

# Operation & Maintenance Manual

**DIESEL GENERATOR ENGINE**

**DP158L, DP180L, DP222L**



# Forward

This Operation and Maintenance Manual provides information on engine management and maintenance techniques to customers and technicians of HD Hyundai Infracore's DP158L/DP180L/DP222L diesel engine.

To provide the best engine to our customers, the DP158L/DP180L/DP222L diesel engine is designed to satisfy all requirements for low noise, economic fuel consumption, high speed and durability with the latest technology and quality.

Exact operation and proper maintenance are essential for operating engines for an extended time with optimum conditions and best performance. This Operation and Maintenance Manual provides detailed descriptions of specifications, specified values, defect diagnosis, component diagrams, and drawings for easier and more precise understanding of the product and for proper maintenance and troubleshooting.

With the help of the recommended operation methods and procedures, high-level maintenance techniques and safety of workers can be ensured. Please read and understand this manual before working with our engines.

To ensure best performance and quality as well as to enhance maintenance techniques, HD Hyundai Infracore is doing its best to continuously develop and invest. The design of our product may be changed without prior notice and HD Hyundai Infracore shall not be held liable for the failure of this manual to contain all the design changes made to improve the product.

We, HD Hyundai Infracore, do our best to provide more convenient and safe maintenance techniques and to meet the requirements of our customers. If you have any questions or find any errors in this Operation and Maintenance Manual, please do not hesitate to contact us.

Thank you for purchasing our engine and we hope this Operation and Maintenance Manual be helpful for you.

2025.05

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**HD Hyundai Infracore**

- \* Items exempted from warranty coverage
  - Malfunctions resulting from failing to comply with the proper handling instructions, regular inspections, and machine storage techniques specified in the user manual
  - Malfunctions resulting from failing to have the machine repaired at a designated dealer or center, or resulting from the use of non-genuine parts
  - Malfunctions resulting from unauthorized modifications, changes, or external hardware
  - Malfunctions resulting from incorrect operation by the user, delayed repairs, accidents, and natural disasters
  
- \* The contents of this operation and maintenance manual are the exclusive property of HD Hyundai Infracore. Any unauthorized reproduction, printing and distribution thereof are strictly prohibited.



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## General information

### General Information

This Operation and Maintenance Manual provides the most efficient methods for engine maintenance as well as quick, efficient methods to determine the cause of engine faults to ensure that any actions taken by authorized skilled technicians are done in the most efficient and efficient way possible. If maintenance is performed by unskilled technicians, or maintenance without the specified tools and facilities, serious bodily injury or critical faults in engine performance may occur.

Regular inspection and maintenance are required to maintain long-term optimal engine conditions and best performance. In the event that a part must be replaced, only genuine parts as defined by the parts the list (PARTS BOOK) should be used. HD Hyundai Infracore shall not be held liable for any critical damage or faults which may be caused by the use of unauthorized or remanufactured parts.

The maintenance methods stated in this Operation and Maintenance Manual are the most efficient and safest work procedures. Some work procedures require special tools. For questions about genuine parts and special tools, please contact us.

This Operation and Maintenance Manual includes 'Danger,' 'Warning,' and 'Caution' in order to reduce possible injuries and engine faults which may occur while performing maintenance. If workers do not follow the instructions, critical faults in engine performance and operation or serious bodily injury may occurred. 'Danger,' 'Warning,' and 'Caution' instructions must be followed. However, we inform you that it is not possible to describe all possible and unexpected dangers which may arise while performing engine maintenance.

# 1. General introduction

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## Danger, warning, caution, and note

### General Information

This Operation & Maintenance manual divides maintenance operations such as performing engine checks, troubleshooting, or diagnosing faults into three categories, "Danger," "Warning," and "Caution." In addition, Note) is used to provide additional descriptions and information required for maintenance technicians to successfully operate HD Hyundai Infracore engines. The recommended repair methods and 'Danger,' 'Warning,' and 'Caution' can enhance the degree of completion of engine maintenance and prevent bodily injury which may occur to workers. However, this manual cannot predict all possible risks.

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### DANGER

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**Workers MUST observe instructions, otherwise fatal or serious injuries to workers and other persons may occur.**

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### WARNING

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**Workers must follow this instruction as failing to do so may result in the death or serious bodily harm of workers or others.**

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### CAUTION

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**Workers must observe this instruction since failing to do so may cause critical faults which can have impact on the engine performance and operation.**

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Note) Indicates additional description, information, and references for workers' easy understanding.

### General Instructions

1. In order to maintain the best long term performance and safety, please read and understand this manual and execute routine inspections and regular inspections.

2. We have divided the content of this manual into causes of bodily injury and damage to assets and causes of pollution.

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### WARNING

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**When a safety accident, such as skin contact with corrosive acids or fuel, burns with hot oil, exposure of eyes to fuel or antifreeze, occurs while starting, inspecting, or repairing an engine, see a doctor immediately.**

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### WARNING

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**When a safety accident, such as skin contact with corrosive acids or fuel, burns with hot oil, exposure of eyes to fuel or antifreeze, occurs while starting, inspecting, or repairing an engine, see a doctor immediately.**

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### WARNING

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**During operating the engine, be careful not to touch the safety guard of cooling fan. Otherwise, it can cause serious injuries such as a cutting of fingers to you by the rotating cooling fan.**

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### WARNING

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**During operating the engine, be careful not to touch the safety guard of v-belt. Otherwise, it can cause serious injuries such as a cutting of fingers to you by the rotating v-belt.**

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### WARNING

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**V-belt safety guard is an optional item for customers. In order to prevent accidents, you should install a v-belt safety guard. If v-belt safety guard is not installed, you should not access to the engine in operating. The engine maker won't be responsible for an accidents or injury arising without an installation of v-belt safety guard.**

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# 1. General introduction

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## WARNING

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Immediately after stopping the engine or during driving, be careful not to touch a part of turbocharger. Otherwise, it can cause you to severe burns due to a hot turbocharger. If you need to contact the turbocharger for maintenance, you should wait until the temperature of the turbocharger will be lower sufficiently.

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## WARNING

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Immediately after stopping the engine or during driving, be careful not to touch a part of exhaust manifold or heat screen. Otherwise, it can cause severe burns to you due to the hot exhaust manifold or heat screen. In particular, be careful not to touch the heat screen installed on the exhaust manifold because it has also a high temperature.

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## WARNING

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If you need an emergency engine stop, use an electronic emergency stop device installed on a generator at first instead of mechanical emergency stop of engine. It is difficult to operate a mechanical emergency stop device mounted on a fuel pump and it can cause serious burns to you by contact with the exhaust manifold. The operator is requested to install the separate cable for operating the mechanical emergency stop. The engine maker won't be responsible for an accidents or injury arising without an installation of separate auxiliary cable.

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### Precautions in Starting the Engine

1. Before starting the engine, please read this manual carefully and fully understand 'Danger,' 'Warning,' and 'Caution'. If you cannot fully understand it or have any question, please contact us.
2. For safety reasons, attach "Warning" signs around engines in operation to keep people other than workers from accessing the engines. Let engine operators know that they are responsible for the safety of the engine room.
3. Only authorized people may start and operate engines. Unauthorized people should not be allowed to handle engines.
4. Do not get close moving or rotating parts while the engine is in operation.

5. Do not touch the hot engine during operation since.
6. Exhaust gas is poisonous. Fully ventilate before starting engine. If the space is enclosed, ensure that it is well ventilated.
7. Keep vicinity of engine, ladders and stairways free of oil and grease. Accidents caused by slipping can have serious consequences.

### Cautions for Inspection and Repair

1. Inspection and repair of engine should be performed only when the engine is stopped.
  2. If it is inevitable to perform inspection or repair on the operating engine, do not get close to the rotating parts.
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## DANGER

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When accessories such as necklaces, rings, watches, or gloves become stuck in rotating parts while the engine is running, serious bodily injury may occur.

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## WARNING

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Do not exchange or disassemble a pipe or hose (from the engine fuel circuit, engine oil circuit, coolant circuit, or compressed air circuit) while the engine is running. The leaked liquid may cause bodily injuries.

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3. Use an engine oil drain container that is large enough to prevent the overflow of engine oil while draining engine oil.
  4. Open the engine coolant cap after fully cooling the engine to exchange or replenish coolant.
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## WARNING

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If the coolant cap is opened while the engine is still hot, hot water will spurt out and may cause burns. Open the engine coolant cap after fully cooling the engine.

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5. Fuel is highly flammable. Smoking or use of fire around an engine may cause fire.
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## WARNING

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Only refuel when the engine is stopped.

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6. Mark and separately manage the containers for storing coolant from beverage bottle for avoiding confusion. See a doctor immediately in case of drinking coolant.

# 1. General introduction

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7. Follow the instructions provided by the battery manufacturer when checking or handling batteries.

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## WARNING

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**Battery fluid is corrosive and dangerous because of its explosiveness and toxicity. Therefore, it should only be handled by a skilled technician who specializes in battery fluid.**

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8. Only authorized skilled technicians should repair and maintain engines.
  9. Only appropriate tools should be used. If the jaws of a wrench are worn out, the wrench might slip during use, causing safety accidents.
  10. Do not allow other persons to stay or pass under an engine when lifting the engine with a crane. Before lifting the engine, ensure that there is no one around the engine and to secure enough safety space.
  11. Before inspecting or replacing the electrical apparatus, disconnect the battery ground wire first. Connect the battery ground wire after completing all required work for checking or replacing the electrical apparatus in order to prevent a short circuit.
  12. Before performing electric welding works, turn off engine, block the power supply to the engine, and remove the wire harness connector.
  13. Do not give any electric or mechanical shocks or perform welding works on the electrical apparatus or the ECU.
7. Replace parts such as cotter pins, gaskets, O-rings, seal rings, oil seals, and washers with new ones during repairs. Reuse of parts may be the cause of engine faults and engine may not operate properly.
  8. Group and store disassembled parts in disassembling order. Due to the fact that bolts and nuts vary in strength, shape and torque according to their assembly position. Please divide and store them accordingly to these characteristics.
  9. Clean disassembled parts to remove foreign substances before inspecting or reassembling parts. Use compressed air to clean the oil holes or holes.
  10. Thinly spread oil or grease on rotating parts or parts requiring lubrication, before assembling them.
  11. If required, use a specified adhesive to assemble gaskets to prevent water or oil from leaking.
  12. Assemble bolts and nuts with the specified tightening torque.
  13. After completing repairs, conduct a final inspection and perform a test operation to check if all works have been successfully completed.

### General Repair

1. Wait until the engine is properly cooled down before starting work, since you may get burned by the heated engine.
  2. Disconnect the battery ground wire from to prevent damage of wires and sensors caused by a short circuit.
  3. Engine oil and coolant may damage paint and should be stored in a separate container and marked for safe management.
  4. Store the disassembled parts in a specified space to avoid damage or pollution.
  5. Use specified and special tools for efficient and safe repair.
  6. If parts need to be replaced, use only genuine parts for replacement. Using unauthorized or remanufactured parts may cause critical damage and faults in engine performance.
- ### Other Safety Instructions and Environmental Pollution
- Observe the following instructions to protect workers from danger and to prevent the environmental pollution while performing engine repairs.
1. Good ventilation and low humidity should be maintained in the work space.
  2. The workspace should be clean, in good order, and no flammables are allowed in the workshop.
  3. Smoking is strictly forbidden in the workshop.
  4. Workers should wear working clothes, protective goggles, and safety shoes.
  5. Workers are not allowed to wear accessories such as necklaces, rings, watches, and earrings.
  6. Start the engine in a well-ventilated space and fully ventilate the space before starting engine to prevent carbon monoxide poisoning.
  7. Wait until the engine is properly cooled down before starting work, since you may get burned by the heated engine.
  8. Do not work on rotating or running parts once the engine has been started.
  9. Discard oil according to the regulations set forth by the relevant authorities.
  10. If engine oil or fuel leaks on the floor or is improperly discharged, serious environmental pollution of sea, river or underground water may occur.

11. Discard the undiluted anticorrosive agent, antifreeze, filter elements, and cartridges as special wastes.
12. Discard coolant and special waste according to the regulations of the appropriate authorities.

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## **WARNING**

**Failure to observe the regulations of the relevant authorities violates environmental pollution regulations and may be subject to legal penalties.**

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### **Use of Genuine Parts**

An engine consists of many parts which are mechanically harmonized. To prevent engine faults in advance and use engines with best performance for a long period, maintenance and replacement of expendable parts should be conducted regularly.

Use of genuine parts is recommended. Using unauthorized or remanufactured parts may cause critical damage and faults to engine for which HD Hyundai Infracore shall not be held liable.

# 1. General introduction

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## Engine maintenance

### Prevention of Damage and Abrasion

Using an engine for any purposes other than the designed purpose may cause critical faults to the engine for which HD Hyundai Infracore shall not be held liable. For details concerning the usage and purpose of the engine, please direct questions to HD Hyundai Infracore Sales Team. Do not adjust, convert, or change the ECU without HD Hyundai Infracore authorization.

If a problem is found in an engine, figure out and solve the cause to prevent the critical faults in advance.

Use of genuine parts is recommended. Using unauthorized or remanufactured parts may cause critical damage and faults to engine for which HD Hyundai Infracore shall not be held liable.

Consider the following while managing engines.

1. Use clean, specified, and qualified fuel only. Use fuel recommended in this Operation and Maintenance Manual.

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### CAUTION

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**Using inappropriate or unspecified fuel may cause critical damage and faults in engine performance.**

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2. Do not operate an engine without lubrication oil or coolant. Use only the products (engine oil, cooling water, anticorrosive agent, and etc) recommended by HD Hyundai Infracore.
3. Always keep surroundings of the engine clean.
4. Use fuel recommended in this Operation & Maintenance manual.
5. Conduct inspections and exchanges regularly according to the regular inspection table.
6. If the engine is overheated, do not stop it immediately, but operate it at idle status for five minutes or more to lower the engine temperature to the proper level.

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### WARNING

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**If the radiator cap is opened while the engine is still hot, hot water will spurt out and may cause burns.**

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7. Check the engine oil level on a flat surface. Do not exceed the maximum of the oil level gauge.

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### CAUTION

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**Immediately replenish engine oil when the engine oil level is below the lower limit of the engine oil gauge.**

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8. If there are gauges for battery, oil pressure and coolant and temperature, check if they indicate a normal status.
9. Do not operate engine without coolant.

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### CAUTION

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**Always use coolant mixed with antifreeze. If coolant without antifreeze is used, the coolant may freeze causing the coolant passage in the cylinder block to freeze and damaging the engine.**

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### CAUTION

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**Do not spray high-pressure water directly on the engine. It may damage engine parts, electronic parts, and wiring.**

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### Prevention of Pollution

Consider the following to manage engine without causing environmental pollution.

1. Discharge oil and coolant using collection containers.
2. Discard oil and coolant according to the regulations of the relevant authorities.
3. Be careful not to let discharged oil and cooling water flow into the ground or the sewer. Otherwise, serious pollution of the drinking water source may occur.
4. Classify the oil, filters, and filter cartridges as environmental pollution wastes and discards them according to regulations.
5. Classify the antifreeze, cooling water, and anticorrosive agent as hazardous wastes and discards them by observing the regulations.

### Handling of Engine Oil

Prolonged and repeated contact of skin with engine oil may cause skin to dry out and contract, causing dermatitis.

Engine oil includes substances toxic to the human body.

Handle engine oil by observing the following safety rules:

1. Do not expose skin to used engine oil for a long time.
2. Always wear working clothes and gloves.
3. If skin comes in contact with engine oil, immediately wipe it off with water, soap or hand cleaners.
4. Do not clean skin with gasoline, fuel, thinner, or solvent.
5. Apply a skin care cream after cleaning from oil.
6. Do not put oil-stained gloves or cloth in ones pocket.

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## **WARNING**

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**Discard oil according to the regulations set forth by the relevant authorities. Disposing of discharged oil into the ground, sewers, drains, rivers, or the sea will cause serious environmental pollution. Violation of regulations regarding discard of engine oil without observing the handling regulations, will be punished.**

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### **HVO (Hydro treated Vegetable Oil)**

HVO is a synthetic diesel which is manufactured through the hydrogenation of plants and animal fats.

To the user, HVO is reminiscent of diesel in accordance with EN590, apart from HVO having a somewhat lower density.

HD Hyundai Infracore approves the use of up to 100% HVO for engines in accordance with the EU standard EN15940.

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## 2. Operation and maintenance

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### Starting and stopping of the engine

#### Preparing for Start

Check the following before starting the engine for the first time after purchase.

1. Before starting an engine, check the levels of fuel, coolant, and oil and replenish those fluids if required.
2. Check if engine oil level is between the upper and lower limit of the oil level gauge. The upper and lower limit of the oil level gauge indicate the maximum and minimum of the engine oil level.

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#### CAUTION

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- **When replenishing engine oil, do not exceed the maximum on the oil level gauge. Too much oil may cause damage to the engine.**
- **The oil required to fill the oil filters and pipes depends upon the engine equipment and use and must be determined individually at the time of initial commissioning. Make a note of the determined quantity.**

3. Be careful not to mix foreign substances in fuel, engine oil, or coolant while adding the fluid, and keep the fluid clean while it is not in use. Use fuel, oil, and coolant recommended by HD Hyundai Infracore. Otherwise, critical damage to the engine may occur

#### Starting the Engine

Observe the following when starting the engine.

1. Insert key in starting lock.
2. Moving control lever to idle speed.
3. Key switch rotate clockwise.
4. Do not operate for longer than 10 seconds at a time.
5. After ignition of the engine, take-off the hands in key switch.
6. and adjust control lever for desired speed.
7. If engine fails to start, release the key, wait about 1 minute, then operate starter again.

8. Avoid running the cold engine for any length of time since in any internal combustion engine this is liable to cause increased wear due to corrosion. Prolonged idling is harmful to the environment.

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#### CAUTION

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- **On initial start of an overhauled engine or after long periods without use, press shutdown lever in “stop” position and operate starter motor for a few seconds (max. 10) until oil pressure is indicated.**
- **Ensure that the engine can not be started by unauthorized persons.**

9. Keep no-load operation to a minimum. During no-load operation combustion chamber temperatures drop to the point where fuel does not burn completely, causing slobbering and white smoke. Always have some load connected when the gen set is run for long periods.

#### Running in

It is recommended that new or overhauled engines should not be operated at a load higher than about 75% minimum load during the first few hours of operation. Initial run-in should be at varying speeds or load. After this initial run-in, the engine should be brought up to fuel output gradually.

#### During Operation

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#### CAUTION

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**Do not overload the engine. Do not exceed the maximum permissible engine tilt. if faults occur, find their cause immediately and have them eliminated in order to prevent more serious damage.**

1. Oil pressure
  - 1) During operation the oil pressure in the engine lubrication system must be monitored. if the monitoring devices register a drop in the lube oil pressure, switch off the engine immediately.
2. Coolant temperature
  - 1) Operating an engine with too low coolant temperature increases fuel consumption, abrasion of the cylinder liner, and shortens the engine's life span.
3. Alternator

In order to avoid damage to the alternator, observe the following instructions while the engine is running.

## 2. Operation and maintenance

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- 1) Do not switch off the main battery.
- 2) Do not disconnect the battery or pole terminals or the cables.
- 3) If during operation the battery charge lamp suddenly lights up, stop the engine immediately and remedy the fault in the electrical system.
- 4) Do not short-circuit the connections of the alternator with those of the regulator or said connection with ground, not even by briefly bringing the connections into contact.
- 5) Do not operate the alternator without battery connection of the alternator with those of the regulator or said connections with ground, not even by briefly bringing the connections into contact.
- 6) Do not operate the alternator without battery connection.

### **Stopping the Engine**

Cut off the main circuit breaker of the generator control panel but do not stop the engine immediately.

Keep running the engine at idle speed for about 5 minutes before stopping the engine.

### Break-in period of the engine

#### General Information

HD Hyundai Infracore engines are subjected to a final approval test to ensure the provision of high quality engines before being shipped. However, engines are not operated for a long period of time in this test. Therefore, new engines require a break-in period of during the initial 50 hours after delivery. By properly breaking-in an engine, the highest levels of engine performance can be maintained long-term.

#### Break-in Period of a New Engine

If the engine's bearings are not properly broken in, they may be easily damaged and the lifetime of the engine may be shortened by overloading or high speeds. In order to prevent this, please follow the guidelines below for the initial 50 hours after delivery of new engine.

1. Fully warm up the engine until the engine temperature reaches the normal operation condition, before starting operation of the engine.
2. Do not overload the engine or operate it at too high RPM.
3. Do not operate the engine with high speed at idle.
4. Do not rapidly start up or stop the engine.
5. Operate the engine with less than 70 % of the engine load.
6. Inspection, check, and repair of engines should be managed by officially-certified technicians at certified service centers in compliance with corresponding rules.

#### Check Points

check the following during the break-in period of a new engine.

1. Periodically check if the engine oil level is between the minimum and maximum limit of the oil level gauge.

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### CAUTION

**If you cannot accurately check the oil level through the oil level gauge, rotate the oil level gauge to 180 degree, put it in the guide tube, and then pick it out again to check.**

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2. If the oil indicator lamp on the apparatus is turned on or blinks, the oil pressure may be insufficient. In this case, check the oil level and replenish oil if required. When replenishing engine oil, do not exceed the maximum on the oil level gauge. If the oil level is normal, check other related parts such as the oil pressure sensor, oil pump, or oil line.

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### CAUTION

**The oil pressure may increase with high rpm and decrease with low rpm. In addition, the pressure of cold oil may be higher at a specific rpm than that of warm oil. This phenomenon may occur when the engine operates properly.**

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3. Check the coolant level to check if the coolant circulates properly. If the coolant in the radiator is not enough, the coolant level indicated may not be accurate.
4. Exchange engine oil and oil filter after the break-in period.

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### CAUTION

**If engine oil and oil filter need to be replaced, use only genuine engine oil and parts recommended by HD Hyundai Infracore.**

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#### Cold Start Operation

Slowly warm up the engine in case of starting up in cold weather or in areas with cold climate. Do not rapidly raise the rpm or load before the engine has not been warmed up. The engine may consume oil until its piston ring is in position. Please check the engine oil level frequently for the initial 50 hours of the break-in period.

#### Inspection after Starting the Engine

Check the pressure of the engine lubrication system by using the engine oil pressure gauge mounted on the apparatus while the engine is in operation. If pressure decreases on oil pressure gauge, immediately stop the engine. In addition, make sure that the recharge alarm indicator lamp of the alternator is turned off while the engine is operating.

1. Tightly connect the +/- terminals to prevent gaps between them. The sheath of battery connection cables should not be damaged or broken.

## 2. Operation and maintenance

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2. If the recharge alarm indicator lamp suddenly turns on or blinks during engine operation and the engine stops, fix the fault of the electric apparatus.
3. If color or odor of exhaust gas is unusual during operation, stop the engine, diagnose the cause and fix the fault.
4. Check the engine status through the alarm indicator lamp and gauges mounted on the apparatus during operation.

### Operation in winter

#### Cold Start

1. The preheat lamp turns on when the key switch is set to "ON." When the preheat lamp goes off, proceed as follows. The pre-heater device activates when the coolant temperature is below 25°C, and the preheating system is automatically adjusted based on the coolant temperature. (The max. preheating time is around 25 seconds) It does not activate when the coolant temperature is over 25°C.

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#### CAUTION

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**The engine is equipped with a preheating system for enhancing cold start ability.**

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2. In order to start the engine after the preheat lamp turns off, turn the key switch to the ignition position. When the key switch is turned to the ignition position, the pre-heater plug or air heater runs continuously to make starting the engine easier and reduce white exhaust gas. If the coolant temperature is over 25°C, it is not necessary to operate the pre-heater plug or air heater.
3. When the engine starts, set the key switch in the ON position. The timer runs for another 5 minutes even after the engine starts to heat the intake air and quickly eliminate white exhaust gas.

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#### CAUTION

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**Do not run the start motor for over 10 seconds. If the engine still cannot be started after preheating, wait for 30 seconds and then perform preheating again before the second attempt to start the engine.**

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#### Preventing Coolant from Freezing

When only water used as coolant without mixing with anti-freeze, corrosion in the engine, degradation of cooling efficiency, and freezing of the engine in winter may occur. If the engine is not operated for a long period during cold weather or in areas with cold climate, fully discharge the coolant from the engine. Freezing of coolant leads to critical damage to the engine. Please use a mixture of coolant with antifreeze at revised ratio when replacing or replenishing the coolant. The antifreeze prevents coolant from freezing.

#### Preventing Over cooling of the Engine

When the engine is cooled below the normal operating temperature, thermal efficiency is lowered and fuel consumption as well as abrasion of the cylinder liner may increase. Therefore, the engine should be operated within the normal operating temperature. If the engine has been sufficiently operated, but the temperature of coolant remains below the normal operating temperature, check the water temperature controller or other parts related to the cooler.

#### Engine Oil

When viscosity of engine oil increases due to its low temperature during cold weather or in areas with cold climate, the rpm may not be stable after starting the engine. To prevent this, replace oil to engine oil for cold weather or areas with cold climate. When replacing engine oil, use of HD Hyundai Infracore genuine engine oil is recommended.

## 2. Operation and maintenance

---

### Inspection and repair of the engine

#### Checking Engine Parts after Prolonged Operation

Wear, corrosion, or degradation of engine elements and assemblies may occur, causing lowered performance of engine parts. To maintain high engine performance, check the engine after prolonged operation to enhance durability of the engine.

Unexpected faults may occur in some weak engine parts after normal operation of the engine, when operation time is prolonged. In this case, it is difficult to maintain high engine performance by simply repairing some parts. It is recommended to replace or repair the entire related parts in order to diagnose the causes more accurately and maintain high engine performance.

To prevent engine failure in advance and use the engine safely for a long period, perform periodic replacements and inspections.

It is recommended to perform engine adjustments and preventive inspections during spring after the engine was exposed to winter or cold weather. This allows economic, long-term use of the engine without faults.

As the following parts affect the engine output and performance, they should be regularly checked and inspected.

#### 1. Parts affecting intake and exhaust

- Air filter
- Inter cooler
- turbocharger, silencer
- Other parts

#### 2. Parts affecting lubrication and cooling

- Air filter
- Oil filter
- Antifreeze
- Other parts

#### Inspection and Repair of Turbocharger

As performance of turbocharger significantly affects the engine performance, regular inspection and repair should be made and inspection and maintenance regulations should be observed.

#### Intake System

Be careful to handle air filter carefully. In regards to the dry air filter, intake resistance should be small to ensure a smooth intake of air.

#### Exhaust System

If exhaust gas is leaked from the connections in the exhaust pipe, the turbocharger efficiency is lowered, causing degraded engine output and seizure of related parts in the worst case. As parts related to exhaust and turbocharger are used at high temperature, be careful not to mix the bolts and nuts with other parts when performing repair.

#### Lubrication System

Inspection and exchange of oil and oil filter should be performed while considering their exchange cycle. Overheated engine oil significantly affects the engine performance as well as the engine itself.

# 3. Performance and specifications

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### 3. Performance and specifications

#### Engine specifications and performance

#### Engine Specifications

Item	DP158L				Remarks
	DP158LCS	DP158LCF	DP158LDS	DP158LDF	
General Information					
Engine types	Water-cooled, 4cycle, V-type, Turbo charger & inter cooled (air to air)				
Cylinder liner type	Wet type liner				
No. of cylinder - bore x stroke (mm)	8 - 128 X 142				
Total displacement(cc)	14,618				
Compression ratio	14.9 : 1				
Rotation	Counter clockwise viewed from flywheel				
Firing order	1-5-7-2-6-3-4-8				
Injection timing (°) (BTDC)	23° ±1°	18° ±1°	23° ±1°	18° ±1°	BOSCH
	25° ±1°	20° ±1°	25° ±1°	20° ±1°	WEIFU
Dry weight (kg)	1,155				With fan
Dimension (L x W x H) (mm)	1,274 X 1,138 X 1,207				With fan
Flywheel housing	SAE NO.1M				
Flywheel	Clutch NO.14M				
No. of teeth on flywheel	160				
Cooling System					
Cooling method	Fresh water forced circulation				
Coolant capacity (L)	Engine only	Approx. 24			
	With radiator	Approx. 79 (Air on 43°C) / Approx 90 (Air on 52°C)			
Coolant flow rate (L /min)	660	550	660	550	
Pressure cap (kPa)	Max. 49				
Water temperature (°C)	Max. for stand by and prime	103			
	Before start of full load	40			
Water pump	Centrifugal type driven by belt				
Thermostat	Type	Wax-pellet type			
	Opening temp. (°C)	71			
	Full open temp. (°C)	85			

### 3. Performance and specifications

Item		DP158L				Remarks
		DP158LCS	DP158LCF	DP158LDS	DP158LDF	
Cooling fan	Type	Blow Type				
	Diameter - blades	915 mm - 7 blades				
Lubrication System						
Lubrication method		Fully forced pressure feed type				
Oil pump	Type	Gear type				
	Driving type	Driven by crankshaft gear				
Oil filter		Full flow, Cartridge type				
Oil capacity (L)	Max.	22				
	Min.	13				
Lubrication oil pressure (kPa)	Idle speed	Min. 100				
	Governed speed	Min. 250				
Max. oil temperature (°)		120				
Oil specification	Oil class	CI-4 or higher				
	SAE	10W/40				
Fuel System						
Injection pump		WEIFU in-line "P" type				
Governor		Electric type				
Fuel feed pump	Type	Mechanical type injection pump				
	Capacity (L/hr)	-				
Injection nozzle	Type	Multi hole (4 holes)				
	Opening pressure (MPa)	28				
Fuel filter		Full flow, Cartridge type with water drain valve				
Fuel Used		Diesel fuel oil				
Intake/Exhaust System						
Max. back pressure (kPa)		5.9				
Max. intake air restriction (kPa)	With clean filter element	2.16				
	With dirty filter element	6.23				
Cylinder block/head						
Valve system type		Overhead valve type				

### 3. Performance and specifications

Item		DP158L				Remarks
		DP158LCS	DP158LCF	DP158LDS	DP158LDF	
No. of valve (per cylinder)	Intake	1				
	Exhaust	1				
Valve lashes (at cold) (mm)	Intake	0.25 ±0.05				
	Exhaust	0.35 ±0.05				
Intake valve (°)	Opening	24° (BTDC)				
	Close	36° (ABDC)				
Exhaust valve (°)	Opening	63° (BBDC)				
	Close	27° (ATDC)				
Electrical System						
Alternator voltage - capacity (V - A)		27.5 - 45				
Voltage regulator		Built-in type IC regulator				
Starting motor voltage - capacity (V - kW)		24 - 7.0				
Battery capacity		2-200Ah (recommended)				

### 3. Performance and specifications

Item	DP180L				Remarks
	DP180LBS	DP180LBF	DP180LAS	DP180LAF	
General Information					
Engine types	Water-cooled, 4cycle, V-type, Turbo charger & inter cooled (air to air)				
Cylinder liner type	Wet type liner				
No. of cylinder - bore x stroke (mm)	10 - 128 X 142				
Total displacement(cc)	18,273				
Compression ratio	14.9 : 1				
Rotation	Counter clockwise viewed from flywheel				
Firing order	1-6-5-10-2-7-3-8-4-9				
Injection timing (°) (BTDC)	21° ±1°	19° ±1°	21° ±1°	19° ±1°	
Dry weight (kg)	1,250				With fan
Dimension (L x W x H) (mm)	1,592 x 1,389 x 1,223				With fan
Flywheel housing	SAE NO.1M				
Flywheel	Clutch NO.14M				
No. of teeth on flywheel	160				
Cooling System					
Cooling method	Fresh water forced circulation				
Coolant capacity (L)	Engine only	Approx. 27			
	With radiator	Approx. 79 (Air on 43°C) / Approx 90 (Air on 52°C)			
Coolant flow rate (L /min)	660	550	660	550	
Pressure cap (kPa)	Max. 49				
Water temperature (°C)	Max. for stand by and prime	103			
	Before start of full load	40			
Water pump	Centrifugal type driven by belt				
Thermostat	Type	Wax-pellet type			
	Opening temp. (°C)	71			
	Full open temp. (°C)	85			
Cooling fan	Type	Blow Type			
	Diameter - blades	915 mm - 7 blades			

### 3. Performance and specifications

Item	DP180L				Remarks
	DP180LBS	DP180LBF	DP180LAS	DP180LAF	
Lubrication System					
Lubrication method		Fully forced pressure feed type			
Oil pump	Type	Gear type			
	Driving type	Driven by crankshaft gear			
Oil filter		Full flow, Cartridge type			
Oil capacity (L)	Max.	34			
	Min.	23			
Lubrication oil pressure (kPa)	Idle speed	Min. 100			
	Governed speed	Min. 250			
Max. oil temperature (°)		120			
Oil specification	Oil class	CI-4 or higher			
	SAE	10W/40			
Fuel System					
Injection pump		BOSCH in-line "P" type			
Governor		Electric type			
Fuel feed pump	Type	Mechanical type injection pump			
	Capacity (L/hr)	630			
Injection nozzle	Type	Multi-hole (4 hole)			
	Opening pressure (MPa)	28			
Fuel filter		Full flow, Cartridge type with water drain valve			
Fuel Used		Diesel fuel oil			
Intake/Exhaust System					
Max. back pressure (kPa)		5.9			
Max. intake air restriction (kPa)	With clean filter element	2.16			
	With dirty filter element	6.23			
Cylinder block/head					
Valve system type		Overhead valve type			
No. of valve (per cylinder)	Intake	1			
	Exhaust	1			

### 3. Performance and specifications

Item		DP180L				Remarks
		DP180LBS	DP180LBF	DP180LAS	DP180LAF	
Valve lashes (at cold) (mm)	Intake	0.25 ±0.05				
	Exhaust	0.35 ±0.05				
Intake valve (°)	Opening	24° (BTDC)				
	Close	36° (ABDC)				
Exhaust valve (°)	Opening	63° (BBDC)				
	Close	27° (ATDC)				
Electrical System						
Alternator voltage - capacity (V - A)		27.5 - 45				
Voltage regulator		Built-in type IC regulator				
Starting motor voltage - capacity (V - kW)		24 - 7.0				
Battery capacity		2-200Ah (recommended)				

### 3. Performance and specifications

Item	DP222L					Remarks
	DP222LAS	DP222LBS	DP222LBF	DP222LCS	DP222LCF	
General Information						
Engine types	Water-cooled, 4cylcle, V-type Turbo charger & Inter cooled (air to air)					
Cylinder liner type	Wet Type					
No. of cylinder - bore x stroke (mm)	12 - 128 X 142					
Total displacement(cc)	21,927					
Compression ratio	14.9 : 1					
Rotation	Counter clockwise viewed from flywheel					
Firing order	1-12-5-8-3-10-6-7-2-11-4-9					
Injection timing (°) (BTDC)	21° ±1°	21° ±1°	19° ±1°	21° ±1°	19° ±1°	BOSCH
	23° ±1°	23° ±1°	21° ±1°	23° ±1°	21° ±1°	WEIFU
Dry weight (kg)	1,420					With fan
Dimension (L x W x H)(mm)	1,738 X 1,389 X 1,258					With fan
Flywheel housing	SAE NO.1M					
Flywheel	Clutch NO.14M					
No. of teeth on flywheel	160					
Cooling System						
Cooling method	Fresh water forced circulation					
Coolant capacity (L)	Engine only	Approx. 33				
	With radiator	Approx. 114 (Air on 43°C) / Approx 125 (Air on 52°C)				
Coolant flow rate (L/min)	660	660	550	660	550	
Pressure cap (kPa)	Max. 49					
Water temperature (°C)	Max. for stand by and prime	103				
	Before start of full load	40				
Water pump	Centrifugal type driven by belt					
Thermostat	Type	Wax-pellet type				
	Opening temp. (°C)	71				
	Full open temp. (°C)	85				

### 3. Performance and specifications

Item		DP222L					Remarks
		DP222LAS	DP222LBS	DP222LBF	DP222LCS	DP222LCF	
Cooling fan	Type	Blow Type					
	Diameter - blades	915 mm - 9 blades					
Lubrication System							
Lubrication method		Fully forced pressure feed type					
Oil pump	Type	Gear type					
	Driving type	Driven by crankshaft gear					
Oil filter		Full flow Cartridge type					
Oil capacity (L)	Max.	40					
	Min.	27					
Lubrication oil pressure (kPa)	Idle speed	Min. 100					
	Governed speed	Min. 250					
Max. oil temperature (°C)		120					
Oil specification	Oil class	CI-4 or higher					
	SAE	10W/40					
Fuel System							
Injection pump		WEIFU in-line "P" type					
Governor		Electric type					
Fuel feed pump	Type	Mechanical type injection pump					
	Capacity (L/hr)	-					
Injection nozzle	Type	Multi hole type (4 holes)					
	Opening pressure (MPa)	28					
Fuel filter		Full flow, Cartridge type with water drain valve					
Fuel Used		Diesel fuel oil					
Intake/Exhaust System							
Max. back pressure (kPa)		5.9					
Max. intake air restriction (kPa)	With clean filter element	2.16					
	With dirty filter element	6.23					
Cylinder block/head							
Valve system type		Overhead valve type					

### 3. Performance and specifications

Item		DP222L					Remarks
		DP222LAS	DP222LBS	DP222LBF	DP222LCS	DP222LCF	
No. of valve (per cylinder)	Intake	1					
	Exhaust	1					
Valve lashes (at cold) (mm)	Intake	0.25 ±0.05					
	Exhaust	0.35 ±0.05					
Intake valve (°)	Opening	24° (BTDC)					
	Close	36° (ABDC)					
Exhaust valve (°)	Opening	63° (BBDC)					
	Close	27° (ATDC)					
Electrical System							
Alternator voltage - capacity (V - A)		27.5 - 45					
Voltage regulator		Built-in type IC regulator					
Starting motor voltage - capacity (V - kW)		24 - 7.0					
Battery capacity		2-200Ah (recommended)					

### 3. Performance and specifications

#### Gross Engine Output

Engine Model			Performance				Remark
			Prime		Stand by		
			PS	kWm	PS	kWm	
DP158L	DP158LCS	60Hz (1,800rpm)	634	466	697	513	
	DP158LCF	50Hz (1,500rpm)	555	408	610	449	
	DP158LDS	60Hz (1,800rpm)	687	505	756	556	
	DP158LDF	50Hz (1,500rpm)	630	464	693	510	
180L	DP180LBS	60Hz (1,800rpm)	817	601	899	661	
	DP180LAS	60Hz (1,800rpm)	760	559	836	615	
	DP180LBF	50Hz (1,500rpm)	756	556	832	612	
	DP180LAF	50Hz (1,500rpm)	682	502	750	552	
DP222L	DP222LCS	60Hz (1,800rpm)	1,023	753	1,126	828	
	DP222LCF	50Hz (1,500rpm)	894	657	983	723	
	DP222LBB	60Hz (1,800rpm)	967	711	1,063	782	
	DP222LBF	50Hz (1,500rpm)	821	604	903	664	
	DP222LAS	60Hz (1,800rpm)	911	670	1,002	737	

Note) Ratings Definitions

The power ratings of Emergency Standby and Prime are in accordance with ISO 8528.

Fuel Stop power in accordance with ISO 3046.

Electric power (kWe) must be considered cooling fan loss, alternator efficiency, altitude derating and ambient temperature.

STANDBY POWER RATING is applicable for supplying emergency power for the duration of the utility power outage. No overload capability is available for this rating. A standby rated engine should be sized for a maximum of an 80% average load factor and 200 hours of operation per year. This includes less than 25 hours per year at the Standby Power rating.

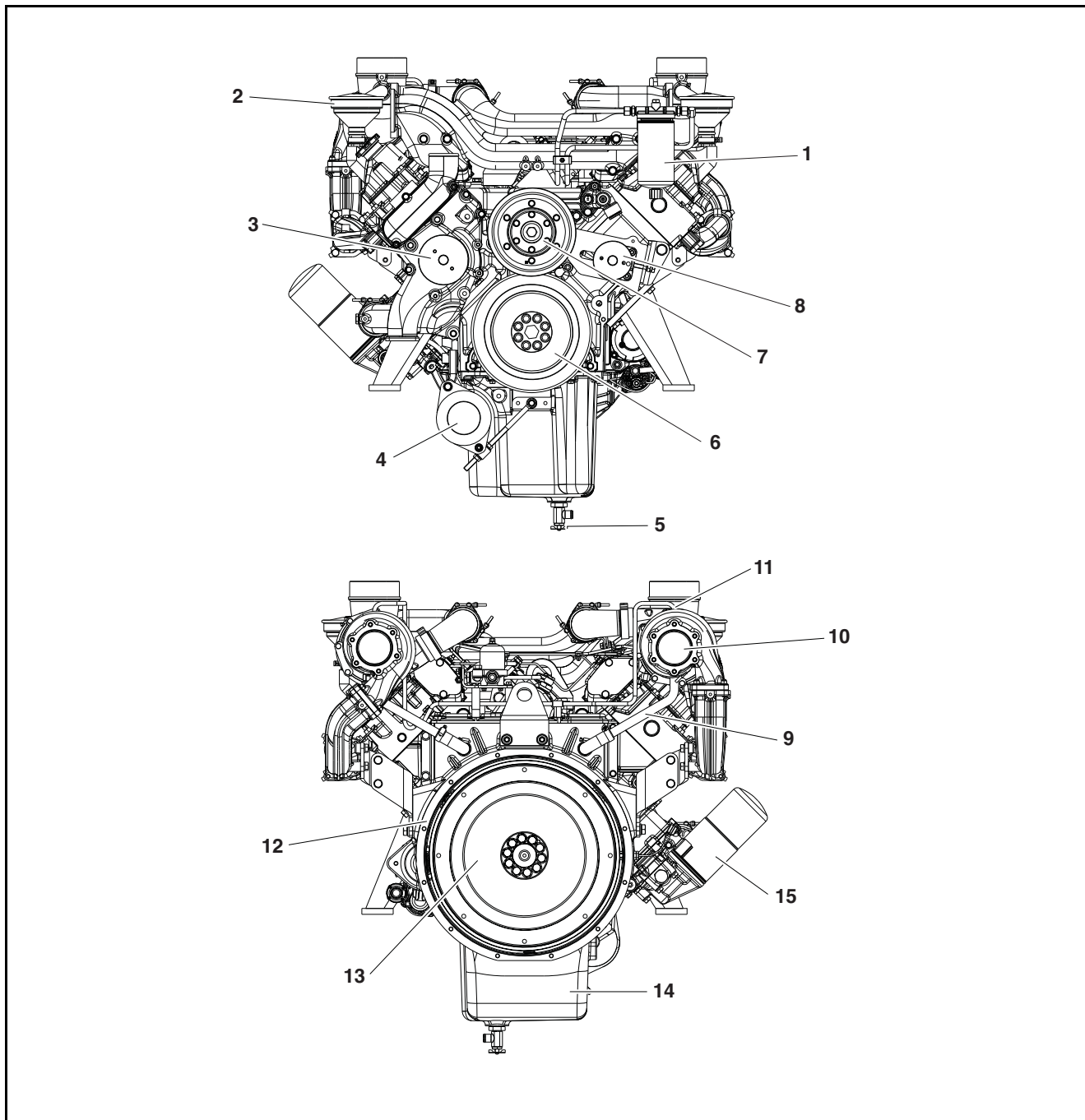
PRIME POWER RATINNG is available for an unlimited number of hours per year in variable load application. Variable load should not exceed a 70% average of the Prime Power rating during any operating period of 24 hours. The Total operating time at 100% Prime Power shall not exceed 500 hours per year. A 10% overload capability is available for a period of 1 hour withing a 12 hour period of operation. Total operating time at the 10% overload power shall not exceed 25 hours per year.

### 3. Performance and specifications

#### Exterior view drawing of the engine

Note) The images shown represent the standard model; they do not include all models.

#### Front/Rear(DP158L)

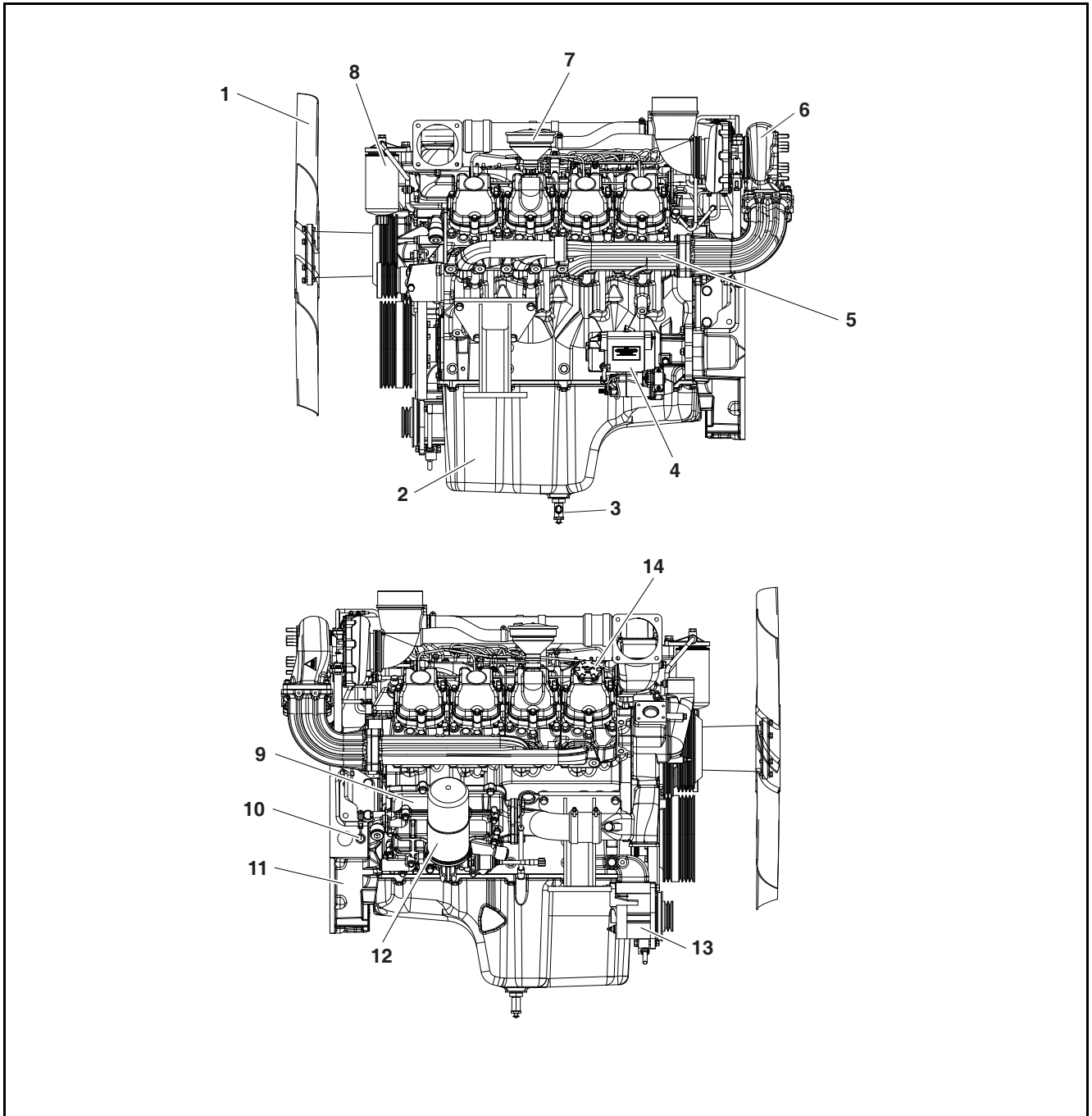


DV2213001A

- |                          |                           |                            |
|--------------------------|---------------------------|----------------------------|
| 1. Fuel Filter           | 6. Crankshaft Pulley      | 11. Engine Oil Supply Pipe |
| 2. Breather              | 7. Cooling Fan Pulley     | 12. Flywheel Housing       |
| 3. Coolant Pump          | 8. Idle Pulley            | 13. Flywheel               |
| 4. Alternator            | 9. Engine Oil Return Pipe | 14. Oil Pan                |
| 5. Engine Oil Drain Plug | 10. Turbocharger          | 15. Oil Filter             |

### 3. Performance and specifications

Left/Right(DP158L)

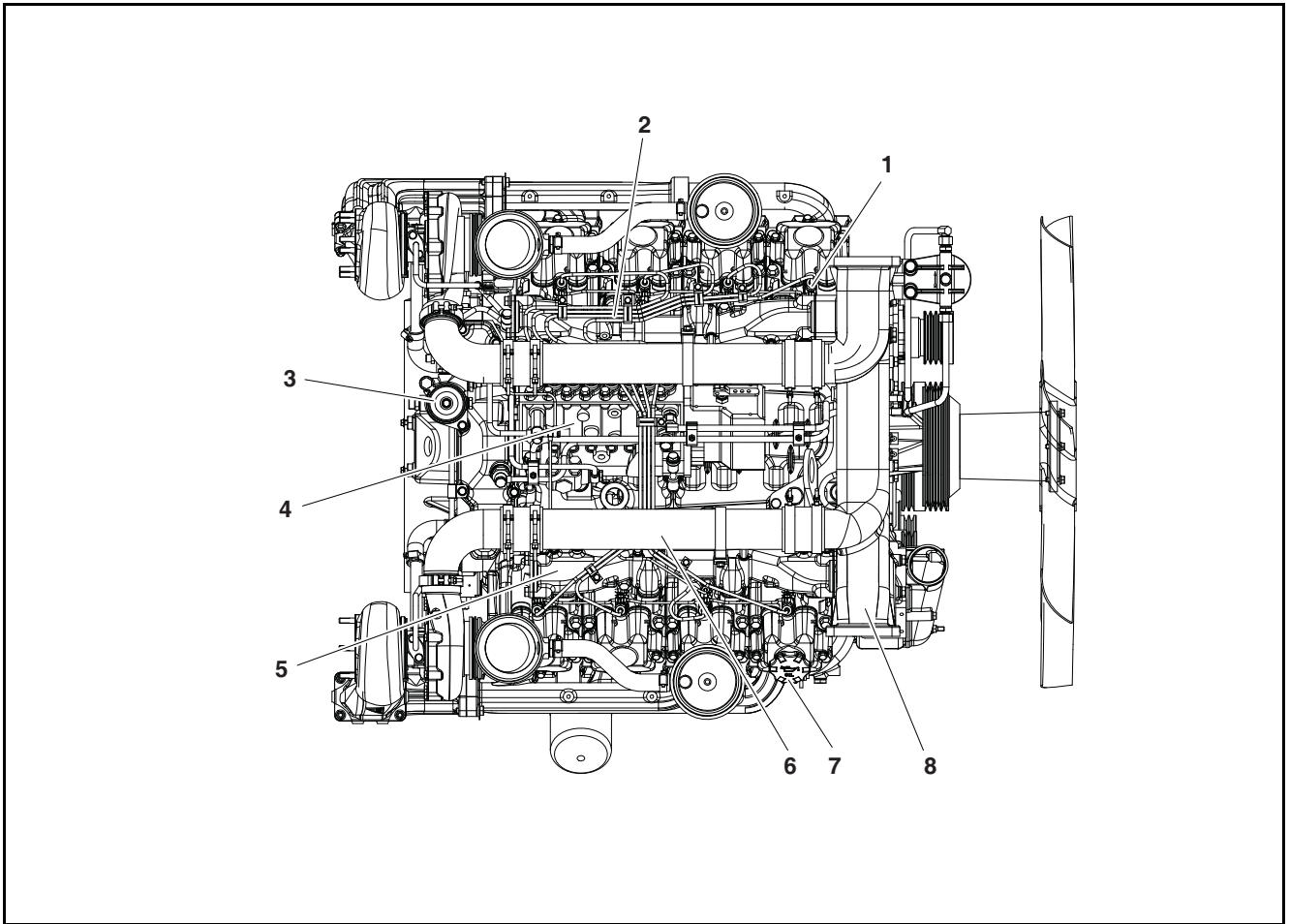


EDV2223001

- |                          |                  |                      |
|--------------------------|------------------|----------------------|
| 1. Cooling Fan           | 6. Turbocharger  | 11. Flywheel Housing |
| 2. Oil Pan               | 7. Breather      | 12. Oil Filter       |
| 3. Engine Oil Drain Plug | 8. Fuel Filter   | 13. Alternator       |
| 4. Starter               | 9. Oil Cooler    | 14. Oil Cap          |
| 5. Exhaust Manifold      | 10. Tacho Sensor |                      |

### 3. Performance and specifications

Top(DP158L)



DV2213003A

1. Injector

2. Fuel Injection Pipe

3. Fuel Pre-Filter/Priming Pump

4. Fuel Injection Pump

5. Intake Manifold

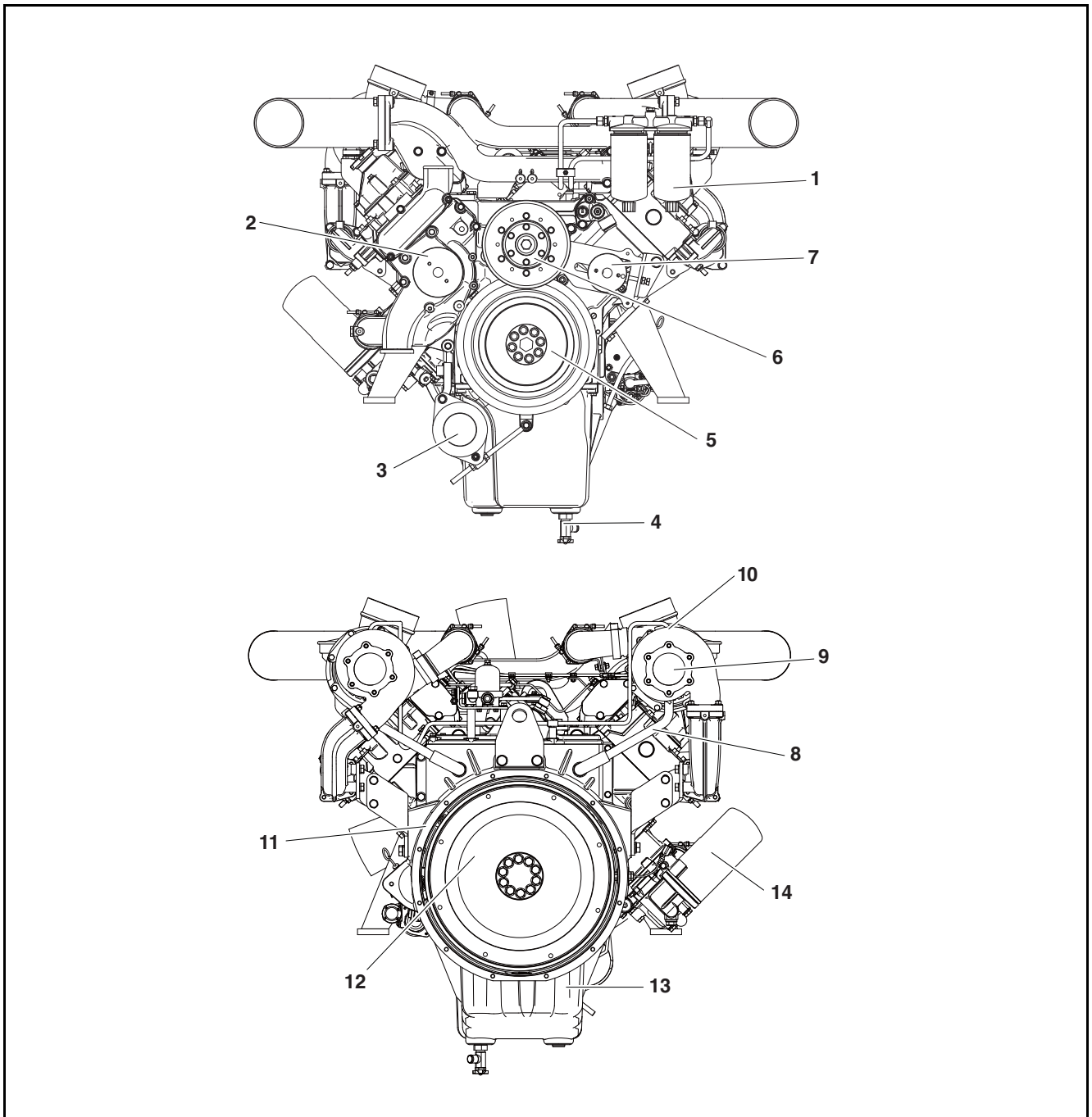
6. Air Pipe

7. Oil Filler Cap

8. Inlet Pipe

### 3. Performance and specifications

#### Front/Rear(DP180L)

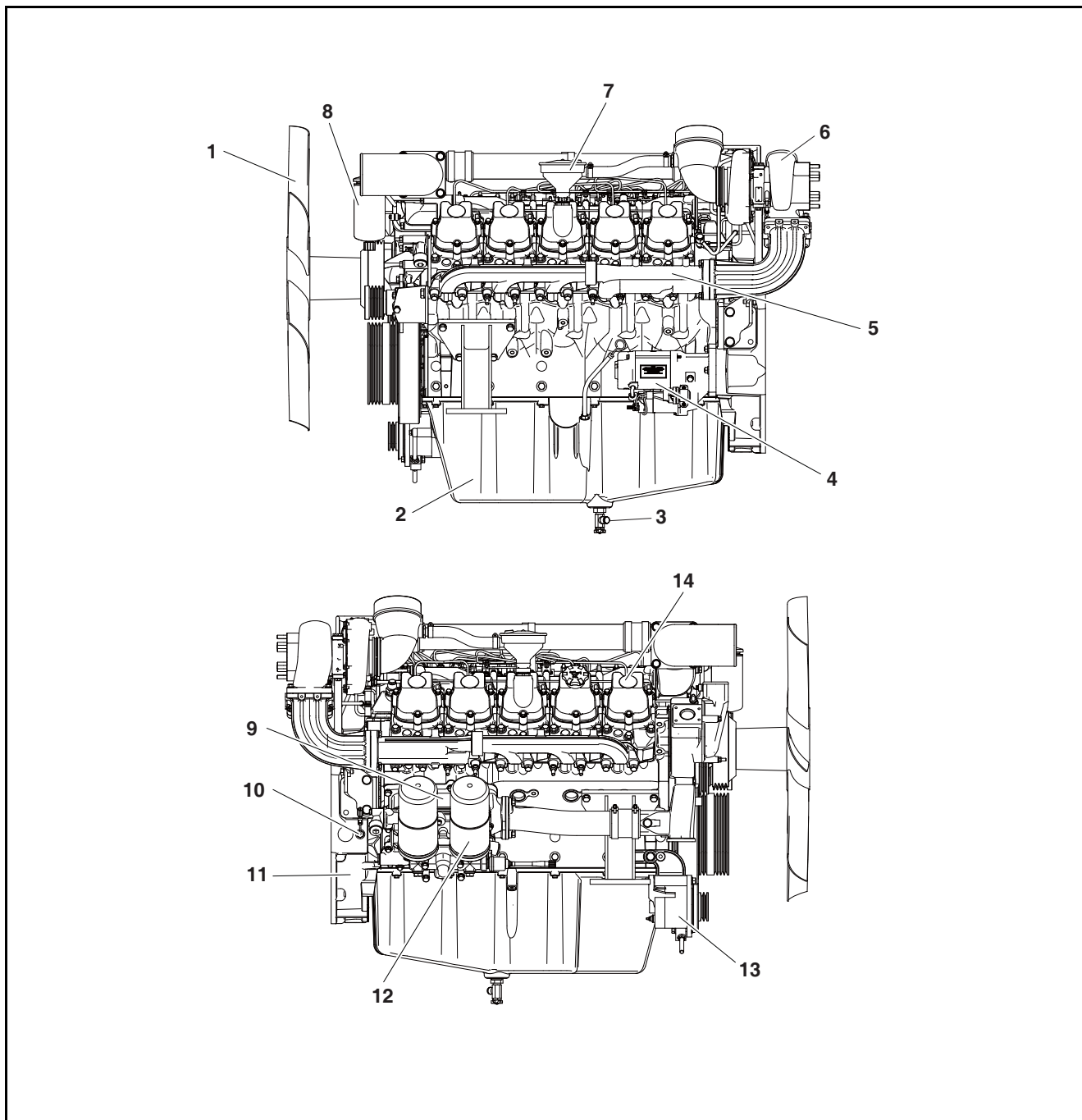


DV2213001B

- |                          |                            |                      |
|--------------------------|----------------------------|----------------------|
| 1. Fuel Filter           | 6. Cooling Fan Pulley      | 11. Flywheel Housing |
| 2. Coolant Pump          | 7. Idle Pulley             | 12. Flywheel         |
| 3. Alternator            | 8. Engine Oil Return Pipe  | 13. Oil Pan          |
| 4. Engine Oil Drain Plug | 9. Turbocharger            | 14. Oil Filter       |
| 5. Crankshaft Pulley     | 10. Engine Oil Supply Pipe |                      |

### 3. Performance and specifications

Left/Right(DP180L)



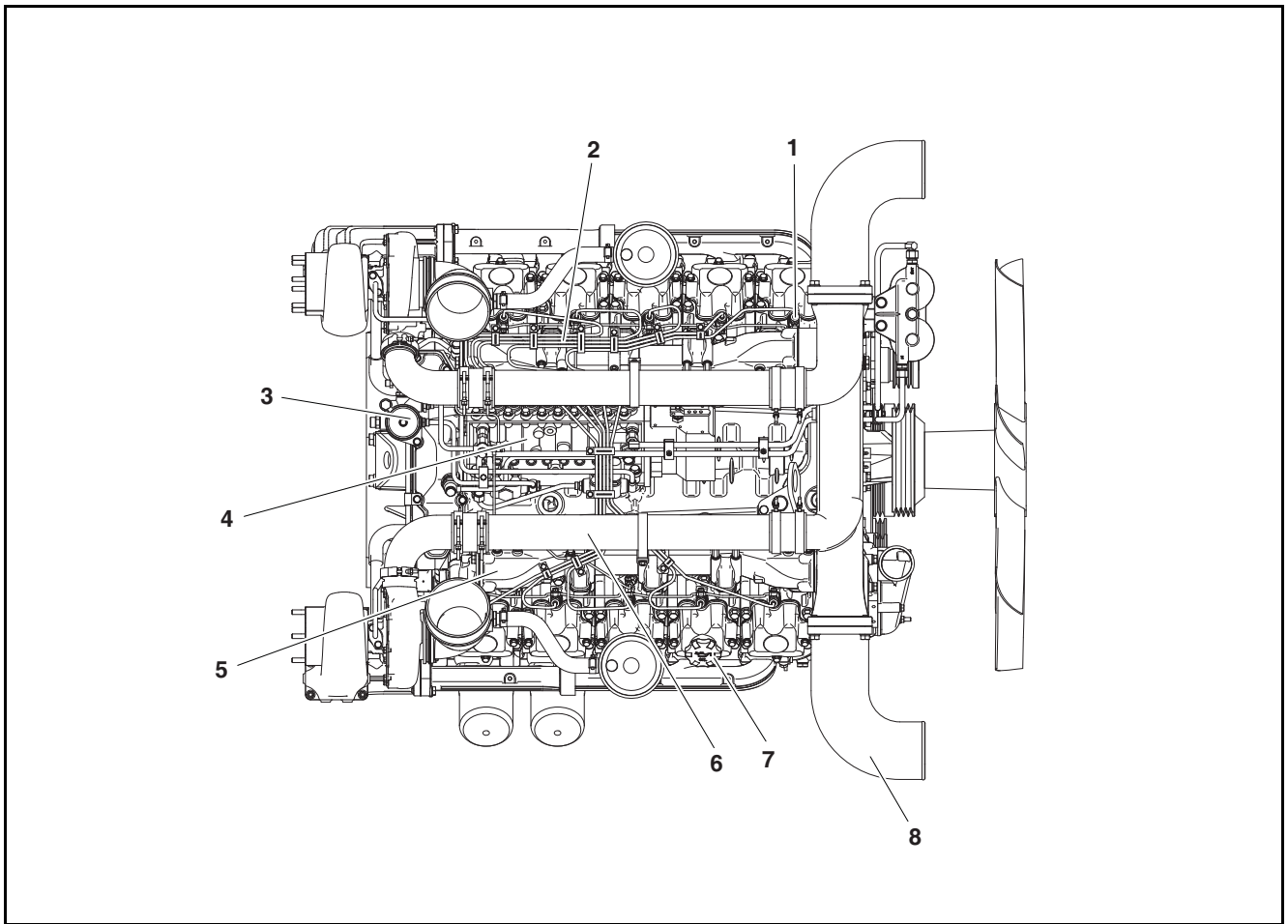
EDV2223002

- |                          |                  |                      |
|--------------------------|------------------|----------------------|
| 1. Cooling Fan           | 6. Turbocharger  | 11. Flywheel Housing |
| 2. Oil Pan               | 7. Breather      | 12. Oil Filter       |
| 3. Engine Oil Drain Plug | 8. Fuel Filter   | 13. Alternator       |
| 4. Starter               | 9. Oil Cooler    | 14. Oil Cap          |
| 5. Exhaust Manifold      | 10. Tacho Sensor |                      |

### 3. Performance and specifications

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Top(DP180L)

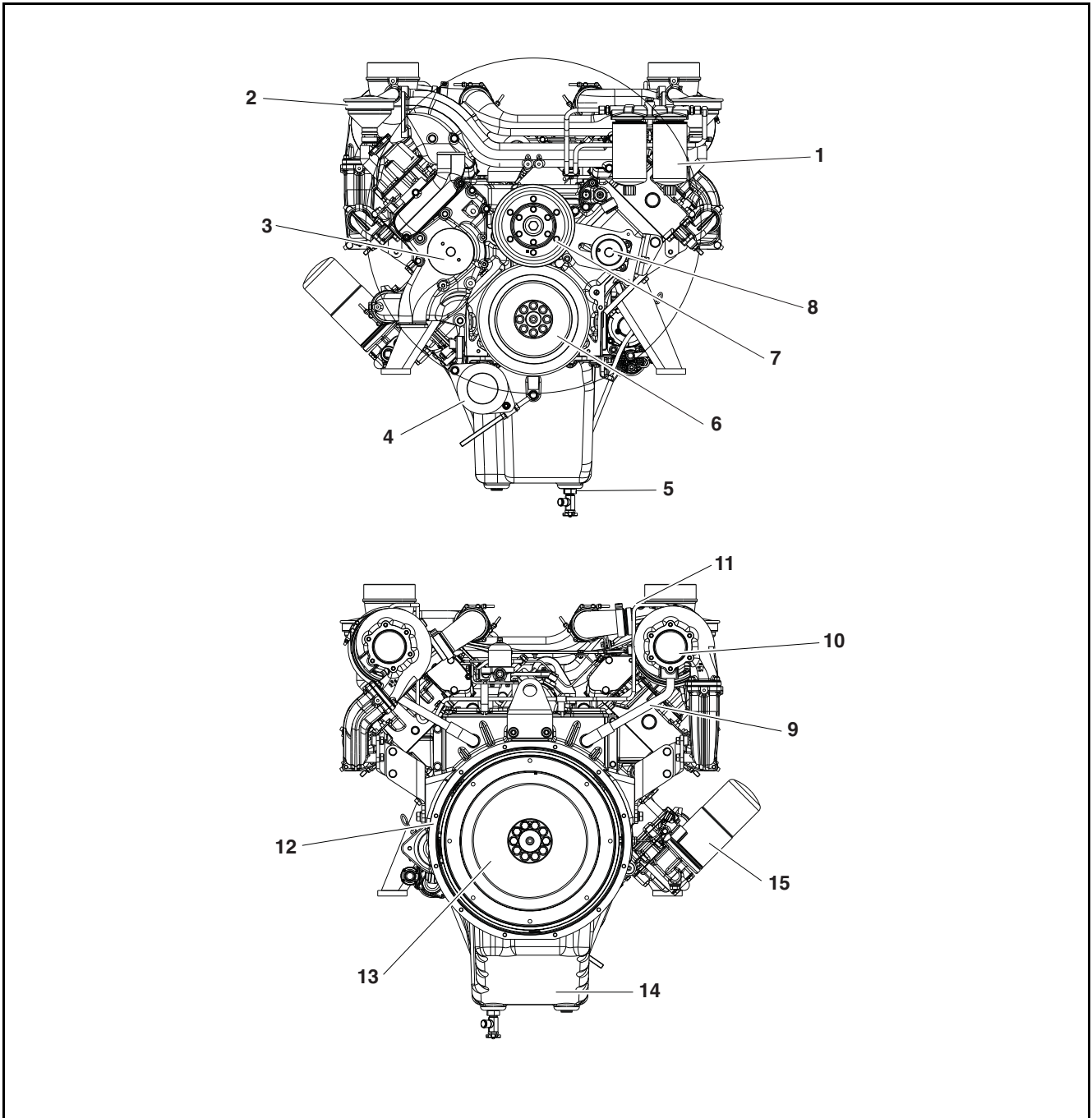


DV2213003B

- |                                 |                        |                   |
|---------------------------------|------------------------|-------------------|
| 1. Injector                     | 4. Fuel Injection Pump | 7. Oil Filler Cap |
| 2. Fuel Injection Pipe          | 5. Intake Manifold     | 8. Inlet Pipe     |
| 3. Fuel Pre-Filter/Priming Pump | 6. Air Pipe            |                   |

### 3. Performance and specifications

#### Front/Rear(DP222L)

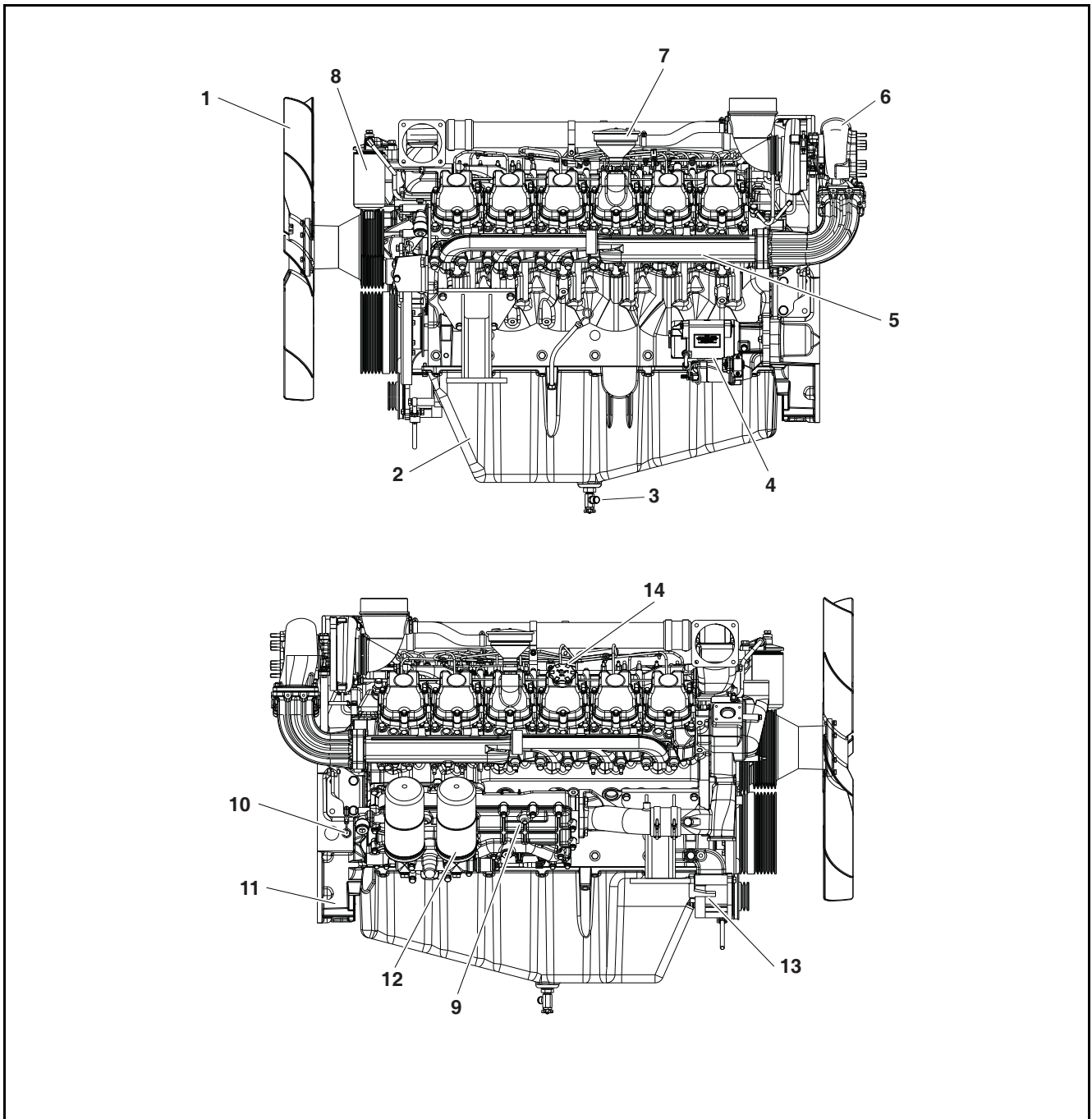


DV2213004A

- |                          |                           |                            |
|--------------------------|---------------------------|----------------------------|
| 1. Fuel Filter           | 6. Crankshaft Pulley      | 11. Engine Oil Supply Pipe |
| 2. Breather              | 7. Cooling Fan Pulley     | 12. Flywheel Housing       |
| 3. Coolant Pump          | 8. Idle Pulley            | 13. Flywheel               |
| 4. Alternator            | 9. Engine Oil Return Pipe | 14. Oil Pan                |
| 5. Engine Oil Drain Plug | 10. Turbocharger          | 15. Oil Filter             |

### 3. Performance and specifications

Left/Right(DP222L)

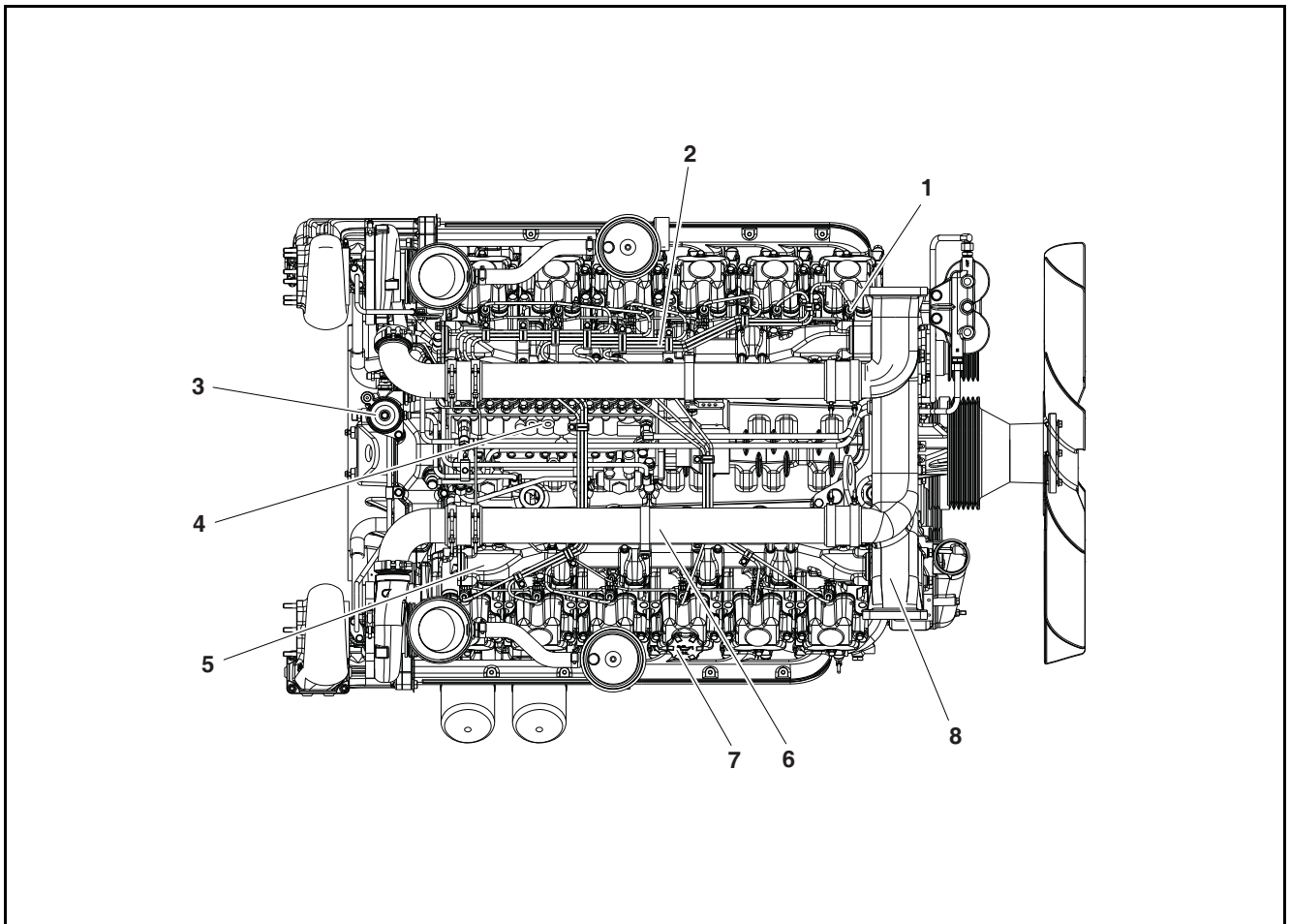


EDV2223003

- |                          |                  |                      |
|--------------------------|------------------|----------------------|
| 1. Cooling Fan           | 6. Turbocharger  | 11. Flywheel Housing |
| 2. Oil Pan               | 7. Breather      | 12. Oil Filter       |
| 3. Engine Oil Drain Plug | 8. Fuel Filter   | 13. Alternator       |
| 4. Starter               | 9. Oil Cooler    | 14. Oil Cap          |
| 5. Exhaust Manifold      | 10. Tacho Sensor |                      |

### 3. Performance and specifications

Top(DP222L)



DV2213006A

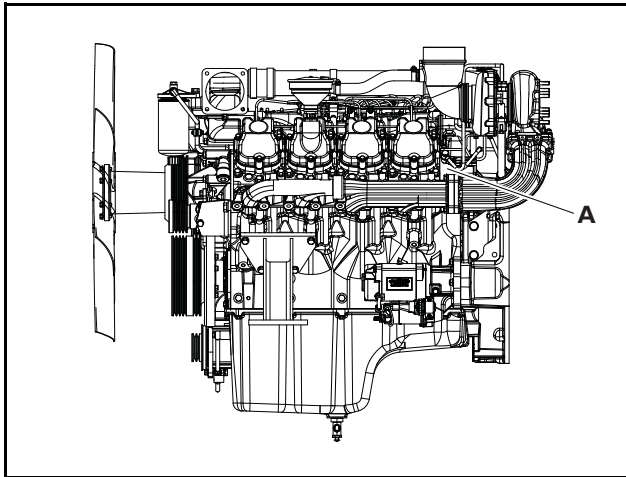
- |                                 |                        |                   |
|---------------------------------|------------------------|-------------------|
| 1. Injector                     | 4. Fuel Injection Pump | 7. Oil Filler Cap |
| 2. Fuel Injection Pipe          | 5. Intake Manifold     | 8. Inlet Pipe     |
| 3. Fuel Pre-Filter/Priming Pump | 6. Air Pipe            |                   |

### 3. Performance and specifications

#### Engine identification number

##### Engine Code and Manufacturing Number

The engine code and manufacturing number are engraved in the position marked (A) in the drawing. These numbers are necessary to request quality assurance or to order parts.



