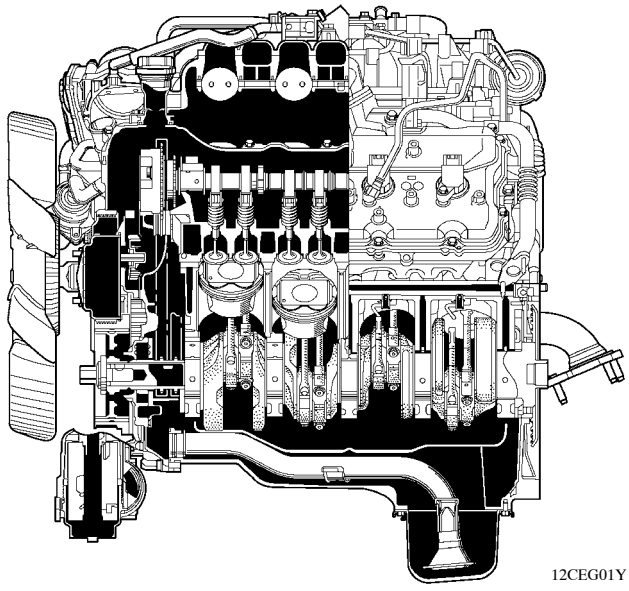
NEW FEATURES

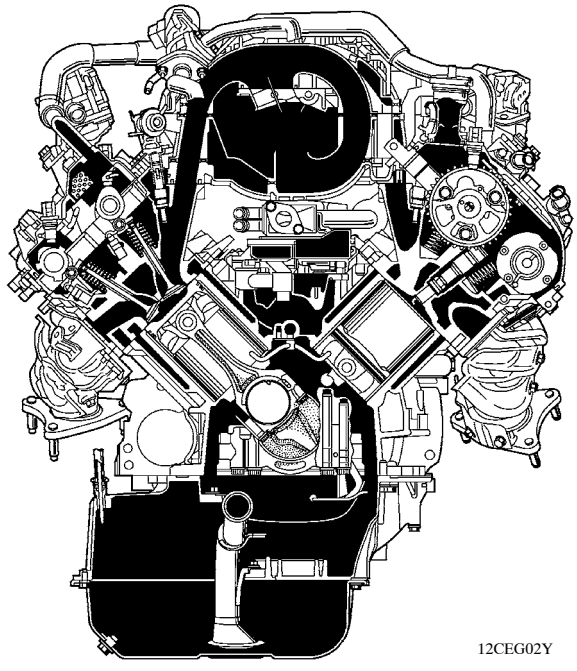
■1UR-FE ENGINE

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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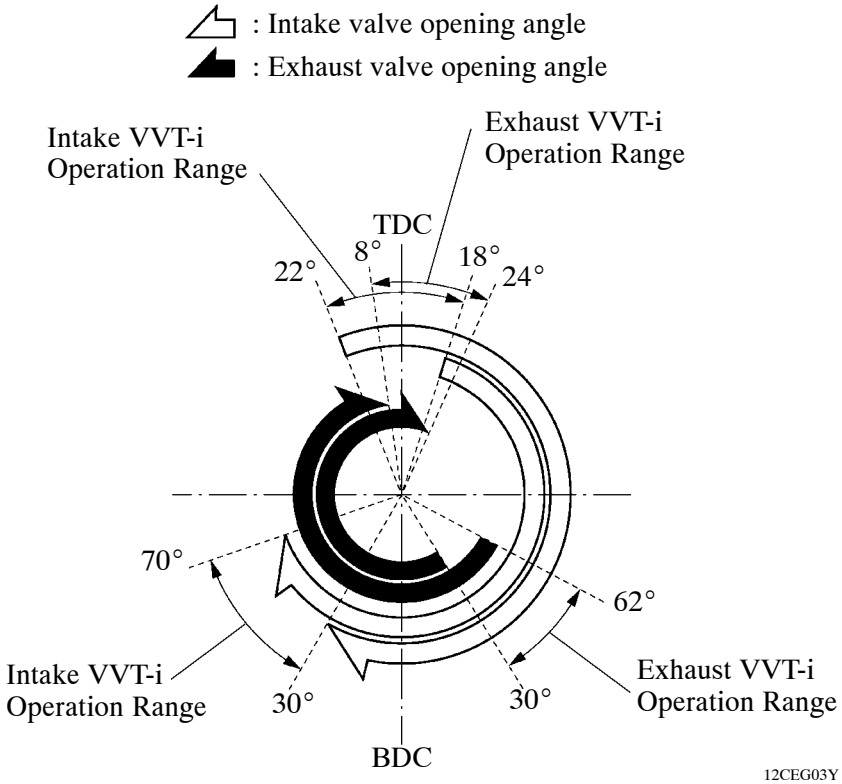
12CEG02Y

▶ Engine Specifications ◀

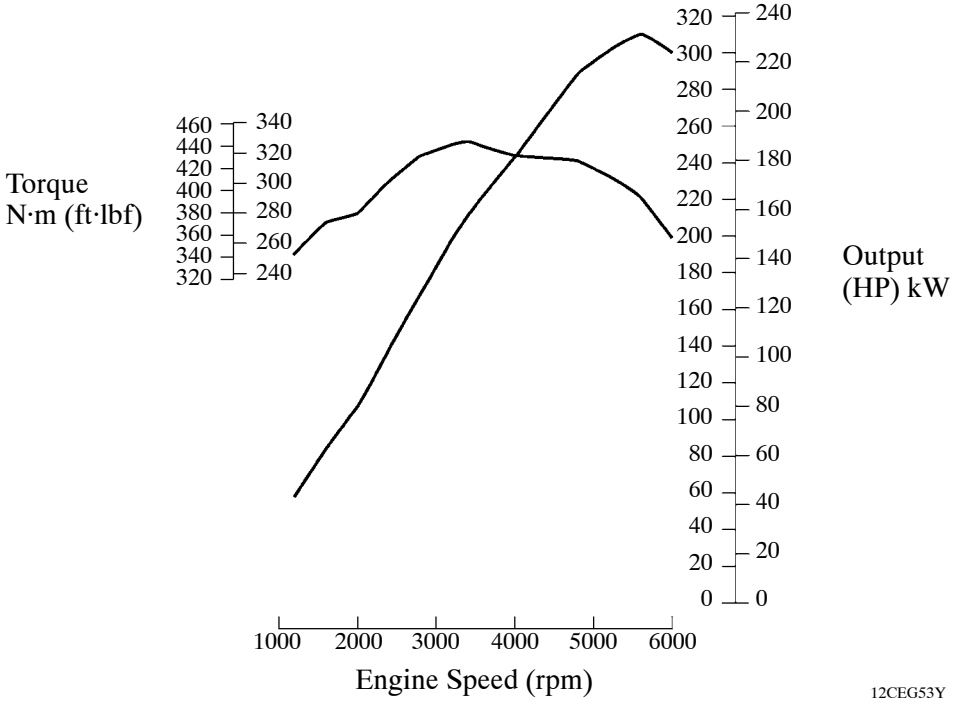
No. of Cyls. & Arrangement			8-cylinder, V Type
Valve Mechanism			32-valve DOHC, Chain Drive (with Dual VVT-i)
Combustion Chamber			Pentroof Type
Manifolds			Cross-flow
Fuel System			SFI
Ignition System			DIS
Displacement cm^3 (cu. in.)			4608 (281.2)
Bore × Stroke mm (in.)			94.0 × 83.0 (3.70 × 3.27)
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)

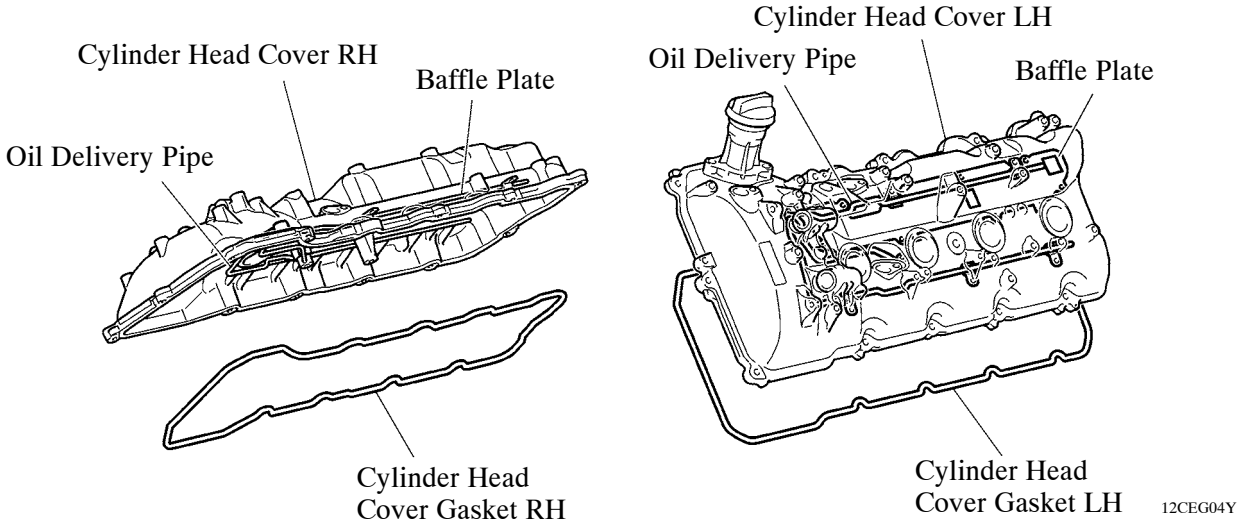
*: Models with towing package

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

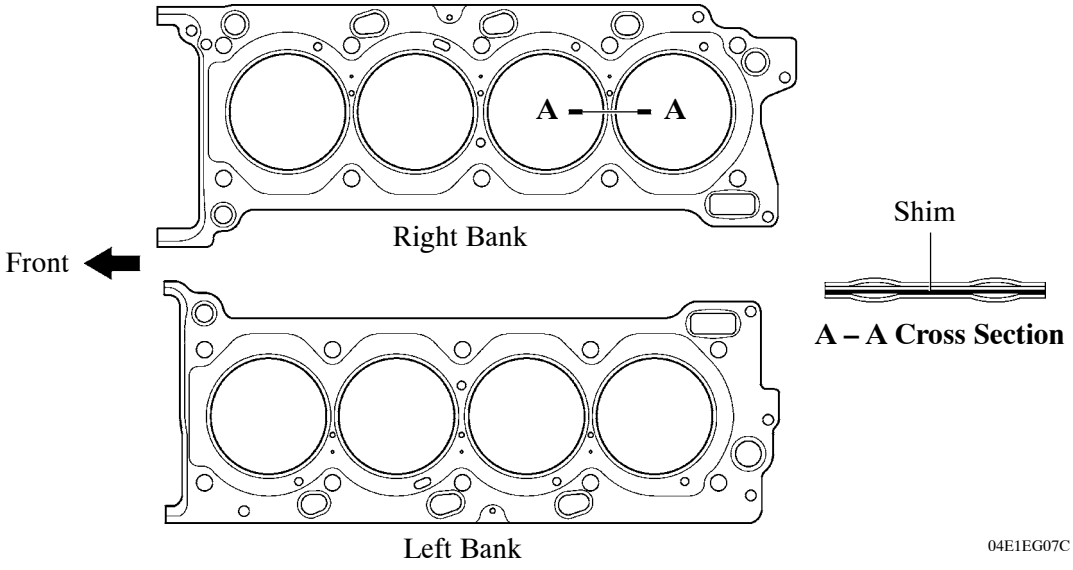
Cylinder Head Cover

- 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.



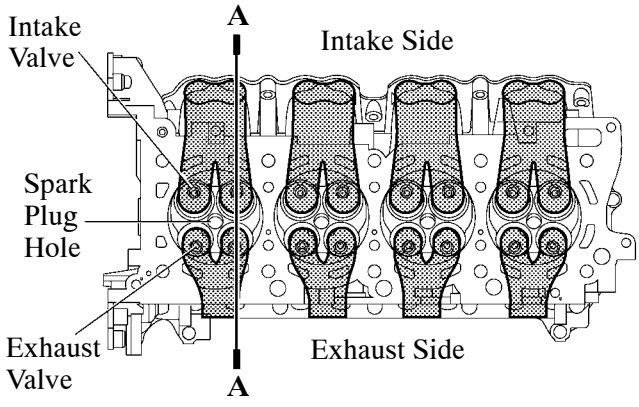
Cylinder Head Gasket

- 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.

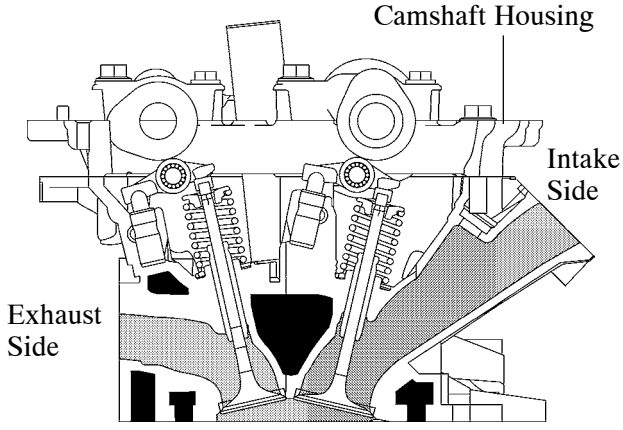


Cylinder Head

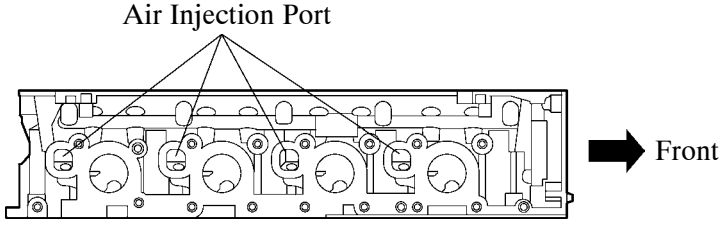
- The cylinder head structure has been simplified by separating the cam journal portion (camshaft housing) from the cylinder head.
- The cylinder head, which is made of aluminum, contains a pentroof type combustion chamber. The spark plug is located in the center of the combustion chamber in order to 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



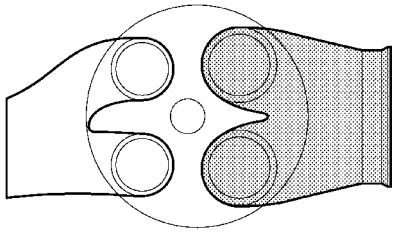
A – A Cross Section 04E1EG09C



Exhaust Side View 04E1EG10C

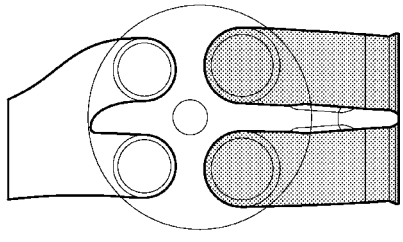
— REFERENCE —

Siamese Type



036EG28TE

Independent Type

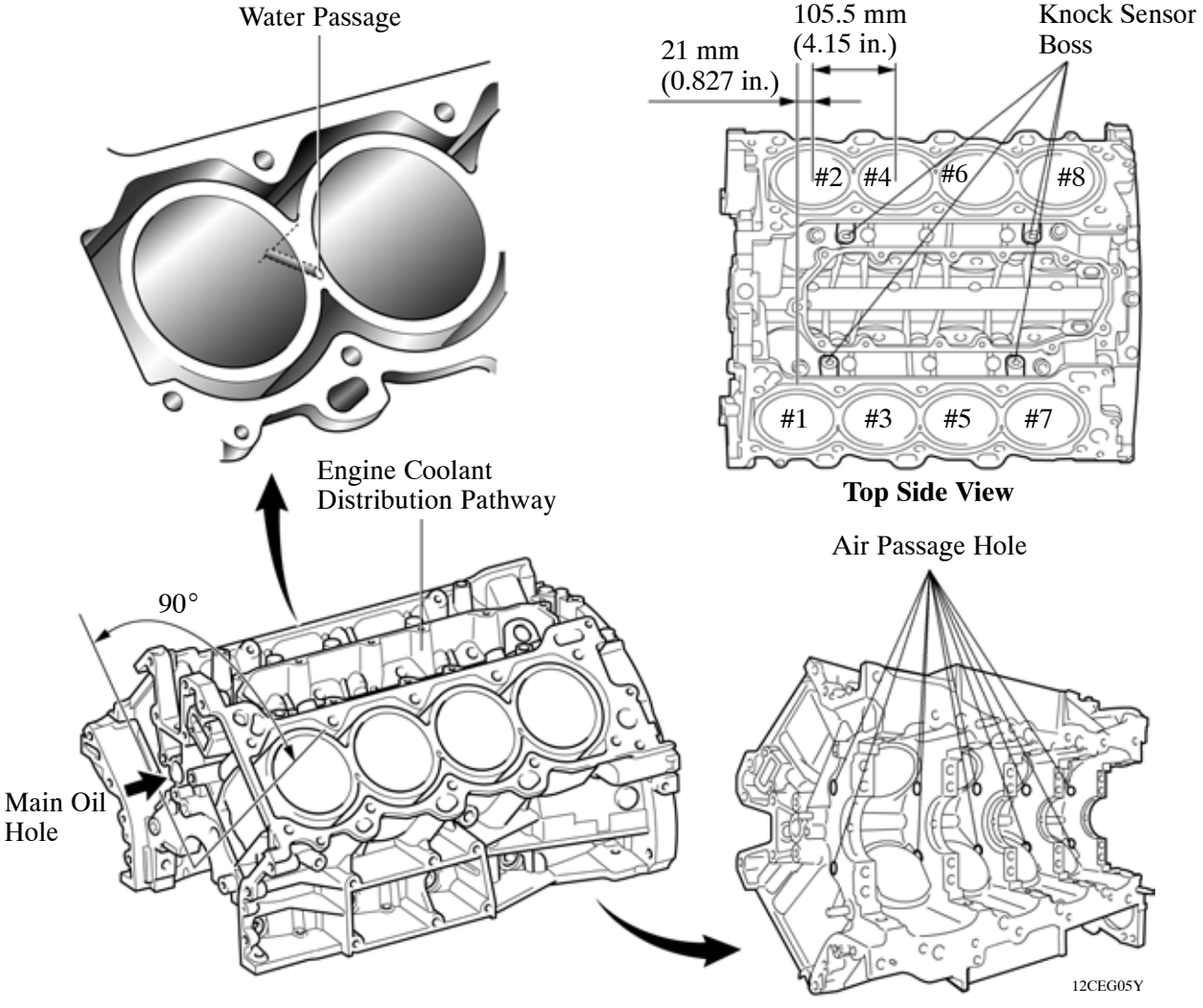


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Cylinder Block

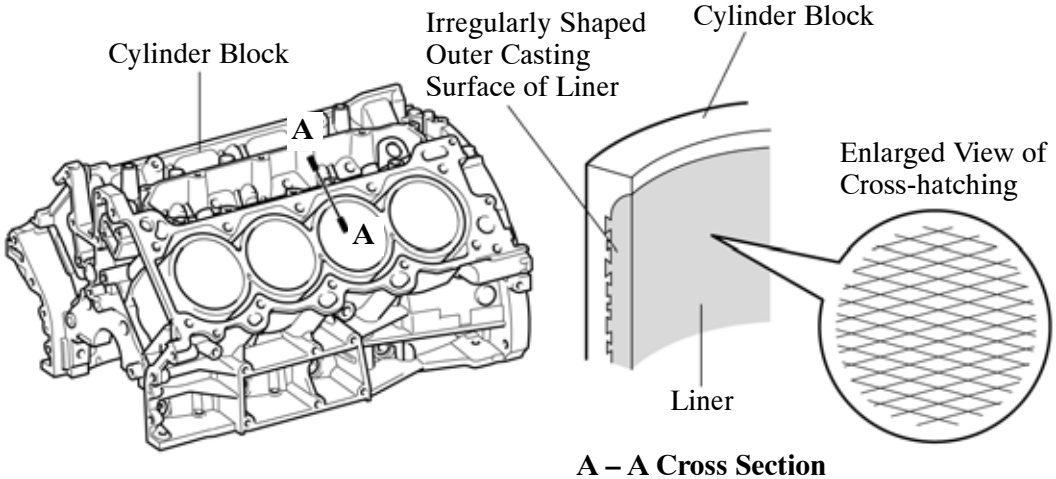
1) General

- 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.

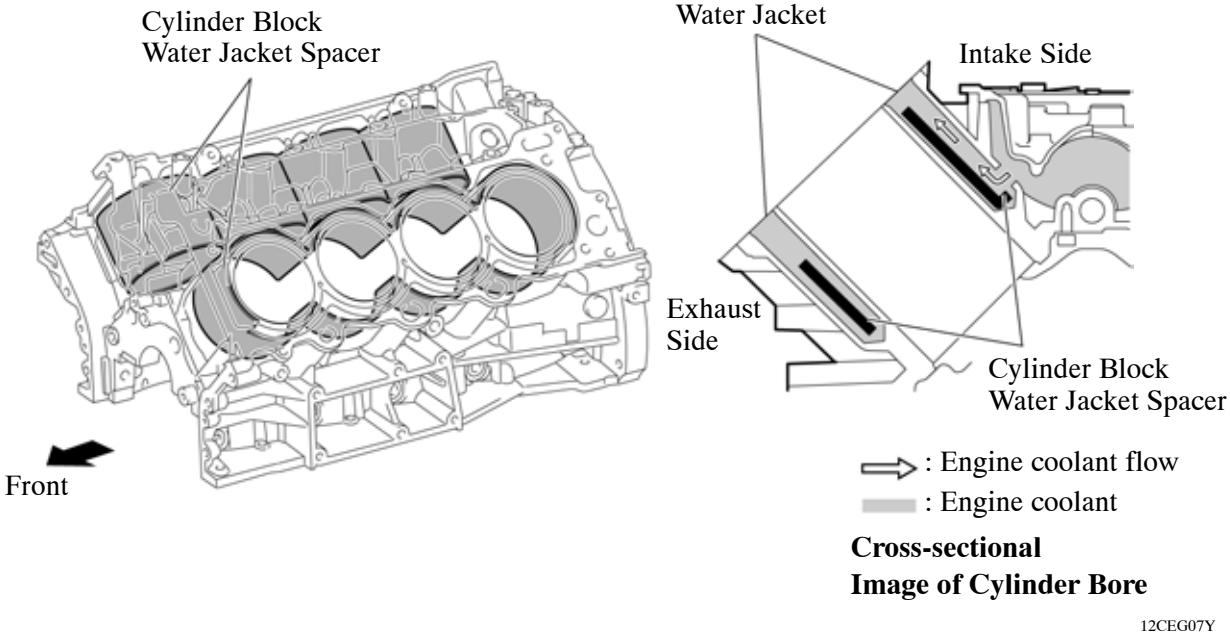


A – A Cross Section

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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.

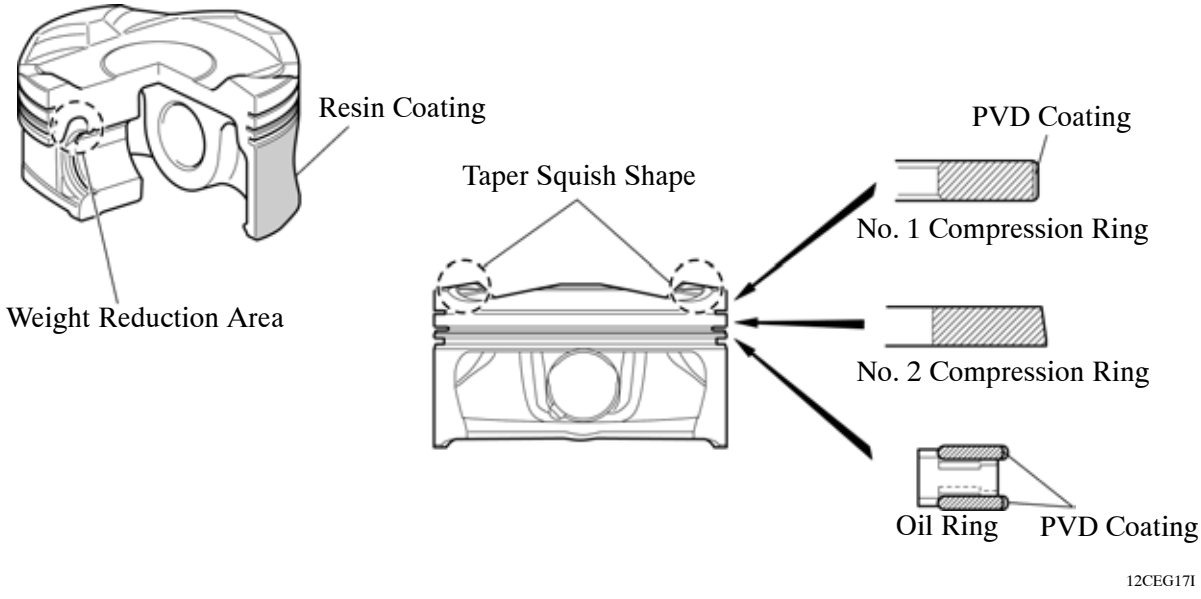


Cross-sectional Image of Cylinder Bore

12CEG07Y

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.

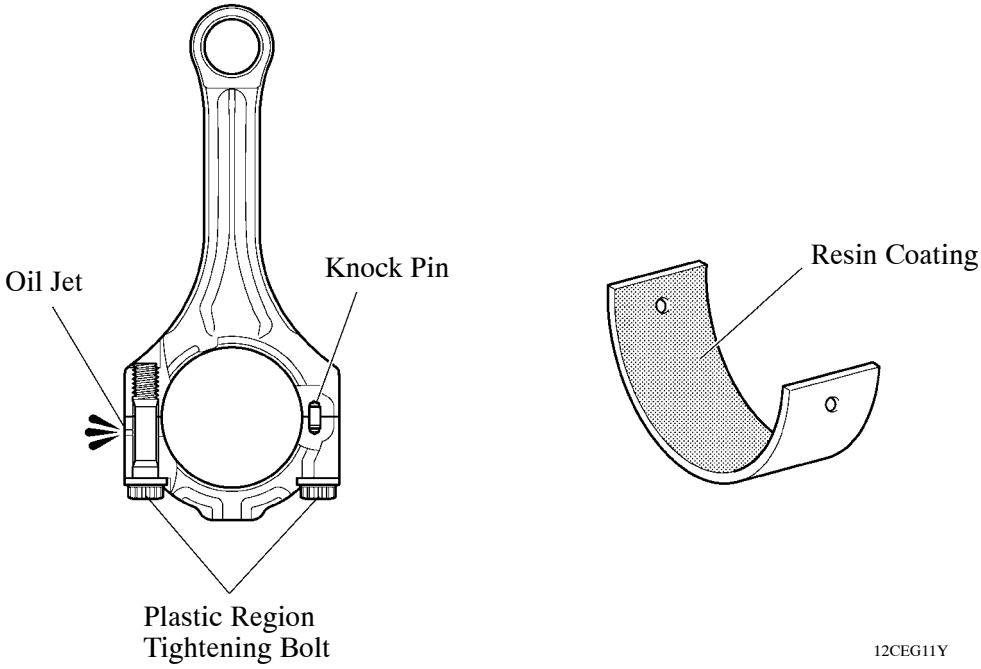


Service Tip

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.

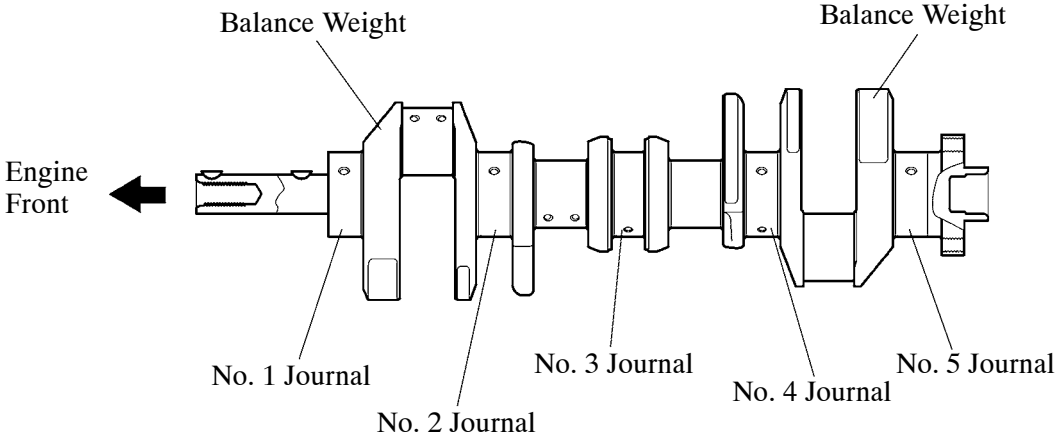
Connecting Rod and Connecting Rod Bearing

- 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.



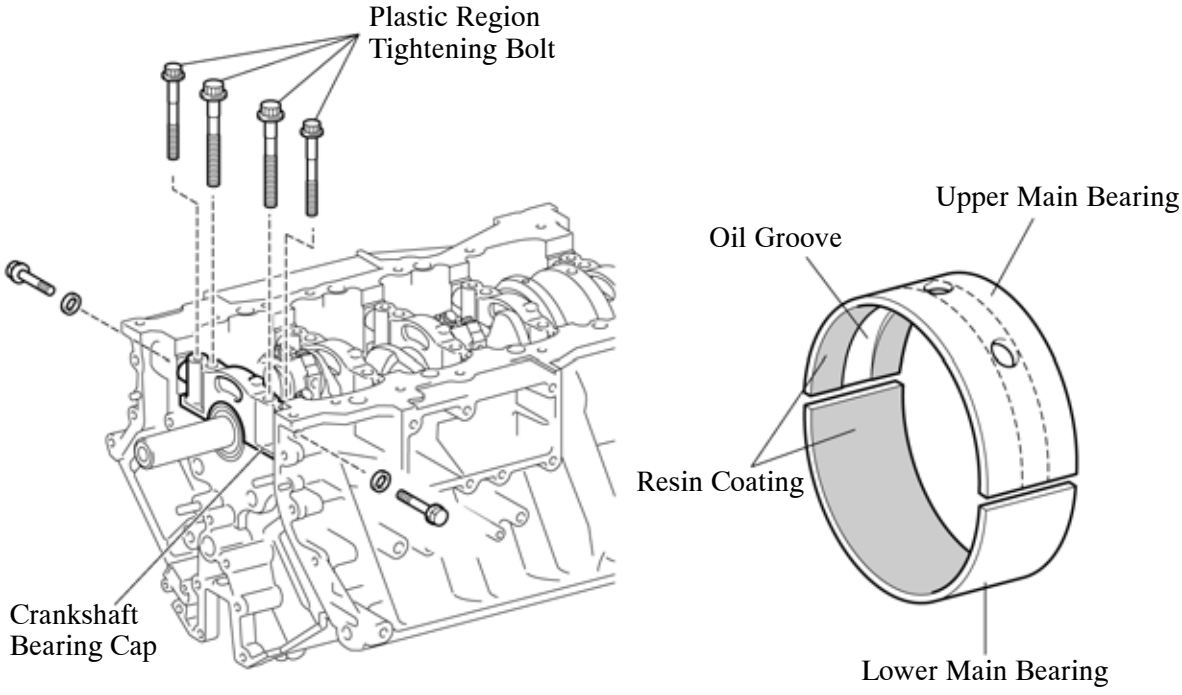
Crankshaft

- 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.



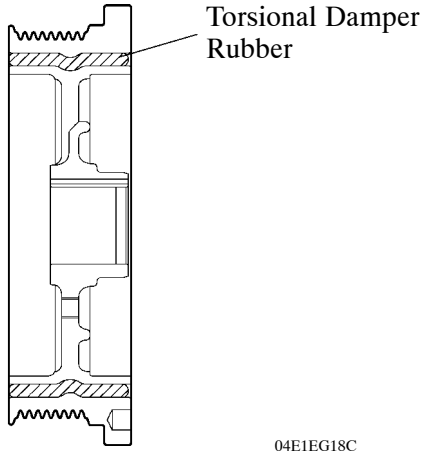
Crankshaft Bearing and Crankshaft Bearing Cap

- 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.



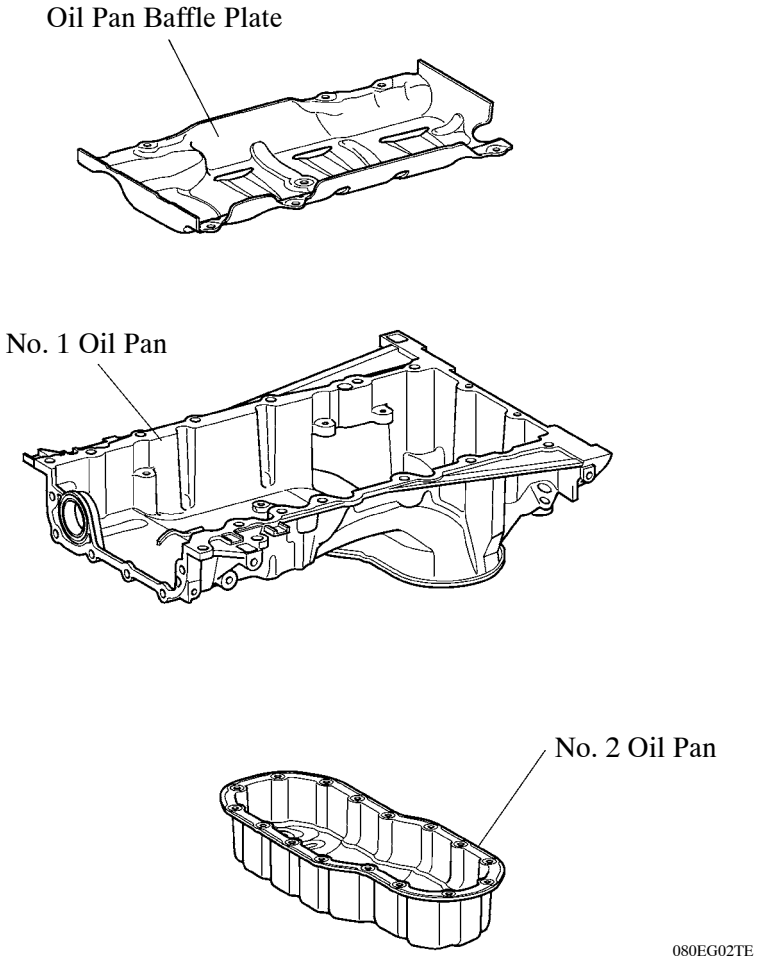
Crankshaft Pulley

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



Oil Pan

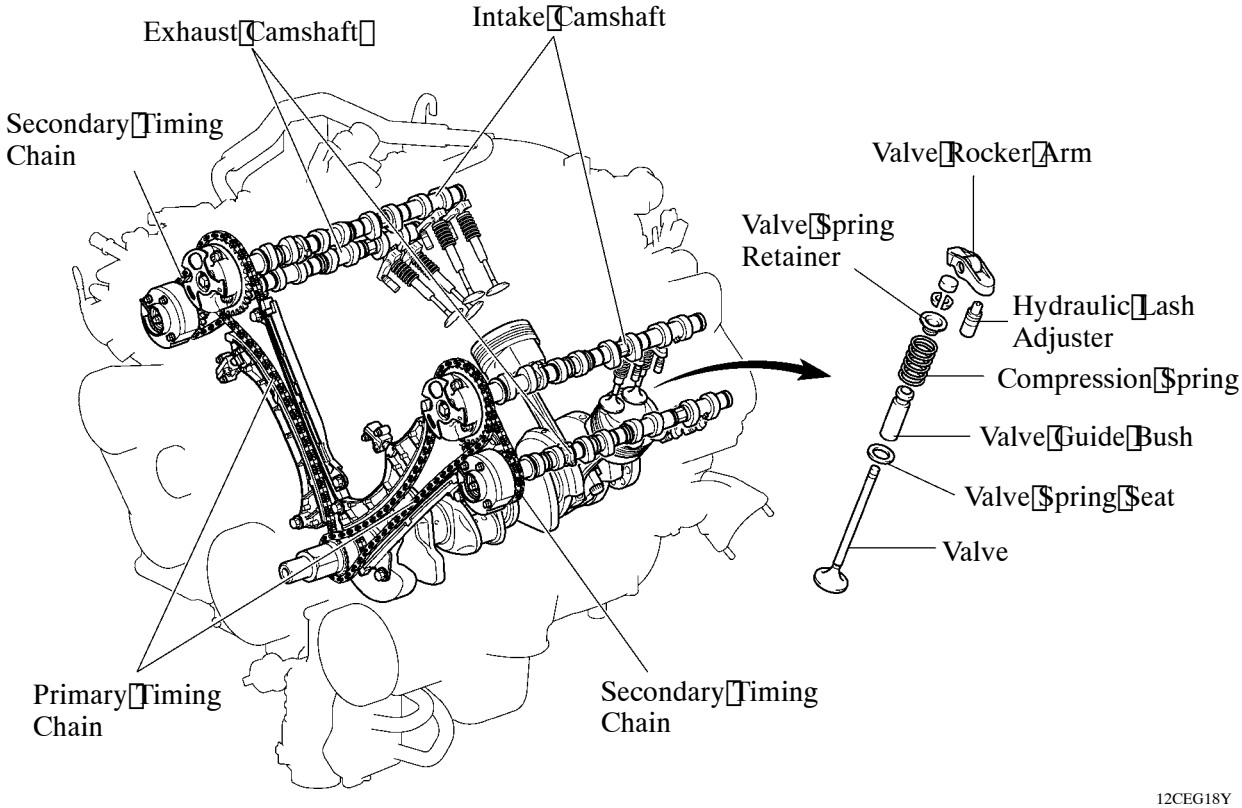
- The No. 1 oil pan is made of aluminum alloy.
- The No. 1 oil pan is secured to the cylinder block and the transmission housing to increase rigidity.
- The shape of the oil pan baffle plate has been optimized to ensure the proper space between the crankshaft and the engine oil surface. This enhances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



4. Valve Mechanism

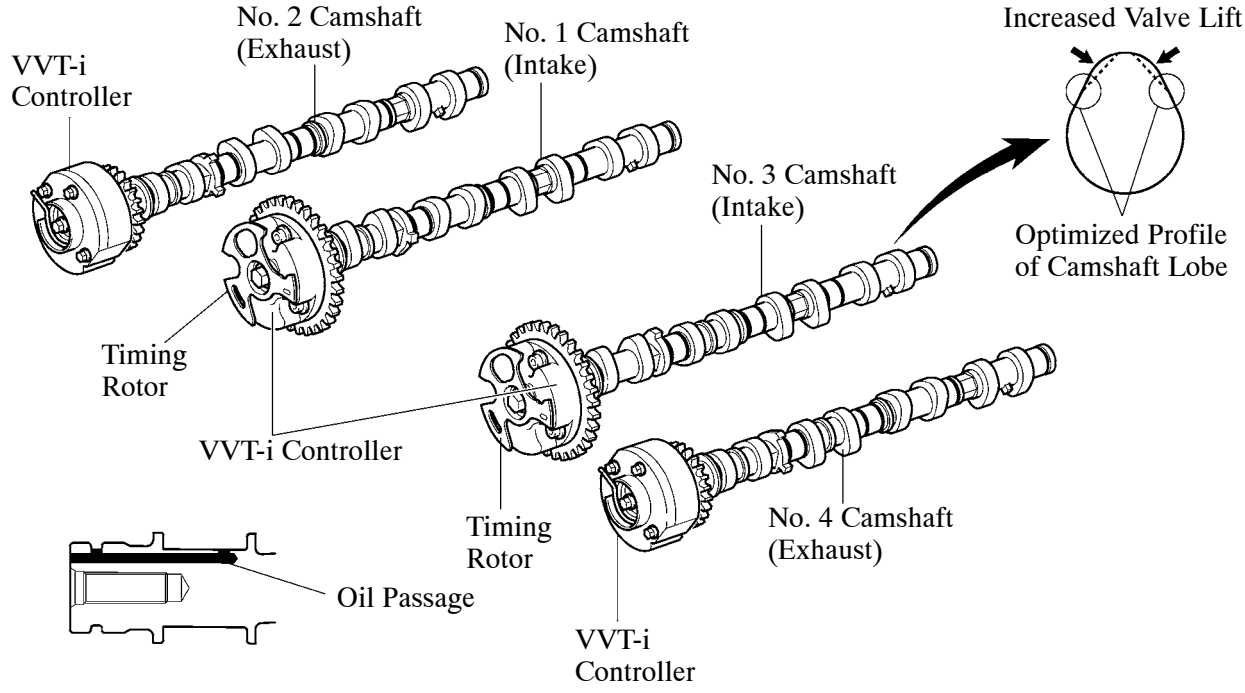
General

- 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.

