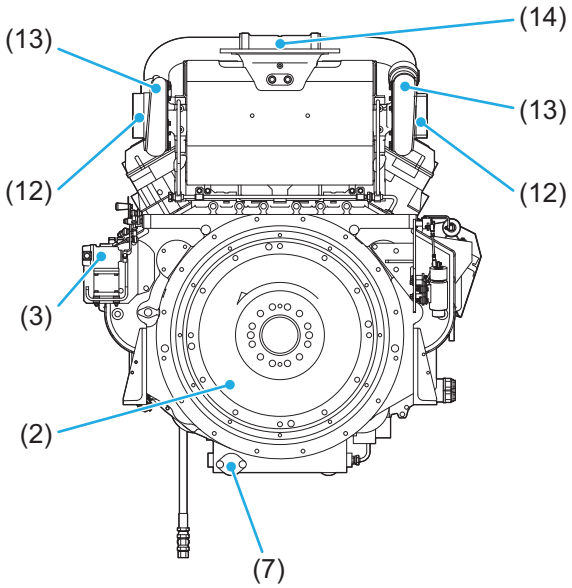
Names of Parts

Refer to the pages corresponding your engine type.

S12R-PTA, S12R-PTA2

■ Engine Front View, Engine Rear View

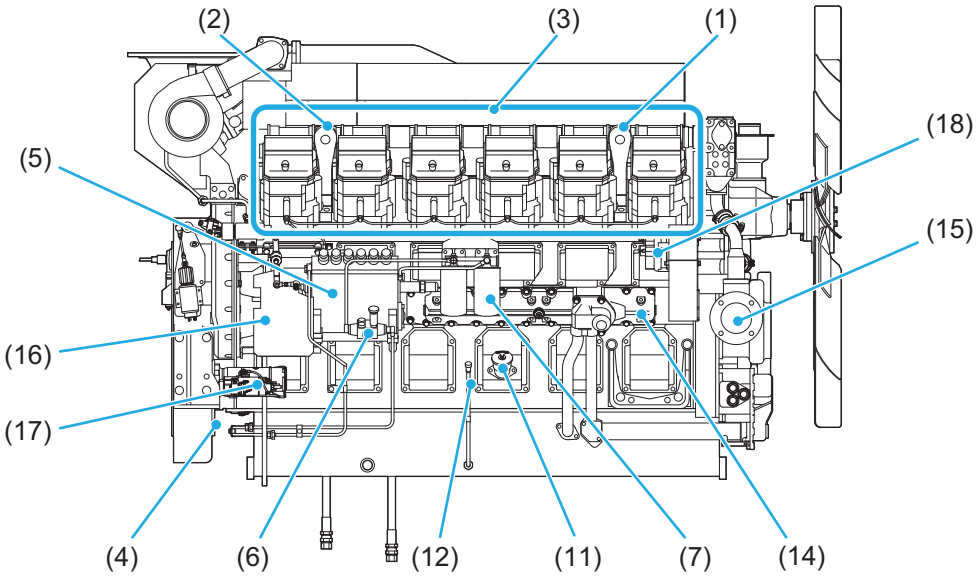




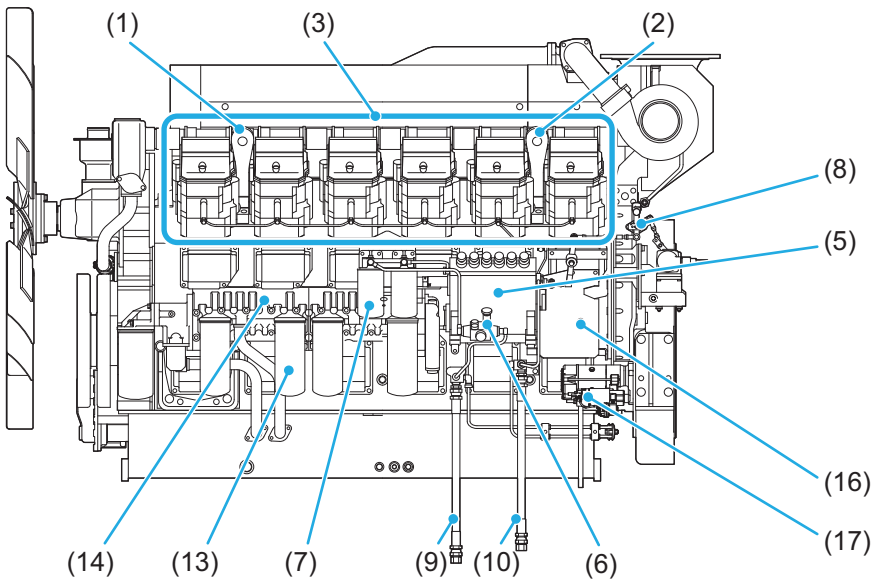
	No.	Name
Engine body	(1)	Damper
	(2)	Flywheel
Fuel system	(3)	Governor actuator
Lubrication system	(4)	Breather
	(5)	Bypass oil filter
	(6)	Oil pan
	(7)	Engine oil drain port
	(8)	Oil pump

	No.	Name
Cooling system	(9)	Coolant outlet
	(10)	Thermostat case
	(11)	Water pump
Inlet and exhaust systems	(12)	Intake port
	(13)	Turbocharger
	(14)	Exhaust outlet

■ Right Side View



■ Left Side View

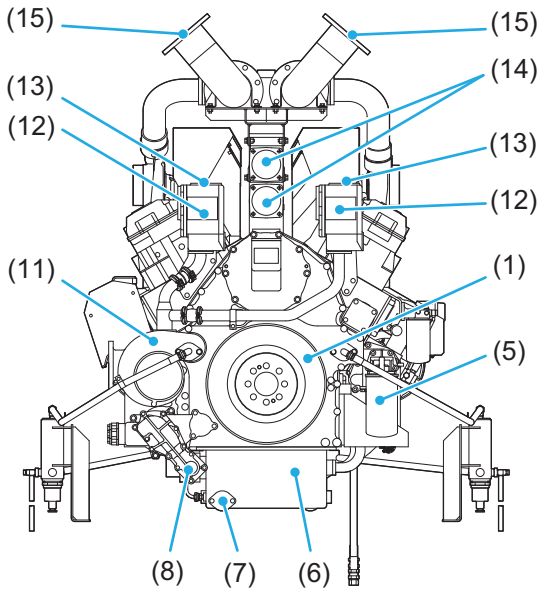


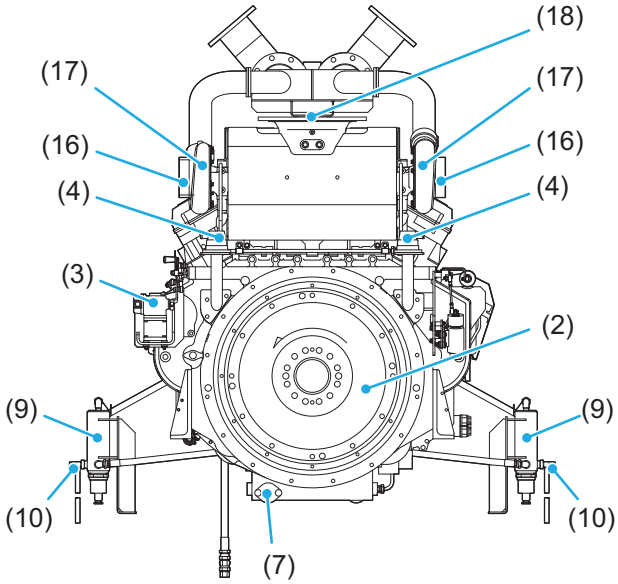
	No.	Name
Engine body	(1)	Front hanger
	(2)	Rear hanger
	(3)	Cylinder head
	(4)	Manual turning gear
Fuel system	(5)	Fuel injection pump
	(6)	Priming pump/ Fuel feed pump
	(7)	Fuel filter
	(8)	Fuel control link
	(9)	Fuel inlet
	(10)	Fuel return port

	No.	Name
Lubrication system	(11)	Oil filler
	(12)	Oil level gauge
	(13)	Oil filter
	(14)	Oil cooler
Cooling system	(15)	Coolant inlet
	(16)	Coolant drain cock
Starting system	(17)	Starter
Electrical system	(18)	Alternator

S12R-PTAA2

■ Engine Front View, Engine Rear View

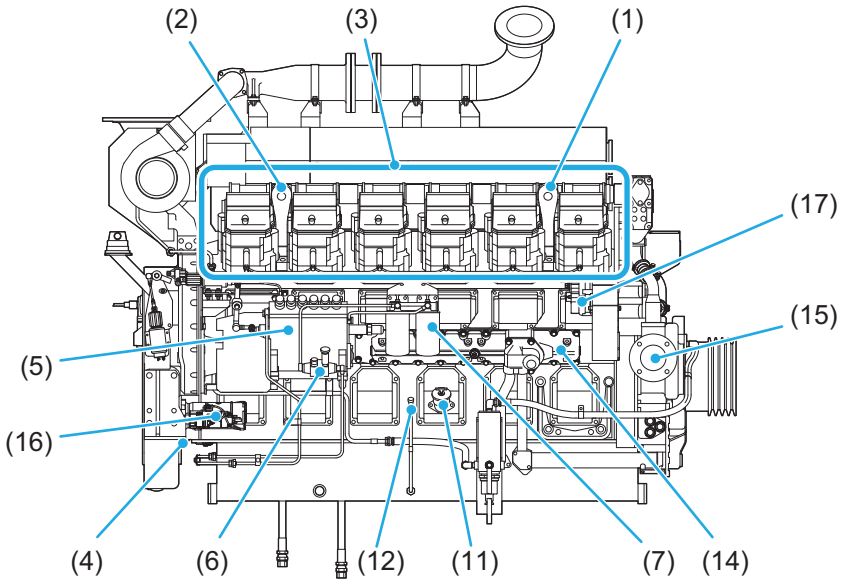




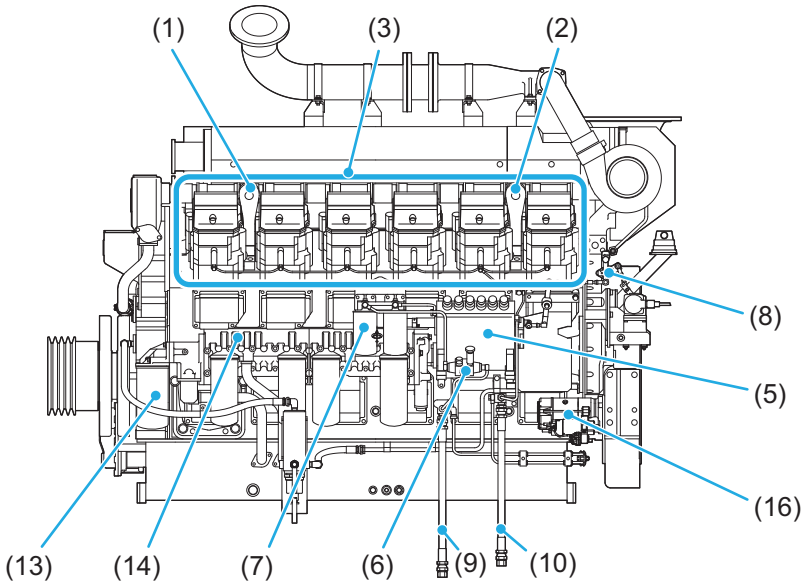
	No.	Name
Engine body	(1)	Damper
	(2)	Flywheel
Fuel system	(3)	Governor actuator
Lubrication system	(4)	Breather
	(5)	Bypass oil filter
	(6)	Oil pan
	(7)	Engine oil drain port
	(8)	Oil pump

	No.	Name
Cooling system	(9)	Water heater
	(10)	Coolant drain cock
	(11)	Water pump
	(12)	Thermostat case
	(13)	Coolant outlet
Inlet and exhaust systems	(14)	Intake port (from air cooler)
	(15)	Intake air outlet (to air cooler)
	(16)	Intake port
	(17)	Turbocharger
	(18)	Exhaust outlet

■ Right Side View



■ Left Side View



	No.	Name
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	(8)	Fuel control link
	(9)	Fuel inlet
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	No.	Name
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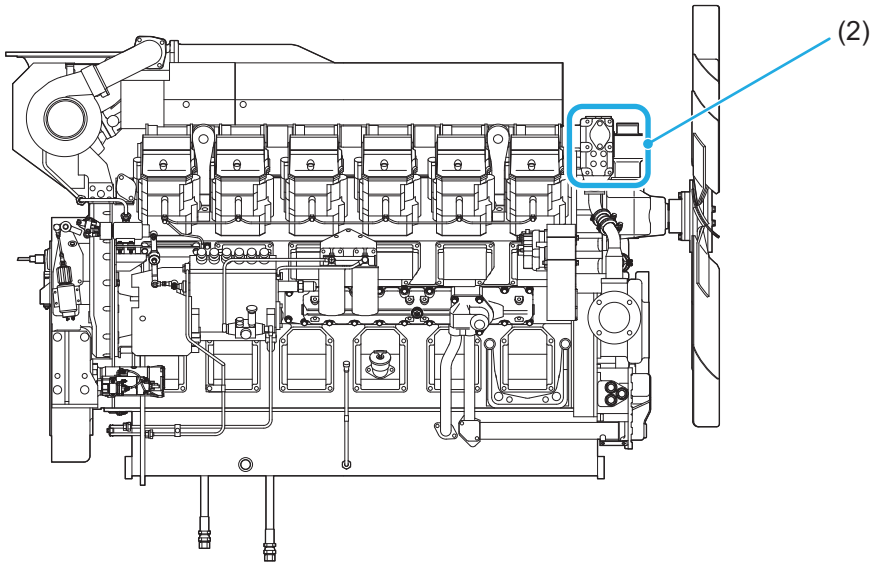
	(12)	Oil level gauge
	(13)	Oil filter
	(14)	Oil cooler
Cooling system	(15)	Coolant inlet
Starting system	(16)	Starter
Electrical system	(17)	Alternator

Protection System - Location

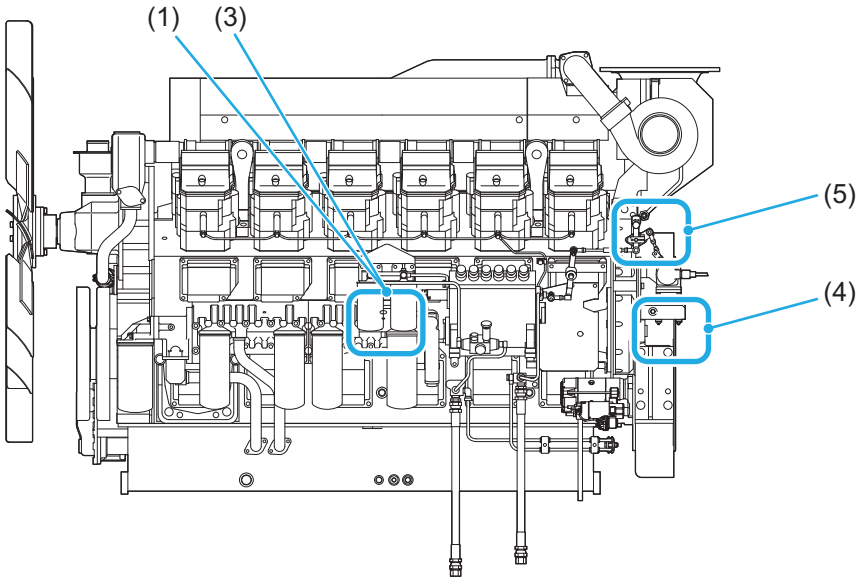
Refer to the pages corresponding your engine type.

S12R-PTA, S12R-PTA2

■ Right Side View



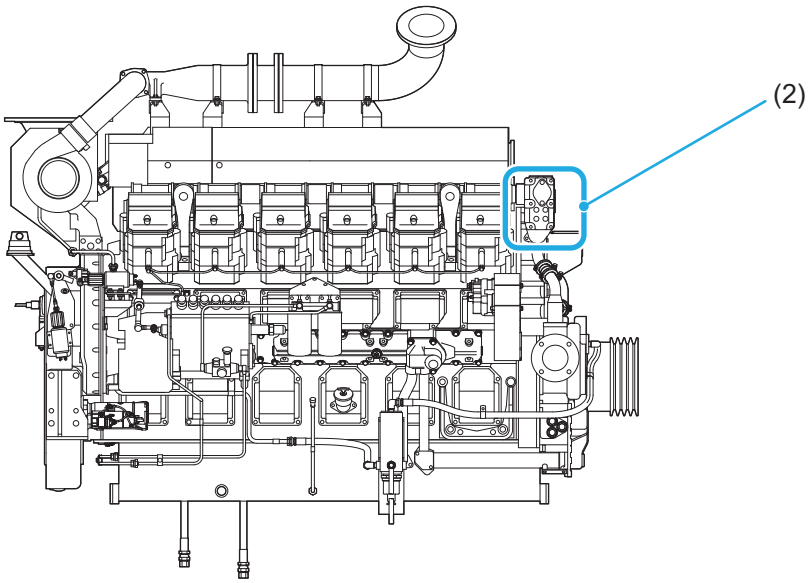
■ Left Side View



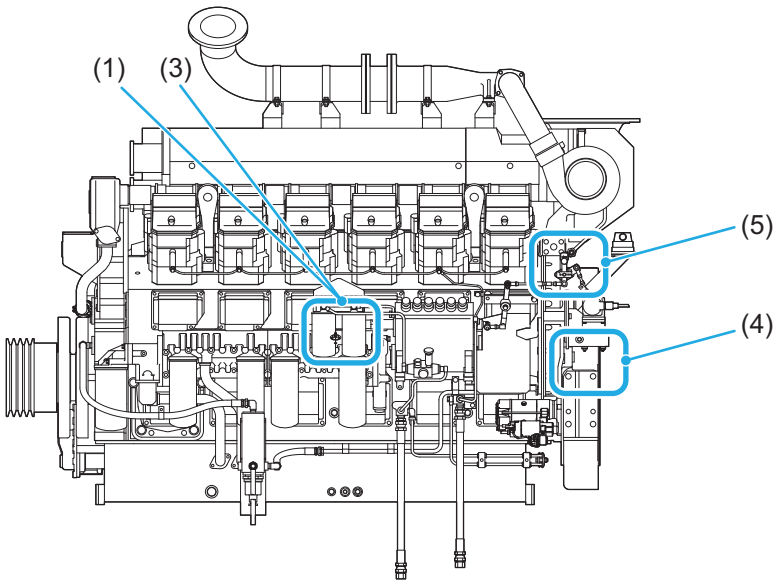
No.	Name
(1)	Oil pressure switch
(2)	Thermo switch
(3)	Oil filter alarm switch
(4)	Rotational detection pickup
(5)	Manual stop lever

S12R-PTAA2

■ Right Side View



■ Left Side View



No.	Name
(1)	Oil pressure switch
(2)	Thermo switch
(3)	Oil filter alarm switch

No.	Name
(4)	Rotational detection pickup
(5)	Manual stop lever

Starting and Stopping Devices Installed during Manufacturing the Generator

Compile the information about the starting and stopping devices as well as operation panels installed during manufacturing the generator and attach it below.
Also ensure that their locations and function are instructed to, and understand by the operators in addition to the details of the "Safety Manual".

Please compile the information about the starting and stopping devices as well as operation panels installed during manufacturing the generator and attach it on this page.

3 OPERATION

This chapter describes the operation procedures.

Operation - Outline

The method of operation depends on the intended use and starting system of the engine.
Refer to "SPECIFICATIONS - CHECK" (→ Page 10), and check the intended use and starting system previously.

The flow of operation is as shown in the diagram below.

<Intended use>

Continuous :Continuous use engine

Emergency :Emergency use engine

<Starting system>

Common :Common to all starting systems

Self starter :Self Starter Motor Starting

Air direct :Air Direct Admission Starting

Air motor :Air Motor Starting

1 Daily Check

Continuous Emergency Common

- Operational Environment - Check
- Engine Exterior - Check

2 Pre-operation Check

Continuous Emergency

- Fuel Tank Oil Level - Check Common
- Fuel Control Link - Check Common
- Engine Oil Level - Check Common
- Coolant Level - Check Common
- Battery - Check Common
- Pre-cleaner - Check for Clogging Common
- Air Cleaner - Check for Clogging Common
- Damper Temperature - Check Common
- Manual Turning Gear - Check Common
- Air Direct Admission Starting - Check Air direct
- Air Motor Starting - Check Air motor

3 Engine Start-up Continuous Emergency

- Self Starter Motor Starting Self starter
- Air Direct Admission Starting Air direct
- Air Motor Starting Air motor

4 Warm-up Operation

Continuous Emergency Common

5 Operation

Continuous Emergency Common

- Checking During Operation

6 Cooling Operation

Continuous Emergency Common

7 Stopping

Continuous Emergency Common

8 Checking After Stopping

Continuous Emergency Common

Maintenance Operation

Continuous Emergency Common

Daily Check

Check the following iitems everyday, even when the engine is not started.

Note

- **Devices and equipment outside the scope of our supply are included in the facility.**
  For the details, refer to such a document as the specifications sheet prepared by the generator manufacturer.
- **For the devices and equipment outside the scope of our supply, refer the corresponding manual of the generator and the supplier's operation manual.**

Operational Environment - Check

⚠ WARNING

Do not operate in an environment below the lower limit of the ambient temperature specified in the specifications sheet.

* Otherwise, flue explosion may occur, which could cause serious personal injury or damage to the devices.
* When operating in an environment below the lower limit of the ambient temperature, it is necessary to install an additional water heater.

Do not operate in an environment above the upper limit of the ambient temperature specified in the specifications sheet.

* A violation of the law related to the devices could result.
* Damage to the engine due to overheat or worsen exhaust values will result.
* When operating in an environment above the upper limit of the ambient temperature, it is necessary to reexamine the operating conditions and operating time.

Keep away from fire, when working with flammable substances such as fuel, engine oil, coolant (LLC), grease, rust preventive oil and anti-corrosive agent.

* They could cause a fire.

Do not place flammable substances such as fuel and engine oil around the engine.

* They could cause a fire.

⚠ WARNING

Make sure that there is no water (especially, seawater or rain water) seeped in the air intake and exhaust ports.

* Piston scuffing (contact of the piston with the cylinder inner wall) and damage to the devices could result.

Make sure that no foreign particles get into the air inlet.

* They could cause damage to the turbocharger and lead to serious problems in the engine.

Make sure that there is no contamination of water into the fuel, engine oil, air inlet and exhaust systems and combustion chambers.

* Flue explosion, deterioration in the exhaust gas properties or damage to the devices could result.

Make sure that there is no clogging in the air cleaner or pre-cleaner.

* Otherwise, the engine stopping device will work to stop the engine suddenly and cause deterioration in the exhaust gas properties.

Make sure that there is no clogging in the air cleaner element or pre-cleaner element.

* The thermal load could increase excessively and will cause piston scuffing.

Before maintaining electrical components, place the battery switch to the OFF position or disconnect the battery negative (-) terminal.

* Electric shock could result when electricity flows through the circuit.

Be sure to operate the engine in an environment of appropriate humidity.

* High humidity, inrush of rain water, or water condensation in the combustion chamber may cause falling off of valves or water hammering and lead to damage to the devices.

⚠CAUTION

Before starting the engine, check that there are no bolts, nuts, tools, etc. around the rotating parts.

* When the rotating parts work, the above objects can fly and cause personal injury or damage to the surrounding.
* Entanglement in rotating parts could cause machine damage.

Check that the terminals and connectors of the electrical system are connected correctly.

* Otherwise, starting failure or overrun due to inability to stop the engine could occur.

Note

- **Obey the environmental requirements such as ambient temperature and humidity specified in the contract specifications.**
  Otherwise, overheat or overcooling may occur.
  In case of overheat or overcooling, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).
- **Do not install the engine in the following places:**
  - **In a dusty place**
  - **In an atmosphere of inflammable gas**
  - **In a place where salt damage may occur**

  Otherwise, a fire or damage to the devices may occur.
- **Operating the engine in an environment exposed to strong electromagnetic fields may cause uncontrollability or overrun of the engine due to the malfunction of the electronic governor. When operating the engine in an environment possibly exposed to strong electromagnetic fields, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

Make sure the following measures are taken.

(a) Air intake port
- Prevent inrush of water (especially sea water and rainwater)
- Prevent contamination by foreign materials

(b) Rotating parts
- Prevent contamination by foreign materials
- Prevent contact with human body (install a protective cover)

(c) Hot parts
- Prevent contact with human body (confirm warning labels)

(d) Electrical system
- Prevent adhesion of water and dust

(e) Ambient temperature
- Keep in the range between 5 and 40°C [41 and 104°F]

(f) Coolant temperature
- Control properly

(g) Additional equipment of generator (water heater etc.)
- Control properly

Engine Exterior - Check

⚠ WARNING

Make sure that any accumulation of flammables, fuel leaks, engine oil leaks, moisture, etc. are not found around the hot parts of the engine (exhaust manifold) and the battery.

* They could cause a fire.

Make sure that a coolant leak from any part of the engine is not found.

* Coolant will flow out.

Make sure that the open/close conditions of the valves, plugs and cocks on each line are normal.

* Otherwise, the engine may seize.

Make sure that the open/close condition of the coolant drain cock on the water pump is normal.

* Otherwise, insufficient cooling could occur and it could cause serious damage to the devices.

Make sure that the engine oil leak from any part of the engine is not found.

* If engine oil gets in your eyes, it will cause pain and lead to sight loss at the worst.

⚠ CAUTION

Before stating the engine, check the battery and cable terminals for corrosion. In addition, check the connections for looseness.

* Defective contact or short circuit could cause damage to the devices.

1 **Check combustible materials near the engine or battery.**
→If combustible materials or dust are found near the engine or battery, remove them.

2 **Check the engine and battery for contamination.**
→If dirty, clean them.

3 **Check a leak of fuel, engine oil, or coolant from any part of the engine.**

Note

- **If a leak is found, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8) to arrange the repair.**

4 **Check the alternator belt tension. "Belt - Check" (→ Page 127)**

5 **Check bolts and nuts for looseness from the outside.**

6 **Check the battery and cable terminals and connections for corrosion or looseness.**

Note

- **If an abnormality is found, consult your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

7 **Check the following open/close conditions.**
- Fuel feed valve: open
- Coolant drain cock (plug): closed
- Engine oil drain valve: closed

Pre-operation Check

⚠ WARNING

Be sure to perform the pre-operation check and scheduled maintenance as instructed in this Operation & Maintenance Manual.

* Failure to perform the pre-operation check and scheduled maintenance may cause various engine problems and breakage to parts, which may result in serious accidents.

Before starting the engine, make sure the protective covers of the engine are correctly installed.

* If you are caught in rotating parts, you could be seriously injured.

Before starting the engine, be sure to always perform the check mentioned below.

Note

- **Devices and equipment outside the scope of our supply are included in the facility.**
  For the details, refer to such a document as the specifications sheet prepared by the generator manufacturer.
- **For the devices and equipment outside the scope of our supply, refer the corresponding manual of the generator and the supplier's operation manual.**

Fuel Tank Oil Level - Check

⚠ WARNING

When discarding a waste cloth used to wipe off combustible material, put it into a lidded can and obey the Waste Management and Public Cleansing Act to handle it as a special industrial waste.

* It may cause a fire.
* It could lead to environmental pollution.
* If you violate rules, you may be subject to penalties.

Before handling fuel, remove static electricity.

* Otherwise, the fuel could be ignited.
* Ground the fuel tank.

⚠ CAUTION

Do not remove the strainer while filling the fuel tank.

* Otherwise, foreign particles could enter and cause damage to the fuel pump.

Note

- **When handling fuel, refer to "4 FUEL" (→ Page 98).**
- **The fuel tank is outside the scope of our supply. For the details, refer to such a document as the corresponding manual of the generator and the supplier's operation manual.**

1 **Check the fuel tank oil level.**

2 **Refuel the fuel tank to the upper limit of the specified quantity.**

Fuel Control Link - Check

Refer to "Fuel Control Link - Check" (→ Page 143).

Engine Oil Level - Check

Refer to "Engine Oil Level - Check" (→ Page 86).

Note

- **When handling engine oil, refer to "5 ENGINE OIL" (→ Page 103).**

Coolant Level - Check

⚠ DANGER

Use the genuine LLC specified in this Operation & Maintenance Manual.

* Otherwise, the devices could be damaged.

Keep LLC to be the specified concentration.

* If LLC concentration is low, it could cause corrosion of the radiator or heat exchanger.
* If LLC concentration is high, it may cause damage to the devices or overheat due to the seized engine parts.

⚠ WARNING

Do not open the radiator cap or coolant tank cap while the engine is hot.

* Otherwise, you could get burns by steam or water splashing out.

Tighten the drain cock on the water pump properly.

* Insufficient tightening may cause a coolant leak.

When handling coolant (LLC), always wear suitable personal protective equipment such as rubber gloves and protective eyeglasses.

* If LLC comes into contact with your eyes, it will result in sight loss at the worst.
* If LLC comes into contact with your skin while the engine is hot, you could get burned by heat.

Maintain the coolant level properly.

* If the coolant level is low, overheat or cavitation in the engine could occur.

Check the coolant level.

- If the level is low, refill the coolant. "Coolant - Refill" (→ Page 163)
- After refilling the coolant level, bleed air from the cooling system. "Cooling System - Bleed Air" (→ Page 164)

Note

- **When handling coolant, refer to "6 COOLANT" (→ Page 105).**
- **For how to check the coolant level, refer to the corresponding manual of the generator and the supplier's operation manual.**
- **For the specified quantity of coolant, refer to "SPECIFICATIONS - CHECK" (→ Page 10).**

Battery - Check

⚠ WARNING

Do not short the battery terminals.

* Otherwise, sparks could occur and cause a fire or an explosion.

Do not touch battery terminal with a wet hand.

* There are possibilities to get an electric shock.

When checking and servicing the battery, wear suitable personal protective equipment such as protective eyeglasses, rubber gloves, working clothes with long sleeves and long trousers.

* If battery fluid comes into contact with your eyes or skin, it may result in sight loss or burns.

Note

- **The battery is outside the scope of our supply.**
  For the details, refer to such a document as the corresponding manual of the generator and the supplier's operation manual.

1 **Check the battery fluid level.**
- Refill the battery fluid, if necessary.

2 **Check the battery fluid specific gravity.**
- Charge the battery, if necessary.

Pre-cleaner - Check for Clogging

⚠ WARNING

Make sure that the pre-cleaner is free from clogging.

* Insufficient intake air could result in loss of power, incomplete combustion, exhaust gas temperature rise, and overspeed of the turbocharger.

Check the pre-cleaner for clogging.

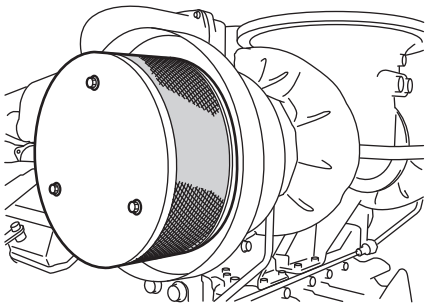


Fig. 3-1 Pre-cleaner - Check for Clogging

Air Cleaner - Check for Clogging

⚠ WARNING

Make sure that the air cleaner is free from clogging.

* Insufficient intake air could result in loss of power, incomplete combustion, exhaust gas temperature rise, and overspeed of the turbocharger.

Check the air cleaner for clogging.

Note

- **The air cleaner may be outside the scope of our supply. For the details, refer to such a document as the specification sheet prepared by the generator manufacturer.**
- **If it is not supplied by MHISH, follow the instructions in the supplier's operation manual.**

Damper Temperature - Check

⚠ WARNING

Make sure that the damper temperature is within the permissible range (for continuous use: 90°C [194°F] or lower; for emergency use: 100°C [212°F] or lower).

* Degradation of silicone oil could result in a loss of damping and breakage of the crankshaft.

On the damper, a thermo label is attached as a guide.
Check the temperature by using the thermo label as follows:

Note

- **For the location of the dampers, refer to "2 ENGINE - OUTLINE" (→ Page 73).**

1 **Check the heat-sensitive area of the thermo label and record the highest temperature.**
→If a temperature rise is observed, locate the defect in the engine or other causes.In addition, replace the thermo label with a new one and check the change of temperature again. "Damper Temperature - Check" (→ Page 132)

Note

- **A thermo label is attached as a guide.It is recommended to measure the temperature while operating the engine with a noncontact thermometer (thermo gun) and to control and record it accordingly.**
- **If the detected temperature comes close to the limit temperature of the damper as shown in the table below, or if there is any abnormal change of temperature, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

Table 3-1 Limit temperature of damper

Type of damper	Continuous use engine	Emergency use engine
Viscous damper	90°C [194°F]	100°C [212°F]

Manual Turning Gear - Check

⚠ DANGER

Before starting the engine, pull out the manual turning gear shaft.

* Starting the engine while the turning gear is engaged with the ring gear could result in serious personal injury or destruction of the engine.

⚠ WARNING

Make sure that the plate of the manual turning gear is securely engaged in the shaft groove.

* Otherwise, the devices could be damaged.

Check whether the manual turning gear is pulled out.

Note

- **For the location of the manual turning gear, refer to "2 ENGINE - OUTLINE" (→ Page 73).**

1 **Check that the manual turning gear shaft (1) is pulled out and fixed by the plate (2).**

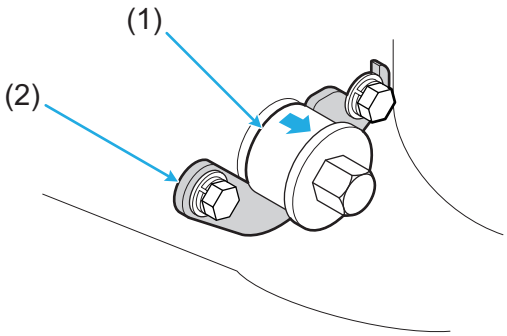


Fig. 3-2 Manual Turning Gear - Check

Air Direct Admission Starting - Check

■ Starting Air Tank - Check

⚠ WARNING

Be sure to drain water from the starting air tank.