EDV2223004

##### Engine number engraving

- Type 1

□□□□□   □   □□□□□  
(A)                    (B)                    (C)

- A. Engine model SUFFIX(5 digits)
- B. Production Year(1 digit)
- C. Serial Number(5 digits)

- Type 2

□□□□□□□   □   □□□□□□   □□  
(A)                    (B)                    (C)                    (D)

- A. Sales Model name(4~7 digits)
- B. Production Year(1 digit)
- C. Serial Number(5 digits)
- D. After engine model SUFFIX(2 digits)

- Type 3

□□□□□   □□□   □   □□□□□□   □□  
(A)                    (B)                    (C)                    (D)                    (E)

- A. Sales Model name(5 digits)
- B. Engine output(3 digits)
- C. Production Year(1 digit)
- D. Serial Number(5 digits)
- E. After engine model SUFFIX(2 digits)

- Type 4

□□□□□□□□□   □   □□□□□  
(A)                    (B)                    (C)

- A. New representative specification (9 digits)
- B. Production Year(1 digit)
- C. Serial Number(5 digits)

- Type 5

□□□□□□□   □   □□□□□□   □□□  
(A)                    (B)                    (C)                    (D)

- A. Sales Model name(4~7 digits)
- B. Production Year(1 digit)
- C. Serial Number(5 digits)
- D. After new representative specification(3 digits)

- Type 6

□□□□□   □□□   □   □□□□□□   □□□  
(A)                    (B)                    (C)                    (D)                    (E)

- A. Sales Model name(5 digits)
- B. Engine output(3 digits)
- C. Production Year(1 digit)
- D. Serial Number(5 digits)
- E. After new representative specification(3 digits)

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### General information

#### General Information

As time passes after purchasing an engine, each of the engines parts age and initial engine performance cannot be maintained.

Regular inspection and replacement according to the recommended regular inspection table allows you to maintain an engine with the optimum conditions and best performance for a long period and prevent unexpected accidents in advance.

Users are responsible for the proper operation and maintenance of engines. Engines should be inspected and replaced by officially-certified technicians in a workspace with the specified tools and facilities. Observe the following instructions to perform inspections.

1. Perform inspections on a flat floor without a slope.
2. Excluding extreme circumstances, only perform inspection while the engine is stopped.
3. Disconnect the '-' terminal of the battery before performing an inspection.
4. Perform inspection in a well ventilated space.
5. Use a wooden prop or lift when working under the engine.

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### DANGER

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- **Wait until the engine is sufficiently cooled before starting inspection after operating the engine. Otherwise, you may be burned.**
  - **You may be poisoned by the emission when starting an engine in a closed space. Perform inspection at the well-ventilate space.**
  - **Unless absolutely compelled, do not perform inspection under an engine.**
  - **Do not be close to fire when inspecting an engine. Fuel, oil, or batteries may generate gas, causing fire.**
  - **If inspecting the engine while it is running, do not wear accessories such as necklaces, rings, watches or gloves. Such accessories may become stuck in rotating parts while the engine is running and may cause serious bodily injury.**
- 

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### CAUTION

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- **Incorrect inspection methods may cause of engine faults.**
  - **Cleaning an engine with liquids such as water or wax may cause breakdown of electrical parts.**
  - **Be careful when handling batteries, cables, and electrical wirings because current flows through those parts.**
  - **Do not put heavy things or apply excessive force or impact on the fuel-related units.**
  - **Make sure that you connect the battery terminal ('+' and '-') to the right terminal. Connecting the '+' and '-' terminals to the wrong terminal may cause damage to the electrical unit parts and fire.**
- 

#### Routine Inspection

Routine inspection is an inspection performed by an engine operator before operating the engine. It should be performed to protect operator's safety, as well as the engine.

The following is a minimal check list.

1. Check whether the engine smoothly starts and the levels of fuel, oil, and coolant are within the normal range.
2. Check if any discharged emissions are colored and if the exhaust contains toxic gas elements.
3. Check whether abnormal noise occurs after starting an engine or not.
4. Check whether oil or water is leaking.

## 4. Regular inspection

### Regular inspection table

#### General Conditions

Regular inspection and replacement according to the recommended regular inspection table allows you to maintain the engine with optimum conditions and best performance for a long period and prevent unexpected accidents in advance.

(○ : Inspection and Adjustment, ● : Replacement)

Inspection		Daily	Inspection time (hours)						Remark
			50	200	500	600	800	1,200	
Cooling System	Check for leakage (hoses, clamp)	○							Every 2 year
	Check the water level	○							
	Change the coolant water							●	
	Adjust the V-belt tension	○							Every 2,000 hrs
	Replace V-belt								Every 1,600 hrs / Every 2 year
	Clean the radiator							○	
Lubrication System	Check for leakage	○							
	Replace oil hoses, clamps								Every 2 year
	Check the oil level gauge	○							
	Change the lubricating oil		● 1st	●					Every 200 hrs / Every 1 year
Intake & Exhaust System	Replace the oil filter cartridge			●					Every 200 hrs / Every 1 year
	Check the leakage for intercooler (hoses, clamp)	○							Every 2 year
	Clean and change the air cleaner element			○ clean					Every 400 hrs
	Clean the inter-cooler air fins					○			
Fuel System	Clean the turbo-charger								Every 2,000 hrs
	Check the leakage fuel line	○							
	Clean the fuel strainer of fuel feed pump							○	
	Remove sediment from fuel tank							○	
	Drain the water in separator			○					
	Replace the fuel filter element		● 1st		●				
	Check fuel Injection timing			○					When necessary
	Check the injection nozzles			○					When necessary
Replace fuel hoses, clamps								Every 2 year	
Engine Adjust	Check the state of exhaust gas	○							
	Check the battery charging	○							
	Check the compression pressure							○	When necessary
	Adjust Intake / Exhaust valve clearance		○ 1st						Every 1,000 hrs

\* If the sulfur content of the fuel is more than 0.5%, the replacement and inspection cycle should be cut in half.

### **Use of Genuine Parts**

An engine consists of many parts which are mechanically harmonized. To prevent engine faults in advance and use engines with best performance for a long period, maintenance and replacement of expendable parts should be conducted regularly.

Use of genuine parts is recommended. Using unauthorized or remanufactured parts may cause critical damage and faults to engine for which HD Hyundai Infracore shall not be held liable.

## 4. Regular inspection

### Cooling system

#### General Information

The coolant should be replaced according to the cycle specified in the inspection interval table. If the coolant gets dirty, the engine is overheated, and the coolant overflows in the thermal expansion tank.

#### Coolant standards

We recommend you to inject the antifreeze about 40~50% of the entire coolant. The antifreeze prevents the freezing and corrosion of the system, and increases the boiling point of water. In winter, you may need to change the amount of antifreeze per ambient temperature as shown in the table below. The freezing point per antifreeze ratio shown in the table may differ slightly depending on the antifreeze type. For more information, see the specifications provided by the manufacturer.

Whenever you add coolant(water) to replenish the amount reduced by engine operation, the antifreeze portion is decreased. So, you need to increase the antifreeze level to the proper level after replenishing the coolant.

- concentration of antifreeze during winter

Ambient temperature (°C)	Coolant (%)	Antifreeze (%)
Above -10	85	15
-10	80	20
-15	73	27
-20	67	33
-25	60	40
-30	56	44
-40	50	50

#### Capacity of coolant

Engine Mode	Coolant capacity ( ℓ )	
	Inside engine	With radiator
DP 158L	About 23	About 79 (Air on 43°C)
		About 90 (Air on 52°C)

Engine Mode	Coolant capacity ( ℓ )	
	Inside engine	With radiator
DP180L	About 27	About 91 (Air on 43°C)
		About 114 (Air on 43°C)
DP 222L	About 33	About 114 (Air on 43°C)
		About 125 (Air on 52°C)

#### Checking the Coolant

### DANGER

If the radiator cap is opened to exchange or replenish coolant while the engine is overheated, hot water will spurt out and may cause serious burns. If it is absolutely necessary to open the radiator cap while the engine is overheated, wrap the radiator cap with a cloth and slowly open the cap in two steps until the steam pressure has been released from the inside. After the steam pressure has been completely released, remove the radiator cap.

1. For the engine coolant, you should use clean tap water.
2. To the engine coolant add 40% of antifreeze, and 3~5% of additive (DCA4) to prevent corrosion.
3. Periodically check coolant to maintain the concentration of antifreeze and additives.

### DANGER


If you keep the antifreeze and corrosion inhibitor at a proper level, you can prevent the corrosion of engine effectively and keep the quality of the engine. Be careful that, if managed improperly, it can give a fatal impact on the coolant pump and cylinder liner.

4. The engine cylinder liner is of a wet type which specially requires good coolant flow.
5. You can check the concentration of antifreeze and corrosion inhibitor using the coolant test sheet.

## 4. Regular inspection

### Measurement of Coolant Concentration

- Special Tools

Figure	Product Number/Name
	60.99901-0038 CC2602M Coolant test sheet

The coolant concentration can be measured as follows.

- If the engine coolant temperature is within a range of 10 ~ 55°C, drain the coolant and fill half a plastic cup with it.

### CAUTION

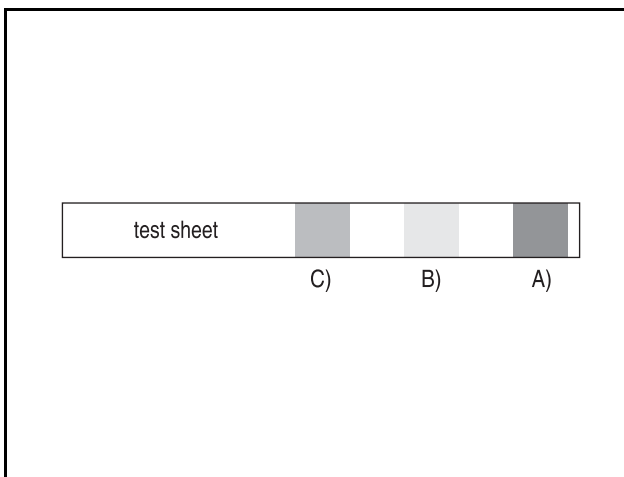
When taking out a sample of coolant from the supplementary tank, it is difficult to measure the precise concentration. Always take out sample by opening the drain plug of coolant.

- Soak the test sheet in the coolant and take it out after 3 ~ 5 seconds. Shake the sheet to remove the remaining coolant.
- Wait for about 45 seconds until the test sheet changes its color.

### CAUTION

Measurement time should not exceed 75 seconds. The color changes as time passes.

- Check the color on test sheet.



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- Compare the color of part A on the test sheet to the color of GLYCOL/FREEZEPOINT (End pad) of the standard color table.

- Compare the color of the test sheet (B) to the color of MOLYBDATE (Middle pad) of the standard color table.
- Compare the color of the test sheet (C) to the color of NITRITE of the standard color table.
- Compare and confirm the parts with identical colors on the test sheet and the standard color table.

		% GLYCOL / FREEZEPOINT (°C) (End Pad)								
		25%	33%	40%	50%	60%				
		-12°	-15°	-18°	-21°	-23°	-29°	-34°	-43°	-51°
		SCA Units per litre.								
Row 6		0.0	0.4	0.7	0.9	1.0	1.1	1.3	1.5	
Row 5		0.0	0.4	0.6	0.7	0.9	0.9	1.1	1.3	TEST
Row 4		0.0	0.4	0.5	0.5	0.6	0.7	1.0	1.2	
Row 3		0.0	0.3	0.4	0.4	0.6	0.7	0.9	1.1	SERVICE
Row 2		0.0	0.2	0.3	0.4	0.5	0.6	0.8	1.0	
Row 1		0.0	0.2	0.2	0.2	0.4	0.5	0.7	0.9	PRE CHARGE
Row 0		0.0	0.1	0.2	0.3	0.4	0.6	0.9		
	MOLYBDATE (MIDDLE PAD)	A	B	C	D	E	F	G	H	
	NITRITE									

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- Compare the changed pink color part A of the test sheet with the GLYCOL/FREEZEPOINT (End pad) of the standard color table on top of the container and confirm the concentration. The concentration indication has to be within the color scope of 33~50%.
- The state of additives for anticorrosion is shown on the point where the color of MOLYBDATE (Middle pad) on the standard color table (which is identical with the Middle (B) of the test sheet) is crossed with the color of NITRITE on the standard color table (which is identical with the (C) of the test sheet). It should be maintained at the optimum range, in the green section between 0.3 to 0.8.
- If the measurement result is below 0.3, replenish anticorrosion additives (DCA4). If it is above 0.8 or, drain a little coolant and then add clean tap water to adjust the concentration.

### CAUTION

- If the color on the test sheet does not match the color of the standard color table, find a middle color on the standard color table. For example, if the color of (C) of the test sheet matches D and F on the NITRITE of the standard color table, select E.
- To prevent corrosion inside of the engine cooling unit, drain the coolant and replace it with new coolant once a year.

## 4. Regular inspection

### Discharging the coolant

The coolant can be discharged as follows.

1. Make sure that engine and radiator are cooled.
2. Open the radiator cap.

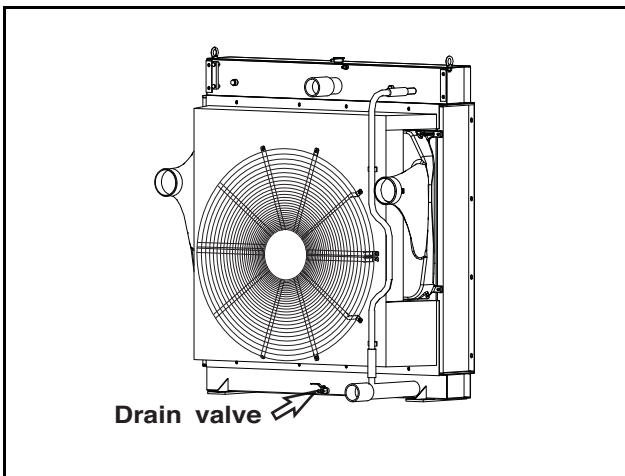
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#### **⚠ DANGER**

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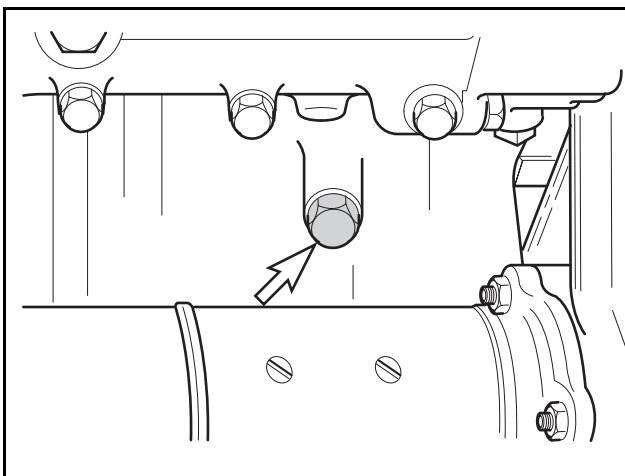
- **Never open the radiator cap while the engine is overheated. If the radiator cap is opened while the engine is overheated, hot water will spurt out and may cause serious burns. Open the radiator cap after ensuring that the engine has been cooled sufficiently.**
- **Mark and separately manage the containers for storing coolant from beverage containers to avoid confusion. If coolant is ingested, see a doctor immediately.**

3. Loosen the drain valve which is located under the radiator to discharge the coolant.



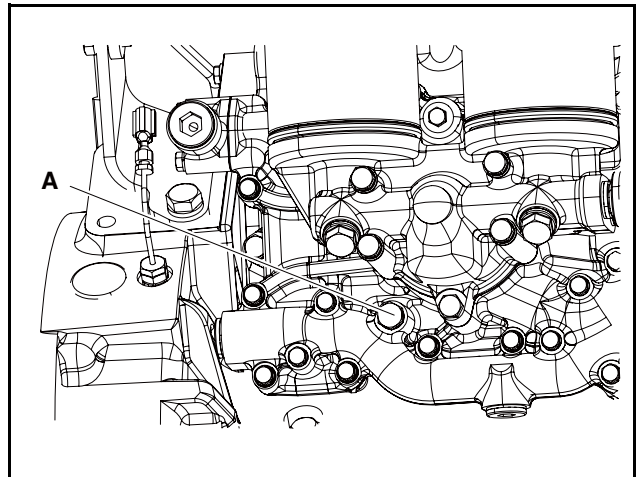
DV2213011A\_E

4. Disassemble the coolant discharge plug of the cylinder block, and discharge it to a container.



DV2213012A

5. Drain cooling water in the oil cooler.



DV2213167A

- 1) Loosen the drain plug(A) of the oil cooler cover and then drain cooling water.

### Charging the Coolant

1. Make sure that engine is coolant.
2. Open the radiator cap.

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#### **⚠ DANGER**

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- **Never open the radiator cap while the engine is overheated. If the radiator cap is opened while the engine is overheated, hot water will spurt out and may cause serious burns. Open the radiator cap after ensuring that the engine has been cooled sufficiently.**
- **Mark and separately manage the containers for storing coolant from beverage containers to avoid confusion. If coolant is ingested, see a doctor immediately.**

3. Put in the coolant slowly.

---

#### **⚠ CAUTION**

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**Be careful not to let foreign substances flow into the engine when replenishing coolant.**

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4. Be sure that the air is gone out from cooling system.

## 4. Regular inspection

5. After checking the coolant level when the engine is warmed up, replenish coolant if necessary.

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### DANGER

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**If the engine is hot, wrap the coolant pressure cap with a cloth upon opening it so that the steam may be discharged. This can prevent you from burning by the hot steam coming out of the cap inlet.**

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### CAUTION

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- Do not mix antifreezes from different manufacturers.
  - Do not mix the coolant with different concentrations.
  - Do not add antirust which is not recommended by us.
  - As insufficient coolant concentration may cause corrosion or freezing, on the other hand, an excessive concentration may degrade the cooling performance. Mix coolant with 40% antifreeze and 3~5% additives (DCA4) to prevent corrosion.
- 

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### WARNING

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**Discard exchanged coolant according to the regulations set forth by the relevant authorities. Disposing of exchanged coolant into the ground, sewers, drains, rivers, or the sea will cause serious environmental pollution. Violation of regulations regarding discard of coolant without observing the handling regulations, will be punished.**

---

### Cleaning the cooling circuit

If the internal coolant circuit is contaminated by corrosion or foreign substance, the cooling effect is reduced. The resistance in the coolant circuit may damage the mechanical seal of the coolant pump.

The negative impact on the cooling circuit may be caused by use of improper antifreeze or corrosion inhibitor, or by use of coolant without such ingredients. If the coolant pump leaks or the coolant is severely contaminated within short period of time (6 months) after start of using the operation (e.g., the coolant color becomes muddy - probably brown, gray or black depending on the degree of contamination), before removing the coolant pump, clean the cooling system in the following way.

1. Discharge the coolant.

2. If you want to clean the cooling circuit swiftly, remove the thermostat.
  3. Mix water and 1.5% of cleaning solution and fill the cooling circuit with this liquid.
  4. Load the engine. When the coolant temperature reaches 60°C, run the engine for about 15 minutes.
  5. Discharge the cleansing solution.
  6. Repeat the step 3 and 4 above.
  7. Fill the cooling circuit with hot water.
  8. While running the engine at idle speed for 30 minutes, check if there is any leakage in the drain plug and coolant line. If the coolant is insufficient, replenish it.
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### CAUTION

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**Clean the cooling circuit regularly with cleansing solution.**

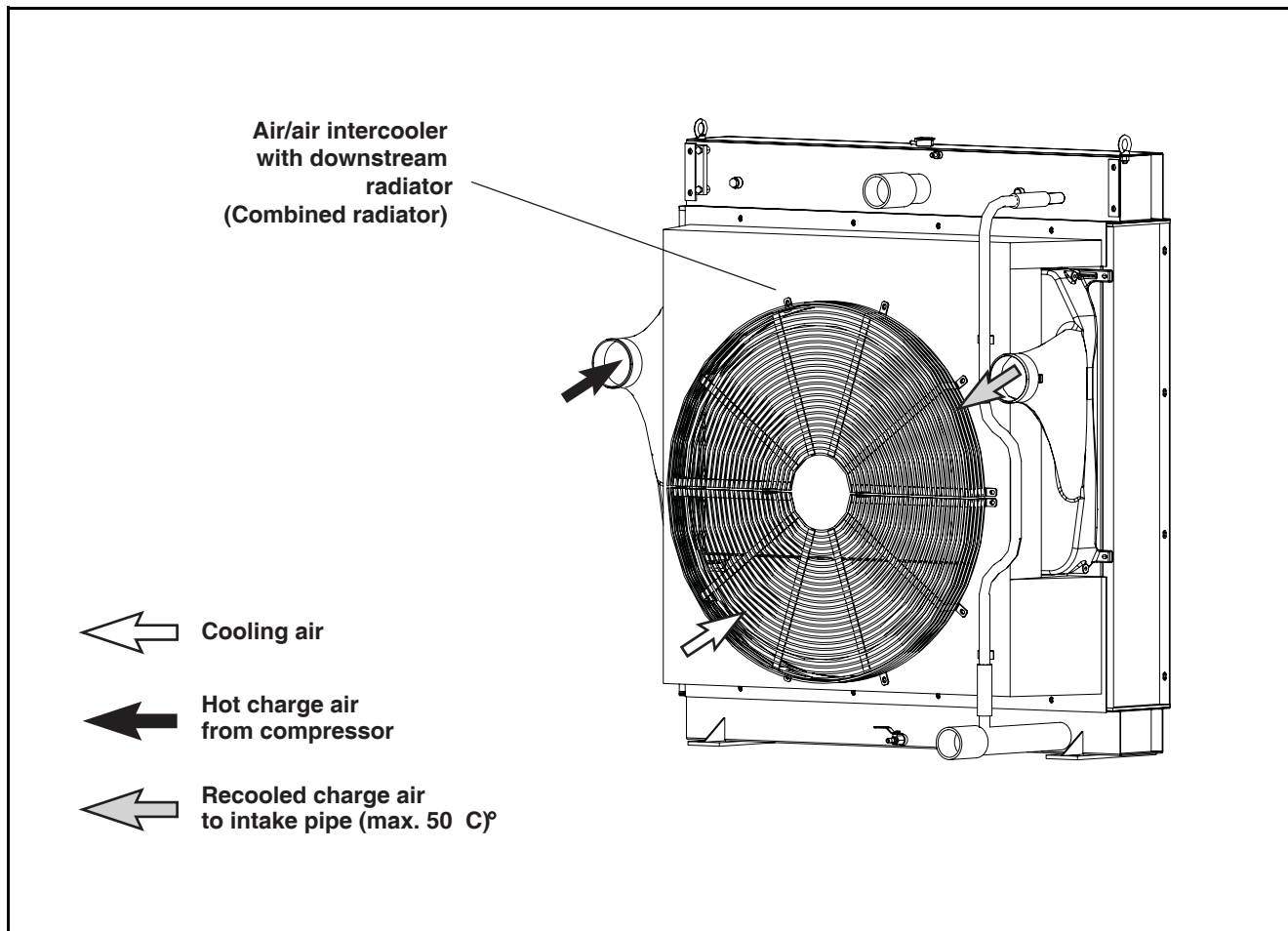
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### Inter cooler

The air cooler adopts an air cooling fan, which has sufficient cooling capacity. The life and performance of an air cooler greatly depends on the intake air conditions. Dirty air may contaminate and clog the cooling pins. This results in reduced engine power or engine failure. So, always check the intake system for air leak, damage or contamination of air filter.

## 4. Regular inspection

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DV2213205B

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### CAUTION

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To keep the optimum performance of the air cooler, clean it regularly.

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### Lubrication system

#### General Information

Engine oil lubricates, cools, seals, prevents corrosion, and cleans engines, enhancing engine performance and extending the engine's lifetime. If a vehicle is continuously driven while engine oil is insufficient, the moving parts of the engine may get stuck, causing engine faults.

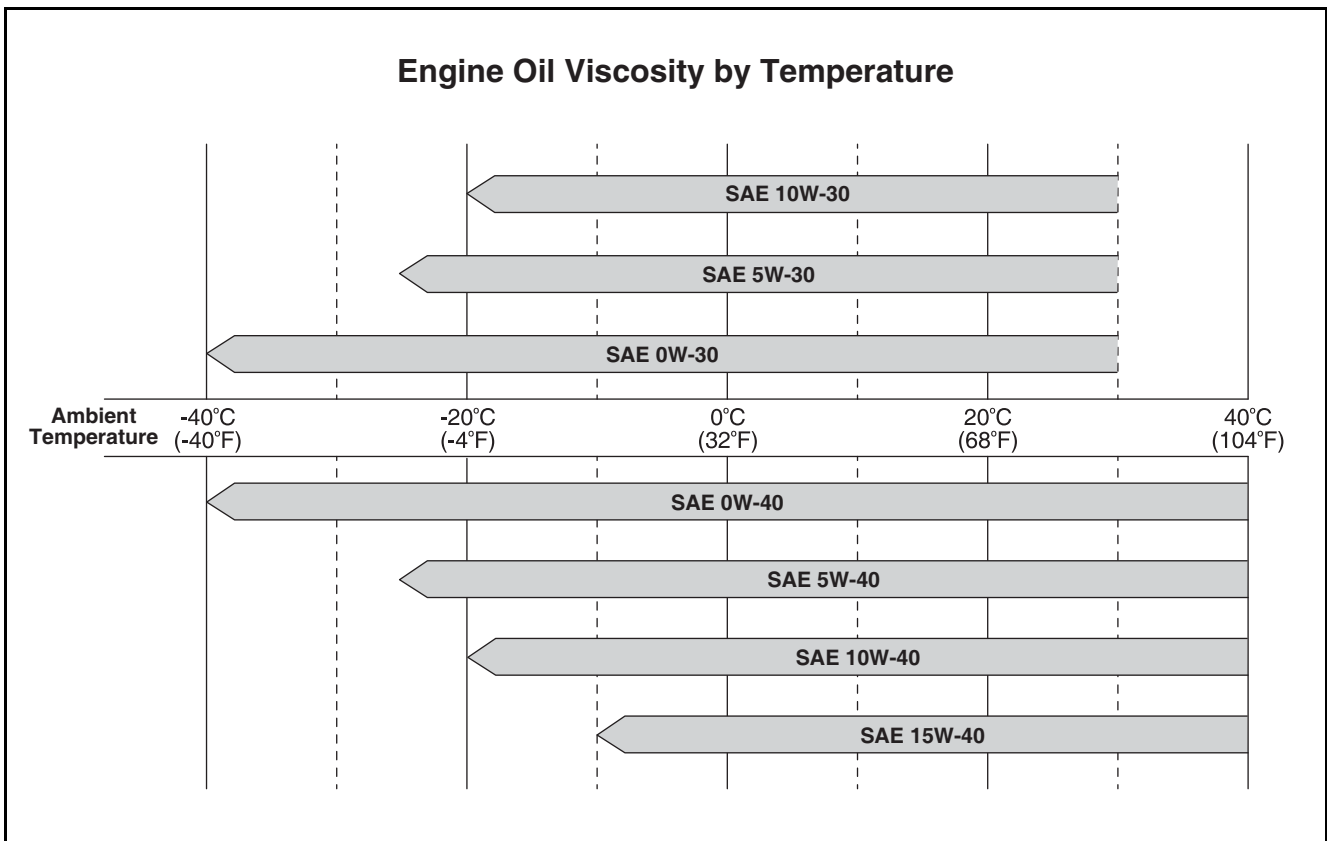
Engine oil should be checked through the oil level gauge and replenished if required. Oil level should be checked while the engine is stopped. To check the oil level,

turn off the engine while it is running and wait for 5 ~10 minutes to allow the engine oil to flow back into the oil pan. The engine oil level should indicate between the upper limit and the lower limit of the oil level gauge.

Engine oil should be periodically replaced based on the regular inspection table and the oil filter and the cartridge should be replaced as the engine oil is replaced.

#### Engine oil standards

Use the specified engine oil suitable for the environment and conditions of the site where the engine will be used.



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Please use the engine oil which satisfies the following recommended specifications.

Engine Model and Product Code	SAE Classification	Oil Class
DP158L/DP180L/DP 222L	SAE 10W40	CI-4 or higher

Note) Use of HD Hyundai Infracore genuine engine oil is recommended.

## 4. Regular inspection

### Engine Oil Capacity

Please replenish the engine oil based on the following recommended oil amount.

Engine Model	Engine oil capacity ( ℓ )	
	Max.	Min.
DP 158L	22	13
DP 180L	34	23
DP 222L	40	27

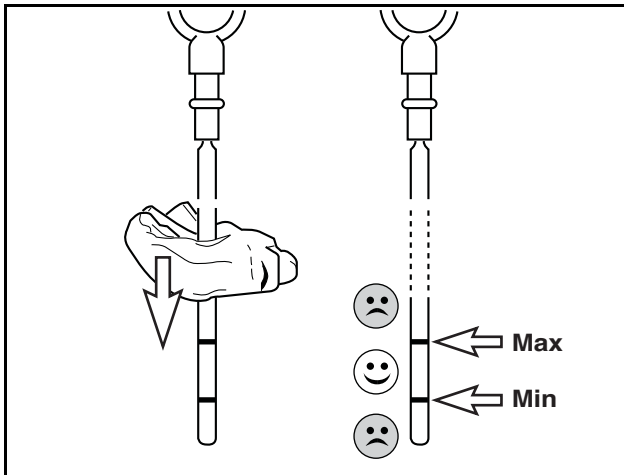
### Checking the Engine Oil

Check the oil level everyday using an oil level gauge.

1. The oil level should be checked when the engine is stopped and on an even level. If you started the engine, wait for 5~10 minutes to allow the engine oil to flow back into the oil pan.
2. Pull out the oil level gauge, and clean the indication line of the oil level gauge with clean cloth.

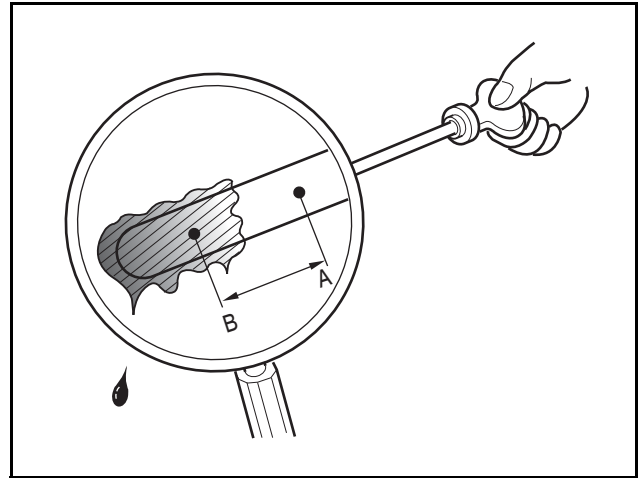
### CAUTION

Cleaning the indication line of the oil level gauge with dirty cloth allows the foreign substances to get into the engine, causing damage to the engine.



DV2213163A

3. Insert the oil level gauge, and then pull it out to check the engine oil level, viscosity, and contamination. Replenish or replace the engine oil if required.



DV2213016A

- 1) Check the oil level everyday using an oil level gauge.
- 2) Check if the oil is smeared between the upper limit (A) and the lower limit (B) of the oil level gauge.
- 3) If engine oil is smeared below the lower limit (B) or not smeared on the gauge at all, replenish engine oil.
- 4) Check condition of engine oil. If it is polluted, replace it with new oil.

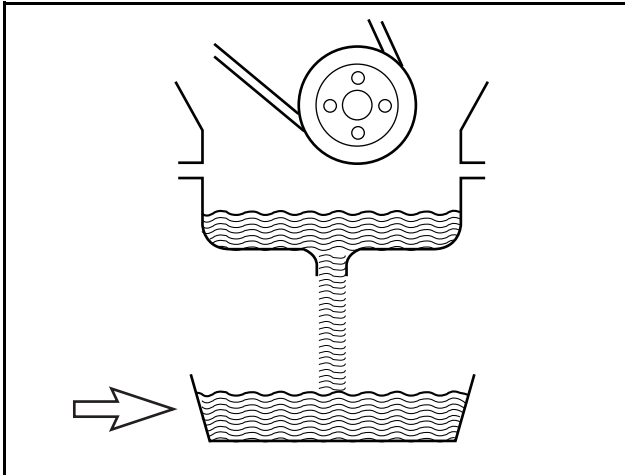
### CAUTION

- Do not fill the engine oil above the upper limit. Exceeding the upper limit may damage the engine.
- Be careful not to let foreign substances flow into the engine when replenishing engine oil.

### Replacement of Engine Oil

Check the oil level using an oil level gauge and replenish it if required. Replace the engine oil in the following steps when the engine is warm by running it.

1. Pull out the oil level gauge.
2. Open the drain plug of the oil pan to discharge the engine oil from the container.



DV2213017A

3. After discharging the engine oil, assemble the drain plug of the oil pan again.
4. Fill the engine oil into the cartridge of the oil filter.
5. Through the oil filler cap, fill the engine oil.
6. Idle the engine for several minutes so that the oil circulate through the lubrication system.
7. Then, stop the engine, wait for about 10 minutes, check the oil level, and fill the oil if required.

### DANGER

- Prolonged and repeated contact of skin with engine oil may lead to shrinking, dryness of skin and even cause dermatitis.
- Do not expose skin with exchanged engine oil for a long period.
- Always wear work clothes and gloves.
- When skin is stained with engine oil, immediately wash it with water, soap or hand cleaners.
- Do not clean skin with gasoline, fuel, thinner, or solvent.
- Apply a skin protective cream after cleaning from oil.
- Do not put oil-stained gloves or cloth in pockets.

### WARNING

Discard exchanged oil according to the regulations set forth by the relevant authorities. Disposing of discharged oil into the ground, sewers, drains, rivers, or the sea will cause serious environmental pollution. Violation of regulations regarding discard of engine oil without observing the handling regulations, will be punished.

### Replacement of Engine Filter

Check the oil pressure and leakage, and replace the oil filter if required. Whenever replacing the oil, the oil filter cartridge should be replaced with a new one.

1. Using an oil filter wrench, loosen the cartridge by turning it counterclockwise.
2. Wipe the oil filter head and cartridge contact thoroughly, and make sure that the oil filter cartridge is positioned properly.
3. Apply a little bit of oil to the o-ring area of the cartridge, assemble it until the O-ring surface may contact, and turn it 3/4 or 1 turn using a wrench to keep it air-tight.

### CAUTION

When replacing the oil filter cartridge, be sure to use the genuine part of HD Hyundai Infracore.

## 4. Regular inspection

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### Fuel system

#### General Information

The fuel injection pump and nozzle are composed of very sophisticated components with high precision. If fuel is mixed with foreign substance, it may clog the nozzle or the fuel injection pump components may be seized. So, be sure to keep the fuel system clean all the time.

---

#### CAUTION

- **Use clean, certified and qualified fuel only. Using irregular or unspecified fuel may cause critical damage and faults to the engine.**
  - **Replenish fuel while the engine is stopped.**
- 

#### Fuel Standards

The quality of fuel is very important to satisfy the engine performance, extension of engine life and the allowable exhaust gas level. HD Hyundai Infracore engine is designed to use diesel fuel available in the local market. If you want the optimum engine performance, select the proper fuel referring to the fuel selection table below.

## 4. Regular inspection

- Low Sulfur Diesel

Property	ASTM D975 2GRADE		EN 590:2013	
Flash point, min	No 2D 52°C	D923	55°C	EN2719
Water & sediment, max.	0.05% vol.	D2709		
Water, max.			200 mg/kg	EN ISO 12937
Total contamination, max.			24 mg/kg	EN 12662
Distillation temperature (% vol recovered)	90%	D86	65%: 250°C	EN ISO 3405
	2D 282-338°C		85%: 350°C	
Kinematic viscosity (at 40°C)	2D 1.9-4.1 mm <sup>2</sup> /s	D445	2.0-4.5 mm <sup>2</sup> /s	EN ISO 3104
Density (at 15°C)			820-845 kg/m <sup>3</sup>	EN ISO 3675
				EN ISO 12185
Ester content	5% vol. max.	EN14078	7% vol. max. FAME	EN 14078
Ash, max.	0.01% wt	D482	0.01% wt	EN ISO 6245
Sulfur, max. (by mass)	2D	D5453 D2622 D129 <sup>2</sup>	10	EN ISO 20846
	S15 15 mg/kg			EN ISO 20884
	S500 0.50%			EN ISO 13032
	S5000 0.50%			
Copper strip corrosion, max.	No 3	D130	Class 1	EN ISO 2160
Cetane number, min.	40	D613	51	EN ISO 5165
Cetane index, min.			46	EN ISO 4264
- Cetane index	40 min.	D976-80		
- Aromaticity	35% vol. max.	D1319		
PAH, max.			11% wet	EN 12916
Operability, one of:	Report	D2500 D4539 D6371		
- Cloud point				
- LTFT/CFPP				
Cloud point			Location & season dependant	EN 23015
CFPP			Location & season dependant	EN 116
Carbon residue on 10% distillation residue, max.		D524	0.30% wt	EN ISO 10370
	2D: 0.35% wt			
Oxidation stability, max.			25 g/m <sup>3</sup>	EN ISO 12205
Lubricity (at 60°C), max.	520 μm	D6079 D7688	460 μm	ISO 12156-1
Conductivity, min.	25 pS/m	D2624 D4308		

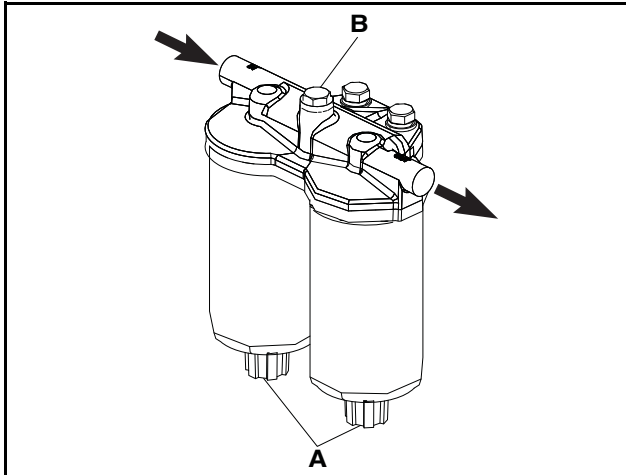
Note) If the sulfur content of the fuel is more than 0.5%, the replacement and inspection cycle should be cut in half.

## 4. Regular inspection

### Water draining from fuel filter

An oil filter has two functions: oil filtering and water separation.

1. the water separation function of the fuel filter discharges water and sediment from the water separator.
2. Stop the engine, and loosen the drain plug for water separation manually.



DV2213164B

3. Turn the drain plug (A) for water separation counterclockwise 2~3times until water is drained. Drain the water in the cartridge until fuel is discharged.
4. Tighten the drain plug for water separation by turning it clockwise.

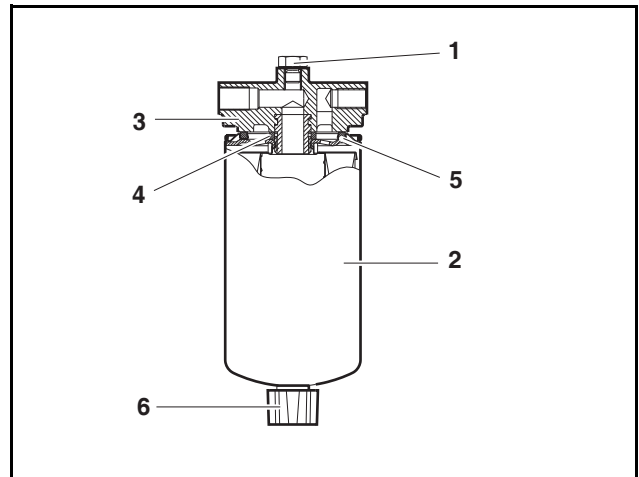
### **⚠ DANGER**

**Fuel may be drained when water is drained from the fuel filter. Fuel is highly inflammable. Fire may occur when you use fire near the engine when draining water from the fuel filter.**

### **⚠ CAUTION**

- Do not tighten the plug excessively because it may damage the screw.
- If you do not check the fuel filter regularly and drain the water in the fuel filter, water flows into the fuel system of the engine, causing serious failure in the fuel system, etc., and decrease in or damage to the fuel filter performance. Inflow of water to the fuel system may stop the engine.
- Use clean, specified, and qualified fuel only. using irregular or unspecified fuel may result in more water in the fuel filter.

### Replacing fuel filter



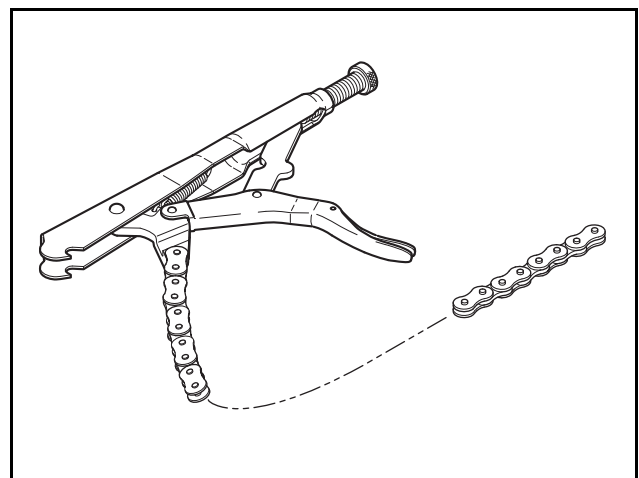
DV2213019A

1. Clean the area around the fuel filter head(3).
2. Disassemble the cartridge(2) by turning it counterclockwise with a fuel filter wrench.

### **⚠ CAUTION**

**Do not reuse the cartridge; replace them with new ones.**

3. Remove the fuel filter screw adapter seal ring(4).
4. Clean the gasket contact of the fuel filter head(3).
5. Check the position of the new cartridge adapter seal ring(4).
6. Apply thin coat of clean oil to the O-ring(5) area of the cartridge, and fill the cartridge with fuel.
7. Assemble the cartridge to the fuel filter head.
8. Tighten the cartridge with hand until the O-ring contacts the fuel filter head surface.
9. Turn it by 3/4 to 1 turn with a fuel filter wrench.



DV2213020A

## 4. Regular inspection

### CAUTION

If you tighten the cartridge excessively, the screw may be distorted or O-ring damaged.

### Preventing fuel contamination

Most of the fuel contaminations encountered while using the alternator engine are caused by water and propagation of microbes.

Usually, the contamination results from improper handling of fuel. Propagation of microbes requires water contained in the fuel. To prevent propagation of microbes, you have to keep the water to the minimum level possible in the storage tank.

### Fuel injection pump

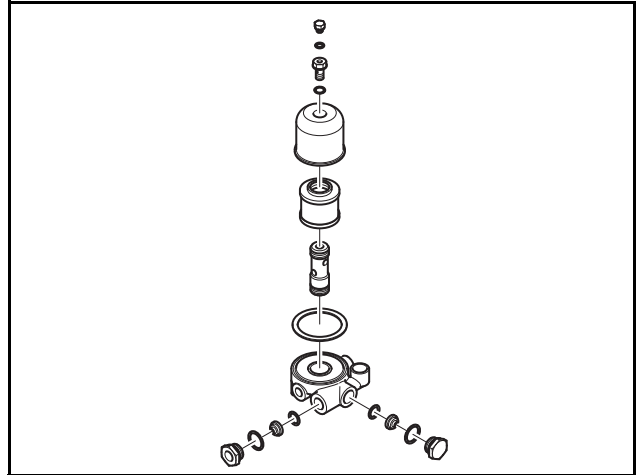
- Check the fuel injection pump housing, and replace it if crack or damage is found.
- Check if the idle operation and speed control lever's sealing device was not removed.
- Check if the idling or speed control lever's sealing line is not damaged.
- You should not modify the fuel injection pump if the sealing line is damaged, such engine cannot receive compensation.
- If the fuel injection pump is found abnormal, authorized personnel should handle it.
- The adjustment and test of the fuel injection pump must be conducted using a tester.

### CAUTION

If you separate the parts where the seal ring (copper seal ring, rubber coating seal ring, etc.) is assembled, you should replace the seal ring with a new one. Otherwise, leakage may occur in the fuel filter connections, preventing normal functioning.

### Cleaning the fuel pre-filter

The fuel pre-filter should be cleaned periodically through disassembly. The fuel pre-filter is mounted individually for easy maintenance. Open the cover of the pre-filter and clean the element with compressed air first, and then rinse it with diesel fuel to remove foreign substances.

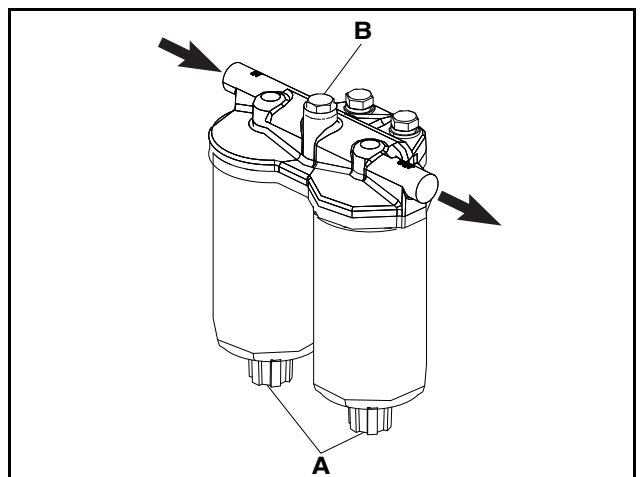


DV2213021C

### Air bleeding in the fuel circuit

When the engine stops due to replacement of fuel filter, fuel injection pump or insufficient fuel, you should perform air bleeding.

1. Loosen the air bleeding plug (B) on the fuel filter.
2. Operate the priming pump by hand to bleed air inside the fuel circuit.
3. Operate the priming pump until the air is discharged completely through visual checking.



DV2213164B

### DANGER

Fuel is highly inflammable. Fire may occur when you use fire near the engine when air bleeding in the fuel circuit from the priming pump.

## 4. Regular inspection

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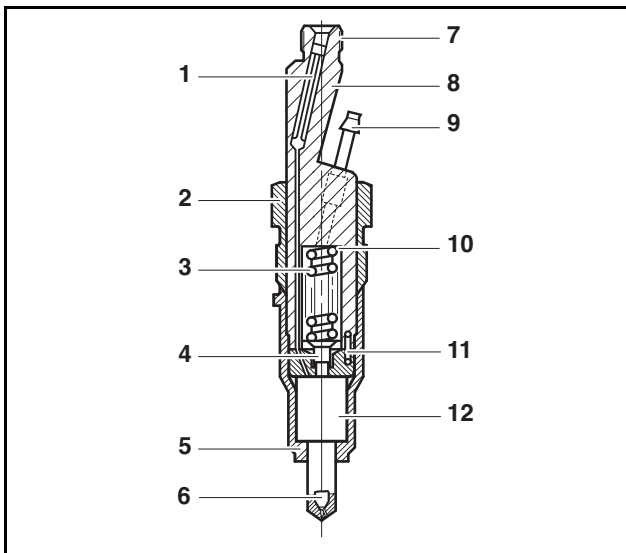
### CAUTION

If you separate the parts where the seal ring (copper seal ring, rubber coating seal ring, etc.) is assembled, you should replace the seal ring with a new one. otherwise, leakage may occur in the fuel filter connections, preventing normal functioning.

---

### Injector maintenance

- The injectors are designed to spray the fuel delivered by the injection pump directly into the spherical combustion chamber in the piston crown.
- The injector consists of the nozzle and the nozzle holder.
- A copper gasket fitted to the injector ensures gas-tight seating and good heat dissipation.
- The opening pressure of the nozzle is adjusted by means of shims at the compression spring.



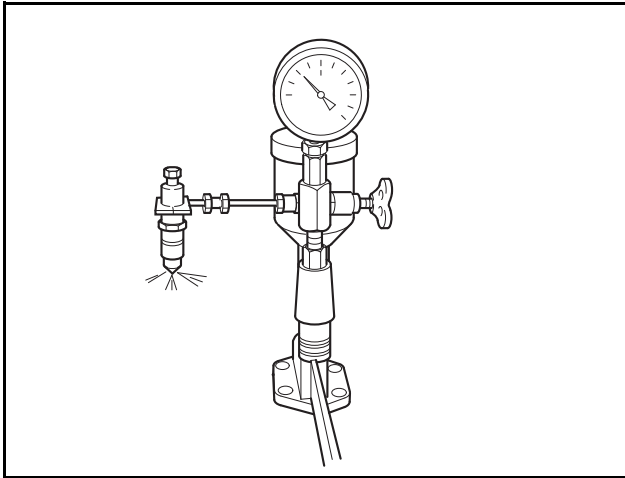
DV2213022A

- |                             |                                   |
|-----------------------------|-----------------------------------|
| 1. Rod type filter          | 7. Connect hole for fuel delivery |
| 2. Cap nut                  | 8. Nozzle holder                  |
| 3. Compression spring       | 9. Connect tube for overflow      |
| 4. Compression pin          | 10. Shim                          |
| 5. Cap nut for fixed nozzle | 11. Pin                           |
| 6. Nozzle                   | 12. Nozzle bush                   |

## 4. Regular inspection

### Fuel injection nozzle

1. Install a nozzle to the nozzle tester.

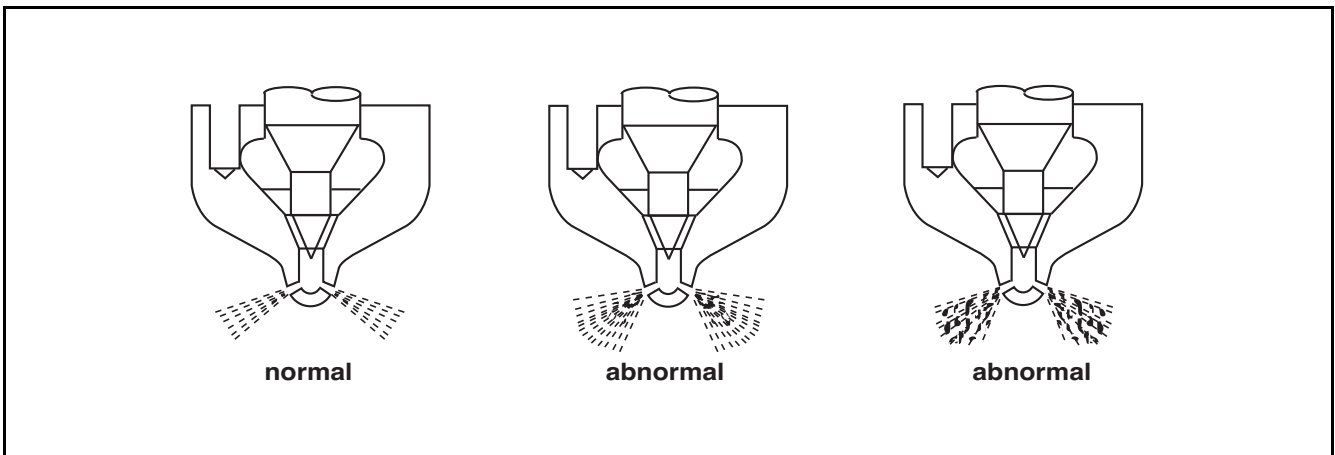


DV2213023A

2. Check the fuel injection pressure. If the pressure does not satisfy the reference value, adjust the injection pressure of the nozzle using an adjustment shim.
3. Check the nozzle spray status. If it is defective, replace the nozzle.

### **⚠ CAUTION**

- As the nozzle injection nozzle is designed to operate under high pressure, you should handle it with special care.
- Do not hold your hands under the fuel jet, as there is a rise of injury. Do not inhale the atomized oil fuel. If possible, work under an extraction system.



DV2213165A

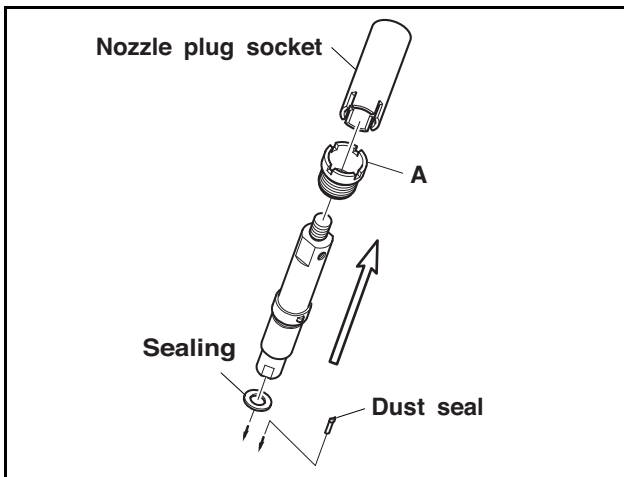
Engine Model		Nozzle injection pressure (Mpa)
DP158L	DP158LCS	28
	DP158LCF	28
	DP158LDS	28
	DP158LDF	28
DP180L	DP180LBS	28
	DP180LBF	28
	DP180LAS	28
	DP180LAF	28

Engine Model		Nozzle injection pressure (Mpa)
DP222L	DP222LAS	28
	DP222LBS	28
	DP222LBF	28
	DP222LCS	28
	DP222LCF	28

## 4. Regular inspection

### Removal of nozzle

1. Remove fuel injection pipe between nozzle holder and injection pump.
2. Remove fuel return pipe.
3. Loosen the Union screw(A) of nozzle holder with Nozzle plug socket (EI.03004-0225)
4. Remove nozzle holder with sealing from the cylinder head.



DV2213166B

### Installation nozzle

1. Clean seat in cylinder head.
2. Insert nozzle holder with new gasket.
3. Tighten union nut.

Torque	7 kgf·m
--------	---------

4. Install injection lines free of constraint. Install leak fuel lines, screw delivery pipe at nozzle holder and at the injection pump.

### Note for cleaning nozzle

- Clean nozzle body externally from soot and carbon. When cleaning several nozzles at the same time, make sure nozzle bodies and needles are not mixed up. Visually inspect needle and body.
- Cleaning is useless if the seat of the needle is indented or the pintle is damaged and the nozzle should be replaced.
- Clean annular groove with scraper over full circumference. Wash out dislodged carbon deposits and dirt.
- Scrape needle seat with cleaning cutter, Dip cutter in test oil before use. The cutter can also be clamped in a lathe.
- Polish needle seat with wooden cleaning tool, preferably by chucking the needle in a lathe at the pintle end.
- Clean the spray holes of nozzles by chucking a cleaning needle of suitable diameter in the collect. If the carbon deposits in the spray holes cannot be removed by rotating and pressing, have the needle project only slightly from the collect and drive out the carbon by lightly tapping on the tool.
- Before reassembly thoroughly wash nozzle body and needle in clean test oil.
- Hold the needle at the pintle end only ; to avoid corrosion do not touch the lapped surfaces of the needle with your fingers.
- Thoroughly clean all other parts of the nozzle holder with clean fuel.
- Check nozzle discharge pressure in nozzle tester. The edge-type filter should not be pressed into the nozzle holder by more than about 5 mm. If this depth is exceeded the injector must be replaced.

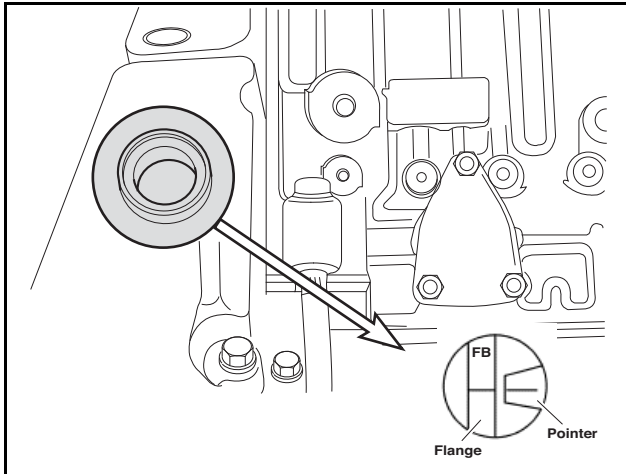
## ⚠ CAUTION

- The injection lines are designed for high operating pressure and should thus be handled with particular care.
- When mounting the pipes to the engine take care of good fitness.
- Do not bend pipes to permanent deformation. (not for replacing the nozzles either)
- Do not mount any heavily bent pipes.
- Avoid bending the pipes at the ends by more than 2 to 3 degrees.
- In case of faults in the injection system which might have resulted in excessive operating pressures, not only the failed part but also the injection line has to be replaced.

## 4. Regular inspection

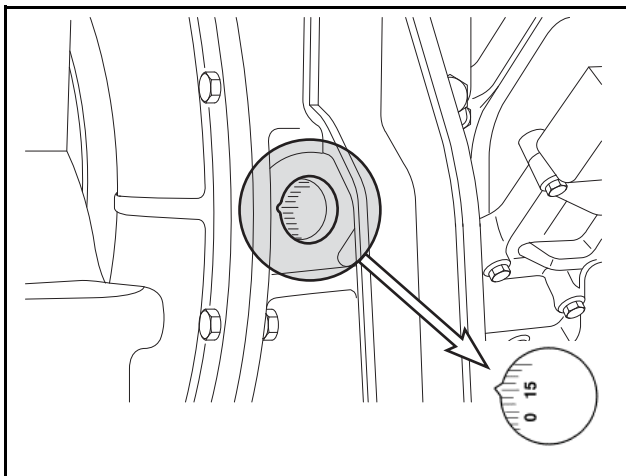
### Checking the injection timing

1. Remove the plug screw on the flywheel housing cover.  
Note) Some cases are needed to remove cover assembly.
2. Turn the crank pulley so that the mark on pointer provided on injection pump coincides with matching mark(FB) on the flange surface of the drive gear.



DV2213164A\_K

3. Check the injection timing degree whether the V-type edge of the flywheel housing sight hole coincides with the engine injection timing degree marked on the flywheel corresponding to fuel delivery position.



DV2213165A\_K

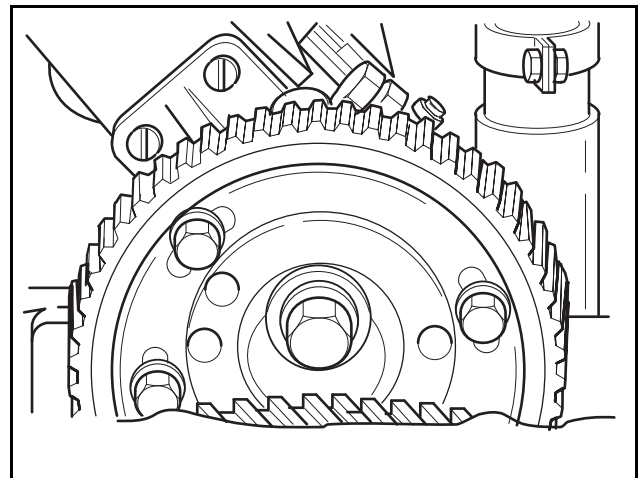
Engine Model		Injection Timing (°)
DP158L	DP158LCS	25° ±1°
	DP158LCF	20° ±1°
	DP158LDS	25° ±1°
	DP158LDF	20° ±1°

Engine Model		Injection Timing (°)
DP180L	DP180LBS	21° ±1°
	DP180LBF	19° ±1°
	DP180LAS	21° ±1°
	DP180LAF	19° ±1°
DP222L	DP222LAS	23° ±1°
	DP222LBS	23° ±1°
	DP222LBF	21° ±1°
	DP222LCS	23° ±1°
	DP222LCF	21° ±1°

### Adjusting injection timing

If upper pre-checked injection timing degree is wrong, follow as below.

1. Loosen the fixing bolts(M8) of the injection pump driving gear in order to adjust the injection timing slightly.



DV2213028A

2. Turn the crank pulley clockwise until V-groove of the flywheel housing sight hole is aligned with the injection timing degree of the engine.
3. Coincide the mark on pointer provided in injection pump with the matching mark(FB) on the flange surface of the drive gear by turning the flange in the oblong holes of the drive gear.
4. Tighten the bolt(M8) to specified torque, (2.2 kgf-m) not to move the drive gear.
5. After confirmation that fastening bolts are completely tightened check the start point (injection timing degree) of fuel delivery setting once more if not right repeat it again as same as upper way.

## 4. Regular inspection

### Intake/exhaust system

#### General Information

The air filter purifies dust and foreign substances included in the air and supplies clean air into the engine. The air filter is directly related to engine lifetime, emissions, and engine output. Please periodically check, clean, and replace the air filter.

#### CAUTION

- Do not operate the engine when the air filter is separated from the engine.
- Use specified air filters only. Using unauthorized or remanufactured air filters may result in critical faults.
- Foreign substances in the engine may cause abrasion inside the engine.
- Immediately exchange a damaged air filter with a new one.
- Be careful not to let foreign substances flow into engine or damage the air filter related electric apparatus when replacing an air filter.
- Be careful not let dust inside when assembling the air filter.

#### Air Filter

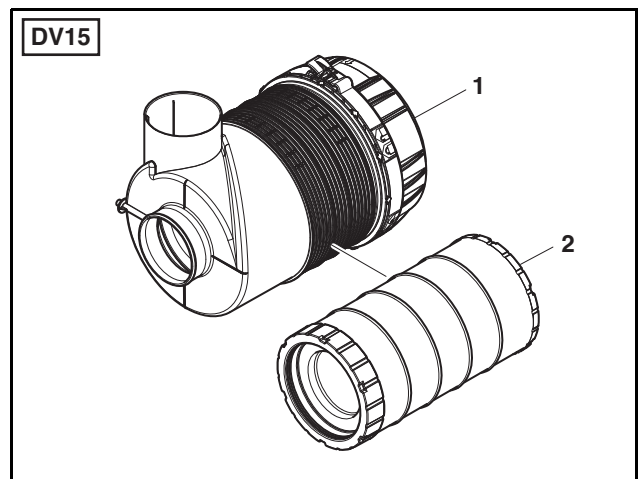
- Air cleaner is mounted on the engine to purify the air for combustion.
- The intervals at which the air cleaner requires servicing depend on the specific operating conditions encountered.
- Clogged air filters may cause black smoke and reduce power.
- A check should be made from time to time to see that the fastening elements securing the air cleaner to the intake manifold seal the connection tightly.
- Any ingress of unfiltered air is liable to cause a high rate of cylinder and piston wear.

#### Disassembly of air filter

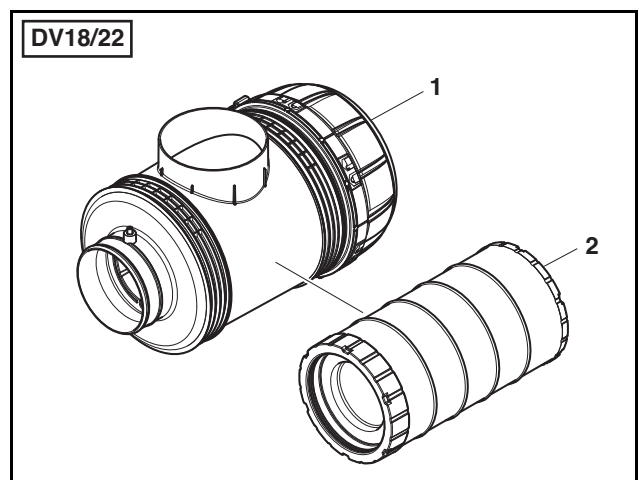
#### DANGER

Allowed only when the engine is stopped.

1. Empty the dust bucket periodically. The dust should not exceed the half of the dust bucket capacity.
2. You can disassemble the dust bucket by removing two clamps. Remove the dust bucket cover and empty the dust inside.
3. Assemble the cover and dust bucket accurately with care.
4. For easy alignment, the cover has dent and the dust collector has a protrusion. Here is the position where a filter is mounted horizontally, check the "TOP" mark on the air filter canister.



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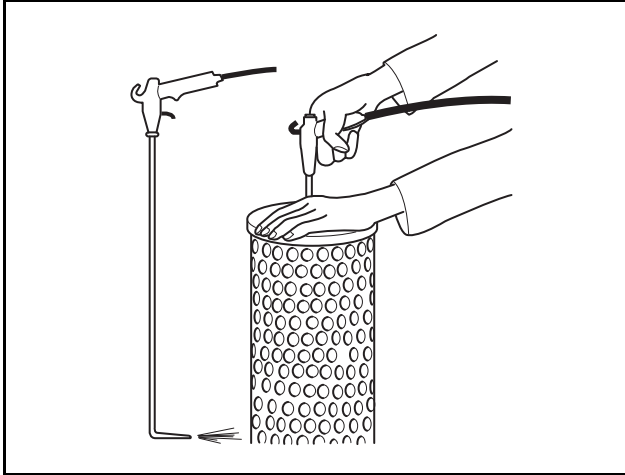
1. Air cleaner ass'y
2. Air cleaner element

## 4. Regular inspection

### Cleaning of the Air Filter Element

Clean the air filter element by using the most suitable method for your work environment among the three methods stated below.

1. Use compressed air to clean the air filter element.



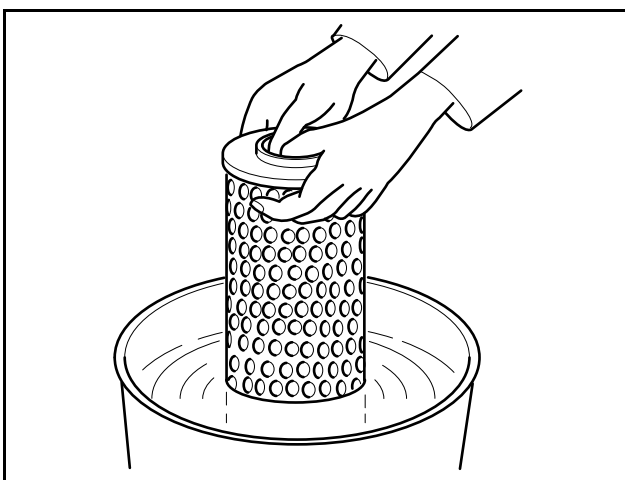
EDL022155A

- 1) To clean, let sufficient compressed air reach the inside bottom of the element at 90° direction with an air gun.
- 2) Move air gun up and down the element to blow air from inside to outside until no more dust is coming out from the element.
- 3) Do not use compressed air pressure exceeding 5 bars.

### **! DANGER**

**Always wear protective goggles before starting work. Otherwise, dust or foreign substances from the element may get in your eyes and cause injuries.**

2. Clean the element by washing it.



EDL022156A

- 1) Before washing the element, clean the element by using compressed air as described above.

- 2) Soak the element in the warm cleaning solvent for 10 minutes and then shake it back and forth for about 5 minutes.
- 3) Rinse the element with clean water, drain the water, and then dry it at room temperature. Fully dry the element before reassembling it to the engine.

### **! CAUTION**

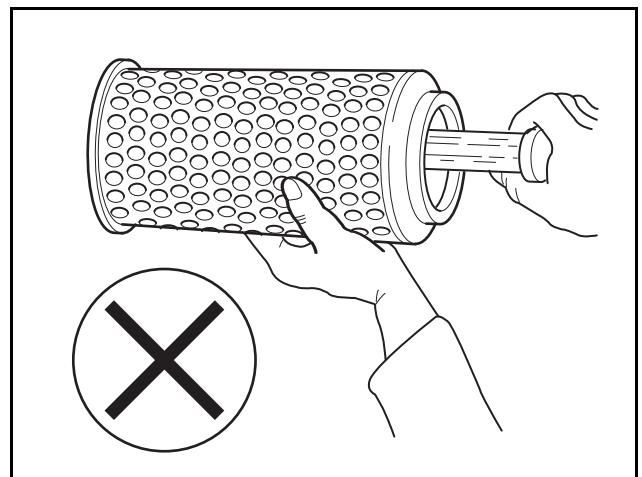
**Never use steam spray, gasoline, alkali or hot cleansing solution to cleansing the element.**

3. In an emergency, temporarily clean the element by using the following method.

- 1) Tap the end plate of the element with the thumb to clean it temporarily.

### **! CAUTION**

- **This method should only be used in an emergency when cleaning of element is necessary and no compressed air or cleansing solution is available.**
- **Under no circumstances should the surface of the element be hit or beaten with a hard object to shake the dust off.**



EDL022157A

Note) Before reassembling the element, make sure that the filter paper is not wrinkled, the state of rubber sealing is good, and there is no deformed part in the element.

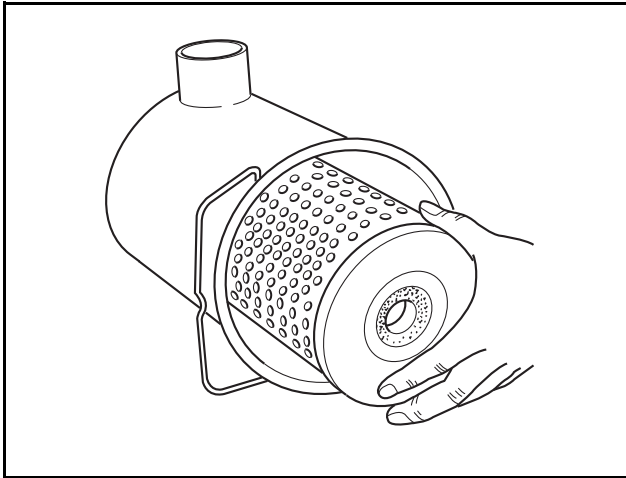
Note) Under any circumstances, do not reuse damaged elements. When in doubt, replace the element with a new one.

## 4. Regular inspection

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### Changing the air filter element

1. Remove the hex nut, remove the dirty element.



DV2213030A

2. Replace with a new one or wash it.
3. Using a wet rag, wipe the inside of the filter housing.
4. The sealing contact of element.

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### **! DANGER**

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**Do not let dust come into the end of air filter.**

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### Turbocharger

The Turbocharger does not need a specific maintenance. Whenever replacing the engine oil, check oil pipe for leakage or clogging.

- You should handle the air filter with special care to prevent foreign substance from getting in.
- The turbocharged compressed air and exhaust gas pipe should be checked periodically. Air leakage causes engine overheat, so repair is required.

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### **! CAUTION**

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**Be careful not to bend it.**

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- If the impeller is severely contaminated, soak only the wheel in a solvent and clean it with a rigid brush thoroughly. Here, be sure to soak only impeller, and the turbocharger should be supported by a bearing housing, not by an impeller.

### Routine check and serving the turbocharger

The turbocharger performance is determined by maintenance state of the engine. So you should regularly perform inspection and check as specified.

1. Intake system

For the intake system, the air filter should be carefully managed. For a wet type air filter, the intake resistance should be small as possible.

2. Exhaust system

For the exhaust system, when exhaust gas leaks from the exhaust pipe or turbocharger joint, supercharging efficiency is lowered. So you need to pay attention to prevent gas leakage and burn. Heat resistant nuts are used for parts which are highly heated during operation, such as the turbine seal, and the nuts should not be mixed with other nuts. The screw burn prevention paint should be applied to the assembly nuts of the specified positions.

3. Fuel system

If the spray status of the fuel injection nozzle is not good, or the injection timing is not correct, the exhaust gas temperature increases to give a negative impact on the turbocharger. So, the nozzle should be tested.

4. Lubrication system

For the lubrication system, pay attention with the oil quality and the replacement time of the cartridge of the oil filter. Degradation of engine oil has bad effect on the turbocharger, as well as the engine body.

### Disassembly and cleaning a turbocharger

You can disassemble the turbocharger from the engine to clean or inspect it. Here, be sure to seal the oil inlet and outlet with a tape, etc.

### Cylinder block/head

#### Valve Clearance

Adjust the valve clearance.

- When disassembling the engine or cylinder head.
- When there is excessive noise in the valve connection.
- When the engine runs abnormally even if the fuel injection system is normal.

#### Adjusting the Valve Clearance

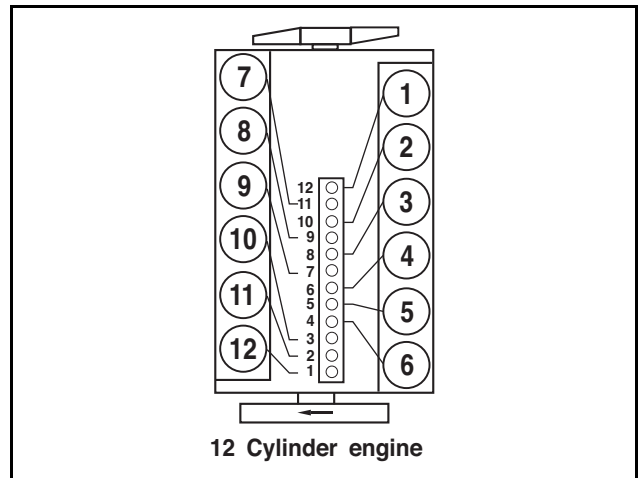
##### Method 1

- 1) Rotate the crankshaft so that #1. cylinder may be positioned at the compression TDC (Top Dead Center).

Note) #1. Cylinder is located at the side where cooling water pump was installed.

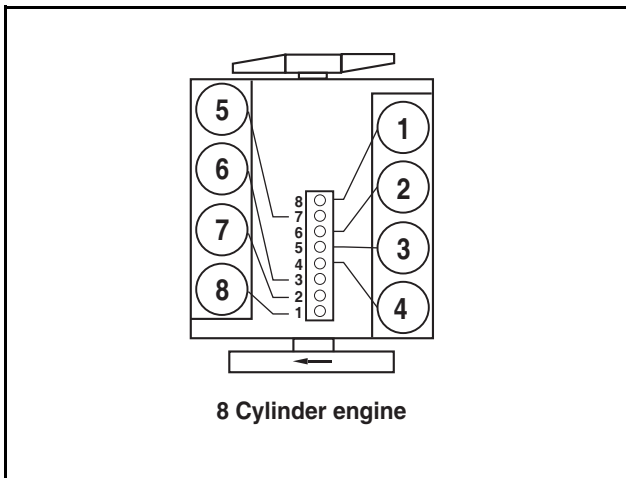
Note) In case of 8/12 cylinder engine, #6. cylinder is positioned at the valve overlap when #1. cylinder is positioned at the compression TDC (Top Dead Center).