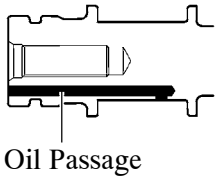


Camshaft

- 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

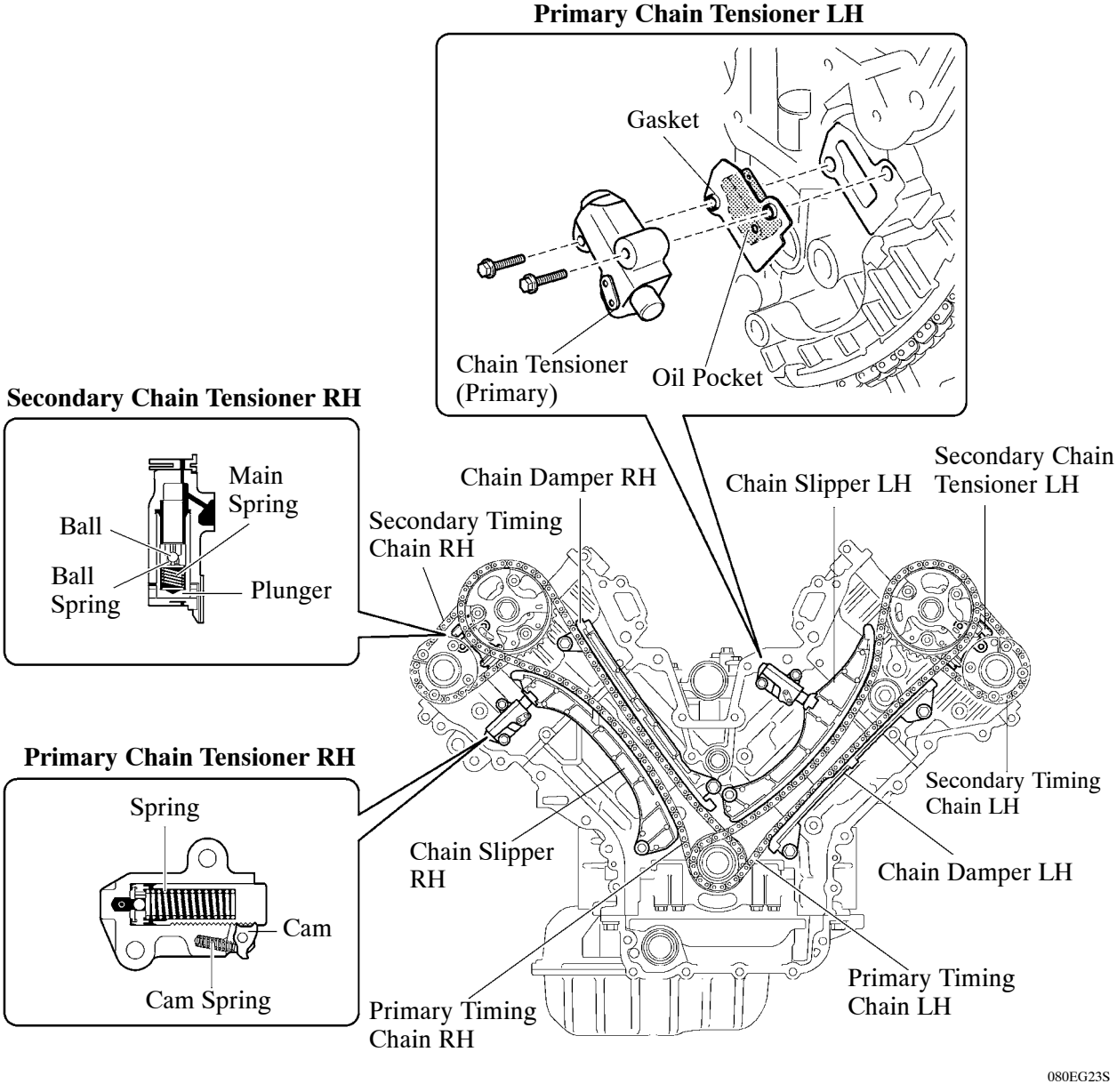


Cross Section of End of Exhaust Camshaft

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Timing Chains and Chain Tensioners

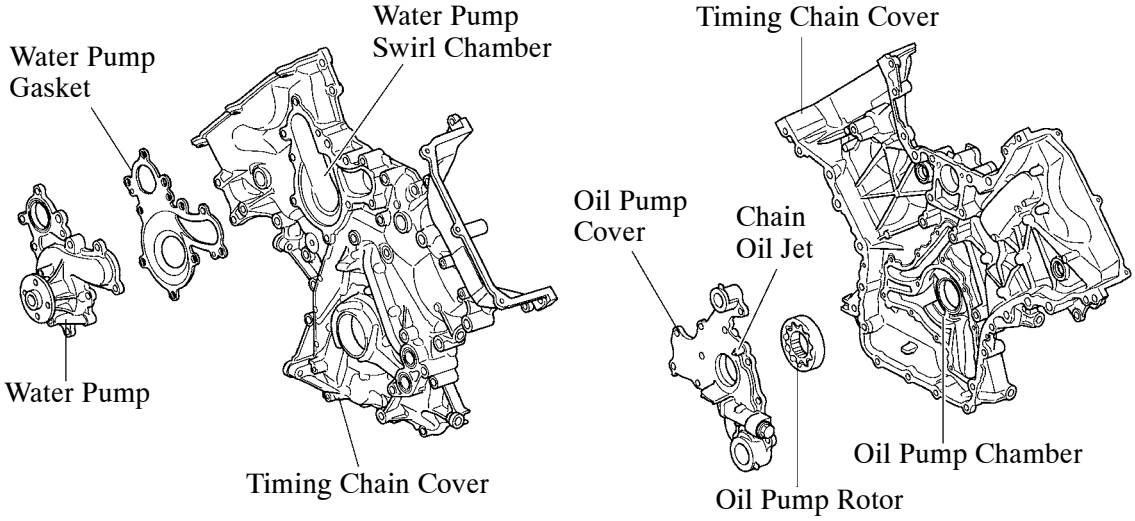
- Both the primary and secondary timing chains use roller chains with a pitch of 9.525 mm (0.375 in.).
- A chain tensioner is provided for each primary timing chain and secondary timing chain in each bank.
- Both the primary and secondary chain tensioners use oil pressure and a spring to maintain proper 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.



080EG23S

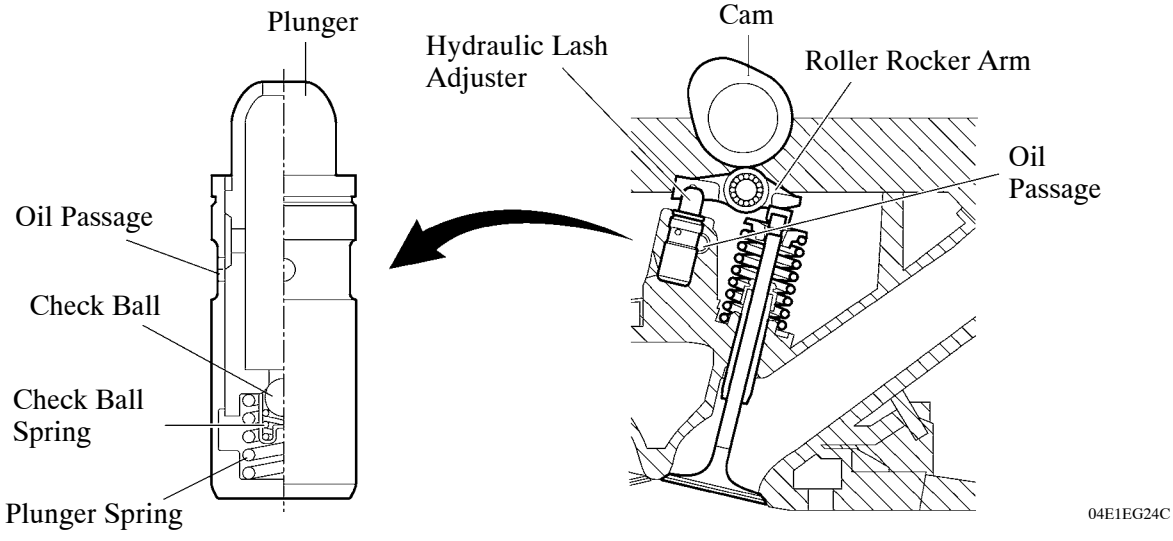
Timing Chain Cover

- 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.



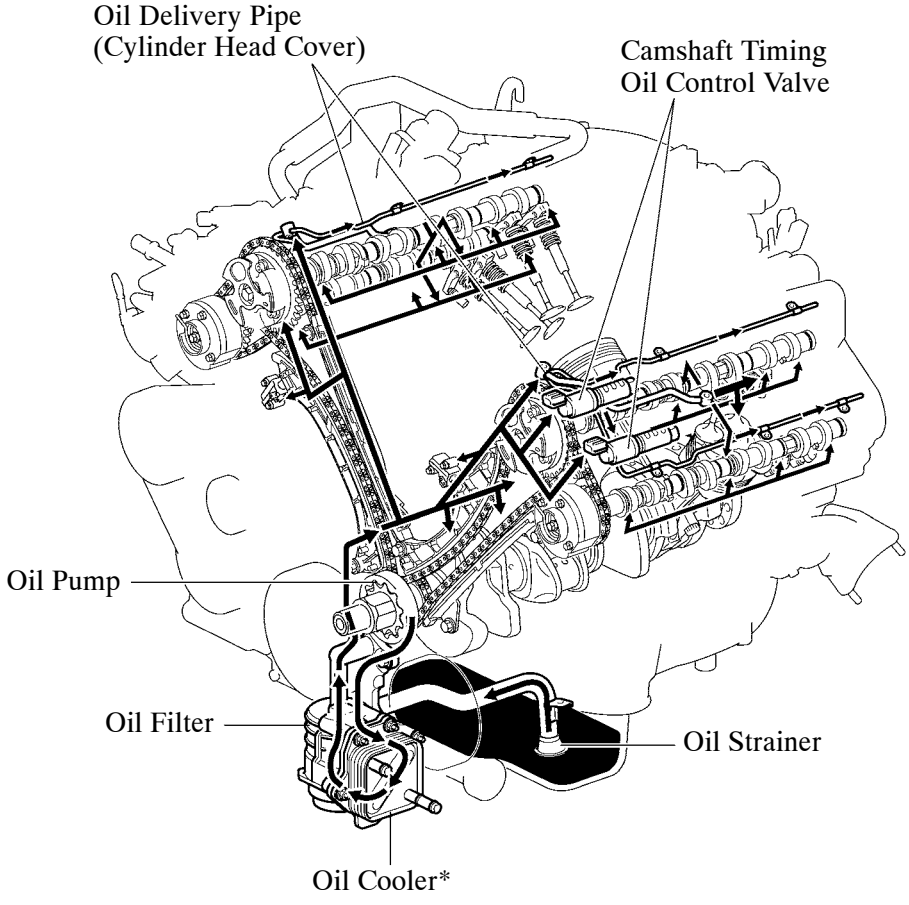
Service Tip

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

5. Lubrication System

General

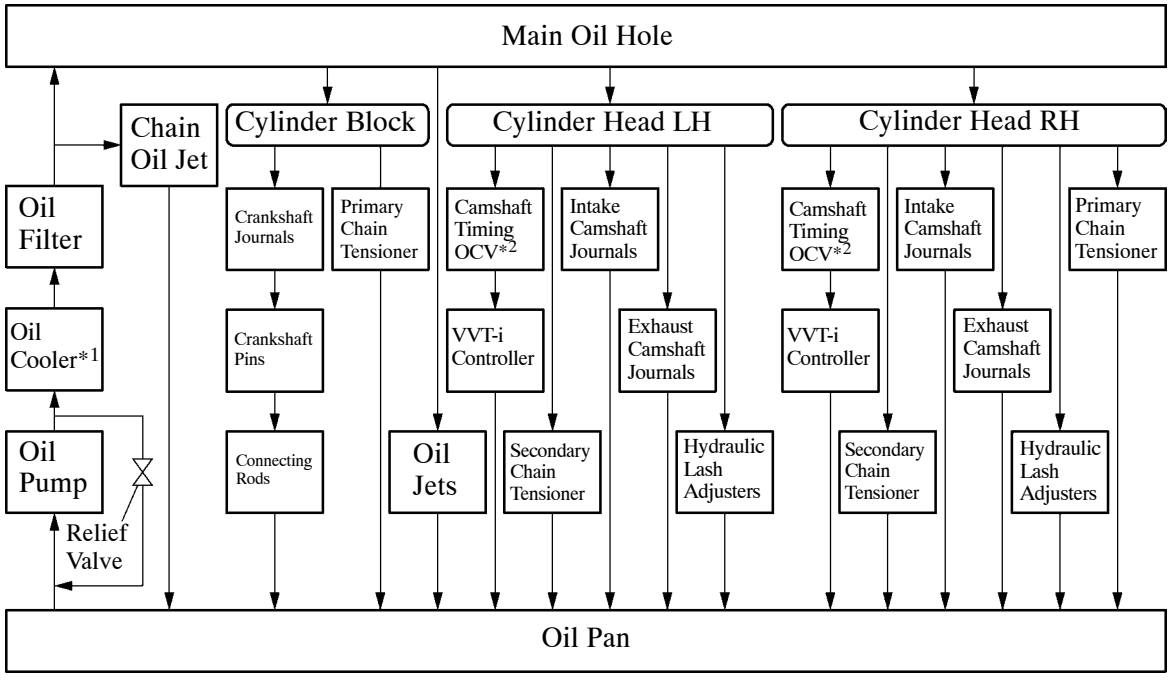
- The lubrication circuit is fully pressurized and oil passes through an oil filter.
- A cycloid rotor type oil pump is used.
- An oil filter with a replaceable element is used.
- A water-cooled type oil cooler is provided as optional equipment.



*: Models with towing package

12CEG19Y

▶ Oil Circuit ◀

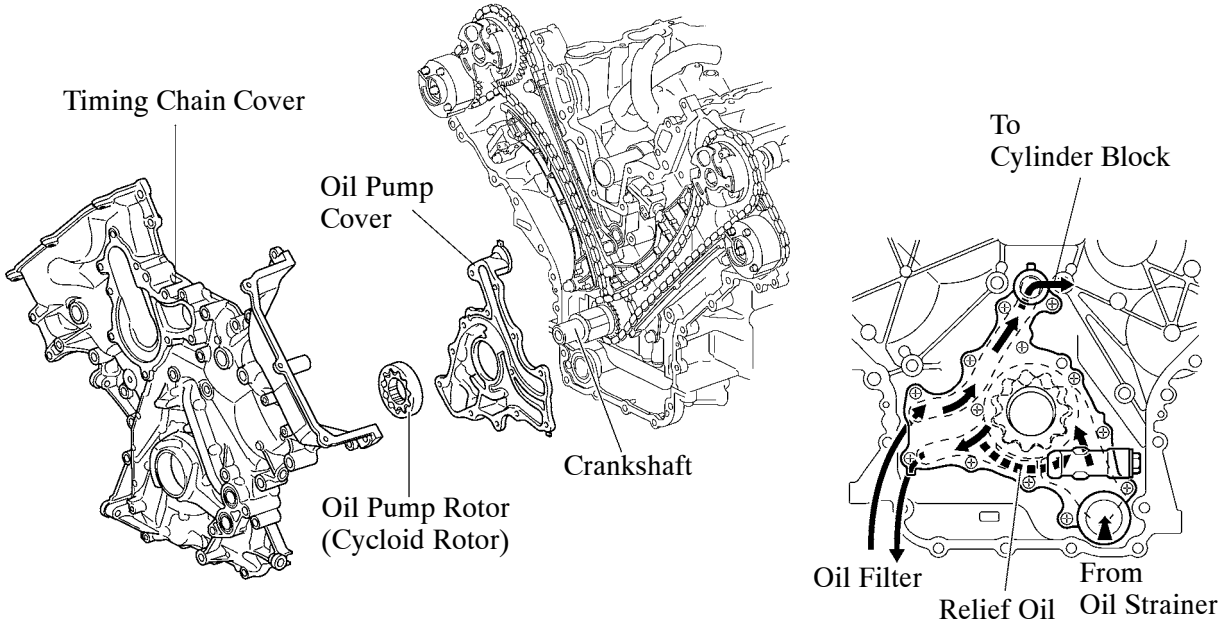


*1: Models with towing package
*2: Oil Control Valve

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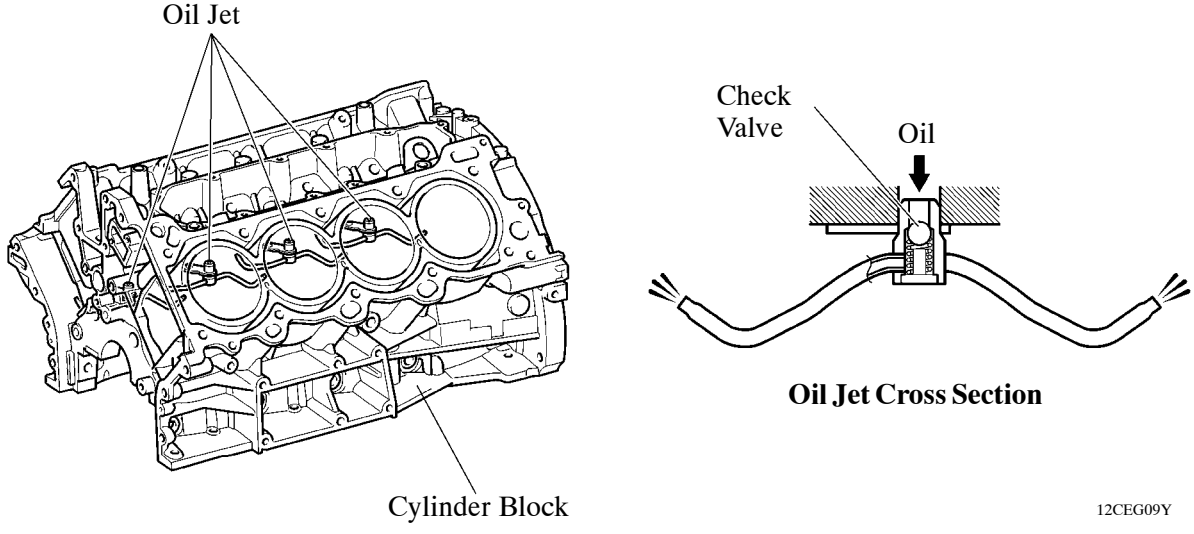
Oil Pump

- 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.



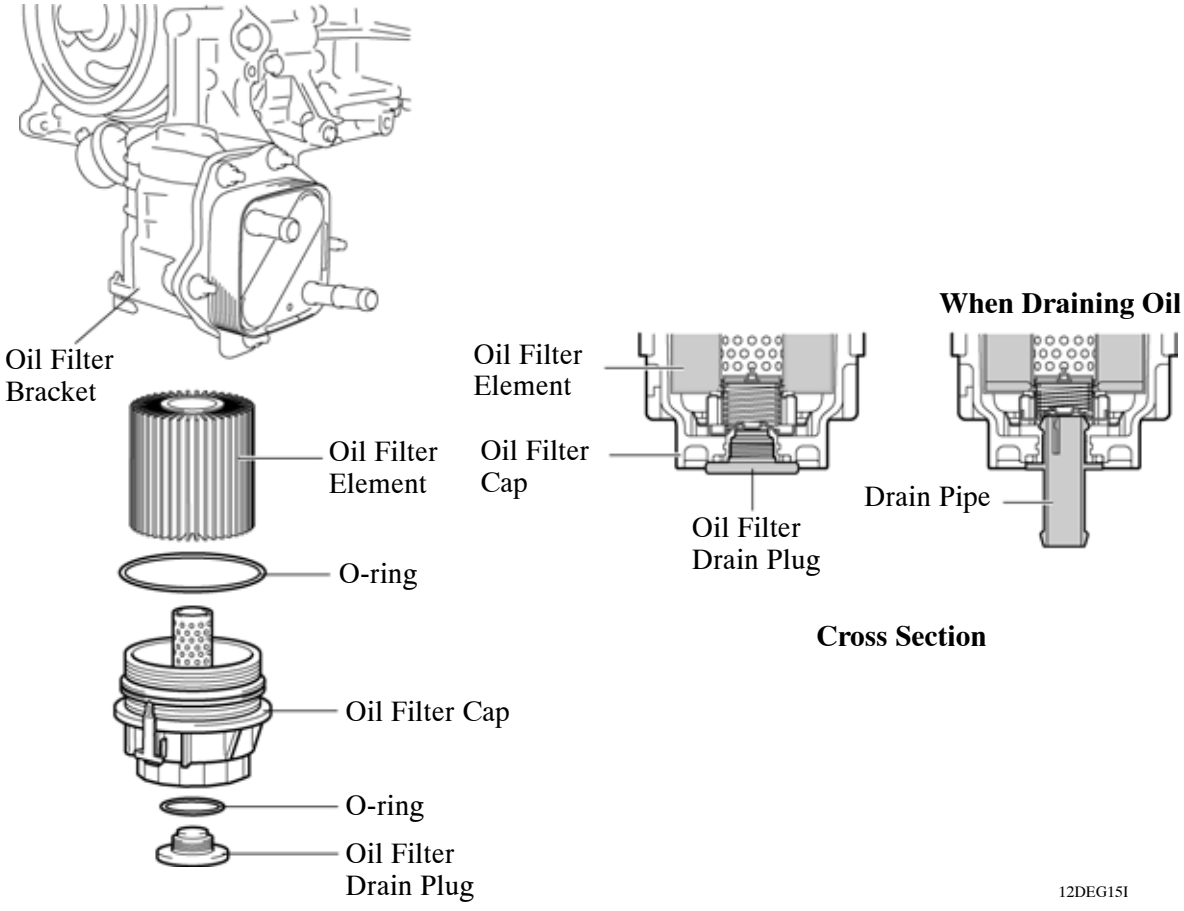
Oil Jet

- 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.

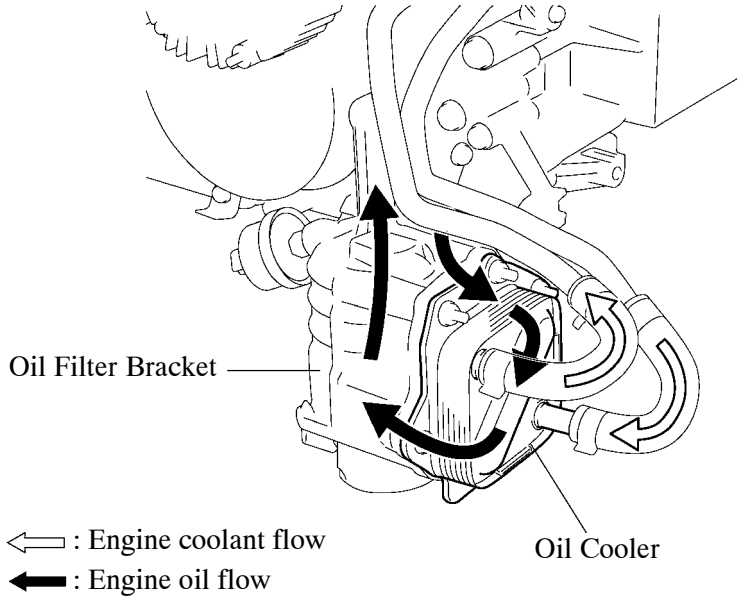


Service Tip

- 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.

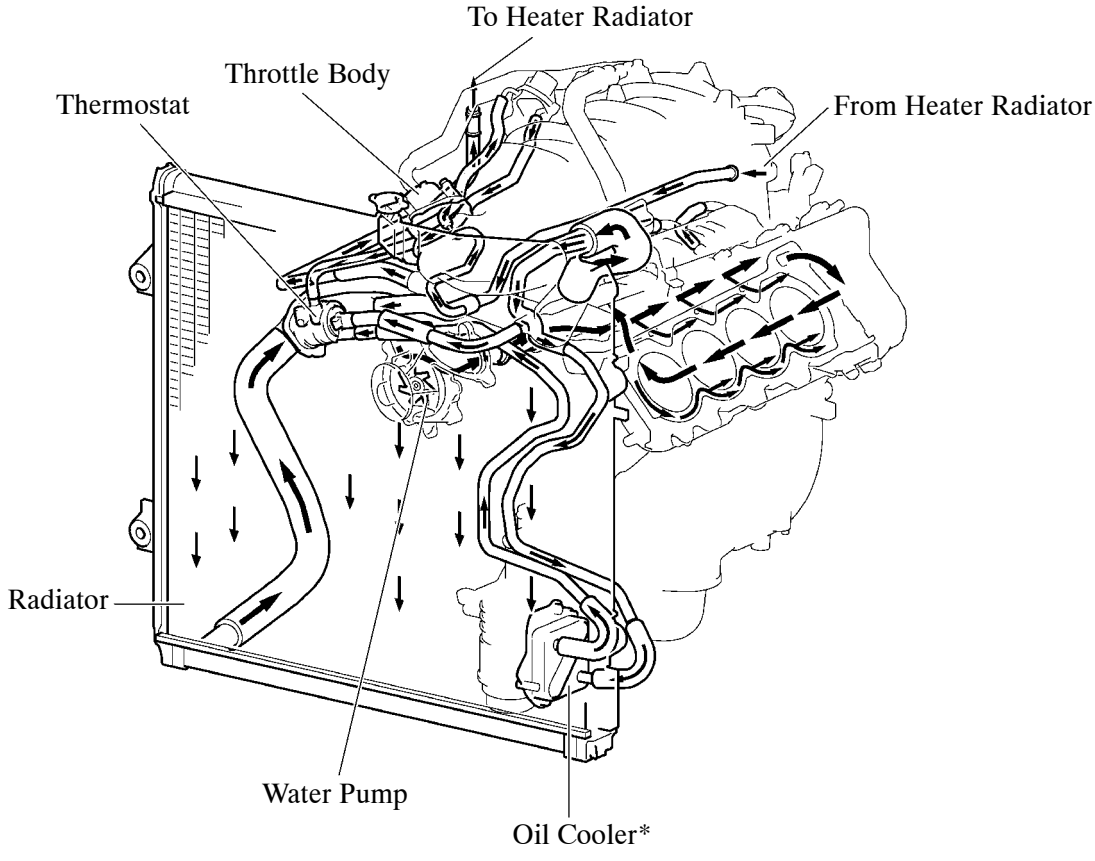


11YEG11Y

6. Cooling System

General

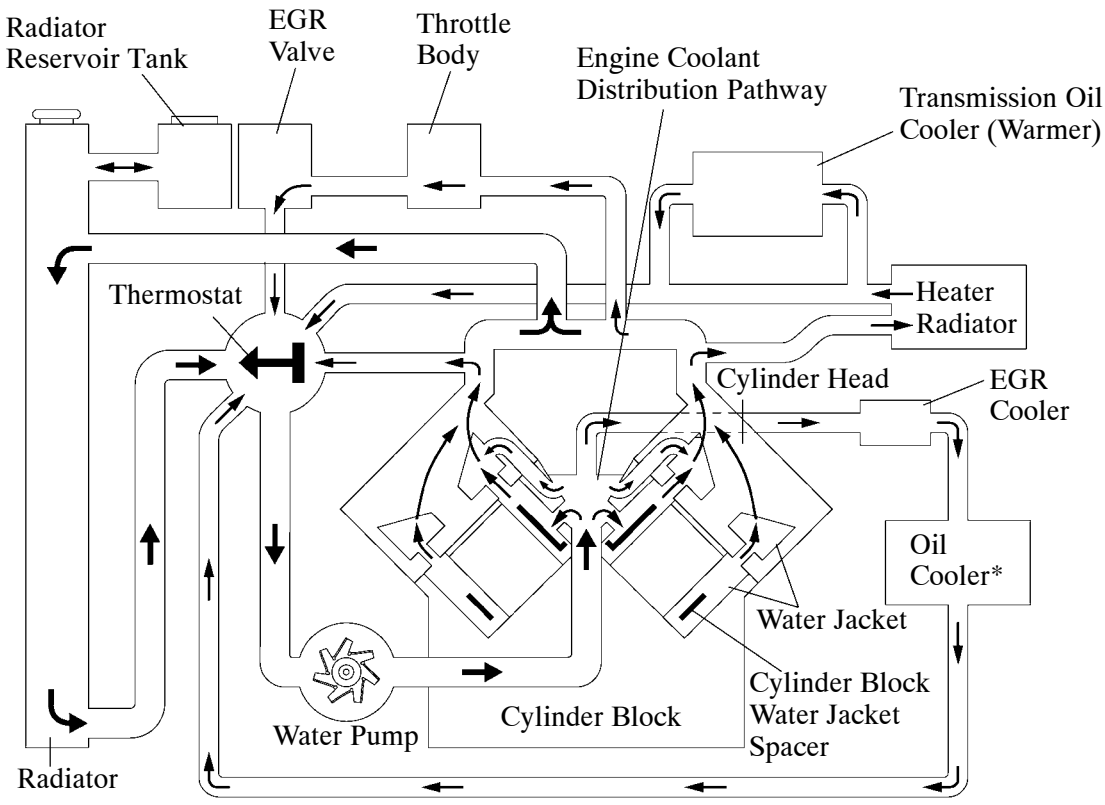
- The cooling system uses a pressurized forced circulation system with an open air type reservoir tank.
- An engine coolant distribution pathway is provided between the left and right banks of the cylinder block.
- A thermostat with a bypass valve is located on the plastic water inlet to maintain suitable 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

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▶ Water Circuit ◀



*: Models with towing package

12CEG40I

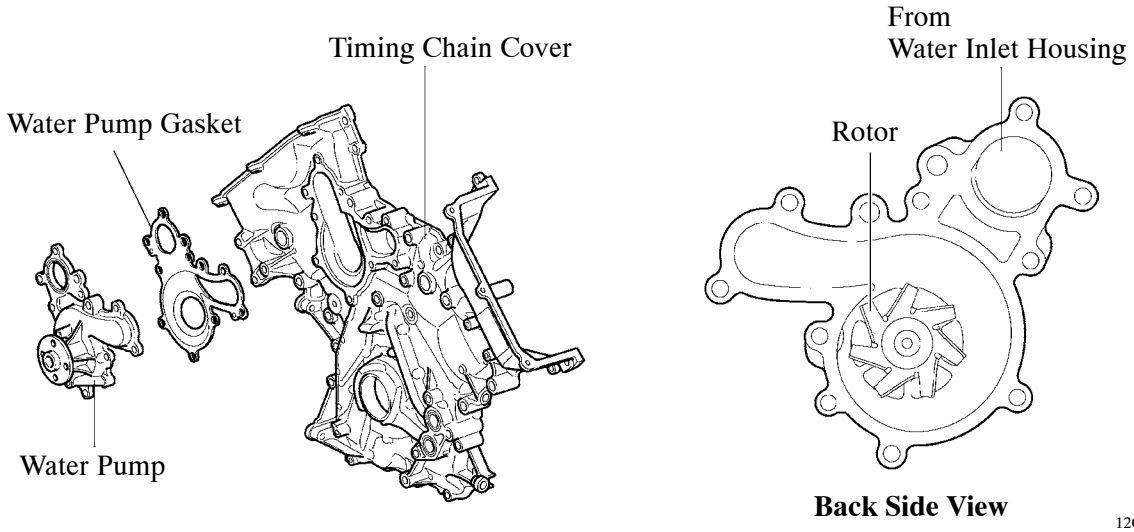
▶ Specifications ◀

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.

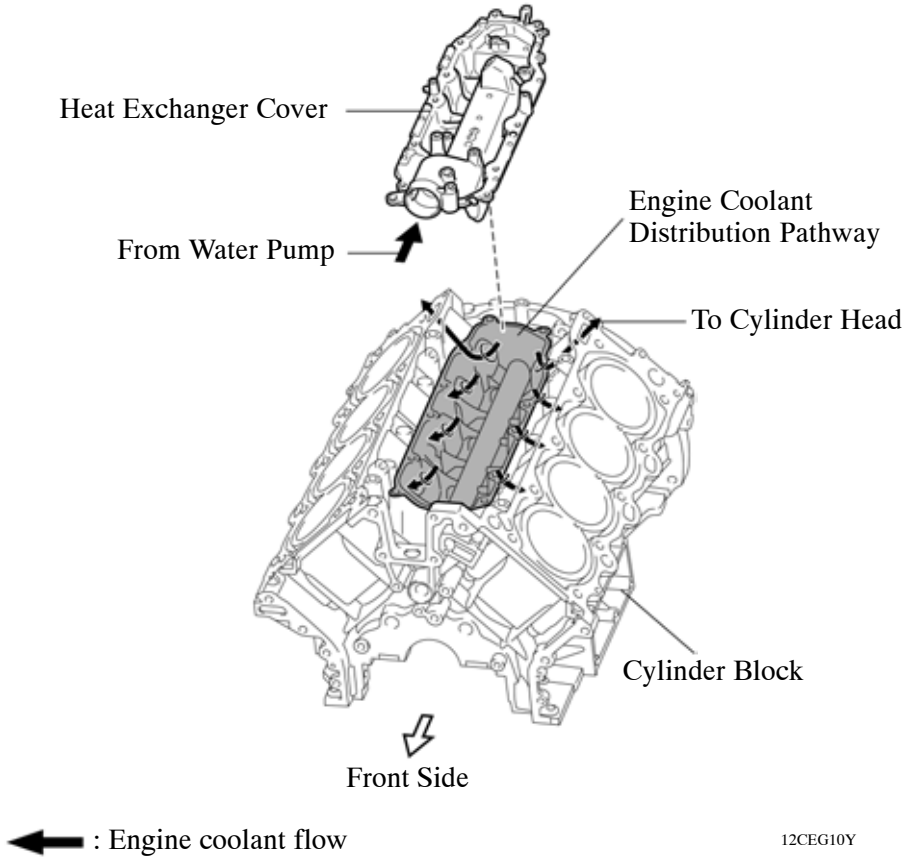
Water Pump

- 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

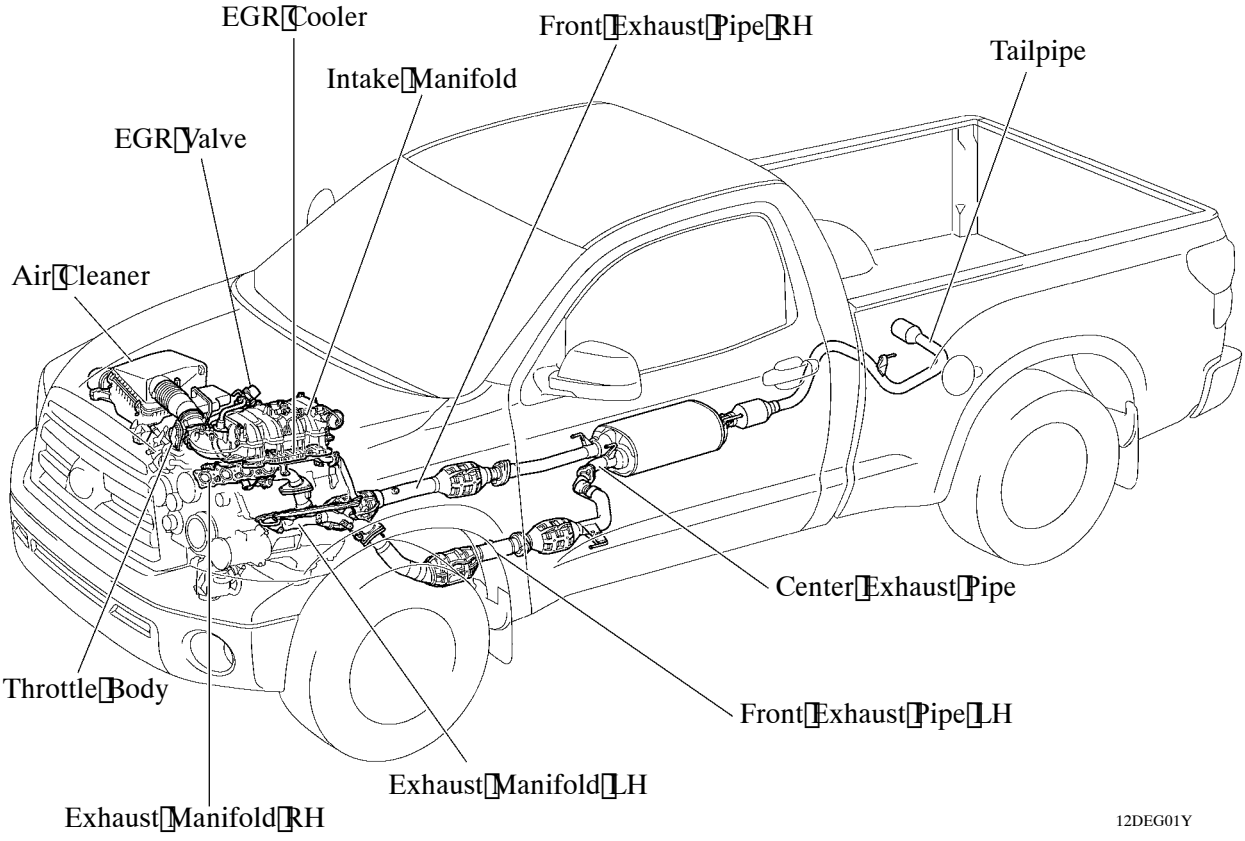
The water pump circulates the engine coolant and directs it to the engine coolant distribution pathway located between the left and right banks. From there, the engine coolant is uniformly distributed to each cylinder of the cylinder block, and is also directly discharged to the cylinder heads. As a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



7. Intake and Exhaust System

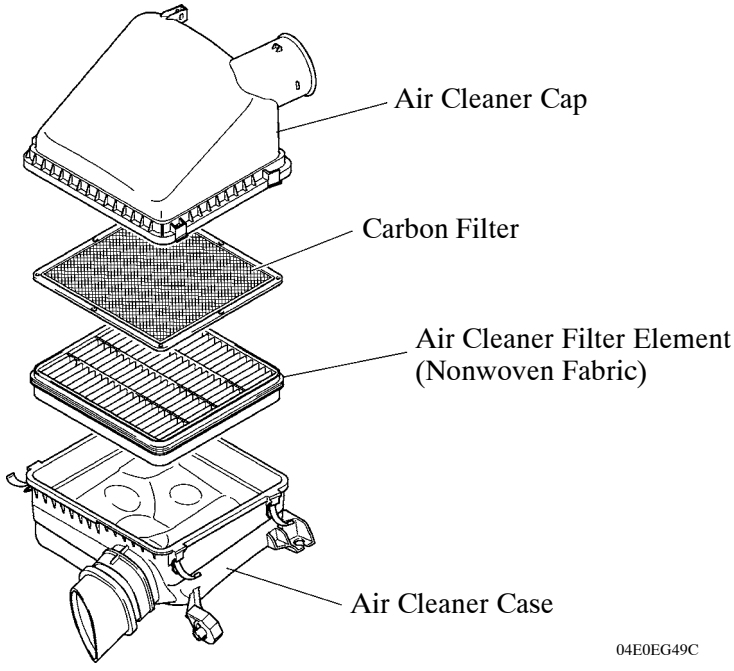
General

- 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.



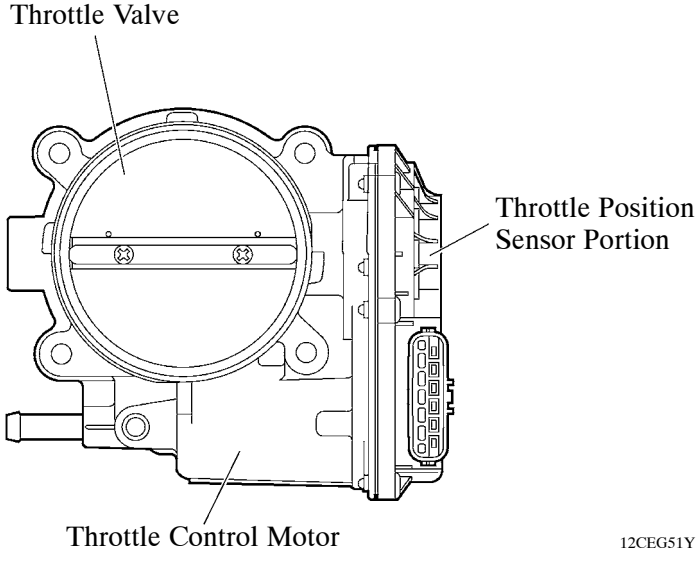
Air Cleaner

- 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.



