

***DOOSAN***

950106-107008EN

# Operation & Maintenance Manual

**DIESEL POWER UNIT ENGINE**

**DM03P, DM03V**



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

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

For more information go to [www.P65Warnings.ca.gov](http://www.P65Warnings.ca.gov).



**WARNING:** This product can expose you to chemicals including lead, which is known to the State of California to cause cancer and birth defects or other reproductive harm.

For more information go to [www.P65Warnings.ca.gov](http://www.P65Warnings.ca.gov).



# Preface

This Operation and Maintenance Manual provides information on engine management and maintenance techniques to customers and technicians of Hyundai Doosan Infracore's DM03-MFP04/LEP04 electronically controlled industrial diesel engines.

To provide the best engine to our customers, the DM03-MFP04/LEP04 electronically controlled industrial diesel engines are designed to satisfy all requirements for low noise, economic fuel consumption, high speed and durability with the latest technology and quality.

Precise operating techniques and suitable maintenance are required for maintaining long-term optimal engine conditions and performance. For easier and more precise understanding, maintenance and operation, this Operation and Maintenance Manual provides detailed information through specifications, specified values, troubleshooting, components and pictures.

You can protect the safety of the operator and high-quality maintenance techniques by means of the proper operating techniques and procedures recommended by Hyundai Doosan Infracore, so be sure to handle the engine only after familiarizing yourself with this Operation and Maintenance Manual first.

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

We are constantly striving to provide information about convenient and safe maintenance techniques to future customers, as well as to respond to the demands of our customers.

If there is any incorrect or suspect information in this Operation and Maintenance Manual, please contact Hyundai Doosan Infracore.

Thank you for purchasing a Hyundai Doosan Infracore engine, and we hope that this Operation and Maintenance Manual will be helpful to you.

2021. 11.

950106-107008EN

**Hyundai Doosan 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 Hyundai Doosan Infracore. Any unauthorized reproduction, printing and distribution thereof are strictly prohibited.



# Table of Contents

<b>1. General Introduction .....</b>	<b>1</b>
General Information .....	3
Danger, Warning, Caution and Note .....	4
Emission Information .....	7
Engine Maintenance .....	10
<b>2. Operation and Maintenance .....</b>	<b>13</b>
Starting and Stopping of the Engine .....	15
Break-in Period of the Engine .....	16
Operation in Winter .....	17
Inspection and Repair of the Engine .....	18
Injection Nozzle Maintenance .....	19
<b>3. Performance and Specifications .....</b>	<b>21</b>
Engine Specifications and Performance .....	23
Outside Drawing of the Engine (Stage-V) .....	29
Outside Drawing of the Engine (Tier-4 Final) .....	33
Engine Serial Number .....	37
<b>4. Regular Inspections .....</b>	<b>41</b>
General Information .....	43
Regular Inspection Table .....	44
Cooling System .....	46
Lubrication System .....	50
Fuel System .....	55
Intake/Exhaust System .....	60
Other/Driving System .....	62
<b>5. General Engine Information .....</b>	<b>63</b>
Indicating Units .....	65
Tightening Torque .....	66
Disassembling the Engine .....	68
Assembling the Engine .....	81

<b>6. Cooling System .....</b>	<b>101</b>
General Information .....	103
Coolant Pump .....	105
Thermostat .....	108
Cooling Fan .....	110
<b>7. Lubrication System .....</b>	<b>113</b>
General Information .....	115
Oil Pump .....	117
Oil Cooler .....	124
Oil Pan .....	126
<b>8. Fuel System .....</b>	<b>129</b>
General Information .....	131
Fuel Return Hose .....	132
Injector .....	133
Common Rail .....	138
Fuel Injection Pump .....	145
<b>9. Intake/Exhaust System .....</b>	<b>149</b>
Turbocharger .....	151
EGR .....	160
Intake Manifold .....	163
Exhaust Manifold .....	168
Throttle (Inlet Pipe) & the Intake Stake .....	171
<b>10. Cylinder Block/Head .....</b>	<b>173</b>
General Information .....	175
Cylinder Block .....	176
Cylinder Head .....	178
Valves .....	180
Rocker Arms .....	183
Tappet and Push rod .....	190
Camshaft .....	198
Flywheel Housing .....	200
Breather .....	204
Cylinder Head Cover .....	205
Idle Gear .....	210
Lifting Hook .....	215

Oil Seal .....	216
<b>11. Electrical System .....</b>	<b>219</b>
Electric Parts .....	221
Circuit Diagram .....	222
Switches and Sensors .....	229
Wire Harness .....	234
Engine Control Unit (ECU) .....	235
Starter .....	238
Alternator .....	242
<b>12. Other/Driving System .....</b>	<b>245</b>
General Information .....	247
Crankshaft .....	249
Piston .....	254
Connecting Rod .....	257
Crankshaft Pulley .....	259
Others .....	261
<b>13. Aftertreatment System .....</b>	<b>265</b>
Exhaust Gas Reduction System (Stage-V) .....	267
Exhaust Gas Reduction System (Tier-4 Final) .....	275
<b>14. Accessory System .....</b>	<b>277</b>
Radiator & Cooling Fan .....	279
Intake & CAC .....	287
Engine Mount .....	290
<b>15. Option .....</b>	<b>291</b>
Base Option .....	293
Part Option .....	294



# 1. General Introduction

<b>General Information .....</b>	<b>3</b>
General Information .....	3
<b>Danger, Warning, Caution and Note .....</b>	<b>4</b>
General Information .....	4
General Instructions.....	4
Cautions for Starting the Engine .....	4
Cautions for Inspection and Repair.....	4
General Repair.....	5
Other Safety Instructions and Environmental Pollution.....	6
Use of Genuine Parts.....	6
<b>Emission Information .....</b>	<b>7</b>
REGULATION (EU) 2017/654 ANNEX XV (Applies to customers using equipment in EU only.).....	7
<b>Engine Maintenance .....</b>	<b>10</b>
Prevention of Damage and Abrasion .....	10
Prevention of Pollution .....	10
Handling of Engine Oil .....	10
Biodiesel Blend Fuel .....	11
HVO (Hydro treated Vegetable Oil) .....	11
GTL (Gas To Liquids) .....	11





## 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 professionally certified maintenance 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. Hyundai Doosan 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

---

## 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 our 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.

---

### **DANGER**

---

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

---

---

### **WARNING**

---

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

---

---

### **CAUTION**

---

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

---

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.

---

### **WARNING**

---

**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.**

---

### Cautions for 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 access running or rotating parts while the engine is in operation.
5. Be careful not to touch or contact the engine during operation since it becomes hot during operation.
6. Exhaust gas is poisonous. Fully ventilate before starting engine. If the space is airtight, ensure that it is well ventilated.

### Cautions for Inspection and Repair

1. Inspection and repair of engine should be performed only when the engine is stopped. Otherwise, burns or safety accidents may occur, so do not perform inspection or repair while the engine is running.
2. If it is absolutely necessary to perform inspection or repair on the operating engine, do not get close to the rotating parts.

---

### **DANGER**

---

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

---

---

## WARNING

---

**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.**

---

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.
- 

---

## WARNING

---

**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.**

---

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

---

## WARNING

---

**Only refuel when the engine is stopped.**

---

6. Mark and separately manage the containers for storing coolant from beverage containers for avoiding confusion. See a doctor immediately in case of drinking coolant.
  7. Follow the instructions provided by the battery manufacturer when checking or handling batteries.
- 

---

## WARNING

---

**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.**

---

8. Only certified professional 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 reserve 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 connected to the engine control unit (ECU).
13. Do not give any electric or mechanical shocks or perform welding works on the electrical apparatus or the ECU.

## General Repair

1. Wait until the engine is properly cooled down before starting work, since you may get burned by the heated engine.  
Before performing fuel line work, check the common rail pressure and engine temperature by using the failure diagnosis device.
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.
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. The strength, shape, and screw torque of bolts and nuts are different 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.

# 1. General Introduction

---

13. After completing repairs, conduct a final inspection and perform a test operation to check if all works have been successfully completed.

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

## 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.

---

### **WARNING**

---

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

---

## 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.

# 1. General Introduction

## Emission Information

Tampering with the engine voids the US and EU type-approval of that particular engine.

### REGULATION (EU) 2017/654 ANNEX XV (Applies to customers using equipment in EU only.)

Hyundai Doosan Infracore provide to the customer all information and necessary instructions for the correct operation of the engine in order to maintain the gaseous and particulate pollutant emissions of the engine within the limits of the approved engine type or engine family. The customer should operate machine in accordance with the following information and instruction.

The customer should operate machine in accordance with the following information and instruction.

## Engine Operation and Maintenance


You must comply with the following things when you operate an engine.

- The engine, including the emissions control system, shall be operated, used and maintained in accordance with the instructions provided to the end users in order to maintain the emissions performance of the engine within the requirements applicable to the engine's category.
- No deliberate tampering with or misuse of the engine emissions control system in particular with regard to deactivating or not maintaining an exhaust gas recirculation (EGR) system should take place.
- This machine is equipped with an engine exhaust emission control system. The operator is responsible for proper operation and maintenance of the emission controls system. For details, see "Engine Exhaust Emission Control System" in the Operation and Maintenance Manual.
- It is essential to take prompt action to rectify any incorrect operation, use or maintenance of the emissions control system in accordance with the rectification measures indicated by the warnings referred to "Malfunctions & Inducement"
- Where the engine is to be operated within the Union on diesel or non-road gas-oil, a fuel with sulphur content not greater than 10 mg/kg (20 mg/kg at point of final distribution) cetane number not less than 45 and a FAME content not greater than 8% v/v shall be used.
- Use the correct lubrication oil to maintain the performance of the emissions control system. For details, see "Engine Oil Standards" in the Lubrication system.
- Maintain in accordance with the scheduled emission-related maintenance requirements. For details, see "General Conditions" in the Regular inspection table.

## Malfunctions & Inducement

The operator will be informed by the operator warning system when the emission control system does not function correctly. Ignoring the operator warning signals will lead to the activation of the operator inducement system, resulting in an effective disablement of machine operation.

### Operator Warning System & Inducement

Diagnosis		Warning symbols	Action	
Functions	Detection targets		Low level inducement	Severe level inducement
NOx control diagnosis (NCD)	Impeded EGR		36hr after warning, Torque reduction 25%	64hr after low level inducement, Torque reduction 50% & engine rpm reduction 60%
	Tampering			
Particulate control diagnosis (PCD)	Removing of DPF	Check engine lamp (It's up to the decision of Vehicle maker(s))	PCD related faults are stored in ECU ROM from fault healing during 40 warming up cycle. (=Typically over 20 hours engine operation). Authority must have capability to confirm. (Can be through service tool)	
	Malfunction and tampering in PCD			

# 1. General Introduction

Malfunction Table

(P: Plausibility fault, E: Electric fault)

Component	Fault detection type	Actions after fault confirmation						Fault code			
		Check engine lamp activation	Depends on NCD inducement level	Torque reduction (level1 30%)	Torque reduction (level2 50%)	Speed limit	Engine stop	P-code	SPN	FMI	NCD or PCD
EGR	P	ON	●					P0C17	27	20	N
	E	ON	●					P2143	2791	5	N
	E	ON	●					P2145	2791	3	N
	E	ON	●					P2144	2791	4	N
	P	ON	●					P042	27	1	N
	P	Flashing	●		●			P042E	27	0	N
	P	ON	●					P0C18	27	22	N
	P	ON	●					P0C19	27	23	N
	E	ON	●	●				P0406	27	3	N
	E	ON	●					P0407	27	4	N
MAF sensor	P	Flashing	●		●			P00BE	132	21	N
	E	ON	●	●				P0100	132	19	N
	E	ON	●	●				P0103	132	3	N
	E	ON	●	●				P0102	132	4	N
	P	ON	●	●				P049B	3236	0	N
	P	ON	●	●				P0408	3236	16	N
Intake manifold pressure & Temperature sensor	E	ON	●	●				P0108	102	3	N
	E	ON	●	●				P0107	102	4	N
	E	ON	●					P00AD	105	3	N
	E	ON	●					P00AC	105	4	N
Coolant temperature sensor	E	ON	●	●				P0118	110	3	N
	E	ON	●	●				P0117	110	4	N
Exhaust manifold temperature sensor	E	ON	●					P0546	2789	3	N
	E	ON	●					P0545	2789	4	N
DPF differential pressure sensor	P	ON						P3052	3251	13	P
	P	ON		●				P1454	3251	18	P
	E	ON		●				P2455	3251	3	P
	E	ON		●				P2454	3251	4	P
DPF inlet temperature sensor	E	ON						P2034	3242	11	P
	E	ON						P2033	3242	3	N, P
	E	ON						P2032	3242	4	N, P

### The Value of the Carbon Dioxide (CO<sub>2</sub>) Emissions

This CO<sub>2</sub> measurement results from testing over a fixed test cycle under laboratory conditions a(n) (parent) engine representative of the engine type (engine family) and shall not imply or express any guarantee of the performance of a particular engine.

<b>Engine family name</b>	<b>DM03V</b>
NRSC CO <sub>2</sub>	805.5 g/kWh
NRTC CO <sub>2</sub>	908.4 g/kWh

# 1. General Introduction

---

## Engine Maintenance

### Prevention of Damage and Abrasion

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

---

### CAUTION

---

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

---

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 Hyundai Doosan 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.

---

### WARNING

---

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

---

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

---

### CAUTION

---

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

---

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.

---

### CAUTION

---

**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.**

---

---

### CAUTION

---

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

---

### 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 according to 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 new 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 protective cream after cleaning from oil.
6. Do not put oil-stained gloves or cloth in ones pocket.



---

## **WARNING**

---

**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.**

---

### **Biodiesel Blend Fuel**

Note) Biodiesel blend fuel may also be used in this machine.

Biodiesel blend fuel must contain no more than five percent biodiesel mixed with ultra low sulfur petroleum based diesel.

This biodiesel blend fuel is commonly marketed as B5/B7 (US/EU) blended diesel fuel. B5/B7 (US/EU) blended diesel fuel must meet ASTM D975 (US Standard) or EN590 (EU Standard) specifications.

Biodiesel blend fuel unique qualities that should be considered before using in engine.

- Cold weather conditions can lead to plugged fuel system components and hard starting.
- Biodiesel blend fuel is excellent medium for microbial growth and contamination that can cause corrosion and plugging of fuel system components.
- Use of biodiesel blend fuel may result in premature failure of fuel system components, such as: plugged fuel filters and deteriorated fuel lines.
- Shorter maintenance intervals may be required, such as: cleaning the fuel system and replacing fuel filters and fuel lines.
- Using biodiesel blended fuels containing more than five percent biodiesel can affect engine life and cause deterioration of hoses, tubelines, injectors, injection pump, and seals.

Apply the following guidelines if biodiesel blend fuel is used:

- Ensure the fuel tank is as full as possible at all times to prevent moisture from collecting in the fuel tank.
- Ensure that the fuel tank cap is securely tightened.
- Biodiesel blend fuel can damage painted surfaces, remove all spilled fuel from painted surfaces immediately.
- Drain all water from the fuel filter daily before operating the engine.
- Do not exceed engine oil change interval. Extended oil change interval can cause engine damage.
- Before vehicle storage: drain the fuel tank, refill with 100% petroleum diesel fuel, add fuel stabilizer, and operate the engine for at least 30 minutes.

Note) Biodiesel blend fuel does not have long term stability and should not be stored for more than 3 months.

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

### **GTL (Gas To Liquids)**

GTL is a synthetic fuel that is often refined from natural gas. To the user, GTL is reminiscent of diesel in accordance with EN590, apart from GTL having a somewhat lower density and less odour.

Hyundai Doosan Infracore approves the use of up to 100% GTL in accordance with the EU standard EN15940.

# 1. General Introduction

---

- Fuel requirements
  - The properties of diesel fuels can easily change by various factors, under different conditions used by customers. (Particles in atmosphere, moisture in air, temperature change, storage periods, local fuel quality, dirty storage condition, etc..)
  - Biodiesel (BD) is derived from natural oils, and can thus, deteriorate. The deteriorated BD contains acid, sticky substances (sludge), diesel fungi, and etc., which can increase in fuel.
  - These contaminated and deteriorated fuels can cause critical engine troubles, thereby leading to higher maintenance costs. (e.g. fuel filter early clogging, wear/damage of fuel injection equipment, injector inner deposit, piston melting due to injector clogging)
  - 0% BD fuels must be used for emergency generator after a long stand still. (Engine dose will not start due to fuel line and filter plugging, caused by deteriorated BD.)
  - Do not use BD after 3 months from the date of its manufacture.
  - Any problems or risks associated with the use of unsuitable fuels will not be covered by Hyundai Doosan Infracore warranty. (Such claims will not be covered by Hyundai Doosan Infracore warranty)
- Day fuel tank and fuel storage tank (for operation site) system requirements
  - An air breathing device (the pressure/vacuum relief valve or air vent port) should be installed at the clean side of the day fuel tank and the fuel storage tank.
    - (i) The end of the air inlet should be protected from dirt/mud/water intrusion.
    - (ii) A suitable air/moisture filter system should be included in the tank breathing system.
  - A day fuel tank and a fuel storage tank should be included in the water drain and the contamination cleaning port.
    - (i) Drain/clean the sludge, contamination, condensed water inside the fuel tank on a weekly basis.
    - (ii) Check the contamination status of the fuel tank and flush with clean diesel on a monthly basis.
  - The amount of condensed water, created due to the difference in temperatures, must be minimized inside the storage tank.
    - (i) The fuel tank should be positioned at least 30 cm above the ground.
  - Avoid the entry of air in the fuel tank by adequately designing and installing the tank (e.g. swirl pot).
  - The fuel storage tank (operation site) should have a dirt/water separation filter in the dispensing nozzle. (e.g. 10 micron rating filter)
  - Do not paint the inner surface of the fuel tank when biodiesel is used. (Biodiesel will strip the paint, which will plug the filter and fuel line)

# 2. Operation and Maintenance

<b>Starting and Stopping of the Engine .....</b>	<b>15</b>
Preparing for Start.....	15
Starting the Engine .....	15
After Starting the Engine .....	15
During Operation.....	15
Stopping the Engine.....	15
ECU Learning after Engine Key Off .....	15
<b>Break-in Period of the Engine .....</b>	<b>16</b>
General Information .....	16
Break-in Period of a New Engine.....	16
Check Points.....	16
Inspection after Starting the Engine.....	16
<b>Operation in Winter .....</b>	<b>17</b>
Cold Start.....	17
Preventing Coolant from Freezing. ....	17
Preventing Overcooling of the Engine .....	17
Engine Oil .....	17
<b>Inspection and Repair of the Engine .....</b>	<b>18</b>
Checking Engine Parts after Prolonged Operation .....	18
Inspection and Repair of Turbocharger .....	18
Intake Unit.....	18
Exhaust Unit.....	18
Lubrication System .....	18
<b>Injection Nozzle Maintenance .....</b>	<b>19</b>
Tips for Preventing Internal Clogging of the Injector!.....	19



### 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.

---

### CAUTION

---

**When replenishing engine oil, do not exceed the maximum on the oil level gauge. Too much oil may cause damage to the engine.**

**Refer to the engine specifications or the lubrication system.**

---

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 Hyundai Doosan Infracore. Otherwise, critical damage to the engine may occur.

#### Starting the Engine

Observe the following when starting the engine.

Make sure to check the oil and coolant levels before starting the engine.

When to start engine for the first time, it may not start correctly because of air in fuel system. In this case, please try cranking 2 ~ 3 more times. It leads bleed air in fuel line and the engine will be start well.

1. For a cold start, start the engine after preheating it sufficiently through the glow plug.

#### After Starting the Engine

1. Immediately after starting the engine, do not increase the rpm abruptly until the engine has warmed up sufficiently. Otherwise, it may increase the load upon the engine and burning may occur at the positions that have not been sufficiently lubricated yet. To prevent this, rotate the engine at idle after starting it to lubricate the turbocharger with oil.
2. Oil, air, or gas leaks may lower the oil pressure. Additionally, oil leaks may cause burning of bearings. As such, if oil, air, or gas leaks occur, check the leaking parts and solve the problem.

#### During Operation

1. Insufficient oil pressure may cause abnormal wear and burning of bearings and excessive oil pressure may cause leaks.
2. Continuing to operate the engine after noises or vibrations coming from the engine may lead to serious engine damage. As such, if noises or vibrations come from the engine, immediately decrease the rpm to a stop the engine.

#### Stopping the Engine

Do not suddenly stop the engine if operated under high loads for a long period. If oil burns because of heat sent from the high-temperature turbine blade to the bearing part, the bearing metal and rotating shaft may burn. As such, if the engine was operated under high loads for a long period, sufficiently rotate the engine at idle before stopping it.

#### ECU Learning after Engine Key Off

1. Metering unit on high pressure pump
  - Metering unit on the high pressure pump can make a 'buzzing sound' when key off during 20 ~ 30 seconds.
  - This is for fast pressure reduction of high pressure system by metering unit actuation.
2. Throttle valve
  - Throttle valve position sensor need to learn close position after key off during 20 ~ 30 seconds.
3. E-feed pump
  - E-feed pump with pressure sensor operates after key off during 15 ~ 20 seconds for diagnostic.
  - It doesn't work E-feed pump without pressure sensor.

## 2. Operation and Maintenance

---

### Break-in Period of the Engine

#### General Information

Hyundai Doosan Infracore engines are subjected to a final approval test to ensure the provision of high quality engines before being shipped to ensure the best quality possible. 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 normal operation condition, before starting operation of the engine.
2. Do not overload the engine or operate it at excessive 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.

Note) The amount of engine oil has a significant effect on engine performance, so check it every day check the engine oil in the following order.

1. After parking in a flat area, warm up the engine to normal operating temperature.
2. Turn off the engine, wait until the oil is stabilized (about 5 minutes), pull out the level gauge, wipe it off with a clean cloth, and insert the level gauge again.
3. Pull out the level gauge and check.

---

### 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 pull it out again to check.**

---

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 the 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.
- 

### 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 of warm oil. Use oil with the correct specifications for the engine.**

---

3. Check the level in the coolant tank and add more if necessary.  
Coolant is added as follows: Add coolant → Run the engine for one or two minutes → Add coolant if tank is lower than minimum level → Run the engine for one or two minutes → (Add more if necessary)
- 

### CAUTION

---

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

---

#### Inspection after Starting the Engine

The output torque may be limited if the engine oil pressure is abnormal. Check the P-CODE with a diagnostic tool or OBD. 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. 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

Periodically check for frozen coolant and viscosity of lubrication oil.

---

#### CAUTION

---

- **Check the battery is good condition. If battery condition is not good, please fully charge the battery before trying to start.**
  - **Operate starter motor upto 30 second while engine speed (rpm) is not over 300 rpm. If engine rpm is below 100 rpm up to 20 seconds, stop operating starter motor and try again from preheating.**
- 

Perform the cold start in the following order.

1. Turn the key switch to 'Preheat' and then the preheat lamp will operate for about 20 seconds.

Note) If the coolant is below 10°C, preheater will operate automatically.

2. When the preheat lamp switches off, turn the key switch to 'Start' to start the engine.

Note) Preheater heats about 180 seconds after starting the engine in order to quick reducing the exhaust white smoke.

#### 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 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 Overcooling 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 the 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 the oil with engine oil for cold weather or areas with cold climate. When replacing engine oil, Use only engine oil recommended by Hyundai Doosan Infracore.

## 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 the 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. We recommend the entire part be replaced or repaired in order to find out 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, these parts should be regularly checked and inspected.

1. Parts affecting intake and exhaust
  - Air filter
  - Air cooler
  - Turbocharger, silencer
  - EGR cooler and valve
  - Others
2. Parts affecting lubrication and cooling
  - Air filter
  - Oil filter
  - Antifreeze
  - Others

#### Inspection and Repair of Turbocharger

As performance of turbocharger significantly affects the engine performance, regular inspections and repairs should be performed and inspection and maintenance regulations should be observed.

#### Intake Unit

Be careful when handling the air filter in the intake unit. If oil level of the wet air filter is below the specified level, filtering performance is degraded. On the other hand, if the oil level is higher, oil may flow into the case, and it may become polluted. In regards to the dry air filter, intake resistance should be small to ensure the smooth intake of air.

#### Exhaust Unit

If exhaust emission is leaked from the part connecting the exhaust tube and the turbocharger, the turbocharger efficiency is lowered, causing degraded engine output and, if serious, burning of related parts. 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 replacement of the lubrication system should be performed according to the replacement schedule of oil and oil filter. Overheated engine oil can affect not only the engine itself, but also the engine performance.



### Injection Nozzle Maintenance

Clogging (lacquering or coking) of the valve and nozzle within the injector is a phenomenon where fuel is not injected normally due to an influx of prohibited chemical components into the fuel which accumulate on the valve or needle inside the injector.

Clogging of the valve/nozzle inside the injector can cause exhaust smoke, decreased power and failure to start the engine.

If you suspect that the valve/nozzle within the injector is clogged, we recommend adding the Hyundai Doosan Infracore fuel additive (500203-00127) immediately and proceeding with working under a load in order to effectively resolve the issue.

Using the fuel additive (500203-00127) in the following cases as well can prevent injector clogging so we recommend using the fuel additive regardless of the suitable intervals for usage.

- When reactivating machinery which has not been used for an extended period of time (over one month)
- When using fuel with a high content of biodiesel
- When the quality of the fuel in use is suspect

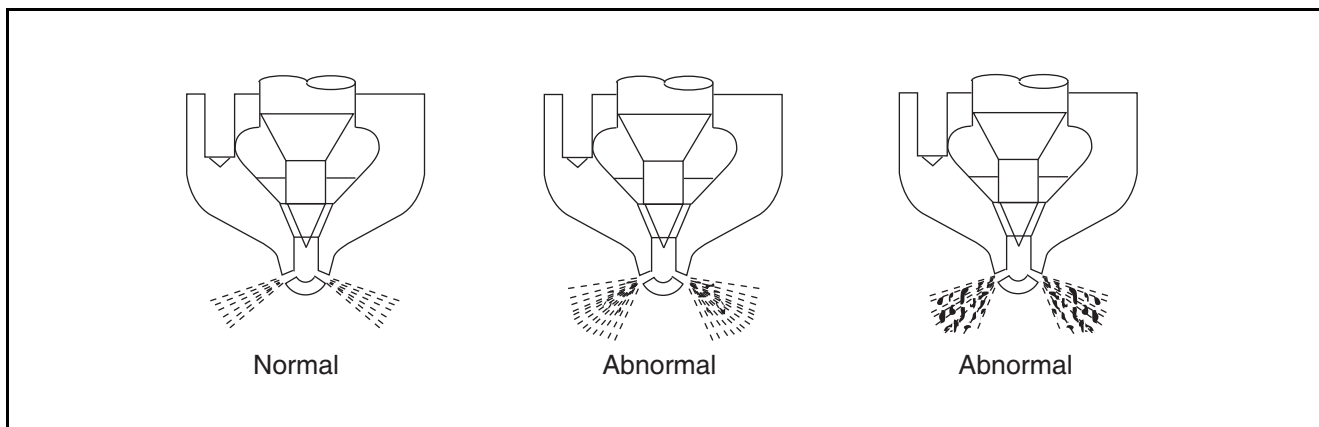
**The Hyundai Doosan Infracore fuel additive (500203-00127) is effective in eliminating and preventing the accumulation of such deposits.**

**The proper amount to use is 100 mL per 100 L of fuel, and it should be used every 500 hours.**

### Tips for Preventing Internal Clogging of the Injector!

- Only use B7 or lower biodiesel.  
The oxidation stability of biodiesel drops and may lead to a rapid change in the properties of the fuel. It also contains a large amount of acidic material so it may corrode metal in the engine.
- Avoid using fuel which has been stored for an extended period of time.  
Fuel which has been stored for an extended period of time begins to oxidize and may cause clogging in the injector.
- If the problem persists, change service stations.  
There is a strong correlation between the management of fuel at the service station and clogging within the injector.
- Add the Hyundai Doosan Infracore fuel additive (500203-00127) whenever replacing the fuel filter. Avoid using any fuel additives except the genuine Hyundai Doosan Infracore fuel additive.  
Using unverified additives may even cause problems in the injector.

For customers overseas, we recommend using commercially available equivalents of genuine Hyundai Doosan Infracore products.



EFM1006I

## 2. Operation and Maintenance

---

# 3. Performance and Specifications

<b>Engine Specifications and Performance .....</b>	<b>23</b>
Engine Specifications.....	23
Engine Performance Curve.....	28
<b>Outside Drawing of the Engine (Stage-V) .....</b>	<b>29</b>
Structural Diagram .....	29
Front View/Rear View .....	30
Left/Right Sectional View .....	31
Top/Bottom Sectional View .....	32
<b>Outside Drawing of the Engine (Tier-4 Final) .....</b>	<b>33</b>
Structural Diagram .....	33
Front View/Rear View .....	34
Left/Right Sectional View .....	35
Top/Bottom Sectional View .....	36
<b>Engine Serial Number .....</b>	<b>37</b>
Number Engraved on Engine.....	37
Number Engraved on Cylinder Block.....	37
Piston Bore Class Engraved on Cylinder Block .....	38
Main Bearing Bore Class Engraved on Cylinder Block .....	38
Crankshaft Main Journal Engraving .....	38
Connecting Rod Engraving .....	38
Piston Engraving .....	39
Cylinder Head Gasket Engraving.....	39



### 3. Performance and Specifications

#### Engine Specifications and Performance

#### Engine Specifications

Item	Specifications		Remarks
	DM03-MFP04	DM03-LEP04	
General information			
Engine type	4-stroke, inline, water-cooled, turbocharged and air-cooled		
Combustion chamber type	Direct injection		
Cylinder liner type	No liner		
Timing gear system	Gear driven type		
No. of piston rings	2 compression rings and one oil ring		
No. of cylinders	4		
Cylinder I.D.	98 mm		
Cylinder stroke	113 mm		
Total displacement	3,409 cc		
Compression ratio	18 : 1		
Engine dimensions (length x width x height)	838 mm x 657 mm x 825 mm		
Engine weight	383 kg		
Direction of rotation	Counter-clockwise		Direction of view: Flywheel
Ignition order	1 - 3 - 4 - 2		
Cooling system			
Cooling method	Radiator		
Coolant capacity	4.7 L		
Coolant pump	Type	Centrifugal	
	Drive type	Belt driven	
	Pump speed	2,880 rpm	
	Drive ratio	1 : 1.2	
	Supply	Over 160 LPM	Engine body
	Pump back pressure	0.8 bar	
Cooling fan	Driven type	Suction/Blower	
	Rotation ratio (Engine rpm : fan rpm)	1 : 1.3	

### 3. Performance and Specifications

Item		Specifications		Remarks
		DM03-MFP04	DM03-LEP04	
Thermostat	Type	Unit + Housing (Wax-Pellet)		
	Opening temp.	82 °C		
	Full opening temp.	97 °C		
	Lift	8 mm		
Coolant temp. sensor	Type	Thermo temp. sensor		
Coolant temp. sensor	Resistance (at 20 °C)	2.5 kΩ		
	Resistance (at 110 °C)	0.148 kΩ		
Surge tank cap	Pressure for opening high pressure valve	0.97 kg/cm <sup>2</sup>		
Lubrication system				
Lubrication method		Forced lubrication		
Oil pressure	No load (idle rpm)	above 1.4 bar		
	Max. load (rated RPM)	above 4.6 bar		
Oil specifications	Oil grade	SAE 10W30/40 (API CJ-4 CK-4/ACEA E6, E9)		
Oil capacity	Maximum	12.6 L		
	Minimum	6.0 L		
Allowable tilt angle (oil pan) (front/rear/left/right)		35°/35°/35°/35°		
Oil pump	Type	Gear type		
	Drive type	Gear type driven by crankshaft		
Oil cooler type		Stack plate cooler type		
Oil filter	Type	Spin-on filter		
	Allowable temperature	-40°C ~ 140°C		
	Flow rate	36 L/min		
Lubrication indicator		Oil pressure type		
Opening pressure of the oil spray nozzle adjustment valve		1.0 ~ 1.4 kg/cm <sup>2</sup>		
Hydraulic pressure indicator		Oil pressure type		
Fuel system				
Fuel injection pump type		Bosch common-rail pump		
Engine control type		E.C.U (BOSCH, EDC17C87)		
Delivery pump type		Gear type (with in CP4)		
Injection nozzle	Type	Multi hole type		
	Injection opening pressure (Operating pressure)	1,800 bar		

### 3. Performance and Specifications

Item	Specifications		Remarks
	DM03-MFP04	DM03-LEP04	
Fuel filter type	Spin-on type		
Intake/exhaust system			
Turbocharger	Model	BorgWarner WGT	
	Drive type	Exhaust pressure feed type	
	Lubrication method	Forced pressure feed type	
	Air pressure at turbocharger outlet	2.22 kgf·cm <sup>2</sup>	At max. output
	Intake air amount	133.6 g/s	At max. output
	Turbine speed	161 krpm	At max. output
	Allowable maximum speed	194 krpm	From the turbine inlet
	Allowable max. exhaust temperature	750 °C	
	Weight	4.3 kg	
Valve clearance	Intake valve	0.0 mm	Cold
	Exhaust valve	0.0 mm	Cold
Intake valve	Open (BTDC)	16°	
	Closed (ABDC)	54°	
Exhaust valve	Open (BBDC)	38°	
	Closed (ATDC)	24°	
Valve length	Intake	108.3 mm	
	Exhaust	110.3 mm	
Stem O.D.	Intake	6.97 ±0.007 mm	
	Exhaust	6.96 ±0.007 mm	
Valve guide I.D.	Intake	7 ~ 7.015 mm	
	Exhaust	7 ~ 7.015 mm	
Valve guide length	Intake	43.4 ~ 43.6 mm	
	Exhaust	43.4 ~ 43.6 mm	
Valve seat contact width	Intake	1.75 mm	
	Exhaust	1.62 mm	
Valve seat angle	Intake	29.5° ~ 30°	
	Exhaust	29.5° ~ 30°	
Valve spring free length	55.23 mm		
Valve spring squareness	Less than 2° (less than 1.8 mm)		

### 3. Performance and Specifications

Item		Specifications		Remarks
		DM03-MFP04	DM03-LEP04	
Cylinder block/head				
Cylinder head flatness	Gasket surface	0.05 mm 0.03 mm / 100 mm		
	Manifold mounting surface	0.05 mm / 100 mm		
Camshaft height	Intake	39.078 mm		
	Exhaust	38.716 mm		
Camshaft journal O.D.		44.919 ~ 44.935 mm		
Camshaft bearing oil clearance		0.065 ~ 0.106 mm		
Camshaft end play		0.1 ~ 0.2 mm		
Inside diameter of cylinder block piston bore		97.99 ~ 98.01 mm		
Flatness of cylinder block gasket surface		0.05 mm 0.03 mm / 100 mm		
Electrical system				
Engine control type		Electronically controlled type (ECU)		
Engine stopping mechanism		Shutoff of fuel supply by engine control unit (ECU)		
Other/driving system				
Piston O.D.		Class A : 97.920 ~ 97.930 mm Class B : 97.930 ~ 97.940 mm		
Cylinder and piston clearance		0.060 ~ 0.080 mm		
Piston ring groove area	Top ring groove	2.415 ~ 2.445 mm		
	Second ring groove	2.060 ~ 2.080 mm		
	Oil ring groove	3.020 ~ 3.040 mm		
Piston ring side gap	Top ring	0.083 ~ 0.133 mm		
	Second ring	0.070 ~ 0.110 mm		
	Oil ring	0.030 ~ 0.070 mm		
Piston ring end gap	Top ring	0.25 ~ 0.40 mm		
	Second ring	0.55 ~ 0.70 mm		
	Oil ring	0.2 ~ 0.4 mm		

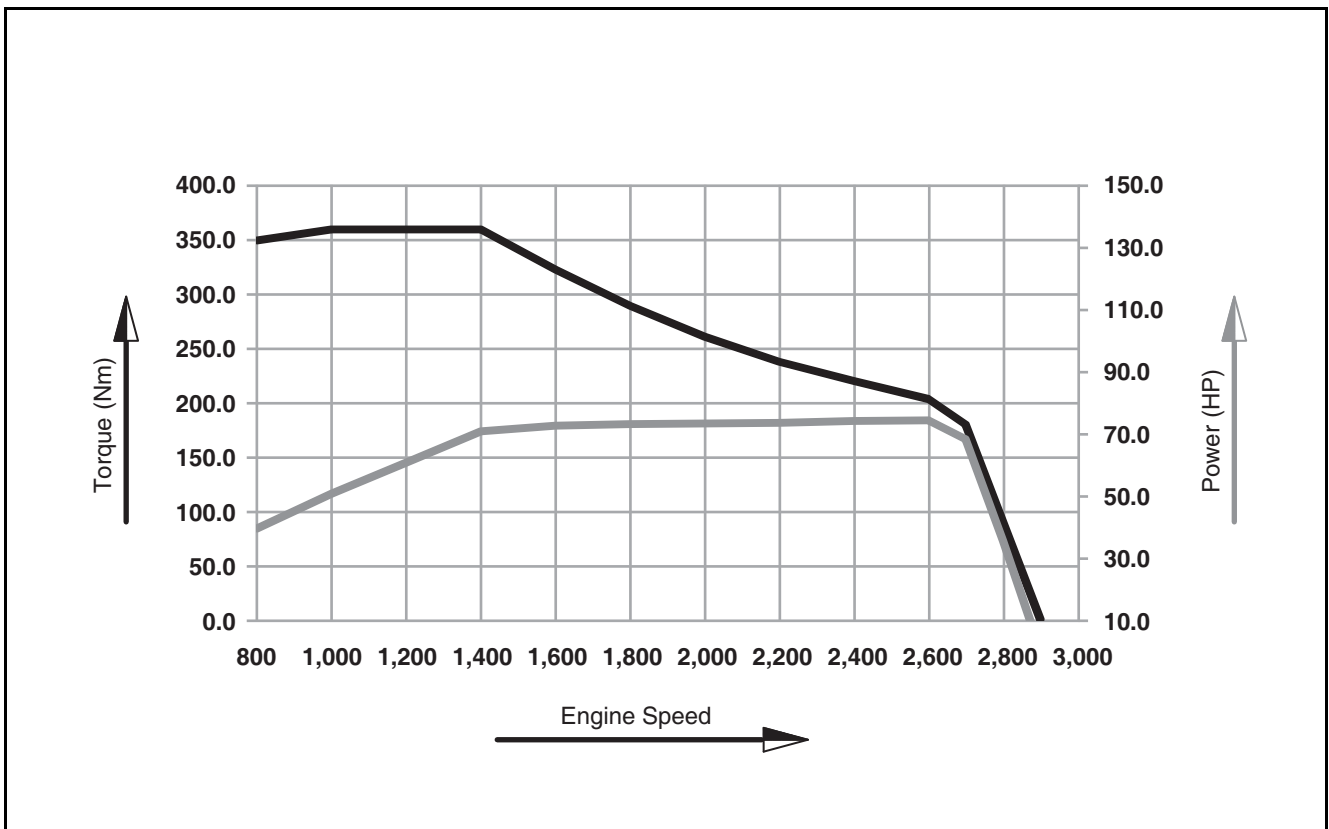


### 3. Performance and Specifications

Item	Specifications		Remarks
	DM03-MFP04	DM03-LEP04	
Piston pin O.D.	35.995 ~ 36.000 mm		
Piston pin hole I.D.	36.008 ~ 36.014 mm		
Piston pin hole clearance	0.008 ~ 0.019 mm		
Connecting rod small end I.D.	36.025 ~ 36.038 mm		
Connecting rod small end hole clearance	0.025 ~ 0.043 mm		
Connecting rod big end I.D.	66.000 ~ 66.015 mm		
Connecting rod bearing oil clearance	0.026 ~ 0.066 mm		
Connecting rod end play	0.15 ~ 0.3 mm		
Crankshaft main journal O.D.	74.955 ~ 74.970 mm		
Crankshaft pin journal O.D.	62.955 ~ 62.970 mm		
Crankshaft main bearing oil clearance	0.029 ~ 0.059 mm		
Crankshaft end play	0.1 ~ 0.31 mm		

### 3. Performance and Specifications

#### Engine Performance Curve



EDM03190265

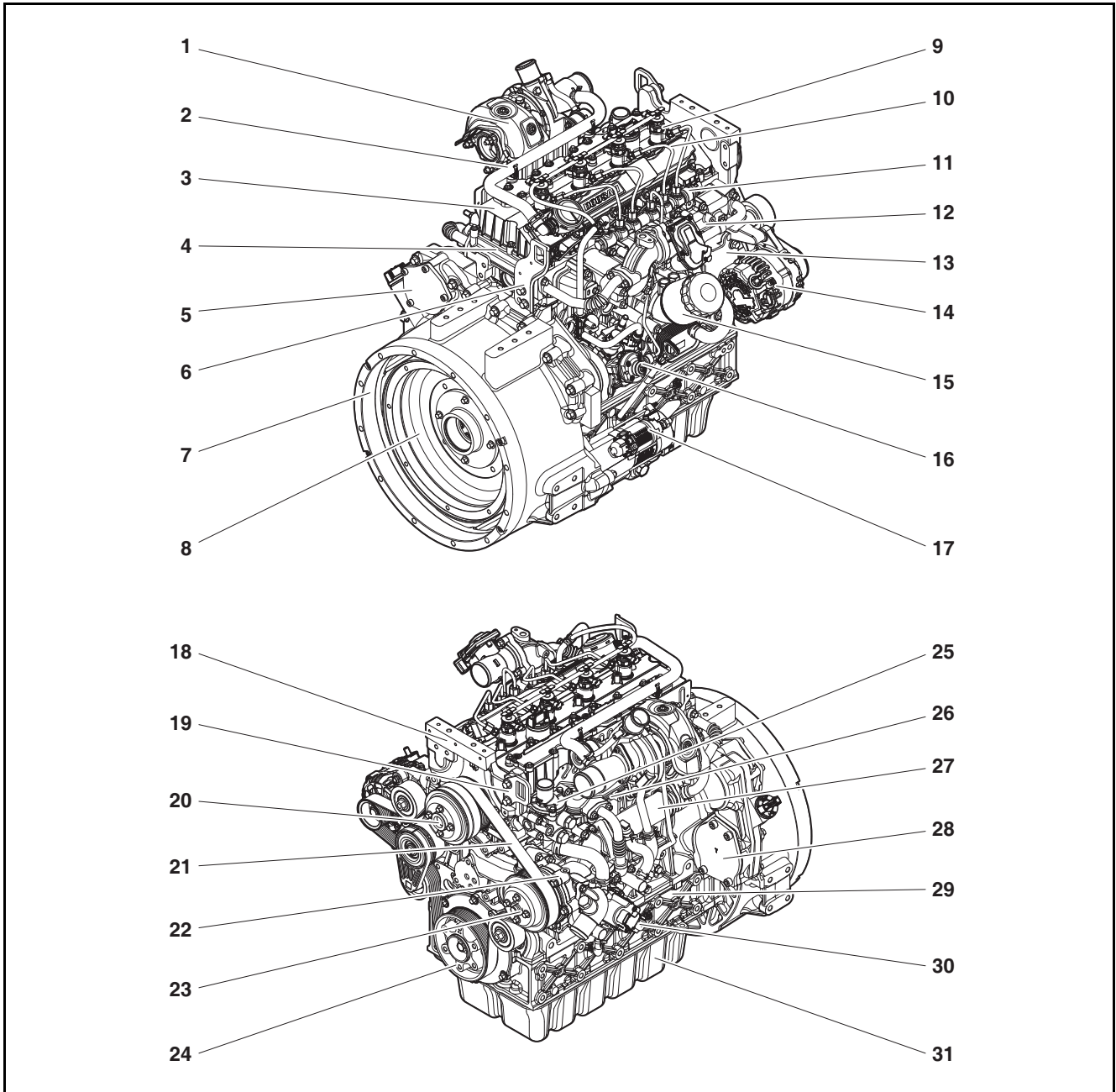
Test evaluation method	ISO8178
Engine output (rated)	55.4 kW (74.3 HP)
Torque (Max.)	360 Nm
Specific fuel consumption	228 g/kW.h

## 3. Performance and Specifications

### Outside Drawing of the Engine (Stage-V)

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

#### Structural Diagram

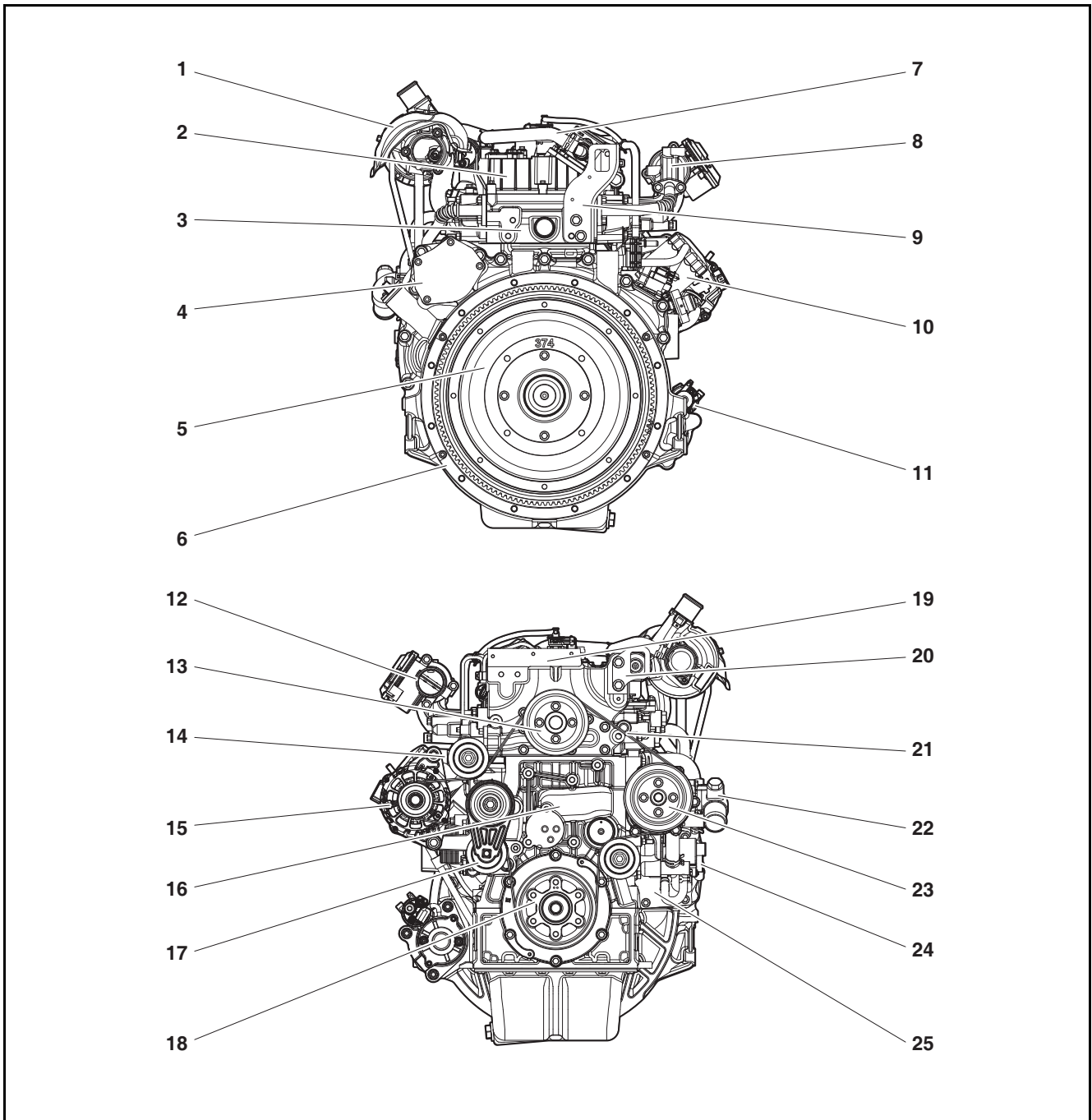


EDM03190196

- |                        |                         |                          |                      |
|------------------------|-------------------------|--------------------------|----------------------|
| 1. Turbocharger        | 9. Injector             | 17. Starter              | 25. Thermostat       |
| 2. Breather hose       | 10. Fuel injection pipe | 18. Fan mounting bracket | 26. Exhaust manifold |
| 3. Cylinder head cover | 11. Common rail         | 19. Rear lifting hook    | 27. EGR cooler       |
| 4. Cylinder head       | 12. Intake manifold     | 20. Fan pulley           | 28. Rear PTO cover   |
| 5. Front PTO cover     | 13. Alternator mounting | 21. V-belt               | 29. Cylinder block   |
| 6. Front lifting hook  | 14. Alternator          | 22. Coolant pump         | 30. EGR valve        |
| 7. Flywheel housing    | 15. Oil filter          | 23. Coolant pump pulley  | 31. Oil pan          |
| 8. Flywheel            | 16. Fuel injection pump | 24. Crankshaft pulley    |                      |

### 3. Performance and Specifications

#### Front View/Rear View

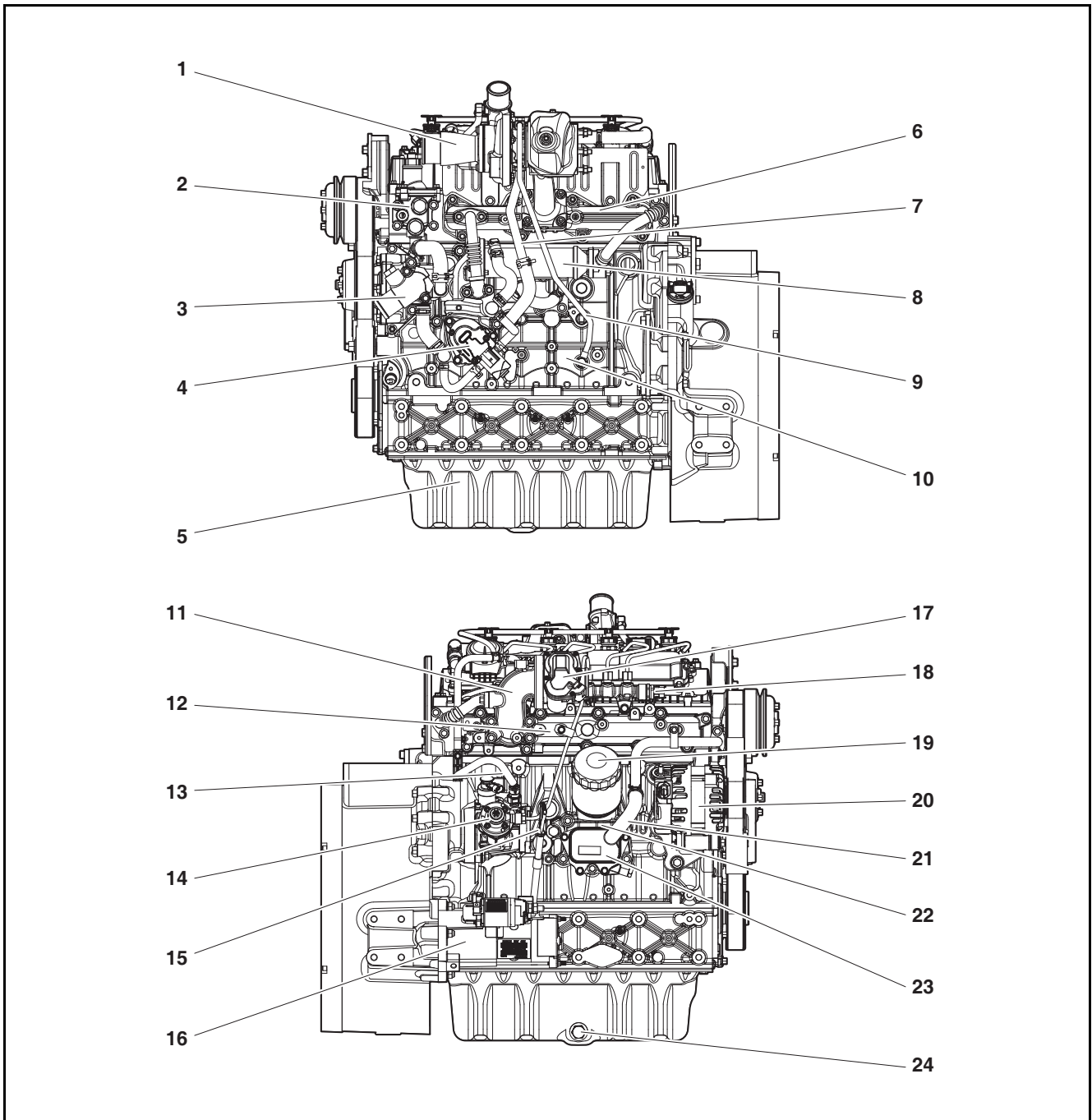


EDM03190197

- |                        |                          |                          |                         |
|------------------------|--------------------------|--------------------------|-------------------------|
| 1. Turbocharger        | 8. Intake stake          | 15. Alternator           | 22. Coolant pump        |
| 2. Cylinder head cover | 9. Front lifting hook    | 16. Cylinder block       | 23. Coolant pump pulley |
| 3. Cylinder head       | 10. Oil filter           | 17. Auto tensioner       | 24. EGR valve           |
| 4. Front PTO cover     | 11. Starter              | 18. Crankshaft pulley    | 25. Rear PTO cover      |
| 5. Flywheel            | 12. Throttle valve (ACV) |                          |                         |
| 6. Flywheel housing    | 13. Fan pulley           | 19. Fan mounting bracket |                         |
| 7. Breather hose       | 14. Alternator mounting  | 20. Rear lifting hook    |                         |
|                        |                          | 21. V-belt               |                         |

### 3. Performance and Specifications

#### Left/Right Sectional View

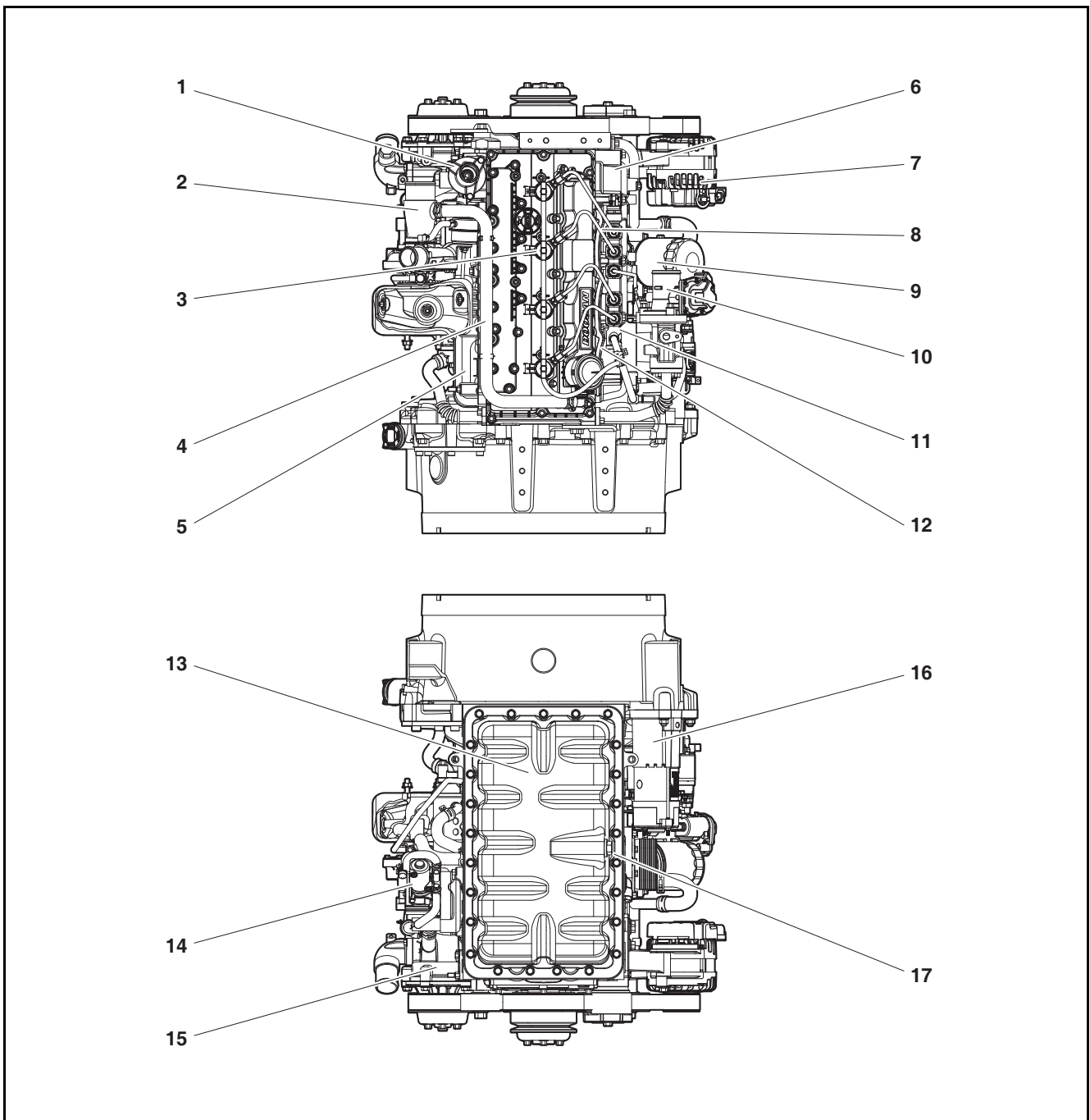


EDM03190198

- |                     |                                 |                          |                       |
|---------------------|---------------------------------|--------------------------|-----------------------|
| 1. Turbocharger     | 8. EGR cooler                   | 14. Fuel injection pump  | 21. Coolant hose      |
| 2. Thermostat       | 9. Oil supply pipe              | 15. Oil gauge            | 22. Oil filter module |
| 3. Coolant pump     | 10. Cylinder block              | 16. Starter              | 23. Oil cooler        |
| 4. EGR Valve        | 11. Intake stake                | 17. Throttle valve (ACV) | 24. Drain plug        |
| 5. Oil pan          | 12. Intake manifold             | 18. Common rail          |                       |
| 6. Exhaust manifold | 13. Fuel return hose            | 19. Oil filter           |                       |
| 7. Oil return pipe  | (Injector- fuel injection pump) | 20. Alternator           |                       |

### 3. Performance and Specifications

#### Top/Bottom Sectional View



EDM03190199

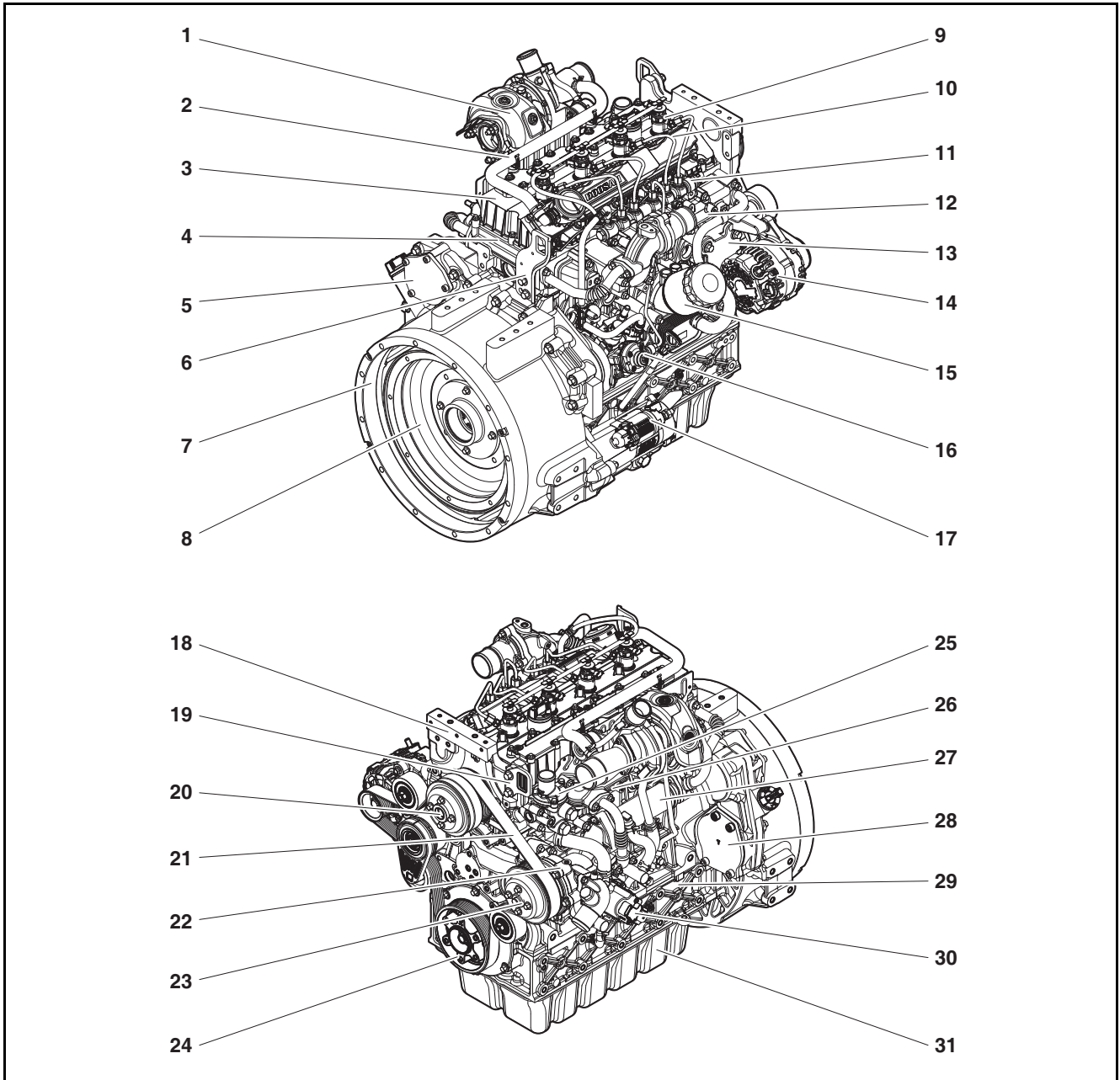
- |                     |                          |                  |
|---------------------|--------------------------|------------------|
| 1. Thermostat       | 7. Alternator            | 13. Oil pan      |
| 2. Turbocharger     | 8. Fuel injection pipe   | 14. EGR Valve    |
| 3. Injector         | 9. Oil filter            | 15. Coolant pump |
| 4. Breather hose    | 10. Throttle valve (ACV) | 16. Starter      |
| 5. Exhaust manifold | 11. Common rail          | 17. Drain plug   |
| 6. Intake manifold  | 12. Glow plug            |                  |

## 3. Performance and Specifications

### Outside Drawing of the Engine (Tier-4 Final)

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

#### Structural Diagram



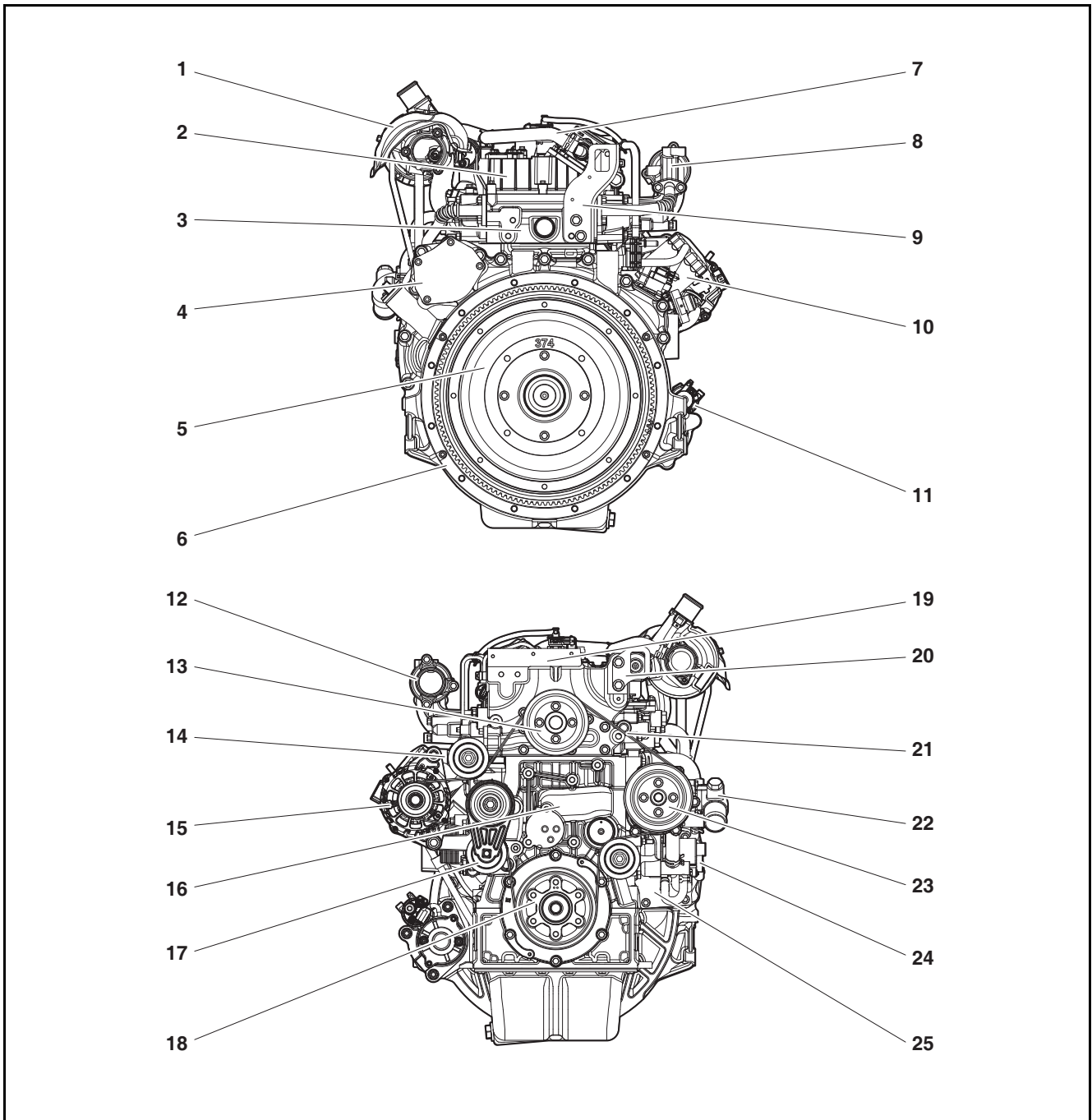
EDM03190201

- |                        |                         |                          |                      |
|------------------------|-------------------------|--------------------------|----------------------|
| 1. Turbocharger        | 9. Injector             | 17. Starter              | 25. Thermostat       |
| 2. Breather hose       | 10. Fuel injection pipe | 18. Fan mounting bracket | 26. Exhaust manifold |
| 3. Cylinder head cover | 11. Common rail         | 19. Rear lifting hook    | 27. EGR cooler       |
| 4. Cylinder head       | 12. Intake manifold     | 20. Fan pulley           | 28. Rear PTO cover   |
| 5. Front PTO cover     | 13. Alternator mounting | 21. V-belt               | 29. Cylinder block   |
| 6. Front lifting hook  | 14. Alternator          | 22. Coolant pump         | 30. EGR valve        |
| 7. Flywheel housing    | 15. Oil filter          | 23. Coolant pump pulley  | 31. Oil pan          |
| 8. Flywheel            | 16. Fuel injection pump | 24. Crankshaft pulley    |                      |



### 3. Performance and Specifications

#### Front View/Rear View



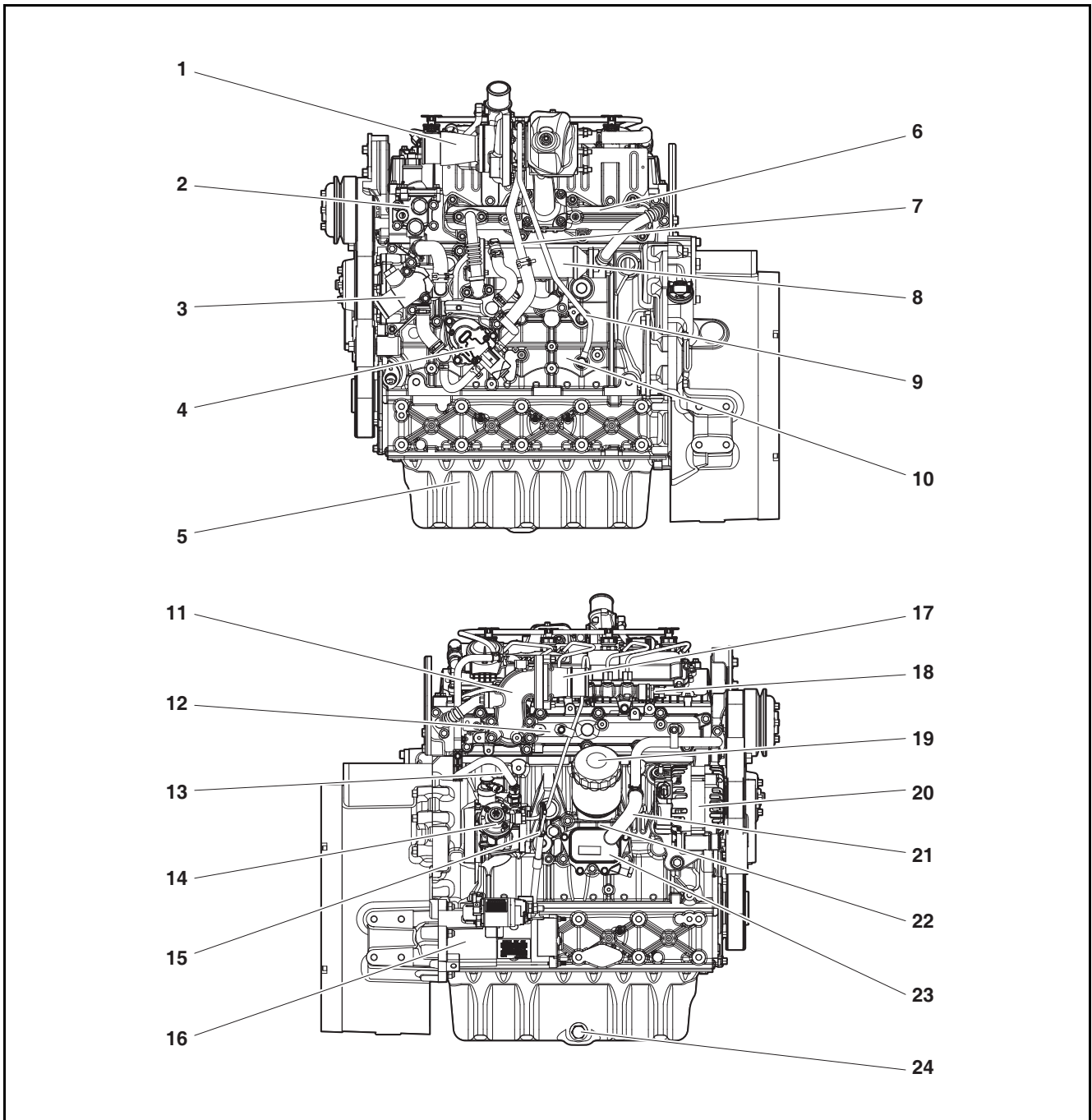
EDM03190202

- |                        |                         |                          |                         |
|------------------------|-------------------------|--------------------------|-------------------------|
| 1. Turbocharger        | 8. Intake stake         | 15. Alternator           | 22. Coolant pump        |
| 2. Cylinder head cover | 9. Front lifting hook   | 16. Cylinder block       | 23. Coolant pump pulley |
| 3. Cylinder head       | 10. Oil filter          | 17. Auto tensioner       | 24. EGR valve           |
| 4. Front PTO cover     | 11. Starter             | 18. Crankshaft pulley    | 25. Rear PTO cover      |
| 5. Flywheel            | 12. Inlet pipe          | 19. Fan mounting bracket |                         |
| 6. Flywheel housing    | 13. Fan pulley          | 20. Rear lifting hook    |                         |
| 7. Breather hose       | 14. Alternator mounting | 21. V-belt               |                         |



### 3. Performance and Specifications

#### Left/Right Sectional View

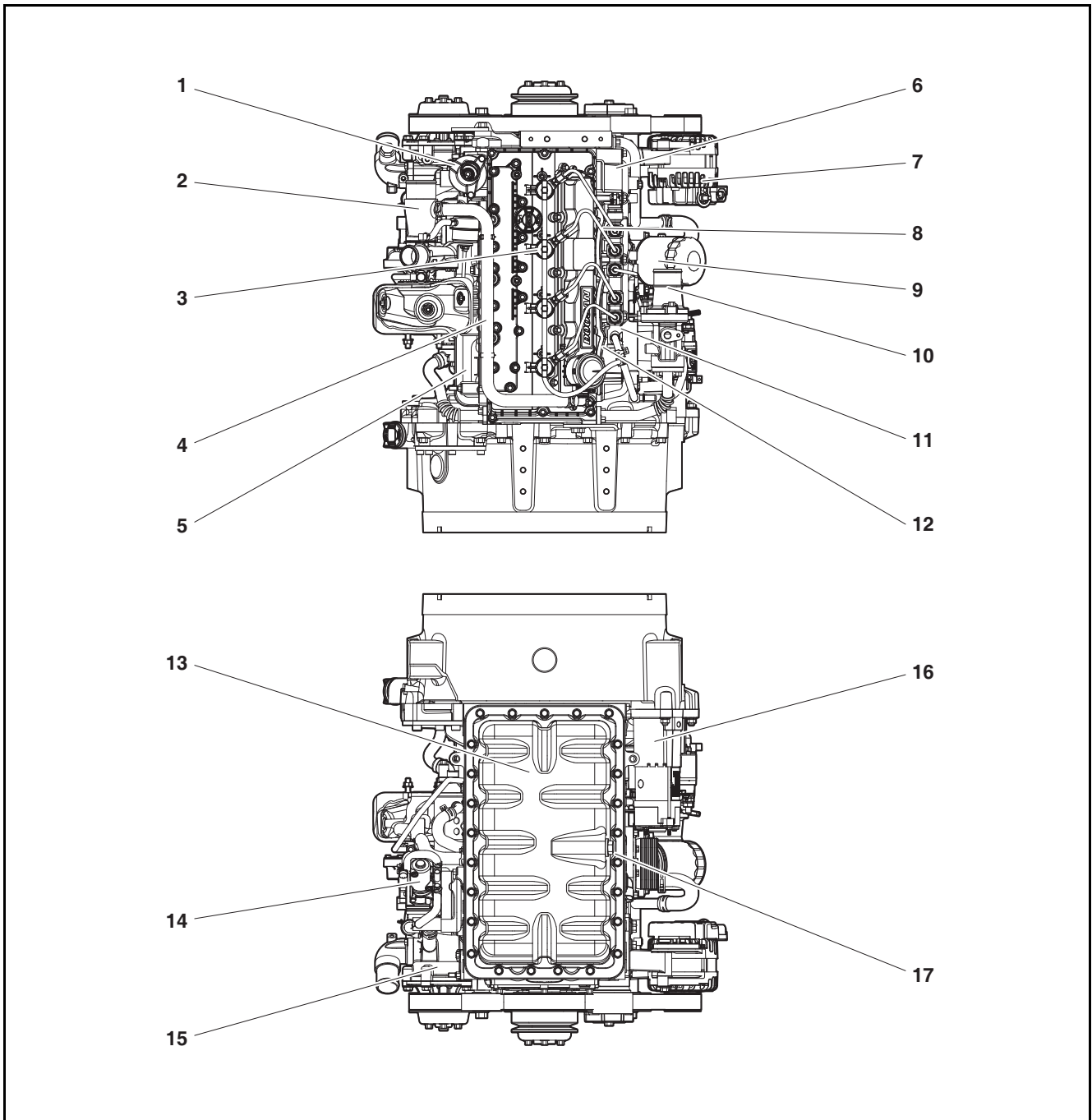


EDM03190203

- |                     |                                 |                         |                       |
|---------------------|---------------------------------|-------------------------|-----------------------|
| 1. Turbocharger     | 8. EGR cooler                   | 14. Fuel injection pump | 21. Coolant hose      |
| 2. Thermostat       | 9. Oil supply pipe              | 15. Oil gauge           | 22. Oil filter module |
| 3. Coolant pump     | 10. Cylinder block              | 16. Starter             | 23. Oil cooler        |
| 4. EGR valve        | 11. Intake stake                | 17. Inlet pipe          | 24. Drain plug        |
| 5. Oil pan          | 12. Intake manifold             | 18. Common rail         |                       |
| 6. Exhaust manifold | 13. Fuel return hose            | 19. Oil filter          |                       |
| 7. Oil return pipe  | (Injector- fuel injection pump) | 20. Alternator          |                       |

### 3. Performance and Specifications

#### Top/Bottom Sectional View



EDM03190204

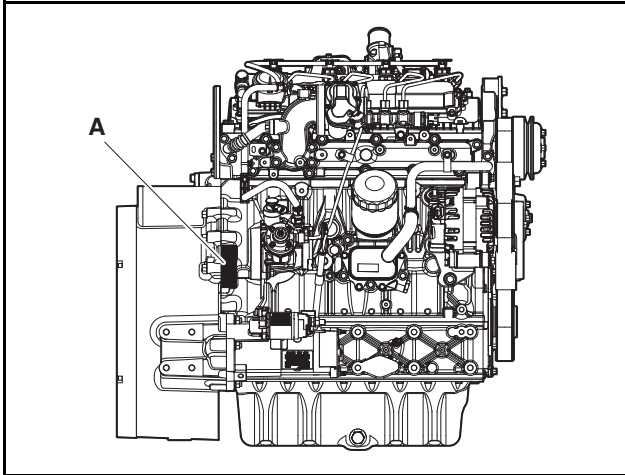
- |                     |                        |                  |
|---------------------|------------------------|------------------|
| 1. Thermostat       | 7. Alternator          | 13. Oil pan      |
| 2. Turbocharger     | 8. Fuel injection pipe | 14. EGR valve    |
| 3. Injector         | 9. Oil filter          | 15. Coolant pump |
| 4. Breather hose    | 10. Inlet pipe         | 16. Starter      |
| 5. Exhaust manifold | 11. Common rail        | 17. Drain plug   |
| 6. Intake manifold  | 12. Glow plug          |                  |

### 3. Performance and Specifications

#### Engine Serial Number

##### Number Engraved on Engine

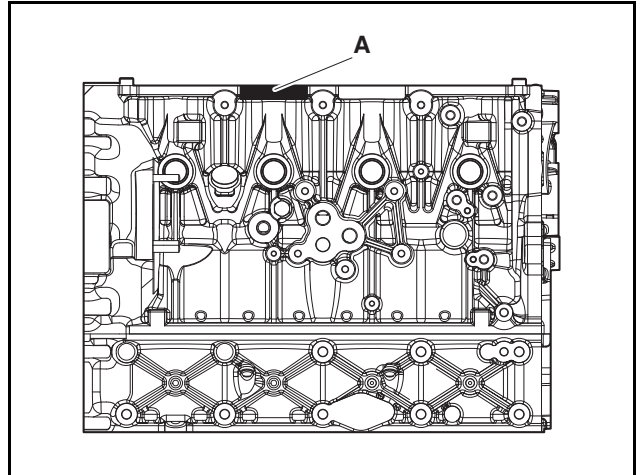
The engine code and production number are engraved in the position indicated in the picture (A). These numbers are required for warranty claims and part orders.



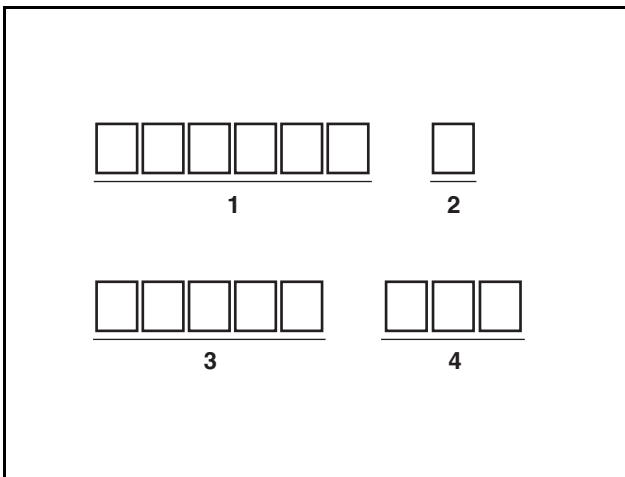
EDM03190225

##### Number Engraved on Cylinder Block

The cylinder block serial number is engraved in the position indicated in the picture (A).



EDM03190006



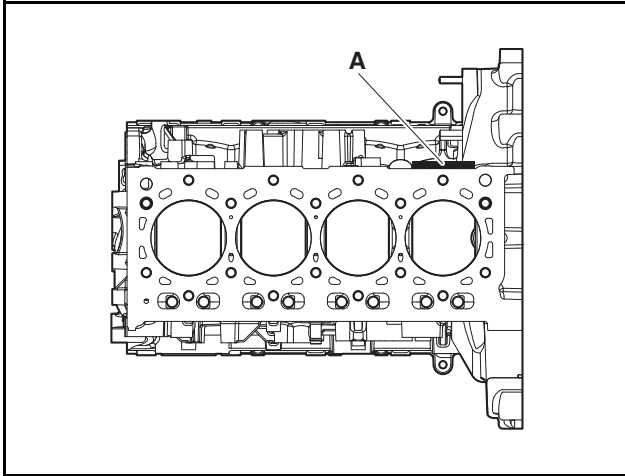
EDL022165B

- |                               |  |
|-------------------------------|--|
| 1. Product name<br>(6 digits) | 3. Number (5 digits)                           |
| 2. Year (1 digit)             | 4. After main new specifications<br>(3 digits) |

### 3. Performance and Specifications

#### Piston Bore Class Engraved on Cylinder Block

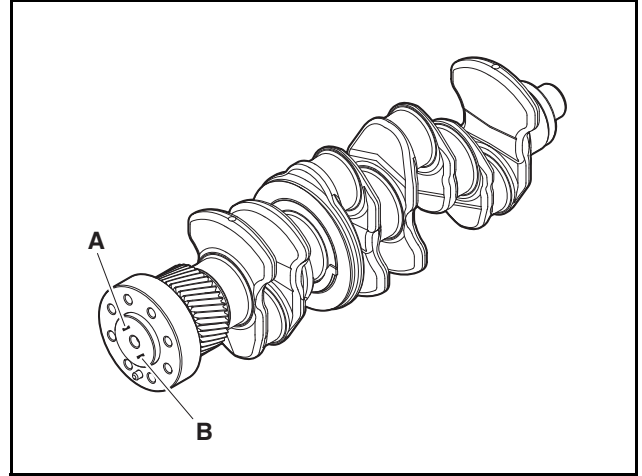
The cylinder block piston bore I.D. class is engraved in the position indicated in the picture (A). The cylinder block piston bore I.D. class is divided into class A and B. This class is required for ordering the correct pistons for the cylinder block piston bore I.D.



EDM03190007

#### Crankshaft Main Journal Engraving

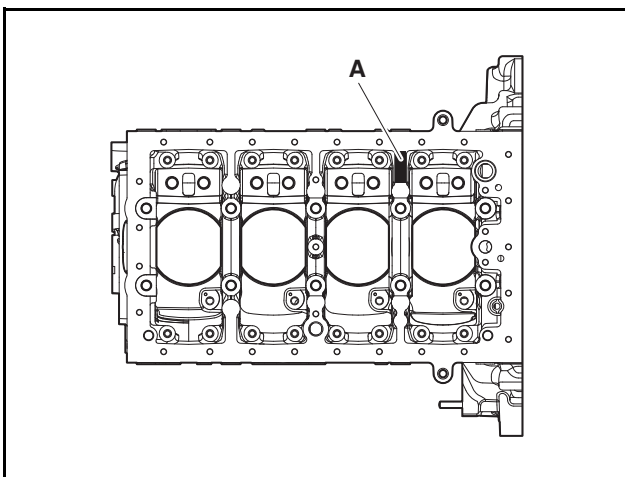
The crankshaft serial number is engraved in the position indicated in the picture (A), and the crankshaft main journal diameter class is engraved in the position indicated in the picture (B). The crankshaft main journal diameter classes are divided into classes A ~ C. This class is required for ordering the correct main bearings.



EDM03190009

#### Main Bearing Bore Class Engraved on Cylinder Block

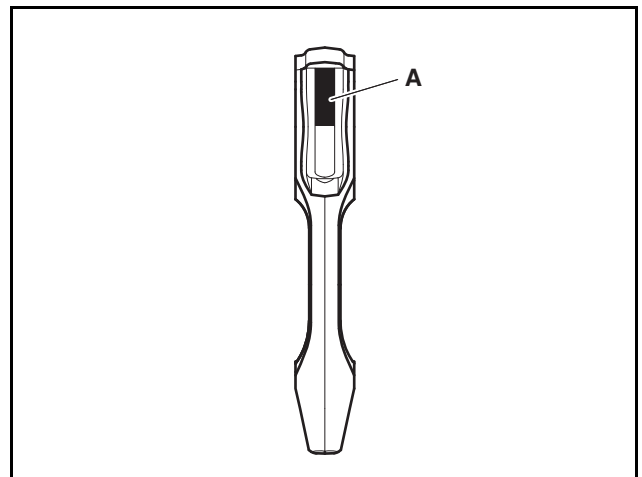
The cylinder block main bearing bore class is engraved in the position indicated in the picture (A). The cylinder block main bearing bore classes are divided into classes A ~ C. This class is required for ordering the correct main bearings for the cylinder block main bearing bore I.D.



EDM03190008

#### Connecting Rod Engraving

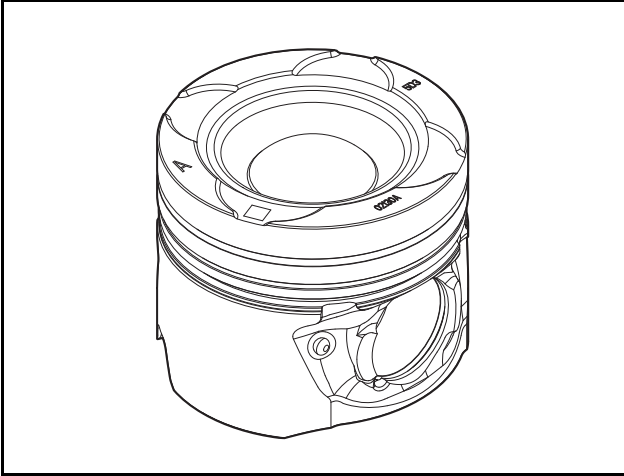
The weight of the connecting rod is engraved in the position indicated in the picture (A), and the weight of the connecting rod is divided into classes A ~ F. This class is required for ordering connecting rods.



EDL022217A

### Piston Engraving

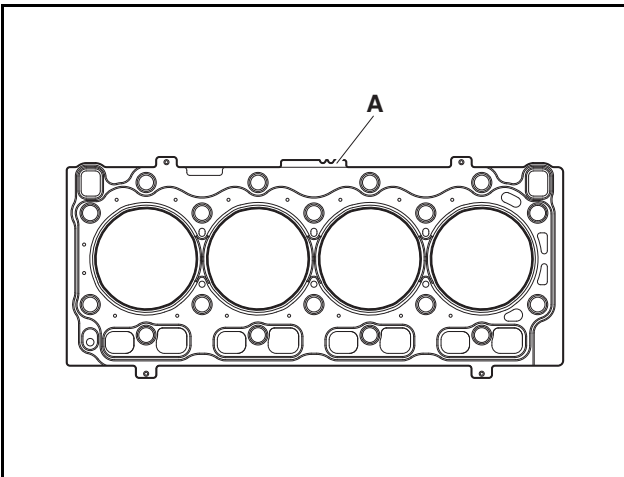
The piston class is engraved in the position indicated in the picture (A). The piston classes are divided into classes A and B. This class is required for checking the correct piston class.



EDM03190226

### Cylinder Head Gasket Engraving

The cylinder head gasket identification mark is engraved in the position indicated in the picture (A). One hole in the identification mark on the top side of the cylinder head gasket means class A; two holes mean class B; and three holes mean class C. These engravings are required for ordering the correct cylinder head gaskets.



EDM03190010

### 3. Performance and Specifications

---

# 4. Regular Inspections

<b>General Information .....</b>	<b>43</b>
General Information .....	43
Daily Inspections .....	43
<b>Regular Inspection Table .....</b>	<b>44</b>
General Conditions .....	44
<b>Cooling System .....</b>	<b>46</b>
General Information .....	46
Amount of Antifreeze in Winter .....	46
Coolant Capacity .....	46
Checking the Coolant .....	46
Measuring the Coolant Concentration .....	47
Adding Coolant .....	48
Replacing Coolant .....	48
<b>Lubrication System .....</b>	<b>50</b>
General Information .....	50
Engine Oil Specifications .....	51
Engine Oil Capacity .....	52
Checking the Engine Oil .....	52
Adding Engine Oil .....	53
Replacing Engine Oil .....	53
<b>Fuel System .....</b>	<b>55</b>
General Information .....	55
Fuel Specifications .....	55
Injector & Fuel Return Hose .....	55
Fuel Filter .....	55
Replacing the Fuel Filter .....	56
Bleeding Air From the Fuel Delivery Line .....	57
Draining Water From the Fuel Filter .....	58
<b>Intake/Exhaust System .....</b>	<b>60</b>
General Information .....	60
Cleaning the Air Filter .....	60
Cleaning the Air Filter Element .....	60
Replacing the Air Filter Element .....	61

<b>Other/Driving System .....</b>	<b>62</b>
Belt Tension.....	62



### General Information

#### General Information

As time passes after purchasing the engine, the various components of the engine deteriorate and the initial engine performance cannot be maintained.

By performing regular inspections and replacements according to the inspection interval chart recommended by Hyundai Doosan Infracore, you can maintain long-term optimal engine performance and prevent unanticipated accidents in advance.

Operating and maintaining the engine in the correct way is the responsibility of the user. Inspections and replacements should be performed by professionally certified maintenance technicians in workshops furnished with the designated tools and equipment. Make sure to do the following when performing inspections.

1. Perform inspections on level ground without any slope.
2. Be sure to perform inspections with the engine stopped unless it is otherwise unavoidable.
3. Disconnect the negative battery terminal before performing inspections.
4. Perform inspections in a well-ventilated place.
5. When working with the engine loaded, be sure to chock the wheels or use a lifter.

---

### DANGER

- **When performing inspections after running the engine, wait until the engine has cooled off sufficiently before inspecting it. Otherwise, you may be burned.**
  - **Starting the engine in an enclosed space may cause poisoning due to exhaust gas. Perform inspections in a well-ventilated place.**
  - **Do not inspect the engine while it is loaded except in cases where doing so is unavoidable.**
  - **Stay away from open flames during engine inspections. Evaporation gas from fuel, oil or batteries may cause a fire.**
  - **When unavoidably working on the engine while it is running, do not wear accessories such as necklaces, rings, watches or gloves. Severe injuries can be caused if these get caught in rotating parts.**
  - **People with an artificial heart or artificial organs should not approach the engine while it is running. Malfunctions can be caused by the high-pressure current of the injectors or engine control devices.**
- 

---

### CAUTION

---

- **Performing inspections incorrectly can cause faults in the engine.**
  - **Washing the engine with liquids such as water or wax can cause electrical parts to malfunction.**
  - **There is a current flowing through batteries, cables and electrical wiring so be careful.**
  - **Do not put heavy objects or apply excessive force or impact to fuel-related components.**
  - **When connecting the battery terminals, check that the positive and negative terminals are correct before connecting them. Connecting the positive and negative terminals backwards may damage electrical components and cause a fire.**
- 

#### Daily Inspections

Daily inspections refer to inspections performed every day by the operator using the engine before running it. These must be performed to protect not only the engine but also the safety of the operator.

The following inspection items are the minimum daily inspection items which must be performed.

1. Check whether the engine starts smoothly and whether the fuel, oil and coolant are at normal levels.
2. Check the color of the exhaust gas and whether fumes containing toxic components are being discharged.
3. Check whether there are any abnormal noises after starting the engine.
4. Check for any oil or water leaks.

## 4. Regular Inspections

### 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)

Check Points	Daily	Inspection interval (x 1,000 hours)										Remarks
		0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	
<b>Coolant system</b>												
State of connection between cooler and coolant hose	○											
Capacity and state of coolant Note 1) Note 2)	○	General genuine coolant: replace every 1,200 hours										
		Genuine Hyundai Doosan Infracore LLC coolant: replace every 6,000 hours <sup>Note 3)</sup>										
Cooling fan belt tension	○	Inspect every 1,000 hrs (or 6 months) and replace if required Replace every 3,000 hrs (or 3 years)										
<b>Lubrication system</b>												
Lubricating device and oil leakage	○											
Capacity and condition of engine oil	○											
Engine oil filter			●		●		●		●		●	
Engine oil	○*	500 hr interval or 1 year (Option: 1,000 hr**)										
<b>Fuel system</b>												
Fuel line and connection unit	○											
Fuel filter			●		●		●		●		●	
Fuel volume	○											
Water draining from water separator	○											
Fuel injection time		Inspect and adjust if required										
Injector		Inspect and adjust if required										
Compression pressure <sup>Note 4)</sup>		Inspect and adjust if required										
<b>Intake/Exhaust system</b>												
Air cleaner	○	Clean and replace if required										
Throttle body cleaning		Clean and replace if required										
Intake line and connection unit		Clean and replace if required										
Exhaust line and connection unit		Clean and replace if required										
Emission state												

## 4. Regular Inspections

<b>Cylinder head</b>												
Head cover injectors oil seal		Inspect and replace if required (Replace when replacing injectors)										
<b>Electric system</b>												
Battery charging state	○											
Various electric units	○											

Note 1) Replenish coolant if required.

Note 2) Check coolant every 500 hours to maintain the concentration of antifreeze and additives.

Note 3) Part number for 200 L drum: 500201-00011, part number for 3 L pail: 500201-00012

Note 4) Compression Pressure Range: 28 ~ 33 bar

Compression Pressure Lowest limit: 20 bar

(Sea level/Cranking speed 180 ~ 200 rpm/Battery SOC Over 80%)

However, The result can be varied by the condition of measurement.

In addition, the measurement is lower than the figures above.

Even though the measurement is lower than the guided figures, and when the differences among cylinders are lower than 10%, the compression pressures are regarded as Normal.

When other cases than the Hyundai Doosan Infracore guide above are encountered, please contact the service manager in regional Hyundai Doosan Infracore office and Hyundai Doosan Infracore HQ service.

\* If an OLS is not installed, check the oil level gauge and add oil when the oil level gauge indicates the minimum level.

If an OLS is installed, even in the event of a low level warning, stop the machine on flat, even ground, perform a cross-check with the oil dipstick gauge, and add oil as necessary.

\*\* Service interval varies depending on engine oil, diesel fuel quality and operation conditions.

Determine service intervals by analyzing the engine oil properties under working conditions after analyzing the result of the test. 1,000 hr interval is only for the customer who get the confirmation from DI for the machine usage profile.

## 4. Regular Inspections

### Cooling System

#### General Information

Coolant plays an important role in preventing overheating and freezing of the engine. However, as the engine is used over time, the anticorrosive and anti-rust performance of the coolant diminishes. The state of the coolant must be maintained through daily inspections and replaced regularly.

Genuine Hyundai Doosan Infracore LLC may be used continuously for up to 3 years or 6,000 hours.

We recommend using genuine Hyundai Doosan Infracore LLC. When genuine Hyundai Doosan Infracore LLC coolant is used, there is no need to add an anti-corrosive.

	DI general genuine coolant	DI general genuine LLC coolant
Replacement interval	1,200 hours or 1 year	6,000 hours or 3 years

Note) Genuine Hyundai Doosan Infracore LLC (part number for 200 L drum: 500201-00011, part number for 3 L pail: 500201-00012)

The mixture ratio for engine coolant should be 45 ~ 50% antifreeze included (Note: If anti-corrosive agent is not contained, the DCA should be added 3 ~ 5%) and 3 to 5% of an additive (DCA4) for preventing corrosion. For the water in the coolant, use clean tap water. The coolant must be inspected regularly in order to maintain the concentration of antifreeze and additives.

#### CAUTION

**By maintaining the coolant at the mixture ratio recommended by Hyundai Doosan Infracore, you can effectively prevent corrosion in the engine and maintain long-term optimal engine performance. Using contaminated water or an unspecified antifreeze or additive can cause serious faults in the cooling system.**

#### Amount of Antifreeze in Winter

- Coolant freezing point according to anti-freezing ratio

Coolant (%)	Antifreeze (%)	Freezing point (°C)
85	15	Above -10
80	20	-10
73	27	-15
67	33	-20
60	40	-25
56	44	-30
50	50	-35

#### Coolant Capacity

Engine model and product code	Coolant capacity ( ℓ )
DM03-MFP04/LEP04	4.7

#### Checking the Coolant

### DANGER

**If the surge tank cap is opened to replace or replenish coolant while the engine is overheated, hot coolant will spurt and may cause serious burns. If the surge tank cap must unavoidably be opened, wrap the surge tank cap in a cloth and open it slowly in two stages to release the steam pressure inside. Remove the surge tank cap after all of the steam pressure inside has been released.**

1. Check the position of the surge tank.
2. Check whether the engine and radiator are cool.
3. If the coolant is between the upper and lower limits indicated on the surge tank, this means that the coolant level is normal.
4. If the coolant level is low, add coolant.
5. Open the surge tank cap and check the condition of the coolant. Measure the concentration of the coolant if the coolant is contaminated or if necessary. If the concentration of the coolant exceeds the specified concentration range, replace the coolant.

## 4. Regular Inspections

### Measuring the Coolant Concentration

You can measure the coolant concentration with the following method.

1. When the engine coolant temperature is between 10 ~ 55 °C, drain the coolant and fill half of a plastic cup with it.

### **CAUTION**

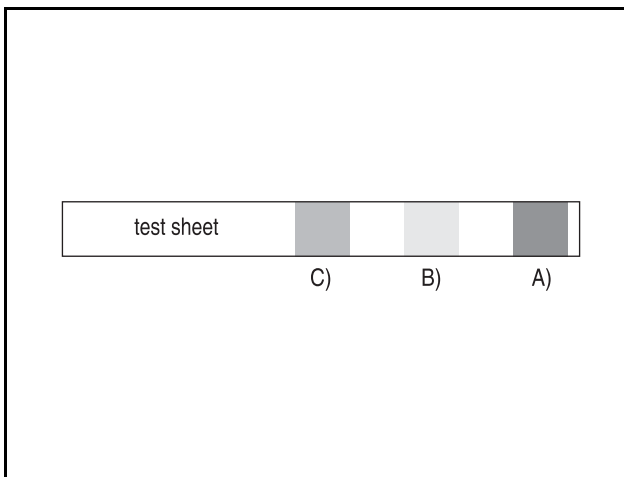
When obtaining coolant for testing, it is difficult to measure the precise concentration if the coolant is obtained from the reservoir tank. Make sure to use coolant collected for the test by removing the coolant drain plug.

2. Soak the test strip in the collected coolant for 3 ~ 5 seconds and remove the strip from the coolant. Then, shake off excess coolant from it.
3. Wait around 45 seconds until the color of the test strip changes.

### **CAUTION**

During the measurement, do not wait for longer than 75 seconds. The color of the strip may change drastically after a long period of time.

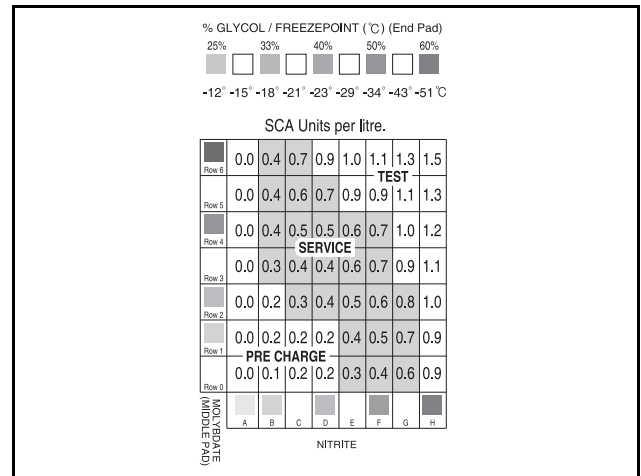
4. Check the color of the test trip.



EDL022153A

- 1) Compare the color of part (A) of the test trip with the color of the GLYCOL/FREEZEPOINT (end of the strip) part of the standard color table.
- 2) Compare the color of part (B) of the test trip with the color of the MOLYBDATE (middle of the strip) part of the standard color table.
- 3) Compare the color of part (C) of the test trip with the color of the NITRITE part of the standard color stable.

5. Compare and check the parts where the color of the test strip matches the color on the standard color table.



EDL022154A

- 1) Check the concentration by comparing the changed color on the pink (A) part at the end of the test trip with GLYCOL/FREEZEPOINT (end of the strip) on the standard color table at the top of the storage container. The concentration should be between 33% and 50% of the color range.
- 2) The point where the color of MOLYBDATE (middle of the strip) on the standard color table corresponding to the middle (B) part of the test strip and the color of NITRITE on the standard color table corresponding to part (C) of the test strip intersect indicates the state of the additive for anti-corrosion. It should be kept within the green range of 0.3 ~ 0.8, the normal range.
- 3) If the result is below 0.3, add more anti-corrosive (DCA4). If the result is over 0.8, drain some coolant and add some tap water to adjust the concentration.
- 4) Use distilled water or tap water. Natural water such as river water or underground water (hard water) contains a significant amount of minerals which form deposits in the cooling system and degrade the cooling performance, so make sure to use tap water which satisfies the following standards.

< Standards for usable tap water >

Standard					
Item	Inorganic chloride	Sulphate	Hardness	Solids	Acidity
Amount	< 40 ppm	< 50 ppm	< 9.5 °d.H	< 340 ppm	5.5 ~ 9.0

PPM (Parts Per Million) - Unit of concentration for small amounts of matter.

- 1 ppm = 1 mg/1 kg, 1 mL/1 L

## 4. Regular Inspections

°d.H - Unit of concentration for small amounts of matter.

- 1°d.H = 17 ppm

### CAUTION

- The tap water standards are intended for reference only. Do not use them as absolute standards.
- If the water quality is suspect, avoid using tap water and use distilled water instead, if possible.

### CAUTION

- If there is no matching color when you compare the color of the test strip with the standard color table, look for a color between the colors shown on the standard color table. For example, if the color of part (C) of the test strip is D and F in the NITRITE section of the standard color table, select position E.
- It is necessary to drain coolant and add new coolant every year in order to prevent internal corrosion of the engine cooling system.

### Adding Coolant

If the coolant is below the lower limit indicated on the surge tank, add coolant as follows.

1. Remove the surge tank cap.
2. Add coolant until the coolant level is between the upper and lower limits on the surge tank.
3. Mount the surge tank cap.

### CAUTION

**When adding coolant, be careful not to allow any foreign matter to enter the engine.**

In the event that there is no coolant in the surge tank, add coolant as follows.

1. Remove the surge tank cap while the engine and radiator are cold.
2. Add coolant up to the upper limit on the surge tank.
3. Start the engine, then circulate the coolant sufficiently and check the coolant level. If there is not enough coolant, add more.
4. Add coolant until the coolant level is between the upper and lower limits on the surge tank.

5. Mount the surge tank cap.

### CAUTION

- Do not open the surge tank cap while the engine is overheated. If the surge tank cap is opened, hot coolant will spurt and may cause burns. Open the surge tank cap after ensuring that the engine has cooled down sufficiently.
- Label and store containers for coolant separately to avoid confusing them with containers for drinks. If you happen to drink coolant, consult a doctor immediately.

### Replacing Coolant

- General genuine coolant: 1 year or 1,200 hours
- Genuine Hyundai Doosan Infracore LCC coolant: 3 years or 6,000 hours

Note) In the event that separate specifications from the client are applied, use coolant which satisfies the standards below.

Specification	Specification number
ASTM	D3306, D6210
JIS	K2234
SAE	J1034

### DANGER

- Do not open the surge tank cap while the engine is overheated. If the surge tank cap is opened, hot coolant will spurt and may cause burns. Open the surge tank cap after ensuring that the engine has cooled down sufficiently.
- Label and store containers for coolant separately to avoid confusing them with containers for drinks. If you happen to drink coolant, consult a doctor immediately.

### CAUTION

**When replacing coolant, be careful not to spill any coolant on belts and electrical devices.**

1. Check whether the engine and radiator are cool.
2. Place a container in front of the coolant drain plug.
3. Remove the surge tank cap.
4. Remove the coolant drain plug on the radiator and then drain the coolant.

## 4. Regular Inspections

---

5. After draining the coolant is complete, reinstall the coolant drain plug.
6. Drain the coolant and clean the surge tank.
7. Fill the surge tank inlet with water and mount the surge tank cap.

Note: Pour the coolant slowly to allow the air inside the radiator to be discharged, then press the hose connected to the radiator to discharge the air easily.

8. Run the engine until the cooling fan has run 2 to 3 times, then once it is warmed up, rev the engine up two to three times.
9. Stop the engine and wait until it is cool.
10. Remove the radiator drain plug and drain the water.
11. Repeat this one to eight times until the water drained is clean.
12. Press the hose connected to the radiator to allow the air inside the radiator to be discharged easily, then slowly pour the coolant with the specified mixture ratio into the surge tank inlet.

Note: Use the genuine antifreeze recommended by Hyundai Doosan Infracore.

---

### CAUTION

---

- **Do not use a mix of antifreezes from different manufacturers.**
  - **Do not use a mix of coolants with different concentrations.**
  - **Do not add anticorrosives which have not been recommended by Hyundai Doosan Infracore.**
  - **If the coolant concentration is low, there is a risk of corrosion or freezing. If it is too high, it may degrade the cooling effect. Use a mixture of 40% antifreeze in the coolant.**
- 

13. After starting the engine, idle the engine. When the cooling fan is running and coolant is circulated, remove the surge tank cap and add coolant through the inlet.
14. Add coolant until the cooling fan has run 3 to 5 times.
15. Add coolant up to the upper limit on the surge tank, then mount the surge tank cap.
16. Idle the engine until the cooling fan has run 2 to 3 times.
17. Stop the engine and wait until the engine and radiator cool down.
18. Check the coolant level in the surge tank, then add coolant repeatedly until the level in the surge tank remains between the upper and lower limits without fluctuating.

Note: Check the coolant level in the surge tank for at least 2 to 3 days after replacing the coolant.

---

### CAUTION

---

**Check the coolant level in the surge tank for at least 2 to 3 days after replacing the coolant.**

---

### WARNING

---

**Follow the regulations of the public institutions in your area when disposing of used coolant. Dumping coolant on the ground, in sewers, drains, rivers and seas, etc. can cause severe environmental contamination. Disposing of coolant incorrectly without complying with treatment regulations can be punished as a violation of treatment regulations.**

---

## 4. Regular Inspections

---

### Lubrication System

#### General Information

Engine oil lubricates, cools, seals, prevents corrosion, and cleans engines, enhancing engine performance and extending the engine life. If the vehicle is continuously driven without sufficient engine oil, the moving parts of the engine may get stuck, causing engine faults.

Check the amount of oil with the oil level gauge and add more oil if low. Check the oil level with the engine stopped. While the engine is running, stop the engine, wait around 5 to 10 minutes for the engine oil to return to the oil pan, then check the oil level. The oil level must be between the upper and lower limits on the oil level gauge.

Engine oil must be replaced regularly with reference to the inspection interval chart. The oil filter and cartridge must also be replaced when replacing the engine oil.

---

#### CAUTION

**The engine is capable of operating in all directions with a maximum tilted angle of 55° for a short period of time when the oil level is at its highest.**

**However, such usage is not recommended as it can lead to engine damage.**

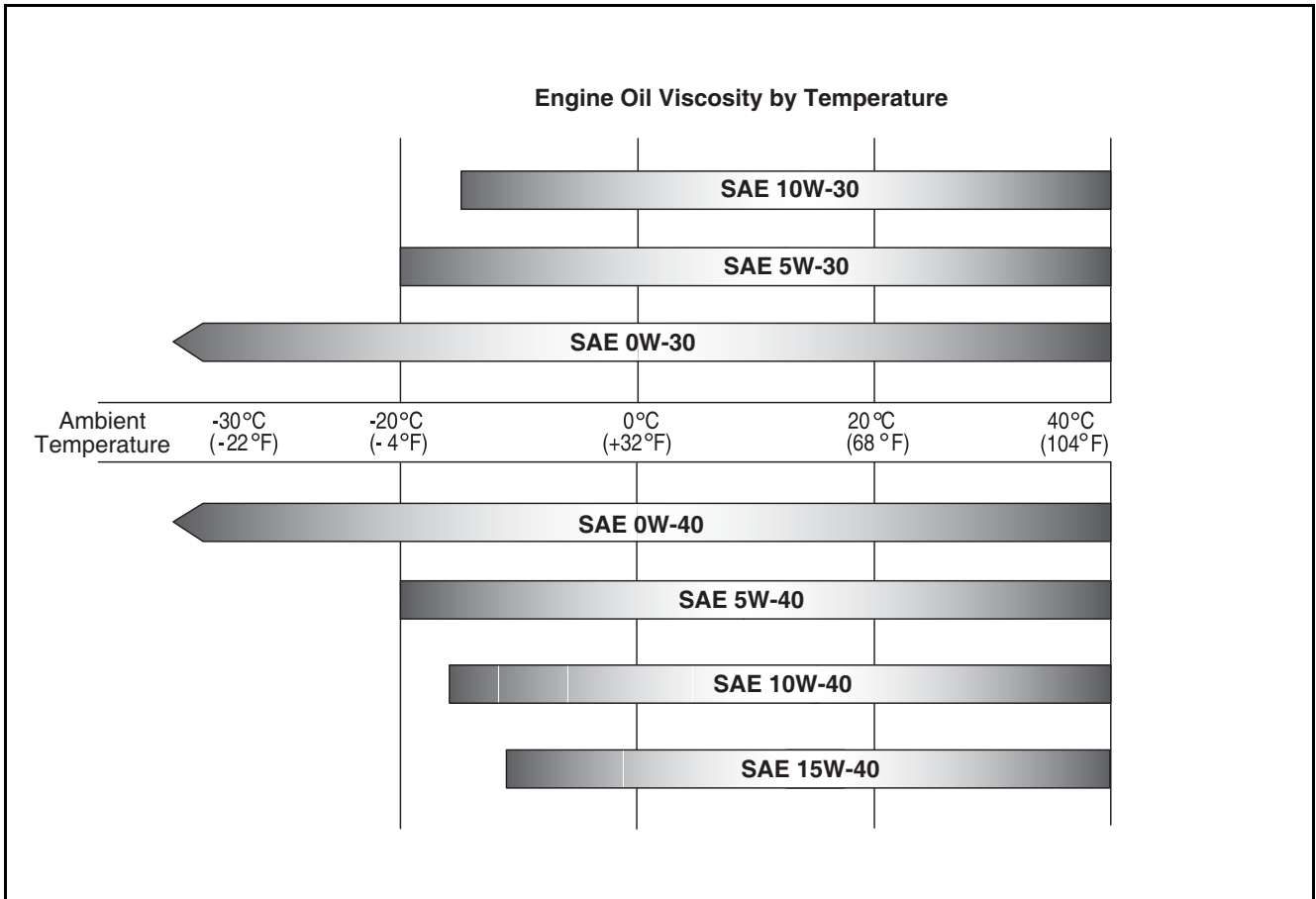
---



## 4. Regular Inspections

### Engine Oil Specifications

Use the designated engine oil which suits the environment and conditions of the region in which the engine is being used.



EDL02180008

Be sure to use engine oil which satisfies the following recommended specifications:

Engine model and product code	Oil grade
DM03-MFP04/LEP04	SAE 10W30/40 (API CJ-4 CK-4/ACEA E6, E9)

Note: Use genuine oil recommended by Hyundai Doosan Infracore.

## 4. Regular Inspections

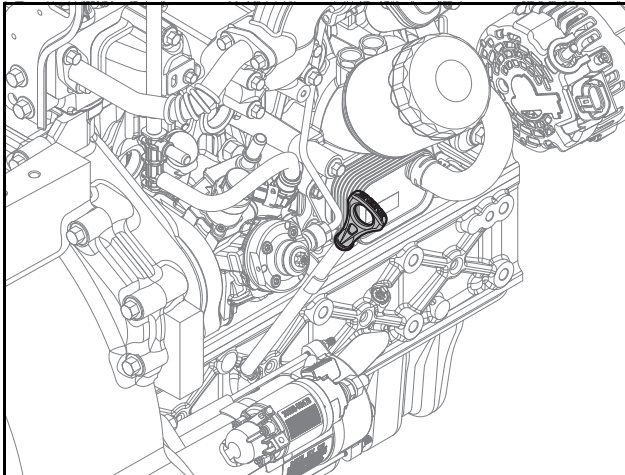
### Engine Oil Capacity

Add engine oil to the following recommended amounts.

Engine model and product code	Engine oil capacity ( ℓ )	
	Inside oil pan	
	Maximum	Minimum
DM03-MFP04/LEP04	12.6	6.0

### Checking the Engine Oil

1. Move to level ground so that the engine is horizontal.
2. After starting the engine, stop the engine when the engine reaches the normal temperature.
3. Wait 5 to 10 minutes.
4. Pull the oil level gauge upwards to remove it.



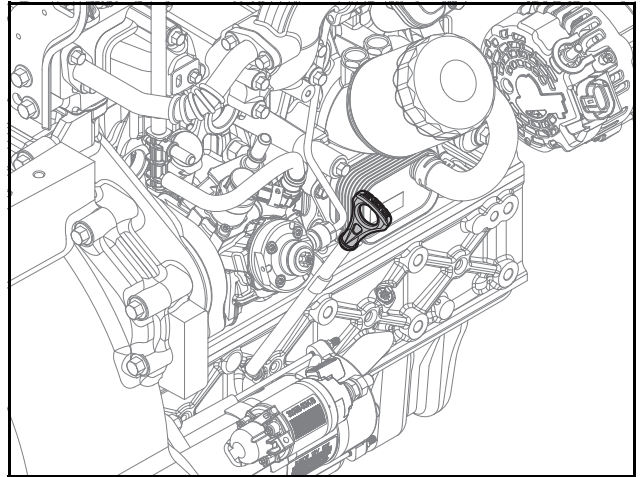
EDM03190227

- 1) Check the position of the oil level gauge.
- 2) The oil level gauge is next to the oil filter on the side of the engine.
- 3) Insert your finger into the loop on the oil level gauge and pull it.
5. Use a clean cloth to wipe the part of the oil level gauge with the reference line.

### CAUTION

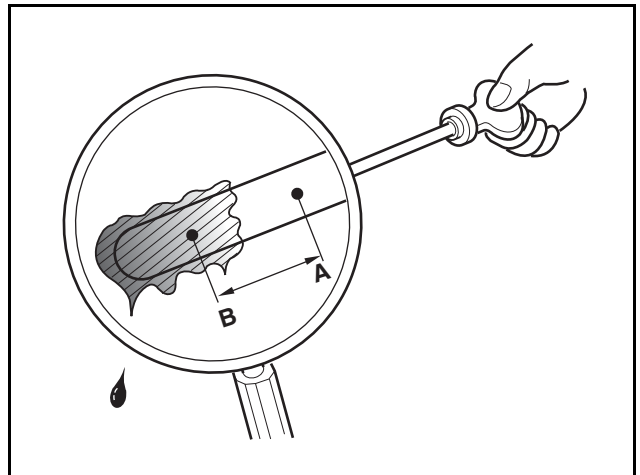
**Wiping the engine oil gauge with a dirty cloth causes foreign matter to enter the engine and may lead to engine faults.**

6. Insert the oil level gauge again.



EDM03190227

- 1) Grab the loop on the oil level gauge and insert it again.
- 2) If the oil level gauge does not go in, turn the oil level gauge 180° and then insert it again.
7. Remove the oil level gauge again and check the level and condition of the oil.



EDL022152A

- 1) Check whether there is engine oil smeared between the upper limit (A) and lower limit (B) on the oil level gauge.
- 2) If the engine oil is below the lower limit (B) or there is none on the gauge, the engine oil must be added.
- 3) Check the condition of the engine oil. If contaminated, the engine oil must be replaced.

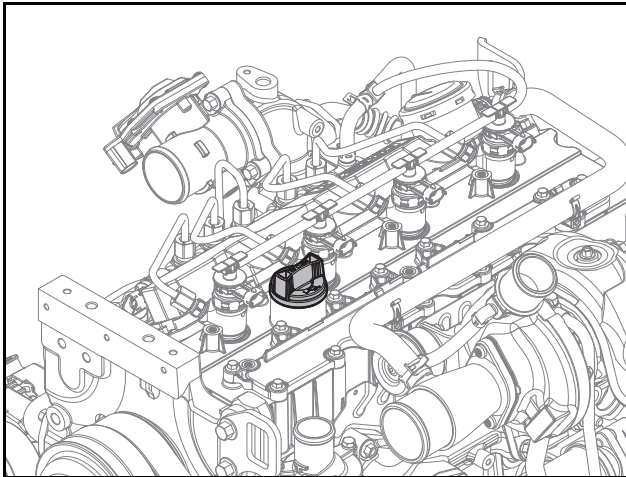
## 4. Regular Inspections

### Adding Engine Oil

#### **⚠ CAUTION**

When removing the oil filler cap for work, be careful not to allow any foreign matter to enter the engine.

1. Remove the oil filler cap on the top of the engine.



EDM03190228

2. Add the oil using genuine oil recommended by Hyundai Doosan Infracore.
  - 1) Add the oil gradually in several stages using genuine oil recommended by Hyundai Doosan Infracore.
  - 2) Wait around one or two minutes and then check the engine oil.
  - 3) Check whether there is engine oil smeared between the upper limit and lower limit on the oil level gauge.
  - 4) Repeat until the engine oil reaches a suitable level.

#### **⚠ CAUTION**

- When adding engine oil, be careful not to allow any foreign matter to enter the engine.
- Overfilling engine oil past the upper limit on the oil level gauge can cause faults in the engine. If the engine oil has been overfilled past the upper limit, the engine oil must be drained until the engine oil is between the upper and lower limits on the oil level gauge.
- Do not use unspecified engine oil additives.

3. Install the oil filler cap after adding the engine oil.

### Replacing Engine Oil

- Tightening Torque

Component	Tightening Torque
Drain plug	3 kgf·m

- Oil capacity

Engine model and product code	Engine oil capacity ( ℓ )	
	Inside oil pan	
	Maximum	Minimum
DM03-MFP04/LEP04	12.6	6

#### **⚠ DANGER**

- If engine oil makes repeated contact with skin over a long period of time, the skin can become contracted and dry, causing inflammation.
- Do not repeatedly make contact with used engine oil over a long period of time.
- Wear work clothes and gloves.
- If you spill engine oil on your skin, quickly use water and soap or hand cleaner to wipe it off completely.
- Do not use gasoline, fuel, thinner or solvents to clean your skin.
- After cleaning off the oil, apply a protective skin cream.
- Do not keep oil-stained gloves or rags in your pockets, etc.

#### **⚠ WARNING**

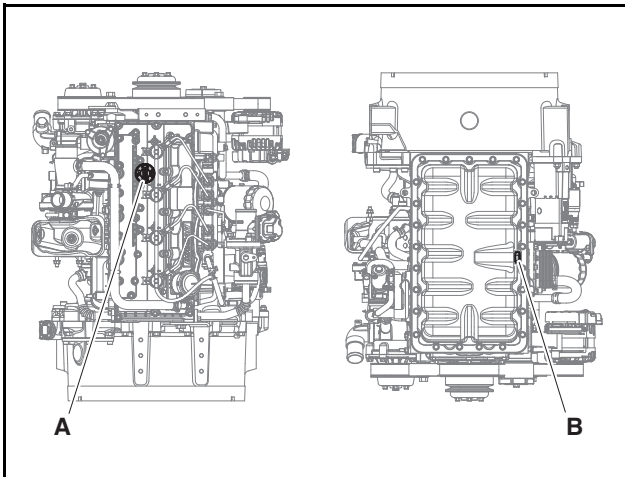
Follow the regulations of the public institutions in your area when disposing of used oil. Dumping engine oil on the ground, in sewers, drains, rivers and seas, etc. can cause severe environmental contamination. Disposing of engine oil incorrectly without complying with treatment regulations can be punished as a violation of treatment regulations.

#### **⚠ CAUTION**

When replacing the oil filter, discard the oil remaining inside the removed oil filter along with the filter.

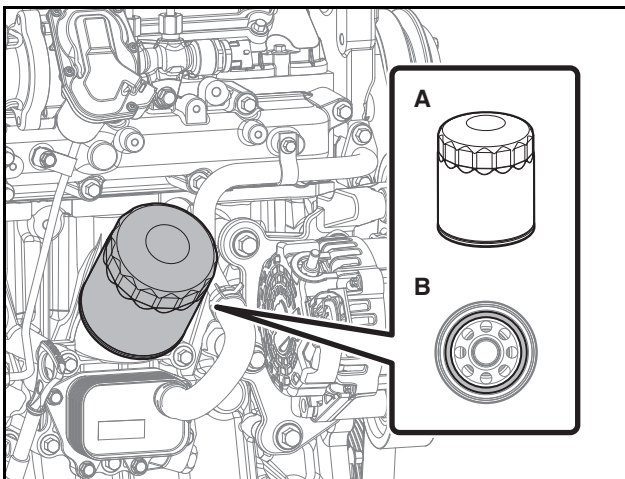
## 4. Regular Inspections

### 1. Drain the engine oil.



EDM03190229

- 1) Place a container for draining the engine oil below the engine.
  - 2) Remove the drain plug (B) and drain the engine oil.
  - 3) Remove the oil filler cap (A).
2. Replace the oil filter (A).



EDM03190230

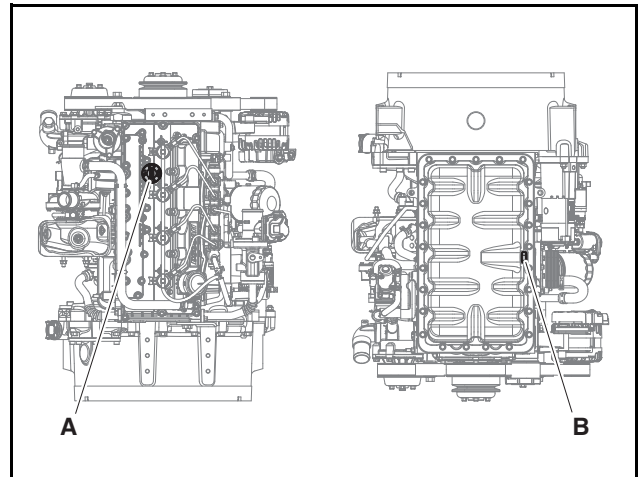
- 1) Use a filter wrench to remove the oil filter (A).