* Otherwise, water could enter the cylinders when starting the engine.

Drain water from the starting air tank and check the air pressure.

Note

- **The starting air tank may be outside the scope of our supply. For the details, refer to such a document as the specification sheet prepared by the generator manufacturer.**
- **If it is not supplied by MHISH, follow the instructions in the supplier's operation manual.**

■ Starting Air Compressor - Check

Check the starting air compressor.

Note

- **The starting air compressor may be outside the scope of our supply. For the details, refer to such a document as the specification sheet prepared by the generator manufacturer.**
- **If it is not supplied by MHISH, follow the instructions in the supplier's operation manual.**

■ Air Filter - Check

Check the air filter.

Note

- **The air filter may be outside the scope of our supply. For the details, refer to such a document as the specification sheet prepared by the generator manufacturer.**
- **If it is not supplied by MHISH, follow the instructions in the supplier's operation manual.**

■ Starting Valve - Check

Check the starting valve.

Note

- **The starting valve may be outside the scope of our supply. For the details, refer to such a document as the specification sheet prepared by the generator manufacturer.**
- **If it is not supplied by MHISH, follow the instructions in the supplier's operation manual.**

Air Motor Starting - Check

■ Starting Air Tank - Check

⚠ WARNING

Make sure that the air pressure in the starting air tank satisfies the specification.

* If starting is attempted several times in a row, the air motor could get damaged.

⚠ CAUTION

Be sure to drain water from the starting air tank.

* Otherwise, water could enter the air motor when starting the engine.

Drain water from the starting air tank and check the air pressure.

Note

- **The starting air tank may be outside the scope of our supply. For the details, refer to such a document as the specification sheet prepared by the generator manufacturer.**
- **If it is not supplied by MHISH, follow the instructions in the supplier's operation manual.**

■ Starting Air Compressor - Check

Check the starting air compressor.

Note

- **The starting air compressor may be outside the scope of our supply. For the details, refer to such a document as the specification sheet prepared by the generator manufacturer.**
- **If it is not supplied by MHISH, follow the instructions in the supplier's operation manual.**

■ Air Filter - Check

Check the air filter.

Note

- **The air filter may be outside the scope of our supply. For the details, refer to such a document as the specification sheet prepared by the generator manufacturer.**
- **If it is not supplied by MHISH, follow the instructions in the supplier's operation manual.**

■ Reducing Valve - Check

Check the reducing valve.

Note

- **The reducing valve may be outside the scope of our supply. For the details, refer to such a document as the specification sheet prepared by the generator manufacturer.**
- **If it is not supplied by MHISH, follow the instructions in the supplier's operation manual.**

■ Lubricator - Check

Check the lubricator.

Note

- **The lubricator may be outside the scope of our supply. For the details, refer to such a document as the specification sheet prepared by the generator manufacturer.**
- **If it is not supplied by MHISH, follow the instructions in the supplier's operation manual.**

Engine Start-up

⚠ WARNING

Do not apply load to the engine at startup.

* Otherwise, the devices could be damaged.

Do not use the starter continuously for 10 seconds or longer. In case that the engine does not start after three consecutive trials, contact your Mitsubishi dealer.

* Otherwise, flue explosion due to the accumulation of unburnt fuel or burn-damage to the starter may occur.

While a warning sign such as "DO NOT OPERATE" is hanged out on the starting system, do not start the engine.

* Otherwise, serious personal injury, environmental pollution or damage to the devices could occur.

Do not start the engine with water inside its combustion chamber.

* Otherwise, water hammering could cause damage to the engine inner parts and a serious accident.

Before starting the engine, make sure there is no one in the vicinity of the engine.

* Otherwise, he/she may be caught in the rotating parts and get seriously injured or suffer noise-induced hearing loss.

Note

- **Devices and equipment outside the scope of our supply are included in the facility. For the details, refer to such a document as the specifications sheet prepared by the generator manufacturer.**
- **For the devices and equipment outside the scope of our supply, refer the corresponding manual of the generator and the supplier's operation manual.**

Self Starter Motor Starting

A general starting procedure is as follows:

Note

- **The engine start switch is outside the scope of our supply. For the details, refer to such a document as the corresponding manual of the generator and the supplier's operation manual.**

1 **Operate the start switch of the generator "Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81)to start the engine.**

Air Direct Admission Starting

A general starting procedure is as follows:

Note

- **The starting air tank and starting system may be outside the scope of our supply. For the details, refer to such a document as the specification sheet prepared by the generator manufacturer.**
- **If it is not supplied by MHISH, follow the instructions in the supplier's operation manual.**

1 **Check the air pressure gauge to see if the air pressure in the starting air tank satisfies the specification.**

2 **Open the main valve of the starting air tank.**

3 **Operate the start switch of the generator "Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81) to start the engine.**

→If the engine doesn't start, check the points below and reset the pressure in the starting air tank. Restart the engine after 2 minutes interval.

- Is the air pressure gauge in order?
- Is a leak found from the air system?

Note

- **In case there is an abnormality or the engine does not start after three consecutive trials, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

4 **After the engine has started, close the main valve of starting air tank.**

Air Motor Starting

A general starting procedure is as follows:

Note

- **The starting air tank and starting system may be outside the scope of our supply. For the details, refer to such a document as the specification sheet prepared by the generator manufacturer.**
- **If it is not supplied by MHISH, follow the instructions in the supplier's operation manual.**

1 **Check the air pressure gauge to see if the air pressure in the starting air tank satisfies the specification.**

2 **Open the main valve of the starting air tank.**

3 **Operate the start switch of the generator "Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81)to start the engine.**

→If the engine doesn't start, check the points below and reset the pressure in the starting air tank. Restart the engine after 2 minutes interval.

- Is the air pressure gauge in order?
- Is a leak found from the air system?
- Does too much oil flow out of the air motor muffler (1)?

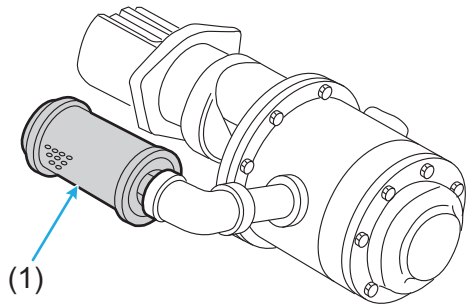


Fig. 3-3 Air Motor Muffler

Note

- **In case there is an abnormality or the engine does not start after three consecutive trials, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

4 **After the engine has started, close the main valve of starting air tank.**

Warm-up Operation

⚠ WARNING

Stay away from rotating parts during operation.

* Otherwise you may get caught in the rotating parts and seriously injured.

Do not apply excessive load when the engine is cold.

* Otherwise, it could cause a failure.
* If the engine is driven at an idle speed in the low load range for a prolonged period of time, unburnt fuel may accumulate in the flue and explode.

When operating at low load (less than 30%), limit the operation to an hour or less.

* Prolonged warm-up operation causes carbon build-up in the cylinders that leads to incomplete combustion.
* After one hour operation at a low load, operate the engine at 50% or more of rated load for 30 minutes or longer to prevent the formation of carbon deposits.

While the engine is warming up, check the connections for leak (fuel, engine oil, coolant and exhaust gas). If an abnormality is found, stop the engine immediately.

* Otherwise, a fire or damage to the devices may occur.
* It could lead to carbon monoxide intoxication or environmental pollution.

Applying an excessive load when the engine is cold may cause failure. Be sure to warm up the engine according to the operating guidelines of the generator.

1 **Warm up the engine according to the starting sequence of the generator.**

- When warming up the engine by setting particularly, operate it at no load and idle speed.

2 **Check the engine oil pressure with the oil pressure gauge.**

- Standard value: 0.3 MPa {3.06 kgf/cm^2} [43.51 psi] or more

3 **Check the connections for a leak of fuel, engine oil, coolant and exhaust gas.**

- Check around the engine thoroughly.

Note

- **If a leak is found, stop the engine and contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

Operation

⚠ WARNING

Stay away from rotating parts during operation.

* Otherwise you may get caught in the rotating parts and seriously injured.

Do not approach the engine side without care during operation.

* Serious injury may result due to unexpected device operation.

Do not touch any part of the engine (other than the manual stop lever) during or immediately after operation and immediately after stopping.

* If you touch, you could get burned by heat.
* Before starting the inspection and maintenance work, make sure that the engine is cooled down.

Do not turn off the battery switch during operation.

* Otherwise, the instruments will become inoperable, damage to the devices due to operation at low oil pressure may occur, the engine may be forcibly stopped by the solenoids, or the engine may become unable to stop.
* It may also cause degradation of the diodes and transistors in the alternator.

Never turn the key to the "START" position during operation.

* Otherwise, the starter could be damaged.

Do not remove the protective covers during operation.

* If you are caught in rotating parts, you could be seriously injured.

Do not perform the inspection and maintenance work during operation.

* Unexpected activation of the devices could cause serious personal injury or damage to the devices.

Do not clean the engine during operation.

* Otherwise, water or cleaning solution could enter the engine, and will cause piston scuffing and damage to the devices.

Do not operate the engine at no load or low load for a prolonged period of time.

* Otherwise, it could cause deterioration in the exhaust gas properties.

⚠ WARNING

Do not operate the engine at a load exceeding the specified value or for a prolonged period of time.

* Otherwise, the main bearing or connecting rod bearing could seize.
* The thermal load could increase excessively and will cause piston scuffing.
* Otherwise, the crankshaft stress could become too large, and the crankshaft could crack or break.

Do not approach near the breather or breather gas.

* The breather releases breather gas in the air. Contacting the breather gas may cause burns.

Ventilate the machine room (engine room) sufficiently.

* Otherwise, deterioration in the exhaust gas properties and damage to the devices could occur due to insufficient air intake.

When operating at low load (less than 30%), limit the operation to an hour or less.

* Prolonged warm-up operation causes carbon build-up in the cylinders that leads to incomplete combustion.
* After one hour operation at a low load, operate the engine at 50% or more of rated load for 30 minutes or longer to prevent the formation of carbon deposits.

Be sure to start the engine according to the operating guidelines of the generator.
After continuous operating at low load (less than 30%), operate the engine at 50% load or more for 30 minutes or longer.

Note

- **Devices and equipment outside the scope of our supply are included in the facility. For the details, refer to such a document as the specifications sheet prepared by the generator manufacturer.**
- **For the devices and equipment outside the scope of our supply, refer the corresponding manual of the generator and the supplier's operation manual.**

Checking During Operation

⚠ WARNING

If an engine abnormality is observed during operation, stop the engine immediately.

* Sustained use of the engine without any remedy could cause serious personal injury or damage to the devices.
* Investigate the cause of abnormality, correct the defect, then restart the engine.
* If the cause of problem cannot be located, contact your Mitsubishi dealer.

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

* Overload could not only cause increase in fuel consumption but also lead to malfunction and environmental pollution (outbreak of the black smoke) due to carbon deposits.

Check exhaust pipes and pipe joints for exhaust gas leaks.

* Otherwise, it may cause carbon monoxide intoxication and lead to death at the worst.
* If an exhaust leak is found, contact your Mitsubishi dealer.

If an abnormal engine oil pressure drop is observed, stop the engine immediately, and check the engine oil system to locate the cause.

* Sustained use of the engine without any remedy could cause seizure of the bearings and lead to serious damage to the devices.
* If the cause of problem cannot be located, contact your Mitsubishi dealer.

If a belt breaks, stop the engine immediately and replace the belt.

* Sustained use of the engine without any remedy could cause defective battery charge and cooling fault, and result in serious engine problems.

⚠ CAUTION

Keep the intake air temperature at the specified level.

* If the intake air temperature is higher than the specified level, the engine stopping device may work due to the increased exhaust temperature and stop the engine suddenly.
* The thermal load could increase excessively and will cause piston scuffing.
* If the intake air temperature cannot be kept at the specified level, reconsider the operating conditions and operating time.

Keep the engine oil and coolant temperatures at the specified level.

* If the engine oil or coolant temperatures is increased, the engine stopping device may work due to the increased exhaust temperature and stop the engine suddenly.

During engine operation, check engine for abnormal noise and vibrations due to knocking, and leaks from pipes.
Also carefully check the followings for abnormalities.

Table 3-2 Checking During Operation

Check item	Criteria/Reference Value
Warning indicator/in-struments	Lighting/numerical value normality
Engine speed/ frequency	No large fluctuation
Breather mist volume	To be normal.
Exhaust color	To be normal.
Damper temperature*	For continuous use: 90°C [194°F] or lower For emergency use: 100°C [212°F] or lower
Engine oil pressure	0.39 MPa {3.98 kgf/cm^2} [56.56 psi] or more
Engine oil temperature (Oil pan)	110°C [230°F] or lower
Coolant temperature	70 to 90 °C [158 to194°F] (in the water jacket)
Exhaust temperature	550.0°C [1022°F] or lower
Intake air pressure	0.15 to 0.25 MPa {1.53 to 2.55 kgf/cm^2} [21.76 to 36.26 psi]

*: Check, control and record the temperature change during operation. Checking by means of a noncontact thermometer (thermo gun) is recommended.

Note

- **If any abnormality is found, refer to "11 TROUBLESHOOTING" (→ Page 179) and correct the defect.**

Cooling Operation

⚠ WARNING

Except in a time of emergency, operate the engine at low idle for 5 to 6 minutes to cool down before stopping the engine.

* If the engine is stopped without cooling down, the devices could be damaged.

⚠ CAUTION

Do not stop the engine suddenly at high speed.

* It could cause damage to the devices due to degradation of the damper or stopped circulation of the engine oil to the turbocharger.

Stopping the engine suddenly at high speed or high load could cause a malfunction.
Be sure to cool down the engine according to the operating guidelines of the generator.

1 **Cool down the engine according to the stopping sequence of the generator.**

- When cooling down the engine by setting particularly, operate it for 5 to 6 minutes at an idle speed.

Stopping

⚠ WARNING

Do not restart the engine immediately after an abnormal stop.

* Investigate the cause of abnormality, correct the defect, then restart the engine.

Do not race the engine immediately before shutting it down.

* Otherwise, the devices could be damaged.

Be sure to stop the engine as per the operating guidelines of the generator.

1 **Operate the stop switch of the generator "Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81) to turn off the engine.**

Note

- **If the engine will not stop, perform an emergency stop by means of the manual stop lever of the engine. "Emergency Stop Procedure" (→ Page 63)**

Checking After Stopping

Check that a fuel, oil or coolant leak from any part of the engine is not found after the engine is stopped.

Note

- **In case of an unallocated defective point or leakage, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

Maintenance Operation

In order to ensure performance of the engine, perform maintenance operation regularly, in case that both of the engines for continuous use and emergency use will not be used for a long time.

Note

- **For the generator set of emergency use, maintenance operation and/or the report according to the Electric Utilities Industry Law, Fire Services Law, or Building Standard Law etc. is obliged according to the generator set application.**
- **The method of inspection and maintenance, and maintenance operation differs according to the device. Contact the device supplier.**

■ Once a Week

Operate the engine for 5 to 10 minutes at no load and check the following points:

- Startability, exhaust color
- Abnormal vibration, noise and odor
- Indication of various instruments (oil pressure gauge, water temperature gauge, oil temperature gauge, exhaust temperature gauge, tachometer, etc.)

Note

- **If any abnormality is found, refer to "11 TROUBLESHOOTING" (→ Page 179) and correct the defect.**

■ Once a Month

Operate the engine at least for 30 minutes at 50% load or more and check the following points:

- Startability, exhaust color
- Abnormal vibration, noise and odor
- Indication of various instruments (oil pressure gauge, water temperature gauge, oil temperature gauge, exhaust temperature gauge, tachometer, etc.)
- Fuel injection pump and governor rack movement
- Damper temperature and external view

Note

- **If any abnormality is found, refer to "11 TROUBLESHOOTING" (→ Page 179) and correct the defect.**

4 FUEL

This chapter describes the fuel which is used for this engine.

Fuel

⚠ WARNING

Do not refill the fuel tank more than the specified level.

* Otherwise, fuel will leak out and may cause a fire.

Do not mix and use fuels of different types and/or manufacturers.

* Otherwise, damage to the fuel supply pump or deterioration in the exhaust gas properties may occur.

Do not use fuel after the recommended storage expiration date.

* Otherwise, incomplete combustion may occur, which could result in flue explosion or deterioration in the exhaust gas properties.

Use only the fuel that meets our fuel quality standards specified in this Operation & Maintenance Manual.

* Otherwise, damage to the fuel supply pump or deterioration in the exhaust gas properties may occur.
* Using a fuel with low cetane number (lower than 45) may result in flue explosion.

Change the fuel remained in the tank or the pipelines over the period recommended by the manufacturer with new fuel.

* Otherwise, deterioration in the components may cause clogged pipe lines, which could result in starting failure.

Note

- **Use a fuel which meets the requirements specified in "Fuel Quality Standard" (→ Page 100).**
  Do not mix and use fuels of different types and/or manufacturers.

Diesel Fuel

If the using engine is not an emission control approved model, use the diesel fuel from "Table 4-1 Fuel Specifications".
Also choose the fuel with the pour point which meets the environmental temperature.

Note

- **Select the fuel used for the engine to conform to the laws and regulations of the country and area where the engine is used.**

Table 4-1 Fuel Specifications

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 K 2204	Special No.1,No.1, No.2, No.3, Special No.3
EN 590	DIESEL-FUEL

Fuel - Handling

⚠ WARNING

Do not discard waste oil into sewerage, river, lake or other similar places.

* Be sure to discard waste oil in accordance with the applicable laws and regulations.

Do not store fuel in a poorly ventilated place.

* Otherwise, vaporized fuel may build up, which could cause an explosion or a fire on exposure to a flame.

Before handling fuel, remove static electricity.

* Otherwise, the fuel could be ignited.
* Ground the fuel tank.

When working with fuel, wear suitable personal protective equipment such as protective mask, protective eyeglasses, rubber gloves, working clothes with long sleeves and long trousers.

* If fuel comes into contact with your eyes, mouth or skin, it will cause irritation or disorders.

Do not breathe in vaporized fuel.

* Otherwise, it could be hazardous to your health.

When storing fuel in the container, close its cap tightly.

* Otherwise, vaporized fuel may build up, which could cause an explosion or a fire on exposure to a flame.

Note

- **Devices and equipment outside the scope of our supply are included in the facility.**
  For the details, refer to such a document as the specifications sheet prepared by the generator manufacturer.
- **For the devices and equipment outside the scope of our supply, refer the corresponding manual of the generator and the supplier's operation manual.**

Refill the fuel tank or a day tank up to the upper limit of the specified quantity at the end of each operation.

Note

- **By refilling up to the upper limit of the specified quantity, entering of water into the tank can be avoided. In addition, in case that dust or water entered into the tank, a time for separation and precipitation can be given.**

Fuel - Refill

⚠ WARNING

Be sure to drain water from fuel, and pay attention that coolant or other water will not get mixed with fuel.

* Otherwise, rust could form on the plunger, which could interfere engine stopping or cause flue explosion, dilution, or water hammering.

⚠ CAUTION

Do not remove the strainer while filling the fuel tank.

* Otherwise, foreign particles could enter and cause damage to the fuel pump.

When using fuel from a storage tank, leave it to sit for more than 24 hours so that dust and water can settle at the bottom. Then, use the upper clean fuel.

* Otherwise, clogging of the filter may occur, which could cause decrease in the output power.
* Depending on the specification of the tank, prolonged sedimentation time may be required.

- Before removing the cap of a drum can or the tank, clean its surrounding thoroughly. Also clean your hands and hoses.
- When pumping up fuel using a hand-operated pump, be careful not to pump water or sediment accumulated at the bottom of the storage tank.
- When filling the fuel tank, be sure to use a strainer so that foreign particles will not enter.

Fuel Quality Standard

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

Table 4-2 Fuel Properties Table (1/2)

Item		Recommended limit	Service limit	Remark
Flash point		Diesel fuel 50°C [122°F] or higher	50°C [122°F] or higher (depending on the laws and regulations for handling fuel)	JIS K 2265:2007 ISO 3679 ISO 2719
Distillation Properties	Initial boiling point	170°C [338°F] or higher	170°C [338°F] or higher	JIS K 2254:1998 ISO 3405
	90% distillation temperature	330 to 380°C [626 to 716°F]	330 to 380°C [626 to 716°F]	
Pour point (PP)		Lower than ambient temperature by 6°C [10.8°F] or more	Lower than ambient temperature by 6°C [10.8°F] or more	JIS K 2269:1987 ISO 3016
Cloud point (CP)		Ambient temperature or below	Ambient temperature or below	
Cold filter plugging point (CFPP)		Lower than the ambient temperature by 3°C [5.4°F] or more	Lower than the ambient temperature by 3°C [5.4°F] or more	JIS K 2288:2000 ISO 3015
Carbon residue content	10% residual oil	0.4 weight% or lower	1.0 weight% or lower	JIS K 2270:2000 ISO 6615 ISO 10370
Cetane number		45 or higher *1	45 or higher *2	JIS K 2280:1996
Cetane Index	(New method)	45 or higher	45 or higher	ISO 5165 ISO/DIS 4264
Kinetic viscosity		2.0 mm^2/s or higher at 30°C [86°F] 8.0 mm^2/s or lower at 50°C [122°F]	2.0 mm^2/s or higher at 30°C [86°F] 8.0 mm^2/s or lower at 50°C [122°F]	JIS K 2283:2000 ISO 3104
Sulfur content		0.2 weight% or lower	1.0 weight% or lower *2 *3 (Shorten the engine oil change intervals.)	JIS K 2541:1996 (The content amount as low as that of regular light oil is desirable.) ISO 4260, ISO 8754
Water content and sediment		0.1 volume% or lower	0.1 volume% or lower	JIS K 2275:1996 ISO 3733
Ash content		0.01 weight% or lower	0.03 weight% or lower	JIS K 2272:1998 ISO 6245
Copper corrosion	50°C [122°F], 3 Hr	Discoloration = Copper plate No. 3 or less (deep discoloration)	Discoloration = Copper plate No. 3 or less (deep discoloration)	JIS K 2513:2000 ISO 2160
Density	15°C [59°F]	0.83 to 0.87 g/cm^3 [51.82 to 54.31 lb/ft^3]	0.80 to 0.87 g/cm^3 [49.94 to 54.31 lb/ft^3]	JIS K 2249:1995 ISO 3675

Table 4-3 Fuel Properties Table (2/2)

Item		Recommended limit	Service limit	Remark
Coking	250°C [482°F], 24 Hr	Carbonization 75% or less	Carbonization 80% or less	Fed791B (U.S.A.)
	230°C [446°F], 24 Hr	Carbonization 55% or less	-	
	180°C [356°F], 48 Hr	Tar-free	-	
Aromatics	HPLC method	38 volume% or lower (total of aromatic content)	38 volume% or lower (total of aromatic content)	JIS K 2536:2003 ISO 3837
Polycyclic aromatic content		8 volume% or lower	8 volume% or lower	
Asphaltene		0.1 weight% or lower	0.1 weight% or lower	-
Paticulate foreign substance	Foreign substances at engine fuel inlet	1.0 mg/L or less	1.0 mg/L or less	JIS B 9931: 2000 ISO 4405
Lubricity	HFRR wear test MWSD (Measured mean Wear Scar Diameter) At 60°C [140°F]	460 µm [0.02 in.] or less (calculated wear scar diameter at standard vapour pressure 1.4 kPa {0.01 kgf/cm^2} [0.20 psi])	-	ISO 12156-1
BDF: Biodiesel fuel (FAME: Fatty Acid Methyl Ester)		BDF quality shall meet JIS K 2390, or ASTM D6751 or EN14214. BDF blending of 5% by volume or less is approved *4	-	JIS K 2390:2008 (FAME for blended fuel) ASTM D6751, EN 14214

*1: Cetane index (JIS K 2280) substitutes. When the fuel which satisfies the service limit of cetane number is not available with some inevitable reasons, the use of cetane booster is allowed. However, this is allowed only for the period before getting the fuel which satisfies the service limit after consulting with the fuel supplier and the manufacturer of cetane booster, and at the customer's own risk.
The additive rate of 0.5 % or less of cetane booster, and the lube oil analysis at every 125 hours are recommended.
High concentration of additive may cause metal elusion, rubber material infiltration, increased load in high-load operation, and acceleration of lube oil deterioration.

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

*2: Only the emergency generator operated at an ambient temperature of 5°C [41°F] or higher, a fuel of cetane number 40 to 45 and sulfur content 0.2% or less can be used, if the below requirements are satisfied:

- Install a water heater.
- Time from startup to load input is to be 40 seconds.
- Operating the engine at no load or low load (load factor 30% or less) for a prolonged period of time is avoided.

*3: If the sulfer content of using fuel is higher than 0.2 weight%, use the specified engine oil "5 ENGINE OIL" (→ Page 103).

*4: In case of using BDF, consult with the fuel supplier, and consider and take necessary treatment such as;

- Antioxidation at high temperature
- Prevention from fuel solidification at low temperature
- Prevention from growth of microbe
- Removal of moisture

For details, refer to ‘Technical Information’

For Engine warranty coverage, refer to Limited Warranty conditions in this manual.

*5: Disregarding the value in ☐ could result in serious accident.

5 ENGINE OIL

This chapter describes the engine oil which is used for this engine.

Engine Oil

⚠ WARNING

Refer to the Engine Oil Properties table in this Operation & Maintenance Manual, and even if one item exceeds the limit, the engine oil must not be used.

* Otherwise, seizure of the sliding parts may occur, which could cause serious damage to the devices.

Use the genuine engine oil specified in this Operation & Maintenance Manual.

* Otherwise, seizure of bearings, breakage of a valve, sticking of a piston ring, seizure between a ring and a cylinder, premature wear of bearings and sliding parts may occur, which could shorten the service life of the engine.

Conduct analysis of the engine oil periodically and check to make sure that the engine oil does not show milky color.

* If the engine oil shows milky color, water may be mixed into the engine oil system due to coolant leak or a damaged cylinder liner O-ring. Sustained use of the engine without any remedy could cause seizure of the crankshaft and lead to serious damage to the devices.

Keep the quantity and properties (viscosity) of the engine oil at the specified level.

* If the supply or kinematic viscosity of engine oil is too low, insufficient lubrication of the bearing could occur, which could cause seizure of the crankshaft.
* If kinematic viscosity of engine oil increases, fuel consumption will increase.

Use the genuine engine oil.

- JUKOIL Cojera CF15W-40
- JUKOIL Cojera CF30

When using the engine oil other than the genuine ones, use the engine oil which meets "Engine Oil Quality Standards" (→ Page 198).
Do not mix and use Engine oil of different types and/or manufacturers.
In addition, conduct the oil analysis earlier than the normal change interval and check the change interval.

Note

- **If you use the engine oil which does not meet "Engine Oil Quality Standards" (→ Page 198), for failures caused by the engine oil, the warranty will become invalid.**

Engine Oil Grade

Use a CF grade engine oil or a CH-4 grade oil which is certified by API service classification.

Note

- **When using a CF grade engine oil, use the engine oil which had been certified by API service classification CF grade by 2009 and meets "Engine Oil Quality Standards" (→ Page 198).**
- **When using a CH-4 grade oil, the sulfur content of fuel must be 0.2 weight% or less.**

Engine Oil Viscosity

Use the engine oil which viscosity is suitable to the ambient temperature.
Excessively high oil viscosity causes power loss and an abnormal rise in oil temperature.
Conversely, excessively low oil viscosity accelerates wear due to inadequate lubrication, and also causes a decrease in engine output by combustion gas blowing through.

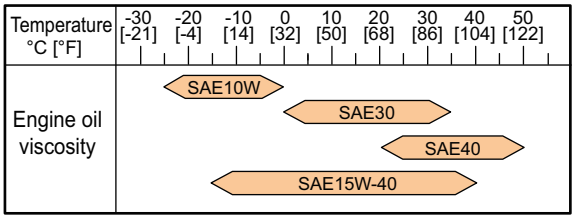


Fig. 5-1 Ambient Temperature and Engine Oil Viscosity

Handling Engine Oil

⚠ WARNING

Keep away from fire, when working with flammable substances such as engine oil.

* They may cause a fire.

Do not operate the engine with fuel or water mixed in the engine oil.

* Otherwise, viscosity of engine oil could decrease, which could cause seizure of the bearings or other serious accidents.

Do not store engine oil in a poorly ventilated place.

* Otherwise, vaporized engine oil may build up, which could cause an explosion or a fire on exposure to a flame.

⚠ WARNING

Wipe off spilled flammable substances such as engine oil thoroughly with a waste cloth.

* They may cause a fire.

When discarding a waste cloth used to wipe off combustible material, put it into a lidded can and obey the Waste Management and Public Cleansing Act to handle it as a special industrial waste.

* It may cause a fire.
* It could lead to environmental pollution.
* If you violate rules, you may be subject to penalties.

When handling engine oil, obey the manufacturer's SDS.

* If engine oil gets in your eyes, it will cause pain and lead to sight loss at the worst.

Do not breathe in vaporized engine oil.

* Otherwise, it could be hazardous to your health.

When storing engine oil in the container, be sure to close the cap.

* Otherwise, vaporized engine oil may build up, which could cause an explosion or a fire on exposure to a flame.

- When handling a large amount of engine oil more than the legally specified quantities, be sure to have the work performed in a service station operated under the provision of the law.
- When taking oil from the oil can or the like, use the oil pump.
- Tighten the oil can cap securely, and store the oil can in a well-ventilated place and out of direct sunlight.
- Be sure to obtain the SDS of the engine oil to be used and obey the instructions in the SDS.

6 COOLANT

This chapter describes coolant to be used. In this manual, the word "coolant" represents a mixture of water and LLC.

Water to Be Used

⚠ WARNING

When you add water to coolant, use only the water that meets the water quality standard specified in this Operation & Maintenance Manual.

* Otherwise, premature corrosion or overheating in the engine parts may occur.

Use soft water which meets the requirements specified in the table below. If tap water meets the requirements, the tap water can be used.

Table 6-1 Water Quality Standard

	pH (25°C [77°F])	Electrical conductivity (mS/m)	Total hard-ness	M alkalinity	Chlorine ion	Sulphate ion	Total iron	Silica	Residue by evaporation
			mg/l						
Recom-mend value	6.5 to 8.0	≤ 25	≤95	≤70	≤100	≤50	≤1.0	-	≤250
Limit value	6.5 to 8.5	≤40	≤100	≤150	≤100	≤100	≤1.0	≤50	≤400
Main harm	Corrosion Scale formation	Corrosion Scale formation	Scale formation	Scale formation	Corrosion	Corrosion	Scale formation	Scale formation	Scale formation

- **In addition to the items specified above, turbidity must be below 15 mg/liter.**
- **Basically, the water quality must be within the range of the recommended values, however, up to the limit value is acceptable.**

LLC to Be Used

⚠ DANGER

Use the genuine LLC specified in this Operation & Maintenance Manual.

* Otherwise, the devices could be damaged.

Use the genuine LLC.

- GLASSY Long Life Coolant (ethylene glycol type)
- PG GLASSY long life coolant (propylene glycol type)

Note

- **For GLASSY Long Life Coolant, 30% diluted solution (18L [4.76 US gal], 200L [52.84 US gal]) is available.**

When using the LLC other than genuine ones, use the LLC which meets "Requirements for LLC" (→ Page 201) and "LLC Quality Standard" (→ Page 201). Do not mix and use LLC of different types and/or manufacturers.

Note

- **If you use the LLC which does not meet "Requirements for LLC" (→ Page 201) and "LLC Quality Standard" (→ Page 201), for the failure due to the LLC, warranty will become invalid.**
- **The quality and performance of commercially available LLC 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.**
- **Be sure to use an all-season (non-amine) type long life coolant that prevent freezing of cooling water. Do not use antifreeze alone instead of LLC. For details, refer to "Examples of Abnormalities Caused by LLC (Amine Type)" (→ Page 205).**

Coolant (LLC) - Handling

⚠ WARNING

Keep away from fire, when working with flammable substances such as coolant (LLC).

* They may cause a fire.

Wipe off spilled flammable substances such as coolant (LLC) thoroughly with a waste cloth.

* They may cause a fire.

When discarding a waste cloth used to wipe off combustible material, put it into a lidded can and obey the Waste Management and Public Cleansing Act to handle it as a special industrial waste.

* It may cause a fire.
* It could lead to environmental pollution.
* If you violate rules, you may be subject to penalties.

Use care not to let oil mixed with coolant.

* Otherwise, cooling fault could occur, which could cause overheating.

When handling coolant (LLC), always wear suitable personal protective equipment such as rubber gloves and protective eyeglasses.

* If LLC comes into contact with your eyes, it will result in sight loss at the worst.
* If LLC comes into contact with your skin while the engine is hot, you could get burned by heat.

Maintenance of LLC

LLC Concentration in Coolant - Check

Be sure to drain a small amount of coolant and check the LLC concentration every 4000 service hours for the continuous use engine, and every six months for the emergency use engine.
"LLC Concentration in Coolant - Measure" (→ Page 108)

Replacement Period

⚠ DANGER

Do not use LLC after the recommended storage expiration date.

* Otherwise, the devices could be damaged.

Change the coolant every 8000 hours or 2 years, whichever comes first for the continuous use engine. For the emergency use engine, be sure to change the coolant once every 2 years.