Note) In case of 10 cylinder engine, #7. cylinder is positioned at the valve overlap when #1. cylinder is positioned at the compression TDC (Top Dead center).

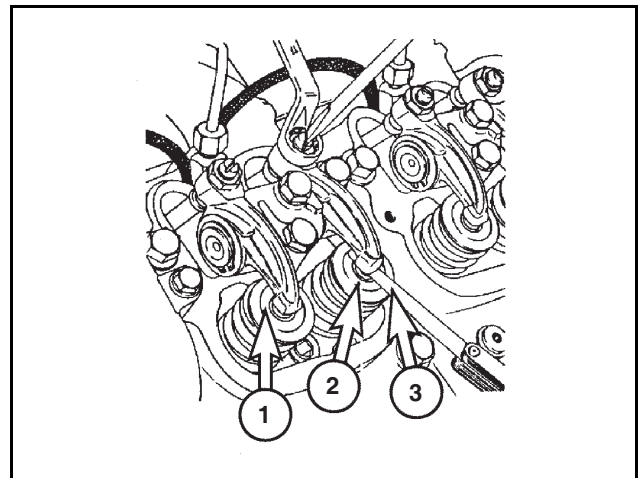


DV2213043A

- 2) Loosen the lock nut of the #1. cylinder rocker arm.
- 3) Push the feeler gauge between a rocker arm and a valve stem.
- 4) Adjust the clearance screw respectively and then tighten with the lock nut.



DV2213042A

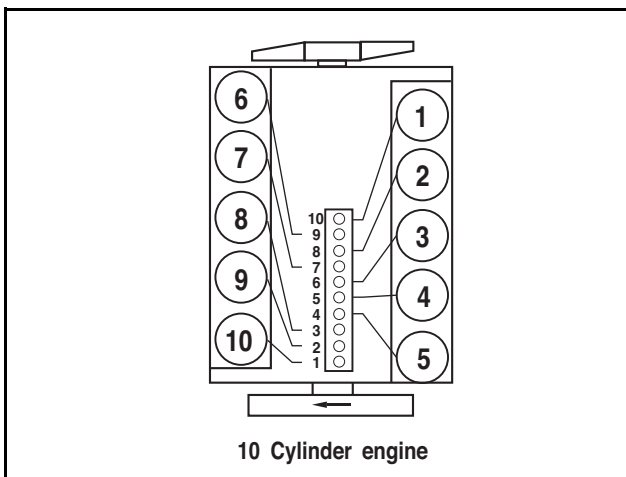


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- 5) As for the valve clearance, adjust it when in cold, as follows.

Specified value		Measurement tolerance	
In. valve	Ex. valve	In. valve	Ex. valve
0.25 mm	0.35 mm	±0.05 mm	

- 6) Rotate the crankshaft. When a cylinder reaches the compression TDC (Top Dead Center), adjust the valve clearance of the cylinder.
- 7) When a cylinder valve overlap, adjust the valve clearance cylinder of the compression TDC (Top Dead Center), as follow.



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## 4. Regular inspection

- 8 cylinder engine(DP158L)

Valve overlap cylinder No.							
1	5	7	2	6	3	4	8
6	3	4	8	1	5	7	2
Adjusting valve cylinder No. (In./Ex. Valve)							

- 10 cylinder engine(DP180L)

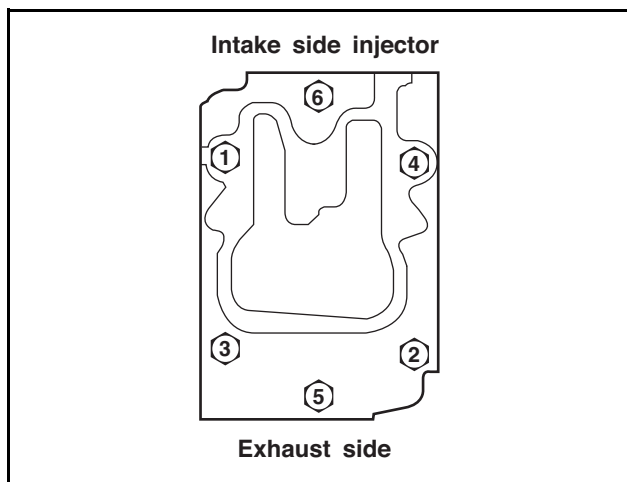
Valve overlap cylinder No.									
1	6	5	10	2	7	3	8	4	9
7	3	8	4	9	1	6	5	10	2
Adjusting valve cylinder No. (In./Ex. Valve)									

- 12 cylinder engine(DP222L)

Valve overlap cylinder No.											
1	12	5	8	3	10	6	7	2	11	4	9
6	7	2	11	4	9	1	12	5	8	3	10
Adjusting valve cylinder No. (In./Ex. Valve)											

### Tightening Cylinder Head Bolt

- Tightening cylinder head bolts after a repair. (Engine cold)



DV2213045A\_E

- Tighten temporarily 1~2 threads by hands.
- 1st step: Tighten to about 8kgf•m with a wrench.
- 2nd step: Tighten to about 15kgf•m with a wrench.
- 3rd step: Rotate 90° with a wrench.

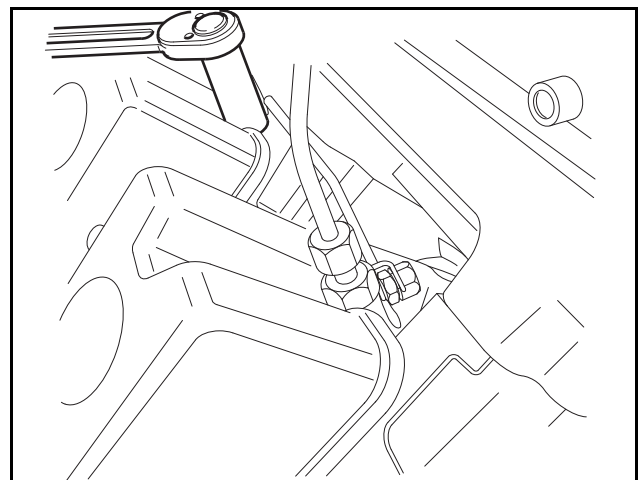
- Final step: Rotate 90° with a wrench.

## ⚠ CAUTION

- If excessive torque may damage the cylinder head gasket, cylinder liner flange and cylinder head bolt, so keep the specified torque.
- When tightening cylinder head bolts after a repair must always adjust the valve clearance.
- When a cylinder head has been removed the cylinder head gasket must always be changed.

### Cylinder Compression Pressure

- Start and warm up the engine.
- Stop the engine and disassemble the fuel injection nozzle holder assembly.
- Install a special tool, compression pressure gauge adapter (EU.2-0532), in the fuel injection nozzle holder hole.



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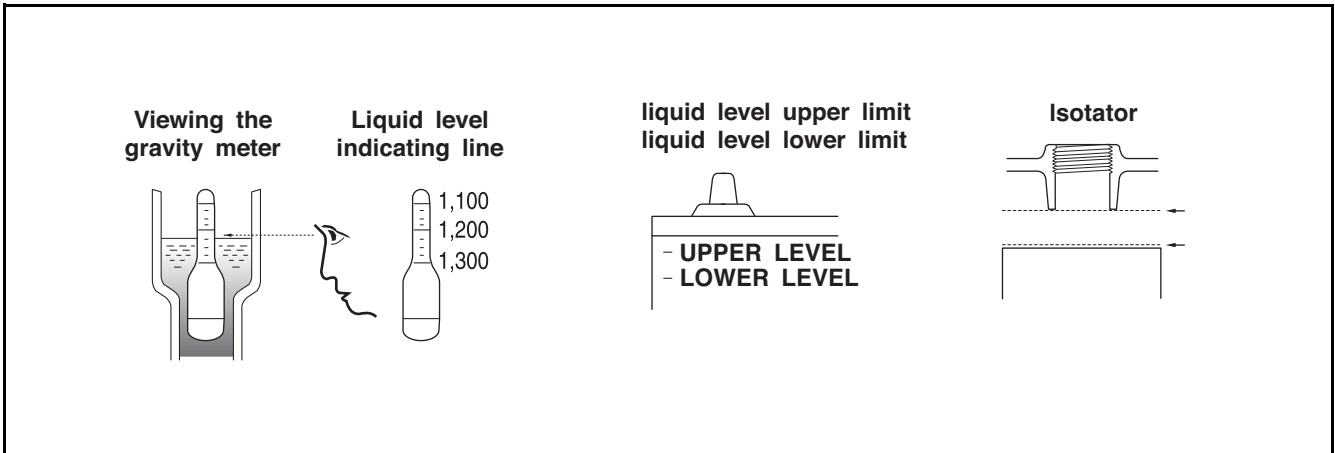
- Connect the compression pressure gauge to the adapter.

Standard	Above 28kg/cm <sup>2</sup>
Tolerance limit	24kg/cm <sup>2</sup>
Difference between each cylinder	Within ±10%

### Electric system

#### Battery

- Check for the electrolyte leakage by crack in the battery, and replace the battery if defective.
- Check the amount of electrolyte, and replenish distilled water if insufficient.
- Check the specific gravity of electrolyte. If it is below the specified value (1.12 ~ 1.28), replenish it.



DV2213040A\_E

#### Starter

When servicing the engine, immerse the starter motor's pinion gear and ring gear in the fuel, wash them completely, and apply grease again. When you clean the surrounding of engine, be careful so that water may not enter the starter.

### CAUTION

- **Starter should be protected from humidity all the time.**
- **Before working on the electric system, be sure to disconnect the ground wire ("-" minus wire) of the battery. Short circuit may occur while working on the electrical system. Connect the ground wire last after completing all of work.**

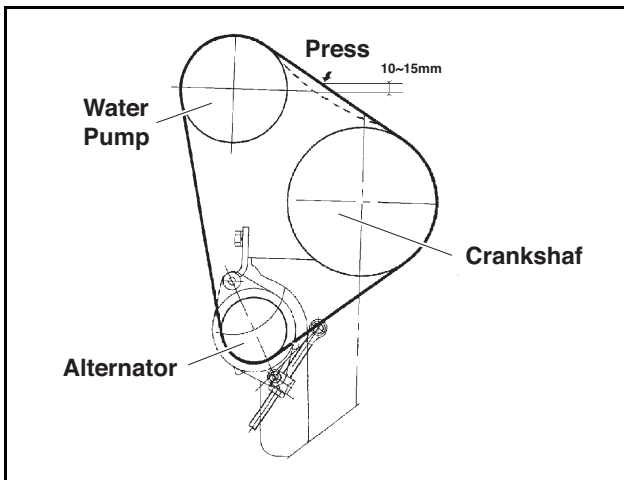
## 4. Regular inspection

### Others/driving system

#### V-Belt

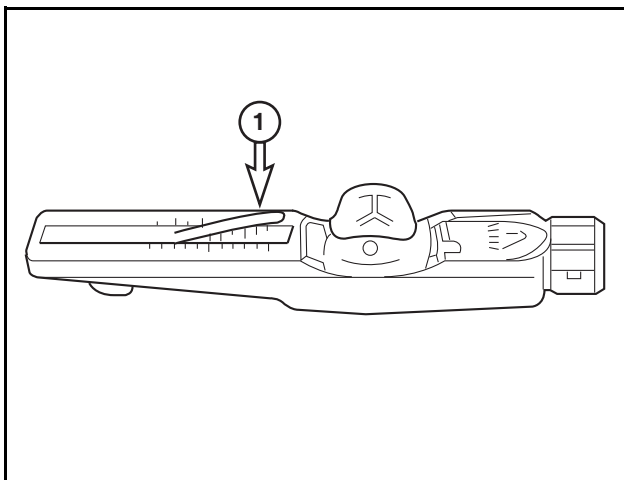
The tension of the V-belts should be checked daily .

1. Change the V-belts if necessary
  - 1) If in the case of a multiple V-belt drive, wear or differing tensions are found, always replace the complete set of V-belts.
2. Checking condition
  - 1) Check V-belts for cracks, oil, overheating and wear.
3. Testing by hand



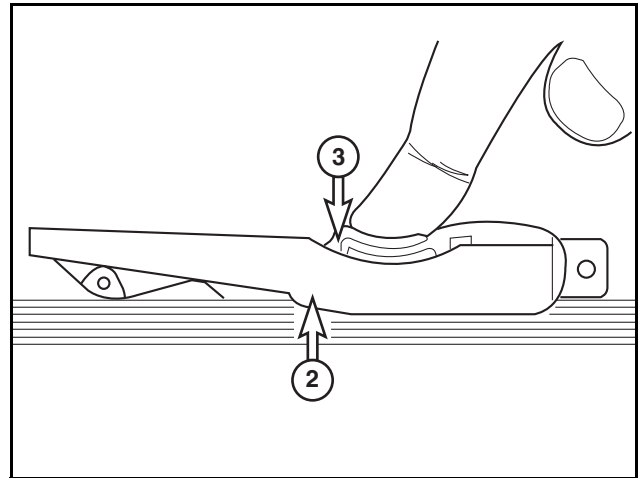
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- 1) For the V-belt tension, when you press the center between pulleys, if it is pressed by 10~15 mm, it is normal.
- 2) To check the tension of V-belt more accurately, you can use a V-belt tension gauge.
4. Tension measurement
  - 1) Lower indicator arm (1) into the scale.



DV2213048A

- 2) Apply tester to belt at a point midway between two pulleys so that edge of contact surface (2) is flush with the V-belt.



DV2213049A

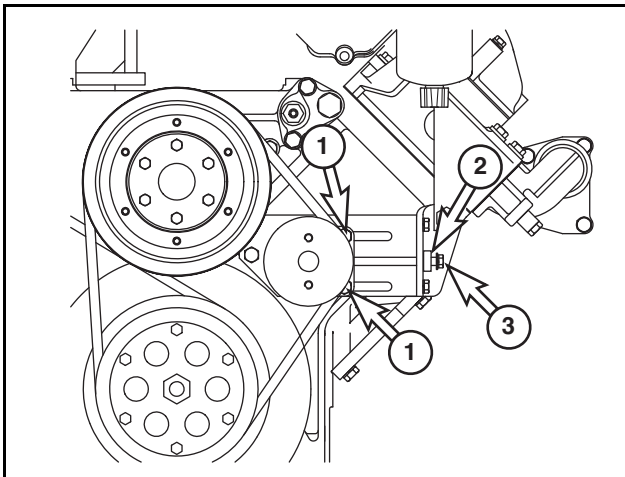
- 3) Slowly depress pad (3) until the spring can be heard to disengage. This will cause the indicator (1) to move upwards.
 

Note) If pressure is maintained after the spring has disengaged a false reading will be obtained.
- 4) Read the tension value at the point that the top surface of indicator arm(1) intersects with the scale.
- 5) Before taking readings makes ensure that the indicator arm remains in its position.
 

Note) If the value measured devotes from the setting value specified, the V-belt tension must be corrected according to the following table.

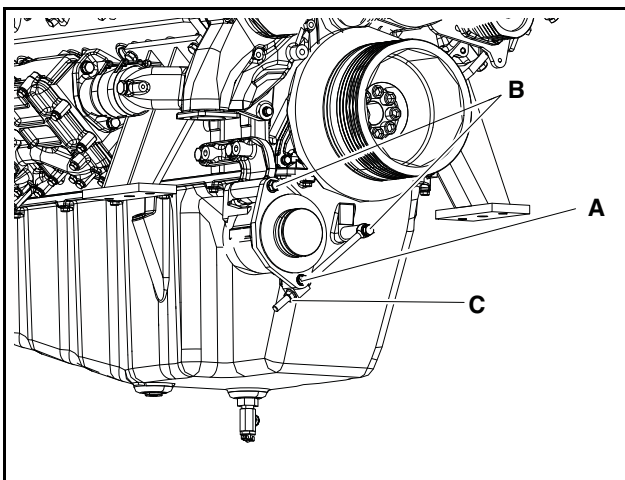
Type	Belt width (mm)	Tension from a Tension Meter		
		New belt (kg)		Replacement required
		Upon installation	After 10 minute	
M	8.5	50	45	40
A	11.8	55	50	45
B	15.5	75	70	60
C	20.2	75	70	60
3V-2	18.8	90~100	70~80	60
3V-4	39.4	180~200	140~160	120
3V-6	60.0	270~300	210~240	180
8pk Micro V	27.61	86	77	40

### 5. Tension adjustment and V-belt replacement



DV2213050B

- 1) Loosen the fixing bolt(1).
- 2) Loosen the lock nut(2).
- 3) Adjust the bolt(3) until belt have correct tension.
- 4) Tighten the fixing bolt(1) and nut(2).
- 5) To replace the V-belt, loosen the fixing bolts(1) and the lock nut(2) and push the tension pulley inwards by turning the adjusting bolt(3) counter clockwise.



DV2213055A

- 6) Loosen the mounting bolts(B).
- 7) Loosen the lock nut(A).
- 8) Adjust the nut(C) until the belt tension has correct tensions.
- 9) Retighten the lock nut(A) and the mounting bolt(B).
- 10) To replace the belt, loosen the lock nut and push the alternator inwards.

## 4. Regular inspection

---

# 5. About the engine

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### Marking system of units

#### Unit Conversion Methods

The following methods show how to convert SI units to US units and vice versa.

- To convert an SI unit to a US unit, multiply a SI unit with the number in the following table.

Note) (SI Unit) X (Number) = (US Unit)

Note) 1 mm X 0.03937 = 0.03937 in

- To convert a US unit to an SI unit, divide the US unit by the number in the following table.

Note) (US Unit) ÷ (Number) = (SI Unit)

Note) 1 in ÷ 0.03937 = 25.4 mm

Item	Number	SI Unit	US Unit
Length	0.03937	mm	in
	3.28084	m	ft
	1.093613	m	yd
	0.621371	km	mile
Area	0.00155	mm <sup>2</sup>	in <sup>2</sup>
	0.1550	cm <sup>2</sup>	in <sup>2</sup>
	10.76391	m <sup>2</sup>	ft <sup>2</sup>
	1.19599	m <sup>2</sup>	yd <sup>2</sup>
Weight	2.204623	kg	lb
	0.001	kg	t (ton)
Volume	0.061024	cc	in <sup>3</sup>
	0.061024	ml	in <sup>3</sup>
	0.061024	cm <sup>3</sup>	in <sup>3</sup>
	61.023744	L	in <sup>3</sup>
	0.264172	L	gal
Force <sup>a</sup>	2.204622	kgf	lbf
	0.2248089	N	lbf
Acceleration	3.28084	m/s <sup>2</sup>	ft/s <sup>2</sup>
	39.37008	m/s <sup>2</sup>	in/s <sup>2</sup>
Torque <sup>b</sup>	7.233014	kgf·m	ibf·ft
	86.79619	kgf·m	ibf·in
	0.7375621	N·m	ibf·ft
	8.850748	N·m	ibf·in

Item	Number	SI Unit	US Unit
Power	1.340483	kw	Hp
Pressure	0.01	kPa	bar
	7.500615	kPa	mmHg
	20.88543	kPa	lb/ft <sup>2</sup>
	14.2233	psi	kg/cm <sup>2</sup>
Power	1.3596	kw	PS
	0.98635	ps	hp
Fuel Consumption	0.00162	g/kwh	lb/psh
Energy	0.000947817	J	BTU
	0.7375621	J	lbf·ft
	0.000277778	J	Wh
Luminous Flux	0.09290304	lm/m <sup>2</sup>	lm/ft <sup>2</sup>
Speed	0.6213712	km/h	mph
Temperature	°C	°C	°F

a.  $9.806 \times (\text{kgf}) = (\text{N})$

b.  $9.806 \times (\text{kgf} \cdot \text{m}) = (\text{N} \cdot \text{m})$

c.  $\{(9/5) \times (^\circ\text{C}) + 32\} = (^\circ\text{F})$   
 $\{(^\circ\text{F}) - 32\} \times (5/9) = (^\circ\text{C})$

## 5. About the engine

### Tightening torque

#### Tightening Torque of Main Parts

Main Parts		Screws (Diameter X Pitch)	Strength	Tightening Torque (kgf·m)
Cylinder block & bedplate	Bedplate bolt	M8 x 1.25	8.8T	2.2 ±0.22
	Screw plug (PT)	PT 3/8	-	6.5 ±0.5
	Coolant drain plug	M12 x 1.5	-	5 ±0.5
Oil spray nozzle valve		M10 x 1.25	-	2 ±0.2
Flywheel housing bolt		M10 x 1.5	10.9T	6.2 ±0.62
CRS V pulley bolt		M16 x 1.5	12.9T	21 ±2.1
Flywheel bolt (43 mm, option)		M12 x 1.5	10.9T	1st: 7 ±0.35 / 2nd: 45° ±4°
Flywheel bolt (25 mm, option)		M12 x 1.5	12.9T	17 ±0.85
Head cover bolt (LH,RH)		M6 x 1.0	8.8T	0.8 ±0.05
Head cover bolt (Main)		M6 x 1.0	8.8T	0.8 ±0.05
Injector mounting bolt (Socket)		M8 x 1.25	12.9T	4.35 ±0.35
Thermostat mounting spacer bolt		M8 x 1.25	8.8T	2.2 ±0.22
Thermostat plug		UNF 3/4 - 16	-	1.75 ±0.25
Oil pan drain plug		UNF 3/4 - 16	-	3 ±0.3
Glow plug body		M8 x 1.0	-	1.05 ±0.15
Glow plug terminal		M4 x 0.7	-	0.275 ±0.03
Turbocharger oil supply screw		M10 x 1.0	-	1.9 ±0.1
Turbocharger mounting nut		M10 x 1.25	10.9T	6.2 ±0.6
Water pump mounting nut		M8 x 1.25	-	2.2 ±0.22
Rocker arm adjustment hex nut		M12 x 1.0	8.8T	5.0 ±0.5
Camshaft thrust washer bolt		M8 x 1.25	10.9T	3.1 ±0.31
Rocker arm bracket bolt		M10 x 1.5	10.9T	6.2 ±0.62
PTO housing bolt		M10 x 1.5	12.9T	4.4 ±0.44
HP pump mounting nut		M8 x 1.25	-	2.2 ±0.22
Alternator nut		M8 x 1.25	-	2.2 ±0.22
Alternator bolt		M8 x 1.25	8.8T	2.2 ±0.22
Starter nut		M10 x 1.5	-	4.4 ±0.44
Idler pulley assy. bolt		M10 x 1.5	-	4.5 ±0.5
Fuel hose bracket bolt		M12 x 1.75	8.8T	5.5 ±0.55
Drive type clamp		-	-	0.525 ±0.03
Band clamp (DOC & SCR)		-	-	1.4 ±0.1

## 5. About the engine

---

Main Parts	Screws (Diameter X Pitch)	Strength	Tightening Torque (kgf·m)
Pressure sensor adapter bolt	M6 x 1.0	8.8T	0.85 ±0.15
Coolant temperature sensor	M12 x 1.5	-	2.5 ±0.3
Boost Sensor	M14 x 1.5	-	4.0 ±0.5
Exhaust temperature sensor	M14 x 1.5	-	4.0 ±0.5
NOx sensor	M20 x 1.5	-	5.0 ±1.0

## 5. About the engine

### Tightening Torque of General Bolts

Please refer to the following tightening torque for the bolts which are not listed in Tightening Torque of Main Parts.

#### 1. Tightening Torque of General Bolts

Nominal Diameter x Pitch (mm)	Strength Classification										
	3.6	4.6	4.8	5.6	5.8	6.6	6.8	6.9	8.8	10.9	12.9
	(4A)	(4D)	(4S)	(5D)	(5S)	(6D)	(6S)	(6G)	(8G)	(10K)	(12K)
	Elastic Limit Value (kg/mm <sup>2</sup> )										
	20	24	32	30	40	36	46	54	64	90	106
Tightening Torque (kg·m)											
M5	0.15	0.16	0.25	0.22	0.31	0.28	0.43	0.48	0.5	0.75	0.9
M6	0.28	0.30	0.45	0.4	0.55	0.47	0.77	0.85	0.9	1.25	1.5
M7	0.43	0.46	0.7	0.63	0.83	0.78	1.2	1.3	1.4	1.95	2.35
M8	0.7	0.75	1.1	1	1.4	1.25	1.9	2.1	2.2	3.1	3.8
M8 x 1	0.73	0.8	1.2	1.1	1.5	1.34	2.1	2.3	2.4	3.35	4.1
M10	1.35	1.4	2.2	1.9	2.7	2.35	3.7	4.2	4.4	6.2	7.4
M10 x 1	1.5	1.6	2.5	2.1	3.1	2.8	4.3	4.9	5	7	8.4
M12	2.4	2.5	3.7	3.3	4.7	4.2	6.3	7.2	7.5	10.5	12.5
M12 x 1.5	2.55	2.7	4	3.5	5	4.6	6.8	7.7	8	11.2	13.4
M14	3.7	3.9	6	5.2	7.5	7	10	11.5	12	17	20
M14 x 1.5	4.1	4.3	6.6	5.7	8.3	7.5	11.1	12.5	13	18.5	22
M16	5.6	6	9	8	11.5	10.5	17.9	18.5	18	26	31
M16 x 1.5	6.2	6.5	9.7	8.6	12.5	11.3	17	19.5	20	28	33
M18	7.8	8.3	12.5	11	16	14.5	21	24.2	25	36	43
M18 x 1.5	9.1	9.5	14.5	12.5	18.5	16.7	24.5	27.5	28	41	49
M20	11.5	12	18	16	22	19	31.5	35	36	51	60
M20 x 1.5	12.8	13.5	20.5	18	25	22.5	35	39.5	41	58	68
M22	15.5	16	24.5	21	30	26	42	46	49	67	75
M22 x 1.5	17	18.5	28	24	34	29	47	52	56	75	85
M24	20.5	21.5	33	27	40	34	55	58	63	82	92
M24 x 1.5	23	25	37	31	45	38	61	67	74	93	103

Note) The standard torque values above are about 70% of the bolt elastic limit values.

Note) The tensile force has been calculated by multiplying the tensile strength with the screw cross-sectional area.

Note) A special screw should be tightened with 85% of the tightening torque of the standard value. For example, a MoS2-coated screw should be tightened with 60% of the tightening torque of the standard value.

## 5. About the engine

### 2. Tightening Torque of Key General Bolts

Nominal Diameter x Pitch (mm)	Strength Classification			Remarks
	8.8T	10.9T	12.9T	
	Tightening Torque (kgf·m) ± 10%			
M6 x 1	1	1.25	1.5	
M8 x 1.25	2.2	3.1	3.8	
M8 x 1	2.4	3.35	4.1	
M10 x 1.5	4.4	6.2	7.4	
M10 x 1.0	5	7	8.4	
M12 x 1.75	7.5	10.5	12.5	
M12 x 1.5	8	11.2	13.4	
M14 x 1.5	13	18.5	22	

### Tightening torque of plug screw

M10	M12	M14	M16	M18	M22	M24	M26	M30
5.0	5.0	8.0	8.0	10.0	10.0	12.0	12.0	15.0

### Hollow Screw (4-Hole) Tightening Torque

Material Classification	M8	M10	M12	M14	M16	M18	M22	M26	M30	M38
SM25C	-	1.6	2.5	3.5	4.5	5.5	9.0	13.0	18.0	30.0
SUM22L <sup>a</sup>	0.8	1.8	3.0	4.0	5.5	6.5	11.0	16.0	20.0	35.0
STS304	0.8	1.8	3.0	4.0	5.5	6.5	11.0	16.0	20.0	35.0

a. Applied to HD Hyundai Infracore Engines

## 5. About the engine

### Engine Disassembly

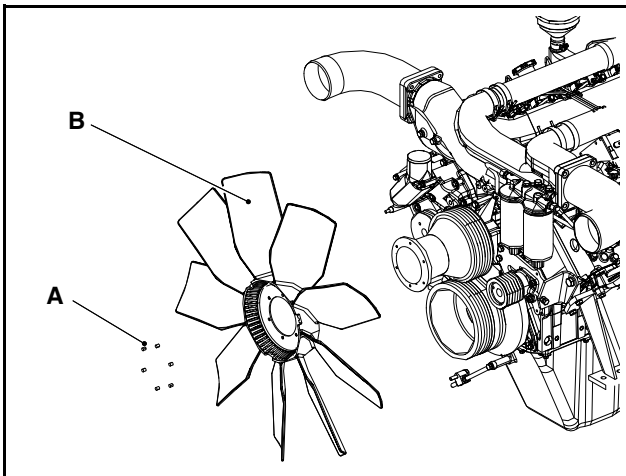
#### Procedure of Disassembling an Engine

#### CAUTION

- Prepare tools and genuine parts necessary before disassembling engine.
- Prepare a shelf for the storage of removed parts.
- Perform repairs in a light and clean space.
- Keep hands clean while performing repairs.
- Keep parts removed from the engine in the order of disassembly.
- Do not allow parts removed from the engine to touch each other or be mixed with other parts.

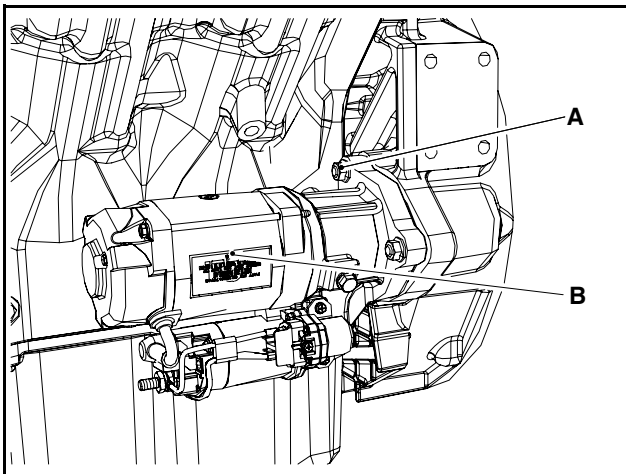
Disassemble the engine in the following order.

1. Remove the cooling fan.



DV2213052A

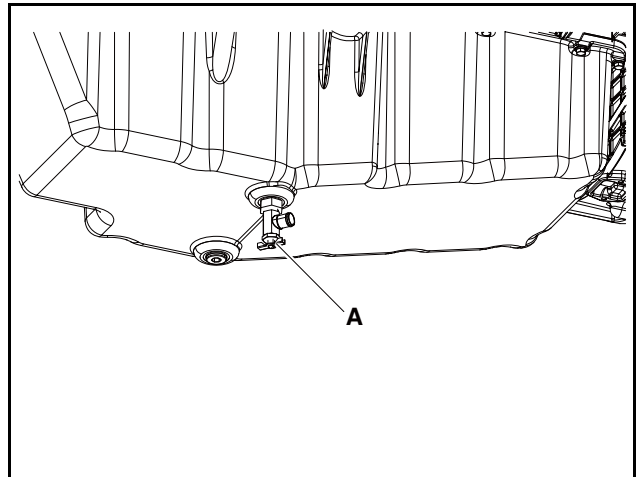
- 1) Loosen 6 fixing bolts(A).
  - 2) Remove the cooling fan(B).
2. Remove the starter.



EDV2223005

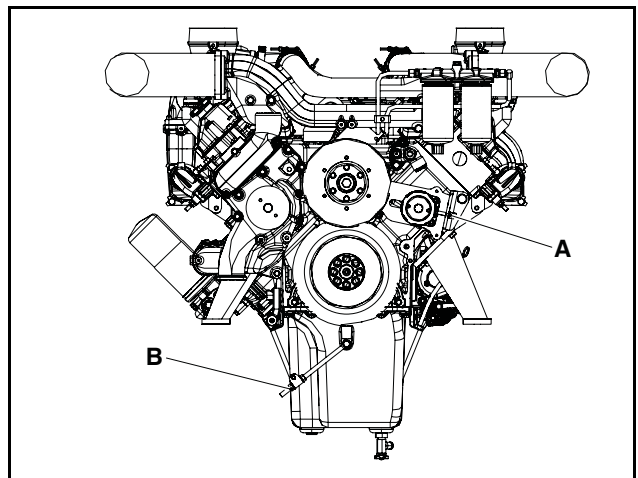
- 1) Loosen 3 fixing nuts(A).

- 2) Remove the starter(B).
3. Discharge cooling water.  
"Discharging the coolant" on page 48
4. Drain engine oil.



DV2213168A

- 1) Loosen the drain valve(A) of the oil pan and then drain engine oil.
5. Remove the V-belt.

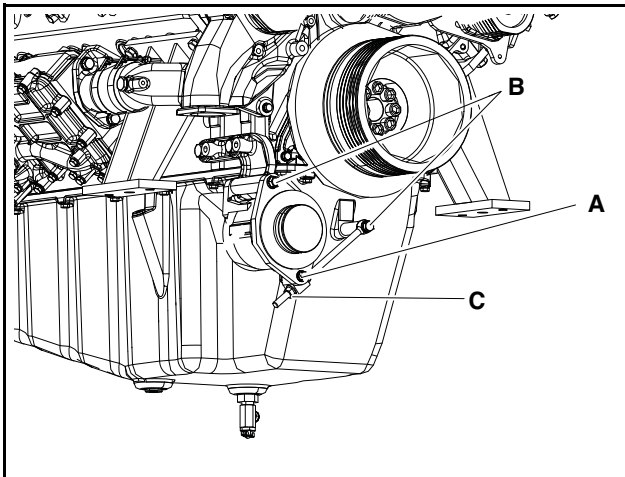


DV2213054A

- 1) Turn the adjusting nut(A) and then remove the V-belt.
- 2) Turn the adjusting nut(B) and then remove the V-belt.

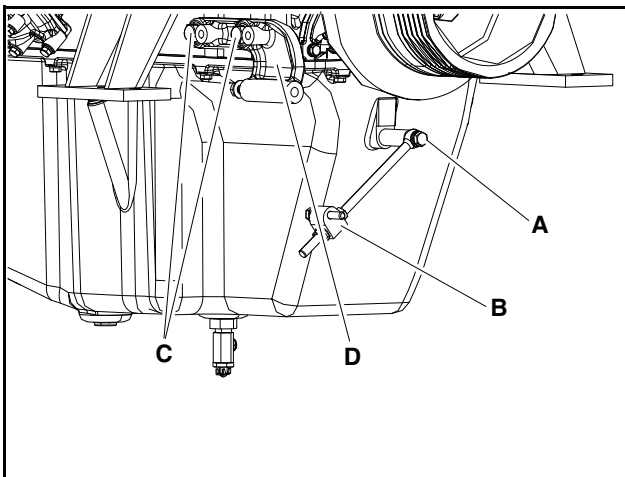
## 5. About the engine

6. Remove the alternator.



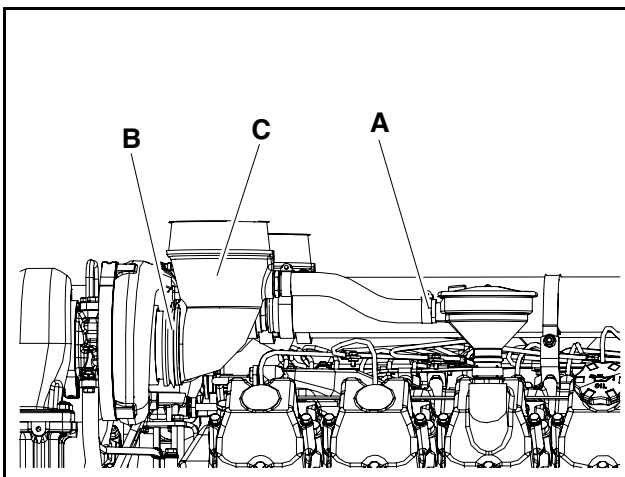
DV2213055A

- 1) Loosen the fixing nut(A) and bolt(B).
- 2) Remove the alternator(C).
7. Remove the alternator bracket.



DV2213056A

- 1) Loosen the fixing bolt(A) and then remove the eyebolt(B).
- 2) Loosen the fixing bolt(C) and then remove the alternator bracket(C).
8. Remove the inlet elbow.



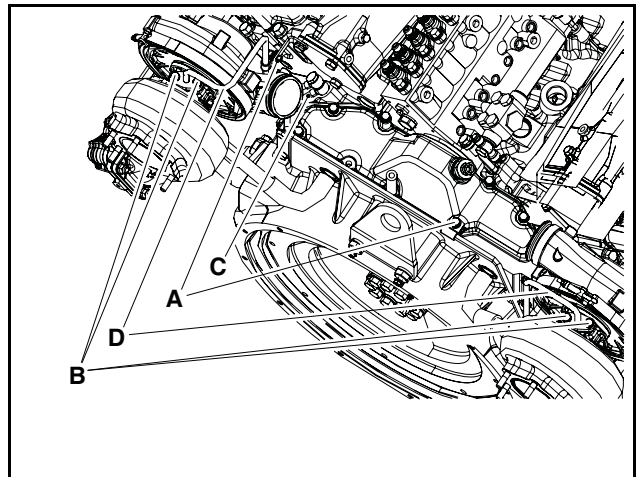
DV2213057A

- 1) Loosen the hose clamp(A).
- 2) Loosen the V-clamp(B).
- 3) Remove the inlet elbow(C).
- 4) Remove the other side elbow as the same procedure.

### **⚠ CAUTION**

**Be careful not to lose the O-ring and insert parts when removing the inlet elbow.**

9. Remove the oil delivery pipe.



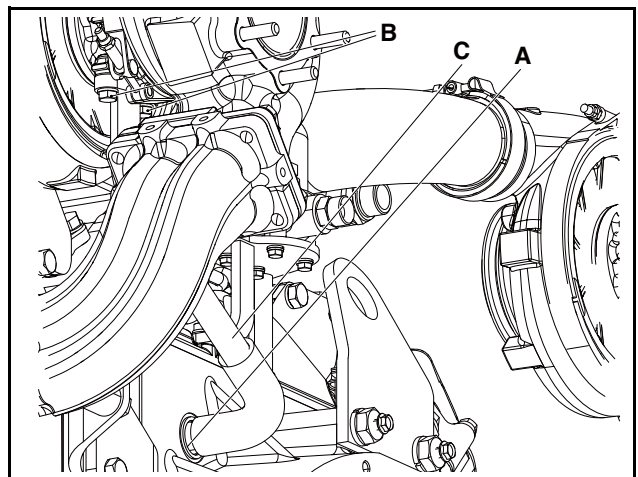
DV2213058A

- 1) Loosen the the fixing bracket bolts(A) of the oil delivery pipe.
- 2) Loosen the fixing bolts(B) of the oil delivery pipe.
- 3) Loosen the hollow screw(C).
- 4) Remove the oil delivery pipe(D).

### **⚠ CAUTION**

**Be careful not to lose the O-ring and the gasket.**

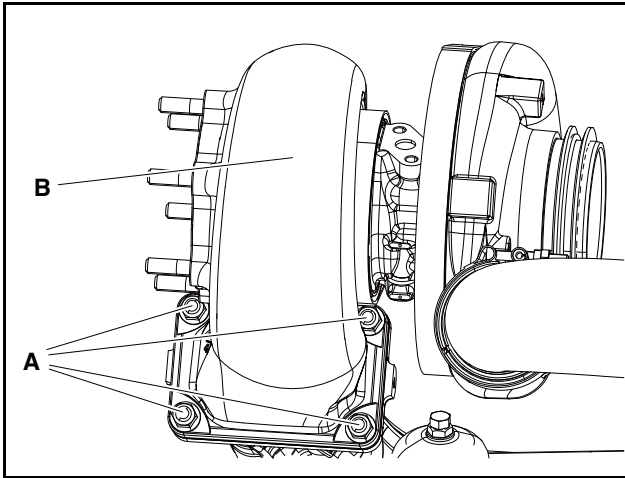
10. Remove the oil return pipe.



DV2213169A

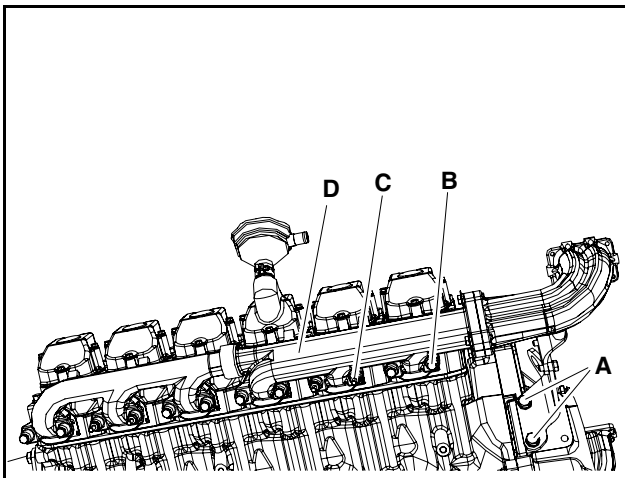
## 5. About the engine

- 1) Loosen the clamp(A).
- 2) Loosen 2 fixing bolts(B)
11. Remove the turbocharger.



DV2213170A

- 1) Loosen 4 fixing nuts(A).
- 2) Remove the turbocharger(B).
- 3) Remove the other side turbocharger as the same procedure.
12. Remove the exhaust manifold and elbow assembly.



DV2213060A

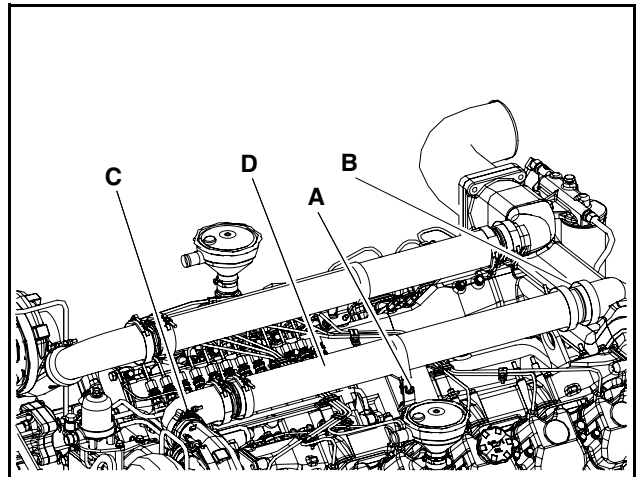
- 1) Remove the heat screen.
- 2) Loosen the fixing bolts(A) of the exhaust elbow bracket.
- 3) Loosen 8 fixing bolts(B) and 4 fixing bolts(C).
- 4) Remove the exhaust manifold and elbow assembly(D).
- 5) Remove the other side exhaust manifold and elbow assembly as the same procedure.

### **⚠ CAUTION**

**Be careful not to mix the fixing bolts each other.**

15. Remove the inlet pipe.

13. Remove the intake stake.



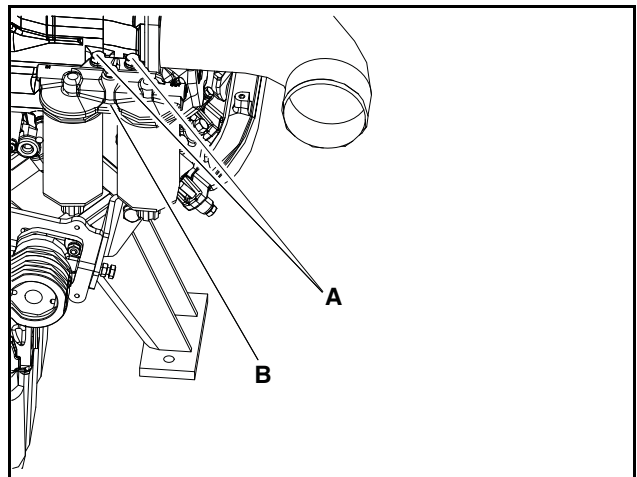
DV2213061A

- 1) Loosen the fixing bolt(A).
- 2) Loosen the hose clamp(B).
- 3) Loosen the V-clamp(C).
- 4) Remove the intake stake(D).
- 5) Remove the other side intake stake as the same procedure.

### **⚠ CAUTION**

**Be careful not to let dust inside the engine.**

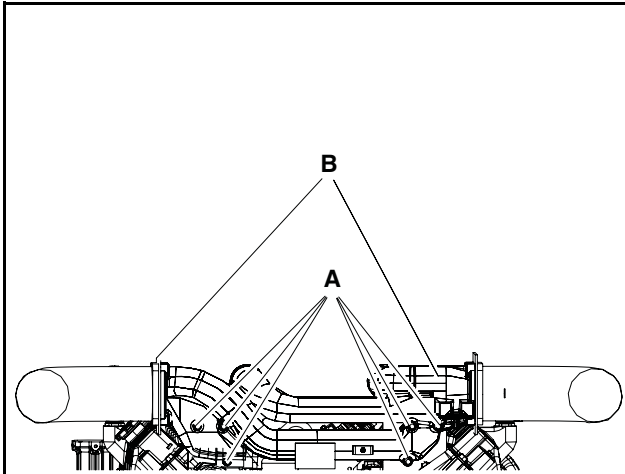
14. Remove the fuel filter.



DV2213062A

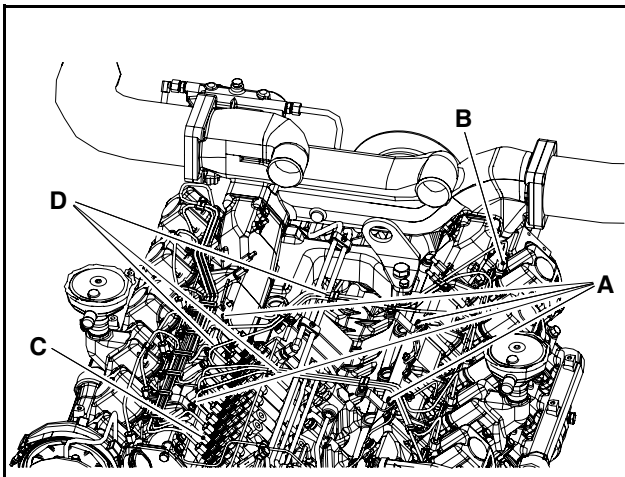
- 1) Loosen the fixing bolts(A).
- 2) Remove the fuel filter assembly(B).

## 5. About the engine



DV2213063A

- 1) Loosen the fixing bolts(A).
  - 2) Remove the inlet pipe(B).
16. Remove the fuel injection pipe assembly.



DV2213064A

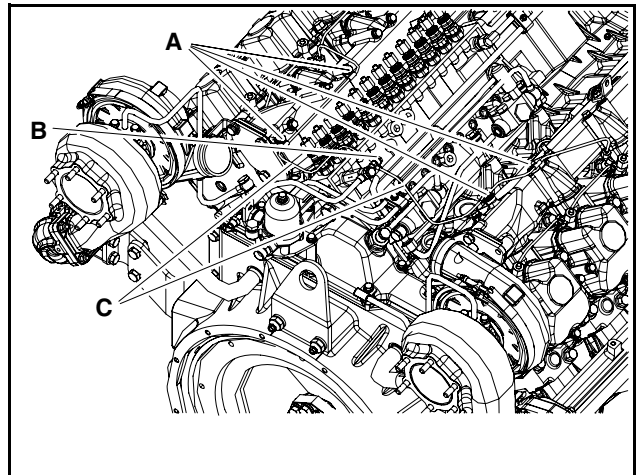
- 1) Loosen the fixing bolts(A).
- 2) Loosen 12 fuel injection pipe nuts(B) connected the injector.
- 3) Loosen 12 fuel injection pipe nuts(C) connected the fuel injection pump.
- 4) Remove 3 fuel injection pipe assemblies.

### **CAUTION**

- Be careful not to damage the fuel injection pipes.
- Be careful not to let dust inside the fuel injection pipes.
- Be careful not to let dust inside the fuel injection pipes.

19. Remove the fuel and oil hoses.

17. Remove the fuel pipe.



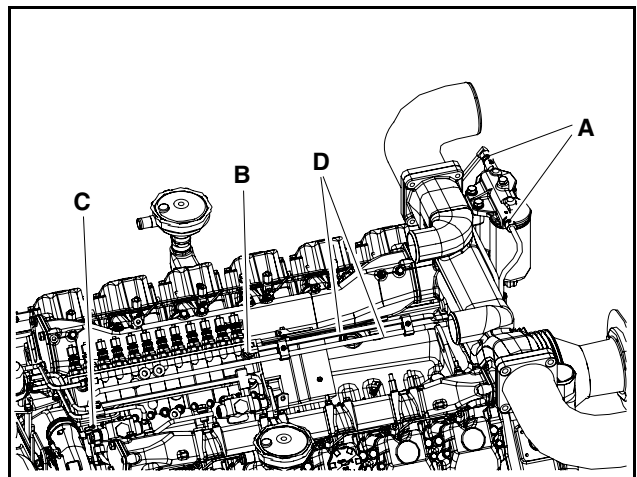
DV2213067A

- 1) Loosen the fixing bolts(A).
- 2) Loosen the hollow screw(B).
- 3) Remove the fuel pipes(C).

### **CAUTION**

- Be careful not to lose the O-ring.
- Be careful not to damage the fuel pipes.

18. Remove the fuel pipe.



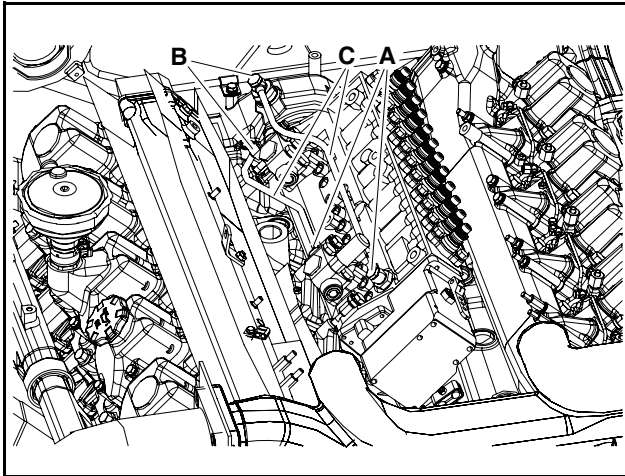
DV2213068A

- 1) Loosen the fixing nuts(A).
- 2) Loosen the fixing nuts(B) and (C).
- 3) Remove the fuel pipe(C)

### **CAUTION**

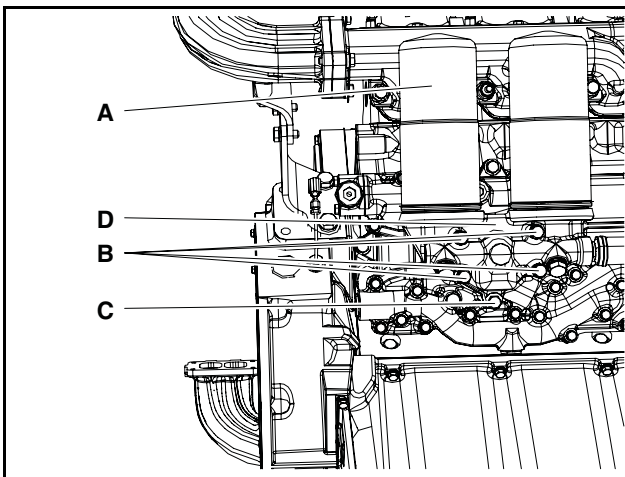
**Be careful not to damage the fuel pipes.**

## 5. About the engine



DV2213070A

- 1) Loosen the fixing bolts(A).
  - 2) Loosen the hollow screws(B).
  - 3) Remove the fuel and oil hoses(C).
20. Remove the oil filter assembly.



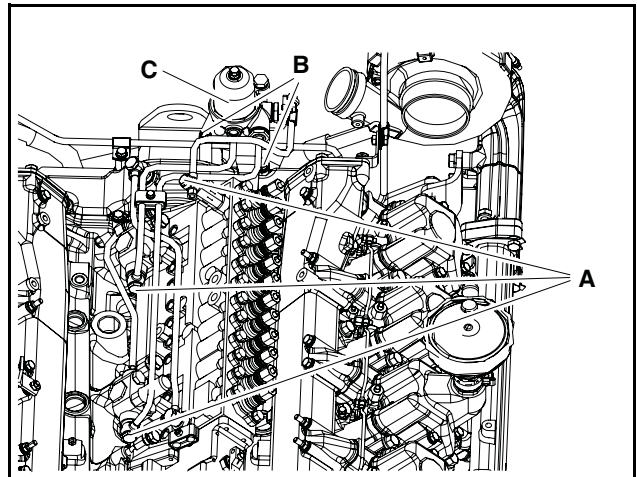
DV2213082A

- 1) Remove the oil filter with the chain plier(EF.200-038).
- 2) Loosen the fixing bolt(B) and (C).
- 3) Remove the oil filter housing.

### CAUTION

- Be careful not to lose the gasket.
- Be careful not to run down oil.

21. Remove the fuel pre-filter.



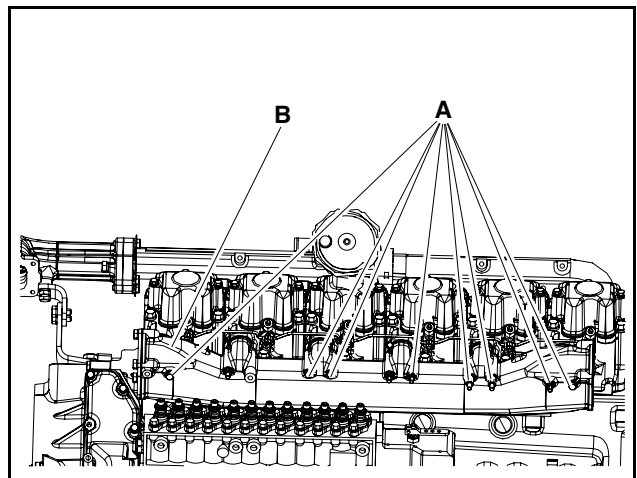
DV2213065A

- 1) Loosen the hollow screws(A).
- 2) Loosen the fixing bolts(B).
- 3) Remove the fuel return pipe and fuel pre-filter.

### CAUTION

Be careful not to damage the fuel injection pipes.

22. Remove the intake manifold.



DV2213066A

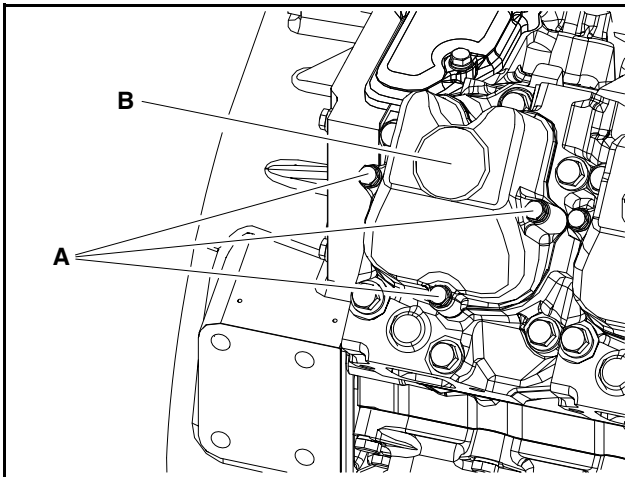
- 1) Loosen the fixing bolts(A).
- 2) Remove the intake manifold(B).
- 3) Remove the other side intake manifold as the same procedure.

### CAUTION

Be careful not to mix the fixing bolts each other.

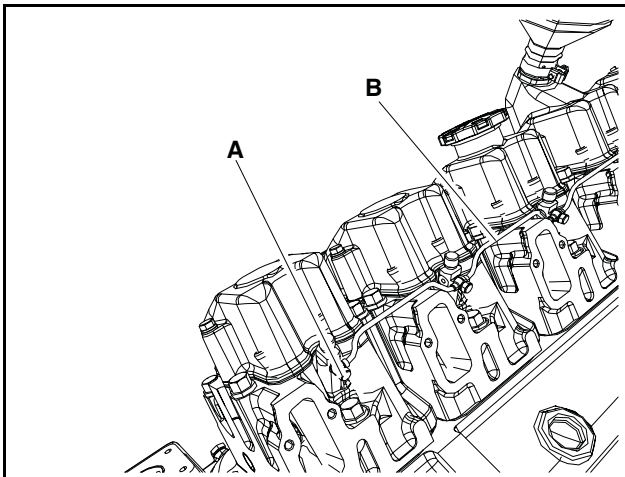
## 5. About the engine

23. Remove the cylinder head cover.



DV2213074A

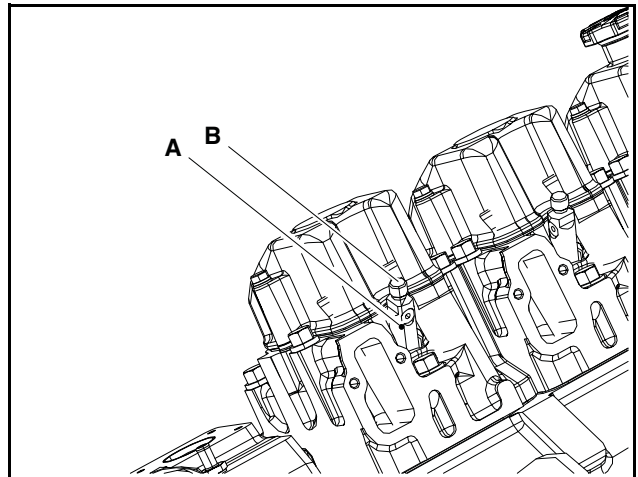
- 1) Loosen 3 fixing bolts(A).
  - 2) Remove the cylinder head cover(B) and the gasket.
  - 3) Remove the other side cylinder head cover and gasket as the same procedure.
24. Remove the fuel return pipe.



DV2213069A

- 1) Remove the hollow screw and 6 seal rings(A).
- 2) Remove the fuel return pipe(B).
- 3) Remove the other side fuel return pipe as the same procedure.

25. Remove the injectors.



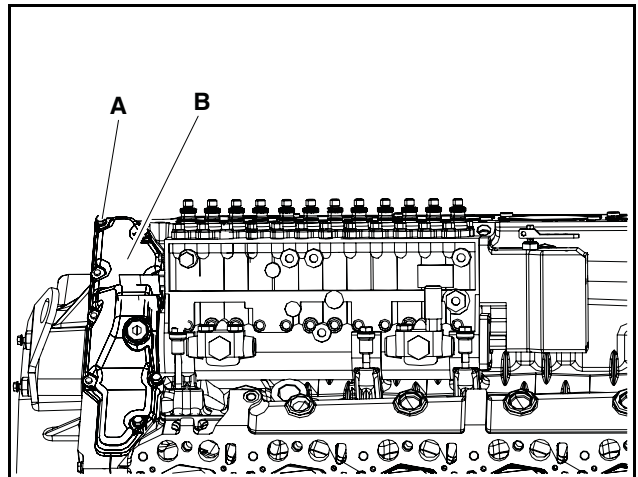
DV2213073A

- 1) Remove the injector holer fixing nut(B) with the jig for injection nozzle detach(60.99901-0036).
- 2) Remove the injector(A).
- 3) Remove 12 injectors as the same procedure.

### CAUTION

Be careful not to damage the fuel pipes.

26. Remove the flywheel housing cover.

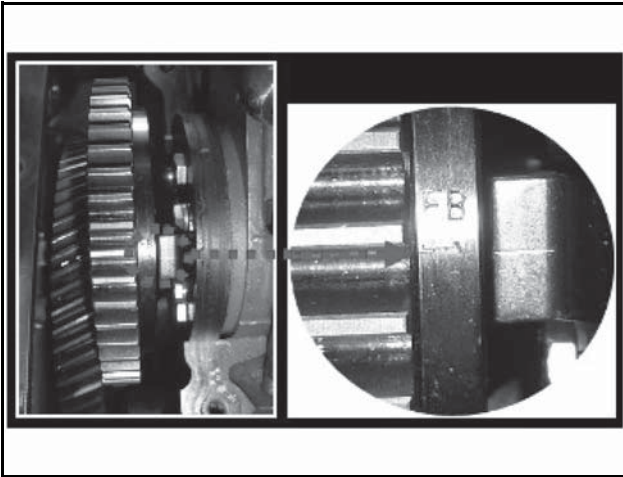


DV2213071A

- 1) Loosen the fixing bolts(A).
- 2) Remove the flywheel housing cover(B).

## 5. About the engine

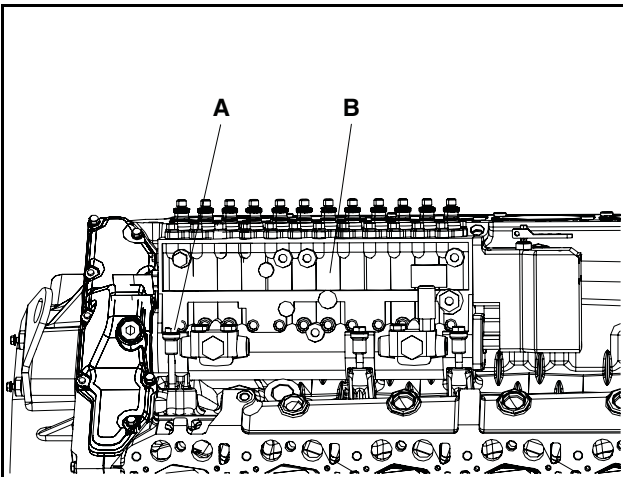
27. Align the fuel injection pump pointer.



DV2213171A

- 1) Rotate the flywheel to the engine rotation direction.
- 2) The injection timing pointer marking on the fuel injection pump driven gear is aligned with marking on the cylindrical surface.

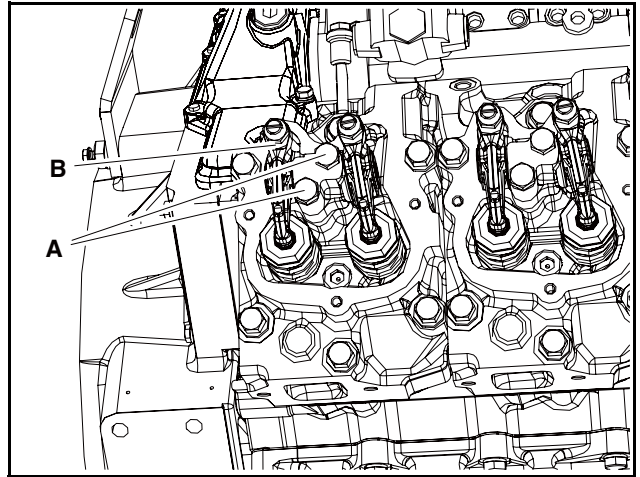
28. Remove the fuel injection pump.



DV2213072A

- 1) Loosen 6 fixing bolts(A).
- 2) Remove the fuel injection pump(B).

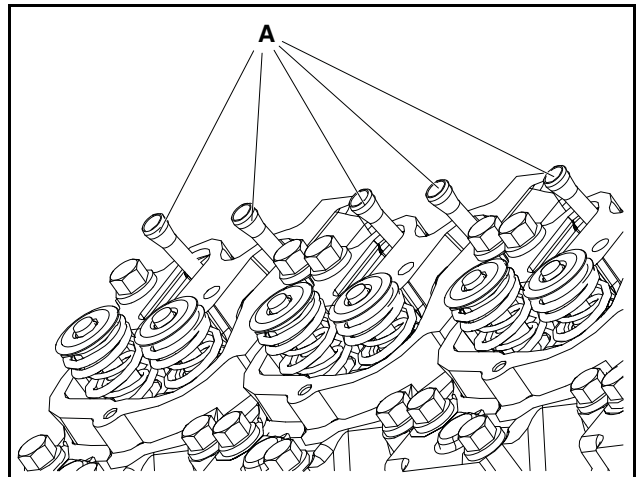
29. Remove the rocker arm assembly.



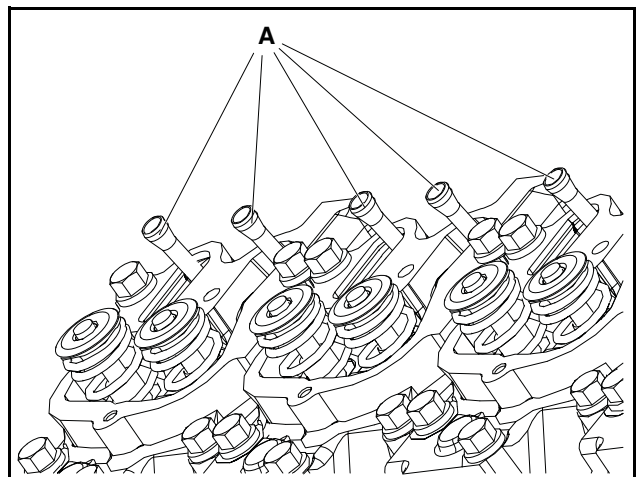
DV2213075A

- 1) Loosen the fixing bolts(A).
- 2) Remove the rocker arm assembly(B).
- 3) Remove 12 rocker arm assemblies as the same procedure.

30. Remove the push rods.



DV2213076A

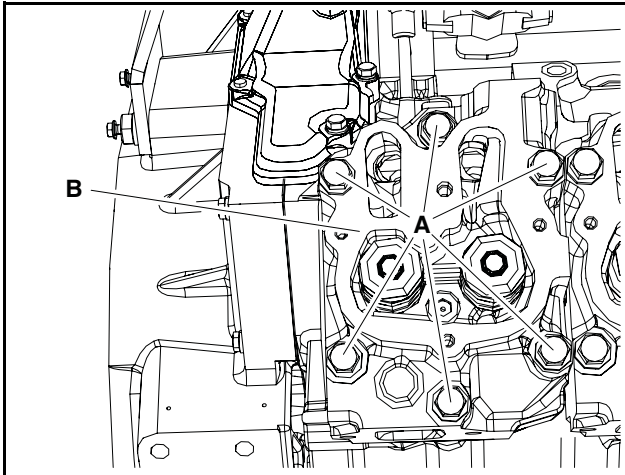


EDV2218002

- 1) Remove 24 push rods(A).

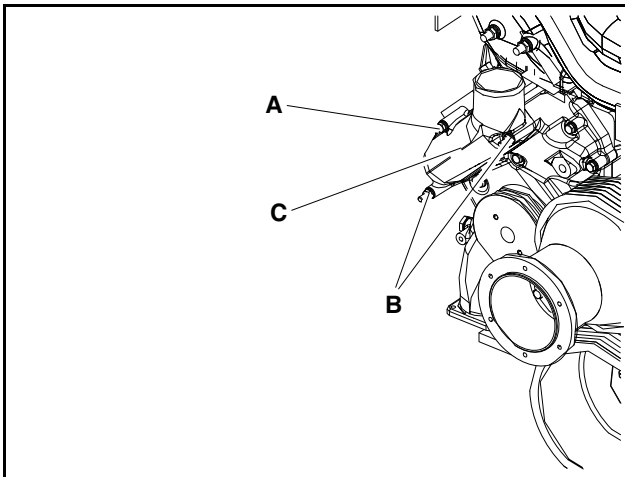
## 5. About the engine

31. Remove the cylinder head assembly.



DV2213077A

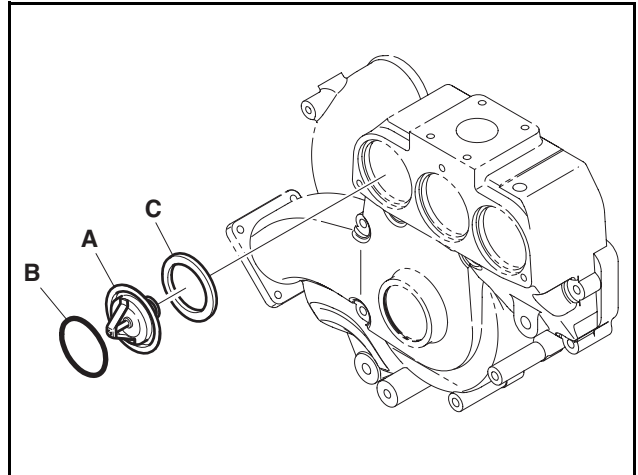
- 1) Loosen 6 fixing bolts(A).
  - 2) Remove the cylinder head assembly(B).
  - 3) Remove 12 cylinder head assemblies as the same procedure.
32. Remove the cooling water pipe.



DV2213078A

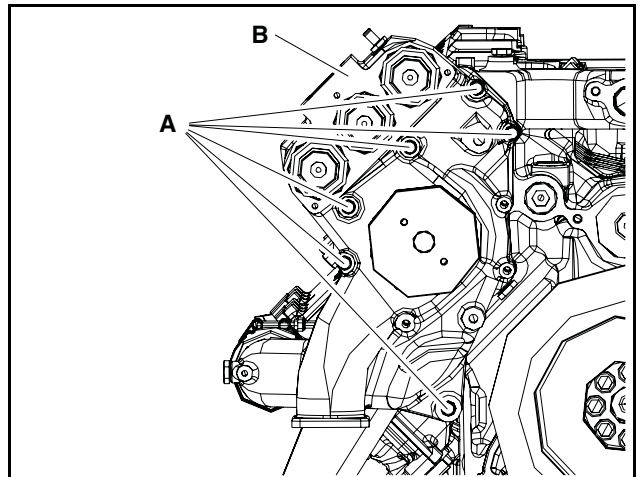
- 1) Loosen the fixing bolts(A) and nuts(B).
- 2) Remove the cooling water pipe(C).

33. Remove the thermostat.



DV2213172A

- 1) Remove the O-ring(B).
  - 2) Remove the thermostat(A).
  - 3) Remove the gasket(C).
  - 4) Remove 3 thermostats as the same procedure.
34. Remove the water pump assembly.



DV2213173A

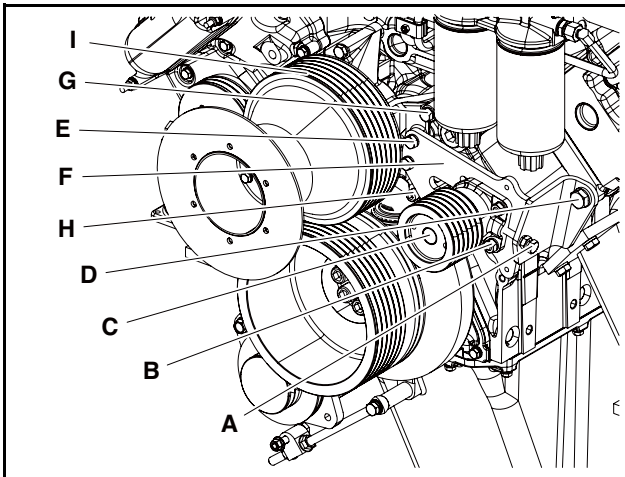
- 1) Loosen 6 fixing bolts(A).
- 2) Remove the water pump assembly(B).

### CAUTION

Be careful not to mix the fixing bolts each other.

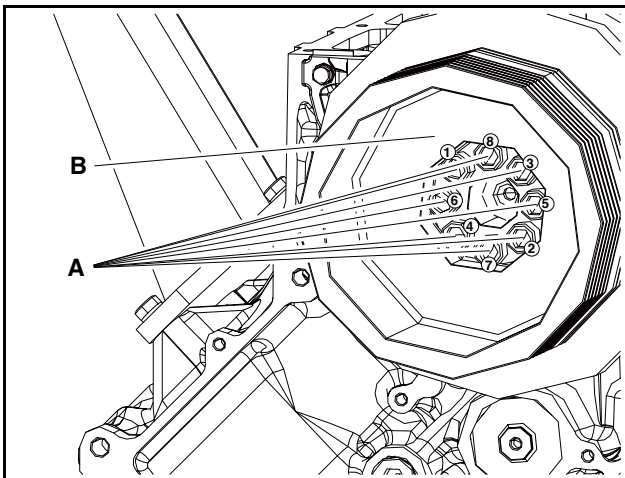
## 5. About the engine

35. Remove the idle pulley and cooling fan pulley assembly.



DV2213174A

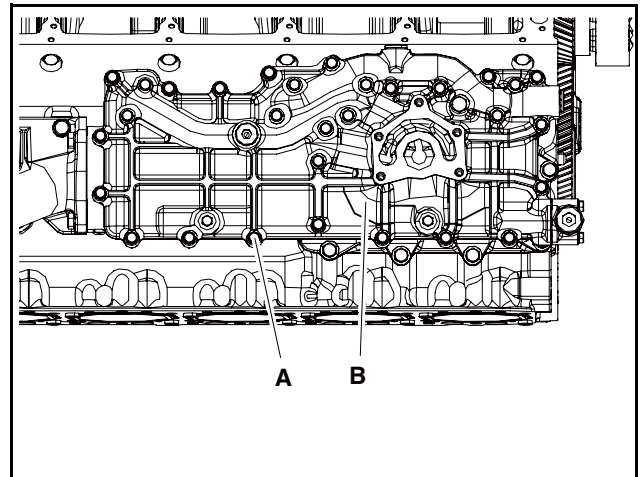
- 1) Loosen 1 fixing bolt(A) and 2 fixing nuts(B).
  - 2) Remove the idle pulley(C).
  - 3) Loosen 1 fixing bolt(D) and 2 fixing bolts(E).
  - 4) Remove the idle pulley bracket(F).
  - 5) Loosen 3 fixing bolts and 1 socket bolt.
  - 6) Remove the cooling fan assembly(I).
36. Remove the crankshaft pulley.



DV2213175A

- 1) Loosen 8 fixing bolts(A) in the order of 1 ~ 8.
- 2) Remove the crankshaft pulley(B).

37. Remove the oil cooler cover.



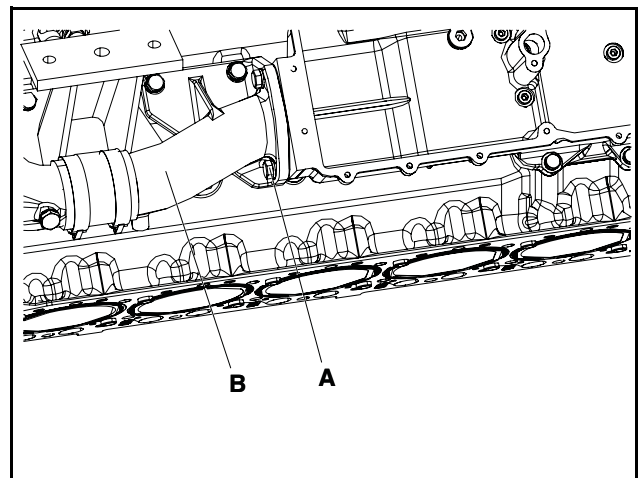
DV2213083A

- 1) Loosen 20 fixing bolts(A).
- 2) Remove the oil cooler cover(B).

### **⚠ CAUTION**

**Remove the gasket on the assembly surface.**

38. Remove the cooling water pipe.

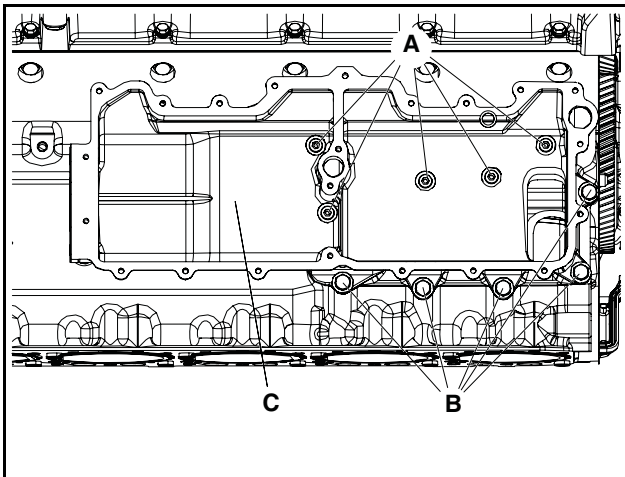


DV2213084A

- 1) Loosen fixing bolts(A).
- 2) Remove the cooling water pipe(B).

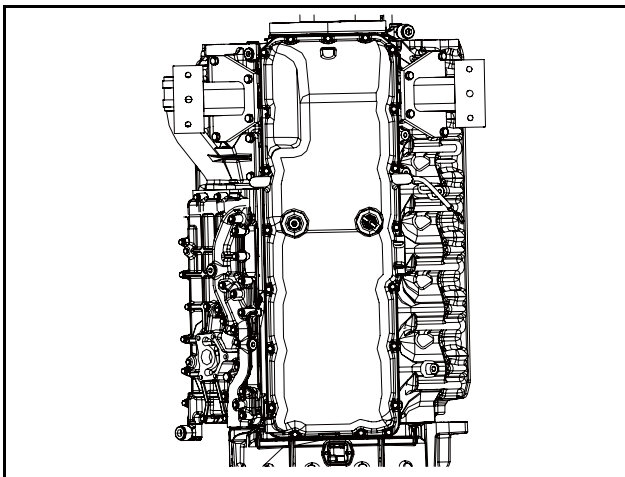
## 5. About the engine

39. Remove the oil cooler housinging.



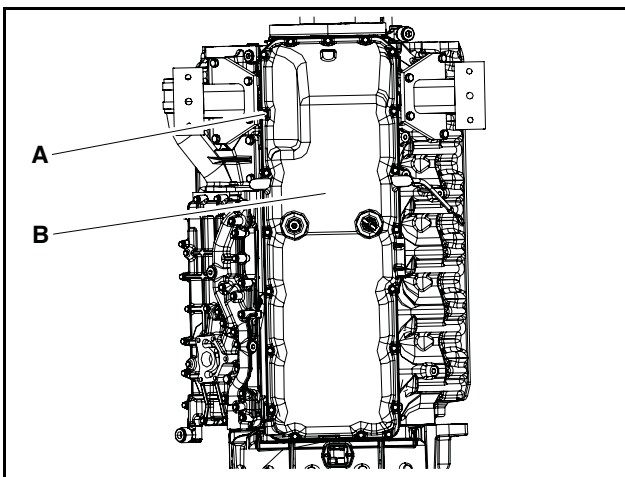
DV2213085A

- 1) Loosen 5 inner socket bolts(A).
  - 2) Loosen 5 outer fixing bolts(B).
  - 3) Remove the oil cooler housinging(C).
40. Change the engine position.



