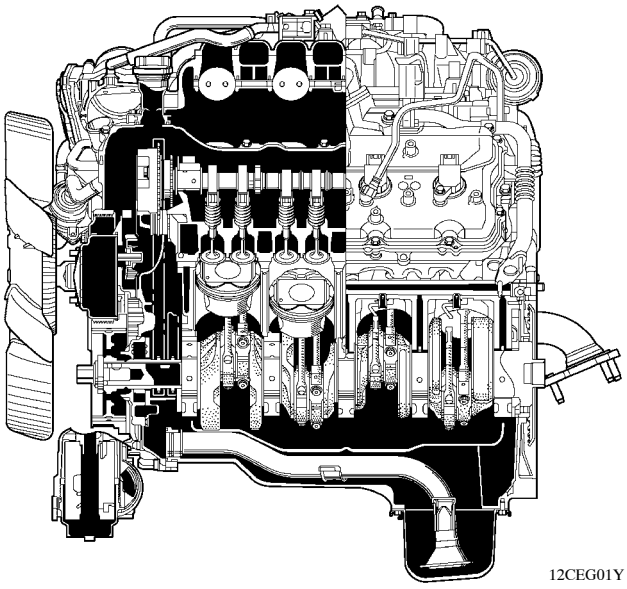
NEW FEATURES

■1UR-FE ENGINE

1. Description

The 1UR-FE engine is a 4.6-liter, 32-valve DOHC V8. This engine uses the Dual Variable Valve Timing-intelligent (Dual VVT-i) system, Direct Ignition System (DIS), Acoustic Control Induction System (ACIS), Electronic Throttle Control System-intelligent (ETCS-i), air injection system and Exhaust Gas Recirculation (EGR) control. These control functions achieve improved engine performance, fuel economy, and clean emissions.



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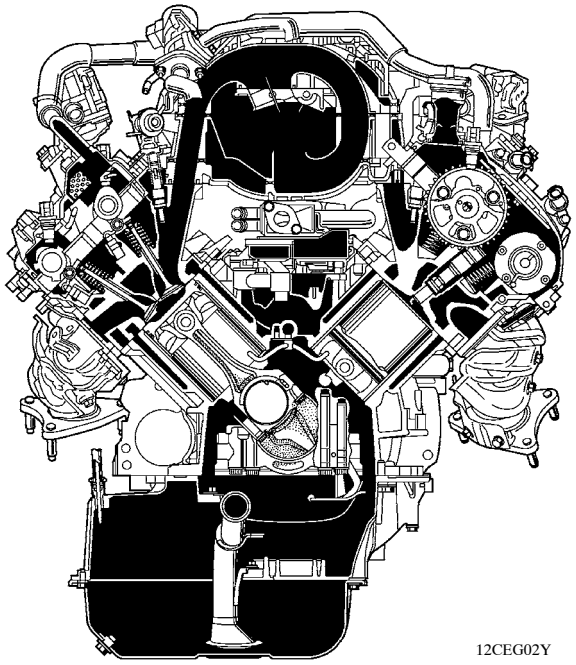

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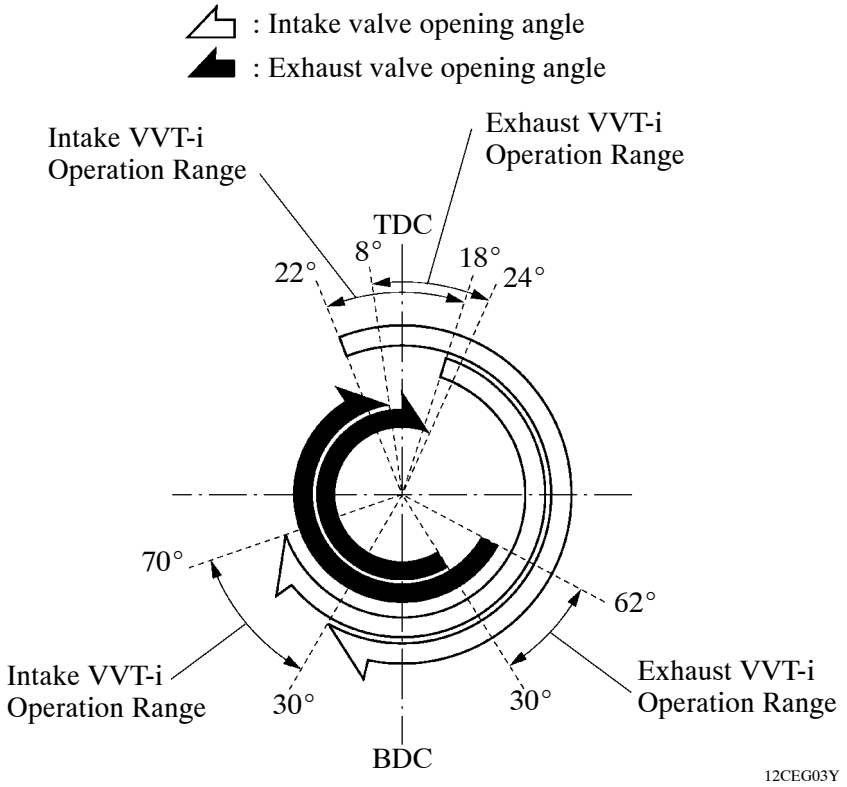
▶ Engine Specifications ◀

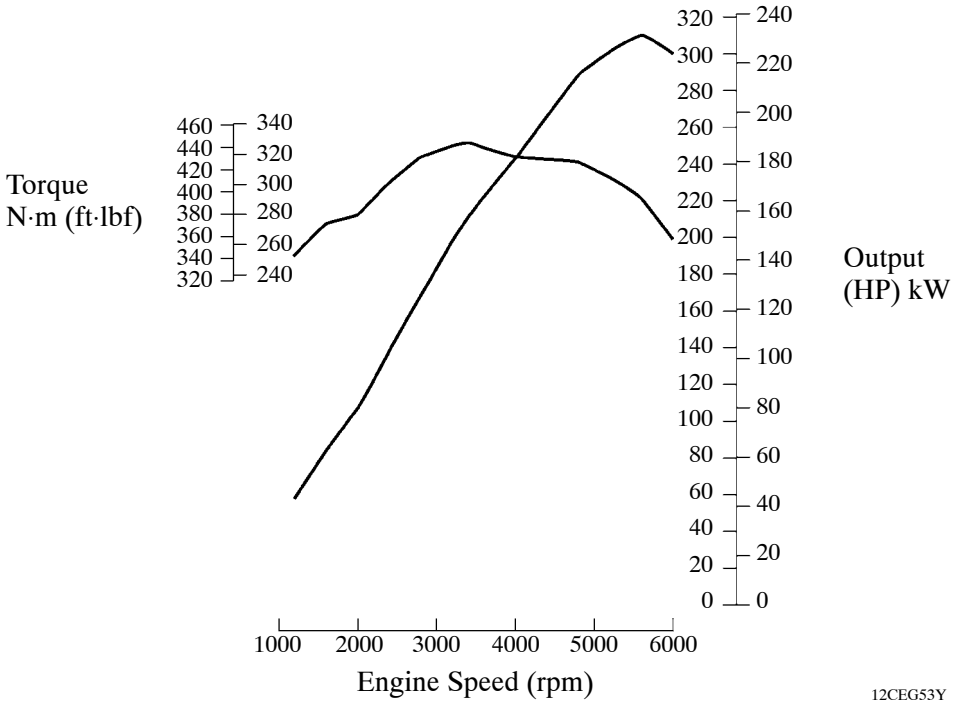
No. of Cyls. & Arrangement			8-cylinder, V Type
Valve Mechanism			32-valve DOHC, Chain Drive (with Dual VVT-i)
Combustion Chamber			Pentroof Type
Manifolds			Cross-flow
Fuel System			SFI
Ignition System			DIS
Displacement cm^3 (cu. in.)			4608 (281.2)
Bore × Stroke mm (in.)			94.0 × 83.0 (3.70 × 3.27)
Compression Ratio			10.2 : 1
Max. Output (SAE-NET)*1			231 kW @ 5600 rpm (310 HP @ 5600 rpm)
Max. Torque (SAE-NET)*1			443 N·m @ 3400 rpm (327 ft·lbf @ 3400 rpm)
Valve Timing	Intake	Open	–18° to 22° BTDC
		Closed	70° to 30° ABDC
	Exhaust	Open	62° to 30° BBDC
		Closed	– 8° to 24° ATDC
Firing Order			1 – 8 – 7 – 3 – 6 – 5 – 4 – 2
Octane Rating			87 or higher
Research Octane Number (RON)			91 or higher
Tailpipe Emission Regulation			LEVII-ULEV, SFTP
Evaporative Emission Regulation			LEVII, ORVR
Engine Service Mass*2 (Reference) kg (lb)			216.1 (476.5)

*1: Maximum output and torque ratings are determined by revised SAE J1349 standard.
*2: The figure shown is the weight of the part without coolant and oil.

▶ Valve Timing ◀



▶ Performance Curve ◀



2. Features of 1UR-FE Engine

The 1UR-FE engine has achieved the following performance through the use of the items listed below:

(1) High performance and reliability

(2) Low noise and vibration

(3) Lightweight and compact design

(4) Good serviceability

(5) Clean emission and fuel economy

Item		(1)	(2)	(3)	(4)	(5)
Engine Proper	A taper squish shape is used for the combustion chamber.	○				○
	An aluminum alloy cylinder block containing an engine coolant distribution pathway is used.	○		○		
	Spiny-type liners are used in the cylinder bores.	○		○		
	Cylinder block water jacket spacers are used.	○				
	The piston skirt is coated with resin.	○	○			○
	A No. 1 oil pan made of aluminum alloy is used.	○	○	○		
Valve Mechanism	Timing chains and chain tensioners are used.	○		○		
	Hydraulic lash adjusters are used.	○	○		○	○
	Roller rocker arms are used.	○				○
Lubrication System	An oil filter with a replaceable element is used.				○	
	A water-cooled type oil cooler is used.*	○				
Intake and Exhaust System	A carbon filter is used in the air cleaner cap.					○
	A linkless-type throttle body is used.	○		○		
	An intake manifold made of plastic is used.	○		○		
	A step motor type EGR valve is used.					○
	A water-cooled type EGR cooler is used.					○
	Stainless steel exhaust manifolds are used.	○		○		○
	Ceramic type Three-Way Catalytic converters (TWCs) are used.					○
Fuel System	12-hole type fuel injectors are used to improve the atomization of fuel.	○				○
Ignition System	The Direct Ignition System (DIS) makes ignition timing adjustment unnecessary.	○			○	○
	Long-reach type iridium-tipped spark plugs are used.	○			○	○

(Continued)

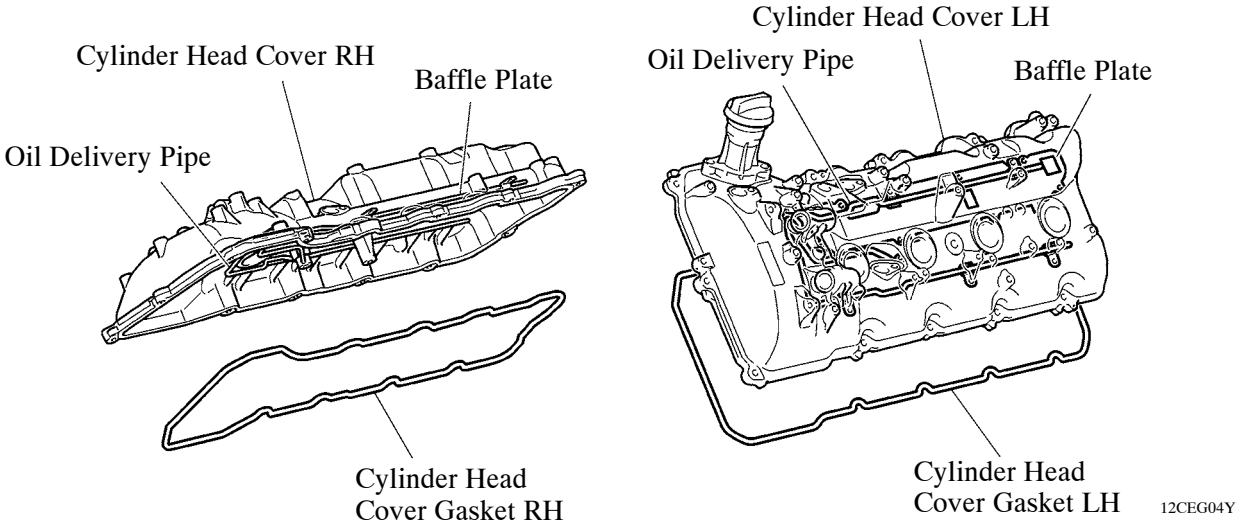
*: Models with towing package

Item		(1)	(2)	(3)	(4)	(5)
Charging System	A segment conductor type generator is used.	○		○		
Starting System	A planetary reduction type starter is used.			○		
Serpentine Belt Drive System	A serpentine belt drive system is used.			○	○	
Blowby Gas Ventilation System	A separator case is provided between the cylinder block and the intake manifold.	○				○
Engine Control System	An magnetic Resistance Element (MRE) type crankshaft position, a camshaft position, and VVT sensors are used.	○				
	The Electronic Throttle Control System-intelligent (ETCS-i) is used.	○				○
	The Dual Variable Valve Timing-intelligent (Dual VVT-i) system is used.	○				○
	The Acoustic Control Induction System (ACIS) is used.	○				○
	The Exhaust Gas Recirculation (EGR) control is used.					○
	An air injection system is used.					○
	A starter control (cranking hold function) is used.	○				
	An evaporative emission control system is used.					○

3. Engine Proper

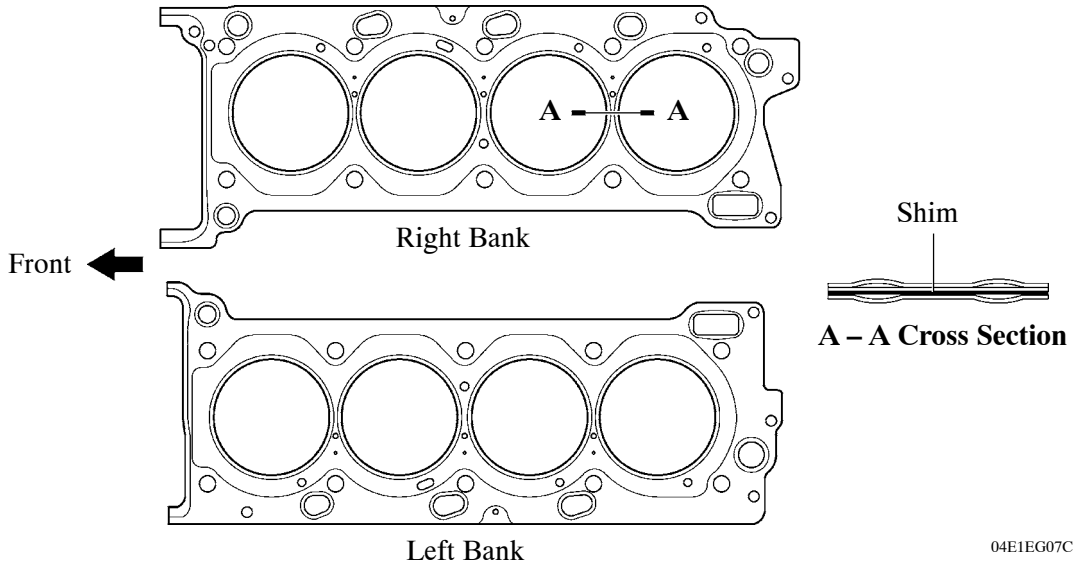
Cylinder Head Cover

- Lightweight yet high-strength aluminum cylinder head covers are used.
- An oil delivery pipe is installed inside the cylinder head covers. This ensures lubrication to the sliding parts of the valve rocker arms, improving reliability.
- Large baffle plates are built into the cylinder head covers. As a result, the speed of blowby gas flow is reduced, and the oil mist is removed from the blowby gas. Due to this, the amount of oil lost is reduced.



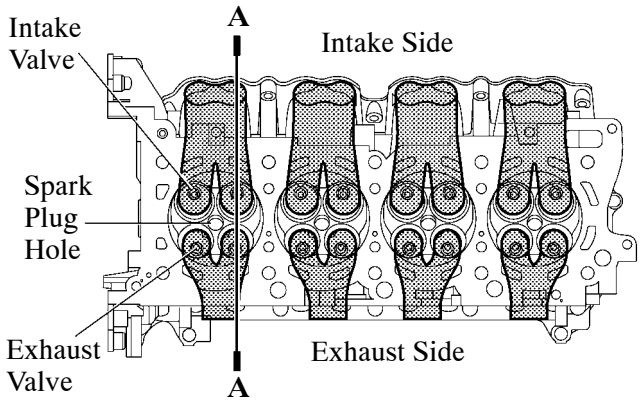
Cylinder Head Gasket

- 3-layer steel-laminate type cylinder head gaskets are used. A shim is used around the cylinder bore of each gasket to help enhance sealing performance and durability. This results in improved fuel economy, reduced consumption rate of engine oil and reduced emission of exhaust gases.
- The surface is coated with highly heat-resistant fluoro rubber to support high power output.

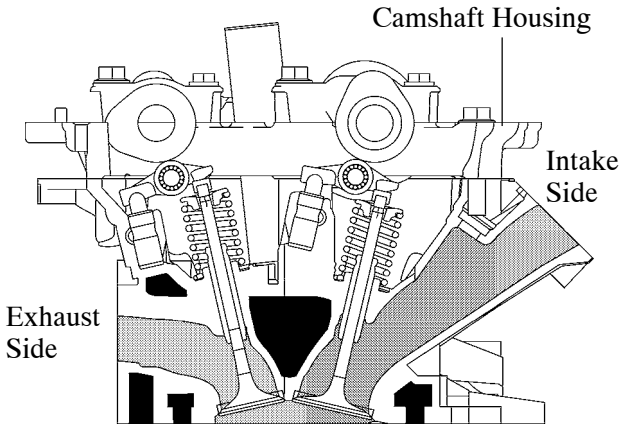


Cylinder Head

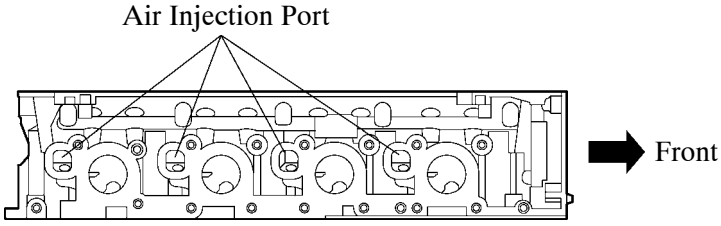
- The cylinder head structure has been simplified by separating the cam journal portion (camshaft housing) from the cylinder head.
- The cylinder head, which is made of aluminum, contains a pentroof type combustion chamber. The spark plug is located in the center of the combustion chamber in order to improve the engine's anti-knocking performance.
- The port configuration is an efficient cross-flow type in which the intake ports face the inside of the V bank and the exhaust ports face the outside.
- A siamese type intake port is used. The port diameter gradually decreases toward the combustion chamber to optimize the airflow speed and intake pulsation.
- An air injection port is provided for the air injection system.



Bottom Side View 080EG31TE



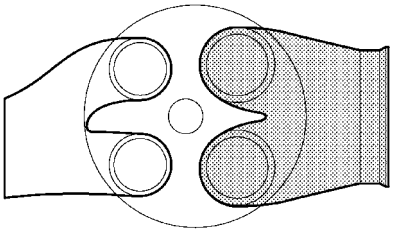
A – A Cross Section 04E1EG09C



Exhaust Side View 04E1EG10C

— REFERENCE —

Siamese Type



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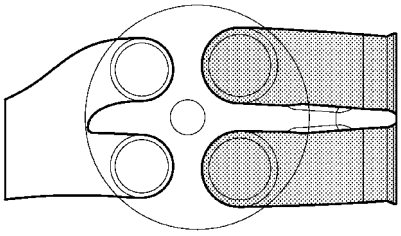
Independent Type



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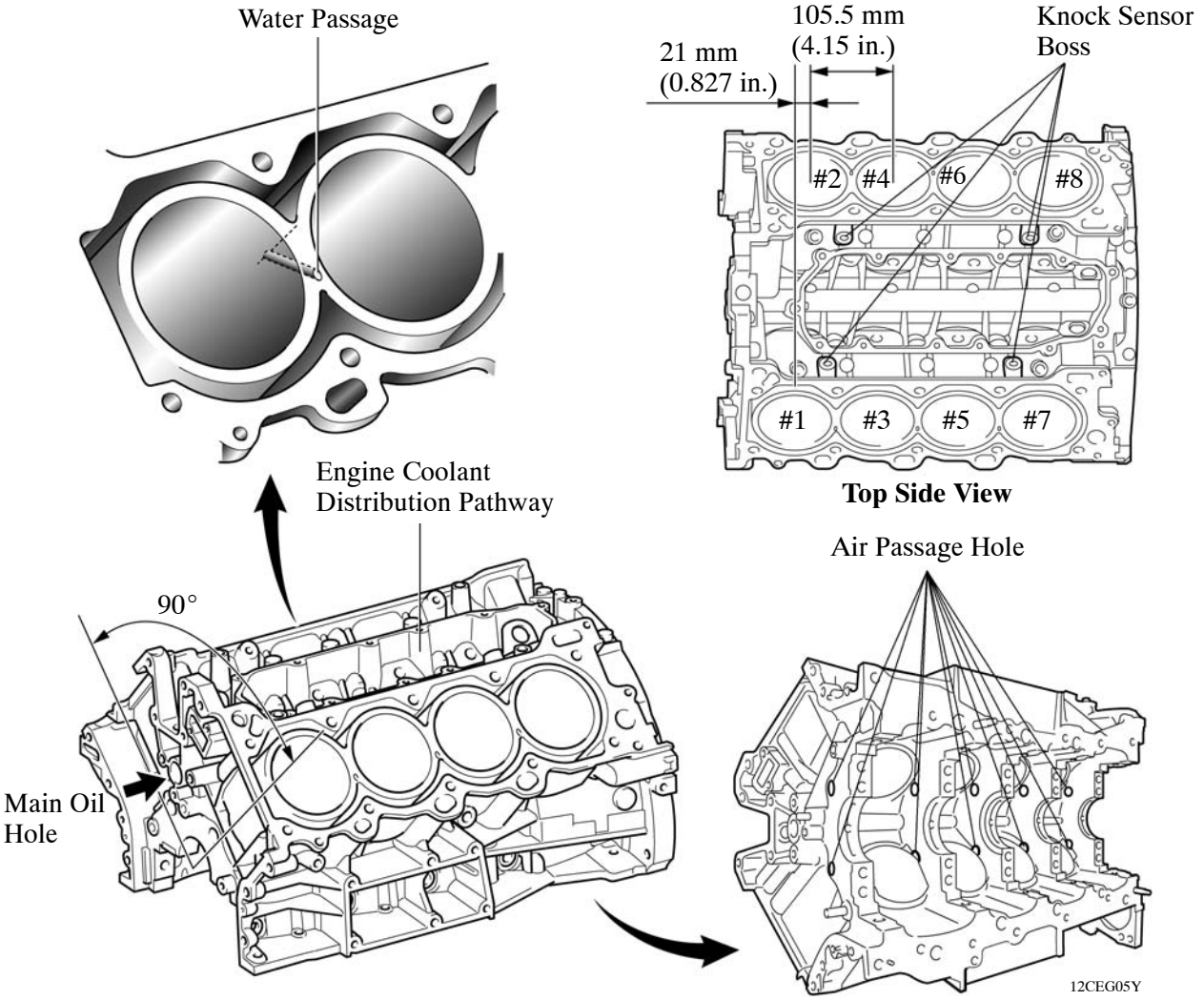
Cylinder Block

