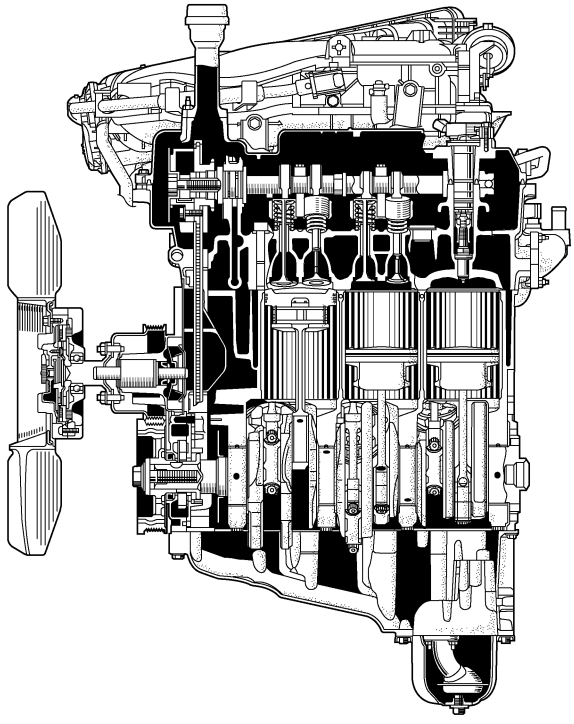
ENGINE

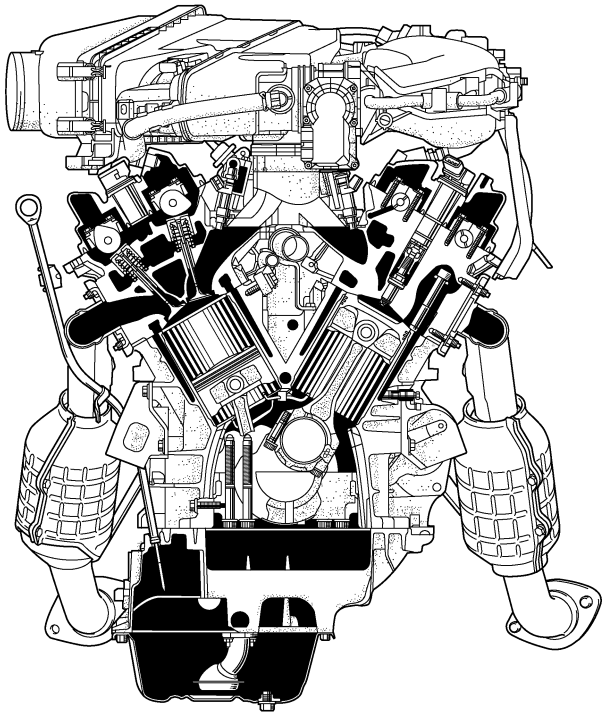
1GR-FE ENGINE

■ DESCRIPTION

The 1GR-FE engine is a V6 4.0-liter, 24-valve DOHC. This engine uses the VVT-i (Variable Valve Timing-intelligent) system, DIS (Direct Ignition System), ACIS (Acoustic Control Induction System), and ETCS-i (Electronic Throttle Control System-intelligent). These control functions achieve improved engine performance, fuel economy, and clean emissions.



238EG01



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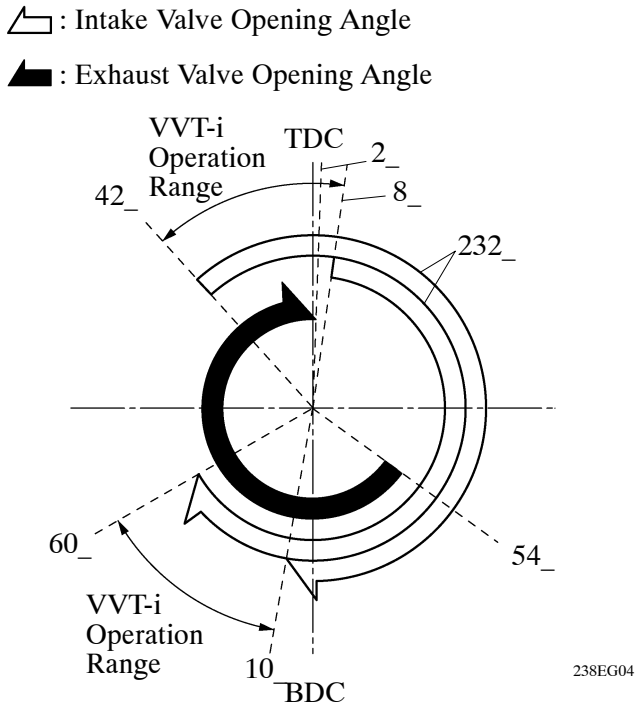
▶ Engine Specifications ◀

No. of Cyls. & Arrangement			6-Cylinder, V Type
Valve Mechanism			24-Valve DOHC, Chain Drive (with VVT-i)
Combustion Chamber			Pentroof Type
Manifolds			Cross-flow
Fuel System			EFI
Ignition System			DIS
Displacement	cm^3 (cu. in.)		3956 (241.4)
Bore × Stroke	mm (in.)		94.0 × 95.0 (3.70 × 3.74)
Compression Ratio			10.0 : 1
Max. Output	[EEC-NET]		179 kW @ 5200 rpm
Max. Torque	[EEC-NET]		376 N·m @ 3800 rpm
Valve Timing	Intake	Open	42° BTDC to 8° ATDC
		Close	10° ABDC to 60° ABDC
	Exhaust	Open	54° BBDC
		Close	2° ATDC
Firing Order			1-2-3-4-5-6
Oil Grade			API grade SL "Energy-Conserving", SM "Energy-Conserving" or ILSAC
Research Octane Number (RON)			95 or higher*2
Emission Regulation	Models for G.C.C. Countries		EURO II
	Models except G.C.C. Countries		EURO III
Engine Service Mass*1 (Reference)	kg (lb)	A/T	166 (366)
		M/T	181 (399)

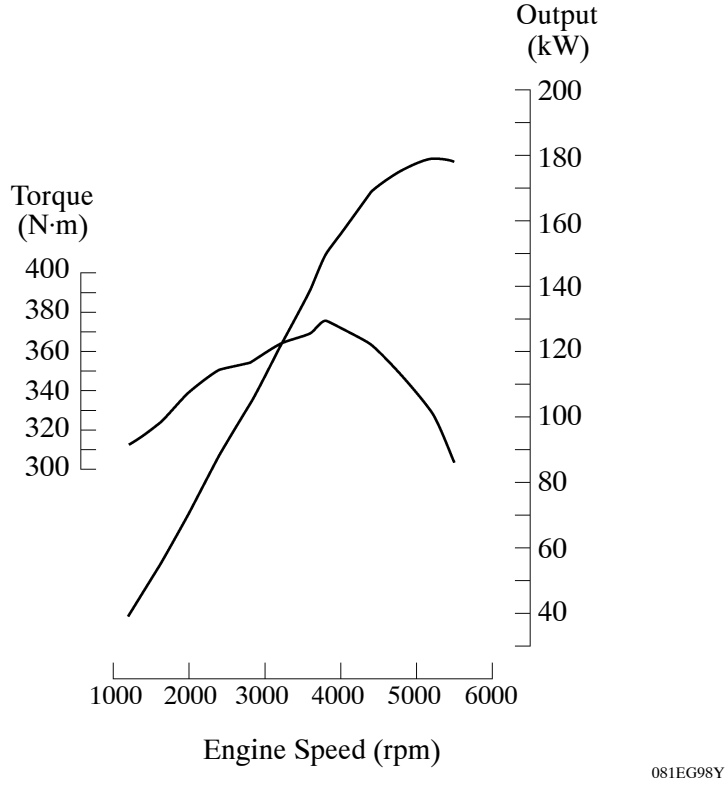
*1: The figure shown is the weight of the part without coolant and oil.

*2: Premium unleaded gasoline with a Research Octane Number 95 or higher required for optimum engine performance. If 95 octane cannot be obtained, you may use unleaded gasoline with a Research Octane Number as low as 91. Use of unleaded fuel with a Research Octane Number lower than 95 may result in engine knocking and significantly reduced performance. Persistent knocking can lead to engine damage and should be corrected by refueling with higher octane unleaded gasoline.

▶ Valve Timing ◀



▶ Performance Curve ◀



■FEATURES OF 1GR-FE ENGINE

The 1GR-FE engine has been able to achieve the following performance through the adoption 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	An upright intake port is used.	○		○		
	A taper squish shape is used for combustion chamber.	○				○
	A cylinder block made of aluminum alloy is used			○		
	The piston skirt is coated with resin.	○	○			
	An oil pan No.1 sub-assembly made of aluminum alloy is used.		○	○		
Valve Mechanism	The shim-less type valve lifters are used.	○		○		
	Timing chains and chain tensioners are used.	○	○	○		
Lubrication System	A water-cooled type engine oil cooler is used.	○				
Cooling System	TOYOTA Genuine SLLC (Super Long Life Coolant) is used as the engine coolant.				○	
Intake and Exhaust System	The intake air chamber made of plastic is used.			○		
	The link-less type throttle body is used.			○	○	
	Stainless steel exhaust manifolds are used.			○		
	Ceramic type TWCs (Three Way catalytic Converters) are used.					○
Fuel System	12-hole type fuel injectors are used to improve the atomization of fuel.	○				○
	The fuel delivery pipe made of plastic is used.			○		
Ignition System	The DIS (Direct Ignition System) makes ignition timing adjustment unnecessary.	○			○	○
	The long-reach type spark plugs is used.	○				
Charging System	Segment Conductor type generator is used.	○		○		
Starting System	PS (Planetary reduction-Segment conductor motor) type starter is used.			○		
Serpentine Belt Drive System	A serpentine belt drive system is used.			○	○	