DV2213176A

- 1) Change the engine position. The flywheel housing direction is downward.
41. Remove the oil pan.



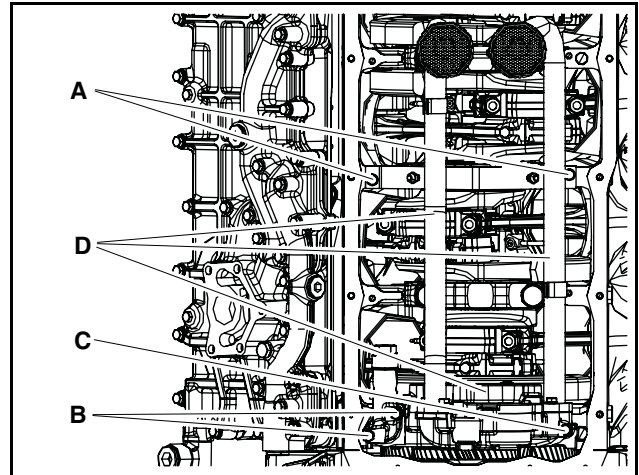
DV2213086A

- 1) Loosen 20 fixing bolts(A).
- 2) Remove the oil pan(B).

### **CAUTION**

**Remove the gasket on the assembly surface.**

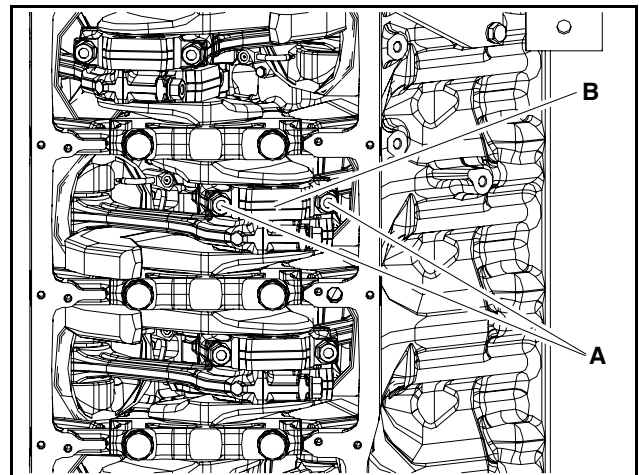
42. Remove the oil suction pipe and the oil pump.



DV2213087A

- 1) Loosen 2 fixing bolts(A).
- 2) Loosen 2 fixing bolts(B).
- 3) Loosen the fixing bolt(C).
- 4) Remove the oil suction pipe and the oil pump(D).

43. Remove the connecting rod and piston assembly.



DV2213088A

- 1) Loosen 2 connecting rod bolts and then remove the connecting rod cap(B).
- 2) Push the connectin rod.

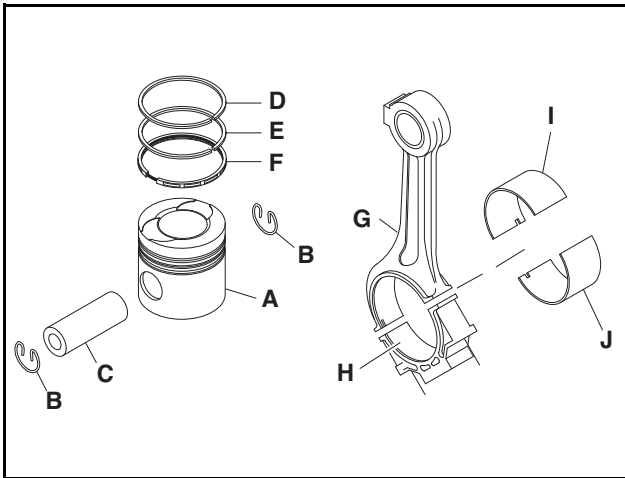
## 5. About the engine

- 3) Remove 12 connecting rod and piston assemblies as the same procedure.

### **CAUTION**

- Be careful not to interference between the crankshaft and the crank weight.
- Be careful not to mix disconnected connecting rods, connecting rod caps, and removed connecting rod bolts as they are set aside.

44. Disassemble the piston from the connecting rod.



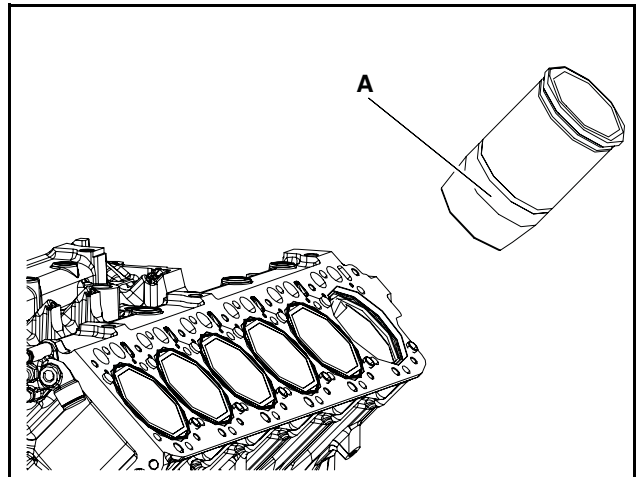
DV2213177A

- 1) Remove 2 snap rings(B) with the snap ring-plier(T7510001E).
- 2) Remove the piston pin(C).
- 3) Remove the piston(A) from connecting rod(G).
- 4) Remove the top ring(D), 2nd ring(E), oil ring(F) with the piston ring plier(T7621010E).
- 5) Remove the upper connecting rod bearing(I) from connecting rod(G).
- 6) Remove the lower connecting rod bearing(J) from connecting rod cap(H).

### **CAUTION**

Be careful not to mix the parts each other.

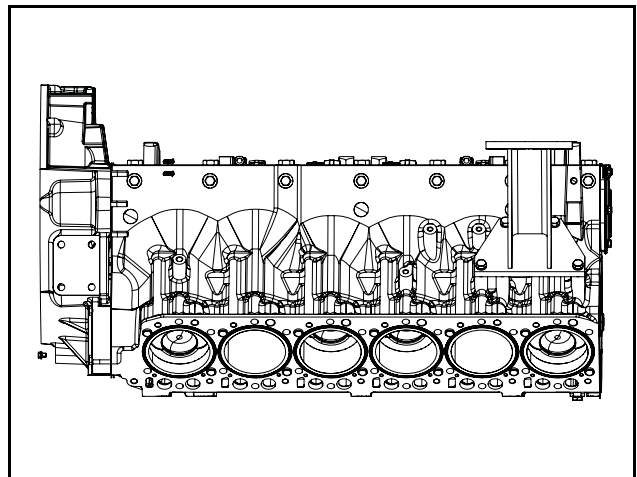
45. Remove the cylinder liner.



DV2213089A

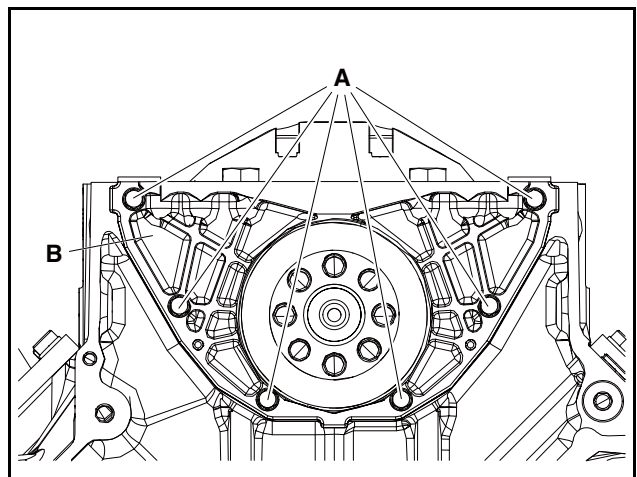
- 1) Remove the cylinder liner(A) from the cylinder block with the cylinder liner puller(EF.123-365).
- 2) Remove 12 cylinder liners as the same procedure.

46. Change the engine position.



DV2213178A

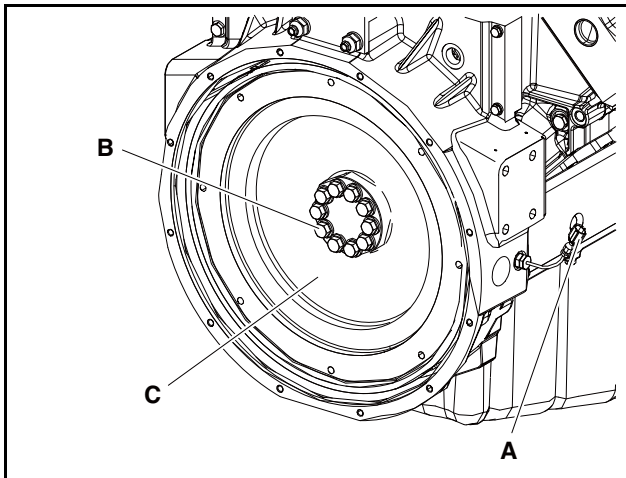
- 1) Change the engine position. The crankshaft direction is upward.
47. Remove the front oil seal.



DV2213090A

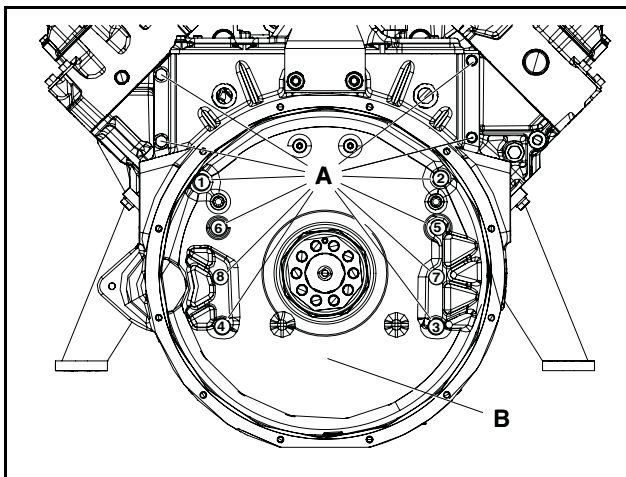
## 5. About the engine

- 1) loosen 6 fixing bolts(A).
  - 2) Remove the front oil seal(B).
48. Remove the flywheel.



DV2213091A

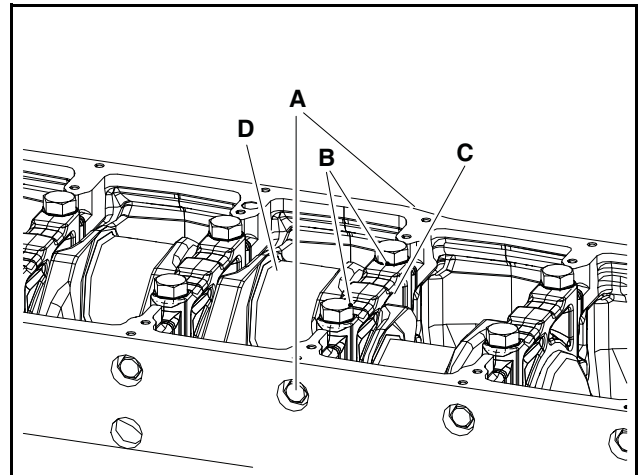
- 1) Remove the tachometer sensor(A).
  - 2) Loosen 10 hex bolts(B) and then remove the flywheel.
49. Remove the flywheel housing.



DV2213179A

- 1) Loosen 12 fixing bolts(A).
- 2) Remove the flywheel housing(B).

50. Remove the crankshaft.



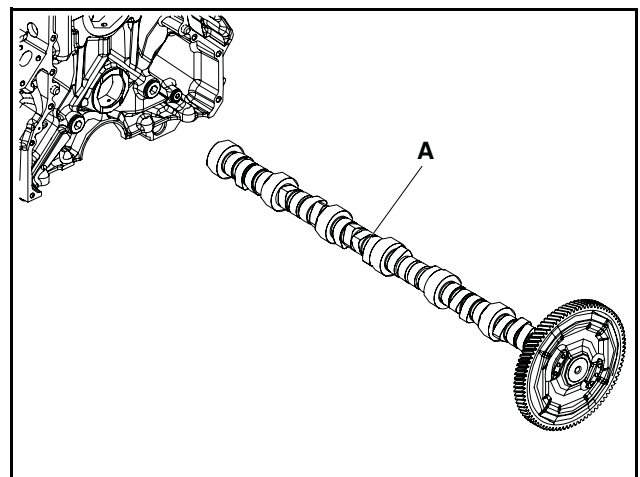
DV2213093A

- 1) Loosen 2 side fixing bolts(A) and 2 bearing cap bolts(B).
- 2) Remove bearing cap(C).
- 3) Remove 12 bearing caps as the same procedure.
- 4) Remove the crankshaft(D).
- 5) Remove the main bearing and the thrust bearing.

### CAUTION

Be careful not to lose bearings.

51. Remove the camshaft.



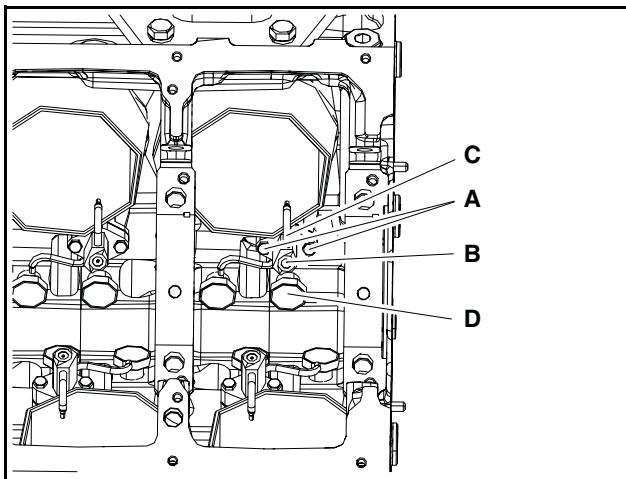
DV2213094A

- 1) Remove the camshaft(A) from cylinder block.

## 5. About the engine

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52. Remove the valve tappet and the spray nozzle.



DV2213095A

- 1) Loosen 2 fixing bolts(A) and 1 hollow screw(B).
- 2) Remove the oil spray nozzle(C).
- 3) Remove 12 oil spray nozzles as the same procedure.
- 4) Remove the valve tappet(D).
- 5) Remove 24 valve tappets as the same procedure.

### Engine Assembly

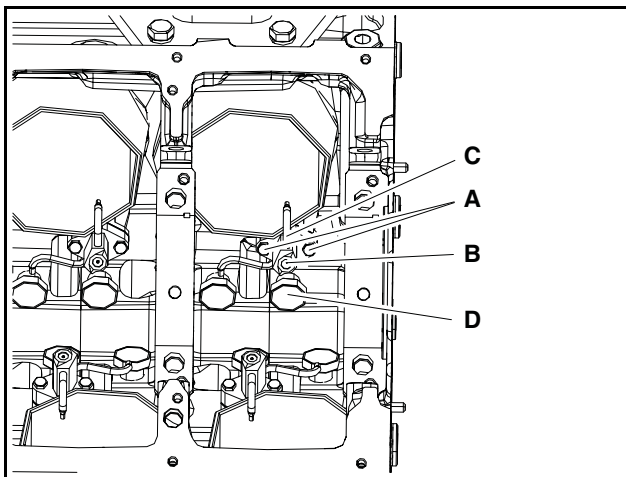
#### Procedure of Assembling Engine

#### CAUTION

- Cleanse all disassembled and disconnected parts. Especially, clean the oil and coolant path with compressed air and check if there is any resistance.
- Arrange general tools and special tools for engine assembly.
- Prepare clean engine oil to be applied on each sliding component.
- Prepare repair materials such as sealant and gaskets.
- Replace used gaskets, seal rings, and expendable parts with new ones.
- Each bolt should be tightened with the specified tightening torque in the order of tightening; however, excessive tightening torque should be avoided.
- Ensure that all engine parts are successfully operating after reassembly.
- Check if any bolts are loose after the first assembly.
- Always keep hands clean during assembly.

Assemble the engine in the following order.

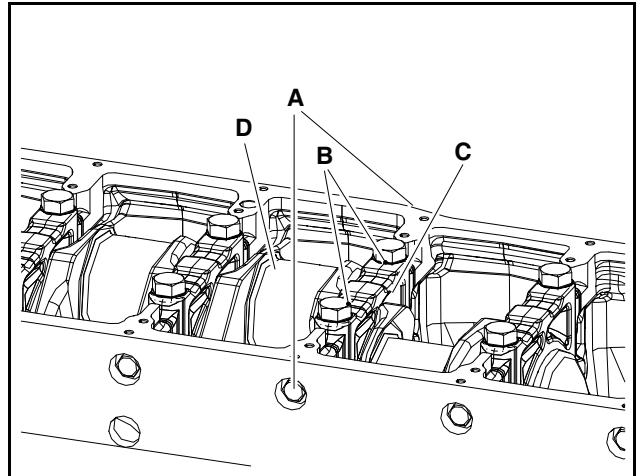
1. Attach the valve tapet and the oil spray nozzle.



DV2213095A

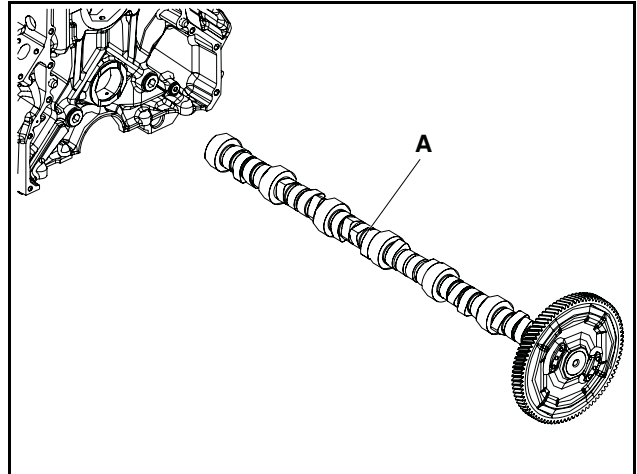
- 1) Attach the valve tapet(D).
- 2) Attach 24 valve tapets as the same procedure.
- 3) Attach the oil spray nozzle(C).
- 4) Tighten 1 M14 hollow screw(B) at a tightening torque of 4 kgf·m.
- 5) Tighten 2 M6 fixing bolts(A) at a tightening torque of 1.2 kgf·m.
- 6) Attach 12 oil spray nozzle as the same procedure.

2. Attach the crankshaft.dps



DV2213093A

- 1) Attach the main bearing and the thrust bearing.
  - 2) Attach the crankshaft(D).
  - 3) Attach the bearing cap(C).
  - 4) Attach 12 bearing cap as the same procedure.
  - 5) Tighten M18 bearing cap bolt(B) at a tightening torque of 30 kgf·m + 90° by using the angle method.
3. Attach the camshaft.



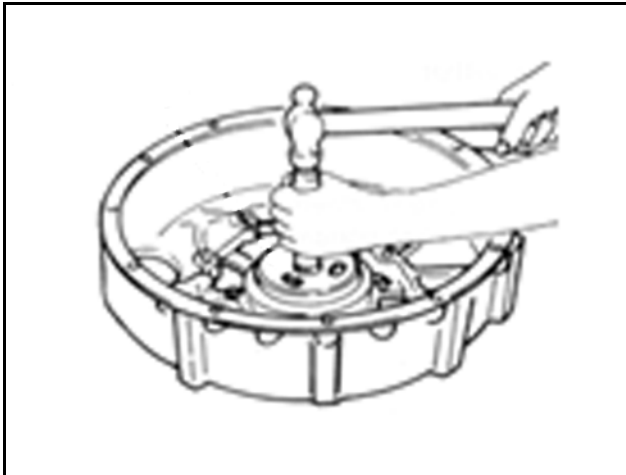
DV2213094A

- 1) Apply engine oil inside cam hole and outside cam journal of the cylinder block.
- 2) Attach the camshaft(A) to the cylinder block.
- 3) Align the cam gear marking to the crankshaft gear marking(Timing mark).

Note) The engraved marks is "1".

## 5. About the engine

4. Attach the oil seal to the flywheel housing.



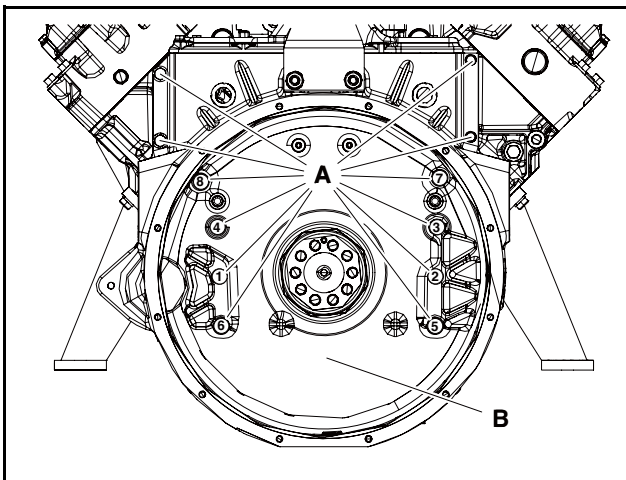
DV2213180A

- 1) Apply engine oil on the surface of the oil seal rotation contact.
- 2) Install the oil seal to the rear oil seal assembly jig(EF.120-029).
- 3) Align the rear oil seal assembly jig with the oil seal hole of the flywheel housing.
- 4) Attach the oil seal to the flywheel housing and beat the rear part of the rear oil seal assembly jig with a rubber hammer.
- 5) Pull off the rear oil seal assembly jig.

### **⚠ CAUTION**

- Be careful not to damage the oil seal.
- Do not reuse the oil seal.

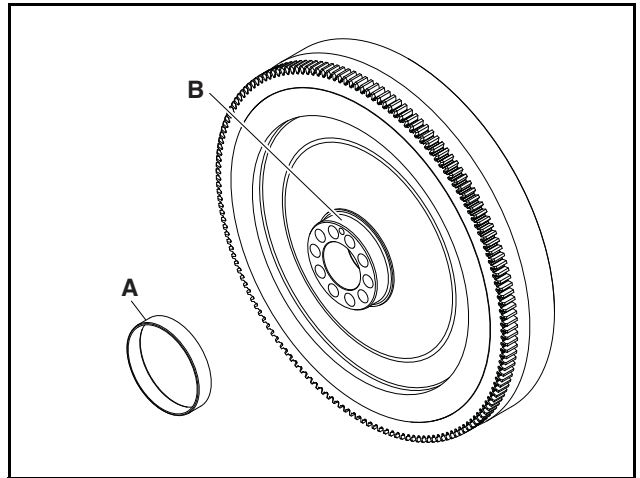
5. Attach the flywheel housing.



DV2213181A

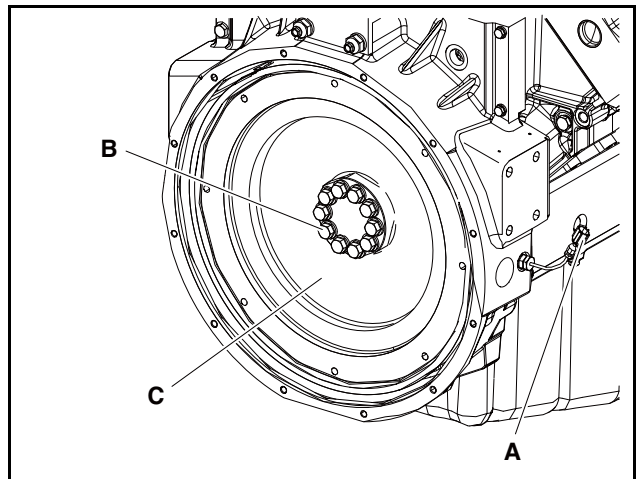
- 1) Attach the gasket.
- 2) Attach the flywheel housing(B).
- 3) Tighten 12 fixing bolts(A).

- 4) Tighten M12 fixing bolts(A) at a tightening torque of  $11.2 \pm 1.5$  kgf-m and M10 fixing bolts(A) at a tightening torque of  $7.4 \text{ kgf-m} \pm 1.0$  kgf-m.
6. Attach the flywheel wearing.



DV2213182A

- 1) Apply LOCTITE 271 on the flywheel surface with the thickness  $0.5 \text{ mm} \sim 1.0 \text{ mm}$ .
- 2) Heat the wearing at  $150 \pm 10^\circ\text{C}$  for above 5 minutes.
- 3) Attach the wearing(A) to the flywheel. Align the wearing end with the flywheel end.
7. Attach the flywheel.



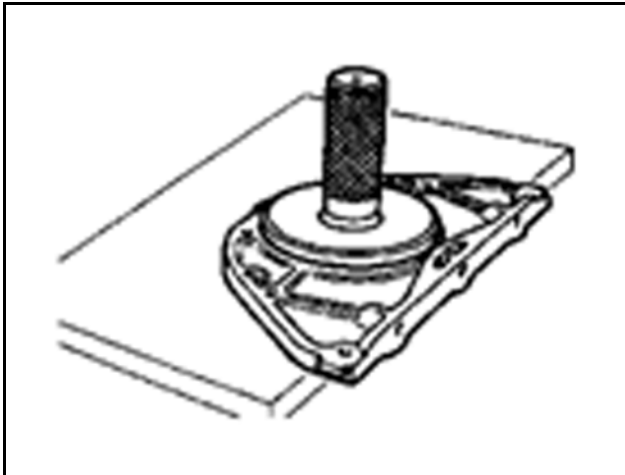
DV2213091A

- 1) Attach the flywheel(C).
- 2) Tighten 10 M16 hex bolts(B) at a tightening torque of  $10 \text{ kgf-m} + 90^\circ + 90^\circ$  by using the angle method.
- 3) Tighten the tachometer sensor(A) at a tightening torque  $1.5 \pm 0.5$  kgf-m.

Note) The clearance between the tachometer sensor and the flywheel is  $1.0 \pm 0.1 \text{ mm}$ .

## 5. About the engine

8. Attach the oil seal to the front oil seal cover.



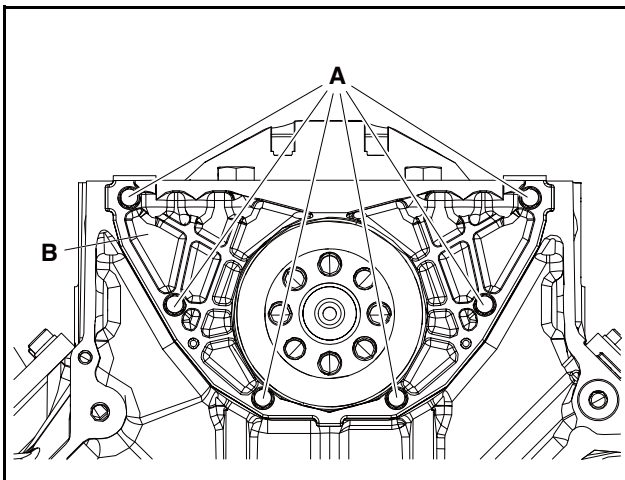
DV2213183A

- 1) Apply engine oil on the surface of the oil seal rotation contact.
- 2) Install the oil seal to the front oil seal assembly jig (EF.120-030).
- 3) Align the front oil seal assembly jig with the oil seal hole of the front oil seal cover.
- 4) Attach the oil seal to the front oil seal cover and beat the rear part of the front oil seal assembly jig with a rubber hammer.
- 5) Pull off the front oil seal assembly jig.

### CAUTION

- Be careful not to damage the oil seal.
- Do not reuse the oil seal.

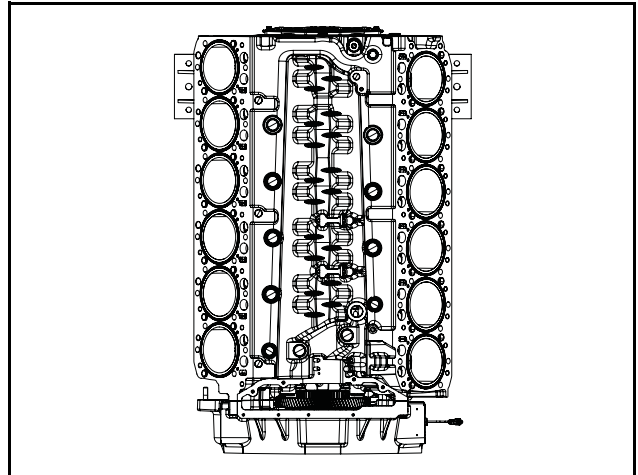
9. Attach the front oil seal cover.



DV2213090A

- 1) Attach the front oil seal cover(B).
- 2) Tighten 6 M8 fixing bolts(A) at a tightening torque 2.24 kgf·m.

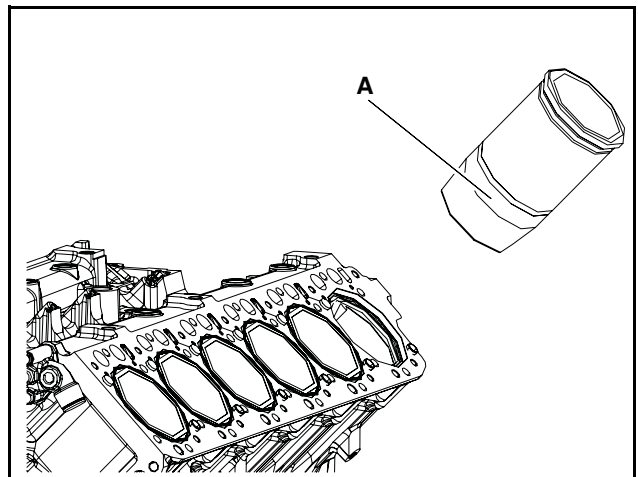
10. Change the engine position.



DV2213184A

- 1) Change the engine position. The flywheel direction is downward.

11. Attach the cylinder liner.

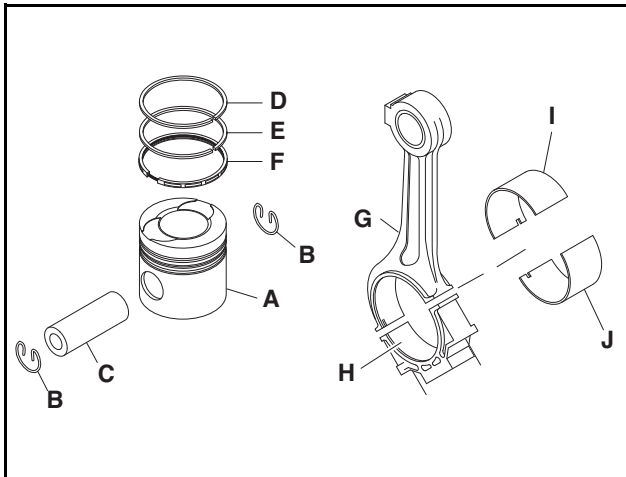


DV2213089A

- 1) Apply engine oil on the surface of the cylinder liner.
- 2) Attach the cylinder liner(A) to the cylinder block with the cylinder liner puller(EF.123-365).
- 3) Attach 12 cylinder liners as the same procedure.

## 5. About the engine

12. Attach the piston to the connecting rod.



DV2213177A

1) Install the 1st ring(D), 2nd ring(E), and the oil ring(F) with the piston ring plier(T7621010E).

### ⚠ CAUTION

- Ensure that the 'Y' mark of the piston ring faces the top surface of the piston.
- Make the piston ring position dislocated to 120°

2) Apply engine oil on the piston pin(C).

3) Align the pin hole of the connecting rod(G) small-end with that of the piston(A).

### ⚠ CAUTION

- The intake valve pocket is larger than the exhaust valve pocket.
- Attach the engine as the same piston weight. Place the Class of the piston weight on the top surface of the piston.

CLASS	Piston Weight(g)
A	2,371 ~ 2,380
B	2,381 ~ 2,390
C	2,391 ~ 2,400
D	2,401 ~ 2,410
E	2,411 ~ 2,420

4) Attach the piston pin(C).

### ⚠ CAUTION

Check the attached piston and piston ring. If the piston should be replaced, replace the piston pin along with the piston.

5) Attach 2 snap rings(B) with the snap ring plier (T7610001E).

### ⚠ CAUTION

- Do not reuse the snap rings.
- Assemble snap rings with the opening of the snap rings facing 12 o'clock.

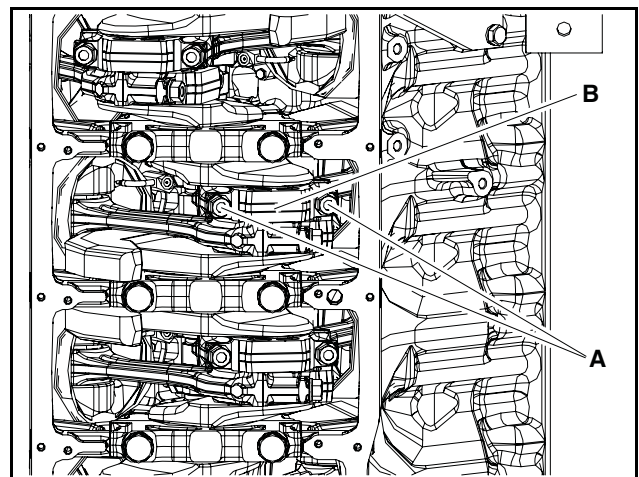
6) Align the upper bearing groove with connecting rod. Attach the upper connecting rod bearing(I) to the connecting rod(G).

7) Align the lower bearing groove with connecting rod. Attach the lower connecting rod bearing(J) to the connecting rod bearing cap(H).

### ⚠ CAUTION

- Be careful the direction when assembling the connecting rods and the connecting rod caps.
- Ensure that the marks of the connecting rod and the bearing cap are facing the same direction.

13. Attach the connecting rod and piston assembly.



DV2213088A

1) Attach the connecting rod and piston assembly to the cylinder block.

2) Attach the connecting rod cap(B).

3) Tighten 2 M16X1 flange hex bolts(A) at a tightening torque 10 kgf·m + 90° by using the angle method.

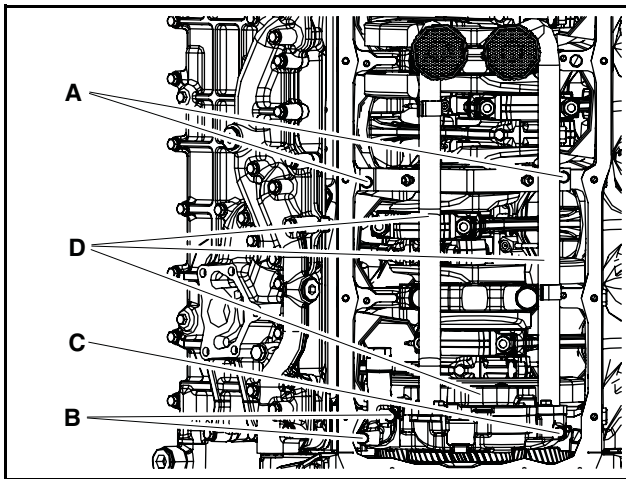
## 5. About the engine

- Attach 12 connecting rod and piston assembly as the same procedure.

### CAUTION

- Be careful to note the direction when attaching the connecting rods and the connecting rod caps. Ensure that the number engraved on the connecting rods is same with that engraved on the connecting rod caps and the assembly direction is same.
- Attach the connecting rod and piston assembly without contacting the crankshaft weight. Rotate the crankshaft.

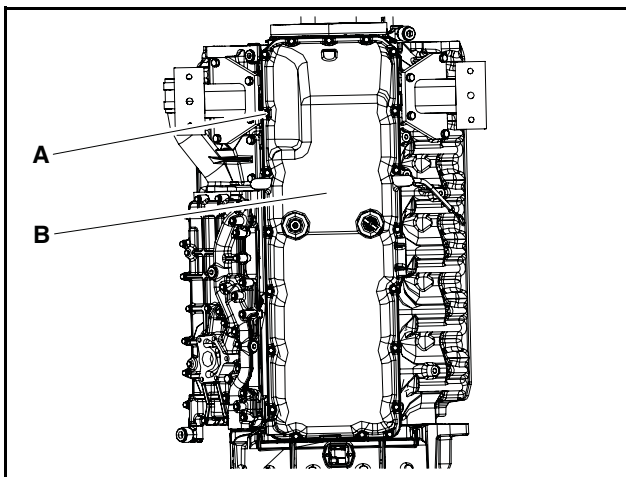
- Attach the oil suction pipe and the oil pump.



DV2213087A

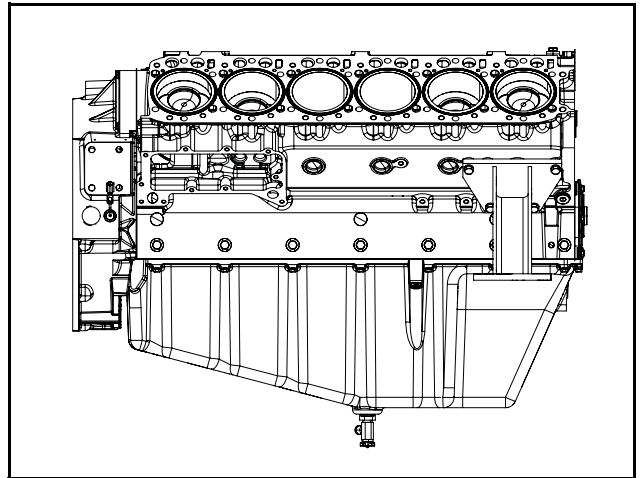
- Attach the oil suction pipe and the oil pump(D).
- Tighten M8 fixing bolt(C) at a tightening torque 2.2 kgf·m.
- Tighten 2 M8 fixing bolts(B) at a tightening torque 2.2 kgf·m.
- Tighten 2 M8 fixing bolt(A) at a tightening torque 2.2 kgf·m.

- Attach the oil pan.



DV2213086A

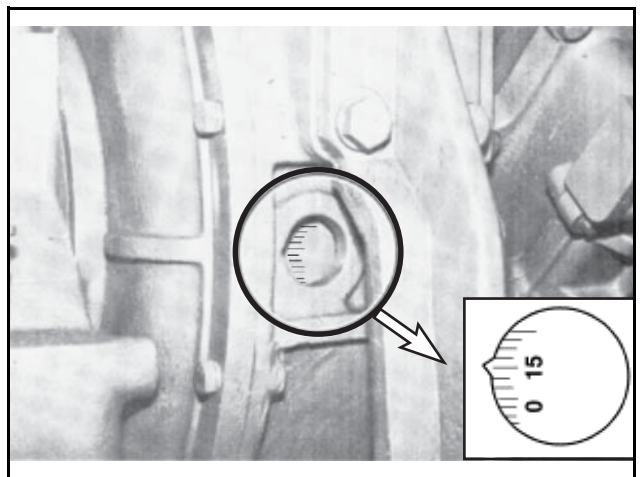
- Attach the oil pan(B).
  - Tighten 20 M8 fixing bolts(A) at a tightening torque 2.2 ±0.33 kgf·m.
- Change the engine position.



DV2213185A

- Change the engine position. The piston direction is upward.

- Adjust the fuel injection timing.



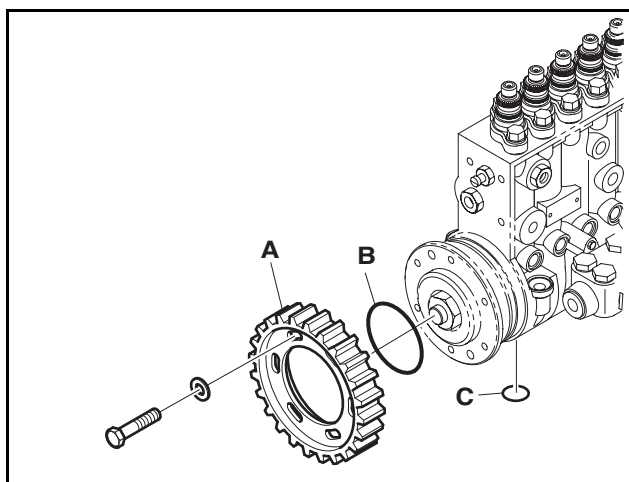
DV2213027A

- Rotate the crankshaft so that the #1 cylinder piston may be positioned at the top dead center(OT) and the #6 cylinder piston may be positioned at the valve overlap. Note) In case of 8/12 cylinder engine, #6. cylinder is positioned at the valve overlap when #1. cylinder is positioned at the compression TDC(Top Dead Center). Note) In case of 10 cylinder engine, #7. cylinder is positioned at the valve overlap when #1. cylinder is positioned at the compression TDC(Top Dead center).
- Rotate the crankshaft until the yellow mark of the camshaft gear is not shown.
- Adjust the fuel injection timing with rotating the flywheel to the engine rotating direction.

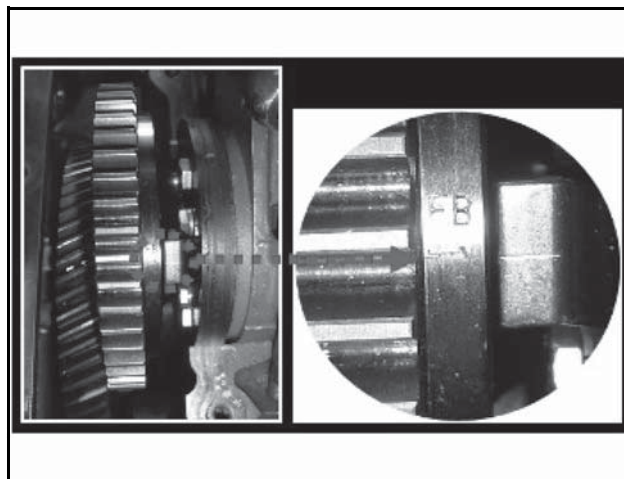
## 5. About the engine

Engine Model		Fuel Injection Timing (°)
DP158L	DP158LCS	25° ±1°
	DP158LCF	20° ±1°
	DP158LDS	25° ±1°
	DP158LDF	20° ±1°
DP180L	DP180LBS	21° ±1°
	DP180LBF	19° ±1°
	DP180LAS	21° ±1°
	DP180LAF	19° ±1°
DP222L	DP222LAS	23° ±1°
	DP222LBS	23° ±1°
	DP222LBF	21° ±1°
	DP222LCS	23° ±1°
	DP222LCF	21° ±1°

18. Attach the fuel injection driven gear temporarily.

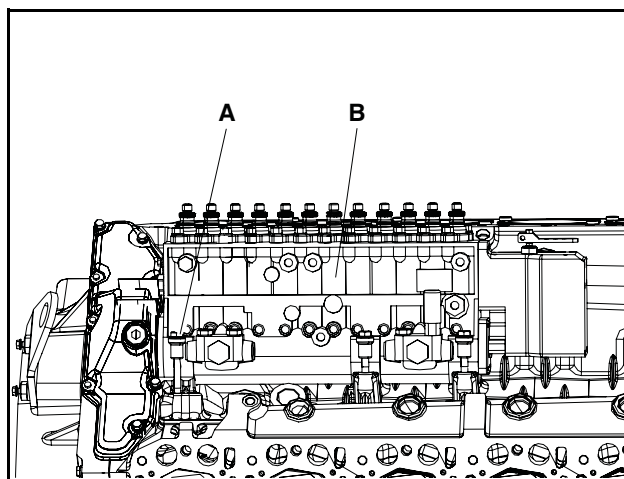


DV2213186A



DV2213171A

- 1) Attach the driven gear(A) to the fuel injection pump temporarily.
  - 2) Attach the O-ring(B) and (C) to the fuel injection pump.
  - 3) Align the injection timing pointer of the fuel injection pump driven gear with the marking on the cylindrical surface.
19. Attach the fuel injection pump.

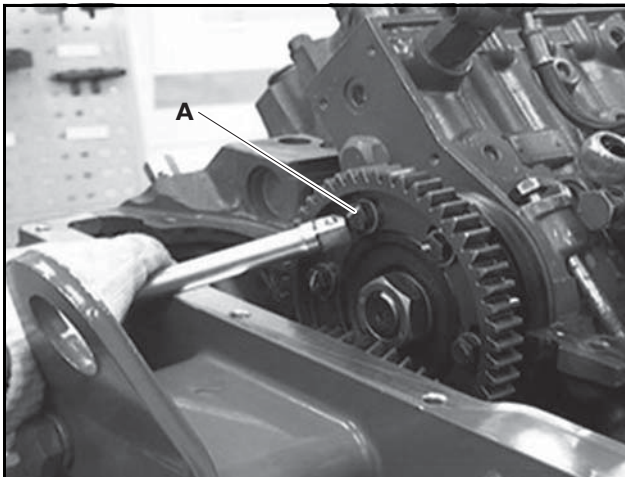


DV2213072A

- 1) Attach the fuel injection pump(B) with the injection pump alignment jig(EF.120-189).
- 2) Tighten 6 fixing bolts(A) at a tightening torque 5.0 ±0.5 kgf-m.

## 5. About the engine

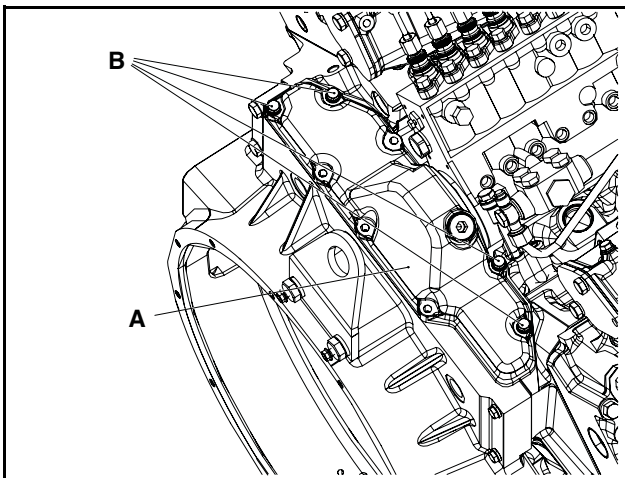
20. Attach the fuel injection pump driven gear.



DV2213187A

- 1) Tighten 3 M8 fixing bolts(A) of the fuel injection pump driven gear at a tightening torque  $3.1 \pm 0.46$  kgf·m.
- 2) Rotate the fuel injection pump driven gear  $360^\circ$  with rotating flywheel.
- 3) Tighten 3 the other M8 fixing bolts(A) of the fuel injection pump driven gear at a tightening torque  $3.1 \pm 0.46$  kgf·m.

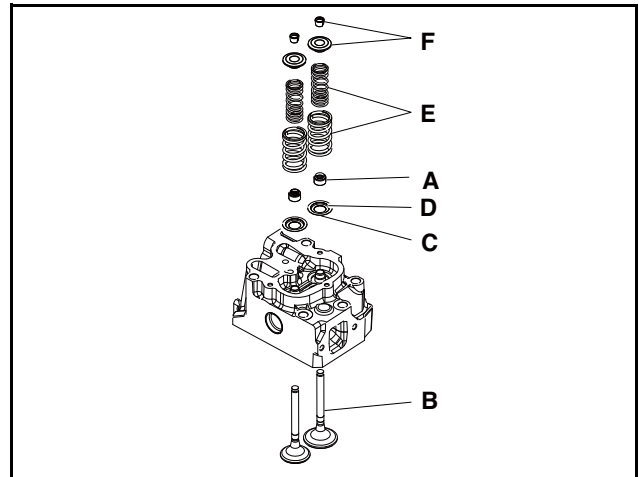
21. Attach the flywheel housing cover.



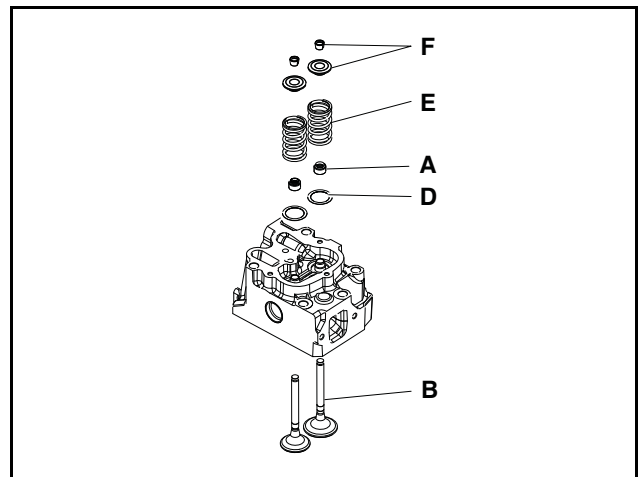
DV2213188A

- 1) Attach the flywheel housing cover(A).
- 2) Tighten 4 M8 fixing bolts(B) at a tightening torque  $2.2 \pm 0.3$  kgf·m.

22. Attach the cylinder head.



DV2213189A



EDV2218001

- 1) Attach the outer washer(D).
- 2) Attach the valve stem seal(A) with the valve stem seal punch(EF.120-183).

### CAUTION

**Do not give an excessive shock on the valve stem seals; otherwise, they may be damaged.**

- 3) Attach the valve(B).

### CAUTION

**Be careful to use the right valve without confusing the intake valve with the exhaust valve. The intake valve is the mark " I " engraved on the head and the exhaust valve is the mark " E " engraved on the head.**

## 5. About the engine

- 4) Attach the valve spring(E).

### CAUTION

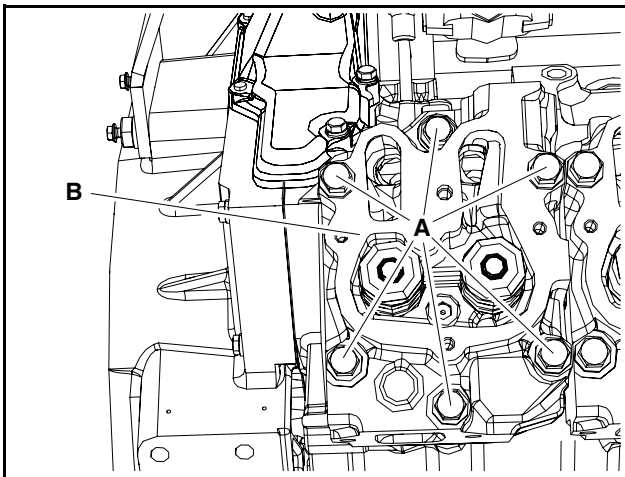
Be careful the valve direction. Install the valve spring seat with “TOP” (painted in Dual Spring - Yellow / Single Spring - Red) side up.

- 5) Compress the valve with the valve spring press (EF.120-262).
- 6) Attach the valve cotters(F).

### CAUTION

Check if the valve cotters have been positioned correctly with the plastic hammer after completing attaching them.

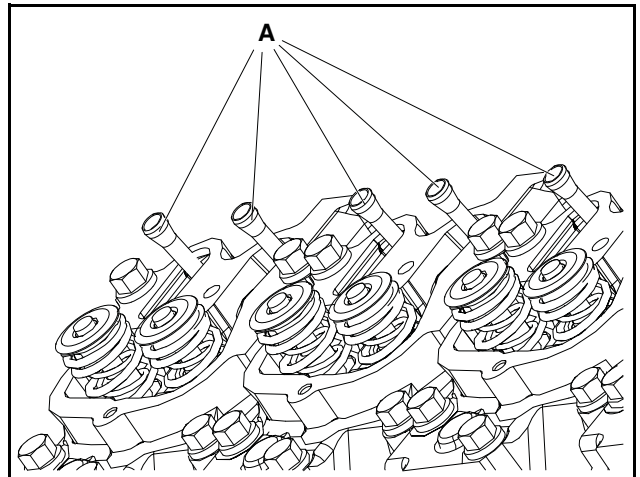
23. Attach the cylinder head assembly.



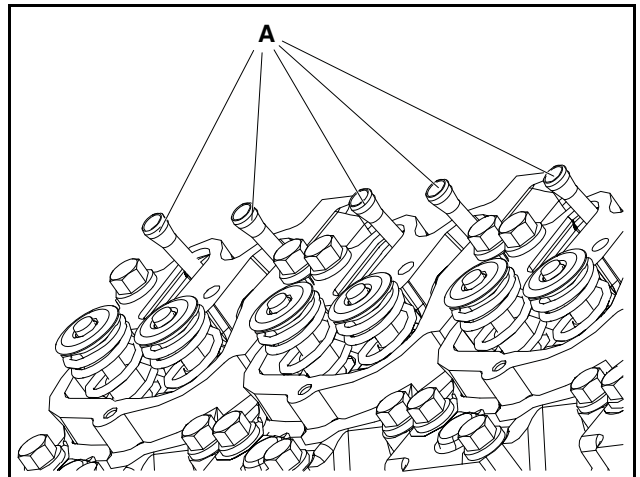
DV2213077A

- 1) Attach the gasket assembly.
- 2) Attach the cylinder head assembly(B).
- 3) Tighten 6 cylinder head fixing bolts(A) at a tightening torque  $8 \text{ kgf}\cdot\text{m} + 15 \text{ kgf}\cdot\text{m} + 90^\circ + 90^\circ$  by using the angle method.
- 4) Attach 12 cylinder head assembly as the same procedure.

24. Attach the push rods.

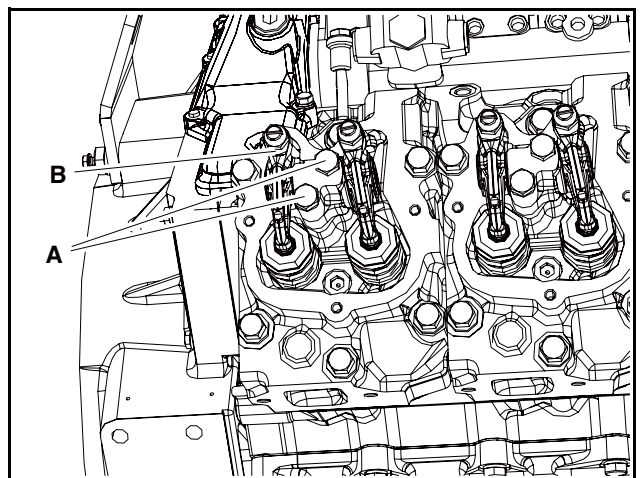


DV2213076A



EDV2218002

- 1) Attach 24 push rods(A).
25. Attach the rocker arm assembly.

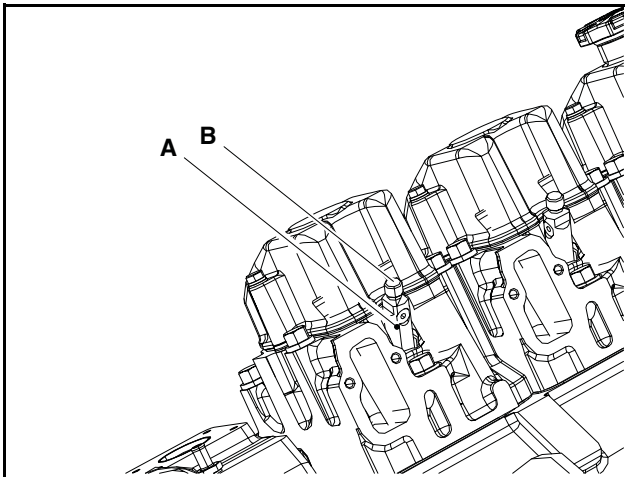


DV2213075A

- 1) Attach the rocker arm assembly(B).
- 2) Tighten the fixing bolts(A).
- 3) Attach 12 rocker arms as the same procedure.

## 5. About the engine

26. Attach the injectors.



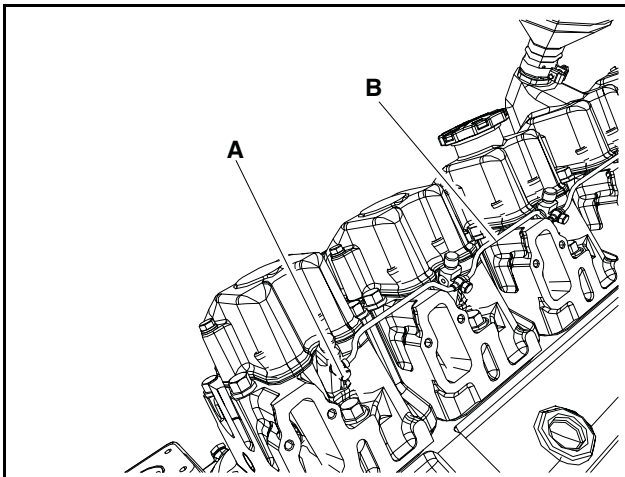
DV2213073A

- 1) Attach the seal ring and then attach the injector (A).
- 2) Tighten the injector holder fixing nut with the jig for injection nozzle detach (60.99901-0036).
- 3) Attach 12 injectors as the same procedure.

### CAUTION

**Be careful not to damage the fuel pipes.**

27. Attach the fuel return pipe.



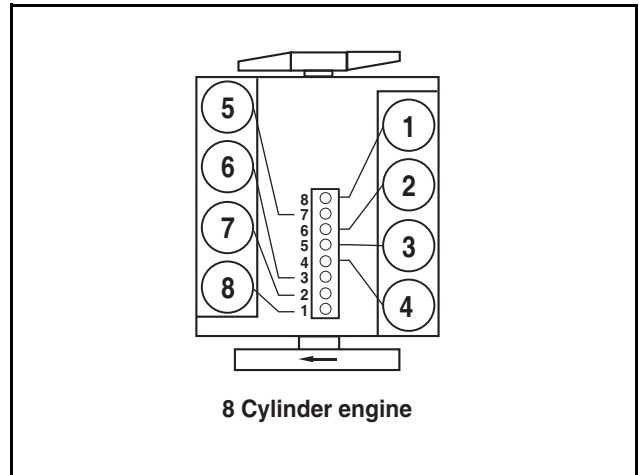
DV2213069A

- 1) Attach the fuel return pipe (B).
  - 2) Attach the double seal ring.
  - 3) Tighten the hollow screw (A) at a tightening torque  $0.8 \pm 0.12$  kgf-m.
  - 4) Attach the other fuel return pipe as the same procedure.
28. Adjust the valve clearance. (Method 1)

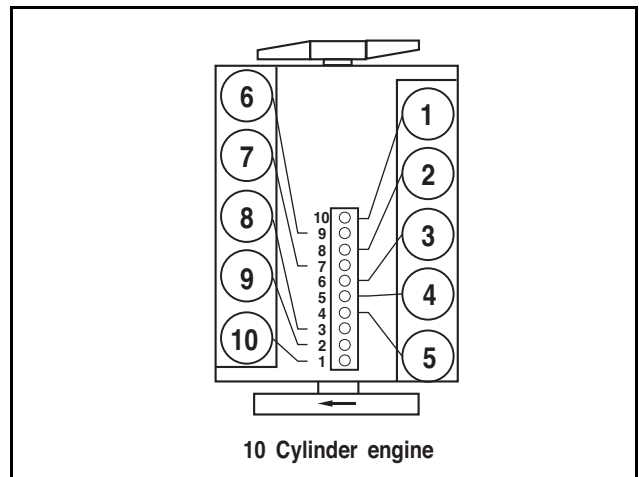
- 1) Rotate the crankshaft so that #1. cylinder may be positioned at the compression TDC (Top Dead Center).
- Note) #1. Cylinder is located at the side where cooling water pump was installed.

Note) In case of 8/12 cylinder engine, #6. cylinder is positioned at the valve overlap when #1. cylinder is positioned at the compression TDC (Top Dead Center).

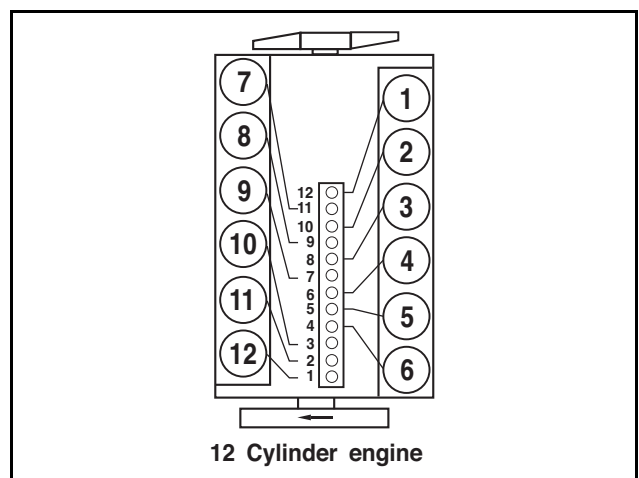
Note) In case of 10 cylinder engine, #7. cylinder is positioned at the valve overlap when #1. cylinder is positioned at the compression TDC (Top Dead center).



DV2213042A



DV2213213A

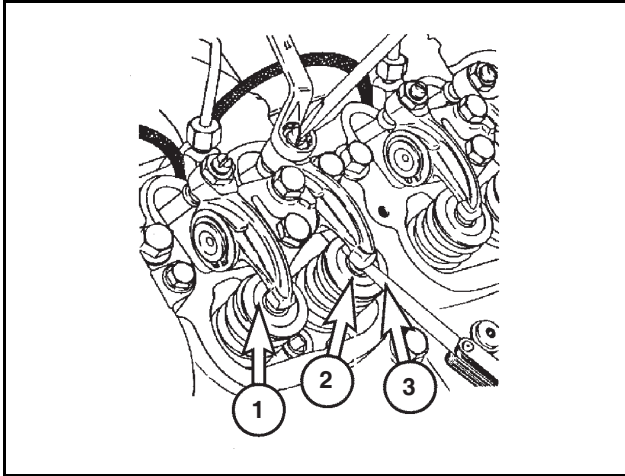


DV2213043A

- 2) Loosen the lock nut of the #1. cylinder rocker arm.

## 5. About the engine

- 3) Push the feeler gauge between a rocker arm and a valve stem.
- 4) Adjust the clearance screw respectively and then tighten with the lock nut.



DV2213041A

- 5) As for the valve clearance, adjust it when in cold, as follows.

Specified value		Measurement tolerance	
In. valve	Ex. valve	In. valve	Ex. valve
0.25 mm	0.35 mm	±0.05 mm	

- 6) Rotate the crankshaft. When a cylinder reaches the compression TDC (Top Dead Center), adjust the valve clearance of the cylinder.
- 7) When a cylinder valve overlap, adjust the valve clearance cylinder of the compression TDC (Top Dead Center), as follow.

- 8 cylinder engine (DP158L)

Valve overlap cylinder No.							
1	5	7	2	6	3	4	8
6	3	4	8	1	5	7	2
Adjusting valve cylinder No. (In./Ex. Valve)							

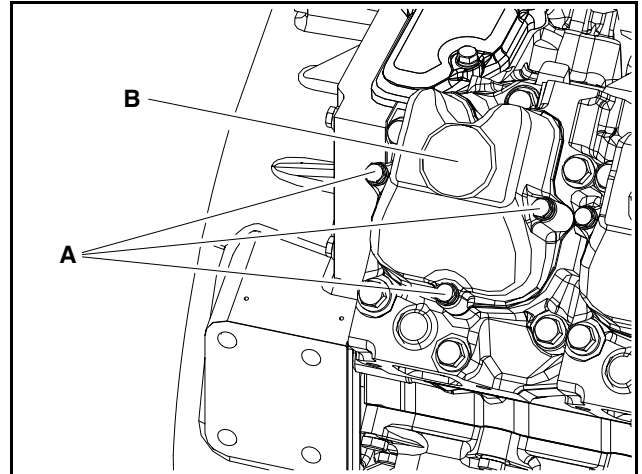
- 10 cylinder engine (DP180L)

Valve overlap cylinder No.									
1	6	5	10	2	7	3	8	4	9
7	3	8	4	9	1	6	5	10	2
Adjusting valve cylinder No. (In./Ex. Valve)									

- 12cylinder engine (DP222L)

Valve overlap cylinder No.											
1	12	5	8	3	10	6	7	2	11	4	9
6	7	2	11	4	9	1	12	5	8	3	10
Adjusting valve cylinder No. (In./Ex. Valve)											

29. Attach the cylinder head cover.



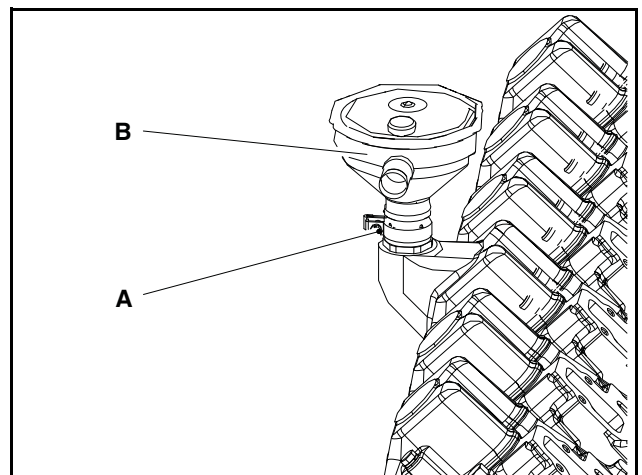
DV2213074A

- 1) Attach the cylinder head cover (B).
- 2) Tighten 3 fixing bolts (A) at a tightening torque 2.2 ±0.33 kgf-m.

### CAUTION

**#3 and #4 cylinder head covers have the breather. #10 cylinder head cover has the oil filler cap. the others are the same cylinder head cover.**

30. Attach the breather.

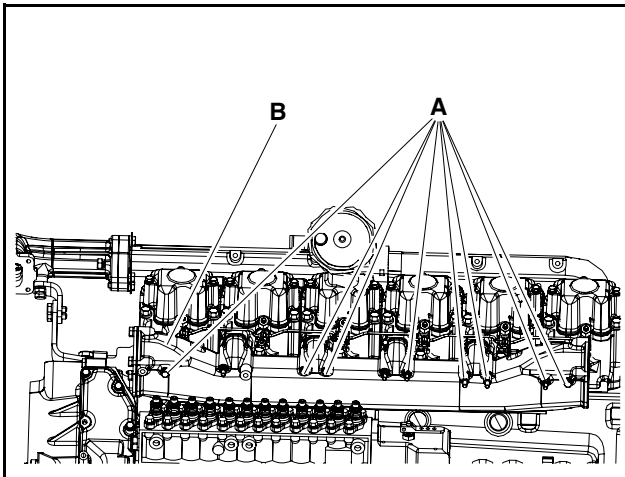


DV2213096A

- 1) Attach the breather (B).
- 2) Tighten the clamp.
- 3) Attach the other breather as the same procedure.

## 5. About the engine

31. Attach the intake manifold.



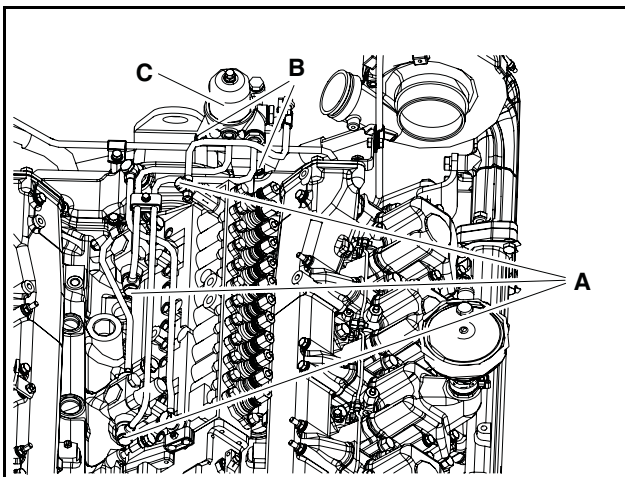
DV2213066A

- 1) Attach the intake manifold(B).
- 2) Tighten the fixing bolts(A) by hand temporarily.
- 3) Tighten the fixing bolts(A) at a tightening torque  $2.2 \pm 0.33$  kgf-m.
- 4) Attach the other intake manifold as the same procedure.

### CAUTION

- Be careful not to let dust inside the engine.
- Be careful not to mix the fixing bolts.

32. Attach the fuel pre filter.



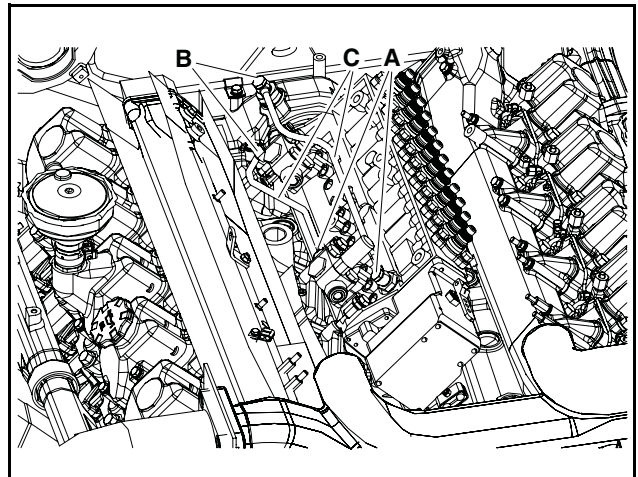
DV2213065A

- 1) Attach the fuel return pipe and fuel pre filter(C).
- 2) Tighten the fixing bolts(B) at a tightening torque  $2.2 \pm 0.33$  kgf-m.
- 3) Tighten the hollow screw(A) at a tightening torque  $1.2 \pm 0.14$  kgf-m.

### CAUTION

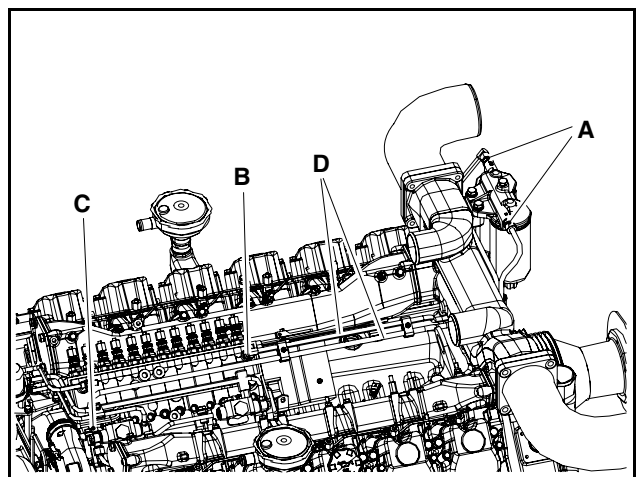
Be careful not to damage the fuel pipes.

33. Attach the fuel and oil hose.



DV2213070A

- 1) Attach the fuel and oil hose(C).
  - 2) Tighten the hollow screw(B) at a tightening torque  $1.8 \pm 0.27$  kgf-m.
  - 3) Tighten the fixing bolts(A) at a tightening torque  $1.8 \pm 0.27$  kgf-m.
34. Attach the fuel pipe.



DV2213068A

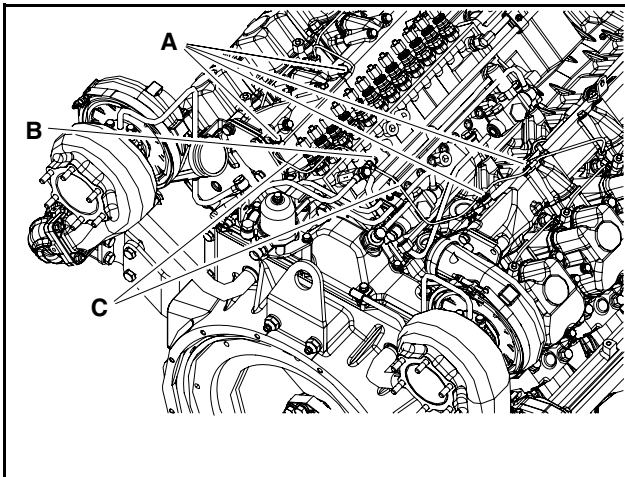
- 1) Attach the fuel pipe(D).
- 2) Tighten the fixing nut(B) and (C) at a tightening torque  $5.5 \pm 0.825$  kgf-m.
- 3) Tighten the fixing nut(A) at a tightening torque  $5.5 \pm 0.825$  kgf-m.

### CAUTION

Be careful not to damage the fuel pipes.

## 5. About the engine

35. Attach the fuel pipe.



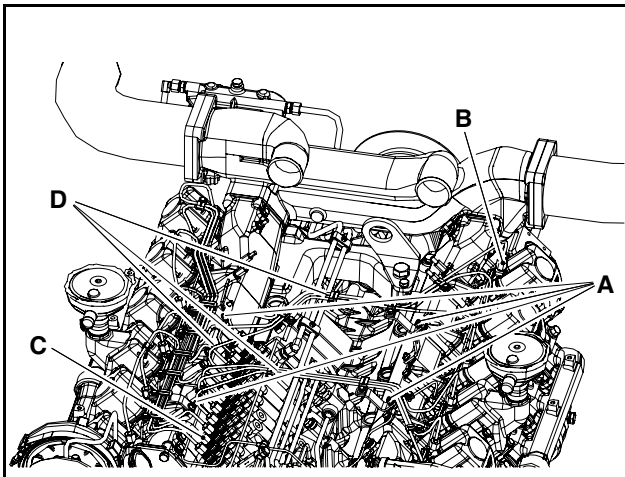
DV2213067A

- 1) Attach the fuel pipe(C).
- 2) Tighten the hollow screw(B) at a tightening torque  $1.2 \pm 0.14$  kgf·m.
- 3) Tighten the fixing bolt(A) at a tightening torque  $2.2 \pm 0.33$  kgf·m.

### ⚠ CAUTION

- Be careful not to lose the O-ring.
- Be careful not to damage the fuel pipes.

36. Attach the fuel injection pipe.



DV2213064A

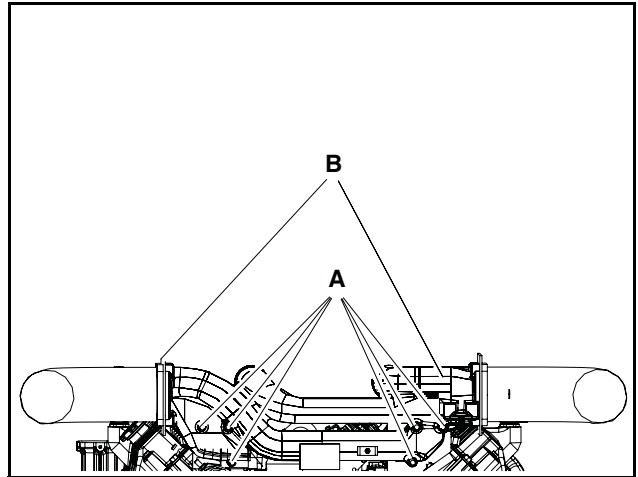
- 1) Attach 3 fuel injection pipe assemblies(D).
- 2) Attach the fuel pipe nut temporarily.
- 3) Tighten 12 fuel pipe nuts(A) of the injection pump at a tightening torque  $5.5 \pm 0.825$  kgf·m.
- 4) Tighten 12 fuel pipe nuts(A) of the injector at a tightening torque  $5.5 \pm 0.825$  kgf·m.

5) Tighten the fixing bolt(A).

### ⚠ CAUTION

- Be careful not to damage the fuel pipes.
- Be careful not to let dust inside the engine.

37. Attach the inlet pipe.



DV2213063A

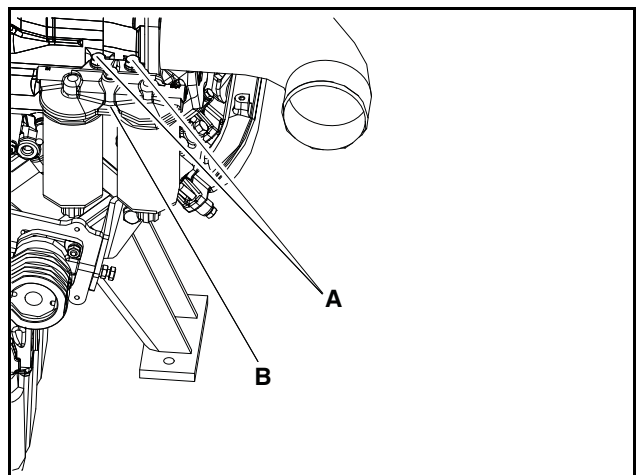
- 1) Attach the inlet pipe(B).
- 2) Tighten the fixing bolt(A) at a tightening torque  $4.4 \pm 0.66$  kgf·m.

