



Operation & Maintenance Manual

DIESEL ENGINE

D18NAP

Preface

This Operation and Maintenance Manual provides information on engine management and maintenance techniques to customers and technicians of Doosan Infracore's D18NAP electronically controlled industrial diesel engine.

To provide the best engine to our customers, the D18NAP electronically controlled industrial diesel engine is designed to satisfy all requirements for low noise, economic fuel consumption, high speed and durability with the latest technology and quality.

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

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

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

We, Doosan Infracore, do our best to provide more convenient and safe maintenance techniques and to meet the requirements of our customers.

If you have any questions or find any errors in this Operation and Maintenance Manual, please do not hesitate to contact us.

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

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Doosan Infracore

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General Preface

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

WARNING

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

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.

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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

1. General Introduction

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

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.

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

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Engine Management

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 Doosan 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 Doosan 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 Doosan.
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.

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.

1. General Introduction

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.

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2. Operation and Management

Operation and Management

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.

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

Starting the Engine

Observe the following when starting the engine.

1. For a cold start, start the engine after preheating it sufficiently through the glow plug.
2. Starting the engine too quickly leads to engine rotation without lubricating the supercharger and other engine parts, causing abnormal wear to or burning of bearings. Therefore, start the engine with the starter motor to check raising of oil pressure (until the gradation of the oil pressure gauge mounted on the apparatus moves or the pressure indicator lamp is turned on).
3. If the engine was not used or kept cold for a long period of time, oil circulation will be poor. If you replace oil, oil filter cartridge, or lubrication system parts or use an engine in cold areas, or the engine has been stopped for a long period, loosen the oil pipe joint at inlet of the supercharger and run the

starter motor until oil flows out. After completing the work, tighten the oil pipe joint again and start the engine.

After Starting the Engine

1. Do not rapidly raise the rpm while the engine and turbocharger do not rotate smoothly after starting the engine. 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, slowly decrease the rpm to a stop the engine and examine the cause.

Stopping the Engine

Do not suddenly stop the engine after it was 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.

2. Operation and Management

Break-in Period of the Engine

General Information

Doosan 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 $\overline{70}$ % 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.

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. This phenomenon may occur when the engine is operating successfully.

3. Check the coolant gauge on the apparatus and if the coolant circulates properly. If the coolant level in the supplementary tank is too low, the coolant gauge may be inaccurate. (may be disturbed).
4. Exchange engine oil and oil filter after the break-in period.

CAUTION

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

Operation after Break-in

Slowly preheat the engine when starting up during cold weather or in areas with cold climate. Do not rapidly raise the rpm while the engine has not been properly preheated yet. The engine consumes additional oil until its piston ring is positioned properly and operates successfully. Please check the engine oil level frequently during the initial 50 hour break-in period.

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. Operation and Management

Inspection after Starting the Engine

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

1. Tightly connect the +/- terminals to prevent gaps between them. The sheath of battery connection cables should not be damaged or broken.
2. 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.

Engine Oil Pressure

If the engine oil pressure is not consistent at idle or does not reach the reference value while the engine is operating in high speed mode, immediately stop the engine and check the oil level and leakage.

Coolant Temperature

Operating an engine with insufficient coolant temperature increases fuel consumption, abrasion of the cylinder liner, shortening the engine's life span.

Revolutions per Minute (rpm)

In the electronic control engine, the engine control unit (ECU) prevents the engine from being operated at too high rpm over the specifications to protect the engine. The memory of ECU has various functions which cannot be changed by operators, such as fuel flow control, ignition time delay, and blocking of fuel and ignition.

2. Operation and Management

Operation in Winter

Cold Start

Periodically check for frozen coolant and viscosity of lubrication oil.

CAUTION

- **A preheater should be mounted on the engine to improve the cold start performance.**
 - **Start the engine after turning off the preheating lamp.**
 - **Do not operate the starter motor for over 10 seconds. If the engine does not start even though it is fully preheated, wait for about 30 seconds, preheat the engine again, and then start the engine.**
-

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) Operate the preheater if coolant is below 10 °C during cold weather. If preheating is not necessary, the preheat lamp will not switch on.

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

Note) If the key is turned to 'Start', the air heater is continuously heated to provide an easy start and reduce white exhaust gas. If the coolant temperature is above 10°C , it is not necessary to heat the air heater.

3. After starting the engine, the key switch changes to ON.

CAUTION

As the ECU heats the intake air for about 180 seconds after starting the engine, the white exhaust gas is reduced quickly.

Preventing Coolant from Freezing.

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

antifreeze at revised ratio when replacing or replenishing the coolant. The antifreeze prevents coolant from freezing.

Preventing 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 Doosan.

2. Operation and Management

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
 - Intercooler
 - Supercharger, silencer
 - EGR cooler and Calve
 - Other parts
2. Parts affecting lubrication and cooling
 - Air filter
 - Oil filter
 - Antifreeze
 - Other parts

Inspection and Repair of Supercharger

As performance of supercharger 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 supercharger 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 Unit

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

2. Operation and Management

3. Performance and Specifications

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3. Performance and Specifications

Performance and Specifications

Engine Specifications and Performance

Engine Specifications

Item		D18NAP		Remark
		DL01-LEE00	DL01-LEL00	
General Information				
Engine types		4-Stroke series, water-cooled, Turbocharger and air cooling type	←	
Combustion chamber type		Direct injection	←	
Cylinder liner type		No liner	←	
Timing gear unit		Gear drive	←	
Number of piston rings		Two compression rings and one oil ring	←	
Number of cylinders		3	←	
Cylinder bore		90 mm	←	
Cylinder stroke		94 mm	←	
Total displacement		1,794 cc	←	
Compression ratio		17.0:1	←	
Engine Dimension (L x W x H)		674.7mm X 477.5mm X 737.6mm	514.5mm X 542.1mm X 695.8mm	
Engine weight		165 Kg	170 Kg	View from flywheel
Direction of rotation		Counter-clockwise	←	View from flywheel
Firing order		1 - 2 - 3	←	
Cooling system				
Cooling Type		Water-forced cooling	←	
Capacity of coolant		2.7 L	←	
Water pump	Type	Centrifugal (impeller type)	←	
	Driving Type	Ribbed-Belt driven	←	
	Pump Speed	2,640 rpm	3,360 rpm	
	Flow rate	1 : 1.1	1 : 1.2	
	Supply	Above 110 LPM	←	
	Pump back pressure	0.66 bar	←	
Cooling fan	Type	-	←	
	Driving Type	Directly connected to water pump	←	-
	Rotation Ratio (Engine RPM: fan RPM)	1:1.1	1:1.2	

3. Performance and Specifications

Item		D18NAP		Remark
		DL01-LEE00	DL01-LEL00	
Thermostat	Type	Wax pellet type	←	
	Valve-opening temperature	82 °C	←	
	Full valve-opening temperature	97 °C	←	
	Lift	8 mm	←	
Lubrication System				
Lubricating type		Forced lubrication system	←	
Oil Pressure	Idle (Idling revolution count)	Above 1.5 kg/cm ²	←	
	Max. Load (rated RPM)	4.0 kg/cm ² ~ 5.5 kg/cm ²	←	
Oil Specifications	Oil Class	API CJ-4 (ACEA-E9)	←	
	SAE	SAE 10W30	←	
Oil Capacity	Total	6.7L (Including 0.4L in the engine)	←	
	Max.	6.3 L	←	
	Min.	2.8 L	←	
Allowable tilt angle (oil pan) (front/rear/left/right)		35° / 35° / 35° / 35°	←	
Oil pump	Type	Gear type	←	
	Driving Type	CRANK GEAR driven	←	
Oil coolant type		Water-cooled stack plate type	←	
Oil filter	Type	Spin on Type Filter	←	
	Allowable temperature	-40°C ~ 140°C	←	
	Flow	36 L/min	←	
Lubrication indicator		Oil pressure type	←	
Opening pressure of the oil spray nozzle adjustment valve		1.0 ~ 1.4 kg/cm ²	←	
Hydraulic indicator		Oil Pressure Sensor	←	
Fuel System				
Fuel injection pump type		DELPHI DFP 4.4	←	
Control type		E.C.U (DELPHI)	←	
Delivery pump type		Gear type (with in DFP 4.4)	←	
Injection nozzle	Type	Multi hole type	←	
	Opening pressure (Operating pressure)	1,800 bar	←	
Fuel filter type		BCT (spin-on type)	←	

3. Performance and Specifications

Item		D18NAP		Remark
		DL01-LEE00	DL01-LEL00	
Intake/Exhaust System				
Turbocharger	Model	Borgwarner WGT	←	
	Driving Type	EXHAUST PRESSURE FEED TYPE	←	
	Lubricating type	FORCED PRESSURE FEED TYPE	←	
	Compressor outlet air pressure	1.98 kgf·cm ²	2.14 kgf·cm ²	At max. output
	Air intake	50 g/s	64 g/s	At max. output
	Turbine speed	-	←	At max. output
	Allowable max. RPM	275 krpm	←	From the turbine inlet
	Allowable max. exhaust temperature	750 °C	←	
	Weight	3.8 kg	←	
	Valve gap	Intake valve	0.4 mm	←
Exhaust valve		0.45 mm	←	
Intake valve	Open (BTDC)	19°	←	
	Closed (ABDC)	45°	←	
Exhaust valve	Open (BBDC)	29°	←	
	Closed (ATDC)	23°	←	
Valve length	Intake	104.53 mm	←	
	Exhaust	106.33 mm	←	
Stem outside diameter	Intake	6.97 ± 0.007 mm	←	
	Exhaust	6.96 ± 0.007 mm	←	
Valve guide bore	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 sheet contact width	Intake	1.91 mm	←	
	Exhaust	1.89 mm	←	
Valve sheet angle	Intake	44.5° ~ 45.0°	←	
	Exhaust	44.5° ~ 45.0°	←	
Free length of valve spring		53.8 mm	←	
Valve spring squareness		Below2° (below 1.8 mm)	←	

3. Performance and Specifications

Item		D18NAP		Remark
		DL01-LEE00	DL01-LEL00	
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	39.498 mm	←	
	Exhaust	38.453 mm	←	
Camshaft journal outside diameter	Intake	44.919 ~ 44.935 mm	←	
	Exhaust	44.919 ~ 44.935 mm	←	
Camshaft bearing oil gap		0.065 ~ 0.106 mm	←	
Camshaft end play		0.1 ~ 0.2 mm	←	
Inside diameter of cylinder block piston bore		89.99 ~ 90.10 mm	←	
Flatness of cylinder block gasket surface		0.05 mm 0.03 mm / 100 mm	←	
Electric apparatus				
Engine control type		Electronic Control Unit (ECU)	←	
Engine stop unit		Cut off fuel supply through ECU	←	
Preheating system		Glow Plug (12V X 3EA)	←	
Other/Driving System				
Piston outside diameter		Grade A: 89.920 ~ 89.930mm Grade B: 89.930 ~ 89.940mm	←	
Gap between cylinder and piston		0.060 ~ 0.080 mm	←	
Piston ring groove area	Top ring groove	1.915 ~ 1.945 mm	←	
	2nd ring groove	2.060 ~ 2.080 mm	←	
	Oil ring groove	3.020 ~ 3.040 mm	←	
Piston ring side gap	Top ring side gap	0.083 ~ 0.133 mm	←	
	2dn ring side gap	0.070 ~ 0.110 mm	←	
	Oil ring side gap	0.030 ~ 0.070 mm	←	
Piston ring end gap	Top ring end gap	0.20 ~ 0.30 mm	←	
	2nd ring end gap	0.55 ~ 0.70 mm	←	
	Oil ring end gap	0.2 ~ 0.4 mm	←	

3. Performance and Specifications

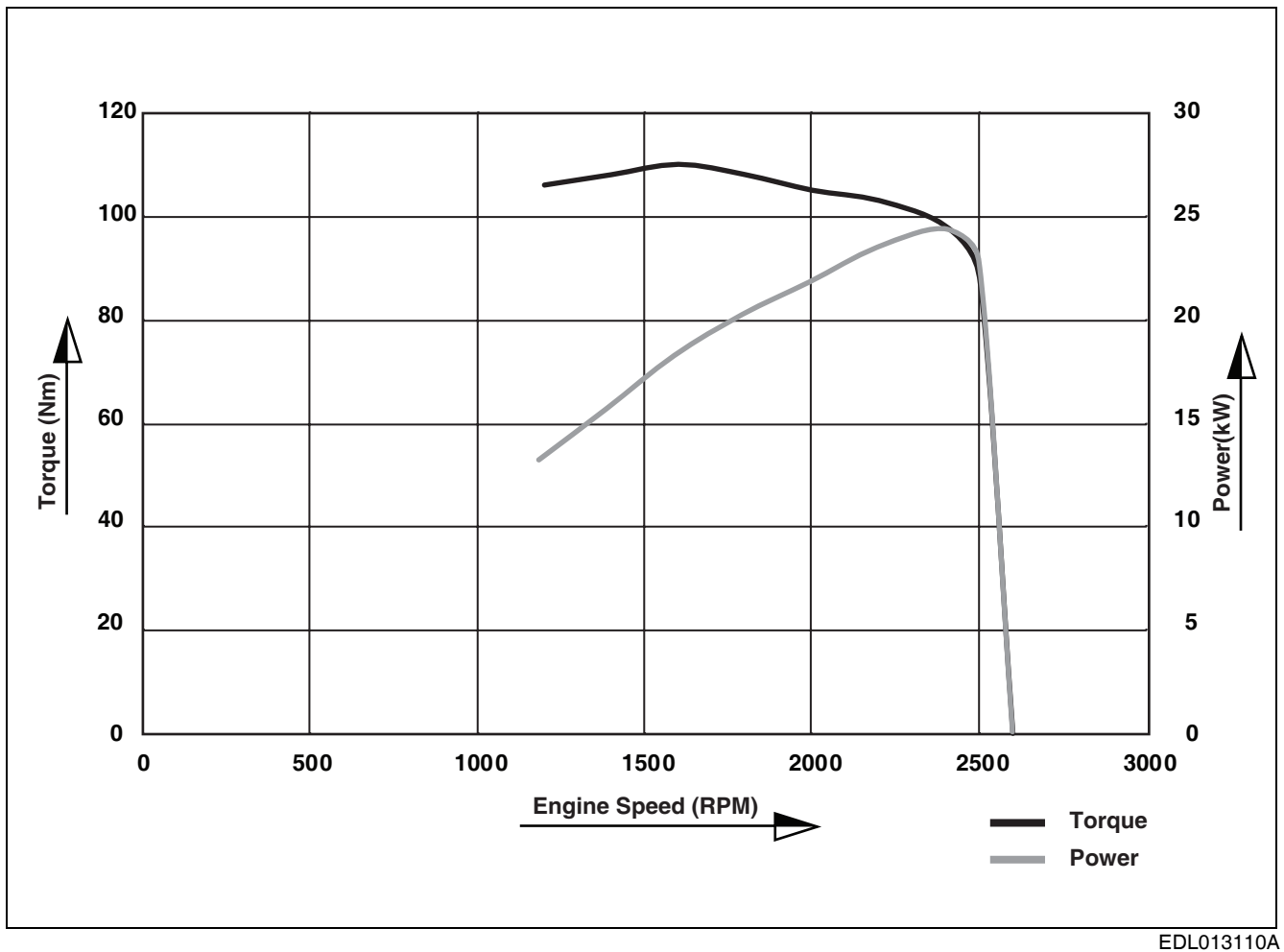
Item	D18NAP		Remark
	DL01-LEE00	DL01-LEL00	
Piston pin outside diameter	30.995 ~ 31,000 mm	←	
Piston pin hole bore	31.008 ~ 31.014 mm	←	
Piston pin hole gap	0.008 ~ 0.019 mm	←	
Connecting rod small-end bore	31.025 ~ 31.038 mm	←	
Connecting rod small-end hole gap	0.025 ~ 0.043 mm	←	
Connecting rod large-end bore	57.000 ~ 57.015 mm	←	
Connecting rod bearing oil gap	0.026 ~ 0.064 mm	←	
Connecting rod end play	0.15 ~ 0.3 mm	←	
Crankshaft main journal outside diameter	57.955 ~ 57.970 mm	←	
Crankshaft pin journal outside diameter	53.955 ~ 53.970 mm	←	
Crankshaft main bearing oil gap	0.029 ~ 0.059 mm	←	
Crankshaft end play	0.1 ~ 0.31 mm	←	

Engine output

Engine		Performance			
Model	Product code	Output (PS/rpm)	Torque (N·m/rpm)	Idle at low speed (rpm)	Idle at high speed (rpm)
D18NAP	DL01-LEE00	33/2,400	110/1,600	1,220	2,400
	DL01-LEL00	49/2,800	165/1,800	1,150	2,800

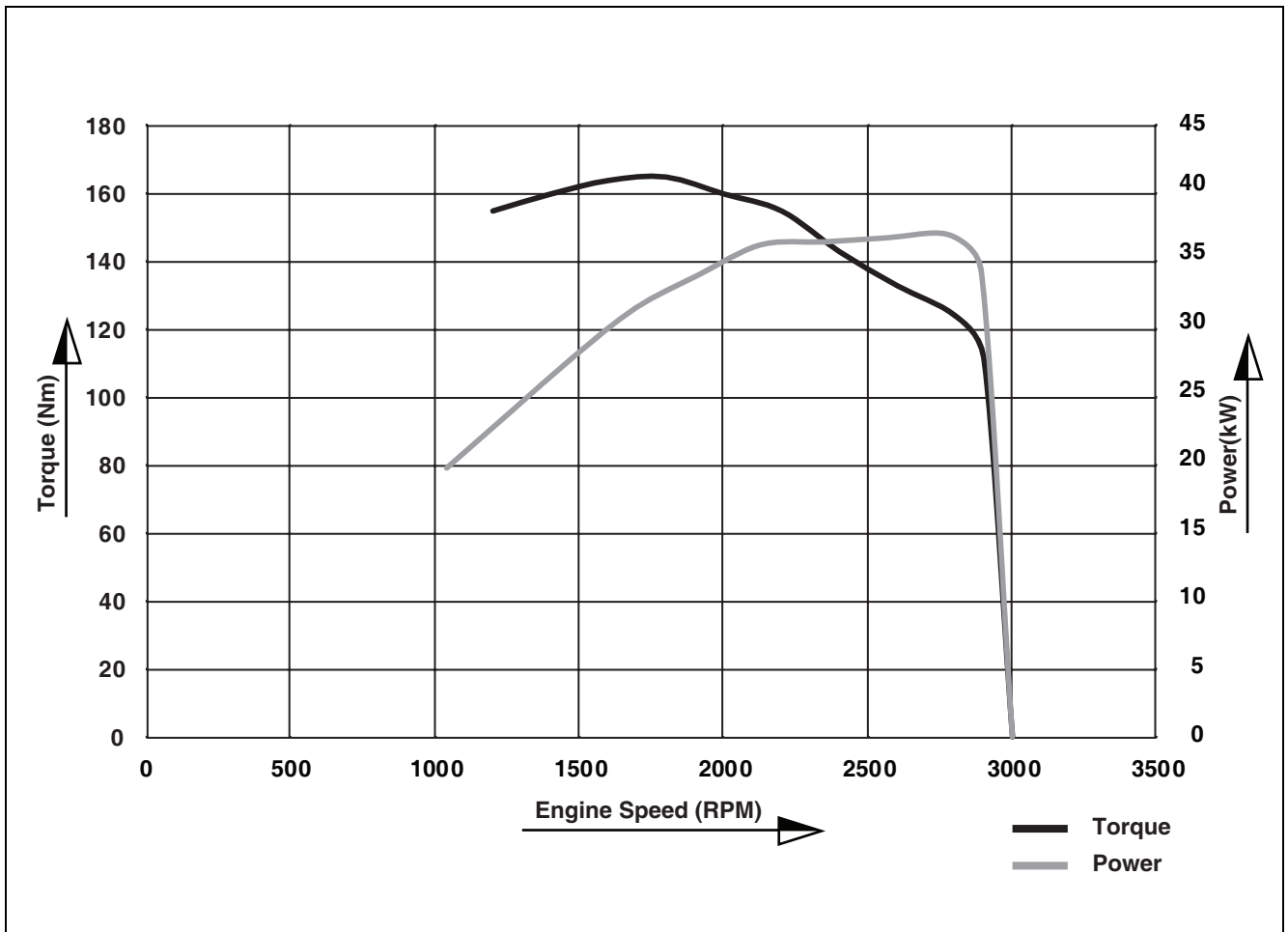
3. Performance and Specifications

Engine performance curve (DL01-LEE00)



3. Performance and Specifications

Engine performance curve (DL01-LEL00)

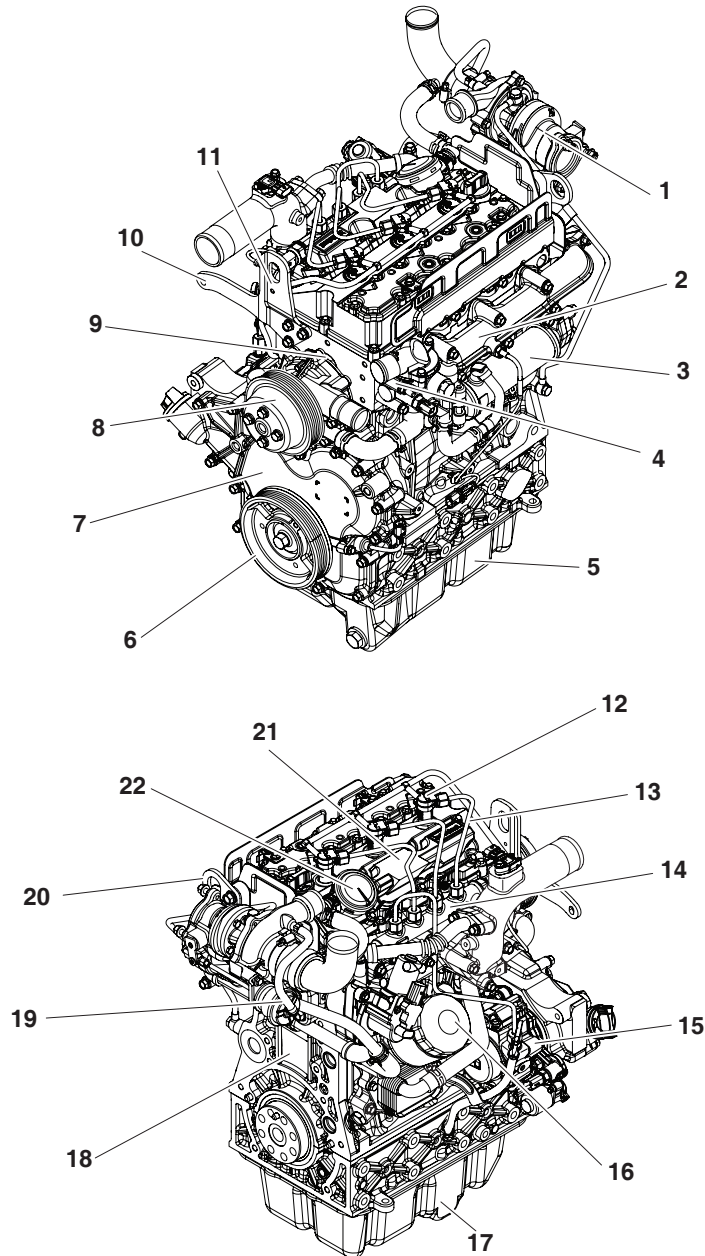


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3. Performance and Specifications

Outside Drawing of the Engine (DL01-LEE00)

Isometric assembly drawings

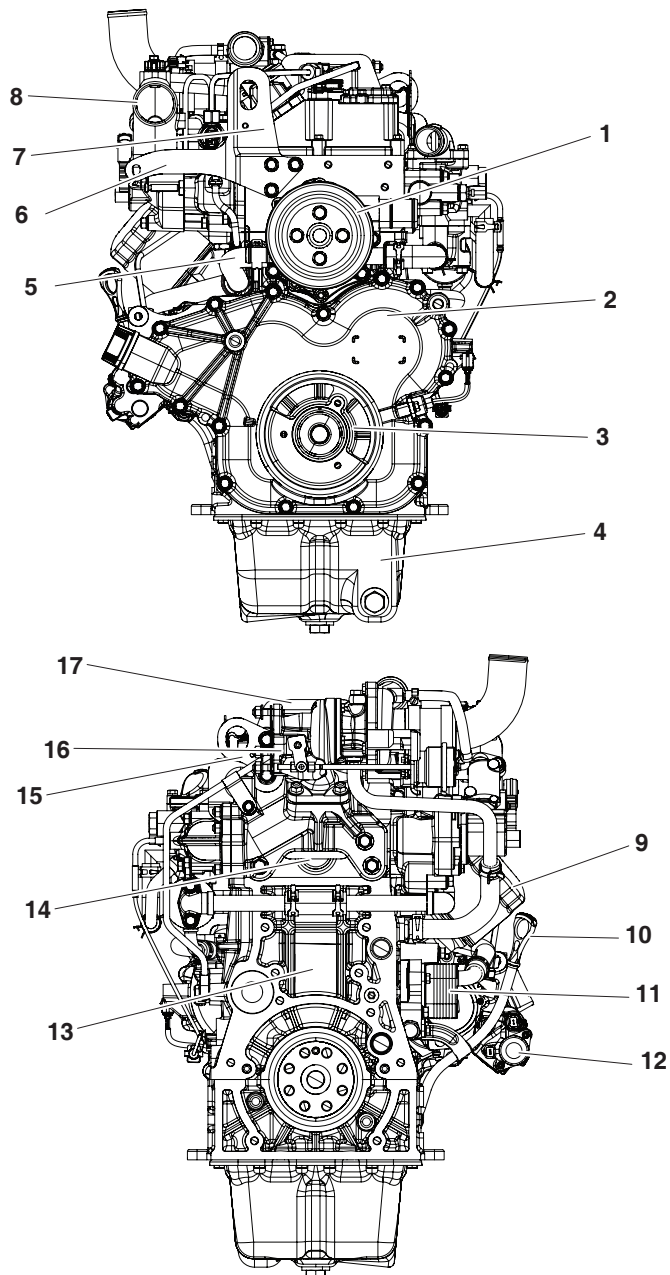


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- | | | | |
|----------------------|-------------------------|-------------------------|--------------|
| 1. Turbocharger | 8. Coolant pump pulley | 15. Fuel injection pump | 22. Breather |
| 2. Exhaust manifold | 9. Coolant pump | 16. Oil filter | |
| 3. EGR cooler | 10. Alternator mountng | 17. Drain cock | |
| 4. Thermostat | 11. Front lifting hook | 18. Cylinder block | |
| 5. Oil Pan | 12. Injector | 19. Intake manifold | |
| 6. Crankshaft Pulley | 13. Fuel Injection pipe | 20. Rear lifting hook | |
| 7. Timing gear case | 14. Common rail | 21. Cylinder head cover | |

3. Performance and Specifications

Assembly drawings (Front/Rear)

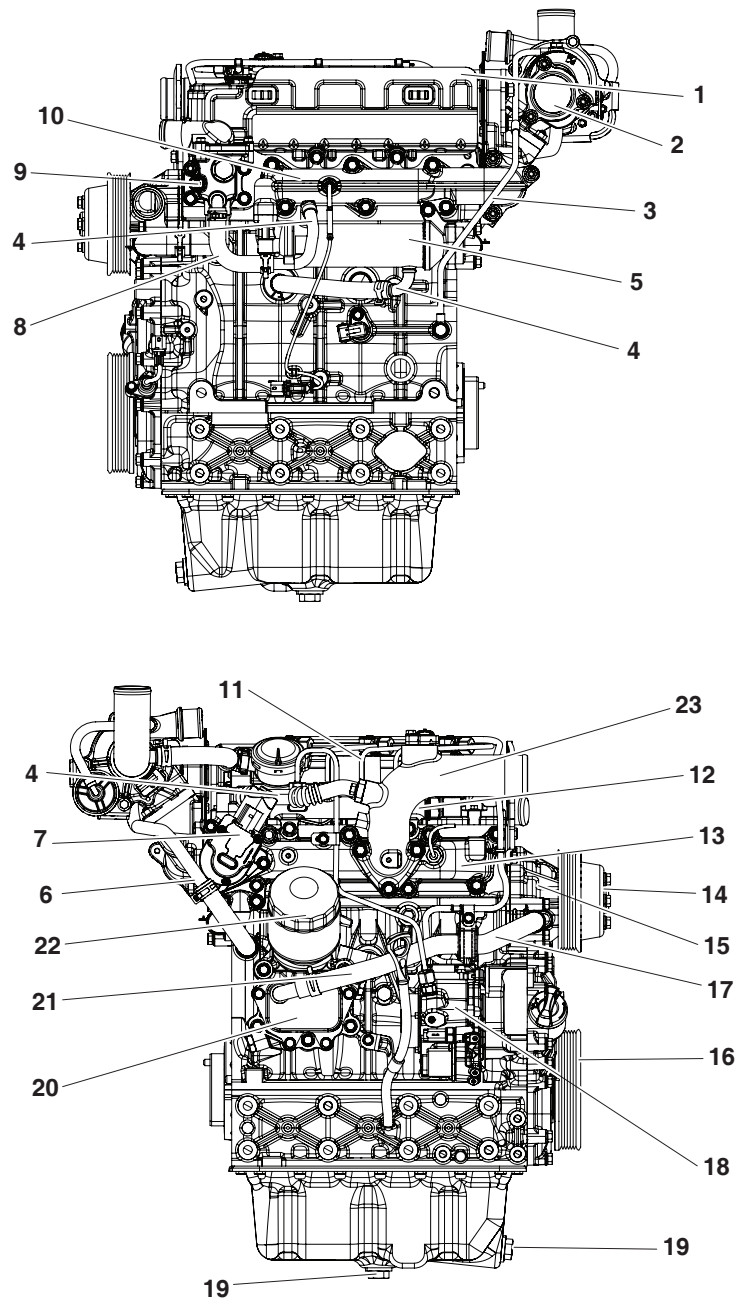


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- | | | |
|------------------------|-------------------------|-------------------------|
| 1. Coolant pump pulley | 8. Intake stake | 15. Rear lifting hook |
| 2. Timing gear case | 9. Oil filter | 16. Cylinder head cover |
| 3. Crankshaft pulley | 10. Oil level gauge | 17. Breather hose |
| 4. Oil pan | 11. Oil cooler | |
| 5. Coolant hose | 12. Fuel injection pump | |
| 6. Alternator mountin | 13. Cylinder block | |
| 7. Front lifting hook | 14. Cylinder head | |

3. Performance and Specifications

Assembly drawings (Left/Right)

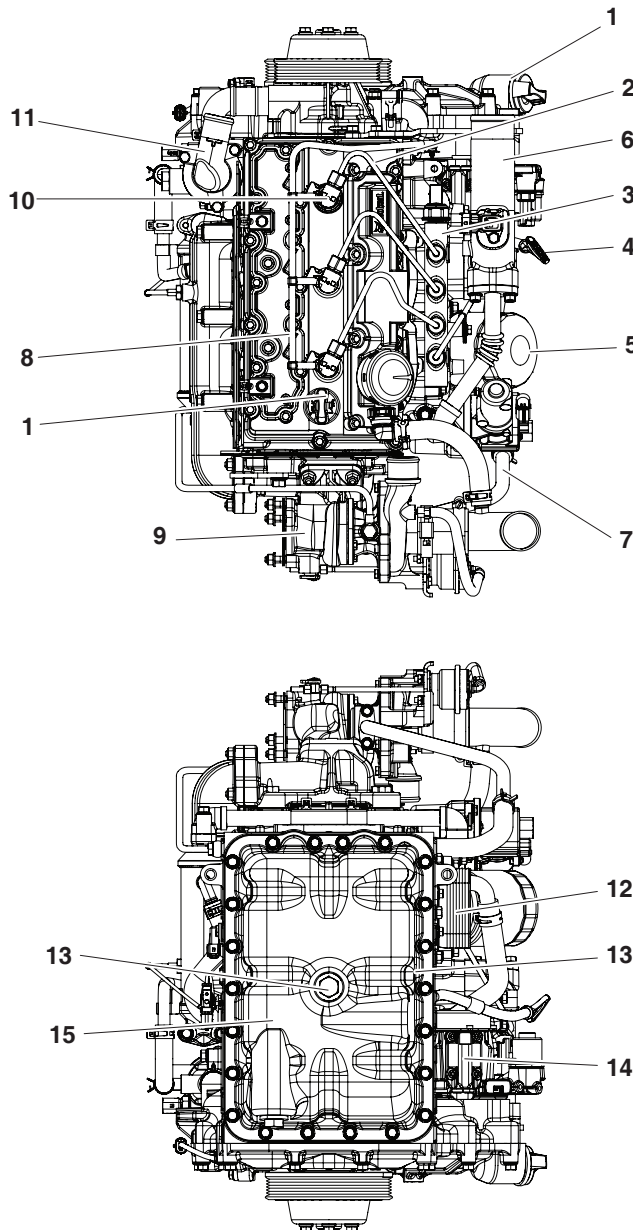


EDL013104A

- | | | | |
|------------------------|-------------------------|-------------------------|------------------|
| 1. Heat screen | 8. Coolant rubber hose | 15. Coolant pump | 22. Oil filter |
| 2. Turbocharger | 9. Thermostat | 16. Crankshaft pulley | 23. Intake stake |
| 3. Oil supply pipe | 10. Exhaust manifold | 17. Oil level gauge | |
| 4. EGR connection pipe | 11. Fuel Injection pipe | 18. Fuel injection pump | |
| 5. EGR cooler | 12. Common rail | 19. Drain cock | |
| 6. Oil return pipe | 13. Intake manifold | 20. Oil cooler | |
| 7. EGR Valve | 14. Coolant pump pulley | 21. Coolant hose | |

3. Performance and Specifications

Assembly drawings (Top/Bottom)



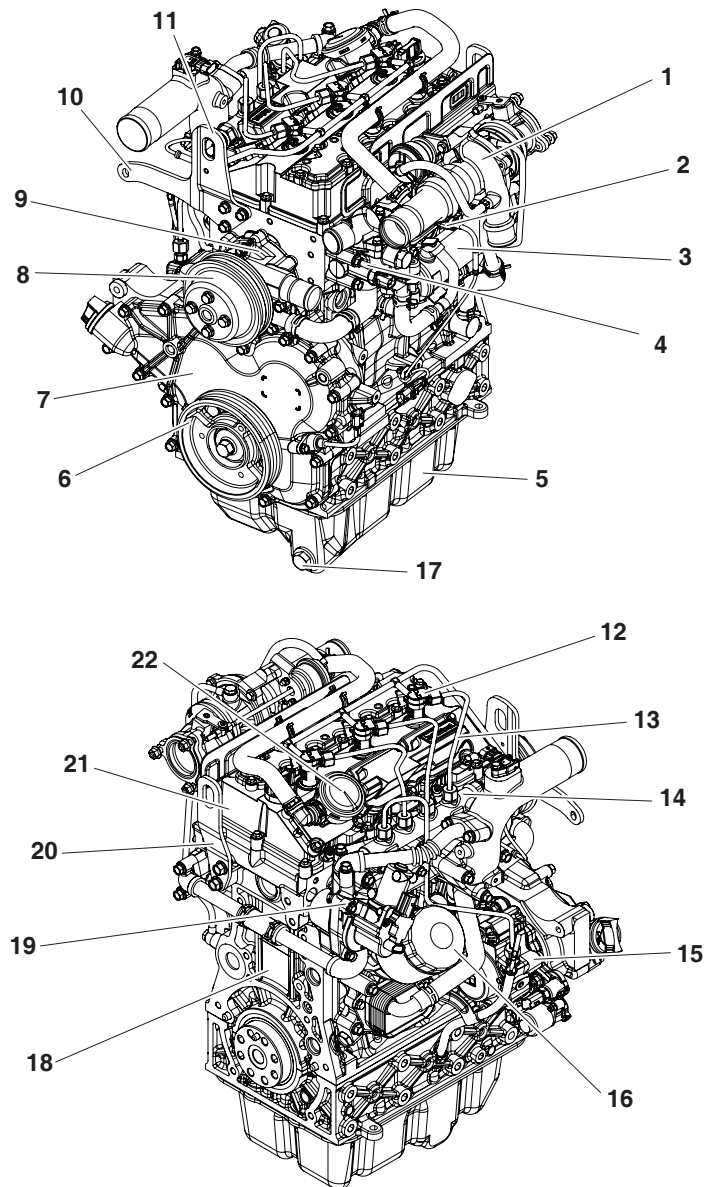
EDL013105A

- | | | |
|------------------------|------------------------|-------------------------|
| 1. Oil cap | 7. EGR connection pipe | 13. Drain cock |
| 2. Fuel Injection pipe | 8. Breather hose | 14. Fuel injection pump |
| 3. Common rail | 9. Turbocharger | 15. Oil pan |
| 4. Oil level gauge | 10. Injector | |
| 5. Oil filter | 11. Thermostat | |
| 6. Intake stake | 12. Oil cooler | |

3. Performance and Specifications

Outside Drawing of the Engine (DL01-LEL00)

Isometric assembly drawings

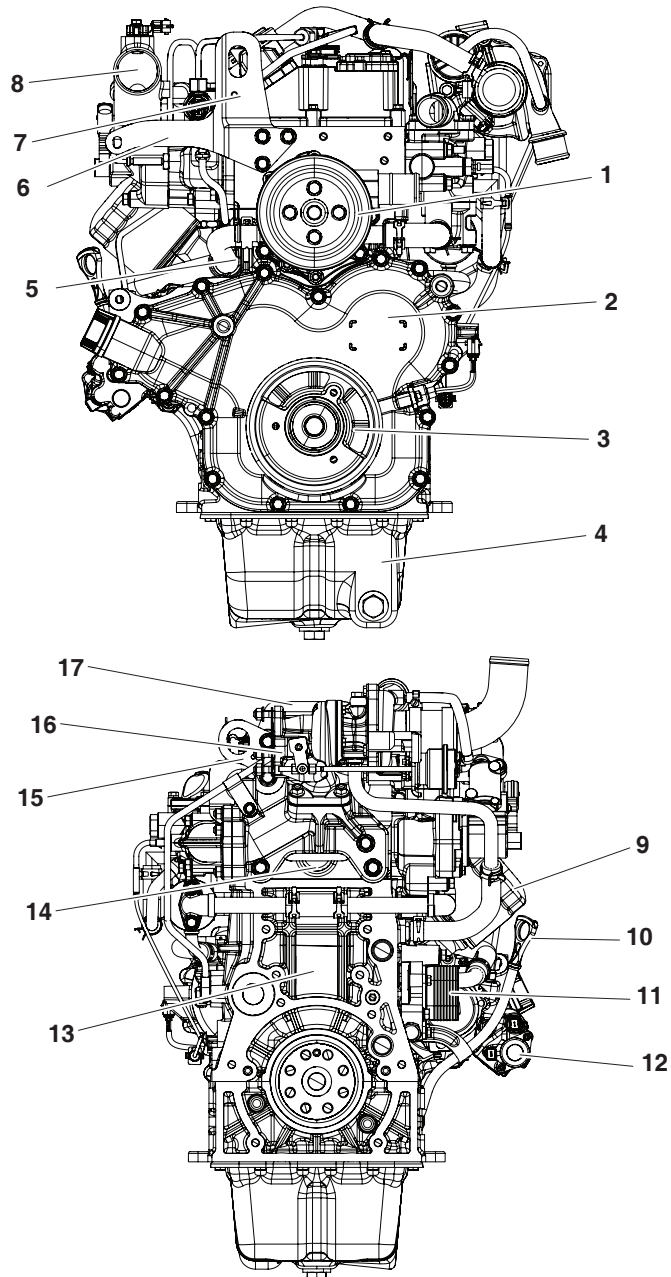


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- | | | | |
|----------------------|-------------------------|-------------------------|--------------|
| 1. Turbocharger | 8. Coolant pump pulley | 15. Fuel injection pump | 22. Breather |
| 2. Exhaust manifold | 9. Coolant pump | 16. Oil filter | |
| 3. EGR cooler | 10. Alternator mountng | 17. Drain cock | |
| 4. Thermostat | 11. Front lifting hook | 18. Cylinder block | |
| 5. Oil Pan | 12. Injector | 19. Intake manifold | |
| 6. Crankshaft Pulley | 13. Fuel Injection pipe | 20. Rear lifting hook | |
| 7. Timing gear case | 14. Common rail | 21. Cylinder head cover | |

3. Performance and Specifications

Assembly drawings (Front/Rear)

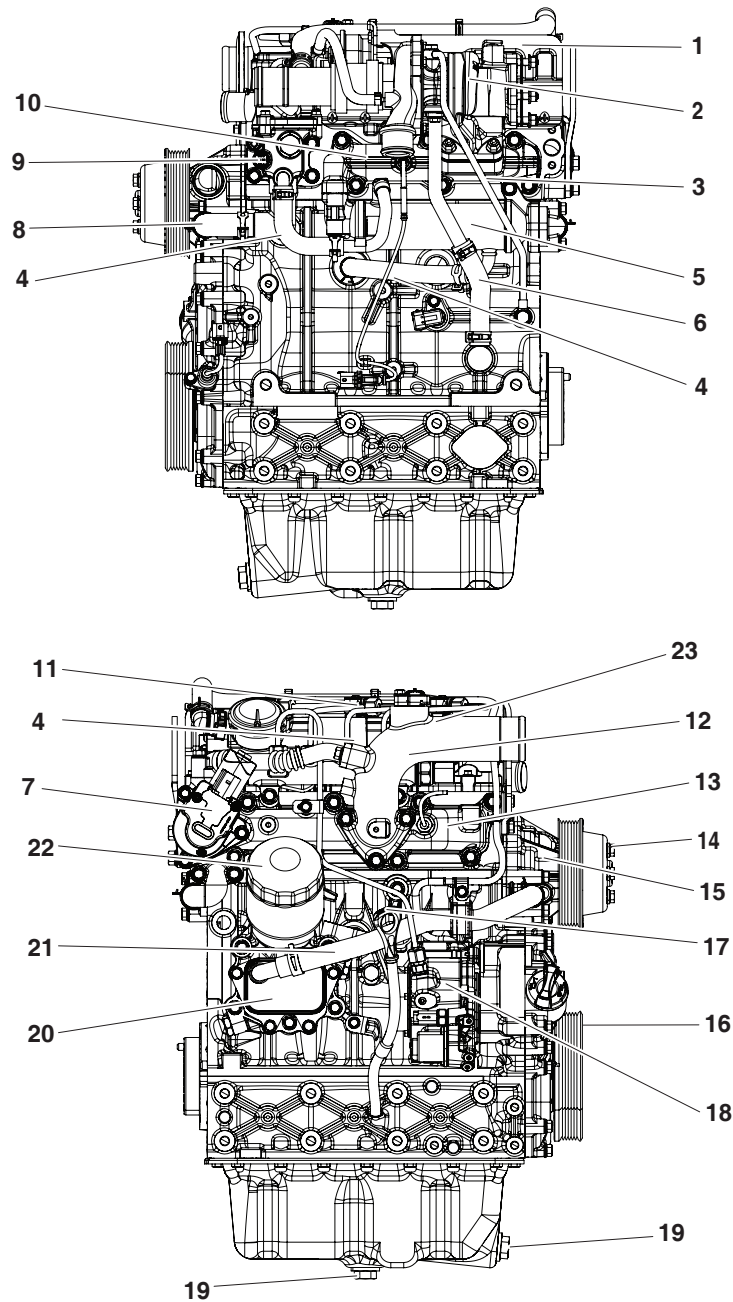


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- | | | |
|------------------------|-------------------------|-------------------------|
| 1. Coolant pump pulley | 8. Intake stake | 15. Rear lifting hook |
| 2. Timing gear case | 9. Oil filter | 16. Cylinder head cover |
| 3. Crankshaft pulley | 10. Oil level gauge | 17. Breather hose |
| 4. Oil pan | 11. Oil cooler | |
| 5. Coolant hose | 12. Fuel injection pump | |
| 6. Alternator mountin | 13. Cylinder block | |
| 7. Front lifting hook | 14. Cylinder head | |

3. Performance and Specifications

Assembly drawings (Left/Right)

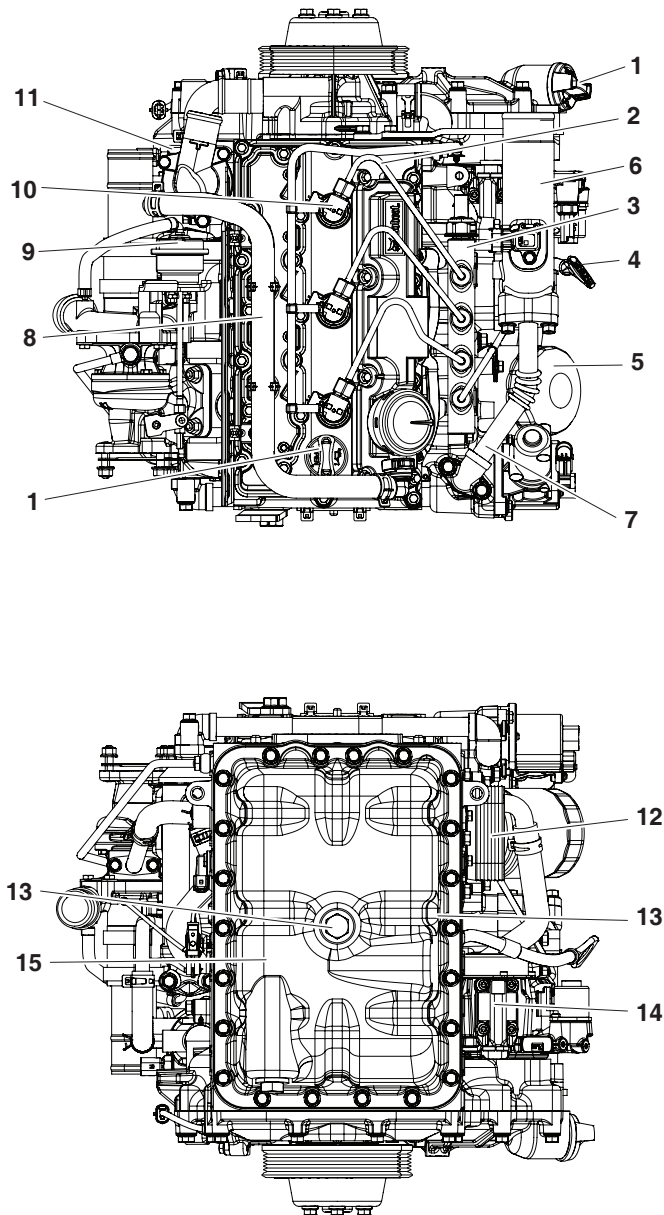


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- | | | | |
|------------------------|-------------------------|-------------------------|------------------|
| 1. Heat screen | 8. Coolant rubber hose | 15. Coolant pump | 22. Oil filter |
| 2. Turbocharger | 9. Thermostat | 16. Crankshaft pulley | 23. Intake stake |
| 3. Oil suply pipe | 10. Exhaust manifold | 17. Oil level gauge | |
| 4. EGR connection pipe | 11. Fuel Injection pipe | 18. Fuel injection pump | |
| 5. EGR cooler | 12. Common rail | 19. Drain cock | |
| 6. Oil return pipe | 13. Intake manifold | 20. Oil cooler | |
| 7. EGR Valve | 14. Coolant pump pulley | 21. Coolant hose | |

3. Performance and Specifications

Assembly drawings (Top/Bottom)



EDL013109A

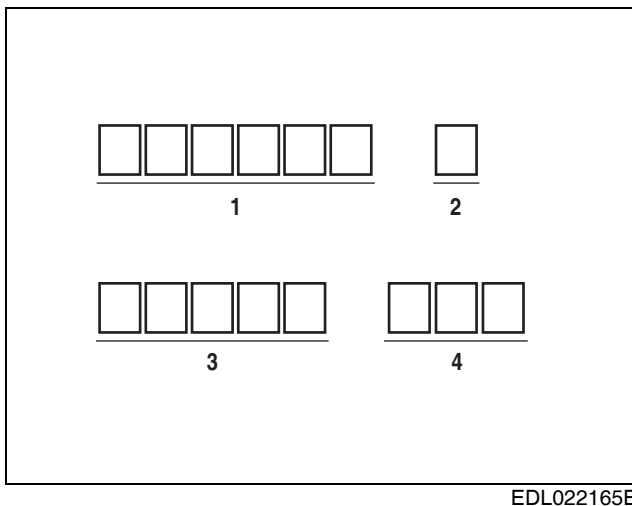
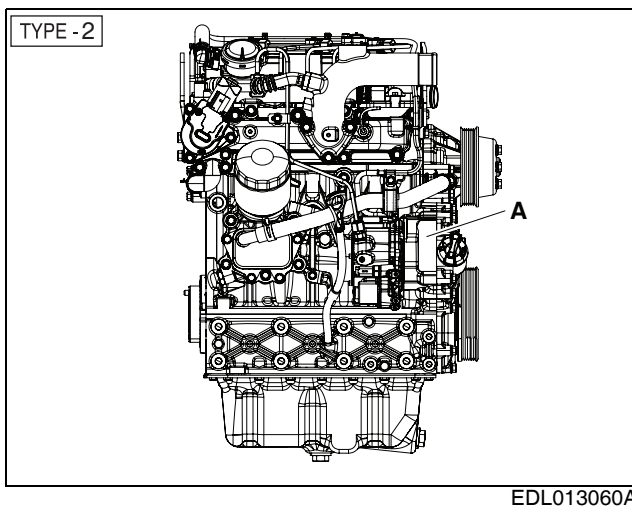
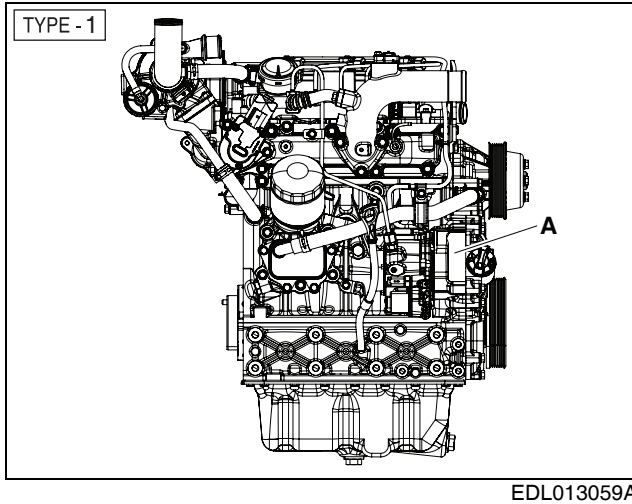
- | | | |
|------------------------|------------------------|-------------------------|
| 1. Oil cap | 7. EGR connection pipe | 13. Drain cock |
| 2. Fuel Injection pipe | 8. Breather hose | 14. Fuel injection pump |
| 3. Common rail | 9. Turbocharger | 15. Oil pan |
| 4. Oil level gauge | 10. Injector | |
| 5. Oil filter | 11. Thermostat | |
| 6. Intake stake | 12. Oil cooler | |

3. Performance and Specifications

Engine Identification Number

Engine number engraving

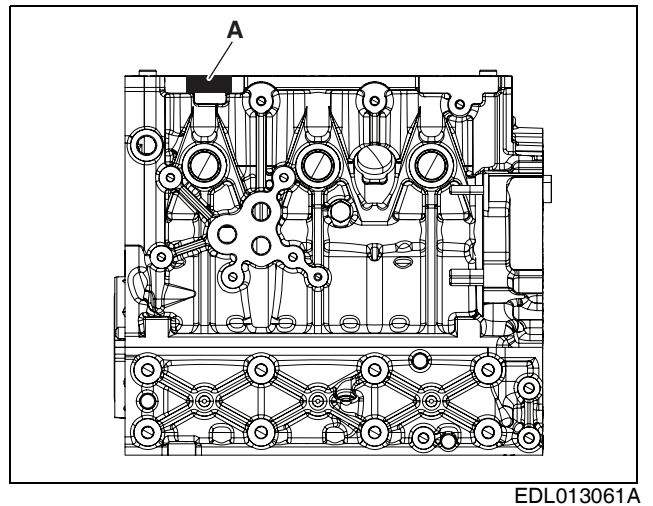
The engine code and manufacturing number are engraved in the position marked with A in the drawing. These numbers are necessary to request quality assurance or to order parts.



1. Product name (6 digits)
2. Year (1 digit)
3. Serial Number (5 digits)
4. After new representative specification (3 digits)

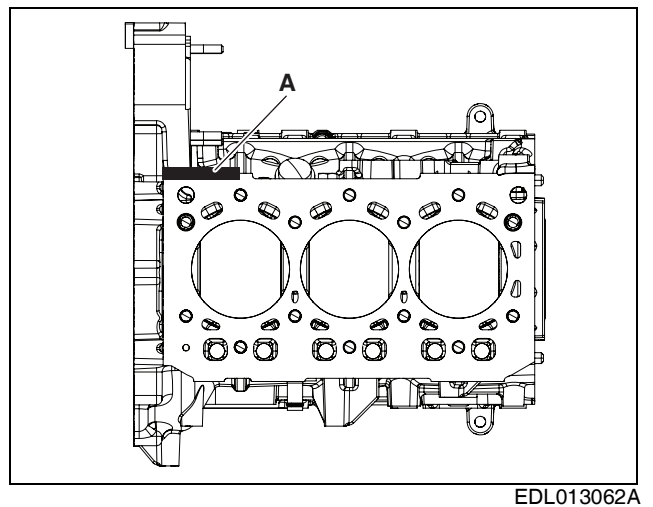
Cylinder block number engraving

The cylinder block serial number is engraved in the position marked as A in the drawing.



Engraving of piston bore level of cylinder block

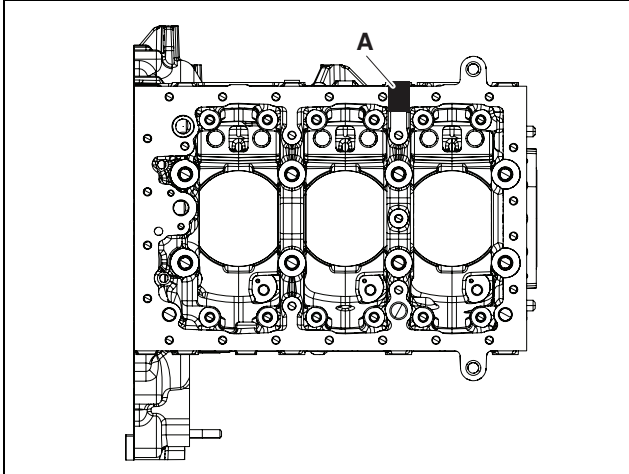
The piston bore level of the cylinder block is engraved in the position marked as A in the drawing. The piston bore level of the cylinder block is classified as A or B. These levels are necessary to order the suitable piston for the piston bore of the cylinder block.



3. Performance and Specifications

Engraving of main bearing bore level of cylinder block

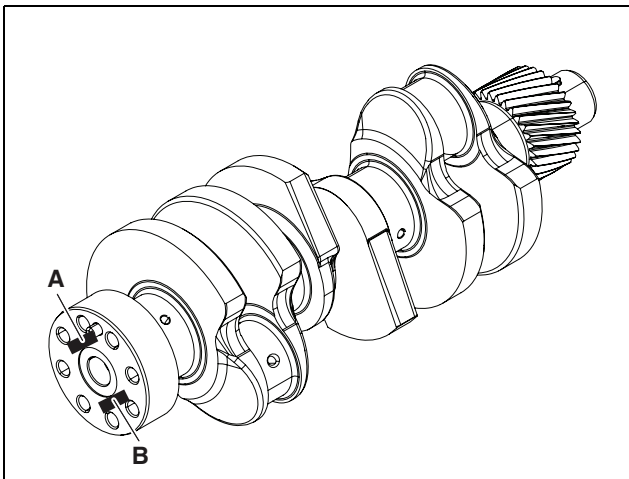
The main bearing bore level of the cylinder block is engraved in the position marked as A in the drawing. The main bearing bore level of the cylinder block is classified as A, B, or C. These levels are necessary to order the suitable main bearing for the main bearing bore of cylinder block.



EDL013063A

Crankshaft main journal engraving

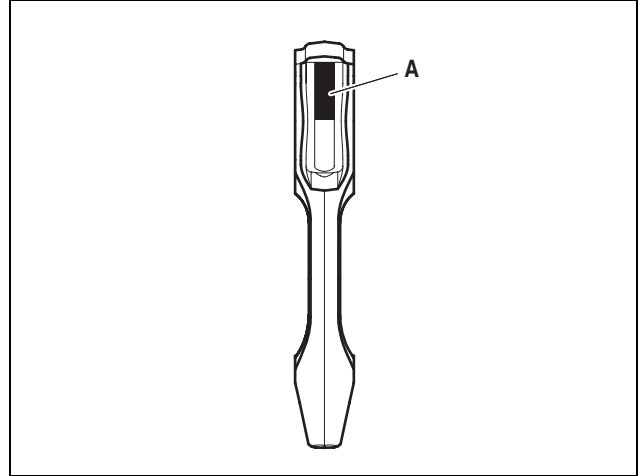
The crankshaft serial number is engraved at the position (A) in the drawing and the crankshaft main journal diameter class is engraved at the position (B) in the drawing. The crankshaft main journal diameter class is classified into A, B, and C. These levels are necessary to order the suitable main bearing.



EDL013064A

Connecting rod engraving

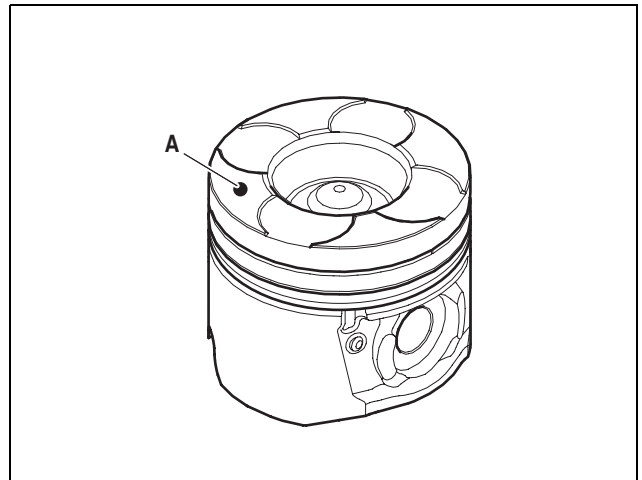
The connecting rod weight is engraved in the position marked as A in the drawing and classified by a letter from A to F. These levels are necessary to order the connecting rod.



EDL022217A

Piston engraving

The piston class is engraved on the position marked as A in the drawing. The piston class is classified into A and B. These levels are necessary to check the suitable piston class.

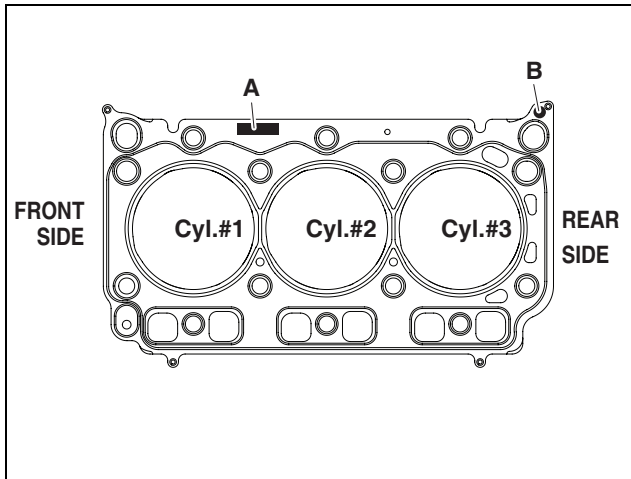


EDL022218B

3. Performance and Specifications

Cylinder head gasket engraving

The cylinder head gasket identification mark is engraved in the position marked as (A) in the drawing, and the class is engraved in the position marked as (B). It belongs to class A if there is one hole of the identification mark on the cylinder head gasket, to class B if there are two holes, and class C if there are three holes. These engravings are necessary to order the suitable cylinder head gasket.



EDL013065A

4. Regular Inspection

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4. Regular Inspection

Regular Inspection

General Information

General Information

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

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

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

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

DANGER

- **Wait until the engine is sufficiently cooled before starting inspection after operating the engine. Otherwise, you may be burned.**
 - **You may be poisoned by the emission when starting an engine in a closed space. Perform inspection at the well-ventilate space.**
 - **Unless absolutely compelled, do not perform inspection under an engine.**
 - **Do not be close to fire when inspecting an engine. Fuel, oil, or batteries may generate gas, causing fire.**
 - **If inspecting the engine while it is running, do not wear accessories such as necklaces, rings, watches or gloves. Such accessories may become stuck in rotating parts while the engine is running and may cause serious bodily injury.**
 - **Individuals who use a mechanical heart or artificial internal organ should not enter the area near an engine while it is running. The high-voltage current of the injectors or ECU may cause abnormal operation of such equipment.**
-

CAUTION

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

Routine Inspection

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

The following is a minimal check list.

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

4. Regular Inspection

Regular Inspection Table

General Conditions

Regular inspection and replacement according to the recommended regular inspection table allows you to

maintain the engine with optimum conditions and best performance for a long period and prevent unexpected accidents in advance.

(○ : Inspection and Adjustment, ● : Replacement)

Check Points	Daily	Inspection interval (x 1,000 hours)									
		0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Coolant system											
State of connection between cooler and coolant hose	○										
Capacity and state of coolant Note 1)	○	Replace every 1,200 hours Note 2)									
Cooling fan belt tension	○										
Lubrication system											
Lubricating device and oil leakage	○										
Capacity and condition of engine oil	○	●	●	●	●	●	●	●	●	●	●
Engine oil filter	○	●	●	●	●	●	●	●	●	●	●
Fuel system											
Fuel line and connection unit	○										
Fuel volume	○										
Water draining from water separator	○										
Fuel injection time		Inspect and adjust if required									
Injector		Inspect and adjust if required									
Compression pressure		Inspect and adjust if required									
Intake/Exhaust system											
Air cleaner	○	Clean and replace if required									
Throttle body cleaning	○										
Intake line and connection unit	○										
Exhaust line and connection unit	○										
Emission state	○										
Cylinder head											
Intake/Exhaust valve gap state		○	○	○	○	○	○	○	○	○	○
head cover rubber seal		●	●	●	●	●	●	●	●	●	●
Cylinder head cover rubber gasket (when adjusting valve gap)		●	●	●	●	●	●	●	●	●	●
Electric system											
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.

4. Regular Inspection

Engine oil

General Information

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

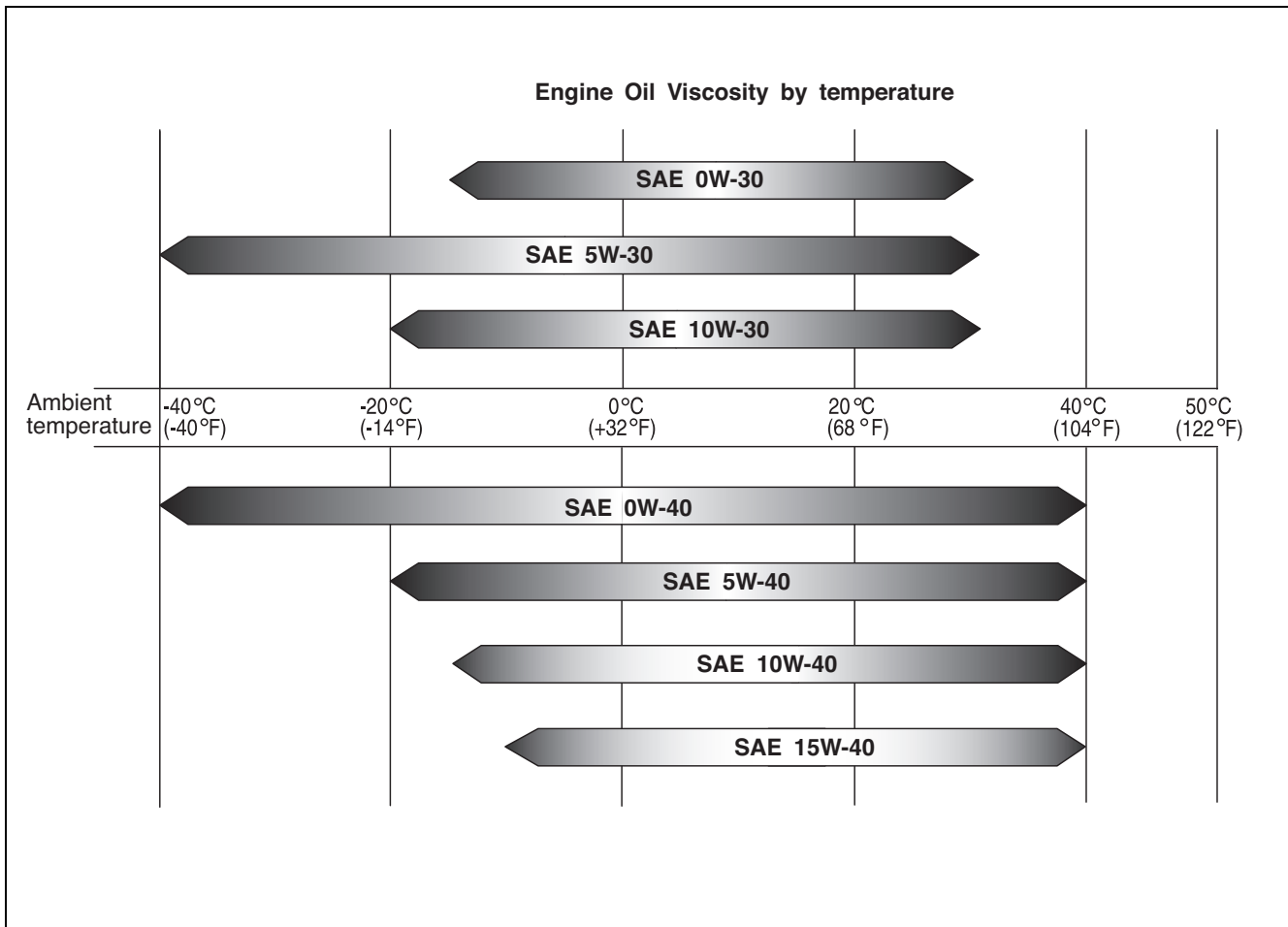
Engine oil should be checked through the oil level gauge and replenished if required. Oil level should be checked while the engine is stopped. To check the oil level, turn off the engine while it is running and wait for 5 ~10 minutes to allow the engine oil

to flow back into the oil pan. The engine oil level should indicate between the upper limit and the lower limit of the oil level gauge.

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

Engine oil standards

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



EDL0213001C

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

Engine Model	SAE Classification	Oil Class
D18NAP	SAE 10W30	API CJ-4 (ACEA-E9)

Note) Use our genuine oil recommended by us.

4. Regular Inspection

Engine Oil Capacity

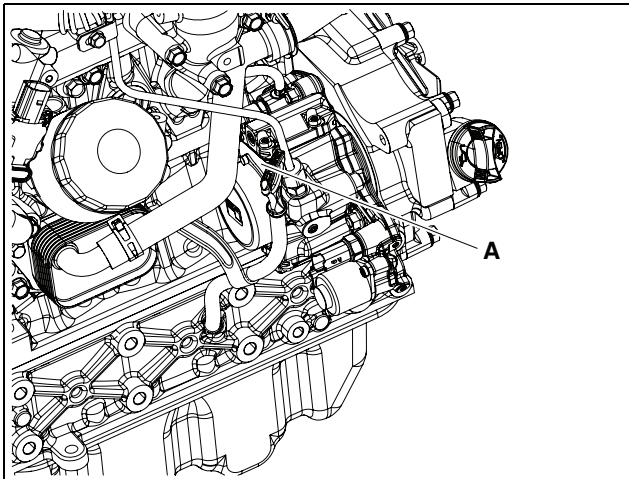
Please replenish the engine oil based on the following recommended oil injection amount.

Engine Model	Engine oil capacity (ℓ)		
	Inside of the oil pan		Total Note)
	Max.	Min.	
D18NAP	6.3	2.8	6.7

Note) Including 0.6 liter in the engine

Checking the Engine Oil

1. Move the engine to a flat surface to maintain the engine level.
2. Start the engine and then stop it when it reaches the normal temperature.
3. Wait for 5 ~ 10 minutes.
4. Pull the oil level gauge (A) upward to pick it out.



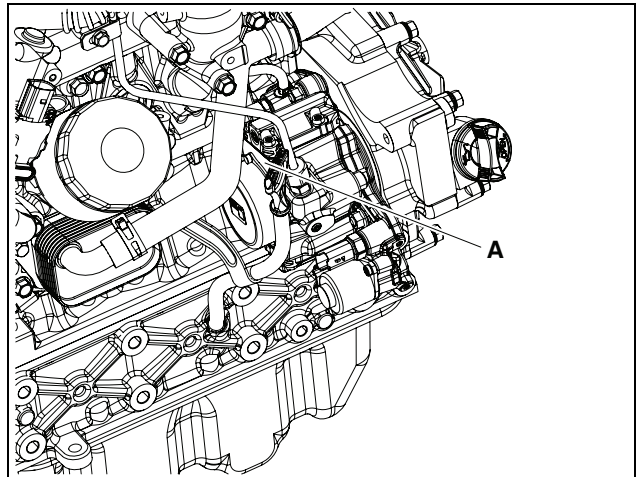
EDL013066A

- 1) Check the position of the oil level gauge (A).
- 2) It is mounted beside the oil filter at the side of the engine.
- 3) Pull the ring of the oil level gauge (A) to pick it out.
5. Clean the indication line of the oil level gauge with clean cloth.

CAUTION

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

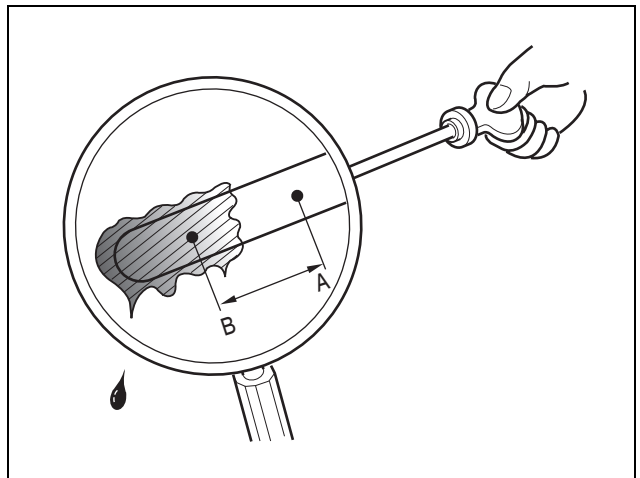
6. Insert the oil level gauge (A) again.



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- 1) Insert the oil level gauge (A) again by using the ring.
- 2) If the dipstick doesn't slide in, rotate it 180° and try again.

7. Pull the oil level dipstick (A) upward to pull it out.



EDL022152A

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

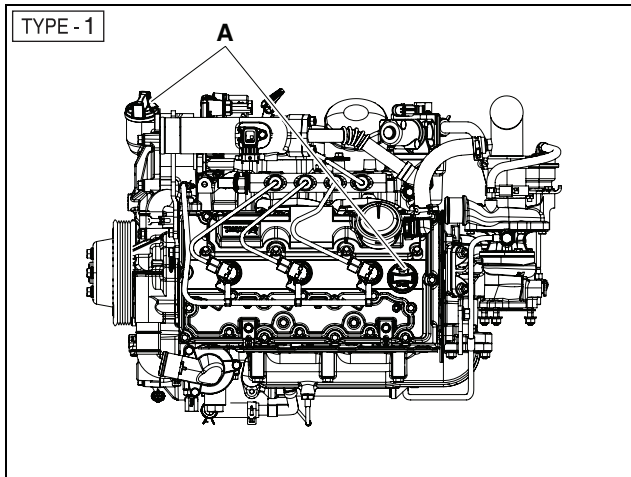
4. Regular Inspection

Replenishment of Engine Oil

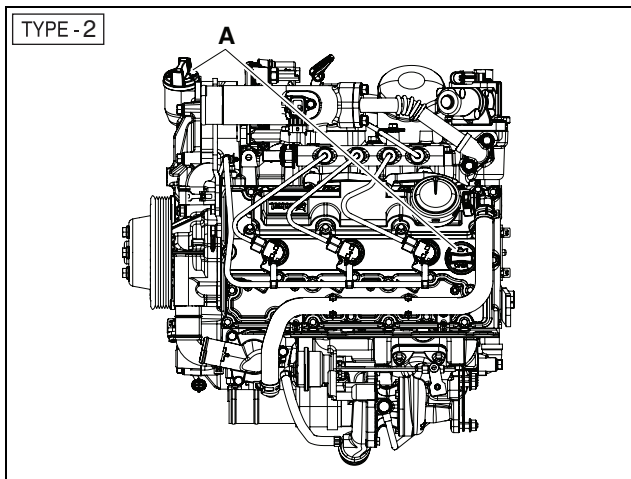
CAUTION

Be careful not to let foreign substances flow into the engine when removing the oil cap.

1. Remove the oil cap(A).



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EDL013068A

2. Add our recommended genuine oil to replenish the oil level.
 - 1) Add our recommended genuine oil by dividing it into several portions for replenishment.
 - 2) Wait for about 1 ~ 2 minutes and then check the engine oil level.
 - 3) Check whether the oil is smeared between the upper limit and the lower limit of the oil level gauge.
 - 4) Repeat the above process until the engine oil level reaches the appropriate level.

CAUTION

- Be careful not to let foreign substances flow into the engine when replenishing engine oil.
- Exceeding the upper limit of the oil level gauge may cause engine faults. If you have exceeded the upper limit of the oil gauge, drain it until the engine oil level is indicated between the upper limit and the lower limit of the oil level gauge.
- Do not use unspecified engine oil additives.

3. Complete engine oil replenishment and cover the oil cap.

Replacement of Engine Oil

- Tightening Torque

Component	Tightening Torque
Drain plug	3 kgf·m

- Oil capacity

Engine Model	Engine oil capacity (ℓ)		
	Inside of the oil pan		Total ^{Note)}
	Max.	Min.	
D18NAP	6.3	2.8	6.7

4. Regular Inspection

Note) Including 0.6 ℓ in the engine

DANGER

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

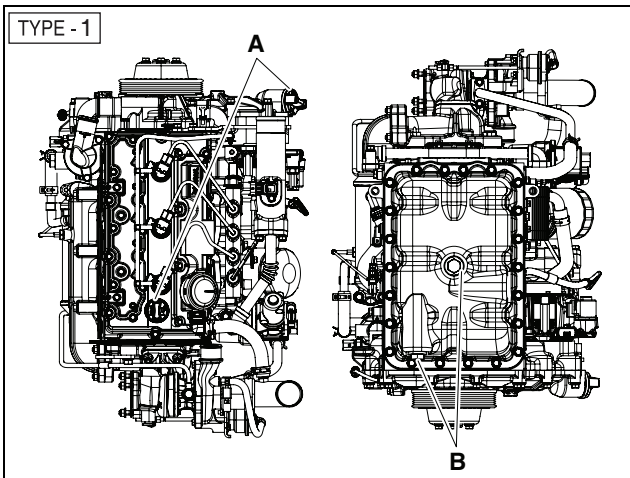
WARNING

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

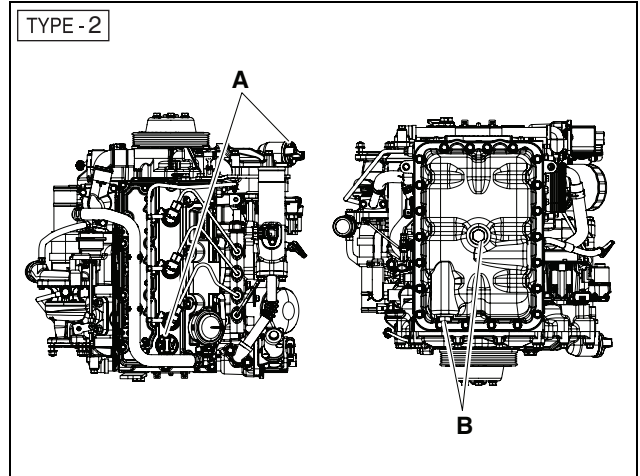
CAUTION

When exchange the New Oil filter, Please dispose of the Old Oil and filter.

1. Drain engine oil.

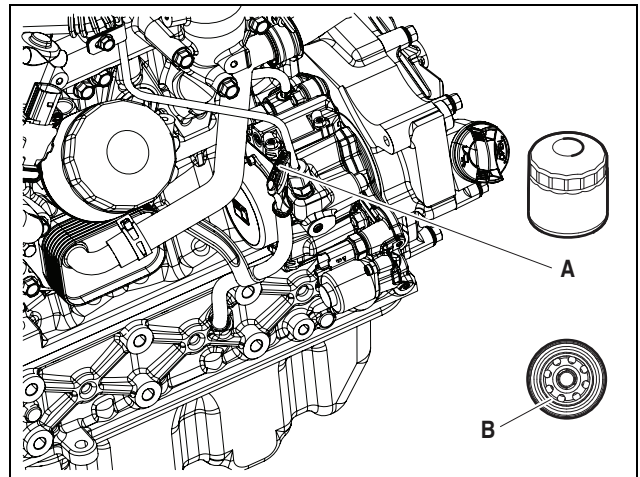


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EDL013070A

- 1) Place a container under the engine to drain the engine oil.
 - 2) Remove the drain plug B and drain the engine oil.
 - 3) Remove the oil cap A.
2. Remove the oil cap A.



EDL013071A

- 1) Disassemble oil filter A with the filter wrench.

CAUTION

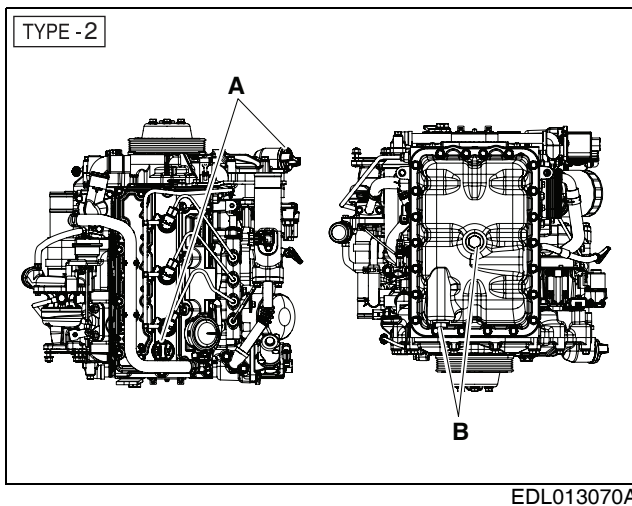
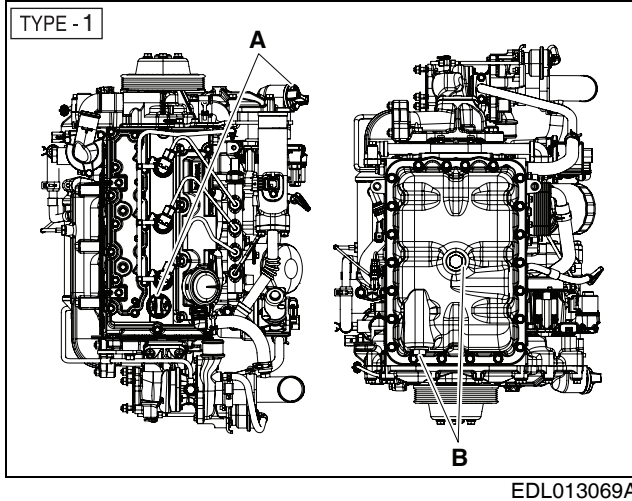
Oil in the filter may run down while detaching the oil filter. Be careful not to contaminate the other parts by using a cloth when detaching the filter. After replacing the oil filter, wipe clean any other parts which the oil has touched.

- 2) Cleanly wipe the surface on which the oil filter is mounted.
- 3) Thinly spread engine oil over the rubber packing B of the new oil filter A.
- 4) Temporarily assemble the new oil filter by rotating it by hand.

4. Regular Inspection

- 5) Assemble the oil filter with the filter wrench at a torque of 16 ~ 20 N•m.

3. Add the engine oil.



- 1) Connect the drain plug B at a torque of 3.0 kgf•m.
 - 2) Disassemble the oil level gauge.
 - 3) Inject genuine oil recommended by Doosan.
- Note) Inject 1/2 of specified oil and then wait for about 1 minute. Then inject the other 1/2 of oil.
- 4) Assemble the oil cap A.
 - 5) Assemble the oil level gauge.
 - 6) Remove the engine oil drain container from under the engine.
-
4. After this, perform the final inspection.
 - 1) Check if engine oil leaks after starting the engine.
 - 2) Start the engine and then stop it when it reaches a normal temperature.
 - 3) Wait for 5 ~ 10 minutes.
 - 4) Check the engine oil level with the oil level gauge.

CAUTION

Adding oil which exceeds the upper limit of the oil level gauge may cause engine faults. If you have injected engine oil far over the upper limit of the oil level gauge, drain it until the engine oil level indicates somewhere between the upper and lower limit of the oil level gauge.

4. Regular Inspection

Coolant

General Information

The coolant plays an important role in the prevention of overheating and freezing of the engine. However, if the engine is used for a long period, the performance of antifreezing and anticorrosion of the coolant degrades. Maintain the condition of the coolant through daily inspections and periodic replacements.

The mixing ratio for the engine coolant is 40 % antifreeze and 3~5 % additives (DCA4) to prevent corrosion. For the water in the coolant, use clean tap water. Periodically check coolant to maintain the concentration of antifreeze and additives.

CAUTION

The recommended mixing ratio allows coolant to prevent corrosion of the engine efficiently and to maintain the best engine performance for a long period. Using contaminated water or unspecified antifreeze or additives may cause critical faults in the cooler.

Coolant standards

- Amount of antifreeze during winter

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

Capacity of coolant

Engine Model and Product Code	Coolant capacity (ℓ)
DL01-LEE00	2.7
DL01-LEL00	2.7

Checking the Coolant

DANGER

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

- Check the position of the supplementary tank.
- Make sure that the engine and radiator are cooled.
- If the coolant level indicates between the upper limit and the lower limit on the supplementary tank, it means that the coolant volume is normal.
- If there is insufficient coolant, replenish it.
- Open the radiator cap and check the condition of the coolant. If the coolant cap is contaminated or insufficient, measure the coolant concentration. If the coolant concentration is outside the specified range, exchange the coolant.

Measurement of Coolant Concentration

- Special Tools

Figure	Product Number/Name
	60.99901-0038 CC2602M (Fleet guard number) Coolant test sheet

The coolant concentration can be measured as follows.

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

CAUTION

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

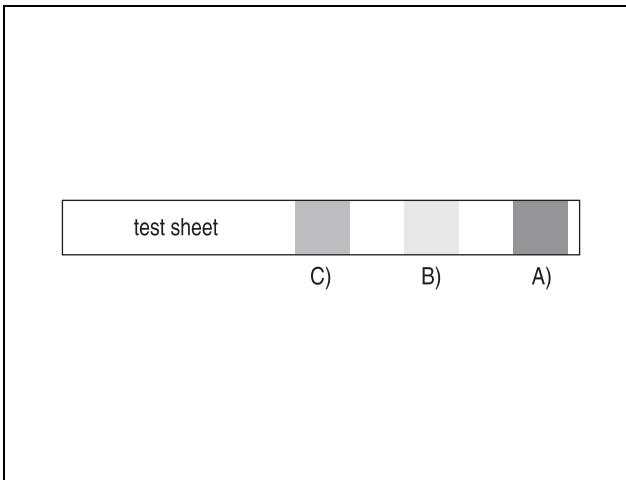
4. Regular Inspection

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

CAUTION

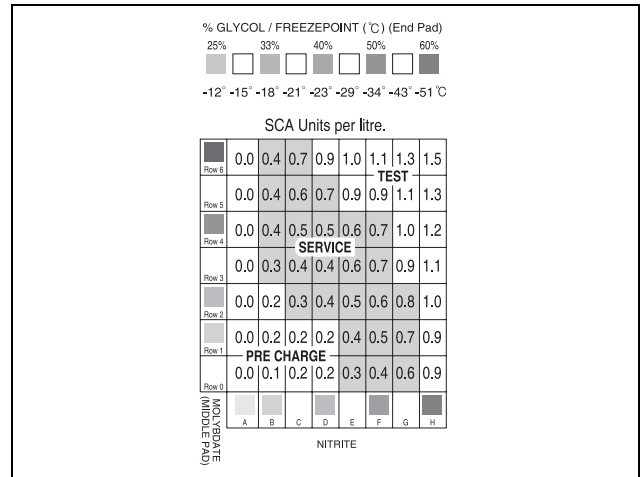
**Measurement time should not exceed 75 seconds.
The color changes as time passes.**

- Check the color on test sheet.



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



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

CAUTION

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

4. Regular Inspection

Replenishment of Coolant

If the coolant level of the supplementary tank is below the lower limit, replenish the coolant as follows.

1. Remove the supplementary tank cap.
2. Replenish coolant until its level is between the upper and lower limit of the supplementary tank.
3. Install the supplementary tank cap.

CAUTION

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

If there is not coolant in the supplementary tank, replenish the coolant as follows.

1. Remove the radiator cap while the engine and radiator are cold.
2. Replenish coolant up to the inlet of the radiator.
3. After starting the engine let the coolant circulate sufficiently and check the coolant level. If there is insufficient coolant, replenish more.
4. Install the supplementary tank cap.
5. Remove the supplementary tank cap.
6. Replenish coolant until its level is between the upper and lower limit of the supplementary tank.

CAUTION

- **If the radiator cap is opened while the engine is hot, hot water will spurt out and may cause serious burns. Open the radiator cap after making sure that the engine has been fully cooled.**
 - **Mark and separately manage the containers for storing coolant from beverage containers for avoiding confusion. See a doctor immediately in case of drinking coolant.**
-

Replacement of Coolant

DANGER

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

CAUTION

Be careful not to get coolant on any belts or electric apparatus when replacing the coolant.

1. Make sure that engine and radiator are cooled.
2. Place a container in front of the coolant drain plug.
3. Remove the radiator cap.
4. Unplug the coolant drain plug of the radiator and then drain coolant.
5. After completing coolant drain, connect the coolant drain plug again.
6. Drain the coolant from the coolant supplementary tank and cleanse the tank.
7. Fill the radiator inlet with water and install radiator cap.

Note) Slowly pour coolant in to let the air be discharged from radiator and press the hose connected to it to discharge the air inside.

8. Start the engine to let the cooling fan rotate 2 or 3 times. When the engine is warmed up, increase the engine RPM two or three times.
9. Stop engine and wait until engine is cooled.
10. Remove the radiator drain plug and drain water.
11. Repeat the above mentioned processes from 1 to 8 until the drained water becomes clear.
12. Press the hose connected to the radiator to discharge the air from inside of the radiator and slowly fill the radiator with the coolant at the specified mixing ratio to let the air be discharged from the radiator.

Note) Use recommended genuine antifreeze.

4. Regular Inspection

CAUTION

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

13. Operate the engine at idle after starting. When cooling fan is running and coolant is circulated, remove radiator cap and replenish coolant through the inlet.
14. Replenish coolant until the cooling fan rotates 3 ~ 5 times.
15. Replenish coolant to the upper limit of the supplementary tank and then install radiator cap.
16. Operate the engine at idle until the cooling fan rotates 2 ~ 3 times.
17. Stop the engine and wait until the engine and the radiator are cooled.
18. After checking the coolant level in the supplementary tank, replenish coolant until the tank level stays between the upper and lower limit without changing.

Note) After replenishing coolant, check the coolant level of the supplementary tank for at least two or three days.

CAUTION

After replenishing coolant, check the coolant level of the supplementary tank for at least two or three days.

WARNING

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

4. Regular Inspection

Fuel

General Information

Fuel quality is an important factors in satisfy standards for engine performance, engine lifetime, and emissions. Doosan engines are designed to use diesel fuel available in the area where the engines are sold.

CAUTION

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

Fuel Standards

To maintain the optimum engine performance, refer to the following recommended fuel table to select the appropriate fuel.

- Ultra Low Sulfur Diesel

Fuel Ingredients		Standard
Specific Gravity	(kg/lit)	0.820 ~ 0.845
Fire Point	(°C)	Above 40
Viscosity (40 °C)	(cSt)	1.9 ~ 5.5
Sulfur Content	(wtppm)	Below15
Cloud Point	(°C)	-
Pour Point	(°C)	Below-17.5
Low temperature filter clogging point	(°C)	Below-16
Color (ASTM)		Below 2.5
Residual carbon (10%) Vapor/residual fraction (wt)	(%)	Below0.15
Total acid value	(mg KOH/g)	Below0.40
Back plate corrosion rate (100 °C, 3 hours)		Below 1
Ash Content	(mass %)	Below0.01
Moisture and Precipitation	(vol. %)	Below0.02
Cetane Index		Above 45
Distillation Test Temperature	50 % Distillation Point	-
	90 % Distillation Point	Below360

Note) The fuel product level has been prepared based on SK Ultra Low Sulfur Diesel.

4. Regular Inspection

Air filter

General Information

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

CAUTION

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

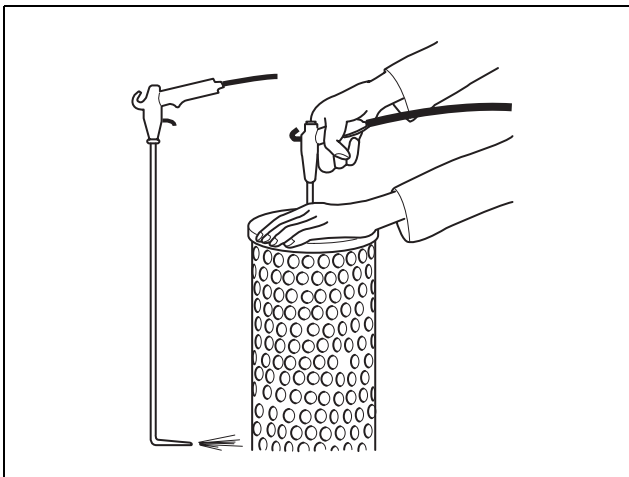
Cleaning of Air Filter

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

Cleaning of the Air Filter Element

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

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



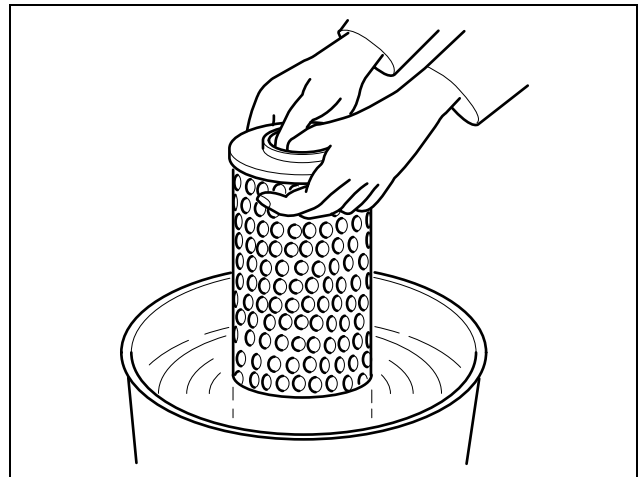
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- 1) To clean, let sufficient compressed air reach the inside bottom of the element at 90° direction with an air gun.
- 2) Move air gun up and down the element to blow air from inside to outside until no more dust is coming out from the element.
-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

DANGER

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

2. Clean the element by washing it.



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- 1) Before washing the element, clean the element by using compressed air as described above.
- 2) Soak the element in the warm cleaning solvent for 10 minutes and then shake it back and forth for about 5 minutes.
- 3) Rinse the element with clean water, drain the water, and then dry it at room temperature. Fully dry the element before reassembling it to the engine.

CAUTION

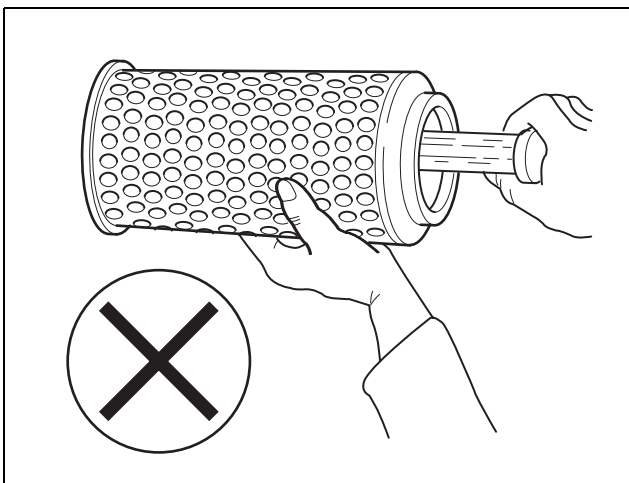
Never use steam spray, gasoline, alkali or hot cleansing solution to cleansing the element.

4. Regular Inspection

3. In an emergency, temporarily clean the element by using the following method.
 - 1) Tab the end plate of the element with the thumb to clean it temporarily.

CAUTION

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



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

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

Replacement of Air Filter Element

CAUTION

Do not let dust get inside the air filter end.

1. Remove the fixed parts.
2. Remove the damaged or contaminated element.
3. Thoroughly cleanse the contact surface of the sealing ring and the inside of the filter housing.
4. Assemble a new element.
5. Attach the fixed parts again.

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P02F0 Injector Short Circuit fault (Cylinder #3).....	5-98
P0268 Wiring harness resistance high fault (Cylinder #3)	5-100
P0267 Wiring harness resistance low fault (Cylinder #3).....	5-101
P02A3 Injector Minimum drive pulse drift (Cylinder #3)	5-102
P0384 Glow plug relay electrical fault (SCVBAT)	5-103
P0383 Glow plug relay electrical fault (SCGND).....	5-104
P0380 Glow plug relay electrical fault (OC).....	5-105
P0325 Fault on the accelerometer 0 sensor decode circuit.....	5-106
P0007 Rail pressure control error (IMV resistance trim value is too high).....	5-107

P0006 Rail pressure control error (IMV resistance trim value is too low)	5-108
P0004 Rail pressure control feedback high fault	5-109
P0003 Rail pressure control feedback low fault.....	5-110
P0259 RPC error (IMV current trim drift high/high).....	5-111
P0254 RPC error (IMV current trim drift high/low)	5-113
P0253 RPC error (IMV current trim drift low/high)	5-115
P0258 RPC error (IMV current trim drift low/low).....	5-117
P0252 RPC PWM error.....	5-119
P0251 IMV control fault.....	5-121
P2080 Turbo in temperature plausibility fault	5-122
P0546 Turbo in temperature sensor high fault	5-123
P0545 Turbo in temperature sensor low fault.....	5-124
P2081 Turbo in temperature sensor noisy fault.....	5-125
P0685 Main relay stuck fault	5-126
P068A Main relay unexpected low state	5-127
P062D Injector Bank 1 electric or SPI fault.....	5-128
P062E Injector Bank 2 electric or SPI fault.....	5-130
P2145 EGR H-Bridge driver short circuit to battery voltage.....	5-131
P2144 EGR H-Bridge driver short circuit to ground.....	5-132
P2143 EGR H-Bridge driver open circuit.....	5-133
P0404 EGR position control fault	5-134
P0641 5V Supply #1 fault.....	5-135
P0651 5V Supply #2 fault.....	5-136
P0697 5V Aux supply #2 fault	5-137
P025D IMV drive electrical fault (SCVBATT)	5-138
P025C IMV drive electrical fault (SCGND).....	5-139
P025A IMV drive electrical fault (OC).....	5-140
P037F Glow plug feedback fault (SCVBAT).....	5-141
P037E Glow plug feedback fault (OC / SCGND).....	5-142
P0606, P0607, P060A, P060C ECU safety monitoring fault.....	5-143

5. Failure Diagnosis

Failure Diagnosis

General Information

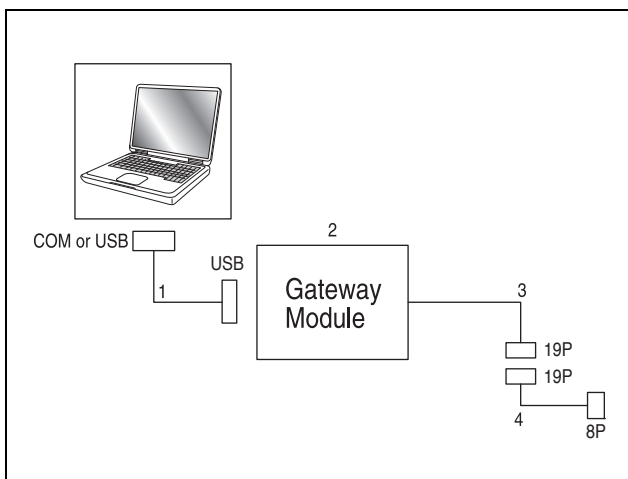
Failure Diagnosis Unit

Electrical problems of an apparatus where the DL02-LCF00/LDF00 engine is mounted, can easily be diagnosed through failure diagnosis using a laptop computer.



EDL022210A

Electrical problems can easily be diagnosed through a failure diagnosis using a laptop computer. For more details about how to use the function, refer to the Failure Diagnosis Unit of the User Manual.



EDL022211B

5. Failure Diagnosis

Failure Code

Fault Code Items

E-Code	DTC	Description	CEL	Torque
27-0	P0402	EGR control fault (airflow error too high)	ON	LV0
27-1	P0401	EGR control fault (airflow error too low)	ON	LV0
27-3	P0406	EGR actuator position feedback signal high fault	ON	LV0
27-4	P0407	EGR actuator position feedback signal low fault	ON	LV0
27-10	P046D	EGR actuator position feedback signal noisy fault	ON	LV0
27-20	P0C17	EGR position learning fault (drifted)	ON	LV0
27-30	P0C18	EGR position learning fault (wrong range)	ON	LV0
91-19	U0140	J1939 CAN pedal fault	FLASH	
94-11	P0088	Rail pressure control fault	FLASH	LV1
97-3	P2267	Water in Fuel sensor electrical fault (OC/SCVBATT)	FLASH	LV1
97-4	P2266	Water in Fuel sensor electrical fault (SCGND)	FLASH	LV1
97-31	P2269	Water in Fuel Detected	FLASH	LV1
100-1	P0524	Oil pressure remains low at engine run	FLASH	LV1
100-3	P0523	Oil pressure sensor high fault	ON	LV0
100-4	P0522	Oil pressure sensor low fault	ON	LV0
105-2	P0111	Intake manifold temperature plausibility fault		
105-3	P0113	Intake manifold temperature sensor high fault	ON	
105-4	P0112	Intake manifold temperature sensor low fault	ON	
105-10	P0114	Intake manifold temperature sensor noisy fault	ON	
106-3	P0108	Manifold Pressure sensor electrical high fault	ON	LV0
106-4	P0107	Manifold Pressure sensor electrical low fault	ON	LV0
108-3	P2229	Barometric pressure sensor electrical high fault	ON	LV0
108-4	P2228	Barometric pressure sensor electrical low fault	ON	LV0
110-2	P0116	Coolant temperature plausibility fault		
110-3	P0118	Coolant temperature sensor high fault	ON	LV1
110-4	P0117	Coolant temperature sensor low fault	ON	LV1
132-0	P00BD	MAF plausibility high fault	ON	LV0
132-1	P00BC	MAF plausibility low fault	ON	LV0
132-3	P0103	MAF sensor electrical high fault	ON	LV0
132-4	P0102	MAF sensor electrical low fault	ON	LV0
157-2	P0190	Rail Pressure Sensor gradient fault	FLASH	LV1
157-3	P0193	Rail Pressure Sensor high fault	FLASH	LV1
157-4	P0192	Rail Pressure Sensor low fault	FLASH	LV1
157-10	P0087	Rail Pressure build up during cranking too slow	ON	
157-11	P0191	Rail Pressure Sensor fault (Sensor drift at key-on)	FLASH	LV1
157-21	P0002	Rail Pressure Control fault (RPC using IMV only)	FLASH	LV1

5. Failure Diagnosis

E-Code	DTC	Description	CEL	Torque
157-22	P0089	Rail Pressure Control fault (RPC using Rail Discharge)	FLASH	LV1
168-3	P0563	Battery voltage high fault	ON	LV0
168-4	P0562	Battery voltage low fault	ON	LV0
172-2	P0074	Inlet Air Temperature sensor gradient fault	ON	LV0
172-3	P0073	Inlet Air Temperature sensor high fault	ON	LV0
172-4	P0072	Inlet Air Temperature sensor low fault	ON	LV0
173-0	P2428	Exhaust over temperature fault	ON	LV0
174-2	P0181	Fuel temperature gradient fault	ON	LV0
174-3	P0183	Fuel temperature sensor high fault	ON	LV0
174-4	P0182	Fuel temperature sensor low fault	ON	LV0
175-2	P0196	Oil temperature plausibility fault		
175-31	P0195	Oil temperature sensor signal fault	ON	LV0
629-12	P060B	ADC circuit fault	FLASH	
630-11	P0602	C2I data not programmed	ON	LV1
630-23	P0603	ECU memory integrity fault (data / cal integrity)	FLASH	
630-24	P0604	ECU memory integrity fault (RAM integrity)	FLASH	
630-25	P0605	ECU memory integrity fault (code integrity)	FLASH	
630-31	P062F	ECU non volatile memory fault	FLASH	LV1
636-0	P0371	Crank signal is too close to the previous one		
636-1	P0339	CRANK signal fault (gap lost)	ON	LV0
636-2	P0372	Elapsed time between CPS events is too high	ON	LV0
636-8	P0374	Crank signal lost (no CPS signal seen in 1 cam rotation)	ON	LV0
636-11	P0335	Crank signal over speed fault	ON	
637-2	P0344	CAM signal fault (missing event within the window)	ON	LV0
637-8	P0342	Cam signal lost (no cam signal seen in 2 crank rotations)	ON	LV0
637-20	P0341	Cam signal drift higher than threshold		
637-30	P0340	Cam signal last learnt value is outside of limits		
639-19	U0100	CAN communication error: CAN bus confirmed off	ON	
651-5	P0201	Injector Open Circuit fault (Cylinder #1)	ON	LV0
651-6	P02EE	Injector Short Circuit fault (Cylinder #1)	ON	LV0
651-20	P0262	Wiring harness resistance high fault (Cylinder #1)		
651-21	P0261	Wiring harness resistance low fault (Cylinder #1)		
651-31	P029B	Injector Minimum drive pulse drift (Cylinder #1)	ON	
652-5	P0202	Injector Open Circuit fault (Cylinder #2)	ON	LV0
652-6	P02EF	Injector Short Circuit fault (Cylinder #2)	ON	LV0
652-20	P0265	Wiring harness resistance high fault (Cylinder #2)		
652-21	P0264	Wiring harness resistance low fault (Cylinder #2)		
652-31	P029F	Injector Minimum drive pulse drift (Cylinder #2)	ON	
653-5	P0203	Injector Open Circuit fault (Cylinder #3)	ON	LV0

5. Failure Diagnosis

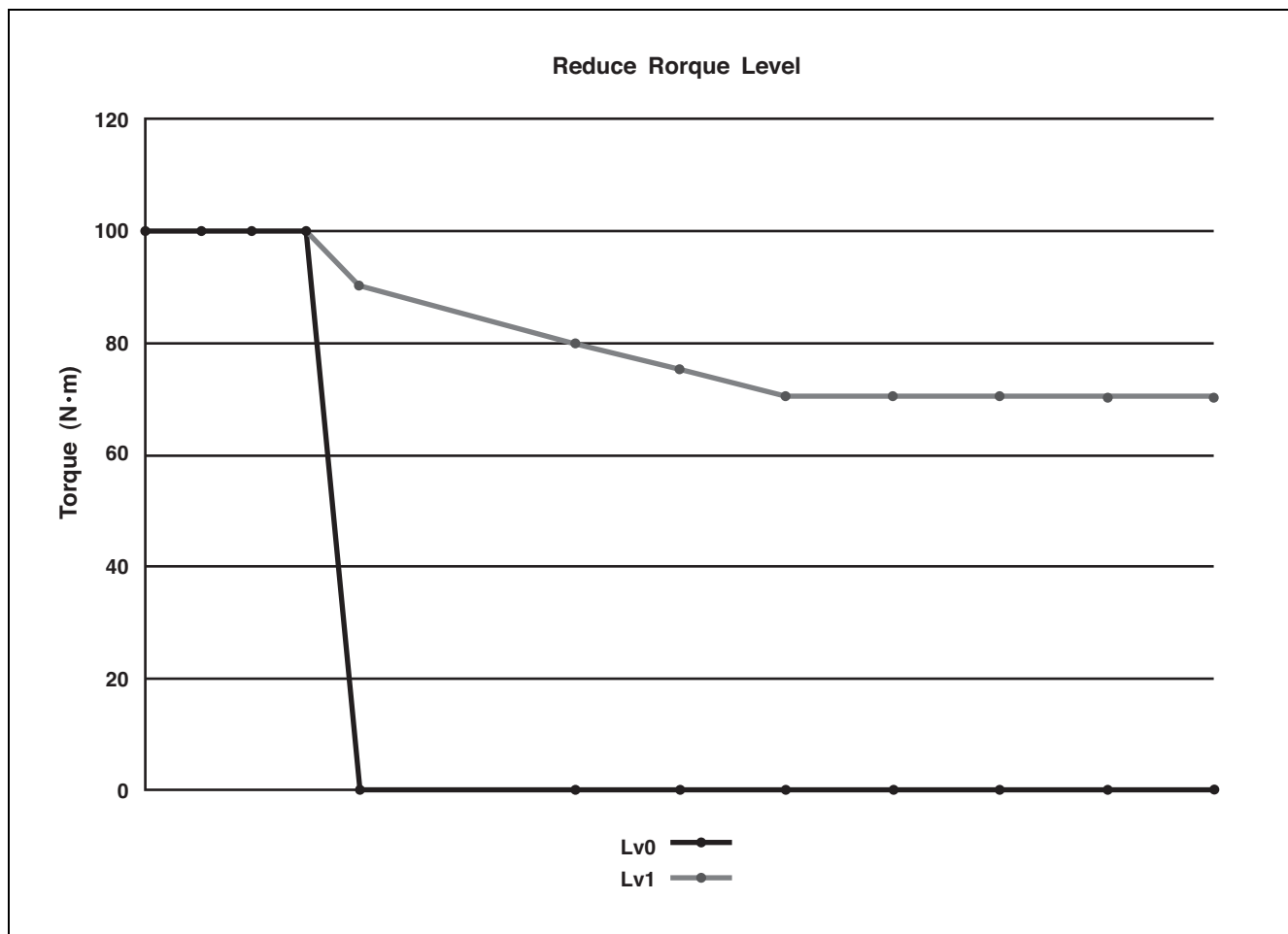
E-Code	DTC	Description	CEL	Torque
653-6	P02F0	Injector Short Circuit fault (Cylinder #3)	ON	LV0
653-20	P0268	Wiring harness resistance high fault (Cylinder #3)		
653-21	P0267	Wiring harness resistance low fault (Cylinder #3)		
653-31	P02A3	Injector Minimum drive pulse drift (Cylinder #3)	ON	
676-3	P0384	Glow plug relay electrical fault (SCVBAT)	ON	
676-4	P0383	Glow plug relay electrical fault (SCGND)	ON	
676-5	P0380	Glow plug relay electrical fault (OC)	ON	
731-20	P0325	Fault on the accelerometer 0 sensor decode circuit		
731-21	P0330	Fault on the accelerometer 1 sensor decode circuit		
1076-0	P0007	Rail pressure control error (IMV resistance which is evaluated the trim value is too high)	FLASH	LV1
1076-1	P0006	Rail pressure control error (IMV resistance which is evaluated the trim value is too low)	FLASH	LV1
1076-3	P0004	Rail pressure control feedback high fault	FLASH	LV1
1076-4	P0003	Rail pressure control feedback low fault	ON	LV0
1076-15	P0259	Rail pressure control error IMV current trim drift high/high)	ON	LV0
1076-16	P0254	Rail pressure control error (IMV current trim drift high/low)	FLASH	LV1
1076-17	P0253	Rail pressure control error (IMV current trim drift low/high)	ON	LV0
1076-18	P0258	Rail pressure control error (IMV current trim drift low/low)	ON	LV0
1076-20	P0252	RPC PWM error	ON	LV0
1076-31	P0251	Rail pressure control error (IMV trim current is too high)	ON	LV0
1180-2	P2080	Turbo in temperature plausibility fault		
1180-3	P0546	Turbo in temperature sensor high fault	ON	LV0
1180-4	P0545	Turbo in temperature sensor low fault	ON	LV0
1180-10	P2081	Turbo in temperature sensor noisy fault	ON	LV0
1485-7	P0685	Main relay stuck fault	ON	
1485-11	P068A	Main relay unexpected low state	ON	
1612-3	P062D	Injector Bank 1 fault (SCVBATT)	FLASH	
1612-4	P062D	Injector Bank 1 fault (SCGND)	FLASH	
1612-11	P062D	Injector Bank 1 SPI communication fault	ON	LV0
1613-3	P062E	Injector Bank 2 fault (SCVBAT)	FLASH	
1613-4	P062E	Injector Bank 2 fault (SCGND)	FLASH	
1613-11	P062E	Injector Bank 2 SPI communication fault	ON	LV0
2791-3	P2145	EGR H-Bridge driver short circuit to battery fault	ON	LV0
2791-4	P2144	EGR H-Bridge driver short circuit to ground fault	ON	LV0
2791-5	P2143	EGR H-Bridge driver open circuit fault	ON	LV0
2791-8	P0404	EGR position control fault	ON	LV0

5. Failure Diagnosis

E-Code	DTC	Description	CEL	Torque
3509-11	P0641	5V sensor supply #1 fault	FLASH	LV0
3510-11	P0651	5V sensor supply #2 fault	FLASH	LV0
3511-11	P0697	5V Aux sensor supply #2 fault	FLASH	LV0
4082-3	P025D	IMV drive electrical fault (SCVBATT)	FLASH	LV1
4082-4	P025C	IMV drive electrical fault (SCGND)	FLASH	LV1
4082-5	P025A	IMV drive electrical fault (OC)	FLASH	LV1
5324-3	P037F	Glow plug feedback fault (SCVBATT)	ON	
5324-4	P037E	Glow plug feedback fault (OC/SCGND)	ON	
1221-XX	P0606 P0607 P060A P060C	ECU Safety monitoring fault	ON	

Note 1) LMP: Lamp control (ON: Continuous / FLASH: Flashing)

Note 2) TRQ: Torque de-rate (LV0: level0 not severe / LV1: level1 is more severe)



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5. Failure Diagnosis

Failure Code Diagnosis

P0402 EGR control fault (airflow error too high)

1. Overview

Code	Causes	Impact
P0402	EGR air path leakage, MAF sensor drift, damage of MAF sensor, Intake manifold pressure drift, Intake manifold temperature sensor drift	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	193	EGR (H-Bridge Neg)
2	164	EGR, VREF3
3	-	Not used
4	172	EGR Sensor Return GND
5	192	EGR (H-Bridge Pos)
6	116	EGR Position Sensor Signal

2. Condition for Running Diagnostic During engine running

3. Condition for Setting the Fault Code Air mass difference between air flow meter and calculated air flow into the cylinder with EGR enable condition is out of the threshold, fault code is raised.