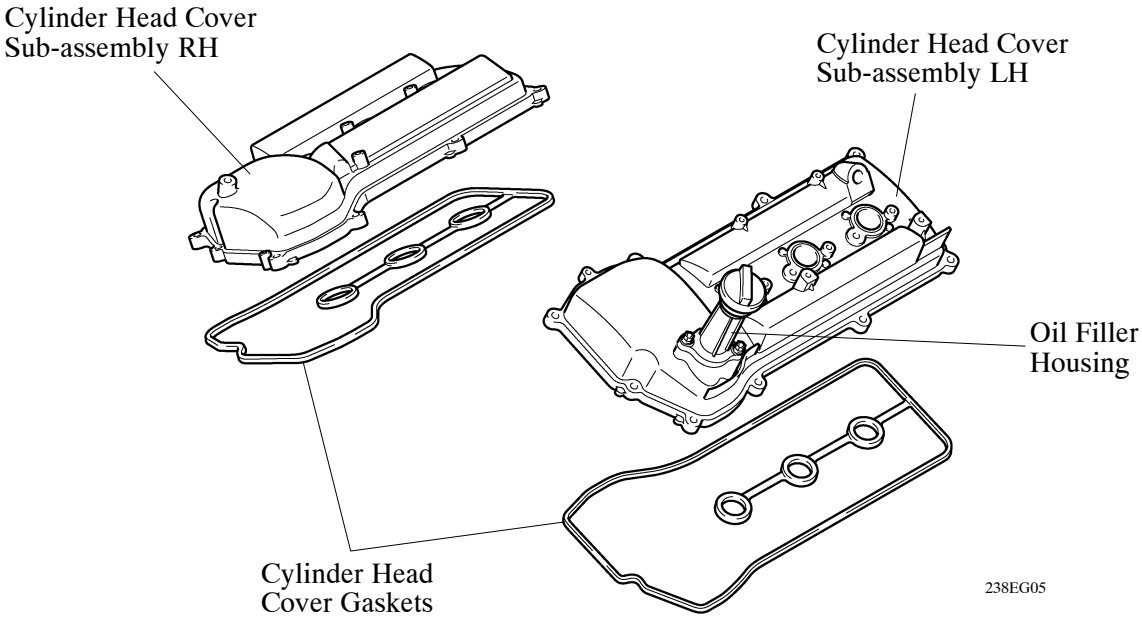
(Continued)

Item		(1)	(2)	(3)	(4)	(5)
Engine Control System	MRE (Magnetic Resistance Element) type VVT sensors are used.	○				
	The ETCS-i (Electronic Throttle Control System- intelligent) is used.	○				○
	The VVT-i (Variable Valve Timing-intelligent) system is used.	○				○
	The ACIS (Acoustic Control Induction System) is used.	○				○
	The cranking hold function is used.	○				

■ENGINE PROPER

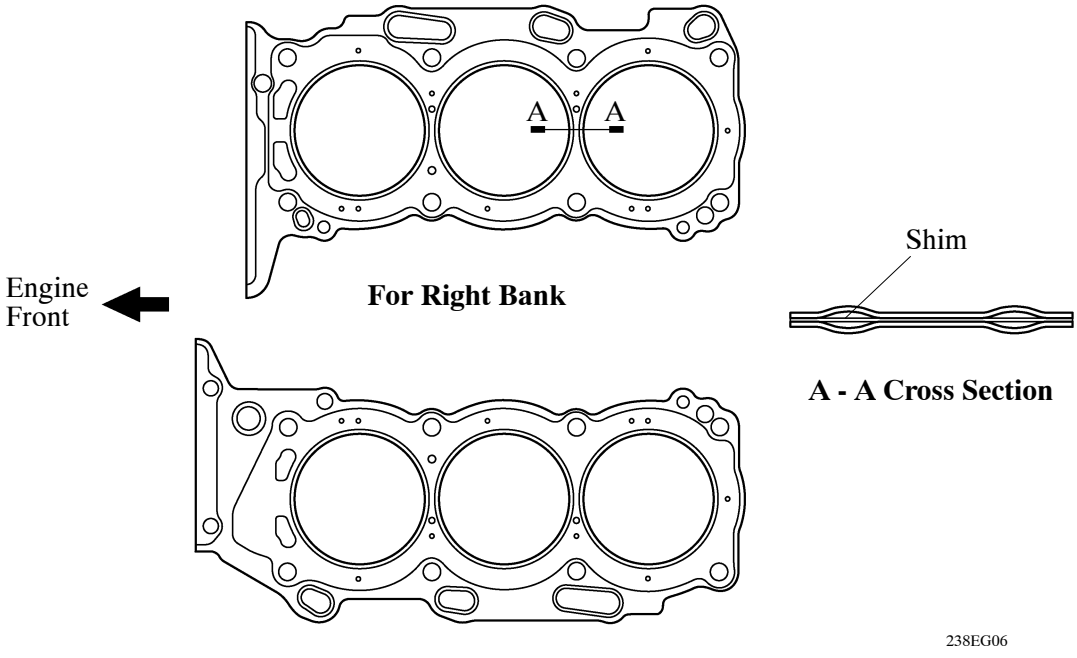
1. Cylinder Head Cover

- Lightweight yet high-strength aluminum cylinder head cover sub-assemblies are used.
- An oil filler housing has been provided on the cylinder head cover sub-assembly LH to improve the serviceability when filling the engine oil.
- The cylinder head cover gasket and a gasket to seal the ignition coil circumference have been integrated to reduce the number of parts.



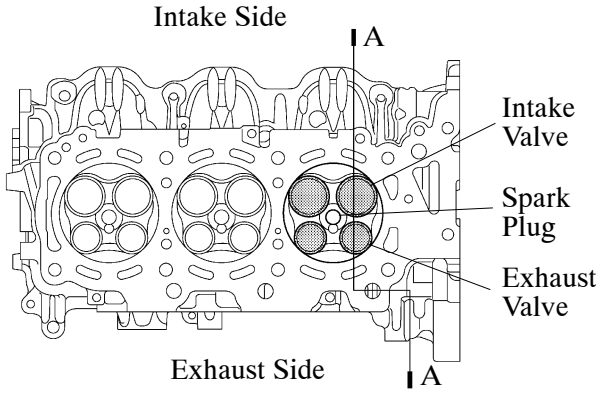
2. Cylinder Head Gasket

- A steel-laminate type cylinder head gasket is used.
- A shim has been added around the cylinder bore to increase the sealing surface, thus improving the sealing performance and durability.

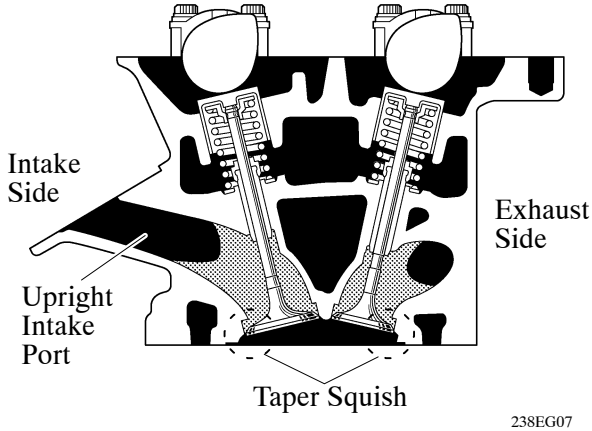


3. Cylinder Head

- The cylinder head, which is made of aluminum, contains a pentroof-type combustion chamber. The spark plug has been located in the center of the combustion chamber in order to improve the engine's anti-knocking performance.
- The intake ports are on the inside and the exhaust ports on the outside of the left and right banks respectively.
- Upright intake ports are used to improve the intake efficiency.
- A taper squish combustion chamber is used to improve anti-knocking performance and intake efficiency. In addition, engine performance and fuel economy have been improved.
- The siamese type intake port is used to reduce the overall surface area of the intake port walls. This prevents the fuel from adhering onto the intake port walls, thus reducing HC exhaust emissions.