### **⚠ CAUTION**

When removing the oil filter, oil inside the filter may leak out of the filter so use a cloth to avoid contaminating nearby parts. After replacing the oil filter, be sure to completely wipe off any oil spilled nearby. Use genuine oil filter.

- 2) Wipe the mounting surface of the oil filter thoroughly.
- 3) Apply a thin layer of engine oil to the rubber packing (B) in the new oil filter (A).
- 4) Temporarily mount the oil filter by turning it by hand.
- 5) Use a filter wrench to tighten the oil filter to a tightening torque of 16 ~ 20 N·m.

### 3. Add the engine oil.



EDM03190229

- 1) Mount the drain plug (B) at a tightening torque of 3.0 kgf·m.
- 2) Remove the oil level gauge.
- 3) Add genuine oil recommended by Hyundai Doosan Infracore.

Note: Add about half of the specified capacity, then wait around one minute before adding the remaining half.

- 4) Assemble the oil filler cap (A).
  - 5) Assemble the oil level gauge.
  - 6) Move the engine oil drain pan under the engine.
4. Perform a final inspection after completing the work.
- 1) Check for any engine oil leaks after starting the engine.
  - 2) After starting the engine, stop the engine when the engine reaches the normal temperature.
  - 3) Wait 5 to 10 minutes.
  - 4) Use the oil level gauge to check the engine oil level.

### **⚠ CAUTION**

Overfilling engine oil past the upper limit on the oil level gauge can cause faults in the engine. If the engine oil has been overfilled past the upper limit, the engine oil must be drained until the engine oil is between the upper and lower limits on the oil level gauge.

### Fuel System

#### General Information

The quality of fuel is important for satisfying engine performance, engine life and allowable emission standards. Hyundai Doosan Infracore engines are designed to be used with diesel fuel in the area in which the engine is sold.

#### **⚠ CAUTION**

- Only use specified, clean, high-quality fuel. Using imitation or unspecified fuel may cause severe faults in the engine.
- When fuel needs to be added, be sure to add fuel with the engine stopped.

#### Fuel Specifications

In order to maintain optimal engine performance, refer to the following recommended fuel selection chart to use the appropriate fuel.

- Ultra Low Sulfur Diesel

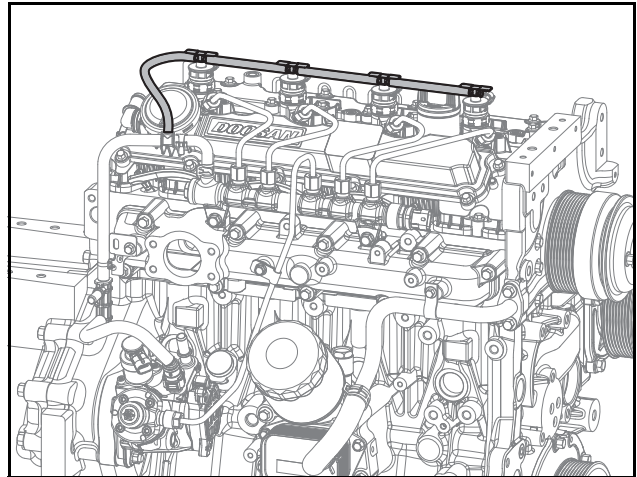
Fuel Components		Standard
Specific gravity	(kg/lit)	0.820 ~ 0.845
Flash point	(°C)	40 or higher
Kinematic viscosity (40 °C)	(cSt)	1.9 ~ 5.5
Sulfur content	(wtppm)	15 or less
Cloud point	(°C)	-
Pour point	(°C)	-17.5 or less
Low-temperature filter clogging temperature	(°C)	-16 or less
Color (ASTM)		2.5 or less
Carbon residue (10 % Distillation residue (wt)	(%)	0.15 or less
Total acid number	(mg KOH/g)	0.40 or less
Copper corrosion (100 °C, 3 hours)		1 or less
Ash content	(mass %)	0.01 or less
Water and deposits	(vol. %)	0.02 or less
Cetane number		45 or higher
Distillation test temperature	50% distillation point	-
	90 % distillation point	360 or less

Note: The fuel product standards were formulated with reference to SK (Inc.) Ultra Low Sulfur Diesel

#### Injector & Fuel Return Hose

Be careful to avoid damage for fuel return hose of injector. Don't press on the fuel hose, don't drop heavy tool like as spanner on engine, don't step on fuel hose, don't stand on engine.

If the fuel hose are broken by wrong handling, it is possible fire.



EDM03200146

#### Fuel Filter

Removes water and impurities in fuel and moves fuel to the fuel injection pump.

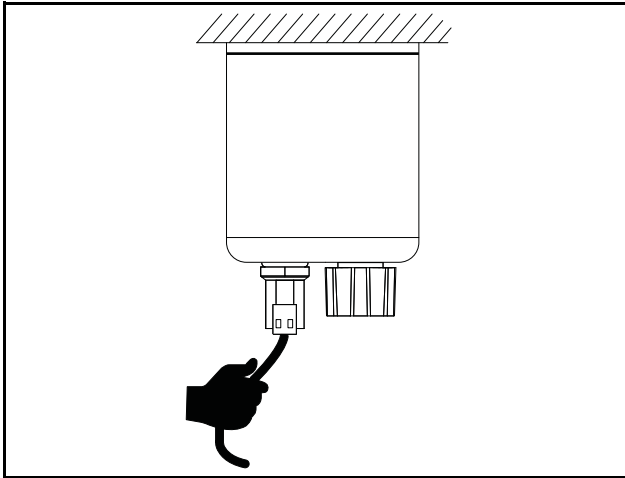
#### **⚠ CAUTION**

- If you do not regularly inspect the fuel filter and discharge the water in the fuel filter, water enters the fuel system of the engine and can cause severe faults in the fuel injection pump, fuel injection pipe, common rail and injector. In addition, the fuel filter performance can be degraded or damaged.
- When draining the water in the fuel filter, fuel may also be drained as well. Fuel is a highly flammable substance so smoking or being exposed to open flames near the engine while draining water may cause a fire.
- Only use specified, clean, high-quality fuel. Using imitation or unspecified fuel may increase the amount of water in the fuel filter.
- If you do not drain the water in the fuel filter when the fuel filter warning lamp is illuminated, water may enter the fuel system and cause the engine to turn off.
- New fuel filters must be assembled without any fuel in them. Do not use the fuel in replaced fuel filters or the fuel in the fuel tank in new fuel filters.

## 4. Regular Inspections

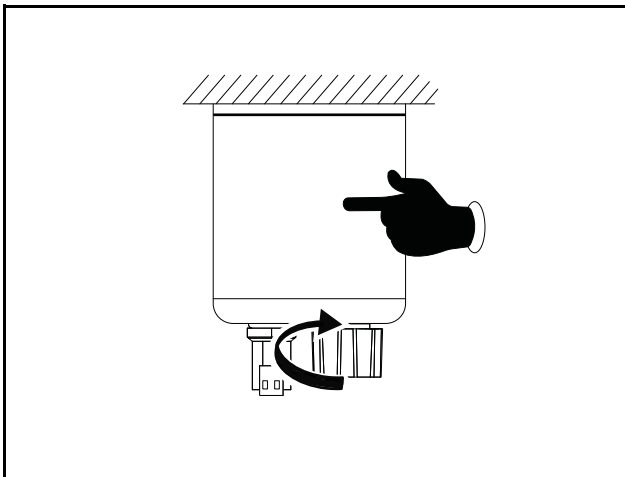
### Replacing the Fuel Filter

1. Remove the water in fuel sensor connector.



EDL032813A

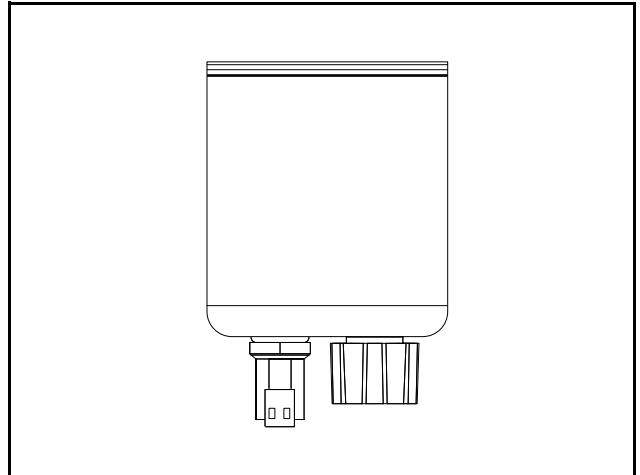
- 1) Keep the area around the fuel filter clear to prevent interference.
- 2) Remove the water in fuel sensor connector from the fuel filter.
2. Remove the fuel filter.



EDL032813B

- 1) Turn the fuel filter counterclockwise to loosen it.

3. Replace the fuel filter.



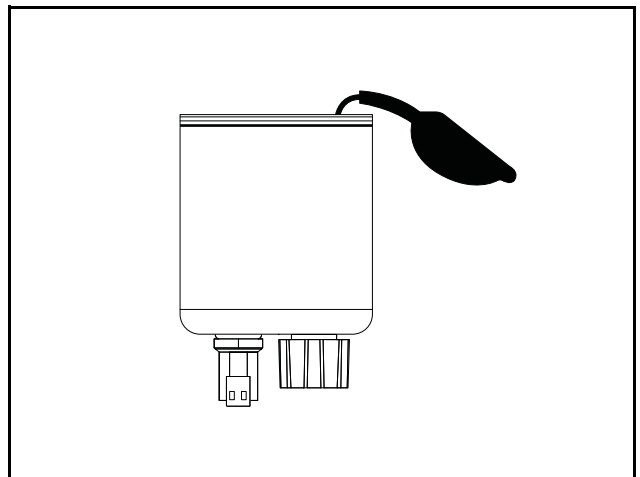
EDL032813C

- 1) Prepare a new fuel filter.

### CAUTION

- We recommend using the recommended genuine fuel filter. Using imitation or recycled parts may cause severe engine faults and damage.
- New fuel filters must be assembled without any fuel in them.
- Do not reuse the remaining fuel which was used in the previous fuel filter or fuel in the tank in the new fuel filter.

4. Apply oil to the gasket.



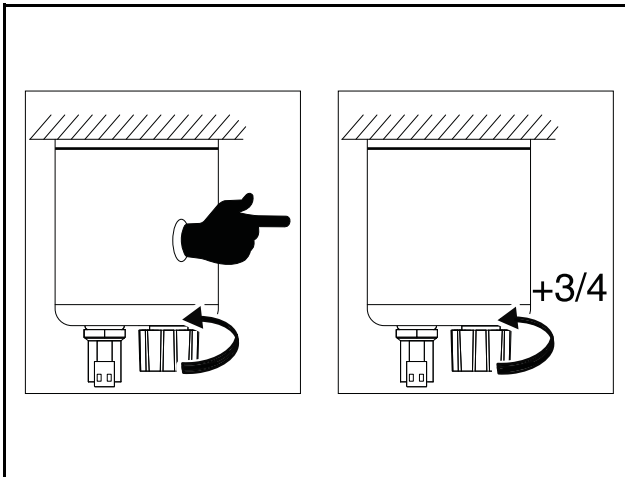
EDL032813D

- 1) Apply oil to the fuel filter gasket.



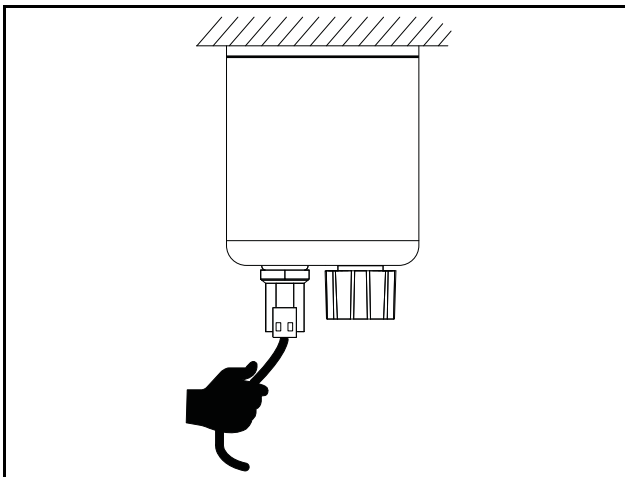
## 4. Regular Inspections

5. Assemble the fuel filter.



EDL032813E

- 1) Turn the fuel filter clockwise until the fuel filter gasket makes contact with the fuel filter cap.
  - 2) Turn the fuel filter 3/4 to tighten it.
6. Connect the water in fuel sensor connector.

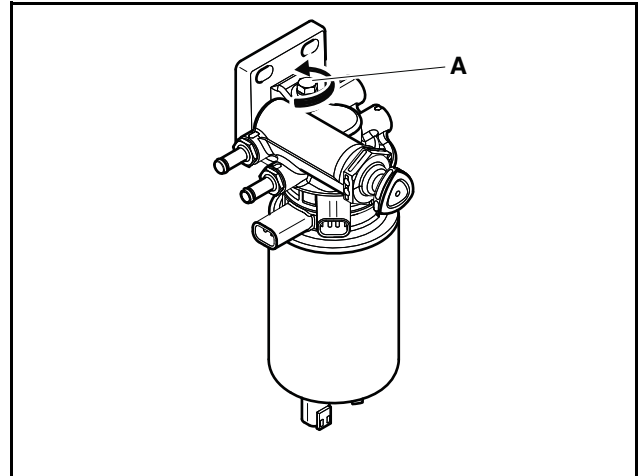


EDL032813A

- 1) Connect the water in fuel sensor connector to the fuel filter.
  - 2) Keep the area around the fuel filter clean and free of foreign matter such as fuel.
7. Bleed the air from the fuel supply line.

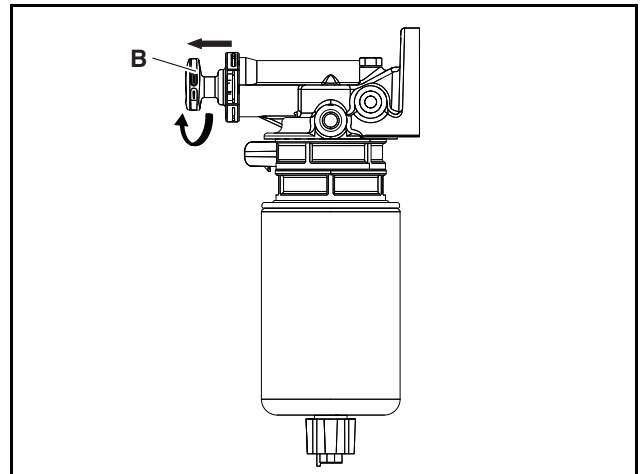
### Bleeding Air From the Fuel Delivery Line

1. Loosen the air bleed valve.



EDL032814A

- 1) Turn the air bleed valve (A) on the top of the fuel filter counterclockwise to loosen it.
2. Loosen the pump 5handle.

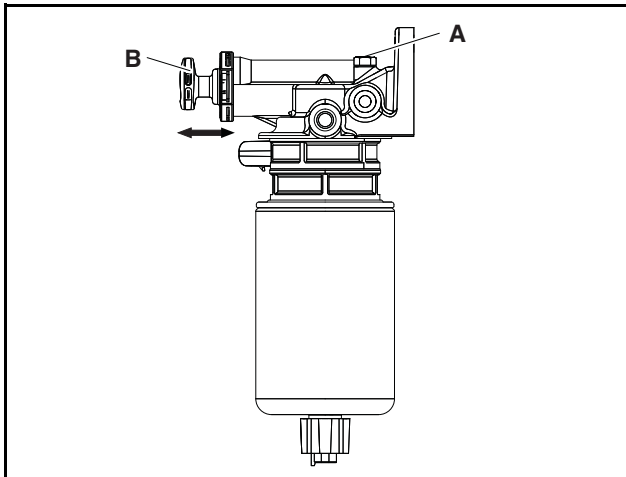


EDL032815A

- 1) Turn the pump handle (B) counterclockwise to loosen it.

## 4. Regular Inspections

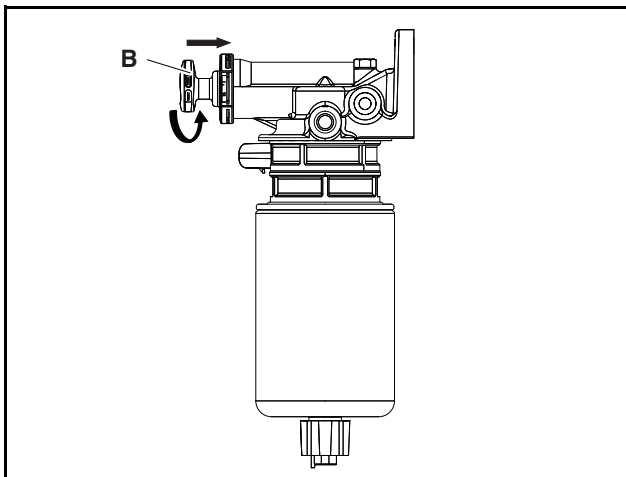
3. Bleed the air from the fuel supply line.



EDL032815C

1) Pump the pump handle (B) until fuel comes out of the air bleed valve (A).

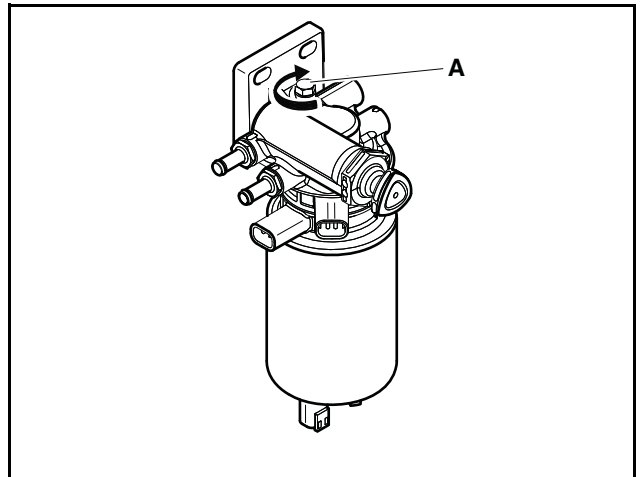
4. Fix the pump handle in place.



EDL032815B

1) Turn the pump handle (B) clockwise while pressing on it to fix it in place.

5. Tighten the air bleed valve.

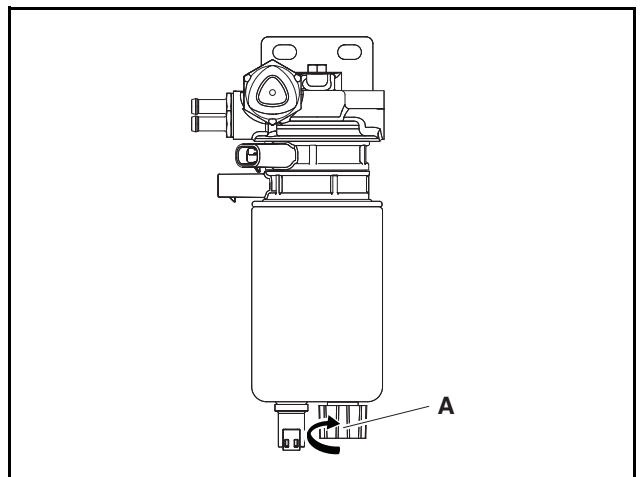


EDL032814B

1) Turn the air bleed valve (A) clockwise to tighten it.

### Draining Water From the Fuel Filter

1. Turn the drain valve to loosen it.



EDL032818A

1) Turn the drain valve (A) at the bottom of the fuel filter to loosen it.

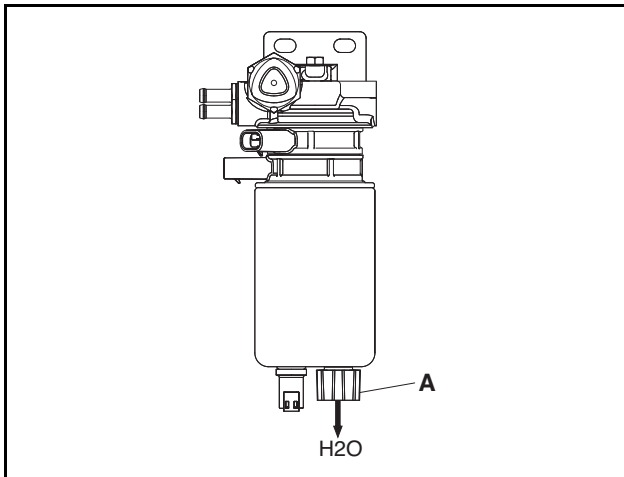
### CAUTION

Do not use a tool to loosen the drain valve. Otherwise, the drain valve may be damaged.



## 4. Regular Inspections

2. Drain water from the fuel filter.



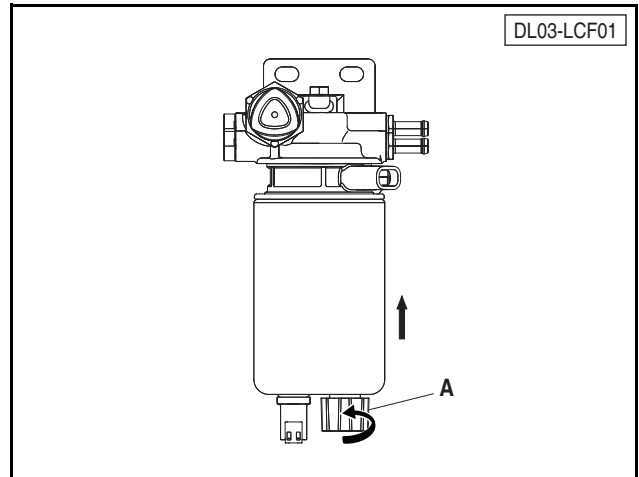
EDL032818B

1) Drain the water in the fuel filter with the drain valve (A) for around 10 seconds.

### **⚠ CAUTION**

- If you do not regularly inspect the fuel filter and discharge the water in the fuel filter, water enters the fuel system of the engine and can cause severe faults in the fuel injection pump, fuel injection pipe, common rail and injectors. In addition, the fuel filter performance can be degraded or damaged.
- When draining the water in the fuel filter, fuel may also be drained as well. Fuel is a highly flammable substance so smoking or being exposed to open flames near the engine while draining water may cause a fire.
- Only use specified, clean, high-quality fuel. Using imitation or unspecified fuel may increase the amount of water in the fuel filter.
- If you do not drain the water in the fuel filter when the fuel filter warning lamp is illuminated, water may enter the fuel system and cause the engine to turn off.

3. Tighten the drain valve.



EDL032807F

1) Turn the drain valve (A) at the bottom of the fuel filter to tighten it.

### **⚠ CAUTION**

**Do not use a tool to tighten the drain valve. Otherwise, the drain valve may be damaged.**

## 4. Regular Inspections

### Intake/Exhaust System

#### General Information

The air filter serves to filter out dust and foreign matter included in the outside air, thereby delivering clean air to the engine. The air filter is directly related to the engine life, exhaust smoke and engine power so be sure to inspect, clean and replace it regularly.

#### CAUTION

- Do not operate the engine with the air filter removed.
- Only use the specified air filter. Using imitation products or recycled products may cause severe faults.
- If foreign matter enters the engine, it may cause wear inside the engine.
- If the air filter is damaged, replace it immediately.
- When replacing the air filter, be careful not to damage related electrical components or to allow any foreign matter to enter the engine.
- Make sure that dust does not enter when installing the air filter.

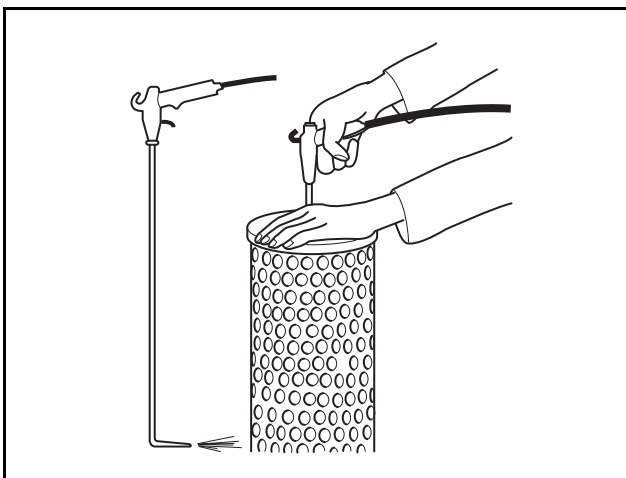
#### Cleaning the Air Filter

1. Remove the air filter cover.
2. Remove the air filter element.
3. Remove the dust inside the air filter.

#### Cleaning the Air Filter Element

Clean the air filter element using whichever of the following 3 methods is most suited to the work environment.

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



EDL022155A

- 1) Use an air gun to clean the element thoroughly all the way to the bottom. Compressed air should be shot at a 90° angle to the bottom of the element.

- 2) Move the air gun up and down along the element to blow compressed air from the inside toward the outside until dust is no longer blown out.
- 3) The pressure of compressed air should not exceed 5 bars.

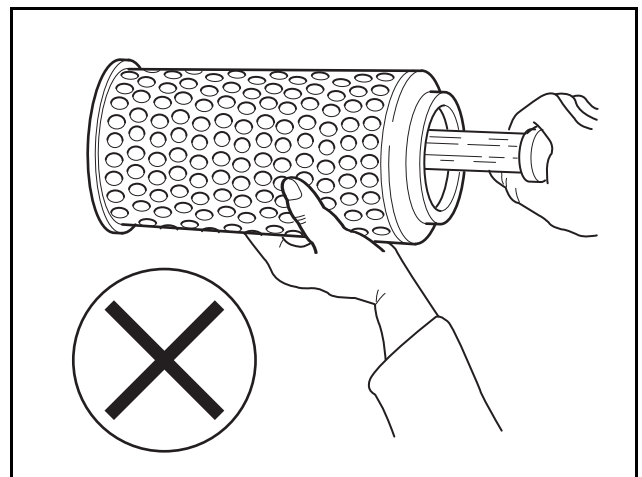
#### DANGER

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

2. In emergencies, use the following method to clean the element temporarily.
  - 1) Tap the end plate of the element with your thumb to clean it temporarily.

#### CAUTION

- Only use this method as a temporary measure in emergency situations where the element needs to be cleaned but you do not have compressed air or a cleaning product.
- Never use a hard object to tap the surface of the element or tap the element against a hard object in order to remove dust residue.



EDL022157A

Note: Before reinstalling the element, check whether the paper is folded, as well as the condition of the rubber seal ring and whether there is any deformation.

Note: Never use a damaged element. If you are unsure about the element condition, replace the element with a new one.

### Replacing the Air Filter Element

---

 **CAUTION**

---

**Make sure that dust does not enter through the tip of the air cleaner.**

---

1. Remove the fastening component.
2. Remove the damaged or contaminated element.
3. Wash the inside of the filter housing and the contact surface of the element seal ring thoroughly.
4. Install a new element.
5. Assemble the fastening component.

## 4. Regular Inspections

### Other/Driving System

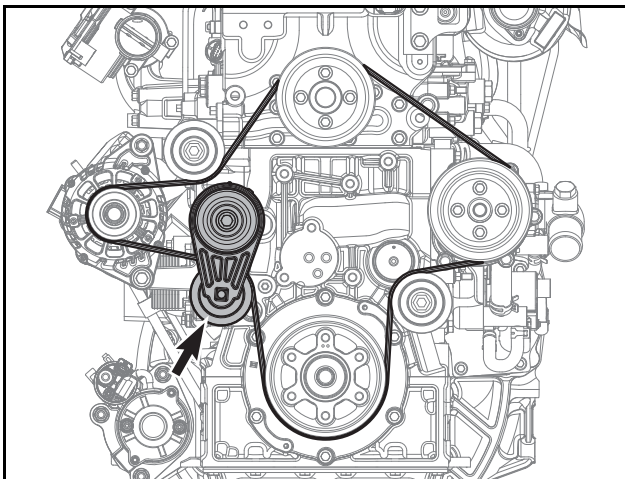
#### Belt Tension

1. The belt is equipped with an auto tensioner which automatically adjusts the belt tension so there is no need for extra adjustment of the tension.

During daily inspections, be sure to inspect whether the pointer on the auto tensioner is indicating that it is time for a replacement, as well as whether there is any damage to the belt due to external factors.

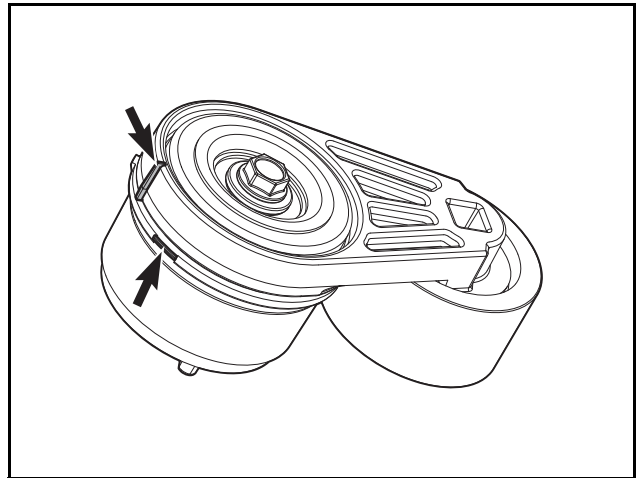
- Replacing the Micro V-Belt if necessary

Replace the belt set in the event that the pointer on the auto tensioner indicates that it is time for a replacement, or cases where damage to the belt from external factors has been confirmed and there are concerns of severe damage occurring.



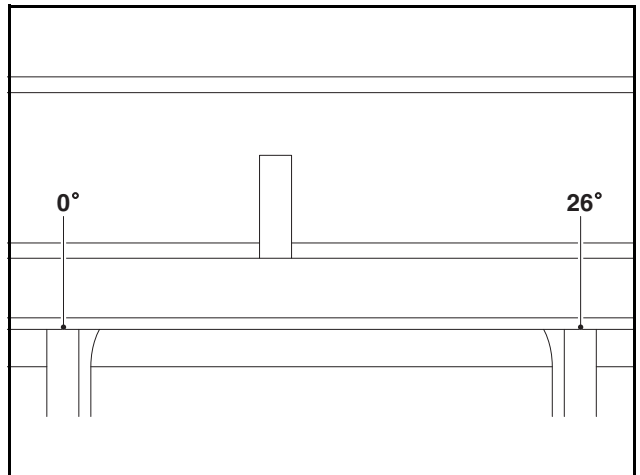
EDM03190231

- Inspecting the condition  
Inspect the Micro V-belt for cracks, oil, overheating and wear.



EDM03190329

- The vertical rod shown by the arrow is the "pointer," and the belt replacement period is indicated when this "pointer" enters the horizontal range shown in orange.  
Note) The minimum/maximum range indication is a reference value; the belt must be inspected according to its maintenance schedule.



EDM02190122

# 5. General Engine Information

<b>Indicating Units</b> .....	<b>65</b>
Unit Conversion Method .....	65
<b>Tightening Torque</b> .....	<b>66</b>
Tightening Torque of Main Parts.....	66
Tightening Torque of General Bolts .....	67
<b>Disassembling the Engine</b> .....	<b>68</b>
Engine Disassembly Order .....	68
<b>Assembling the Engine</b> .....	<b>81</b>
Order of Engine Assembly .....	81



## 5. General Engine Information

### Indicating Units

#### Unit Conversion Method

This is the method for converting between SI and US units.

1. Multiplying the number below with the SI unit gives you the US unit.

Note: (SI unit) X (number) = (US unit)

Note: 1 mm X 0.03937 = 0.03937 in

2. Dividing the US unit by the number below gives you the SI unit.

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	lbf·ft
	86.79619	kgf·m	lbf·in
	0.7375621	N·m	lbf·ft
	8.850748	N·m	lbf·in

Item	Number	SI Unit	US Unit
Power Supply	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
	0.0002777778	J	Wh
Light	0.09290304	lm/m <sup>2</sup>	lm/ft <sup>2</sup>
Speed	0.6213712	km/h	mph
Temperature	°C	°C	°F

- a.  $9.806 \times (\text{kg}\cdot\text{f}) = (\text{N})$
- 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. General Engine Information

### Tightening Torque

#### Tightening Torque of Main Parts

Major parts		Screw (Diameter x pitch)	Strength (Grade)	Tightening torque (kgf.m)	Remark
Cylinder block & Bed plate	Main bearing cap bolt (D18, D24)	M12 x 1.5	10.9T	Initial 5.5 ±0.28 + angle 90° ±4° + angle 90° ±4°	Not reusable (Tier-4 Final, Stage-V all)
	Main bearing cap bolt (D34)	M12 x 1.5	12.9T	Initial 5.5 ±0.28 + angle 90° ±4° + angle 90° ±4°	Not reusable (Tier-4 Final, Stage-V all)
	Bed plate bolt	M8 x 1.25	8.8T	2.2 ±0.22	
	Plug, screw (PT)	PT 3/8	-	6.5 ±0.5	
	Plug, screw Water drain plug (D18, D24)	M12 x 1.5	-	3.0 ±0.3	Oil filter ass'y
	Plug, screw Water drain plug (D34)	M12 x 1.5	-	5.0 ±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	Not reusable (Tier-4 Final, Stage-V all)
CRS V pulley, bolt		M14 x 1.5	10.9T	26 ±1	Not reusable (Tier-4 Final, Stage-V all)
Connecting rod bolt (D18, D24)		M8 x 1.0	10.9T	1st: 2.0 ±0.1 / 2nd: 90° ±4°	
Connecting rod bolt (D34)		M9 x 1.0	10.9T	1st: 3.0 ±0.15 / 2nd: 90° ±4°	
MBS bolt (D34, option)		M10 x 1.5	10.9T	Initial 6.0 ±0.3 + angle 90° ±4° + angle 90° ±4°	
Flywheel bolt (25 mm, option) for flat type flywheel		M12 x 1.5	12.9T	15 ±0.75	
Flywheel bolt (43 mm, option)		M12 x 1.5	10.9T	1st: 7 ±0.35 / 2nd: 45° ±4°	Not reusable
Head bolt (D18, D24)		M11 x 1.25	9T	Initial 4.0 ±0.2 + angle 90° ±4° + angle 90° ±4° + angle 90° ±4°	Not reusable (Tier-4 Final, Stage-V all)
Head bolt (D34)		M12 x 1.25	9T	Initial 4.5 ±0.23 + angle 90° ±4° + angle 90° ±4°	Not reusable (Tier-4 Final only)
				Initial 6.0 ±0.3 + angle 90° ±4° + angle 90° ±4°	Not reusable (Stage-V only)
Head cover bolt (LH, RH)		M6 x 1.0	8.8T	1 ±0.1	
Head cover bolt (Main)		M6 x 1.0	8.8T	1 ±0.1	
EX manifold bolts		M8 x 1.25 (60mm)	10.9T	3.4 ±0.3	
Injector fixture bolts		M8 x 1.25	12.9T	4.4 ±0.4	
HP pump drive gear nut		M18 x 1.5	-	8.2 ±0.5	
HP pump MTG nut		M8 x 1.25	-	2.2 ±0.22	
HP pipe nut - injector to rail		Union nut	-	3.0 ±0.3	
HP pipe nut - rail to pump		Union nut	-	3.0 ±0.3	
Thermostat MTG space bolt		M8 x 1.25	8.8T	2.2 ±0.22	



## 5. General Engine Information

Major parts	Screw (Diameter x pitch)	Strength (Grade)	Tightening torque (kgf.m)	Remark
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	-	0.165 ±0.035	
Turbocharger hollow screw	M10 x 1.0	-	1.9 ±0.1	
Turbocharger MTG nut	M8 x 1.25	-	2.2 ±0.22	
Water pump MTG nut	M8 x 1.25	-	2.2 ±0.22	
Rocker arm adjusting hex nut	M8 x 1.0	-	1.5 ±0.15	
Camshaft thrust washer bolt	M8 x 1.25	8.8T	2.2 ±0.22	
Idle gear shaft bolt	M10 x 1.5	8.8T	4.4 ±0.44	
Rocker arm Brkt bolt	M8 x 1.25	8.8T	2.2 ±0.22	
PTO housing bolt	M10 x 1.5	12.9T	4.4 ±0.44	
PTO (D24)	M8 x 1.25	8.8T	2.2 ±0.22	Stage-V only
PTO (D34)	M8 x 1.25	8.8T	2nd: 2.2 ±0.22	Stage-V only
	M10 x 1.5	12.9T	1st: 4.4 ±0.44	Not reusable (Tier-4 Final)
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	
Idle pulley ass'y bolt	M10 x 1.5	-	4.5 ±0.5	
Extension hose Brkt bolt (Fuel)	M12 x 1.75	8.8T	5.5 ±0.55	
Worm drive type clamp	-	-	0.525 ±0.03	
Band clamp (DOC & SCR)	-	-	1.4 ±0.1	
V-clamp (Exhaust pipe)	-	-	1.0 ±0.1	
Oil pressure sensor	M14 x 1.5	-	1.0 ±0.1	
EGT sensor*	M14 x 1.5	-	4.0 ±0.5	Stage-V only
Water temp. sensor	M12 x 1.5	-	2.5 ±0.3	

### Tightening Torque of General Bolts

Tightening Torque of Key General Bolts

Strength Classification	Nominal Diameter X Pitch (mm)							
	M6 x 1	M8 x 1.25	M8 x 1	M10 x 1.5	M10 x 1.0	M12 x 1.75	M12 x 1.5	M14 x 1.5
	Tightening Torque (kgf.m) ±10%							
8.8T	1 ±0.1	2.2 ±0.22	2.4 ±0.24	4.4 ±0.44	5 ±0.5	7.5 ±0.75	8 ±0.8	13 ±1.3
10.9T	1.25 ±0.13	3.1 ±0.31	3.35 ±0.34	6.2 ±0.62	7 ±0.7	10.5 ±1.05	11.2 ±1.12	18.5 ±1.85
12.9T	1.5 ±0.15	3.8 ±0.38	4.1 ±0.41	7.4 ±0.74	8.4 ±0.84	12.5 ±1.25	13.4 ±1.34	22 ±2.2

## 5. General Engine Information

### Disassembling the Engine

#### Engine Disassembly Order

#### CAUTION

- Prepare any necessary tools and genuine parts before disassembling the engine.
- Prepare a shelf for storing removed parts.
- Always work in a bright and clean environment.
- Always keep your hands clean while working.
- Store removed parts in the order that they were disassembled from the engine.
- 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. Drain the coolant.
  - 1) Check whether the engine and radiator have cooled down.
  - 2) Place a container in front of the coolant drain plug.
  - 3) Remove the surge tank cap.
  - 4) Remove the coolant drain plug on the radiator and then drain the coolant.
  - 5) After draining the coolant is complete, reinstall the coolant drain plug.

#### DANGER

- Do not open the surge tank cap while the engine is overheated. If the surge tank cap is opened, hot coolant will spurt and may cause burns. Open the surge tank cap after ensuring that the engine has cooled down sufficiently.
- Label and store containers for coolant separately to avoid confusing them with containers for drinks. If you happen to ingest coolant, consult a doctor immediately.

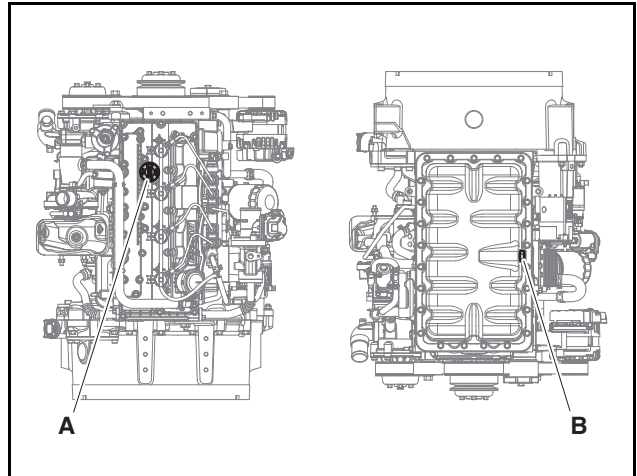
#### WARNING

Follow the regulations of the public institutions in your area when disposing of used coolant. Dumping engine oil on the ground, in sewers, drains, rivers and seas, etc. can cause severe environmental contamination. Disposing of engine oil incorrectly without complying with treatment regulations can be punished as a violation of treatment regulations.

#### CAUTION

When replacing coolant, be careful not to spill any coolant on belts and electrical devices.

2. Drain the engine oil.



EDM03190229

- 1) Place a container for draining the engine oil below the engine.
- 2) Remove the drain plug (B) and drain the engine oil.
- 3) Remove the oil filler cap (A).
- 4) Remove the engine oil filter.
- 5) When draining the engine oil is complete, assemble the engine oil filter and drain plug.

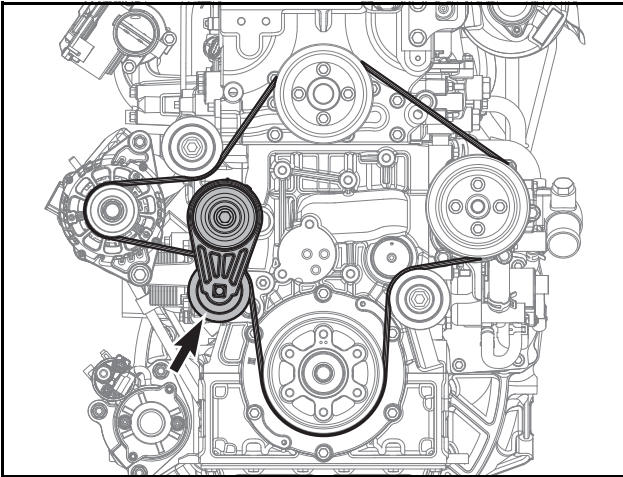
#### WARNING

Follow the regulations of the public institutions in your area when disposing of used oil. Dumping engine oil on the ground, in sewers, drains, rivers and seas, etc. can cause severe environmental contamination. Disposing of engine oil incorrectly without complying with treatment regulations can be punished as a violation of treatment regulations.

3. Remove the air cooler and cooling fan connected to the engine.
4. Remove the engine from the vehicle.
5. Disconnect the cables and harness connected to each sensor in the engine.

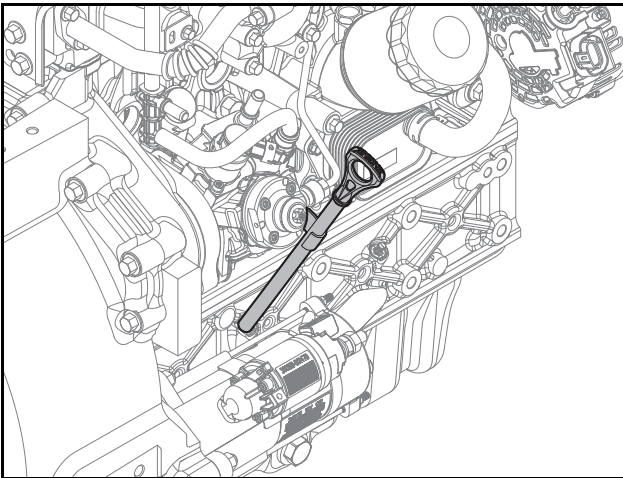
## 5. General Engine Information

### 6. Remove the V-belt.



EDM03190231

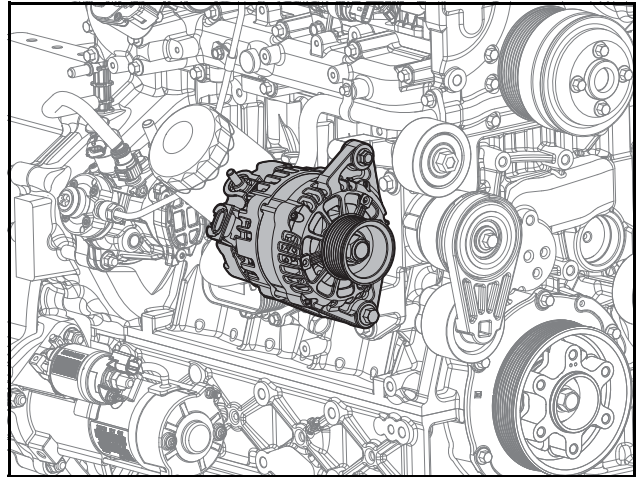
- 1) Turn the auto tensioner counterclockwise by using a quadrangular groove at the top of the auto tensioner pulley (Use a 10 mm x 10 mm quadrangular tool).
  - 2) Remove the belt wound around the auto tensioner pulley by using a space generated by the rotation of the auto tensioner.
7. Remove the oil level gauge.



EDM03190232

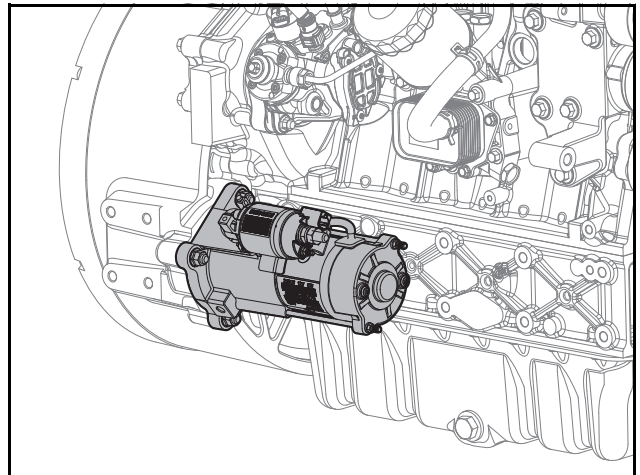
- 1) Remove the oil level gauge.
- 2) Loosen the flange hex bolt holding the oil level gauge guide tube in place.
- 3) Remove the oil level gauge guide tube from the cylinder block.
- 4) Remove the O-rings.

### 8. Detach the alternator.



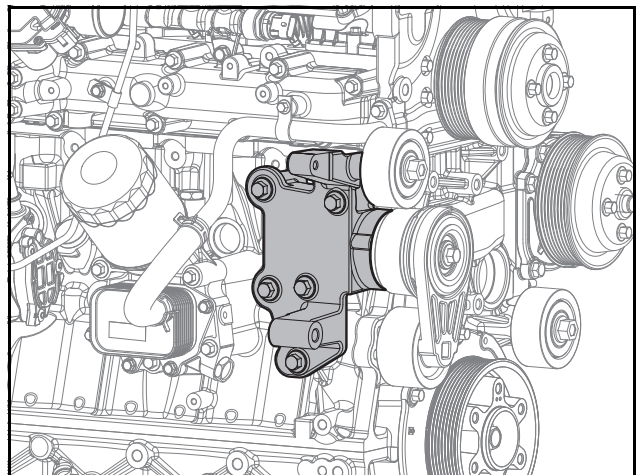
EDM03190243

- 1) Loosen the upper/lower bolt and remove the alternator.
  - 2) When loosening bolt, take care not to lose nut.
9. Remove the starter motor.



EDM03190242

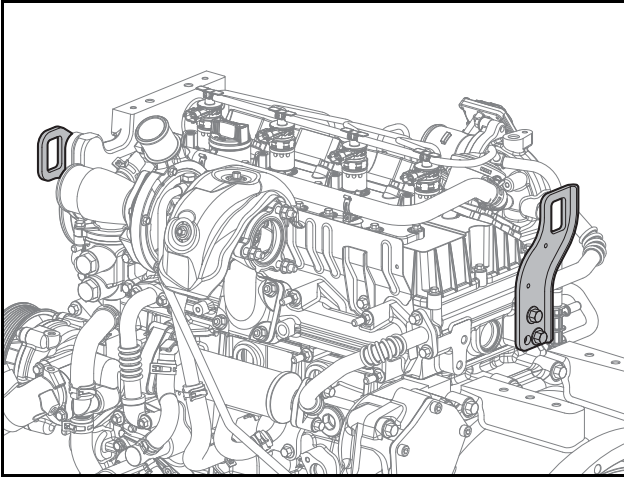
- 1) Turn and loosen the flange nut.
  - 2) Remove the starter motor.
10. Remove the alternator bracket.



EDM03190244

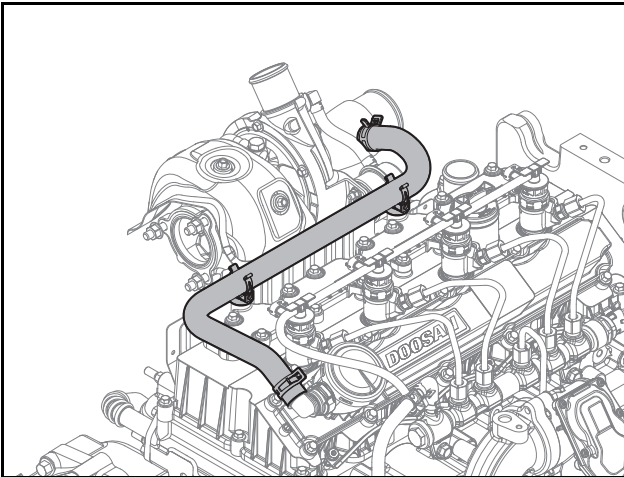
## 5. General Engine Information

- 1) Loosen 5 flange hex bolt.
- 2) Remove the alternator bracket.
11. Remove the lifting hooks.



EDM03190233

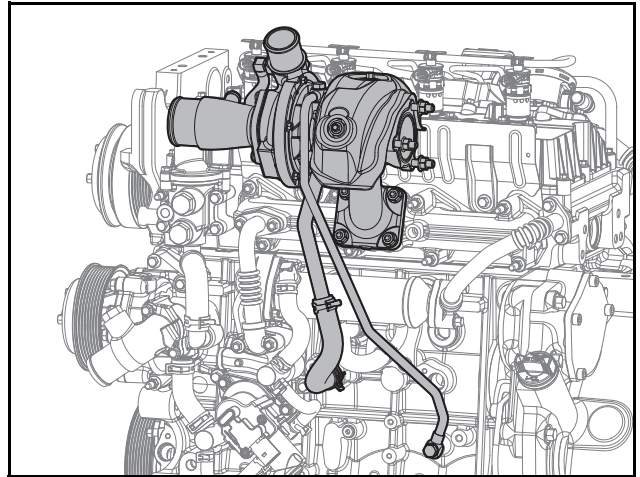
- 1) Loosen flange bolt.
- 2) Remove the lifting hooks.
12. Remove the breather hose.



EDM03190234

- 1) Press on the clamps on the quick connector and T/C air inlet pipe assembly, then disconnect the breather hose.
- Note: There is no need to disconnect the hose on the quick connector.

13. Remove the turbocharger.



EDM03190235

- 1) Loosen the hollow screws on both ends of the oil supply pipe.
- 2) Remove the oil supply pipe and copper washers.

### CAUTION

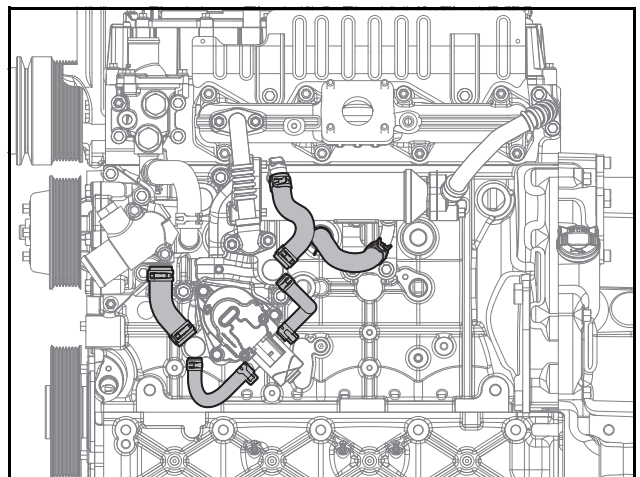
**Do not reuse copper washers; replace them with new ones.**

- 3) Press on the clamp and disconnect the oil return hose.
- 4) Loosen the flange hex nut.
- 5) Remove the turbocharger.
- 6) Remove the gasket.
- 7) Loosen the hex bolt.
- 8) Remove the oil return pipe and gasket.

### CAUTION

**Do not reuse gaskets; replace them with new ones.**

14. Remove the EGR hose & pipe.

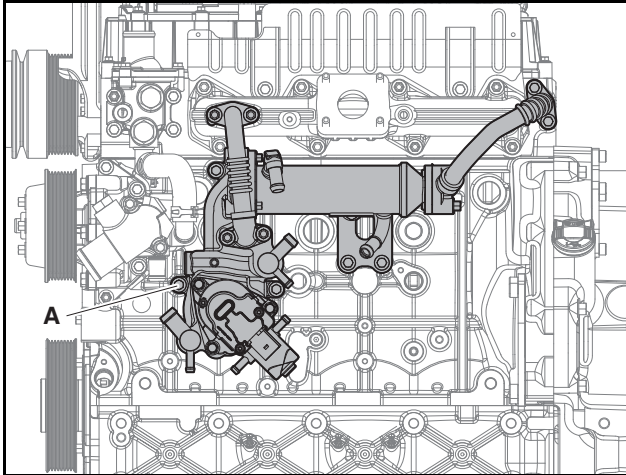


EDM03190239



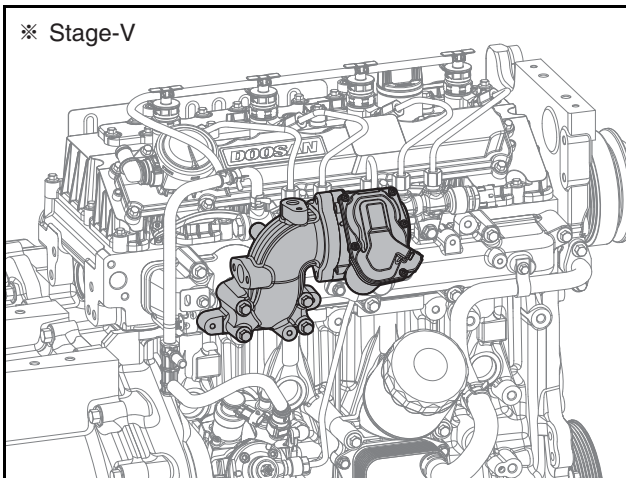
## 5. General Engine Information

- 1) Press on clamps on both ends of the hoses and disconnect hoses.
- 2) Loosen 4 flange hex bolts.
- 3) Remove the EGR pipe.
15. Remove the EGR cooler assembly.

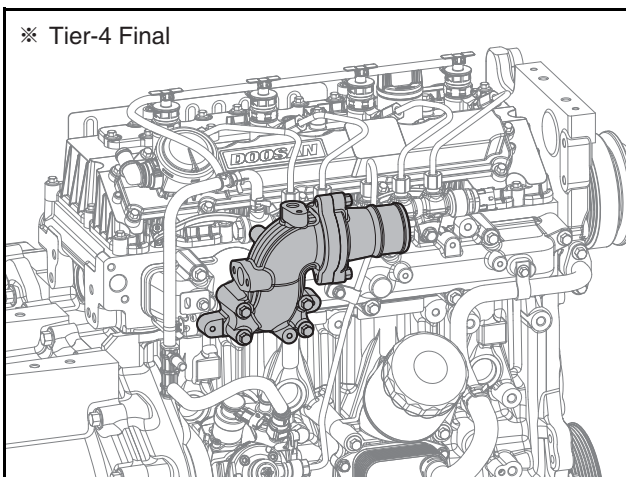


EDM03190238

- 1) Loosen 7 flange hex bolts (A).
- 2) Remove the EGR assembly.
16. Remove the throttle (inlet pipe) & the intake stake.



EDM03190237



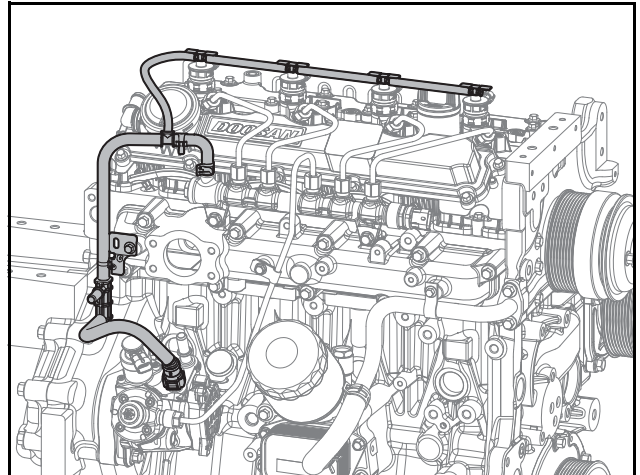
EDM03190236

- 1) Loosen the flange hex bolt.
- 2) Remove the throttle (inlet pipe) & the intake stake.
- 3) Remove the gasket.

### CAUTION

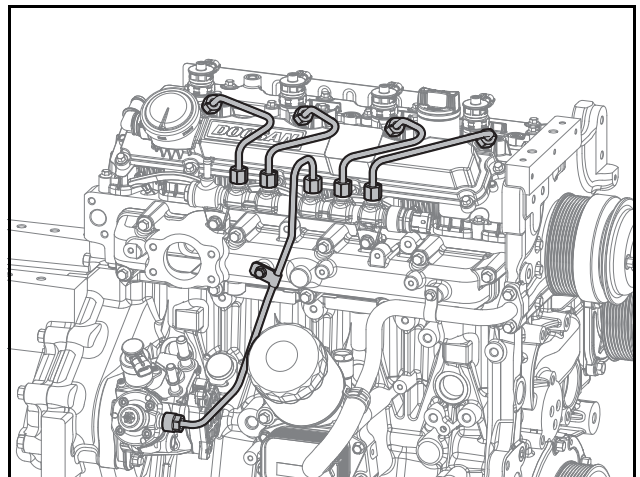
**Do not reuse gaskets; replace them with new ones.**

17. Disconnect the fuel return hose.



EDM03190241

- 1) Press on the clamps to remove the common rail, injectors, and fuel return hose on the fuel injection pump.
- 2) Disconnect the fuel return hose.
18. Remove the fuel injection pipe.



EDM03190240

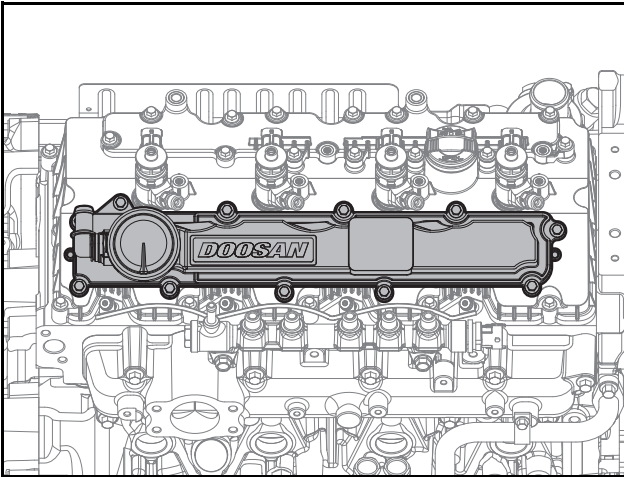
- 1) Loosen the flange hex bolt.
- 2) Loosen the nuts on both ends of the fuel injection pipes and remove the fuel injection pipes.

### CAUTION

**Do not bend the fuel injection pipe by force.**

## 5. General Engine Information

19. Remove the right cylinder head cover.

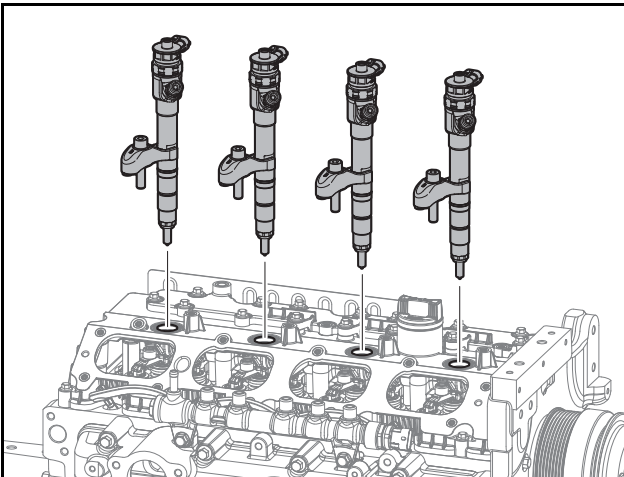


EDM03190245

1) Loosen the flange hex bolts from outside to inside in the direction of the arrow.

2) Remove the right cylinder head cover.

20. Remove the injector.



EDM03190247

1) Loosen the hex bolts.

2) Remove the injector mounting brackets.

3) Remove the injectors.

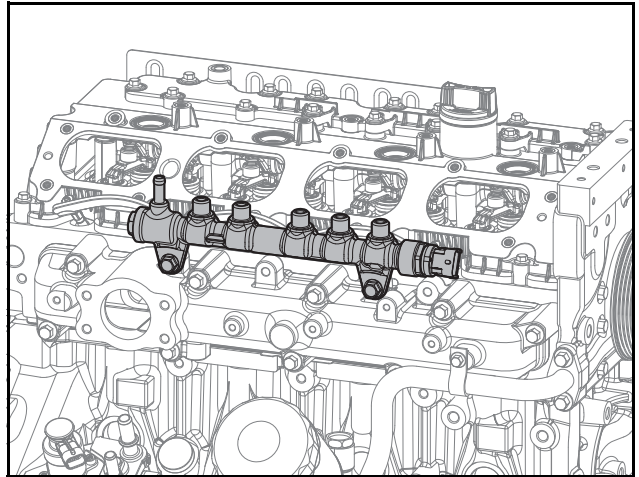
4) Remove the injector sealing washer.

Note: Remove the cylinder head cover and remove the injector sealing washer.

### **⚠ CAUTION**

- Be careful not to damage the injectors during disassembly.
- When removing injectors, be sure to remove them together with the washers so as not to lose them.

21. Remove the common rail.



EDM03190246

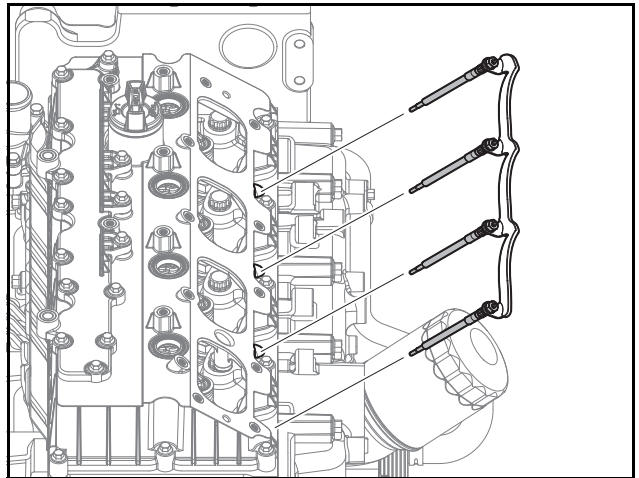
1) Loosen the hex bolts.

2) Remove the common rail from the intake manifold.

### **⚠ CAUTION**

Be careful not to damage the common rail during disassembly.

22. Disconnect the glow plugs.



EDM03190248

1) Loosen 4 hex nuts.

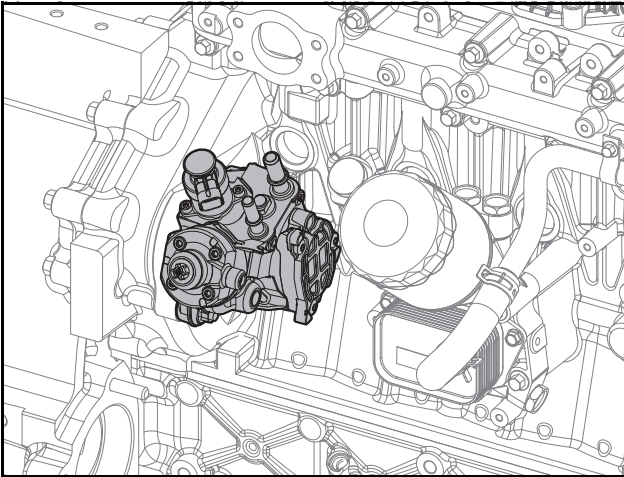
2) Remove the electric connector.

3) Disconnect 4 glow plugs.



## 5. General Engine Information

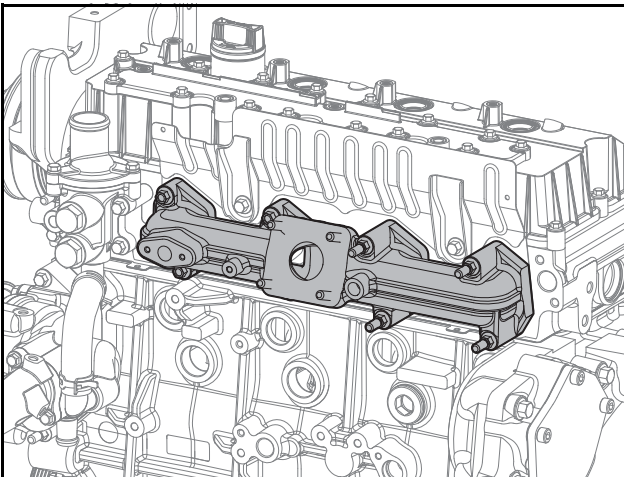
23. Remove the fuel injection pump.



EDM03190249

- 1) Loosen the flange hex bolt.
- 2) Remove the fuel injection pump.

24. Remove the exhaust manifold.



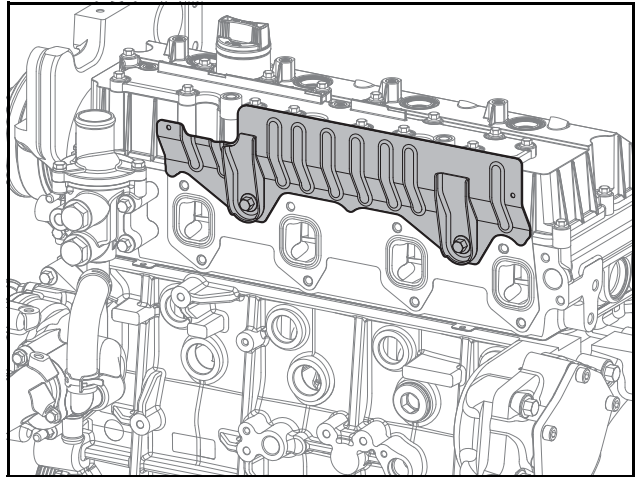
EDM03190250

- 1) Loosen the flange hex bolt.
- 2) Remove the exhaust manifold.

### CAUTION

**Do not reuse exhaust manifold gaskets; replace them with new ones.**

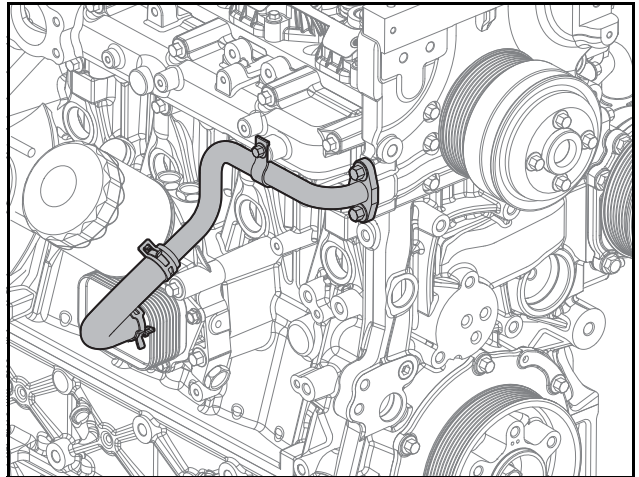
25. Remove the heat shield.



EDM03190251

- 1) Loosen the mounting bolts and remove the heat shield.

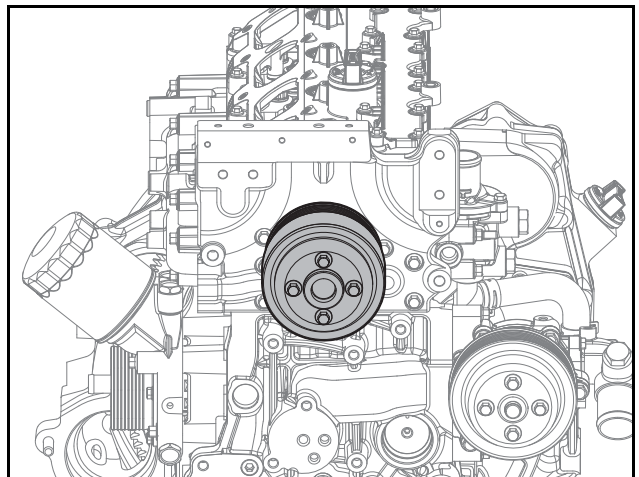
26. Disconnect the coolant pipe & hose.



EDM03190252

- 1) Press on the clamps on both ends of the coolant hoses and disconnect the coolant hoses.
- 2) Loosen the flange hex bolt.
- 3) Remove the coolant pipe.

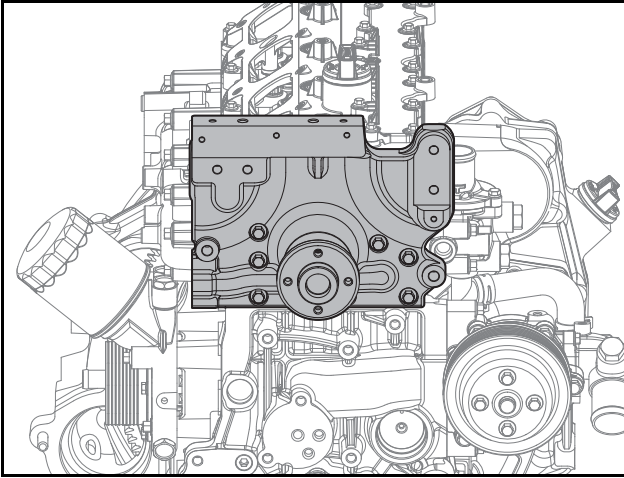
27. Remove the fan pulley.



EDM03190176

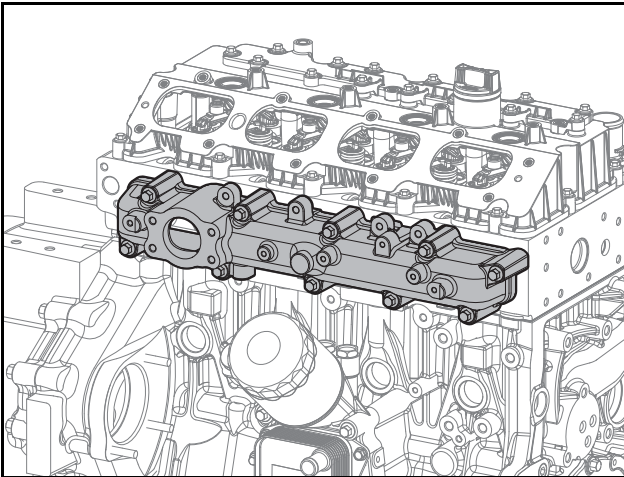
## 5. General Engine Information

- 1) Loosen 4 flange hex bolts.
  - 2) Remove the fan pulley.
28. Remove the fan mounting bracket.



EDM03190175

- 1) Loosen 7 flange hex bolts.
  - 2) Remove the fan mounting bracket.
29. Remove the intake manifold.



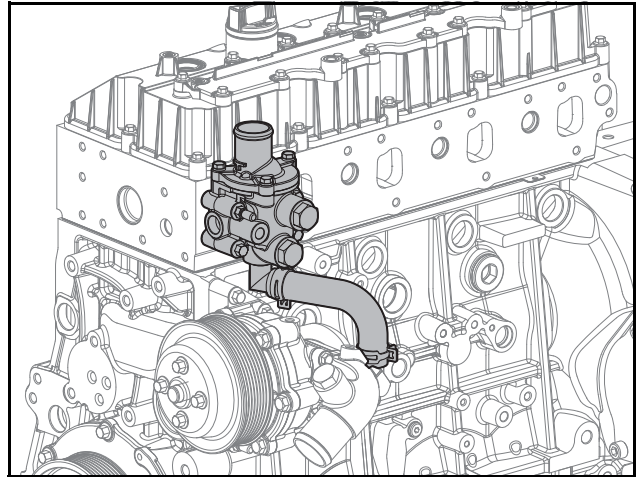
EDM03190173

- 1) Remove the flange hex bolt.
- 2) Remove the intake manifold.
- 3) Remove the intake manifold gasket.

### CAUTION

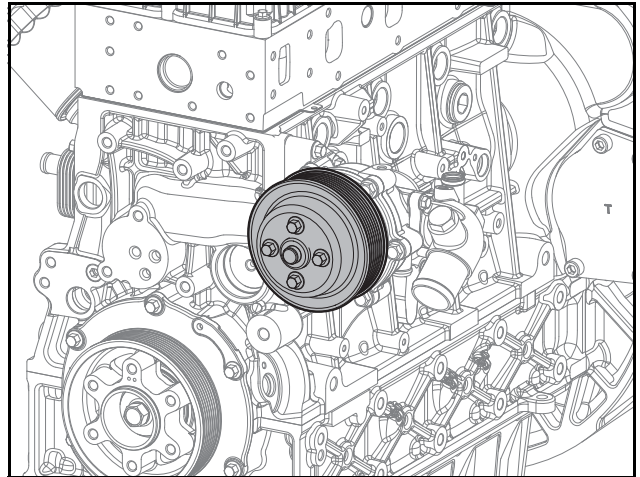
**Do not reuse gaskets; replace them with new ones.**

30. Remove the thermostat.



EDM03190253

- 1) Press on the clamp and disconnect the rubber hose.
  - 2) Remove the spacer bolt.
  - 3) Loosen the flange hex bolt.
  - 4) Remove the thermostat.
31. Remove the coolant pump pulley.



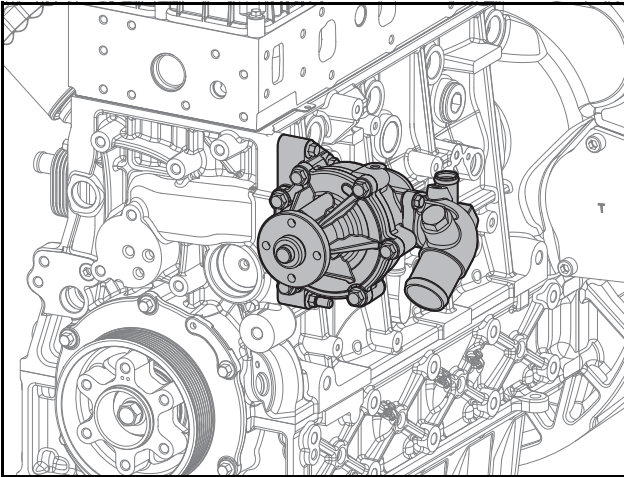
EDM03190254

- 1) Loosen the hex bolts.
- 2) Remove the coolant pump pulley.



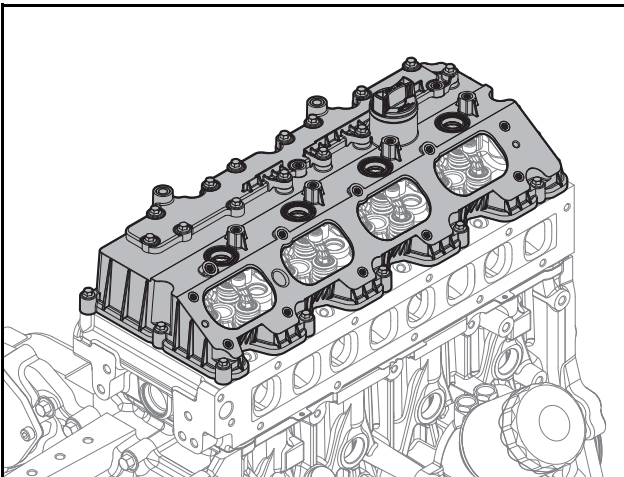
## 5. General Engine Information

32. Remove the coolant pump.



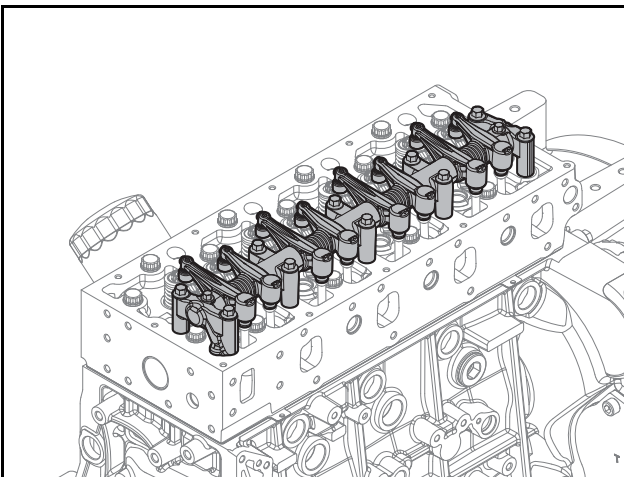
EDM03190255

- 1) Loosen the hex bolts.
  - 2) Remove the coolant pump.
33. Remove the cylinder head cover.



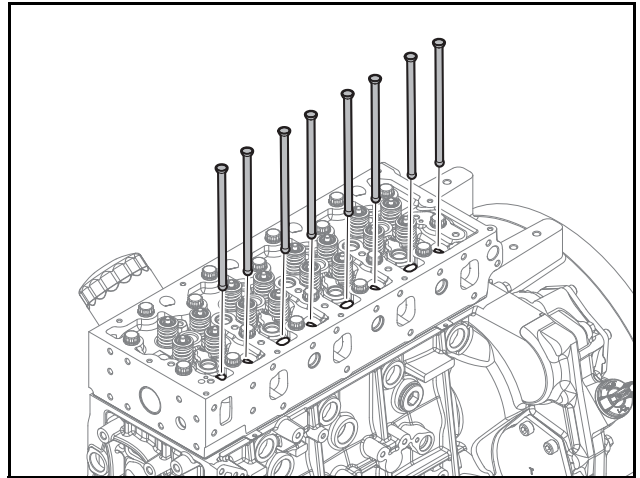
EDM03190169

- 1) Loosen the hex bolts from outside to inside in the direction of the arrow.
  - 2) Remove the cylinder head cover.
34. Remove the rocker arms.



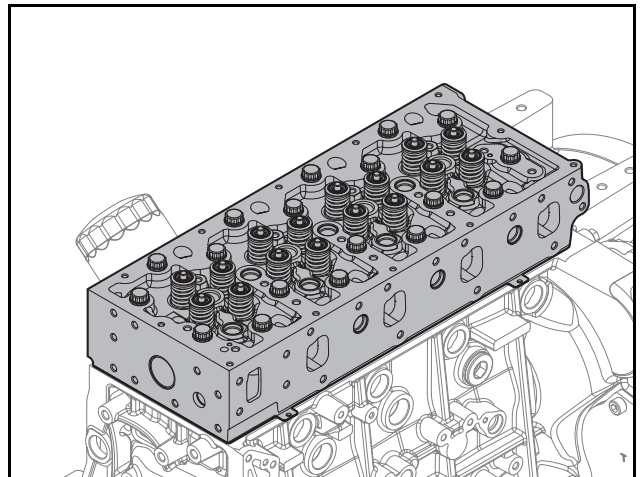
EDM03190168

- 1) Loosen the flange hex bolt.
  - 2) Remove the rocker arms.
35. Disconnect the push rods.



EDM03190167

- 1) Remove the push rods from the holes in the cylinder head.
36. Remove the cylinder head.



EDM03190166

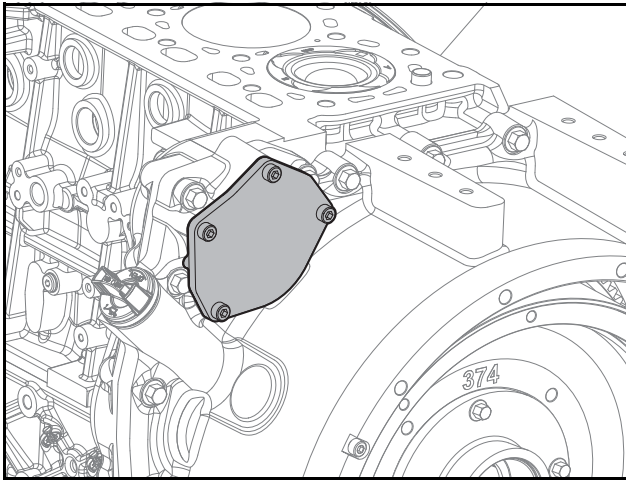
- 1) Remove the cylinder head.
- 2) Remove the cylinder head gasket.

### CAUTION

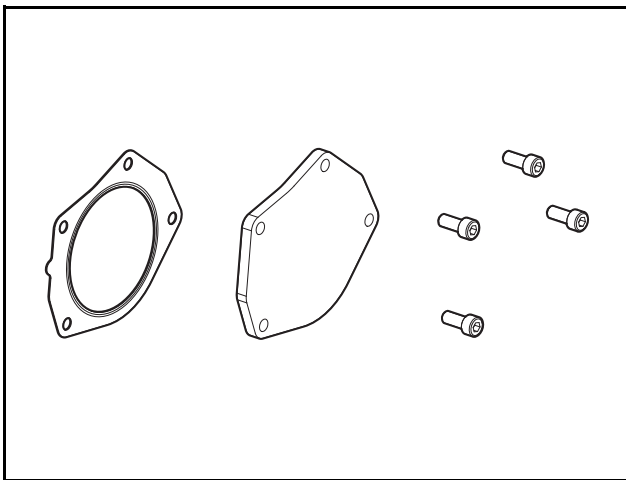
**Do not reuse cylinder head gaskets; replace them with new ones.**

## 5. General Engine Information

37. Remove the front/rear PTO (Power Take Off) cover & gasket.

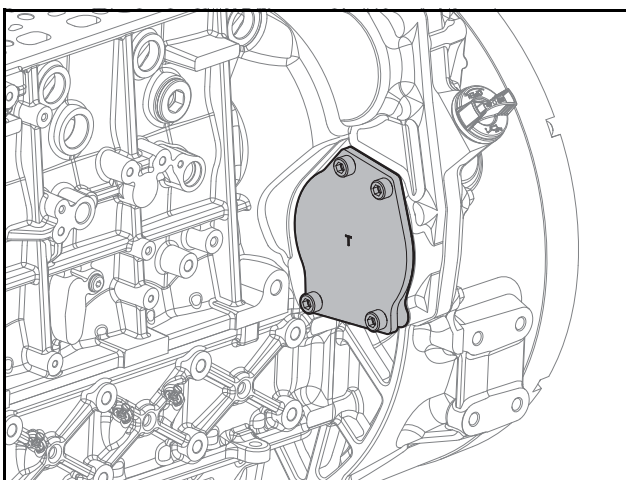


EDM03190257

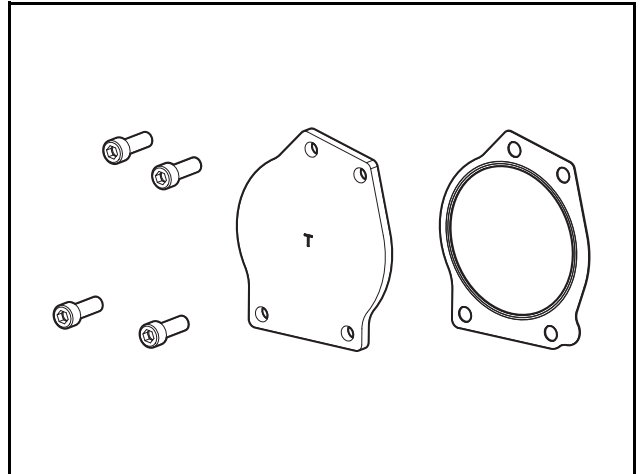


EDM03190319

- 1) Remove 4 inner socket bolts from the front PTO (Power Take Off) cover & gasket.
- 2) Remove the front PTO (Power Take Off) cover & gasket.



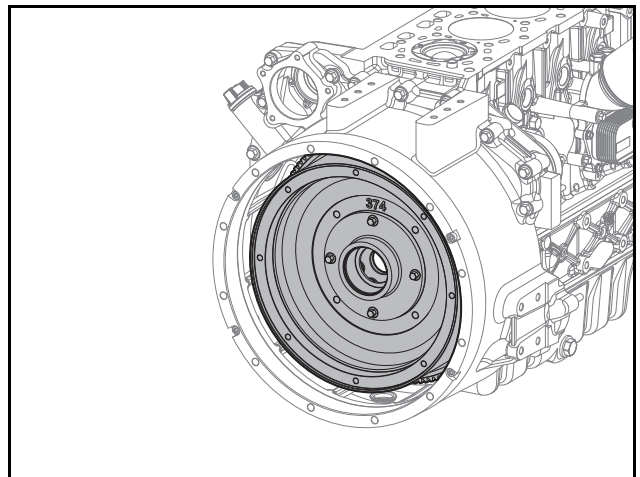
EDM03190256



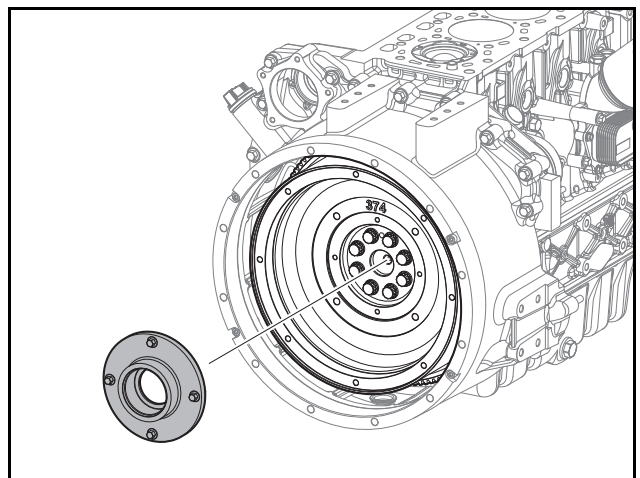
EDM03190320

- 3) Remove 4 inner socket bolts from the rear PTO (Power Take Off) cover & gasket.
- 4) Remove the rear PTO (Power Take Off) cover & gasket.

38. Remove the flywheel.



EDM03190259

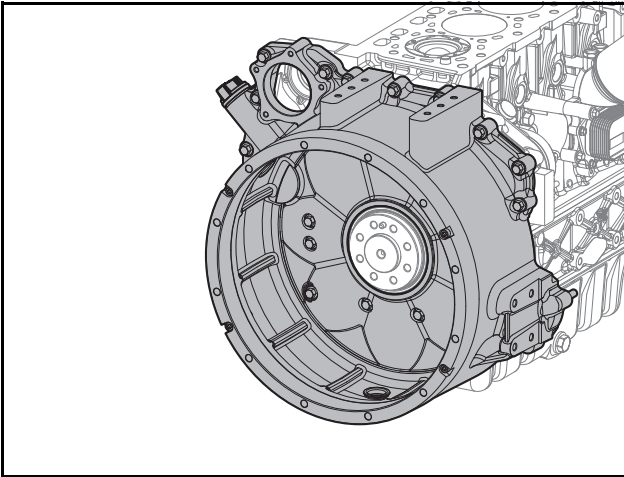


EDM03190260

- 1) Loosen 8 flange hex bolts.
- 2) Remove the flywheel.

## 5. General Engine Information

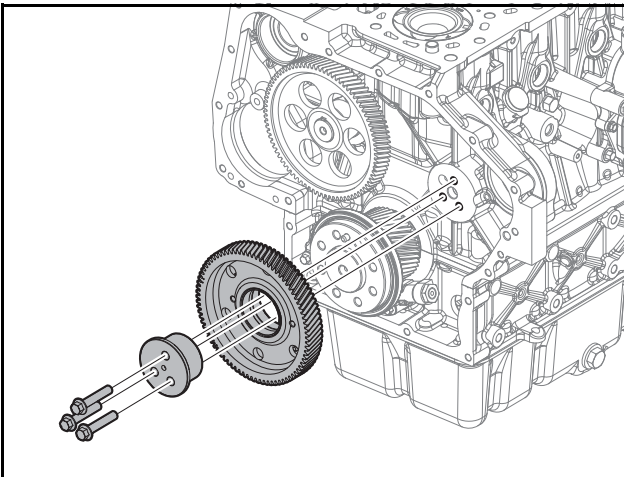
39. Remove the flywheel housing.



EDM03190258

- 1) Loosen the hex bolts.
- 2) Remove the flywheel housing.

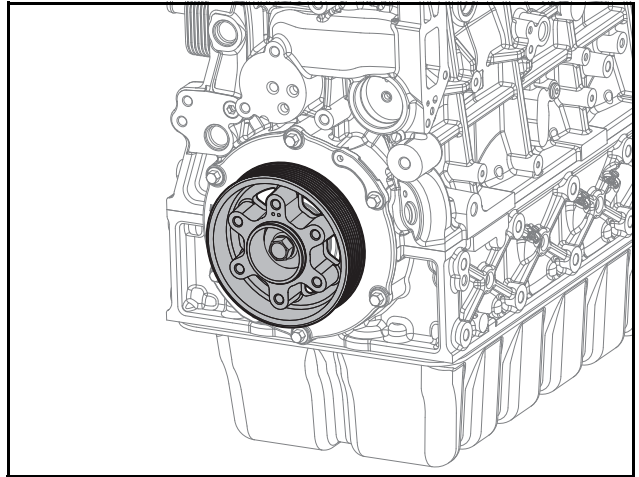
40. Remove the idle gear.



EDM03190261

- 1) Loosen the flange hex bolt.
- 2) Remove the idle gear shaft.
- 3) Use the idle gear removal tab to remove the idle gear.

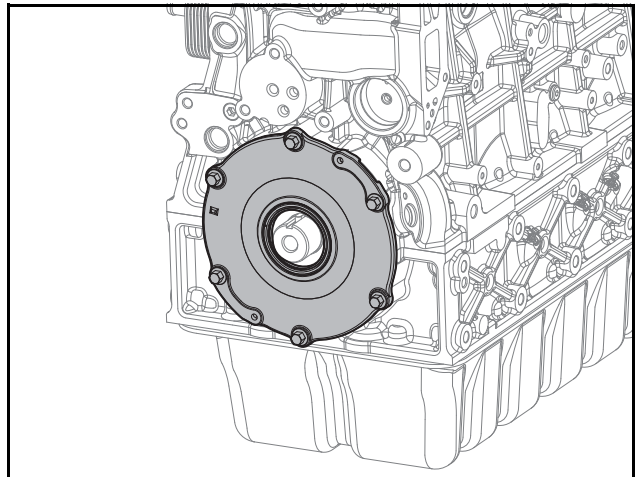
41. Remove the crankshaft pulley.



EDM03190262

- 1) Loosen the flange hex bolts.
- 2) Remove the crankshaft pulley.

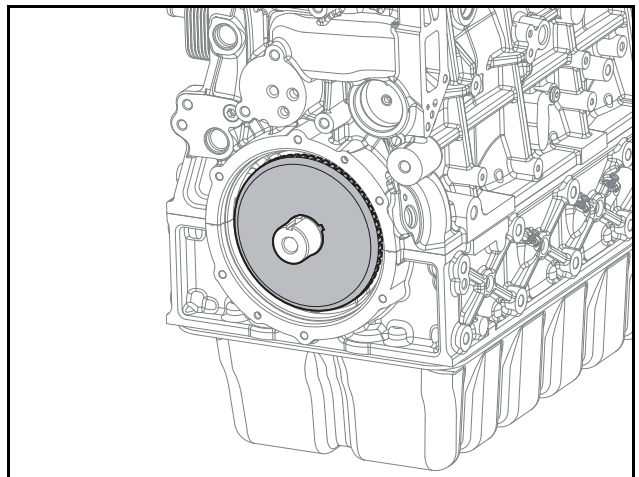
42. Remove the front oil seal holder.



EDM03190141

- 1) Loosen the flange hex bolt.
- 2) Use a screwdriver in the groove to remove the front oil seal holder.

43. Remove the timing wheel.



EDM03190142



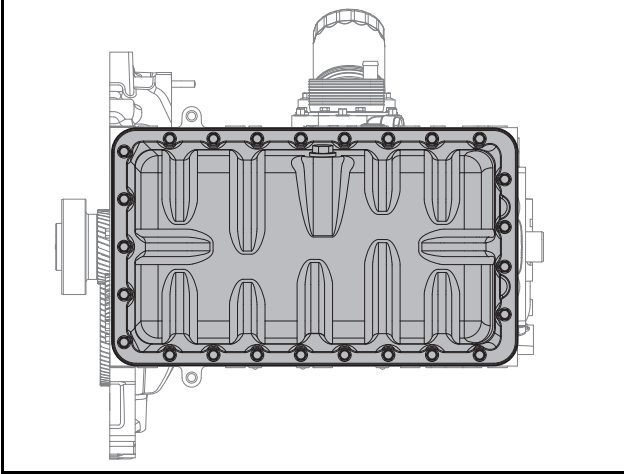
## 5. General Engine Information

- 1) Remove the key.
- 2) Remove the timing wheel.

### CAUTION

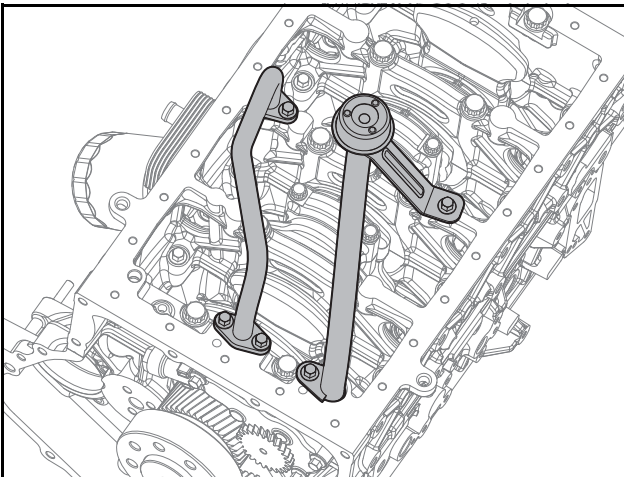
Be careful not to damage the teeth of the timing wheel.

44. Remove the oil pan.



EDM03190182

- 1) Loosen the flange hex bolts from outside to inside in the counterclockwise direction.
  - 2) Remove the oil pan.
45. Remove the oil suction pipe and oil supply pipe.



EDM03190080

- 1) Loosen the hex bolts.
- 2) Remove the oil suction pipe and O-ring.

### CAUTION

Be careful not to damage the O-rings during disassembly.

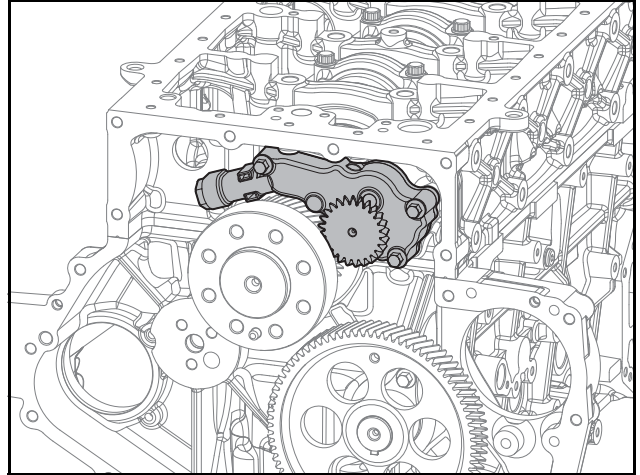
- 3) Loosen the flange hex bolt.

- 4) Remove the oil supply pipe and O-rings.

### CAUTION

Be careful not to damage the O-rings during disassembly.

46. Remove the oil pump.



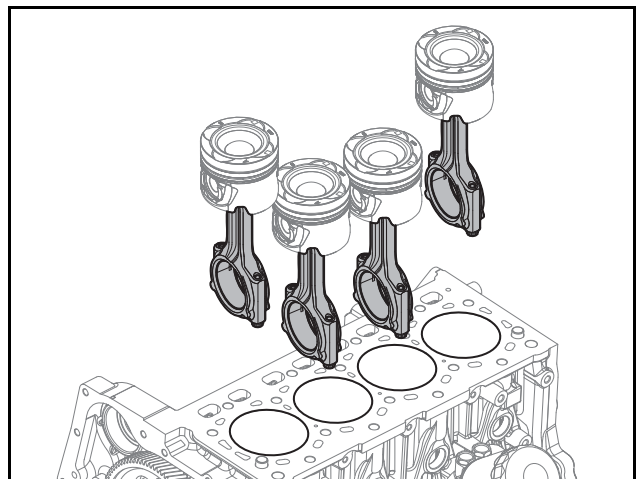
EDM03190139

- 1) Loosen the hex bolts.
- 2) Remove the oil pump.

### CAUTION

Be careful not to damage the O-rings during disassembly.

47. Disconnect the connecting rod.



EDM03190263

- 1) Loosen the connecting rod bolts.
- 2) Remove the connecting rod caps.

## 5. General Engine Information

- 3) Disconnect the connecting rod from the cylinder block.

### **⚠ CAUTION**

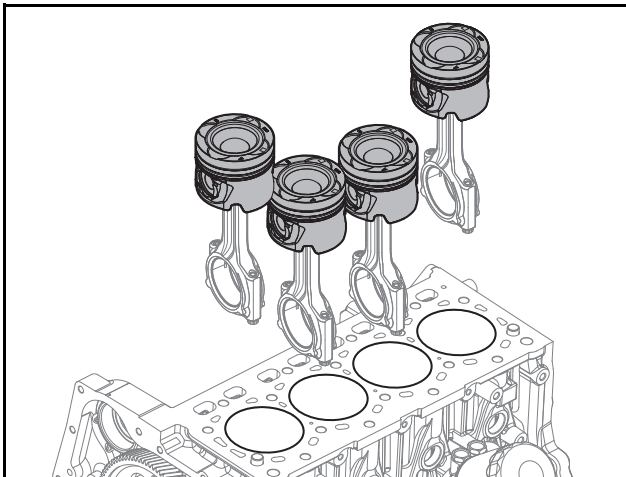
**Be careful not to damage the piston and the piston rings.**

- 4) Disconnect the lower connecting rod bearing from the connecting rod cap.
- 5) Disconnect the upper connecting rod bearing from the connecting rod.

### **⚠ CAUTION**

**Store the connecting rods and connecting rod caps carefully so as not to mix up the order.**

48. Remove the pistons.



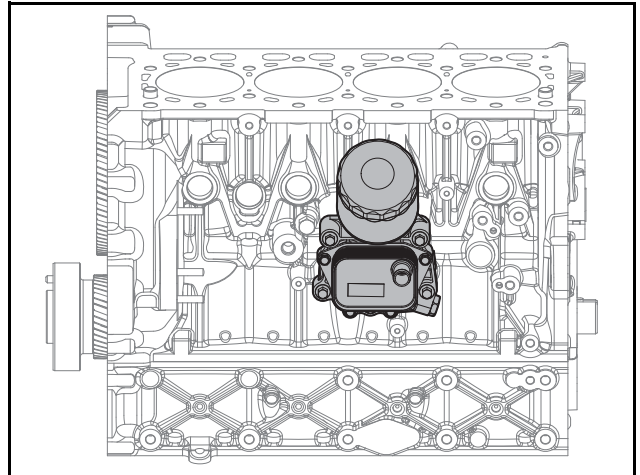
EDM03190264

- 1) Remove the snap rings on both sides of the piston.
- 2) Remove the piston pins.
- 3) Remove the piston from the connecting rod small end.

### **⚠ CAUTION**

- **Ensure that the protruding parts of the piston and connecting rod face the same direction when storing them.**
- **Be careful not to mix up the connecting rod, pistons, piston pins and snap rings when storing them.**

49. Detach the oil cooler and the oil filter module.



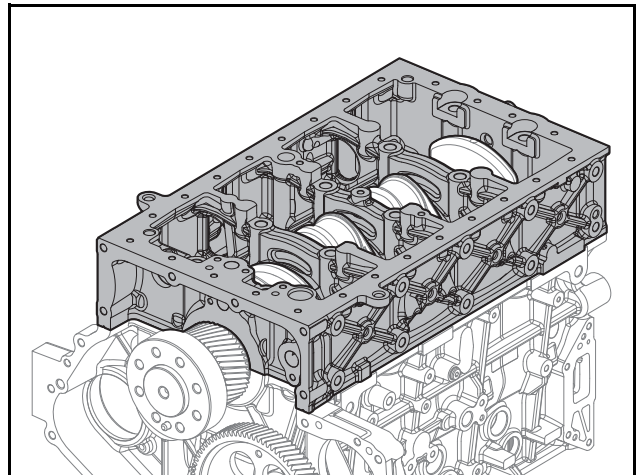
EDM03190136

- 1) Loosen the flange hex bolt.
- 2) Remove the oil filter assembly.

### **⚠ CAUTION**

- **Be careful not to damage the O-rings during disassembly.**
- **When removing the oil filter, oil inside the filter may leak out of the filter so use a cloth to avoid contaminating nearby parts. After replacing the oil filter, be sure to completely wipe off any oil spilled nearby.**

50. Remove the main bearing cap bolts & the crank case.



EDM03190135

- 1) Loosen the hex bolts from outside to inside in the counterclockwise direction.

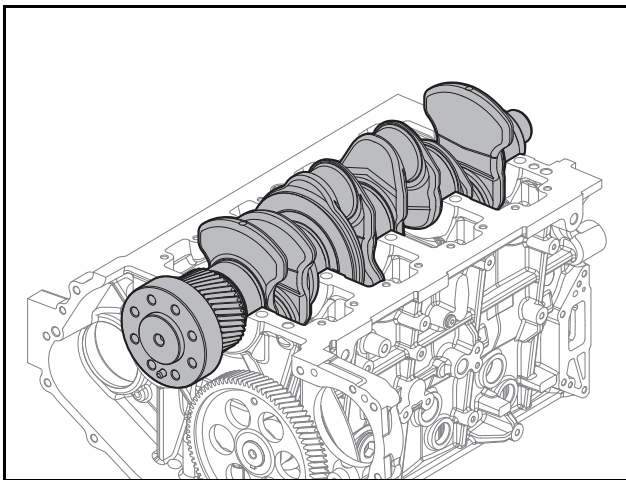
## 5. General Engine Information

- 2) Loosen the main bearing cap bolts from outside to inside in the counterclockwise direction.

### CAUTION

- Do not loosen the hex bolts and main bearing cap bolts at once; loosen them in several turns.
- Remove the main bearing cap bolts after removing the hex bolts.
- Do not reuse main bearing cap bolts; replace them with new ones.

- 3) Remove the crank case from the cylinder block.
51. Remove the crankshaft.



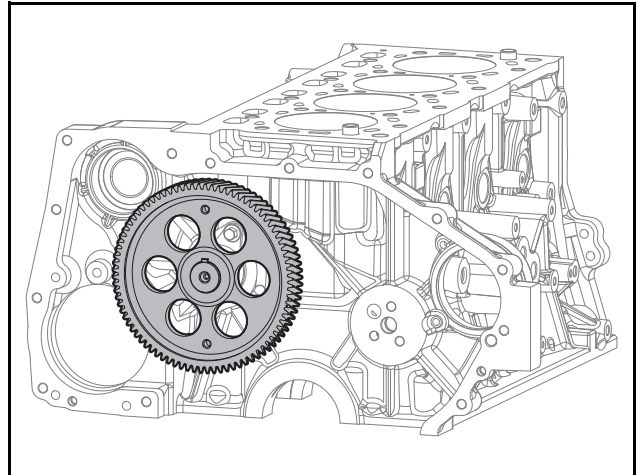
EDM03190134

- 1) Remove the crankshaft from the cylinder block.
- 2) Remove the thrust bearings from the cylinder block.
- 3) Remove the top main bearings from the cylinder block.

### CAUTION

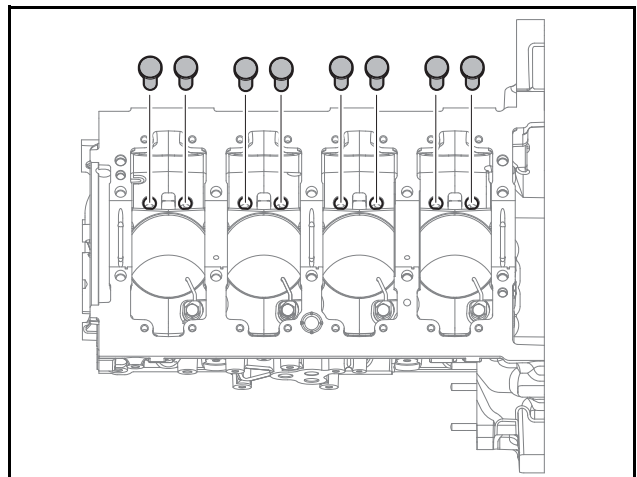
The top main bearings have a groove inside the bearings and the bottom main bearings do not have a groove inside the bearings.

52. Remove the camshaft.



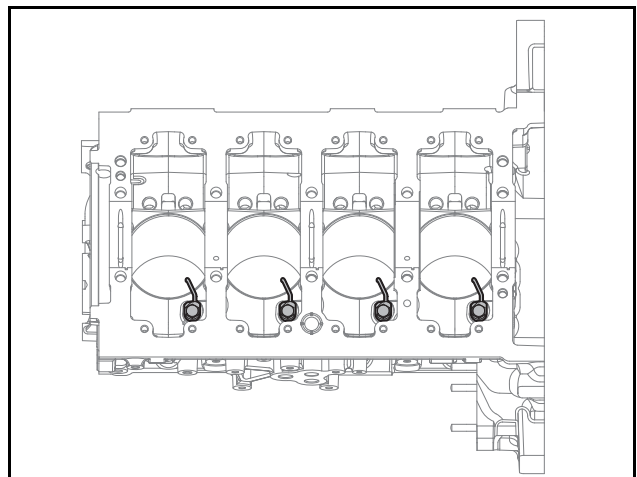
EDM03190133

- 1) Loosen the hex bolts.
- 2) Remove the camshaft.
53. Remove the valve tappet.



EDM03190132

- 1) Remove the valve tappets from the cylinder block.
54. Disconnect the oil spray nozzles.



EDM03190131

- 1) Remove the relief valves.
- 2) Remove the oil spray nozzles.

## 5. General Engine Information

### Assembling the Engine

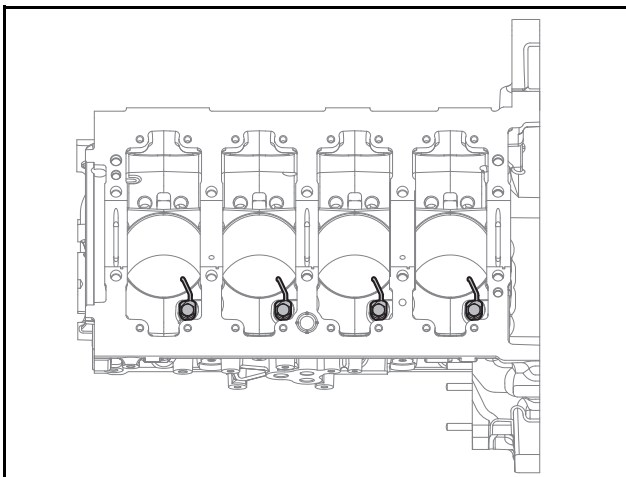
#### Order of Engine Assembly

#### CAUTION

- Clean all the removed components thoroughly. In particular, clean the oil and coolant passages with compressed air and check if there is any resistance.
- Organize general tools and special service tools for engine assembly.
- Prepare clean engine oil to be applied to each sliding section.
- Prepare service items, such as sealant and gaskets.
- Used gaskets, seal rings and consumable parts should be replaced with new ones.
- Each bolt should be tightened to their specified torque in order and should not be over-tightened.
- After installing engine components, check that they work properly.
- After the primary assembly, check each bolt for looseness.
- Keep your hands clean at all times while working.

Assemble the engine in the following order.

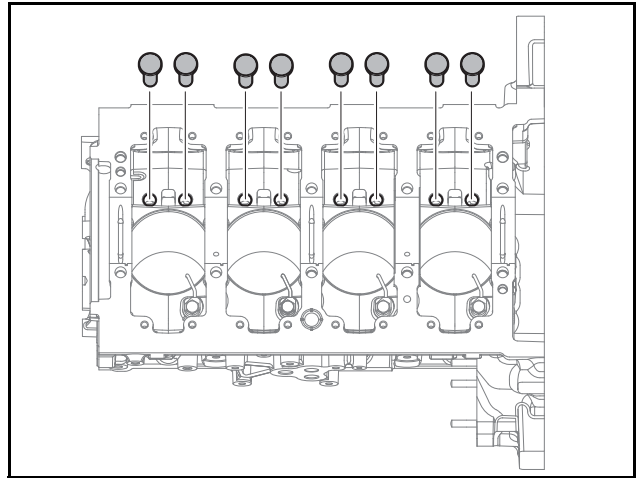
1. Assemble the oil spray nozzles.



EDM03190131

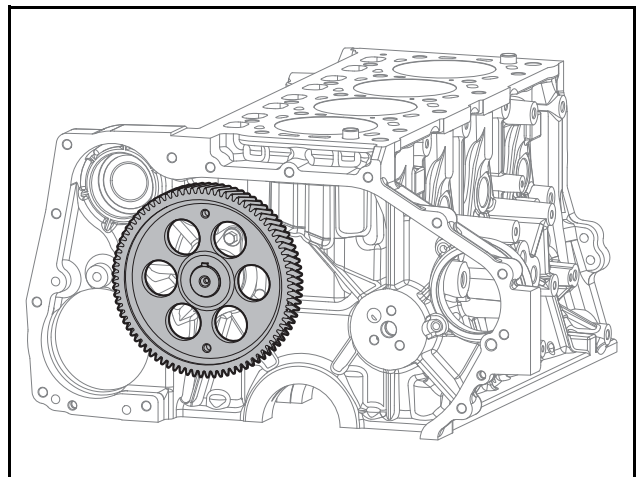
- 1) Align the oil spray nozzles with the pins to assemble them.
- 2) Tighten the relief valves to a tightening torque of 2.0 kgf·m.

2. Assemble the valve tappet.



EDM03190132

- 1) Apply engine oil to the surface where the cylinder block and the valve tappets are assembled.
- 2) Assemble the valve tappets.
3. Assemble the camshaft.



EDM03190133

- 1) Apply engine oil in the cam hole of the cylinder block.
- 2) Apply engine oil to the journal of the camshaft.

#### CAUTION

**Check for any abnormalities inside the camshaft journal and the cylinder block bushing.**

- 3) Align the camshaft thrust washer with the cylinder block.
- 4) After first temporarily assembling one hex bolt, rotate the camshaft gear and assemble the other hex bolt.
- 5) Tighten the hex bolts to a tightening torque of 2.2 kgf·m.

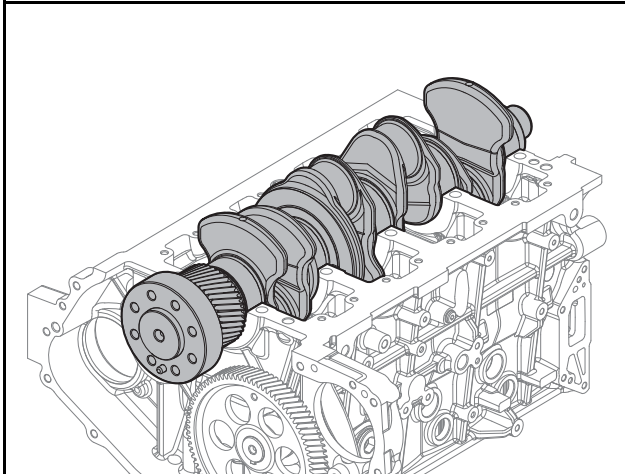


## 5. General Engine Information

6) The camshaft end play is 0.1 ~ 0.2 mm.

Item	Specified value
Camshaft end play	0.1 ~ 0.2 mm

4. Assemble the crankshaft.



EDM03190134

1) Mount the top main bearings on the cylinder block.

### **⚠ CAUTION**

- The top main bearings have a groove inside the bearings and the bottom main bearings do not have a groove inside the bearings.
- Remove foreign matter such as residues and sealant (TB1217H) from the inside of the main bearings and the oil seal assembly outside diameter.
- Do not apply engine oil to the assembly surface of the cylinder block and main bearings.
- The class of main bearing bore inside diameter of the cylinder block is engraved on the cylinder block and the class of main journal diameter of the crankshaft is engraved on the crankshaft. For the locations of the engravings, refer to the engine serial number in Chapter 3 Performance and Specifications.
- Check or measure the class of the main bearing bore inside diameter of the cylinder block and the main journal diameter of the crankshaft to select and assemble the main bearing with the right class.
- The main bearings are classified with colors depending on their thickness. Use top main bearings and bottom main bearings of the same color.

- 2) Apply sufficient engine oil to the assembly surface of the top main bearings and the crankshaft.
- 3) Install the crankshaft.

4) Mount the thrust washers on the front and back of the diameter of the second crankshaft main journal at the back of the engine.

### **⚠ CAUTION**

**Align the key groove of the cylinder block with the key of the thrust washers.**

Note: The classes of the main bearings are as follows.

Inside diameter of cylinder block main bearing bore	Diameter of the crankshaft main journal		
	Class A	Class B	Class C
Class A	Yellow	Blue	Blue
Class B	Yellow	Yellow	Blue
Class C	Red	Red	Yellow

Cylinder block inside diameter of the main bearing bore	Specified value
Class A	79.000 ~ 79.007 mm
Class B	79.007 ~ 79.014 mm
Class C	79.014 ~ 79.021 mm

Note: For the method of measuring the inside diameter of the cylinder block main bearing bore, refer to Chapter 11 Cylinder Block/Head.

Diameter of the crankshaft main journal	Specified value
Class A	74.955 ~ 74.960 mm
Class B	74.960 ~ 74.965 mm
Class C	74.965 ~ 74.970 mm

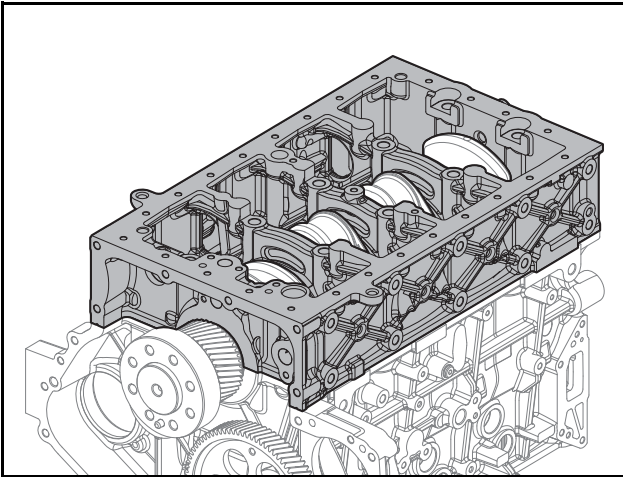
Note: For the method of measuring the diameter of the crankshaft main journal, refer to Other/Driving System.

Thickness of main bearing	Specified value
Blue	1.995 ~ 2.000 mm
Yellow	2.000 ~ 2.005 mm
Red	2.005 ~ 2.010 mm



## 5. General Engine Information

5. Mount the main bearing cap bolts & the crank case.

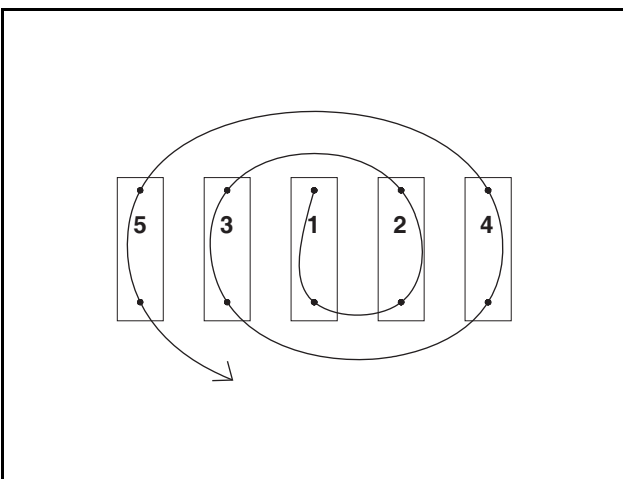


EDM03190135

- 1) On the assembly surface of the crank case, apply sealant (TB1217H) with a diameter of  $\varnothing 3 \pm 0.5$  mm to the front of the engine and with a diameter of  $\varnothing 6 \pm 0.5$  mm to the back of the engine.
- 2) Assemble the crank case with the cylinder block.

### **CAUTION**

- Pay attention to the direction of the cylinder block and crank case during assembly.
- Assemble within 5 minutes of applying sealant (TB1217H).
- Do not start the engine or apply pressure within 25 minutes of applying sealant (TB1217H).
- Apply the sealant (TB1217H) which was previously applied.



EPM02190075

- 3) Temporarily mount the main bearing cap bolts from inside to outside in the clockwise direction.
- 4) Use the angle tightening method to tighten the main bearing cap bolts from inside to outside in the clockwise direction at a tightening torque of  $5.5 \text{ kgf}\cdot\text{m} + 90^\circ + 90^\circ$ .

### Angle tightening method for main bearing cap bolts

Stage 1	Tightening torque of $5.5 \text{ kgf}\cdot\text{m}$
Stage 2	$90^\circ$ rotation
Stage 3	$90^\circ$ rotation

### **CAUTION**

- Tighten the main bearing cap bolts with the angle tightening method.
  - Mount the main bearing cap bolts and then mount the hex bolts.
  - Do not reuse main bearing cap bolts; replace them with new ones.
- 5) Temporarily assemble the hex bolts in the clockwise direction.
  - 6) Tighten the hex bolts in the clockwise direction to a tightening torque of  $2.2 \text{ kgf}\cdot\text{m}$ .

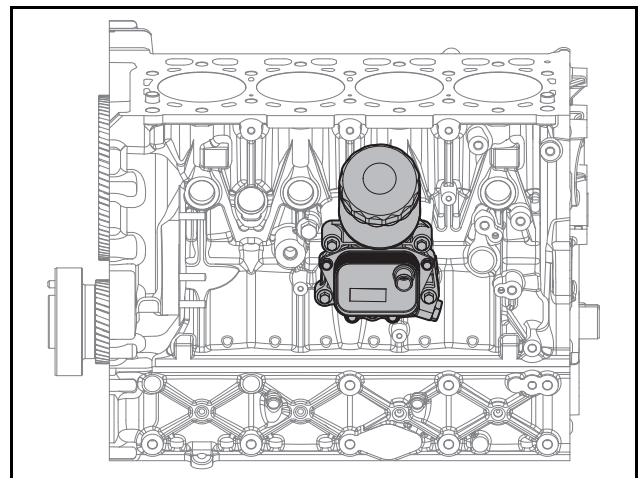
### **CAUTION**

After mounting the main bearing cap bolts and the hex bolts, rotate the crankshaft 2 to 3 times to check for any abnormalities.

- 7) The crankshaft end play is  $0.1 \sim 0.31$  mm.

Item	Specified value
Crankshaft end play	$0.1 \sim 0.31$ mm

6. Assemble the oil cooler and the oil filter module.



EDM03190136

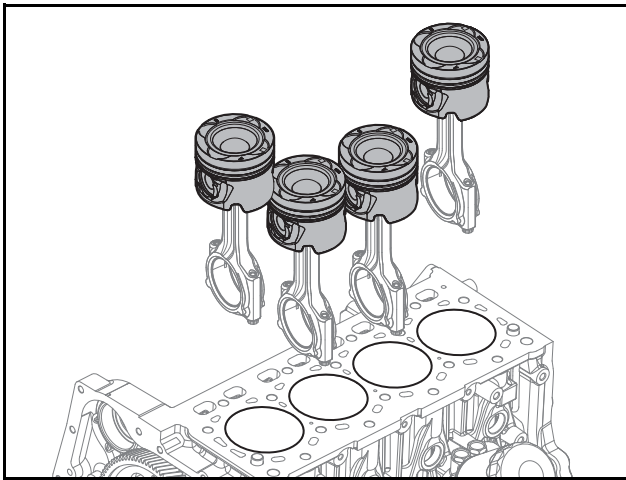
## 5. General Engine Information

- 1) Assemble the oil filter assembly.

### **⚠ CAUTION**

- Check whether the O-rings have been assembled with the oil filter assembly.
- Be careful not to damage the O-rings during assembly.

- 2) Tighten the flange hex bolts to a tightening torque of 2.2 kgf·m.
7. Assemble the pistons.



EDM03190264

- 1) Ensure that the protruding parts of the piston and connecting rod face the same direction.

### **⚠ CAUTION**

- Pay attention to the direction of the piston and connecting rod.
- Assemble the protruding parts of the piston and connecting rod to face the same direction and make sure that they face the front of the cylinder block.

- 2) Assemble the piston with the connecting rod small end.
- Note: The classes of the cylinder block and the piston are as follows.

Inside diameter of cylinder block piston bore	Piston	
	Class A	Class B
Class A	○	-
Class B	-	○

Inside diameter of cylinder block piston bore	Specified value
Class A	97.990 ~ 98.000 mm
Class B	98.000 ~ 98.010 mm

Note: For the method of measuring the inside diameter of the cylinder block piston bore, refer to Chapter 11 Cylinder Block/Head.

Piston	Specified value
Class A	97.920 ~ 97.930 mm
Class B	97.930 ~ 97.940 mm

Note: The piston class is engraved on the top of the piston.

### **⚠ CAUTION**

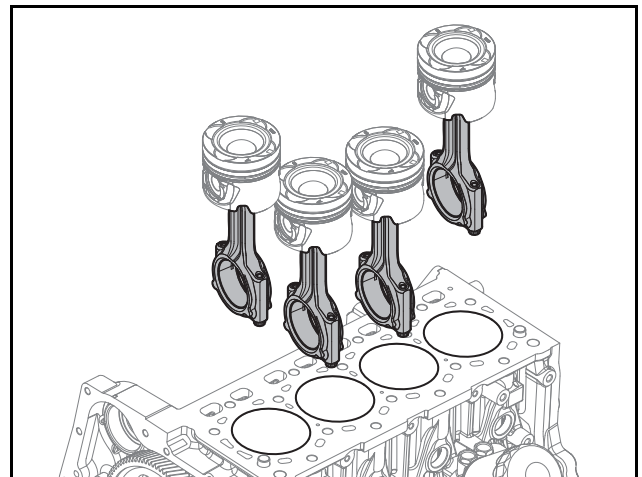
- The class of the inside diameter of the cylinder head piston bore is engraved on the cylinder block, and the piston class is engraved on the top of the piston. For the locations of the engravings, refer to the engine serial number in Chapter 3 Performance and Specifications.
- Assemble the same class of cylinder block piston bore inside diameter and piston.

- 3) Apply engine oil to the piston pin and assemble it.
- 4) Mount the snap rings on both sides of the piston so that the open part faces the 12 o'clock direction.

### **⚠ CAUTION**

**Do not reuse snap rings; replace them with new ones.**

8. Assemble the connecting rod.



EDM03190263

## 5. General Engine Information

- 1) Mount the upper connecting rod bearing on the connecting rod.
- 2) Mount the lower connecting rod bearing on the connecting rod cap.