Coolant - Mix

1 **Check the LLC concentration in coolant "LLC Concentration (Genuine LLC)" (→ Page 107).**

2 **Check the quantity of coolant to be refilled.**

- When replacing, check the specified quantity of coolant. "SPECIFICATIONS - CHECK" (→ Page 10)
- When refiling, check with the scale on the tank.

Note

- **Refill coolant into the engine after mixing. Do not refill only water or LLC.**
- **If coolant is refilled without proper stirring, partially contrasting density of the LLC concentration may occur, which could interfere with the sufficient anticorrosion and cooling properties.**

3 **Prepare a vessel for mixing and pour in water "Water to Be Used" (→ Page 105).**

4 **In accordance with the LLC concentration checked in Step 1, add LLC "LLC to Be Used" (→ Page 106).**

5 **Check the LLC concentration in mixed coolant. "LLC Concentration in Coolant - Measure" (→ Page 108)**

6 **Refill the mixed coolant into the engine. "Coolant - Change" (→ Page 157)**

LLC Concentration (Genuine LLC)

⚠ DANGER

Keep LLC to be the specified concentration.

* If LLC concentration is low, it could cause corrosion of the radiator or heat exchanger.

* If LLC concentration is high, it may cause damage to the devices or overheat due to the seized engine parts.

The concentration of LLC required for anti-freeze is determined by the ambient minimum temperature. Be sure to follow the range shown in the following table.

Table 6-2 LLC Concentration

Type	External appearance	Ambient temperature			
		down to -10°C [14°F]	down to -20°C [-4°F]	down to -30°C [-22°F]	down to -45°C [-49°F]
GLASSY	Green	30%	40%	50%	60%
PG GLASSY	Red	40%	55%	70%	90%

- The upper limit of the LLC concentration is 60% for GLASSY and 90% for PG GLASSY. If the concentration is higher than above, the antifreeze effect will be lowered, or the coolant temperature will be increased due to the lowered specific heat.
- The coolant temperature increases by approximately 1.5°C [2.7°F] for GLASSY at 60% concentration and by approximately 3°C [5.4°F] for PG GLASSY at 90% concentration. Check heat exchanger capacity of the cooling system to avoid overheating.

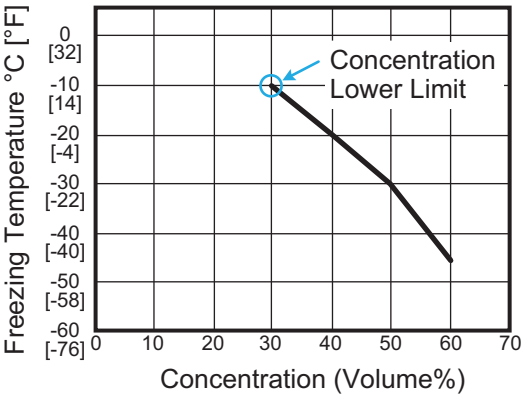


Fig. 6-1 Freezing Temperature of GLASSY

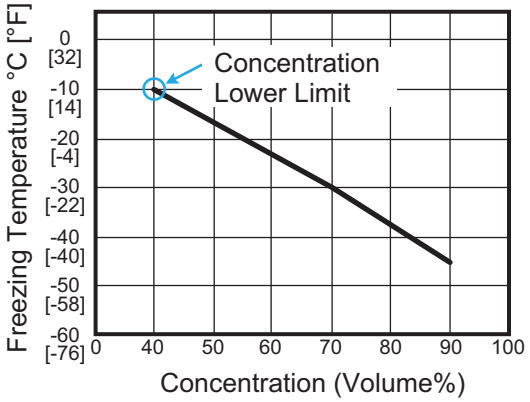


Fig. 6-2 Freezing Temperature of PG GLASSY

Note

- **When using the other LLC follow the instruction manual of LLC to be used.**

LLC Concentration in Coolant - Measure

To measure the LLC concentration, the following tool is required.

- Tool: Coolant tester

Note

- **When using other tools, follow the instruction manual attached to the tool to be used.**

Tool - Adjust

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

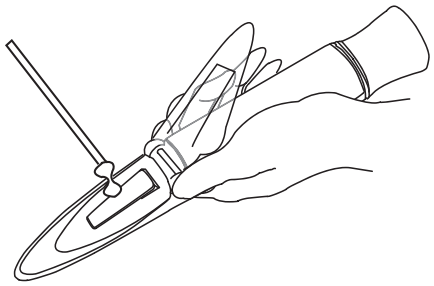


Fig. 6-3 Tool - Adjust 1

2 **Close the daylight plate slowly.**

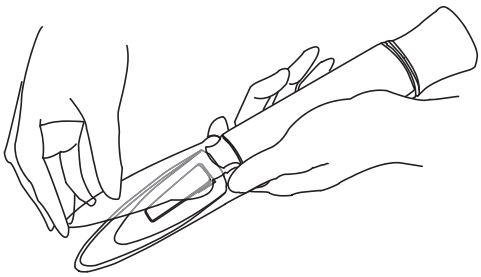


Fig. 6-4 Tool - Adjust 2

3 **Spread a drop of water over the surface of the prism taking care that air bubbles will not enter it.**

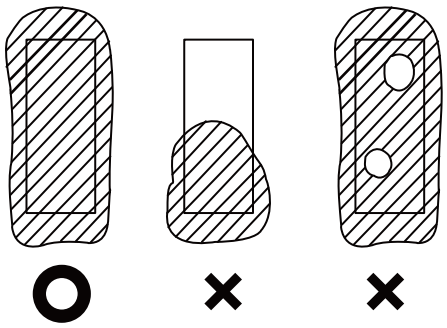


Fig. 6-5 Tool - Adjust 3

4 **Read the scale through the eye piece.**

- Rotate the eyepiece to either side to focus.

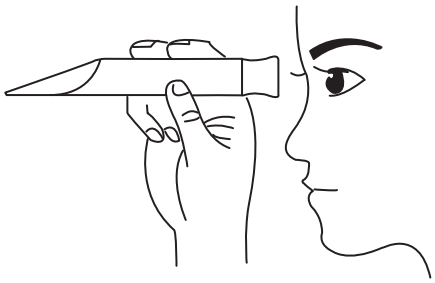


Fig. 6-6 Tool - Adjust 4

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

- If it does not align, rotate the scale adjusting screw by using a scale adjusting tool and let it align.

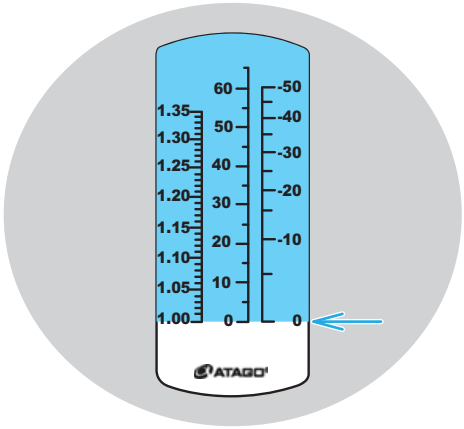


Fig. 6-7 Tool - Adjust 5

6 **Wipe the surface of the prism and daylight plate with water-soaked soft facial tissue.**

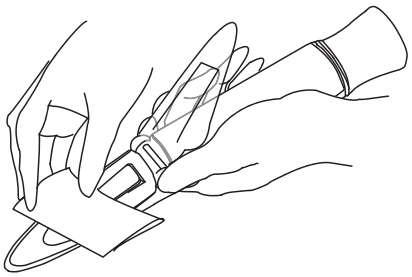


Fig. 6-8 Tool - Adjust 6

Measurement

Note

- **Before measuring the LLC concentration, be sure to adjust tools "Tool - Adjust" (→ Page 108).**

1 Place a sample of 1 or 2 drops of coolant/water mixture on the prism.

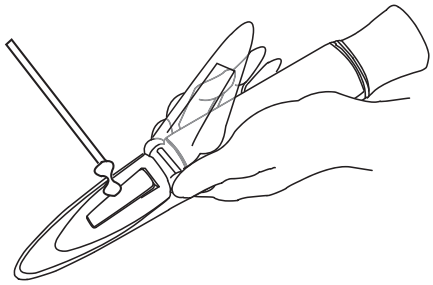


Fig. 6-9 LLC concentration measurement 1

2 Close the daylight plate slowly.

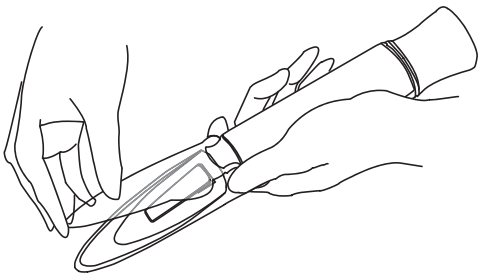


Fig. 6-10 LLC concentration measurement 2

3 Spread a drop of water over the surface of the prism taking care that air bubbles will not enter it.

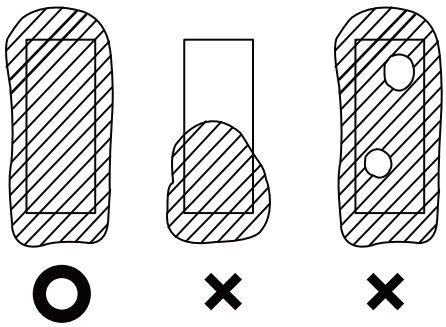


Fig. 6-11 LLC concentration measurement 3

4 Read the scale through the eye piece.

- Rotate the eyepiece to either side to focus.

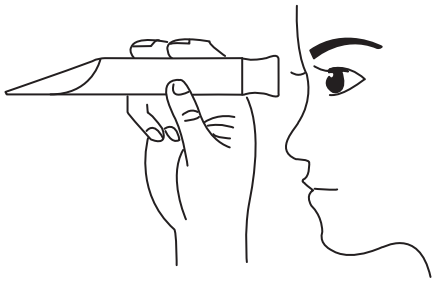


Fig. 6-12 LLC concentration measurement 4

5 Read the scale at the position where the blue boundary line comes across.

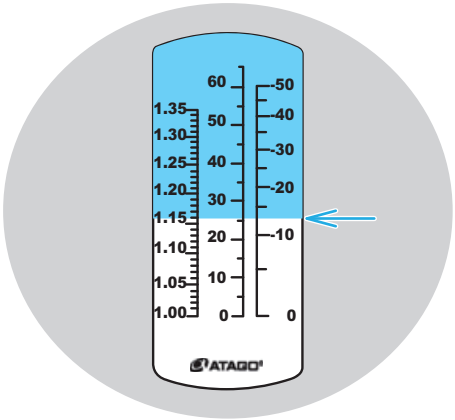


Fig. 6-13 LLC concentration measurement 5

- How to read the Scale
  The scale of the coolant tester is for the ethylene glycol type. When measuring a propylene glycol type, convert the reading to judge by using the table below.

Table 6-3 Scale Conversion Table

Scale markings	0	5	10	15	20	25	30	35	40	45	50
Corre-sponding value	0	5	9	14	18	22	26	31	35	39	44

6 Wipe the surface of the prism and daylight plate with water-soaked soft facial tissue.

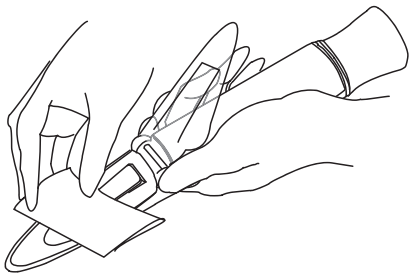


Fig. 6-14 LLC concentration measurement 6

7 SCHEDULED MAINTENANCE

This chapter describes the scheduled maintenance schedule in which details of the scheduled maintenance and its cycle are listed up.

⚠ WARNING

Do not take actions for items indicated as "Contact your Mitsubishi dealer" in the measure column in the Scheduled Maintenance.

* Otherwise, serious accident, environmental pollution or damage to the devices may occur. Be sure to contact your Mitsubishi dealer.

Be sure to perform the pre-operation check and scheduled maintenance as instructed in this Operation & Maintenance Manual.

* Failure to perform the pre-operation check and scheduled maintenance may cause various engine problems and breakage to parts, which may result in serious accidents.

How to Use the Scheduled Maintenance

Scheduled 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 in accordance with the "SCHEDULED MAINTENANCE".
However, if you notice abnormalities as shown below, be sure to conduct the inspection and maintenance work regardless of recommended service intervals in the "SCHEDULED MAINTENANCE".

- Noise
- Significant black or white exhaust smoke
- Abnormal exhaust gas temperature
- Abnormal vibration
- Fuel leaks
- Engine oil leaks
- Exhaust gas leaks

Note

- **Appropriate service intervals vary with usage and operating conditions as well as conditions of fuel, oil, and coolant. Check the results and shorten the interval as necessary.**

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

Category of Scheduled Maintenance Chart

- Appropriate service intervals vary depending on the intended purpose or use of the engine. Perform all daily check items in accordance with the following 2 categories.
- Regardless of the intended use, its operation is regulated in terms of the annual operating time. Refer to the rating definition "Rating Definition" (→ Page 114) to check the interval of overhauls.

■ Scheduled Maintenance for Continuous Use Engine

For the continuous use engine, perform the scheduled maintenance in accordance with the "Scheduled Maintenance for Continuous Use Engines".

■ Scheduled Maintenance for Emergency Use Engine

For the emergency use engine, perform the scheduled maintenance in accordance with the "Scheduled Maintenance for Emergency Use Engines".
In addition, carry out maintenance operation regularly. "Maintenance Operation" (→ Page 97)

Rating Definition

Table 7-1 MHISH Generator Use Diesel Engine Rating Definition

Symbol			E	P		C		D
Name of rating			Stand-by	Prime		Continuous		
				Limited Running Time	Unlimited Running Time			
Overload operation (Rack set)			Not possible (E)	+10% (E)		Not possible (C)		Not possible (D)
Definition			Rated power of an emergency generator that supplies power in case of a failure of main power source or commercial power.	Regular power source of which the operating hour is limited to the short period as specified in the required conditions for warranty in this document. This rating shall be used for applications that require overload operation with Stand-by. LTP as specified in ISO 8528:2005.	For generators with variable load and unlimited operating hour. PRP (Prime Power) as specified in ISO 8528:2005.	Rating that can continuously generate power without limitation for operating hour per year under the required conditions for warranty in this document. COP as specified in ISO 8528:2005.		In addition to the definition for C above, this rating shall be used 90% or higher average load factor or longer maintenance interval are required.
Required conditions for warranty (*1)	Load/operating time (*2)	Ave. load factor/24 Hr	80% or lower (100% in emergency)	Overload (≤ 110%) : allowed for 1Hr per 12Hr.	80% or lower ·Overload operation (≤110%) is allowed for 1Hr per 12Hr. ·>90% load is allowed for max. 3Hr per 24Hr operation.	100% or lower	90% or lower	100% or lower
		Ave. load factor/yr	60% or lower	As per ISO 8528:2005. 100% or lower	60% or lower	100% or lower	90% or lower	100% or lower
		Operating Hr/yr	500Hr or lower	As per ISO 8528:2005 500Hr or lower	None	None	None	None
	Overhaul interval after delivery <Maximum> (*3)	Top	4 yr	4 yr	4000Hr or 4yr whichever comes earlier	6000Hr or 4yr whichever comes earlier (Recommended: 4000Hr)	8000Hr or 4yr whichever comes earlier (Recommended: 6000Hr)	8000Hr or 4yr whichever comes earlier (Recommended: 6000Hr)
		Major	3000Hr or 8yr whichever comes earlier	1000Hr or 8yr whichever comes earlier	8000Hr or 8yr whichever comes earlier	12000Hr or 8yr whichever comes earlier (Recommended: 8000Hr)	16000Hr or 8yr whichever comes earlier (Recommended: 12000Hr)	16000Hr or 8yr whichever comes earlier (Recommended: 12000Hr)
Application			Emergency, stand-by	Seasonal peak cut	Daily peak cut, portable generator	Base load, cogeneration system		

*1: This condition constitutes a part of required conditions for warranty that Mitsubishi Heavy Industries (Shanghai) Co., Ltd. (hereinafter “MHISH”) agrees with the other party under Diesel Engine Sales Contract with the party (hereinafter “Individual Contract”), however details of the warranty descriptions and the conditions shall be referred to the Individual Contract. Atmospheric condition as per ISO 15550:2002 (JIS B 8003:2005) (Barometic pressure:100 kPa, ambient temperature:298 K, relative humidity:30%).

*2: Average load factor (per day or year) shall be calculated as per the formula in ISO 8528:2005 ‘average power output (Ppp)’.

*3: Refer to Operation Manual for more information regarding inspection and maintenance including items and descriptions.

This document may be changed without prior notification.

Scheduled Maintenance for Continuous Use Engine

For the continuous use engine, perform the scheduled maintenance in accordance with the following table.

Note

- **Conduct the scheduled maintenance at specified intervals, either service hours or service period, whichever comes first.**

Table 7-2 Scheduled Maintenance for Continuous Use Engine (1/3)

Inspection and Maintenance Period		Service Items	Reference Page
Service period	Service hours		
Every month	Every 50 service hours,	• Fuel Tank - Drain Water * 1	134
		• Water Separator - Drain Water *1	138
-	First 50 service hours for a new or overhauled engine	• Bolts and Nuts on the Engine - Retighten	85
		• Engine Oil, Oil Filter, and Bypass Oil Filter - Replace *2 *3	152 154 154
		• Engine Oil - Analysis (Recommended)	-
-	Every 250 service hours	• Engine Oil, Oil Filter, and Bypass Oil Filter - Replace * 2*3	152 154 154
		• Engine Oil - Analysis (Recommended)	-
-	First 250 service hours for a new or overhauled engine	• Valve Clearance - Check and Adjust (Check the valve mechanism parts at the same time.)	8 (Contact your Mitsubishi dealer)
-	Every 1000 service hours	• Fuel Filter - Replace	140
		• Water Separator Element - Replace *1	138
		• Gauze Filter - Clean	139
		• Belt and Belt Tension - Check and Adjust (Replace parts as needed.)	127 129

*1: If the part is not supplied from Mitsubishi Heavy Industries (Shanghai) Co., Ltd. (MHISH), service the part following the supplier's operation manual.

*2: Replace also the oil filters when the filter alarm lamp is turned on.

*3: Replacing interval of the oil filter can be changed according to the results of engine oil analysis or the type of oil pan.

Table 7-3 Scheduled Maintenance for Continuous Use Engine (2/3)

Inspection and Maintenance Period		Service Items	Reference Page
Service period	Service hours		
-	Every 2000 service hours	• Fuel Tank - Drain Water (Replace parts as needed.) *1	134
		• Valve Clearance - Check and Adjust (Check the valve mechanism parts at the same time.) • Fuel Injection Timing - Check and Adjust • Fuel Injection Nozzle Tip, Spacer, and Nozzle Spring - Replace (Check the spray condition and adjust the fuel injection pressure after the replacement.) • Movement of Rack of the Fuel Injection Pump (Including the Governor) - Check (During Operation)	8 (Contact your Mitsubishi dealer)
		• Fuel Pipe - Check	145
		• Oil Pipe - Check	156
-	Every 4000 service hours * 2	• Engine - Top Overhaul (Remove the cylinder head, and inspect and service the combustion chambers.)	165 (Contact your Mitsubishi dealer
		• Turbocharger - Check	165
		• Damper - Check	132
		• Starter - Check	169
		• Unit Seal and Oil Seal of Water Pump - Replace • Protection System - Check	8 (Contact your Mitsubishi dealer)
		• LLC Concentration in Coolant - Check	108
-	Every 8000 service hours * 2	• Engine - Major Overhaul (Disassemble the engine, and then clean, check, and replace major parts.) <At the major overhaul> Parts to be replaced: Inlet and exhaust valves, inlet and exhaust valve seat O-rings, valve rotators, valve cotters, rocker arm adjusting screws, valve push rods, bridge caps, camshaft bushings, main bearings, cylinder liners, main bearing cap bolts and washers, piston rings, connecting rod bearings, damper, crankcase thrust plates and consumable items (gaskets, oil seals, O-rings, and others.)	8 (Contact your Mitsubishi dealer)

*1: If the part is not supplied from Mitsubishi Heavy Industries (Shanghai) Co., Ltd. (MHISH), service the part following the supplier's operation manual.

*2: Service intervals vary depending on the use conditions. For details, see the rating definition "Rating Definition" (→ Page 114).

Table 7-4 Scheduled Maintenance for Continuous Use Engine (3/3)

Inspection and Maintenance Period		Service Items	Reference Page
Service period	Service hours		
-	Every 8000 service hours * 2	<At the second overhaul> Replace the following parts in addition to the parts listed at the major overhaul. Cylinder head bolts, valve guides, valve bridge guides, valve bridge, valve spring, tappets, camshaft thrust plates, pistons, piston pins, connecting rod bolts, rocker bushings, fuel injection pipe assembly, oil pipe assembly • Fuel Injection Pump - Inspect and Test (Replace parts as needed.) • Protective Devices - Repair and Replace *1 (High coolant temperature, low oil pressure, overspeeding, starting stall, cooling water supply fault, undervoltage, overvoltage, overcurrent, low coolant level in tank, low fuel level in tank, low air pressure in tank, and others.) • Auxiliary Devices Operation - Check *1 (Water heater, oil heater, oil priming pump, fuel transfer pump, governor motor, and others.)	8 (Contact your Mitsubishi dealer)
Every 2 years	Every 8000 service hours	• Coolant - Change	157
As required		• Fuel System - Bleed Air *1	135
		• Radiator Fins - Check and Clean *1	165
		• Pre-cleaner - Clean, Check and Replace	166
		• Air Cleaner Element - Clean, Check, and Replace *1	168
		• Inside of Engine Breather - Clean • Stop Solenoid - Check or Replace • Couplings - Check or Replace *1 • Vibration-Isolating Rubber - Check *1	8 (Contact your Mitsubishi dealer)

*1: If the part is not supplied from Mitsubishi Heavy Industries (Shanghai) Co., Ltd. (MHISH), service the part following the supplier's operation manual.

*2: Service intervals vary depending on the use conditions. For details, see the rating definition "Rating Definition" (→ Page 114).

Scheduled Maintenance for Emergency Use Engine

For the emergency use engine, perform the scheduled maintenance in accordance with the table below.

Table 7-5 Schedule Maintenance for Emergency Use Engine (1/5)

Inspection and Maintenance Period Service period	Service Items	Reference Page
Every week	• Walk around check (Check leakage of fuel, oil, and coolant.)	85
	• Fuel Tank Oil Level - Check *1	134
	• Engine Oil Level - Check	86
	• Coolant Level - Check	87
	• Starting Air Tank Air Pressure - Check (Air Direct Admission Starting, Air Motor Starting)	89
	• Air Cooler - Check Water Leak	-
	• Maintenance Operation (Operate the engine at no load for 5 to 10 minutes.) (Check startability, color of exhaust smoke, abnormal vibration, abnormal noise, abnormal smell and gauge indication {oil pressure gauge, coolant temperature gauge, oil temperature gauge, exhaust temperature gauge, tachometer, and others.})	97
Every month	• Ingress of Fuel and Water In Engine Oil - Check	8 (Contact your Mitsubishi dealer)
	• Fuel Control Link - Check	143
	• Battery Electrolyte Level - Check *1	168
	• Starting Air Tank - Drain water	171
	• Air Compressor Oil Level - Check and Refill	-
	• Maintenance Operation (Operate the engine at 50% load or higher for 30 minutes or longer.) (Check startability, color of exhaust smoke, abnormal vibration, abnormal noise, abnormal smell and gauge indication {oil pressure gauge, coolant temperature gauge, oil temperature gauge, exhaust temperature gauge, tachometer, and others}. Check the movement of rack of the fuel injection pump including the governor, check temperature of damper, check damper visually.)	97
Every 6 months	• LLC Concentration in Coolant - Check	108
	• Inside of Coolant Tank - Clean *1	-

*1: If the part is not supplied from Mitsubishi Heavy Industries (Shanghai) Co., Ltd. (MHISH), service the part following the supplier's operation manual.

Table 7-6 Scheduled Maintenance for Emergency Use Engine (2/5)

Inspection and Maintenance Period Service period	Service Items		Reference Page
Every year	Engine body	• Belt and Belt Tension -Check and Adjust (Replace parts as needed)	127 129
		• Bolts and Nuts on Engine - Check and Retighten	85
		• Damper - Check	132
		• Valve Clearance - Check and adjust (Check the valve mechanism parts at the same time) • Vibration-Isolating Rubber - Check *1 • Foundation Bolts - Check *1 • Couplings - Check or Replace *1	8 (Contact your Mitsubishi dealer)
	Fuel system	• Fuel Tank - Drain Water *1	134
		• Water Separator - Drain Water *1	138
		• Fuel Injection Nozzle Spray Condition and Injection Pressure - Inspect and Adjust • Fuel Injection Timing - Check and Adjust	8 (Contact your Mitsubishi dealer)
		• Fuel Pipe -Check	145
	Lubrication system	• Oil Pipe - Check	156
		• Engine Oil Properties - Analyze • Engine Oil Pressure (Maintenance Operation) - Check and Adjust	8 (Contact your Mitsubishi dealer)
	Cooling system	• Water Pump -Check • Solenoid Valve and Pressure Reducing Valve of Cooling System - Checkt, Disassemble, and Clean *1 • Strainer (Including with Ball Tap) of Cooling Water - Check, Disassemble and Clean *1 • Coolant Properties - Inspect (Change Coolant Based on Analysis Results)	8 (Contact your Mitsubishi dealer)
	Air Intake system	• Air Cleaner Element - Clean, Check and Replace	168
		• Pre-cleaner - Clean, Check and Replace	166
	Electrical system	• Starter - Check	169
		• Alternator - Check	169
		• Specific Gravity of Battery Electrolyte - Check *1	168
		• Air Heater - Check	-

*1: If the part is not supplied from Mitsubishi Heavy Industries (Shanghai) Co., Ltd. (MHISH), service the part following the supplier's operation manual.

Table 7-7 Scheduled Maintenance for Emergency Use Engine (3/5)

Inspection and Maintenance Period Service period	Service Items		Reference Page
Every year	Air starter system	• Starter Air Strainer - Drain Water and Clean	170
		• Starting Air Tank Safety Valve Operation -Check	171
		• Air Starter Valve - Check • Solenoid Valve and Pressure Reducing Valve - Check and Clean • Air Distribution Valve -Check • Air Compressor Belt Tension -Check	8 (Contact your Mitsubishi dealer)
	• Protection System - Check *1 (High coolant temperature, low oil pressure, overspeeding, start stalling, cooling water supply fault, undervoltage, overvoltage, overcurrent, low coolant level in tank, low fuel level in tank, low air pressure in tank, and others.) • Auxiliary Devices - Check *1 (Engine control devices, fuel transfer pump, governor motor, room ventilating fan, solenoid, lifting pump, water tank ball tap, water heater, oil heater, oil priming pump, and others.)		8 (Contact your Mitsubishi dealer)
Every 2 years	• Engine Oil, Oil Filter, and Bypass Oil Filter - Replace *2 *3		152 154 154
	• Engine Oil - Analysis (recommended)		-
	• Fuel Filter - Replace		140
	• Water Separator Element - Replace *1		138
	• Gauze Filter - Clean		139
	• Fuel Control Link Ball Joint -Check (Replace parts as needed)		143
	• Coolant - Change		157
	• Thermostat - Check		8 (Contact your Mitsubishi dealer)
	• Turbocharger - Check		165
	• Exhaust Muffler - Drain Water *1		165
	• Starting Air Compressor - Overhaul (Air Direct Admission Starting, Air Motor Starting)		8 (Contact your Mitsubishi dealer)

*1: If the part is not supplied from Mitsubishi Heavy Industries (Shanghai) Co., Ltd. (MHISH), service the part following the supplier's operation manual.

*2: Replace also the oil filters when the filter alarm lamp is turned on.

*3: Engine oil change intervals for the emergency-use engine vary depending on the installation conditions. For details, refer to "Engine Oil Service Limits for Emergency Use" (→ Page 200).

Table 7-8 Scheduled Maintenance for Emergency Use Engine (4/5)

Inspection and Maintenance Period Service period	Service Items	Reference Page
Every 4 years*2	• Engine - Top Overhaul (Remove the cylinder head, and inspect and service the combustion chambers { Inspect the cylinder No. 1 and 2. If any abnormality is found, inspect all the cylinders}.) • Oil Cooler - Check Contamination, Clogging, and Leak • Oil Pump - Check Discoloration and Other External Defects	8 (Contact your Mitsubishi dealer)
	• Governor Oil Filter - Replace	154
	• Fuel Tank - Clean *1	134
	• Fuel Injection Pump - Inspect and Test (Replace parts as needed.)	8 (Contact your Mitsubishi dealer)
	• Governor - Inspect and Test (Replace parts as needed.)	
	• Radiator Fins - Check and Clean *1	165
	• Rubber Hose - Replace	8 (Contact your Mitsubishi dealer)
	• Pre-cleaner - Clean, Check and Replace	168
	• Air Cleaner Element - Clean, Check, and Replace *1	166
	• Various Instruments - Repair or Replace *1 (Oil pressure gauge, coolant temperature gauge, oil temperature gauge, exhaust temperature gauge, tachometer)	8 (Contact your Mitsubishi dealer)

*1: If the part is not supplied from Mitsubishi Heavy Industries (Shanghai) Co., Ltd. (MHISH), service the part following the supplier's operation manual.

*2: Service intervals vary depending on the use conditions. For details, see the rating definition "Rating Definition" (→ Page 114).

Table 7-9 Scheduled Maintenance for Emergency Use Engine (5/5)

Inspection and Maintenance Period Service period	Service Items	Reference Page
Every 8 years*2	• Engine - Major Overhaul (Disassemble the engine, and then clean, check, and replace major parts.) • Damper - Replace • Oil Pump - Repair or Replace • Fuel Injection Nozzle Tip, Spacer, and Nozzle Spring - Replace (Check the spray condition and adjust the fuel injection pressure after the replacement.) • Rubber Parts and O-rings - Replace • Water Pump Unit Seal and Oil Seal - Replace • Turbocharger - Disassemble and Inspect • Air Cooler - Disassemble and Clean • Vibration-isolating Rubber - Repair or Replace *1 • Couplings - Repair or Replace *1 • Governor Motor - Repair or Replace *1 • Indoor Ventilation Fan - Repair or Replace *1 • Stop Solenoid - Check or Replace • Ball Tap of Water Tank - Repair or Replace *1 • Other Consumable Parts - Replace	8 (Contact your Mitsubishi dealer)

*1: If the part is not supplied from Mitsubishi Heavy Industries (Shanghai) Co., Ltd. (MHISH), service the part following the supplier's operation manual.

*2: Service intervals vary depending on the use conditions. For details, see the rating definition "Rating Definition" (→ Page 114).

Scheduled Maintenance for Air Direct Admission Starting

For the starting air system of the air direct admission starting, perform the scheduled maintenance in accordance with the table below.

Table 7-10 Scheduled Maintenance for Air Direct Admission Starting

Inspection and Maintenance Period	Service Items	Reference Page
Before Starting	Starting Air Tank - Check	89
	Starting Air Compressor - Check	
	Air Filter - Check	
	Starting Valve - Check	

Scheduled Maintenance for Air Motor Starting

For the starting air system of the air motor starting, perform the scheduled maintenance in accordance with the table below.

Table 7-11 Scheduled Maintenance for Air Motor Starting

Inspection and Maintenance Period	Service Items	Reference Page
Before Starting	Starting Air Tank - Check	90
	Starting Air Compressor - Check	
	Air Filter - Check	
	Reducing Valve - Check	
	Lubricator - Check	

8 INSPECTION AND MAINTENANCE

This chapter describes the inspection and maintenance procedure.

Inspection and Maintenance - General Information

Be sure to conduct the inspection and maintenance according to the "7 SCHEDULED MAINTENANCE" (→ Page 112).

Inspection and Maintenance - Prepare

- Inspection and Maintenance - Prepare (with Engine Switched ON)
- Inspection and Maintenance - Prepare (with Engine Switched OFF)

Engine Body - Check

- Belt - Check
- Belt Tension (Alternator) - Adjust
- Damper - Check
- Damper Temperature - Check

Fuel System - Check

- Fuel Tank -Check and Service
- Fuel System - Bleed Air
- Water Separator - Check and Service
- Gauze Filter - Clean
- Fuel Filter - Replace
- Fuel Control Link - Check
- Fuel Pipe - Check

Engine Oil System - Check

- Engine Oil - Change
- Oil Filter - Replace
- Bypass Oil Filter - Replace
- Governor Oil Filter - Replace (Hydraulic governor spec)
- Oil Pipe - Check

Cooling System - Check

- Coolant - Change
- Cooling System - Bleed Air
- Radiator Fins - Check and Clean (Radiator Spec)

Intake and Exhaust Systems - Check

- Turbocharger - Check
- Exhaust Muffler - Drain Water
- Pre-cleaner - Check and Service
- Air Cleaner - Check and Service

Electrical System -Check

- Battery - Check
- Starter - Check (Self Starter Motor Starting)
- Alternator - Check

Air Direct Admission Starting, Air Motor Starting - Check

- Starter Air Strainer - Drain Water and Clean
- Starting Air Tank - Check and Service (Air Direct Admission Starting, Air Motor Starting)
- Starting Air Motor - Check (Air Motor Starting)

Precautions for General Inspection and Maintenance

⚠ DANGER

Before starting the engine, pull out the manual turning gear shaft.

* Starting the engine while the turning gear is engaged with the ring gear could result in serious personal injury or destruction of the engine.

Before inspecting and maintaining the engine, read this Operation & Maintenance Manual thoroughly to understand the construction and the required work to service the corresponding part. In addition, conduct the work after fully studying the procedure

* In case of conducting the work without studying enough, an accident or damage due to wrong installation, or deterioration in the exhaust gas properties may occur.