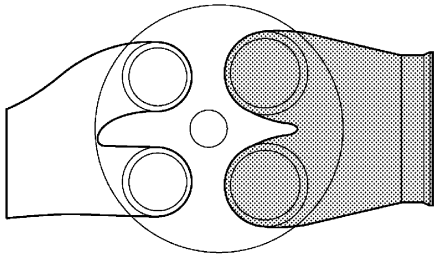
View from Back Side



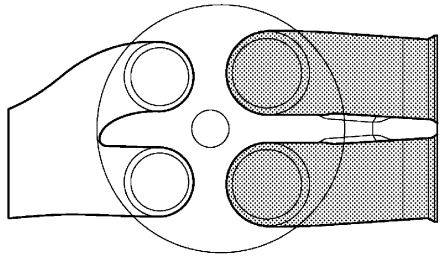
A - A Cross Section

— REFERENCE —

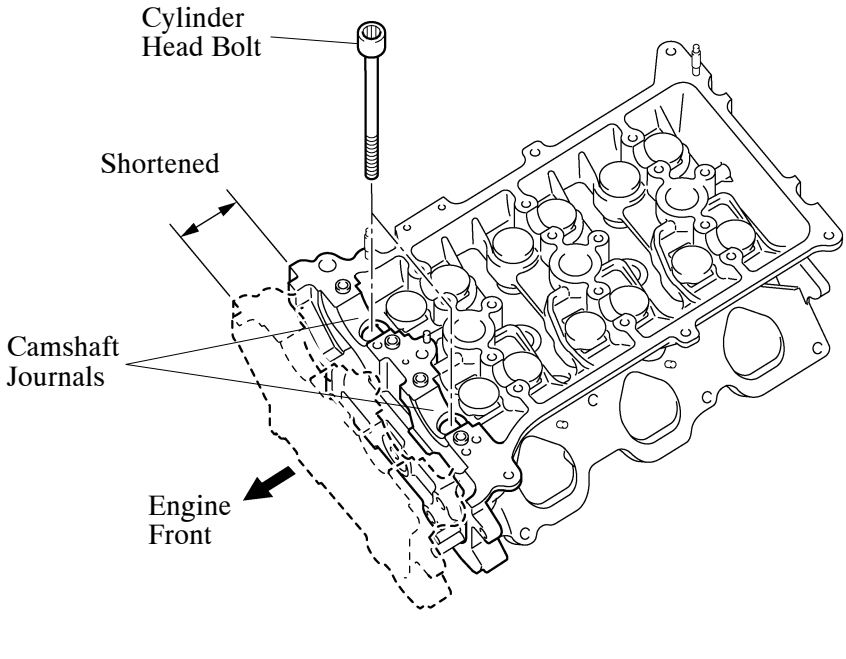
Siamese Type



Independent Type



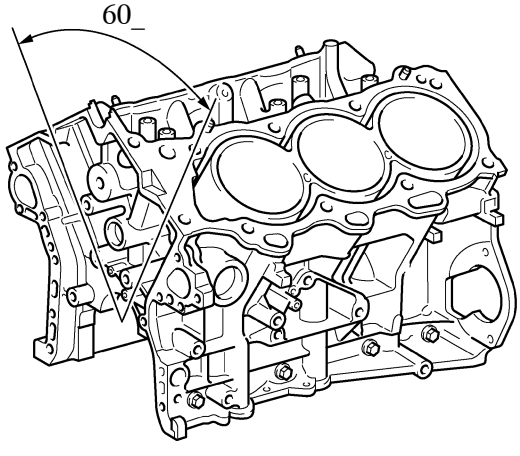
- The cylinder head bolts have been positioned below the camshaft journal in the front of the right bank, and the holes for placing the bolts have been provided above the camshaft journal. Thus, the front end of the right bank has been shortened, resulting in a shorter overall length of the engine.

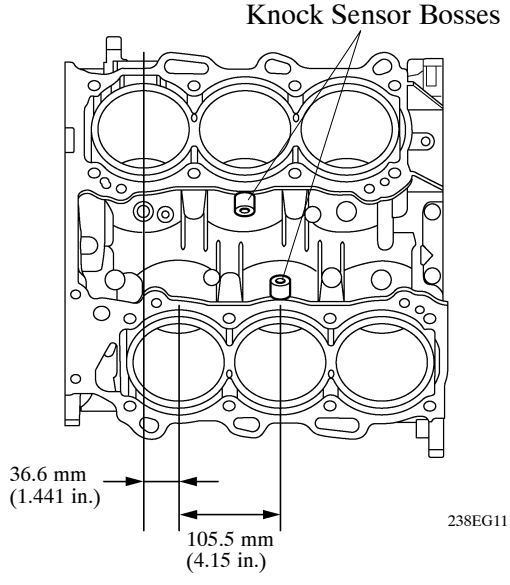


Right Bank Cylinder Head

4. Cylinder Block

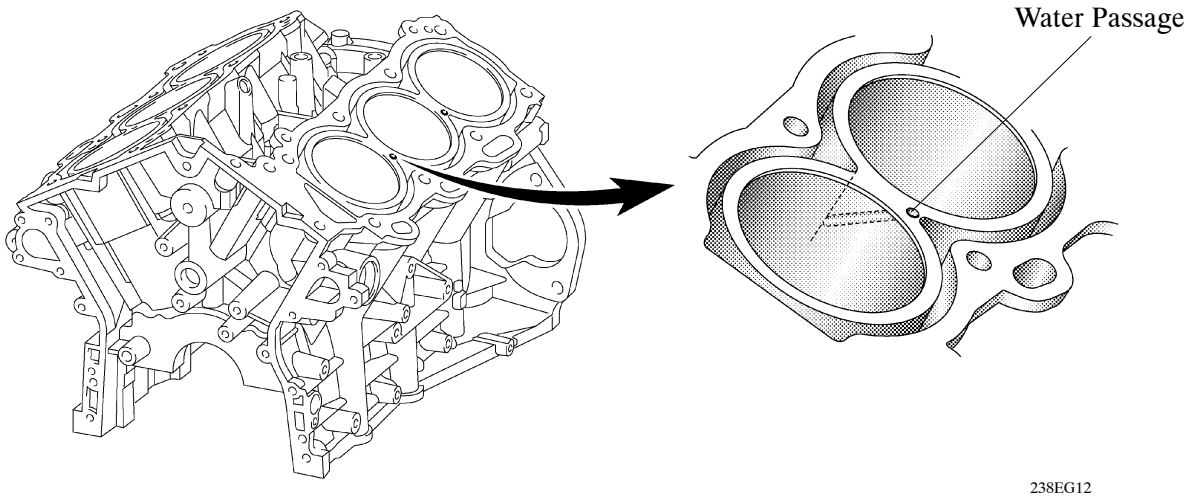
- The cylinder block is made of aluminum alloy.
- The cylinder block has a bank angle of 60_, a bank offset of 36.6 mm (1.441 in.) and a bore pitch of 105.5 mm (4.15 in.), resulting in a compact block in its length and width even for its displacement.
- Installation bosses of the two knock sensors are located on the inner side of left and right banks.



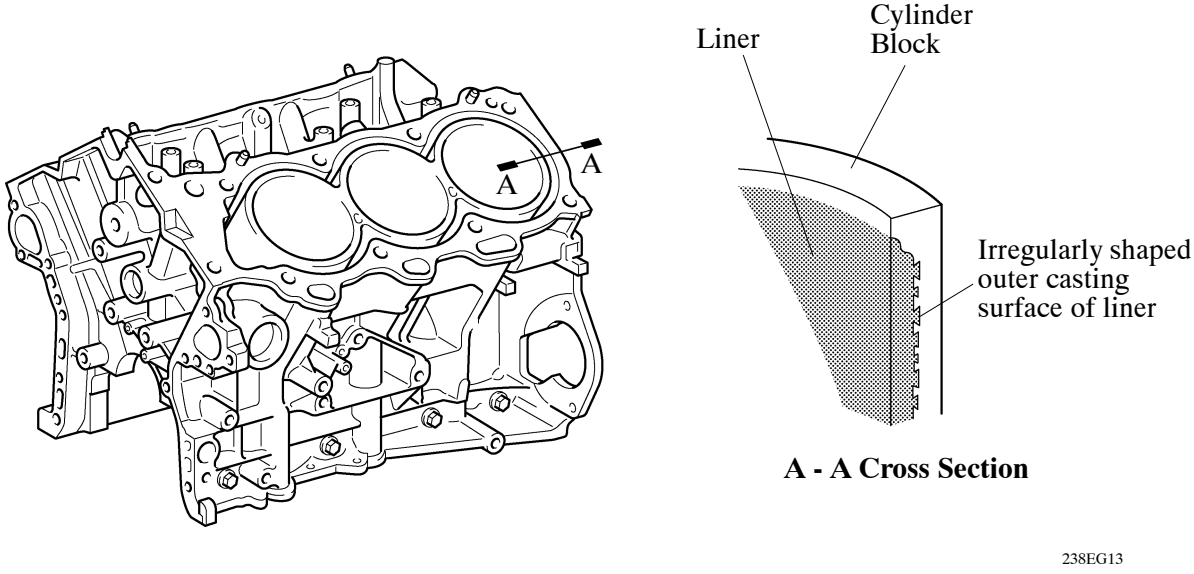


View from Top Side

- Water passages have been provided between the cylinder bores. By allowing the engine coolant to flow between the cylinder bores, this construction enables the temperature of the cylinder walls to be kept uniform.

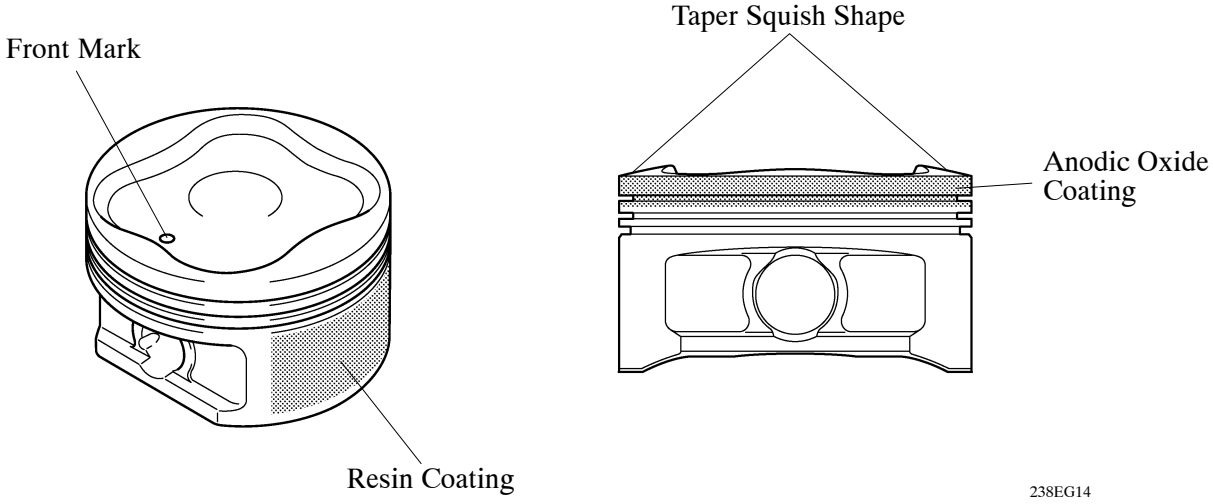


- A compact block has been achieved by producing the thin cast-iron liners and cylinder block as a unit. Do not bore the block with this liner.
- The liners are the spiny-type, which have been manufactured so that their casting exterior forms a large irregular surface in order to enhance the adhesion between the liners and the aluminum cylinder block. The enhanced adhesion helps improve heat dissipation, resulting in a lower overall temperature and heat deformation of the cylinder bores.