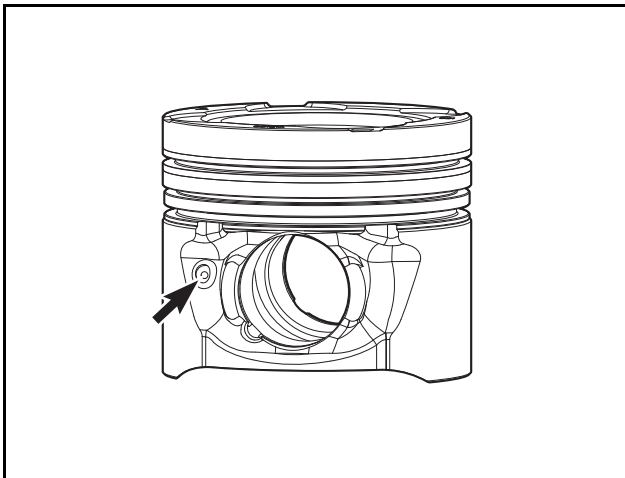
### **⚠ CAUTION**

- Assemble both upper and lower connecting rod bearings with the yellow-marked class.
- Do not apply engine oil to the assembly of the connecting rod and bearing.

Note: The thickness of the connecting rod bearings is as follows.

Thickness of connecting rod bearing	Specified value
Yellow	1.497 ~ 1.502 mm

- 3) Apply sufficient engine oil to the inside of the cylinder block bore and the inside of the connecting rod bearings.
- 4) Use a piston inserter to assemble the piston and connecting rod with the cylinder block.



EDM03190318

### **⚠ CAUTION**

- Make sure that the protruding parts of the piston and connecting rod face the front of the engine when assembling them. The part with the crankshaft pulley is the front of the engine.
- Be careful not to damage the piston and the piston rings.

- 5) Assemble the connecting rod caps.

### **⚠ CAUTION**

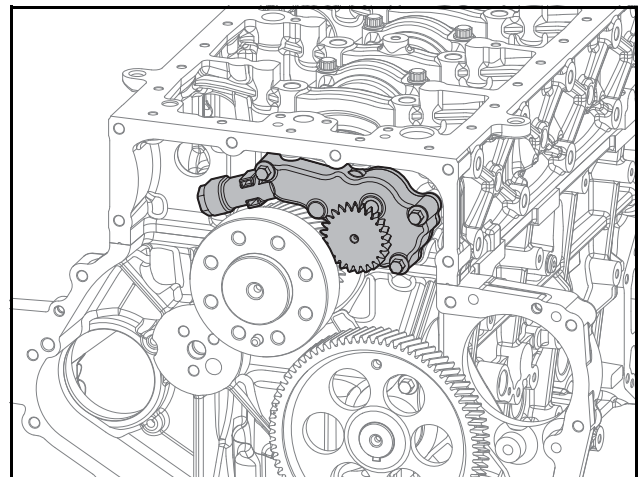
- Be careful to mind the direction of the connecting rods and the connecting rod caps.
- Assemble the connecting rods and connecting rod caps so that the numbers engraved on them are the same and in the same direction.

- 6) Temporarily tighten the connecting rod bolts by hand.
- 7) Use the angle tightening method to tighten the connecting rod bolts to a tightening torque of 3.0 kgf·m + 90°.

#### Angle tightening method for connecting rod bolts

Stage 1	Tightening torque of 3.0 kgf·m
Stage 2	90° rotation

9. Assemble the oil pump.



EDM03190139

- 1) Align the O-rings with the engine oil inlet and outlet.
- 2) Align the oil pump with the pin and push it into the cylinder block as far as possible to assemble it.
- 3) Tighten the hex bolts to a tightening torque of 2.2 kgf·m.
- 4) The backlash between the crankshaft gear and the oil pump gear is 0.066 ~ 0.247 mm.

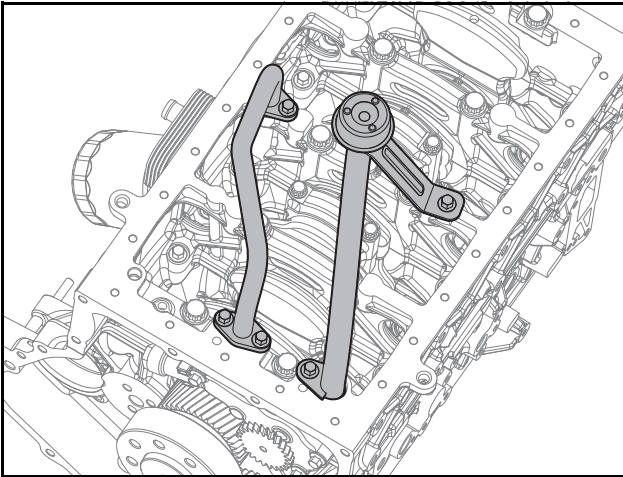
Item	Specified value
Backlash between crankshaft gear	0.066 ~ 0.247 mm
Oil pump gear backlash	

### **⚠ CAUTION**

- Be sure to check whether the O-rings have been assembled.
- Be careful not to damage the O-rings during assembly.

## 5. General Engine Information

10. Assemble the oil suction pipe and oil supply pipe.



EDM03190080

1) Assemble the O-rings.

### **⚠ CAUTION**

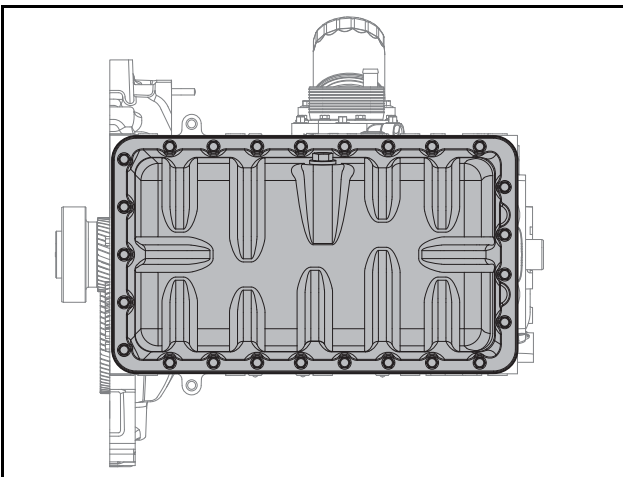
- Check whether the O-rings have been assembled.
- Be careful not to damage the O-rings during assembly.

- 2) Assemble the oil supply pipe.
- 3) Tighten the flange hex bolt.
- 4) Assemble the O-ring.
- 5) Assemble the oil suction pipe.
- 6) Tighten the hex bolt to a tightening torque of 2.2 kgf·m.

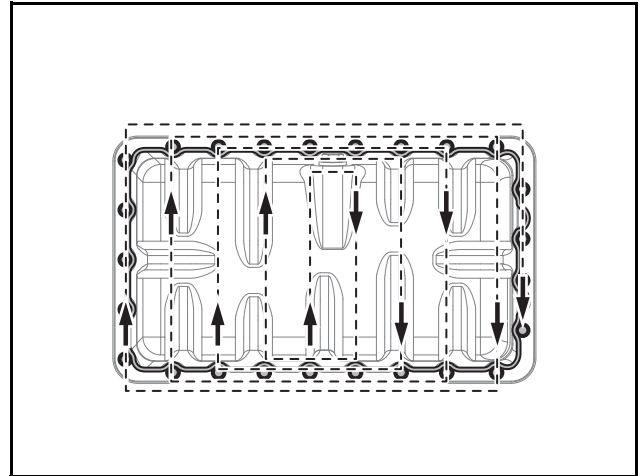
### **⚠ CAUTION**

- Check whether the O-rings have been assembled.
- Be careful not to damage the O-rings during assembly.

11. Assemble the oil pan.



EDM03190182



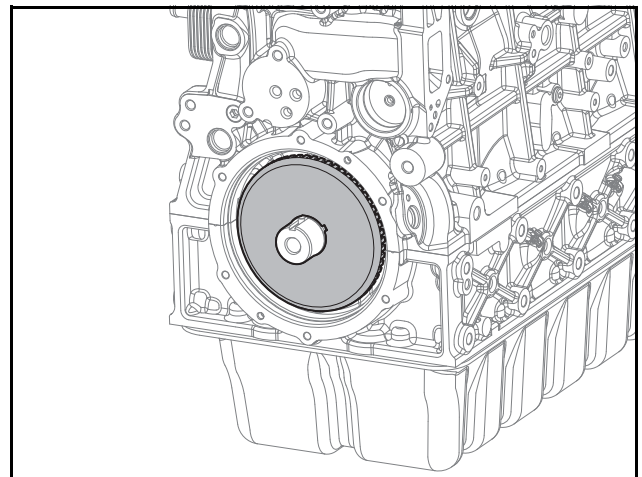
EDM03190129

- 1) Before installing the oil pan, apply sealant (TB1217H) at an offset of 1 mm to the chamfered end of the sealing surface.
- 2) Apply it with a diameter of  $\varnothing 2.5 \pm 0.5$  mm at a 1 mm offset to the chamfered end.

### **⚠ CAUTION**

- Pay attention to the assembled direction of the oil pan.
- Assemble within 5 minutes of applying sealant (TB1217H).
- Do not start the engine or apply pressure within 25 minutes of applying sealant (TB1217H).

- 3) Assemble the oil pan.
  - 4) Temporarily mount the flange hex bolts from inside to outside in the clockwise direction.
  - 5) Tighten the flange hex bolts from inside to outside in the clockwise direction at a tightening torque of 2.2 kgf·m.
12. Assemble the timing wheel.



EDM03190142



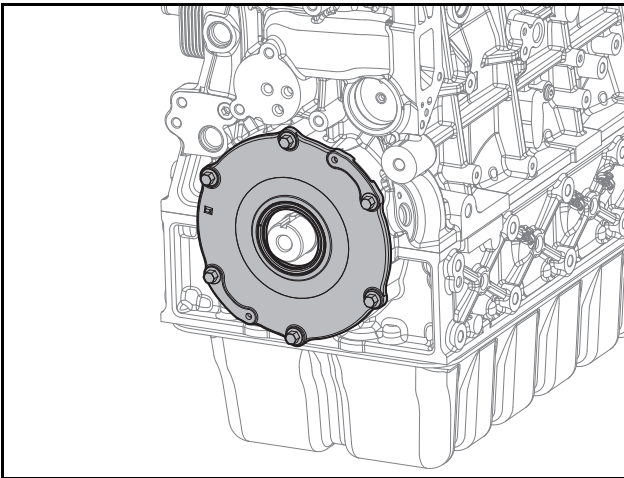
## 5. General Engine Information

- 1) Align the timing wheel with the dowel pin and assemble it with the surface of the crankshaft.
- 2) Assemble the key.

### CAUTION

- Be careful not to damage the teeth of the timing wheel.
- Assemble it so that the toothless part of the timing wheel faces the 7 o'clock direction at the front of the engine.

13. Assemble the front oil seal holder.



EDM03190141

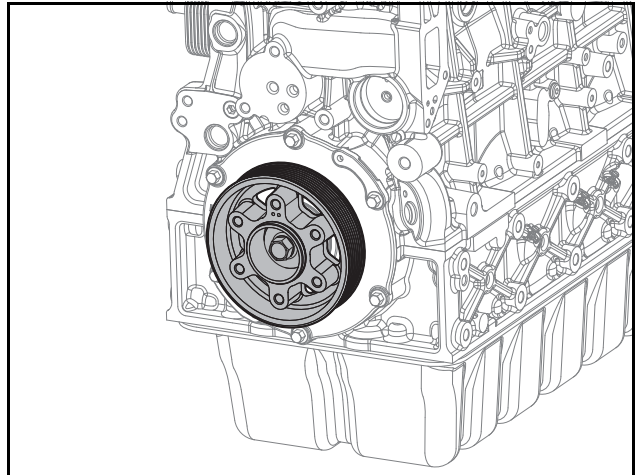
- 1) Remove any foreign matter from the assembly surface of the front oil seal holder and wipe it clean with a dry cloth.
- 2) The sealant which had been applied before the assembly must be removed. Be careful when removing the sealant as damaging the oil seal holder may cause oil leaks.
- 3) Apply sealant to the assembly surface of the front oil seal holder with a diameter of  $\varnothing 2.5 \pm 0.5$  mm.

### CAUTION

- Pay attention to the assembly direction of the front oil seal holder.
- Assemble within 5 minutes of applying sealant (TB1217H).
- Do not start the engine or apply pressure within 25 minutes of applying sealant (TB1217H).

- 4) Align the front oil seal holder with the dowel pin and assemble it.
- 5) Tighten the flange hex bolt to a tightening torque of 2.2 kgf·m.

14. Assemble the crankshaft pulley.



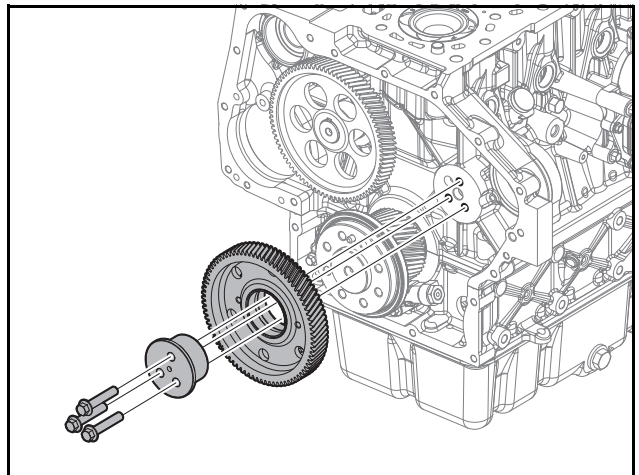
EDM03190262

- 1) Align the crankshaft pulley with the key to assemble it.
- 2) Tighten the flange hex bolt to a tightening torque of 26 kgf·m.
- 3) Connect crankshaft pulley.
- 4) Tighten the hex bolts to a tightening torque of 2.2 kgf·m.

### CAUTION

- Be careful not to damage the oil seals.
- Mount the crankshaft so that the flange hex bolts can be installed at the specified torque.

15. Assemble the idle gear.



EDM03190261

- 1) Line up the idle gear and camshaft engravings.

### CAUTION

There are 2 markings on the idle gear engraving and the camshaft gear engraving

## 5. General Engine Information

- 2) Make sure that the engraving on the crankshaft gear is between the engravings on the idle gear.

### CAUTION

- There are 4 markings on the idle gear engravings.
- There is one engraved marking on the 4th tooth of the crankshaft with the crankshaft gear key groove in the 12 o'clock direction.

- 3) Align the idle gear with the engraved marking and assemble it.

### CAUTION

**Make sure that the direction of the engraved marking on the idle gear faces outside the engine during assembly.**

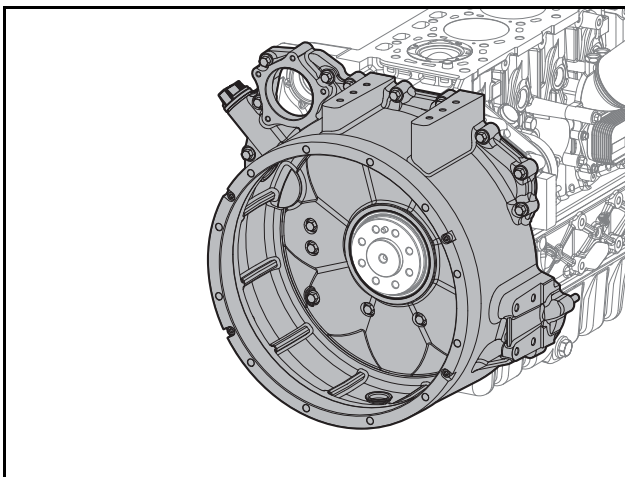
- 4) Make sure that the oil hole in the idle gear shaft faces upwards when assembling it.
- 5) Align the flange hex bolts with the holes in the idle gear shaft and temporarily assemble them.
- 6) Tighten the flange hex bolts to a tightening torque of 4.4 kgf·m.
- 7) The backlash between the idle gear and the crankshaft gear is 0.087 ~ 0.202 mm.

Item	Specified value
Backlash between idle gear and crankshaft gear	0.087 ~ 0.202 mm

- 8) The backlash between the idle gear and the camshaft gear is 0.087 ~ 0.213 mm.

Item	Specified value
Backlash between idle gear and camshaft gear	0.087 ~ 0.213 mm

16. Assemble the flywheel housing.



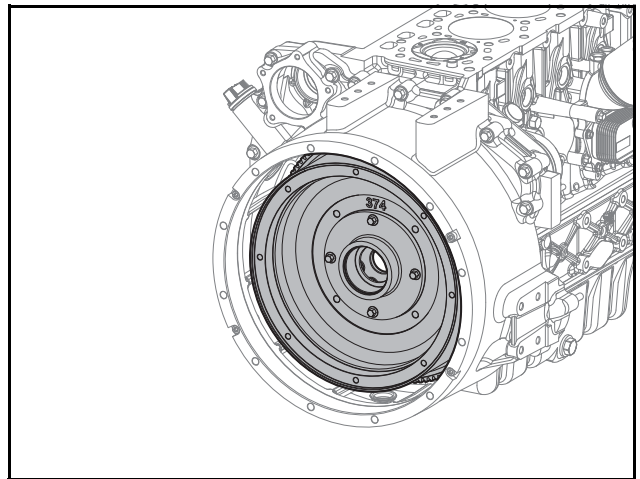
EDM03190258

- 1) Apply sealant to the assembly surface of the flywheel housing with a diameter of  $\varnothing 2.5 \pm 0.5$  mm.

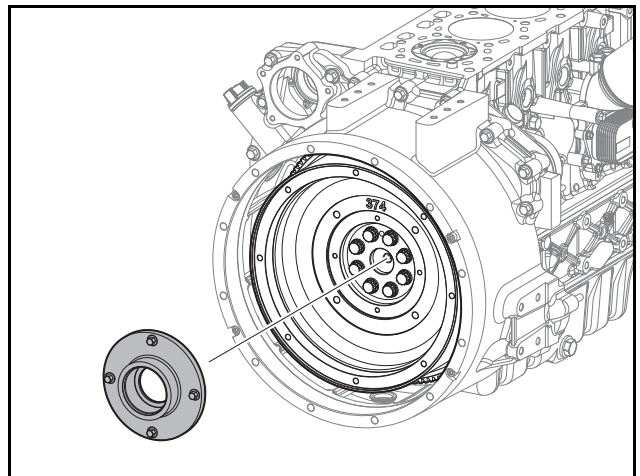
### CAUTION

- Pay attention to the assembly direction of the flywheel housing.
- Assemble within 5 minutes of applying sealant (TB1217H).
- Do not start the engine or apply pressure within 25 minutes of applying sealant (TB1217H).

- 2) Assemble the flywheel housing.
- 3) Tighten the hex bolt to a tightening torque of 2.2 kgf·m.
17. Assemble the flywheel.



EDM03190259



EDM03190260

- 1) Assemble the flywheel.
- 2) Use the angle tightening method to tighten the flange hex bolts to a tightening torque.

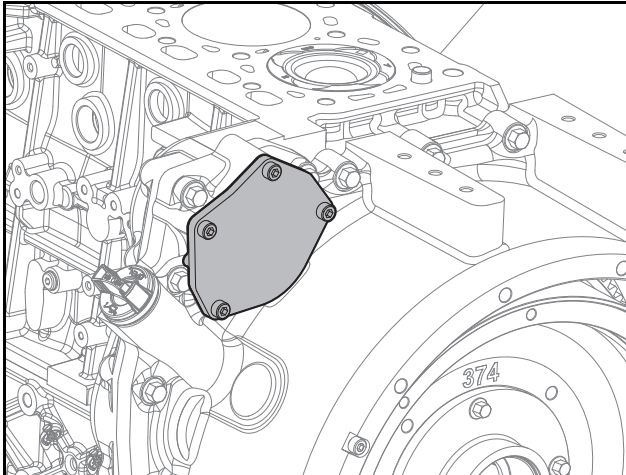
Flywheel bolt (43 mm, option)	1st: $7 \pm 0.35$ kgf.m/2nd: $45^\circ \pm 4^\circ$
Flywheel bolt (25 mm, option) for flat type flywheel	$17 \pm 0.85$ kgf.m

## 5. General Engine Information

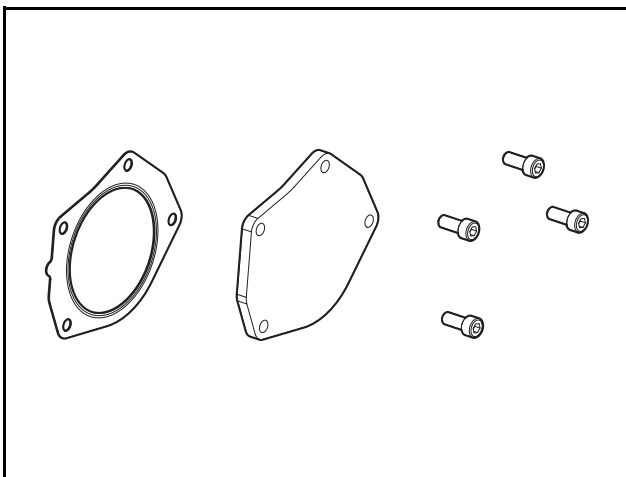
### CAUTION

Do not reuse flange hex bolts when assembling the flywheel.

18. Assemble the front/rear PTO (Power Take Off) cover & gasket.

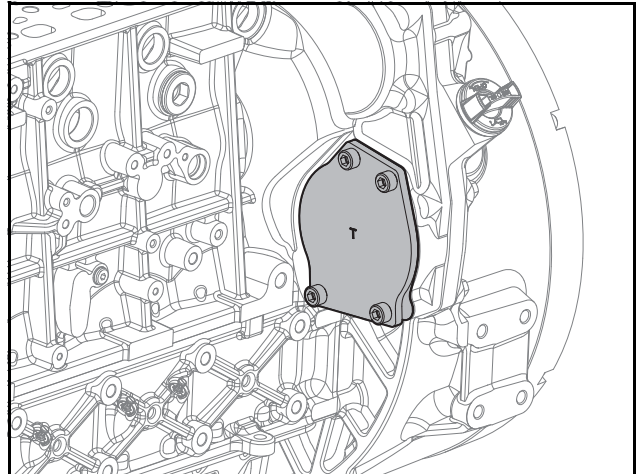


EDM03190257

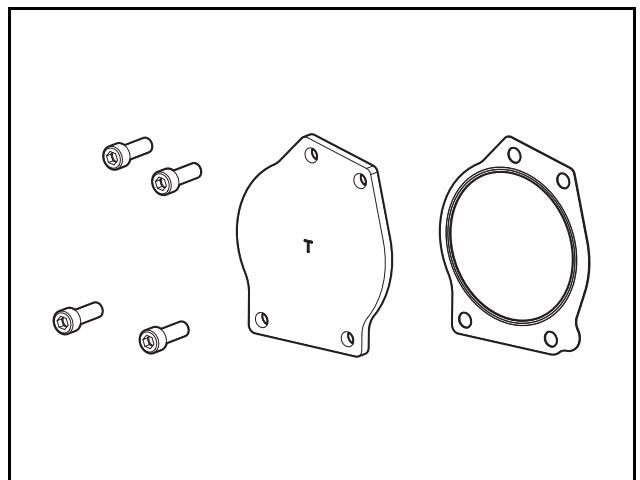


EDM03190319

- 1) Assemble the front PTO (Power Take Off) cover & gasket.
- 2) Tighten 4 inner socket bolts to a tightening torque of  $2.2 \pm 0.2$  kgf·m.

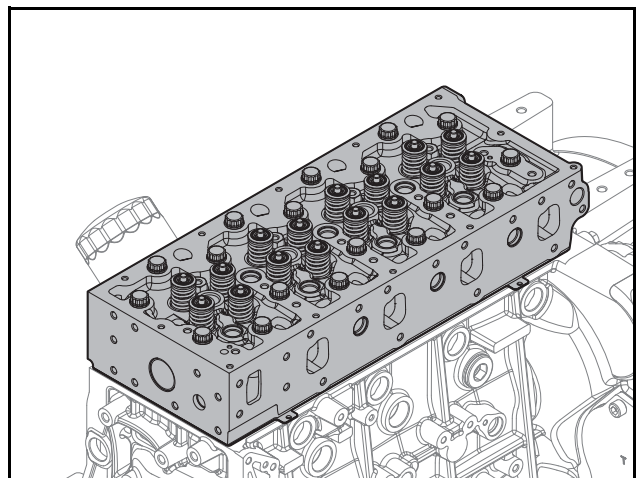


EDM03190256



EDM03190320

- 3) Assemble the rear PTO (Power Take Off) cover & gasket.
  - 4) Tighten 4 inner socket bolts to a tightening torque of  $4.4 \pm 0.4$  kgf·m
19. Assemble the cylinder head.



EDM03190166

- 1) Temporarily tighten the cylinder head bolts from inside to outside in the clockwise direction at a tightening torque of  $3.5$  kgf·m.

## 5. General Engine Information

- 2) Use the angle tightening method to tighten the cylinder head bolts from inside to outside in the clockwise direction at a tightening torque of 6 kgf·m + 90° + 90°.

Angle tightening method for cylinder head bolts	
Stage 1	Tightening torque of 6 kgf·m
Stage 2	90° rotation
Stage 3	90° rotation

### CAUTION

- The cylinder head bolts must be tightened from inside to outside in the clockwise direction.
- Do not reuse cylinder head bolts.
- Do not apply engine oil to the cylinder head bolts.

- 3) Align the cylinder head gasket with the pin and assemble it.

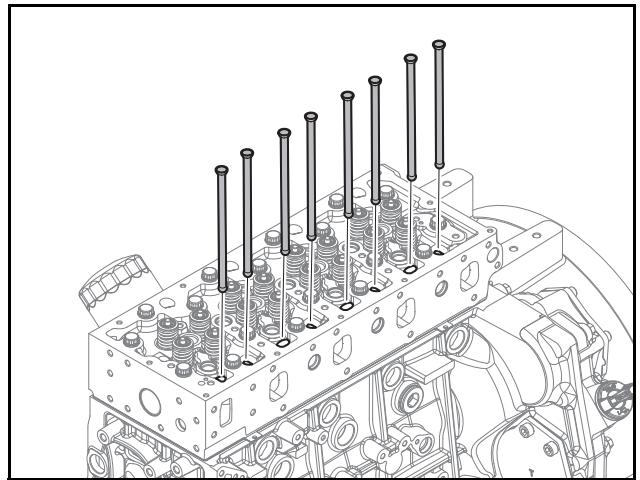
### CAUTION

- Measure the step height of the top side of the piston and select the cylinder head gasket with the right class. For the method of measuring the step height of the top side of the piston, refer to Measuring the Step Height of the Piston Top Side in Other/Driving System.
- Pay attention to the direction of the cylinder head gasket.
- Make sure that the class marking faces upwards during assembly.
- Align the push rod hole, cylinder head bolt hole and cylinder head gasket hole to assemble them.
- Do not reuse cylinder head gaskets; replace them with new ones.
- Class A has one semi-circle of the identification mark on the cylinder head gasket, Class B has two semi-circles and Class C has three semi-circles.

Note: The classes of the cylinder head gaskets are as follows.

Head gasket grade			Piston protrusion specification 0.50 ±0.16 mm	
Symbol	Hole	Thickness	Over	To
Mark	EA	mm	mm	mm
A	1	1.02	0.34	0.45
B	2	1.12	0.45	0.55
C	3	1.22	0.55	0.66

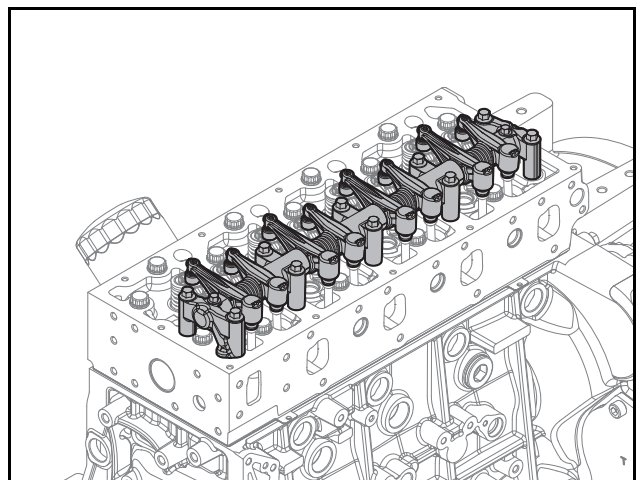
20. Assemble the push rods.



EDM03190167

- 1) Apply engine oil to both ends of the push rods.
- 2) Assemble the push rods with the holes in the cylinder head.
- 3) Use a rubber hammer to lightly tap the head of the push rods one to two times and position them properly in the tappet holes.

21. Assemble the rocker arms.



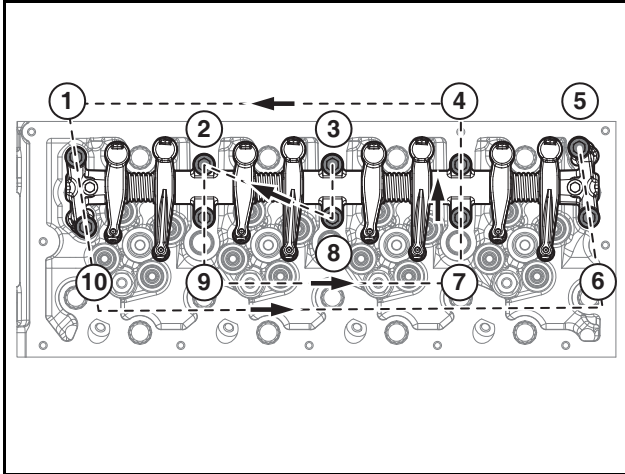
EDM03190168

- 1) Assemble the rocker arms.
- 2) Pre-assemble for positioning the bolts and locating pin with hands.



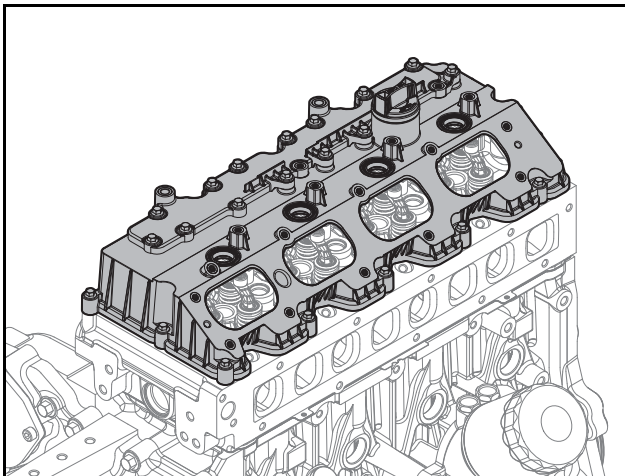
## 5. General Engine Information

- 3) Apply torque as follow below sequence.
  - Tightening torque:  $2.2 \pm 0.22$  kgf-m.
  - 3 → 8 → 2 → 9 → 7 → 4 → 1 → 10 → 6 → 5
- 4) Apply check torque as follow below sequence again.
  - Tightening torque:  $2.2 \pm 0.22$  kgf-m.
  - 3 → 8 → 2 → 9 → 7 → 4 → 1 → 10 → 6 → 5



EDM03210161

22. Assemble the cylinder head cover.



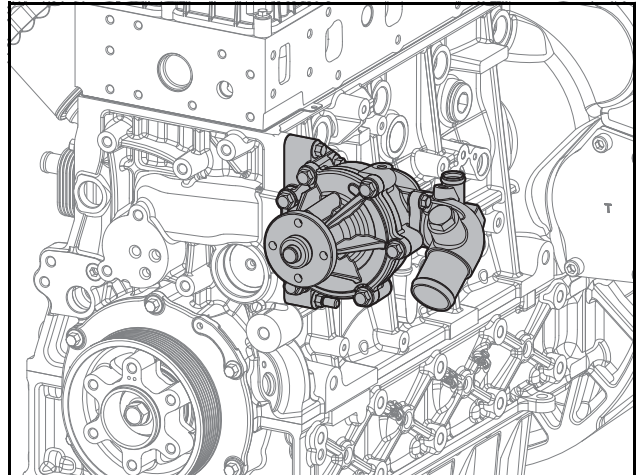
EDM03190169

- 1) Align the rubber packing with the cylinder head cover groove and assemble the cylinder head cover.
- 2) Temporarily mount the hex bolts from inside to outside in the direction of the arrow.
- 3) Tighten the hex bolts from inside to outside in the direction of the arrow at a tightening torque of  $0.8 \pm 0.05$  kgf-m.

### ⚠ CAUTION

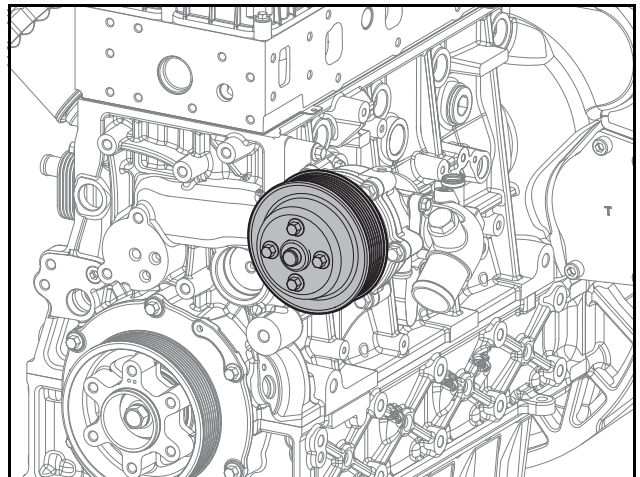
- When performing maintenance, do not reuse the head cover rubber seals and injector oil seals; replace them with new ones.
- When replacing oil seals, use an inserter to press fit them completely.

23. Assemble the coolant pump.



EDM03190255

- 1) Assemble the coolant pump.
  - 2) Temporarily tighten the hex bolts to a tightening torque of 1.0 kgf-m.
  - 3) Tighten the hex bolts to a tightening torque of 2.2 kgf-m.
24. Assemble the coolant pump pulley.

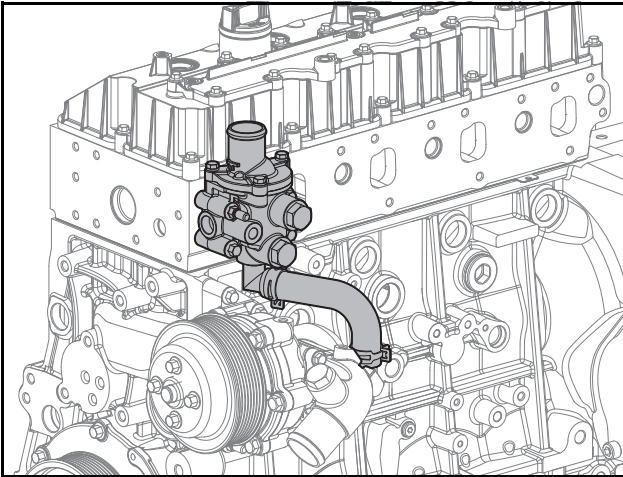


EDM03190254

- 1) Assemble the coolant pump pulley.
- 2) Tighten the hex bolts to a tightening torque of 2.2 kgf-m.

## 5. General Engine Information

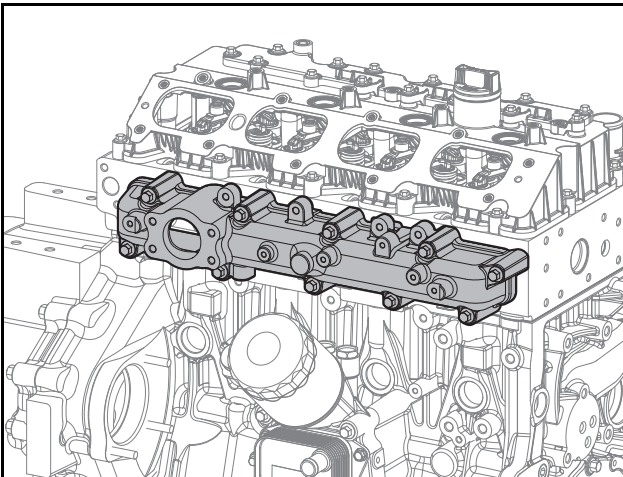
25. Assemble the thermostat.



EDM03190253

- 1) Assemble the thermostat.
- 2) Mount the spacer bolt.
- 3) Tighten the flange hex bolts to a tightening torque of 2.2 kgf·m.
- 4) Press on the clamp and connect the rubber hose.

26. Assemble the intake manifold.



EDM03190173

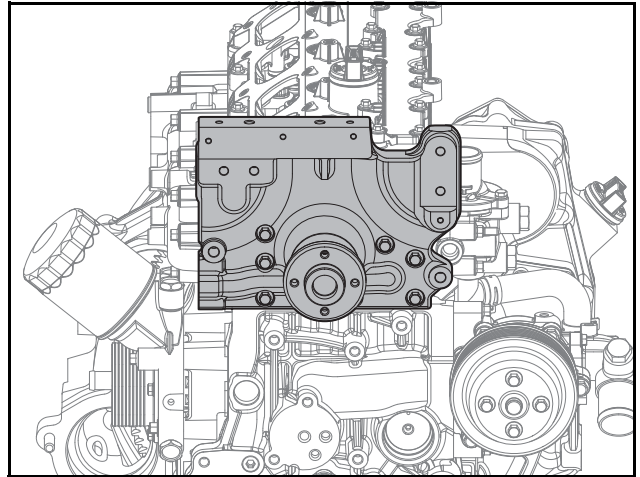
- 1) Assemble the gasket.

### CAUTION

- Pay attention to the assembled direction of gaskets.
- Be careful not to damage the gasket during assembly.
- Do not reuse gaskets; replace them with new ones.

- 2) Assemble the intake manifold.
- 3) Tighten the flange hex bolts to a tightening torque of 2.2 kgf·m.

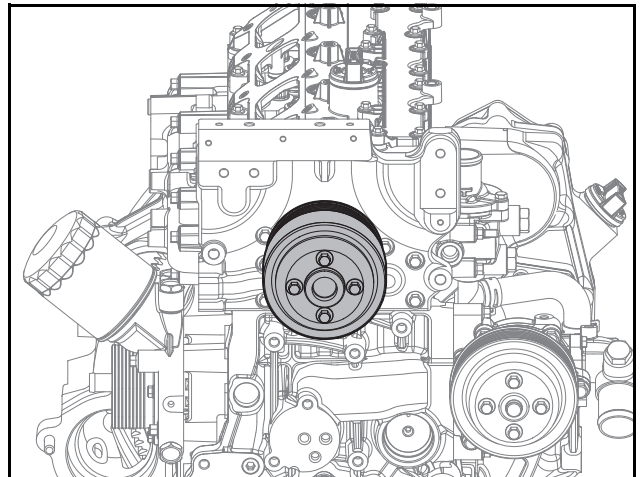
27. Assemble the fan mounting bracket.



EDM03190175

- 1) Assemble the fan mounting bracket.
- 2) Tighten 7 flange bolts to a tightening torque 2.2 kgf·m.

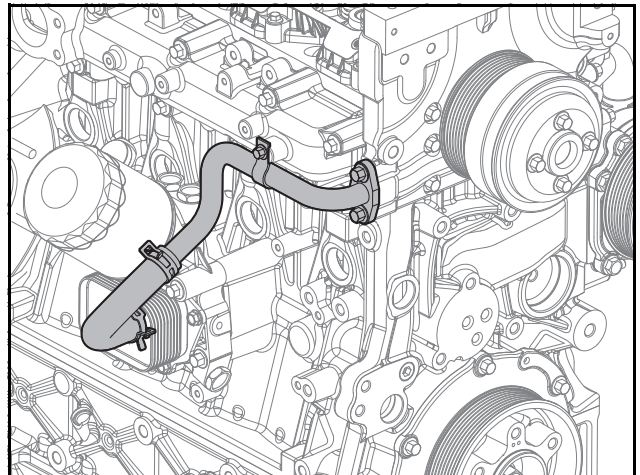
28. Assemble the fan pulley.



EDM03190176

- 1) Assemble the fan pulley.
- 2) Tighten 4 flange bolts to a tightening torque of 2.2 kgf·m.

29. Assemble the coolant pipe & hose.



EDM03190252



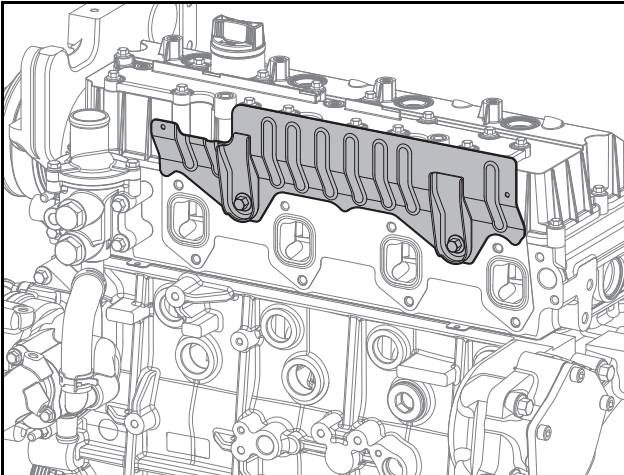
## 5. General Engine Information

- 1) Tighten the flange hex bolts to fix the coolant pipe in place.

### **⚠ CAUTION**

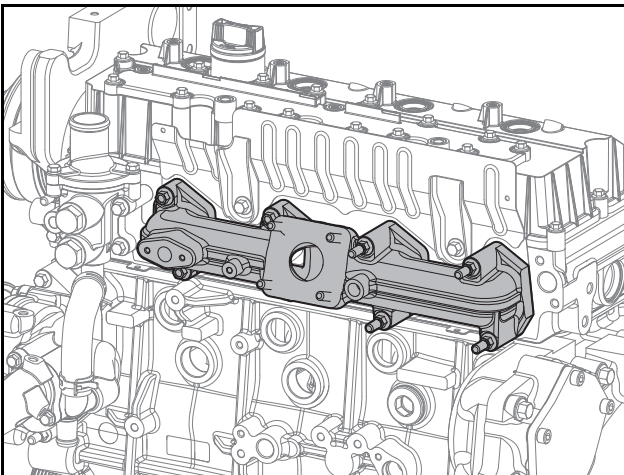
**Do not reuse clamps more than three times; replace them with new ones.**

- 2) Press on the clamps on both ends of the coolant hoses and connect the coolant hoses.
30. Assemble the heat shield.



EDM03190251

- 1) Assemble the heat shield.
- 2) Tighten the mounting bolt to a tightening torque of 2.2 kgf·m.
31. Assemble the exhaust manifold.



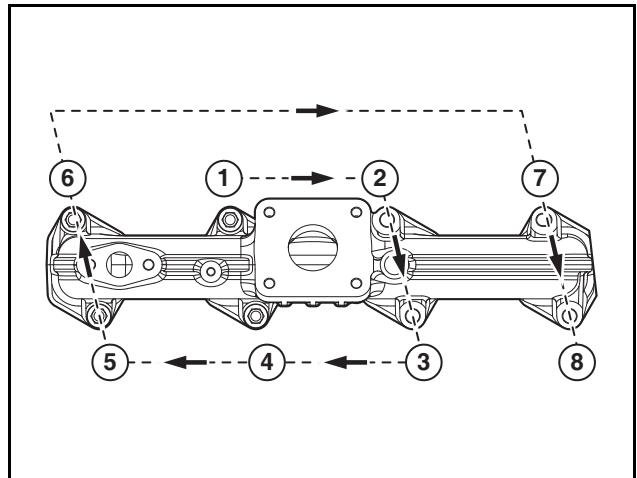
EDM03190250

- 1) Assemble the exhaust manifold.

### **⚠ CAUTION**

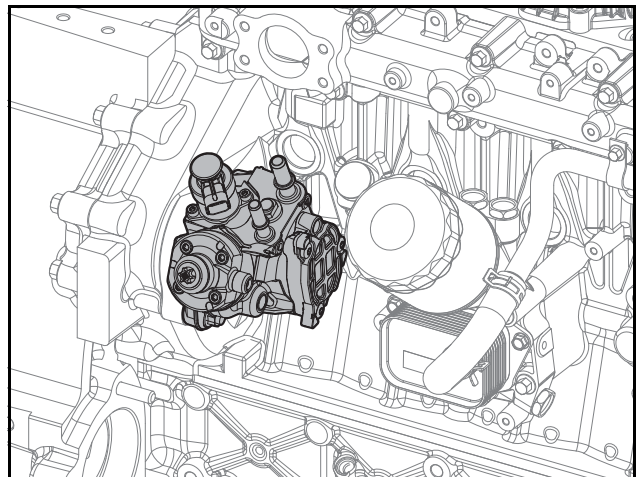
**Be careful not to damage the gaskets while assembling the exhaust manifold. Do not reuse gaskets if they are damaged; replace them with new ones.**

- 2) Apply torque as follow below sequence.
  - Tightening torque: 3.4 ±0.3 kgf·m.
- 3) Apply check torque as follow below sequence again.
  - Tightening torque: 3.4 ±0.3 kgf·m.



EDM03200143

32. Assemble the fuel injection pump.



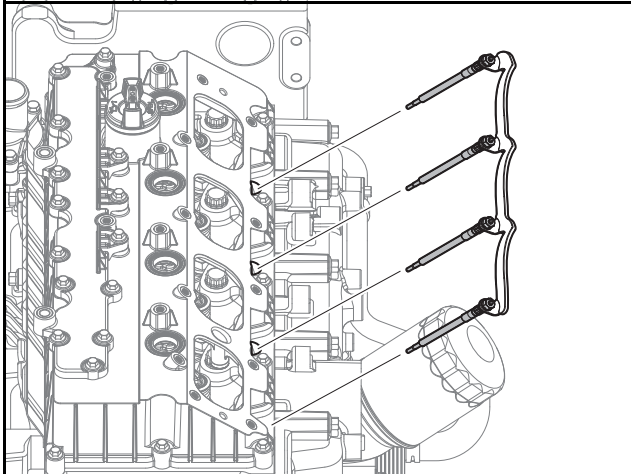
EDM03190249

- 1) If you are able to check the gear engravings, position the idle gear engraving between the engravings on the fuel injection pump drive gear. However, if you are unable to check the gear engravings, assemble the fuel injection pump regardless of the positions of the gear engravings. Note: There are two engraved markings on the fuel injection pump drive gear and one engraved marking on the idle gear.
- 2) Align the fuel injection pump with the stud bolts to assemble it.
- 3) Tighten the flange hex bolt to a tightening torque of 2.2 kgf·m.
- 4) The backlash between the fuel injection pump drive gear and the idle gear is 0.081 ~ 0.196 mm.

## 5. General Engine Information

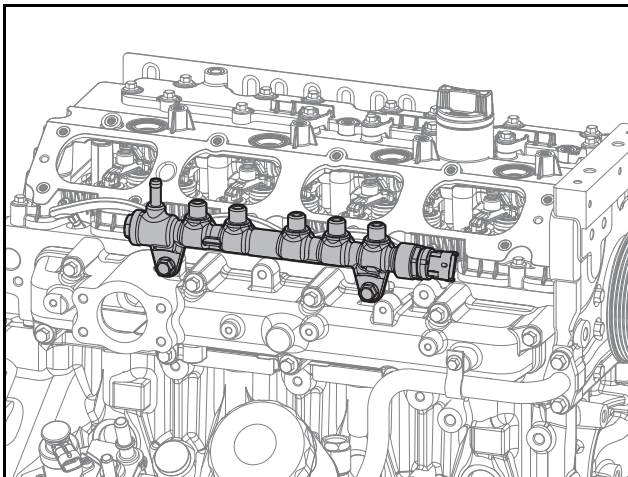
Item	Specified value
Backlash between fuel injection pump drive gear and idle gear	0.081 ~ 0.196 mm

33. Connect the glow plugs.



EDM03190248

- 1) Tightening 4 glow plugs to the cylinder head at a tightening torque of 9 ~ 12 N·m.
  - 2) Attach the electric connector.
  - 3) Mount 4 washers.
  - 4) Tighten 4 hex nuts at a tightening torque of 1.3 ~ 2 N·m.
34. Assemble the common rail.



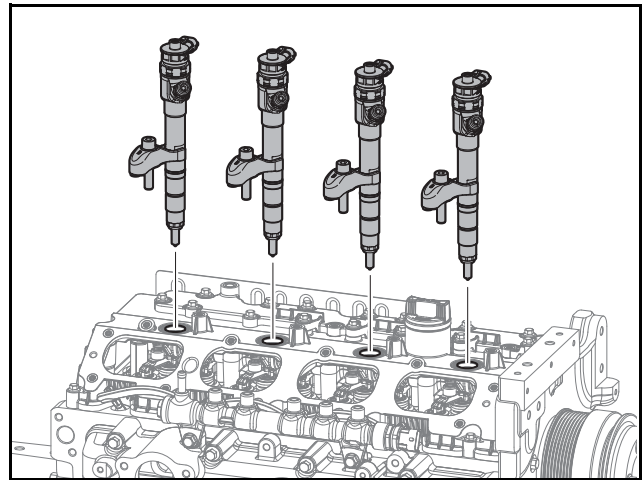
EDM03190246

- 1) Assemble the common rail with the intake manifold.

### **⚠ CAUTION**

- Pay attention to the assembled direction of the common rail.
- Be careful not to damage the common rail during assembly.
- Be careful not to allow any foreign matter to enter the common rail fuel inlet and outlet holes.

- 2) Temporarily assemble the hex bolts by hand.
  - 3) Tighten the hex bolts to a tightening torque of 2.2 kgf·m.
35. Assemble the injector.



EDM03190247

- 1) Align the injector sealing washers with the center of the injector hole and mount them.
- 2) Apply sufficient oil to the contact surface of the injector on the cylinder head cover.
- 3) Assemble the injectors.

### **⚠ CAUTION**

- Slowly turn the injector while assembling it to avoid damaging the injector oil seal on the cylinder head cover.
- Do not reuse injector sealing washers. Otherwise serious faults may occur in the engine due to unstable combustion.

- 4) Assemble the injector mounting brackets.
- 5) Temporarily tighten the hex bolts to a tightening torque of 0.3 kgf·m.

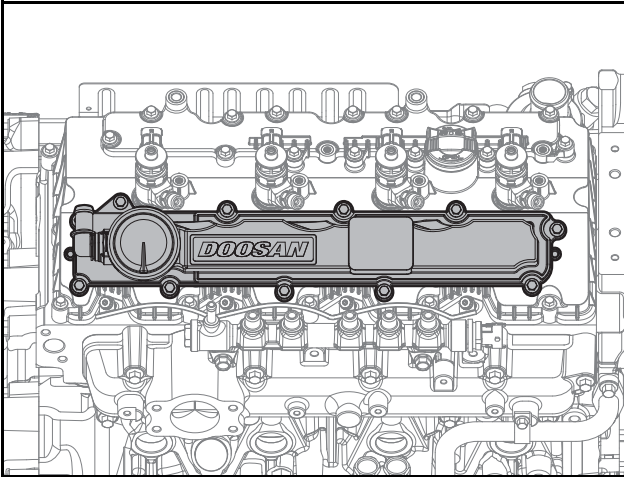
### **⚠ CAUTION**

If the hex bolts cannot be tightened while temporarily tightening them, do not tighten them by force. Tightening them by force may damage the cylinder head.

- 6) Tighten the hex bolts to a tightening torque of 4.35 ±0.35 kgf·m.

## 5. General Engine Information

36. Assemble the right cylinder head cover.



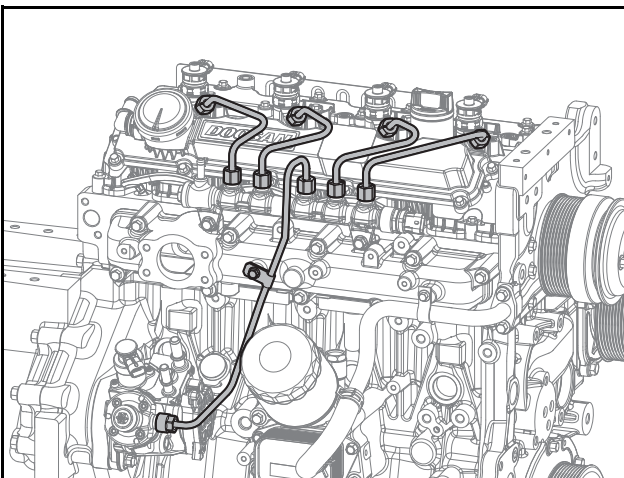
EDM03190245

- 1) Align the rubber packing with the right cylinder head cover groove and assemble the right cylinder head cover.
- 2) Temporarily mount the flange hex bolts from inside to outside in the direction of the arrow.
- 3) Tighten the flange hex bolts from inside to outside in the direction of the arrow at a tightening torque of  $0.8 \pm 0.05$  kgf-m.

### **⚠ CAUTION**

- When performing maintenance, do not reuse head cover rubber seals; replace them with new ones.
- Before assembly, completely remove any foreign matter from inside the quick connector and the RH cover nipple.

37. Assemble fuel injection pipe.



EDM03190240

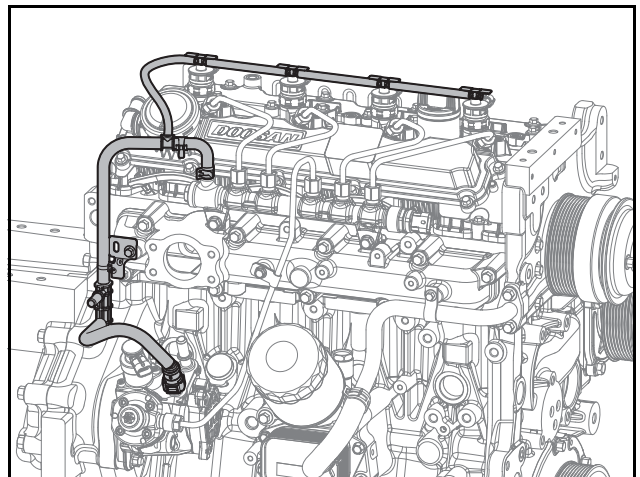
- 1) Loosen the hex bolts on the common rail and temporarily tighten them.
- 2) Temporarily tighten all of the nuts on the fuel injection pipes.

- 3) Tighten the hex bolts on the common rail to a tightening torque of 2.2 kgf-m.
- 4) Tighten the fuel injection pipe nuts to a tightening torque of 3.0 kgf-m.
- 5) Tighten the flange hex bolts assembled with the pipe clips to a tightening torque of 0.8 kgf-m.

### **⚠ CAUTION**

- Do not bend the fuel injection pipe by force.
- Pay attention to the assembled direction of the fuel injection pipe.
- Assemble the nuts on one side of the fuel injection pipe, then assemble the other side and make sure that the round part of the pipe and the part in contact with it are in their proper positions.
- Replace the fuel injection pipe and pipe clip with new ones; do not reuse them. Otherwise it may severely deteriorate the engine performance.

38. Assemble the fuel return hose.



EDM03190241



## 5. General Engine Information

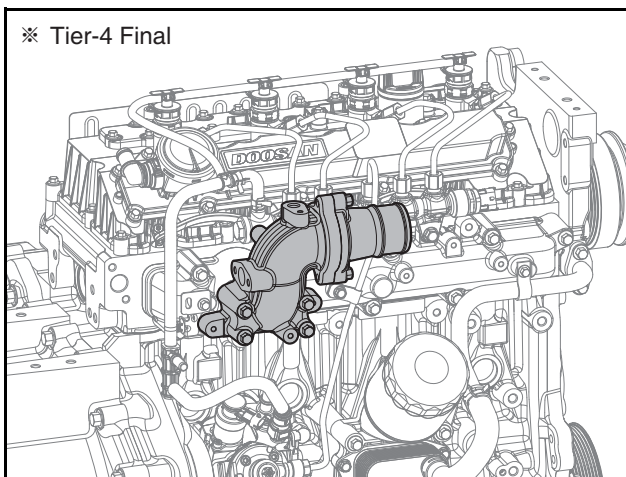
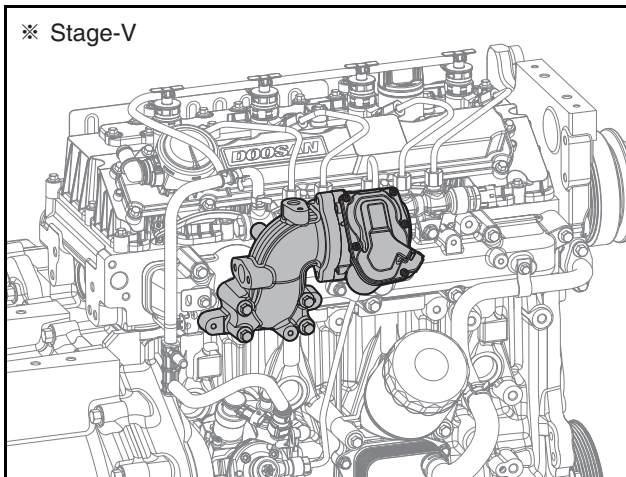
- 1) Assemble the fuel return hose.

### **⚠ CAUTION**

- Pay attention to the assembled direction of the fuel return hose.
- Assemble the injectors and fuel return hoses so that they interlock sufficiently.
- Do not reuse fuel return hoses; replace them with new ones. Failure to do so may cause serious faults in the engine performance.
- Be careful to avoid damage for fuel return hose of injector.
- Don't press on the fuel hose, don't drop heavy tool like as spanner on engine, don't step on fuel hose, don't stand on engine.
- If the fuel hose are broken by wrong handling, it is possible fire.

- 2) Press on the clamps to attach the common rail, injectors, and fuel return hoses on the fuel injection pump.

39. Assemble the throttle (inlet pipe) & the intake stake.

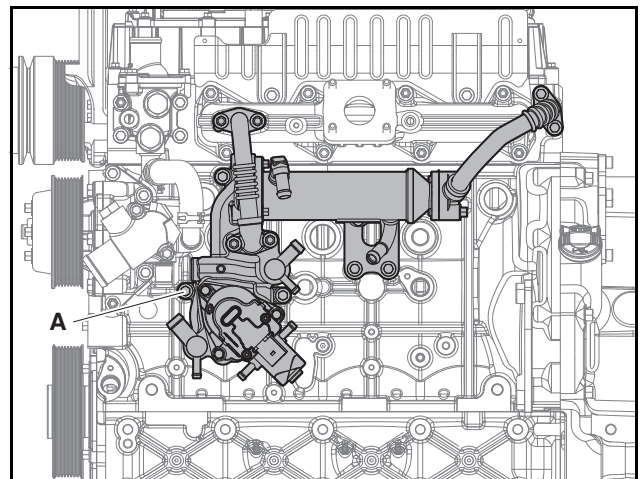


- 1) Mount the gasket between the throttle (inlet pipe) and intake stake.

### **⚠ CAUTION**

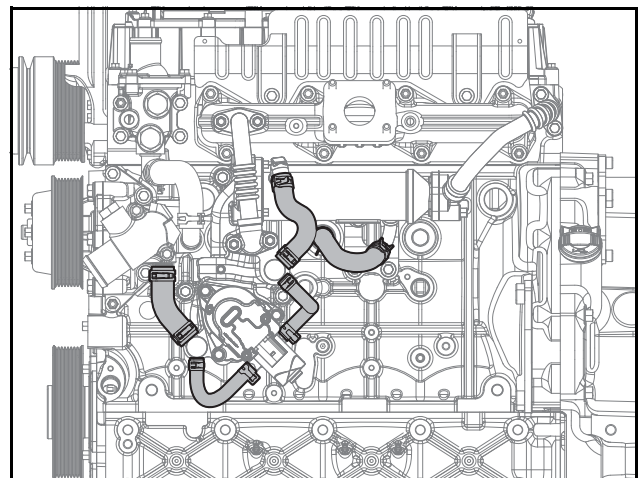
- Pay attention to the direction of gaskets. The vertical direction is narrow and the horizontal direction is wide.
- Remove any foreign matter from the gasket assembly surface.
- Do not reuse gaskets; replace them with new ones.

- 2) Assemble the throttle (inlet pipe) & the intake stake.
- 3) Tighten 4 (3) flange hex bolt to a tightening torque of  $2.2 \pm 0.22$  kgf·m.
40. Assemble the EGR assembly.



- 1) Attach the EGR assembly.
- 2) Tighten 7 flange hex bolts (A) at tightening torque of  $2.2 \pm 0.2$  kgf·m.

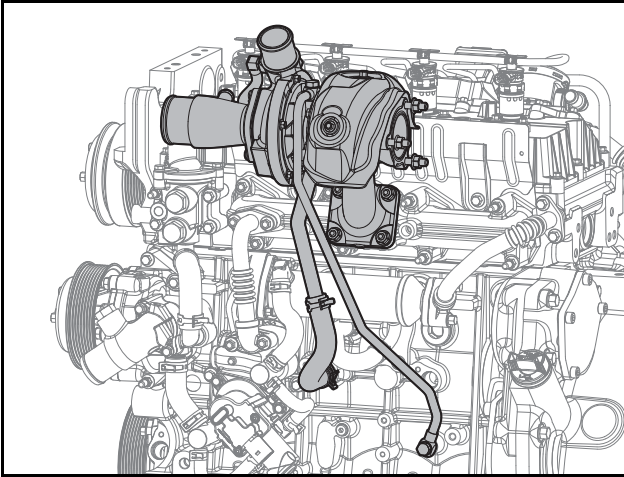
41. Assemble the EGR pipe & hose.



- 1) Attach the EGR hose & pipe.
- 2) Mount the hose clamp.

## 5. General Engine Information

- 3) Mount the EGR pipe to the EGR valve and exhaust manifold.
- 4) Tighten 4 flange hex bolts at tightening torque of  $3.1 \pm 0.3$  kgf·m.
42. Assemble the turbocharger.



EDM03190235

- 1) Press on the clamp and connect the oil return hose to the cylinder block.

### **⚠ CAUTION**

**Do not reuse clamps more than three times; replace them with new ones.**

- 2) Align the exhaust manifold stud bolts and assemble the gasket.

### **⚠ CAUTION**

- Pay attention to the assembled direction of gaskets.
- Do not reuse gaskets; replace them with new ones.

- 3) Connect the gasket and oil return pipe to the turbocharger.

### **⚠ CAUTION**

**Do not reuse gaskets; replace them with new ones.**

- 4) Tighten the hex bolt to a tightening torque of 1.0 kgf·m.
- 5) Align the exhaust manifold stud bolts and assemble the turbocharger.
- 6) Tighten the flange hex nut to a tightening torque of 2.2 kgf·m.
- 7) Press on the clamp and connect the oil return hose to the oil return pipe.
- 8) Assemble the copper washers with both sides of the banjo union, then temporarily tighten the hollow screws.

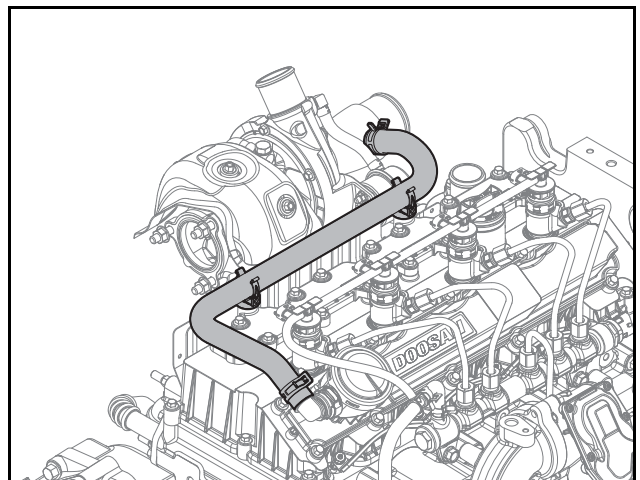
- 9) Tighten the hollow screws on both ends of the oil supply pipe to a tightening torque of 2.0 kgf·m.

### **⚠ CAUTION**

- Do not reuse copper washers; replace them with new ones.
- When assembling the oil supply pipe, be sure to check whether all of the copper washers have been assembled. There are a total of 4 copper washers assembled, with 2 on each side of the banjo union. Leaks may occur if the copper washers are not positioned correctly or are missing.
- When assembling the oil supply pipe, assemble the hollow screws on the cylinder block first, then assemble the hollow screws on the turbocharger.
- After temporarily tightening the hollow screws, hold the oil supply pipe in place by hand so that it does not bend and then tighten them to the specified tightening torque.

Note) During assembly, add 3 cc of clean oil to the turbocharger oil inlet.

43. Assemble the breather hose.



EDM03190234

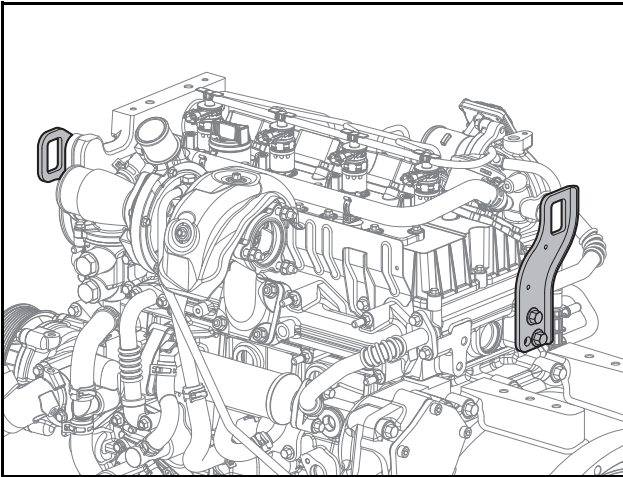
- 1) Assemble the breather hose with the hose clips.
- 2) Press on the clamps on the quick connector and T/C air inlet pipe, then connect the breather hose.

### **⚠ CAUTION**

- Do not reuse clamps more than three times; replace them with new ones.
- Do not apply oil to hoses, clamps, etc.

## 5. General Engine Information

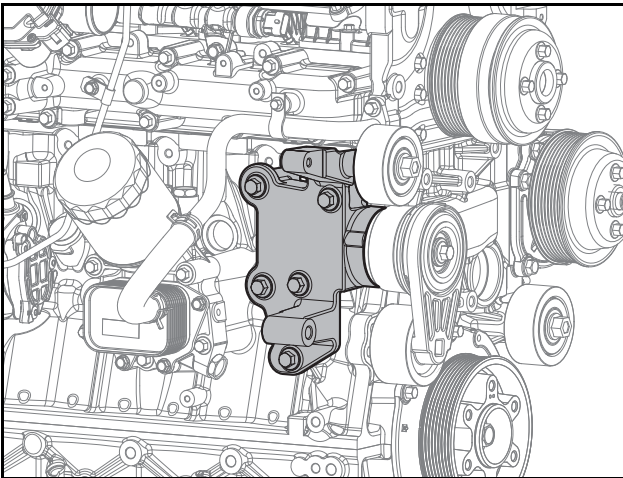
44. Assemble the rear & front lifting hooks.



EDM03190233

- 1) Assemble the rear lifting hook.
- 2) Tighten the flange hex bolt to a tightening torque of 4.4 kgf·m.
- 3) Assemble the front lifting hook.
- 4) Tighten the flange hex bolt to a tightening torque of 4.4 kgf·m.

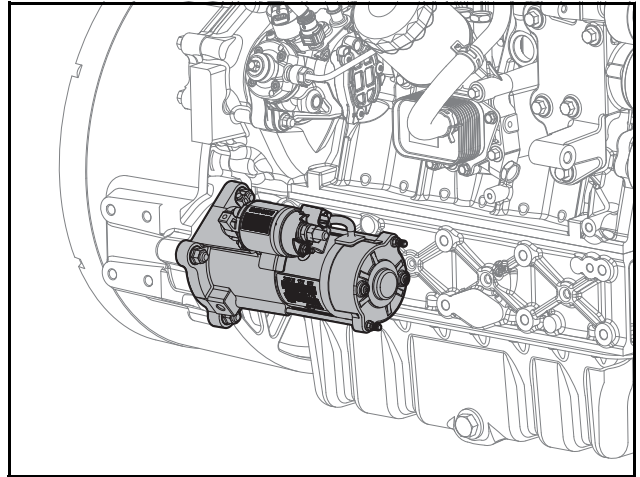
45. Assemble the alternator bracket.



EDM03190244

- 1) Assemble the alternator bracket.
- 2) Tighten 5 flange hex bolts to a tightening torque of  $6.2 \pm 0.6$  kgf·m.

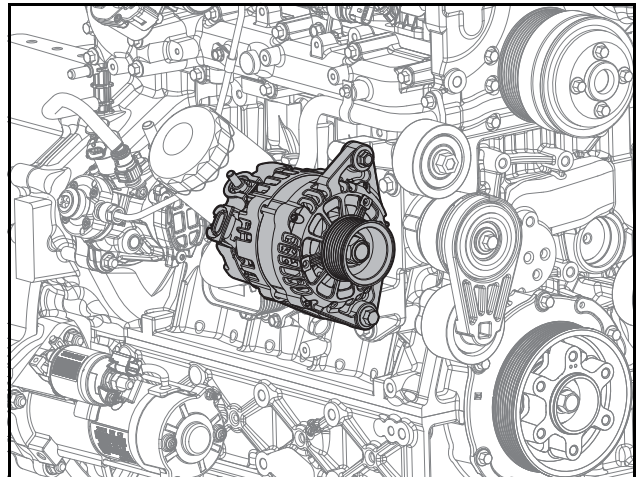
46. Assemble the starter motor.



EDM03190242

- 1) Align the starter motor with the stud bolts and assemble it.
- 2) Tighten the flange nuts to a tightening torque of 4.4 kgf·m.

47. Assemble the alternator.



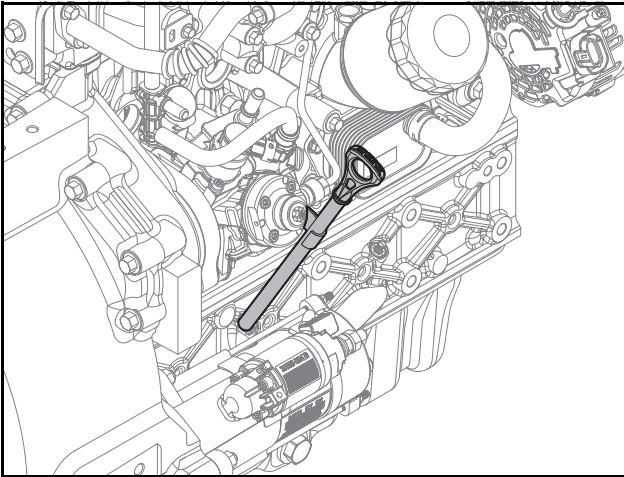
EDM03190243

- 1) Using bolt and nut, attach the alternator temporarily.
- 2) By tightening bolt, set the position of the alternator properly.
- 3) Tighten upper bolt to a torque of  $2.2 \pm 0.2$  kgf·m.
- 4) Tighten lower bolt to a torque of  $6.2 \pm 0.6$  kgf·m.



## 5. General Engine Information

48. Assemble the oil level gauge.



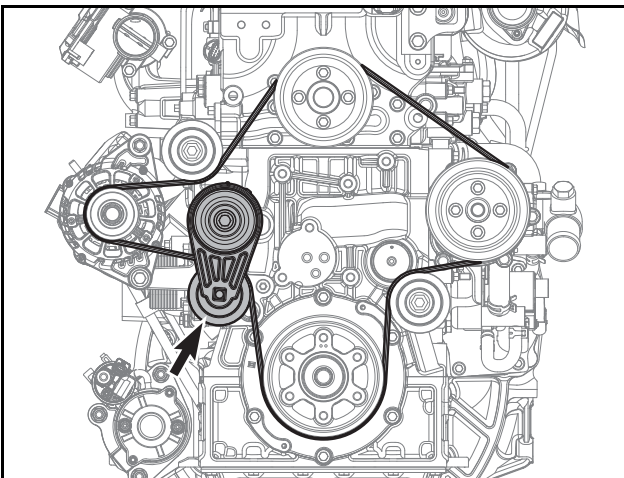
EDM03190232

- 1) Replace the O-ring on the guide tube for the oil level gauge with a new one.
- 2) Apply oil to the surface of the O-rings on the guide tube for the oil level gauge.
- 3) Press fit the oil level gauge guide tube into the cylinder block.

### **⚠ CAUTION**

**Assemble the oil level gauge guide tube so that the direction of the oil level gauge handle faces the opposite direction from the center of the engine.**

- 4) Tighten the flange hex bolt to a tightening torque of 1.0 kgf·m to fix the oil level gauge tube in place.
  - 5) Mount the oil level gauge.
49. Assemble the V-belt.



EDM03190231

- 1) Wind a new belt around all pulleys except for the auto tensioner.

- 2) Turn the auto tensioner counterclockwise by using a quadrangular groove at the top of the auto tensioner pulley (use a 10 mm x 10 mm quadrangular tool).
- 3) Wind the belt around the auto tensioner pulley by using a space generated by the rotation of the auto tensioner, and then naturally release the tensioner that has been pulled counterclockwise.

### **⚠ CAUTION**

**For checking and measuring the belt tension, refer to Belt Tension in Chapter 12 (Others/Driving Units).**

## 5. General Engine Information

---

# 6. Cooling System

<b>General Information .....</b>	<b>103</b>
General Information .....	103
Troubleshooting .....	104
<b>Coolant Pump .....</b>	<b>105</b>
General Information .....	105
Removing the Coolant Pulley.....	105
Assembling the Coolant Pump.....	106
<b>Thermostat .....</b>	<b>108</b>
General Information .....	108
Removing the Thermostat.....	108
Assembling the Thermostat .....	109
Checking the Thermostat.....	109
<b>Cooling Fan .....</b>	<b>110</b>
Removing the Fan Mounting Bracket.....	110
Assembling the Fan Mounting Bracket .....	111

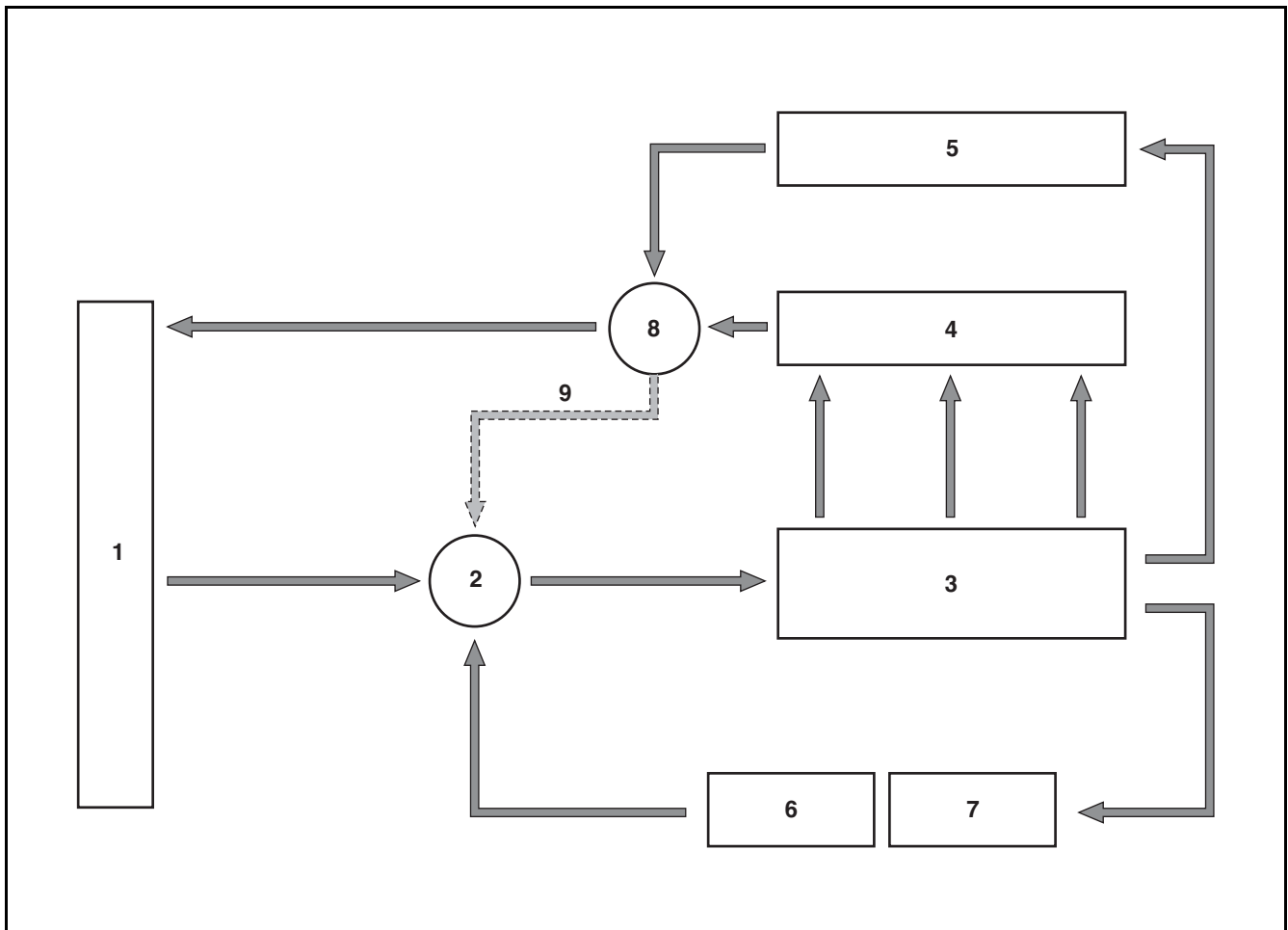


### General Information

#### General Information

This engine is water-cooled. The function of the cooling system is to use coolant to absorb the combustion heat generated in the cylinder block and head by the combustion of fuel while the engine is running, as well as heat from engine oil and EGR gas. This is then cooled by the radiator and cooling fan, enabling the engine to operate normally.

In the cooling system, coolant delivered to the coolant jacket in the cylinder block by the coolant pump then diverges and flows into the oil cooler, EGR cooler and cylinder head. Heat absorbed by the EGR cooler flows into the pump, while heat absorbed by the oil cooler and cylinder head flows into the thermostat. If the coolant temperature is lower than the valve opening temperature of the thermostat, the coolant is returned to the coolant pump. Otherwise, it flows to the radiator. In the radiator, the coolant releases heat by means of the cooling process and is then returned to the coolant pump.



EDL022059E

- |                   |                  |               |
|-------------------|------------------|---------------|
| 1. Radiator       | 4. Cylinder head | 7. EGR cooler |
| 2. Coolant pump   | 5. Oil cooler    | 8. Thermostat |
| 3. Cylinder block | 6. EGR valve     | 9. Bypass     |

## 6. Cooling System

### Troubleshooting

Symptom	Cause	Solution
Overheated engine	Insufficient coolant	Adding Coolant
	Faulty surge tank cap	Replace
	Contaminated radiator	Clean the outside of the radiator
	Problem with V-belt free play	Adjust or replace
	Contaminated or damaged V-belt	Replace
	Damaged impeller	Replace coolant pump
	Faulty impeller installation	Replace coolant pump
	Malfunctioning coolant pump	Replace
	Malfunctioning thermostat	Replace
	Poor coolant flow	Cleaning coolant passage
	Incorrect injection timing	Check using fault diagnostic device
	Damaged cylinder head gasket	Replace
Overcooled engine	Malfunctioning thermostat	Replace
	Excessively low ambient temperature	Block heating
Coolant leak	Damaged radiator	Repair or replace
	Loose or damaged radiator connection	Repair or replace connection
	Faulty surge tank cap	Replace
	Faulty coolant pump installation	Repair or replace
	Faulty or damaged coolant pump gasket	Replace the gasket
	Faulty thermostat installation	Repair or replace
	Faulty or damaged thermostat gasket	Replace the gasket
	Damaged cylinder head gasket	Replace the gasket
	Damaged cylinder head or block	Replace
Noise	Faulty coolant pump bearing	Replace the bearing
	Faulty or damaged cooling fan	Repair or replace
	Poor rotation of the cooling fan	Replace
	Problem with V-belt free play	Adjust or replace

### Coolant Pump

#### General Information

The coolant pump prevents the engine from being overheated by combustion heat during engine operation and delivers coolant from the radiator to each part of the engine in order to maintain a suitable temperature.

#### Removing the Coolant Pulley

1. Drain the coolant.
  - 1) Check whether the engine and radiator have cooled down.
  - 2) Place a container in front of the coolant drain plug.
  - 3) Remove the surge tank cap.
  - 4) Remove the coolant drain plug on the radiator and then drain the coolant.
  - 5) After draining the coolant is complete, reinstall the coolant drain plug.

#### DANGER

- Do not open the surge tank cap while the engine is overheated. If the surge tank cap is opened, hot coolant will spurt and may cause burns. Open the surge tank cap after ensuring that the engine has cooled down sufficiently.
- Label and store containers for coolant separately to avoid confusing them with containers for drinks. If you happen to ingest coolant, consult a doctor immediately.

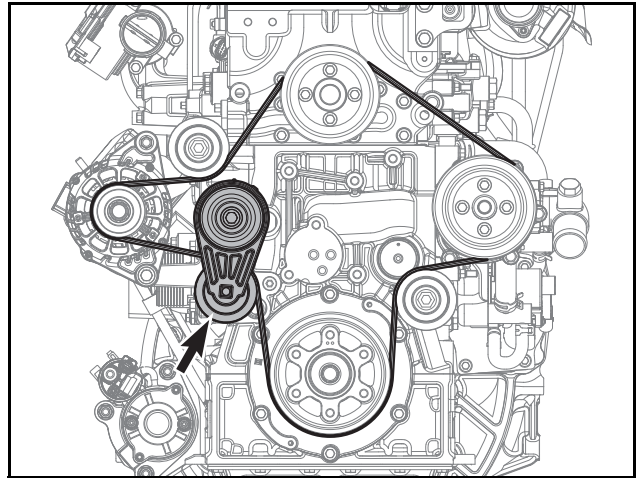
#### WARNING

Follow the regulations of the public institutions in your area when disposing of used coolant. Dumping engine oil on the ground, in sewers, drains, rivers and seas, etc. can cause severe environmental contamination. Disposing of engine oil incorrectly without complying with treatment regulations can be punished as a violation of treatment regulations.

#### CAUTION

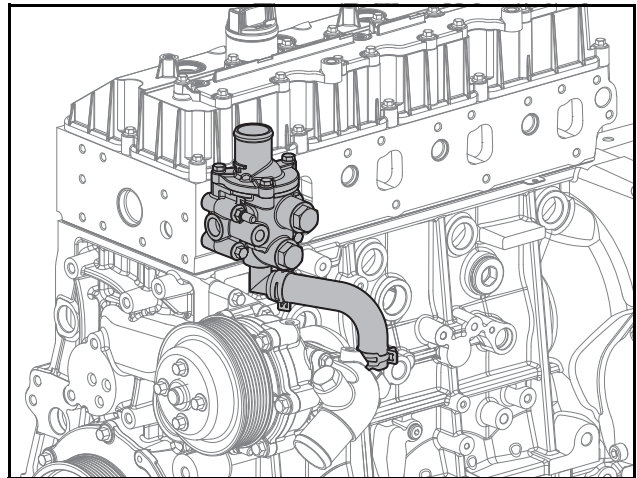
When replacing coolant, be careful not to spill any coolant on belts and electrical devices.

2. Remove the V-belt.



EDM03190231

- 1) Turn the auto tensioner counterclockwise by using a quadrangular groove at the top of the auto tensioner pulley (Use a 10 mm x 10 mm quadrangular tool).
- 2) Remove the belt wound around the auto tensioner pulley by using a space generated by the rotation of the auto tensioner.
3. Remove the thermostat.

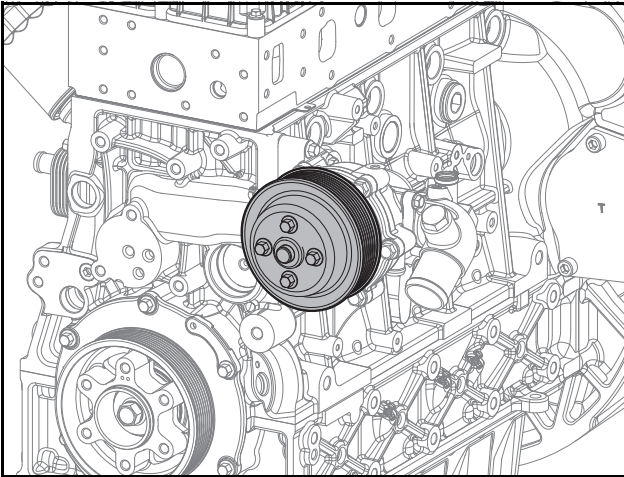


EDM03190253

- 1) Press on the clamp and disconnect the rubber hose.
- 2) Remove the spacer bolt.
- 3) Loosen the flange hex bolt.
- 4) Remove the thermostat.

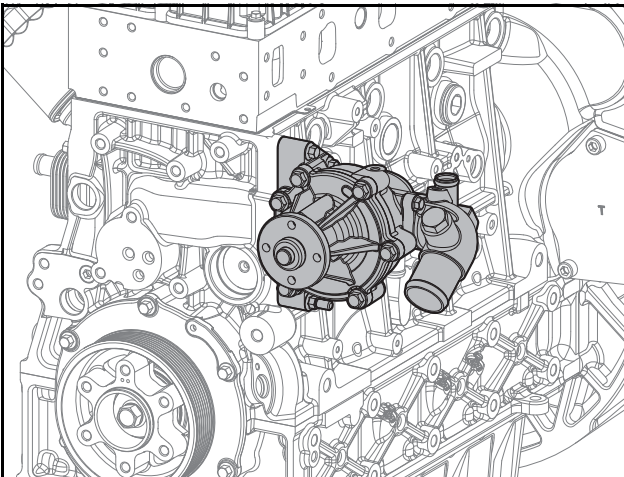
## 6. Cooling System

4. Remove the coolant pump pulley.



EDM03190254

- 1) Loosen the hex bolts.
- 2) Remove the coolant pump pulley.
5. Remove the coolant pump.

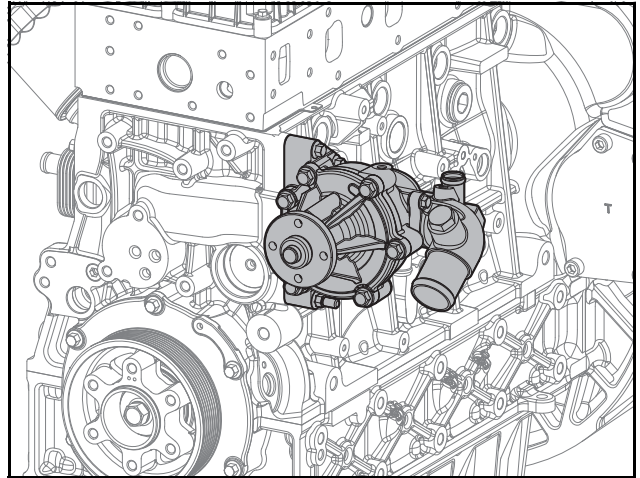


EDM03190255

- 1) Loosen the hex bolts.
- 2) Remove the coolant pump.

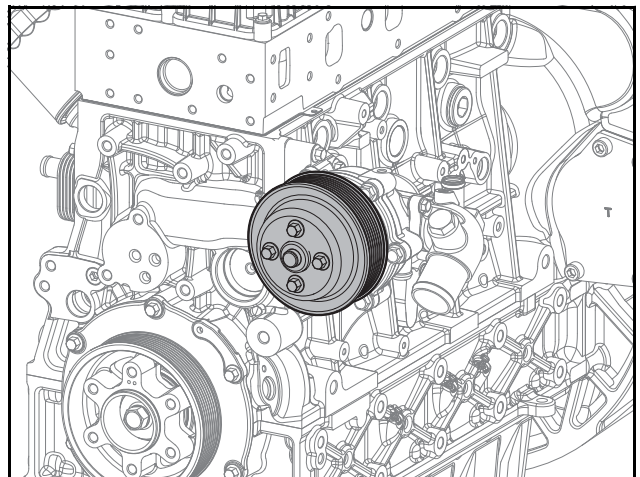
### Assembling the Coolant Pump

1. Assemble the coolant pump.



EDM03190255

- 1) Assemble the coolant pump.
- 2) Temporarily tighten the hex bolts to a tightening torque of 1.0 kgf·m.
- 3) Tighten the hex bolts to a tightening torque of 2.2 kgf·m.
2. Assemble the coolant pump pulley.



EDM03190254

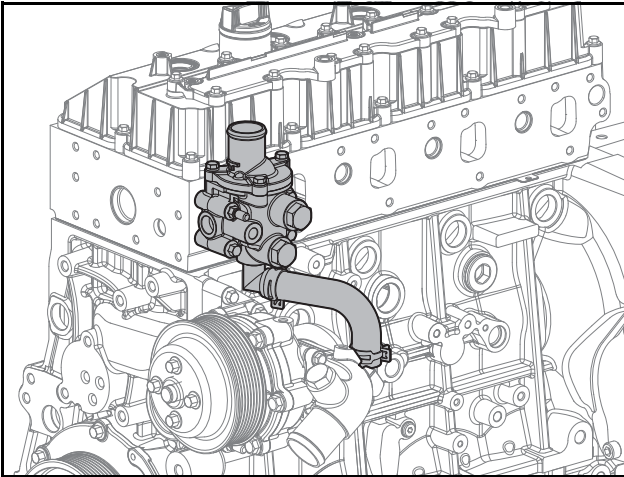
- 1) Assemble the coolant pump pulley.
- 2) Tighten the hex bolts to a tightening torque of 2.2 kgf·m.
3. Add coolant.
- 1) Open the radiator cap and add the coolant prepared in advance.

### CAUTION

Use the specified coolant recommended by Hyundai Doosan Infracore.

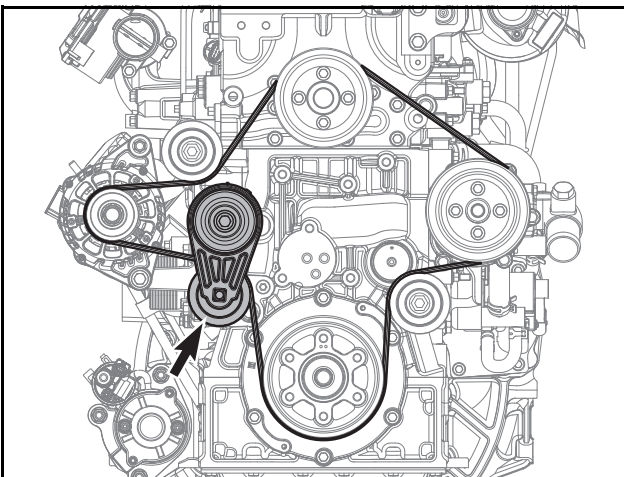


### 4. Assemble the thermostat.



EDM03190253

- 1) Assemble the thermostat.
- 2) Mount the spacer bolt.
- 3) Tighten the flange hex bolts to a tightening torque of 2.2 kgf·m.
- 4) Press on the clamp and connect the rubber hose.
5. Assemble the V-belt.



EDM03190231

- 1) Wind a new belt around all pulleys except for the auto tensioner.
- 2) Turn the auto tensioner counterclockwise by using a quadrangular groove at the top of the auto tensioner pulley (use a 10 mm x 10 mm quadrangular tool).
- 3) Wind the belt around the auto tensioner pulley by using a space generated by the rotation of the auto tensioner, and then naturally release the tensioner that has been pulled counterclockwise.

### CAUTION

For checking and measuring the belt tension, refer to Belt Tension in Chapter 12 (Others/Driving Units).

## 6. Cooling System

### Thermostat

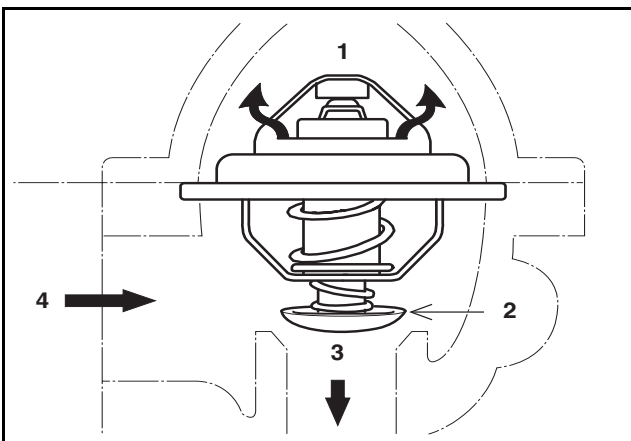
#### General Information

The thermostat is used to maintain a consistent coolant temperature in the engine and prevent heat loss in order to enhance the engine's thermal efficiency.

When the coolant temperature is less than normal, the thermostat valve closes so that coolant is bypassed back to the coolant pump. When the coolant temperature is above normal, the thermostat valve opens completely, the bypass valve closes and the coolant flows to the radiator.

#### **⚠ CAUTION**

- The reaction rate of the wax pellet type against changes in the thermostat coolant temperature is slower than the bellows type. This is because the wax pellet type has a higher thermal capacity. Therefore, the engine must be idled sufficiently first to prevent a rapid rise in the engine coolant temperature. In cold weather, avoid overloading or overspeeding right after the engine is started.
- When draining coolant from or adding coolant to the engine cooling system, drain or pour it slowly so that air escapes the system sufficiently.
- If the thermostat is defective, replace it with a new one.



EDL022060A

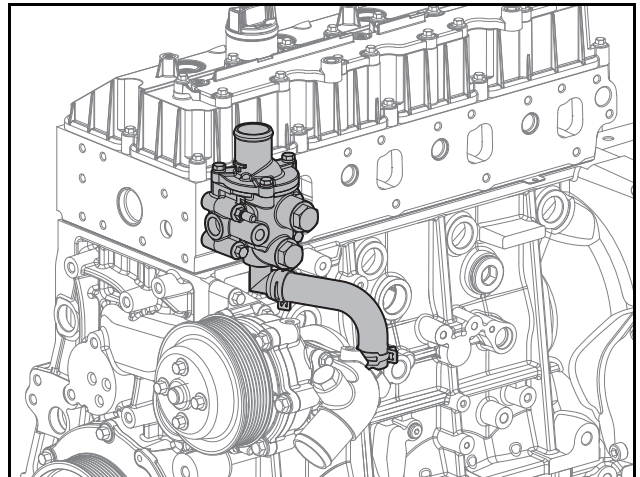
- |                   |                 |
|-------------------|-----------------|
| 1. Heat exchanger | 3. Coolant pump |
| 2. Bypass valve   | 4. Coolant pipe |

#### Removing the Thermostat

#### **⚠ CAUTION**

**Removing the thermostat itself may degrade the cooling performance so do not remove it.**

1. Drain the coolant until the coolant level is less than the height of the thermostat.
2. Remove the thermostat.

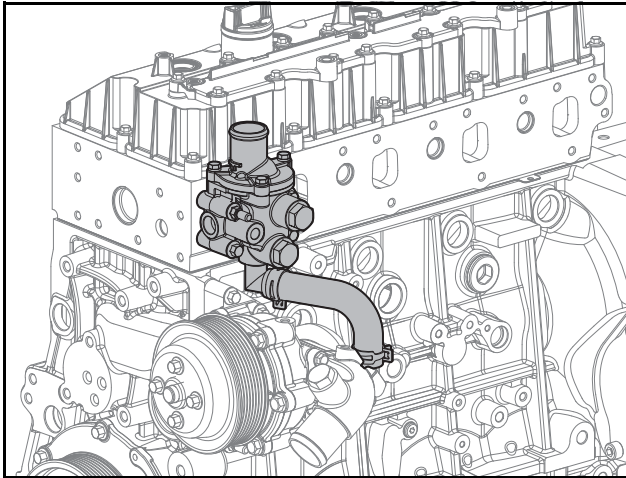


EDM03190253

- 1) Press on the clamp and disconnect the rubber hose.
- 2) Remove the spacer bolt.
- 3) Loosen the flange hex bolt.
- 4) Remove the thermostat.

### Assembling the Thermostat

1. Assemble the thermostat.

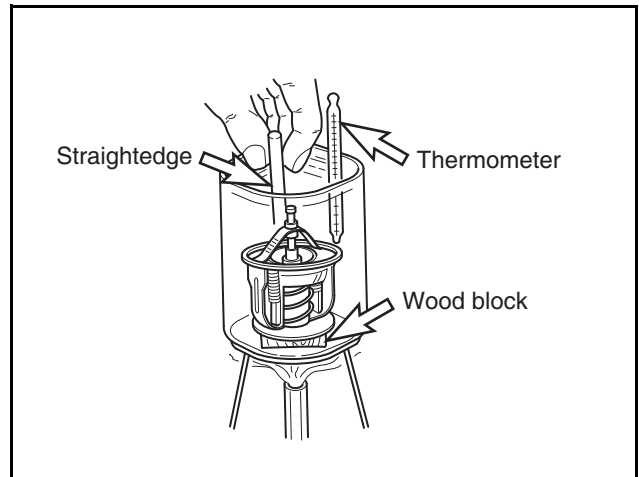


EDM03190253

- 1) Assemble the thermostat.
  - 2) Mount the spacer bolt.
  - 3) Tighten the flange hex bolts to a tightening torque of 2.2 kgf·m.
  - 4) Press on the clamp and connect the rubber hose.
2. Add coolant.

### Checking 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 following case: The opening and fully open temperature is refer the next page.



EDM03190404

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

<The open and full open temperature as Hyundai Doosan Infracore part number>

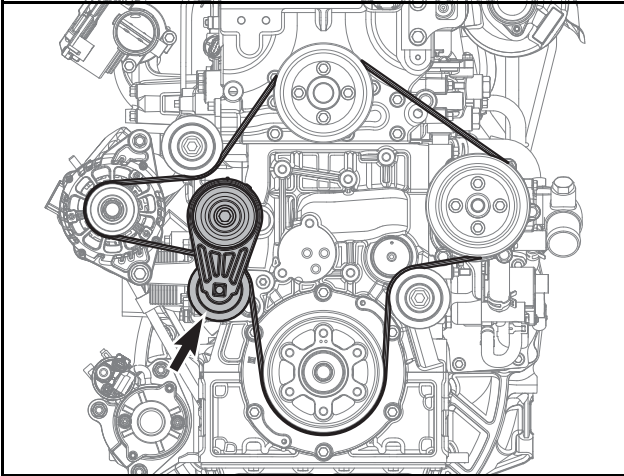
Type	Opening Temp.	Full Open Temp.	Full Open Lift
Type 1	71 ±2°C	85°C	>8 mm
Type 2	79 ±2°C	94°C	>8 mm
Type 3	83 ±2°C	95°C	>8 mm

## 6. Cooling System

### Cooling Fan

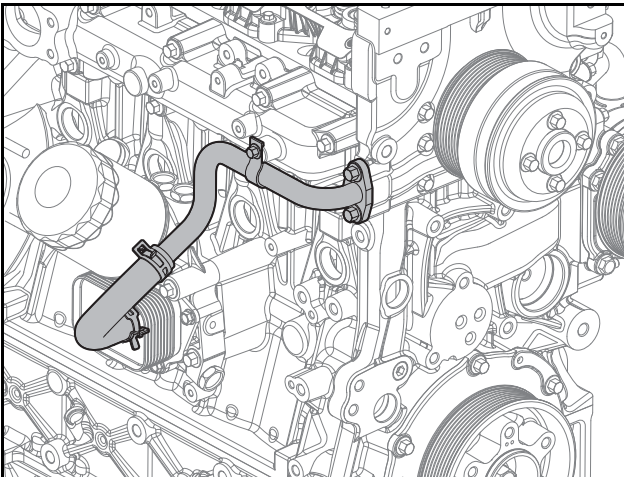
#### Removing the Fan Mounting Bracket

1. Remove the V-belt.



EDM03190231

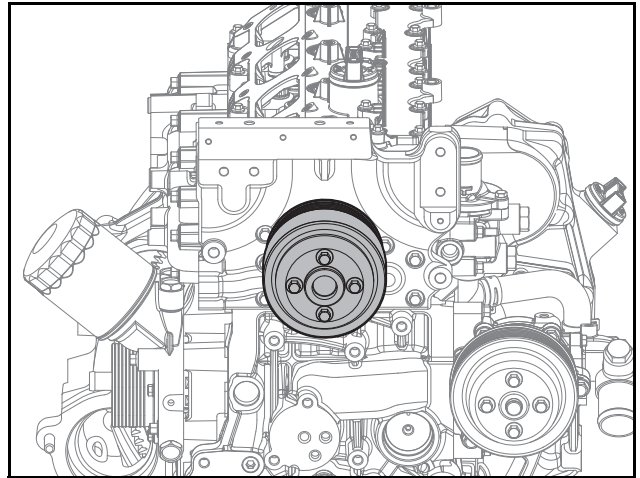
- 1) Turn the auto tensioner counterclockwise by using a quadrangular groove at the top of the auto tensioner pulley (Use a 10 mm x 10 mm quadrangular tool).
  - 2) Remove the belt wound around the auto tensioner pulley by using a space generated by the rotation of the auto tensioner.
2. Disconnect the coolant pipe & hose.



EDM03190252

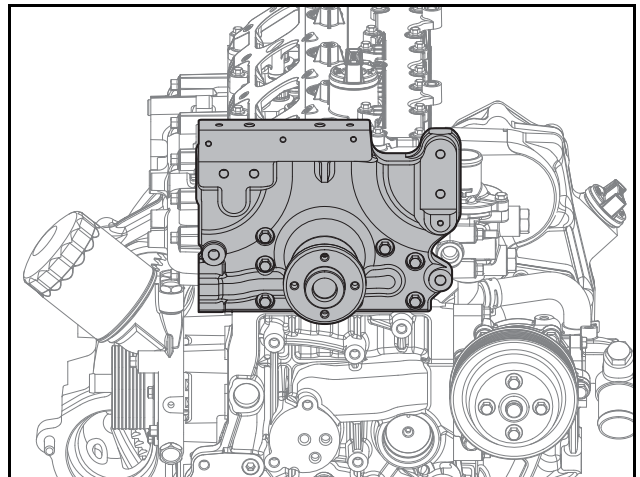
- 1) Press on the clamps on both ends of the coolant hoses and disconnect the coolant hoses.
- 2) Loosen the flange hex bolt.
- 3) Remove the coolant pipe.

3. Remove the fan pulley.



EDM03190176

- 1) Loosen 4 flange hex bolts.
  - 2) Remove the fan pulley.
4. Remove the fan mounting bracket.



EDM03190175

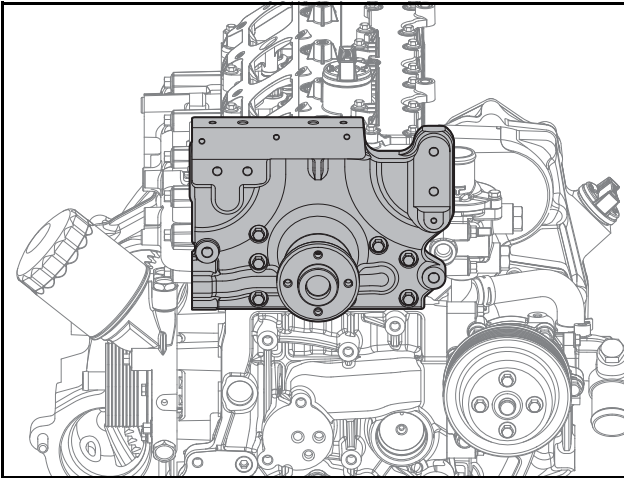
- 1) Loosen 7 flange hex bolts.
- 2) Remove the fan mounting bracket.



## 6. Cooling System

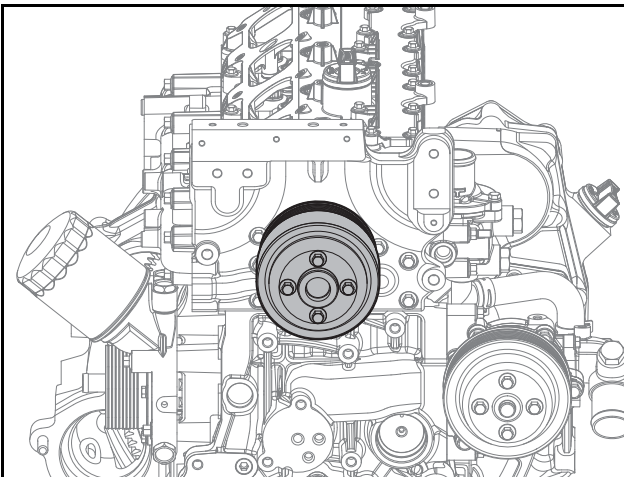
### Assembling the Fan Mounting Bracket

1. Assemble the fan mounting bracket.



EDM03190175

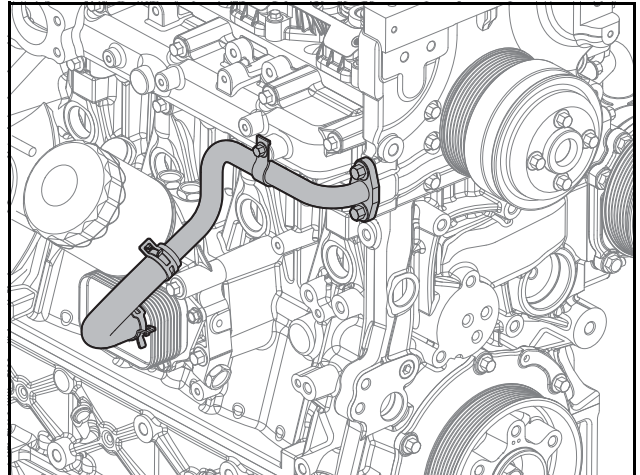
- 1) Assemble the fan mounting bracket.
  - 2) Tighten 7 flange bolts to a tightening torque 2.2 kgf·m.
2. Assemble the fan pulley.



EDM03190176

- 1) Assemble the fan pulley.
- 2) Tighten 4 flange bolts to a tightening torque of 2.2 kgf·m.

3. Assemble the coolant pipe & hose.



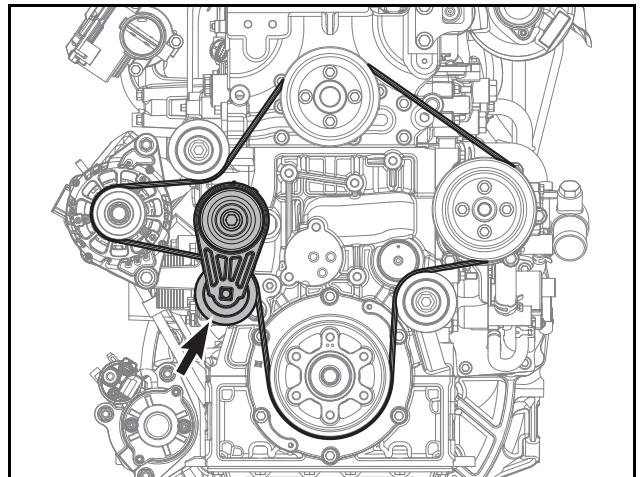
EDM03190252

- 1) Tighten the flange hex bolts to fix the coolant pipe in place.

### **⚠ CAUTION**

**Do not reuse clamps more than three times; replace them with new ones.**

- 2) Press on the clamps on both ends of the coolant hoses and connect the coolant hoses.
4. Assemble the V-belt.



EDM03190231

- 1) Wind a new belt around all pulleys except for the auto tensioner.
- 2) Turn the auto tensioner counterclockwise by using a quadrangular groove at the top of the auto tensioner pulley (use a 10 mm x 10 mm quadrangular tool).

## 6. Cooling System

---

- 3) Wind the belt around the auto tensioner pulley by using a space generated by the rotation of the auto tensioner, and then naturally release the tensioner that has been pulled counterclockwise.

---

### **CAUTION**

---

**For checking and measuring the belt tension, refer to Belt Tension in Chapter 12 (Others/Driving Units).**

---

# 7. Lubrication System

<b>General Information .....</b>	<b>115</b>
General Information .....	115
Troubleshooting .....	116
<b>Oil Pump .....</b>	<b>117</b>
General Information .....	117
Disassembling the Oil Pump.....	117
Assembling the Oil Pump.....	119
Checking the Oil Pump .....	121
Removing the Oil Suction Pipe .....	121
Assembling the Oil Suction Pipe.....	122
<b>Oil Cooler .....</b>	<b>124</b>
General Information .....	124
Removing the Oil Filter Assembly.....	124
Assembling the Oil Filter Assembly .....	125
Checking the Oil Filter Assembly .....	125
<b>Oil Pan .....</b>	<b>126</b>
Removing the Oil Pan.....	126
Assembling the Oil Pan.....	127





## 7. Lubrication System

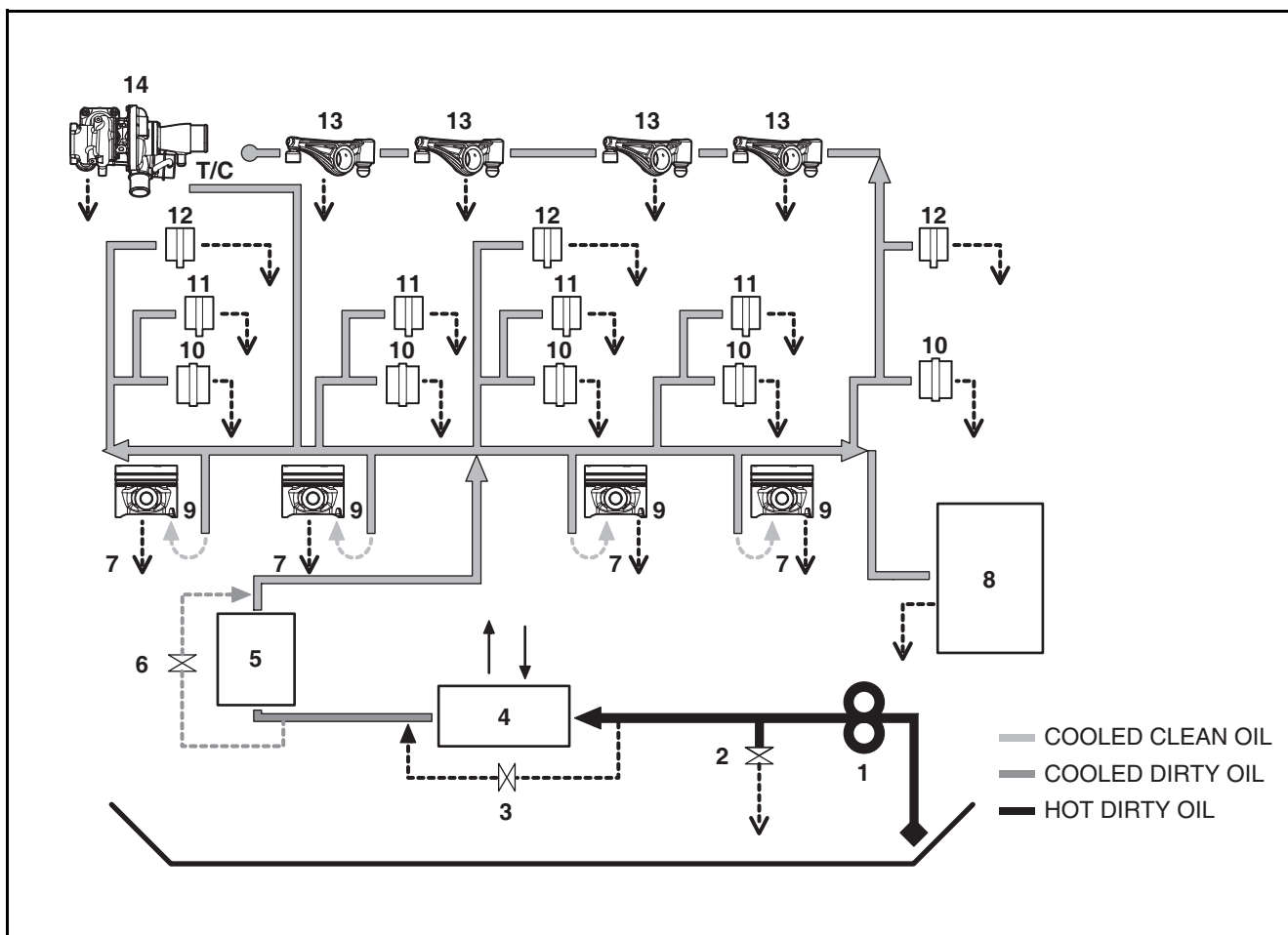
### General Information

#### General Information

This engine is lubricated by a forced lubrication system. Oil pressure is generated and delivered by rotating the gear of the oil pump which is directly engaged with the crankshaft gear on the front of the cylinder block.

After the oil pump sucks in oil from the oil pan through the suction pipe, this oil is sent to the main gallery of the cylinder block through the oil cooler and oil filter. Then, it is distributed to the crankshaft bearings, camshaft bearings and rocker arms in order to lubricate them.

In addition, the turbocharger is connected to the engine lubrication circuit. Oil is sprayed around the cylinder block and timing gear for proper lubrication. Each cylinder has an oil injection nozzle for cooling the bottom of the piston. Foreign matter is removed from engine oil by the oil filter.



EDM03200001

- |                 |                              |                             |
|-----------------|------------------------------|-----------------------------|
| 1. Oil pump     | 6. Bypass valve              | 11. Connecting rod bearings |
| 2. Relief valve | 7. Piston cooling jets       | 12. Camshaft bearings       |
| 3. Bypass valve | 8. Idle gear                 | 13. Rocker arms             |
| 4. Oil cooler   | 9. Piston                    | 14. Turbocharger            |
| 5. Oil filter   | 10. Crankshaft main bearings |                             |

## 7. Lubrication System

### Troubleshooting

Symptom	Possible cause	Solution
Excessive oil consumption	Faulty oil	Replace with specified oil
	Leaky oil seal ring and packing	Replace
	Worn or damaged piston and piston ring	Replace
	Worn cylinder liner	Replace
	Seized piston ring	Replace
	Worn valve guide oil seal, valve guide, or valve stem	Replace
Oil pressure drop	Faulty oil	Replace with specified oil
	Seized oil pump relief valve	Replace
	Clogged oil pump strainer	Wash the strainer
	Worn oil pump gear	Replace
	Cracked oil pump delivery pipe	Replace
	Defective oil pump	Repair or replace
	Defective hydraulic system	Repair or replace
	Worn bearing	Replace
Contaminated oil	Clogged oil filter	Replace oil filter
	Gas leak	Replace the piston ring
	Faulty oil	Replace with specified oil

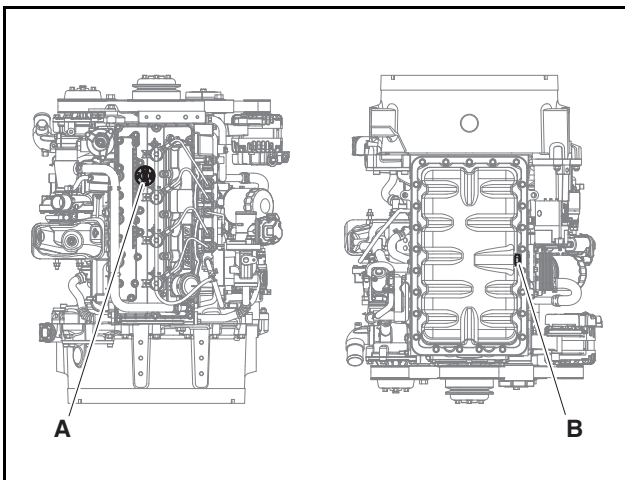
## Oil Pump

### General Information

As engine oil is sucked in and delivered from the oil pan through the gear oil pump, all of it passes through the oil cooler and oil filter to be filtered. Then, this filtered oil flows through the main oil gallery in the cylinder block to lubricate each bearing and the turbocharger in the engine in order to maintain normal engine performance.

### Disassembling the Oil Pump

1. Drain the engine oil.



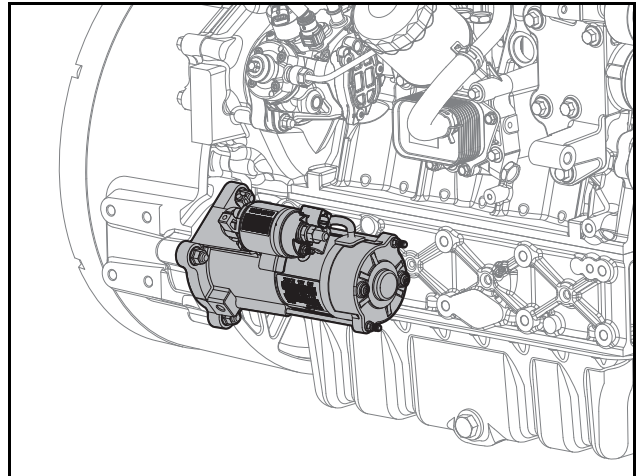
EDM03190229

- 1) Place a container for draining the engine oil below the engine.
- 2) Remove the drain plug (B) and drain the engine oil.
- 3) Remove the oil filler cap (A).
- 4) Remove the engine oil filter.
- 5) When draining the engine oil is complete, assemble the engine oil filter and drain plug.

### WARNING

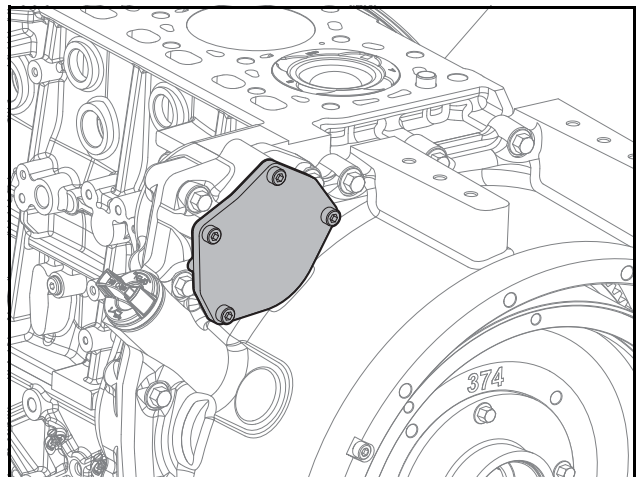
Follow the regulations of the public institutions in your area when disposing of used oil. Dumping engine oil on the ground, in sewers, drains, rivers and seas, etc. can cause severe environmental contamination. Disposing of engine oil incorrectly without complying with treatment regulations can be punished as a violation of treatment regulations.

2. Remove the starter motor.

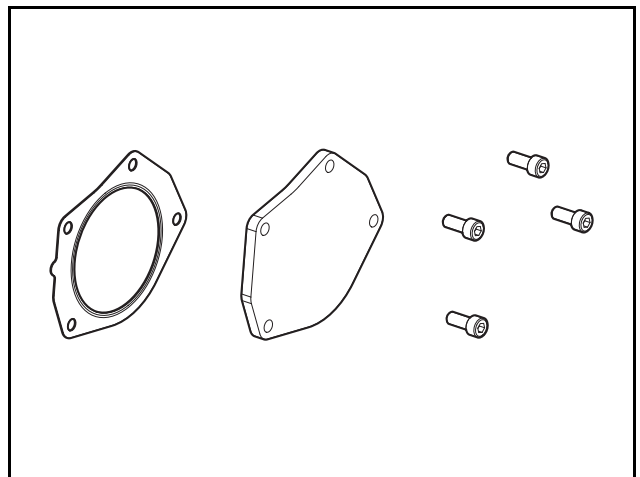


EDM03190242

- 1) Turn and loosen the flange nut.
- 2) Remove the starter motor.
3. Remove the front/rear PTO (Power Take Off) cover & gasket.



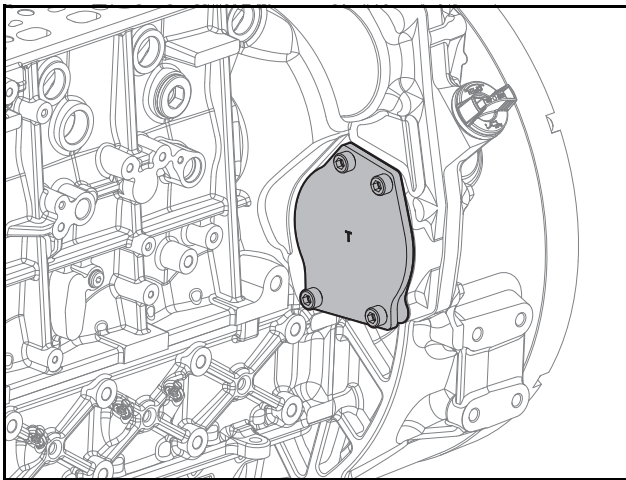
EDM03190257



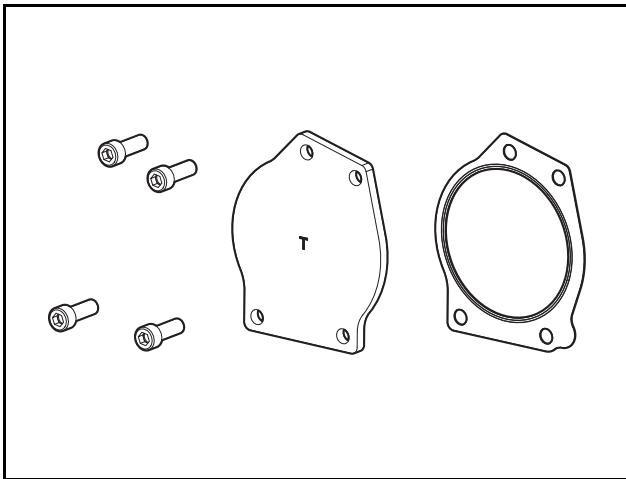
EDM03190319

## 7. Lubrication System

- 1) Remove 4 inner socket bolts from the front PTO (Power Take Off) cover & gasket.
- 2) Remove the front PTO (Power Take Off) cover & gasket.

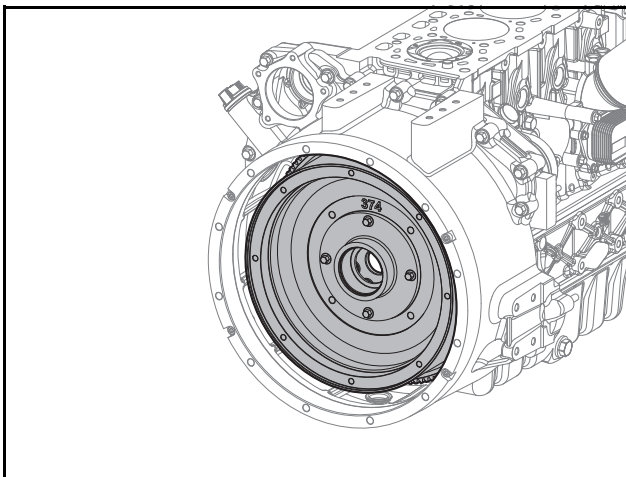


EDM03190256

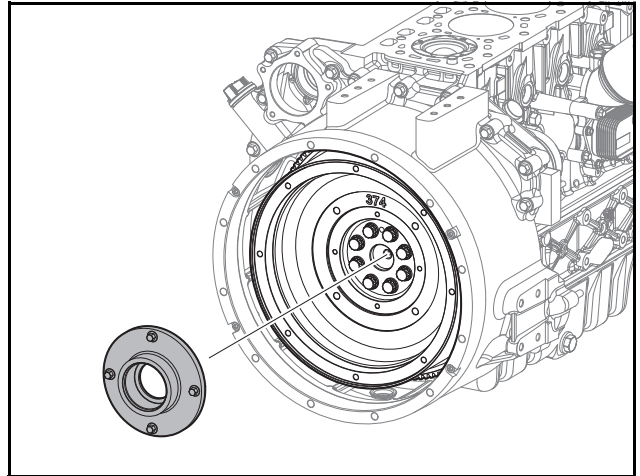


EDM03190320

- 3) Remove 4 inner socket bolts from the rear PTO (Power Take Off) cover & gasket.
- 4) Remove the rear PTO (Power Take Off) cover & gasket.
4. Remove the flywheel.