⚠ WARNING

Do not make any modifications to the engine without our previous written agreement.

* Otherwise, damage to the devices or significant environmental pollution may occur.
* In such a case, the whole warranty will become invalid.

Do not work while standing on the engine.

* Otherwise, you may slip and fall by accident, and get injured.
* In addition, the devices or pipes may be damaged.

Do not disconnect the fuel or engine oil piping while the engine is operating or at high temperature.

* Otherwise, fuel could come in contact with the engine, which could cause a fire.

Do not disconnect the pipes immediately after the engine is stopped.

* Otherwise, you could get burned by hot engine oil or coolant splashing out.

⚠ WARNING

Do not touch any part of the engine (other than the manual stop lever) during or immediately after operation and immediately after stopping.

* If you touch, you could get burned by heat.
* Before starting the inspection and maintenance work, make sure that the engine is cooled down.

Only the genuine parts are recommended to use.

* Using non-genuine parts could cause deterioration in the exhaust gas properties and damage to the devices.
* Faults or damages caused by using non-genuine parts will be outside the scope of the warranty.

While washing the engine, pay attention that water or foreign particles will not enter the engine.

* Otherwise, the devices could be damaged.

After washing the engine, blow off water around the terminals by using compressed air.

* Otherwise, it may cause damage to the devices due to short circuit.

Before maintaining electrical components, place the battery switch to the OFF position or disconnect the battery negative (-) terminal.

* Electric shock could result when electricity flows through the circuit.

Wipe off spilled flammable substances such as fuel, engine oil, coolant (LLC), grease, rust preventive oil and anti-corrosive agent.

* They may cause a fire.

When discarding a waste cloth used to wipe off combustible material, put it into a lidded can and obey the Waste Management and Public Cleansing Act to handle it as a special industrial waste.

* It may cause a fire.
* It could lead to environmental pollution.
* If you violate rules, you may be subject to penalties.

⚠ WARNING

Make sure that dripped oil, parts, tools or other things are not left on the floor around the engine. Always maintain cleanliness and tidiness.

* Otherwise, a tumbling accident may occur.
* Wear proper personal protective equipment for the work.

Watch your step during inspection and maintenance work.

* Otherwise, a tumbling accident or a falling accident may occur while working on the floor panel or other high positions.
* The floor could be extremely slippery due to spilt oil. Thoroughly wipe off oil on the floor and the sole of your shoes.
* Install a stable scaffold as required.

Cover the disconnected pipes or joints and their openings properly so that dusts or other foreign objects will not enter into them.

* Otherwise, the devices may be damaged.

The engine must be inspected and maintained only by qualified persons who have received a required training or on-site instructions, or done so under the mentorship of a person who have completed our training course.

* Otherwise, serious personal injury or damage to the devices may occur.

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

* Do not stand on an old stool or parts box. Otherwise, it may result in personal injury. In addition, do not put any unnecessary objects on a work platform.

⚠ CAUTION

While inspecting and maintaining, do not put your hand in a gap between the connecting rod, crankshaft, timing gear or others and the crankcase.

* Otherwise, you may be stuck and injured.

While operating the engine, stay away from the moving parts.

* Otherwise, you may cut your hand by the rotating parts, or be caught in them and injured.

Inspection and Maintenance - Prepare

⚠ WARNING

Make sure that the tools to be used are not damaged.

* Using a damaged tool or a wrong-size tool may cause personal injury or damage to the devices.

Check and calibrate measurement equipment periodically.

* Using uncalibrated measurement equipment may cause damage to the devices or performance degradation of them.

Before inspection and maintenance work, be sure to prepare as follows according to the content of inspection and maintenance:

Note

- **Devices and equipment outside the scope of our supply are included in the facility.**
  For the details, refer to such a document as the specification sheet prepared by the generator supplier.
- **For the devices and equipment outside the scope of our supply, refer the corresponding manual of the generator and the supplier's operation manual.**

Inspection and Maintenance - Prepare (with Engine Switched ON)

1 **Post a sign "Do Not Operate", for example, on the operation panel of the generator and let the other operators not to operate.**
"Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81)

Inspection and Maintenance - Prepare (with Engine Switched OFF)

⚠ WARNING

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

* Unexpected startup of the engine could cause serious personal injury or damage to the devices.

Be sure to establish zero energy state before starting inspection and maintenance work.

* Unexpected activation of the devices could cause serious personal injury or damage to the devices.

1 **Operate the stop switch of the generator "Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81) to turn off the engine.**

2 **Make sure with the thermometer (thermo gun, etc.) that the surface of the engine is cooled down so that you can touch.**

3 **Conduct lockout/tagout. "Lockout/Tagout" (→ Page 58)**

Engine Body - Check

Note

- **Devices and equipment outside the scope of our supply are included in the facility. For the details, refer to such a document as the specification sheet prepared by the generator supplier.**
- **For the devices and equipment outside the scope of our supply, refer the corresponding manual of the generator and the supplier's operation manual.**

Belt - Check

⚠ WARNING

Stay away from rotating parts during operation.

* Otherwise you may get caught in the rotating parts and seriously injured.

⚠ CAUTION

Keep the belt for the crankshaft pulley or alternator free from oil and grease.

* Otherwise, a slip could occur, which will shorten the service life of the belt.

Check each belt status (tension, damage and the like) of the crankshaft pulley or alternator.

* If the belt has been stretched, the battery cannot be cahrged and DC power supply will be lost.

Check each belt for the crankshaft pulley or alternator in the engine.

1 **Check the belt visually.**

- Check for peeling or breaks.

→If any abnormality is found, replace the belt with a new one.

2 **Check the belt tension.**

→If the belt tension is out of the standard value, adjust the belt tension. "Table 8-3 Ribbed Belt Tensile Force" (→ Page 131)

Note

- **The new belt has an initial stretch. Operate the engine for about 1 hour and adjust the belt tension again.**

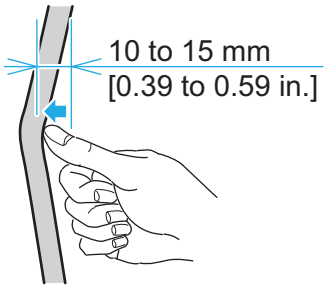


Fig. 8-1 Belt Tension - Adjust (V-belt)

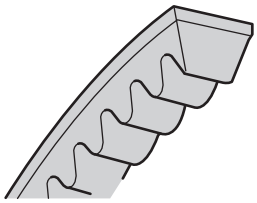


Fig. 8-2 Shape of V-belt

Table 8-1 Type of Belt (V-belt)

Type of Belt	Standard value
V-belt	When the center of the belt span is pressed with a force of approx. 98 N {9.99 kgf} [22.03 lbf] to 147N {14.99 kgf} [33.05 lbf], the deflection of the belt must be 10 to 15 mm [0.39 to 0.59 in.].

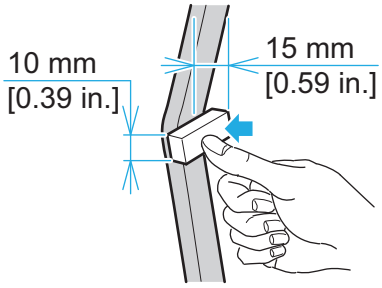


Fig. 8-3 Belt Tension - Adjust (Ribbed Belt)

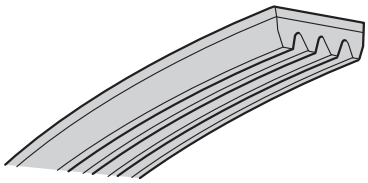


Fig. 8-4 Shape of Ribbed Belt

- Tool: Gauge (10 mm [0.39 in.] wide)

Table 8-2 Type of Belt (Ribbed Belt)

Type of Belt	Standard value
Ribbed Belt	When the midpoint of the straight part of the belt is pressed with a force of "Table 8-3 Ribbed Belt Tensile Force" (→ Page 131)by using a 10 mm [0.39 in.] wide gauge, the deflection is 15 mm [0.59 in.].

Belt Tension (Alternator) - Adjust

⚠ WARNING

Stay away from rotating parts during operation.

* Otherwise you may get caught in the rotating parts and seriously injured.

Adjust the belt tension properly in accordance with the procedures recommended by MHISH.

* Otherwise, the service life of the alternator, bearing or belt could be shortened.
* After you replaced the belt with a new one, check the tension again after the initial stretch of the belt is settled.

⚠ CAUTION

Keep the belt for the crankshaft pulley or alternator free from oil and grease.

* Otherwise, a slip could occur, which will shorten the service life of the belt.

Adjust the alternator belt tension.

Note

- **For the location of the alternator, refer to "2 ENGINE - OUTLINE" (→ Page 73).**

1 Remove the belt cover of the alternator.

- Tool: Wrench

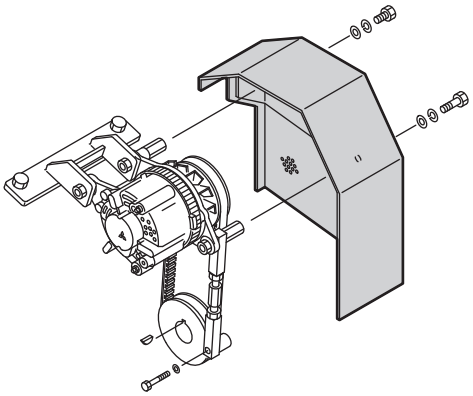


Fig. 8-5 Belt Cover - Remove

2 Loosen all retaining bolts (1) of the alternator and the adjusting rod.

- Tool: Wrench

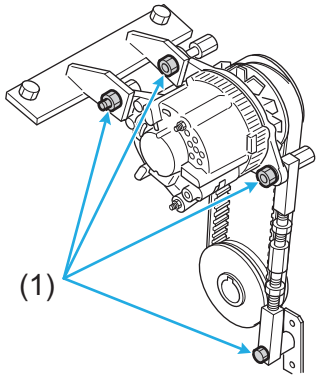


Fig. 8-6 Belt Tension - Adjust (Retaining Bolt)

3 Loosen the lock nut of adjusting rod.

- The upper lock nut (2) has a right-hand thread.
- The lower lock nut (3) has a left-hand thread.
- Tool: Wrench

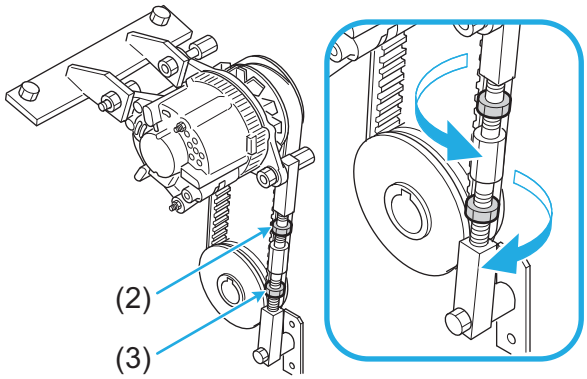


Fig. 8-7 Belt Tension - Adjust (Lock Nut)

4 Turn the turn buckle (4) of the adjusting bolt to adjust the belt tension.

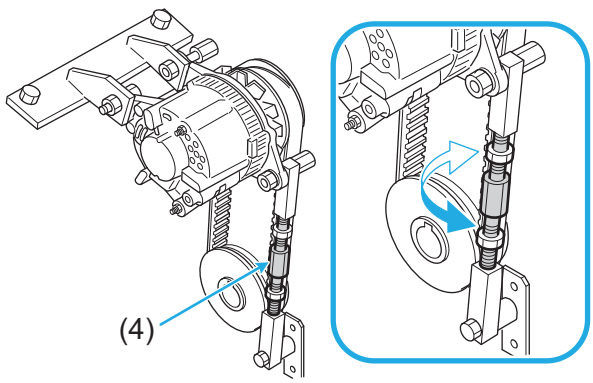


Fig. 8-8 Belt Tension - Adjust (Turn Buckle)

5 **After adjusting deflection, tighten the lock nut of the adjusting rod.**

- The upper lock nut (2) has a right-hand thread.
- The lower lock nut (3) has a left-hand thread.
- Tool: Wrench

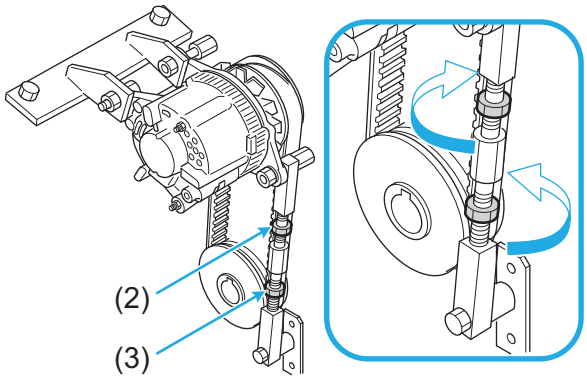


Fig. 8-9 Belt Tension - Adjust (Lock Nut)

6 **Tighten the retaining bolts (1) of the alternator and the adjusting rod which were loosened in Step 2.**

- Tool: Wrench

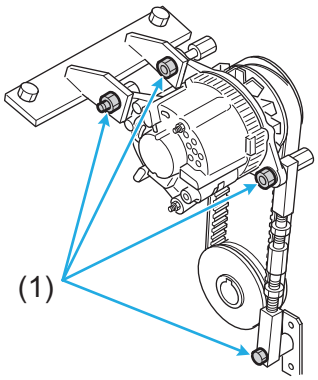


Fig. 8-10 Belt Tension - Adjust (Retaining Bolt)

7 **Install the belt cover of the alternator which was removed in Step 1.**

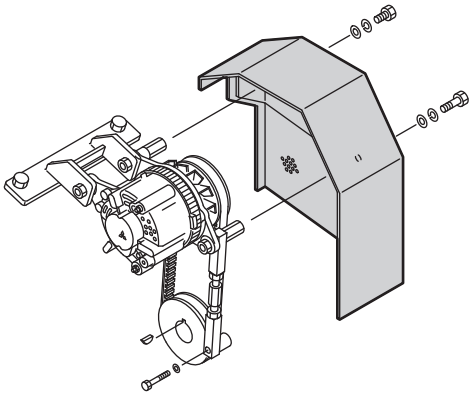


Fig. 8-11 Belt Cover - Install

8 **Install the front cover.**

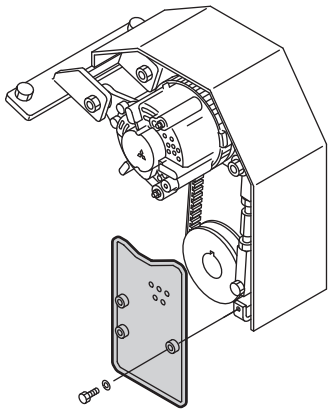


Fig. 8-12 Front cover - Install

Table 8-3 Ribbed Belt Tensile Force

Measuring item	Number of ribs	Belt straight distance (mm)				
		300 or less	more than 300 and 400 or less	more than 400 and 500 or less	more than 500 and 600 or less	more than 600
When a new belt is installed	3	74 N {7.55 kgf} [16.64 lbf]	49 N {5.00 kgf} [11.02 lbf]	37 N {3.77 kgf} [8.32 lbf]	29 N {2.96 kgf} [6.52 lbf]	25 N {2.55 kgf} [5.62 lbf]
	4	88 N {8.97 kgf} [19.78 lbf]	59 N 6.02 kgf} [13.26 lbf]	44 N {4.49 kgf} [9.89 lbf]	35 N {3.57 kgf} [7.87 lbf]	29 N {2.96 kgf} [6.52 lbf]
	5	103 N {10.50 kgf} [23.16 lbf]	69 N {7.04 kgf} [15.51 lbf]	51 N {5.20 kgf} [11.47 lbf]	41 N {4.18 kgf} [9.22 lbf]	34 N {3.47 kgf} [7.64 lbf]
	6	118 N {12.03 kgf} [26.53 lbf]	79 N {8.06 kgf} [17.76 lbf]	59 N {6.02 kgf} [13.26 lbf]	47 N {4.79 kgf} [10.57 lbf]	39 N {3.98 kgf} [8.77 lbf]
	7	132 N {13.46 kgf} [29.67 lbf]	88 N {8.97 kgf} [19.78 lbf]	66 N {6.73 kgf} [14.84 lbf]	53 N {5.40 kgf} [11.91 lbf]	44 N {4.49 kgf} [9.89 lbf]
	8	147 N {14.99 kgf} [33.05 lbf]	98 N {9.99 kgf} [22.03 lbf]	74 N {7.55 kgf} [16.64 lbf]	59 N {6.02 kgf} [13.26 lbf]	49 N {5.00 kgf} [11.02 lbf]
	9	162 N {16.52 kgf} [36.42 lbf]	108 N {11.01 kgf} [24.28 lbf]	81 N {8.26 kgf} [18.21 lbf]	65 N {6.63 kgf} [14.61 lbf]	54 N {5.51 kgf} [12.14 lbf]
	10	176 N {17.95 kgf} [39.57 lbf]	118 N {12.03 kgf} [26.53 lbf]	88 N {8.97 kgf} [19.78 lbf]	71 N {7.24 kgf} [15.96 lbf]	59 N {6.02 kgf} [13.26 lbf]
	11	191 N {19.48 kgf} [42.94 lbf]	127 N {12.95 kgf} [28.55 lbf]	96 N {9.79 kgf} [21.58 lbf]	76 N {7.75 kgf} [17.09 lbf]	64 N {6.53 kgf} [14.39 lbf]
	12	206 N {21.01 kgf} [46.31 lbf]	137N {13.97 kgf} [30.80 lbf]	103 N {10.50 kgf} [23.16 lbf]	82 N {8.36 kgf} [18.43 lbf]	69 N {7.04 kgf} [15.51 lbf]
When retightened	3	51 N {5.20 kgf} [11.47 lbf]	34 N {3.47 kgf} [7.64 lbf]	26 N {2.65 kgf} [5.85 lbf]	21 N {2.14 kgf} [4.72 lbf]	17 N {1.73 kgf} [3.82 lbf]
	4	62 N {6.32 kgf} [13.94 lbf]	41 N {4.18 kgf} [9.22 lbf]	31 N {3.16 kgf} [6.97 lbf]	25 N {2.55 kgf} [5.62 lbf]	21 N {2.14 kgf} [4.72 lbf]
	5	72 N {7.34 kgf} [16.19 lbf]	48 N {4.89 kgf} [10.79 lbf]	36 N {3.67 kgf} [8.09 lbf]	29 N {2.96 kgf} [6.52 lbf]	24 N {2.45 kgf} [5.40 lbf]
	6	82 N {8.36 kgf} [18.43 lbf]	55 N {5.61 kgf} [12.36 lbf]	41 N {4.18 kgf} [9.22 lbf]	33 N {3.37 kgf} [7.42 lbf]	27 N {2.75 kgf} [6.07 lbf]
	7	93 N {9.48 kgf} [20.91 lbf]	62 N {6.32 kgf} [13.94 lbf]	46 N {4.69 kgf} [10.34 lbf]	37 N {3.77 kgf} [8.32 lbf]	31 N {3.16 kgf} [6.97 lbf]
	8	103 N {10.50 kgf} [23.16 lbf]	69 N {7.04 kgf} [15.51 lbf]	51 N {5.20 kgf} [11.47 lbf]	41 N {4.18 kgf} [9.22 lbf]	34 N {3.47 kgf} [7.64 lbf]
	9	113 N {11.52 kgf} [25.40 lbf]	75 N {7.65 kgf} [16.86 lbf]	57 N {5.81 kgf} [12.81 lbf]	45 N {4.59 kgf} [10.12 lbf]	38 N {3.87 kgf} [8.54 lbf]
	10	123 N {12.54 kgf} [27.65 lbf]	82 N {8.36 kgf} [18.43 lbf]	62 N {6.32 kgf} [13.94 lbf]	49 N {5.00 kgf} [11.02 lbf]	41 N {4.18 kgf} [9.22 lbf]
	11	134 N {13.66 kgf} [30.12 lbf]	89 N {9.08 kgf} [20.01 lbf]	67 N {6.83 kgf} [15.06 lbf]	54 N {5.51 kgf} [12.14 lbf]	45 N {4.59 kgf} [10.12 lbf]
	12	144 N {14.68 kgf} [32.37 lbf]	96 N {9.79 kgf} [21.58 lbf]	72 N {7.34 kgf} [16.19 lbf]	58 N {5.91 kgf} [13.04 lbf]	48 N {4.89 kgf} [10.79 lbf]

Note

- **The pressing force when the midpoint of belt straight line is pressed by using the gauge with 10 mm [0.39 in.] wide and the belt is deflected by 15 mm [0.59 in.].**

Damper - Check

⚠ WARNING

Install a protective cover which can dissipate heat.

* Otherwise, the damper could be enclosed and degenerated due to poor heat dissipation and ventilation, and which may cause breakage of the crankshaft.

Note

- **For the location of the dampers, refer to "2 ENGINE - OUTLINE" (→ Page 73).**

1 Check the external appearance of the damper for the items below:

- Oil leak from the cauking
- Flaw
- Deformation such as bulge of the cover (by applying a scale on it)
- Paint discoloring with heat
- Peeling

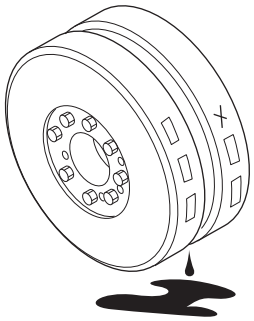


Fig. 8-13 Damper - Check

Note

- **If the damper is defective, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

Damper Temperature - Check

To ensure the proper function of damper, heat must be dissipated from its surface to prevent excessive heating.
Be sure to obey the instructions below:

- Make sure the temperature of the damper outside surface does not exceed the temperature described in the following table when operating the engine at the rated power output.
- When installing a protective cover to the damper, provide adequate ventilation so that the damper temperature does not exceed the temperature listed in the table below.

Table 8-4 Limit Temperature of Damper

Type of damper	Continuous use engine	Emergency use engine
Viscous damper	90°C [194°F]	100°C [212°F]

■ Temperature control with thermo label

On the damper, a thermo label is attached as a guide.
When the thermo label reaches the specified temperature, the white heat-sensitive area turns black.
Control and Record the temperature regularly, and check any abnormal temperature changes.

Note

- **Once the heat-sensitive area of the thermo label turns its color, it will never return to the original color again.**
- **A thermo label is attached as a guide. It is recommended to measure the temperature while operating the engine with a noncontact thermometer (thermo gun) and to control and record it accordingly.**

1 **Make sure with a noncontact thermometer (thermo gun, and others) that the surface of the engine is cooled down so that you can touch.**

2 **Stick a thermo label (1) onto the outer face of the damper.**

Note

- **Avoid the stamped marking.**

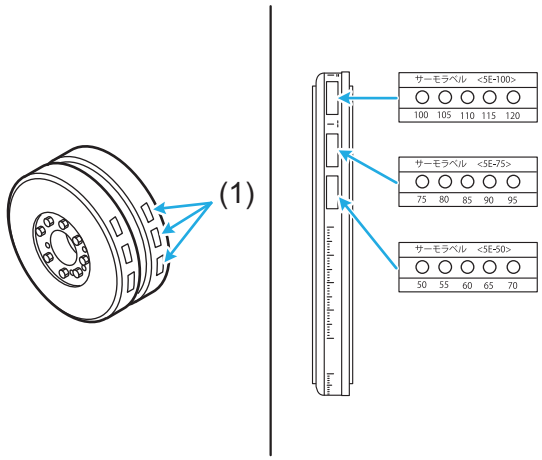


Fig. 8-14 Thermo Label - Stick

Table 8-5 Types of Thermo Labels

Part name	Measurable temperature range (°C)
Thermo label 100-120	100 to 120
Thermo label 75-95	75 to 95
Thermo label 50-70	50 to 70

3 **Operate the engine at the rated load for about an hour.**

4 **Operate the stop switch "Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81) of the generator to turn off the engine.**

5 **Check the heat-sensitive area of the thermo label and record the highest temperature.**
→If a temperature rise is observed, locate the defect in the engine or other causes. In addition, replace the thermo label with a new one and check the change of temperature again.

Note

- **If the detected temperature comes close to the limit temperature of the damper, or if there is any abnormal change in temperature, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**
- **For the temperature limit of the damper, refer to "Table8-4 Limit Temperature of Damper" (→ Page 132).**

Fuel System - Check

⚠ WARNING

Keep away from fire, when working with flammable substances such as fuel.

* They may cause a fire.

If fuel leaks or splashes out from the high pressure injection pipe, do not touch the fuel.

* The fuel injection pipe delivers high pressure fuel. If the fuel contacts your skin, it goes into deep skin tissues and may result in gangrene.

Wipe off spilled flammable substances such as fuel thoroughly with a waste cloth.

* They may cause a fire.

When discarding a waste cloth used to wipe off combustible material, put it into a lidded can and obey the Waste Management and Public Cleansing Act to handle it as a special industrial waste.

* It may cause a fire.
* It could lead to environmental pollution.
* If you violate rules, you may be subject to penalties.

Note

- **When handling fuel, refer to "4 FUEL" (→ Page 98).**
- **Devices and equipment outside the scope of our supply are included in the facility.**
  For the details, refer to such a document as the specification sheet prepared by the generator supplier.
- **For the devices and equipment outside the scope of our supply, refer the corresponding manual of the generator and the supplier's operation manual.**

Fuel tank - Check and Service

Clean and drain water from the fuel tank.

Note

- **The fuel tank is outside the scope of our supply.**
  For the details, refer to the corresponding manual of the generator and the supplier's operation manual.

■ Fuel Tank - Clean

⚠ WARNING

Tighten the fuel supply valve to the engine firmly.

* Otherwise, fuel may leak out, which could cause a fire.

⚠ CAUTION

After cleaning the fuel tank, do not leave the used waste cloth in the fuel tank.

* Otherwise, it may cause damage to the devices in the fuel system.

When draining fuel through the drain cock, always use a container which can accept all the fuel in the tank.

* Otherwise, the drained fuel will overflow from the container and may run to outside of the facility.
* The fuel drained into the container shall be discarded in accordance with the local laws and regulations as well as the manufacturer's SDS.

1 **Clean the fuel tank.**

2 **Refill fuel into the fuel tank, and bleed the fuel system "Fuel System - Bleed Air" (→ Page 135).**

■ Fuel Tank - Drain Water

⚠ CAUTION

When draining water from the fuel tank, always use a container which is suitable for the water quantity.

* Otherwise, the drained water will overflow from the container and may run to outside of the facility.
* The water drained into the container is contaminated with fuel. Discard the water in accordance with the local laws and regulations as well as the manufacturer's SDS.

Drain water properly from the fuel tank.

* If water, dust or other foreign particles are left, they may mix with fuel, which could cause low output power or damage to the devices in the fuel system.

Drain water from the fuel tank.

Fuel System - Bleed Air

⚠ WARNING

Bleed air sufficiently from the fuel system.

* Otherwise, starting failure may occur.

After bleeding, tighten the priming pump firmly.

* If the tightening torque is too weak, fuel leak may occur.
* If the tightening torque is too strong, the priming pump could be damaged.

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

Note

- **Devices and equipment outside the scope of our supply are included in the facility.**
  For the details, refer to such a document as the specifications sheet prepared by the generator manufacturer.
- **For the devices and equipment outside the scope of our supply, refer the corresponding manual of the generator and the supplier's operation manual.**

■ Priming Pump - Operate

There are two different types (A-type and B-type) of priming pumps.

Note

- **For the location of the priming pumps, refer to "2 ENGINE - OUTLINE" (→ Page 73).**

<A-type>

1 **Loosen the priming pump cap (1) by turning it counterclockwise.**
→The cap (1) is released and the cap (1) is raised.

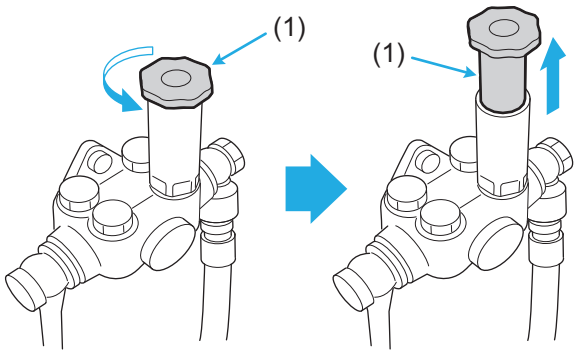


Fig. 8-15 Priming Pump - Operation <A-type>

2 **Move the cap (1) up and down.**
→Fuel is discharged.

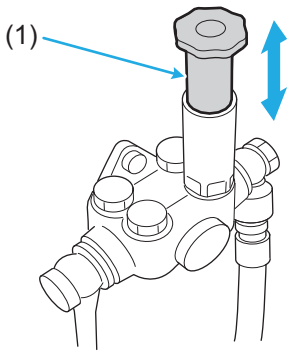


Fig. 8-16 Priming Pump - Operation <A-type>

3 **After bleeding air, turn the cap (1) clockwise while pushing it.**

- Make the cap (1) to contact with the head packing (2).

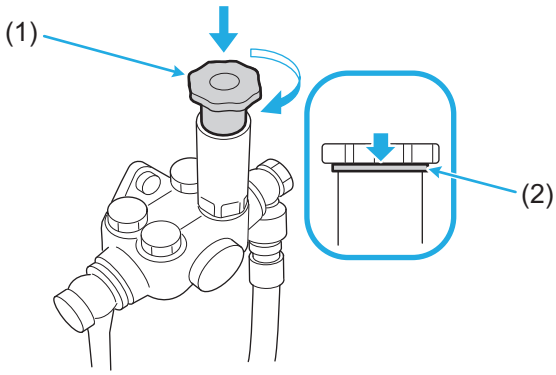


Fig. 8-17 Priming Pump - Operation <A-type>

4 **Retightened by 80 to 100°.**

- Tool: Adjustable wrench

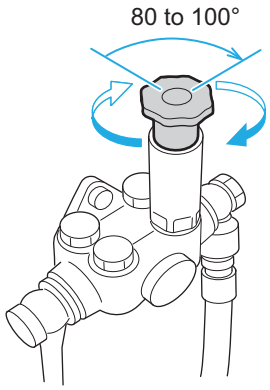


Fig. 8-18 Priming Pump - Operation <A-type>

5 **Check the head packing (3) for an abnormality such as deformation or scratches.**

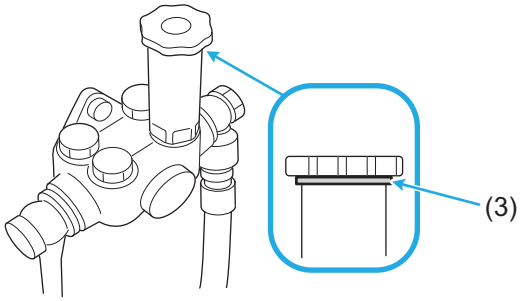


Fig. 8-19 Priming Pump - Operation <A-type>

Note

- **If the head packing has an abnormality such as deformation or scratches, the priming pump must be replaced. Contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

<B-type>

1 **Move the handle up and down.**
→Fuel is discharged.

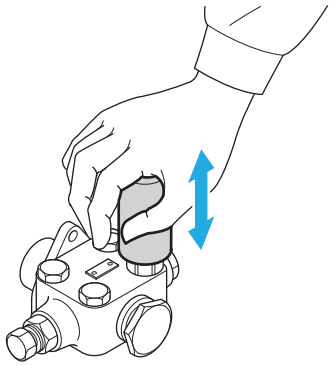


Fig. 8-20 Priming Pump - Operation <B-type>

Note

- **There is not a locking mechanism.**

■ Water Separator - Bleed Air

Bleed air from the water separator.

Note

- **The water separator is outside the scope of our supply.
For the details, refer to such a document as the corresponding manual of the generator and the supplier's operation manual.**

■ Fuel Filter - Bleed Air

Bleed air from the fuel filter.

Note

- **For the location of the fuel filter, refer to "2 ENGINE - OUTLINE" (→ Page 73).**

1 **Loosen the air vent plug of the fuel filter by turning it counterclockwise.**
- Tool: Ring spanner

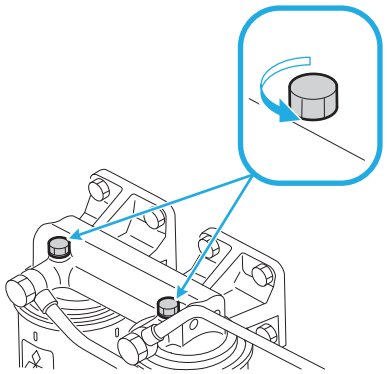


Fig. 8-21 Fuel Filter - Bleed Air 1

2 **Operate the priming pump up and down to feed fuel "Priming Pump - Operate" (→ Page 135).**

3 **Wipe off fuel seeped out from the air vent plug with a waste cloth.**

4 **Tighten the air vent plug of the fuel filter by turning it clockwise.**
- Tool: Torque wrench
- Tightening torque:
  7.8 to 9.8 N·m {0.80 to 1.00 kgf·m} [5.75 to 7.23 lbf·ft]

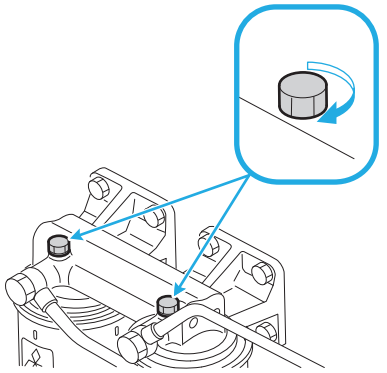


Fig. 8-22 Fuel Filter - Bleed Air 2

■ Fuel Injection Pump - Bleed Air

Bleed air from the fuel injection pump.