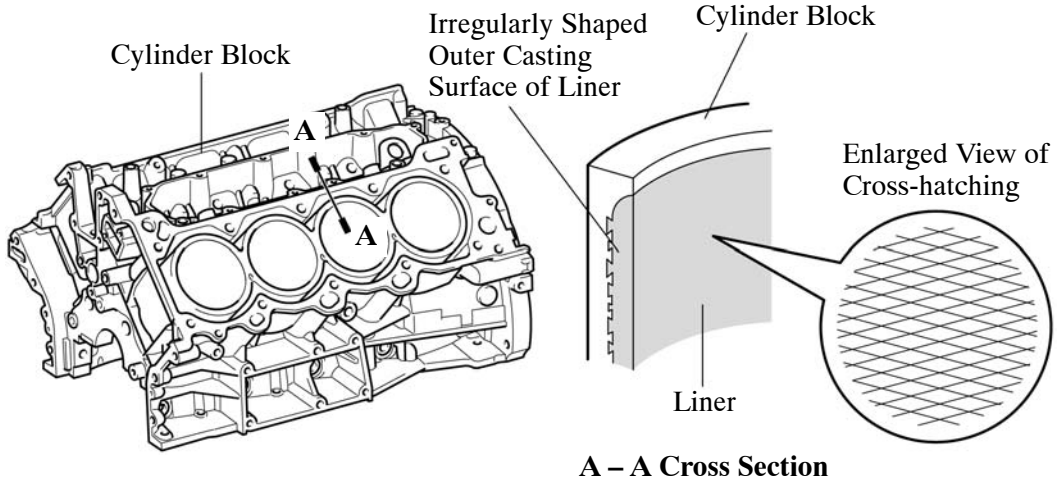
1) General

- The cylinder block is made of aluminum alloy.
- The cylinder block has a bank angle of 90°, a bank offset of 21 mm (0.827 in.) and a bore pitch of 105.5 mm (4.15 in.), resulting in a compact block in its length and width considering its displacement.
- Spiny-type liners are used.
- An engine coolant distribution pathway is provided between the left and right banks. The engine coolant sent by the water pump passes through the engine coolant distribution pathway and flows to the cylinder head and water jackets of both banks. The engine coolant distribution pathway also cools the engine oil in the main oil hole located directly below the pathway.
- A water passage is provided between the cylinder bores. By allowing the engine coolant to flow between the cylinder bores, this construction keeps the temperature of the cylinder walls uniform.
- Plastic cylinder block water jacket spacers are inserted in the water jacket. They control the flow of the engine coolant in order to attain a uniform temperature around the combustion chambers.
- Installation bosses of the 4 knock sensors are located on the inner side of the left and right banks to enhance the accuracy of the knock sensors.
- Air passage holes are provided on the bulkheads of the cylinder block. As a result, the air at the bottom of the cylinder flows smoother, and pumping loss (back pressure at the bottom of the piston generated by the piston's reciprocating movement) is reduced to improve the engine's output.



2) Spiny-type Liner

- The liners are the spiny-type which have been manufactured so that their casting exteriors form large irregular surfaces in order to enhance the adhesion between the liners and the aluminum cylinder block. The enhanced adhesion helps heat dissipation, resulting in a lower overall temperature and heat deformation of the cylinder bores.
- The shape of the cross-hatching of the liner surface has been optimized to improve oil retention performance, resulting in reduced friction.



A – A Cross Section

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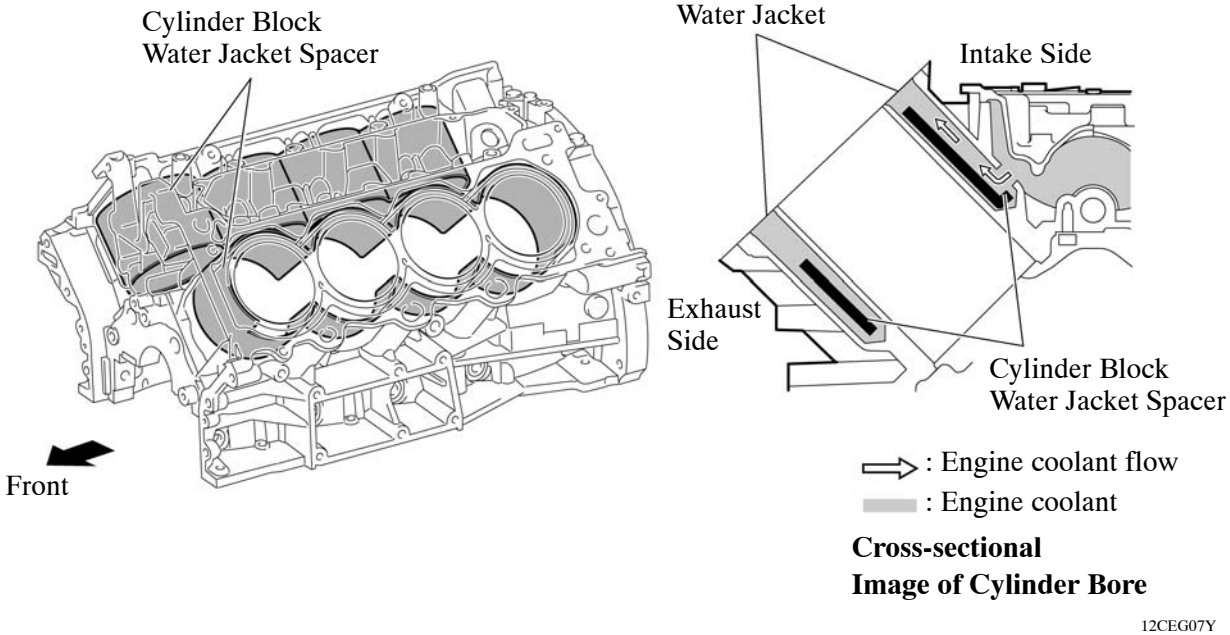
3) Cylinder Block Water Jacket Spacer

The temperature in the intake side of the cylinder bore tends to be lower. For this reason, a wide cylinder block water jacket spacer covers the cylinder bores in order to suppress the flow of the engine coolant and prevent excessive cooling. On the other hand, the temperature of the exhaust side of the cylinder bore tends to be higher. A cylinder block water jacket spacer covers the lower area of the cylinder bores in order to direct the engine coolant to the upper area of the cylinder bores where the temperature is higher. This makes the temperature around the cylinder bores more uniform. As a result, the viscosity of the engine oil (which lubricates the area between the wall surface of the cylinder bore and the piston) decreases, thus reducing friction between the cylinder bore and the piston.



Cross-sectional
Image of Cylinder Bore

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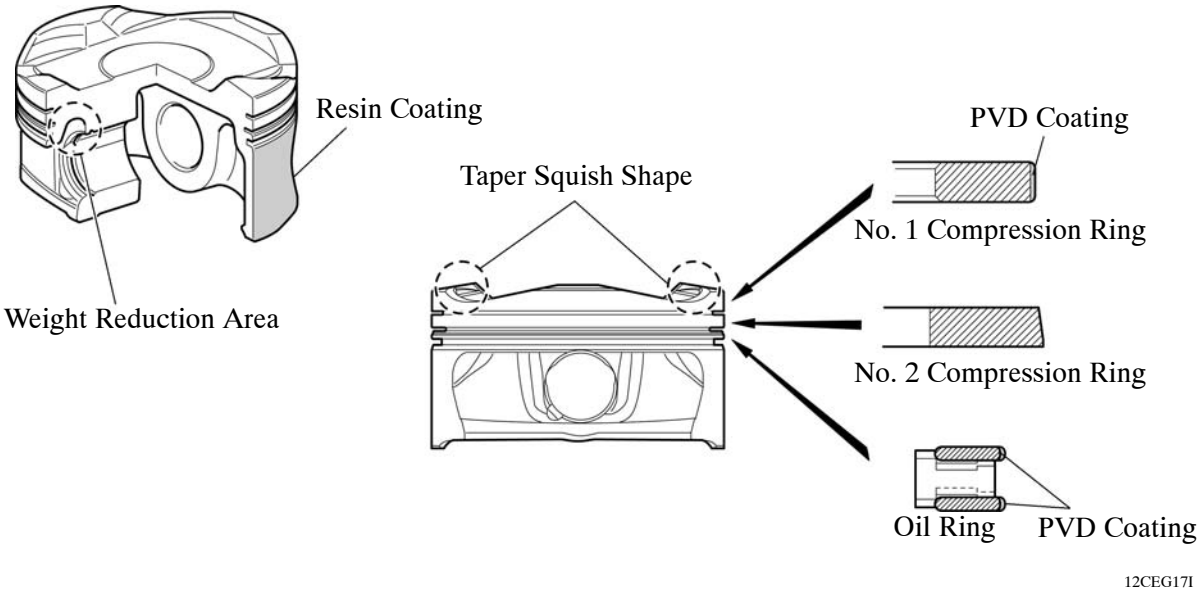
Piston

- The pistons are made of aluminum alloy.
- A compact combustion chamber is provided on top of the piston to achieve stable combustion. Together with the pentroof type combustion chamber of the cylinder head, this achieves a high compression ratio, resulting in both high performance and excellent fuel economy.
- A taper squish combustion chamber is used to improve anti-knocking performance and intake efficiency. In addition, engine performance and fuel economy are improved.
- In order to reduce weight, cast holes are provided on the bottom of the piston head near the pin bosses as shown in the illustration below.
- The piston skirt is coated with resin to reduce friction losses.
- A Physical Vapor Deposition (PVD) coating has been applied to the surface of the No. 1 compression ring and oil ring, in order to improve its wear resistance.
- By increasing the machining precision of the cylinder bore diameter in the block, only one size of piston is required.

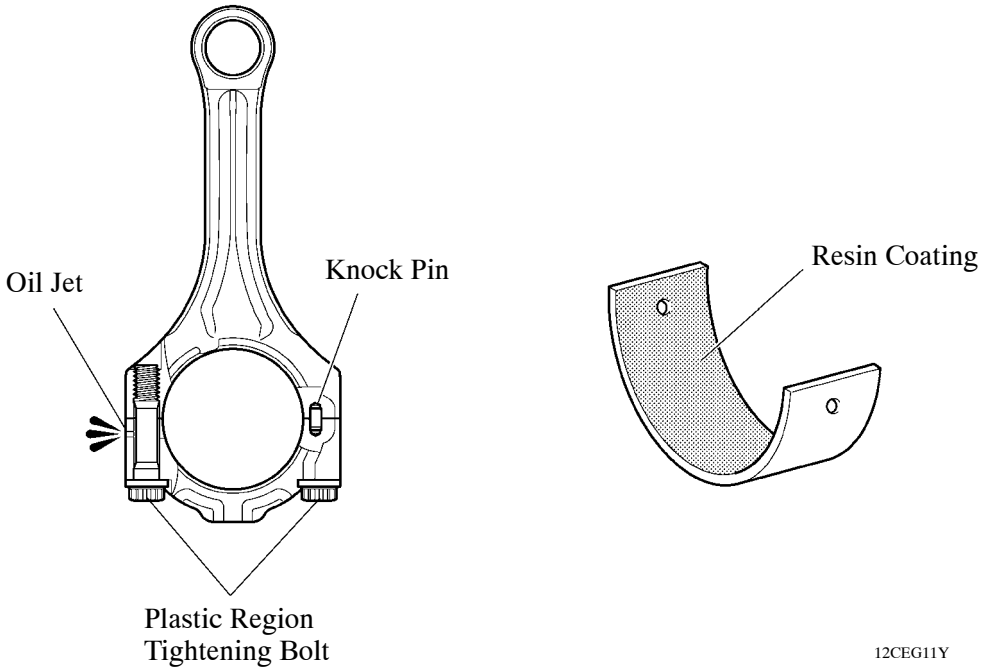


Service Tip

The same pistons are used for both right and left banks. When installing a piston, the front mark should face the front of the engine.

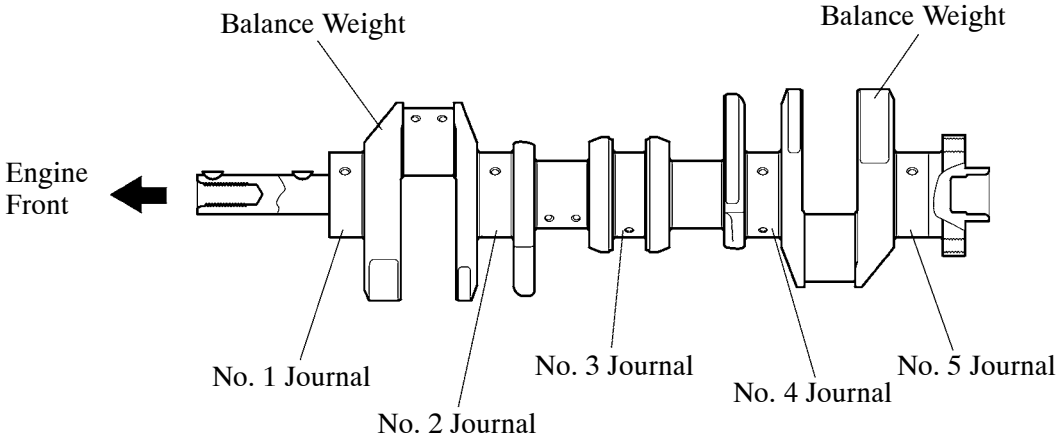
Connecting Rod and Connecting Rod Bearing

- Connecting rods that have been forged for high strength are used for weight reduction.
- Knock pins are used at the mating surfaces of the bearing caps of the connecting rod to minimize the shifting of the bearing caps during assembly.
- Plastic region tightening bolts are used on the connecting rods.
- Resin-coated aluminum bearings are used for the connecting rod bearings. The connecting rod bearings are reduced in width to reduce friction.



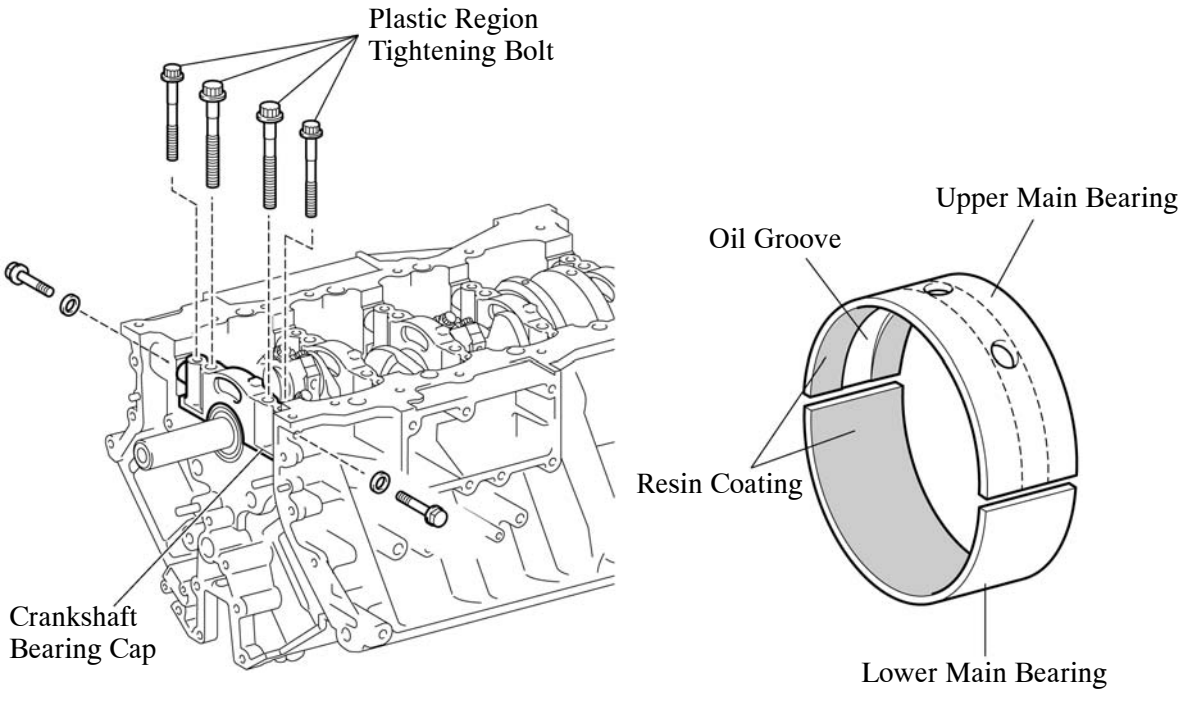
Crankshaft

- A crankshaft made of forged steel, which excels in rigidity and wear resistance, is used.
- The crankshaft has 5 main bearing journals and 6 balance weights.



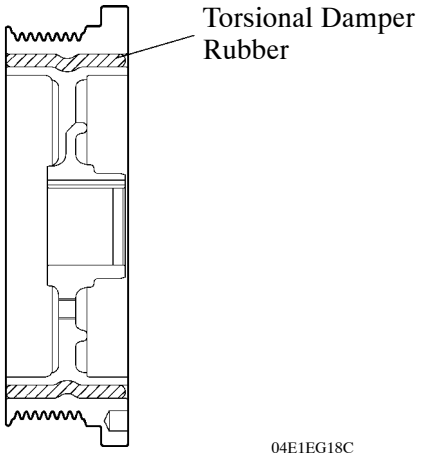
Crankshaft Bearing and Crankshaft Bearing Cap

- The crankshaft bearings are made of aluminum alloy.
- The crankshaft bearings are reduced in width to reduce friction. The bearing lining surface is coated with resin to improve wear and seizure resistance.
- The upper crankshaft bearing has an oil groove around its inside circumference.
- The crankshaft bearing caps use 4 plastic region tightening bolts of different sizes in the inner and outer sides to secure the journals. This makes the crankshaft bearing caps more compact and lightweight. In addition, each cap has been tightened laterally to improve its reliability.



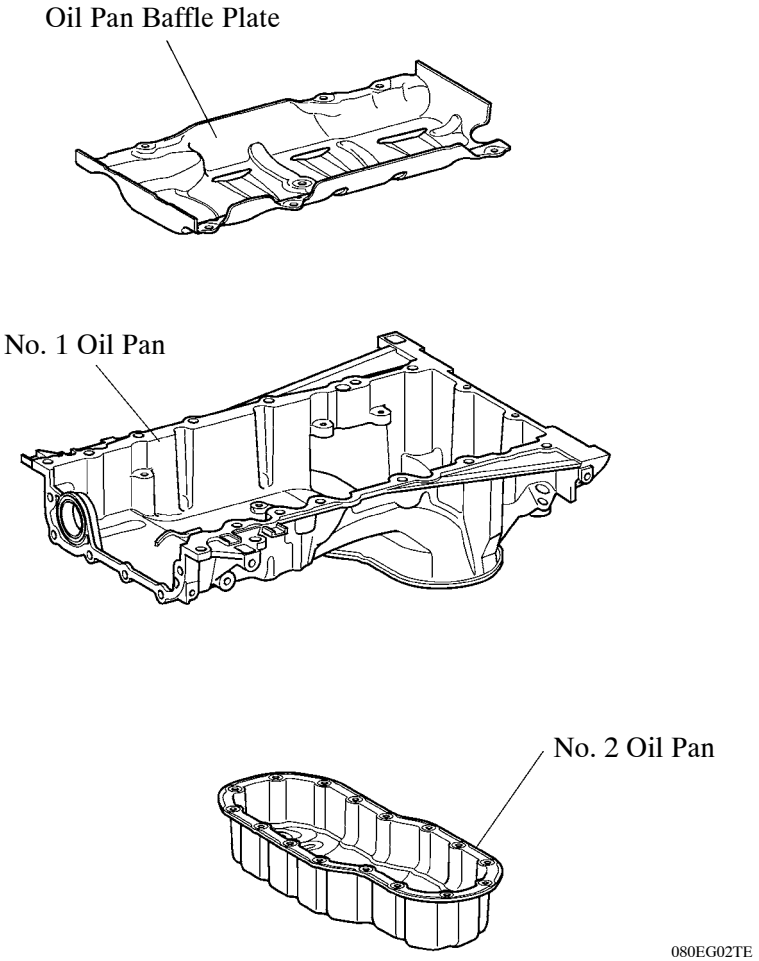
Crankshaft Pulley

The crankshaft pulley uses torsional damper rubber and has been optimized to reduce noise and vibration.



Oil Pan

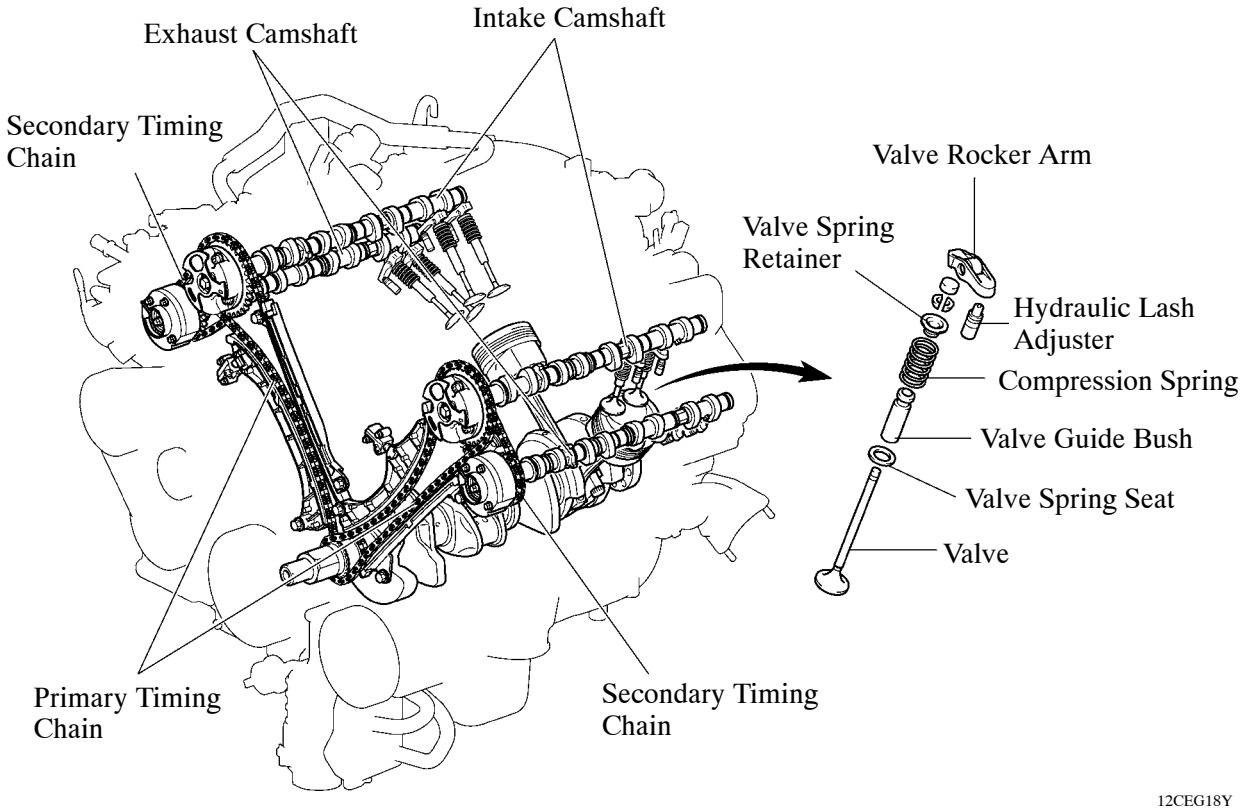
- The No. 1 oil pan is made of aluminum alloy.
- The No. 1 oil pan is secured to the cylinder block and the transmission housing to increase rigidity.
- The shape of the oil pan baffle plate has been optimized to ensure the proper space between the crankshaft and the engine oil surface. This enhances the separation of oil flow and ventilation gases, thus reducing friction and improving lubrication performance.