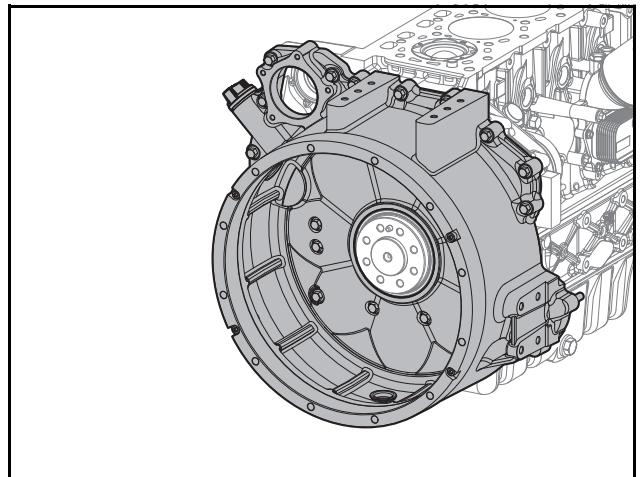


EDM03190259



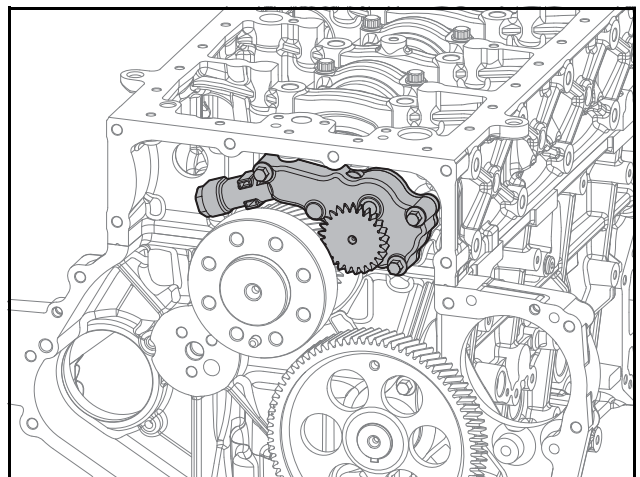
EDM03190260

- 1) Loosen 8 flange hex bolts.
- 2) Remove the flywheel.
5. Remove the flywheel housing.



EDM03190258

- 1) Loosen the hex bolts.
- 2) Remove the flywheel housing.
6. Remove the oil pump.



EDM03190139

## 7. Lubrication System

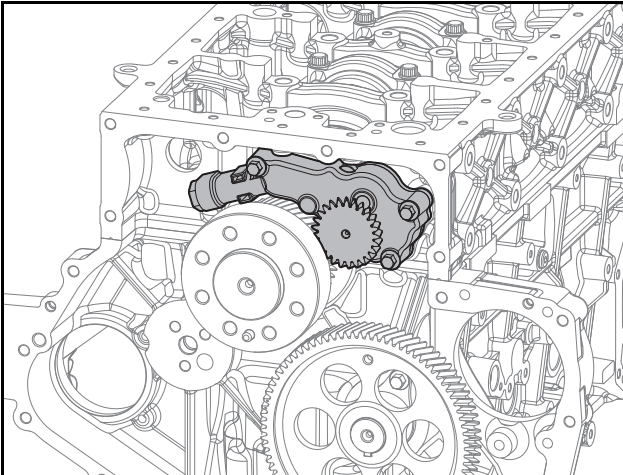
- 1) Loosen the hex bolts.
- 2) Remove the oil pump.

### CAUTION

Be careful not to damage the O-rings during disassembly.

### Assembling the Oil Pump

1. Assemble the oil pump.



EDM03190139

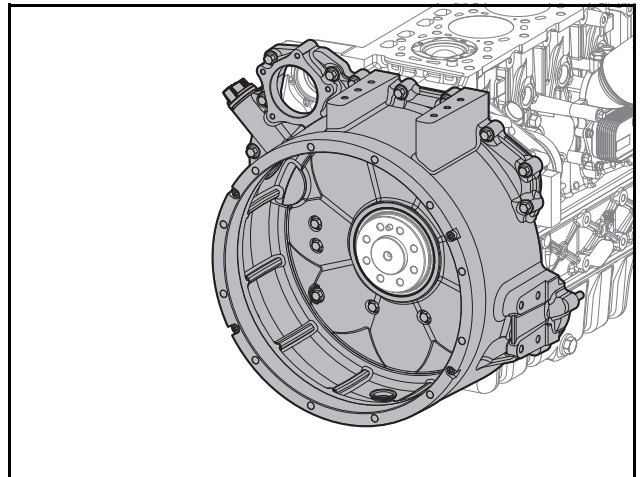
- 1) Align the O-rings with the engine oil inlet and outlet.
- 2) Align the oil pump with the pin and push it into the cylinder block as far as possible to assemble it.
- 3) Tighten the hex bolt to a tightening torque of 2.2 kgf·m.
- 4) The backlash between the crankshaft gear and the oil pump gear is 0.066 ~ 0.247 mm.

Item	Specified value
Backlash between crankshaft gear Oil pump gear backlash	0.066 ~ 0.247 mm

### CAUTION

- Be sure to check whether the O-rings have been assembled.
- Be careful not to damage the O-rings during assembly.

2. Assemble the flywheel housing.



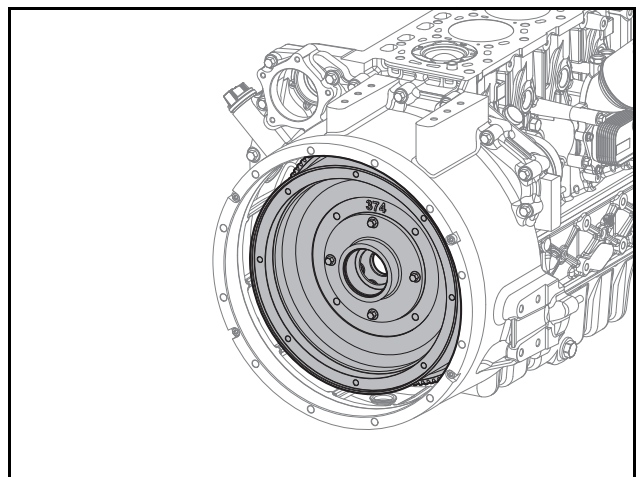
EDM03190258

- 1) Apply sealant to the assembly surface of the flywheel housing with a diameter of  $\varnothing 2.5 \pm 0.5$  mm.

### CAUTION

- Pay attention to the assembly direction of the flywheel housing.
- Assemble within 5 minutes of applying sealant (TB1217H).
- Do not start the engine or apply pressure within 25 minutes of applying sealant (TB1217H).

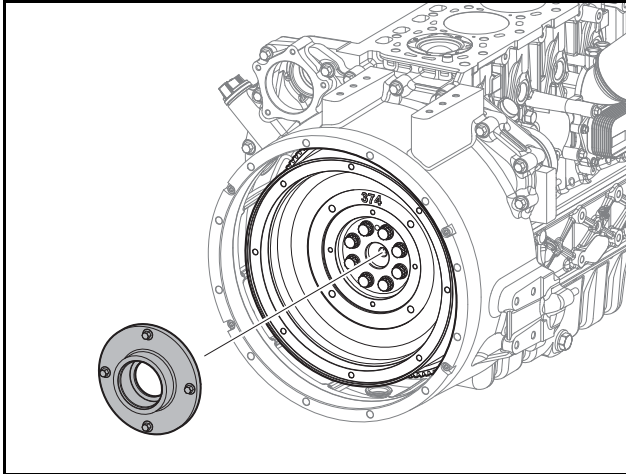
- 2) Assemble the flywheel housing.
- 3) Tighten the hex bolt to a tightening torque of 2.2 kgf·m.
3. Assemble the flywheel.



EDM03190259



## 7. Lubrication System



EDM03190260

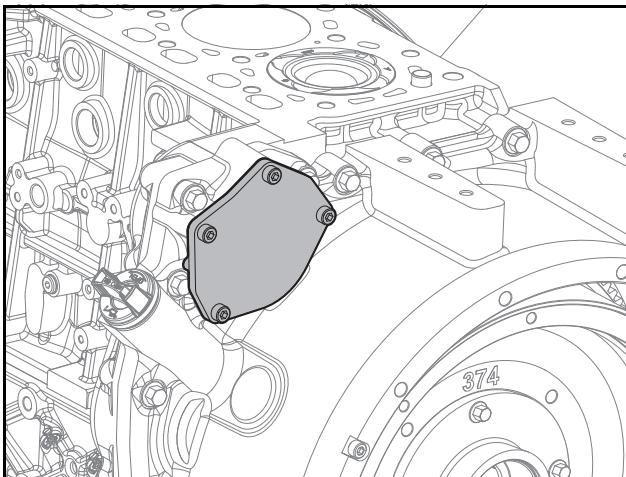
- 1) Assemble the flywheel.
- 2) Use the angle tightening method to tighten the flange hex bolts to a tightening torque.

Flywheel bolt (43 mm, option)	1st: $7 \pm 0.35 \text{ kgf}\cdot\text{m}$ /2nd: $45^\circ \pm 4^\circ$
Flywheel bolt (25 mm, option) for flat type flywheel	$17 \pm 0.85 \text{ kgf}\cdot\text{m}$

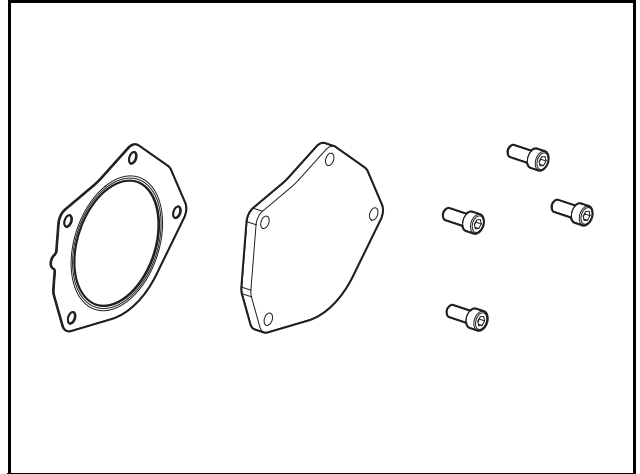
### **⚠ CAUTION**

**Do not reuse flange hex bolts when assembling the flywheel.**

4. Assemble the front/rear PTO (Power Take Off) cover & gasket.

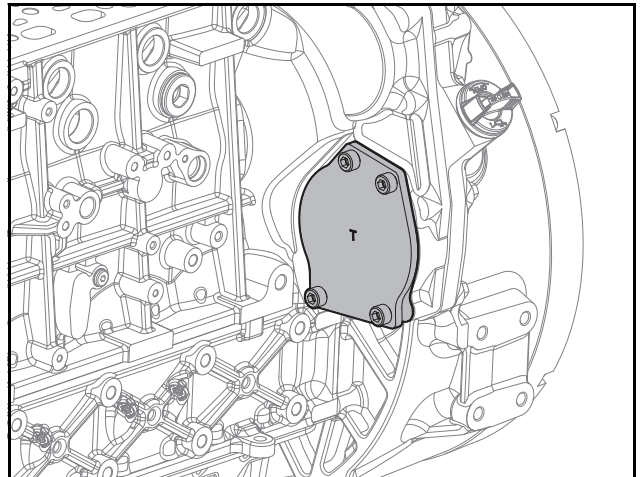


EDM03190257

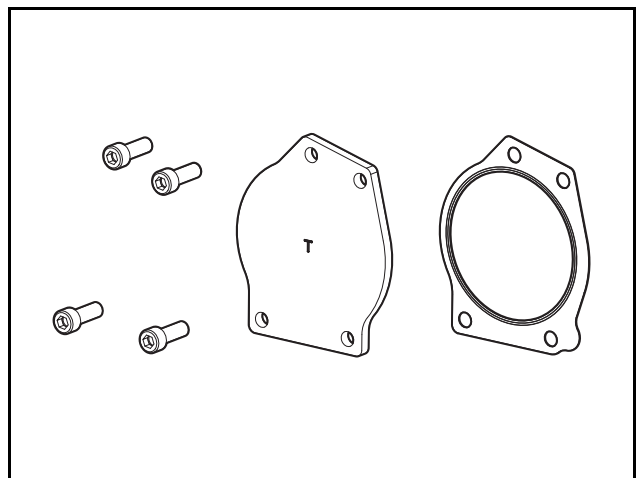


EDM03190319

- 1) Assemble the front PTO (Power Take Off) cover & gasket.
- 2) Tighten 4 inner socket bolts to a tightening torque of  $2.2 \pm 0.2 \text{ kgf}\cdot\text{m}$ .



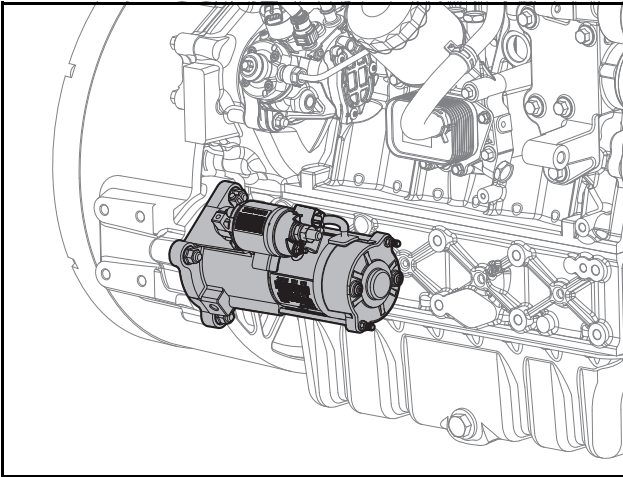
EDM03190256



EDM03190320

- 3) Assemble the rear PTO (Power Take Off) cover & gasket.
- 4) Tighten 4 inner socket bolts to a tightening torque of  $4.4 \pm 0.4 \text{ kgf}\cdot\text{m}$ .

5. Assemble the starter motor.



EDM03190242

- 1) Align the starter motor with the stud bolts and assemble it.
- 2) Tighten the flange nut to a tightening torque of 4.4 kgf·m.
6. Add engine oil.
- 1) Open the oil filler cap on the top of the cylinder head cover and add the engine oil prepared in advance.

### CAUTION

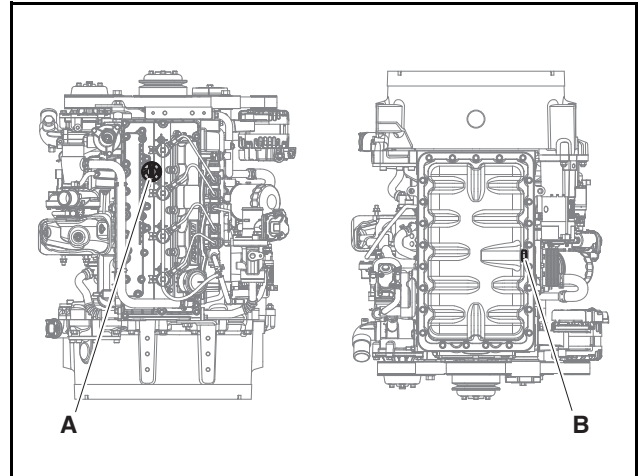
Use the specified genuine oil recommended by Hyundai Doosan Infracore.

### Checking the Oil Pump

1. Check whether the oil pump gear returns smoothly when pushed with a force of 3.0 kgf·cm or less.

### Removing the Oil Suction Pipe

1. Drain the engine oil.



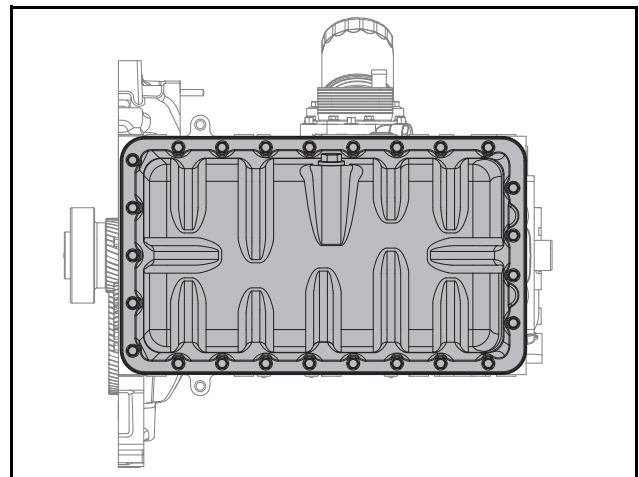
EDM03190229

- 1) Place a container for draining the engine oil below the engine.
- 2) Remove the drain plug (B) and drain the engine oil.
- 3) Remove the oil filler cap (A).
- 4) Remove the engine oil filter.
- 5) When draining the engine oil is complete, assemble the engine oil filter and drain plug.

### WARNING

Follow the regulations of the public institutions in your area when disposing of used oil. Dumping engine oil on the ground, in sewers, drains, rivers and seas, etc. can cause severe environmental contamination. Disposing of engine oil incorrectly without complying with treatment regulations can be punished as a violation of treatment regulations.

2. Remove the oil pan.

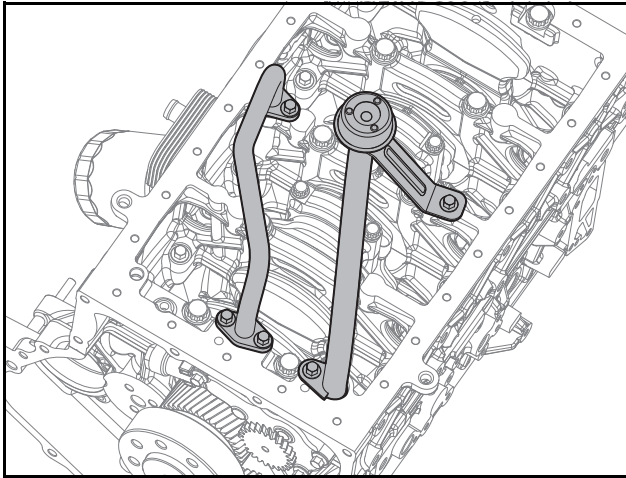


EDM03190182



## 7. Lubrication System

- 1) Loosen the flange hex bolts from outside to inside in the counterclockwise direction.
- 2) Remove the oil pan.
- 3) Remove the oil suction pipe and oil supply pipe.



- 1) Loosen the hex bolts.
- 2) Remove the oil suction pipe and O-ring.

---

### CAUTION

---

Be careful not to damage the O-rings during disassembly.

---

- 3) Loosen the flange hex bolt.
- 4) Remove the oil supply pipe and O-rings.

---

### CAUTION

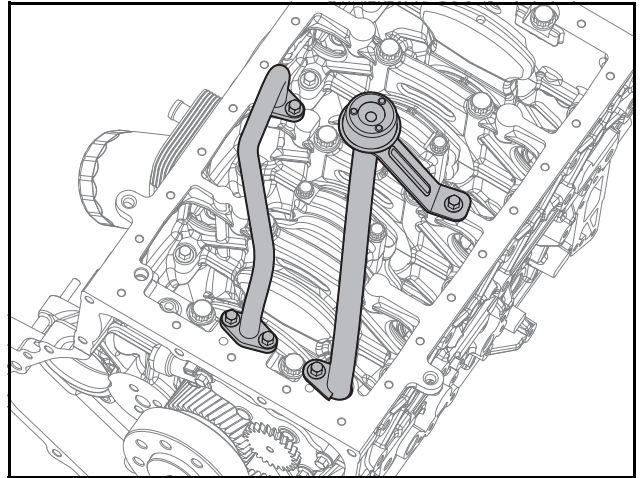
---

Be careful not to damage the O-rings during disassembly.

---

### Assembling the Oil Suction Pipe

1. Assemble the oil suction pipe and oil supply pipe.



EDM03190080

- 1) Assemble the O-rings.

---

### CAUTION

---

- Check whether the O-rings have been assembled.
  - Be careful not to damage the O-rings during assembly.
- 

- 2) Assemble the oil supply pipe.
  - 3) Tighten the flange hex bolt.
  - 4) Assemble the O-ring.
  - 5) Assemble the oil suction pipe.
  - 6) Tighten the hex bolt to a tightening torque of 2.2 kgf·m.
- 

---

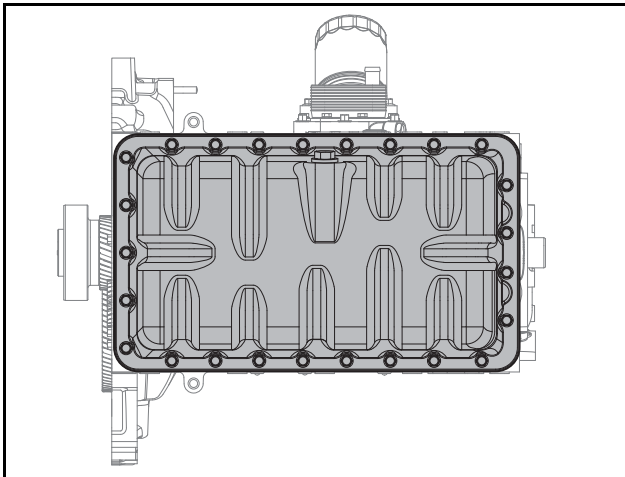
### CAUTION

---

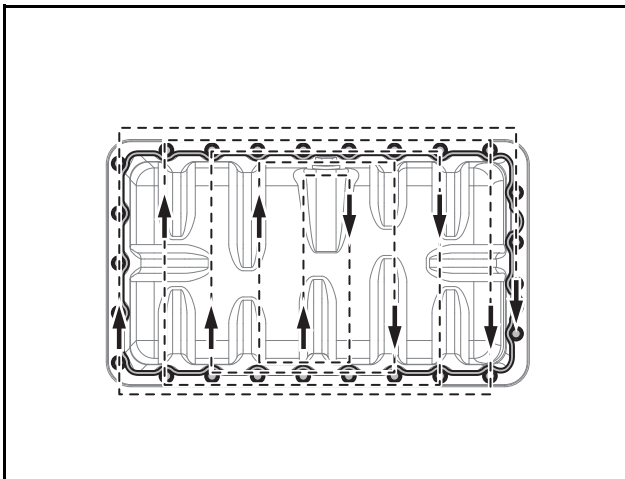
- Check whether the O-rings have been assembled.
  - Be careful not to damage the O-rings during assembly.
-

## 7. Lubrication System

2. Assemble the oil pan.



EDM03190182



EDM03190129

- 1) Before installing the oil pan, apply sealant (TB1217H) at an offset of 1 mm to the chamfered end of the sealing surface.
- 2) Apply it with a diameter of  $\text{Ø}2.5 \pm 0.5$  mm at a 1 mm offset to the chamfered end.

### **⚠ CAUTION**

- Pay attention to the assembled direction of the oil pan.
- Assemble within 5 minutes of applying sealant (TB1217H).
- Do not start the engine or apply pressure within 25 minutes of applying sealant (TB1217H).

- 3) Assemble the oil pan.
- 4) Temporarily mount the flange hex bolts from inside to outside in the clockwise direction.
- 5) Tighten the flange hex bolts from inside to outside in the clockwise direction at a tightening torque of 2.2 kgf·m.

3. Add engine oil.

- 1) Open the oil filler cap on the top of the cylinder head cover and add the engine oil prepared in advance.

### **⚠ CAUTION**

Use the specified genuine oil recommended by Hyundai Doosan Infracore.

# 7. Lubrication System

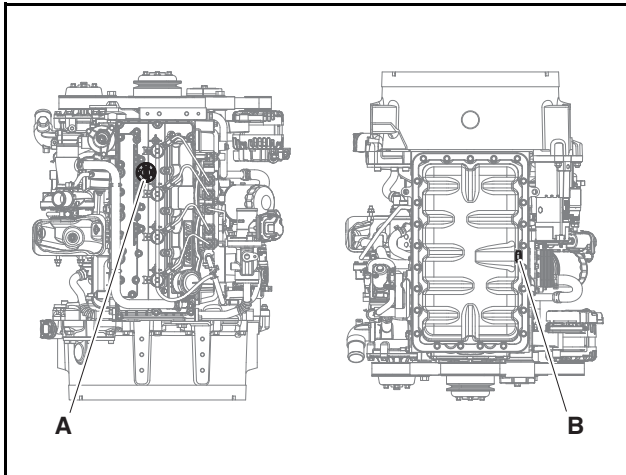
## Oil Cooler

### General Information

Oil is cooled by coolant in the oil cooler, then the oil filter removes any foreign matter in the oil.

### Removing the Oil Filter Assembly

1. Drain the engine oil.



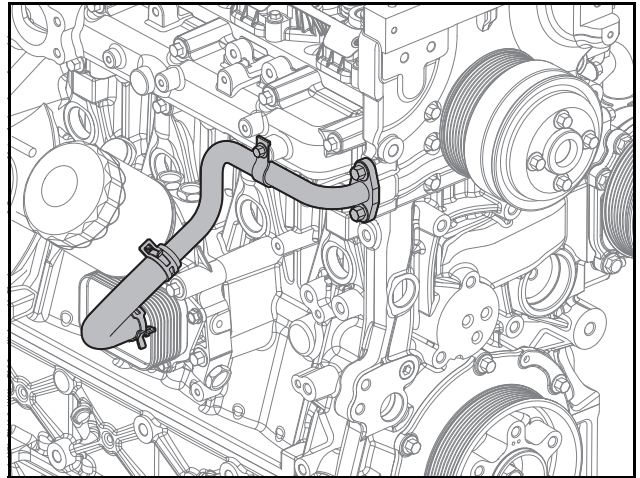
EDM03190229

- 1) Place a container for draining the engine oil below the engine.
- 2) Remove the drain plug (B) and drain the engine oil.
- 3) Remove the oil filler cap (A).
- 4) Remove the engine oil filter.
- 5) When draining the engine oil is complete, assemble the engine oil filter and drain plug.

### WARNING

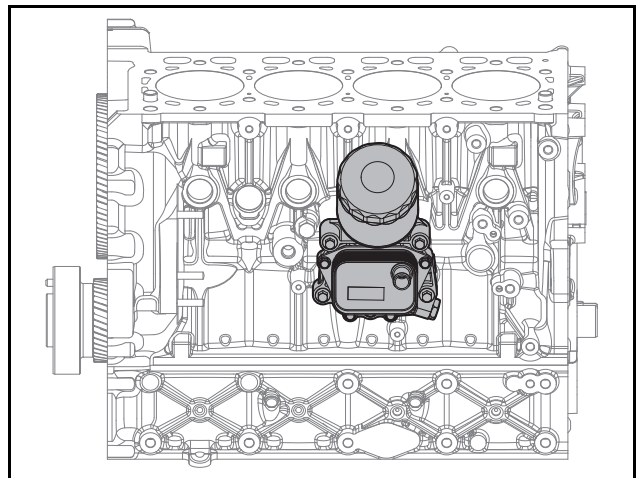
Follow the regulations of the public institutions in your area when disposing of used oil. Dumping engine oil on the ground, in sewers, drains, rivers and seas, etc. can cause severe environmental contamination. Disposing of engine oil incorrectly without complying with treatment regulations can be punished as a violation of treatment regulations.

2. Disconnect the coolant pipe and hose.



EDM03190252

- 1) Press on the clamps on both ends of the coolant hoses and disconnect the coolant hoses.
- 2) Loosen the flange hex bolt.
- 3) Remove the coolant pipe.
3. Detach the oil cooler and the oil filter module.



EDM03190136

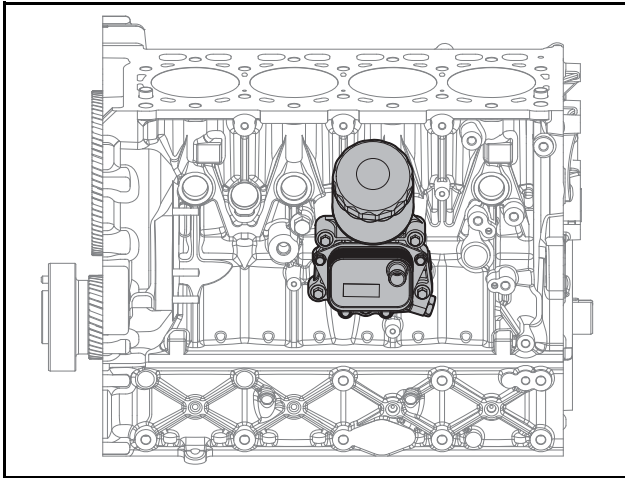
- 1) Loosen the flange hex bolt.
- 2) Remove the oil filter assembly.

### CAUTION

- Be careful not to damage the O-rings during disassembly.
- When removing the oil filter, oil inside the filter may leak out of the filter so use a cloth to avoid contaminating nearby parts. After replacing the oil filter, be sure to completely wipe off any oil spilled nearby.

### Assembling the Oil Filter Assembly

1. Assemble the oil cooler and the oil filter module.



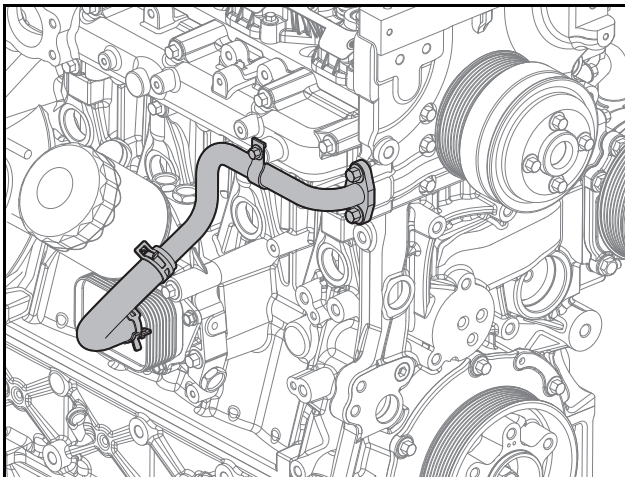
EDM03190136

- 1) Assemble the oil filter assembly.

### **⚠ CAUTION**

- Check whether the O-rings have been assembled with the oil filter assembly.
- Be careful not to damage the O-rings during assembly.

- 2) Tighten the flange hex bolts to a tightening torque of 2.2 kgf·m.
2. Assemble the coolant pipe & hose.



EDM03190252

- 1) Tighten the flange hex bolts to fix the coolant pipe in place.

### **⚠ CAUTION**

**Do not reuse clamps more than three times; replace them with new ones.**

- 2) Press on the clamps on both ends of the coolant hoses and connect the coolant hoses.

3. Add engine oil.

- 1) Open the oil filler cap on the top of the cylinder head cover and add the engine oil prepared in advance.

### **⚠ CAUTION**

**Use the specified genuine oil recommended by Hyundai Doosan Infracore.**

### Checking the Oil Filter Assembly

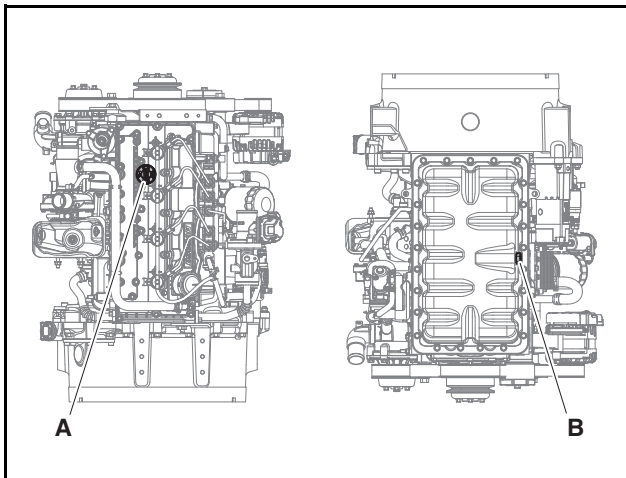
1. Check for any damage or leaks in the coolant inlet of the oil cooler.
2. Check for any damage or leaks in the oil inlet and outlet of the oil cooler.
3. Check for any damage or leaks on the exterior of the oil cooler.

# 7. Lubrication System

## Oil Pan

### Removing the Oil Pan

1. Drain the engine oil.



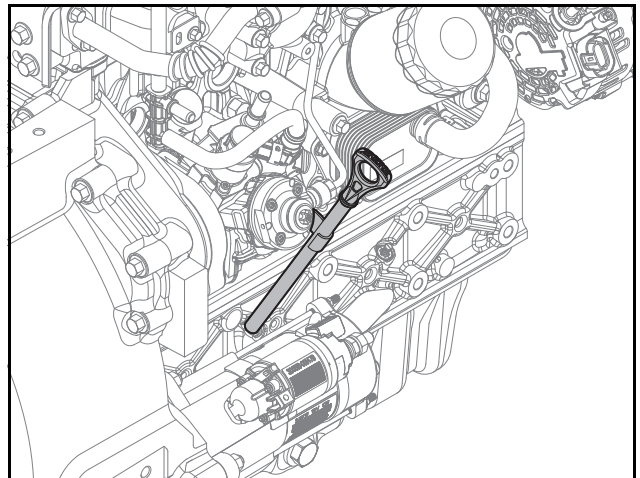
EDM03190229

- 1) Place a container for draining the engine oil below the engine.
- 2) Remove the drain plug (B) and drain the engine oil.
- 3) Remove the oil filler cap (A).
- 4) Remove the engine oil filter.
- 5) When draining the engine oil is complete, assemble the engine oil filter and drain plug.

### WARNING

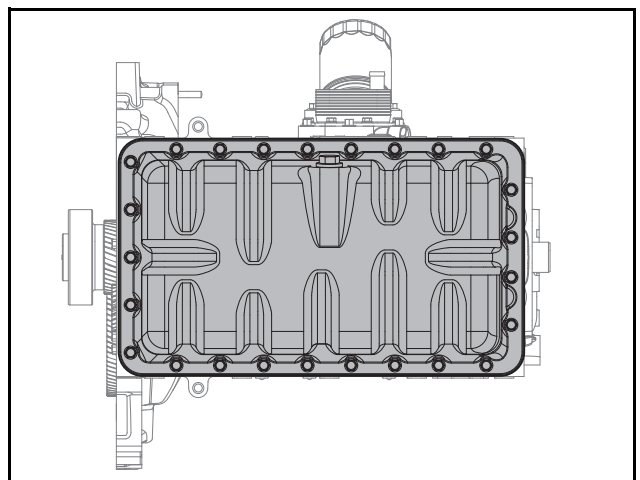
Follow the regulations of the public institutions in your area when disposing of used oil. Dumping engine oil on the ground, in sewers, drains, rivers and seas, etc. can cause severe environmental contamination. Disposing of engine oil incorrectly without complying with treatment regulations can be punished as a violation of treatment regulations.

2. Remove the oil level gauge.



EDM03190232

- 1) Remove the oil level gauge.
  - 2) Loosen the flange hex bolt holding the oil level gauge guide tube in place.
  - 3) Remove the oil level gauge guide tube from the cylinder block.
  - 4) Remove the O-rings.
3. Remove the oil pan.



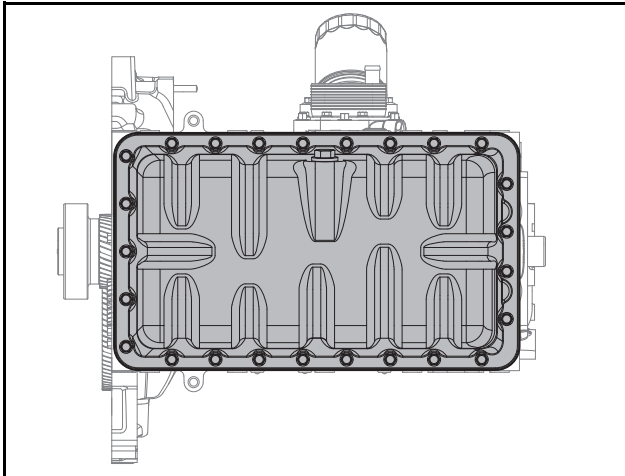
EDM03190182

- 1) Loosen the flange hex bolts from outside to inside in the counterclockwise direction.
- 2) Remove the oil pan.

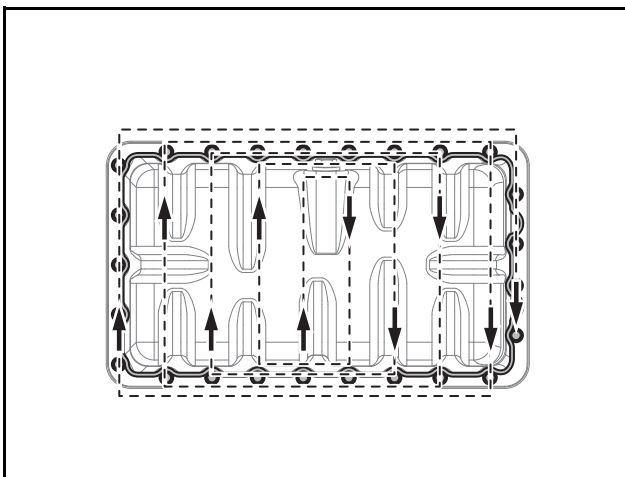


### Assembling the Oil Pan

1. Assemble the oil pan.



EDM03190182



EDM03190129

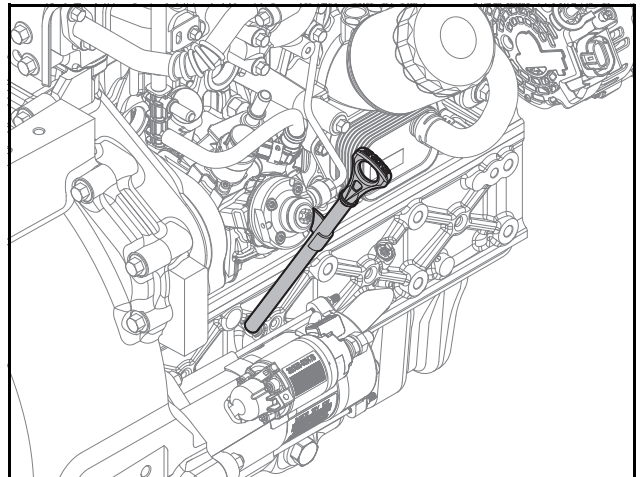
- 1) Before installing the oil pan, apply sealant (TB1217H) at an offset of 1 mm to the chamfered end of the sealing surface.
- 2) Apply it with a diameter of  $\varnothing 2.5 \pm 0.5$  mm at a 1 mm offset to the chamfered end.

#### **⚠ CAUTION**

- Pay attention to the assembled direction of the oil pan.
- Assemble within 5 minutes of applying sealant (TB1217H).
- Do not start the engine or apply pressure within 25 minutes of applying sealant (TB1217H).

- 3) Assemble the oil pan.
- 4) Temporarily mount the flange hex bolts from inside to outside in the clockwise direction.
- 5) Tighten the flange hex bolts from inside to outside in the clockwise direction at a tightening torque of 2.2 kgf·m.

2. Assemble the oil level gauge.



EDM03190232

- 1) Replace the O-ring on the guide tube for the oil level gauge with a new one.
- 2) Apply oil to the surface of the O-rings on the guide tube for the oil level gauge.
- 3) Press fit the oil level gauge guide tube into the cylinder block.

#### **⚠ CAUTION**

Assemble the oil level gauge guide tube so that the direction of the oil level gauge handle faces the opposite direction from the center of the engine.

- 4) Tighten the flange hex bolt to a tightening torque of 1.0 kgf·m to fix the oil level gauge tube in place.
- 5) Mount the oil level gauge.
3. Add engine oil.
- 1) Open the oil filler cap on the top of the cylinder head cover and add the engine oil prepared in advance.

#### **⚠ CAUTION**

Use the specified genuine oil recommended by Hyundai Doosan Infracore.

## 7. Lubrication System

---



# 8. Fuel System

<b>General Information .....</b>	<b>131</b>
General Information .....	131
<b>Fuel Return Hose .....</b>	<b>132</b>
General Information .....	132
Disconnecting the Fuel Return Hose .....	132
Assembling the Fuel Return Hose .....	132
<b>Injector .....</b>	<b>133</b>
General Information .....	133
Injector Operating Principles .....	133
Removing the Injector .....	134
Assembling the Injector .....	135
Checking the Injector .....	137
<b>Common Rail .....</b>	<b>138</b>
General Information .....	138
Pressure Limit Valve & Rail Pressure Sensor .....	141
Injection Pipe .....	142
Removing the Common Rail .....	143
Assembling the Common Rail .....	143
Checking the Common Rail .....	144
<b>Fuel Injection Pump .....</b>	<b>145</b>
General Information .....	145
Removing the Fuel Injection Pump .....	146
Assembling the Fuel Injection Pump .....	147
Removing the Fuel Injection Pump Drive Gear .....	148
Assembling the Fuel Injection Pump Drive Gear .....	148



## General Information

### General Information

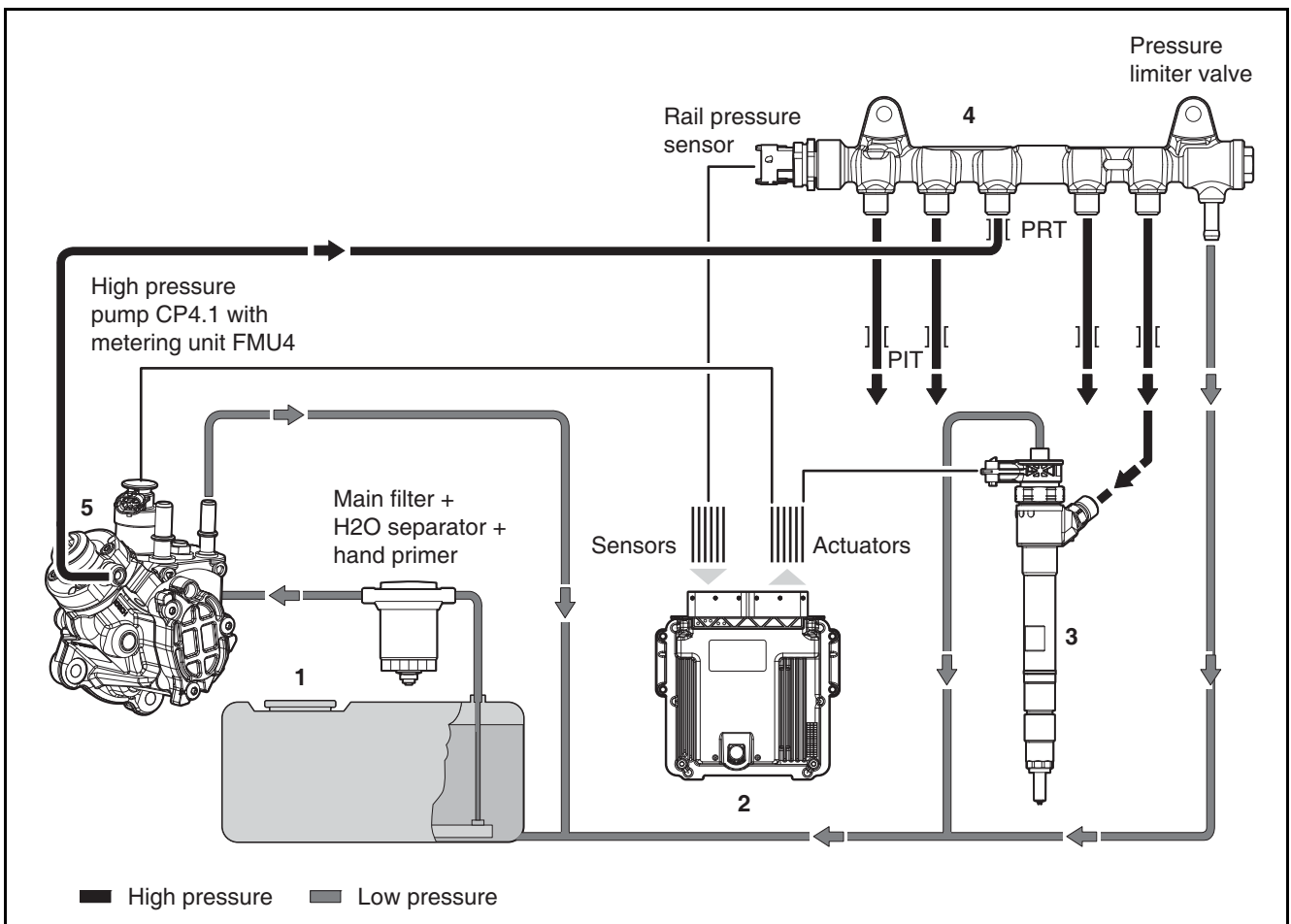
Diesel engines compress air drawn into the cylinders, creating compression heat, then when fuel is injected through the injection nozzles, combustion arises due to the compression heat.

The high-pressure fuel created by the high-pressure fuel pump is stored in the common rail, and the injection timing and injection amount are determined by the electronic control unit (ECU). The electronic control unit activates the solenoid valve on the injectors installed in each cylinder and causes them to inject fuel.

Hyundai Doosan Infracore common rail fuel injection system is divided into a pressurizing device and a fuel injection device. In order to provide optimal performance based on the engine operating conditions, fuel is injected into the cylinders after the amount of fuel, injection timing and injection pressure are determined by the electronic control unit.

The common rail fuel injection system is composed of a low-pressure stage for the low-pressure delivery of fuel, a high-pressure stage for high-pressure delivery, and an electronic control unit.

The fuel tank must be made of a non-corrosive material and there must be no leaks at twice the operating pressure of the low-pressure fuel pump. The pressure inside the tank must not exceed 0.3 bar.



EDM03190023

- |                                  |                |                       |
|----------------------------------|----------------|-----------------------|
| 1. Tank with pre-filter          | 3. Injector    | 5. Fuel injector pump |
| 2. Electronic Control Unit (ECU) | 4. Common rail |                       |

## 8. Fuel System

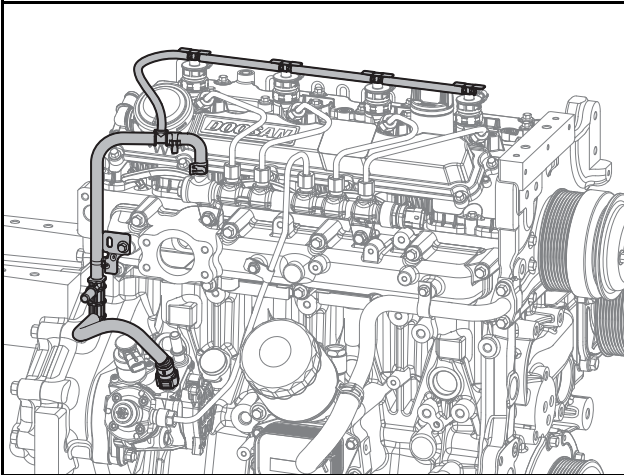
### Fuel Return Hose

#### General Information

This is a line for moving fuel returned from the injector back to the high-pressure pipe.

#### Disconnecting the Fuel Return Hose

1. Disconnect the fuel return hose.

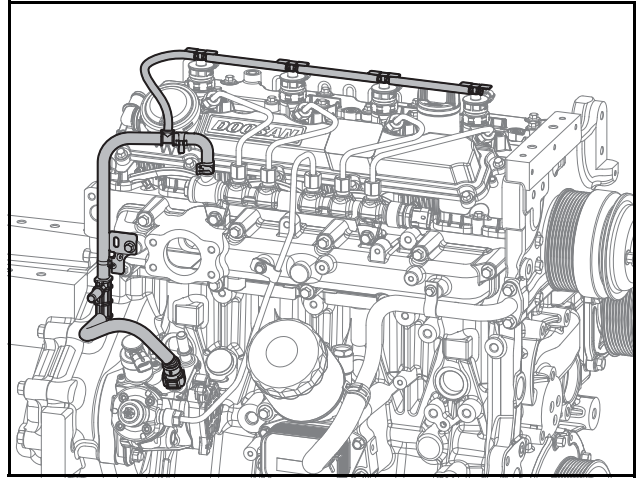


EDM03190241

- 1) Press on the clamps to remove the common rail, injectors, and fuel return hose on the fuel injection pump.
- 2) Disconnect the fuel return hose.

#### Assembling the Fuel Return Hose

1. Assemble the fuel return hose.



EDM03190241

- 1) Assemble the fuel return hose.

### CAUTION

- Pay attention to the assembled direction of the fuel return hose.
- Assemble the injectors and fuel return hoses so that they interlock sufficiently.
- Do not reuse fuel return hoses; replace them with new ones. Failure to do so may cause serious faults in the engine performance.
- Be careful to avoid damage for fuel return hose of injector.
- Don't press on the fuel hose, don't drop heavy tool like as spanner on engine, don't step on fuel hose, don't stand on engine.
- If the fuel hose are broken by wrong handling, it is possible fire.

- 2) Press on the clamps to attach the common rail, injectors, and fuel return hoses on the fuel injection pump.

### Injector

#### General Information

In the nozzle of the injector, a solenoid valve activates to enable fuel to flow, then the injector injects fuel directly into the combustion chamber of the engine.

When the injector nozzle opens, the required fuel is delivered and the remaining fuel returns to the tank via the return line. In addition, the fuel returned from the fuel pressure adjustment valve and low-pressure stage, and the fuel used to lubricate the high-pressure pump return to the fuel tank together via the return line.

The start of fuel injection and the amount of injection are adjusted by the solenoid valve installed in the injector. The injector replaces the function of the nozzle and nozzle holder in previous engines. Fuel is delivered to the injector through the high-pressure connector installed in the cylinder head, and then delivered to the valve control chamber through the delivery hole.

The valve control chamber is opened by the solenoid valve, passes through the discharge hole and then connected to the fuel return line.

The force of the hydraulic pressure applied to the valve control plunger while the discharge hole is closed exceeds the pressure value of the nozzle needle.

As a result, the fuel supply to the combustion chamber is shut off by the force applied to the contact surface of the nozzle needle.

When the solenoid valve of the injector is pulled, the discharge hole is opened. This lowers the pressure in the control chamber and the force of the hydraulic pressure acting on the plunger also drops. If the force of the hydraulic pressure drops below the force acting on the nozzle needle pressure, the nozzle needle opens. Then fuel is injected into the combustion chamber via the injection nozzle hole.

This is because in controlling the nozzle needle using the force of hydraulic pressure, the force needed to open the valve quickly is not generated directly by the solenoid valve. The fuel control amount required for opening the nozzle needle is added to the amount of fuel actually injected. And the used fuel is discharged to the fuel return line through the hole in the valve control chamber. Fuel loss occurs not only in the control but also in the nozzle needle and valve plunger guide. The control leakage fuel and the fuel gathered from the line which connects the overflow valve, the high-pressure pump, and the pressure control valve, is returned to the fuel tank through the fuel return line.

#### Injector Operating Principles

The operation of the injector is divided into four actions of engine operation and the high-pressure pump which generates pressure.

1. Injector closed (fuel is pressurized)
2. Injector open (fuel injection begins)
3. Injector fully open (fuel injection)
4. Injector closed (end of fuel injection)

These operating stages are determined by the distribution of the force acting on the components of the injector, and if the engine is stopped or there is no pressure on the common rail, the injector nozzle does not work.

1. Injector closed (resting)

During the resting state where no power is provided to the solenoid valve of the injector, the injector does not operate. The valve ball is pressed against the discharge hole seat surface of the injector by the force of the valve spring and a magnetic force. The high pressure within the common rail is maintained by the fuel control valve and formed in the nozzle chamber of the injector by the same pressure. The common rail fuel pressure acting on the end of the valve control chamber in the injector and the force acting on the nozzle spring in the injector are greater than the force of the nozzle attempting to open, so the closed state is maintained.

2. Injector open (fuel injection begins)

When power is supplied while the injector solenoid valve is closed, the fuel discharge hole is opened by the pulling force of the solenoid valve. At this time, the high current applied to the solenoid almost simultaneously decreases to a low current. This is possible because the air gap in the electromagnetic circuit decreased. The fuel in the valve control chamber flows through the discharge valve hole, and from there, it passes through the fuel return line into the fuel tank.

The discharge hole completely disrupts the pressure balance and drops the pressure in the valve control chamber. This further drops the chamber pressure in the nozzle which is at the same pressure as the common rail and the pressure in the valve control chamber. This pressure reduced in the valve control chamber causes a decrease in the force acting on the control plunger and as a result, the nozzle needle opens and fuel injection begins.

3. Injector fully open (fuel injection)

The valve control plunger stops in the upper position due to the fuel buffer created when fuel flows between the discharge and delivery hole. At this time, the injector nozzle opens completely and fuel is injected into the combustion chamber at the same pressure as the common rail.

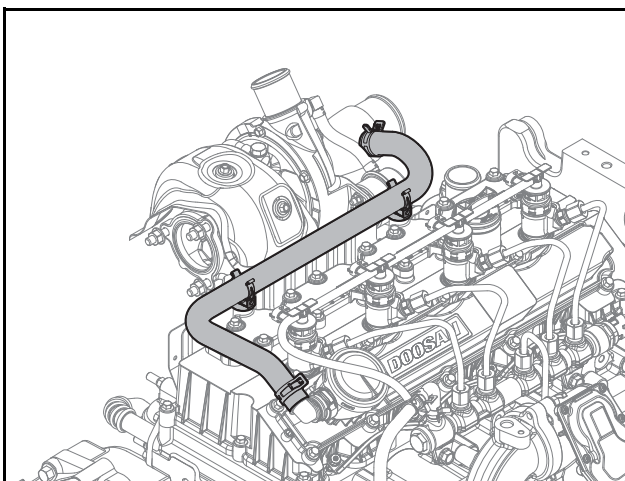
## 8. Fuel System

### 4. Injector closed (end of injection)

When the power supply to the injector solenoid valve is shut off, the valve spring immediately applies a downward force to the armature and the valve ball closes the discharge hole. The armature is composed of two parts. The armature plate is guided by the driving shoulder and pressed downward. However, an overspring with a return spring is used so that the force acting on the armature and valve ball is not applied downwards. The closing of the discharge hole causes fuel to enter from the delivery hole and form pressure in the control chamber. This fuel pressure, identical to the pressure in the common rail, applies pressure to the valve control plunger through the end of the valve control plunger. This and the force of the spring exceed the pressure formed in the nozzle chamber and close the nozzle needle. The closing speed of the nozzle needle is determined by the flow rate passing through the delivery hole, and as soon as the nozzle needle reaches the stop position, fuel injection is shut off.

### Removing the Injector

#### 1. Remove the breather hose.

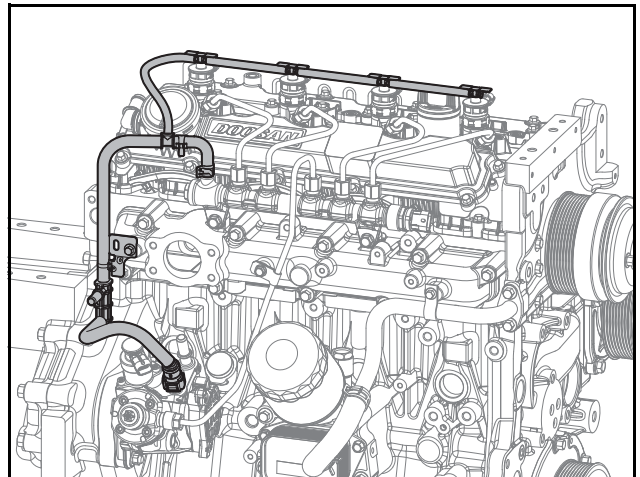


EDM03190234

- 1) Press on the clamps on the quick connector and T/C air inlet pipe assembly, then disconnect the breather hose.

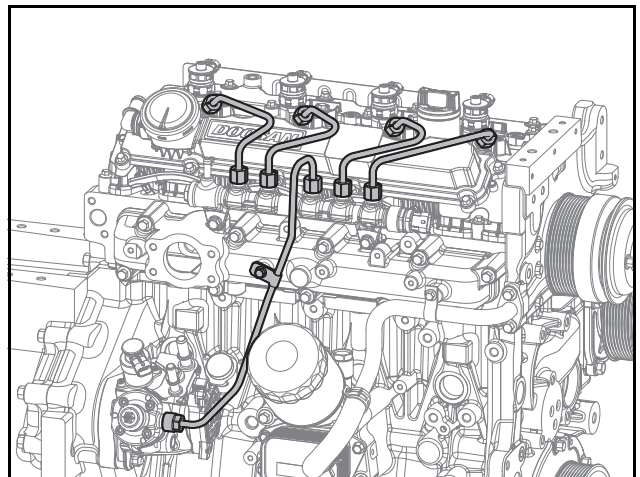
Note: There is no need to disconnect the hose on the quick connector.

#### 2. Disconnect the fuel return hose.



EDM03190241

- 1) Press on the clamps to remove the common rail, injectors, and fuel return hose on the fuel injection pump.
- 2) Disconnect the fuel return hose.
3. Remove the fuel injection pipe.



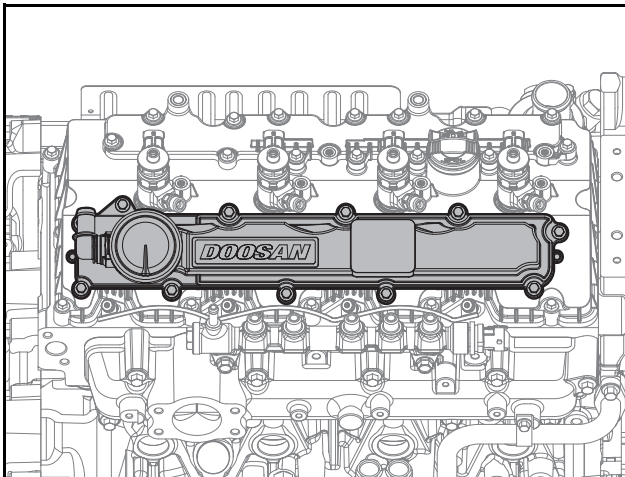
EDM03190240

- 1) Loosen the flange hex bolt.
- 2) Loosen the nuts on both ends of the fuel injection pipes and remove the fuel injection pipes.

### **⚠ CAUTION**

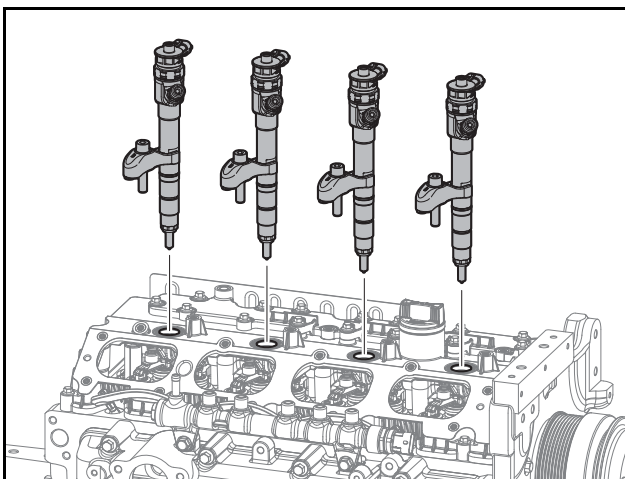
**Do not bend the fuel injection pipe by force.**

4. Remove the right cylinder head cover.



EDM03190245

- 1) Loosen the flange hex bolts from outside to inside in the direction of the arrow.
- 2) Remove the right cylinder head cover.
5. Remove the injector.



EDM03190247

- 1) Loosen the hex bolts.
- 2) Remove the injector mounting brackets.
- 3) Remove the injectors.
- 4) Remove the injector sealing washer.

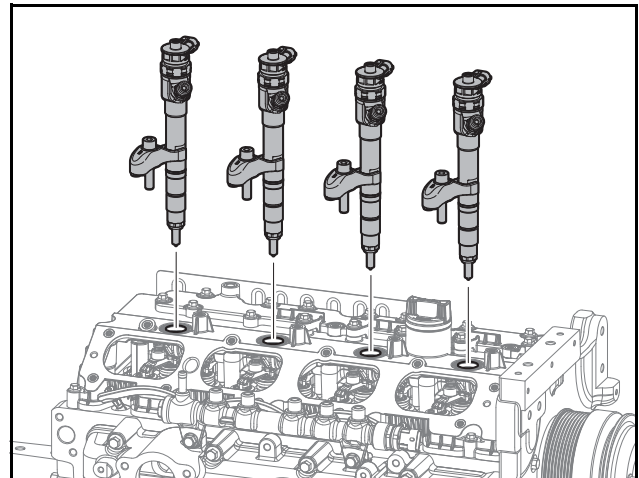
Note: Remove the cylinder head cover and remove the injector sealing washer.

### **⚠ CAUTION**

- Be careful not to damage the injectors during disassembly.
- When removing injectors, be sure to remove them together with the washers so as not to lose them.

### Assembling the Injector

1. Assemble the injector.



EDM03190247

- 1) Align the injector sealing washers with the center of the injector hole and mount them.
- 2) Apply sufficient oil to the contact surface of the injector on the cylinder head cover.
- 3) Assemble the injectors.

### **⚠ CAUTION**

- Slowly turn the injector while assembling it to avoid damaging the injector oil seal on the cylinder head cover.
- Do not reuse injector sealing washers. Otherwise serious faults may occur in the engine due to unstable combustion.

- 4) Assemble the injector mounting brackets.
- 5) Temporarily tighten the hex bolts to a tightening torque of 0.3 kgf·m.

### **⚠ CAUTION**

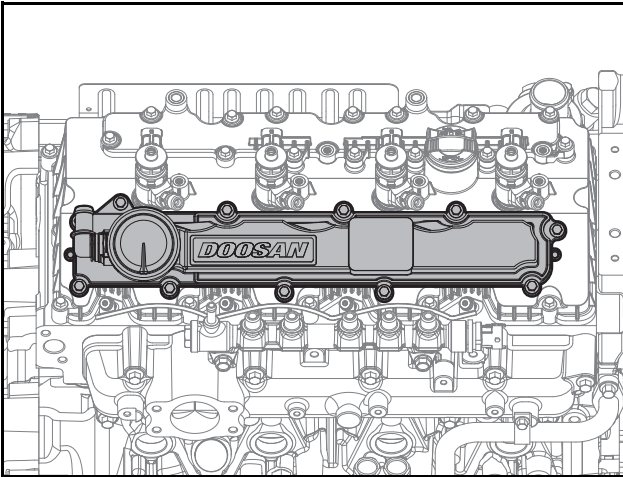
If the hex bolts cannot be tightened while temporarily tightening them, do not tighten them by force. Tightening them by force may damage the cylinder head.

- 6) Tighten the hex bolts to a tightening torque of 4.35 ±0.35 kgf·m.



## 8. Fuel System

2. Assemble the right cylinder head cover.



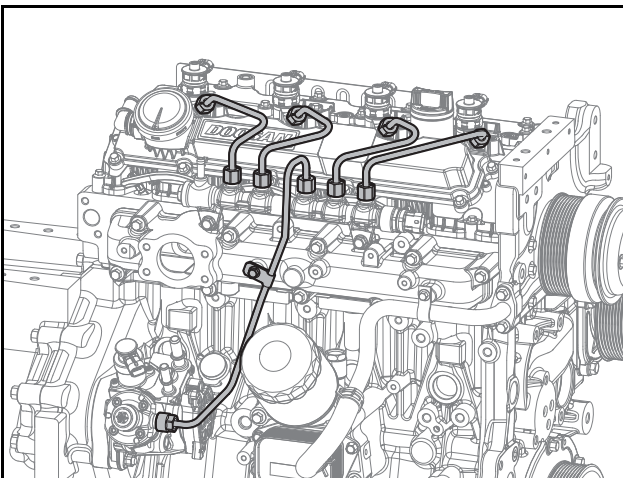
EDM03190245

- 1) Align the rubber packing with the right cylinder head cover groove and assemble the right cylinder head cover.
- 2) Temporarily mount the flange hex bolts from inside to outside in the direction of the arrow.
- 3) Tighten the flange hex bolts from inside to outside in the direction of the arrow at a tightening torque of  $0.8 \pm 0.05$  kgf-m.

### **⚠ CAUTION**

- When performing maintenance, do not reuse head cover rubber seals; replace them with new ones.
- Before assembly, completely remove any foreign matter from inside the quick connector and the RH cover nipple.

3. Assemble fuel injection pipe.



EDM03190240

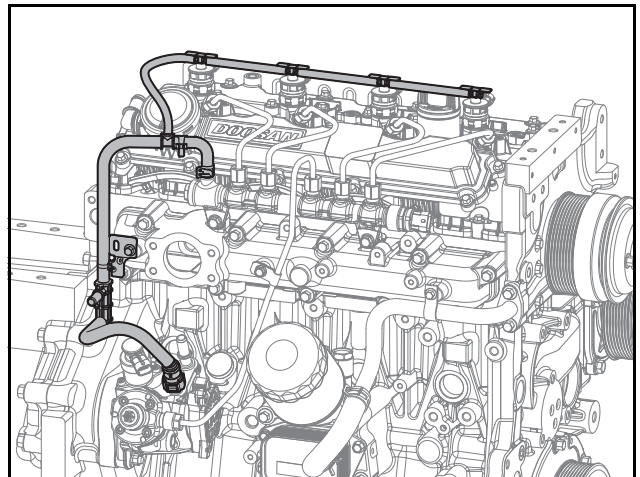
- 1) Loosen the hex bolts on the common rail and temporarily tighten them.
- 2) Temporarily tighten all of the nuts on the fuel injection pipes.

- 3) Tighten the hex bolts on the common rail to a tightening torque of 2.2 kgf-m.
- 4) Tighten the fuel injection pipe nuts to a tightening torque of 3.0 kgf-m.
- 5) Tighten the flange hex bolts assembled with the pipe clips to a tightening torque of 0.8 kgf-m.

### **⚠ CAUTION**

- Do not bend the fuel injection pipe by force.
- Pay attention to the assembled direction of the fuel injection pipe.
- Assemble the nuts on one side of the fuel injection pipe, then assemble the other side and make sure that the round part of the pipe and the part in contact with it are in their proper positions.
- Replace the fuel injection pipe and pipe clip with new ones; do not reuse them. Otherwise it may severely deteriorate the engine performance.

4. Assemble the fuel return hose.



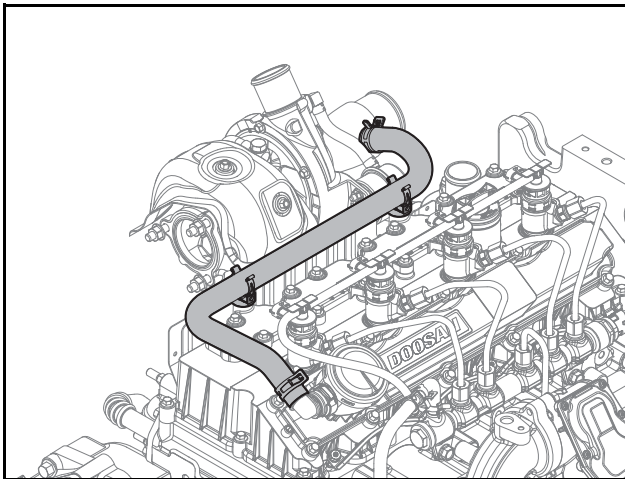
EDM03190241

- 1) Assemble the fuel return hose.

### CAUTION

- Pay attention to the assembled direction of the fuel return hose.
- Assemble the injectors and fuel return hoses so that they interlock sufficiently.
- Do not reuse fuel return hoses; replace them with new ones. Failure to do so may cause serious faults in the engine performance.
- Be careful to avoid damage for fuel return hose of injector.
- Don't press on the fuel hose, don't drop heavy tool like as spanner on engine, don't step on fuel hose, don't stand on engine.
- If the fuel hose are broken by wrong handling, it is possible fire.

- 2) Press on the clamps to attach the common rail, injectors, and fuel return hoses on the fuel injection pump.
5. Assemble the breather hose.



EDM03190234

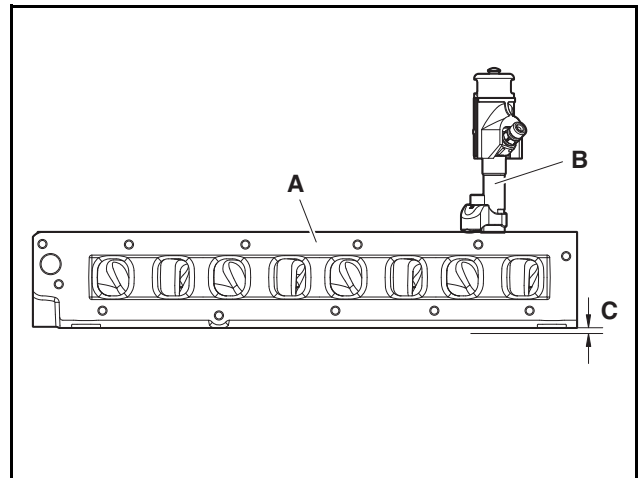
- 1) Assemble the breather hose with the hose clips.
- 2) Press on the clamps on the quick connector and T/C air inlet pipe, then connect the breather hose.

### CAUTION

- Do not reuse clamps more than three times; replace them with new ones.
- Do not apply oil to hoses, clamps, etc.

### Checking the Injector

1. Check for any foreign matter on the inside and any deformation on the end of the injector.
2. Check the injector protrusion (C).



EDM03200136

- 1) Remove the cylinder head (A).
- 2) Insert the seal ring in the cylinder head (A) and attach the injector (B).
- 3) Use a dial gauge to check the injector protrusion (C) based on the cylinder head (A) surface.

Note: During disassembly and inspection, be careful not to let any foreign matter enter the injector and high-pressure connector.

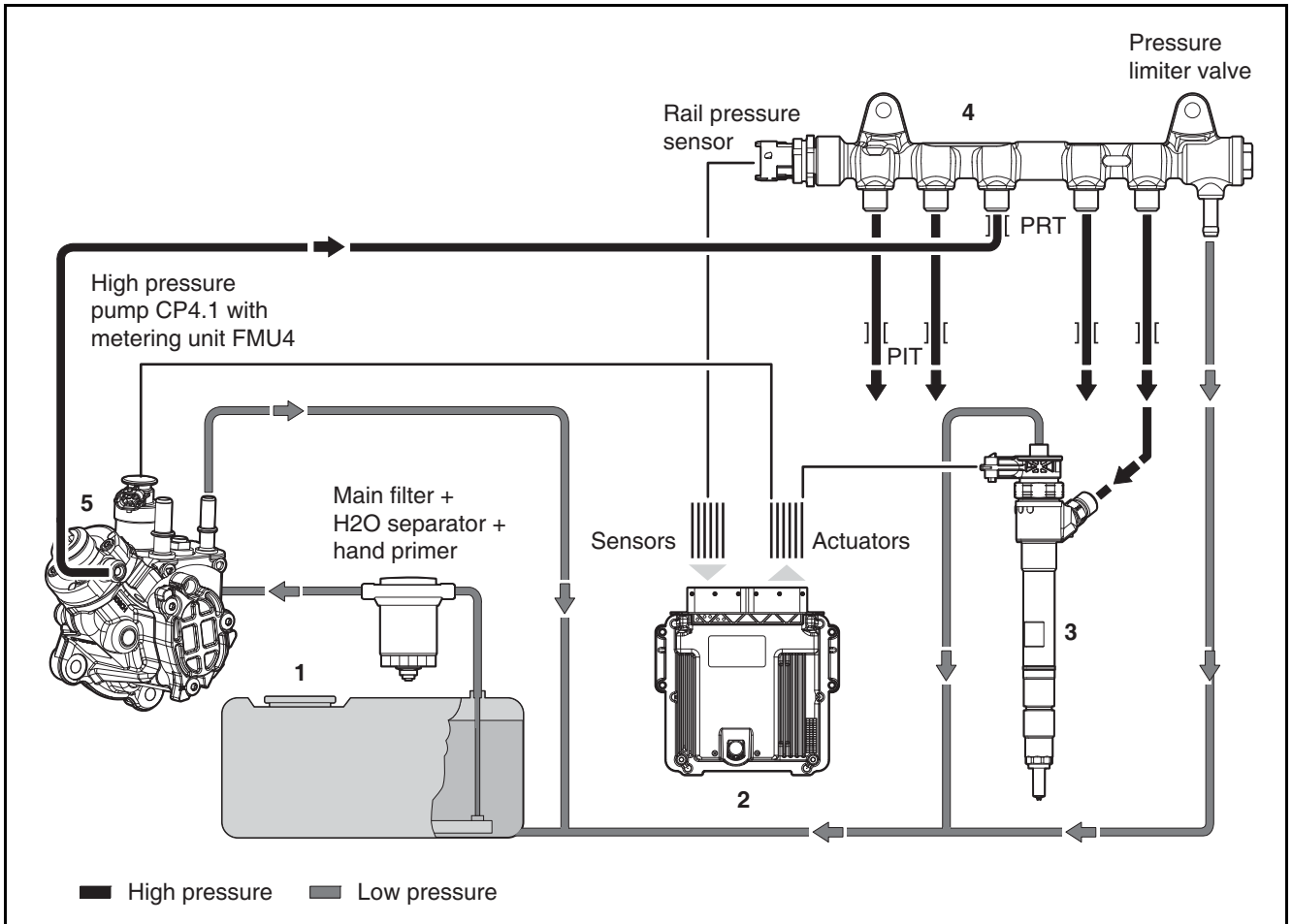
Item	Specified value
Injector protrusion	1.88 ±0.35 mm

# 8. Fuel System

## Common Rail

### General Information

Hyundai Doosan Infracore common rail fuel injection system is divided into a pressurizing device and a fuel injection device. In order to provide optimal performance based on the engine operating conditions, fuel is injected into the cylinders after the amount of fuel, injection timing and injection pressure are determined by the electronic control unit. The high-pressure fuel created by the high-pressure fuel pump is stored in the common rail, and when the driver operates the machinery, the optimal amount of fuel and fuel injection timing are determined based on the data set in the electronic control unit (ECU) according to the vehicle speed and driving conditions. The solenoid valves in the injectors installed on each engine cylinder are then activated and the fuel is injected into the cylinders.



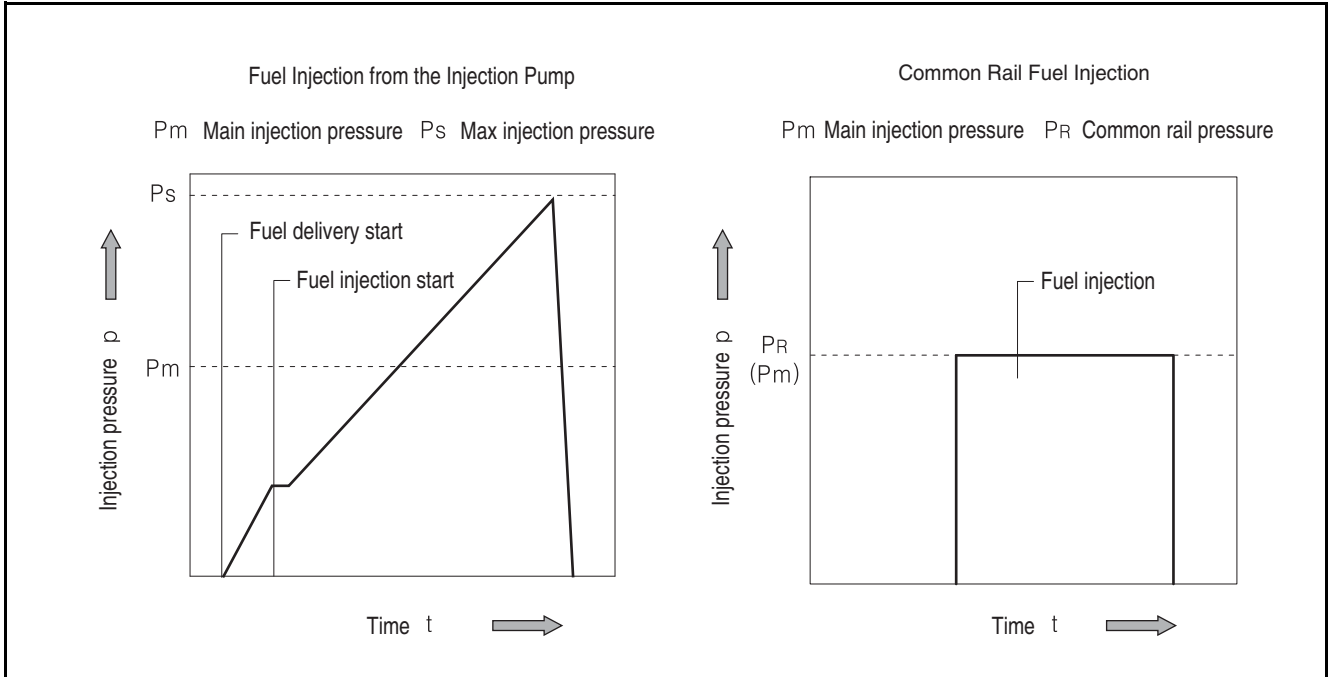
EDM03190023

- 1. Tank with pre-filter
- 2. Electronic Control Unit (ECU)
- 3. Injector
- 4. Common rail
- 5. Fuel injector pump

The main components of the common rail fuel injection system are as follows.

1. Electronic control unit (ECU)
  - 1) The electronic control unit (ECU) receives an input signal from the sensor above based on the operator's accelerator reaction and momentarily adjusts the engine and vehicle to the operating performance. The electronic control unit also uses this information to activate the open/ close circuit and circulation circuit of the vehicle and engine.
  - 2) The engine speed is measured by the crankshaft rpm sensor, and the camshaft rpm sensor is used to determine the firing order. The electrical signal created in the potentiometer of the accelerator pedal sensor lets the electronic control unit know how far down the operator has pushed the pedal. In addition, there are turbocharger and intake pressure sensors installed. The intake pressure sensor measures the intake pressure.
  - 3) In cold outside weather and when the engine is cold, the electronic control unit receives data from the coolant temperature sensor and air temperature sensor and enables the vehicle to run under conditions suitable to the engine operation.
2. Crankshaft RPM sensor
  - 1) The positions of pistons in the combustion chamber play a very important role in injecting fuel. All engine pistons are connected to the crankshaft by means of connecting rods. The crankshaft rpm sensor installed in the flywheel housing provides information about the position of every piston. The rotation speed is defined as the number of rotations of the crankshaft per minute, and the main input variables are calculated by the electronic control unit (ECU) using signals from the crankshaft rpm sensor.
3. Camshaft RPM Sensor
  - 1) The camshaft rpm sensor controls the engine intake and exhaust valves. This rotates at half the speed of the crankshaft and determines whether the camshaft position is in the compression stage or the exhaust stage when the piston moves in the TDC direction. This information cannot be detected by the crankshaft rpm sensor. On the other hand, while the engine is running normally, the data generated by the crankshaft ramp sensor is sufficient for defining the state of the engine. This means that the electronic control unit receives the state of the engine from the crankshaft rpm sensor if the camshaft rpm sensor is not responding while the vehicle is in operation.
4. Accelerator Pedal Sensor
  - 1) The accelerator pedal sensor delivers the data generated when the operator steps on the accelerator to the electronic control unit (ECU). The voltage value is created by the potentiometer in the accelerator pedal sensor, and the programmed characteristic curve is used to calculate the position of the pedal.
5. Fuel Temperature Sensor
  - 1) A sensor that measures the fuel temperature in the fuel pump.
6. Boost Pressure and Temperature Sensor
  - 1) The boost pressure and temperature sensor is connected to the intake manifold with an O-ring and measures the absolute pressure and temperature inside the intake manifold.
  - 2) The output signal is inputted in the electronic control unit, and here, the boost pressure is calculated based on the programmed characteristic curve.
7. Oil Press Sensor
  - 1) The engine oil press sensor detects the pressure and temperature and conveys them to the electronic control unit (ECU).
8. Common Rail Pressure Sensor
  - 1) A sensor installed on the end of the common rail which measures the instantaneous internal pressure in the common rail.
9. Engine Coolant Temperature Sensor
  - 1) The engine coolant temperature sensor detects the temperature of the engine coolant and conveys it to the electronic control unit (ECU).

## 8. Fuel System



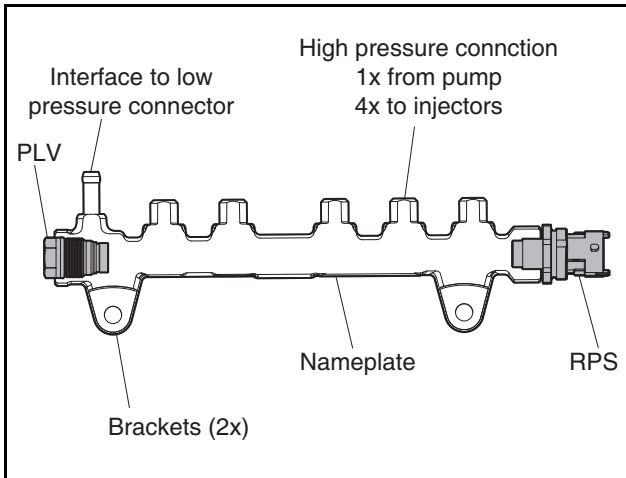
EDL022065A

The injection characteristics of the common rail are as follows.

1. Common rail fuel injection requires the following ideal fuel injection in comparison with previous injection characteristics. The common rail fuel injection amount and injection pressure operate independently of one another and satisfy all engine conditions.
2. At the start of the fuel injection process, the amount of injection during the ignition delay time between the start of fuel injection and the start of combustion needs to be adjustable to a low level.
3. The common rail system is a modular system and the following components play a fundamentally important role in the injection characteristics.
  - 1) Injector solenoid valve installed on the cylinder head
  - 2) Common Rail
  - 3) High-pressure fuel pump
  - 4) Electronic control unit (ECU)
  - 5) Crankshaft RPM sensor

## Pressure Limit Valve & Rail Pressure Sensor

### Safety Regulations



EDM02200090

Before working on the common rail high pressure fuel system, a minimum waiting time of 30second after engine shut-down is mandatory.

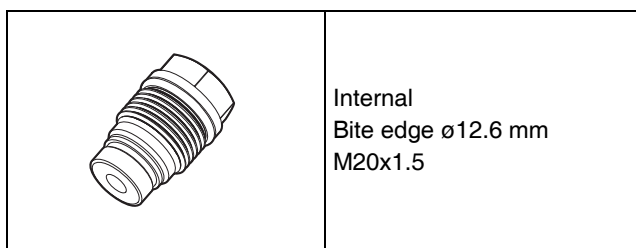
Any work at the common rail high pressure fuel system (rail, function-block, pressure control valve, pressure limiting valve, rail pressure sensor, pipe connection, high pressure pipes (pump/rail or /function block, function block/rail, rail/injectors)) is not permitted when the engine is running.

### ⚠ CAUTION

- **Cutting fuel jets: injury-risk at eyes and skin.**
- **When opening the high pressure fuel system, fuel jets can ignite on hot engine surfaces.**

The first high pressure component has to loosened slowly, so that the pressure inside the fuel system can adjust to ambient pressure.

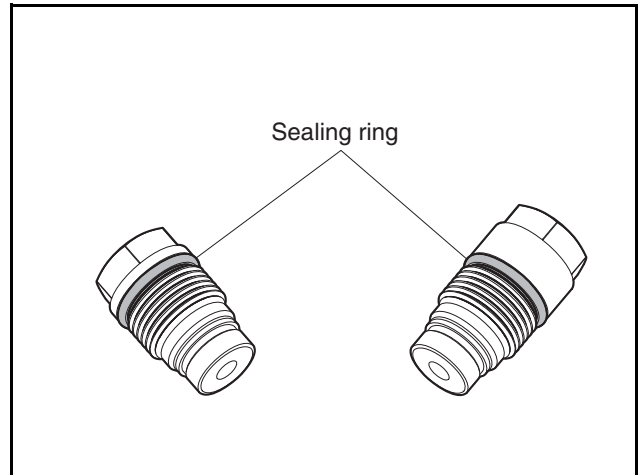
### Pressure Limit Valve (PLV)



#### Disassembly

1. Clean interface area of PLV using proper degrease materials and compressed air for drying.
2. Loosen the PLV using a commercial wrench (WAF dependent on PLV) and unscrew manually.
3. If PLV is used with a gasket remove the gasket with proper tools.

4. Clean the thread and sealing surface of the rail.
5. Close the rail orifice using a plastic cap after removing the PLV. (to protect the high pressure system from dust and dirty)
6. If the PLV will be reused, remove the sealing ring carefully.



EDM02200092

### Preparation for Assembly

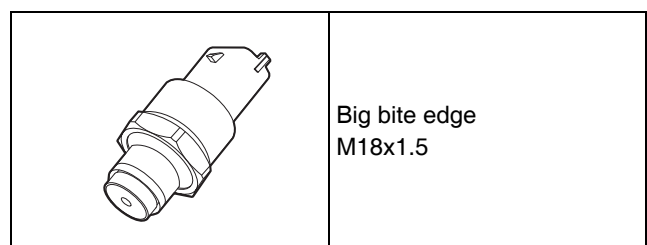
1. Interface inspection  
Inspect thread and sealing surfaces of the PLV and the rail concerning any damage.  
Only concentric grooves are allowed. No cuts in radial direction are tolerable.  
The sealing ring has to be replaced.

### Assembly

1. Remove the plastic cap from the rail orifice
2. Screw in the PLV manually
3. Tighten the PLV using a commercial torque-wrench according to table.

Tightening torque	100 $\pm$ 5 Nm
-------------------	----------------

### Rail Pressure Sensor (RPS)

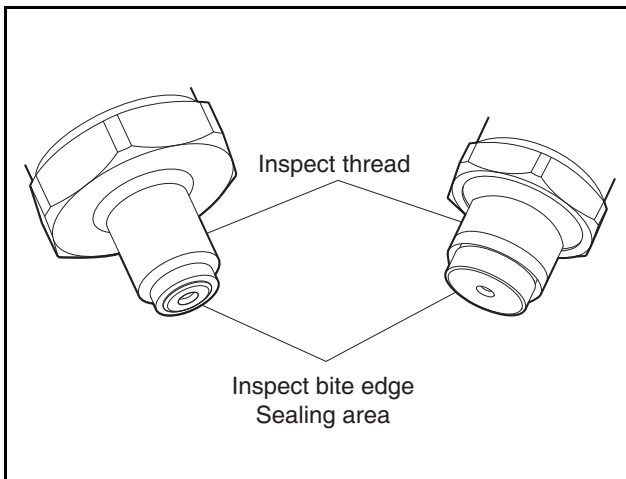


#### Disassembly

1. Clean interface area of RPS using proper degrease materials and compressed air for drying.  
Note) Clean material must not penetrate the electric connector!
2. Unplug electric connector.

## 8. Fuel System

3. Loosen the RPS using commercial wrench and unscrew manually.
4. If RPS is used with a gasket remove the gasket with proper tools.
5. Clean the thread and sealing surface of the rail
6. Close the rail orifice using a plastic cap after removing the RPS to prevent contamination.
7. Not all RPS types are sufficiently protected against electrical discharge (ESD).
8. Don't touch the connector pins of the RPS with bare hands.



EDM02200093

### Preparation for Assembly

Inspect thread and sealing surfaces of the RPS and the rail concerning any damage.

Only concentric grooves are allowed. No cuts in radial direction are tolerable.

### Assembly

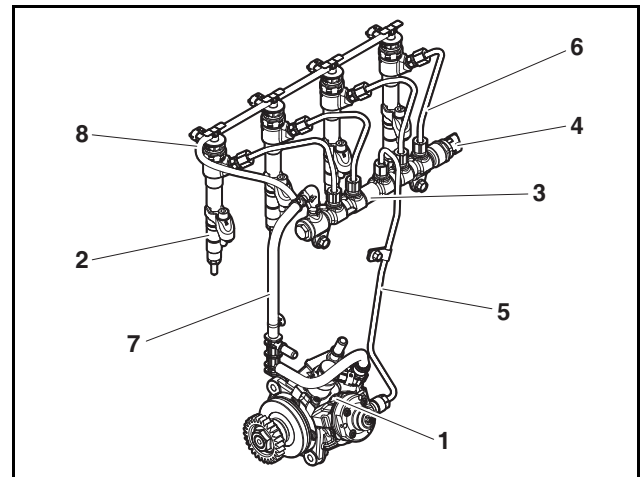
1. Screw in the RPS manually.
2. Tighten the RPS using a commercial torque-wrench according to table.

Note) The electric cable must not be under tension.

Tightening torque	100 ±5 Nm
-------------------	-----------

### Injection Pipe

1. High-pressure fuel pipe
  - 1) The high-pressure fuel pipe delivers 1,800 bar high-pressure fuel. Hence, the pipe of the fuel line is made of a special material which is able to withstand even the maximum pressure of the system and the fluctuations in high pressure arising during fuel injection. The high-pressure pipe has an outside diameter of Ø6.35 and an inside diameter of Ø3.0. In addition, the length of the high-pressure fuel pipes installed between the common rail and injectors must be identical and as short as possible.
2. Common Rail



EDM03190024

- |                        |  |
|------------------------|--|
| 1. Fuel Injection pump | 5. Fuel injection pipe (Fuel injection pump - Common rail) |
| 2. Injector            | 6. Fuel injection pipe (Common rail - Injector)            |
| 3. Common rail         | 7. Fuel return hose (Common rail - Fuel injection pump)    |
| 4. Pressure sensor     | 8. Fuel return hose (Injector - Fuel injection pump)       |

Note: The front engine direction (F) is the coolant pump direction and the rear engine direction (R) is the flywheel direction.

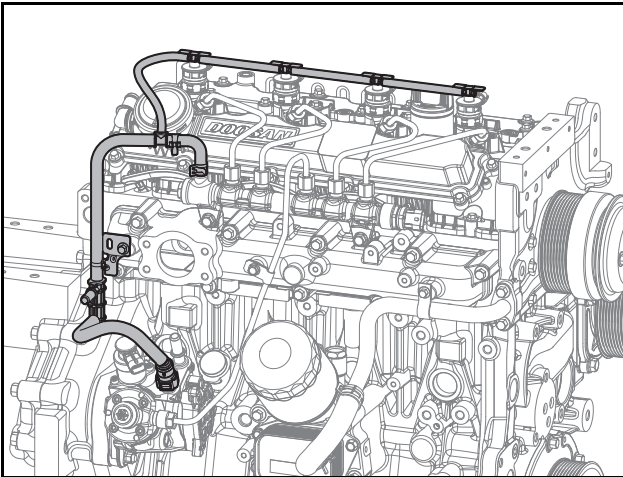
- 1) Even after the injector uses fuel from the common rail for fuel injection, the fuel pressure within the common rail actually remains consistent. The fuel pressure is measured by the common rail pressure sensor and maintained at the desired value by the pressure adjustment valve. The fuel pressure reaches a maximum of 1,800 bar within the common rail, which is controlled by the pressure control valve.
- 2) The common rail stores fuel pumped from the high-pressure fuel pump at a high pressure. Even after the injector uses fuel from the common rail for fuel injection, the pressure pulsation within the common rail and fuel pressure actual remain consistent due to the volume of the common rail. The fuel pressure is measured by the common rail pressure sensor and maintained at the desired value by the pressure adjustment valve. The fuel pressure reaches a maximum of 1,800 bar within the common rail, which is controlled by the pressure control valve.



- 3) Hyundai Doosan Infracore common rail fuel injection system is divided into a pressurizing device and a fuel injection device. In order to provide optimal performance based on the engine operating conditions, fuel is injected into the cylinders after the amount of fuel, injection timing and injection pressure are determined by the electronic control unit.

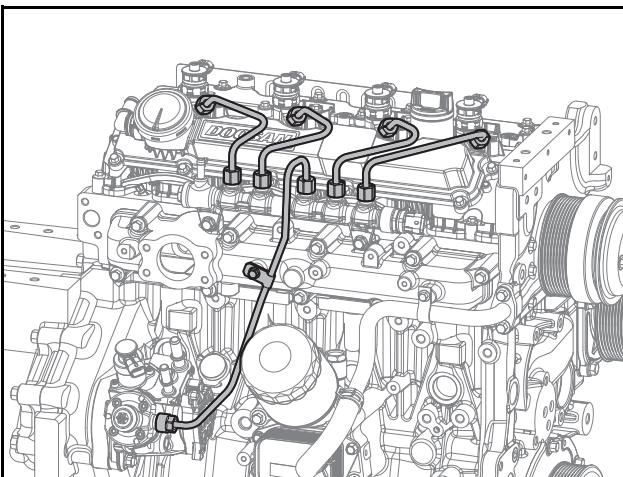
### Removing the Common Rail

1. Disconnect the fuel return hose.



EDM03190241

- 1) Press on the clamps to remove the common rail, injectors, and fuel return hose on the fuel injection pump.
  - 2) Disconnect the fuel return hose.
2. Remove the fuel injection pipe.



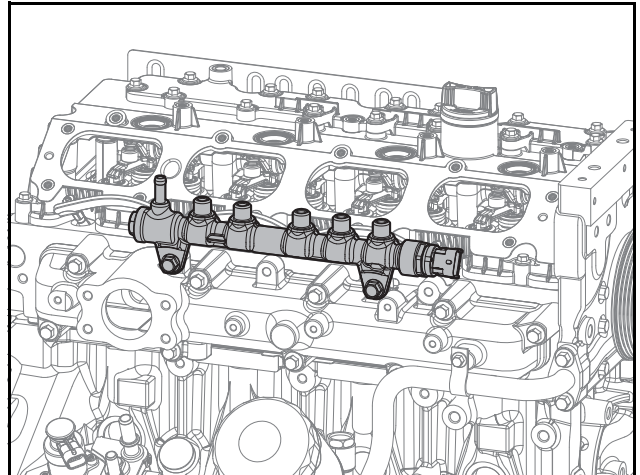
EDM03190240

- 1) Loosen the flange hex bolt.
- 2) Loosen the nuts on both ends of the fuel injection pipes and remove the fuel injection pipes.

### **⚠ CAUTION**

**Do not bend the fuel injection pipe by force.**

3. Remove the common rail.



EDM03190246

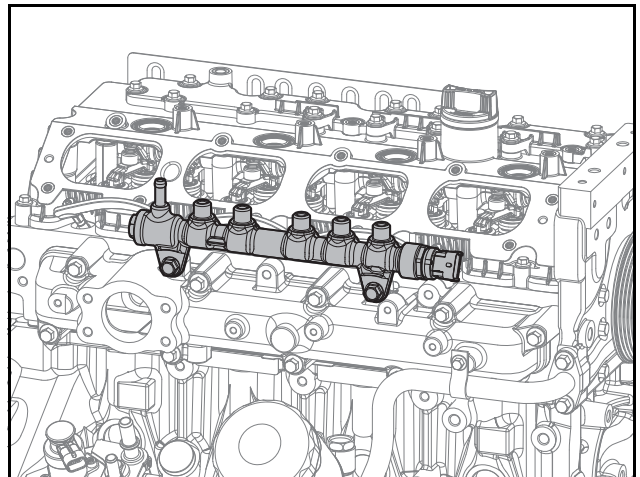
- 1) Loosen the hex bolts.
- 2) Remove the common rail from the intake manifold.

### **⚠ CAUTION**

**Be careful not to damage the common rail during disassembly.**

### Assembling the Common Rail

1. Assemble the common rail.



EDM03190246

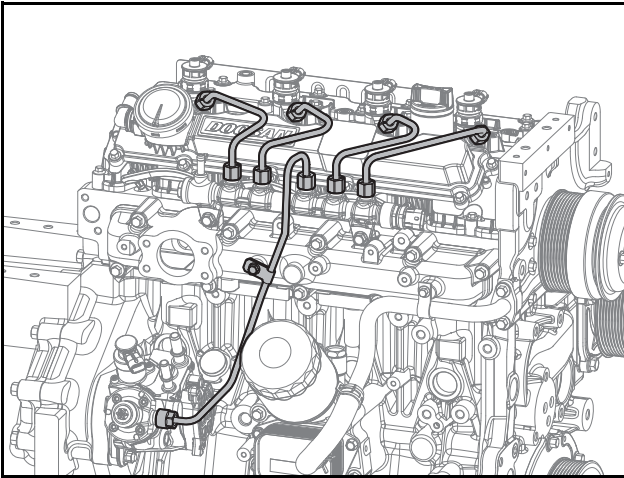
- 1) Assemble the common rail with the intake manifold.

### **⚠ CAUTION**

- Pay attention to the assembled direction of the common rail.
- Be careful not to damage the common rail during assembly.
- Be careful not to allow any foreign matter to enter the common rail fuel inlet and outlet holes.

## 8. Fuel System

- 2) Temporarily assemble the hex bolts by hand.
- 3) Tighten the hex bolts to a tightening torque of 2.2 kgf·m.
2. Assemble the fuel injection pipe.



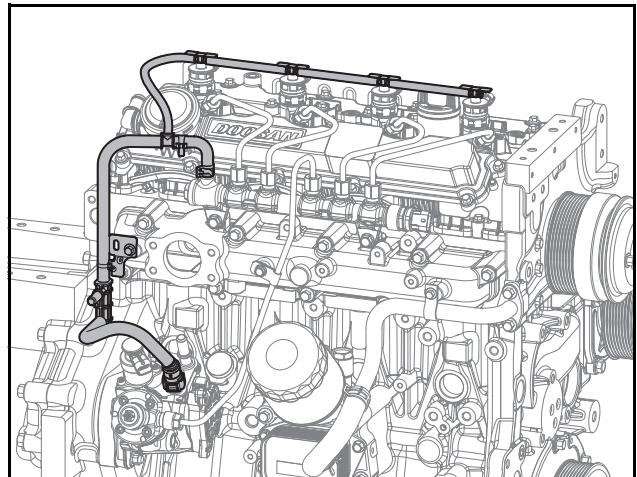
EDM03190240

- 1) Loosen the hex bolts on the common rail and temporarily tighten them.
- 2) Temporarily tighten all of the nuts on the fuel injection pipes.
- 3) Tighten the hex bolts on the common rail to a tightening torque of 2.2 kgf·m.
- 4) Tighten the fuel injection pipe nuts to a tightening torque of 3.0 kgf·m.
- 5) Tighten the flange hex bolts assembled with the pipe clips to a tightening torque of 0.8 kgf·m.

### CAUTION

- Do not bend the fuel injection pipe by force.
- Pay attention to the assembled direction of the fuel injection pipe.
- Assemble the nuts on one side of the fuel injection pipe, then assemble the other side and make sure that the round part of the pipe and the part in contact with it are in their proper positions.
- Replace the fuel injection pipe and pipe clip with new ones; do not reuse them. Otherwise it may severely deteriorate the engine performance.

3. Assemble the fuel return hose.



EDM03190241

- 1) Assemble the fuel return hose.

### CAUTION

- Pay attention to the assembled direction of the fuel return hose.
- Assemble the injectors and fuel return hoses so that they interlock sufficiently.
- Do not reuse fuel return hoses; replace them with new ones. Failure to do so may cause serious faults in the engine performance.
- Be careful to avoid damage for fuel return hose of injector.
- Don't press on the fuel hose, don't drop heavy tool like as spanner on engine, don't step on fuel hose, don't stand on engine.
- If the fuel hose are broken by wrong handling, it is possible fire.

- 2) Press on the clamps to attach the common rail, injectors, and fuel return hoses on the fuel injection pump.

### Checking the Common Rail

1. Check the exterior of the common rail for damage.
2. Check the common rail pressure sensor for damage.
3. Check the fuel pressure limiter valve for damage.

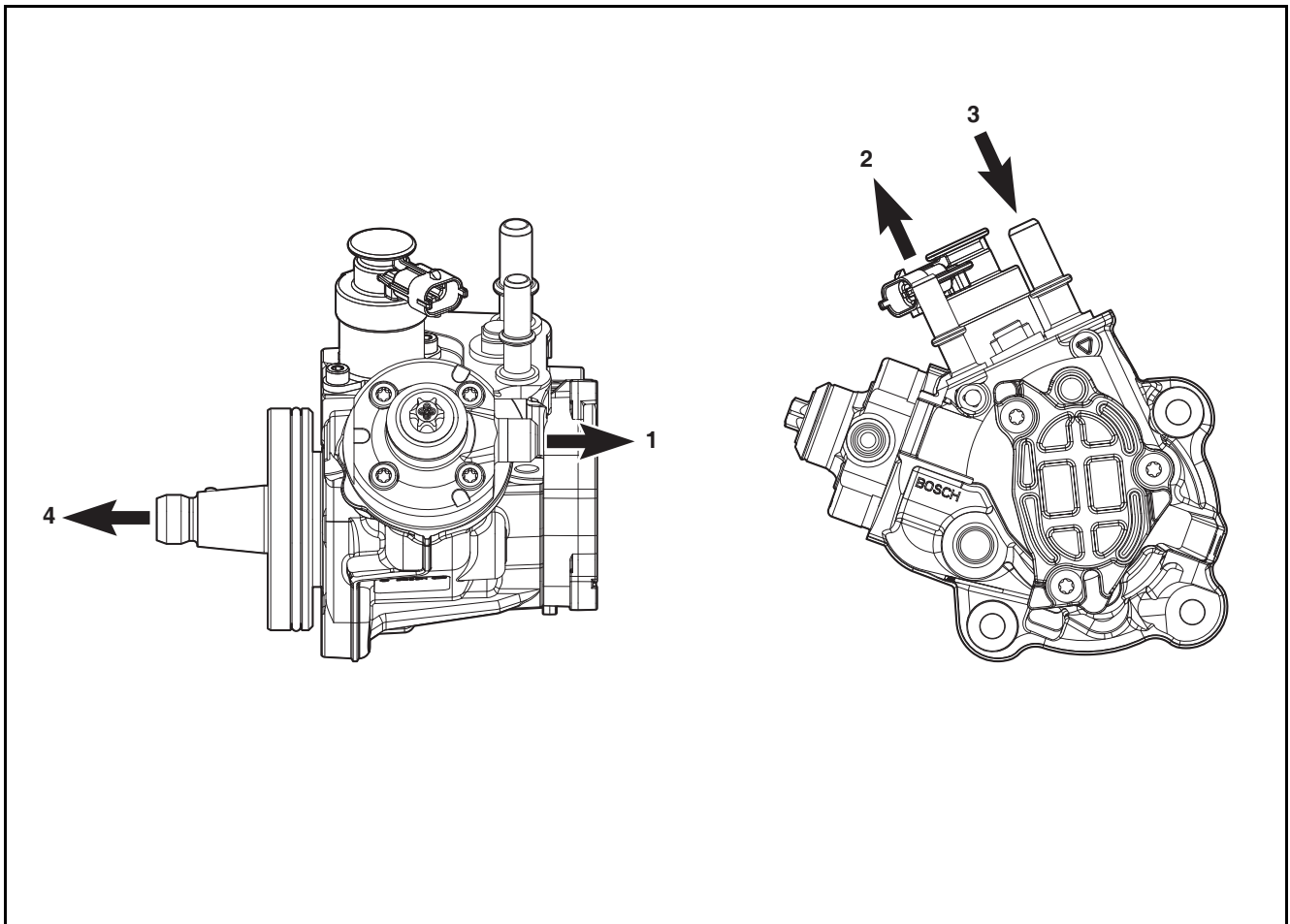
### Fuel Injection Pump

#### General Information

The high pressure in the high-pressure fuel pump is generated using a radial piston pump. The pressure is generated independently in the fuel injection process. The rpm of the high-pressure fuel pump is related directly to the engine rpm, regardless of the transmission speed. In comparison with previous injection systems, the amount of fuel delivery in the common rail injection system is consistent.

The injector is connected to the common rail with a high-pressure pipe and is composed of a nozzle and solenoid valve. When the key switch is activated, operating power is supplied to the solenoid valve by the electronic control unit. When the key switch is turned off, the solenoid valve ceases injection.

The solenoid valve switch (ON/ OFF) on the injector is activated by high voltage and current. This causes the injector solenoid valve to operate sequentially based on the value set in the electronic control unit. The crankshaft sensor and camshaft sensor are used to detect the engine rpm for adjusting the start of fuel injection and injection timing. The high-pressure fuel pump pressurizes fuel to a pressure of around 1,800 bar, and this pressurized fuel is sent through the high-pressure line to the pipe-shaped common rail. The high-pressure fuel pump is composed as follows.



EDM03200137

1. High pressure fuel line outlet
2. Low pressure fuel line outlet

3. Low pressure fuel line inlet
4. Drive shaft



## 8. Fuel System

### 1. Purpose

1) The high-pressure fuel pump has low-pressure and high-pressure stages. It serves to deliver high-pressure fuel throughout the entire life of the vehicle under all operating conditions. It also supplies fuel required for abruptly starting the vehicle or abrupt changes in pressure within the common rail. The high-pressure fuel pump continuously generates system pressure required within the common rail.

### 2. Operating Principles

1) The fuel delivery pump delivers fuel from the tank to the high-pressure pump through the fuel inlet and safety valve. This forces the fuel into the lubrication and cooling circuit of the high-pressure pump through the safety valve. The driveshaft with an eccentric cam moves the pump piston up and down according to the shape of the cam.

2) When the delivery pressure of the fuel supply pump exceeds the full opening pressure of the safety valve, the fuel is delivered through the intake valve in the high-pressure fuel pump to the position of the intake stroke of the pumping chamber where the pump piston is moving downwards. When the pump piston passes the BDC, the valve inlet closes and the fuel cannot escape from the pumping chamber, so the fuel is compressed to higher than the delivered pressure.

3) As soon as the fuel pressure reaches the pressure of the common rail, it opens the outlet valve. Then the compressed fuel enters the high-pressure circuit. The pump piston continues sending fuel until it reaches the TDC and then the outlet valve closes when the pressure drops. The fuel remaining in the pumping chamber is released and the pump piston moves downwards again. When the pressure inside the pumping chamber drops below the pressure of the fuel delivery pump, the inlet valve opens and the process described above restarts.

### 3. Fuel Delivery Circuit

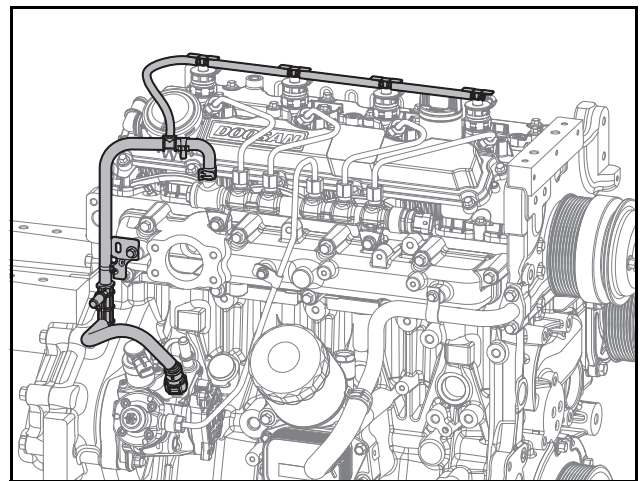
1) The high-pressure fuel pump is designed to deliver a large amount of fuel, and while the engine is idling or operating under a partial load, excess fuel delivered returns to the tank through the pressure adjustment valve.

### 4. High-pressure fuel pumping shut-off valve

1) When the switch on the high-pressure fuel pumping shut-off valve turns off, the amount of fuel delivered to the common rail is maximized. In the 'Switch-OFF' state, the intake valve is open and the fuel pumping solenoid valve is pulled, with the pin attached to the electromagnet keeping the valve inlet open. Hence, fuel which flows into this pumping valve cannot be compressed during the delivery stroke. The fuel returns to the low-pressure passage so no pressure is generated at all. The pumping shut-off valve is operated with a small amount of power so fuel delivery and shut-off are performed at short intervals.

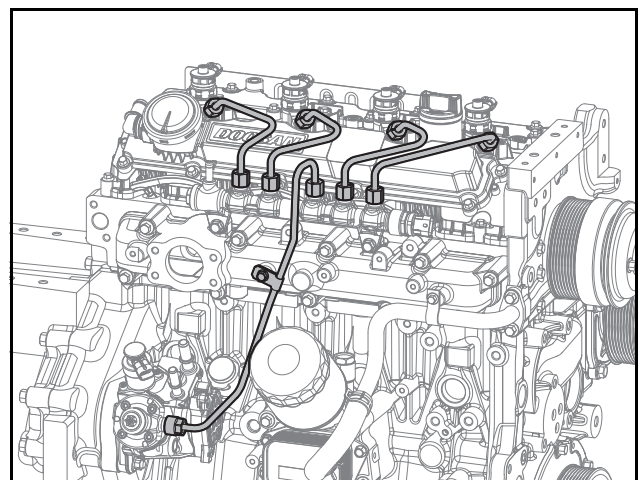
## Removing the Fuel Injection Pump

1. Disconnect the fuel return hose.



EDM03190241

- 1) Press on the clamps to remove the common rail, injectors, and fuel return hose on the fuel injection pump.
- 2) Disconnect the fuel return hose.
2. Remove the fuel injection pipe.



EDM03190240

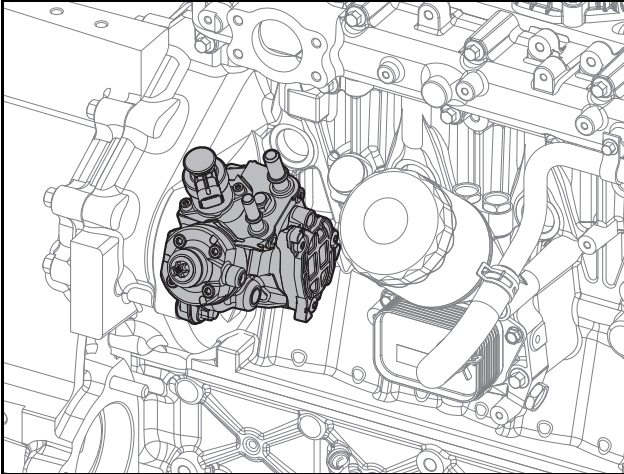
- 1) Loosen the flange hex bolt.

- Loosen the nuts on both ends of the fuel injection pipes and remove the fuel injection pipes.

### **⚠ CAUTION**

**Do not bend the fuel injection pipe by force.**

- Remove the fuel injection pump.

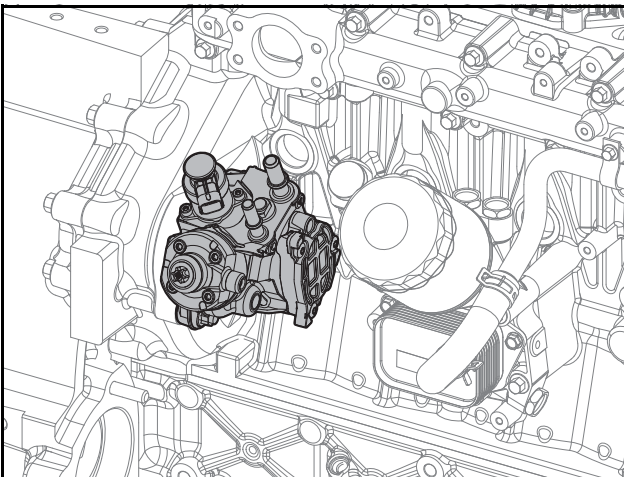


EDM03190249

- Loosen the flange hex bolt.
- Remove the fuel injection pump.

### **Assembling the Fuel Injection Pump**

- Assemble the fuel injection pump.



EDM03190249

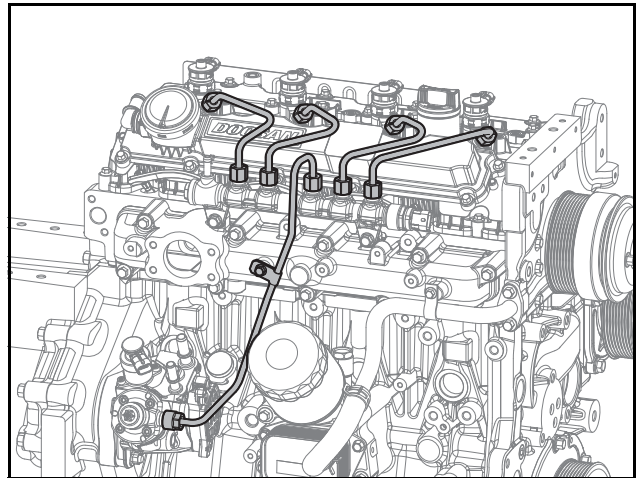
- If you are able to check the gear engravings, position the idle gear engraving between the engravings on the fuel injection pump drive gear. However, if you are unable to check the gear engravings, assemble the fuel injection pump regardless of the positions of the gear engravings.

Note: There are two engraved markings on the fuel injection pump drive gear and one engraved marking on the idle gear.

- Align the fuel injection pump with the stud bolts to assemble it.
- Tighten the flange hex bolt to a tightening torque of 2.2 kgf·m.
- The backlash between the fuel injection pump drive gear and the idle gear is 0.081 ~ 0.196 mm.

Item	Specified value
Backlash between fuel injection pump drive gear and idle gear	0.081 ~ 0.196 mm

- Assemble fuel injection pipe.



EDM03190240

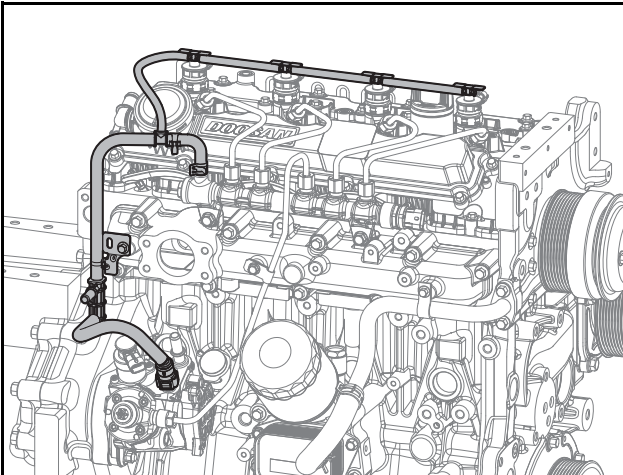
- Loosen the hex bolts on the common rail and temporarily tighten them.
- Temporarily tighten all of the nuts on the fuel injection pipes.
- Tighten the hex bolts on the common rail to a tightening torque of 2.2 kgf·m.
- Tighten the fuel injection pipe nuts to a tightening torque of 3.0 kgf·m.
- Tighten the flange hex bolts assembled with the pipe clips to a tightening torque of 0.8 kgf·m.

### **⚠ CAUTION**

- Do not bend the fuel injection pipe by force.
- Pay attention to the assembled direction of the fuel injection pipe.
- Assemble the nuts on one side of the fuel injection pipe, then assemble the other side and make sure that the round part of the pipe and the part in contact with it are in their proper positions.
- Replace the fuel injection pipe and pipe clip with new ones; do not reuse them. Otherwise it may severely deteriorate the engine performance.

## 8. Fuel System

3. Assemble the fuel return hose.



EDM03190241

- 1) Assemble the fuel return hose.

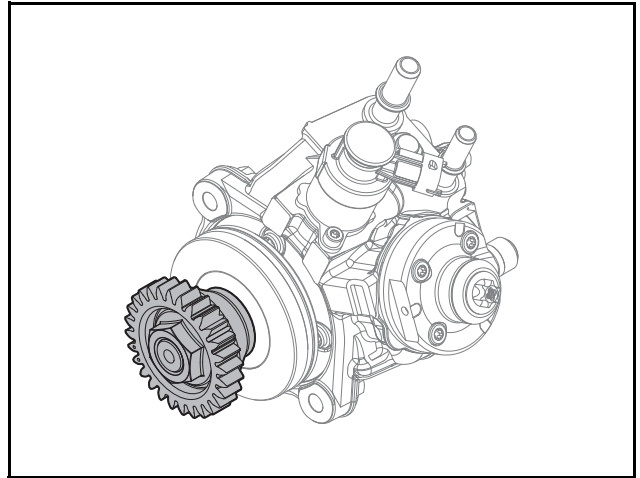
### CAUTION

- Pay attention to the assembled direction of the fuel return hose.
- Assemble the injectors and fuel return hoses so that they interlock sufficiently.
- Do not reuse fuel return hoses; replace them with new ones. Failure to do so may cause serious faults in the engine performance.
- Be careful to avoid damage for fuel return hose of injector.
- Don't press on the fuel hose, don't drop heavy tool like as spanner on engine, don't step on fuel hose, don't stand on engine.
- If the fuel hose are broken by wrong handling, it is possible fire.

- 2) Press on the clamps to attach the common rail, injectors, and fuel return hoses on the fuel injection pump.

### Removing the Fuel Injection Pump Drive Gear

1. Remove the fuel injection pump drive gear.

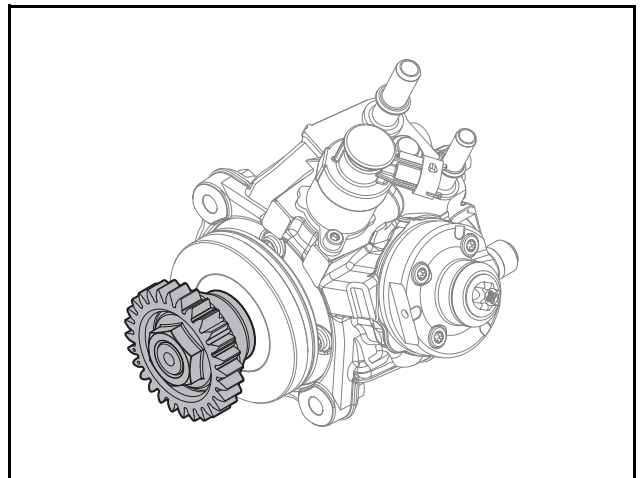


EDM03190092

- 1) Loosen the flange hex nuts.
- 2) Remove the fuel injection pump drive gear from the fuel injection pump driveshaft.

### Assembling the Fuel Injection Pump Drive Gear

1. Assemble the fuel injection pump drive gear.



EDM03190092

- 1) Align the fuel injection pump drive gear with the pin on the fuel injection pump driveshaft and assemble it.

### CAUTION

**Make sure that the direction of the engraved marking on the fuel injection pump drive gear faces outside the engine during assembly.**

- 2) Tighten the flange hex nut to a tightening torque of  $6.5 \pm 0.5$  kgf·m.

# 9. Intake/Exhaust System

<b>Turbocharger .....</b>	<b>151</b>
General Information .....	151
Troubleshooting .....	153
Handling the Turbocharger .....	156
Removing the Turbocharger .....	157
Assembling the Turbocharger.....	158
Checking the Turbocharger .....	159
<b>EGR .....</b>	<b>160</b>
Removing the EGR.....	160
Assembling the EGR.....	161
<b>Intake Manifold .....</b>	<b>163</b>
Removing the Intake Manifold .....	163
Assembling the Intake Manifold .....	165
<b>Exhaust Manifold .....</b>	<b>168</b>
Removing the Exhaust Manifold .....	168
Assembling the Exhaust Manifold.....	169
<b>Throttle (Inlet Pipe) &amp; the Intake Stake .....</b>	<b>171</b>
Removing the Throttle (Inlet Pipe) & the Intake Stake.....	171
Assembling the Throttle (Inlet Pipe) & the Intake Stake .....	172

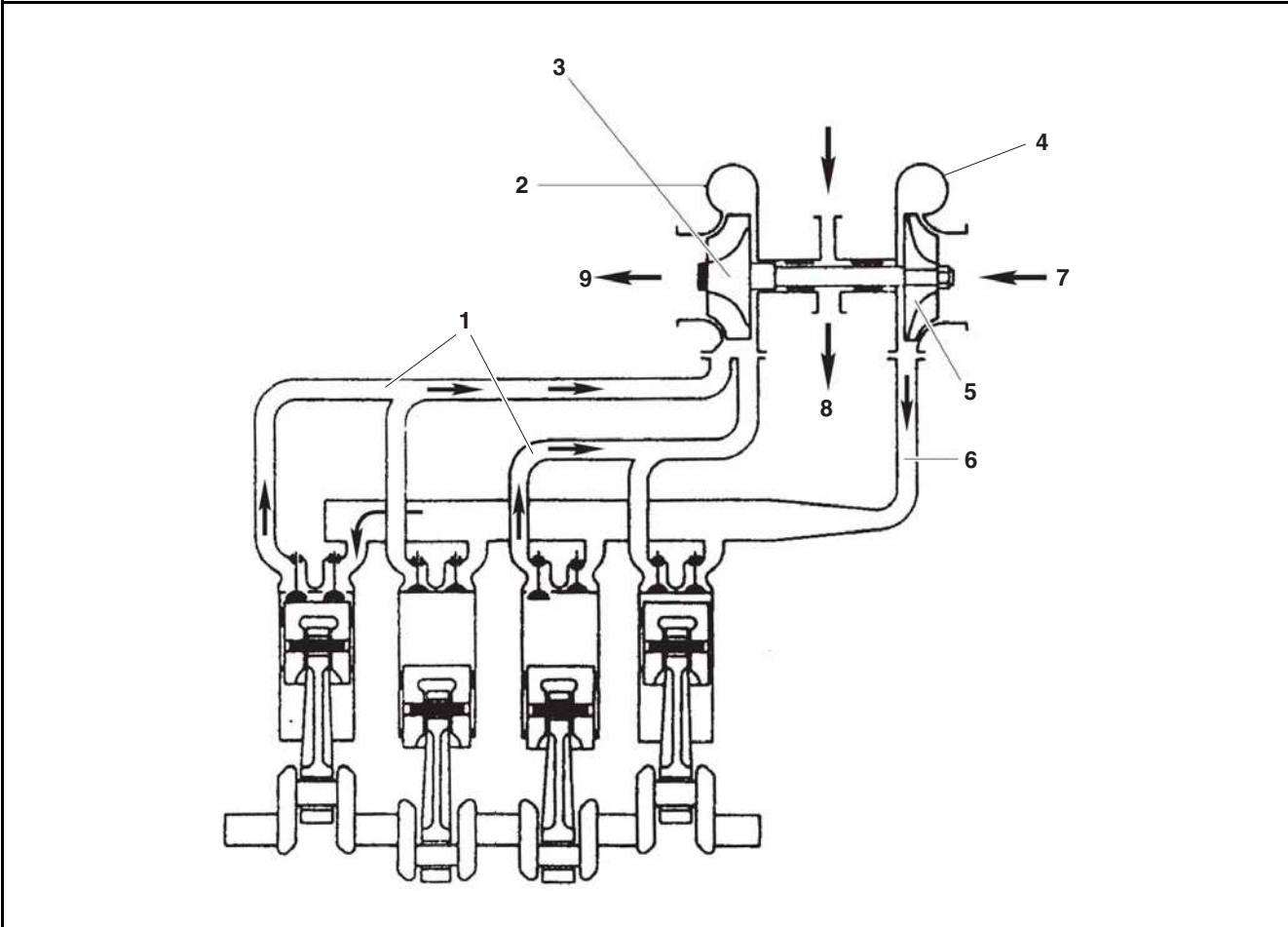




Turbocharger

General Information

The turbocharger is designed to use the thermal energy of exhaust gas to supply high-density air to the engine cylinders in order to increase the engine power.