Note

- **For the location of the fuel injection pump, refer to "2 ENGINE - OUTLINE" (→ Page 73).**

1 **Loosen the air vent plug of the fuel filter by turning it counterclockwise.**
- Tool: Ring spanner

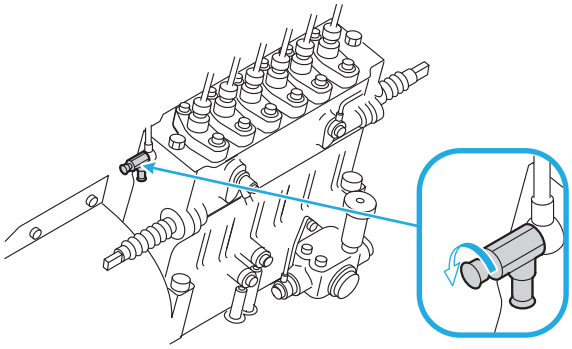


Fig. 8-23 Fuel Injection Pump - Bleed Air 1

2 **Connect a clear plastic tube onto the bleeder screw of the fuel injection pump, and place a container to receive fuel.**

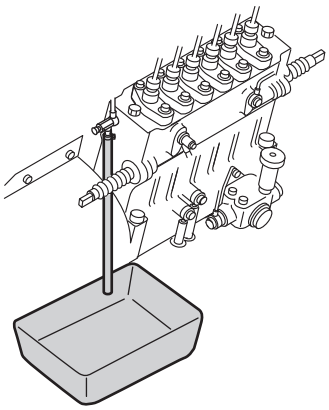


Fig. 8-24 Fuel Injection Pump - Bleed Air 2

Note

- **Prepare a plastic tube (6 mm [0.24 in.] in diameter, approx. 2 m [78.74 in.] long).**

3 **Operate the priming pump up and down to feed fuel "Priming Pump - Operate" (→ Page 135).**
- Feed fuel until the fuel free of bubbles flows from the air vent plug, while observing the plastic tube.

4 **Remove the plastic tube connected in Step 2, and discard fuel in the container properly.**

5 **Tighten the air vent plug of the fuel filter by turning it clockwise.**
- Tool: Torque wrench
- Tightening torque:
  13 to 17 N·m {1.33 to 1.73 kgf·m}
  [9.59 to 12.54 lbf·ft]

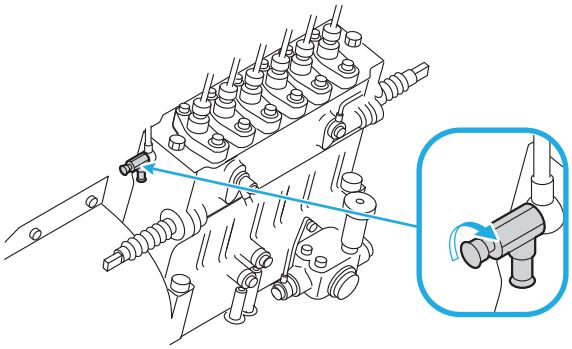


Fig. 8-25 Fuel Injection Pump - Bleed Air 3

Water Separator - Check and Service

Drain water from the water separator and replace its element.

Note

- **The water separator is outside the scope of our supply.**
  For the details, refer to the corresponding manual of the generator and the supplier's operation manual.

■ Water Separator - Drain Water

⚠CAUTION

When draining water from the water separator, always use a container which is suitable for the water quantity.
* Otherwise, the drained water will overflow from the container and may run to outside of the facility.
* The water drained into the container is contaminated with waste oil. Discard the water in accordance with the local laws and regulations as well as the manufacturer's SDS.

Drain water properly from the water separator.
* If draining the water separator is insufficient, water may enter into the fuel system, which could cause damage to the devices.

Drain water from the water separator.

■ Water Separator Element - Replace

⚠WARNING

Open the inlet valve of the water separator slowly to prevent fuel in the water separator from spilling out. Wrap a cloth around the water separator.
* Otherwise, spilled fuel may be ignited, which could cause a fire.

⚠CAUTION

Tighten the cover and cock on the water separator appropriately.
* If the tightening torque is too weak, fuel may leak, causing a fire or fuel flow-out, which could lead to environmental pollution.

1 **Replace the water separator element.**

2 **After the new fuel filter element is installed, bleed air from the fuel system. "Fuel System - Bleed Air" (→ Page 135)**

Gauze Filter - Clean

⚠ WARNING

Clean the gauze filter properly.

* A clogged gauze filter may result in insufficient fuel supply, low power output, or engine stall during operation.

⚠ CAUTION

When replacing the gauze filter, tighten the new one under the same condition as the old one was installed.

* If the tightening torque is too weak, fuel may leak, causing a fire or fuel flow-out, which could lead to environmental pollution.

Note

- **For the location of the fuel supply pump, refer to "2 ENGINE - OUTLINE" (→ Page 73).**
- **Some parts such as joint and hose may be outside the scope of our supply. For the details, refer to such a document as the specification sheet prepared by the generator manufacturer.**
- **If it is not supplied by MHISH, follow the instructions in the supplier's operation manual.**

1 **Remove the banjo bolt at the inlet port of the fuel feed pump.**
- Tool: Wrench

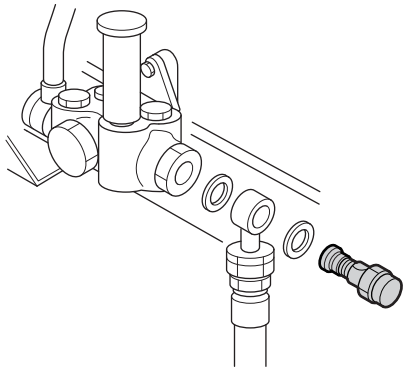


Fig. 8-26 Banjo Bolt - Remove

2 **Remove the gauze filter that is fitted inside the banjo bolt.**
- Tool: Flat blade screwdriver

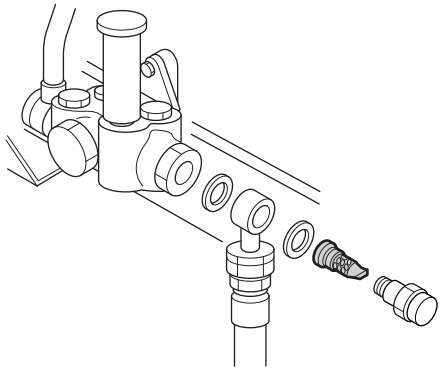


Fig. 8-27 Gauze Filter - Remove

3 **Soak the gauze filter into fresh fuel oil in the container, and wash it with a soft brush or others.**
- Replace the gauze filter with a new one, if it has a break or deformation.

4 **After cleaning, install the gauze filter into the banjo bolt.**
- Tool: Flat blade screwdriver

5 **Align the phase and angle between the joint (1) and the hose (2) as they were when removed.**
- Always replace the sealing washer with a new one once it is disturbed.

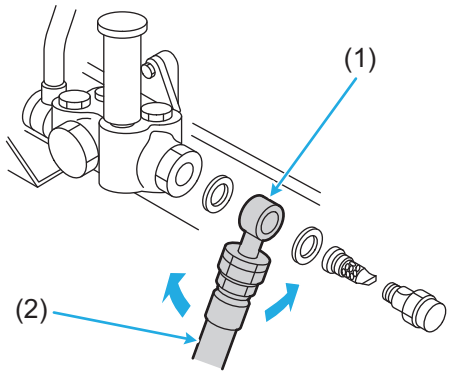


Fig. 8-28 Joint, Hose

6 **Install the banjo bolt in Step 4 to the fuel feed pump.**
- Tool: Torque wrench
- Tightening torque:
  30 to 38 N·m {3.06 to 3.87 kgf·m}
  [22.13 to 28.03 ibf·ft]
- Always replace the sealing washer with a new one once it is disturbed.

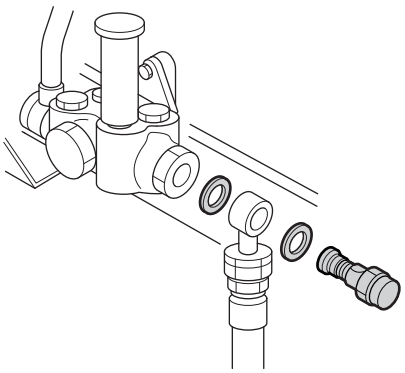


Fig. 8-29 Banjo Bolt - Install

7 **Bleed air from the fuel filter "Fuel Filter - Bleed Air" (→ Page 137).**

Fuel Filter - Replace

⚠ WARNING

Do not pour fuel into the fuel filter before installing it.
* Otherwise, it may cause serious personal injury, environmental pollution due to fuel running to outside of the facility, or damage to the devices.
* Follow the installation procedure described in this Operation & Maintenance Manual.

Use a genuine fuel filter.
* If a non-genuine filter is used, , deterioration in the exhaust gas properties and damage to the devices could occur due to insufficient air intake.
* Faults or damages caused by using non-genuine parts will be outside the scope of the warranty.

⚠ CAUTION

Do not use a fuel filter with a scratch or dent.
* Otherwise, damage to the filter or fuel leak may occur, which could cause a fire or environmental pollution due to fuel running to outside of the facility.

Do not use a filter wrench when installing the fuel filter.
* It may cause a dent or damage to the fuel filter.

If fuel spills out while removing the fuel filter, wipe off with a waste cloth.
* Otherwise, it may cause a fire or environmental pollution due to fuel running to outside of the facility.
* The waste cloth used to wipe off fuel shall be discarded in according with the local laws and regulations as well as the manufacturer's SDS.

Check the specification of the fuel filter when installing it.
* The fuel filter of which specification does not apply to the fuel may cause damage to the devices.

Note
- **For the location of the fuel filter, refer to "2 ENGINE - OUTLINE" (→ Page 73).**

1 Clean the area around the fuel filter with a waste cloth.

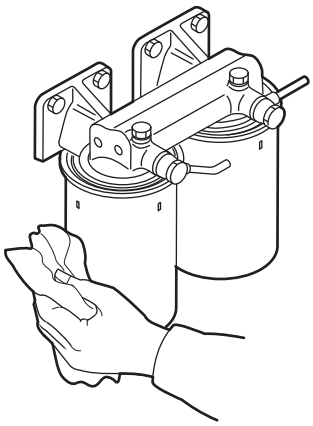


Fig. 8-30 Around Fuel Filter - Clean

2 Prepare a container to receive spilled fuel and place it under the fuel filter.

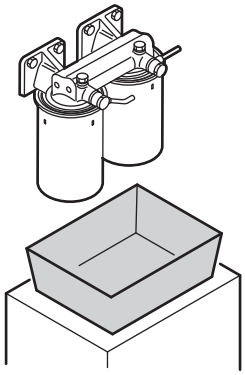


Fig. 8-31 Container to Receive Fuel

Note

- **The customer is required to prepare the container.**

3 Remove the fuel filter.

- Tool: Filter wrench

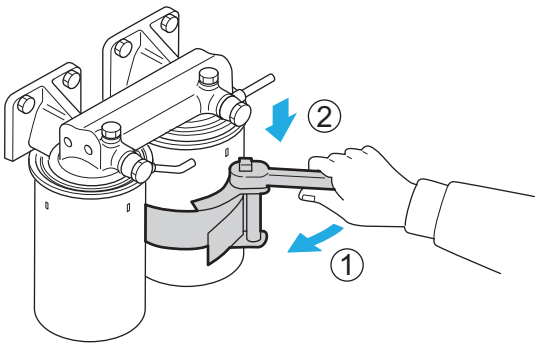


Fig. 8-32 Fuel Filter - Remove

Note

- **Remove it slowly so that fuel will not spill.**

4 Wipe off fuel on the fuel filter installing surface of the filter bracket with a waste cloth.

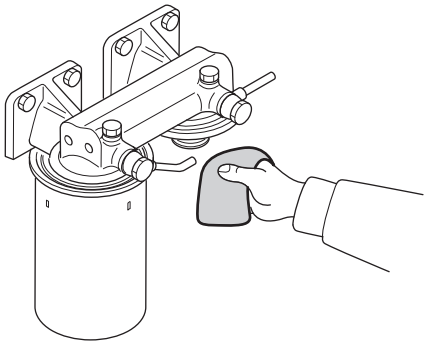


Fig. 8-33 Fuel Filter Installing Surface - Clean

5 Prepare a new fuel filter.

1) Check that the gasket is properly seated in the groove.
2) Apply clean fuel on the fuel filter gasket.

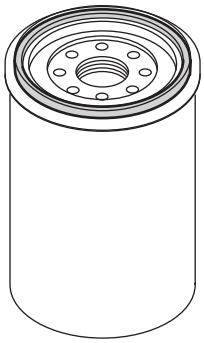


Fig. 8-34 Fuel Filter Gasket

6 **Install the fuel filter in Step 5 on the filter bracket.**

- When the fuel filter gasket comes in contact with the installing surface of the filter bracket, further tighten the fuel filter by 3/4 to a full turn.

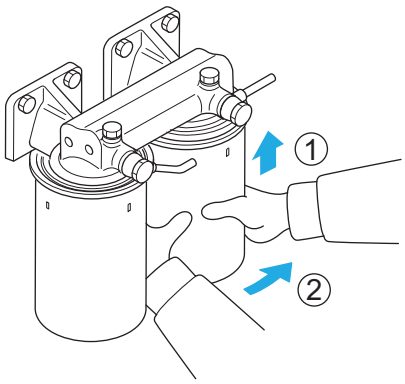


Fig. 8-35 Fuel Filter - Install

Note

- **If the fuel filter is slippery and therefore hard to install, wipe the fuel filter surface with a waste cloth thoroughly, and tighten the fuel filter with anti-slip gloves.**

7 **Bleed air from the fuel filter "Fuel Filter - Bleed Air" (→ Page 137).**

8 **Check the fuel control link "Fuel Control Link - Check" (→ Page 143).**

9 **Operate the start switch of the generator "Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81) to start the engine.**

10 **Operate the engine at an idle speed for several minutes.**

11 **Operate "Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81) the stop switch of the generator to turn off the engine.**

12 **Check the fuel filter installing surface of the filter bracket for leakage.**

→If a fuel leak is found, remove the fuel filter and check the gasket for damage.

→Replace the gauze filter with a new one, if it has damage.

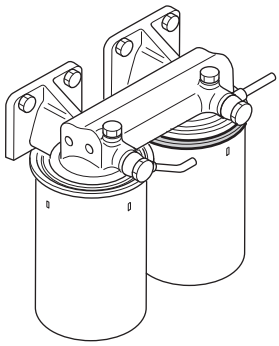


Fig. 8-36 Fuel Filter Installing Surface - Check

13 **Discard fuel in the container in Step 2 properly.**

Fuel Control Link - Check

⚠ WARNING

Never cut the seal of the fuel control link.

* If you cut the seal, damage to the engine or deterioration in the exhaust gas properties could occur.
* In case that the seal is cut, warranty will become invalid.

Make sure there is no looseness or play at the fuel control link.

* Otherwise, the engine may overrun.

⚠ CAUTION

When checking the fuel control link, do not insert your finger into the moving parts.

* Otherwise, you may get injured.

Note

- **For the location of the fuel control link, refer to "2 ENGINE - OUTLINE" (→ Page 73).**

1 Check the fuel control link if it moves smoothly and is free of play and looseness.

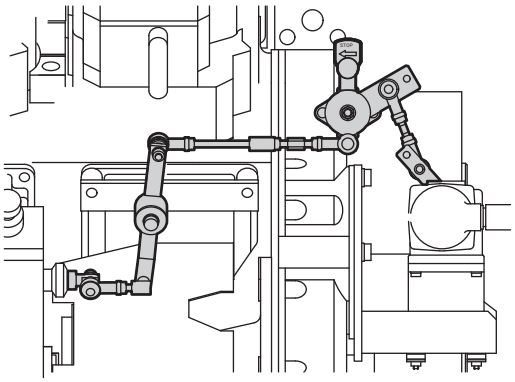


Fig. 8-37 Fuel Control Link - Check

Note

- **If there is play or looseness, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

2 Push the manual stop lever to the fuel increase direction and hold this position.

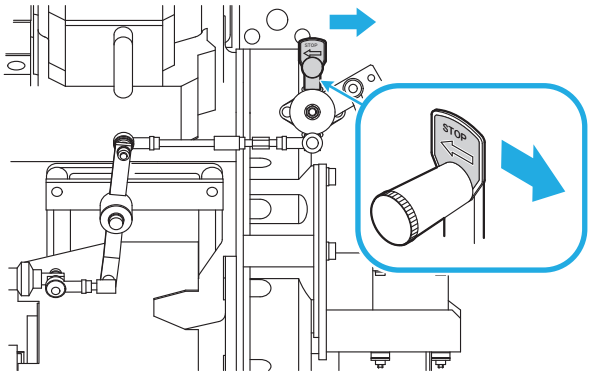


Fig. 8-38 Manual Stop Lever - Operate

Note

- **The location of the manual stop lever varies depending on the specification of the engine. Refer to "Protection System - Location" (→ Page 78).**

3 Decrease the pushing pressure little by little, and check the manual stop lever for smooth returning to the previous position.

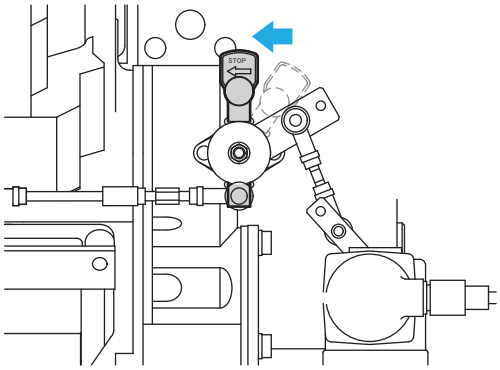


Fig. 8-39 Manual Stop Lever - Check

Note

- **If the lever cannot be returned back smoothly, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

4 **Check the ball joint (1) for looseness of 0.1 mm [0.004 in.] or more.**

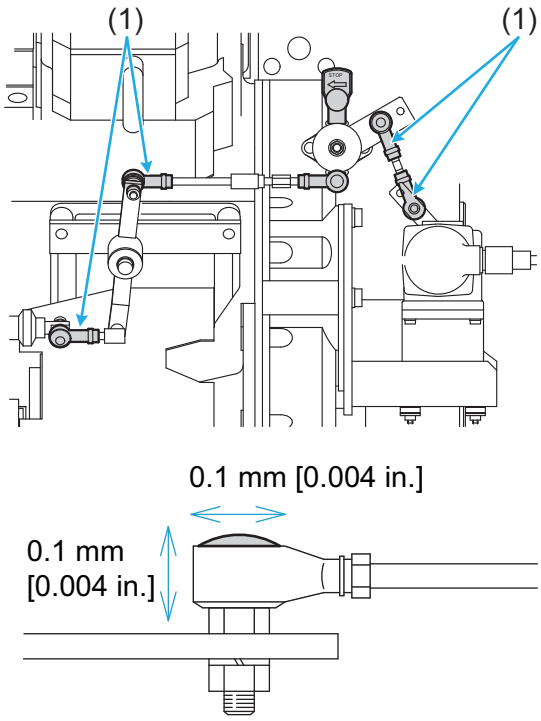


Fig. 8-40 Ball Joint - Check

Note

- **If looseness is detected, replace the ball joint with a new one. "Ball Joint - Replace" (→ Page 144)**
- **If the sealing is defective, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

■ Ball Joint - Replace

Note

- **If the ball joint is integrated with the control link, replace the assembly.**

1 **Remove the nut (or lock nut) which fixes the ball joint.**

- Tool: Wrench

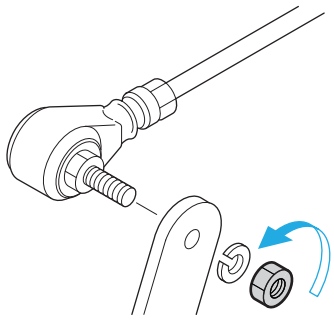


Fig. 8-41 Ball Joint - Remove

2 **Ball Joint and Washer - Remove**

- The lock nut does not have a washer.

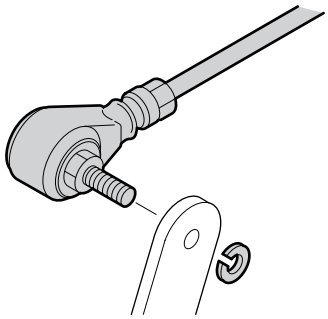


Fig. 8-42 Ball Joint and Washer - Remove

3 **Install the new ball joint, and insert the washer.**

- Replace the washer with a new one.

4 Tighten the nut, and fix the ball joint.

- Replace the nut with a new one.
- Tool: Wrench

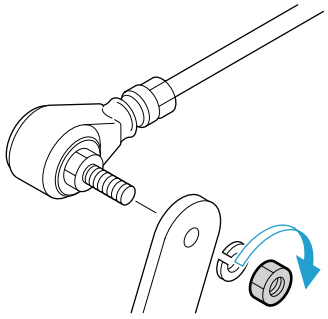


Fig. 8-43 Ball Joint - Fix

Fuel Pipe - Check

⚠ WARNING

Check the clamp for the high pressure fuel injection pipe for looseness.

* If looseness or play is detected at the clamp for the high pressure fuel injection pipe, damage to the pipe may occur, which could cause a fire.

Install the clamp for the high pressure fuel injection pipe at the correct position.

* If it is installed at a wrong position, the pipe could be damaged, which could cause a fire.

1 Check the clamp (1) and the seat (2) for cracks and wear.

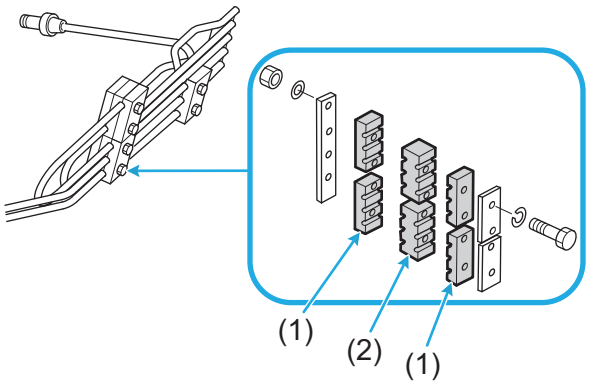


Fig. 8-44 Clamp and Seat - Check

Note

- **If there are cracks or wear, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

2 Install the clamp for the high pressure fuel injection pipe at the previous position. "Fig. 8-45 High Pressure Fuel Injection Pipe Clamp - Location" (→ Page 146)

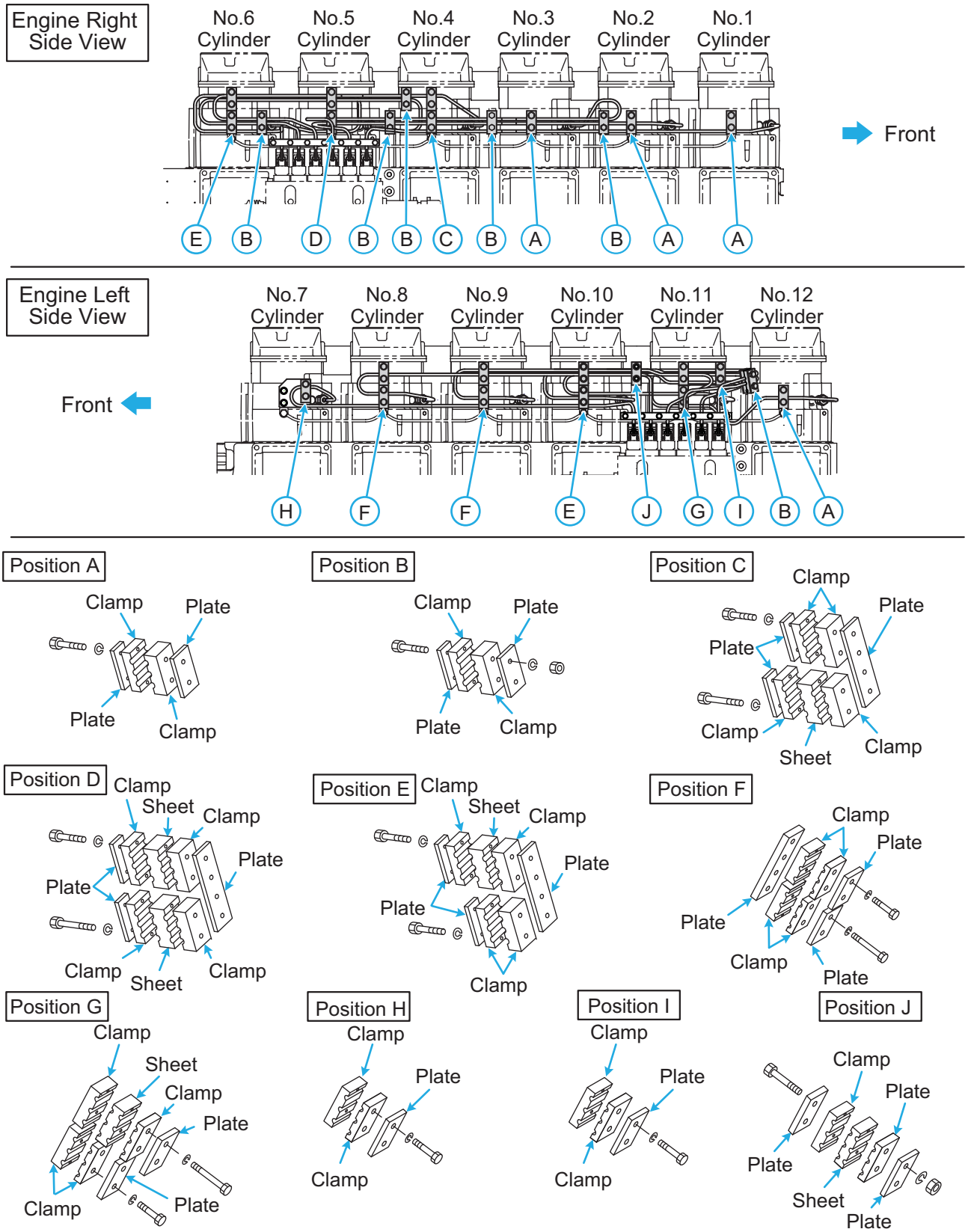


Fig. 8-45 High Pressure Fuel Injection Pipe Clamp - Location

3 **Check the high pressure fuel injection pipe (3) for wear.**

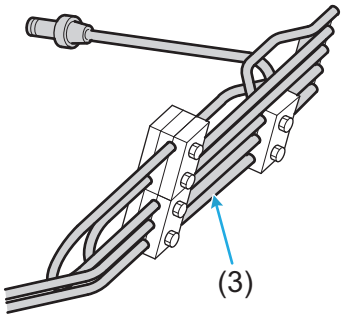


Fig. 8-46 High Pressure Fuel Injection Pipe - Check

Note

- **If wear is found, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

4 **Loosen clamp retaining bolt and check wear of clip (4) and metal contact between the pipe and the clamp.**

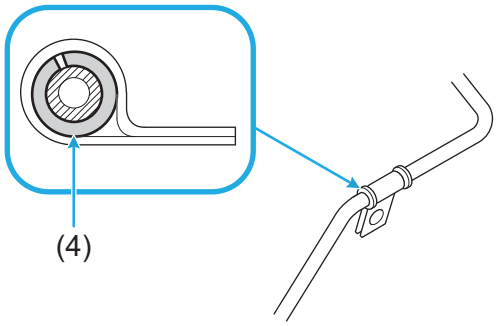


Fig. 8-47 Low Pressure Fuel Pipe - Check

Note

- **If wear or metal contact is found, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

Engine Oil System - Check

⚠ WARNING

Do not touch hot engine oil or parts.

* Otherwise, you could get burned.

Do not discard waste oil into sewerage, river, lake or other similar places.

* Be sure to discard waste oil in accordance with the applicable laws and regulations.

Note

- **When handling engine oil, refer to "5 ENGINE OIL" (→ Page 103).**
- **Devices and equipment outside the scope of our supply are included in the facility. For the details, refer to such a document as the specification sheet prepared by the generator supplier.**
- **For the devices and equipment outside the scope of our supply, refer the corresponding manual of the generator and the supplier's operation manual.**
- **If automatic oil supply is provided, refer to the corresponding manual of the generator and the supplier's operation manual.**

Engine Oil - Change

■ Corresponding Equipment - Location

Examples of corresponding equipment at the engine side are given as follows. For the actual location, refer to "2 ENGINE - OUTLINE" (→ Page 73).

Table 8-6 Corresponding Equipment

No.	Name
(1)	Cylinder head
(2)	Oil level gauge
(3)	Oil filler
(4)	Oil pan

<S12R-PTA - Right-Side View>

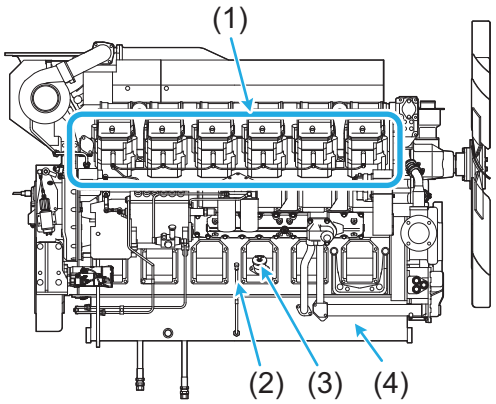


Fig. 8-48 <S12R-PTA - Right-Side View>

<S12R-PTA - Left-Side View>

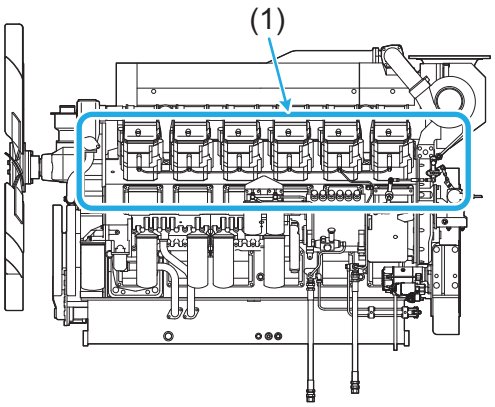


Fig. 8-49 <S12R-PTA - Left-Side View>

■ Engine Oil - Drain

1 **Operate the stop switch of the generator "Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81) to turn off the engine.**

2 **Prepare a container of the suitable size for receiving drained engine oil, and place it under the oil pan drain port.**

Note

- **The customer is required to prepare the container.**

3 **Drain engine oil from the oil pan drain port.**

4 **Discard engine oil in the container in Step 2 properly.**

■ Engine Oil - Check

⚠ WARNING

Conduct analysis of the engine oil periodically and check to make sure that the engine oil does not show milky color.

* If the engine oil shows milky color, water may be mixed into the engine oil system due to coolant leak or a damaged cylinder liner O-ring. Sustained use of the engine without any remedy could cause seizure of the crankshaft and lead to serious damage to the devices.

1 **Extract 1 to 2 L [0.26 to 0.53 US gal.] of engine oil from the oil pan.**

2 **Check for odor and discoloration to determine if the oil is contaminated with fuel or water.**

- If fuel is mixed, the oil will smell like fuel.
- If water is mixed, the engine oil becomes milky.

Note

- **If the engine oil is contaminated with fuel or water, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

■ Engine Oil - Refill

⚠ WARNING

Be sure to install the oil filler cap after engine oil is refilled.

* Otherwise, seizure due to insufficient oil or environmental pollution due to engine oil running out from the facility may occur.

Make sure that engine oil is not leaking from the oil pan. When checking the engine oil level, wear protective glasses to prevent engine oil from getting in your eyes.

* If engine oil gets in your eyes, it will cause pain and lead to sight loss at the worst.

Refill engine oil enough to raise the level to within the specified range (between the highest line {H} and the lowest line {L}).

* If the engine oil level exceeds the upper limit, the oil pan may crack or oil may splash out from the breather.
* If the engine oil level is too low, seizure of the bearings could occur.

Keep the quantity and properties (viscosity) of the engine oil at the specified level.

* If the supply or kinematic viscosity of engine oil is too low, insufficient lubrication of the bearing could occur, which could cause seizure of the crankshaft.
* If kinematic viscosity of engine oil increases, fuel consumption will increase.

1 Remove the oil filler cap.

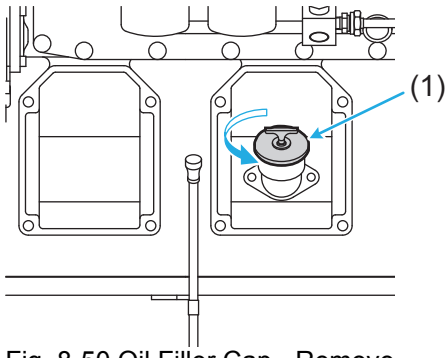


Fig. 8-50 Oil Filler Cap - Remove

2 Refill engine oil to the specified level.

- Tool: Hand pump, and others.

Note

- **For the specified quantity of engine oil, refer to "SPECIFICATIONS - CHECK" (→ Page 10).**

3 Remove the rocker cover from all the cylinder heads.

- Tool: Wrench

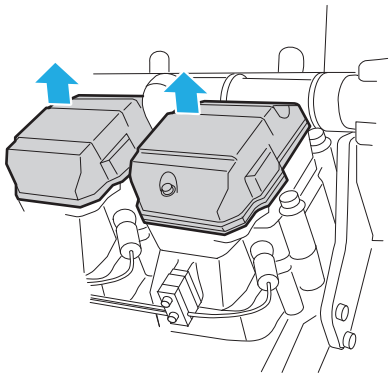


Fig. 8-51 Rocker Cover - Remove

4 Apply engine oil on the valve mechanisms of all the cylinder heads.

- Tool: Oiler, oil jug, and others.