4. Valve Mechanism

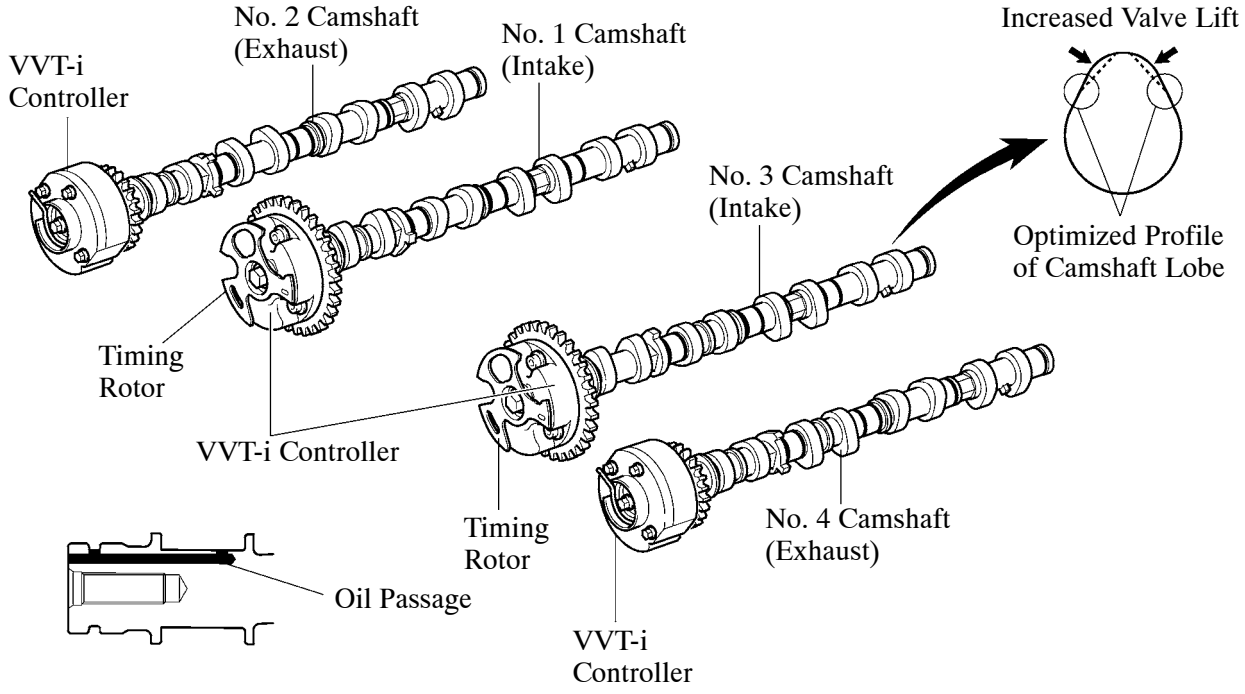
General

- Each cylinder of this engine has 2 intake valves and 2 exhaust valves. Intake and exhaust efficiency has been increased due to the larger total port areas.
- This engine uses roller rocker arms with built-in needle bearings. This reduces the friction that occurs between the cams and the valve rocker arms that push the valves down, thus improving fuel economy.
- A hydraulic lash adjuster, which maintains a constant zero valve clearance through the use of oil pressure and spring force, is used.
- To ensure highly accurate valve timing, separate primary timing chains are driven by the crankshaft in order to rotate the intake camshafts of the left and right banks. The exhaust camshafts are driven by the intake camshaft of the respective bank via secondary timing chains.
- This engine has a Dual Variable Valve Timing-intelligent (Dual VVT-i) system which controls the intake and exhaust camshafts to provide optimal valve timing in accordance with driving conditions. Using this system, lower fuel consumption, higher engine performance, and lower exhaust emissions have been achieved. For details of Dual VVT-i control, see page 78.

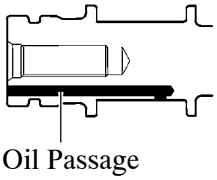


Camshaft

- The camshafts are made of cast iron alloy.
- Oil passages are provided in the intake and exhaust camshafts in order to supply engine oil to the VVT-i system.
- VVT-i controllers are installed on the front of the intake and exhaust camshafts to vary the timing of the intake and exhaust valves.
- Together with the use of the roller rocker arms, the cam profile has been optimized. This results in increased valve lift when the valve begins to open and when it finishes closing, helping to achieve enhanced output performance.



Cross Section of End of Intake Camshaft



Cross Section of End of Exhaust Camshaft

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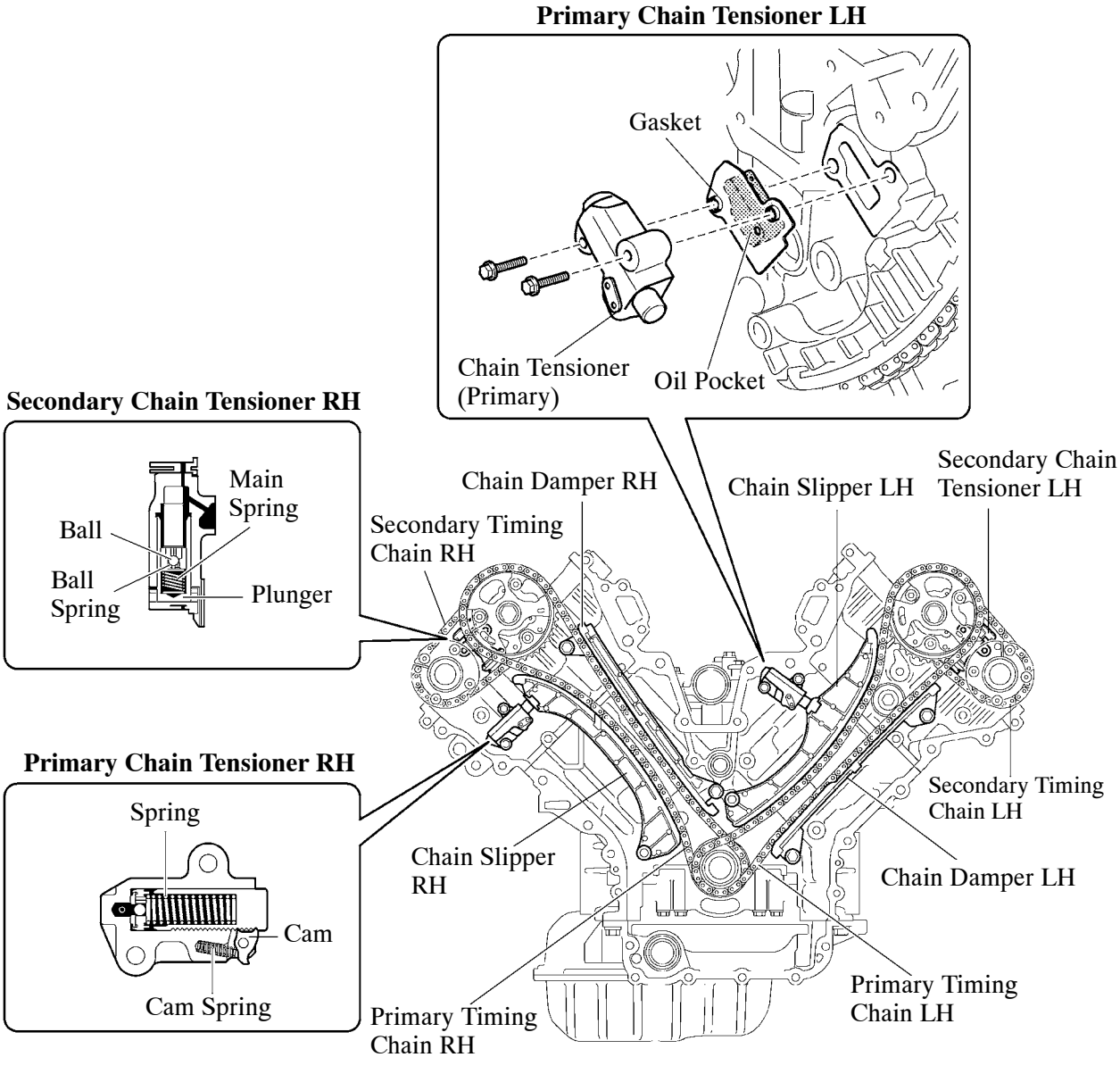
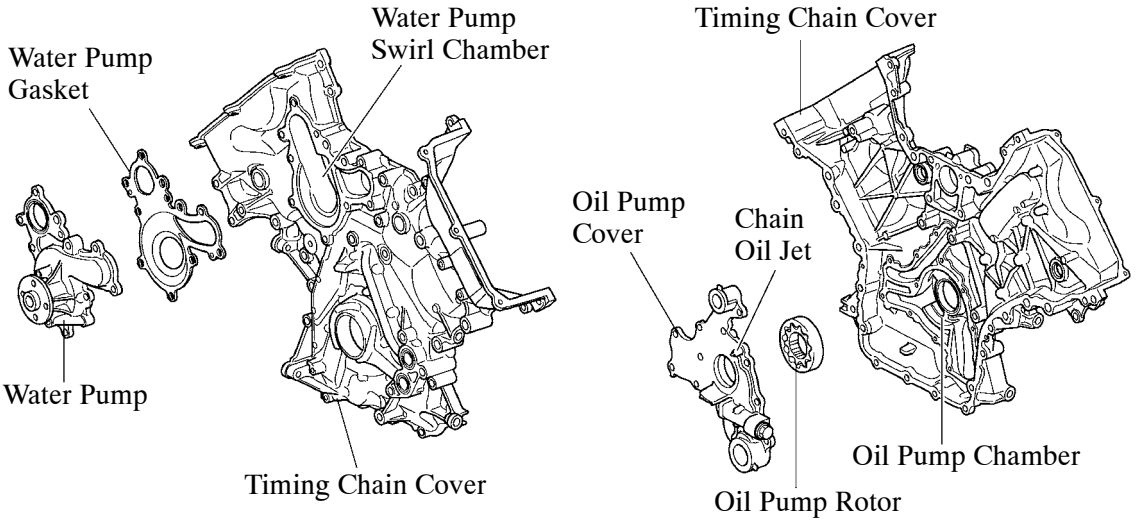
Timing Chains and Chain Tensioners

- Both the primary and secondary timing chains use roller chains with a pitch of 9.525 mm (0.375 in.).
- A chain tensioner is provided for each primary timing chain and secondary timing chain in each bank.
- Both the primary and secondary chain tensioners use oil pressure and a spring to maintain proper chain tension at all times. The tensioners suppress noise generated by the timing chains.
- The chain tensioner for the primary timing chain is a ratchet type with a non-return mechanism. Furthermore, an oil pocket creates oil pressure when the engine is started, and simultaneously applies oil pressure to the chain tensioner. This prevents the timing chain from flapping and reduces noise.



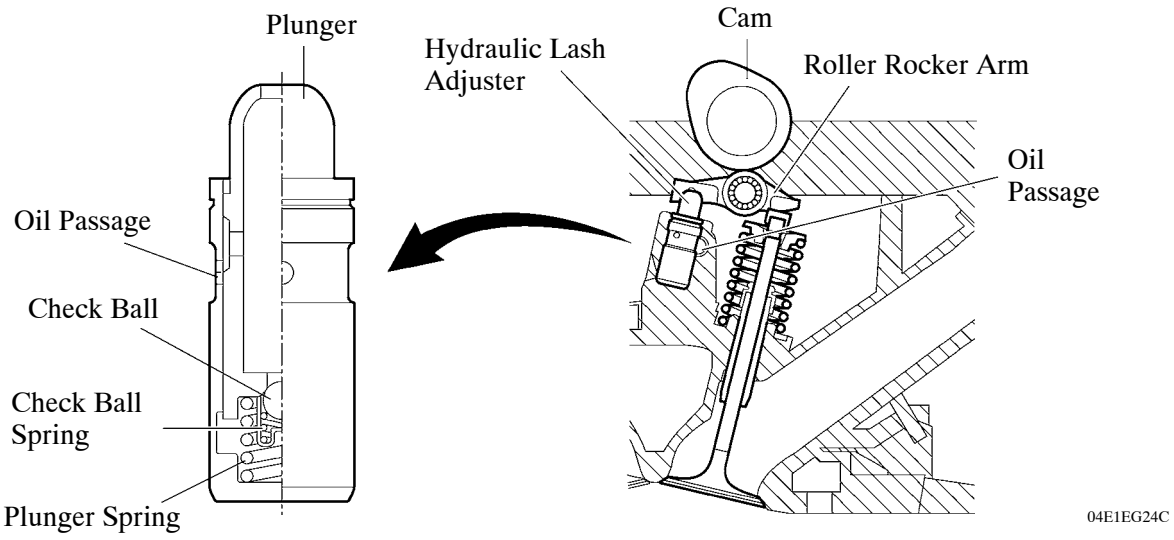
Timing Chain Cover

- The timing chain cover has an integrated construction consisting of a cooling system (water pump and water passage) and a lubrication system (oil pump and oil passage). Thus, the number of parts has been reduced, resulting in a weight reduction.
- A chain oil jet is provided in the oil pump cover to lubricate the timing chains.



Hydraulic Lash Adjuster

- The hydraulic lash adjuster, which is located at the fulcrum (pivot point) of the roller rocker arms, consists primarily of a plunger, a plunger spring, a check ball, and a check ball spring.
- The engine oil supplied from the cylinder head and the built-in spring actuate the hydraulic lash adjuster. The oil pressure and the spring force, that act on the plunger, push the roller rocker arm against the cam, in order to adjust the clearance between the valve stem and rocker arm. This prevents the generation of noise during the opening and closing of the valves. As a result, engine noise has been reduced.



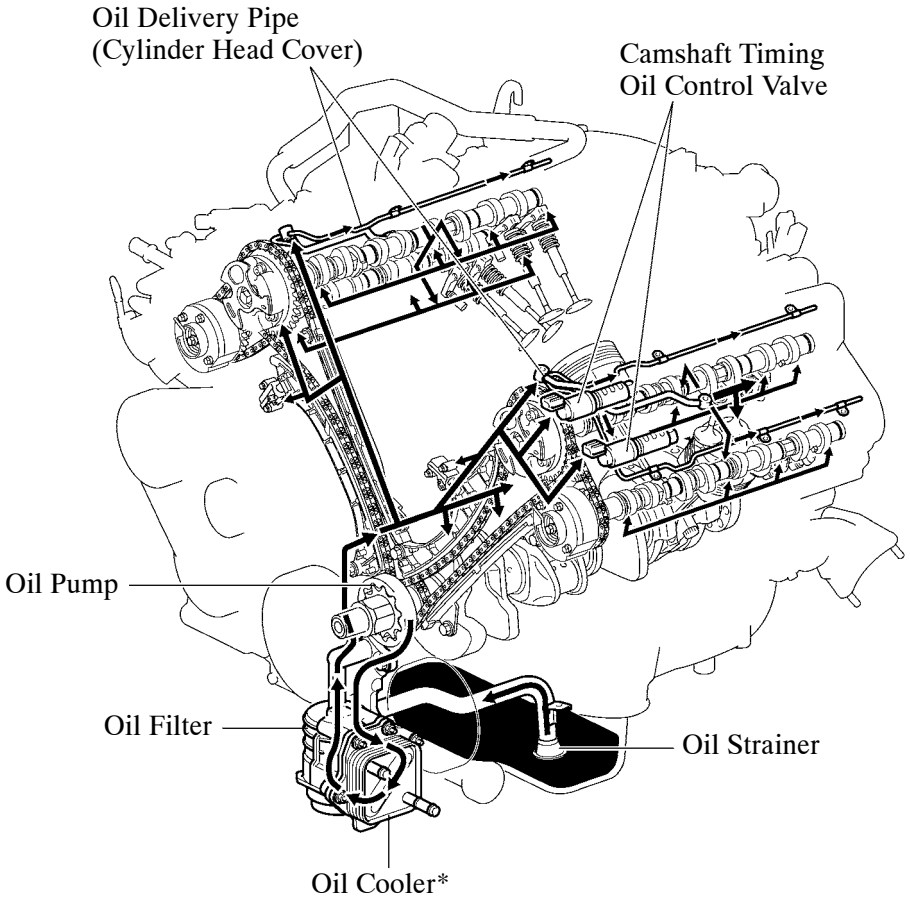
Service Tip

Valve clearance adjustment is not necessary because hydraulic lash adjusters are used on this model.

5. Lubrication System

General

- The lubrication circuit is fully pressurized and oil passes through an oil filter.
- A cycloid rotor type oil pump is used.
- An oil filter with a replaceable element is used.
- A water-cooled type oil cooler is provided as optional equipment.



*: Models with towing package

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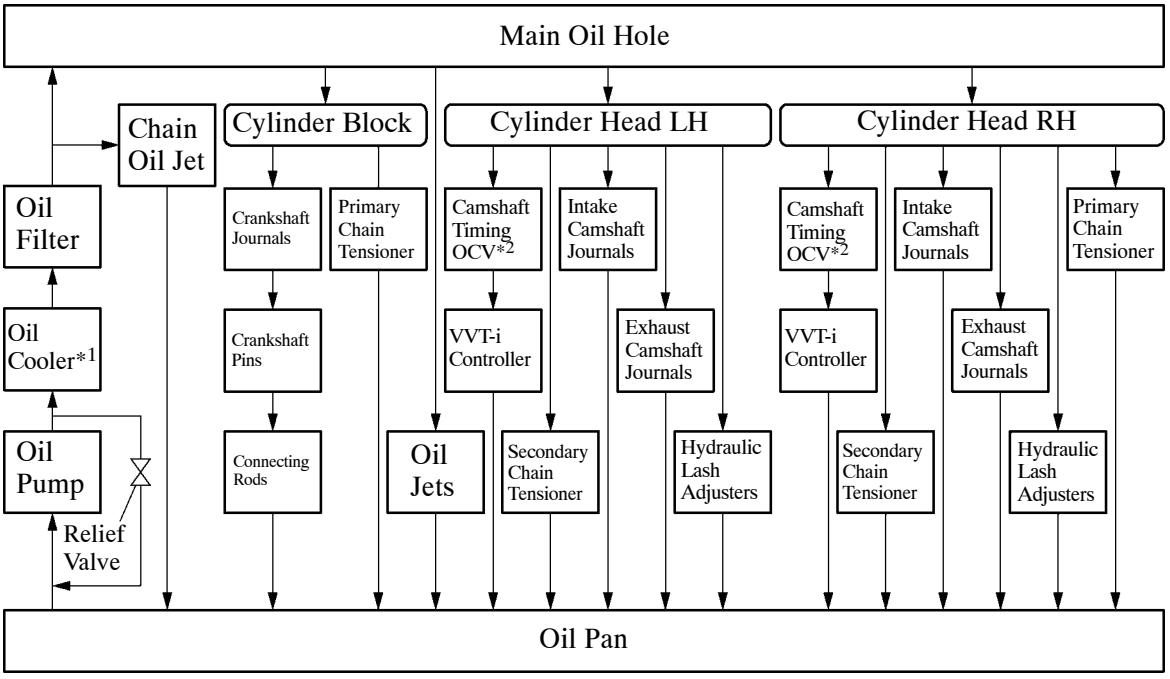
▶ Oil Circuit ◀

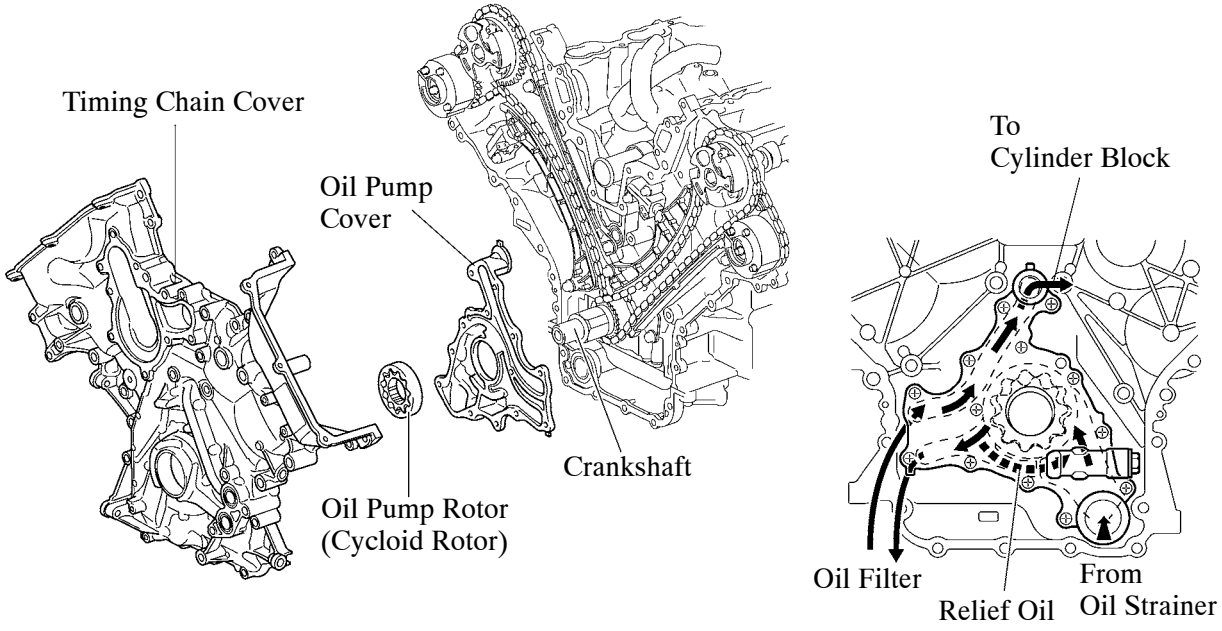


*1: Models with towing package
*2: Oil Control Valve

04E1EG26C

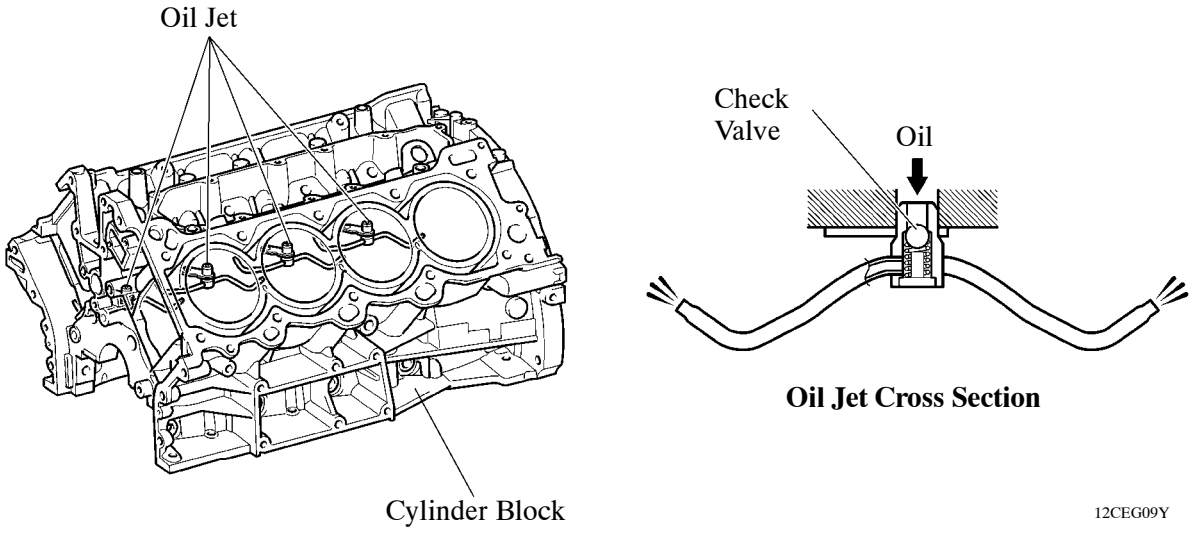
Oil Pump

- A compact cycloid rotor type oil pump, directly driven by the crankshaft, is used.
- This oil pump uses an internal relief method which circulates relief oil to the suction passage in the oil pump. This aims to minimize oil level change in the oil pan, reduce friction, and reduce the air mixing rate in the oil.