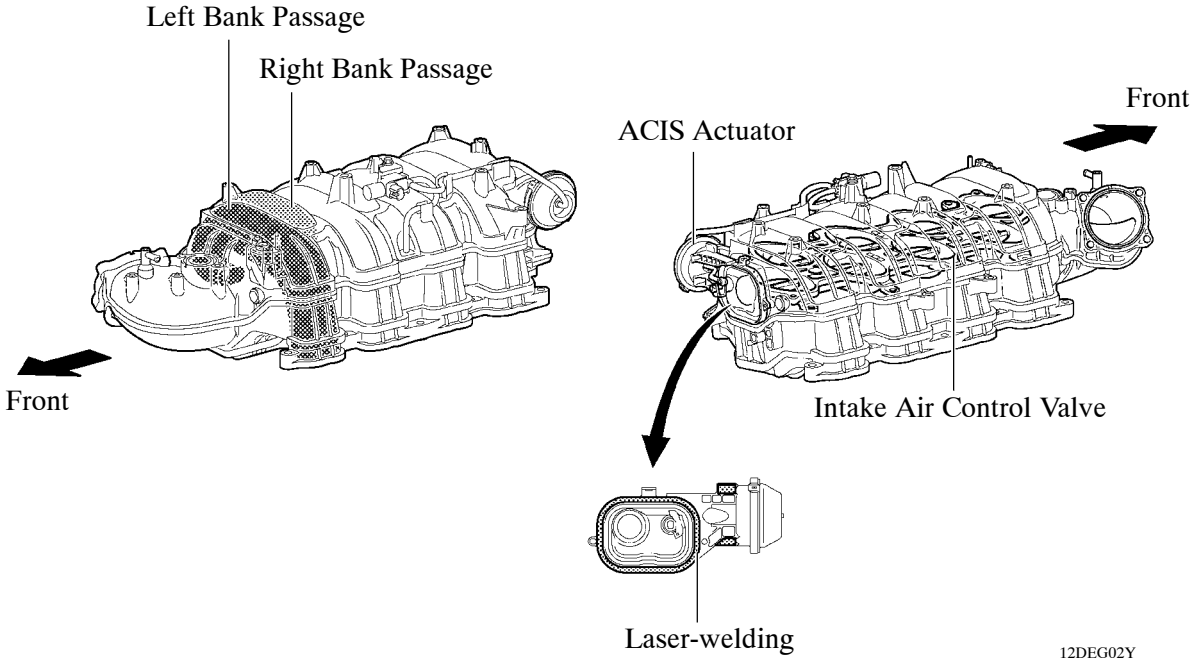
Throttle Body

- 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.



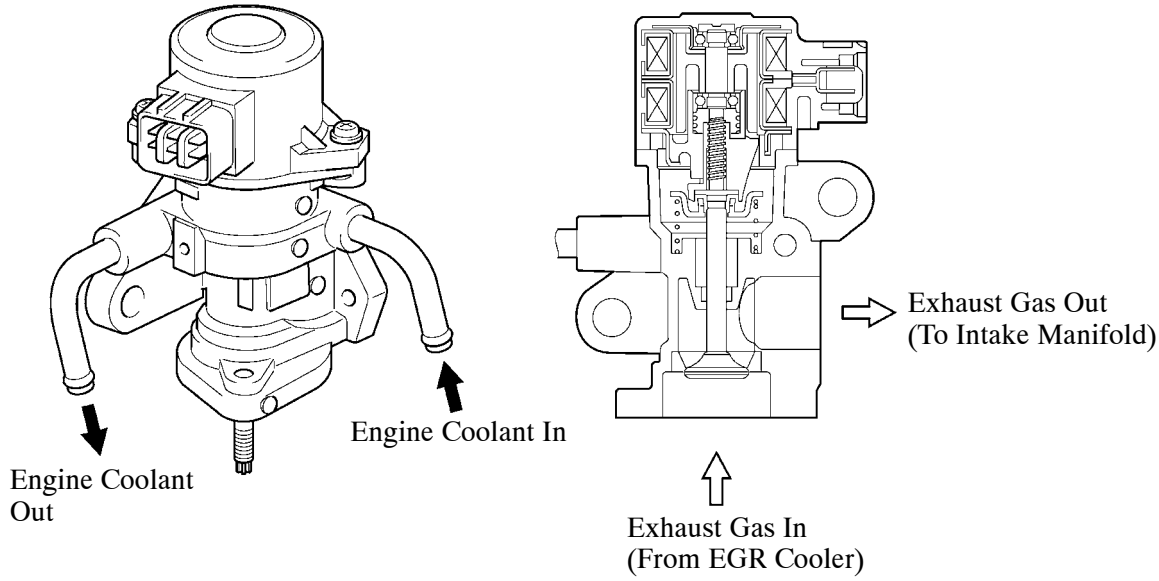
— REFERENCE —

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.

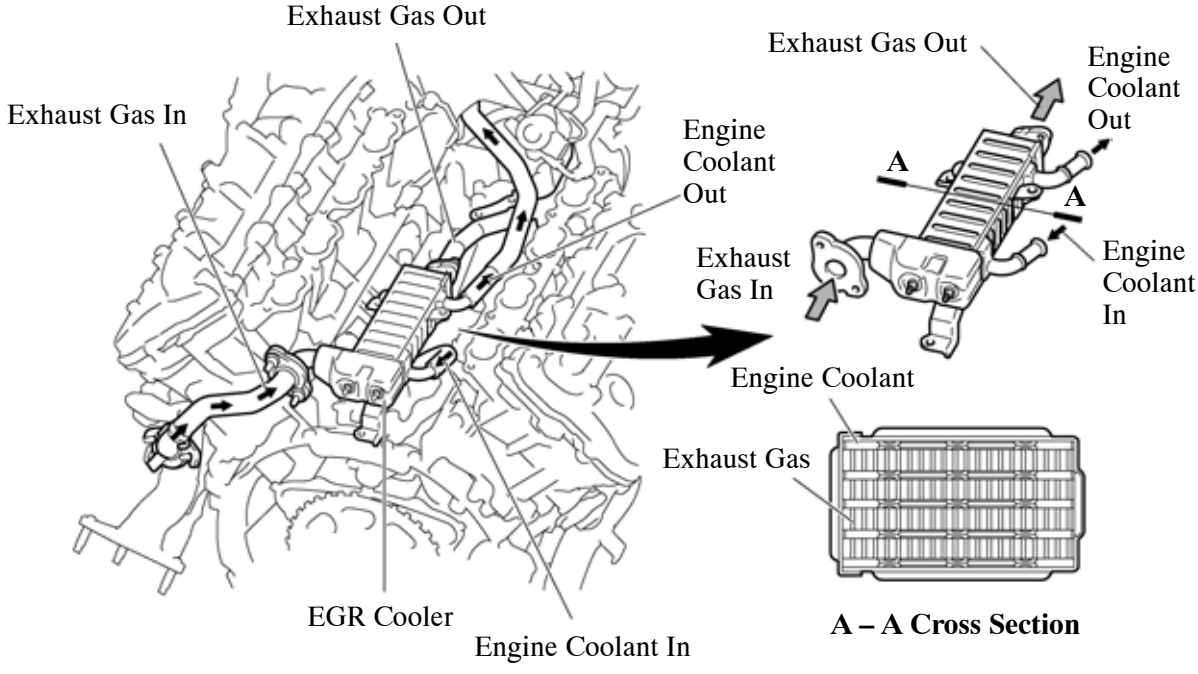


EGR Valve Cross Section

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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.

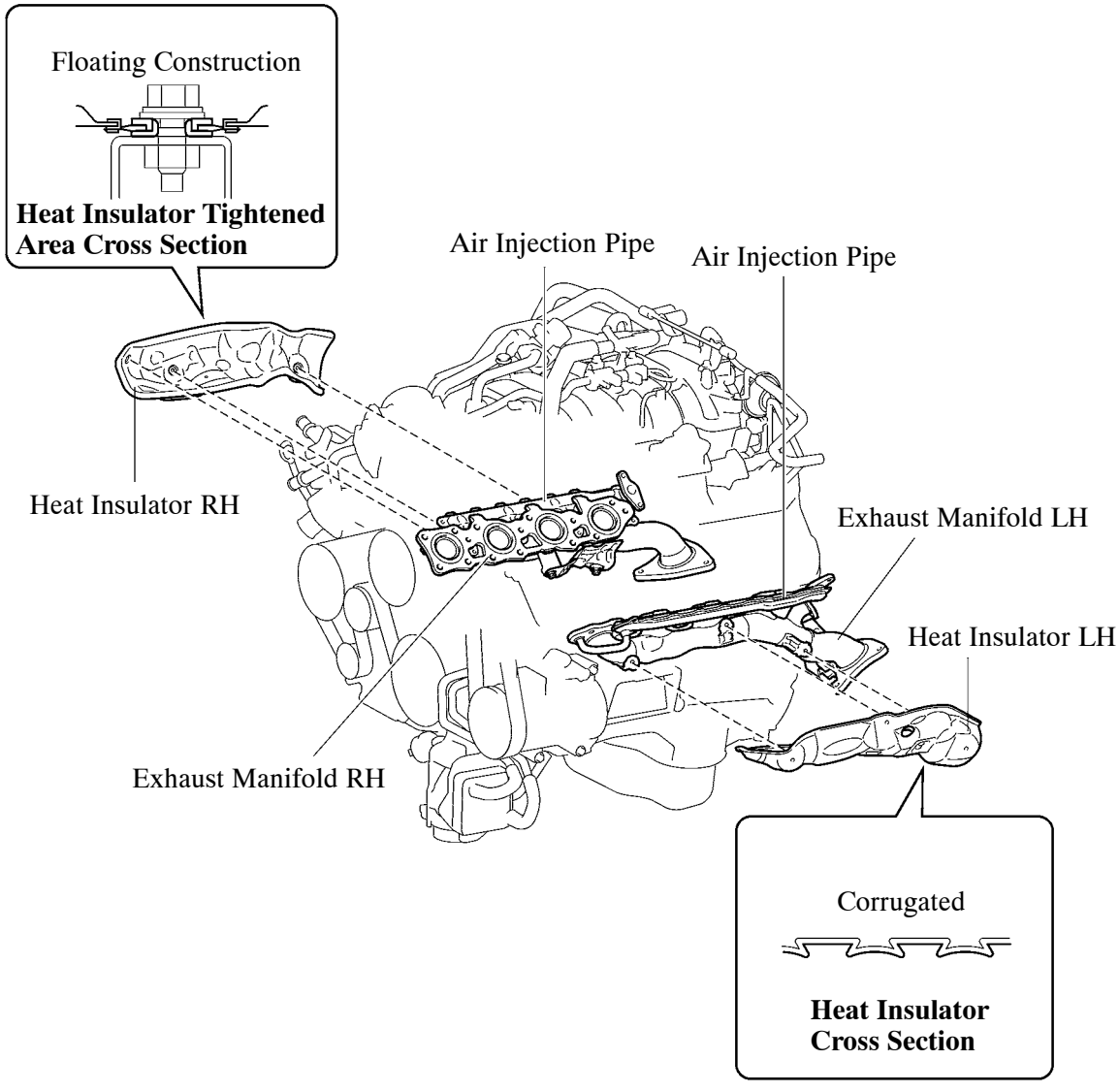


A – A Cross Section

12CEG21Y

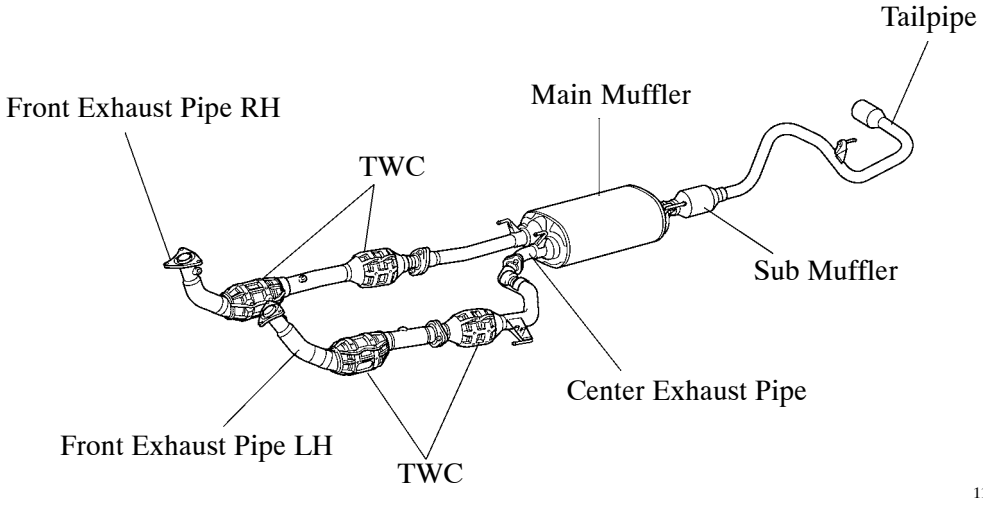
Exhaust Manifold

- 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

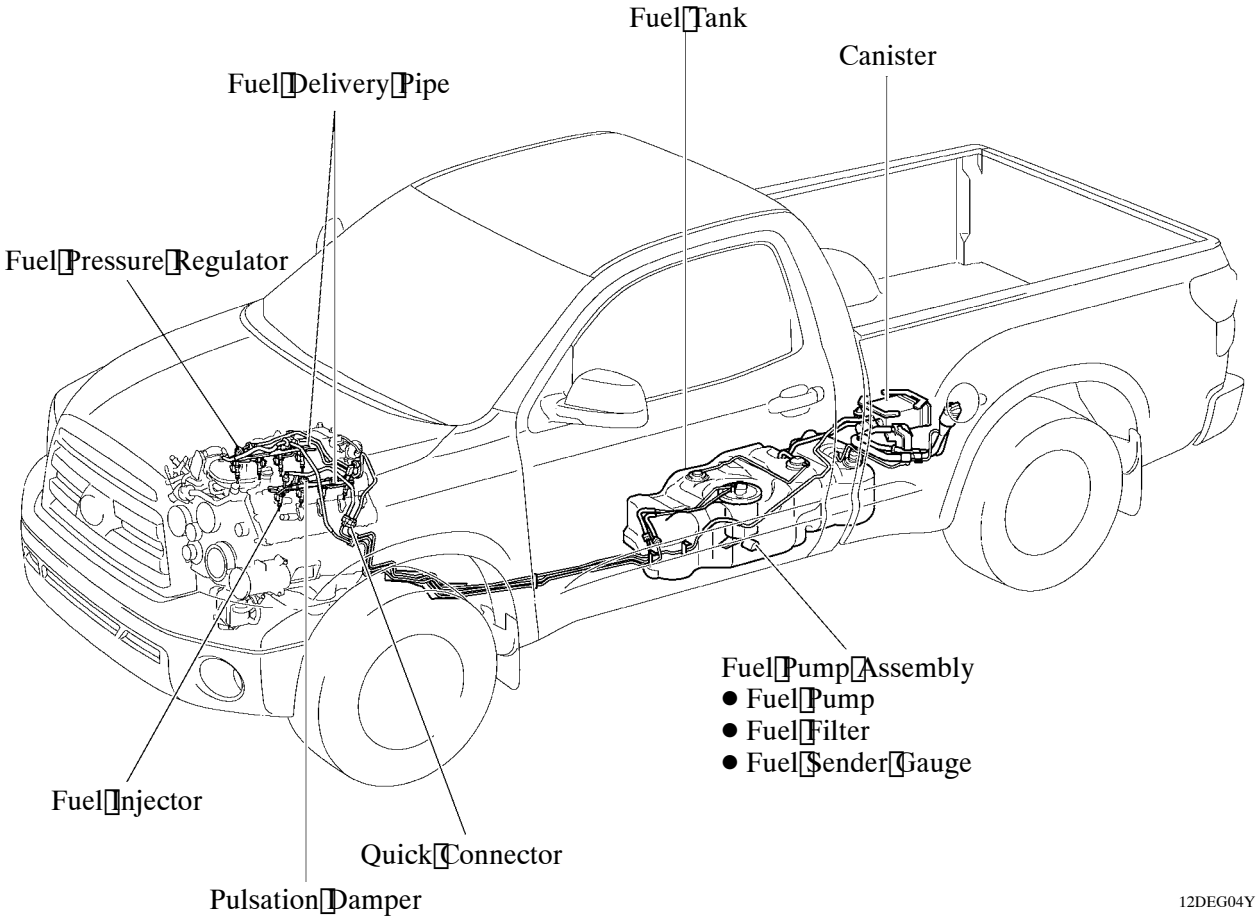
- The exhaust pipes are made of stainless steel to reduce their weight and improve rust resistance.
- 2 ceramic type Three-Way Catalytic converters (TWCs) are provided in the front exhaust pipe for the right bank, and another 2 are also provided for the left bank. As a result, the exhaust emission performance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



8. Fuel System

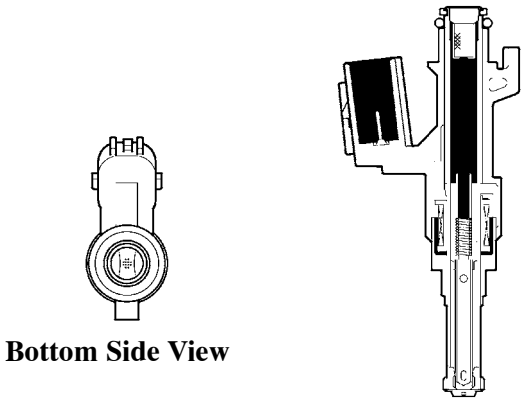
General

- 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.



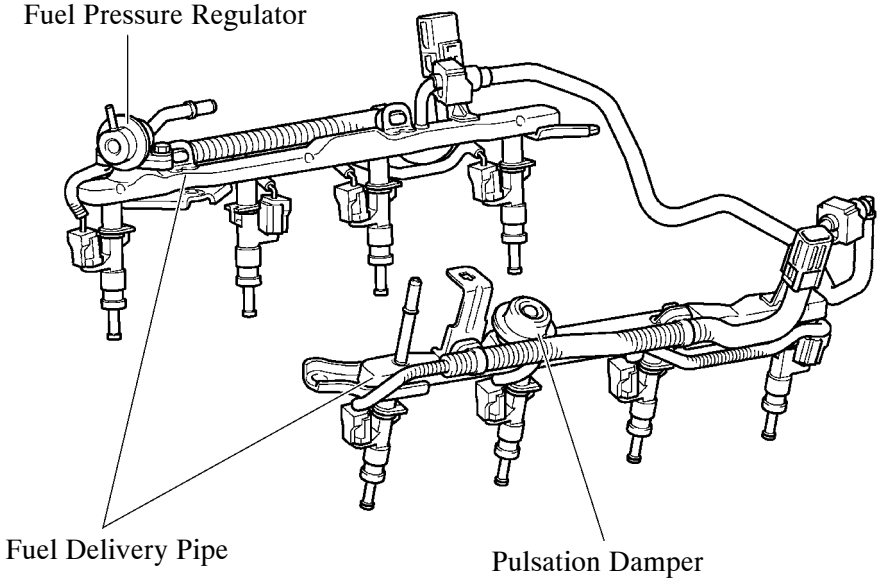
Bottom Side View

Fuel Injector Cross Section

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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.

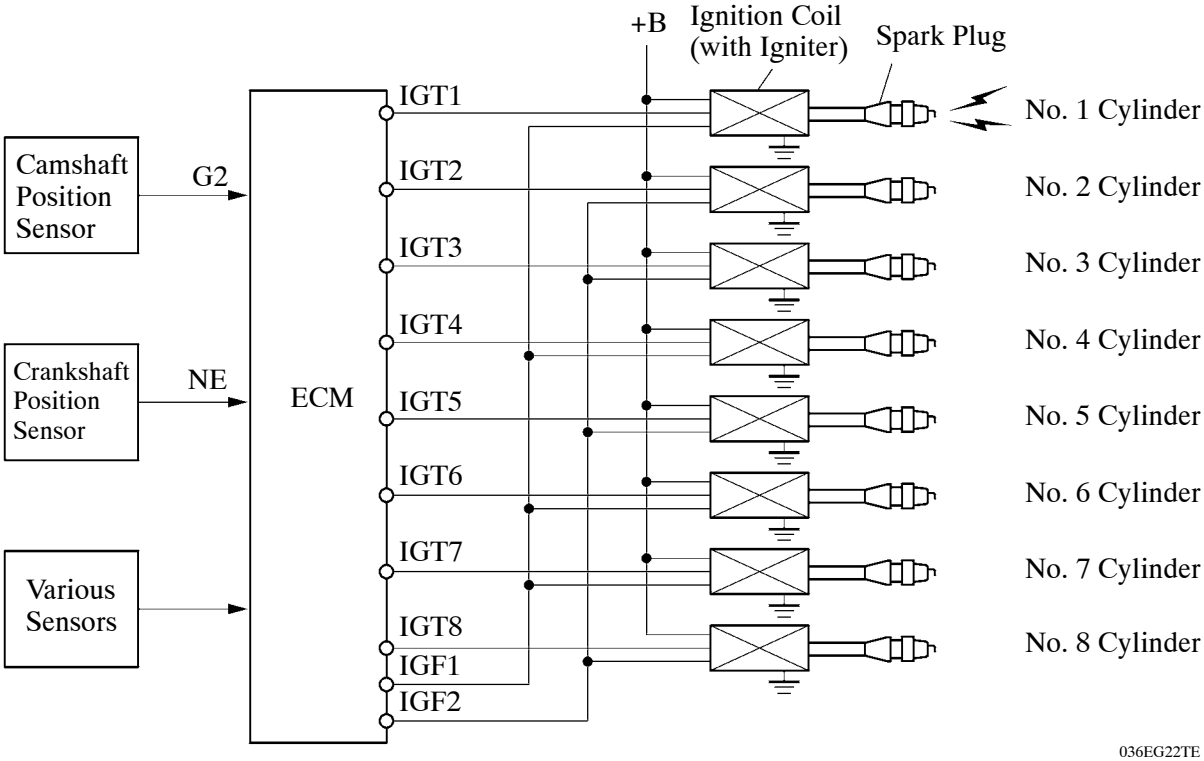


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9. Ignition System

General

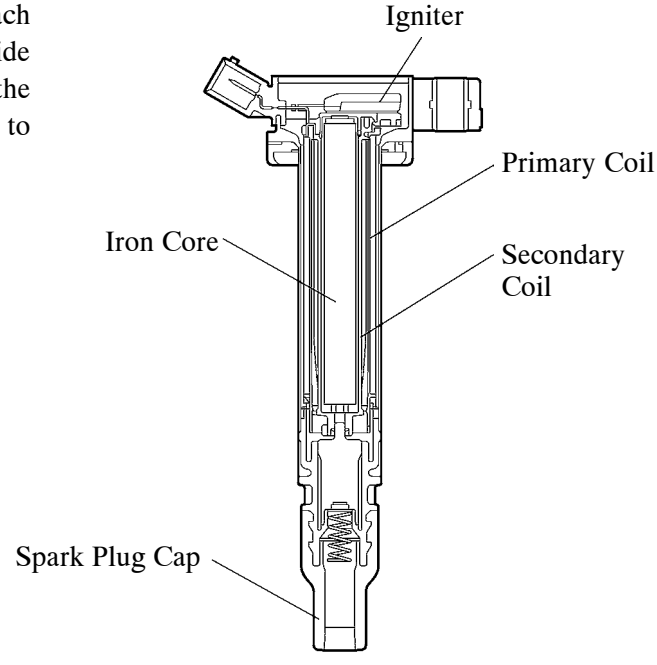
- A Direct Ignition System (DIS) is used. The DIS improves ignition timing accuracy, reduces high-voltage loss, and enhances the overall reliability of the ignition system by eliminating the distributor.
- The DIS is an independent ignition system which has one ignition coil (with an integrated igniter)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

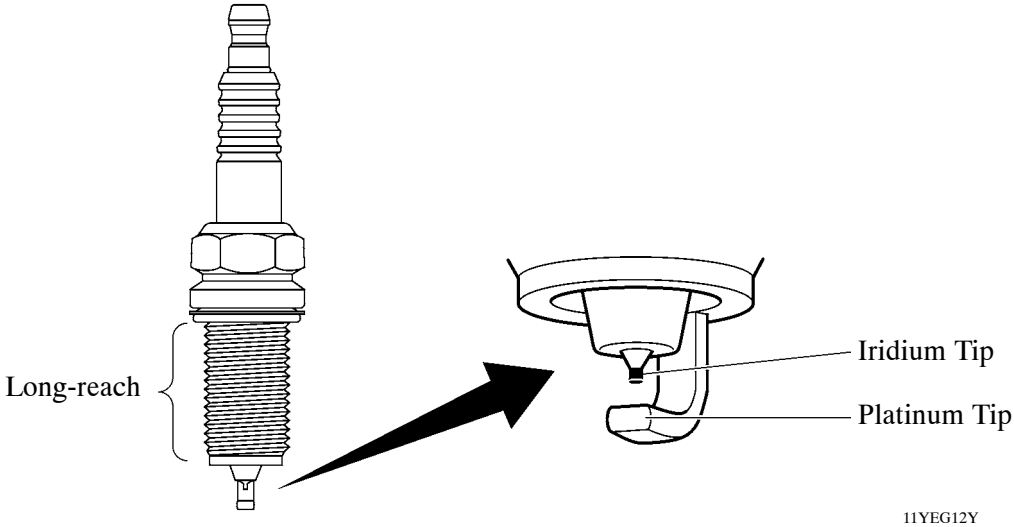


Ignition Coil Cross Section

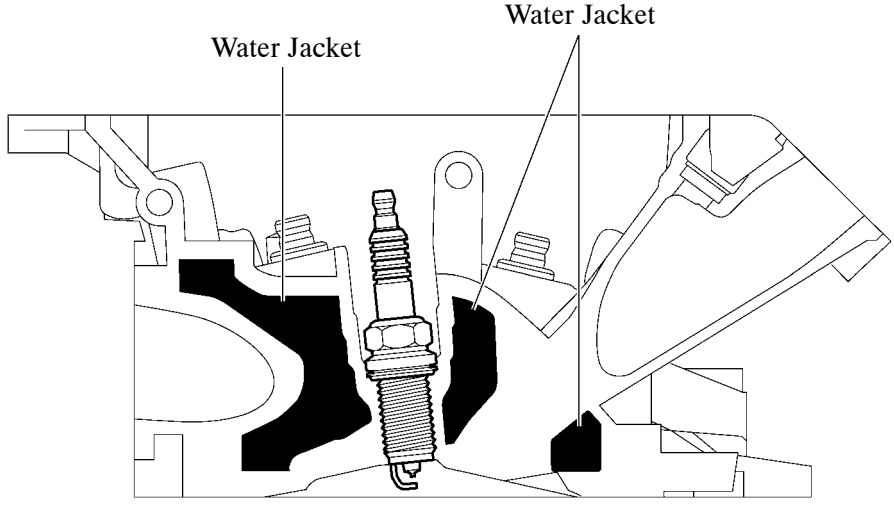
05AEG39TE

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

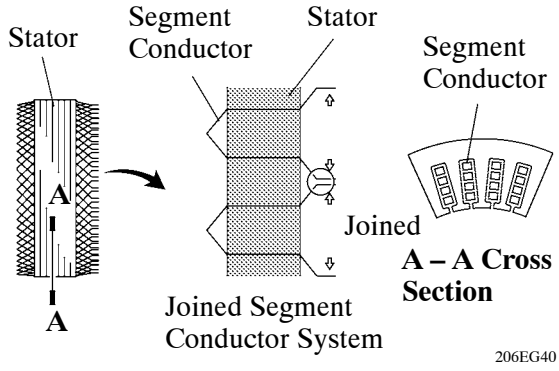
▶ Specifications ◀

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

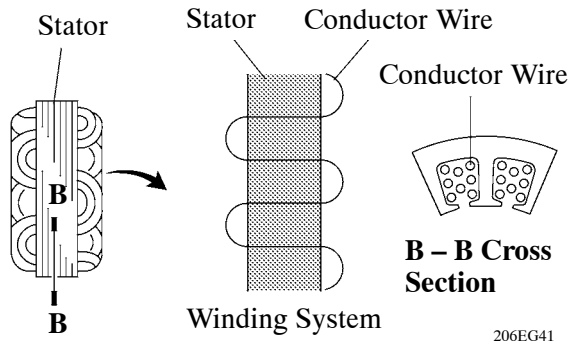
10. Charging System

General

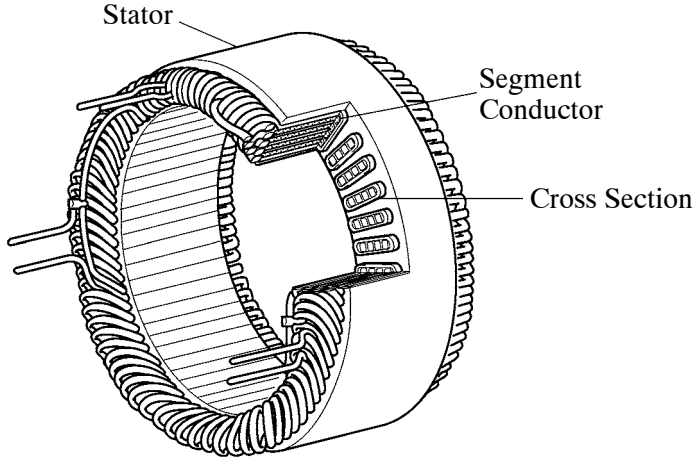
- A compact and lightweight segment conductor type generator that generates high amperage output in a highly efficient manner is provided as standard equipment.
- This generator has a joined segment conductor system in which multiple segment conductors are welded together to form the stator. Compared 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 ◀

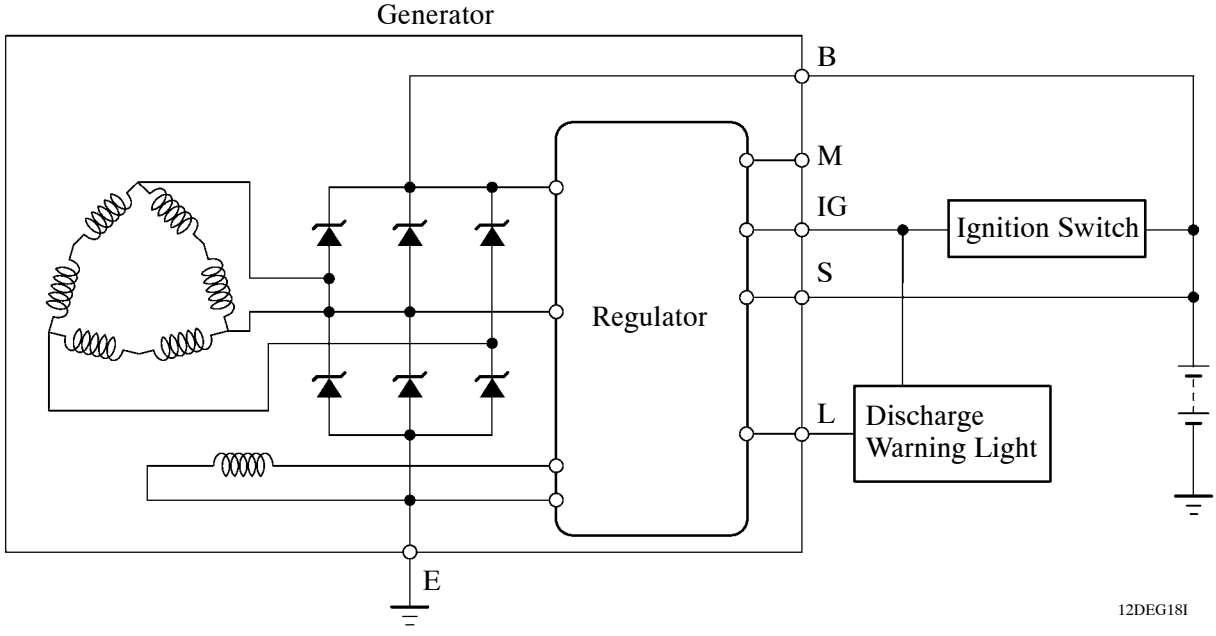
Vehicle Type			Generator Type		
			SE0	SC1	SC2
Regular Cab			○	—	Δ*1
Double Cab	Standard Deck	SR5	○	—	Δ*1
		Limited	—	○	Δ*1
	Long Deck		—	—	○
CrewMax		SR5	○	Δ*2	Δ*1
		Limited	—	○	Δ*1

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

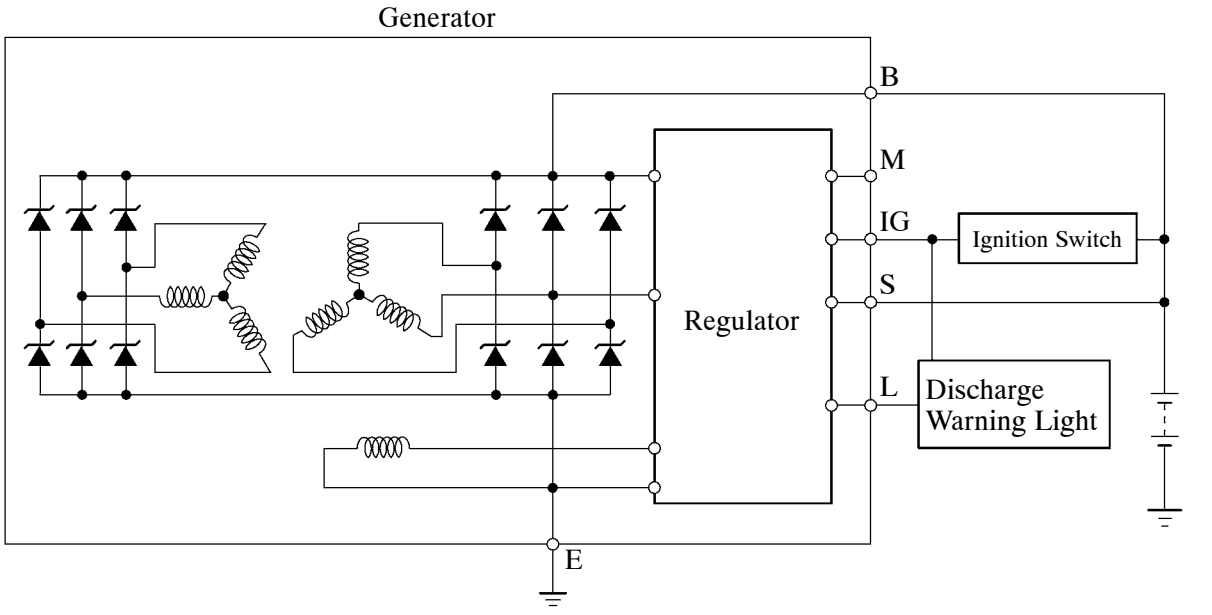
▶ Specifications ◀

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 ◀



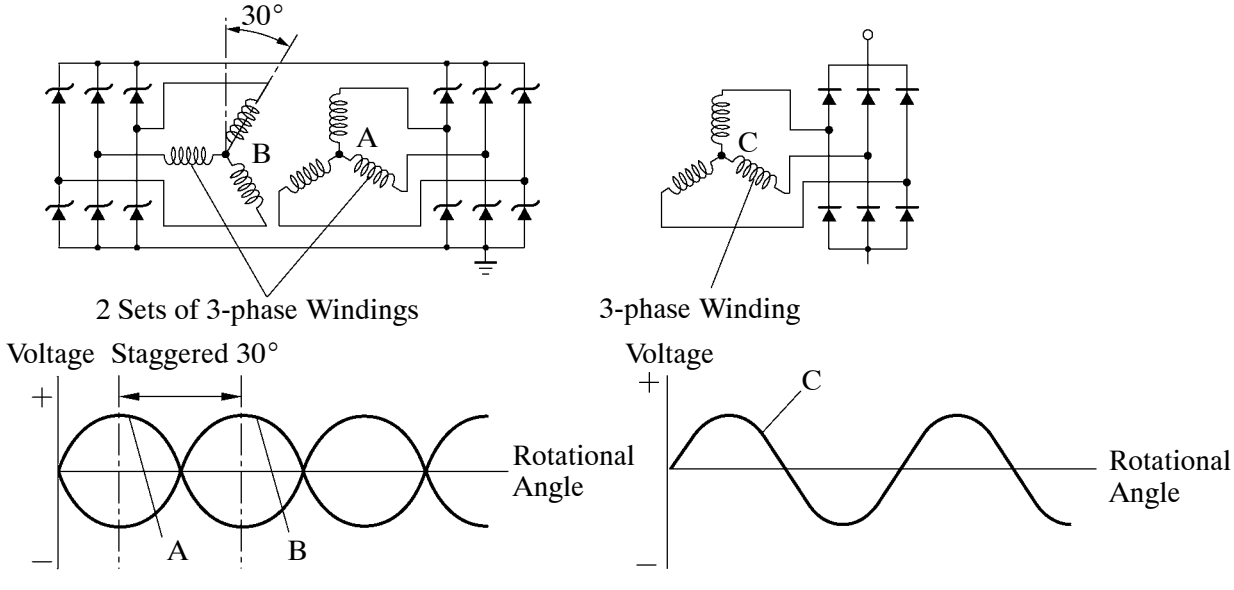
SE0 type



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.

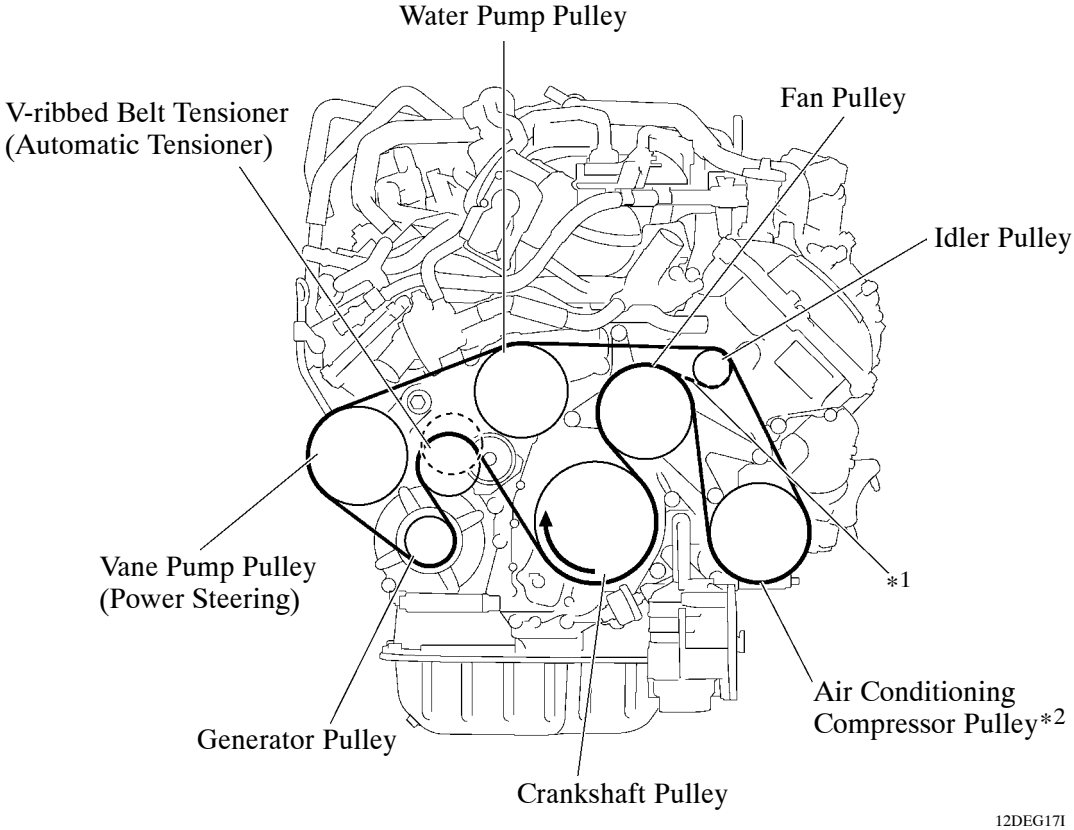
▶ Specification ◀

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.