Note) Tighten the fixing bolts to attach the inlet elbow and the inlet pipe at a tightening torque  $2.2 \pm 0.33$  kgf·m.

### ⚠ CAUTION

Be careful not to let dust inside the engine.

38. Attach the fuel filter.

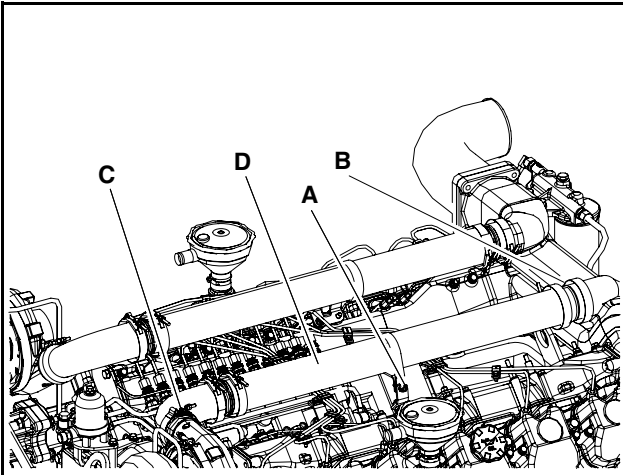


DV2213062A

- 1) Attach the fuel filter assembly(B).
- 2) Tighten the fixing bolt(A) at a tightening torque  $7.5 \pm 1.12$  kgf·m.

## 5. About the engine

39. Attach the intake stake.



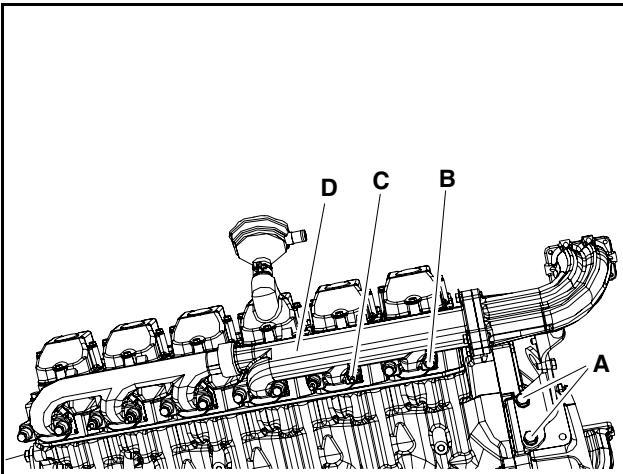
DV2213061A

- 1) Attach the intake stake(D).
- 2) Tighten the V-clamp(C).
- 3) Tighten the hose clamp(B).
- 4) Tighten the fixing bolt(A) at a tightening torque  $2.2 \pm 0.33$  kgf·m.
- 5) Attach the other intake stake as the same procedure.

### **⚠ CAUTION**

**Be careful not to let dust inside the engine.**

40. Attach the exhaust manifold and exhaust elbow.



DV2213060A

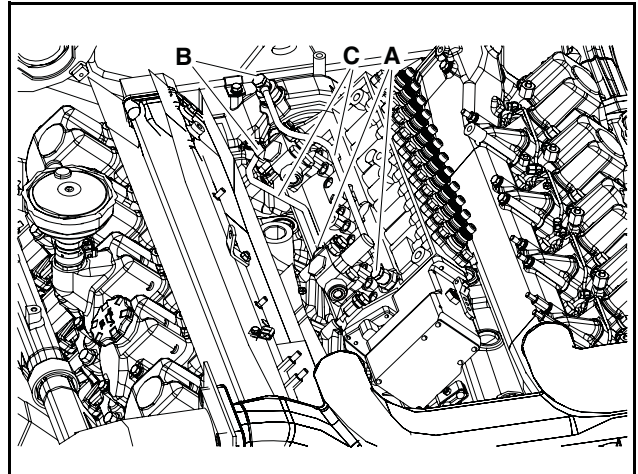
- 1) Attach the exhaust manifold and exhaust elbow assembly(D).
- 2) Tighten 8 fixing bolts(B) and 4 fixing bolts(C) at a tightening torque  $7.0 \pm 1.05$  kgf·m.
- 3) Tighten the exhaust elbow bracket fixing bolts(A) at a tightening torque  $20.0 \pm 1.5$  kgf·m.
- 4) Attach the other exhaust manifold and exhaust elbow assembly as the same procedure.

Note) Tighten the fixing bolts to attach the exhaust manifold and the elbow bracket at a tightening torque  $8.0 \pm 0.5$  kgf·m

### **⚠ CAUTION**

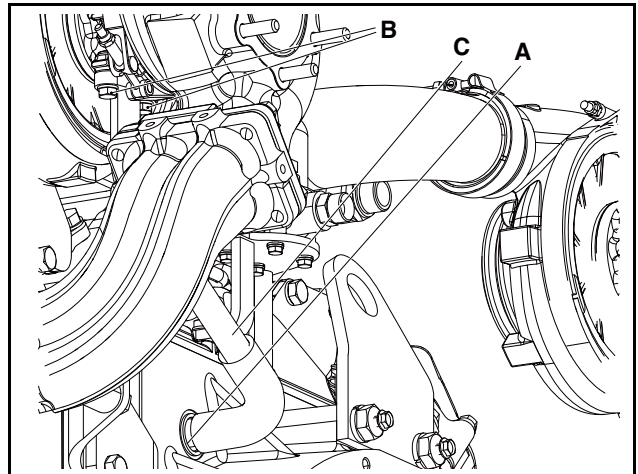
**Be careful not to mix the fixing bolts.**

41. Attach the turbocharger.



DV2213070A

- 1) Attach the turbocharger(B).
  - 2) Tighten 4 fixing bolts(A).
  - 3) Attach the other turbocharger as the same procedure.
42. Attach the oil return pipe.

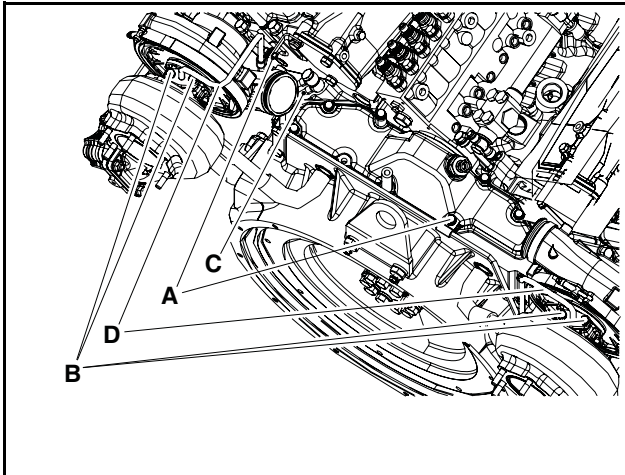


DV2213169A

- 1) Attach the oil return pipe(C).
- 2) Tighten 2 fixing bolts(B).
- 3) Tighten the clamp.
- 4) Attach the other turbocharger as the same procedure.

## 5. About the engine

43. Attach the oil delivery pipe.



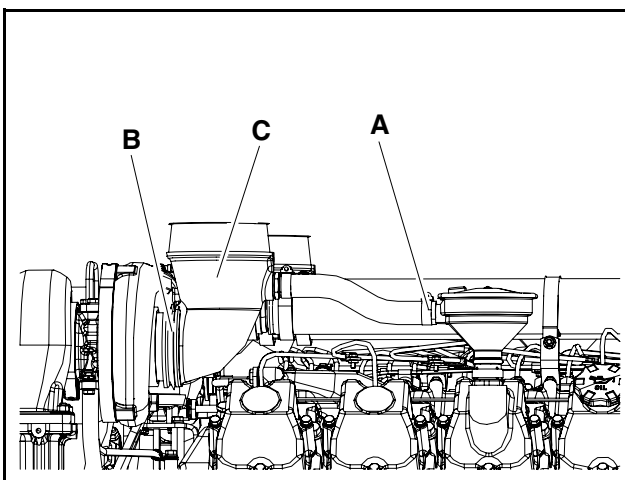
DV2213058A

- 1) Attach the oil delivery pipe(D).
- 2) Attach the hollow screw(C).
- 3) Tighten the oil delivery pipe fixing bolts(B) at a tightening torque  $2.2 \pm 0.33$  kgf·m.
- 4) Tighten the oil delivery pipe fixing bracket bolts(A) at a tightening torque  $2.2 \pm 0.33$  kgf·m.

### **⚠ CAUTION**

**Make sure that the O-rings and the gaskets have been attached.**

44. Attach the inlet elbow.



DV2213057A

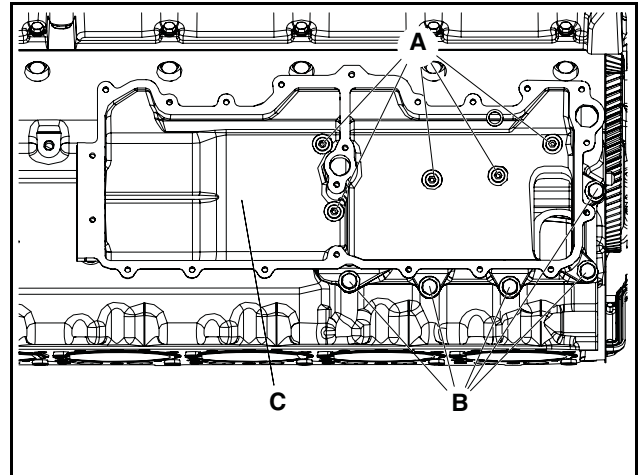
- 1) Attach the inlet elbow(C).
- 2) Tighten the V-clamp(B).
- 3) Tighten the hose clamp(A).

4) Attach the other inlet elbow as the same procedure.

### **⚠ CAUTION**

**Make sure that the O-ring and the insert parts have been attached.**

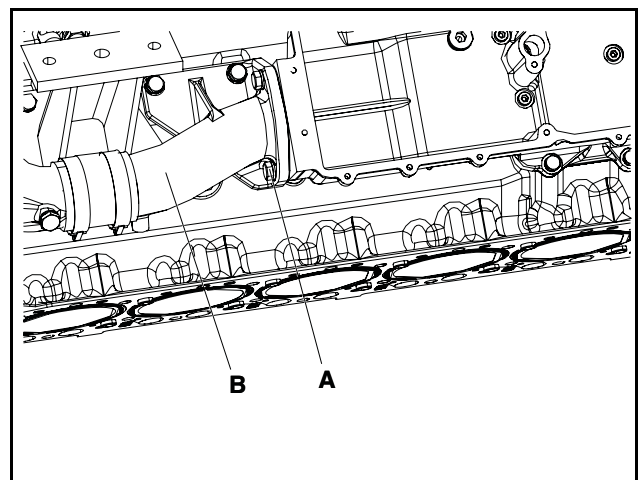
45. Attach the oil cooler housing.



DV2213085A

- 1) Attach the oil cooler housing(C).
- 2) Tighten 5 M10 outer fixing bolts(B) at a tightening torque 6.2 kgf·m.
- 3) Apply LOCTITE 262 on the M10 inner socket bolts(A).
- 4) Tighten 5 M10 inner socket bolts(A) at a tightening torque 6.2 kgf·m.

46. Attach the cooling water pipe.

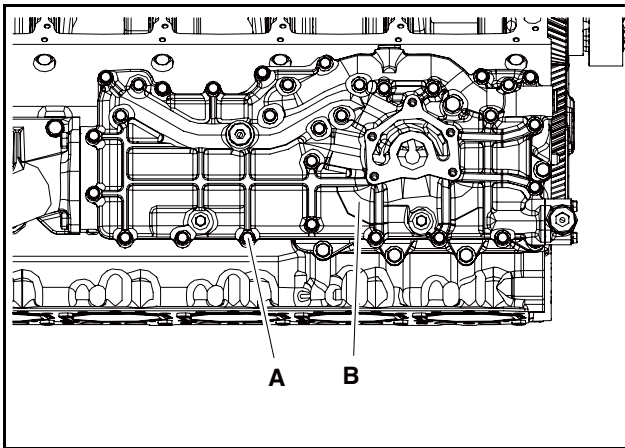


DV2213084A

- 1) Attach the cooling water pipe(B).
- 2) Tighten 4 fixing bolts(A) at a tightening torque  $8.0 \pm 1.2$  kgf·m.

## 5. About the engine

47. Attach the oil cooler cover.



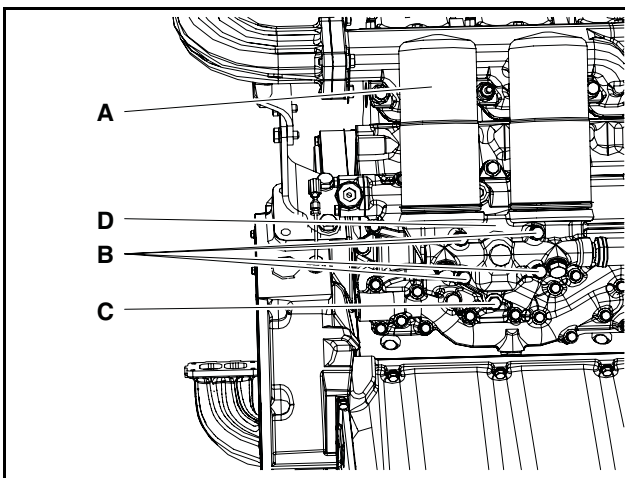
DV2213083A

- 1) Attach the oil cooler and the oil cooler cover(B).
- 2) Tighten 20 M8 fixing bolts(A) at a tightening torque 3.1 kgf·m.

### CAUTION

**Make sure that the gaskets have been attached.**

48. Attach the oil filter assembly.



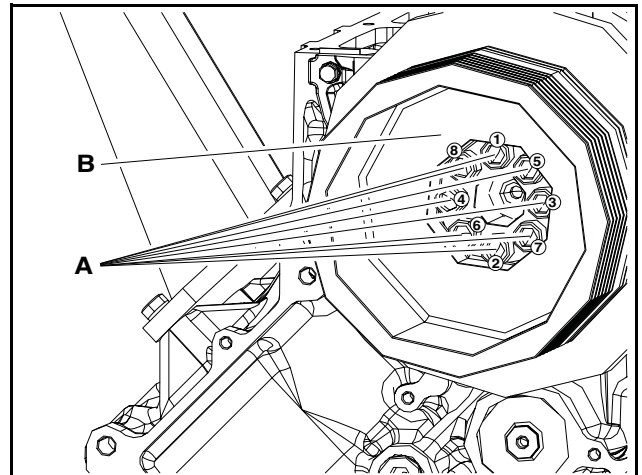
DV2213082A

- 1) Attach the oil filter housing(D).
- 2) Tighten the fixign bolts(B) and (C).
- 3) Attach the oil filter(A) with the chain plier(EF.200-038).

### CAUTION

- **Make sure that the gaskets have been attached.**
- **Be careful not to run down oil.**

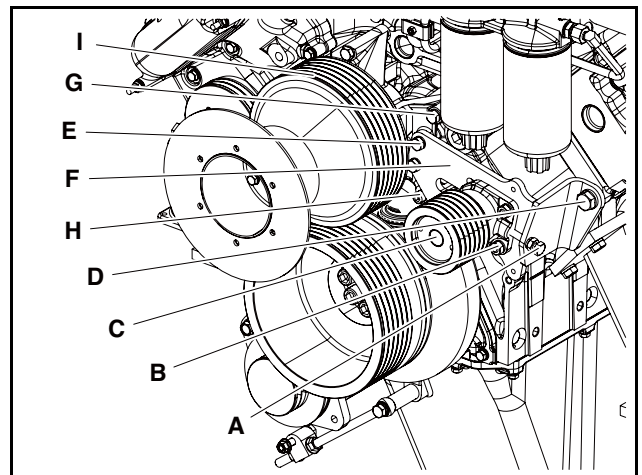
49. Attach the crankshaft pulley.



DV2213190A

- 1) Attach the crankshaft pulley(B).
- 2) Tighten 8 M16 stud head bolts(A) at a tightening torque 21.0 ±1.0 kgf·m.

Note) Tighten the stud head bolts in the order from (1) ~ (8).  
50. Attach the cooling fan pulley and the idle pulley.



DV2213174A

- 1) Attach the cooling fan pulley assembly(I).
- 2) Tighten 3 fixing bolts(G) and 1 socket bolt(H) at a tightening torque 4.4 ±0.33 kgf·m.
- 3) Fix the cooling fan pulley using the jig.
- 4) Tighten 1 cooling fan fixing bolt at a tightening torque 20 kgf·m.
- 5) Attach the idle pulley bracket(F).
- 6) Tighten 3 fixing bolts(G) and 1 socket bolt(H) at a tightening torque 4.4 ±0.33 kgf·m.
- 7) Tighten 1 fixing bolt(D).
- 8) Attach the idle pulley(C).

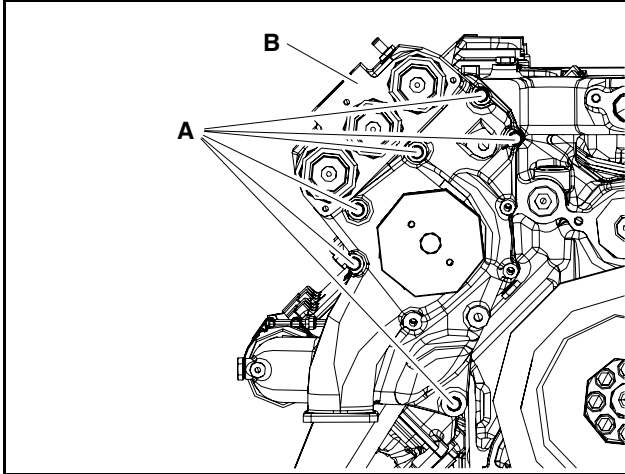
## 5. About the engine

- 9) Tighten 1 fixing bolt(A) and 2 fixing nuts(B).

### **⚠ CAUTION**

**Make sure that the cooling fan pulley can be rotated after attaching.**

51. Attach the water pump.



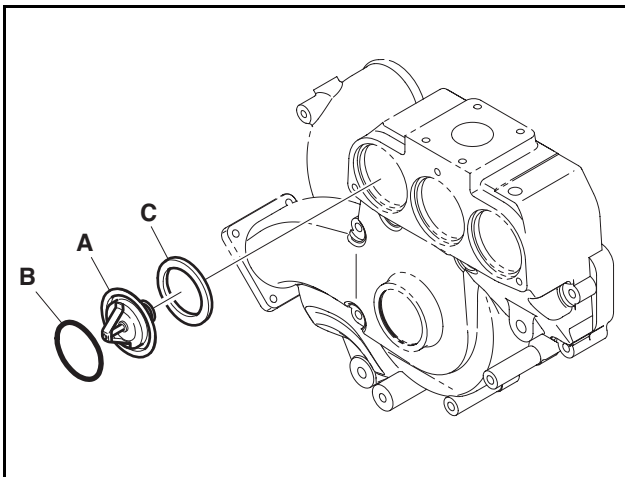
DV2213097A

- 1) Attach the water pump assembly(B).
- 2) Tighten 16 fixing bolts(A).

### **⚠ CAUTION**

**Be careful not to mix the fixing bolts each other.**

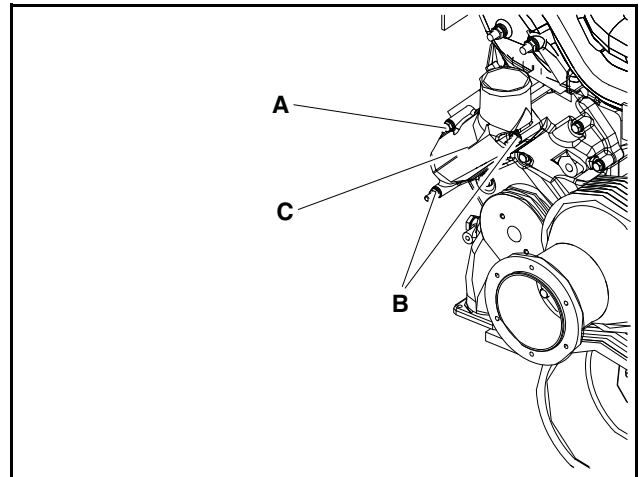
52. Attach the thermostat.



DV2213172A

- 1) Attach the gasket(C).
- 2) Attach the thermostat(A).
- 3) Attach the o-ring(B).
- 4) Attach 3 thermostats as the same procedure.

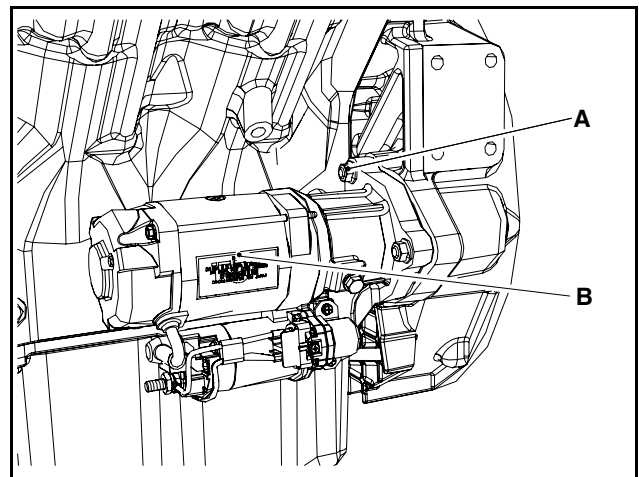
53. Attach the cooling water pipe.



DV2213078A

- 1) Attach the cooling water pipe(C).
- 2) Tighten the fixing bolts(A) and nuts(B) at a tightening torque  $2.2 \pm 0.33$  kgf-m.

54. Attach the starter.

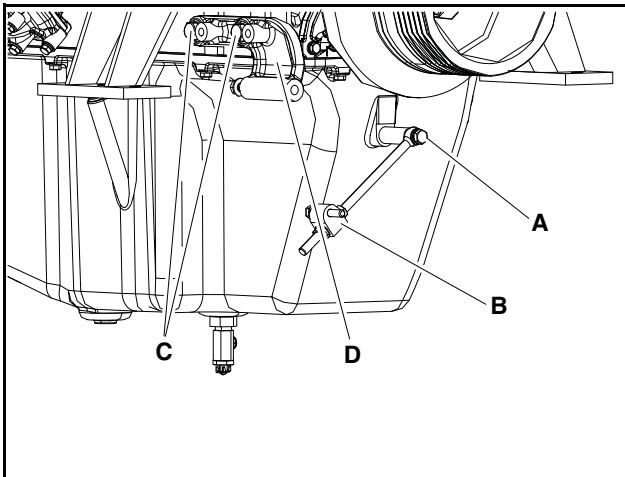


EDV2223005

- 1) Attach the starter(B).
- 2) Tighten 3 fixing bolts(A) at a tightening torque  $4.4 \pm 1.2$  kgf-m.

## 5. About the engine

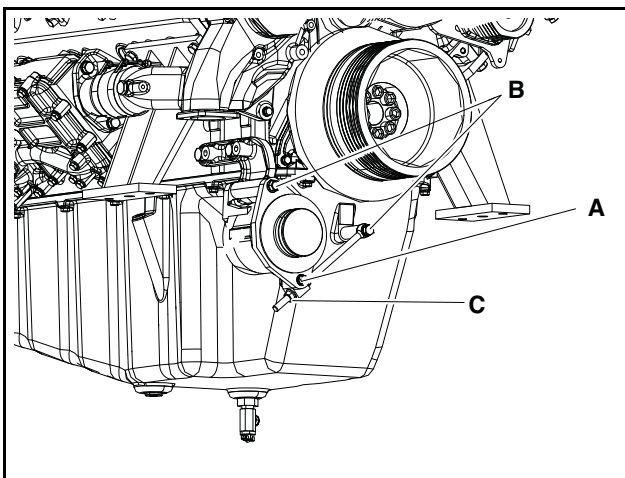
55. Attach the alternator bracket.



DV2213056A

- 1) Attach the alternator(D).
- 2) Tighten the fixing bolts(C) at a tightening torque  $7.0 \pm 0.5$  kgf·m.
- 3) Attach the eyebolt(B).
- 4) Tighten the fixing bolt(A) at a tightening torque  $2.2 \pm 0.33$  kgf·m.

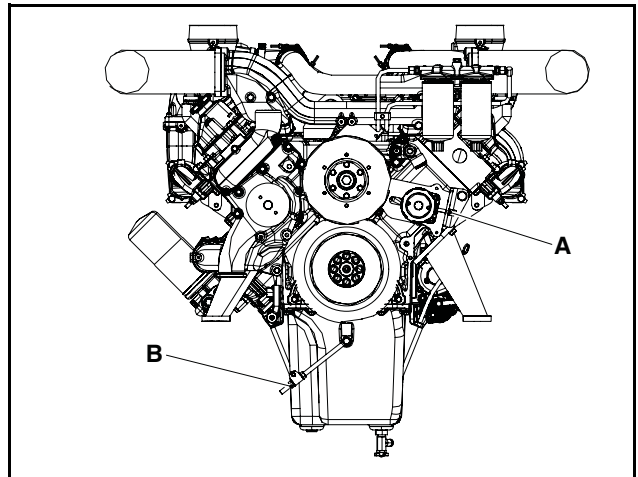
56. Attach the alternator.



DV2213055A

- 1) Attach the alternator(C).
- 2) Tighten the fixing bolt(B).
- 3) Tighten the fixing nut(A) at a tightening torque  $2.2 \pm 0.33$  kgf·m.

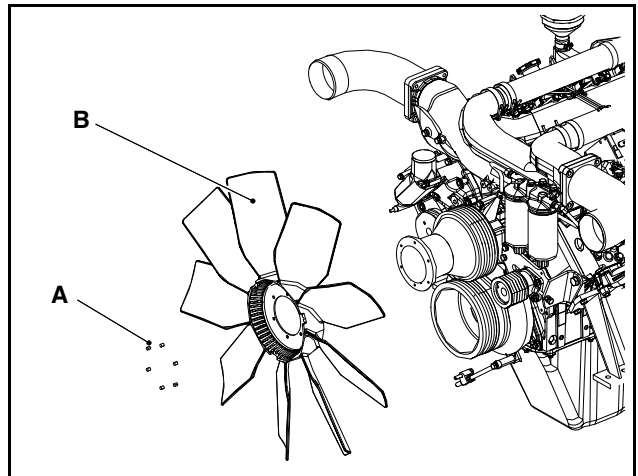
57. Adjust the tension after attaching the V-belt.



DV2213054A

- 1) Attach the V-belt and then adjust the tension with turning the adjusting nut(B).
- 2) Attach the V-belt and then adjust the tension with turning the adjusting nut(A).

58. Attach the cooling fan.



DV2213052A

- 1) Attach the cooling fan(B).
- 2) Tighten 6 fixing bolts(A).

59. Inject the coolant.

- 1) The mixing ratio for the engine coolant is 40% antifreeze and 3~5% additives (DCA4) to prevent corrosion.
- 2) Add the coolant of the correct mixing ratio.

### CAUTION

**Use coolant recommended by HD Hyundai Infracore.**

## 5. About the engine

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60. Add the engine oil.

1) Add our recommended genuine oil to replenish the oil level.

---

 **CAUTION**

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**Use genuine engine oil recommended by HD Hyundai Infracore.**

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# 6. Cooling system

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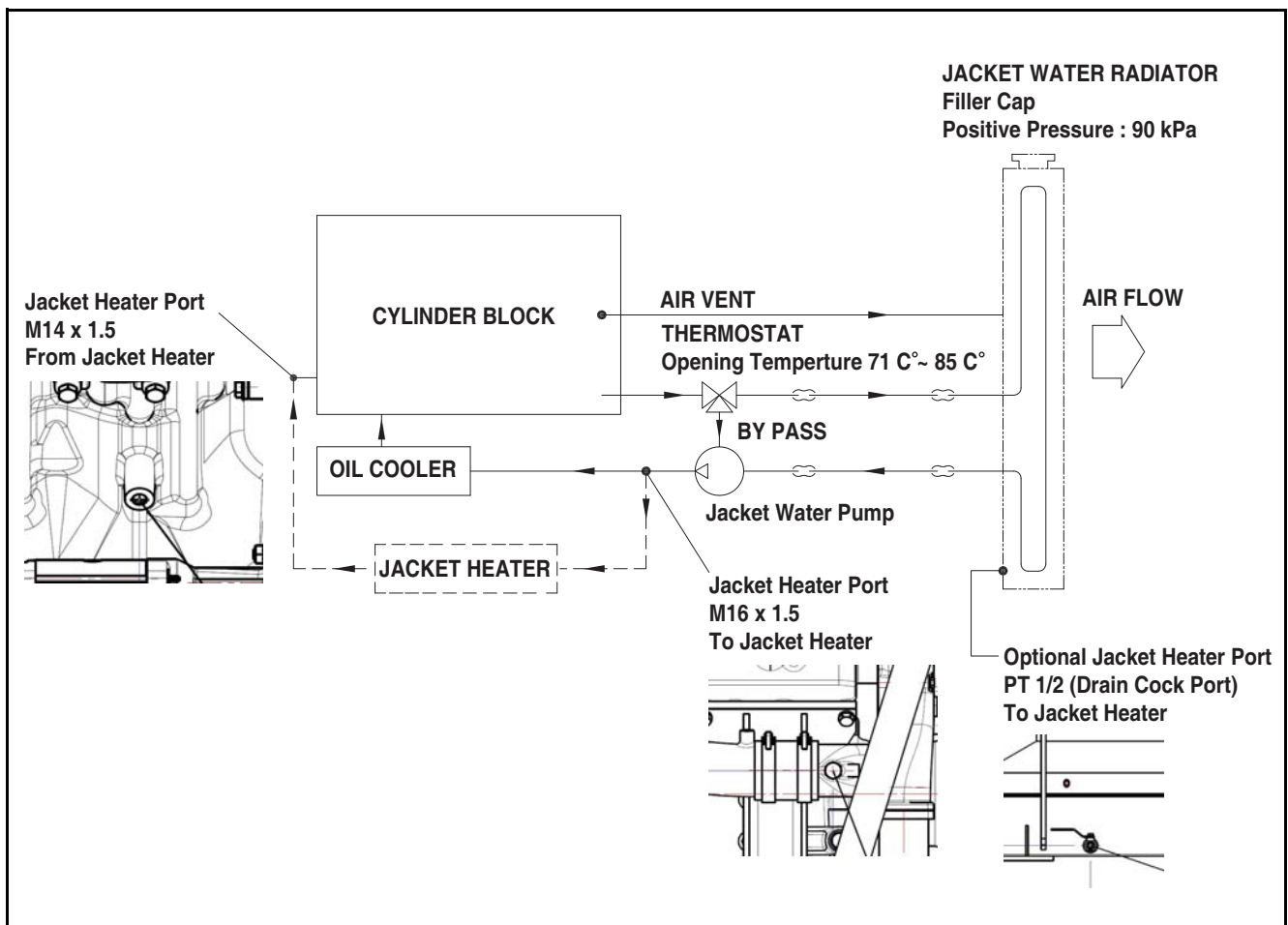
### General information

#### General Information

This engine is water-cooled. It uses coolant to cool the engine by absorbing heat from the combustion chamber and the engine oil and then releases the heat, allowing for normal engine operation.

In this cooling system, coolant provided by the coolant pump flows into the oil cooler through the coolant pipe to absorb oil heat and passes through the coolant jacket of the cylinder block and the cooling path of the cylinder head to absorb the combustion heat.

Coolant which absorbed the oil and combustion heat flows into the water temperature controller through the coolant pipe. If the coolant temperature is lower than the valve-opening temperature of the water temperature controller, the coolant flows into the coolant pump. If higher, it flows into the radiator. The radiator releases the heat absorbed from the coolant and sends the coolant to the coolant pump again.



EDV2221001

## 6. Cooling system

### Specifications

Item	DP158L				Remarks
	DP158LCS	DP158LCF	DP158LDS	DP158LDF10	
Cooling System					
Cooling method		Fresh water forced circulation			
Coolant capacity (L)	Engine only	Approx. 23			
	With radiator	Approx. 79 (Air on 43°C) / Approx 90 (Air on 52°C)			
Coolant flow rate (L /min)		660	550	660	550
Pressure cap (kPa)		Max. 49			
Water temperature (°C)	Max. for stand by and prime	103			
	Before start of full load	40			
Water pump		Centrifugal type driven by belt			
Thermostat	Type	Wax-pellet type			
	Opening temp. (°C)	71			
	Full open temp. (°C)	85			
Cooling fan	Type	Blow Type			
	Diameter - blades	915 mm - 7 blades			

Item	DP180L				Remarks
	DP180LBS	DP180LBF	DP180LAS	DP180LAF	
Cooling System					
Cooling method		Fresh water forced circulation			
Coolant capacity (L)	Engine only	Approx. 27			
	With radiator	Approx. 79 (Air on 43°C) / Approx 90 (Air on 52°C)			
Coolant flow rate (L /min)		660	550	660	550
Pressure cap (kPa)		Max. 49			
Water temperature (°C)	Max. for stand by and prime	103			
	Before start of full load	40			
Water pump		Centrifugal type driven by belt			
Thermostat	Type	Wax-pellet type			
	Opening temp. (°C)	71			
	Full open temp. (°C)	85			
Cooling fan	Type	Blow Type			
	Diameter - blades	915 mm - 7 blades			

## 6. Cooling system

Item	DP222L					Remarks
	DP222LAS	DP222LBS	DP222LBF	DP222LCS	DP222LCF	
Cooling System						
Cooling method		Fresh water forced circulation				
Coolant capacity (L)	Engine only	Approx. 33				
	With radiator	Approx. 114 (Air on 43°C) / Approx 125 (Air on 52°C)				
Coolant flow rate (L/min)		660	660	550	660	550
Pressure cap (kPa)		Max. 49				
Water temperature (°C)	Max. for stand by and prime	103				
	Before start of full load	40				
Water pump		Centrifugal type driven by belt				
Thermostat	Type	Wax-pellet type				
	Opening temp. (°C)	71				
	Full open temp. (°C)	85				
Cooling fan	Type	Blow Type				
	Diameter - blades	915 mm - 9 blades				

## 6. Cooling system

### Failure Diagnosis

Phenomenon	Causes	Troubleshooting
Overheated engine	Not enough coolant	Replenish the coolant
	Defective radiator cap	Replace it
	Contaminated radiator	Clean the exterior of the radiator
	Defective V-belt offset	Adjust or replace it
	Contaminated or damaged V-belt	Replace it
	Damaged impeller	Replace the coolant pump
	Defective impeller fix	Replace the coolant pump
	Bad coolant pump operation	Replace it
	Bad water temperature controller operation	Replace it
	Bad coolant flow	Clean the coolant path
	Improper injection time	Check it with the failure diagnosis unit
	Damaged cylinder head gasket	Replace it
Overcooled engine	Bad water temperature controller operation	Replace it
	Too low ambient temperature	Heat the block
Leaking coolant	Damaged radiator	Repair or replace it
	Loosened or damaged radiator connection	Repair or replace the connection
	Defective radiator cap	Replace it
	Badly mounted coolant pump	Repair or replace it
	Bad or damaged coolant pump gasket	Replace the gasket
	Badly mounted water temperature controller	Repair or replace it
	Bad or damaged water temperature controller gasket	Replace the gasket
	Damaged cylinder head gasket	Replace the gasket
	Damaged cylinder head or block	Replace it
Noise	Bad coolant pump bearing	Replace the bearing
	Bad or damaged cooling fan	Repair or replace it
	Bad rotation of the cooling fan	Replace it
	Defective V-belt offset	Adjust or replace it

### Thermostat

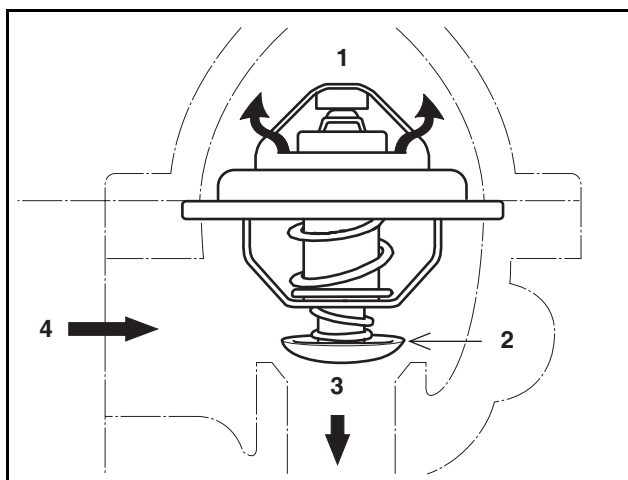
#### General Information

The thermostat maintains water temperature in the engine consistently and prevents heat loss to improve heat efficiency of the engine.

When the coolant temperature is below the normal temperature, the thermostat is closed and the coolant is bypassed and directly flows into the water pump. When the coolant temperature reaches the normal temperature or is higher than the temperature, the thermostat is fully open and the bypass circuit is closed. So the coolant flows into the radiator.

#### CAUTION

- The wax pellet type thermostat shows slower response to the change of cooling water than the bellows type thermostat. This happens because the heat capacity of the wax pellet type water temperature controller is larger than that of the bellows type water temperature controller. Therefore, to prevent rapid increase of engine coolant temperature, you must first operate the engine at idle until the engine is fully warmed up. When the weather is very cold, do not operate the engine in an overloaded condition or at high speed after starting the engine.
- When draining water from the engine cooler or injecting water to the engine cooler, work slowly to let the air in the cooler is fully exhausted.
- When a defect is found in the water temperature controller, replace it with a new one.

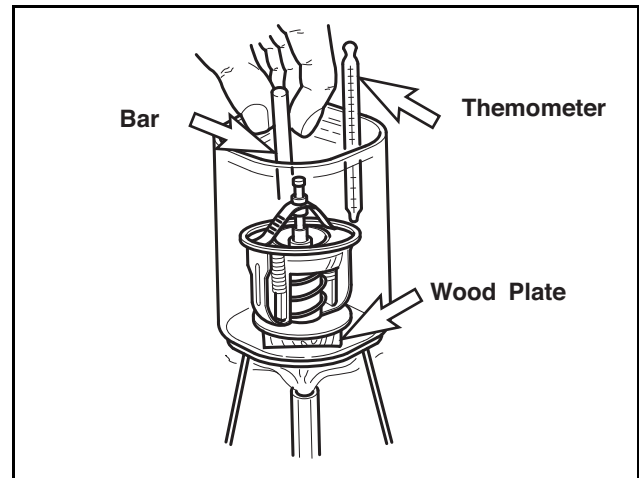


DV2213099A

- |                   |                 |
|-------------------|-----------------|
| 1. Heat exchanger | 3. Coolant pump |
| 2. Bypass valve   | 4. Coolant pipe |

#### Check of the thermostat

1. Check whether the wax pellet and the spring are damaged or not.
2. Put the water temperature controller into water and heat the water slowly to check water temperature controller operation.
3. The water temperature controller is normal in the following case: it starts to be open at the water temperature of 82°C and it is fully open at the water temperature of 97°C.



DV2213100A\_E

4. Check if there is any foreign substance in the water temperature controller.  
Note) Clean the inside of the water temperature controller with an air gun.
5. Check if there are any foreign substance or damage part inside and outside of the hose.

## 6. Cooling system

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# 7. Lubrication system

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## 7. Lubrication system

### Specifications

Item	DP158L				Remarks	
	DP158LCS	DP158LCF	DP158LDS	DP158LDF10		
Lubrication System						
Lubrication method		Fully forced pressure feed type				
Oil pump	Type	Gear type				
	Driving type	Driven by crankshaft gear				
Oil filter		Full flow, Cartridge type				
Oil capacity (L)	Max.	22				
	Min.	13				
Lubrication oil pressure (kPa)	Idle speed	Min. 100				
	Governed speed	Min. 250				
Max. oil temperature (°)		120				
Oil specification	Oil class	CI-4 or higher				
	SAE	10W/40				

Item	DP180L				Remarks	
	DP180LBS	DP180LBF	DP180LAS	DP180LAF		
Lubrication System						
Lubrication method		Fully forced pressure feed type				
Oil pump	Type	Gear type				
	Driving type	Driven by crankshaft gear				
Oil filter		Full flow, Cartridge type				
Oil capacity (L)	Max.	34				
	Min.	23				
Lubrication oil pressure (kPa)	Idle speed	Min. 100				
	Governed speed	Min. 250				
Max. oil temperature (°)		120				
Oil specification	Oil class	CI-4 or higher				
	SAE	10W/40				

## 7. Lubrication system

Item	DP222L					Remarks
	DP222LAS	DP222LBS	DP222LBF	DP222LCS	DP222LCF	
Lubrication System						
Lubrication method		Fully forced pressure feed type				
Oil pump	Type	Gear type				
	Driving type	Driven by crankshaft gear				
Oil filter		Full flow Cartridge type				
Oil capacity (L)	Max.	40				
	Min.	27				
Lubrication oil pressure (kPa)	Idle speed	Min. 100				
	Governed speed	Min. 250				
Max. oil temperature (°C)		120				
Oil specification	Oil class	CI-4 or higher				
	SAE	10W/40				

## 7. Lubrication system

### Failure Diagnosis

Phenomenon	Causes	Troubleshooting
Too much oil consumption	Bad oil	Replace oil with specified oil.
	Oil leakage from the oil seal ring and packing part	Replace it
	Worn or damaged piston and piston ring	Replace it
	Worn cylinder liner	Replace it
	Burnt piston ring	Replace it
	Worn valve guide oil seal, valve guide, or valve stem	Replace it
Low oil pressure	Bad oil	Replace oil with specified oil.
	Burnt oil pump relief valve	Replace it
	Clogged oil pump strainer	Cleanse the strainer
	Worn oil pump gear	Replace it
	Cracked oil delivery pipe of the oil pump	Replace it
	Defect oil pump	Repair or replace it
	Oil pressure gauge fault	Repair or replace it
	Worn bearings	Replace it
Contaminated oil	Clogged oil filter	Replace the oil filter with a new one
	Gas leakage	Replace piston ring with a new one
	Bad oil	Replace oil with specified oil.

# 8. Fuel system

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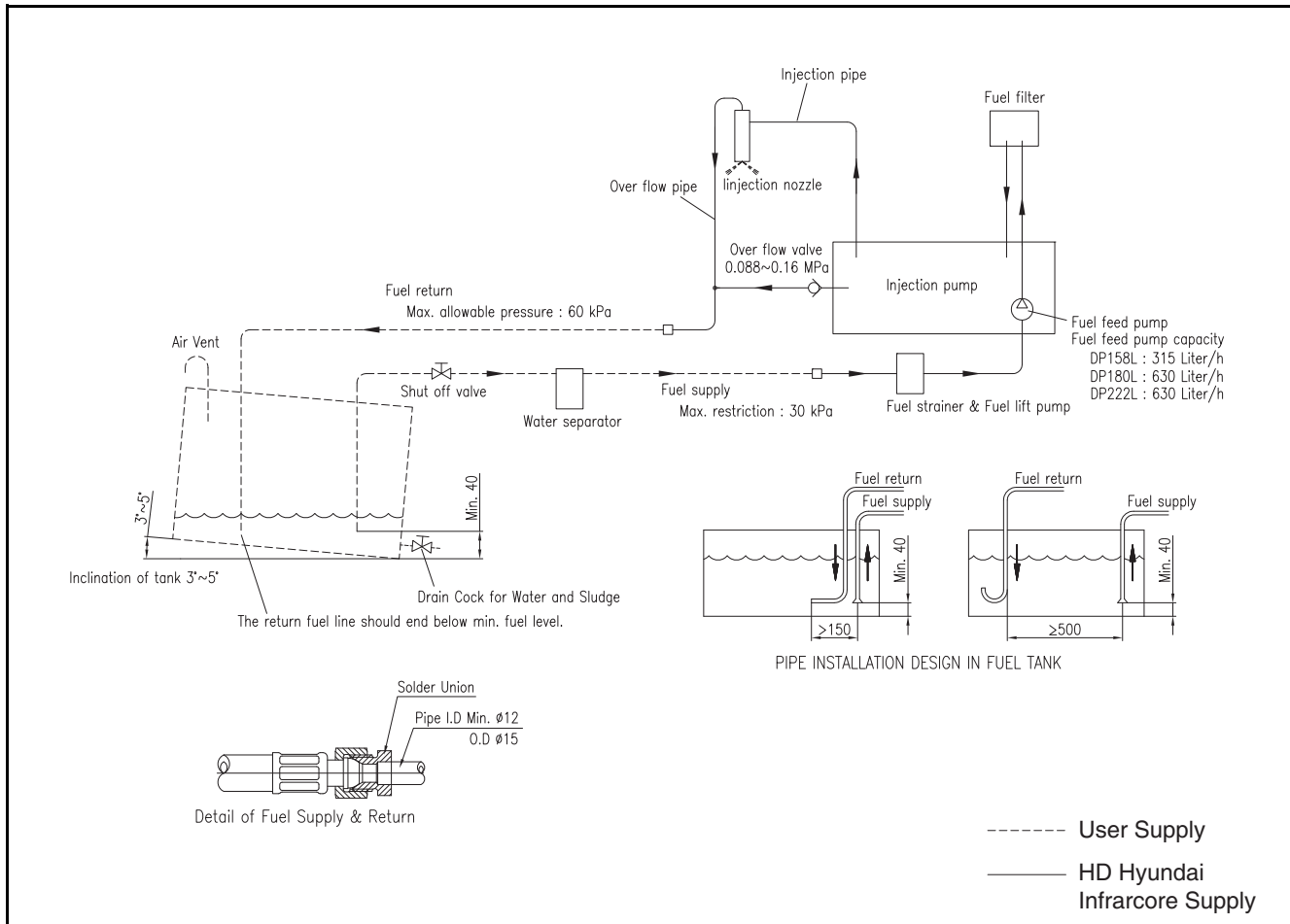


## General information

### General Information

The fuel is supplied by the fuel delivery pump through fuel filter to the fuel injection pump which delivers the fuel to the fuel injection nozzle.

The fuel is injected to the cylinder through the nozzle assembled to the fuel injection nozzle holder of the cylinder head. Over-supplied fuel returns to the fuel tank through the return pipe.



EDV2223007

The fuel lines should have a sufficient inner diameter.  
The fuel lines should be routed so that the fuel is not excessively heated by the heat radiation from the engine.  
The pipes should be laid as straight as possible without sharp bends. Make sure the pipes are protected against mechanical wear and well fastened to avoid vibrations.  
It is important that there are no fuel leakages or air infiltration neither on the suction or return line installation.  
Therefore securely fasten all the connections of fuel line.  
The return line back to the fuel tank must not be adjoin the suction line.

In case of diesel fuel containing high water content due to insufficient fuel quality, maintenance difficulty or environmental adversity, an extra water separator with adequate capacity must be installed as user supply scope.

### High Sulfur content in diesel fuel

HD Hyundai Infracore diesel engines can be operated with fuels Whose sulfur content is max. 0.05wt%.  
Fuels with a sulfur content of > 0.05wt% are not Permitted as they result in increased corrosion and Hence greatly reduce the service life of the engines.  
The oil and oil filter change intervals must be halved If the sulfur content is > 0.02wt%.

## 8. Fuel system

### Water (Moisture) in diesel fuel

Water in the fuel causes;

- Incomplete combustion
- lammed or clogged nozzle
- Damaged to the injection pump
- Piston damage

- Destruction of engine

In case of diesel fuel containing high water content due to insufficient fuel quality, maintenance difficulty or environmental adversity, an extra water separator with adequate capacity must be installed as user supply scope.

### Specifications (BOSCH)

Item	DP158L				Remarks
	DP158LCS	DP158LCF	DP158LDS	DP158LDF	
Fuel System					
Injection pump		BOSCH in-line "P" type			
Governor		Electric type			
Fuel feed pump	Type	Mechanical type injection pump			
	Capacity (L/hr)	315			
Injection nozzle	Type	Multi hole type			
	Opening pressure (MPa)	28			
Fuel filter		Full flow, Cartridge type with water drain valve			
Fuel Used		Diesel fuel oil			

Item	DP180L				Remarks
	DP180LBS	DP180LBF	DP180LAS	DP180LAF	
Fuel System					
Injection pump		BOSCH in-line "P" type			
Governor		Electric type			
Fuel feed pump	Type	Mechanical type injection pump			
	Capacity (L/hr)	630			
Injection nozzle	Type	Multi-hole (4 hole)			
	Opening pressure (MPa)	28			
Fuel filter		Full flow, Cartridge type with water drain valve			
Fuel Used		Diesel fuel oil			

## 8. Fuel system

Item	DP222L					Remarks
	DP222LAS	DP222LBS	DP222LBF	DP222LCS	DP222LCF	
Fuel System						
Injection pump		BOSCH in-line "P" type				
Governor		Electric type				
Fuel feed pump	Type	Mechanical type injection pump				
	Capacity (L/hr)	630				
Injection nozzle	Type	Multi hole type				
	Opening pressure (MPa)	28				
Fuel filter		Full flow, Cartridge type with water drain valve				
Fuel Used		Diesel fuel oil				

## 8. Fuel system

### Specifications (WEIFU)

Item		DP158L				Remarks
		DP158LCS	DP158LCF	DP158LDS	DP158LDF	
Fuel System						
Injection pump		WEIFU in-line "P" type				
Governor		Electric type				
Fuel feed pump	Type	Mechanical type injection pump				
	Capacity (L/hr)	-				
Injection nozzle	Type	Multi hole type (4 holes)				
	Opening pressure (MPa)	28				
Fuel filter		Full flow, Cartridge type with water drain valve				
Fuel Used		Diesel fuel oil				

Item		DP222L					Remarks
		DP222LAS	DP222LBS	DP222LBF	DP222LCS	DP222LCF	
Fuel System							
Injection pump		WEIFU in-line "P" type					
Governor		Electric type					
Fuel feed pump	Type	Mechanical type injection pump					
	Capacity (L/hr)	-					
Injection nozzle	Type	Multi hole type (4 holes)					
	Opening pressure (MPa)	28					
Fuel filter		Full flow, Cartridge type with water drain valve					
Fuel Used		Diesel fuel oil					

### Failure Diagnosis

Symptom	Causes	Troubleshooting
1. Engine does not start A. Fuel is not supplied from the fuel delivery pump	<ul style="list-style-type: none"> <li>• Clogged fuel pipe, or air entered the fuel pipe line</li> <li>• Defective delivery pump valve</li> <li>• Seized delivery pump piston or push rod</li> </ul>	<ul style="list-style-type: none"> <li>• Correct</li> <li>• Replace</li> <li>• Disassemble / correct</li> </ul>
B. Fuel is not injected from the fuel injection pump	<ul style="list-style-type: none"> <li>• Clogged fuel filter cartridge</li> <li>• Air entered to the fuel filter or injection pump</li> <li>• Seizure or defect in the plunger or delivery valve</li> </ul>	<ul style="list-style-type: none"> <li>• Clean / replace</li> <li>• Bleed</li> <li>• Disassemble / correct</li> </ul>
C. Improper fuel injection timing	<ul style="list-style-type: none"> <li>• Defective installation of fuel injection pump bracket</li> <li>• Defective adjustment of the fuel injection pump tappet</li> <li>• Excessively worn cam of camshaft</li> </ul>	<ul style="list-style-type: none"> <li>• Inspect / correct</li> <li>• Inspect / correct</li> <li>• Replace</li> </ul>
D. Fuel injection nozzle not working	<ul style="list-style-type: none"> <li>• Seizure of needle valve of nozzle</li> <li>• Fuel leakage between nozzle and needle valve</li> <li>• Improper fuel injection pressure</li> </ul>	<ul style="list-style-type: none"> <li>• Service or replace</li> <li>• Service or replace</li> <li>• Adjust</li> </ul>
2. Engine starts but stops immediately	<ul style="list-style-type: none"> <li>• Clogged fuel filter or clogged pipe between fuel delivery pump and injection pump</li> <li>• Air entered into fuel</li> <li>• Insufficient supply of oil by fuel delivery pump</li> <li>• Clogged air breather in fuel tank, causing insufficient fuel supply.</li> </ul>	<ul style="list-style-type: none"> <li>• Clean or replace</li> <li>• Air bleeding</li> <li>• Disassemble / correct</li> <li>• Replace breather</li> </ul>
3. Insufficient engine power	<ul style="list-style-type: none"> <li>• Excessively work plunger</li> <li>• Improper injection timing</li> <li>• Defective delivery valve</li> <li>• Excessive fuel leakage in injection nozzle</li> <li>• Nozzle not working properly</li> </ul>	<ul style="list-style-type: none"> <li>• Replace</li> <li>• Adjust</li> <li>• Replace</li> <li>• Service or replace</li> <li>• Disassemble / correct</li> </ul>
4. Engine knocking occurs	<ul style="list-style-type: none"> <li>• Early injection timing</li> <li>• High nozzle injection pressure</li> <li>• Nozzle not working properly</li> </ul>	<ul style="list-style-type: none"> <li>• Adjust</li> <li>• Adjust</li> <li>• Disassemble / correct</li> </ul>
5. Excessive engine smoke and knocking	<ul style="list-style-type: none"> <li>• Defective injection timing</li> <li>• Too low nozzle injection pressure</li> <li>• Broken nozzle spring</li> <li>• Nozzle not working properly</li> <li>• Excessively work plunger</li> <li>• Defective delivery valve seat</li> <li>• Excessive fuel supply</li> </ul>	<ul style="list-style-type: none"> <li>• Adjust</li> <li>• Adjust</li> <li>• Replace it</li> <li>• Replace it</li> <li>• Adjust</li> <li>• Replace it</li> <li>• Check feed pump</li> </ul>
6. Unstable engine power	<ul style="list-style-type: none"> <li>• Insufficient fuel supply</li> <li>• Air entered into fuel</li> <li>• Water entered into fuel</li> <li>• Defective plunger operation</li> <li>• Defective actuator operation</li> <li>• Defective nozzle</li> <li>• Injection start pressure different between cylinders</li> <li>• Defective controller</li> </ul>	<ul style="list-style-type: none"> <li>• Check feed pump</li> <li>• Air bleeding</li> <li>• Replace fuel</li> <li>• Disassemble / correct</li> <li>• Disassemble / correct</li> <li>• Disassemble / correct</li> <li>• Adjust</li> <li>• Adjust</li> </ul>
7. Engine cannot reach the max. speed	<ul style="list-style-type: none"> <li>• Nozzle not working properly</li> <li>• Defective operation of actuator or controller</li> </ul>	<ul style="list-style-type: none"> <li>• Disassemble / correct</li> <li>• Adjust</li> </ul>
8. Unstable engine idling	<ul style="list-style-type: none"> <li>• Defective controller operation</li> <li>• Defective plunger operation</li> <li>• Defective magnetic pickup sensor</li> </ul>	<ul style="list-style-type: none"> <li>• Adjust</li> <li>• Disassemble / correct</li> <li>• Inspect or replace</li> </ul>

## 8. Fuel system

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### Fuel injection pump

#### General Information

The fuel injection pump is driven by the crankshaft gear. It is connected to the forced lubrication system, so separate connection is not required.

The governor of electric fuel injection pump is consist of the actuator that is operated by the signal of the control system and the control system that maintain the engine RPM as the changing load.

## 8. Fuel system

### Adjustment Fuel Injection Pump (BOSCH)

1. DP158L (60Hz)

1) Fuel injection pump : 400912-00026C

- Model : PE8P120A500/4LS7935 (0 412 628 937)
- Governor : HD Hyundai Infracore electric governor
- Plunger & Barrel : 2 418 455 545
- Delivery valve : 2 418 559 045
- Feed pump : FP/KD22P78-2 (0 440 008 152)

- Prestroke : 4.5 ±0.05 mm (13 ±1.5 mm)

2) Nozzle holder assembly : 65.10101-7051 (0 432 131 667)

3) Nozzle : 65.10102-6047 (0 433 171 174)

4) Injection pipe : 420208-00453, 420208-00454

5) Firing order : 1 - 5 - 7 - 2 - 6 - 3 - 4 - 8

6) Fuel injection timing : BTDC 23°

(A)Test condition for injection pump	Nozzle & Holder Ass'y	1688 901 019	Opening pressure : 210 bar
	Injection pipe (ID X OD - L)	-	Ø3.0 x Ø8.0-1,000 mm
	Test oil	ISO4113	Temperature : 40 ±5°C
(B)Engine standard parts	Nozzle & Holder Ass'y	65.10101-7051	Nozzle (4 x Ø0.40) Opening pressure : 280 bar
	Injection pipe (ID X OD -L)	420208-00455, 420208-00456	Ø2.0 x Ø6.35-750 mm

Rack diagram and setting valve at each point

	Check Point	Rack Position (mm)	Pump Speed (rpm)	Injection Q'ty on RIG (mm <sup>3</sup> /1,000st)		Pressure (mmHg)
				(A)Test (mmHg) condition for Inj. pump	(B)Engine standard parts	
Stand by Power	A	16.0	900	432	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

## 8. Fuel system

2. DP158L (50Hz)

1) Fuel injection pump : 400912-00026C

- Model : PE8P120A500/4LS7935 (0 412 628 937)
- Governor : HD Hyundai Infracore electric governor
- Plunger & Barrel : 2 418 455 545
- Delivery valve : 2 418 559 045
- Feed pump : FP/KD22P78-2 (0 440 008 152)

- Prestroke : 4.5 ±0.05 mm (13 ±1.5 mm)
- 2) Nozzle holder assembly : 65.10101-7051 (0 432 131 667)
- 3) Nozzle : 65.10102-6047 (0 433 171 174)
- 4) Injection pipe : 420208-00453, 420208-00454
- 5) Firing order : 1 - 5 - 7 - 2 - 6 - 3 - 4 - 8
- 6) Fuel injection timing : BTDC 18°

(A)Test condition for injection pump	Nozzle & Holder Ass'y	1688 901 019	Opening pressure : 210 bar
	Injection pipe (ID X OD - L)	-	Ø3.0 x Ø8.0-1,000 mm
	Test oil	ISO4113	Temperature : 40 ±5°C
(B)Engine standard parts	Nozzle & Holder Ass'y	65.10101-7051	Nozzle (4 x Ø0.40) Opening pressure : 280 bar
	Injection pipe (ID X OD -L)	420208-00455, 420208-00456	Ø2.0 x Ø6.35-750 mm

Rack diagram and setting valve at each point

	Check Point	Rack Position (mm)	Pump Speed (rpm)	Injection Q'ty on RIG (mm <sup>3</sup> /1,000st)		Pressure (mmHg)
				(A)Test (mmHg) condition for Inj. pump	(B)Engine standard parts	
Stand by Power	A	16.3	750	466	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

## 8. Fuel system

3. DP180L (60Hz)

1) Fuel injection pump : 65.11101-7302 (0 402 619 802 BOSCH)

- Model : PE10P120A500LS7936 (0 412 629 815)
- Governor : HD Hyundai Infracore electric governor
- Plunger & Barrel : 2 418 455 545
- Delivery valve : 2 418 559 045
- Feed pump : FP/KD22P80-1 (0 440 008 090), FP/KD22P78-2 (0 440 008 152)

- Prestroke : 4.5 ±0.05 mm (13 ±1.5 mm)

2) Nozzle holder assembly : 65.10101-7051 (0 432 131 667)

3) Nozzle : 65.10102-6047 (0 433 171 174)

4) Injection pipe : 420208-00399, 420208-00400

5) Firing order : 1 - 6 - 5 - 10 - 2 - 7 - 3 - 8 - 4 - 9

6) Fuel injection timing : BTDC 21°

(A)Test condition for injection pump	Nozzle & Holder Ass'y	1688 901 015	Opening pressure : 208.5 ±1.5 bar
	Injection pipe (ID X OD - L)	-	Ø3.0 x Ø8.0-600 mm
	Test oil	ISO4113	Temperature : 40 ±5°C
(B)Engine standard parts	Nozzle & Holder Ass'y	65.10101-7051	Nozzle (4 x Ø0.40) Opening pressure : 280 bar
	Injection pipe (ID X OD -L)	420208-00399, 420208-00400	Ø2.0 x Ø6.35-800 mm

Rack diagram and setting valve at each point

	Check Point	Rack Position (mm)	Pump Speed (rpm)	Injection Q'ty on RIG (mm <sup>3</sup> /1,000st)		Pressure (mmHg)
				(A)Test (mmHg) condition for Inj. pump	(B)Engine standard parts	
Stand by Power	A	14.6	900	383	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

## 8. Fuel system

4. DP180L (50Hz)

1) Fuel injection pump : 65.11101-7302 (0 402 619 802 BOSCH)

- Model : PE10P120A500LS7936 (0 412 629 815)
- Governor : HD Hyundai Infracore electric governor
- Plunger & Barrel : 2 418 455 545
- Delivery valve : 2 418 559 045
- Feed pump : FP/KD22P80-1 (0 440 008 090), FP/KD22P78-2 (0 440 008 152)

- Prestroke : 4.5 ±0.05 mm (13 ±1.5 mm)

2) Nozzle holder assembly : 65.10101-7051 (0 432 131 667)

3) Nozzle : 65.10102-6047 (0 433 171 174)

4) Injection pipe : 420208-00399, 420208-00400

5) Firing order : 1 - 6 - 5 - 10 - 2 - 7 - 3 - 8 - 4 - 9

6) Fuel injection timing : BTDC 19°

(A)Test condition for injection pump	Nozzle & Holder Ass'y	1688 901 019	Opening pressure : 210 bar
	Injection pipe (ID X OD - L)	-	Ø3.0 x Ø8.0-1,000 mm
	Test oil	ISO4113	Temperature : 40 ±5°C
(B)Engine standard parts	Nozzle & Holder Ass'y	65.10101-7051	Nozzle (4 x Ø0.40) Opening pressure : 280 bar
	Injection pipe (ID X OD -L)	420208-00399, 420208-00400	Ø2.0 x Ø6.35-800 mm

Rack diagram and setting valve at each point

	Check Point	Rack Position (mm)	Pump Speed (rpm)	Injection Q'ty on RIG (mm <sup>3</sup> /1,000st)		Pressure (mmHg)
				(A)Test (mmHg) condition for Inj. pump	(B)Engine standard parts	
Stand by Power	A	14.7	750	407	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

## 8. Fuel system

5. DP222L (60Hz)
- 1) Fuel injection pump : 400912-00028C
- Model : PE12P120A500LS7937 (0 412 620 854)
  - Governor : HD Hyundai Infracore electric governor
  - Plunger & Barrel : 2 418 455 545
  - Delivery valve : 2 418 559 045
  - Feed pump : FP/KD22P80-1 (0 440 008 090),  
FP/KD22P78-2 (0 440 008 152)
- Prestroke : 4.5 ±0.05 mm (13 ±1.5 mm)
- 2) Nozzle holder assembly : 65.10101-7051 (0 432 131 667)
- 3) Nozzle : 65.10102-6047 (0 433 171 174)
- 4) Injection pipe : 420208-00445, 420208-00443,  
420208-00441
- 5) Firing order : 1 - 12 - 5 - 8 - 3 - 10 - 6 - 7 - 2 - 11 - 4 - 9
- 6) Fuel injection timing : BTDC 21°

(A)Test condition for injection pump	Nozzle & Holder Ass'y	1688 901 019	Opening pressure : 210 bar
	Injection pipe (ID X OD - L)	-	Ø3.0 x Ø8.0-1,000 mm
	Test oil	ISO4113	Temperature : 40 ±5°C
(B)Engine standard parts	Nozzle & Holder Ass'y	65.10101-7051	Nozzle (4 x Ø0.40) Opening pressure : 280 bar
	Injection pipe (ID X OD -L)	420208-00446A, 420208-00444A, 420208-00551	Ø2.0 x Ø6.35-850 mm

Rack diagram and setting valve at each point

	Check Point	Rack Position (mm)	Pump Speed (rpm)	Injection Q'ty on RIG (mm <sup>3</sup> /1,000st)		Pressure (mmHg)
				(A)Test (mmHg) condition for Inj. pump	(B)Engine standard parts	
				Stand by Power	A	
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

## 8. Fuel system

6. DP222L (50Hz)

1) Fuel injection pump : 400912-00028C

- Model : PE12P120A500LS7937 (0 412 620 854)
- Governor : HD Hyundai Infracore electric governor
- Plunger & Barrel : 2 418 455 545
- Delivery valve : 2 418 559 045
- Feed pump : FP/KD22P80-1 (0 440 008 090),  
FP/KD22P78-2 (0 440 008 152)

- Prestroke : 4.5 ±0.05 mm (13 ±1.5 mm)

- 2) Nozzle holder assembly : 65.10101-7051 (0 432 131 667)
- 3) Nozzle : 65.10102-6047 (0 433 171 174)
- 4) Injection pipe : 420208-00445, 420208-00443,  
420208-00441
- 5) Firing order : 1 - 12 - 5 - 8 - 3 - 10 - 6 - 7 - 2 - 11 - 4 - 9
- 6) Fuel injection timing : BTDC 19°

(A)Test condition for injection pump	Nozzle & Holder Ass'y	1688 901 019	Opening pressure : 210 bar
	Injection pipe (ID X OD - L)	-	Ø3.0 x Ø8.0-1,000 mm
	Test oil	ISO4113	Temperature : 40 ±5°C
(B)Engine standard parts	Nozzle & Holder Ass'y	65.10101-7051	Nozzle (4 x Ø0.40) Opening pressure : 280 bar
	Injection pipe (ID X OD -L)	420208-00446A, 420208-00444A, 420208-00551	Ø2.0 x Ø6.35-850 mm

Rack diagram and setting valve at each point

	Check Point	Rack Position (mm)	Pump Speed (rpm)	Injection Q'ty on RIG (mm <sup>3</sup> /1,000st)		Pressure (mmHg)
				(A)Test (mmHg) condition for Inj. pump	(B)Engine standard parts	
Stand by Power	A	15.5	750	435	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

## 8. Fuel system

### Adjustment Fuel Injection Pump (WEIFU)

1. DP158L (60Hz)

1) Fuel injection pump : 400912-00734

- Model : PW2000
- Governor : 300701-00133 (Electric governor)
- Plunger & Barrel : 05U817-00
- Delivery valve : 05F238-00
- Feed pump : -

- Prestroke : 4.1 ±0.05 mm

2) Nozzle holder assembly : 65.10101-7051 (0 432 131 667)

3) Nozzle : 65.10102-6047 (0 433 171 174)

4) Injection pipe : 420208-01253, 400208-01248

5) Firing order : 1 - 5 - 7 - 2 - 6 - 3 - 4 - 8

6) Fuel injection timing : BTDC 25°

(A)Test condition for injection pump	Nozzle & Holder Ass'y	-	Opening pressure : 175 bar
	Injection pipe (ID X OD - L)	-	Ø2.0 x Ø6.0-600 mm
	Test oil	-	Temperature : 40 ±5°C
(B)Engine standard parts	Nozzle & Holder Ass'y	65.10101-7051	Nozzle (4 x Ø0.40) Opening pressure : 280 bar
	Injection pipe (ID X OD -L)	420208-01253, 400208-01248	Ø2.0 x Ø6.35-750 mm

Rack diagram and setting valve at each point

	Check Point	Rack Position (mm)	Pump Speed (rpm)	Injection Q'ty on RIG (mm <sup>3</sup> /1,000st)		Pressure (mmHg)
				(A)Test (mmHg) condition for Inj. pump	(B)Engine standard parts	
				Stand by Power	A	
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

## 8. Fuel system

2. DP158L (50Hz)

1) Fuel injection pump : 400912-00734

- Model : PW2000
- Governor : 300701-00133 (Electric governor)
- Plunger & Barrel : 05U817-00
- Delivery valve : 05F238-00
- Feed pump : -

- Prestroke : 4.1 ±0.05 mm

2) Nozzle holder assembly : 65.10101-7051

3) Nozzle : 65.10102-6047

4) Injection pipe : 420208-01253, 400208-01248

5) Firing order : 1 - 5 - 7 - 2 - 6 - 3 - 4 - 8

6) Fuel injection timing : BTDC 20°

(A) Test condition for injection pump	Nozzle & Holder Ass'y	-	Opening pressure : 175 bar
	Injection pipe (ID X OD - L)	-	Ø2.0 x Ø6.0-600 mm
	Test oil	ISO4113	Temperature : 40 ±5°C
(B) Engine standard parts	Nozzle & Holder Ass'y	65.10101-7051	Nozzle (4 x Ø0.40) Opening pressure : 280 bar
	Injection pipe (ID X OD -L)	420208-01253, 400208-01248	Ø2.0 x Ø6.35-750 mm

Rack diagram and setting valve at each point

	Check Point	Rack Position (mm)	Pump Speed (rpm)	Injection Q'ty on RIG (mm <sup>3</sup> /1,000st)		Pressure (mmHg)
				(A) Test (mmHg) condition for Inj. pump	(B) Engine standard parts	
Stand by Power	A	16	750	477	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

## 8. Fuel system

3. DP222L (60Hz)

1) Fuel injection pump : 400912-00735

- Model : PW2000
- Governor : 300701-00133 (Electric governor)
- Plunger & Barrel : 05U817-00
- Delivery valve : 05F238-00
- Feed pump : 400908-00042A

- Prestroke : 4.1 ±0.05 mm

2) Nozzle holder assembly : 65.10101-7051

3) Nozzle : 65.10102-6047

4) Injection pipe : 420208-01233, 420208-01234,  
420208-01235

5) Firing order : 1 - 12 - 5 - 8 - 3 - 10 - 6 - 7 - 2 - 11 - 4 - 9

6) Fuel injection timing : BTDC 23°

(A)Test condition for injection pump	Nozzle & Holder Ass'y	-	Opening pressure : 175 bar
	Injection pipe (ID X OD - L)	-	Ø2.0 x Ø6.0-600 mm
	Test oil	ISO4113	Temperature : 40 ±5°C
(B)Engine standard parts	Nozzle & Holder Ass'y	65.10101-7051	Nozzle (4 x Ø0.40) Opening pressure : 280 bar
	Injection pipe (ID X OD -L)	420208-01233, 420208-01234, 420208-01235	Ø2.0 x Ø6.35-850 mm

Rack diagram and setting valve at each point

	Check Point	Rack Position (mm)	Pump Speed (rpm)	Injection Q'ty on RIG (mm <sup>3</sup> /1,000st)		Pressure (mmHg)
				(A)Test (mmHg) condition for Inj. pump	(B)Engine standard parts	
Stand by Power	A	16	900	431	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

## 8. Fuel system

4. DP222L (50Hz)

1) Fuel injection pump : 400912-00735

- Model : PW2000
- Governor : 300701-00133 (Electric governor)
- Plunger & Barrel : 05U817-00
- Delivery valve : 05F238-00
- Feed pump : -

- Prestroke : 4.1 ±0.05 mm

2) Nozzle holder assembly : 65.10101-7051

3) Nozzle : 65.10102-6047

4) Injection pipe : 420208-01233, 420208-01234,  
420208-01235

5) Firing order : 1 - 12 - 5 - 8 - 3 - 10 - 6 - 7 - 2 - 11 - 4 - 9

6) Fuel injection timing : BTDC 21°

(A)Test condition for injection pump	Nozzle & Holder Ass'y	-	Opening pressure : 175 bar
	Injection pipe (ID X OD - L)	-	Ø2.0 x Ø6.0-600 mm
	Test oil	ISO4113	Temperature : 40 ±5°C
(B)Engine standard parts	Nozzle & Holder Ass'y	65.10101-7051	Nozzle (4 x Ø0.40) Opening pressure : 280 bar
	Injection pipe (ID X OD -L)	420208-01233, 420208-01234, 420208-01235	Ø2.0 x Ø6.35-850 mm

Rack diagram and setting valve at each point

	Check Point	Rack Position (mm)	Pump Speed (rpm)	Injection Q'ty on RIG (mm <sup>3</sup> /1,000st)		Pressure (mmHg)
				(A)Test (mmHg) condition for Inj. pump	(B)Engine standard parts	
Stand by Power	A	15.5	750	441	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

# 9. Intake/exhaust system

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## 9. Intake/exhaust system

### General information

#### General Information

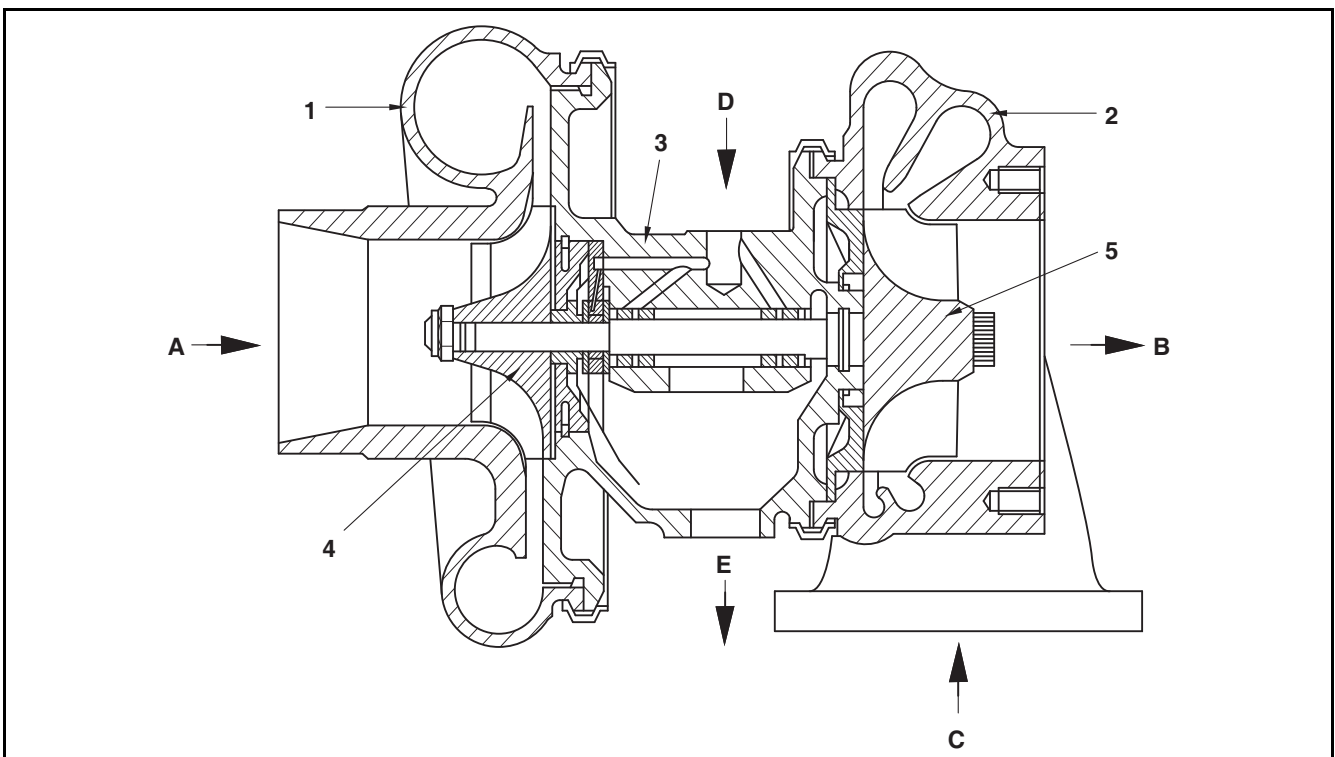
The exhaust gas of the engine passes through the turbine wing of turbocharger to rotate the turbine. At the same time, the impeller air of the compressor mounted on the other end of same shaft rotates to suck in the fresh air through air filter, and delivers it to the cylinder through inter cooler with high pressure.

The turbocharger is air-cooled. The bearing is lubricated by the lubricant supplied from the engine lubrication system.

The engine power depends on the supplied fuel amount and engine efficiency.

In order to make the supplied fuel burned completely to work for the engine efficiently, the sufficient air should be delivered to the cylinder. That is, the engine power is virtually determined by the size of cylinder. If compressed air is delivered to the cylinder with a given capacity, the air amount in the cylinder increases to burn more fuel, thereby increasing the engine power.

The method of compressing the air to supply it into the engine cylinder is called supercharging; and the method of using the exhaust gas discharged from the combustion chamber for the same purpose is called turbocharging.