4. Condition for Clearing the Fault Code Air mass difference between air flow meter and calculated air flow into the cylinder with EGR enable condition is within the threshold, fault code is cleared.

5. Check Items

Step	Inspection	Standard Value	YES	NO
1	P0402 is raised on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch.		Step 3	
3	Check the EGR pipe between exhaust manifold and EGR valve? Is there any leakage? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.		Step 6	Step 4
4	Check EGR pipe between EGR cooler and intake manifold. Is there any leakage? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.		Step 6	Step 5

5. Failure Diagnosis

Step	Inspection	Standard Value	YES	NO
5	Is there any fault code related intake manifold pressure sensor, intake manifold temperature sensor? If yes, fix the fault based on its troubleshooting guide.		Fix the fault based on its troubleshooting guide	Step 7
6	Fix the leakage or change the pipe. After fix the leakage, start the engine and change the RPM from low idle to high idle. Please keep the RPM as high idle at least 60 seconds. Fault code is cleared?		Problem solved	Step 7
7	Change the air flow meter sensor(MAF) After change the MAF, start the engine and change the RPM from low idle to high idle. Please keep the RPM as high idle at least 30 seconds. Fault code is cleared?		Problem solved	Call Hot-line

5. Failure Diagnosis

P0401 EGR control fault (airflow error too low)

1. Overview

Code	Causes	Impact
P0401	EGR air path leakage, MAF sensor drift, damage of MAF sensor, Intake manifold pressure drift, Intake manifold temperature sensor drift	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	193	EGR (H-Bridge Neg)
2	164	EGR, VREF3
3	-	Not used
4	172	EGR Sensor Return GND
5	192	EGR (H-Bridge Pos)
6	116	EGR Position Sensor Signal

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

Air mass difference between air flow meter and calculated air flow into the cylinder with EGR enable condition is out of the threshold, fault code is raised.

4. Condition for Clearing the Fault Code

Air mass difference between air flow meter and calculated air flow into the cylinder with EGR enable condition is within the threshold, fault code is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0401 is raised on diagnostic tool?			
2	After let the machine be in safety area and turn-off the key switch.			
3	Check the EGR pipe between exhaust manifold and EGR valve? Is there any leakage? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.			
4	Check EGR pipe between EGR cooler and intake manifold. Is there any leakage? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.			

5. Failure Diagnosis

Step	Inspection	Standard Value	YES	NO
5	Is there any fault code related intake manifold pressure sensor, intake manifold temperature sensor? If yes, fix the fault based on its troubleshooting guide.			Step 7
6	Fix the leakage or change the pipe. After fix the leakage, start the engine and change the RPM from low idle to high idle. Please keep the RPM as high idle at least 60 seconds. Fault code is cleared?		Problem solved	Step 7
7	Change the air flow meter sensor(MAF) After change the MAF, start the engine and change the RPM from low idle to high idle. Please keep the RPM as high idle at least 30 seconds. Fault code is cleared?		Problem solved	Call Hot-line

5. Failure Diagnosis

P0406 EGR actuator position feedback signal high fault

1. Overview

Code	Causes	Impact
P0406	Electrical problem Connection problem Sensor problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	193	EGR (H-Bridge Neg)
2	164	EGR, VREF3
3	-	Not used
4	172	EGR Sensor Return GND
5	192	EGR (H-Bridge Pos)
6	116	EGR Position Sensor Signal

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

EGR Feedback Position value is more than maximum operation range

4. Condition for Clearing the Fault Code

EGR Feedback Position value is in operation range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0406 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check air inlet circuit: * Valve state * Depression circuit * Vacuum value pump * Open solenoid valve * Vanne state * Air inlet valve functionality		Step 4	
4	Check connection of the valve Check that the supply voltage is correct Check that the valve position can reach MIN to MAX position (0% to 100%) If applicable, launch a learning of EGR position Problem of connection / supply / position?		Do necessary repair	Problem solved

5. Failure Diagnosis

P0407 EGR actuator position feedback signal low fault

1. Overview

Code	Causes	Impact
P0407	Electrical problem Connection problem Sensor problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	193	EGR (H-Bridge Neg)
2	164	EGR, VREF3
3	-	Not used
4	172	EGR Sensor Return GND
5	192	EGR (H-Bridge Pos)
6	116	EGR Position Sensor Signal

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

EGR Feedback Position value is less than minimum operation range

4. Condition for Clearing the Fault Code

EGR Feedback Position value is in operation range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0407 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check air inlet circuit: * Valve state * Depression circuit * Vacuum value pump * Open solenoid valve * Vanne state * Air inlet valve functionality		Step 4	
4	Check connection of the valve Check that the supply voltage is correct Check that the valve position can reach MIN to MAX position (0% to 100%) If applicable, launch a learning of EGR position Problem of connection / supply / position?		Do necessary repair	Problem solved

5. Failure Diagnosis

P046D EGR actuator position feedback signal noisy fault

1. Overview

Code	Causes	Impact
P046D	Electrical problem Connection problem Sensor problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	193	EGR (H-Bridge Neg)
2	164	EGR, VREF3
3	-	Not used
4	172	EGR Sensor Return GND
5	192	EGR (H-Bridge Pos)
6	116	EGR Position Sensor Signal

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

There is not EGR sensor fault and there is a noise spike on the sensor signal.

(Noise detect: If the absolute difference, comparing the raw actual position to low pass filtered position value, exceeds calibration value (4.6V).

4. Condition for Clearing the Fault Code

The noise spike is restored.

5. Check Items

Step	Inspection	Standard Value	YES	NO
1	P046D is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check air inlet circuit: * Valve state * Depression circuit * Vacuum value pump * Open solenoid valve * Vanne state * Air inlet valve functionality		Step 4	
4	Check connection of the valve Check that the supply voltage is correct Check that the valve position can reach MIN to MAX position (0% to 100%) If applicable, launch a learning of EGR position Problem of connection / supply / position?		Do necessary repair	Problem solved

5. Failure Diagnosis

P0C17 EGR position learning fault (drifted)

1. Overview

Code	Causes	Impact
P0C17	Electrical problem Connection problem Actuator problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	193	EGR (H-Bridge Neg)
2	164	EGR, VREF3
3	-	Not used
4	172	EGR Sensor Return GND
5	192	EGR (H-Bridge Pos)
6	116	EGR Position Sensor Signal

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

If the EGR position control has an electrical error then fault code is arisen.

4. Condition for Clearing the Fault Code

The EGR control is normal operating.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0C17 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check air inlet circuit: * Valve state * Depression circuit * Vacuum value pump * Open solenoid valve * Vanne state * Air inlet valve functionality		Step 4	
4	Check connection of the valve Check that the supply voltage is correct Check that the valve position can reach MIN to MAX position (0% to 100%) If applicable, launch a learning of EGR position Problem of connection / supply / position?		Do necessary repair	Problem solved

5. Failure Diagnosis

P0C18 EGR position learning fault (wrong range)

1. Overview

Code	Causes	Impact
P0C18	Electrical problem Connection problem Actuator problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	193	EGR (H-Bridge Neg)
2	164	EGR, VREF3
3	-	Not used
4	172	EGR Sensor Return GND
5	192	EGR (H-Bridge Pos)
6	116	EGR Position Sensor Signal

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

If the EGR position control has an electrical error then fault code is arisen.

4. Condition for Clearing the Fault Code

The EGR control is normal operating.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0C18 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check air inlet circuit: * Valve state * Depression circuit * Vacuum value pump * Open solenoid valve * Vanne state * Air inlet valve functionality		Step 4	
4	Check connection of the valve Check that the supply voltage is correct Check that the valve position can reach MIN to MAX position (0% to 100%) If applicable, launch a learning of EGR position Problem of connection / supply / position?		Do necessary repair	Problem solved

5. Failure Diagnosis

U0140 J1939 CAN pedal fault

1. Overview

Code	Causes	Impact
U0140	Electrical problem Connection problem Network problem	CE lamp Flashing Limp-home mode

NO	ECU Pin	Description
1	248	CAN Hi
2	247	CAN Lo

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

J1939 EEC2 message is not coming during specific time threshold

4. Condition for Clearing the Fault Code

J1939 EEC2 message is coming as normally.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	U0140 is happened on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check ECU connection Connection problem?		Do necessary repair	Step 3
4	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 4
5	Check Network Network problem?		Do necessary repair	Call Hot-line

5. Failure Diagnosis

P0088 Rail pressure control fault

1. Overview

Code	Causes	Impact
P0088	Faulty IMV (sticking,leaking etc), Faulty rail pressure sensor. (Aged or malfunction) Faulty Injector LPC(Low pressure circuit)problem. (leakage, fuel is not supplied due to some reason.) HPC(High pressure circuit)problem.(leakage etc)	CE lamp Flashing Torque Reduction Lv1 Delay engine stop

NO	ECU Pin	Description
1	138	VREF1 Rail Pressure Sensor
2	119	Rail Pressure Sensor Return
3	135	Rail Pressure Sensor

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If the feedback rail pressure of rail pressure sensor is out of the threshold during restricted condition, fault code is raised.

4. Condition for Clearing the Fault Code

If the feedback rail pressure of rail pressure is within the threshold during restricted condition, fault code is cleared.

5. Inspection Items

1) A

Step	Inspection	Standard Value	YES	NO
1	P0088 is occurred on diagnostic tool?		Step 2	O.K
2	After let the machine be in safety area and turn-off the key switch.		Step 3	
3	Please do visual inspection throughout all fuel line. (Low pressure circuit & high pressure circuit) Is there any leakage or blocking of fuel? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.		Step 4	Step 5
4	Please fix the leakage. After fix the problem, start the engine and change the RPM from low idle to high idle. Please keep the RPM as a high idle at least 10 minutes. Fault code is cleared?		O.K	Step 5
5	Please do the Shut off test & Run up test for detecting which injector has fault or not. Do you find faulty injector?		Step 6	Step 7

5. Failure Diagnosis

Step	Inspection	Standard Value	YES	NO
6	Change the injector which has a fault as a normal one. Start the engine and set the RPM in high idle at least 10 minutes. Fault code is cleared?		O.K	Step 7
7	Change the high pressure pump with DOOSAN A.S support. Fault code is cleared?		O.K	Call DOOSAN Hot line

2) B

Step	Inspection	Standard Value	YES	NO
1	P0088 is occurred on diagnostic tool?		Step 2	
2	Fault of type IMV or rail pressure sensor?		First, fix the corresponding fault	Step 3
3	DTC link to High Pressure control?		Step 4	No problem
4	Check that: * fuel feed circuit is in good condition * there is diesel fuel present in the system * there is no air (no bubbles or emulsion in the pipes) * there is enough fuel pressure in inlet pump * there are no high pressure circuit leaks * there is diesel fuel of the correct quality and type Low pressure circuit faulty?		Repair the low pressure circuit	Step 5
5	According to engine start or not, different tests are to be done. Does engine start?		Step 6	Step 7
6	Perform "DYNAMIC IMV TEST" Faulty IMV?		Replace IMV	Step 8
7	Perform "STATIC INJECTOR BACKLEAK TEST" Carry out the "tube test: Result?		Replace corresponding injector(s)	Replace HP pump
8	Perform "DYNAMIC INJECTOR BACKLEAK TEST" Backleak above limit?		Replace corresponding injector(s)	Step 9
9	Perform "PUMP PRESSURE BUILD CAPACITY" This test need specific equipment "hydraulic-T" Result?		End	Replace HP pump

5. Failure Diagnosis

P2267 Water in Fuel sensor electrical fault (OC/SCVBATT)

1. Overview

Code	Causes	Impact
P2267	Electrical problem Connection problem Sensor problem	CE lamp Flashing Torque Reduction Lv1

NO	ECU Pin	Description
1	209	Water In Fuel Sensor
2	234	WIF Return

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Water in Fuel Feedback value is more than maximum operation position

4. Condition for Clearing the Fault Code

Water in Fuel Feedback value is in operation range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P2267 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Empty filter to remove water		Step 4	
4	Water presence?		Problem solved	Step 5
5	Check presence of electrical default on water sensor. Electrical problem?		Do necessary repair	Step 6
6	Check water sensor connection. Connection problem?		Do necessary repair	Step 7
7	Check water sensor variables Resistance problem?		Change water sensor	Step 8
8	Check ECU connection Connection problem?		Do necessary repair	Step 9
9	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P2266 Water in Fuel sensor electrical fault (SCGND)

1. Overview

Code	Causes	Impact
P2266	Electrical problem Connection problem Sensor problem	CE lamp Flashing Torque Reduction Lv1

NO	ECU Pin	Description
1	209	Water In Fuel Sensor
2	234	WIF Return

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Water in Fuel Feedback value is less than minimum operation position

4. Condition for Clearing the Fault Code

Water in Fuel Feedback value is in operation range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P2266 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Empty filter to remove water		Step 4	
4	Water presence?		Problem solved	Step 5
5	Check presence of electrical default on water sensor. Electrical problem?		Do necessary repair	Step 6
6	Check water sensor connection. Connection problem?		Do necessary repair	Step 7
7	Check water sensor variables Resistance problem?		Change water sensor	Step 8
8	Check ECU connection Connection problem?		Do necessary repair	Step 9
9	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P2269 Water in Fuel Detected

1. Overview

Code	Causes	Impact
P2269	Electrical problem Connection problem Sensor problem Water in fuel state	CE lamp Flashing Torque Reduction Lv1

NO	ECU Pin	Description
1	209	Water In Fuel Sensor
2	234	WIF Return

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

If there is water in fuel

4. Condition for Clearing the Fault Code

Water in fuel is removed.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P2269 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Empty filter to remove water		Step 4	
4	Water presence?		Problem solved	Step 5
5	Check presence of electrical default on water sensor. Electrical problem?		Do necessary repair	Step 6
6	Check water sensor connection. Connection problem?		Do necessary repair	Step 7
7	Check water sensor variables Resistance problem?		Change water sensor	Step 8
8	Check ECU connection Connection problem?		Do necessary repair	Step 9
9	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P0524 Oil pressure remains low at engine run

1. Overview

Code	Causes	Impact
P0524	Oil pressure is below the threshold value in main gallery of engine cylinder block During engine running.	CE lamp Flashing Torque Reduction Lv1 Delay engine stop

NO	ECU Pin	Description
1	148	Engine Oil Pressure & Temp Return GND
2	104	Engine Oil Temperature Sensor
3	165	VREF3, Engine Oil Pressure
4	111	Engine Oil Pressure Sensor

2. Condition for Running Diagnostic

After engine run

3. Condition for Setting the Fault Code

After engine run, oil pressure sensor value is below the threshold value.

4. Condition for Clearing the Fault Code

After engine run, oil pressure sensor value is within the normal range, fault is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0524 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check the engine oil level in the oil pan. Oil level is within the specification?		Step 4	Step 6
4	Check the engine oil leakage in oil path. Is there any leakage?		Call Hot-line	Step 5
5	Oil pump damage or oil filter blocked or oil path blocked or oil sensor drift can be suspected.		Call Hot-line	
6	Refill the engine oil and start the engine. Keep low idle during 3minutes. The same fault code is happened from low idle to high idle?		Step 4	Fault is cleared

5. Failure Diagnosis

P0523 Oil pressure sensor high fault

1. Overview

Code	Causes	Impact
P0523	Sensor supply voltage problem Electrical problem Connection problem Sensor problem	CEL is ON. Torque is reduced.

NO	ECU Pin	Description
1	148	Engine Oil Pressure & Temp Return GND
2	104	Engine Oil Temperature Sensor
3	165	VREF3, Engine Oil Pressure
4	111	Engine Oil Pressure Sensor

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Oil pressure sensor value is more than maximum operation pressure or

At engine run, Oil pressure sensor value is more than maximum calibration range

4. Condition for Clearing the Fault Code

Oil pressure sensor value is in the operation range or

At engine run, Oil pressure sensor value is in calibration range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0523 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P0522 Oil pressure sensor low fault

1. Overview

Code	Causes	Impact
P0522	Sensor supply voltage problem Electrical problem Connection problem Sensor problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	148	Engine Oil Pressure & Temp Return GND
2	104	Engine Oil Temperature Sensor
3	165	VREF3, Engine Oil Pressure
4	111	Engine Oil Pressure Sensor

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Oil pressure sensor value is less than minimum operation pressure or
At engine run, Oil pressure sensor value is less than minimum calibration range

4. Condition for Clearing the Fault Code

Oil pressure sensor value is in the operation range or
At engine run, Oil pressure sensor value is in calibration range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0522 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P0111 Intake Manifold Temperature plausibility fault

1. Overview

Code	Causes	Impact
P0111	Leakage Electrical problem Connection problem Sensor problem	No

NO	ECU Pin	Description
1	169	Inlet Boost Temperature, Return
2	194	Inlet Boost Temperature, Signal

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If the T2 temperature is out of the threshold during restricted condition, fault code is raised.

4. Condition for Clearing the Fault Code

If the T2 temperature is within the threshold during restricted condition, fault code is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0111 is raised on diagnostic tool?		Step 2	O.K
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Please do visual inspection between air filter and t2 temperature sensor location. Is there any leakage? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.		Step 4	Step 5
4	Please fix the leakage. After fix the problem, start the engine and change the RPM from low idle to high idle. Please keep the RPM as a high idle at least 10 minutes. Fault code is cleared?		O.K	Step 5
5	Change the T2 temperature sensor as a normal one. Start the engine and set the RPM in high idle at least 10 minutes. Fault code is cleared?		O.K	Call DOOSAN Hot line

5. Failure Diagnosis

P0113 Intake Manifold Temperature sensor high fault

1. Overview

Code	Causes	Impact
P0113	Electrical problem Connection problem Sensor problem	CE lamp ON

NO	ECU Pin	Description
1	169	Inlet Boost Temperature, Return
2	194	Inlet Boost Temperature, Signal

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

T2 temperature sensor value is more than maximum operation temperature

4. Condition for Clearing the Fault Code

T2 temperature sensor value is in operation range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0113 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P0112 Intake Manifold Temperature sensor low fault

1. Overview

Code	Causes	Impact
P0112	Electrical problem Connection problem Sensor problem	CE lamp ON

NO	ECU Pin	Description
1	169	Inlet Boost Temperature, Return
2	194	Inlet Boost Temperature, Signal

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

T2 temperature sensor value is less than minimum operation temperature

4. Condition for Clearing the Fault Code

T2 temperature sensor value is in operation range

5. Check Items

Step	Inspection	Standard Value	YES	NO
1	P0112 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P0114 Intake Manifold Temperature sensor noisy fault

1. Overview

Code	Causes	Impact
P0114	Electrical problem Connection problem Sensor problem Noise	CE lamp ON

NO	ECU Pin	Description
1	169	Inlet Boost Temperature, Return
2	194	Inlet Boost Temperature, Signal

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

There is not T2 sensor fault and there is a noise spike on the sensor signal.

(Noise detect: If the absolute difference, comparing the raw actual temp to low pass filtered temp value, exceeds calibration value.

4. Condition for Clearing the Fault Code

The noise spike is restored.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0114 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P0108 Manifold Pressure sensor electrical high fault

1. Overview

Code	Causes	Impact
P0108	Electrical problem Connection problem Sensor problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	161	VREF2, INPRES
2	167	INPRES Return GND
3	112	Intake Manifold Pressure Sensor

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Manifold pressure sensor value is more than maximum operation pressure

4. Condition for Clearing the Fault Code

Manifold pressure sensor value is in operation range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0108 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P0107 Manifold Pressure sensor electrical low fault

1. Overview

Code	Causes	Impact
P0107	Electrical problem Connection problem Sensor problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	161	VREF2, INPRES
2	167	INPRES Return GND
3	112	Intake Manifold Pressure Sensor

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Manifold pressure sensor value is less than minimum operation pressure

4. Condition for Clearing the Fault Code

Manifold pressure sensor value is in operation range.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0107 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P2229 Barometric pressure sensor electrical high fault

1. Overview

Code	Causes	Impact
P2229	ECU problem Atmospheric pressure sensor problem	CE lamp ON Torque Reduction Lv0

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Atmospheric Pressure value is more than
Maximum operation pressure

4. Condition for Clearing the Fault Code

Atmospheric Pressure value is in operation
pressure

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P2229 is occurred on diagnostic tool?		Call Hot-line	

5. Failure Diagnosis

P2228 Barometric pressure sensor electrical low fault

1. Overview

Code	Causes	Impact
P2228	ECU problem Atmospheric pressure sensor problem	CE lamp ON Torque Reduction Lv0

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Atmospheric Pressure value is less than
minimum operation pressure

4. Condition for Clearing the Fault Code

Atmospheric Pressure value is in operation
pressure

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P2228 is occurred on diagnostic tool?		Call Hot-line	

5. Failure Diagnosis

P0116 Coolant temperature plausibility fault

1. Overview

Code	Causes	Impact
P0116	Thermostat problem(broken or normally open), Connection problem Sensor problem	No

NO	ECU Pin	Description
1	145	Coolant Temperature Return
2	109	Coolant Temperature Sensor

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If the coolant temperature is increased more than the threshold during restricted condition, fault code is raised.

4. Condition for Clearing the Fault Code

If the coolant temperature is increased higher than the threshold during restricted condition, fault code is cleared.

5. Check Items

Step	Inspection	Standard Value	YES	NO
1	P0116 is occurred on diagnostic tool?		Step 2	O.K
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check the thermostat. Is the thermostat broken? For example thermostat is always wide open.		Step 5	Step 4
4	Change the coolant temperature sensor. Start the engine and set the RPM in high idle, 10 minutes. After that set the RPM in low idle, fault code is cleared and torque limit is deactivated?		O.K	Call DOOSAN Hot line
5	Change the thermostat as a normal one. Start the engine and set the RPM in high idle, 10 minutes. After that set the RPM in low idle, fault code is cleared and torque limit is deactivated?		O.K	Call DOOSAN Hot line

5. Failure Diagnosis

P0118 Coolant temperature sensor high fault

1. Overview

Code	Causes	Impact
P0118	Electrical problem Connection problem Sensor problem	CE lamp ON Torque Reduction Lv1

NO	ECU Pin	Description
1	145	Coolant Temperature Return
2	109	Coolant Temperature Sensor

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Coolant temperature signal value is more than maximum operation temperature

4. Condition for Clearing the Fault Code

Coolant temperature signal value is in operation range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0118 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P0117 Coolant temperature sensor low fault

1. Overview

Code	Causes	Impact
P0117	Electrical problem Connection problem Sensor problem	CE lamp ON Torque Reduction Lv1

NO	ECU Pin	Description
1	145	Coolant Temperature Return
2	109	Coolant Temperature Sensor

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Coolant temperature signal value is less than minimum operation temperature

4. Condition for Clearing the Fault Code

Coolant temperature signal value is in operation range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0117 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P00BD MAF plausibility high fault

1. Overview

Code	Causes	Impact
P00BD	Intake air path leakage MAF sensor drift damage of MAF sensor	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	235	Air Inlet Temperature, analogue signal
2	137	Supply Voltage (5V)
3	120	TMAF Sensor Return
4	228	Air Mass Flow Sensor, frequency signal

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

Air mass difference between air flow meter and calculated air flow into the cylinder is out of the threshold, fault code is raised.

4. Condition for Clearing the Fault Code

Air mass difference between air flow meter and calculated air flow into the cylinder is within the threshold, fault code is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P00BD is raised on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check the intake hose between air filter and turbocharger compressor? Is there any leakage? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.		Step 6	Step 4
4	Check the intake hose between turbocharger compressor outlet and intercooler. Is there any leakage? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.		Step 6	Step 5
5	Check the intake hose between intercooler and intake manifold. Is there any leakage? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.		Step 6	Step 7

5. Failure Diagnosis

Step	Inspection	Standard Value	YES	NO
6	Fix the leakage or change the hose. After fix the leakage, start the engine and change the RPM from low idle to high idle. Please keep the RPM as high idle at least 30 seconds. Fault code is cleared?		O.K	Step 7
7	Change the air flow meter sensor(MAF) After change the MAF, start the engine and change the RPM from low idle to high idle. Please keep the RPM as high idle at least 30 seconds. Fault code is cleared?		O.K	Call DOOSAN Hot line

5. Failure Diagnosis

P00BC MAF plausibility low fault

1. Overview

Code	Causes	Impact
P00BC	Intake air path leakage MAF sensor drift damage of MAF sensor	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	235	Air Inlet Temperature, analogue signal
2	137	Supply Voltage (5V)
3	120	TMAF Sensor Return
4	228	Air Mass Flow Sensor, frequency signal

2. Condition for Running Diagnostic During engine running

3. Condition for Setting the Fault Code Air mass difference between air flow meter and calculated air flow into the cylinder is out of the threshold, fault code is raised.

4. Condition for Clearing the Fault Code Air mass difference between air flow meter and calculated air flow into the cylinder is within the threshold, fault code is cleared.

5. Check Items

Step	Inspection	Standard Value	YES	NO
1	P00BC is raised on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check the intake hose between air filter and turbocharger compressor? Is there any leakage? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.		Step 6	Step 4
4	Check the intake hose between turbocharger compressor outlet and intercooler. Is there any leakage? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.		Step 6	Step 5
5	Check the intake hose between intercooler and intake manifold. Is there any leakage? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.		Step 6	Step 7

5. Failure Diagnosis

Step	Inspection	Standard Value	YES	NO
6	Fix the leakage or change the hose. After fix the leakage, start the engine and change the RPM from low idle to high idle. Please keep the RPM as high idle at least 30 seconds. Fault code is cleared?		O.K	Step 7
7	Change the air flow meter sensor(MAF) After change the MAF, start the engine and change the RPM from low idle to high idle. Please keep the RPM as high idle at least 30 seconds. Fault code is cleared?		O.K	Call DOOSAN Hot line

5. Failure Diagnosis

P0103 MAF sensor electrical high fault

1. Overview

Code	Causes	Impact
P0103	Electrical problem Connection problem Sensor problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	235	Air Inlet Temperature, analogue signal
2	137	Supply Voltage (5V)
3	120	TMAF Sensor Return
4	228	Air Mass Flow Sensor, frequency signal

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Air mass flow value is more than maximum operation frequency

4. Condition for Clearing the Fault Code

Air mass flow value is in operation range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0103 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P0102 MAF sensor electrical low fault

1. Overview

Code	Causes	Impact
P0102	Electrical problem Connection problem Sensor problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	235	Air Inlet Temperature, analogue signal
2	137	Supply Voltage (5V)
3	120	TMAF Sensor Return
4	228	Air Mass Flow Sensor, frequency signal

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Air mass flow value is less than minimum operation frequency

4. Condition for Clearing the Fault Code

Air mass flow value is in operation range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0102 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P0190 Rail Pressure Sensor gradient fault

1. Overview

Code	Causes	Impact
P0190	Faulty IMV (sticking,leaking etc), Faulty rail pressure sensor. (Aged or malfunction) Faulty Injector LPC(Low pressure circuit)problem. (leakage, fuel is not supplied due to some reason.) HPC(High pressure circuit)problem.(leakage etc)	CE lamp Flashing Torque Reduction Lv1 Delay engine stop

NO	ECU Pin	Description
1	138	VREF1 Rail Pressure Sensor
2	119	Rail Pressure Sensor Return
3	135	Rail Pressure Sensor

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If the feedback rail pressure of rail pressure sensor is out of the threshold during restricted condition, fault code is raised.

4. Condition for Clearing the Fault Code

If the feedback rail pressure of rail pressure is within the threshold during restricted condition, fault code is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0190 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	This fault could be caused by pushing vehicle while engine is off. Vehicle been pushed?		Clear fault. Poor detection	Step 3
4	VEXT fault present?		Step 5	Step 6
5	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness			
6	Check sensor connection Connection problem?		Do necessary repair	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 10
9	Change sensor + rail Problem still present?		Call Hot-line	

5. Failure Diagnosis

P0193 Rail Pressure Sensor high fault

1. Overview

Code	Causes	Impact
P0193	Electrical problem Connection problem Sensor problem Abnormally vehicle be pushed	CE lamp Flashing Torque Reduction Lv1 Delay engine stop

NO	ECU Pin	Description
1	138	VREF1 Rail Pressure Sensor
2	119	Rail Pressure Sensor Return
3	135	Rail Pressure Sensor

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If the feedback rail pressure of rail pressure sensor is out of the threshold

4. Condition for Clearing the Fault Code

If the feedback rail pressure of rail pressure is within the threshold

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0193 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	This fault could be caused by pushing vehicle while engine is off. Vehicle been pushed?		Clear fault. Poor detection	Step 3
4	VEXT fault present?		Step 5	Step 6
5	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness			
6	Check sensor connection Connection problem?		Do necessary repair	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 10
9	Change sensor + rail Problem still present?		Call Hot-line	

5. Failure Diagnosis

P0192 Rail Pressure Sensor low fault

1. Overview

Code	Causes	Impact
P0192	Electrical problem Connection problem Sensor problem Abnormally vehicle be pushed	CE lamp Flashing Torque Reduction Lv1 Delay engine stop

NO	ECU Pin	Description
1	138	VREF1 Rail Pressure Sensor
2	119	Rail Pressure Sensor Return
3	135	Rail Pressure Sensor

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If the feedback rail pressure of rail pressure sensor is out of the threshold

4. Condition for Clearing the Fault Code

If the feedback rail pressure of rail pressure is within the threshold

5. Check Items

Step	Inspection	Standard Value	YES	NO
1	P0192 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	This fault could be caused by pushing vehicle while engine is off. Vehicle been pushed?		Clear fault. Poor detection	Step 3
4	VEXT fault present?		Step 5	Step 6
5	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness			
6	Check sensor connection Connection problem?		Do necessary repair	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 10
9	Change sensor + rail Problem still present?		Call Hot-line	

5. Failure Diagnosis

P0087 Rail Pressure Sensor fault (pressure build up during cranking too slow)

1. Overview

Code	Causes	Impact
P0087	Faulty IMV (sticking,leaking etc), Faulty rail pressure sensor. (Aged or malfunction) Failure of rail filling LPC(Low pressure circuit)problem. (leakage, fuel is not supplied due to some reason.) HPC(High pressure circuit)problem.(leakage etc)	CE lamp ON

NO	ECU Pin	Description
1	138	VREF1 Rail Pressure Sensor
2	119	Rail Pressure Sensor Return
3	135	Rail Pressure Sensor

2. Condition for Running Diagnostic

During rail filling

3. Condition for Setting the Fault Code

If rail filling time is longer than threshold, fault code is raised.

4. Condition for Clearing the Fault Code

If Rail filling time is within the threshold, fault code is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0087 is occurred on diagnostic tool?		Step 2	
2	Fault of type IMV or rail pressure sensor?		First, fix the corresponding fault	Step 3
3	DTC link to High Pressure control?		Step 4	No problem
4	Check that: * fuel feed circuit is in good condition * there is diesel fuel present in the system * there is no air (no bubbles or emulsion in the pipes) * there is enough fuel pressure in inlet pump * there are no high pressure circuit leaks * there is diesel fuel of the correct quality and type Low pressure circuit faulty?		Repair the low pressure circuit	Step 5
5	According to engine start or not, different tests are to be done. Does engine start?		Step 6	Step 7
6	Perform "DYNAMIC IMV TEST" Faulty IMV?		Replace IMV	Step 8
7	Perform "STATIC INJECTOR BACKLEAK TEST" Carry out the "tube test: Result?		Replace corresponding injector(s)	Replace HP pump

5. Failure Diagnosis

Step	Inspection	Standard Value	YES	NO
8	Perform "DYNAMIC INJECTOR BACKLEAK TEST" Backleak above limit?		Replace corresponding injector(s)	Step 9
9	Perform "PUMP PRESSURE BUILD CAPACITY" This test need specific equipment "hydraulic-T" Result?		End	Replace HP pump

5. Failure Diagnosis

P0191 Rail Pressure Sensor fault (Sensor drift at key-on)

1. Overview

Code	Causes	Impact
P0191	Faulty IMV (sticking,leaking etc), Faulty rail pressure sensor. (Aged or malfunction) Faulty Injector LPC(Low pressure circuit)problem. (leakage, fuel is not supplied due to some reason.) HPC(High pressure circuit)problem.(leakage etc)	CE lamp Flashing Torque Reduction Lv1 Delay engine stop

NO	ECU Pin	Description
1	138	VREF1 Rail Pressure Sensor
2	119	Rail Pressure Sensor Return
3	135	Rail Pressure Sensor

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If the feedback rail pressure of rail pressure sensor is out of the threshold during restricted condition, fault code is raised.

4. Condition for Clearing the Fault Code

If the feedback rail pressure of rail pressure is within the threshold during restricted condition, fault code is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0191 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	This fault could be caused by pushing vehicle while engine is off. Vehicle been pushed?		Clear fault. Poor detection	Step 3
4	VEXT fault present?		Step 5	Step 6
5	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness			
6	Check sensor connection Connection problem?		Do necessary repair	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 10
9	Change sensor + rail Problem still present?		Call Hot-line	

5. Failure Diagnosis

P0002 Rail Pressure Control fault (RPC using IMV only)

1. Overview

Code	Causes	Impact
P0002	Faulty injector (sticking, coking, leaking etc), Injector wiring problem, Faulty IMV	CE lamp Flashing Torque Reduction Lv1

NO	ECU Pin	Description
1	177	Inlet Metering Valve PWM
2	-	Pbatt

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If the resistance of IMV is out of the threshold during restricted condition, fault code is raised.

4. Condition for Clearing the Fault Code

If the resistance of IMV is within the threshold during restricted condition, fault code is cleared.

5. Inspection Items

1) A

Step	Inspection	Standard Value	YES	NO
1	P0002 is raised on diagnostic tool?		Step 2	O.K
2	After let the machine be in safety area and turn-off the key switch.		Step 3	
3	Please do visual inspection throughout all fuel line & electric wire of injector. (Low pressure circuit & high pressure circuit) Is there any leakage or wire problem? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.		Step 4	Step 5
4	Please fix the leakage. After fix the problem, start the engine and change the RPM from low idle to high idle. Please keep the RPM as a high idle at least 10 minutes. Fault code is cleared?		O.K	Step 5
5	Please do the Shut off test & Run up test for detecting which injector has fault or not. Do you find faulty injector?		Step 6	Call DOOSAN Hot line
6	Change the faulty injector as a normal one. Start the engine and set the RPM in high idle at least 10 minutes. Fault code is cleared?		O.K	Step 7
7	Change the high pressure pump with DOOSAN A.S support. Fault code is cleared?		O.K	Call DOOSAN Hot line

5. Failure Diagnosis

2) B

Step	Inspection	Standard Value	YES	NO
1	P0002 is occurred on diagnostic tool?		Step 2	
2	Fault of type IMV or rail pressure sensor?		First, fix the corresponding fault	Step 3
3	DTC link to High Pressure control?		Step 4	No problem
4	Check that: * fuel feed circuit is in good condition * there is diesel fuel present in the system * there is no air (no bubbles or emulsion in the pipes) * there is enough fuel pressure in inlet pump * there are no high pressure circuit leaks * there is diesel fuel of the correct quality and type Low pressure circuit faulty?		Repair the low pressure circuit	Step 5
5	According to engine start or not, different tests are to be done. Does engine start?		Step 6	Step 7
6	Perform "DYNAMIC IMV TEST" Faulty IMV?		Replace IMV	Step 8
7	Perform "STATIC INJECTOR BACKLEAK TEST" Carry out the "tube test: Result?		Replace corresponding injector(s)	Replace HP pump
8	Perform "DYNAMIC INJECTOR BACKLEAK TEST" Backleak above limit?		Replace corresponding injector(s)	Step 9
9	Perform "PUMP PRESSURE BUILD CAPACITY" This test need specific equipment "hydraulic-T" Result?		End	Replace HP pump

5. Failure Diagnosis

P0089 Rail Pressure Control fault (RPC using Rail Discharge)

1. Overview

Code	Causes	Impact
P0089	Faulty IMV (sticking,leaking etc), Faulty rail pressure sensor. (Aged or malfunction) Faulty Injector LPC(Low pressure circuit)problem. (leakage, fuel is not supplied due to some reason.) HPC(High pressure circuit)problem.(leakage etc)	CE lamp Flashing Torque Reduction Lv1

NO	ECU Pin	Description
1	138	VREF1 Rail Pressure Sensor
2	119	Rail Pressure Sensor Return
3	135	Rail Pressure Sensor

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If the feedback rail pressure of rail pressure sensor is out of the threshold during restricted condition, fault code is raised.

4. Condition for Clearing the Fault Code

If the feedback rail pressure of rail pressure is within the threshold during restricted condition, fault code is cleared.

5. Inspection Items

1) A

Step	Inspection	Standard Value	YES	NO
1	P0089 is occurred on diagnostic tool?		Step 2	O.K
2	After let the machine be in safety area and turn-off the key switch.		Step 3	
3	Please do visual inspection throughout all fuel line. (Low pressure circuit & high pressure circuit) Is there any leakage or blocking of fuel? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.		Step 4	Step 5
4	Please fix the leakage. After fix the problem, start the engine and change the RPM from low idle to high idle. Please keep the RPM as a high idle at least 10 minutes. Fault code is cleared?		O.K	Step 6
5	Please do visual inspection rail pressure sensor connector and related wire. Are there any water inside connector or faulty wire of rail pressure sensor?		Step 6	Step 7

5. Failure Diagnosis

Step	Inspection	Standard Value	YES	NO
6	Please fix the faulty wire or clean the water. After fix the problem, start the engine and change the RPM from low idle to high idle. Please keep the RPM as a high idle at least 10 minutes. Fault code is cleared?		O.K	Step 7
7	Please do the Shut off test & Run up test for detecting which injector has fault or not. Do you find faulty injector?		Step 7	Step 8
8	Change the injector which has a fault as a normal one. Start the engine and set the RPM in high idle at least 10 minutes. Fault code is cleared?		O.K	Step 9
9	Change the ECU as a new one. Start the engine and set the RPM in high idle at least 10 minutes. Fault code is cleared?		O.K	Step 10
10	Change the high pressure pump with DOOSAN A.S support. Fault code is cleared?		O.K	Call DOOSAN Hot line

2) B

Step	Inspection	Standard Value	YES	NO
1	P0089 is occurred on diagnostic tool?		Step 2	
2	Fault of type IMV or rail pressure sensor?		First, fix the corresponding fault	Step 3
3	DTC link to High Pressure control?		Step 4	No problem
4	Check that: * fuel feed circuit is in good condition * there is diesel fuel present in the system * there is no air (no bubbles or emulsion in the pipes) * there is enough fuel pressure in inlet pump * there are no high pressure circuit leaks * there is diesel fuel of the correct quality and type Low pressure circuit faulty?		Repair the low pressure circuit	Step 5
5	According to engine start or not, different tests are to be done. Does engine start?		Step 6	Step 7
6	Perform "DYNAMIC IMV TEST" Faulty IMV?		Replace IMV	Step 8
7	Perform "STATIC INJECTOR BACKLEAK TEST" Carry out the "tube test: Result?		Replace corresponding injector(s)	Replace HP pump
8	Perform "DYNAMIC INJECTOR BACKLEAK TEST" Backleak above limit?		Replace corresponding injector(s)	Step 9
9	Perform "PUMP PRESSURE BUILD CAPACITY" This test need specific equipment "hydraulic-T" Result?		End	Replace HP pump

5. Failure Diagnosis

P0563 Battery voltage high fault

1. Overview

Code	Causes	Impact
P0563	Battery terminal problem Connection problem Battery charge circuit problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	201	Protected Battery
2	203	Protected Battery
3	205	Protected Battery
4	202	Power Ground
5	204	Power Ground
6	206	Power Ground

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Battery voltage is more than maximum operation voltage

4. Condition for Clearing the Fault Code

Battery voltage is in operation range (9V~16V)

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0563 is occurred on diagnostic tool?		Step 2	
2	Check battery voltage at Key On Battery problem?		Charge battery	Step 3
3	Check the battery terminals, tightening the lugs, absence of oxidation, absence of consumers (with an Ohm-meter) Battery connection problem?		Do necessary repair	Step 4
4	Check ECU connection Connection problem?		Do necessary repair	Step 5
5	Check resistance between vehicle chassis ground and ECU ground Resistance too high?		Fix ECU ground	Step 6
6	Check battery charge circuit Charge circuit problem?		Do necessary repair	Call Hot-line

5. Failure Diagnosis

P0562 Battery voltage low fault

1. Overview

Code	Causes	Impact
P0562	Battery terminal problem Connection problem Battery charge circuit problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	201	Protected Battery
2	203	Protected Battery
3	205	Protected Battery
4	202	Power Ground
5	204	Power Ground
6	206	Power Ground

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Battery voltage is less than minimum operation voltage

4. Condition for Clearing the Fault Code

Battery voltage is in operation range (9V~16V)

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0562 is occurred on diagnostic tool?		Step 2	
2	Check battery voltage at Key On Battery problem?		Charge battery	Step 3
3	Check the battery terminals, tightening the lugs, absence of oxidation, absence of consumers (with an Ohm-meter) Battery connection problem?		Do necessary repair	Step 4
4	Check ECU connection Connection problem?		Do necessary repair	Step 5
5	Check resistance between vehicle chassis ground and ECU ground Resistance too high?		Fix ECU ground	Step 6
6	Check battery charge circuit Charge circuit problem?		Do necessary repair	Call Hot-line

5. Failure Diagnosis

P0074 Inlet Air Temperature sensor gradient fault

1. Overview

Code	Causes	Impact
P0074	Electrical problem Connection problem Sensor problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	235	Air Inlet Temperature, analogue signal
2	137	Supply Voltage (5V)
3	120	TMAF Sensor Return
4	228	Air Mass Flow Sensor, frequency signal

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Inlet Air Temperature Sensor signal gradient exceeds a threshold.

4. Condition for Clearing the Fault Code

Inlet Air Temperature Sensor signal gradient in a threshold.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0074 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P0073 Inlet Air Temperature sensor high fault

1. Overview

Code	Causes	Impact
P0073	Electrical problem Connection problem Sensor problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	235	Air Inlet Temperature, analogue signal
2	137	Supply Voltage (5V)
3	120	TMAF Sensor Return
4	228	Air Mass Flow Sensor, frequency signal

2. Condition for Running Diagnostic Key on or engine run

3. Condition for Setting the Fault Code Inlet Air temperature signal value is more than maximum operation temperature

4. Condition for Clearing the Fault Code Coolant temperature signal value is in operation range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0073 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P0072 Inlet Air Temperature sensor low fault

1. Overview

Code	Causes	Impact
P0072	Electrical problem Connection problem Sensor problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	235	Air Inlet Temperature, analogue signal
2	137	Supply Voltage (5V)
3	120	TMAF Sensor Return
4	228	Air Mass Flow Sensor, frequency signal

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Inlet air temperature signal value is less than minimum operation temperature

4. Condition for Clearing the Fault Code

Inlet Air temperature signal value is in operation range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0072 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P2428 Exhaust over temperature fault

1. Overview

Code	Causes	Impact
P2428	Leakage Sensor problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	123	Exhaust gas temp 2 (Pre-Turbo), Return
2	106	Exhaust gas temp 2 (Pre-Turbo), Signal

2. Condition for Running Diagnostic

During engine running & DPF regeneration is activated

3. Condition for Setting the Fault Code

If the turbine in temperature is out of the threshold (over mechanical limit), fault code is raised.

4. Condition for Clearing the Fault Code

If the turbine in temperature is within the threshold (within mechanical limit), fault code is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P2428 is raised on diagnostic tool?		Step 2	O.K
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Please do visual inspections between air-filter and exhaust manifold (throughout all air path). Is there any leakage? If you cannot find with your eyes, You can check leakage during engine running with high idle in machine stationary condition. You have to record IN_Turbine_in_temp with high idle condition.		Step 4	Step 6
4	Please fix the leakage. After fix the problem, start the engine and change the RPM from low idle to high idle. Please keep the RPM as a high idle at least 3 minutes. Please record IN_Turbine_in_temp with high idle condition. IN_Turbine_in_temp gets lower after fixing the leakage? Fault code is cleared?		Step 5	Step 6
5	Operate the machine what you want to do and please check IN_Turbine_in_temp. Fault code is not occurred again?		O.K	Step 6
6	Please check the pressure drop after air filter. Is there any clogging or blocking air filter with dust? If pressure drop is out of spec [-5kPa] with rated power, please change the air filter cartridge. After change the air filter cartridge, start the engine and change the RPM from low idle to high idle. Please keep the RPM as a high idle at least 3 minutes. Please record IN_Turbine_in_temp with high idle condition. IN_Turbine_in_temp gets lower after changing the cartridge? Fault code is cleared?		Step 5	Call DOOSAN Hot line

5. Failure Diagnosis

P0181 Fuel temperature plausibility fault

1. Overview

Code	Causes	Impact
P0181	Connection problem Sensor problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	146	Sensor Return GND
2	110	Fuel Temperature Sensor

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Fuel temperature signal has an electric noise
or abnormal signal deviation.

4. Condition for Clearing the Fault Code

Fuel temperature signal value has no noise
and normal physical deviation.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0181 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P0183 Fuel temperature sensor high fault

1. Overview

Code	Causes	Impact
P0183	Electrical problem Connection problem Sensor problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	146	Sensor Return GND
2	110	Fuel Temperature Sensor

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Fuel temperature value is more than maximum operation position

4. Condition for Clearing the Fault Code

Fuel temperature value is in operation range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0183 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P0182 Fuel temperature sensor low fault

1. Overview

Code	Causes	Impact
P0182	Electrical problem Connection problem Sensor problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	146	Sensor Return GND
2	110	Fuel Temperature Sensor

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Fuel temperature value is less than minimum operation position

4. Condition for Clearing the Fault Code

Fuel temperature value is in operation range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0182 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P0196 Oil temperature plausibility fault

1. Overview

Code	Causes	Impact
P0196	Sensor problem, Oil passage problem.	No

NO	ECU Pin	Description
1	148	Engine oil pressure and temperature return ground
2	104	Engine oil temperature sensor
3	165	VREF3, Engine Oil Pressure
4	111	Engine Oil Pressure Sensor

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If the oil temperature is increased more than the threshold during restricted condition, fault code is raised.

4. Condition for Clearing the Fault Code

If the oil temperature is increased higher than the threshold during restricted condition, fault code is cleared

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0196 is raised on machine dashboard?		Step 2	O.K
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Change the oil temperature sensor. Start the engine and set the RPM in high idle, 10 minutes. After that set the RPM in low idle, fault code is cleared and torque limit is deactivated?		O.K	Call DOOSAN Hot line

5. Failure Diagnosis

P0195 Oil temperature sensor signal fault

1. Overview

Code	Causes	Impact
P0195	Electrical problem Connection problem Sensor problem Sensor supply voltage problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	148	Engine oil pressure and temperature return ground
2	104	Engine oil temperature sensor
3	165	VREF3, Engine Oil Pressure
4	111	Engine Oil Pressure Sensor

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Oil temperature signal value is out of operation range.

4. Condition for Clearing the Fault Code

Oil temperature signal value is in operation range.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0195 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P060B ADC circuit fault

1. Overview

Code	Causes	Impact
P060B	Electrical problem ECU problem	CE lamp Flashing Engine will be stopped

2. Condition for Running Diagnostic

Key on

3. Condition for Setting the Fault Code

When the ECU memory Code has corrupted

4. Condition for Clearing the Fault Code

When the ECU memory has no error

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P060B is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch.		Step 3	
3	Other fault present?		Step 7	Step 4
4	Visually check ECU pins and counterparts in wiring harness Electrical problem?		Do necessary repair	Step 5
5	Check conformity of ground connection of vehicle chassis Electrical problem?		Do necessary repair	Step 6
6	Connection conform Problem still present?		Call Hot-line	Problem solved

5. Failure Diagnosis

P0602 C2I data not programmed

1. Overview

Code	Causes	Impact
P0602	Injector C2I data is not matched or corrupted	CE lamp ON Torque Reduction Lv1 Limp-home mode

2. Condition for Running Diagnostic

Key on

3. Condition for Setting the Fault Code

If the C2I data of ECU is not matched with each injector

4. Condition for Clearing the Fault Code

If the C2I data of ECU is matched with each injector

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0602 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Re-Write (Cxl), respecting power down and up delay and taking care of injector position. Then erase faults Fault disappeared?		Problem solved	Step 4
4	Check power relay operation. Relay not operation?		Fix relay or wiring	Step 5
5	Check ECU connection. Connection problem?		Do necessary repair	Step 6
6	Check continuity and electrical insulation Electrical problem?		Fix Harness	Call Hot-line

5. Failure Diagnosis

P0603 ECU memory integrity fault (data / cal integrity)

1. Overview

Code	Causes	Impact
P0603	ECU Memory Data integrity Error	CE lamp Flashing

2. Condition for Running Diagnostic

Key on

3. Condition for Setting the Fault Code

When the ECU memory data has corrupted

4. Condition for Clearing the Fault Code

When the ECU memory has no error

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0603 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch.		Step 3	
3	Other fault present?		Step 7	Step 4
4	Visually check ECU pins and counterparts in wiring harness Electrical problem?		Do necessary repair	Step 5
5	Check conformity of ground connection of vehicle chassis Electrical problem?		Do necessary repair	Step 6
6	Connection conform Problem still present?		Call Hot-line	Problem solved

5. Failure Diagnosis

P0604 ECU memory integrity fault (RAM integrity)

1. Overview

Code	Causes	Impact
P0604	ECU Memory RAM integrity Error	CE lamp Flashing

2. Condition for Running Diagnostic

Key on

3. Condition for Setting the Fault Code

When the ECU memory RAM has corrupted

4. Condition for Clearing the Fault Code

When the ECU memory has no error

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0604 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch.		Step 3	
3	Other fault present?		Step 7	Step 4
4	Visually check ECU pins and counterparts in wiring harness Electrical problem?		Do necessary repair	Step 5
5	Check conformity of ground connection of vehicle chassis Electrical problem?		Do necessary repair	Step 6
6	Connection conform Problem still present?		Call Hot-line	Problem solved

5. Failure Diagnosis

P0605 ECU memory integrity fault (code integrity)

1. Overview

Code	Causes	Impact
P0605	ECU Memory Code integrity Error	CE lamp Flashing

2. Condition for Running Diagnostic

Key on

3. Condition for Setting the Fault Code

When the ECU memory Code has corrupted

4. Condition for Clearing the Fault Code

When the ECU memory has no error

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0605 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch.		Step 3	
3	Other fault present?		Step 7	Step 4
4	Visually check ECU pins and counterparts in wiring harness Electrical problem?		Do necessary repair	Step 5
5	Check conformity of ground connection of vehicle chassis Electrical problem?		Do necessary repair	Step 6
6	Connection conform Problem still present?		Call Hot-line	Problem solved

5. Failure Diagnosis

P062F ECU non volatile memory fault

1. Overview

Code	Causes	Impact
P062F	Data storage fault Non Volatile Memory	CE lamp Flashing Torque Reduction Lv1

2. Condition for Running Diagnostic Key on

3. Condition for Setting the Fault Code If the ECU NVM memory is corrupted, then the fault is set.

4. Condition for Clearing the Fault Code If the ECU NVM memory has no error, then the fault is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P062F is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch.		Step 3	
3	Other fault present?		Step 7	Step 4
4	Visually check ECU pins and counterparts in wiring harness Electrical problem?		Do necessary repair	Step 5
5	Check conformity of ground connection of vehicle chassis Electrical problem?		Do necessary repair	Step 6
6	Connection conform Problem still present?		Call Hot-line	Problem solved

5. Failure Diagnosis

P0371 Crank signal is too close to the previous one

1. Overview

Code	Causes	Impact
P0371	Sensor connection problem Wiring fault. Fault with trigger wheel. Fault with crank signal processing in ECU. Faulty ECU live or ground. Fault with ECU wiring or connectors	Low idle RPM increase

NO	ECU Pin	Description
1	136	Crank Sensor Neg
2	160	Crank Sensor Pos
3	-	Not used

2. Condition for Running Diagnostic

Since cranking phase

3. Condition for Setting the Fault Code

Crank sensor signal is abnormal deviation

4. Condition for Clearing the Fault Code

Crank sensor signal is normal.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0371 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check sensor connection Connection problem?		Do necessary repair	Step 4
4	Check ECU connection Connection problem?		Do necessary repair	Step 5
5	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 6
6	If scope available, display CAM and Crank signals on the scope Signals not conform to template?		Change Hall effect or VR sensor	Step 7
7	New sensor connected Problem still present?		Change APS target wheel	Step 8
8	New target wheel fitted Problem still present?		Call Hot-line	Problem solved

5. Failure Diagnosis

P0339 CRANK signal fault (gap lost)

1. Overview

Code	Causes	Impact
P0339	Sensor connection problem Wiring fault. Fault with trigger wheel. Fault with crank signal processing in ECU. Faulty ECU live or ground. Fault with ECU wiring or connectors	CE lamp ON Torque Reduction Lv0 Low idle RPM increase

NO	ECU Pin	Description
1	136	Crank Sensor Neg
2	160	Crank Sensor Pos
3	-	Not used

2. Condition for Running Diagnostic

Since cranking phase

3. Condition for Setting the Fault Code

Crank sensor signal is abnormal deviation

4. Condition for Clearing the Fault Code

Crank sensor signal is normal.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0339 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check sensor connection Connection problem?		Do necessary repair	Step 4
4	Check ECU connection Connection problem?		Do necessary repair	Step 5
5	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 6
6	If scope available, display CAM and Crank signals on the scope Signals not conform to template?		Change Hall effect or VR sensor	Step 7
7	New sensor connected Problem still present?		Change APS target wheel	Step 8
8	New target wheel fitted Problem still present?		Call Hot-line	Problem solved

5. Failure Diagnosis

P0372 Elapsed time between CPS events is too high

1. Overview

Code	Causes	Impact
P0372	Sensor connection problem Wiring fault. Fault with trigger wheel. Fault with crank signal processing in ECU. Faulty ECU live or ground. Fault with ECU wiring or connectors	CEL is ON. Torque is reduced.

NO	ECU Pin	Description
1	136	Crank Sensor Neg
2	160	Crank Sensor Pos
3	-	Not used

2. Condition for Running Diagnostic

Since cranking phase

3. Condition for Setting the Fault Code

Crank sensor signal is missed

4. Condition for Clearing the Fault Code

Crank sensor signal is coming as normally

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0372 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check sensor connection Connection problem?		Do necessary repair	Step 4
4	Check ECU connection Connection problem?		Do necessary repair	Step 5
5	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 6
6	If scope available, display CAM and Crank signals on the scope Signals not conform to template?		Change Hall effect or VR sensor	Step 7
7	New sensor connected Problem still present?		Change APS target wheel	Step 8
8	New target wheel fitted Problem still present?		Call Hot-line	Problem solved

5. Failure Diagnosis

P0374 Crank signal lost(no CPS signal seen in 1 cam rotation)

1. Overview

Code	Causes	Impact
P0374	Sensor connection problem Wiring fault. Fault with trigger wheel. Fault with crank signal processing in ECU. Faulty ECU live or ground. Fault with ECU wiring or connectors	CE lamp ON Torque Reduction Lv0 Low idle RPM increase

NO	ECU Pin	Description
1	136	Crank Sensor Neg
2	160	Crank Sensor Pos
3	-	Not used

2. Condition for Running Diagnostic

Since cranking phase

3. Condition for Setting the Fault Code

Crank sensor signal is missed

4. Condition for Clearing the Fault Code

Crank sensor signal is coming as normally

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0374 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check sensor connection Connection problem?		Do necessary repair	Step 4
4	Check ECU connection Connection problem?		Do necessary repair	Step 5
5	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 6
6	If scope available, display CAM and Crank signals on the scope Signals not conform to template?		Change Hall effect or VR sensor	Step 7
7	New sensor connected Problem still present?		Change APS target wheel	Step 8
8	New target wheel fitted Problem still present?		Call Hot-line	Problem solved

5. Failure Diagnosis

P0335 Crank signal over speed fault

1. Overview

Code	Causes	Impact
P0335	Sensor connection problem Wiring fault. Fault with trigger wheel. Fault with crank signal processing in ECU. Faulty ECU live or ground. Fault with ECU wiring or connectors	CE lamp ON Low idle RPM increase

NO	ECU Pin	Description
1	136	Crank Sensor Neg
2	160	Crank Sensor Pos
3	-	Not used

2. Condition for Running Diagnostic

Since cranking phase

3. Condition for Setting the Fault Code

Crank sensor signal is out of range

4. Condition for Clearing the Fault Code

Crank sensor signal is in a range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0335 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check sensor connection Connection problem?		Do necessary repair	Step 4
4	Check ECU connection Connection problem?		Do necessary repair	Step 5
5	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 6
6	If scope available, display CAM and Crank signals on the scope Signals not conform to template?		Change Hall effect or VR sensor	Step 7
7	New sensor connected Problem still present?		Change APS target wheel	Step 8
8	New target wheel fitted Problem still present?		Call Hot-line	Problem solved

5. Failure Diagnosis

P0344 CAM signal fault (missing event within the expected window)

1. Overview

Code	Causes	Impact
P0344	Sensor connection problem wiring fault Fault with cam trigger wheel Fault with cam wheel signal processing in ECU Faulty ECU live or ground Fault with ECU wiring or connectors Engine fault causing camshaft speed variation.	CE lamp ON Torque Reduction Lv0 Low idle RPM increase

NO	ECU Pin	Description
1	-	Pbatt
2	159	CAM Shaft Position Sensor
3	147	CAM Shaft Position Sensor Return

2. Condition for Running Diagnostic

Since cranking phase

3. Condition for Setting the Fault Code

Cam sensor signal is missed

4. Condition for Clearing the Fault Code

Cam sensor signal is coming normally.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0344 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check sensor connection Connection problem?		Do necessary repair	Step 4
4	Visually check sensor Sensor problem?		Change sensor	Step 5
5	Check ECU connection Connection problem?		Do necessary repair	Step 6
6	If scope available, display CAM and Crank signals on the scope Signals not conform to template?		Do necessary repair	Step 7
7	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 8
8	Check Cam target wheel Target wheel problem?		Change target wheel	Step 9
9	Check distribution Distribution problem?		Fix distribution	Call Hot-line

5. Failure Diagnosis

P0342 Cam signal lost (no cam signal seen in 2 crank rotations)

1. Overview

Code	Causes	Impact
P0342	Sensor connection problem wiring fault Fault with cam trigger wheel Fault with cam wheel signal processing in ECU Faulty ECU live or ground Fault with ECU wiring or connectors Engine fault causing camshaft speed variation	CE lamp ON Torque Reduction Lv0 Low idle RPM increase

NO	ECU Pin	Description
1	-	Pbatt
2	159	CAM Shaft Position Sensor
3	147	CAM Shaft Position Sensor Return

2. Condition for Running Diagnostic

Since cranking phase

3. Condition for Setting the Fault Code

Cam sensor signal is missed

4. Condition for Clearing the Fault Code

Cam sensor signal is coming normally.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0342 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check sensor connection Connection problem?		Do necessary repair	Step 4
4	Visually check sensor Sensor problem?		Change sensor	Step 5
5	Check ECU connection Connection problem?		Do necessary repair	Step 6
6	If scope available, display CAM and Crank signals on the scope Signals not conform to template?		Do necessary repair	Step 7
7	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 8
8	Check Cam target wheel Target wheel problem?		Change target wheel	Step 9
9	Check distribution Distribution problem?		Fix distribution	Call Hot-line

5. Failure Diagnosis

P0341 Cam signal drift higher than threshold

1. Overview

Code	Causes	Impact
P0341	Sensor connection problem wiring fault Fault with cam trigger wheel Fault with cam wheel signal processing in ECU Faulty ECU live or ground Fault with ECU wiring or connectors Engine fault causing camshaft speed variation	Low idle RPM increase

NO	ECU Pin	Description
1	-	Pbatt
2	159	CAM Shaft Position Sensor
3	147	CAM Shaft Position Sensor Return

2. Condition for Running Diagnostic

Since cranking phase

3. Condition for Setting the Fault Code

Cam sensor signal is out of range

4. Condition for Clearing the Fault Code

Cam sensor signal is in a range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0341 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check sensor connection Connection problem?		Do necessary repair	Step 4
4	Visually check sensor Sensor problem?		Change sensor	Step 5
5	Check ECU connection Connection problem?		Do necessary repair	Step 6
6	If scope available, display CAM and Crank signals on the scope Signals not conform to template?		Do necessary repair	Step 7
7	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 8
8	Check Cam target wheel Target wheel problem?		Change target wheel	Step 9
9	Check distribution Distribution problem?		Fix distribution	Call Hot-line

5. Failure Diagnosis

P0340 Cam signal last learnt value is outside of limits

1. Overview

Code	Causes	Impact
P0340	Sensor connection problem wiring fault Fault with cam trigger wheel Fault with cam wheel signal processing in ECU Faulty ECU live or ground Fault with ECU wiring or connectors Engine fault causing camshaft speed variation	Low idle RPM increase

NO	ECU Pin	Description
1	-	Pbatt
2	159	CAM Shaft Position Sensor
3	147	CAM Shaft Position Sensor Return

2. Condition for Running Diagnostic

Since cranking phase

3. Condition for Setting the Fault Code

Cam sensor learning is failed

4. Condition for Clearing the Fault Code

Cam sensor learning is succeed

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0340 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check sensor connection Connection problem?		Do necessary repair	Step 4
4	Visually check sensor Sensor problem?		Change sensor	Step 5
5	Check ECU connection Connection problem?		Do necessary repair	Step 6
6	If scope available, display CAM and Crank signals on the scope Signals not conform to template?		Do necessary repair	Step 7
7	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 8
8	Check Cam target wheel Target wheel problem?		Change target wheel	Step 9
9	Check distribution Distribution problem?		Fix distribution	Call Hot-line

5. Failure Diagnosis

U0100 CAN communication error: CAN bus confirmed off

1. Overview

Code	Causes	Impact
U0100	Electrical problem Connection problem Network problem	CE lamp ON Delay engine stop

NO	ECU Pin	Description
1	248	CAN Hi
2	247	CAN Lo

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

CAN Bus OFF

4. Condition for Clearing the Fault Code

CAN Bus Repair

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	U0100 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check ECU connection Connection problem?		Do necessary repair	Step 4
4	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 5
5	Check Network Network problem?		Do necessary repair	Call Hot-line

5. Failure Diagnosis

P0201 Injector Open Circuit fault (Cylinder #1)

1. Overview

Code	Causes	Impact
P0201	Electrical problem Connection problem Injector problem	CE lamp ON Torque Reduction Lv0 Low idle RPM increase

NO	ECU Pin	Description
1	126	Fuel Injector LSD1A
2	127	Fuel Injector HSD1A

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

The injector of cylinder #1 is opened.

4. Condition for Clearing the Fault Code

The injector of cylinder #1 is restored

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0201 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Perform injector buzzing test?		Step 4	Call Hot-line
4	Fault Check open Circuit?		Step 5	Step 11
5	Check injector Connection Connection problem?		Do necessary repair	Step 6
6	Check resistance of injector (0.4Ω~ 1Ω)		Step 7	Change injector
7	Swap connection between 2 injectors if harness enables it.		Change injector	Step 8
8	Check continuity and electrical insulation. Electrical problem?		Do necessary repair	Step 9
9	Check ECU Connection Connection problem?		Do necessary repair	Step 10
10	Check continuity and electrical insulation. Electrical problem?		Fix Harness	Call Hot-line
11	Fault Check short Circuit?		Step 12	
12	Check injector Connection Connection problem?		Do necessary repair	Step 13
13	Disconnect injector. Fault disappeared?		Change injector	Step 14

5. Failure Diagnosis

Step	Inspection	Standard Value	YES	NO
14	If an intermediate engine connector is present, disconnect it. Fault disappeared?		Fix intermediate engine harness	Step 15
15	Short circuit before injector. Check ECU connection. Connection problem?		Do necessary repair	Step 16
16	Check continuity and electrical insulation. Electrical problem?		Fix Harness	Call Hot-line

5. Failure Diagnosis

P02EE Injector Short Circuit fault (Cylinder #1)

1. Overview

Code	Causes	Impact
P02EE	Electrical problem Connection problem Injector problem	CE lamp ON Torque Reduction Lv0 Low idle RPM increase

NO	ECU Pin	Description
1	126	Fuel Injector LSD1A
2	127	Fuel Injector HSD1A

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

The injector of cylinder #1 is shorted.

4. Condition for Clearing the Fault Code

The injector of cylinder #1 is restored

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P02EE is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Perform injector buzzing test?		Step 4	Call Hot-line
4	Fault Check open Circuit?		Step 5	Step 11
5	Check injector Connection Connection problem?		Do necessary repair	Step 6
6	Check resistance of injector (0.4Ω~ 1Ω)		Step 7	Change injector
7	Swap connection between 2 injectors if harness enables it.		Change injector	Step 8
8	Check continuity and electrical insulation. Electrical problem?		Do necessary repair	Step 9
9	Check ECU Connection Connection problem?		Do necessary repair	Step 10
10	Check continuity and electrical insulation. Electrical problem?		Fix Harness	Call Hot-line
11	Fault Check short Circuit?		Step 12	
12	Check injector Connection Connection problem?		Do necessary repair	Step 13
13	Disconnect injector. Fault disappeared?		Change injector	Step 14

5. Failure Diagnosis

Step	Inspection	Standard Value	YES	NO
14	If an intermediate engine connector is present, disconnect it. Fault disappeared?		Fix intermediate engine harness	Step 15
15	Short circuit before injector. Check ECU connection. Connection problem?		Do necessary repair	Step 16
16	Check continuity and electrical insulation. Electrical problem?		Fix Harness	Call Hot-line

5. Failure Diagnosis

P0262 Wiring harness resistance high fault (Cylinder #1)

1. Overview

Code	Causes	Impact
P0262	Electrical problem Connection problem Wiring fault	No

NO	ECU Pin	Description
1	126	Fuel Injector LSD1A
2	127	Fuel Injector HSD1A

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

The injector of cylinder #1 wiring resistance is above the range.

4. Condition for Clearing the Fault Code

The injector of cylinder #1 wiring resistance it in a range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0262 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Perform injector buzzing test Test addible?		Call Hot-line	Step 4
4	Key off and check injector connection Connection problem?		Do necessary repair	Step 5
5	Check resistance of injector. For solenoid, it should be less than 1Ω For Piezzo, it should be around 1MΩ and should settle within some 10s. Resistance incorrect?		Step 11	Step 6
6	Swap connection between 2 injectors if harness enable it Same problem still present?		Step 11	Step 7
7	Check continuity and electrical insulation Electrical problem?		Do necessary repair	Step 8
8	If intermediate engine connector is present, check it electrically Electrical problem?		Do necessary repair	Step 9
9	Check ECU connection Connection problem?		Fix harness	Step 10
10	Check continuity and electrical insulation Electrical problem?			Call Hot-line
11	Change injector. Mandatory: update Individual Corrections (taking care of its position)			

5. Failure Diagnosis

P0261 Wiring harness resistance low fault (Cylinder #1)

1. Overview

Code	Causes	Impact
P0261	Electrical problem Connection problem Wiring fault	No

NO	ECU Pin	Description
1	126	Fuel Injector LSD1A
2	127	Fuel Injector HSD1A

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

The injector of cylinder #1 wiring resistance is below the range.

4. Condition for Clearing the Fault Code

The injector of cylinder #1 wiring resistance it in a range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0261 is occurred on diagnostic tool?		Step 2	
2	Perform injector buzzing test Test addible?		Call Hot-line	Step 3
3	Key off and check injector connection Connection problem?		Do necessary repair	Step 4
4	Disconnect injector Fault disappeared?		Step 8	Step 5
5	If an intermediate engine connector is present, disconnect it Fault disappeared?		Fix intermediate engine harness	Step 6
6	Short circuit before injector. Check ECU connection Connection problem?		Do necessary repair	Step 7
7	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line
8	Change corresponding injector Do not forget to write new Individual Injector Correction to ECU			

5. Failure Diagnosis

P029B Injector Minimum drive pulse drift (Cylinder #1)

1. Overview

Code	Causes	Impact
P029B	Connection problem Software problem	CE lamp ON Low idle RPM increase

NO	ECU Pin	Description
1	126	Fuel Injector LSD1A
2	127	Fuel Injector HSD1A

2. Condition for Running Diagnostic During engine running

3. Condition for Setting the Fault Code If the MDP (Minimum Driving Pulse) of cylinder #1 injector is out of the threshold during restricted condition, fault code is raised.

4. Condition for Clearing the Fault Code If the MDP (Minimum Driving Pulse) of cylinder #1 injector is within the threshold during restricted condition, fault code is cleared

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P029B is occurred on diagnostic tool?		Step 2	
2	After let the machine is in safety area and turn-off the key switch.		Step 3	
3	Check if new software that solves this problem is available or if SW is up to date. Upgrade possible?		Re flash SW Re Write I2C	Step 4
4	Check that individual injector corrections (I2C) are correctly entered in ECU. Check particularly position and value Problem of I2C?		Re Write I2C	Step 5
5	Check accelerometer connection and screwing torque. Mandatory: Check particularly ground shield connection of accelerometer Connection problem?		Do necessary	Call Hot line

5. Failure Diagnosis

P0202 Injector Open Circuit fault (Cylinder #2)

1. Overview

Code	Causes	Impact
P0202	Electrical problem Connection problem Injector problem	CE lamp ON Torque Reduction Lv0 Low idle RPM increase

NO	ECU Pin	Description
1	175	Fuel Injector LSD1B
2	151	Fuel Injector HSD1B

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

The injector of cylinder #2 is opened.

4. Condition for Clearing the Fault Code

The injector of cylinder #2 is restored

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0202 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Perform injector buzzing test?		Step 4	Call Hot-line
4	Fault Check open Circuit?		Step 5	Step 11
5	Check injector Connection Connection problem?		Do necessary repair	Step 6
6	Check resistance of injector (0.4Ω~ 1Ω)		Step 7	Change injector
7	Swap connection between 2 injectors if harness enables it.		Change injector	Step 8
8	Check continuity and electrical insulation. Electrical problem?		Do necessary repair	Step 9
9	Check ECU Connection Connection problem?		Do necessary repair	Step 10
10	Check continuity and electrical insulation. Electrical problem?		Fix Harness	Call Hot-line
11	Fault Check short Circuit?		Step 12	
12	Check injector Connection Connection problem?		Do necessary repair	Step 13
13	Disconnect injector. Fault disappeared?		Change injector	Step 14

5. Failure Diagnosis

Step	Inspection	Standard Value	YES	NO
14	If an intermediate engine connector is present, disconnect it. Fault disappeared?		Fix intermediate engine harness	Step 15
15	Short circuit before injector. Check ECU connection. Connection problem?		Do necessary repair	Step 16
16	Check continuity and electrical insulation. Electrical problem?		Fix Harness	Call Hot-line

5. Failure Diagnosis

P02EF Injector Short Circuit fault (Cylinder #2)

1. Overview

Code	Causes	Impact
P02EF	Electrical problem Connection problem Injector problem	CE lamp ON Torque Reduction Lv0 Low idle RPM increase

NO	ECU Pin	Description
1	175	Fuel Injector LSD1B
2	151	Fuel Injector HSD1B

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

The injector of cylinder #2 is shorted.

4. Condition for Clearing the Fault Code

The injector of cylinder #2 is restored

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P02EF is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Perform injector buzzing test?		Step 4	Call Hot-line
4	Fault Check open Circuit?		Step 5	Step 11
5	Check injector Connection Connection problem?		Do necessary repair	Step 6
6	Check resistance of injector (0.4Ω~ 1Ω)		Step 7	Change injector
7	Swap connection between 2 injectors if harness enables it.		Change injector	Step 8
8	Check continuity and electrical insulation. Electrical problem?		Do necessary repair	Step 9
9	Check ECU Connection Connection problem?		Do necessary repair	Step 10
10	Check continuity and electrical insulation. Electrical problem?		Fix Harness	Call Hot-line
11	Fault Check short Circuit?		Step 12	
12	Check injector Connection Connection problem?		Do necessary repair	Step 13
13	Disconnect injector. Fault disappeared?		Change injector	Step 14

5. Failure Diagnosis

Step	Inspection	Standard Value	YES	NO
14	If an intermediate engine connector is present, disconnect it. Fault disappeared?		Fix intermediate engine harness	Step 15
15	Short circuit before injector. Check ECU connection. Connection problem?		Do necessary repair	Step 16
16	Check continuity and electrical insulation. Electrical problem?		Fix Harness	Call Hot-line

5. Failure Diagnosis

P0265 Wiring harness resistance high fault (Cylinder #2)

1. Overview

Code	Causes	Impact
P0265	Electrical problem Connection problem Wiring fault	No

NO	ECU Pin	Description
1	175	Fuel Injector LSD1B
2	151	Fuel Injector HSD1B

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

The injector of cylinder #2 wiring resistance is above the range.

4. Condition for Clearing the Fault Code

The injector of cylinder #2 wiring resistance it in a range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0265 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Perform injector buzzing test Test addible?		Call Hot-line	Step 4
4	Key off and check injector connection Connection problem?		Do necessary repair	Step 5
5	Check resistance of injector. For solenoid, it should be less than 1Ω For Piezzo, it should be around 1MΩ and should settle within some 10s. Resistance incorrect?		Step 11	Step 6
6	Swap connection between 2 injectors if harness enable it Same problem still present?		Step 11	Step 7
7	Check continuity and electrical insulation Electrical problem?		Do necessary repair	Step 8
8	If intermediate engine connector is present, check it electrically Electrical problem?		Do necessary repair	Step 9
9	Check ECU connection Connection problem?		Fix harness	Step 10
10	Check continuity and electrical insulation Electrical problem?			Call Hot-line
11	Change injector. Mandatory: update Individual Corrections (taking care of its position)			

5. Failure Diagnosis

P0264 Wiring harness resistance low fault (Cylinder #2)

1. Overview

Code	Causes	Impact
P0264	Electrical problem Connection problem Wiring fault	No

NO	ECU Pin	Description
1	175	Fuel Injector LSD1B
2	151	Fuel Injector HSD1B

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

The injector of cylinder #2 wiring resistance is below the range.

4. Condition for Clearing the Fault Code

The injector of cylinder #2 wiring resistance it in a range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0264 is occurred on diagnostic tool?		Step 2	
2	Perform injector buzzing test Test addible?		Call Hot-line	Step 3
3	Key off and check injector connection Connection problem?		Do necessary repair	Step 4
4	Disconnect injector Fault disappeared?		Step 8	Step 5
5	If an intermediate engine connector is present, disconnect it Fault disappeared?		Fix intermediate engine harness	Step 6
6	Short circuit before injector. Check ECU connection Connection problem?		Do necessary repair	Step 7
7	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line
8	Change corresponding injector Do not forget to write new Individual Injector Correction to ECU			

5. Failure Diagnosis

P029F Injector Minimum drive pulse drift (Cylinder #2)

1. Overview

Code	Causes	Impact
P029F	Injector of cylinder #2 MDP absolute below the minimum limit	CE lamp ON Low idle RPM increase

NO	ECU Pin	Description
1	175	Fuel Injector LSD1B
2	151	Fuel Injector HSD1B

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If the MDP (Minimum Driving Pulse) of cylinder #2 injector is out of the threshold during restricted condition, fault code is raised.

4. Condition for Clearing the Fault Code

If the MDP (Minimum Driving Pulse) of cylinder #2 injector is within the threshold during restricted condition, fault code is cleared

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P029F is occurred on diagnostic tool?		Step 2	
2	After let the machine is in safety area and turn-off the key switch.		Step 3	
3	Check if new software that solves this problem is available or if SW is up to date. Upgrade possible?		Re flash SW Re Write I2C	Step 4
4	Check that individual injector corrections (I2C) are correctly entered in ECU. Check particularly position and value Problem of IC?		Re Write I2C	Step 5
5	Check accelerometer connection and screwing torque. Mandatory: Check particularly ground shield connection of accelerometer Connection problem?		Do necessary	Call Hot line

5. Failure Diagnosis

P0203 Injector Open Circuit fault (Cylinder #3)

1. Overview

Code	Causes	Impact
P0203	Injector of cylinder #3 open circuit	CE lamp ON Torque Reduction Lv0 Low idle RPM increase

NO	ECU Pin	Description
1	125	Fuel Injector LSD2A
2	103	Fuel Injector HSD2A

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

The injector of cylinder #3 is opened.

4. Condition for Clearing the Fault Code

The injector of cylinder #3 is restored

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P203 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Perform injector buzzing test?		Step 4	Call Hot-line
4	Fault Check open Circuit?		Step 5	Step 11
5	Check injector Connection Connection problem?		Do necessary repair	Step 6
6	Check resistance of injector (0.4Ω~ 1Ω)		Step 7	Change injector
7	Swap connection between 2 injectors if harness enables it.		Change injector	Step 8
8	Check continuity and electrical insulation. Electrical problem?		Do necessary repair	Step 9
9	Check ECU Connection Connection problem?		Do necessary repair	Step 10
10	Check continuity and electrical insulation. Electrical problem?		Fix Harness	Call Hot-line
11	Fault Check short Circuit?		Step 12	
12	Check injector Connection Connection problem?		Do necessary repair	Step 13
13	Disconnect injector. Fault disappeared?		Change injector	Step 14

5. Failure Diagnosis

Step	Inspection	Standard Value	YES	NO
14	If an intermediate engine connector is present, disconnect it. Fault disappeared?		Fix intermediate engine harness	Step 15
15	Short circuit before injector. Check ECU connection. Connection problem?		Do necessary repair	Step 16
16	Check continuity and electrical insulation. Electrical problem?		Fix Harness	Call Hot-line

5. Failure Diagnosis

P02F0 Injector Short Circuit fault (Cylinder #3)

1. Overview

Code	Causes	Impact
P02F0	Injector of cylinder #3 short circuit	CE lamp ON Torque Reduction Lv0 Low idle RPM increase

NO	ECU Pin	Description
1	125	Fuel Injector LSD2A
2	103	Fuel Injector HSD2A

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

The injector of cylinder #3 is shorted.

4. Condition for Clearing the Fault Code

The injector of cylinder #3 is restored

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P02F0 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Perform injector buzzing test?		Step 4	Call Hot-line
4	Fault Check open Circuit?		Step 5	Step 11
5	Check injector Connection Connection problem?		Do necessary repair	Step 6
6	Check resistance of injector (0.4Ω~ 1Ω)		Step 7	Change injector
7	Swap connection between 2 injectors if harness enables it.		Change injector	Step 8
8	Check continuity and electrical insulation. Electrical problem?		Do necessary repair	Step 9
9	Check ECU Connection Connection problem?		Do necessary repair	Step 10
10	Check continuity and electrical insulation. Electrical problem?		Fix Harness	Call Hot-line
11	Fault Check short Circuit?		Step 12	
12	Check injector Connection Connection problem?		Do necessary repair	Step 13
13	Disconnect injector. Fault disappeared?		Change injector	Step 14

5. Failure Diagnosis

Step	Inspection	Standard Value	YES	NO
14	If an intermediate engine connector is present, disconnect it. Fault disappeared?		Fix intermediate engine harness	Step 15
15	Short circuit before injector. Check ECU connection. Connection problem?		Do necessary repair	Step 16
16	Check continuity and electrical insulation. Electrical problem?		Fix Harness	Call Hot-line

5. Failure Diagnosis

P0268 Wiring harness resistance high fault (Cylinder #3)

1. Overview

Code	Causes	Impact
P0268	Electrical problem Connection problem Wiring fault	No

NO	ECU Pin	Description
1	125	Fuel Injector LSD2A
2	103	Fuel Injector HSD2A

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

The injector of cylinder #3 wiring resistance is above the range.

4. Condition for Clearing the Fault Code

The injector of cylinder #3 wiring resistance it in a range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0268 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Perform injector buzzing test Test addible?		Call Hot-line	Step 4
4	Key off and check injector connection Connection problem?		Do necessary repair	Step 5
5	Check resistance of injector. For solenoid, it should be less than 1Ω For Piezzo, it should be around 1MΩ and should settle within some 10s. Resistance incorrect?		Step 11	Step 6
6	Swap connection between 2 injectors if harness enable it Same problem still present?		Step 11	Step 7
7	Check continuity and electrical insulation Electrical problem?		Do necessary repair	Step 8
8	If intermediate engine connector is present, check it electrically Electrical problem?		Do necessary repair	Step 9
9	Check ECU connection Connection problem?		Fix harness	Step 10
10	Check continuity and electrical insulation Electrical problem?			Call Hot-line
11	Change injector. Mandatory: update Individual Corrections (taking care of its position)			

5. Failure Diagnosis

P0267 Wiring harness resistance low fault (Cylinder #3)

1. Overview

Code	Causes	Impact
P0267	Electrical problem Connection problem Wiring fault	No

NO	ECU Pin	Description
1	125	Fuel Injector LSD2A
2	103	Fuel Injector HSD2A

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

The injector of cylinder #3 wiring resistance is below the range.

4. Condition for Clearing the Fault Code

The injector of cylinder #3 wiring resistance it in a range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0267 is occurred on diagnostic tool?		Step 2	
2	Perform injector buzzing test Test addible?		Call Hot-line	Step 3
3	Key off and check injector connection Connection problem?		Do necessary repair	Step 4
4	Disconnect injector Fault disappeared?		Step 8	Step 5
5	If an intermediate engine connector is present, disconnect it Fault disappeared?		Fix intermediate engine harness	Step 6
6	Short circuit before injector. Check ECU connection Connection problem?		Do necessary repair	Step 7
7	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line
8	Change corresponding injector Do not forget to write new Individual Injector Correction to ECU			

5. Failure Diagnosis

P02A3 Injector Minimum drive pulse drift (Cylinder #3)

1. Overview

Code	Causes	Impact
P02A3	Injector of cylinder #3 MDP absolute below the minimum limit	CE lamp ON Low idle RPM increase

NO	ECU Pin	Description
1	125	Fuel Injector LSD2A
2	103	Fuel Injector HSD2A

2. Condition for Running Diagnostic During engine running

3. Condition for Setting the Fault Code If the MDP (Minimum Driving Pulse) of cylinder #3 injector is out of the threshold during restricted condition, fault code is raised.

4. Condition for Clearing the Fault Code If the MDP (Minimum Driving Pulse) of cylinder #3 injector is within the threshold during restricted condition, fault code is cleared

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P02A3 is occurred on diagnostic tool?		Step 2	
2	After let the machine is in safety area and turn-off the key switch.		Step 3	
3	Check if new software that solves this problem is available or if SW is up to date. Upgrade possible?		Re flash SW Re Write I2C	Step 4
4	Check that individual injector corrections (I2C) are correctly entered in ECU. Check particularly position and value Problem of IC?		Re Write I2C	Step 5
5	Check accelerometer connection and screwing torque. Mandatory: Check particularly ground shield connection of accelerometer Connection problem?		Do necessary	Call Hot line

5. Failure Diagnosis

P0384 Glow plug relay electrical fault (SCVBAT)

1. Overview

Code	Causes	Impact
P0384	Electrical problem Connection problem Relay problem	CE lamp ON

NO	ECU Pin	Description
1	256	Glow Plug Relay driver

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Glow plug relay connected to battery (SC2V)

4. Condition for Clearing the Fault Code

Glow plug relay problem is restored.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0384 is occurred on diagnostic tool?		Step 2	
2	Perform relay test routine Test OK?		Call Hot-line	Step 3
3	Check relay connection Connection problem?		Do necessary repair	Step 4
4	Check ECU connection Connection problem?		Do necessary repair	Step 5
5	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 6
6	Change relay (run ISO cycle) ISO cycle OK?		Problem solved	Call Hot-line

5. Failure Diagnosis

P0383 Glow plug relay electrical fault (SCGND)

1. Overview

Code	Causes	Impact
P0383	Electrical problem Connection problem Relay problem	CE lamp ON

NO	ECU Pin	Description
1	256	Glow Plug Relay driver

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Glow plug relay is connected to ground (SC2G)

4. Condition for Clearing the Fault Code

Glow plug relay problem is restored.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0383 is occurred on diagnostic tool?		Step 2	
2	Perform relay test routine Test OK?		Call Hot-line	Step 3
3	Check relay connection Connection problem?		Do necessary repair	Step 4
4	Check ECU connection Connection problem?		Do necessary repair	Step 5
5	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 6
6	Change relay (run ISO cycle) ISO cycle OK?		Problem solved	Call Hot-line

5. Failure Diagnosis

P0380 Glow plug relay electrical fault (OC)

1. Overview

Code	Causes	Impact
P0380	Electrical problem Connection problem Relay problem	CE lamp ON

NO	ECU Pin	Description
1	256	Glow Plug Relay driver

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Glow plug relay is not connected (open)

4. Condition for Clearing the Fault Code

Glow plug relay problem is restored.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0380 is occurred on diagnostic tool?		Step 2	
2	Perform relay test routine Test OK?		Call Hot-line	Step 3
3	Check relay connection Connection problem?		Do necessary repair	Step 4
4	Check ECU connection Connection problem?		Do necessary repair	Step 5
5	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 6
6	Change relay (run ISO cycle) ISO cycle OK?		Problem solved	Call Hot-line

5. Failure Diagnosis

P0325 Fault on the accelerometer 0 sensor decode circuit

1. Overview

Code	Causes	Impact
P0325	Electrical problem Connection problem Sensor problem	No

NO	ECU Pin	Description
1	131	Engine Block Accelerometer #1
2	130	Engine Block Accelerometer Return
3	128	Engine Block Accelerometer Screen

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Accelerometer 0 is opened or shorted to ground

4. Condition for Clearing the Fault Code

Accelerometer 0 problem is restored.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0325 is occurred on diagnostic tool?		Step 2	
2	VEXT fault present?		Step 3	Step 4
3	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness			
4	Check sensor connection Connection problem?		Do necessary repair	Step 5
5	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 6
6	Check ECU connection Connection problem?		Do necessary repair	Step 7
7	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P0007 Rail pressure control error (IMV resistance trim value is too high)

1. Overview

Code	Causes	Impact
P0007	Electrical problem Connection problem Resistance problem	CE lamp Flashing Torque Reduction Lv1 Delay engine stop

NO	ECU Pin	Description
1	177	Inlet Metering Valve PWM
2	-	Pbatt

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If the resistance of IMV trim value is higher than threshold, fault code is raised.

4. Condition for Clearing the Fault Code

If the resistance of IMV trim value is within the threshold, fault code is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0007 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check the IMV connection Connection problem? (pin to pin)		Do necessary repair	Step 4
4	Check the ECU Connection. Connection problem?		Do necessary repair	Step 5
5	Check continuity and electrical insulation. Electrical problem?		Fix wire harness	Step 6
6	Measure IMV electrical resistance? (around 5.3Ω at 20°C) Resistance problem?		Change IMV	Step 7
7	Perform IMV buzzing test? (Test not applicable) IMV is buzzing?		Call Hot-Line	Change IMV

5. Failure Diagnosis

P0006 Rail pressure control error (IMV resistance trim value is too low)

1. Overview

Code	Causes	Impact
P0006	Electrical problem Connection problem Resistance problem	CE lamp Flashing Torque Reduction Lv1 Delay engine stop

NO	ECU Pin	Description
1	177	Inlet Metering Valve PWM
2	-	Pbatt

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If the resistance of IMV trim value is low than threshold, fault code is raised.

4. Condition for Clearing the Fault Code

If the resistance of IMV trim value is within the threshold, fault code is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0006 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check the IMV connection Connection problem? (pin to pin)		Do necessary repair	Step 4
4	Check the ECU Connection. Connection problem?		Do necessary repair	Step 5
5	Check continuity and electrical insulation. Electrical problem?		Fix wire harness	Step 6
6	Measure IMV electrical resistance? (around 5.3Ω at 20°C) Resistance problem?		Change IMV	Step 7
7	Perform IMV buzzing test? (Test not applicable) IMV is buzzing?		Call Hot-Line	Change IMV

5. Failure Diagnosis

P0004 Rail pressure control feedback high fault

1. Overview

Code	Causes	Impact
P0004	Electrical problem Connection problem Resistance problem	CE lamp Flashing Torque Reduction Lv1 Delay engine stop

NO	ECU Pin	Description
1	177	Inlet Metering Valve PWM
2	-	Pbatt

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If the resistance of IMV is out of the threshold during restricted condition, fault code is raised.

4. Condition for Clearing the Fault Code

If the resistance of IMV is within the threshold during restricted condition, fault code is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0004 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check the IMV connection Connection problem? (pin to pin)		Do necessary repair	Step 4
4	Check the ECU Connection. Connection problem?		Do necessary repair	Step 5
5	Check continuity and electrical insulation. Electrical problem?		Fix wire harness	Step 6
6	Measure IMV electrical resistance? (around 5.3Ω at 20°C) Resistance problem?		Change IMV	Step 7
7	Perform IMV buzzing test? (Test not applicable) IMV is buzzing?		Call Hot-Line	Change IMV

5. Failure Diagnosis

P0003 Rail pressure control feedback low fault

1. Overview

Code	Causes	Impact
P0003	Electrical problem Connection problem Resistance problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	177	Inlet Metering Valve PWM
2	-	Pbatt

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If the resistance of IMV is out of the threshold during restricted condition, fault code is raised.

4. Condition for Clearing the Fault Code

If the resistance of IMV is within the threshold during restricted condition, fault code is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0003 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check the IMV connection Connection problem? (pin to pin)		Do necessary repair	Step 4
4	Check the ECU Connection. Connection problem?		Do necessary repair	Step 5
5	Check continuity and electrical insulation. Electrical problem?		Fix wire harness	Step 6
6	Measure IMV electrical resistance? (around 5.3Ω at 20°C) Resistance problem?		Change IMV	Step 7
7	Perform IMV buzzing test? (Test not applicable) IMV is buzzing?		Call Hot-Line	Change IMV

5. Failure Diagnosis

P0259 RPC error (IMV current trim drift high/high)

1. Overview

Code	Causes	Impact
P0259	There is a problem in the ADC of the ECU or the power supplied to the torque converter switch.	CEL is ON.

NO	ECU Pin	Description
1	177	Inlet Metering Valve PWM
2	-	Pbatt

2. Condition for Running Diagnostic During engine running

3. Condition for Setting the Fault Code If the current of IMV trim value is out of the threshold, fault code is raised.

4. Condition for Clearing the Fault Code If the current of IMV trim value is within the threshold, fault code is cleared.

5. Inspection Items

1) A

Step	Inspection	Standard Value	YES	NO
1	P0259 is occurred on diagnostic tool?		Step 2	O.K
2	After let the machine be in safety area and turn-off the key switch.		Step 3	
3	Please do visual inspection throughout all fuel line. (Low pressure circuit & high pressure circuit) Is there any leakage or blocking of fuel? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.		Step 4	Step 5
4	Please fix the leakage. After fix the problem, start the engine and change the RPM from low idle to high idle. Please keep the RPM as a high idle at least 10 minutes. Fault code is cleared?		O.K	Step 5
5	Please do the Shut off test & Run up test for detecting which injector has fault or not. Do you find faulty injector?		Step 6	Step 7
6	Change the injector which has a fault as a normal one. Start the engine and set the RPM in high idle at least 10 minutes. Fault code is cleared?		O.K	Step 7
7	Change the high pressure pump with DOOSAN A.S support. Fault code is cleared?		O.K	Call DOOSAN Hot line

5. Failure Diagnosis

2) B

Step	Inspection	Standard Value	YES	NO
1	P0259 is occurred on diagnostic tool?		Step 2	
2	Fault of type IMV or rail pressure sensor?		First, fix the corresponding fault	Step 3
3	DTC link to High Pressure control?		Step 4	No problem
4	Check that: * fuel feed circuit is in good condition * there is diesel fuel present in the system * there is no air (no bubbles or emulsion in the pipes) * there is enough fuel pressure in inlet pump * there are no high pressure circuit leaks * there is diesel fuel of the correct quality and type Low pressure circuit faulty?		Repair the low pressure circuit	Step 5
5	According to engine start or not, different tests are to be done. Does engine start?		Step 6	Step 7
6	Perform "DYNAMIC IMV TEST" Faulty IMV?		Replace IMV	Step 8
7	Perform "STATIC INJECTOR BACKLEAK TEST" Carry out the "tube test: Result?		Replace corresponding injector(s)	Replace HP pump
8	Perform "DYNAMIC INJECTOR BACKLEAK TEST" Backleak above limit?		Replace corresponding injector(s)	Step 9
9	Perform "PUMP PRESSURE BUILD CAPACITY" This test need specific equipment "hydraulic-T" Result?		End	Replace HP pump

5. Failure Diagnosis

P0254 RPC error (IMV current trim drift high/low)

1. Overview

Code	Causes	Impact
P0254	Faulty injector (sticking, coking, leaking etc), Injector wiring problem, Faulty IMV	CE lamp Flashing Torque Reduction Lv1 Delay engine stop

NO	ECU Pin	Description
1	177	Inlet Metering Valve PWM
2	-	Pbatt

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If the current of IMV trim value is out of the threshold, fault code is raised.

4. Condition for Clearing the Fault Code

If the current of IMV trim value is within the threshold, fault code is cleared

5. Inspection Items

1) A

Step	Inspection	Standard Value	YES	NO
1	P0254 is occurred on diagnostic tool?		Step 2	O.K
2	After let the machine be in safety area and turn-off the key switch.		Step 3	
3	Please do visual inspection throughout all fuel line. (Low pressure circuit & high pressure circuit) Is there any leakage or blocking of fuel? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.		Step 4	Step 5
4	Please fix the leakage. After fix the problem, start the engine and change the RPM from low idle to high idle. Please keep the RPM as a high idle at least 10 minutes. Fault code is cleared?		O.K	Step 5
5	Please do the Shut off test & Run up test for detecting which injector has fault or not. Do you find faulty injector?		Step 6	Step 7
6	Change the injector which has a fault as a normal one. Start the engine and set the RPM in high idle at least 10 minutes. Fault code is cleared?		O.K	Step 7
7	Change the high pressure pump with DOOSAN A.S support. Fault code is cleared?		O.K	Call DOOSAN Hot line

5. Failure Diagnosis

2) B

Step	Inspection	Standard Value	YES	NO
1	P0254 is occurred on diagnostic tool?		Step 2	
2	Fault of type IMV or rail pressure sensor?		First, fix the corresponding fault	Step 3
3	DTC link to High Pressure control?		Step 4	No problem
4	Check that: * fuel feed circuit is in good condition * there is diesel fuel present in the system * there is no air (no bubbles or emulsion in the pipes) * there is enough fuel pressure in inlet pump * there are no high pressure circuit leaks * there is diesel fuel of the correct quality and type Low pressure circuit faulty?		Repair the low pressure circuit	Step 5
5	According to engine start or not, different tests are to be done. Does engine start?		Step 6	Step 7
6	Perform "DYNAMIC IMV TEST" Faulty IMV?		Replace IMV	Step 8
7	Perform "STATIC INJECTOR BACKLEAK TEST" Carry out the "tube test: Result?		Replace corresponding injector(s)	Replace HP pump
8	Perform "DYNAMIC INJECTOR BACKLEAK TEST" Backleak above limit?		Replace corresponding injector(s)	Step 9
9	Perform "PUMP PRESSURE BUILD CAPACITY" This test need specific equipment "hydraulic-T" Result?		End	Replace HP pump

5. Failure Diagnosis

P0253 RPC error (IMV current trim drift low/high)

1. Overview

Code	Causes	Impact
P0253	Faulty injector (sticking, coking, leaking etc), Injector wiring problem, Faulty IMV	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	177	Inlet Metering Valve PWM
2	-	Pbatt

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If the current of IMV trim value is out of the threshold, fault code is raised.

4. Condition for Clearing the Fault Code

If the current of IMV trim value is within the threshold, fault code is cleared

5. Inspection Items

1) A

Step	Inspection	Standard Value	YES	NO
1	P0253 is occurred on diagnostic tool?		Step 2	O.K
2	After let the machine be in safety area and turn-off the key switch.		Step 3	
3	Please do visual inspection throughout all fuel line. (Low pressure circuit & high pressure circuit) Is there any leakage or blocking of fuel? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.		Step 4	Step 5
4	Please fix the leakage. After fix the problem, start the engine and change the RPM from low idle to high idle. Please keep the RPM as a high idle at least 10 minutes. Fault code is cleared?		O.K	Step 5
5	Please do the Shut off test & Run up test for detecting which injector has fault or not. Do you find faulty injector?		Step 6	Step 7
6	Change the injector which has a fault as a normal one. Start the engine and set the RPM in high idle at least 10 minutes. Fault code is cleared?		O.K	Step 7
7	Change the high pressure pump with DOOSAN A.S support. Fault code is cleared?		O.K	Call DOOSAN Hot line

5. Failure Diagnosis

2) B

Step	Inspection	Standard Value	YES	NO
1	P0253 is occurred on diagnostic tool?		Step 2	
2	Fault of type IMV or rail pressure sensor?		First, fix the corresponding fault	Step 3
3	DTC link to High Pressure control?		Step 4	No problem
4	Check that: * fuel feed circuit is in good condition * there is diesel fuel present in the system * there is no air (no bubbles or emulsion in the pipes) * there is enough fuel pressure in inlet pump * there are no high pressure circuit leaks * there is diesel fuel of the correct quality and type Low pressure circuit faulty?		Repair the low pressure circuit	Step 5
5	According to engine start or not, different tests are to be done. Does engine start?		Step 6	Step 7
6	Perform "DYNAMIC IMV TEST" Faulty IMV?		Replace IMV	Step 8
7	Perform "STATIC INJECTOR BACKLEAK TEST" Carry out the "tube test: Result?		Replace corresponding injector(s)	Replace HP pump
8	Perform "DYNAMIC INJECTOR BACKLEAK TEST" Backleak above limit?		Replace corresponding injector(s)	Step 9
9	Perform "PUMP PRESSURE BUILD CAPACITY" This test need specific equipment "hydraulic-T" Result?		End	Replace HP pump

5. Failure Diagnosis

P0258 RPC error (IMV current trim drift low/low)

1. Overview

Code	Causes	Impact
P0258	Faulty injector (sticking, coking, leaking etc), Injector wiring problem, Faulty IMV	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	177	Inlet Metering Valve PWM
2	-	Pbatt

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If the current of IMV trim value is out of the threshold, fault code is raised.

4. Condition for Clearing the Fault Code

If the current of IMV trim value is within the threshold, fault code is cleared

5. Inspection Items

1) A

Step	Inspection	Standard Value	YES	NO
1	P0258 is occurred on diagnostic tool?		Step 2	O.K
2	After let the machine be in safety area and turn-off the key switch.		Step 3	
3	Please do visual inspection throughout all fuel line. (Low pressure circuit & high pressure circuit) Is there any leakage or blocking of fuel? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.		Step 4	Step 5
4	Please fix the leakage. After fix the problem, start the engine and change the RPM from low idle to high idle. Please keep the RPM as a high idle at least 10 minutes. Fault code is cleared?		O.K	Step 5
5	Please do the Shut off test & Run up test for detecting which injector has fault or not. Do you find faulty injector?		Step 6	Step 7
6	Change the injector which has a fault as a normal one. Start the engine and set the RPM in high idle at least 10 minutes. Fault code is cleared?		O.K	Step 7
7	Change the high pressure pump with DOOSAN A.S support. Fault code is cleared?		O.K	Call DOOSAN Hot line

5. Failure Diagnosis

2) B

Step	Inspection	Standard Value	YES	NO
1	P0258 is occurred on diagnostic tool?		Step 2	
2	Fault of type IMV or rail pressure sensor?		First, fix the corresponding fault	Step 3
3	DTC link to High Pressure control?		Step 4	No problem
4	Check that: * fuel feed circuit is in good condition * there is diesel fuel present in the system * there is no air (no bubbles or emulsion in the pipes) * there is enough fuel pressure in inlet pump * there are no high pressure circuit leaks * there is diesel fuel of the correct quality and type Low pressure circuit faulty?		Repair the low pressure circuit	Step 5
5	According to engine start or not, different tests are to be done. Does engine start?		Step 6	Step 7
6	Perform "DYNAMIC IMV TEST" Faulty IMV?		Replace IMV	Step 8
7	Perform "STATIC INJECTOR BACKLEAK TEST" Carry out the "tube test: Result?		Replace corresponding injector(s)	Replace HP pump
8	Perform "DYNAMIC INJECTOR BACKLEAK TEST" Backleak above limit?		Replace corresponding injector(s)	Step 9
9	Perform "PUMP PRESSURE BUILD CAPACITY" This test need specific equipment "hydraulic-T" Result?		End	Replace HP pump

5. Failure Diagnosis

P0252 RPC PWM error

1. Overview

Code	Causes	Impact
P0252	Faulty injector (sticking, coking, leaking etc), Injector wiring problem, Faulty IMV	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	177	Inlet Metering Valve PWM
2	-	Pbatt

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If IMV PWM demand is larger than threshold,
fault code is raised.

4. Condition for Clearing the Fault Code

If IMV PWM demand is within the threshold,
fault code is cleared

5. Inspection Items

1) A

Step	Inspection	Standard Value	YES	NO
1	P0252 is occurred on diagnostic tool?		Step 2	O.K
2	After let the machine be in safety area and turn-off the key switch.		Step 3	
3	Please do visual inspection throughout all fuel line. (Low pressure circuit & high pressure circuit) Is there any leakage or blocking of fuel? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.		Step 4	Step 5
4	Please fix the leakage. After fix the problem, start the engine and change the RPM from low idle to high idle. Please keep the RPM as a high idle at least 10 minutes. Fault code is cleared?		O.K	Step 5
5	Please do the Shut off test & Run up test for detecting which injector has fault or not. Do you find faulty injector?		Step 6	Step 7
6	Change the injector which has a fault as a normal one. Start the engine and set the RPM in high idle at least 10 minutes. Fault code is cleared?		O.K	Step 7
7	Change the high pressure pump with DOOSAN A.S support. Fault code is cleared?		O.K	Call DOOSAN Hot line

5. Failure Diagnosis

2) B

Step	Inspection	Standard Value	YES	NO
1	P0252 is occurred on diagnostic tool?		Step 2	
2	Fault of type IMV or rail pressure sensor?		First, fix the corresponding fault	Step 3
3	DTC link to High Pressure control?		Step 4	No problem
4	Check that: * fuel feed circuit is in good condition * there is diesel fuel present in the system * there is no air (no bubbles or emulsion in the pipes) * there is enough fuel pressure in inlet pump * there are no high pressure circuit leaks * there is diesel fuel of the correct quality and type Low pressure circuit faulty?		Repair the low pressure circuit	Step 5
5	According to engine start or not, different tests are to be done. Does engine start?		Step 6	Step 7
6	Perform "DYNAMIC IMV TEST" Faulty IMV?		Replace IMV	Step 8
7	Perform "STATIC INJECTOR BACKLEAK TEST" Carry out the "tube test: Result?		Replace corresponding injector(s)	Replace HP pump
8	Perform "DYNAMIC INJECTOR BACKLEAK TEST" Backleak above limit?		Replace corresponding injector(s)	Step 9
9	Perform "PUMP PRESSURE BUILD CAPACITY" This test need specific equipment "hydraulic-T" Result?		End	Replace HP pump

5. Failure Diagnosis

P0251 IMV control fault

1. Overview

Code	Causes	Impact
P0251	Faulty IMV. Fault with IMV wiring or connectors. ECU fault (IMV driver/processing within ECU). Faulty ECU live or ground. Fault with ECU wiring or connectors	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	177	Inlet Metering Valve PWM
2	-	Pbatt

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If IMV PWM demand is out of range, fault code is raised.

4. Condition for Clearing the Fault Code

If IMV PWM demand is in the range, fault code is cleared

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0251 is occurred on diagnostic tool?		Step 2	
2	Fault of type IMV or rail pressure sensor?		First, fix the corresponding fault	Step 3
3	DTC link to High Pressure control?		Step 4	No problem
4	Check that: * fuel feed circuit is in good condition * there is diesel fuel present in the system * there is no air (no bubbles or emulsion in the pipes) * there is enough fuel pressure in inlet pump * there are no high pressure circuit leaks * there is diesel fuel of the correct quality and type Low pressure circuit faulty?		Repair the low pressure circuit	Step 5
5	According to engine start or not, different tests are to be done. Does engine start?		Step 6	Step 7
6	Perform "DYNAMIC IMV TEST" Faulty IMV?		Replace IMV	Step 8
7	Perform "STATIC INJECTOR BACKLEAK TEST" Carry out the "tube test: Result?		Replace corresponding injector(s)	Replace HP pump
8	Perform "DYNAMIC INJECTOR BACKLEAK TEST" Backleak above limit?		Replace corresponding injector(s)	Step 9
9	Perform "PUMP PRESSURE BUILD CAPACITY" This test need specific equipment "hydraulic-T" Result?		End	Replace HP pump

5. Failure Diagnosis

P2080 Turbo in temperature plausibility fault

1. Overview

Code	Causes	Impact
P2080	Leakage Electrical problem Connection problem Sensor problem	

NO	ECU Pin	Description
1	123	Exhaust gas temp 2 (Pre-Turbo), return
2	106	Exhaust gas temp 2 (Pre-Turbo), signal

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

If the turbine in temperature is out of the threshold during restricted condition, fault code is raised.

4. Condition for Clearing the Fault Code

If the turbine in temperature is within the threshold during restricted condition, fault code is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P2080 is raised on machine dashboard?		Step 2	O.K
2	After let the machine be in safety area and turn-off the key switch.		Step 3	
3	Please do visual inspection throughout all air path. (From air cleaner to exhaust manifold including EGR passage) Is there any leakage? If you cannot find with your eyes, You can check leakage during engine running in machine stationary condition.		Step 4	Step 5
4	Please fix the leakage. After fix the problem, start the engine and change the RPM from low idle to high idle. Please keep the RPM as a high idle at least 10 minutes. Fault code is cleared?		O.K	Step 5
5	Change the turbine in temperature sensor as a normal one. Start the engine and set the RPM in high idle at least 10 minutes. Fault code is cleared?		O.K	Call DOOSAN Hot line

5. Failure Diagnosis

P0546 Turbo in temperature sensor high fault

1. Overview

Code	Causes	Impact
P0546	Electrical problem Connection problem Sensor problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	123	Exhaust gas temp 2 (Pre-Turbo), return
2	106	Exhaust gas temp 2 (Pre-Turbo), signal

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Turbine in temperature signal value is more than maximum operation range

4. Condition for Clearing the Fault Code

Turbine in temperature signal value is in operation range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0546 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P0545 Turbo in temperature sensor low fault

1. Overview

Code	Causes	Impact
P0545	Electrical problem Connection problem Sensor problem	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	123	Exhaust gas temp 2 (Pre-Turbo), return
2	106	Exhaust gas temp 2 (Pre-Turbo), signal

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Turbine in temperature signal value is lower than minimum operation range

4. Condition for Clearing the Fault Code

Turbine in temperature signal value is in operation range

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0545 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P2081 Turbo in temperature sensor noisy fault

1. Overview

Code	Causes	Impact
P2081	Electrical problem Connection problem Sensor problem Noise	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	123	Exhaust gas temp 2 (Pre-Turbo), return
2	106	Exhaust gas temp 2 (Pre-Turbo), signal

2. Condition for Running Diagnostic

During engine running

3. Condition for Setting the Fault Code

There is not turbine in temp sensor fault and there is a noise spike on the sensor signal.
(Noise detect: If the absolute difference, comparing the raw actual temp to low pass filtered temp value, exceeds calibration value).

4. Condition for Clearing the Fault Code

The noise spike is restored.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P2081 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness		Step 5	
5	Check sensor connection Connection problem?		Do necessary repair	Step 6
6	Check sensor resistance (checking it is coherent with vehicle conditions) if applicable. Resistance problem?		Change sensor	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P0685 Main relay stuck fault

1. Overview

Code	Causes	Impact
P0685	Electrical problem Connection problem Relay problem	CE lamp ON

NO	ECU Pin	Description
1	201	Protected Battery
2	203	Protected Battery
3	205	Protected Battery
4	202	Power Ground
5	204	Power Ground
6	206	Power Ground

2. Condition for Running Diagnostic

Key ON or Engine Run

3. Condition for Setting the Fault Code

If main relay status to be low state.

If abnormal shutdown happened by battery disconnection.