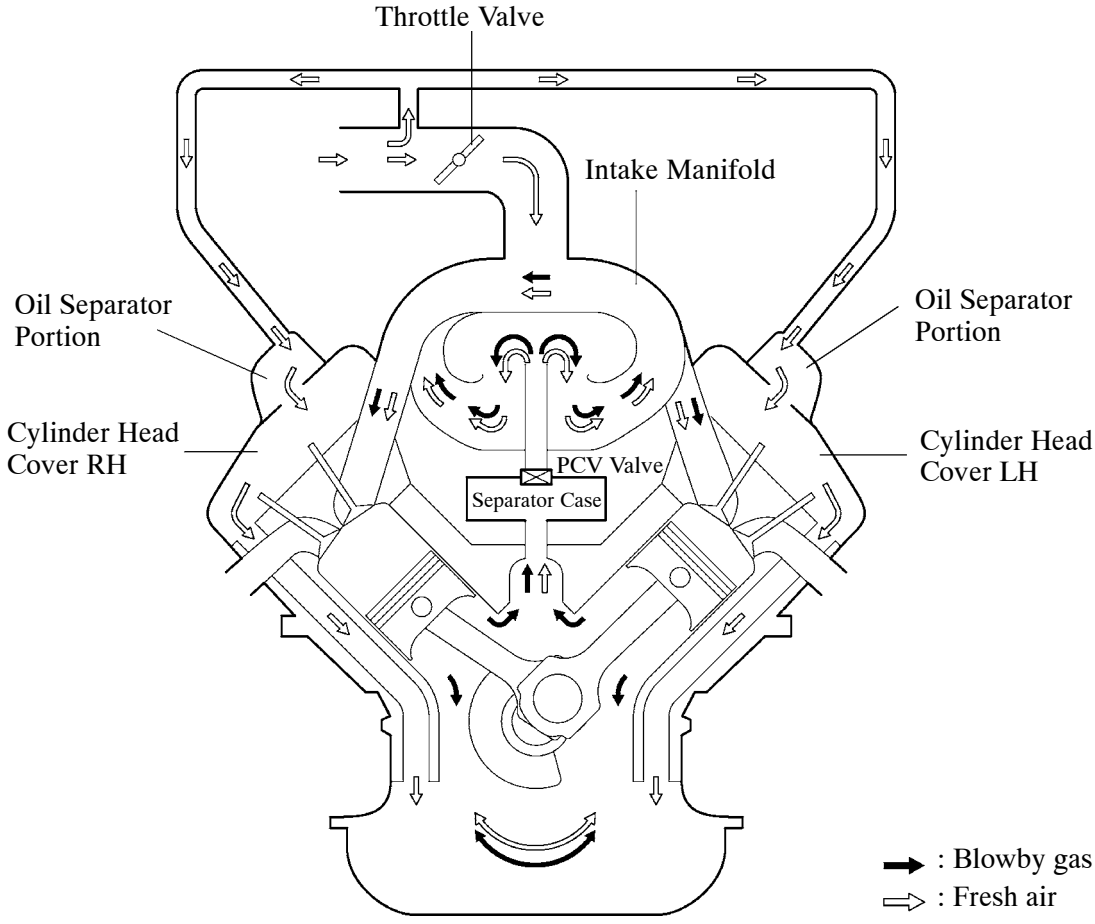


*1: Models without air conditioning
*2: Models with air conditioning

13. Blowby Gas Ventilation System

General

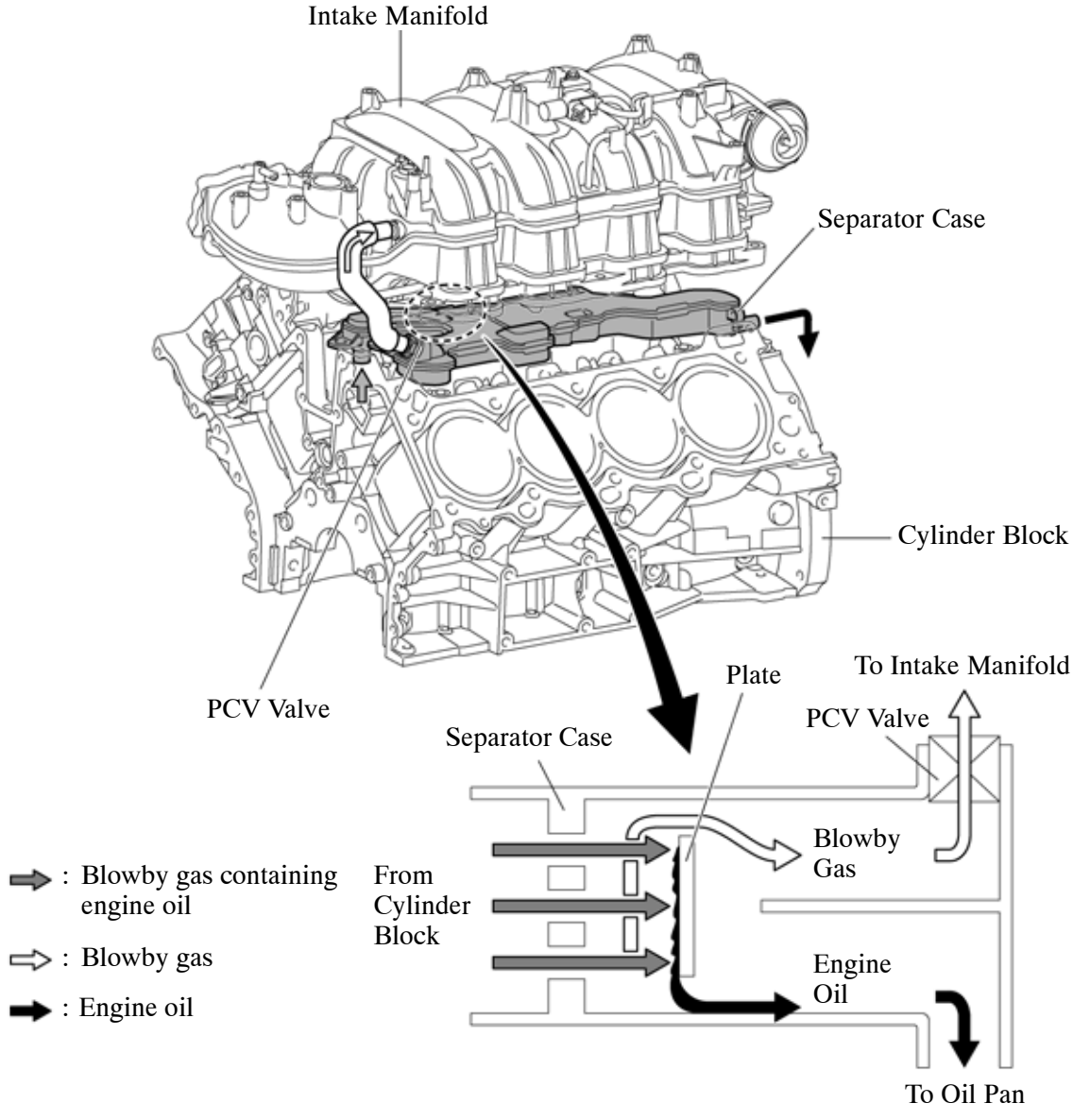
- The oil separator portion of the cylinder head covers has been made compact through the use of an independent separator case. This contributes to making the entire engine compact.
- Fresh air is drawn from the right and left bank cylinder head covers to improve the ventilation inside the engine and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



04E1EG45C

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.

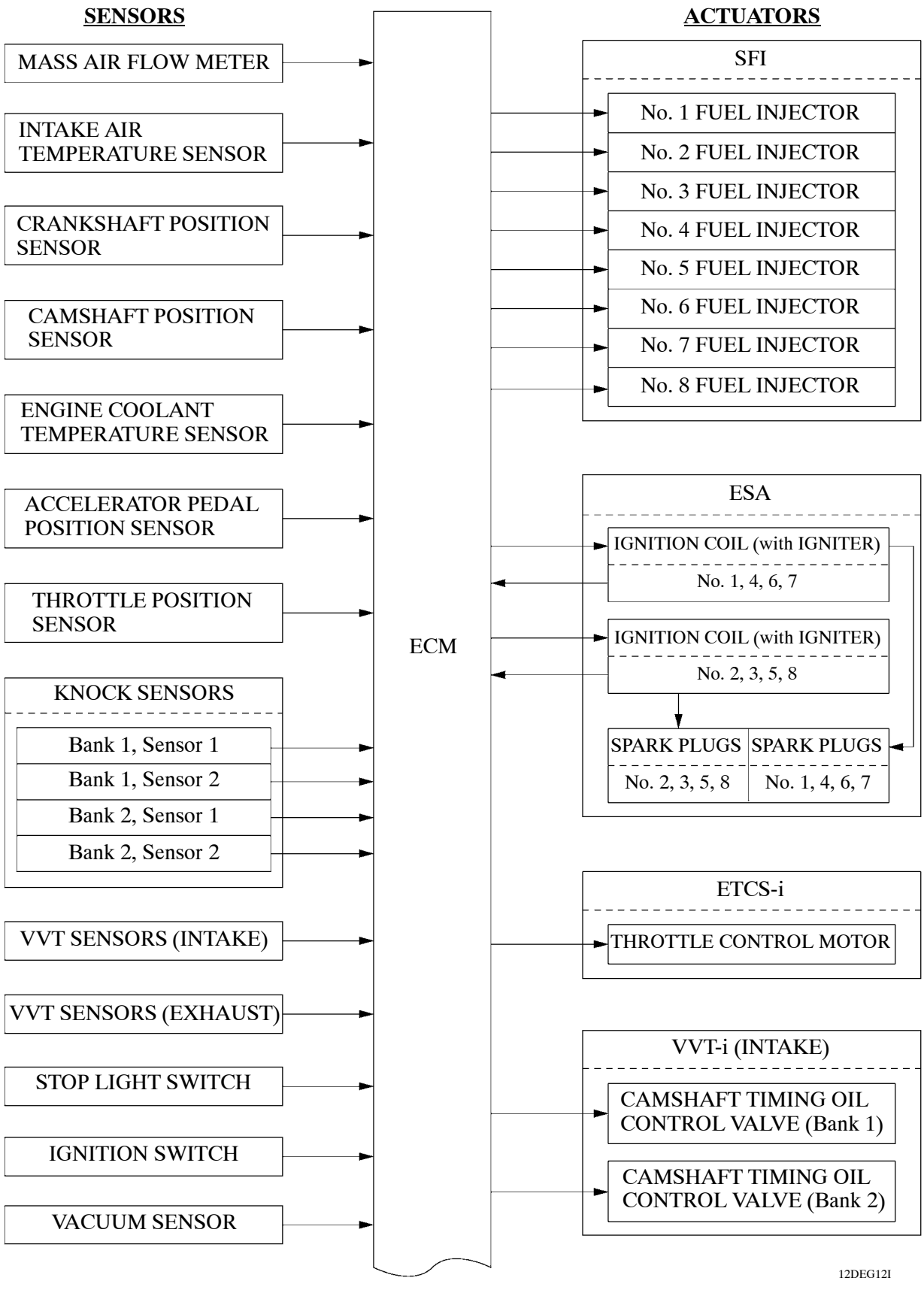
(Continued)

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.

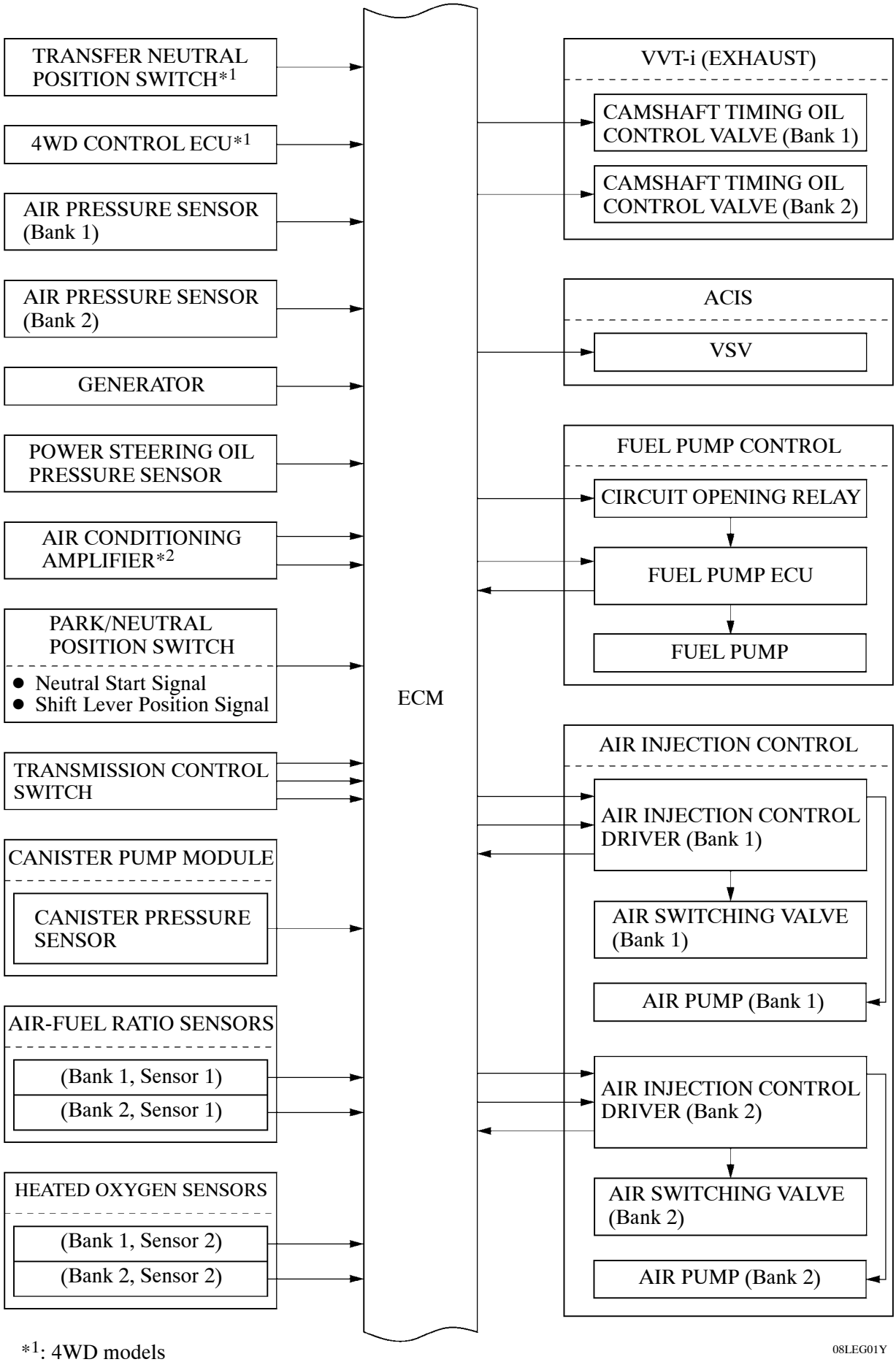
*: Models with air conditioning

Construction

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



(Continued)

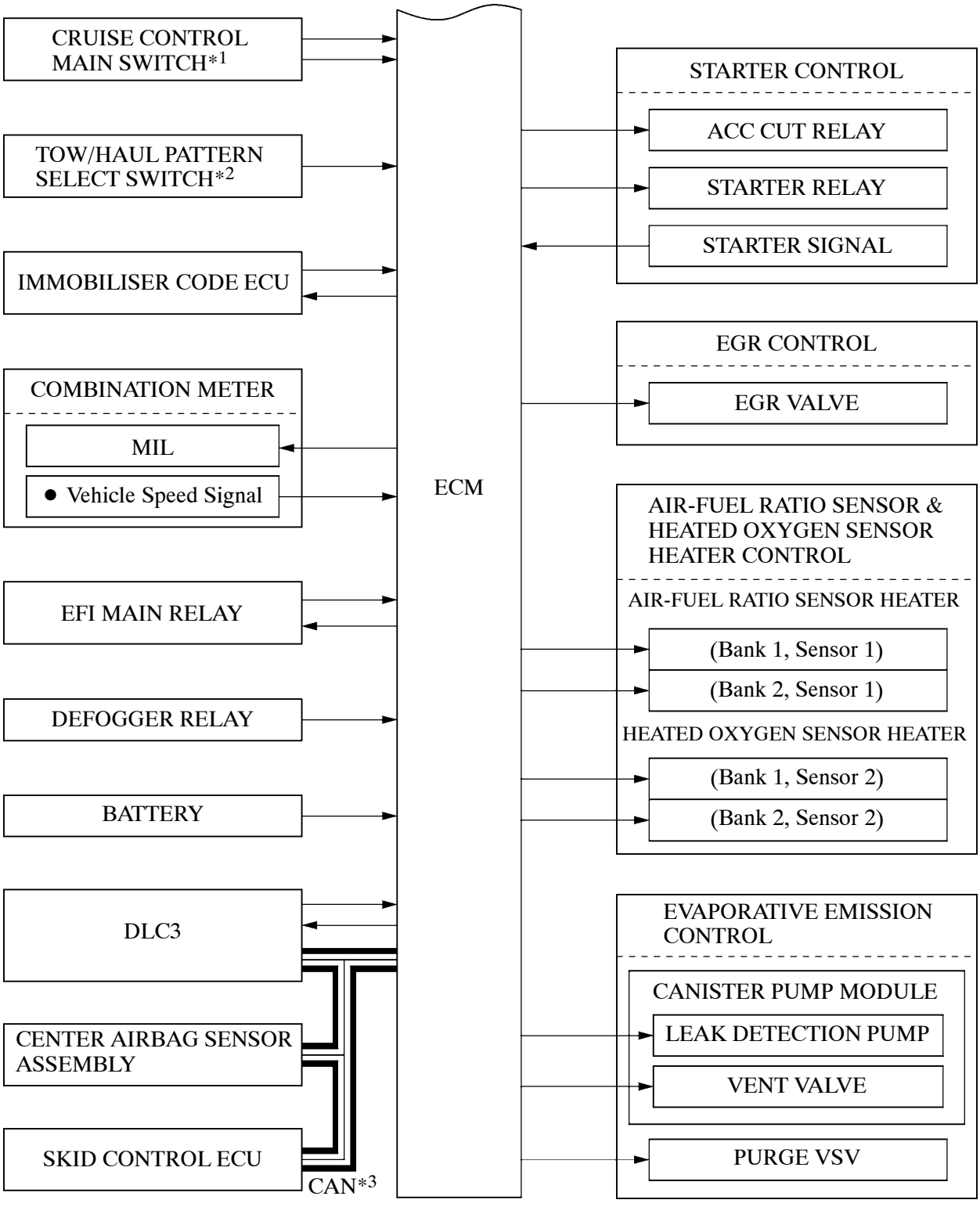


08LEG01Y

*1: 4WD models

*2: Models with air conditioning

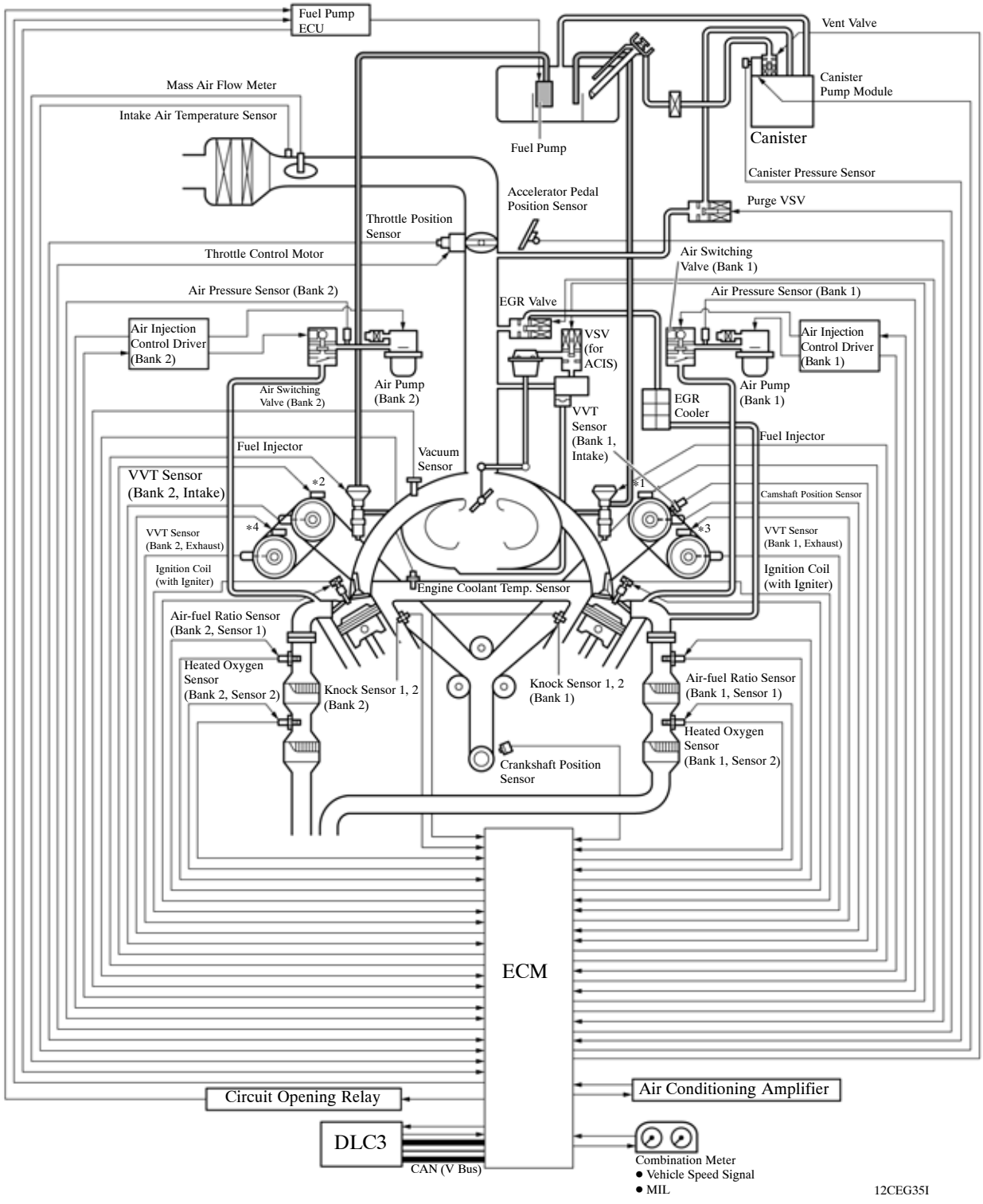
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12DEG13I

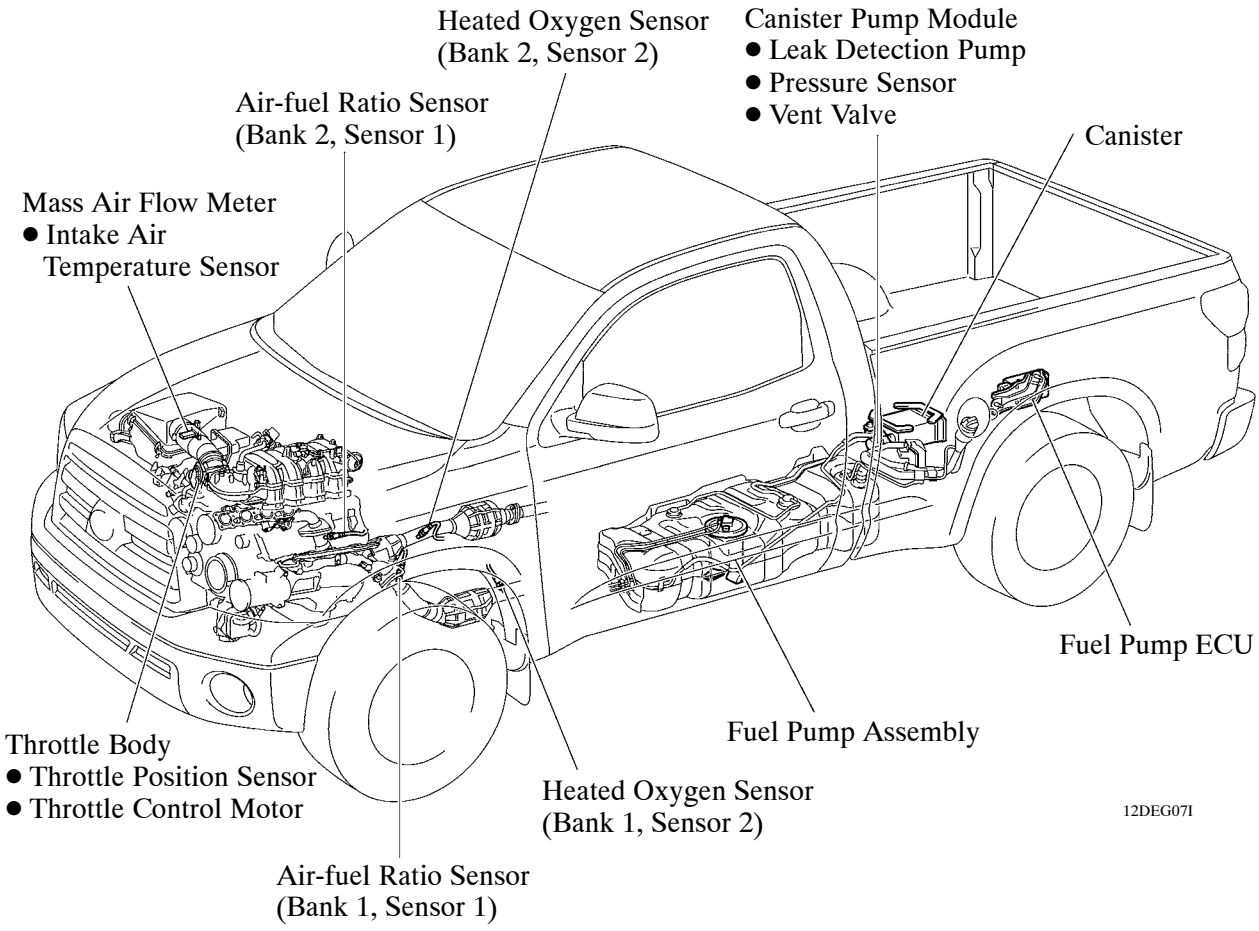
*1: Models with cruise control system
*2: Models with towing package
*3: V bus

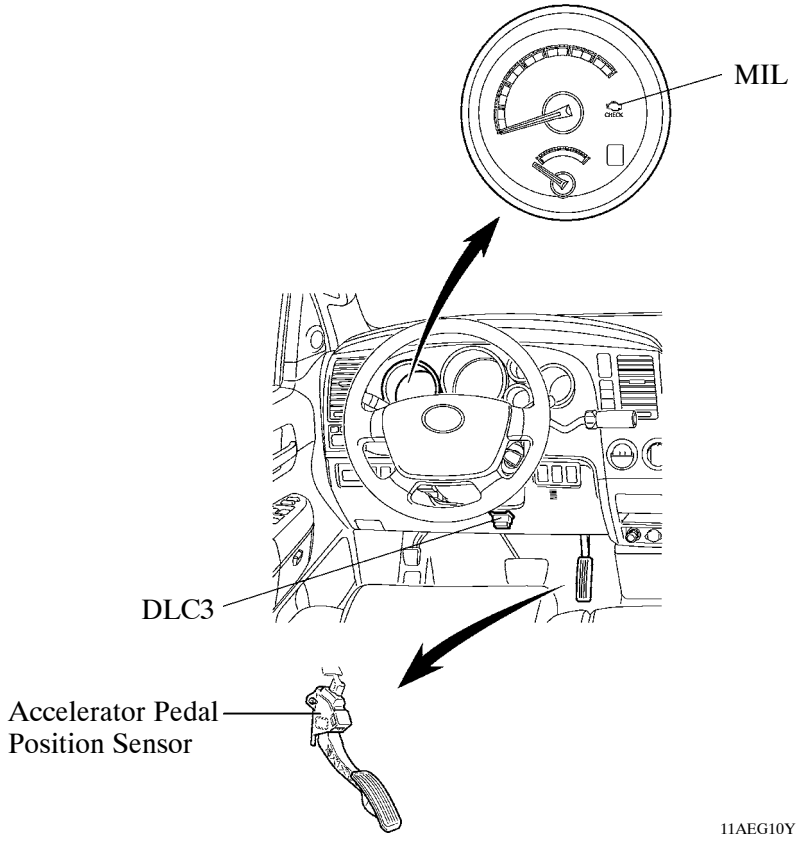
Engine Control System Diagram

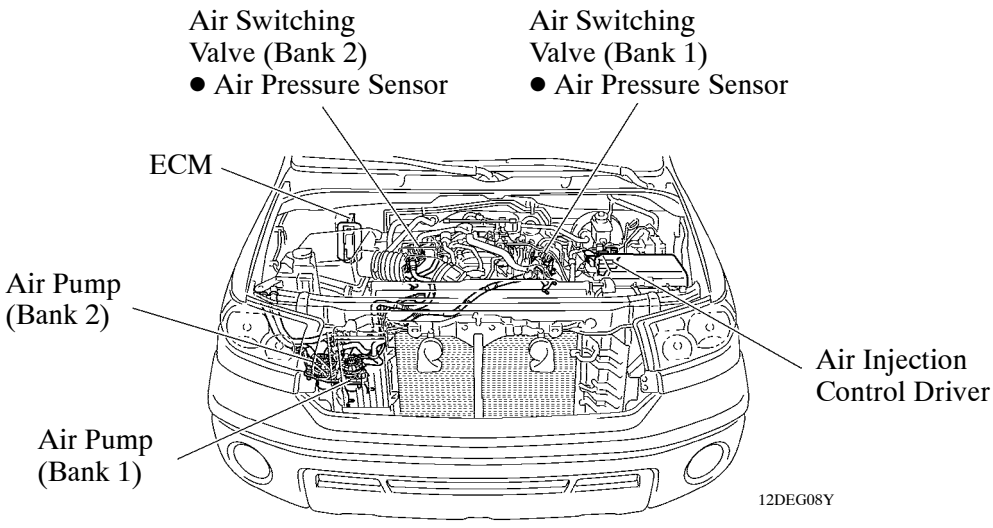


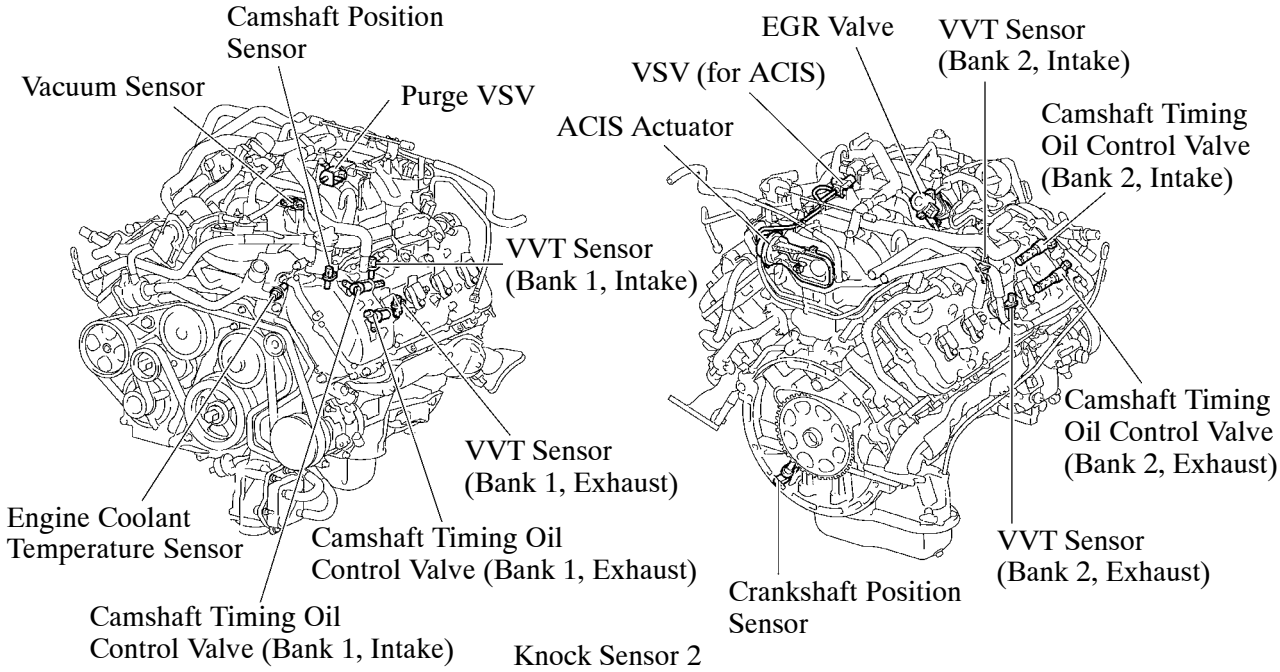
*1: Intake camshaft timing oil control valve (Bank 1) *2: Intake camshaft timing oil control valve (Bank 2)
*3: Exhaust camshaft timing oil control valve (Bank 1) *4: Exhaust camshaft timing oil control valve (Bank 2)

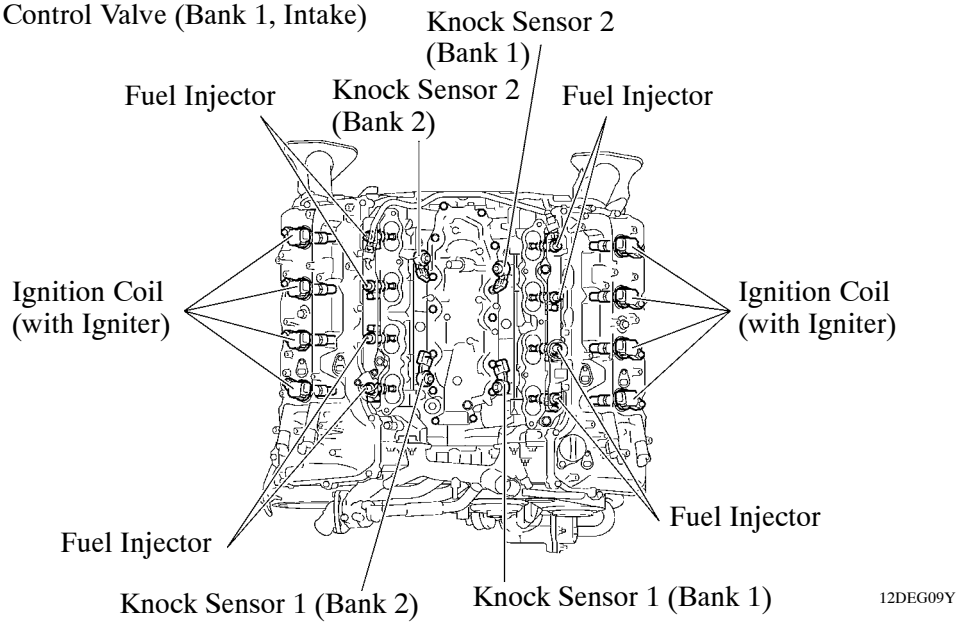
Layout of Main Components






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

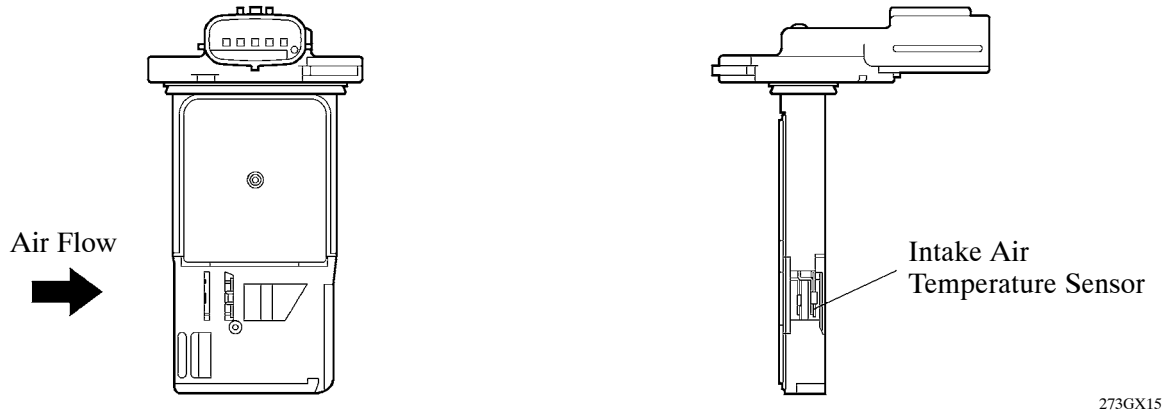
1) General

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.

2) Mass Air Flow Meter

- This mass air flow meter, which is a slot-in type, allows a portion of the intake air to flow through the detection area. By directly measuring the mass and the flow rate of the intake air, the detection precision is improved and the intake air resistance is reduced.
- This mass air flow meter has a built-in intake air temperature sensor.



3) Knock Sensor (Flat Type)

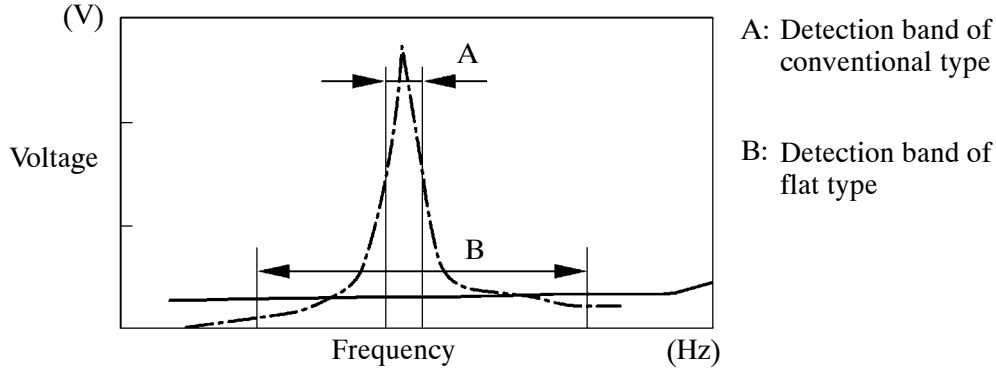
a. General

In the conventional type knock sensor (resonant type), a vibration plate which has the same resonance point as the knocking frequency of the engine is built in and can detect the vibration in this frequency band.
However, a flat type knock sensor (non-resonant type) has the ability to detect vibration in a wider frequency band from approximately 6 kHz to 15 kHz, and has the following feature:

- The engine knocking frequency will change a little depending on the engine speed. The flat type knock sensor can detect the vibration even when the engine knocking frequency is changed. Thus the vibration detection ability has been increased compared to the conventional type knock sensor, and more precise ignition timing control has been made possible.

— - — : Resonance characteristic of conventional type

——— : Resonance characteristic of flat type

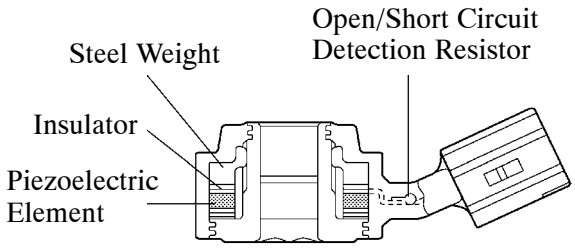


Characteristic of Knock Sensor

214CE04

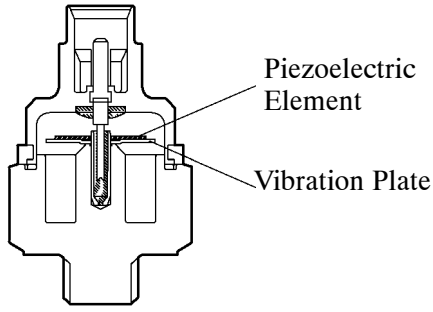
b. Construction

- The flat type knock sensor is installed on the engine through the stud bolt installed on the cylinder block. For this reason, a hole for the stud bolt runs through the center of the sensor.
- Inside of the sensor, a steel weight is located on the upper portion and a piezoelectric element is located under the weight through the insulator.
- The open/short circuit detection resistor is integrated.



Flat Type Knock Sensor (Non-resonant Type)

214CE01

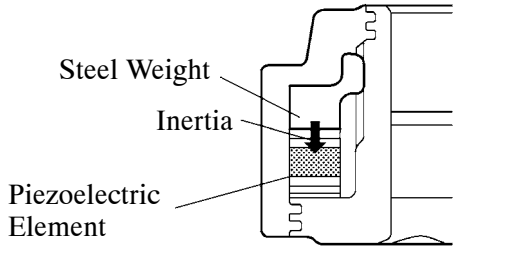


Conventional Type Knock Sensor (Resonant Type)

214CE02

c. Operation

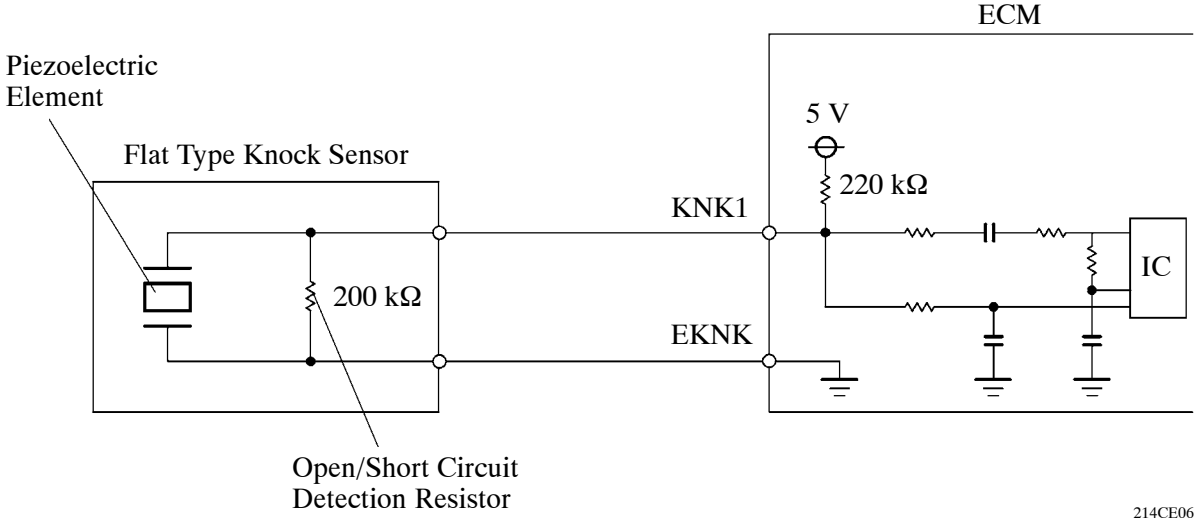
The knocking vibration is transmitted to the steel weight and its inertia applies pressure to the piezoelectric element. This action generates electromotive force.