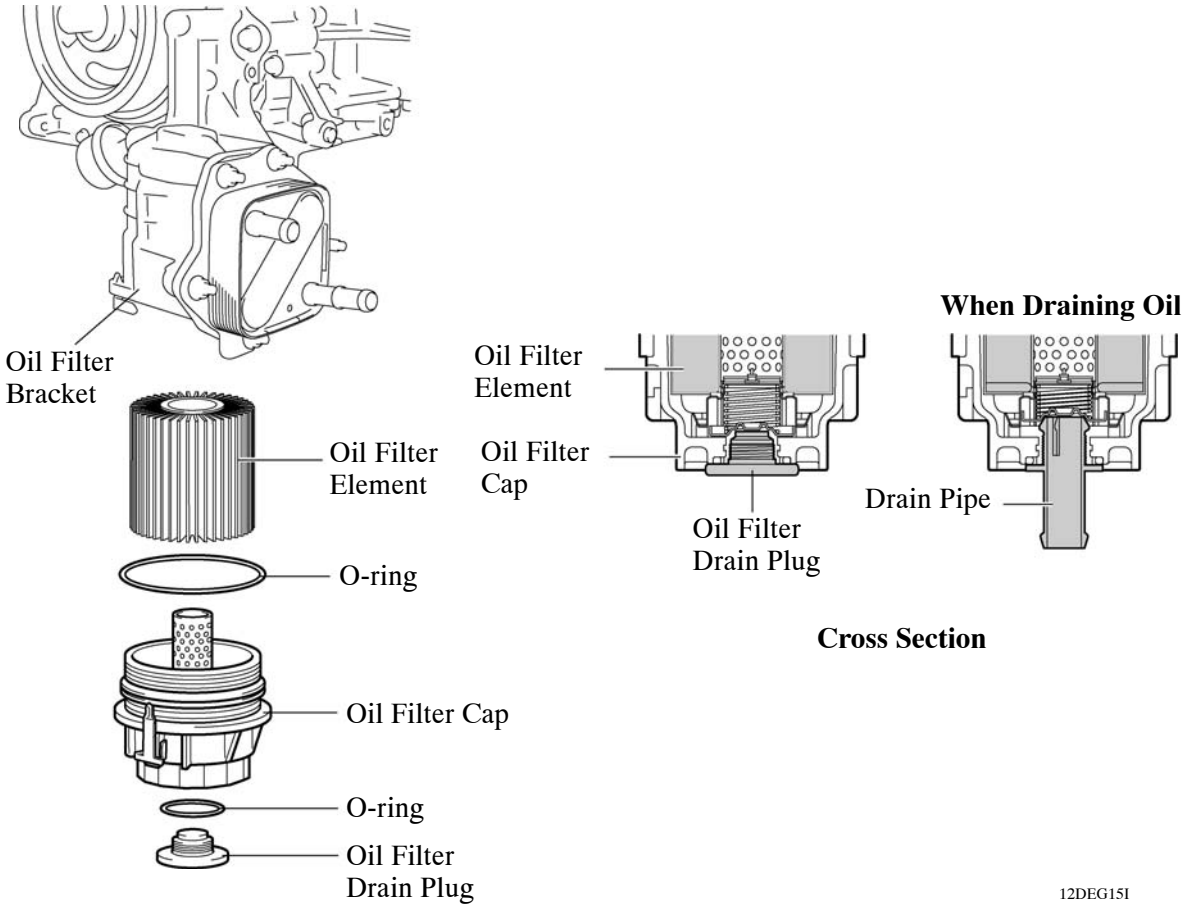
Oil Jet

- 4 oil jets for cooling and lubricating the pistons are provided in the cylinder block, in the center of the right and left banks.
- These oil jets contain a check valve to prevent oil from being fed when the oil pressure is low. This prevents the overall oil pressure in the engine from dropping.



Oil Filter

- A newly developed oil filter with a replaceable element is used. The oil filter element uses high-performance filter paper to improve filtration performance. It is also burnable for environmental protection.
- A plastic oil filter cap is used for weight reduction.
- This oil filter has a structure which can drain the oil remaining in the oil filter. This prevents oil from spattering when the element is replaced and allows the technician to work without touching hot oil.

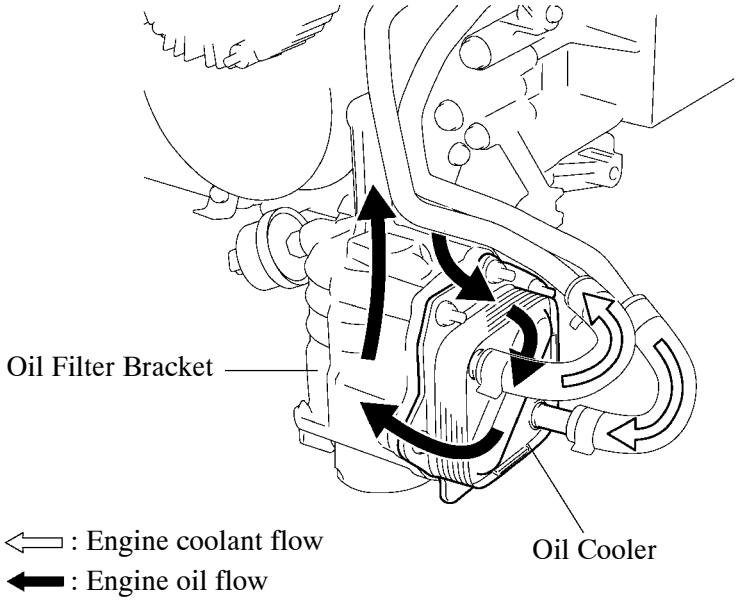


Service Tip

- The oil in the oil filter can be drained by removing the oil filter drain plug and inserting the drain pipe supplied with the element into the oil filter. For details, refer to the 2010 TOYOTA TUNDRA Repair Manual.
- The engine oil maintenance interval for a model that has an oil filter with a replaceable element is the same as that for the conventional model.

Oil Cooler

- To suppress the increase in oil temperature while towing and to improve reliability, a water-cooled oil cooler is used.
- This oil cooler uses a square-shaped laminated aluminum core to achieve a lightweight, compact size, and high heat radiation.

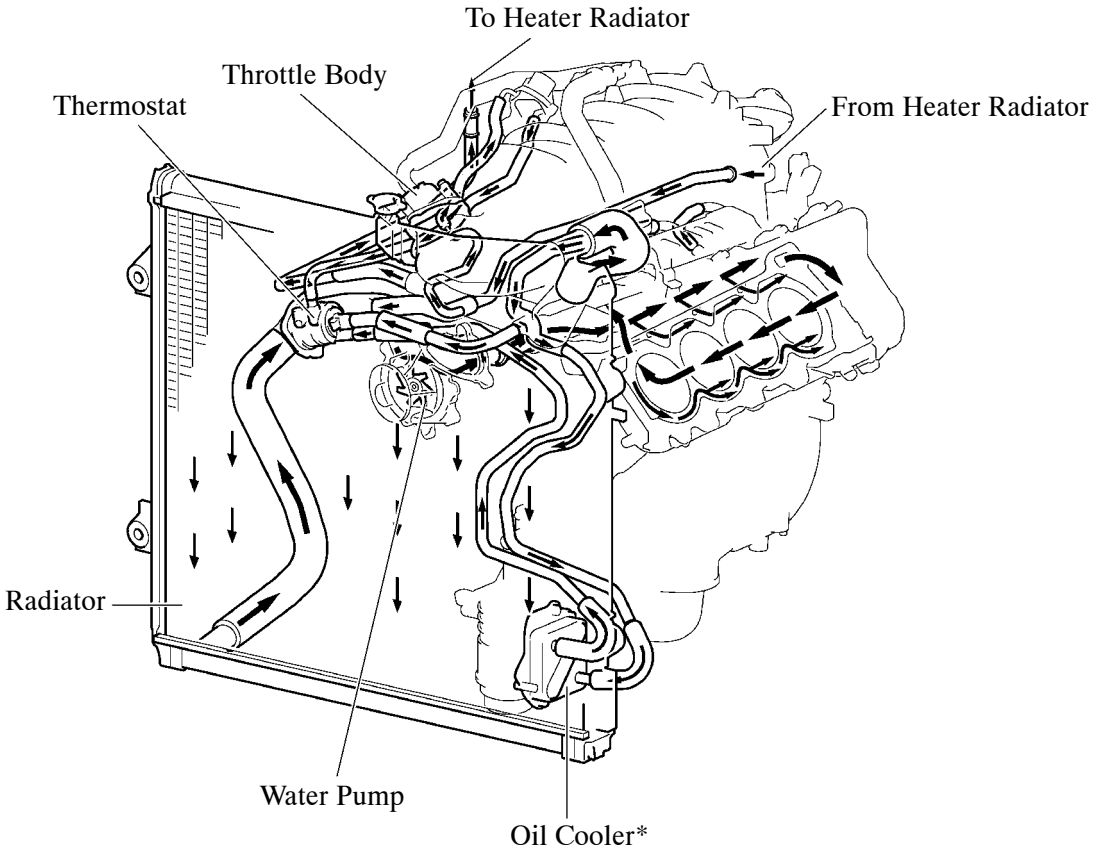


11YEG11Y

6. Cooling System

General

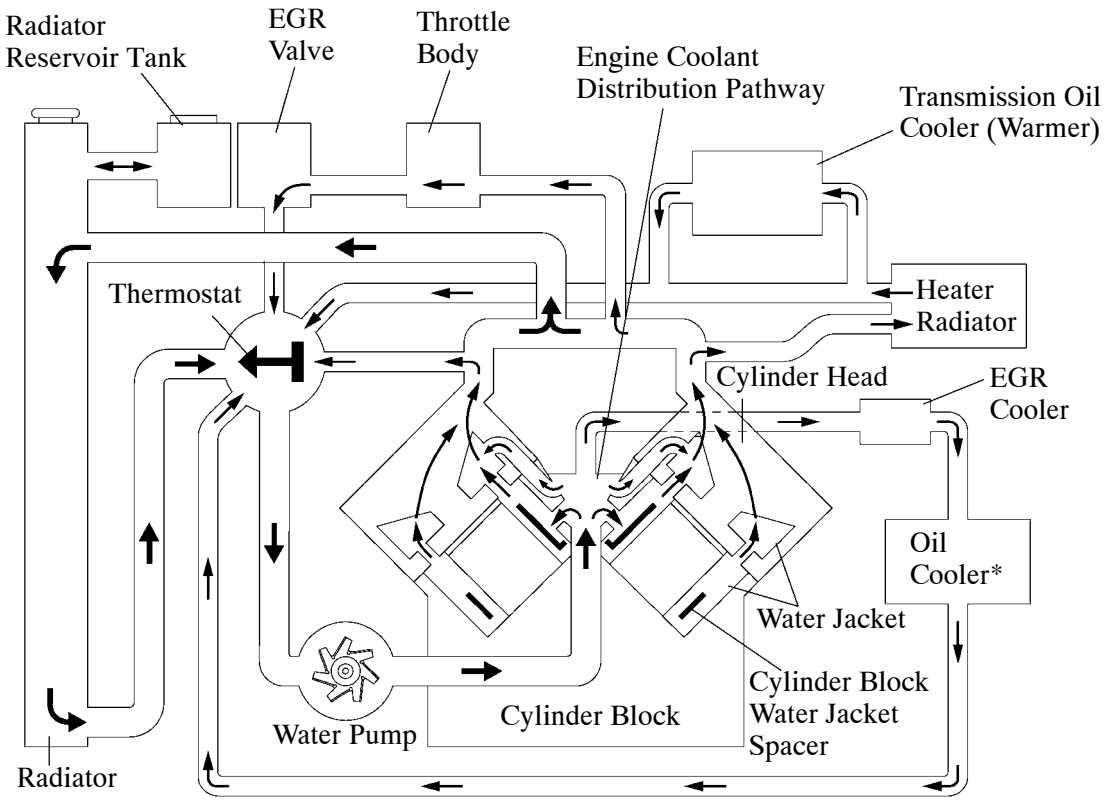
- The cooling system uses a pressurized forced circulation system with an open air type reservoir tank.
- An engine coolant distribution pathway is provided between the left and right banks of the cylinder block.
- A thermostat with a bypass valve is located on the plastic water inlet to maintain suitable temperature distribution in the cooling system.
- An aluminum radiator core is used for weight reduction.
- A 2-stage temperature-controlled coupling fan is used. It rotates at lower speeds when the engine is cold to minimize fan noise.
- Toyota Genuine Super Long Life Coolant (SLLC) is used as the engine coolant.



*: Models with towing package

12CEG39Y

▶ Water Circuit ◀



*: Models with towing package

12CEG40I

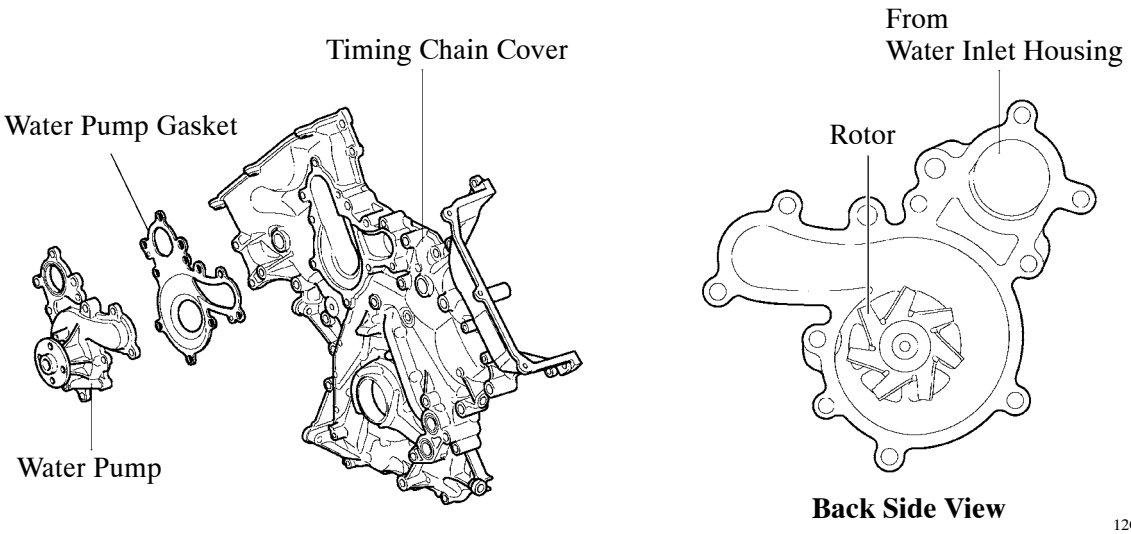
▶ Specifications ◀

Engine Coolant Type		Toyota Genuine Super Long Life Coolant (SLLC) or similar high quality ethylene glycol based non-silicate, non-amine, non-nitrite and non-borate coolant with long-life hybrid organic acid technology (coolant with long-life hybrid organic acid technology is a combination of low phosphates and organic acids). Do not use plain water alone.
Color		Pink
Maintenance Intervals	First Time	100000 miles (160000 km)
	Subsequent	Every 50000 miles (80000 km)
Thermostat	Opening Temperature	80°C to 84°C (176°F to 183°F)

SLLC is pre-mixed (models for U.S.A. : 50% coolant and 50% deionized water, models for Canada: 55% coolant and 45% deionized water). Therefore, no dilution is needed when SLLC in the vehicle is added to or replaced.

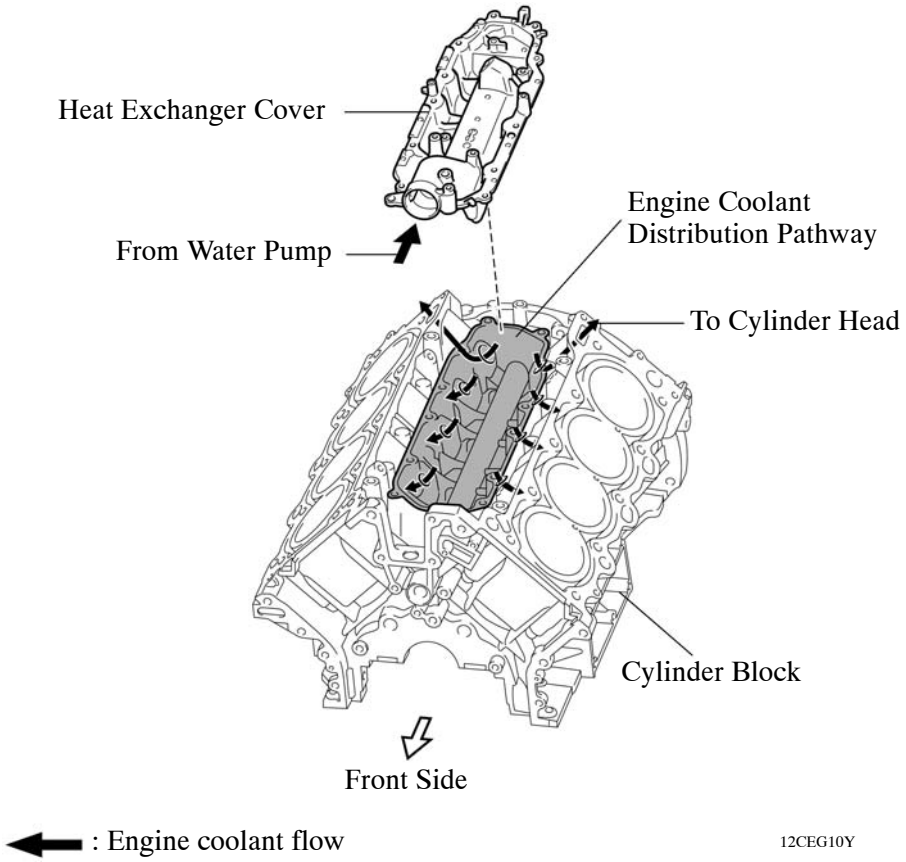
Water Pump

- A rust-resistant water pump rotor made of stainless steel is used.
- The water pump circulates the engine coolant to the engine coolant distribution pathway located between the left and right banks of the cylinder block.



Engine Coolant Distribution Pathway

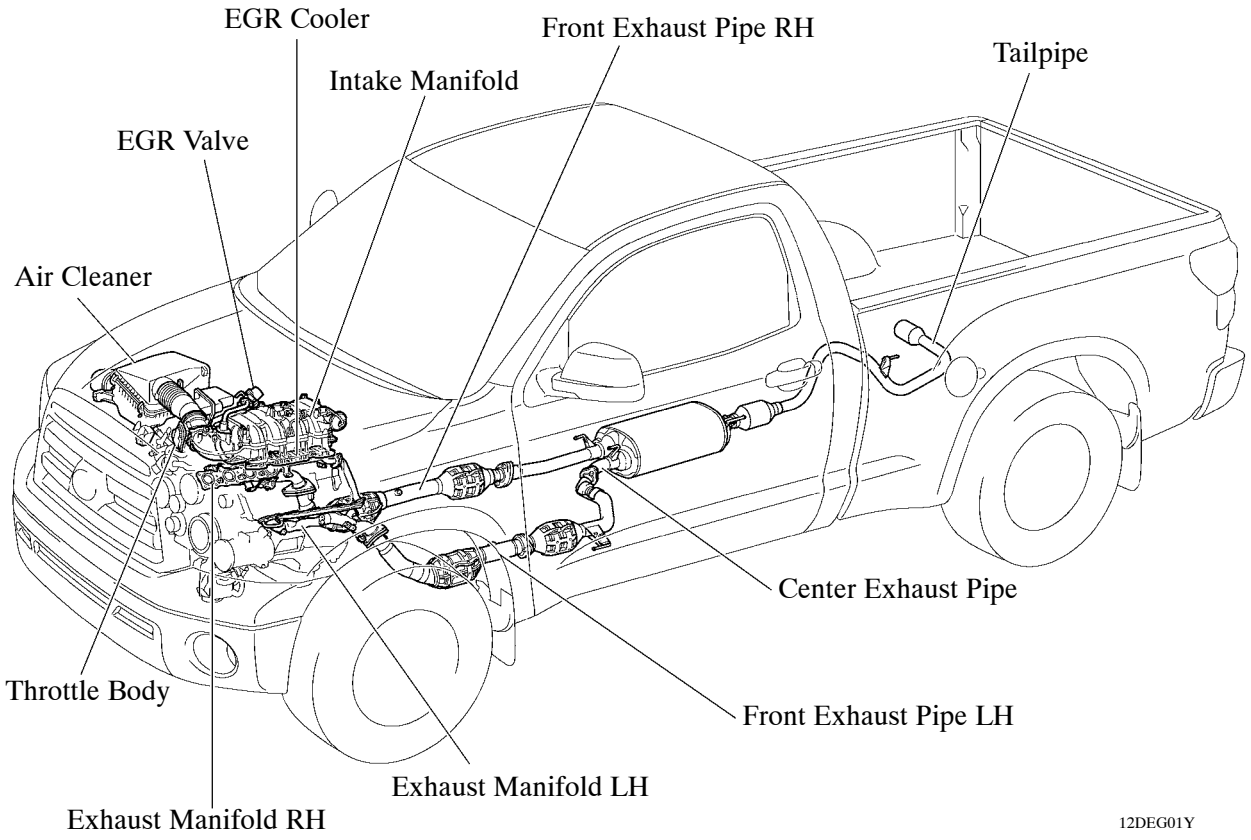
The water pump circulates the engine coolant and directs it to the engine coolant distribution pathway located between the left and right banks. From there, the engine coolant is uniformly distributed to each cylinder of the cylinder block, and is also directly discharged to the cylinder heads. As a result, the cooling performance of the cylinder heads is assured and reliability is improved.