EDL022073B

- |                                     |                       |                   |
|-------------------------------------|-----------------------|-------------------|
| 1. Exhaust manifold                 | 4. Compressor housing | 7. Air inlet      |
| 2. Turbine housing                  | 5. Compressor wheel   | 8. Oil outlet     |
| 3. Turbine wheel and shaft assembly | 6. Intake manifold    | 9. Exhaust outlet |

## 9. Intake/Exhaust System

---

1. Engine power is determined by the amount of fuel delivery and the engine efficiency.
2. In order to burn the supplied fuel completely and convert it into effective work for the engine, a sufficient amount of air should be supplied for complete fuel combustion.
3. Engine power is actually determined by the volume of the cylinders. If compressed air is delivered to cylinders of a given volume, the amount of air in the cylinders is increased, enabling more fuel to be burned and increasing engine power.
4. Delivering compressed air to the cylinders is called Supercharging, while the device which supercharges the energy of exhaust gas discharged from the combustion chamber into the air is called a turbocharger.
5. The main functions of the turbocharger are as follows.
  - 1) Turbine : As exhaust gas discharged from the combustion chamber passes through the turbine housing, its energy is transferred to the turbine blades, thereby rotating the turbine shaft. The component that performs this action is known as a turbine, and the turbine is equipped with a seal ring and heat shield which prevent exhaust gas from adversely affecting the bearings.
  - 2) Compressor : Being connected to the same shaft as the turbine, by rotating together, it receives the rotating force from the turbine shaft to suck in, compress and supply air to the intake manifold. This is the basic operating principle of the compressor.
  - 3) Bearings:
    - Thrust bearing : An axial force acts upon the turbine wheel. This is to prevent the shaft from moving due to this axial force.
    - Journal bearing : This bearing is a floating-type bearing which forms dual oil film layers on its inner and outer surfaces, enabling the bearing to rotate independently. Its dual oil layers act as buffers so the sliding speed on the bearing surface is slower than the rotating speed of the shaft, thereby enhancing the dynamic stability.
  - 4) Compressor shaft sealing : The seal plate and seal ring are composed of a dual structure to prevent the leakage of compressed intake air and lubricant.

## 9. Intake/Exhaust System

### Troubleshooting

Symptom	Possible cause	Solution
Noise or vibrations	Contact with rotating part	Repair or replace
	Unevenly rotating rotor	Repair or replace.
	Seized	Repair or replace.
	Loose connection	Check or replace.
	Deformed or damaged intake unit hose	Replace
	Poorly tightened clamp	Adjust and tighten.
	Contaminated or damaged air filter	Replace or check for damage to turbocharger impeller.
	Turbocharger coolant leak or oil hose leak	Replace hose or gasket.
	Gas leaking from exhaust manifold	Replace the gasket or tighten the mounting nut.
	Turbo actuator operating poorly	Replace the turbocharger.
	Leak in engine block and exhaust manifold	Check the engine.
	Contaminated blow-by gas or abnormal oil amount	Check the turbo impeller and turbo intake outlet.
	Excessive free play of turbocharger wheel causing interference with wall	Replace the turbocharger.
	Damaged turbocharger wheel	Replace the turbocharger.
	Damaged turbocharger wheel and shaft	Replace the turbocharger.
Poor rotating force of turbocharger wheel	Replace the turbocharger.	
Power drop	Gas leak in exhaust system	Check or replace.
	Clogged air filter element	Replace or clean.
	Contaminated or damaged turbocharger	Repair or replace.
	Air leak from outlet on compressor shaft	Check or replace.
	Deformed or damaged intake unit hose	Replace
	Poorly tightened clamp	Adjust and tighten.
	Contaminated or damaged air filter	Replace or check for damage to turbocharger impeller.
	Turbo actuator operating poorly	Replace the turbocharger.
	Leak in engine block and exhaust manifold	Check the engine.
	Contaminated blow-by gas or abnormal oil amount	Check the turbo impeller and turbo intake outlet.
	Excessive free play of turbocharger wheel causing interference with wall	Replace the turbocharger.
	Damaged turbocharger wheel	Replace the turbocharger.
	Damaged turbocharger wheel and shaft	Replace the turbocharger.
Poor rotating force of turbocharger wheel	Replace the turbocharger.	

## 9. Intake/Exhaust System

Symptom	Possible cause	Solution
Oil leak	Deformed or damaged intake unit hose	Replace
	Poorly tightened clamp	Adjust and tighten.
	Contaminated or damaged air filter	Replace or check for damage to turbocharger impeller.
	Turbocharger coolant leak or oil hose leak	Replace hose or gasket.
	Turbo actuator operating poorly	Replace the turbocharger.
	Leak in engine block and exhaust manifold	Check the engine.
	Contaminated blow-by gas or abnormal oil amount	Check the turbo impeller and turbo intake outlet.
	Excessive free play of turbocharger wheel causing interference with wall	Replace the turbocharger.
	Damaged turbocharger wheel	Replace the turbocharger.
	Damaged turbocharger wheel and shaft	Replace the turbocharger.
Poor rotating force of turbocharger wheel	Replace the turbocharger.	
Oil consumption	Poorly tightened clamp	Adjust and tighten.
	Turbocharger coolant leak or oil hose leak	Replace hose or gasket.
	Leak in engine block and exhaust manifold	Check the engine.
	Contaminated blow-by gas or abnormal oil amount	Check the turbo impeller and turbo intake outlet.
	Excessive free play of turbocharger wheel causing interference with wall	Replace the turbocharger.
	Damaged turbocharger wheel	Replace the turbocharger.
	Damaged turbocharger wheel and shaft	Replace the turbocharger.
Poor rotating force of turbocharger wheel	Replace the turbocharger.	
Black exhaust fumes	Deformed or damaged intake unit hose	Replace
	Contaminated or damaged air filter	Replace or check for damage to turbocharger impeller.
	Turbocharger coolant leak or oil hose leak	Replace hose or gasket.
	Turbo actuator operating poorly	Replace the turbocharger.
	Contaminated blow-by gas or abnormal oil amount	Check the turbo impeller and turbo intake outlet.
	Excessive free play of turbocharger wheel causing interference with wall	Replace the turbocharger.
	Damaged turbocharger wheel	Replace the turbocharger.
	Damaged turbocharger wheel and shaft	Replace the turbocharger.
Poor rotating force of turbocharger wheel	Replace the turbocharger.	
Blue exhaust fumes	Leak in engine block and exhaust manifold	Check the engine.

## 9. Intake/Exhaust System

Symptom	Possible cause	Solution
Excessive white smoke	Oil leaking into turbine or compressor	Repair or replace.
	Worn or damaged seal ring due to excessive bearing wear	Repair or replace.
Excessive emissions	Clogged air filter element	Replace or clean.
	Clogged air duct	Check or replace.
	Air leaking from intake system	Check or replace.
	Turbocharger has seized up and cannot rotate	Repair or replace.
	Turbine or compressor blades making contact or damaged	Repair or replace.
	Deformed or clogged exhaust system pipe	Check or replace.

## 9. Intake/Exhaust System

### Handling the Turbocharger

#### 1. Cautions for engine operation

##### 1) Do the following when starting, running and stopping the engine:

Item	Cautions	Reason
Starting	Check the oil level	
	Before starting the engine, it is necessary to run it with the starter motor to check for a rise in hydraulic pressure (until the needle on the hydraulic pressure gauge moves or the pressure indicator turns on).	If the engine is started abruptly, oil cannot reach the turbocharger as well as each part of the engine, and this lack of lubrication can lead to abnormal wear or seizure of the bearings.
	After changing the oil, replacing the oil filter cartridge or lubrication system components or leaving the engine stopped for an extended period of time or in cold weather, undo the oil pipe connection at the inlet of the turbocharger and run the starter motor until oil flows out of it. After doing so, make sure to retighten the pipe connection to start the engine.	Leaving the engine stopped for an extended period of time or in cold weather deteriorates the oil flow in the pipes.
Right after starting	Idle the engine for 5 minutes after starting it.	If the engine is overloaded abruptly right after it is started, the turbocharger is still not rotating freely and the lack of lubrication can lead to the seizure of parts.
	Check each part for oil leaks, gas leaks and air leaks, and take any necessary actions.	Oil leaks, gas leaks or air leaks (especially oil leaks) can drop hydraulic pressure and oil loss can seize bearings.
During Operation	Check the following:	
	Hydraulic pressure Idling : 1.5 ~ 3.0 kg/cm <sup>2</sup> Full load : 3.0 ~ 5.5 kg/cm <sup>2</sup>	If the oil pressure is excessively low, it can lead to abnormal wear or seizure of bearings. If it is excessively high, it can cause oil leaks.
	If abnormal noise or vibrations occur, lower the speed slowly and stop the engine to find the cause.	Continuing to drive with abnormal noise or vibrations can cause severe engine damage which cannot be repaired.
Stopping	When stopping the engine, idle the engine for 5 minutes first.	If the engine is stopped abruptly after overloaded operation, heat is transferred from the hot turbine blades to the bearings. Since this heat burns oil on the bearings, the bearing metals and rotating shaft can be seized.

#### 2. Cautions for handling

- 1) If the engine rpm is increased abruptly after starting the engine, the crankshaft rotates at an excessive speed before the crankshaft journal bearing has been lubricated and the lubricant is not supplied properly. If the turbocharger rotates in this state, cooling and lubrication are not performed properly, causing the bearings to seize and damage to related parts.
- 2) After replacing the engine oil or oil filter, be sure to idle the engine for at least 2 minutes before operating the machinery in order to enable lubricant to circulate in the turbocharger sufficiently.

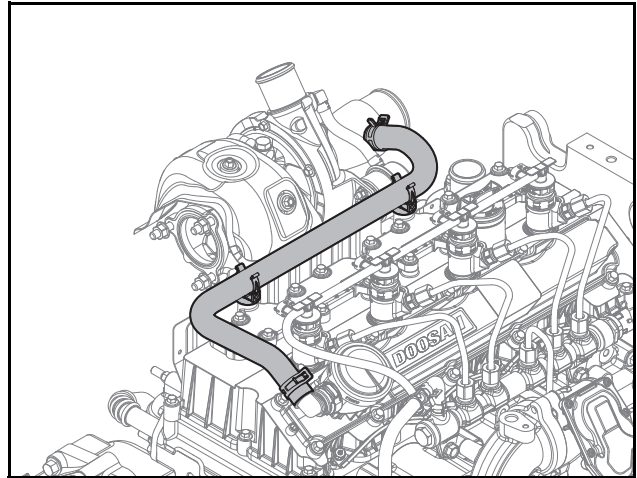


## 9. Intake/Exhaust System

- 3) In the event that the engine has been run at a high speed for an extended period of time, idle the engine sufficiently before stopping the engine. Otherwise the turbine wheel continues running without any hydraulic pressure in the turbocharger and an oil film is not formed on the center bearing and journal bearing of the turbocharger, causing wear and shortening the life of the turbocharger.
- 4) In cold weather or when the engine has not been run for an extended period of time, start the engine and then idle it sufficiently until you confirm that the hydraulic pressure in the engine is at a normal level.
- 5) The turbocharger turbine spins at a very high speed of 50,000 ~ 200,000 rpm. Hence, the supply of oil to the bearing parts can have a significant impact on the life of the turbocharger so be sure to use the genuine engine oil recommended by Hyundai Doosan Infracore and to regularly check and replace the engine oil.
- 6) Using a contaminated air cleaner for an extended period of time can cause critical damage to the turbocharger so check and replace the air cleaner regularly.
- 7) The turbocharger is a very complex and precise component which only certified technicians should work on.
- 8) In the event that the turbocharger is run without the intake and exhaust manifold installed, it can cause severe damage to the engine or cause physical injuries to the operator. Be sure to run the turbocharger with all of the parts installed correctly in their designated positions.
- 9) Do not grab the turbocharger actuator to lift the turbocharger. It can be damaged by the weight of the turbocharger.
- 10) The turbocharger is a heavy component. When lifting the turbocharger to remove or install it, the worker should lower their center of gravity or press their body close to the turbocharger. Otherwise the worker may drop the turbocharger, causing damage to the parts and physical injuries to the worker.

### Removing the Turbocharger

1. Remove the breather hose.

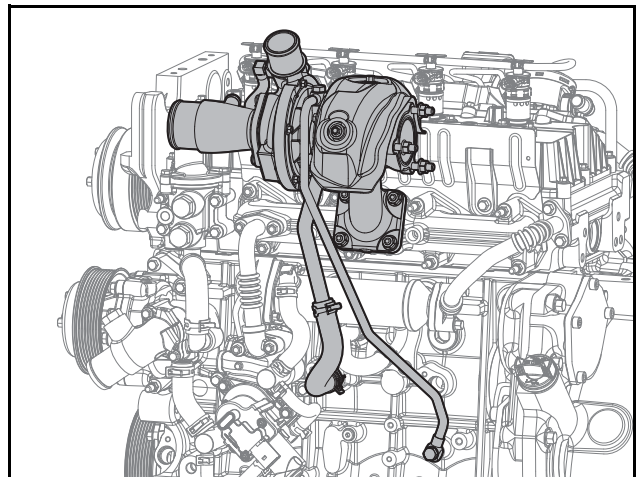


EDM03190234

- 1) Press on the clamps on the quick connector and T/C air inlet pipe assembly, then disconnect the breather hose.

Note: There is no need to disconnect the hose on the quick connector.

2. Remove the turbocharger.



EDM03190235

- 1) Loosen the hollow screws on both ends of the oil supply pipe.
- 2) Remove the oil supply pipe and copper washers.

### CAUTION

**Do not reuse copper washers; replace them with new ones.**

- 3) Press on the clamp and disconnect the oil return hose.
- 4) Loosen the flange hex nut.
- 5) Remove the turbocharger.
- 6) Remove the gasket.
- 7) Loosen the hex bolt.

## 9. Intake/Exhaust System

- 8) Remove the oil return pipe and gasket.

---

### **⚠ CAUTION**

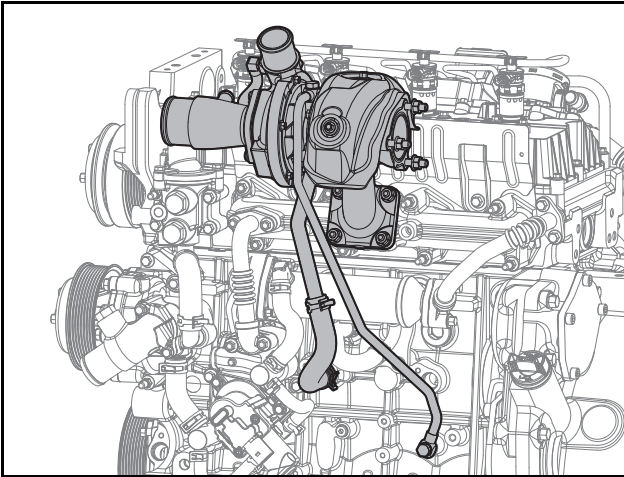
---

**Do not reuse gaskets; replace them with new ones.**

---

### **Assembling the Turbocharger**

1. Assemble the turbocharger.



EDM03190235

- 1) Press on the clamp and connect the oil return hose to the cylinder block.

---

### **⚠ CAUTION**

---

**Do not reuse clamps more than three times; replace them with new ones.**

---

- 2) Align the exhaust manifold stud bolts and assemble the gasket.

---

### **⚠ CAUTION**

---

- Pay attention to the assembled direction of gaskets.
  - Do not reuse gaskets; replace them with new ones.
- 

- 3) Connect the gasket and oil return pipe to the turbocharger.

---

### **⚠ CAUTION**

---

**Do not reuse gaskets; replace them with new ones.**

---

- 4) Tighten the hex bolt to a tightening torque of 1.0 kgf·m.
- 5) Align the exhaust manifold stud bolts and assemble the turbocharger.
- 6) Tighten the flange hex nut to a tightening torque of 2.2 kgf·m.
- 7) Press on the clamp and connect the oil return hose to the oil return pipe.

- 8) Assemble the copper washers with both sides of the banjo union, then temporarily tighten the hollow screws.
- 9) Tighten the hollow screws on both ends of the oil supply pipe to a tightening torque of 2.0 kgf·m.

---

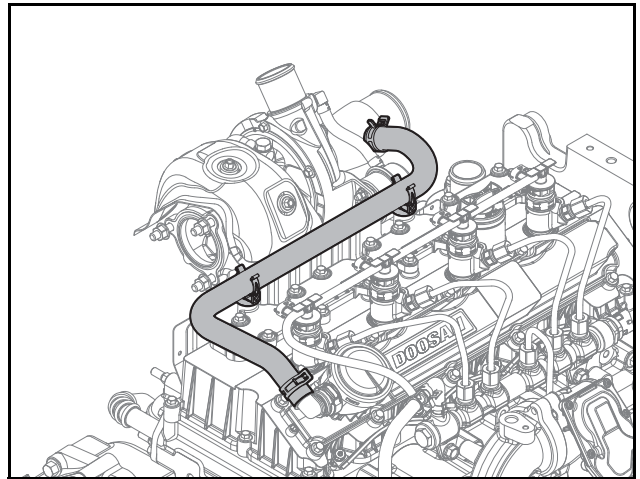
### **⚠ CAUTION**

---

- Do not reuse copper washers; replace them with new ones.
  - When assembling the oil supply pipe, be sure to check whether all of the copper washers have been assembled. There are a total of 4 copper washers assembled, with 2 on each side of the banjo union. Leaks may occur if the copper washers are not positioned correctly or are missing.
  - When assembling the oil supply pipe, assemble the hollow screws on the cylinder block first, then assemble the hollow screws on the turbocharger.
  - After temporarily tightening the hollow screws, hold the oil supply pipe in place by hand so that it does not bend and then tighten them to the specified tightening torque.
- 

Note) During assembly, add 3 cc of clean oil to the turbocharger oil inlet.

2. Assemble the breather hose.



EDM03190234

- 1) Assemble the breather hose with the hose clips.
- 2) Press on the clamps on the quick connector and T/C air inlet pipe, then connect the breather hose.

---

### **⚠ CAUTION**

---

- Do not reuse clamps more than three times; replace them with new ones.
  - Do not apply oil to hoses, clamps, etc.
-

### Checking the Turbocharger

#### 1. Daily inspection and service

The turbocharger's performance is significantly affected by the maintenance condition of the engine. Therefore, the specified engine maintenance work needs to be performed to ensure the overall performance of the engine.

#### 1) Intake system

In the intake system, attention must be given to maintaining the air filter. For a wet type air filter, if the oil level is below the specified level, its filtering performance is degraded. On the other hand, if the oil level is too high, it sucks in oil, contaminating its case. In particular, if the rotor is contaminated, the finely tuned balance is lost, causing vibrations. Also, a massive load is applied to the bearing, causing seizure and abnormal wear. Therefore, use of the air filter is essential for full use of the machine. For a dry type air filter, the intake air resistance should be as low as possible.

#### 2) Exhaust system

In the exhaust system, if exhaust gas leaks from the exhaust manifold or turbocharger connection, the turbocharger performance is degraded. Therefore, particular care should be taken to prevent gas leaks and seizure. Since heat-resistant steel nuts are used for components that become hot during operation, such as the turbine chamber, these nuts should not be confused with other general nuts. Also, an anti-sticking agent should be applied to mounting nuts if specified.

#### 3) Lubrication system

In the lubrication system, pay attention to the oil quality and oil filter cartridge replacement interval. Degraded engine oil can adversely affect the turbocharger as well as the engine itself.

#### 4) Removing and inspecting the turbocharger

When removing the turbocharger for cleaning or inspections, plug the oil inlet and outlet with tape or a similar material.

#### 5) Cautions for turbocharger installation

Be sure to comply with the following when installing the turbocharger in the engine or handling it after installation. Be especially careful not to let any foreign matter enter the turbocharger.

- Lubrication system

- Before installing it in the engine, add fresh oil through its oil filler port and turn the turbine shaft by hand to lubricate the journal bearing and thrust bearing.
- Wash the pipe between the engine and oil inlet and pipe from the oil outlet, and check them for damage or foreign material.
- Tighten each connection of the oil pipes firmly to prevent oil leaks.

- Intake system

- Check that there is no foreign material in the intake system.
- Install it securely so that there is no air leakage from each connection of the intake system and air filter.

- Exhaust system

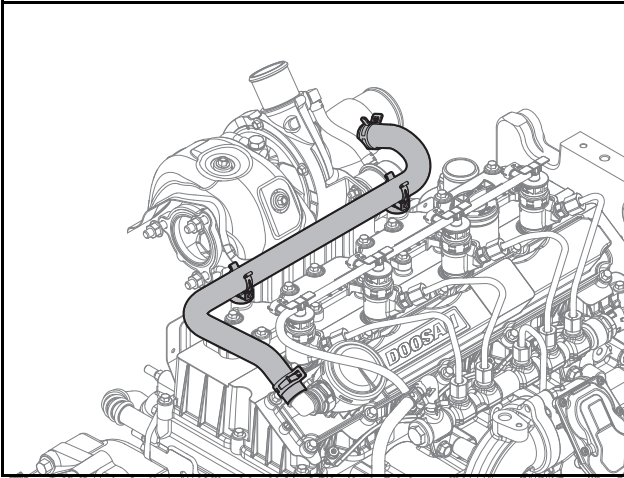
- Check that there is no foreign material in the exhaust system.
- Use heat-resistant steel bolts and nuts and keep them separate from general bolts and nuts during assembly. Apply an anti-sticking agent to bolts and nuts.
- Install it securely so that there is no gas leakage from the exhaust system connections.

## 9. Intake/Exhaust System

### EGR

#### Removing the EGR

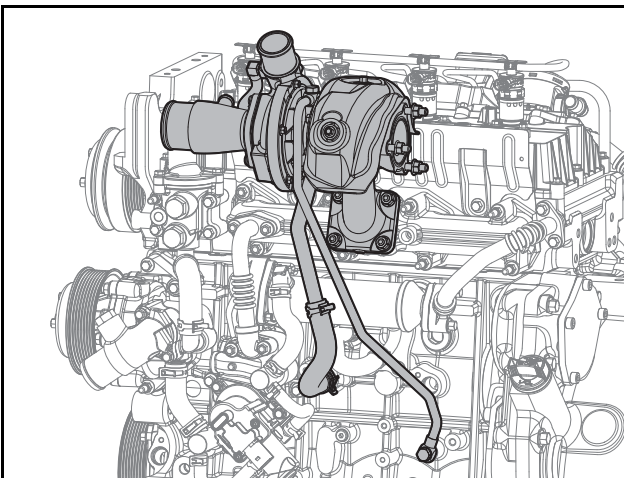
1. Remove the breather hose.



EDM03190234

- 1) Press on the clamps on the quick connector and T/C air inlet pipe assembly, then disconnect the breather hose.  
Note: There is no need to disconnect the hose on the quick connector.

2. Remove the turbocharger.



EDM03190235

- 1) Loosen the hollow screws on both ends of the oil supply pipe.
- 2) Remove the oil supply pipe and copper washers.

### **⚠ CAUTION**

**Do not reuse copper washers; replace them with new ones.**

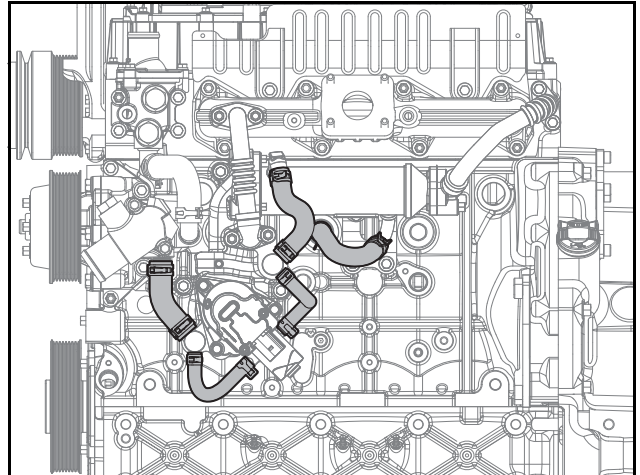
- 3) Press on the clamp and disconnect the oil return hose.
- 4) Loosen the flange hex nut.
- 5) Remove the turbocharger.
- 6) Remove the gasket.

- 7) Loosen the hex bolt.
- 8) Remove the oil return pipe and gasket.

### **⚠ CAUTION**

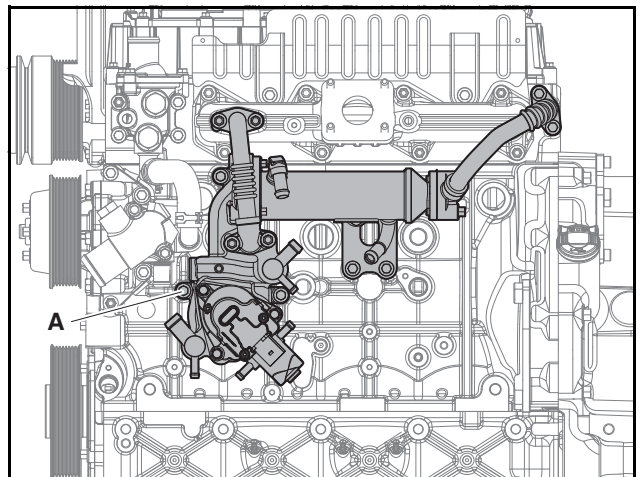
**Do not reuse gaskets; replace them with new ones.**

3. Remove the EGR hose & pipe.



EDM03190239

- 1) Press on clamps on both ends of the hoses and disconnect hoses.
- 2) Loosen 4 flange hex bolts.
- 3) Remove the EGR pipe.
4. Remove the EGR cooler assembly.



EDM03190238

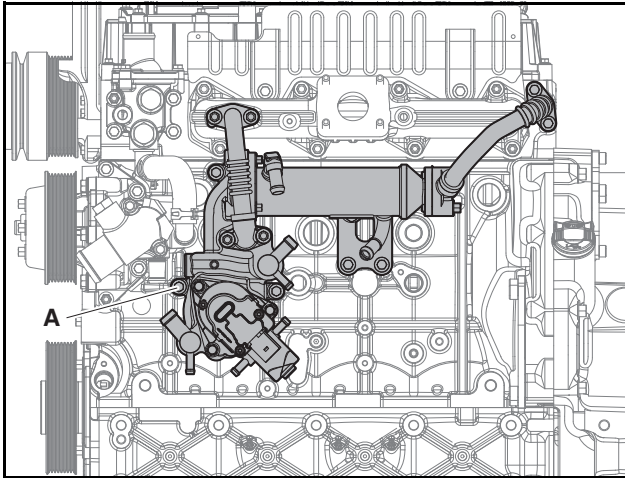
- 1) Loosen 7 flange hex bolts (A).
- 2) Remove the EGR assembly.



## 9. Intake/Exhaust System

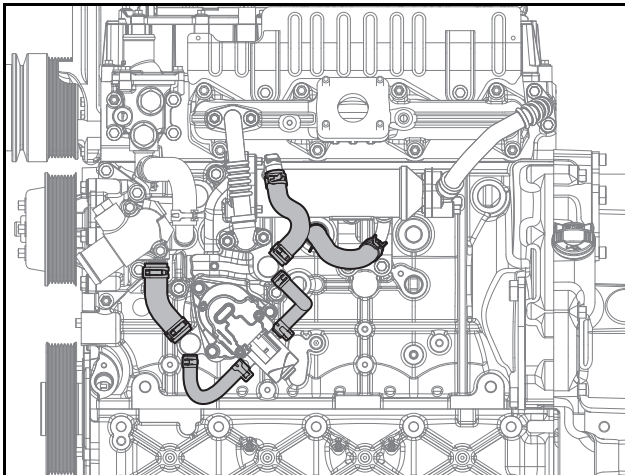
### Assembling the EGR

1. Assemble the EGR assembly.



EDM03190238

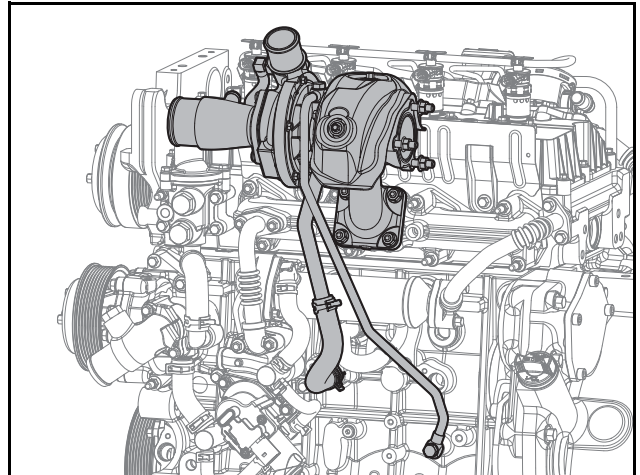
- 1) Attach the EGR assembly.
  - 2) Tighten 7 flange hex bolts (A) at tightening torque of  $2.2 \pm 0.2$  kgf·m.
2. Assemble the EGR pipe & hose.



EDM03190239

- 1) Attach the EGR hose & pipe.
- 2) Mount the hose clamp.
- 3) Mount the EGR pipe to the EGR valve and exhaust manifold.
- 4) Tighten 4 flange hex bolts at tightening torque of  $3.1 \pm 0.3$  kgf·m.

3. Assemble the turbocharger.



EDM03190235

- 1) Press on the clamp and connect the oil return hose to the cylinder block.

### **⚠ CAUTION**

**Do not reuse clamps more than three times; replace them with new ones.**

- 2) Align the exhaust manifold stud bolts and assemble the gasket.

### **⚠ CAUTION**

- Pay attention to the assembled direction of gaskets.
- Do not reuse gaskets; replace them with new ones.

- 3) Connect the gasket and oil return pipe to the turbocharger.

### **⚠ CAUTION**

**Do not reuse gaskets; replace them with new ones.**

- 4) Tighten the hex bolt to a tightening torque of 1.0 kgf·m.
- 5) Align the exhaust manifold stud bolts and assemble the turbocharger.
- 6) Tighten the flange hex nut to a tightening torque of 2.2 kgf·m.
- 7) Press on the clamp and connect the oil return hose to the oil return pipe.
- 8) Assemble the copper washers with both sides of the banjo union, then temporarily tighten the hollow screws.

## 9. Intake/Exhaust System

---

- 9) Tighten the hollow screws on both ends of the oil supply pipe to a tightening torque of 2.0 kgf·m.

---

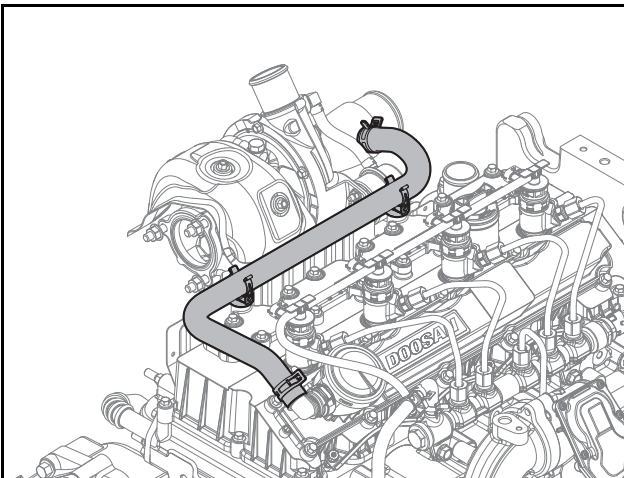
### CAUTION

---

- Do not reuse copper washers; replace them with new ones.
  - When assembling the oil supply pipe, be sure to check whether all of the copper washers have been assembled. There are a total of 4 copper washers assembled, with 2 on each side of the banjo union. Leaks may occur if the copper washers are not positioned correctly or are missing.
  - When assembling the oil supply pipe, assemble the hollow screws on the cylinder block first, then assemble the hollow screws on the turbocharger.
  - After temporarily tightening the hollow screws, hold the oil supply pipe in place by hand so that it does not bend and then tighten them to the specified tightening torque.
- 

Note) During assembly, add 3 cc of clean oil to the turbocharger oil inlet.

4. Assemble the breather hose.



EDM03190234

- 1) Assemble the breather hose with the hose clips.
- 2) Press on the clamps on the quick connector and T/C air inlet pipe, then connect the breather hose.

---

### CAUTION

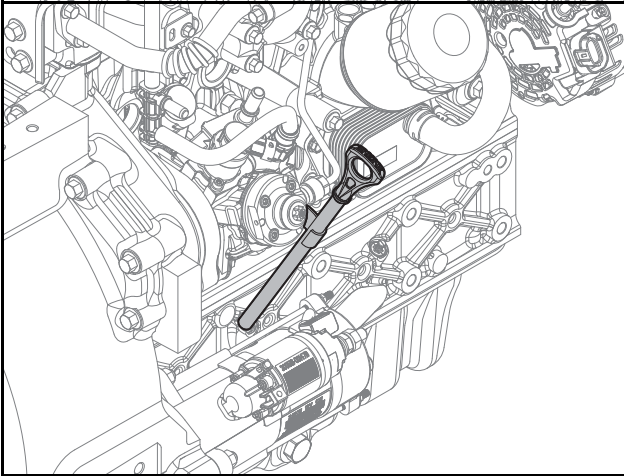
---

- Do not reuse clamps more than three times; replace them with new ones.
  - Do not apply oil to hoses, clamps, etc.
-

### Intake Manifold

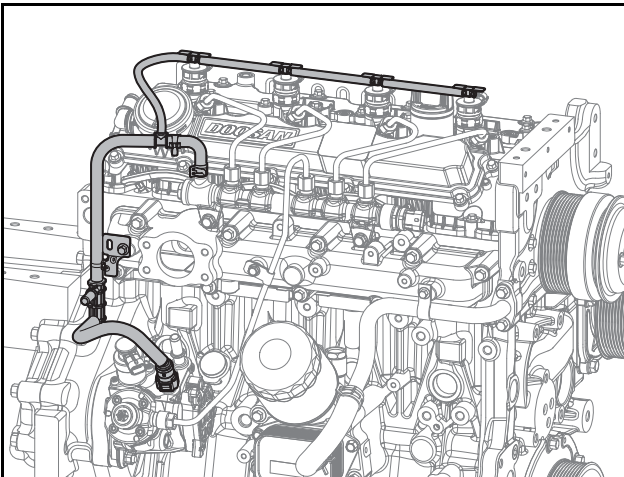
#### Removing the Intake Manifold

1. Remove the oil level gauge.



EDM03190232

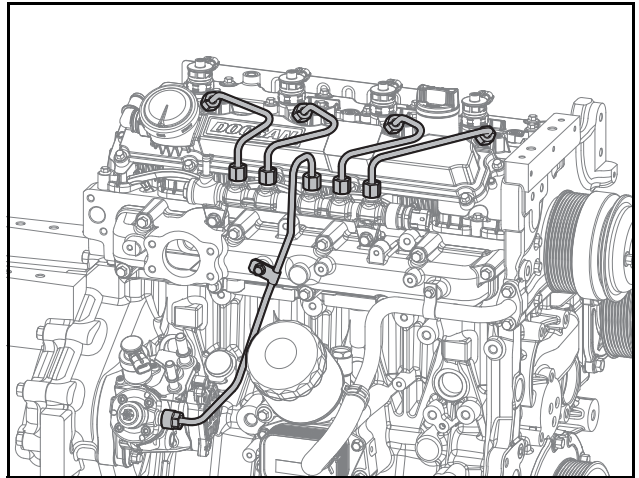
- 1) Remove the oil level gauge.
  - 2) Loosen the flange hex bolt holding the oil level gauge guide tube in place.
  - 3) Remove the oil level gauge guide tube from the cylinder block.
  - 4) Remove the O-rings.
2. Disconnect the fuel return hose.



EDM03190241

- 1) Press on the clamps to remove the common rail, injectors, and fuel return hose on the fuel injection pump.
- 2) Disconnect the fuel return hose.

3. Remove the fuel injection pipe.



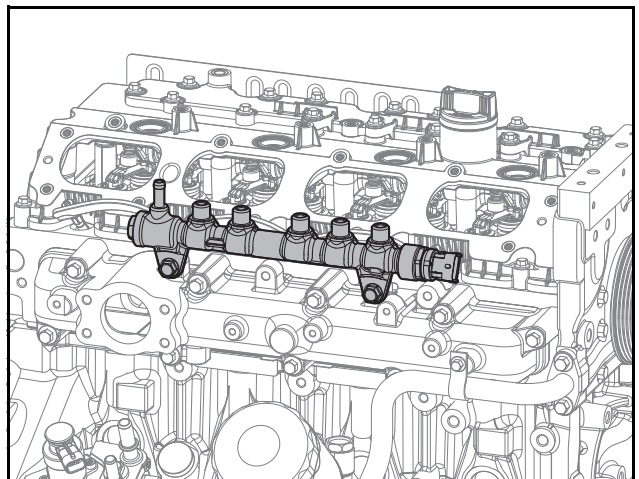
EDM03190240

- 1) Loosen the flange hex bolt.
- 2) Loosen the nuts on both ends of the fuel injection pipes and remove the fuel injection pipes.

### **⚠ CAUTION**

**Do not bend the fuel injection pipe by force.**

4. Remove the common rail.



EDM03190246

- 1) Loosen the hex bolts.
- 2) Remove the common rail from the intake manifold.

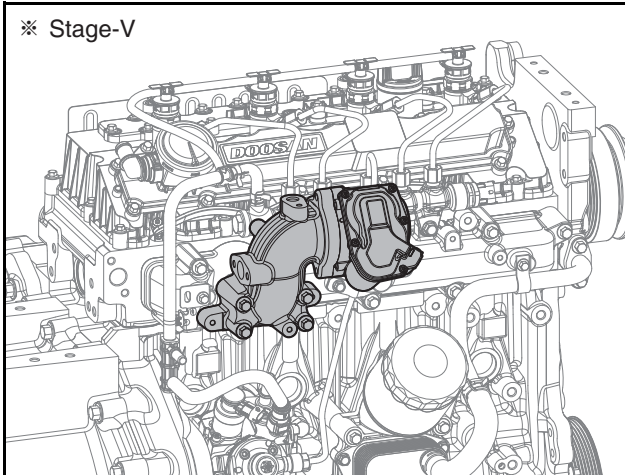
### **⚠ CAUTION**

**Be careful not to damage the common rail during disassembly.**

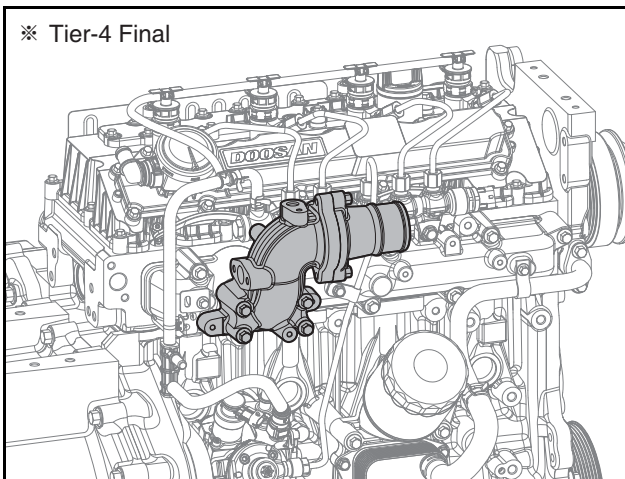


## 9. Intake/Exhaust System

5. Remove the throttle (inlet pipe) & the intake stake.



EDM03190237



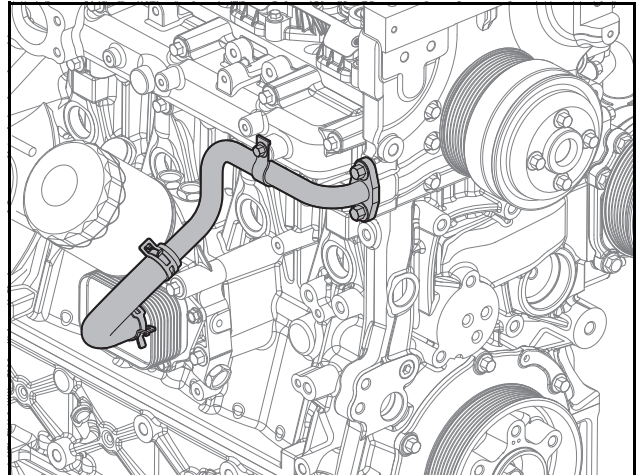
EDM03190236

- 1) Loosen the flange hex bolt.
- 2) Remove the throttle (inlet pipe) & the intake stake.
- 3) Remove the gasket.

### CAUTION

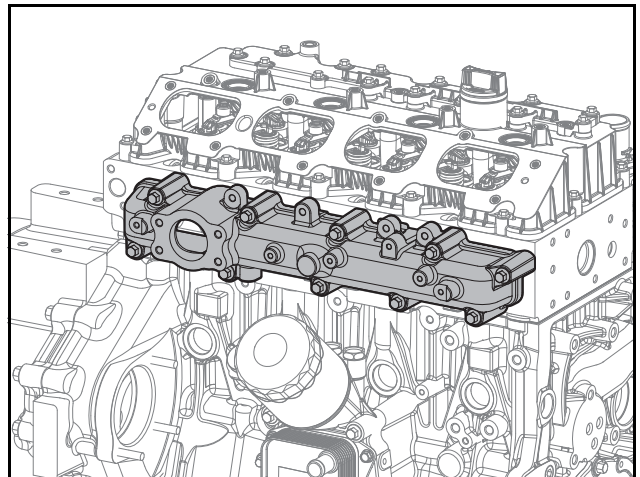
**Do not reuse gaskets; replace them with new ones.**

6. Disconnect the coolant pipe & hose.



EDM03190252

- 1) Press on the clamps on both ends of the coolant hoses and disconnect the coolant hoses.
- 2) Loosen the flange hex bolt.
- 3) Remove the coolant pipe.
7. Remove the intake manifold.



EDM03190173

- 1) Remove the flange hex bolt.
- 2) Remove the intake manifold.
- 3) Remove the intake manifold gasket.

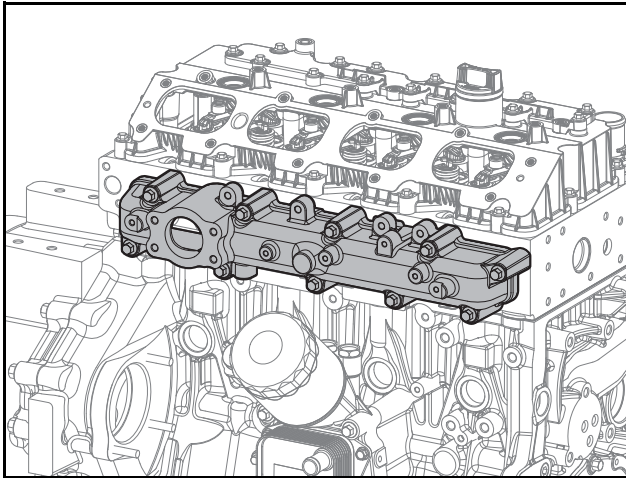
### CAUTION

**Do not reuse gaskets; replace them with new ones.**

## 9. Intake/Exhaust System

### Assembling the Intake Manifold

1. Assemble the intake manifold.



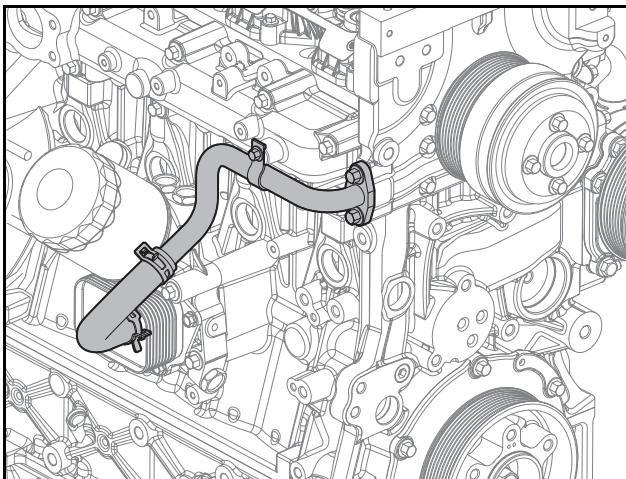
EDM03190173

- 1) Assemble the gasket.

#### **⚠ CAUTION**

- Pay attention to the assembled direction of gaskets.
- Be careful not to damage the gasket during assembly.
- Do not reuse gaskets; replace them with new ones.

- 2) Assemble the intake manifold.
  - 3) Tighten the flange hex bolts to a tightening torque of 2.2 kgf·m.
2. Assemble the coolant pipe & hose.



EDM03190252

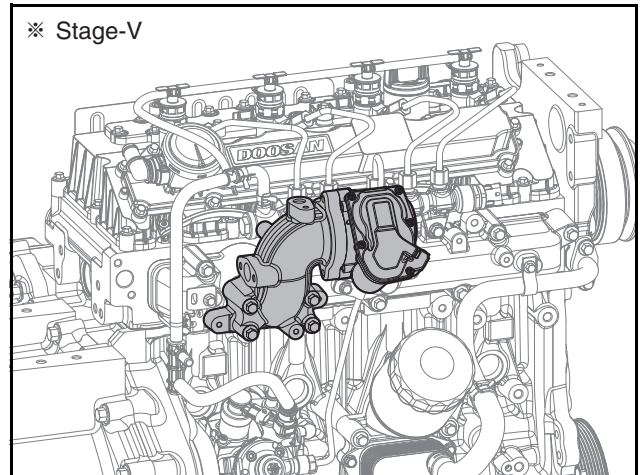
- 1) Tighten the flange hex bolts to fix the coolant pipe in place.

#### **⚠ CAUTION**

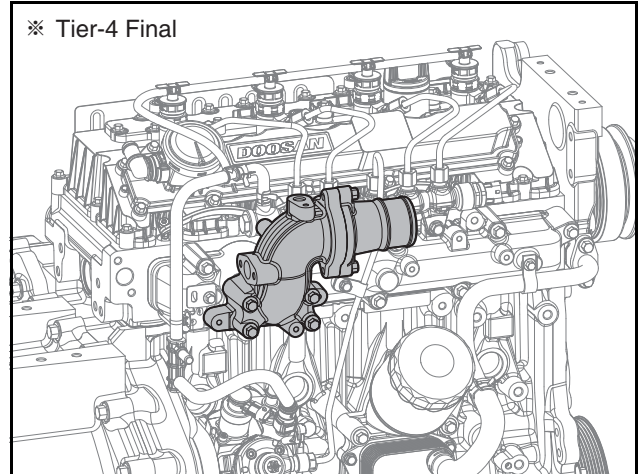
**Do not reuse clamps more than three times; replace them with new ones.**

- 2) Press on the clamps on both ends of the coolant hoses and connect the coolant hoses.

3. Assemble the throttle (inlet pipe) & the intake stake.



EDM03190237



EDM03190236

- 1) Mount the gasket between the throttle (inlet pipe) and intake stake.

#### **⚠ CAUTION**

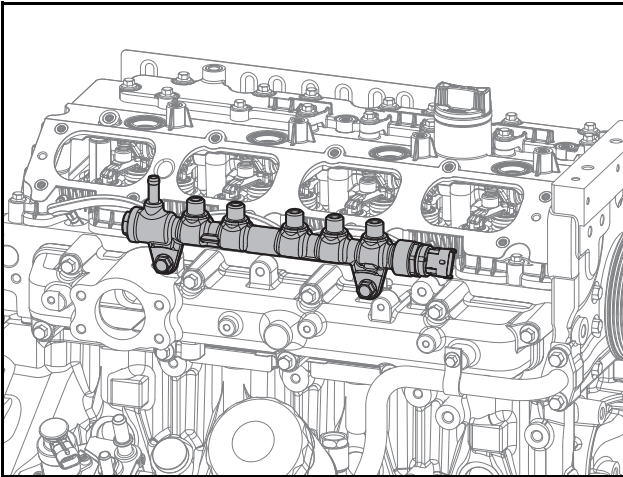
- Pay attention to the direction of gaskets. The vertical direction is narrow and the horizontal direction is wide.
- Remove any foreign matter from the gasket assembly surface.
- Do not reuse gaskets; replace them with new ones.

- 2) Assemble the throttle (inlet pipe) & the intake stake.
- 3) Tighten 4 (3) flange hex bolt to a tightening torque of  $2.2 \pm 0.22$  kgf·m.



## 9. Intake/Exhaust System

4. Assemble the common rail.



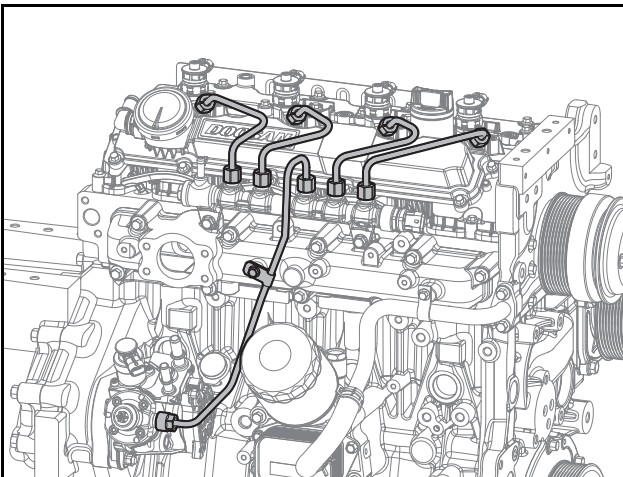
EDM03190246

- 1) Assemble the common rail with the intake manifold.

### **⚠ CAUTION**

- Pay attention to the assembled direction of the common rail.
- Be careful not to damage the common rail during assembly.
- Be careful not to allow any foreign matter to enter the common rail fuel inlet and outlet holes.

- 2) Temporarily assemble the hex bolts by hand.
- 3) Tighten the hex bolts to a tightening torque of 2.2 kgf-m.
5. Assemble fuel injection pipe.



EDM03190240

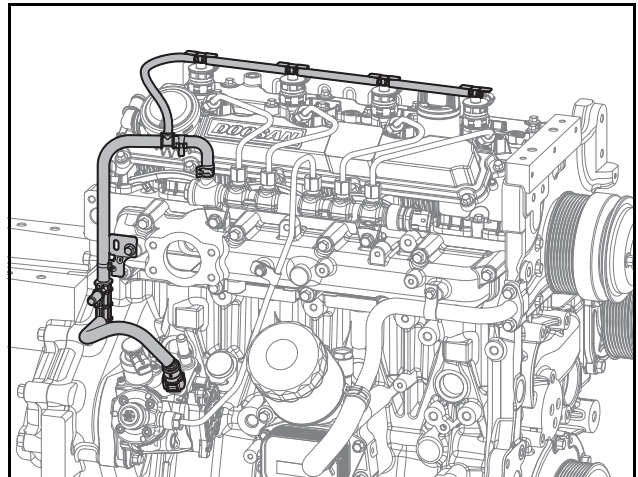
- 1) Loosen the hex bolts on the common rail and temporarily tighten them.
- 2) Temporarily tighten all of the nuts on the fuel injection pipes.
- 3) Tighten the hex bolts on the common rail to a tightening torque of 2.2 kgf-m.
- 4) Tighten the fuel injection pipe nuts to a tightening torque of 3.0 kgf-m.

- 5) Tighten the flange hex bolts assembled with the pipe clips to a tightening torque of 0.8 kgf-m.

### **⚠ CAUTION**

- Do not bend the fuel injection pipe by force.
- Pay attention to the assembled direction of the fuel injection pipe.
- Assemble the nuts on one side of the fuel injection pipe, then assemble the other side and make sure that the round part of the pipe and the part in contact with it are in their proper positions.
- Replace the fuel injection pipe and pipe clip with new ones; do not reuse them. Otherwise it may severely deteriorate the engine performance.

6. Assemble the fuel return hose.



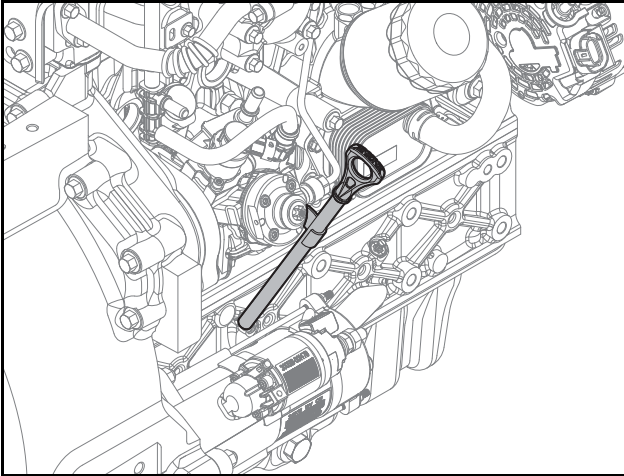
EDM03190241

- 1) Assemble the fuel return hose.

### **⚠ CAUTION**

- Pay attention to the assembled direction of the fuel return hose.
- Assemble the injectors and fuel return hoses so that they interlock sufficiently.
- Do not reuse fuel return hoses; replace them with new ones. Failure to do so may cause serious faults in the engine performance.
- Be careful to avoid damage for fuel return hose of injector.
- Don't press on the fuel hose, don't drop heavy tool like as spanner on engine, don't step on fuel hose, don't stand on engine.
- If the fuel hose are broken by wrong handling, it is possible fire.

- 2) Press on the clamps to attach the common rail, injectors, and fuel return hoses on the fuel injection pump.
7. Assemble the oil level gauge.



EDM03190232

- 1) Replace the O-ring on the guide tube for the oil level gauge with a new one.
- 2) Apply oil to the surface of the O-rings on the guide tube for the oil level gauge.
- 3) Press fit the oil level gauge guide tube into the cylinder block.

---

### CAUTION

**Assemble the oil level gauge guide tube so that the direction of the oil level gauge handle faces the opposite direction from the center of the engine.**

---

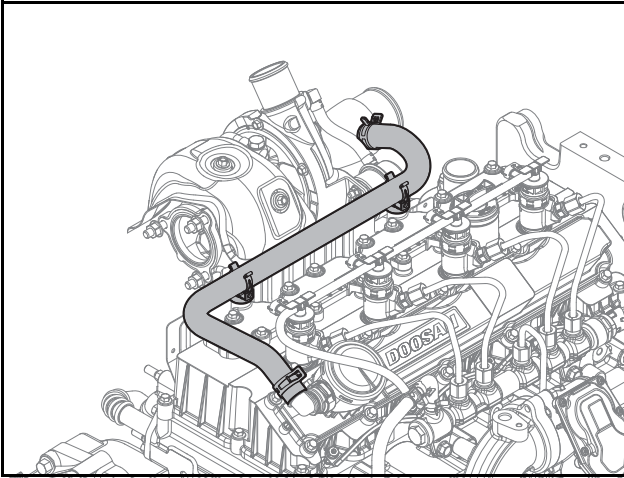
- 4) Tighten the flange hex bolt to a tightening torque of 1.0 kgf·m to fix the oil level gauge tube in place.
- 5) Mount the oil level gauge.

## 9. Intake/Exhaust System

### Exhaust Manifold

#### Removing the Exhaust Manifold

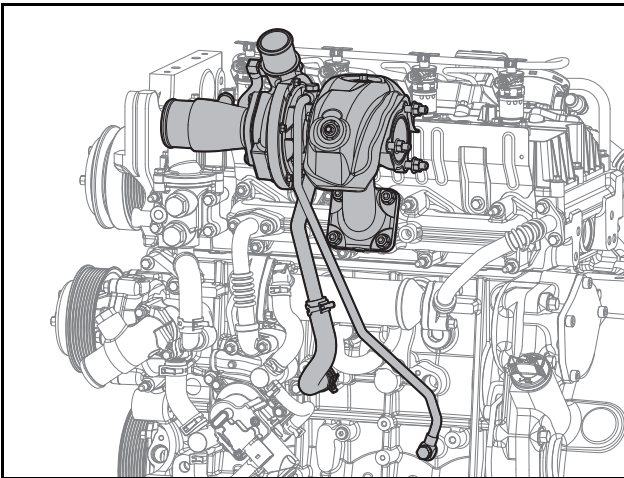
1. Remove the breather hose.



EDM03190234

- 1) Press on the clamps on the quick connector and T/C air inlet pipe assembly, then disconnect the breather hose.  
Note: There is no need to disconnect the hose on the quick connector.

2. Remove the turbocharger.



EDM03190235

- 1) Loosen the hollow screws on both ends of the oil supply pipe.
- 2) Remove the oil supply pipe and copper washers.

#### **⚠ CAUTION**

**Do not reuse copper washers; replace them with new ones.**

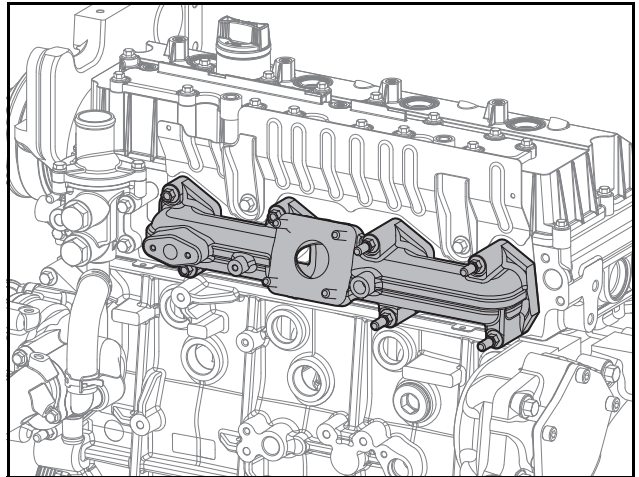
- 3) Press on the clamp and disconnect the oil return hose.
- 4) Loosen the flange hex nut.
- 5) Remove the turbocharger.
- 6) Remove the gasket.
- 7) Loosen the hex bolt.

- 8) Remove the oil return pipe and gasket.

#### **⚠ CAUTION**

**Do not reuse gaskets; replace them with new ones.**

3. Remove the exhaust manifold.



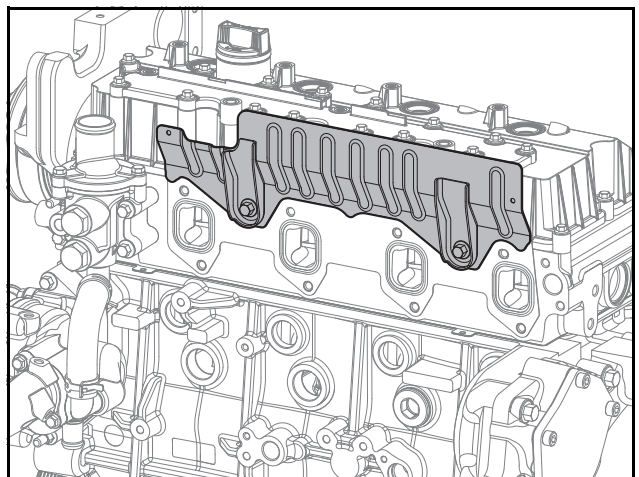
EDM03190250

- 1) Loosen the flange hex bolt.
- 2) Remove the exhaust manifold.

#### **⚠ CAUTION**

**Do not reuse exhaust manifold gaskets; replace them with new ones.**

4. Remove the heat shield.



EDM03190251

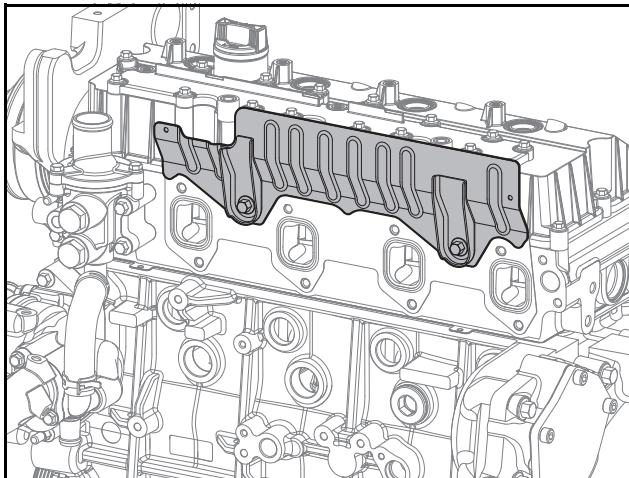
- 1) Loosen the mounting bolts and remove the heat shield.



## 9. Intake/Exhaust System

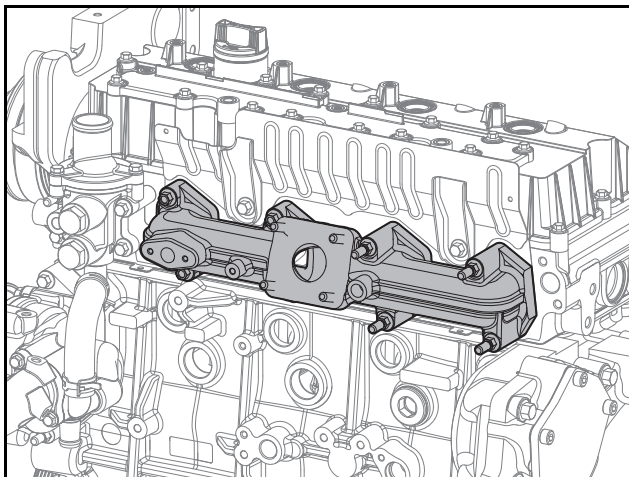
### Assembling the Exhaust Manifold

1. Assemble the heat shield.



EDM03190251

- 1) Assemble the heat shield.
  - 2) Tighten the mounting bolt to a tightening torque of 2.2 kgf·m.
2. Assemble the exhaust manifold.



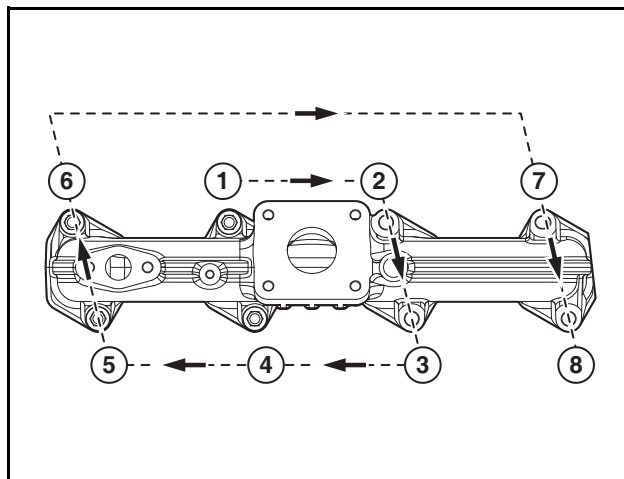
EDM03190250

- 1) Assemble the exhaust manifold.

### **⚠ CAUTION**

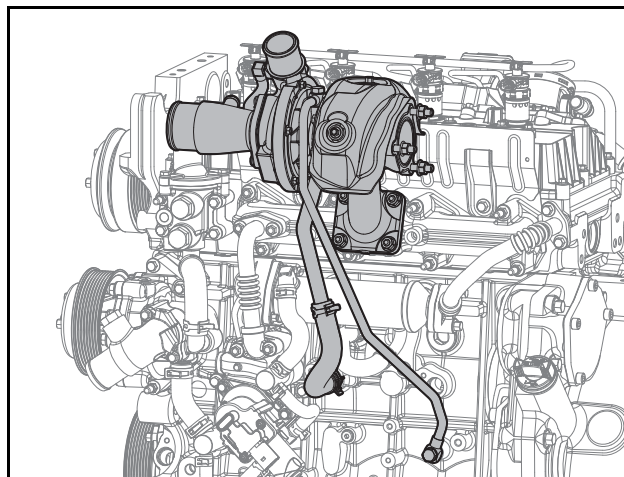
**Be careful not to damage the gaskets while assembling the exhaust manifold. Do not reuse gaskets if they are damaged; replace them with new ones.**

- 2) Apply torque as follow below sequence.
  - Tightening torque: 3.4 ±0.3 kgf·m.
- 3) Apply check torque as follow below sequence again.
  - Tightening torque: 3.4 ±0.3 kgf·m.



EDM03200143

3. Assemble the turbocharger.



EDM03190235

- 1) Press on the clamp and connect the oil return hose to the cylinder block.

### **⚠ CAUTION**

**Do not reuse clamps more than three times; replace them with new ones.**

- 2) Align the exhaust manifold stud bolts and assemble the gasket.

### **⚠ CAUTION**

- **Pay attention to the assembled direction of gaskets.**
- **Do not reuse gaskets; replace them with new ones.**

## 9. Intake/Exhaust System

- 3) Connect the gasket and oil return pipe to the turbo-charger.

---

### CAUTION

---

**Do not reuse gaskets; replace them with new ones.**

---

- 4) Tighten the hex bolt to a tightening torque of 1.0 kgf·m.
- 5) Align the exhaust manifold stud bolts and assemble the turbocharger.
- 6) Tighten the flange hex nut to a tightening torque of 2.2 kgf·m.
- 7) Press on the clamp and connect the oil return hose to the oil return pipe.
- 8) Assemble the copper washers with both sides of the banjo union, then temporarily tighten the hollow screws.
- 9) Tighten the hollow screws on both ends of the oil supply pipe to a tightening torque of 2.0 kgf·m.

---

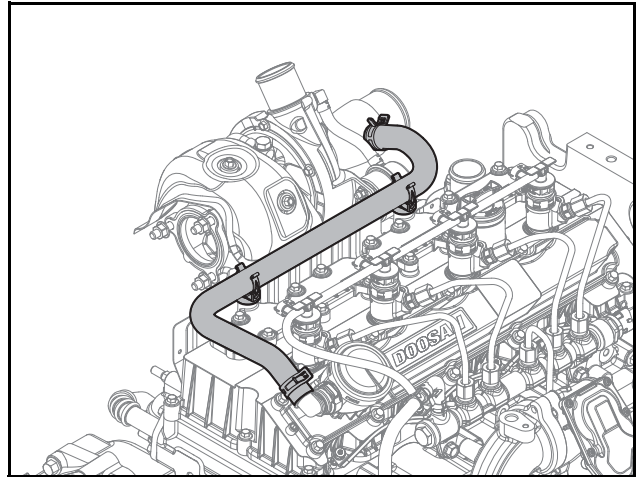
### CAUTION

---

- Do not reuse copper washers; replace them with new ones.
- When assembling the oil supply pipe, be sure to check whether all of the copper washers have been assembled. There are a total of 4 copper washers assembled, with 2 on each side of the banjo union. Leaks may occur if the copper washers are not positioned correctly or are missing.
- When assembling the oil supply pipe, assemble the hollow screws on the cylinder block first, then assemble the hollow screws on the turbocharger.
- After temporarily tightening the hollow screws, hold the oil supply pipe in place by hand so that it does not bend and then tighten them to the specified tightening torque.

Note) During assembly, add 3 cc of clean oil to the turbo-charger oil inlet.

4. Assemble the breather hose.



EDM03190234

- 1) Assemble the breather hose with the hose clips.
- 2) Press on the clamps on the quick connector and T/C air inlet pipe, then connect the breather hose.

---

### CAUTION

---

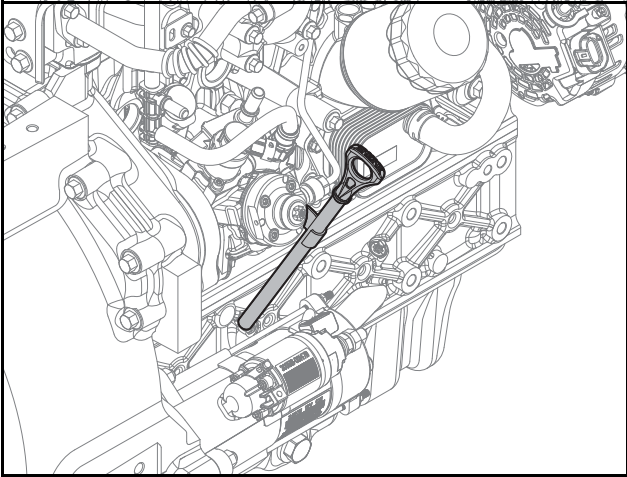
- Do not reuse clamps more than three times; replace them with new ones.
  - Do not apply oil to hoses, clamps, etc.
-



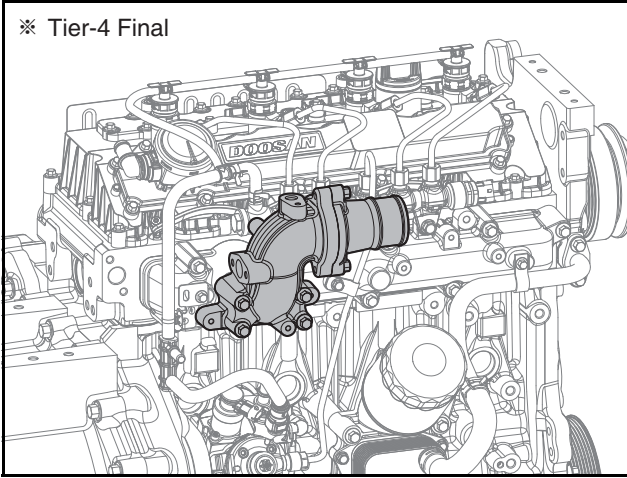
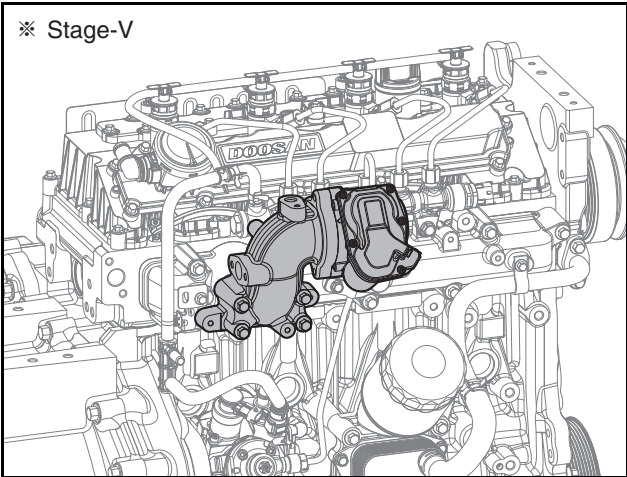
Throttle (Inlet Pipe) & the Intake Stake

Removing the Throttle (Inlet Pipe) & the Intake Stake

- 1. Remove the oil level gauge.



- 1) Remove the oil level gauge.
  - 2) Loosen the flange hex bolt holding the oil level gauge guide tube in place.
  - 3) Remove the oil level gauge guide tube from the cylinder block.
  - 4) Remove the O-rings.
2. Remove the throttle (inlet pipe) & the intake stake.



- 1) Loosen the flange hex bolt.
- 2) Remove the throttle (inlet pipe) & the intake stake.
- 3) Remove the gasket.

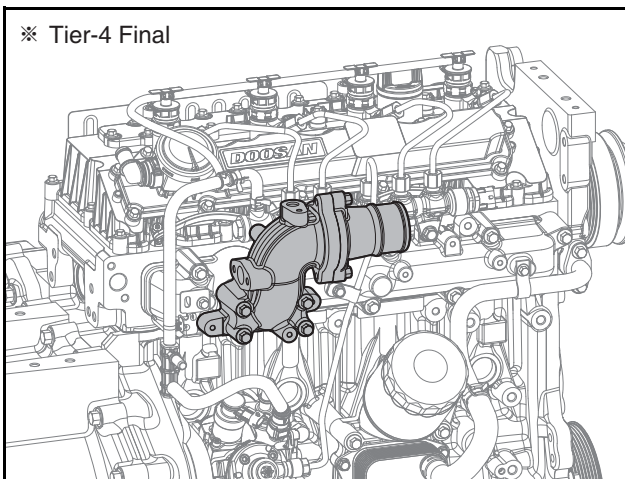
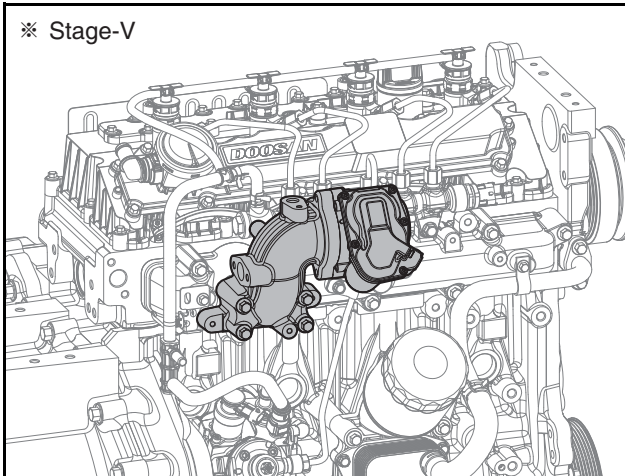
**CAUTION**

**Do not reuse gaskets; replace them with new ones.**

## 9. Intake/Exhaust System

### Assembling the Throttle (Inlet Pipe) & the Intake Stake

1. Assemble the throttle (inlet pipe) & the intake stake.



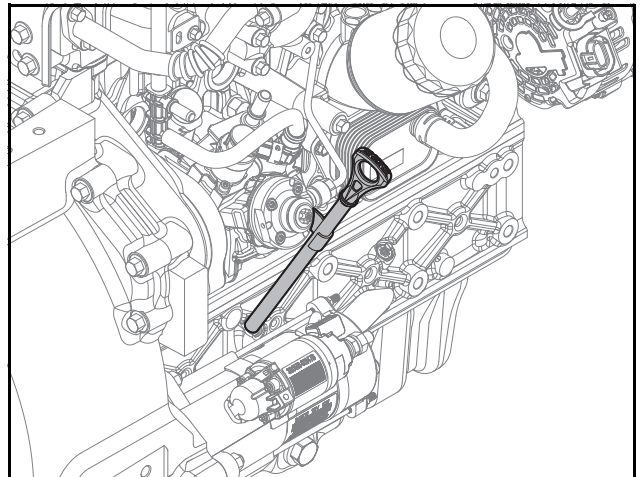
- 1) Mount the gasket between the throttle (inlet pipe) and intake stake.

#### **⚠ CAUTION**

- Pay attention to the direction of gaskets. The vertical direction is narrow and the horizontal direction is wide.
- Remove any foreign matter from the gasket assembly surface.
- Do not reuse gaskets; replace them with new ones.

- 2) Assemble the throttle (inlet pipe) & the intake stake.
- 3) Tighten 4 (3) flange hex bolt to a tightening torque of  $2.2 \pm 0.22$  kgf·m.

2. Assemble the oil level gauge.



- 1) Replace the O-ring on the guide tube for the oil level gauge with a new one.
- 2) Apply oil to the surface of the O-rings on the guide tube for the oil level gauge.
- 3) Press fit the oil level gauge guide tube into the cylinder block.

#### **⚠ CAUTION**

**Assemble the oil level gauge guide tube so that the direction of the oil level gauge handle faces the opposite direction from the center of the engine.**

- 4) Tighten the flange hex bolt to a tightening torque of 1.0 kgf·m to fix the oil level gauge tube in place.
- 5) Mount the oil level gauge.

# 10. Cylinder Block/Head

<b>General Information .....</b>	<b>175</b>
General Information .....	175
<b>Cylinder Block .....</b>	<b>176</b>
Disassembling the Cylinder Block.....	176
Assembly of Cylinder Block .....	176
General Inspection of Cylinder Block.....	176
Measurement of Inside Diameter of Main Bearing Bore of Cylinder Block .....	176
Measurement of Inside Diameter of Piston Bore of Cylinder Block .....	176
Measurement of Inside Diameter of Camshaft Bearing of Cylinder Block .....	177
<b>Cylinder Head .....</b>	<b>178</b>
Disassembling the Cylinder Head.....	178
Assembly of Cylinder Head.....	178
Checking the Cylinder Head .....	178
<b>Valves .....</b>	<b>180</b>
Removing Valves .....	180
Assembling Valves.....	180
Measurement of Inside Diameter of Valve Guide .....	180
Measurement of Valve Stem End .....	180
Measurement of Valve Step Height .....	180
Measurement of Gap between Piston and Valve.....	181
Checking the Valve Spring.....	181
<b>Rocker Arms .....</b>	<b>183</b>
Disassembling the Rocker Arms.....	183
Assembling the Rocker Arms.....	185
Checking the Rocker Arms .....	188
Checking the Rocker Arm Shaft.....	189
<b>Tappet and Push rod .....</b>	<b>190</b>
Removing the Valve Tappet.....	190
Assembling the Valve Tappet .....	190
Checking the Valve Tappet.....	190
Disassembling the Push rod .....	191
Assembling the Push rod .....	193
Checking the Deflection of the Push rod.....	197

<b>Camshaft .....</b>	<b>198</b>
Removing the Camshaft .....	198
Assembling the Camshaft .....	198
Measuring the Camshaft Journal O.D.....	198
Measuring the Camshaft.....	199
<b>Flywheel Housing .....</b>	<b>200</b>
Detaching the Flywheel Housing .....	200
Assembling the Flywheel Housing .....	201
<b>Breather .....</b>	<b>204</b>
Disconnecting the Breather Hose .....	204
Assembling the Breather Hose .....	204
<b>Cylinder Head Cover .....</b>	<b>205</b>
Disassembling the Cylinder Head Cover .....	205
Assembling the Cylinder Head Cover .....	207
<b>Idle Gear .....</b>	<b>210</b>
Removing the Idle Gear .....	210
Assembling the Idle Gear.....	211
Measuring the Outside Diameter of the Idle Gear Shaft.....	214
Measuring the Inside Diameter of the Idle Gear .....	214
<b>Lifting Hook .....</b>	<b>215</b>
Removing the Lifting Hooks .....	215
Assembling the Lifting Hook .....	215
<b>Oil Seal .....</b>	<b>216</b>
Removing the Front Oil Seal Holder .....	216
Assembling the Front Oil Seal Holder.....	217

### General Information

#### General Information

Hyundai Doosan Infracore diesel engines are electronically controlled engines equipped with overhead valves and a turbocharger, and are air-cooled by a cooling fan.

The high-pressure fuel created by the high-pressure fuel pump is stored in the common rail, and when the driver operates the machinery, the optimal amount of fuel and fuel injection timing are determined based on the data set in the electronic control unit (ECU) according to the vehicle speed and driving conditions. The solenoid valves in the injectors installed on each engine cylinder are then activated and the fuel is injected into the cylinders.

The cylinder block is a cast iron alloy unit fitted with a crank case which cuts down on vibrations and noise. The cylinder block was also designed to be integrated with the timing gear case to reduce the length of the engine and increase hermeticity. The cylinder head is an integral type.

The crankshaft is a forged single unit. The crankshaft and flywheel oil seals prevent oil from seeping into the flywheel housing.

The connecting rod is a single unit. Since its big end can be disconnected vertically, it can be removed with the piston through the top of the cylinder. The moving parts of the crankshaft and connecting rod are equipped with alloy bearings.

# 10. Cylinder Block/Head

## Cylinder Block

### Disassembling the Cylinder Block

1. Detach the cylinder block.

Note: Refer to the order of engine disassembly.

### Assembly of Cylinder Block

1. Assemble the cylinder block.

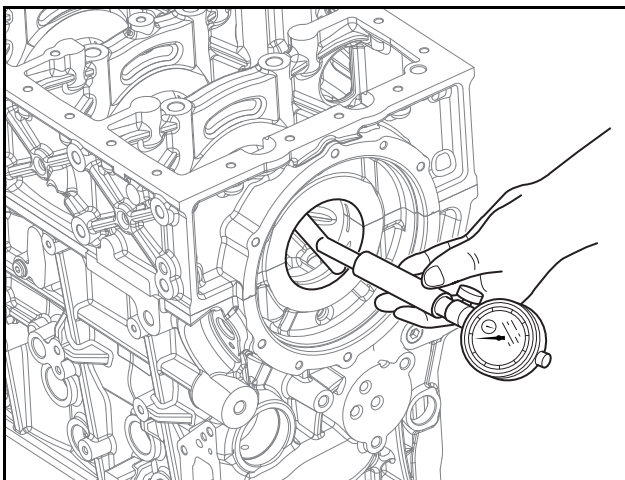
Note: Refer to the order of engine assembly.

### General Inspection of Cylinder Block

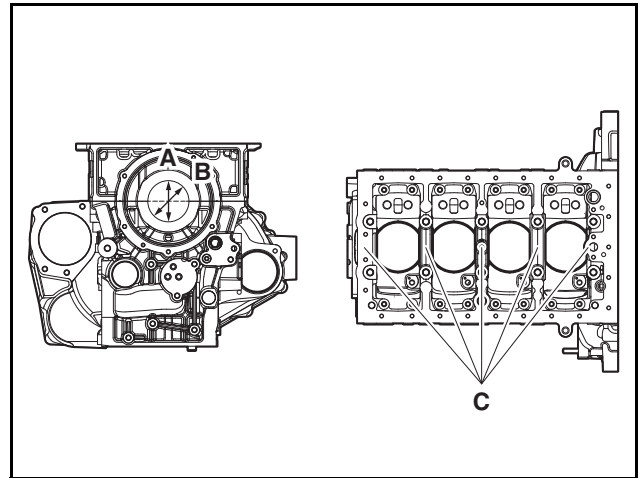
1. Clean the cylinder block thoroughly and check it visually for damage.
2. If it is severely cracked or damaged, replace it with a new one. Correct any minor damage.
3. Check the oil passage and coolant passage for clogging and corrosion.
4. Perform a water pressure test to check for cracks or air leaks.
5. Plug the coolant and oil outlets of the cylinder block and supply approx. 4 kg/cm<sup>2</sup> of pressure through the inlet. Then, soak the cylinder block in 70°C water for approx. 1 minute and check for air leaks.

### Measurement of Inside Diameter of Main Bearing Bore of Cylinder Block

1. Assemble the cylinder block and the crank case.
2. Set up the gauge.
3. Remove any foreign matter from the main bearing bore of the cylinder block.
4. Measure the inside diameter of the main bearing bore of the cylinder block.



EDM03190159



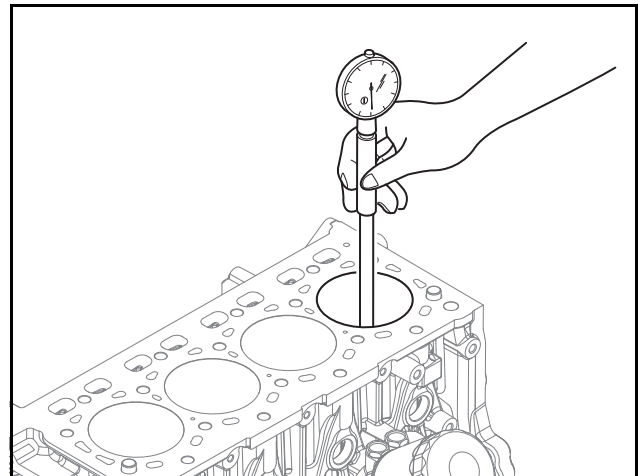
EDM03190156

- 1) Measure a total of 10 places at the front and rear of 5 main bearings (C) on the cylinder block.
- 2) Measure the main bearings on the cylinder block at 2 points: A, B.
- 3) The measured size of the main bearing bore I.D. on the cylinder block should be 79.0 ~ 79.021 mm.

Item	Specified value
Inside diameter of the cylinder block main bearing bore	79.0 ~ 79.021 mm

### Measurement of Inside Diameter of Piston Bore of Cylinder Block

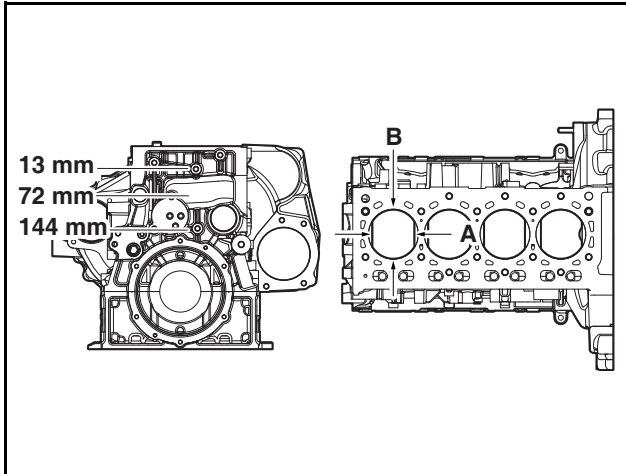
1. Set up the gauge.
2. Remove any foreign matter from the cylinder bore.
3. Measure the inside diameter of the piston bore of the cylinder block.



EDM03190189



## 10. Cylinder Block/Head



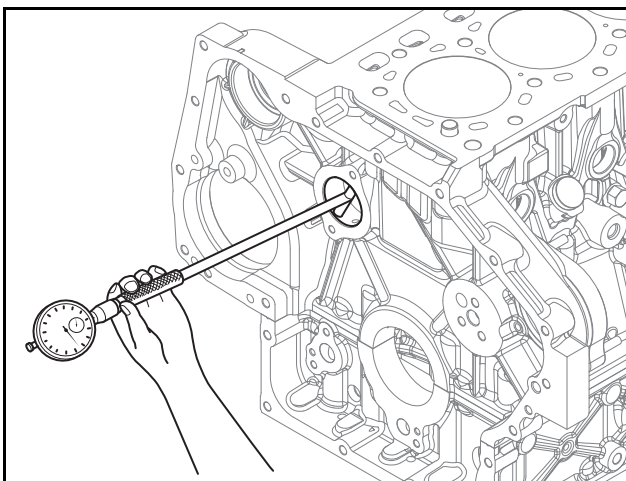
EDM03190157

- 1) Measure a total of 12 places at the top, middle and bottom of 4 cylinder bores.
- 2) Measure the cylinder bore at 2 points: A, B.
- 3) The measured size of the piston bore I.D. on the cylinder block should be 97.990 ~ 98.010 mm.

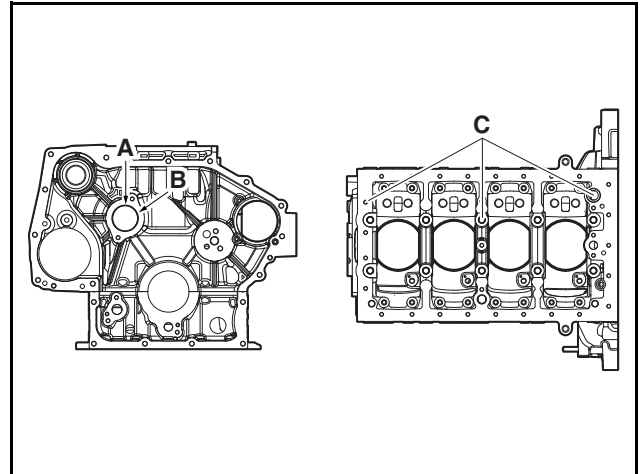
Item	Specified value
Inside diameter of cylinder block piston bore	97.990 ~ 98.010 mm

### Measurement of Inside Diameter of Camshaft Bearing of Cylinder Block

1. Set up the gauge.
2. Remove any foreign matter from the shell of the camshaft bearing on the cylinder block.
3. Measure the inside diameter of the camshaft bearing on the cylinder block.



EDM03190155



EDM03190158

- 1) Measure a total of 6 places at the front and rear of 3 camshaft bearing shells (C) on the cylinder block.
- 2) Measure the camshaft bearing shells on the cylinder block at 2 points: A, B.
- 3) The measured size of the inside diameter of the camshaft bearings should be 45.0 ~ 45.025 mm.

Item	Specified value
Inside diameter of cylinder block camshaft bearings	45.0 ~ 45.025 mm

# 10. Cylinder Block/Head

## Cylinder Head

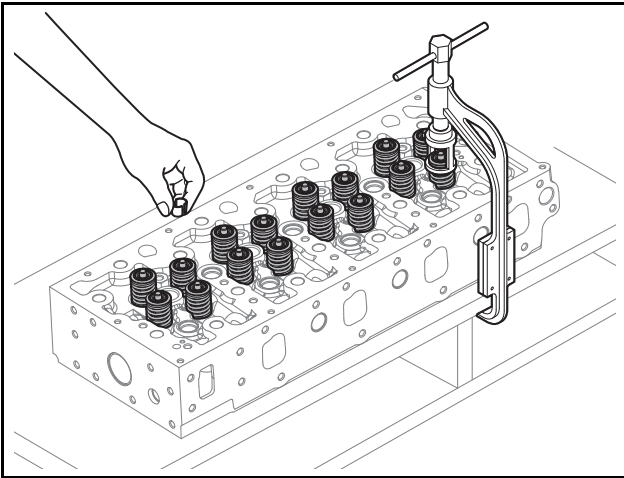
### Disassembling the Cylinder Head

1. Disassemble the cylinder head and keep the components on a shelf for reassembly later.

**⚠ CAUTION**

Be careful not to damage the cylinder head gasket contact surface.

2. Remove the valve cotter, spring and spring seat using a valve spring compressor.



EDM03190033

3. Remove the intake and exhaust valves.
4. Remove the valve stem seal.

**⚠ CAUTION**

Keep the removed parts in order.

### Assembly of Cylinder Head

1. Assemble the cylinder head.

Note: Refer to the order of engine assembly.

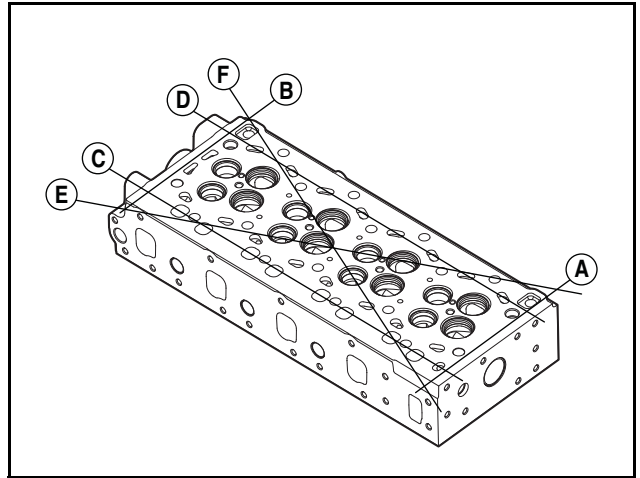
### Checking the Cylinder Head

1. Remove carbon from the bottom of the cylinder head.

Note: Be careful not to scratch the valve seat surface.

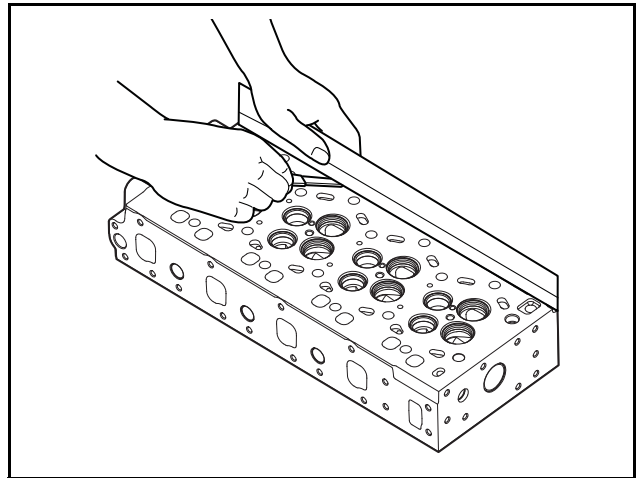
2. Perform a water pressure test or magnetic particle test to check for small cracks or damage that cannot be identified with the naked eye.

3. Inspect the cylinder head for warpage.



EDM03190034

- 1) Place the cylinder head on a flat surface with the bottom facing upwards.
- 2) Use a horizontal leveler and feeler gauge to inspect 6 directions from A to F.
4. Check the flatness of the cylinder head.



EDM03190035

- 1) Place the cylinder head on a flat surface with the bottom facing upwards.
- 2) Measure the flatness of the cylinder head gasket surface by using a horizontal leveler and feeler gauge.
- 3) The measured value of the flatness of the cylinder head gasket surface should be 0.05 mm, 0.03 mm/100 mm.

Item	Specified value
Flatness of cylinder head gasket surface	0.05 mm 0.03 mm/100 mm

- 4) Use a horizontal leveler and feeler gauge to measure the flatness of the assembly surface of the intake manifold and exhaust manifold.

## 10. Cylinder Block/Head

---

- 5) The measured value for the flatness of the assembly surface of the intake manifold and exhaust manifold should be 0.05 mm/100 mm.

Item	Specified value
Flatness of exhaust manifold assembly surface	0.05 mm/100 mm
Flatness of intake manifold assembly surface	0.05 mm/100 mm

5. Perform a water pressure test.
- 1) Plug the coolant and oil outlets of the cylinder head and supply approx. 4 kg/cm<sup>2</sup> of pressure through the inlet. Then, soak the cylinder head in 70°C water for approx. 1 minute and check for air leaks.

# 10. Cylinder Block/Head

## Valves

### Removing Valves

1. Remove the valve.

Note: Refer to the order of engine disassembly.

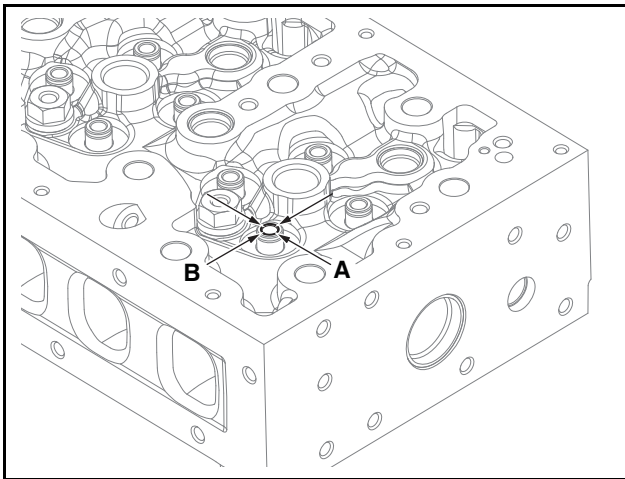
### Assembling Valves

1. Assemble the valve.

Note: Refer to the order of engine assembly.

### Measurement of Inside Diameter of Valve Guide

1. Install the valve guide in the cylinder head.
2. Set up the measuring device.
3. Measure the inside diameter of the valve guide.



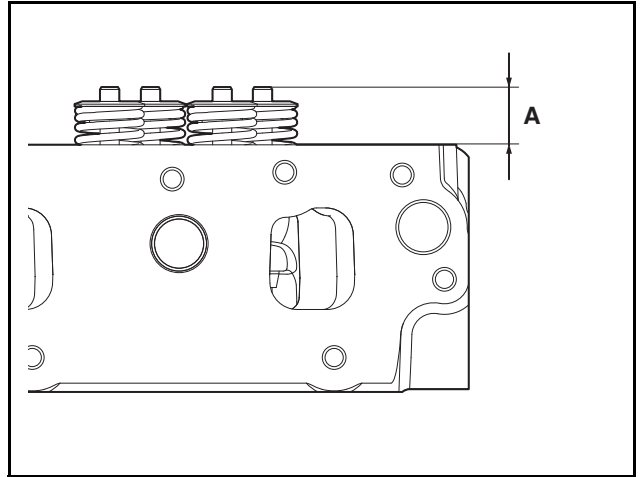
EDM03190036

- 1) Measure a total of 6 vertical (B) and horizontal (A) directions at the top, middle and bottom of the valve guide.
- 2) Measure all of the intake and exhaust valves.
- 3) The measured size of the valve guide I.D. should be 7.0 ~ 7.015 mm.

Item	Specified value
Valve guide I.D.	7.0 ~ 7.015 mm

### Measurement of Valve Stem End

1. Install the valve in the cylinder head.
2. Adjust the measuring device to zero.
3. Measure the valve stem end (A).



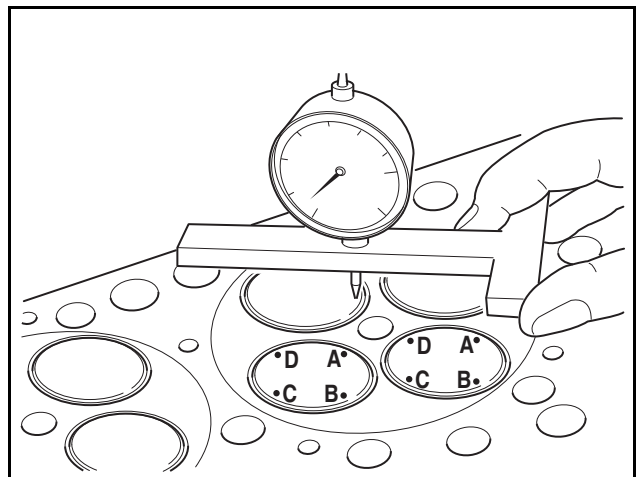
EDM03190037

- 1) Measure the 8 intake valve stem ends.
- 2) The measured size of the intake valve stem ends should be 20.8 ~ 21.3 mm.
- 3) Measure the 8 exhaust valve stem ends.
- 4) The measured size of the exhaust valve stem ends should be 20.8 ~ 21.3 mm.

Item	Specified value
Intake valve stem end	20.8 ~ 21.3 mm
Exhaust valve stem end	20.8 ~ 21.3 mm

### Measurement of Valve Step Height

1. For wear on the valve seat, measure the height of the contact surface between the intake and exhaust valve. Replace it if the measured value exceeds the allowable limit.
2. Measure the valve step height.



EDL022094A

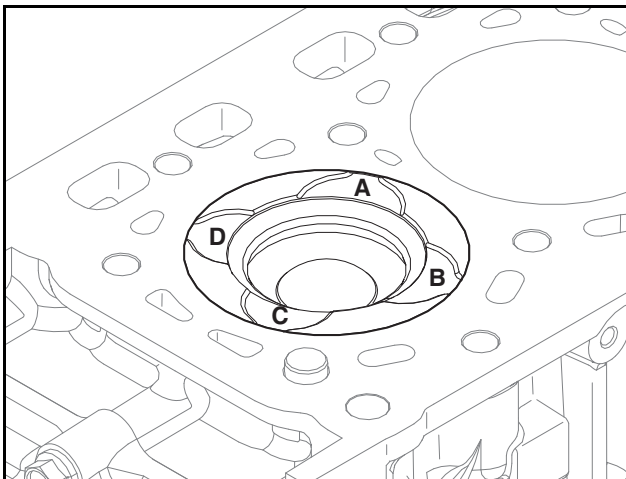
## 10. Cylinder Block/Head

- 1) Insert the valve into the valve seat in the cylinder head and use a dial gauge to measure how far the valve goes in from the bottom surface of the cylinder head.
- 2) Measure the valve in 4 places: A, B, C, D.
- 3) The measured size of the intake valve should be 0.2 ~ 0.5 mm.
- 4) The measured size of the exhaust valve should be 0.1 ~ 0.4 mm.

Item	Specified value
Intake Valve Step Height	0.2 ~ 0.5 mm
Exhaust Valve Step Height	0.1 ~ 0.4 mm

### Measurement of Gap between Piston and Valve

1. Remove the cylinder head.
2. Prepare to measure the gap between the piston and valve.



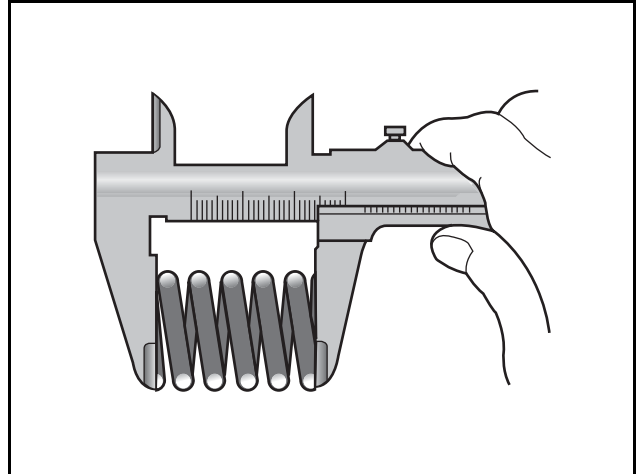
EDM03190266

- 1) Prepare lead with a thickness of around 3 mm.
  - 2) After applying grease to the lead, place it on 4 places at A, B, C and D at the top of each piston for a total of 16 places.
  - 3) Assemble the cylinder head.
  - 4) Rotate the crankshaft pulley to make the piston perform a reciprocating motion.
  - 5) Remove the cylinder head.
3. Measure the gap between the piston and valve.
    - 1) Use vernier calipers to measure the thickness of the lead.
    - 2) The size of the gap with the intake valve should be 1.69 ~ 2.52 mm.
    - 3) The size of the gap with the exhaust valve should be 1.54 ~ 2.33 mm.

Item	Specified value
Gap with intake valve	1.69 ~ 2.52 mm
Gap with exhaust valve	1.54 ~ 2.33 mm

### Checking the Valve Spring

1. Perform a visual inspection of the exterior of the valve spring.
  - 1) Visually inspect the valve spring for external damage and replace it if necessary.
  2. Check the free length of the valve spring.

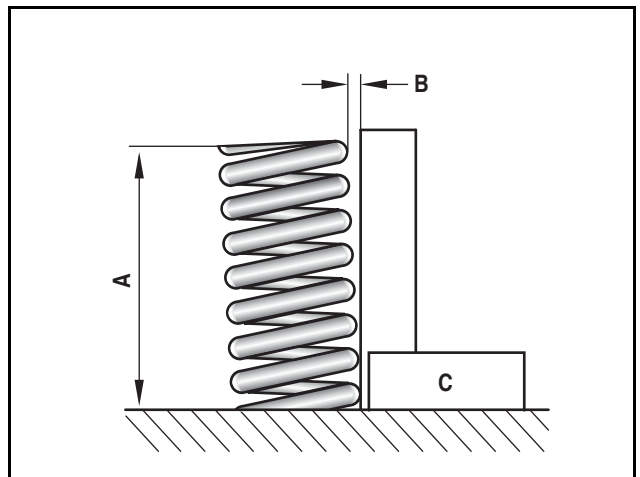


EDL022096A

- 1) Measure the free length of the valve spring with vernier calipers.
- 2) The free length of the valve spring should be 55.23 mm.

Item	Specified value
Valve spring free length	55.23 mm

3. Check the squareness of the valve spring.



EDL022097A

A. Free length    B. Squareness    C. Square

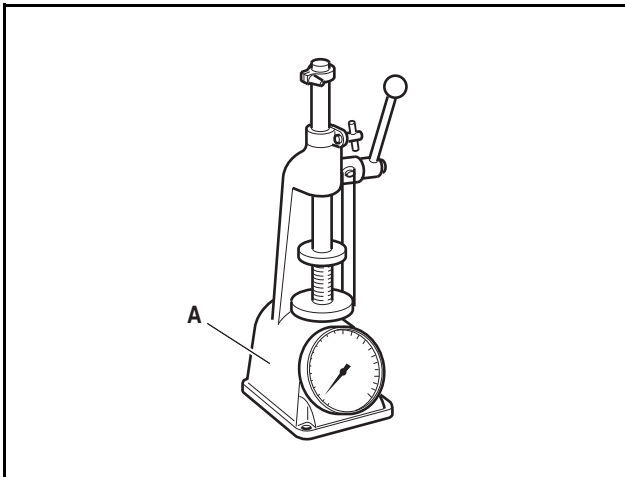
- 1) Use a surface plate and square to measure the squareness of the valve spring.
- 2) The squareness of the valve spring should be 2° (less than 1.8 mm).

Item	Specified value
Valve spring squareness	2° (less than 1.8 mm)

## 10. Cylinder Block/Head

---

4. Check the tension of the valve spring.



EDL022098B

1) Use a spring tester (A) to measure the tension of the valve spring.

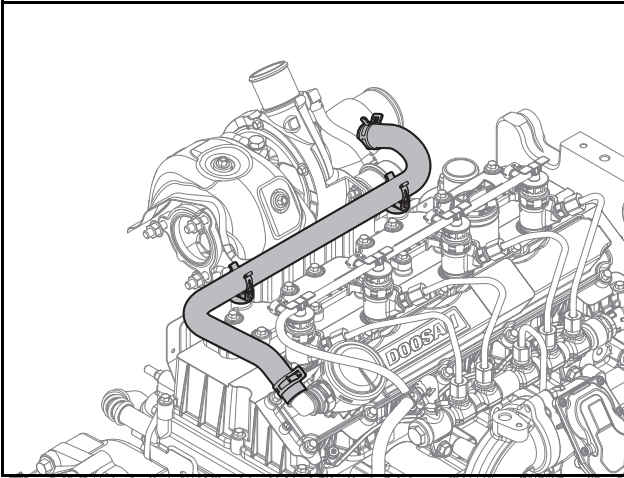
Note: If the spring tension is abnormal, replace the valve spring with a new one.



## Rocker Arms

### Disassembling the Rocker Arms

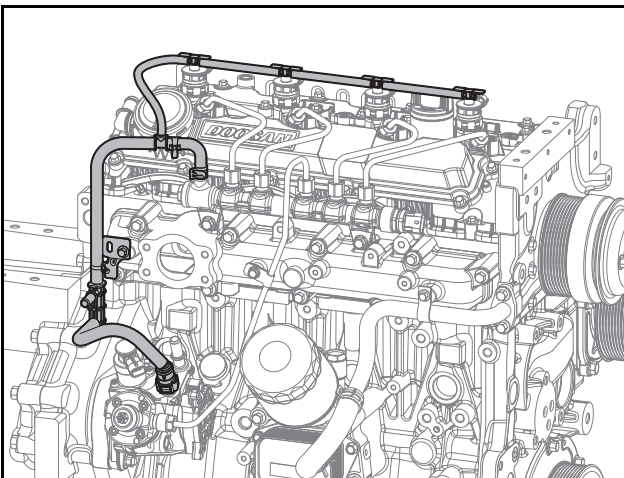
1. Remove the breather hose.



EDM03190234

- 1) Press on the clamps on the quick connector and T/C air inlet pipe assembly, then disconnect the breather hose.  
Note: There is no need to disconnect the hose on the quick connector.

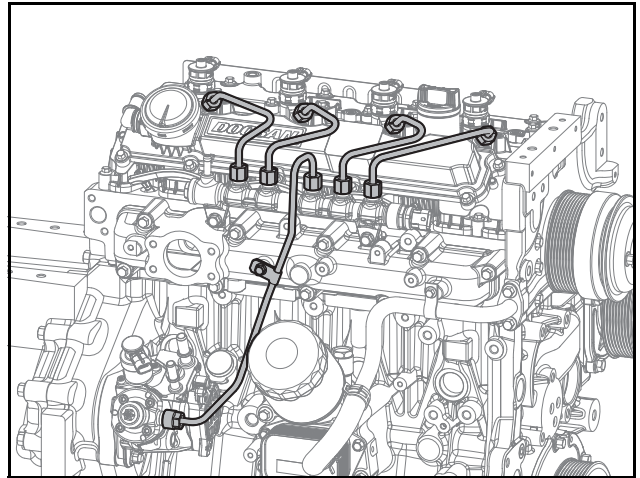
2. Disconnect the fuel return hose.



EDM03190241

- 1) Press on the clamps to remove the common rail, injectors, and fuel return hose on the fuel injection pump.
- 2) Disconnect the fuel return hose.

3. Remove the fuel injection pipe.



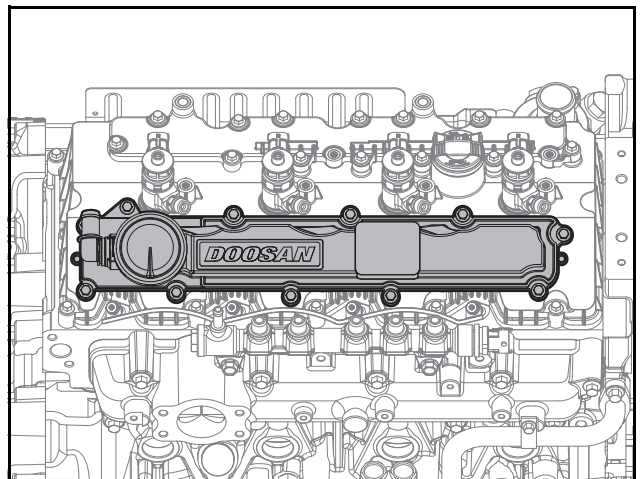
EDM03190240

- 1) Loosen the flange hex bolt.
- 2) Loosen the nuts on both ends of the fuel injection pipes and remove the fuel injection pipes.

### CAUTION

**Do not bend the fuel injection pipe by force.**

4. Remove the right cylinder head cover.

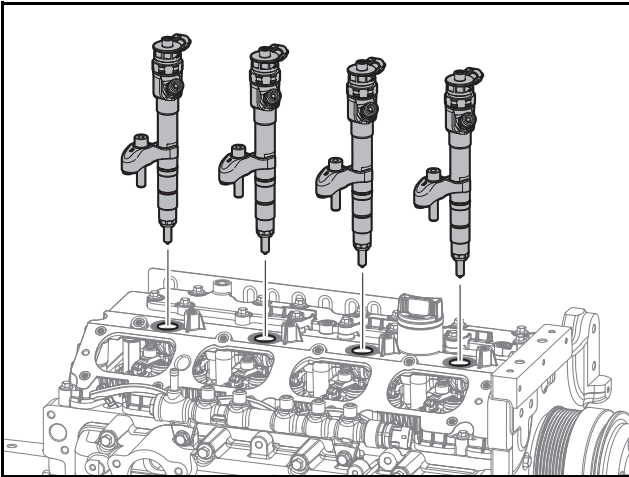


EDM03190245

- 1) Loosen the flange hex bolts from outside to inside in the direction of the arrow.
- 2) Remove the right cylinder head cover.

## 10. Cylinder Block/Head

5. Remove the injector.



EDM03190247

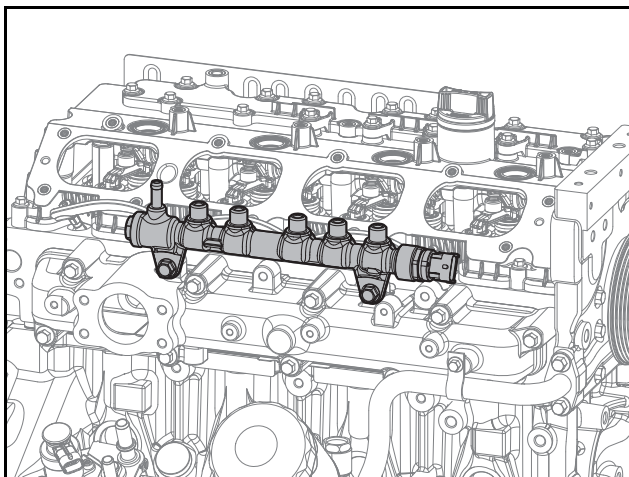
- 1) Loosen the hex bolts.
- 2) Remove the injector mounting brackets.
- 3) Remove the injectors.
- 4) Remove the injector sealing washer.

Note: Remove the cylinder head cover and remove the injector sealing washer.

### CAUTION

- Be careful not to damage the injectors during disassembly.
- When removing injectors, be sure to remove them together with the washers so as not to lose them.

6. Remove the common rail.



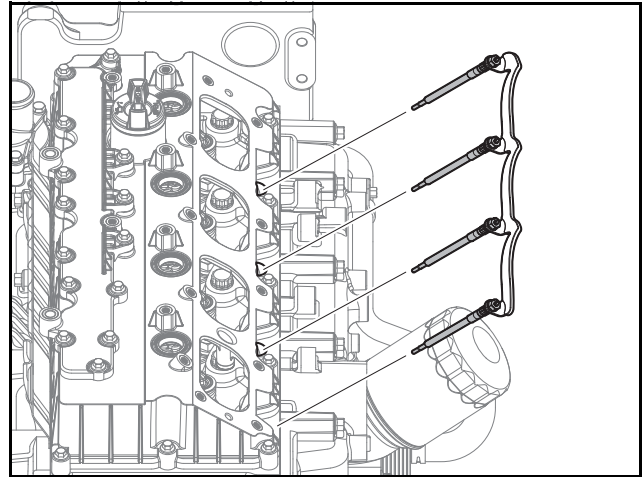
EDM03190246

- 1) Loosen the hex bolts.
- 2) Remove the common rail from the intake manifold.

### CAUTION

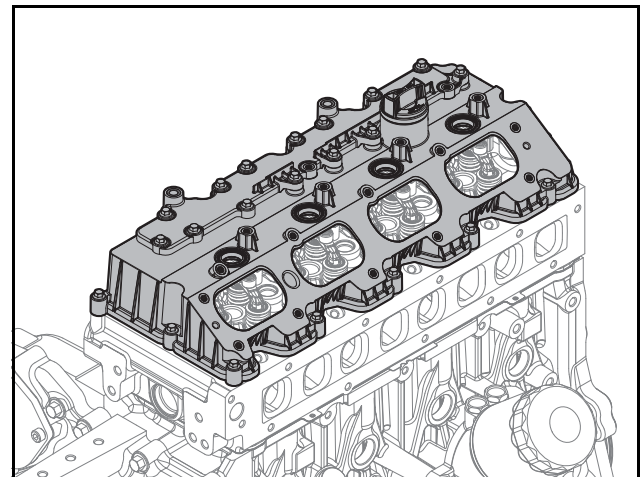
Be careful not to damage the common rail during disassembly.

7. Disconnect the glow plugs.



EDM03190248

- 1) Loosen 4 hex nuts.
- 2) Remove the electric connector.
- 3) Disconnect 4 glow plugs.
8. Remove the cylinder head cover.

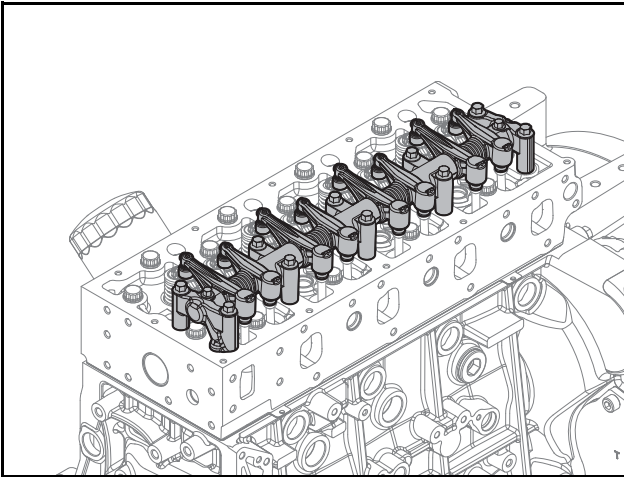


EDM03190169

- 1) Loosen the hex bolts from outside to inside in the direction of the arrow.
- 2) Remove the cylinder head cover.

## 10. Cylinder Block/Head

9. Remove the rocker arms.

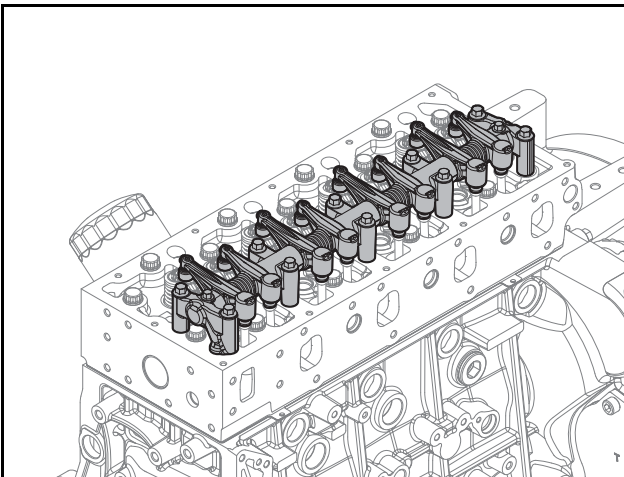


EDM03190168

- 1) Loosen the flange hex bolt.
- 2) Remove the rocker arms.

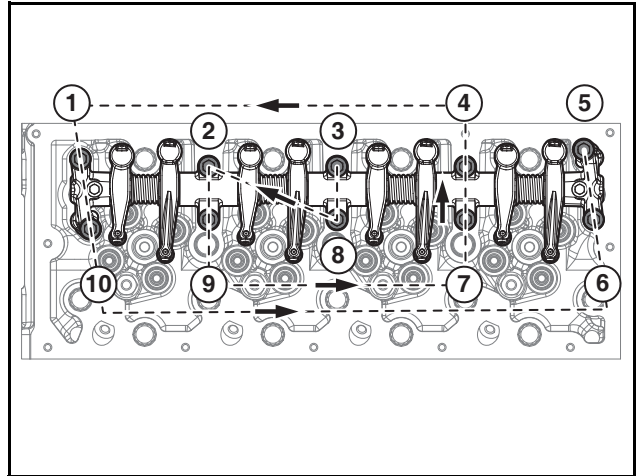
### Assembling the Rocker Arms

1. Assemble the rocker arms.



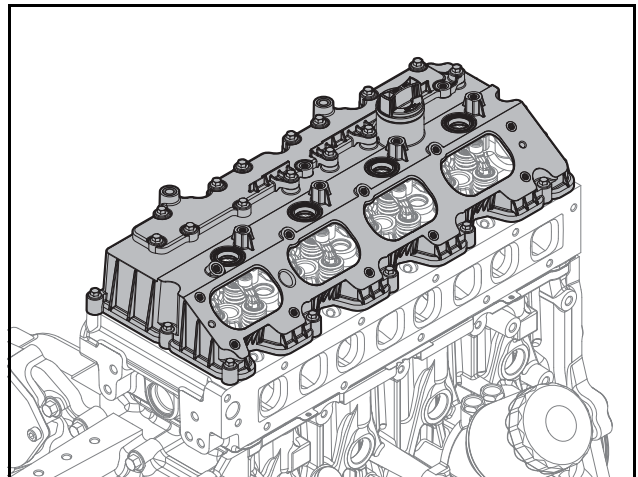
EDM03190168

- 1) Assemble the rocker arms.
- 2) Pre-assemble for positioning the bolts and locating pin with hands.
- 3) Apply torque as follow below sequence.
  - Tightening torque:  $2.2 \pm 0.22$  kgf·m.
  - 3 → 8 → 2 → 9 → 7 → 4 → 1 → 10 → 6 → 5
- 4) Apply check torque as follow below sequence again.
  - Tightening torque:  $2.2 \pm 0.22$  kgf·m.
  - 3 → 8 → 2 → 9 → 7 → 4 → 1 → 10 → 6 → 5



EDM03210161

2. Assemble the cylinder head cover.



EDM03190169

- 1) Align the rubber packing with the cylinder head cover groove and assemble the cylinder head cover.
- 2) Temporarily mount the hex bolts from inside to outside in the direction of the arrow.
- 3) Tighten the hex bolts from inside to outside in the direction of the arrow at a tightening torque of  $0.8 \pm 0.05$  kgf·m.

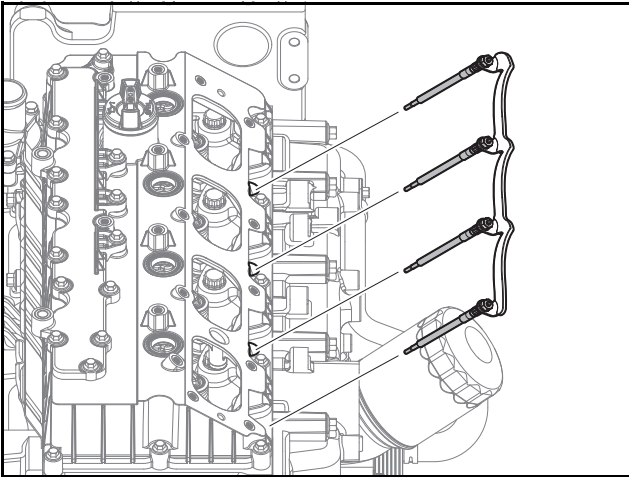
### CAUTION

- When performing maintenance, do not reuse the head cover rubber seals and injector oil seals; replace them with new ones.
- When replacing oil seals, use an inserter to press fit them completely.



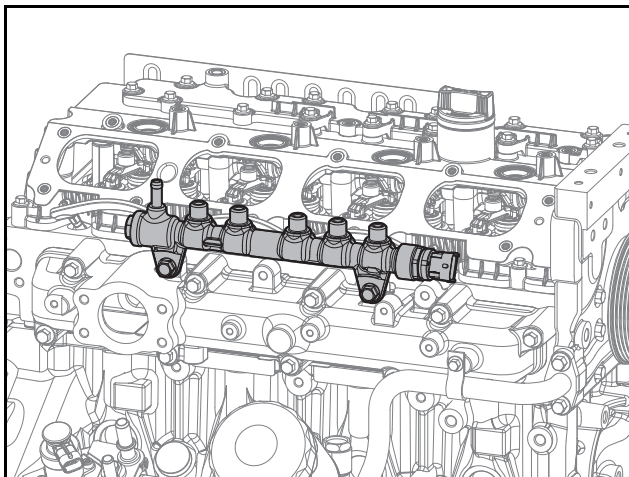
## 10. Cylinder Block/Head

### 3. Connect the glow plugs.



EDM03190248

- 1) Tightening 4 glow plugs to the cylinder head at a tightening torque of 9 ~ 12 N·m.
- 2) Attach the electric connector.
- 3) Mount 4 washers.
- 4) Tighten 4 hex nuts at a tightening torque of 1.3 ~ 2 N·m.
4. Assemble the common rail.



EDM03190246

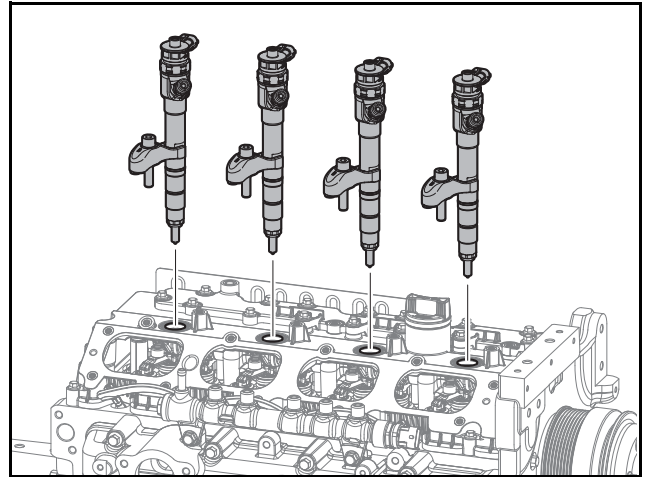
- 1) Assemble the common rail with the intake manifold.

### **⚠ CAUTION**

- Pay attention to the assembled direction of the common rail.
- Be careful not to damage the common rail during assembly.
- Be careful not to allow any foreign matter to enter the common rail fuel inlet and outlet holes.

- 2) Temporarily assemble the hex bolts by hand.
- 3) Tighten the hex bolts to a tightening torque of 2.2 kgf·m.

### 5. Assemble the injector.



EDM03190247

- 1) Align the injector sealing washers with the center of the injector hole and mount them.
- 2) Apply sufficient oil to the contact surface of the injector on the cylinder head cover.
- 3) Assemble the injectors.

### **⚠ CAUTION**

- Slowly turn the injector while assembling it to avoid damaging the injector oil seal on the cylinder head cover.
- Do not reuse injector sealing washers. Otherwise serious faults may occur in the engine due to unstable combustion.

- 4) Assemble the injector mounting brackets.
- 5) Temporarily tighten the hex bolts to a tightening torque of 0.3 kgf·m.