214CE08

d. Open/Short Circuit Detection Resistor

- While the ignition is ON, the open/short circuit detection resistor in the knock sensor and the resistor in the ECM keep the voltage at terminal KNK1 of the engine constant.
- An Integrated Circuit (IC) in the ECM constantly monitors the voltage of terminal KNK1. If the open/short circuit occurs between the knock sensor and the ECM, the voltage of terminal KNK1 will change and the ECM will detect the open/short circuit and store a Diagnostic Trouble Code (DTC).



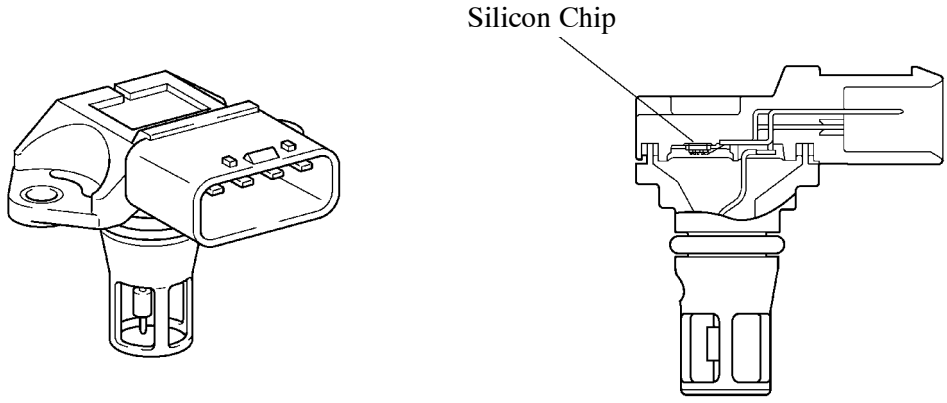
214CE06

Service Tip

These knock sensors are mounted in specific directions at specific angles. To prevent the right and left bank wiring connectors from being interchanged, be sure to install each sensor in its prescribed direction. For details, refer to the 2010 TOYOTA TUNDRA Repair Manual.

4) Vacuum Sensor

The vacuum sensor consists of a silicon chip that changes its electrical resistance when pressure is applied to it. The sensor converts the pressure into an electrical signal, and sends it to the ECM in an amplified form.

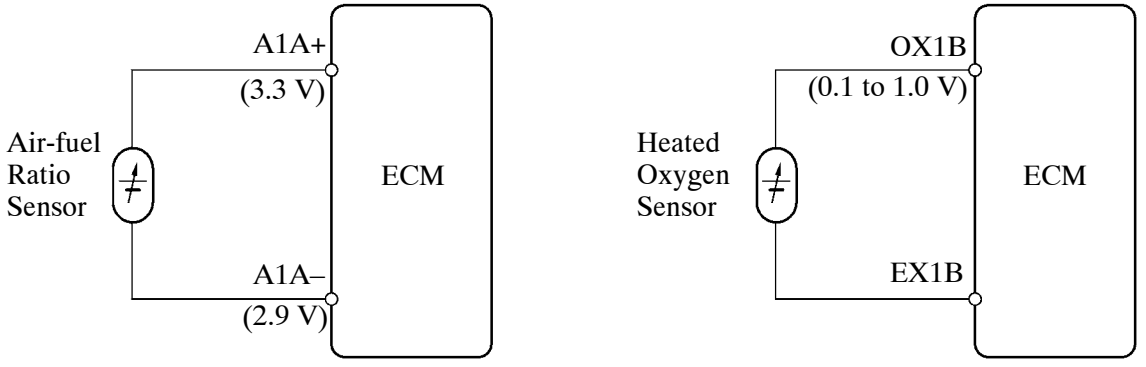


12CEG42Y

5) Air-fuel Ratio Sensor and Heated Oxygen Sensor

a. General

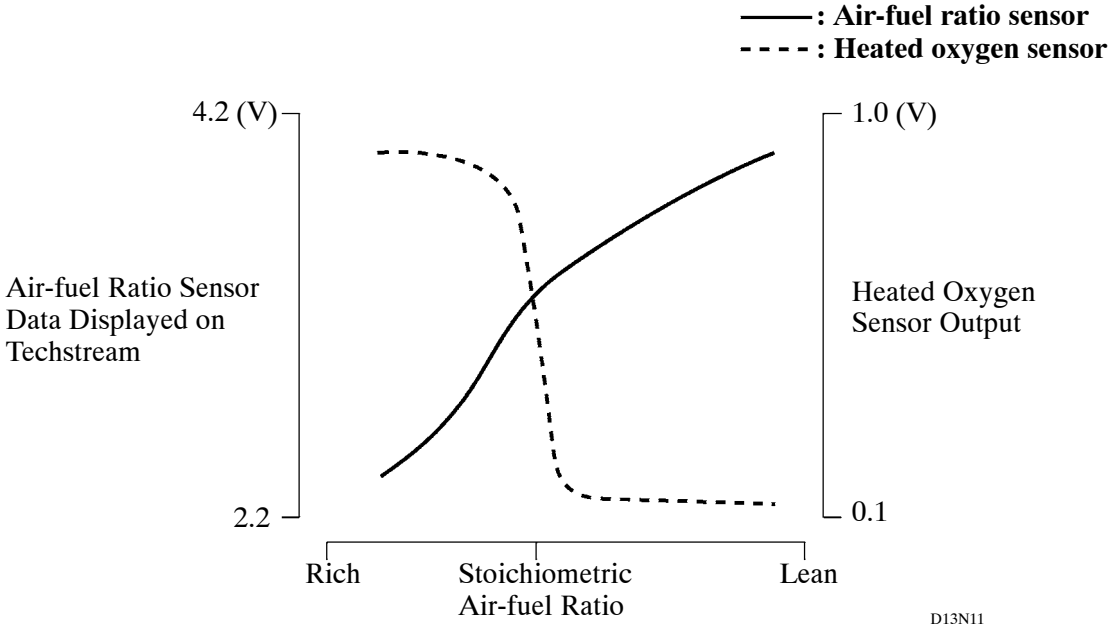
- The heated oxygen sensor and the air-fuel ratio sensor differ in output characteristics.
- The output voltage of the heated oxygen sensor changes in accordance with the oxygen concentration in the exhaust gas. The ECM uses this output voltage to determine whether the present air-fuel ratio is richer or leaner than the stoichiometric air-fuel ratio.
- Approximately 0.4 V is constantly applied to the air-fuel ratio sensor, which outputs an amperage that varies in accordance with the oxygen concentration in the exhaust gas. The ECM uses this output voltage to determine whether the present air-fuel ratio is richer or leaner than the stoichiometric air-fuel ratio. The air-fuel ratio sensor data is read out by the Techstream.



Air-fuel Ratio Sensor Circuit (Bank 1, Sensor 1)

Heated Oxygen Sensor Circuit (Bank 1, Sensor 2)

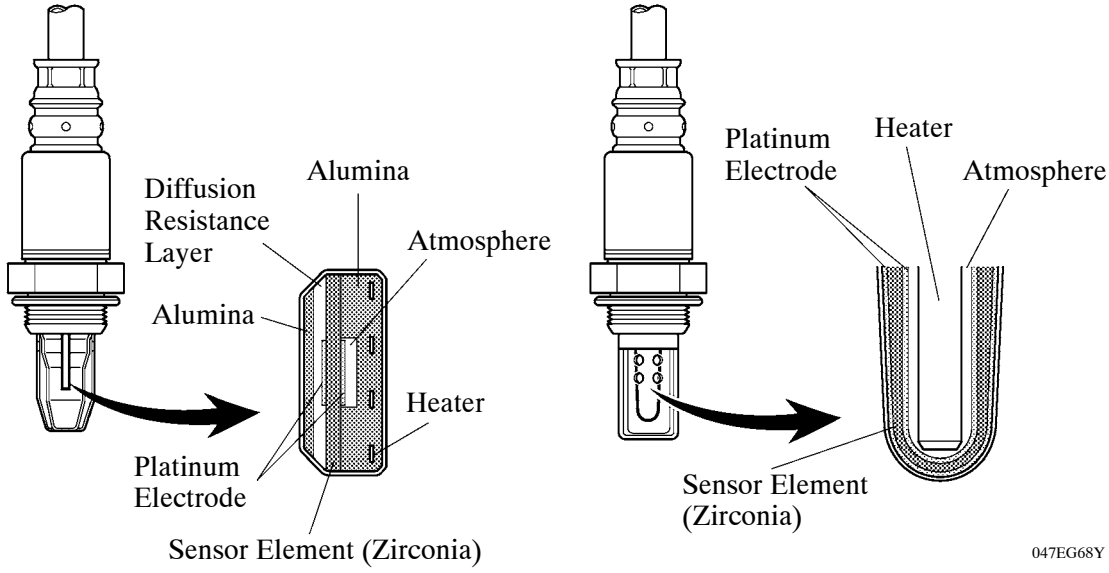
02HEG56Y



D13N11

b. Construction

- The basic construction of the heated oxygen sensor and the air-fuel ratio sensor is the same. However, they are divided into the cup type and the planar type, according to the different types of heater construction that are used.
- The cup type sensor contains a sensor element that surrounds the heater.
- The planar type sensor uses alumina, which excels in heat conductivity and insulation, to integrate a sensor element with the heater, thus improving the warm-up performance of the sensor.



Air-fuel Ratio Sensor (Planar Type) **Heated Oxygen Sensor (Cup Type)**

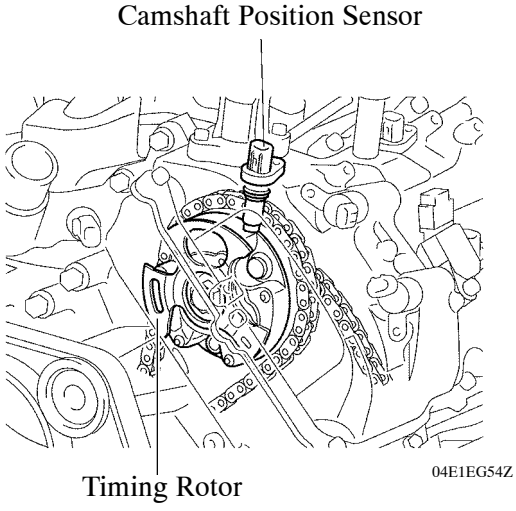
▶ Warm-up Specification ◀

Sensor Type	Planar Type	Cup Type
Warm-up Time	Approx. 10 sec.	Approx. 30 sec.

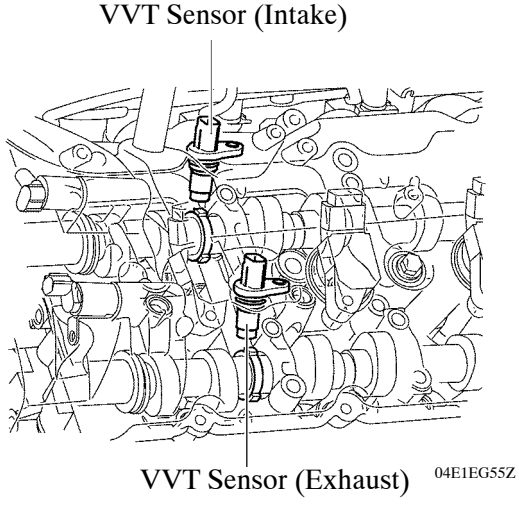
6) Crankshaft Position, Camshaft Position and VVT Sensors

a. General

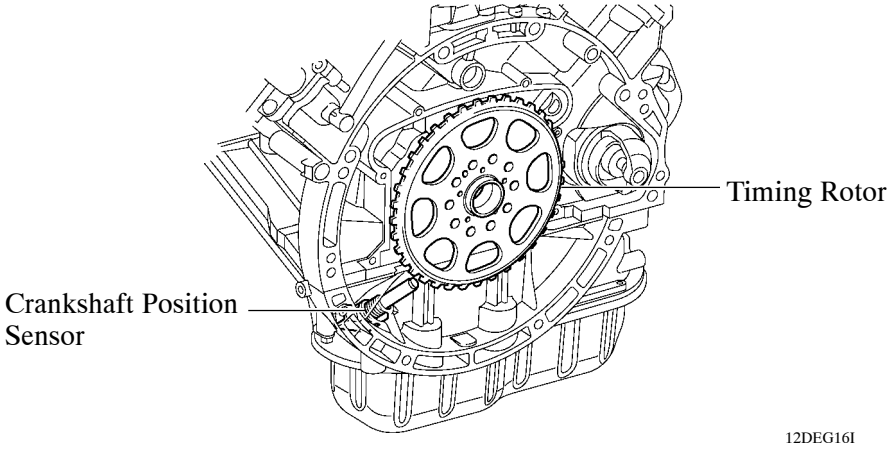
- Magnetic Resistance Element (MRE) sensors are used for the crankshaft position, camshaft position, and VVT sensors.
- The timing rotor for the crankshaft position sensor is installed on the back end of the crankshaft. The timing rotor has 34 teeth, with 2 teeth missing, at 10° intervals. Based on these teeth, the crankshaft position sensor transmits crankshaft position signals (NE signal) consisting of 33 high and low output pulses every 10° per revolution of the crankshaft, and 1 high and low output pulse every 30°. The ECM uses the NE signal for detecting the crankshaft position as well as for detecting the engine speed. It uses the missing teeth signal to determine the top dead center.
- The camshaft position sensor uses a timing rotor installed on the front end of the intake camshaft sprocket of the left bank. Based on the timing rotor, the sensor outputs camshaft position signals (G2 signal) consisting of 3 (3 high output, 3 low output) pulses for every 2 revolutions of the crankshaft. The ECM compares the G2 and NE signals to detect the camshaft position and identify the cylinder.
- The VVT sensors (intake and exhaust) use timing rotors installed on the intake and exhaust camshafts of each bank. Based on the timing rotors, the sensors output VVT position signals consisting of 3 (3 high output, 3 low output) pulses for every 2 revolutions of the crankshaft. The ECM compares these VVT position signals and the NE signal to detect the actual valve timing.



Camshaft Position Sensor

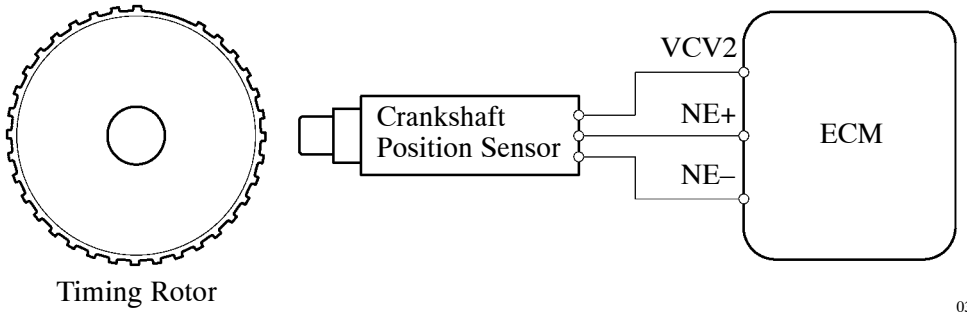


VVT Sensor (Bank 1)



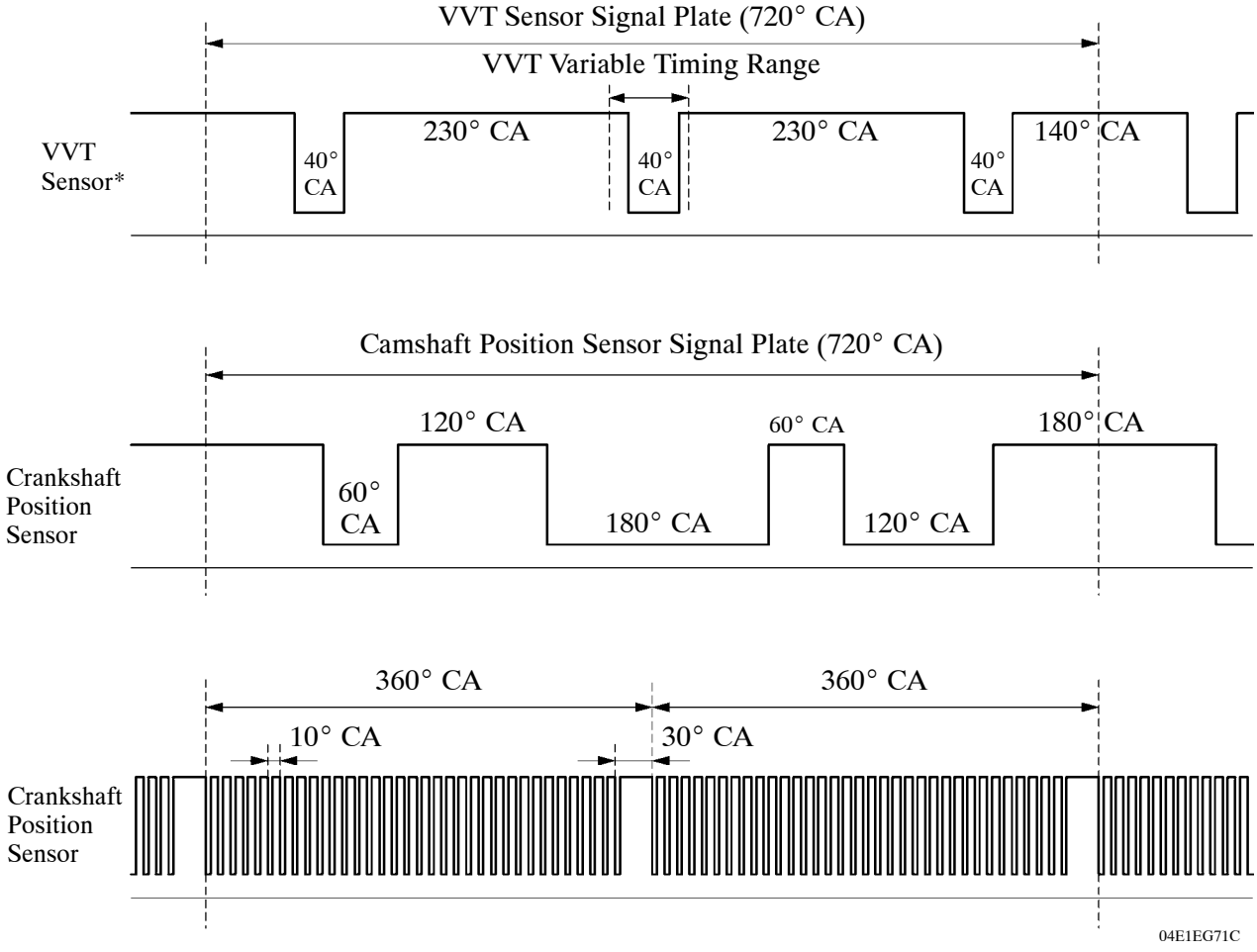
Crankshaft Position Sensor

▶ Wiring Diagram ◀



Crankshaft Position Sensor Circuit

▶ Sensor Output Waveforms ◀

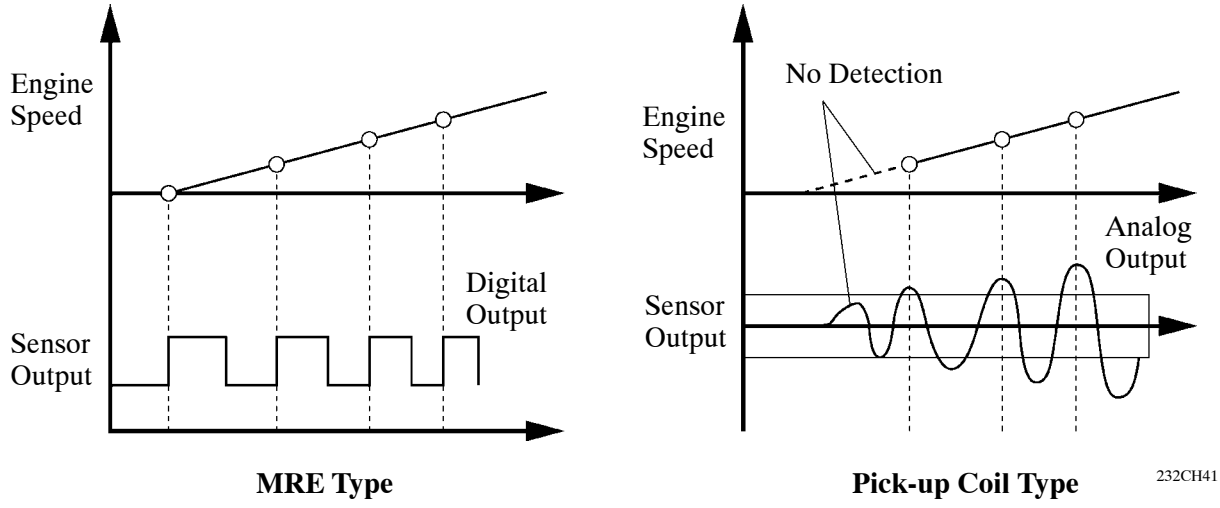


*: This is an example of an output waveform of the VVT sensor (Bank 1, Intake).

b. MRE Type Sensor

- The MRE type sensor consists of an MRE, a magnet and a sensor.
- The direction of the magnetic field changes due to the profile (protruding and non-protruding portions) of the timing rotor, which passes by the sensor. As a result, the resistance of the MRE changes, and the output voltage to the ECM changes to high or low. The ECM detects the crankshaft and camshaft positions based on this output voltage.
- The differences between the MRE type sensor and the pick-up coil type sensor used on the conventional models are as follows:
  - The MRE type sensor outputs a constant level of high and low digital signals regardless of the engine speed. Therefore, the MRE type sensor can detect the positions of the crankshaft and camshaft at an early stage of cranking.
  - The pick-up coil type sensor outputs analog signals with levels that change with the engine speed.

▶ MRE Type and Pick-up Coil Type Output Waveform Image Comparison ◀

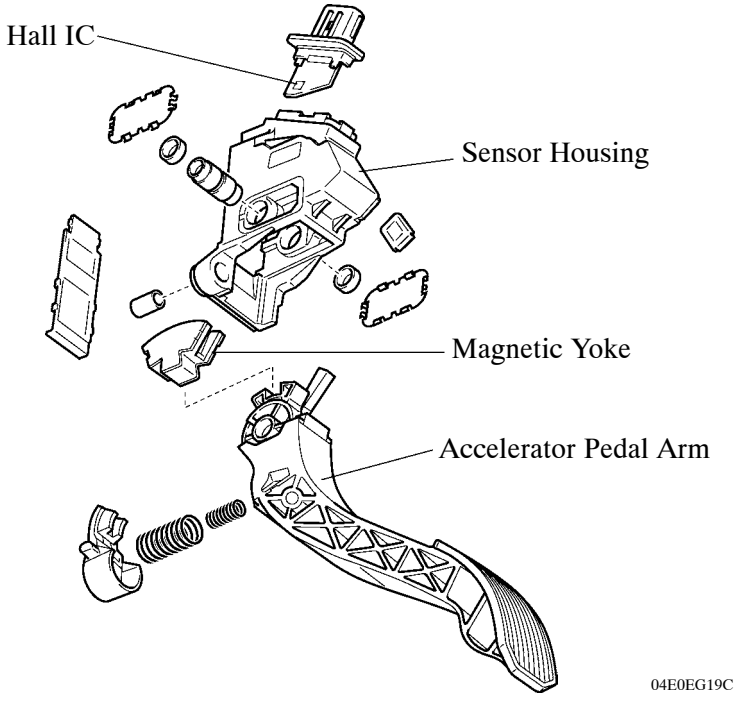


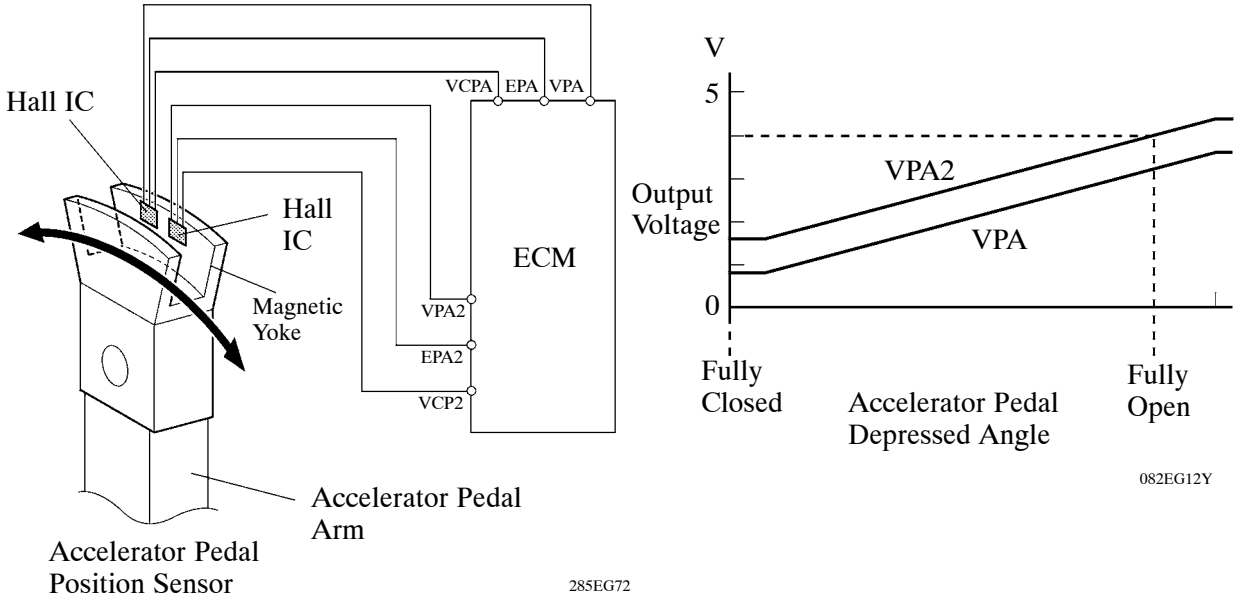
MRE Type **Pick-up Coil Type** 232CH41

7) Accelerator Pedal Position Sensor

The non-contact type accelerator pedal position sensor uses a Hall IC, which is mounted on the accelerator pedal arm.

- The magnetic yoke mounted at the base of the accelerator pedal arm moves around the Hall IC in accordance with the amount of effort applied to the accelerator pedal. The Hall IC converts the changes in the magnetic flux that occur into electrical signals, and outputs them in the form of accelerator pedal position signals to the ECM.
- This accelerator pedal position sensor includes 2 Hall ICs and circuits for the main and sub signals. It converts the accelerator pedal depression angles into 2 electric signals with differing characteristics and outputs them to the ECM.

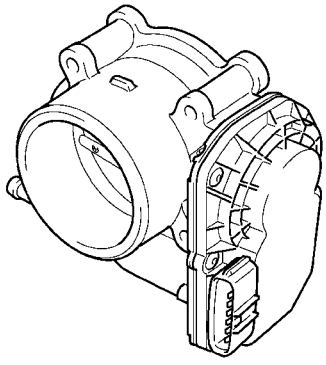


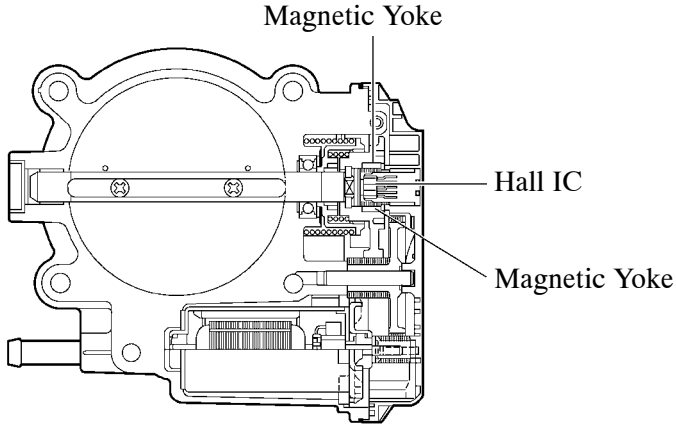


8) Throttle Position Sensor

The non-contact type throttle position sensor is mounted on the throttle body, and it uses a Hall IC.

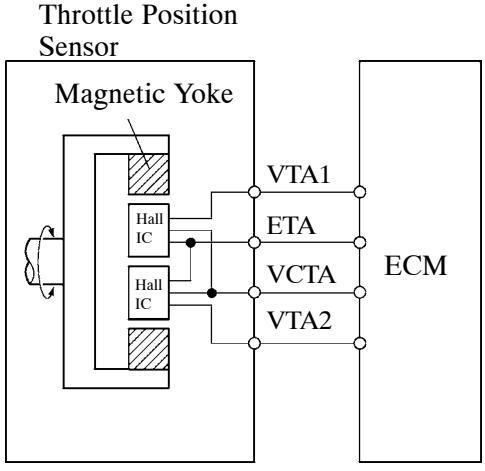
- The Hall IC is surrounded by a magnetic yoke. The Hall IC converts the changes that occur in the magnetic flux into electrical signals, and outputs them in the form of throttle valve position signals to the ECM.
- The Hall IC contains circuits for the main and sub signals. It converts the throttle valve opening angle into 2 electrical signals that have differing characteristics and outputs them to the ECM.



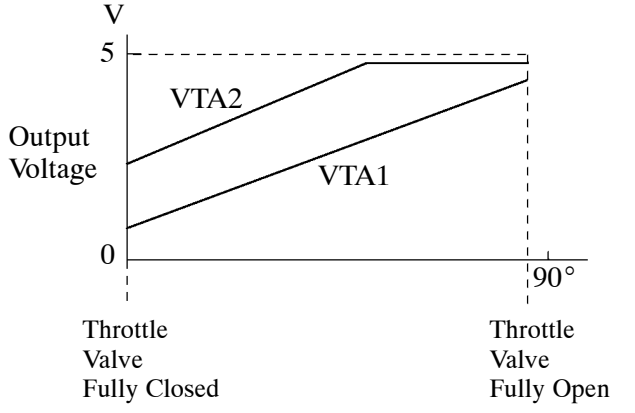


Cross Section

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230LX12



Throttle Valve Opening Angle

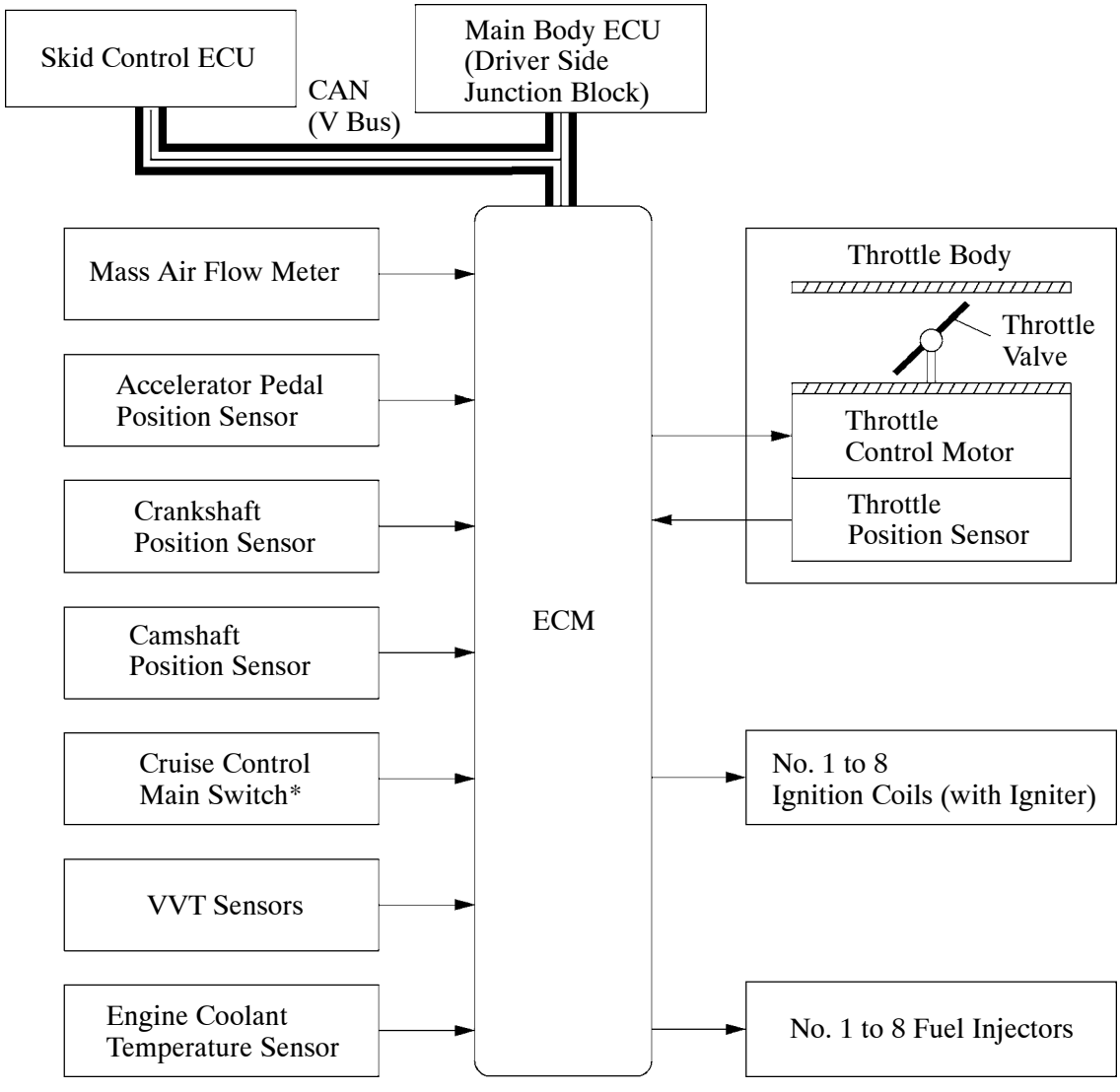
082EG14Y

Electronic Throttle Control System-intelligent (ETCS-i)

1) General

- In the conventional throttle body, the throttle valve angle is determined invariably by the amount of accelerator pedal effort. In contrast, ETCS-i uses the ECM to calculate the optimal throttle valve angle that is appropriate for the respective driving condition and uses a throttle control motor to control the angle.
- In case of an abnormal condition, this system transfers to the fail-safe mode.

▶ System Diagram ◀



12DEG10I

*: Models with cruise control system

2) Control

a. General

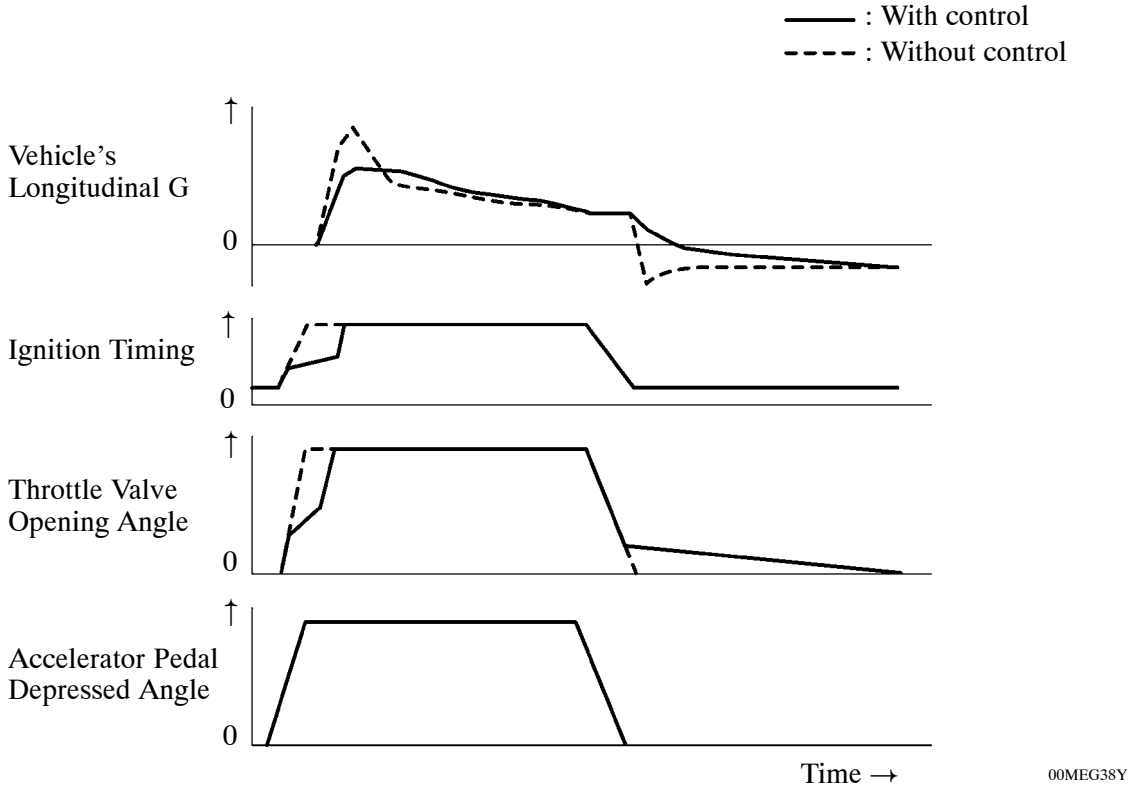
The ETCS-i consists of the following functions:

- Normal Throttle Control (Non-linear Control)
- Idle Speed Control (ISC)
- TRAC (Active Traction Control/A-TRAC*1)
- Vehicle Stability Control (VSC) Coordination Control
- Cruise Control*2
- TOW/HAUL Control*3

b. Normal Throttle Control (Non-linear Control)

This control optimizes the throttle valve angle to an angle that is appropriate for driving conditions such as the amount of accelerator pedal effort and the engine speed, in order to achieve excellent throttle control and comfort in all operating ranges.

▶ Conceptual Diagrams of Engine Control during Acceleration and Deceleration ◀



c. Idle Speed Control

The ECM controls the throttle valve in order to constantly maintain an ideal idle speed.

d. TRAC/A-TRAC*1

As part of the A-TRAC, the throttle valve opening angle is reduced by a demand signal sent from the skid control ECU to the ECM. This demand signal is sent if an excessive amount of slippage occurs at a drive wheel, thus ensuring vehicle stability and applying an appropriate amount of power to the road.

e. VSC Coordination Control

In order to bring the effectiveness of the VSC into full play, the throttle valve angle is regulated through a coordination control by the skid control ECU and the ECM.

f. Cruise Control*2

The ECM directly actuates the throttle valve for operation of the cruise control.

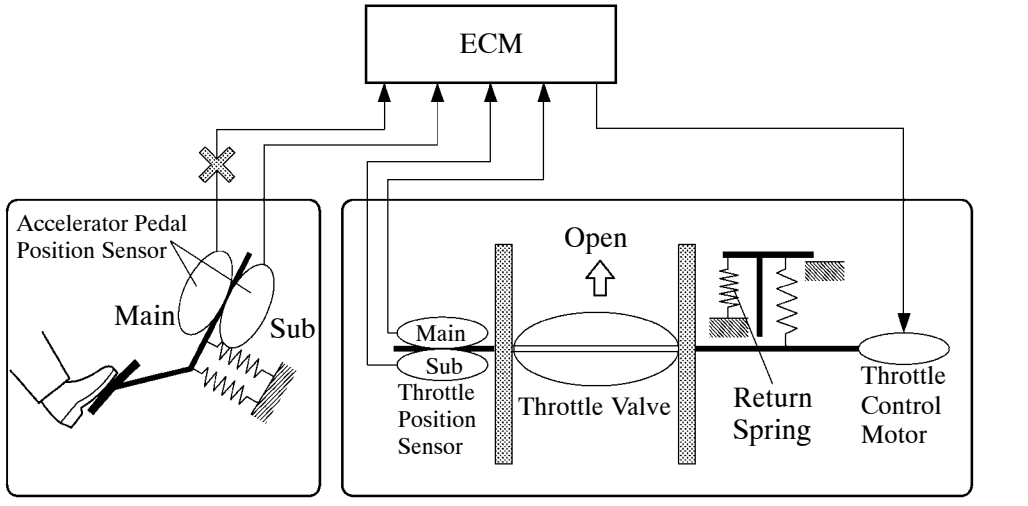
g. Tow/Haul Control*3

When the tow/haul control is operating, the throttle valve opening angle relationship to the accelerator pedal angle is increased. As a result, during tow/haul control, acceleration performance is ensured.