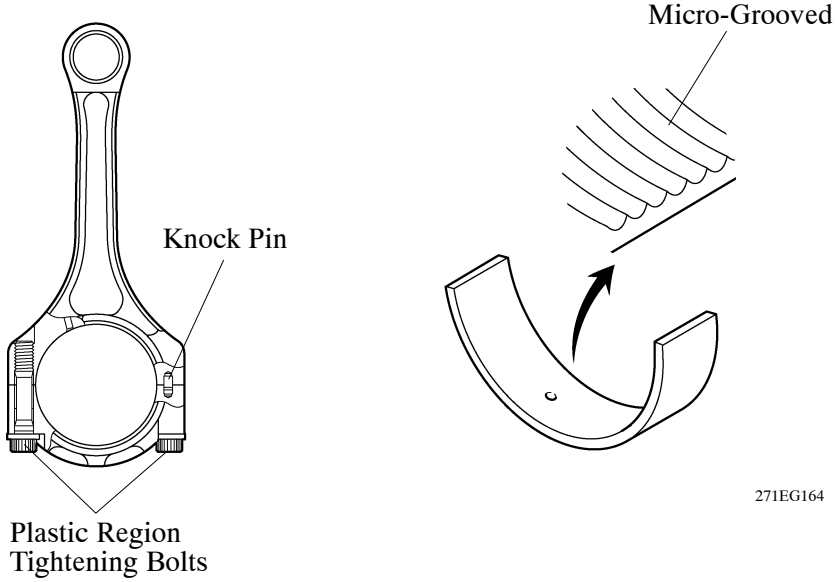
5. Piston

- The piston is made of aluminum alloy.
- The piston head portion uses a taper squish shape to accomplish fuel combustion efficiency.
- The piston skirt has been coated with resin to reduce the friction loss.
- The groove of the top ring has been coated with anodic oxide to improve wear resistance and rust resistance.
- This piston is common to all cylinders. Therefore, the pistons are not shaped especially for the right or the left bank. As a result, serviceability has been improved.
- By increasing the machining precision of the cylinder bore diameter, the outer diameter of the piston has been made into one size.



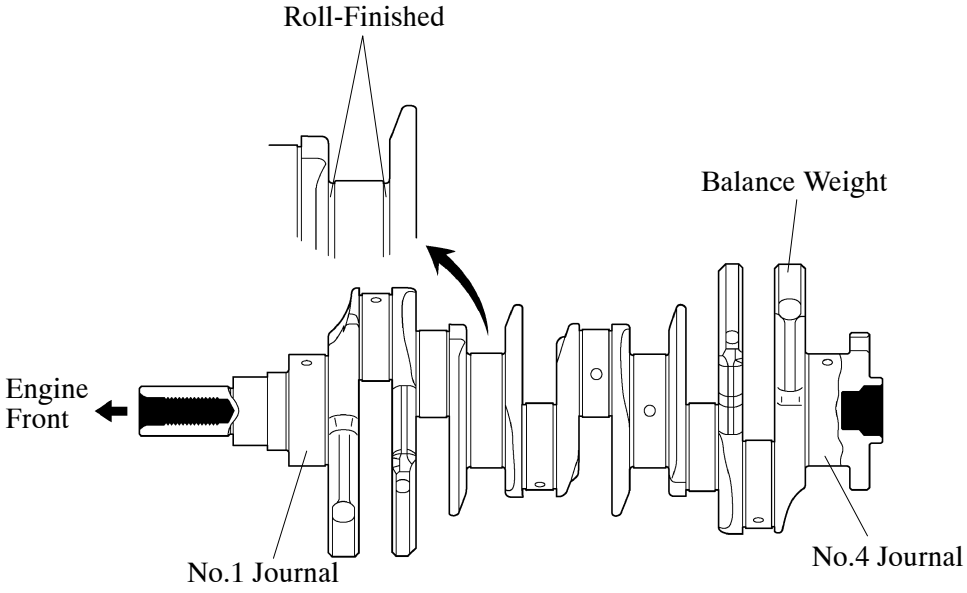
6. Connecting Rod and Connecting Rod Bearing

- 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.
- An aluminum bearing is used for the connecting rod bearings.
- The lining surface of the connecting rod bearing has been micro-grooved to realize an optimal amount of oil clearance. As a result, cold-engine cranking performance has been improved and engine vibrations have been reduced.



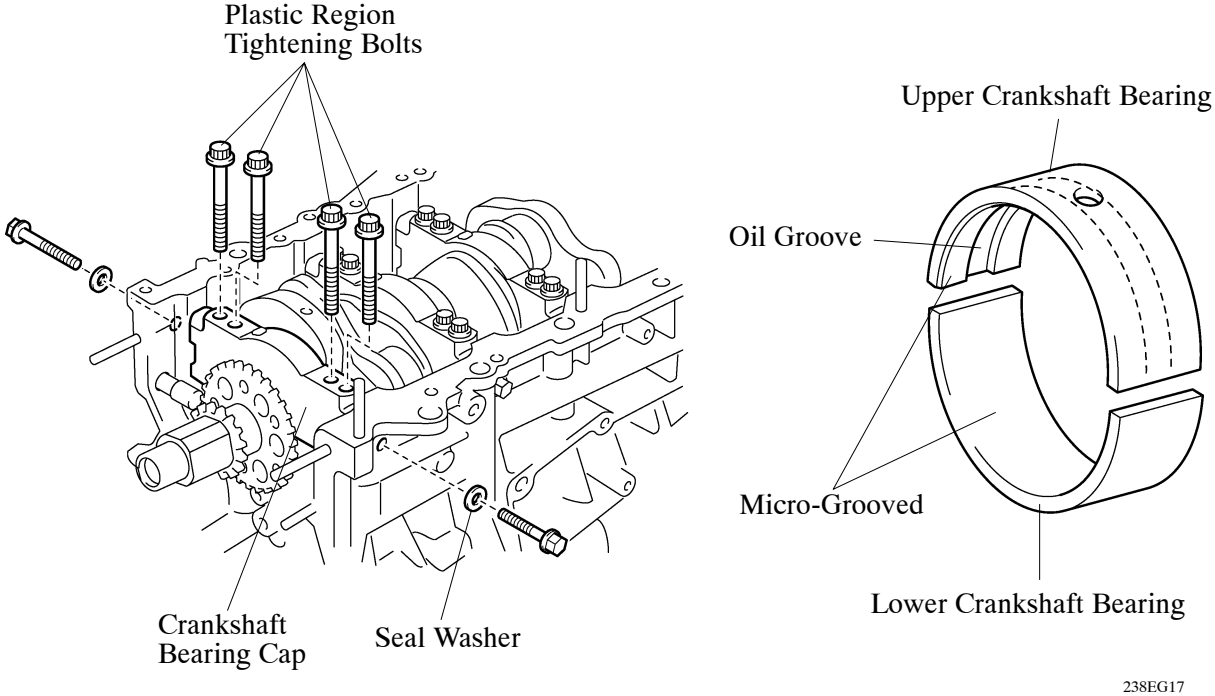
7. Crankshaft

- A crankshaft made of steel, which excels in rigidity and wear resistance, is used.
- The crankshaft has 4 journals and 9 balance weights.
- All pin and journal fillets are roll-finished to maintain adequate strength.



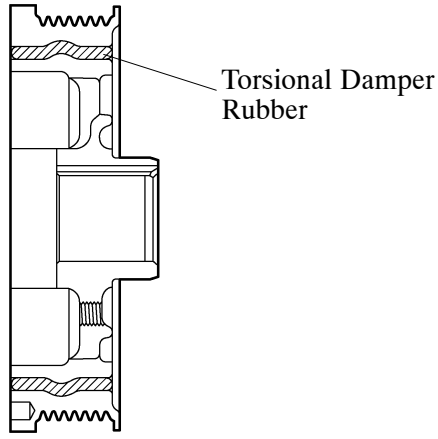
8. Crankshaft Bearing and Crankshaft Bearing Cap

- The crankshaft bearing is made of aluminum alloy.
- Similar to the connecting rod bearings, the lining surface of the crankshaft bearings has been micro-grooved to realize an optimal amount of oil clearance. As a result, cold-engine cranking performance has been improved and engine vibrations have been reduced.
- The upper crankshaft bearing has an oil groove around its inside circumference.
- The crankshaft bearing caps are tightened using 4 plastic-region tightening bolts for each journal. In addition, each cap is tightened laterally to improve its reliability.