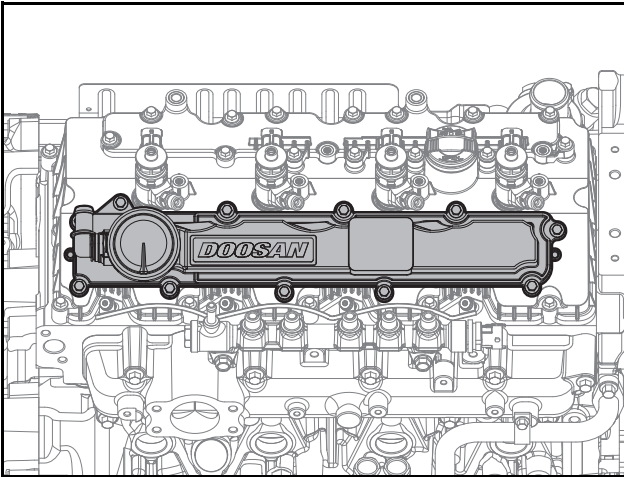
### **⚠ CAUTION**

If the hex bolts cannot be tightened while temporarily tightening them, do not tighten them by force. Tightening them by force may damage the cylinder head.

- 6) Tighten the hex bolts to a tightening torque of 4.35 ± 0.35 kgf·m.

## 10. Cylinder Block/Head

6. Assemble the right cylinder head cover.



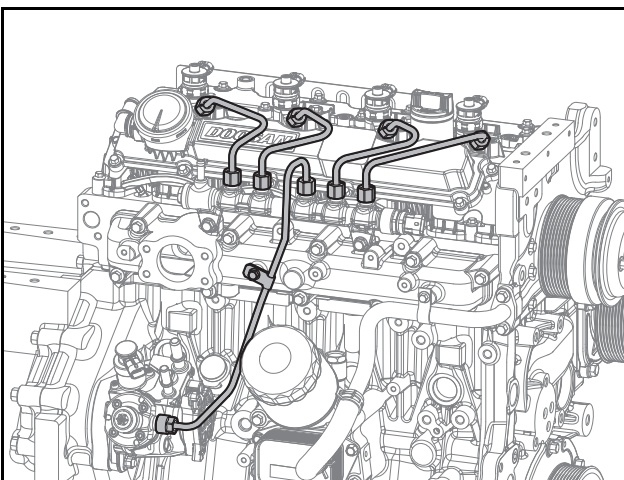
EDM03190245

- 1) Align the rubber packing with the right cylinder head cover groove and assemble the right cylinder head cover.
- 2) Temporarily mount the flange hex bolts from inside to outside in the direction of the arrow.
- 3) Tighten the flange hex bolts from inside to outside in the direction of the arrow at a tightening torque of  $0.8 \pm 0.05$  kgf·m.

### **⚠ CAUTION**

- When performing maintenance, do not reuse head cover rubber seals; replace them with new ones.
- Before assembly, completely remove any foreign matter from inside the quick connector and the RH cover nipple.

7. Assemble fuel injection pipe.



EDM03190240

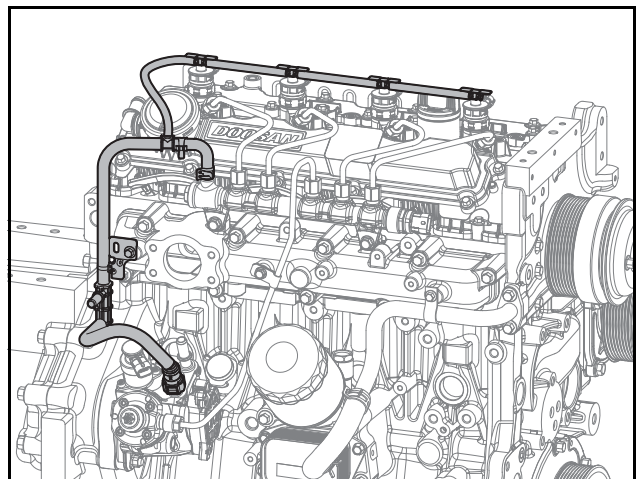
- 1) Loosen the hex bolts on the common rail and temporarily tighten them.
- 2) Temporarily tighten all of the nuts on the fuel injection pipes.

- 3) Tighten the hex bolts on the common rail to a tightening torque of 2.2 kgf·m.
- 4) Tighten the fuel injection pipe nuts to a tightening torque of 3.0 kgf·m.
- 5) Tighten the flange hex bolts assembled with the pipe clips to a tightening torque of 0.8 kgf·m.

### **⚠ CAUTION**

- Do not bend the fuel injection pipe by force.
- Pay attention to the assembled direction of the fuel injection pipe.
- Assemble the nuts on one side of the fuel injection pipe, then assemble the other side and make sure that the round part of the pipe and the part in contact with it are in their proper positions.
- Replace the fuel injection pipe and pipe clip with new ones; do not reuse them. Otherwise it may severely deteriorate the engine performance.

8. Assemble the fuel return hose.



EDM03190241

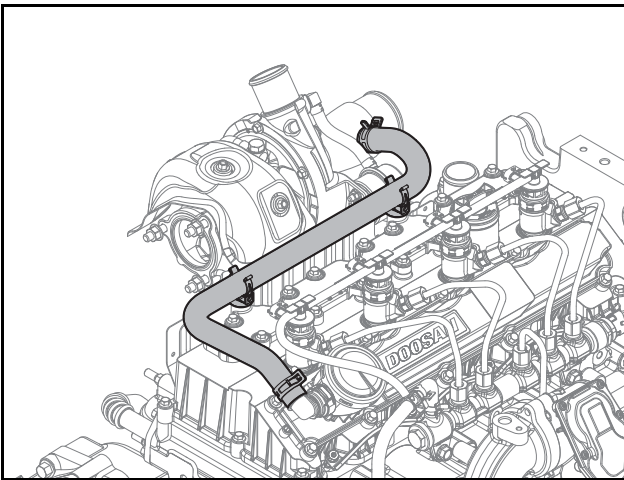
## 10. Cylinder Block/Head

- 1) Assemble the fuel return hose.

### CAUTION

- Pay attention to the assembled direction of the fuel return hose.
- Assemble the injectors and fuel return hoses so that they interlock sufficiently.
- Do not reuse fuel return hoses; replace them with new ones. Failure to do so may cause serious faults in the engine performance.
- Be careful to avoid damage for fuel return hose of injector.
- Don't press on the fuel hose, don't drop heavy tool like as spanner on engine, don't step on fuel hose, don't stand on engine.
- If the fuel hose are broken by wrong handling, it is possible fire.

- 2) Press on the clamps to attach the common rail, injectors, and fuel return hoses on the fuel injection pump.
9. Assemble the breather hose.



EDM03190234

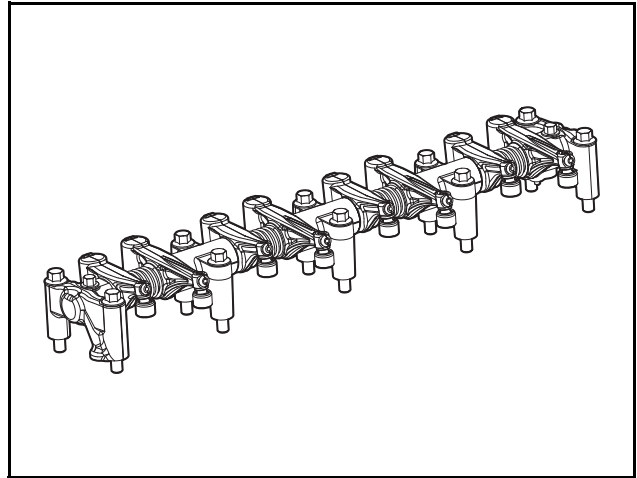
- 1) Assemble the breather hose with the hose clips.
- 2) Press on the clamps on the quick connector and T/C air inlet pipe, then connect the breather hose.

### CAUTION

- Do not reuse clamps more than three times; replace them with new ones.
- Do not apply oil to hoses, clamps, etc.

## Checking the Rocker Arms

1. Remove the rocker arms.



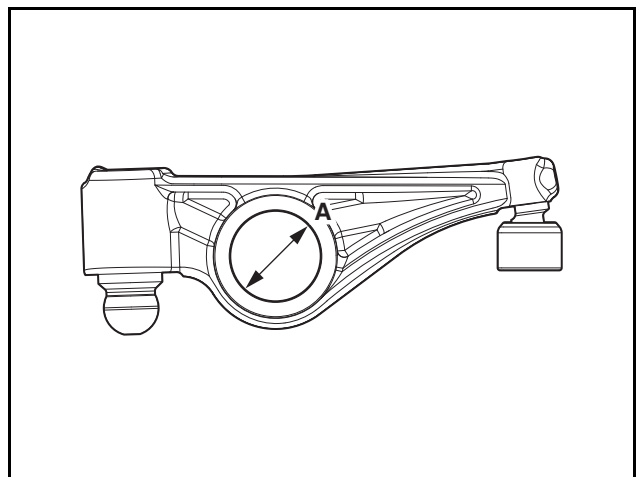
EDM03190038

- 1) Remove the mounting bolt on the rocker arm bracket.
- 2) Remove the rocker arm bracket, rocker arm shaft spring and rocker arm in order.
2. Visually inspect the exterior of the rocker arms.
  - 1) Visually check for any scratches and layered wear on the surface of the adjustment screw cap assembly which slides in contact with the valve stem.

Note: For minor wear, use an oily grindstone or fine sandpaper to polish the surface. For severe layered wear, replace the rocker arms.

Note: To polish the rocker arms, use sandpaper soaked in oil.

3. Measure the inside diameter of the rocker arms.



EDM03190039

- 1) Use a micrometer or vernier calipers to measure the inside diameter of the rocker arms.

Note: Compare the measured value to the outside diameter of the rocker arm shaft. If the gap is excessive, replace whichever part is more worn.

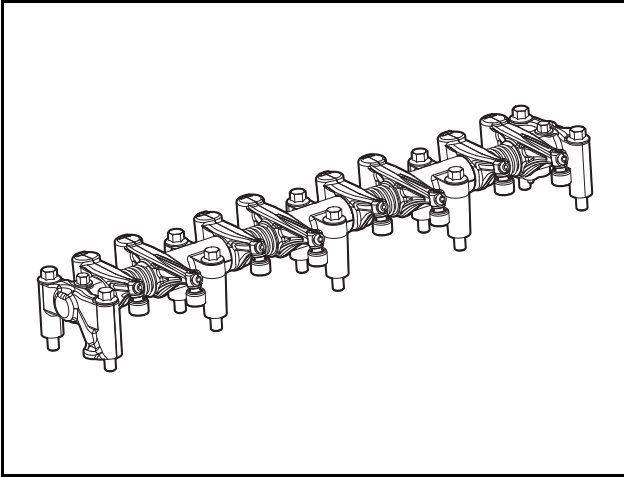


## 10. Cylinder Block/Head

Item	Specified value
Inside diameter of rocker arms	$\varnothing 20 \pm 0.03$ / $\varnothing 20 -0.015$ mm

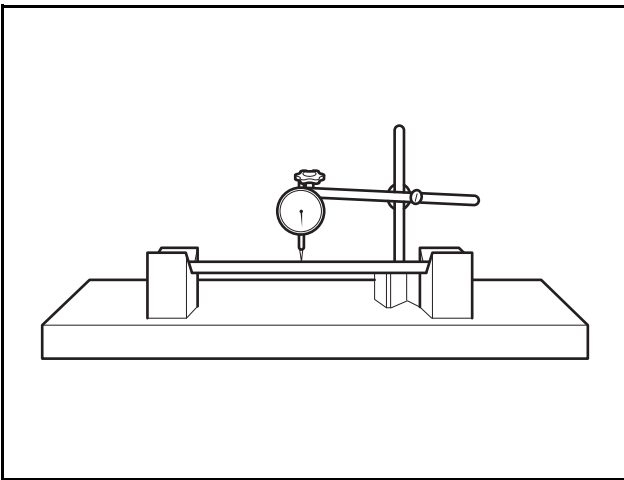
### Checking the Rocker Arm Shaft

1. Remove the rocker arm shaft.



EDM03190038

- 1) Remove the mounting bolt on the rocker arm bracket.
- 2) Remove the rocker arm bracket, rocker arm shaft spring, rocker arm and rocker arm shaft in order.
2. Check the deflection of the rocker arm shaft.



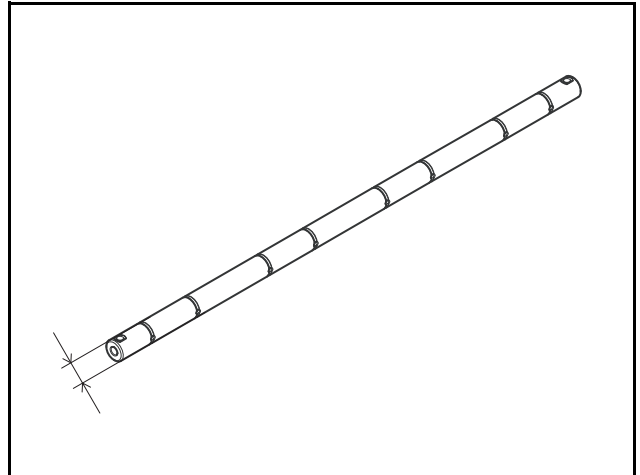
EDL022101A

- 1) Place the rocker arm shaft on two V-blocks.
- 2) Install the dial gauge.
- 3) Rotate the rocker arm shaft and check the deflection of the rocker arm shaft.

Note: If the deflection is minor, correct it by pressing the shaft with a press. If the deflection is over the allowable limit, replace the shaft with a new one.

Item	Specified value
Rocker arm shaft deflection	0.05 mm / 0.01 mm (L=25)

3. Check the outside diameter of the rocker arm shaft.



EDL032102A

- 1) Use an outside diameter micrometer to measure the outside diameter of the rocker arm shaft at the place where the rocker arms are assembled.

Note: If it exceeds the allowable limit, replace it with a new one.

Item	Specified value
Outside diameter of rocker arm shaft	20 ~ 20 -0.015 mm

# 10. Cylinder Block/Head

## Tappet and Push rod

### Removing the Valve Tappet

1. Remove the valve tappet.

Note: Refer to the order of engine disassembly.

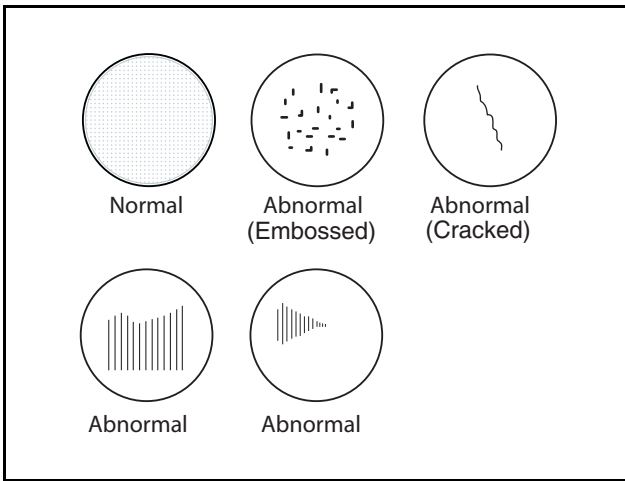
### Assembling the Valve Tappet

1. Assemble the valve tappet.

Note: Refer to the order of engine assembly.

### Checking the Valve Tappet

1. Perform a visual inspection of the exterior of the valve tappet.



EDL022104C

- 1) Check the surface of the valve tappet, which slides in contact with the camshaft, for cracks, scratches and other damage.

Note: For minor wear, use an oily grindstone or fine sandpaper to correct the wear. For severe wear, replace the part.

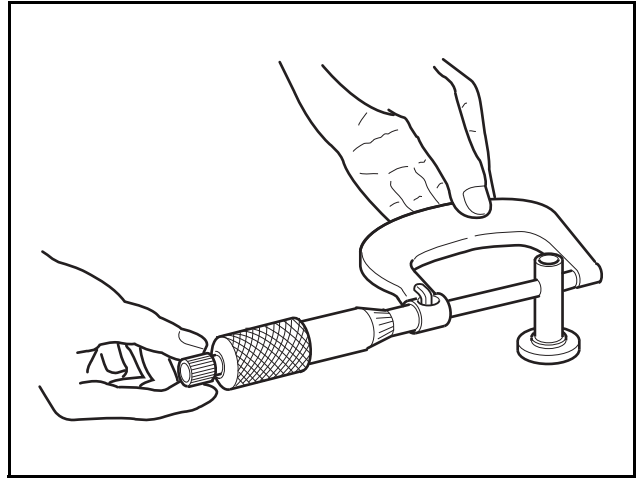
Note: To polish the camshaft, use sandpaper soaked in oil.

2. Measure the valve tappet clearance.

- 1) Measure the outside diameter of the valve tappet and the inside diameter of the cylinder block tappet hole.

Note: If it exceeds the allowable limit, replace the valve tappet.

3. Measure the outside diameter of the valve tappet.



EDL022105A

- 1) Use an O.D. micrometer to measure the outside diameter of the valve tappet.

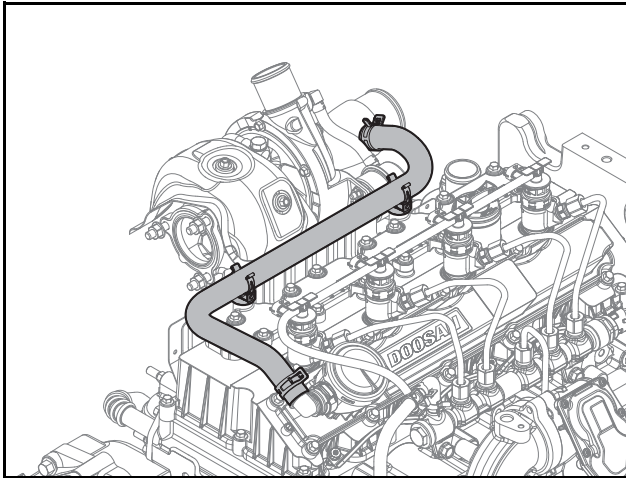
Note: If it exceeds the allowable limit, replace the valve tappet.

Item	Specified value
Outside diameter of valve tappet	Ø14.2 mm

## 10. Cylinder Block/Head

### Disassembling the Push rod

1. Remove the breather hose.

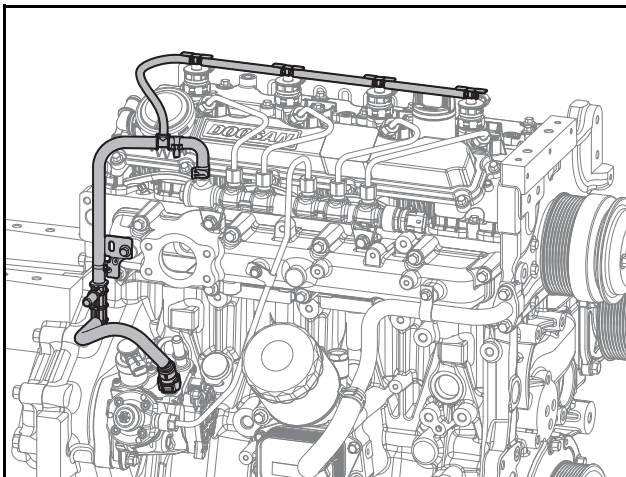


EDM03190234

- 1) Press on the clamps on the quick connector and T/C air inlet pipe assembly, then disconnect the breather hose.

Note: There is no need to disconnect the hose on the quick connector.

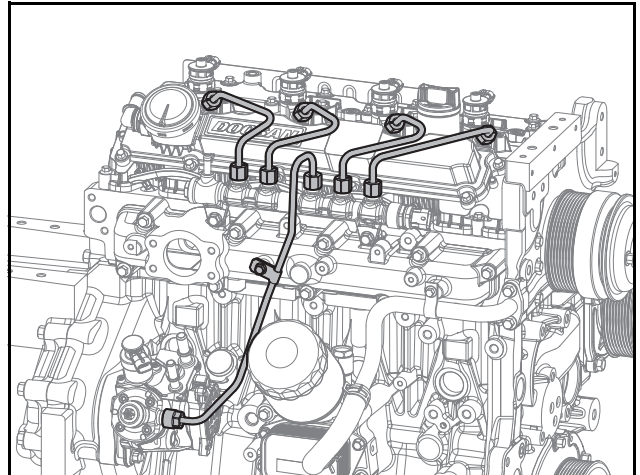
2. Disconnect the fuel return hose.



EDM03190241

- 1) Press on the clamps to remove the common rail, injectors, and fuel return hose on the fuel injection pump.
- 2) Disconnect the fuel return hose.

3. Remove the fuel injection pipe.



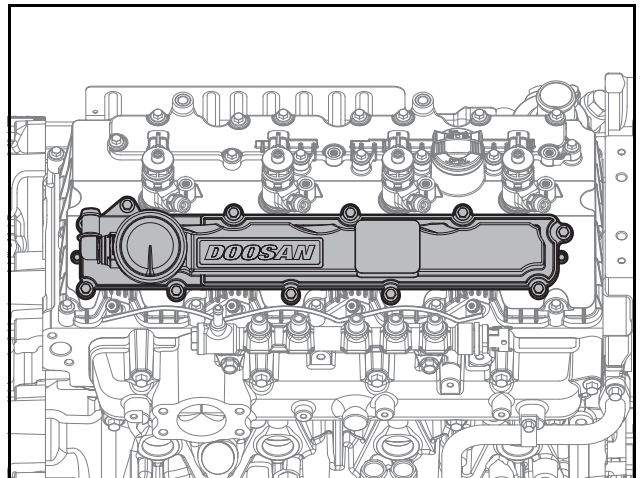
EDM03190240

- 1) Loosen the flange hex bolt.
- 2) Loosen the nuts on both ends of the fuel injection pipes and remove the fuel injection pipes.

### CAUTION

**Do not bend the fuel injection pipe by force.**

4. Remove the right cylinder head cover.

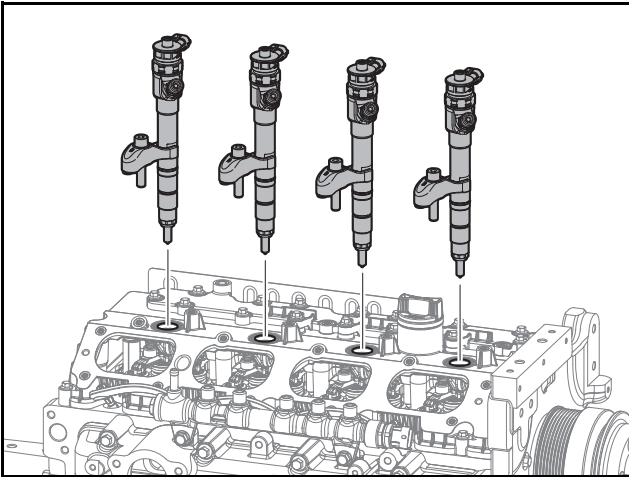


EDM03190245

- 1) Loosen the flange hex bolts from outside to inside in the direction of the arrow.
- 2) Remove the right cylinder head cover.

## 10. Cylinder Block/Head

5. Remove the injector.



EDM03190247

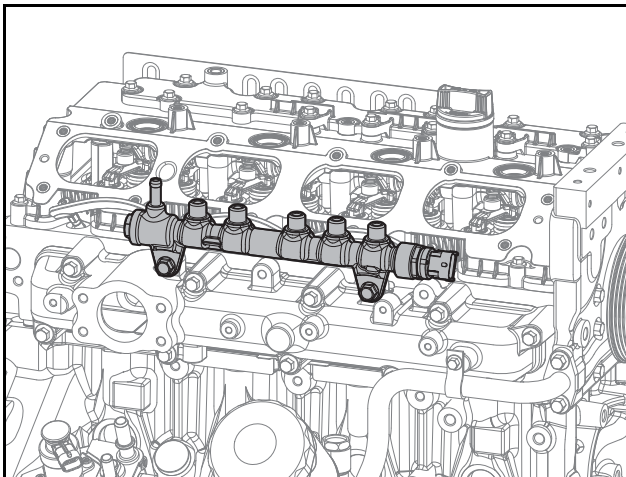
- 1) Loosen the hex bolts.
- 2) Remove the injector mounting brackets.
- 3) Remove the injectors.
- 4) Remove the injector sealing washer.

Note: Remove the cylinder head cover and remove the injector sealing washer.

### CAUTION

- Be careful not to damage the injectors during disassembly.
- When removing injectors, be sure to remove them together with the washers so as not to lose them.

6. Remove the common rail.



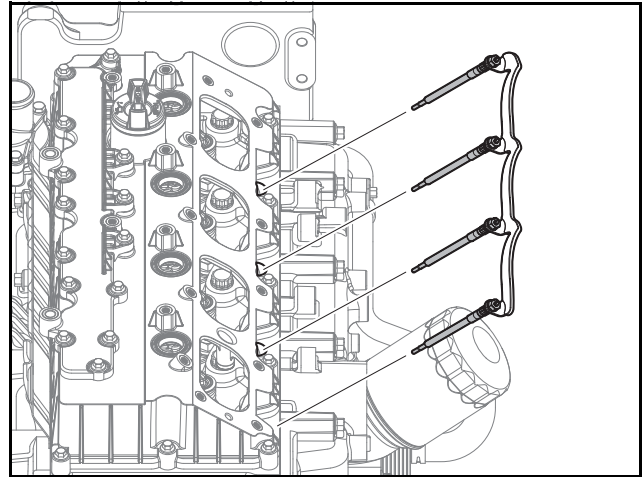
EDM03190246

- 1) Loosen the hex bolts.
- 2) Remove the common rail from the intake manifold.

### CAUTION

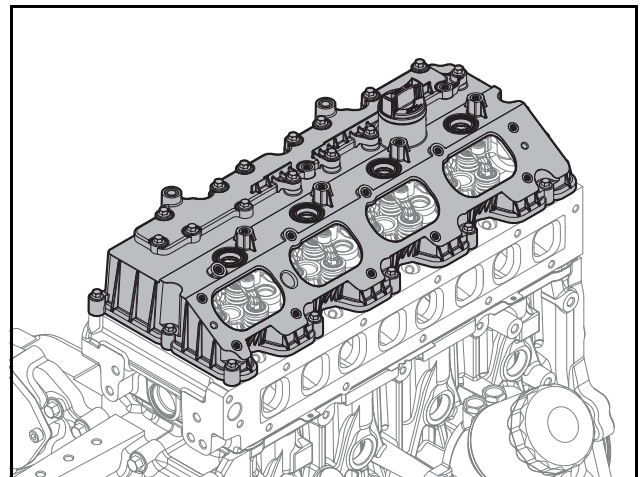
Be careful not to damage the common rail during disassembly.

7. Disconnect the glow plugs.



EDM03190248

- 1) Loosen 4 hex nuts.
- 2) Remove the electric connector.
- 3) Disconnect 4 glow plugs.
8. Remove the cylinder head cover.



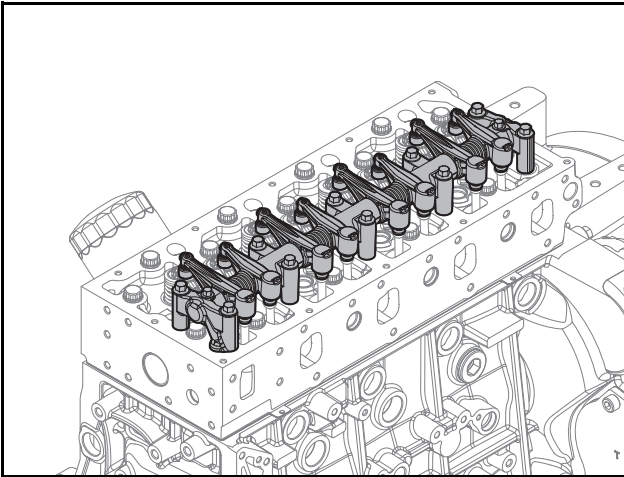
EDM03190169

- 1) Loosen the hex bolts from outside to inside in the direction of the arrow.
- 2) Remove the cylinder head cover.



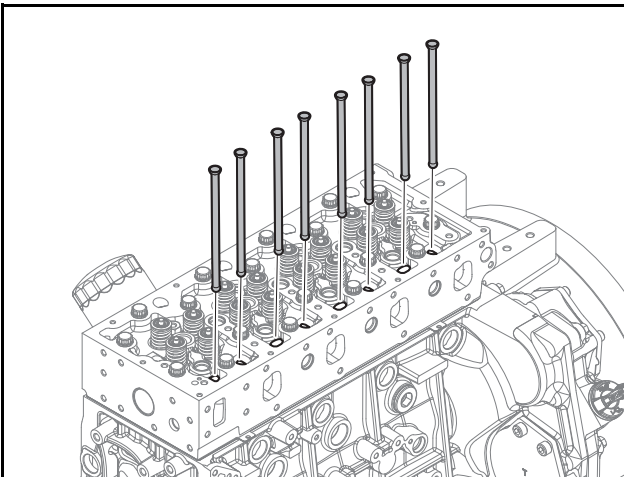
## 10. Cylinder Block/Head

9. Remove the rocker arms.



EDM03190168

- 1) Loosen the flange hex bolt.
  - 2) Remove the rocker arms.
10. Disconnect the push rods.

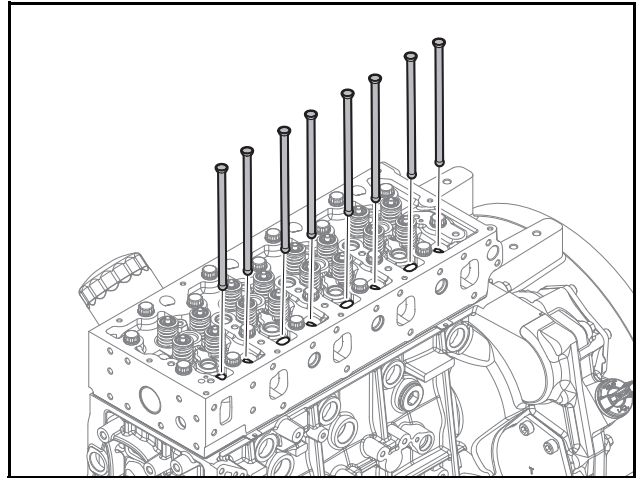


EDM03190167

- 1) Remove the push rods from the holes in the cylinder head.

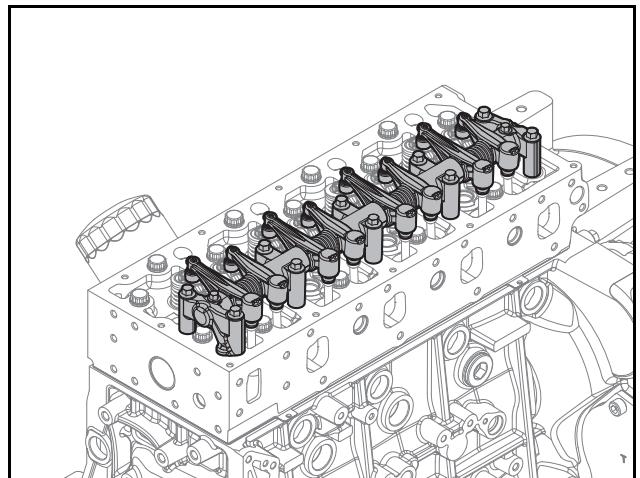
### Assembling the Push rod

1. Assemble the push rods.



EDM03190167

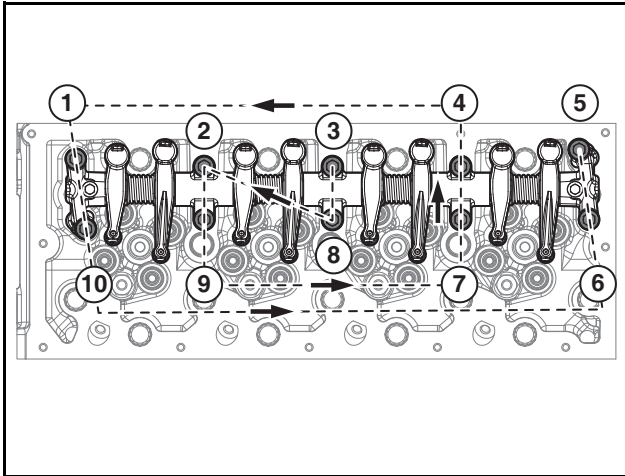
- 1) Apply engine oil to both ends of the push rods.
  - 2) Assemble the push rods with the holes in the cylinder head.
  - 3) Use a rubber hammer to lightly tap the head of the push rods one to two times and position them properly in the tappet holes.
2. Assemble the rocker arms.



EDM03190168

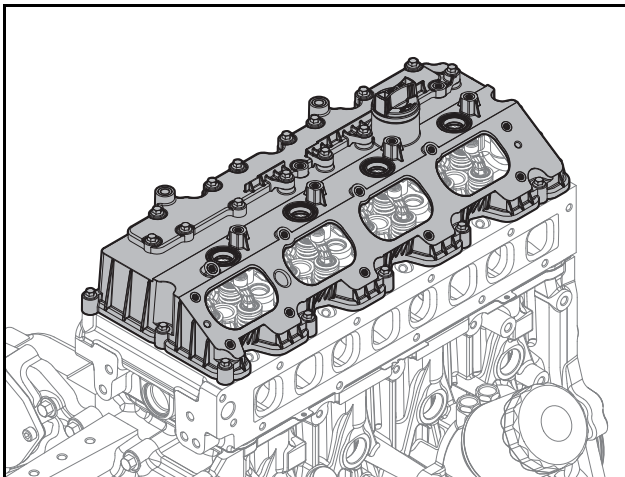
- 1) Assemble the rocker arms.
- 2) Pre-assemble for positioning the bolts and locating pin with hands.
- 3) Apply torque as follow below sequence.
  - Tightening torque:  $2.2 \pm 0.22$  kgf-m.
  - 3 → 8 → 2 → 9 → 7 → 4 → 1 → 10 → 6 → 5
- 4) Apply check torque as follow below sequence again.
  - Tightening torque:  $2.2 \pm 0.22$  kgf-m.
  - 3 → 8 → 2 → 9 → 7 → 4 → 1 → 10 → 6 → 5

## 10. Cylinder Block/Head



EDM03210161

3. Assemble the cylinder head cover.



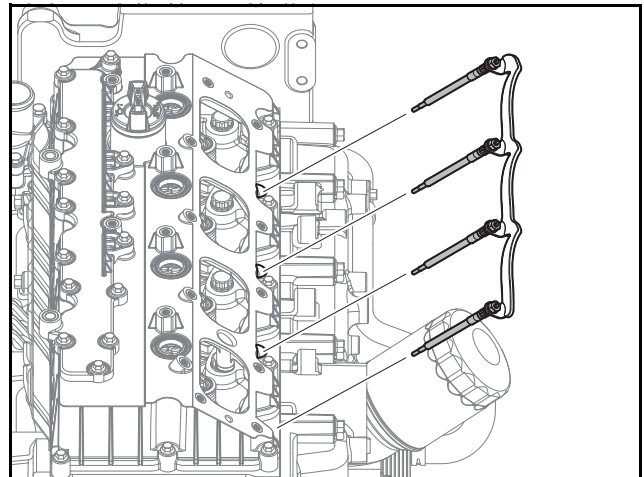
EDM03190169

- 1) Align the rubber packing with the cylinder head cover groove and assemble the cylinder head cover.
- 2) Temporarily mount the hex bolts from inside to outside in the direction of the arrow.
- 3) Tighten the hex bolts from inside to outside in the direction of the arrow at a tightening torque of  $0.8 \pm 0.05$  kgf·m.

### CAUTION

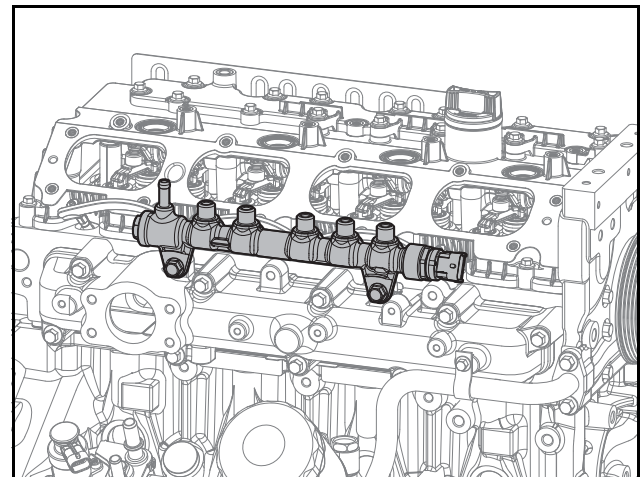
- When performing maintenance, do not reuse the head cover rubber seals and injector oil seals; replace them with new ones.
- When replacing oil seals, use an inserter to press fit them completely.

4. Connect the glow plugs.



EDM03190248

- 1) Tightening 4 glow plugs to the cylinder head at a tightening torque of  $9 \sim 12$  N·m.
- 2) Attach the electric connector.
- 3) Mount 4 washers.
- 4) Tighten 4 hex nuts at a tightening torque of  $1.3 \sim 2$  N·m.
5. Assemble the common rail.



EDM03190246

- 1) Assemble the common rail with the intake manifold.

### CAUTION

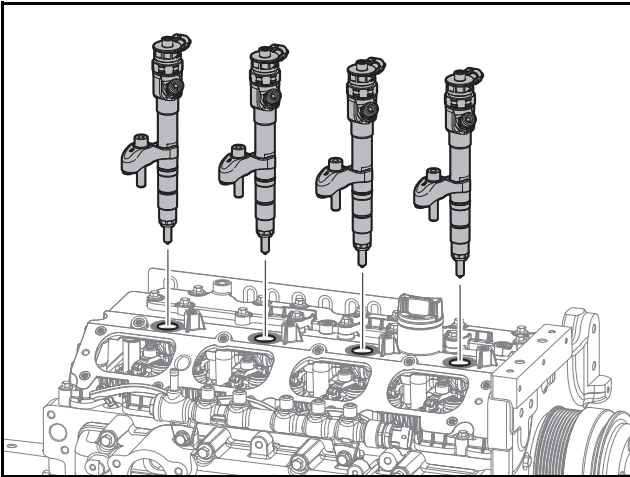
- Pay attention to the assembled direction of the common rail.
- Be careful not to damage the common rail during assembly.
- Be careful not to allow any foreign matter to enter the common rail fuel inlet and outlet holes.

- 2) Temporarily assemble the hex bolts by hand.
- 3) Tighten the hex bolts to a tightening torque of  $2.2$  kgf·m.



## 10. Cylinder Block/Head

### 6. Assemble the injector.



EDM03190247

- 1) Align the injector sealing washers with the center of the injector hole and mount them.
- 2) Apply sufficient oil to the contact surface of the injector on the cylinder head cover.
- 3) Assemble the injectors.

### **⚠ CAUTION**

- Slowly turn the injector while assembling it to avoid damaging the injector oil seal on the cylinder head cover.
- Do not reuse injector sealing washers. Otherwise serious faults may occur in the engine due to unstable combustion.

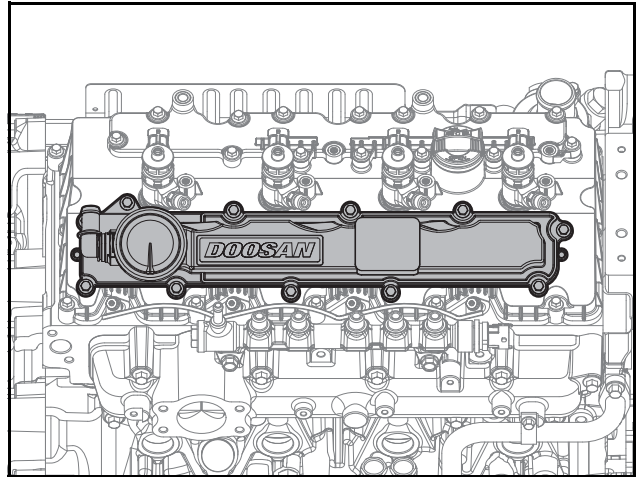
- 4) Assemble the injector mounting brackets.
- 5) Temporarily tighten the hex bolts to a tightening torque of 0.3 kgf·m.

### **⚠ CAUTION**

If the hex bolts cannot be tightened while temporarily tightening them, do not tighten them by force. Tightening them by force may damage the cylinder head.

- 6) Tighten the hex bolts to a tightening torque of  $4.35 \pm 0.35$  kgf·m.

### 7. Assemble the right cylinder head cover.



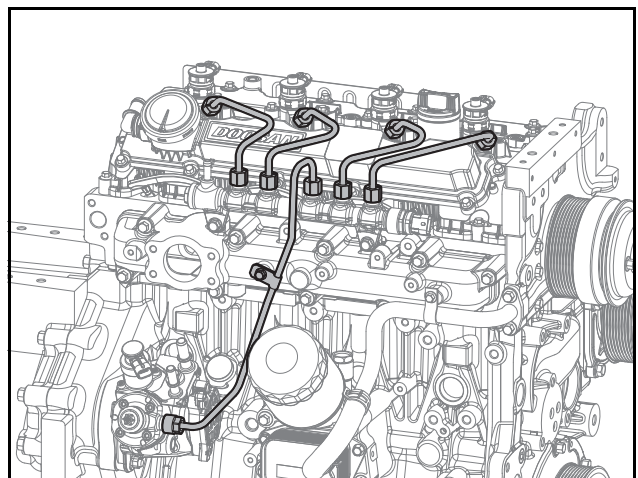
EDM03190245

- 1) Align the rubber packing with the right cylinder head cover groove and assemble the right cylinder head cover.
- 2) Temporarily mount the flange hex bolts from inside to outside in the direction of the arrow.
- 3) Tighten the flange hex bolts from inside to outside in the direction of the arrow at a tightening torque of  $0.8 \pm 0.05$  kgf·m.

### **⚠ CAUTION**

- When performing maintenance, do not reuse head cover rubber seals; replace them with new ones.
- Before assembly, completely remove any foreign matter from inside the quick connector and the RH cover nipple.

### 8. Assemble fuel injection pipe.



EDM03190240

- 1) Loosen the hex bolts on the common rail and temporarily tighten them.
- 2) Temporarily tighten all of the nuts on the fuel injection pipes.

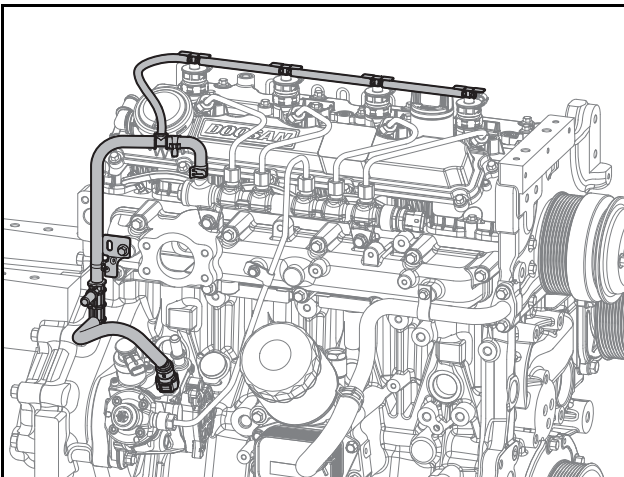
## 10. Cylinder Block/Head

- 3) Tighten the hex bolts on the common rail to a tightening torque of 2.2 kgf-m.
- 4) Tighten the fuel injection pipe nuts to a tightening torque of 3.0 kgf-m.
- 5) Tighten the flange hex bolts assembled with the pipe clips to a tightening torque of 0.8 kgf-m.

### CAUTION

- Do not bend the fuel injection pipe by force.
- Pay attention to the assembled direction of the fuel injection pipe.
- Assemble the nuts on one side of the fuel injection pipe, then assemble the other side and make sure that the round part of the pipe and the part in contact with it are in their proper positions.
- Replace the fuel injection pipe and pipe clip with new ones; do not reuse them. Otherwise it may severely deteriorate the engine performance.

9. Assemble the fuel return hose.



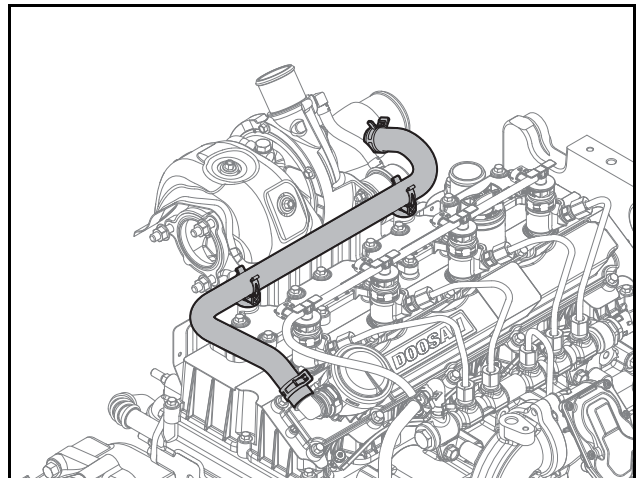
EDM03190241

- 1) Assemble the fuel return hose.

### CAUTION

- Pay attention to the assembled direction of the fuel return hose.
- Assemble the injectors and fuel return hoses so that they interlock sufficiently.
- Do not reuse fuel return hoses; replace them with new ones. Failure to do so may cause serious faults in the engine performance.
- Be careful to avoid damage for fuel return hose of injector.
- Don't press on the fuel hose, don't drop heavy tool like as spanner on engine, don't step on fuel hose, don't stand on engine.
- If the fuel hose are broken by wrong handling, it is possible fire.

- 2) Press on the clamps to attach the common rail, injectors, and fuel return hoses on the fuel injection pump.
10. Assemble the breather hose.



EDM03190234

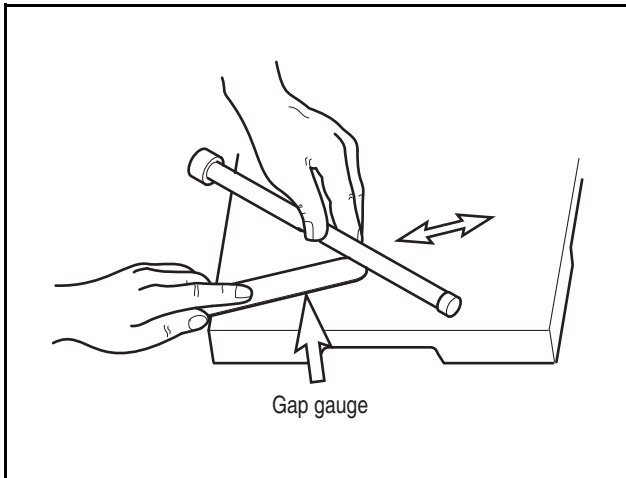
- 1) Assemble the breather hose with the hose clips.
- 2) Press on the clamps on the quick connector and T/C air inlet pipe, then connect the breather hose.

### CAUTION

- Do not reuse clamps more than three times; replace them with new ones.
- Do not apply oil to hoses, clamps, etc.

### Checking the Deflection of the Push rod

1. Check the deflection of the push rod.



EDL022106A

- 1) Place the push rod on a surface plate.
- 2) Roll the push rod and check the amount of deflection using a feeler gauge.

Item	Specified value
Push rod deflection	0.5 mm

# 10. Cylinder Block/Head

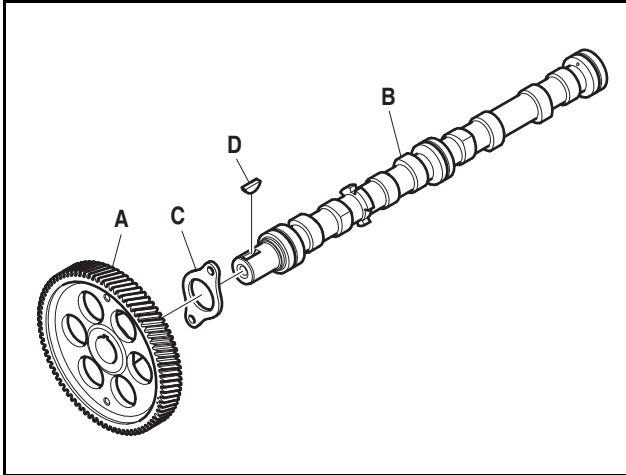
## Camshaft

### Removing the Camshaft

1. Remove the camshaft.

Note: Refer to the order of engine disassembly.

2. Remove the camshaft gear (A).



EDL032107A

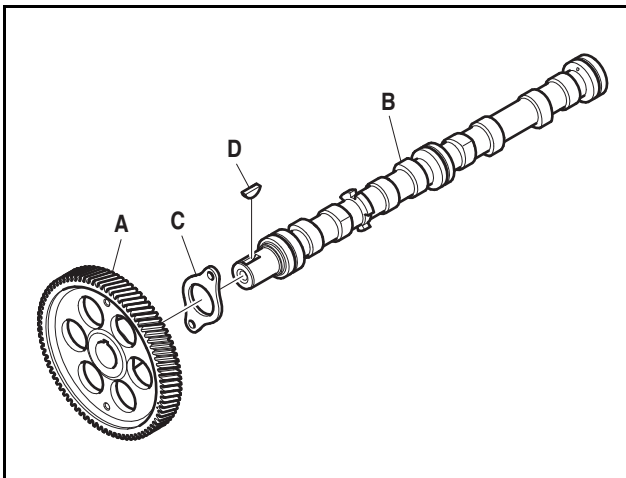
- 1) Heat the camshaft gear (A) to  $180^{\circ}\text{C} \pm 10^{\circ}\text{C}$ .
- 2) Remove the camshaft gear (A) and the thrust washer (C) from the camshaft (B).

### CAUTION

- Maintain the heated temperature of the camshaft gear at over  $160^{\circ}\text{C}$  and never allow the temperature to exceed  $200^{\circ}\text{C}$ .

### Assembling the Camshaft

1. Assemble the cam gear (A).



EDL032107A

- 1) Heat the cam gear (A) to  $180^{\circ}\text{C} \pm 10^{\circ}\text{C}$ .
- 2) Assemble the thrust washer (C) and parallel key (D) with the camshaft (B).

- 3) Heat fit the cam gear (A) into the parallel key groove.

### CAUTION

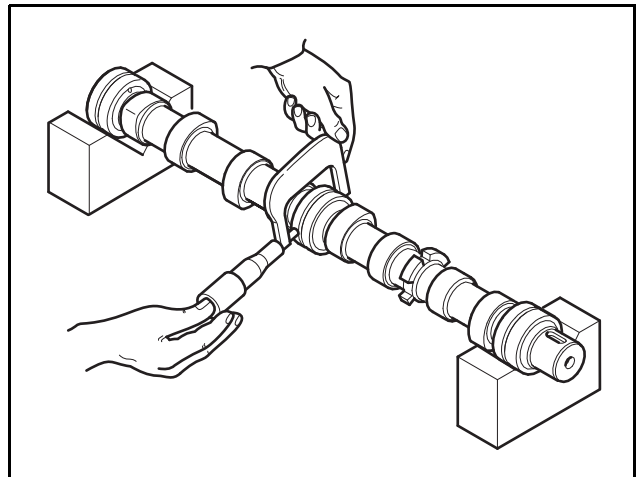
- Maintain the heated temperature of the camshaft gear at over  $160^{\circ}\text{C}$  and never allow the temperature to exceed  $200^{\circ}\text{C}$ .
- Assemble it so that the engraving on the gear faces outwards.

2. Assemble the camshaft.

Note: Refer to the order of engine assembly.

### Measuring the Camshaft Journal O.D.

1. Set up the gauge.
2. Remove any foreign matter from the camshaft.
3. Measure the outside diameter of the camshaft journal.



EDL022108B

- 1) Measure the outside diameter of the camshaft journal in a total of 6 places on the front and back of 3 camshaft journals.
- 2) Measure two vertical and horizontal points on the outside diameter of the camshaft journal.
- 3) The measured size of the outside diameter of the camshaft journal should be  $44.919 \sim 44.935 \text{ mm}$ .

Item	Specified value
Camshaft journal	$44.919 \sim 44.935 \text{ mm}$

Note: If the measurement is below the allowable limit, replace the camshaft.

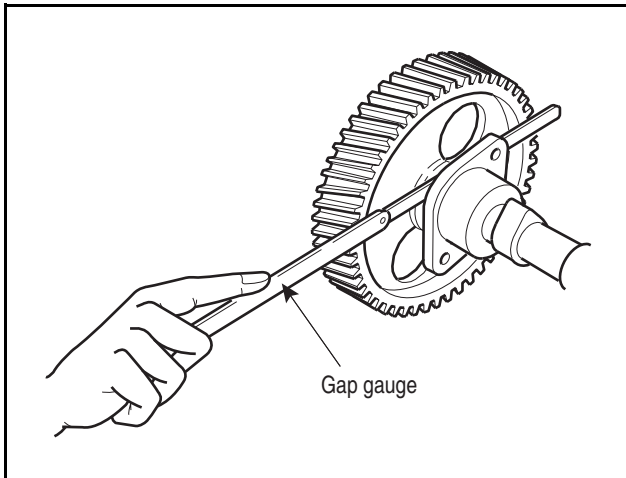
Note: Check the cam surface for scratches or damage.

Note: For minor layered wear or damage, use an oily grindstone or fine sandpaper to polish the surface. For severe damage, replace the cam.

Note: To polish the camshaft, use sandpaper soaked in oil.

### Measuring the Camshaft

1. Measure the free play of the camshaft.



EDL022109A

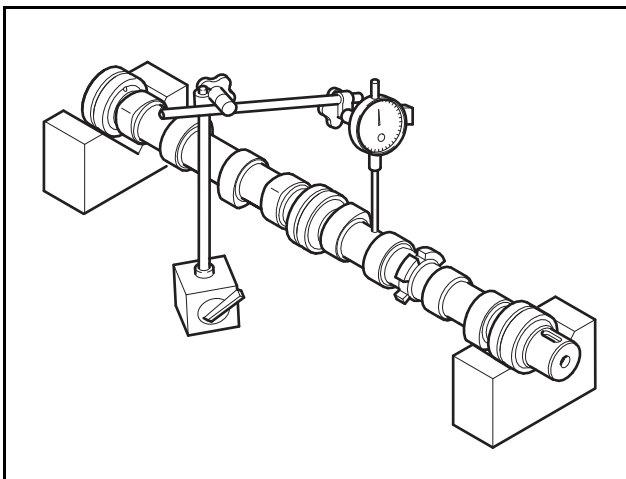
- 1) Move the camshaft gear to the opposite side of the cylinder block.
- 2) Use a feeler gauge to measure the clearance between the thrust washer and camshaft gear.

Item	Specified value
Camshaft free play	0.1 ~ 0.2 mm

Note: Check whether the gap is 0.1 ~ 0.2 mm.

Note: If the free play is excessive, replace the thrust washer.

2. Measure the deflection of the camshaft.



EDL022110A

- 1) Place the camshaft on two V-blocks.
- 2) Use a dial gauge to check the deflection of the camshaft.

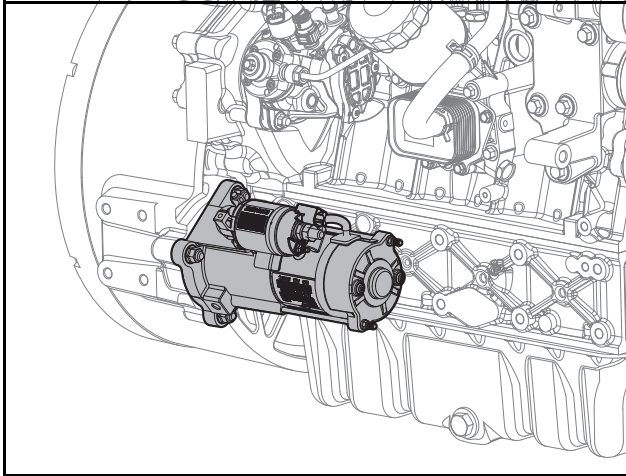
Note: If the deflection is excessive, replace the camshaft.

# 10. Cylinder Block/Head

## Flywheel Housing

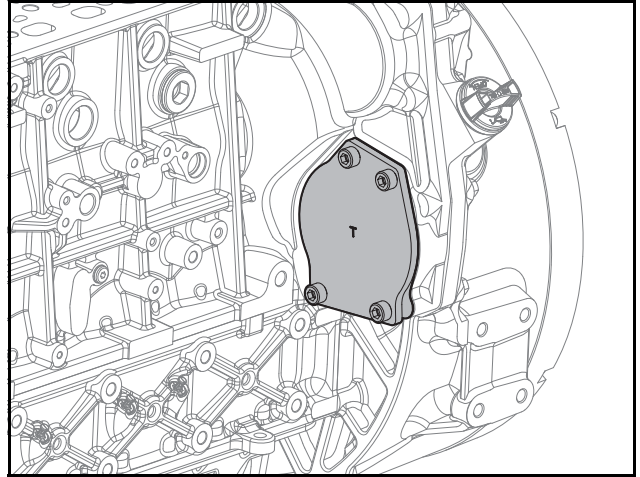
### Detaching the Flywheel Housing

1. Remove the starter motor.



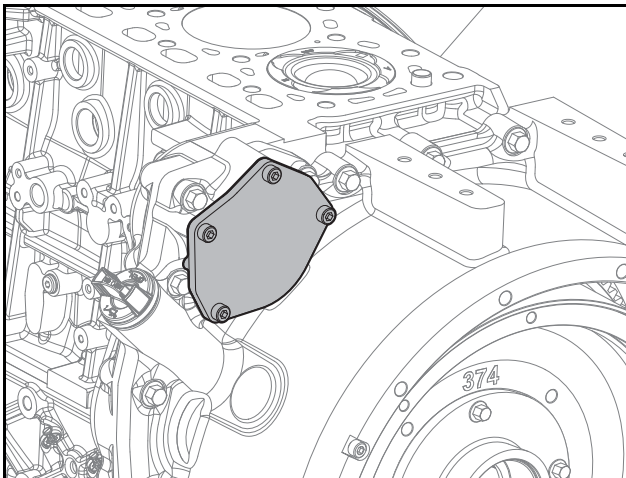
EDM03190242

- 1) Remove 4 inner socket bolts from the front PTO (Power Take Off) cover & gasket.
- 2) Remove the front PTO (Power Take Off) cover & gasket.

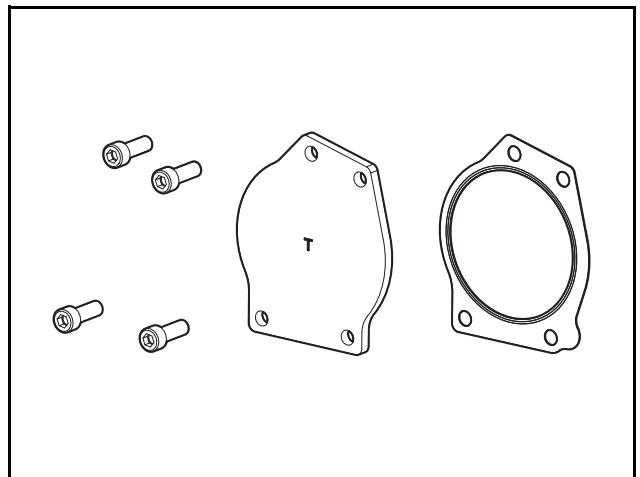


EDM03190256

- 1) Turn and loosen the flange nut.
- 2) Remove the starter motor.
2. Remove the front/rear PTO (Power Take Off) cover & gasket.

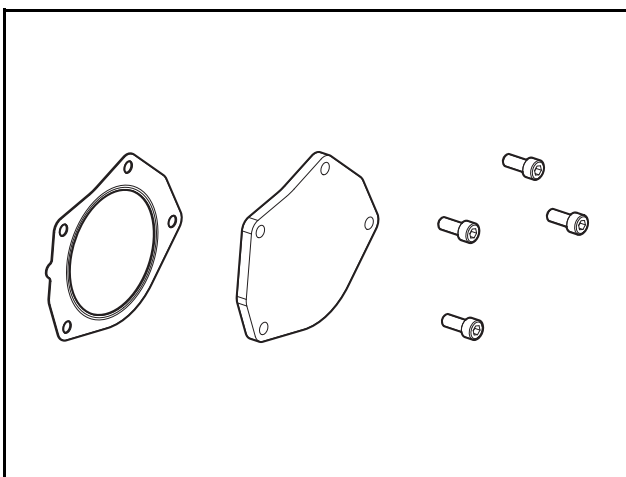


EDM03190257



EDM03190320

- 3) Remove 4 inner socket bolts from the rear PTO (Power Take Off) cover & gasket.
- 4) Remove the rear PTO (Power Take Off) cover & gasket.

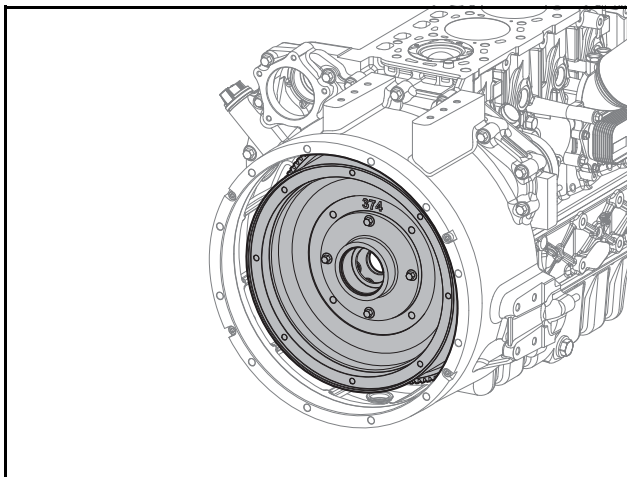


EDM03190319

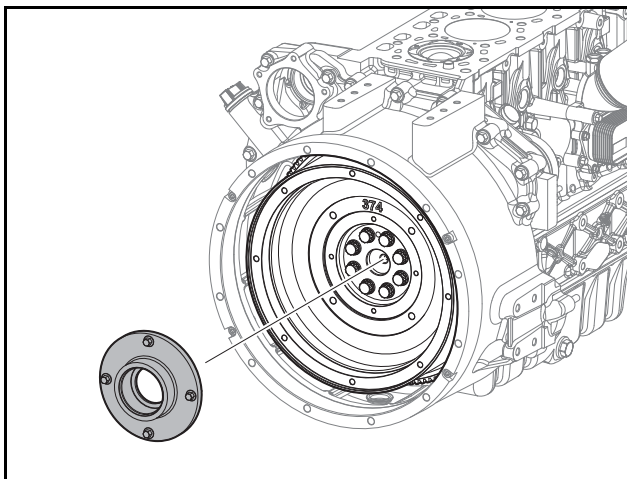


## 10. Cylinder Block/Head

3. Remove the flywheel.

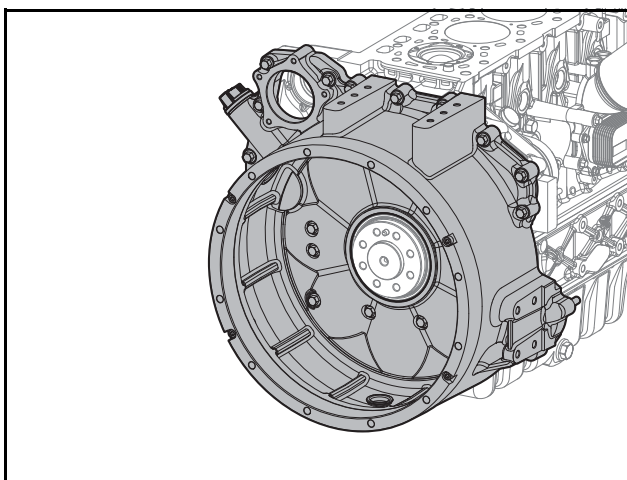


EDM03190259



EDM03190260

- 1) Loosen 8 flange hex bolts.
- 2) Remove the flywheel.
4. Remove the flywheel housing.

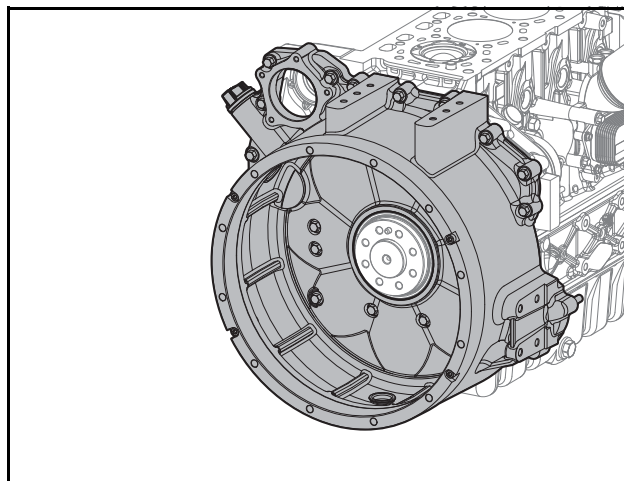


EDM03190258

- 1) Loosen the hex bolts.
- 2) Remove the flywheel housing.

### Assembling the Flywheel Housing

1. Assemble the flywheel housing.



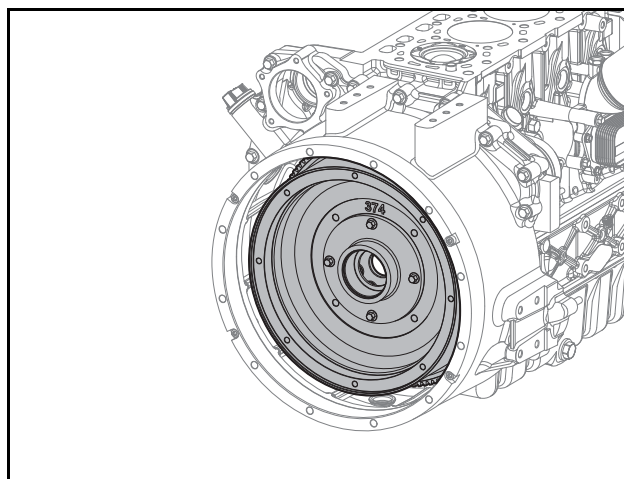
EDM03190258

- 1) Apply sealant to the assembly surface of the flywheel housing with a diameter of  $\text{Ø}2.5 \pm 0.5 \text{ mm}$ .

### CAUTION

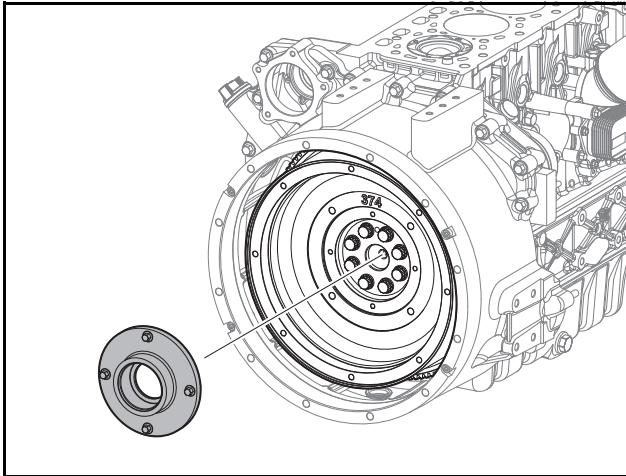
- Pay attention to the assembly direction of the flywheel housing.
- Assemble within 5 minutes of applying sealant (TB1217H).
- Do not start the engine or apply pressure within 25 minutes of applying sealant (TB1217H).

- 2) Assemble the flywheel housing.
- 3) Tighten the hex bolt to a tightening torque of 2.2 kgf·m.
2. Assemble the flywheel.



EDM03190259

# 10. Cylinder Block/Head



EDM03190260

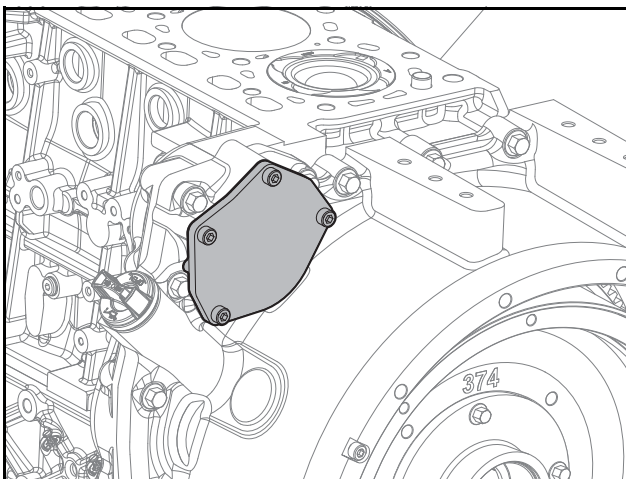
- 1) Assemble the flywheel.
- 2) Use the angle tightening method to tighten the flange hex bolts to a tightening torque.

Flywheel bolt (43 mm, option)	1st: $7 \pm 0.35 \text{ kgf}\cdot\text{m}$ /2nd: $45^\circ \pm 4^\circ$
Flywheel bolt (25 mm, option) for flat type flywheel	$17 \pm 0.85 \text{ kgf}\cdot\text{m}$

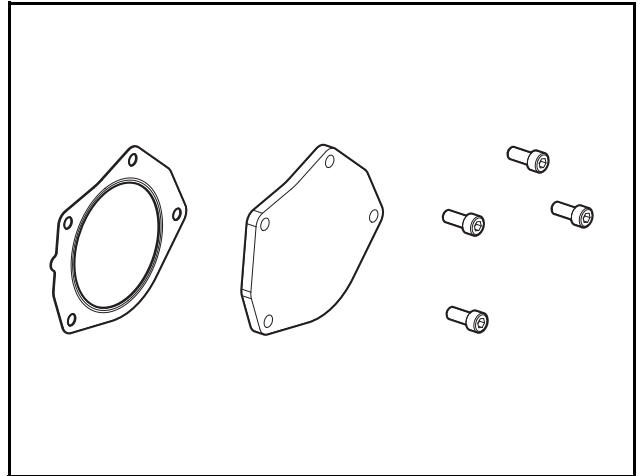
## CAUTION

**Do not reuse flange hex bolts when assembling the flywheel.**

3. Assemble the front/rear PTO (Power Take Off) cover & gasket.

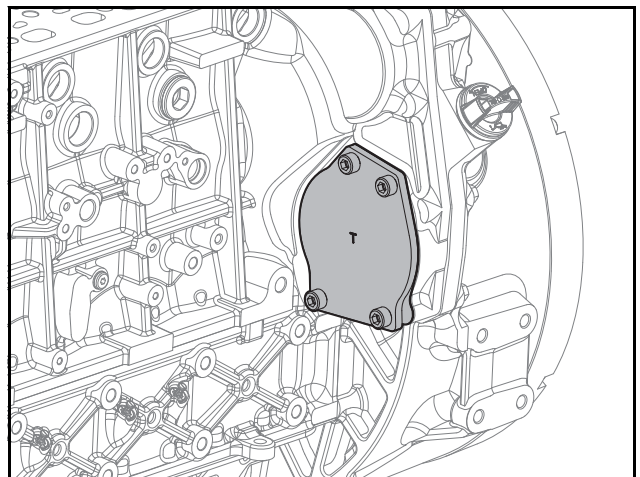


EDM03190257

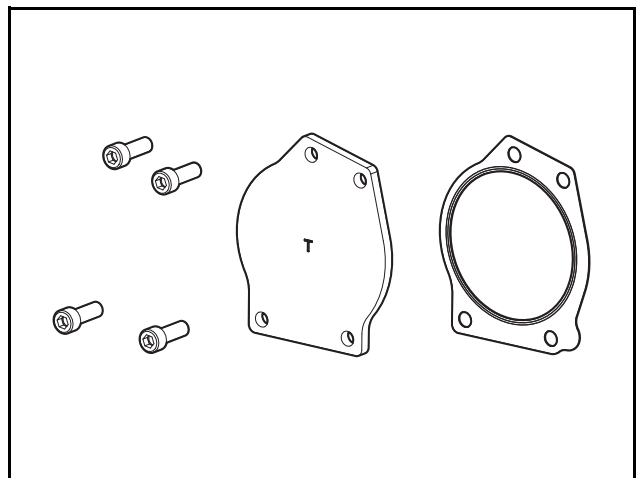


EDM03190319

- 1) Assemble the front PTO (Power Take Off) cover & gasket.
- 2) Tighten 4 inner socket bolts to a tightening torque of  $2.2 \pm 0.2 \text{ kgf}\cdot\text{m}$ .



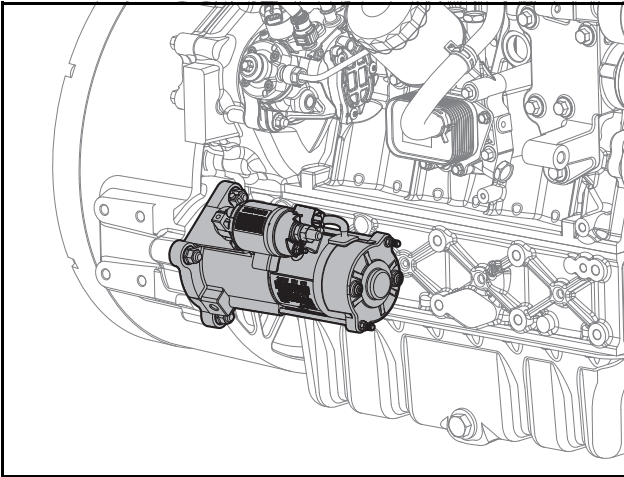
EDM03190256



EDM03190320

- 3) Assemble the rear PTO (Power Take Off) cover & gasket.
- 4) Tighten 4 inner socket bolts to a tightening torque of  $4.4 \pm 0.4 \text{ kgf}\cdot\text{m}$

### 4. Assemble the starter motor.



EDM03190242

- 1) Align the starter motor with the stud bolts and assemble it.
- 2) Tighten the flange nuts to a tightening torque of 4.4 kgf·m.

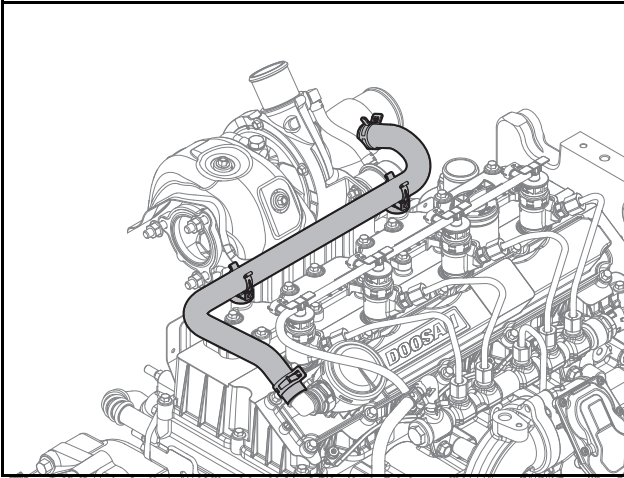
## 10. Cylinder Block/Head

---

### Breather

#### Disconnecting the Breather Hose

1. Remove the breather hose.



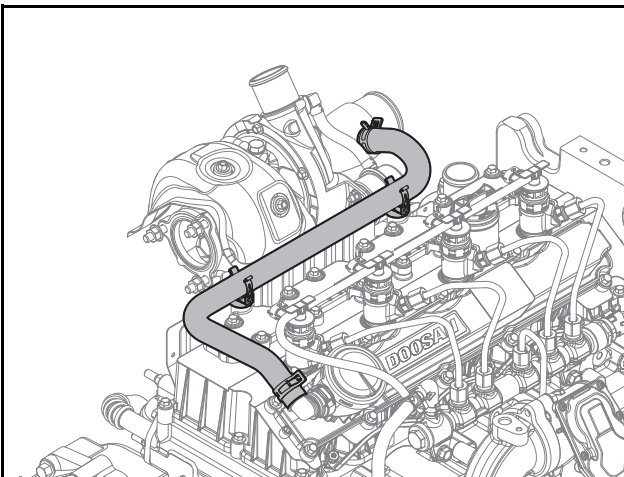
EDM03190234

- 1) Press on the clamps on the quick connector and T/C air inlet pipe assembly, then disconnect the breather hose.

Note: There is no need to disconnect the hose on the quick connector.

#### Assembling the Breather Hose

1. Assemble the breather hose.



EDM03190234

- 1) Assemble the breather hose with the hose clips.
- 2) Press on the clamps on the quick connector and T/C air inlet pipe, then connect the breather hose.

---

### CAUTION

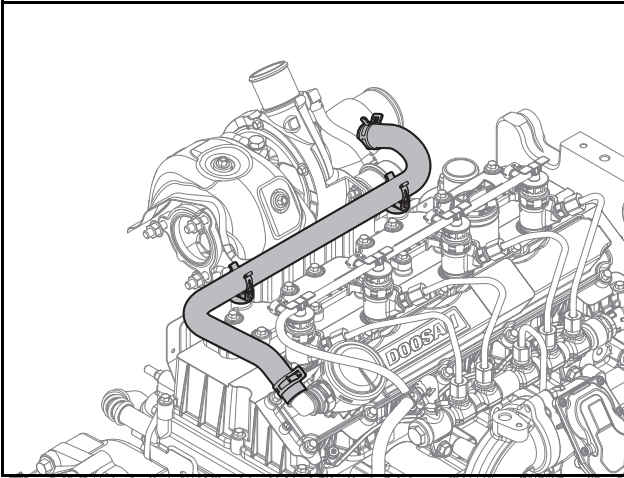
- Do not reuse clamps more than three times; replace them with new ones.
  - Do not apply oil to hoses, clamps, etc.
-



## Cylinder Head Cover

### Disassembling the Cylinder Head Cover

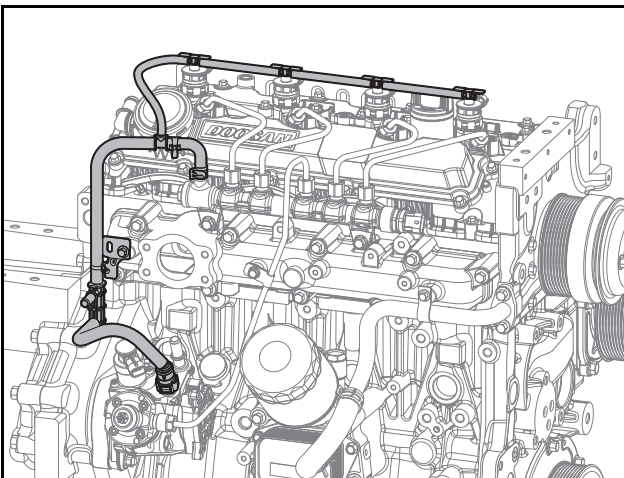
1. Remove the breather hose.



EDM03190234

- 1) Press on the clamps on the quick connector and T/C air inlet pipe assembly, then disconnect the breather hose.  
Note: There is no need to disconnect the hose on the quick connector.

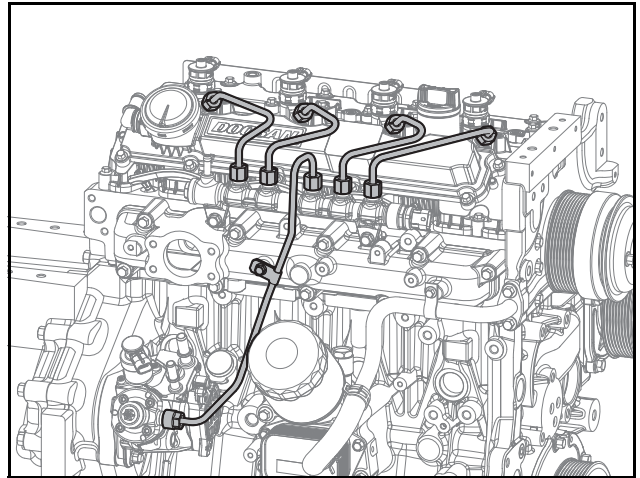
2. Disconnect the fuel return hose.



EDM03190241

- 1) Press on the clamps to remove the common rail, injectors, and fuel return hose on the fuel injection pump.
- 2) Disconnect the fuel return hose.

3. Remove the fuel injection pipe.



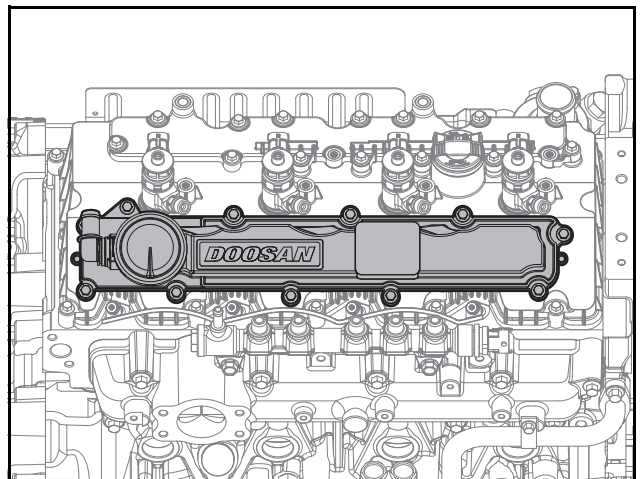
EDM03190240

- 1) Loosen the flange hex bolt.
- 2) Loosen the nuts on both ends of the fuel injection pipes and remove the fuel injection pipes.

### **⚠ CAUTION**

**Do not bend the fuel injection pipe by force.**

4. Remove the right cylinder head cover.

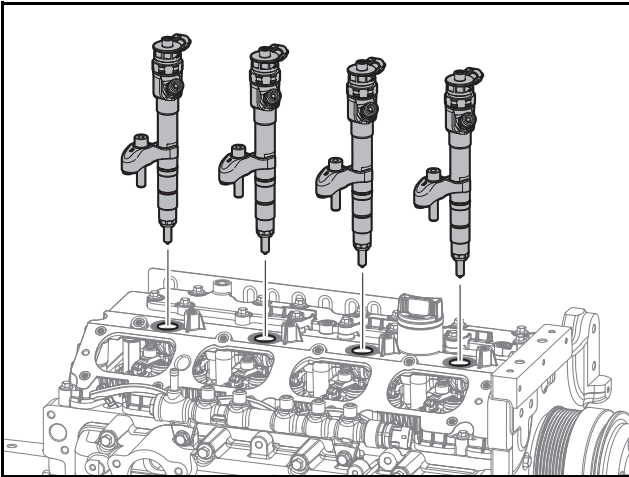


EDM03190245

- 1) Loosen the flange hex bolts from outside to inside in the direction of the arrow.
- 2) Remove the right cylinder head cover.

## 10. Cylinder Block/Head

5. Remove the injector.



EDM03190247

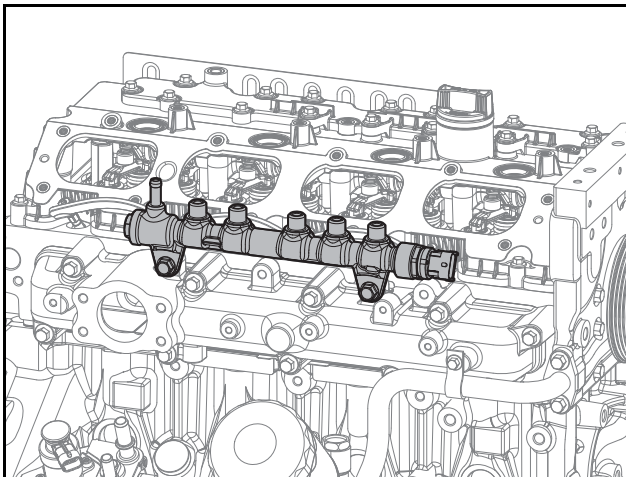
- 1) Loosen the hex bolts.
- 2) Remove the injector mounting brackets.
- 3) Remove the injectors.
- 4) Remove the injector sealing washer.

Note: Remove the cylinder head cover and remove the injector sealing washer.

### CAUTION

- Be careful not to damage the injectors during disassembly.
- When removing injectors, be sure to remove them together with the washers so as not to lose them.

6. Remove the common rail.



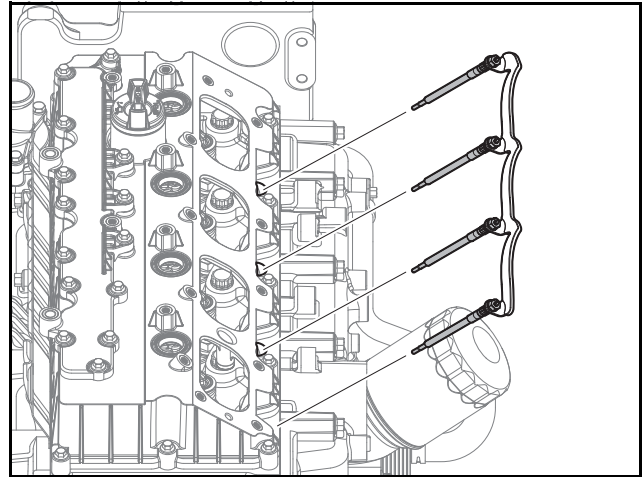
EDM03190246

- 1) Loosen the hex bolts.
- 2) Remove the common rail from the intake manifold.

### CAUTION

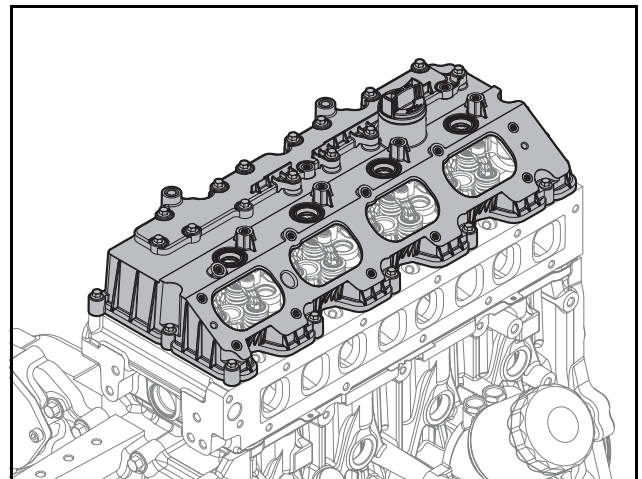
Be careful not to damage the common rail during disassembly.

7. Disconnect the glow plugs.



EDM03190248

- 1) Loosen 4 hex nuts.
- 2) Remove the electric connector.
- 3) Disconnect 4 glow plugs.
8. Remove the cylinder head cover.



EDM03190169

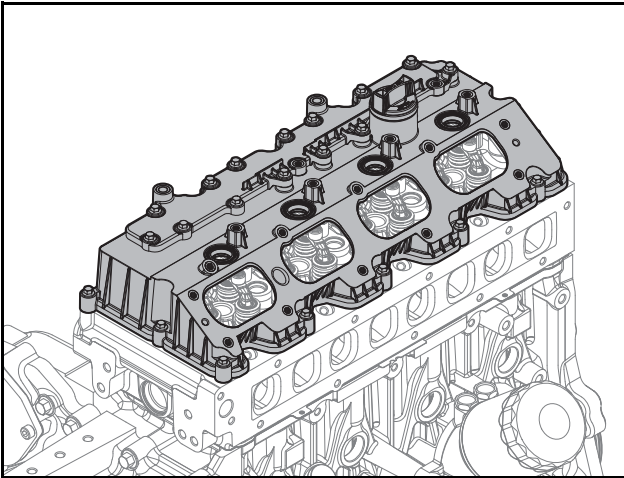
- 1) Loosen the hex bolts from outside to inside in the direction of the arrow.
- 2) Remove the cylinder head cover.



## 10. Cylinder Block/Head

### Assembling the Cylinder Head Cover

1. Assemble the cylinder head cover.



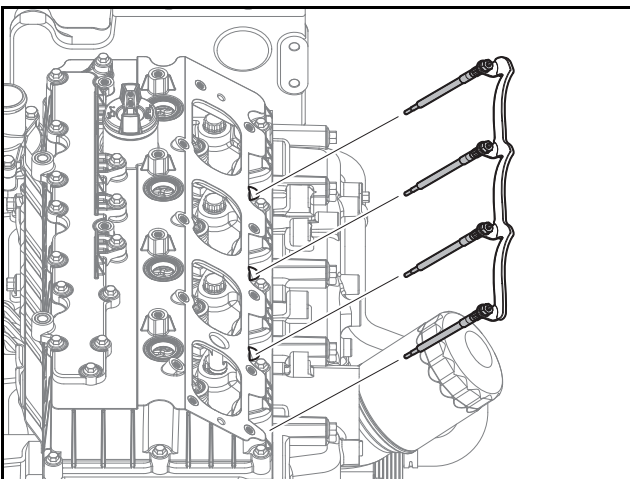
EDM03190169

- 1) Align the rubber packing with the cylinder head cover groove and assemble the cylinder head cover.
- 2) Temporarily mount the hex bolts from inside to outside in the direction of the arrow.
- 3) Tighten the hex bolts from inside to outside in the direction of the arrow at a tightening torque of  $0.8 \pm 0.05$  kgf·m.

### **CAUTION**

- When performing maintenance, do not reuse the head cover rubber seals and injector oil seals; replace them with new ones.
- When replacing oil seals, use an inserter to press fit them completely.

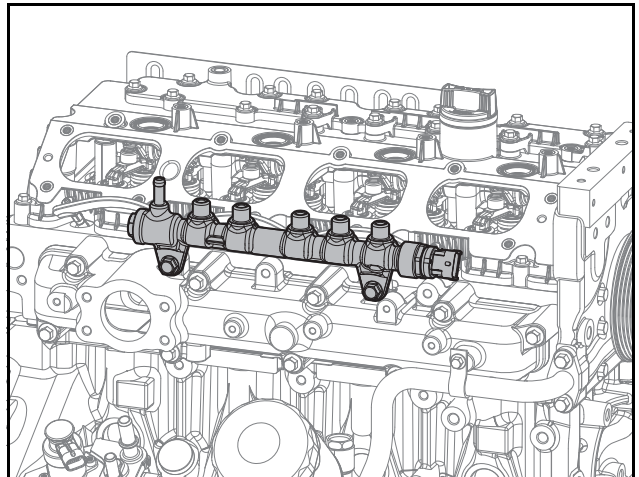
2. Connect the glow plugs.



EDM03190248

- 1) Tightening 4 glow plugs to the cylinder head at a tightening torque of  $9 \sim 12$  N·m.
- 2) Attach the electric connector.
- 3) Mount 4 washers.
- 4) Tighten 4 hex nuts at a tightening torque of  $1.3 \sim 2$  N·m.

3. Assemble the common rail.



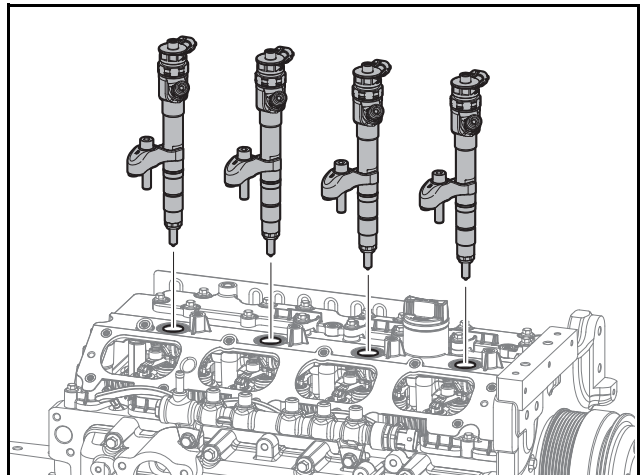
EDM03190246

- 1) Assemble the common rail with the intake manifold.

### **CAUTION**

- Pay attention to the assembled direction of the common rail.
- Be careful not to damage the common rail during assembly.
- Be careful not to allow any foreign matter to enter the common rail fuel inlet and outlet holes.

- 2) Temporarily assemble the hex bolts by hand.
- 3) Tighten the hex bolts to a tightening torque of  $2.2$  kgf·m.
4. Assemble the injector.



EDM03190247

- 1) Align the injector sealing washers with the center of the injector hole and mount them.
- 2) Apply sufficient oil to the contact surface of the injector on the cylinder head cover.

## 10. Cylinder Block/Head

- 3) Assemble the injectors.

### CAUTION

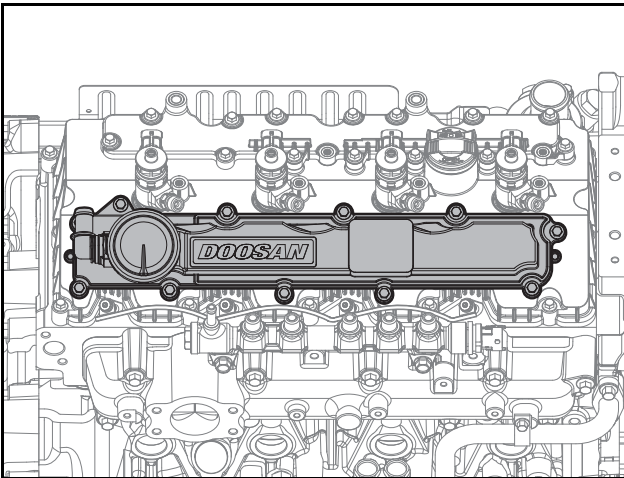
- Slowly turn the injector while assembling it to avoid damaging the injector oil seal on the cylinder head cover.
- Do not reuse injector sealing washers. Otherwise serious faults may occur in the engine due to unstable combustion.

- 4) Assemble the injector mounting brackets.
- 5) Temporarily tighten the hex bolts to a tightening torque of 0.3 kgf-m.

### CAUTION

If the hex bolts cannot be tightened while temporarily tightening them, do not tighten them by force. Tightening them by force may damage the cylinder head.

- 6) Tighten the hex bolts to a tightening torque of  $4.35 \pm 0.35$  kgf-m.
5. Assemble the right cylinder head cover.



EDM03190245

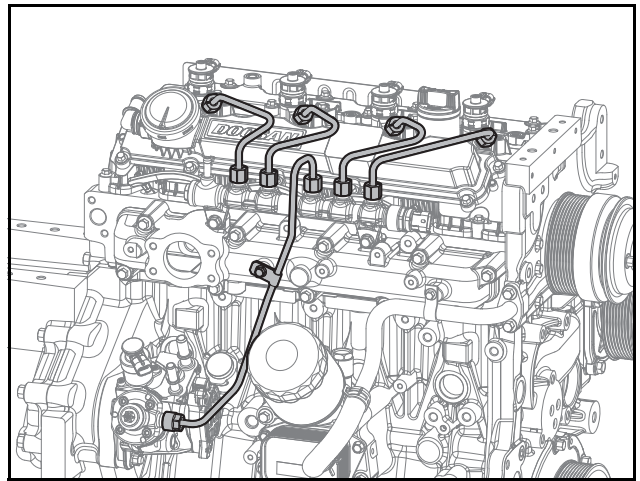
- 1) Align the rubber packing with the right cylinder head cover groove and assemble the right cylinder head cover.
- 2) Temporarily mount the flange hex bolts from inside to outside in the direction of the arrow.

- 3) Tighten the flange hex bolts from inside to outside in the direction of the arrow at a tightening torque of  $0.8 \pm 0.05$  kgf-m.

### CAUTION

- When performing maintenance, do not reuse head cover rubber seals; replace them with new ones.
- Before assembly, completely remove any foreign matter from inside the quick connector and the RH cover nipple.

6. Assemble fuel injection pipe.



EDM03190240

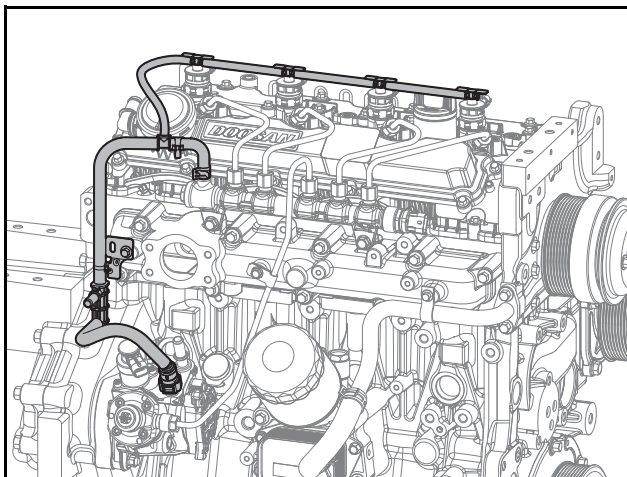
- 1) Loosen the hex bolts on the common rail and temporarily tighten them.
- 2) Temporarily tighten all of the nuts on the fuel injection pipes.
- 3) Tighten the hex bolts on the common rail to a tightening torque of 2.2 kgf-m.
- 4) Tighten the fuel injection pipe nuts to a tightening torque of 3.0 kgf-m.
- 5) Tighten the flange hex bolts assembled with the pipe clips to a tightening torque of 0.8 kgf-m.

### CAUTION

- Do not bend the fuel injection pipe by force.
- Pay attention to the assembled direction of the fuel injection pipe.
- Assemble the nuts on one side of the fuel injection pipe, then assemble the other side and make sure that the round part of the pipe and the part in contact with it are in their proper positions.
- Replace the fuel injection pipe and pipe clip with new ones; do not reuse them. Otherwise it may severely deteriorate the engine performance.

## 10. Cylinder Block/Head

7. Assemble the fuel return hose.



EDM03190241

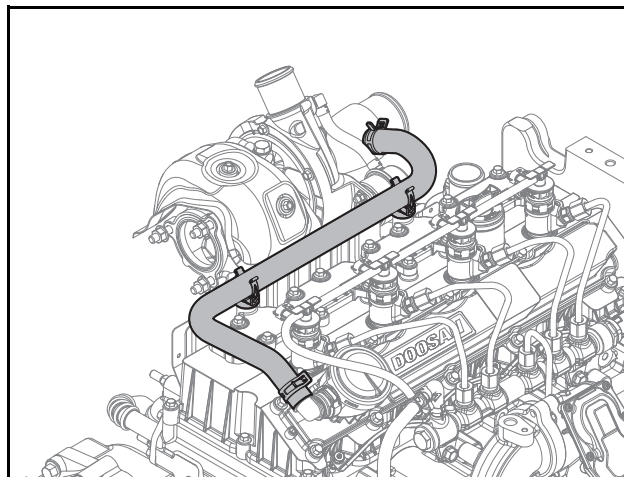
1) Assemble the fuel return hose.

### CAUTION

- Pay attention to the assembled direction of the fuel return hose.
- Assemble the injectors and fuel return hoses so that they interlock sufficiently.
- Do not reuse fuel return hoses; replace them with new ones. Failure to do so may cause serious faults in the engine performance.
- Be careful to avoid damage for fuel return hose of injector.
- Don't press on the fuel hose, don't drop heavy tool like as spanner on engine, don't step on fuel hose, don't stand on engine.
- If the fuel hose are broken by wrong handling, it is possible fire.

2) Press on the clamps to attach the common rail, injectors, and fuel return hoses on the fuel injection pump.

8. Assemble the breather hose.



EDM03190234

1) Assemble the breather hose with the hose clips.  
2) Press on the clamps on the quick connector and T/C air inlet pipe, then connect the breather hose.

### CAUTION

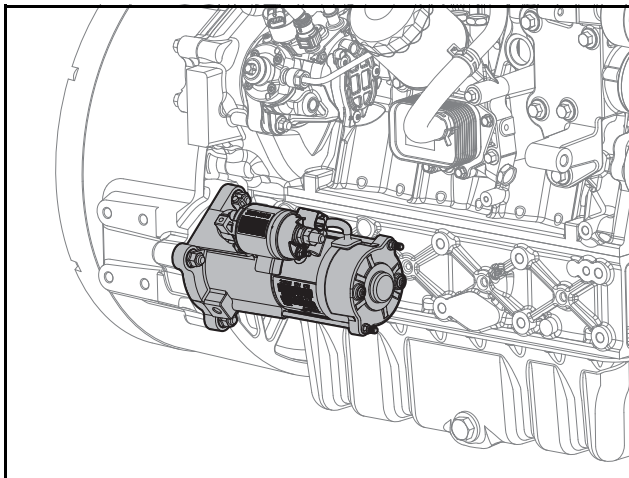
- Do not reuse clamps more than three times; replace them with new ones.
- Do not apply oil to hoses, clamps, etc.

# 10. Cylinder Block/Head

## Idle Gear

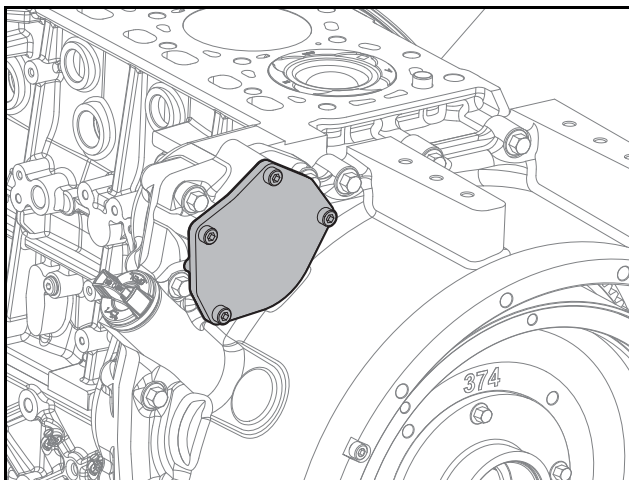
### Removing the Idle Gear

1. Remove the starter motor.

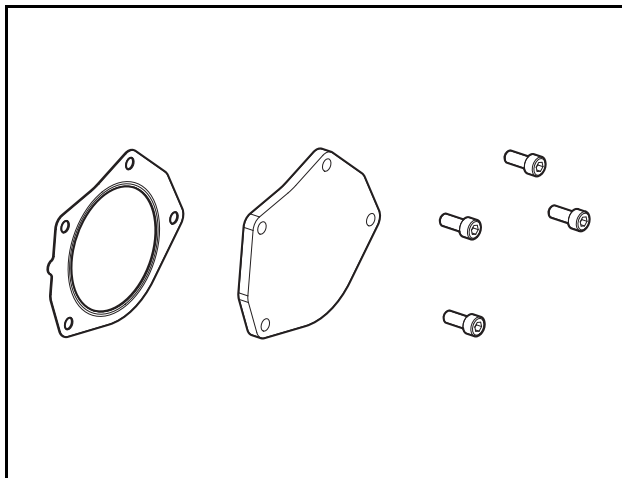


EDM03190242

- 1) Turn and loosen the flange nut.
  - 2) Remove the starter motor.
2. Remove the front/rear PTO (Power Take Off) cover & gasket.

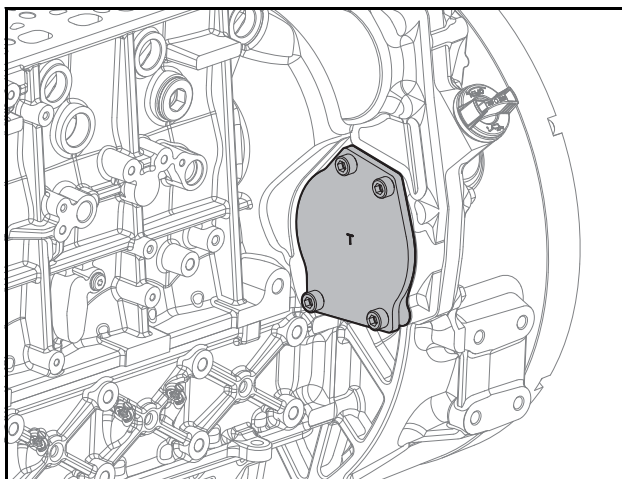


EDM03190257

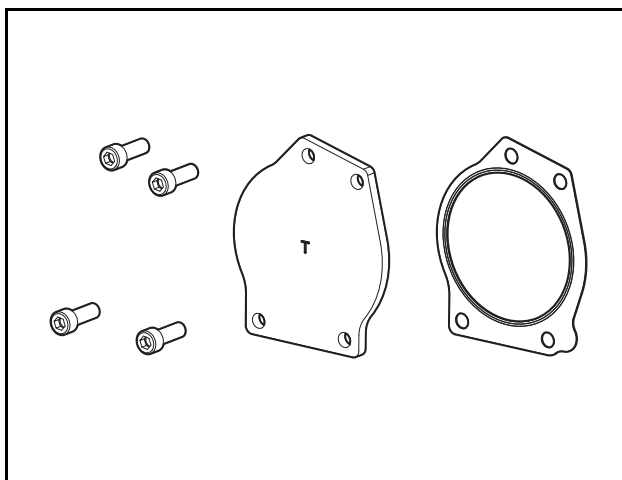


EDM03190319

- 1) Remove 4 inner socket bolts from the front PTO (Power Take Off) cover & gasket.
- 2) Remove the front PTO (Power Take Off) cover & gasket.



EDM03190256



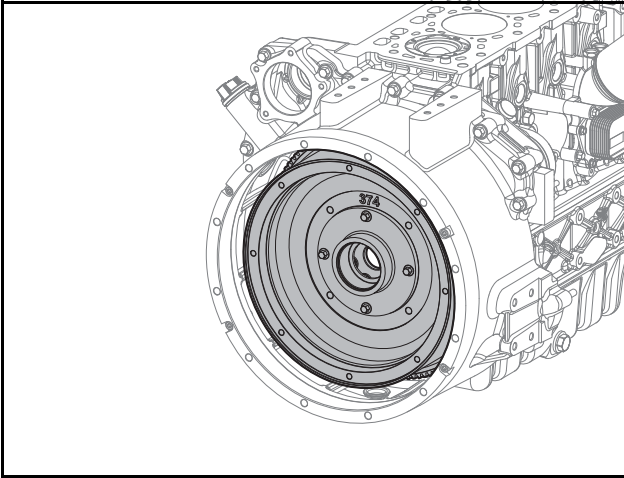
EDM03190320

- 3) Remove 4 inner socket bolts from the rear PTO (Power Take Off) cover & gasket.

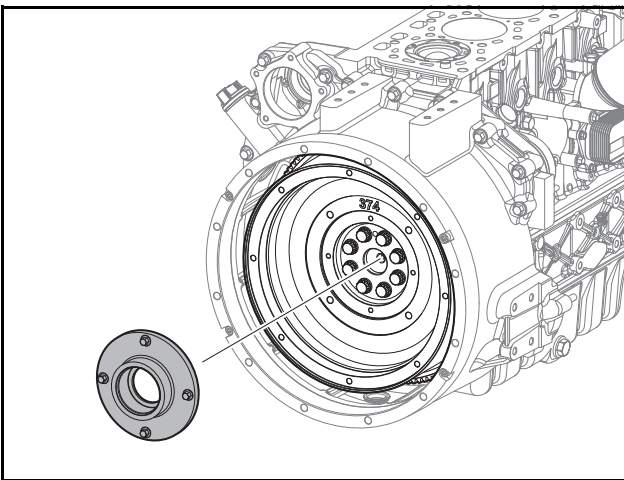


## 10. Cylinder Block/Head

- 4) Remove the rear PTO (Power Take Off) cover & gasket.
3. Remove the flywheel.

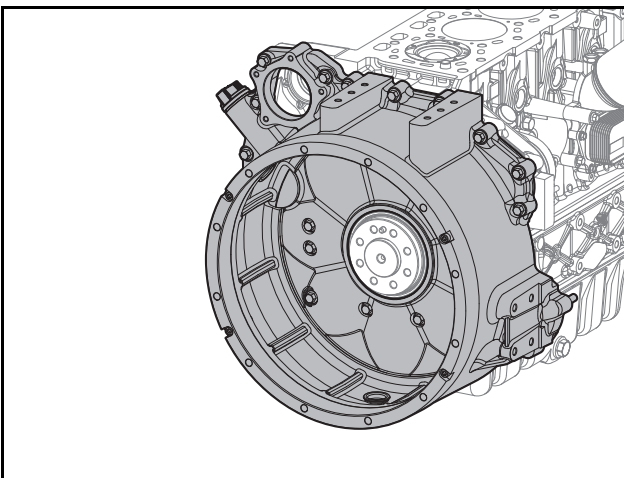


EDM03190259



EDM03190260

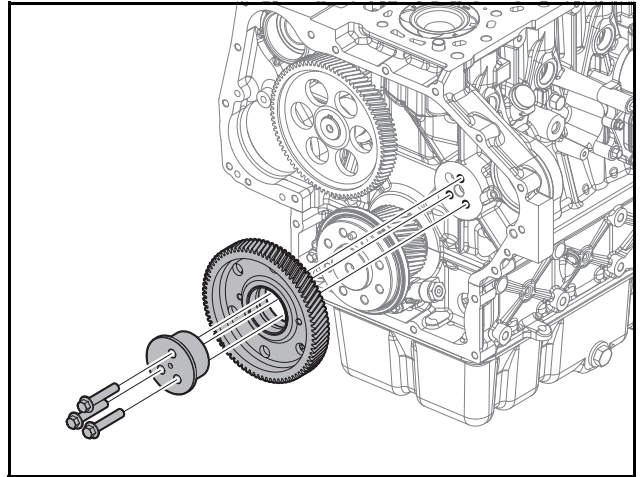
- 1) Loosen 8 flange hex bolts.
- 2) Remove the flywheel.
4. Remove the flywheel housing.



EDM03190258

- 1) Loosen the hex bolts.
- 2) Remove the flywheel housing.

5. Remove the idle gear.

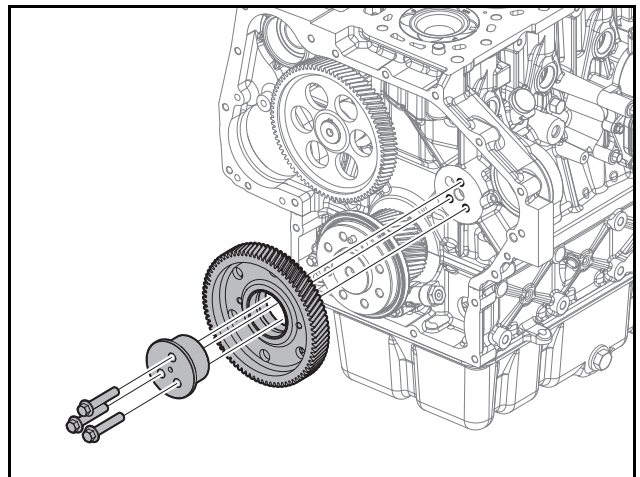


EDM03190261

- 1) Loosen the flange hex bolt.
- 2) Remove the idle gear shaft.
- 3) Use the idle gear removal tab to remove the idle gear.

### Assembling the Idle Gear

1. Assemble the idle gear.



EDM03190261

- 1) Line up the idle gear and camshaft engravings.

### **⚠ CAUTION**

**There are 2 markings on the idle gear engraving and the camshaft gear engraving**

## 10. Cylinder Block/Head

- 2) Make sure that the engraving on the crankshaft gear is between the engravings on the idle gear.

### CAUTION

- There are 4 markings on the idle gear engravings.
- There is one engraved marking on the 4th tooth of the crankshaft with the crankshaft gear key groove in the 12 o'clock direction.

- 3) Align the idle gear with the engraved marking and assemble it.

### CAUTION

**Make sure that the direction of the engraved marking on the idle gear faces outside the engine during assembly.**

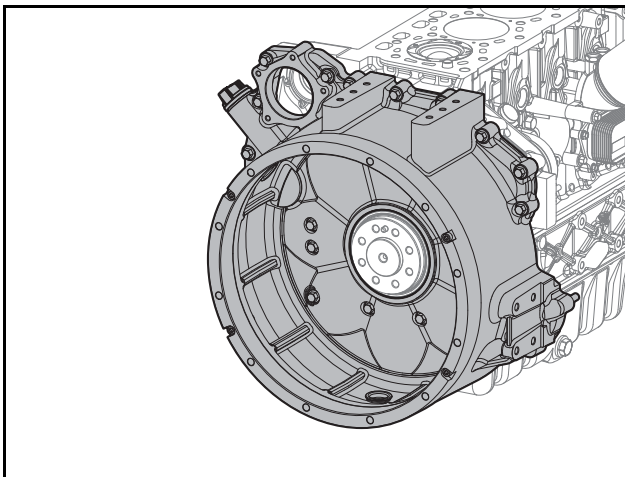
- 4) Make sure that the oil hole in the idle gear shaft faces upwards when assembling it.
- 5) Align the flange hex bolts with the holes in the idle gear shaft and temporarily assemble them.
- 6) Tighten the flange hex bolts to a tightening torque of 4.4 kgf·m.
- 7) The backlash between the idle gear and the crankshaft gear is 0.087 ~ 0.202 mm.

Item	Specified value
Backlash between idle gear and crankshaft gear	0.087 ~ 0.202 mm

- 8) The backlash between the idle gear and the camshaft gear is 0.087 ~ 0.213 mm.

Item	Specified value
Backlash between idle gear and camshaft gear	0.087 ~ 0.213 mm

2. Assemble the flywheel housing.



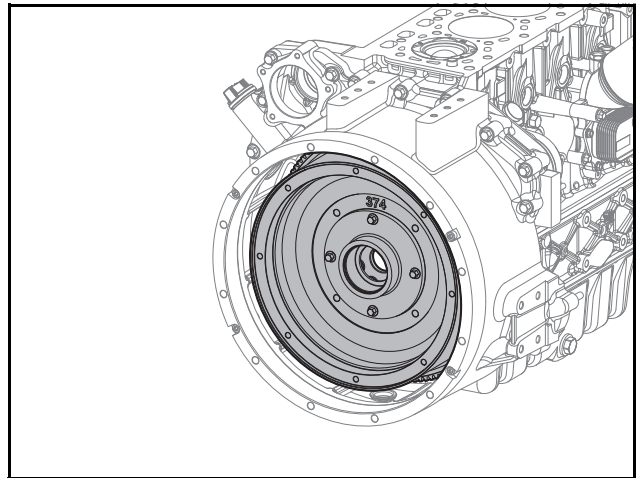
EDM03190258

- 1) Apply sealant to the assembly surface of the flywheel housing with a diameter of  $\varnothing 2.5 \pm 0.5$  mm.

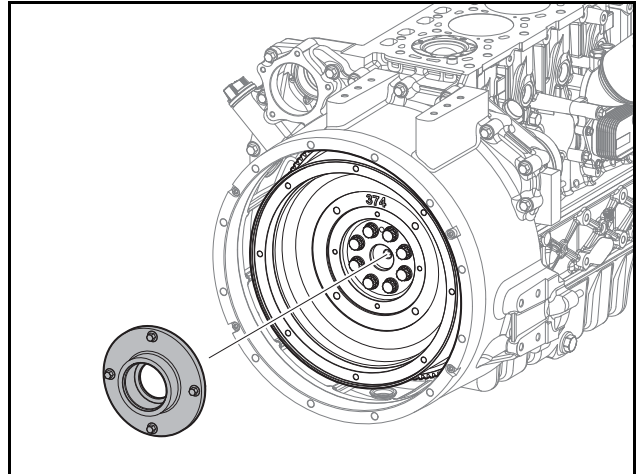
### CAUTION

- Pay attention to the assembly direction of the flywheel housing.
- Assemble within 5 minutes of applying sealant (TB1217H).
- Do not start the engine or apply pressure within 25 minutes of applying sealant (TB1217H).

- 2) Assemble the flywheel housing.
- 3) Tighten the hex bolt to a tightening torque of 2.2 kgf·m.
3. Assemble the flywheel.



EDM03190259



EDM03190260

- 1) Assemble the flywheel.
- 2) Use the angle tightening method to tighten the flange hex bolts to a tightening torque.

Flywheel bolt (43 mm, option)	1st: $7 \pm 0.35$ kgf·m/2nd: $45^\circ \pm 4^\circ$
Flywheel bolt (25 mm, option) for flat type flywheel	$17 \pm 0.85$ kgf·m

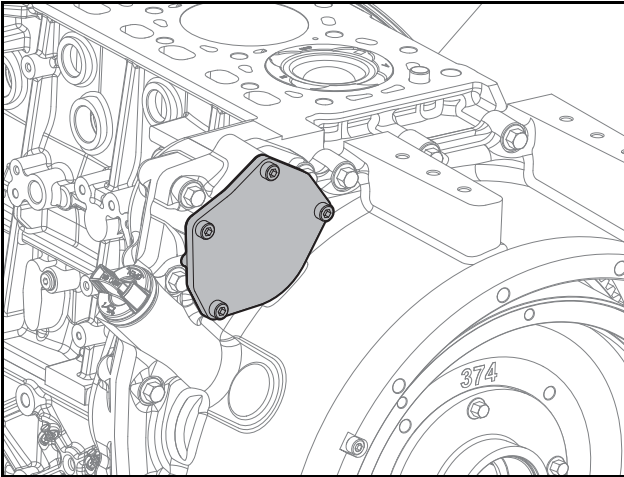


## 10. Cylinder Block/Head

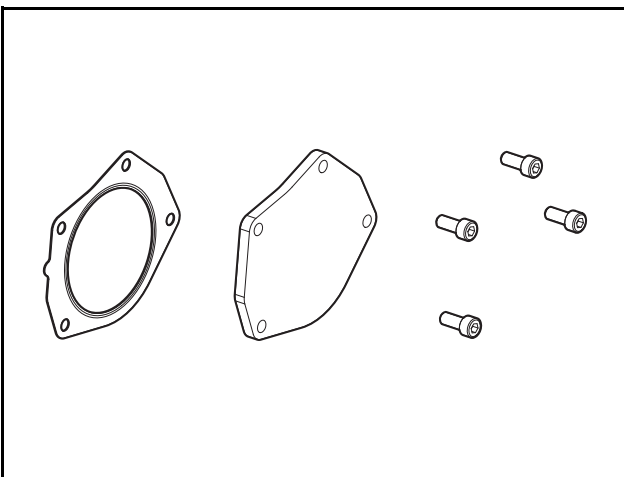
### CAUTION

Do not reuse flange hex bolts when assembling the flywheel.

4. Assemble the front/rear PTO (Power Take Off) cover & gasket.

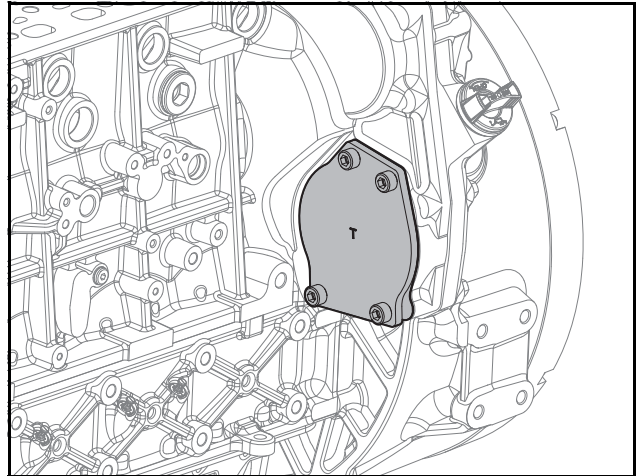


EDM03190257

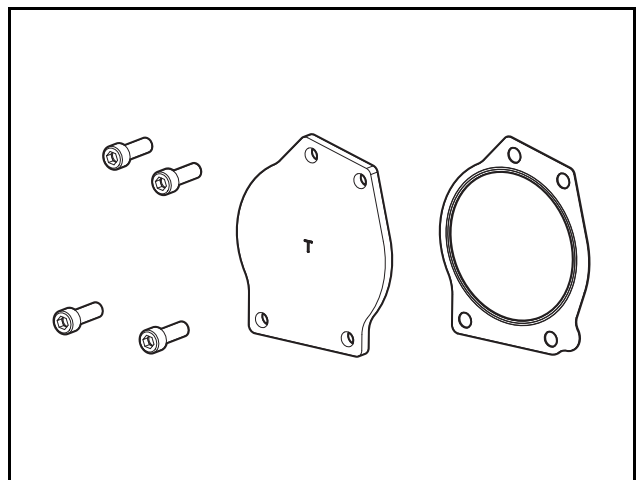


EDM03190319

- 1) Assemble the front PTO (Power Take Off) cover & gasket.
- 2) Tighten 4 inner socket bolts to a tightening torque of  $2.2 \pm 0.2$  kgf·m.

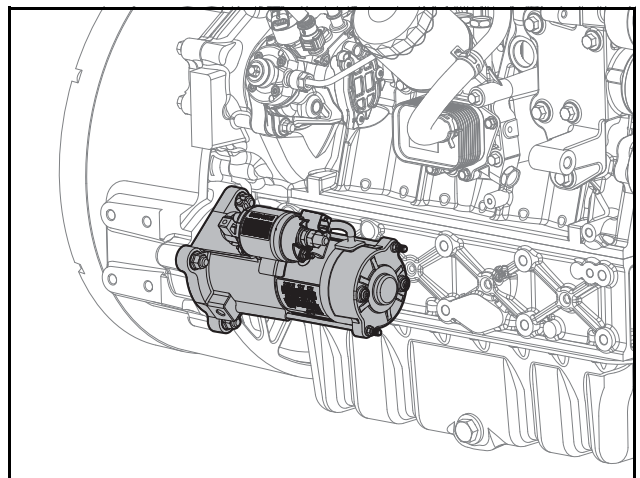


EDM03190256



EDM03190320

- 3) Assemble the rear PTO (Power Take Off) cover & gasket.
- 4) Tighten 4 inner socket bolts to a tightening torque of  $4.4 \pm 0.4$  kgf·m
5. Assemble the starter motor.



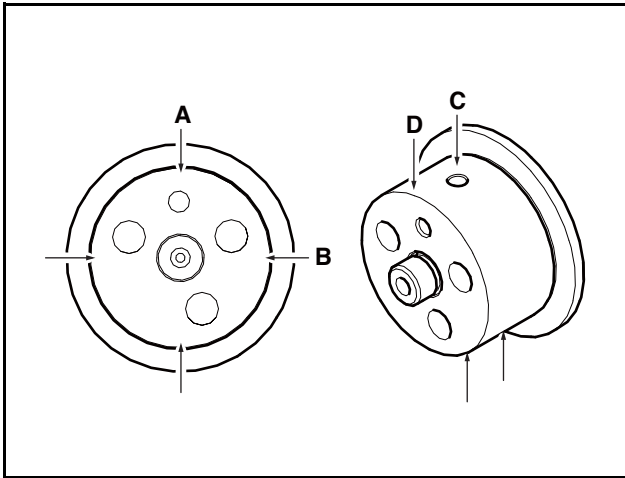
EDM03190242

- 1) Align the starter motor with the stud bolts and assemble it.
- 2) Tighten the flange nuts to a tightening torque of  $4.4$  kgf·m.

# 10. Cylinder Block/Head

## Measuring the Outside Diameter of the Idle Gear Shaft

1. Set up the gauge.
2. Measure the outside diameter of the idle gear shaft.



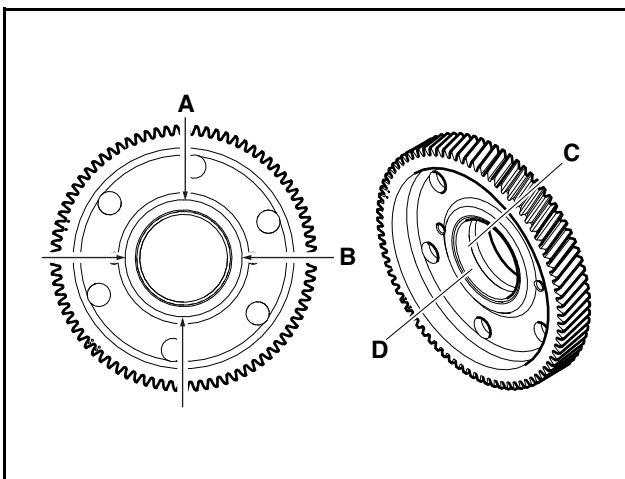
EDL032111A

- 1) Measure the outside diameter of the idle gear shaft in a total of 4 places: vertically (A), horizontally (B), front (C) and back (D).
- 2) The measured size of the outside diameter of the idle gear shaft should be 59.921 ~ 59.940 mm.