4. Condition for Clearing the Fault Code

When normal shutdown happened and main relay is operating normally.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0685 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Perform relay test routine Test OK?		Call Hot-line	Step 4
4	Check relay connection Connection problem?		Do necessary repair	Step 5
5	Check ECU connection Connection problem?		Do necessary repair	Step 6
6	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 7
7	Change relay (run ISO cycle) ISO cycle OK?		Problem solved	Call Hot-line

5. Failure Diagnosis

P068A Main relay unexpected low state

1. Overview

Code	Causes	Impact
P068A	Electrical problem Connection problem Relay problem	CE lamp ON

NO	ECU Pin	Description
1	201	Protected Battery
2	203	Protected Battery
3	205	Protected Battery
4	202	Power Ground
5	204	Power Ground
6	206	Power Ground

2. Condition for Running Diagnostic

Key ON or Engine Run

3. Condition for Setting the Fault Code

If main relay status to be low state.

If abnormal shutdown happened by battery disconnection.

4. Condition for Clearing the Fault Code

When normal shutdown happened and main relay is operating normally.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P068A is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Perform relay test routine Test OK?		Call Hot-line	Step 4
4	Check relay connection Connection problem?		Do necessary repair	Step 5
5	Check ECU connection Connection problem?		Do necessary repair	Step 6
6	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 7
7	Change relay (run ISO cycle) ISO cycle OK?		Problem solved	Call Hot-line

5. Failure Diagnosis

P062D Injector Bank 1 electric or SPI fault

1. Overview

Code	Causes	Impact
P062D	Injector bank #1 has shorted to ground or battery or SPI (Serial Peripheral Interface) fault	CE lamp Flashing Low idle RPM increase (SPI fault - CE lamp ON Torque Reduction Lv0)

NO	ECU Pin	Description
1	126	Fuel Injector LSD1A
2	127	Fuel Injector HSD1A

NO	ECU Pin	Description
1	125	Fuel Injector LSD2A
2	103	Fuel Injector HSD2A

2. Condition for Running Diagnostic During engine running

3. Condition for Setting the Fault Code

The injector bank 0 high side driver feedback voltage is constantly monitored. If the voltage is lower/higher than the calibrated threshold, then the fault is set.
Or SPI (Serial Peripheral Interface) has a problem

4. Condition for Clearing the Fault Code

The injector bank 0 high side driver feedback voltage is constantly monitored. If the voltage is inside the calibrated threshold range, then the fault is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0602D is occurred on diagnostic tool?		Step 2	
2	After let the machine is in safety area and turn-off the key switch.		Step 3	
3	Check injector connections corresponding to fault bank Connection problem?		Do necessary repair	Step 4
4	Disconnect injectors and key on Problem still present?			Step 7
5	Check ECU Connection Connection problem?		Do necessary repair	Step 6
6	Clear fault then key off then reconnect ONE injector then key on Problem back?		Step 7	Step 8

5. Failure Diagnosis

Step	Inspection	Standard Value	YES	NO
7	Change corresponding injector Do not forget to write new Individual Injector Correction to ECU		Step 8	
8	Iterate previous step on all injectors Try another injector (STEP 5) Problem back?		Step 7	Step 8
9	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P062E Injector Bank 2 electric or SPI fault

1. Overview

Code	Causes	Impact
P062E	Injector bank #2 has shorted to ground or battery or SPI (Serial Peripheral Interface) fault	CE lamp Flashing Low idle RPM increase (SPI fault - CE lamp ON Torque Reduction Lv0)

NO	ECU Pin	Description
1	175	Fuel Injector LSD1B
2	151	Fuel Injector HSD1B

2. Condition for Running Diagnostic During engine running

3. Condition for Setting the Fault Code

The injector bank 1 high side driver feedback voltage is constantly monitored. If the voltage is lower/higher than the calibrated threshold, then the fault is set.
or SPI (Serial Peripheral Interface) has a problem

4. Condition for Clearing the Fault Code

The injector bank 1 high side driver feedback voltage is constantly monitored. If the voltage is inside the calibrated threshold range, then the fault is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P062E is occurred on diagnostic tool?		Step 2	
2	After let the machine is in safety area and turn-off the key switch.		Step 3	
3	Check injector connections corresponding to fault bank Connection problem?		Do necessary repair	Step 4
4	Disconnect injectors and key on Problem still present?			Step 7
5	Check ECU Connection Connection problem?		Do necessary repair	Step 6
6	Clear fault then key off then reconnect ONE injector then key on Problem back?		Step 7	Step 8
7	Change corresponding injector Do not forget to write new Individual Injector Correction to ECU		Step 8	
8	Iterate previous step on all injectors Try another injector (STEP 5) Problem back?		Step 7	Step 8
9	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P2145 EGR H-Bridge driver short circuit to battery voltage

1. Overview

Code	Causes	Impact
P2145	EGR H-bridge Driver is shorted to battery	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	193	EGR (H-Bridge Neg)
2	164	EGR, VREF3
3	-	Not used
4	172	EGR Sensor Return GND
5	192	EGR (H-Bridge Pos)
6	116	EGR Position Sensor Signal

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

If the pins of EGR H-bridge have been shorted to battery then fault code is arisen.

4. Condition for Clearing the Fault Code

The fault status is removed

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P2145 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness			
5	Connection conform Problem still present?		Do necessary repair	Step 6
6	Visually check device Device problem?		Change device	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 9
9	Change device Problem still present?		Call Hot-line	Problem solved

5. Failure Diagnosis

P2144 EGR H-Bridge driver short circuit to ground

1. Overview

Code	Causes	Impact
P2144	EGR H-bridge Driver is shorted to ground	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	193	EGR (H-Bridge Neg)
2	164	EGR, VREF3
3	-	Not used
4	172	EGR Sensor Return GND
5	192	EGR (H-Bridge Pos)
6	116	EGR Position Sensor Signal

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

If the pins of EGR H-bridge have been shorted to battery then fault code is arisen.

4. Condition for Clearing the Fault Code

The fault status is removed

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P2144 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness			
5	Connection conform Problem still present?		Do necessary repair	Step 6
6	Visually check device Device problem?		Change device	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 9
9	Change device Problem still present?		Call Hot-line	Problem solved

5. Failure Diagnosis

P2143 EGR H-Bridge driver open circuit

1. Overview

Code	Causes	Impact
P2143	EGR H-bridge Driver is opened	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	193	EGR (H-Bridge Neg)
2	164	EGR, VREF3
3	-	Not used
4	172	EGR Sensor Return GND
5	192	EGR (H-Bridge Pos)
6	116	EGR Position Sensor Signal

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

If the pins of EGR H-bridge have been shorted to battery then fault code is arisen.

4. Condition for Clearing the Fault Code

The fault status is removed

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P2143 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	VEXT fault present?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness			
5	Connection conform Problem still present?		Do necessary repair	Step 6
6	Visually check device Device problem?		Change device	Step 7
7	Check ECU connection Connection problem?		Do necessary repair	Step 8
8	Check continuity and electrical insulation Electrical problem?		Fix harness	Step 9
9	Change device Problem still present?		Call Hot-line	Problem solved

5. Failure Diagnosis

P0404 EGR position control fault

1. Overview

Code	Causes	Impact
P0404	EGR valve control fault	CE lamp ON Torque Reduction Lv0

NO	ECU Pin	Description
1	193	EGR (H-Bridge Neg)
2	164	EGR, VREF3
3	-	Not used
4	172	EGR Sensor Return GND
5	192	EGR (H-Bridge Pos)
6	116	EGR Position Sensor Signal

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

EGR valve is not operating as normally.

4. Condition for Clearing the Fault Code

EGR valve is operating as normally.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0404 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check air inlet circuit: * Valve state * Depression circuit * Vacuum value pump * Open solenoid valve * Vanne state * Air inlet valve functionality		Step 4	
4	Check connection of the valve Check that the supply voltage is correct Check that the valve position can reach MIN to MAX position (0% to 100%) If applicable, launch a learning of EGR position Problem of connection / supply / position?		Do necessary repair	Problem solved

5. Failure Diagnosis

P0641 5V Supply #1 fault

1. Overview

Code	Causes	Impact
P0641	ECU sensor supply voltage(Vext1) Fault	CE lamp Flashing Torque Reduction Lv0 Engine will be stopped

NO	ECU Pin	Description
1		VREF1(Voltage)

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

If VREF voltage from ECU is not in normal range, then the fault is set

4. Condition for Clearing the Fault Code

If VREF voltage from ECU is in normal range, then the fault is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0641 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch.		Step 3	
3	DTC of all corresponding sensors connection to this sensor supply voltage (Vext)?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness			
5	Connection conform Problem still present?		Call Hot-Line	Problem solved

5. Failure Diagnosis

P0651 5V Supply #2 fault

1. Overview

Code	Causes	Impact
P0651	ECU sensor supply voltage(Vext2) Fault	CE lamp Flashing Torque Reduction Lv0 Engine will be stopped

NO	ECU Pin	Description
1		VREF2(Voltage)

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

If VREF voltage from ECU is not in normal range, then the fault is set

4. Condition for Clearing the Fault Code

If VREF voltage from ECU is in normal range, then the fault is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0651 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch.		Step 3	
3	DTC of all corresponding sensors connection to this sensor supply voltage (Vext)?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness			
5	Connection conform Problem still present?		Call Hot-Line	Problem solved

5. Failure Diagnosis

P0697 5V Aux supply #2 fault

1. Overview

Code	Causes	Impact
P0697	ECU sensor supply voltage(Vext2) AUX Fault	CE lamp Flashing Torque Reduction Lv0 Engine will be stopped

NO	ECU Pin	Description
1		VREF3(Voltage)

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

If VREF voltage from ECU is not in normal range, then the fault is set

4. Condition for Clearing the Fault Code

If VREF voltage from ECU is in normal range, then the fault is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0697 is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch.		Step 3	
3	DTC of all corresponding sensors connection to this sensor supply voltage (Vext)?		Step 4	Step 5
4	Problem with one of these sensors causing loss of Vext: Disconnect sensors one by one checking if fault disappear to find which one is faulty. If None is found faulty, check short circuit and isolation of Vext lines on the harness			
5	Connection conform Problem still present?		Call Hot-Line	Problem solved

5. Failure Diagnosis

P025D IMV drive electrical fault (SCVBATT)

1. Overview

Code	Causes	Impact
P025D	Electrical problem Connection problem Resistance problem Failure of IMV	CE lamp Flashing Torque Reduction Lv1 Delay engine stop

NO	ECU Pin	Description
1	177	Inlet Metering Valve PWM
2	-	Pbatt

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

If the IMV signal is shorted to battery, fault code is raised.

4. Condition for Clearing the Fault Code

If the fault condition is restored, fault code is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P025D is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check the IMV connection Connection problem? (pin to pin)		Do necessary repair	Step 4
4	Check the ECU Connection. Connection problem?		Do necessary repair	Step 5
5	Check continuity and electrical insulation. Electrical problem?		Fix wire harness	Step 6
6	Measure IMV electrical resistance? (around 5.3Ω at 20 °C) Resistance problem?		Change IMV	Step 7
7	Perform IMV buzzing test? (Test not applicable) IMV is buzzing?		Call Hot-Line	Change IMV

5. Failure Diagnosis

P025C IMV drive electrical fault (SCGND)

1. Overview

Code	Causes	Impact
P025C	Electrical problem Connection problem Resistance problem Failure of IMV	CE lamp Flashing Torque Reduction Lv1

NO	ECU Pin	Description
1	177	Inlet Metering Valve PWM
2	-	Pbatt

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

If the IMV signal is shorted to ground, fault code is raised.

4. Condition for Clearing the Fault Code

If the fault condition is restored, fault code is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P025C is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check the IMV connection Connection problem? (pin to pin)		Do necessary repair	Step 4
4	Check the ECU Connection. Connection problem?		Do necessary repair	Step 5
5	Check continuity and electrical insulation. Electrical problem?		Fix wire harness	Step 6
6	Measure IMV electrical resistance? (around 5.3Ω at 20 °C) Resistance problem?		Change IMV	Step 7
7	Perform IMV buzzing test? (Test not applicable) IMV is buzzing?		Call Hot-Line	Change IMV

5. Failure Diagnosis

P025A IMV drive electrical fault (OC)

1. Overview

Code	Causes	Impact
P025A	Electrical problem Connection problem Resistance problem Failure of IMV	CE lamp Flashing Torque Reduction Lv1 Delay engine stop

NO	ECU Pin	Description
1	177	Inlet Metering Valve PWM
2	-	Pbatt

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

If the IMV signal is shorted to ground, fault code is raised.

4. Condition for Clearing the Fault Code

If the fault condition is restored, fault code is cleared.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P025A is occurred on diagnostic tool?		Step 2	
2	After let the machine be in safety area and turn-off the key switch		Step 3	
3	Check the IMV connection Connection problem? (pin to pin)		Do necessary repair	Step 4
4	Check the ECU Connection. Connection problem?		Do necessary repair	Step 5
5	Check continuity and electrical insulation. Electrical problem?		Fix wire harness	Step 6
6	Measure IMV electrical resistance? (around 5.3Ω at 20 °C) Resistance problem?		Change IMV	Step 7
7	Perform IMV buzzing test? (Test not applicable) IMV is buzzing?		Call Hot-Line	Change IMV

5. Failure Diagnosis

P037F Glow plug feedback fault (SCVBAT)

1. Overview

Code	Causes	Impact
P037F	Electrical problem Connection problem Glow plug problem	CE lamp ON

NO	ECU Pin	Description
1	179	Glow Plug Feedback

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Glow plug feedback wire is shorted to battery

4. Condition for Clearing the Fault Code

Glow plug feedback wire problem is restored.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P037F is occurred on diagnostic tool?		Step 2	
2	Battery fault present?		Change the Battery	Step 3
3	Check glow plug connection Connection problem?		Do necessary repair	Step 4
4	Check ECU connection Connection problem?		Do necessary repair	Step 5
5	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P037E Glow plug feedback fault (OC / SCGND)

1. Overview

Code	Causes	Impact
P037E	Electrical problem Connection problem Glow plug problem	CE lamp ON

NO	ECU Pin	Description
1	179	Glow Plug Feedback

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

Glow plug feedback wire is shorted to battery

4. Condition for Clearing the Fault Code

Glow plug feedback wire problem is restored.

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P037E is occurred on diagnostic tool?		Step 2	
2	Battery fault present?		Change the Battery	Step 3
3	Check glow plug connection Connection problem?		Do necessary repair	Step 4
4	Check ECU connection Connection problem?		Do necessary repair	Step 5
5	Check continuity and electrical insulation Electrical problem?		Fix harness	Call Hot-line

5. Failure Diagnosis

P0606, P0607, P060A, P060C ECU safety monitoring fault

1. Overview

Code	Causes	Impact
P0606, P0607, P060A, P060C	ECU problem	CE lamp ON

NO	ECU Pin	Description
1	179	Glow Plug Feedback

2. Condition for Running Diagnostic

Key on or engine run

3. Condition for Setting the Fault Code

ECU internal chipset has a problem

4. Condition for Clearing the Fault Code

ECU internal chipset problem is restored

5. Inspection Items

Step	Inspection	Standard Value	YES	NO
1	P0606/P0607/P060A/P060C is occurred on diagnostic tool?		Call Hot-line	

5. Failure Diagnosis

6. About the engine

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6. About the engine

About the engine

Marking system of Units

Unit Conversion Methods

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

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

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

Note) 1mm X 0.03937 = 0.03937 in

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

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

Note) 1 in ÷ 0.03937 = 25.4 mm

Item	Number	SI Unit	US Unit
Length	0.03937	mm	in
	3.28084	m	ft
	1.093613	m	yd
	0.621371	km	mile
Area	0.00155	mm ²	in ²
	0.1550	cm ²	in ²
	10.76391	m ²	ft ²
	1.19599	m ²	yd ²
Weight	2.204623	kg	lb
	0.001	kg	t (ton)
Volume	0.061024	cc	in ³
	0.061024	ml	in ³
	0.061024	cm ³	in ³
	61.023744	L	in ³
	0.264172	L	gal
Force Note 1)	2.204622	kgf	lbf
	0.2248089	N	lbf
Acceleration	3.28084	m/s ²	ft/s ²
	39.37008	m/s ²	in/s ²
Torque Note 2)	7.233014	kgf•m	lbf•in
	86.79619	kgf•m	lbf•in
	0.7375621	N•m	lbf•ft
	8.850748	N•m	lbf•in
Power	1.340483	kw	Hp
Pressure	0.01	kPa	bar

Item	Number	SI Unit	US Unit
Pressure	7.500615	kPa	mmHg
	20.88543	kPa	lb/ft ²
	14.2233	psi	kg/cm ²
Electric 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
Luminous Flux	0.09290304	lm/m ²	lm/ft ²
Speed	0.6213712	km/h	mph
Temperature	Note 3)	°C	°F

Note 1) 9.806 x (kgf) = (N)

Note 2) 9.806 x (kgf•m) = (N•m)

Note 3) {(9/5) x (°C)+32} = (°F)

{(°F)-32} x (5/9) = (°C)

6. About the engine

Tightening Torque

Tightening Torque of Main Parts

Main Parts	Nominal (Diameter X Pitch)	Tensile Strength Rank	Tightening Torque	Remarks
Main Bearing Cap Bolt	M12x1.5x118	10.9T	1st: 5.5 kgf•m $\pm$ 0.28 kgf•m 2nd: 90° $\pm$ 4° 3rd: 90° $\pm$ 4°	
Cylinder Head Bolt	M11x1.25x130	10.9T	1st: 4.0 kgf•m $\pm$ 0.2 kgf•m 2nd: 90° $\pm$ 4° 3rd: 90° $\pm$ 4° 4th: 90° $\pm$ 4°	
Connecting Rod Bolt	M8x1.0x56	10.9T	1st: 2.0 kgf•m $\pm$ 0.1 kgf•m 2nd: 90° $\pm$ 4°	
Crankshaft Pulley Bolt	M14x1.5	10.9T	26 kgf•m $\pm$ 1 kgf•m	
Cylinder Head Cover (Left, Right)	M6x1.0	8.8T	0.8 kgf•m $\pm$ 0.05 kgf•m	
Cylinder Head Cover Bolt	M6x1.0	8.8T	0.8 kgf•m $\pm$ 0.05 kgf•m	
Injector Fixing Bracket Bolt (Socket)	M8x1.25	12.9T	4.35 kgf•m	$\pm$ 0.35 kgf•m
Thermostat Mounting Space Bolt	M8x1.25	8.8T	2.2 kgf•m	$\pm$ 10%
Pressure Sensor Adaptor Bolt	M6x1.0	8.8T	0.7 kgf•m ~ 1.0 kgf•m	
Turbocharger Hollow Screw (M10)	M10x1.0	-	1.8 kgf•m ~ 2.0 kgf•m	
Oil Pan Drain Plug	UNF 3/4-16	-	3.0 kgf•m	$\pm$ 10%
Glow Plug Body	M8x1	-	0.9 kgf•m ~ 1.2 kgf•m	
Glow Plug Terminal	M4x0.7	-	0.25 kgf•m ~ 0.3 kgf•m	
Turbocharger Mounting Nut	M8x1.25	-	2.2 kgf•m	$\pm$ 10%
water pump Mounting Nut	M8x1.25	-	2.2 kgf•m	$\pm$ 10%
Rocker Arm Adjust Hex Nut	M8x1.0	-	1.5 kgf•m	$\pm$ 10%
High Pressure Pump Drive Gear Nut	M14x1.5	-	6.5 kgf•m $\pm$ 0.5 kgf•m	
High Pressure Pump Mounting Nut	M8x1.25	-	2.2 kgf•m	$\pm$ 10%
Turbocharger Oil Delivery Pipe Nut	Union Nut	-	2.0 kgf•m	$\pm$ 10%
High Pressure Pipe Nut - High Pressure Pump	Union Nut	-	3.0 kgf•m $\pm$ 0.2 kgf•m	
High Pressure Pipe Nut - Common Rail	Union Nut	-	3.0 kgf•m $\pm$ 0.2 kgf•m	
High Pressure Pipe Nut - Injector	Union Nut	-	3.0 kgf•m $\pm$ 0.2 kgf•m	
High Pressure Pump Fuel Hose Bracket Bolt	M12x1.75	8.8T	5.5 kgf•m	

6. About the engine

Tightening Torque of General Bolts

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

1. Tightening Torque of General Bolts

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

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

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

Note) A special screw should be tightened with 85% of the tightening torque of the standard value.

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

6. About the engine

2. Tightening Torque of Key General Bolts

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

Tightening torque of plug screw

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

Hollow Screw (4-Hole) Tightening Torque

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

Note) Applied to Doosan Engines

6. About the engine

Engine Disassembly

Special Tools

Figure	Product Number/Name
	EF.120-262 Valve Spring Compression Tool
	T7621010E Piston Ring Plier
	850306-00078 Oil seal disassembly jig

Procedure of Disassembling an Engine

CAUTION

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

Disassemble the engine in the following order.

1. Drain coolant.
- 1) Check if the engine and radiator are cooled.
- 2) Place a container in front of the coolant drain plug.
- 3) Remove the radiator cap.
- 4) Remove the coolant drain plug of the radiator and then drain coolant.

- 5) After completing coolant drain, reconnect the coolant drain plug.

DANGER

- If the radiator cap is opened while the engine is hot, hot water will spurt out and may cause serious burns. Open the radiator cap after making sure that the engine has been fully cooled.
- Mark and separately manage the containers for storing coolant from beverage containers to avoid confusion. See a doctor immediately in case of drinking coolant.

WARNING

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

CAUTION

Be careful not to get coolant on any belts or electric apparatus when replacing the coolant.

2. Drain the engine oil.
- 1) Place a container under the engine to drain the engine oil.
- 2) Remove the oil cap.
- 3) Remove the drain plug and drain the engine oil.

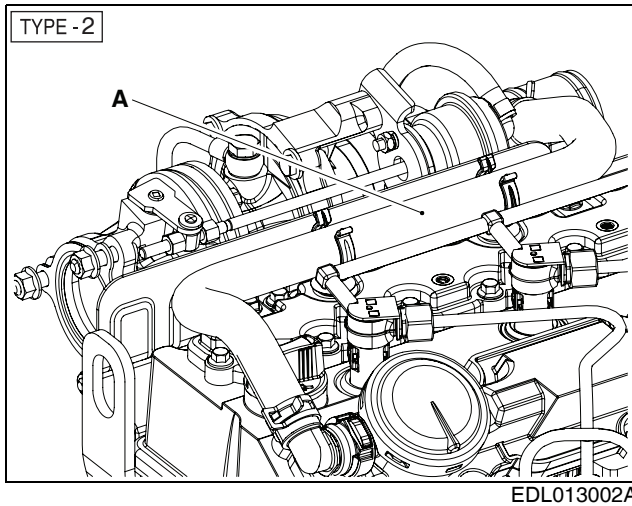
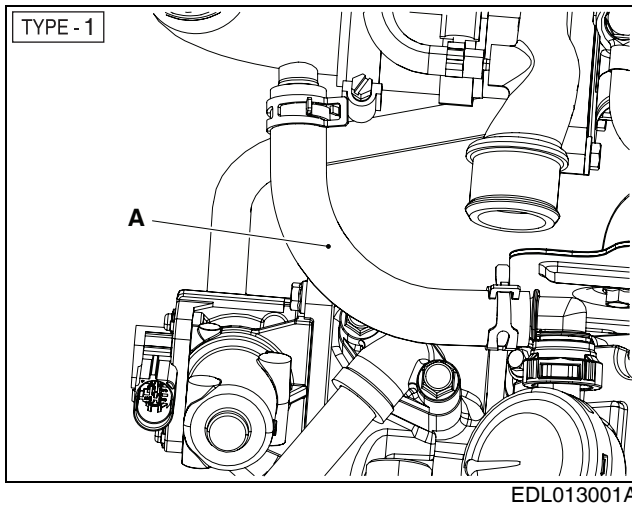
WARNING

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 when discarding engine oil without observing the handling regulations, will be punished.

3. Detach the air cooler and cooling fan from engine.
4. Detach the engine from the machine.
5. Disconnect the cables and harness connected to each sensor of the engine.
6. Remove the V-belt.

6. About the engine

7. Remove the breather hose.

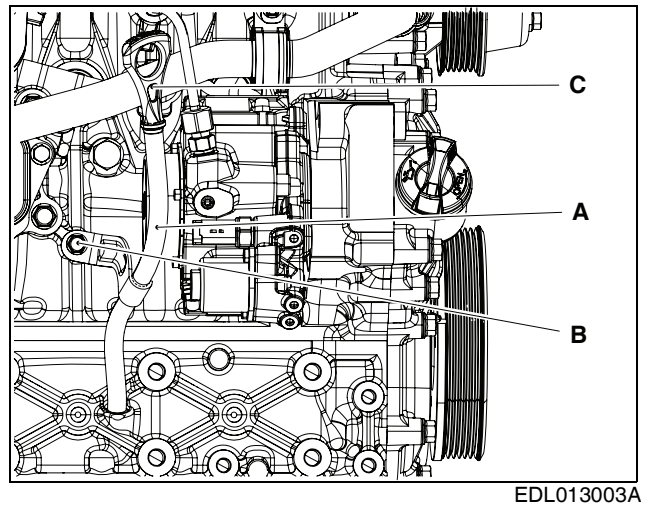


1) Remove the breather hose (A).

CAUTION

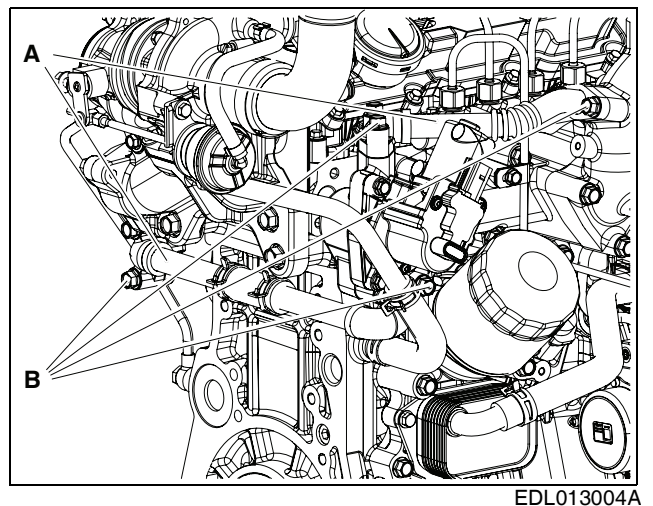
Do not use the clamps more than three times but replace them with new ones.

8. Remove the oil level gauge.



- 1) Remove the oil level gauge (C).
- 2) Loosen the flange hex bolt (B).
- 3) Disconnect the oil level gauge guide tube (A).

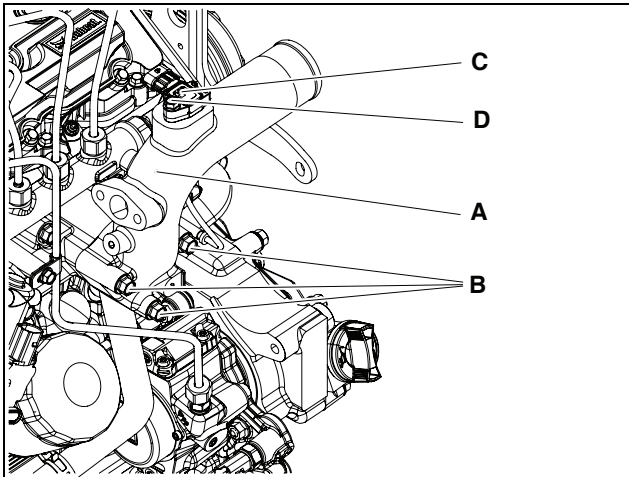
9. Remove the EGR connection pipes.



- 1) Loosen 6 fixing bolts (B).
- 2) Remove the EGR pipes (A).
- 3) Remove 4 gaskets.

6. About the engine

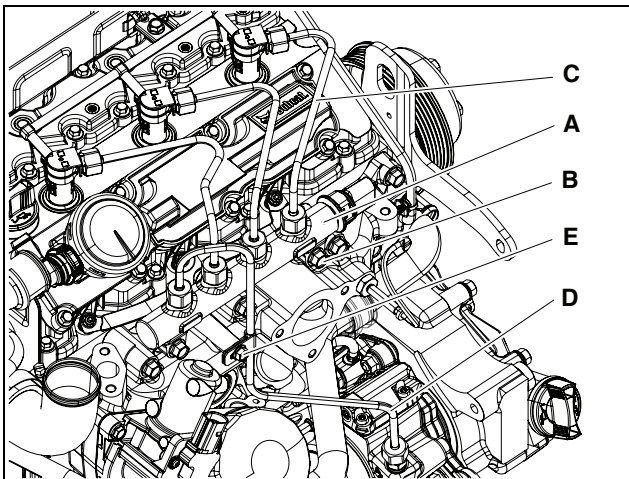
10. Remove the intake stake.



EDL013005A

- 1) Loosen the flange hex bolt (D).
- 2) Remove the boost pressure sensor (C).
- 3) Loosen 3 flange hex bolts (B).
- 4) Remove the gasket and the intake stake (A).

11. Remove the common rail and the injection pipes.



EDL013006A

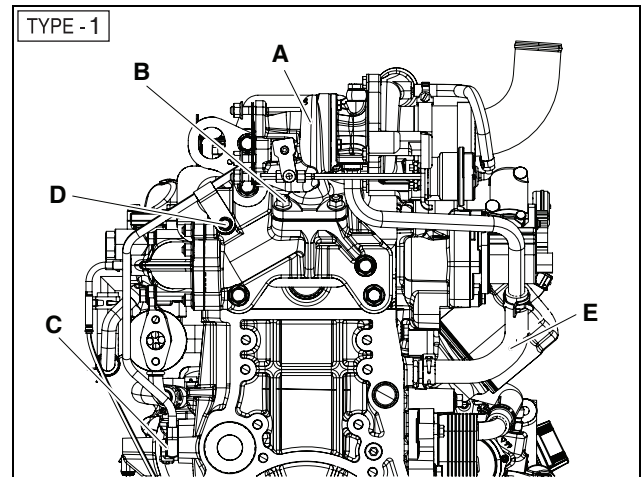
- 1) Loosen the fixing bolt (E).
- 2) Loosen the nuts of the fuel injection pipes.
- 3) Remove 4 fuel injection pipes (C) and (D).

CAUTION

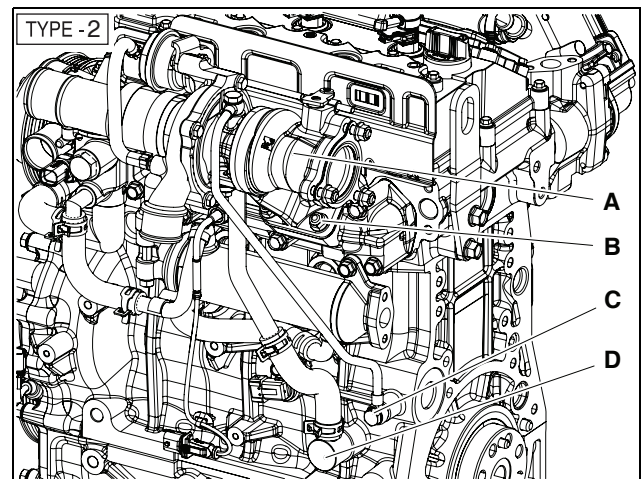
Do not reuse fuel injection pipes; replace them with new ones. If fuel injection pipes are reused it may allow foreign substances into the fuel pipes or cause oil leaks from bolt clamping and cause a critical fault in engine performance.

- 4) Loosen 2 collared hex bolts (B) of the common rail.
- 5) Remove the common rail (A) from the intake manifold.

12. Remove the turbocharger.



EDL013007A



EDL013008A

- 1) Disconnect the oil return pipe.

Note) The oil return pipe is that TYPE-1 is (E) and TYPE-2 is (D).

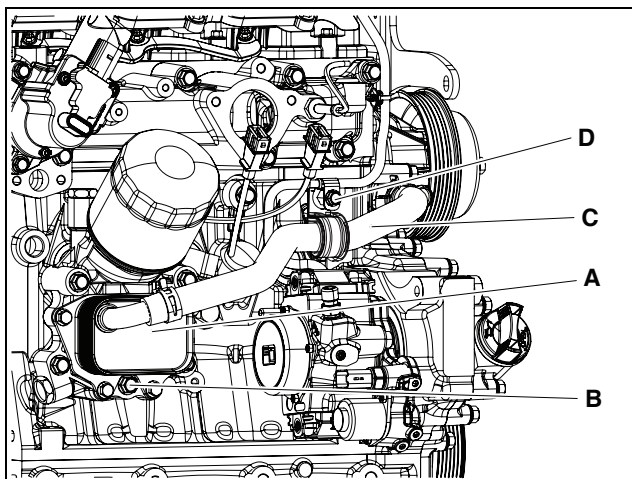
- 2) Loosen 2 hollow screws from the oil delivery pipe.

Note) Loosen the fixing bolt(D) if the engine is TYPE-1.

- 3) Disconnect the oil delivery pipe (C).
- 4) Loosen 4 flange hex nuts (B)
- 5) Remove the gasket and the turbocharger (A).

6. About the engine

13. Remove the oil filter assembly.



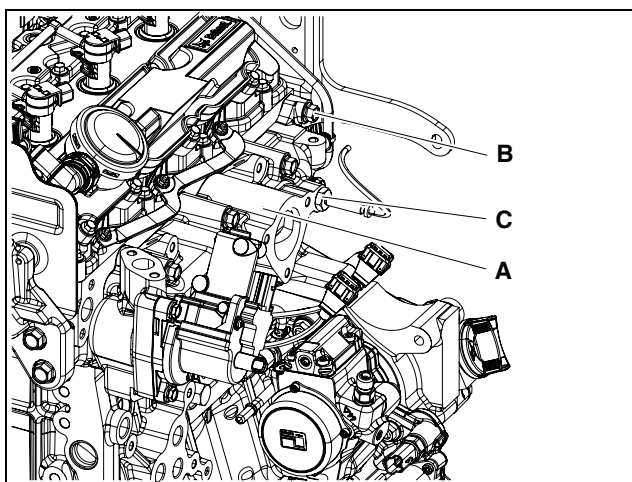
EDL013009A

- 1) Loosen the fixing bolt (D).
- 2) Disconnect the coolant hose (C).
- 3) Loosen 5 flange hex bolts (B).
- 4) Remove the 3 O-rings and the oil filter assembly (A).

CAUTION

Oil in the filter may run down while removing the oil filter. Be careful not to contaminate the other parts by using a cloth when removing the filter. After replacing the oil filter, wipe clean any other parts which the oil has touched.

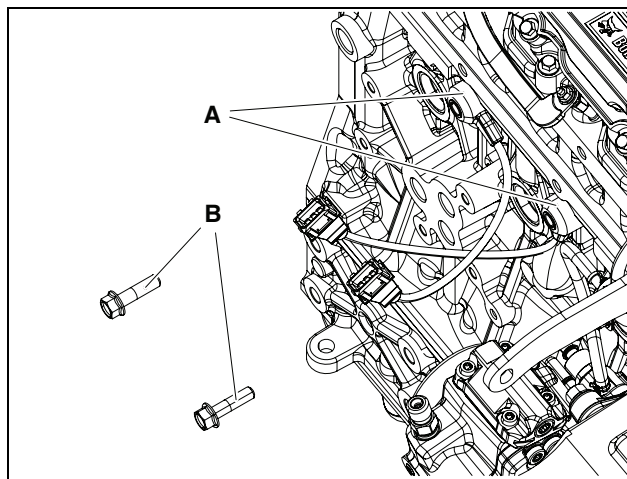
14. Remove the intake manifold.



EDL013010A

- 1) Remove the boost temperature sensor (C).
- 2) Loosen 8 flange hex bolts (B).
- 3) Remove the gasket and the intake manifold (A) from the cylinder block.

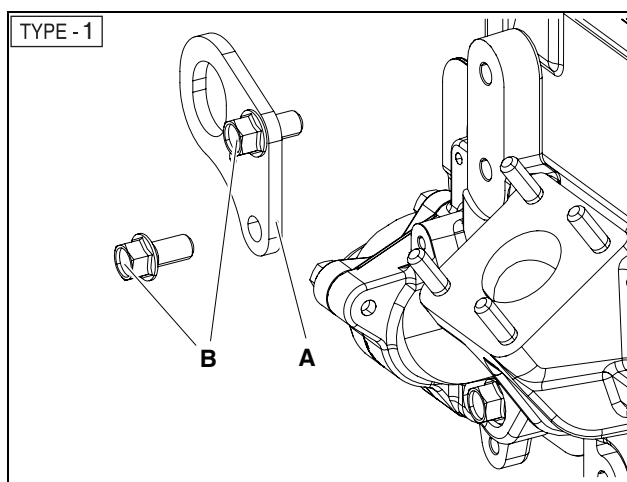
15. Remove the knock sensors.



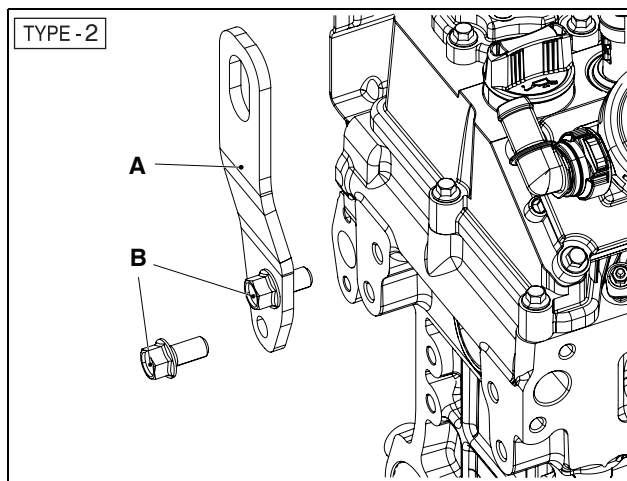
EDL013011A

- 1) Loosen 2 fixing bolts (B).
- 2) Remove 2 knock sensors (A) from the cylinder block.

16. Remove the rear lifting hook.



EDL013012A

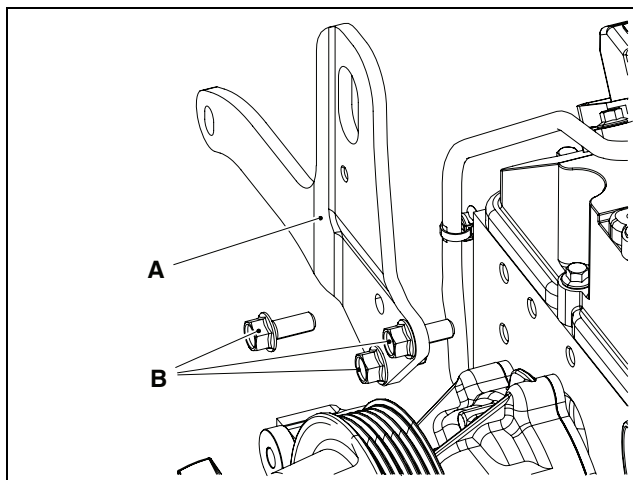


EDL013013A

6. About the engine

- 1) Loosen 2 fixing bolts (B).
- 2) Remove the rear lifting hook (A).

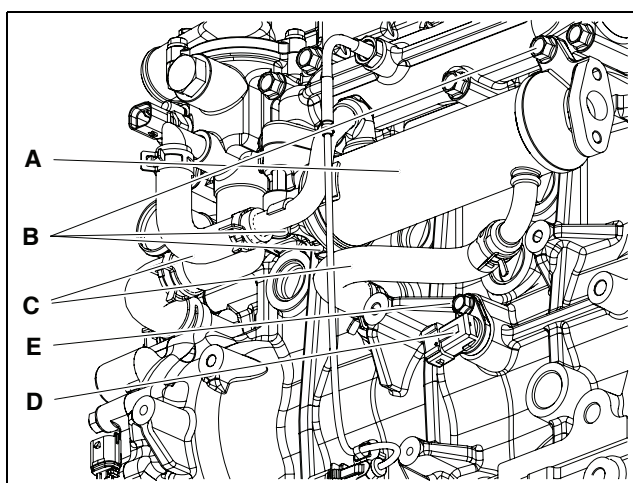
17. Remove the front lifting hook.



EDL013014A

- 1) Loosen 3 fixing bolts (B).
- 2) Remove the front lifting hook (A).

18. Remove the EGR cooler assembly and the cam position sensor.



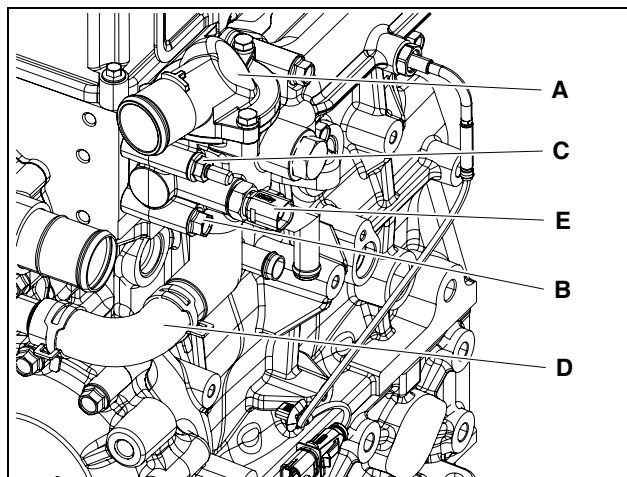
EDL013015A

- 1) Loosen the fixing bolt (E).
- 2) Remove the cam position sensor (D).
- 3) Disconnect the rubber hoses (C).
- 4) Loosen 3 flange hex bolts (B).
- 5) Remove the EGR cooler assembly (A).

CAUTION

Exhaust gas make engine parts extremely hot. Only remove the parts when they have fully cooled to prevent burns.

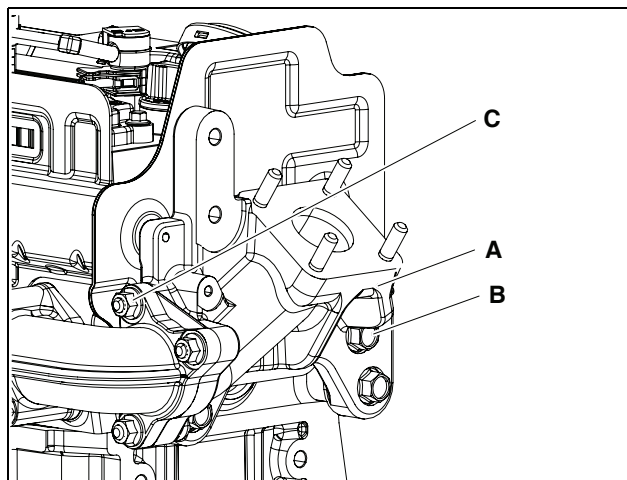
19. Remove the thermostat.



EDL013016A

- 1) Remove the water temperature sensor (E).
- 2) Disconnect the rubber hose (D).
- 3) Loosen the flange nut and spacer bolt (C).
- 4) Loosen the 3 flange hex bolts (B).
- 5) Remove the thermostat (A).

20. Remove the exhaust manifold pipe (Only TYPE-1).



EDL013017A

- 1) Loosen 3 flange hex nuts (C).
- 2) Loosen 3 flange hex bolts (B).
- 3) Remove the exhaust manifold pipe (A).

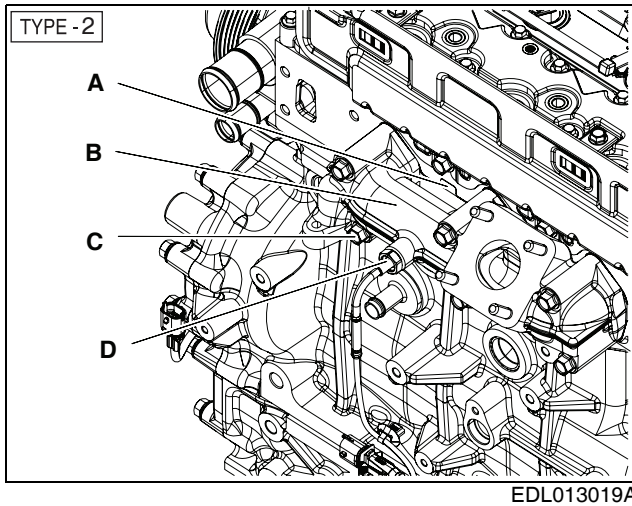
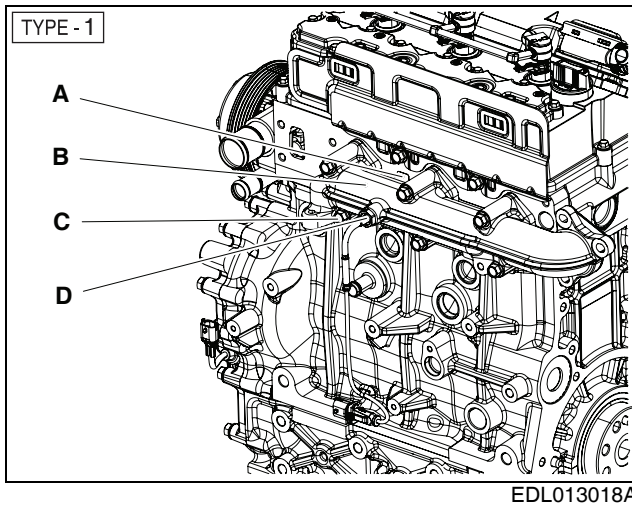
Note) The exhaust manifold pipe (A) is only TYPE-1.

CAUTION

Exhaust gas make engine parts extremely hot. Only remove the parts when they have fully cooled to prevent burns.

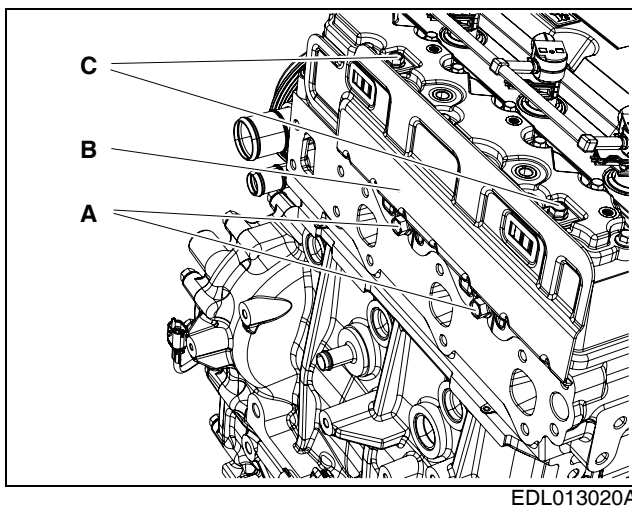
6. About the engine

21. Remove the exhaust manifold.



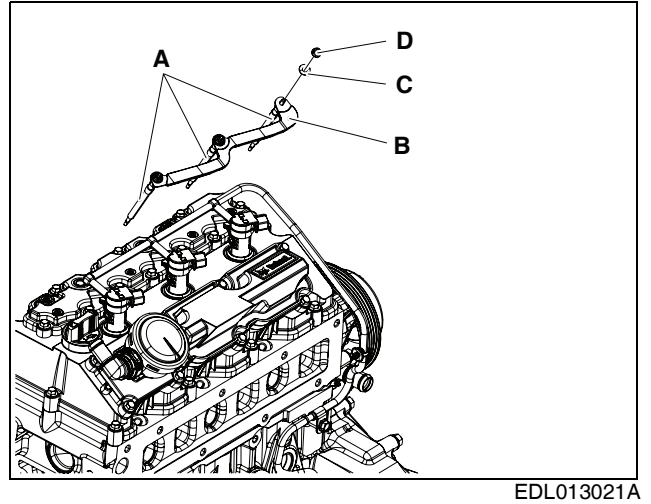
- 1) Remove the exhaust gas temperature sensor (D).
- 2) Loosen 6 flange hex bolts (C).
- 3) Remove the exhaust manifold (B) and the gasket (A).

22. Remove the heat screen.



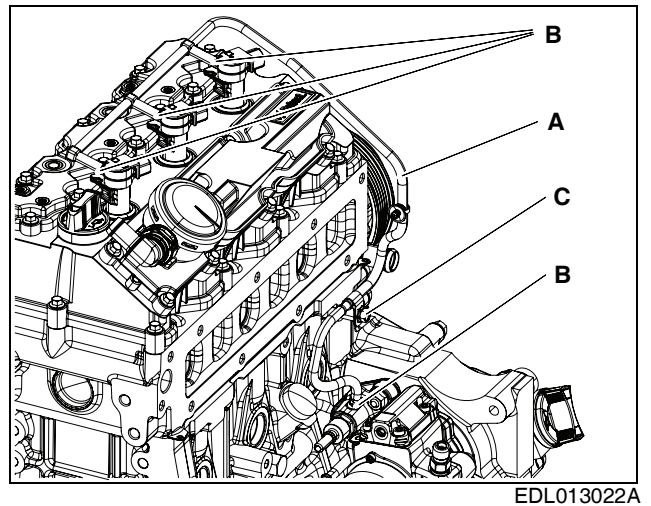
- 1) Loosen 2 fixing bolts (C).
- 2) Loosen 2 flange hex bolts (B).
- 3) Remove the heat screen (A).

23. Remove the glow plug.



- 1) Loosen 3 hex nuts (D) and remove 3 washers (C).
- 2) Remove the electric connector (B) and 3 glow plugs (A).

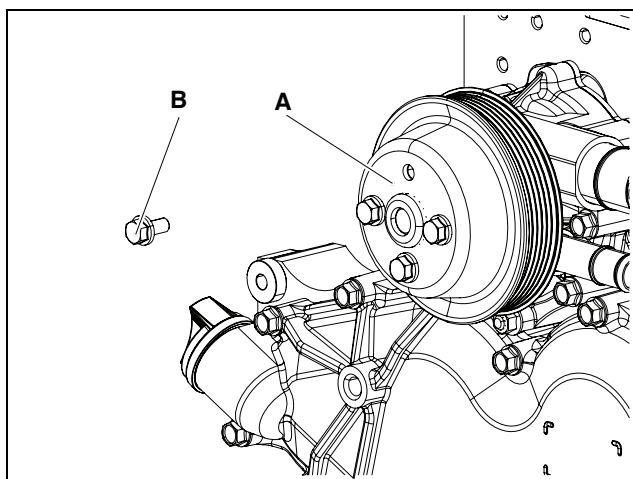
24. Remove the fuel return hose.



- 1) Loosen the flange hex bolts (C).
- 2) Remove the hose clips and disconnect the fuel hose (A).

6. About the engine

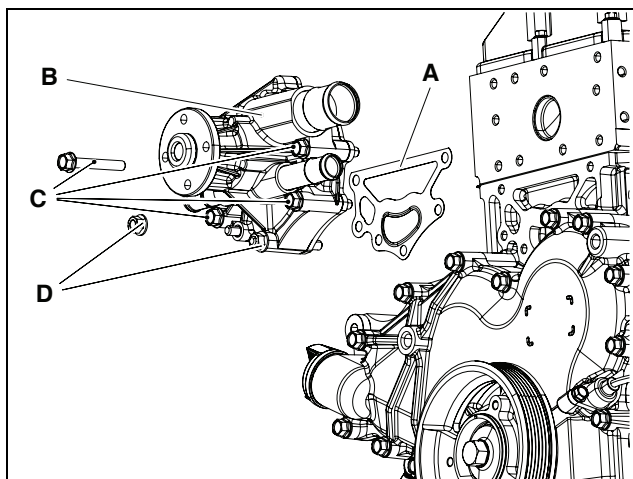
25. Remove the water pump pulley.



EDL013023A

- 1) Loosen 4 flange hex bolts (B).
- 2) Remove the water pump pulley (A).

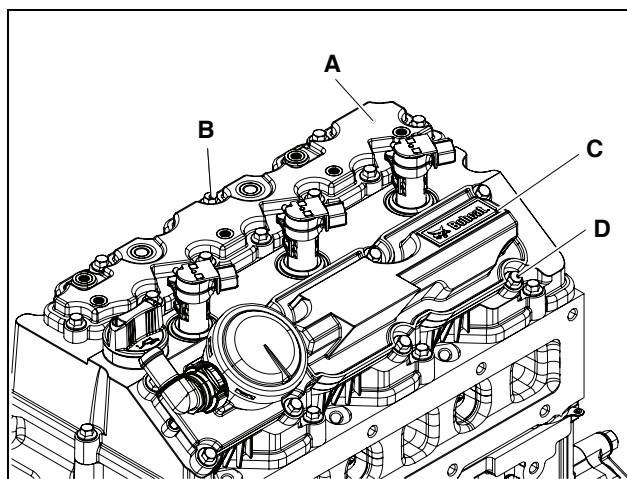
26. Remove the water pump.



EDL013024A

- 1) Loosen 2 flange hex nuts (D) and 4 hex bolts (C).
- 2) Remove the water pump (B) and the gasket (A).

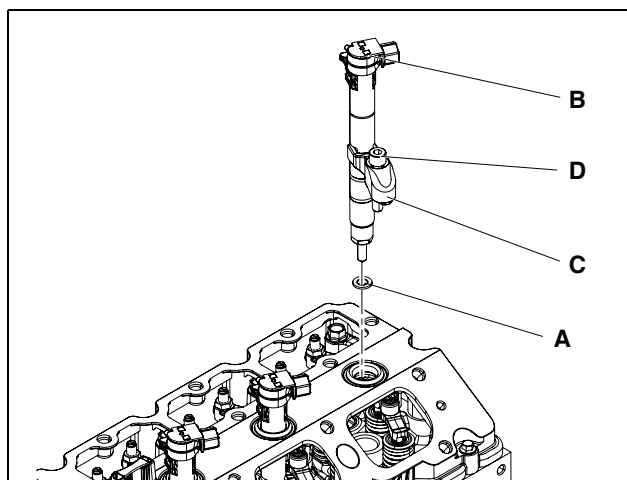
27. Remove the right and left cylinder head cover.



EDL013025A

- 1) Loosen 8 flange hex bolts (D).
- 2) Remove the right cylinder head cover (C).
- 3) Loosen 10 flange hex bolts (B).
- 4) Remove the left cylinder head cover (A).

28. Remove the injectors.



EDL013026A

- 1) Loosen 3 hex bolts (D).
- 2) Remove 3 injector fixtures (C).
- 3) Remove 4 injectors (B).
- 4) Remove 3 injector seal ring washers (D).

CAUTION

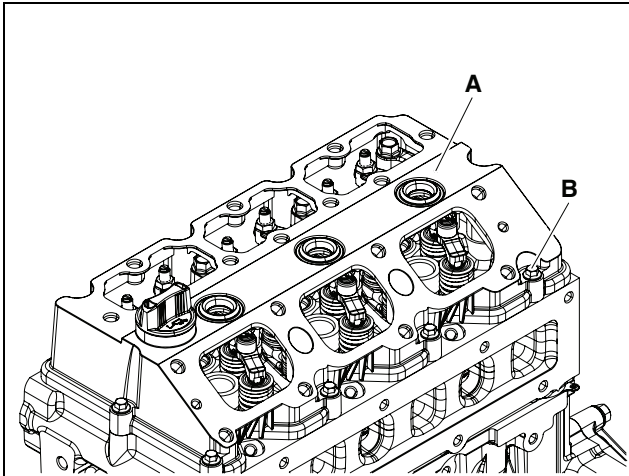
- Do not reuse the head cover rubber seal and the injector oil seal but replace with new ones.
- Be careful not to damage the injector oil seal of the cylinder head cover.
- Remove it by turning the injector slowly from left to right.

6. About the engine

CAUTION

Do not reuse the injector seal ring washers. Reuse of the injector seal ring washers may cause critical damage to the engine due to unstable combustion.

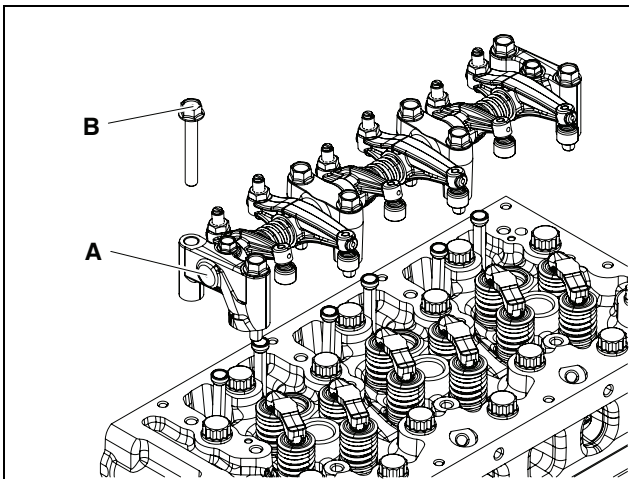
29. Remove the cylinder head cover.



EDL013027A

- 1) Loosen 10 hex bolts (B).
- 2) Remove the cylinder head cover (A).

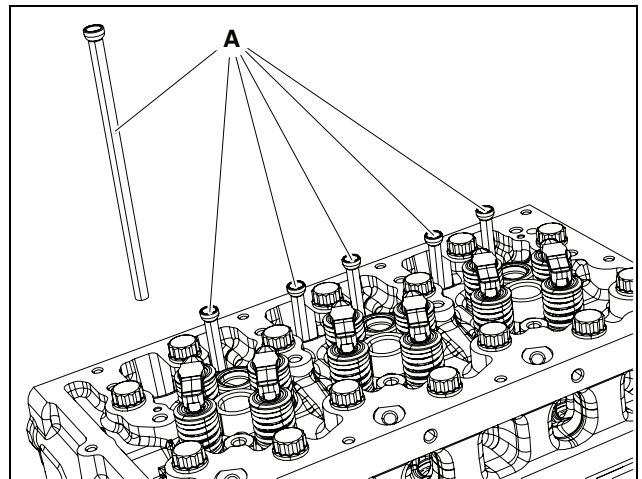
30. Remove the rocker arm.



EDL013028A

- 1) Loosen 8 flange hex bolts (B).
- 2) Remove the rocker arm (A).

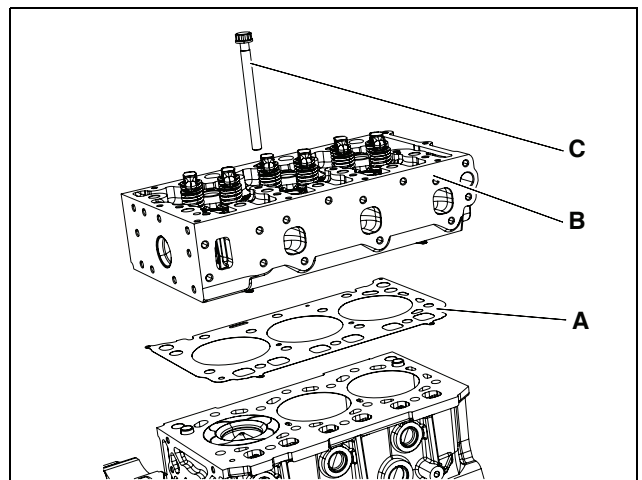
31. Remove the push rods.



EDL013029A

- 1) Remove 6 push rods (A).

32. Remove the cylinder head.



EDL013030A

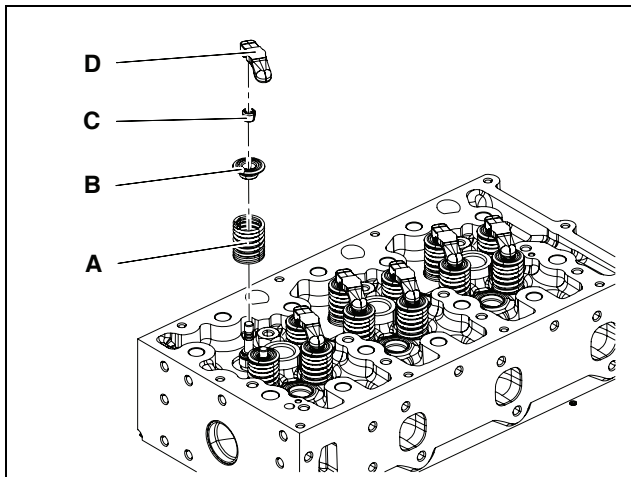
- 1) Loosen 14 cylinder head bolts (C).
- 2) Remove the cylinder head (B).
- 3) Remove the cylinder head gasket (A).

CAUTION

Do not reuse the cylinder head gasket but replace with new one.

6. About the engine

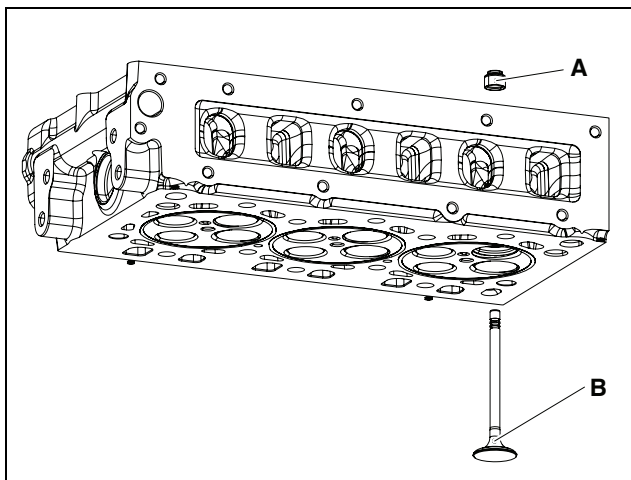
33. Remove the valve spring.



EDL013031A

- 1) Remove the calipers (D).
- 2) Compress the valve with the valve spring compression tool (EF.120-262).
- 3) Remove the valve coppers (C).
- 4) Remove the valve spring retainers (B).
- 5) Remove the valve springs (A).

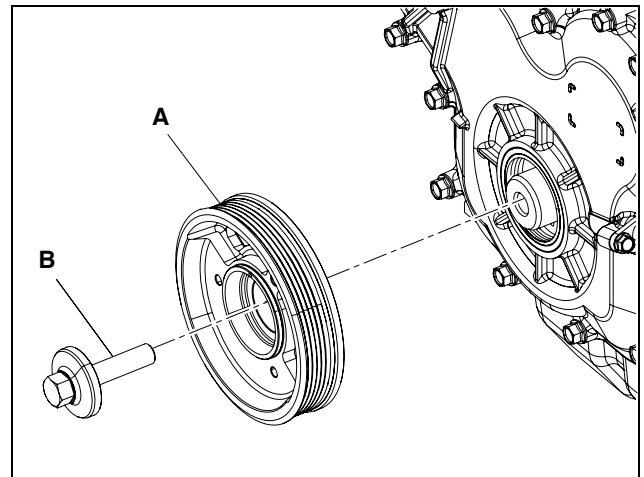
34. Remove the valves.



EDL013032A

- 1) Remove the valves (B).
- 2) Remove the valve stem seals (A).

35. Remove the crankshaft pulley.



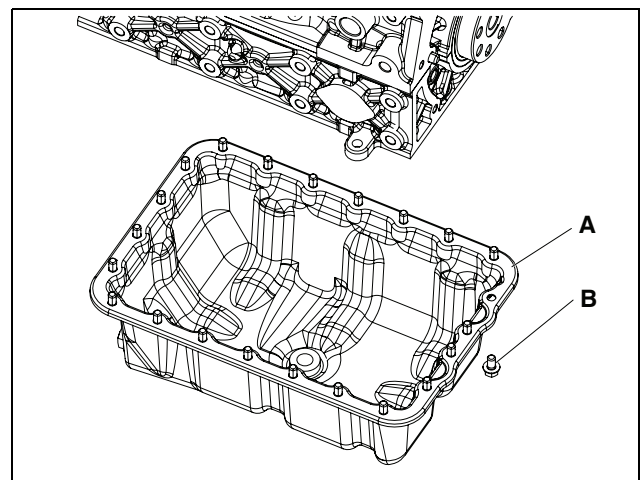
EDL013033A

- 1) Loosen the flange hex bolt (B).
- 2) Remove the crankshaft pulley (A).

CAUTION

Be careful not to damage the oil seal.

36. Remove the oil pan.

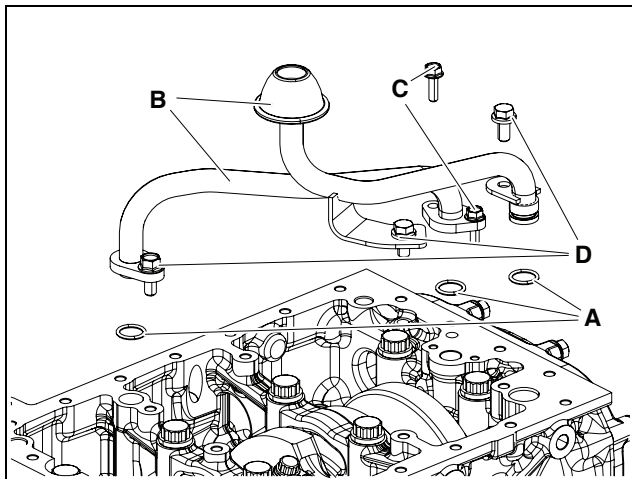


EDL013034A

- 1) Loosen 22 flange hex bolts (B).
- 2) Remove the oil pan (A).

6. About the engine

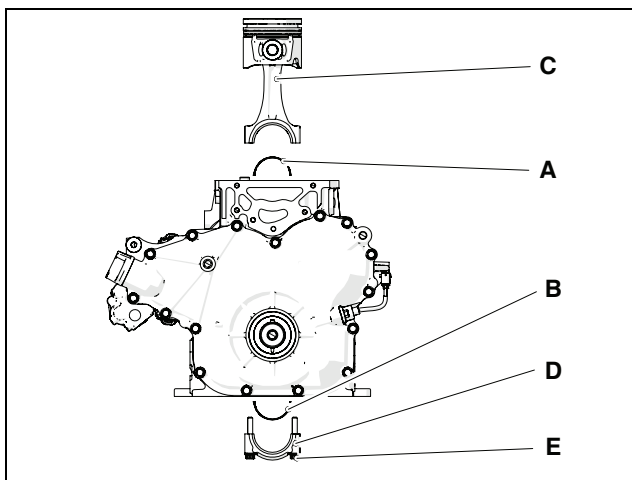
37. Remove the oil suction pipe and oil delivery pipe.



EDL013035A

- 1) Loosen 3 hex bolts (D) and 2 hex bolts (C).
- 2) Remove the oil suction pipe and the oil delivery pipe (B).
- 3) Remove 3 O-rings (A).

38. Remove the connecting rods assembly.



EDL013036A

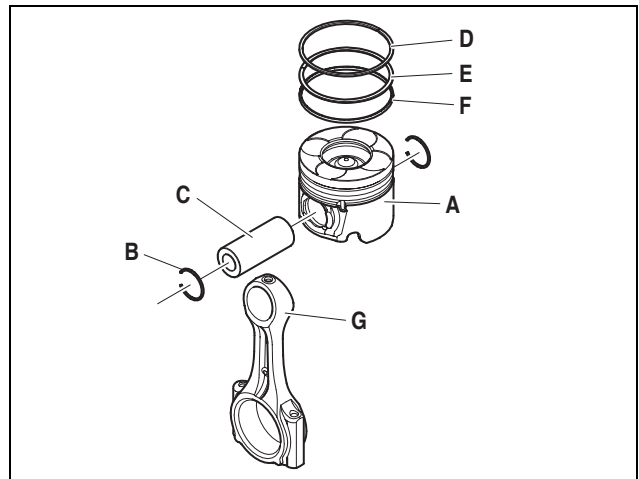
- 1) Loosen 6 connecting rod bolts (E).
- 2) Remove the lower connecting rod caps (D).
- 3) Remove the connecting rods (C).

CAUTION

Be careful not to mix disconnected connecting rods, connecting rod caps, and removed connecting rod bolts as they are set aside.

- 4) Remove the upper connecting rod bearings(A) and the lower connecting rod bearings (B).

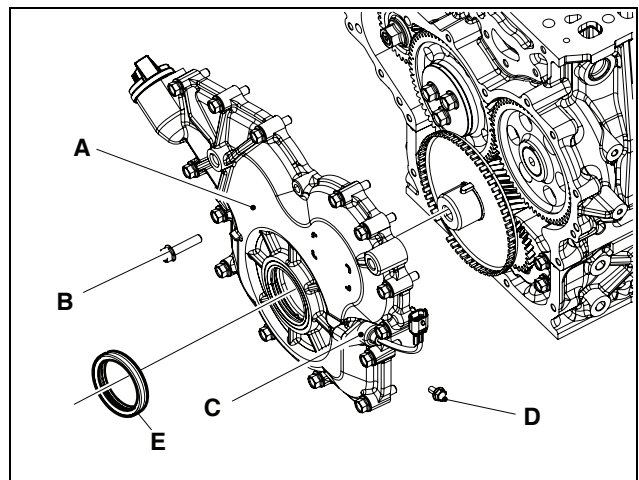
39. Remove the piston.



EDL022038A

- 1) Remove 2 snap rings (B) from the both ends of the piston.
- 2) Remove the piston pin (C).
- 3) Remove the piston (A) from the connecting rod (G).
- 4) Remove the 1st ring (D), the 2nd ring (E), and the oil ring (F) with the piston ring plier (T7621010E).

40. Remove the timing gear case.



EDL013037A

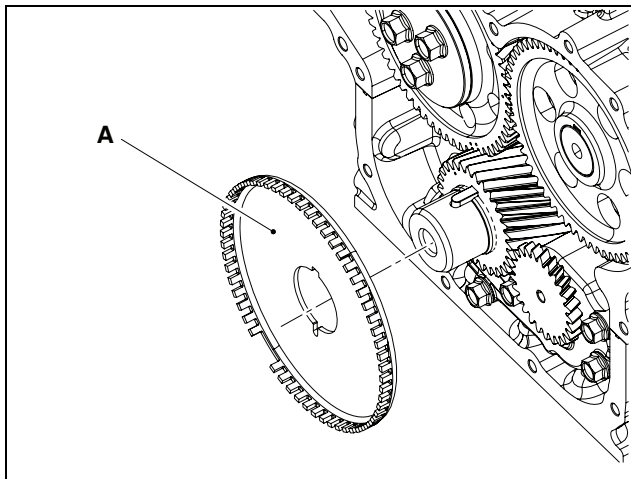
- 1) Loosen the fixing bolt (D).
- 2) Remove the crank speed sensor (C).
- 3) Loosen 16 hex bolts (B).
- 4) Remove the timing gear case (A).
- 5) Remove the front oil seal (E) with the oil seal disassembly jig (850306-00078).

CAUTION

Do not reuse the oil seal but replace them with new ones.

6. About the engine

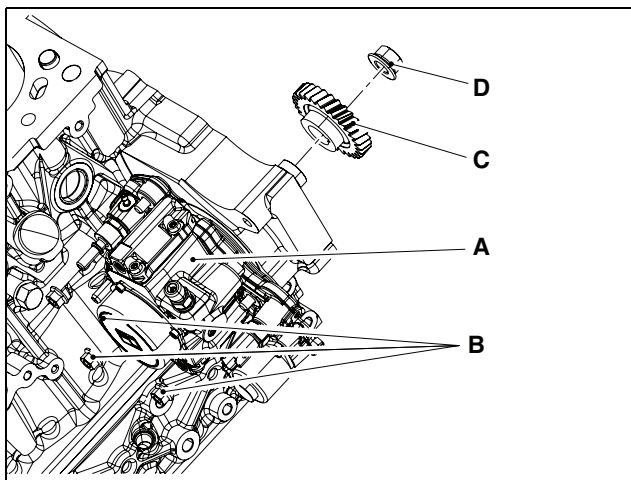
41. Remove the timing wheel.



EDL013038A

- 1) Remove the timing wheel (A).

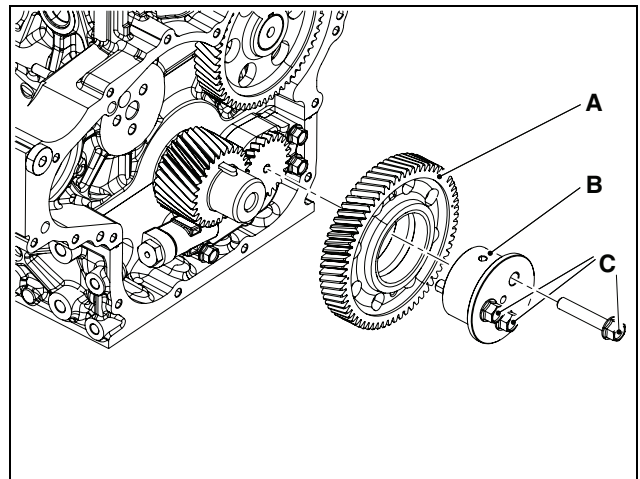
42. Remove the fuel injection pump.



EDL013039A

- 1) Loosen the flange hex nut (D).
- 2) Remove the fuel injection pump drive gear (C).
- 3) Loosen 3 flange hex nuts (B).
- 4) Remove the injection pump (A).

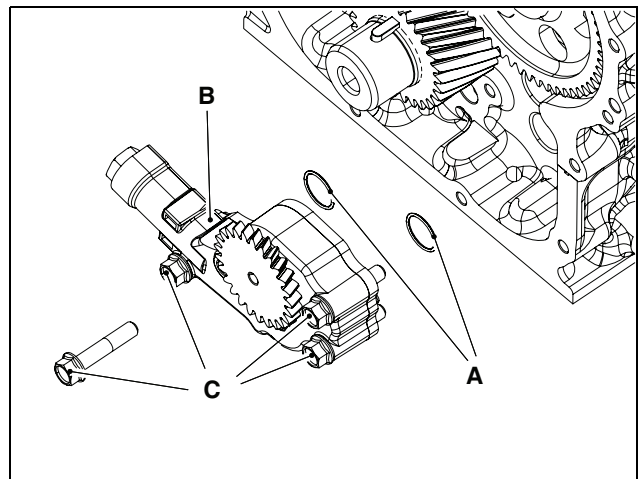
43. Remove the idle gear.



EDL013040A

- 1) Loosen 3 flange hex bolts (C).
- 2) Remove the idle gear shaft (B).
- 3) Remove the idle gear (A) using remove tap.

44. Remove the oil pump.

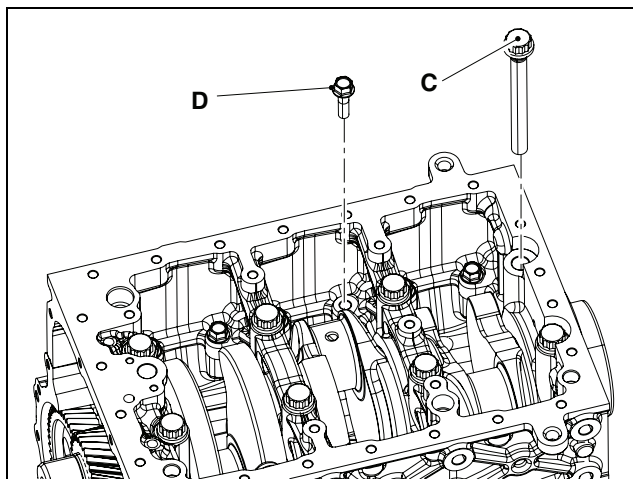


EDL013041A

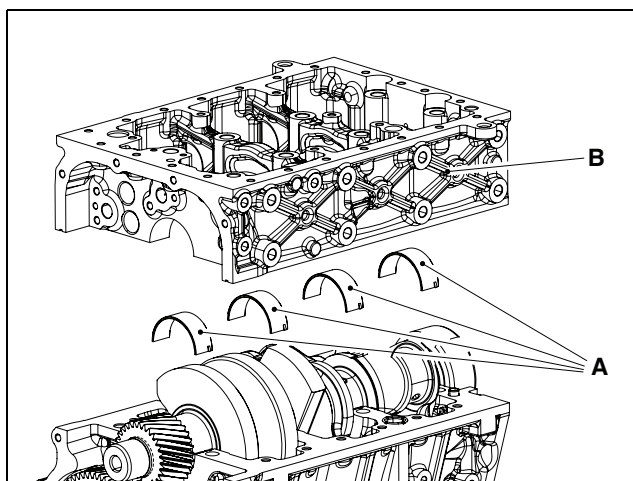
- 1) Loosen 4 hex bolts (C).
- 2) Remove the oil pump (B).
- 3) Remove 2 O-rings (A).

6. About the engine

45. Remove the crank case.



EDL013042A



EDL013043A

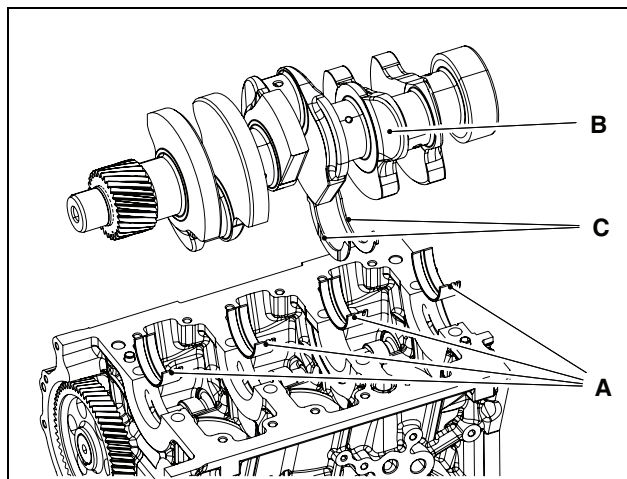
- 1) Remove the rear oil seal with oil seal disassembly jig (850306-00078).

CAUTION

Do not reuse the oil seal; replace it with a new one.

- 2) Loosen 12 collared hex bolts (D).
- 3) Loosen 8 main bearing cap bolts (C).
- 4) Remove the crank case (B).
- 5) Loosen 4 lower main bearings (A) from the crank case.

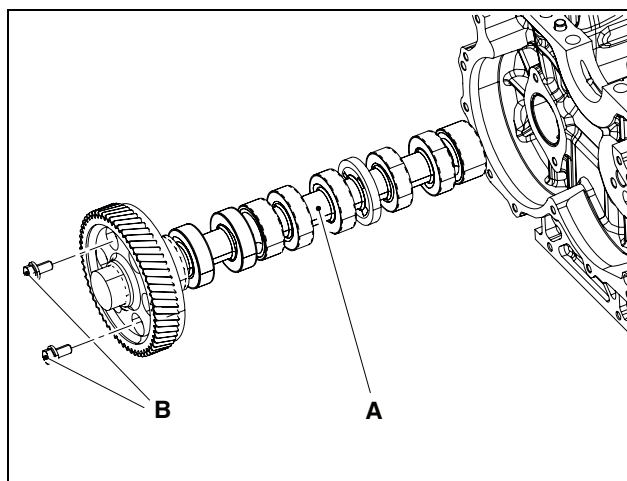
46. Remove the crankshaft.



EDL013044A

- 1) Remove 2 thrust washers (C).
- 2) Remove the crankshaft (B).
- 3) Remove 4 upper main bearings (A) from the cylinder block.

47. Remove the camshaft.

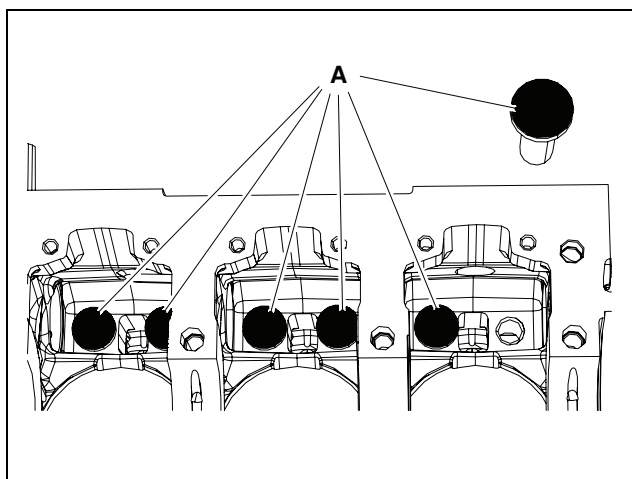


EDL013045A

- 1) Loosen 2 hex bolts (B).
- 2) Remove the camshaft (A).

6. About the engine

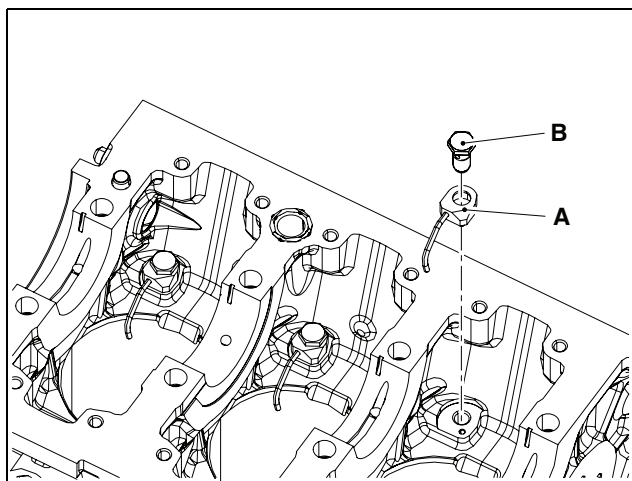
48. Remove the valve tappets.



EDL013046A

- 1) Remove 6 valve tappets (A) from the cylinder block.

49. Remove the oil spray nozzles.



EDL013047A

- 1) Loosen 3 relief valve screws (B).
- 2) Remove 3 oil spray nozzles (A).

6. About the engine

Engine Assembly

Special Tools

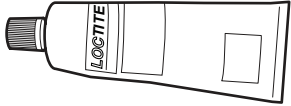
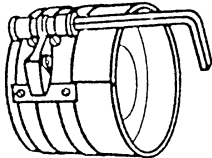
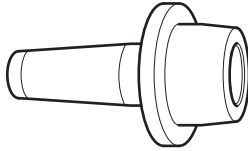
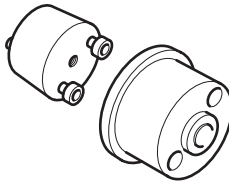
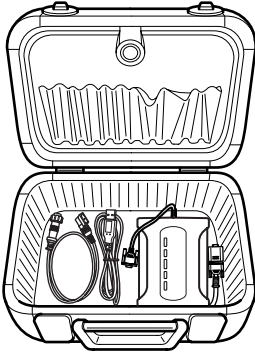
Figure	Product Number/Name
	LOCTITE 272
	500212-00016 LOCTITE 5902
	T7621010E Piston Ring Plier
	EF.120-208 Piston insertion tool
	09-0666 LOCTITE BLUE 587
	860104-02041 Valve Stem Seal Jig
	EF.120-262 Valve spring compression tool

Figure	Product Number/Name
	860104-02047 Front Oil Seal Disassembly Jig
	860104-02048 Rear Oil Seal Disassembly Jig
	860104-02793 G2 Diagnostic Tool - UVM(CAN Communication) - 14pin OBD Connector - USB Cable - 6pin OBD Connector

6. About the engine

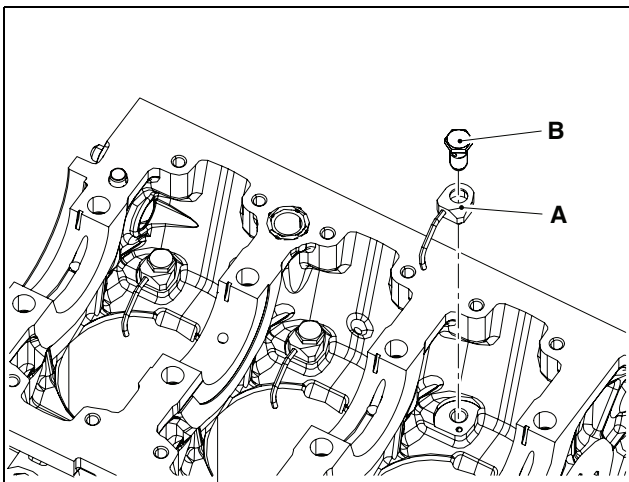
Procedure of Assembling Engine

CAUTION

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

Assemble the engine in the following order.

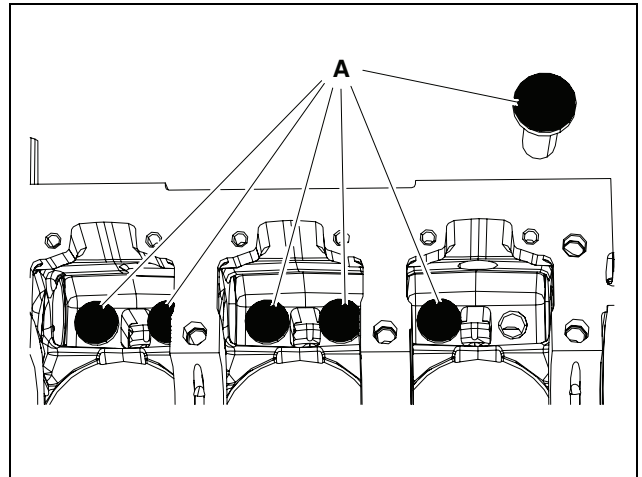
1. Attach the oil spray nozzles.



EDL013047A

- 1) Attach 3 oil spray nozzles (A) to the corresponding pins.
- 2) Tighten 4 relief valve screws (B) at a tightening torque of 2.0 kgf•m.

2. Attach the valve tappets.



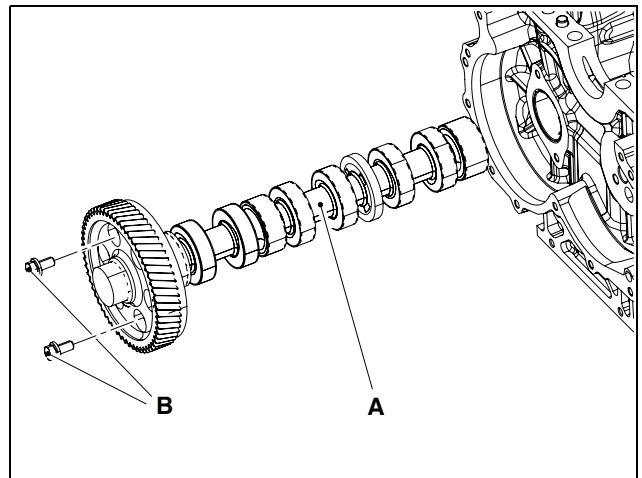
EDL013046A

- 1) Apply a mixture of engine oil and molykote on the surface where the cylinder block and the valve tappets are assembled.

Note) Engine oil : MOLYKOTE = 1 : 5

- 2) Connect 6 valve tappets (A).

3. Attach the camshaft.



EDL013045A

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

Note) Ensure that the camshaft journal and the inside of the cylinder block bush are normal.

- 3) Align the thrust washer with the cylinder block part.
- 4) Tighten 2 hex bolts (B) at a tightening torque of 2.2 kgf•m.

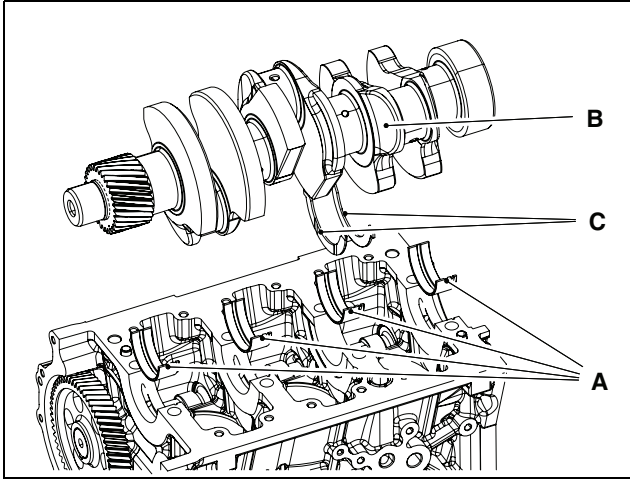
Note) Temporarily mount one hex bolt manually and then rotate the camshaft gear to tighten the other hex bolt.

- 5) The camshaft end play is 0.1 ~ 0.2 mm.

6. About the engine

Item	Specified Value
Camshaft end play	0.1 ~ 0.2 mm

4. Attach the crankshaft.



EDL013044A

- 1) Attach 4 upper main bearings (A) to the cylinder block.

⚠ CAUTION

- Bearings with a groove are the upper main bearings on the cylinder block side and bearings without a groove are the lower main bearings on the crank case side.
- Remove foreign substances such as residues and LOCTITE from the inside of the main bearings and the oil seal assembly bore.
- Do not apply engine oil on the surface where the cylinder block and the main bearings are assembled.
- The class of the 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 engraving positions, see the Engine Unique Number of Chapter 3 (Performance and Specifications).
- Select the proper main bearing class by checking or measuring the class of main bearing bore inside diameter of the cylinder block and the class of the main journal diameter of the crankshaft.
- The upper main bearing class should be same as the lower main bearing class.

- 2) Sufficiently apply engine oil on the surface where the upper main bearings and the crankshaft are assembled.
- 3) Attach the crankshaft (B).
- 4) Attach 2 thrust washers (C).

⚠ CAUTION

Align the key groove of the cylinder block with the key of thrust washer.

Note) The class of the main bearing is as follows.

Block journal bore	Crankshaft main journal diameter		
	Class A	Class B	Class C
Class A	YELLOW	BLUE	BLUE
Class B	YELLOW	YELLOW	BLUE
Class C	RED	RED	YELLOW

Block main bearing bore diameter	Specified Value
Class A	62.000 ~ 62.007 mm
Class B	62.007 ~ 62.014 mm
Class C	62.014 ~ 62.021 mm

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

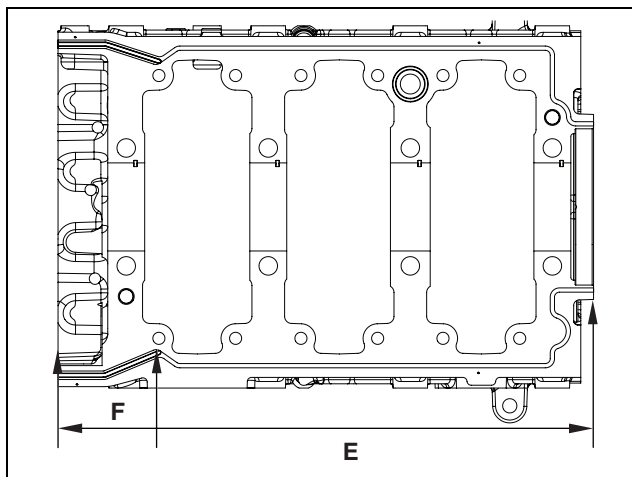
Crankshaft main journal diameter	Specified Value
Class A	57.955 ~ 57.960 mm
Class B	57.960 ~ 57.965 mm
Class C	57.965 ~ 57.970 mm

Note) For the method to measure the crankshaft main journal diameter, refer to Chapter 13 Others/Driving Units.

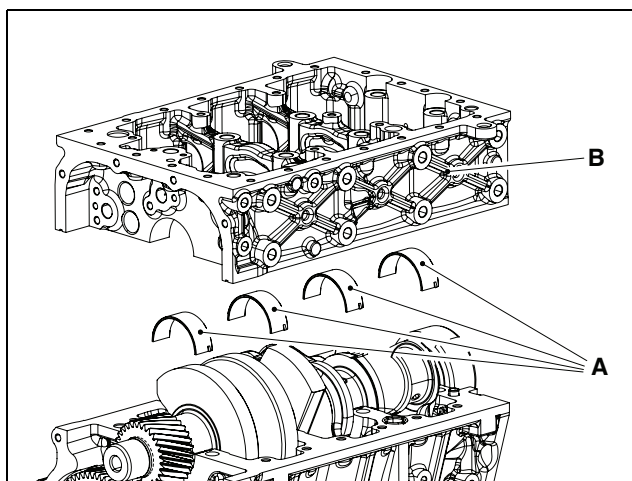
Main bearing thickness	Specified Value
BLUE	1.995 ~ 2.000 mm
YELLOW	2.000 ~ 2.005 mm
RED	2.005 ~ 2.010 mm

6. About the engine

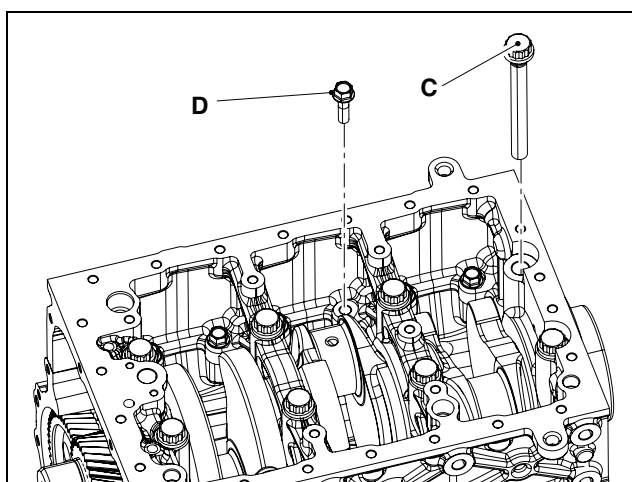
5. Attach the crank case.



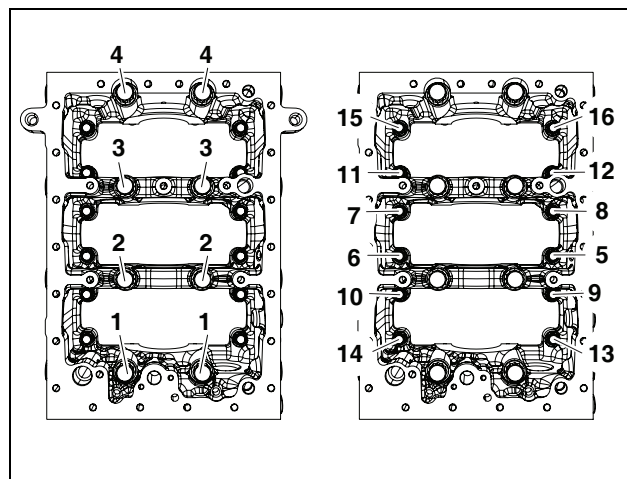
EDL013048A



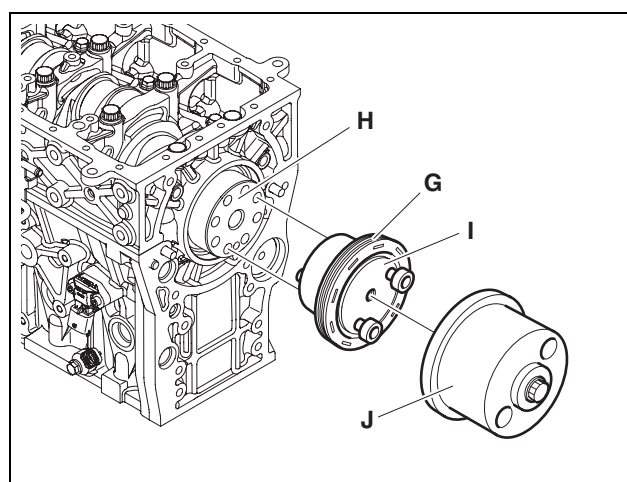
EDL013043A



EDL013042A



EDL013049A



EDL013050A

- 1) Apply 4 lower main bearings (A) to the crank case.

CAUTION

- Bearings with a groove are the upper main bearings on the cylinder block side and bearings without a groove are the bottom main bearings on the crank case side.
- Do not apply engine oil on the surface where the cylinder block and the main bearings are assembled.
- 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 engraving positions, see the Engine Unique Number of Chapter 3 (Performance and Specifications).
- Select the proper main bearing class by checking or measuring the class of main bearing bore inside diameter of the cylinder block and the class of main journal diameter of the crankshaft.
- The upper main bearing class should be same with the lower main bearing class.

6. About the engine

- 2) Sufficiently apply engine oil on the surface where the lower main bearings and the crankshaft are assembled.
- 3) Apply LOCTITE 5902 on the crank case assembly surface. Apply it on the rear part of the engine (F) with the diameter $\varnothing 6 \pm 0.5$ mm and on the front part of the engine (E) with the diameter $\varnothing 3 \pm 0.5$ mm.

CAUTION

- Keep clean liquid gasket dispensing surface.
- Dispensing line should not be snapped.

- 4) Attach the crank case(B).

CAUTION

- Be careful to attach the cylinder block and the crank case in the right direction.
 - Assemble bed plate in 5 minutes after dispensing liquid gasket.
 - Do not pressurize inside crank case in 25 minutes after dispensing liquid gasket.
 - Remove all liquid gasket inside oil seal bore and front/rear side of crank case after assembly
- 5) Temporarily mount 8 main bearing cap bolts (C) in order from (1) - (4).
 - 6) Tighten 8 main bearing cap bolts (C) at a tightening torque of $5.5 \text{ kgf}\cdot\text{m} (\pm 5\%) + 90^\circ (\pm 4^\circ) + 90^\circ (\pm 4^\circ)$ by using the angle method.

CAUTION

- Tighten the main bearing cap bolts with the angle method.
 - Tighten the main bearing cap bolts in order from (1) - (4). The front engine direction is the water pump direction and the rear engine direction is the flywheel direction.
 - Attach the crank case by tightening the main bearing cap bolts and then the collared hex bolts.
- 7) Temporarily tighten 16 collared hex bolts in order from (5) - (16).
 - 8) Tighten 12 collared hex bolts (D) at a tightening torque of $2.2 \text{ kgf}\cdot\text{m}$.

CAUTION

- Tighten collared hex bolts in order from (5) - (16). The front engine direction is the water pump direction and the rear engine direction is the flywheel direction.
 - Rotate the crankshaft 2 or 3 times to check for defects.
- 9) The crankshaft end play is $0.1 \sim 0.31$ mm.

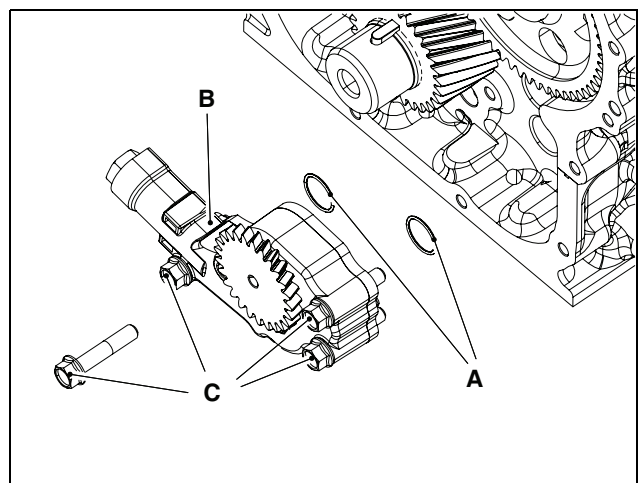
Item	Specified Value
Crankshaft end play	$0.1 \sim 0.31$ mm

- 10) Attach the rear oil seal assembly jig (860104-02048) to the rear oil seal (G) of guide (I).
- 11) Attach the rear oil seal assembly jig (860104-02048) guide (I) to the crankshaft (H).
- 12) Mount the rear oil seal assembly jig (860104-02048) holder (J) to the guide (I).
- 13) Turn the bolt on the center of the rear oil seal assembly jig until the rear oil seal assembly jig (860104-02048) holder (J) contacts with the cylinder block surface and the crank case surface and press in the rear oil seal (G).

CAUTION

- Be careful in noting the direction of the oil seal assembly and ensuring that the oil seal surface faces the outside of the engine.
- Be careful of the depth of the oil seal when attaching it.
- Be careful not to damage the oil seal.
- Attach the oil seal without applying lubrication, coolant, fuel, LOCTITE, or silicon.
- Remove foreign substances such as residues and LOCTITE from the oil seal assembly bore.
- Do not reuse the oil seal; replace it with a new one.
- Be careful not to damage the oil seal when attaching it.

6. Attach the oil pump.



EDL013041A

- 1) Align 2 O-rings (A) to the engine oil inlet and outlet.
- 2) Align the oil pump (B) with the pin and press it to the cylinder block as much as possible.

6. About the engine

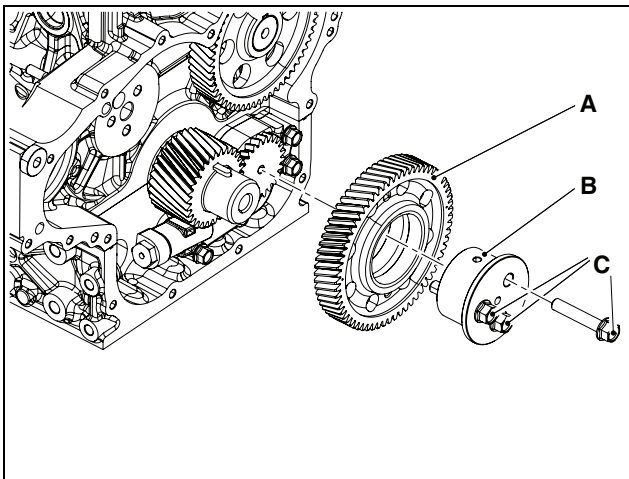
- 3) Tighten 4 hex bolts (C) at a tightening torque of 2.2 kgf•m.
- 4) The backlash between the crankshaft gear and the oil pump gear is 0.006 ~ 0.259 mm.

Item	Specified Value
Backlash between the crankshaft gear and the oil pump gear	0.06 ~ 0.259 mm

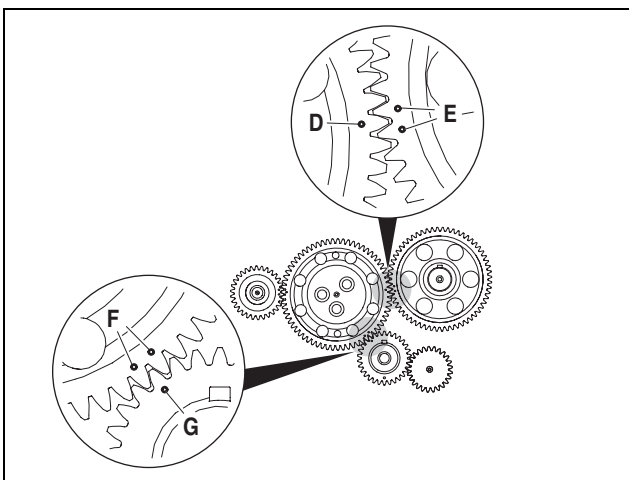
⚠ CAUTION

- Make sure that the O-rings have been mounted.
- Be careful not to damage the O-rings while mounting them.

7. Attach the idle gear.



EDL013040A



EDL022052A

- 1) Apply engine oil to the inside of the idle gear bush in the idle gear.
- 2) Attach the idle gear (A).

⚠ CAUTION

Make sure that you are attaching the idle gear so that its engraving faces the outside of the cylinder block.

- 3) Position the idle gear engraving (D) between the camshaft gear engravings (E).

Note) You can see two camshaft gear engravings and one idle gear engraving.

⚠ CAUTION

Make sure that the idle gear engraving is positioned between the two camshaft gear engravings.

- 4) Position the crankshaft gear engraving mark (G) between the idle gear engravings (F).

Note) You can see one crankshaft gear engraving and two idle gear engravings.

⚠ CAUTION

Make sure that the crankshaft gear engraving is positioned between two idle gear engravings.

- 5) Align the flange hex holes of the cylinder block to those of the idle gear shaft.
- 6) Attach the idle gear shaft (B).

⚠ CAUTION

Make the oil hole of the idle gear shaft(B) face the top surface of the cylinder block.

- 7) Tighten 3 flange hex bolts (C) at a tightening torque of 4.4 kgf•m.
- 8) Backlash of the idle gear and the crankshaft gear is 0.087 ~ 0.200 mm.

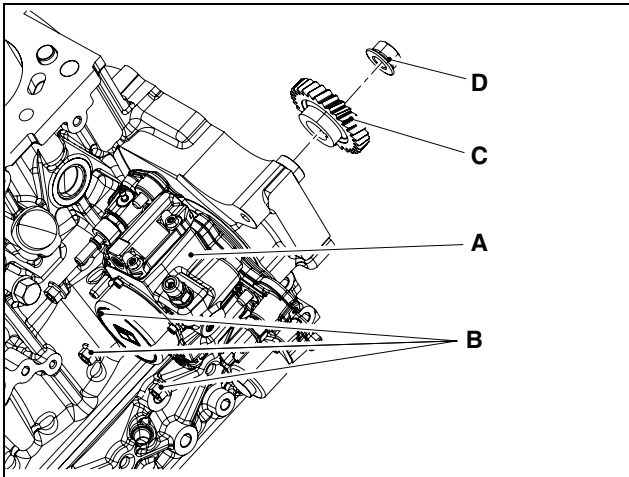
Item	Specified Value
Backlash between the idle gear and the crankshaft gear	0.087 ~ 0.200 mm

- 9) The backlash between the idle gear and the camshaft gear is 0.087 ~ 0.211 mm.

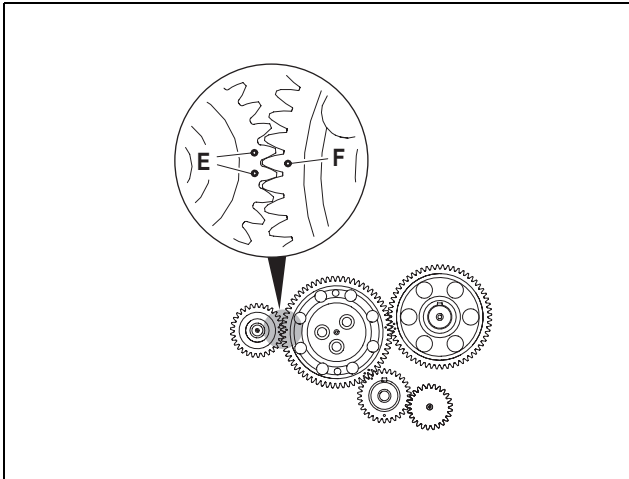
Item	Specified Value
Backlash between the idle gear and the camshaft gear	0.087 ~ 0.211 mm

6. About the engine

8. Attach the fuel injection pump.



EDL013039A



EDL013051A

1) Attach the fuel injection pump(A).

Note) To replace stud bolts, apply LOCTITE 272 to the stud bolts and then press in those bolts.

2) Tighten 3 flange hex nuts (B) at a tightening torque of 2.2 kgf•m.

3) Be careful to mount the injection pump drive gear (C) with attention to the pin direction.

Note) If the gear mark is visible, place the idle gear mark between the marks of the fuel injection pump drive gear. But if not visible, install the fuel injection pump regardless of the position of gear mark.

⚠ CAUTION

- Ensure that you are attaching the injection pump drive gear so that its engraving faces the outside of the cylinder block.
- Ensure that the pin direction is the opposite direction of the idle gear.

4) Position the idle gear engraving (F) between the injection pump drive gear engravings (E).

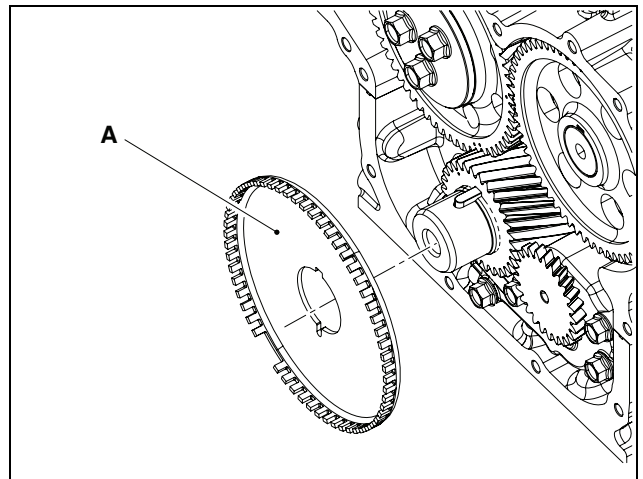
Note) You can see two injection pump drive gear engravings and one idle gear engraving.

5) The backlash between the fuel injection pump and the idle gear is 0.087 ~ 0.2 mm.

Item	Specified Value
Backlash between the fuel injection pump and the idle gear	0.087 ~ 0.2 mm

6) Tighten the flange hex nuts (D) at a tightening torque of 6.5 ± 0.5 kgf•m.

9. Attach the timing wheel.



EDL013038A

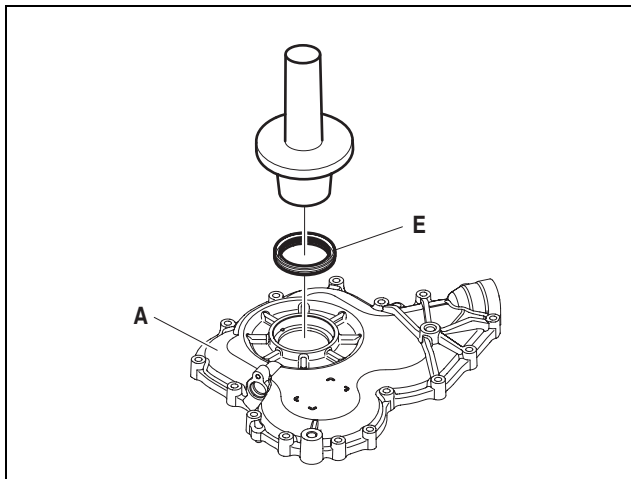
1) Attach the timing wheel (A).

⚠ CAUTION

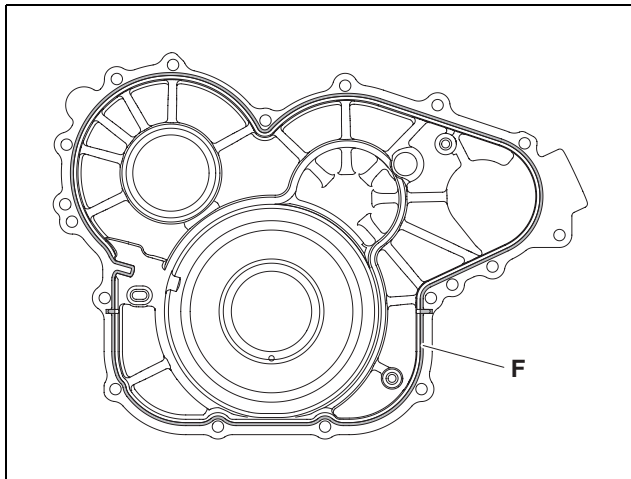
Be careful not to damage the teeth of the timing wheel.