DV2213107A

No.	Name	No.	Name
1.	Compressor casing	A.	Air inlet
2.	Turbine casing	B.	Exhaust gas outlet
3.	Compressor wheel	C.	Exhaust gas inlet
4.	Impeller	D.	Engine oil delivery
5.	Turbine	E.	Engine oil recovery

## 9. Intake/exhaust system

### Specifications

Item	DP158L				Remarks
	DP158LCS	DP158LCF	DP158LDS	DP158LDF10	
Intake/Exhaust System					
Max. back pressure (kPa)		5.9			
Max. intake air restriction (kPa)	With clean filter element	2.16			
	With dirty filter element	6.23			

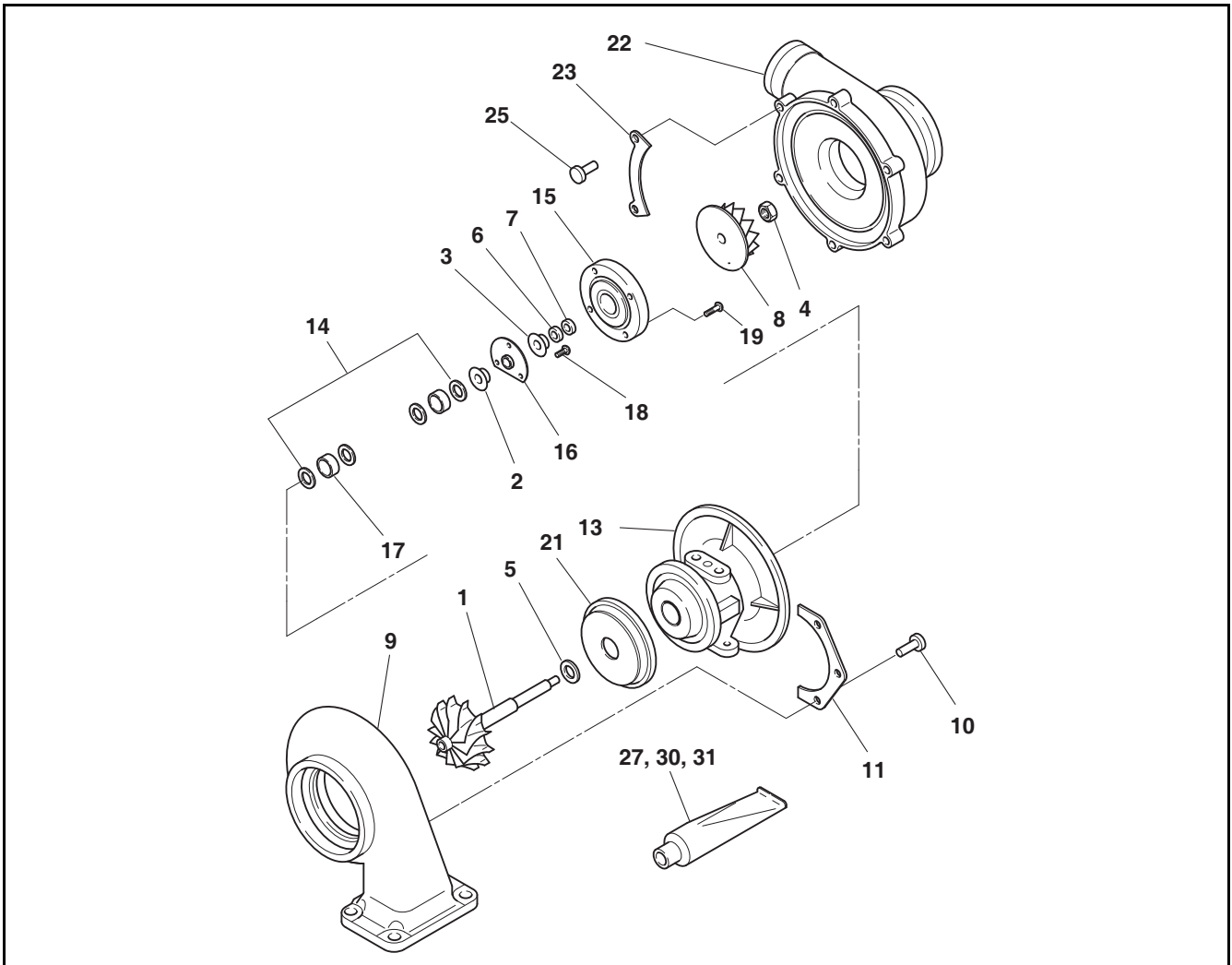
Item	DP180L				Remarks
	DP180LBS	DP180LBF	DP180LAS	DP180LAF	
Intake/Exhaust System					
Max. back pressure (kPa)		5.9			
Max. intake air restriction (kPa)	With clean filter element	2.16			
	With dirty filter element	6.23			

Item	DP222L					Remarks
	DP222LAS	DP222LBS	DP222LBF	DP222LCS	DP222LCF	
Intake/Exhaust System						
Max. back pressure (kPa)		5.9				
Max. intake air restriction (kPa)	With clean filter element	2.16				
	With dirty filter element	6.23				

Generator Engine	DP158L	DP180L	DP222L
Turbocharger Model	T45	GTA4294	GT45
Max. Output	756 PS (556 kW) @ 60 Hz	899 PS (661 kW) @ 60 Hz	1,126 PS (828 kW) @ 60 Hz

### General information

### Construction



DV2213108A

- |                          |                     |                             |
|--------------------------|---------------------|-----------------------------|
| 1. Turbine shaft         | 10. Bolt            | 21. Heat screen             |
| 2. Thrust bush           | 11. Clamp           | 22. Compressor housing      |
| 3. Oil shut off          | 13. Bearing housing | 23. Clamp                   |
| 4. Fixing nut            | 14. Retainer ring   | 24. Bolt                    |
| 5. Seal ring             | 15. Seal plate      | 27. Liquid gasket           |
| 6. Seal ring             | 16. Thrust bearing  | 30. Loctite                 |
| 7. Seal ring             | 17. Journal bearing | 31. Liquid anti-burn agents |
| 8. Compressor wing wheel | 18. Screw           |                             |
| 9. Turbine housing       | 19. Screw           |                             |

## 9. Intake/exhaust system

### Function

#### 1. Turbine

The exhaust gas that is discharged from combustion chamber passes through turbine housing conveying an energy to turbine wings to give the rotating power, This is called as the turbine and in order not to influence a bad effect at bearing part, there are the seal ring and heat dissipator.

#### 2. Compressor

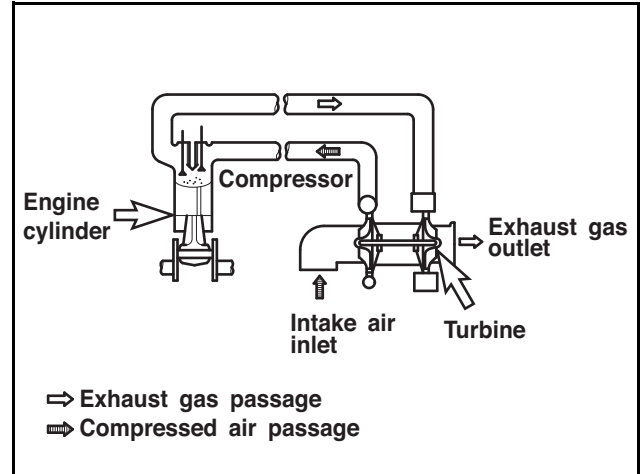
It is connected to the same shaft with the turbine to make a revolving assembly, and receive the revolving force of turbine, and sends air to the suction manifold by suctioning and compressing it. This is called as the compressor.

#### 3. Bearing

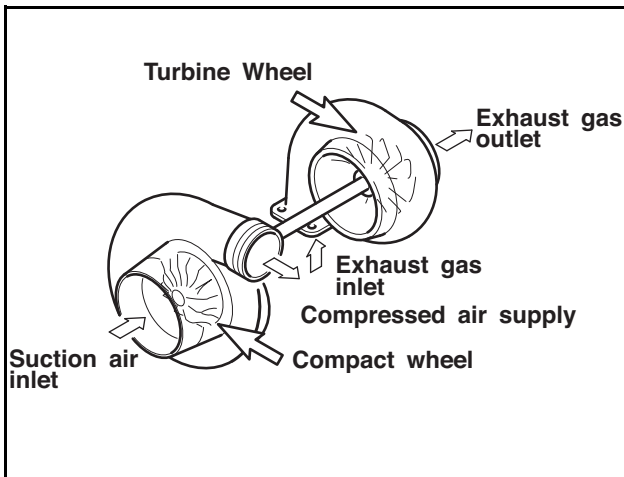
- 1) Thrust bearing force is applied to the turbine wheel and an arrangement is made for the shaft not to shift.
- 2) journal bearing (floating bearing) is adopted and it forms the double oil films at the in out surfaces in comparison to the general stationary type so that the bearing may be able to rotate independently and consequently the double layers of films act as the damper to make the slipping speed on the bearing surface less than the rotating speed of shaft so that the dynamic stability may be obtained.

#### 4. Sealing at compressor shaft

In order for the compressed intake air and lubricating oil not to leak, a seal plate and a seal ring are made to the double structures.



DV2213110A\_E



DV2213109A\_E

## 9. Intake/exhaust system

### Failure Diagnosis

Phenomenon	Causes	Troubleshooting
Noise or vibration	Rotating part is contacted	Repair or replace it
	Unbalanced rotation of a rotor	Repair or replace it
	Burn	Repair or replace it
	Loose joint	Check or repair it
	Deformed or damaged intake system hose	Replace it
	Poor clamping state	Adjust and tighten the clamp
	Contaminated or damaged air filter	Replace and check if the impeller of the turbocharger is damaged
	Leakage of coolant from the turbocharger or oil from the oil hose	Replace the hose and the gasket
	Leakage of gas from the exhaust manifold	Replace the gasket or tighten the fixing nut
	Poor turbo actuator operation	Replace the turbocharger
	Leakage from the engine block and the exhaust manifold	Check the engine
	Contaminated blowby gas and abnormal oil amount	Check the turbo impeller and the turbo intake outlet
	Large gap of the turbocharger wheel, causing interference with the wall	Check if there is any sand or metallic foreign substance
	Damaged turbocharger wheel	Check if there is any sand or metallic foreign substance
	Damaged wheel and shaft of the turbocharger	Check if there is any sand or metallic foreign substance
Poor rotating force of the turbocharger wheel	Check if there is any sand or metallic foreign substance	

## 9. Intake/exhaust system

Phenomenon	Causes	Troubleshooting
Lowered output	Leakage of gas from each part of the exhaust system	Check or repair it
	Clogged air filter element	Replace or clean it
	Contaminated or damaged turbocharger	Repair or replace it
	Leakage of air from the discharging part of the compressor shaft	Check or repair it
	Deformed or damaged intake system hose	Replace it
	Poor clamping state	Adjust and tighten the clamp
	Contaminated or damaged air filter	Replace and check if the impeller of the turbocharger is damaged
	Poor turbo actuator operation	Replace the turbocharger
	Leakage from the engine block and the exhaust manifold	Check the engine
	Contaminated blowby gas and abnormal oil amount	Check the turbo impeller and the turbo intake outlet
	Large gap of the turbocharger wheel, causing interference with the wall	Check if there is any sand or metallic foreign substance
	Damaged turbocharger wheel	Check if there is any sand or metallic foreign substance
	Damaged wheel and shaft of the turbocharger	Check if there is any sand or metallic foreign substance
Poor rotating force of the turbocharger wheel	Check if there is any sand or metallic foreign substance	
Oil leakage	Deformed or damaged intake system hose	Replace it
	Poor clamping state	Adjust and tighten the clamp
	Contaminated or damaged air filter	Replace and check if the impeller of the turbocharger is damaged
	Leakage of coolant from the turbocharger or oil from the oil hose	Replace the hose and the gasket
	Poor turbo actuator operation	Replace the turbocharger

## 9. Intake/exhaust system

Phenomenon	Causes	Troubleshooting
Oil leakage	Leakage from the engine block and the exhaust manifold	Check the engine
	Contaminated blowby gas and abnormal oil amount	Check the turbo impeller and the turbo intake outlet
	Large gap of the turbocharger wheel, causing interference with the wall	Check if there is any sand or metallic foreign substance
	Damaged turbocharger wheel	Check if there is any sand or metallic foreign substance
	Damaged wheel and shaft of the turbocharger	Check if there is any sand or metallic foreign substance
	Poor rotating force of the turbocharger wheel	Check if there is any sand or metallic foreign substance
Oil consumption	Poor clamping state	Adjust and tighten the clamp
	Leakage of coolant from the turbocharger or oil from the oil hose	Replace the hose and the gasket
	Leakage from the engine block and the exhaust manifold	Check the engine
	Contaminated blowby gas and abnormal oil amount	Check the turbo impeller and the turbo intake outlet
	Large gap of the turbocharger wheel, causing interference with the wall	Check if there is any sand or metallic foreign substance
	Damaged turbocharger wheel	Check if there is any sand or metallic foreign substance
	Damaged wheel and shaft of the turbocharger	Check if there is any sand or metallic foreign substance
	Poor rotating force of the turbocharger wheel	Check if there is any sand or metallic foreign substance

## 9. Intake/exhaust system

Phenomenon	Causes	Troubleshooting
Black and white emissions	Deformed or damaged intake system hose	Replace it
	Contaminated or damaged air filter	Replace and check if the impeller of the turbocharger is damaged
	Leakage of coolant from the turbocharger or oil from the oil hose	Replace the hose and the gasket
	Poor turbo actuator operation	Replace the turbocharger
	Contaminated blowby gas and abnormal oil amount	Check the turbo impeller and the turbo intake outlet
	Large gap of the turbocharger wheel, causing interference with the wall	Check if there is any sand or metallic foreign substance
	Damaged turbocharger wheel	Check if there is any sand or metallic foreign substance
	Damaged wheel and shaft of the turbocharger	Check if there is any sand or metallic foreign substance
	Poor rotating force of the turbocharger wheel	Check if there is any sand or metallic foreign substance
Blue emissions	Leakage from the engine block and the exhaust manifold	Check the engine
Too much fog	Oil leakage to the turbine or compressor	Repair or replace it
	Worn or damaged seal ring due to worn bearing	Repair or replace it
Too much exhaust emissions	Clogged air filter element	Replace or clean it
	Clogged air duct	Check or repair it
	Air leakage from the intake system	Check or repair it
	The turbocharger cannot rotate because of burning	Repair or replace it
	A turbine blade or compression wing contacts with the other one or is damaged	Repair or replace it
	Deformed or clogged exhaust system pipe	Check or repair it

### How to Maintain Turbocharger

#### 1. Cautions for engine operation

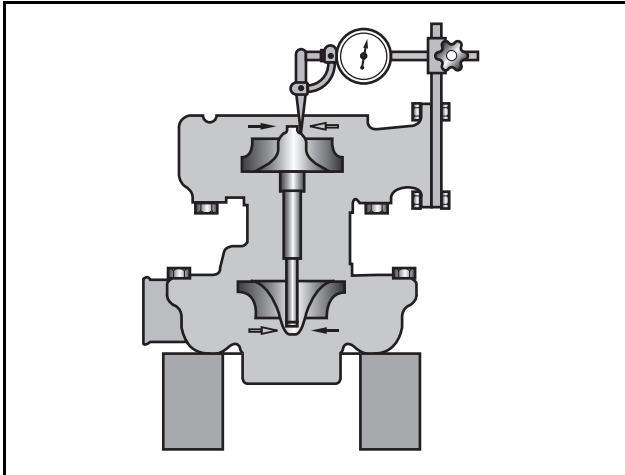
- 1) Observe the followings when starting, operating, and stopping an engine.

Item	Cautions	Reasons
Starting an engine	1) Check the oil amount	
	2) Therefore, start the engine with the starter motor to check the rise of oil pressure (until the gradation of the oil pressure gauge moves or the pressure indicator lamp is turned on).	2) Overhasty start of engine leads to engine rotation without lubricating turbocharger and other engine parts, causing abnormal wear or burning of bearings.
	3) If you replace oil, oil filter cartridge, or lubrication system parts or use an engine in cold areas, or the engine has stopped for a long period, loosen the oil pipe joint at the inlet of the turbocharger and run the starter motor until oil flows out. After completing the work, tighten the oil pipe joint again and start the engine.	3) When an engine has stopped or kept cold for a long period, circulation of oil in the pipe gets poor.
After starting an engine	1) Operate the engine at idle for five minutes from starting it.	1) When the engine is suddenly loaded while the engine and the turbocharger have not been smoothly rotated after starting the engine, parts with insufficient oil may be burnt.
	2) Check if oil, gas, or air is leaked from each part. If so, take proper action.	2) Leakage of oil, gas, or air (especially oil) reduces oil pressure and loss of oil cause burning of bearings.
During Operation	check the following.	
	1) Oil pressure At idle: 1.5 ~ 3.0 kg/cm <sup>2</sup> Fully loaded: 3.0 ~ 5.5 kg/cm <sup>2</sup>	1) Too low oil pressure causes abnormal wearing or burning of bearings. Too high oil pressure causes oil leakage.
	2) When abnormal noise or vibration occurs, slowly reduce the rotate count until the engine stops and then figure out the causes.	2) Operating an engine with noise or vibration may cause irreversible damage of the engine.
Stopping an Engine	1) Operate the engine at idle for five minutes before stopping it.	1) Sudden engine stop after operating the engine under high load allows the heat from the red-heated turbine blade to be delivered to the bearing system. Then oil burns and the bearing metal and rotation shaft are burnt.

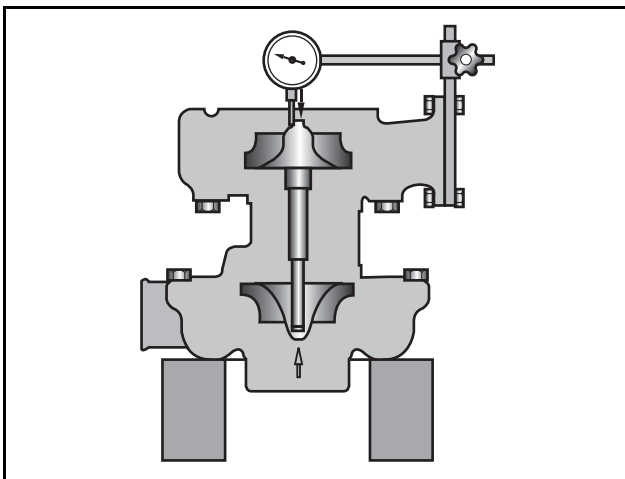
## 9. Intake/exhaust system

### Special inspection of turbocharger

You should check the radial and axial clearance of a rotor. This preventive action is to find the bearing wear status of the axial clearance so as to prevent the severe damage to the rotor and bearing.



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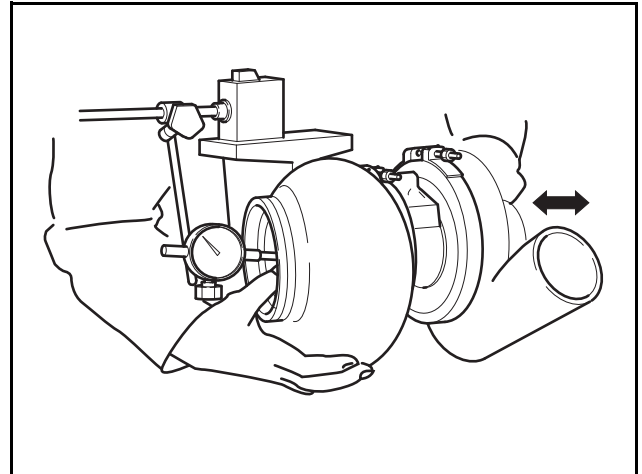


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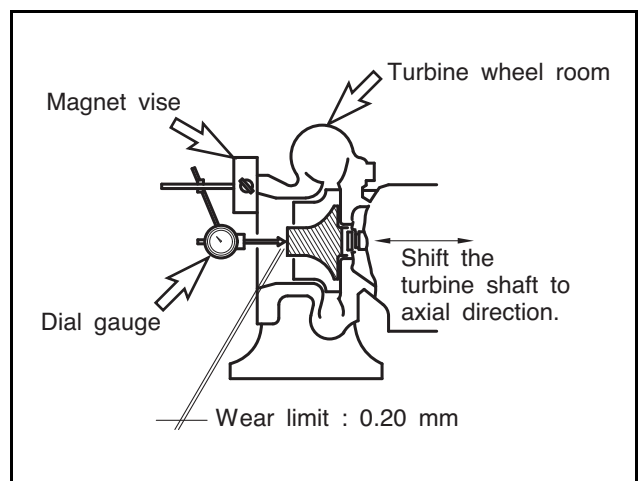
1. Checking the rotating state of a rotor assembly Check the rotating state when strange noise is heard during rotation. If you use a sound rod, contact the neck of the sound rod to the turbocharger housing and slowly raise the RPM. If high-pitched sound continues, it means that the state is abnormal. In this case, the bearing or the rotor assembly may be abnormal. So you need to replace or repair the turbocharger.
2. Checking the play of rotor assembly Remove a turbocharger from the engine, and check the axial and radial play of the rotor assembly. When you disassemble the turbocharger, be sure to seal the oil inlet and outlet with a tape, etc.

#### 1) Axial play of the rotor assembly

Wear limit	0.20 mm
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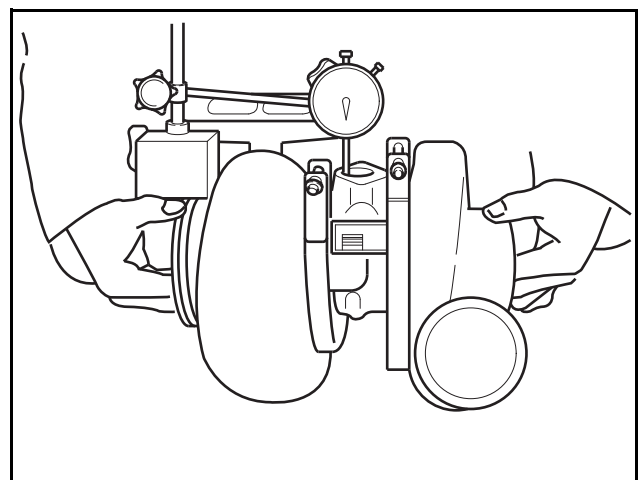
DV2213036A



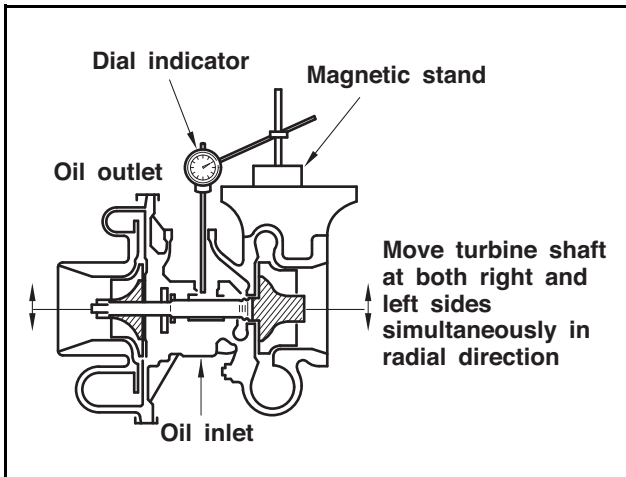
DV2213037A\_E

#### 2) Radial clearance

Wear limit	0.65 mm
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DV2213038A



DV2213039A\_E

- 3) In case that the end plays to axial and circumference directions, replace or repair the turbocharger.

## 9. Intake/exhaust system

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# 10. Cylinder block/head

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## 10. Cylinder block/head

### General information

#### General Information

The cylinder block is a single piece of alloy cast iron. To increase its stiffness, it is extended to a level below the crankshaft center line. The engine has replaceable wet cylinder liners and individual cylinder heads with strung-in valve seat rings and replaceable valve guides.

#### Specifications

Item	DP158L				Remarks	
	DP158LCS	DP158LCF	DP158LDS	DP158LDF10		
Cylinder block/head						
Valve system type		Overhead valve type				
No. of valve (per cylinder)	Intake	1				
	Exhaust	1				
Valve lashes (at cold) (mm)	Intake	0.25 ±0.05				
	Exhaust	0.35 ±0.05				
Intake valve (°)	Opening	24° (BTDC)				
	Close	36° (ABDC)				
Exhaust valve (°)	Opening	63° (BBDC)				
	Close	27° (ATDC)				

Item	DP180L				Remarks	
	DP180LBS	DP180LBF	DP180LAS	DP180LAF		
Cylinder block/head						
Valve system type		Overhead valve type				
No. of valve (per cylinder)	Intake	1				
	Exhaust	1				
Valve lashes (at cold) (mm)	Intake	0.25 ±0.05				
	Exhaust	0.35 ±0.05				
Intake valve (°)	Opening	24° (BTDC)				
	Close	36° (ABDC)				
Exhaust valve (°)	Opening	63° (BBDC)				
	Close	27° (ATDC)				

## 10. Cylinder block/head

Item		DP222L					Remarks
		DP222LAS	DP222LBS	DP222LBF	DP222LCS	DP222LCF	
Cylinder block/head							
Valve system type		Overhead valve type					
No. of valve (per cylinder)	Intake	1					
	Exhaust	1					
Valve lashes (at cold) (mm)	Intake	0.25 ±0.05					
	Exhaust	0.35 ±0.05					
Intake valve (°)	Opening	24° (BTDC)					
	Close	36° (ABDC)					
Exhaust valve (°)	Opening	63° (BBDC)					
	Close	27° (ATDC)					

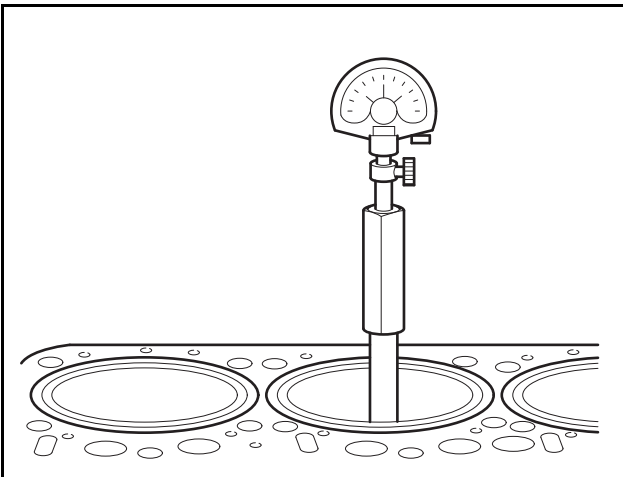
### Cylinder block

#### Check of Cylinder Block

1. Cleanse the cylinder block and check if there is any cracked or damaged part with naked eye.
2. Replace the cylinder block if it is seriously cracked or damaged. Repair tiny cracks if existing.
3. Check if the oil path or coolant path is clogged or corroded.
4. Perform the hydrostatic test to check whether there is a crack or an air leakage.
5. Block the discharging outlets of the cooling water path and the oil path of the cylinder block and put pressure of  $4 \text{ kg/cm}^2$  on the inlet. Then sink the cylinder block in the  $70^\circ\text{C}$  water for 1 minute and check if air leaks.

#### Measurement of Cylinder Liner

1. Assemble the cylinder liner at the cylinder block and measure inner diameter at upper, middle, lower that is, 3 step by  $45^\circ$  interval.



DV2213111A

2. Calculate the average values after eliminating the maximum and minimum values.
3. If the measured values are very close to the limit value or beyond, replace it.

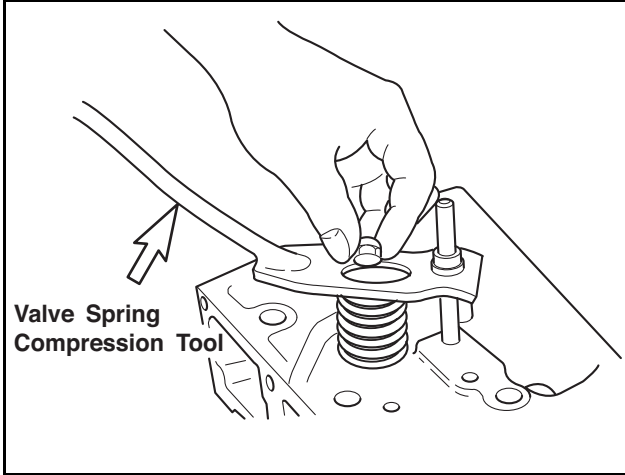
Standard	Limit
$\text{Ø}127.990 \sim \text{Ø}128.010 \text{ mm}$	0.15 mm

# 10. Cylinder block/head

## Cylinder head

### Measurement of Cylinder Liner

1. Remove the cotter pin pressing the valve spring by means of a special tool.

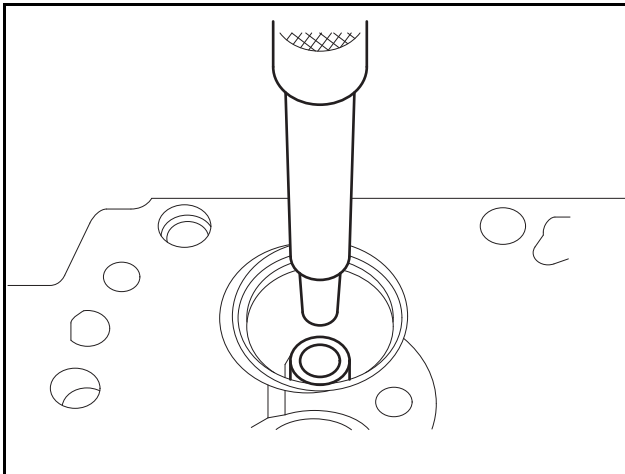


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### **⚠ CAUTION**

Be careful not to damage the cylinder gasket.

2. Remove out the valve stem seal.
3. Remove the intake valve and the exhaust valve.
4. Remove the valve guide from the cylinder head combustion with the special tool.



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### Assembly of Cylinder Head

1. Clean the cylinder head.
2. Apply engine oil on the valve stem and the valve guide, and then attach the valve.

3. Replace the new valve stem seal and then attach the stem seal to the valve guide of the cylinder head with the special tool.

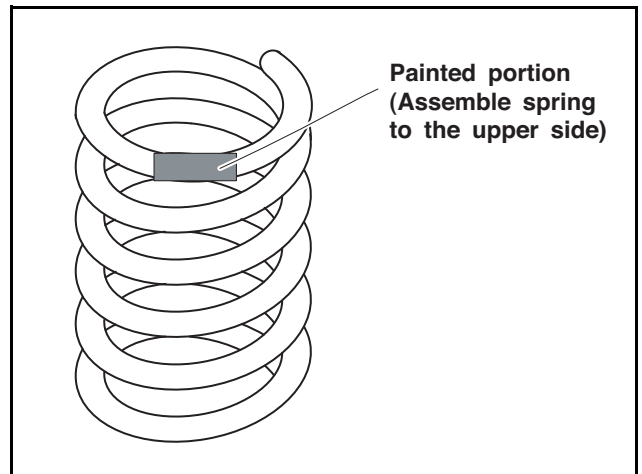
### **⚠ CAUTION**

Be careful not to damage the valve stem seal.

4. Attach the valve spring washer to valve guide.
5. Put in the valve spring and then attach the valve spring plate on the springs.

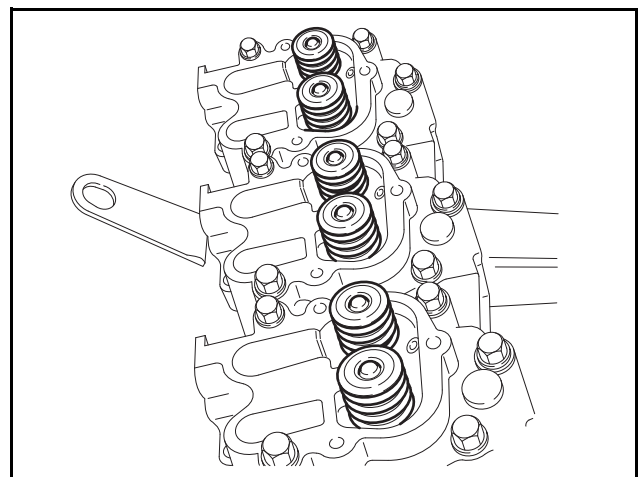
### **⚠ CAUTION**

Install the valve spring seat with "TOP" (painted in Dual Spring - Yellow / Single Spring - Red) side up.



EE10M070-E

6. Attach the valve cotter with the valve spring compress tool.
7. Check if the valve cotters have been positioned correctly with the plastic hammer after completing attaching them.



DV2213114A

## 10. Cylinder block/head

### Check of Cylinder Head

1. Checking cylinder head
  - 1) Check cracks or damage of the cylinder head.
  - 2) Remove carbon from the bottom surface of the cylinder head. Here, be careful not to scratch the valve seat surface.

Standard	Limit
Below 0.05 mm	0.2 mm

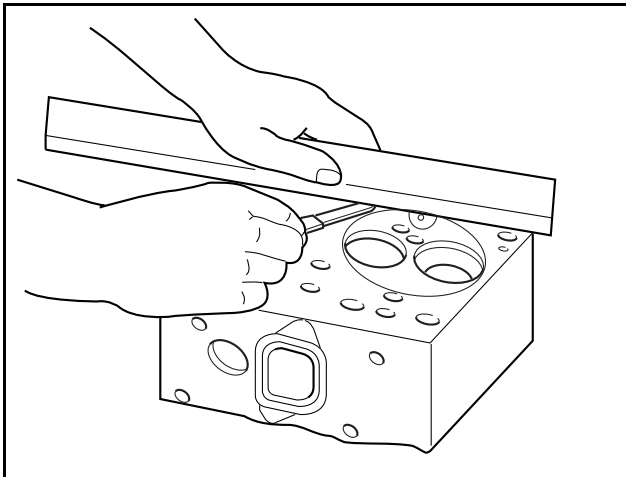
### CAUTION

**Be careful not to scratch the valve seat surface.**

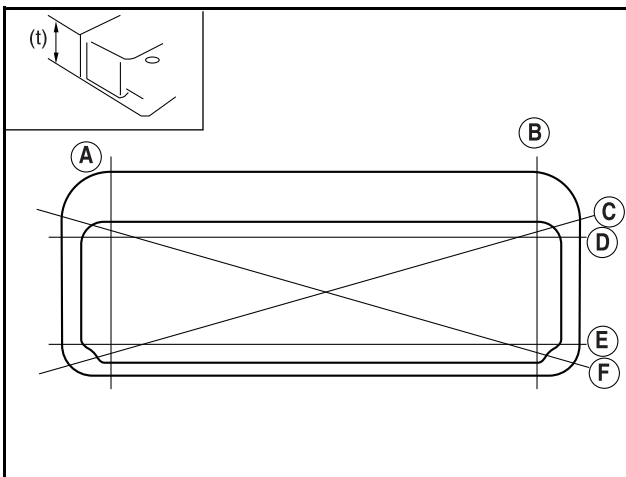
- 3) For cracks or damage which cannot be checked with the naked eye, perform the hydrostatic test or the magnetic particle testing.

Note) Hydraulic test is same as for cylinder block.

2. Distortion at the lower face



DV2213115A



DV2213116A

- 1) Measure the amount of distortion using a straight edge and a feeler gauge at six positions as shown in the figure.
- 2) If the measured value exceeds the maximum allowable limit, replace the cylinder head.

# 10. Cylinder block/head

## Valve

### General Information

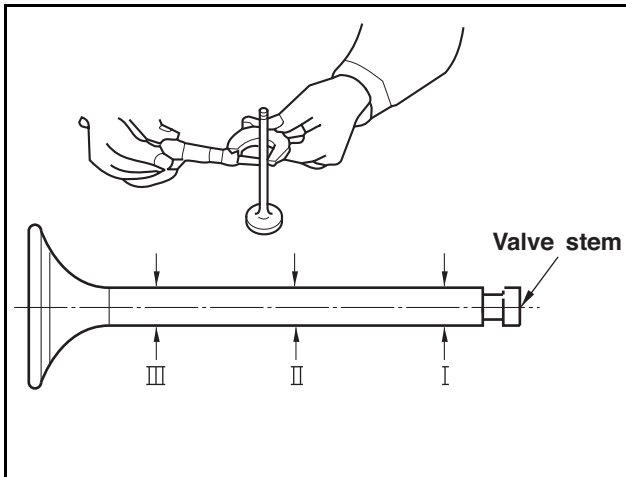
The overhead valves are actuated via chilled cast iron tapets, push rods and rocker arms from the camshaft.

### Check of Valve

After cleaning the valves with clean diesel oil, measure the valve as follow.

1. Measure the valve stem's outside diameter at upper, middle, and lower to determine the wears and when the wear limit is more than limit, replace the valves.

Item	Standard	Limit
In.	Ø11.969 ~ Ø11.980 mm	Ø11.949 mm
Ex.	Ø11.945 ~ Ø11.955 mm	Ø11.914 mm



DV2213117A\_E

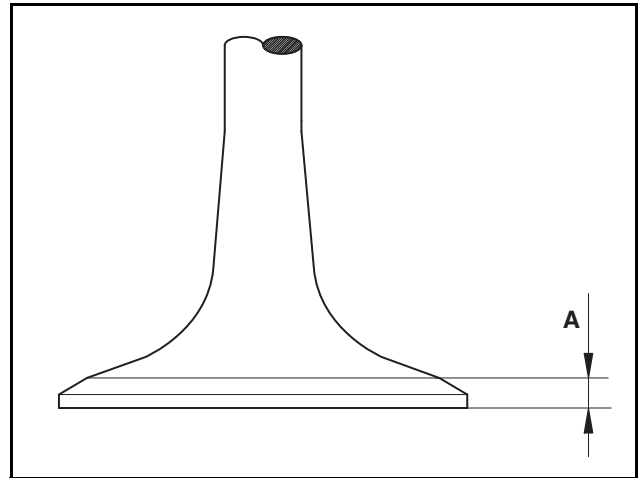
2. inspect the scratch and wear of valve stem seal contacting face, and if necessary correct with the grinding paper but if severe replace it.

### ⚠ CAUTION

**If the damage is severe, replace new one.**

3. if valve head thickness becomes less than limit, replace the valve.

Item	Standard	Limit
In.	4.6 ~ 5.0 mm	4.1 mm
Ex.	4.33 ~ 4.83 mm	3.83 mm

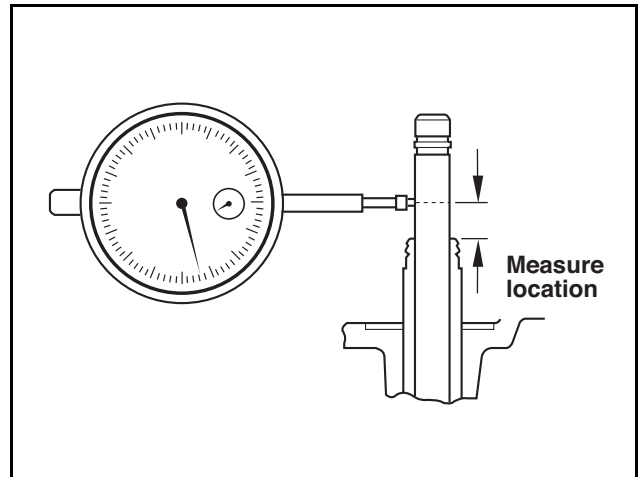


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### Check of Valve Guide

1. Insert the valve into valve guide and measure the clearance between valve and valve guide by the shaking degree of valve. If the clearance is bigger, measure the valve and then replace the more worn valve guide.

Item	Standard	Limit
In.	0.020 ~ 0.049 mm	0.10 mm
Ex.	0.045 ~ 0.074 mm	0.15 mm



DV2213119A\_E

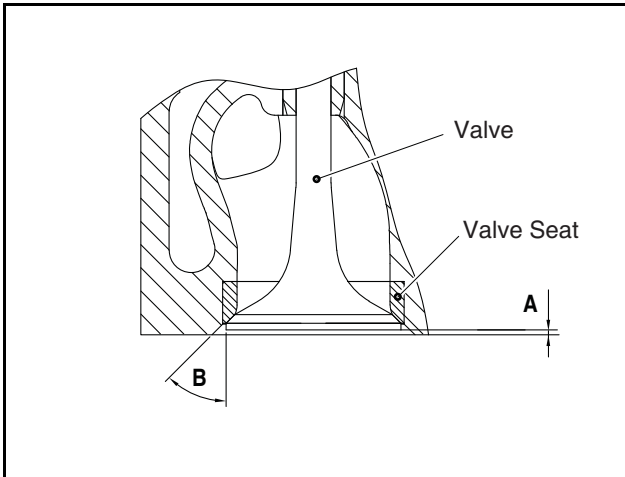
2. If the valve guide has already been replaced, measure the center with valve seat if it deviates or not and if abnormal it must be corrected.

Note) Simultaneously be processed when in guide reamer process.

# 10. Cylinder block/head

## Valve Seat

1. Visual inspection: Inspect the damage and wear of valve seat and if necessary replace.
2. Valve seat thickness and angle: Assemble the valves at the cylinder head and using the measuring instrument from the lower face, measure the projection amount of valve. If the measured wear is excessive, replace the valve seat.

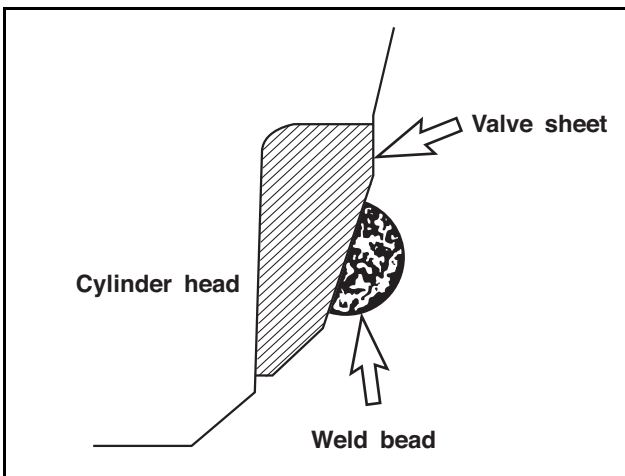


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Item		Standard	Limit
Valve projecting amount (A)	In. Valve	0.65 ~ 0.95 mm	2.5 mm
	Ex. Valve	0.65 ~ 0.95 mm	2.5 mm

Item		Limit
Valve seat angle (B)	In. Valve	60°
	Ex. Valve	45°

3. The disassembly of valve seat can be pulled out by means of a special tool with the arc welding done at two points of valve seat rotating tool or valve seat.

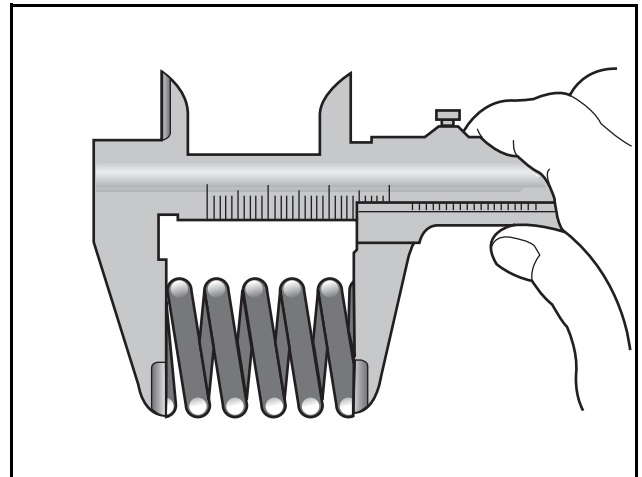


DV2213122A\_E

4. Regarding the valve seat assembling, shrink the valve seat by putting it in the dry ices for about 1 hour or so, and then press it into the cylinder head by means of a special tool.
5. After coating the grinding powder paste on valve head contacting face of valve seat, and after executing a sufficient lapping operation with the rotating and grinding motion of valve, wipe off the grinding agent thoroughly.

## Valve Spring

1. Visual inspection: Check if the exterior of the valve spring is damaged with the naked eye. Replace it with a new one if required.
2. Free length of valve spring: Measure the free length of the valve spring with the vernier calipers. If the reading is larger than the specified valve, replace the valve spring.



DV2213123A

### <Dual Spring Perpendicularity Regular>

Item		Free Length
Spring	Inside	65.5 mm
	Outside	64 mm

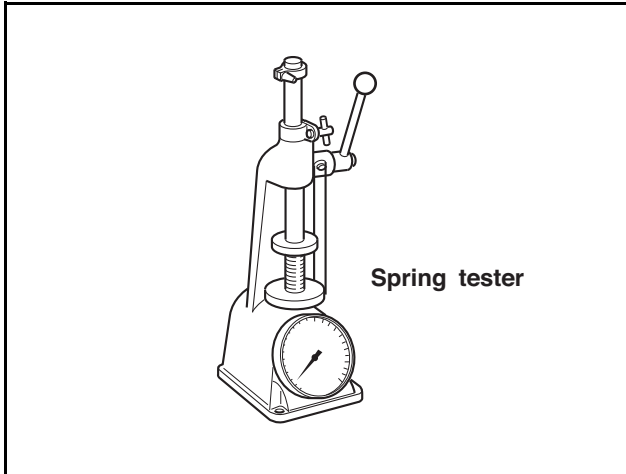
### <Single Spring Perpendicularity Regular>

Item		Free Length
Intake / Exhaust	Outside	61.9 mm

### <Single Spring Perpendicularity Regular>

Item		Length (mm)	Spring Tension (kg)	Limit (kg)
Intake / Exhaust	Outside	46.8/	47.0/	±2.5/
		32.8	90.5	±4.5

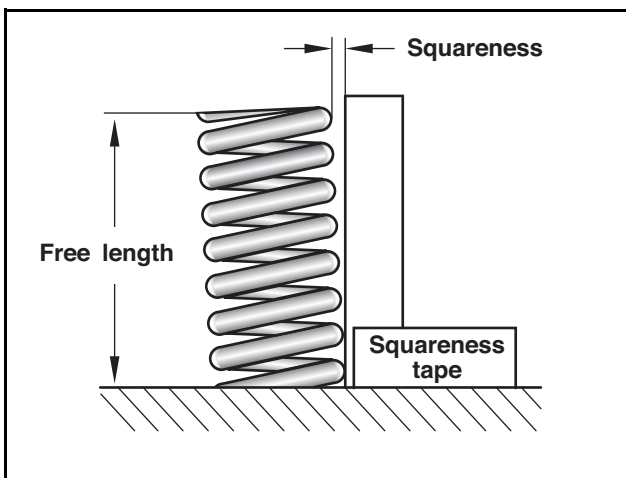
## 10. Cylinder block/head



DV2213125A\_E

3. Squareness of valve spring: Measure the squareness of the valve spring with the surface plate and the right-angle square. If the reading exceeds the tolerance limit, replace the valve spring.

Item		Standard	Limit
Intake / Exhaust	Outside	1.2 mm	2.0 mm



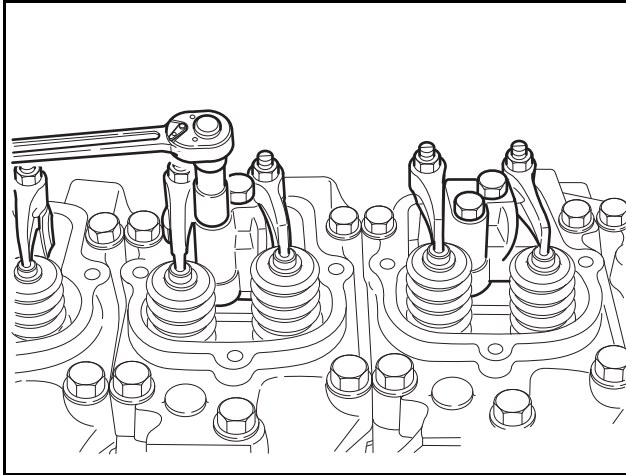
DV2213124A\_E

4. Tension of valve spring: Measure the tension of a valve spring by using a spring tester. If the reading is below the tolerance limit, replace the valve spring.

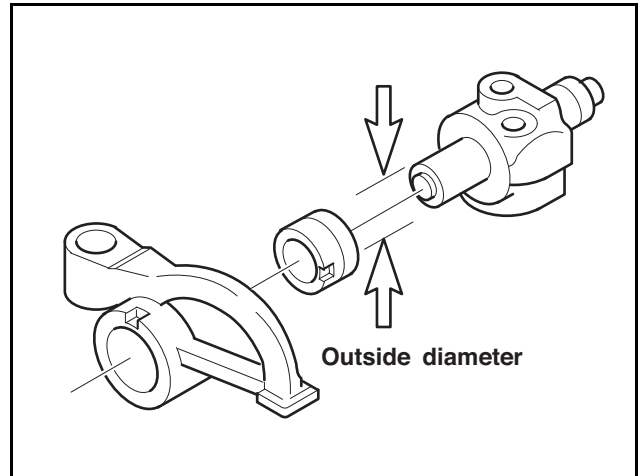
## Rocker arm

### Disassembly Rocker Arm

1. Remove the snap ring on both sides of the rocker arm shaft using snap ring plier.
2. Remove the washer and rocker arm.
3. Remove the rocker arm bush using press.



DV2213126A



DV2213127A\_E

2. Rocker arm: Inspect the rocker arm surface that contacts with the valve stem for any scratch, step wear and correct the minor degree of wear with an oil stone or the fine grinding paper and replace if they are severe.

### Check of Rocker Arm

1. Rocker arm bracket (Single unit type with a shaft): Measure the outer diameter of rocker arm bracket with outside micrometer at the position that the rocker arm is installed, and in case that it exceeds the limit value, replace.

Item	Standard	Limit
Bush Inner Dia.	Ø25.005 ~ Ø25.035	Ø25.083
Shaft Outer Dia.	Ø24.967 ~ Ø24.990	Ø24.930
Clearance	0.015 ~ 0.068 mm	0.14 mm

### **⚠ CAUTION**

**If the wear is severe, replace new one.**

### Assembly Rocker Arm

1. Check if there is foreign substance in the oil delivery hole of the rocker arm shaft, and clean it, if any.
2. Attach the rocker arm in the reverse order of assembly.

### **⚠ CAUTION**

**Be careful not to change the rocker arm position or assemble it in a reverse order.**

# 10. Cylinder block/head

## Tappet and push rod

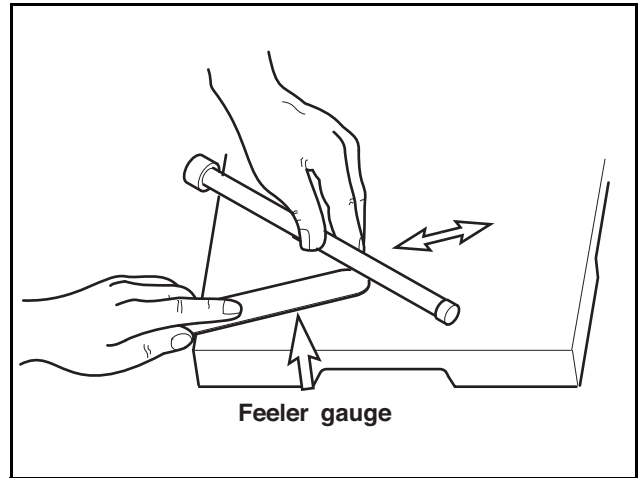
### Tappet Clearance

Measure the outer diameter of a tappet and the inner diameter of the tappet bore. If the reading exceeds the tolerance limit, replace the tappet.

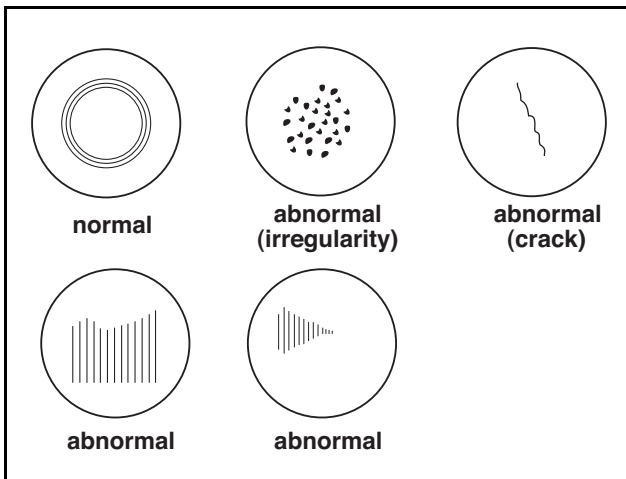
Standard	Limit
0.035 ~ 0.077 mm	0.25 mm

### Visual inspection of tappet

Inspection if the tappet surface which contacts the camshaft has damage like crack or scratch. If the damage is small, correct it with oil stone or fine grinding paper, if excessive, replace it.



DV2213129A\_E



DV2213128A\_E

### Warpage of Push Rod

Put the push rod on a surface plate, and measure the warpage with a feeler gauge while spinning it. If the reading exceeds the tolerance limit, replace it.

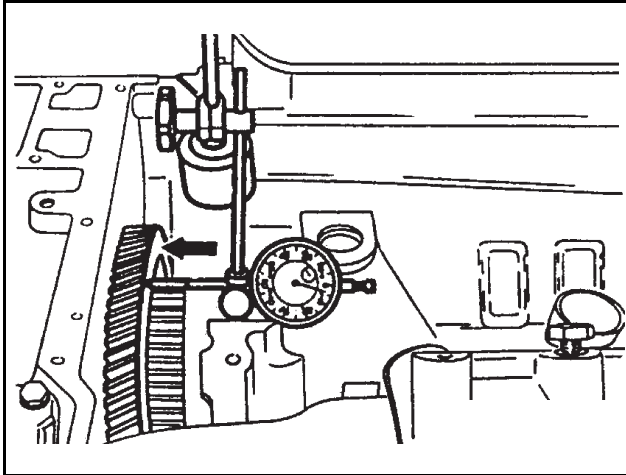
Limit	Below 0.3 mm
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## Camshaft

### Camshaft End Play

Measure the camshaft's axial end play.

1. Push the camshaft toward the pulley side.
2. Place a dial gauge onto the camshaft gear.

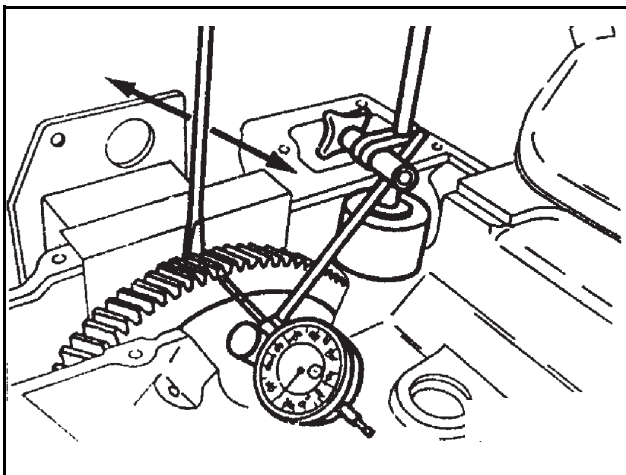


DV2213130A

3. Measure the camshaft's axial end play, moving the camshaft gear by means of driver.

Item	Standard	Limit
End play	0.24 ~ 0.86 mm	0.9 mm

4. If excessive end play, assembly it by means of other thrust washer.

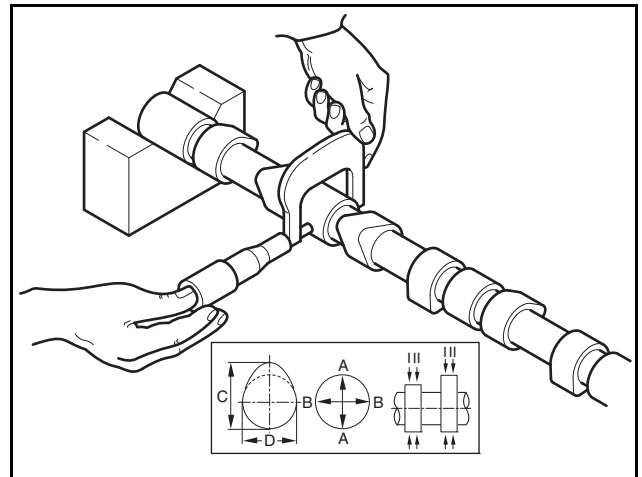


DV2213131A

### Check and measurement of Camshaft

1. Visual check  
With inspecting the cam surface for any damage with naked eyes and correct any minor scratches by means of an oil stone grinding and if severe, replace it.
2. Cam lobe height  
Use a micrometer to measure the cam lobe height and journal diameter. If the measured number is less than the specified limit, the camshaft must replaced.

Item		Standard	Limit
Cam lobe height(C)	Intake	56.370 mm	56.032 mm
	Exhaust	56.430 mm	56.091 mm
Cam bearing outside (A,B)		Ø69.91 ~ 69.94 mm	Ø69.560 mm



DV2213132A

3. Cam bearing diameter  
Measure the camshaft bush inside diameter with a cylinder gauge and by comparing the inside and outside diameters, replace if abnormal.

Item	Standard	Limit
Thust	Ø70.070 ~ Ø70.090 mm	Ø69.464 mm
Middle	Ø70.000 ~ Ø70.030 mm	Ø69.192 mm

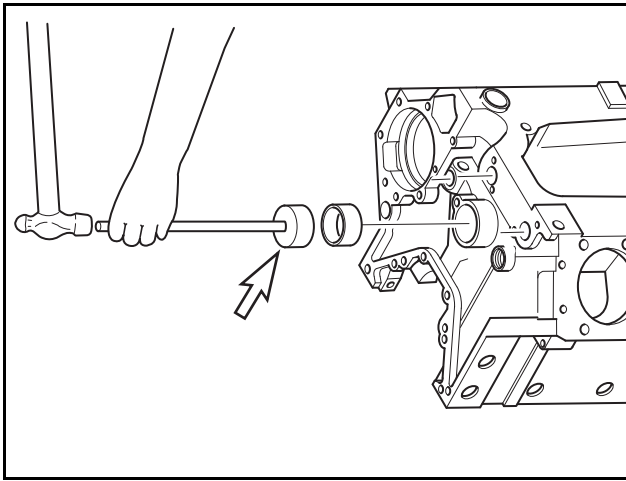
4. Clearance  
Between camshaft journal and body.

Item	Standard	Limit
Thust	0.060 ~ 0.120 mm	0.240 mm
Middle	0.130 ~ 0.180 mm	0.240 mm

# 10. Cylinder block/head

## 5. Camshaft bearing replacement

Replace the camshaft bearing with a special tool.

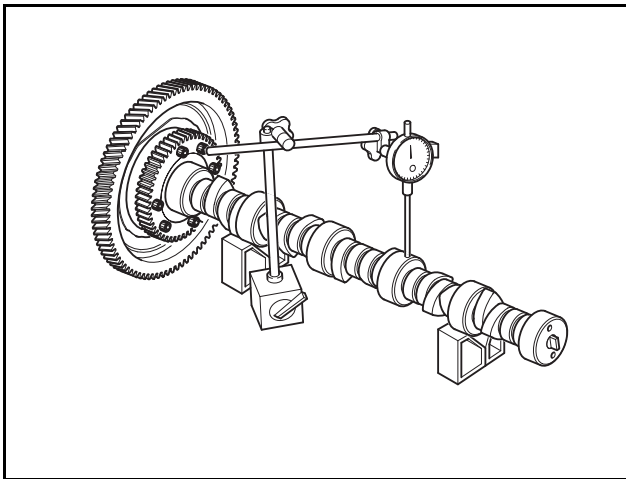


EDP2218003

## 6. Camshaft run-out

With placing the camshaft on the 2 ea of V-blocks, and inspect the run-out of the camshaft, adjust or replace the severe one.

Standard	Limit
0.05 mm	0.15 mm

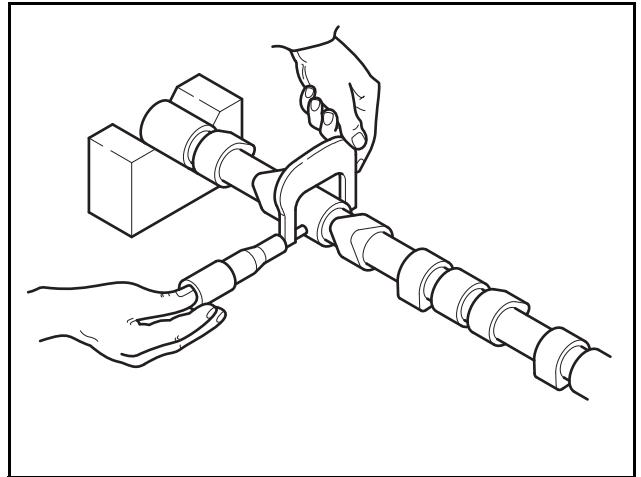


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## Check of camshaft

1. Camshaft bearing outer diameter: Using an outer diameter micrometer, measure the outer diameter of the camshaft bearing.

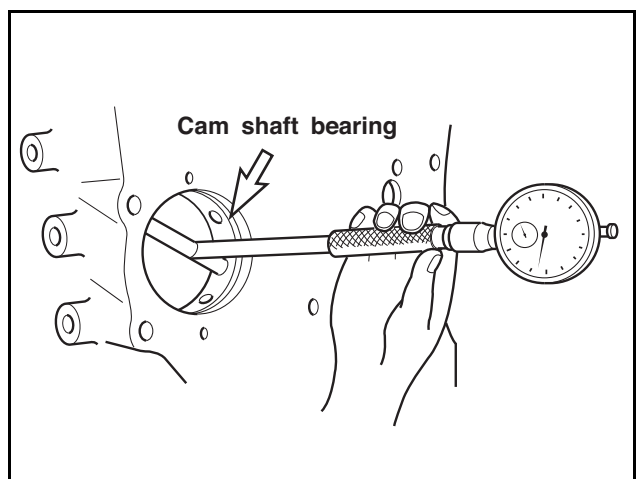
Item	Standard
Camshaft bearing outer diameter	Ø69.91 ~ Ø69.94 mm



DV2213133A

2. Camshaft bearing inner diameter of cylinder block: Using a cylinder inner gauge, measure the inner diameter of the camshaft bearing.

Item	Standard
Camshaft bearing inner diameter of cylinder block	Ø70.077 ~ Ø70.061 mm



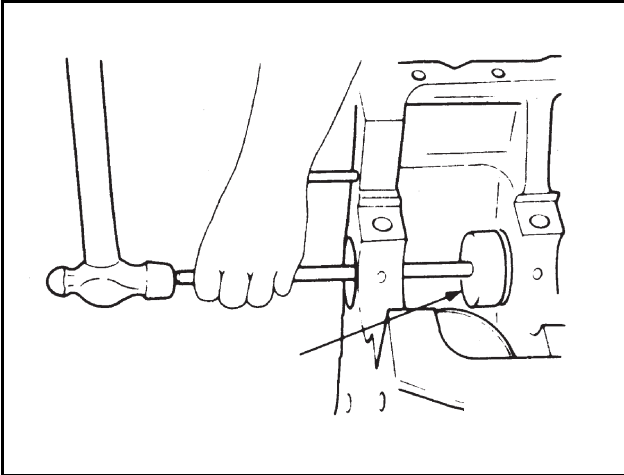
DV2213134A\_E

3. Clearance between camshaft and bearing: Compare the inner diameter of the camshaft bearing with the outer diameter value of the camshaft to determine the clearance. If the reading exceeds the tolerance limit, replace the camshaft bearing.

## 10. Cylinder block/head

Item	Limit
Clearance between camshaft and bearing	0.18 mm

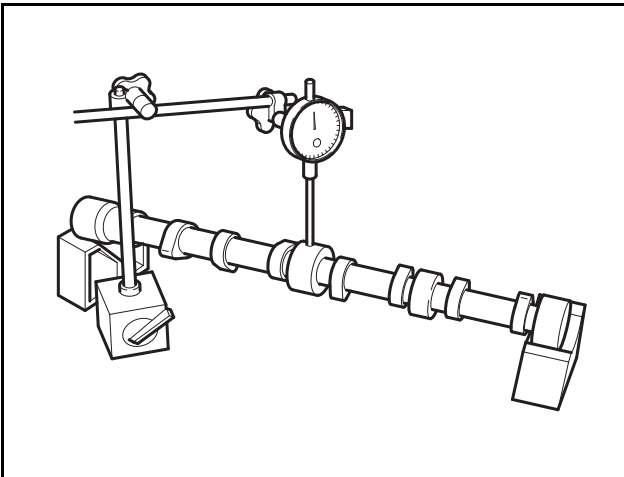
4. Camshaft bearing replacement: Replace the camshaft bearing with a special tool.



DV2213135A

5. Warpage of camshaft: Place the camshaft on 2 V blocks, and inspect the warpage of the camshaft by using a dial gauge to correct it. if excessive, replace the camshaft.

Item	Limit
Warpage of camshaft	0.1 mm



DV2213136A

## 10. Cylinder block/head

---

# 11. Electric system

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## 11. Electric system

### General information

### Specification

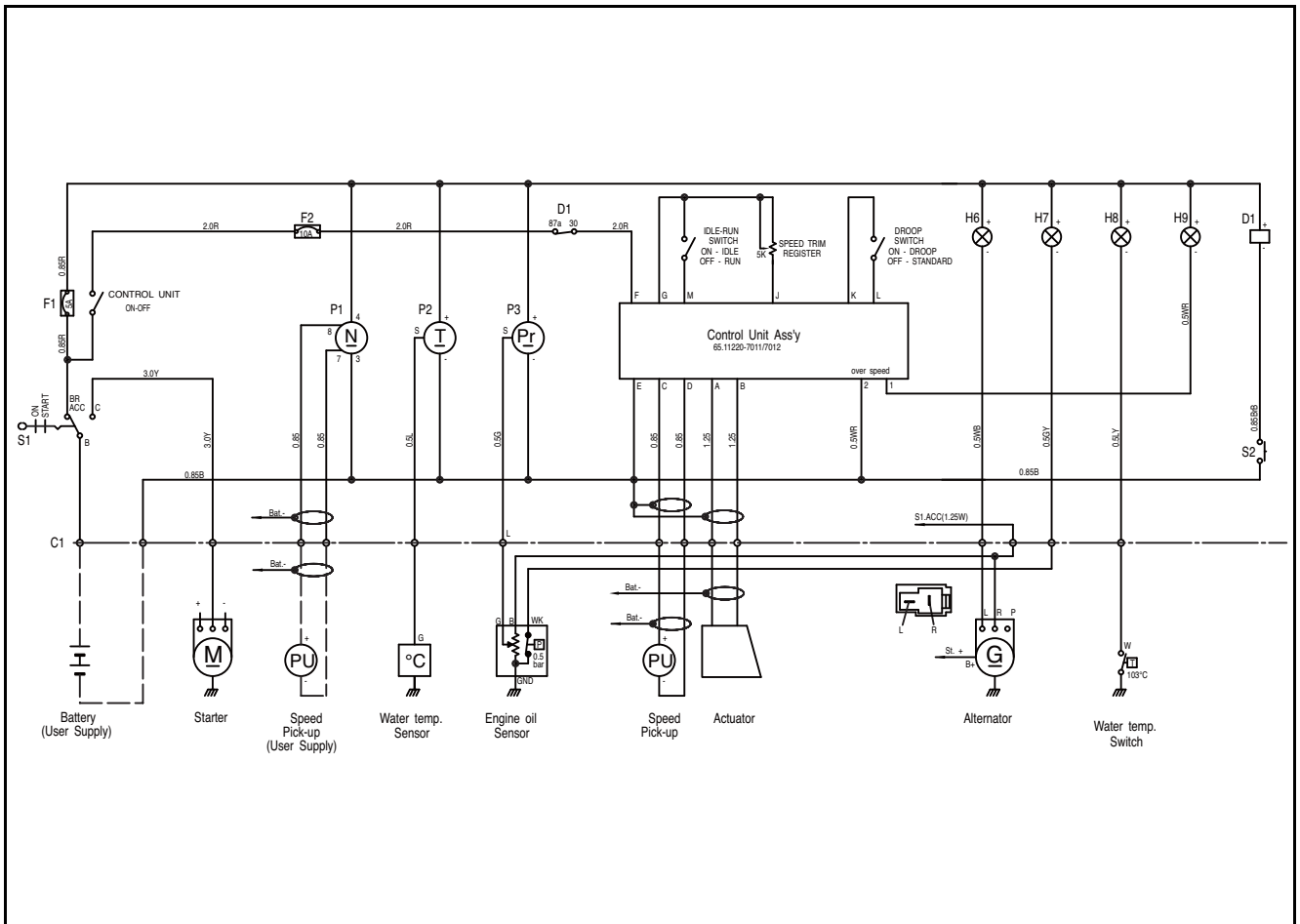
Item	DP158L				Remarks
	DP158LCS	DP158LCF	DP158LDS	DP158LDF10	
Electrical System					
Alternator voltage - capacity (V - A)	27.5 - 45				
Voltage regulator	Built-in type IC regulator				
Starting motor voltage - capacity (V - kW)	24 - 7.0				
Battery capacity	2-200Ah (recommended)				

Item	DP180L				Remarks
	DP180LBS	DP180LBF	DP180LAS	DP180LAF	
Electrical System					
Alternator voltage - capacity (V - A)	27.5 - 45				
Voltage regulator	Built-in type IC regulator				
Starting motor voltage - capacity (V - kW)	24 - 7.0				
Battery capacity	2-200Ah (recommended)				

Item	DP222L					Remarks
	DP222LAS	DP222LBS	DP222LBF	DP222LCS	DP222LCF	
Electrical System						
Alternator voltage - capacity (V - A)	27.5 - 45					
Voltage regulator	Built-in type IC regulator					
Starting motor voltage - capacity (V - kW)	24 - 7.0					
Battery capacity	2-200Ah (recommended)					

# 11. Electric system

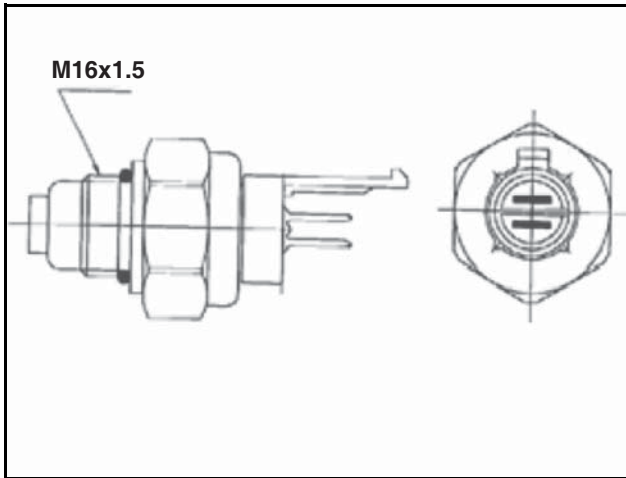
## Electrical Wiring diagram



DV2213212A

## Switches and sensors

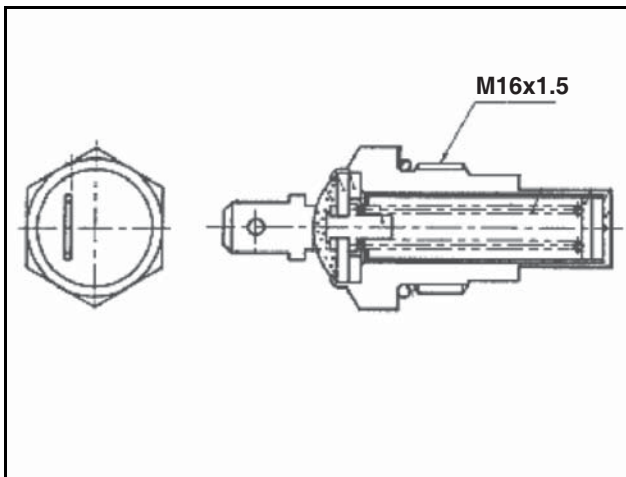
### Temperature Switch



DV2213141A

<b>Operation Temperature</b>	ON: 103 ±3°C, OFF: 96°C
<b>Current Capacity</b>	DC12V, 9A
<b>TYPE</b>	Normal Open
<b>Insulation Resistance</b>	more than 10MΩ

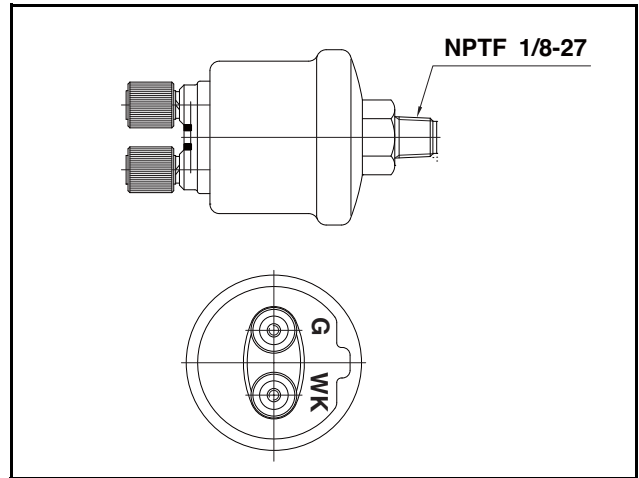
### Temperature Sensor



DV2213142A

<b>Temperature (°C)</b>	50	80	100	120
<b>Resistance (?)</b>	153.9	47.5~58.0	26.2~31.3	16.1

### Pressure Sensor & Switch



DV2213143B

#### 1. Output characteristic

Pressure (bar)	Resistance (Ω)
0	10 ±5
2	52 ±5
4	88 ±5
6	124 ±5
8	155 ±7
10	184 <sup>+9</sup> <sub>-7</sub>
Warning pressure (bar)	0.5 <sup>+0.2</sup> <sub>-0.1</sub>

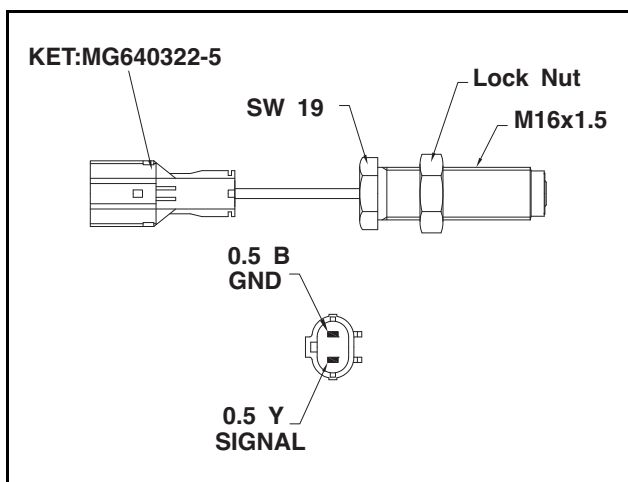
- Warning output: switch(WK) to GND at 0.5 ±0.2 bar
- Max. pressure: 30 bar (momentary 2sec)
- Operating temperature: -30°C ~ 100°C (Max. 120°C, 1h)
- R-T Conversion table

t (°C)	Rmin. (kΩ)	Rnom. (kΩ)	Rmax (kΩ)
-10	3.284	3.467	3.651
0	1.939	2.047	2.155
10	1.152	1.217	1.281
20	0.6896	0.7283	0.7669
30	0.4200	0.4435	0.4670
40	0.2650	0.2798	0.2946
50	0.1722	0.1818	0.1914
60	0.1149	0.1213	0.1277

## 11. Electric system

t (°C)	Rmin. (kΩ)	Rnom. (kΩ)	Rmax (kΩ)
70	0.0786	0.0830	0.0873
80	0.0550	0.0580	0.0610
90	0.0394	0.0415	0.0437
100	0.0289	0.0305	0.0321
110	0.0217	0.0228	0.0240
120	0.0165	0.0174	0.0183

### Magnetic Pick-up



DV2213146B

1. Operating temperature: -40°C ~ 120°C
2. Output Volt (P-P)

	above 14V	above 7V
Gear	Module M=3, Teeth Z=32	M=3, Z=32
Clearance	1.0 ±0.1 mm	1.0 ±0.1 mm
Revolution	1,000 ±20 RPM	1,000 ±20 RPM
Load	Open	5kΩ Resistive

3. DC resistance: 1.8kΩ ± 15%
4. Inductance: 3.1H ± 25%
5. Insulation Resistance: 10MΩ or more at 500V DC
6. Resistance (B ~ Y): 350Ω ± 10%

## Starter

### General Information

The starter is attached to the back of the flywheel housing. When disassembling the engine, immerse the pinion gear and ring gear of the starter in fuel, brush them, and then apply greases to them in order to prevent rust.