Item	Specified value
Outside diameter of idle gear shaft	59.921 ~ 59.940 mm

## Measuring the Inside Diameter of the Idle Gear

1. Set up the gauge.
2. Measure the inside diameter of the idle gear.



EDL032112A

- 1) Measure the inside diameter of the idle gear in a total of 4 places: vertically (A), horizontally (B), front (C) and back (D).
- 2) The measured size of the inside diameter of the idle gear should be 59.97 ~ 60 mm.

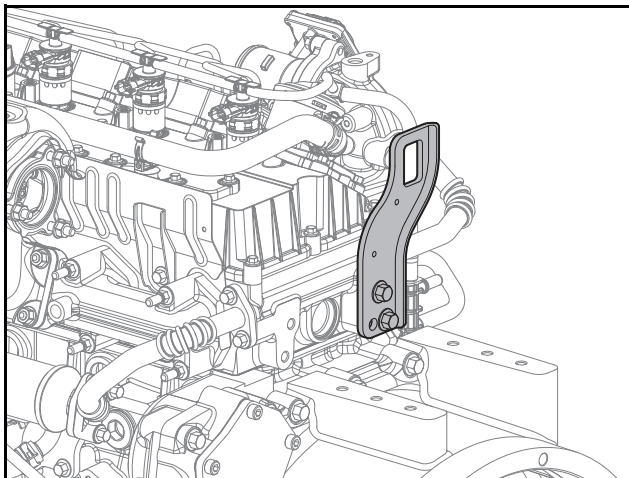
Item	Specified value
Inside diameter of idle gear	59.97 ~ 60 mm

## 10. Cylinder Block/Head

### Lifting Hook

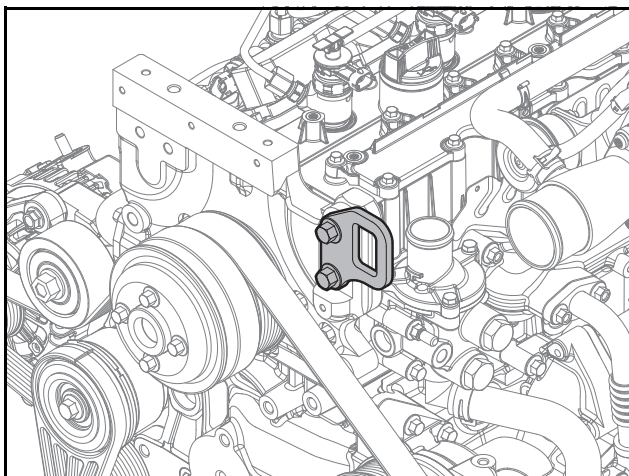
#### Removing the Lifting Hooks

1. Remove the front lifting hook.



EDM03190267

- 1) Loosen the flange hex bolt.
- 2) Remove the front lifting hook.
2. Remove the rear lifting hook.

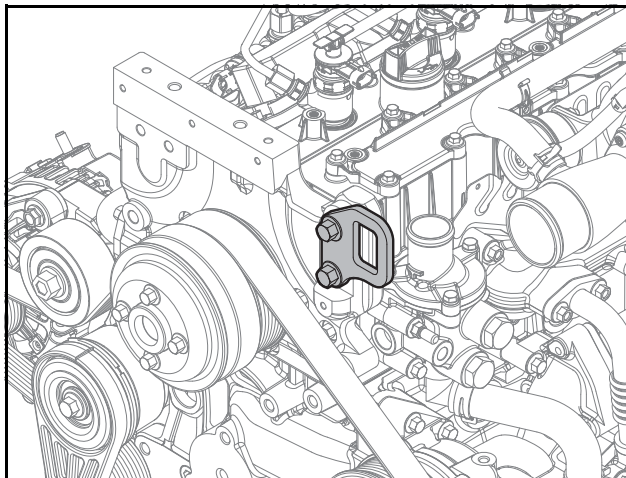


EDM03190268

- 1) Loosen the flange hex bolt.
- 2) Remove the rear lifting hook.

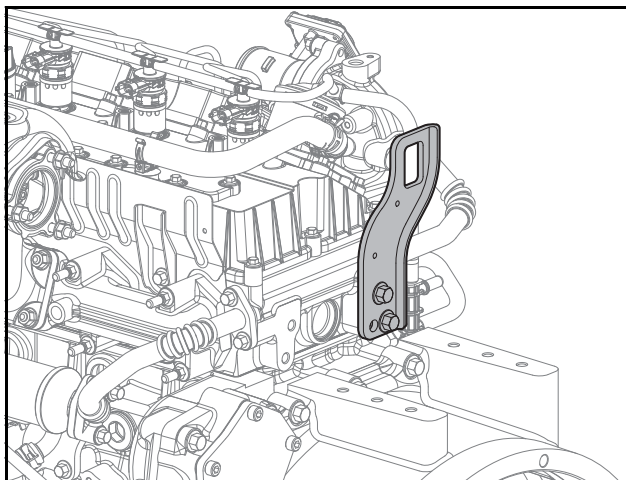
#### Assembling the Lifting Hook

1. Assemble the rear lifting hook.



EDM03190268

- 1) Assemble the rear lifting hook.
- 2) Tighten the flange hex bolts to a tightening torque of 4.4 kgf·m.
2. Assemble the front lifting hook.



EDM03190267

- 1) Assemble the front lifting hook.
- 2) Tighten the flange hex bolts to a tightening torque of 4.4 kgf·m.

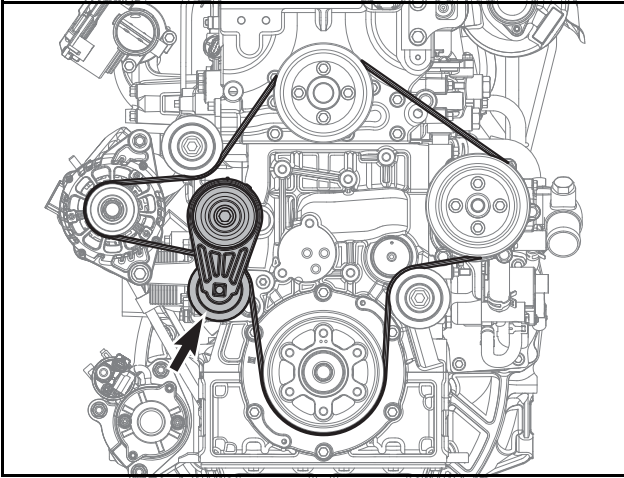


# 10. Cylinder Block/Head

## Oil Seal

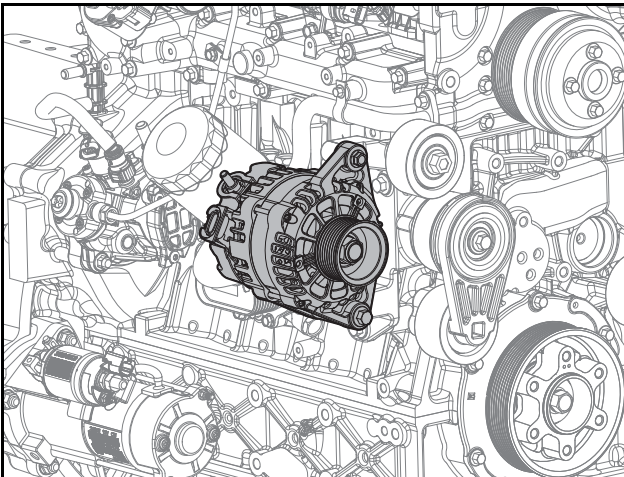
### Removing the Front Oil Seal Holder

1. Remove the V-belt.



EDM03190231

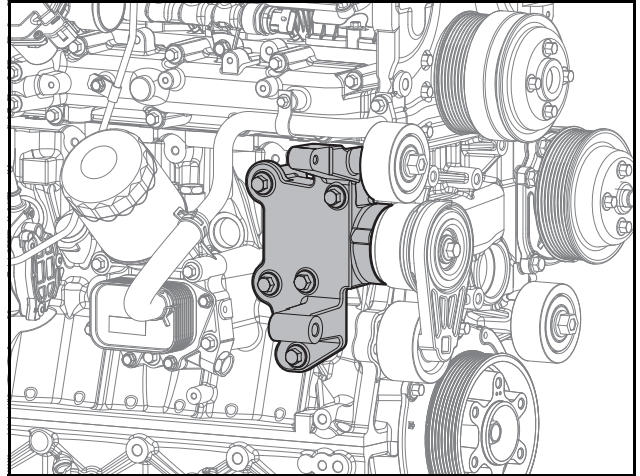
- 1) Turn the auto tensioner counterclockwise by using a quadrangular groove at the top of the auto tensioner pulley (Use a 10 mm x 10 mm quadrangular tool).
  - 2) Remove the belt wound around the auto tensioner pulley by using a space generated by the rotation of the auto tensioner.
2. Detach the alternator.



EDM03190243

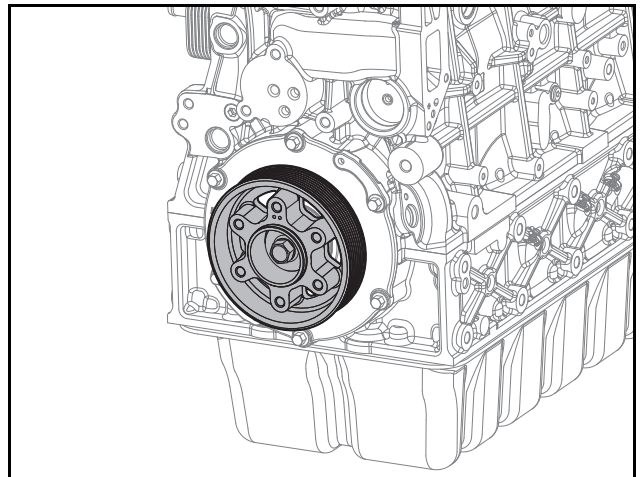
- 1) Loosen the upper/lower bolt and remove the alternator.
- 2) When loosening bolt, take care not to lose nut.

3. Remove the alternator bracket.



EDM03190244

- 1) Loosen 5 flange hex bolt.
  - 2) Remove the alternator bracket.
4. Remove the crankshaft pulley.

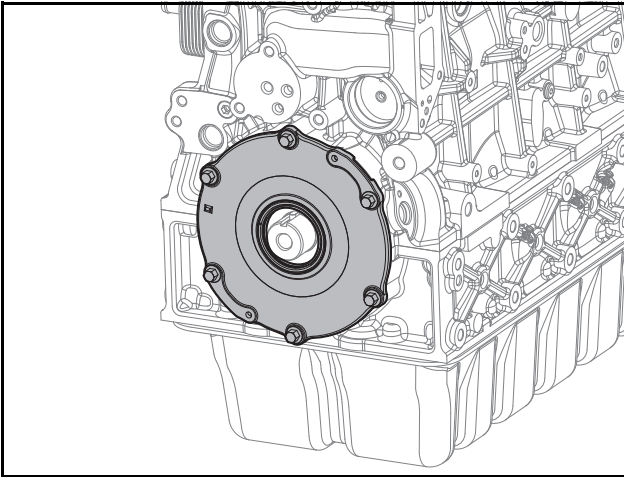


EDM03190262

- 1) Loosen the flange hex bolts.
- 2) Remove the crankshaft pulley.

## 10. Cylinder Block/Head

5. Remove the front oil seal holder.

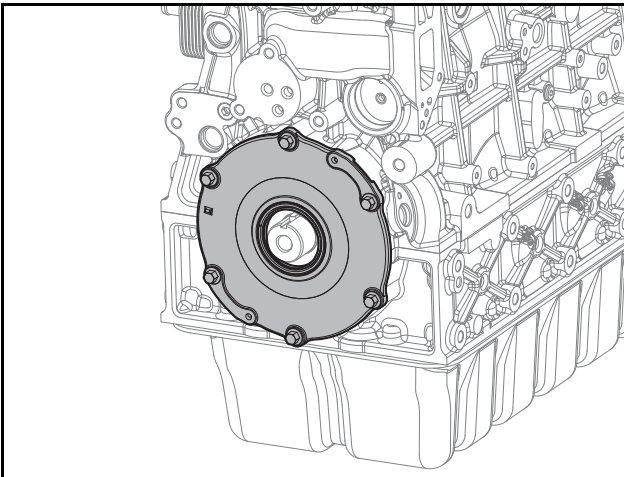


EDM03190141

- 1) Loosen the flange hex bolt.
- 2) Use a screwdriver in the groove to remove the front oil seal holder.

### Assembling the Front Oil Seal Holder

1. Assemble the front oil seal holder.



EDM03190141

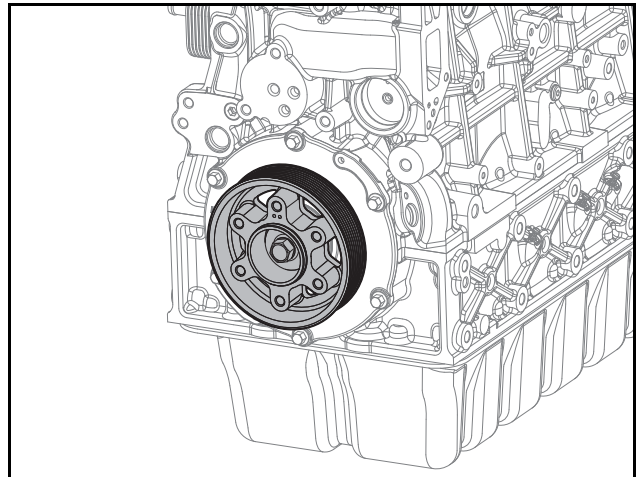
- 1) Remove any foreign matter from the assembly surface of the front oil seal holder and wipe it clean with a dry cloth.
- 2) The sealant which had been applied before the assembly must be removed. Be careful when removing the sealant as damaging the oil seal holder may cause oil leaks.

- 3) Apply sealant to the assembly surface of the front oil seal holder with a diameter of  $\varnothing 2.5 \pm 0.5$  mm.

### CAUTION

- Pay attention to the assembly direction of the front oil seal holder.
- Assemble within 5 minutes of applying sealant (TB1217H).
- Do not start the engine or apply pressure within 25 minutes of applying sealant (TB1217H).

- 4) Align the front oil seal holder with the dowel pin and assemble it.
- 5) Tighten the flange hex bolt to a tightening torque of 2.2 kgf·m.
2. Assemble the crankshaft pulley.



EDM03190262

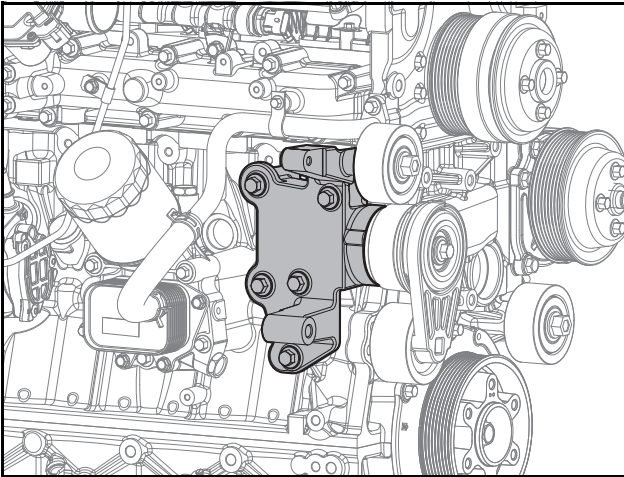
- 1) Align the crankshaft pulley with the key to assemble it.
- 2) Tighten the flange hex bolt to a tightening torque of 26 kgf·m.
- 3) Connect crankshaft pulley.
- 4) Tighten the hex bolts to a tightening torque of 2.2 kgf·m.

### CAUTION

- Be careful not to damage the oil seals.
- Mount the crankshaft so that the flange hex bolts can be installed at the specified torque.

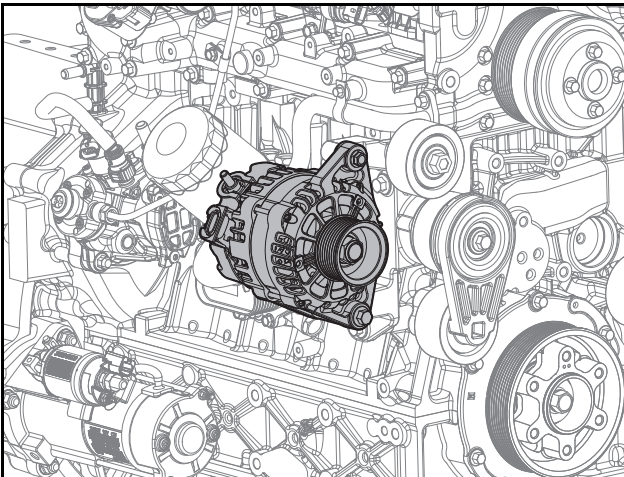
## 10. Cylinder Block/Head

### 3. Assemble the alternator bracket.



EDM03190244

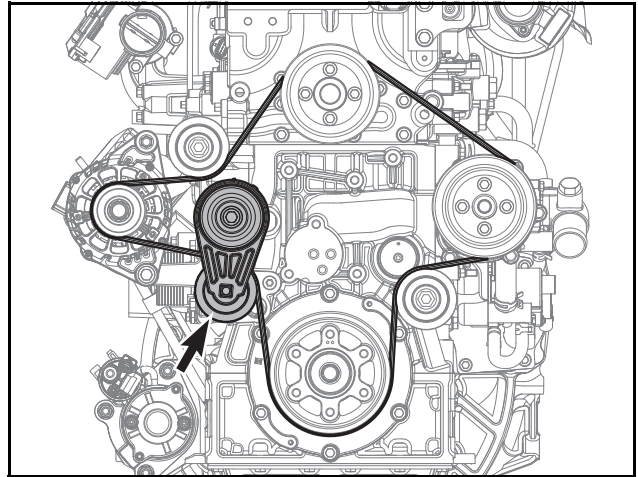
- 1) Assemble the alternator bracket.
- 2) Tighten 5 flange hex bolts to a tightening torque of  $6.2 \pm 0.6$  kgf·m.
4. Assemble the alternator.



EDM03190243

- 1) Using bolt and nut, attach the alternator temporarily.
- 2) By tightening bolt, set the position of the alternator properly.
- 3) Tighten upper bolt to a torque of  $2.2 \pm 0.2$  kgf·m.
- 4) Tighten lower bolt to a torque of  $6.2 \pm 0.6$  kgf·m.

### 5. Assemble the V-belt.



EDM03190231

- 1) Wind a new belt around all pulleys except for the auto tensioner.
- 2) Turn the auto tensioner counterclockwise by using a quadrangular groove at the top of the auto tensioner pulley (use a 10 mm x 10 mm quadrangular tool).
- 3) Wind the belt around the auto tensioner pulley by using a space generated by the rotation of the auto tensioner, and then naturally release the tensioner that has been pulled counterclockwise.

### CAUTION

For checking and measuring the belt tension, refer to **Belt Tension in Chapter 12 (Others/Driving Units)**.



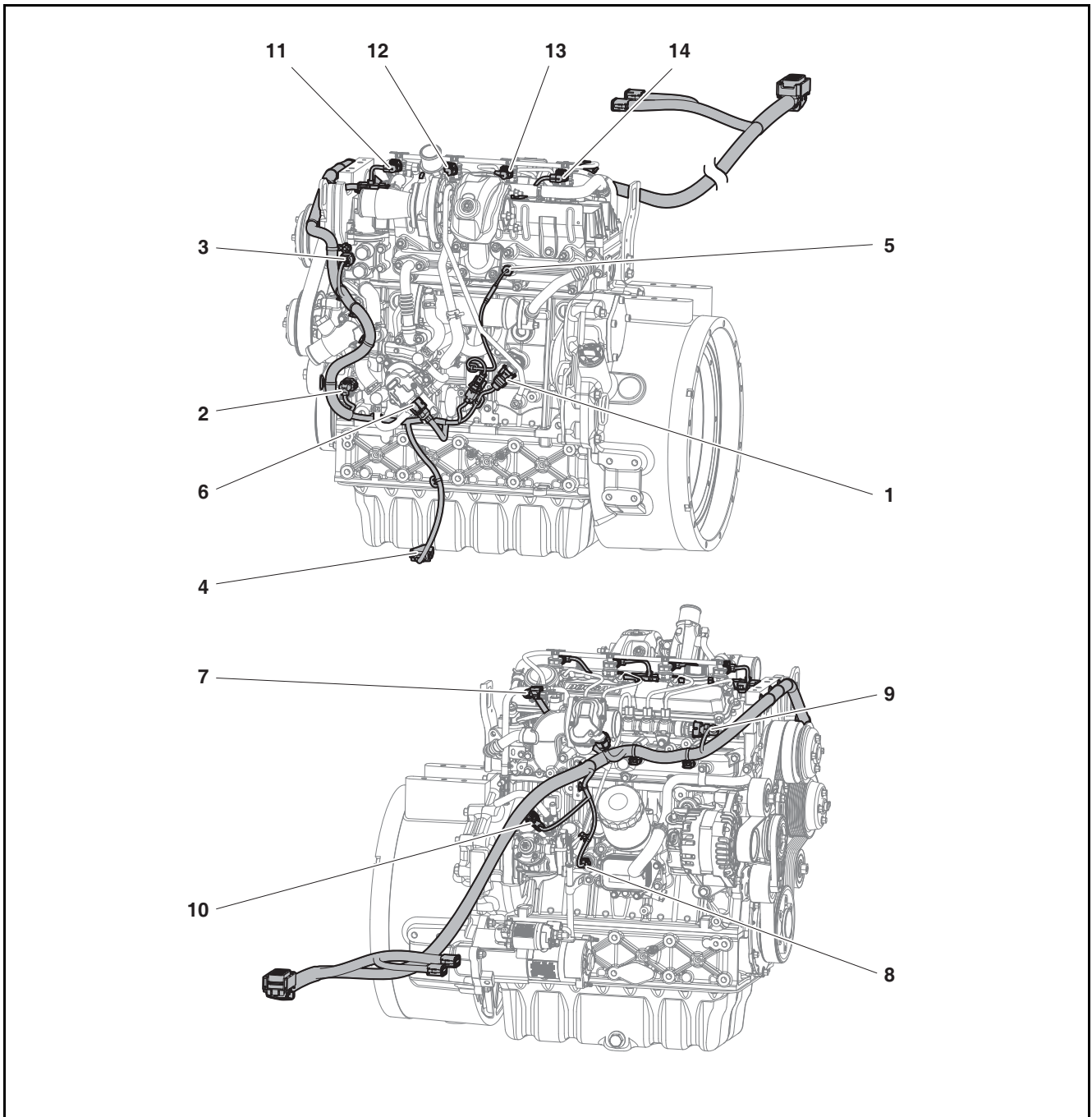
# 11. Electrical System

<b>Electric Parts .....</b>	<b>221</b>
Electric Parts .....	221
<b>Circuit Diagram .....</b>	<b>222</b>
General Information .....	222
Engine Connector (Stage-V) .....	223
Engine Connector (Tier-4 Final) .....	225
Engine Connector for Engine Control Unit (ECU) .....	227
<b>Switches and Sensors .....</b>	<b>229</b>
Injector#1 .....	229
Injector#2 .....	229
Injector#3 .....	229
Injector#4 .....	229
Coolant Temperature Sensor (COOLANT TEMP) .....	230
Exhaust Gas Recirculation Valve Position Sensor (EGR) .....	230
Crank Shaft Position Sensor (CRANK) .....	230
CAM Shaft Position Sensor (CAM) .....	231
Temperature Manifold Absolute Pressure Sensor (TMAP) .....	231
Oil Pressure Sensor (OIL PRES) .....	231
Rail Pressure Sensor (RPS) .....	232
Fuel Metering Unit (METERING UNIT) .....	232
Oil Level Sensor (OIL LEVEL) .....	232
Throttle Valve Actuator/Position Sensor .....	232
Exhaust Gas Temperature Sensor (EGT) .....	233
<b>Wire Harness .....</b>	<b>234</b>
Removing the Wire Harness .....	234
Assembling the Wire Harness .....	234
<b>Engine Control Unit (ECU) .....</b>	<b>235</b>
General Information .....	235
Engine Control Unit (ECU) Connector .....	235
Engine Control Unit (ECU) Input/Output .....	236
Engine Control Unit (ECU) Operating Conditions .....	237

<b>Starter .....</b>	<b>238</b>
General Information .....	238
Specifications .....	239
Circuit Diagram .....	239
Starter Motor Performance Curve .....	240
Removing the Starter Motor .....	241
Assembling the Starter Motor .....	241
<b>Alternator .....</b>	<b>242</b>
General Information .....	242
Wiring Diagram .....	243
Disassembly of Alternator .....	243
Assembly of Alternator .....	243

## Electric Parts

### Electric Parts



EDM03190323

- |   |                               |                      |
|---|-------------------------------|----------------------|
| 1. CAM: CAM Shaft Position Sensor                     | 6. EGR Valve                  | 11. INJ: Injector #1 |
| 2. CRK: Crank Shaft Position Sensor                   | 7. T-MAP Sensor               | 12. INJ: Injector #2 |
| 3. WTS: Water Temperature Sensor                      | 8. OPS: Oil Pressure Sensor   | 13. INJ: Injector #3 |
| 4. Oil Level Sensor (option)                          | 9. RPS: Rail Pressure Sensor  | 14. INJ: Injector #4 |
| 5. EGT: Exhaust Gas Temperature Sensor (Stage-V only) | 10. IMV: Inlet Metering Valve |                      |

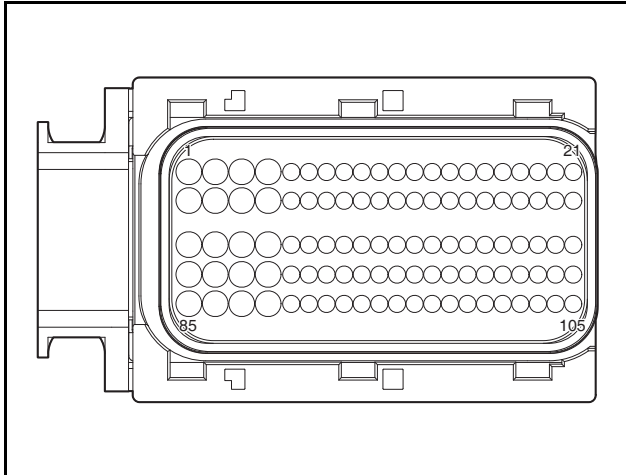
# 11. Electrical System

---

## Circuit Diagram

### General Information

1. Circuit diagrams allow you to check the circuit number of the connector connected to the engine connector of the engine control unit (ECU).



EDM03190313

2. The wire colors are as follows.

- 1) B: Black
- 2) Brn: Brown
- 3) R: Red
- 4) G: Green
- 5) W: White
- 6) L: Blue
- 7) RG: Red & Green
- 8) RW: Red & White
- 9) VL: Violet & Blue
- 10) O: Orange
- 11) P: Pink
- 12) GrL: Gray & Blue
- 13) RV: Red & Violet
- 14) RY: Red & Yellow
- 15) Lgra: Blue & Gray
- 16) LW: Blue & White

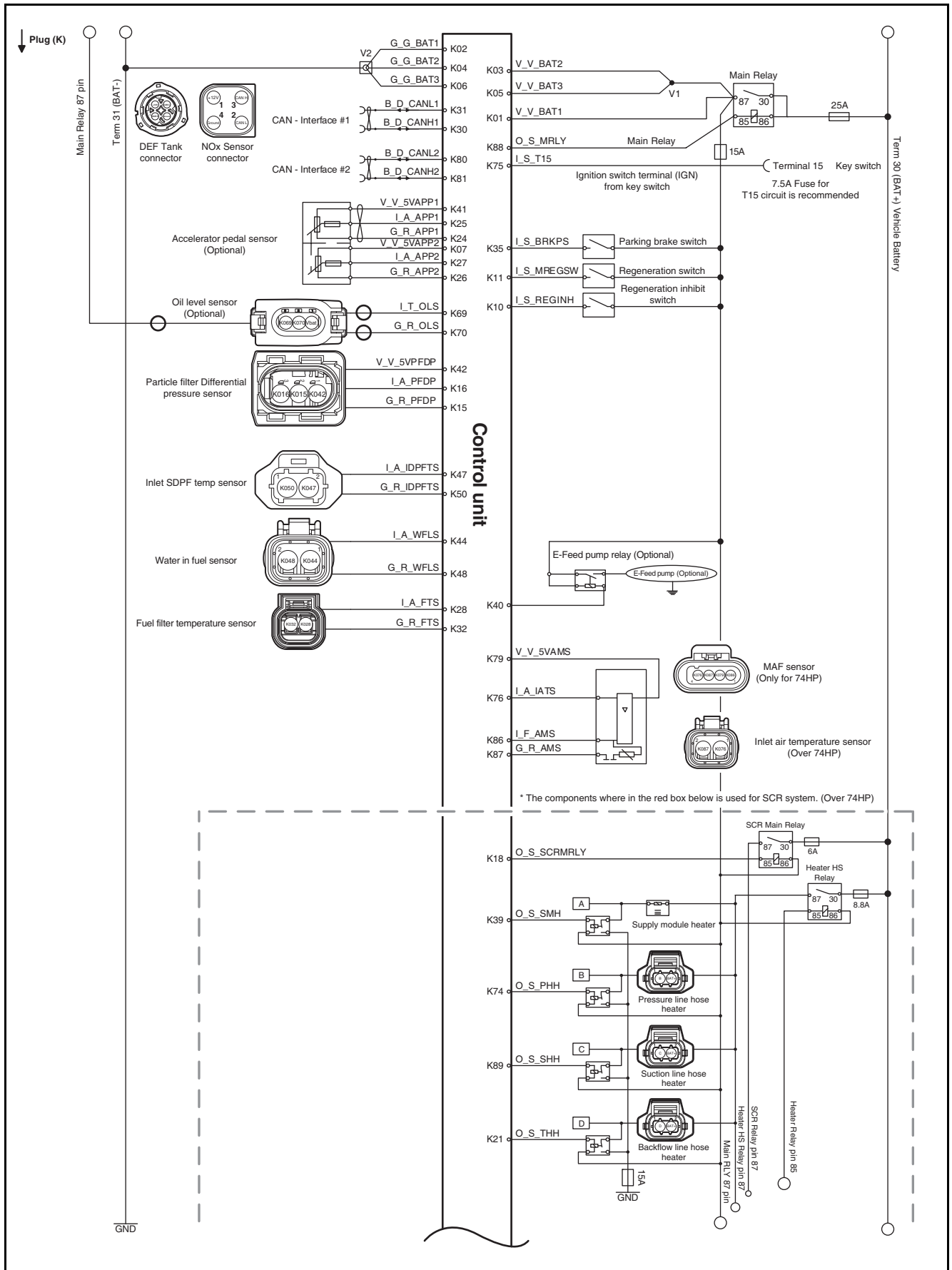
3. The wire types are as follows.

- 1) FLR91X-A
- 2) FLR91X-A\_T01 (Twist)
- 3) FLR91X-A\_T03 (Twist)
- 4) FLR91X-A\_T04 (Twist)
- 5) FLR91X-A\_T05 (Twist)
- 6) FLR91X-A\_T06 (Twist)
- 7) FLR91X-A\_T07 (Twist)
- 8) FLR91X-A\_T08 (Twist)
- 9) FLR91X-A\_T09 (Twist)

- 10) FLR91X-A\_BS01 (Shield)

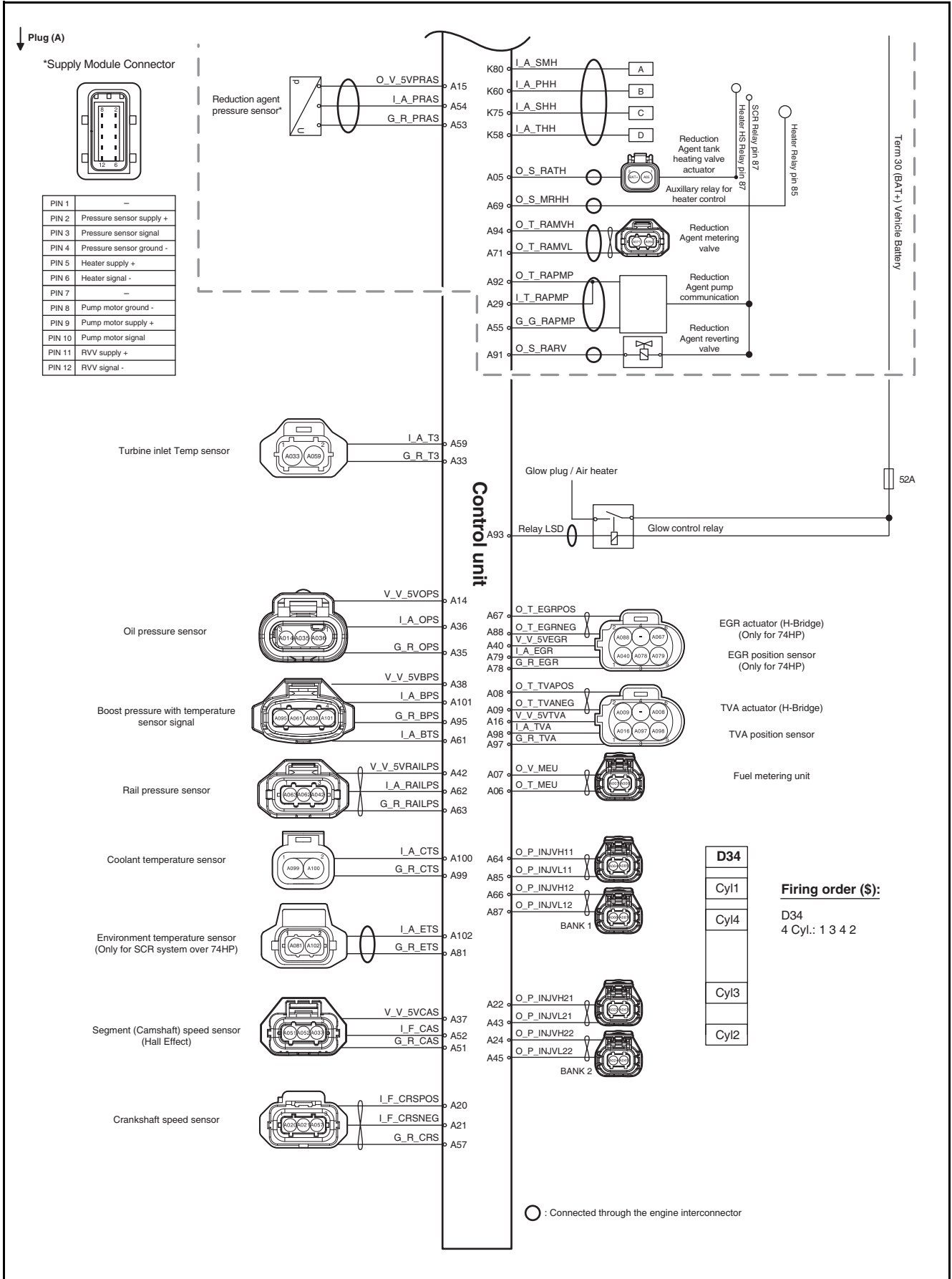
4. The ECU Pin No. is the pin number of the engine connector.
5. The Sensor Pin No. is the pin number of the sensor connector.

## Engine Connector (Stage-V)



EDM03200106

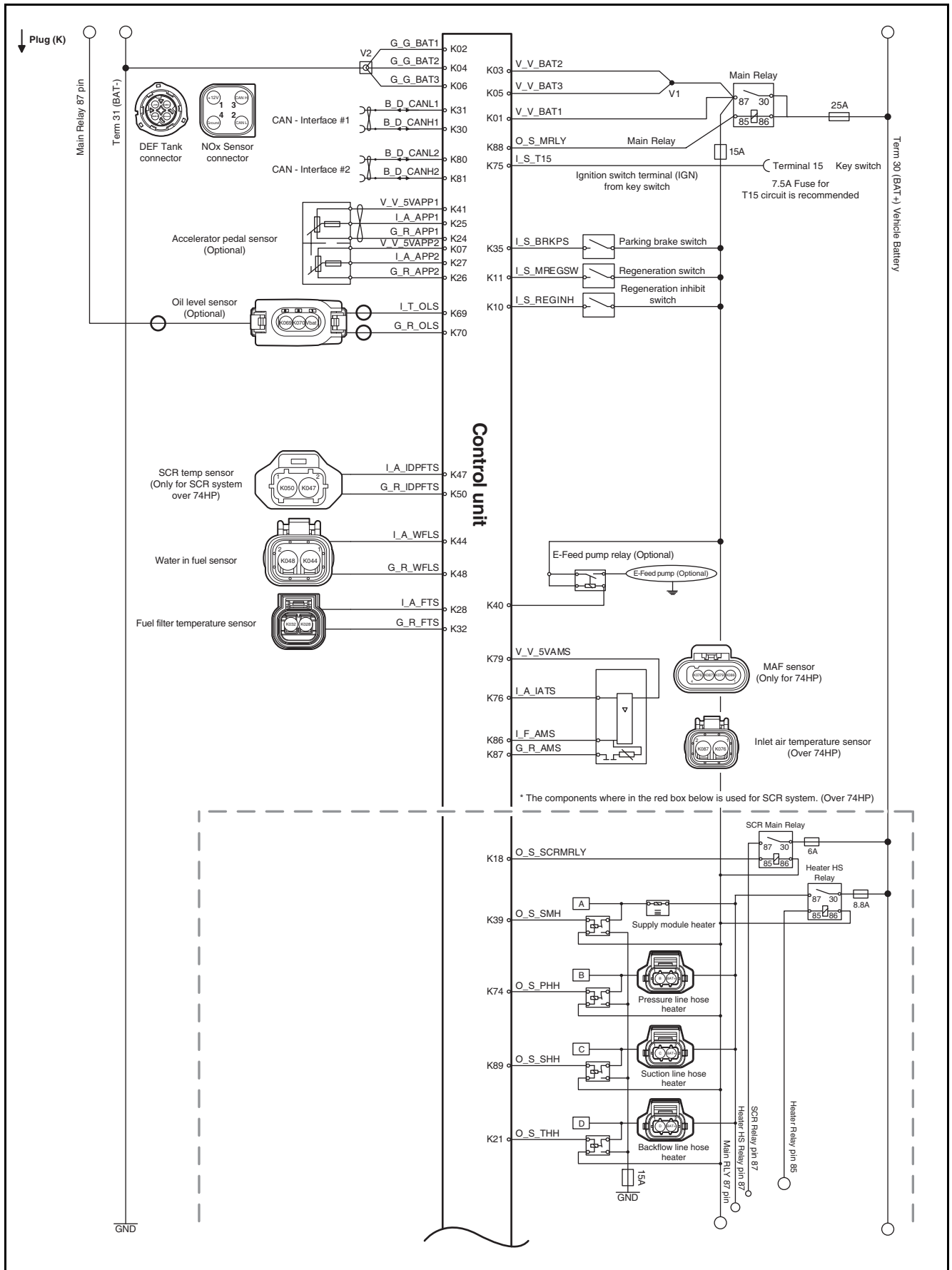
# 11. Electrical System



EDM03200107

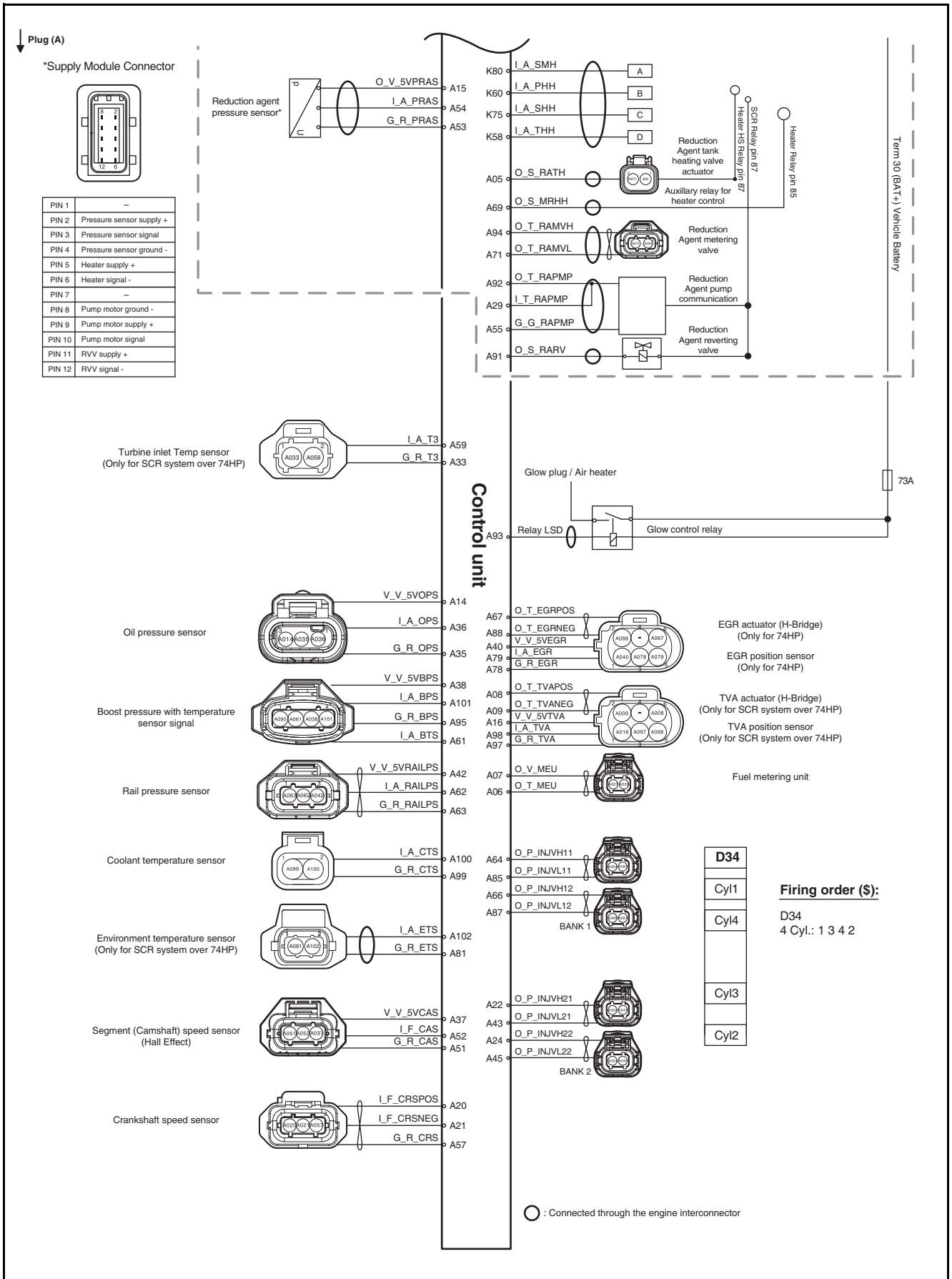


## Engine Connector (Tier-4 Final)



EDM03200108

# 11. Electrical System



EDM03200109

## 11. Electrical System

### Engine Connector for Engine Control Unit (ECU)

Circuit No.	SQ	Color	Type	Description	To		From		Remark
A063	0.75	B	FLR91X-A_T01	Rail pressure sensor ground	ECU	63	RPS	1	
A062	0.75	Brn	FLR91X-A_T01	Rail pressure sensor signal	ECU	62	RPS	2	
A042	0.75	R	FLR91X-A_T01	Rail pressure sensor supply	ECU	42	RPS	3	
A040	0.75	R	FLR91X-A	EGR position sensor supply	ECU	40	EGR	1	
A088	1	G	FLR91X-A_T02	EGR motor minus	ECU	88	EGR	2	
A078	0.75	B	FLR91X-A	EGR position sensor ground	ECU	78	EGR	3	
A079	0.75	W	FLR91X-A	EGR position sensor signal	ECU	79	EGR	5	
A067	1	L	FLR91X-A_T02	EGR motor plus	ECU	67	EGR	6	
A016	0.75	R	FLR91X-A	Throttle position sensor supply	ECU	16	TROTTL	1	Stage-V only
A009	0.75	LW	FLR91X-A_T03	Throttle plate actuator motor minus	ECU	9	TROTTL	2	Stage-V only
A097	0.75	B	FLR91X-A	Throttle plate actuator feedback ground	ECU	97	TROTTL	3	Stage-V only
A098	0.75	P	FLR91X-A	Throttle plate actuator feedback signal	ECU	98	TROTTL	5	Stage-V only
A008	0.75	R	FLR91X-A_T03	Throttle plate actuator motor plus	ECU	8	TROTTL	6	Stage-V only
A099	0.75	RG	FLR91X-A	Coolant temperature sensor ground	ECU	99	COOLANT TMEP	1	
A100	0.75	RW	FLR91X-A	Coolant temperature sensor signal	ECU	100	COOLANT TMEP	2	
A007	0.75	VL	FLR91X-A_T04	Fuel metering unit supply (BAT+)	ECU	7	METERING UNIT	1	
A006	0.75	W	FLR91X-A_T04	Fuel metering unit	ECU	6	METERING UNIT	2	
A020	0.75	O	FLR91X-A_BS01	Crankshaft speed sensor signal plus	ECU	20	CRANK	1	
A021	0.75	P	FLR91X-A_BS01	Crankshaft speed sensor signal minus	ECU	21	CRANK	2	
A057	0.75	B	FLR91X-A	Crankshaft sensor ground	ECU	57	CRANK	3	
A051	0.75	B	FLR91X-A	Camshaft speed sensor ground	ECU	51	CAM	1	
A052	0.75	Brn	FLR91X-A	Camshaft speed sensor signal	ECU	52	CAM	2	
A037	0.75	R	FLR91X-A	Camshaft speed sensor supply	ECU	37	CAM	3	
A095	0.75	B	FLR91X-A	TMAP sensor ground	ECU	95	TMAP	1	
A061	0.75	G	FLR91X-A	TAMP sensor signal (Temp)	ECU	61	TMAP	2	
A038	0.75	R	FLR91X-A	TAMP sensor supply	ECU	38	TMAP	3	
A101	0.75	GrL	FLR91X-A	TAMP sensor signal (Pres)	ECU	101	TMAP	4	
A014	0.75	R	FLR91X-A	Oil pressure sensor supply	ECU	14	OIL PRES	3	
A035	0.75	B	FLR91X-A	Oil pressure sensor ground	ECU	35	OIL PRES	2	
A036	0.75	O	FLR91X-A	Oil pressure sensor input signal	ECU	36	OIL PRES	1	
A064	1.5	B	FLR91X-A_T05	Injector 1 "high"	ECU	64	INJECTOR#1	1	
A085	1.5	RW	FLR91X-A_T05	Injector 1 "low"	ECU	85	INJECTOR#1	2	
A024	1.5	RG	FLR91X-A_T06	Injector 2 "high"	ECU	24	INJECTOR#2	1	
A45	1.5	B	FLR91X-A_T06	Injector 2 "low"	ECU	45	INJECTOR#2	2	

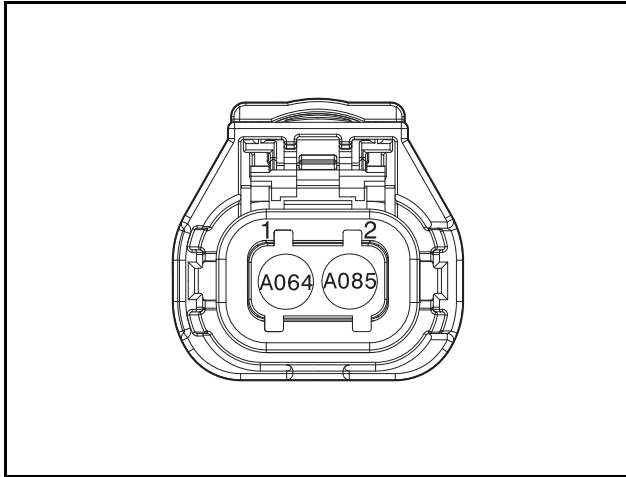
## 11. Electrical System

Circuit No.	SQ	Color	Type	Description	To		From		Remark
A022	1.5	RG	FLR91X-A_T07	Injector 3 "high"	ECU	22	INJECTOR#3	1	
A043	1.5	RV	FLR91X-A_T07	Injector 3 "low"	ECU	43	INJECTOR#3	2	
A066	1.5	RY	FLR91X-A_T08	Injector 4 "high"	ECU	66	INJECTOR#4	1	
A087	1.5	B	FLR91X-A_T08	Injector 4 "low"	ECU	87	INJECTOR#4	2	
A033	0.75	O	FLR91X-A	Exhaust gas temperature sensor ground	ECU	33	EGT	1	Stage-V only
A059	0.75	P	FLR91X-A	Exhaust gas temperature sensor signal	ECU	59	EGT	2	Stage-V only
S87	0.75	R	FLR91X-A	Oil level sensor supply	OIL LEVEL	1	INTER	1	Option
K070	0.75	B	FLR91X-A	Oil level sensor ground	OIL LEVEL	2	INTER	3	Option
K069	0.75	G	FLR91X-A	Oil level sensor input signal	OIL LEVEL	3	INTER	4	Option
A093	0.75	Lgra	FLR91X-A	Glow plug relay	ECU	93	INTER	2	

## Switches and Sensors

### Injector#1

A part that injects fuel according to the injection signal received from the ECU.

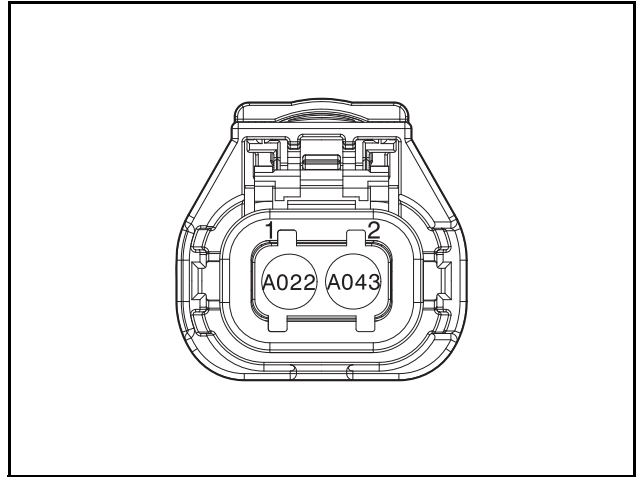


ED24190081

No	ECU Pin	Description
1	64	Injector 1 "High"
2	85	Injector 1 "Low"

### Injector#3

A part that injects fuel according to the injection signal received from the ECU.

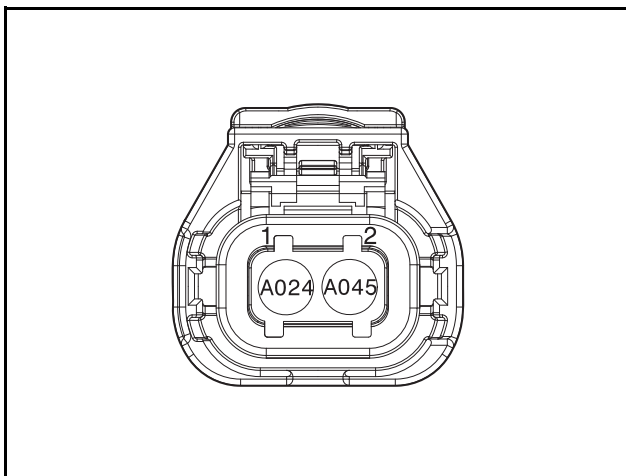


ED24190083

No	ECU Pin	Description
1	22	Injector 3 "High"
2	43	Injector 3 "Low"

### Injector#2

A part that injects fuel according to the injection signal received from the ECU.

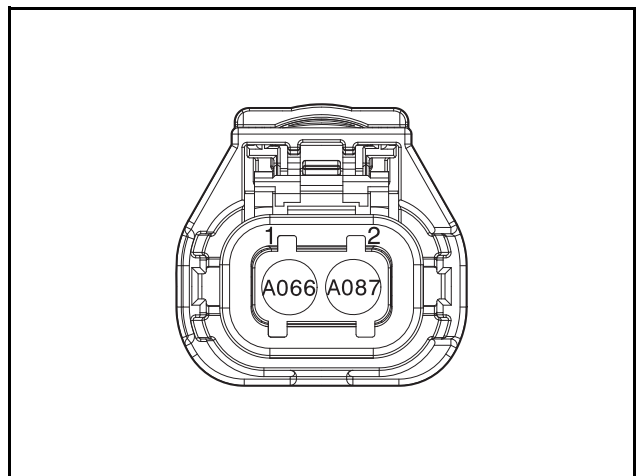


ED24190082

No	ECU Pin	Description
1	24	Injector 2 "High"
2	45	Injector 2 "Low"

### Injector#4

A part that injects fuel according to the injection signal received from the ECU.



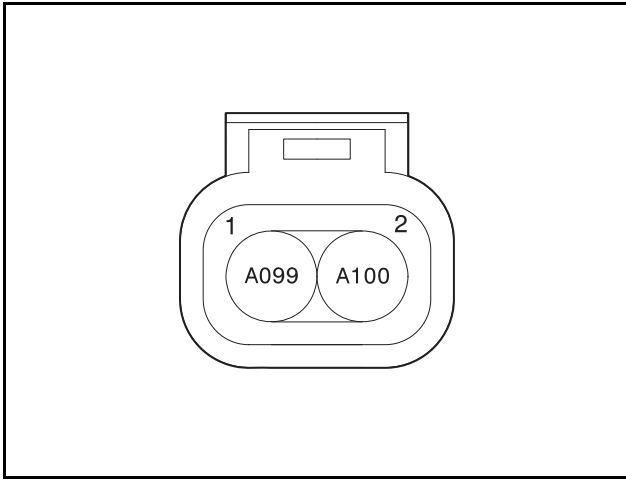
ED24190084

No	ECU Pin	Description
1	66	Injector 4 "High"
2	87	Injector 4 "Low"

# 11. Electrical System

## Coolant Temperature Sensor (COOLANT TEMP)

A sensor that senses the temperature of engine cooling water.

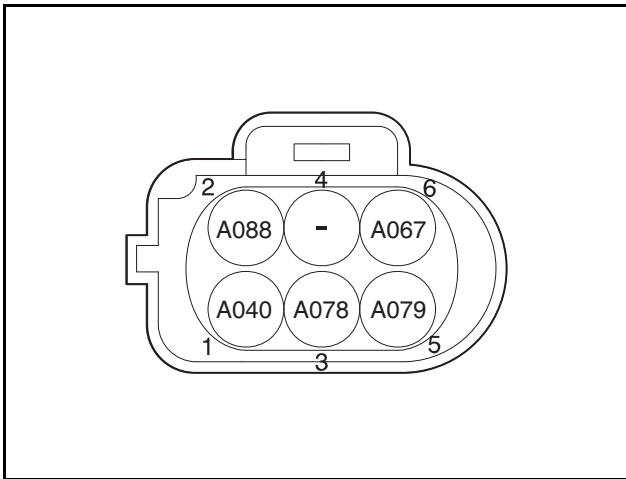


ED24190085

No	ECU Pin	Description
1	99	Coolant temperature sensor ground
2	100	Coolant temperature sensor signal

## Exhaust Gas Recirculation Valve Position Sensor (EGR)

A sensor used to reduce nitrogen oxide (NOx) from the exhaust gas. It recirculates some of the exhaust gas from the engine to the intake side. In this way, the combustion temperature is reduced and the discharged NOx is reduced.



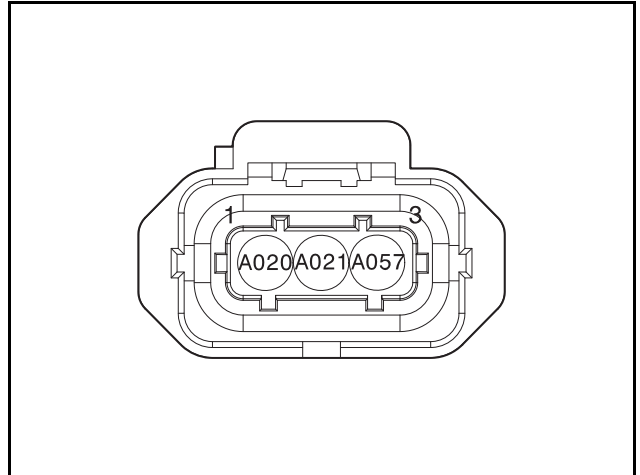
EDM03190325

No	ECU Pin	Description
1	40	EGR position sensor supply
2	88	EGR motor minus
3	78	EGR position sensor ground

No	ECU Pin	Description
5	79	EGR position sensor signal
6	67	EGR motor plus

## Crank Shaft Position Sensor (CRANK)

A sensor that senses the position of the crankshaft in order to sense the engine rotation speed and the position of the piston.



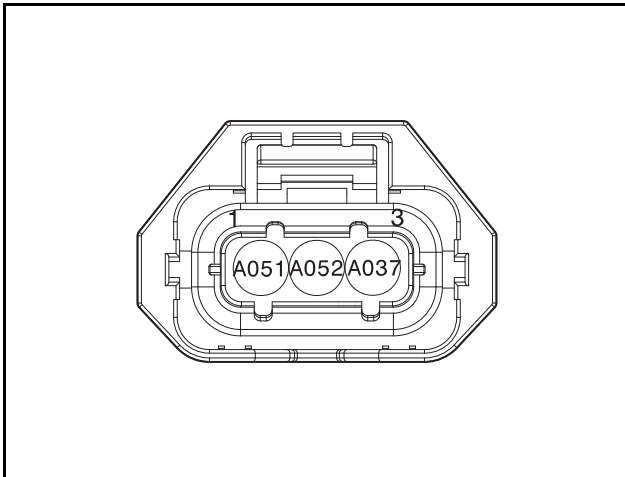
ED24190087

No	ECU Pin	Description
1	20	Crankshaft speed sensor signal plus
2	21	Crankshaft speed sensor signal minus
3	57	Crankshaft sensor ground



## CAM Shaft Position Sensor (CAM)

A sensor that senses the position of the camshaft, allowing it to check the position of each piston by using the reference points with the same basis of the crank shaft position sensor which cannot check the position of each piston.

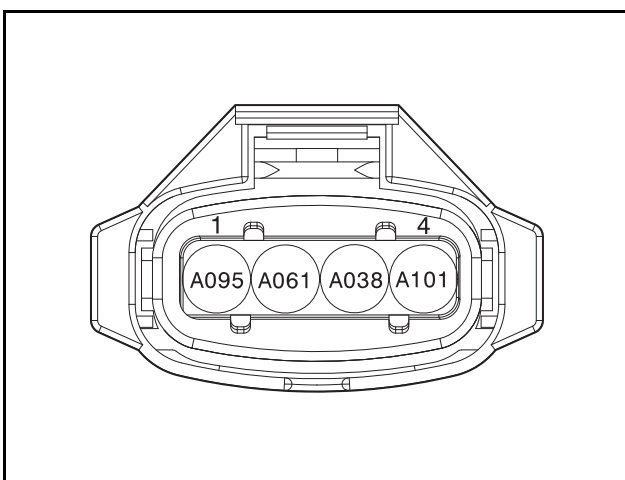


ED24190088

No	ECU Pin	Description
1	51	Camshaft speed sensor ground
2	52	Camshaft speed sensor signal
3	37	Camshaft speed sensor supply

## Temperature Manifold Absolute Pressure Sensor (TMAP)

A sensor that measures the pressure and the temperature of air in the intake manifold.



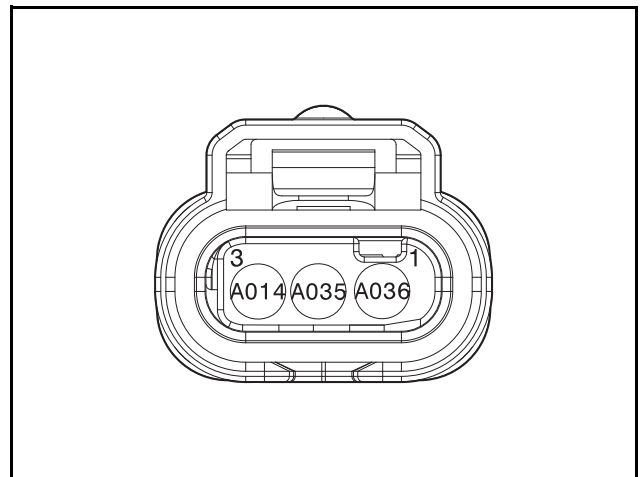
ED24190089

No	ECU Pin	Description
1	95	TMAP sensor ground
2	61	TMAP sensor signal (Temp)

No	ECU Pin	Description
3	38	TMAP sensor supply
4	101	TMAP sensor signal (Pres)

## Oil Pressure Sensor (OIL PRES)

A sensor that measures the pressure of engine oil in the main gallery.



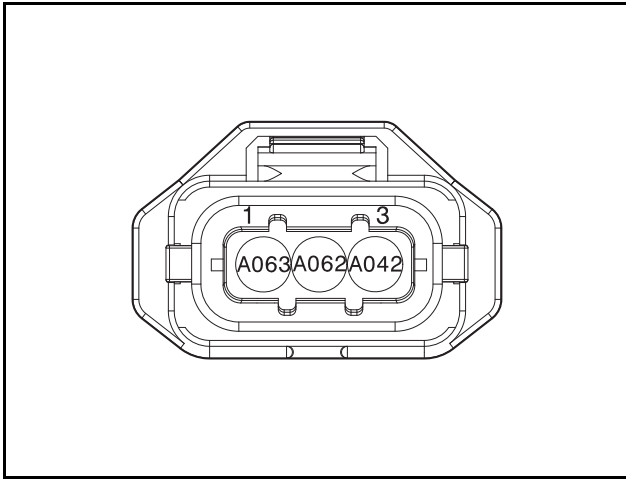
ED24190090

No	ECU Pin	Description
1	36	Oil pressure sensor input signal
2	35	Oil pressure sensor ground
3	14	Oil pressure sensor supply

# 11. Electrical System

## Rail Pressure Sensor (RPS)

A sensor that is installed at the end of the common rail, measuring the instantaneous internal pressure of the common rail.

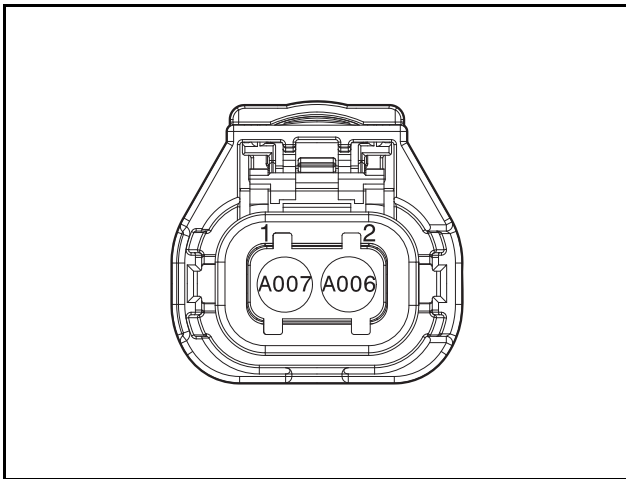


ED24190091

No	ECU Pin	Description
1	63	Rail pressure sensor ground
2	62	Rail pressure sensor signal
3	42	Rail pressure sensor supply

## Fuel Metering Unit (METERING UNIT)

A valve mounted on the high-pressure pump. It adjusts the fuel volume pumped from the pump to the rail to control the fuel pressure on the rail.

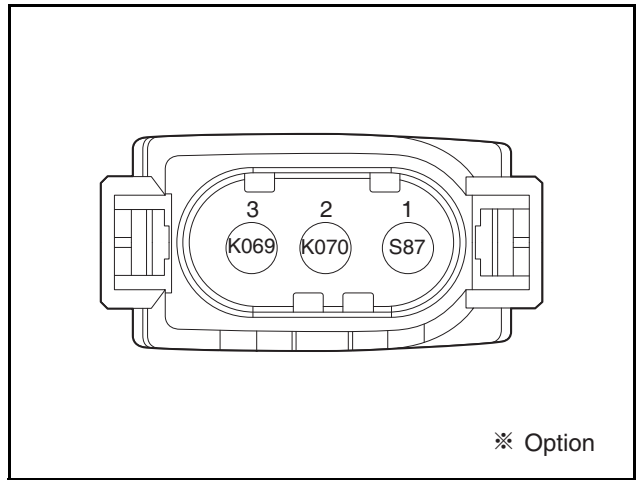


ED24190092

No	ECU Pin	Description
1	7	Fuel metering unit supply (BAT+)
2	6	Fuel metering unit

## Oil Level Sensor (OIL LEVEL)

A sensor that measures the level of engine oil in the oil pan.



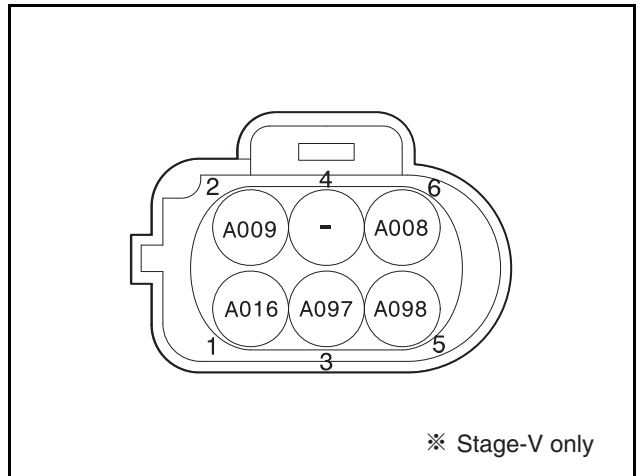
※ Option

EDM03190326

No	-	Description
1	Inter 1	Oil level sensor supply
2	Inter 3	Oil level sensor ground
3	Inter 4	Oil level sensor input signal

## Throttle Valve Actuator/Position Sensor

Throttle Valve measures real value of valve angle for PID control by ECU.



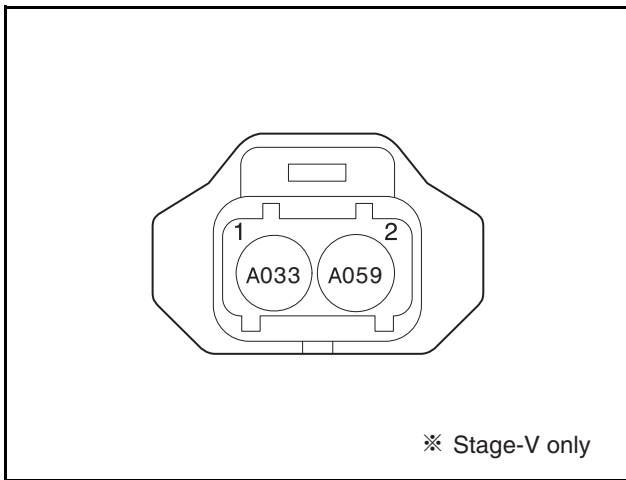
※ Stage-V only

EDM02190171

No	ECU Pin	Description
1	16	Throttle position sensor supply
2	9	Throttle plate actuator motor minus
3	97	Throttle plate actuator feedback ground
5	98	Throttle plate actuator feedback signal
6	8	Throttle plate actuator motor plus

## Exhaust Gas Temperature Sensor (EGT)

A sensor that measures the temperature of exhaust gas in the exhaust manifold.



EDM02190170

No	ECU Pin	Description
1	33	Exhaust gas temperature sensor ground
2	59	Exhaust gas temperature sensor signal

# 11. Electrical System

---

## Wire Harness

### Removing the Wire Harness

1. Disconnect the connectors linked to each sensor.
2. Remove the mounting bolts connected to the wire harness bracket.
3. Remove the wire harness.

### Assembling the Wire Harness

1. Assemble the wire harness.
2. Install the mounting bolts connected to the wire harness bracket.
3. Connect the connectors to each sensor.

## Engine Control Unit (ECU)

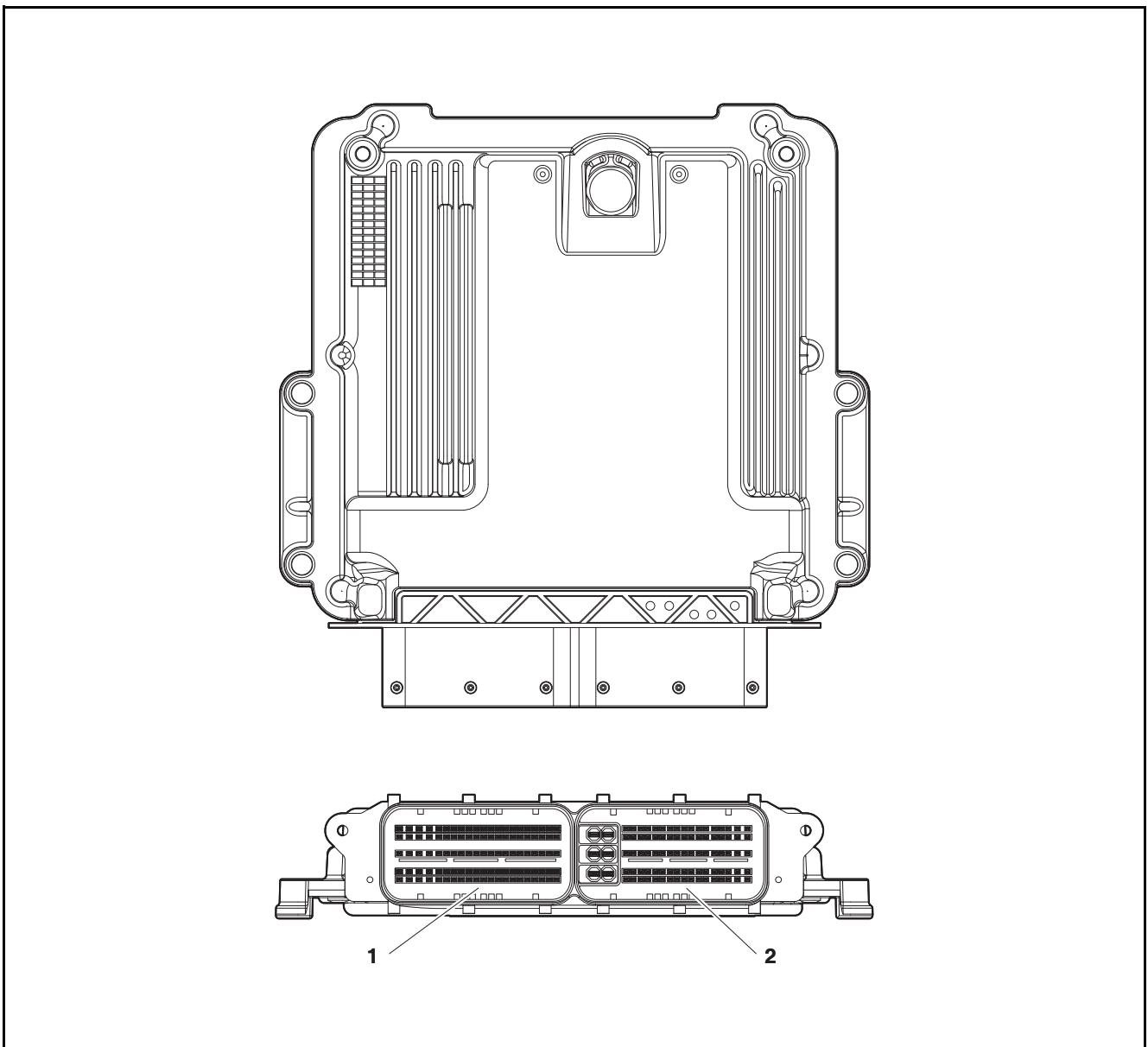
### General Information

The engine control unit (ECU) is used to control fuel delivery. The engine control unit is connected to various types of sensors and provides control based on the values received from these sensors to enable the engine to run in an optimal state.

In cases where the connectors of the engine control unit must be disconnected, be sure to disconnect the negative (ground) terminal of the battery cable first. Do not disassemble the inside of the engine control unit (ECU).

### Engine Control Unit (ECU) Connector

The connectors of the engine control unit (ECU) are divided into connectors for connections to the vehicle and connectors for connections to the engine.

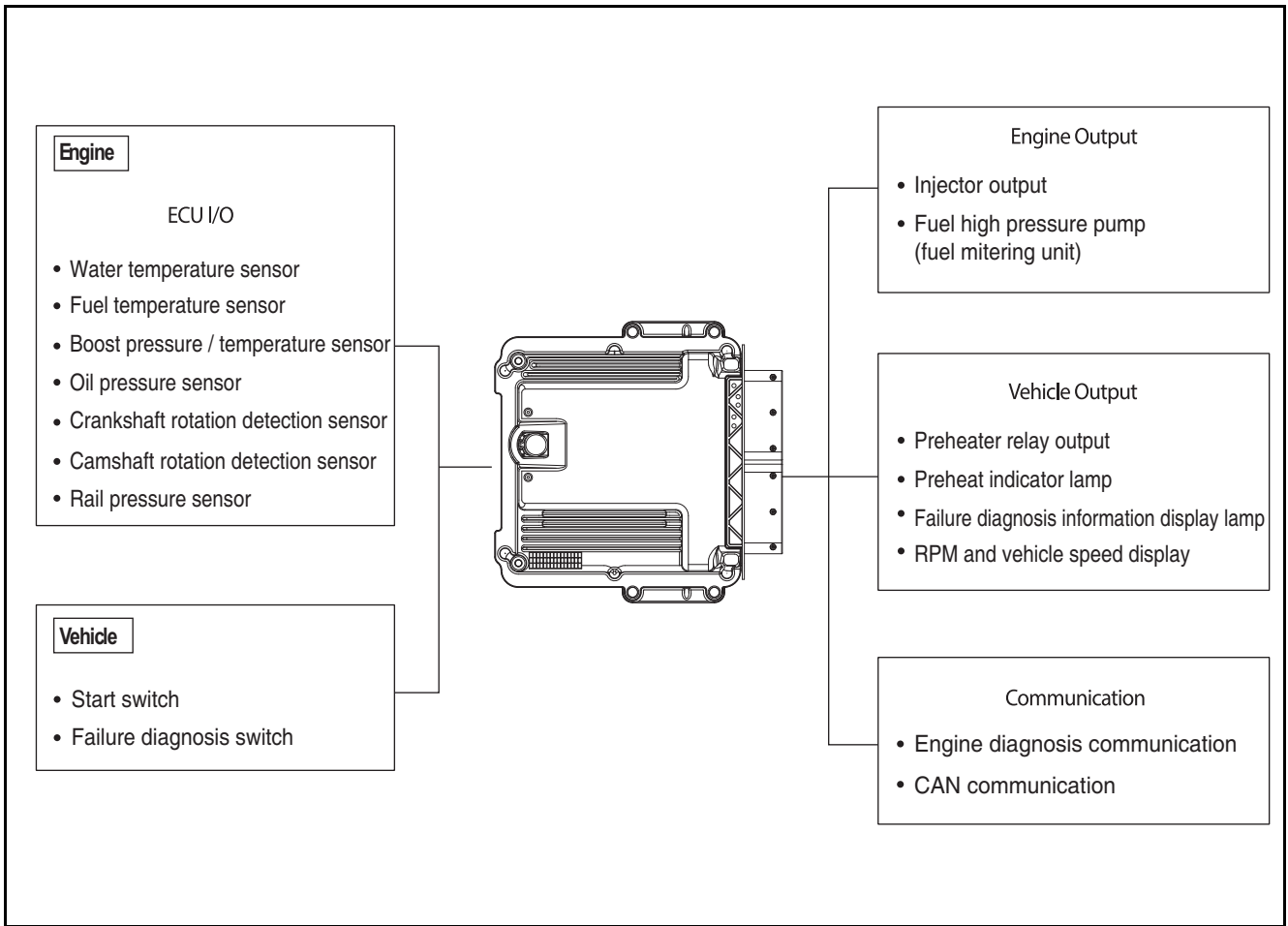


EDM03190095

1. Connectors for Connections on the Engine
2. Connectors for Connections on the Vehicle

# 11. Electrical System

## Engine Control Unit (ECU) Input/Output



EDM03190096



## Engine Control Unit (ECU) Operating Conditions

### 1. Starting the Engine

- 1) Sets the lowest value among the coolant temperature, fuel temperature, intake air temperature and oil temperature as the reference temperature in order to set the reference temperature for determining whether to preheat the engine.
- 2) Sets the reference temperature based on the engine coolant temperature in order to set the reference temperature for determining the amount of fuel.
- 3) Delivers fuel to the engine after determining a suitable amount of fuel for starting the engine, then uses the crankshaft rotation sensor to measure the engine rpm signal.

### 2. Driving the Vehicle

- 1) Calculates the necessary data required for driving the vehicle, such as the CAN data and engine rpm transmitted from the vehicle control unit.

### 3. Adjusting the Engine RPM Demanded by the Operator

- 1) Controls the engine rpm based on the demands of the operator and the vehicle control unit controls the engine so that the required engine rpm meets the demands.

### 4. Limp Home Function

- 1) This function enables the vehicle to be driven safely to a service center under the minimum conditions required for running the vehicle when a fault code occurs.
- 2) The Limp Home function activates under the following conditions.
  - Malfunctioning accelerator pedal : The vehicle drives at a constant engine rpm regardless of whether the accelerator pedal is pushed.
  - Malfunctioning sensor : The vehicle is driven with consistent alternate values in the event that a fault occurs in the various sensors.
  - Restricted power : Restricts the amount of fuel delivered to the engine depending on the type of fault. There are a total of four levels. The more severe the fault, the more the amount of fuel is restricted.
  - Diagnostic information output lamp : Provides information about the current state of faults to the operator to enable safe driving.

### 5. Troubleshooting

- 1) If a fault occurs, the troubleshooting information output lamp on the gauge panel activates.
- 2) You can use the troubleshooting information output lamp to check the fault code.

Note: You can use the troubleshooting information on the gauge panel to check.

- 3) You can connect a diagnostic device to the check connector on the back of the driver's seat to diagnose the fault.

### 6. Driving Record

- 1) Records information about driving in the engine control unit.
- 2) The fuel consumption rate, period of engine use, period of use of the engine control unit, etc. are recorded in the engine control unit.
- 3) You can use the ECU diagnostic system to monitor the vehicle.

# 11. Electrical System

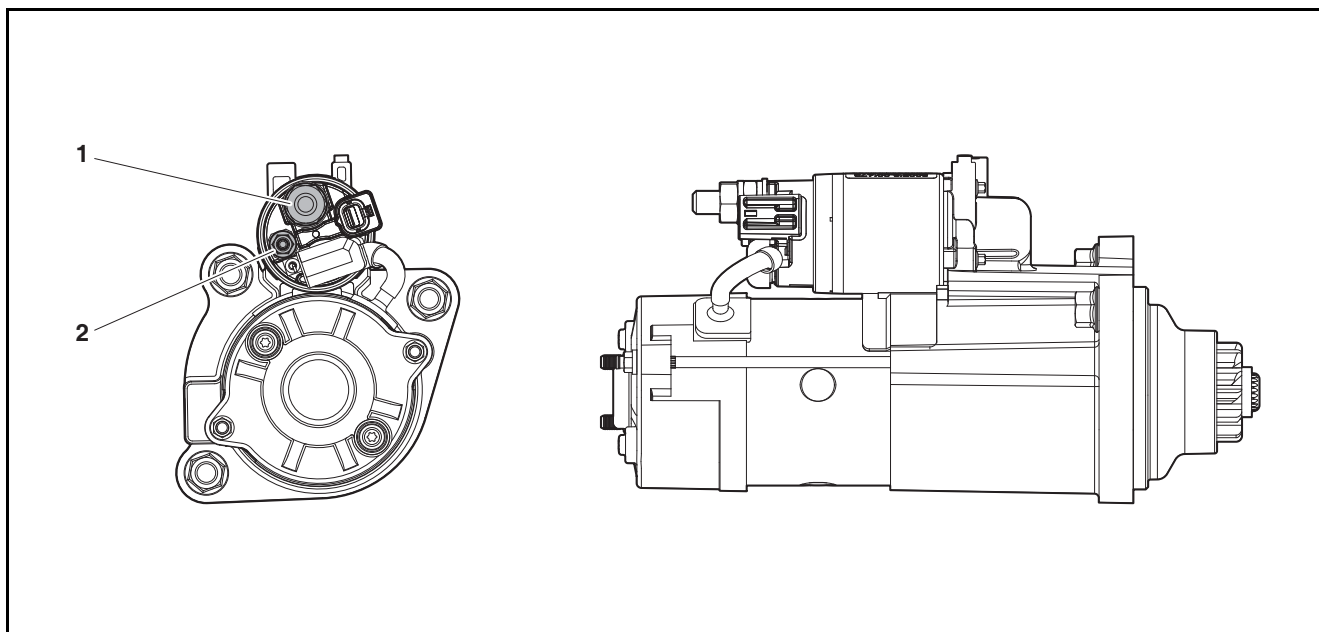
---

## Starter

### General Information

The starter motor is installed behind the flywheel housing.  
When disassembling the engine, soak the starter motor pinion gear and ring gear in fuel and clean them thoroughly with a brush. Then, apply grease to them to prevent rust.

**12 V X 2.5 kW**



EDM03190163

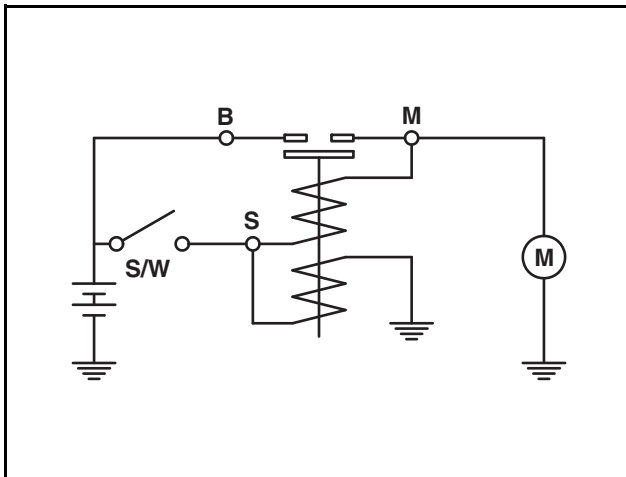
1. B Terminal : M10 X 1.5P

2. S/W Terminal : M5 X 0.8P

## Specifications

Item	Specifications		Remarks
	DM03-MFP04	DM03-LEP04	
Starter Motor	Power	12 V, 2.5 kW	
	No. of teeth on pinions	12	
	Terminal voltage	11 V	No-load characteristics
	Max. current	170 A	No-load characteristics
	Minimum speed	3,000 rpm	No-load characteristics

## Circuit Diagram



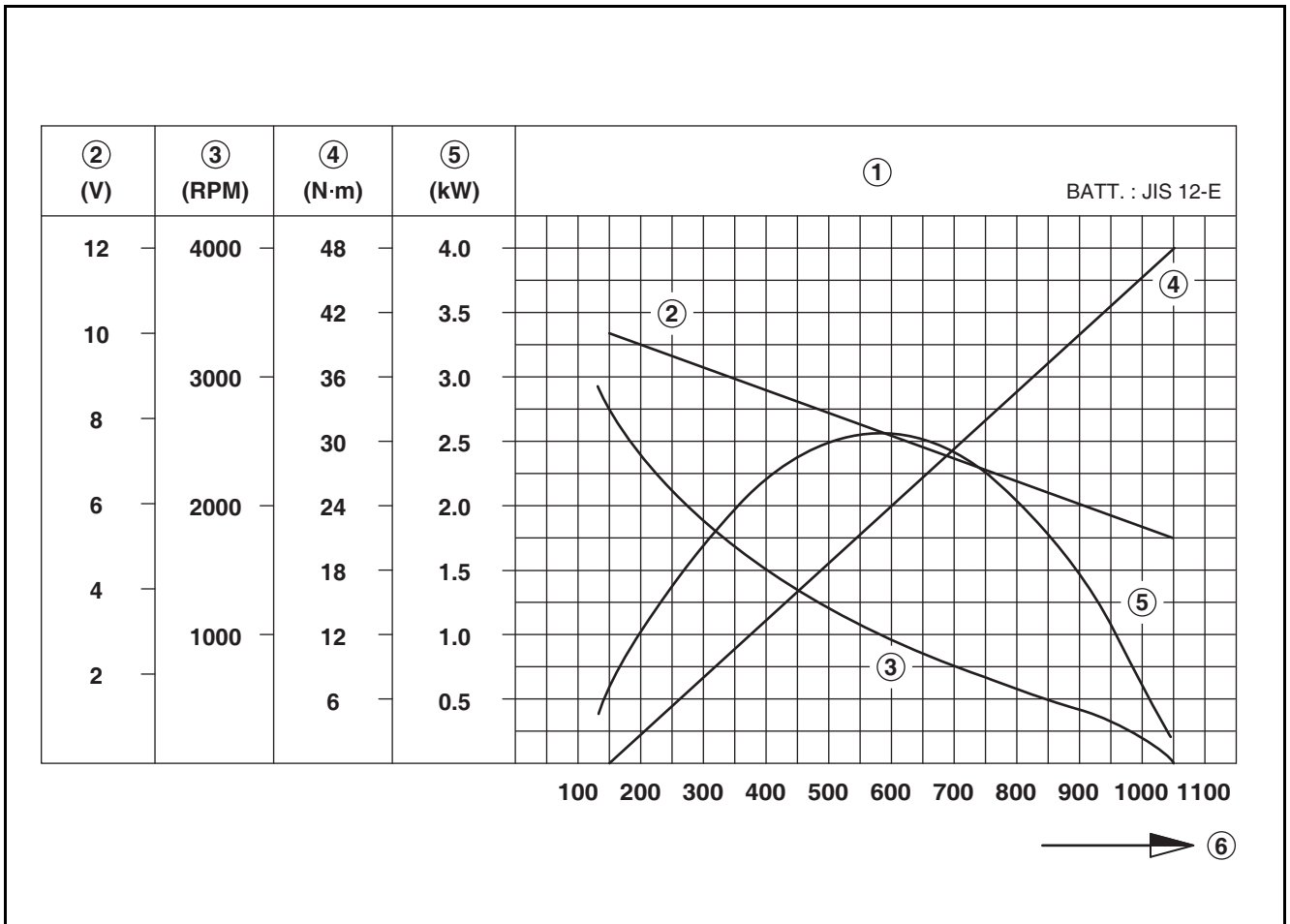
EDM03190192

### CAUTION

Before working on any electrical systems, disconnect the negative battery cable (ground cable). To prevent a short circuit while working, connect the ground cable after the work is complete.

# 11. Electrical System

## Starter Motor Performance Curve



EDM03190193

1. Nominal performance

2. Voltage (V)

3. Speed (RPM)

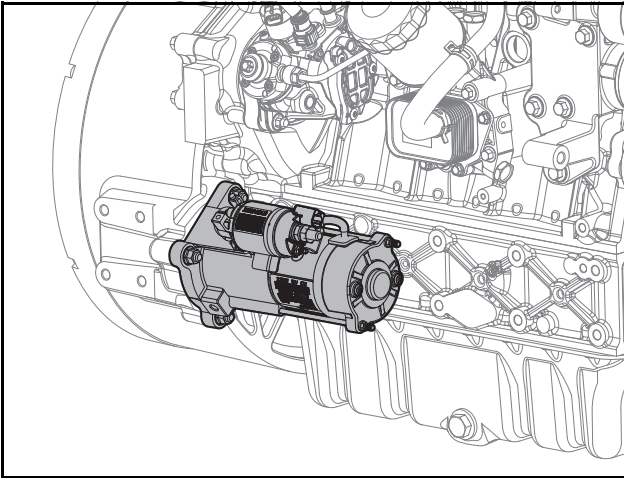
4. Torque (N·m)

5. Output (kW)

6. Load current

## Removing the Starter Motor

1. Remove the starter motor.

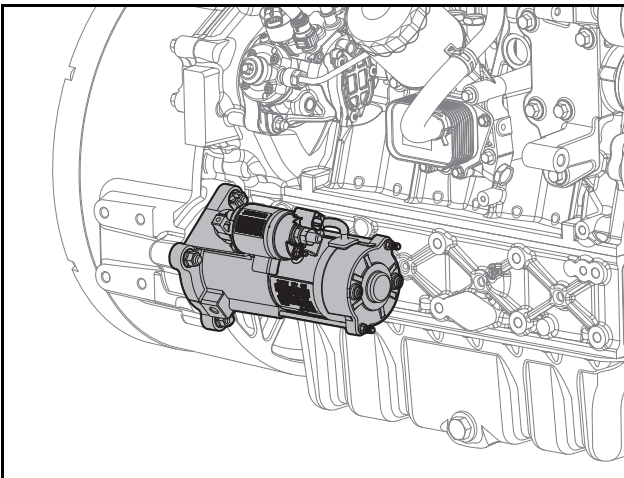


EDM03190242

- 1) Turn and loosen the flange nut.
- 2) Remove the starter motor.

## Assembling the Starter Motor

1. Assemble the starter motor.



EDM03190242

- 1) Align the starter motor with the stud bolts and assemble it.
- 2) Tighten the flange nuts to a tightening torque of 4.4 kgf·m.

# 11. Electrical System

---

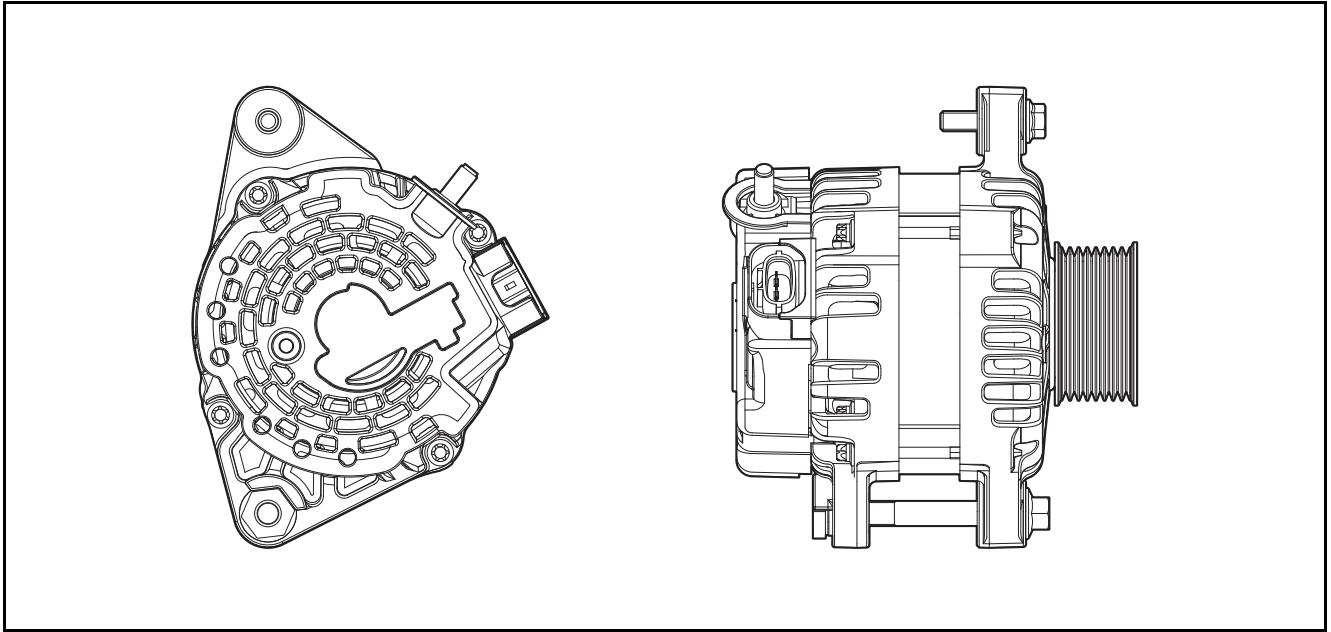
## Alternator

### 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.

13.5 V X 110 A

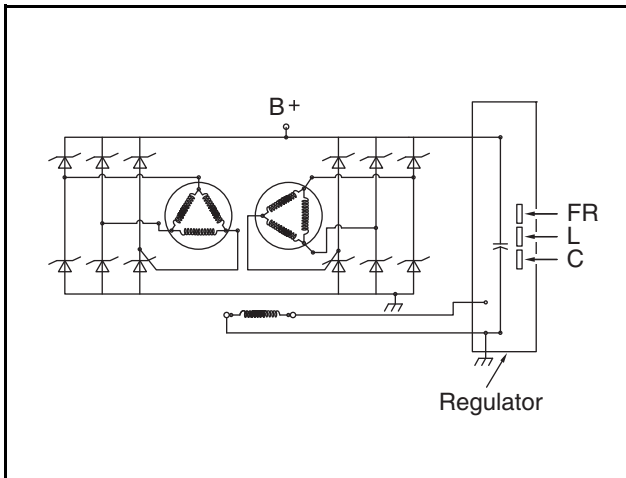


EDM03190162



## Wiring Diagram

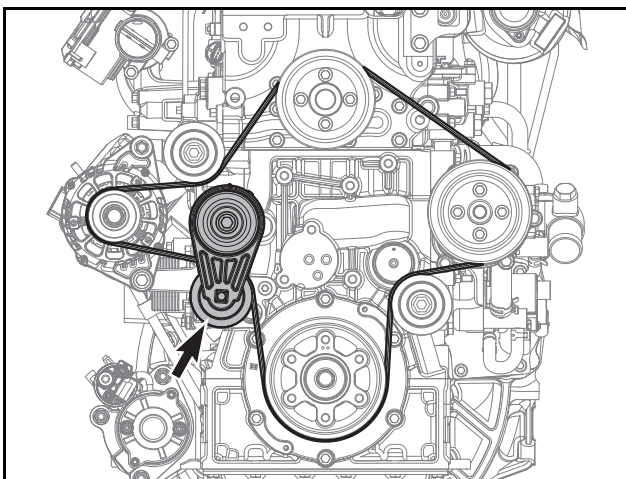
The alternator is maintenance-free, nevertheless, it must be protected against dust and, above all, against moisture and water.



EDM03190194

## Disassembly of Alternator

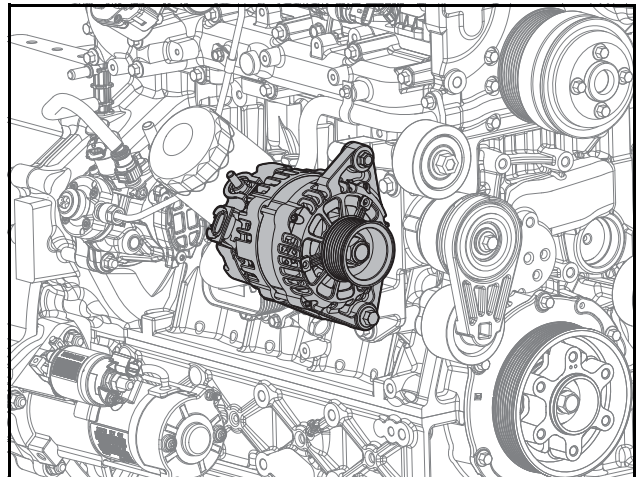
1. Remove the V-belt.



EDM03190231

- 1) Turn the auto tensioner counterclockwise by using a quadrangular groove at the top of the auto tensioner pulley (Use a 10 mm x 10 mm quadrangular tool).
- 2) Remove the belt wound around the auto tensioner pulley by using a space generated by the rotation of the auto tensioner.

2. Detach the alternator.

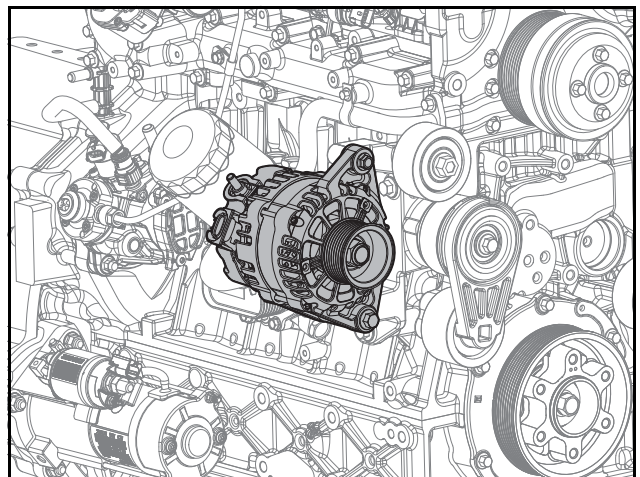


EDM03190243

- 1) Loosen the upper/lower bolt and remove the alternator.
- 2) When loosening bolt, take care not to lose nut.

## Assembly of Alternator

1. Attach the alternator.



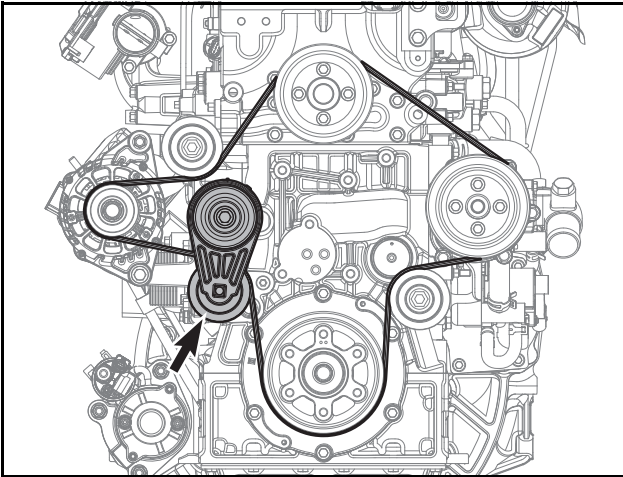
EDM03190243

- 1) Using bolt B and nut, attach the alternator temporarily.
- 2) By tightening bolt, set the position of the alternator properly.
- 3) Tighten upper bolt to a torque of  $2.2 \pm 0.2$  kgf·m.
- 4) Tighten lower bolt to a torque of  $6.2 \pm 0.6$  kgf·m.

## 11. Electrical System

---

2. Attach the V-belt.



EDM03190231

- 1) Wind a new belt around all pulleys except for the auto tensioner.
- 2) Turn the auto tensioner counterclockwise by using a quadrangular groove at the top of the auto tensioner pulley (Use a 10 mm x 10 mm quadrangular tool).
- 3) Wind the belt around the auto tensioner pulley by using a space generated by the rotation of the auto tensioner, and then naturally release the tensioner that has been pulled counterclockwise.

---

### CAUTION

**For checking and measuring the belt tension, refer to Belt Tension in Chapter 12 (Others/Driving Units).**

---

# 12. Other/Driving System

<b>General Information .....</b>	<b>247</b>
General Information .....	247
Specifications .....	248
<b>Crankshaft .....</b>	<b>249</b>
Removing the Crankshaft .....	249
Assembling the Crankshaft .....	249
Measuring the Diameter of the Crankshaft Main Journal .....	249
Measuring the Crankshaft Bearing Clearance .....	249
Measuring the Deflection of the Crankshaft .....	250
Disassembling the Timing Wheel .....	250
Assembling the Timing Wheel .....	251
<b>Piston .....</b>	<b>254</b>
Disassembling the Pistons .....	254
Assembling the Pistons .....	254
Measuring the Inside Diameter of the Piston Pin Bore in Pistons .....	255
Measuring the Step Height of the Piston Top Side .....	255
Measuring the Piston Ring End Gap .....	255
Measuring the Outside Diameter of the Piston Pin .....	256
<b>Connecting Rod .....</b>	<b>257</b>
Disconnecting the Connecting Rod .....	257
Assembling the Connecting Rod .....	257
Measuring the Inside Diameter of the Connecting Rod Small End .....	257
Measuring the Inside Diameter of the Connecting Rod Big End .....	257
Measuring the Connecting Rod Big End Clearance .....	258
<b>Crankshaft Pulley .....</b>	<b>259</b>
Removing the Crankshaft Pulley .....	259
Assembling the Crankshaft Pulley .....	260
<b>Others .....</b>	<b>261</b>
Engine Timing .....	261
Adjusting the Engine Timing .....	262
Checking the Gear Backlash .....	262
Checking the Axial Play of Gears .....	263



### General Information

#### General Information

1. The engine pistons are cooled by the oil gallery. In piston gallery cooling, the shape of the gallery, the shape of the nozzle, the position of the nozzle and the oil flow rate are very important for lowering the temperature. The cross-sectional shape of the piston gallery is designed to achieve maximum cooling effect with efficient oil flow.
2. The crankshaft is a forged single unit. The oil seals on the crankshaft and the rear are designed to prevent oil from entering the inside of the flywheel housing.
3. The connecting rod is a single unit. Since its big end can be disconnected horizontally, it can be removed with the piston through the top of the cylinder. The moving parts of the crankshaft and connecting rod are equipped with alloy bearings.
4. The camshaft, oil pump and high-pressure injection pump are driven by the gear connections inside the timing gear case.

## 12. Other/Driving System

### Specifications

Item	Specifications		Remarks
	DM03-MFP04	DM03-LEP04	
Other/driving system			
Piston O.D.	Class A : 97.920 ~ 97.930 mm Class B : 97.930 ~ 97.940 mm		
Cylinder and piston clearance	0.060 ~ 0.080 mm		
Piston ring groove area	Top ring groove	2.415 ~ 2.445 mm	
	Second ring groove	2.060 ~ 2.080 mm	
	Oil ring groove	3.020 ~ 3.040 mm	
Piston ring side gap	Top ring	0.083 ~ 0.133 mm	
	Second ring	0.070 ~ 0.110 mm	
	Oil ring	0.030 ~ 0.070 mm	
Piston ring end gap	Top ring	0.25 ~ 0.40 mm	
	Second ring	0.55 ~ 0.70 mm	
	Oil ring	0.2 ~ 0.4 mm	
Piston pin outside diameter	35.995 ~ 36.000 mm		
Piston pin hole I.D.	36.008 ~ 36.014 mm		
Piston pin hole clearance	0.008 ~ 0.019 mm		
Connecting rod small end I.D.	36.025 ~ 36.038 mm		
Connecting rod small end hole clearance	0.025 ~ 0.043 mm		
Connecting rod big end I.D.	66.000 ~ 66.015 mm		
Connecting rod bearing oil clearance	0.026 ~ 0.066 mm		
Connecting rod end play	0.15 ~ 0.3 mm		
Crankshaft main journal O.D.	74.955 ~ 74.970 mm		
Crankshaft pin journal O.D.	62.955 ~ 62.970 mm		
Crankshaft main bearing oil clearance	0.029 ~ 0.059 mm		
Crankshaft end play	0.1 ~ 0.31 mm		



## Crankshaft

### Removing the Crankshaft

1. Remove the crankshaft.

Note: Refer to the order of engine disassembly.

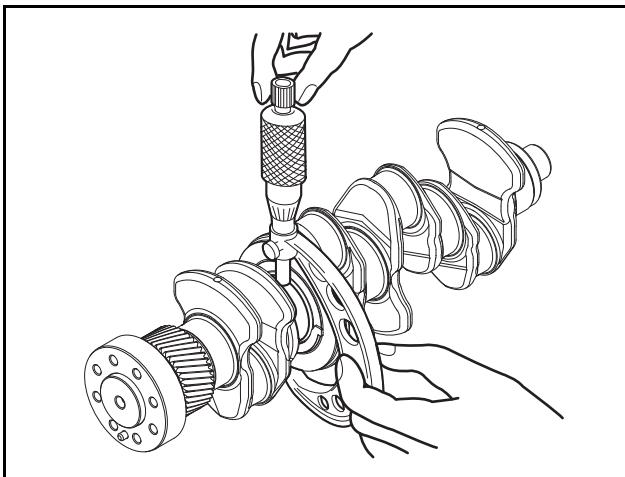
### Assembling the Crankshaft

1. Assemble the crankshaft.

Note: Refer to the order of engine assembly.

### Measuring the Diameter of the Crankshaft Main Journal

1. Check the journal and crank pin part of the crankshaft visually for scratches or cracks.
2. Perform a magnetic particle test or dye penetrant test to check the crankshaft for cracks. If there are any cracks, replace the crankshaft.
3. Set up the gauge.
4. Remove any foreign matter from the crankshaft.
5. Measure the diameter of the crankshaft main journal.



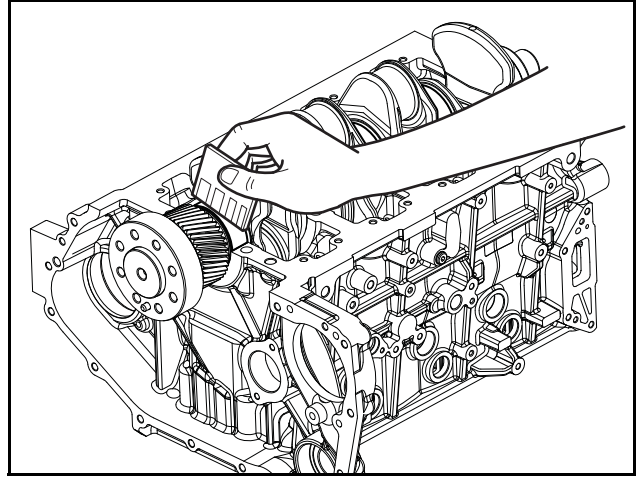
EDM03190041

- 1) Use an O.D. micrometer to measure the diameter of the crankshaft journal.
- 2) Measure a total of 20 places on the crankshaft journal: 5 places vertically, horizontally, front and back.
- 3) The measured size of the crankshaft journal outside diameter should be 74.955 ~ 74.970 mm.

Item	Specified value
Crankshaft journal diameter	74.955 ~ 74.970 mm

### Measuring the Crankshaft Bearing Clearance

1. Install the crankshaft in the cylinder block.
2. Measure the crankshaft bearing clearance.



EDM03190154

- 1) Place a plastic gauge on a total of 5 places on the crankshaft where it makes contact with the crankshaft bearing.
- 2) Assemble the crank case to the specified torque and then disassemble it.
- 3) Check the area of the plastic gauge.
- 4) The measured size of the crankshaft bearing clearance should be 0.029 ~ 0.059 mm.

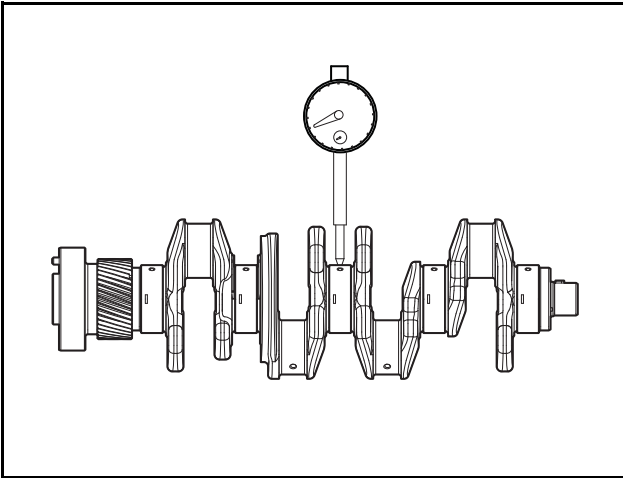
Item	Specified value
Crankshaft bearing clearance	0.029 ~ 0.059 mm

3. Remove the plastic gauge.
  - 1) Remove the plastic gauge.
  - 2) Remove any foreign matter from the cylinder block and the crankshaft.

## 12. Other/Driving System

### Measuring the Deflection of the Crankshaft

1. Measure the deflection of the crankshaft.

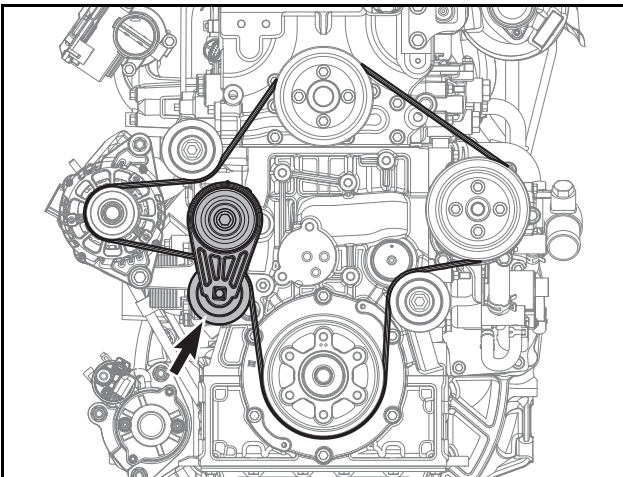


EDM03190043

- 1) Place parts #1 and #5 of the crankshaft main journal on a V-block.
- 2) Place a dial gauge on the surface plate and turn the crankshaft to measure the crankshaft deflection.
- 3) Based on main journals #1 and #5, the measured value of the crankshaft deflection should be 0.05 mm for #2, #3 and #4.

### Disassembling the Timing Wheel

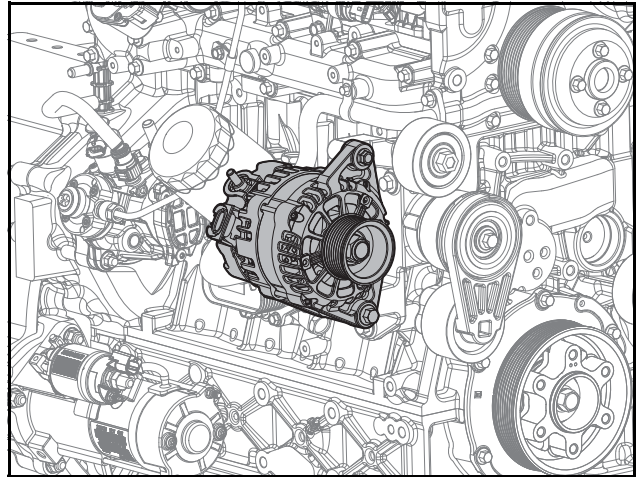
1. Remove the V-belt.



EDM03190231

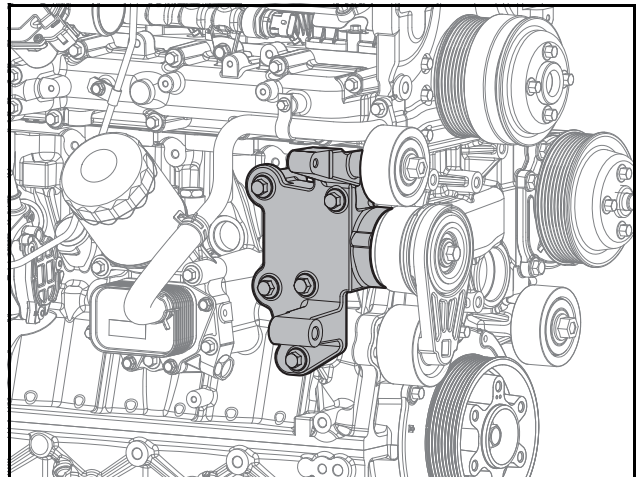
- 1) Turn the auto tensioner counterclockwise by using a quadrangular groove at the top of the auto tensioner pulley (Use a 10 mm x 10 mm quadrangular tool).
- 2) Remove the belt wound around the auto tensioner pulley by using a space generated by the rotation of the auto tensioner.

2. Detach the alternator.



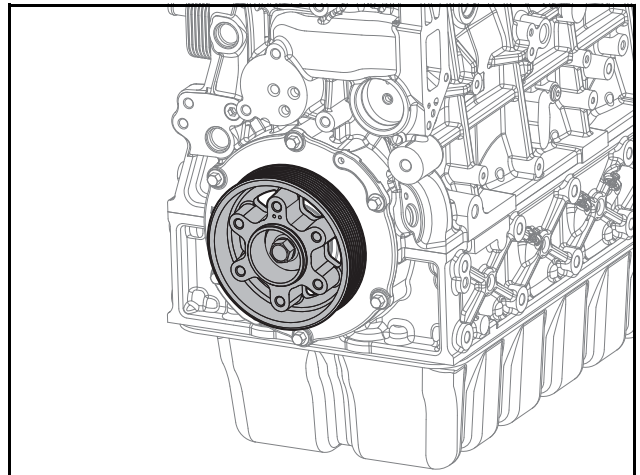
EDM03190243

- 1) Loosen the upper/lower bolt and remove the alternator.
- 2) When loosening bolt, take care not to lose nut.
3. Remove the alternator bracket.



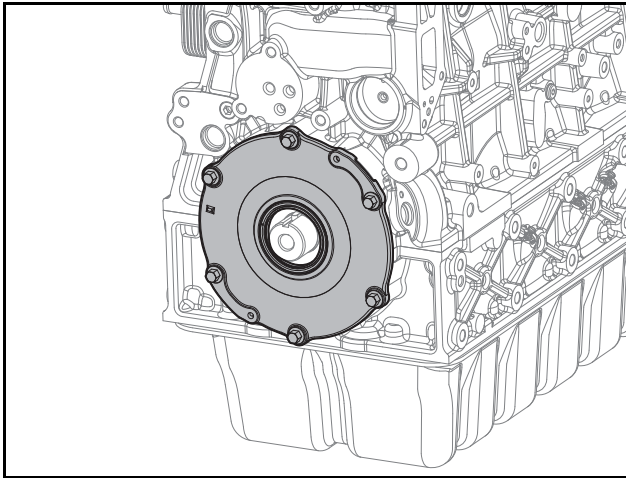
EDM03190244

- 1) Loosen 5 flange hex bolt.
- 2) Remove the alternator bracket.
4. Remove the crankshaft pulley.



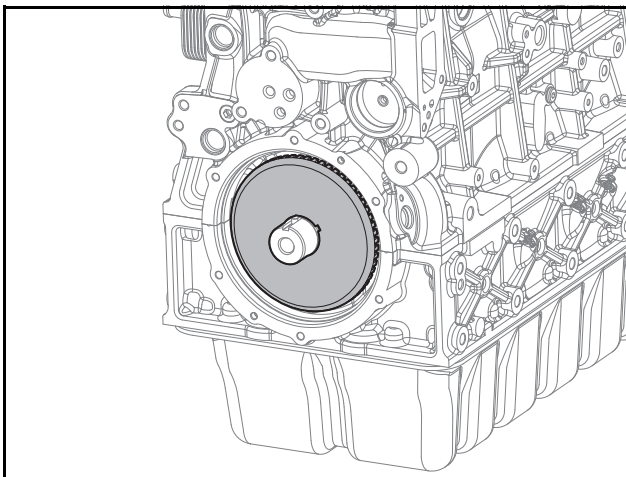
EDM03190262

- 1) Loosen the flange hex bolts.
- 2) Remove the crankshaft pulley.
5. Remove the front oil seal holder.



EDM03190141

- 1) Loosen the flange hex bolt.
- 2) Use a screwdriver in the groove to remove the front oil seal holder.
6. Remove the timing wheel.



EDM03190142

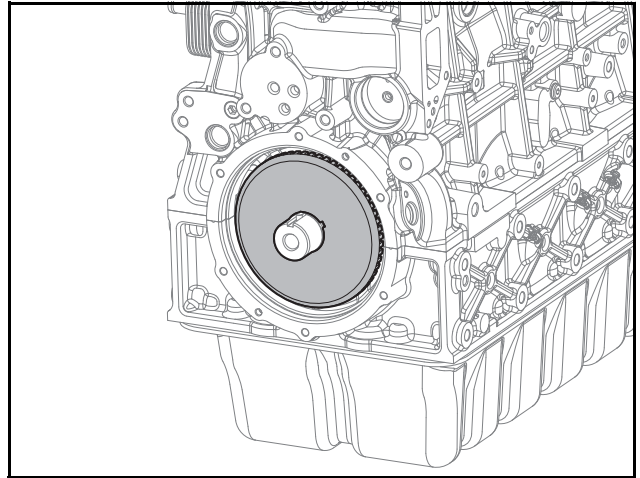
- 1) Remove the key.
- 2) Remove the timing wheel.

### CAUTION

**Be careful not to damage the teeth of the timing wheel.**

### Assembling the Timing Wheel

1. Assemble the timing wheel.



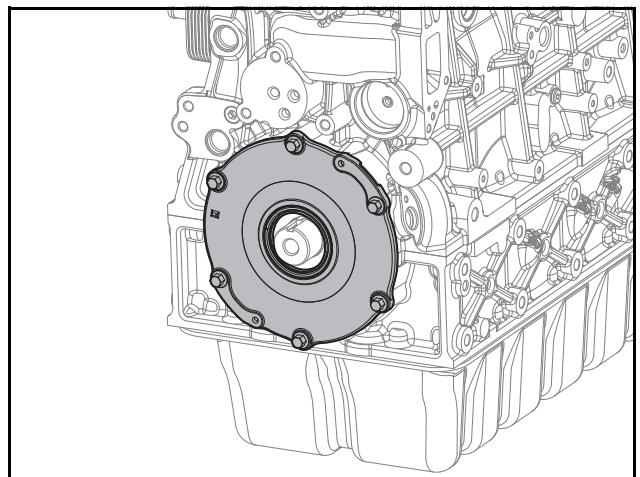
EDM03190142

- 1) Align the timing wheel with the dowel pin and assemble it with the surface of the crankshaft.
- 2) Assemble the key.

### CAUTION

- Be careful not to damage the teeth of the timing wheel.
- Assemble it so that the toothless part of the timing wheel faces the 7 o'clock direction at the front of the engine.

2. Assemble the front oil seal holder.



EDM03190141

- 1) Remove any foreign matter from the assembly surface of the front oil seal holder and wipe it clean with a dry cloth.
- 2) The sealant which had been applied before the assembly must be removed. Be careful when removing the sealant as damaging the oil seal holder may cause oil leaks.



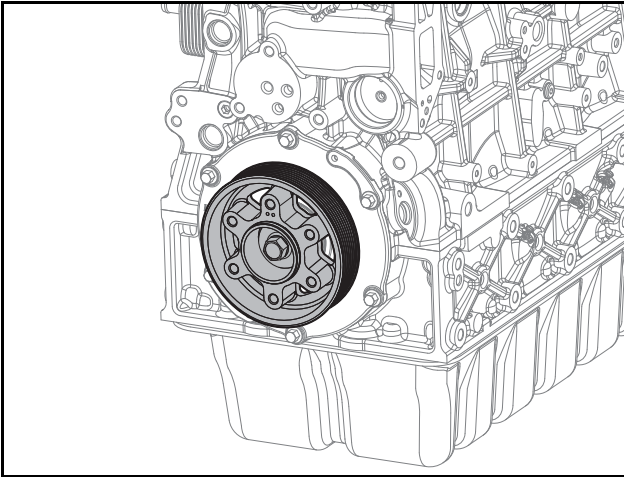
## 12. Other/Driving System

- 3) Apply sealant to the assembly surface of the front oil seal holder with a diameter of  $\varnothing 2.5 \pm 0.5$  mm.

### CAUTION

- Pay attention to the assembly direction of the front oil seal holder.
- Assemble within 5 minutes of applying sealant (TB1217H).
- Do not start the engine or apply pressure within 25 minutes of applying sealant (TB1217H).

- 4) Align the front oil seal holder with the dowel pin and assemble it.
- 5) Tighten the flange hex bolt to a tightening torque of 2.2 kgf·m.
3. Assemble the crankshaft pulley.



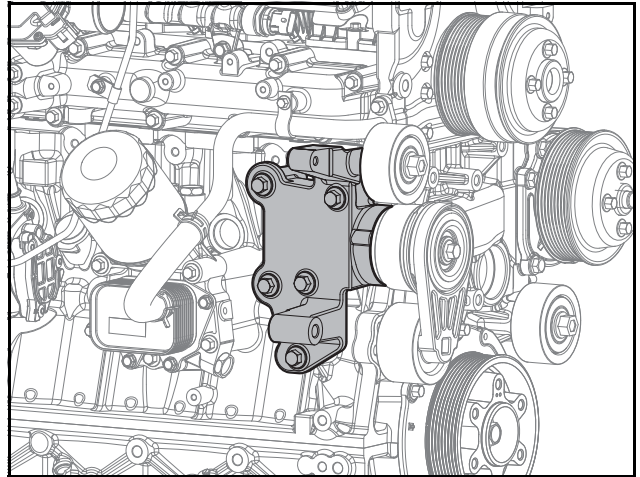
EDM03190262

- 1) Align the crankshaft pulley with the key to assemble it.
- 2) Tighten the flange hex bolt to a tightening torque of 26 kgf·m.
- 3) Connect crankshaft pulley.
- 4) Tighten the hex bolts to a tightening torque of 2.2 kgf·m.

### CAUTION

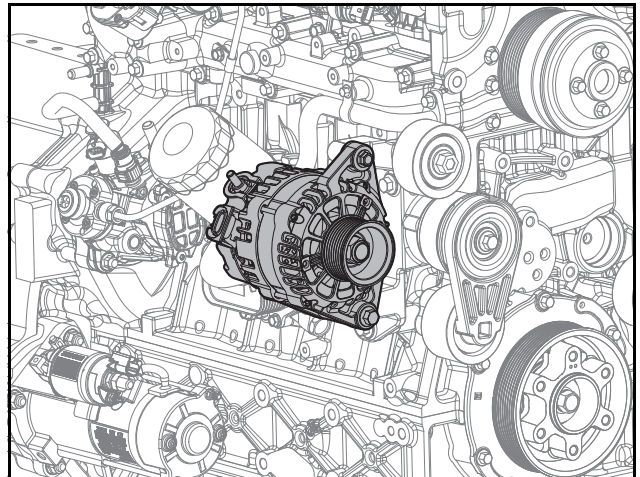
- Be careful not to damage the oil seals.
- Mount the crankshaft so that the flange hex bolts can be installed at the specified torque.

4. Assemble the alternator bracket.



EDM03190244

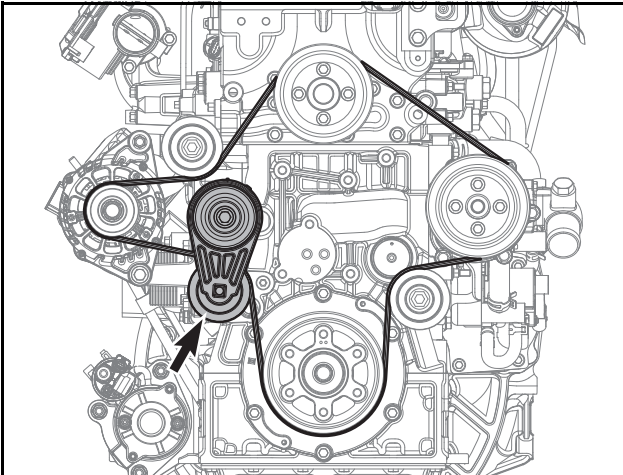
- 1) Assemble the alternator bracket.
- 2) Tighten 5 flange hex bolts to a tightening torque of  $6.2 \pm 0.6$  kgf·m.
5. Assemble the alternator.



EDM03190243

- 1) Using bolt and nut, attach the alternator temporarily.
- 2) By tightening bolt, set the position of the alternator properly.
- 3) Tighten upper bolt to a torque of  $2.2 \pm 0.2$  kgf·m.
- 4) Tighten lower bolt to a torque of  $6.2 \pm 0.6$  kgf·m.