7. Intake and Exhaust System

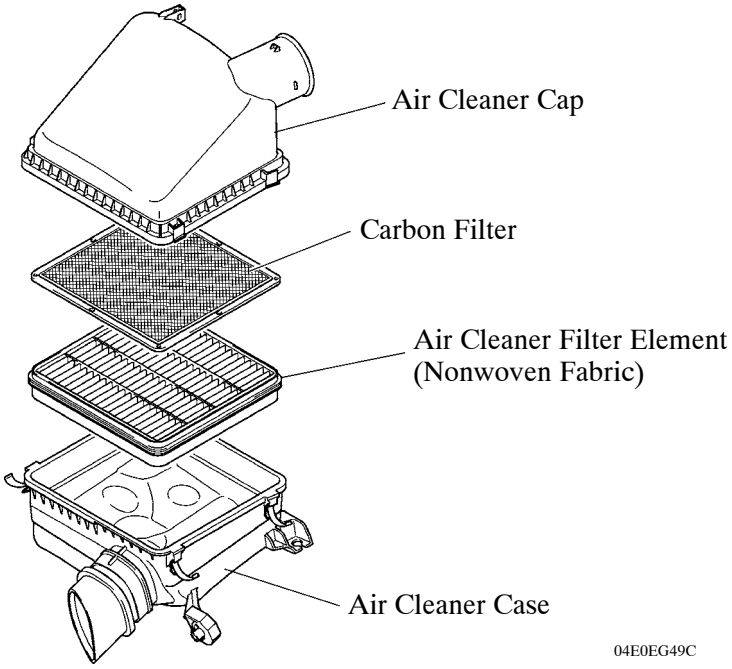
General

- A linkless-type throttle body is used, thus achieving excellent throttle control.
- The Electronic Throttle Control System-intelligent (ETCS-i) is used to ensure excellent throttle control in all operating ranges. For details, see page 73.
- The Acoustic Control Induction System (ACIS) is used to improve engine performance in all speed ranges. For details, see page 84.
- A plastic intake manifold is used.
- A step motor type EGR valve and a water-cooled EGR cooler are used in order to improve fuel economy.
- Stainless steel exhaust manifolds and exhaust pipes are used.



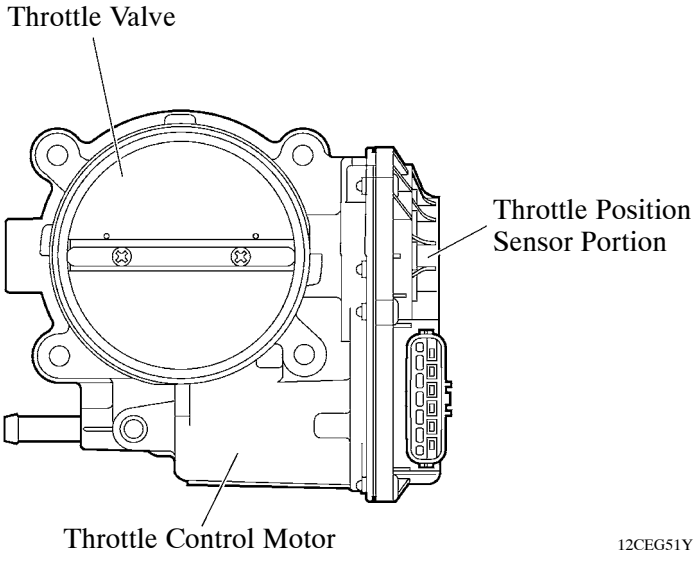
Air Cleaner

- A nonwoven, fabric type air cleaner filter element is used.
- A carbon filter, which absorbs the HC that accumulates in the intake system when the engine is stopped, is used in the air cleaner case in order to reduce evaporative emissions. This filter is maintenance-free.



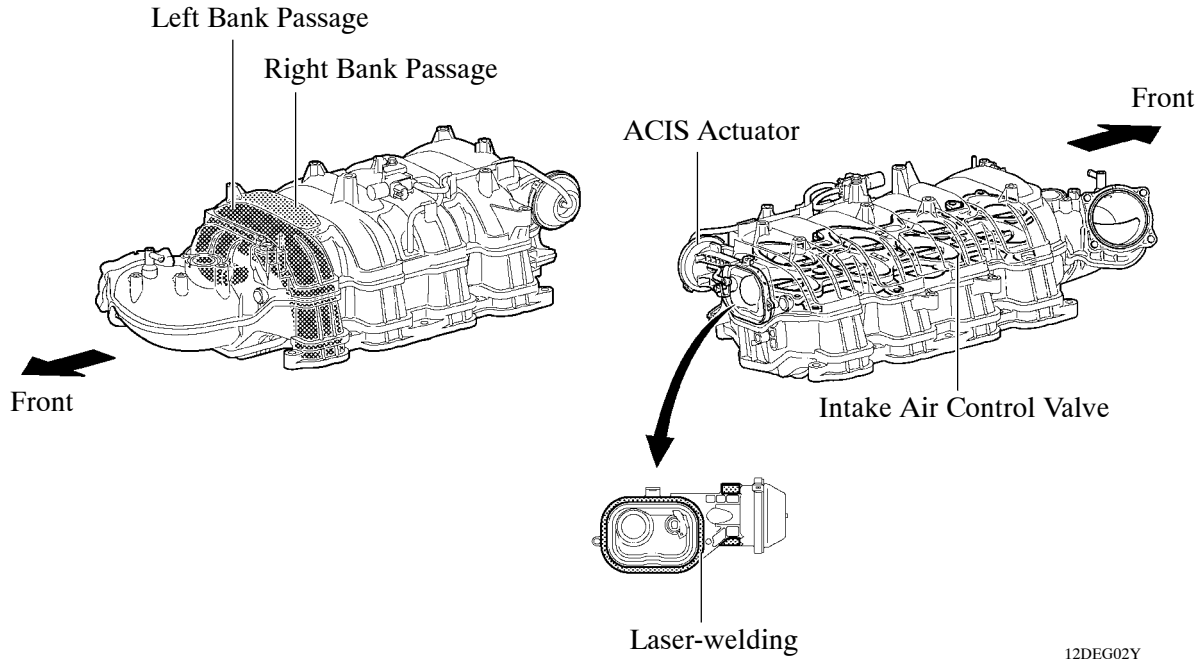
Throttle Body

- A linkless-type throttle body, in which the throttle position sensor and the throttle control motor are integrated, is used. It achieves excellent throttle valve control.
- For the throttle control motor, a DC motor with excellent response and minimal power consumption is used. The ECM performs duty cycle control of the direction and the amperage of the current supplied to the throttle control motor in order to regulate the throttle valve angle.



Intake Manifold

- An intake manifold with a built-in plastic intake air chamber is used for weight reduction.
- The diameter and length of the port have been optimized to achieve high torque in all driving ranges.
- The intake manifold contains valves for the Acoustic Control Induction System (ACIS), and the actuator is laser-welded to the intake manifold.



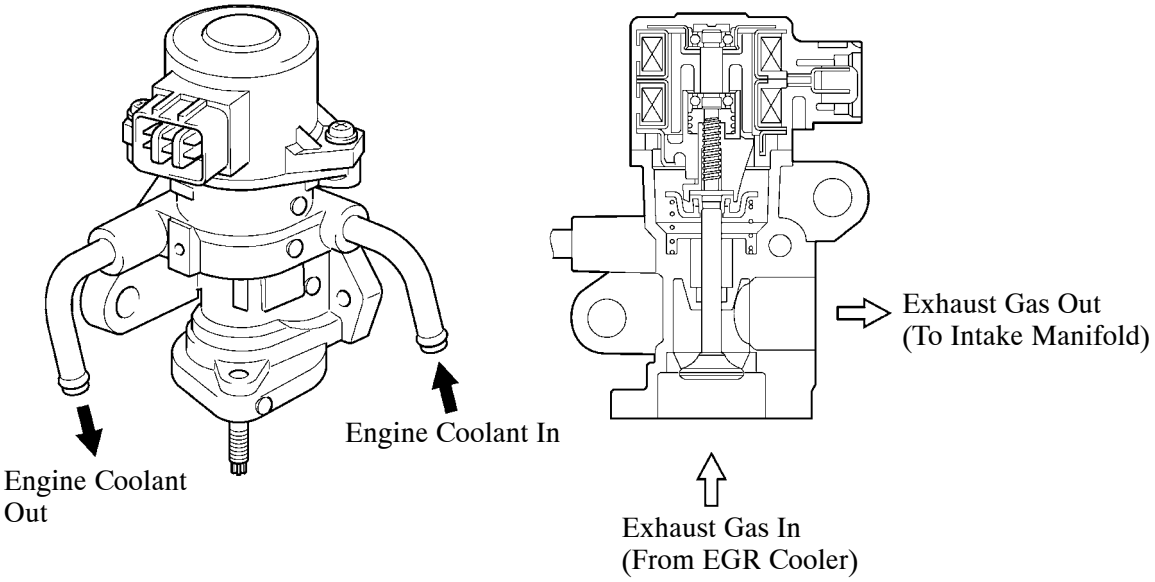
— REFERENCE —

Laser-welding:

In laser-welding, a laser-absorbing material (for the intake manifold) is joined to a laser-transmitting material (for the ACIS actuator). Laser beams are then irradiated from the laser-transmitting side. The beams penetrate the laser-transmitting material to heat and melt the surface of the laser-absorbing material. Then, the heat of the laser-absorbing material melts the laser-transmitting material and causes both materials to become welded.

EGR Valve

- A step motor is used on the EGR valve to enable the ECM to directly control the EGR valve.
- The water circulates through the EGR valve to ensure proper cooling performance.

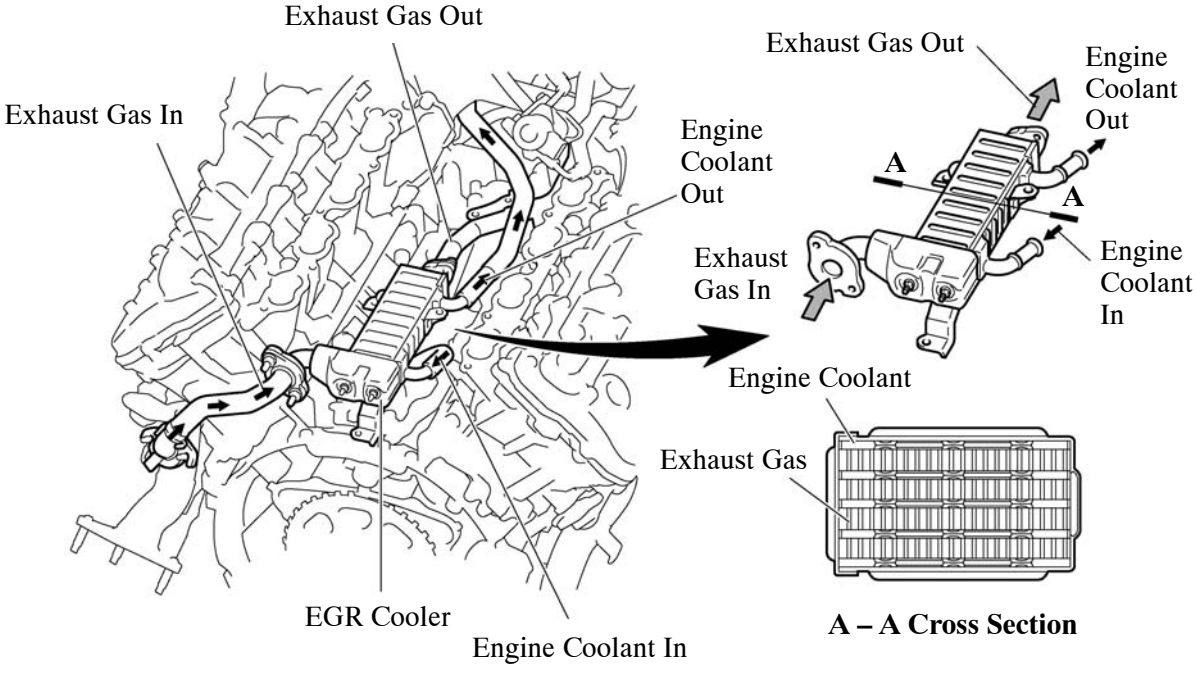


EGR Valve Cross Section

12CEG20Y

EGR Cooler

- The water-cooled type EGR cooler is used in the EGR passage between the cylinder head and EGR valve.
- In the water-cooled type EGR cooler, engine coolant flows to the 4-layered gas passage to cool down.

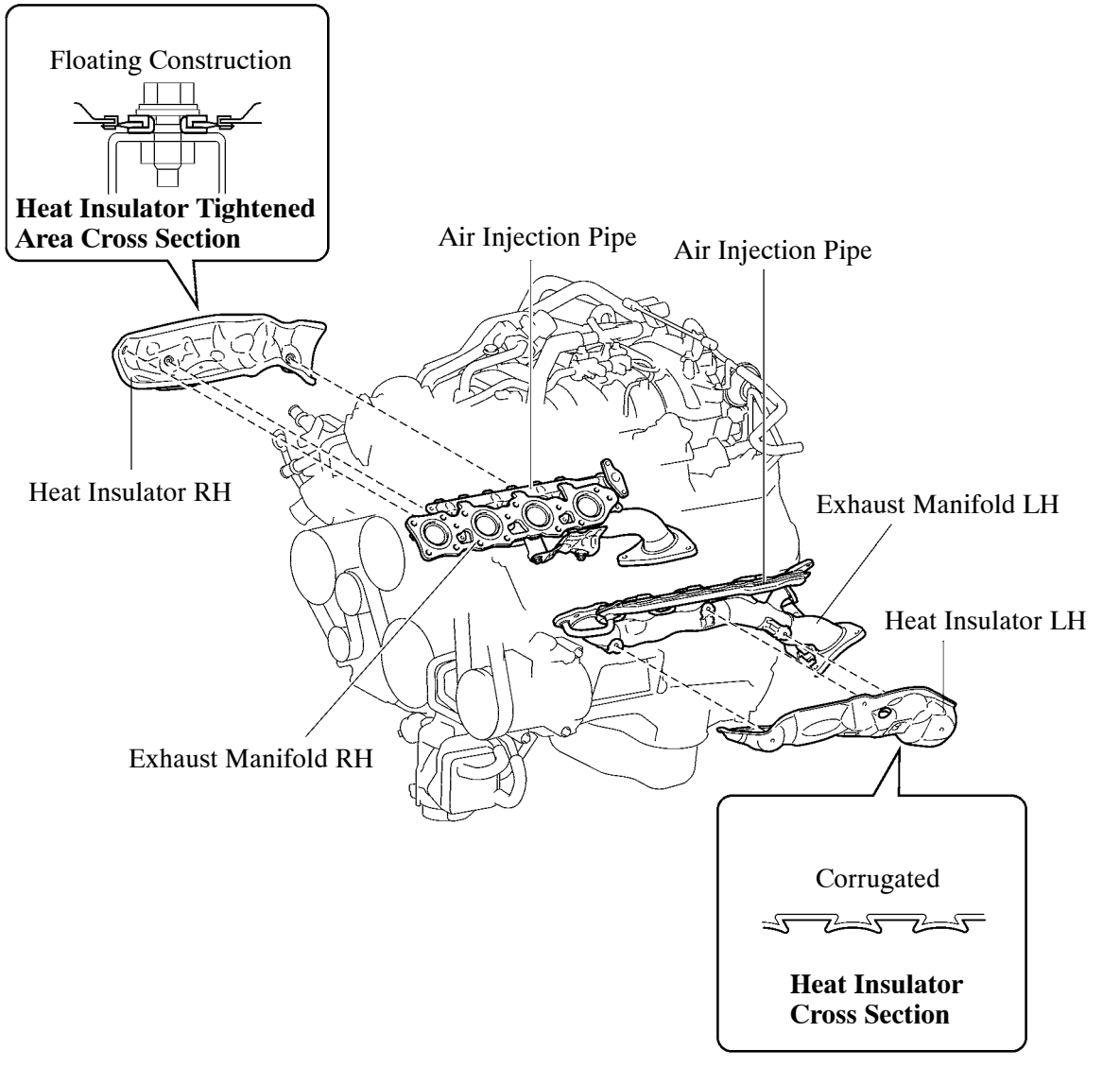


A – A Cross Section

12CEG21Y

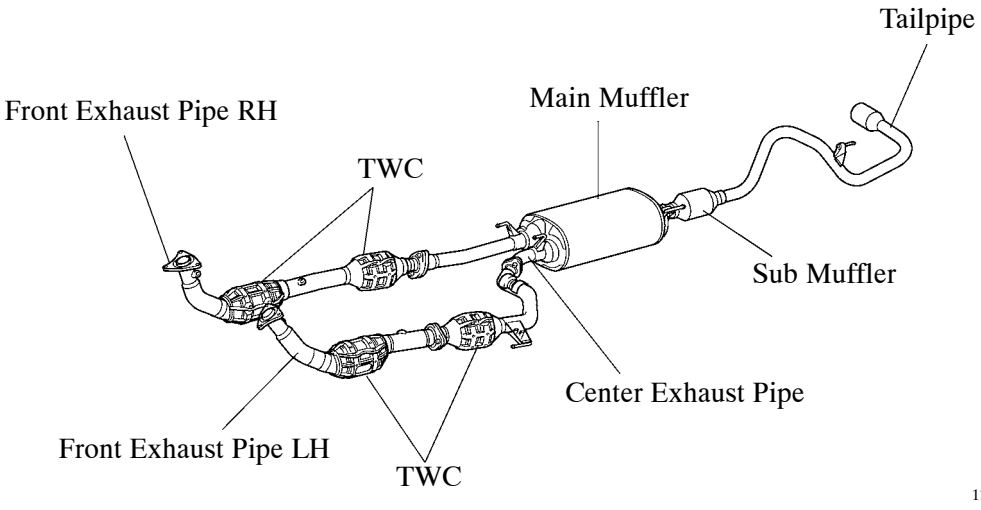
Exhaust Manifold

- A stainless steel exhaust manifold is used for weight reduction and rust resistance.
- The exhaust manifold for each bank uses a single structure (in a 4-1 grouping).
- The exhaust manifold heat insulator is made of corrugated aluminum. This ensures rigidity, and at the same time, increases the surface area to improve heat dissipation. Furthermore, a floating construction is used in the tightened area to reduce the transfer of heat and vibration to the heat insulator and to improve reliability.
- Along with the use of the air injection system, air injection pipes are provided for the right and left bank exhaust manifolds.



Exhaust Pipe

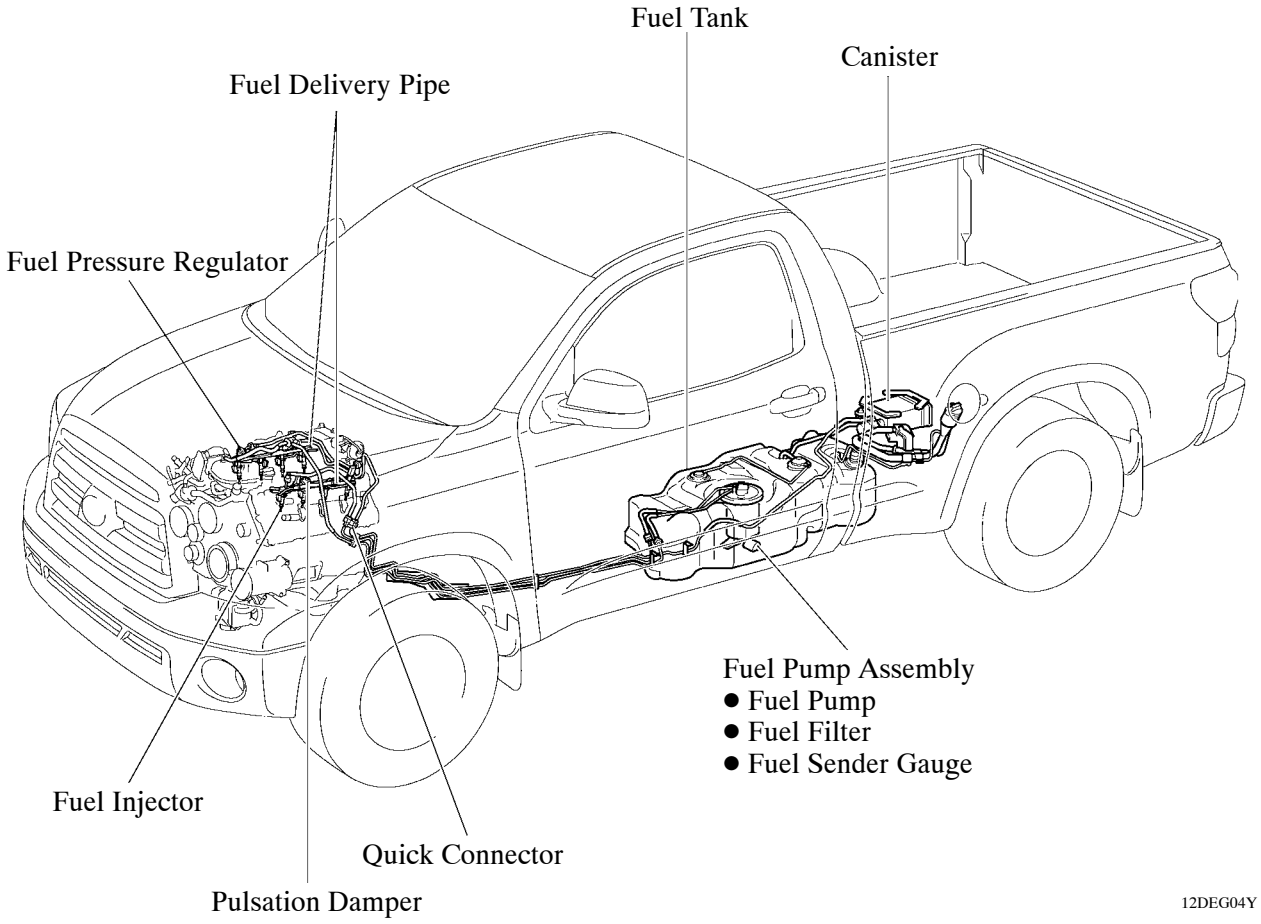
- The exhaust pipes are made of stainless steel to reduce their weight and improve rust resistance.
- 2 ceramic type Three-Way Catalytic converters (TWCs) are provided in the front exhaust pipe for the right bank, and another 2 are also provided for the left bank. As a result, the exhaust emission performance of the engine is improved.