9. Crankshaft Pulley

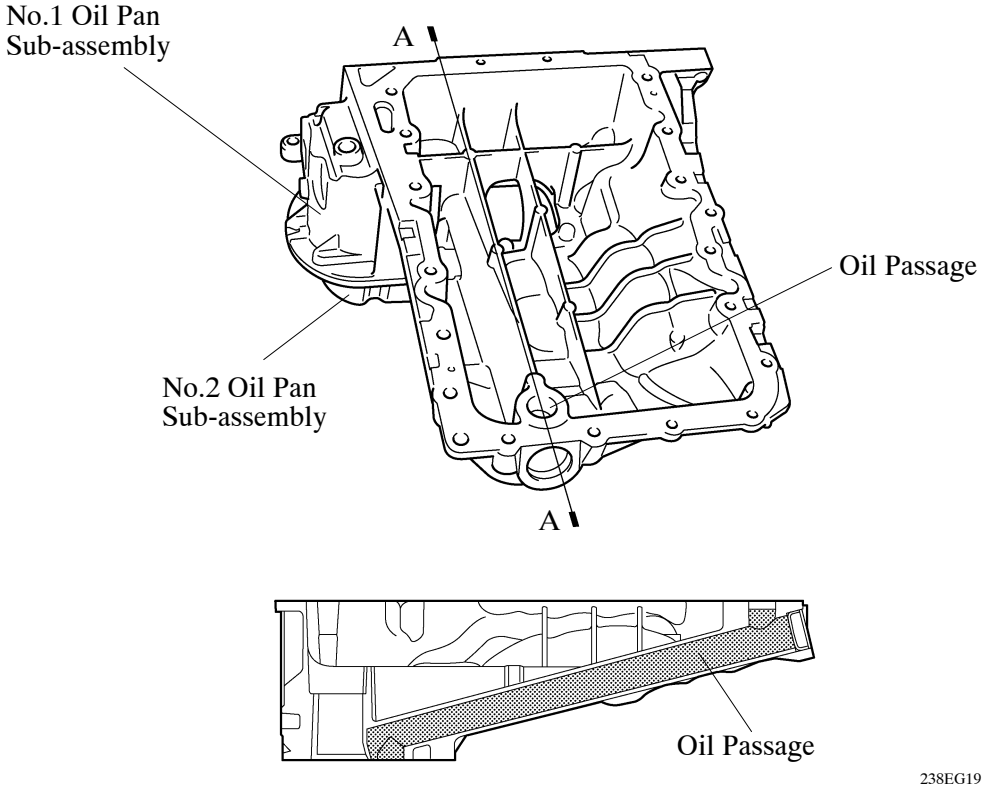
The rigidity of the torsional damper rubber has been optimized to reduce noise.



238EG18

10. Oil Pan

- The No.1 oil pan sub-assembly is made of aluminum alloy.
- The No.2 oil pan sub-assembly is made of steel.
- An oil passage has been integrated in the No.1 oil pan sub-assembly to simplify the construction of the oil strainer.
- The No.1 oil pan sub-assembly is secured to the cylinder block and the torque converter housing and is increasing rigidity.



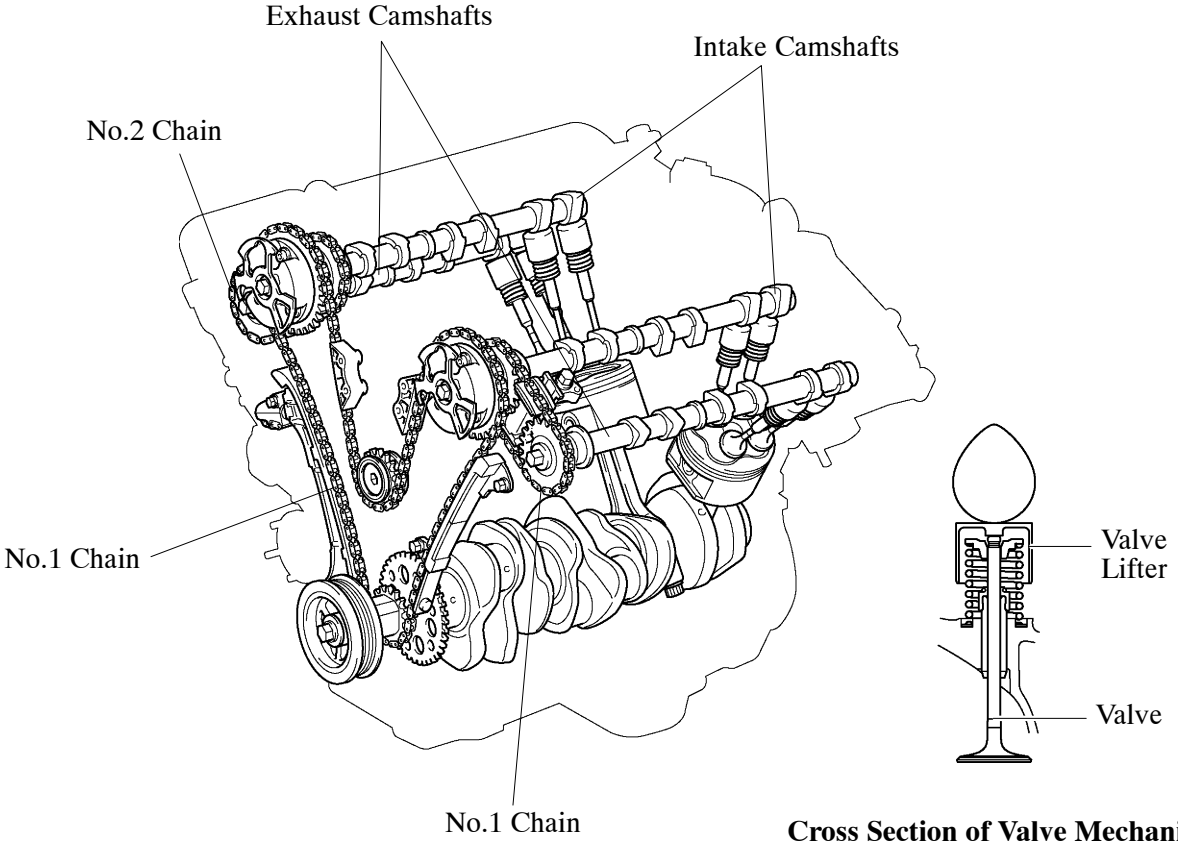
238EG19

A - A Cross Section

■VALVE MECHANISM

1. General

- The intake camshafts are driven by the crankshaft via the No.1 chain. The intake camshaft of the respective bank drives the exhaust camshafts via the No.2 chain.
- The valves are directly opened and closed by the 4 camshafts.
- The VVT-i controller is installed on the front of the intake camshafts to vary the timing of the intake valves.
- Along with increase in the amount of valve lift, a shimless type valve lifter is used. This valve lifter raises the cam contact surface.



Cross Section of Valve Mechanism

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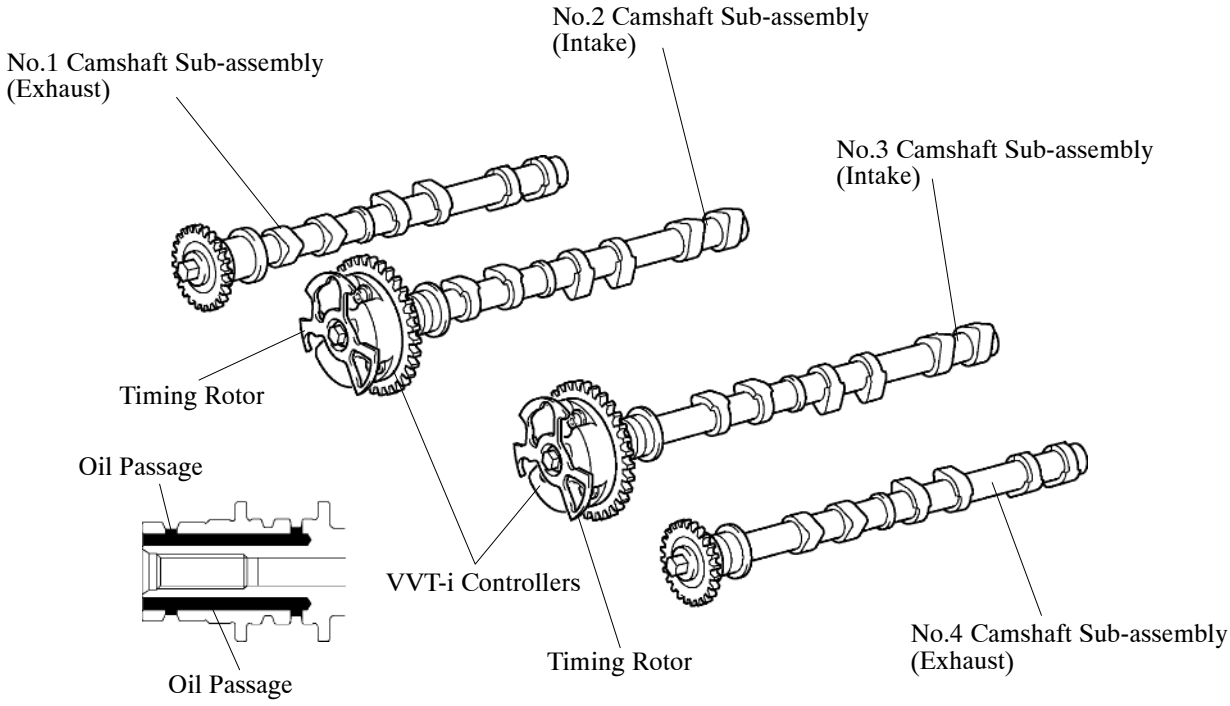
Service Tip

The adjustment of the valve clearance is accomplished by selecting and replacing the appropriate valve lifters.

A total of 35 valve lifters are available in 0.020 mm (0.008 in.) increments, from 5.060 mm (0.199 in.) to 5.740 mm (0.226 in.). For details, refer to the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

2. Camshaft

- The camshafts are made of a cast iron alloy.
- Oil passages are provided in the intake camshaft in order to supply engine oil to the VVT-i system.
- A timing rotor is provided in front of the VVT-i controller to detect the actual position of the intake camshaft.