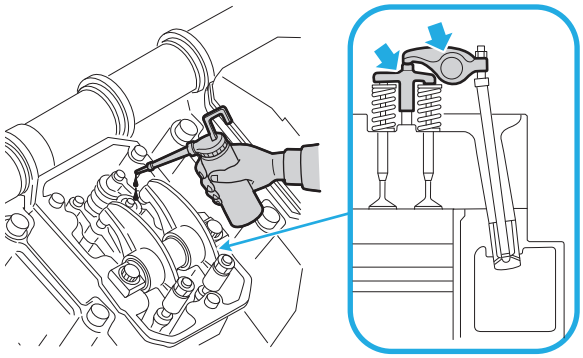


Fig. 8-52 Engine Oil - Apply (Valve Mechanism)

5 **Apply engine oil to the camshaft oil baths of all the cylinder heads.**
- Apply oil through the cylinder heads.
- Oil capacity per cylinder: 0.8 L [0.21 US gal.] (as a guide)
- Tool: Oiler, oil jug, and others.

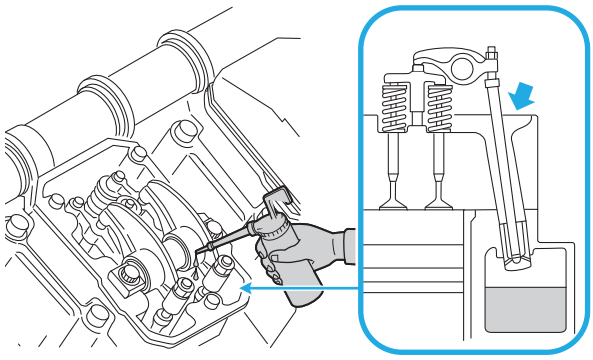


Fig. 8-53 Engine Oil - Apply (Camshaft Oil Bath)

6 **Install the rocker covers onto all the cylinder heads.**
- Tool: Wrench

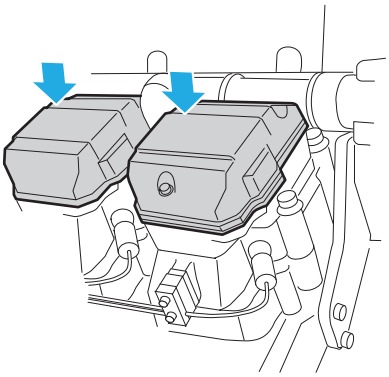


Fig. 8-54 Rocker Cover - Install

■ Engine Oil Level - Check

⚠ WARNING

Keep away from fire, when checking the engine oil level.

* It may cause a fire.

After filling engine oil, check and adjust the engine oil level.

1 **Check the specified level of the engine oil.** **"SPECIFICATIONS - CHECK" (→ Page 10)**

2 **Pull out the oil level gauge (1) slowly and wipe off the engine oil with a waste cloth.**

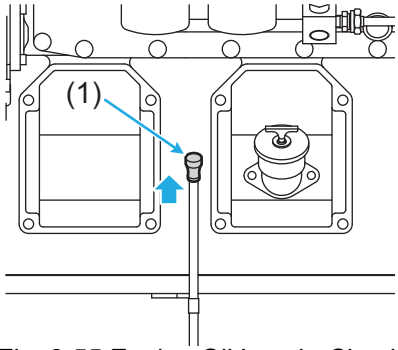


Fig. 8-55 Engine Oil Level - Check

3 **Insert the oil level gauge fully into the oil level gauge guide and then pull it out slowly.**

4 **Check the level of the engine oil on the oil level gauge.**

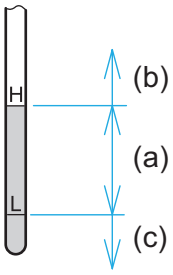


Fig. 8-56 Oil level gauge

(a) If the engine oil level is between the "maximum line (H)" and the "minimum line (L)", it is normal.

(b) If the engine oil level is higher than the "maximum line (H)", drain the oil. "Engine Oil - Drain" (→ Page 148)

(c) If the engine oil level is lower than the "minimum line (L)", add the specified engine oil. "Engine Oil - Refill" (→ Page 149)

5 **After adjusting the engine oil level, install the oil filler cap (2).**

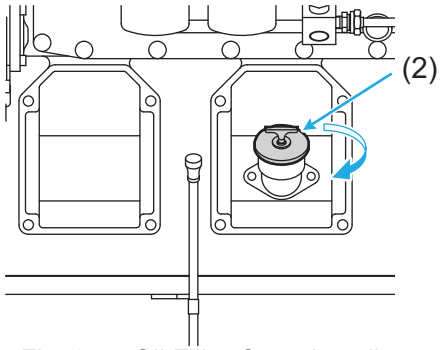


Fig. 8-57 Oil Filler Cap - Install

6 **Check that the oil pan drain port is closed.**

7 **Check the engine oil system including the oil pan for leak of engine oil.**

Note

- **If a leak is found, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

■ Engine - Adjust after Oil Change

After changing engine oil, operate the engine as follows.

1 **Pull the manual stop lever in the direction to stop and hold the position, and crank the engine for approx. 10 seconds using the starter.**
→Engine oil is supplied to the engine parts.

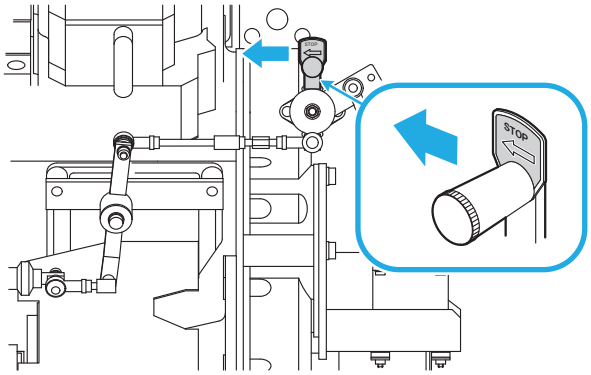


Fig. 8-58 Engine - Adjust after Oil Change

Note

- **The location of the manual stop lever varies depending on the specification of the engine. Refer to "Protection System - Location" (→ Page 78).**

2 **Pause for about 1 minute.**

3 **Repeat the operation of Step 1 and 2 for 2 or 3 times.**
→The engine oil reaches the engine parts.

4 **Check the engine oil level "Engine Oil Level - Check" (→ Page 150).**

Oil Filter - Replace

⚠ WARNING

When replacing the oil filter, do not pour the remaining engine oil in the old filter into the new filter.

* Otherwise, foreign particles could enter the engine oil system, which could cause damage to the devices.

Before replacing the oil filter, make sure that the engine has cooled down to the normal temperature.

* Otherwise, you could get burned by heat.

Use a genuine oil filter.

* Using non-genuine parts could cause damage to the devices or degradation in the performance.
* Faults or damages caused by using non-genuine parts will be outside the scope of the warranty.

If paint or other matter is adhering around the sealing surface, remove them before assembling.

* If paint or other matter is stuck on the sealing surface, fuel could leak through the gap, which could cause a fire.

If engine oil spills out while removing the oil filter, wipe off with a waste cloth.

* Otherwise, it may cause a fire or environmental pollution due to fuel running to outside of the facility.
* The waste cloth used to wipe off engine oil shall be discarded in according with the local laws and regulations as well as the manufacturer's SDS.

⚠ CAUTION

Do not use the oil filter with a scratch or dent.

* Otherwise, damage to the filter or oil leak may occur, which could cause a fire or environmental pollution due to fuel running to outside of the facility.

Do not use a filter wrench when installing the oil filter.

* It may cause a dent or damage to the oil filter.

⚠ CAUTION

When replacing the oil filter, set the gasket into the groove properly.

* Otherwise, engine oil leak could occur, which could cause a fire or environmental pollution due to oil running to outside of the facility.
* Follow the replacing procedure described in this Operation & Maintenance Manual.

Note

- **For the location of the oil filter, refer to "2 ENGINE - OUTLINE" (→ Page 73).**

1 **Clean the area around the oil filter, with a waste cloth.**

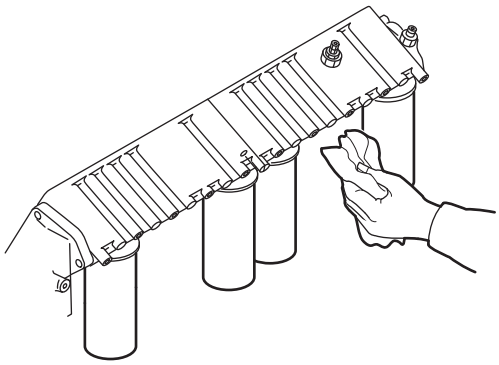


Fig. 8-59 Around Oil Filter - Clean

2 **Prepare a container to receive spilled oil and place it under the oil filter.**

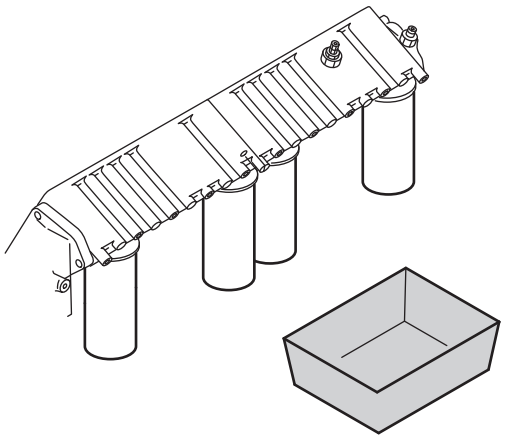


Fig. 8-60 Container to Receive Engine Oil

Note

- **The customer is required to prepared the container.**

3 Remove the oil filter.

- Tool: Filter wrench

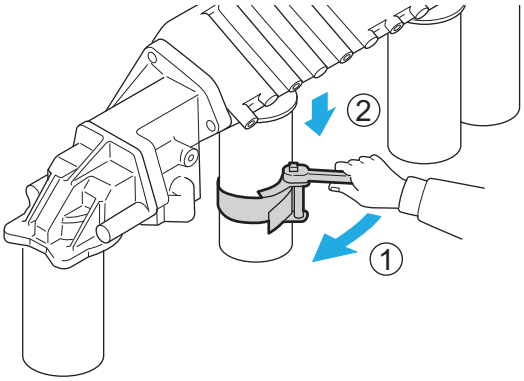


Fig. 8-61 Oil Filter - Remove

Note

- **Remove it slowly so that engine oil will not spill.**
- **Cut the removed oil filter and check the element. If metal particles are found, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

4 Thoroughly wipe off engine oil on the oil filter installing surface of the filter bracket with a waste cloth.

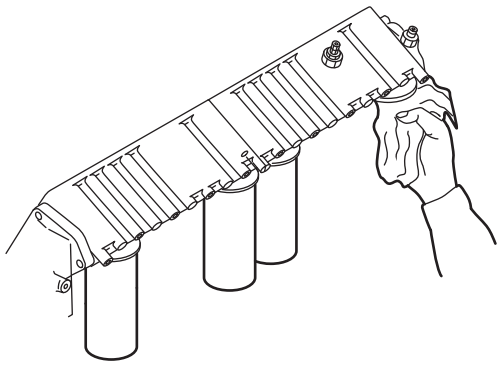


Fig. 8-62 Oil Filter Installing Surface - Clean

5 Prepare a new oil filter.

1) Check that the gasket is properly seated in the groove.
2) Apply clethe engine oil to the gasket.

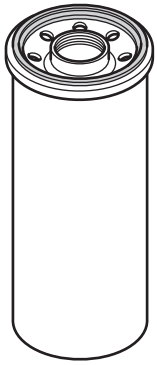


Fig. 8-63 Oil Filter Gasket

6 Install the oil filter in Step 5 on the filter bracket.

- When the oil filter gasket comes in contact with the installing surface of the filter bracket, further tighten the oil filter by 3/4 to a full turn.

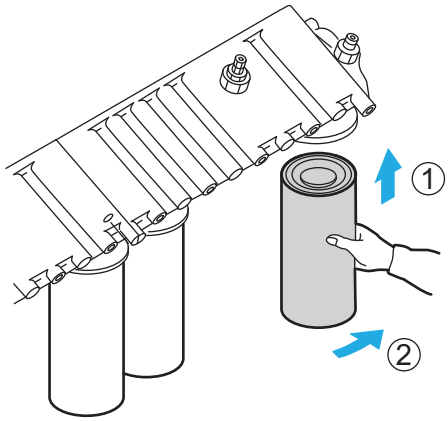


Fig. 8-64 Oil filter - Install

Note

- **If the oil filter is slippery and therefore hard to install, wipe the oil filter surface with a waste cloth thoroughly, and tighten the oil filter with anti-slip gloves.**

Bypass Oil Filter - Replace

Replace using the same procedure as "Oil Filter - Replace" (→ Page 152).

Note

- **For the location of the bypass oil filter, refer to "2 ENGINE - OUTLINE" (→ Page 73).**

Governor Oil Filter - Replace (Hydraulic Governor Spec)

⚠ WARNING

Do not touch hot engine oil or parts.
* Otherwise, you could get burned.

1 **Clean the area around the governor oil filter, with a waste cloth.**
2 **Prepare a container to receive spilled oil and place it under the governor oil filter.**

Note

- **The customer is required to prepare the container.**

3 **Drain engine oil in the governor oil filter.**
- Tool: Wrench

1) Loosen the air vent plug (1).
2) Remove the drain plug (2).

→Engine oil is drained.

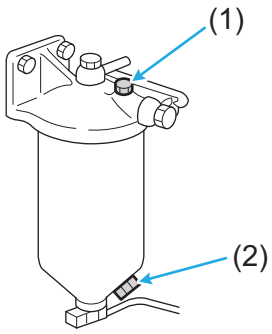


Fig. 8-65 Engine Oil - Drain

4 **Remove the oil pipe (3) from center bolt.**
- Tool: Wrench

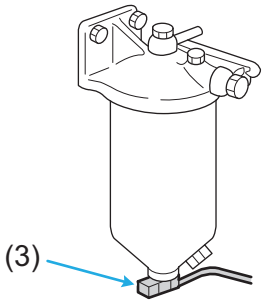


Fig. 8-66 Oil Pipe - Remove

5 **Remove the center bolt (4).**
→The case (5) can be removed.
- Tool: Wrench

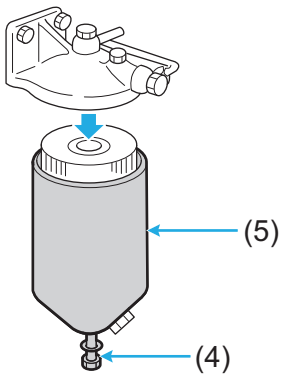


Fig. 8-67 Center Bolt - Remove

6 **Pull out the element from the case.**

Note

- **Pull it out slowly so that engine oil will not spill.**

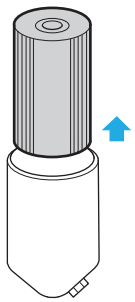


Fig. 8-68 Element - Pull Out

7 Install a new element in the case along the center bolt.

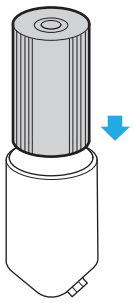


Fig. 8-69 Element - Install

8 Install the case (5) in Step 7 to the filter bracket. Fix it by tightening the center bolt (4).

- Tool: Wrench

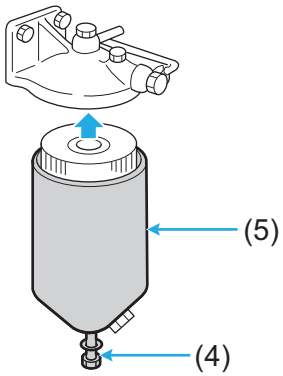


Fig. 8-70 Case - Install

9 Install the oil pipe (3) was removed in Step 4.

- Tool: Wrench

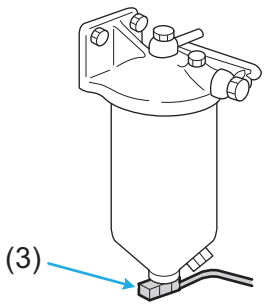


Fig. 8-71 Oil pipe - Install

10 Install the drain plug (2) which was removed in Step 3.

- Tool: Wrench

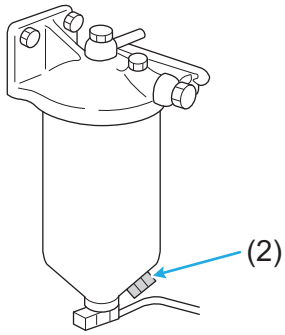


Fig. 8-72 Drain Plug - Install

11 Remove the air vent plug (1).

- Tool: Ring spanner

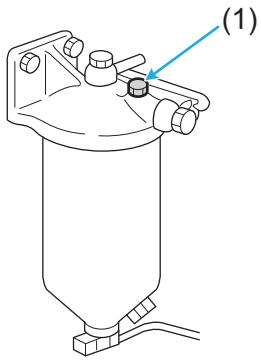


Fig. 8-73 Air Vent Plug - Remove

12 After filling the filter with engine oil, install the air vent plug (1).

- Tool: Wrench

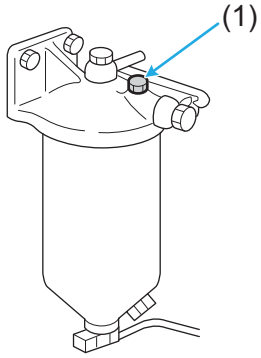


Fig. 8-74 Air Vent Plug - Install

Oil Pipe - Check

1 **Loosen the clamp retaining bolt of the oil pipe and check for wear of the clip (1) and metal contact between the pipe (2) and the clamp (2).**

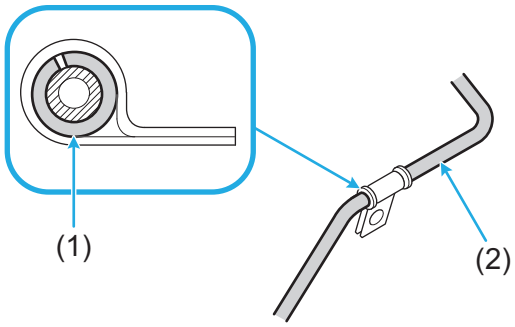


Fig. 8-75 Oil Pipe - Check

Note

- **If wear is found, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

Cooling System - Check

⚠ WARNING

Do not continue to operate the engine with engine oil mixed in coolant.

* Otherwise, cooling fault may occur, which could cause damage to the engine.

Do not open the radiator cap or coolant tank cap while the engine is hot.

* Otherwise, you could get burns by steam or water splashing out.

Tighten the drain cock on the water pump properly.

* Insufficient tightening may cause a coolant leak.

⚠ CAUTION

Follow the coolant draining procedure described in this Operation & Maintenance Manual.

* Draining in the incorrect procedure may cause burns or environmental pollution due to coolant running to outside of the facility.

When handling cleaning solution for washing the cooling system, obey the manufacturer's SDS.

* Improper wearing or using of personal protective equipment may cause personal injury.

Note

- **When handling coolant (LLC), refer to "6 COOLANT" (→ Page 105).**
- **Devices and equipment outside the scope of our supply are included in the facility. For the details, refer to such a document as the specification sheet prepared by the generator supplier.**
- **For the devices and equipment outside the scope of our supply, refer the corresponding manual of the generator and the supplier's operation manual.**

Corresponding Equipment - Location

Examples of corresponding equipment at the engine side are given as follows. For the actual location, refer to "2 ENGINE - OUTLINE" (→ Page 73).

Table 8-7 Corresponding Equipment - Location

Part	Name
(1)	Coolant drain cock (engine body)
(2)	Thermostat
(3)	Water pump

<S12R-PTA - Right-Side View>

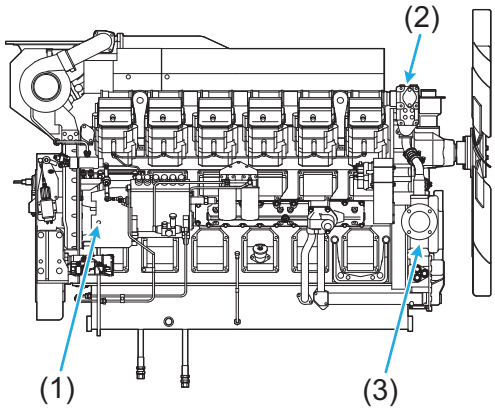


Fig. 8-76 <S12R-PTA - Right-Side View>

<S12R-PTA - Left-Side View>

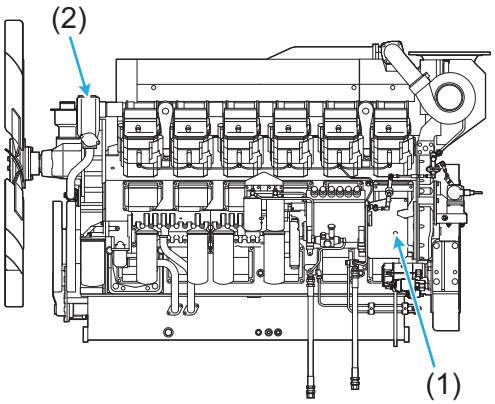


Fig. 8-77 <S12R-PTA - Left-Side View>

Coolant - Change

■ Coolant - Drain

Note

- **When draining coolant immediately after engine operation, run the engine at low idle for 5 to 6 minutes and check that the coolant becomes to the room temperature.**

1 **Prepare a container for receiving drained coolant and place it under the coolant drain cock on the engine body.**

Note

- **The customer is required to prepare the container.**

2 **Slightly open the coolant drain cock (1) on the engine body.**

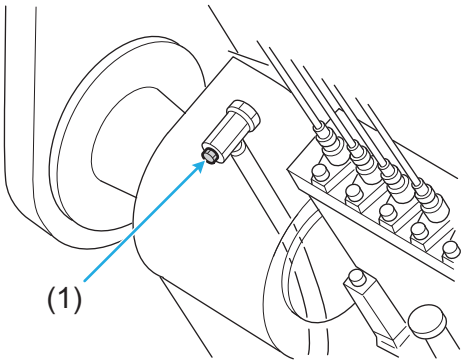


Fig. 8-78 Coolant Drain Cock on Engine Body

3 Connect a clear plastic tube (3) to the coolant drain cock (2) on the water pump and fix with a band.

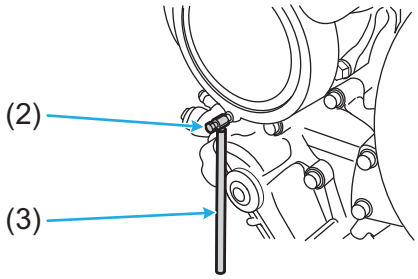


Fig. 8-79 Coolant Drain Cock on Water Pump

Note

- **Prepare a plastic tube (5 mm [0.20 in.] in diameter, approx. 1 m [39.37 in.] long) and a band.**

4 Prepare a container for receiving drained coolant and place it under the coolant drain cock on the water pump.

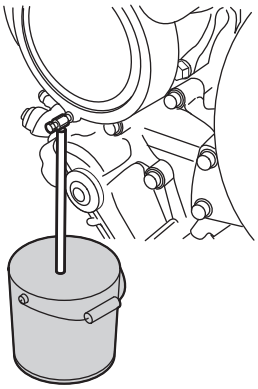


Fig. 8-80 Container to Receive Coolant

Note

- **The customer is required to prepare the container.**

5 Slightly open the coolant drain cock (2) on the water pump.

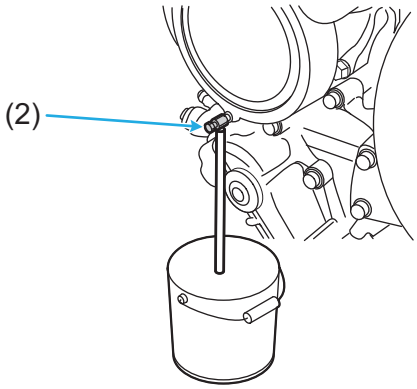


Fig. 8-81 Coolant Drain Cock on Water Pump

6 Slightly open the coolant filler port to release pressure.

- If the radiator cap has a pressure release lever, move the lever upward to release pressure.

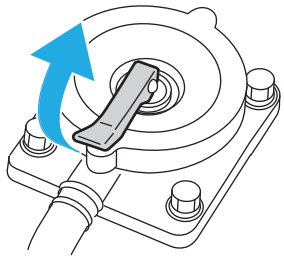


Fig. 8-82 Radiator Cap - Pressure Release (With Lever)

- If the radiator cap does not have a pressure release lever, cover the radiator cap with a waste cloth, and loosen the radiator cap a half-turn to release pressure.

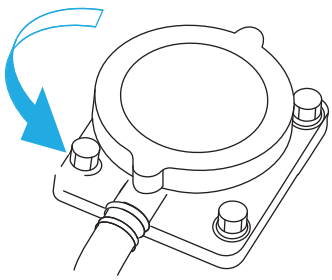


Fig. 8-83 Radiator Cap - Pressure Release (Without Lever)

7 **Open the coolant drain cock (1) on the engine body.**
→Coolant is drained.

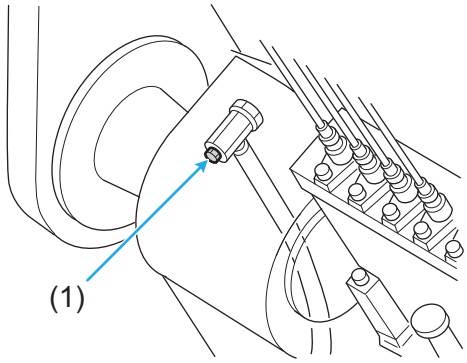


Fig. 8-84 Coolant Drain Cock on Engine Body

8 **Open the coolant drain cock (2) on the water pump.**
→Coolant is drained.

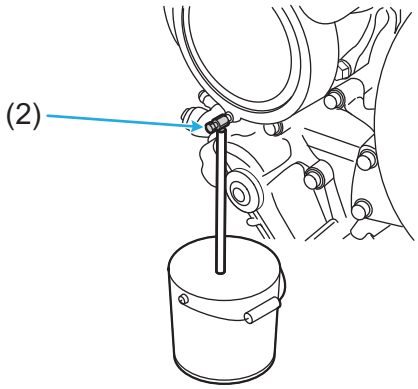


Fig. 8-85 Coolant Drain Cock on Water Pump

■ Cooling System - Clean

⚠CAUTION

When handling cleaning solution for washing the cooling system, obey the manufacturer's SDS.

* Improper wearing or using of personal protective equipment may cause personal injury.

When using the engine or radiator for the first time or after a long term storage, clean the cooling system.

1 **Close the coolant drain cock (1) and (2) on the engine body and water pump.**

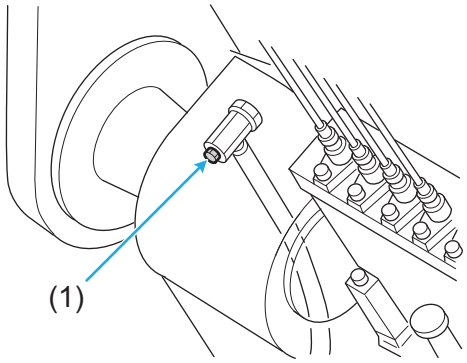


Fig. 8-86 Coolant Drain Cock on Engine Body

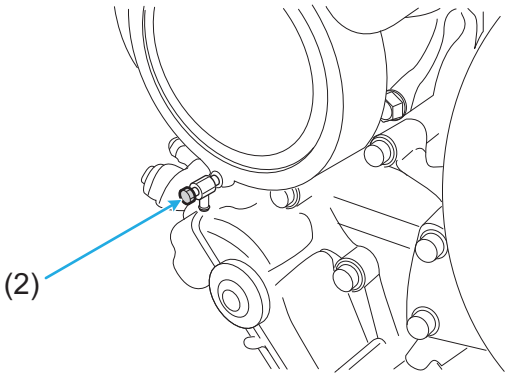


Fig. 8-87 Coolant Drain Cock on Water Pump

2 **Pour cleaning solution (non-corrosive to rubber and metals) into the cooling system through the cooling filler cap.**

3 **Operate the start switch of the generator "Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81) to start the engine.**

4 **Operate the engine at the rated speed for about 15 minutes.**

5 **Operate the stop switch of the generator "Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81) to turn off the engine.**

6 **Prepare a container for receiving drained coolant and place it under the coolant drain cock on the engine body.**

Note

- **The customer is required to prepare the container.**

7 **Connect a clear plastic tube (3) to the coolant drain cock (2) on the water pump and fix with a band.**

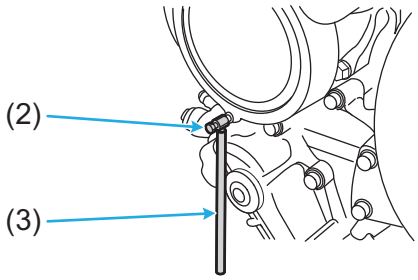


Fig. 8-88 Coolant Drain Cock on Water Pump

Note

- **Prepare a plastic tube (5 mm [0.20 in.] in diameter, approx. 1 m [39.97 in.] long) and a band.**

8 **Prepare a container for receiving drained cleaning solution and place it under the coolant drain cock on the water pump.**

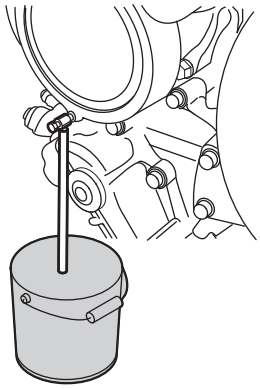


Fig. 8-89 Container to Receive Tap Water

Note

- **The customer is required to prepare the container.**

9 **Open the coolant drain cock (1) and (2) on the engine body and water pump.**

→The cleaning solution poured in Step 2 is drained.

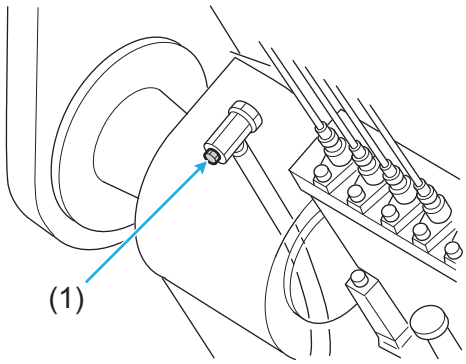


Fig. 8-90 Coolant Drain Cock on Engine Body

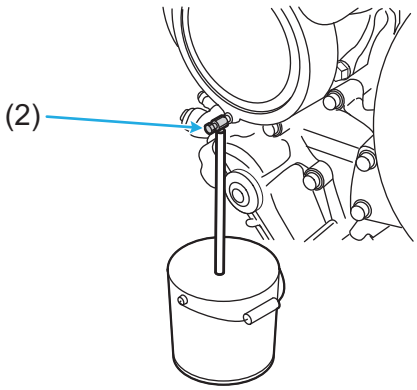


Fig. 8-91 Coolant Drain Cock on Water Pump

10 **Close the coolant drain cock (1) and (2) on the engine body and water pump.**

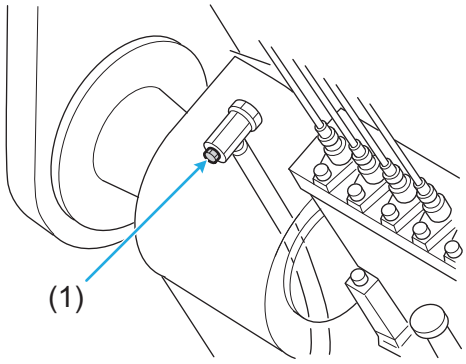


Fig. 8-92 Coolant Drain Cock on Engine Body

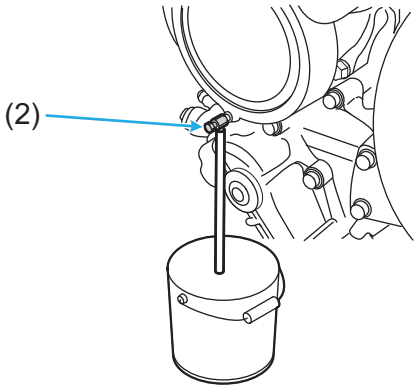


Fig. 8-93 Coolant Drain Cock on Water Pump

11 **Remove the plastic tube connected to the coolant drain cock on the water pump in Step 7.**

12 **Discard cleaning solution in the container in Step 6 and Step 8 properly.**

■ Cooling System - Flush

After cleaning the cooling system, flush the cooling system.

1 **Pour tap water through the coolant filler cap.**

2 **Operate the start switch of the generator "Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81) to start the engine.**

3 **Operate the engine at the rated speed for about 10 minutes.**

4 **Operate the stop switch of the generator "Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81) to turn off the engine.**

5 **Prepare a container for receiving drained tap water and place it under the coolant drain cock on the engine body.**

Note

- **The customer is required to prepare the container.**

6 **Connect a clear plastic tube to the coolant drain cock on the water pump and fix with a band.**

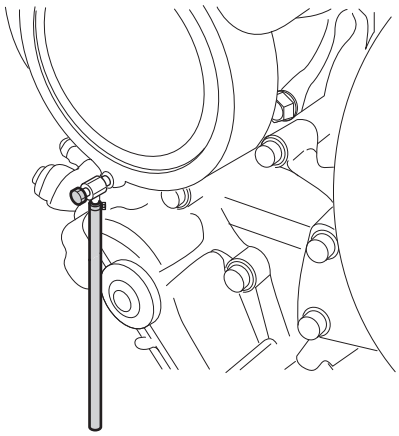


Fig. 8-94 Coolant Drain Cock on Water Pump

Note

- **Prepare a plastic tube (5 mm [0.20 in.] in diameter, approx. 1 m [39.37 in.] long) and a band.**

7 **Prepare a container for receiving drained tap water and place it under the coolant drain cock on the water pump.**

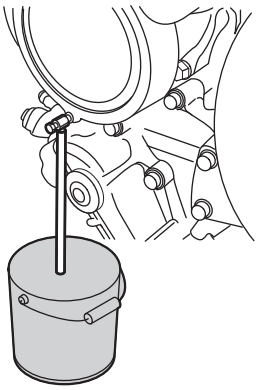


Fig. 8-95 Container to Receive Tap Water

Note

- **The customer is required to prepare the container.**

8 **Open the coolant drain cock (1) and (2) on the engine body and water pump.**

→The tap water poured in Step 1 will be drained.