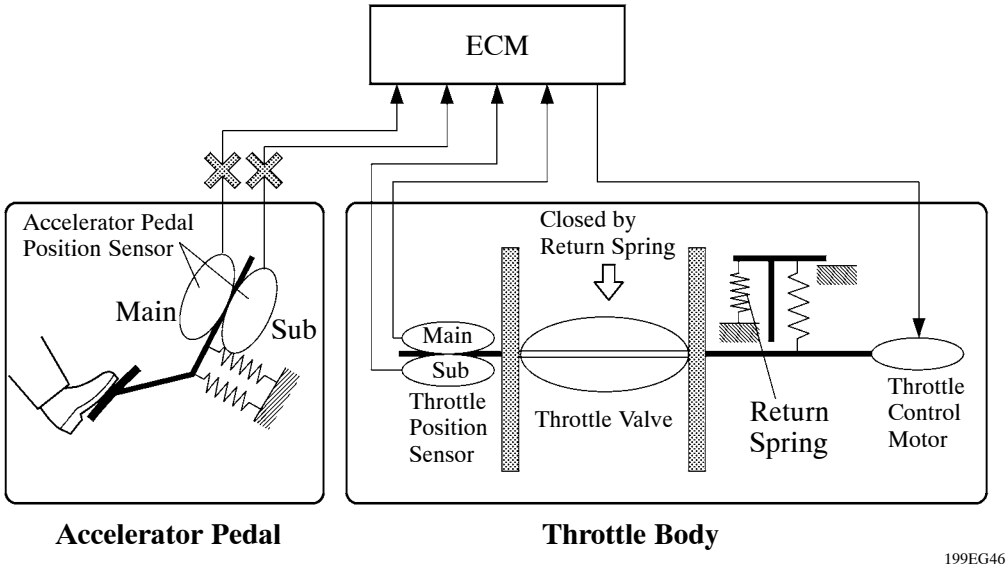
*1: 4WD models
*2: Models with cruise control system
*3: Models with towing package

3) Fail-safe Operation due to Accelerator Pedal Position Sensor Trouble

- The accelerator pedal position sensor is comprised of 2 (main, sub) sensor circuits.
- If a malfunction occurs in either of the sensor circuits, the ECM detects the abnormal signal voltage difference between these two sensor circuits and switches into a fail-safe mode. In this fail-safe mode, the remaining circuit is used to calculate the accelerator pedal opening, in order to operate the vehicle under fail-safe mode control.

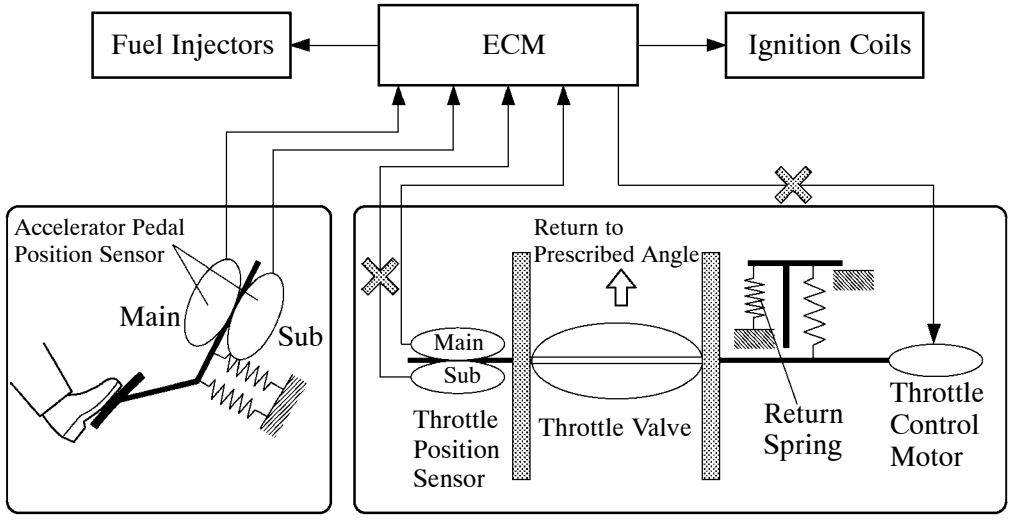


- If both circuits malfunction, the ECM detects the abnormal signal voltage from these two sensor circuits and discontinues the throttle control. At this time, the vehicle can be driven within its idling range.



4) Fail-safe Operation Caused by Throttle Position Sensor Trouble

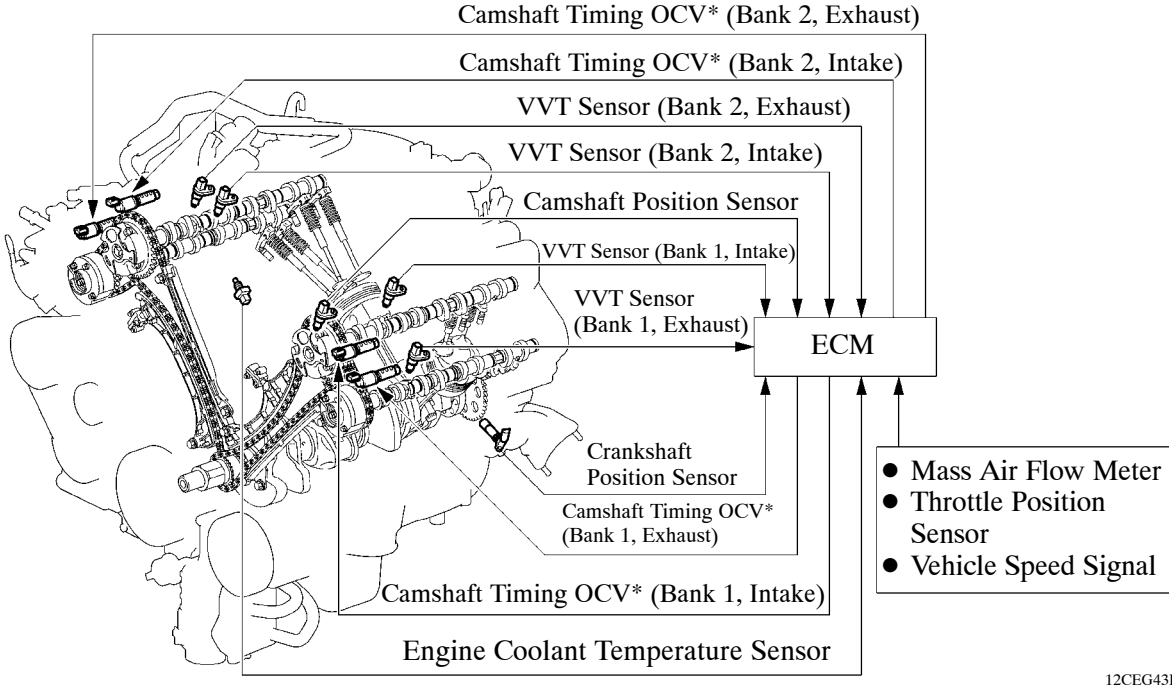
- The throttle position sensor is comprised of 2 (main, sub) sensor circuits.
- If a malfunction occurs in either of the sensor circuits, the ECM detects the abnormal signal voltage difference between these 2 sensor circuits, cuts off the current to the throttle control motor, and switches to a fail-safe mode.
- Then, the force of the return spring causes the throttle valve to return and stay at the prescribed base opening position. At this time, the vehicle can be driven in the fail-safe mode while the engine output is regulated through control of the fuel injection and ignition timing in accordance with the accelerator pedal position.
- The same control as above is effected if the ECM detects a malfunction in the throttle control motor system.



Dual Variable Valve Timing-intelligent (Dual VVT-i) System

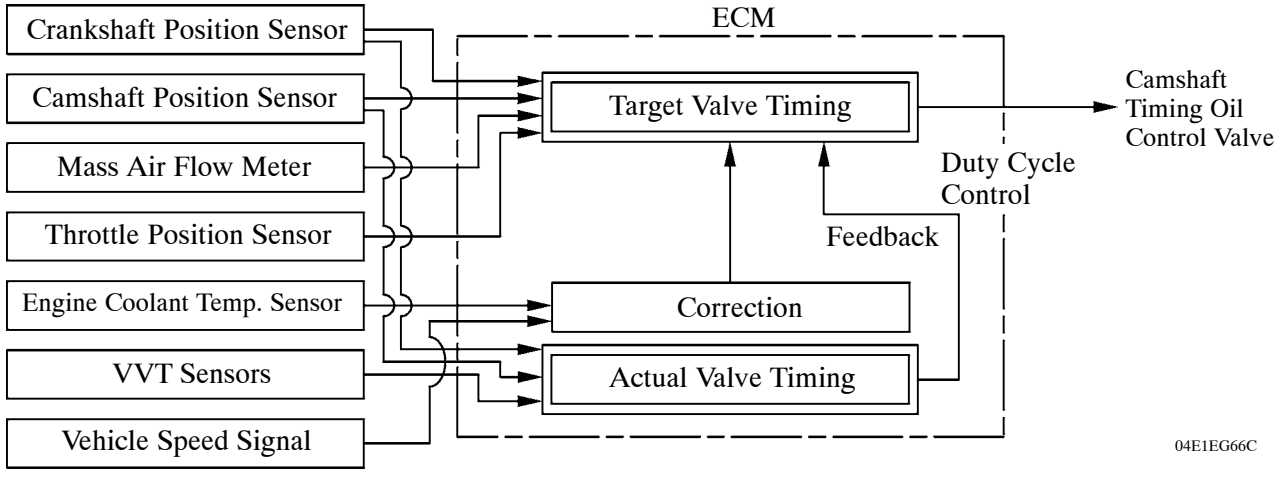
1) General

- The Dual VVT-i system is designed to control the intake and exhaust camshafts within a range of 40° and 32° respectively (of crankshaft angle) to provide valve timing optimally suited to the engine operating conditions. This improves torque in all the speed ranges as well as increasing fuel economy and reducing exhaust emissions.

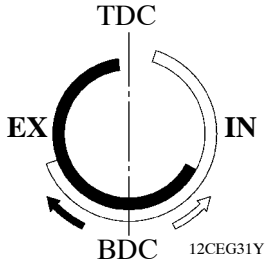
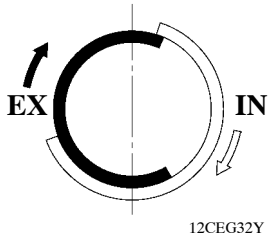
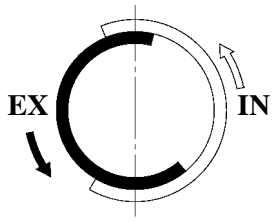
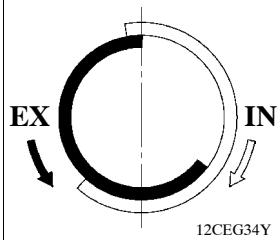
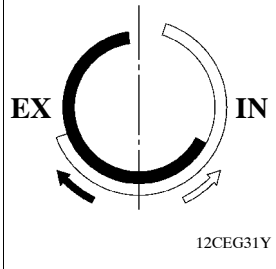
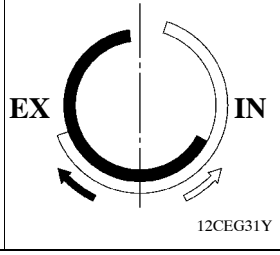


*: Oil Control Valve

- By using the engine speed, intake air mass, throttle position and engine coolant temperature, the ECM calculates the optimal valve timing for each driving condition and controls the camshaft timing oil control valves. In addition, the ECM uses signals from the intake and exhaust VVT sensors for each bank and the crankshaft position sensor to detect the actual valve timing, thus providing feedback control to achieve the target valve timing.



2) Effectiveness of Dual VVT-i System

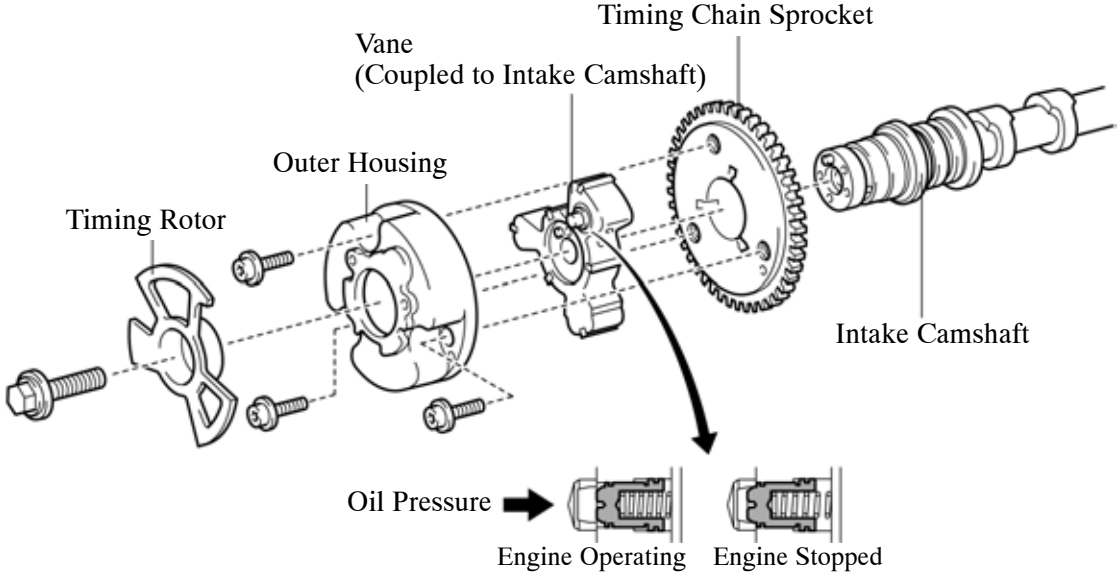
Condition	Operation		Timing/ Position	Objective	Effect
During Idling		IN	Most Retarded Position	Eliminating overlap to reduce blow back to the intake side.	● Stabilized idle speed ● Better fuel economy
		EX	Most Advanced Position		
In Low Speed Range with Light to Medium Load		IN	Retarded	Retarding the intake valve close timing and reducing pumping loss. Increasing overlap and internal EGR.	● Better fuel economy ● Improved emission control
		EX	Retarded		
In Low to Medium Speed Range with Heavy Load		IN	Advanced	Advancing the intake valve close timing, reducing intake air blow back to the intake side, and improving volumetric efficiency.	Improved torque in low to medium speed range
		EX	Advanced		
In High Speed Range with Heavy Load		IN	Retarded	Retarding the intake valve close timing and improving volumetric efficiency using the inertia force of the intake air.	Improved output
		EX	Advanced		
At Low Temperatures		IN	Most Retarded Position	Eliminating overlap to reduce blow back to the intake side. Fixing valve timing at extremely low temperatures and increasing the control range as the temperature rises.	● Stabilized fast idle speed ● Better fuel economy
		EX	Most Advanced Position		
● Upon Starting ● Stopping Engine		IN	Most Retarded Position	Controlling valve timing and fixing it to the optimal timing for engine start.	Improved startability
		EX	Most Advanced Position		

3) Construction

a. VVT-i Controller

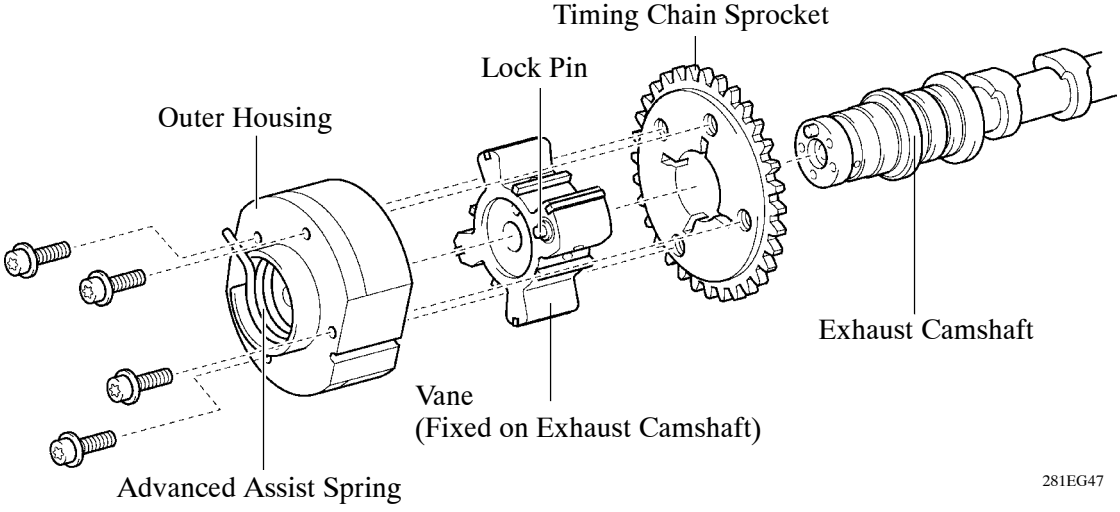
- This controller consists of an outer housing driven by the timing chain sprocket, and a vane coupled to each camshaft.
- The intake side uses a VVT-i controller with 3 vanes, and the exhaust side uses one with 4 vanes.
- When the engine stops, the intake side VVT-i controller is locked at the most retarded angle by its lock pin, and the exhaust side controller is locked at the most advanced angle. This ensures excellent engine startability.
- The oil pressure sent from the advance or retard side passages of the intake and exhaust camshafts causes rotation of the VVT-i controller vane sub-assembly relative to the timing chain sprocket, to vary the valve timing continuously.
- An advance assist spring is provided on the exhaust side VVT-i controller. This helps to apply torque in the advanced angle direction so that the vane lock pin securely engages with the housing when the engine stops.

▶ Intake Side VVT-i Controller ◀



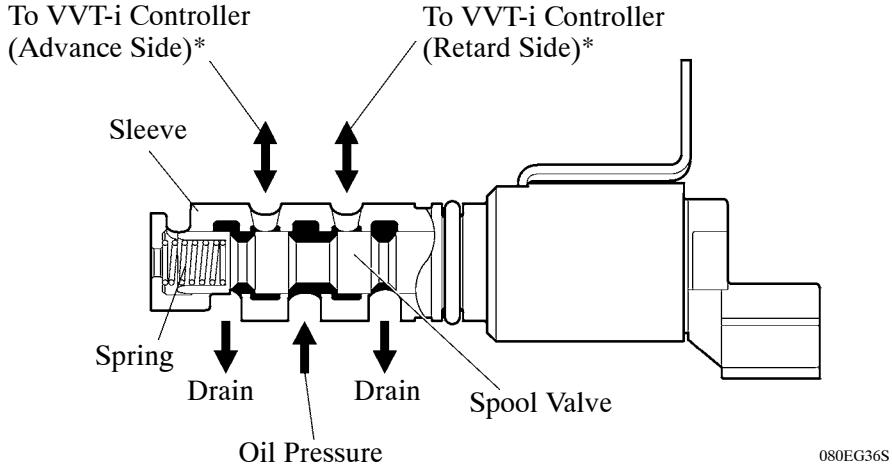
Lock Pin

▶ Exhaust Side VVT-i Controller ◀



b. Camshaft Timing Oil Control Valve

This camshaft timing oil control valve controls the spool valve using duty cycle control from the ECM. This allows hydraulic pressure to be applied to the VVT-i controller advance or retard side. When the engine is stopped, the camshaft timing oil control valve (intake) will move to the retard position, and the camshaft timing oil control valve (exhaust) will move to the advance position.



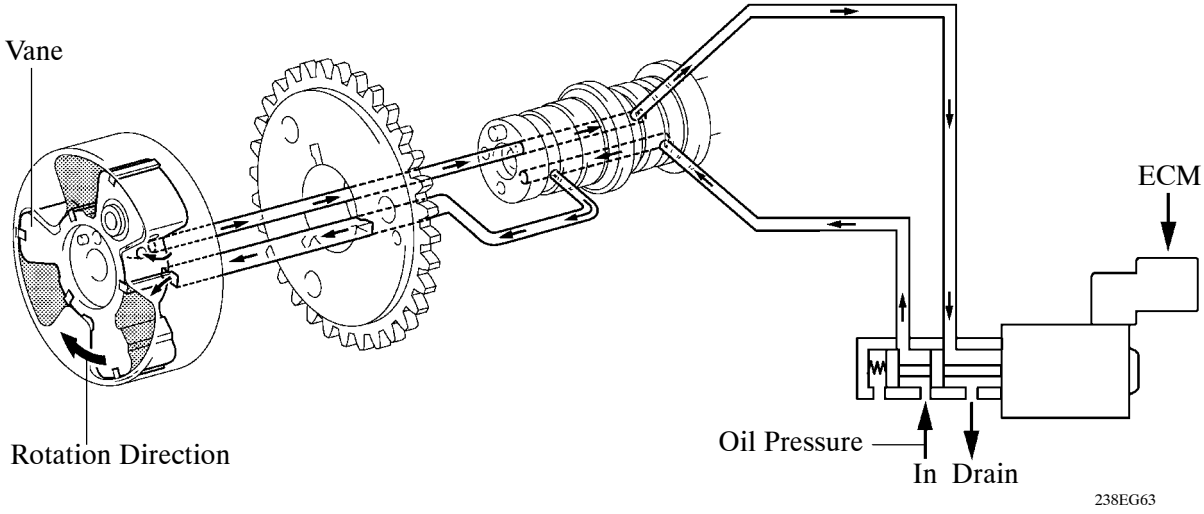
*: On the exhaust side oil control valve, the advance and retard sides are reversed.

4) Operation

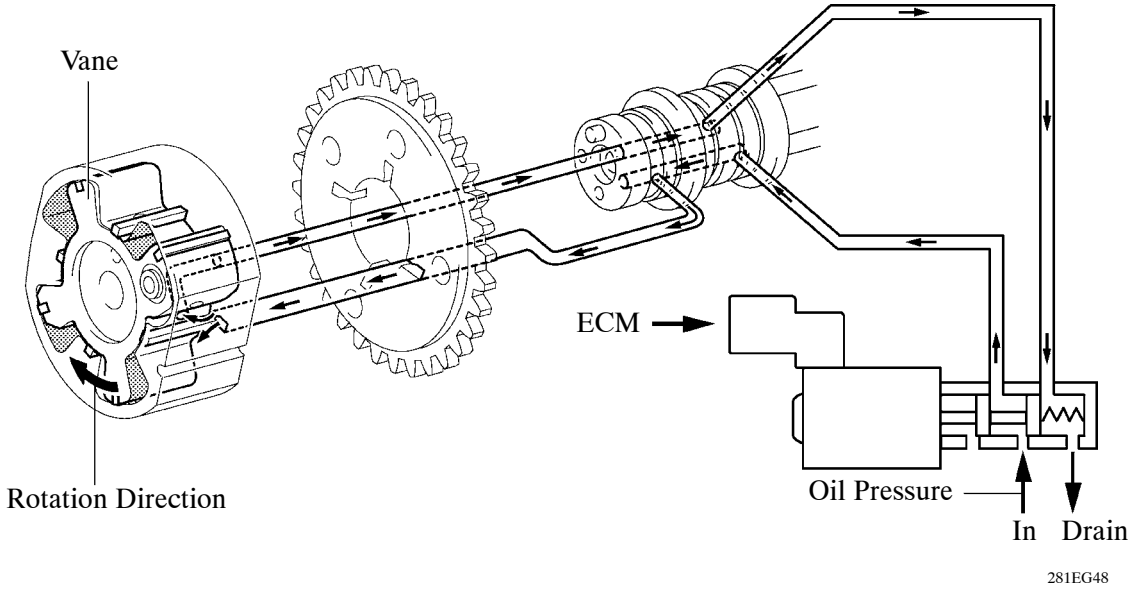
a. Advance

When the camshaft timing oil control valve is positioned as illustrated below by the advance signals from the ECM, the resultant oil pressure is applied to the timing advance side vane chamber to rotate the camshaft in the timing advance direction.

▶ Intake Side ◀



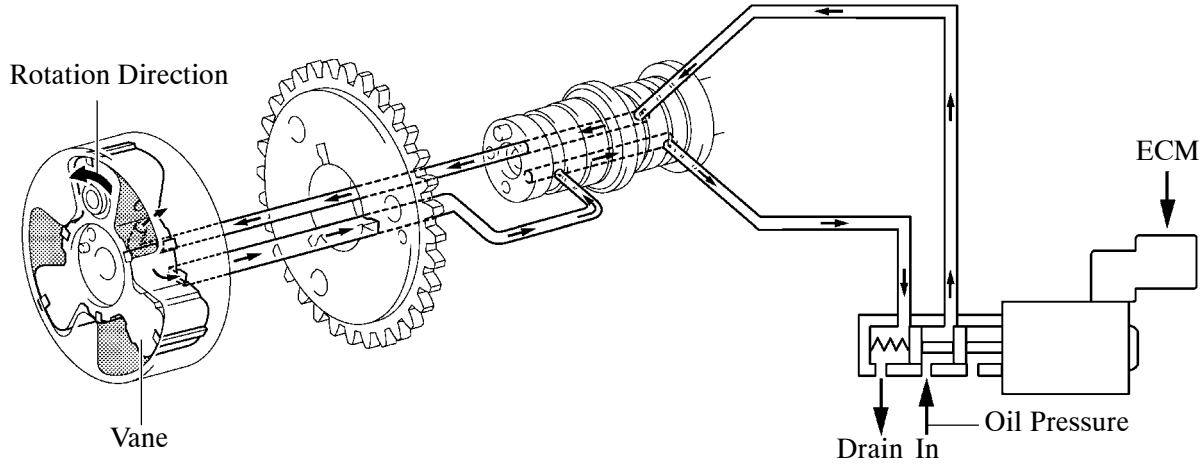
▶ Exhaust Side ◀



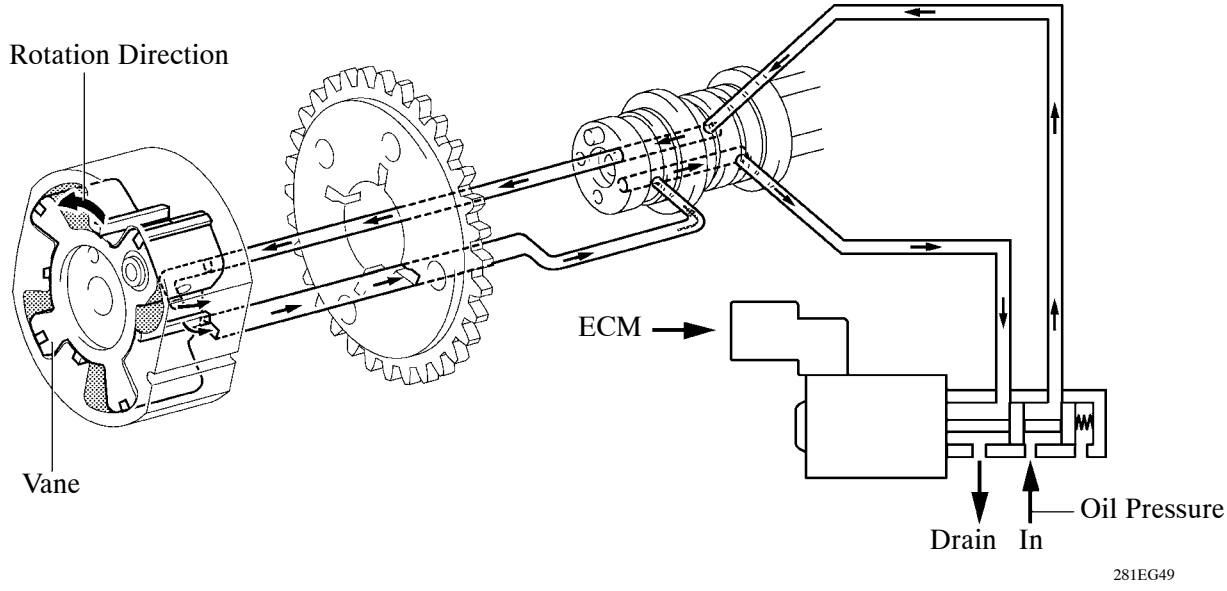
b. Retard

When the camshaft timing oil control valve is positioned as illustrated below by the retard signals from the ECM, the resultant oil pressure is applied to the timing retard side vane chamber to rotate the camshaft in the timing retard direction.

▶ Intake Side ◀



▶ Exhaust Side ◀



c. Hold

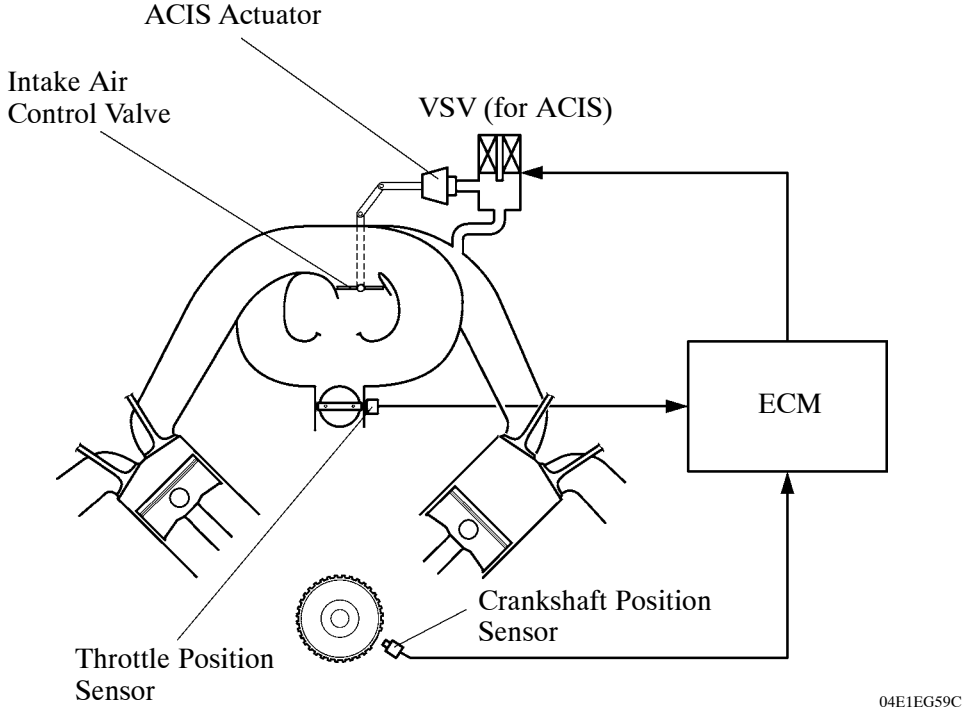
After reaching the target timing, the engine valve timing is maintained by keeping the camshaft timing oil control valve in the neutral position unless the engine operating conditions change.
This maintains the engine valve timing at the desired target position by preventing the engine oil from running out of the oil control valve.

Acoustic Control Induction System (ACIS)

1) General

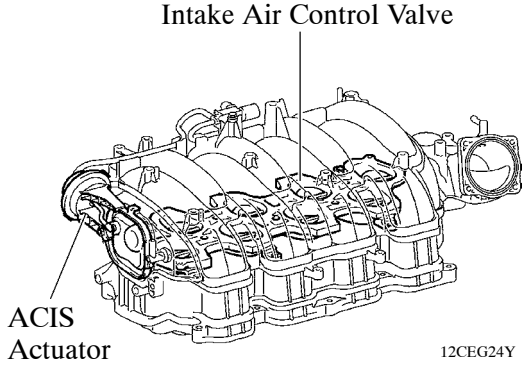
The ACIS is implemented by using a bulkhead to divide the intake manifold into 2 stages, with an intake air control valve in the bulkhead being opened and closed to vary the effective length of the intake manifold in accordance with the engine speed and throttle valve opening angle. This increases the power output in all ranges from low to high speed.

▶ System Diagram ◀



2) Intake Air Control Valve and ACIS Actuator

The intake air control valve and ACIS actuator are integrated with the intake manifold. This valve opens and closes to change the effective length of the intake manifold in 2 stages.

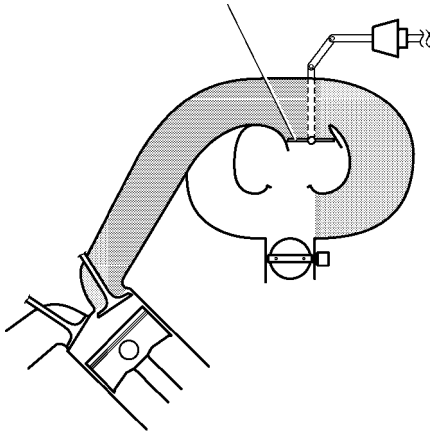


3) Operation

a. When Intake Control Valve Closes (VSV On)

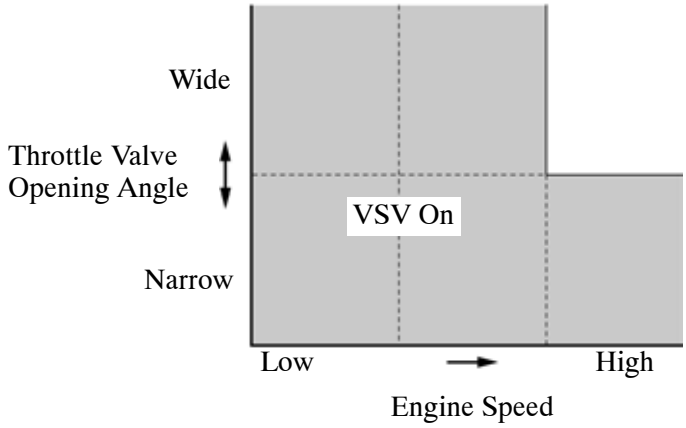
The ECM activates the VSV so that the negative pressure acts on the diaphragm chamber of the actuator. This closes the control valve to match the longer pulsation cycle. As a result, the effective length of the intake manifold is lengthened and the intake efficiency in the low-to-medium engine speed range under heavy load and low-to-high engine speed range under low load is improved due to the dynamic effect of the intake air, thereby increasing the power output.

Intake Air Control Valve (Closed)



: Effective intake manifold length

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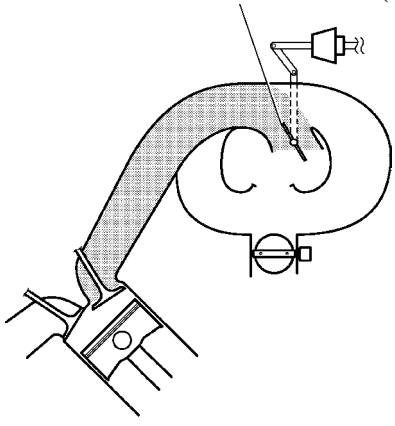


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b. When Intake Control Valve Opens (VSV Off)

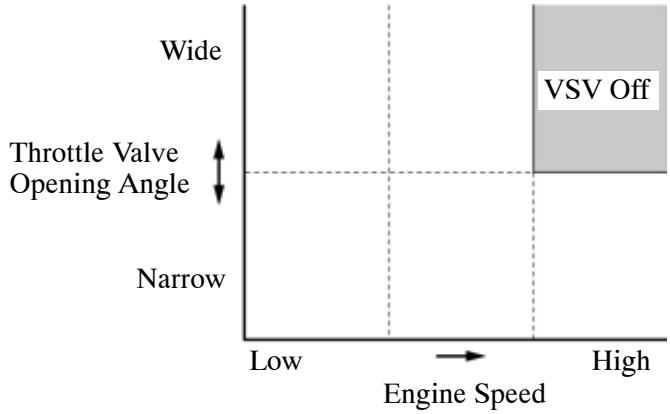
The ECM deactivates the VSV so that atmospheric air is led into the diaphragm chamber of the actuator. This opens the control valve to match the shorter pulsation cycle. When the control valve is open, the effective length of the intake manifold is shortened and peak intake efficiency is shifted. This benefits the high engine speed range under heavy load, thus providing greater output at high engine speeds.

Intake Air Control Valve (Open)



: Effective intake manifold length

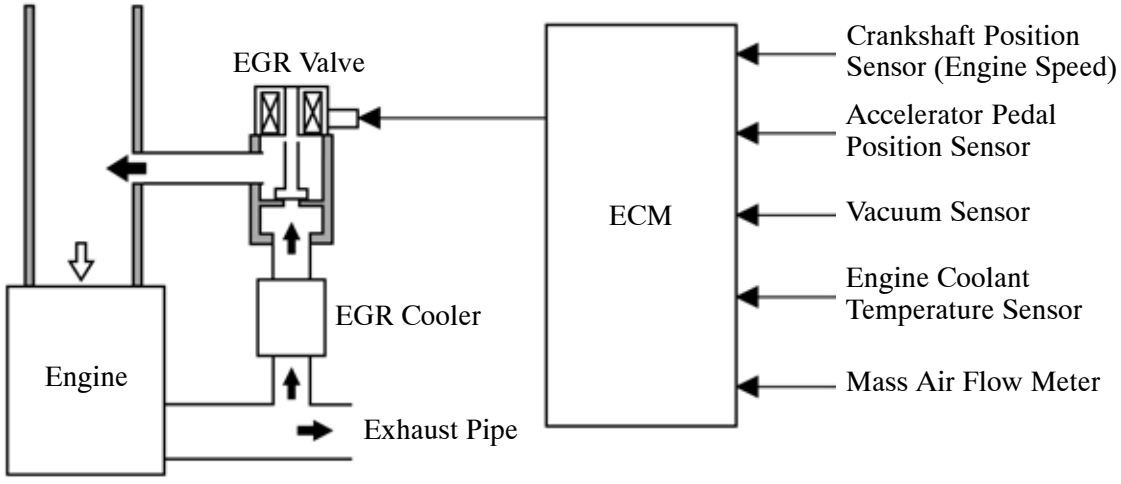
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EGR Control

The ECM determines the engine condition based primarily on various sensors. The ECM controls the EGR valve to regulate the amount of the EGR gas. This control does not operate when the engine is cold.



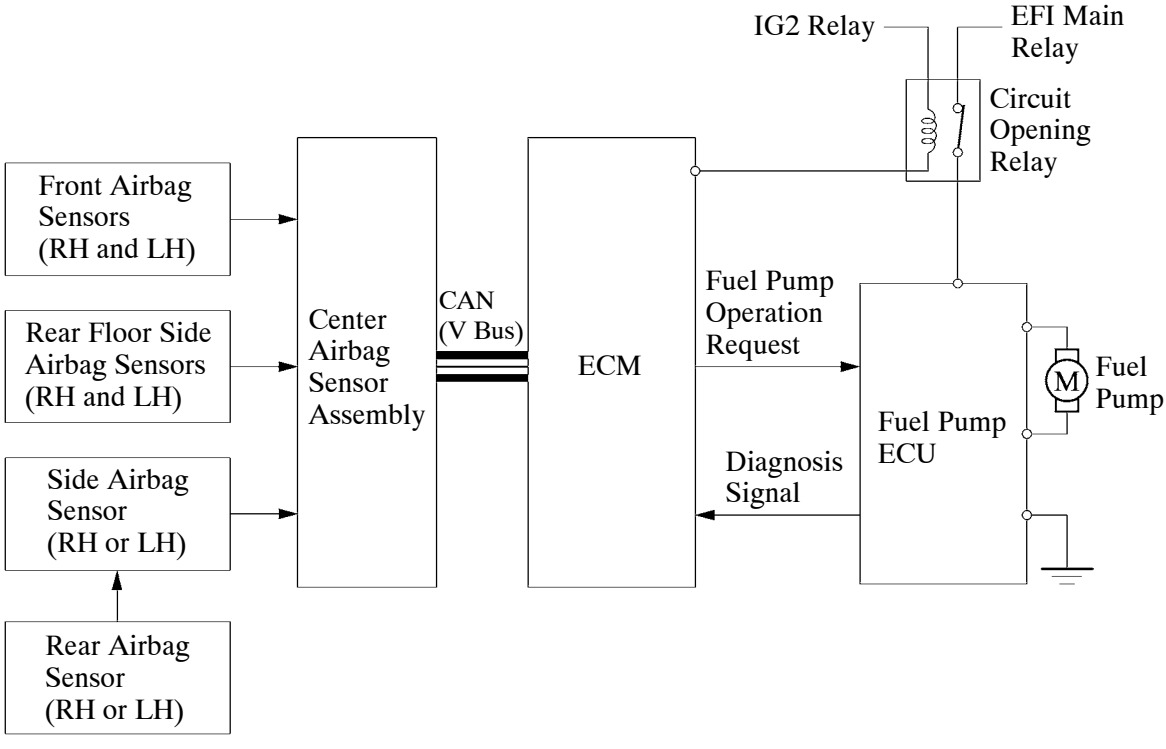
Fuel Pump Control

1) General

In this vehicle, there are 2 types of fuel pump controls. The fuel pump is controlled to an optimum speed to match the engine operating conditions, and the fuel pump operation is stopped when the SRS airbags deploy.