8. Fuel System

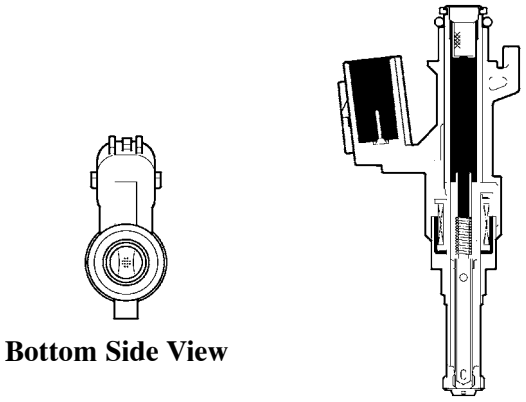
General

- A fuel cut control is used to stop the fuel pump when SRS airbags deploy in a frontal or side collision. For details, see page 87.
- Compact 12-hole type fuel injectors are used to improve the atomization of fuel.
- Quick connectors are used to connect the fuel lines for ease of serviceability.
- A multi-layer plastic fuel tank is used.
- An evaporative emission control system is used. For details, see page 95.



Fuel Injector

A 12-hole fuel injector with optimized fuel flow amount is used to improve the atomization of fuel.



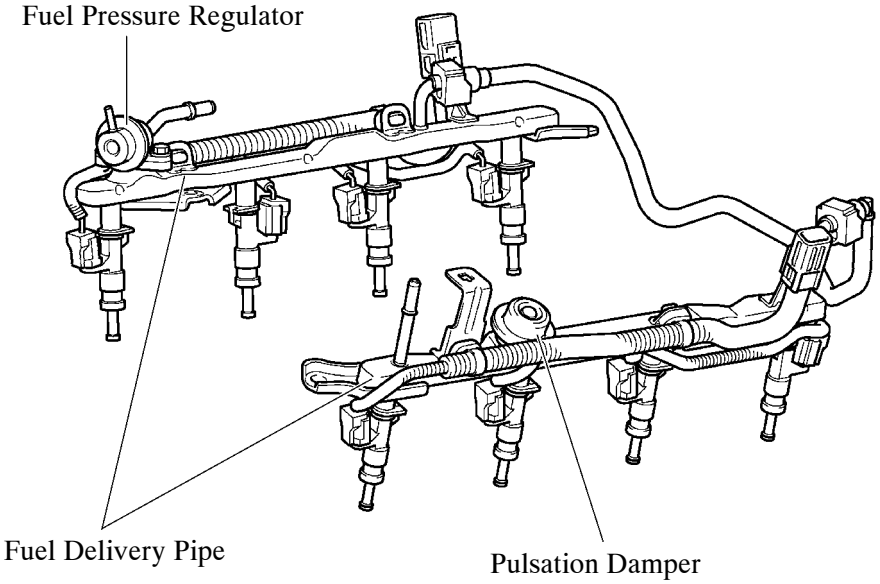
Bottom Side View

Fuel Injector Cross Section

10ZEG11Y

Delivery Pipe

- Fuel delivery pipes formed from stamped steel are used to deliver fuel to the fuel injectors.
- A pulsation damper is provided on the fuel delivery pipe in the left bank. A fuel pressure regulator is installed on the right bank fuel delivery pipe.



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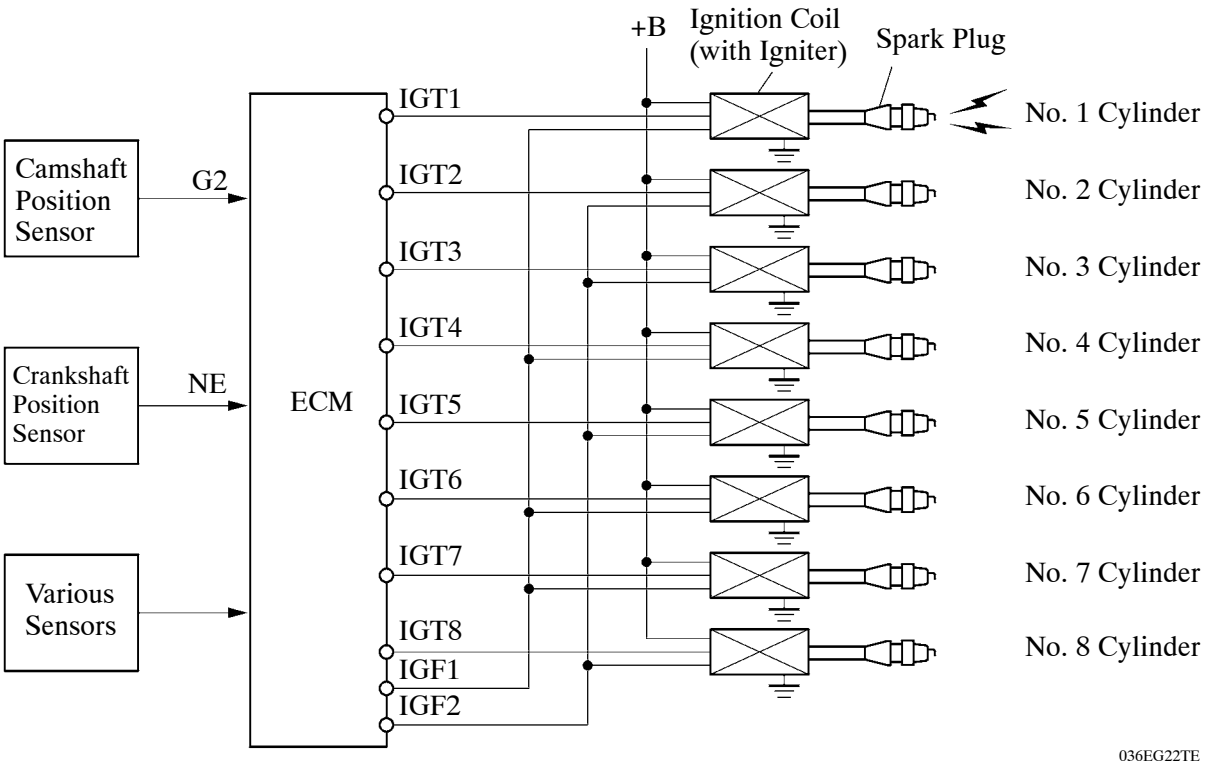
9. Ignition System

General

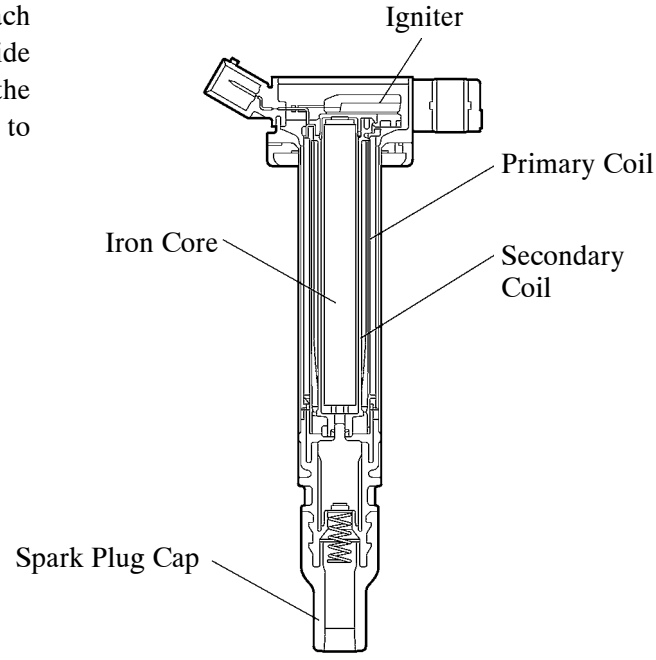
- A Direct Ignition System (DIS) is used. The DIS improves ignition timing accuracy, reduces high-voltage loss, and enhances the overall reliability of the ignition system by eliminating the distributor.
- The DIS is an independent ignition system which has one ignition coil (with an integrated igniter) for each cylinder.



036EG22TE

Ignition Coil

The DIS provides 8 ignition coils, one for each cylinder. The spark plug caps, which provide contact to spark plugs, are integrated with the ignition coil. Also, an igniter is enclosed to simplify the system.

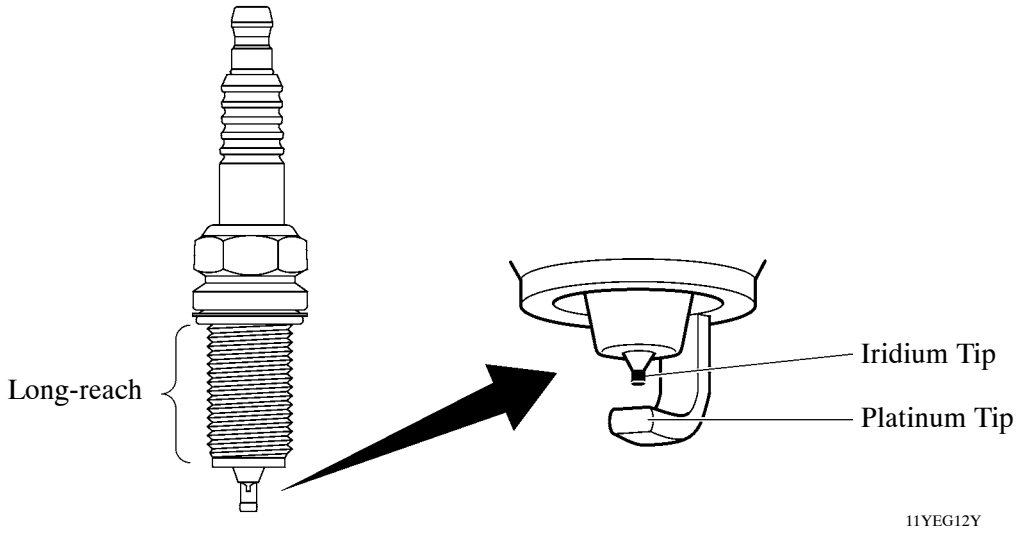


Ignition Coil Cross Section

05AEG39TE

Spark Plug

- Long-reach type spark plugs are used. This type of spark plug allows the area of the cylinder head that receives the spark plugs to be made thick. Thus, the water jacket can be extended near the combustion chamber, contributing to cooling system performance.
- Iridium-tipped spark plugs are used to achieve 120000 mile (200000 km) maintenance intervals. By using an iridium center electrode, ignition performance superior to that of platinum-tipped spark plugs has been achieved and durability has been increased.



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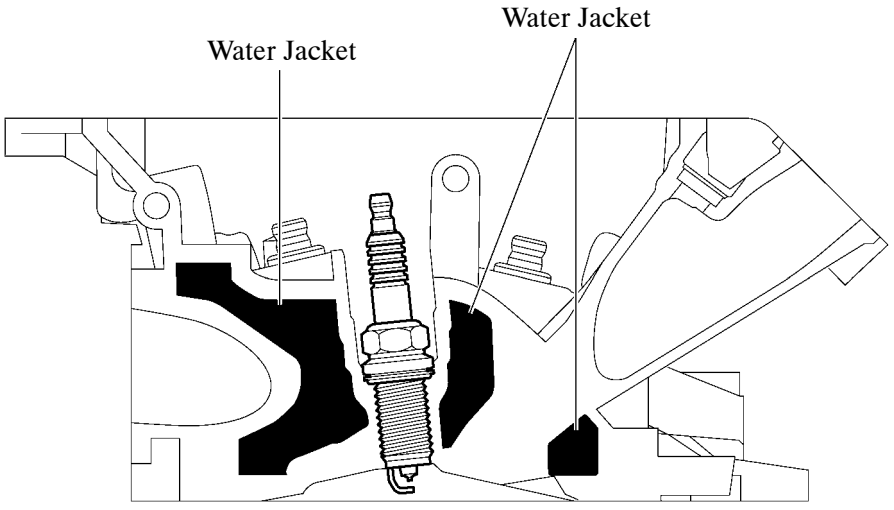


Cylinder Head Cross Section

11YEG13Y

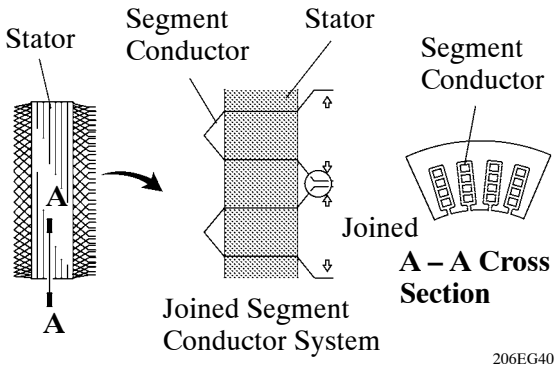
▶ Specifications ◀

Manufacturer	DENSO
Type	SK20HR11
Plug Gap	1.0 to 1.1 mm (0.0394 in. to 0.043 in.)

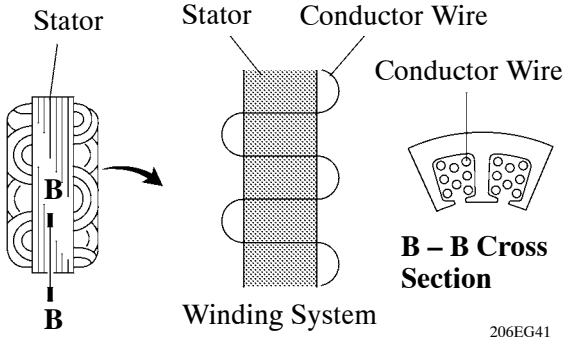
10. Charging System

General

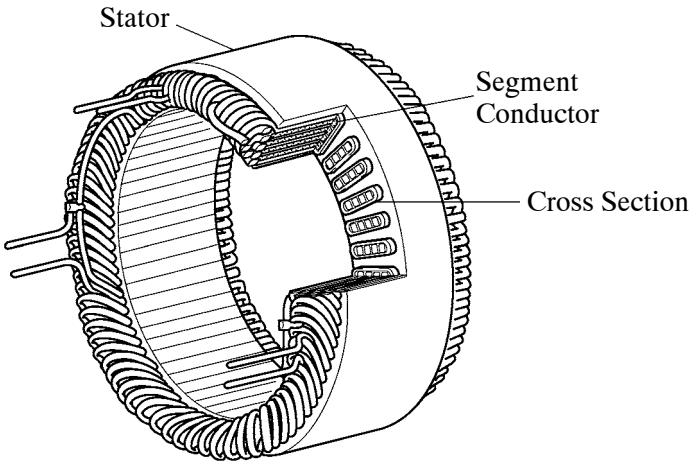
- A compact and lightweight segment conductor type generator that generates high amperage output in a highly efficient manner is provided as standard equipment.
- This generator has a joined segment conductor system in which multiple segment conductors are welded together to form the stator. Compared to the conventional winding system, the electrical resistance is lower due to the shape of the segment conductors, and their arrangement helps to make the generator compact.



Segment Conductor Type Generator



Conventional Type Generator



Stator of Segment Conductor Type Generator

206EG42

▶ Generator Provision ◀

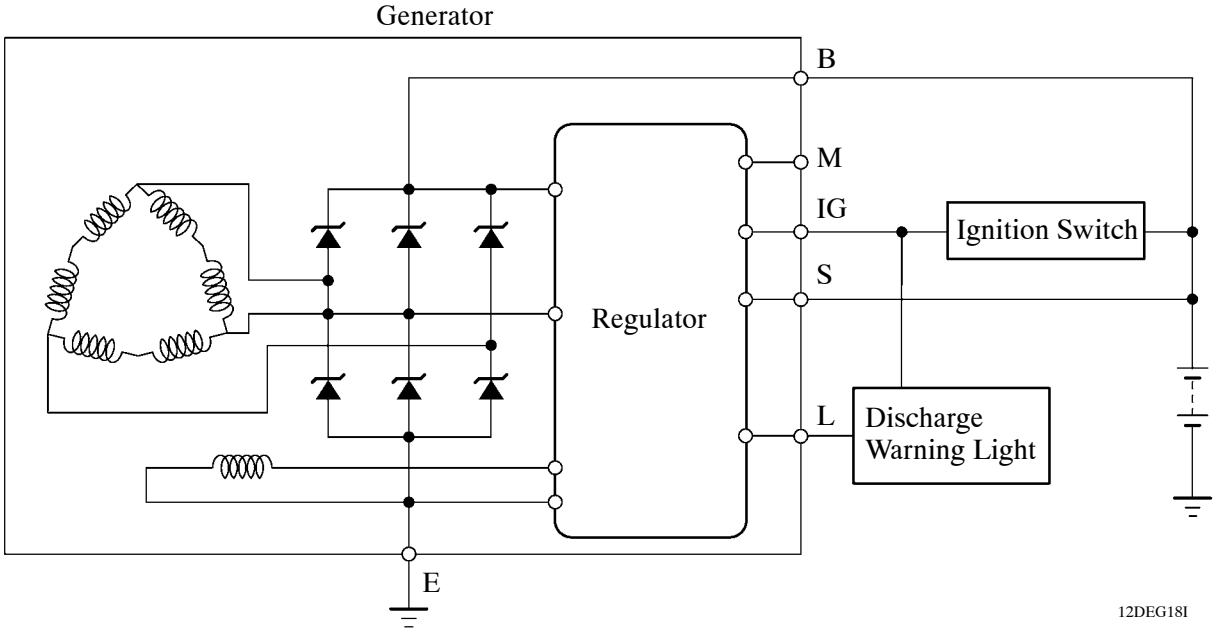
Vehicle Type			Generator Type		
			SE0	SC1	SC2
Regular Cab			○	—	Δ*1
Double Cab	Standard Deck	SR5	○	—	Δ*1
		Limited	—	○	Δ*1
	Long Deck		—	—	○
CrewMax		SR5	○	Δ*2	Δ*1
		Limited	—	○	Δ*1

○: Standard equipment
Δ: Optional equipment
—: Not equipped
*1: Models with towing package
*2: Models with rear seat entertainment system (except models with towing package)

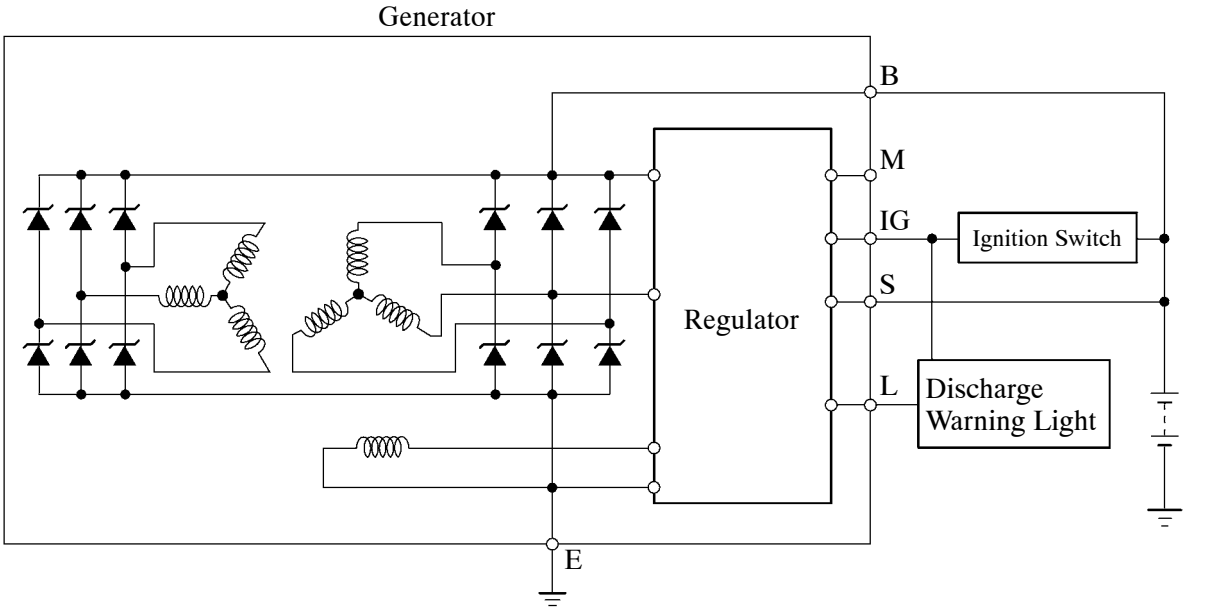
▶ Specifications ◀

Type	SE0	SC1	SC2
Rated Voltage	12 V	←	←
Rated Output	100 A	130 A	150 A
Initial Output Starting Speed	Max. 1500 rpm	←	←

▶ Wiring Diagram ◀



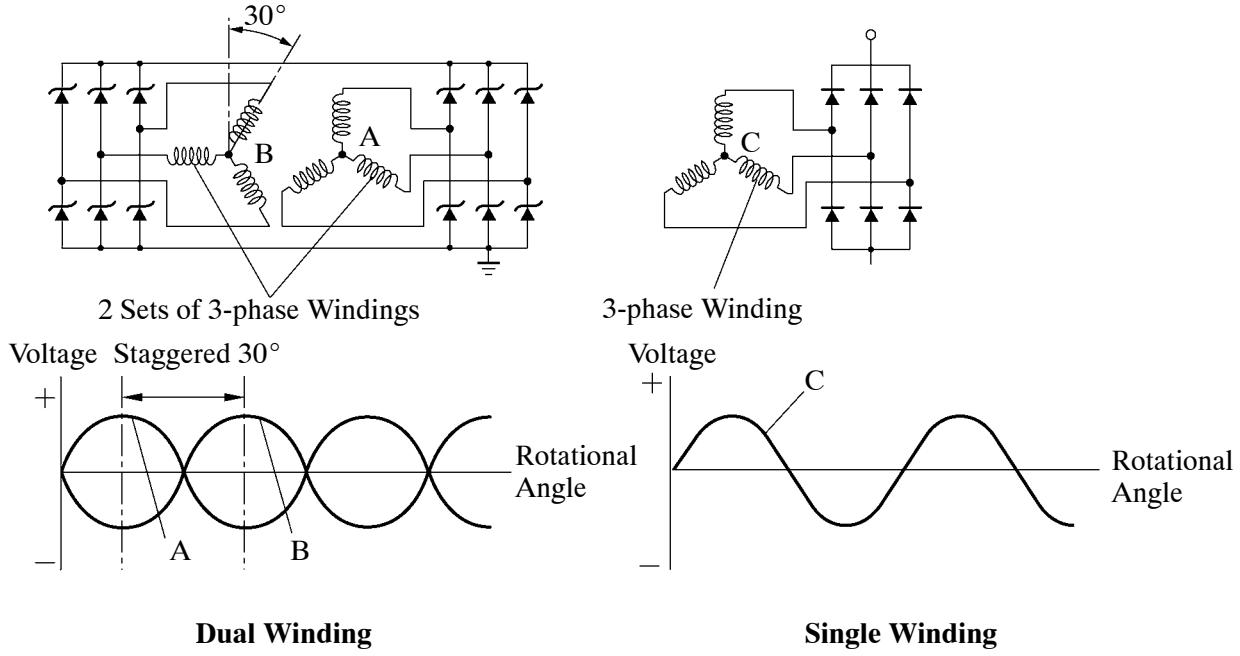
SE0 type



SC1 and SC2 type

Dual Winding System (SC1 or SC2 Type Generator)

A dual winding system is used. This system consists of 2 sets of 3-phase windings whose phases are staggered by 30°. This system results in the reduction of both electrical noises (ripple and spike) and magnetic noise (a hum heard as generator load is increased). This system significantly suppresses noise at the source (generator). Since the waves that the respective windings generate have opposite polarities, magnetic noise is reduced. However, the electrical power generated does not cancel itself out due to the use of separate rectifiers. The opposite polarities generated are shown below:



Dual Winding **Single Winding**

11. Starting System

A planetary reduction type starter is used.