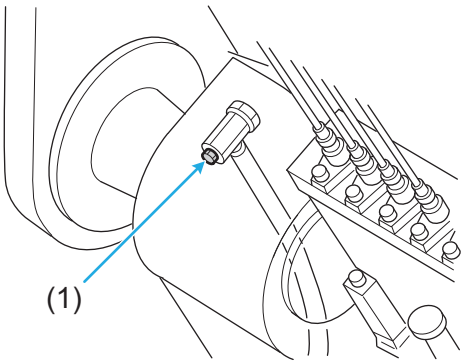


Fig. 8-96 Coolant Drain Cock on Engine Body

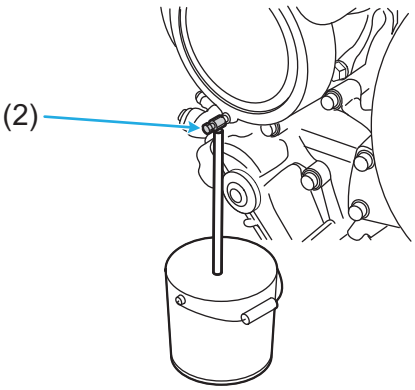


Fig. 8-97 Coolant Drain Cock on Water Pump

9 **Close the coolant drain cock (1) and (2) on the engine body and water pump.**

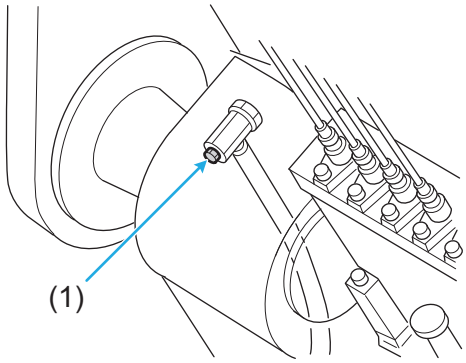


Fig. 8-98 Coolant Drain Cock on Engine Body

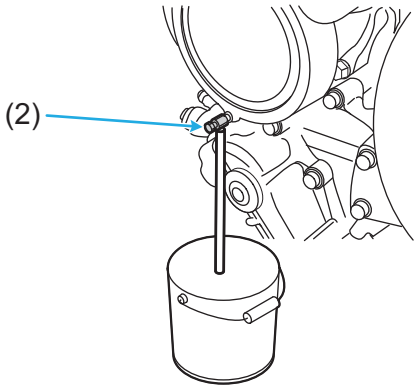


Fig. 8-99 Coolant Drain Cock on Water Pump

10 **Discard tap water in the container in Step 5 and Step 7 properly.**

11 **Repeat Step 1 to 10 until clean water is drained.**

12 **Remove the plastic tube connected to the coolant drain cock on the water pump in Step 6.**

13 **Discard water in the container or cleaning solution properly.**

■ Coolant - Refill

1 **Close the coolant drain cock of (1) on the engine securely.**

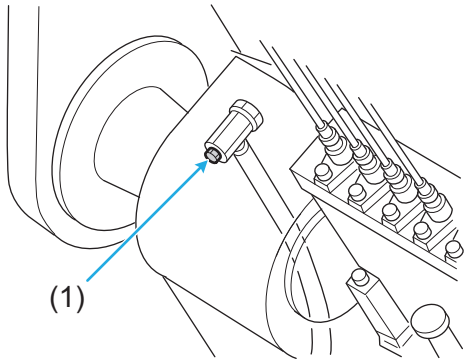


Fig. 8-100 Coolant Drain Cock on Engine Body

2 **Close the coolant drain cock (2) on the water pump securely.**

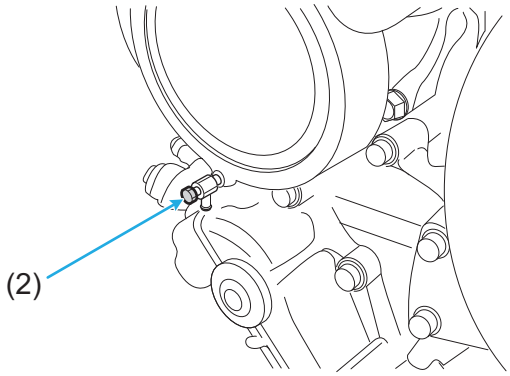


Fig. 8-101 Coolant Drain Cock on Water Pump

3 **Open the coolant filler cap and slowly refill the specified quantity of coolant.**

Note

- **For the specified quantity of coolant, refer to "SPECIFICATIONS - CHECK" (→ Page 10).**
- **For mixing coolant, refer to "Coolant - Mix" (→ Page 107).**
- **Refill slowly to prevent air included in the coolant.**

4 **Wait approx. 30 minutes untill the coolant to circulate all parts of the coolant system, then check the coolant quantity again.**

5 **Check the heat exchanger and other part in the coolant system for coolant leaks.**

Note

- **If a leak is found, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8) to arrange the repair.**

6 **Close the coolant filler cap properly.**

7 **Bleed air from the fuel system "Cooling System - Bleed Air" (→ Page 164).**

Cooling System - Bleed Air

⚠ WARNING

Bleed air sufficiently from the cooling system.

* If air remains in the coolant, cooling performance may decrease, and seizure of the engine or piston scuffing may occur.

After changing or refilling coolant, operate the engine as follows:

1 **Pull the manual stop lever in the direction to stop and hold the position, and crank the engine for approx. 10 seconds using the starter.**
→Coolant will be supplied to each part.

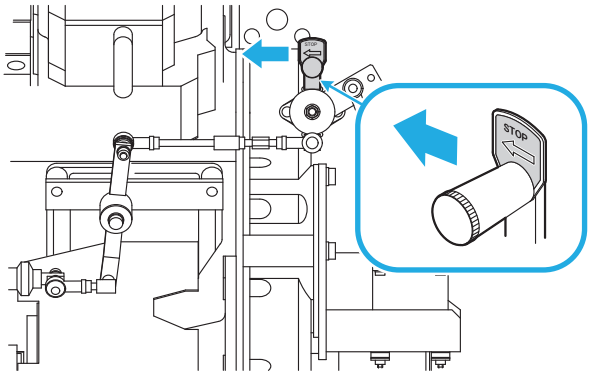


Fig. 8-102 After Coolant Change - Adjust

Note

- **The location of the manual stop lever varies depending on the specification of the engine. Refer to "Protection System - Location" (→ Page 78).**

2 **Pause for about 1 minute.**

3 **Repeat the operation of Step 1 and 2 for 2 or 3 times.**
→Coolant will reach each part.

4 **Slightly loosen the air vent plug at the engine coolant outlet pipe and bleed air.**

Note

- **For the location of the air vent plug, refer to such a document as the corresponding manual of the generator.**

5 **After checking that air has been bled, tighten the air vent plug.**

6 **Check the coolant level.**
- If the level is low, refill "Coolant - Refill" (→ Page 163).

Note

- **For the specified quantity of coolant, refer to "SPECIFICATIONS - CHECK" (→ Page 10).**

Radiator Fins - Check and Clean (Radiator Spec)

⚠ WARNING

When working by using compressed air, wear protective glasses.

* Not wearing or not properly wearing personal protective equipment may result in serious personal injury.

Check the radiator fins for holes and cracks.

* Otherwise, overheating, damage to the devices, or performance degradation may occur.

Dirty radiator fins may cause overheating or performance degradation.

Note

- **The radiator may be outside the scope of our supply. For the details, refer to such a document as the specification sheet prepared by the generator manufacturer.**
- **If it is not supplied by MHISH, follow the instructions in the supplier's operation manual.**

1 **Check the radiator fins for holes and cracks.**

2 **Clean the radiator fins.**

Intake and Exhaust Systems - Check

Note

- **Devices and equipment outside the scope of our supply are included in the facility. For the details, refer to such a document as the specification sheet prepared by the generator supplier.**
- **For the devices and equipment outside the scope of our supply, refer the corresponding manual of the generator and the supplier's operation manual.**

Turbocharger - Check

⚠ WARNING

Before checking the turbocharger, make sure that the engine has cooled down to normal temperature. Before checking, make sure that the compressor wheel is not rotating.

* Otherwise, you could get burned.
* If you are caught in a rotating compressor wheel, you will suffer laceration.

Make sure that there is no intake air leak in the piping to the compressor of the turbocharger.

* If there is intake air leak, insufficient boost pressure could occur, which could cause deterioration in the exhaust gas properties.

⚠ CAUTION

Check that the compressor or turbine of the turbocharger is not dirty.

* If the compressor or turbine of the turbocharger is dirty, performance degradation of the turbocharger may occur, which could cause power reduction.

Note

- **For the location of the turbocharger, refer to "2 ENGINE - OUTLINE" (→ Page 73).**
- **When the inspection requires the removal of turbocharger, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

1 **Remove the pipe on the inlet side.**

2 **Rotate the tightening nut of the compressor wheel by hand to check that it rotates smoothly.**

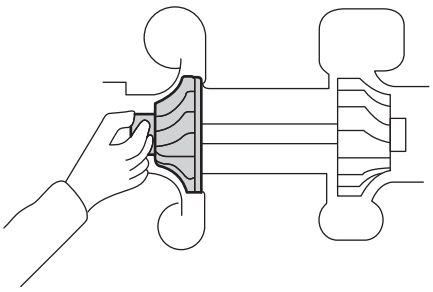


Fig. 8-103 Turbocharger - Check

Note

- **If a play or sluggish rotation is detected, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

3 **Check the compressor wheel fins for discoloration or damage.**

Note

- **If discoloration or damage is detected, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

Exhaust Muffler - Drain Water

⚠ WARNING

Do not touch the exhaust muffler immediately after the engine is stopped.

- Make sure that the engine is cooled down to the normal temperature.

* Otherwise, you could get burned.

Be sure to drain the exhaust muffler.

Note

- **The exhaust muffler is outside the scope of our supply. For the details, refer to the corresponding manual of the generator and the supplier's operation manual.**

Pre-cleaner - Check and Service

⚠ WARNING

Do not check, maintain or remove the pre-cleaner during operation.

* Otherwise, dust or other foreign particles may enter the engine, which could accelerate wear of the parts or cause damage to the devices including the turbocharger.

Take care that parts will not fall down and get caught in the fuel control link.

* If parts are caught in the fuel control rack, the engine will become out of control.

Check the pre-cleaner for clogging and clean it.

■ Pre-cleaner - Check for Clogging

⚠ WARNING

Make sure that the pre-cleaner is free from clogging.

* Insufficient intake air could result in loss of power, incomplete combustion, exhaust gas temperature rise, and overspeed of the turbocharger.

Check the pre-cleaner for clogging.

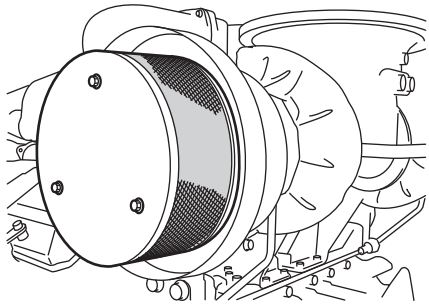


Fig. 8-104 Pre-cleaner - Check for Clogging

■ Pre-cleaner - Clean

The following is a general procedure.

1 **Release the hook-and-loop fastener (1), and take the pre-cleaner (2) from the silencer.**

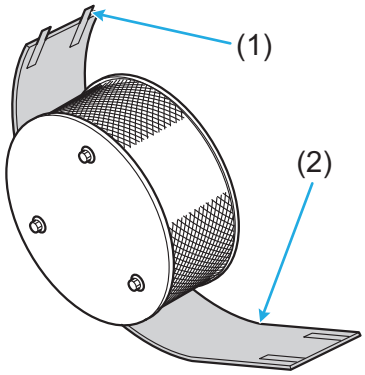


Fig. 8-105 Pre-cleaner - Remove

2 **Wash the pre-cleaner by hand using a neutral detergent.**

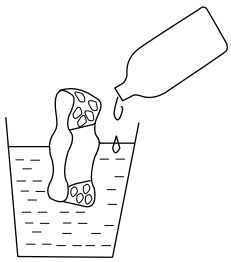


Fig. 8-106 Pre-cleaner - Clean 1

3 **Rinse the pre-cleaner with fresh water.**

- Discard the rinsed water properly.

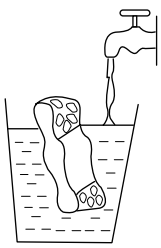


Fig. 8-107 Pre-cleaner - Clean 2

4 **Dry the pre-cleaner naturally and sufficiently.**

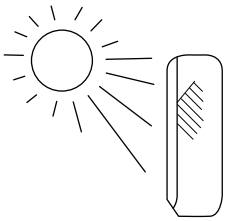


Fig. 8-108 Pre-cleaner - Clean 3

5 **Check the pre-cleaner for tears.**

→If a tear or other damage is found, replace the pre-cleaner with a new one.

6 **Install the pre-cleaner (2) on the silencer.**

- Check that the hook-and-loop fastener (1) is retained firmly so that the pre-cleaner will not drop off.

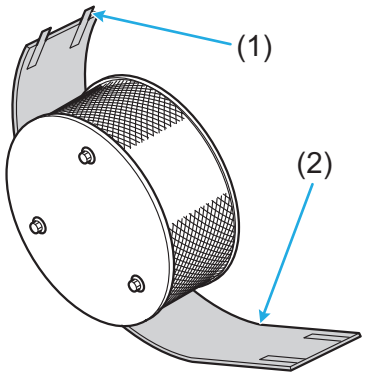


Fig. 8-109 Pre-cleaner - Install

Air Cleaner - Check and Service

Check the air cleaner for clogging and clean the air cleaner element.

Note

- **The air cleaner may be outside the scope of our supply. For the details, refer to such a document as the specification sheet prepared by the generator manufacturer.**
- **If it is not supplied by MHISH, follow the instructions in the supplier's operation manual.**

■ Air Cleaner - Check for Clogging

⚠ WARNING

Make sure that the air cleaner is free from clogging.

* Insufficient intake air could result in loss of power, incomplete combustion, exhaust gas temperature rise, and overspeed of the turbocharger.

Check the air cleaner for clogging.

■ Air Cleaner Element - Clean

Clean the air cleaner element.

- If necessary, replace the air cleaner element with a new one.

Electrical System - Check

Battery - Check

⚠ WARNING

Do not short the battery terminals.

* Otherwise, sparks could occur and cause a fire or an explosion.

Do not touch battery terminal with a wet hand.

* There are possibilities to get an electric shock.

When checking and servicing the battery, wear suitable personal protective equipment such as protective eyeglasses, rubber gloves, working clothes with long sleeves and long trousers.

* If battery fluid comes into contact with your eyes or skin, it may result in sight loss or burns.

Note

- **The battery is outside the scope of our supply.**
  For the details, refer to the corresponding manual of the generator and the supplier's operation manual.

1 **Check the battery fluid level.**
- Refill the battery fluid, if necessary.

2 **Check the battery fluid specific gravity.**
- Charge the battery, if necessary.

Starter - Check (Self Starter Motor Starting)

⚠CAUTION

Check that there is no damage to the pinion gear of the starter.

* Otherwise, a spark or damage to the devices could occur.

Note

- **For the location of the starter, refer to "2 ENGINE - OUTLINE" (→ Page 73).**

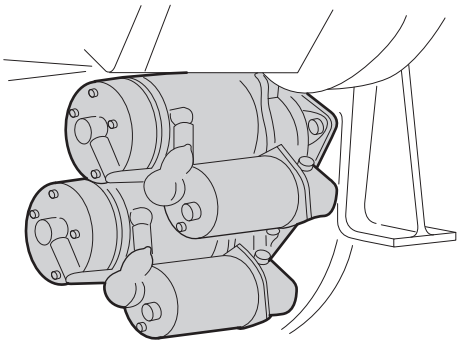


Fig. 8-110 Starter - Check (Self Starter Motor Starting)

Visually check the starter.

- Check for damage.

Note

- **If the starter is damaged or defective, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

Alternator - Check

⚠CAUTION

Do not touch the rotating part of the alternator.

* Otherwise, you may get caught in the rotating part and suffer an injury or damage to the devices could occur.

Note

- **For the location of the alternator, refer to "2 ENGINE - OUTLINE" (→ Page 73).**

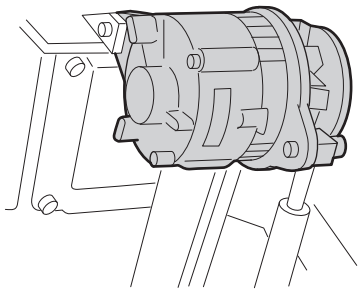


Fig. 8-111 Alternator - Check

1 **Check the alternator for damage.**

2 **Remove the belt.**

3 **Rotate the pulley by hand to check the smooth rotation.**

Note

- **If the alternator is defective, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

Air Direct Admission Starting, Air Motor Starting - Check

Note

- **Devices and equipment outside the scope of our supply are included in the facility. For the details, refer to such a document as the specification sheet prepared by the generator supplier.**
- **For the devices and equipment outside the scope of our supply, refer the corresponding manual of the generator and the supplier's operation manual.**

Air Strainer - Drain Water and Clean

⚠ WARNING

When working by using compressed air, wear protective glasses.

* Not wearing or not properly wearing personal protective equipment may result in serious personal injury.

⚠ CAUTION

Before draining or cleaning the starting air strainer, bleed air completely. In addition, check the pressure reduction with the pressure gauge.

* If high pressure air remains in the pipe, the drain valve may blow off, which could cause personal injury or damage to the devices.

Note

- **The starting air strainer may be outside the scope of our supply. For the details, refer to such a document as the specification sheet prepared by the generator manufacturer.**
- **If it is not supplied by MHISH, follow the instructions in the supplier's operation manual.**

1 **Close the main valve of the starting air tank.**
→The air supply stops.

2 **While cranking the engine lightly, bleed air remaining in the engine and the starting air system.**

3 **Prepare a container for receiving drained water and place it under the drain plug of the air strainer.**

Note

- **The customer is required to prepare the container.**

4 **Remove the drain plug on the air strainer.**
→Water accumulated in the air strainer is drained.

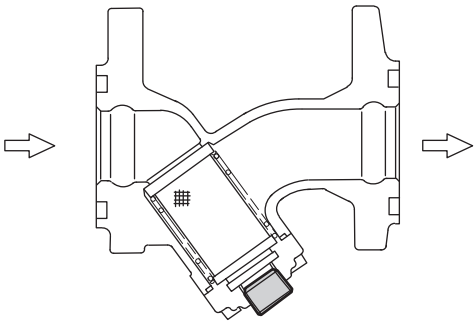


Fig. 8-112 Drain Plug - Remove

5 **Remove the cap (1) and remove the filter (2) from the cap.**

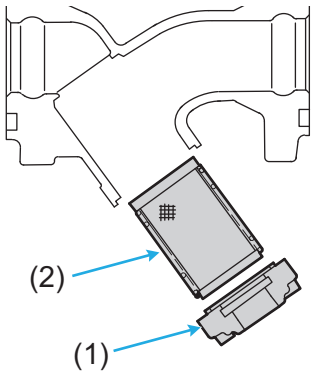


Fig. 8-113 Cap and Filter - Remove

6 **Clean the filter with diesel fuel, then blow compressed air to dry.**
7 **Reassemble the starting air strainer as it was.**
8 **Open the main valve of starting air tank slowly.**
→This allows air to be supplied.

Starting Air Tank - Check and Service (Air Direct Admission Starting, Air Motor Starting)

⚠ WARNING

Be sure to drain water from the starting air tank.

* Otherwise, water could enter the cylinders when starting the engine.

Make sure that the safety valve on the starting air tank is not malfunctioning.

* If the safety valve is out of order, improper operation could occur, which could result in explosion of the starting air tank.

⚠ CAUTION

Be sure to drain water from the starting air tank.

* Otherwise, water could enter the air motor when starting the engine.

Drain the starting air tank and check the operation of the safety valve.

Note

- **The starting air tank may be outside the scope of our supply. For the details, refer to such a document as the specification sheet prepared by the generator manufacturer.**
- **If it is not supplied by MHISH, follow the instructions in the supplier's operation manual.**
- **If the safety valve is defective, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

Starting Air Motor - Check (Air Motor Starting)

1 **Check the starting air motor for damage.**

2 **If the air motor is dusty, blow dry compressed air to the starting air motor to remove the dust.**

9 LONG-TERM STORAGE

This chapter describes the long-term storage procedure.

Storing Engine in Inoperable Condition

If you will store this engine in inoperable condition for 3 months or longer (1 year at longest), follow the procedure shown below.

Note

- **Devices and equipment outside the scope of our supply are included in the facility. For the details, refer to such a document as the specifications sheet prepared by the generator manufacturer.**
- **For the devices and equipment outside the scope of our supply, refer the corresponding manual of the generator and the supplier's operation manual.**

Storage - Prepare (Rust-preventive Measure)

⚠ WARNING

Keep away from fire, when working with flammable substances such as volatile corrosion inhibitor or rust preventive oil.

* They may cause a fire.

Keep away from fire, when working with flammable substances such as grease.

* They may cause a fire.
* When handling grease, obey the manufacturer's SDS.

If the engine is stored for 3 month or longer (up to 1 year), apply rust-preventive measure properly.

* Otherwise, the internal engine parts and/or sliding parts may be rusted, which could cause damage to the devices.
* Follow the storage procedure described in this Operation & Maintenance Manual.

⚠ WARNING

Use volatile corrosion inhibitor and rust preventive oil recommended by us.

* If a product other than the recommendation is used, the internal engine parts may be rusted due to insufficient anti-rust effect.

Use new (immediately after opened) desiccant.

* If you use a product which has been unused for a long time since its package was opened, moisture absorbency may be weakened, and may cause the internal engine parts and/or sliding parts to rust.

After stopping the engine, spray volatile corrosion inhibitor while cranking the engine for at least 2 times.

* Otherwise, anti-corrosive agent may accumulate and harden on the piston, which could block turning.

⚠ CAUTION

When handling volatile corrosion inhibitor or rust preventive oil, wear personal protective equipment such as protective mask or protective glasses, and obey the manufacturer's SDS.

* If such products are breathed in or comes in contact with the skin, serious personal injury may occur.

When working with grease, wear suitable personal protective equipment such as protective eyeglasses, rubber gloves, working clothes with long sleeves and long trousers.

* If grease comes into contact with your eyes, it will cause irritations.
* When handling grease, obey the manufacturer's SDS.

Before storing this engine, prepare as follows.

■ Lubrication system

Change engine oil "Engine Oil - Change" (→ Page 148).

■ Fuel system

1 **Prepare a fuel mixture containing 50% rust-preventive fuel.**
- Recommended product:
  ANTIRUST TERAMI LN (JXTG Nippon Oil & Energy Corporation)

Note

- **The quantity varies depending on the pipings and others. Identify the required quantity previously.**

2 **Operate the start switch of the generator "Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81) to start the engine.**

3 **Operate the engine at an idle speed until the fuel remained in the engine is completely consumed.**

4 **After that the fuel remained in the engine is completely consumed, refill the fuel mixture into the fuel tank, or switch the fuel pipes to feed the fuel mixture into the engine.**

5 **Operate the start switch of the generator "Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81) to start the engine.**

6 **Close the fuel valve.**

■ Air Intake System

Spray volatile corrosion inhibitor while cranking the engine for 2 times or more.
- Recommended product:
  V.C.I. Volatile Corrosion Inhibitor DIANA ND (Ryoko Chemical CO.,LTD.)

■ Machined area

Apply corrosion inhibitor to the machined and exposed area (around the flywheel, and others) sufficiently.
- Recommended product:
  ANTIRUST TERAMI SC (JXTG Nippon Oil & Energy Corporation)

■ Others

1 **Seal the air inlet, exhaust outlet, breather and other openings with adhesive cloth tape.**

2 **Loosen the tension of each belt on the crank pulley or alternator. "Belt Tension (Alternator) - Adjust" (→ Page 129)**

3 **Wind adhesive cloth tape around the terminals of the starter and alternator.**

Storage

1 **Disconnect the cables from the battery terminals.**

2 **Place a cover over the entire engine and put in desiccant.**

Note

- **Store the engine in a well-ventilated and dried indoor area.**
- **Post a sign noted as "Fuel tank must be filled" on the fuel inlet pipe, etc. for the first startup after storage.**

3 **Charge the battery disconnected in Step 1.**

4 **After charging, clean around the battery terminals, and apply grease lightly.**

Note

- **Store the battery in a dry cool indoor area.**

Maintenance During Storage

⚠ WARNING

Do not short the battery terminals.

* Otherwise, sparks could occur and cause a fire or an explosion.

When checking and servicing the battery, wear suitable personal protective equipment such as protective eyeglasses, rubber gloves, working clothes with long sleeves and long trousers.

* If battery fluid comes into contact with your eyes or skin, it may result in sight loss or burns.

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

Restart after Storing

When restarting the engine after storing, follow the next procedure:

■ Preparation

1 **Remove the cover that has been placed over the entire engine.**

2 **Remove the adhesive cloth tape from around the terminals of the starter and alternator.**

3 **Adjust the tension of each belt on the crank pulley or alternator.** **"Belt Tension (Alternator) - Adjust" (→ Page 129)**

4 **Remove the adhesive cloth tape from around the air inlet, exhaust outlet, breather and other openings.**

5 **Connect each piping of the fuel system and others.**

6 **Connect a well-charged battery stored.**

7 **Perform the pre-operation check.** **"Pre-operation Check" (→ Page 86)**

8 **Remove the rocker cover from all the cylinder heads.**

- Tool: Wrench

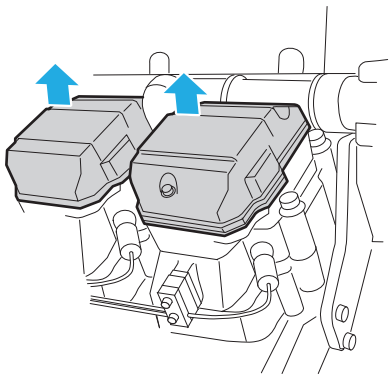


Fig. 9-1 Rocker Cover - Remove

9 **Apply engine oil on the valve mechanisms of all the cylinder heads.**
- Tool: Oiler, oil jug, and others.

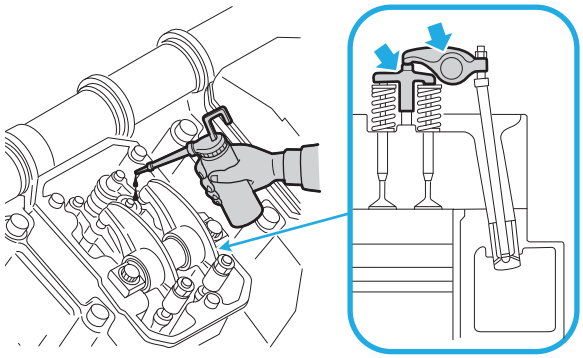


Fig. 9-2 Engine Oil - Apply (Valve Mechanism)

10 **Install the rocker covers onto all the cylinder heads.**
- Tool: Wrench

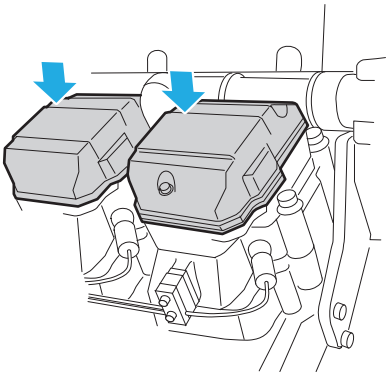


Fig. 9-3 Rocker Cover - Install

■ Restart

1 **Pull the manual stop lever in the direction to stop and hold the position, and crank the engine for approx. 10 seconds using the starter.**

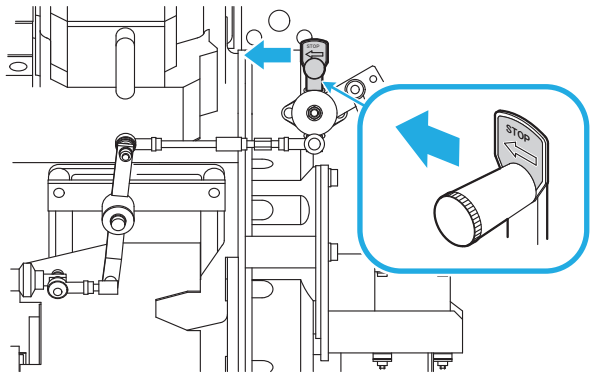


Fig. 9-4 Restart after Storing

Note

- **The location of the manual stop lever varies depending on the specification of the engine. Refer to "Protection System - Location" (→ Page 78).**

2 **Pause for about 1 minute.**

3 **Repeat the operation of Step 1 and 2 for 2 or 3 times.**

4 **After starting the engine, check that the engine oil pressure rises with a pressure gauge.**

5 **Conduct a warm-up operation "Warm-up Operation" (→ Page 93) for a sufficient duration to fully lubricate all the components.**

6 **Apply load and increase the engine speed to the rated speed.**

Storing Engine in Operable Condition

Perform maintenance operation "Maintenance Operation" (→ Page 97) once a month.

10 TRANSPORTATION

This chapter describes the transporting procedure of this engine.

Precautions on Transportation

⚠ WARNING

When transporting the engine on a truck, consider the engine weight, width and height to ensure safety. Abide by road traffic law, road vehicles act, vehicle restriction ordinance and other pertinent laws.

* Operation of the truck disregarding the laws and regulations may cause traffic accident or damage to the devices.

Be extremely careful when transporting the engine on rough roads.

* Otherwise, a traffic accident such as rollover or damage to the devices may occur.

Obey the laws or regulations of each country where this engine is used.

Engine - Lift

⚠ WARNING

When lifting up the engine, do not allow the operators to stay under the engine.

* Otherwise, if the wire breaks, the engine may fall down, which could cause serious personal injury.

The engine must be lifted only by an operator who is qualified for a crane and slinging works and also well skilled.

* Otherwise, the engine may fall by an operation error, which could cause serious personal injury or damage to the devices.

⚠ WARNING

To lift the engine, take the mass of the engine and that of water remained in the engine into account, and use wire ropes, shackles, and slings which are strong enough to support the weight.

* Otherwise, the engine may slip down, which could cause serious personnel injury or damage to the devices.
* Check the contract specifications for engine dry mass.

Use sling/hoisting tools in accordance with their instruction manual.

* Otherwise, the engine may slip down, which could cause serious personnel injury or damage to the devices.

Use the hangers of the engine only for lifting the engine unit.

* If you use them when the engine is assembled with the generator and additional devices, the hanger may not be able to endure the mass and may break. If the engine falls, serious personnel injury or damage to the devices will occur.

Before lifting the engine, drain fuel, engine oil and coolant.

* Otherwise, the hanger may not be able to endure the mass and break. If the engine falls, serious personnel injury or damage to the devices may occur.

Lift the slings while keeping the angle formed by the slings attached to the hangers within 60°.

* If the angle is too large, excessive weight will be imposed on the hanger, which could cause damage to the hanger.

- When using the crane, the person who has obtained the crane operator's license and also have a certificate of the skill training course for slinging opearation must operate the crane.
- Also when using a mobile crane, the person must have a mobile crane operator's license.
- Obey the corresponding laws and regulations.

The above-mentioned description is based on the premise that this engine is used in Japan.
Obey the laws or regulations of each country where this engine is actually used.

Note

- **Devices and equipment outside the scope of our supply are included in the facility.**
  For the details, refer to such a document as the specifications sheet prepared by the generator manufacturer.
- **For the devices and equipment outside the scope of our supply. refer the corresponding manual of the generator and the supplier's operation manual.**

1 **Drain fuel, engine oil and coolant from the engine.**

2 **Disconnect the wiring and pipings from the engine.**

3 **Remove pipe covers and insulators located near the hangers.**

4 **Hook the slings on the hangers.**

Note

- **For the location of the hangers, refer to "ENGINE - OUTLINE" (→ Page 73).**

5 **Release the lockings between the engine and the common bed.**

6 **Lift up the engine by using a crane while checking the balance.**
- Consider the engine's center of gravity to lift the engine.