---

### CAUTION

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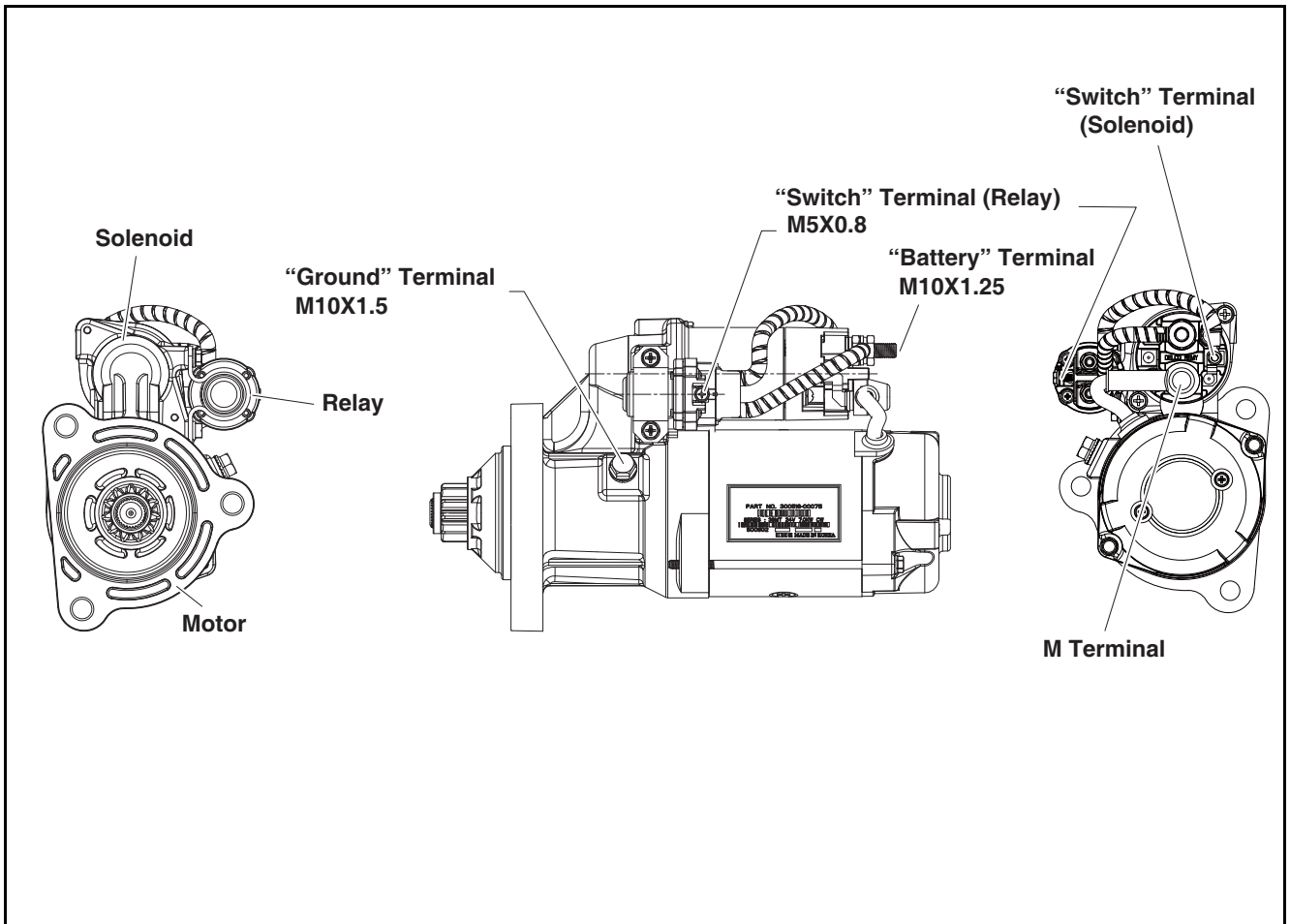
- **Starter should be protected from humidity all the time.**
  - **Before working on the electric system, be sure to disconnect the ground wire("-" minus wire) of the battery. Short circuit may occur while working on the electrical system. Connect the ground wire last after completing all of work.**
- 

### Specification

Specification		
NOMINAL OUTPUT		24V, 7.0kW
ENGAGEMENT SYSTEM		AUXILIARY ROTATION SYSTEM/SOFT START
Max. RATED TIME		30 SEC
ROTATION		CLOCKWISE VIEWED FROM THE PINION
SWITCH HOLD-IN CURRENT	MAGNETIC SWITCH	2.3A
	SOLENOID SWITCH	15A

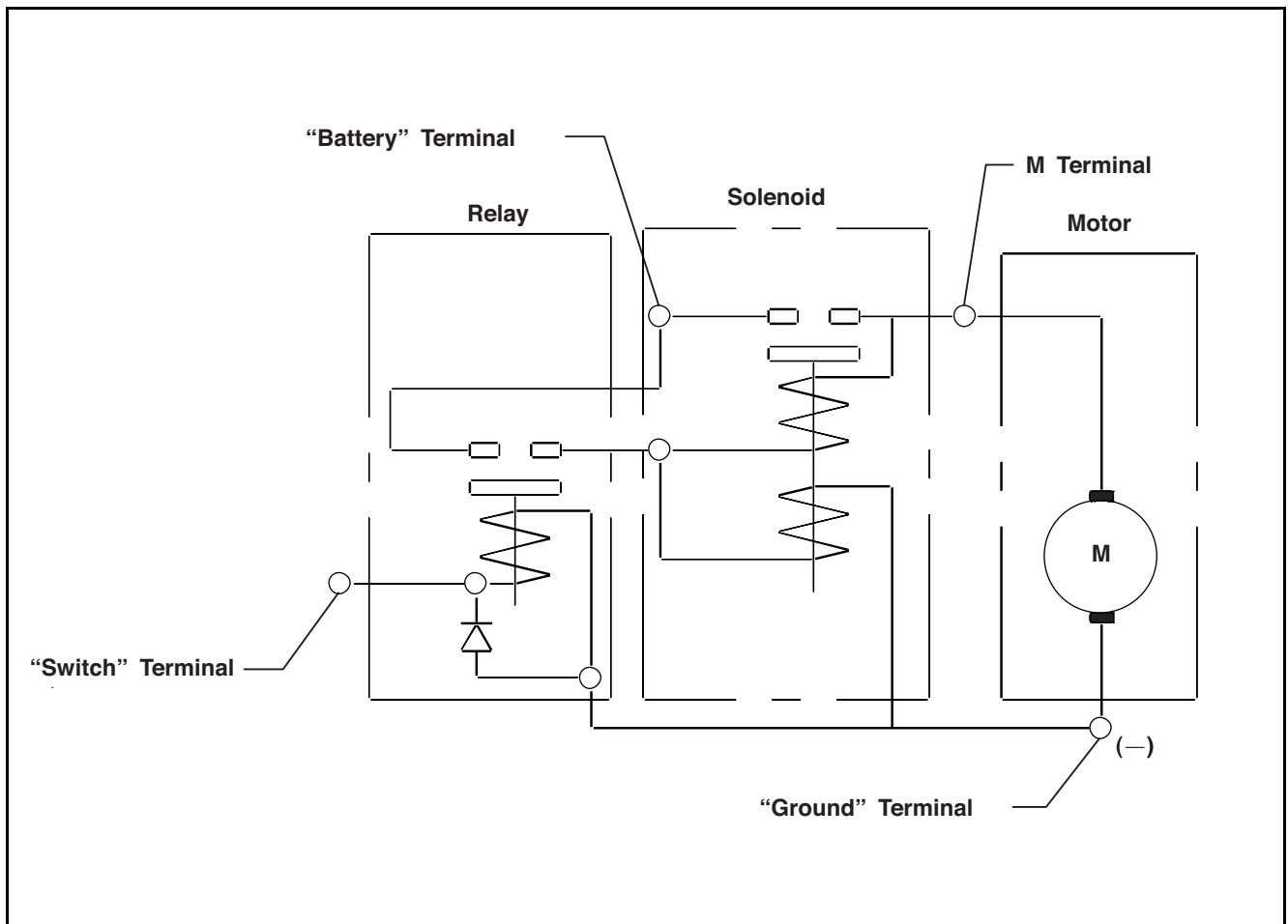
# 11. Electric system

## Views



EDV2223006

## Wiring Diagram



DV2213140A

## Resistance

Item	+	-	Spec.
Relay	Switch Terminal	Relay Case	$23.5\text{k}\Omega \pm 2.35$
Solenoid	Switch Terminal	M Terminal	$0.124\Omega \pm 5\%$

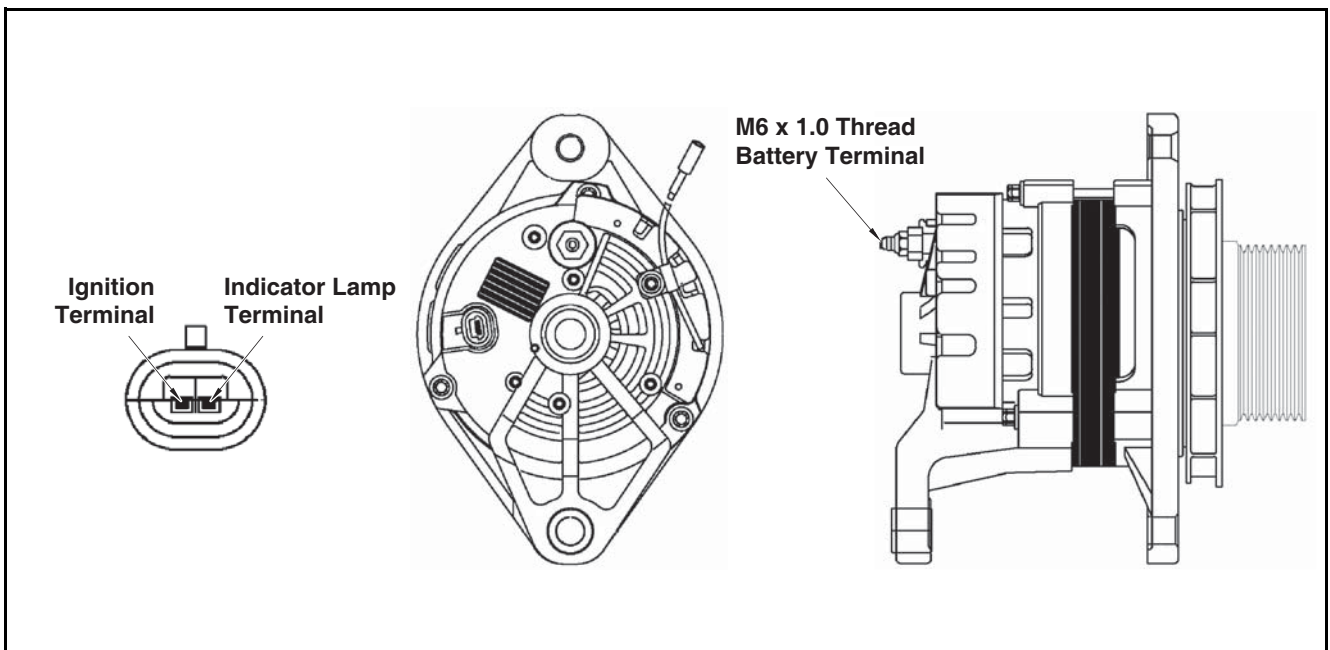
# 11. Electric system

## Alternator

### General Information

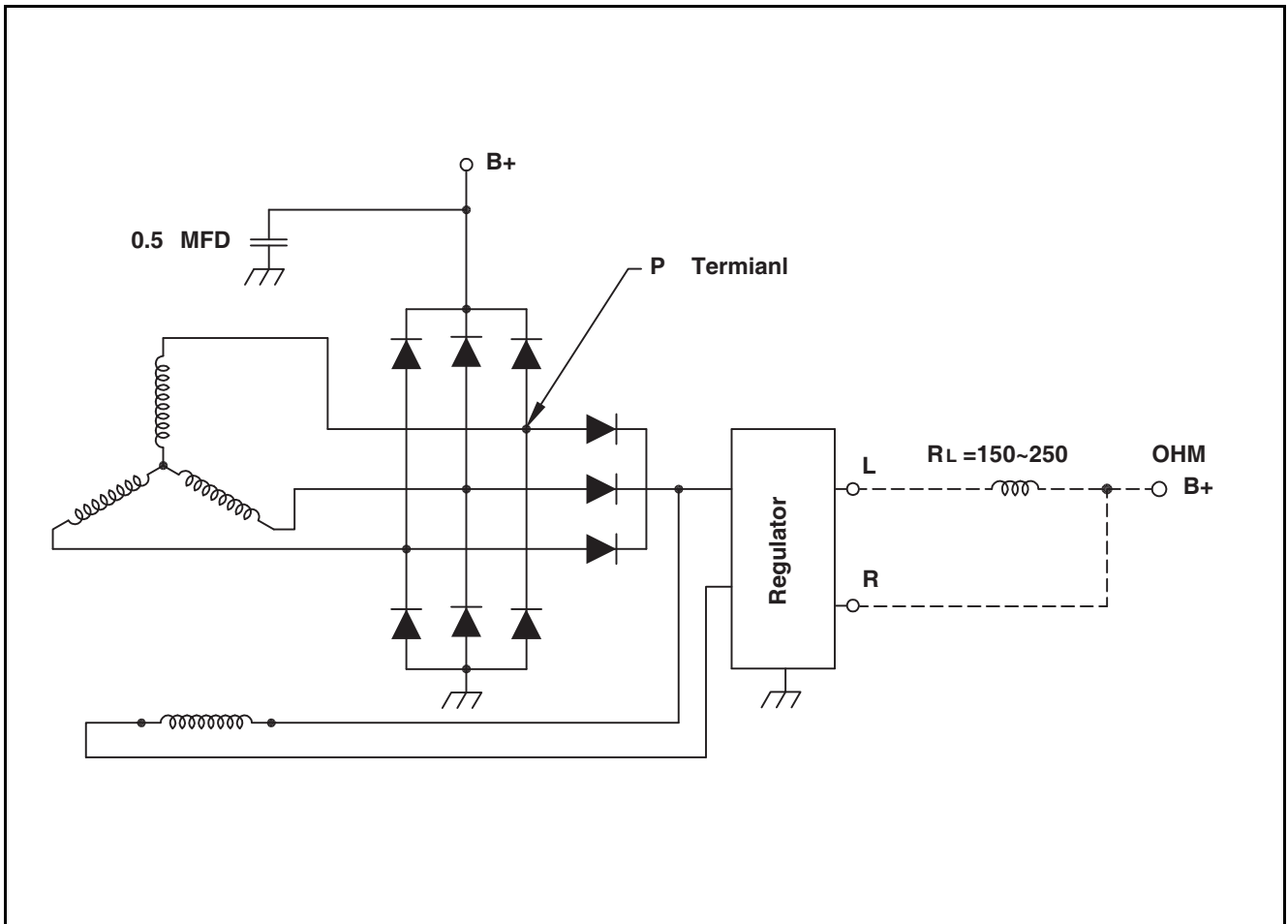
The alternator is fitted with integral silicon rectifiers. A transistorized regulator mounted on the alternator body interior limits the alternator voltage. The alternator should not be operated except with the regulator and battery connected in circuit to avoid damage to the rectifier and regulator. The alternator is maintenance-free, nevertheless, it must be protected against dust and, above all, against moisture and water.

### Views



EDP2218005

## Wiring Diagram



DV2213138A

## Specification

Specification		
Rating	Continuous rating	
Rotation Direction	Clockwise	
Battery Voltage	24V	
Turn on Rpm	Max. 1,050 RPM	
Speed in Use	1,000 ~ 8,000 RPM	
Max. Inlet Air Temp	105°C	
Polarity	Set. Volt.	27.5V
	Temp. Grad	10 ±3mV/°C

## Performance

Performance			
Voltage (V)	Output current (A)		Speed (RPM)
	COLD	HOT	
27.5V	(22)	17.5	1,800
	(48)	45	5,000

# 11. Electric system

---

## Abnormally Charging

1. Measuring the voltage between the terminal and the alternator body when operating.

Note) Measuring the voltage in order to check the wire condition needs only the terminal when the engine is stopped.

- 1) During operation

Position	Voltage
Terminal B - Body	About DC27V ~ 29.5V
Terminal L - Body	About DC27V ~ 29.5V
Terminal R - Body	About DC3V ~ 5V

- 2) During Stop

Position	Voltage
Terminal B - Body	About DC22V ~ 27V
Terminal L - Body	About DC22V ~ 27V
Terminal R - Body	0

2. Check of a voltage regulators: Measuring the resistance between the terminals.

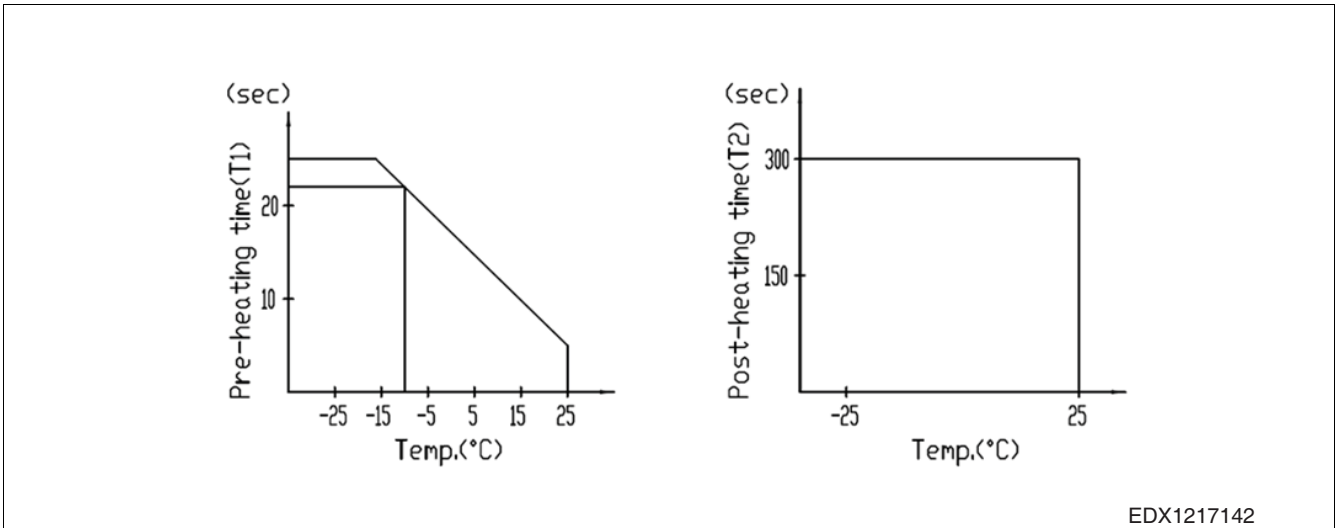
- 1) The resistance value between the voltage regulators.

Terminal		Resistance
+	-	
L	Body	4 ~ 4.5 k $\Omega$
R	Body	110 ~ 180 k $\Omega$
Body	R	110 ~ 180 k $\Omega$
L	R	110 ~ 180 k $\Omega$

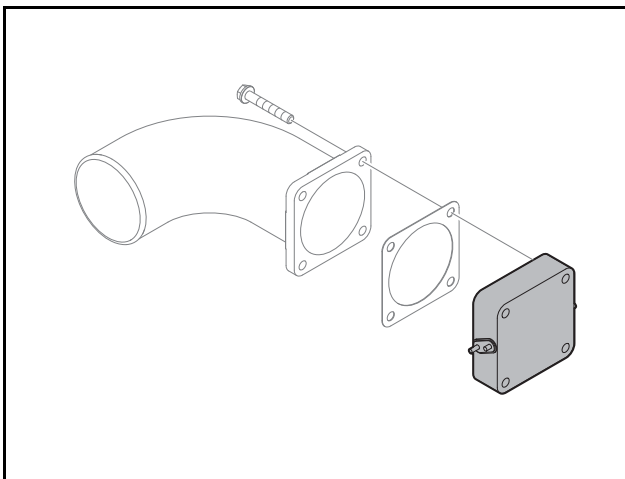
## Air Heater

### 1. Air heater Operating Conditions

- It is recommended to use the air heater when the cooling water temperature is below 5 degrees.
- Air heater, Timer, Relay is supplied, and the heater operation time is automatically adjusted according to the cooling water temperature.
- Preheating / Post-heating time



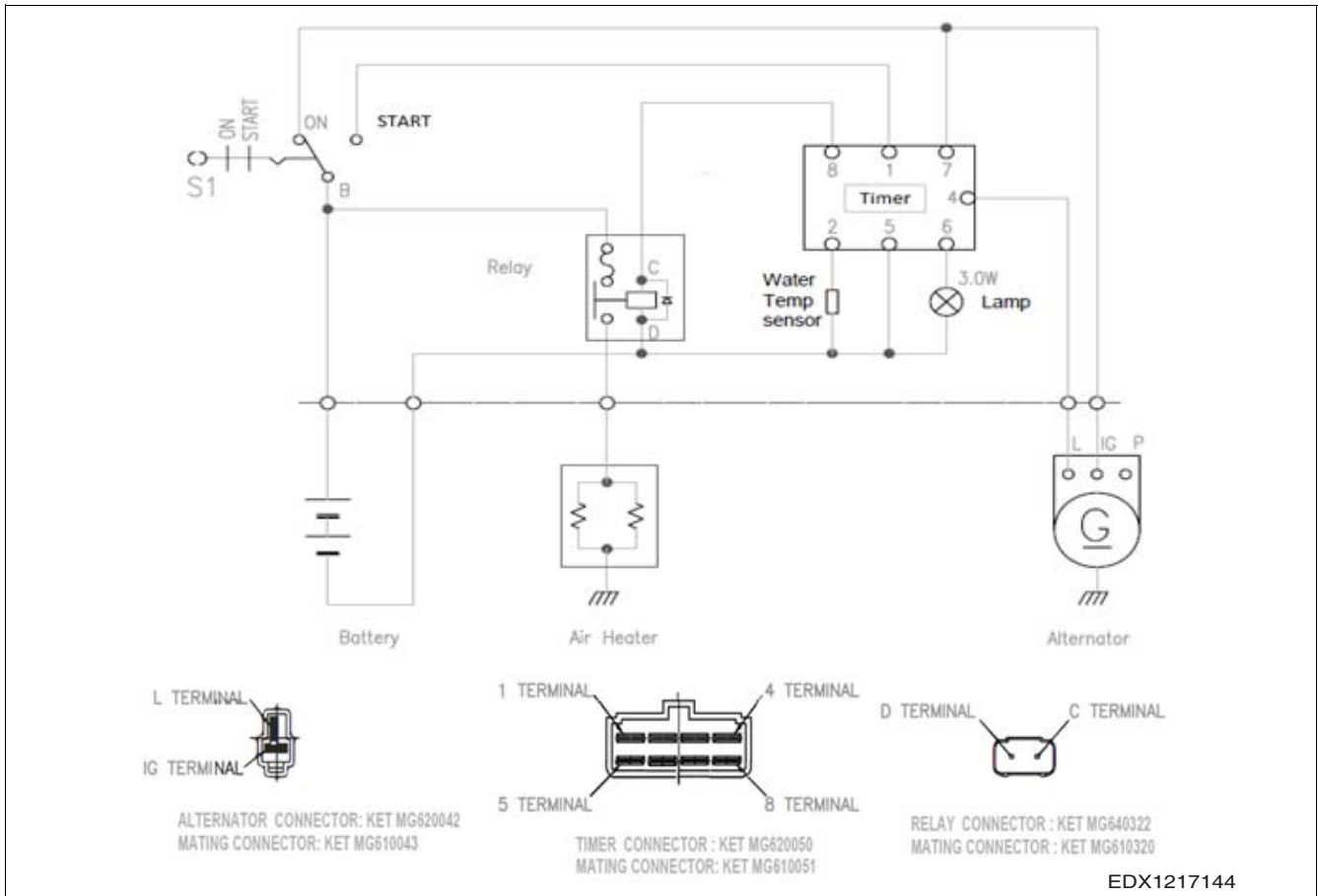
### 2. Air heater Mounting parts



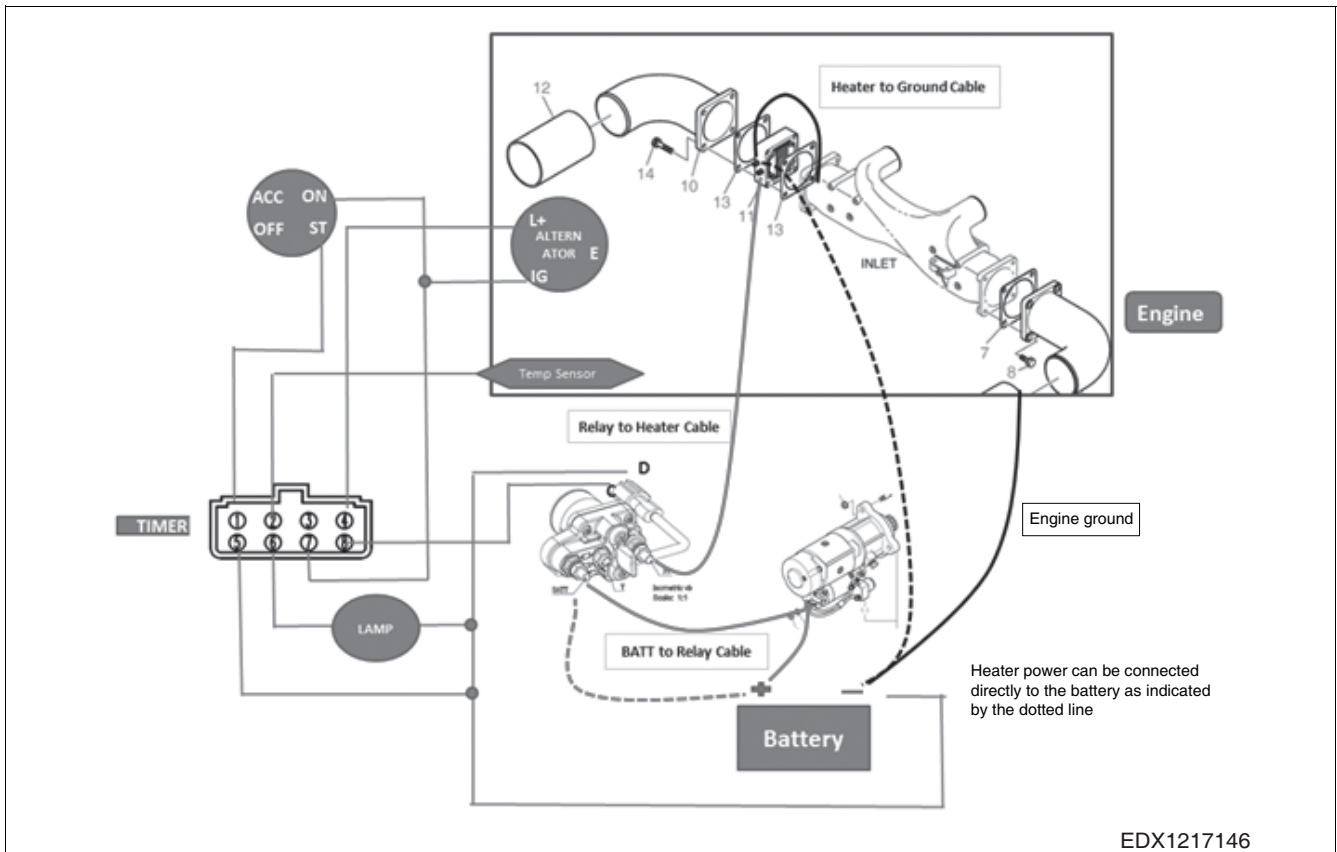
EDP2218006

# 11. Electric system

## 3. Air heater Diagram



## 4. Air heater schematic



# 12. Others/driving system

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### General information

#### General Information

The forged crankshaft has screwed-on counterweights.

Radial seals with replaceable wearing rings on crankshaft and flywheel are provided to seal the crankcase penetrations.

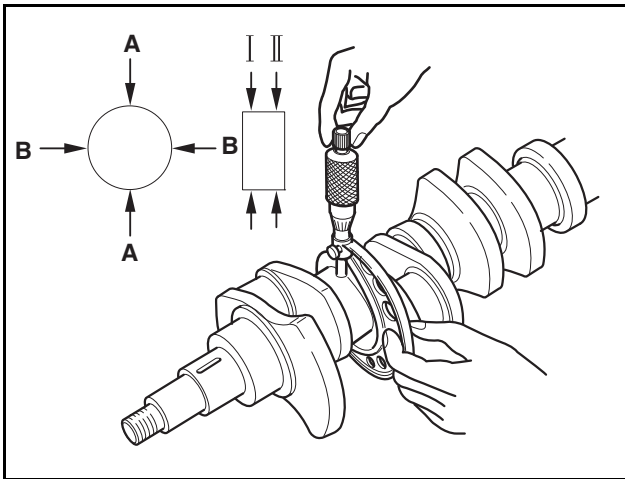
The connecting rods are die-forged, diagonally split and can be removed through the top of the cylinders together with the pistons. Crankshaft and connecting rods run in steel-backed lead bronze ready-to-fit bearings.

## 12. Others/driving system

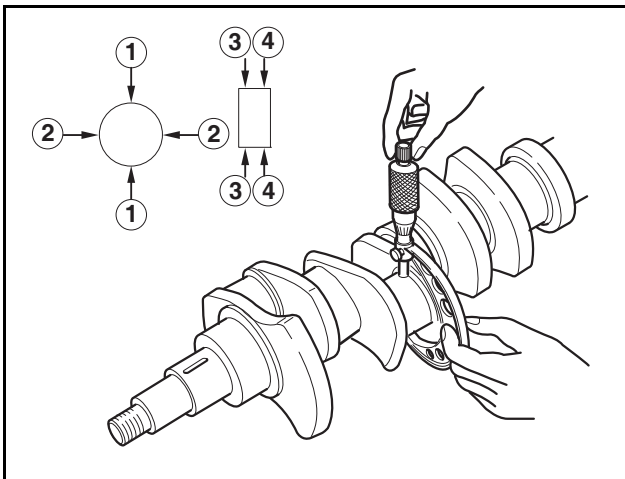
### Crankshaft

#### Measurement of Crankshaft

1. Inspection and measurement
  - 1) Visually inspect whether there is any crack or scratch on the journal and pins of the crankshaft.
  - 2) Perform the magnetic particle testing or the liquid penetrant testing (color check) to check the cracks on the crankshaft. If cracks are found, replace the crankshaft with a new one.
2. Measuring journal and pin diameter
  - 1) Using an outer diameter micrometer, measure the crankshaft journals and pins toward the direction as shown in the figure to determine the amount of wear.



DV2213147A

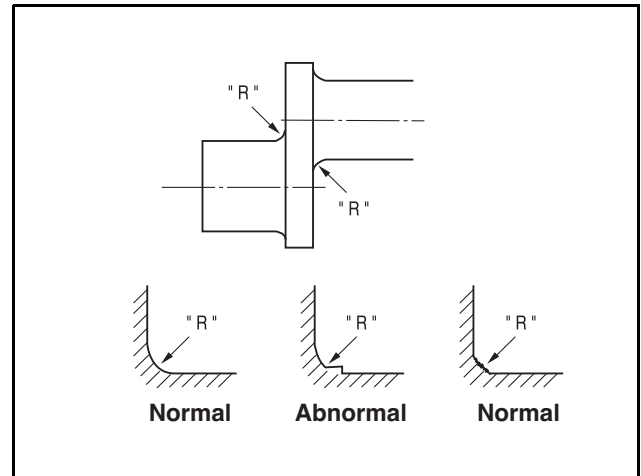


DV2213148A

- 2) If the amount of wear exceeds the tolerance limit, grind the crankshaft and assemble an under-size bearing.
- 3) There are 5 kinds as below, and the crankshaft also can be used by regrinding as below.
  - Standard
  - 0.10 (Inside diameter 0.10 mm less than standard)
  - 0.25 (Inside diameter 0.25 mm less than standard)
  - 0.50 (Inside diameter 0.50 mm less than standard)
  - 0.75 (Inside diameter 0.75 mm less than standard)
  - 1.00 (Inside diameter 1.00 mm less than standard)
- 4) "R" part standard value
  - Crank pin "R": 3.5 ~ 4.0
  - Crank journal "R": 3.5 ~ 4.0

#### CAUTION

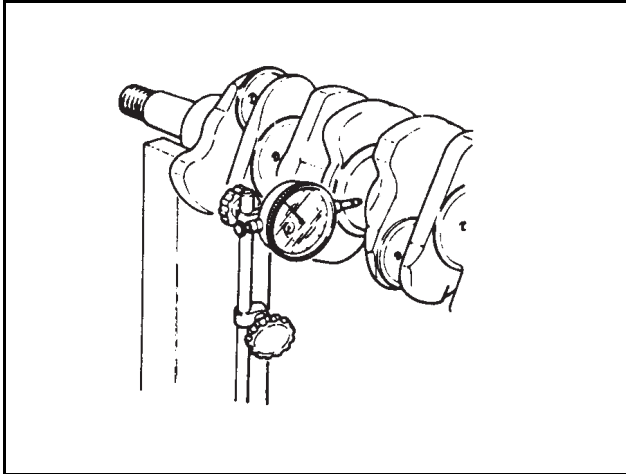
In case of crankshaft regrinding, the "R" part at the end of bearing must accurately be ground without fail and should avoid any processed jaw or coarse surface.



DV2213149A\_E

3. Warpage of crankshaft
  - 1) Put the crankshaft on the V block.
  - 2) Put the dial gauge on the surface plate and measure the warpage of the crankshaft as spinning the crankshaft.

Item	Standard
Crankshaft journal's outer diameter	Ø103.98 ~ Ø104.00 mm
Crankshaft pin's outer diameter	Ø89.98 ~ Ø90.00 mm



DV2213150A

Item	Standard	Limit
Warpage of crankshaft	0.06 mm	0.4 mm

### Measurement of Crankshaft Bearing and Connecting Rod Bearing

#### 1. Visual inspection

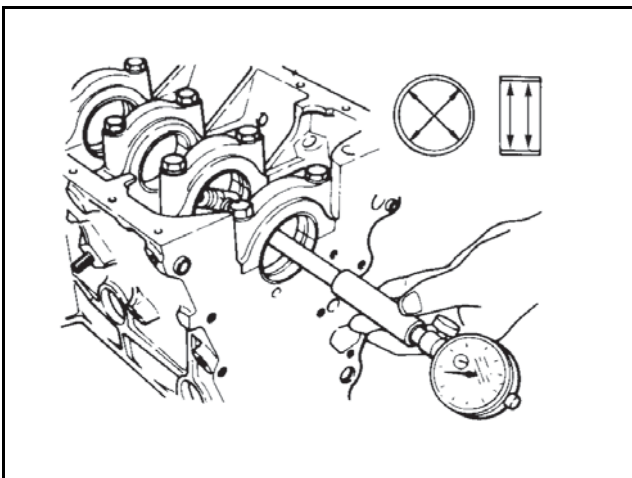
Visually inspect the crankshaft bearing and connecting rod bearing for scratch, unusual wear or damage.

#### 2. Oil clearance between crankshaft and bearing (Method 1: Dial gauge)

- 1) Assemble the main bearing to the cylinder block, tighten the bearing cap to the specified torque.

Item	Standard
Tightening torque	First 30 kgf·m + 90°

- 2) Measure the inner diameter.



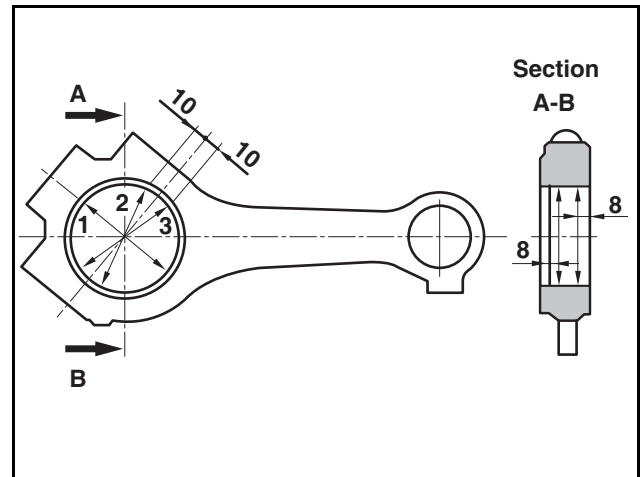
DV2213151A

Item	Standard
Journal's inner diameter	Ø104 mm

- 3) Assemble the bearing to the connecting rod, tighten the bearing cap to the specified torque.

Item	Standard
Tightening torque	First 10 kgf·m + 90°

- 4) Measure the connecting rod bearing journal inner diameter.



DV2213152A

Item	Standard
Inner diameter	Ø90.00

- 5) if the clearance exceeds the tolerance limit, grind the crankshaft journal and pin, and assemble under size bearing.

Item	Standard	Limit
Clearance	0.056 ~ 0.118 mm	0.143 mm

3. Oil clearance between crankshaft and bearing. (Method 2: Plastic gauge)

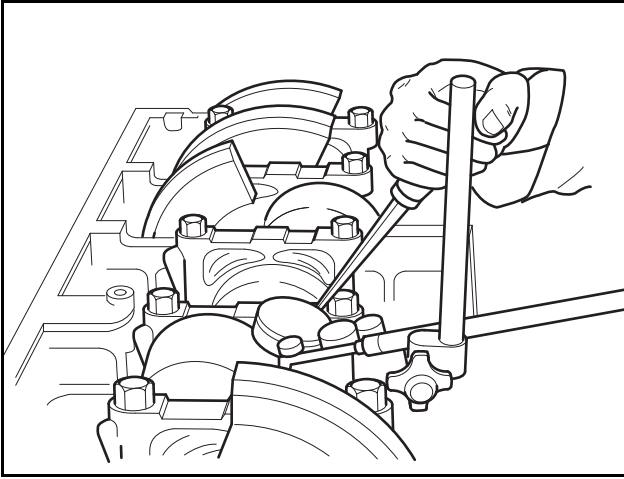
- 1) Assemble the crankshaft to the cylinder block.
- 2) Place the plastic gauge on the crankshaft journal and pan.
- 3) Assemble the bearing cap and tighten the bolt to the specified torque.
- 4) Loosen the bolt, remove the bearing cap.
- 5) Measure the width of the plastic gauge at the widest point using the ruler for plastic gauge measurement. This is the oil clearance.
- 6) Measure the oil clearance of connecting rod as the same procedure.

## 12. Others/driving system

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### 4. End play

- 1) Assemble the crankshaft in the cylinder block.
- 2) Install the dial gauge, and measure the end play of crankshaft by pushing the crankshaft to axial direction.



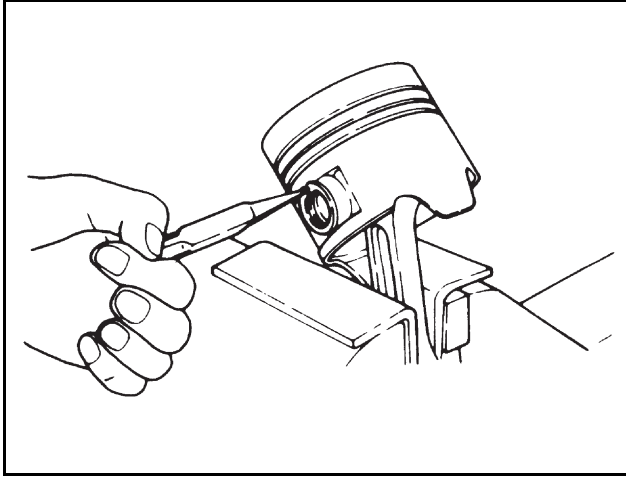
DV2213153A

Item	Standard	Limit
Axial end play	0.140 ~ 0.361 mm	0.4 mm

### Piston

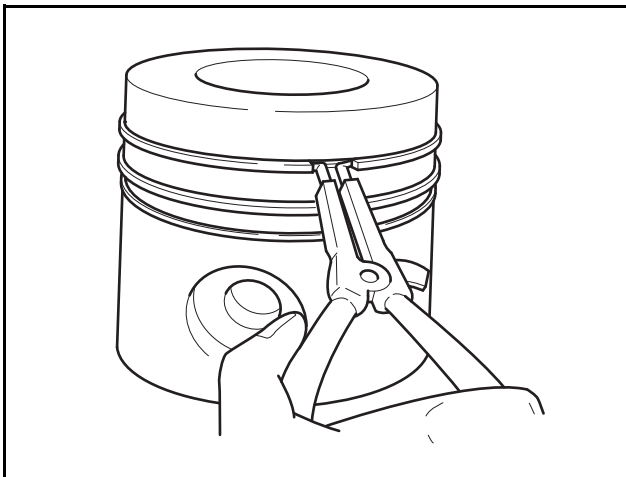
#### Disassembly of Piston

1. Pull out the snap ring for piston pin and with a pair of snap ring pliers.



DV2213154A

2. With a round bar, remove the piston pin.
3. With a pair of pliers, remove the piston rings.

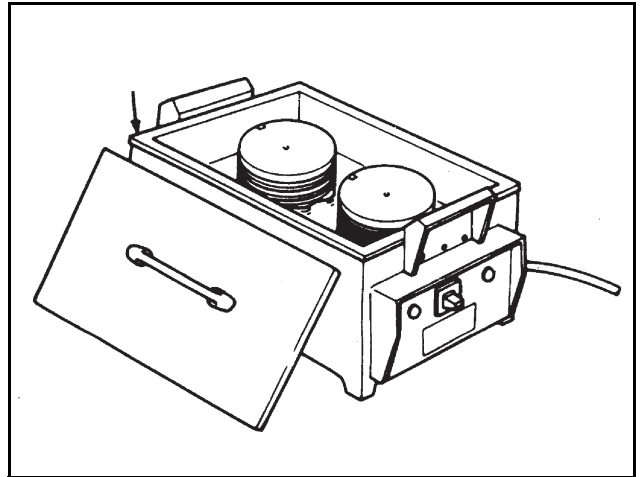


DV2213155A

4. Clean the piston thoroughly.

#### Assembly of Piston

1. Heat the piston at the piston heater for about 5 minutes (120 ~ 150°C).



DV2213156A

2. By aligning the piston pin hole with the pin hole of connecting rod's smaller end, insert the oil coated piston pin.

#### **CAUTION**

**Confirm the direction of connecting rod and assemble.**

3. With the snap ring plier, insert the snap rings of the piston pin.
4. With confirming the upper side indication of piston ring, after assembling the ring in the piston ring groove, inspect if the movement of ring is smooth.

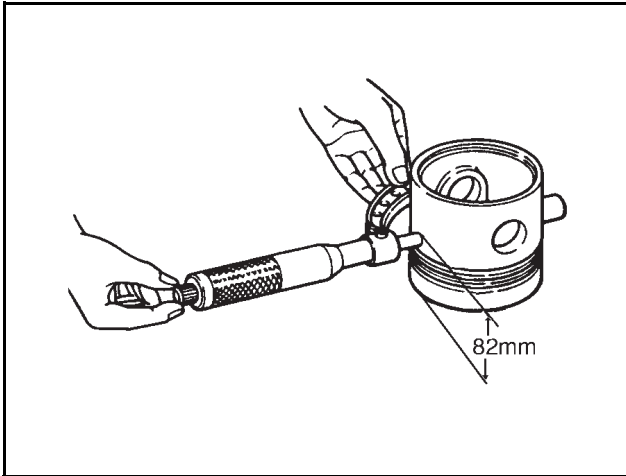
#### **CAUTION**

**Arrange the assembled piston in order as the cylinder number.**

#### Piston Inspection

1. Visual inspection
  - 1) Visually check the piston for crack, scratch, wear, etc. Specially, check the wear status of the ring groove.
2. Piston outside diameter inspection
  - 1) With the outside micrometer, measure the outside diameter.
  - 2) The measuring position is 71.5 mm from the piston lower end, and the direction of measurement must be perpendicular to the piston pin direction.

## 12. Others/driving system



DV2213157A

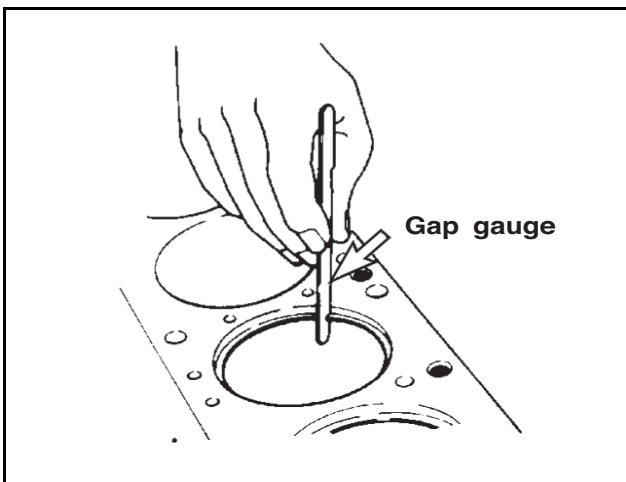
Item	Standard
Piston outside diameter	Ø127.739 ~ Ø127.757 mm

### ⚠ CAUTION

By comparing the measured value of the piston outside diameter with the cylinder liner inside diameter, the bigger clearance is replaced.

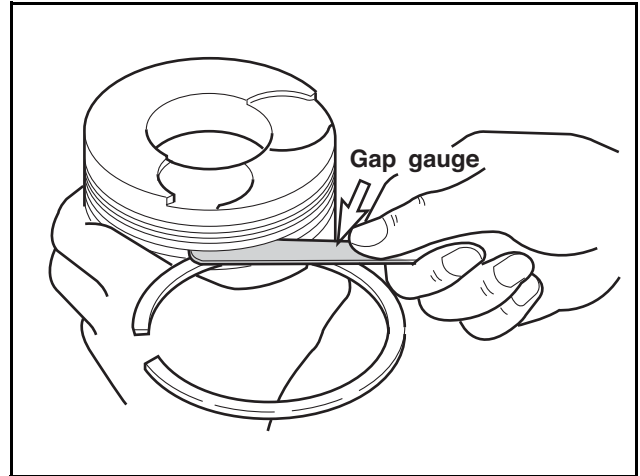
### Piston Ring and Ring Groove

- In case of piston ring's wear, damage or engine overhaul, replace piston rings.
- Piston ring gap clearance: measure the piston ring cut part.
  - Insert the piston ring at the cylinder liner's upper part perpendicular.
  - With a feeler gauge, measure the gap clearance of piston ring.



DV2213158A\_E

- If the measured value exceeds the limit value, replace it.

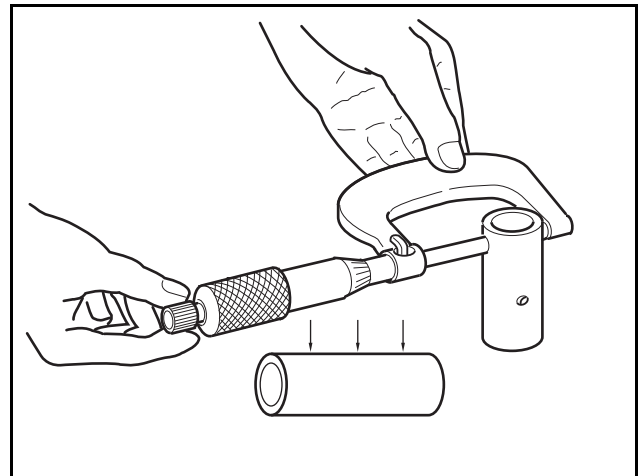


DV2213159A\_E

Item	Standard	Limit
Top ring	0.35 ~ 0.50 mm	1.5 mm
2nd ring	0.40 ~ 0.60 mm	1.5 mm
Oil ring	0.40 ~ 0.70 mm	1.5 mm

### Piston pin

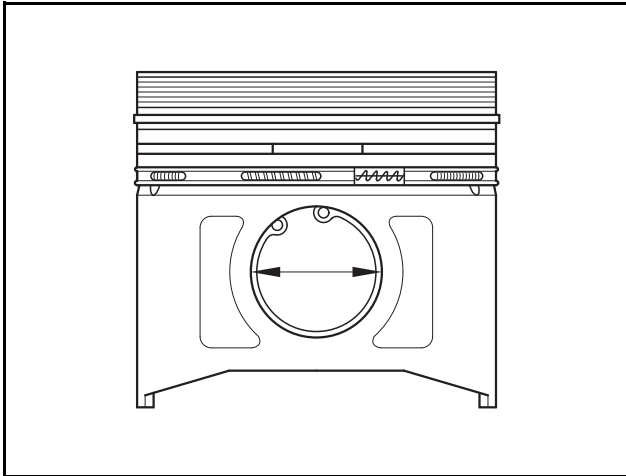
- Wear
  - Measure the wear amount of the piston pin with a outside micrometer.
  - If the reading exceeds the tolerance limit, replace the pin.



DV2213160A

Item	Standard	Limit
Outside diameter	Ø45.994~Ø46.000 mm	Ø45.983 mm

- Clearance
  - Measure the clearance between the piston pin and connecting rod bush.
  - If the reading exceeds the tolerance limit, replace the one which are worn more.



DV2213161A

Item	Standard
Clearance	0.010 ~ 0.022 mm

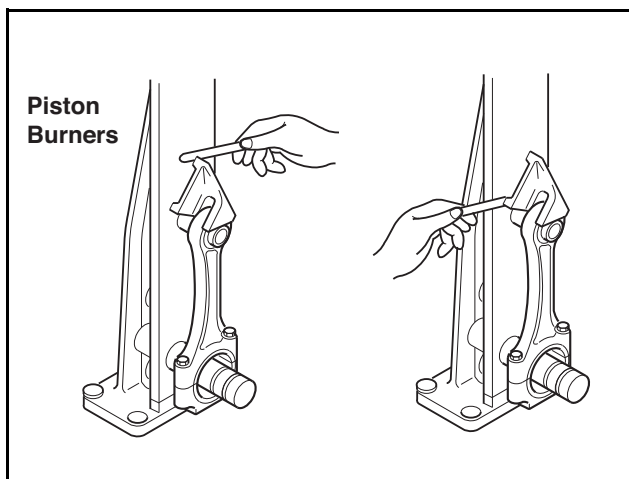
## 12. Others/driving system

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### Connecting rod

#### Inspecting the connecting rod

1. Measure the parallelism between the connecting rod small end's bush hole and the large end bearing hole.  
Here, use both the connecting rod measuring device and feeler gauge.



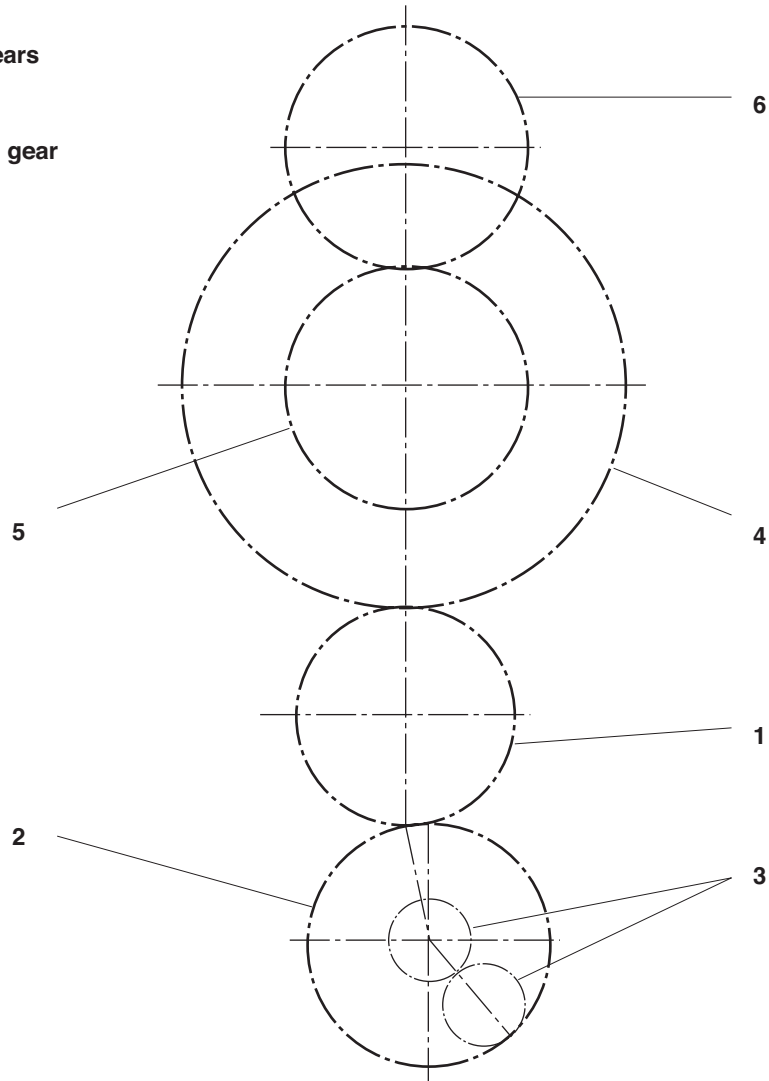
DV2213162A\_E

Item	Standard	Limit
Degree of parallelization	0.02 mm	0.2 mm

### Others

#### Engine Timing

1. Crankshaft gear
2. Oil pump drive gear
3. Oil pump impeller gears
4. Camshaft drive gear
5. Injection pump drive gear



DV2213204A

## 12. Others/driving system

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# Appendix

Maintenance specification table .....199



## Maintenance specification table

(unit: mm)

Group	Part	Inspection item	Stand value for assembly	Limit for use	Correction	Remark	
Cylinder block	Cylinder block & liner	Inside diameter of cylinder liner	ø127.99 ~ ø128.01	ø128.122	Replace liner	Measure unworn portion beneath the rim of the upper side	
		Liner's roundness & columnness (upper)	0.005	–		From top up to 168 mm	
		Liner's roundness & columnness (lower)	0.008	–		From bottom up to 85 mm	
		Amount of liner projection	0.04 ~ 0.09	–		Measure at upper side of cylinder block	
		The flatness of upper surface of cylinder block	0.03	–	Correct with a surface grinder	0.015 for a length of 150 mm	
		Hydraulic test for 1 minute (kg/cm <sup>2</sup> )	4	–	Replace if leaky	Temperature 70°C	
	Cylinder head & valve	Valve seat depression	Intake	0.65 ~ 0.95	2.5	Replace valve seat	0.25↓ @250 hr valve clearance inspection interval
			Exhaust	0.65 ~ 0.95	2.5		
		Cylinder head height		113.9 ~ 114	113.35	Replace cylinder head	
		The flatness of lower surface of cylinder head		0.015	0.1		
		Inner diameter of valve guide	Intake	ø8.015 ~ ø8.030	–		
			Exhaust	ø8.015 ~ ø8.030	–		
		Thick of cylinder head gasket (at assembly status)		1.215 ~ 1.285	–		
		Hydraulic test for 1 minute (kg/cm <sup>2</sup> )		4	–	Replace if leaky	Room temperature
Major moving parts	Piston	Outer diameter of piston	ø127.739 ~ ø127.757	–	Replace piston	Measure at 56.8 mm away from piston head (long diameter)	
		Clearance between piston and liner		0.233 ~ 0.271	0.35	Replace one worn more	
		Inner diameter of piston pin		ø46.010 ~ ø46.016	–		Standard diameter
		Width of piston ring grooves	Top ring	3.20 ~ 3.23	–	Replace piston if groove width is beyond specified value	Measure at 125 mm of top ring groove
			2nd ring	3.040 ~ 3.060	–		
			Oil ring	4.020 ~ 4.040	–		
		Piston projection from cylinder block upper surface		0.18 ~ 0.47	–		Measure unworn portion beneath the rim of the upper side
Permissible weight difference of each piston		50 g	50 g ↓	Replace piston			

# Appendix

(unit: mm)

Group	Part	Inspection item	Stand value for assembly	Limit for use	Correction	Remark		
Major moving parts	Piston ring	Width of piston ring	Top ring	3.075 ~ 3.095	–	Replace ring		
			2nd ring	2.975 ~ 2.990	–			
			Oil ring	3.97 ~ 3.99	–			
		Piston ring gap	Top ring	0.30 ~ 0.45	0.70	Replace ring		Standard gauge inside diameter: $\phi$ 128
			2nd ring	1.10 ~ 1.30	1.45			
			Oil ring	0.40 ~ 0.70	0.95			
		Piston ring side clearance	Top ring	0.105 ~ 0.150	0.30	Replace ring or piston		Limit for use is if for standard clearance
			2nd ring	0.05 ~ 0.082	0.15			
			Oil ring	0.030 ~ 0.070	0.15			
		Direction of ring gap		–	–	Cross Install by 120°		
	Piston pin	Outer diameter of piston pin		$\phi$ 45.994 ~ $\phi$ 46.000	$\phi$ 45.94	Replace piston pin		
		Clearance between piston pin and its bush		0.010 ~ 0.022	0.08	Replace one worn more		
	Crank shaft	Radial run-out of journal and pin		0.02	–	Correct with a grinder	Measure in horizontal and vertical directions	
		Outside diameter of journal		$\phi$ 103.98 ~ $\phi$ 104.00	$\phi$ 102.98	Use under sized bearings respectively (0.10, 0.25, 0.5, 0.75, 1.0)		
		Outside diameter of pin		$\phi$ 89.980 ~ $\phi$ 90.000	$\phi$ 88.980			
		Width of thrust journal		38.000 ~ 38.062	37.000			
		Ellipticity of journal and pin		0.01	0.025			
		Taper of journal and pin		0.02	0.03			
		Clearance between crankshaft and bearing		0.066 ~ 0.134	0.166	Replace bearings	Measure at crown part not parting line	
		End play of crankshaft		0.140 ~ 0.361	0.452	Replace thrust bearing		
		Balance of crankshaft (g·cm)		60 ↓	60 or less	Check dynamic balance	Measure at 400 rpm	
		Torque of journal bearing cap bolt		30 kg·m + 90°	–	Coat the bolt with engine oil	Clean out foreign objects on joining surface.	
		Crush height of Journal bearing cap	Main	0.3 ~ 1.2	–		Measure after tightening metal cap and releasing one bolt	
			Thrust	0.3 ~ 1.2	–			
		Out diameter of wear ring after assembled		$\phi$ 104.86 ~ $\phi$ 105.00	–		5 minutes or more at 220°C	
		Oil seal for wear (crank shaft rear)		–	–	Replace oil seal if oil leaking		

(unit: mm)

Group	Part	Inspection item	Stand value for assembly	Limit for use	Correction	Remark	
Major moving parts	Connecting rod	Width of connecting rod	Small end	38.7 ~ 39.0	—		
			Big end	35.38 ~ 35.341	—		
			Cap	32.8 ~ 33.1	—		
		Inner diameter of small end with bush		ø50.6 ~ ø50.9	—		
		Outer diameter of big end with bearing		ø94.97 ~ ø94.99	—		
		End play of connecting rod	Big end	0.15 ~ 0.351	0.50	Replace connecting rod	
			Small end	1.5	—		
		Clearance between connecting rod bearing and crank pin		0.056 ~ 0.118	0.154	Replace bearing	
		Clearance between small end bush & piston pin		0.055 ~ 0.071	0.12		
		Crush height of connecting rod bearing cap		0.125 ~ 0.155	—		Measure after installing the bearing and releasing one bolt
		Perpendicularity of big end inner diameter		0.035	0.08	Replace connecting rod	
		Roundness of big end inner diameter		0.005	0.01		
		Parallelness of small end side and big end		0.02	0.1		
		Allowable weight difference per con-rods		50g ↓	—		
	Torque value of connecting rod bearing cap bolt (kg·m)		10kg·m + 90°	—	Coat the bolt with engine oil	Clean out foreign objects on joining surface	
	Cam shaft	Diameter (bearing) of cam shaft side of cylinder block	Inner diameter of thrust bush	ø70.07 ~ ø70.09	—		
			Inner diameter of cam bush	ø70.00 ~ ø70.03	—		
		Diameter of cam shaft journal		ø69.910 ~ ø69.940	ø69.560		
		Clearance between camshaft and thrust bushing		0.130 ~ 0.180	0.24	Replace cam bush	
		Clearance between cam shaft and cam bush		0.060 ~ 0.120	0.24	Replace cam bush	
		End play of camshaft		0.24 ~ 0.86	0.9	Replace thrust washer	
Run-out of camshaft		0.05	0.15	Correct or replace the cam shaft			

# Appendix

(unit: mm)

Group	Part	Inspection item	Stand value for assembly	Limit for use	Correction	Remark
Major moving parts	Fly wheel	Ring gear assembly part's outer diameter	ø432.590 ~ ø432.700	–		Heating temperature at ring gear assembly (200 ~ 230°C)
		Ring gear inner diameter	ø432.000 ~ ø432.200	–		
		Overlap	0.390 ~ 0.700	–		
		Allowable shaking amount after assembly	0.5	–		
		Outer diameter after assembly wear ring	ø119.860 ~ ø120.000	–		
Valve system	Valve and valve guide	Exhaust valve	Stem O.D.	ø11.945 ~ ø11.955	–	
			Radial clearance	0.045 ~ 0.073	–	
			Seat angle	45°	–	
			Head diameter	ø50.9 ~ ø51.1	–	
			Valve head thickness ("H")	1.9 ~ 2.3	–	
			Valve seat head diameter	ø53.00 ~ ø53.03	–	
			Valve seat O.D.	ø53.10 ~ ø53.11	–	
		Intake valve	Stem O.D.	ø11.969 ~ ø11.980	–	
			Radial clearance	0.020 ~ 0.049	–	
			Seat angle	30°	–	
			Head diameter	ø57.85 ~ ø58.15	–	
			Valve head thickness ("H")	2.6 ~ 3.0	–	
			Valve seat head diameter	ø61.00 ~ ø61.03	–	
			Valve seat O.D.	ø61.10 ~ ø61.11	–	
	Head valve seat assembly part's depth	12.5 ~ 12.6	–			
	Valve guide I.D.	ø12.000 ~ ø12.018	–			
	Head valve guide I.D.	ø18.000 ~ ø18.018	–			
	Valve guide O.D.	ø18.028 ~ ø18.046	–			
	Valve guide mounting clamp	0.010 ~ 0.046	–			
	Valve guide play	0.04	–			
	Valve spring	Valve lift	14.1	–		
		Valve guide protrusion	17.1 ~ 17.5	–		
		Free length of inner spring	72.43	–		
Load on inner spring		15 ~ 17 kg	–			
Load on inner spring		27 ~ 32 kg	–			
Free length of outer spring		68.17	–			
Load on outer spring		37 ~ 41 kg	–			
Load on outer spring	66.5 ~ 76.5 kg	–				

(unit: mm)

Group	Part	Inspection item	Stand value for assembly	Limit for use	Correction	Remark		
Valve system	Valve and valve guide	Intake and exhaust valve spring (inner)	Free length	59.5	–	Replace valve spring		
			Tension force (kg)	41 mm	14.8		13.3 or less	
				28.6 mm	25		23 or less	
			Inclination (free length)	1.5 mm	2.0 or less			
		Intake and exhaust valve spring (outer)	Free length	57.0	–	Replace valve spring		
			Tension force (kg)	44 mm	25.5		23.5 or less	
				31.6 mm	52.3		49.8 or less	
			Inclination (free length)	1.5 mm	2.0 or less			
	Rocker arm & push rod	Joining surface of valve stem and rocker arm bush		–	–	Grind or replace if severely pitted on tip of rocker arm and stem		
		Inner diameter of rocker arm bush		ø24.991 ~ ø25.012	–			
		Diameter of rocker arm shaft		ø24.953 ~ ø24.976	ø24.916			
		Clearance between rocker arm shaft & rocker arm bush		0.015 ~ 0.059	0.12	Replace bush or shaft		
		Run-out of push rod		0.3	0.3 or less	Replace or correct		
	Tappet	Tappet assembly part's inner diameter of cylinder head		ø20.000 ~ ø20.021	–			
		Diameter of tappet		ø19.944 ~ ø19.965	–	Replace tappet		
		Clearance between tappet & tappet hole of cylinder block		0.035 ~ 0.077	0.15	Replace tappet		
Tappet face in contact with cam		–	–	Replace if severely worn or deformed				

# Appendix

(unit: mm)

Group	Part	Inspection item	Stand value for assembly	Limit for use	Correction	Remark
Lubricating system	Engine oil	Oil pressure (kg/cm <sup>2</sup> ) (at rated speed)	3.0 ~ 6.5	–	Check oil leakage and clearance between each part	
		Oil pressure (kg/cm <sup>2</sup> ) (at idle speed)	1.0 ~ 3.0	0.8 or more	Use recommended oil	
		Oil temperature (°C)	110 or less	–		Must not exceed this value
		Permissible oil temperature in short time (°C)	Max. 120	–		
	Oil spray nozzle	Operating pressure	1.5 ~ 1.9		Replace valve	
	Oil pump	Delivery volume lit/min – Pump rpm: 2,440 rpm – Oil temperature: 50°C	275 or more	–	Replace gear or cover	
		Oil pump pressure control valve (kg/cm <sup>2</sup> )	9 ~ 10	–	Replace valve	
	Oil filter and oil cooler	Damage of oil filter element	–	–	Clean or replace	
		By-pass valve pressure of oil filter (kg/cm <sup>2</sup> )	2.2 ~ 2.5			
		By-pass valve pressure of oil cooler (kg/cm <sup>2</sup> )	4.5 ~ 5.5			
Cooling system	Radiator	Radiator & water pump for corrosion, damage & improper connecting	–	–	Correct or replace	
		Test for leakage by air pressure (kg/cm <sup>2</sup> )	1.2 ~ 1.3	–	Submerge in water and replace if air bubbles found	
		Pressure valve for opening pressure (kg/cm <sup>2</sup> )	0.9	–		
		Pressure valve for vacuum (kg/cm <sup>2</sup> )	0.05			
	Water pump	Delivery volume lit/min – Pump speed: 3,500 rpm – Water temp.: 25°C – Pressure: 1.8 kg/cm <sup>2</sup>	700 or more	–	Check the water passage	
		Fan belt depression	Refer to adjust table	–	Adjust	

(unit: mm)

Group	Part	Inspection item	Stand value for assembly	Limit for use	Correction	Remark	
Cooling system	Cooling water temperature	Operating temperature (°C)	79 ~ 95	–	Must not exceed this value		
		Permissible temperature in a short time (°C)	–	105			
	Thermostat	Operating temperature (°C)	2V TIL	71	–	Replace	
			2V TIM/TIH	79	–		
		Full opening temperature (°C)	2V TIL	85	–	Replace if defective Stroke: min. 8 mm	
2V TIM/TIH	94		–				
Fuel system	Fuel injection pump maker		BOSCH	–			
	Fuel piping & others	Fuel pipe, injection pipe & injector for damage, cracks, improper O-ring	–	–	Replace		
		Damage of fuel filter cartridge	–	–	Replace cartridge		
	Injector opening pressure (kg/cm <sup>2</sup> )		285.5 ~ 297.8	–			
	Operating pressure of overflow valve (kg/cm <sup>2</sup> )		1.33 ~ 1.84	–	Replace valve		
	Diameter of injector nozzle		–	–	Differs for each suffix		
	Projection height of nozzle from the cylinder head surface (mm)		3.0	–	Replace sealing		
Drive system	Gear back lash	Between crank gear & oil pump drive gear	0.099 ~ 0.451	–	Adjust back lash		
		Between crank gear & cam shaft gear	0.143 ~ 0.292	0.3			
		Between drive gear & fuel pump gear	0.102 ~ 0.338	0.45			



Paper Size : 120mmx165mm

# Diesel Engine for Generators (Land/Marine) Digital Speed Controller User Manual

Ver\_1.07

300611-01127A(Land)

300611-01440(Marine)



# HYUNDAI

HD Hyundai Infracore

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# 1. Product Overview and General Specification

## 1.1 Product Information

**Digital Speed Controller (300611-01127A/01440)** is applicable to generator (vehicles and vessels) engines as a high performance embedded electronic control system designed based on PID control for fast and precise control of engine speed with an enhanced micro controller unit (MCU) that minimizes analog circuits vulnerable to user environments.

This product features PID auto setting functions along with battery voltage, pick-up sensors and actuator condition checking. It also has a black box function that manages engine operation records when faults are detected for users to have more convenience in operating this precise digital speed controller.

### [Product Features]

- Rigid and stable case structure and easily recognizable front design
- Readily understandable GUI (graphic user interface) with graphic LCD displays
- Easy and simple setup with 8 button keys without manual controls by users
- Fast setting available by migrating initial settings depending on types of the engines
- Listing fault messages (over speed, pick-up error, etc.) and recording messages
- RS232 and CAN ports available for communication
- Digital inputs and PID auto setup functions for PID control parameters
- Application of digital clock for fault timing and engine operating hours

## 1.2 Product Appearance

**Digital Speed Controller** is made of a rigid aluminum case taking into account anti-shock, electromagnetic resistance and environmental protection. An embedded system containing graphic LCD and high performance MCU is inside the controller and a heat sink is located on the outside of the case for protection and precise control of actuator operating elements.

A terminal block is located on the bottom and right of the front side for easy connection to external devices. Over speed, run and crank signals are displayed on the front LED and contact points (a or b) are also available for outputs on external controllers or indicators.

RS232 and CAN communication is available and DSUB-9 connector enables universal use of RS232 communication.

Users can easily input and adjust values for parameter inputs using 8 button keys. In addition, graphic LCD shows graphic displays, bar graphs and design symbols so that users can readily identify the control information while external LED displays important conditions of the engine.

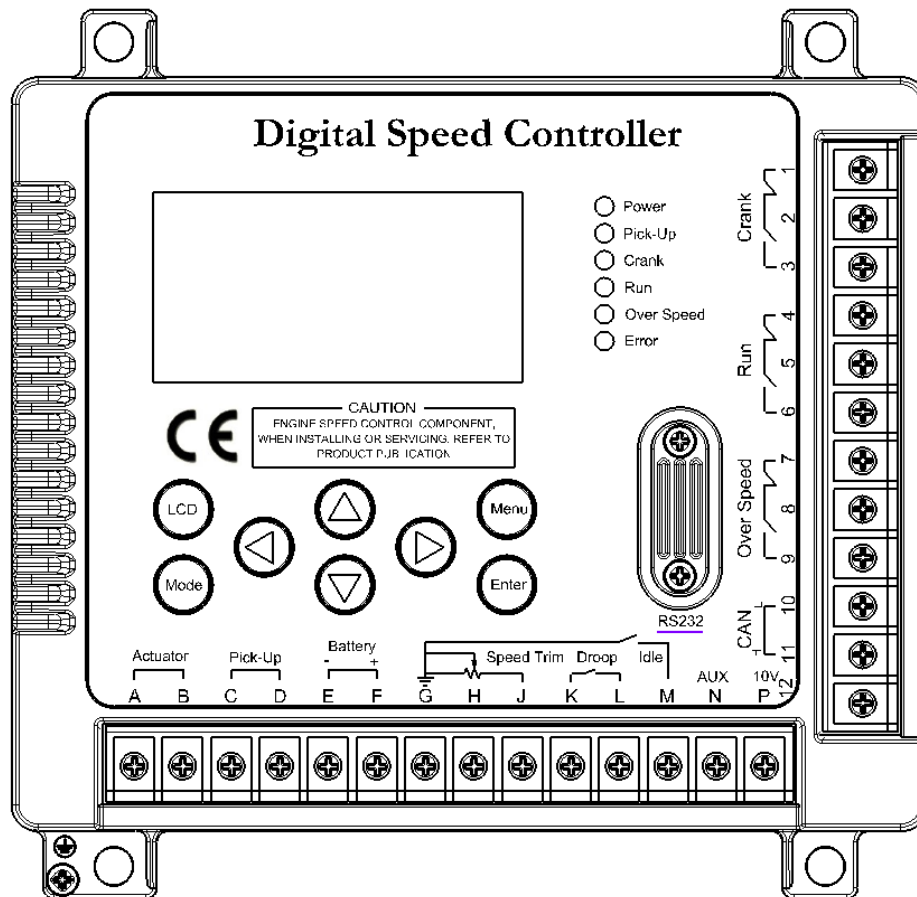


Figure 1: Product Front View

### 1.3 Product Specification

No.	Item	Description
1	MCU	16-bit DSC dsPIC33FJ256
2	Display	Graphic LCD 128*64
		LED: 6 EA
3	Keypad	8 Button Keys
4	Output	3 Contact Points (a and b)
5	Input	RMS 3V (Min)
6	Memory	128Mb
7	Communication	RS232 57600bps
		CAN (J1939) / 250kbps
8	Rated Power	DC 24V (12V to 32V)
9	Current Consumption	120mA
10	Operating Temperature	-20 to +70°C
11	Storing Temperature	-30 to +80°C
12	Operating Humidity	0 to 95%

## 1.4 Product System Diagram

### Cautions on wiring

- The total length of the Actuator(15AWG), Pick-up(24AWG\_Shield Cable), and Battery(15AWG) connections shall be limited to 10m or less.
- Refer to the system diagram (Figure 2) to wire the circuit and check the cable type.
- Wiring assembly must be checked before use as it will cause fatal damage to the controller.
- The fuse 10A for circuit protection is always provided at the front end of the battery input terminal "F".
- RS232 communication cable should use designated dedicated cable.
- It does not guarantee the fault of the product caused by not following the system diagram and wiring connection precautions.

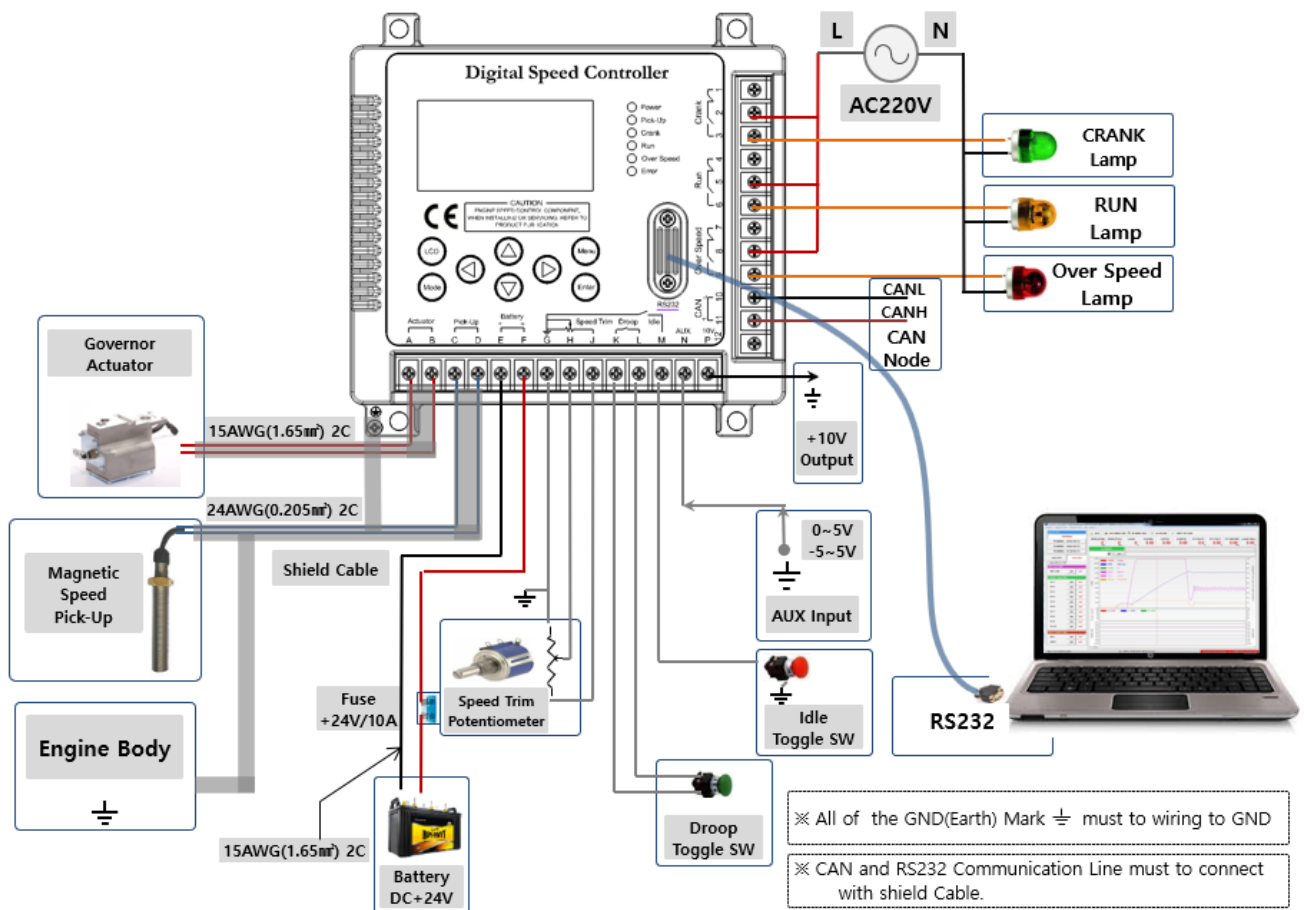


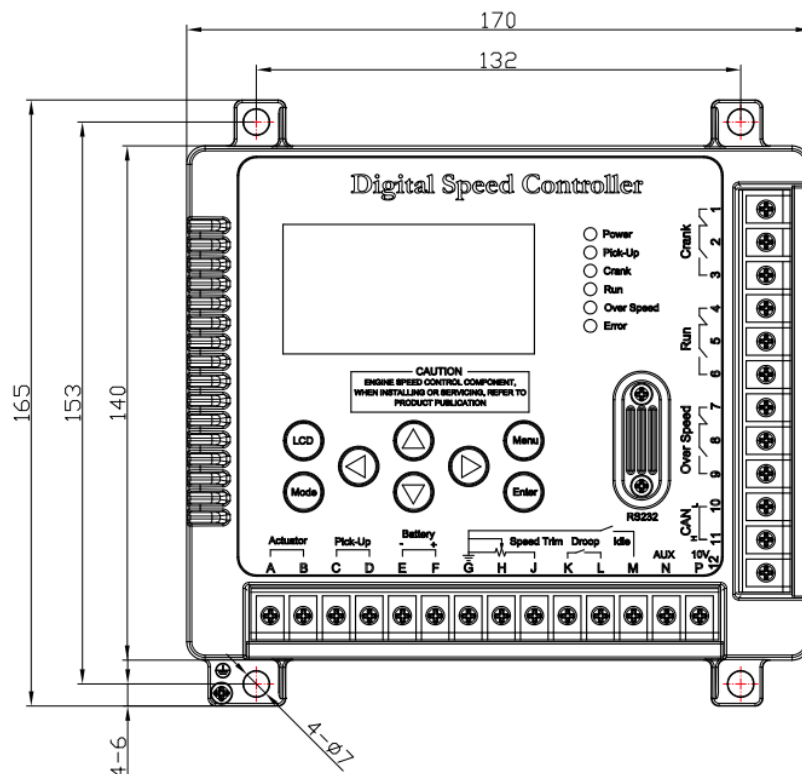
Figure 2: System Diagram for Digital Speed Controller

## 1.5 Product I/O Signals

No	Terminal	I/O type	Terminal Functions
1	Actuator ( A, B )	Output	Outputs are actuator control signals. Wiring should be 15AWG (105°C) or better. (However, terminals A and B can be used regardless of their polarities. Actuator's shield cable terminal should be connected to Ground(Engine body). (Voltage measuring terminals are A and E.)
2	Pick-Up ( C, D )	Input	Inputs are RPM sensor signals. Terminal D should be connected to the ground(Engine body) in connection with the shield cable. Gap between the RPM sensor and the gear tooth should be adjusted between 0.9 and 1.1mm (sensor inputs should be at least 3V AC RMS). Pick-up voltage shown on System monitor menu is Peak value
3	Battery Voltage (-E, +F)	Input	It is a power input terminal for the controller and inputs are DC +24V/10A. The positive pole of the battery should be connected to the terminal F. (Back voltage protection circuit is built in.)
4	Speed Trim (G, H, J)	Input (G)	It has a ground signal and is connected to the ground of the potentiometer.
5		Input (H)	Inputs are RPM trim signal values and the voltage level is between 0 and 5V. It is connected to the output of the potentiometer.
6		Input (J)	Outputs are DC +5V and it is connected to VCC of the potentiometer.
7	Droop ( K, L )	Input	Terminal K receives droop function selecting information. Terminal L has a ground signal and the switch is connected to terminals K and L. Once the terminal K is connected to the ground, droop starts to operate.
8	Idle ( M )	Input	Terminal M receives idle function selection signals. Once it is connected to the ground, idle operation starts.
9	AUX ( N )	Input	Terminal N receive load sharing and synchronization signal for parallel operation. The signal level is an input between DC -5 and +5V.
10	10V ( P )	Output	Outputs are +10V/20mA ratings and it can be used for various purposes including power to external auxiliary devices.
11	Crank Contact Point (1, 2, 3)	Output	The second crank contact point is a shared terminal while terminals 1 and 2 are for the contract point b and terminals 2 and 3 for the contact point a. The contact point a starts to operate when the digital speed controller reaches at the RPM delivering control signals to the actuator after the engine is activated.
12	Run Contact Point (4, 5, 6)	Output	The fifth run contact point is a shared terminal while terminals 4 and 5 are for the contact point b and terminals 5 and 6 for the contact point a. The contact point a starts to operate when the engine reaches its designated normal speed RPM.
13	Over Speed Contact Point (7, 8, 9)	Output	The eighth over speed contact point is a shared terminal while terminals 7 and 8 are for the contact point b and terminals 8 and 9 for the contact point a. The contact point a starts to operate when the engine reaches its designated over speed RPM.
14	CAN ( 10, 11 )	I/O	Terminal 10 is for CAN-L communication and 11 is for CAN-H communication. CAN-H and CAN-L are used for CAN communication.