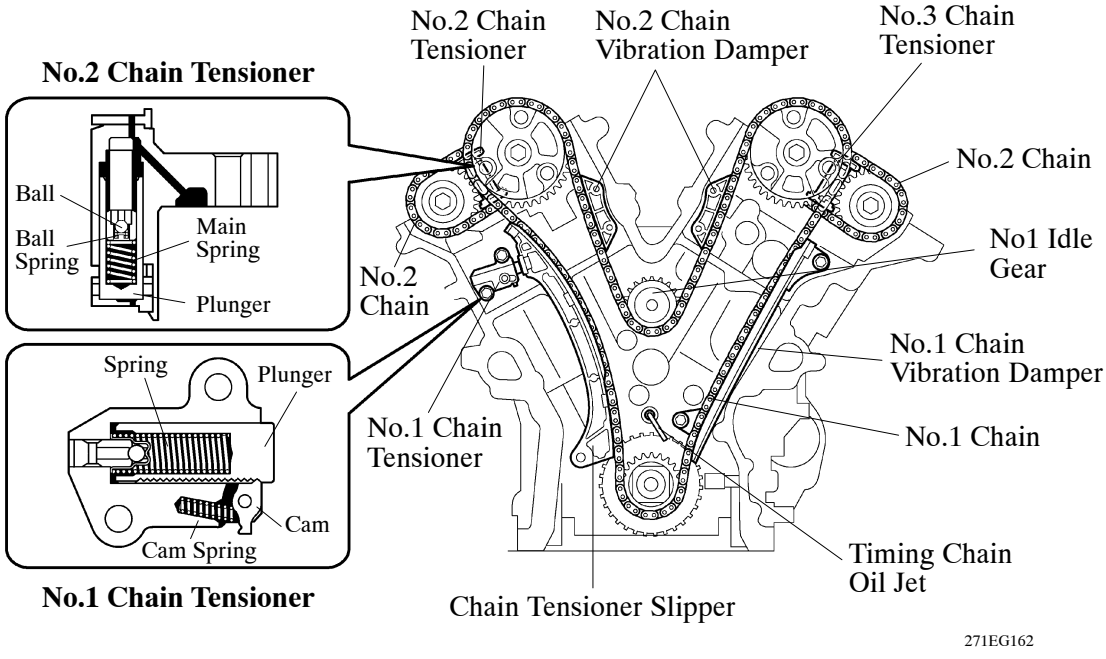
Cross Section of the End of the Intake Camshaft

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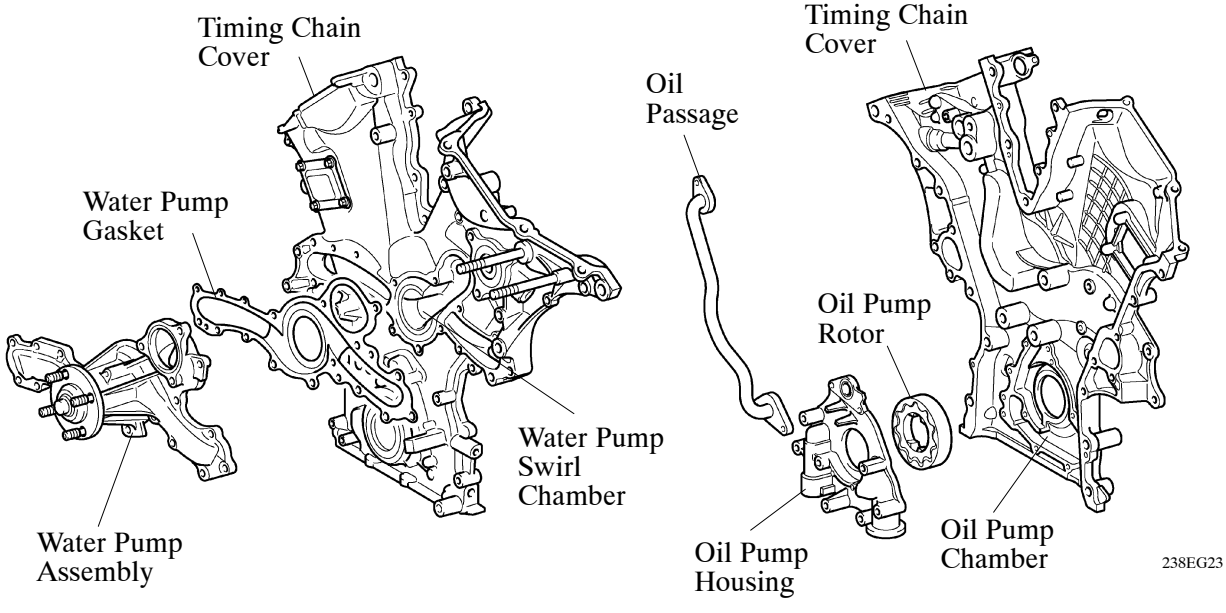
3. Timing Chain and Chain Tensioner

- Both the No.1 and No.2 chains use roller chains with a pitch of 9.525mm (0.375 in.).
- The timing chain is lubricated by timing chain oil jet.
- The No.1 chain uses one timing chain tensioner and each of the No.2 chains for the right and left banks uses one timing chain tensioner.
- The chain tensioners use a spring and oil pressure to maintain proper chain tension at all times. They suppress noise generated by the timing chains.
- The No.1 chain tensioner is the ratchet type with a non-return mechanism.



4. Timing Chain Cover

The timing chain cover has an integrated construction consisting of the cooling system (water pump and water passage) and the lubrication system (oil pump and oil passage). Thus, the number of parts has been reduced to reduce weight.

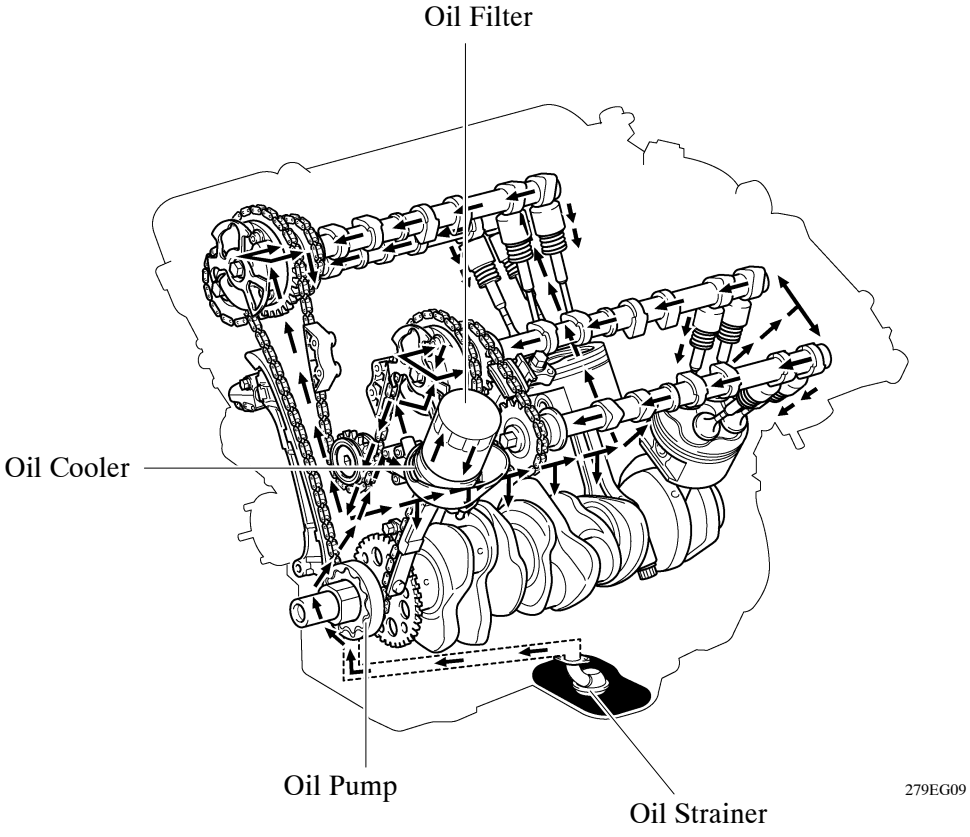


View from Front Side **View from Back Side**

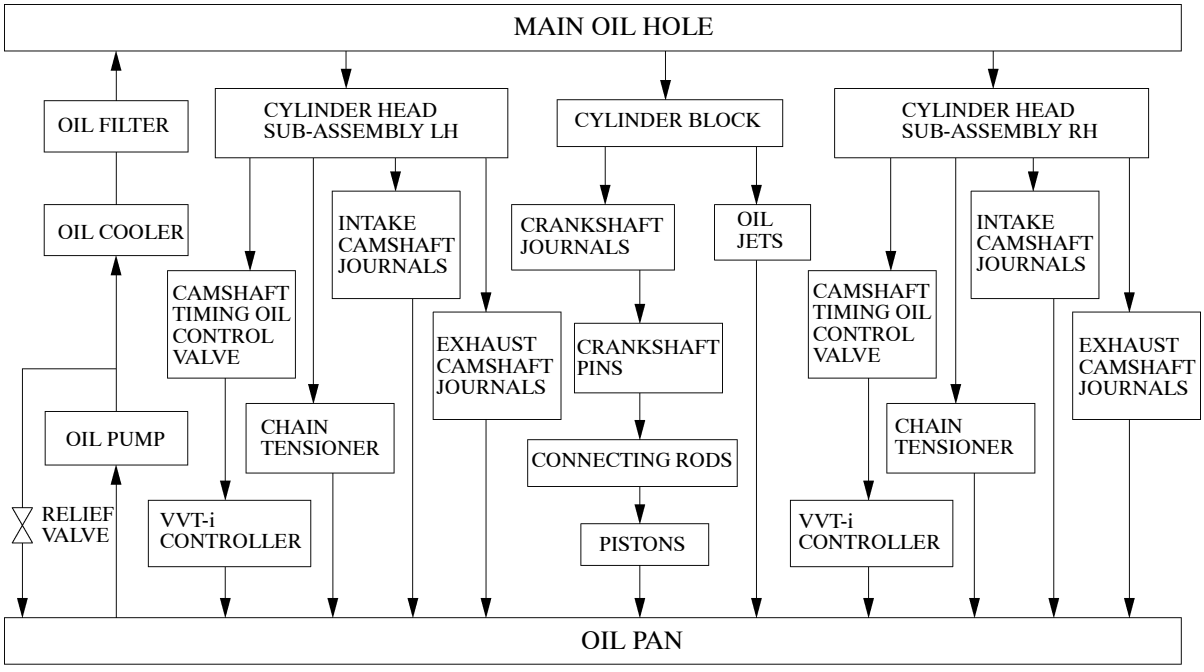
■LUBRICATION SYSTEM

1. General

- The lubrication circuit is fully pressurized and all oil passes through an oil cooler and an oil filter.
- A cycloid rotor type oil pump is used.
- A water-cooled type engine oil cooler is used.