6. About the engine

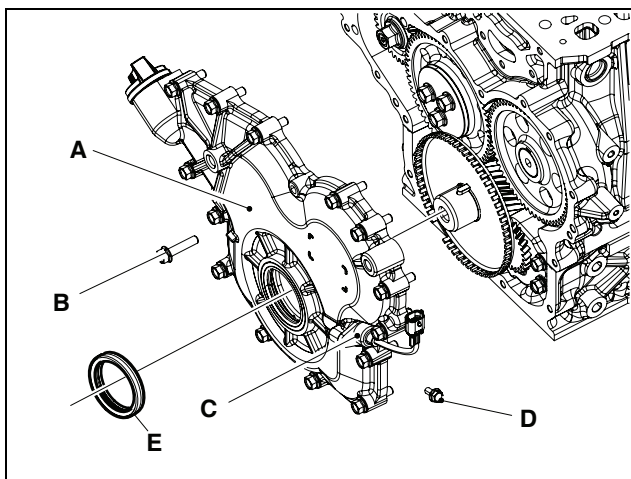
10. Attach the timing gear case.



EDL013052A



EDL013053A



EDL013037A

- 1) Make the assembly surface of the timing gear case face the ground.
- 2) Mount the front oil seal (E) to the front oil seal assembly jig (860104-02047).
- 3) Align the front oil seal assembly jig (860104-02047) where the front oil seal (E) is mounted to

the timing gear case (A) and beat it with a rubber hammer.

- 4) when the front oil seal (E) is inserted to the timing gear case(A), pull off the front oil seal assembly jig (860104-02047).

⚠ CAUTION

- Be careful in noting the direction of the oil seal assembly and ensuring that the oil seal surface faces the outside of the engine.
- Be careful of the depth of the oil seal when attaching it.
- Be careful not to damage the oil seal.
- Attach the oil seal without applying lubrication, coolant, fuel, LOCTITE, or silicon.

⚠ CAUTION

- Remove foreign substances such as residues and LOCTITE from the oil seal assembly bore.
- Do not reuse the oil seal; replace it with a new one.
- Be careful not to damage the oil seal when attaching it.

- 5) Remove the foreign substances on the timing gear case assembly surface and clean it with a dry cloth.
- 6) Apply LOCTITE 5902 to the timing gear case assembly surface (F) with the diameter of $\varnothing 2.5 \pm 0.5\text{mm}$.

⚠ CAUTION

- Keep clean liquid gasket dispensing surface.
- Dispensing line should not be snapped.

- 7) Align the timing gear case (A) with the pin and attach it.

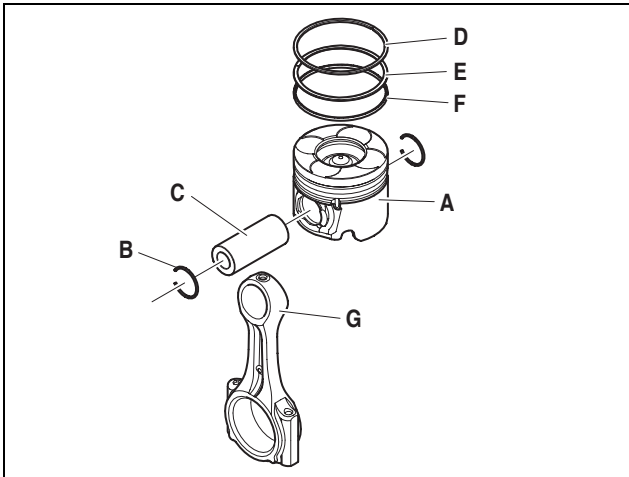
⚠ CAUTION

- Be careful that the timing gear case has been attached in the right direction.
- Assemble the timing gear case in 5 minutes after dispensing liquid gasket.
- Do not pressureize inside the timing gear case in 25 minutes after dispensing liquid gasket.

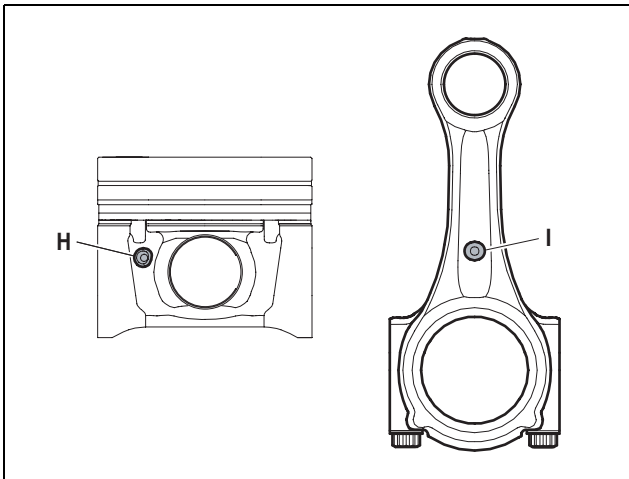
- 8) Tighten 16 hex bolts (B) at a tightening torque of $2.2\text{kgf}\cdot\text{m}$.
- 9) Attach the crank speed sensor (C).
- 10) Tighten the fixing bolt (D).

6. About the engine

11. Attach the piston.



EDL022038A



EDL022054A

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

CAUTION

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

- 2) Apply engine oil on the piston pin (C).
- 3) Align the pin hole of the connecting rod small-end with that of the piston (A).

CAUTION

- Be careful to mind the direction when attaching the piston and the connecting rod.
- Place the product number on the top surface of the piston, the larger side of the valve contact. and the bumpy side of the piston to make them face the front of the cylinder block.
- Make the bumpy side of the connecting rod face the front of the cylinder block.
- Make the direction of the bumpy side of the piston the same as that of the bumpy side of the connecting rod.
- The class of the inside diameter of the cylinder block piston bore is engraved on the cylinder block and the piston class is engraved on the top surface of the piston. For the engraving positions, see the Engine Unique Number of Chapter 3 (Performance and Specifications).
- Check or measure the class of the inside diameter of the cylinder block piston bore and the cylinder block piston to select a suitable piston class.
- Be careful in noting the direction of the piston and the connecting rod when attaching them.
- Make the direction of the bumpy side (H) of the piston the same as that of the bumpy side (I) of the connecting rod.
- If the gap between the piston ring and the small end of the connecting rod is out of the range of 0.025 - 0.043, replace the more worn of the two.

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	O	-
Class B	-	O

Inside Diameter of Cylinder Block Piston Bore	Specified Value
Class A	89.990 ~ 90.000 mm
Class B	90.000 ~ 90.010 mm

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

Piston	Specified Value
Class A	89.920 ~ 89.930 mm
Class B	89.930 ~ 89.940 mm

Note) The piston class is engraved on the top surface of the piston.

- 4) Attach the piston pin (C).

6. About the engine

⚠ CAUTION

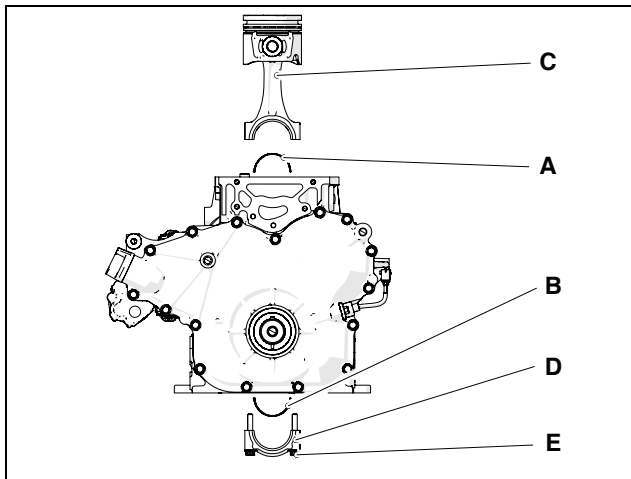
- Check the attached piston and piston ring. If the piston should be replaced, replace the piston pin along with the piston.
- The gap between the piston pin bore and the piston pin should be within the range from 0.008 mm to 0.019 mm.

5) Mount 2 snap rings (B) on the both ends of the piston.

⚠ CAUTION

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

12. Attach the connecting rods assembly.



EDL013036A

1) Attach the upper connecting rod bearings (A) and the lower connecting rod bearings (D).

⚠ CAUTION

- Regardless of the tolerance of the connecting rod or the crankshaft, select the top connecting rod bearings and the bottom connecting rod bearings with the yellow-marked class.
- Do not use the upper connecting rod bearings and the lower connecting rod bearings with the blue-marked or red-marked class when repairing the engine.
- Do not apply engine oil to the assembly part of the connecting rods and the bearings.
- You can see the oil gap by comparing the connecting rod bearing bore with the crankshaft pin outside diameter.

Note) The class of the connecting rod bearing is as follows.

Thickness of connecting rod bearing	Specified Value
YELLOW	1.498 ~ 1.502 mm

- 2) Sufficiently apply engine oil on the inside of the cylinder block bore and the connecting rod bearings.
- 3) Mount the piston and the connecting rods assembly (C) to the cylinder block with the piston insertion tool (EF.120-208).

⚠ CAUTION

- Be careful to mind the direction when attaching the piston and the connecting rod.
- Make the bumpy side of the connecting rod face the front of the cylinder block.

⚠ CAUTION

- The front engine direction is the water pump direction and the rear engine direction is the flywheel direction.
- Be careful not to damage the piston and the piston rings.

4) Attach the connecting rod caps (D).

⚠ CAUTION

- Be careful to mind the direction when attaching the connecting rods and the connecting rod caps.
- Ensure that the number engraved on the connecting rods is same with that engraved on the connecting rod caps and the assembly direction is same.

5) Temporarily tighten 6 connecting rod bolts (E) by hand.

⚠ CAUTION

Do not reuse connecting rod bolts; replace them with new ones.

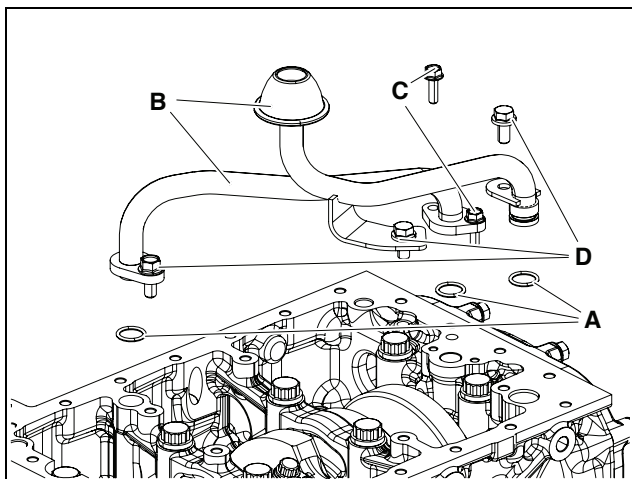
6) Tighten 6 connecting rod bolts (E) at a tightening torque 2.0 kgf·m + 90° by using the angle method.

⚠ CAUTION

After attaching the connecting rods, rotate the crankshaft 2 or 3 times to check whether there is any interference.

6. About the engine

13. Attach the oil suction pipe and oil delivery pipe.

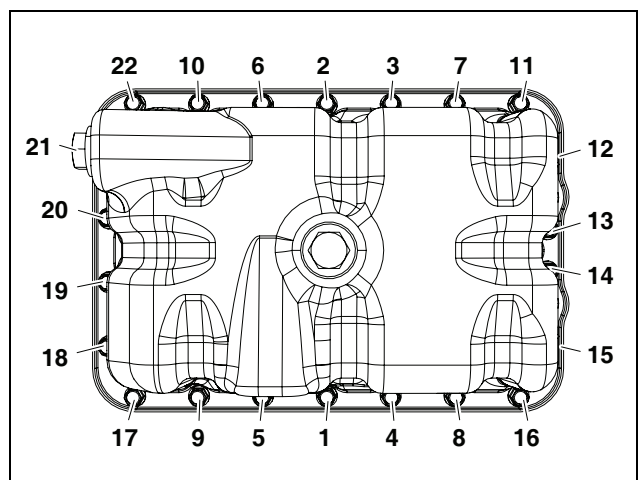
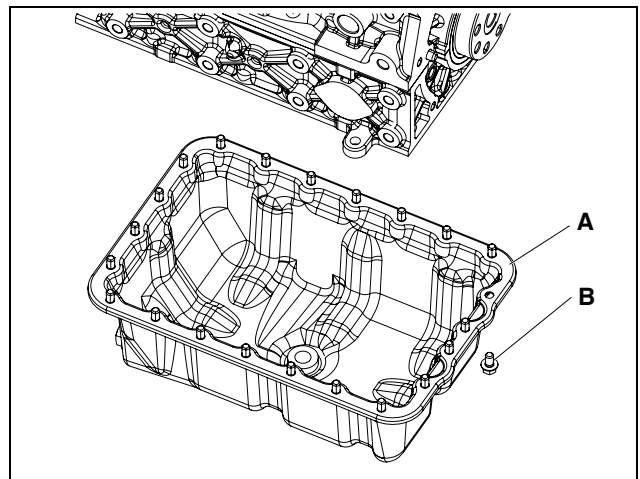
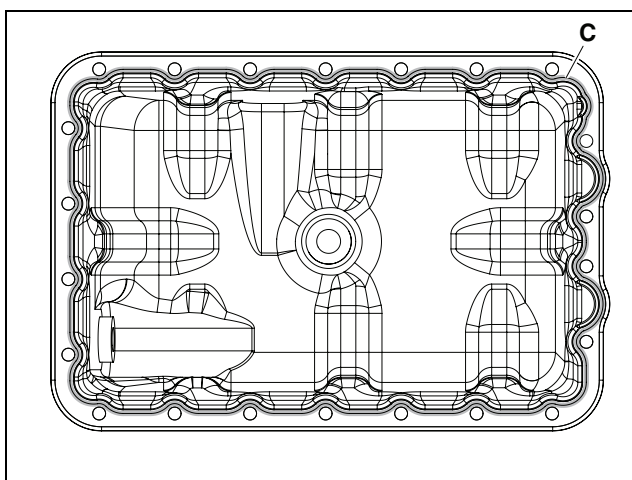


- 1) Attach 3 O-rings (A).
- 2) Attach the oil suction pipe and the oil delivery pipe (B).
- 3) Tighten 2 hex bolts (C) at a tightening torque of $1.0 \pm 0.3 \text{ kgf}\cdot\text{m}$.
- 4) Tighten 3 hex bolts (D) at a tightening torque of $2.2 \pm 0.3 \text{ kgf}\cdot\text{m}$.

CAUTION

- Ensure that the O-rings of the inlet and the outlet have been mounted.
- Be careful not to damage the O-rings while mounting them.

14. Attach the oil pan.



- 1) Apply LOCTITE 5902 to the oil pan assembly surface (C) with the diameter of $\varnothing 3 \pm 0.5 \text{ mm}$.

CAUTION

- Keep clean liquid gasket dispensing surface.
- Dispensing line should not be snapped.

- 2) Attach the oil pan (A).

CAUTION

- Be careful that the oil pan has been attached in the right direction.
- Assemble oil pan in 5 minutes after dispensing liquid gasket.
- Do not pressurize inside oil pan in 25 minutes after dispensing liquid gasket.

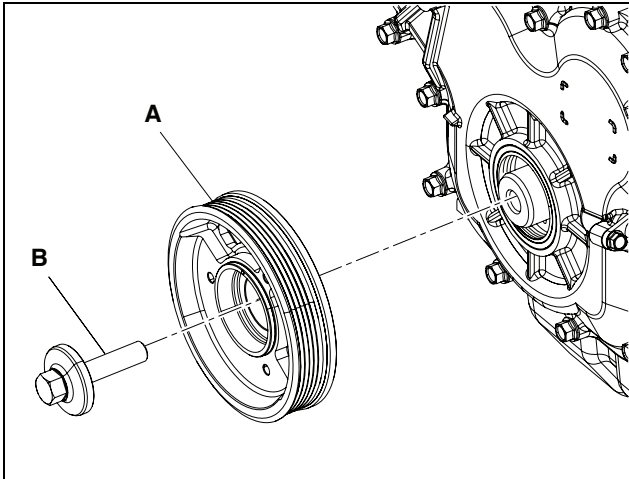
- 3) Tighten 22 flange hex bolts (B) at a tightening torque of $2.2 \text{ kgf}\cdot\text{m}$.

6. About the engine

CAUTION

Tighten flange hex bolts in the order from (1) - (22). The front engine direction is the water pump direction and the rear engine direction is the flywheel direction.

15. Attach the crankshaft pulley.



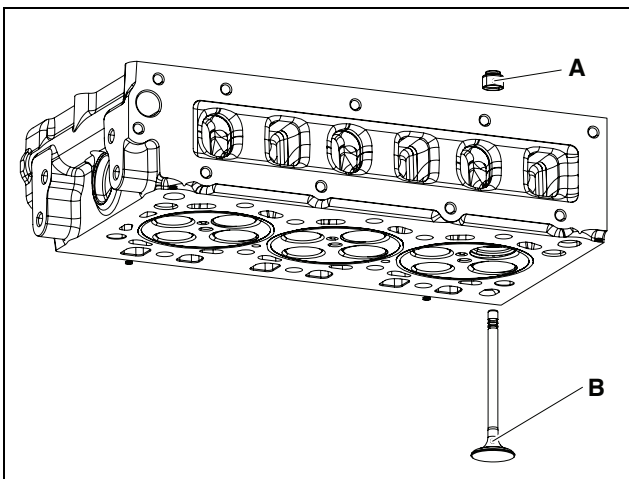
EDL013033A

- 1) Align the crankshaft pulley (A) to the pin and attach it.
- 2) Apply LOCTITE Blue 587 to the inside of the flange hex bolts (B).
- 3) Tighten flange hex bolts (B) at a tightening torque of 26 kgf•m.

CAUTION

- Be careful not to damage the oil seal.
- Fix the crankshaft to allow the flange hex bolts to be tightened with the specified torque.

16. Attach the valves.



EDL013032A

- 1) Align the valve stem seal jig (860104-02041) to the valve stem seal (A) and beat it with a rubber hammer to press it in.

CAUTION

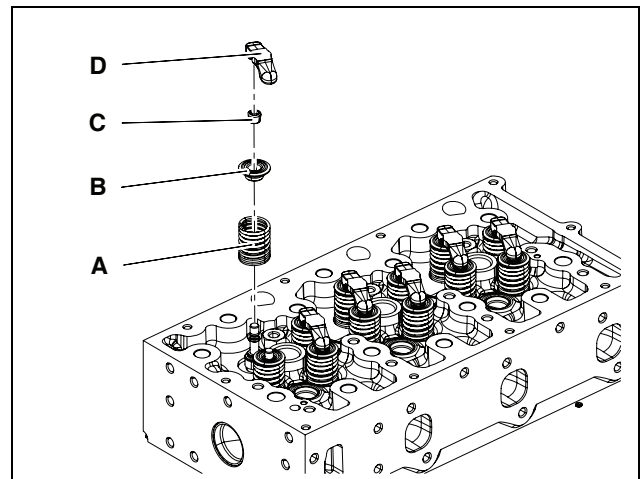
Do not give an excessive shock on the valve stem seals; otherwise, they may be damaged.

- 2) Apply engine oil on the surface where the valves and the valve stem seals are assembled.
- 3) Attach the valves (B).

CAUTION

- Be careful to use the right valve without confusing the intake valve with the exhaust valve.
- The intake valve has the larger valve head diameter and the exhaust valve has the smaller one.

17. Attach the valve springs.



EDL013031A

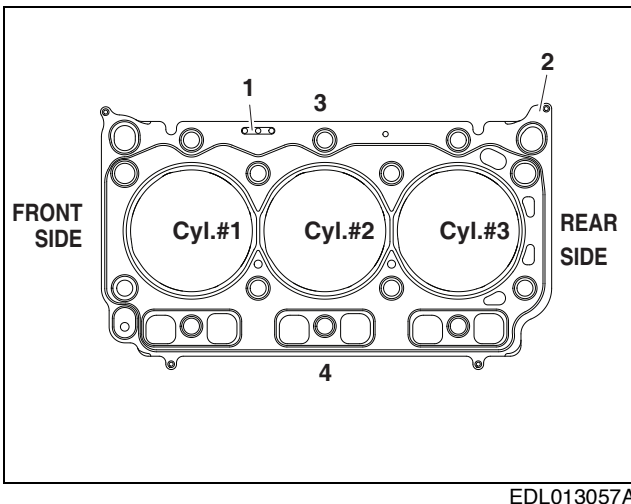
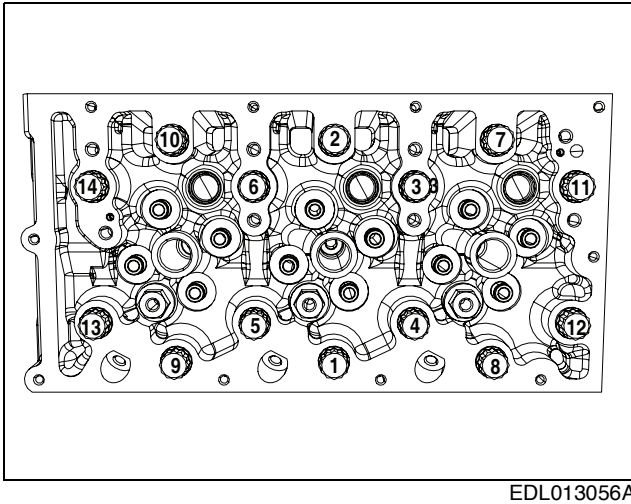
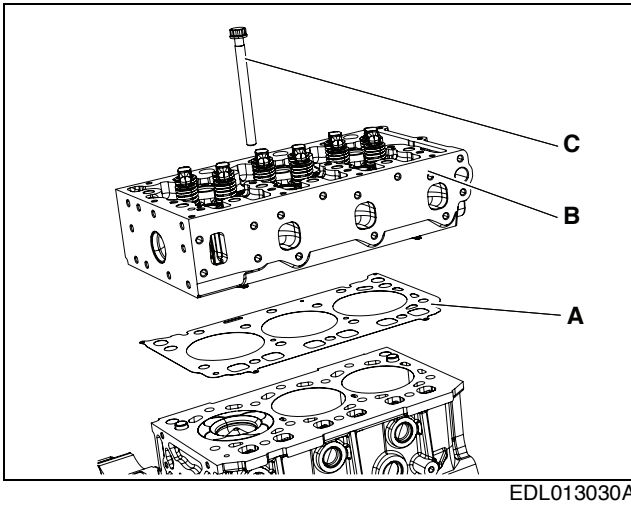
- 1) Attach the valve springs (A).
- 2) Attach the valve spring retainers (B).
- 3) Compress the valve with the valve spring compression tool (EF.120-262).
- 4) Attach the valve cotters (C).
- 5) Attach the calipers (D).

CAUTION

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

6. About the engine

18. Attach the cylinder head.



1. Identification mark of the cylinder head gasket
2. Cylinder head gasket mark
3. Intake manifold side
4. Exhaust manifold side

1) Align the cylinder head gasket (A) with the pin and mount it.

⚠ CAUTION

- Measure the step height of the piston top side and select the cylinder head gasket with the suitable mark. For methods to measure the step height of the piston top side, refer to Measurement of the step height of the piston top side in Chapter 13 (Others/Driving Units).
- Be careful to mind the direction when assembling the cylinder head gasket.
- Attach the cylinder head so that its identification mark and class mark face upward.
- Align the push rod hole, the cylinder head bolt hole, and the cylinder head gasket hole and attach the cylinder head.
- Do not reuse the cylinder head gasket but replace with new one.
- Mark A has one hole of the identification mark on the cylinder head gasket, Mark B has two holes, and Mark C has three holes.

Note) The Mark of the cylinder head gasket is as follows.

Head gasket grade			Piston Protrusion
Symbol (Mark)	Hole	Thickness	
A	1ea	0.9T	0.24 ~ 0.33 mm
B	2ea	1.0T	0.33 ~ 0.43 mm
C	3ea	1.1T	0.43 ~ 0.52 mm

Note) For method to measure the step height of the piston top side, refer to Measurement of the step height of the piston top side in Chapter 13 (Others/Driving Units).

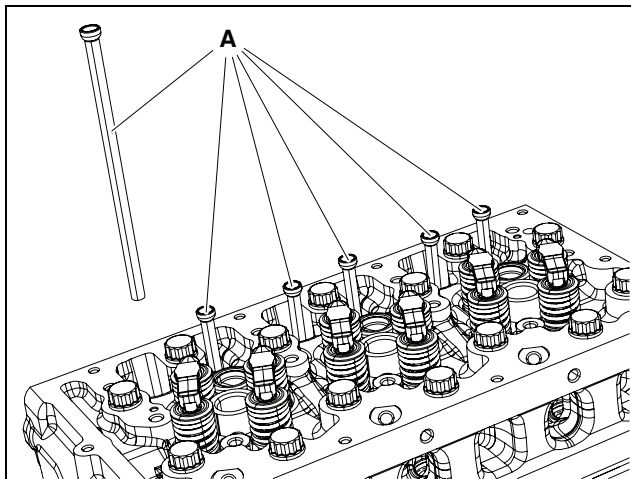
- 2) Attach the cylinder head (B).
- 3) Temporarily tighten 14 cylinder head bolts (C) in the order from (1) - (14).
- 4) Tighten 14 cylinder head bolts (C) at a tightening torque 8.7 kgf·m + 90° with the angle method.

⚠ CAUTION

- Tighten cylinder head bolts in order from (1) - (14).
- The front engine direction is the water pump direction and the rear engine direction is the flywheel direction.
- Do not reuse cylinder head bolts.
- Do not apply engine oil to the cylinder head bolts.

6. About the engine

19. Attach the push rods.



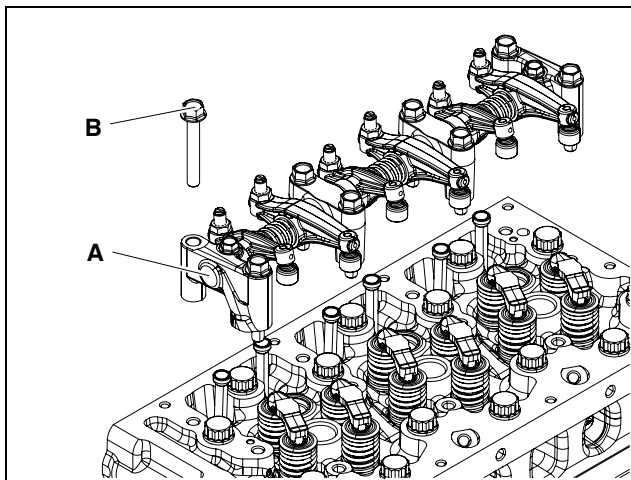
EDL013029A

- 1) Apply engine oil on both ends of the push rods.
- 2) Attach the push rods(A) in the cylinder head holes.
- 3) Hit the head of the push rods with a rubber hammer lightly once or twice to get them positioned in the tappet holes.

CAUTION

After connecting the push rods, rotate them to check the connection state.

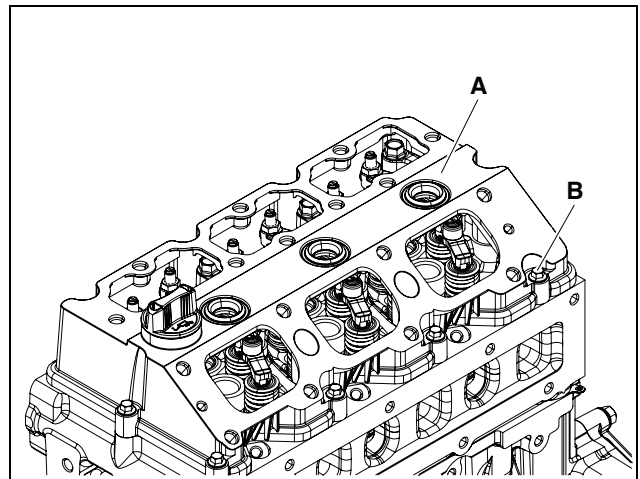
20. Attach the rocker arm.



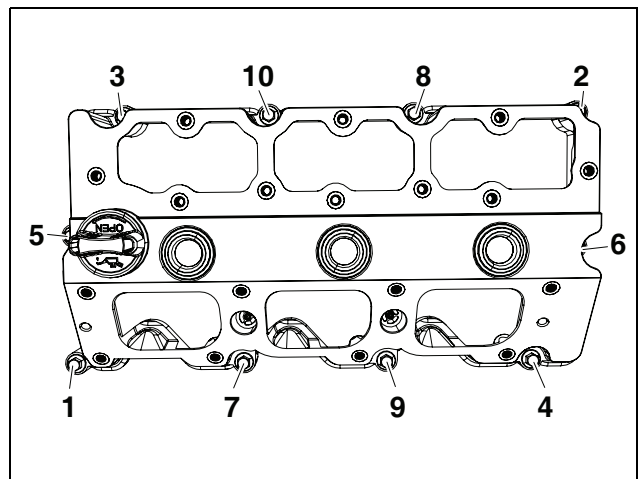
EDL013028A

- 1) Attach the rocker arm (A).
- 2) Tighten 8 flange hex bolts (B) at a tightening torque of $2.2 \pm 0.3 \text{ kgf}\cdot\text{m}$.

21. Attach the cylinder head cover.



EDL013027A



EDL013058A

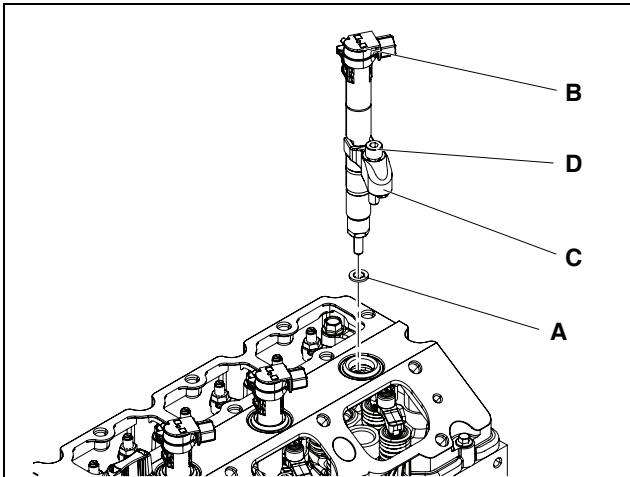
- 1) Attach the cylinder head cover (A).
- 2) Temporarily tighten 10 hex bolts (B) in the order of (1) ~ (10).
- 3) Tighten 10 hex bolts (B) at a tightening torque of $0.8 \text{ kgf}\cdot\text{m}$.

CAUTION

- Be careful not to allow the seal ring of the cylinder head cover to get out to the outside.
- Tighten the hex bolts of the cylinder head cover in the order from (1) ~ (10). The front engine direction is the water pump direction and the rear engine direction is the flywheel direction.
- Do not reuse the cylinder head rubber gasket but replace with new one.

6. About the engine

22. Attach the injectors.



EDL013026A

- 1) Align the injector seal ring washer (A) with the center of the injector hole and mount it.
- 2) Sufficiently apply engine oil on the cylinder head cover surface where the injectors contact.
- 3) Attach 3 injectors (B).

⚠ CAUTION

- Do not reuse the head cover rubber seal and the injector oil seal but replace with new ones.
- Attach injectors by slowly turning them to prevent damage to the cylinder head cover surface which contacts the injectors.
- Do not reuse the injector seal ring washers. Otherwise, critical damage to the engine may occur because of unstable combustion.

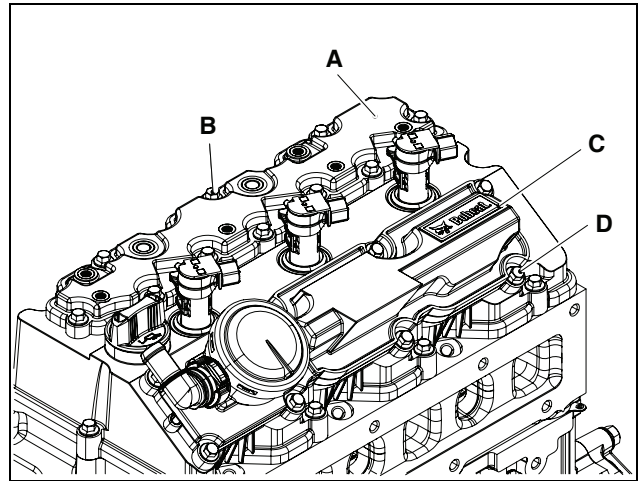
- 4) Mount 3 injector fixtures (C).
- 5) Temporarily tighten 3 hex bolts (D).

⚠ CAUTION

Do not tighten the hex bolts by force when it is difficult to tighten them temporarily. Forced tightening may cause damage to the cylinder head.

- 6) Tighten 3 hex bolts (D) at a tightening torque of 3.5 kgf•m.

23. Attach the right and left cylinder head cover.



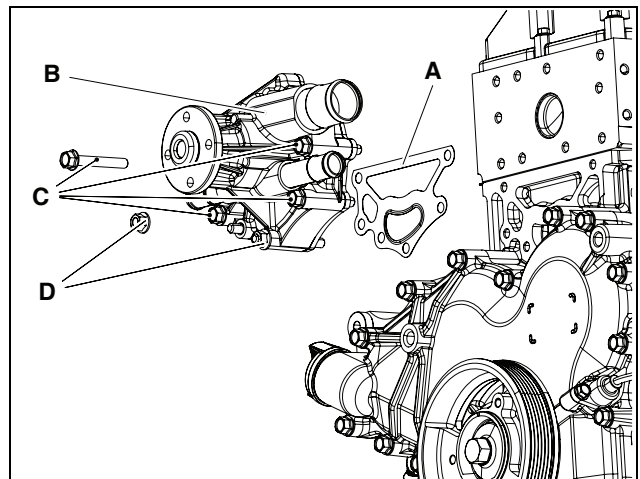
EDL013025A

- 1) Attach the left cylinder head cover (A).
- 2) Tighten 10 flange hex bolts (B) at a tightening torque of 1.0 kgf•m.
- 3) Attach the right cylinder head cover (C).
- 4) Tighten 8 flange hex bolts (D) at a tightening torque of 1.0 kgf•m.

⚠ CAUTION

Do not reuse the cylinder head cover rubber gasket but replace with new ones.

24. Attach the water pump.



EDL013024A

- 1) Align the gasket (A) with 2 stud bolts and attach it.
- 2) Align the water pump (B) with 2 stud bolts and attach it.

Note) To replace stud bolts, apply LOCTITE 272 to the stud bolts and then press in those bolts.

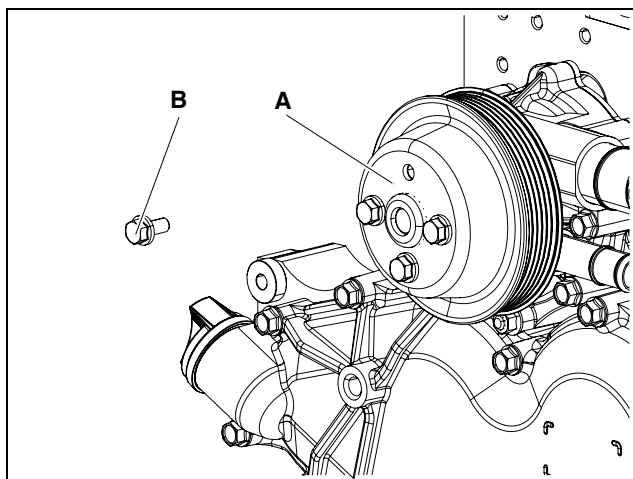
- 3) Tighten 4 hex bolts (C) and 2 flange hex nuts (D) at a tightening torque of 2.2 kgf•m

6. About the engine

CAUTION

- Do not allow the gasket to protrude from or be to one side of the water pump.
- Be careful not to damage the gasket while mounting it.

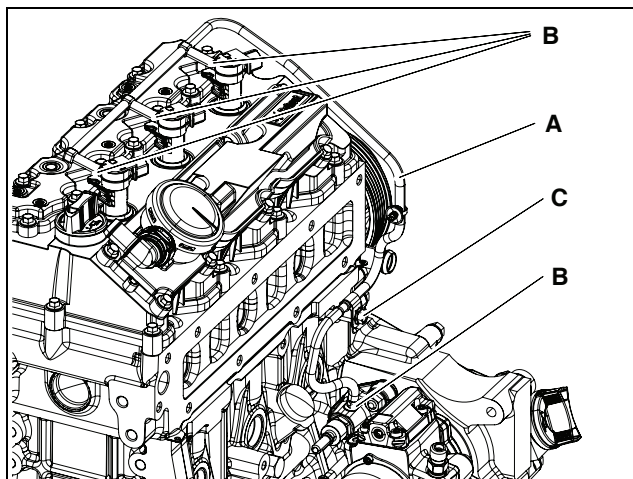
25. Attach the water pump pulley.



EDL013023A

- 1) Attach the water pump pulley (A).
- 2) Tighten 4 flange hex bolts (B) at a tightening torque of 2.2 kgf·m.

26. Connect the fuel return hose.



EDL013022A

- 1) Press the fuel return hose (A) into the end of the nipple and connect it.

CAUTION

- Be careful to note the direction when connecting the fuel return hose.
- The injector should be fully connected with the hose.

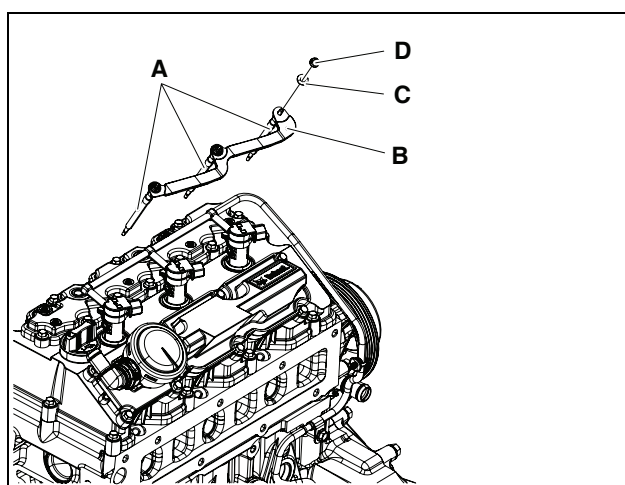
2) Attach the hose clips (B).

CAUTION

Fix the handle of hose clip to face the front of the engine.

3) Tighten the fixing bolt (C).

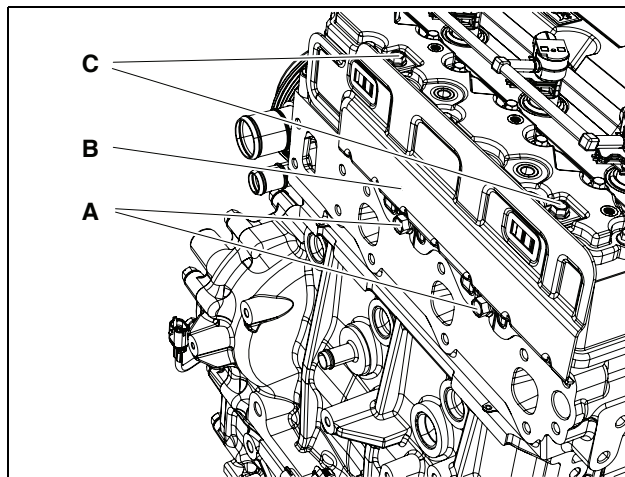
27. Attach the glow plug.



EDL013021A

- 1) Tightening 3 glow plugs (A) to the cylinder head at a tightening torque of 9~12 N·m.
- 2) Attach the electric connector (B).
- 3) Attach 3 washers (C).
- 4) Tighten 3 hex nuts (D) at a tightening torque of 2.5~3 N·m.

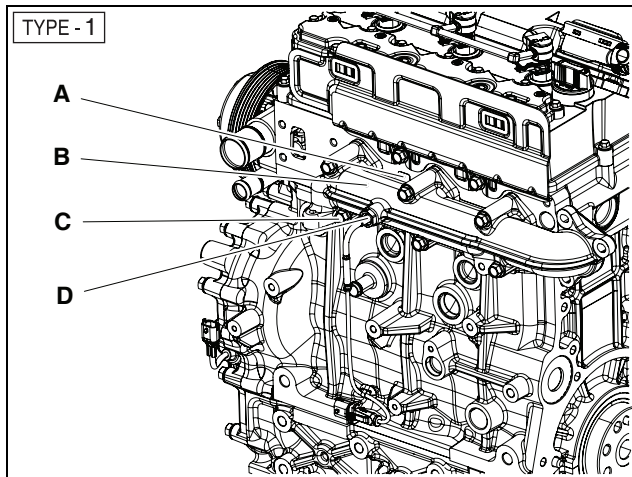
28. Attach the heat screen.



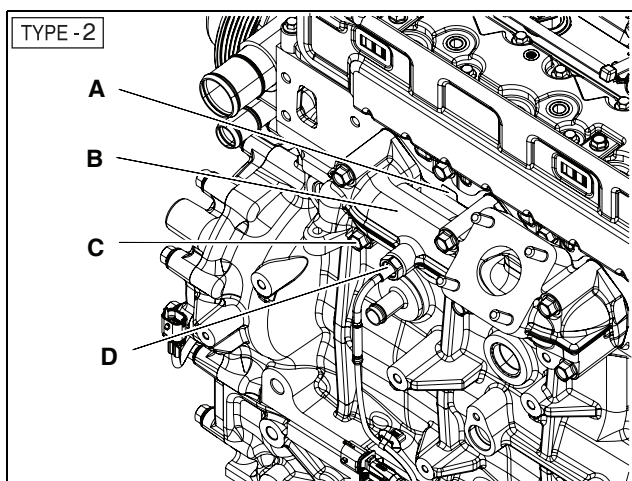
EDL013020A

6. About the engine

- 1) Temporarily tighten 2 hex bolts (A) to the exhaust manifold side.
 - 2) Attach the heat screen (B).
 - 3) Tighten 2 fixing bolts (C).
29. Attach the exhaust manifold.



EDL013018A



EDL013019A

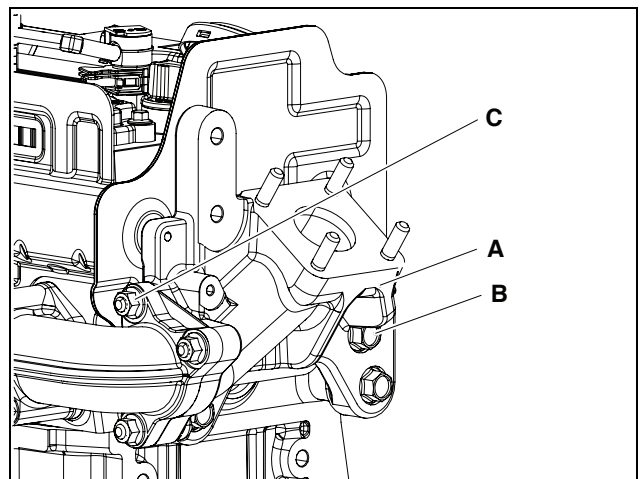
- 1) Attach the gasket (A) so that the TOP mark faces the top surface and the front of the engine.
- 2) Attach the exhaust manifold (B).

CAUTION

- Be careful to note the direction in which the gasket is mounted. Mount the gasket so that the TOP mark faces the front of the engine.
- Be careful not to damage the gasket while mounting it.

- 3) Tighten 6 flange hex bolts (C) at a tightening torque of 3.1 kgf•m.
- 4) Attach the exhaust gas temperature sensor (D).

30. Attach the exhaust manifold pipe (Only TYPE-1).

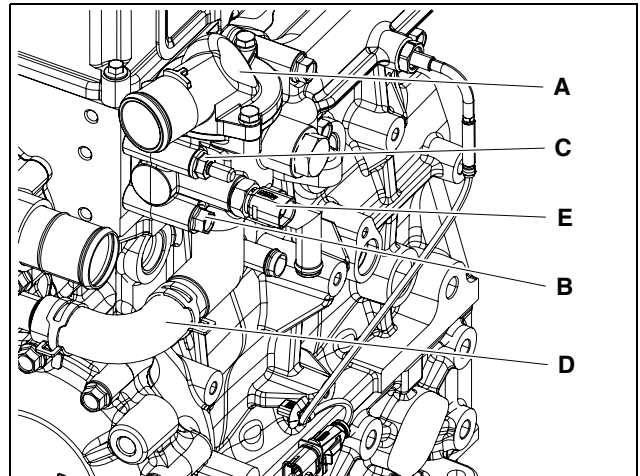


EDL013017A

- 1) Attach the exhaust manifold pipe (A).
- 2) Tighten 3 flange hex bolts (B) at a tightening torque of 4.4 kgf•m.
- 3) Tighten 3 hex nuts (C) at a tightening torque of 2.2 kgf•m.

Note) The exhaust manifold pipe (A) is only TYPE-1.

31. Attach the thermostat.



EDL013016A

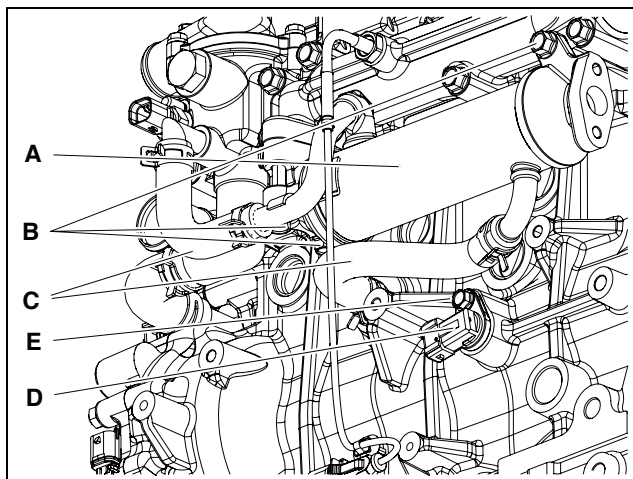
- 1) Attach the thermostat (A) to the cylinder head.
- 2) Tighten 3 flange hex bolts (B) at a tightening torque of 2.2 kgf•m.
- 3) Tighten the space bolt and the flange hex nut (C) at a tightening torque of 2.2 kgf•m.
- 4) Connect the rubber hose (D).
- 5) Attach the water temperature sensor (E).

6. About the engine

CAUTION

- After mounting the hose clamps, make the protrusion face the cylinder head side to prevent interference between the protrusion and the water pump pulley.
- Do not use the hose clamps more than twice; replace them with new ones.

32. Attach the EGR cooler assembly and the cam position sensor.



EDL013015A

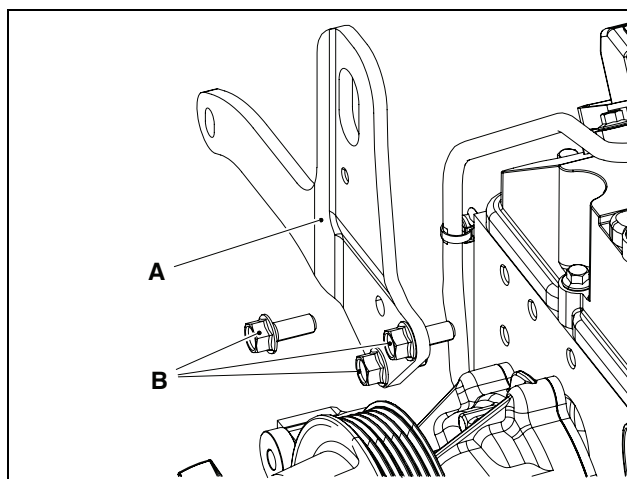
1) Attach the EGR cooler assembly(A).

CAUTION

Be careful to note the direction when mounting the EGR cooler.

- 2) Tighten 3 flange hex bolts(B) at a tightening torque of 3.1 kgf•m.
- 3) Connect the rubber hoses(C)
- 4) Attach the cam position sensor(D).
- 5) Tighten the fixing bolt(E).

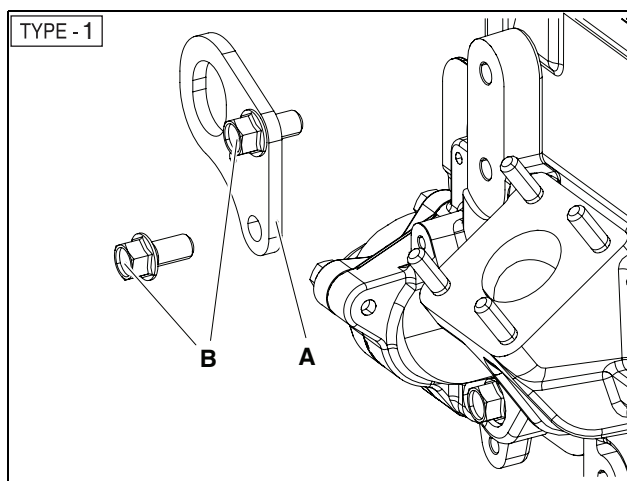
33. Attach the front lifting hook.



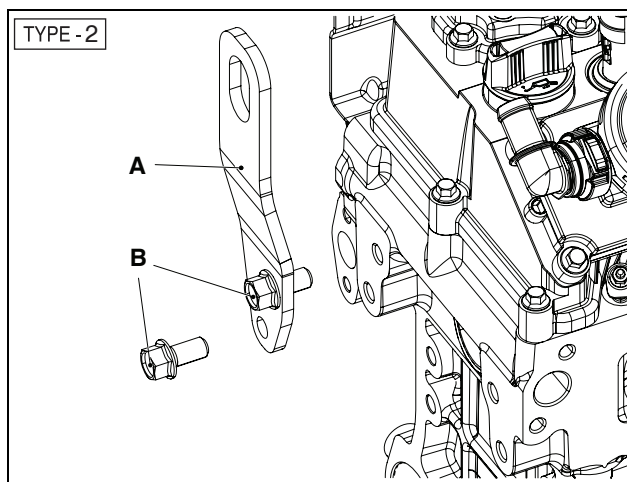
EDL013014A

- 1) Attach the front lifting hook(A).
- 2) Tighten 3 flange hex bolts(B) at a tightening torque of 2.2 kgf•m.

34. Attach the rear lifting hook.



EDL013012A



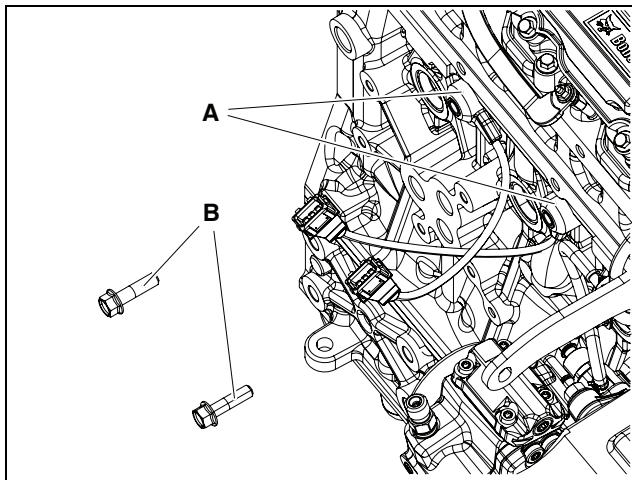
EDL013013A

- 1) Attach the rear lifting hook(A).

6. About the engine

- 2) Tighten 2 flange hex bolts (B) at a tightening torque of 4.4 kgf•m.

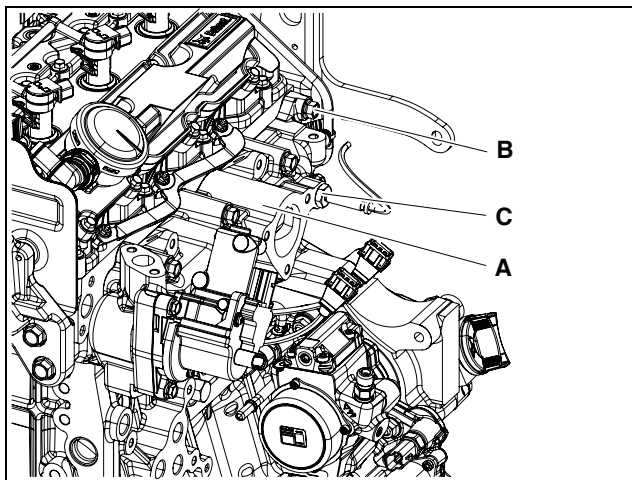
35. Attach the knock sensors.



EDL013011A

- 1) Attach 2 knock sensors (A) to the cylinder block.
- 2) Tighten 2 fixing bolts (B).

36. Attach the intake manifold.



EDL013010A

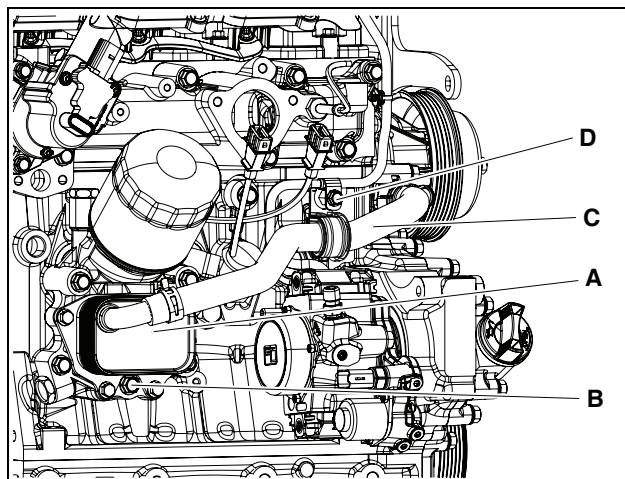
- 1) Attach the gasket and the intake manifold (A).

⚠ CAUTION

- Be careful to note the direction when mounting the gasket.
- Be careful not to damage the gasket while mounting it.

- 2) Tighten 8 flange hex bolts (B) at a tightening torque of 2.2 kgf•m.
- 3) Attach the boost temperature sensor (C).

37. Attach the oil filter assembly.



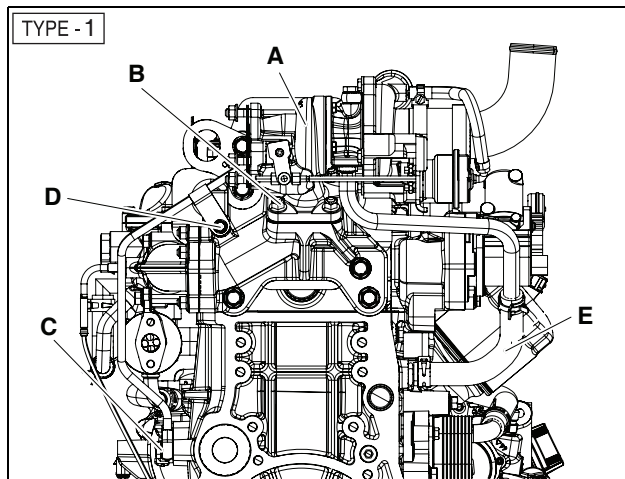
EDL013009A

- 1) Attach the 3 O-rings and the oil filter assembly (A).
- 2) Tighten 5 flange hex bolts (B).
- 3) Connect the coolant hose (C)
- 4) Tighten the fixing bolt (D).

⚠ CAUTION

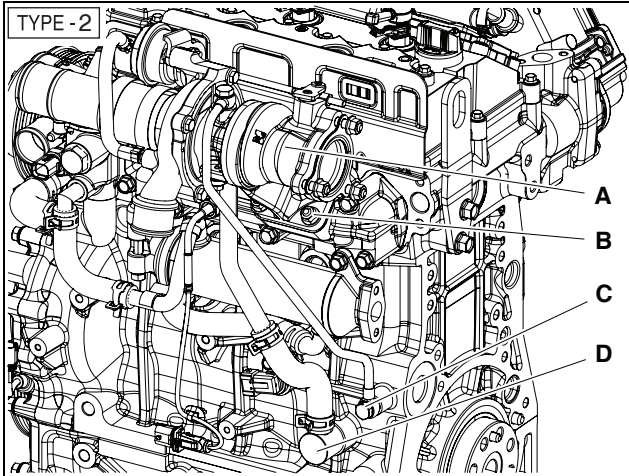
- Make sure that the O-rings have been mounted.
- Be careful not to damage the O-rings while mounting them.

38. Attach the turbocharger.



EDL013007A

6. About the engine



EDL013008A

- 1) Attach the gasket and the turbocharger(A).
- 2) Tighten 4 flange hex bolts (B) at a tightening torque of 2.2 kgf•m.
- 3) Connect the oil delivery pipe (C).
- 4) Tighten 2 hollow screws from the oil delivery pipe at a tightening torque of 2.0 kgf•m.

Note) Tighten the fixing bolt (D) if the engine is TYPE-1.

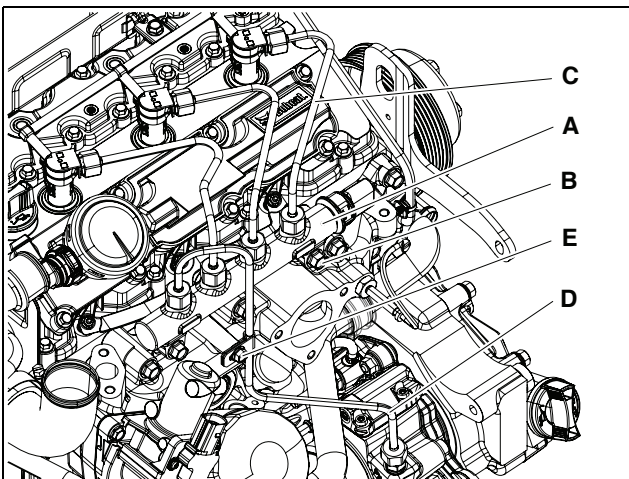
- 5) Connect the oil return pipe.

Note) The oil return pipe is that TYPE-1 is (E) and TYPE-2 is (D).

⚠ CAUTION

- Be careful to note the direction when connecting the hose and gasket.
- Be careful not to damage the gasket while mounting it.
- Do not reuse the hose clamps but replace them with new ones.
- Do not reuse the oil delivery pipe but replace it with new one.

39. Attach the common rail and the injection pipe.



EDL013006A

- 1) Attach the common rail (A) to the intake manifold.

⚠ CAUTION

- Be careful to note the direction when attaching the common rail.
- Be careful not to damage the common rail while attaching it.

- 2) Temporarily tighten 2 collared hex bolts (B) by hand.

- 3) Temporarily connect the fuel injection pipes (C) and (D) by hand.

⚠ CAUTION

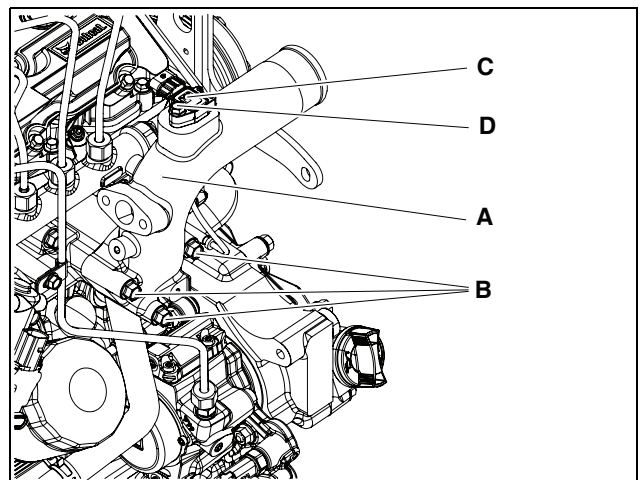
- Do not bend the fuel injection pipes by force.
- Be careful to note the direction when connecting the fuel injection pipes.
- Assemble the nut on one side of the fuel injection pipe first, and then the nut on the other side to connect the round part of the pipe to the correspondent part correctly.
- Do not reuse fuel injection pipes but replace them with new ones. Reusing fuel injection pipes may allow foreign substances into the fuel pipes or oil leaks from the bolt clamping to occur, causing a critical fault in engine performance.

- 4) Tighten 2 collared hex bolts(B) at a tightening torque of 2.2 kgf•m.

- 5) Tighten the fuel injection pipes (C) and (D) at a tightening torque of 3.0 kgf•m.

- 6) Tighten the fixing bolt (E).

40. Attach the intake stake.



EDL013005A

- 1) Attach the gasket and the intake stake(A).

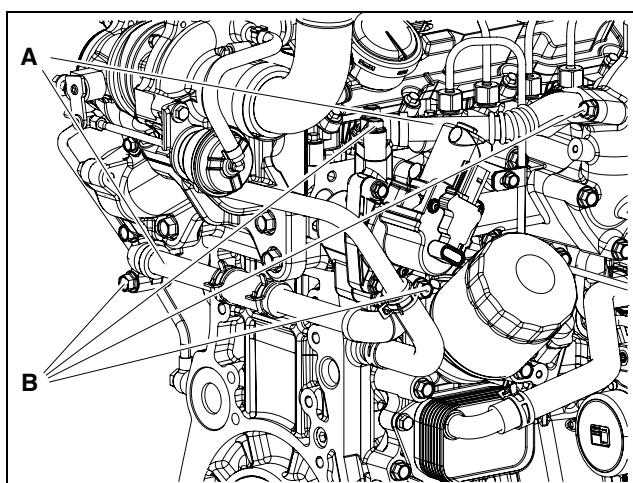
6. About the engine

CAUTION

- Be careful to note the direction when attaching the gasket.
- Be careful not to damage the gasket while attaching it.

- 2) Tighten 3 flange hex bolts (B) at a tightening torque of 2.2 kgf•m.
- 3) Attach the boost pressure sensor (C).
- 4) Tighten the flange hex bolt (D) at a tightening torque of 1.0 kgf•m.

41. Attach the EGR connection pipes.



EDL013004A

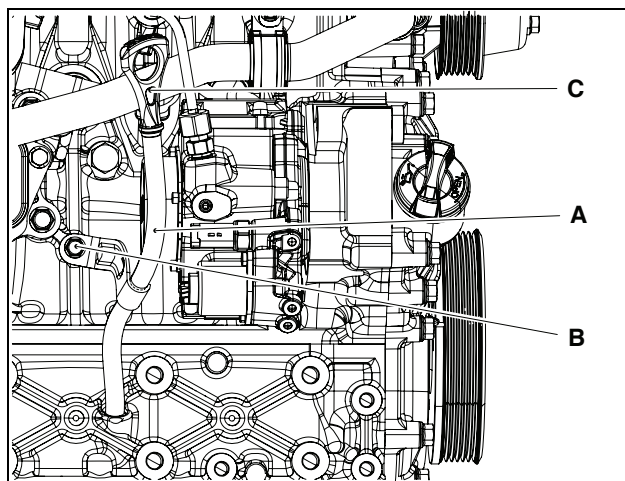
- 1) Attach 4 gaskets.
- 2) Attach the EGR pipes (A)

CAUTION

- Be careful to note the direction when attaching the the EGR connection pipe.
- Be careful not to damage the gasket while attaching it.

- 3) Tighten 6 fixing bolts (B) at a tightening torque of 2.2 kgf•m.

42. Attach the oil level gauge.



EDL013003A

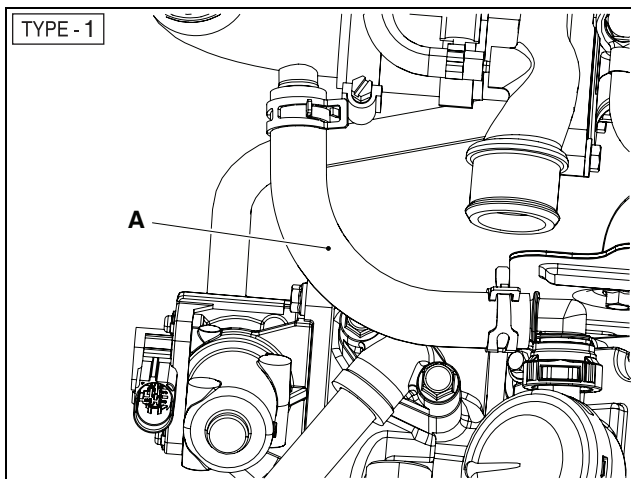
- 1) Attach the oil level gauge guide tube (A) in the cylinder block.
- 2) Tighen the flange hex bolt (B) at a tightening torque of 1.0 kgf•m.
- 3) Insert the oil level gauge (C).

CAUTION

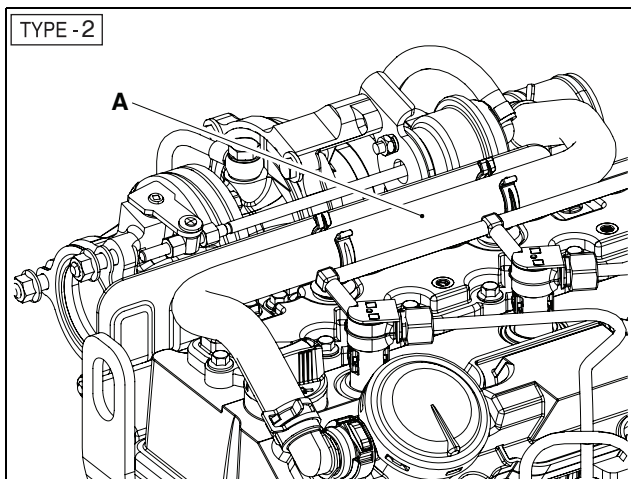
Make the handle of the oil level gauge face the reverse direction from the center of the engine.

6. About the engine

43. Attach the breather hose.



EDL013001A



EDL013002A

1) Attach the breather hose(A).

CAUTION

Do not use the clamps more than three times but replace them with new ones.

44. Attach the V-belt.

45. Connect the cables and harness connected to each sensor or the engine.

46. Install the engine to the machine.

47. Assemble the air cooler and the cooling fan on the engine.

48. Inject the engine oil.

1) Open the oil injection cap.

2) Inject engine oil.

WARNING

Use genuine engine oil recommended.

49. Inject coolant.

1) Open the radiator cap and add coolant.

WARNING

Use coolant recommended.

6. About the engine

7. Cooling System

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Cooling System

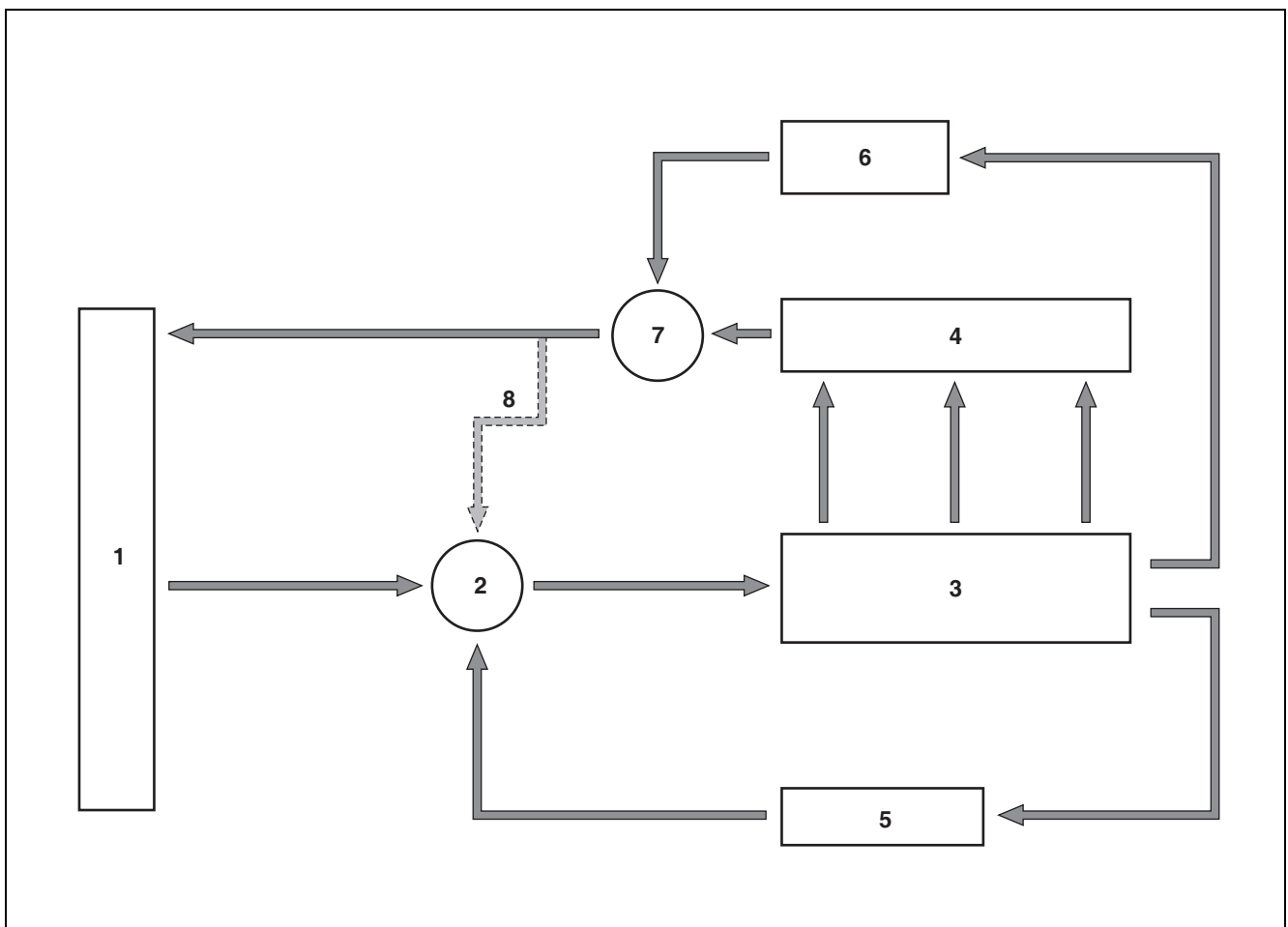
General Information

General Information

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

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

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



EDL022059C

- | | | |
|-------------------|------------------|---------------|
| 1. Radiator | 4. Cylinder head | 7. thermostat |
| 2. water pump | 5. Oil cooler | 8. Bypass |
| 3. Cylinder Block | 6. EGR cooler | |

7. Cooling System

Specifications

Item		D18NAP		Remark
		DL01-LEE00	DL01-LEL00	
Cooling system				
Cooling Type		Water-forced cooling	←	
Capacity of coolant		2.7 L	←	
Water pump	Type	Centrifugal (impeller type)	←	
	Driving Type	Ribbed-Belt driven	←	
	Pump Speed	2,640 rpm	3,360 rpm	
	Flow rate	1 : 1.1	1 : 1.2	
	Supply	Above 110 LPM	←	
	Pump back pressure	0.66 bar	←	
Cooling fan	Type	-	←	
	Driving Type	Directly connected to water pump	1 : 1.2	-
	Rotation Ratio (Engine RPM: fan RPM)	1:1.1	←	
Thermostat	Type	Wax pellet type	←	
	Valve-opening temperature	82 °C	←	
	Full valve-opening temperature	97 °C	←	
	Lift	8 mm	←	

7. Cooling System

Failure Diagnosis

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

7. Cooling System

Water pump

General Information

The water 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.

Water pump Disassembly

1. Drain coolant.
- 1) Check if the engine and radiator are cooled.
- 2) Place a container in front of the coolant drain plug.
- 3) Remove the radiator cap.
- 4) Remove the coolant drain plug of the radiator and then drain coolant.
- 5) After completing coolant drain, reconnect the coolant drain plug.

DANGER

- If the radiator cap is opened while the engine is hot, hot water will spurt out and may cause serious burns. Open the radiator cap after making sure that the engine has been fully cooled.
- Mark and separately manage the containers for storing coolant from beverage containers to avoid confusion. See a doctor immediately in case of drinking coolant.

WARNING

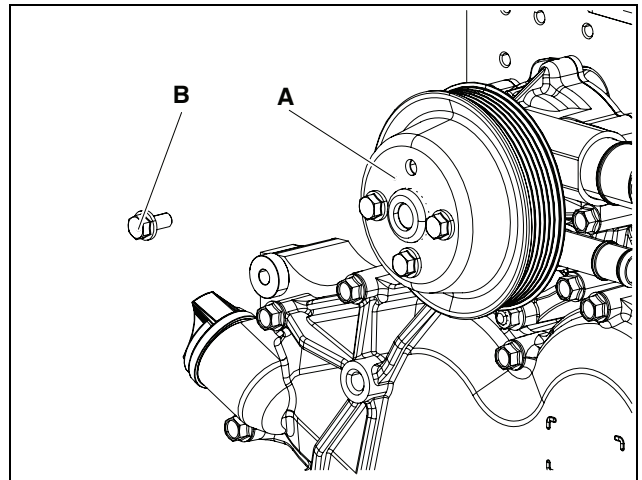
Discard coolant according to the regulations set forth by the relevant authorities. Disposing of discharged coolant into the ground, sewers, drains, rivers, or the sea will cause serious environmental pollution. Violation of regulations when discarding engine oil without observing the handling regulations,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

CAUTION

Be careful not to get coolant on any belts or electric apparatus when replacing the coolant.

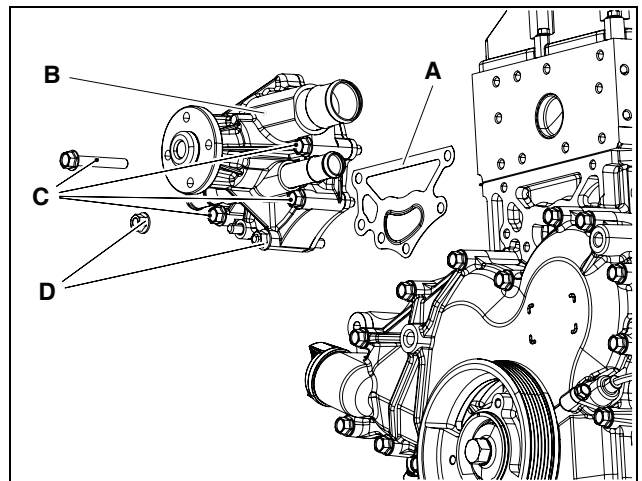
2. Remove the V-belt.

3. Remove the water pump pulley.



- 1) Loosen 4 flange hex bolts (B).
- 2) Remove the water pump pulley (A).

4. Remove the water pump.

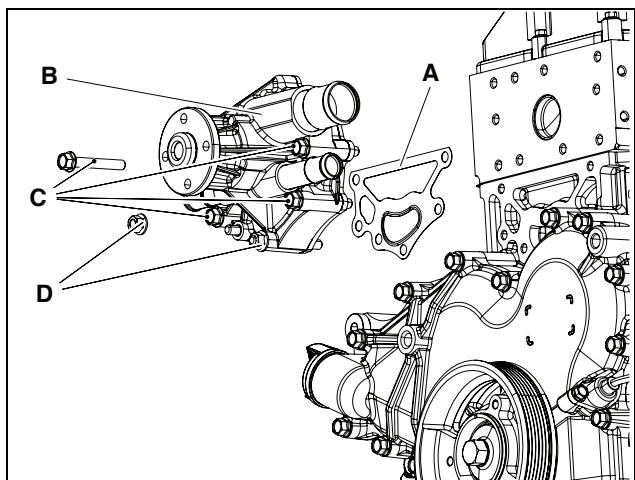


- 1) Loosen 2 flange hex nuts (D) and 4 hex bolts (C).
- 2) Remove the water pump (B) and the gasket (A).

7. Cooling System

Water pump Assembly

1. Attach the water pump.



EDL013024A

- 1) Align the gasket(A) with 2 stud bolts and attach it.
- 2) Align the water pump (B) with 2 stud bolts and attach it.

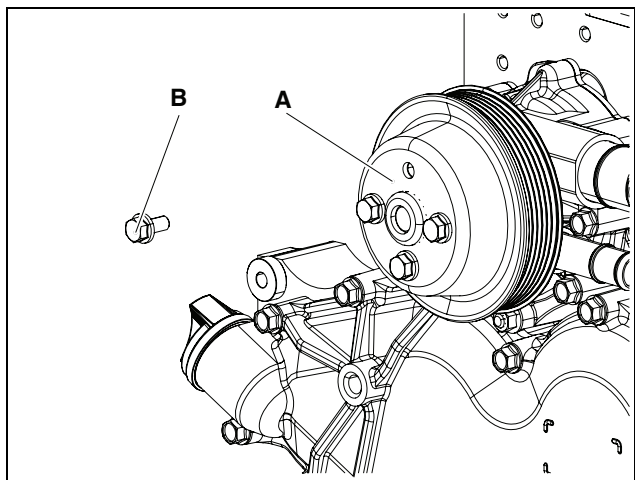
Note) To replace stud bolts, apply LOCTITE 272 to the stud bolts and then press in those bolts.

- 3) Tighten 4 hex bolts (C) and 2 flange hex nuts (D) at a tightening torque of 2.2 kgf•m

CAUTION

- Do not allow the gasket to protrude from or be to one side of the water pump.
- Be careful not to damage the gasket while mounting it.

2. Attach the water pump pulley.



EDL013023A

- 1) Attach the water pump pulley (A).
- 2) Tighten 4 flange hex bolts (B) at a tightening torque of 2.2 kgf•m.

3. Attach the V-belt.

4. Inject coolant.

- 1) Open the radiator cap and add coolant.

WARNING

Use coolant recommended.

7. Cooling System

Thermostat

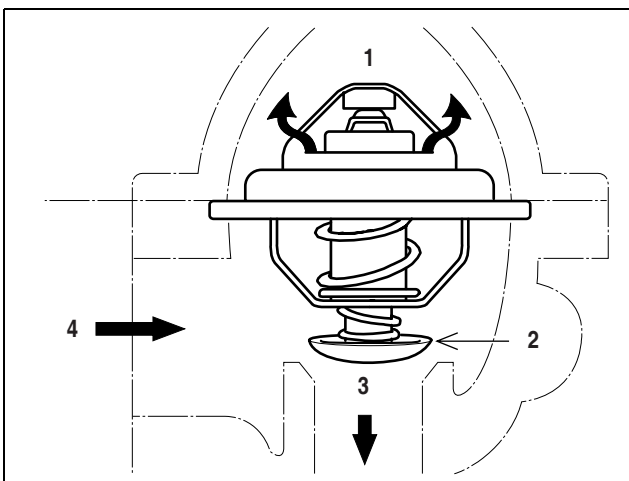
General Information

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

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

⚠ CAUTION

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



EDL022060A

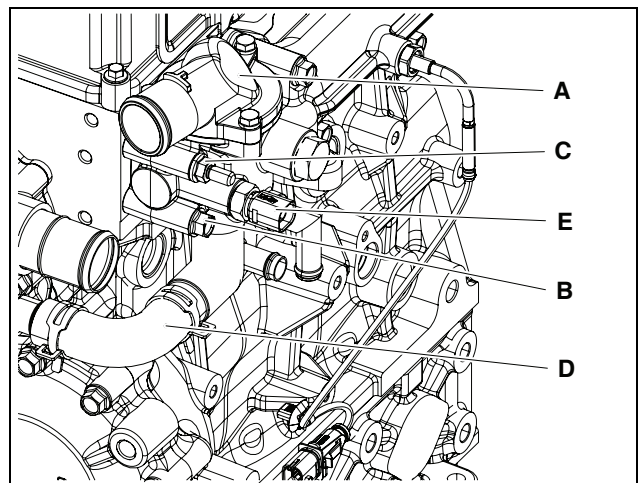
- | | |
|-------------------|-----------------|
| 1. Heat Exchanger | 3. water pump |
| 2. Bypass valve | 4. Coolant pipe |

Thermostat Disassembly

⚠ CAUTION

Detaching the thermostat itself may degrade cooling performance. Do not detach the thermostat itself.

1. Drain coolant until the coolant level is below the thermostat height.
2. Remove the thermostat.



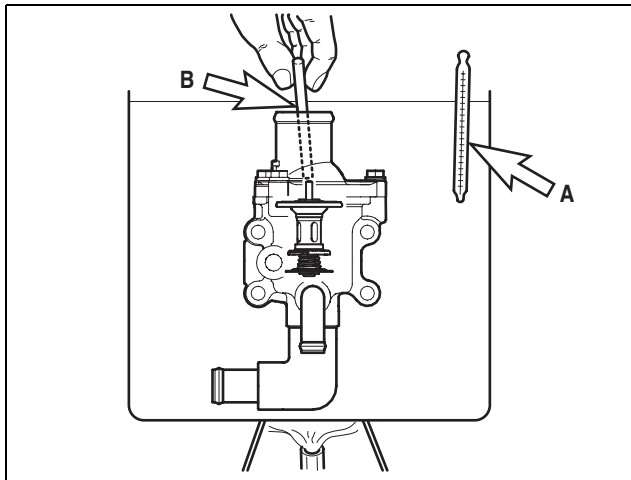
EDL013016A

- 1) Remove the water temperature sensor (E).
- 2) Disconnect the rubber hose (D).
- 3) Loosen the flange nut and spacer bolt (C).
- 4) Loosen the 3 flange hex bolts (B).
- 5) Remove the thermostat (A).

7. Cooling System

Check of Thermostat

1. Check whether the wax pellet and the spring are damaged or not.
2. Put the thermostat into water and heat the water slowly to inspect thermostat operation.
3. If the thermostat starts open approximately 0.3 mm at a water temperature of 82°C and is fully open at more than 8.0 mm at a water temperature of 97 °C, the thermostat is normal.



EDL022212A

A. Thermometer B. Measuring point

4. Check if there are any foreign substances in the thermostat.

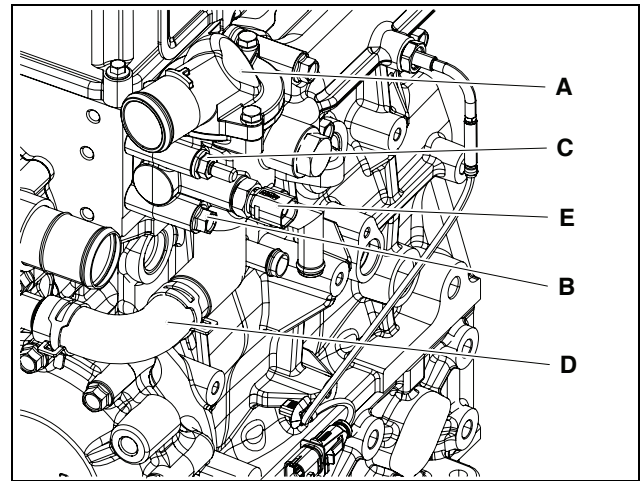
Note) Clean the inside of the thermostat with an air gun.

5. Check if there are any foreign substances or damaged parts inside and outside of the hose.

Item	Specified Value
thermostat Open Temperature	0.3 mm (at 82 °C) 8.0 mm or larger (at 97 °C)

Thermostat Assembly

1. Attach the thermostat.



EDL013016A

- 1) Attach the thermostat (A) to the cylinder head.
- 2) Tighten 3 flange hex bolts (B) at a tightening torque of 2.2 kgf•m.
- 3) Tighten the space bolt and the flange hex nut (C) at a tightening torque of 2.2 kgf•m.
- 4) Connect the rubber hose (D).
- 5) Attach the water temperature sensor (E).

CAUTION

- After mounting the hose clamps, make the protrusion face the cylinder head side to prevent interference between the protrusion and the water pump pulley.
- Do not use the hose clamps more than twice; replace them with new ones.

2. Replenish the coolant.

8. Lubrication System

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8. Lubrication System

Lubrication System

General Information

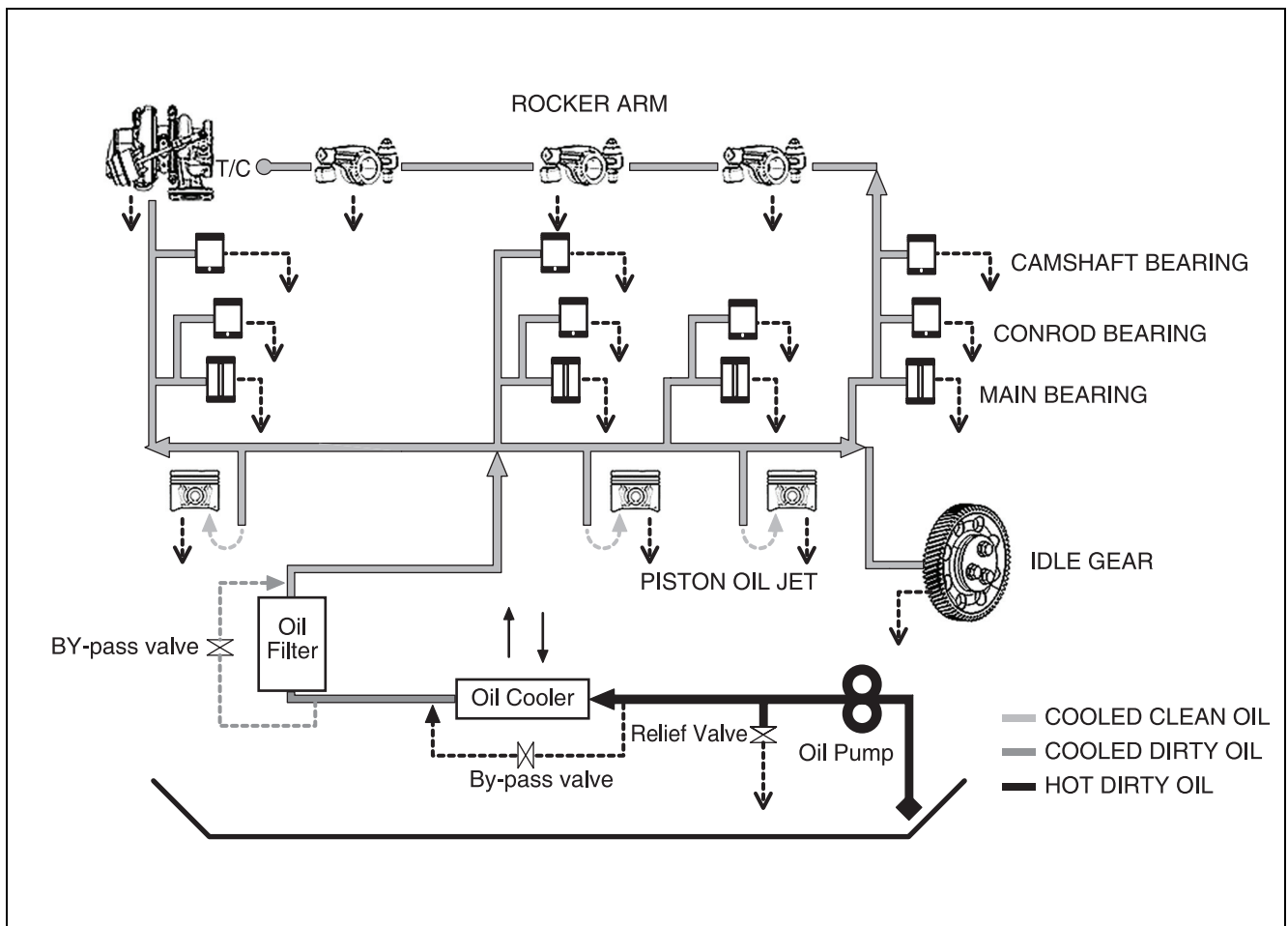
General Information

This engine is a forced lubrication type of engine. 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.

The oil pump delivers oil sucked from the oil pan with the suction pipe to the main path of the cylinder block through the oil cooler and oil filter.

From the cylinder block, oil is delivered to the crankshaft bearings, camshaft bearings, and rocker arm for lubrication.

In addition, the turbocharger is connected to the engine lubrication circuit. Around the cylinder block and the timing gear, lubricating oil is dispersed. Each cylinder has an oil injection nozzle for cooling the bottom of the piston. Engine oil is filtered through the oil filter and purified.



EDL013112A

8. Lubrication System

Specifications

Item		D18NAP		Remark
		DL01-LEE00	DL01-LEL00	
Lubrication System				
Lubricating type		Forced lubrication system	←	
Oil Pressure	Idle (Idling revolution count)	Above 1.5 kg/cm ²	←	
	Max. Load (rated RPM)	4.0 kg/cm ² ~ 5.5 kg/cm ²	←	
Oil Specifications	Oil Class	API CJ-4 (ACEA-E9)	←	
	SAE	SAE 10W30	←	
Oil Capacity	Total	6.7L (Including 0.4L in the engine)	←	
	Max.	6.3 L	←	
	Min.	2.8 L	←	
Allowable tilt angle (oil pan) (front/rear/left/right)		35° / 35° / 35° / 35°	←	
Oil pump	Type	Gear type	←	
	Driving Type	CRANK GEAR driven	←	
Oil coolant type		Water-cooled stack plate type	←	
Oil filter	Type	Spin on Type Filter	←	
	Allowable temperature	-40°C ~ 140°C	←	
	Flow	36 L/min	←	
Lubrication indicator		Oil pressure type	←	
Opening pressure of the oil spray nozzle adjustment valve		1.0 ~ 1.4 kg/cm ²	←	
Hydraulic indicator		Oil Pressure Sensor	←	

8. Lubrication System

Failure Diagnosis

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

8. Lubrication System

Oil pump

General Information

Engine oil is sucked from the oil pan by the gear type oil pump and then all of the oil is forcibly delivered to the oil cooler and filter for filtering. The filtered oil passes through the main oil path of the cylinder block and lubricates bearing parts and the turbocharger of the engine in order to maintain normal engine performance.

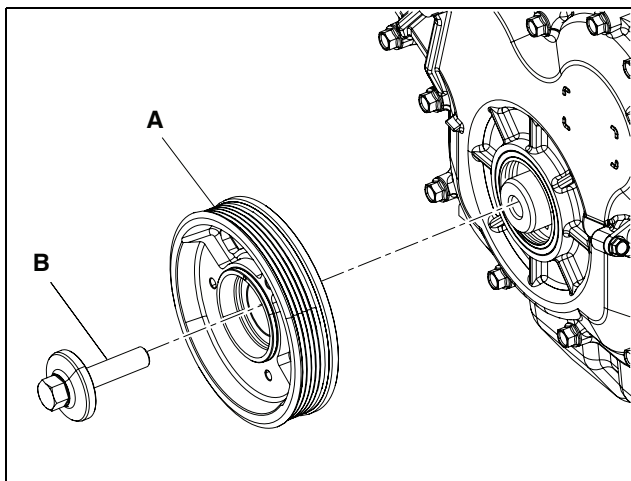
Oil Pump Disassembly

1. Drain the engine oil.
- 1) Place a container under the engine to drain the engine oil.
- 2) Remove the oil cap.
- 3) Remove the drain plug and drain the engine oil.

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 when discarding engine oil without observing the handling regulations, will be punished.

2. Remove the V-belt.
3. Remove the crankshaft pulley.



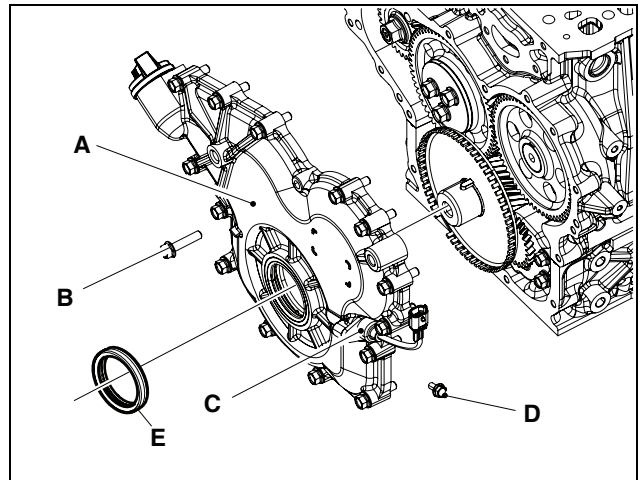
EDL013033A

- 1) Loosen the flange hex bolt (B).
- 2) Remove the crankshaft pulley (A).

CAUTION

Be careful not to damage the oil seal.

4. Remove the timing gear case.



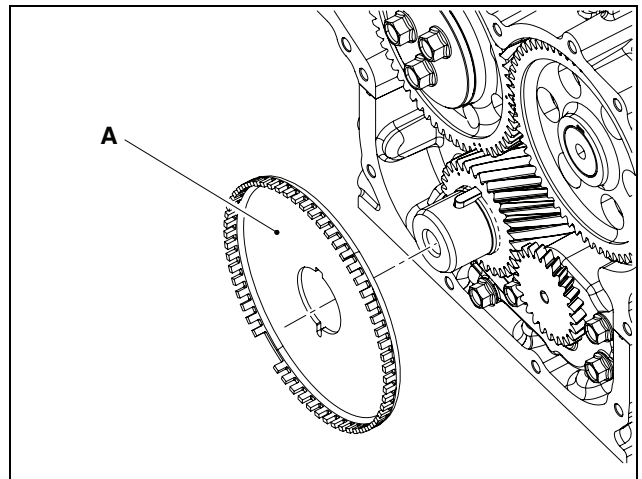
EDL013037A

- 1) Loosen the fixing bolt (D).
- 2) Remove the crank speed sensor (C).
- 3) Loosen 16 hex bolts (B).
- 4) Remove the timing gear case (A).

CAUTION

Do not reuse the oil seal; replace them with new ones.

5. Remove the timing wheel.

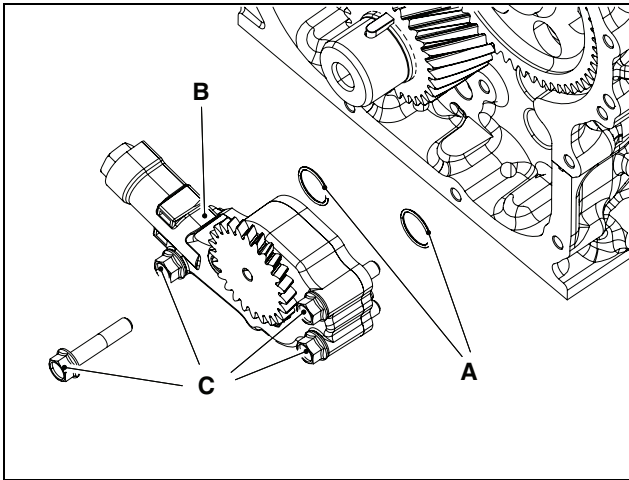


EDL013038A

- 1) Remove the timing wheel (A).

8. Lubrication System

6. Remove the oil pump.

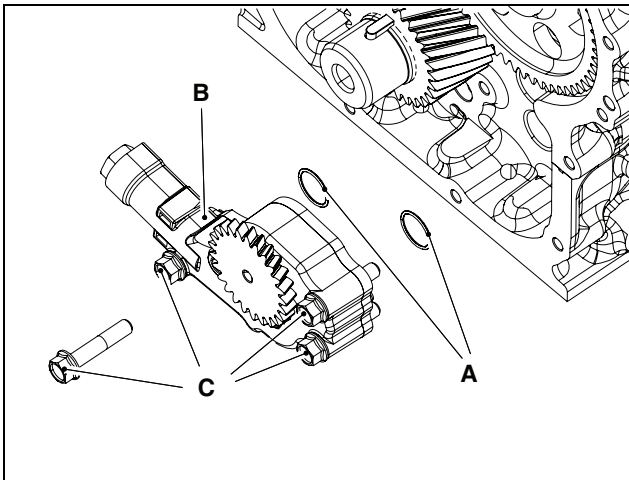


EDL013041A

- 1) Loosen 4 hex bolts (C).
- 2) Remove the oil pump (B).
- 3) Remove 2 O-rings (A).

Oil Pump Assembly

1. Attach the oil pump.



EDL013041A

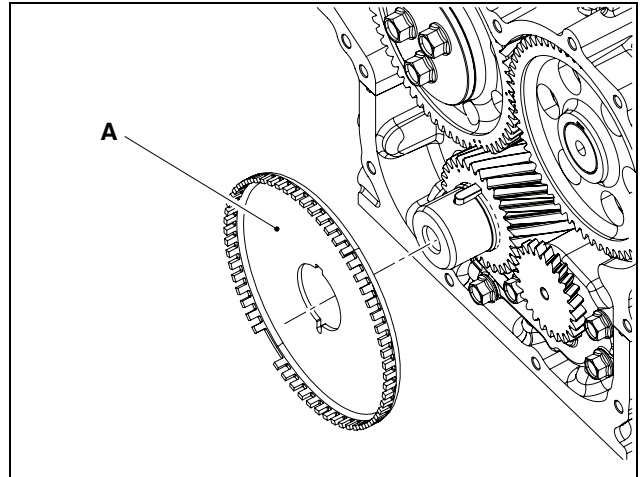
- 1) Align 2 O-rings (A) to the engine oil inlet and outlet.
- 2) Align the oil pump (B) with the pin and press it to the cylinder block as much as possible.
- 3) Tighten 4 hex bolts (C) at a tightening torque of 2.2 kgf•m.
- 4) The backlash between the crankshaft gear and the oil pump gear is 0.006 ~ 0.259 mm.

Item	Specified Value
Backlash between the crankshaft gear and the oil pump gear	0.06 ~ 0.259 mm

⚠ CAUTION

- Make sure that the O-rings have been mounted.
- Be careful not to damage the O-rings while mounting them.

2. Attach the timing wheel.



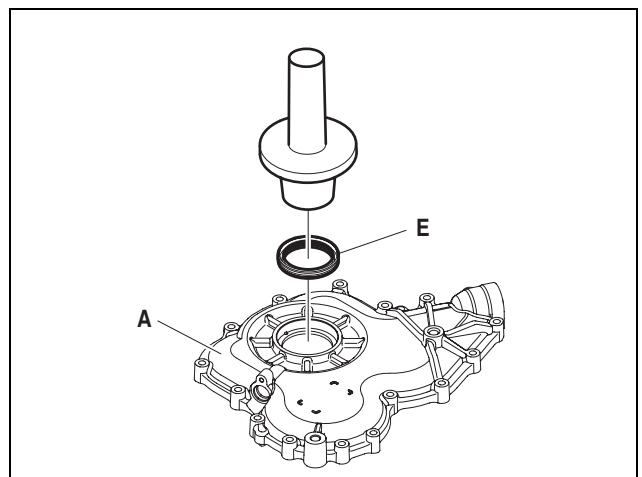
EDL013038A

- 1) Attach the timing wheel (A).

⚠ CAUTION

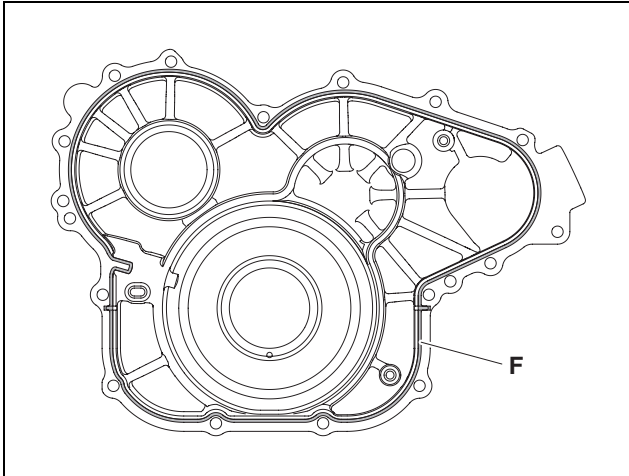
Be careful not to damage the teeth of the timing wheel.

3. Attach the timing gear case.



EDL013052A

8. Lubrication System



EDL013053A

⚠ CAUTION

- Remove foreign substances such as residues and LOCTITE from the oil seal assembly bore.
- Do not reuse the oil seal; replace it with a new one.
- Be careful not to damage the oil seal when attaching it.

- 5) Remove the foreign substances on the timing gear case assembly surface and clean it with a dry cloth.
- 6) Apply LOCTITE 5902 to the timing gear case assembly surface (F) with the diameter of $\varnothing 2.5 \pm 0.5\text{mm}$.

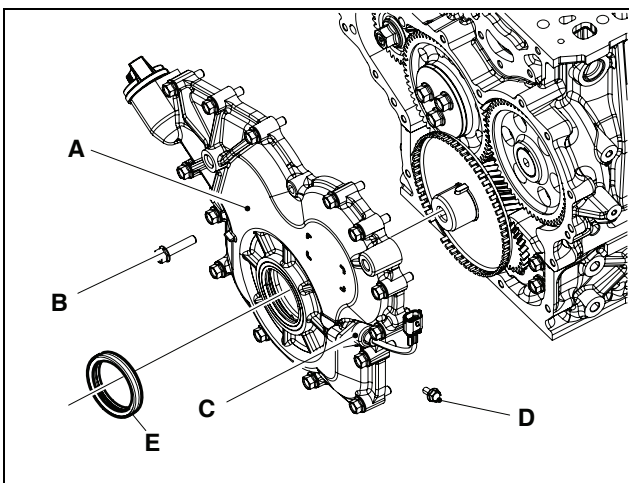
⚠ CAUTION

- Keep clean liquid gasket dispensing surface.
- Dispensing line should not be snapped.

- 7) Align the timing gear case (A) with the pin and attach it.

⚠ CAUTION

- Be careful that the timing gear case has been attached in the right direction.
- Assemble the timing gear case in 5 minutes after dispensing liquid gasket.
- Do not pressureize inside the timing gear case in 25 minutes after dispensing liquid gasket.



EDL013037A

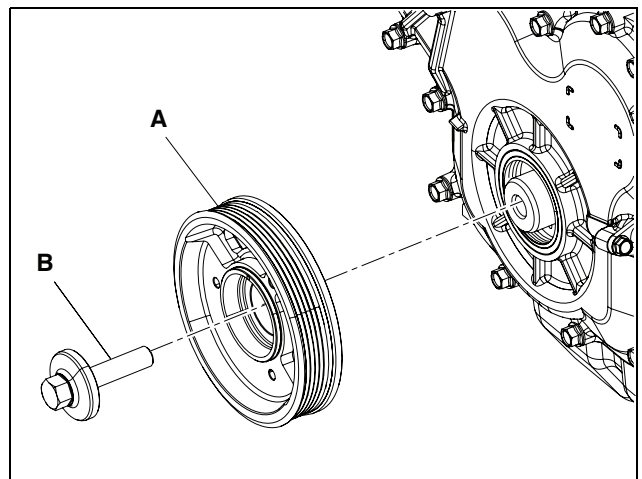
- 1) Make the assembly surface of the timing gear case face the ground.
- 2) Mount the front oil seal (E) to the front oil seal assembly jig (860104-02047).
- 3) Align the front oil seal assembly jig (860104-02047) where the front oil seal (E) is mounted to the timing gear case (A) and beat it with a rubber hammer.
- 4) when the front oil seal (E) is inserted to the timing gear case(A), pull off the front oil seal assembly jig (860104-02047).

⚠ CAUTION

- Be careful in noting the direction of the oil seal assembly and ensuring that the oil seal surface faces the outside of the engine.
- Be careful of the depth of the oil seal when attaching it.
- Be careful not to damage the oil seal.
- Attach the oil seal without applying lubrication. coolant, fuel, LOCTITE, or silicon.

- 8) Tighten 16 hex bolts (B) at a tightening torque of $2.2\text{kgf}\cdot\text{m}$.
- 9) Attach the crank speed sensor (C).
- 10) Tighten the fixing bolt (D).

4. Attach the crankshaft pulley.



EDL013033A

8. Lubrication System

- 1) Align the crankshaft pulley (A) to the pin and attach it.
- 2) Apply LOCTITE Blue 587 to the inside of the flange hex bolts (B).
- 3) Tighten flange hex bolts (B) at a tightening torque of 26 kgf•m.

CAUTION

- Be careful not to damage the oil seal.
- Fix the crankshaft to allow the flange hex bolts to be tightened with the specified torque.

5. Attach the V-belt.

6. Inject the engine oil.

- 1) Open the oil injection cap.
- 2) Inject engine oil.

WARNING

Use genuine engine oil recommended.

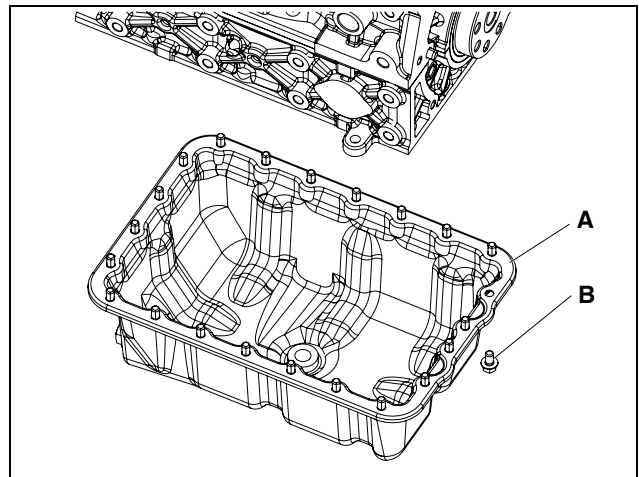
Disassembly of Oil Suction Pipe and Oil Delivery Pipe

1. Drain the engine oil.
- 1) Place a container under the engine to drain the engine oil.
- 2) Remove the oil cap.
- 3) Remove the drain plug and drain the engine oil.

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 when discarding engine oil without observing the handling regulations, will be punished.

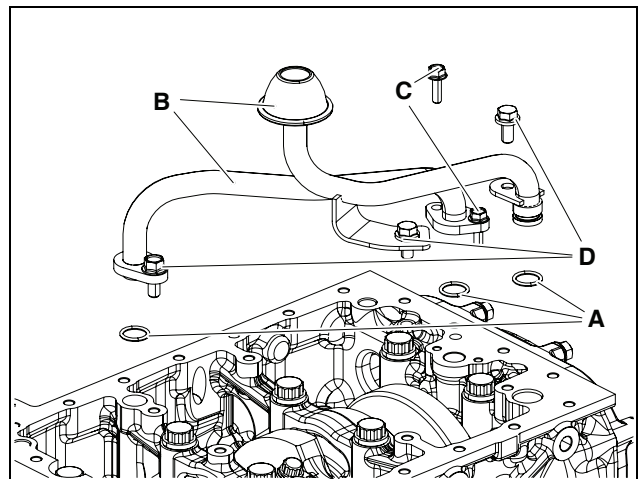
2. Remove the oil pan.



EDL013034A

- 1) Loosen 22 flange hex bolts (B).
- 2) Remove the oil pan (A).

3. Remove the oil suction pipe and oil delivery pipe.



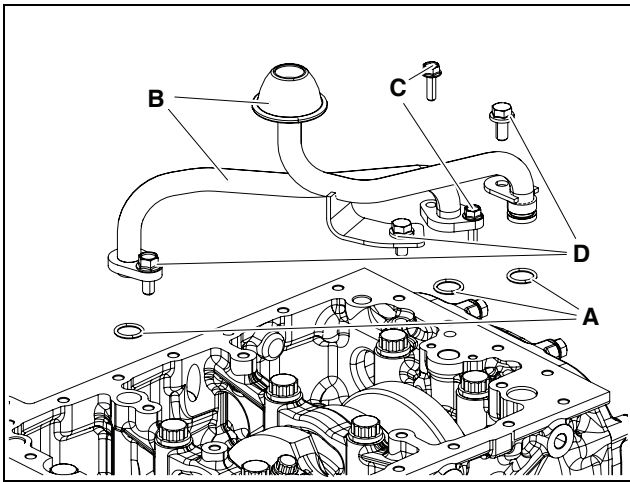
EDL013035A

- 1) Loosen 3 hex bolts (D) and 2 hex bolts (C).
- 2) Remove the oil suction pipe and the oil delivery pipe (B).
- 3) Remove 3 O-rings (A).

8. Lubrication System

Assembly of Oil Suction Pipe and Oil Delivery Pipe

1. Attach the oil suction pipe and oil delivery pipe.

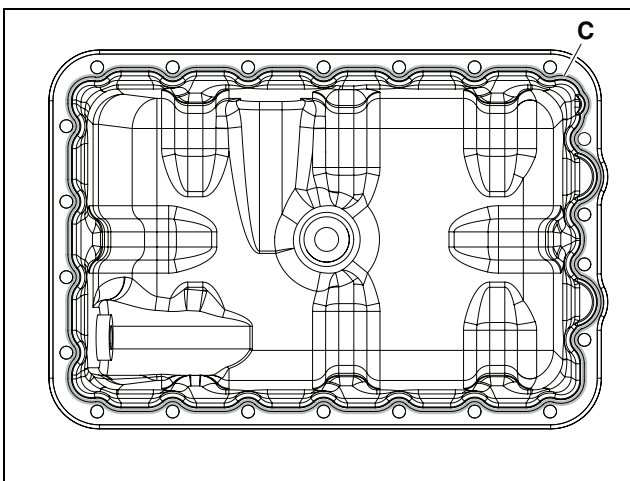


- 1) Attach 3 O-rings (A).
- 2) Attach the oil suction pipe and the oil delivery pipe (B).
- 3) Tighten 2 hex bolts (C) at a tightening torque of $1.0 \pm 0.3 \text{ kgf}\cdot\text{m}$.
- 4) Tighten 3 hex bolts (D) at a tightening torque of $2.2 \pm 0.3 \text{ kgf}\cdot\text{m}$.

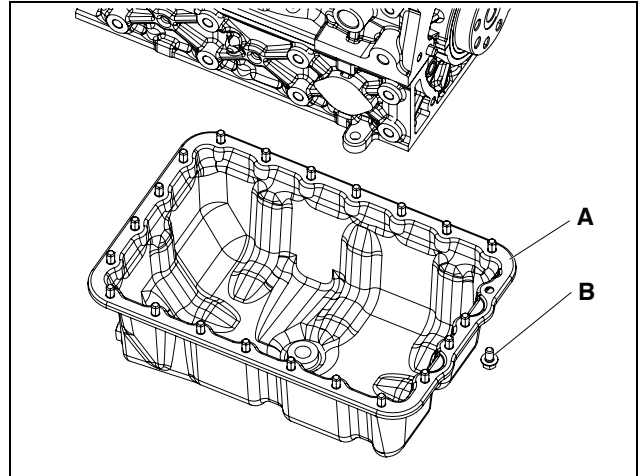
CAUTION

- Ensure that the O-rings of the inlet and the outlet have been mounted.
- Be careful not to damage the O-rings while mounting them.