7 **Slowly lower the engine on to a rack for transport, and so on.**

8 **Fix the engine to the rack for transport, and so on.**

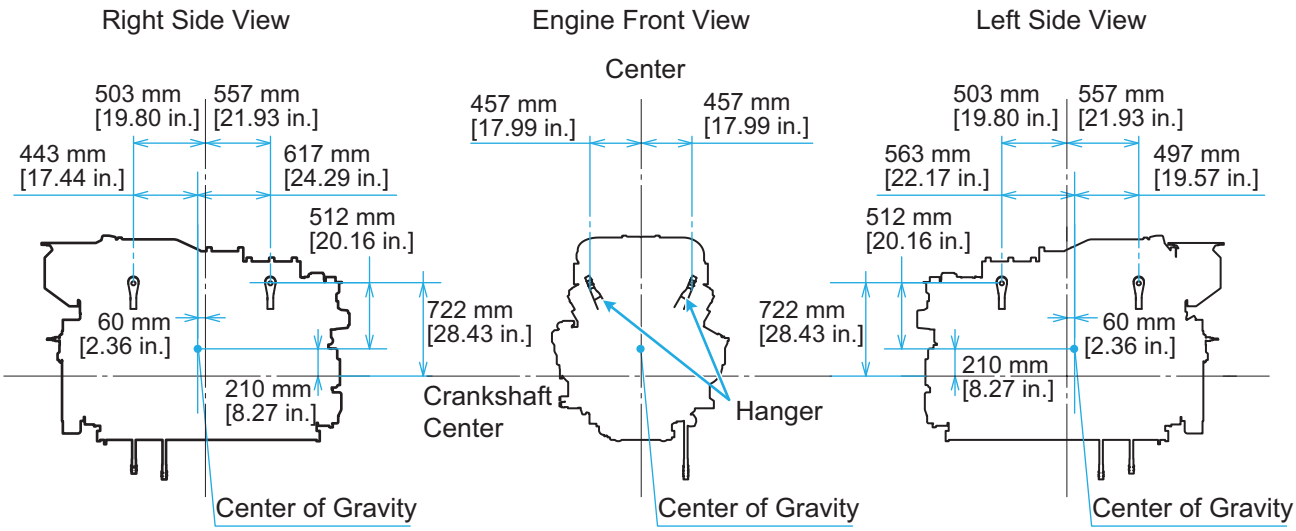


Fig. 10-1 Engine's Center of Gravity

11 TROUBLESHOOTING

This chapter describes the troubleshooting and action procedures.

Precautions on Troubleshooting

⚠ DANGER

Before inspecting and maintaining the engine, read this Operation & Maintenance Manual thoroughly to understand the construction and the required work to service the corresponding part. In addition, conduct the work after fully studying the procedure

* In case of conducting the work without studying enough, an accident or damage due to wrong installation, or deterioration in the exhaust gas properties may occur.

⚠ WARNING

Do not take actions for items indicated as "Contact your Mitsubishi dealer" in the measure column in the Scheduled Maintenance.

* Otherwise, serious accident, environmental pollution or damage to the devices may occur. Be sure to contact your Mitsubishi dealer.

Do not disconnect the pipes immediately after the engine is stopped.

* Otherwise, you could get burned by hot engine oil or coolant splashing out.

When lifting a part or tool, check its weight and lift it slowly.

* If you lift it carelessly, you may hurt your back or get injured by dropping the part.

Make sure that dripped oil, parts, tools or other things are not left on the floor around the engine. Always maintain cleanliness and tidiness.

* Otherwise, a tumbling accident may occur.
* Wear proper personal protective equipment for the work.

⚠ WARNING

Make sure that the tools to be used are not damaged.

* Using a damaged tool or a wrong-size tool may cause personal injury or damage to the devices.

Check and calibrate measurement equipment periodically.

* Using uncalibrated measurement equipment may cause damage to the devices or performance degradation of them.

Watch your step during inspection and maintenance work.

* Otherwise, a tumbling accident or a falling accident may occur while working on the floor panel or other high positions.
* The floor could be extremely slippery due to spilt oil. Thoroughly wipe off oil on the floor and the sole of your shoes.
* Install a stable scaffold as required.

Before maintaining electrical components, place the battery switch to the OFF position or disconnect the battery negative (-) terminal.

* Electric shock could result when electricity flows through the circuit.

Cover the disconnected pipes or joints and their openings properly so that dusts or other foreign objects will not enter into them.

* Otherwise, the devices could be damaged.

■ Remedies to Faults

Except for refilling fuel, engine oil, and coolant, remedies to faults will require special equipment or involves dangerous work.
Contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).

■ Before taking actions

Before taking any remedies, inspect possible causes of the fault and try to find out if the same fault has occurred in the past.
In addition, closely investigate the parts that may be causing the problem.
When disassembly of any part of the engine is needed, pay close attention to the disassembly sequence so that you can effectively assemble later.

■ Cautions Against Contamination

Wear of parts are very often caused by aged deterioration or impurities such as dust.
When disassembling any part of the engine, take measures to prevent dust and foreign materials from entering.

■ Parts - Handling

Handle parts carefully.
When replacing, use genuine parts.

■ Safety Working Practices

Use correct tools, and perform work with the utmost care.
If you misjudge the weight, you may damage the part by dropping it, or get injured.

How to Troubleshoot

In general, problems can be divided into 3 types:

(a) Machine-related problems
(b) Electricity-related problems
(c) Operation-related problems

If any problem occurs, it is necessary to precisely determine which of the three types applies.
Perform the troubleshooting by using the following steps:

1 **Check the following items.**
- Under what conditions was the engine running?
- What operation was performed?
- Any external factors?

2 **Refer to the next "Troubleshooting" and determine the cause.**

3 **Take the measures according to the Remedies.**

Note

- **If the problem is not solved after the measures have been taken, or if there is any uncertainty about the cause or remedies of the problem, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**

Troubleshooting

Note

- **Devices and equipment outside the scope of our supply are included in the facility. For the details, refer to such a document as the specifications sheet prepared by the generator manufacturer.**
- **For the devices and equipment outside the scope of our supply, refer the corresponding manual of the generator and the supplier's operation manual.**

Starter Does Not Crank or Cranks Slowly, Resulting in Starting Failure

Table 11-1 Starter does not crank or cranks slowly, resulting in starting failure

Problem	Cause		Remedies	Reference Page
Starter does not crank or cranks slowly, resulting in starting failure	Electrical System	Faulty wire connection, insufficient capacity	• Check fuse. • Check wiring connection between battery, starter, and starter switch.	-
		Battery charge fault	• Alternator -Check	169
			• Check and adjust the belt.	127 129
		Capacity degradation of the battery	• Check the level and specific gravity of the electrolyte • Charge battery. • Replace battery.	168
		Faulty starter or faulty safety relay	• Contact your Mitsubishi dealer.	8
	Lubrication System	Oil viscosity too high	• Change with appropriate engine oil.	103 148
		Excessive oil level	• Engine Oil Level - Check • Check lubrication system.	150
	Engine Body	Wear or lock of sliding parts	• Contact your Mitsubishi dealer.	8

Starter Cranks, but Engine Does Not Start

Table 11-2 Starter Cranks, but Engine Does Not Start

Problem	Cause		Remedies	Reference Page
Starter Cranks, but Engine Does Not Start	Fuel System	Run out of fuel, blocked pipe	• Check fuel tank, add fuel and bleed air. • Check fuel pipes and valves.	134
		Improper fuel properties	• Change with appropriate fuel. • Remove dust, water and impurities.	98 134
		Fuel leaks from low pressure fuel line	• Check defects of low pressure fuel line and retighten, if necessary.	145
		Fuel leaks from high pressure fuel injection pipe	• Check defects of high pressure fuel injection pipe	145
			• Contact your Mitsubishi dealer.	8
		Clogged fuel filter	• Check and replace fuel filter. • Gauze Filter - Clean • Change to fuel suitable for the ambient temperature.	140 139 98
		Fuel feed pump malfunction	• Contact your Mitsubishi dealer.	8
		Fuel injection pump malfunction	• Check fuel injection pump rack stroke.	-
			• Contact your Mitsubishi dealer.	8
		Fuel injection nozzle malfunction	• Contact your Mitsubishi dealer.	8
	Air Intake System	Insufficient amount of intake air	• Turbocharger - Check	165
		Poor ventilation	• Clean, check and replace air cleaner element. • Clean, check and replace precleaner.	168
	Control System	Governor malfunction	• Fuel Control Link - Check	143
			• Contact your Mitsubishi dealer.	8
	Engine Body	Compression pressure drop	• Contact your Mitsubishi dealer.	8
	Additional Equipment	Water heater switch "OFF"	• Check water heater switch	-

Output Shortage

Table 11-3 Output Shortage (1/2)

Problem	Cause		Remedies	Reference Page
Output Shortage	Fuel System	Improper fuel properties	• Change with appropriate fuel.	98
		Faulty fuel injection timing	• Check fuel injection pump drive coupling.	-
			• Contact your Mitsubishi dealer.	8
		Improper maximum injection volume	• Fuel System - Bleed Air	135
			• Check fuel injection pump rack stroke. • Check the balance between left and right banks.	-
			• Contact your Mitsubishi dealer.	8
		Clogged fuel filter	• Check and replace fuel filter. • Gauze Filter - Clean • Change to fuel suitable for the ambient temperature.	140 139 98
		Fuel feed pump malfunction	• Contact your Mitsubishi dealer.	8
	Cooling System	Overheating	• Refer to the items of overheating.	189
		Overcooling	• Check fan and heat exchanger. • Check control system.	-
			• Contact your Mitsubishi dealer.	8
	Inlet and Exhaust Systems	Insufficient amount of intake air	• Turbocharger - Check • Clean, check and replace precleaner. • Clean, check and replace air cleaner element. • Check intake air pressure and leakage of intake air. • Check intake air temperature and ventilation device.	165 166 168
			• Contact your Mitsubishi dealer.	8
		Increase of exhaust resistance	• Turbocharger - Check • Check exhaust pipes, muffler and silencer.	165
			• Contact your Mitsubishi dealer.	8

Table 11-4 Output Shortage (2/2)

Problem	Cause		Remedies	Reference Page
Output Shortage	Control System	Faulty governor control	• Contact your Mitsubishi dealer.	8
	Engine Body	Compression pressure drop	• Contact your Mitsubishi dealer.	8
		Faulty valve timing		
		Wear of sliding parts		
	Additional Equipment	Water heater switch "OFF"	• Check water heater switch	-

Exhaust Smoke is White or Blue

Table 11-5 Exhaust Smoke is White or Blue

Problem	Cause		Remedies	Reference Page
Exhaust Smoke is White or Blue	Fuel System	Improper fuel properties	• Check cetane index. • Change with appropriate fuel.	100 98
		Faulty fuel injection timing Not good	• Check fuel injection pump drive coupling.	-
			• Contact your Mitsubishi dealer.	8
		Uneven fuel injection volume	• Check ignition sound, exhaust temperature and the balance between left and right banks.	-
			• Contact your Mitsubishi dealer.	8
		Fuel injection nozzle malfunction	• Contact your Mitsubishi dealer.	8
	Lubrication System	Combustion of engine oil	• Engine Oil Level - Check • Check lubrication system.	150
			• Contact your Mitsubishi dealer.	8
	Cooling System	Overcooling	• Check heat exchanger. • Check control system. • Check thermostat.	-
			• Contact your Mitsubishi dealer.	8
	Engine Body	Faulty valve timing	• Contact your Mitsubishi dealer.	8
		Compression pressure drop		
	Additional Equipment	Water heater switch "OFF"	• Check water heater switch.	-

Exhaust Smoke is Black or Dark Grey

Table 11-6 Exhaust Smoke is Black or Dark Grey (1/2)

Problem	Cause		Remedies	Reference Page
Exhaust Smoke is Black or Dark Grey	Fuel System	Improper fuel properties	• Change with appropriate fuel.	98
		Fuel feed pump malfunction	• Contact your Mitsubishi dealer.	8
		Fuel injection pump malfunction		
		Fuel injection nozzle malfunction		
		Faulty fuel injection timing	• Check fuel injection pump drive coupling.	-
			• Contact your Mitsubishi dealer.	8
		Uneven fuel injection volume	• Check ignition sound, exhaust temperature and the balance between left and right banks.	-
			• Contact your Mitsubishi dealer.	8
	Lubrication System	Combustion of engine oil	• Check engine oil properties. • Engine Oil Level - Check	150
			• Contact your Mitsubishi dealer.	8
	Inlet and Exhaust Systems	Insufficient amount of intake air	• Turbocharger - Check • Clean, check and replace pre-cleaner. • Clean, check and replace air cleaner element. • Check intake air pressure and leakage of intake air. • Check intake air temperature and ventilation system.	165 166 168
			• Contact your Mitsubishi dealer.	8
		Increase of exhaust resistance	• Turbocharger - Check • Check exhaust pipes, muffler and silencer.	165 166
			• Contact your Mitsubishi dealer.	8

Table 11-7 Exhaust Smoke is Black or Dark Grey (2/2)

Problem	Cause		Remedies	Reference Page
Exhaust Smoke is Black or Dark Grey	Control System	Excessive load	• Check control system and governor controller. • Check boost compensator.	-
			• Contact your Mitsubishi dealer.	8
	Engine Body	Compression pressure drop	• Contact your Mitsubishi dealer.	8
		Faulty valve timing		
		Wear of sliding parts		

Excessive Fuel Consumption

Table 11-8 Excessive Fuel Consumption

Problem	Cause		Remedies	Reference Page
Excessive Fuel Consumption	Fuel System	Fuel injection nozzle malfunction	• Contact your Mitsubishi dealer.	8
		Faulty fuel injection timing	• Check fuel injection pump drive coupling.	-
			• Contact your Mitsubishi dealer.	8
		Improper fuel properties	• Change with appropriate fuel.	98
		Fuel leaks from low pressure fuel line	• Check defects of low pressure fuel line and retighten, if necessary.	145
		Fuel leaks from high pressure fuel injection pipe	• Check defects of high pressure fuel injection pipe	145
			• Contact your Mitsubishi dealer.	8
	Cooling System	Overcooling	• Check fan and heat exchanger. • Check control system. • Check thermostat.	-
			• Contact your Mitsubishi dealer.	8
	Inlet and Exhaust Systems	Insufficient amount of intake air	• Turbocharger - Check	165
			• Clean, check and replace pre-cleaner.	166
			• Clean, check and replace air cleaner element.	168
			• Check intake air pressure and leakage of intake air. • Check intake air temperature and ventilation system.	
			• Contact your Mitsubishi dealer.	8
		Increase of exhaust resistance	• Turbocharger - Check	165
			• Check exhaust pipes, muffler and silencer.	166
			• Contact your Mitsubishi dealer.	8
	Engine Body	Compression pressure drop	• Contact your Mitsubishi dealer.	8
		Faulty valve timing		
		Wear of sliding parts		

Excessive Engine Oil Consumption

Table 11-9 Excessive Engine Oil Consumption

Problem	Cause		Remedies	Reference Page
Excessive Engine Oil Consumption	Fuel System	Faulty fuel injection timing	• Check fuel injection pump drive coupling.	-
			• Contact your Mitsubishi dealer.	8
	Lubrication System	Oil leaking on engine outside	• Check engine oil leaks.	-
			• Contact your Mitsubishi dealer.	8
		Faulty engine oil property (viscosity)	• Analyze engine oil properties • Change with the engine oil of proper viscosity.	- 198
		Excessive engine oil temperature	• Engine Oil Level - Check • Check lubrication system. • Check oil cooler and oil thermostat.	150
			• Contact your Mitsubishi dealer.	8
	Cooling System	Overheating	• Refer to the items of overheating.	189
	Inlet and Exhaust Systems	Oil entry to the air supply chamber	• Check oil leakage to the turbocharger.	-
			• Contact your Mitsubishi dealer.	8
		Worn parts in valve operating system	• Contact your Mitsubishi dealer.	8
	Control System	Excessive load	• Check control system and governor controller.	-
			• Contact your Mitsubishi dealer.	8
	Engine Body	Wear of sliding parts	• Contact your Mitsubishi dealer.	8

Overheating

Table 11-10 Overheating

Problem	Cause		Remedies	Reference Page
Overheating	Cooling System	Low coolant level	• Check coolant leakage. • Coolant Level - Check	-
		Excessive LLC concentration	• Check LLC concentration	107
		Water pump malfunction	• Contact your Mitsubishi dealer.	8
		Thermostat malfunction	• Contact your Mitsubishi dealer.	8
		Heat exchanger malfunction	• Check and clean heat exchanger.	-
	Control System	Excessive load	• Check fuel injection pump rack stroke.	-
			• Check control system and governor controller.	-
			• Contact your Mitsubishi dealer.	8
	Engine Body	Wear of sliding parts	• Contact your Mitsubishi dealer.	8

Engine Oil Pressure Drop

Table 11-11 Engine Oil Pressure Drop

Problem	Cause		Remedies	Reference Page
Engine Oil Pressure Drop	Lubrication System	Low engine oil level	• Engine Oil Level - Check • Check lubrication system.	150
		Faulty engine oil property (viscosity)	• Analyze engine oil properties • Change with the engine oil of proper viscosity.	- 198
		Excessive engine oil temperature	• Cooling system - Check	-
			• Contact your Mitsubishi dealer.	8
		Clogged oil filter	• Check and replace oil filter and bypass oil filter	152 154
		Oil pump malfunction	• Contact your Mitsubishi dealer.	8
		Relief valve malfunction	• Contact your Mitsubishi dealer.	8
	Control System	Oil pressure gauge malfunction	• Check control system and wiring.	-
			• Contact your Mitsubishi dealer.	8
		Excessive load	• Check fuel injection pump rack stroke.	-
			• Contact your Mitsubishi dealer.	8
	Engine Body	Increased wear of sliding parts	• Contact your Mitsubishi dealer.	8
		Increased clearance of sliding parts		

Engine Stops

Table 11-12 Engine Stops

Problem	Cause	Remedies	Reference Page
Engine Stops	Run out of fuel	Restart the engine in the following order: **1 Turn the start switch to the "ON" position.** **2 Fill the fuel tank with fuel.** **3 Bleed air from the fuel system. "Fuel System - Bleed Air" (→ Page 135)** **4 Operate the start switch of the generator "Starting and Stopping Devices Installed during Manufacturing the Generator" (→ Page 81) to start the engine.**	-

During Normal Operation, Thermo Switch Activated

Table 11-13 During Normal Operation, Thermo Switch Activated

Problem	Cause	Remedies	Reference Page
During Normal Operation, Thermo Switch Activated	Coolant temperature raised	Restart the engine in the following order: **1 Operate the engine at low idle speed to cool down immediately.** **2 Stop the engine.** **3 Check the coolant level.** **4 Check the ambient temperature.** **5 Bleed air from the cooling system.** **6 Check the radiator, fan, and fan belt.** **7 Check the coolant temperature.** **8 If no fault has been found, restart the engine.** **Note** • **If any fault is found, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).**	-

12 AFTER-SALES SERVICE

This chapter describes the after-sales service.

Supply of Performance Parts for Repair

Supply Period

The supply period is stipulated as 10 years after the end of manufacturing of this engine.

Within this period, the performance parts for repair are always in stock and immediately supplied.

However, some items such as electronic parts may become unavailable before the end of this period due to termination of production by the manufacturer. Contact your Mitsubishi dealer for the availability, price, delivery date, and so on.

Parts That Reached the Supply Period

As a general rule, a performance part for repair which reached its supply period will be terminated for supply.

However, according to the scale of the demand and the production situation of the supplier, it may be supplied. In addition, reproduction at your cost may be considered.

When Requesting Repair

If you cannot restore the engine to normal operating condition, in spite that the cause has been identified according to "11 TROUBLESHOOTING" (→ Page 179) and the remedies have been taken, disconnect the power supply and contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).

- During the warranty period, we will repair in accordance with the stipulation of the Warranty Policy.
- When the warranty period is expired, parts which will be usable, if repaired, can be repaired at your request and cost.

Inquiry Counter

For repair, inspection and maintenance, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8).

At that time, also inform the following items described on the nameplate "MODEL NAME" (→ Page 9).

(a) Serial number

(b) Model name

13 DISPOSAL

This chapter describes the information for disposal.

Disposal Precautions

■ Fuel - Drain

⚠ WARNING

Do not discard waste oil into sewerage, river, lake or other similar places.

* Be sure to discard waste oil in accordance with the applicable laws and regulations.

Keep away from fire, when working with flammable substances such as fuel.

* They may cause a fire.

When working with fuel, wear suitable personal protective equipment such as protective mask, protective eyeglasses, rubber gloves, working clothes with long sleeves and long trousers.

* If fuel comes into contact with your eyes, mouth or skin, it will cause irritation or disorders.

Wipe off spilled flammable substances such as fuel thoroughly with a waste cloth.

* They may cause a fire.

When discarding a waste cloth used to wipe off combustible material, put it into a lidded can and obey the Waste Management and Public Cleansing Act to handle it as a special industrial waste.

* It may cause a fire.
* It could lead to environmental pollution.
* If you violate rules, you may be subject to penalties.

■ Engine Oil - Drain

⚠ WARNING

Do not discard waste oil into sewerage, river, lake or other similar places.

* Be sure to discard waste oil in accordance with the applicable laws and regulations.

Keep away from fire, when working with flammable substances such as engine oil.

* They may cause a fire.

When handling engine oil, obey the manufacturer's SDS.

* If engine oil gets in your eyes, it will cause pain and lead to sight loss at the worst.

Wipe off spilled flammable substances such as engine oil thoroughly with a waste cloth.

* They may cause a fire.

When discarding a waste cloth used to wipe off combustible material, put it into a lidded can and obey the Waste Management and Public Cleansing Act to handle it as a special industrial waste.

* It may cause a fire.
* It could lead to environmental pollution.
* If you violate rules, you may be subject to penalties.

■ Coolant (LLC) - Drain

⚠ WARNING

Do not discard coolant (LLC) into sewerage, river, lake or other similar places.

* Be sure to discard coolant (LLC) in accordance with the applicable laws and regulations.

Keep away from fire, when working with flammable substances such as coolant (LLC).

* They may cause a fire.

When handling coolant (LLC), always wear suitable personal protective equipment such as rubber gloves and protective eyeglasses.

* If LLC comes into contact with your eyes, it will result in sight loss at the worst.
* If LLC comes into contact with your skin while the engine is hot, you could get burned by heat.

Wipe off spilled flammable substances such as coolant (LLC) thoroughly with a waste cloth.

* They may cause a fire.

When discarding a waste cloth used to wipe off combustible material, put it into a lidded can and obey the Waste Management and Public Cleansing Act to handle it as a special industrial waste.

* It may cause a fire.
* It could lead to environmental pollution.
* If you violate rules, you may be subject to penalties.

■ Anti-corrosive Agent, Rust Preventive Oil, Rust-preventive Fuel - Drain

⚠ WARNING

Do not discard waste oil into sewerage, river, lake or other similar places.

* Be sure to discard waste oil in accordance with the applicable laws and regulations.

Keep away from fire, when working with flammable substances such as volatile corrosion inhibitor or rust preventive oil.

* They may cause a fire.

⚠ CAUTION

When handling volatile corrosion inhibitor or rust preventive oil, wear personal protective equipment such as protective mask or protective glasses, and obey the manufacturer's SDS.

* If such products are breathed in or comes in contact with the skin, serious personal injury may occur.

■ Battery Fluid (Dilute Sulfuric Acid) - Drain

⚠ WARNING

Do not discard battery fluid (dilute sulfuric acid) into sewerage, river, lake, or other similar places.

* Be sure to discard battery fluid (dilute sulfuric acid) in accordance with the applicable laws and regulations.

Never use flames or allow sparks near the battery.

* An explosion due to catching flame or a fire may occur.

When checking and servicing the battery, wear suitable personal protective equipment such as protective eyeglasses, rubber gloves, working clothes with long sleeves and long trousers.

* If battery fluid comes into contact with your eyes or skin, it may result in sight loss or burns.

■ Engine Body - Disposal

⚠ WARNING

In case that you have to discard the engine body, contact your Mitsubishi dealer.

* You must deal with it as a special industrial waste in accordance with the laws and regulations of the national government and other local municipalities.

Asbestos was used in the parts of the engines that were manufactured in 2005 or earlier. Therefore, when discarding them, obey the "Waste Management and Public Cleansing Act".

* If you violate rules, you may be subject to penalties.

⚠ CAUTION

While discarding the engine body, be sure to wear the appropriate personal protective equipment.

* Without wearing or not properly wearing personal protective equipment, serious personal injury may occur.

■ Other Disposal

⚠ WARNING

When discarding a waste cloth used to wipe off combustible materials such as fuel, the engine oil, and coolant (LLC), put it into a lidded can and obey the Waste Management and Public Cleansing Act to handle it as a special industrial waste.

* It may cause a fire.
* It could lead to environmental pollution.
* If you violate rules, you may be subject to penalties.

⚠ CAUTION

Lift and transport an engine or a heavy object such as tank filled with waste oil or fluid with a forklift only by the qualified operator.

* Otherwise, the heavy object may fall due to improper transportation, and the operator may get injured.
* And the waste oil or fluid leak may occur, which could cause environmental pollution.

Wastes Produced during Inspection and Maintenance

Some wastes produced during inspection and maintenance are subject to control by the laws or regulations of the national government and other local municipalities.

When discarding them, obey the laws or regulations of the national government and other local municipalities and handle them properly, for example, by requesting an industrial waste disposer.

Engine Body - Disposal

In case that you have to discard this engine, contact your Mitsubishi dealer "CONTACT LIST" (→ Page 8). This engine must discarded as industrial waste.

Fig. 13-1 Engine Body - Disposal

14 APPENDIX

This chapter describes information about the appendix.

Engine Oil

When using the engine oil other than the genuine ones, use the engine oil which meets "Engine Oil Quality Standards" (→ Page 198).
Do not mix and use engine oil of different types and/or manufacturers.
In addition, conduct the oil analysis earlier than the normal change interval and check the change interval.

Note

- **If you use the engine oil which does not meet "Engine Oil Quality Standards" (→ Page 198), for fault caused by the engine oil, the warranty will become invalid.**

Engine Oil Quality Standards

Table 14-1 Engine Oil Quality Standards

Item				Unit	Recommended property value	Test method
API/JASO standards				-	CF grade	-
SAE viscosity				-	15W-40	-
ASTM Color				-	L4.0	JIS K 2580
Density			15°C [59°F]	g/cm^3	0.87 to 0.90	JIS K 2249
Kinetic viscosity			40°C [104°F]	mm^2/s	100 to 110	JIS K 2283
			100°C [212°F]		13.5 to 15.5	
Viscosity index				-	-	JIS K 2283
Flash point				°C [°F]	225 to 250 [437 to 482]	JIS K 2265
Base Number	Hydrochloric acid method	Sulfur content in fuel	1.0 weight% or lower	mgKOH/g	10 or higher (up to 13)	JIS K 2501
			0.2 weight% or lower		8 or higher (up to 13)	
	Perchloric acid method		1.0 weight% or lower		13 or higher (up to 16)	
			0.2 weight% or lower		11 or higher (up to 16)	
Acid Number				mgKOH/g	1.5 to 2.0	JIS K 2501
Sulfur content				%	0.5 or lower	JIS K 2541
Sulfuric acid ash				%	2.0 or lower	JIS K 2272
Carbon residue content				%	2.0 or lower	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 or lower [-13 or lower]	JIS K 2269
Additives			Ca	Weight%	0.480 to 0.570	JIS K 0116
			P		0.050 to 0.070	
			Zn		0.060 to 0.080	
			B		-	
			Si		0.001 or lower	
			N		0.030 to 0.060	JIS K 2609
Bubbling test *1			I	mL	10/0	JIS K 2518
			II		30/0	
			III		10/0	
Panel coking test *2			300°C [572°F]	mg	140 or lower	FED791-3462
			325°C [617°F]		300 or lower	

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

*2: 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.

Service Limit for Engine Oil Properties

■ 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 decreases by contamination with blow-by gas and increases by degradation of oil. Due to increased viscosity, sludge produced in the process accumulates in engine and may cause lubrication oil filter clogging.

Also, the viscosity decreases by contamination with fuel or engine oil and molecular disconnection of the viscosity index improver.

The decreased viscosity causes insufficient lubrication that will cause friction or wear of engine parts.

■ Base Number

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

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

■ Acid Number

The acid number in oil increases as the organic acid is being derived by the engine oil oxidation, or sulfurous acid or sulfuric acid derived by the combustion of sulfur content of fuel, or the oil becomes contaminated with imperfect combustion products. An increase in the acid number will result in corrosion or wear of the inner parts of the engine (such as cylinder liner and bearing) due to sulfur content, and the piston ring seizure due to sludge.

■ Water Content

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

Service Limits for Engine Oil

Engine oil degrades through the use and by the lapse of time. The quality of engine oil and the operating condition of the engine have influence on deterioration of the engine oil.

- Engine oil must be changed at the time stipulated in "7 SCHEDULED MAINTENANCE" (→ Page 112).
- 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 14-2 Engine Oil Properties

Properties		Standard value		Test standard
Kinetic viscosity	mm^2/s@100°C	Continuous use	+30% or less rate of change from new oil 10 mm^2/s or more	JIS K 2283:2007 ISO 3107 ISO 2909
		Emergency use	+30% or less of the change rate from new oil -20% or less rate of change from new oil	
		For portable	+30% or less of the change rate from new oil -15% or less 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	Volume%	0.2 or lower		JIS K 2275:1996 ISO 9029
Flash point (open cup)	°C [°F]	180 or more [356 or more]		JIS K 2265:2007 ISO 3679 ISO 2719
Pentane insolubles	Weight%	0.5 or lower		Comply with ASTM D893
Coagulated pentane insolubles	Weight%	3.0 or lower		Comply with ASTM D893

Engine Oil Service Limits for Emergency Use

In case of the engine with long waiting time for operation like emergency use engine, if the fuel level of the fuel tank (fuel day tank) becomes higher and higher than the position of the fuel injection pump, the leak quantity per time increases so that the possibility of dilution increases.
In accordance with the maximum head drop between the fuel level of the fuel tank (fuel day tank) between the position of the fuel injection pump, with or without the water heater, the usage period of the engine varies, in addition, the change interval of the engine oil must be changed accordingly.

Table 14-3 Engine Oil Service Limits for Emergency use

*Maximum head drop (m)	With water heater		Without water heater	
	From 1.0 to 2.0	1.0 or lower	From 1.5 to 2.0	1.5 or lower
Use limit	1 years	2 years	1 year	2 years

*: The maximum head drop means a vertical distance from the center of the fuel injection pump drive shaft to the fuel level of the fuel tank (fuel day tank) when fuel is filled up to the upper limit.

Coolant

When using the LLC other than genuine ones, use the LLC which meets "Requirements for LLC" (→ Page 201) and "LLC Quality Standard" (→ Page 201).
Do not mix and use LLC of different types and/or manufacturers.

Note

- **If you use the LLC which does not meet "Requirements for LLC" (→ Page 201) and "LLC Quality Standard" (→ Page 201), for failures due to LLC, warranty will become invalid.**
- **The quality and performance of commercially available LLC 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.**
- **Be sure to use an all-season (non-amine) type long life coolant that prevent freezing of cooling water. Do not use antifreeze alone instead of LLC.**

Requirements for LLC

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

LLC Quality Standard

LLC must be tested in accordance with JIS K 2234.7, Section 8 "Test method", and satisfy the following table. General matters and specimen sampling method must comply with JIS K 2234.

Table 14-4 LLC Specifications (1/3)

Test items				Standard value
External appearance				No precipitation
Specific gravity				Minimum 1.112 (20/20°C) [68/68 °F] (undiluted solution)
Water content				Maximum 5.0 weight% (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)
Foamability (ASTM D3306-01)		30 volumetric% water solution		4.0 ml or less
		33 1/3 volumetric% water solution		150 ml or less, defoaming time 5 sec. or less
Hard water compatibility				1.0 or less (50 volumetric% water solution)
Corrosive to metal (88 ± 2°C [190.4 ± 3.6°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		Any corrosion must not be observed except for the contacting position of the test piece and spacer. Discoloration is allowed.
	Bubble formation during test			Bubbles must 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 14-5 LLC Specifications (2/3)

Test items				Standard value
Circulating corrosion (98 ± 2°C [208.4 ± 3.6°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		Any corrosion must not be observed except for the contacting position of the test piece and spacer.Discoloration is allowed.
	Property of liquid after test	pH		7.0 to 9.0
		pH change		± 1.0
		Reserve alkalinity change		± 15%
		Precipitation		1.0 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 ± 5.4°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		Any corrosion must not be observed except for the contacting position of the test piece and spacer. Discoloration is allowed.
	Property of liquid after test	pH		6.5 to 11.0
		pH change		Maximum ±1.0
		Visual inspection of liquid		No significant discoloration.No significant changes such as bubbles 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 14-6 LLC Specifications (3/3)

Test items			Standard value
Rubber adaptability (30 volumetric% water solution, 115°C [239°F], 360Hr)	Silicone rubber	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%
	Nitryl 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 propylene diene monomer	Tensile strength change rate	0 to +10%
		Elongation change rate	-30 to 0%
		Volume change rate	0 to +10%
		Hardness change rate*	-10 to 0%
Storage stability volumetric% (30 volumetric%, room temperature, 6 Hr)			0.3 or lower

*: Means International Rubber Hardness Degrees (IRHD).

Necessity of LLC

In recent years, with increasing in performance, the engine is inclined to be compact, lightweight, high output power, lower fuel consumption and low emission, however engine coolant is used under severe conditions such as continuous long operation, high temperature, high flow rate and others. Furthermore, many different materials such as steel, aluminum, copper, solder, and rubber are used in the cooling system, and they are also subject to the severe conditions described above.

Those materials have different ionization characteristics, and this difference accelerates corrosion through the medium of engine coolant. To prevent such a problem, it is necessary to use the LLC containing additives that prevent rust.

Characteristics of LLC Additives

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

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

Examples of Abnormalities Caused by LLC (Amine Type)

■ Corrosion of Iron Parts

Amines are generally effective in suppressing the rusting of ferrous metals, but they are said to cause problems for copper parts. If copper corrosion occurs in the cooling system due to lowering of copper type antirust, dissolved copper will deposit on iron parts. A difference in electrical potential occurs between the copper deposits and the iron, causing corrosion of iron which has a higher ionization characteristics, resulting in problems such as pitting at an early stage.

■ 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 the water pump mechanical seal due to gelification of silicate salt has been observed.

■ Pitting and Clogging of Heat Exchanger

When LLC deteriorates or when its concentration in the coolant becomes low, the anti-corrosion performance of LLC lowers and it results in the corrosion of metals.

Brass and solder tend to corrode faster than other metals, and corrosion of these metals is said to cause troubles such as water leak and clogging in the heat exchanger.

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