▶ Oil Circuit ◀



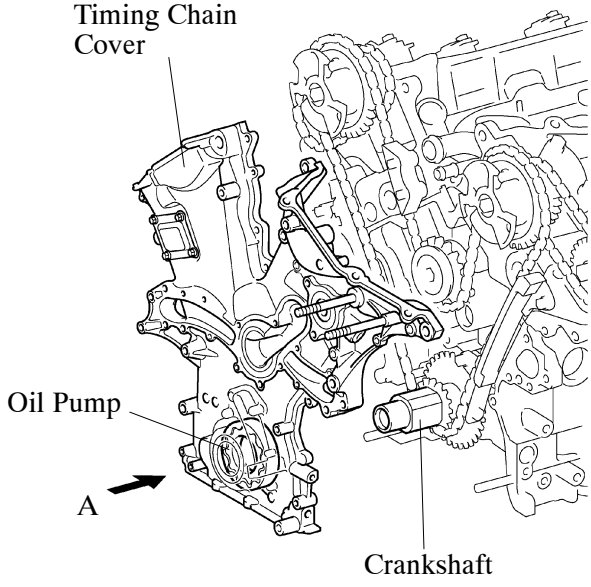
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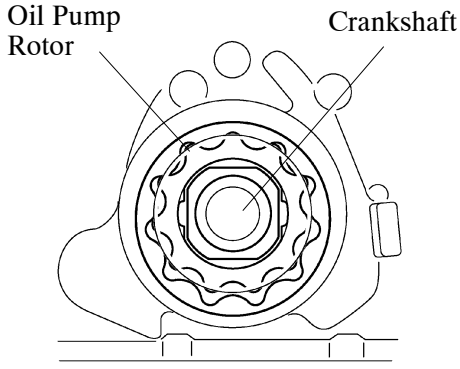
▶ Oil Capacity ◀

Oil Capacity [Liters (US qts, Imp. qts)]	Dry	6.0 (6.3, 5.3)
	with Oil Filter	5.2 (5.5, 4.6)
	without Oil Filter	4.9 (5.2, 4.3)

2. Oil Pump

- A cycloid rotor type oil pump is used. This oil pump is integrated with the timing chain cover.
- This oil pump is directly driven by the crankshaft.
- Ordinarily, the timing chain cover with oil pump construction has only a single position for mounting the oil pump rotor to the crankshaft, when installing the timing chain cover. However, in this engine, the inner shape of the oil pump rotor and the shape of the area of the crankshaft on which the rotor is mounted have been designed to provide 4 different assembly patterns. Thus, the serviceability for assembling the timing chain cover has been improved.



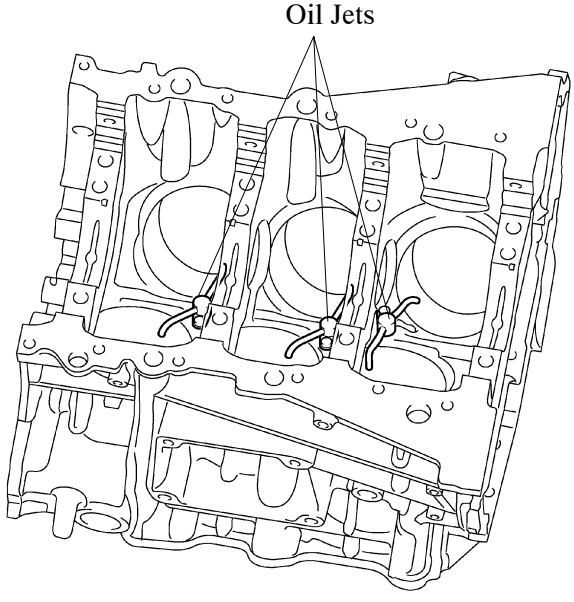


View from A

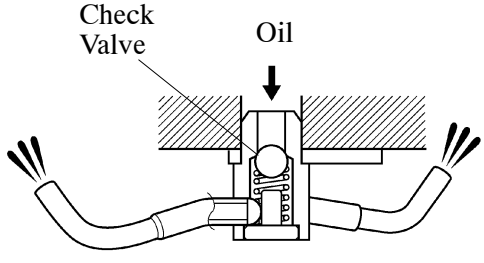
279EG10

3. Oil Jet

- Oil jets for cooling and lubricating the pistons have been provided in the cylinder block.
- 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.



Bottom Side View

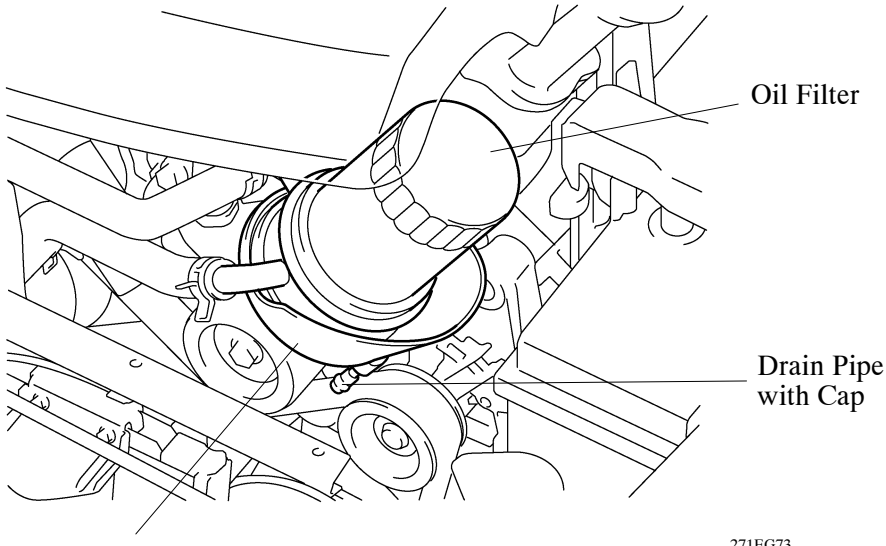


Oil Jet Cross Section

238EG28

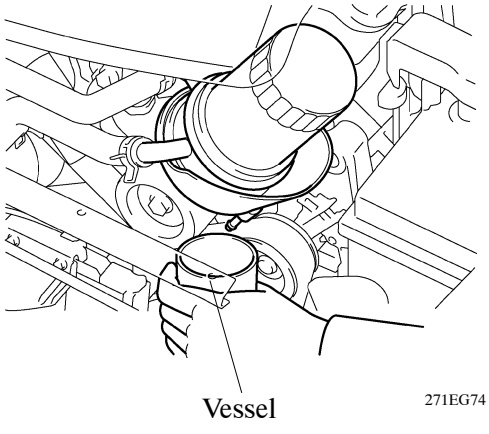
4. Oil Filter Bracket

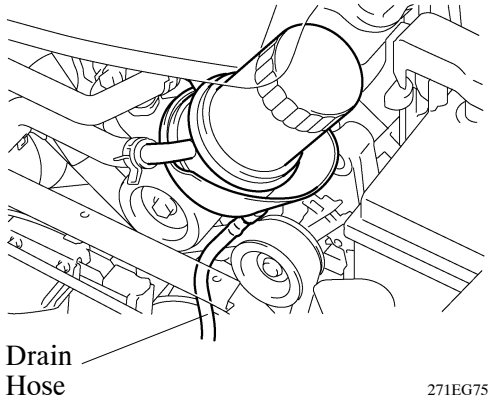
- The oil filter is mounted on an oil filter bracket placed on the left bank. Therefore, the oil filter can be replaced easily.
- During an oil filter replacement, the filter is removed upward. Therefore, the oil filter bracket is designed to catch the oil that leaks from the oil filter. The oil that is initially caught by the oil filter bracket is discharged from a drain pipe that is provided underneath.



Service Tip

- Before removing the oil filter, prepare to catch the oil that will be discharged from the drain pipe. Use a vessel to catch the oil as illustrated below, or attach a hose to the drain pipe and catch the oil on a tray.
- After having completed the oil drain operation, do not forget to replace the rubber cap on the drain pipe.