### 6. Assemble the V-belt.



EDM03190231

- 1) Wind a new belt around all pulleys except for the auto tensioner.
- 2) Turn the auto tensioner counterclockwise by using a quadrangular groove at the top of the auto tensioner pulley (use a 10 mm x 10 mm quadrangular tool).
- 3) Wind the belt around the auto tensioner pulley by using a space generated by the rotation of the auto tensioner, and then naturally release the tensioner that has been pulled counterclockwise.

---

### CAUTION

**For checking and measuring the belt tension, refer to Belt Tension in Chapter 12 (Others/Driving Units).**

---

## 12. Other/Driving System

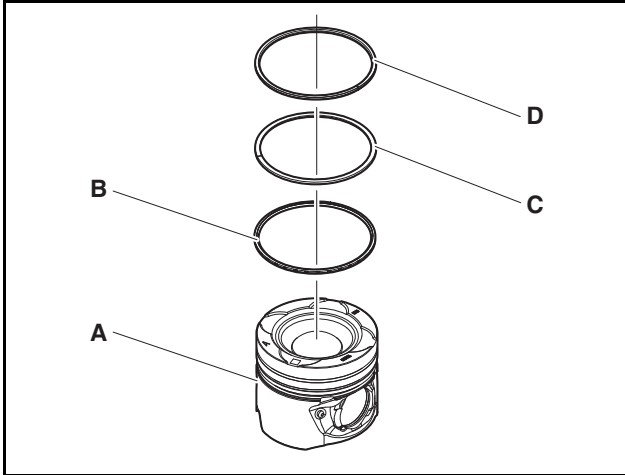
### Piston

#### Disassembling the Pistons

1. Remove the pistons (A).

Note: Refer to the order of engine disassembly.

2. Remove the piston rings.

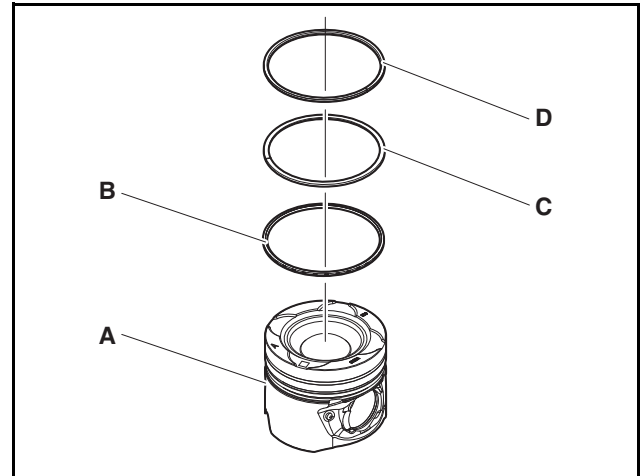


EDM03190269

- 1) Use piston ring pliers to remove the top ring (D), second ring (C) and oil ring (B).

#### Assembling the Pistons

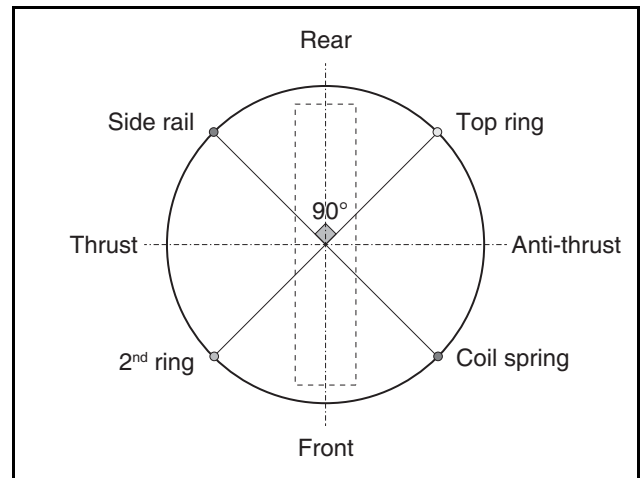
1. Assemble the piston ring.



EDM03190269

- 1) Use piston ring pliers to assemble the top ring (B), second ring (C) and oil ring (D).
2. Assemble the pistons (A).

Note: Refer to the order of engine assembly.



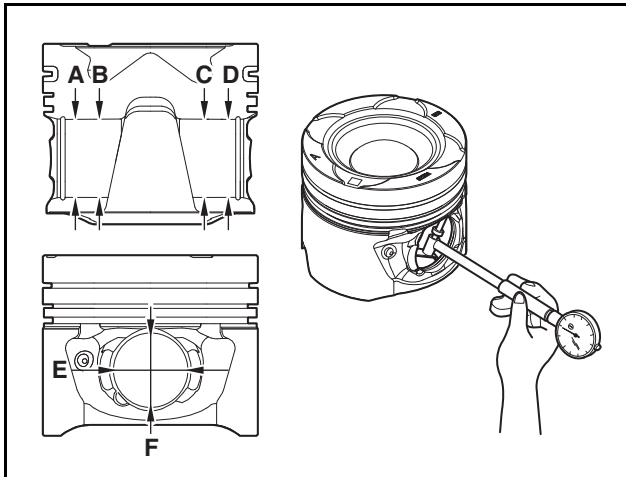
EDM03190321

- 1) Top and 2nd ring should be assembled into the mating ring grooves with upper mark "manufacturer mark" upward
- 2) Ring end gap should be set downwards during assembly.
- 3) Snap ring should be assembled in front side of piston pin hole.



## Measuring the Inside Diameter of the Piston Pin Bore in Pistons

1. Set up the gauge.
2. Measure the inside diameter of the piston pin bore of the piston.



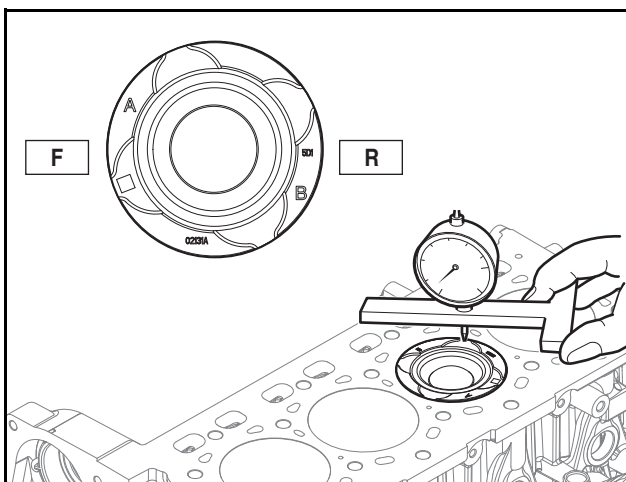
EDM03190271

- 1) Measure the inside diameter of the piston pin bore of the piston in a total of 8 places: vertical (E), horizontal (F), and A, B, C, D.
- 2) Measure all 4 piston pin bores in the pistons.
- 3) The measured size of the piston pin bore I.D. of the pistons should be 36.008 ~ 36.014 mm.

Item	Specified value
Inside diameter of the piston pin bore in pistons	36.008 ~ 36.014 mm

## Measuring the Step Height of the Piston Top Side

1. Adjust the measuring device to 0 based on the top side of the cylinder block.
2. Measure the step height of the top side of the piston.



EDM03190270

- 1) Adjust the piston to the top dead center position.

- 2) Measure the step height with the cylinder block at 2 places on the top side of the piston: A and B.
- 3) Adjust the rest of the pistons to the top dead center position and measure a total of 8 places.
- 4) The measured size of the step height on the top side of the pistons should be 0.24 ~ 0.52 mm.

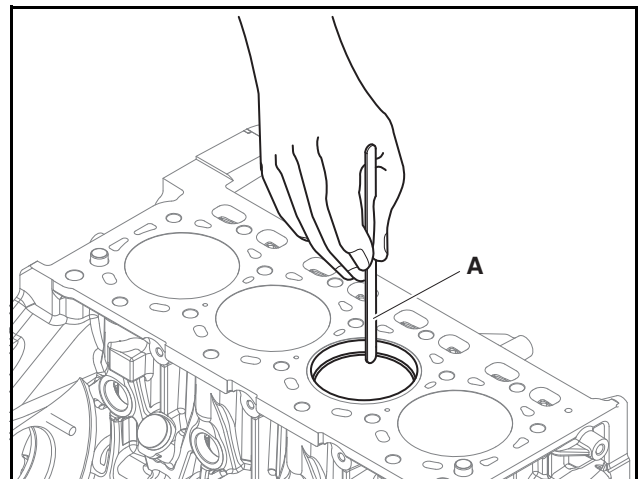
Item	Specified value
Step height of piston top side	0.24 ~ 0.52 mm

## ⚠ CAUTION

- Measure the step height of the piston top side at all 8 places and select a class for the cylinder head gasket based on the average value. For the classes of cylinder gaskets, refer to engine assembly order no.19 in Chapter 6 General Engine Information.
- The front engine direction (F) is the coolant pump direction and the rear engine direction (R) is the flywheel direction.

## Measuring the Piston Ring End Gap

1. Measure the piston ring end gap.



EDM03190160

- 1) Insert the piston ring into the top of the cylinder liner so that it is at a right angle to the wall.
- 2) Measure the piston ring end gap with the feeler gauge (A).
- 3) Measure the top ring, second ring and oil ring.

## 12. Other/Driving System

- 4) The measured size of the piston ring end gap should be 0.25 ~ 0.40 mm for the top ring, 0.55 ~ 0.70 mm for the second ring, and 0.20 ~ 0.40 mm for the oil ring.

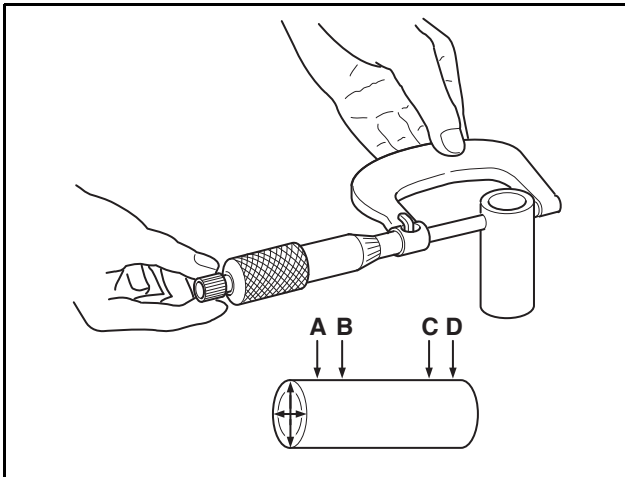
Item	Specified value
Top ring gap	0.25 ~ 0.40 mm
Second ring gap	0.55 ~ 0.70 mm
Oil ring gap	0.20 ~ 0.40 mm

### CAUTION

When measuring the piston ring end gap, be careful not to damage the cylinder with the feeler gauge.

### Measuring the Outside Diameter of the Piston Pin

1. Set up the gauge.
2. Measure the outside diameter of the piston pin.



EDL022132A

- 1) Measure the outside diameter of the piston pin in a total of 8 places: vertical (E), horizontal (F), and A, B, C, D.
- 2) Measure all 4 piston pins.
- 3) The measured size of the outside diameter of the piston pins should be 35.995 ~ 36.000 mm.

Item	Specified value
Piston pin outside diameter	35.995 ~ 36.000 mm

### Connecting Rod

#### Disconnecting the Connecting Rod

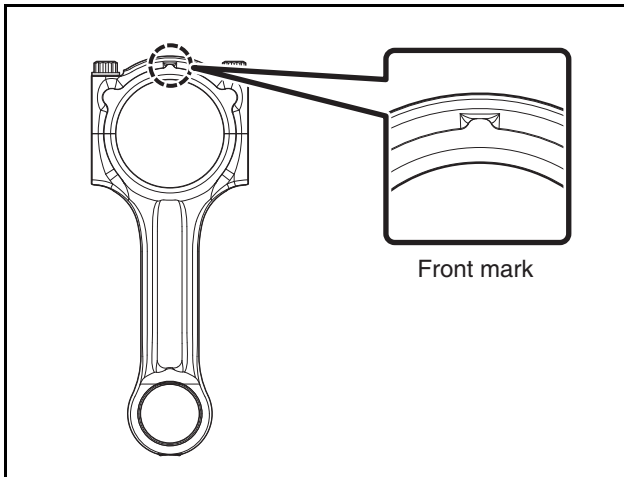
1. Disconnect the connecting rod.

Note: Refer to the order of engine disassembly.

#### Assembling the Connecting Rod

1. Assemble the connecting rod.

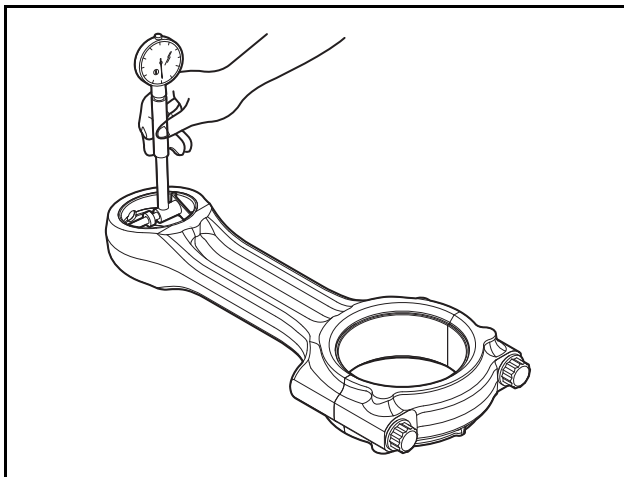
Note: Refer to the order of engine assembly.



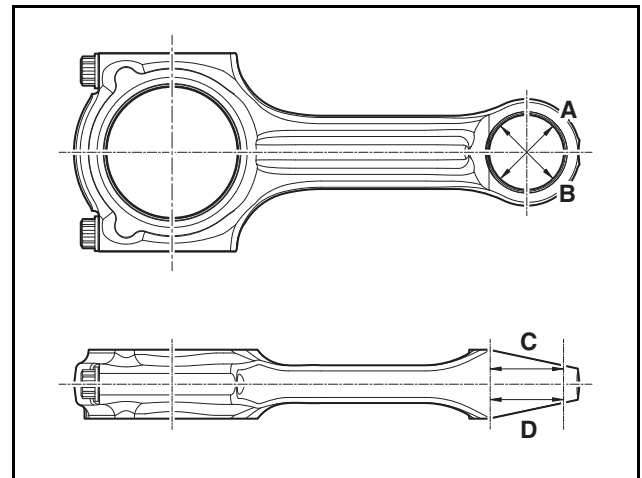
EDM03190322

#### Measuring the Inside Diameter of the Connecting Rod Small End

1. Set up the gauge.
2. Measure the inside diameter of the connecting rod small end.



EDM03190048



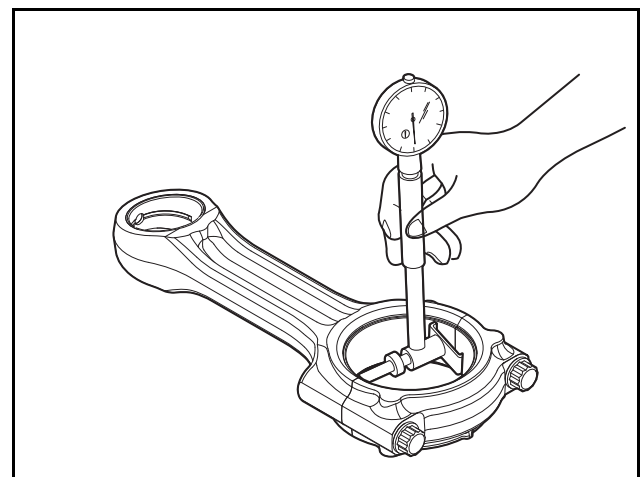
EDM03190049

- 1) Measure a total of 4 places on the connecting rod small end: front (C), rear (D), vertical (A) and horizontal (B).
- 2) Measure all 4 connecting rods.
- 3) The measured size of the connecting rod small end I.D. should be 36.025 ~ 36.038 mm.

Item	Specified value
Connecting rod small end I.D.	36.025 ~ 36.038 mm

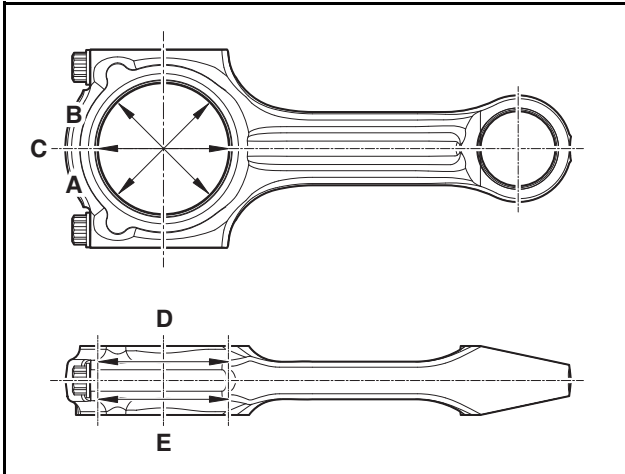
#### Measuring the Inside Diameter of the Connecting Rod Big End

1. Set up the measuring device.
2. Measure the inside diameter of the connecting rod big end.



EDM03190050

## 12. Other/Driving System



EDM03190051

- 1) Measure a total of 6 places on the connecting rod big end: front (D), rear (E), and directions A, B, C.
- 2) Measure all 4 connecting rods.
- 3) The measured size of the connecting rod big end I.D. should be 66.000 ~ 66.015 mm.

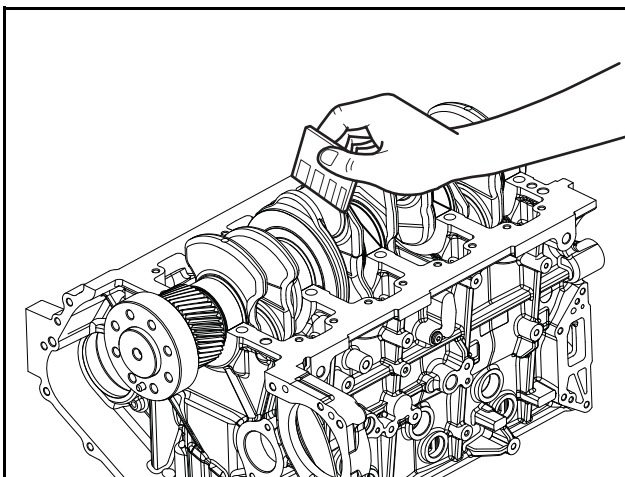
Item	Specified value
Connecting rod big end I.D.	66.000 ~ 66.015 mm

### CAUTION

When assembling the connecting rod, tighten it by hand until the head joint of the connecting rod bolt makes contact with the bolt seats on either side of the connecting rod. Then, finish by tightening it to the specified torque.

### Measuring the Connecting Rod Big End Clearance

1. Assemble crankshaft with the cylinder block.
2. Measure the connecting rod big end clearance.



EDM03190195

- 1) Place a plastic gauge on a total of 4 places where the crankshaft is assembled with the connecting rod.
- 2) Assemble the connecting rod.
- 3) Temporarily tighten the connecting rod bolts by hand.
- 4) Use the angle tightening method to tighten the connecting rod bolts to a tightening torque of 3 kgf·m + 90°.
- 5) Remove the connecting rod bolts.
- 6) Remove the connecting rod caps.
- 7) Check the area of the plastic gauge.
- 8) The measured size of the connecting rod big end clearance should be 0.026 ~ 0.066 mm.

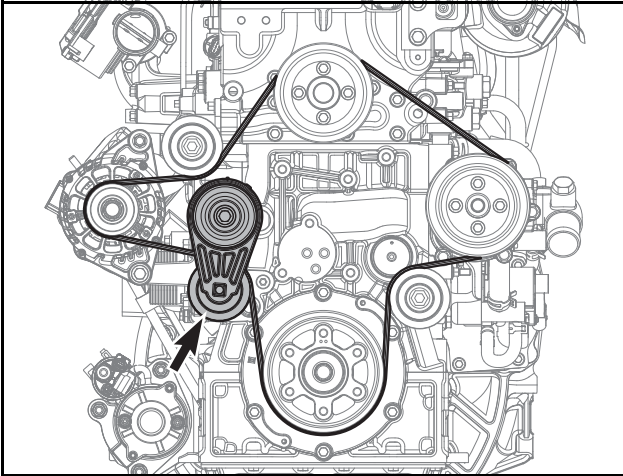
Item	Specified value
Connecting rod big end clearance	0.026 ~ 0.066 mm

3. Remove the plastic gauge.
  - 1) Remove the plastic gauge.
  - 2) Remove any foreign matter from the crankshaft and connecting rod big end.

### Crankshaft Pulley

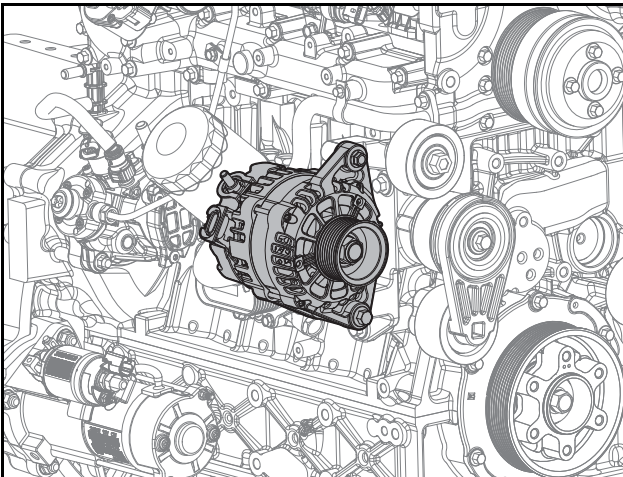
#### Removing the Crankshaft Pulley

1. Remove the V-belt.



EDM03190231

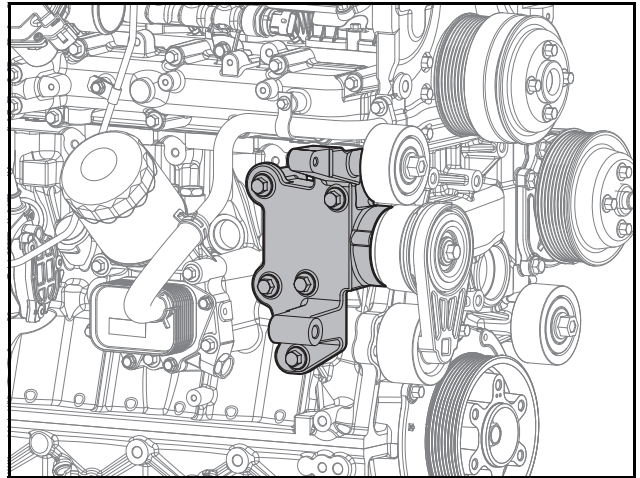
- 1) Turn the auto tensioner counterclockwise by using a quadrangular groove at the top of the auto tensioner pulley (Use a 10 mm x 10 mm quadrangular tool).
  - 2) Remove the belt wound around the auto tensioner pulley by using a space generated by the rotation of the auto tensioner.
2. Detach the alternator.



EDM03190243

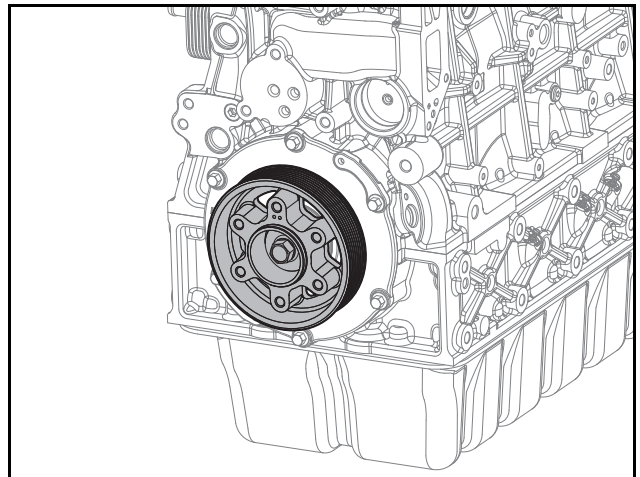
- 1) Loosen the upper/lower bolt and remove the alternator.
- 2) When loosening bolt, take care not to lose nut.

3. Remove the alternator bracket.



EDM03190244

- 1) Loosen 5 flange hex bolt.
  - 2) Remove the alternator bracket.
4. Remove the crankshaft pulley.



EDM03190262

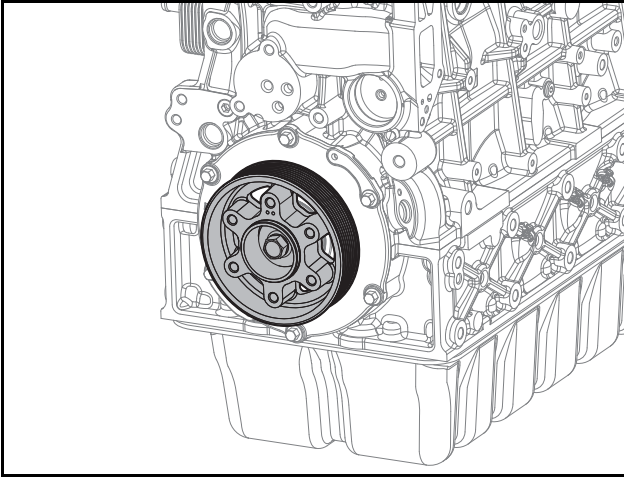
- 1) Loosen the flange hex bolts.
- 2) Remove the crankshaft pulley.



## 12. Other/Driving System

### Assembling the Crankshaft Pulley

1. Assemble the crankshaft pulley.



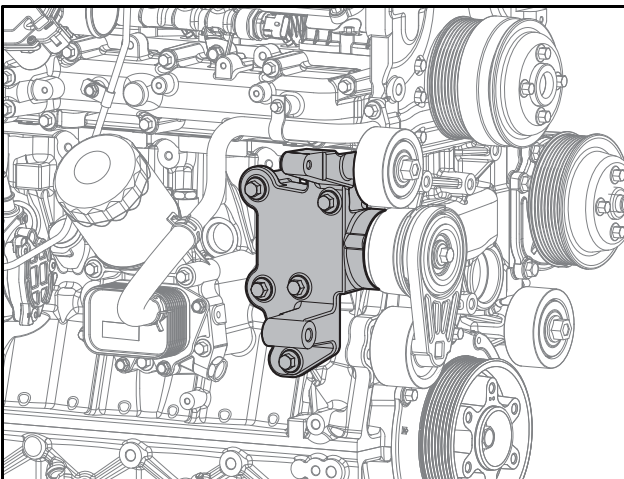
EDM03190262

- 1) Align the crankshaft pulley with the key to assemble it.
- 2) Tighten the flange hex bolt to a tightening torque of 26 kgf-m.
- 3) Connect crankshaft pulley.
- 4) Tighten the hex bolts to a tightening torque of 2.2 kgf-m.

### CAUTION

- Be careful not to damage the oil seals.
- Mount the crankshaft so that the flange hex bolts can be installed at the specified torque.

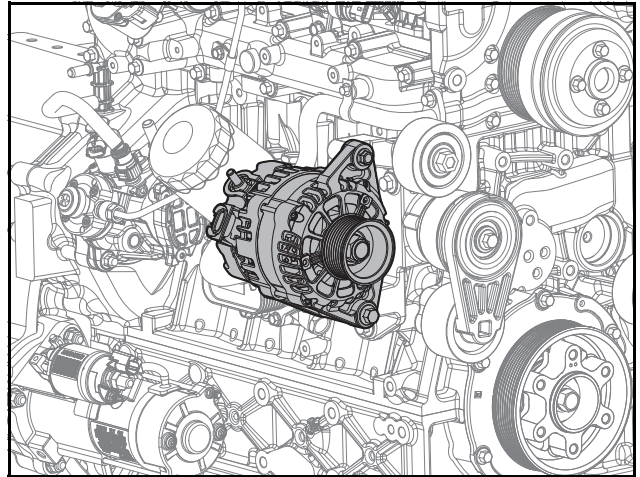
2. Assemble the alternator bracket.



EDM03190244

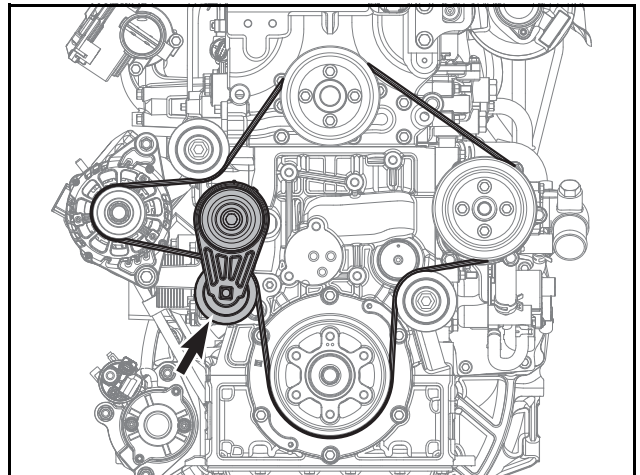
- 1) Assemble the alternator bracket.
- 2) Tighten 5 flange hex bolts to a tightening torque of  $6.2 \pm 0.6$  kgf-m.

3. Assemble the alternator.



EDM03190243

- 1) Using bolt and nut, attach the alternator temporarily.
  - 2) By tightening bolt, set the position of the alternator properly.
  - 3) Tighten upper bolt to a torque of  $2.2 \pm 0.2$  kgf-m.
  - 4) Tighten lower bolt to a torque of  $6.2 \pm 0.6$  kgf-m.
4. Assemble the V-belt.



EDM03190231

- 1) Wind a new belt around all pulleys except for the auto tensioner.
- 2) Turn the auto tensioner counterclockwise by using a quadrangular groove at the top of the auto tensioner pulley (use a 10 mm x 10 mm quadrangular tool).
- 3) Wind the belt around the auto tensioner pulley by using a space generated by the rotation of the auto tensioner, and then naturally release the tensioner that has been pulled counterclockwise.

### CAUTION

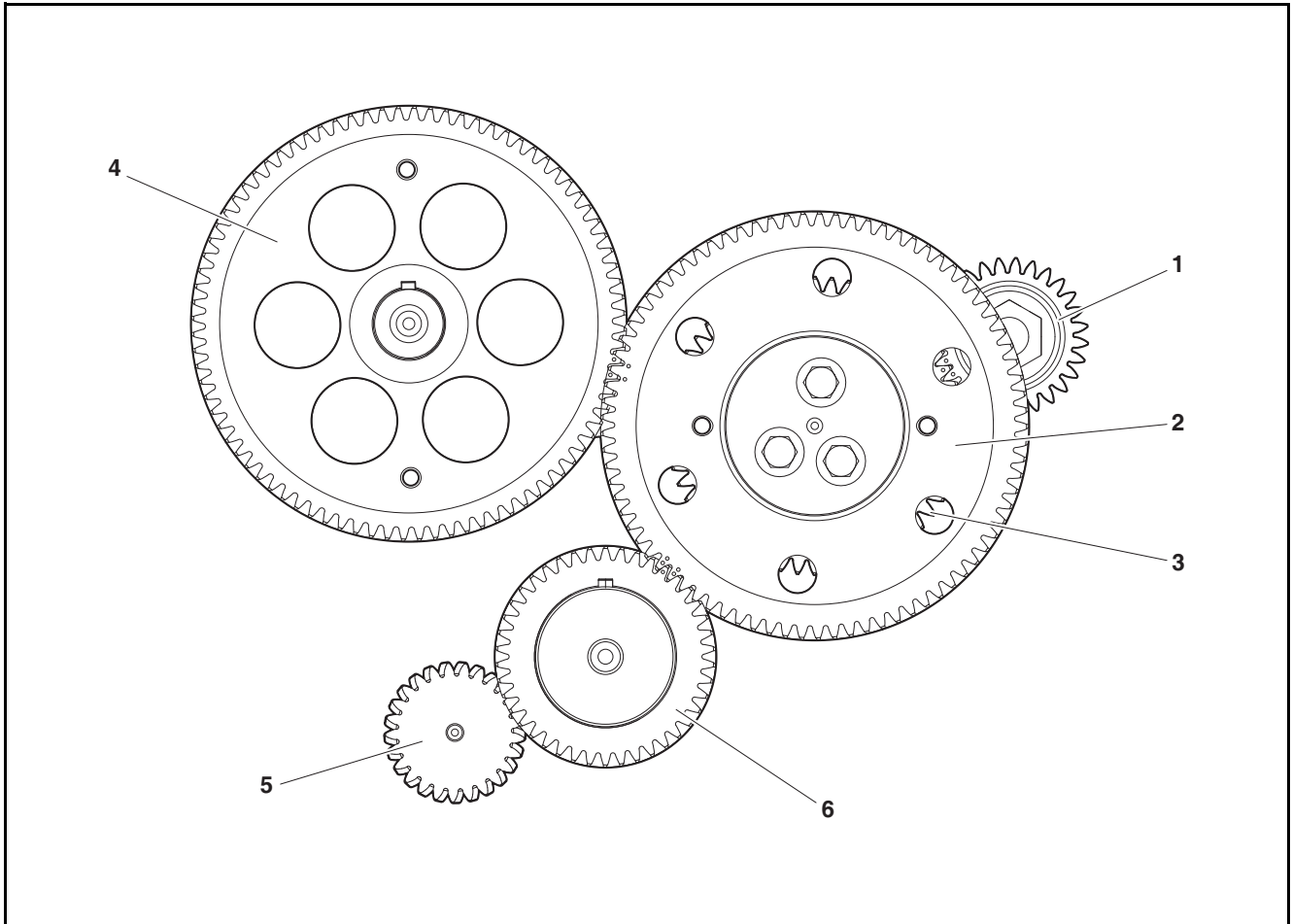
For checking and measuring the belt tension, refer to Belt Tension in Chapter 12 (Others/Driving Units).



### Others

#### Engine Timing

The engine is driven by the connections between the camshaft, oil pump, high-pressure injection pump, idle gear and crankshaft gear.



EDM03190044

1. Injection pump drive gear (no. of teeth : 28)
2. Idle gear (large) (no. of teeth : 81)
3. Idle gear (small) (no. of teeth : 54)
4. Camshaft gear (no. of teeth : 84)
5. Oil pump drive gear (no. of teeth : 25)
6. Crankshaft gear (no. of teeth : 42)

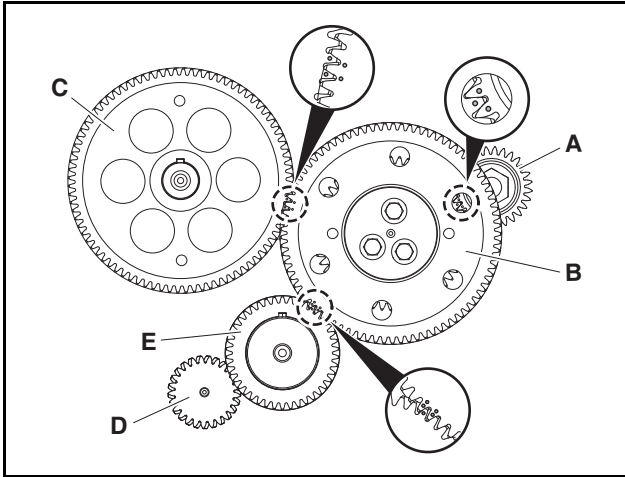
## 12. Other/Driving System

### Adjusting the Engine Timing

1. Remove the flywheel housing.

Note: Refer to Chapter 6 for the order of engine disassembly.

2. Align the engravings on each gear.



EDM03190052

- 1) Line up the idle gear and camshaft gear engravings.

Note: There are 2 markings on the idle gear engraving and the camshaft gear engraving

- 2) Make sure that the engraving on the crankshaft gear is between the engravings on the idle gear.

Note: There are 4 markings on the idle gear engravings.

Note: There is one engraved marking on the 4th tooth of the crankshaft with the crankshaft gear key groove in the 12 o'clock direction.

- 3) Align the engraving on the idle gear between the engravings on the fuel injection pump drive gear.

Note: There are two engraved markings on the fuel injection pump drive gear and one engraved marking on the idle gear.

Note: If you are unable to check the gear engravings, assemble the fuel injection pump regardless of the positions of the fuel injection pump drive gear engravings and the idle gear engravings.

3. Assemble the flywheel housing.

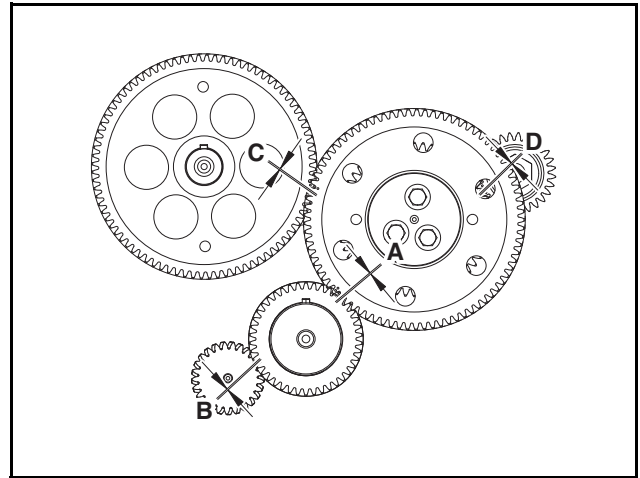
Note: Refer to the order of engine assembly.

### Checking the Gear Backlash

1. Remove the flywheel housing.

Note: Refer to the order of engine disassembly.

2. Check the gear backlash.



EDM03190053

- 1) Use the feeler gauge to check the gear backlash.
- 2) The size of the backlash between the crankshaft gear and idle gear (A) should be 0.087 ~ 0.202 mm.
- 3) The size of the backlash between the crankshaft gear and oil pump drive gear (B) should be 0.066 ~ 0.247 mm.
- 4) The size of the backlash between the idle gear and camshaft gear (C) should be 0.087 ~ 0.213 mm.
- 5) The size of the backlash between the idle gear and injection pump drive gear (D) should be 0.081 ~ 0.196 mm.

Item	Specified value
Backlash between crankshaft gear and idle gear	0.087 ~ 0.202 mm
Backlash between crankshaft gear and oil pump drive gear	0.066 ~ 0.247 mm
Backlash between idle gear and camshaft gear	0.087 ~ 0.213 mm
Backlash between idle gear and injection pump drive gear	0.081 ~ 0.196 mm

3. Assemble the flywheel housing.

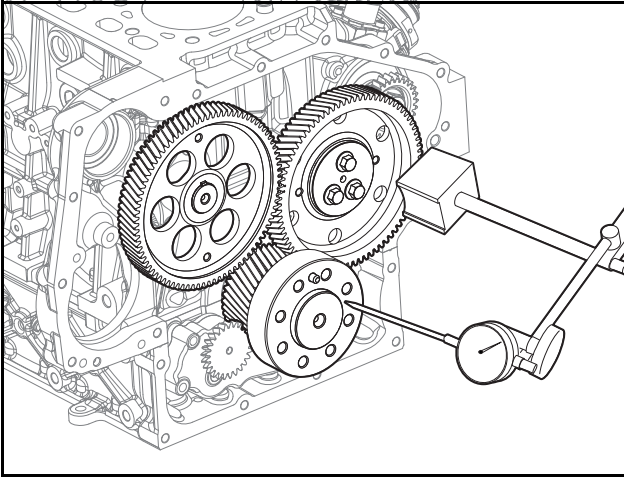
Note: Refer to the order of engine assembly.

### Checking the Axial Play of Gears

1. Remove the flywheel housing.

Note: Refer to the order of engine disassembly.

2. Check the axial play of the gears.



EDM03190151

- 1) Install the dial gauge on the cylinder block.
- 2) Insert the crankshaft gear in the direction of the cylinder block.
- 3) Adjust the dial gauge to 0 based on the surface of the crankshaft gear.
- 4) Pull the crankshaft gear and check the measured value on the dial gauge.

Note: The axial play of the crankshaft gear should be 0.100 ~ 0.300 mm.

- 5) Insert the camshaft gear in the direction of the cylinder block.
- 6) Adjust the dial gauge to 0 based on the surface of the camshaft gear.
- 7) Pull the camshaft gear and check the measured value on the dial gauge.

Note: The axial play of the camshaft gear should be 0.100 ~ 0.200 mm.

- 8) Insert the idle gear in the direction of the cylinder block.
- 9) Adjust the dial gauge to 0 based on the surface of the idle gear.
- 10) Pull the idle gear and check the measured value of the idle gear.

Note: The axial play of the idle gear should be 0.100 ~ 0.200 mm.

Item	Specified value
Axial offset of the crankshaft gear	0.10 ~ 0.31 mm
Axial offset of the camshaft gear	0.10 ~ 0.20 mm
Axial offset of the idle gear	0.10 ~ 0.20 mm

3. Assemble the flywheel housing.

Note: Refer to the order of engine assembly.

## 12. Other/Driving System

---

# 13. Aftertreatment System

<b>Exhaust Gas Reduction System (Stage-V) .....</b>	<b>267</b>
General Instructions .....	267
Aftertreatment .....	268
Diesel Oxidation Catalyst (DOC) .....	268
Diesel Particulate Filter (DPF) .....	269
Cautions for Handling the DPF Assembly .....	274
<b>Exhaust Gas Reduction System (Tier-4 Final) .....</b>	<b>275</b>
General Instructions .....	275
Aftertreatment .....	276
Diesel Oxidation Catalyst (DOC) .....	276



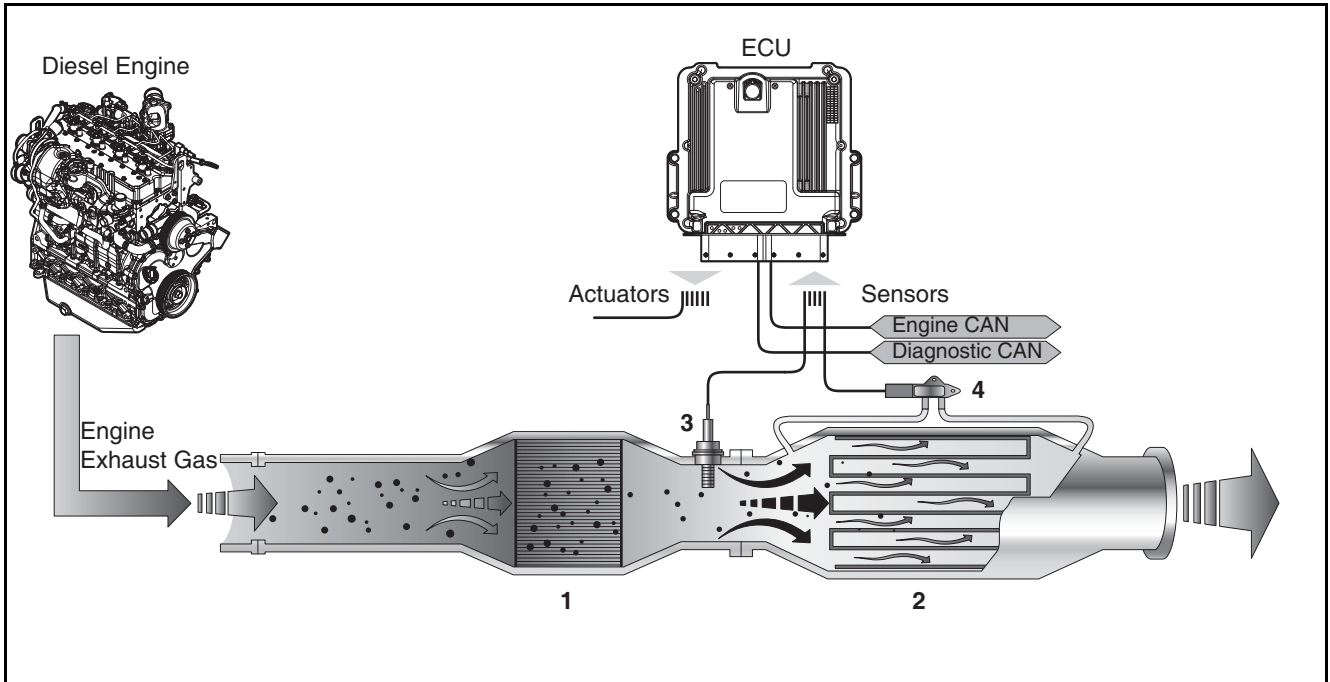


## Exhaust Gas Reduction System (Stage-V)

### General Instructions

Hyundai Doosan Infracore engines are designed to satisfy Stage-V emissions regulations using a DOC (Diesel Oxidation Catalyst) and DPF (Diesel Particulate Filter).

The DOC, an oxidation catalyst, serves to reduce HC and CO emissions by means of a catalyst, while the DPF collects particulate matter (PM) released by diesel engines.



EDM03190314

No.	Part Name	Quantity
1	DOC (Diesel Oxidation Catalyst)	1
2	DPF (Diesel Particulate Filter)	1
3	Temp. Sensor	1
4	DPF Delta P Sensor	1

# 13. Aftertreatment System

## Aftertreatment

The aftertreatment consists of a DOC and a DPF; the DOC containing a DOC (Diesel Oxidation Catalyst) and a DPF containing a DPF (Diesel Particulate Filter).

## Diesel Oxidation Catalyst (DOC)

### Overview

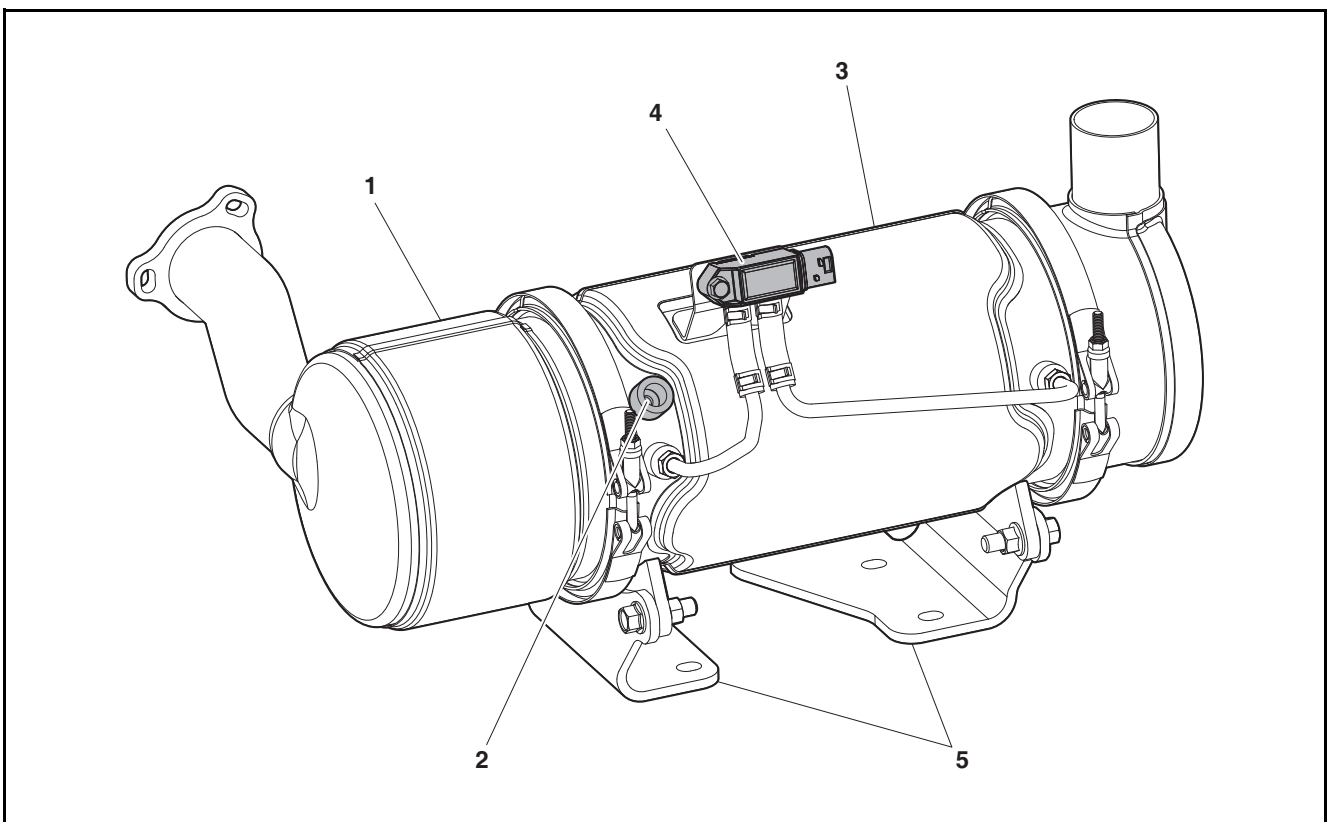
The DOC (Diesel Oxidation Catalyst) is a system which oxidizes and eliminates HC (hydrocarbons) and CO (carbon monoxide) emissions, producing H<sub>2</sub>O (water) and CO<sub>2</sub> (carbon dioxide) in the process.

In Active Regeneration mode, it also increases the temperature of the DPF to help with the oxidation of HC (diesel) discharged through the exhaust manifold, as well as accelerating passive regeneration of particulate matter (PM) gathered in the DPF by converting NO (nitrogen monoxide) into NO<sub>2</sub> (nitrogen dioxide).

As shown in the figure below, a temperature sensor is installed on the front of the DPF (Diesel Particulate Filter) to control the DOC temperature during active regeneration.

**⚠ CAUTION**

**Do not reuse V-clamp and gasket.**



EDM03190299

- 1. DOC
- 2. Temperature sensor
- 3. DPF
- 4. DPF delta P sensor
- 5. Mounting bracket

## Diesel Particulate Filter (DPF)

### Overview

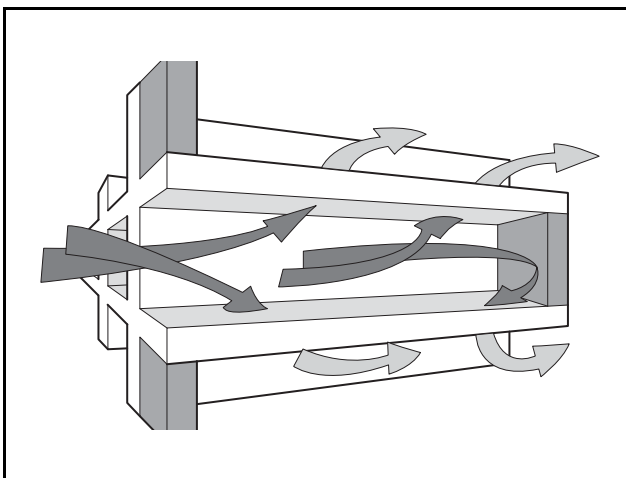
The DPF (Diesel Particulate Filter) system serves to prevent particulate matter (PM) in emissions from being discharged into the air and consists of the DPF body, exhaust gas temperature sensor, and one differential pressure sensor.

The DPF is composed of a porous wall capable of filtering out particulate matter. As exhaust gas passes through the DPF, particulate matter accumulates in the DPF, while the rest of the exhaust gas travels through the DPF to the SCR system. Following this, PM collected in the DPF is eliminated using a suitable regeneration method.

### DPF Regeneration

The DPF serves to filter out soot, a contaminant found in the emissions of diesel engines. An excessive build-up of soot in the DPF leads to issues such as a drop in engine power due to increased back pressure in the engine, making it crucial to perform regeneration in order to eliminate PM in the DPF.

The ECU (Engine Control Unit) calculates the amount of exhaust smoke using the signal from the DPF differential sensor, the vehicle operating time, the vehicle fuel consumption, and engine simulation data. Once this amount reaches a certain level, the ECU performs DPF regeneration. Regeneration—a process which involves burning accumulated PM—increases the temperature upstream of the DOC by means of adjustment of the engine throttle and near post injection, as well as raising the DPF temperature higher than the exhaust combustion temperature (580° or higher) to burn exhaust gas by means of far post injection. After DPF regeneration, only ash remains in the DPF. DPF regeneration comprises active regeneration while driving and forced regeneration performed by the driver.



EJ9OM060

## DPF Regeneration Lamp and Switch

### 1. HEST (High Exhaust System Temperature) Lamp

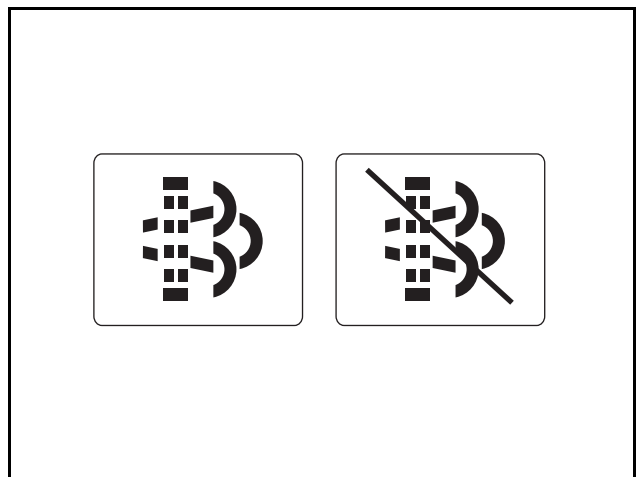
This lamp notifies the driver when hot exhaust gas is being discharged from the engine during DPF regeneration. Be sure to keep the area around the exhaust manifold free of flammable materials.



EJ9OM061

### 2. DPF Regeneration Lamp

This lamp turns on either during regeneration or when regeneration is needed and turns off during active regeneration while driving if the soot level is less than 100%. The lamp appears as shown on the right when the driver disables regeneration.



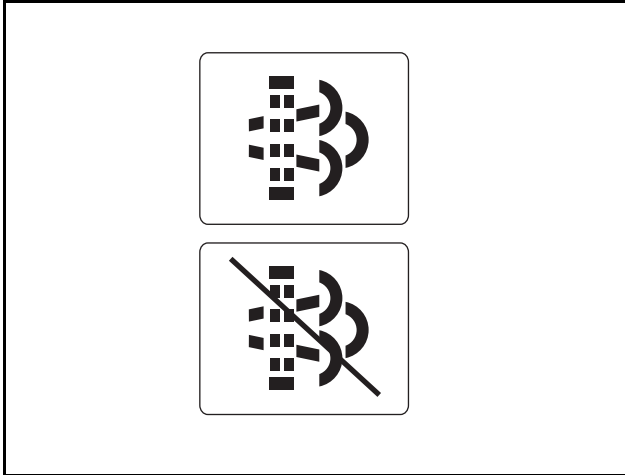
EJ9OM062

## 13. Aftertreatment System

---

### 3. Forced Regeneration

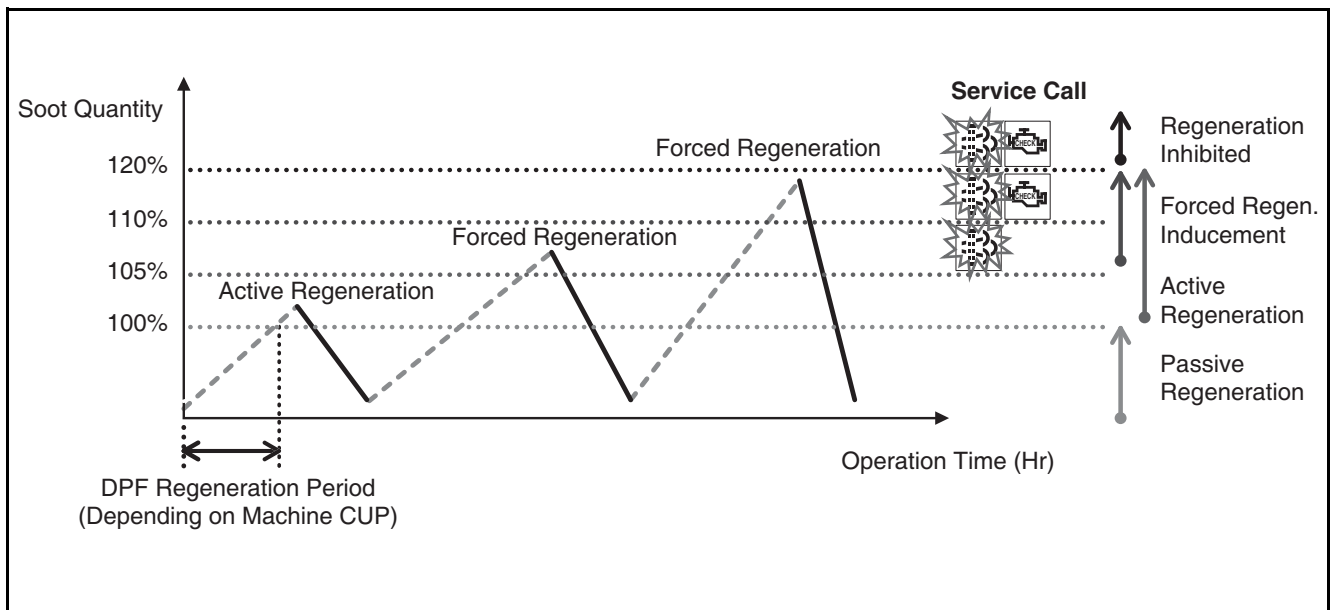
The driver can use these switches to initiate or disable forced regeneration. The switch above is the switch for forced regeneration and the switch below is the switch for disabling regeneration.



EJ9OM063

# 13. Aftertreatment System

## Stage V DPF Regeneration Strategy

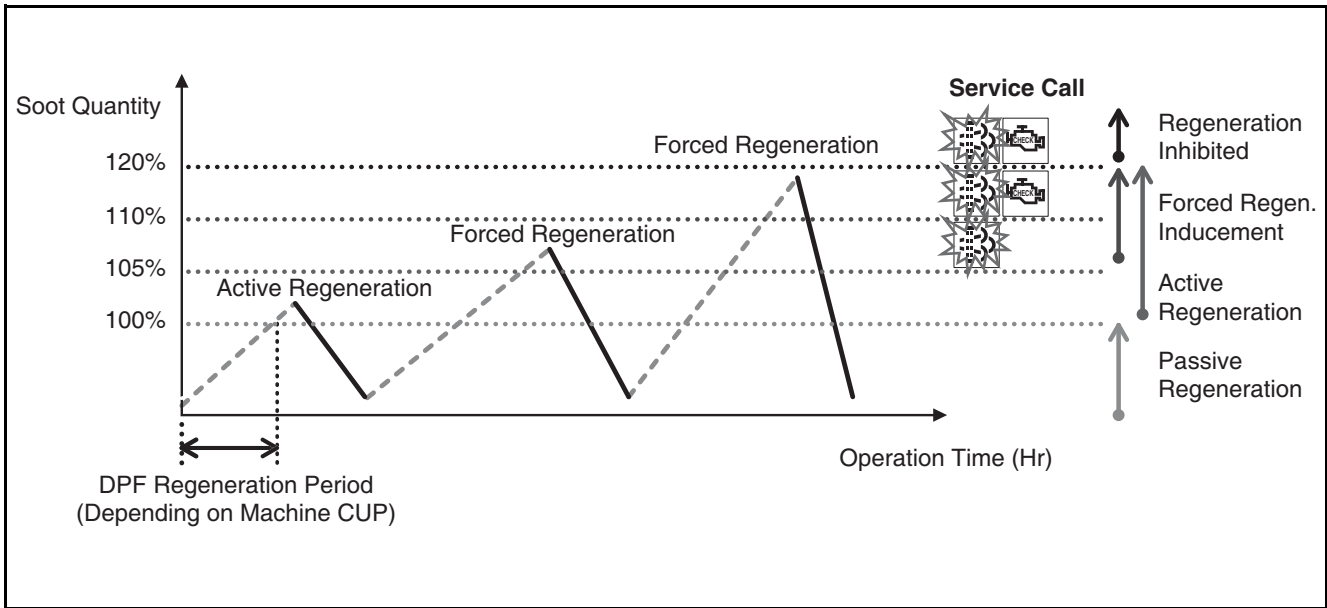


EDM02200009

Step	Soot Quantity	DPF Lamp*	Check Engine Lamp	Torque de-rate	Remark
1	Below 99%	Off	Off	No	<ul style="list-style-type: none"> <li>No action (Passive regeneration dependent on machine CUP)</li> </ul>
2	100% ~ 105%	Off	Off	No	<ul style="list-style-type: none"> <li>Start active regen. With high temp. (580 ~ 640°C) during running</li> </ul>
3	106% ~ 110%	Slow Blink	Off	No	<ul style="list-style-type: none"> <li>Forced regeneration inducement (Alarm only)</li> <li>Start active regen. With high temp. (580 ~ 640°C) during running</li> </ul>
4	111% ~ 120%	Slow Blink	On	Mild Torque de-rate	<ul style="list-style-type: none"> <li>Forced regeneration inducement (Torque de-rate)</li> <li>Start active regen. With high temp. (580 ~ 640°C) during running</li> </ul>
5	Above 121%	Fast Blink	Blink	Severe Torque de-rate	<ul style="list-style-type: none"> <li>Forced regeneration is disabled.</li> <li>Service call is needed to service regeneration for machine operating properly.</li> </ul>

- The regeneration lamp turns on when the DPF soot level exceeds 100%
- The regeneration lamp blinks when the DPF soot level exceeds 105%
- The regeneration lamp blinks slowly, the CE lamp turns on, and engine power is reduced (25%) when the DPF soot level exceeds 111%
- The regeneration lamp blinks quickly, the CE lamp turns on, and engine power is reduced (50%) when the DPF soot level exceeds 121%

# 13. Aftertreatment System



EDM02200009

Step	Soot Quantity	DPF Lamp*	Check Engine Lamp	Torque de-rate	Remark
1	Below 99%	Off	Off	No	<ul style="list-style-type: none"> <li>No action (Passive regeneration dependent on machine CUP)</li> </ul>
2	100% ~ 105%	Off	Off	No	<ul style="list-style-type: none"> <li>Start active regen. With high temp. (580 ~ 640°C) during running</li> </ul>
3	106% ~ 110%	Slow Blink	Off	No	<ul style="list-style-type: none"> <li>Forced regeneration inducement (Alarm only)</li> <li>Start active regen. With high temp. (580 ~ 640°C) during running</li> </ul>
4	111% ~ 120%	Slow Blink	On	Mild Torque de-rate	<ul style="list-style-type: none"> <li>Forced regeneration inducement (Torque de-rate)</li> <li>Start active regen. With high temp. (580 ~ 640°C) during running</li> </ul>
5	Above 121%	Fast Blink	Blink	Severe Torque de-rate	<ul style="list-style-type: none"> <li>Forced regeneration is disabled.</li> <li>Service call is needed to service regeneration for machine operating properly.</li> </ul>

DPF regeneration consists of active regeneration which occurs while driving and forced regeneration which is activated manually by the driver.

When the DPF soot level is less than 105%, active regeneration is activated automatically while driving.

However, at 105% or higher, the system notifies the driver that forced regeneration must be performed manually. At 120% or higher,

the engine warning lamp turns on, engine power drops 50%, and the driver must call for service.

- DPF soot level 105% or less: Active regeneration
- DPF soot level 105 ~ 120%: Forced regeneration + decrease in engine power
- DPF soot level 105 ~ 120%: Notify the driver that forced regeneration needs to be performed
- DPF soot level 120% or higher: Regeneration is not possible/must call for service to regenerate the DPF



## DPF Regeneration Methods

Stage V engines are designed to perform passive regeneration of soot accumulated in the DPF even under normal exhaust conditions without needing to be initiated by the driver. The DPF regeneration modes are divided into the following five stages depending on the level of soot build-up in the DPF.

- 1) Soot level less than 100%: Normal operating conditions
  - 2) Soot level 100 ~ 105%: Automatic regeneration during operation (Active Regeneration)
  - 3) DPF soot level 106 ~ 110%: Forced regeneration is induced + Active regeneration is try to start.  
Notify the driver that forced regeneration needs to be performed.
  - 4) DPF soot level 111 ~ 120%: Forced regeneration is induced + decrease in engine power and Active regeneration is try to start.  
Notify the driver that forced regeneration needs to be performed.
  - 5) DPF soot level 120% or higher: Regeneration is not possible/must call for service to regenerate the DPF.
1. Regeneration mode during operation (Active regeneration)

This regeneration mode is performed automatically by the ECU in order to regenerate the DPF when any of the following regeneration mode conditions are met. During regeneration, the regeneration lamp and HEST lamp turn on to warn the driver of the hot exhaust gas.

At this time, normal operation is possible, although with caution for safety. Once regeneration is complete after 20 ~ 30 minutes, the regeneration lamp and HEST lamp turn off.

---

## CAUTION

**Turning the engine off during regeneration (i.e. while the HEST lamp is turned on) may have a severe impact on the DPF. Hence, do not turn the engine off while the regeneration lamp and HEST lamp are turned on except in emergencies.**

- **When the soot level reaches the specified level in the simulation**

---

### 2. Forced regeneration mode

This regeneration mode is performed by the driver with the vehicle stopped in the event that DPF regeneration is not performed while the vehicle is in operation. Forced regeneration (Active regeneration) may not be performed under the following operating conditions, so the driver must perform forced regeneration according to vehicle warnings as befits the circumstances.

- Working repeatedly under a low load or driving at low speeds over short distances
- Frequent idling

Conditions for forced regeneration

- 1) Coolant (engine oil) temperature: 40° or higher
- 2) Engine rpm: Idling
- 3) Parking brake engaged

Order of forced regeneration

- 1) Stop the vehicle. (Be sure to stop the vehicle in a safe place as the exhaust temperature will increase.)
- 2) Set the engine to an idling rpm.
- 3) Lower the safety lever.
- 4) Place the forced regeneration switch in the ON position.
- 5) The engine rpm increases from idling to high idle rpm (varies depending on the model) and regeneration begins.
- 6) Forced regeneration is performed for 30 ~ 40 minutes. (May take longer depending on the above-mentioned forced regeneration conditions). The regeneration lamp and HEST lamp turn on.
- 7) The engine rpm drops to an idling rpm.
- 8) The regeneration lamp and HEST lamp turn off.
- 9) Place the forced regeneration switch in the OFF position.
  - \* In the event that forced regeneration must be stopped due to an emergency, raise the safety lever. However, doing so has a severely adverse effect on DPF regeneration, so be sure to perform forced regeneration in a safe place with enough time to complete the process.

## Aftertreatment System Inspection

Remove the temperature sensor and differential pressure sensor installed in the DPF, perform a visual inspection upstream and downstream of the DPF to check for any damage or melting, and take care not to damage the DPF.

1. If any soot is found during visual inspection, it is need to be replaced DPF.

## 13. Aftertreatment System

---

### Cautions for Handling the DPF Assembly

Please note the following while handling the DPF assembly.

1. The muffler weighs approx. 13 kg and the DOC/DPF are weak against impacts, so be careful not to damage them during removal.
2. When replacing the differential pressure sensor, take care to ensure that foreign matter does not enter the differential pressure sensor pipe. If foreign matter enters the pipe, a fault may occur due to a misreading of the differential pressure.
3. Take care to ensure that foreign matter does not enter the inlet/outlet after removing the DPF assembly. If foreign matter enters the system, it may damage the DOC/DPF.
4. The differential pressure sensor and temperature sensor are installed on the outside of the DPF assembly, so take care not to damage them during removal and installation.
5. Reusing gaskets may cause air leaks, so be sure to use new gaskets.
6. Air leaks in the exhaust system can lead to violation of emissions regulations, increased noise, and increased exhaust smoke, so be sure to tighten parts to their specified tightening torque.

### Removing DPF Ash and Cleaning the DPF

During the regeneration of soot in the DPF, ash accumulates in the DPF. Once a certain amount of ash accumulates, engine performance and fuel efficiency are affected due to a build-up of back pressure in the exhaust system, so ash cleaning must be performed regularly to prevent any worsening of engine performance and fuel efficiency. The DPF part of the DPF assembly must be disassembled in order to clean out ash. Although the interval varies depending on the operating conditions, operating environment, and type of engine oil used, ash cleaning is usually performed every 5,000 hours of engine operating time under normal conditions.

---

### CAUTION

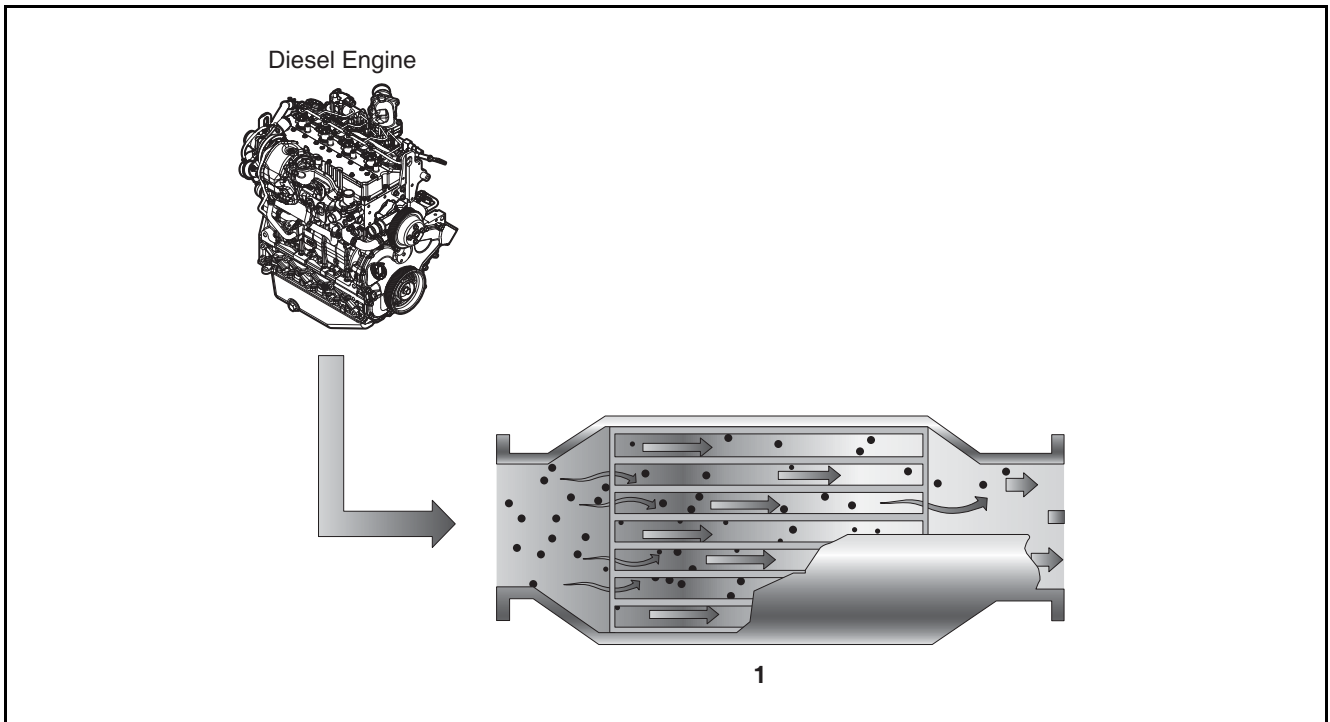
1. **Be sure to use ultra-low-sulfur diesel (ULSD) to ensure normal performance of the DPF.**
  2. **Be sure to use low ash engine lubricant oil (API CJ-4 (500hr interval) / API CK-4 (1,000hr interval)) to establish suitable DPF cleaning intervals.**
-

## Exhaust Gas Reduction System (Tier-4 Final)

### General Instructions

Hyundai Doosan Infracore engines are designed to satisfy Tier-4 Final emissions regulations using a DOC (Diesel Oxidation Catalyst).

The DOC, an oxidation catalyst, serves to reduce HC and CO emissions by means of a catalyst.



ED24190183

No.	Part Name	Quantity
1	Diesel Oxidation Catalyst	1

## 13. Aftertreatment System

---

### Aftertreatment

The aftertreatment consists of a DOC containing a DOC (Diesel Oxidation Catalyst).

### Diesel Oxidation Catalyst (DOC)

#### Overview

The DOC (Diesel Oxidation Catalyst) is a system which oxidizes and eliminates HC (hydrocarbons) and CO (carbon monoxide) emissions, producing H<sub>2</sub>O (water) and CO<sub>2</sub> (carbon dioxide) in the process.

### Removal

Perform a visual inspection downstream of the DOC to check for any damage or melting.

Take care not to damage the DOC during removal.

(For more information on removal, assembly and disassembly, please refer to "Removing, Assembling and Disassembling the DOC Assembly".)

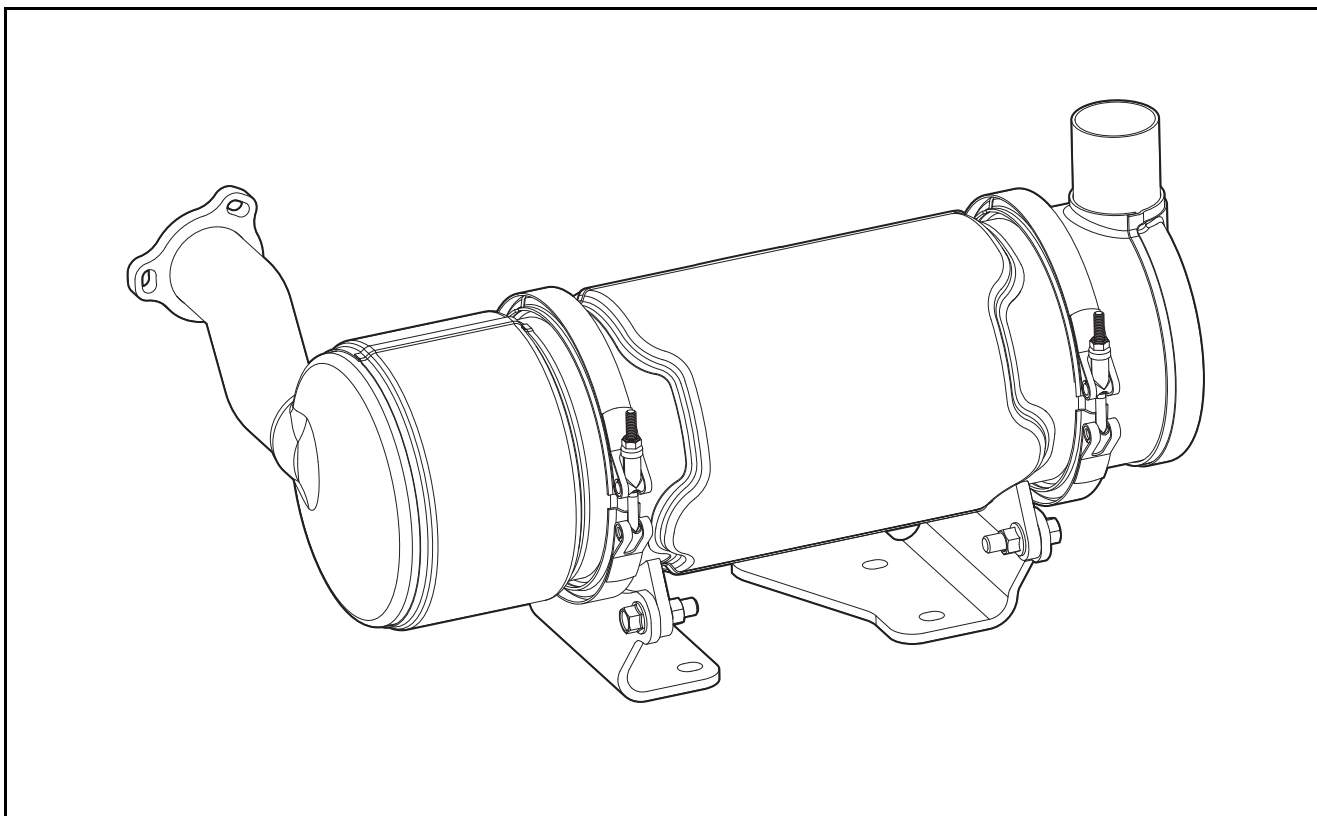
---

**CAUTION**

---

**Do not reuse V-clamp and gasket.**

---



EDM03190300

# 14. Accessory System

<b>Radiator &amp; Cooling Fan .....</b>	<b>279</b>
Genset & Power Unit Layout.....	279
Radiator & Cooling Fan System.....	280
<b>Intake &amp; CAC .....</b>	<b>287</b>
Intake/Exhaust System .....	287
<b>Engine Mount .....</b>	<b>290</b>

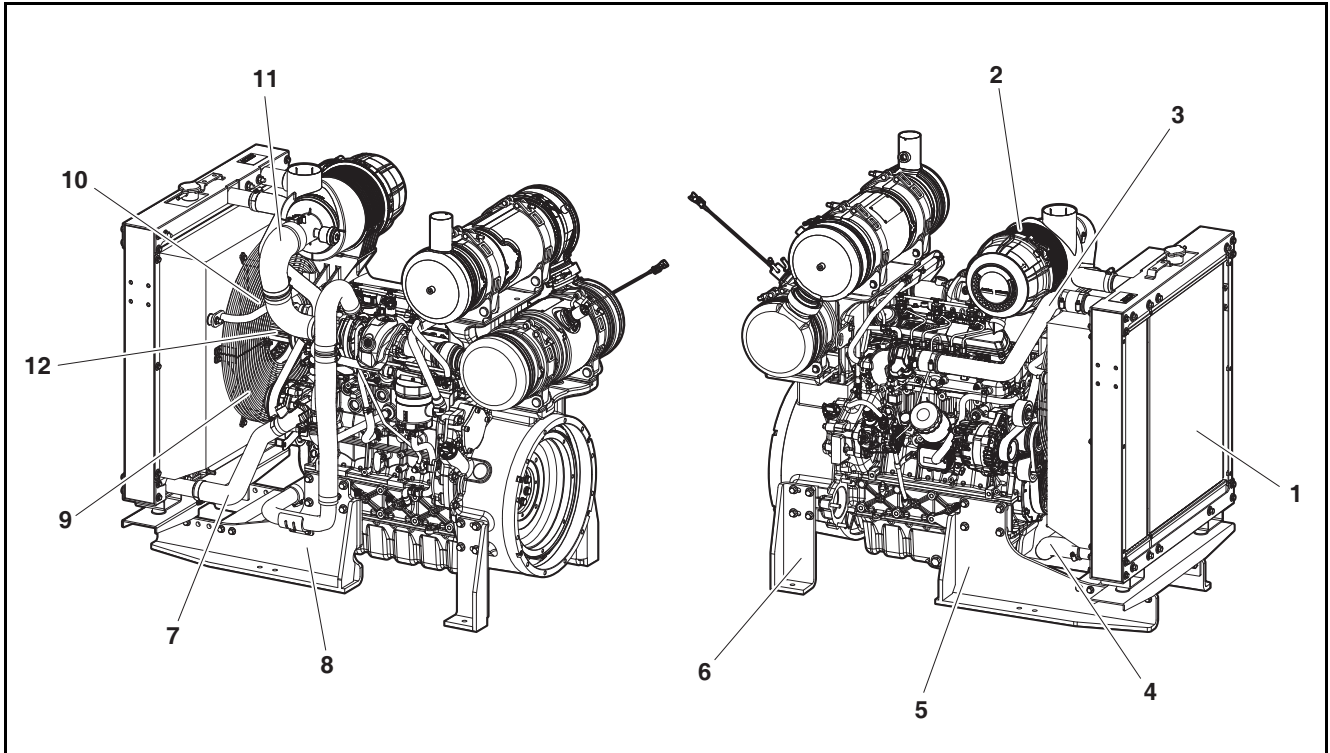




### Radiator & Cooling Fan

### Genset & Power Unit Layout

### Layout



EDM03210162

- |                          |                              |                        |
|--------------------------|------------------------------|------------------------|
| 1. Radiator              | 5. Front engine mount        | 9. Cooling fan         |
| 2. Air cleaner           | 6. Rear engine mount         | 10. Fan guard          |
| 3. CAC outlet hose       | 7. Water inlet hose          | 11. Intake hose & pipe |
| 4. CAC inlet hose & pipe | 8. Engine mount support beam | 12. Fan flange         |

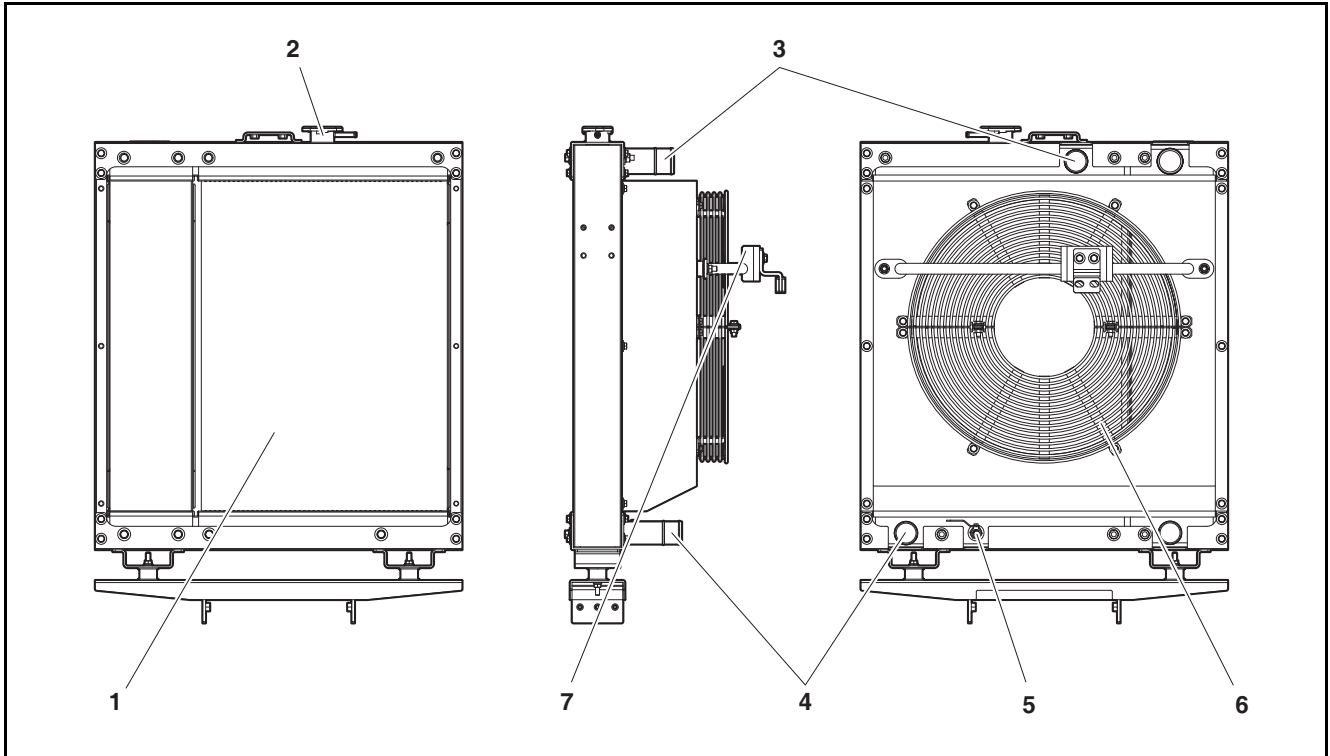
# 14. Accessory System

## Radiator & Cooling Fan System

### Radiator

#### General Information

The radiator is a heat exchanger which releases heat transmitted from inside the engine into the air.



EDM03210174

- |                        |                         |                        |
|------------------------|-------------------------|------------------------|
| 1. Radiator            | 4. Radiator outlet pipe | 7. Top support bracket |
| 2. Radiator cap        | 5. Drain valve          |                        |
| 3. Radiator inlet pipe | 6. Fan guard            |                        |

1. Radiator body.
2. A coolant inlet which maintains a certain level of coolant pressure by means of a pressure/vacuum valve installed in the radiator cap.
3. The radiator inlet pipe acts as an inlet for coolant flowing from the thermostat.
4. The radiator outlet lowers the temperature of the coolant and sends it back to the engine.
5. A coolant drain valve used during service and maintenance.
6. Supplies and discharges air from the cooling fan efficiently and protects the cooling fan.
7. Radiator upper support.

## 14. Accessory System

### Failure Diagnosis

Phenomenon	Causes	Troubleshooting
Coolant leakage	Damaged radiator core	Replace the radiator
	Defective radiator cap	Replace the radiator cap
	Damaged drain valve	Replace the drain valve
Overheating	Clogged radiator	Replace the radiator and coolant
	Damaged fan shroud	Repair or replace the shroud
	Poor coolant quality	Replace with the specified coolant
	Poor air drainage	Open the radiator cap and idle the engine to bleed the air
	Defective radiator cap	Replace the radiator cap
	Insufficient coolant	Add coolant
Overflow	Defective head gasket or deformed head	Check the head gasket and head

### How to Maintain the Radiator

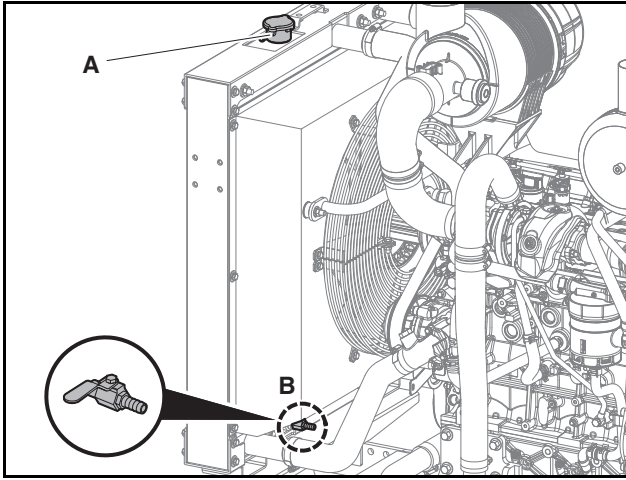
- Cautions for engine operation.
- Observe the following when starting, operating and stopping the engine.

Item	Cautions	Reasons
Starting the engine	Check the coolant level	If the level is too low or too high, the engine may overheat or the reservoir tank may overflow
	Check for leaks	Incorrect pressure levels may cause overheating
Operating	Check the coolant temperature	Incorrect coolant temperatures may cause overheating
Stopping the engine	Check the coolant level	If the level is too low or too high, the engine may overheat or the reservoir tank may overflow
	Radiator cap pressure test (0.9 ±0.15)	Incorrect pressure levels may cause overheating

# 14. Accessory System

## Radiator Disassembly

1. Drain the coolant.



EDM03210163

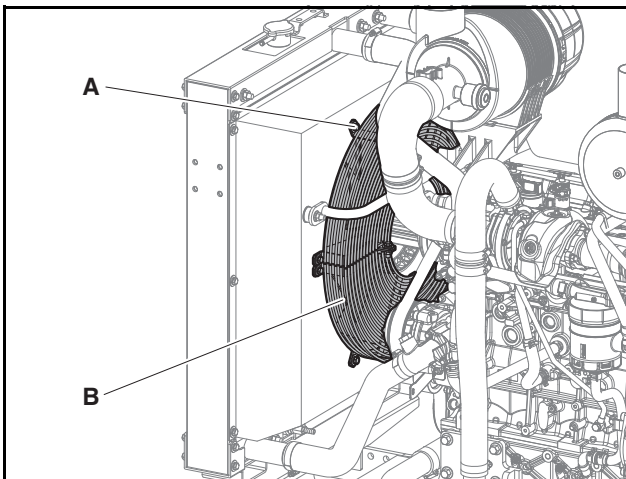
1) Open the radiator cap (A).

### ⚠ CAUTION

Opening the cap while it is hot may cause burns on your hands or face. Hence, wait until the coolant has cooled down; then, cover the cap with a cloth and open the cap slightly to release any excess pressure before opening the cap fully.

2) Open the drain valve (B): open the valve to drain the coolant.

2. Remove the fan guard.



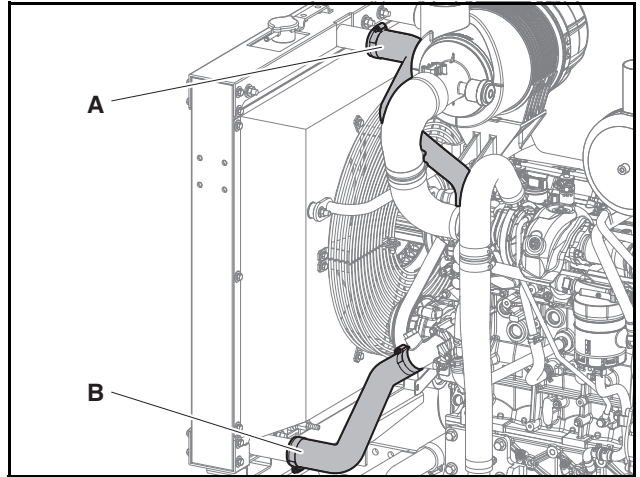
EDM03210164

1) Remove the six bolts (A) (six bolts at 60° angles).

Component	Tightening Torque
Fan guard bolt	2.2 ±0.22 kgf·m

2) Remove the upper and lower fan guards (B).

3. Remove the radiator in & out hoses.

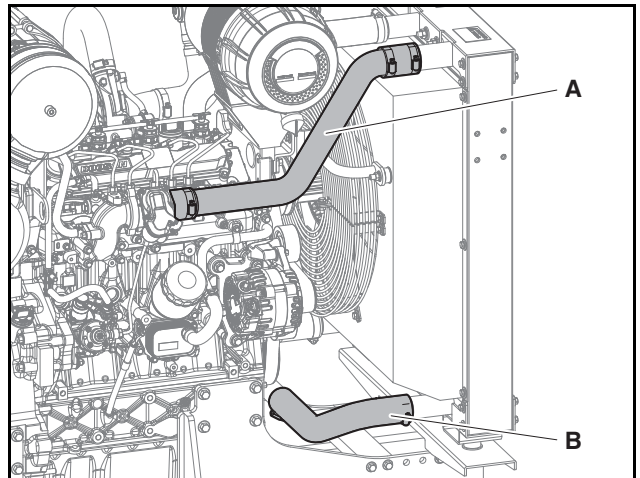


EDM03210165

- 1) Remove the clamp bolts on the radiator inlet hose (A); then, remove the hose.
- 2) Remove the clamp bolts on the radiator outlet hose (B); then, remove the hose.

Component	Tightening Torque
Hose clamp	0.6 ±0.09 kgf·m

4. Remove the CAC inlet & outlet hoses

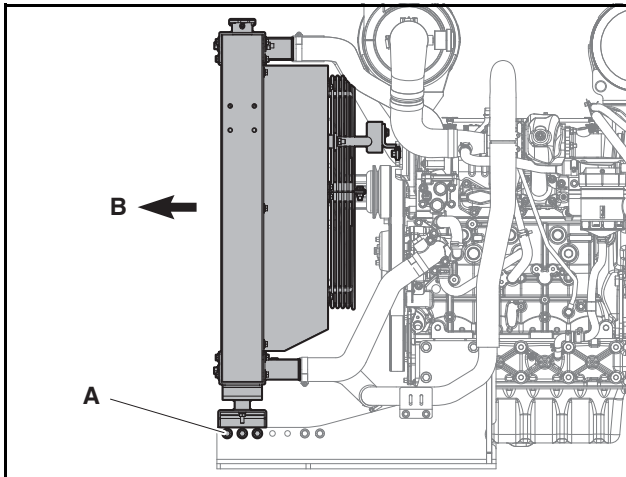


EDM03210166

- 1) Remove the clamp bolts on the CAC outlet pipe (A); then, remove the hose.
- 2) Remove the clamp bolts on the CAC inlet hose (B); then, remove the hose.

Component	Tightening Torque
Hose clamp	0.6 ±0.09 kgf·m

5. Remove the radiator bolts.



EDM03210167

1) Remove the radiator module mounting six bolts (A).

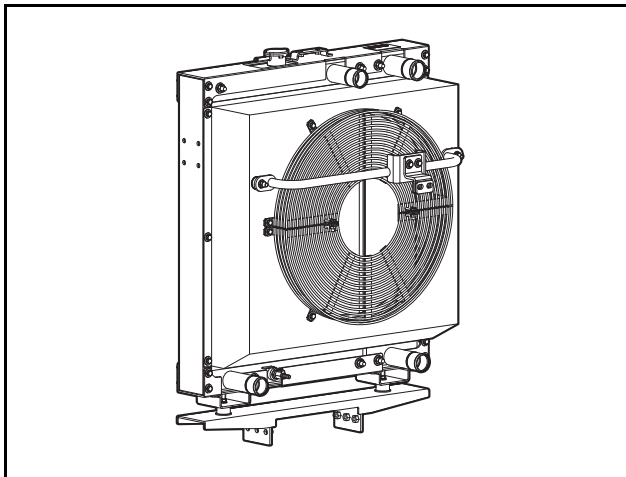
Component	Tightening Torque
Radiator module mounting bolt	4.4 ±0.44 kgf·m

2) Remove the radiator in the direction of (B).

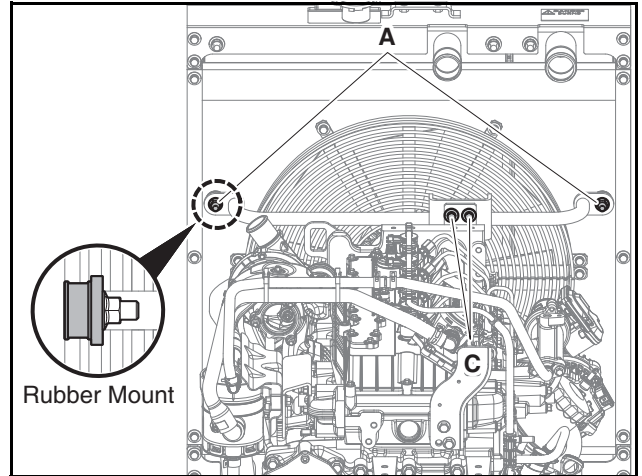
### Assembly

Assemble in the reverse order of disassembly.

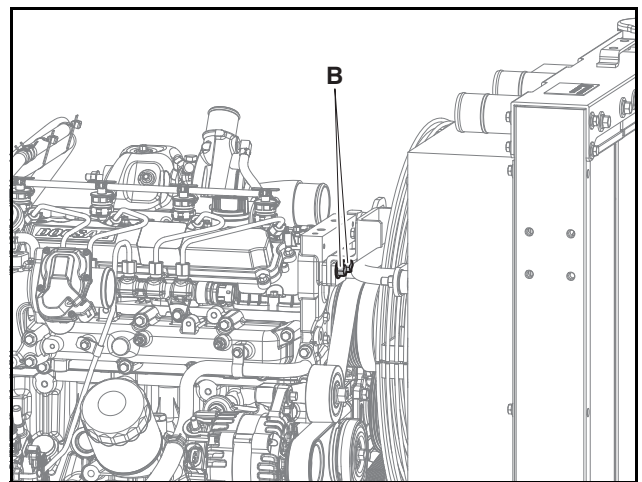
- 1) Keep the radiator at a horizontal level of  $0 \pm 0.5^\circ$  while tightening the bolts.
- 2) Assemble in the order of A, B, C.



EDM03210168



EDM03210169



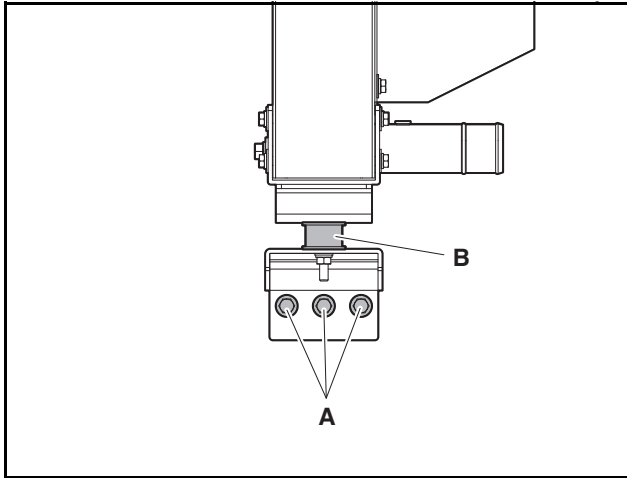
EDM03210170

- A, B tightening torque:  $6.2 \pm 0.62$  kgf·m
- C tightening torque:  $2.2 \pm 0.22$  kgf·m
- When assembling B and C, assemble so that the Rubber Mount of A is not twisted.

# 14. Accessory System

## Rubber Mount

During assembly of Radiator Assy, when assembling A, assemble the Rubber Mount (B) so that it does not twist or bend.



EDM03210171

## Radiator Check

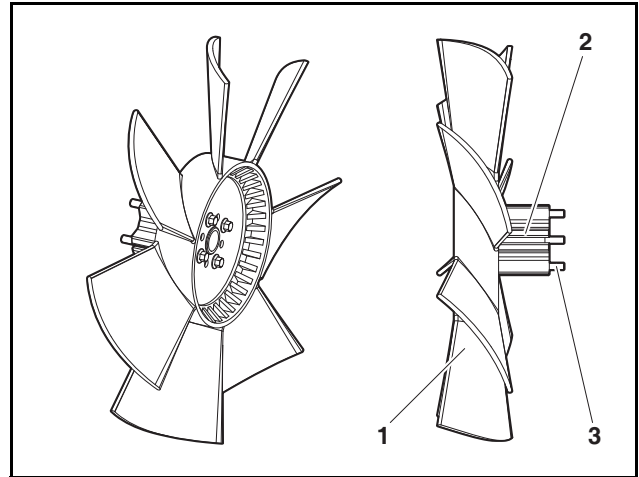
1. Routine checks and repairs: radiator performance is determined by the state of maintenance of the engine. Hence, make sure to perform inspections regularly and check the following.
  - 1) Check the coolant: check the level and condition of the coolant.  
If the specific gravity of the coolant exceeds the specified amount or the color has changed, replace the coolant. Deteriorated coolant may cause overheating, corrosion or damage due to freezing.
  - 2) Coolant leakage: use a flashlight to check for any coolant leakage on the ground. Coolant leakage may cause overheating.
  - 3) Air pockets: if the air in the cooling system is not discharged properly, the engine may overheat even if the reservoir tank has enough coolant.  
After opening the radiator cap, idle the engine sufficiently to bleed the air in the system; then, add coolant.
  - 4) Fan shroud: if the exterior of the shroud is defective, the worsened airflow may lead to overheating.  
Repair or replace the part.
  - 5) Clogged radiator fins: if the fins are clogged with dust, the restricted airflow may cause overheating.  
Clean the radiator with a radiator cleaning tool.
  - 6) Clogged radiator: if there is no airflow after preheating the engine, check whether the radiator is clogged or the thermostat is defective.
  - 7) Check the radiator cap: inspect the radiator cap seal and valve to make sure that they are working correctly.  
A defective radiator cap may cause overheating.

- 8) Horizontal balance of the radiator: check the horizontal balance of the radiator.  
An excessive incline may damage the radiator due to interference with the fan.

## Cooling Fan

### General Information

The cooling fan is a device which creates a forced airflow to enhance the cooling efficiency of the radiator and CAC.



EDM03200081

- |                |         |
|----------------|---------|
| 1. Cooling fan | 3. Bolt |
| 2. Fan flange  |         |
1. Creates airflow.
  2. A spacer added to position the fan.
  3. A bolt which connects the fan and fan flange.



## 14. Accessory System

### Failure Diagnosis

Phenomenon	Causes	Troubleshooting
Noise and vibrations	Poor air suction due to dust or other obstructions	Clean the radiator core or improve the airflow at the front and back of the radiator
	Low speed	Adjust the belt tension
	Improperly secured fan	Check the bolt torque
	Incorrect rotating direction	Assemble in the correct direction
Broken	Poor air suction due to dust or other obstructions	Clean the radiator core or improve the airflow at the front and back of the radiator
	Damage due to foreign matter	Remove the foreign matter and replace the fan

### How to Maintain the Cooling Fan

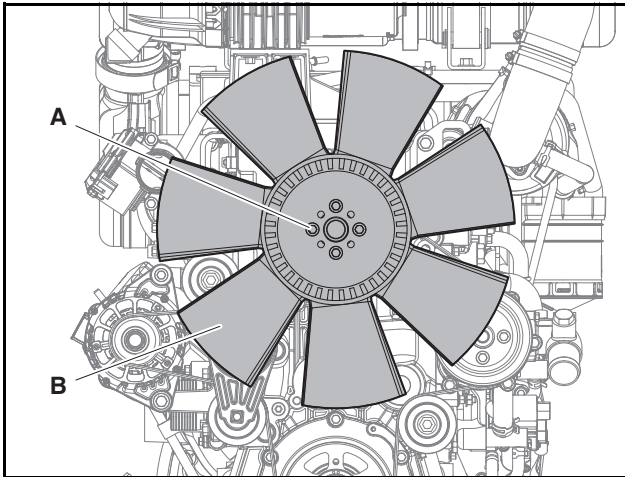
1. Cautions for engine operation.
- 1) Observe the following when starting, operating and stopping the engine.

Item	Cautions	Reasons
Starting the engine	Check the front and back of the radiator module	Damage or poor cooling performance due to clogging
	Check the blades for damage	Blade damage causes poor cooling and additional damage to nearby parts
Operating	Check for noise and vibrations	Blade damage causes poor cooling and additional damage to nearby parts
Stopping the engine	Check the blades for damage	Blade damage causes poor cooling and additional damage to nearby parts

# 14. Accessory System

## Cooling Fan Disassembly

1. Remove the radiator (reuse the figure above).
2. Remove the cooling fan.

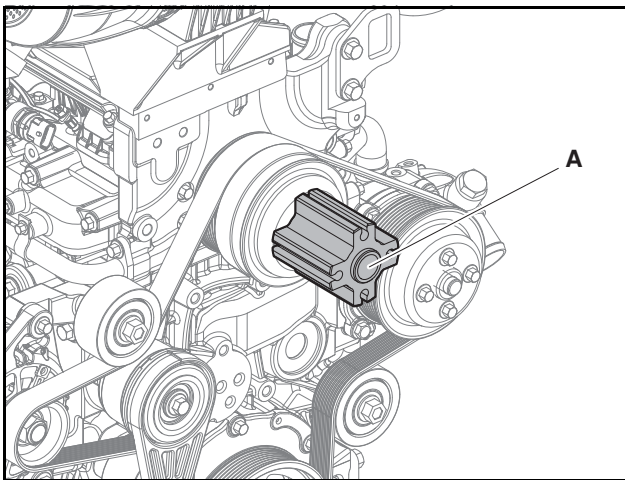


EDM03200082

- 1) Remove the four bolts (A).

Component	Tightening Torque
Cooling fan bolt	2.4 ±0.24 kgf·m

- 2) Remove the cooling fan (B).
3. Remove the fan flange.



EDM03200083

- 1) Remove the fan flange (A).

## Assembly

Assemble in the reverse order of disassembly.

## Cooling Fan Check

1. Routine checks and repairs: cooling fan performance is determined by the state of maintenance of the engine. Hence, make sure to perform inspections regularly and check the following.
  - 1) Noise and vibrations: check for noise and vibrations while operating the machine. Noise and vibrations may be caused by loose bolts, an excessively clogged radiator, etc. and may lead to overheating and damage.
  - 2) Visual inspection of blades: check the blades visually before running the engine. Defective blades may cause overheating and severe damage to nearby parts.

## Intake & CAC

### Intake/Exhaust System

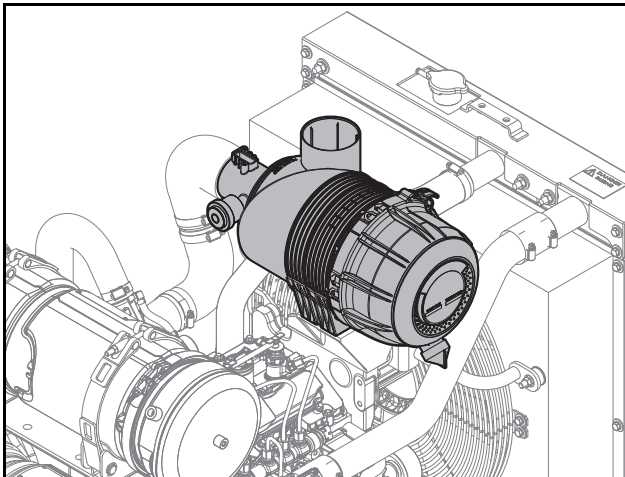
#### Air Cleaner

##### General Information

A device which removes foreign matter from the air delivered to the system.

Air filter types and components (options).

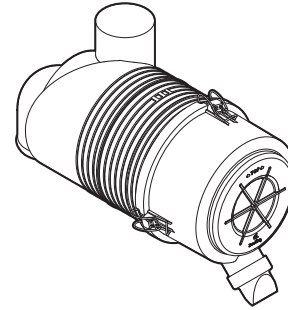
1. Cummins air filter.
  - Model name: OA 600
  - Provided
    - Mounting bracket
    - Air filter hose
    - Inlet air temp adapter



EDM03210172

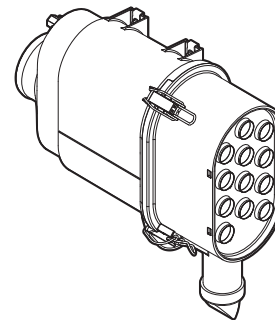
2. Donaldson air filter.
  - Model name: G070018, D080026, D080020
  - No integrated MAF HSG
  - Provided
    - Hose between A/filter and MAF HSG
    - Inlet air temp HSG

Donaldson Filter (G070018)



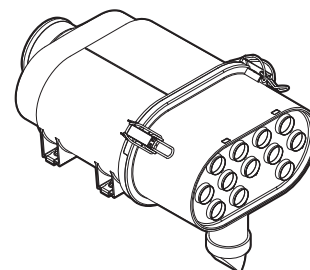
ED24190216

Donaldson Filter (D080026)



ED24190217

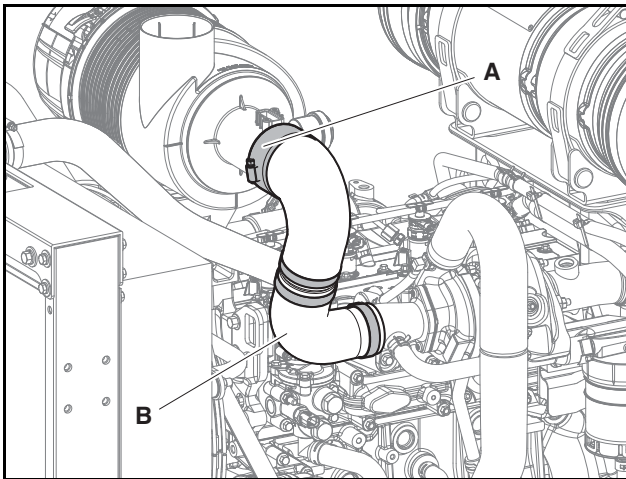
Donaldson Filter (D080020)



ED24190218

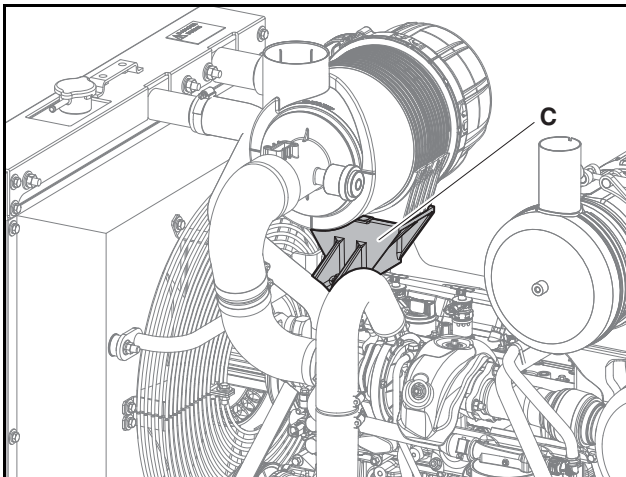
## 14. Accessory System

### Disassembly of Air Cleaner



EDM03210178

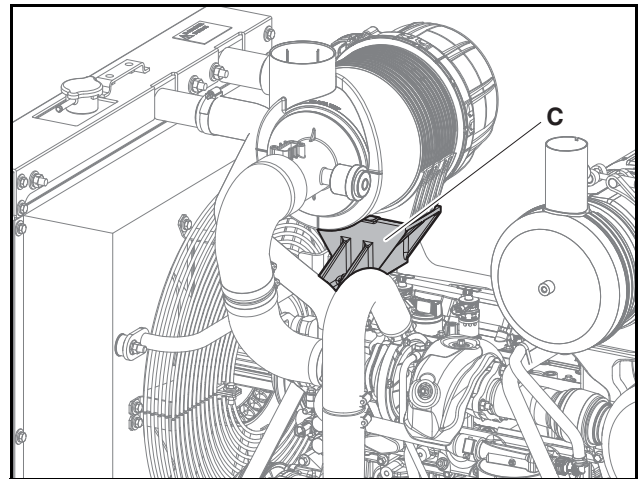
1. Remove the clamps (A) connected to the hose (B).
2. Remove the air filter and disconnect the hose and fitting pipe.



EDM03210179

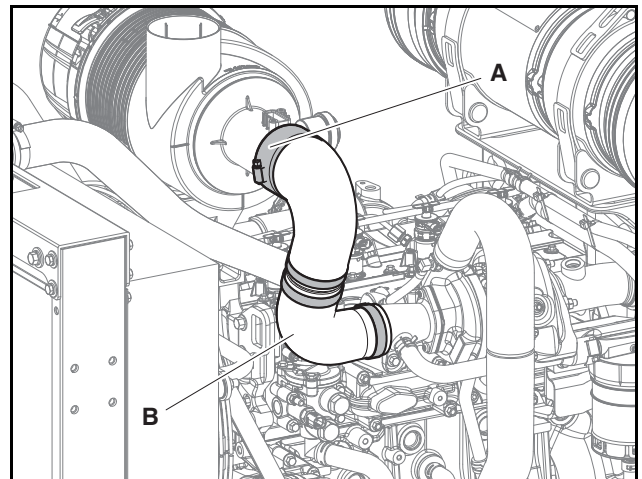
3. Remove all bolts and nuts from the air filter bracket (C).
4. Remove the air filter.

### Assembly of Air Cleaner



EDM03210179

1. Tighten all bolts and nuts on the air filter bracket (C).
2. Connect the air filter, hose and fitting pipe.



EDM03210178

3. Tighten the clamps (A) to the hose (B) connection.

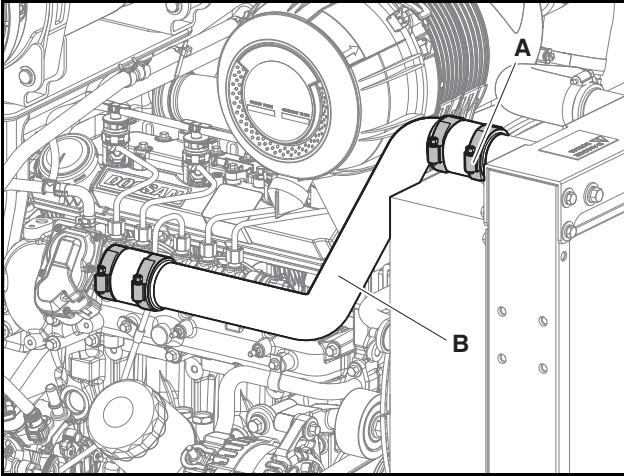
**⚠ CAUTION**

**Do not reuse clamps; replace them with new ones.**

# 14. Accessory System

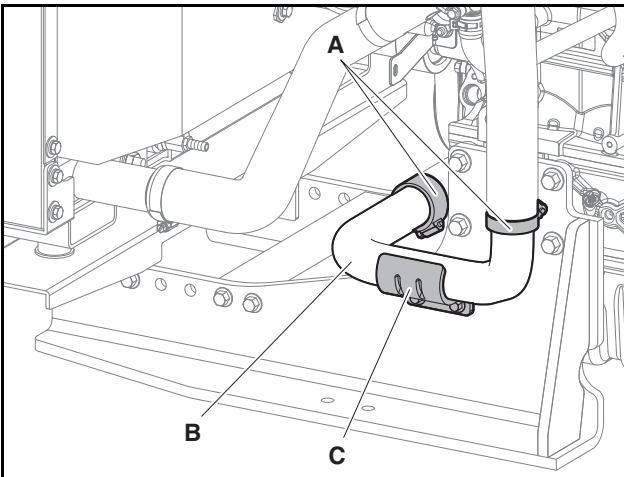
## Air Hose

### Disassembly of Air Hose



EDM03210180

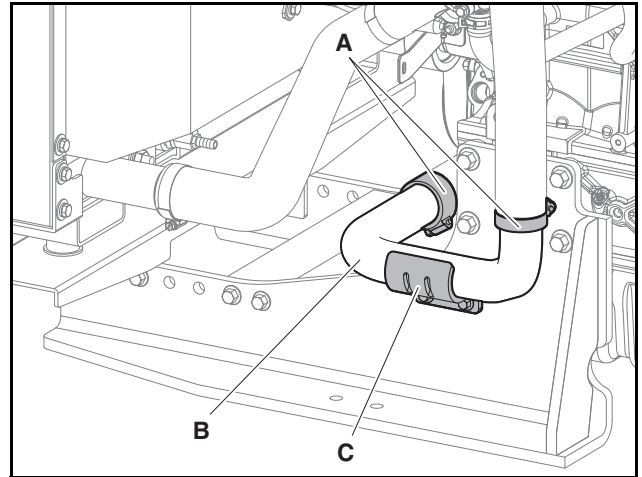
1. Remove the clamps (A) connected to the hose (B).
2. Disconnect the air hose.



EDM03210181

1. Remove the clamps (A) connected to the hose (B).
2. Disconnect the air hose.
3. Remove bolts and nuts from the bracket (C).

### Assembly of Air Hose



EDM03210181

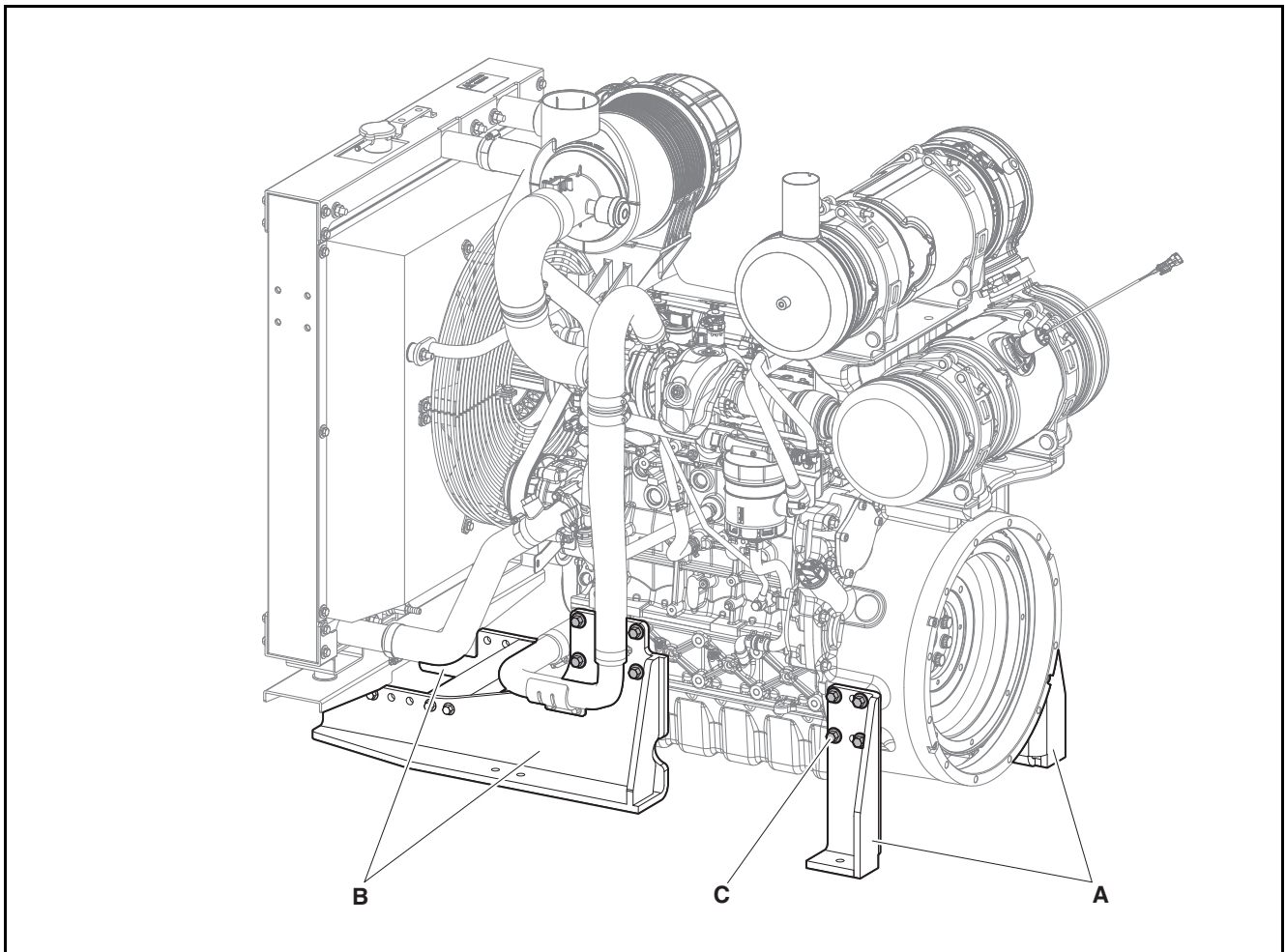
1. Tighten all bolts and nuts on the air hose bracket (C).
2. Connect the air hose.
3. Tighten the clamps (A) on the hose (B) connection.

## CAUTION

**Do not reuse clamps; replace them with new ones.**

## 14. Accessory System

### Engine Mount



EDM03210173

1. Removal and tightening of brackets.

- A: Rear mount bracket
- B: Front mount bracket

---

### CAUTION

**Make sure the brackets are horizontal while tightening them.**

---

2. Bolt torque:  $10.5 \pm 1.05$  kgf·m

- C: 16 bolts (rear & front)



# 15. Option

Base Option .....	293
Part Option .....	294



---

**Base Option**

Parts	Option	Engine
Oil dipstick	Swichable (LH - RH side)	All
Oil filler cap	Head cover + TGCC	D18/D24
	Head cover + FWH	D34
Oil filter	Top direction	All
Oil drain plug	Front + Bottom	D18
	LH + RH	D24/D34
Remote oil filter kit	Provided for option (Hose length: 1,250 mm)	All
2nd CRS pulley	Provided by AS/AM	All
Acceleration	CAN pedal (TSC1)	All
	Analog pedal	
Low idle RPM	Variable	

\* Cooling fan Pulley Ratio (CRS : Pulley)

- D18/24 = 1 : 1.2
- D34 = 1 : 1.3

## 15. Option

### Part Option

Parts	Option	Part number	Type	Remark
Flywheel & Flywheel housing combination	SAE5 w pilot bearing adaptor	N/A	A	
	SAE4 w pilot bearing adaptor	FW: 150111-00377X FWH: 150114-00397X + 110951-02090X P/BRG: 430215-01787X	B	
	SAE3 w pilot bearing adaptor	FW: 150111-00374X FWH: 150114-00397X + 110951-02094X P/BRG: 430215-01787X	C	
	SAE5 w/o pilot bearing	N/A	D	
	SAE4 w/o pilot bearing	FW: 150111-00377X FWH: 150114-00397X + 110951-02090X	E	
	SAE3 w/o pilot bearing	FW: 150111-00374X FWH: 150114-00397X + 110951-02094X	F	
	Flat (Slim)	FW: 150111-00546X FWH: 150114-00403X	G	Aftertreatment: Chassis only
Oil pan type	Flat	150119-00343X	A	
	Rear sump	TBD	B	No- Oil level sensor
Oil level sensor	None	N/A	A	
	Apply	301308-00971X	B	No- Rear sump oil pan
Oil filter type	Engine mounting	400404-00131X	A	
	Remote	400404-00119X	B	
Front PTO	None	130711-00293X	A	
	Apply	130711-00301X	B	
Side PTO	None	follow the spline specification	A	
	PTO_1st	↑	B	
	PTO_2nd	↑	C	
PTO spline specification	None	N/A	A	
	DIN 9t	(1st) 130807-00022X (2nd) 130807-00055X	B	Flange Type: SAE A
	ANSI 9t	(1st) 130807-00048X (2nd) 130807-00056X	C	Flange Type: SAE A
	ANSI 10t	(1st) 130807-00067X (2nd) 130807-00058X	D	Flange Type: SAE A
Fuel filter type	1,000 hrs_12V	400403-00620B	A	
	1,000 hrs_24V	400403-00644A	B	

## 15. Option

Parts	Option	Part number	Type	Remark
Pre fuel filter type	None	N/A	A	
	Pre-filter_12V	400403-00638	B	
	E-pump & Pre-filter_12V & OFV	400909-00347 & 400403-00638 & 400825-00320	C	
	Pre-filter_24V	400403-00639	D	
	E-pump & Pre-filter_24V & OFV	400909-00347 & 400403-00639 & 400825-00320	E	
Aftertreatment system	Engine mounting	PU 74hp S5: 240103-01354X T4F: 240103-01356X 115hp S5: 240103-01443X + 240103-01444X T4F: 240103-01443X + 240103-01557X 135hp S5: 240103-01443X + 240103-01445X T4F: 240103-01443X + 240103-01558X  GEN S5: 240103-01443X + 240103-01444X T4F: 240103-01443X + 240103-01557X	A	Rotational outlet
	Chassis mounting	PU 74hp S5: 240103-01355X T4F: 240103-01357X 115hp S5: 240103-01446X + 240103-01447X T4F: 240103-01446X + 240103-01559X 135hp S5: 240103-01446X + 240103-01448X T4F: 240103-01446X + 240103-01560X	B	Rotational inlet/outlet
UREA tank	15 L	450106-00240A	A	
	30 L	450106-00241A	B	
DEF hose (UREA pressure line)	1.5 m	420108-02370	A	
	2 m	420108-02371	B	
	2.5 m	420108-02372	C	
	3 m	420108-02373	D	
	None	N/A	E	
Starter	12V	300516-00147B	A	Starter: 2.5kW
	24V	300516-00138	B	Starter: 5.0kW
Alternator	110A_12V	300901-00219	A	
	140A_12V	300901-00220	B	
	80A_24V	300901-00222	C	

## 15. Option

Parts	Option	Part number	Type	Remark
Radiator type	42 degC	440211-01223X	A	
	52 degC	440211-01222X	B	
Radiator fan type	Blow	65.06601-5057X (w/440211-01223X only) 210101-00615X (w/440211-01222X only)	A	
	Suction	210101-00609X	B	
Air filter assembly	None	N/A	A	
	OA800_CUMMINS, DI	400414-00824X	C	DI base: Cummins filter
	B080080_DONALDSON	400414-00786X	F	Round type
	D090101_DONALDSON	400414-00787X	I	Vertical type
	D090121_DONALDSON	400414-00788X	J	Horizontal type
Engine & Radiator mount bracket	None	N/A	A	
	Provided	(Front RH) 110427-01138X (Rear RH) 110427-01137X (Front LH) 110427-01147X (Rear LH) 110427-01148X (Bracket beam) 110427-01295X	B	

\* Refer to the next sheet for turbo charger options