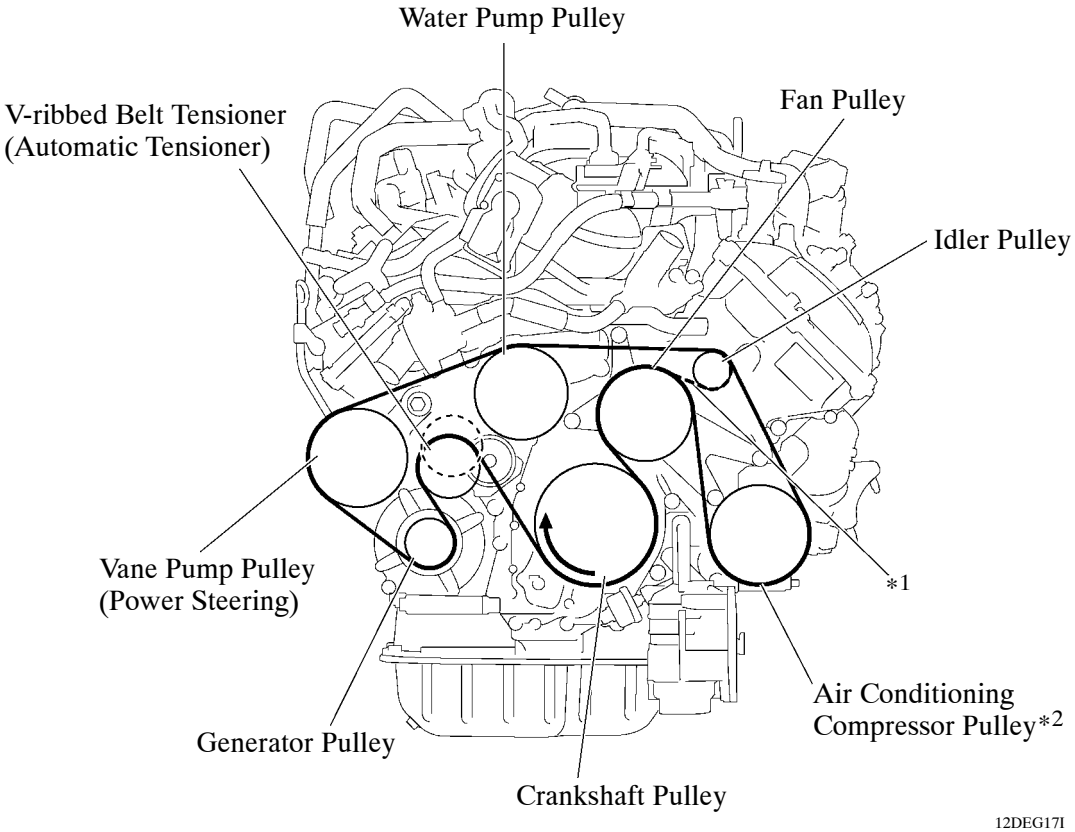
▶ Specification ◀

Models	Standard	Cold Area Specification
Type	PA70	PA78S
Rated Output	1.6 kW	2.0 kW
Rated Voltage	12 V	←
Length*1	136.1 mm (5.36 in.)	168.9 mm (6.65 in.)
Weight	3150 (6.95 lb)	4300 g (9.48 lb)
Rotating Direction	Clockwise*2	←

*1: Length from the mounted area to the rear end of the starter
*2: Viewed from pinion side

12. Serpentine Belt Drive System

- A serpentine belt drive system, which drives all accessory components by a single V-ribbed belt, is used. It reduces the overall engine length, weight and the number of engine parts.
- An automatic tensioner is used. This makes tension adjustment unnecessary.

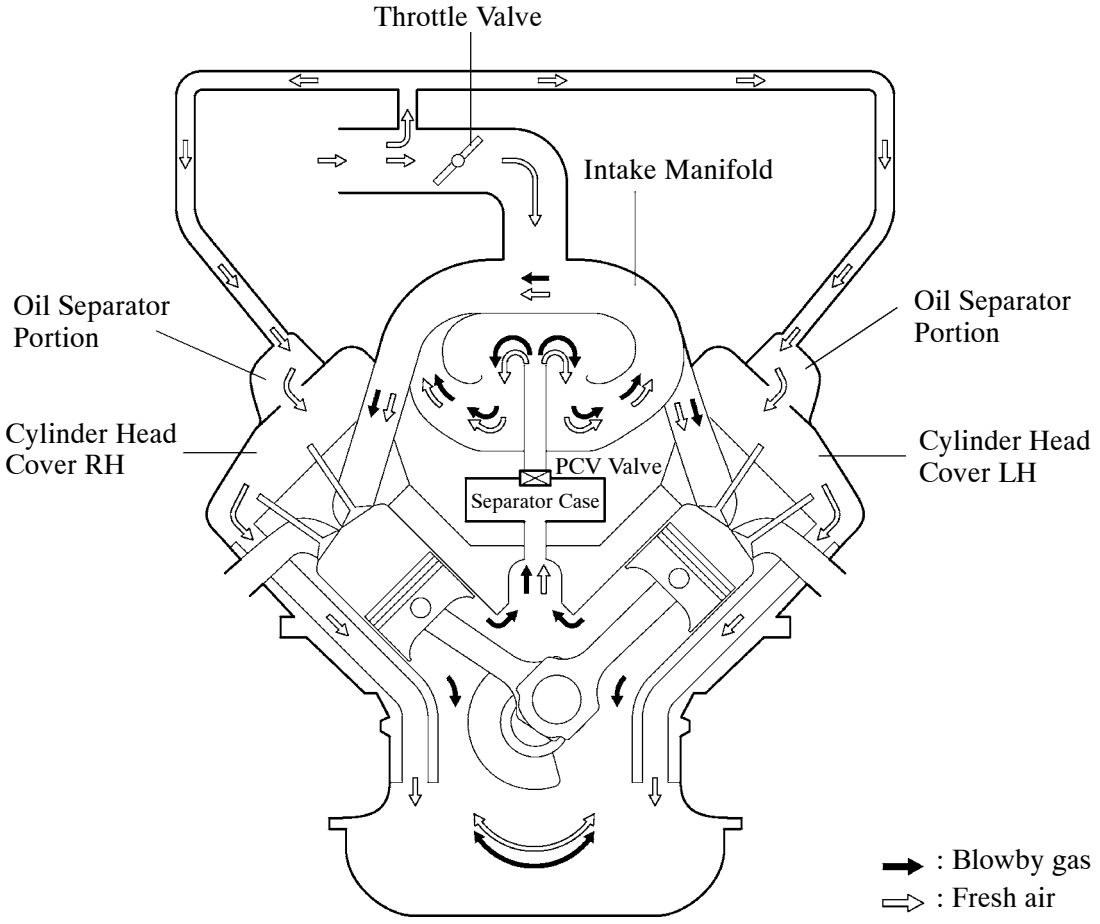


*1: Models without air conditioning
*2: Models with air conditioning

13. Blow–by Gas Ventilation System

General

- The oil separator portion of the cylinder head covers has been made compact through the use of an independent separator case. This contributes to making the entire engine compact.
- Fresh air is drawn from the right and left bank cylinder head covers to improve the ventilation inside the engine and improve the deterioration resistance of the engine oil.



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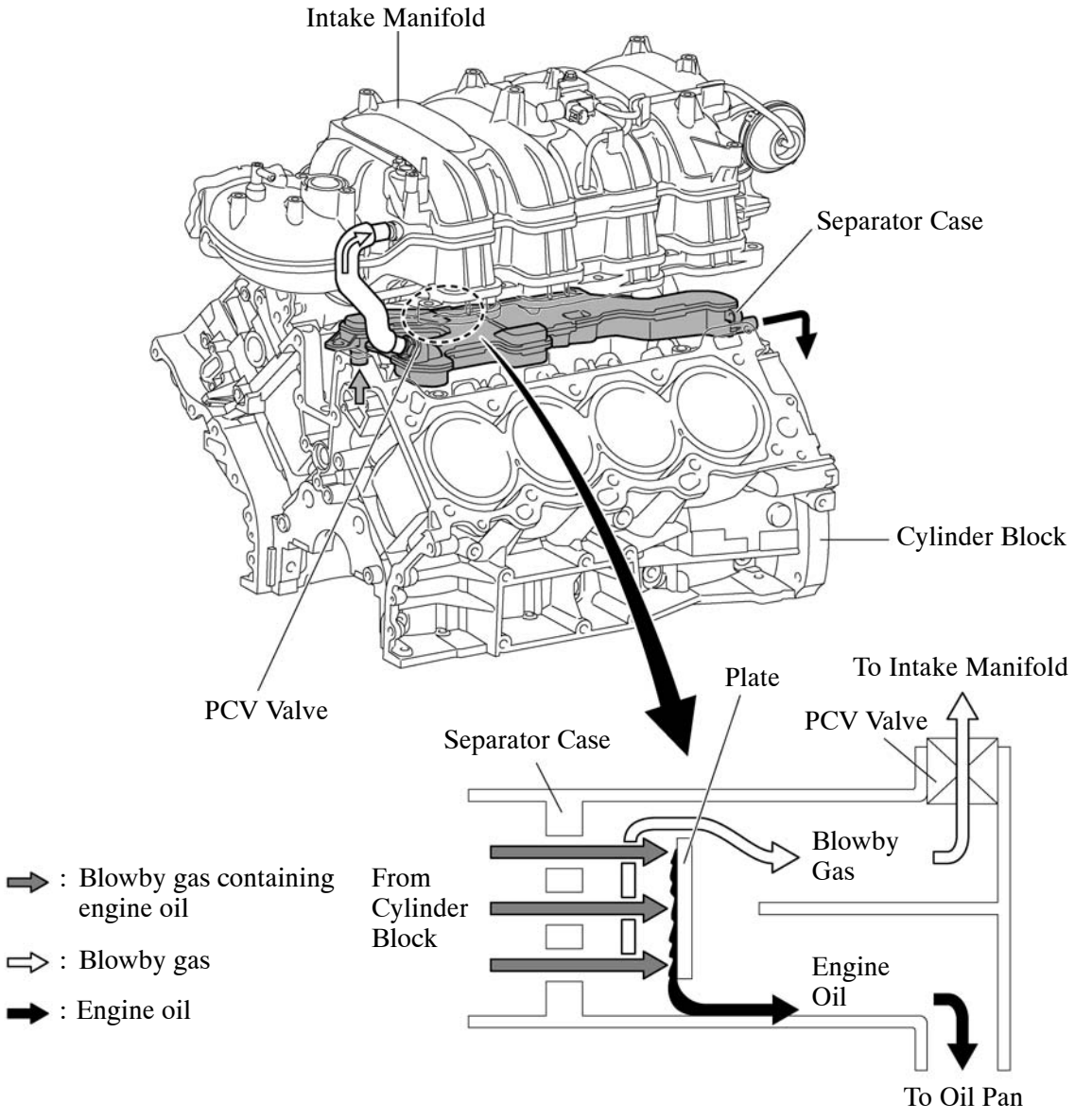
Separator Case

- A plastic separator case is provided between the cylinder block and the intake manifold in order to separate the engine oil included in the blowby gas.
- An inertial impaction system is used in the construction for separating the engine oil in the separator case. Blowby gas containing engine oil hits the plate, thus causing the engine oil to adhere and accumulate on the plate. Then, the oil drips down by way of gravity. Thus, this system efficiently separates the engine oil from the blowby gas. This improves the rate of the collection of the engine oil and reduces the amount of engine oil consumption.



Cross-sectional Image of Separator Case

12DEG06I

14. ENGINE CONTROL SYSTEM

General

The engine control system of the 1UR-FE engine has the following features:

System	Outline
Sequential Multiport Fuel Injection (SFI)	● An L-type SFI system directly detects the intake air mass using a hot-wire type air flow meter. ● An independent injection system (in which fuel is injected once into each intake port for each 2 revolutions of the crankshaft) is used. ● Fuel injection takes 2 forms: – Synchronous injection, in which injection always occurs at the same timing relative to the firing order. – Non-synchronous injection, in which injection is effected regardless of the crankshaft angle. ● Synchronous injection is further divided into 2 sub-categories: – Group injection, conducted during a cold start. – Independent injection, conducted after the engine has started.
Electronic Spark Advance (ESA)	● Ignition timing is determined by the ECM based on signals from various sensors. The ECM corrects ignition timing in response to engine knocking. ● This system selects the optimal ignition timing in accordance with the signals received from the sensors and sends the (IGT) ignition signal to the igniter.
Electronic Throttle Control System-intelligent (ETCS-i) [See page 73]	Optimally controls the throttle valve opening in accordance with the amount of accelerator pedal effort and the condition of the engine and the vehicle.
Dual Variable Valve Timing-intelligent (Dual VVT-i) [See page 78]	Controls the intake and exhaust camshafts to optimal valve timing in accordance with the engine operating conditions.
Acoustic Control Induction System (ACIS) [See page 84]	The intake air passages are switched based on engine speed and throttle valve opening angle to provide high performance in all engine speed ranges.
EGR Control [See page 86]	Based on the signals received from the various sensors, the ECM determines the EGR volume via EGR valve in accordance with the engine condition.
Fuel Pump Control [See page 87]	● Based on signals from the ECM, the fuel pump ECU controls the fuel pump in 3 stages. ● The fuel pump is stopped when the SRS airbag is deployed in a frontal, side, or side rear collision.
Air Injection Control [See page 89]	The ECM controls the air injection time based on the signals from the crankshaft position sensor, engine coolant temperature sensor, mass air flow meter and air pressure sensor.
Starter Control (Cranking Hold Function) [See page 93]	Once the ignition switch is turned ON while the brake pedal is depressed, this control continues to operate the starter until the engine has started.

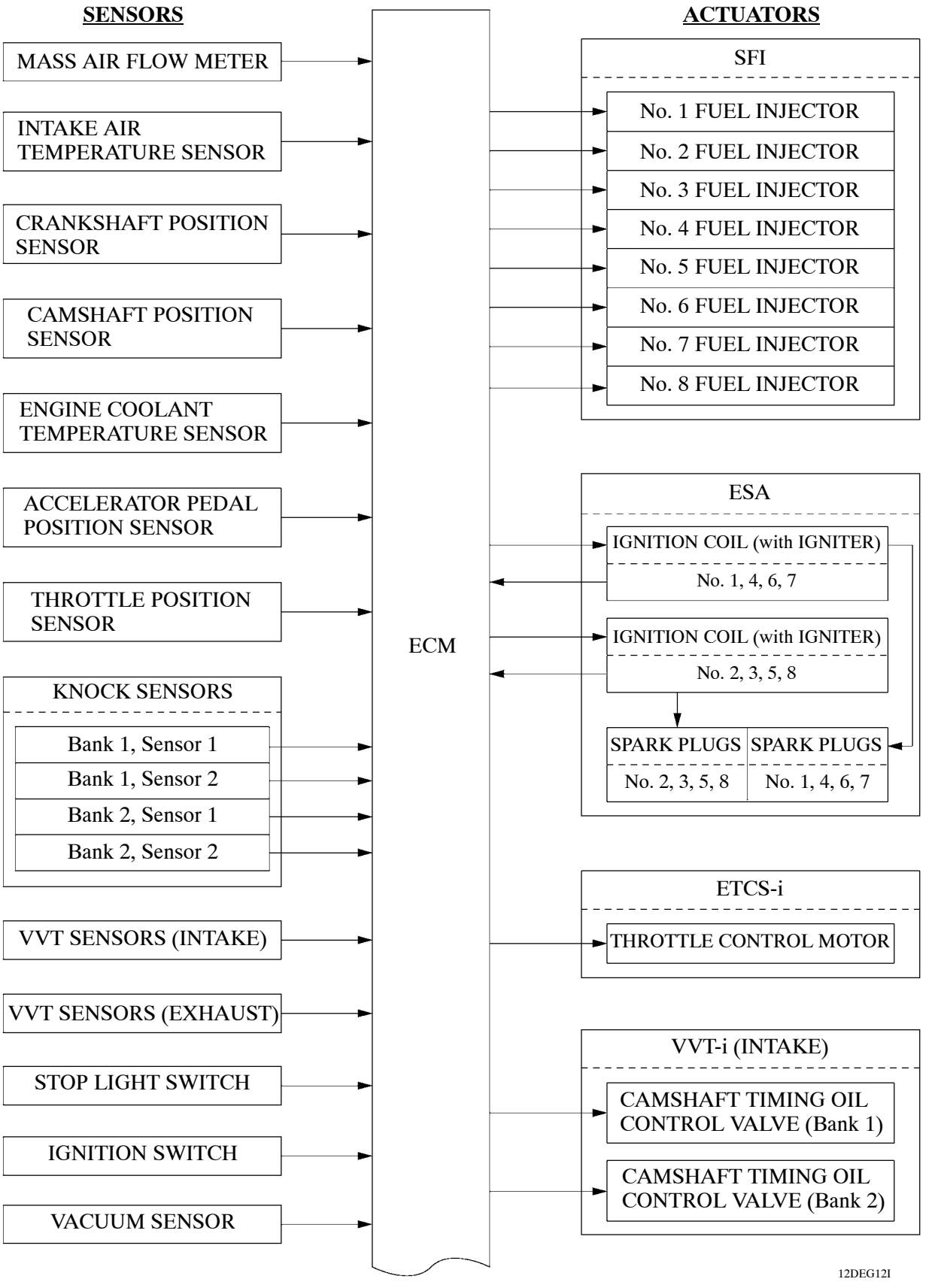
(Continued)

System	Outline
Air-fuel Ratio Sensor and Heated Oxygen Sensor Heater Control	Maintains the temperature of the air-fuel ratio sensors or heated oxygen sensors at an appropriate level to increase the detection accuracy of the exhaust gas oxygen concentration.
Air Conditioning Cut-off Control*	By turning the air conditioning compressor on or off in accordance with the engine condition, driveability is maintained.
Evaporative Emission Control [See page 95]	● The ECM controls the purge flow of evaporative emission (HC) in the canister in accordance with the engine conditions. ● Approximately five hours after the ignition switch has been turned off, the ECM operates the pump module to detect any evaporative emission leakage occurring between the fuel tank and the canister through changes in the fuel tank pressure.
Engine Immobiliser	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid key.
Diagnosis [See page 107]	When the ECM detects a malfunction, the ECM records the malfunction and memorizes information related to the fault.
Fail-safe [See page 107]	When the ECM detects a malfunction, the ECM stops or controls the engine in accordance with the data already stored in the memory.

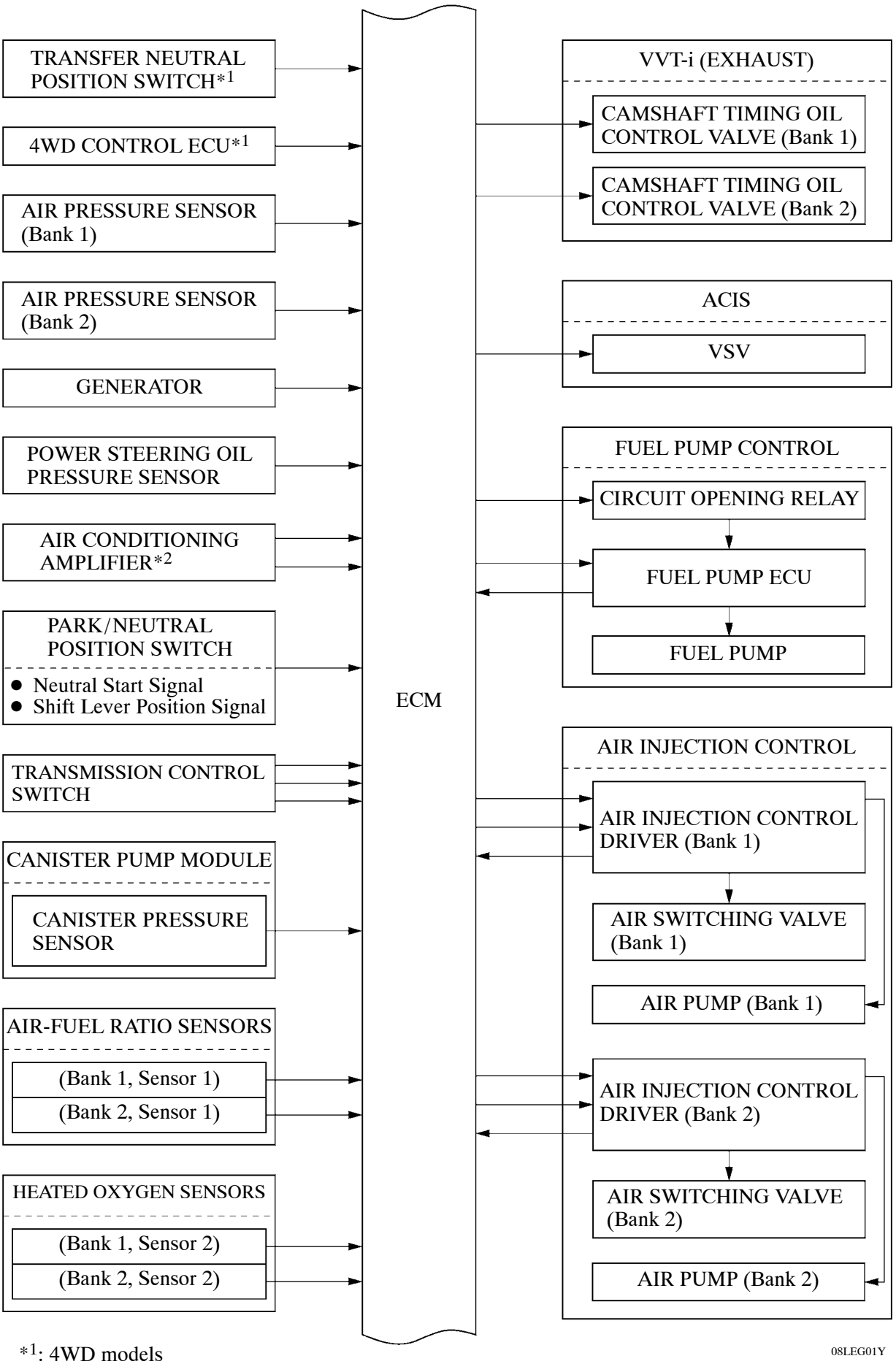
*: Models with air conditioning

Construction

The configuration of the engine control system is as shown in the following chart:



(Continued)