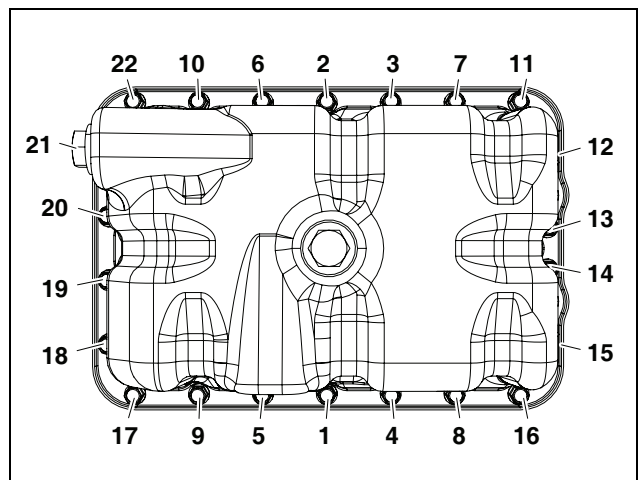
2. Attach the oil pan.



EDL013054A



EDL013034A



EDL013055A

- 1) Apply LOCTITE 5902 to the oil pan assembly surface (C) with the diameter of $\varnothing 3 \pm 0.5 \text{ mm}$.

CAUTION

- Keep clean liquid gasket dispensing surface.
- Dispensing line should not be snapped.

- 2) Attach the oil pan (A).

CAUTION

- Be careful that the oil pan has been attached in the right direction.
- Assemble oil pan in 5 minutes after dispensing liquid gasket.
- Do not pressurize inside oil pan in 25 minutes after dispensing liquid gasket.

- 3) Tighten 22 flange hex bolts (B) at a tightening torque of $2.2 \text{ kgf}\cdot\text{m}$.

8. Lubrication System

CAUTION

Tighten flange hex bolts in the order from (1) - (22). The front engine direction is the water pump direction and the rear engine direction is the flywheel direction.

3. Inject the engine oil.
- 1) Open the oil injection cap.
- 2) Inject engine oil.

WARNING

Use genuine engine oil recommended.

8. Lubrication System

Oil Filter Assembly

General Information

The oil cooler cools oil with coolant and the oil filter removes the foreign substances from the oil.

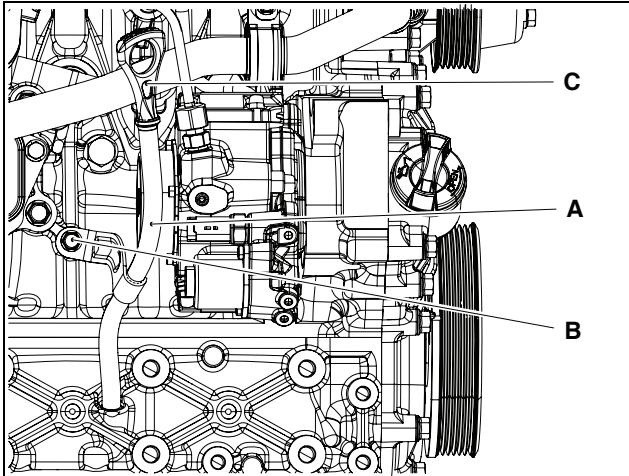
Disassembly of Oil Filter Assembly

1. Drain the engine oil.
 - 1) Place a container under the engine to drain the engine oil.
 - 2) Remove the oil cap.
 - 3) Remove the drain plug and drain the engine oil.

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 when discarding engine oil without observing the handling regulations, will be punished.

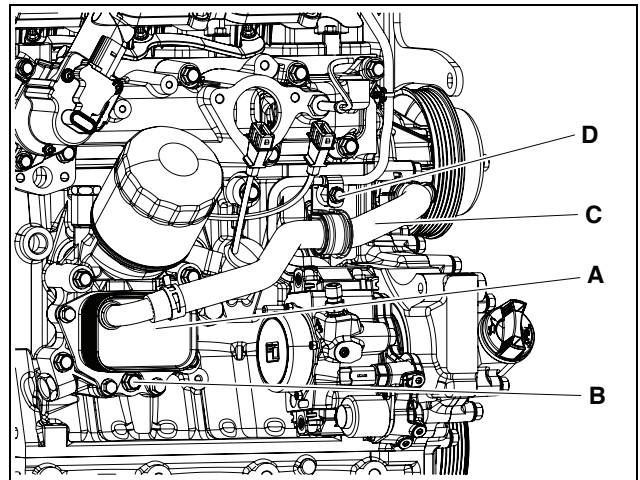
2. Remove the oil level gauge.



EDL013003A

- 1) Remove the oil level gauge (C).
- 2) Loosen the flange hex bolt (B).
- 3) Disconnect the oil level gauge guide tube (A).

3. Remove the oil filter assembly.



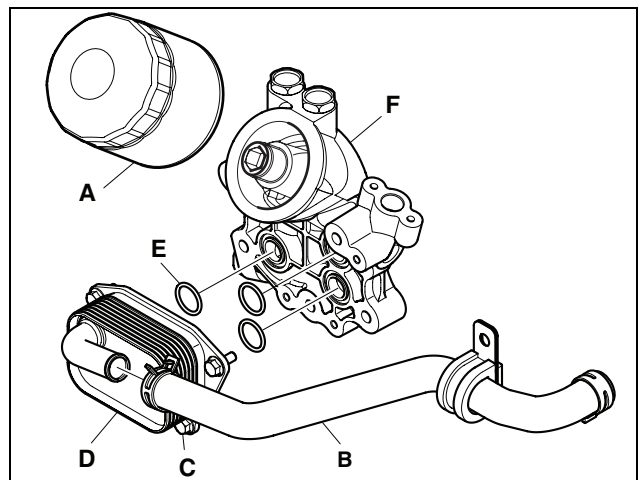
EDL013009A

- 1) Loosen the fixing bolt (D).
- 2) Disconnect the coolant hose (C).
- 3) Loosen 5 flange hex bolts (B).
- 4) Remove the 3 O-rings and the oil filter assembly (A).

CAUTION

Oil in the filter may run down while removing the oil filter. Be careful not to contaminate the other parts by using a cloth when removing the filter. After replacing the oil filter, wipe clean any other parts which the oil has touched.

4. Disassemble the oil filter assembly.



EDL013072A

- 1) Remove the oil filter(A) with the filter wrench.

8. Lubrication System

CAUTION

Oil in the filter may run down while removing the oil filter. Be careful not to contaminate the other parts by using a cloth when removing the filter. After replacing the oil filter, wipe clean any other parts which the oil has touched.

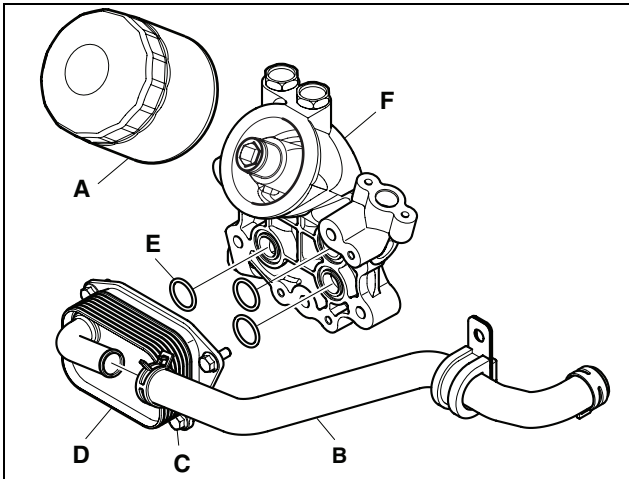
- 2) Disconnect the coolant hose (B).
- 3) Loosen 4 flange hex bolts (C).
- 4) Remove the oil cooler (D).
- 5) Remove the 3 O-rings (E) from the oil filter head (F).

Check of Oil Cooler

1. Check if the coolant inlet of the oil cooler is damaged and if coolant has leaked.
2. Check if the oil inlet and outlet of the oil cooler are damaged and if oil has leaked.
3. Check if the exterior of the oil cooler is damaged and leakage has occurred.

Assembly of Oil Filter Assembly

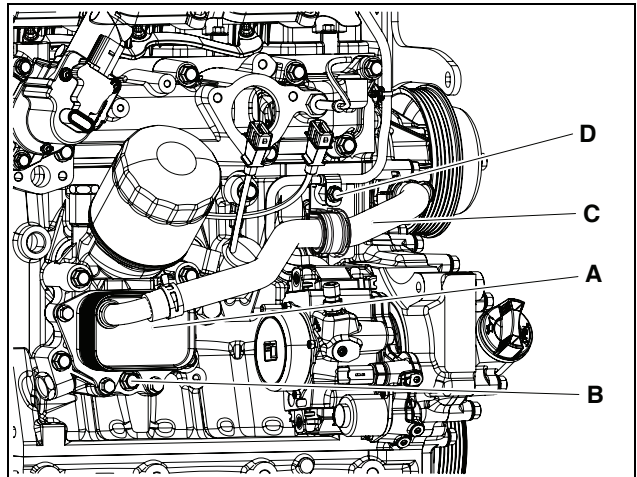
1. Assemble the oil filter assembly.



EDL013072A

- 1) Attach the 3 O-rings (E) to the oil filter head (F).
- 2) Attach the oil cooler (D)
- 3) Tighten 4 flange hex bolts (C).
- 4) Connect the coolant hose (B).
- 5) Wipe the surface on which the oil filter (A) is attached clean.
- 6) Temporarily tighten the oil filter (A) by hand.
- 7) Tighten the oil filter at a tightening torque of 16 ~ 20 N·m with the filter wrench.

2. Attach the oil filter assembly.



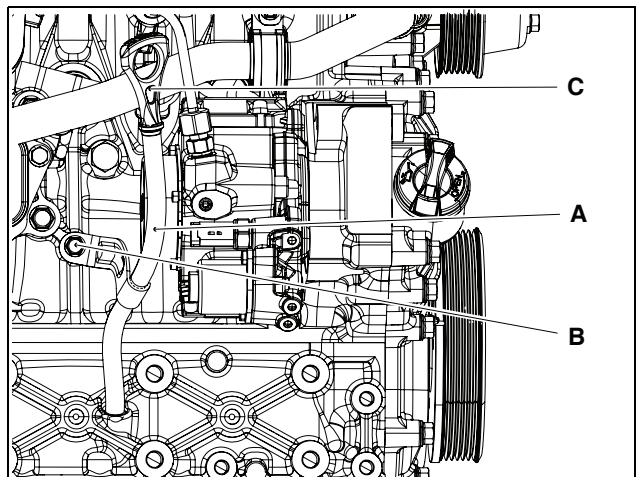
EDL013009A

- 1) Attach the 3 O-rings and the oil filter assembly (A).
- 2) Tighten 5 flange hex bolts (B).
- 3) Connect the coolant hose (C)
- 4) Tighten the fixing bolt (D).

CAUTION

- Make sure that the O-rings have been mounted.
- Be careful not to damage the O-rings while mounting them.

3. Attach the oil level gauge.



EDL013003A

- 1) Attach the oil level gauge guide tube (A) in the cylinder block.
- 2) Tighten the flange hex bolt (B) at a tightening torque of 1.0 kgf·m.
- 3) Insert the oil level gauge (C).

8. Lubrication System

CAUTION

Make the handle of the oil level gauge face the reverse direction from the center of the engine.

4. Inject the engine oil.
 - 1) Open the oil injection cap.
 - 2) Inject engine oil.

WARNING

Use genuine engine oil recommended.

9. Fuel System

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Fuel System

General Information

General Information

A diesel engine is combusted by the compression heat generated by compressing air inhaled into the cylinder and the fuel injected by the fuel injection nozzle.

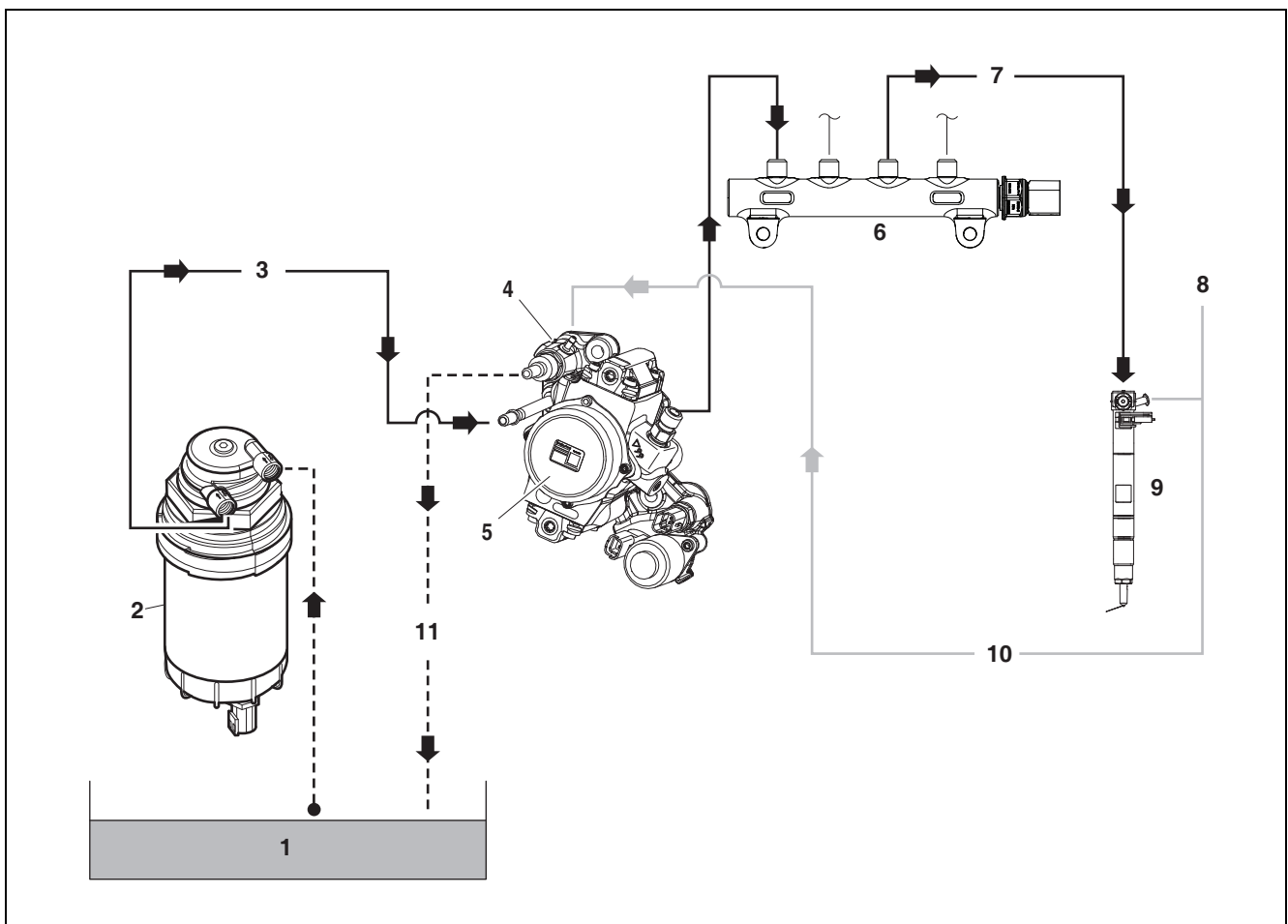
The high-pressured fuel generated by the high-pressure pump is stored in the common rail. The timing and amount of fuel injection is calculated by the Electronic Control Unit (ECU). The ECU injects fuel by operating the solenoid valve for the injector installed in each cylinder.

Doosan's common rail fuel injection system separates the high-pressure apparatus from the fuel injection apparatus. Depending on the conditions of engine

operation, the ECU decides fuel amount, fuel injection timing, and pressure for optimum performance and injects fuel in the cylinder.

The common rail fuel injection system consists of the low-pressure level for low-pressure fuel transfer, the high-pressure level for high-pressure fuel transfer, and the ECU.

The fuel tank should be anti-corrosive. No fuel should be leaked from the fuel tank under the doubled operating pressure of the fuel low-pressure pump. The pressure in the tank should not exceed 0.3 bar.



EDL013073A

- | | | |
|----------------|------------------------------|---|
| 1. Fuel Tank | 5. Fuel injection pump | 9. Injector |
| 2. Fuel Filter | 6. Common Rail | 10. Fuel return hose |
| 3. Fuel hose | 7. Fuel injection pipe | 11. Return fuel hose of fuel injection pipe |
| 4. VENTURI | 8. Injector Fuel Return Hose | |

9. Fuel System

Specifications

Item		D18NAP		Remark
		DL01-LEE00	DL01-LEL00	
Fuel System				
Fuel injection pump type		DELPHI DFP 4.4	←	
Control type		E.C.U (DELPHI)	←	
Delivery pump type		Gear type (with in DFP 4.4)	←	
Injection nozzle	Type	Multi hole type	←	
	Opening pressure (Operating pressure)	1,800 bar	←	
Fuel filter type		BCT (spin-on type)	←	

9. Fuel System

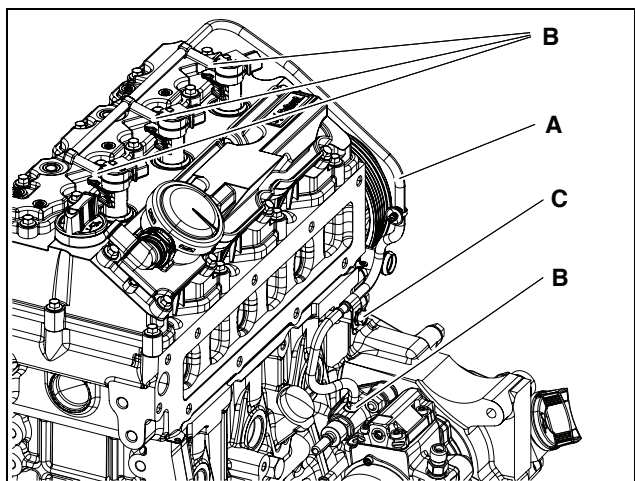
Fuel return hose

General Information

This hose is to transfer the fuel returned from the injector to the high-pressure pipe back.

Disconnection of fuel return hose

1. Remove the fuel return hose.



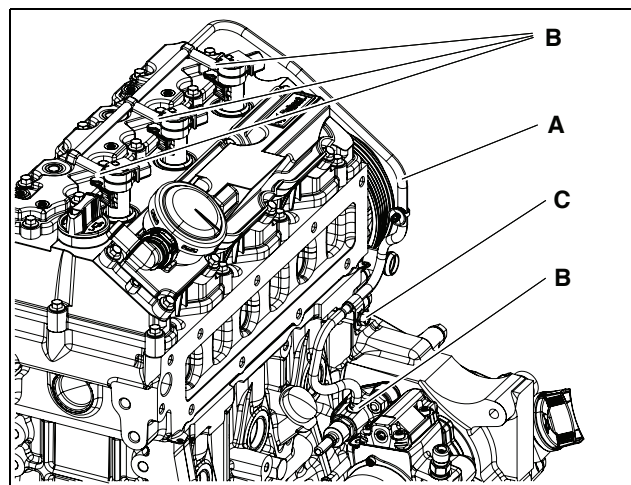
- 1) Loosen the flange hex bolts (C).
- 2) Remove the hose clips and disconnect the fuel hose (A).

Check of fuel return hose

1. Check if there is any foreign substance or damaged part in the inside and the outside of the fuel line.
2. Check if oil is leaked from the joints.
3. Check if the adaptor is damaged and oil is leaked.

Connection of fuel return hose

1. Connect the fuel return hose.



- 1) Press the fuel return hose (A) into the end of the nipple and connect it.

CAUTION

- Be careful to note the direction when connecting the fuel return hose.
- The injector should be fully connected with the hose.

- 2) Attach the hose clips (B).

CAUTION

Fix the handle of hose clip to face the front of the engine.

- 3) Tighten the fixing bolt (C).

9. Fuel System

Injector

General Information

The injector uses the nozzle to inject fuel to the combustion chamber directly. To control the injection, the solenoid valve is used. Fuel is delivered as much as required from the open injector nozzle and the remaining fuel is returned to the fuel tank through the fuel return line. In addition, the fuel which has been used to lubricate the high-pressure pump and returned from the fuel pressure adjustment valve is returned to the fuel tank through the return line.

The solenoid valve controls the fuel injection timing and amount. The injector works instead of the nozzle and the nozzle holder mounted on the existing engine. Fuel is delivered to the injector through the high-pressure connector mounted on 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. It is connected to the fuel return line via the discharge hole. The hydraulic force which has been increased by the valve control plunger with closed discharge hole exceeds the pressure value of the nozzle needle. As a result, fuel delivery to the combustion chamber is blocked by the force given 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 hydraulic power given to the plunger. When hydraulic force is lower than the force given to the nozzle needle pressure, the nozzle needle is opened. Finally, fuel is injected to the combustion chamber through the injection nozzle hole. The reason that the nozzle needle is controlled by hydraulic force is that the power required to open the needle quickly cannot be directly generated from the solenoid valve. Fuel control amount required to open the nozzle needle is added to the fuel amount injected. The used fuel is discharged to the fuel return line through the hole of the valve control chamber.

Fuel loss occurs on the nozzle needle, the valve plunger guide as well as the valve control chamber. The control leakage fuel and the fuel gathered from the line, which connects the over flow valve, the high-pressure pump, and the pressure control valve, is returned to the fuel tank through the fuel return line.

How to Operate an Injector

Injector operation is classified into four operation stages to operate the engine and create pressure in the high-pressure pump.

1. The injector is closed (high fuel pressure state)
2. The injector is open (starting fuel injection).
3. The injector is fully open (injecting fuel).
4. The injector is closed (ending fuel injection).

These operation stages are decided by balancing the force given to the injector components. If there is no pressure on the common rail or the engine is stopped, the injector nozzle does not work.

1. The injector is closed (pause state)
Under the pause state that no power is provided to the solenoid valve of the injector, the injector does not operate. The surface where the discharge hole exists is tightly closed with the valve ball by the force from a valve spring or magnet. High pressure in the common rail is kept by the fuel control valve and the same pressure is generated in the nozzle chamber of the injector. The common rail fuel pressure, which is given to the end face of the valve control chamber of the injector, and the injector nozzle spring force are larger than the force to open the nozzle. Therefore, the injector is closed.
2. The injector is open. (starting fuel injection)
When power is supplied while the injector solenoid valve is closed, the fuel discharge hole is open by the pulling force of the solenoid valve. Almost simultaneous with that, the high current given to the solenoid valve is reduced to the low current. This is because the air gap of the electromagnet circuit gets smaller. Fuel in the valve control chamber flows to the discharge valve hole on the upper side and then goes into the fuel tank via the fuel return line. The discharge hole completely breaks the pressure balance and lowers the pressure in the valve control chamber. As a result, the pressure in the valve control chamber is lower than the nozzle chamber pressure which has been equal to the common rail pressure. The lowered pressure of the valve control chamber lowers the force from the control plunger. So the nozzle needle is open and fuel injection starts.

9. Fuel System

3. The injector is fully open. (injecting fuel)

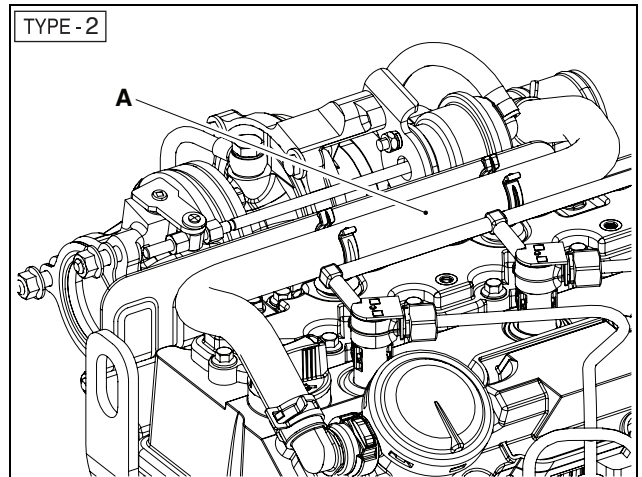
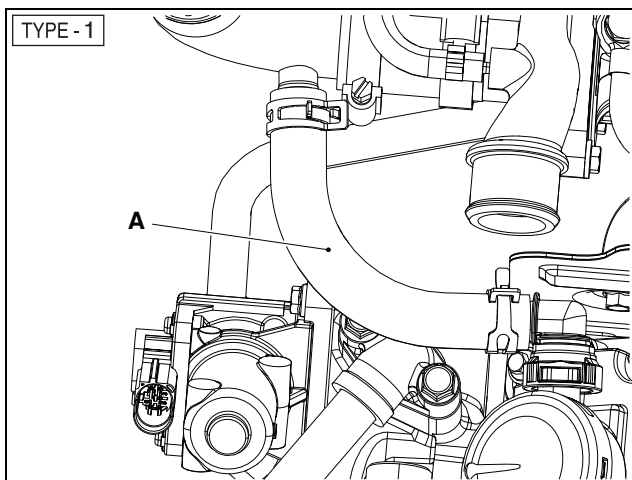
The valve control plunger is stopped at the upper position because fuel is full as fuel flows from the fuel delivery hole. At this time, the injector nozzle is fully open and fuel is injected to the combustion chamber at the pressure equal to that of the common rail.

4. The injector is closed. (ending fuel injection)

As soon as the supply to the solenoid valve of the injector is blocked, the valve spring applies force to the armature downward and the valve ball closes the discharge hole. The armature consists of two components. The armature plate is guided by the driving shoulder and pressed downward. However, in this case, an overspring is used. It is a return spring that prevents the force from being applied to the armature and the valve ball. As the discharge hole is closed, fuel is delivered from the delivery hole and generates pressure in the control chamber. This fuel pressure is equal to the pressure of the common rail and puts pressure on the valve control plunger through the end face of the valve control plunger. As a result, the force of the spring is added to the pressure exceeding the pressure of the nozzle chamber. Therefore, the nozzle needle is closed. The speed of closing the nozzle needle is decided by the flow that passes through the delivery hole. As soon as the nozzle needle is positioned to the stop position, fuel injection is blocked.

Injector Disassembly

1. Remove the breather hose.

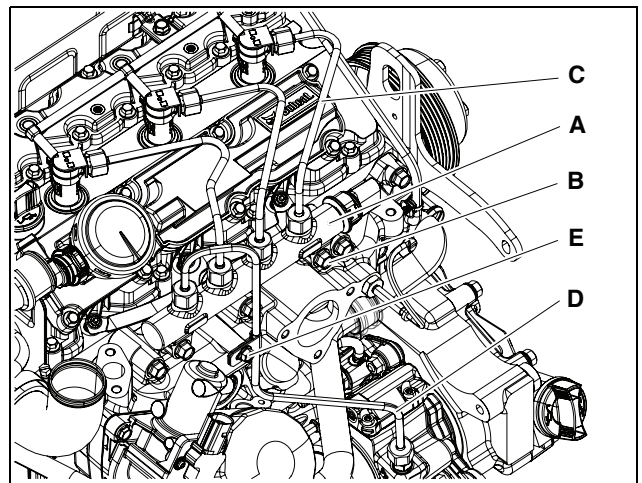


1) Remove the breather hose (A).

⚠ CAUTION

Do not reuse the clamps but replace with new ones.

2. Remove the common rail and the injection pipes.



- 1) Loosen the fixing bolt (E).
- 2) Loosen the nuts of the fuel injection pipes.
- 3) Remove 4 fuel injection pipes (C) and (D).

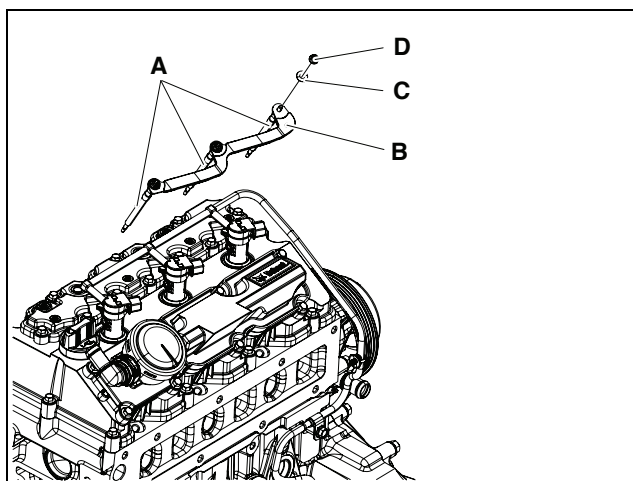
⚠ CAUTION

Do not reuse fuel injection pipes; replace them with new ones. If fuel injection pipes are reused it may allow foreign substances into the fuel pipes or cause oil leaks from bolt clamping and cause a critical fault in engine performance.

- 4) Loosen 2 collared hex bolts (B) of the common rail.
- 5) Remove the common rail (A) from the intake manifold.

9. Fuel System

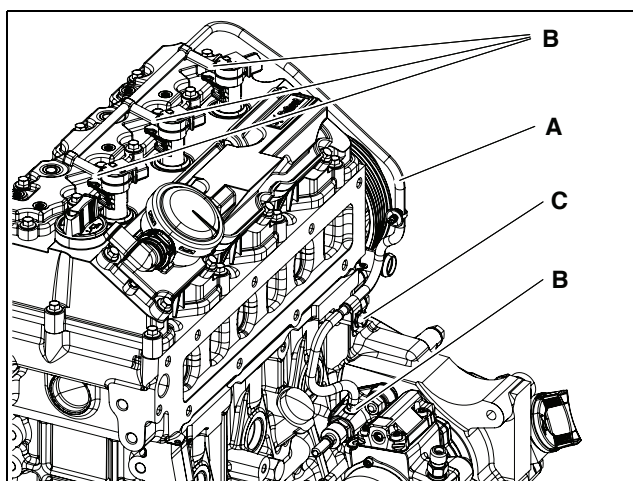
3. Remove the glow plug.



EDL013021A

- 1) Loosen 3 hex nuts (D) and remove 3 washers (C).
- 2) Remove the electric connector (B) and 3 glow plugs (A).

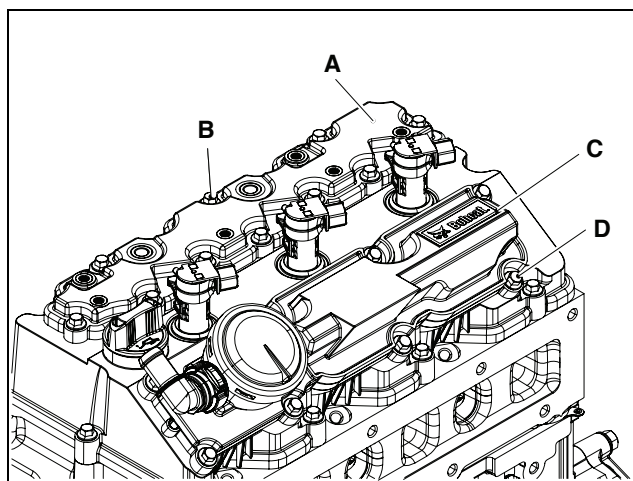
4. Remove the fuel return hose.



EDL013022A

- 1) Loosen the flange hex bolts (C).
- 2) Remove the hose clips and disconnect the fuel hose (A).

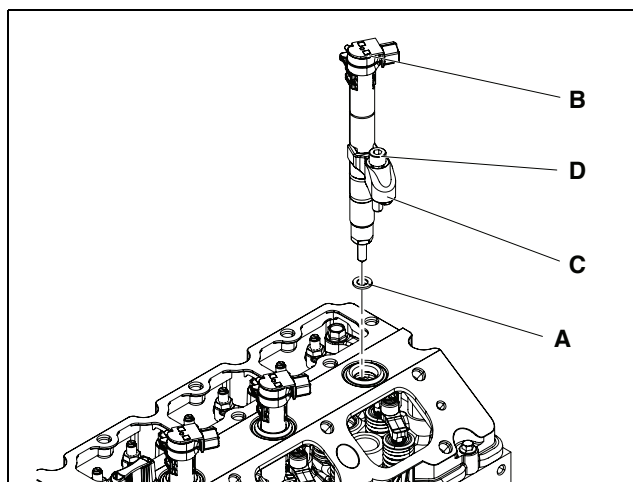
5. Remove the right and left cylinder head cover.



EDL013025A

- 1) Loosen 8 flange hex bolts (D).
- 2) Remove the right cylinder head cover (C).
- 3) Loosen 10 flange hex bolts (B).
- 4) Remove the left cylinder head cover (A).

6. Remove the injectors.



EDL013026A

- 1) Loosen 3 hex bolts (D).
- 2) Remove 3 injector fixtures (C).
- 3) Remove 4 injectors (B).
- 4) Remove 3 injector seal ring washers (D).

CAUTION

- Do not reuse the head cover rubber seal and the injector oil seal but replace with new ones.
- Be careful not to damage the injector oil seal of the cylinder head cover.
- Remove it by turning the injector slowly from left to right.

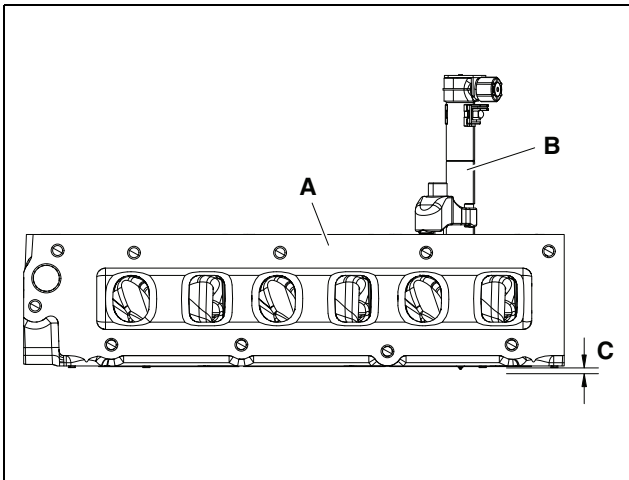
9. Fuel System

CAUTION

Do not reuse the injector seal ring washers. Reuse of the injector seal ring washers may cause critical damage to the engine due to unstable combustion.

Injector Check

1. Check if there are any foreign substances and if the end part of the injector is transformed.
2. Check the injector protrusion (C).



EDL013074A

- 1) Detach the cylinder head (A).

Note) Detach the cylinder head by referring to engine disassembly order in Chapter 6.

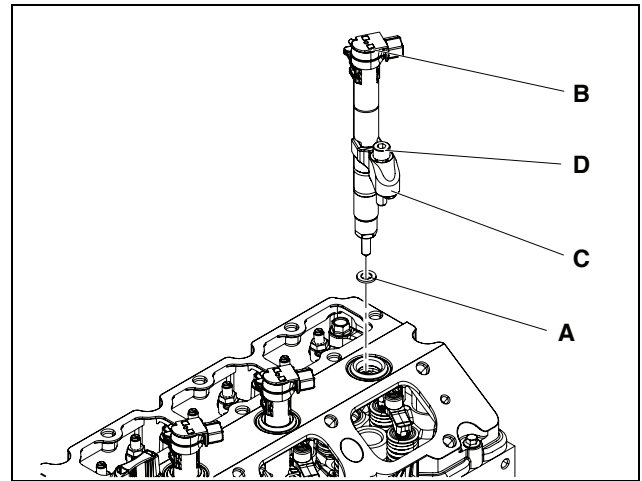
- 2) Insert the seal ring in the cylinder head (A) and attach the injector (B).
- 3) Check the injector protrusion (C) based on the cylinder head (A) surface with a dial gauge.

Note) Be careful not to allow foreign substances to flow into the injector and the high-pressure connector when detaching and checking the injector.

Item	Specified Value
Injector protrusion	1.5 ± 0.65 mm

Injector Assembly

1. Attach the injectors.



EDL013026A

- 1) Align the injector seal ring washer (A) with the center of the injector hole and mount it.
- 2) Sufficiently apply engine oil on the cylinder head cover surface where the injectors contact.
- 3) Attach 3 injectors (B).

CAUTION

- Do not reuse the head cover rubber seal and the injector oil seal but replace with new ones.
- Attach injectors by slowly turning them to prevent damage to the cylinder head cover surface which contacts the injectors.
- Do not reuse the injector seal ring washers. Otherwise, critical damage to the engine may occur because of unstable combustion.

- 4) Mount 3 injector fixtures (C).
- 5) Temporarily tighten 3 hex bolts (D).

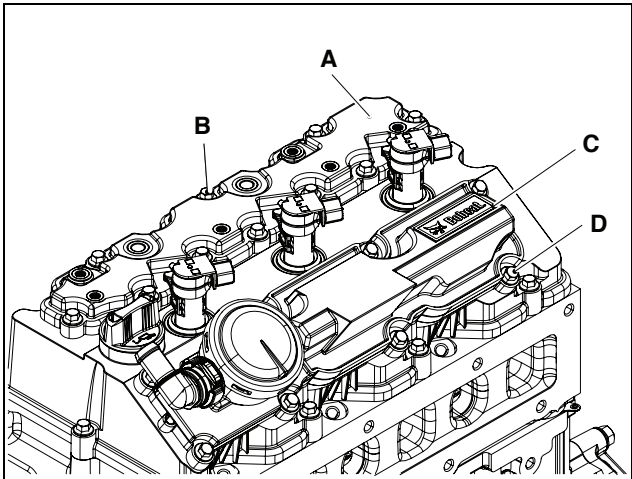
CAUTION

Do not tighten the hex bolts by force when it is difficult to tighten them temporarily. Forced tightening may cause damage to the cylinder head.

- 6) Tighten 3 hex bolts (D) at a tightening torque of 3.5 kgf·m.

9. Fuel System

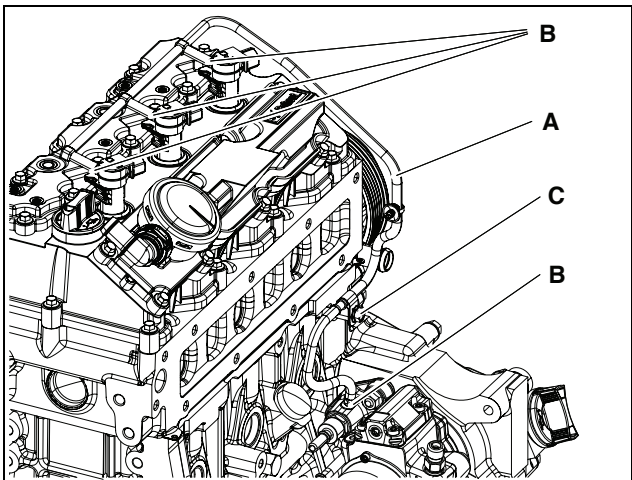
2. Attach the right and left cylinder head cover.



EDL013025A

- 1) Attach the left cylinder head cover(A).
- 2) Tighten 10 flange hex bolts (B) at a tightening torque of 1.0 kgf·m.
- 3) Attach the right cylinder head cover (C).
- 4) Tighten 8 flange hex bolts (D) at a tightening torque of 1.0 kgf·m.

3. Connect the fuel return hose.



EDL013022A

- 1) Press the fuel return hose (A) into the end of the nipple and connect it.

⚠ CAUTION

- Be careful to note the direction when connecting the fuel return hose.
- The injector should be fully connected with the hose.

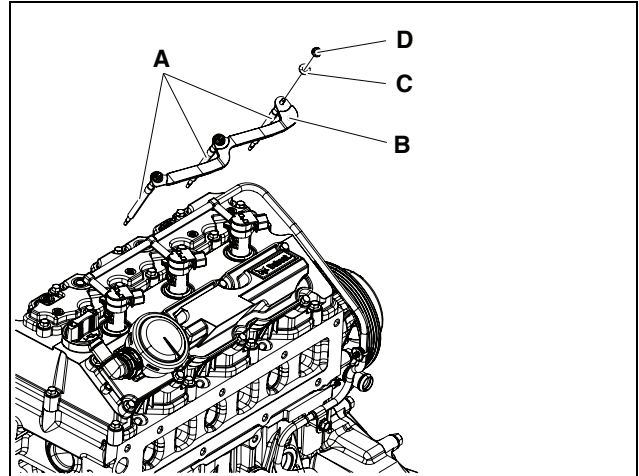
- 2) Attach the hose clips (B).

⚠ CAUTION

Fix the handle of hose clip to face the front of the engine.

- 3) Tighten the fixing bolt (C).

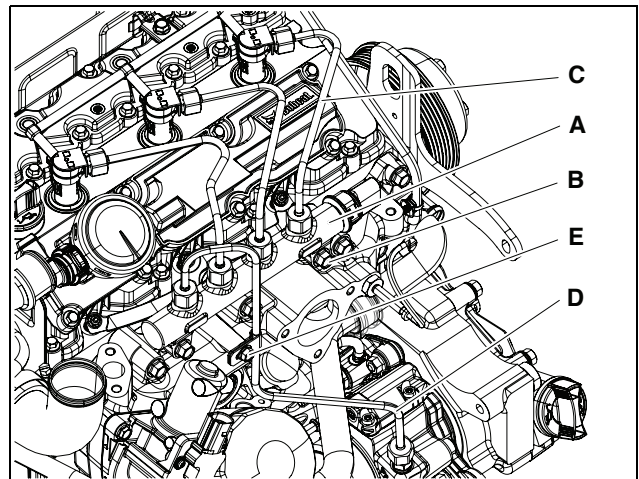
4. Attach the glow plug.



EDL013021A

- 1) Tightening 3 glow plugs (A) to the cylinder head at a tightening torque of 9~12 N·m.
- 2) Attach the electric connector (B).
- 3) Attach 3 washers (C).
- 4) Tighten 3 hex nuts (D) at a tightening torque of 2.5~3 N·m.

5. Attach the common rail and the injection pipe.



EDL013006A

- 1) Attach the common rail(A) to the intake manifold.

9. Fuel System

CAUTION

- Be careful to note the direction when attaching the common rail.
- Be careful not to damage the common rail while attaching it.

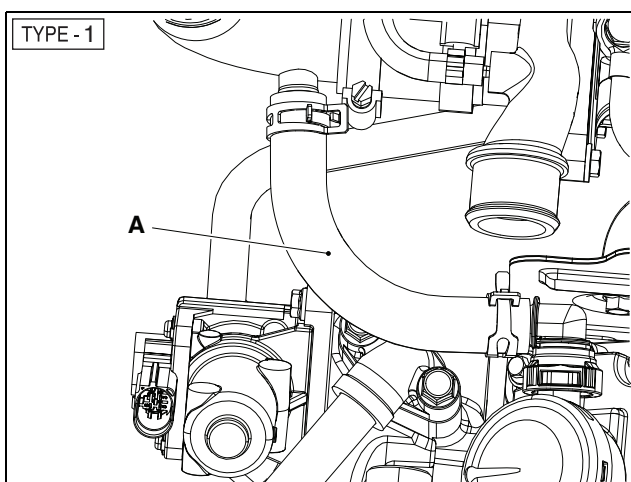
- 2) Temporarily tighten 2 collared hex bolts(B) by hand.
- 3) Temporarily connect the fuel injection pipes(C) and (D) by hand.

CAUTION

- Do not bend the fuel injection pipes by force.
- Be careful to note the direction when connecting the fuel injection pipes.
- Assemble the nut on one side of the fuel injection pipe first, and then the nut on the other side to connect the round part of the pipe to the correspondent part correctly.
- Do not reuse fuel injection pipes but replace them with new ones. Reusing fuel injection pipes may allow foreign substances into the fuel pipes or oil leaks from the bolt clamping to occur, causing a critical fault in engine performance.

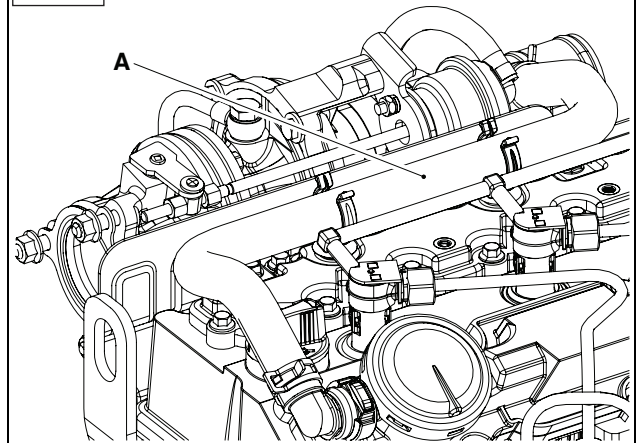
- 4) Tighten 2 collared hex bolts(B) at a tightening torque of 2.2 kgf·m.
- 5) Tighten the fuel injection pipes(C) and (D) at a tightening torque of 3.0 kgf·m.
- 6) Tighten the fixing bolt(E).

6. Attach the breather hose.



EDL013001A

TYPE-2



EDL013002A

- 1) Attach the breather hose(A).

CAUTION

Do not reuse the clamps but replace with new ones.

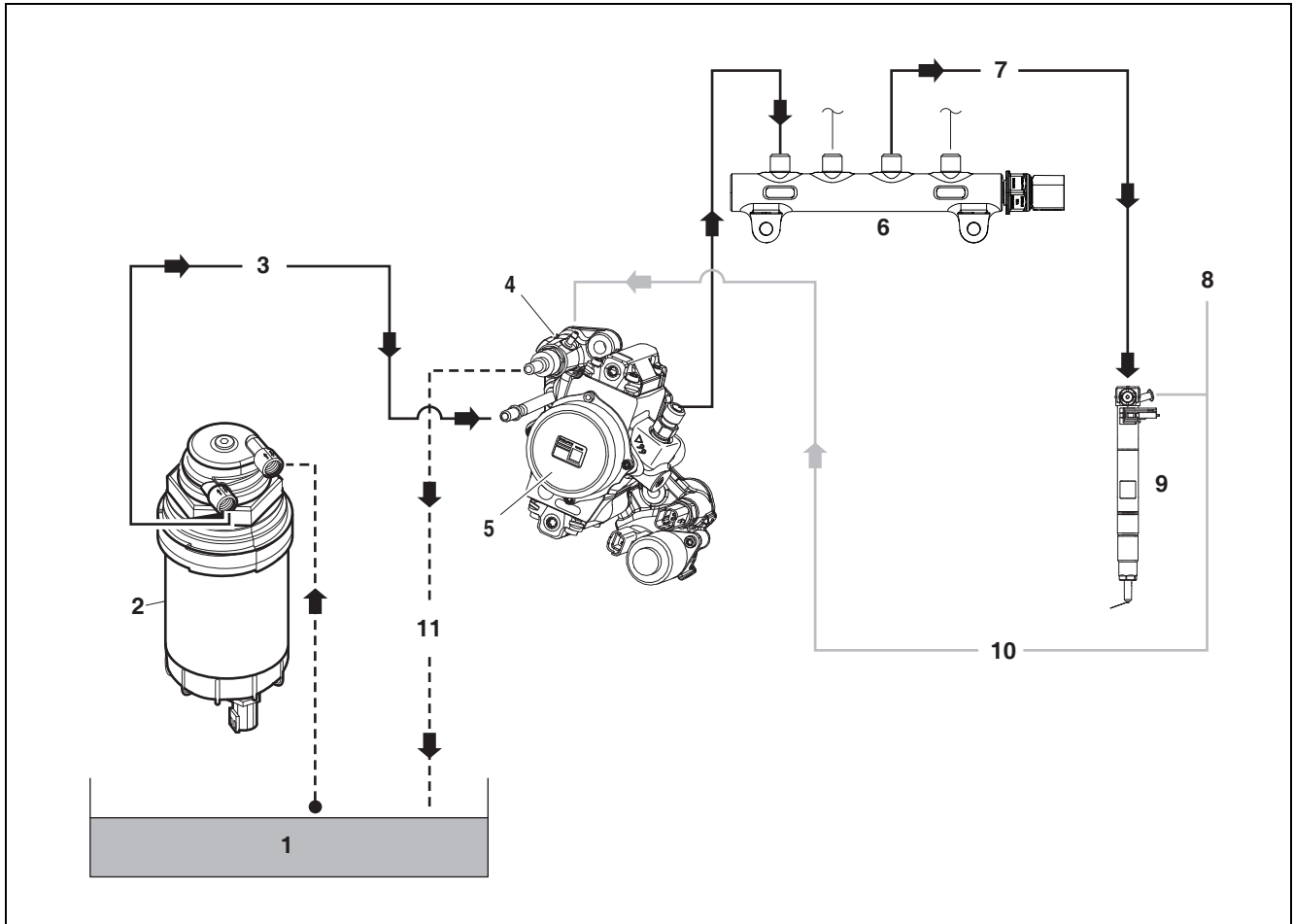
9. Fuel System

Common Rail

General Information

Doosan's common rail fuel injection system separates the high-pressure apparatus from the fuel injection apparatus. The ECU decides the fuel amount and the fuel injection timing and pressure for the optimum performance and injects fuel in the cylinder.

The high-pressure fuel generated from the fuel high-pressure pump is stored in the common rail. When a driver operates the vehicle, fuel injection timing and optimum fuel amount are decided based on the data set in the Electronic Control Unit (ECU) and the solenoid valve of the injector installed in each engine cylinder is operated to inject fuel into the cylinder.



EDL013073A

- | | | |
|----------------|------------------------------|---|
| 1. Fuel Tank | 5. Fuel injection pump | 9. Injector |
| 2. Fuel Filter | 6. Common Rail | 10. Fuel return hose |
| 3. Fuel hose | 7. Fuel injection pipe | 11. Return fuel hose of fuel injection pipe |
| 4. VENTURI | 8. Injector Fuel Return Hose | |

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

1. Electronic Control Unit (ECU)

1) The Electronic Control Unit (ECU) receives the input signals generated by the above input sensors based on the driver's accelerator operation and works immediately according to the driving performance of the engine and the vehicle. In addition, based on the above information, the ECU generates open/close circuit - circulation circuit operations of the vehicle and engine.

- 2) The engine speed is measured by the crankshaft RPM sensor and the ignition order is determined by the camshaft RPM sensor. Through electrical signals generated by the potentiometer of the accelerator pedal sensor, shows how strong the driver has pressed the pedal. In addition, the ECU includes the turbocharger and the intake pressure sensor. The intake pressure sensor measures the intake pressure.
- 3) When it is very cold or the engine is cooled, the ECU receives data from the coolant temperature

9. Fuel System

sensor and the air temperature sensor to operate with the best conditions for engine operation.

2. Crankshaft RPM sensor

- 1) Position of the piston in the combustion chamber is very important. Pistons of all engines are connected to the crankshaft via the connecting rods. The crankshaft RPM sensor installed in the flywheel housing provides information on the position of all pistons. The rev-speed is defined as Revolutions per Minute (RPM) of the crankshaft. The key input parameters are calculated by the ECU by using the signals received from the crankshaft RPM sensor.

3. Camshaft RPM sensor

- 1) The camshaft RPM sensor controls the intake and exhaust valve of the engine. It revolves at the half of the crankshaft speed and determines whether the camshaft position is at the compression stage or the exhaust stage when the piston is moving toward the top dead point. This information cannot be determined by the crankshaft RPM sensor. However, while the engine is normally operating, the information given by the crankshaft RPM sensor is enough to define the engine state. It means that the ECU receives information of the engine from the crankshaft RPM sensor if the camshaft RPM sensor cannot sense the engine state while the vehicle is running.

4. Accelerator pedal sensor

- 1) The accelerator pedal sensor sends the data generated when a driver presses the accelerator pedal to the ECU. The voltage value is generated by the potentiometer in the accelerator pedal sensor. The pedal position is calculated with the programmed characteristics curves.

5. Fuel temperature sensor

- 1) This sensor 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 stake via the O-ring. It measures the absolute pressure and temperature in the intake stake.
- 2) The output signal is input to the ECU and the boost pressure is calculated based on the ECU-programmed characteristics curves.

7. Oil pressure and temperature sensor

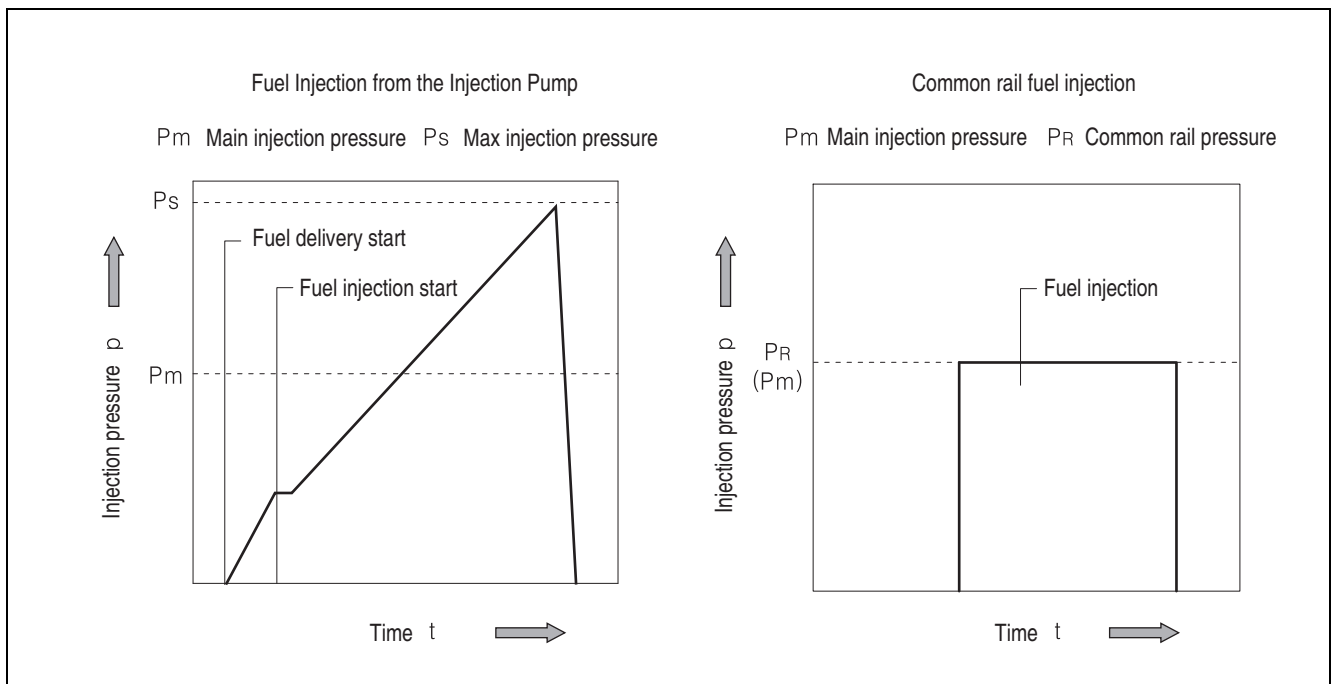
- 1) The engine oil pressure and temperature sensor senses the temperature and pressure of engine oil and sends the data to the ECU.

8. Common rail pressure sensor

- 1) It is installed at the end of the common rail, measuring the instantaneous internal pressure of the common rail.

9. Engine coolant temperature sensor

- 1) The engine coolant temperature sensor perceives the temperature of the engine coolant sends the data to the ECU.



EDL0213004A

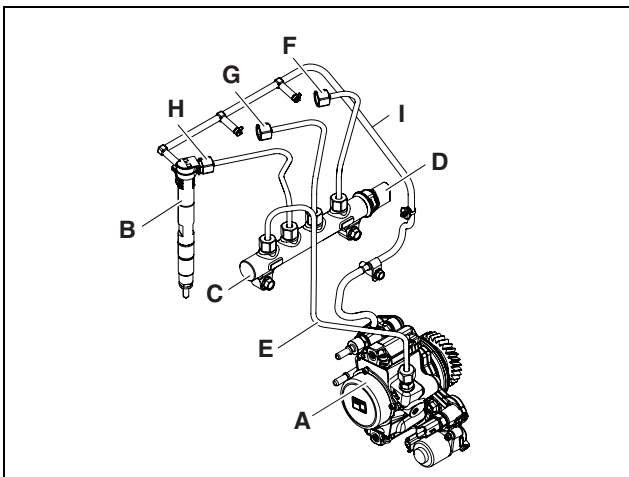
The injection characteristics of the common rail are as follows.

9. Fuel System

1. Comparing to the existing injection characteristics, the common rail requires the ideal fuel injection as follows. The fuel injection amount and the injection pressure work independently from each other, satisfying conditions for all engines.
2. It should be available to adjust the injection amount to low for the ignition delay time, i.e., the period from starting fuel injection to starting combustion at the early stage of fuel injection.
3. The common rail system is a modularized system. Generally, the following components take key roles of the injection characteristics.
 - 1) Injector solenoid valve installed on the cylinder head
 - 2) Common rail
 - 3) Fuel high-pressure pump
 - 4) Electronic Control Unit (ECU)
 - 5) Crankshaft RPM sensor

Injection Pipe

1. Fuel high-pressure pipe
 - 1) The fuel high-pressure pipe transfers high-pressured fuel of 1,800 bar. Therefore, special materials are used for fuel line to stand the maximum pressure of the system and the high-pressure changes which are generated while fuel is injected. The high-pressure pipe uses both the external diameter of $\varnothing 6.35$ and the bore of $\varnothing 3.0$. In addition, the length of the fuel high-pressure pipes between the common rail and the injector should be identical and installed as short as possible.
2. Common rail



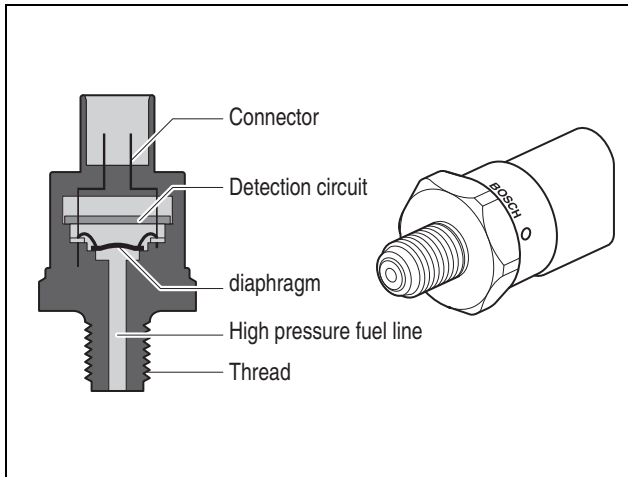
EDL013075A

- | | |
|------------------------|--|
| A. Fuel injection pump | F. Fuel injection pipe for injector #1 |
| B. Injector | G. Fuel injection pipe for injector #2 |
| C. Common Rail | H. Fuel injection pipe for injector #3 |
| D. Pressure sensor | I. Fuel return hose |
| E. Fuel supply | |
| Fuel injection pipe | |

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

- 1) After the injector has used fuel from the common rail for fuel injection, the pressure in the common rail is actually kept consistently. The fuel pressure is measured by the common rail pressure sensor and kept as a desired value by the pressure adjustment valve. The pressure control valve controls the fuel pressure up to 1,800 bar in the common rail.
- 2) The common rail stores the fuel pumped from the high-pressure fuel pump at the high pressure. After the injector has used fuel from the common rail for fuel injection, the pressure pulsation in the common rail is actually kept consistently because of the volume of the common rail. The fuel pressure is measured by the common rail pressure sensor and kept as a desired value by the pressure adjustment valve. The pressure control valve controls the fuel pressure up to 1,800 bar in the common rail.
- 3) Doosan's common rail fuel injection system separates the high-pressure apparatus from the fuel injection apparatus. The ECU decides the fuel amount and the fuel injection timing and pressure for the optimum performance and injects fuel in the cylinder.
 - 1) Fuel flows from the common rail into the common rail pressure sensor through the path. The end of the pressure sensor is sealed with diaphragm. The pressurized fuel reaches the diaphragm of the sensor through the hole. The sensor which converts the fuel pressure to the electrical signal is connected to this diaphragm and the signal amplifies the measurement signal. The signal is sent to the ECU and input in the evaluation circuit.

9. Fuel System



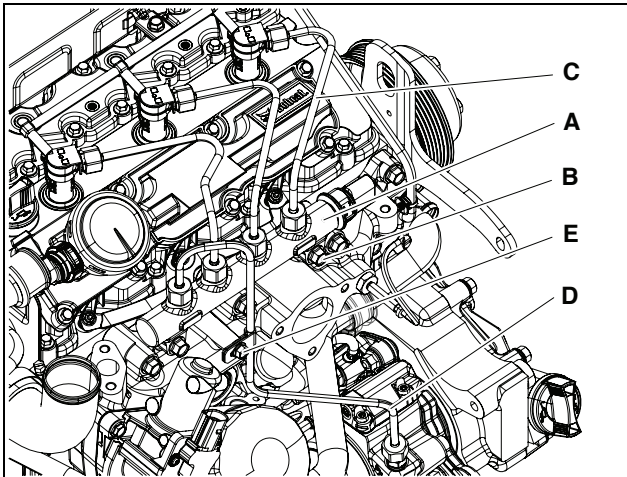
EDL0213005A

Common Rail Check

1. Check if there is any damage on the exterior of the common rail.
2. Check whether there is any damage of the pressure sensor of the common rail.
3. Check if there is any damage of the fuel pressure restrict valve.

Common Rail Disassembly

1. Remove the common rail and the injection pipes.



EDL013006A

- 1) Loosen the fixing bolt (E).
- 2) Loosen the nuts of the fuel injection pipes.
- 3) Remove 4 fuel injection pipes (C) and (D).

CAUTION

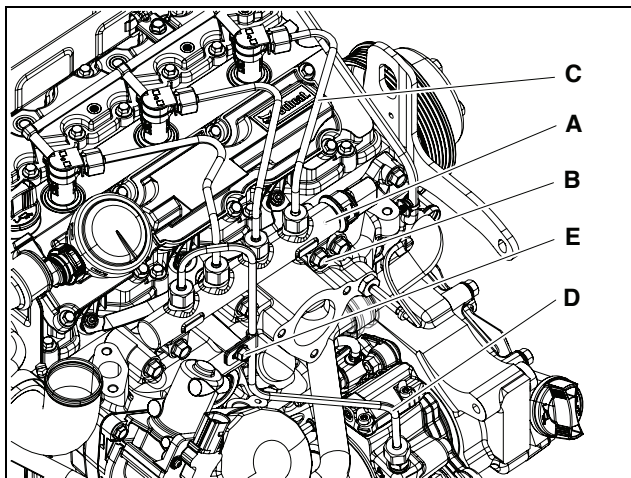
Do not reuse fuel injection pipes; replace them with new ones. If fuel injection pipes are reused it may allow foreign substances into the fuel pipes or cause oil leaks from bolt clamping and cause a critical fault in engine performance.

- 4) Loosen 2 collared hex bolts (B) of the common rail.
- 5) Remove the common rail (A) from the intake manifold.

9. Fuel System

Common rail assembly

1. Attach the common rail and the injection pipe.



EDL013006A

- 1) Attach the common rail (A) to the intake manifold.

⚠ CAUTION

- Be careful to note the direction when attaching the common rail.
 - Be careful not to damage the common rail while attaching it.
-

- 2) Temporarily tighten 2 collared hex bolts (B) by hand.
- 3) Temporarily connect the fuel injection pipes (C) and (D) by hand.

⚠ CAUTION

- Do not bend the fuel injection pipes by force.
 - Be careful to note the direction when connecting the fuel injection pipes.
 - Assemble the nut on one side of the fuel injection pipe first, and then the nut on the other side to connect the round part of the pipe to the correspondent part correctly.
 - Do not reuse fuel injection pipes but replace them with new ones. Reusing fuel injection pipes may allow foreign substances into the fuel pipes or oil leaks from the bolt clamping to occur, causing a critical fault in engine performance.
-

- 4) Tighten 2 collared hex bolts(B) at a tightening torque of 2.2 kgf·m.
- 5) Tighten the fuel injection pipes (C) and (D) at a tightening torque of 3.0 kgf·m.
- 6) Tighten the fixing bolt (E).

9. Fuel System

Fuel injection pump

General Information

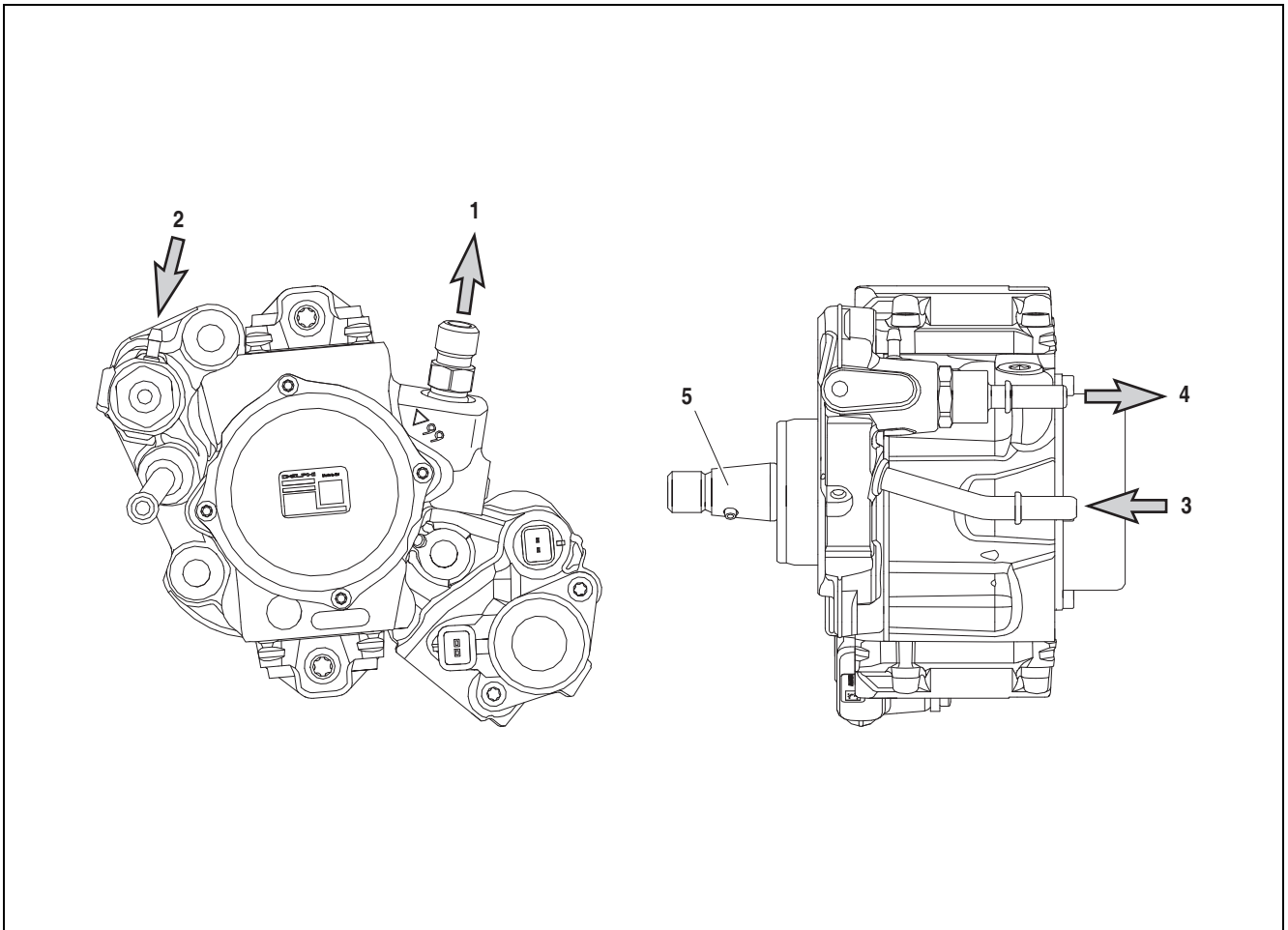
Fuel high-pressure pump uses a radial piston pump to generate high pressure in fuel. Pressure is independently generated as fuel is injected. The RPM of the fuel high-pressure pump is directly connected to the engine rotation speed regardless of the rotation ratio of the transmission. Comparing to the existing injection system, the common rail injection system shows the consistent fuel delivery amount.

The injector is connected to the common rail with the high-pressure pipe. It consists of a nozzle and a solenoid valve. When a key switch is operated, actuating power is supplied to the solenoid valve by the ECU. When the key switch is blocked, the solenoid valve ends injection.

Solenoid valve switching (open/close) is operated by high pressure and high current. Based on the values set in the ECU, the solenoid valve of the injector is sequentially operated. The crankshaft sensor and the camshaft sensor use to detect the engine rev count for starting fuel injection and adjusting the injection timing.

The fuel high pressure pump pressurizes fuel at the pressure of 1,800 bar and the pressurized fuel is delivered to the common rail through the high-pressure line.

The fuel high-pressure pump consists of the following components.



EDL022169A

- | | | |
|---|----------------------------------|----------------|
| 1. High pressure fuel line outlet | 3. Low pressure fuel line inlet | 5. Drive shaft |
| 2. High pressure fuel line return inlet | 4. Low pressure fuel line outlet | |

9. Fuel System

1. Functions

- 1) The fuel high pressure pump has two pressure phase processes: low-pressure phase and high-pressure phase. Under all operating conditions, it transfers high-pressure fuel in a vehicle for the entire service lifetime. In addition, it delivers fuel required to respond to the rapidly-changing pressure in the common rail or quick start of a vehicle. The fuel high pressure pump continuously generates the system pressure necessary for the common rail.

2. Configuration of fuel high pressure pump

- 1) Inside of the fuel high pressure pump, there are three pump pistons and the pistons are installed with 120° compression, compressing fuel to the circumferential direction. Compression strokes occur three times per rotation. Therefore, consistent stress is kept in the pump driving apparatus and low driving force is required. Pump driving force of the common rail requires about 1/9 of that of the existing pump system.

3. Operation method

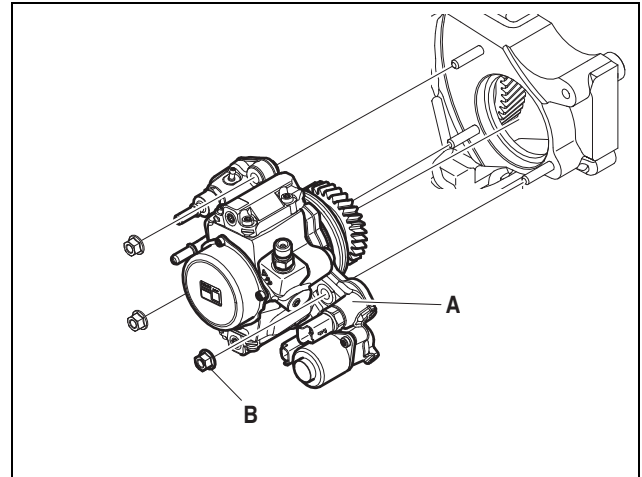
- 1) The fuel delivery pump delivers fuel from the fuel tank to the fuel high pressure pump through the fuel inlet and the safety valve. Then the fuel high pressure pump pumps and transfers the fuel to the lubricating and cooling circuit of the high pressure pump through the safety valve. The driving shaft, which has the eccentric cam, moves the pump piston up and down according to the cam shape.
- 2) When the transfer pressure of the fuel delivery pump exceeds the open pressure of the safety valve, the fuel is transferred to the intake stroke position of the pumping chamber where the pump piston moves up and down through the intake valve of the fuel high pressure pump. When the pump piston exceeds the bottom dead point, the valve inlet is closed and fuel cannot be transferred from the pumping chamber. So the fuel is compressed over the delivered pressure.
- 3) As soon as the fuel pressure reaches the common rail pressure, the outlet valve is opened. Then the compressed fuel flows into the high pressure circuit. The pump piston continuously transfers fuel until it reaches the bottom dead point. After the bottom dead point is reached, the outlet valve is closed. The fuel in the pumping chamber is relaxed and then the pump piston moves down again. When the pressure in the pumping chamber is lower than the pressure of the fuel delivery pump, the inlet valve is opened again and the above procedure is started again.

4. Fuel supply collection

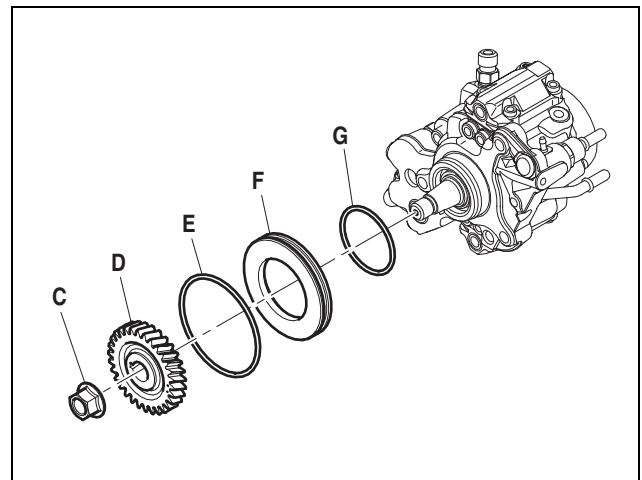
- 1) The fuel high pressure pump is designed to deliver a lot of fuel. While the engine runs at idle or partial load, the fuel excessively delivered returns to the fuel tank through the pressure adjustment valve.

Disassembly of Fuel Injection Pump

1. Remove the fuel injection pump (A).



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EDL022043B

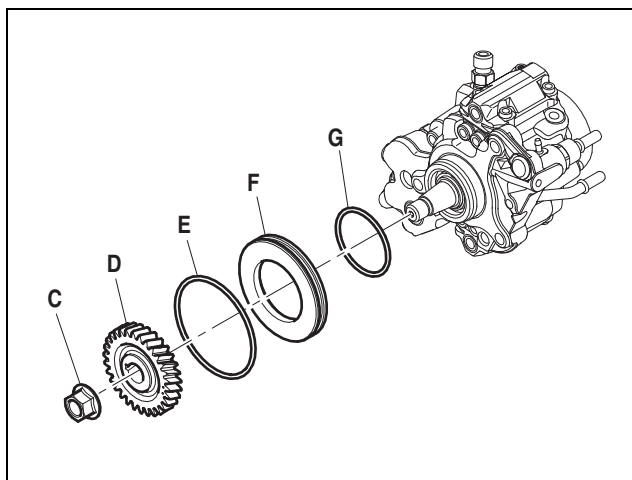
- 1) Loosen 3 flange hex nuts (B).
- 2) Remove the fuel injection pump (A).
- 3) Loosen the flange hex nut (C).
- 4) Remove the injection pump drive gear (D).
- 5) Remove the collar (F).
- 6) Remove the O- ring (E) from the collar (F).
- 7) Remove the O- ring (D).

⚠ CAUTION

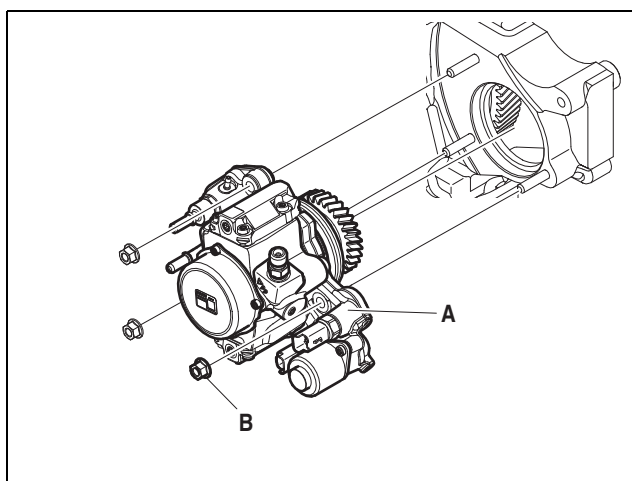
Do not reuse the O-ring; replace with a new one. Reuse of the O-ring may cause critical damage to engine performance to occur.

Assembly of Fuel Injection Pump

1. Attach the fuel injection pump (A).



EDL022043B



EDL022043A

- 1) Mount the O- ring (D).
- 2) Mount the O- ring (E) to the collar (F).
- 3) Mount the collar (F).
- 4) Be careful to mount the injection pump drive gear (D) with attention to the pin direction.

CAUTION

- Ensure that you are attaching the injection pump drive gear so that its engraving faces the outside of the cylinder block.
- Ensure that the pin direction is the opposite direction of the idle gear.

- 5) Tighten the flange hex nuts (C) at a tightening torque of $6.5 \pm 0.5 \text{ kgf}\cdot\text{m}$.
- 6) Attach the fuel injection pump (A).

Note) To replace stud bolts, apply LOCTITE 272 to the stud bolts and then press in those bolts.

- 7) Tighten 3 flange hex nuts (B) at a tightening torque of $2.2 \text{ kgf}\cdot\text{m}$.

9. Fuel System

10. Intake/Exhaust System

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10. Intake/Exhaust System

Intake/Exhaust System

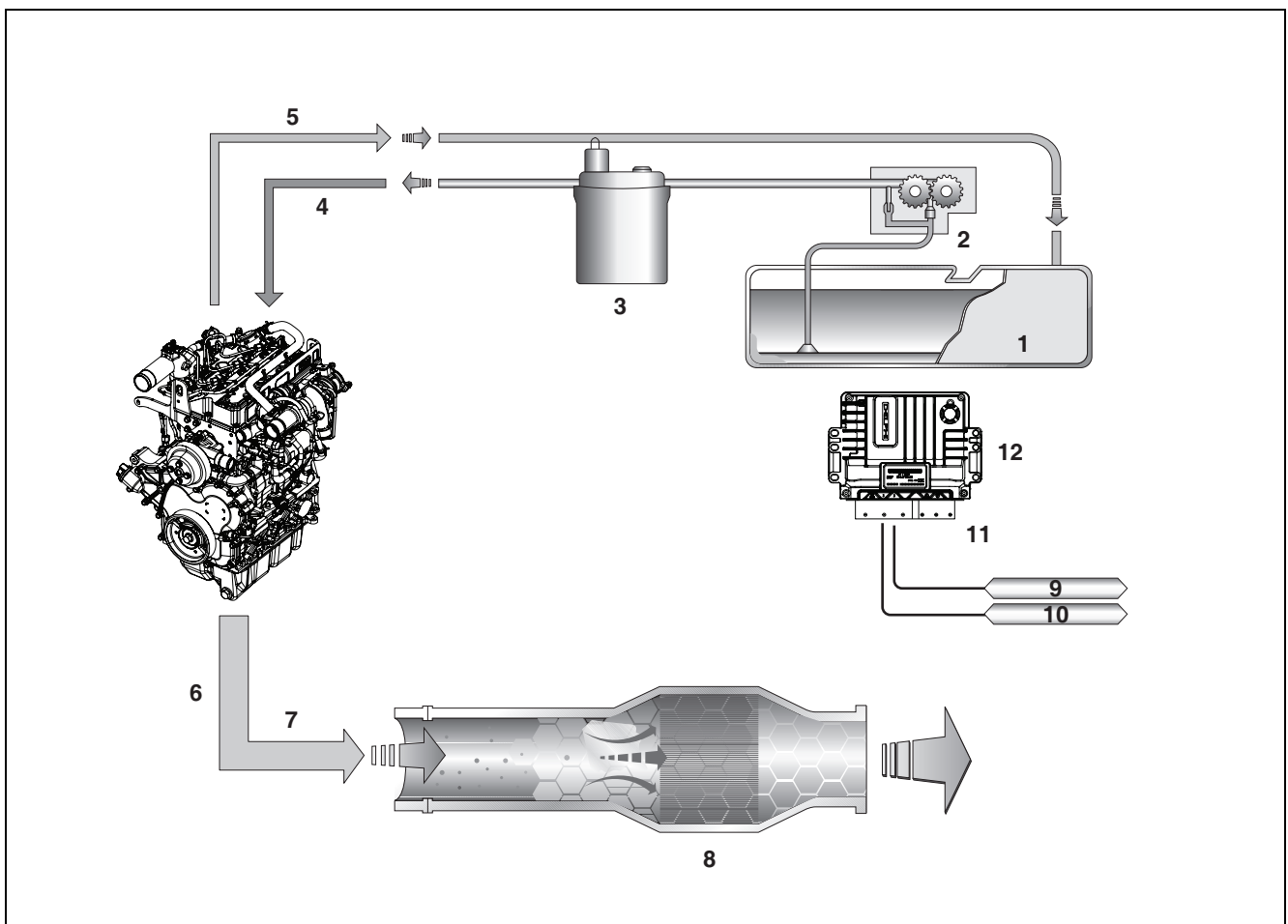
General Information

General Information

Doosan's new engine is designed with Doosan's latest technology to satisfy the tightened exhaust restrictions, improve fuel efficiency, and reduce exhaust fumes.

The Exhaust Gas Reduction is designed with the Diesel Oxidation Catalyst (DOC) to reduce the exhaust soot and the Exhaust Gas Recirculation System (EGR) to reduce nitrogen oxide (NOx) of the engine exhaust emission.

1. The EGR is a system that recirculates exhaust fumes to reduce the Nox.
 2. In the muffler, the Diesel Oxidation Catalyst (DOC) is included.
- 1) The DOC Catalyst reduces HC and CO included in exhaust gas.



EDL013077A

- | | | |
|-------------------|-----------------------------------|---------------------------------|
| 1. Fuel Tank | 5. Fuel Return | 9. Engine CAN Communication |
| 2. Injection Pump | 6. Exhaust Pipe (from the engine) | 10. Diagnosis CAN Communication |
| 3. Fuel Filter | 7. Engine Exhaust Gas | 11. Sensor |
| 4. Fuel Inlet | 8. DOC | 12. ECU |

10. Intake/Exhaust System

Specifications

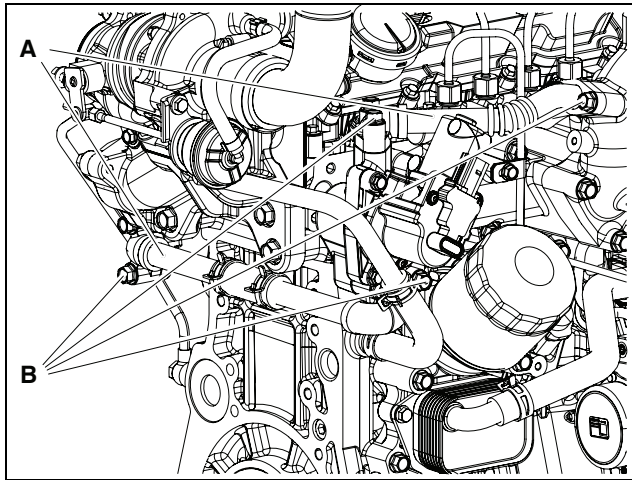
Item		D18NAP		Remark
		DL01-LEE00	DL01-LEL00	
Intake/Exhaust System				
Turbocharger	Model	Borgwarner WGT	←	
	Driving Type	EXHAUST PRESSURE FEED TYPE	←	
	Lubricating type	FORCED PRESSURE FEED TYPE	←	
	Compressor outlet air pressure	1.98 kgf·cm ²	2.14 kgf·cm ²	At max. output
	Air intake	50 g/s	64 g/s	At max. output
	Turbine speed	-	←	At max. output
	Allowable max. RPM	275 krpm	←	From the turbine inlet
	Allowable max. exhaust temperature	750 °C	←	
	Weight	3.8 kg	←	
Valve gap	Intake valve	0.4 mm	←	
	Exhaust valve	0.45 mm	←	
Intake valve	Open (BTDC)	19°	←	
	Closed (ABDC)	45°	←	
Exhaust valve	Open (BBDC)	29°	←	
	Closed (ATDC)	23°	←	
Valve length	Intake	104.53 mm	←	
	Exhaust	106.33 mm	←	
Stem outside diameter	Intake	6.97 ± 0.007 mm	←	
	Exhaust	6.96 ± 0.007 mm	←	
Valve guide bore	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 sheet contact width	Intake	1.91 mm	←	
	Exhaust	1.89 mm	←	
Valve sheet angle	Intake	44.5° ~ 45.0°	←	
	Exhaust	44.5° ~ 45.0°	←	
Free length of valve spring		53.8 mm	←	
Valve spring squareness		Below2° (below 1.8 mm)	←	

10. Intake/Exhaust System

Intake Manifold

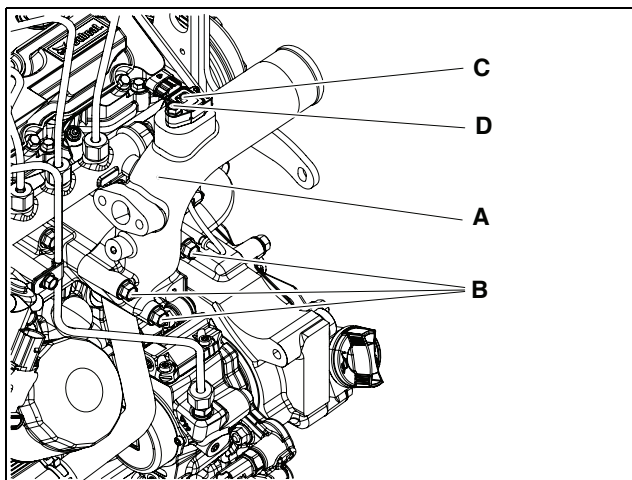
Disassembly of Intake Manifold

1. Remove the EGR connection pipes.



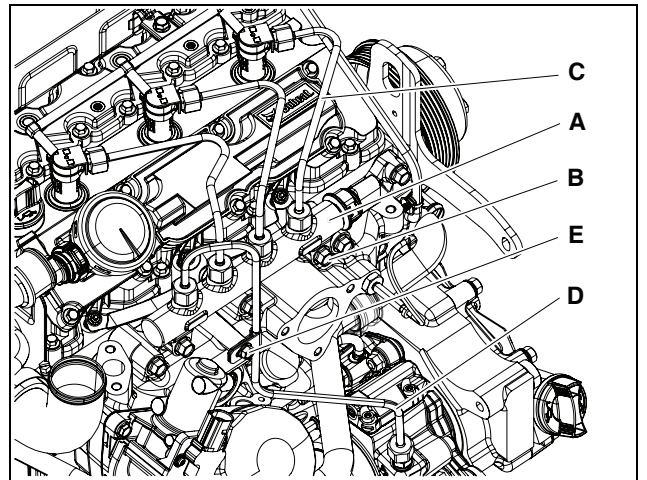
- 1) Loosen 6 fixing bolts (B).
- 2) Remove the EGR pipes (A).
- 3) Remove 4 gaskets.

2. Remove the intake stake.



- 1) Loosen the flange hex bolt (D).
- 2) Remove the boost pressure sensor (C).
- 3) Loosen 3 flange hex bolts (B).
- 4) Remove the gasket and the intake stake (A).

3. Remove the common rail and the injection pipes.



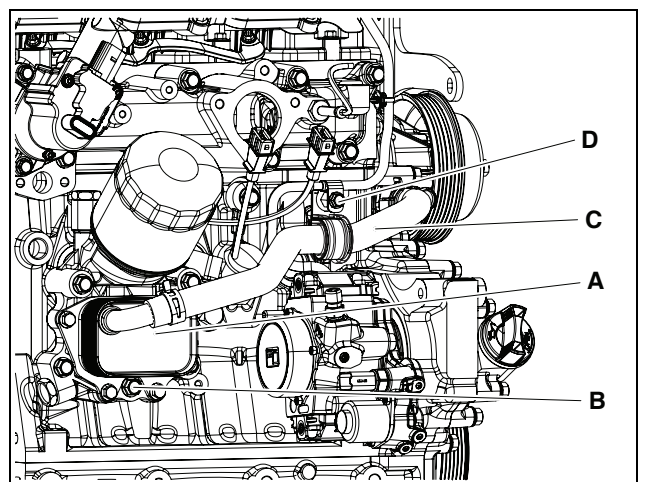
- 1) Loosen the fixing bolt (E).
- 2) Loosen the nuts of the fuel injection pipes.
- 3) Remove 4 fuel injection pipes (C) and (D).

CAUTION

Do not reuse fuel injection pipes; replace them with new ones. If fuel injection pipes are reused it may allow foreign substances into the fuel pipes or cause oil leaks from bolt clamping and cause a critical fault in engine performance.

- 4) Loosen 2 collared hex bolts (B) of the common rail.
- 5) Remove the common rail (A) from the intake manifold.

4. Remove the oil filter assembly.



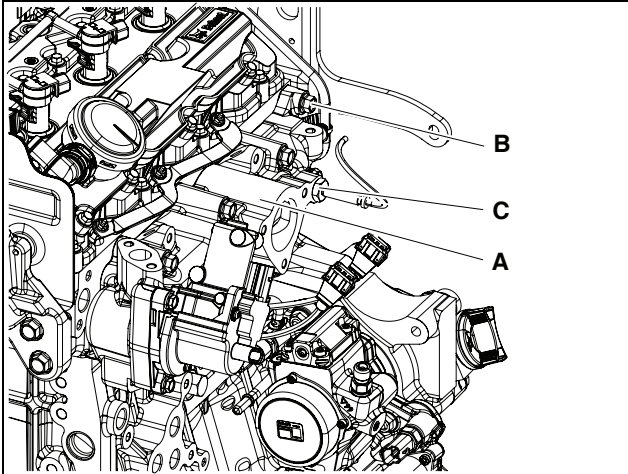
- 1) Loosen the fixing bolt (D).
- 2) Disconnect the coolant hose (C).
- 3) Loosen 5 flange hex bolts (B).
- 4) Remove the 3 O-rings and the oil filter assembly (A).

10. Intake/Exhaust System

CAUTION

Oil in the filter may run down while removing the oil filter. Be careful not to contaminate the other parts by using a cloth when removing the filter. After replacing the oil filter, wipe clean any other parts which the oil has touched.

5. Remove the intake manifold.

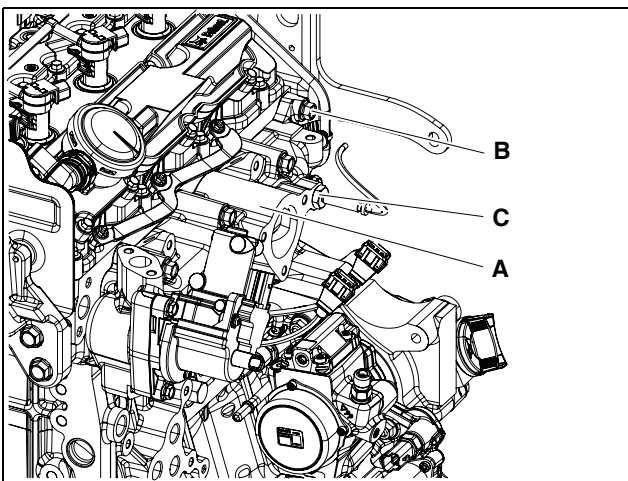


EDL013010A

- 1) Remove the boost temperature sensor (C).
- 2) Loosen 8 flange hex bolts (B).
- 3) Remove the gasket and the intake manifold (A) from the cylinder block.

Assembly of Intake Manifold

1. Attach the intake manifold.



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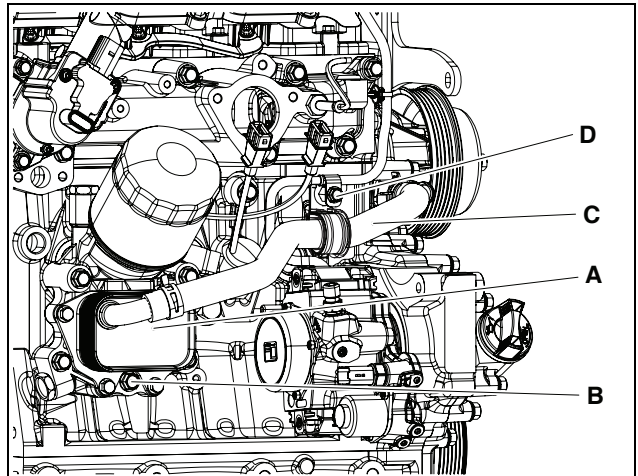
- 1) Attach the gasket and the intake manifold (A).

CAUTION

- Be careful to note the direction when mounting the gasket.
- Be careful not to damage the gasket while mounting it.

- 2) Tighten 8 flange hex bolts (B) at a tightening torque of 2.2 kgf•m.
- 3) Attach the boost temperature sensor (C).

2. Attach the oil filter assembly.



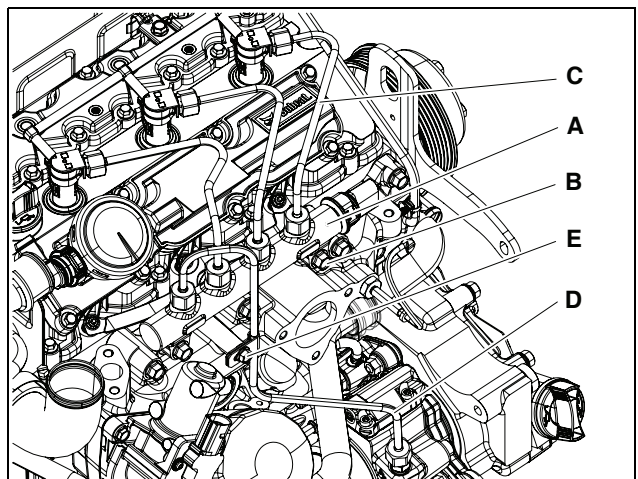
EDL013009A

- 1) Attach the 3 O-rings and the oil filter assembly (A).
- 2) Tighten 5 flange hex bolts (B).
- 3) Connect the coolant hose (C)
- 4) Tighten the fixing bolt (D).

CAUTION

- Make sure that the O-rings have been mounted.
- Be careful not to damage the O-rings while mounting them.

3. Attach the common rail and the injection pipe.



EDL013006A

10. Intake/Exhaust System

- 1) Attach the common rail (A) to the intake manifold.

CAUTION

- Be careful to note the direction when attaching the common rail.
- Be careful not to damage the common rail while attaching it.

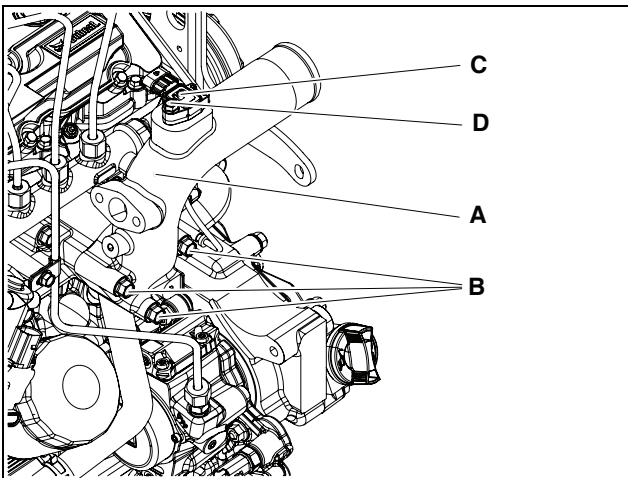
- 2) Temporarily tighten 2 collared hex bolts (B) by hand.
- 3) Temporarily connect the fuel injection pipes (C) and (D) by hand.

CAUTION

- Do not bend the fuel injection pipes by force.
- Be careful to note the direction when connecting the fuel injection pipes.
- Assemble the nut on one side of the fuel injection pipe first, and then the nut on the other side to connect the round part of the pipe to the correspondent part correctly.
- Do not reuse fuel injection pipes but replace them with new ones. Reusing fuel injection pipes may allow foreign substances into the fuel pipes or oil leaks from the bolt clamping to occur, causing a critical fault in engine performance.

- 4) Tighten 2 collared hex bolts(B) at a tightening torque of 2.2 kgf•m.
- 5) Tighten the fuel injection pipes (C) and (D) at a tightening torque of 3.0 kgf•m.
- 6) Tighten the fixing bolt (E).

4. Attach the intake stake.



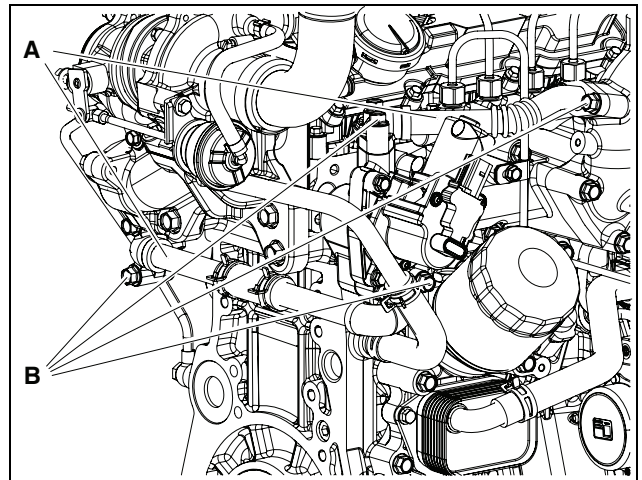
EDL013005A

- 1) Attach the gasket and the intake stake (A).

CAUTION

- Be careful to note the direction when attaching the gasket.
- Be careful not to damage the gasket while attaching it.

- 2) Tighten 3 flange hex bolts (B) at a tightening torque of 2.2 kgf•m.
- 3) Attach the boost pressure sensor (C).
- 4) Tighten the flange hex bolt (D) at a tightening torque of 1.0 kgf•m.
5. Attach the EGR connection pipes.



EDL013004A

- 1) Attach 4 gaskets.
- 2) Attach the EGR pipes (A).

CAUTION

- Be careful to note the direction when attaching the the EGR connection pipe.
- Be careful not to damage the gasket while attaching it.

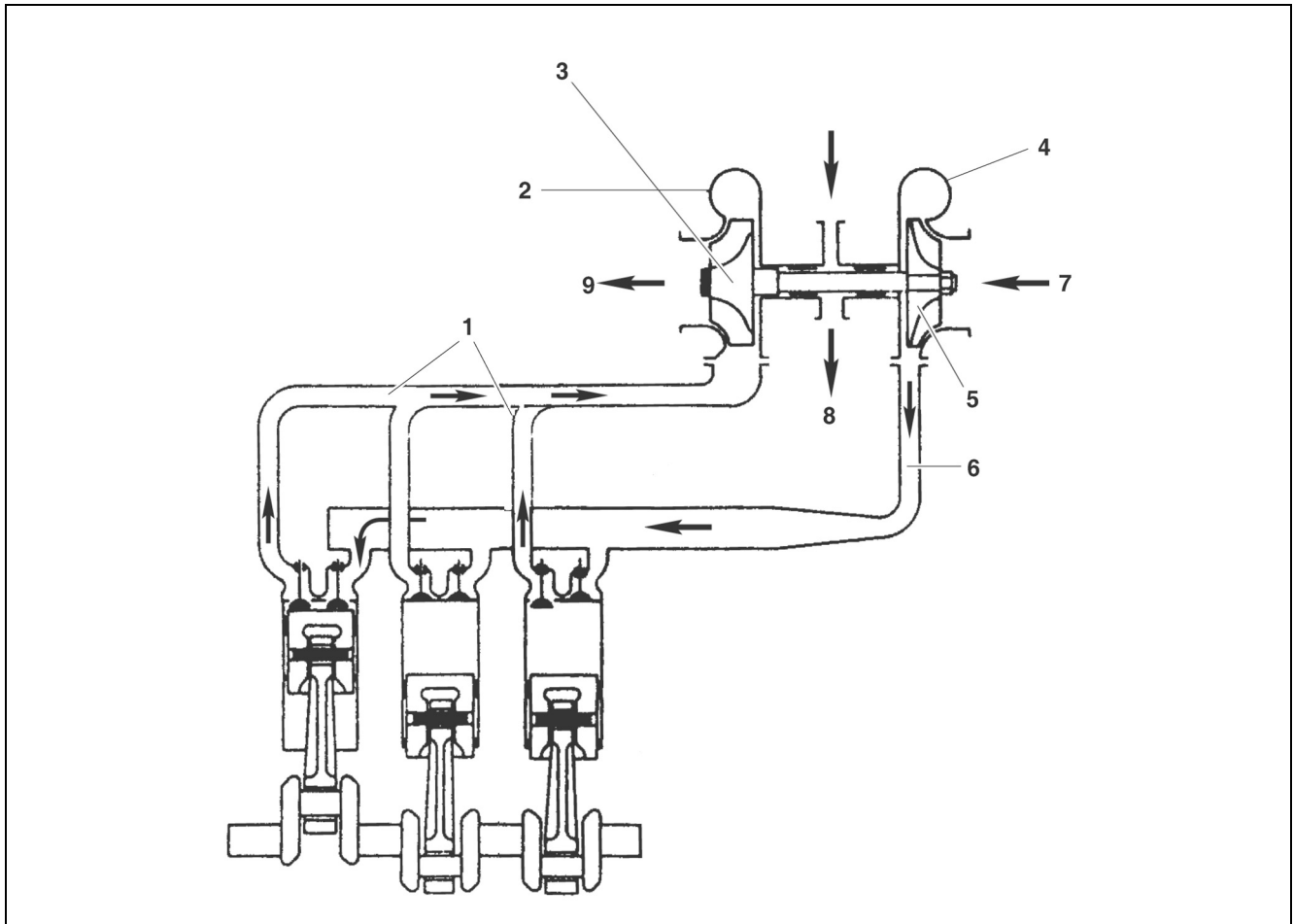
- 3) Tighten 6 fixing bolts(B) at a tightening torque of 2.2 kgf•m.

10. Intake/Exhaust System

Turbocharger

General Information

Turbocharger increases the engine output by inhaling high-density air to the cylinder by using the exhaust heat energy of the engine.



EDL013078A

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

1. The engine output is determined by fuel amount and engine efficiency.
2. To combust the delivered fuel completely and convert it to the useful work of the engine, enough air to completely combust the fuel should be delivered to the cylinder.
3. Actually, the engine output is determined by the capacity of the cylinder. If air is compressed and delivered to the cylinder, the amount of air in the cylinder is increased as

much as compressed. Therefore, more fuel can be combusted and the engine output can be increased.

4. Supercharger is to compress air and deliver the compressed air to a cylinder of an engine and Turbocharger is a forced induction device that forces more intake air, proportionately more fuel, into the combustion chamber and supercharges the exhaust gas energy into the atmosphere.

10. Intake/Exhaust System

5. The key functions of a turbocharger are as follows.
- 1) Turbine: Kinetic energy of the exhaust gas from the combustion chamber passes through the turbine housing and is captured by the turbine blades, transferring the turning force to the turbine shaft. Turbine refers to the device where this operation is generated. A turbine has sealings and the heat screen to protect bearings from harmful impact of exhaust gas.
 - 2) Compressor: A compressor is connected to a shaft where the turbine is connected, composing a rotor assembly. It uses the turning energy from the turbine shaft to inhale and compress air, and then transfers the compressed air to the intake pipe. This is the performance property of a compressor.
 - 3) Bearing system:
 - Thrust bearing: Shaft force acts upon the turbine wheel. The thrust bearing prevents a shaft from being moved by the shaft force.
 - Journal bearing: Journal bearings are floating types. They create a doubled-oil film on the exterior and interior of the bearing,
 - allowing the bearing to spin independently. The doubled oil film works as a buffer reducing the sliding speed on the surface of the bearing lower than the shaft spinning speed, aiming dynamic stability.
 - 4) Sealing of compressor shaft: A seal plate and seal ring compose a dual structure to prevent the compressed intake air and lubricating oil from leaking.

10. Intake/Exhaust System

Failure Diagnosis

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

10. Intake/Exhaust System

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

10. Intake/Exhaust System

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

10. Intake/Exhaust System

How to Maintain Turbocharger

1. Cautions for engine operation

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

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

2. Cautions for Maintenance

- 1) When the RPM is rapidly increased after starting the engine, the journal bearings in the crankshaft is excessively rotated, the crankshaft is rotated at excessive speed before the journal bearing of the crankshaft is lubricated fully. If the turbocharger rotates in this situation, bearings are not smoothly

cooled and lubricated, causing bearing burn and damage of the related parts.

- 2) Please operate the engine for two minutes or more in order to lubricate the turbocharger fully after replacing the engine oil or oil filter.
- 3) If an engine has been operated at high speed for a long period, fully operate the engine at idle and then stop the engine. Otherwise, the turbine wheel

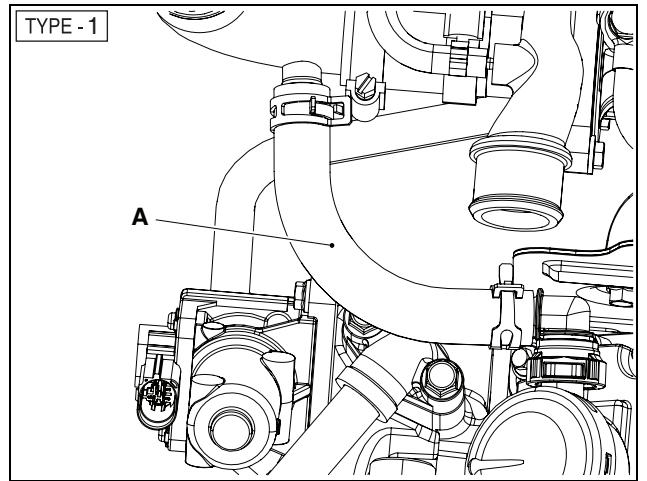
10. Intake/Exhaust System

continuously runs without oil pressure in the turbocharger. Therefore, no oil film is created on the center bearings and the journal bearings of the turbocharger, causing bearing, wearing out and shortening of the turbocharger lifetime.

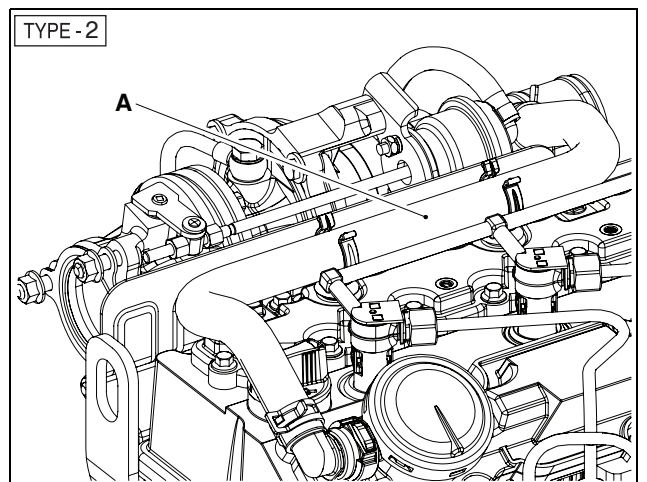
- 4) If an engine is not operated for a long period during cold weather or in areas with cold climate, operate the engine at idle after starting the engine until the engine oil pressure is normal.
- 5) The turbocharger turbine spins at high speed of 50,000 ~ 200,000 rpm. Therefore, lubrication of bearings may determine the turbocharger lifetime. Please use only recommended genuine engine oil and check and replace the engine oil periodically.
- 6) Prolonged usage of contaminated air cleaner may cause a critical damage of the turbocharger. Regularly check and replace the air cleaner.
- 7) A turbocharger is a very complex and precise part. Only certified and skilled technicians should work on it.
- 8) If a turbocharger is operated without intake and exhaust pipe, serious human injury may occur and critical faults of the engine performance may occur. Please operate a turbocharger only when all of parts are exactly mounted on the specified position.
- 9) Do not lift up a turbocharger by grabbing the actuator. The actuator may be damaged because of the weight of the turbocharger.
- 10) The weight of a turbocharger is about 4.0 kg or more. To lift up a turbocharger for installing or removing it, the worker should lower the center of gravity or press his body close to the turbocharger. Otherwise, worker may drop the turbocharger, causing damage of the part and injury.

Turbocharger Disassembly

1. Remove the breather hose.



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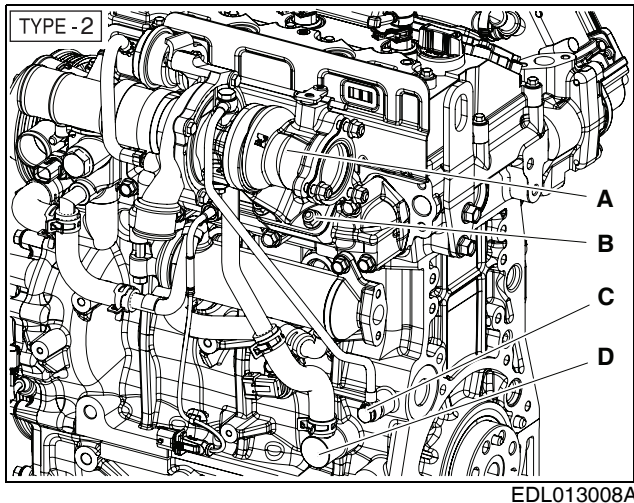
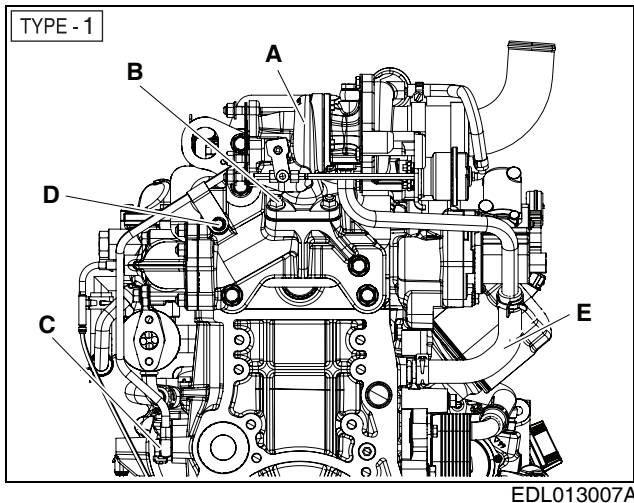
- 1) Remove the breather hose (A).

CAUTION

Do not reuse the clamps but replace with new ones.

10. Intake/Exhaust System

2. Remove the turbocharger.



1) Disconnect the oil return pipe.

Note) The oil return pipe is that TYPE-1 is (E) and TYPE-2 is (D).

2) Loosen 2 hollow screws from the oil delivery pipe.

Note) Loosen the fixing bolt(D) if the engine is TYPE-1.

3) Disconnect the oil delivery pipe (C).

4) Loosen 4 flange hex nuts (B)

5) Remove the gasket and the turbocharger (A).

Turbocharger Check

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

1) Intake system: For the intake system, the air filter should be carefully managed. For a wet type air filter, if the oil amount is lower than the specified amount, filtering efficiency is lowered. On the contrary, if it is

too high, the filter absorbs oil and contaminates the case. Especially, when the rotor is contaminated, the precisely adjusted balance is broken, causing vibration. In addition, the bearings are overloaded, resulting in bearing burn and abnormal wearing. Therefore, an air filter should be carefully used and maintained according to the instructed and specified ways. For a dry type air filter, the intake resistance should be small as possible.