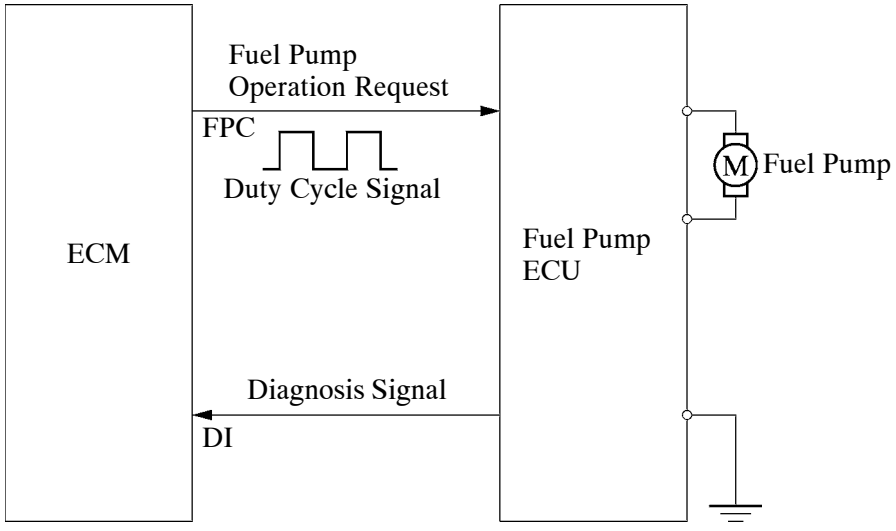
- The ECM transmits a fuel pump operation request signal to the fuel pump ECU that corresponds to the engine operating conditions. The fuel pump ECU receives this request signal and controls the speed of the fuel pump in 3 stages. As a result, under light engine loads, fuel pump speed is kept low to reduce electric power loss.
- A fuel cut control is used to stop the fuel pump when any of the SRS airbags deploys. In this control, if an airbag deployment signal from the center airbag sensor assembly is detected by the ECM, the ECM will turn off the circuit opening relay. As a result, the power supply to the fuel pump ECU is stopped, causing the fuel pump to stop operating. After the fuel cut control has been activated, turning the ignition switch from off to on cancels the fuel cut control, and the engine can be restarted.

▶ System Diagram ◀

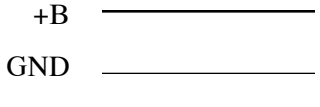
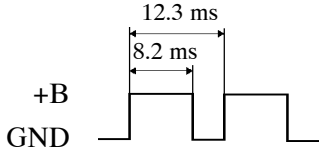
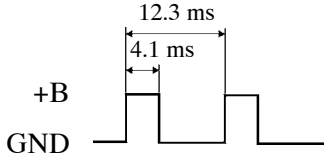
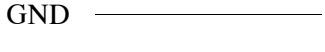


2) Fuel Pump ECU

- The fuel pump ECU controls fuel pump speed by receiving a duty cycle signal (FPC terminal input) from the ECM, and control is performed in 3 stages.
- The fuel pump ECU also detects failures in the input and output circuits at the fuel pump ECU and transmits the failure status to the ECM.



▶ FPC Terminal Input ◀

FPC Input Signal (Duty Cycle Signal)	Fuel Pump Speed
	High
	Middle
	Low
	Stop

Air Injection System

1) General

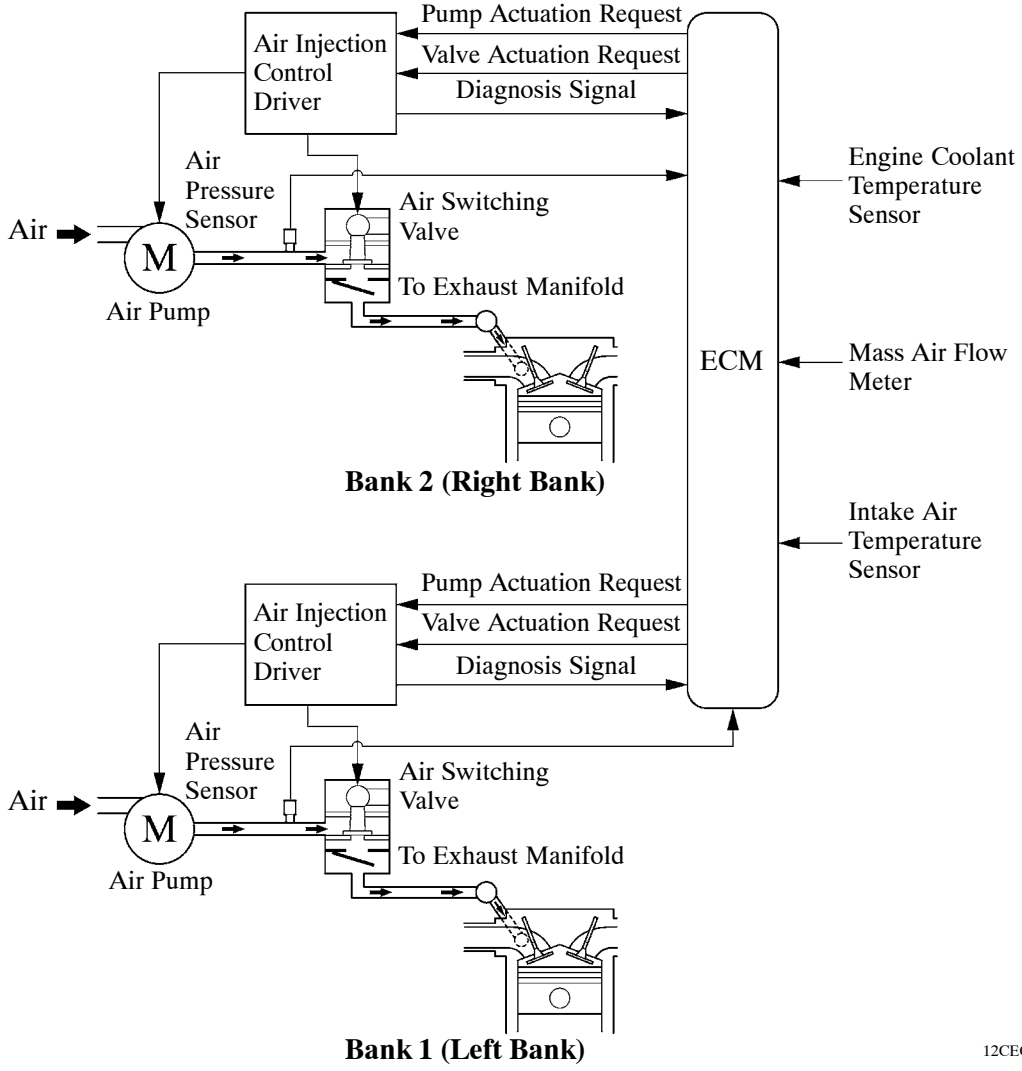
To ensure the proper warm-up performance of the Three-Way Catalytic converters (TWCs) after starting a cold engine, an air injection system is used.

- In this system, both bank 2 (right bank) and bank 1 (left bank) have an air pump, an air injection control driver, an air switching valve, and an air pressure sensor. Control of the right bank and left bank is performed independently. Two pumps are used to increase the amount of air supplied, shortening the catalyst warm-up time.
- The ECM estimates the amount of air injected to the TWCs based on signals from the mass air flow meter in order to regulate the air injection time.
- Air is injected under the following conditions:

▶ Operation Conditions ◀

Engine Coolant Temperature	5°C to 45°C (41°F to 113°F)
Intake Air Temperature	5°C (41°F) or more

▶ System Diagram ◀

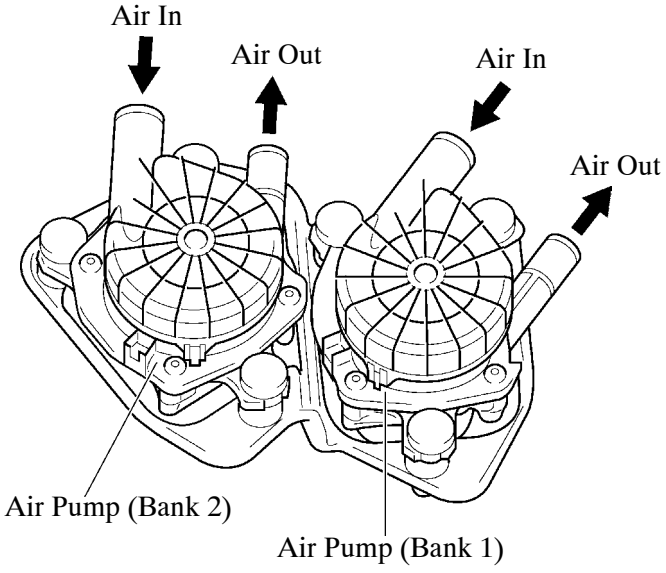


2) Construction and Operation

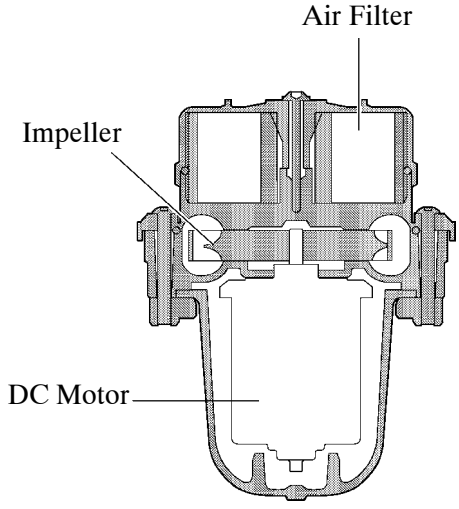
a. Air Pump

Each air pump consists of a DC motor, an impeller and an air filter.

- The air pump supplies air into an air injection control valve using its impeller.
- The air filter is maintenance-free.
- The air pumps for bank 1 and bank 2 have the same basic structure and function.



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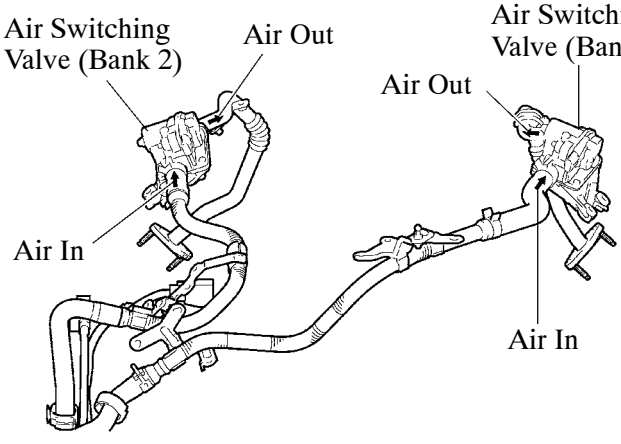


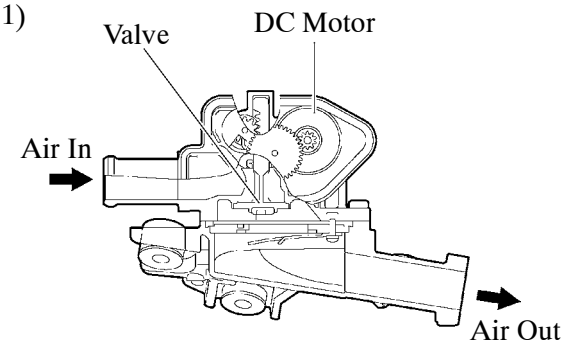
Cross Section

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b. Air Switching Valve

- The air switching valve is operated by a DC motor to control air injection and prevent back-flow of exhaust gas. Opening timing of the valve is synchronized with the operation timing of the air pump.
- An air pressure sensor is built into the corresponding air switching valve.
- The air switching valves for bank 1 and bank 2 have the same basic structure and function.



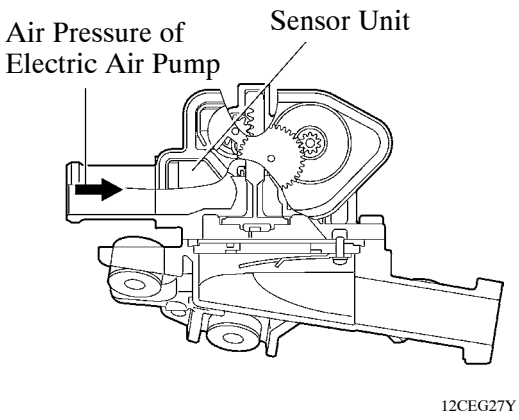


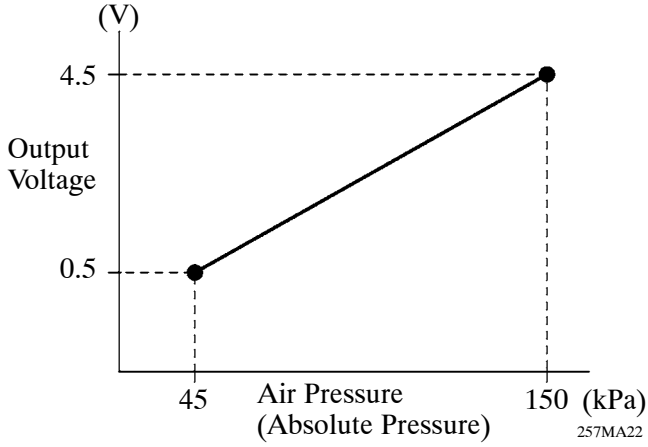
Cross Section (for Bank 1)

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c. Air Pressure Sensor

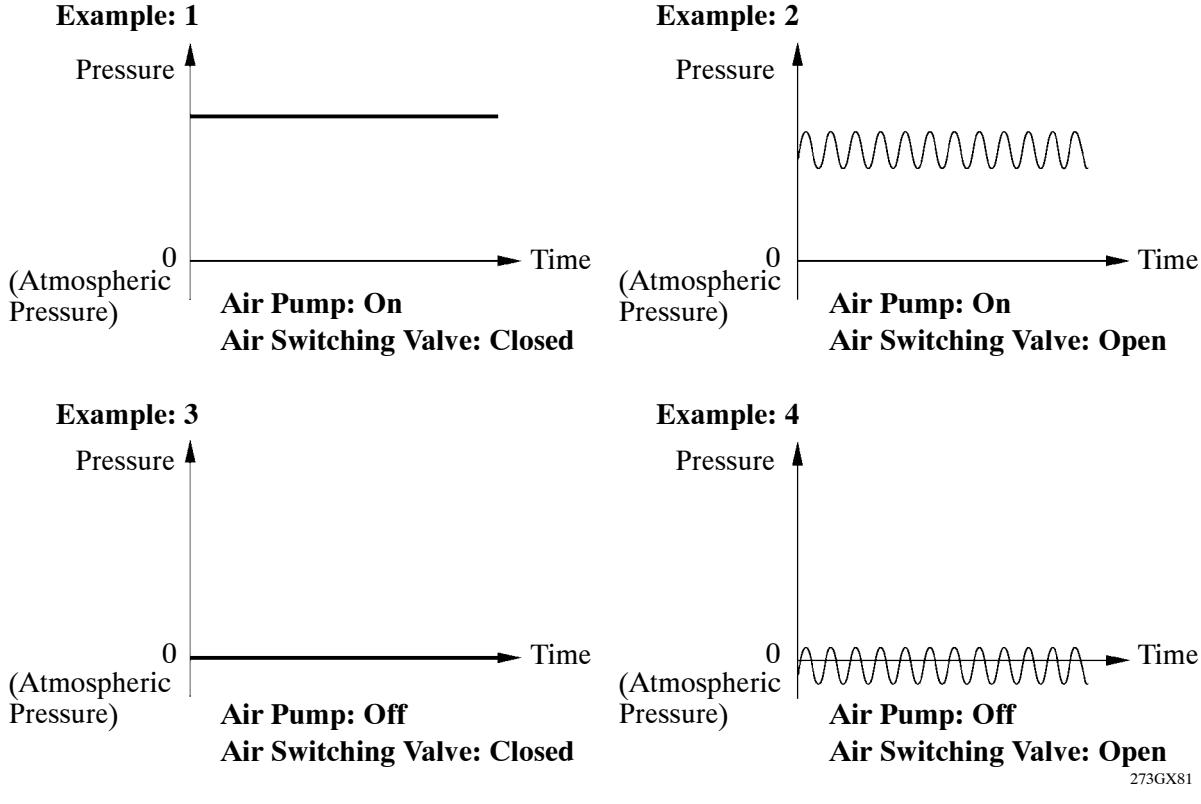
- The air pressure sensor consists of a semiconductor, which has a silicon chip that changes its electrical resistance when pressure is applied to it. The sensor converts the pressure into an electrical signal, and sends it to the ECM in an amplified form.
- The air pressure sensors for bank 1 and bank 2 have the same basic structure and function.





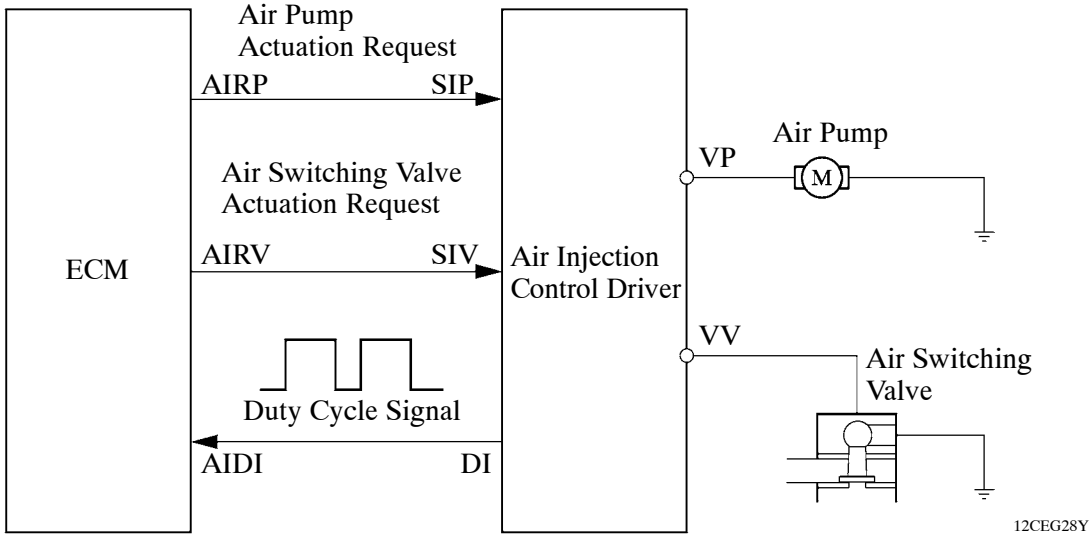
The ECM detects operation of the air injection system based on signals from the air pressure sensor as follows:

1) When the air pump is on and the air switching valve is closed, the pressure is stable.
2) When the air pump is on and the air switching valve is open, the pressure drops slightly and becomes unstable because of exhaust pulses.
3) When the air pump is off and the air switching valve is closed, the pressure remains at atmospheric pressure.
4) When the air pump is off and the air switching valve is open, the pressure drops below atmospheric pressure and becomes unstable because of exhaust pulses.



d. Air Injection Control Driver

- A semiconductor type air injection control driver is used. Activated by the ECM, this driver actuates the air pump and the air switching valve.
- The air injection control driver also detects failures in the input and output circuits of the air injection driver and transmits the failure status to the ECM via duty cycle signals.
- The air injection control drivers for bank 1 and bank 2 have the same basic structure and function. The following system chart shows the bank 1 (left bank):



▶ DI Terminal Output ◀

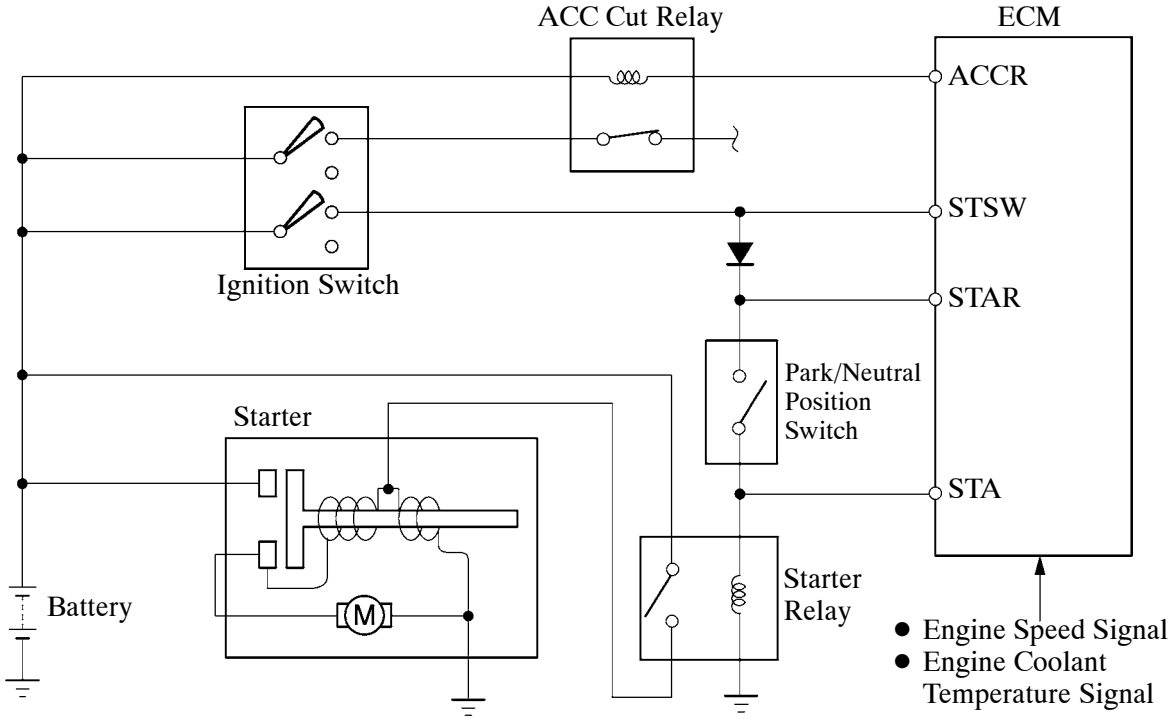
Condition	AIRP	AIRV	Output (Duty Cycle Signal)
Open circuit in line between AIDI and DI terminals.	—	—	GND 273GX28
Failure in line between ECM terminals and air injection control driver.	—	—	GND 273GX29
Output failure at air injection control driver. (Failure in air pump actuation circuit)	—	—	200 ms, Duty 20%, GND 273GX30
Output failure at air injection control driver. (Failure in air switching valve actuation circuit)	—	—	Duty 40%, GND 273GX31
Overheat failure of air injection control driver.	—	—	Duty 60%, GND 273GX32
Normal	On	On	Duty 80%, GND 273GX33
	Off	Off	GND 273GX29
	On	Off	
	Off	On	

Starter Control (Cranking Hold Function)

1) General

- Once the ignition switch is turned to the START position, this control continues to operate the starter until the engine starts, without having to hold the ignition switch in the START position. This prevents starting failures.
- When the ECM detects a start signal from the ignition switch, this system monitors the engine speed (NE) signal and continues to operate the starter until it determines that the engine has started.

▶ System Diagram ◀

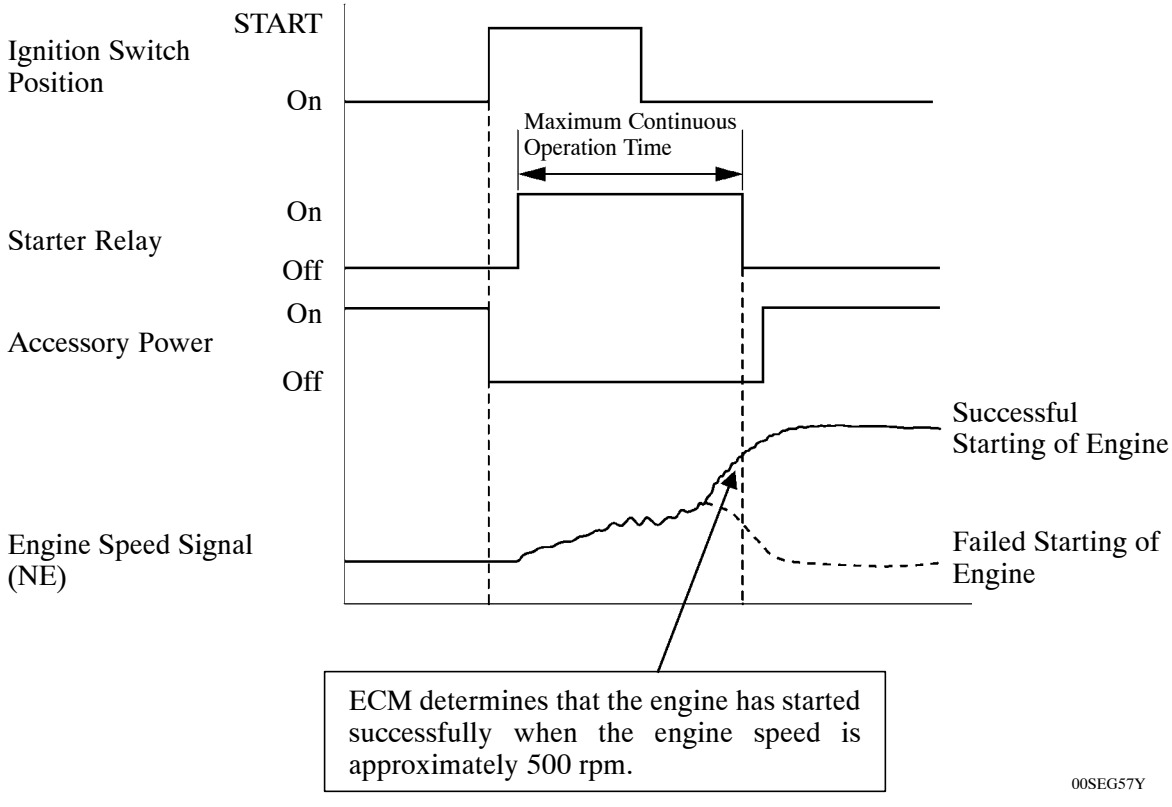


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2) Operation

- As indicated in the following timing chart, when the ECM detects a start signal from the ignition switch, it energizes the starter relay to operate the starter. If the engine is already running, the ECM will not energize the starter relay.
- After the starter operates and the engine speed becomes higher than approximately 500 rpm, the ECM determines that the engine has started and stops the operation of the starter.
- If the engine does not start due to a failure, the starter operates as long as its maximum continuous operation time and stops automatically. The maximum continuous operation time varies depending on the engine coolant temperature condition.
- This system cuts off the current that powers the accessories while the engine is cranking to prevent the accessory illumination from operating intermittently due to the unstable voltage associated with the cranking of the engine.
- This system has the following protections:
  - In the event that the starter begins to operate, but cannot detect the engine speed signal, the ECM will stop the starter operation immediately. However, if the ignition switch is held in the START position, the starter continues to operate.

▶ Timing Chart ◀



Evaporative Emission Control System

1) General

The evaporative emission control system prevents the fuel vapors created in the fuel tank from being released directly into the atmosphere.
The canister stores the fuel vapors that have been created in the fuel tank.

- The ECM controls the purge VSV in accordance with the driving conditions in order to direct the fuel vapors into the engine, where they are burned.
- In this system, the ECM checks for evaporative emission leaks and outputs a Diagnostic Trouble Code (DTC) in the event of a malfunction. An evaporative emission leak check consists of an application of vacuum to the evaporative emissions system and monitoring the system for changes in pressure in order to detect a leakage.
- This system consists of the purge VSV, canister, refueling valve, canister pump module, and ECM.
- An On-board Refueling Vapor Recovery (ORVR) function is provided in the refueling valve.
- A canister pressure sensor has been included with the canister pump module.
- A canister filter has been provided on the fresh air line. This canister filter is maintenance-free.
- The following are the typical conditions necessary to enable an evaporative emission leak check:

Typical Enabling Condition	● 5 hours have elapsed after the engine has been turned off* ● Altitude: Below 2400 m (8000 feet) ● Battery Voltage: 10.5 V or more ● Power Source: Off ● Engine Coolant Temperature: 4.4°C to 35°C (40°F to 95°F) ● Intake Air Temperature: 4.4°C to 35°C (40°F to 95°F)

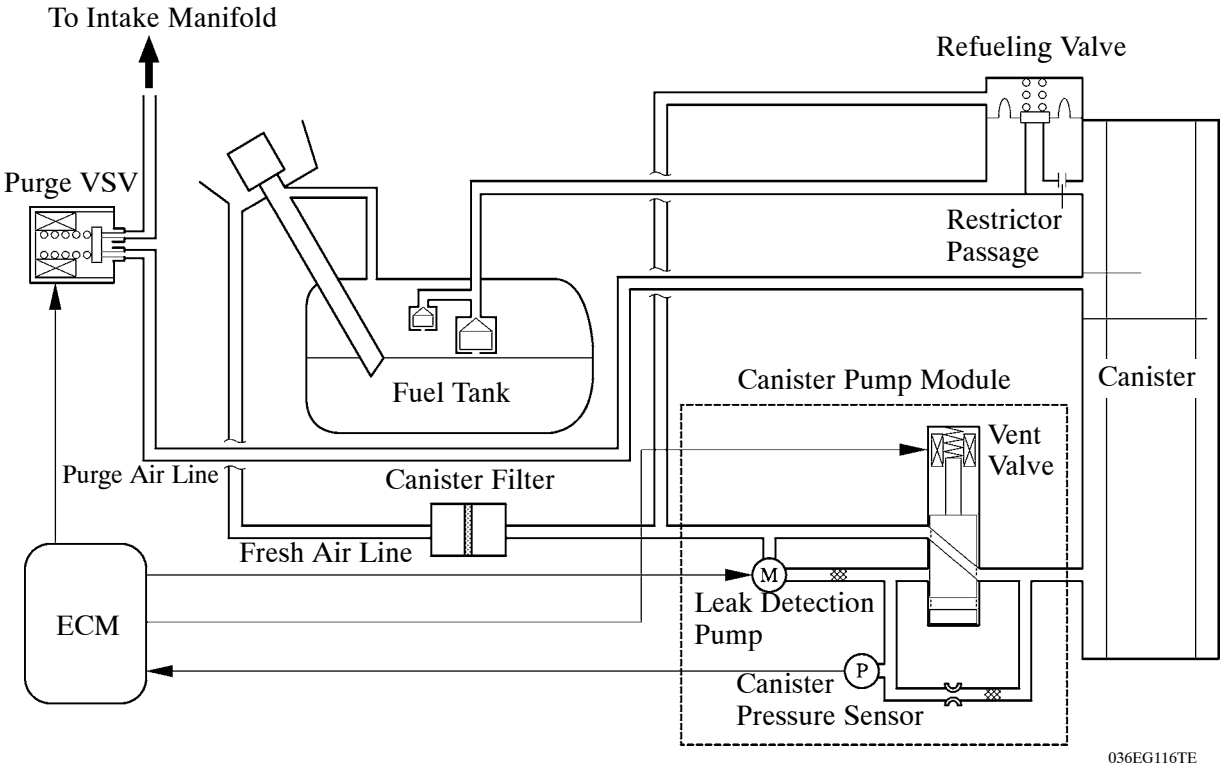
*: If the engine coolant temperature does not drop below 35°C (95°F), this time should be extended to 7 hours. Even after that, if the temperature is not less than 35°C (95°F), the time should be extended to 9.5 hours.

Service Tip

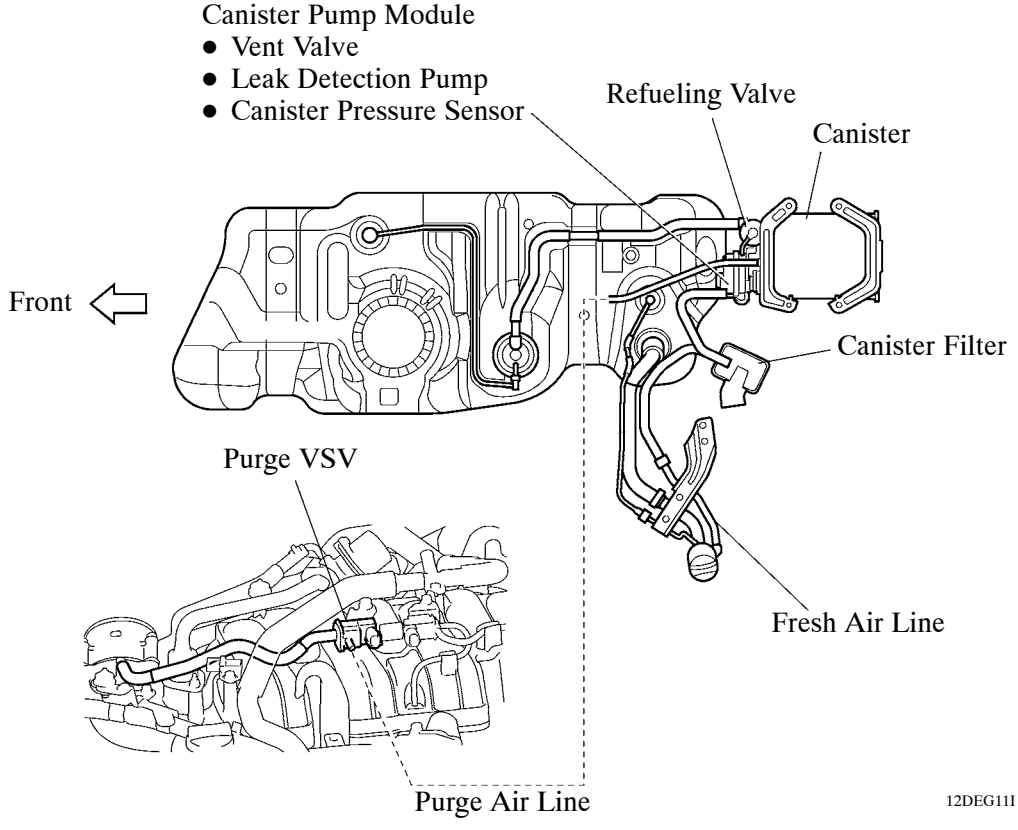
The canister pump module performs a fuel evaporative emission leakage check. This check is done approximately 5 hours after the engine is turned off. Sound may be heard coming from underneath the luggage compartment for several minutes. This does not indicate a malfunction.

- The pinpoint pressure test procedure is implemented by pressurizing the fresh air line that runs from the canister pump module to the air filler neck. For details, refer to the 2010 TOYOTA TUNDRA Repair Manual.

2) System Diagram



3) Layout of Main Components



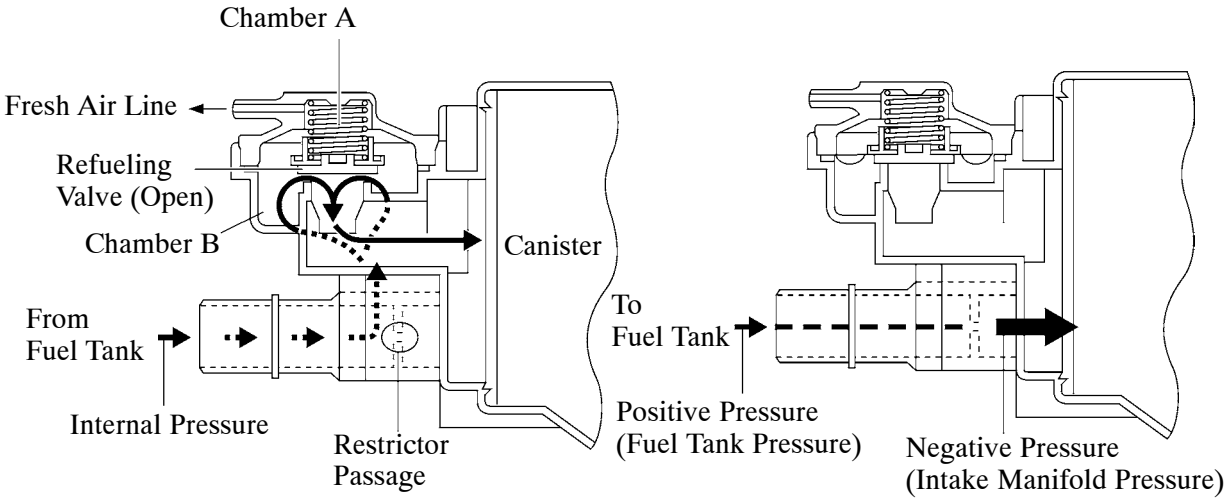
4) Function of Main Components

Component		Function
Canister		Contains activated charcoal to absorb the fuel vapors created in the fuel tank.
Refueling Valve		Controls the flow rate of the fuel vapors from the fuel tank to the canister when the system is purging or during refueling.
	Restrictor Passage	Prevents a large amount of vacuum during purge operation or system monitoring operation from affecting the pressure in the fuel tank.
Fresh Air Line		Fresh air goes into the canister and the cleaned drain air goes out into the atmosphere.
Canister Pump Module	Vent Valve	Opens and closes the fresh air line in accordance with the signals from the ECM.
	Leak Detection Pump	Applies vacuum pressure to the evaporative emission system in accordance with the signals from the ECM.
	Canister Pressure Sensor	Detects the pressure in the evaporative emission system and sends the signals to the ECM.
Purge VSV		Opens in accordance with the signals from the ECM when the system is purging, in order to send the fuel vapors that have been absorbed by the canister into the intake manifold. In system monitoring mode, this valve controls the introduction of the vacuum into the fuel tank.
Canister Filter		Prevents dust and debris in the fresh air from entering the system.
ECM		Controls the canister pump module and the purge VSV in accordance with the signals from various sensors, in order to achieve a purge volume that suits the driving conditions. In addition, the ECM monitors the system for any leakage and outputs a DTC if a malfunction is found.

5) Construction and Operation

a. Refueling Valve

- The refueling valve consists of chamber A, chamber B, and the restrictor passage. A constant atmospheric pressure is applied to chamber A.
- During refueling, the internal pressure of the fuel tank increases. This pressure causes the refueling valve to lift up, allowing the fuel vapors to enter the canister.
- The restrictor passage prevents the large amount of vacuum created during purge operation or system monitoring operation from entering the fuel tank, and limits the flow of the fuel vapors from the fuel tank to the canister. If a large volume of fuel vapors enters the intake manifold, it will affect the air-fuel ratio control of the engine. Therefore, the role of the restrictor passage is to help prevent this from occurring.

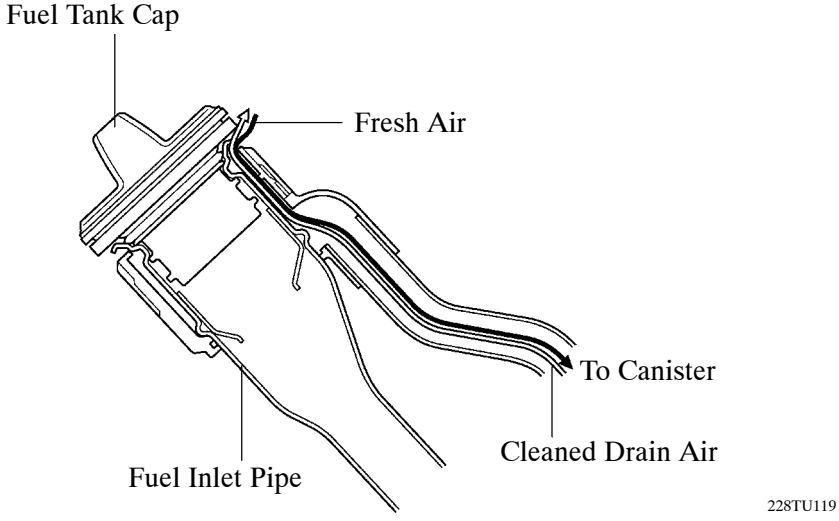


During Refueling

During Purge Operation or System Monitoring Operation

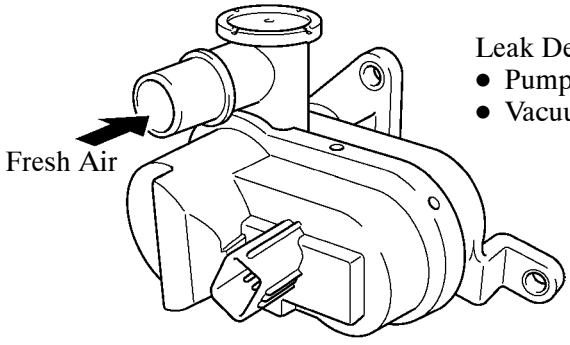
b. Fuel Inlet (Fresh Air Inlet)

In accordance with the change of structure of the evaporative emission control system, the location of the fresh air line inlet has been changed from the air cleaner to the vicinity of the fuel inlet. The fresh air from the atmosphere and drain air cleaned by the canister will go in or out of the system through the passages shown below:

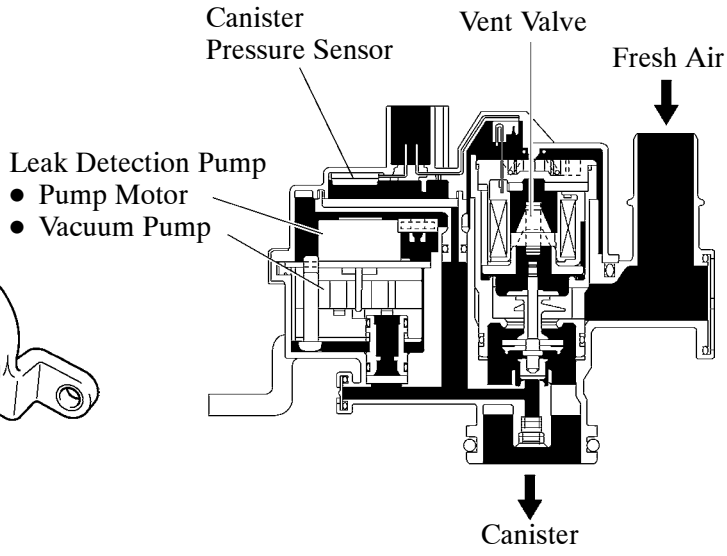


c. Canister Pump Module

- The canister pump module consists of the vent valve, canister pressure sensor, and leak detection pump (vacuum pump and pump motor).
- The vent valve switches the passages in accordance with the signals received from the ECM.
- A brushless type DC motor is used for the pump motor.
- A vane type vacuum pump is used.