*1: 4WD models

*2: Models with air conditioning

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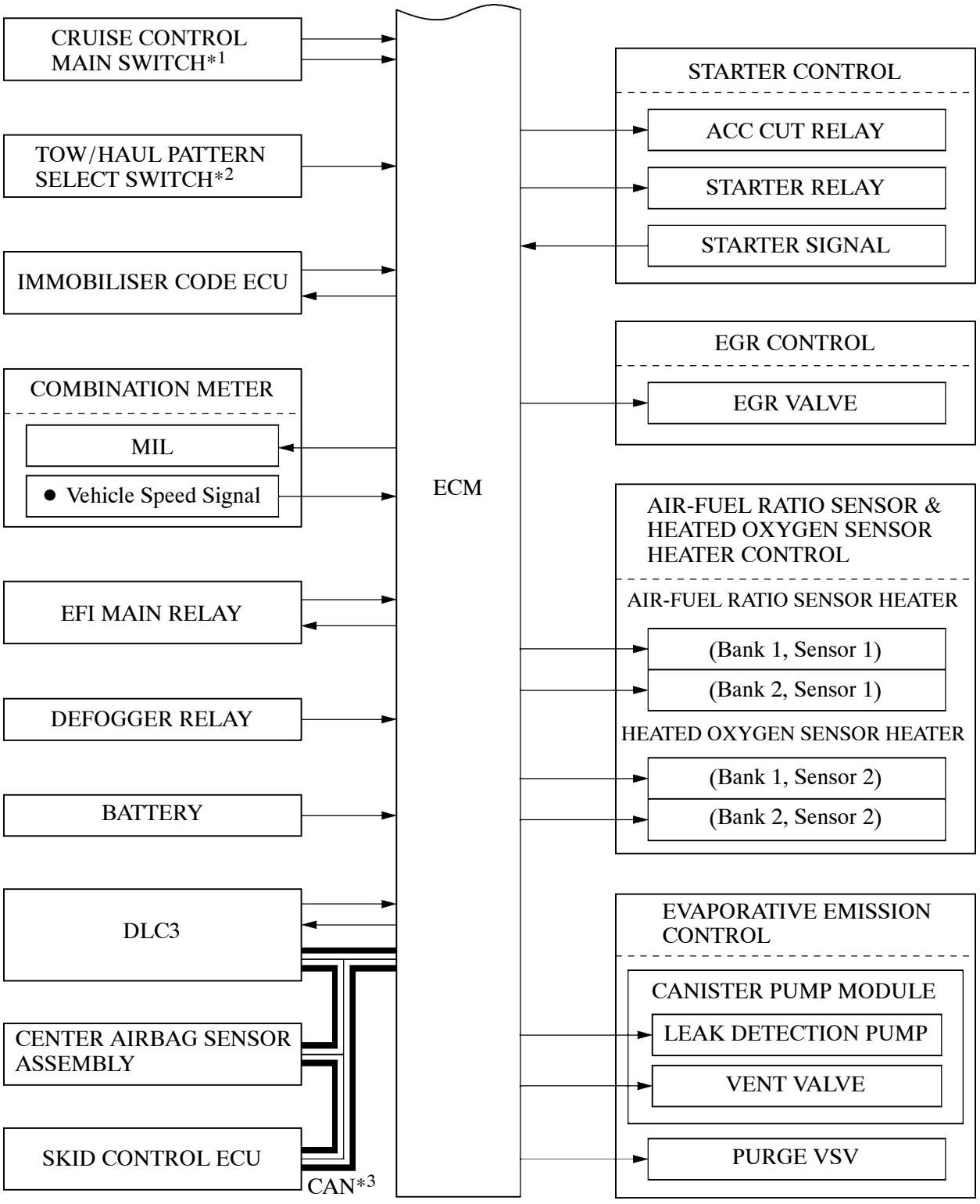
(Continued)



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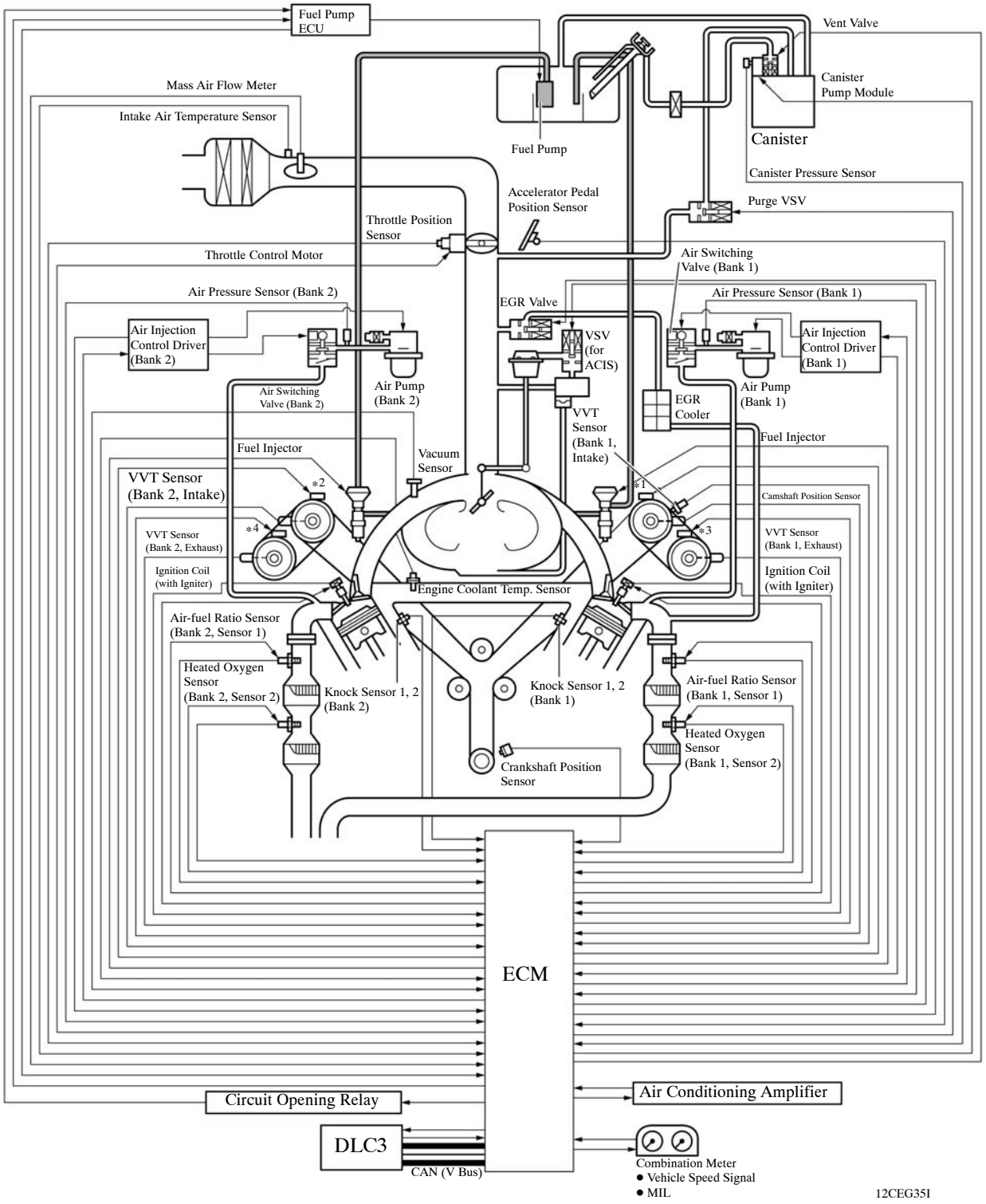
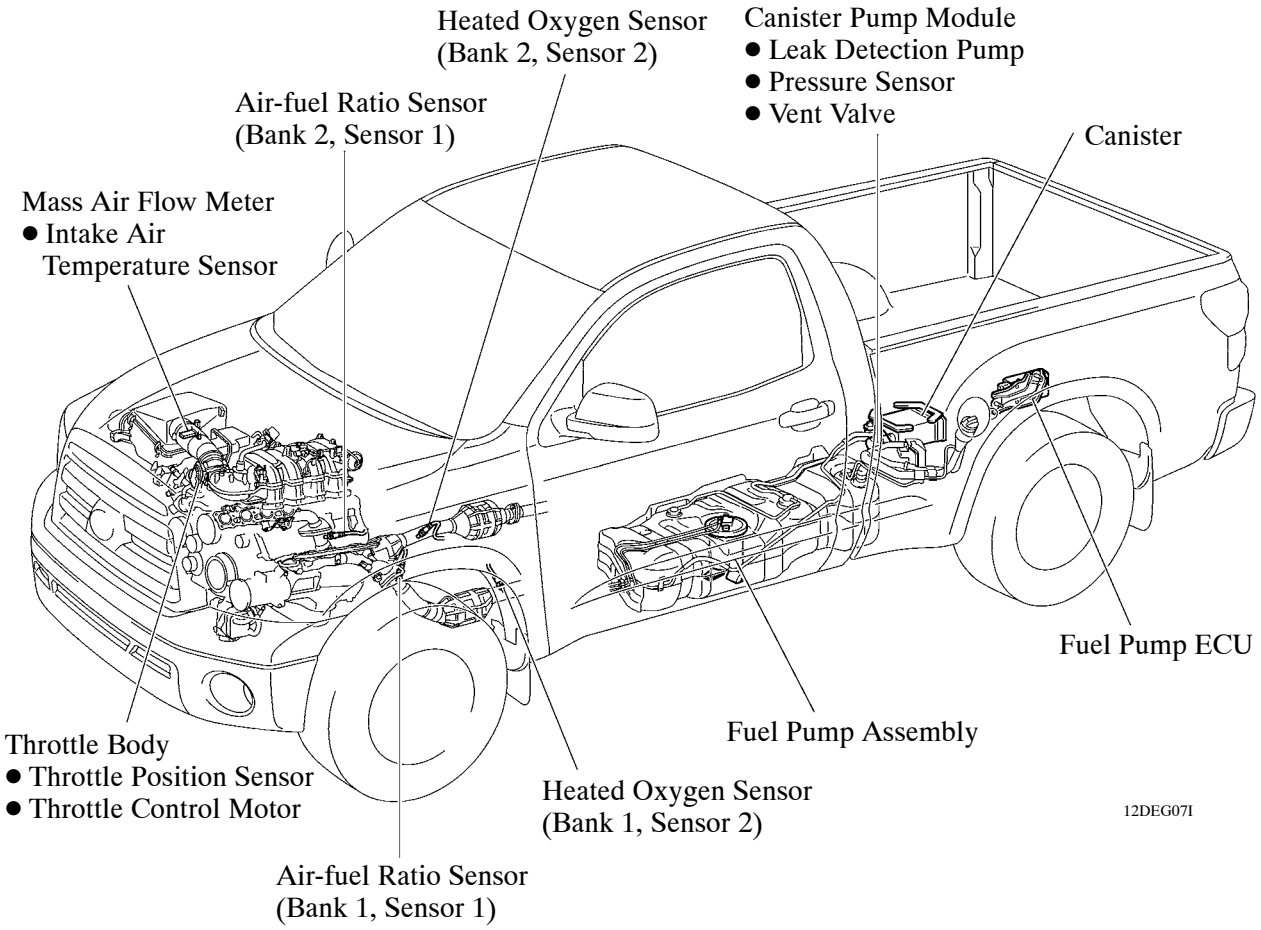
*1: Models with cruise control system
*2: Models with towing package
*3: V bus

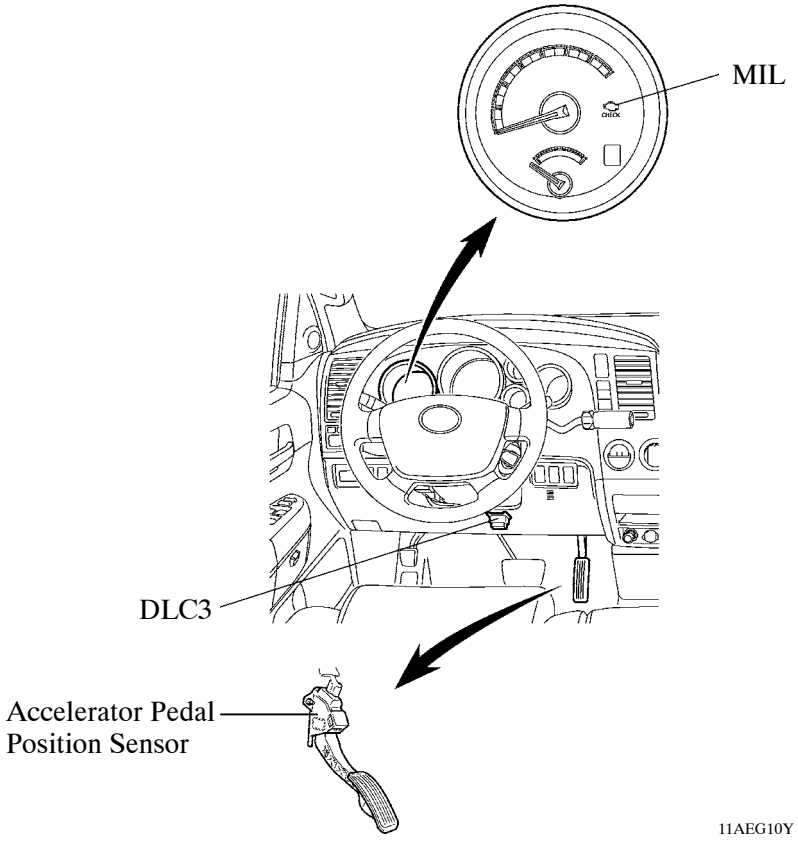
Engine Control System Diagram

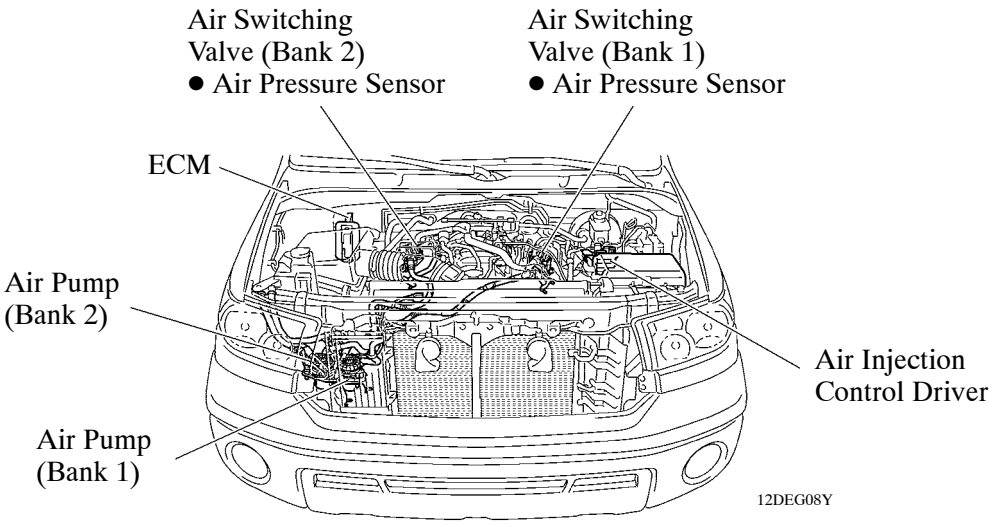


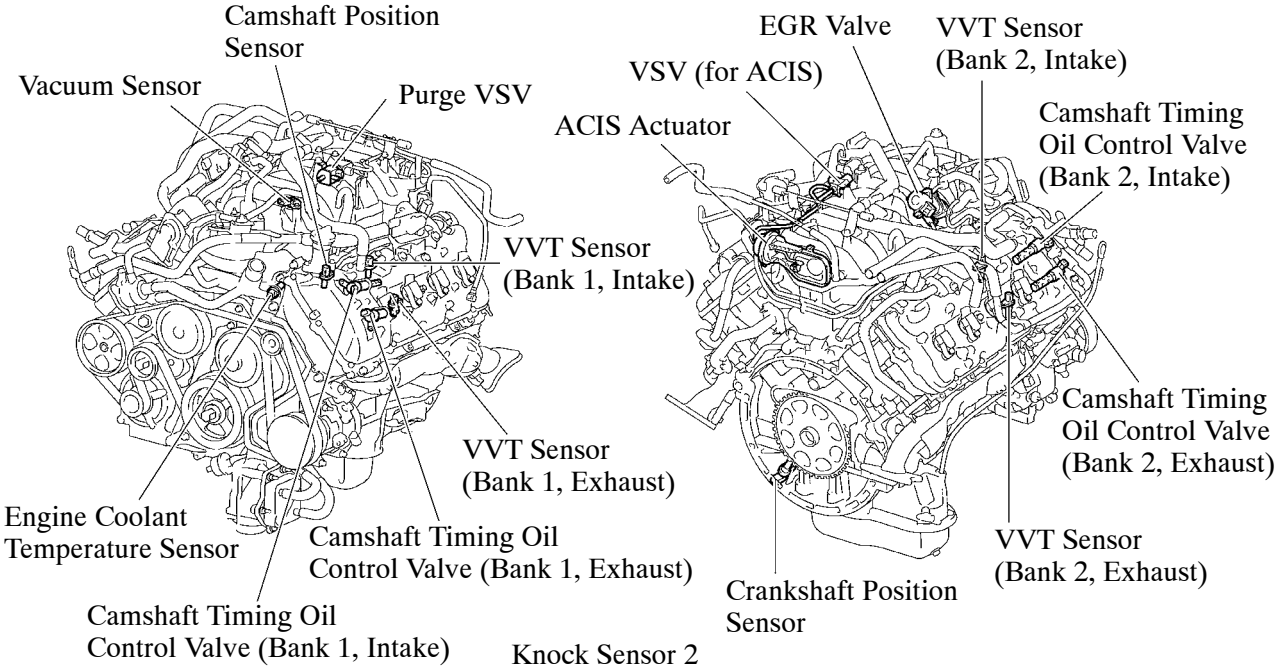
*1: Intake camshaft timing oil control valve (Bank 1)
*2: Intake camshaft timing oil control valve (Bank 2)
*3: Exhaust camshaft timing oil control valve (Bank 1)
*4: Exhaust camshaft timing oil control valve (Bank 2)

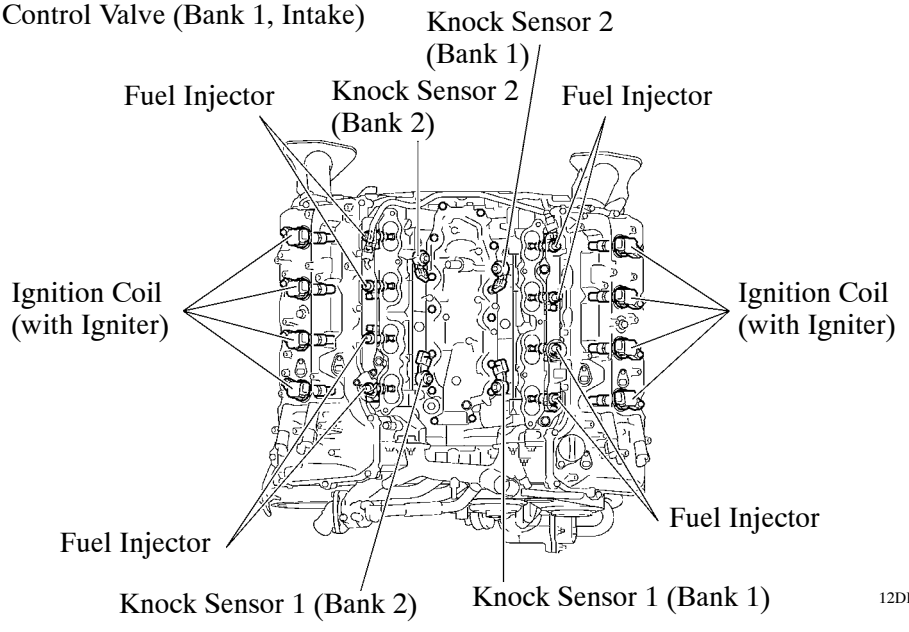
Layout of Main Components






Air Switching Valve (Bank 2)
● Air Pressure Sensor
Air Switching Valve (Bank 1)
● Air Pressure Sensor
ECM
Air Pump (Bank 2)
Air Injection Control Driver
Air Pump (Bank 1)
12DEG08Y


Camshaft Position Sensor
Vacuum Sensor
Purge VSV
VVT Sensor (Bank 1, Intake)
VVT Sensor (Bank 1, Exhaust)
Engine Coolant Temperature Sensor
Camshaft Timing Oil Control Valve (Bank 1, Exhaust)
Camshaft Timing Oil Control Valve (Bank 1, Intake)
EGR Valve
VVT Sensor (Bank 2, Intake)
VSV (for ACIS)
ACIS Actuator
Camshaft Timing Oil Control Valve (Bank 2, Intake)
Camshaft Timing Oil Control Valve (Bank 2, Exhaust)
VVT Sensor (Bank 2, Exhaust)
Crankshaft Position Sensor


Knock Sensor 2 (Bank 1)
Fuel Injector
Knock Sensor 2 (Bank 2)
Fuel Injector
Ignition Coil (with Igniter)
Ignition Coil (with Igniter)
Fuel Injector
Fuel Injector
Knock Sensor 1 (Bank 2)
Knock Sensor 1 (Bank 1)
12DEG09Y

Main Component of Engine Control System

1) General

The main components of the 1UR-FE engine control system are as follows:

Components	Outline	Quantity	Function
ECM	32-bit CPU	1	The ECM optimally controls the SFI, ESA and ISC to suit the operating conditions of the engine in accordance with the signals provided by the sensors.
Mass Air Flow Meter	Hot-wire Type	1	This sensor has a built-in hot-wire to directly detect the intake air mass and flow rate.
Intake Air Temperature Sensor	Thermistor Type	1	This sensor detects the intake air temperature by means of an internal thermistor.
Accelerator Pedal Position Sensor	Hall IC Type (Non-contact Type)	1	This sensor detects the amount of pedal effort applied to the accelerator pedal.
Throttle Position Sensor	Hall IC Type (Non-contact Type)	1	This sensor detects the throttle valve opening angle.
Crankshaft Position Sensor	MRE Type (Rotor Teeth/36-2)	1	This sensor detects the engine speed and the crankshaft position.
Camshaft Position Sensor	MRE Type (Rotor Teeth/3)	1	This sensor detects the camshaft position and performs the cylinder identification.
VVT Sensor (Intake)	MRE Type (Rotor Teeth/3)	1 each bank	This sensor detects the actual valve timing.
VVT Sensor (Exhaust)	MRE Type (Rotor Teeth/3)	1 each bank	This sensor detects the actual valve timing.
Knock Sensor	Built-in Piezoelectric Element (Flat Type)	2 each bank	This sensor detects an occurrence of the engine knocking indirectly from the vibration of the cylinder block caused by the occurrence of engine knocking.
Heated Oxygen Sensor	Cup Type with Heater	1 each bank	This sensor detects the oxygen concentration in the exhaust emission by measuring the electromotive force generated in the sensor itself.
Air-fuel Ratio Sensor	Planar Type with Heater	1 each bank	As with the heated oxygen sensor, this sensor detects the oxygen concentration in the exhaust emissions. However, it detects the oxygen concentration in the exhaust emissions linearly.
Vacuum Sensor	Semiconductor Silicon Chip Type	1	This sensor uses built-in semiconductors to detect the intake manifold pressure.
Engine Coolant Temperature Sensor	Thermistor Type	1	This sensor detects the engine coolant temperature by means of an internal thermistor.
Fuel Injector	12-hole Type	8	This fuel injector contains an electromagnetically operated nozzle to inject fuel into the intake port.
Camshaft Timing Oil Control Valve	Electromagnetic Coil Type	2 each bank	The camshaft timing oil control valve changes the valve timing by switching the oil passage that acts on the VVT-i controller in accordance with the signals received from the ECM.