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

3) Lubrication system: For the lubrication system, be careful with the oil quality and the replacement time of the cartridge of the oil filter. Degradation of engine oil has bad effect on the turbocharger, as well as the engine body.

2. Regular Inspection and Repair: The state and contamination of a turbocharger should be checked regularly.

1) How to check the rotating state of a rotor assembly: You can check the rotating state of a rotor assembly by checking the abnormal sound which occurs while the solid of rotation is rotating. If you use a sound rod, contact the neb of the sound rod to the turbocharger housing and slowly raise the RPM. If high-pitched sound continues, it means that the state is abnormal. In this case, the bearing or the rotor assembly may be abnormal. So you need to replace or repair the turbocharger.

2) How to detach and check the turbocharger: Detach the turbocharger from the engine and clean or check it. At this time, seal the oil inlet and outlet with sealing tape.

3) Cautions for attaching the turbocharger to the engine: Please observe the following precautions as attaching the turbocharger to the engine and handling it after attaching. Especially, be careful not to let foreign substances flow into the turbocharger.

• Lubrication system:

Before attaching the turbocharger to the engine, inject new oil into the oil inlet and spin the turbine shaft to lubricate journal bearings and thrust bearings.

10. Intake/Exhaust System

Cleanse the pipes from starting from the engine to the oil inlet and outlet and check if there is any damage of the pipes or foreign substance in the pipe.

Precisely connect the oil pipes to prevent oil leaks.

- Intake system:

Check if there is any foreign substance within the intake system.

Precisely attach the intake system to the engine to prevent air leaks from the joints of the intake system and the air filter.

- Exhaust system:

Check if there is any foreign substance in the exhaust system.

The heat-resistant bolts and nuts should be used. Do not use any of general nuts and bolts. Apply burn prevention paint to the bolts and nuts.

Precisely attach the exhaust system to the engine to prevent gas leaks from the exhaust system joints.

2) Tighten 4 flange hex bolts (B) at a tightening torque of 2.2 kgf•m.

3) Connect the oil delivery pipe (C).

4) Tighten 2 hollow screws from the oil delivery pipe at a tightening torque of 2.0 kgf•m.

Note) Tighten the fixing bolt (D) if the engine is TYPE-1.

5) Connect the oil return pipe.

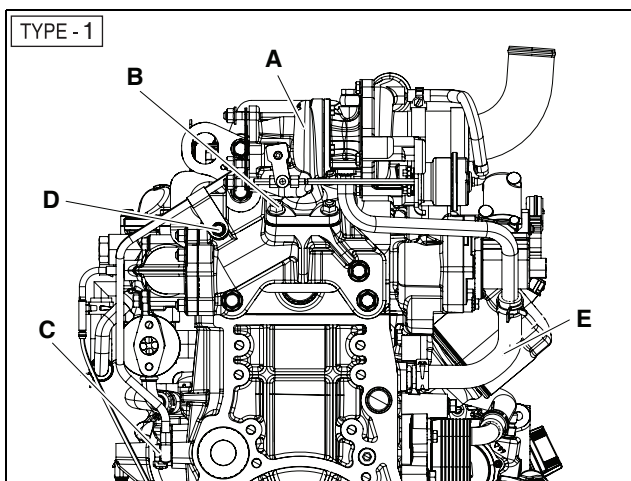
Note) The oil return pipe is that TYPE-1 is (E) and TYPE-2 is (D).

⚠ CAUTION

- Be careful to note the direction when connecting the hose and gasket.
- Be careful not to damage the gasket while mounting it.
- Do not reuse the hose clamps but replace them with new ones.
- Do not reuse the oil delivery pipe but replace it with new one.

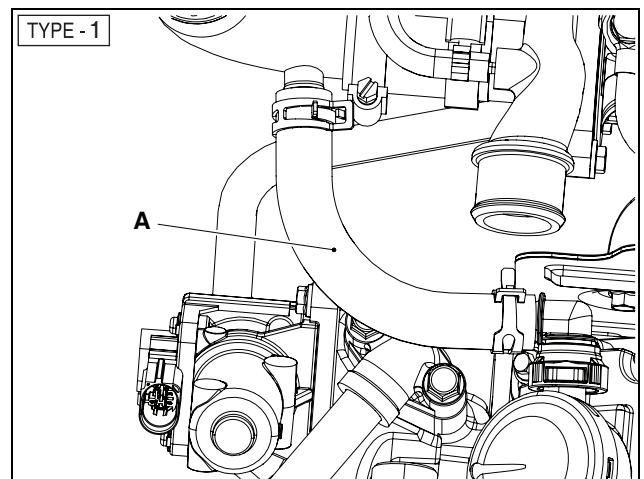
Turbocharger Assembly

1. Attach the turbocharger.

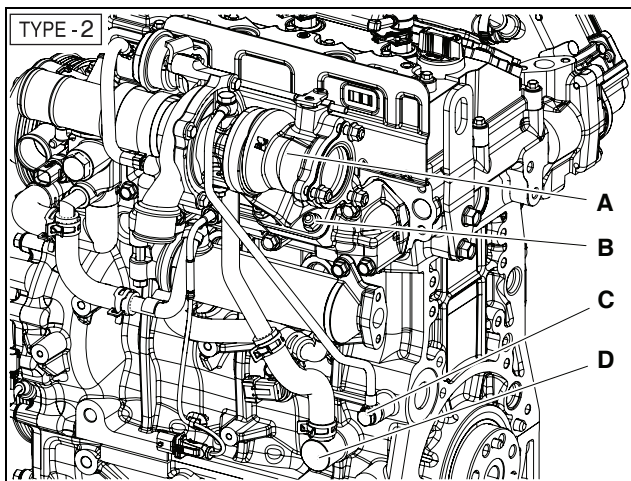


EDL013007A

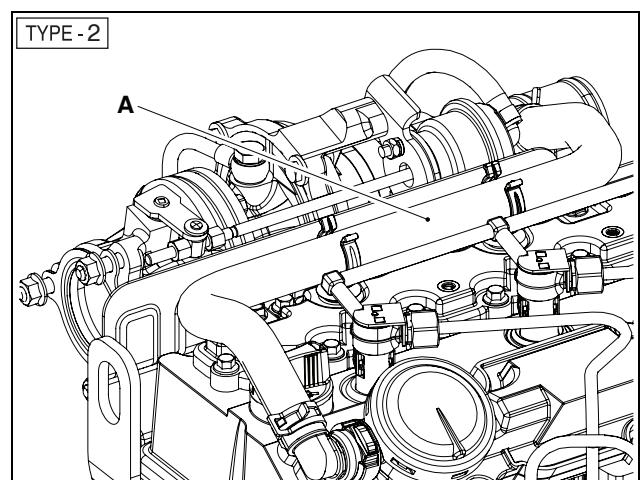
2. Attach the breather hose.



EDL013001A



EDL013008A



EDL013002A

1) Attach the gasket and the turbocharger(A).

10. Intake/Exhaust System

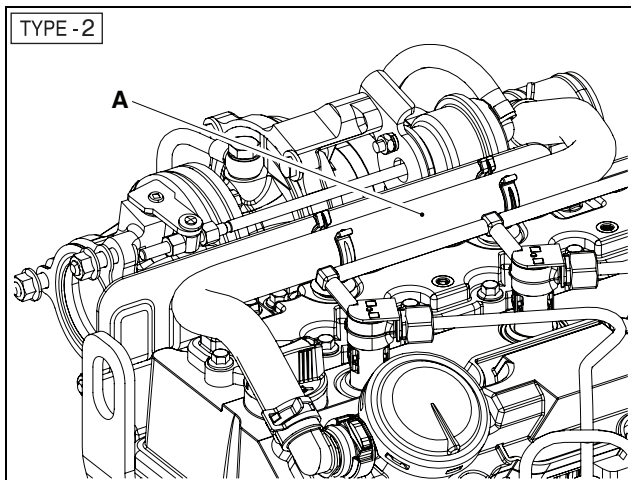
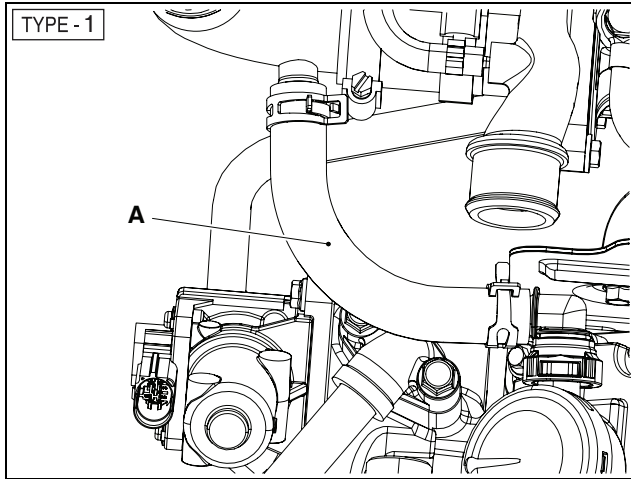
- 1) Attach the breather hose(A).

CAUTION

Do not reuse the clamps but replace with new ones.

Disassembly of Exhaust Manifold

1. Remove the breather hose.

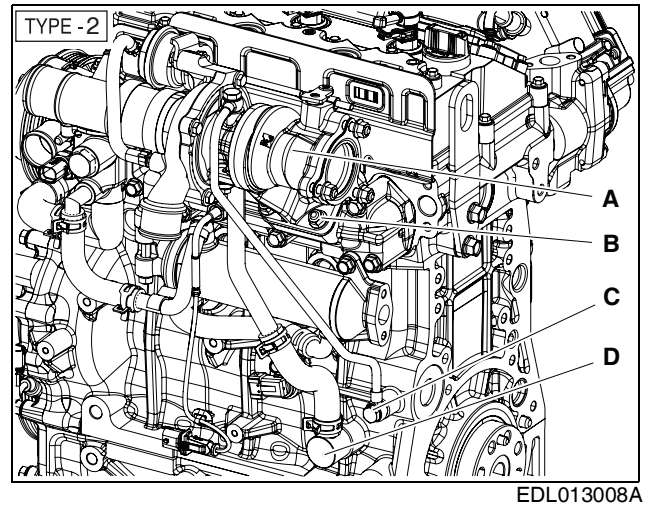
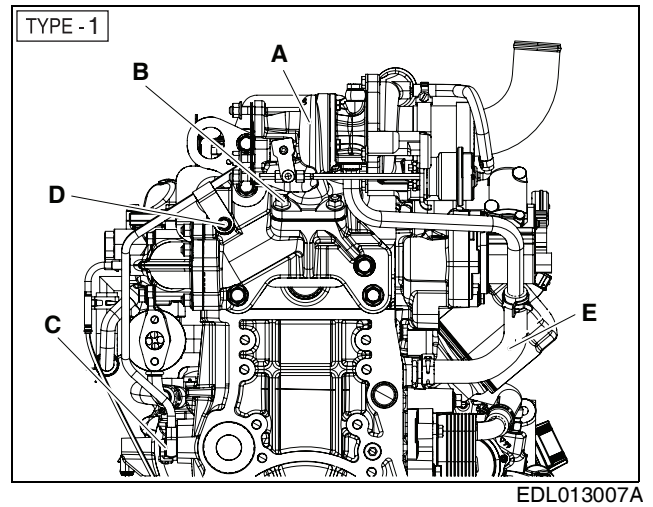


- 1) Remove the breather hose (A).

CAUTION

Do not reuse the clamps but replace with new ones.

2. Remove the turbocharger.



- 1) Disconnect the oil return pipe.

Note) The oil return pipe is that TYPE-1 is (E) and TYPE-2 is (D).

- 2) Loosen 2 hollow screws from the oil delivery pipe.

Note) Loosen the fixing bolt(D) if the engine is TYPE-1.

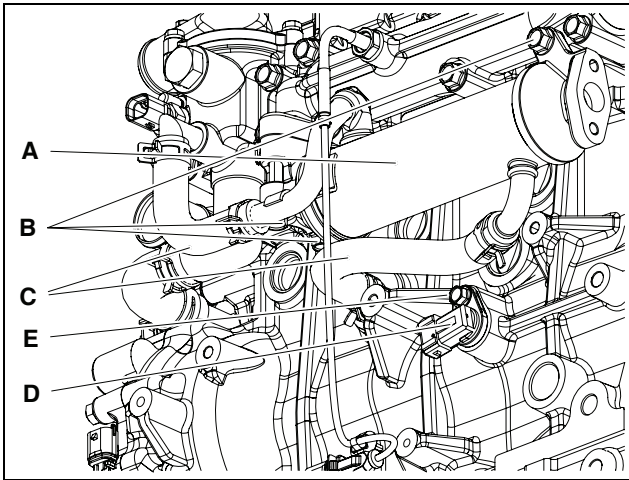
- 3) Disconnect the oil delivery pipe (C).

- 4) Loosen 4 flange hex nuts (B)

- 5) Remove the gasket and the turbocharger (A).

10. Intake/Exhaust System

3. Remove the EGR cooler assembly and the cam position sensor.



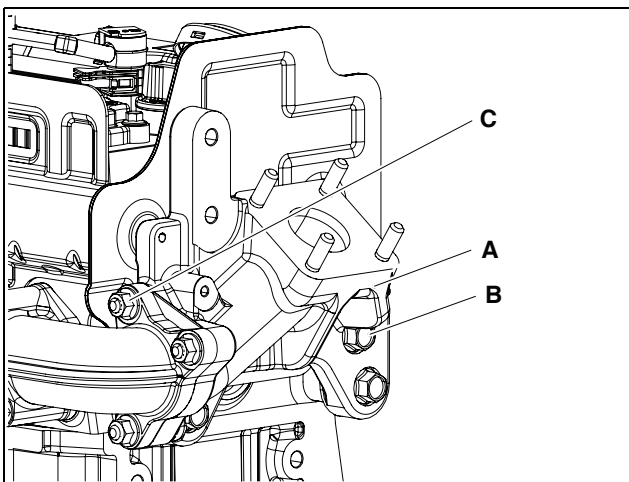
EDL013015A

- 1) Loosen the fixing bolt (E).
- 2) Remove the cam position sensor (D).
- 3) Disconnect the rubber hoses (C).
- 4) Loosen 3 flange hex bolts (B).
- 5) Remove the EGR cooler assembly (A).

⚠ CAUTION

Exhaust gas make engine parts extremely hot. Only remove the parts when they have fully cooled to prevent burns.

4. Remove the exhaust manifold pipe (Only TYPE-1).



EDL013017A

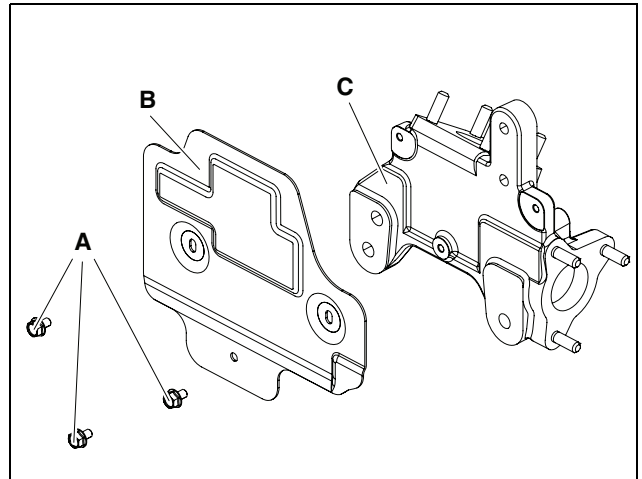
- 1) Loosen 3 flange hex nuts (C).
- 2) Loosen 3 flange hex bolts (B).
- 3) Remove the exhaust manifold pipe (A).

Note) The exhaust manifold pipe (A) is only TYPE-1.

⚠ CAUTION

Exhaust gas make engine parts extremely hot. Only remove the parts when they have fully cooled to prevent burns.

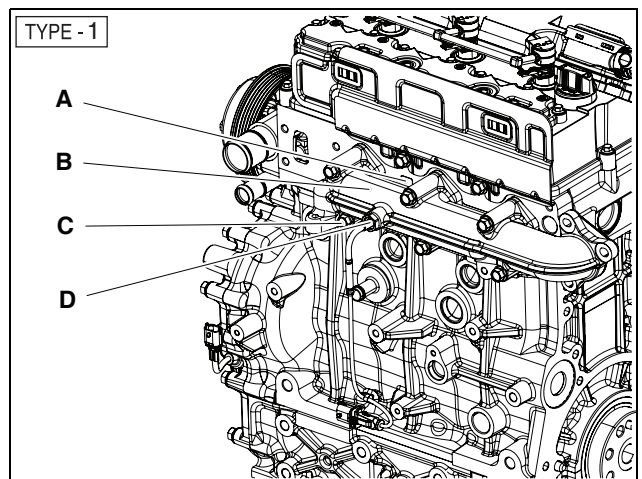
5. Disassemble the exhaust manifold pipe. (Only TYPE-1)



EDL013079A

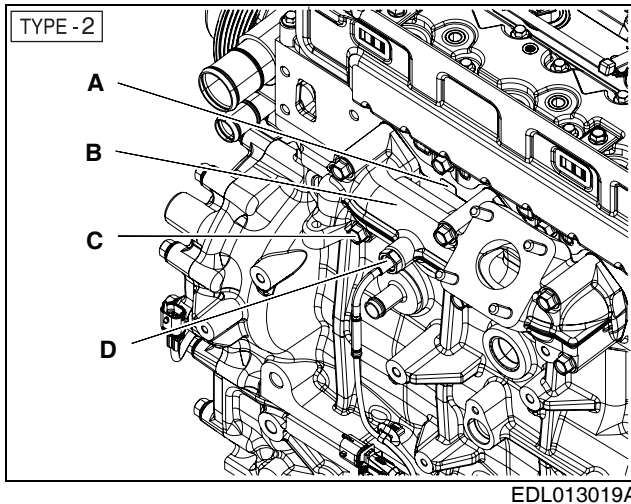
- 1) Loosen 3 fixing bolts (A).
- 2) Remove the heat screen (B) from the exhaust manifold pipe (C).

6. Remove the exhaust manifold.



EDL013018A

10. Intake/Exhaust System

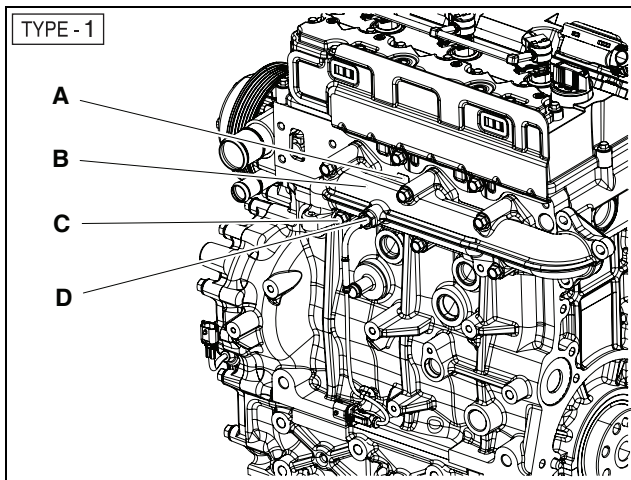


EDL013019A

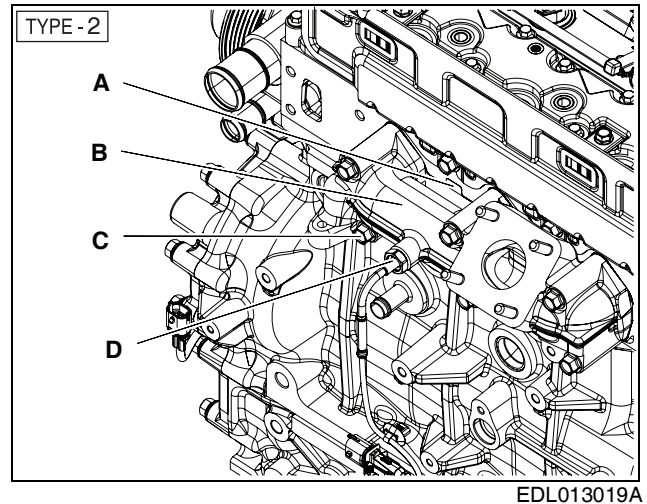
- 1) Remove the exhaust gas temperature sensor (D).
- 2) Loosen 6 flange hex bolts (C).
- 3) Remove the exhaust manifold (B) and the gasket (A).

Assembly of Exhaust Manifold

1. Attach the exhaust manifold.



EDL013018A



EDL013019A

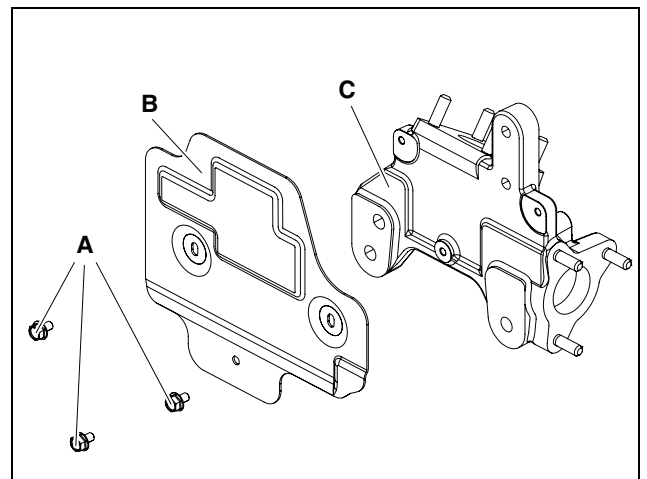
- 1) Attach the gasket (A) so that the TOP mark faces the top surface and the front of the engine.
- 2) Attach the exhaust manifold (B).

⚠ CAUTION

- Be careful to note the direction in which the gasket is mounted. Mount the gasket so that the TOP mark faces the front of the engine.
- Be careful not to damage the gasket while mounting it.

- 3) Tighten 6 flange hex bolts (C) at a tightening torque of 3.1 kgf·m.
- 4) Attach the exhaust gas temperature sensor (D).

2. Assemble the exhaust manifold pipe. (Only TYPE-1).

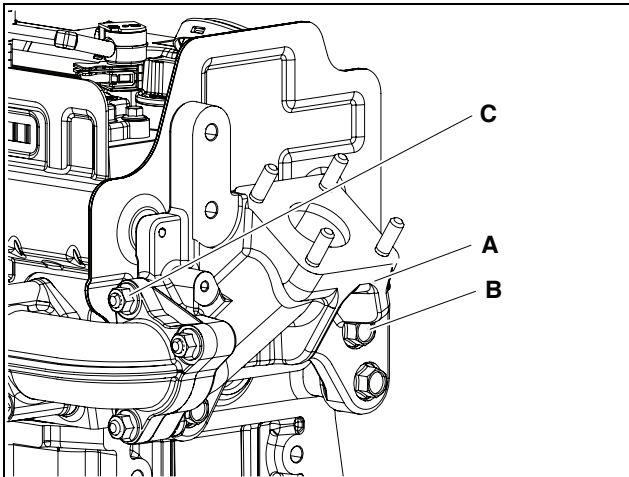


EDL013079A

- 1) Attach the heat screen (B) to the exhaust manifold pipe (C).
- 2) Tighten 3 fixing bolts (A).

10. Intake/Exhaust System

3. Attach the exhaust manifold pipe (Only TYPE-1).

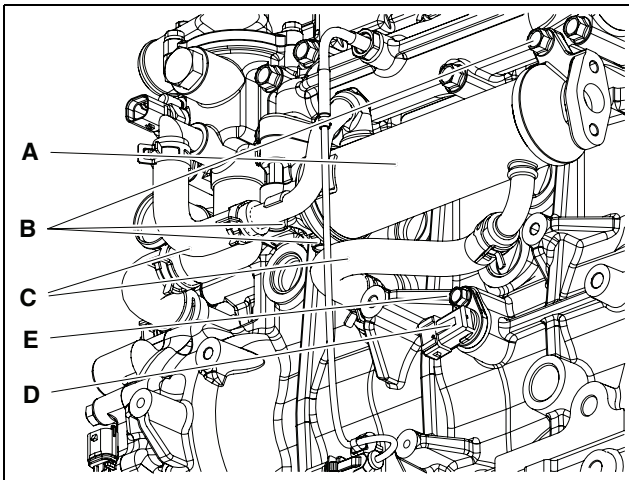


EDL013017A

- 1) Attach the exhaust manifold pipe (A).
- 2) Tighten 3 flange hex bolts (B) at a tightening torque of 4.4 kgf•m.
- 3) Tighten 3 hex nuts (C) at a tightening torque of 2.2 kgf•m.

Note) The exhaust manifold pipe (A) is only TYPE-1.

4. Attach the EGR cooler assembly and the cam position sensor.



EDL013015A

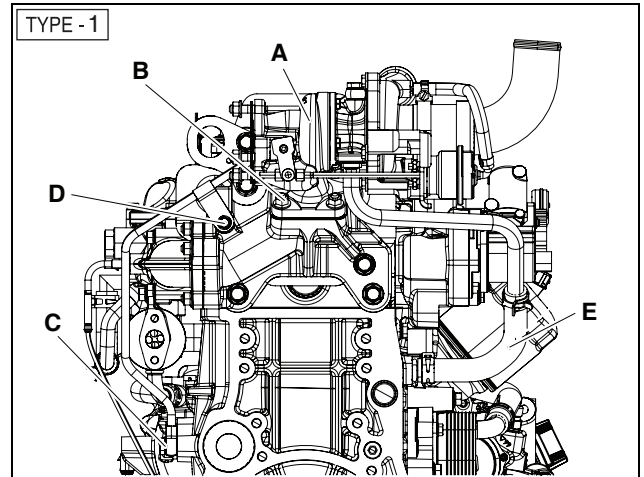
- 1) Attach the EGR cooler assembly (A).

⚠ CAUTION

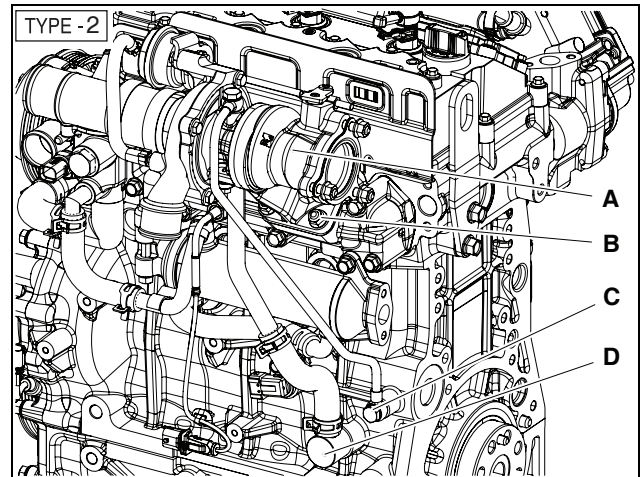
Be careful to note the direction when mounting the EGR cooler.

- 2) Tighten 3 flange hex bolts (B) at a tightening torque of 3.1 kgf•m.
- 3) Connect the rubber hoses (C)
- 4) Attach the cam position sensor (D).
- 5) Tighten the fixing bolt(E).

5. Attach the turbocharger.



EDL013007A



EDL013008A

- 1) Attach the gasket and the turbocharger(A).
- 2) Tighten 4 flange hex bolts (B) at a tightening torque of 2.2 kgf•m.
- 3) Connect the oil delivery pipe (C).
- 4) Tighten 2 hollow screws from the oil delivery pipe at a tightening torque of 2.0 kgf•m.

Note) Tighten the fixing bolt (D) if the engine is TYPE-1.

- 5) Connect the oil return pipe.

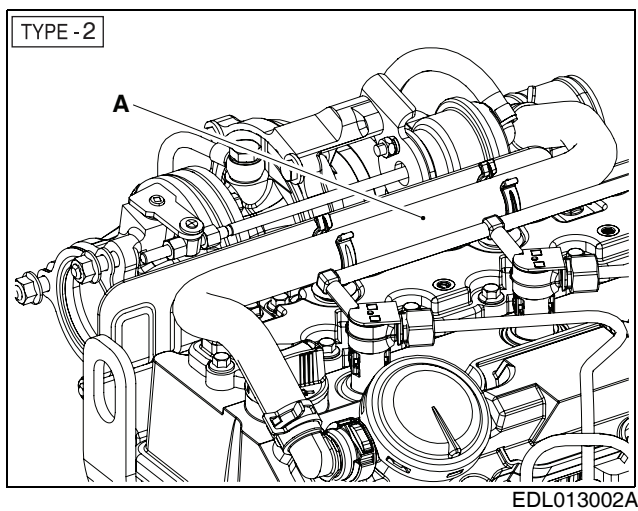
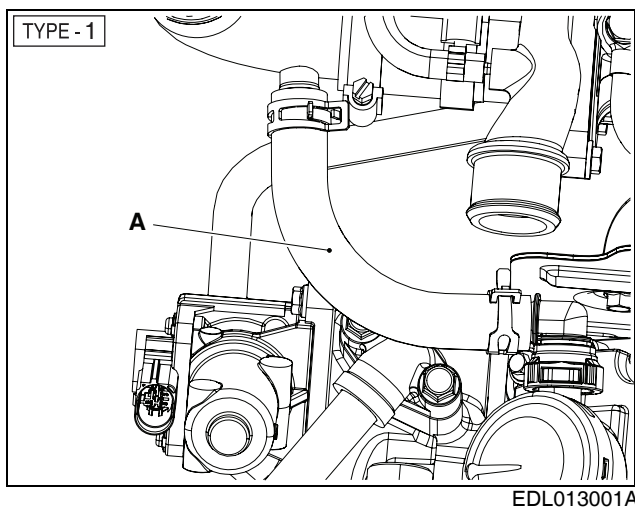
Note) The oil return pipe is that TYPE-1 is (E) and TYPE-2 is (D).

⚠ CAUTION

- Be careful to note the direction when connecting the hose and gasket.
- Be careful not to damage the gasket while mounting it.
- Do not reuse the hose clamps but replace them with new ones.
- Do not reuse the oil delivery pipe but replace it with new one.

10. Intake/Exhaust System

6. Attach the breather hose.



1) Attach the breather hose(A).

CAUTION

Do not reuse the clamps but replace with new ones.

10. Intake/Exhaust System

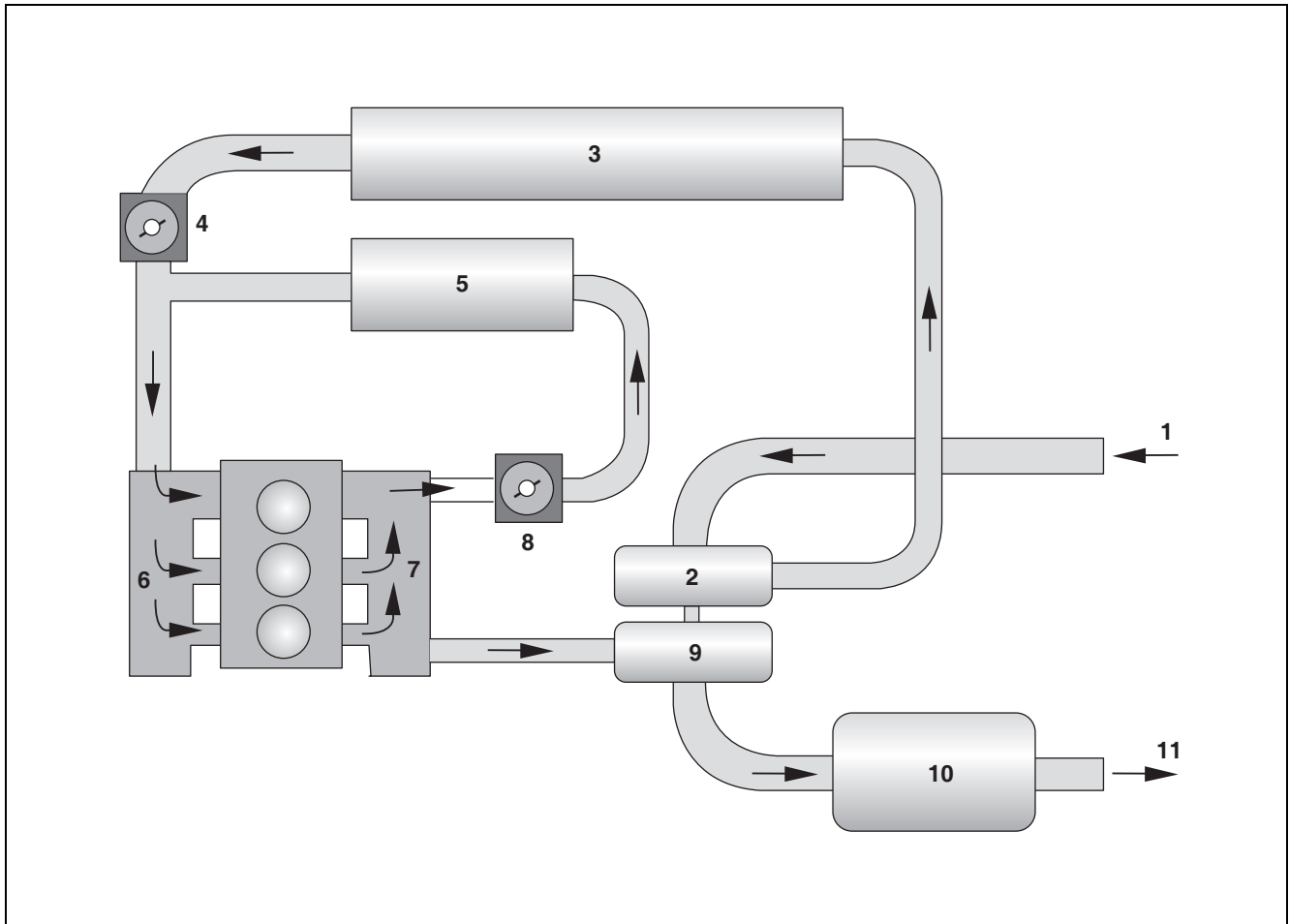
Exhaust Gas Recirculation (EGR) System

General Information

Exhaust Gas Recirculation (EGR) System circulates some of the exhaust gas from the engine to the intake side, cools the gas, and then delivers the cooled gas to the engine for recombustion in order to reduce Nox emission.

To reduce Nox emission from the engine, EGR circulates the exhaust gas of which oxygen concentration is very little to the intake system. As a result, low temperature combustion occurs in the engine and the NOx emission is reduced.

The EGR cooler is used to reduce NOx emission and enhance engine combustion efficiency by reducing temperature of high-temperature exhaust gas.



EDL013080A

- | | | | |
|----------------------|-------------------|--------------|-------------|
| 1. Intake | 4. Throttle valve | 7. Exhaust | 10. DOC |
| 2. Compressor | 5. EGR cooler | 8. EGR Valve | 11. Exhaust |
| 3. Charge air cooler | 6. Intake | 9. Turbine | |

1. Introduction to EGR

- 1) EGR is a system that reduces Nox emission by recirculating some of exhaust gas according to the engine conditions.
- 2) The exhaust gas is piped from the exhaust manifold, mixed with the intake coming from the intercooler, and then flows into the engine.

2. Key Characteristics of EGR

- 1) EGR cooler is used to reduce the temperature of exhaust gas.

- 2) Motor-driven electric EGR valve is used to adjust the EGR rate.

3. EGR cooler summary

- 1) The EGR cooler is a heat exchanger which reduces the high temperature of the circulated exhaust gas.
- 2) With the EGR cooler, the EGR engine can reduce Nox emission and enhance fuel efficiency.

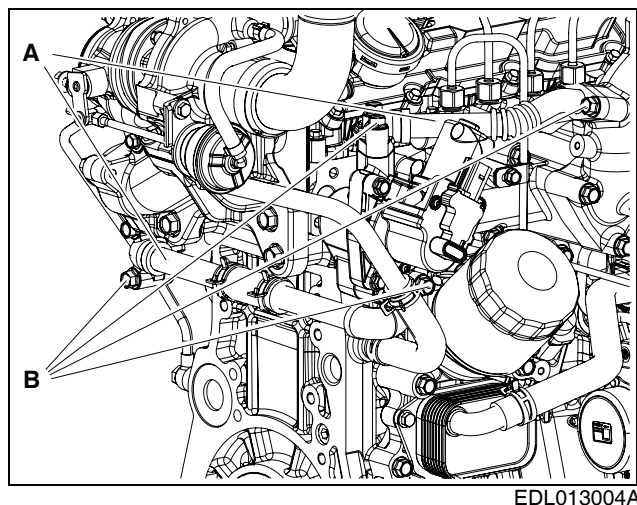
4. Key Characteristics of EGR

- 1) General tube types are used.

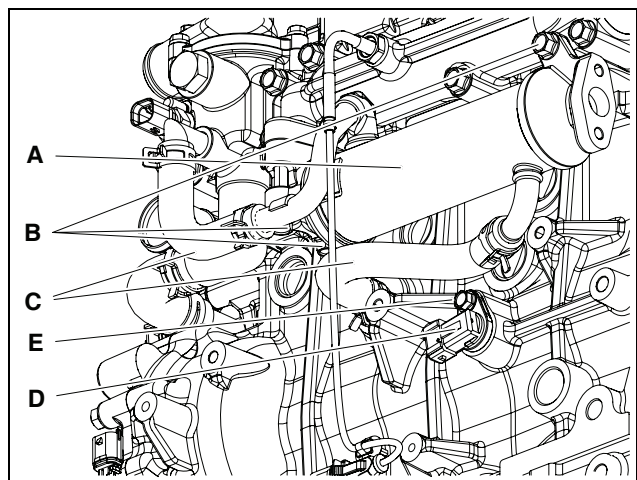
10. Intake/Exhaust System

Disassembly of EGR Cooler

1. Remove the EGR connection pipes.



- 1) Loosen 6 fixing bolts (B).
 - 2) Remove the EGR pipes (A).
 - 3) Remove 4 gaskets.
2. Remove the EGR cooler assembly and the cam position sensor.



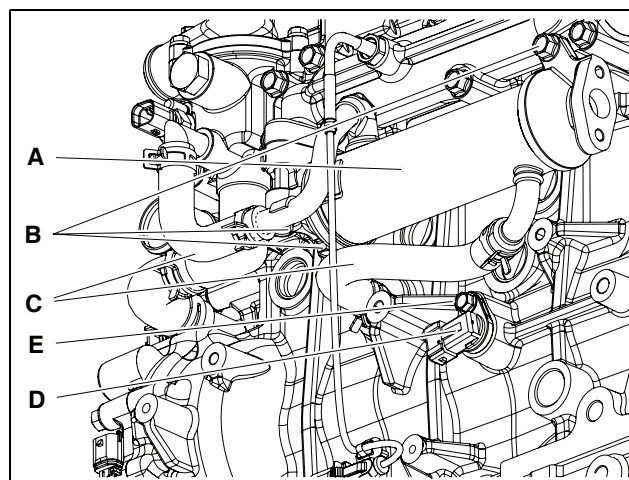
- 1) Loosen the fixing bolt (E).
- 2) Remove the cam position sensor (D).
- 3) Disconnect the rubber hoses (C).
- 4) Loosen 3 flange hex bolts (B).
- 5) Remove the EGR cooler assembly (A).

⚠ CAUTION

Exhaust gas make engine parts extremely hot. Only remove the parts when they have fully cooled to prevent burns.

Assembly of EGR Cooler

1. Attach the EGR cooler assembly and the cam position sensor.



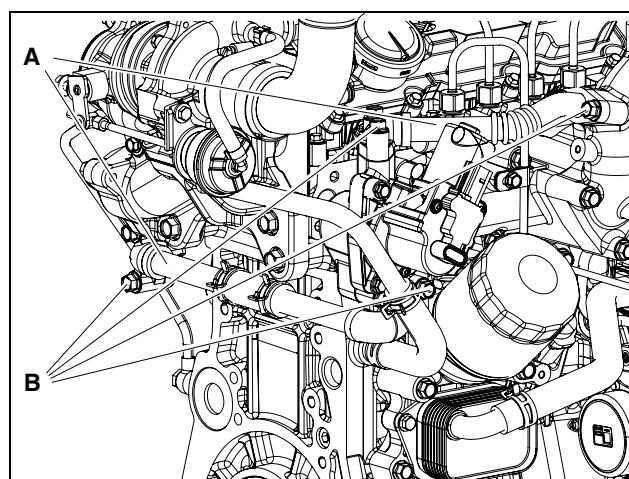
- 1) Attach the EGR cooler assembly(A).

⚠ CAUTION

Be careful to note the direction when mounting the EGR cooler.

- 2) Tighten 3 flange hex bolts(B) at a tightening torque of 3.1 kgf•m.
- 3) Connect the rubber hoses(C)
- 4) Attach the cam position sensor(D).
- 5) Tighten the fixing bolt(E).

2. Attach the EGR connection pipes.



- 1) Attach 4 gaskets.
- 2) Attach the EGR pipes(A)

10. Intake/Exhaust System

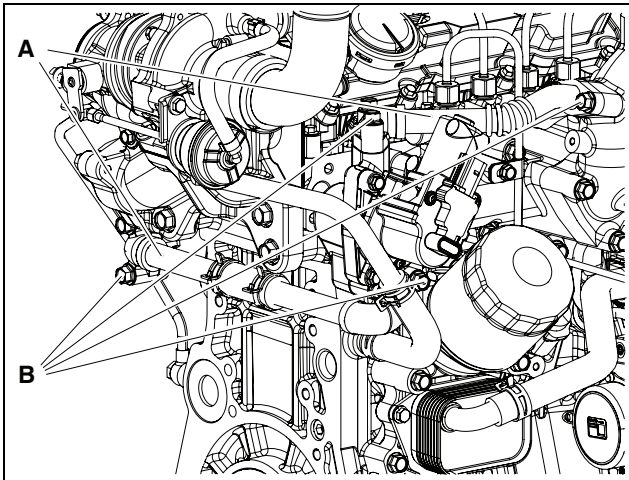
CAUTION

- Be careful to note the direction when attaching the the EGR connection pipe.
- Be careful not to damage the gasket while attaching it.

- 3) Tighten 6 fixing bolts(B) at a tightening torque of 2.2 kgf•m.

Disassembly of EGR Valve

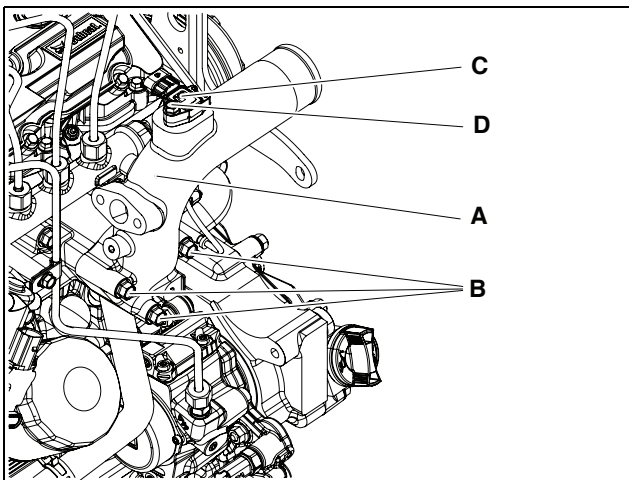
1. Remove the EGR connection pipes.



EDL013004A

- 1) Loosen 6 fixing bolts (B).
- 2) Remove the EGR pipes (A).
- 3) Remove 4 gaskets.

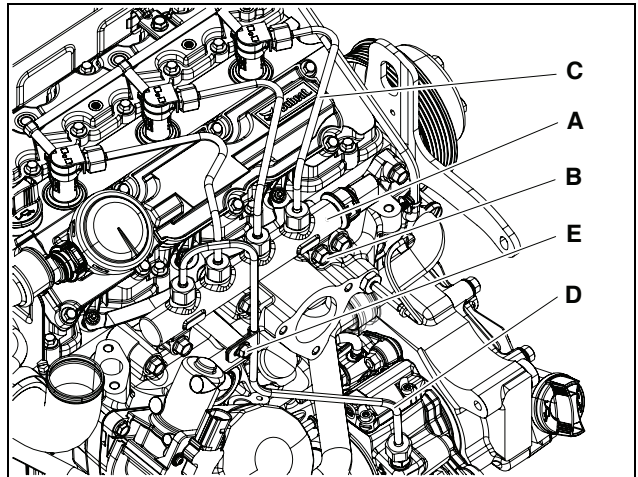
2. Remove the intake stake.



EDL013005A

- 1) Loosen the flange hex bolt (D).
- 2) Remove the boost pressure sensor (C).
- 3) Loosen 3 flange hex bolts (B).
- 4) Remove the gasket and the intake stake (A).

3. Remove the common rail and the injection pipes.



EDL013006A

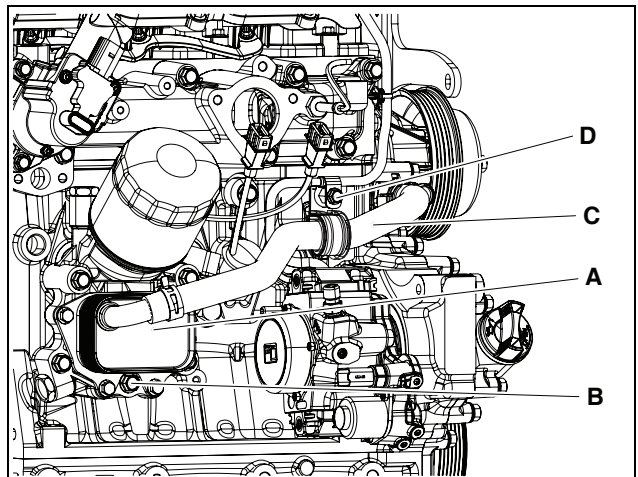
- 1) Loosen the fixing bolt (E).
- 2) Loosen the nuts of the fuel injection pipes.
- 3) Remove 4 fuel injection pipes (C) and (D).

CAUTION

Do not reuse fuel injection pipes; replace them with new ones. If fuel injection pipes are reused it may allow foreign substances into the fuel pipes or cause oil leaks from bolt clamping and cause a critical fault in engine performance.

- 4) Loosen 2 collared hex bolts (B) of the common rail.
- 5) Remove the common rail (A) from the intake manifold.

4. Remove the oil filter assembly.



EDL013009A

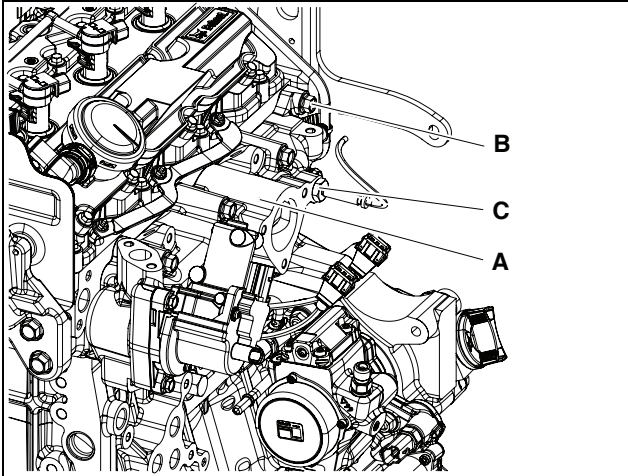
- 1) Loosen the fixing bolt (D).
- 2) Disconnect the coolant hose (C).
- 3) Loosen 5 flange hex bolts (B).
- 4) Remove the 3 O-rings and the oil filter assembly (A).

10. Intake/Exhaust System

CAUTION

Oil in the filter may run down while removing the oil filter. Be careful not to contaminate the other parts by using a cloth when removing the filter. After replacing the oil filter, wipe clean any other parts which the oil has touched.

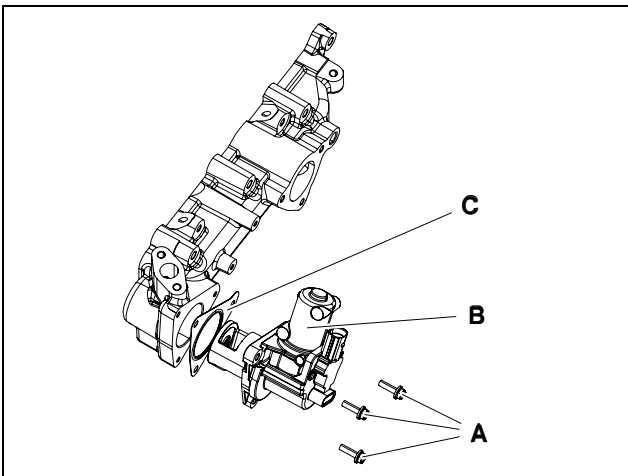
5. Remove the intake manifold.



EDL013010A

- 1) Remove the boost temperature sensor (C).
- 2) Loosen 8 flange hex bolts (B).
- 3) Remove the gasket and the intake manifold (A) from the cylinder block.

6. Disassemble the EGR valve.

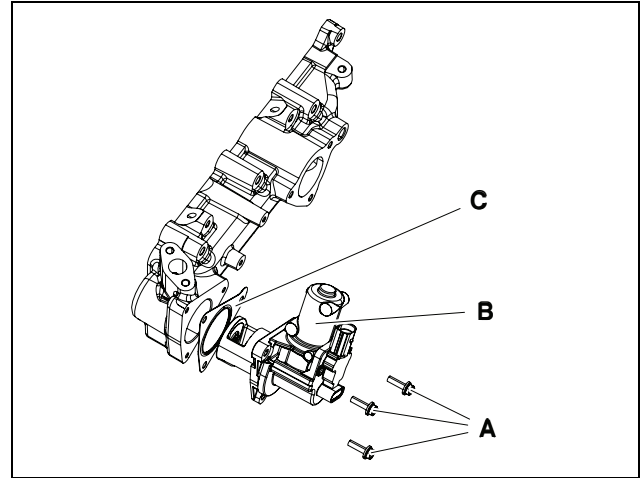


EDL013081A

- 1) Loosen 3 fixing bolts (A).
- 2) Remove the EGR valve (B) and the gasket (C) from the intake manifold.

Assembly of EGR Valve

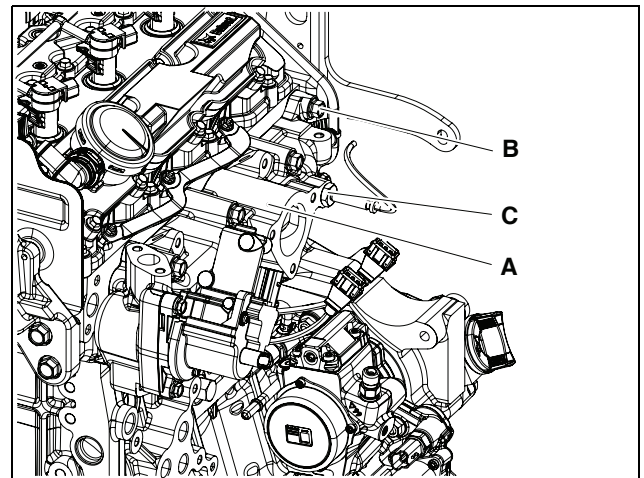
1. Assemble the EGR valve.



EDL013081A

- 1) Attach the gasket (C) and the EGR valve (B) to intake manifold.
- 2) Tighten 3 fixing bolts (A).

2. Attach the intake manifold.



EDL013010A

- 1) Attach the gasket and the intake manifold (A).

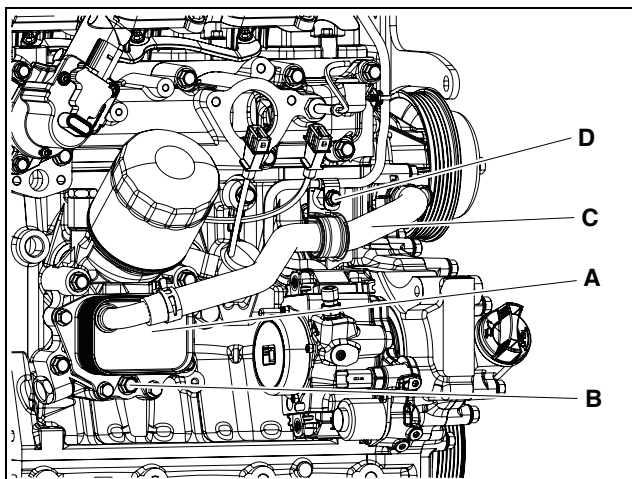
CAUTION

- Be careful to note the direction when mounting the gasket.
- Be careful not to damage the gasket while mounting it.

- 2) Tighten 8 flange hex bolts (B) at a tightening torque of 2.2 kgf·m.
- 3) Attach the boost temperature sensor (C).

10. Intake/Exhaust System

3. Attach the oil filter assembly.



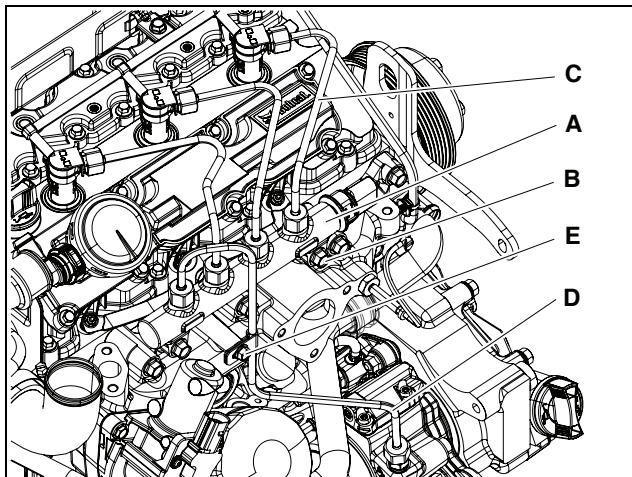
EDL013009A

- 1) Attach the 3 O-rings and the oil filter assembly (A).
- 2) Tighten 5 flange hex bolts (B).
- 3) Connect the coolant hose (C)
- 4) Tighten the fixing bolt (D).

⚠ CAUTION

- Make sure that the O-rings have been mounted.
- Be careful not to damage the O-rings while mounting them.

4. Attach the common rail and the injection pipe.



EDL013006A

- 1) Attach the common rail (A) to the intake manifold.

⚠ CAUTION

- Be careful to note the direction when attaching the common rail.
- Be careful not to damage the common rail while attaching it.

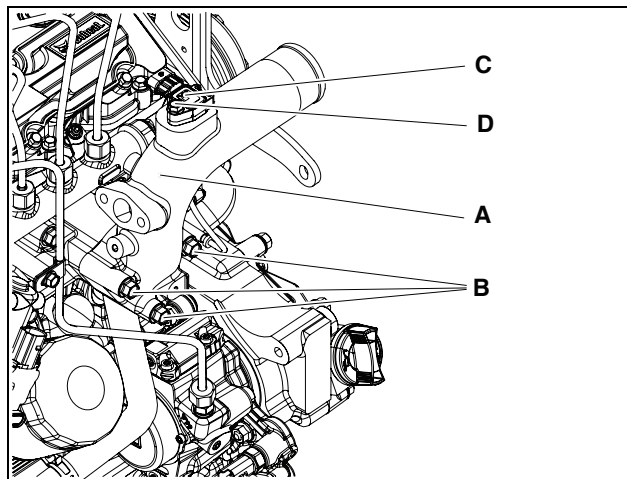
- 2) Temporarily tighten 2 collared hex bolts (B) by hand.
- 3) Temporarily connect the fuel injection pipes (C) and (D) by hand.

⚠ CAUTION

- Do not bend the fuel injection pipes by force.
- Be careful to note the direction when connecting the fuel injection pipes.
- Assemble the nut on one side of the fuel injection pipe first, and then the nut on the other side to connect the round part of the pipe to the correspondent part correctly.
- Do not reuse fuel injection pipes but replace them with new ones. Reusing fuel injection pipes may allow foreign substances into the fuel pipes or oil leaks from the bolt clamping to occur, causing a critical fault in engine performance.

- 4) Tighten 2 collared hex bolts(B) at a tightening torque of 2.2 kgf•m.
- 5) Tighten the fuel injection pipes (C) and (D) at a tightening torque of 3.0 kgf•m.
- 6) Tighten the fixing bolt (E).

5. Attach the intake stake.



EDL013005A

- 1) Attach the gasket and the intake stake(A).

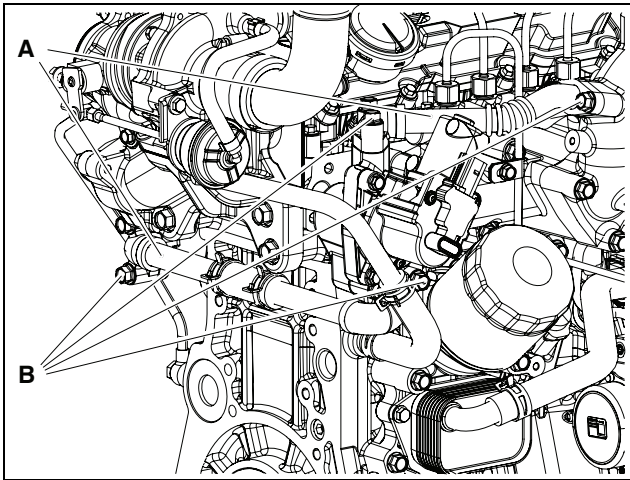
⚠ CAUTION

- Be careful to note the direction when attaching the gasket.
- Be careful not to damage the gasket while attaching it.

- 2) Tighten 3 flange hex bolts(B) at a tightening torque of 2.2 kgf•m.
- 3) Attach the boost pressure sensor(C).

10. Intake/Exhaust System

- 4) Tighten the flange hex bolt(D) at a tightening torque of 1.0 kgf•m.
6. Attach the EGR connection pipes.



EDL013004A

- 1) Attach 4 gaskets.
- 2) Attach the EGR pipes(A)

CAUTION

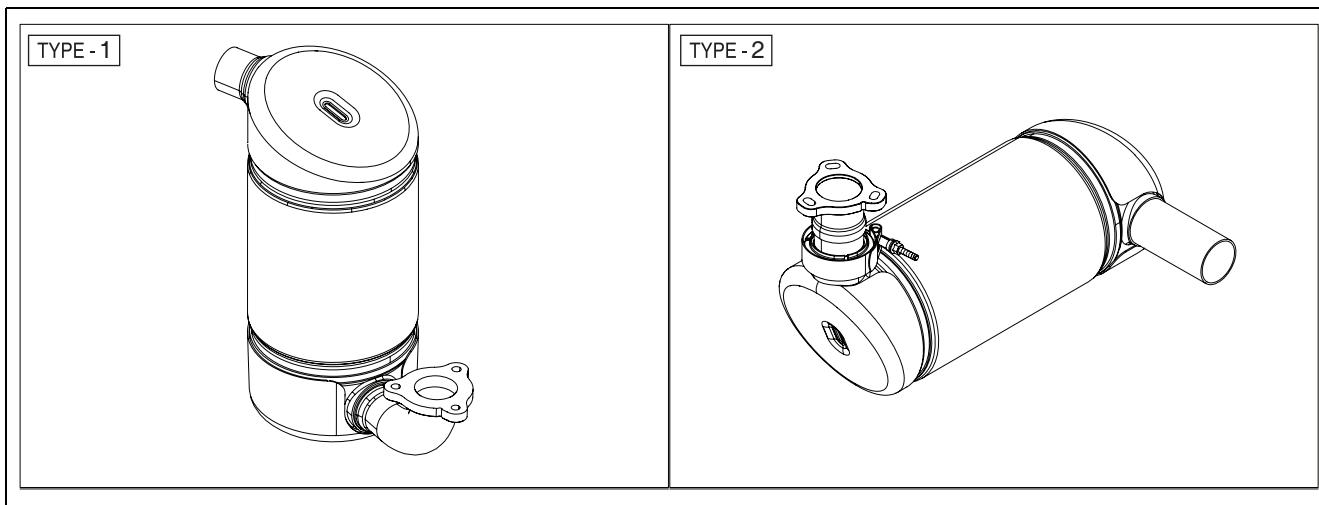
- Be careful to note the direction when attaching the the EGR connection pipe.
- Be careful not to damage the gasket while attaching it.

- 3) Tighten 6 fixing bolts(B) at a tightening torque of 2.2 kgf•m.

10. Intake/Exhaust System

Diesel Oxidation Catalyst (DOC)

DOC oxidizes HC(hydrocarbon) and CO(carbon monoxide) and reduces them from exhaust gas.



EDL022283A

11. Cylinder block/head

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Cylinder block/head

General Information

General Information

Doosan's diesel engine is an air-cooled electronic control diesel engine that uses cooling fans, overhead valve, and turbocharger.

The high-pressure fuel generated from the fuel high-pressure pump is stored in the common rail. When a driver operates the vehicle, fuel injection timing and optimum fuel amount are decided based on the data set in the Electronic Control Unit (ECU) and the solenoid valve of the injector installed in each engine cylinder is operated to inject fuel into the cylinder.

The cylinder block is made out of cast iron alloy and an anti-vibration and anti-noise crank case is mounted. In addition, the cylinder block and the timing gear case are designed as an integral structure to reduce the engine length and improve tightness. The cylinder head is an integral structure, too.

The forged crankshaft is an integral structure. The oil seals of the crankshaft and the flywheel prevents oil from permeating into the flywheel housing.

The connecting rod is forged and its big end part vertically separated. Like a piston, the connecting rod can be disassembled through the upper side of the cylinder. The alloy-type prefabricated bearing is used for the active part of the crankshaft and the connecting rod.

11. Cylinder block/head

Specifications

Item		D18NAP		Remark
		DL01-LEE00	DL01-LEL00	
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	39.498 mm	←	
	Exhaust	38.453 mm	←	
Camshaft journal outside diameter	Intake	44.919 ~ 44.935 mm	←	
	Exhaust	44.919 ~ 44.935 mm	←	
Camshaft bearing oil gap		0.065 ~ 0.106 mm	←	
Camshaft end play		0.1 ~ 0.2 mm	←	
Inside diameter of cylinder block piston bore		89.99 ~ 90.10 mm	←	
Flatness of cylinder block gasket surface		0.05 mm 0.03 mm / 100 mm	←	

11. Cylinder block/head

Cylinder Block

Disassembly of cylinder block

1. Detach the cylinder block.

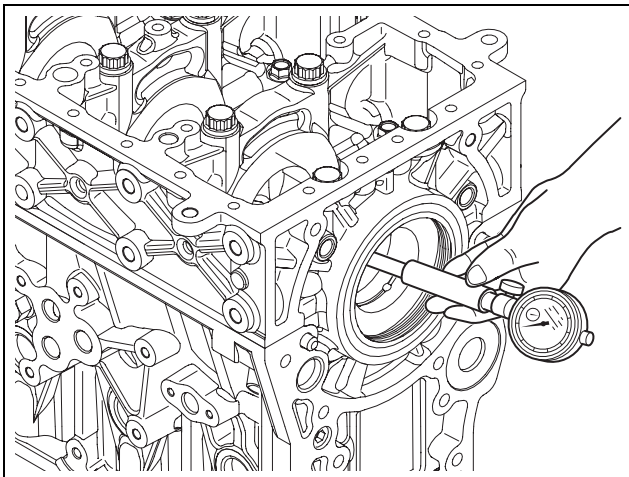
Note) Refer to Chapter 6 (Procedure of Disassembling an Engine)

Check of Cylinder Block

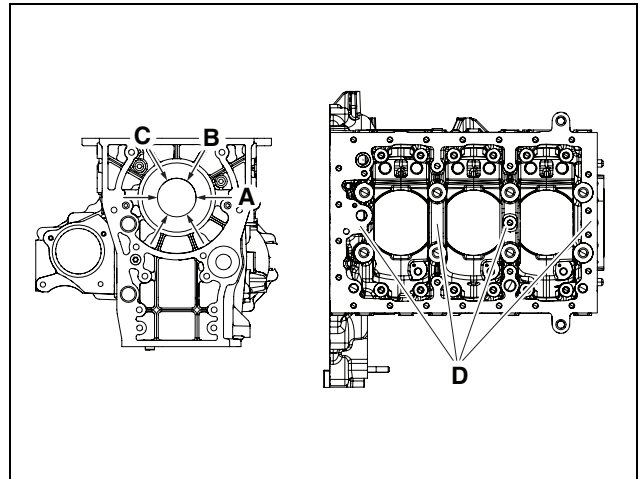
1. Cleanse the cylinder block and check if there is any cracked or damaged part with naked eye.
2. Replace the cylinder block if it is seriously cracked or damaged. Repair tiny cracks if existing.
3. Check if the oil path or coolant path is clogged or corroded.
4. Perform the hydrostatic test to check whether there is a crack or an air leakage.
5. Block the discharging outlets of the cooling water path and the oil path of the cylinder block and put pressure of 4 kg/cm² on the inlet. Then sink the cylinder block in the 70 °C water for 1 minute and check if air leaks.

Measurement of Inside Diameter of Main Bearing Bore of Cylinder Block

1. Assemble the cylinder block and the crank case.
2. Set the gauge.
3. Remove the foreign substances from the main bearing bore of the cylinder block.
4. Measure the inside diameter of the main bearing bore of the cylinder block.



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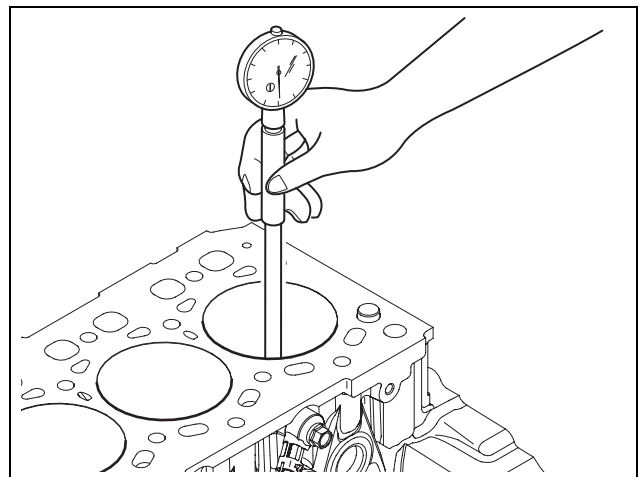
EDL013083A

- 1) For 4ea main bearings (D) of the cylinder block, measure 8 points of the bearings: front and rear.
- 2) Measure three (A, B, and C) points of the main bearing part of the cylinder block.
- 3) The standard measurement value of the inside diameter of the main bearing bore of the cylinder block is within the range of 62.0 ~ 62.021 mm.

Item	Specified Value
Cylinder Block Inside diameter of main bearing bore	62.0 ~ 62.021 mm

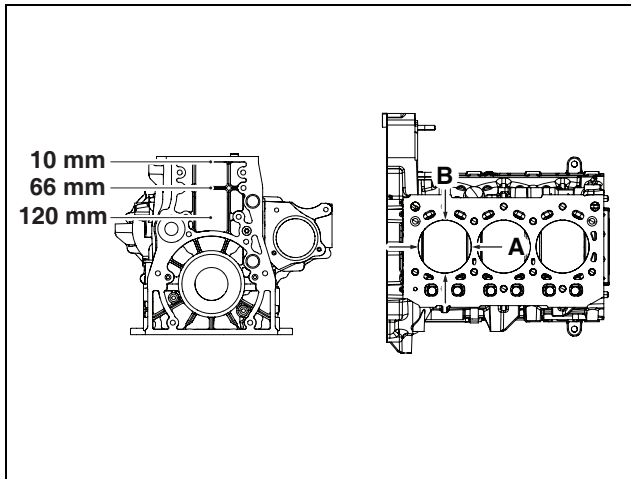
Measurement of Inside Diameter of Piston Bore of Cylinder Block

1. Set the gauge.
2. Remove the foreign substances from the piston bore of the cylinder block.
3. Measure the inside diameter of the piston bore of the cylinder block.



EDL013084A

11. Cylinder block/head



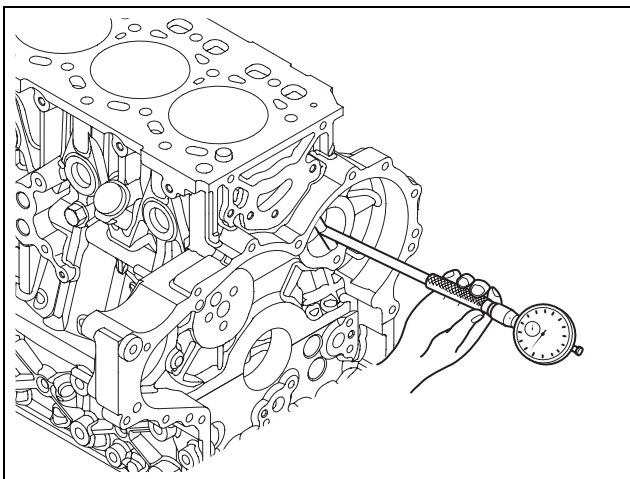
EDL013085A

- 1) For 3ea piston bores of the cylinder block, measure total 9 points of the piston bores: top, middle, and bottom.
- 2) Measure 2 points of A and B on the piston bore of the cylinder block.
- 3) The standard measurement value of the inside diameter of the piston bore of the cylinder block is within the range of 89.990 ~ 90.010 mm.

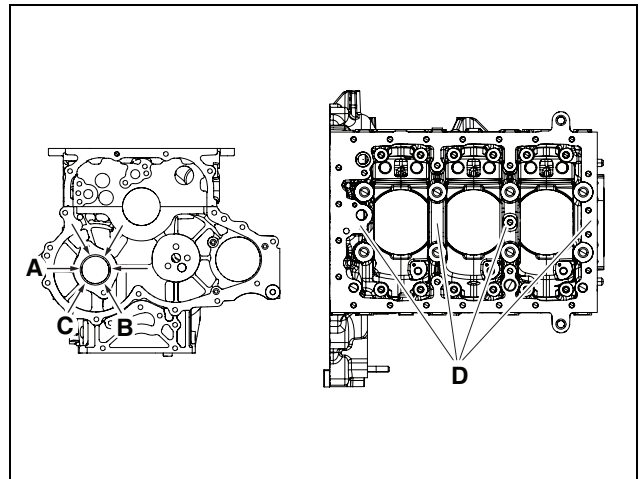
Item	Specified Value
Cylinder Block Piston bore inside diameter	89.990 ~ 90.010 mm

Measurement of Inside Diameter of Camshaft Bearing of Cylinder Block

1. Set the gauge.
2. Remove the foreign substances from the camshaft bearing shell of the cylinder block.
3. Measure the inside diameter of the camshaft bearing of the cylinder block.



EDL022088A



EDL013086A

- 1) For 3ea of the cylinder block, measure total 6 points of the camshaft bores: front and rear.
- 2) Measure 3 points (A, B, and C) of camshaft bearing shells of the cylinder block.
- 3) The standard measurement value of the inside diameter of the camshaft bearing of the cylinder block is within the range of 45.0 ~ 45.025 mm.

Item	Specified Value
Cylinder Block Camshaft bearing inside diameter	45.0 ~ 45.025 mm

Assembly of Cylinder Block

1. Attach the cylinder block.

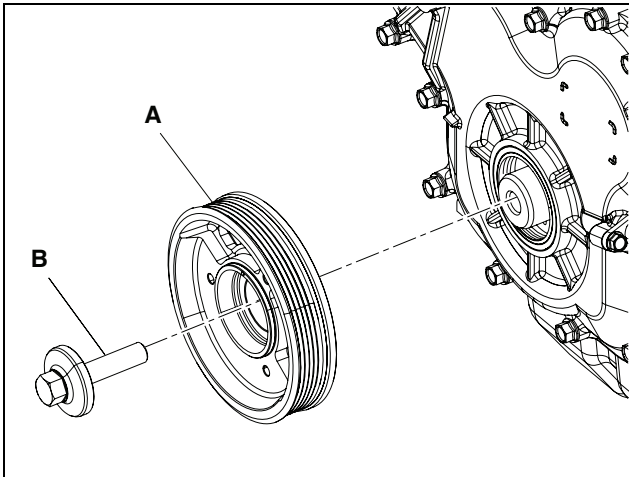
Note) Refer to Chapter 6 (Procedure of Assembling an Engine)

11. Cylinder block/head

Timing gear case

Detaching timing gear case

1. Remove the V-belt.
2. Remove the crankshaft pulley.



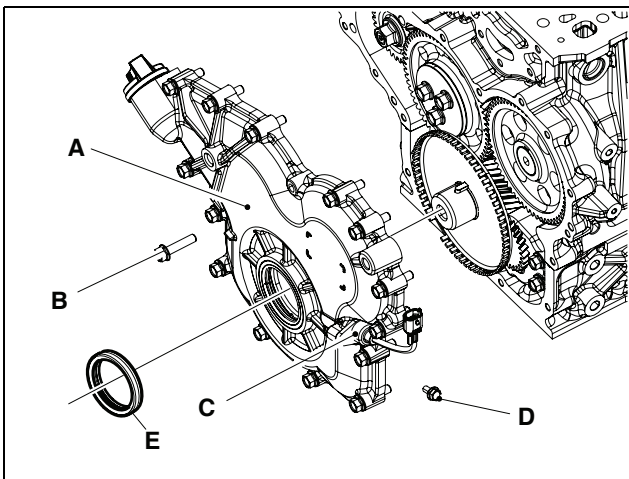
EDL013033A

- 1) Loosen the flange hex bolt (B).
- 2) Remove the crankshaft pulley (A).

⚠ CAUTION

Be careful not to damage the oil seal.

3. Remove the timing gear case.



EDL013037A

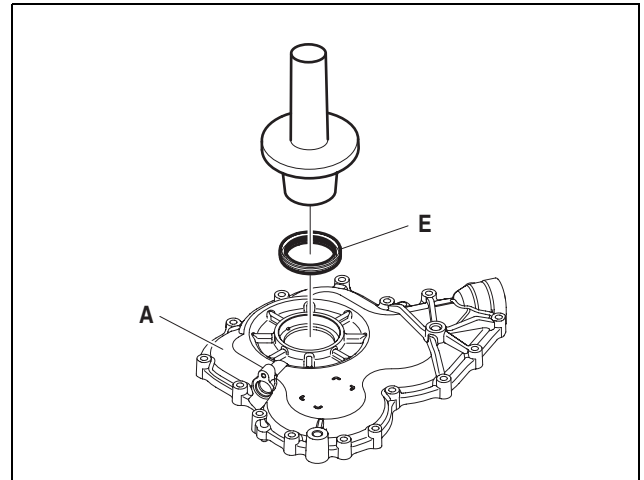
- 1) Loosen the fixing bolt (D).
- 2) Remove the crank speed sensor (C).
- 3) Loosen 16 hex bolts (B).
- 4) Remove the timing gear case (A).

⚠ CAUTION

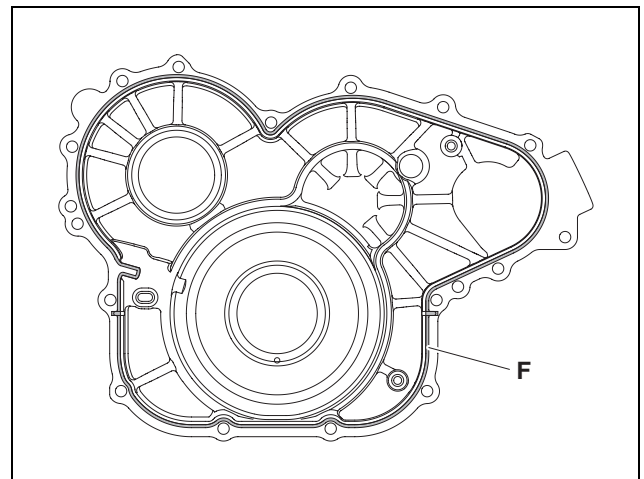
Do not reuse the oil seal; replace them with new ones.

Assembly of Timing Gear Case

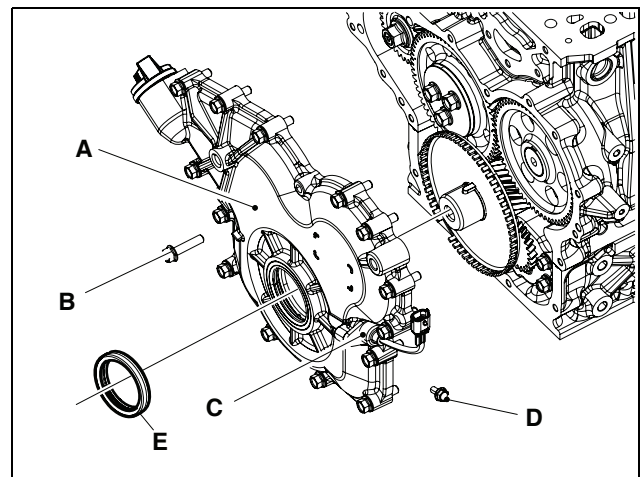
1. Attach the timing gear case (A).



EDL013052A



EDL013053A



EDL013037A

- 1) Make the assembly surface of the timing gear case face the ground.

11. Cylinder block/head

- 2) Mount the front oil seal (E) to the front oil seal assembly jig (860104-02047).
- 3) Align the front oil seal assembly jig (860104-02047) where the front oil seal (E) is mounted to the timing gear case (A) and beat it with a rubber hammer.
- 4) when the front oil seal (E) is inserted to the timing gear case(A), pull off the front oil seal assembly jig (860104-02047).

CAUTION

- Be careful in noting the direction of the oil seal assembly and ensuring that the oil seal surface faces the outside of the engine.
 - Be careful of the depth of the oil seal when attaching it.
 - Be careful not to damage the oil seal.
 - Attach the oil seal without applying lubrication. coolant, fuel, LOCTITE, or silicon.
-

CAUTION

- Remove foreign substances such as residues and LOCTITE from the oil seal assembly bore.
 - Do not reuse the oil seal; replace it with a new one.
 - Be careful not to damage the oil seal when attaching it.
-

- 5) Remove the foreign substances on the timing gear case assembly surface and clean it with a dry cloth.
- 6) Apply LOCTITE 5902 to the timing gear case assembly surface (F) with the diameter of $\varnothing 2.5 \pm 0.5\text{mm}$.

CAUTION

- Keep clean liquid gasket dispensing surface.
 - Dispensing line should not be snapped.
-

- 7) Align the timing gear case (A) with the pin and attach it.

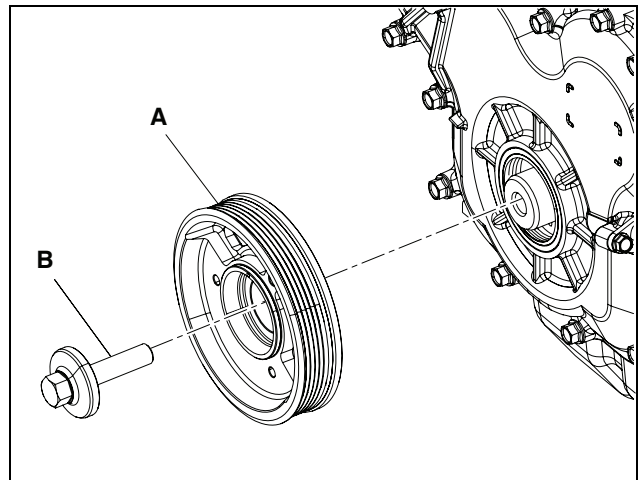
CAUTION

- Be careful that the timing gear case has been attached in the right direction.
 - Assemble the timing gear case in 5 minutes after dispensing liquid gasket.
 - Do not pressureize inside the timing gear case in 25 minutes after dispensing liquid gasket.
-

- 8) Tighten 16 hex bolts (B) at a tightening torque of $2.2\text{kgf}\cdot\text{m}$.

- 9) Attach the crank speed sensor (C).
- 10) Tighten the fixing bolt (D).

2. Attach the crankshaft pulley.



EDL013033A

- 1) Align the crankshaft pulley (A) to the pin and attach it.
- 2) Apply LOCTITE Blue 587 to the inside of the flange hex bolts (B).
- 3) Tighten flange hex bolts (B) at a tightening torque of $26\text{ kgf}\cdot\text{m}$.

CAUTION

- Be careful not to damage the oil seal.
 - Fix the crankshaft to allow the flange hex bolts to be tightened with the specified torque.
-

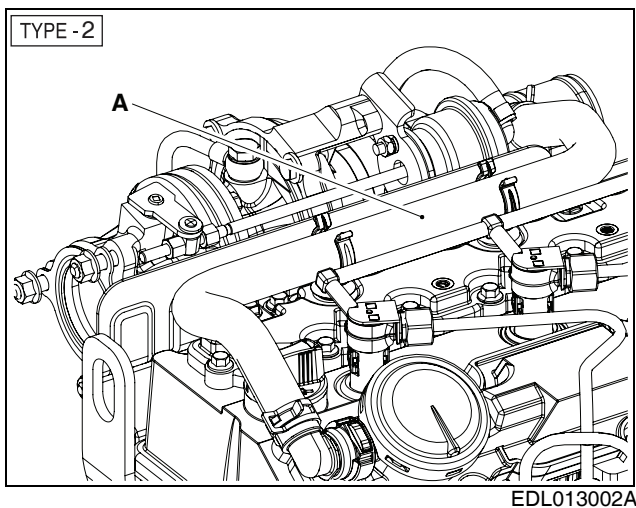
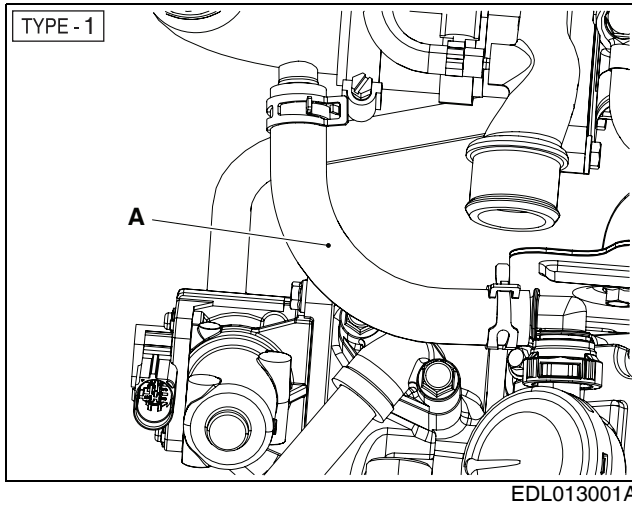
3. Attach the V-belt.

11. Cylinder block/head

Breather

Disconnection of Breather Hose

1. Remove the breather hose.



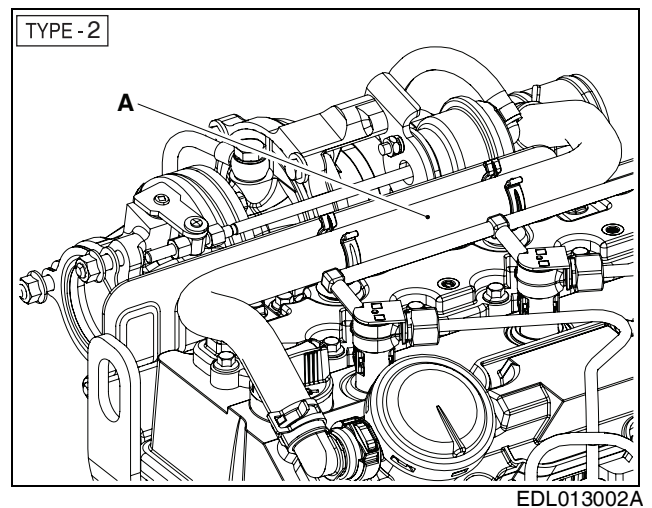
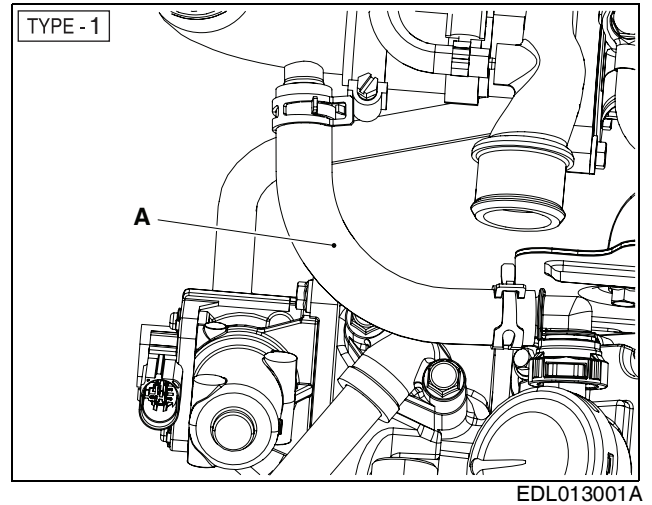
- 1) Remove the breather hose (A).

CAUTION

Do not use the clamps more than three times but replace them with new ones.

Connection of Breather Hose

1. Attach the breather hose.



- 1) Attach the breather hose(A).

CAUTION

Do not use the clamps more than three times but replace them with new ones.

11. Cylinder block/head

Cylinder head

Disassembly of Cylinder Head

1. Detach the cylinder head.

Note) Refer to Chapter 6 (Procedure of Disassembling an Engine)

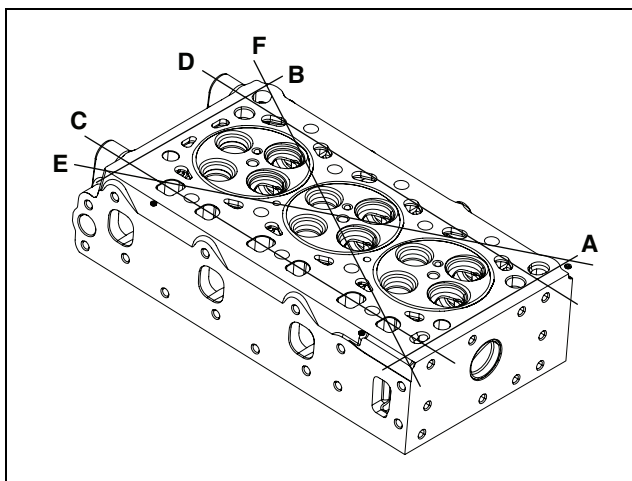
Check of Cylinder Head

1. Remove carbon from the bottom surface of the cylinder head.

Note) Be careful not to scratch the valve seat surface.

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

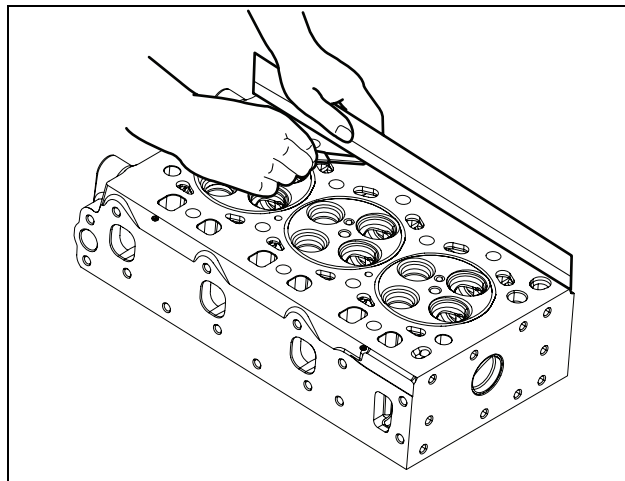
3. Check if the cylinder head is warped.



EDL013087A

- 1) Check 6 directions from A to F with the scale and the gap gauge.

4. Check flatness of the cylinder head.



EDL013088A

- 1) Measure flatness of the intake assembly surface and the exhaust assembly surface of the cylinder head with the scale and the gap gauge.

5. Perform the hydrostatic test.

- 1) Block the discharging outlets of the cooling water path and the oil path of the cylinder head and put pressure of 4 kg/cm² on the inlet. Then sink the cylinder head in the 70 °C water for 1 minute and check if air leaks.

Assembly of Cylinder Head

1. Attach the cylinder head.

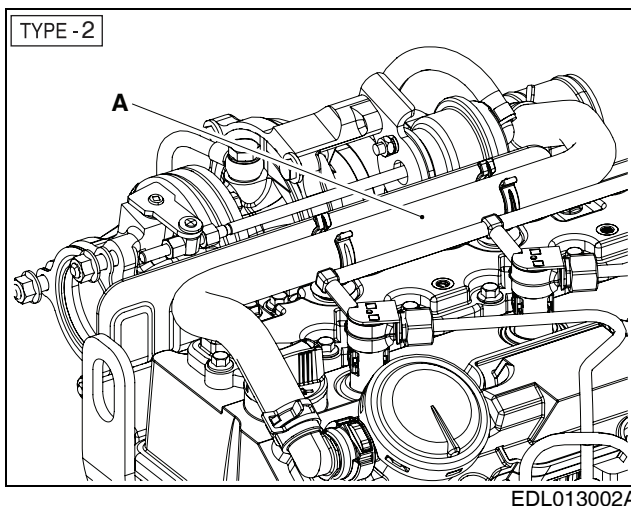
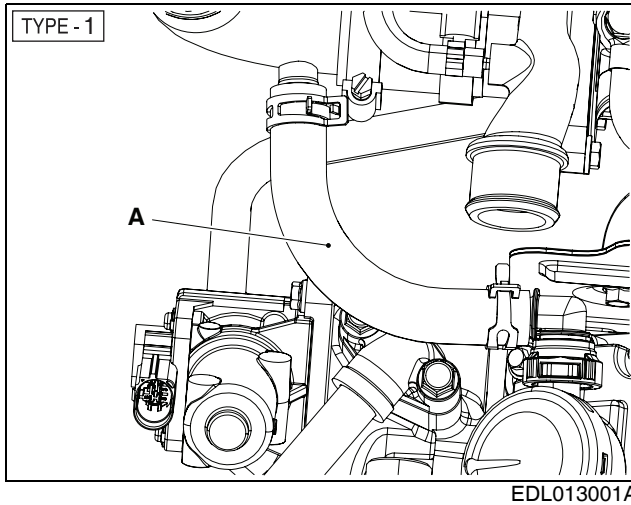
Note) Refer to Chapter 6 (Procedure of Assembling an Engine)

11. Cylinder block/head

Cylinder Head Cover

Disassembly of Cylinder Head Cover

1. Remove the breather hose.

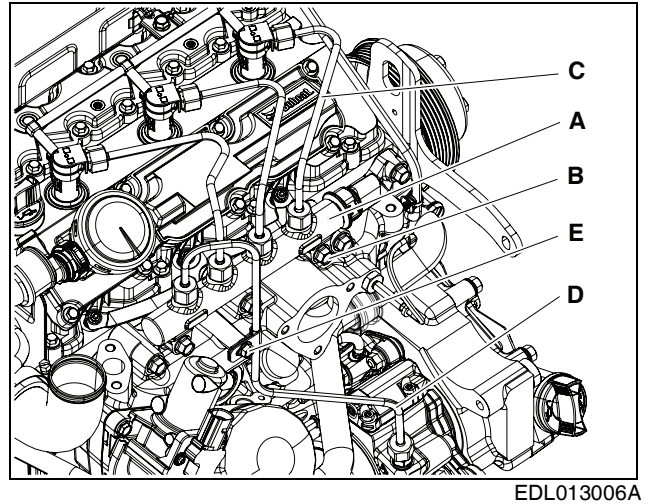


- 1) Remove the breather hose (A).

CAUTION

Do not reuse the clamps but replace with new ones.

2. Remove the common rail and the injection pipes.



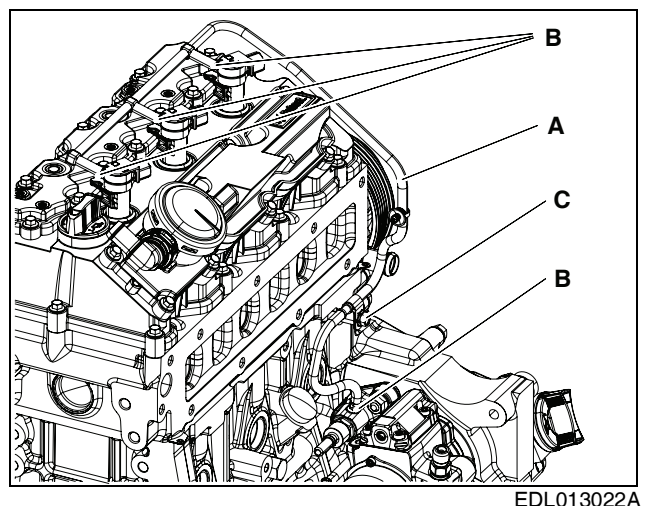
- 1) Loosen the fixing bolt (E).
- 2) Loosen the nuts of the fuel injection pipes.
- 3) Remove 4 fuel injection pipes (C) and (D).

CAUTION

Do not reuse fuel injection pipes; replace them with new ones. If fuel injection pipes are reused it may allow foreign substances into the fuel pipes or cause oil leaks from bolt clamping and cause a critical fault in engine performance.

- 4) Loosen 2 collared hex bolts (B) of the common rail.
- 5) Remove the common rail (A) from the intake manifold.

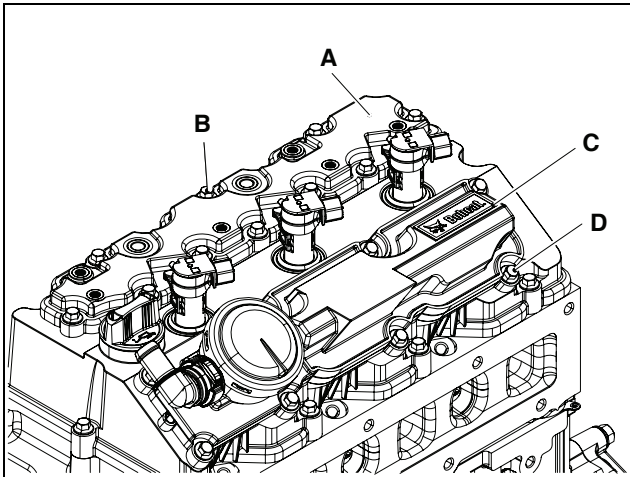
3. Remove the fuel return hose.



- 1) Loosen the flange hex bolts (C).
- 2) Remove the hose clips and disconnect the fuel hose (A).

11. Cylinder block/head

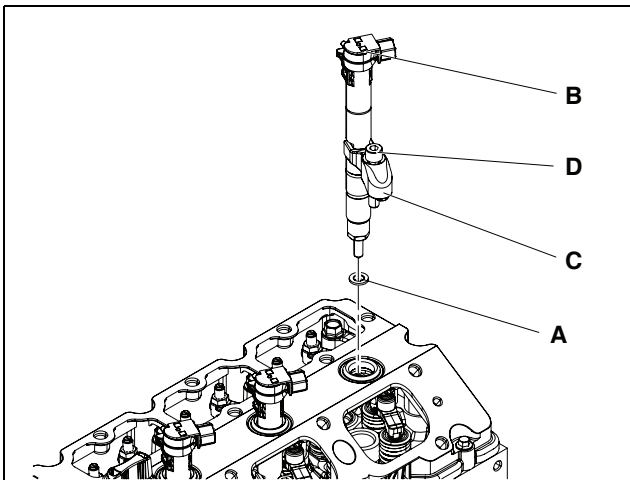
4. Remove the right and left cylinder head cover.



EDL013025A

- 1) Loosen 8 flange hex bolts (D).
- 2) Remove the right cylinder head cover (C).
- 3) Loosen 10 flange hex bolts (B).
- 4) Remove the left cylinder head cover (A).

5. Remove the injectors.



EDL013026A

- 1) Loosen 3 hex bolts (D).
- 2) Remove 3 injector fixtures (C).
- 3) Remove 4 injectors (B).
- 4) Remove 3 injector seal ring washers (D).

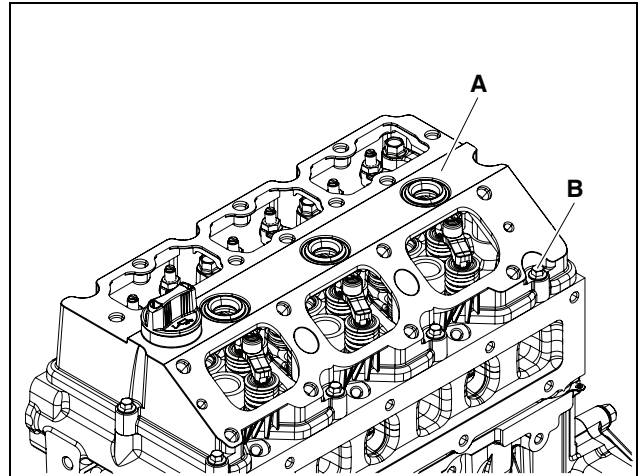
CAUTION

- Do not reuse the head cover rubber seal and the injector oil seal but replace with new ones.
- Be careful not to damage the injector oil seal of the cylinder head cover.
- Remove it by turning the injector slowly from left to right.

CAUTION

Do not reuse the injector seal ring washers. Reuse of the injector seal ring washers may cause critical damage to the engine due to unstable combustion.

6. Remove the cylinder head cover.



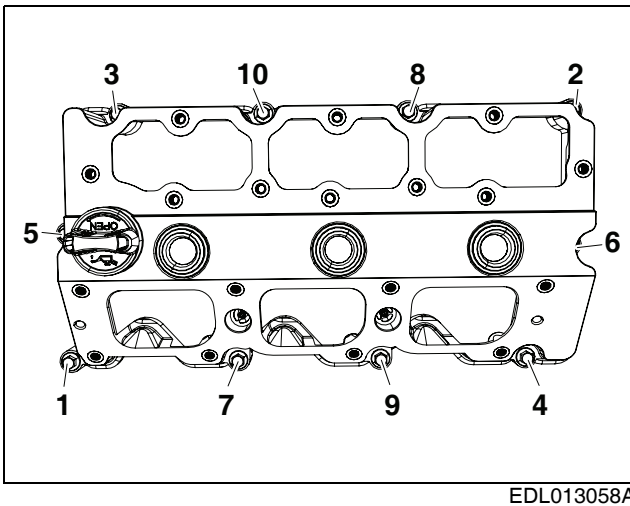
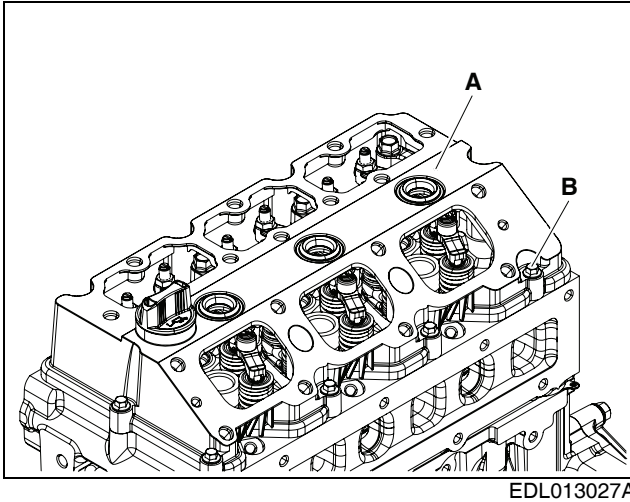
EDL013027A

- 1) Loosen 10 hex bolts (B).
- 2) Remove the cylinder head cover (A).

11. Cylinder block/head

Assembly of Cylinder Head Cover

1. Attach the cylinder head cover.

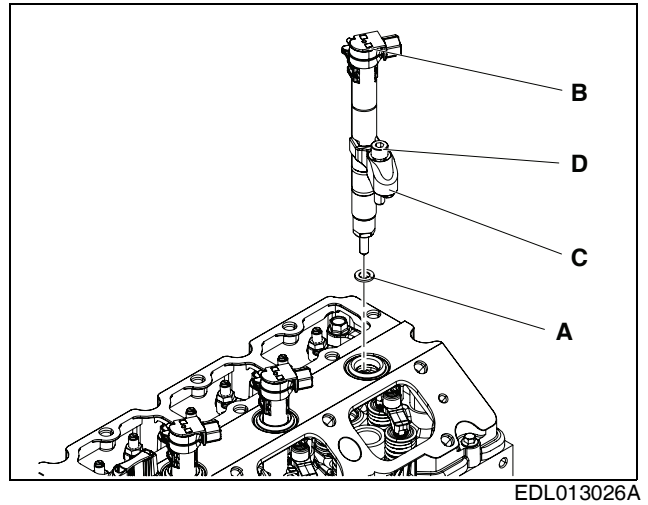


- 1) Attach the cylinder head cover (A).
- 2) Temporarily tighten 10 hex bolts (B) in the order of (1) ~ (10).
- 3) Tighten 10 hex bolts (B) at a tightening torque of 1.0 kgf•m.

⚠ CAUTION

- Be careful not to allow the seal ring of the cylinder head cover to get out to the outside.
- Tighten the hex bolts of the cylinder head cover in the order from (1) ~ (10). The front engine direction is the water pump direction and the rear engine direction is the flywheel direction.

2. Attach the injectors.



- 1) Align the injector seal ring washer (A) with the center of the injector hole and mount it.
- 2) Sufficiently apply engine oil on the cylinder head cover surface where the injectors contact.
- 3) Attach 3 injectors (B).

⚠ CAUTION

- Do not reuse the head cover rubber seal and the injector oil seal but replace with new ones.
- Attach injectors by slowly turning them to prevent damage to the cylinder head cover surface which contacts the injectors.
- Do not reuse the injector seal ring washers. Otherwise, critical damage to the engine may occur because of unstable combustion.

- 4) Mount 3 injector fixtures (C).
- 5) Temporarily tighten 3 hex bolts (D).

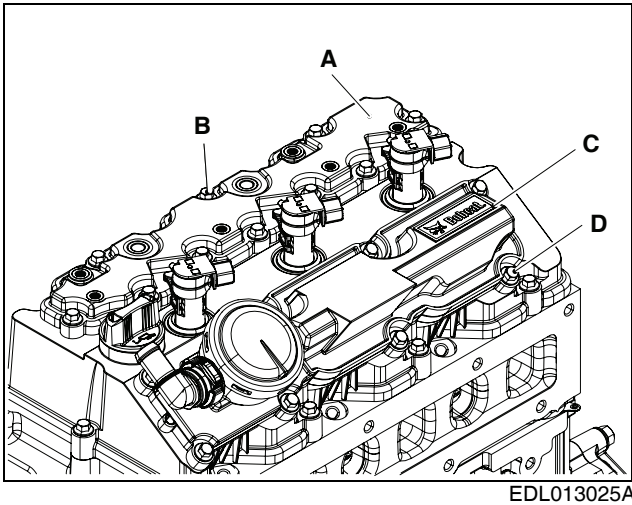
⚠ CAUTION

Do not tighten the hex bolts by force when it is difficult to tighten them temporarily. Forced tightening may cause damage to the cylinder head.

- 6) Tighten 3 hex bolts (D) at a tightening torque of 3.5 kgf•m.

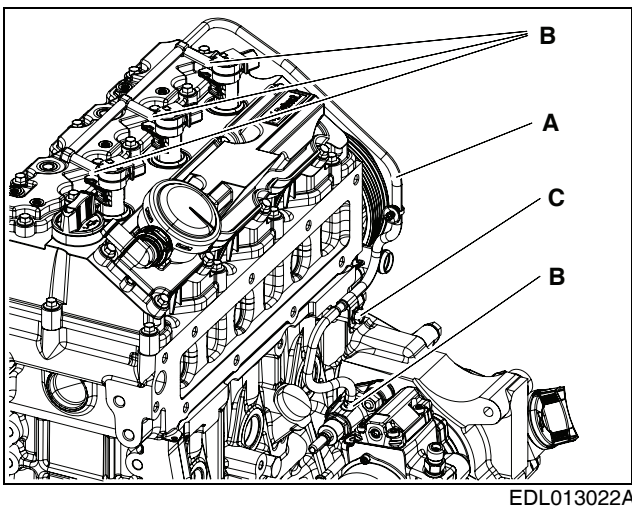
11. Cylinder block/head

3. Attach the right and left cylinder head cover.



- 1) Attach the left cylinder head cover(A).
- 2) Tighten 10 flange hex bolts (B) at a tightening torque of 1.0 kgf•m.
- 3) Attach the right cylinder head cover (C).
- 4) Tighten 8 flange hex bolts (D) at a tightening torque of 1.0 kgf•m.

4. Connect the fuel return hose.



- 1) Press the fuel return hose (A) into the end of the nipple and connect it.

⚠ CAUTION

- Be careful to note the direction when connecting the fuel return hose.
- The injector should be fully connected with the hose.

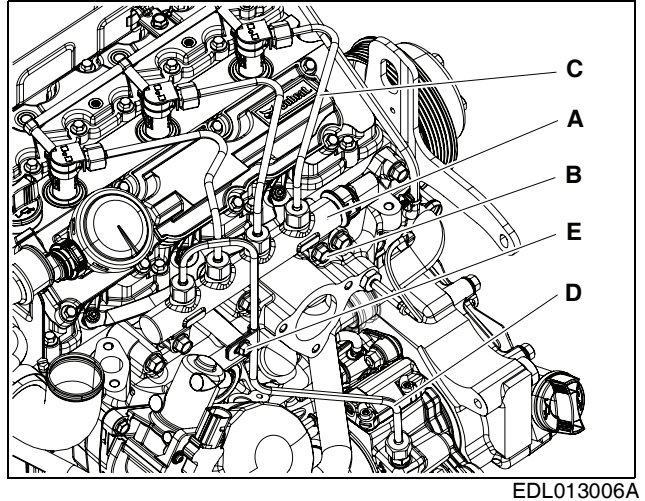
- 2) Attach the hose clips (B).

⚠ CAUTION

Fix the handle of hose clip to face the front of the engine.

- 3) Tighten the fixing bolt (C).

5. Attach the common rail and the injection pipe.



- 1) Attach the common rail (A) to the intake manifold.

⚠ CAUTION

- Be careful to note the direction when attaching the common rail.
- Be careful not to damage the common rail while attaching it.

- 2) Temporarily tighten 2 collared hex bolts (B) by hand.
- 3) Temporarily connect the fuel injection pipes (C) and (D) by hand.

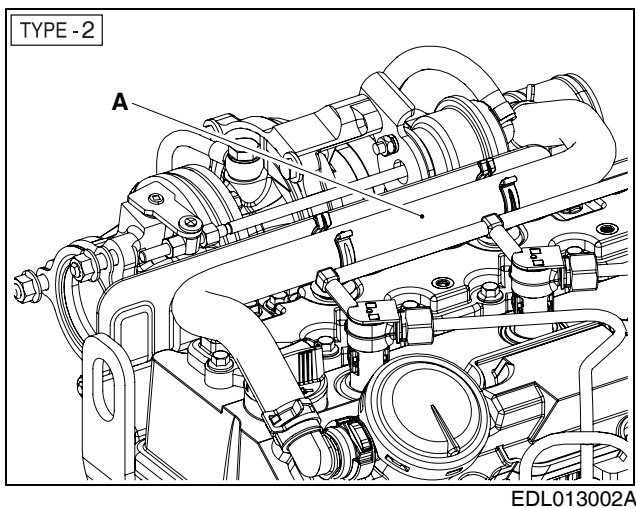
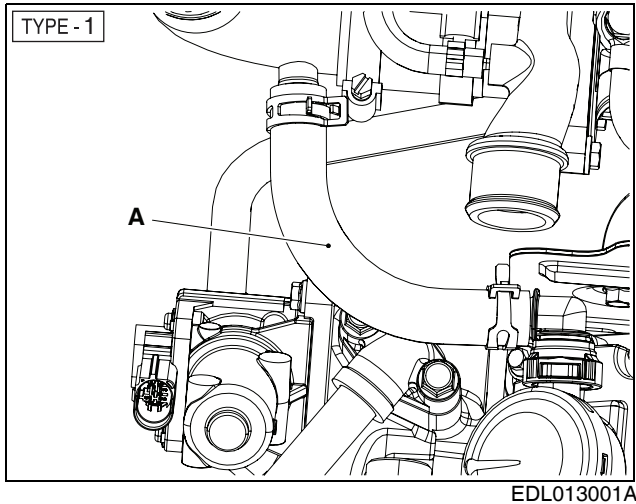
⚠ CAUTION

- Do not bend the fuel injection pipes by force.
- Be careful to note the direction when connecting the fuel injection pipes.
- Assemble the nut on one side of the fuel injection pipe first, and then the nut on the other side to connect the round part of the pipe to the correspondent part correctly.
- Do not reuse fuel injection pipes but replace them with new ones. Reusing fuel injection pipes may allow foreign substances into the fuel pipes or oil leaks from the bolt clamping to occur, causing a critical fault in engine performance.

- 4) Tighten 2 collared hex bolts(B) at a tightening torque of 2.2 kgf•m.

11. Cylinder block/head

- 5) Tighten the fuel injection pipes (C) and (D) at a tightening torque of 3.0 kgf•m.
 - 6) Tighten the fixing bolt (E).
6. Attach the breather hose.



- 1) Attach the breather hose(A).

CAUTION

Do not reuse the clamps but replace with new ones.

11. Cylinder block/head

Oil Pan

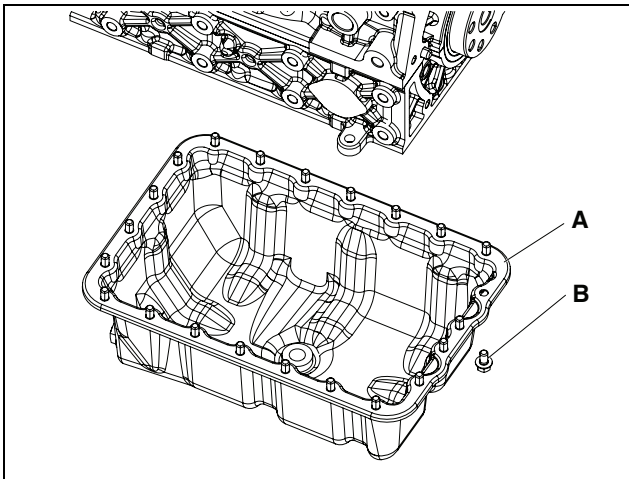
Disassembly of Oil Pan

1. Drain the engine oil.
- 1) Place a container under the engine to drain the engine oil.
- 2) Remove the oil cap.
- 3) Remove the drain plug and drain the engine oil.