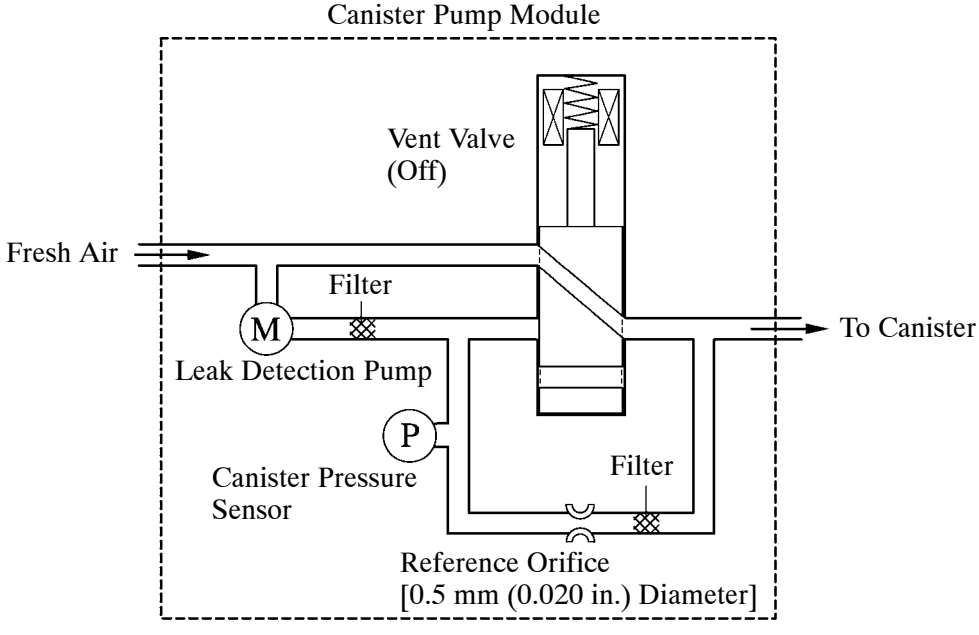


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279EG26

▶ Simple Diagram ◀

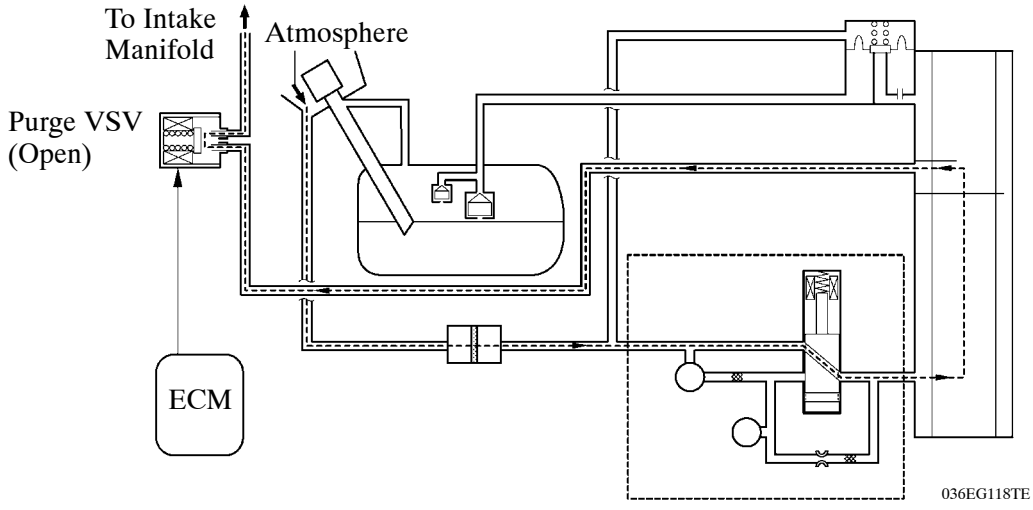


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6) System Operation

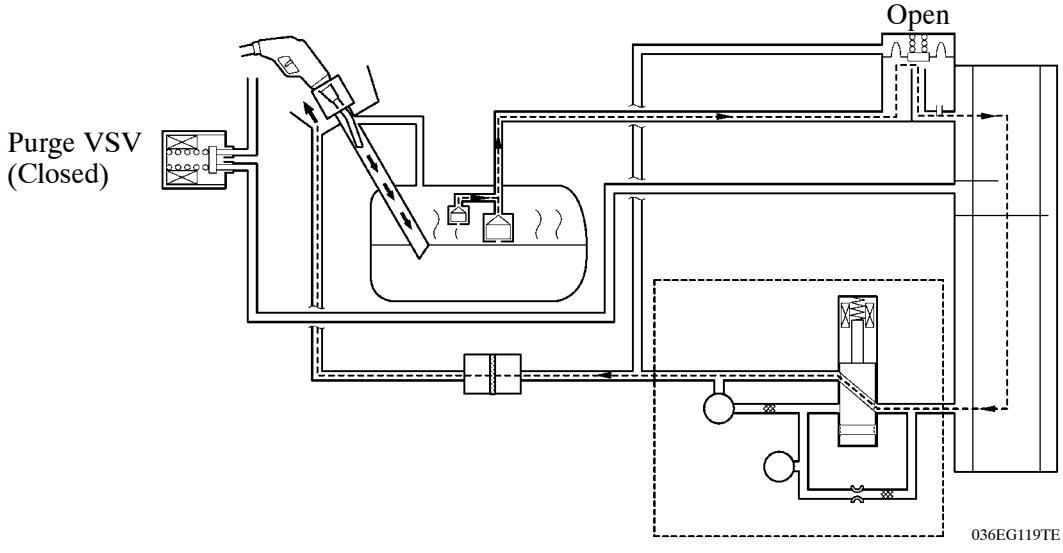
a. Purge Flow Control

When the engine has reached predetermined parameters (closed loop, engine coolant temp. above 70°C (158°F), etc), stored fuel vapors are purged from the canister whenever the purge VSV is opened by the ECM.
The ECM will change the duty cycle of the purge VSV, thus controlling purge flow volume. Purge flow volume is determined by intake manifold pressure and the duty cycle of the purge VSV. Atmospheric pressure is allowed into the canister to ensure that purge flow is constantly maintained whenever purge vacuum is applied to the canister.



b. ORVR (On-board Refueling Vapor Recovery)

When the internal pressure of the fuel tank increases during refueling, this pressure causes the diaphragm in the refueling valve to lift up, allowing the fuel vapors to enter the canister. The air that has had the fuel vapors removed from it will be discharged through the fresh air line. The vent valve is used to open and close the fresh air line, and it is always open (even when the engine is stopped) except when the vehicle is in monitoring mode (the valve will be open as long as the vehicle is not in monitoring mode). If the vehicle is refueled in system monitoring mode, the ECM will recognize the refueling by way of the canister pressure sensor, which detects the sudden pressure increase in the fuel tank, and the ECM will open the vent valve.

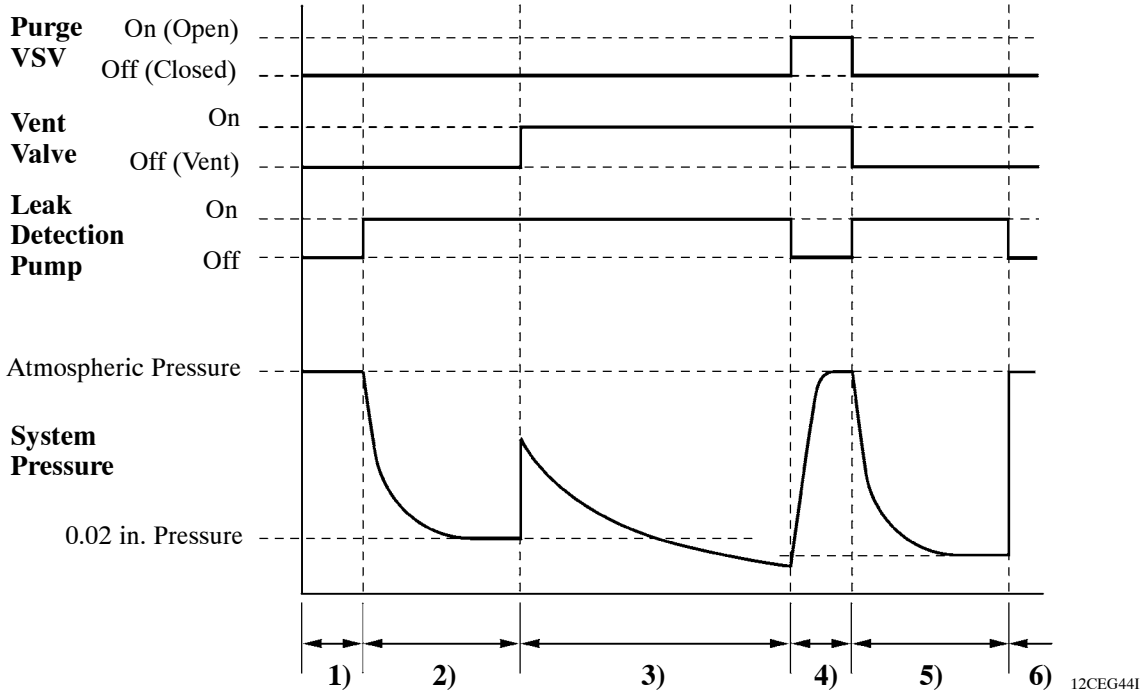


c. EVAP Leak Check

i) General

The EVAP leak check operates in accordance with the following timing chart:

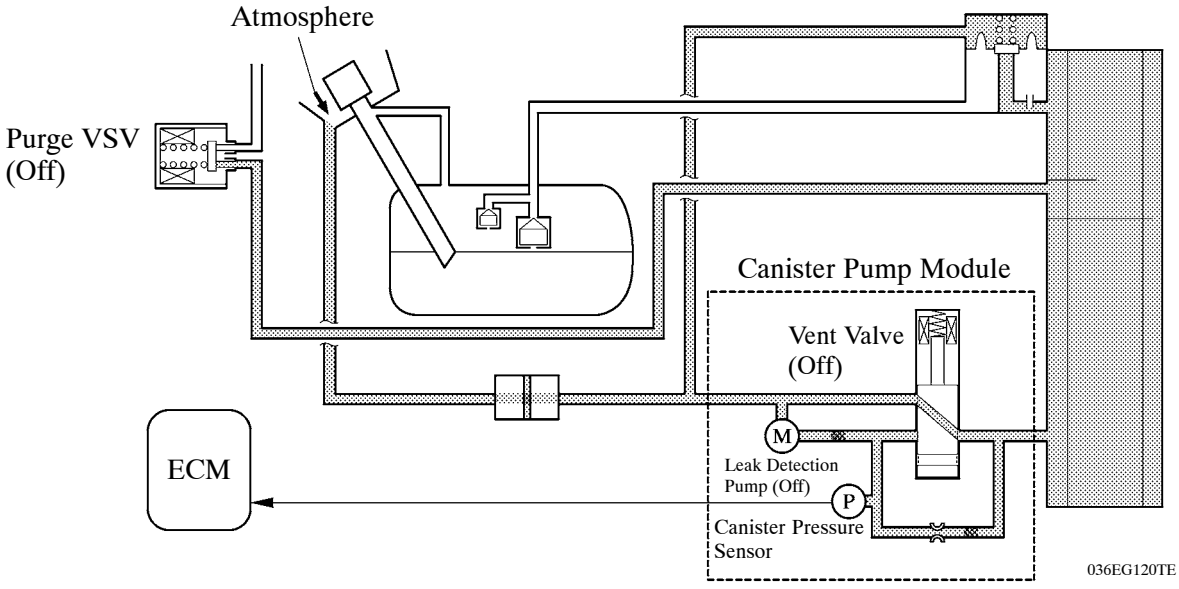
▶ Timing Chart ◀

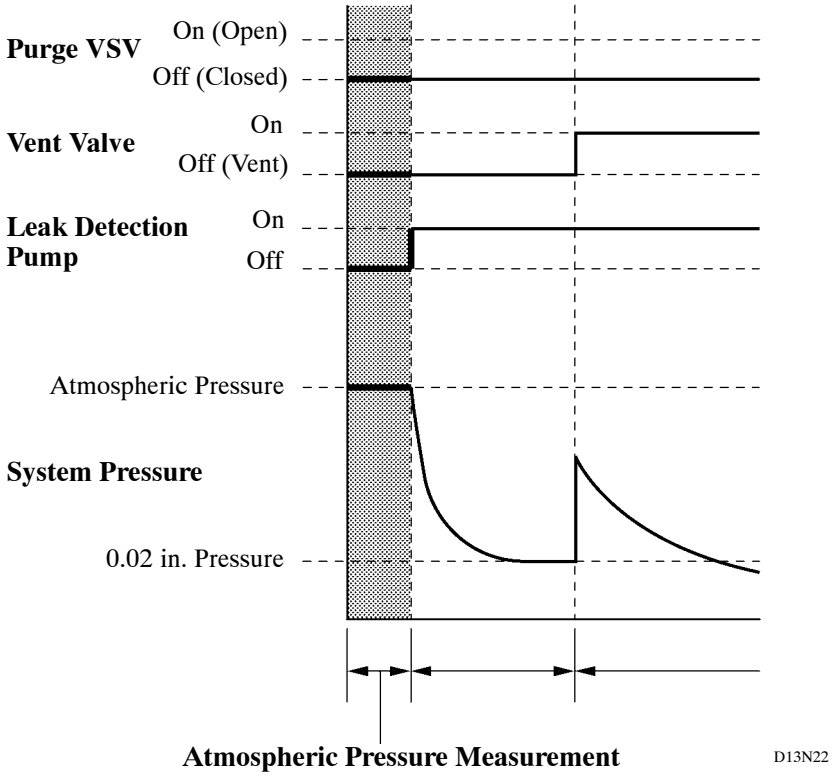


Order	Operation	Description	Time
1)	Atmospheric Pressure Measurement	The ECM turns the vent valve off (vent) and measures EVAP system pressure to memorize the atmospheric pressure.	60 sec.
2)	0.02 in. Leak Pressure Measurement	The leak detection pump creates negative pressure (vacuum) through a 0.02 in. orifice and the pressure is measured. The ECM determines this as the 0.02 in. leak pressure.	60 sec.
3)	EVAP Leak Check	The leak detection pump creates negative pressure (vacuum) in the EVAP system and the EVAP system pressure is measured. If the stabilized pressure is larger than the 0.02 in. leak pressure, the ECM determines that the EVAP system has a leak. If the EVAP pressure does not stabilize within 15 minutes, the ECM cancels EVAP monitor.	Within 17 min.
4)	Purge VSV Monitor	The ECM opens the purge VSV and measures the EVAP pressure increase. If the increase is large, the ECM interprets this as normal.	10 sec.
5)	Repeat 0.02 in. Leak Pressure Measurement	The leak detection pump creates negative pressure (vacuum) through the 0.02 in. orifice and the pressure is measured. The ECM determines this as the 0.02 in. leak pressure.	60 sec.
6)	Final Check	The ECM measures the atmospheric pressure and records the monitor result.	—

ii) Atmospheric Pressure Measurement

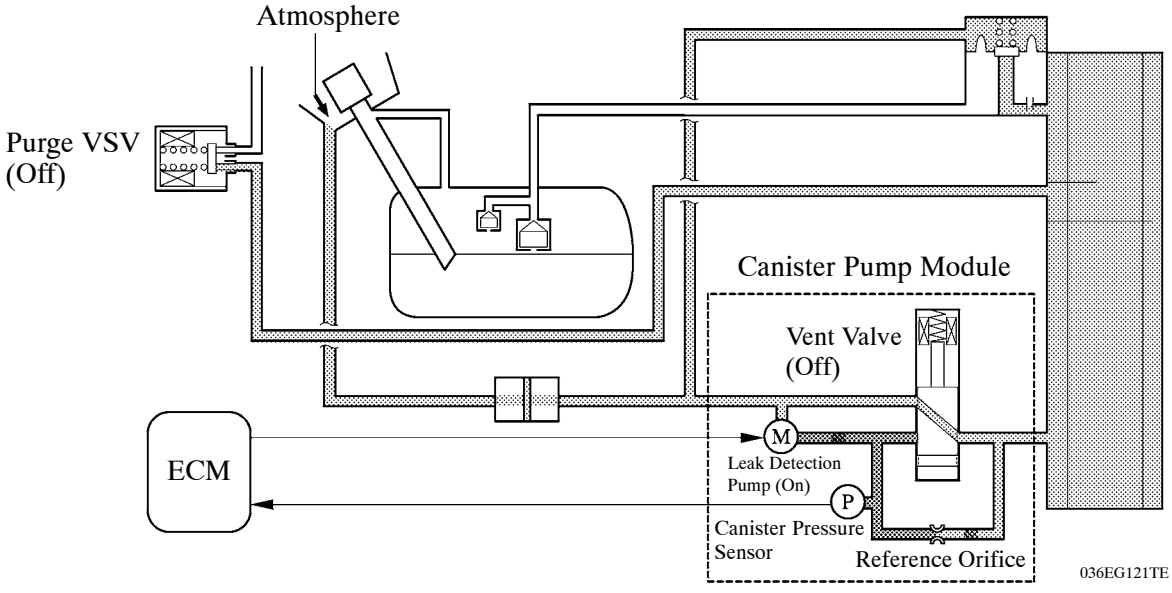
1) When the ignition switch is turned off, the purge VSV and the vent valve are turned off. Therefore, atmospheric pressure is introduced into the canister.
2) The ECM measures the atmospheric pressure based on the signals provided by the canister pressure sensor.
3) If the measurement value is outside the standard pressure, the ECM actuates the leak detection pump in order to monitor the changes in the pressure.

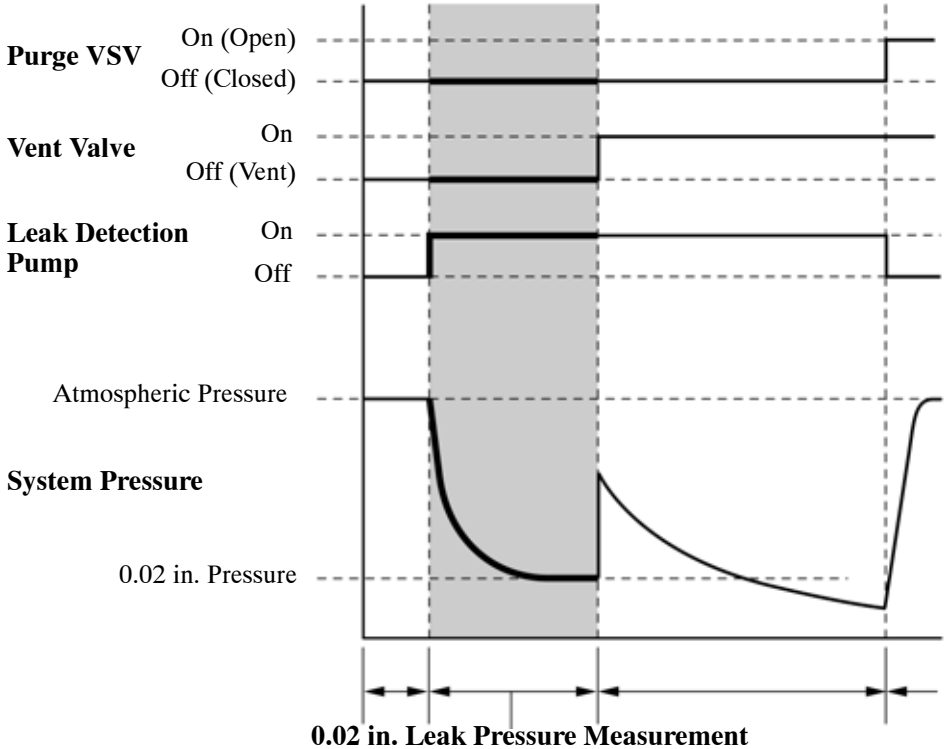




iii) 0.02 in. Leak Pressure Measurement

1) The vent valve remains off, and the ECM introduces atmospheric pressure into the canister and actuates the leak detection pump in order to create a negative pressure.
2) At this time, the pressure will not decrease beyond a 0.02 in. pressure due to the atmospheric pressure that enters through a 0.02 in. diameter reference orifice.
3) The ECM compares the logic value and this pressure, and stores it as a 0.02 in. leak pressure in its memory.
4) If the measurement value is below the standard, the ECM will determine that the reference orifice is clogged and store DTC P043E in its memory.
5) If the measurement value is above the standard, the ECM will determine that a high flow rate pressure is passing through the reference orifice and store DTC P043F, P2401 and P2402 in its memory.



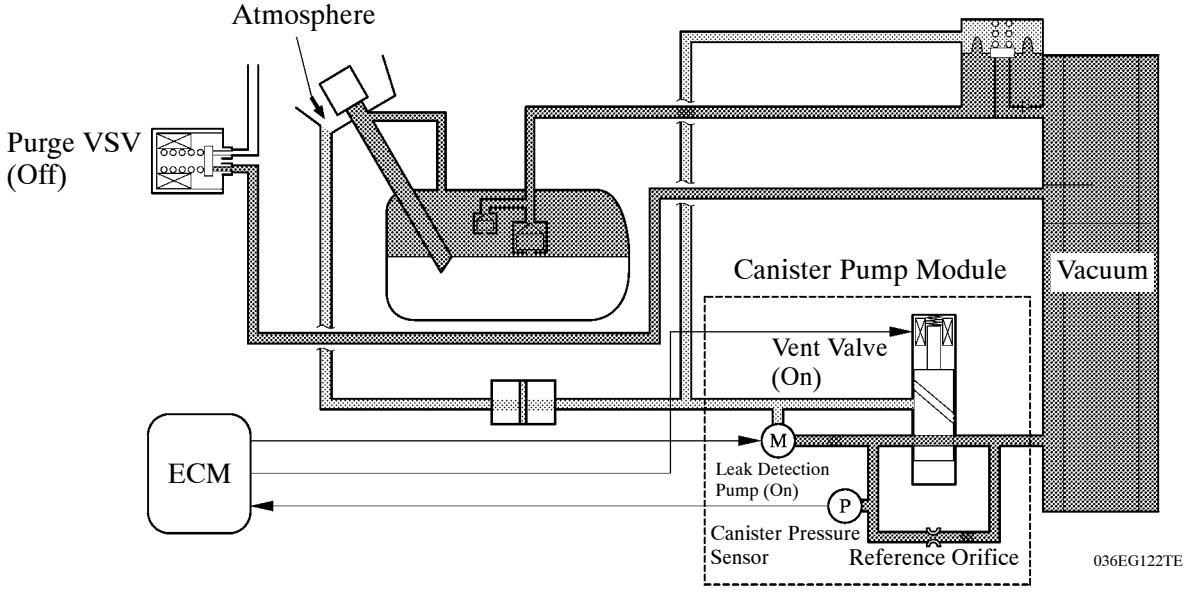


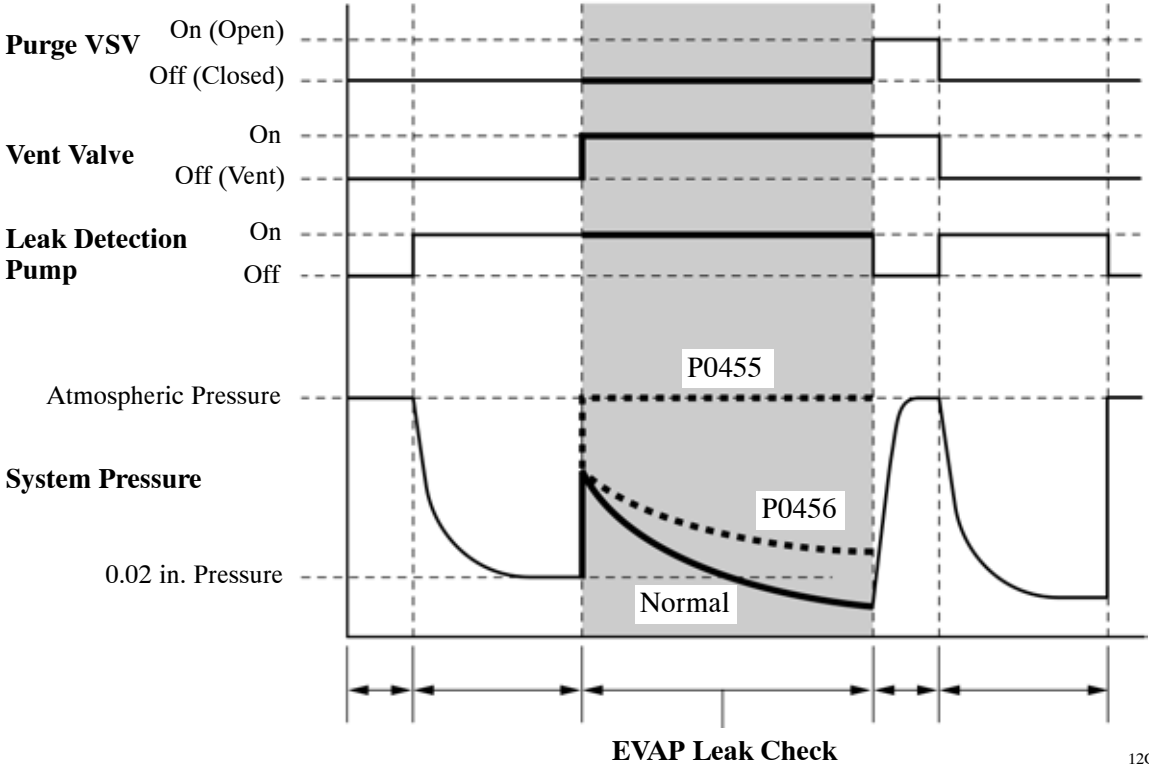
0.02 in. Leak Pressure Measurement

12CEG45I

iv) EVAP Leak Check

1) While actuating the leak detection pump, the ECM turns on the vent valve in order to introduce a vacuum into the canister.
2) When the pressure in the system stabilizes, the ECM compares this pressure and the 0.02 in. pressure in order to check for a leakage.
3) If the detection value is below the 0.02 in. pressure, the ECM determines that there is no leakage.
4) If the detection value is above the 0.02 in. pressure and near atmospheric pressure, the ECM determines that there is a gross leakage (large hole) and stores DTC P0455 in its memory.
5) If the detection value is above the 0.02 in. pressure, the ECM determines that there is a small leakage and stores DTC P0456 in its memory.



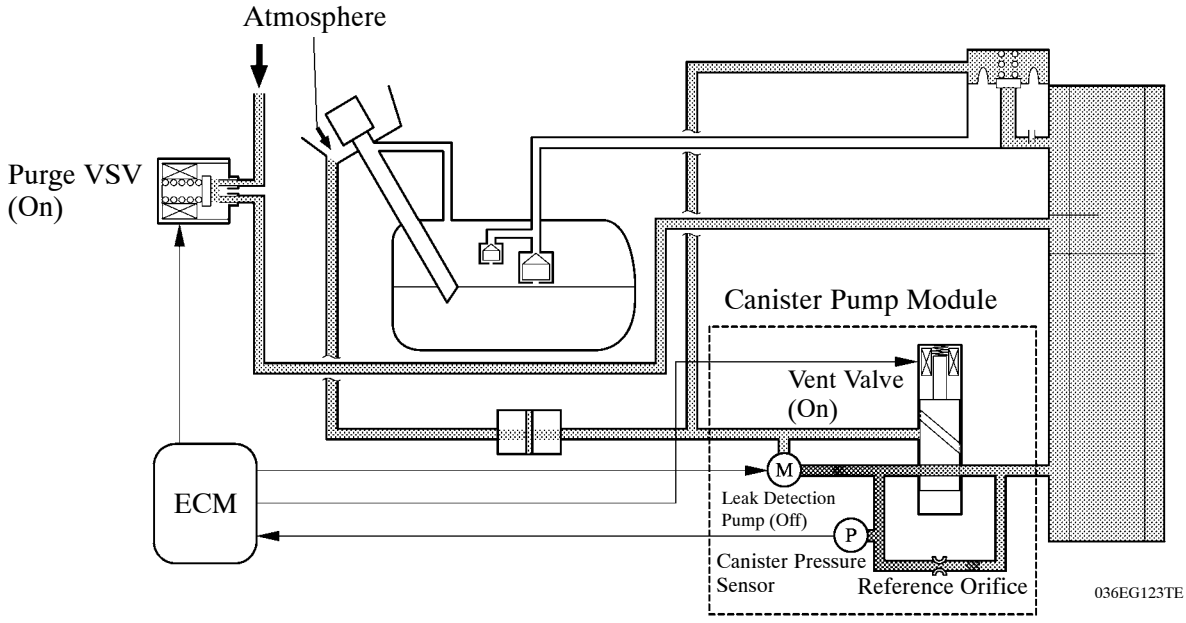


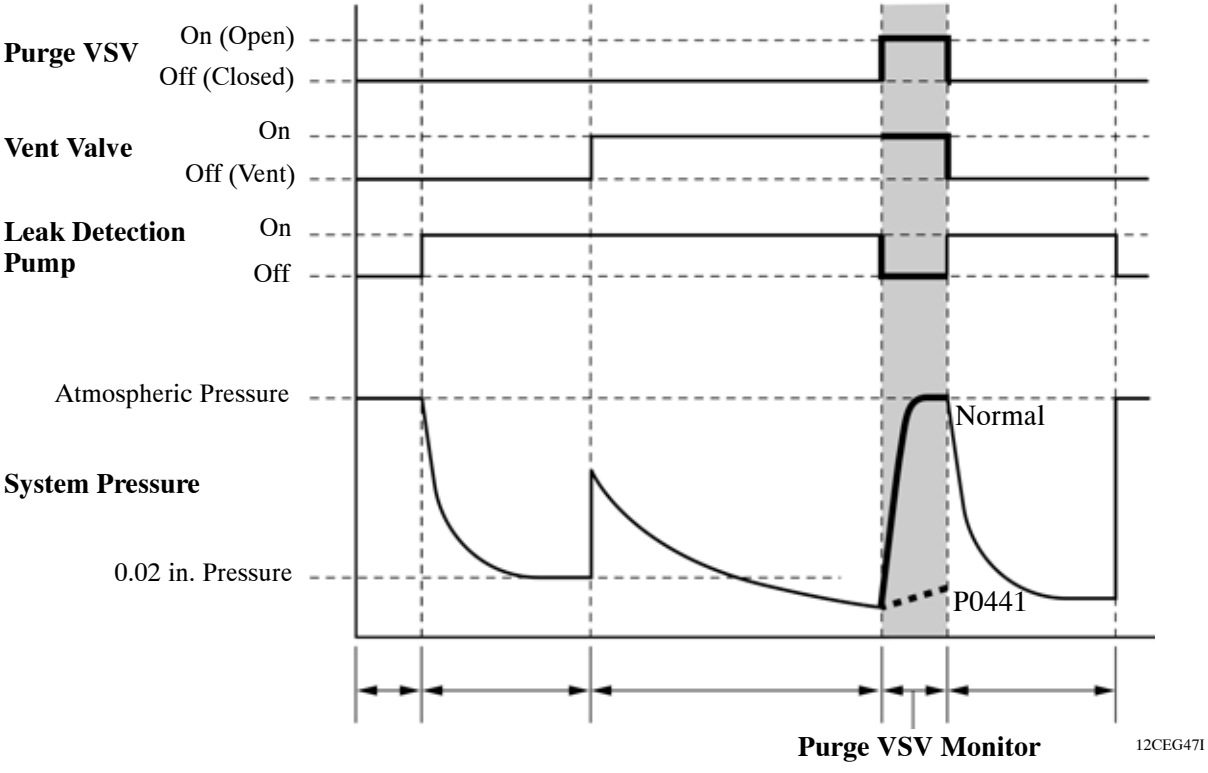
EVAP Leak Check

12CEG46I

v) Purge VSV Monitor

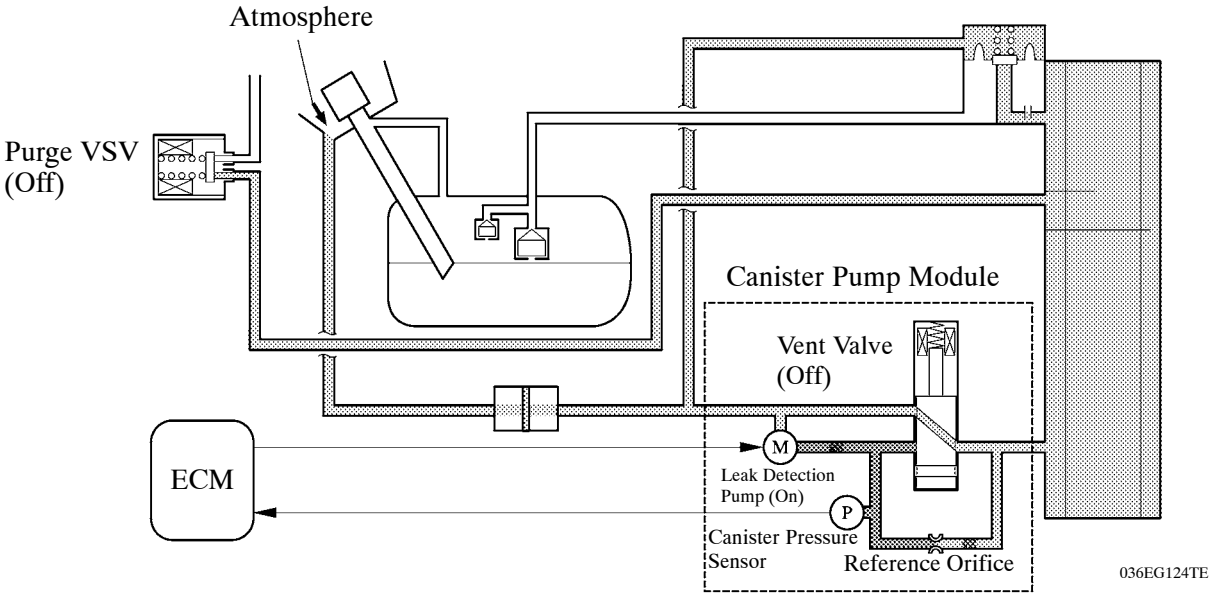
1) After completing an EVAP leak check, the ECM turns on the purge VSV with the leak detection pump actuated, and introduces the atmospheric pressure from the intake manifold to the canister.
2) If the pressure change at this time is within the normal range, the ECM determines the condition to be normal.
3) If the pressure is out of the normal range, the ECM will stop the purge VSV monitor and store DTC P0441 in its memory.

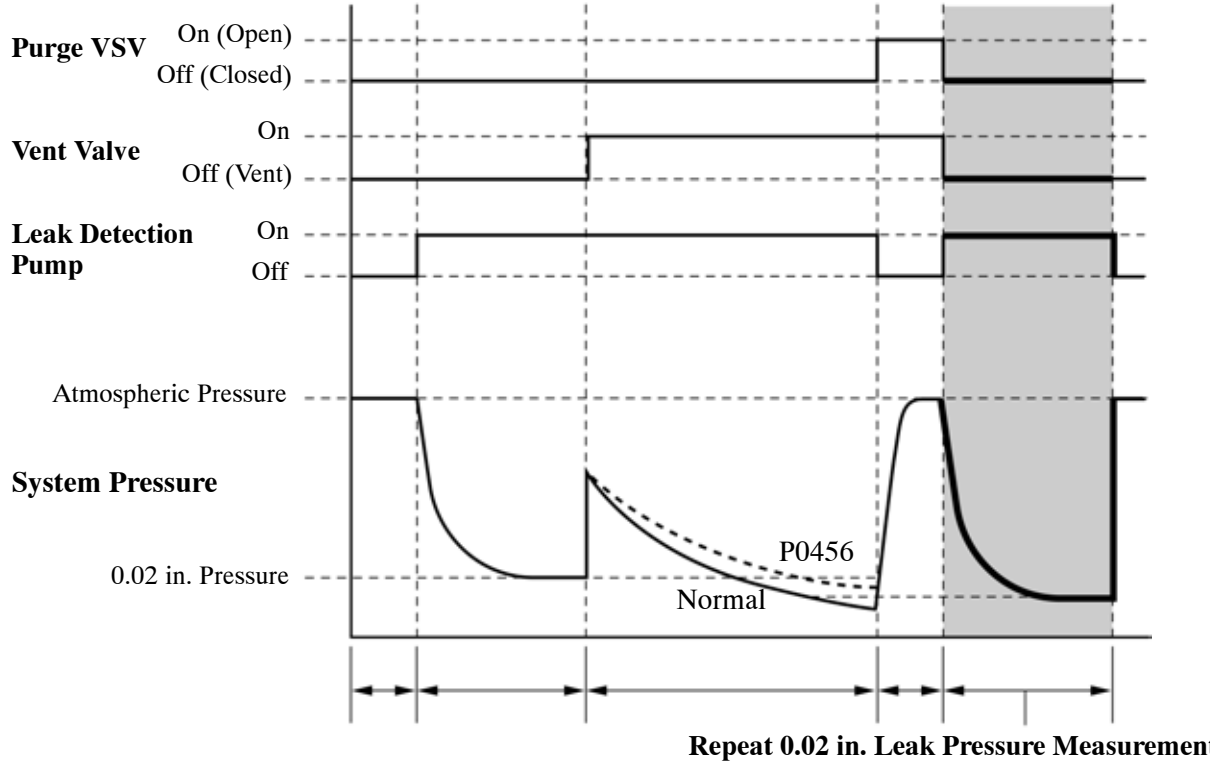




vi) Repeat 0.02 in. Leak Pressure Measurement

1) While the ECM operates the leak detection pump, the purge VSV and vent valve turn off and a repeat 0.02 in. leak pressure measurement is performed.
2) The ECM compares the measured pressure with the pressure during EVAP leak check.
3) If the pressure during the EVAP leak check is below the measured value, the ECM determines that there is no leakage.
4) If the pressure during the EVAP leak check is above the measured value, the ECM determines that there is a small leak and stores DTC P0456 in its memory.





Repeat 0.02 in. Leak Pressure Measurement

12CEG48I

Diagnosis

- When the ECM detects a malfunction, the ECM makes a diagnosis and memorizes the failed section. Furthermore, the Malfunction Indicator Lamp (MIL) in the combination meter illuminates or blinks to inform the driver.
- The ECM will also store the DTC of the malfunctions. The DTC can be accessed by using the Techstream.
- For details, refer to the 2010 TOYOTA TUNDRA Repair Manual.

Service Tip

To clear the DTC that is stored in the ECM, use the Techstream, disconnect the battery terminal or remove the EFI MAIN fuse and ETCS fuse for 1 minute or longer.

Fail-safe

When a malfunction is detected at any of the sensors, there is a possibility of an engine or other malfunction occurring if the ECM continues to control the engine control system in the normal way. To prevent such a problem, the fail-safe function of the ECM either relies on the data stored in memory to allow the engine control system to continue operating, or stops the engine if a hazard is anticipated. For details, refer to the 2010 TOYOTA TUNDRA Repair Manual.