15	Power LED	Output	When DC+24V power is supplied to the controller, the LED turns on in red on the power level.
16	Pick-Up LED	Output	When the controller receives normal input signals from the pick-up sensor, the LED turns on in green on the pick-up level.
17	Crank LED	Output	The 2- and 3-terminal contact point a starts to operate and the LED turns on in yellow on the crank level when the digital speed controller reaches at the RPM delivering control signals to the actuator after the engine is activated. When Cranking Rpm is exceeded, Crank LED turns off.
18	Run LED	Output	The LED turns on in green on the run level when the engine reaches its designated normal speed RPM with 5- and 6-terminal contact point a starting to operate.
19	Over Speed LED	Output	The LED turns on in red on the over speed level when the engine reaches its designated over speed RPM with 8- and 9-terminal contact point a starting to operate..
20	Error LED	Output	The LED turns on in red on the error level when abnormal events of the controller occur.
21	RS232	I/O	D-SUB 9PIN (male) is connected to the host through RS232 communication port. The specified dedicated line should be used and only terminals 2, 3, 5 shall be connected, and the other terminals shall not be connected.
22	Ground	Ground	GND part and earthing should be jointly connected before being earthed to generator's engine body.

## 1.6 Product Dimension



## 2. Installation

### Cautions for installing the digital speed controller

- Mount the controller unit vertically to the surface of a control cabinet to protect from water and high humidity, and do not expose the controller unit to the radiant heat.
- Do not rely solely on the electronic governor's actuator function to prevent overspeed, and use an independent fuel cut-off solenoid auxiliary device.
- When welding around the controller and charging the battery, the controller battery terminal is disconnected.
- We can not guarantee the failure of the product caused by installation neglect.

Digital Speed Controller should be connected to the pick-up sensor attached on the engine and the actuator. Speed trim, droop, idle and aux terminals can be used for additional functions in connection with surrounding circuits. Contact points a or b can also be used to operate external devices using crank, run and over speed functions. RS232 and CAN port allow communication with PCs or external host computers for data transfer and monitoring functions.

### 2.1 Connecting to the Engine

#### 2.1.1 Battery, Pick-Up and Actuator Connection Diagram

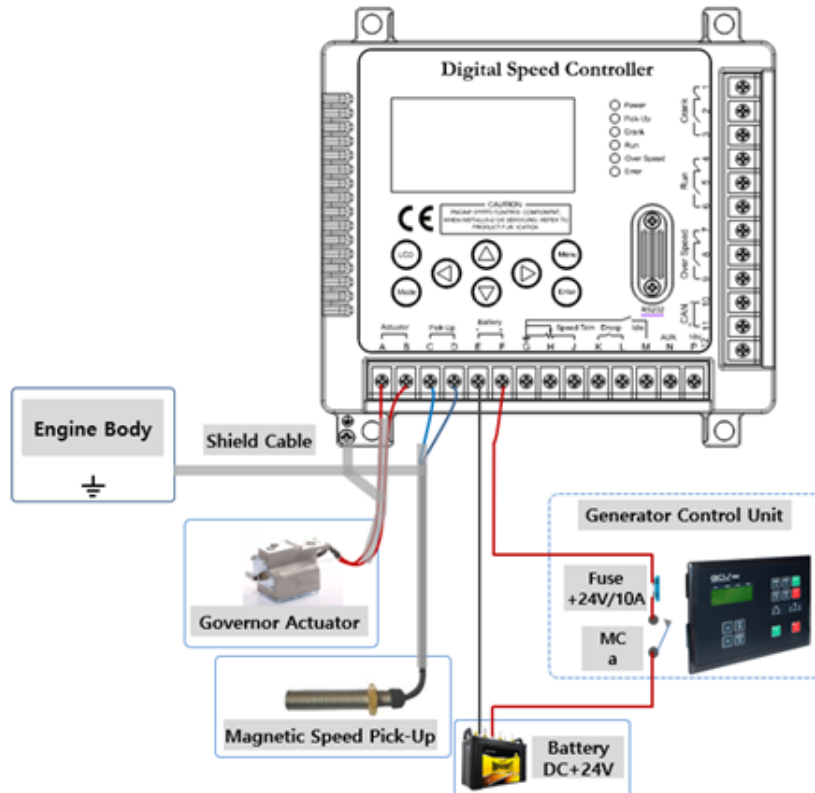


Figure 3: Battery, Pick-Up and Actuator Connection Diagram

### 2.1.2 Connecting to Batteries

Battery voltage is DC +24V and the battery is connected to the controller matching **E (-)** and **F (+)** with the respective polarities of the battery. **E (-)** is connected to **(-)** of the battery and **F (+)** to **(+)** of the battery. The circuit protection fuse 10A must be formed between the F (+) and the battery. Depending on cases, wiring can be done in a serial connection to the contact point a of MC and the fuse (DC +24V/10A) when connecting to system panels or generator control devices.

### 2.1.3 Connecting to Actuators

The actuator is also called governor and controls the amount of the fuel spray to the engine cylinder. The controller is connected to the actuator attached on the engine by connecting two wires of the controller terminal to A and B of the actuator regardless of their polarities. Use more than 15AWG(105°C) for the connection wire, and when using a shielded cable, the shield terminal should be connected to Ground(Engine body).

### 2.1.4 Connecting to Pick-Up Sensors

The pick-up sensor lets users know the engine speed and is connected to terminals **C** and **D** that can receive signals of AC RMS 3V or higher. Gap between the pick-up sensor and the gear tooth should be adjusted between 0.9 and 1.1mm. the shield terminal should be connected to Ground(Engine body).

### 2.1.5 Operating Sequence for Digital Speed Controller

- **Power On/Off:** It means that DC +24V power is either supplied or terminated through **E (-)** and **F (+)** of the battery matching with their respective polarities.
- **LCD On/Off:** It means to turn **on** or **off** the LCD display alone while DC +24V power is supplied through **E (-)** and **F (+)** of the battery matching with their respective polarities and the controller is in operation.

#### [Operating Sequence for the Controller]

- Step1)** When DC +24V power is supplied to the controller, the controller starts to operate. It indicates that power LED turns on and the power is being normally supplied.
- Step2)** Inputs for speed trim, droop and idle functions are received.
- Step3)** The controller checks the signals of the speed pick-up sensor.
- Step4)** Actuator control signals are output together with designated values of other information for crank, run and over speed functions according to the PID control values.
- Step5)** The controller checks the operation condition and displays LED outputs and fault messages according to the detected information.

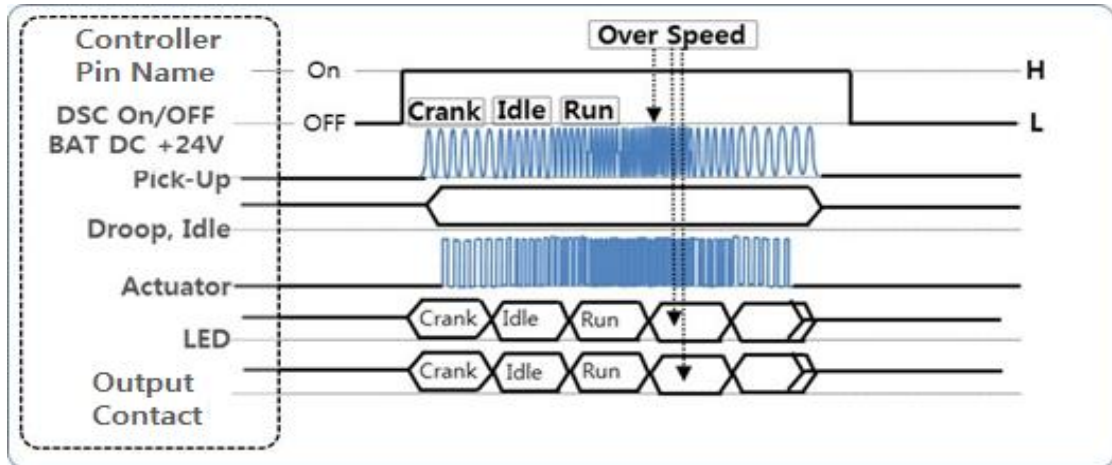


Figure 4: Time Chart for Operation of the Controller

## 2.2 Connecting to Speed Trim, Droop, Idle and Other Inputs

### 2.2.1 Speed Trim, Droop, Idle and Other Inputs Diagram

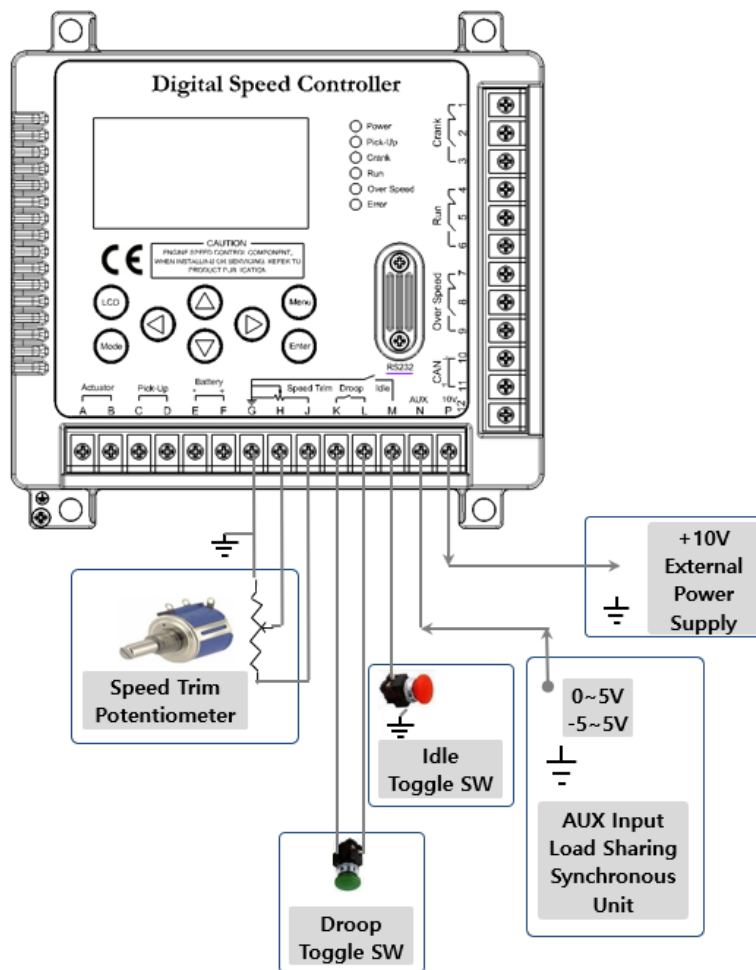


Figure 5: Speed Trim, Droop, Idle and Other Inputs Diagram

### 2.2.2 Connecting to Speed Trim

Speed trim is an analog voltage signal port for input to fine-tune the engine speed. A potentiometer is used for precise adjustment of the resistance values. The potentiometer needs to be connected to terminals **G**, **H** and **J**. Terminal **G** should be connected to the ground and it is recommended to use shielded cables. Terminal H is the terminal to which the fine adjustment voltage value (0 ~ 5V) is input. Terminal J is a terminal that is connected to VCC of the potentiometer with DC + 5V output.

### 2.2.3 Connecting to Droop

The switch is connected to terminals **K** and **L**. Signals indicating whether **droop** function works or not serve as inputs to the controller by keeping K and L either **open** or **close**. Inputs can be done by toggle or converting switches.

### 2.2.4 Connecting to Idle

The port on one side of the switch is connected to terminal **M** and the port on the other side to the **ground**. Connection between terminal **M** and the **ground** becomes either **open** or **close** by keeping the switch **open** or **close**. When connection between the terminal and the **ground** becomes **close**, the controller will have **idle** function. Inputs can be done by toggle or converting switches.

### 2.2.5 Connecting to AUX

AUX is a terminal for control signal inputs from load sharing devices or synchronization devices through terminal **N**. It shares load from the generator in parallel operation and receives signal inputs from synchronization devices for the controller to control changes to load. Input signal level is between **DC -5** and **5V** and it is recommended to use shielded cables for signal wires.

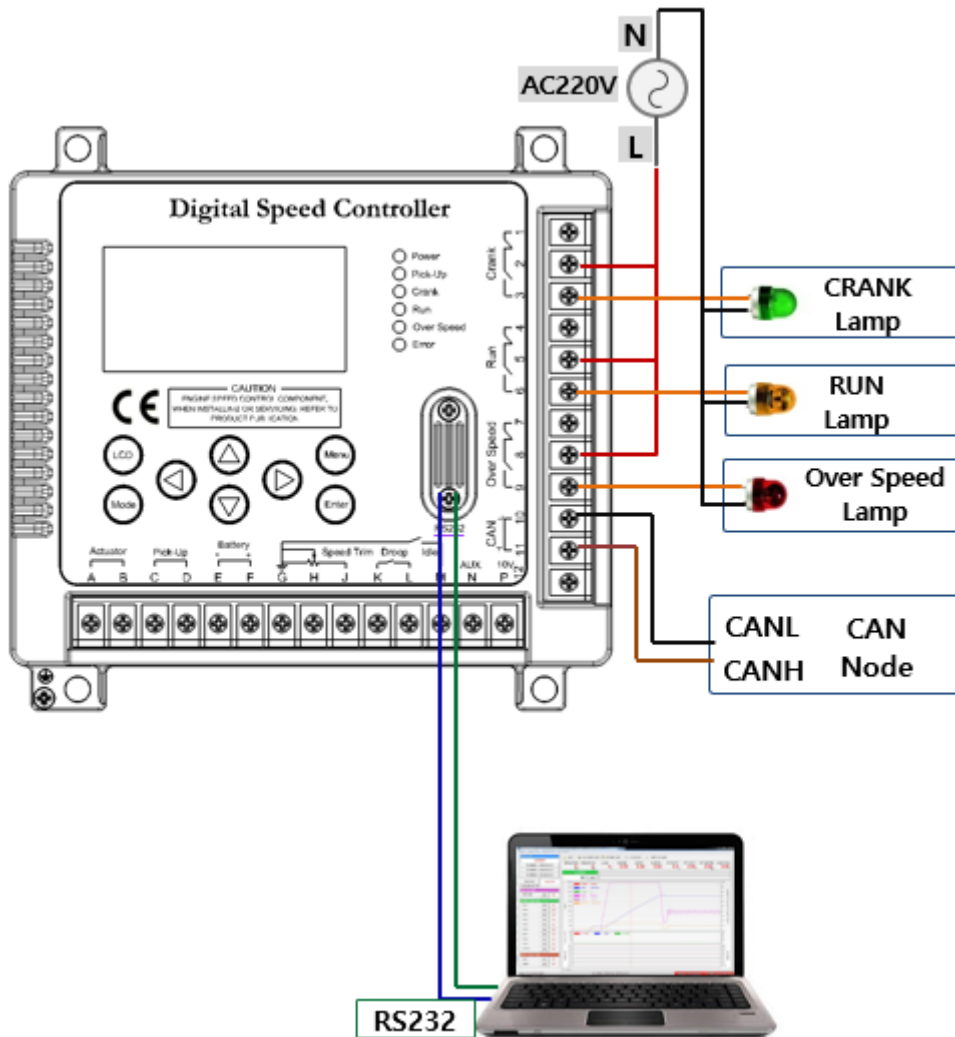
### 2.2.6 Connecting Power to External Devices

It can supply power output of **10V/20mA** to external devices through terminal **P**. Users can easily use this terminal when external auxiliary devices need power supply.

However, power supply of **20mA** or higher should not be used and care should be given to prevent short circuits.

## 2.3 Connecting to Crank, Run, Over Speed and Communication

### 2.3.1 Crank, Run, Over Speed and Communication Connection Diagram



**Figure 6: Crank, Run, Over Speed and Communication Connection Diagram**

It is used to deliver operation information to external devices by activating contact point (a or b) when activating crank, run or over speed functions.

RS232 and CAN communication is connected to external PCs or hosts so that the controller can transmit system settings or operation information.

### 2.3.2 Connecting to Crank Terminals

Terminals **1**, **2** and **3** are the ones for **crank** output contact point and the contact point will be in operation when the controller activates the crank function. The second crank contact point is a shared terminal while terminals **1** and **2** are for the contact point **b** and terminals **2** and **3** for the contact point **a**.

Contact points **a** and **b** start to operate when the controller reaches at the RPM delivering control signals to the actuator after the engine is activated. The diagram shows wiring to operate AC220V lamp. The shared terminal is for 220V inputs and the **crank** lamp turns **on** when the contact point a starts to operate.

### 2.3.3 Connecting to Run Terminals

Terminals **4**, **5** and **6** are the ones for **run** output contact point and the contact point will be in operation when the controller activates the **run** function. The fifth crank contact point is a shared terminal while terminals **4** and **5** are for the contact point **b** and terminals **5** and **6** for the contact point **a**.

Contact points **a** and **b** start to operate when the engine reaches its designated normal speed RPM. The diagram shows wiring to operate AC220V lamp. The shared terminal is for 220V inputs the **run** lamp turns **on** when the contact point a starts to operate.

### 2.3.4 Connecting to Over Speed

Terminals **7**, **8** and **9** are the ones for **over speed** output contact point and the contact point will be in operation when the controller activates the **over speed** function. The eighth **over speed** contact point is a shared terminal while terminals **7** and **8** are for the contact point **b** and terminals **8** and **9** for the contact point **a**.

Contact points **a** and **b** start to operate when the engine reaches its designated over speed RPM. The diagram shows wiring to operate AC220V lamp. The shared terminal is for 220V inputs the **over speed** lamp turns **on** when the contact point a starts to operate.

### 2.3.5 Connecting to CAN Communication

Terminal **10** is for **CAN-L** communication and terminal **11** for **CAN-H** communication. **CAN-H** and **CAN-L** are used for CAN communication with remote control and monitoring of the controller operation. The communication code is based on **J1939**.

### 2.3.6 Connecting to RS232 Communication

D-SUB 9pin (female) is for RS232 communication for connection to external PCs or hosts. The specified dedicated line should be used and only terminals 2, 3, 5 shall be connected, and the other terminals shall not be connected. It can configure system parameters of the controller or communicate with analytic applications.









### 3. Configuration and Operation

The controller can be configured and operated by input keys according to the menus on the LCD display by selecting proper ones and assigning values in the selected menu to input control information to the system. Input information should immediately apply to the controller system once updated.

#### 3.1 Input Keys

The controller has 8 input keys including LCD, Mode, Menu, Enter, Up, Down, Left and Right.

Each key as respective functions as follows:

-  **LCD** LCD key turns on and off the display.
-  **Mode** Mode key switches the display to either operation mode or wave form display.
-  **Menu** Menu key lets users change the menu display and go back to the previous menu.
-  **Enter** Enter key applies designated values on the LCD display to the system.
-  Up key lets users go up or increase values in the selected menu on the LCD display.
-  Down key lets users go down or decrease values in the selected menu on the display.
-  Left key lets users move to the left in the selected menu.
-  Right key lets users move to the right in the selected menu.

### 3.2 LCD Display Menu

The overall menu tree of the controller is as follows:

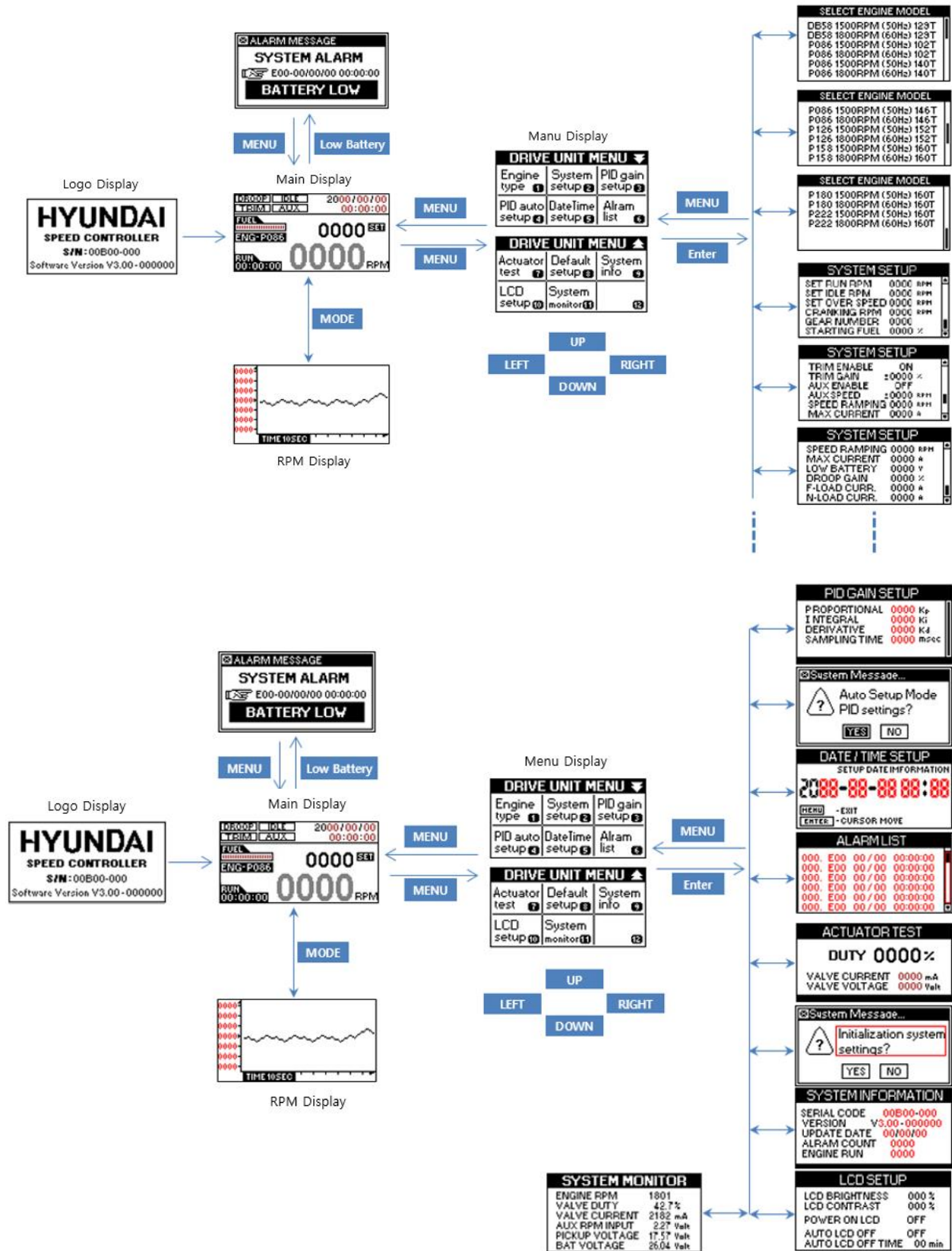


Figure 7: Overall LCD Menu Tree Diagram

### 3.2.1 LCD Displays After Powered On

When DC +24V power is supplied to the battery terminal (E (-), F (+)) of the controller, the **power** LED in the front side of the controller turns on in **red** and the **error** LED turns on in **red** where there are fault conditions. At this moment, the LCD display is not activated and **HYUNDAI** logo will appear for 1 second followed by the operation display after pressing the **LCD** button.

The controller will start control based on information from pick-up sensor and other input devices and designated parameter values. At this moment, where breakdowns of the surrounding devices or system errors occur, the LCD display will show such errors and processing messages.

**Step 1) DC +24V power supply to the terminals E (-) and F (+)**

When DC +24V power is supplied to the terminals E (-) and F (+), the controller will start to operate with the LCD display off. After pressing the **LCD** button, **HYUNDAI** logo will appear for 1 second as shown below followed by the controller operation display. Then, the LCD display will switch between on and off by pressing the **LCD** button.



Figure 8: **HYUNDAI** Logo

**Step 2) The operation display will show 1 second after the logo appears.**

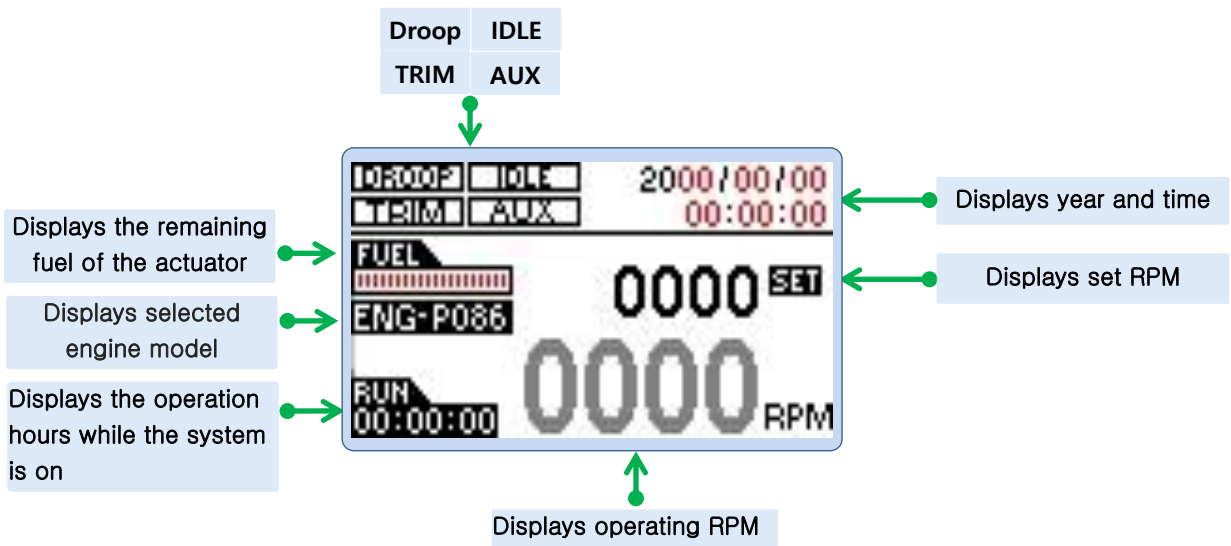
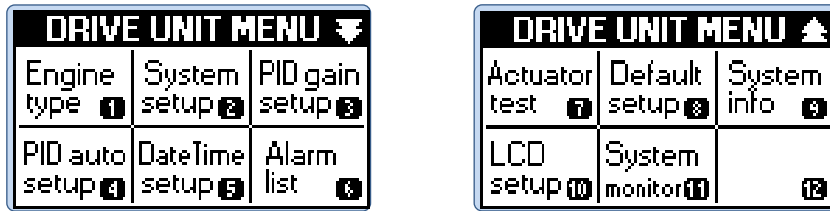


Figure 9: Operation Display

### 3.2.2 LCD Main Menu Display

#### Displays main menu screen of the controller

The main menu of the controller has 10 sub-menus.



Menu 1: Main Menu of the Controller - 1 to 2

#### 1) Engine type

The controller can start operation once the initial system values are configured. Users can load preset values depending on types of the engines by selecting the type.

#### 2) System setup

It consists of sub-menus related to system settings including RUN/IDLE/OVERSPEED/CRANK/GEARNUMBER.

#### 3) PID gain setup

It consists of sub-menus to designate Kp, Ki and Kd parameter values related to the engine PID control.

#### 4) PID auto setup

It offers function for automatic designation of Kp, Ki and Kd parameter values related to the engine PID control.

#### 5) DateTime setup

It offers function for users to move to the screen for designating year, month, day and hour.

#### 6) Alarm list

It offers function for users to move to the alarm display for the alarm list.

#### 7) Actuator Test

It offers menu to test the impedance ( $X_L$ ) of the actuator and any problems in operating load current. It displays current and voltage according to the duty values.

#### 8) Default setup

It offers menu to apply designated default values to the selected engine.

#### 9) System info

It offers menu that shows information of the controller. Such information includes the serial number, software version, last update date, alarm count and engine runs.

#### 10) LCD setup

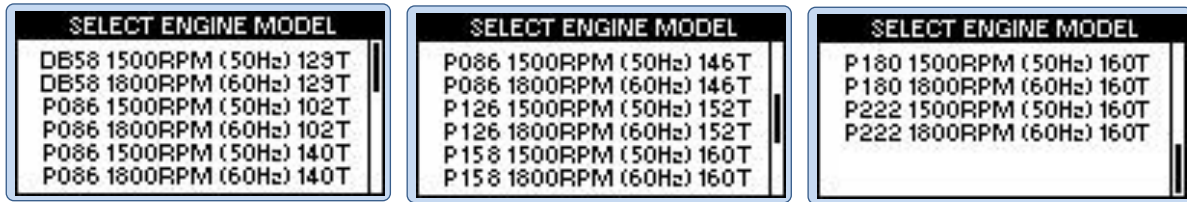
It offers menu to configure LCD operating conditions including brightness, auto on/off and off hours.

#### 11) System monitor

It offers menu to monitor the controller operation. It shows values for Engine RPM, Valve Duty, Valve Current, Aux RPM Input, Pickup Voltage and Bat Voltage.

### 3.2.3 Engine Type Setup Menu

This menu offers function to configure setting values of the controller depending on types of the engines in advance and apply such preset values to the selected engine.

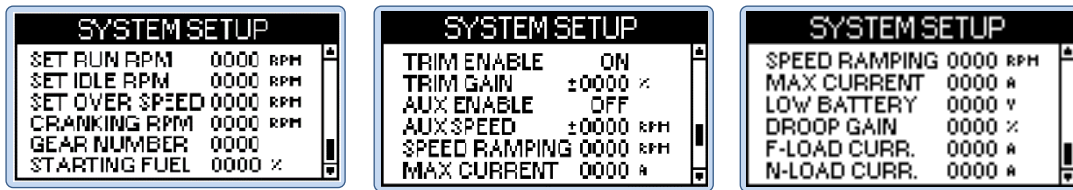


Menu 2: Engine Type Selection Menu

### 3.2.4 System Setup Menu

#### System Setup Menu Display of the Controller

It consists of sub-menus for the system configuration items of the controller including the one for configuring RUN/IDLE/OVERSPEED/CRANK/GEAR NUMBER related to RPM setting. Depending on additional functions, users can designate values for STARTING FUEL/SPEED RAMPING/ACTUATOR MAX/LOW BATTERY.



Menu 3: System Setup Menu - 1 to 3

#### 1) SET RUN RPM

Users can designate normal speed (target RPM) of the engine.

Users need to input different normal speed values depending on the specification of the selected engine.

#### 2) SET IDLE RPM

Users can designate the idle speed values of the engine as RPM.

Users need to input values to control the idle operating speed of the engine.

#### 3) SET OVER SPEED

Users can designate RPM values to activate engine protection function when the speed exceeds the normal level (target RPM) and reaches the overspeed range that may cause problems to the engine.

When the engine RPM reaches the over speed RPM range, the engine immediately stops with error messages and alarms.

#### 4) CRANKING RPM

Users can designate RPM values to activate the actuator when the engine starts to operate.

**5) GEAR NUMBER**

Users can input the number of flywheel teeth in the engine to the controller so that the controller can calculate the accurate RPM depending on the values of the pick-up sensor from the engine.

**6) STARTING FUEL**

Users can designate the amount of fuels used when the engine starts to operate and the operating current for the controller to activate the actuator changes based on these values.

**7) AUX SPEED**

Users can adjust values to ensure safe operation of the engine based on the AUX signal values when AUX is enabled.

**8) SPEED RAMPING**

Users can input ratio values of speed changes when the speed increases or decreases in the idle condition of the engine.

**9) MAX CURRENT**

Users can designate the maximum operating current for the **actuator** of the engine.

**10) LOW BATTERY**

It measures the battery voltage supplied to the controller. When the measured values are lower than the present voltage values, it will be alarmed. Usually, the acceptable battery voltage is between 20 and 22V (without load).

**11) DROOP GAIN**

Users can designate the droop values applicable to maximum load based on the current consumption of the **actuator**.

**12) F-LOAD CURR**

Users can designate the maximum current values when the generator is in full load.

**13) N-LOAD CURR**

Users can designate the operating current values of the actuator when the generator has no load.

**3.2.5 PID Gain Setup Menu**

Users can input Kp, Ki and Kd values as inputs to the PID control of the engine. Kp means proportional values while Ki means integral of the proportional values and Kd means differential of the proportional values.



**Menu 4: PID Gain Setup Menu**

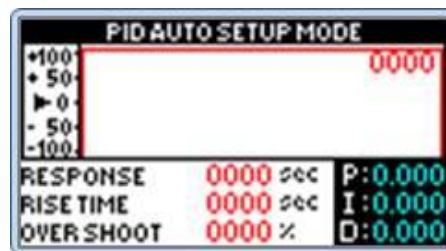
### 3.2.6 PID Auto Setup Menu

The menu offers function for automatic designation of the P, I and D parameter values related to the engine PID control.

After starting the engine, select **DRIVE UNIT MENU** in the main menu while the engine has no load and then **PID auto setup** menu, press Enter. Then, the system message shows "Auto Setup Mode PID setting?" with YES or NO option. If you select YES, the controller will repeatedly change the RPM to automatically calculate the optimized P, I and D values.

If the controller identifies the optimized P, I and D values within 30 cycles, it will display "PID Auto Setup Complete, OK". When you press Enter, it will apply tuned P, I and D values and close the menu.

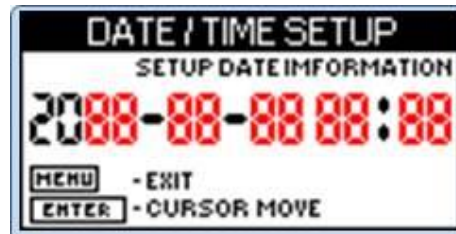
If the controller fails to identify the optimized P, I and D values within 30 cycles, it will display "PID No Successful, OK". When you press Enter, it will apply the final P, I and D values and close the menu.



Menu 5: PID auto setup menu

### 3.2.7 Date/Time Setup Menu

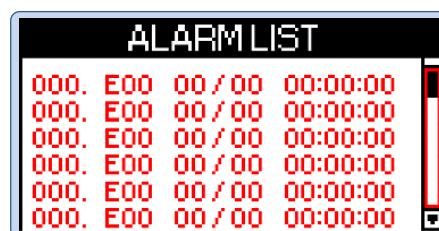
Users can designate year, month, day, hour and minute for the controller and the designated time will be used to monitor the system and manage fault messages.



Menu 6: DATE/TIME SETUP Menu

### 3.2.8 Alarm List Menu

This menu displays year, month, day, hour and minute for the errors in the controller and types of the faults in codes which are used in troubleshooting.



Menu 7: ALARM LIST Menu

### 3.2.9 Default Setup Menu

When you cannot identify the type of the control engine by the controller, this menu offers the most common parameter setting values. For default setup, select YES and then press Enter button. If you don't want to implement this function, press No button.

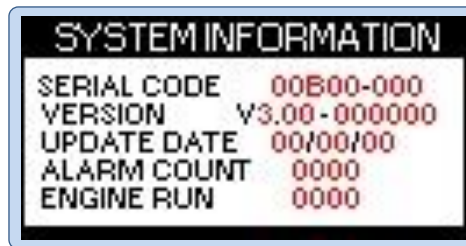
If you press YES, all the configuration values will be changed to the default ones of the engine.



Menu 8: Default Setup Menu

### 3.2.10 System Info Menu

The controller displays its information including the serial number, software version, last update date, alarm count and engine runs.



Menu 9: System Info Menu

## 3.3 Engine Configuration

### 3.3.1 Engine Type Configuration

Users can store control setting information depending on types of the engines in the internal memory of the controller. If you select your engine type, applicable parameters will be automatically configured accordingly. This feature is available for 21 different types of engines.

Designated Parameters by Engine Type (Land use)

No	Menu Name	Run RPM	Over Speed	Gear Teeth	Starting Fuel	PID Value
1	DB58 1500RPM (50Hz) 129T	1500RPM	1725RPM	129	65%	Optimized Value
2	DB58 1800RPM (60Hz) 129T	1800RPM	2070RPM	129	65%	Optimized Value
3	P086 1500RPM (50Hz) 102T	1500RPM	1725RPM	102	65%	Optimized Value
4	P086 1800RPM (60Hz) 102T	1800RPM	2070RPM	102	65%	Optimized Value
5	P086 1500RPM (50Hz) 140T	1500RPM	1725RPM	140	65%	Optimized Value
6	P086 1800RPM (60Hz) 140T	1800RPM	2070RPM	140	65%	Optimized Value
7	P086 1500RPM (50Hz) 146T	1500RPM	1725RPM	146	65%	Optimized Value
8	P086 1800RPM (60Hz) 146T	1800RPM	2070RPM	146	65%	Optimized Value

9	P126 1500RPM (50Hz) 152T	1500RPM	1725RPM	152	65%	Optimized Value
10	P126 1800RPM (60Hz) 152T	1800RPM	2070RPM	152	65%	Optimized Value
11	P126 1500RPM (50Hz) 106T	1500 RPM	1725RPM	106	65%	Optimized Value
12	P126 1800RPM (60Hz) 106T	1800 RPM	2070RPM	106	65%	Optimized Value
13	P158 1500RPM (50Hz) 160T	1500 RPM	1725RPM	160	65%	Optimized Value
14	P158 1800RPM (60Hz) 160T	1800 RPM	2070RPM	160	65%	Optimized Value
15	P158 2350RPM (60Hz) 160T	2350 RPM	2467RPM	160	65%	Optimized Value
16	P180 1500RPM (50Hz) 160T	1500 RPM	1725RPM	160	65%	Optimized Value
17	P180 1800RPM (60Hz) 160T	1800 RPM	2070RPM	160	65%	Optimized Value
18	P180 2350RPM (60Hz) 160T	2350 RPM	2467RPM	160	65%	Optimized Value
19	P222 1500RPM (50Hz) 160T	1500 RPM	1725RPM	160	65%	Optimized Value
20	P222 1800RPM (60Hz) 160T	1800 RPM	2070RPM	160	65%	Optimized Value
21	P222 2350RPM (60Hz) 160T	2350 RPM	2467RPM	160	65%	Optimized Value

### Designated Parameters by Engine Type (marine use)

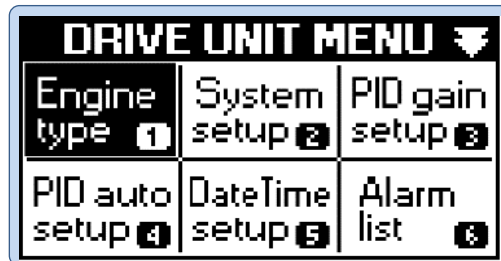
No	Menu Name	Run RPM	Over Speed	Gear Teeth	Starting Fuel	PID Value
1	AD066TI 1500RPM (50Hz) 129T	1500 RPM	1725RPM	129	60%	Optimized Value
2	AD066TI 1800RPM (60Hz) 129T	1800 RPM	2070RPM	129	60%	Optimized Value
3	AD086TI 1500RPM (50Hz) 140T	1500 RPM	1725RPM	140	60%	Optimized Value
4	AD086TI 1800RPM (60Hz) 140T	1800 RPM	2070RPM	140	60%	Optimized Value
5	AD126TI 1500RPM (50Hz) 152T	1500 RPM	1725RPM	152	60%	Optimized Value
6	AD126TI 1800RPM (60Hz) 152T	1800 RPM	2070RPM	152	60%	Optimized Value
7	4AD126TIF 1500RPM (50Hz) 106T	1500 RPM	1725RPM	106	60%	Optimized Value
8	4AD126TIS 1800RPM (60Hz) 106T	1800 RPM	2070RPM	106	60%	Optimized Value
9	AD136 1500RPM (50Hz) 140T	1500 RPM	1725RPM	140	60%	Optimized Value
10	AD136 1800RPM (60Hz) 140T	1800 RPM	2070RPM	140	60%	Optimized Value
11	AD136T 1500RPM (50Hz) 140T	1500 RPM	1725RPM	140	60%	Optimized Value
12	AD136T 1800RPM (60Hz) 140T	1800 RPM	2070RPM	140	60%	Optimized Value
13	AD136TI 1500RPM (50Hz) 140T	1500 RPM	1725RPM	140	60%	Optimized Value
14	AD136TI 1800RPM (60Hz) 140T	1800 RPM	2070RPM	140	60%	Optimized Value
15	AD158TI 1500RPM (50Hz) 160T	1500 RPM	1725RPM	160	60%	Optimized Value
16	AD158TI 1800RPM (60Hz) 160T	1800 RPM	2070RPM	160	60%	Optimized Value
17	4AD158TI 1500RPM (50Hz) 160T	1500 RPM	1725RPM	160	60%	Optimized Value
18	4AD158TI 1800RPM (60Hz) 160T	1800 RPM	2070RPM	160	60%	Optimized Value
19	AD180TI 1500RPM (50Hz) 160T	1500 RPM	1725RPM	160	60%	Optimized Value
20	AD180TI 1800RPM (60Hz) 160T	1800 RPM	2070RPM	160	60%	Optimized Value
21	AD196TI 1500RPM (50Hz) 152T	1500 RPM	1725RPM	152	60%	Optimized Value
22	AD196TI 1800RPM (60Hz) 152T	1800 RPM	2070RPM	152	60%	Optimized Value
23	AD222TI 1500RPM (50Hz) 160T	1500 RPM	1725RPM	160	60%	Optimized Value
24	AD222TI 1800RPM (60Hz) 160T	1800 RPM	2070RPM	160	60%	Optimized Value
25	4AD222TI 1500RPM (50Hz) 160T	1500 RPM	1725RPM	160	60%	Optimized Value
26	4AD222TI 1800RPM (60Hz) 160T	1800 RPM	2070RPM	160	60%	Optimized Value

**Table 1: Configuration Values by Engine Type**

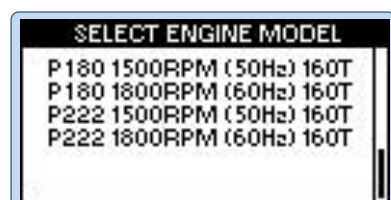
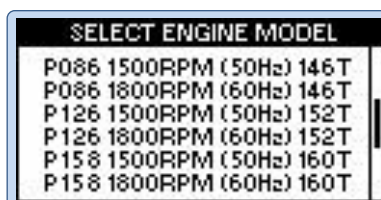
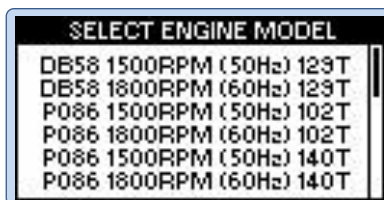
- **Engine Configuration Procedure**

**Step1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

**Step2)** Select **Engine Type** by using **Up** and **Down** buttons in **DRIVE UNIT MENU** and then press **Enter** button.



**Step3)** Go to **Engine Type** menu and select your engine type using **Up** and **Down** buttons. Then, press **Enter** button. At this moment, setting values according to the selected type of the engine are designated and will be used as information for the controller to control the actuator.



**Menu 10: Selection List by Engine Type**

### 3.3.2 System Setup Configuration

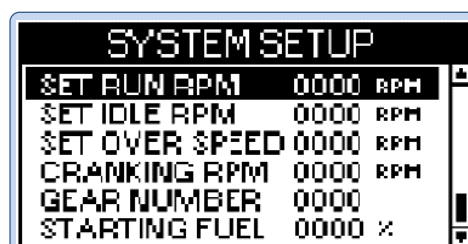
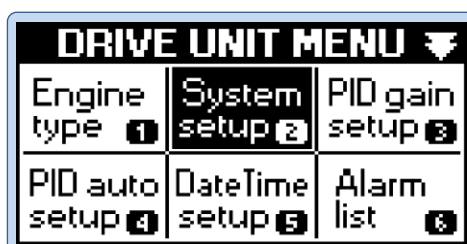
Main setting items of the controller includes **GEAR NUMBER**, **CRANKING RPM** and **SET RUN RPM**. You need to designate setting values to these items. Other system setup items are optional and therefore you can designate values for those items as necessary.

- **Configuring SET RUN RPM**

**Step1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

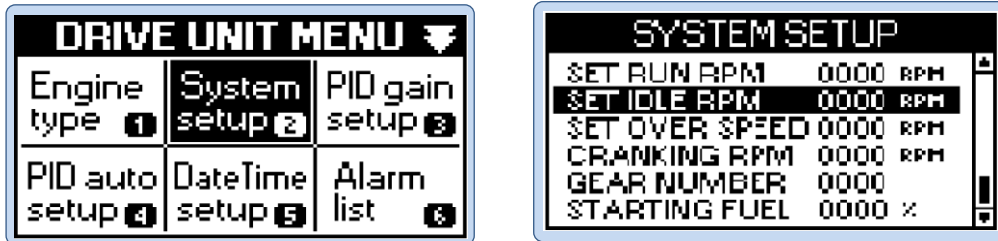
**Step2)** Select **System setup** menu in **DRIVE UNIT MENU** using **Up**, **Down**, **Left** and **Right** buttons and then press **Enter** button.

**Step3)** Select **SET RUN RPM** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the normal operating speed of the engine and then press **Enter** button.



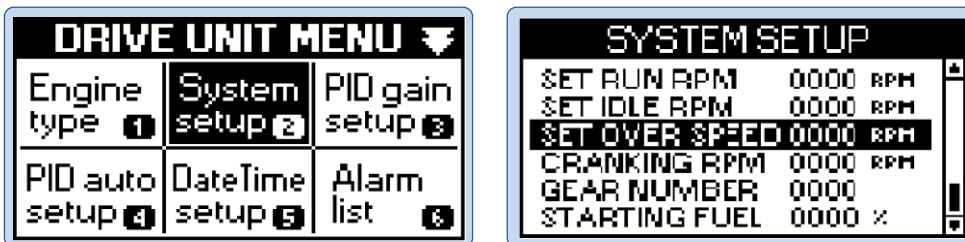
- **Configuring SET IDLE RPM**

- Step1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.
- Step2)** Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.
- Step3)** Select **SET IDLE RPM** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the **idle** operating speed of the engine and then press **Enter** button.



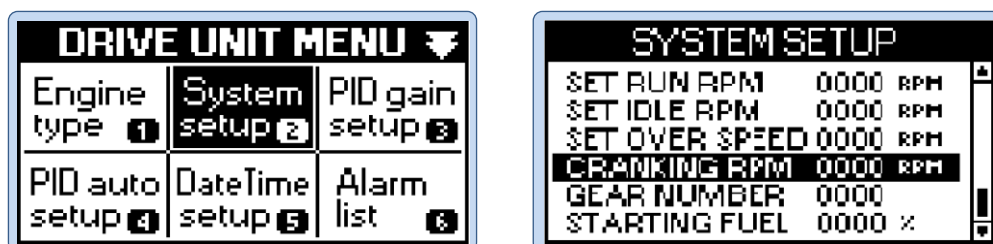
- **Configuring SET OVER SPEED**

- Step1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.
- Step2)** Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.
- Step3)** Select **SET OVER SPEED** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the **over speed** values of the engine and then press **Enter** button.



- **Configuring CRANKING RPM**

- Step1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.
- Step2)** Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.
- Step3)** Select **CRANKING RPM** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the **RPM** values at which the controller starts to control the **actuator** when the engine starts to operate and then press **Enter** button.

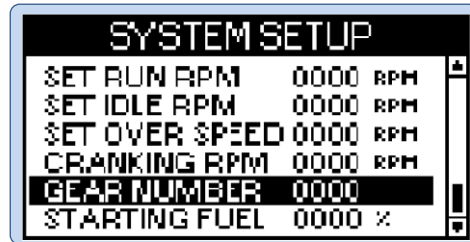
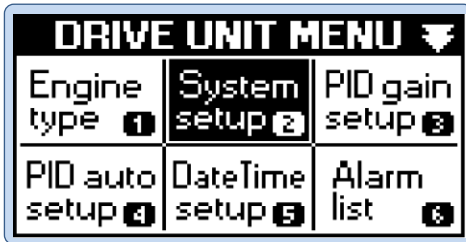


- Configuring **GEAR NUMBER**

**Step1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

**Step2)** Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

**Step3)** Select **GEAR NUMBER** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the number of gear teeth in the engine and then press **Enter** button.

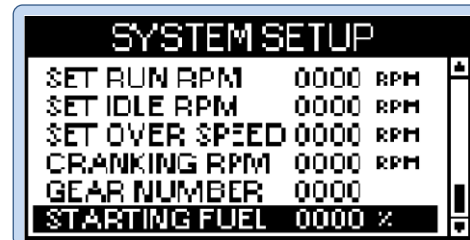
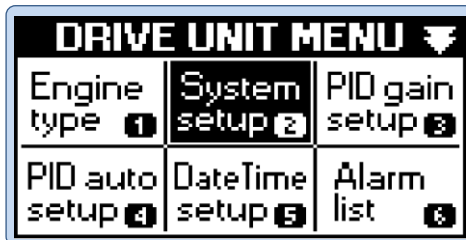


- Configuring **STARTING FUEL**

**Step1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

**Step2)** Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

**Step3)** Select **STARTING FUEL** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the percentage for the amount of fuel sprayed when the engine starts and then press **Enter** button.

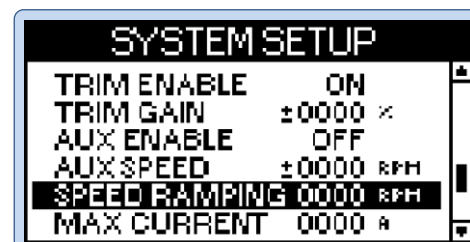
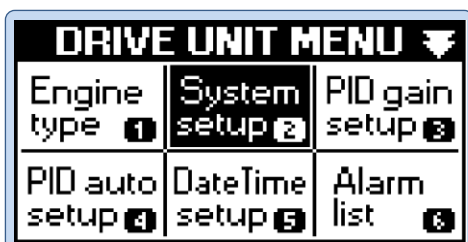


- Configuring **SPEED RAMPING**

**Step1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

**Step2)** Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

**Step3)** Select **SPEED RAMPING** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the ratio of changes to the speed when increasing from the idle speed or decreasing from the increased speed and then press **Enter** button.

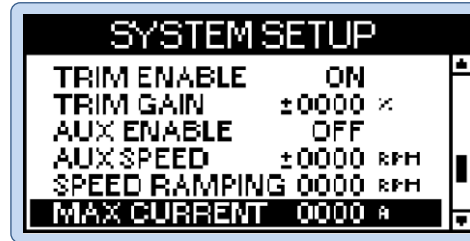
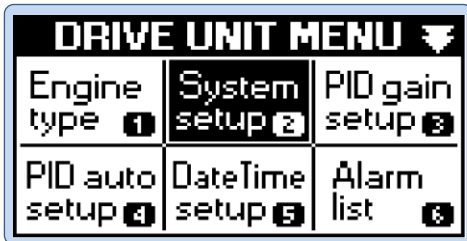


- Configuring **MAX CURRENT**

**Step1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

**Step2)** Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

**Step3)** Select **MAX CURRENT** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the limit of the maximum current consumption of the **actuator** and then press **Enter** button (Max. 10A).

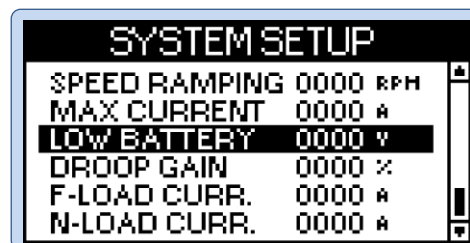
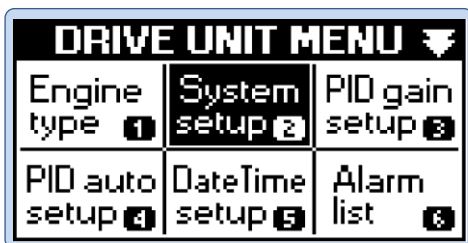


- Configuring **LOW BATTERY**

**Step1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

**Step2)** Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

**Step3)** Select **LOW BATTERY** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to input voltage values at which low battery alarms are activated and then press **Enter** button.

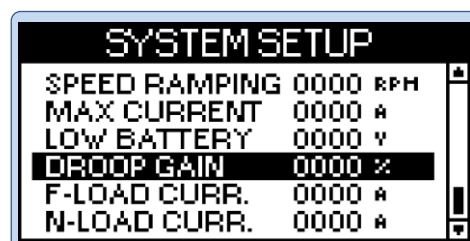
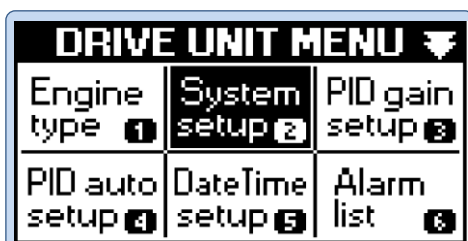


- Configuring **DROOP GAIN**

**Step1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

**Step2)** Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

**Step3)** Select **DROOP GAIN** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to increase or decrease the RPM values with adjusted ratio to decrease at the maximum load when the generator is in parallel operation and then press **Enter** button.



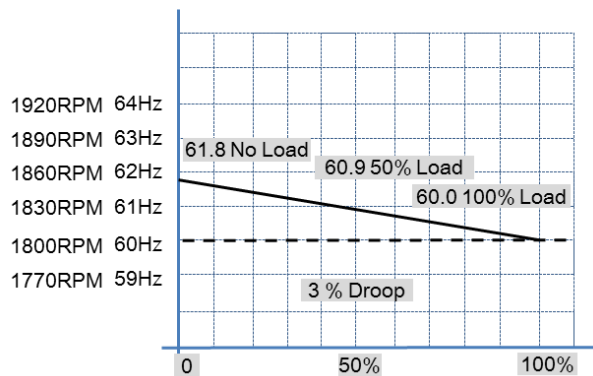
**DROOP Function**

Droop function is indicated in percentages as follows: RPM with no load is subtracted by RPM with maximum load and then divided by RPM with no load.

$$\text{Droop}\% = \frac{\text{RPM with no load} - \text{RPM with maximum load}}{\text{RPM with no load}}$$

**(Example for 3% Droop)**

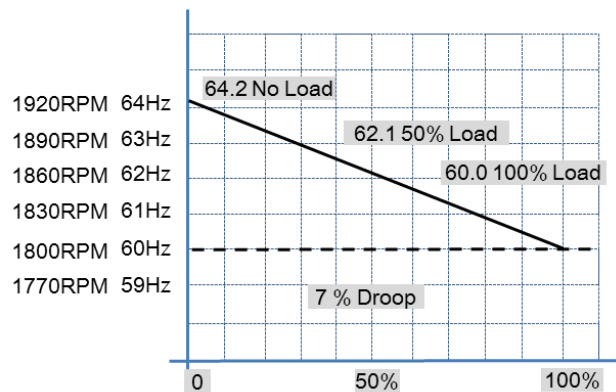
Assuming that RPM with no load is 1,800 and RPM with maximum load is 1,854 then the percentage will be 3%. It means that the generator output will be changed by 33.3% as the frequency changes by 1% due to the actuator control.



**Figure 10: 3% Droop**

**(Example for 7% Droop)**

Assuming that RPM with no load is 1,800 and RPM with maximum load is 1,926 then the percentage will be 7%. It means that the generator output will be changed by 14.3% as the frequency changes by 1% due to the actuator control.



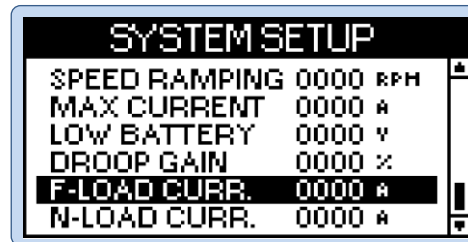
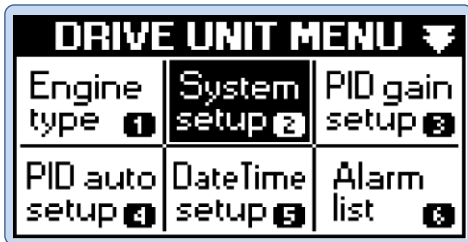
**Figure 11: 7% Droop**

- **F-LOAD CURR.**

**Step1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

**Step2)** Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

**Step3)** Select **F-LOAD CURR.** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to input the maximum current values of the **actuator** for the generator with full load and then press **Enter** button.

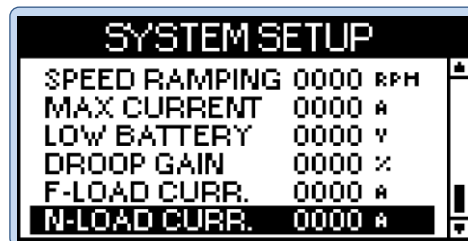
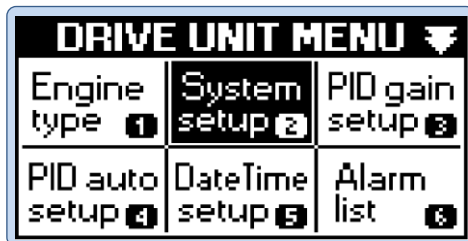


- **N-LOAD CURR.**

**Step1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**.

**Step2)** Select **System setup** menu in **DRIVE UNIT MENU** using **Up, Down, Left** and **Right** buttons and then press **Enter** button.

**Step3)** Select **N-LOAD CURR.** in **SYSTEM SETUP** menu and then press **Enter** button. Use **Up** and **Down** buttons to input the operating current values of the **actuator** for the generator with no load and then press **Enter** button.



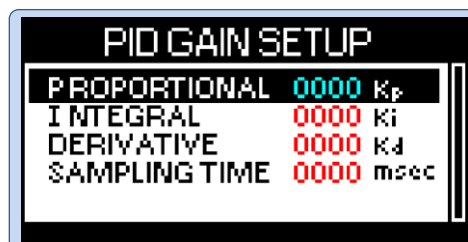
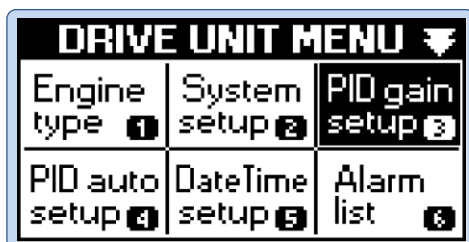
### 3.3.3 PID Gain Setup Configuration

- **Configuring PID Gain Kp, Ki and Kd Values**

**Step1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up, Down, Left** and **Right** buttons to select **PID gain setup** menu and then press **Enter** button.

**Step2)** Use **Up** and **Down** buttons in **PID GAIN SETUP** to select **PROPORTIONAL, INTEGRAL** or **DERIVATIVE** and then press **Enter** button.

In **PID GAIN SETUP**, if a user sets the value over than 100 about each **P, I, D**, we could not the warrant of the product quality.



- Configuring **PID SAMPLING TIME**

**Step1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up**, **Down**, **Left** and **Right** buttons to select **PID gain setup** menu and then press **Enter** button.

**Step2)** Use **Up** and **Down** buttons in **PID GAIN SETUP** to select **SAMPLING TIME** and then press **Enter** button. Use **Up** and **Down** buttons to input **SAMPLING TIME** values and then press **Enter** button.

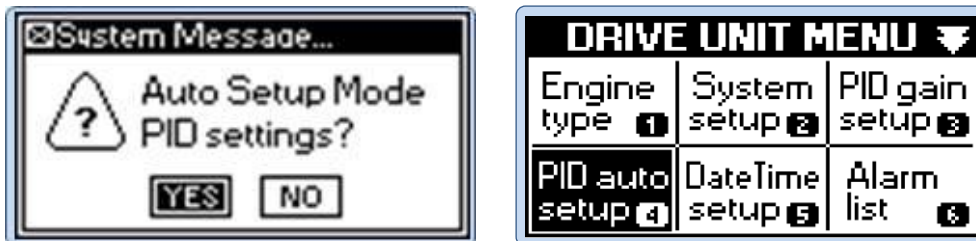


### 3.3.4 PID Auto Setup Value Configuration

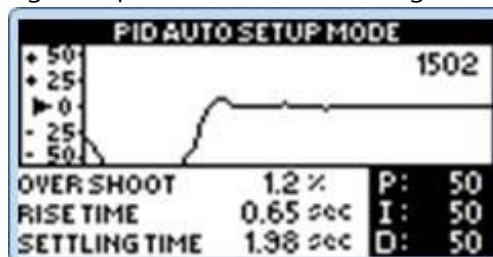
**Step1)** Select your type in Engine Type menu and then start the engine with the preset configuration values maintaining it with no load.

**Step2)** During the normal operation, press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up**, **Down**, **Left** and **Right** buttons to select **PID auto setup** menu and then press **Enter** button.

**Step3)** The menu offers function for automatic designation of the P, I and D parameter values related to the engine PID control. Select PID auto setup menu in **DRIVE UNIT MENU** and then press Enter button to see the system message "Auto Setup Mode PID settings?" with YES or NO options.



**Step4)** Press YES and then the system message "PID AUTO SETUP MODE" will appear. As PID auto setup was initiated during the operation, PID auto tuning is already in progress.



**Step5)** PID tuning repeats a process to obtain PID values and a window to indicate whether the process succeeded or failed will appear in several minutes (approx. 4 to 6 minutes). If the process succeeded, the system message window will appear together with OK button. If you press Enter button, you will go back to normal operation window and the auto-tuned values will apply to the normal operation that will be continued.

**Step6)** If auto-tuning failed to identify optimized P, I and D values within 4 to 6 minutes, the system message window will display failure. If you press Enter button, you will go back to normal operation window. If you want to repeat the process, you need to start with Step1 again.



### 3.3.5 DATE/TIME Value Configuration

**Step1)** press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use direction buttons to select **DateTime setup** menu.

**Step2)** Use **Up, Down, Left** and **Right** buttons to input year, month, day and hour and then press **Enter** button.



### 3.3.6 ALARM LIST

**Step1)** press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use direction buttons to select **Alarm List** menu and then press **Enter** button.

**Step2)** Use **Up, Down, Left** and **Right** buttons in **ALARM LIST** menu to confirm the fault messages.



[Alarm Code Table]

Alarm Code	Alarm Item	Description	Identified Alarm Output
E01	Battery Low	When the battery voltage continues to be lower than Low Battery voltage values for more than 5 seconds	LCD alarm message, Error LED lamp
E02	Battery High	When the battery maintains its voltage exceeding 30VDC for more than 5 seconds	LCD alarm message, Error LED lamp
E03	Pick-up Error	Problems in sensor signals when the engine starts. (Engine RPM lower than 600)	LCD alarm message, Error LED lamp
E04	Pick-up Error	Problems in sensor signals during the engine operation (Engine RPM 600 or higher)	LCD alarm message, Error LED lamp
E05	Actuator Current Short	Disconnection in the actuator or the connecting circuits	LCD alarm message, Error LED lamp
E06	Actuator Current Broken	Short-circuits in the actuator or the connecting circuits	LCD alarm message, Error LED lamp
E07	Over Speed	Engine RPM exceeding the configured over speed values	LCD alarm message, Error LED lamp
E08	FET Drive Error	Damages to components in the actuator output section inside the controller	LCD alarm message, Error LED lamp
E09	Pick-Up Lost	Pick-Up signal lost. (Engine RPM higher than 600rpm)	LCD alarm message, Error LED lamp

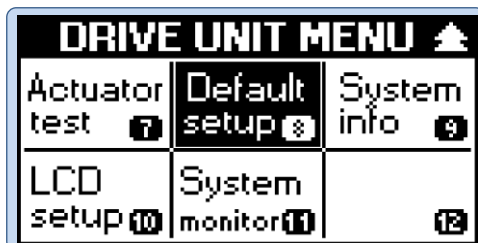
### 3.3.7 Actuator test

The menu offers function to test whether there is any problem in operating load current of the actuator attached to the engine. It indicates voltage and current for on/off.

### 3.3.8 Default setup Functions

**Step1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up**, **Down**, **Left** and **Right** buttons to select **Default setup** menu and then press **Enter** button. At this moment, the system message **"Initialization system settings?"** will appear.

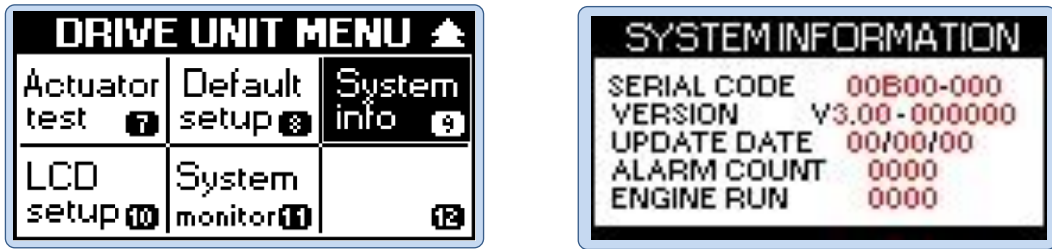
**Step2)** Use **Left** and **Right** buttons to select either **YES** or **NO** in **System Message** and then press **Enter** button.



Default setup will change the configuration values of the engine to the default values. In order to initiate default setup, you need to select **YES** and then press **Enter** button. Press **No** button if you don't want to.

### 3.3.9 System info Functions

**Step1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up**, **Down**, **Left** and **Right** buttons to select **System info** menu and then press **Enter** button.

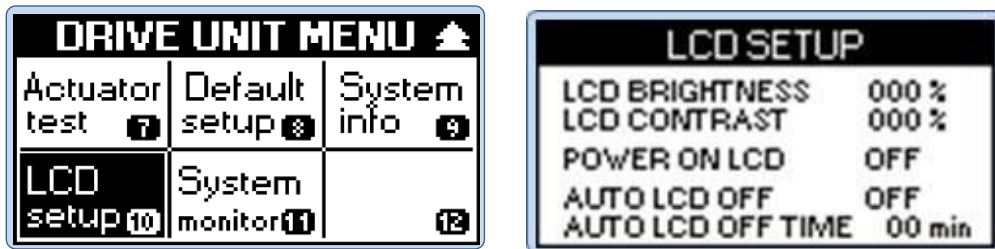


The menu displays information of the controller and the information includes the serial number, software version, last update date, alarm count and engine runs.

### 3.3.10 LCD setup Functions

**Step1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up**, **Down**, **Left** and **Right** buttons to select **LCD setup** menu and then press **Enter** button.

**Step2)** Use **Up** and **Down** buttons to select menus including **LCD BRIGHTNESS** and **LCD CONTRAST** for adjustment and then press **Enter** button. Use **Up** and **Down** buttons to input setting values and then press **Enter** button.



### 3.3.11 System monitor Functions

**Step1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up**, **Down**, **Left** and **Right** buttons to select **System monitor** menu and then press **Enter** button. It offers menu to monitor the controller operation. It shows values for Engine RPM, Valve Duty, Valve Current, Aux RPM Input, Pickup Voltage(Peak Value) and Bat Voltage.

## 4. How to Operate

### 4.1 Operating Sequence for Digital Speed Controller

**STEP1) Supply DC +24V power to the battery terminals (E (-), F (+)) of the controller.**

**STEP2) Configure parameter values required for selection of the engine type and control of the engine.**

**STEP3) Install the controller on the generator system and complete circuit wiring.**

**STEP4) The controller will activate the actuator with power supply and pick-up sensor input.**

### 4.2 Detailed Operating Sequence

**STEP1) Supply DC +24V power to the battery terminals (E (-), F (+)) of the controller.**

Power supply to the controller can be done by direct connection to the battery or power supply controlled by external control devices. Fuses (15A/24V) are required for power supply to the controller through the terminal.

When the controller displays **Low Battery** Fault message, you need to charge the battery or replace it with the one having normal voltage before starting the controller.

**STEP2) Configure parameter values required for selection of the engine type and control of the engine.**

There are 3 ways to configure parameters required for the controller:

1. Using default setup
2. Designating the engine type in Engine Type menu
3. Configuring each parameter in System setup menu

For more information, see **Chapter 3**. Configuration and Operation.

**STEP3) Install the controller on the generator system and complete circuit wiring.**

Once the configuration is completed, the controller will be in **Stand By** condition preparing to receive input information from **pick-up** sensor and surrounding terminals and operate.

**STEP4) The controller will activate the actuator with power supply and pick-up sensor input.**

When the power is supplied and the **pick-up** terminal delivers normal sensor inputs as the **engine** starts, the **controller** activate the **actuator**.

## 5. Troubleshooting

### 5.1 Alarm List Check

Where there are problems in the system operation, you need to review the alarm list menu of the controller and then check the engine and the system in reference to the alarm codes.

Land/marine

Alarm Code	Alarm Item	Alarm Condition	Output Control	Measures
E01	Battery Low	When the battery voltage continues to be lower than Low Battery voltage values for more than 5 seconds	1. Alarm message pop-up on LCD 2. Error LED on	1. Check the battery line 2. Replace the battery
E02	Battery High	When the battery maintains its voltage exceeding 30VDC for more than 5 seconds	1. Alarm message pop-up on LCD 2. Error LED on	1. Check the battery line 2. Replace the battery
E03	Pick-up Error	Problems in sensor signals when the engine starts (Engine RPM lower than 600)	1. Alarm message pop-up on LCD 2. Error LED on 3. Actuator control signal off	1. Check the RPM sensor and connecting circuits 2. Replace the RPM sensor
E04	Pick-up Error	Problems in sensor signals during the engine operation (Engine RPM 600 or higher)	1. Alarm message pop-up on LCD 2. Error LED on 3. Actuator control signal off	1. Check the RPM sensor and connecting circuits 2. Replace the RPM sensor
E05	Actuator Current Short	Disconnection in the actuator or the connecting circuits	1. Alarm message pop-up on LCD 2. Error LED on	1. Check the disconnection in the actuator and connecting circuits 2. Replace the actuator
E06	Actuator Current Broken	Short-circuits in the actuator or the connecting circuits	1. Alarm message pop-up on LCD 2. Error LED on	1. Check the disconnection in the actuator and connecting circuits 2. Replace the actuator
E07	Over Speed	Engine RPM exceeding the configured over speed values	1. Alarm message pop-up on LCD 2. Error LED on 3. Actuator control signal off	1. Check the speed setting 2. Adjust PID setting values
E08	FET Drive Error	Damages to components in the actuator output section inside the controller	1. Alarm message pop-up on LCD 2. Error LED on 3. Actuator output power cutoff	1. Check the actuator and connecting circuits 2. Replace the controller
E09	Pick-Up Lost	Pick-Up signal lost. (Engine RPM higher than 600rpm)	1. Alarm message pop-up on LCD 2. Error LED on 3. Actuator output power cutoff	1. Check the RPM sensor and connecting circuits 2. Replace the RPM sensor

- 1) When problems described in alarm codes E03, E04, E07, E08 or E09 occur, the engine is not available for safe operation and therefore the engine will stop as the controller will turn off the actuator for safety.

- 2) When problems described in alarm codes E03, E04, E07 or E08 occur, the engine will not be able to restart as long as the alarm is not released.
- 3) When alarms occur, you can release them by turning off the power of the controller.

## 5.2 System Checks and Measures

For initial installation, it is recommended for you to check any disconnection in circuits before taking measures described here (see Chapter 2. Installation for how to install the controller).

**You can check the controller for failure diagnosis in accordance with the following procedure.**

**Step1)** Check the battery voltage whether it is higher than the Low Voltage setting value. If normal, supply power to the controller and then operate it. If the voltage is lower than the setting value, you need to charge the battery or replace it before operating the system.

**Step2)** Check the input resistance in the DC +24V input terminals (-E, +F) of the battery whether the resistance is higher than approx. 10K Ohm. If the resistance does not meet this condition, do not supply power to the controller and contact our A/S center for service request.

**Step3)** Check whether the power LED turns on or not after supplying power to DC +24V input terminals (-E, +F) of the battery. If the LED does not turn on, cut the power off and contact our A/S center for service request.

**Step4)** Check whether the power LED turns on and **HYUNDAI** logo appears on the LCD display after supplying power to DC +24V input terminals (-E, +F) of the battery. If you cannot see the logo, press LCD key button to check the LCD display once again. If you cannot still see the logo, cut the power off and contact our A/S center for service request.

**Step5)** Check the controller terminals (C & D) with AC meter or oscilloscope to check whether signal inputs of AC RMS 3V or higher are detected. If no signal detected, check whether the pick-up sensor maintains the gap between 0.9 and 1.1mm and then check whether the pick-up sensor has resistance of 110 Ohms ( $\pm 10\%$ ). If you cannot still detect no signal, replace the pick-up sensor and then operate the controller.

## **6. Warranty and A/S Service**

### **6.1 Warranty**

As this manual contains important contents related to safety, use and maintenance of the product. So please read this manual carefully and then use the product in a proper manner.

Those who are not familiar with the product should keep this manual close to it.

We are not responsible for human injuries or property damages caused by the following reasons:

- Where you use the product for purposes other than the ones described in this manual
- Where you alter the product or its components at discretion
- Where you disassemble the product at discretion to resolve problems
- Where you use accessories or parts not supplied or recommended by us
- ※ Where you use accessories or parts manufactured by other companies, please contact our service center to check their compatibility.

### **6.2 A/S Service Information**

- When you request A/S service, please let us know the model name, breakdown conditions and your contact information.
- Please ask the seller.