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 when discarding engine oil without observing the handling regulations, will be punished.

2. Remove the oil pan.

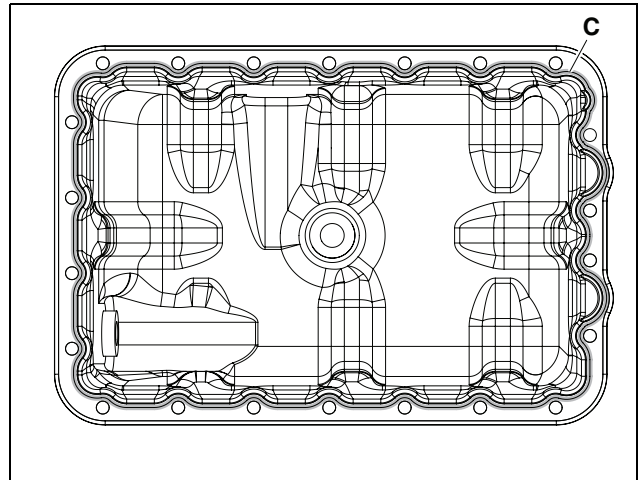


EDL013034A

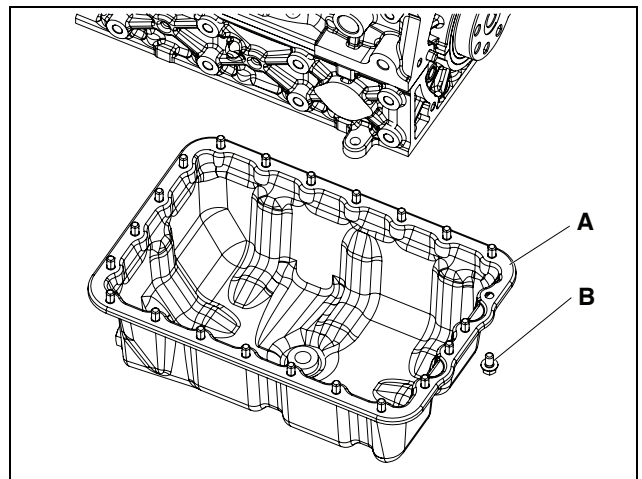
- 1) Loosen 22 flange hex bolts (B).
- 2) Remove the oil pan (A).

Assembly of Oil Pan

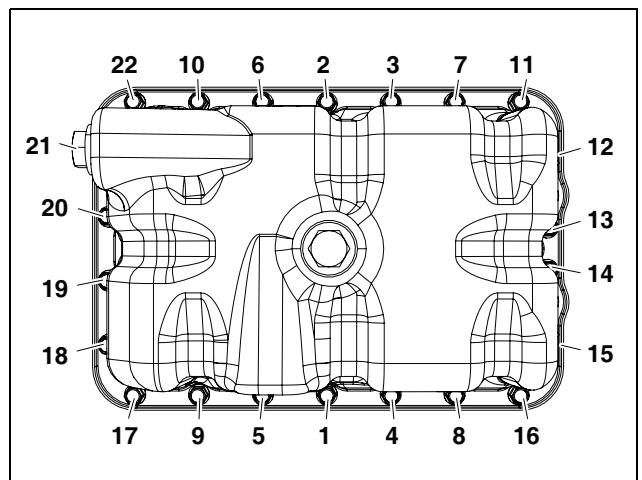
1. Attach the oil pan.



EDL013054A



EDL013034A



EDL013055A

- 1) Apply LOCTITE 5902 to the oil pan assembly surface(C) with the diameter of $\varnothing 3 \pm 0.5$ mm.

11. Cylinder block/head

CAUTION

- Keep clean liquid gasket dispensing surface.
- Dispensing line should not be snapped.

- 2) Attach the oil pan (A).

CAUTION

- Be careful that the oil pan has been attached in the right direction.
- Assemble oil pan in 5 minutes after dispensing liquid gasket.
- Do not pressurize inside oil pan in 25 minutes after dispensing liquid gasket.

- 3) Tighten 22 flange hex bolts (B) at a tightening torque of 2.2 kgf•m.

CAUTION

Tighten flange hex bolts in the order from (1) - (22). The front engine direction is the water pump direction and the rear engine direction is the flywheel direction.

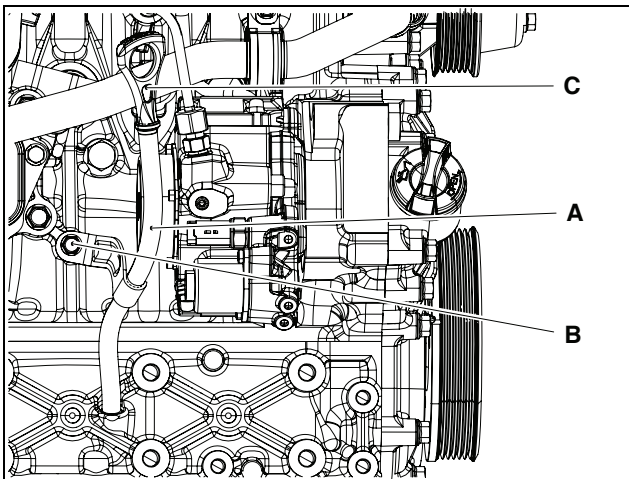
2. Inject the engine oil.
- 1) Open the oil injection cap.
- 2) Inject engine oil.

WARNING

Use genuine engine oil recommended.

Disassembly of Engine Oil Level Gauge and Guide Tube

1. Remove the oil level gauge.



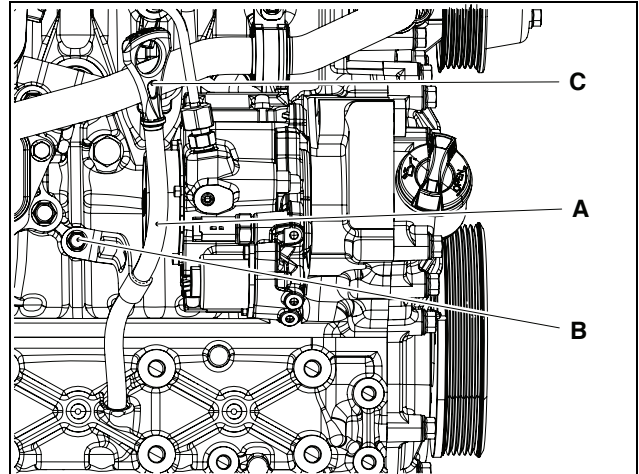
EDL013003A

- 1) Remove the oil level gauge (C).

- 2) Loosen the flange hex bolt (B).
- 3) Disconnect the oil level gauge guide tube (A).

Assembly of Engine Oil Level Gauge and Guide Tube

1. Attach the oil level gauge.



EDL013003A

- 1) Attach the oil level gauge guide tube (A) in the cylinder block.
- 2) Tighten the flange hex bolt (B) at a tightening torque of 1.0 kgf•m.
- 3) Insert the oil level gauge (C).

CAUTION

Make the handle of the oil level gauge face the reverse direction from the center of the engine.

11. Cylinder block/head

Valve

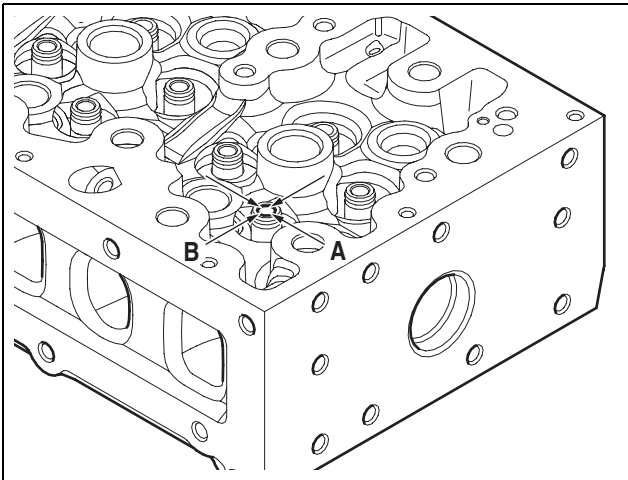
Disassembly of Valve

1. Remove the valve.

Note) Refer to Chapter 6 (Procedure of Disassembling an Engine)

Measurement of Inside Diameter of Valve Guide

1. Mount the valve guide to the cylinder head.
2. Set the meter.
3. Measure the inside diameter of the valve guide.



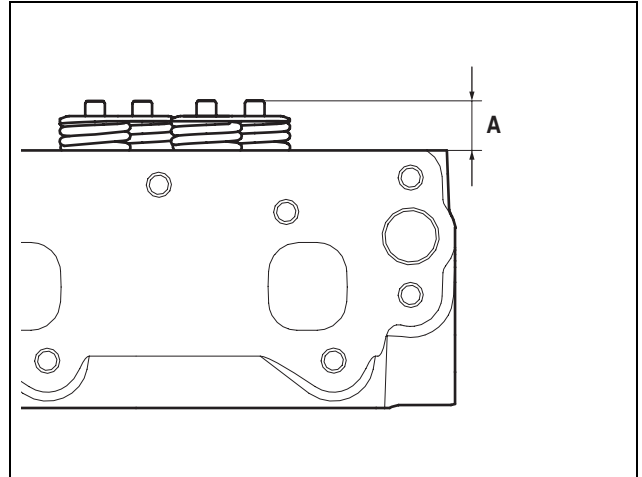
EDL022092A

- 1) Measure total 6 points of the valve guide to the vertical direction (B) and the horizontal direction (A): top, middle, and bottom.
- 2) Measure 16ea valves; 8ea intake valves and 8ea exhaust valves.
- 3) The standard measurement value of the valve guide inside diameter is within the range of 7.0 ~ 7.015 mm.

Item	Specified Value
Valve guide inside diameter	7.0 ~ 7.015 mm

Measurement of Valve Stem End

1. Mount the valve to the cylinder head.
2. Perform the zero point adjustment of the meter.
3. Measure the valve stem end (A).



EDL022093A

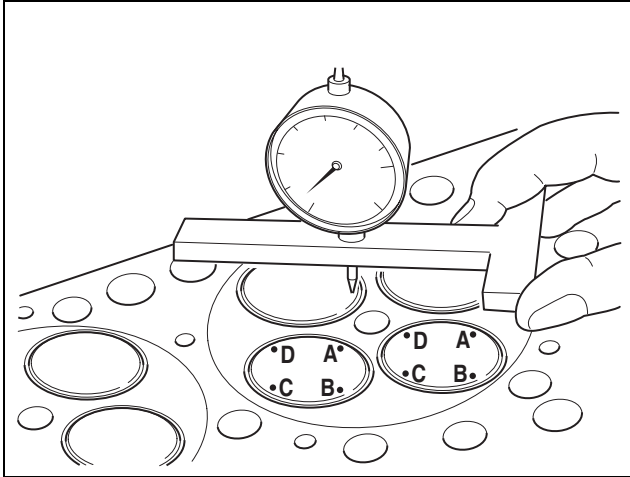
- 1) Measure 8ea intake valve stem ends.
- 2) The standard measurement value of the intake valve stem end is within the range of 17.0 ~ 17.5 mm.
- 3) Measure 8ea exhaust valve stem ends.
- 4) The standard measurement value of the exhaust valve stem end is within the range of 17.1 ~ 17.6 mm.

Item	Specified Value
Intake valve stem end	17.0 ~ 17.5 mm
Exhaust valve stem end	17.1 ~ 17.6 mm

11. Cylinder block/head

Measurement of Valve Step Height

1. Measure the height of the contact surface of the intake and exhaust valve. If the measurement value is over the allowable limit, it means that the valve seat is worn. Replace the valve seat.
2. Measure the valve step height.

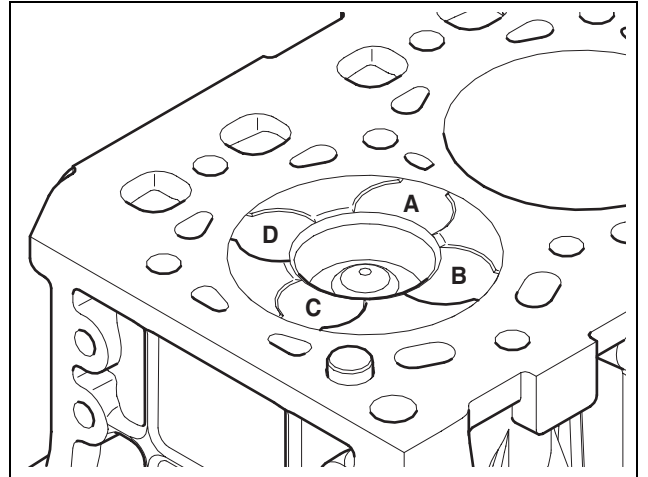


- 1) Put the valves in the valve seat of the cylinder head and measure how deep the valves have been put from the cylinder head bottom surface with the dial gauge.
- 2) Measure 4 points (A, B, C, and D) of the valve.
- 3) The standard measurement value of the intake valve is within the range of 0.6 ~ 0.9 mm.
- 4) The standard measurement value of the exhaust valve is within the range of 0.9 ~ 1.2 mm.

Item	Specified Value
Intake Valve Step Height	0.6 ~ 1.8 mm
Exhaust Valve Step Height	0.9 ~ 1.5 mm

Measurement of Gap between Piston and Valve

1. Detach the cylinder head.
2. Prepare measurement of the gap between the piston and the valve.



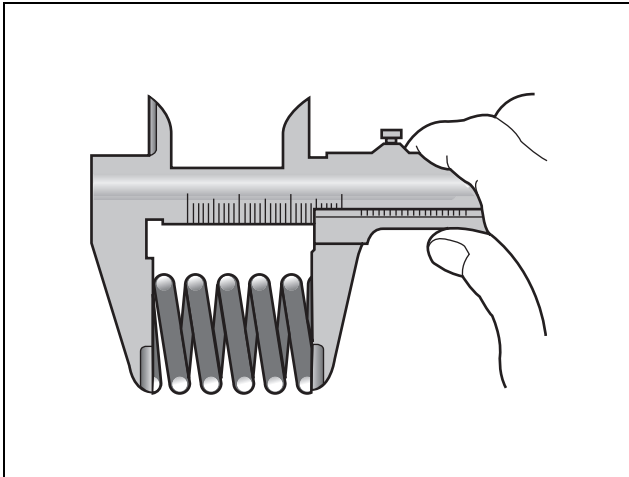
- 1) Prepare the lead with thickness of 3mm.
 - 2) Position the greased lead on total 16 points (A, B, C, and D) on the top of each piston.
 - 3) Attach the cylinder head.
 - 4) Rotate the crankshaft pulley in order to move the piston.
 - 5) Detach the cylinder head.
3. Measure the gap between the piston and the valve.
- 1) Measure thickness of the lead with the vernier calipers.
 - 2) The standard value of gap between the piston and the intake valve is within the range of 1.12 ~ 2.29 mm.
 - 3) The standard value of gap between the piston and the exhaust valve is within the range of 1.44 ~ 2.58 mm.

Item	Specified Value
Gap between the piston and the intake valve	1.12 ~ 2.29 mm
Gap between the piston and the exhaust valve	1.44 ~ 2.58 mm

11. Cylinder block/head

Check of Valve Spring

1. Check the exterior of the valve spring with naked eye.
- 1) Check if the exterior of the valve spring is damaged with naked eye. Replace it with a new one if required.
2. Check the free length of the valve spring.

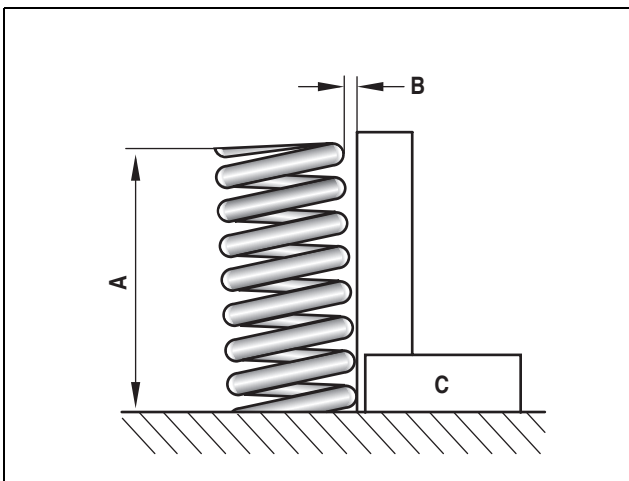


EDL022096A

- 1) Measure the free length of the valve spring with the vernier calipers.

Note) If the length is too small, replace the valve spring with a new one.

3. Check the valve spring squareness.



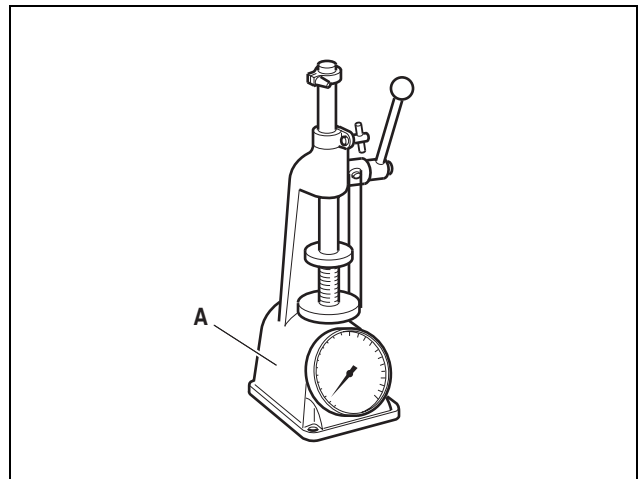
EDL022097A

A. Free length B. Squareness C. Right-angle square

- 1) Measure the squareness of the valve spring with the surface plate and the right-angle square.

Note) If the measurement value is abnormal, replace the valve spring with a new one.

4. Check the tension of the valve spring.



EDL022098B

- 1) Measure the tension of the valve spring with the spring tester (A).

Note) If the measurement value is abnormal, replace the valve spring with a new one.

Assembly of Valve

1. Mount the valve.

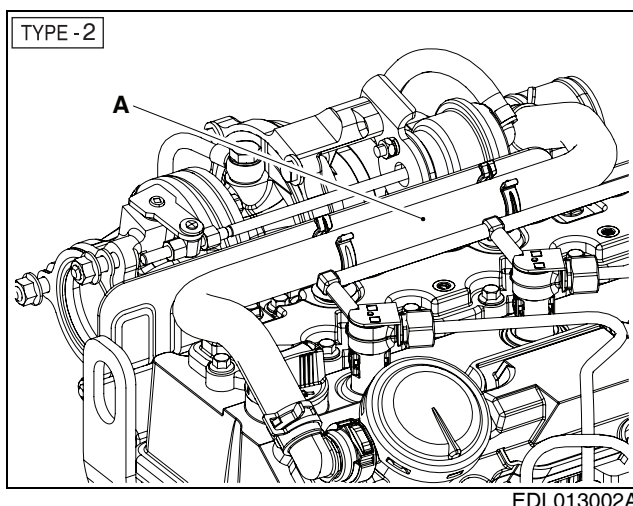
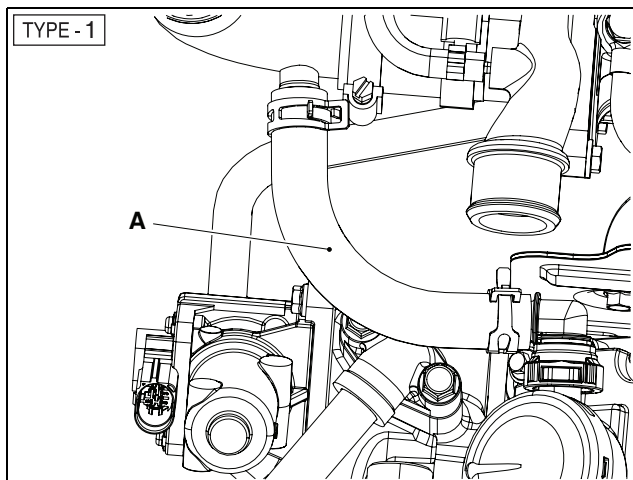
Note) Refer to Chapter 6 (Procedure of Assembling an Engine)

11. Cylinder block/head

Rocker Arm

Disassembly of Rocker Arm

1. Remove the breather hose.

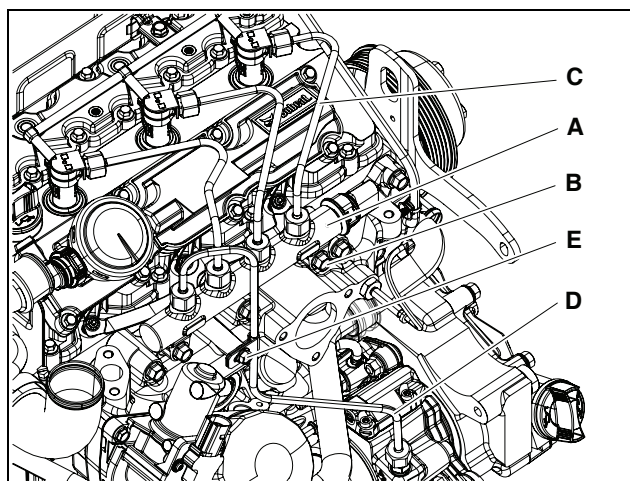


- 1) Remove the breather hose (A).

⚠ CAUTION

Do not reuse the clamps but replace with new ones.

2. Remove the common rail and the injection pipes.



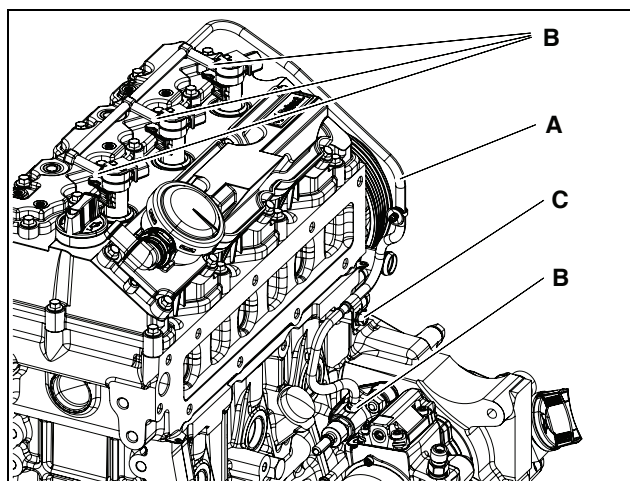
- 1) Loosen the fixing bolt (E).
- 2) Loosen the nuts of the fuel injection pipes.
- 3) Remove 4 fuel injection pipes (C) and (D).

⚠ CAUTION

Do not reuse fuel injection pipes; replace them with new ones. If fuel injection pipes are reused it may allow foreign substances into the fuel pipes or cause oil leaks from bolt clamping and cause a critical fault in engine performance.

- 4) Loosen 2 collared hex bolts (B) of the common rail.
- 5) Remove the common rail (A) from the intake manifold.

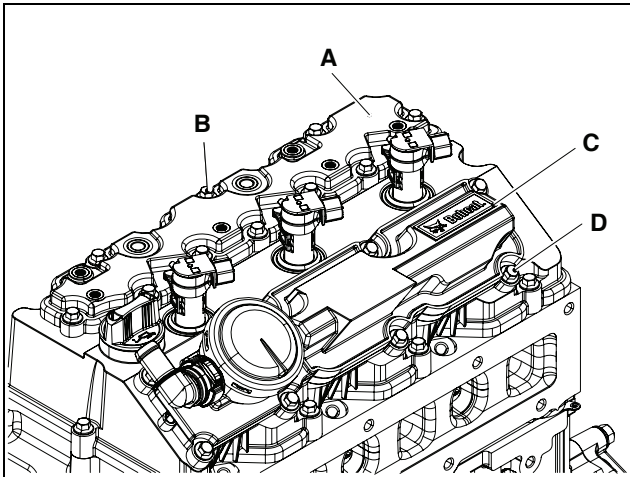
3. Remove the fuel return hose.



- 1) Loosen the flange hex bolts (C).
- 2) Remove the hose clips and disconnect the fuel hose (A).

11. Cylinder block/head

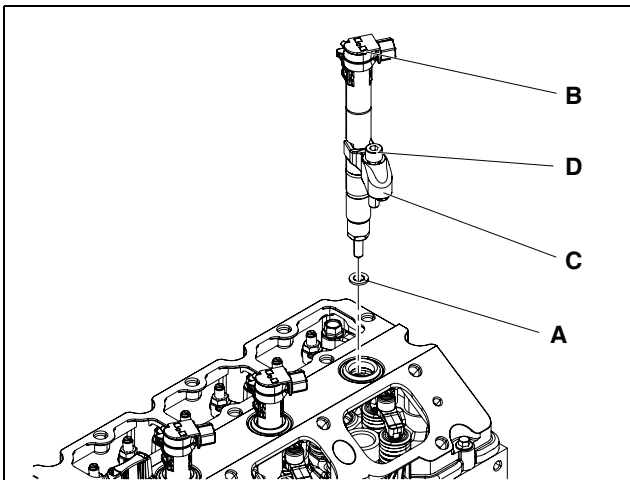
4. Remove the right and left cylinder head cover.



EDL013025A

- 1) Loosen 8 flange hex bolts (D).
- 2) Remove the right cylinder head cover (C).
- 3) Loosen 10 flange hex bolts (B).
- 4) Remove the left cylinder head cover (A).

5. Remove the injectors.



EDL013026A

- 1) Loosen 3 hex bolts (D).
- 2) Remove 3 injector fixtures (C).
- 3) Remove 4 injectors (B).
- 4) Remove 3 injector seal ring washers (D).

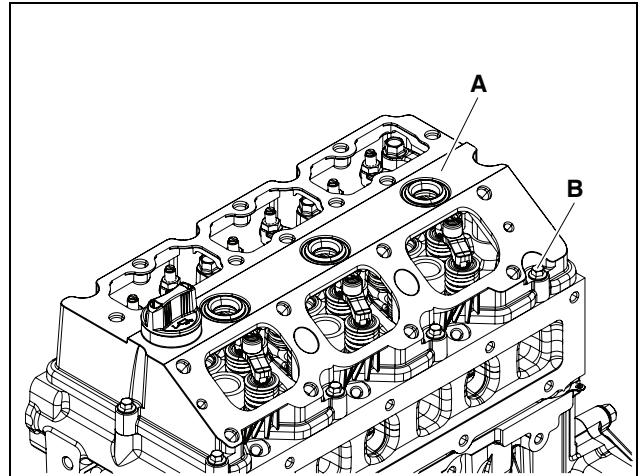
CAUTION

- Do not reuse the head cover rubber seal and the injector oil seal but replace with new ones.
- Be careful not to damage the injector oil seal of the cylinder head cover.
- Remove it by turning the injector slowly from left to right.

CAUTION

Do not reuse the injector seal ring washers. Reuse of the injector seal ring washers may cause critical damage to the engine due to unstable combustion.

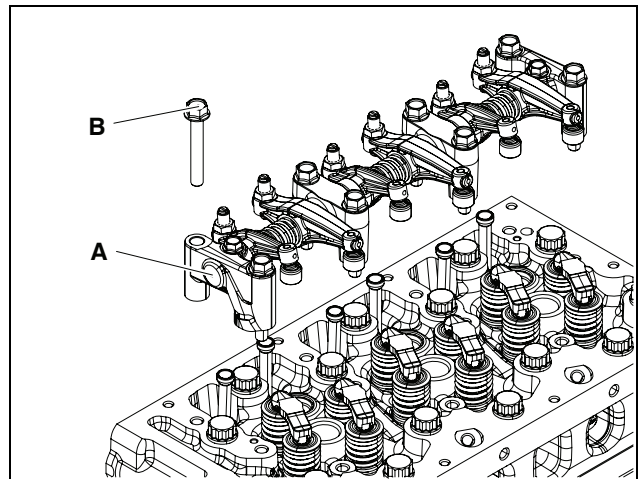
6. Remove the cylinder head cover.



EDL013027A

- 1) Loosen 10 hex bolts (B).
- 2) Remove the cylinder head cover (A).

7. Remove the rocker arm.



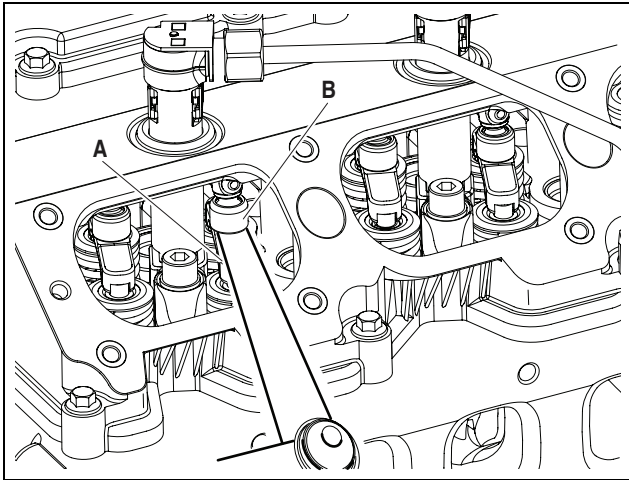
EDL013028A

- 1) Loosen 8 flange hex bolts (B).
- 2) Remove the rocker arm (A).

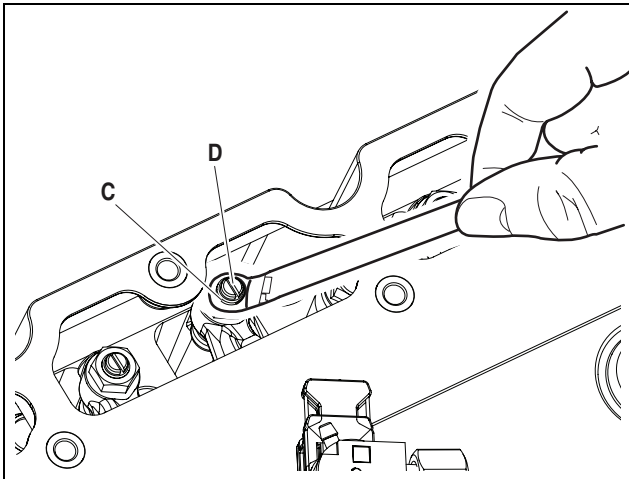
11. Cylinder block/head

Adjustment of Valve Gap

1. Adjust the valve gap.



EDL032822A



EDL032823A

- 1) Remove the left and right cylinder head cover.
- 2) Check the valve gap between the caliper (A) and the adjust screw cap (B) with the gap gauge.
- 3) Loosen the hex nut (C) and tighten the adjust screw (D) to adjust the valve gap.
- 4) Check the valve gap between the caliper (A) and the adjust screw cap (B) with the gap gauge.
- 5) The intake valve gap is 0.4 mm and the exhaust valve gap is 0.45 mm.

Item	Specified Value
Intake valve gap	0.4 mm
Exhaust valve gap	0.45 mm

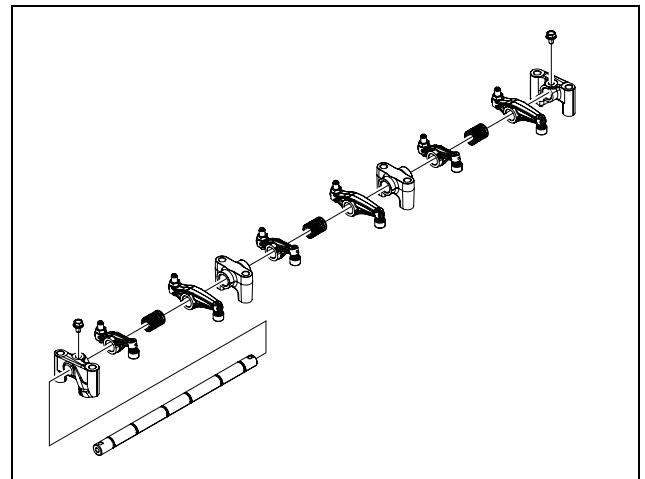
2. Adjust the valve gap in the following order.

CYL No	# 1		# 2		# 3	
Rotation angle	IN	EX	IN	EX	IN	EX
TDC (#1 CYL.)	●	●		●	●	
360° Rotation			●			●

- 1) Check and adjust the following valve gaps when the #1 cylinder is at the top dead point.
 - #1 cylinder: Intake and exhaust valve
 - #2 cylinder: Exhaust valve
 - #3 cylinder: Intake valve
- 2) Rotate a full 360°
- 3) Check and adjust the following valve gap.
 - #2 cylinder: Intake valve
 - #3 cylinder: Exhaust valve
3. Perform the final check after adjusting the gap.
 - 1) Compare the height of the adjust screw of the intake valve to that of the exhaust valve after adjusting the gap by using the adjust screw.
 - 2) If the difference is 2 pitches or more, check the following.
 - Check the assembly state between the push rod and the valve tappet.
 - Check the assembly state between the caliper and the valve.

Check of Rocker Arm Shaft

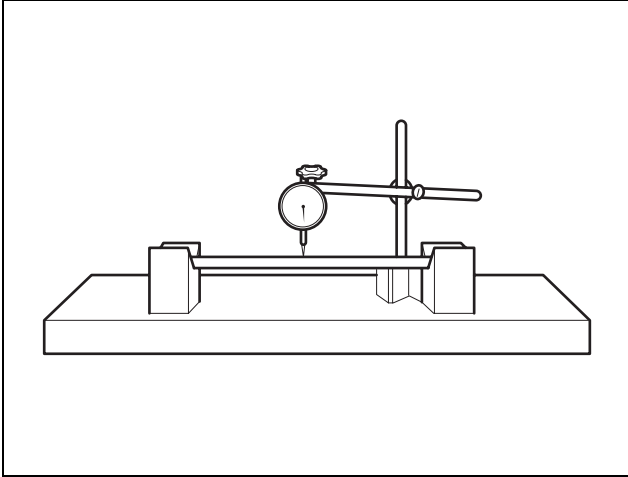
1. Remove the rocker arm shaft.



EDL013089A

- 1) Loosen and remove the fixing bolts from the rocker arm bracket.
- 2) Remove the rocker arm bracket, the rocker arm shaft spring, the rocker arm, and the rocker arm shaft in the order as listed before.
2. Check warpage of the rocker arm shaft.

11. Cylinder block/head

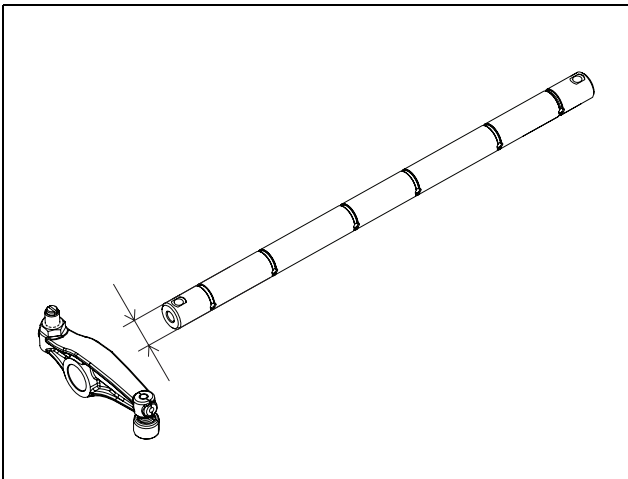


EDL022101A

- 1) Put the rocker arm shaft on two V-blocks.
- 2) Install the dial gauge.
- 3) Check the degree of warpage of the rocker arm shaft as rotating the rocker arm shaft.

Note) If the warpage is slight, correct it by pressing with the press. If the warpage is out of the allowable limit, replace it with a new one.

3. Check the outside diameter of the rocker arm shaft.



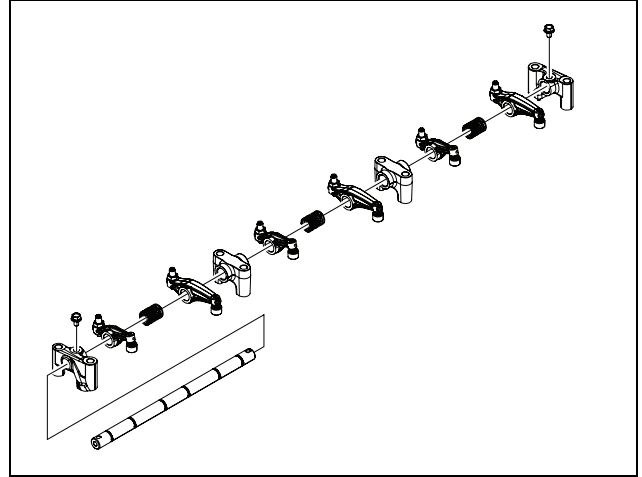
EDL013090A

- 1) Measure the outside diameter of the rocker arm shaft on the position where the rocker arm is attached with the outside diameter micrometer.

Note) If the outside diameter is out of the allowable limit, replace it with a new one.

Check of Rocker Arm

1. Remove the rocker arm.



EDL013089A

- 1) Loosen and remove the fixing bolts from the rocker arm bracket.
- 2) Remove the rocker arm bracket, the rocker arm shaft spring, and the rocker arm in the order as listed before.

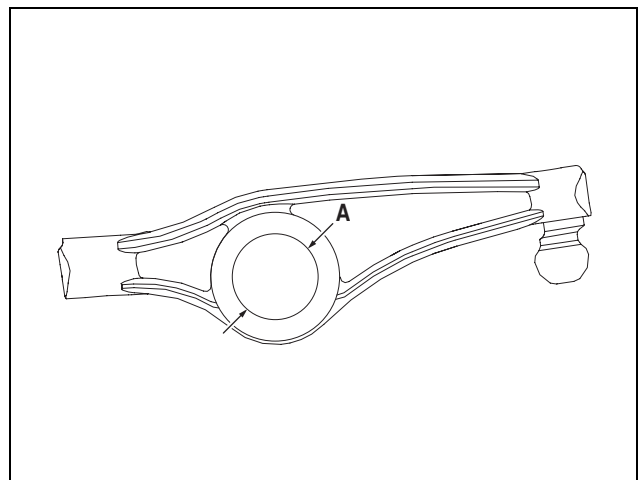
2. Check the exterior of the rocker arm with the naked eye.

- 1) Check whether the adjust screw cap assembly surface, which moves as contacting to the valve stem, is scratched, or the layer is worn with the naked eye.

Note) If the wear is slight, polish it with the oil-contained whetstone or fine sandpaper. If the layer is seriously worn, replace the rocker arm with a new one.

Note) For polishing the rocker arm, use the sandpaper dipped in oil

3. Measure the inside diameter of the rocker arm.



EDL022103A

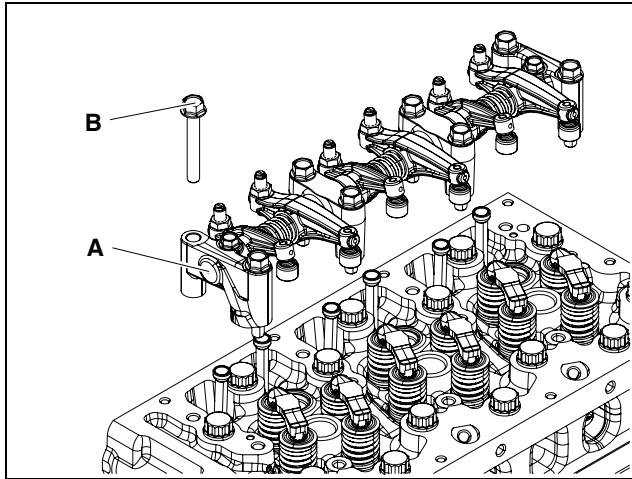
- 1) Measure the rocker arm inside diameter with the micrometer or the vernier calipers.

11. Cylinder block/head

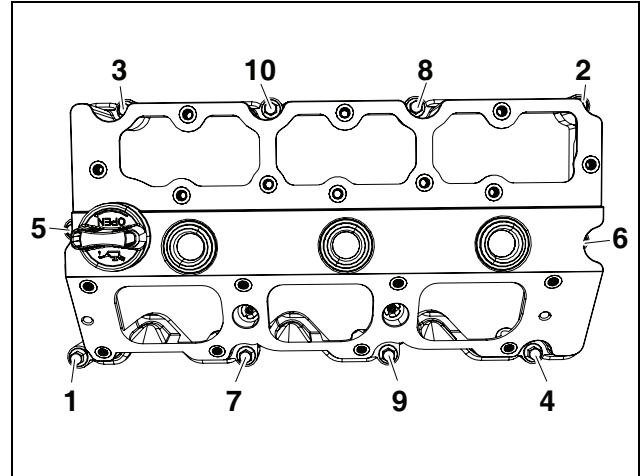
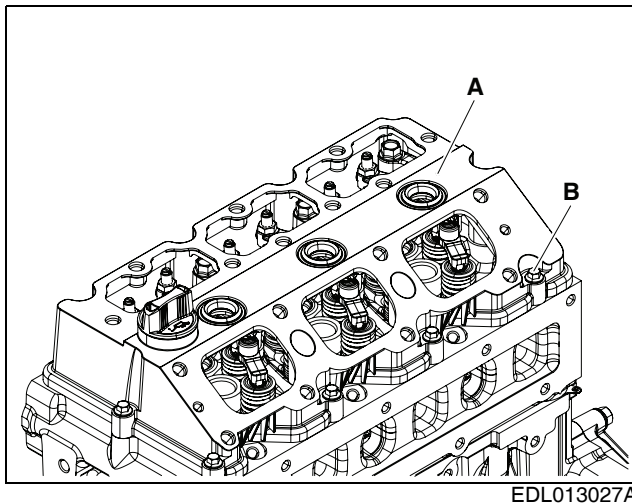
Note) Compare the measurement value with the outside diameter of the rocker arm shaft. If the gap is larger than the specified value, replace the one of which wear is more serious.

Assembly of Rocker Arm

1. Attach the rocker arm.



- 1) Attach the rocker arm (A).
 - 2) Tighten 8 flange hex bolts (B) at a tightening torque of $2.2 \pm 0.3 \text{ kgf}\cdot\text{m}$.
2. Attach the cylinder head cover.

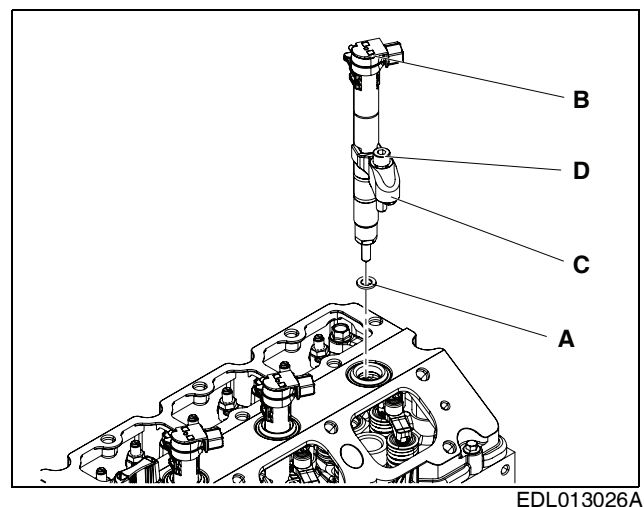


- 1) Attach the cylinder head cover (A).
- 2) Temporarily tighten 10 hex bolts (B) in the order of (1) ~ (10).
- 3) Tighten 10 hex bolts (B) at a tightening torque of $1.0 \text{ kgf}\cdot\text{m}$.

CAUTION

- Be careful not to allow the seal ring of the cylinder head cover to get out to the outside.
- Tighten the hex bolts of the cylinder head cover in the order from (1) ~ (10). The front engine direction is the water pump direction and the rear engine direction is the flywheel direction.
- Do not reuse the cylinder head rubber gasket but replace with new one.

3. Attach the injectors.



- 1) Align the injector seal ring washer (A) with the center of the injector hole and mount it.

11. Cylinder block/head

- 2) Sufficiently apply engine oil on the cylinder head cover surface where the injectors contact.
- 3) Attach 3 injectors (B).

CAUTION

- Do not reuse the head cover rubber seal and the injector oil seal but replace with new ones.
- Attach injectors by slowly turning them to prevent damage to the cylinder head cover surface which contacts the injectors.
- Do not reuse the injector seal ring washers. Otherwise, critical damage to the engine may occur because of unstable combustion.

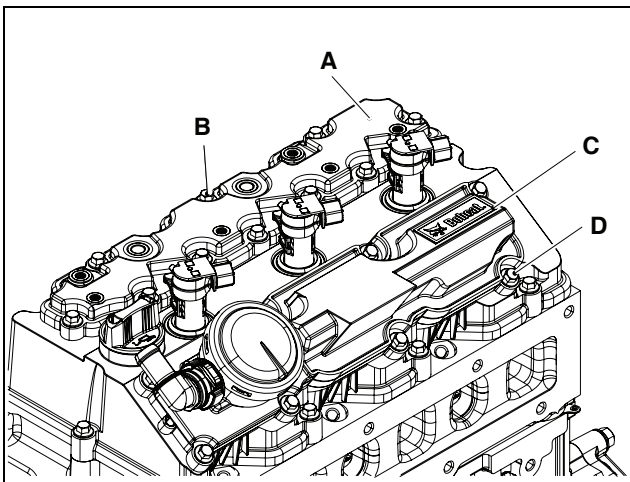
- 4) Mount 3 injector fixtures (C).
- 5) Temporarily tighten 3 hex bolts (D).

CAUTION

Do not tighten the hex bolts by force when it is difficult to tighten them temporarily. Forced tightening may cause damage to the cylinder head.

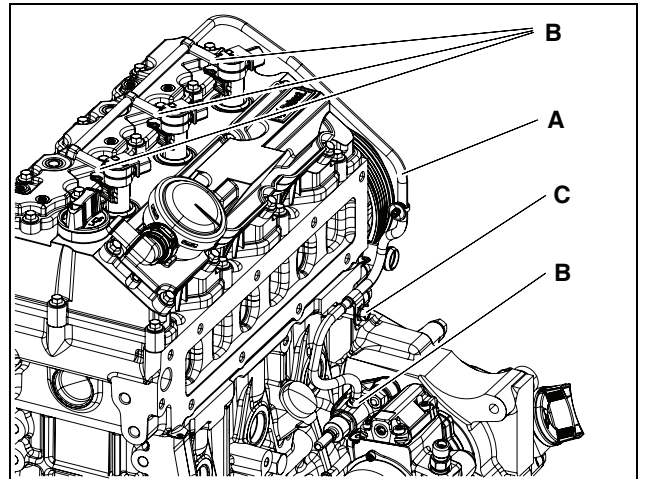
- 6) Tighten 3 hex bolts (D) at a tightening torque of 3.5 kgf•m.

4. Attach the right and left cylinder head cover.



- 1) Attach the left cylinder head cover (A).
- 2) Tighten 10 flange hex bolts (B) at a tightening torque of 1.0 kgf•m.
- 3) Attach the right cylinder head cover (C).
- 4) Tighten 8 flange hex bolts (D) at a tightening torque of 1.0 kgf•m.

5. Connect the fuel return hose.



- 1) Press the fuel return hose (A) into the end of the nipple and connect it.

CAUTION

- Be careful to note the direction when connecting the fuel return hose.
- The injector should be fully connected with the hose.

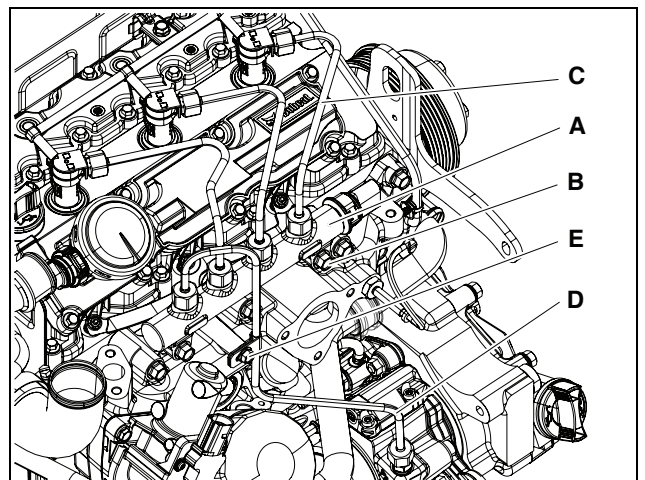
- 2) Attach the hose clips (B).

CAUTION

Fix the handle of hose clip to face the front of the engine.

- 3) Tighten the fixing bolt (C).

6. Attach the common rail and the injection pipe.



- 1) Attach the common rail (A) to the intake manifold.

11. Cylinder block/head

CAUTION

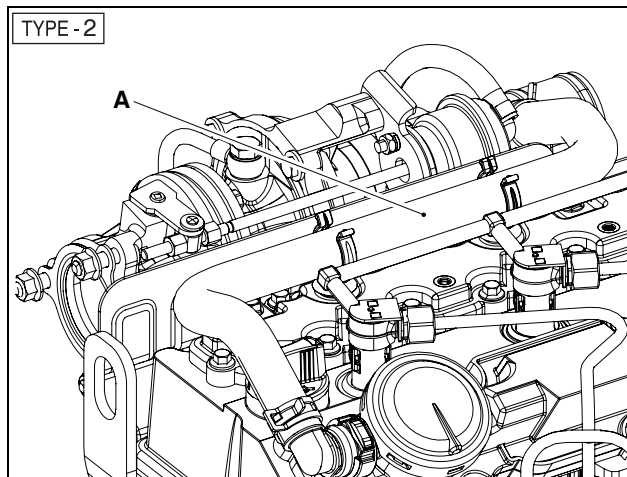
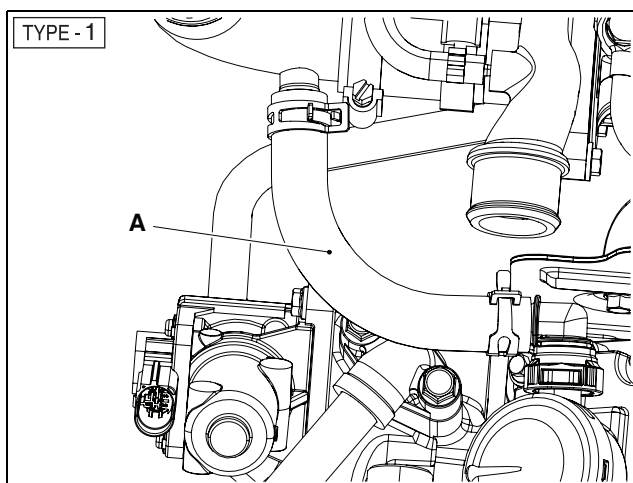
- Be careful to note the direction when attaching the common rail.
- Be careful not to damage the common rail while attaching it.

- 2) Temporarily tighten 2 collared hex bolts (B) by hand.
- 3) Temporarily connect the fuel injection pipes (C) and (D) by hand.

CAUTION

- Do not bend the fuel injection pipes by force.
- Be careful to note the direction when connecting the fuel injection pipes.
- Assemble the nut on one side of the fuel injection pipe first, and then the nut on the other side to connect the round part of the pipe to the correspondent part correctly.
- Do not reuse fuel injection pipes but replace them with new ones. Reusing fuel injection pipes may allow foreign substances into the fuel pipes or oil leaks from the bolt clamping to occur, causing a critical fault in engine performance.

- 4) Tighten 2 collared hex bolts(B) at a tightening torque of 2.2 kgf•m.
- 5) Tighten the fuel injection pipes (C) and (D) at a tightening torque of 3.0 kgf•m.
- 6) Tighten the fixing bolt (E).
7. Attach the breather hose.



- 1) Attach the breather hose(A).

CAUTION

Do not reuse the clamps but replace with new ones.

11. Cylinder block/head

Valve Tappet and Push Rod

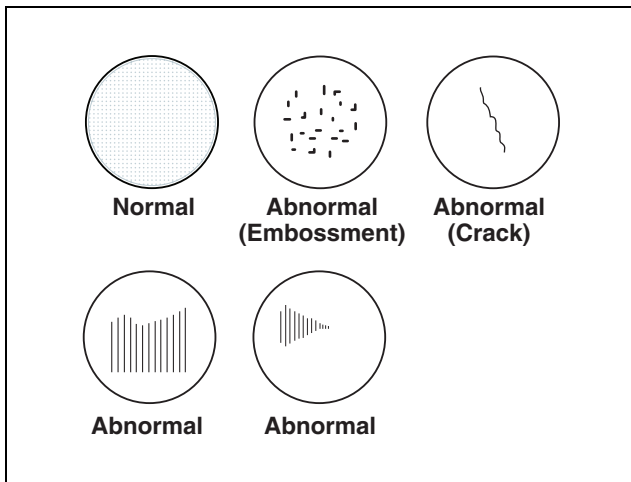
Disassembly of Valve Tappet

1. Detach the valve tappet.

Note) Refer to Chapter 6 (Procedure of Disassembling an Engine)

Check of Valve Tappet

1. Check the exterior of the valve tappet with naked eye.



EDL0213006B

- 1) Check whether the valve tappet surface, which moves as contacting to the camshaft, is cracked or scratched.

Note) If the wear is slight, polish it with the oil-contained whetstone or fine sandpaper. If the crack or scratch is serious, replace the valve tappet with a new one.

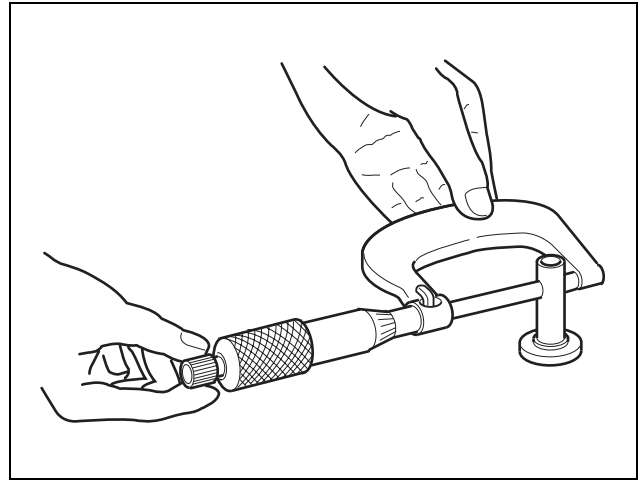
Note) For polishing the camshaft, use the sandpaper dipped in oil.

2. Measure the gap of the valve tappet.

- 1) Measure the outside diameter of the valve tappet and the tappet hole diameter of the cylinder block.

Note) If the diameter is out of the allowable limit, replace the valve tappet with a new one.

3. Measure the outside diameter of the valve tappet.



EDL022105A

- 1) Measure the outside diameter of the valve tappet with the outside diameter micrometer.

Note) If the diameter is out of the allowable limit, replace the valve tappet with a new one.

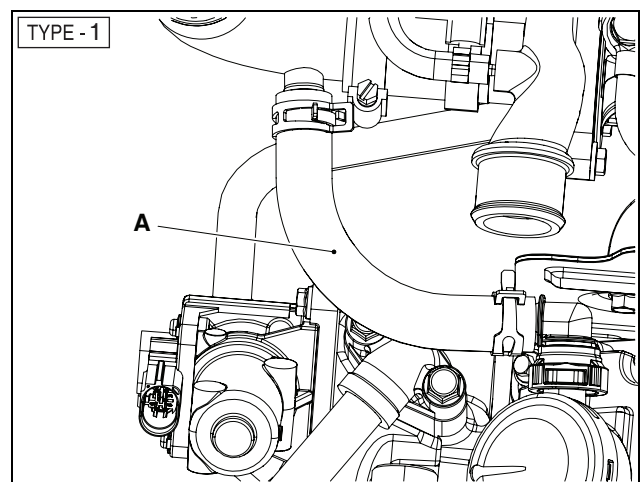
Assembly of Valve Tappet

1. Attach the valve tappet.

Note) Refer to Chapter 6 (Procedure of Assembling an Engine)

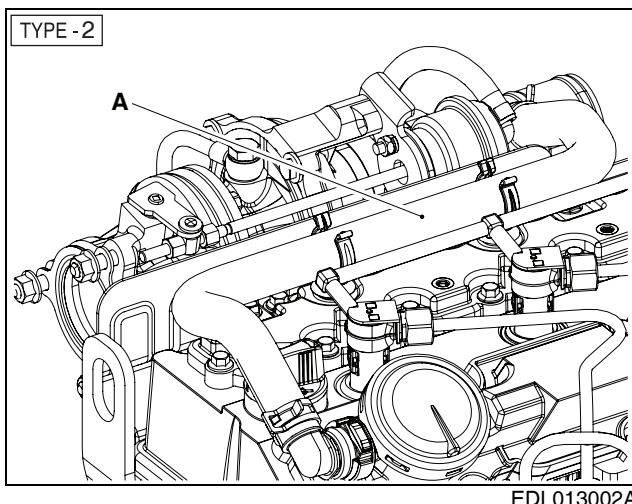
Disassembly of Push Rod

1. Remove the breather hose.



EDL013001A

11. Cylinder block/head

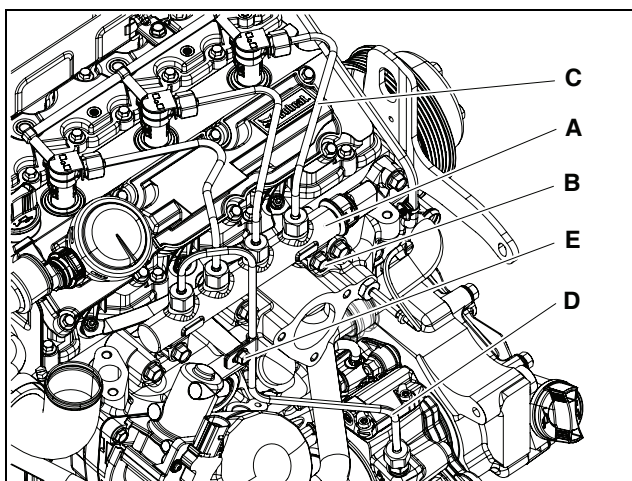


- 1) Remove the breather hose (A).

⚠ CAUTION

Do not reuse the clamps but replace with new ones.

2. Remove the common rail and the injection pipes.



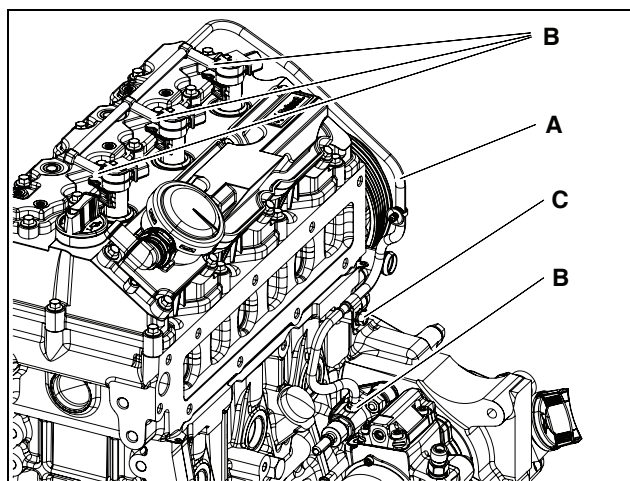
- 1) Loosen the fixing bolt (E).
- 2) Loosen the nuts of the fuel injection pipes.
- 3) Remove 4 fuel injection pipes (C) and (D).

⚠ CAUTION

Do not reuse fuel injection pipes; replace them with new ones. If fuel injection pipes are reused it may allow foreign substances into the fuel pipes or cause oil leaks from bolt clamping and cause a critical fault in engine performance.

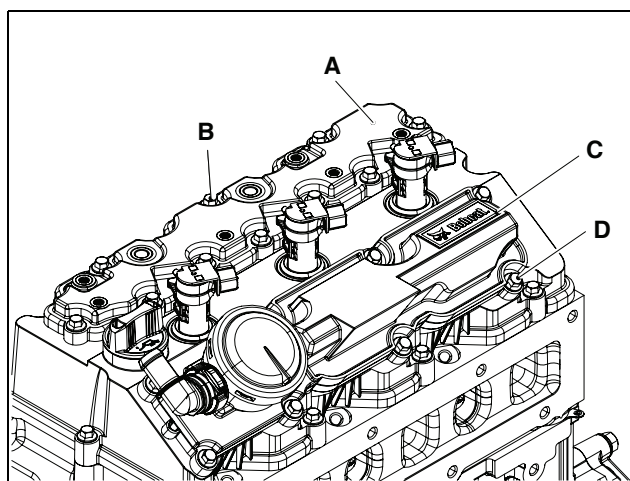
- 4) Loosen 2 collared hex bolts (B) of the common rail. Remove the common rail (A) from the intake manifold.

3. Remove the fuel return hose.



- 1) Loosen the flange hex bolts (C).
- 2) Remove the hose clips and disconnect the fuel hose (A).

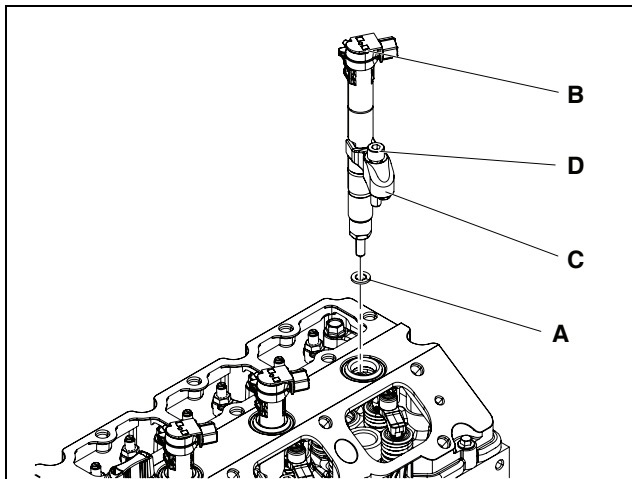
4. Remove the right and left cylinder head cover.



- 1) Loosen 8 flange hex bolts (D).
- 2) Remove the right cylinder head cover (C).
- 3) Loosen 10 flange hex bolts (B).
- 4) Remove the left cylinder head cover (A).

11. Cylinder block/head

5. Remove the injectors.



EDL013026A

- 1) Loosen 3 hex bolts (D).
- 2) Remove 3 injector fixtures (C).
- 3) Remove 4 injectors (B).
- 4) Remove 3 injector seal ring washers (D).

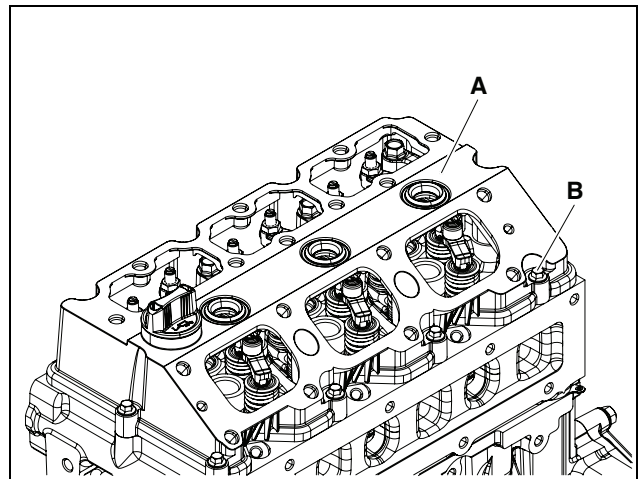
CAUTION

- Do not reuse the head cover rubber seal and the injector oil seal but replace with new ones.
- Be careful not to damage the injector oil seal of the cylinder head cover.
- Remove it by turning the injector slowly from left to right.

CAUTION

Do not reuse the injector seal ring washers. Reuse of the injector seal ring washers may cause critical damage to the engine due to unstable combustion.

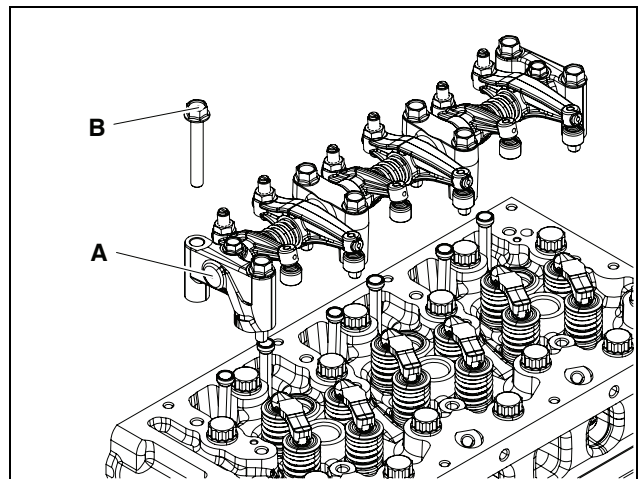
6. Remove the cylinder head cover.



EDL013027A

- 1) Loosen 10 hex bolts (B).
- 2) Remove the cylinder head cover (A).

7. Remove the rocker arm.

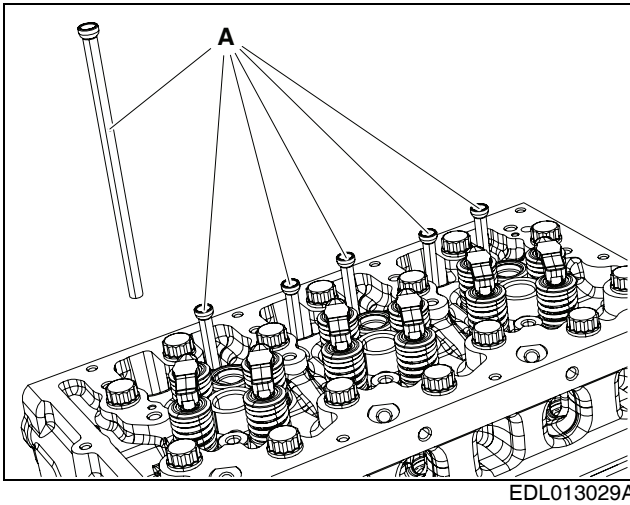


EDL013028A

- 1) Loosen 8 flange hex bolts (B).
- 2) Remove the rocker arm (A).

11. Cylinder block/head

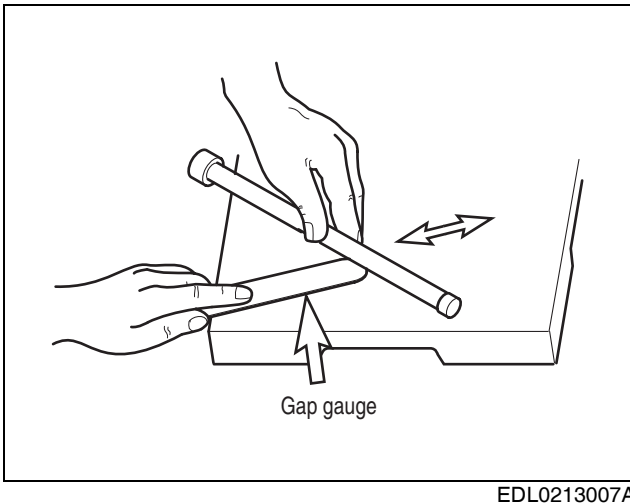
8. Remove the push rods.



- 1) Remove 6 push rods (A).

Check of Warpage of Push Rod

1. Check warpage of the push rod.

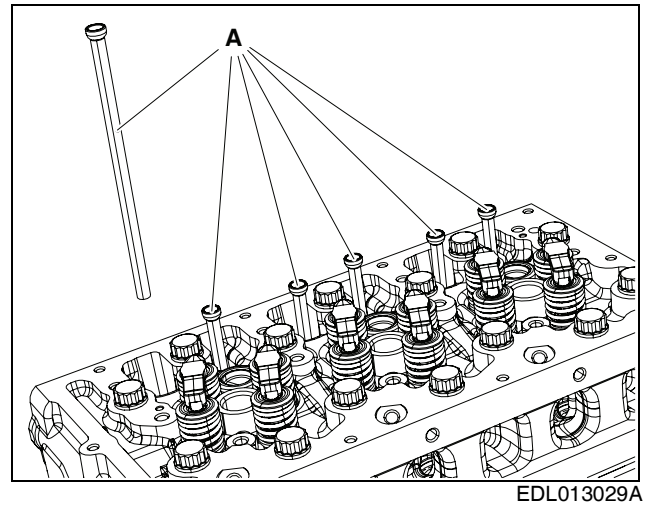


- 1) Put the push rod on the surface plate.
2) Measure the warped degree with the gap gauge as rolling the push rod.

Item	Specified Value
Warpage of push rod	0.5 mm

Assembly of Push Rod

1. Attach the push rods.

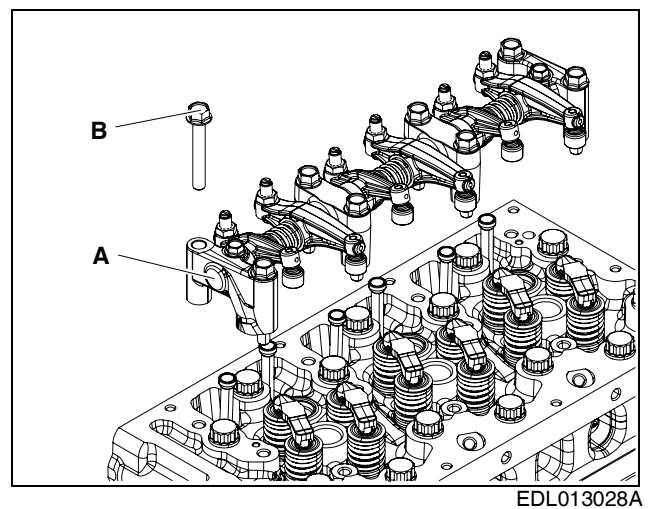


- 1) Apply engine oil on both ends of the push rods.
2) Attach the push rods(A) in the cylinder head holes.
3) Hit the head of the push rods with a rubber hammer lightly once or twice to get them positioned in the tappet holes.

⚠ CAUTION

After connecting the push rods, rotate them to check the connection state.

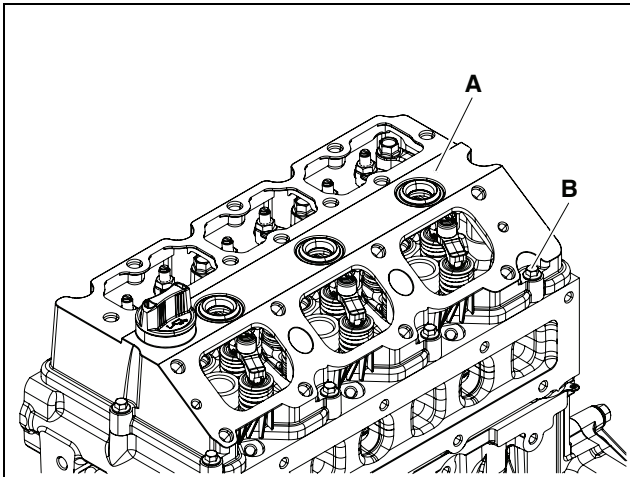
2. Attach the rocker arm.



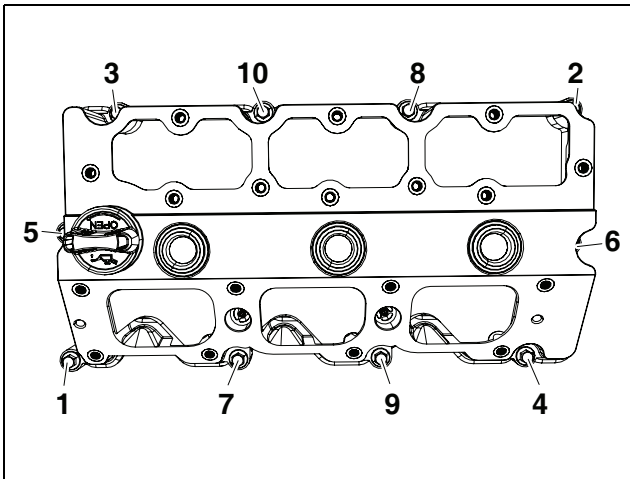
- 1) Attach the rocker arm (A).
2) Tighten 8 flange hex bolts (B) at a tightening torque of $2.2 \pm 0.3 \text{ kgf}\cdot\text{m}$.

11. Cylinder block/head

3. Attach the cylinder head cover.



EDL013027A



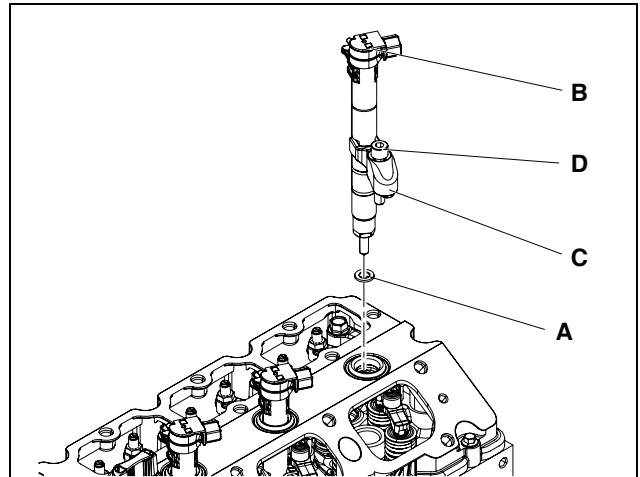
EDL013058A

- 1) Attach the cylinder head cover (A).
- 2) Temporarily tighten 10 hex bolts (B) in the order of (1) ~ (10).
- 3) Tighten 10 hex bolts (B) at a tightening torque of 1.0 kgf•m.

⚠ CAUTION

- Be careful not to allow the seal ring of the cylinder head cover to get out to the outside.
- Tighten the hex bolts of the cylinder head cover in the order from (1) ~ (10). The front engine direction is the water pump direction and the rear engine direction is the flywheel direction.

4. Attach the injectors.



EDL013026A

- 1) Align the injector seal ring washer (A) with the center of the injector hole and mount it.
- 2) Sufficiently apply engine oil on the cylinder head cover surface where the injectors contact.
- 3) Attach 3 injectors (B).

⚠ CAUTION

- Do not reuse the head cover rubber seal and the injector oil seal but replace with new ones.
- Attach injectors by slowly turning them to prevent damage to the cylinder head cover surface which contacts the injectors.
- Do not reuse the injector seal ring washers. Otherwise, critical damage to the engine may occur because of unstable combustion.

- 4) Mount 3 injector fixtures (C).
- 5) Temporarily tighten 3 hex bolts (D).

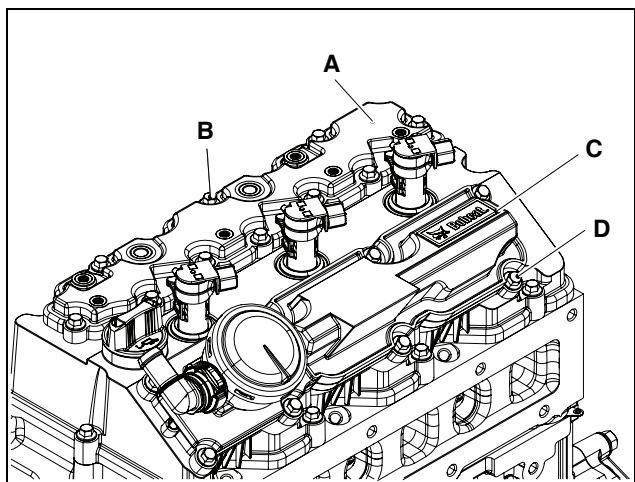
⚠ CAUTION

Do not tighten the hex bolts by force when it is difficult to tighten them temporarily. Forced tightening may cause damage to the cylinder head.

- 6) Tighten 3 hex bolts (D) at a tightening torque of 3.5 kgf•m.

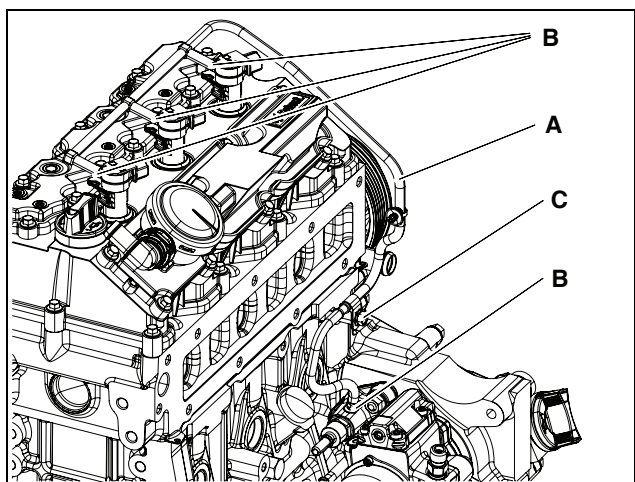
11. Cylinder block/head

5. Attach the right and left cylinder head cover.



- 1) Attach the left cylinder head cover(A).
- 2) Tighten 10 flange hex bolts (B) at a tightening torque of 1.0 kgf•m.
- 3) Attach the right cylinder head cover (C).
- 4) Tighten 8 flange hex bolts (D) at a tightening torque of 1.0 kgf•m.

6. Connect the fuel return hose.



- 1) Press the fuel return hose (A) into the end of the nipple and connect it.

⚠ CAUTION

- Be careful to note the direction when connecting the fuel return hose.
- The injector should be fully connected with the hose.

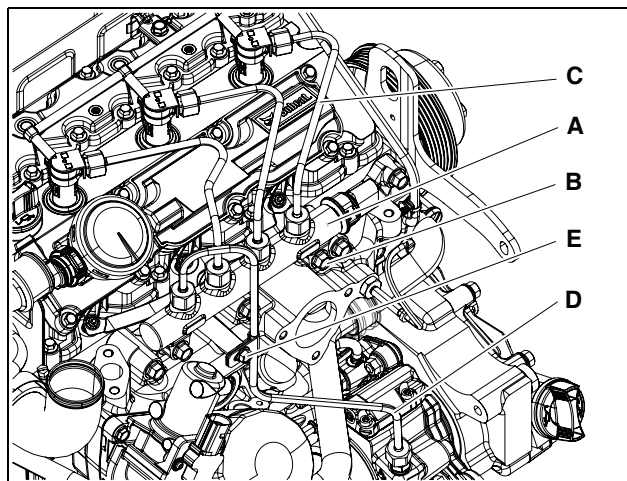
- 2) Attach the hose clips (B).

⚠ CAUTION

Fix the handle of hose clip to face the front of the engine.

- 3) Tighten the fixing bolt (C).

7. Attach the common rail and the injection pipe.



- 1) Attach the common rail (A) to the intake manifold.

⚠ CAUTION

- Be careful to note the direction when attaching the common rail.
- Be careful not to damage the common rail while attaching it.

- 2) Temporarily tighten 2 collared hex bolts (B) by hand.
- 3) Temporarily connect the fuel injection pipes (C) and (D) by hand.

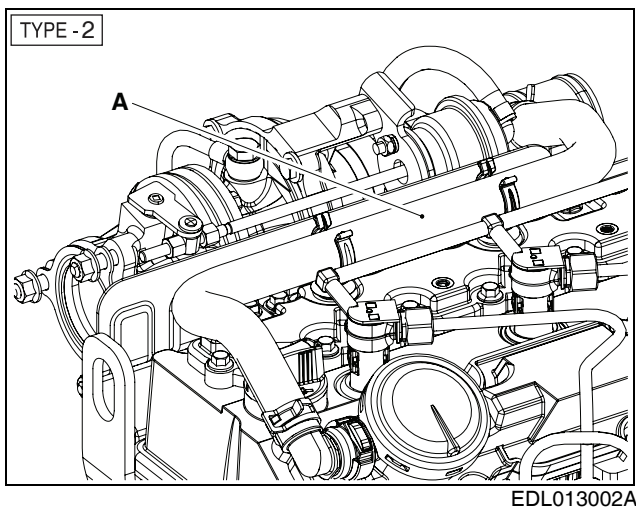
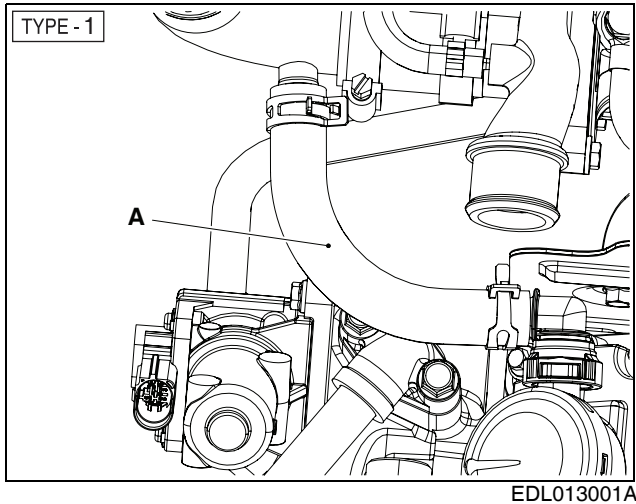
⚠ CAUTION

- Do not bend the fuel injection pipes by force.
- Be careful to note the direction when connecting the fuel injection pipes.
- Assemble the nut on one side of the fuel injection pipe first, and then the nut on the other side to connect the round part of the pipe to the correspondent part correctly.
- Do not reuse fuel injection pipes but replace them with new ones. Reusing fuel injection pipes may allow foreign substances into the fuel pipes or oil leaks from the bolt clamping to occur, causing a critical fault in engine performance.

- 4) Tighten 2 collared hex bolts(B) at a tightening torque of 2.2 kgf•m.

11. Cylinder block/head

- 5) Tighten the fuel injection pipes (C) and (D) at a tightening torque of 3.0 kgf•m.
- 6) Tighten the fixing bolt (E).
8. Attach the breather hose.



- 1) Attach the breather hose(A).

CAUTION

Do not reuse the clamps but replace with new ones.

11. Cylinder block/head

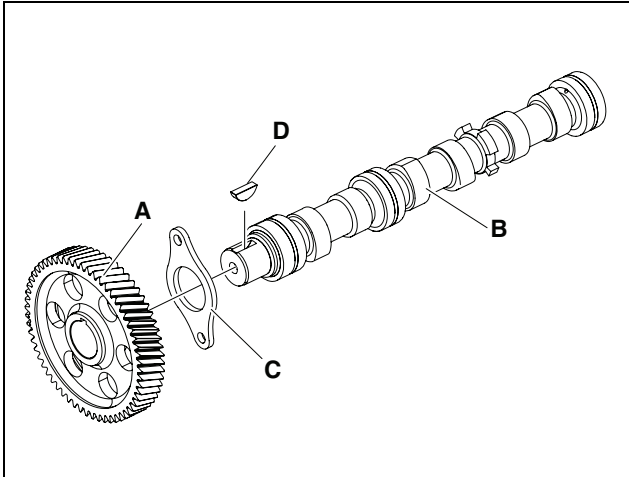
Camshaft

Disassembly of Camshaft

1. Detach the camshaft.

Note) Refer to Chapter 6 (Procedure of Disassembling an Engine)

2. Remove the camshaft gear (A).



EDL013091A

- 1) Heat the camshaft gear (A) at $180^{\circ}\text{C} \pm 10^{\circ}\text{C}$.
- 2) Remove the camshaft gear (A) and the thrust washer (C) from the camshaft (B).

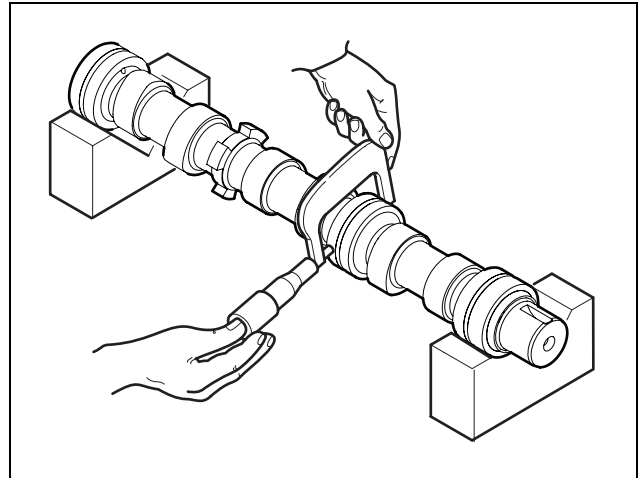
CAUTION

- NEVER let the camshaft gear heat to a temperature exceeding 200°C .

Measurement of Camshaft Journal Outside Diameter

1. Set the gauge.
2. Remove foreign substances from the camshaft.

3. Measure the outside diameter of the camshaft journal.



EDL013092A

- 1) For 3ea camshaft journals, measure total 6 points of the outside diameters: front and rear.
- 2) Measure 2 points (vertical and horizontal) of the outside diameters of the camshaft journals.
- 3) The standard measurement value of the outside diameter of the camshaft journal is within the range of $44.950 \sim 44.966 \text{ mm}$.

Item	Specified Value
Camshaft journal	$44.950 \sim 44.966 \text{ mm}$

Note) If the outside diameter is out of the allowable limit, replace the camshaft with a new one.

Note) Check whether the camshaft surface is cracked or scratched.

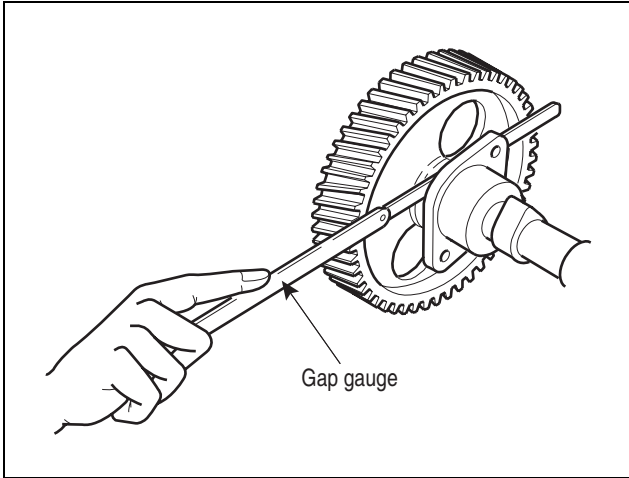
Note) If the wear is slight, polish it with the oil-contained whetstone or fine sandpaper. If the crack or scratch is serious, replace the camshaft with a new one.

Note) For polishing the camshaft, use the sandpaper dipped in oil.

11. Cylinder block/head

Measurement of Camshaft

1. Check the camshaft offset.



EDL0213003A

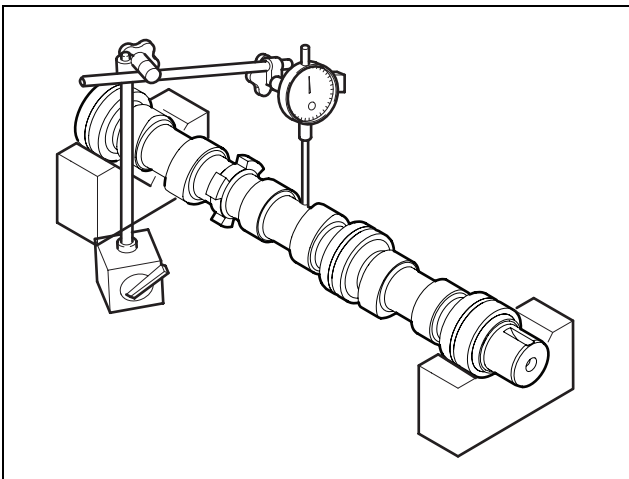
- 1) Move the camshaft gear to the opposite side of the cylinder block.
- 2) Measure the gap between the thrust washer and the camshaft gear with the gap gauge.

Item	Specified Value
Camshaft offset	0.1 ~ 0.2 mm

Note) Check if the gap is within the range of 0.1 ~ 0.2 mm.

Note) If the offset is too large, replace the thrust washer with a new one.

2. Measure warpage of the camshaft.



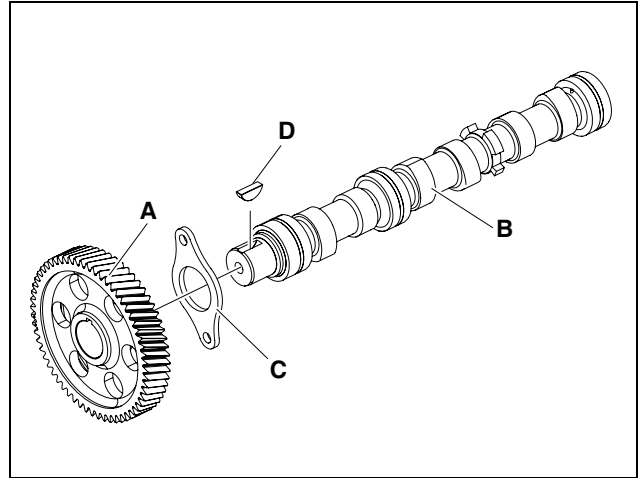
EDL013093A

- 1) Put the camshaft on two V-blocks.
- 2) Check the degree of warpage of the camshaft with the dial gauge.

Note) If the warpage is out of the allowable limit, replace the camshaft with a new one.

Assembly of Camshaft

1. Mount the cam gear (A).



EDL013091A

- 1) Mount the thrust washer (C) on the camshaft (B).
- 2) Mount the woodruff key (D), heat the cam gear (A) at the temperature of $180^{\circ}\text{C} \pm 10^{\circ}\text{C}$, and then press in the camshaft into the cam gear.

CAUTION

- NEVER let the cam gear heat to a temperature exceeding 200°C .
- The gear engraving should face outward.

2. Attach the camshaft.

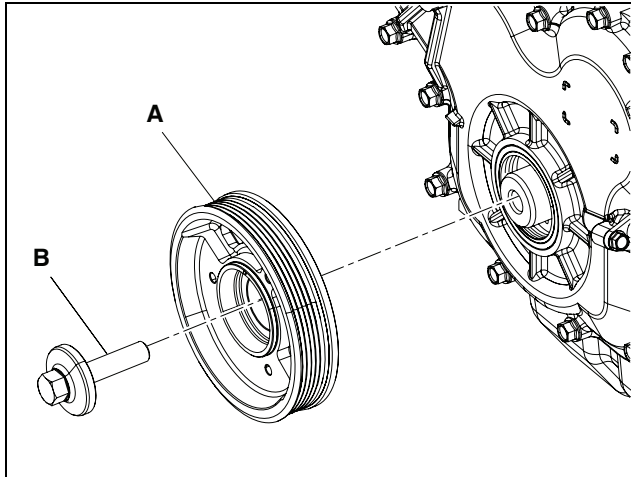
Note) Refer to Chapter 6 (Procedure of Assembling an Engine)

11. Cylinder block/head

Idle gear

Disassembly of Idle Gear

1. Remove the V-belt.
2. Remove the crankshaft pulley.



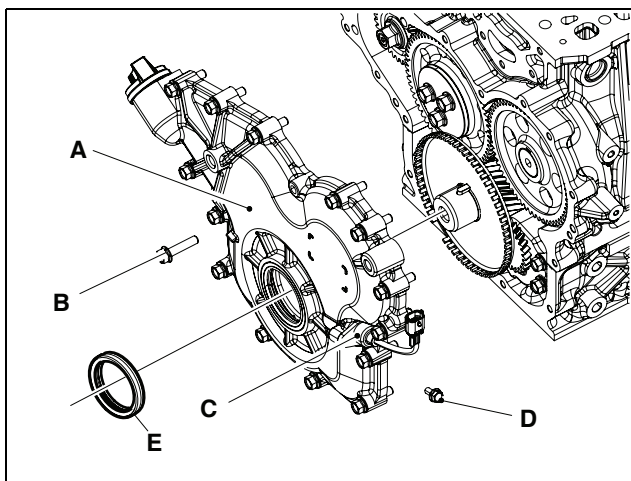
EDL013033A

- 1) Loosen the flange hex bolt (B).
- 2) Remove the crankshaft pulley (A).

⚠ CAUTION

Be careful not to damage the oil seal.

3. Remove the timing gear case.



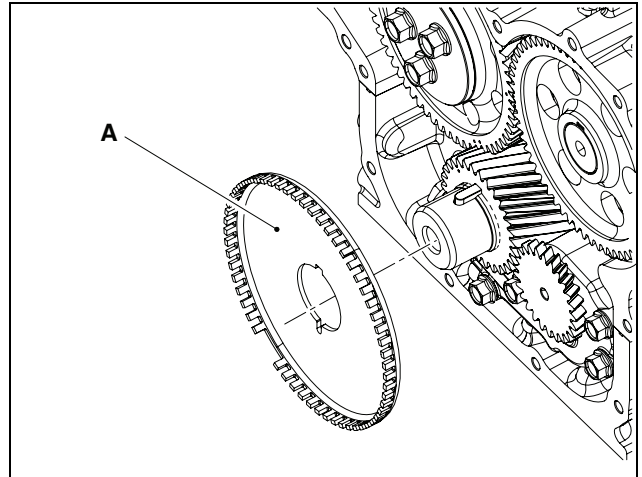
EDL013037A

- 1) Loosen the fixing bolt (D).
- 2) Remove the crank speed sensor (C).
- 3) Loosen 16 hex bolts (B).
- 4) Remove the timing gear case (A).

⚠ CAUTION

Do not reuse the oil seal; replace them with new ones.

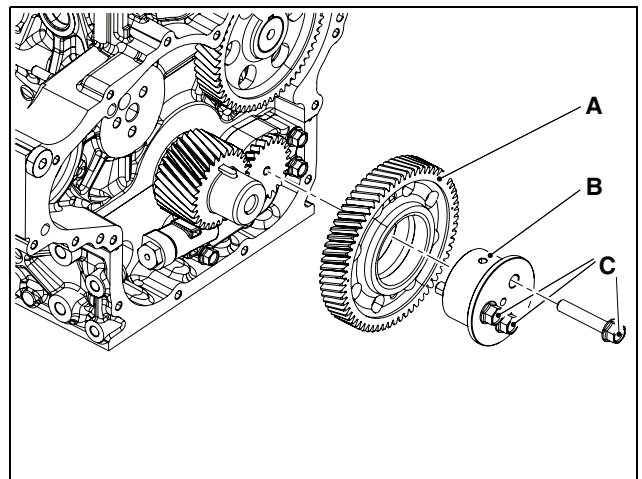
4. Remove the timing wheel.



EDL013038A

- 1) Remove the timing wheel (A).

5. Remove the idle gear.



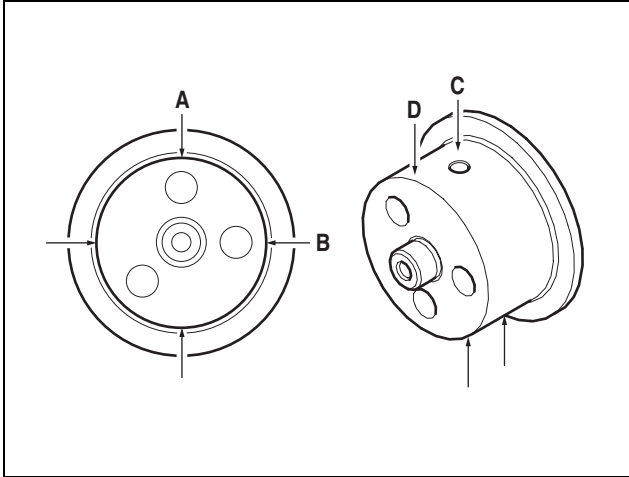
EDL013040A

- 1) Loosen 3 flange hex bolts (C).
- 2) Remove the idle gear shaft (B).
- 3) Remove the idle gear (A) using remove tap.

11. Cylinder block/head

Measurement of Outside Diameter of Idle Gear Shaft

1. Set the gauge.
2. Measure the outside diameter of the idle gear shaft.



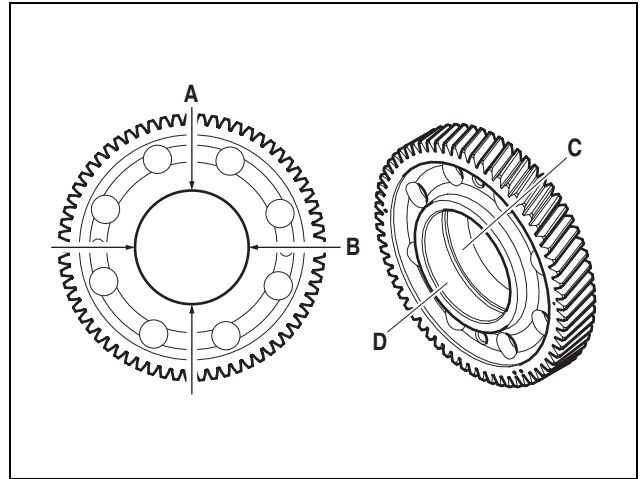
EDL022111A

- 1) Measure total 4 points of the outside diameter of the idle gear shaft: vertical (A), horizontal (B), front (C), and rear (D).
- 2) The standard measurement value of the outside diameter of the idle gear shaft is within the range of 59.921 ~ 59.940 mm.

Item	Specified Value
Outside diameter of the idle gear shaft	59.921 ~ 59.940 mm

Measurement of Inside Diameter of Idle Gear

1. Set the gauge.
2. Measure the inside diameter of the idle gear.



EDL022112A

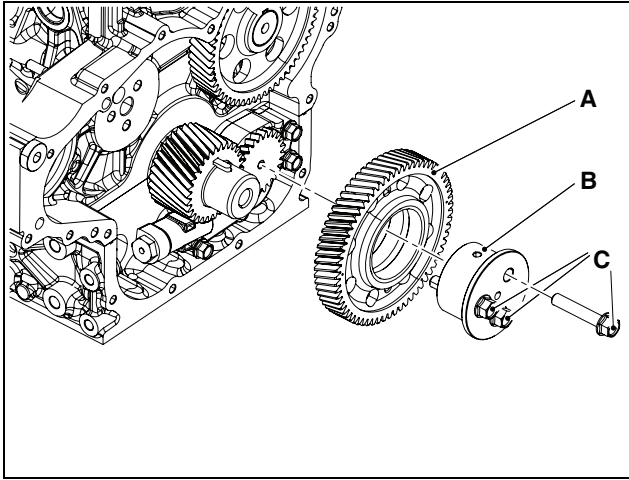
- 1) Measure total 4 points of the inside diameter of the idle gear: vertical (A), horizontal (B), front (C), and rear (D).
- 2) The standard measurement value of the inside diameter of the idle gear is within the range of 64.0 ~ 64.019 mm.

Item	Specified Value
Inside diameter of the idle gear	64.0 ~ 64.019 mm

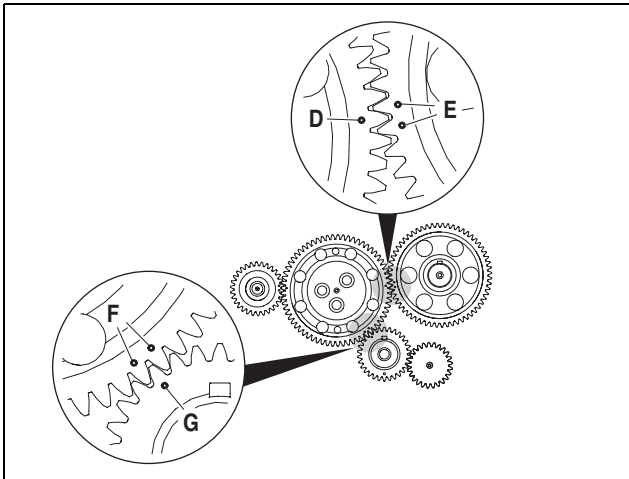
11. Cylinder block/head

Assembly of Idle Gear

1. Attach the idle gear.



EDL013040A



EDL022052A

- 1) Apply engine oil to the inside of the idle gear bush in the idle gear.
- 2) Attach the idle gear (A).

CAUTION

Make sure that you are attaching the idle gear so that its engraving faces the outside of the cylinder block.

- 3) Position the idle gear engraving (D) between the camshaft gear engravings (E).

Note) You can see two camshaft gear engravings and one idle gear engraving.

CAUTION

Make sure that the idle gear engraving is positioned between the two camshaft gear engravings.

- 4) Position the crankshaft gear engraving mark (G) between the idle gear engravings (F).

Note) You can see one crankshaft gear engraving and two idle gear engravings.

CAUTION

Make sure that the crankshaft gear engraving is positioned between two idle gear engravings.

- 5) Align the flange hex holes of the cylinder block to those of the idle gear shaft.
- 6) Attach the idle gear shaft (B).

CAUTION

Make the oil hole of the idle gear shaft(B) face the top surface of the cylinder block.

- 7) Tighten 3 flange hex bolts (C) at a tightening torque of 4.4 kgf•m.
- 8) Backlash of the idle gear and the crankshaft gear is 0.087 ~ 0.200 mm.

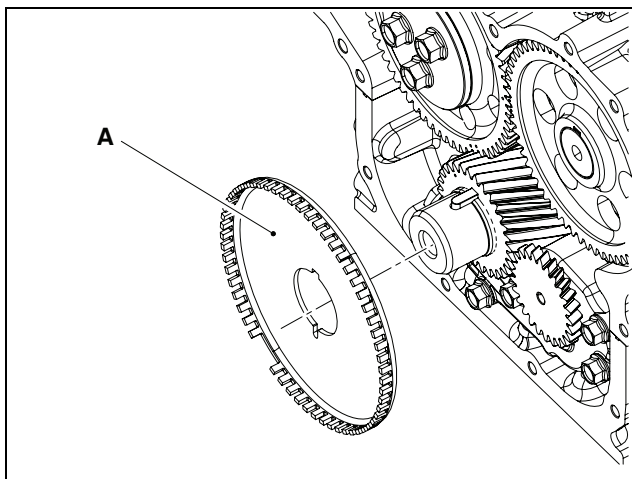
Item	Specified Value
Backlash between the idle gear and the crankshaft gear	0.087 ~ 0.200 mm

- 9) The backlash between the idle gear and the camshaft gear is 0.087 ~ 0.211 mm.

Item	Specified Value
Backlash between the idle gear and the camshaft gear	0.087 ~ 0.211 mm

11. Cylinder block/head

2. Attach the timing wheel.



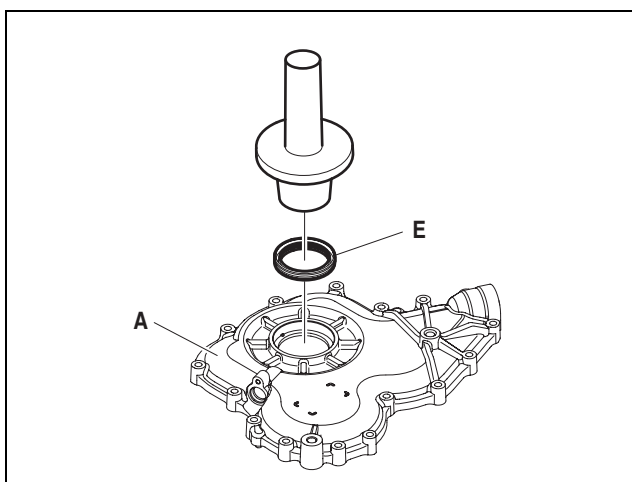
EDL013038A

1) Attach the timing wheel (A).

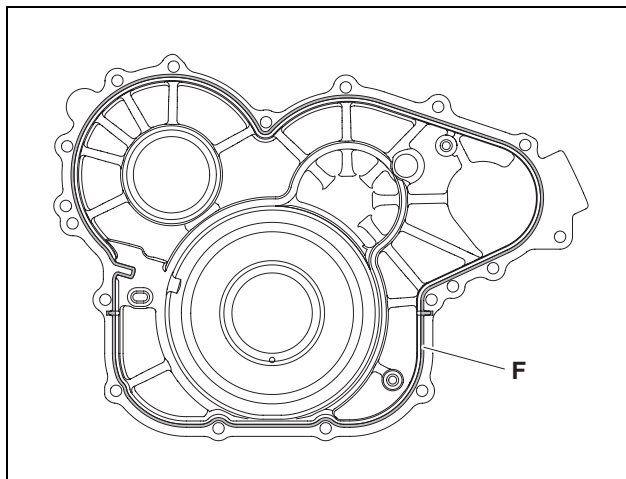
CAUTION

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

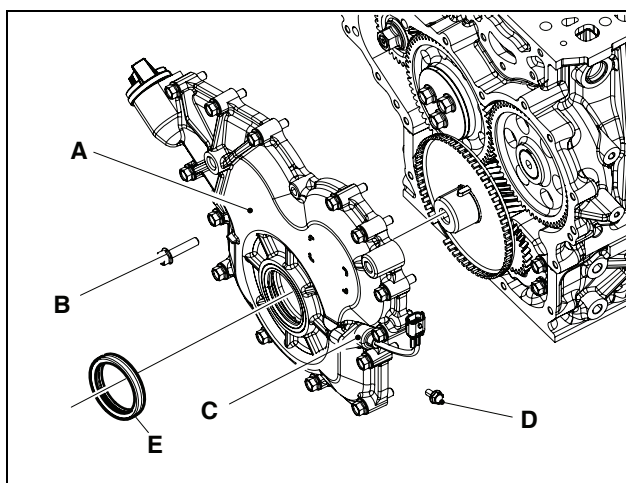
3. Attach the timing gear case (A).



EDL013052A



EDL013053A



EDL013037A

- 1) Make the assembly surface of the timing gear case face the ground.
- 2) Mount the front oil seal (E) to the front oil seal assembly jig (860104-02047).
- 3) Align the front oil seal assembly jig (860104-02047) where the front oil seal (E) is mounted to the timing gear case (A) and beat it with a rubber hammer.
- 4) when the front oil seal (E) is inserted to the timing gear case(A), pull off the front oil seal assembly jig (860104-02047).

CAUTION

- Be careful in noting the direction of the oil seal assembly and ensuring that the oil seal surface faces the outside of the engine.
- Be careful of the depth of the oil seal when attaching it.
- Be careful not to damage the oil seal.
- Attach the oil seal without applying lubrication. coolant, fuel, LOCTITE, or silicon.

11. Cylinder block/head

CAUTION

- Remove foreign substances such as residues and LOCTITE from the oil seal assembly bore.
- Do not reuse the oil seal; replace it with a new one.
- Be careful not to damage the oil seal when attaching it.

- 5) Remove the foreign substances on the timing gear case assembly surface and clean it with a dry cloth.
- 6) Apply LOCTITE 5902 to the timing gear case assembly surface (F) with the diameter of $\varnothing 2.5 \pm 0.5\text{mm}$.

CAUTION

- Keep clean liquid gasket dispensing surface.
- Dispensing line should not be snapped.

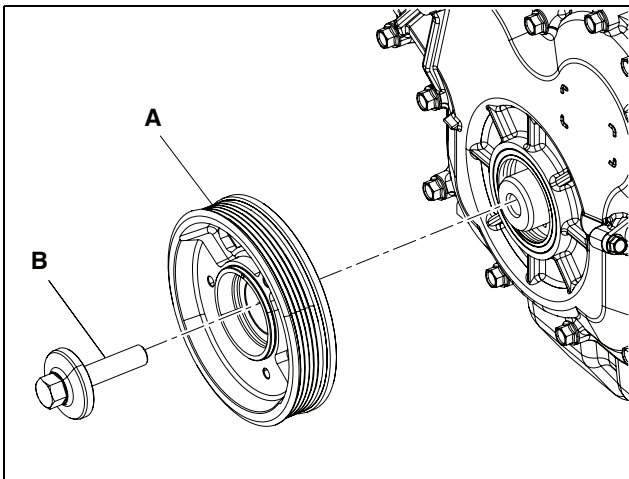
- 7) Align the timing gear case (A) with the pin and attach it.

CAUTION

- Be careful that the timing gear case has been attached in the right direction.
- Assemble the timing gear case in 5 minutes after dispensing liquid gasket.
- Do not pressureize inside the timing gear case in 25 minutes after dispensing liquid gasket.

- 8) Tighten 16 hex bolts (B) at a tightening torque of $2.2\text{kgf}\cdot\text{m}$.
- 9) Attach the crank speed sensor (C).
- 10) Tighten the fixing bolt (D).

4. Attach the crankshaft pulley.



EDL013033A

- 1) Align the crankshaft pulley (A) to the pin and attach it.
- 2) Apply LOCTITE Blue 587 to the inside of the flange hex bolts (B).
- 3) Tighten flange hex bolts (B) at a tightening torque of $26\text{kgf}\cdot\text{m}$.

CAUTION

- Be careful not to damage the oil seal.
- Fix the crankshaft to allow the flange hex bolts to be tightened with the specified torque.

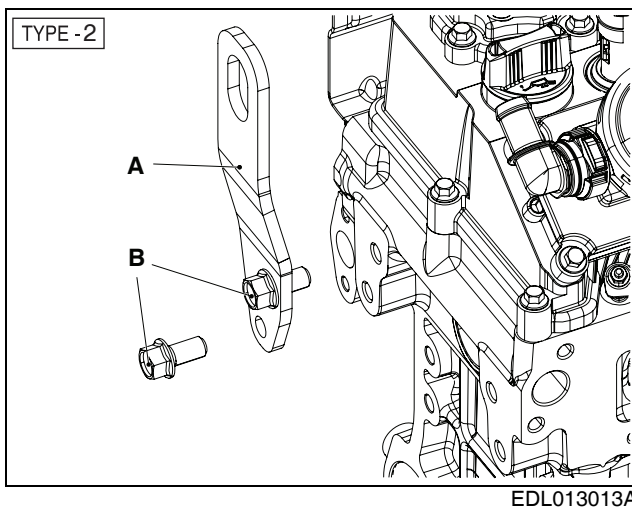
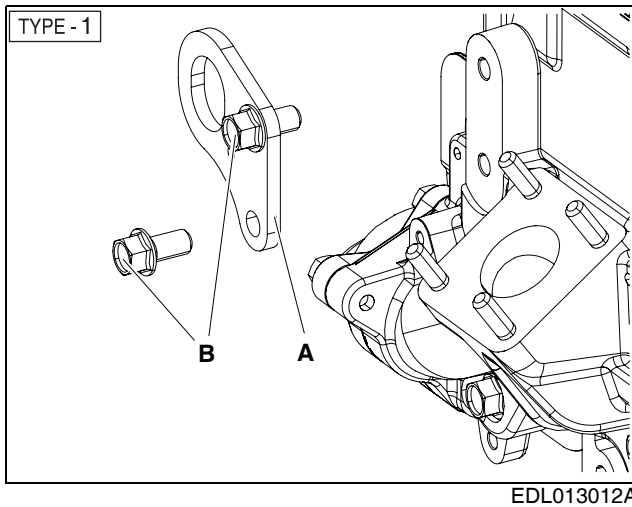
5. Attach the V-belt.

11. Cylinder block/head

Lifting Hook

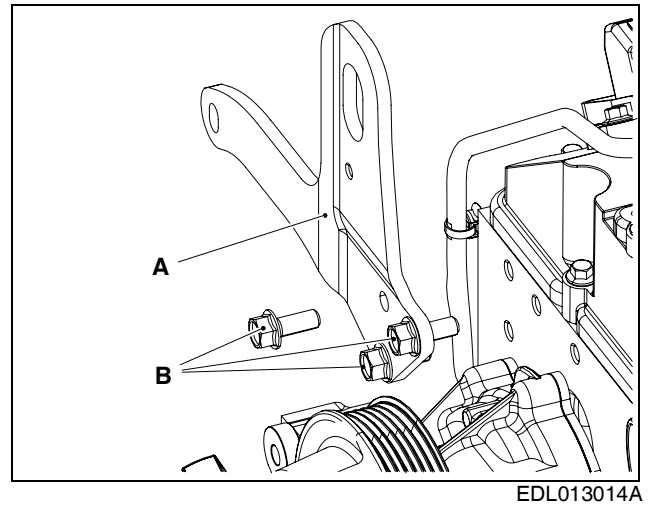
Disassembly of Lifting Hook

1. Remove the rear lifting hook.



- 1) Loosen 2 fixing bolts (B).
- 2) Remove the rear lifting hook (A).

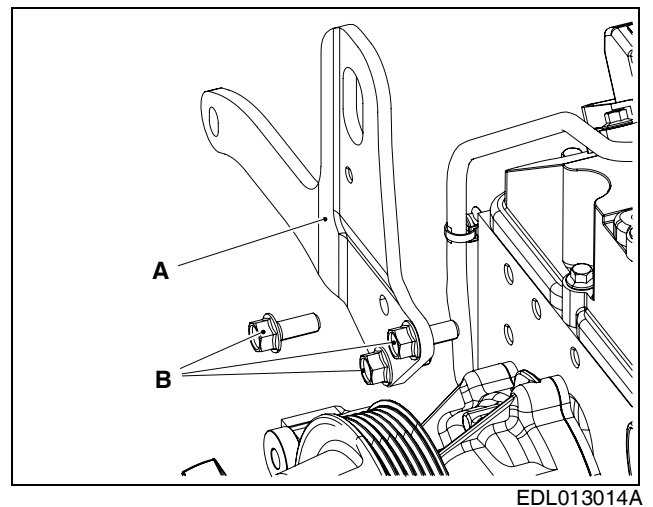
2. Remove the front lifting hook.



- 1) Loosen 3 fixing bolts (B).
- 2) Remove the front lifting hook (A).

Assembly of Lifting Hook

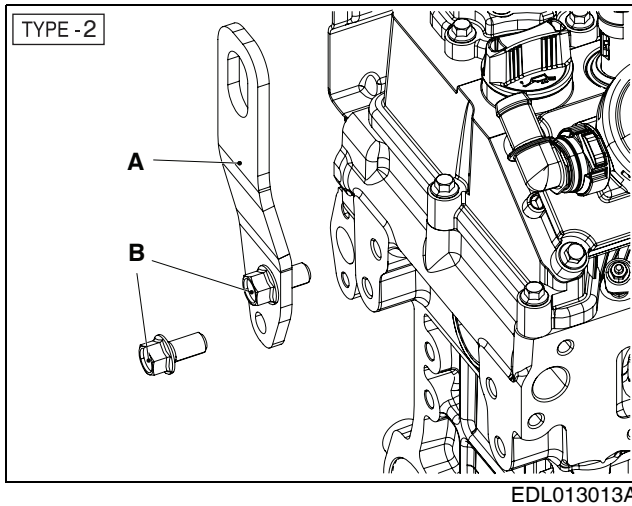
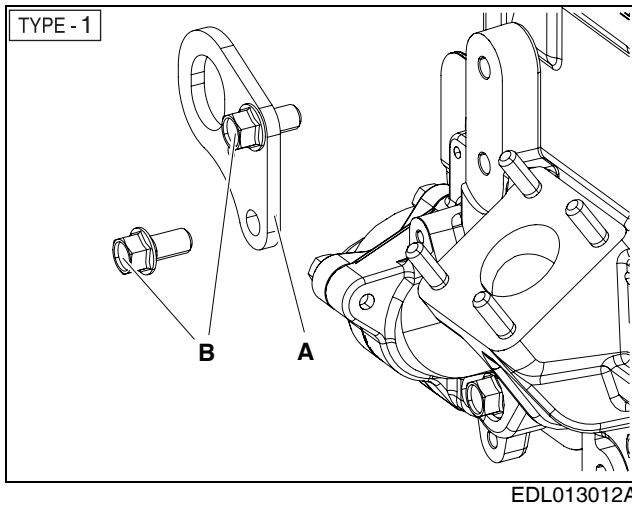
1. Attach the front lifting hook.



- 1) Attach the front lifting hook(A).
- 2) Tighten 3 flange hex bolts(B) at a tightening torque of 2.2 kgf•m.

11. Cylinder block/head

2. Attach the rear lifting hook.



- 1) Attach the rear lifting hook(A).
- 2) Tighten 2 flange hex bolts (B) at a tightening torque of 4.4 kgf•m.

11. Cylinder block/head

12. Electric System

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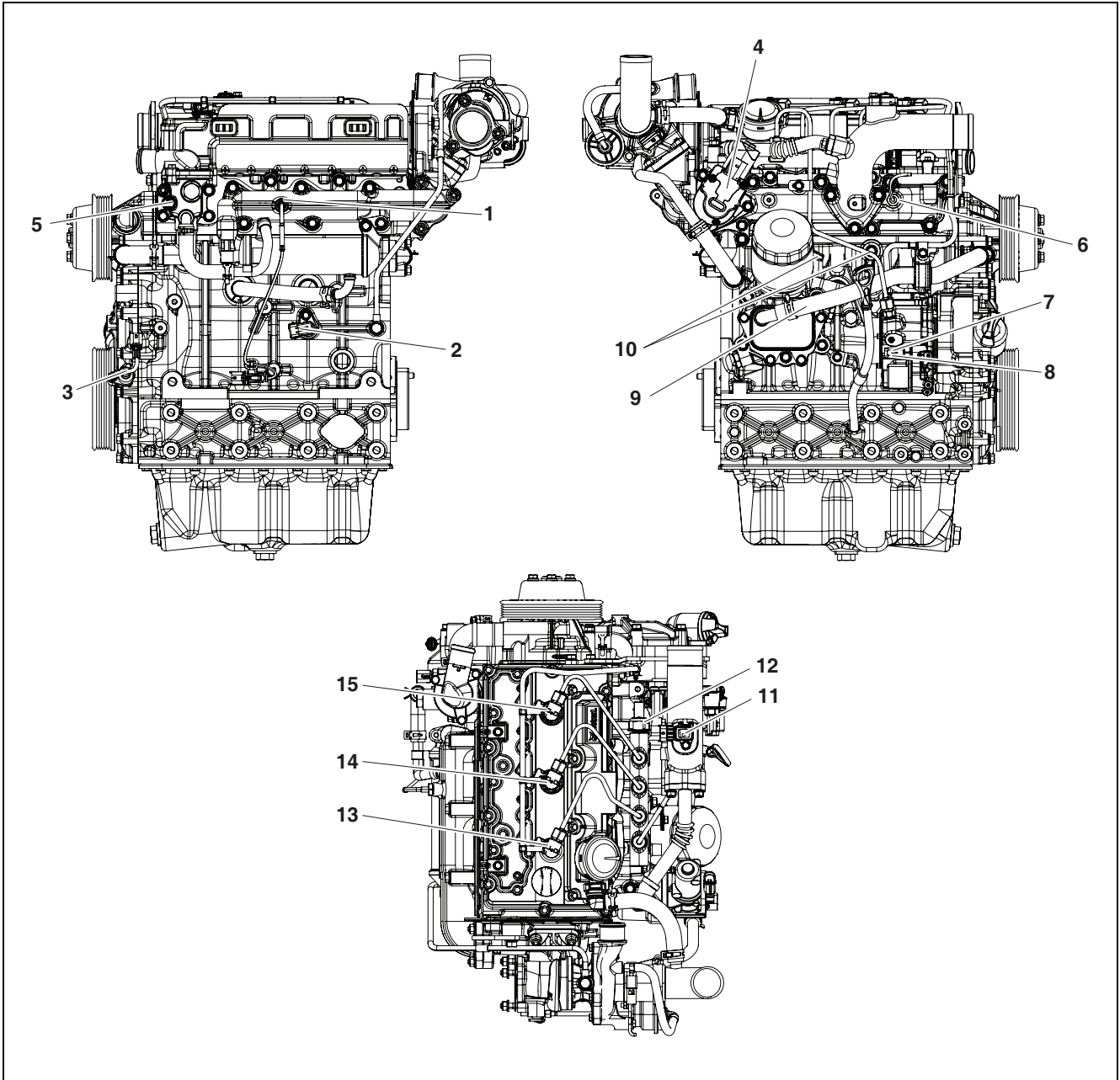
12. Electric System

Electric System

Electric Parts

Electric Parts

DL01-LEE00_ASSEMBLY

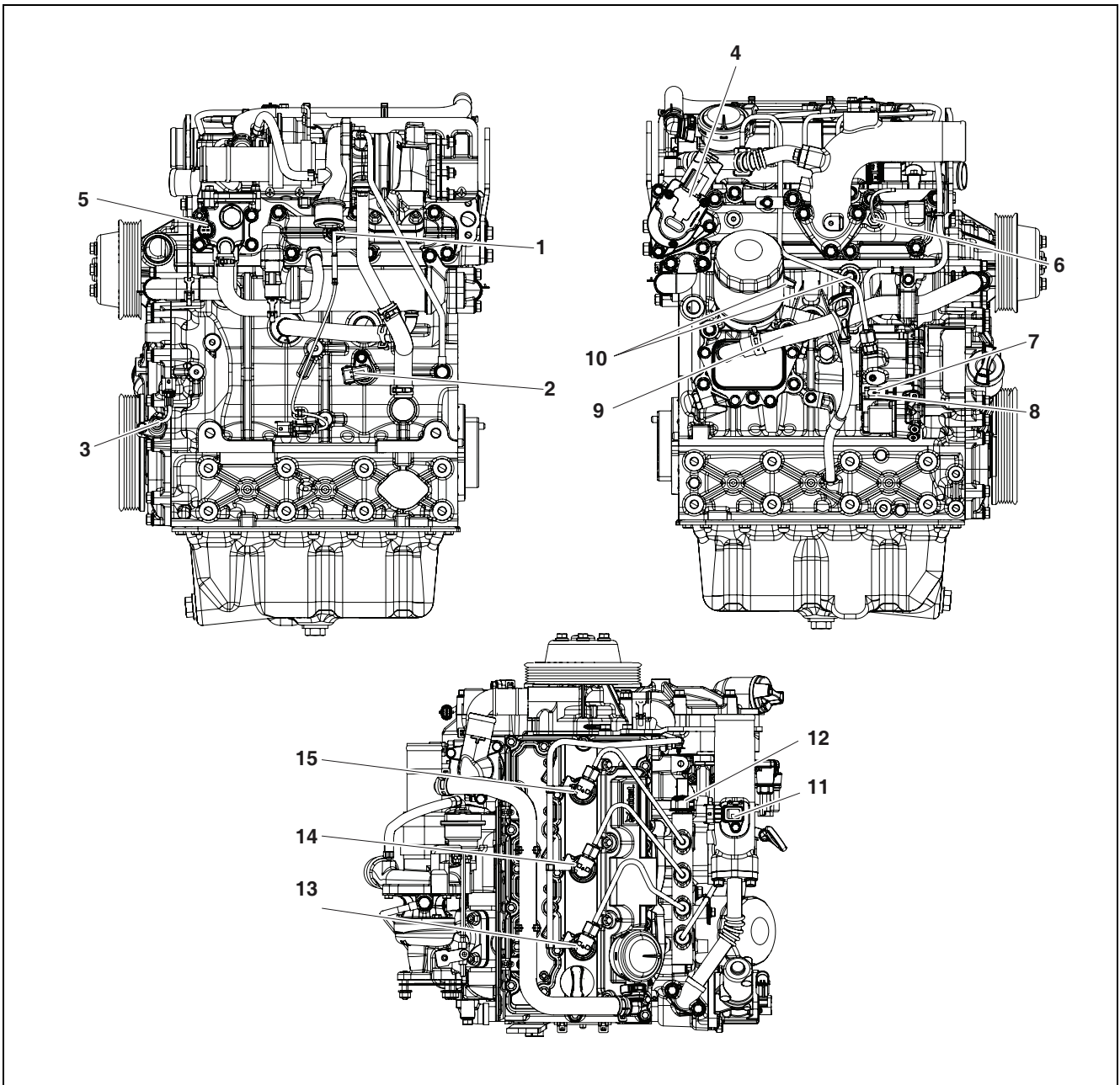


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- | | | |
|--|---|---------------------------------|
| 1. EGTS : Exhaust Gas Temperature Sensor | 6. BTS : Boost Temperature Sensor | 11. BPS : Boost Pressure Sensor |
| 2. CAM : CAM Shaft Position Sensor | 7. FTS : Fuel temperature sensor | 12. RPS : Rail pressure sensor |
| 3. CRK : Crank Shaft Position Sensor | 8. IMV : Inlet Metering Valve | 13. INJ : Injector #3 |
| 4. EGR : Exhaust Gas Recirculation Valve Position Sensor | 9. OPTS : Oil Pressure and Temperature Sensor | 14. INJ : Injector #2 |
| 5. WTS : Water Temperature Sensor | 10. KNOCK : Knock Sensor | 15. INJ : Injector #1 |

12. Electric System

DL01-LEL00_ASSEMBLY



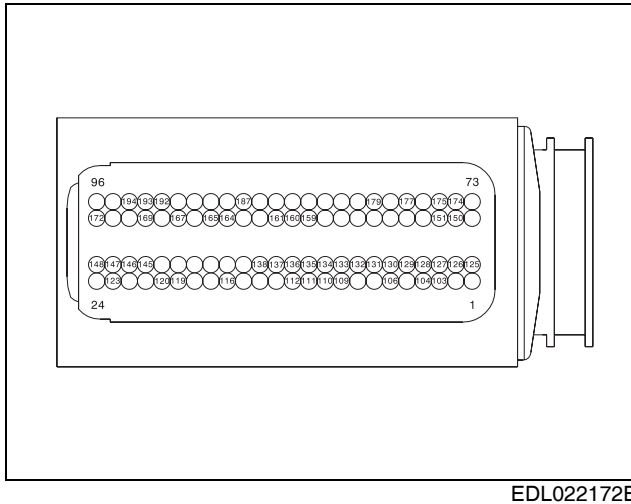
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- | | | |
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| 1. EGTS : Exhaust Gas Temperature Sensor | 6. BTS : Boost Temperature Sensor | 11. BPS : Boost Pressure Sensor |
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Valve Position Sensor | 9. OPTS : Oil Pressure and
Temperature Sensor | 14. INJ : Injector #2 |
| 5. WTS : Water Temperature Sensor | 10. KNOCK : Knock Sensor | 15. INJ : Injector #1 |

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).



2. The wire colors are as follows.

- 1) W: White
- 2) Y: Yellow
- 3) L: Blue
- 4) O: Orange
- 5) P: Purple
- 6) B: Black
- 7) RW: Red & White

3. The wire types are as follows.

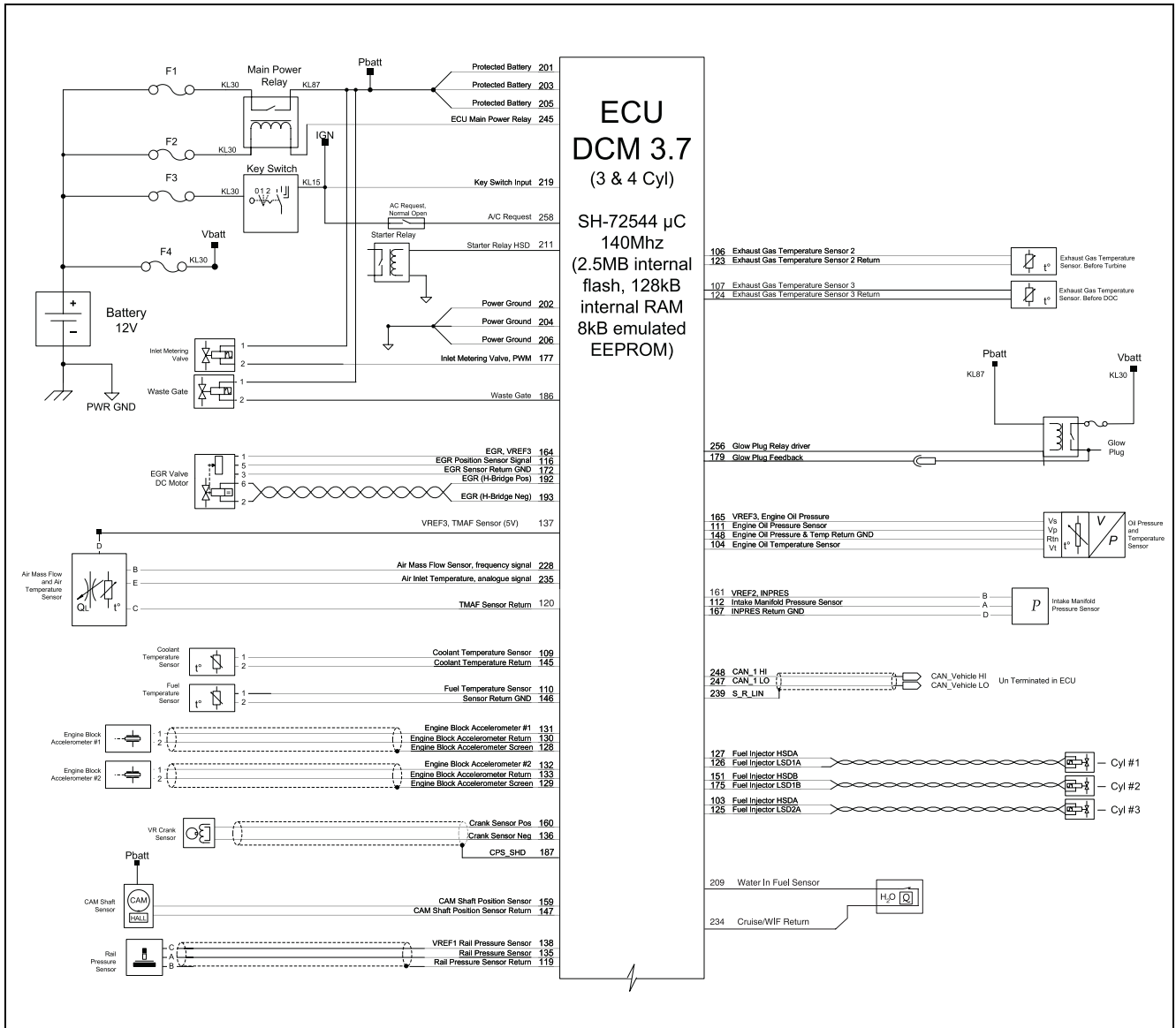
- 1) AESSXF
- 2) TUBE_AMS11
- 3) TUBE_AMS12
- 4) AESSXF_AMS11
- 5) AESSXF_AMS12
- 6) AESSXG_AMS13
- 7) AEXF

4. ECU PIN No. is the pin number of the engine connector.

5. Sensor PIN No. is the pin number of the sensor connector.

12. Electric System

Engine Connector



EDL022123D

12. Electric System

Engine Connector of Engine Control Unit (ECU)

Circuit Number	Wire Size	Wire Color	Wire Type	Circuit Name	ECU PIN No	Sensor PIN No	Remarks
103	0.75	W	AESSXF	FUEL INJECTOR HSDA	3	2	TWIST (103, 125)
104	0.75	Y	AESSXF	Oil Pressure Sensor	4	2	
106	0.75	L	AESSXF	EXHAUST GAS TEMP SENSOR 2	6	2	
109	0.75	O	AESSXF	COOLANT TEMP SENSOR	9	2	
110	0.75	L	AESSXF	FUEL TEMP SENSOR	10	1	
111	0.75	W:	AESSXF	OIL PRESSURE SENSOR	11	4	
112	0.75	L	AESSXF	INTAKE MANIFOLD PRESSURE SENSOR	12	3	
116	0.75	O	AESSXF	EGR POSITION SENSOR SIGNAL	16	5	
119	0.75	B	AESSXF	RAIL PRESSURE SENSOR RETURN	19	2	TWIST (119, 135, 138)
120	0.75	B	AESSXF	AIR MASS FLOW SENSOR RETURN	20	3	
123	0.75	B	AESSXF	EXHAUST GAS TEMP SENSOR 2 RETURN	23	1	
125	0.75	B	AESSXF	FUEL INJECTOR LSD2A	25	1	TWIST (103, 125)
126	0.75	B	AESSXF	FUEL INJECTOR LSD1A	26	1	TWIST (126, 127)
127	0.75	W	AESSXF	FUEL INJECTOR HSDA	27	2	TWIST (126, 127)
128	0.75	B	TUBE_A MS11	ENGINE BLOCK ACCELEROMETER #1 SCREEN	28		SHIELD_130_131 (DRAIN)
129	0.75	B	TUBE_AMS12	ENGINE BLOCK ACCELEROMETER #2 SCREEN	29		SHIELD_132_133 (DRAIN)
130	0.75	P	AESSXF_AMS11	ENGINE BLOCK ACCELEROMETER #1 RETURN	30	1	SHIELD_130_131
131	0.75	O	AESSXF_AMS11	ENGINE BLOCK ACCELEROMETER #1	31	2	SHIELD_130_131
132	0.75	L	AESSXF_AMS12	ENGINE BLOCK ACCELEROMETER #2	32	2	SHIELD_132_133
133	0.75	P	AESSXF_AMS12	ENGINE BLOCK ACCELEROMETER #2 RETURN	33	1	SHIELD_132_133
135	0.75	O:	AESSXF	RAIL PRESSURE SENSOR	35	1	TWIST (119, 135, 138)
136	0.75	P	AESSXF_AMS13	CRANK SENSOR NEG	36	1	SHIELD_136_160
137	0.75	W	AESSXF	VREF3(5V) AIR MASS FLOW SENSOR	37	1	
138	0.75	P	AESSXF	VREF1 RAIL PRESSURE SENSOR	38	3	TWIST (119, 135, 138)
145	0.75	B	AESSXF	COOLANT TEMP SENSOR RETURN	45	1	
146	0.75	P	AESSXF	FUEL TEMP SENSOR RETURN GND	46	2	

12. Electric System

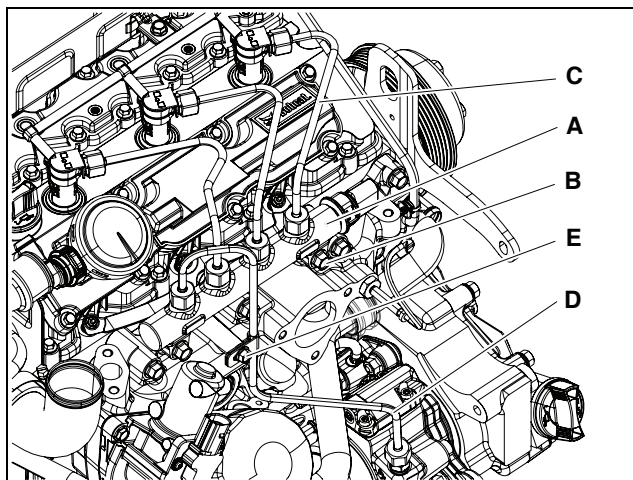
Circuit Number	Wire Size	Wire Color	Wire Type	Circuit Name	ECU PIN No	Sensor PIN No	Remarks
147	0.75	B	AESSXF	CAM SHAFT POSITION SENSOR RETURN	47	3	
148	0.75	L	AESSXF	OIL PRESSURE & TEMP RETURN GND	48	1	
150	0.75	W	AESSXF	FUEL INJECTOR HSDB	50	2	TWIST (150, 174)
151	0.75	W	AESSXF	FUEL INJECTOR HSDB	51	2	TWIST (151, 175)
159	0.75	Y	AESSXF	CAM SHAFT POSITION SENSOR	59	2	
160	0.75	O	AESSXF_AMS13	CRANK SENSOR POS	60	2	SHIELD_136_160
161	0.75	O	AESSXF	VREF2, INPRES	61	1	
164	0.75	W	AESSXF	EGR, VREF3	64	1	
165	0.75	O	AESSXF	VREF3 OIL PRESSURE	65	3	
167	0.75	W	AESSXF	INPRES RETURN GND	67	2	
169	0.75	B	AESSXF	INTAKE AIR TEMP SENSOR RETURN	69	1	
172	0.75	P	AESSXF	EGR SENSOR RETURN GND	72	3	
174	0.75	B	AESSXF	FUEL INJECTOR LSD2B	74	1	TWIST (150, 174)
175	0.75	B	AESSXF	FUEL INJECTOR LSD1B	75	1	TWIST (151, 175)
177	0.75	B	AESSXF	INLET METERING VALVE (PWM)	77	2	
179	0.75	P	AESSXF	GLOW PLUG FEEDBACK	79	4	
187	0.75	B	TUBE_AMS13	CRANK SENSOR SHIELD	87		SHIELD_136_160 (DRAIN)
192	0.75	W	AESSXF	EGR (H-BRIDGE POS)	92	6	TWIST (192, 193)
193	0.75	B	AESSXF	EGR (H-BRIDGE NEG)	93	2	TWIST (192, 193)
194	0.75	P	AESSXF	INTAKE AIR TEMP SENSOR RETURN	94	2	
8500	5	RW	AEXF	GLOW PLUG POWER LINE	1	1	INTER2_1M
K87A	0.75	W	AESSXF	SENSOR 15A FUSE	2	3	INTER1_2M
K87B	0.75	O	AESSXF	SENSOR 15A FUSE	1	1	INTER1_2M
K87C	0.75	O	AESSXF	SPLICE (KL87)	S07	1	K87

12. Electric System

Air Heater

Disconnection of Glow Plug

1. Remove the common rail and the injection pipes.



EDL013006A

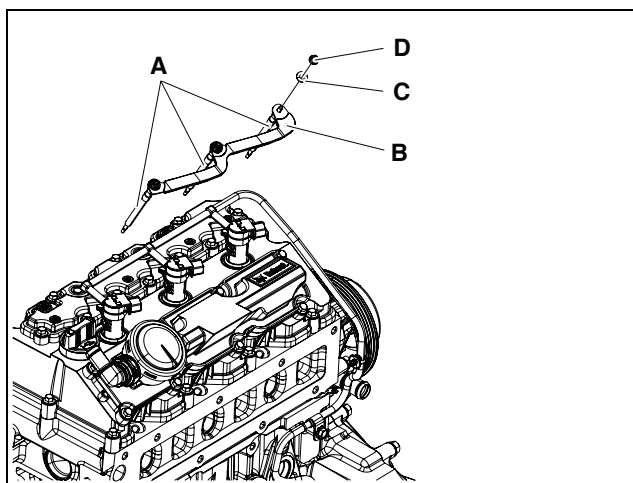
- 1) Loosen the fixing bolt (E).
- 2) Loosen the nuts of the fuel injection pipes.
- 3) Remove 4 fuel injection pipes (C) and (D).

CAUTION

Do not reuse fuel injection pipes; replace them with new ones. If fuel injection pipes are reused it may allow foreign substances into the fuel pipes or cause oil leaks from bolt clamping and cause a critical fault in engine performance.

- 4) Loosen 2 collared hex bolts (B) of the common rail.
- 5) Remove the common rail (A) from the intake manifold.

2. Remove the glow plug.

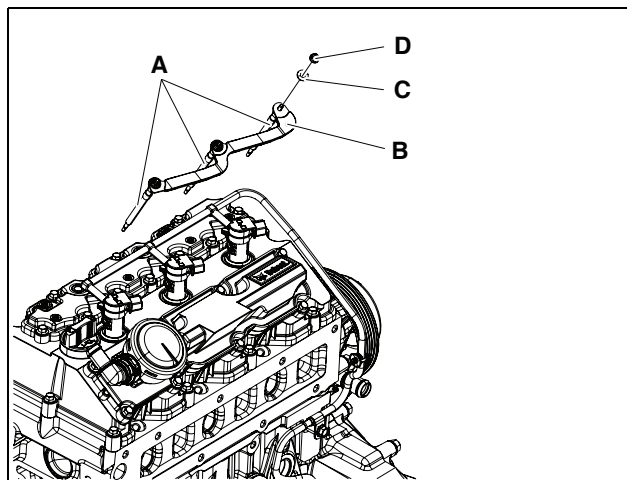


EDL013021A

- 1) Loosen 3 hex nuts (D) and remove 3 washers (C).
- 2) Remove the electric connector (B) and 3 glow plugs (A).

Connection of Glow Plug

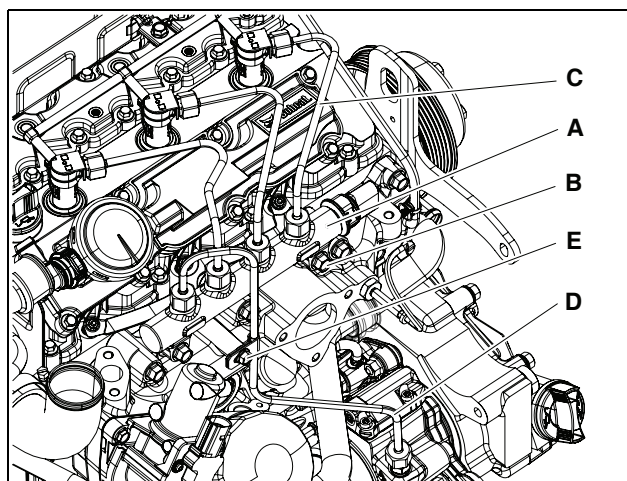
1. Attach the glow plug.



EDL013021A

- 1) Tightening 3 glow plugs (A) to the cylinder head at a tightening torque of 9~12 N•m.
- 2) Attach the electric connector (B).
- 3) Attach 3 washers (C).
- 4) Tighten 3 hex nuts (D) at a tightening torque of 2.5~3 N•m.

2. Attach the common rail and the injection pipe.



EDL013006A

- 1) Attach the common rail (A) to the intake manifold.

CAUTION

- Be careful to note the direction when attaching the common rail.
- Be careful not to damage the common rail while attaching it.

- 2) Temporarily tighten 2 collared hex bolts (B) by hand.

12. Electric System

- 3) Temporarily connect the fuel injection pipes (C) and (D) by hand.

 CAUTION

- Do not bend the fuel injection pipes by force.
 - Be careful to note the direction when connecting the fuel injection pipes.
 - Assemble the nut on one side of the fuel injection pipe first, and then the nut on the other side to connect the round part of the pipe to the correspondent part correctly.
 - Do not reuse fuel injection pipes but replace them with new ones. Reusing fuel injection pipes may allow foreign substances into the fuel pipes or oil leaks from the bolt clamping to occur, causing a critical fault in engine performance.
-
- 4) Tighten 2 collared hex bolts(B) at a tightening torque of 2.2 kgf•m.
- 5) Tighten the fuel injection pipes (C) and (D) at a tightening torque of 3.0 kgf•m.
- 6) Tighten the fixing bolt (E).

12. Electric System

Switches and Sensors

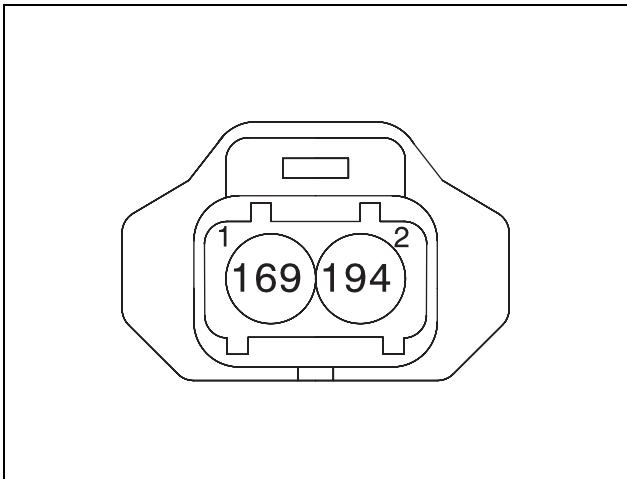
Mass Air Flow Sensor (MAF)

A sensor that measures flow and temperature of air inhaled initially.

No	ECU PIN	Description
1	228	Intake air flow frequency signal
2	235	Intake temperature signal
3	120	Ground
4	137	Supply voltage(12V)

Boost Temperature Sensor (BTS)

A sensor that measures the temperature of air in the intake manifold.

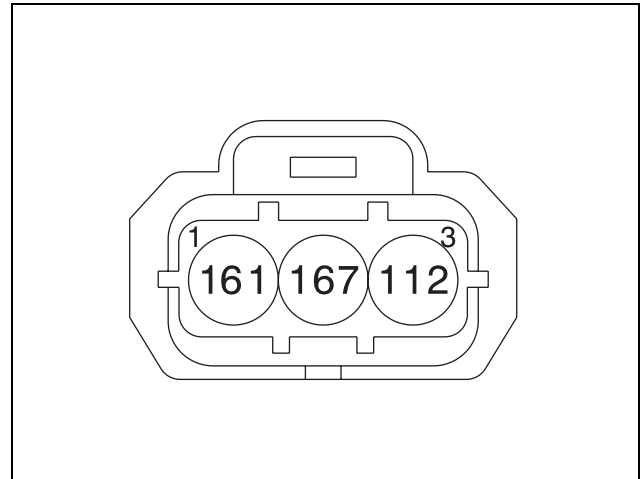


EDL022175A

No	ECU PIN	Description
1	169	Ground
2	194	Temperature signal

Boost Pressure Sensor (BPS)

A sensor that measures the pressure of air in the intake manifold.

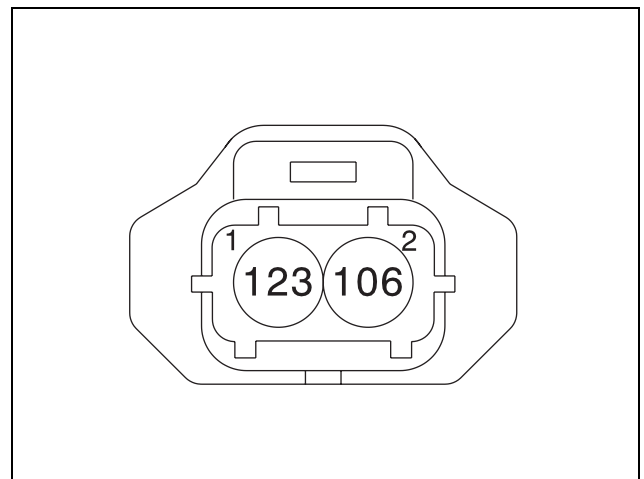


EDL022176B

No	ECU PIN	Description
1	161	Supply voltage(5V)
2	167	Ground
3	112	Pressure signal

Exhaust Gas Temperature Sensor (EGTS)

A sensor that measures the exhaust gas of the turbocharger.



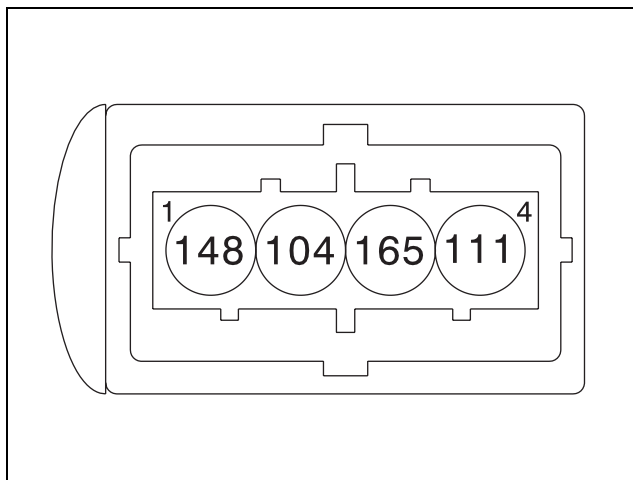
EDL022177A

No	ECU PIN	Description
1	123	Ground
2	106	Temperature signal

12. Electric System

Oil Pressure and Temperature Sensor (OPTS)

A sensor that measures the pressure and temperature of engine oil.

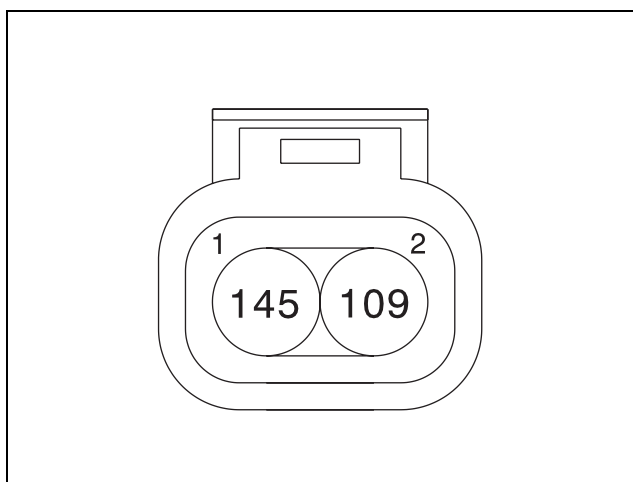


EDL022178A

No	ECU PIN	Description
1	148	Ground
2	104	Temperature signal
3	165	Supply voltage(5V)
4	111	Pressure signal

Water Temperature Sensor (WTS)

A sensor that senses the temperature of engine cooling water.

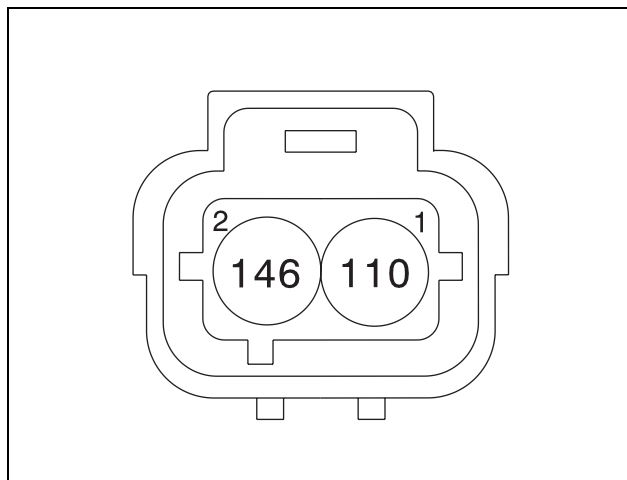


EDL022179A

No	ECU PIN	Description
1	145	Ground
2	109	Temperature signal

Fuel temperature sensor (FTS)

A sensor that measures the fuel temperature in the fuel pump.

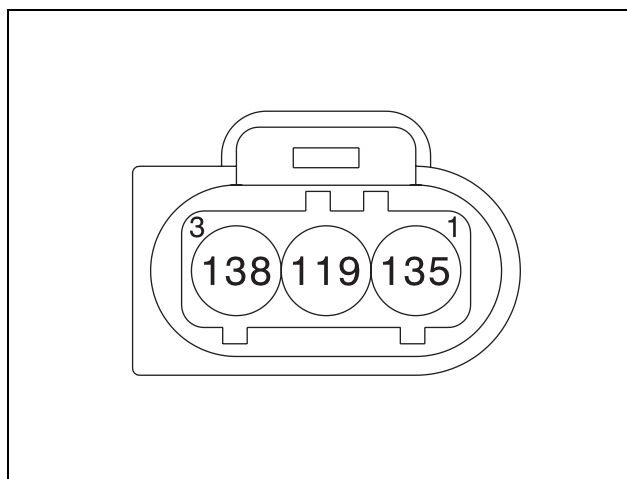


EDL022180A

No	ECU PIN	Description
1	110	Temperature signal
2	146	Ground

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.



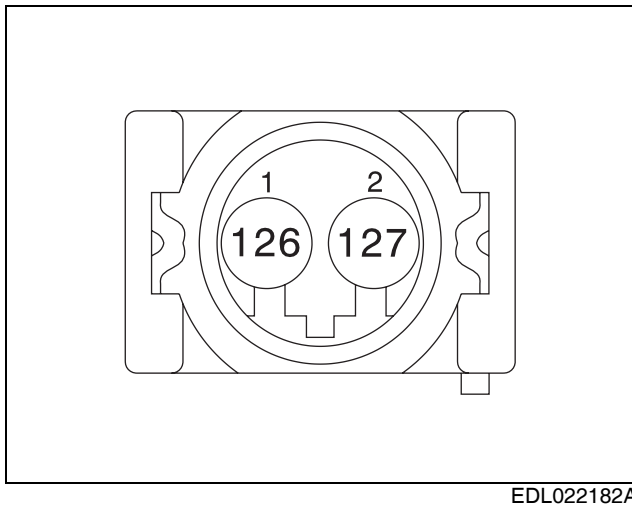
EDL022181A

No	ECU PIN	Description
1	135	Pressure signal
2	119	Ground
3	138	Supply voltage(5V)

12. Electric System

Injector #1 (INJ)

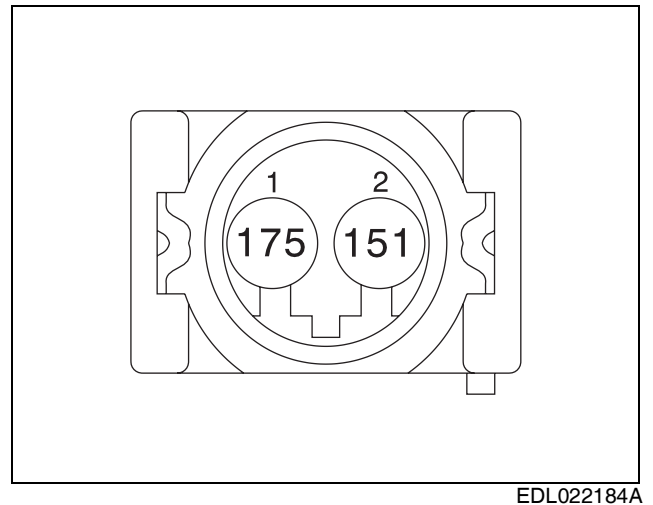
A part that injects fuel according to the injection signal received from the ECU.



No	ECU PIN	Description
1	126	Low Side Drive
2	127	High Side Drive

Injector #3 (INJ)

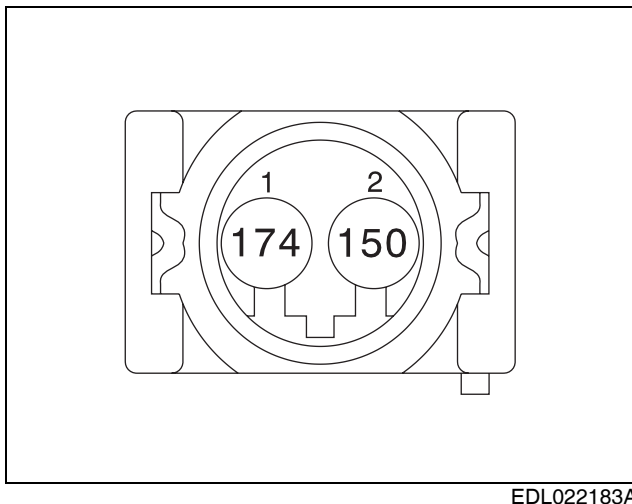
A part that injects fuel according to the injection signal received from the ECU.



No	ECU PIN	Description
1	175	Low Side Drive
2	151	High Side Drive

Injector #2 (INJ)

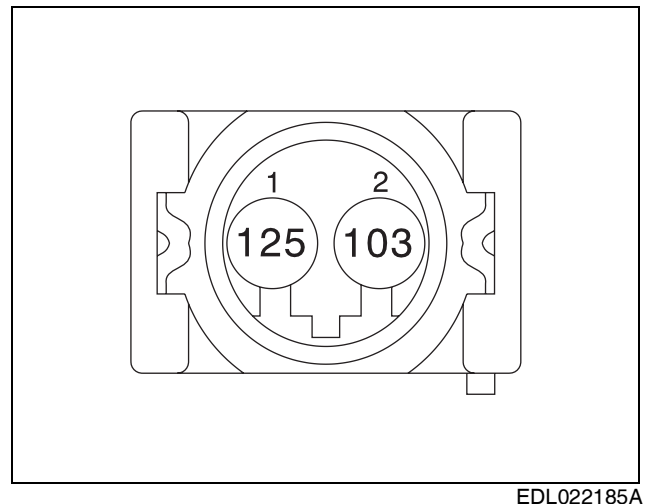
A part that injects fuel according to the injection signal received from the ECU.



No	ECU PIN	Description
1	174	Low Side Drive
2	150	High Side Drive

Injector #4 (INJ)

A part that injects fuel according to the injection signal received from the ECU.

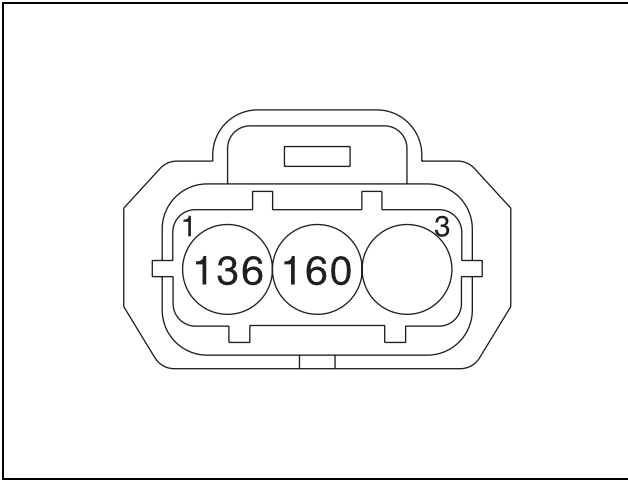


No	ECU PIN	Description
1	125	Low Side Drive
2	103	High Side Drive

12. Electric System

Crank Shaft Position Sensor (CRK)

A sensor that senses the position of the crankshaft in order to sense the engine rotation speed and the position of the piston.

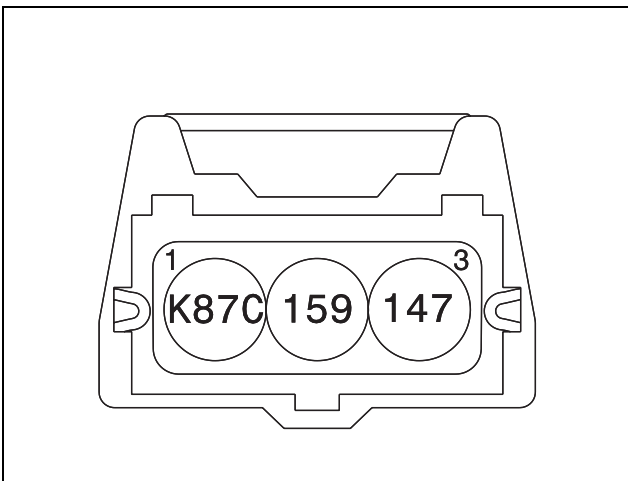


EDL022186A

No	ECU PIN	Description
1	136	CRS NEG
2	160	CRS POS
-	187	Shield

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.

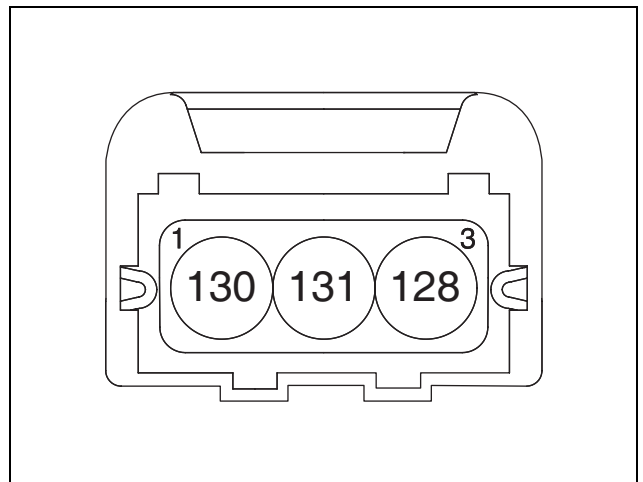


EDL022187A

No	ECU PIN	Description
1	-	Supply voltage(12V)
2	159	Position sensor signal
3	147	Ground

Knock Sensor1(KNOCK1)

A sensor that is mounted on the cylinder block, sensing knocking of the engine. With the piezoelectric ceramic element, when it senses vibration or pressure from the external, it generates voltage higher than the reference voltage and delivers the voltage to the ECU.



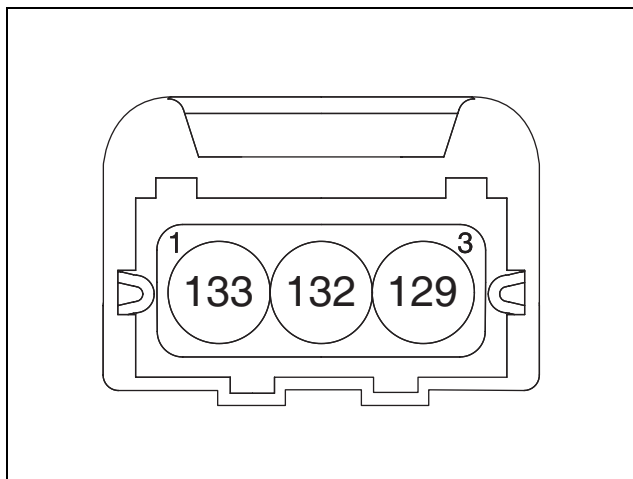
EDL022188B

No	ECU PIN	Description
1	130	Ground
2	131	Accelerometer signal
3	128	Shield (Screen)

12. Electric System

Knock Sensor2(KNOCK2)

A sensor that is mounted on the cylinder block, sensing knocking of the engine. With the piezoelectric ceramic element, when it senses external vibrations or pressure, it generates voltage higher than the reference voltage and delivers the voltage to the ECU.

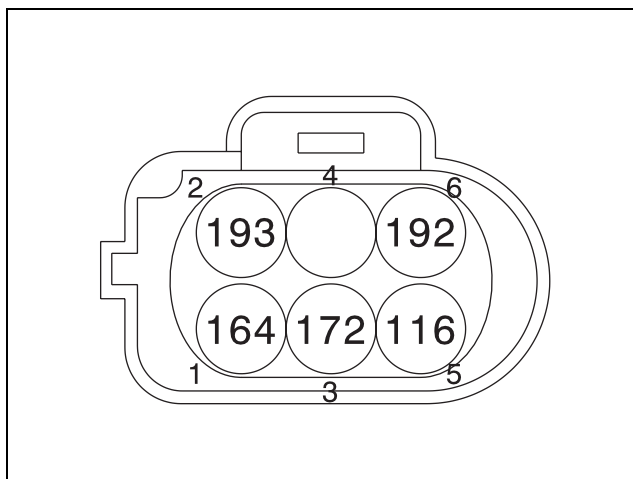


EDL022189B

No	ECU PIN	Description
1	133	Ground
2	132	Accelerometer signal
3	129	Shield (Screen)

Exhaust Gas Recirculation Valve Position Sensor (EGR)

A sensor used to reduce nitrogen oxide (NO_x) 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 NO_x is reduced.

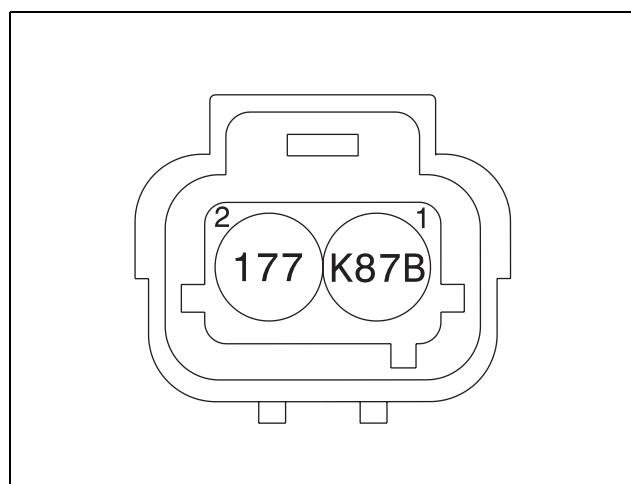


EDL022190A

No	ECU PIN	Description
1	164	Supply voltage(5V)
2	193	H-Bridge NEG
3	172	Ground
5	116	Position sensor signal
6	192	H-Bridge NEG

Inlet Metering Valve (IMV)

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.



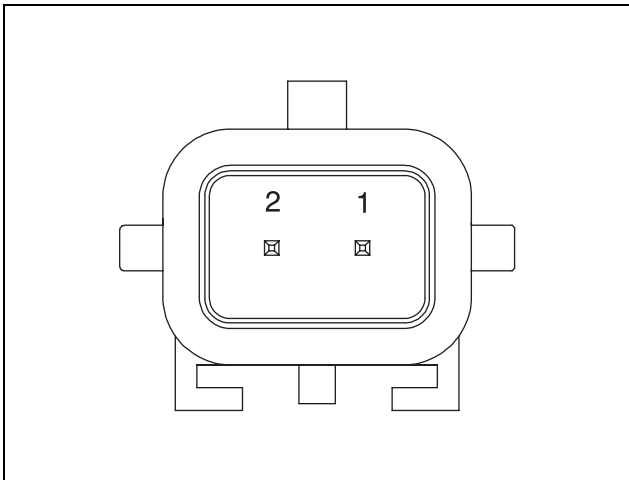
EDL022191A

No	ECU PIN	Description
1	-	Supply voltage(12V)
2	177	PWM signal

12. Electric System

Water In Fuel Sensor (WIFS)

A sensor that senses the moisture in the filter and sends the data to the ECU.



EDL022221A

No	ECU PIN	Description
1	209	Water sensing signal
2	234	Ground

Wire harness

Disassembly of Wire Harness

1. Disconnect the connectors connected to each sensor.
2. Loosen the fixing bolts mounted on the wire harness bracket.
3. Remove the wire harness.

Assembly of Wire Harness

1. Mount the wire harness.
2. Tighten the fixing bolts mounted on the wire harness bracket.
3. Disconnect the connectors connected to each sensor.

12. Electric System

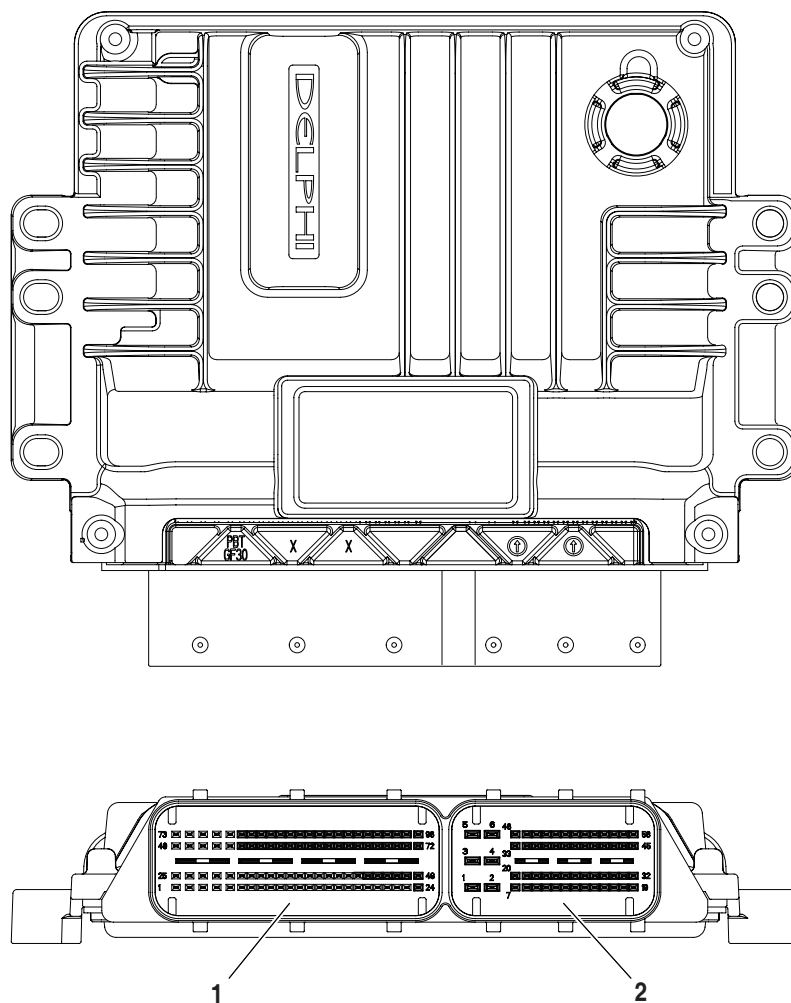
Electronic Control Unit (ECU)

General Information

The engine control unit (ECU) controls fuel delivery. The ECU is connected to various sensors. Based on the input values from the sensors, the ECU controls the engine for optimum operation. Before disconnecting connectors from the ECU, disconnect the ground wire (negative (-) wire) of the battery cable. Do not dismantle the ECU.

Electronic Control Unit (ECU) Connectors

The ECU connectors are classified into the connectors connected to the vehicle and the connectors connected to the engine.

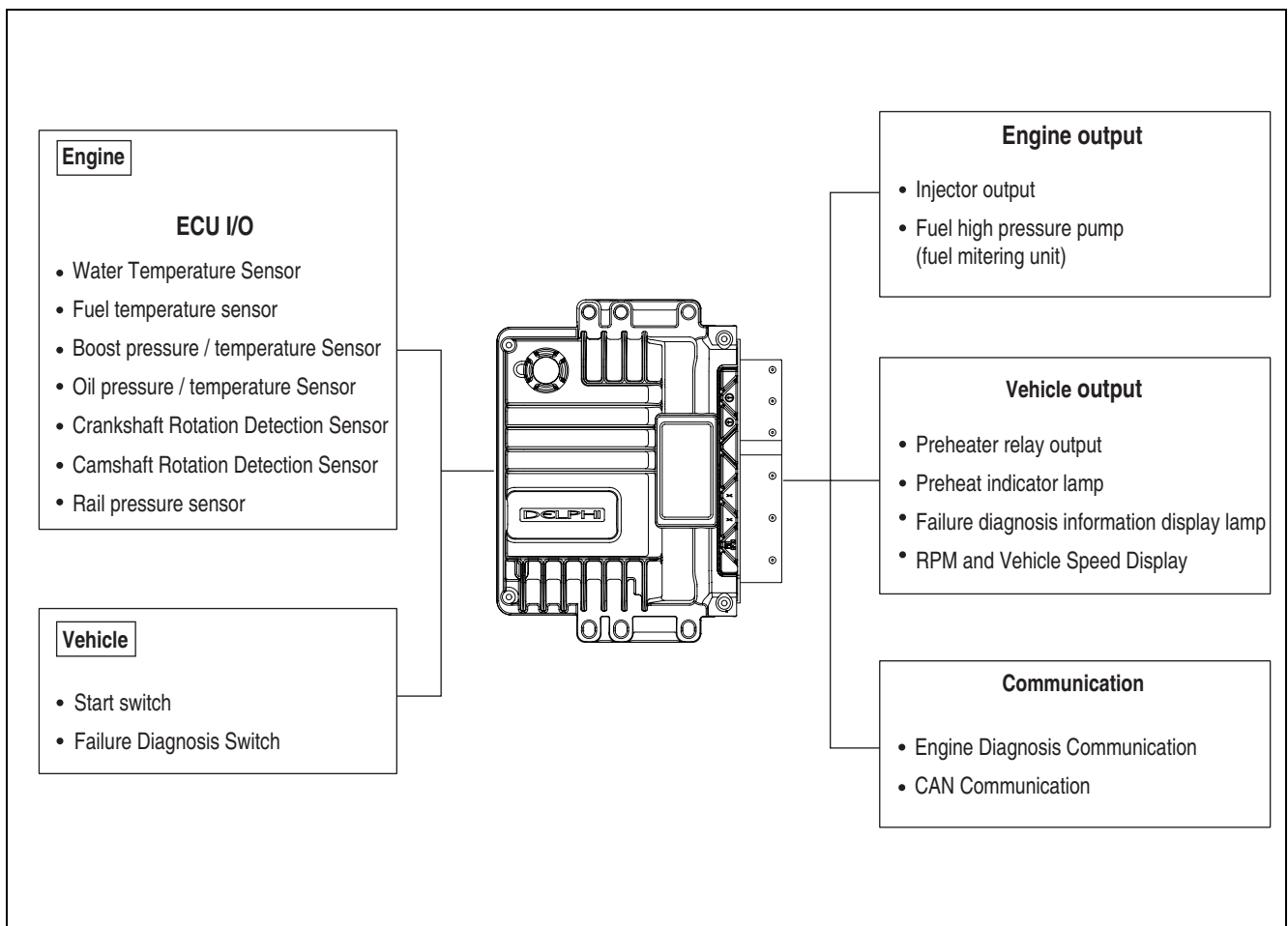


EDL022195A

1. Connectors connected to the engine
2. Connectors connected to the vehicle

12. Electric System

I/O of Electronic Control Unit (ECU)



EDL0213008A

Operational Conditions of Electronic Control Unit (ECU)

1. Engine Start

- 1) Sets the reference temperature for determining preheat to the lowest temperature among coolant temperature, fuel temperature, intake air temperature, and oil temperature.
- 2) Sets the reference temperature for determining fuel volume by setting the engine cooling temperature.
- 3) Determines the appropriate fuel volume to start the engine, delivers the fuel to the engine, and measures the RPM signal by using the crankshaft rev-count sensor.

2. Vehicle driving

- 1) Calculates the required data for driving a vehicle, such as CAN data and the RPM transferred from the vehicle control unit.

3. Driver-requested Adjustment of RPM

- 1) Controls the RPM based on request from the driver and controls the engine based on the RPM requested by the vehicle control unit.

4. Limp Home

- 1) A function that allows drivers to drive their vehicle to the repair center safely with the minimum conditions for driving the vehicle when a fault code occurs.
- 2) Limp Home function is applied under the following conditions.
 - Accelerator pedal has failed: Regardless of pressing the accelerator pedal, the vehicle is driven at a consistent RPM.
 - Sensor has failed: When sensors have failed, the vehicle is driven with the consistent alternative values.
 - Output is limited: According to the fault type, the fuel volume delivered to the engine is limited. The limit is classified into four levels. The fuel volume is limited according to the severity of the fault.

12. Electric System

- **Diagnosis Information Display Lamp:** Provides information of fault state to drivers for safe driving.

5. Failure Diagnosis

- 1) When a fault occurs, the failure diagnosis information display lamp on the gauge board is turned on.
- 2) With the failure diagnosis information display lamp, drivers can see the fault code.

Note) It can be checked from the failure diagnosis information on the gauge board.

- 3) It can be diagnosed by connecting the diagnosis unit to the check connector at the back of the driver's seat.

6. Driving record

- 1) Writes the information related driving to the ECU.
- 2) The information on fuel consumption, engine use time, and ECU use time is written in the ECU.
- 3) The information can be monitored with the ECU diagnosis device.

13. Others/Driving System

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13. Others/Driving System

Others/Driving System

General Information

General Information

1. The forged crankshaft is an integral structure. The crankshaft and the rear oil seals prevent oil from permeating into the flywheel housing.
2. The connecting rod is forged and its large end part is vertically separated.

Therefore, like a piston, the connecting rod can be disassembled through the upper side of the cylinder.

An alloy-type prefabricated bearing is used for the active part of the crankshaft and the connecting rod.

3. The camshaft, oil pump, and high-pressure injection pump are driven by gear connection in the timing gear case.

Specifications

Item		D18NAP		Remark
		DL01-LEE00	DL01-LEL00	
Other/Driving System				
Piston outside diameter		Grade A: 89.920 ~ 89.930mm Grade B: 89.930 ~ 89.940mm	←	
Gap between cylinder and piston		0.060 ~ 0.080 mm	←	
Piston ring groove area	Top ring groove	1.915 ~ 1.945 mm	←	
	2nd ring groove	2.060 ~ 2.080 mm	←	
	Oil ring groove	3.020 ~ 3.040 mm	←	
Piston ring side gap	Top ring side gap	0.083 ~ 0.133 mm	←	
	2dn ring side gap	0.070 ~ 0.110 mm	←	
	Oil ring side gap	0.030 ~ 0.070 mm	←	
Piston ring end gap	Top ring end gap	0.20 ~ 0.30 mm	←	
	2nd ring end gap	0.55 ~ 0.70 mm	←	
	Oil ring end gap	0.2 ~ 0.4 mm	←	
Piston pin outside diameter		30.995 ~ 31,000 mm	←	
Piston pin hole bore		31.008 ~ 31.014 mm	←	
Piston pin hole gap		0.008 ~ 0.019 mm	←	
Connecting rod small-end bore		31.025 ~ 31.038 mm	←	
Connecting rod small-end hole gap		0.025 ~ 0.043 mm	←	
Connecting rod large-end bore		57.000 ~ 57.015 mm	←	

13. Others/Driving System

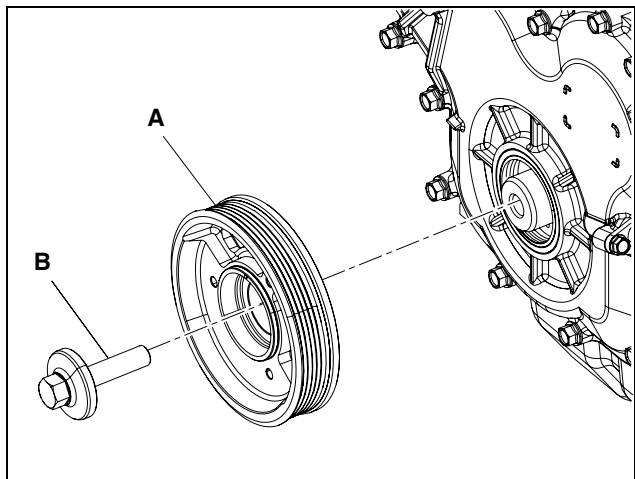
Item	D18NAP		Remark
	DL01-LEE00	DL01-LEL00	
Connecting rod bearing oil gap	0.026 ~ 0.064 mm	←	
Connecting rod end play	0.15 ~ 0.3 mm	←	
Crankshaft main journal outside diameter	57.955 ~ 57.970 mm	←	
Crankshaft pin journal outside diameter	53.955 ~ 53.970 mm	←	
Crankshaft main bearing oil gap	0.029 ~ 0.059 mm	←	
Crankshaft end play	0.1 ~ 0.31 mm	←	

13. Others/Driving System

Crankshaft

Disassembly of Timing Wheel

1. Remove the V-belt.
2. Remove the crankshaft pulley.



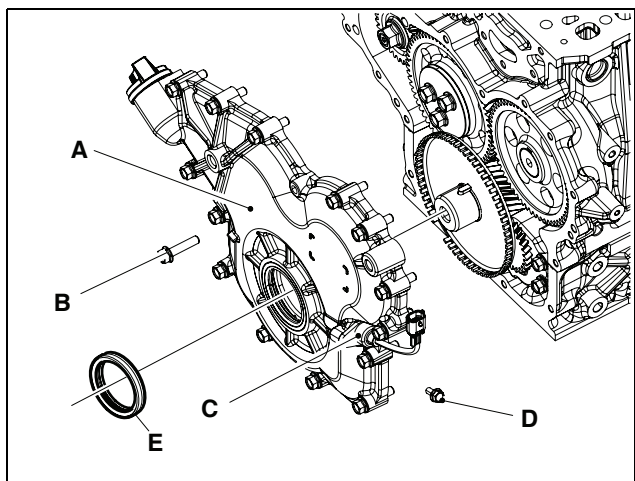
EDL013033A

- 1) Loosen the flange hex bolt (B).
- 2) Remove the crankshaft pulley (A).

⚠ CAUTION

Be careful not to damage the oil seal.

3. Remove the timing gear case.



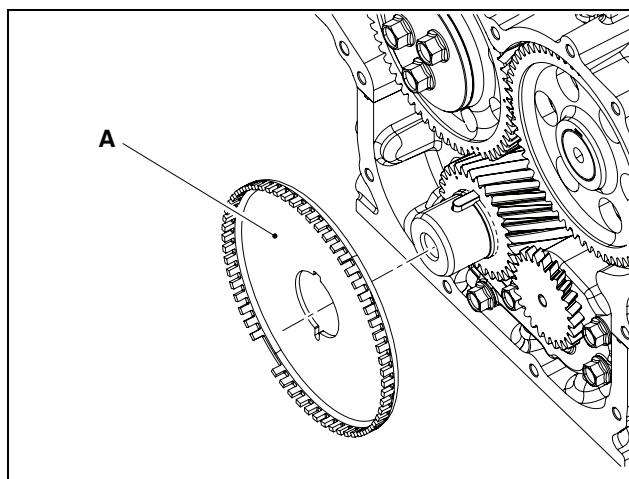
EDL013037A

- 1) Loosen the fixing bolt (D).
- 2) Remove the crank speed sensor (C).
- 3) Loosen 16 hex bolts (B).
- 4) Remove the timing gear case (A).
- 5) Remove the front oil seal(E) with the oil seal disassembly jig (850306-00078).

⚠ CAUTION

Do not reuse the oil seal but replace them with new ones.

4. Remove the timing wheel.

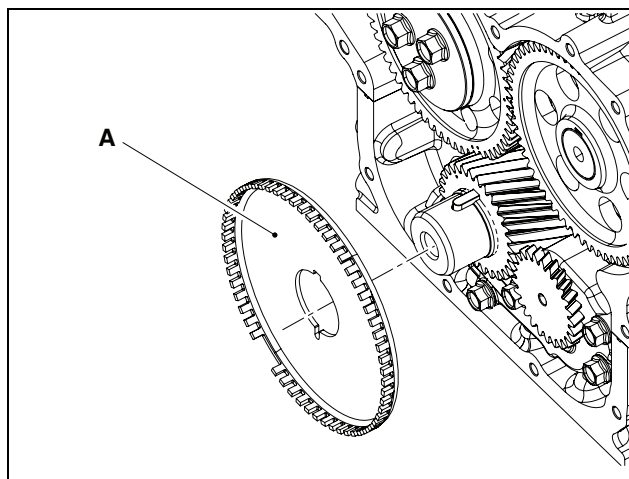


EDL013038A

- 1) Remove the timing wheel (A).

Assembly of Timing Wheel

1. Attach the timing wheel.



EDL013038A

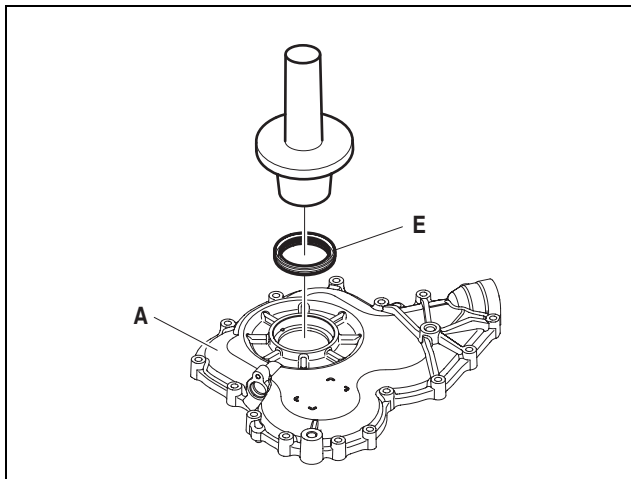
- 1) Attach the timing wheel (A).

⚠ CAUTION

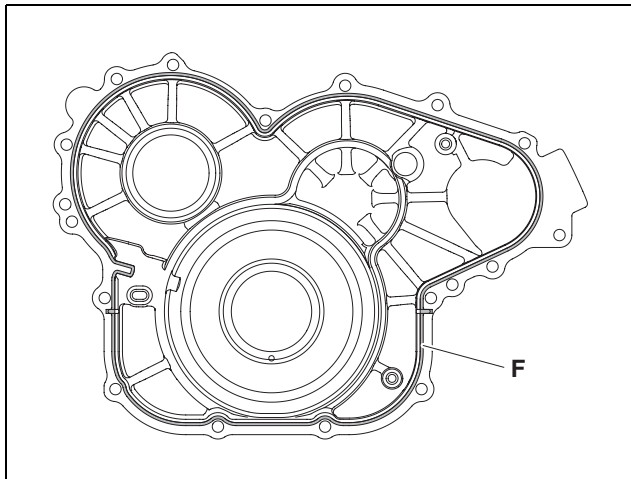
Be careful not to damage the teeth of the timing wheel.

13. Others/Driving System

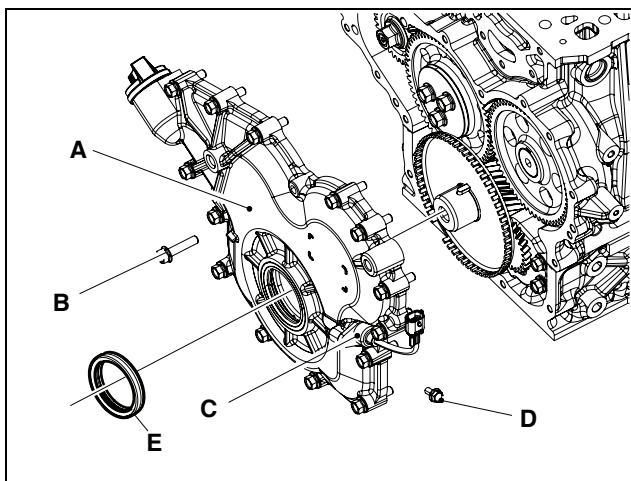
2. Attach the timing gear case (A).



EDL013052A



EDL013053A



EDL013037A

- 1) Make the assembly surface of the timing gear case face the ground.
- 2) Mount the front oil seal (E) to the front oil seal assembly jig (860104-02047).
- 3) Align the front oil seal assembly jig (860104-02047) where the front oil seal (E) is mounted to

the timing gear case (A) and beat it with a rubber hammer.

- 4) when the front oil seal (E) is inserted to the timing gear case(A), pull off the front oil seal assembly jig (860104-02047).

⚠ CAUTION

- Be careful in noting the direction of the oil seal assembly and ensuring that the oil seal surface faces the outside of the engine.
- Be careful of the depth of the oil seal when attaching it.
- Be careful not to damage the oil seal.
- Attach the oil seal without applying lubrication. coolant, fuel, LOCTITE, or silicon.

⚠ CAUTION

- Remove foreign substances such as residues and LOCTITE from the oil seal assembly bore.
- Do not reuse the oil seal; replace it with a new one.
- Be careful not to damage the oil seal when attaching it.

- 5) Remove the foreign substances on the timing gear case assembly surface and clean it with a dry cloth.
- 6) Apply LOCTITE 5902 to the timing gear case assembly surface (F) with the diameter of $\varnothing 2.5 \pm 0.5\text{mm}$.

⚠ CAUTION

- Keep clean liquid gasket dispensing surface.
- Dispensing line should not be snapped.

- 7) Align the timing gear case (A) with the pin and attach it.

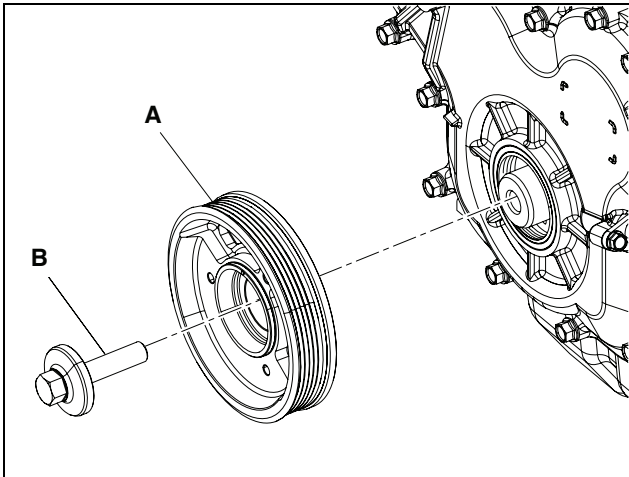
⚠ CAUTION

- Be careful that the timing gear case has been attached in the right direction.
- Assemble the timing gear case in 5 minutes after dispensing liquid gasket.
- Do not pressureize inside the timing gear case in 25 minutes after dispensing liquid gasket.

- 8) Tighten 16 hex bolts (B) at a tightening torque of $2.2\text{kgf}\cdot\text{m}$.
- 9) Attach the crank speed sensor (C).
- 10) Tighten the fixing bolt (D).

13. Others/Driving System

3. Attach the crankshaft pulley.



EDL013033A

- 1) Align the crankshaft pulley (A) to the pin and attach it.
- 2) Apply LOCTITE Blue 587 to the inside of the flange hex bolts (B).
- 3) Tighten flange hex bolts (B) at a tightening torque of 26 kgf•m.

⚠ CAUTION

- Be careful not to damage the oil seal.
- Fix the crankshaft to allow the flange hex bolts to be tightened with the specified torque.

4. Attach the V-belt.

Disassembly of Crankshaft

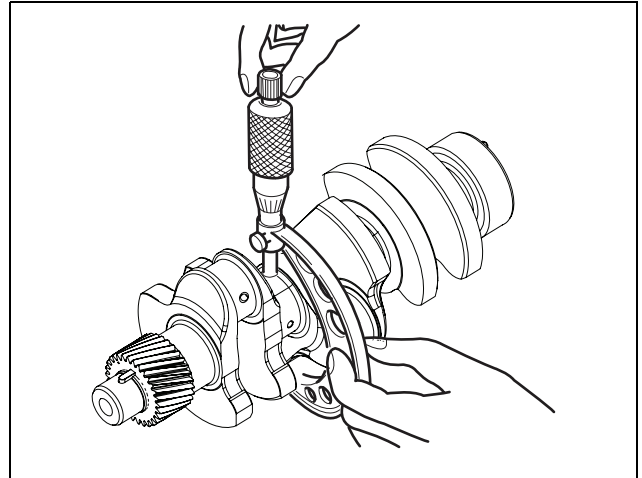
1. Remove the crankshaft.

Note) Refer to Chapter 6 (Procedure of Disassembling an Engine)

Measurement of Crankshaft Main Journal Diameter

1. Check whether there is any cracked or scratched part on the journal and pins of the crankshaft with the naked eye.
2. Perform the magnetic particle testing or the liquid penetrant testing to check the cracks on the crankshaft. If cracks are found, replace the crankshaft with a new one.
3. Set the gauge.
4. Remove foreign substances from the crankshaft.

5. Measure the diameter of the crankshaft main journal



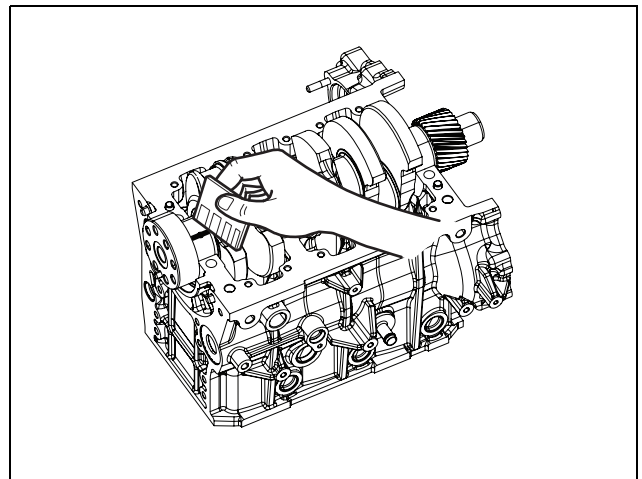
EDL013096A

- 1) Measure the diameter of the crankshaft journal with the outside diameter micrometer.
- 2) Measure total 20 points of the inside diameter of the idle gear: 5 points of vertical (A), horizontal (B), front (C), and rear (D).
- 3) The standard measurement value of the diameter of the crankshaft journal is within the range of 57.955 ~ 57.970 mm.

Item	Specified Value
Crankshaft journal diameter	57.955 ~ 57.970 mm

Measurement of Crankshaft Bearing Gap

1. Mount the crankshaft to the cylinder block.
2. Measure the gap of the crankshaft bearing.



EDL013097A

13. Others/Driving System

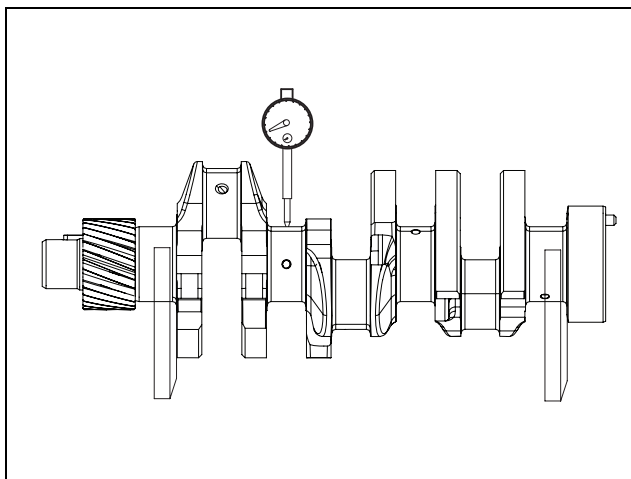
- 1) Put the plastic gauges on 5 points on the crankshaft which contact with the crankshaft bearing part.
- 2) Assemble the crank case at the specified torque and then disassemble it.
- 3) Check the width of the plastic gauges.
- 4) The standard measurement value of the gap of the crankshaft bearing is within the range of 0.029 ~ 0.059 mm.

Item	Specified Value
Crankshaft Bearing Gap	0.029 ~ 0.059 mm

3. Remove the plastic gauges.
- 5) Remove the plastic gauges.
- 6) Remove any foreign substances from the cylinder block and the crankshaft.

Measurement of Crankshaft Warpage

1. Measure the crankshaft warpage.



EDL013098A

- 1) Put the #1 and #5 main journal of the crankshaft on the V- block.
- 2) Put the dial gauge on the surface plate and measure the warpage of the crankshaft as spinning the crankshaft.
- 3) The standard measurement value of the warpage of the crankshaft is 0.02 mm for #2 and #4 and 0.03 mm for #3 based on #1 and #5 main journal.

Assembly of Crankshaft

1. Attach the crankshaft.

Note) Refer to Chapter 6 (Procedure of Assembling an Engine).

13. Others/Driving System

Connecting Rod

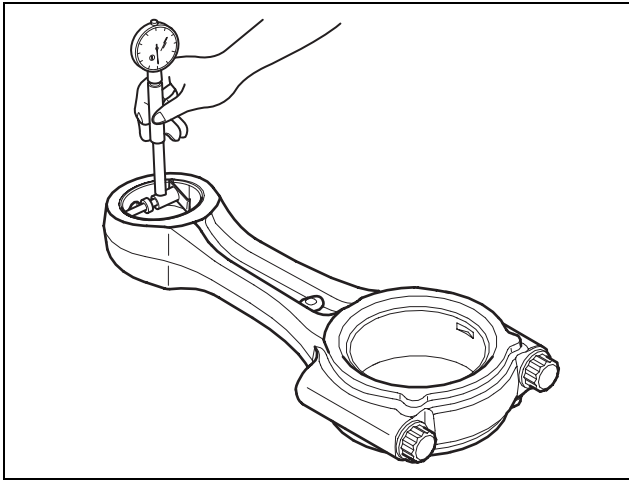
Disconnection of Connecting Rod

1. Disconnect the connecting rod.

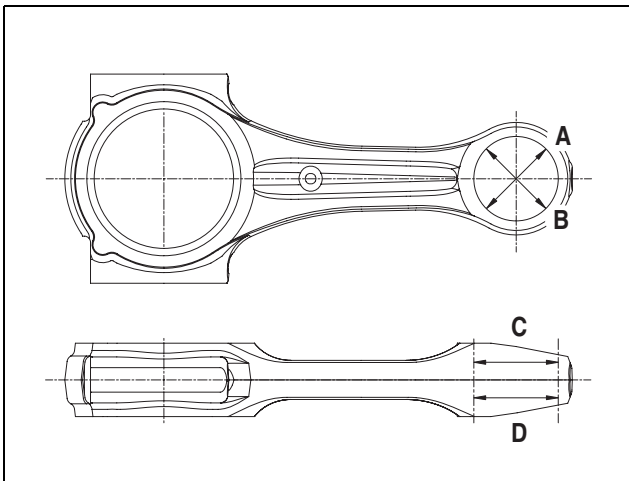
Note) Refer to Chapter 6 (Procedure of Disassembling an Engine).

Measurement of Inside Diameter of Connecting Rod Small-end

1. Set the gauge.
2. Measure the inside diameter of the small end of the connecting rod.



EDL022197B



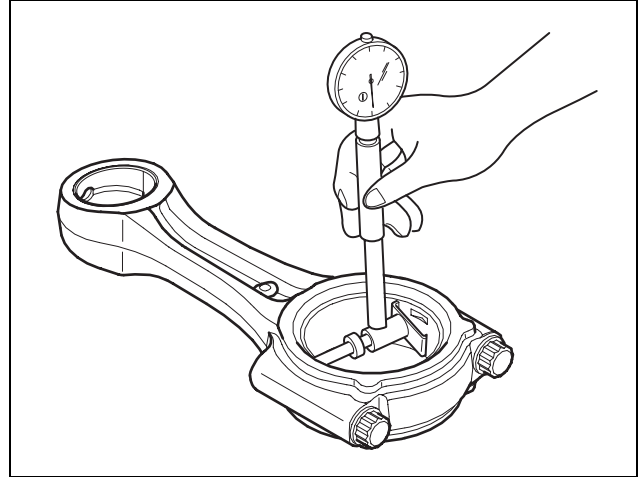
EDL022198B

- 1) Measure total 4 points of the inside diameter of the connecting rod small-end: vertical (A), horizontal (B), front (C), and rear (D).
- 2) Measure all of 3 connecting rods.
- 3) The standard measurement value of the inside diameter of the connecting rod small-end is within the range of 31.025 ~ 31.038 mm.

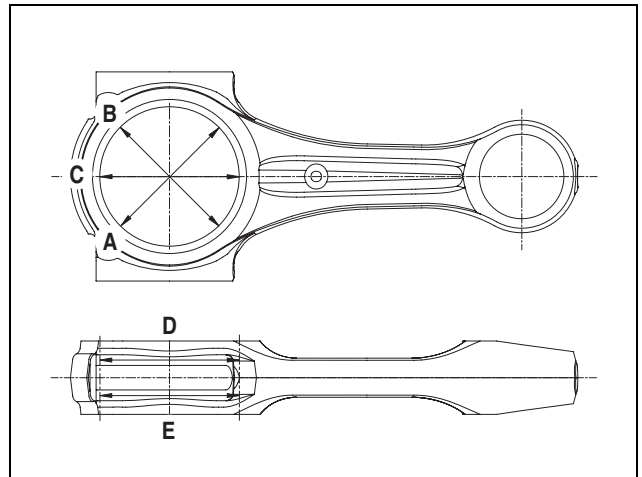
Item	Specified Value
Connecting rod small-end bore	31.025 ~ 31.038 mm

Measurement of Connecting rod large-end bore

1. Set the meter.
2. Measure the inside diameter of the large-end of the connecting rod.



EDL022199B



EDL022200B

- 1) Measure total 6 points of the inside diameter of the connecting rod big-end: A, B, C, front (D), and rear (E).
- 2) Measure all of 3 connecting rods.
- 3) The standard measurement value of the inside diameter of the connecting rod big-end is within the range of 57.0 ~ 57.015 mm.

Item	Specified Value
Connecting rod large-end bore	57.0 ~ 57.015 mm

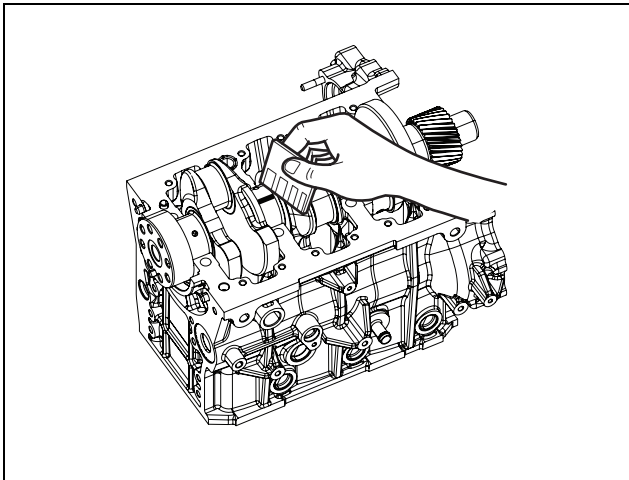
CAUTION

Connect the connecting rods manually until the head of the connecting rod bolt contacts the bolt bearing surfaces on both sides, and then tighten them at the specified torque.

13. Others/Driving System

Measurement of Gap of Connecting Rod Big-end

1. Mount the crankshaft to the cylinder block.
2. Measure the gap of the connecting rod big-end.



EDL013099A

- 1) Put the plastic gauges on 4 points on the crankshaft that contacts with the connecting rods.
- 2) Connect the connecting rods.
- 3) Temporarily connect the connecting rods manually.
- 4) Tighten the connecting rod bolts at a tightening torque of 2 kgf m + 90 with the angle method.
- 5) Loosen the connecting rod bolts.
- 6) Remove the connecting rod cap.
- 7) Check the width of the plastic gauges.
- 8) The standard measurement value of the gap of the connecting rod big-end is within the range of 0.026 ~ 0.064 mm.

Item	Specified Value
Gap of Connecting Rod Big-end	0.026 ~ 0.064 mm

3. Remove the plastic gauges.
- 9) Remove the plastic gauges.
- 10) Remove any foreign substances from the crankshaft and the connecting rod big-end.

Assembly of Connecting Rod

1. Connect the connecting rods.

Note) Refer to Chapter 6 (Procedure of Assembling an Engine).

13. Others/Driving System

Piston

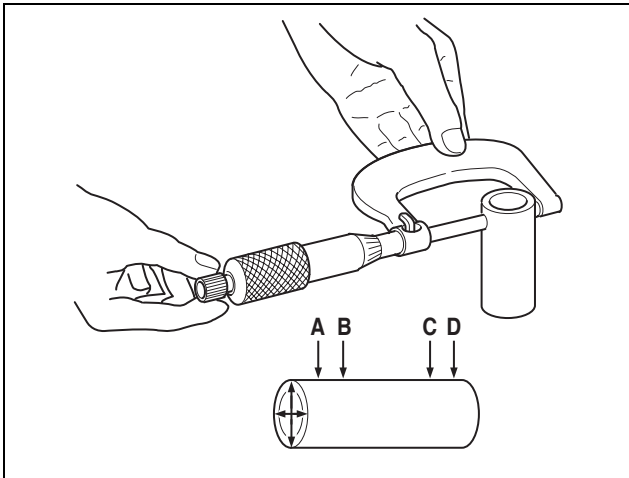
Disassembly of Piston

1. Detach the piston.

Note) Refer to Chapter 6 (Procedure of Disassembling an Engine) .

Measurement of Outside Diameter of Piston Pin

1. Set the gauge.
2. Measure the outside diameter of the piston pin.



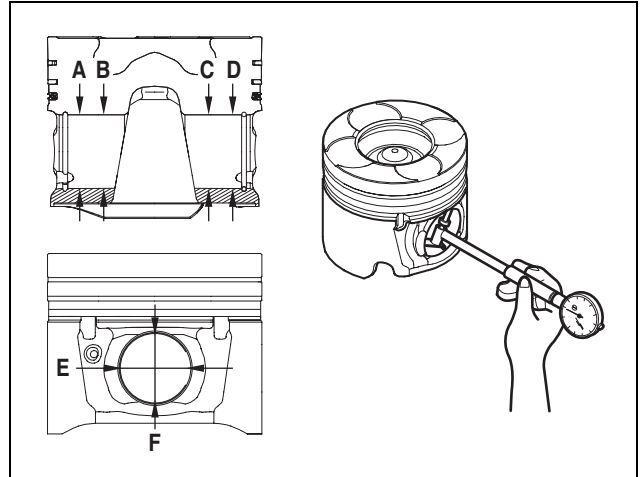
EDL022132A

- 1) Measure total 8 points of the outside diameter of the piston pin: A, B, C, D, vertical (E), and horizontal (F).
- 2) Measure all of 3 piston pins.
- 3) The standard measurement value of the outside diameter of the piston pin is within the range of 30.995 ~ 31 mm.

Item	Specified Value
Piston pin outside diameter	30.995 ~ 31 mm

Measurement of Inside Diameter of Piston Pin Bore

1. Set the gauge.
2. Measure the inside diameter of the piston pin bore.



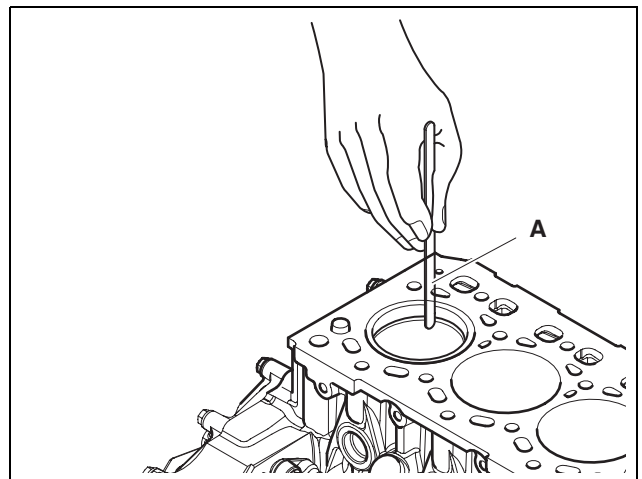
EDL022133A

- 1) Measure total 8 points of the inside diameter of the piston pin bore: A, B, C, D, vertical (E), and horizontal (F).
- 2) Measure all of 3 piston pin bores.
- 3) The standard measurement value of the inside diameter of the piston pin bore is within the range of 31.008 ~ 31.014 mm.

Item	Specified Value
Piston pin of the piston Inside diameter of bore	31.008 ~ 31.014 mm

Measurement of Gap of Piston Ring End

1. Measure the gap of the piston ring end.



EDL013100A

13. Others/Driving System

- 1) Insert the piston ring to the cylinder top at a right angle with the wall.
- 2) Measure the piston ring end gap with the gap gauge (A).
- 3) Measure the gaps of the top ring, the 2nd ring, and the oil ring.
- 4) The standard measurement values of the gap of the piston ring end is within the range of 0.20 ~ 0.35 mm for the top ring, 0.55 ~ 0.70 mm for the 2nd ring, and 0.20 ~ 0.40 mm for the oil ring.

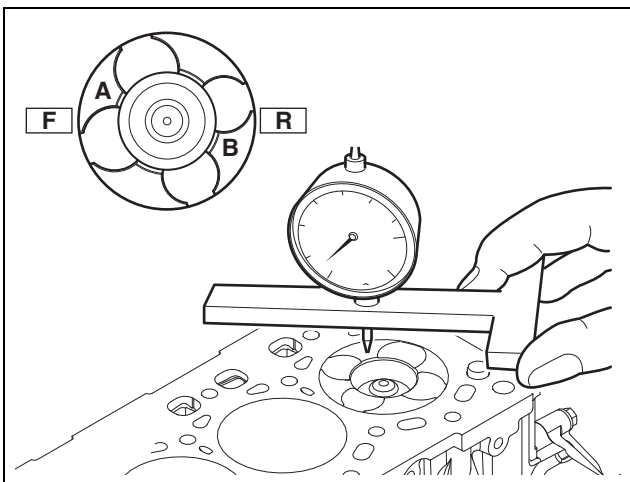
Item	Specified Value
Gap of top ring	0.20 ~ 0.35 mm
Gap of 2nd ring	0.55 ~ 0.70 mm
Gap of oil ring	0.20 ~ 0.40 mm

CAUTION

Be careful not to damage the cylinder with the gap gauge when measuring the gap of the piston ring end.

Measurement of Step Height of Piston Top Side

1. Perform the zero point adjustment of the meter based on the top surface of the cylinder block.
2. Measure the step height of the piston top side.



EDL013101A

- 1) Adjust the piston to position on the top dead point.
- 2) Measure the step height on A and B on the piston top side based on the cylinder block surface.
- 3) Adjust the other pistons to position on the top dead point and measure 8 points.

- 4) The standard measurement value of the step height of the piston top side is within the range of 0.24 ~ 0.52 mm.

Item	Specified Value
Step height of piston top side	0.24 ~ 0.52 mm

CAUTION

- Select the cylinder head gasket class based on the average of step heights of the piston top side by measuring average value of step heights at 8 points. For the cylinder gasket class, refer to #19 of Procedure of Assembling an Engine of General Information in Chapter 6.
- The front engine direction (F) is the water pump direction and the rear engine direction (R) is the flywheel direction.

Assembly of Piston

1. Attach the piston.

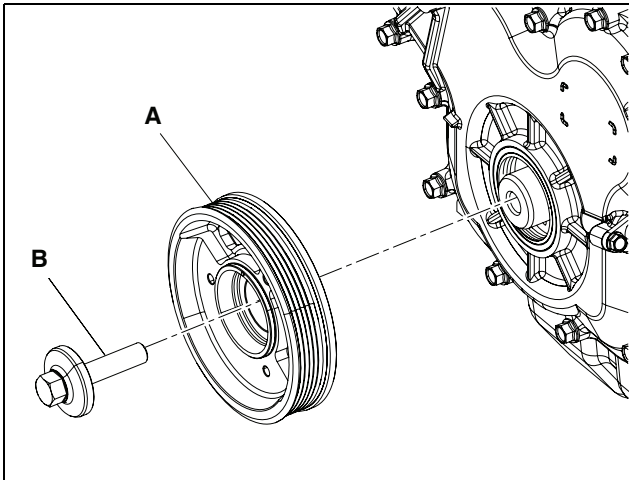
Note) Refer to Chapter 6 (Procedure of Assembling an Engine).

13. Others/Driving System

Crankshaft Pulley

Disassembly of Crankshaft Pulley

1. Remove the crankshaft pulley.



EDL013033A

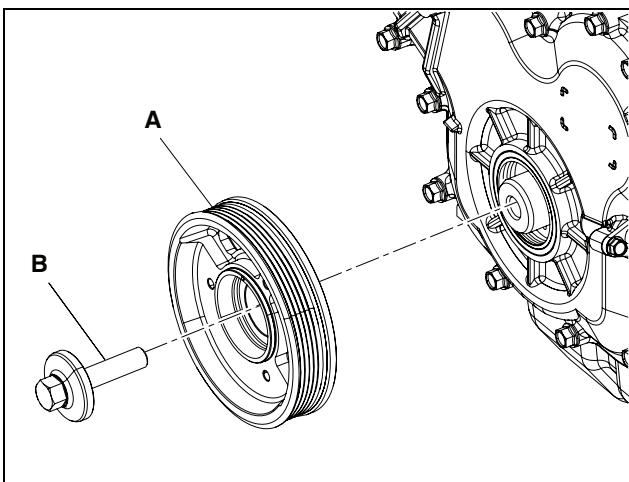
- 1) Loosen the flange hex bolt (B).
- 2) Remove the crankshaft pulley (A).

⚠ CAUTION

Be careful not to damage the oil seal.

Assembly of Crankshaft Pulley

1. Attach the crankshaft pulley.



EDL013033A

- 1) Align the crankshaft pulley (A) to the pin and attach it.
- 2) Apply LOCTITE Blue 587 to the inside of the flange hex bolts (B).
- 3) Tighten flange hex bolts (B) at a tightening torque of 26 kgf•m.

⚠ CAUTION

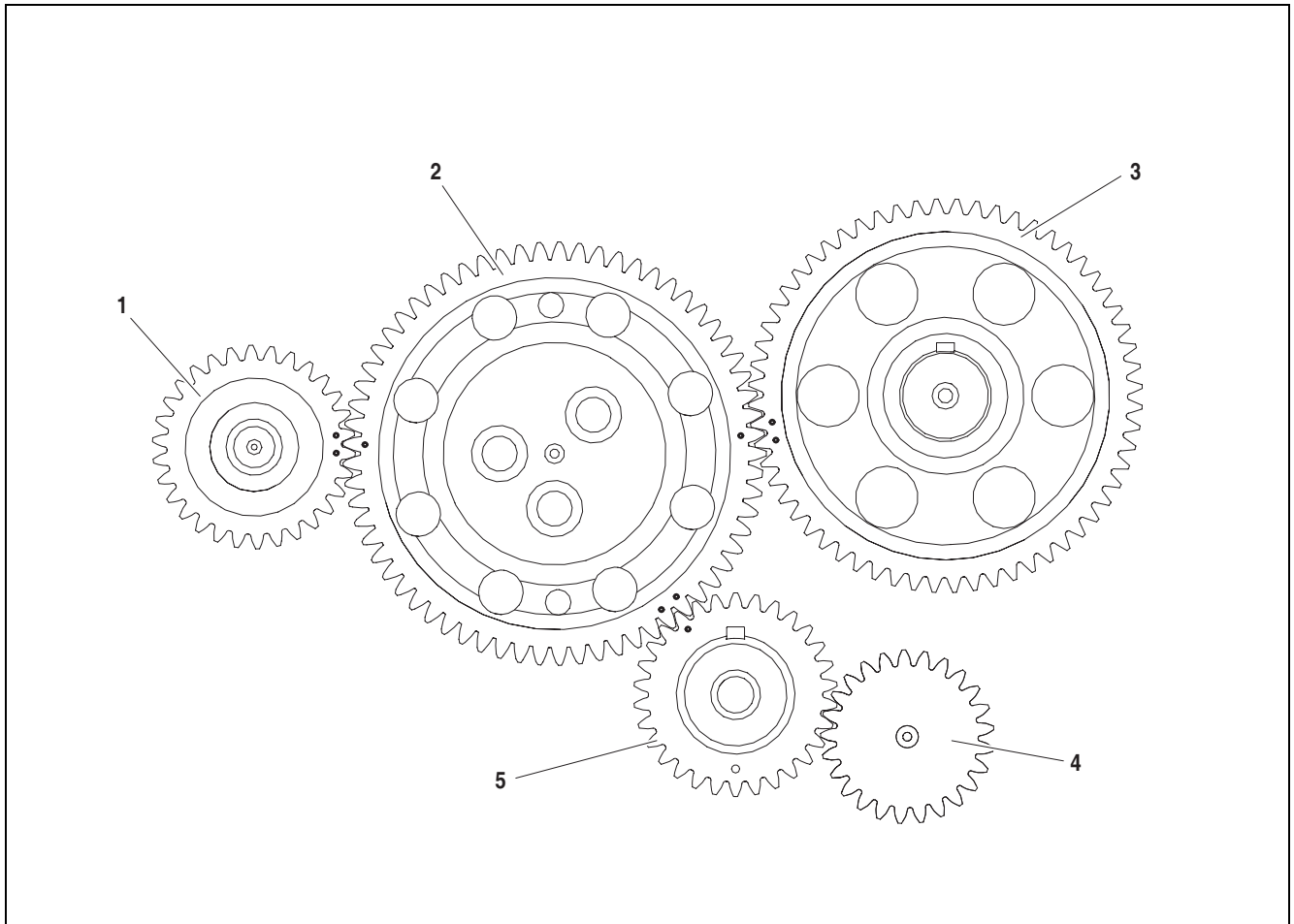
- Be careful not to damage the oil seal.
- Fix the crankshaft to allow the flange hex bolts to be tightened with the specified torque.

13. Others/Driving System

Others

Engine Timing

The camshaft, oil pump, and high-pressure injection pump are driven by gear connection.



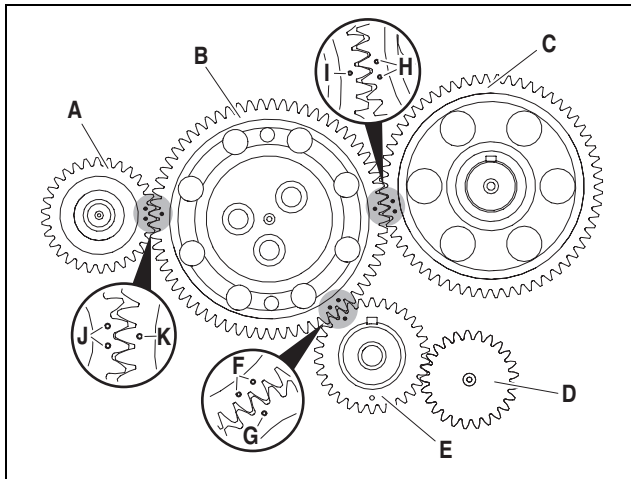
EDL022136A

1. Injection pump drive gear (gear: 30)
2. Idle gear (gear: 65)
3. Camshaft gear (gear: 60)
4. Oil pump drive gear (gear: 25)
5. Crankshaft gear (gear: 30)

13. Others/Driving System

Adjustment of Engine Timing

1. Remove the timing gear case.
2. Align the engravings of gears.



EDL022137A

- 1) Position the crankshaft gear engraving mark (E) between the idle gear engravings (B).

Note) You can see one crankshaft gear engraving (G) and two idle gear engravings (F).

Note) Position the idle gear engraving (B) between the camshaft gear engravings (C).

Note) You can see one idle gear engraving (I) and two camshaft gear engravings (H).

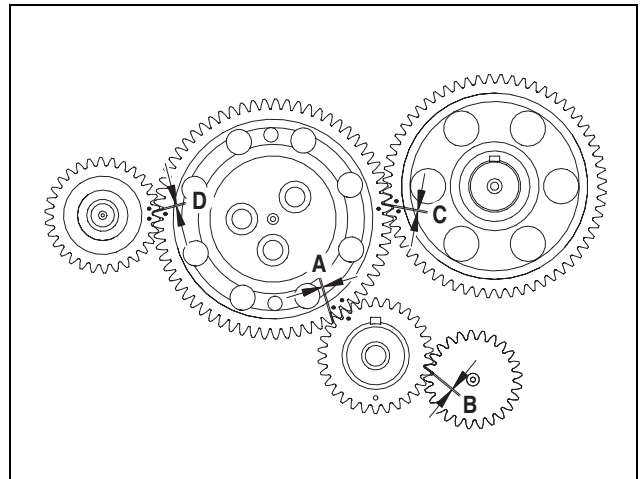
Note) Position the idle gear engraving (B) between the injection pump drive gear engravings (A).

Note) You can see one idle gear engraving (K) and two injection pump drive gear engravings (J).

3. Mount the timing gear case.

Check of Gear Backlash

1. Remove the timing gear case.
2. Check the gear backlash.



EDL022138A

- 1) Check the gear backlash with the gap gauge.
- 2) The standard backlash between the idle gear (A) and the crankshaft gear is 0.087 ~ 0.2 mm.
- 3) The standard backlash between the oil pump drive gear and the crankshaft gear (B) is 0.06 ~ 0.259 mm.
- 4) The standard backlash between the idle gear and the camshaft gear (C) is 0.067 ~ 0.211 mm.
- 5) The standard backlash between the idle gear and the injection pump drive gear (D) is 0.087 ~ 0.2 mm.

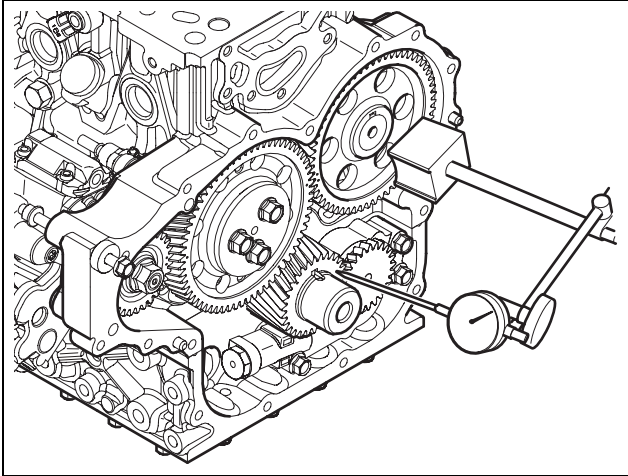
Item	Specified Value
Backlash between the crankshaft gear and the idle gear	0.087 ~ 0.2 mm
Backlash between the crankshaft gear and oil pump drive gear	0.06 ~ 0.259 mm
Backlash between the idle gear and the camshaft gear	0.087 ~ 0.211 mm
Backlash between the idle gear and injection pump drive gear	0.087 ~ 0.2 mm

3. Mount the timing gear case.

13. Others/Driving System

Check of Gear Axial Offset

1. Remove the timing gear case.
2. Check the gear axial offset.



EDL022139A

Item	Specified Value
The axial offset of the idle gear	0.100 ~ 0.300 mm
The axial offset of the idle gear	0.1 ~ 0.2 mm
The axial offset of the idle gear	0.1 ~ 0.2 mm

3. Mount the timing gear case.

- 1) Mount the dial gauge on the cylinder block.
- 2) Press the crankshaft gear (A) into the cylinder block direction.
- 3) Perform the zero point adjustment of the dial gauge based on the crankshaft gear (A).
- 4) Pull the crankshaft gear (A) and check the measured value of the dial gauge.

Note)The axial offset of the crankshaft gear is 0.100 ~ 0.300 mm.

- 5) Press the camshaft gear (B) into the cylinder block direction.
- 6) Perform the zero point adjustment of the dial gauge based on the camshaft gear (B).
- 7) Pull the camshaft gear (B) and check the measured value of the dial gauge.

Note)The axial offset of the camshaft gear is 0.1 ~ 0.2 mm.

- 8) Press the idle gear (C) into the cylinder block direction.
- 9) Perform the zero point adjustment of the dial gauge based on the idle gear (C).
- 10) Pull the idle gear (C) and manually measured value of the dial gauge.

Note)The axial offset of the idle gear is 0.1 ~ 0.2 mm.