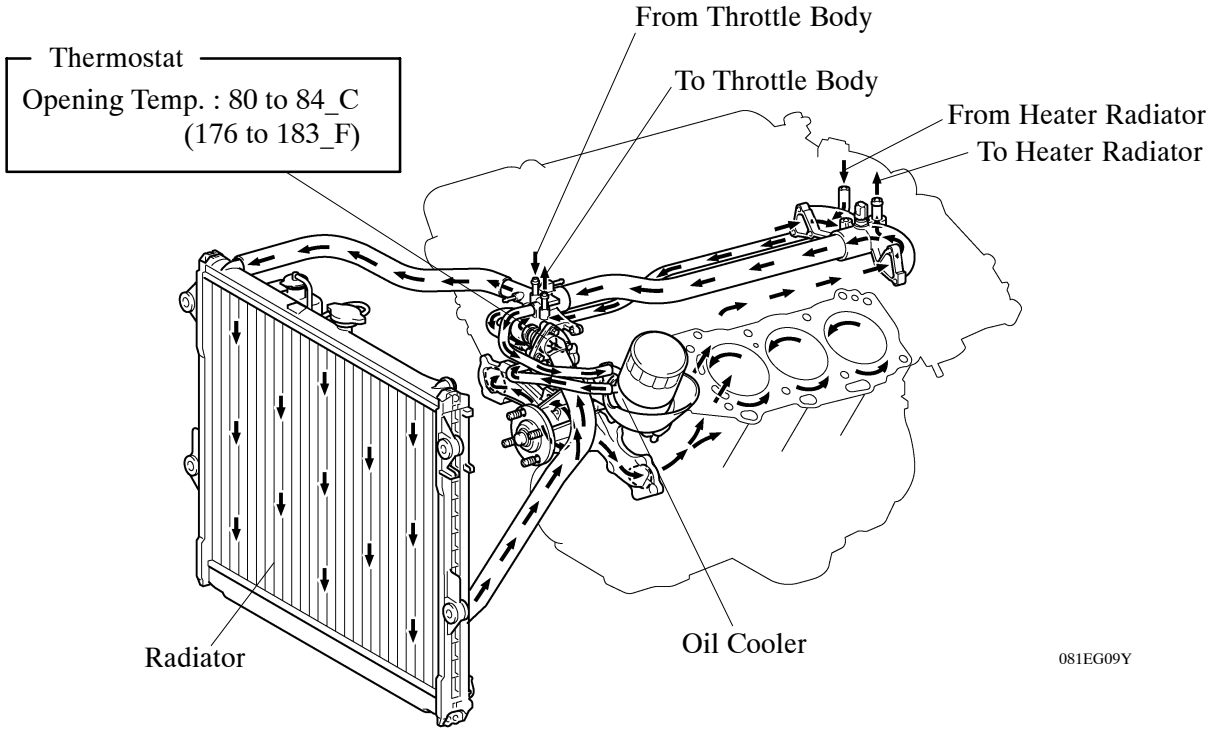




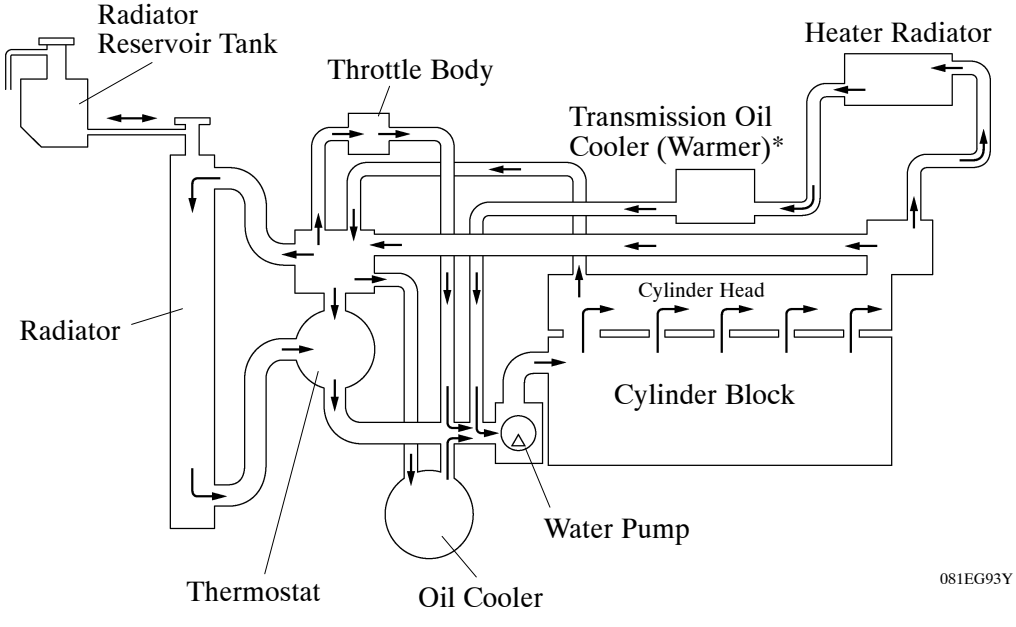
■COOLING SYSTEM

1. General

- The cooling system uses a pressurized forced circulation system with open air type reservoir tank.
- A thermostat with a bypass valve is located on the water inlet housing to maintain suitable temperature distribution in the cooling system.
- An aluminum radiator core is used for weight reduction.
- A 3-stage linear temperature-controlled coupling fan is used.
- TOYOTA genuine SLLC (Super Long Life Coolant) is used as the engine coolant.



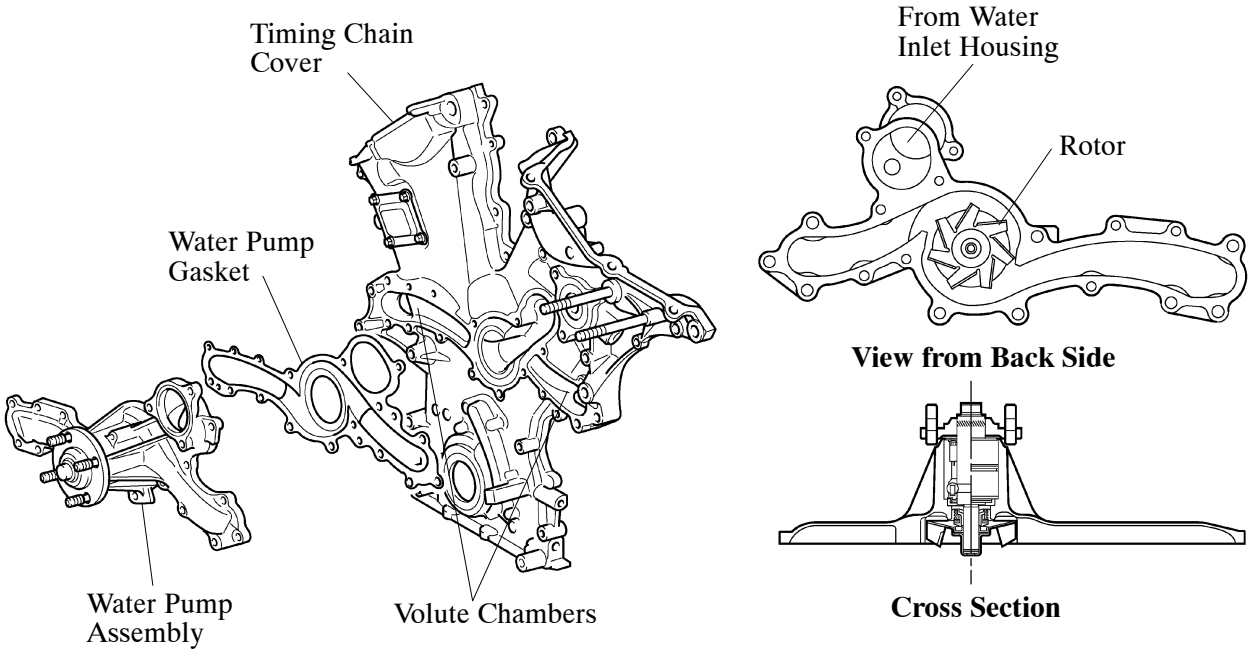
▶ System Diagram ◀



*: Only for models with automatic transmission

2. Water Pump

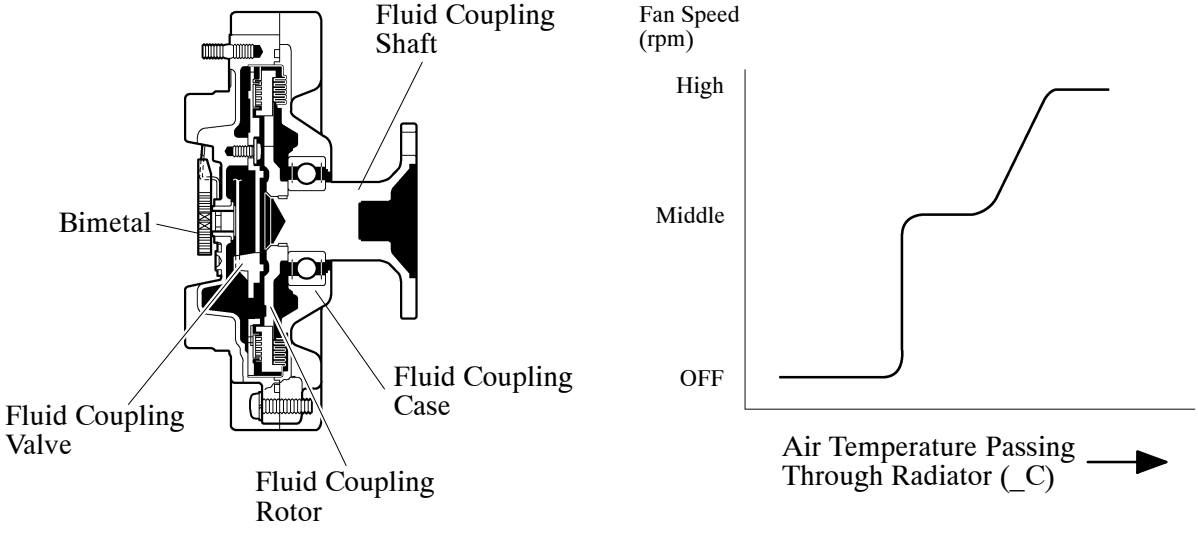
The water pump has two volute chambers, and circulates coolant uniformly to the left and right banks of the cylinder block.



238EG35

3. Coupling Fan

A 3-stage linear temperature-controlled coupling fan is used. This coupling fan utilizes the characteristics of a bimetal to switch the fluid passages and appropriately control the silicon oil, in order to change the fan speed in three stages: OFF, middle, and high. The fan speed from middle to high is controlled linearly.



238EG36

4. Engine Coolant

- TOYOTA genuine SLLC (Super Long Life Coolant) is used.
- SLLC is pre-mixed (50 % coolant and 50 % deionized water), so no dilution is needed when adding or replacing SLLC in the vehicle.
- Maintenance intervals are as shown in the table below:

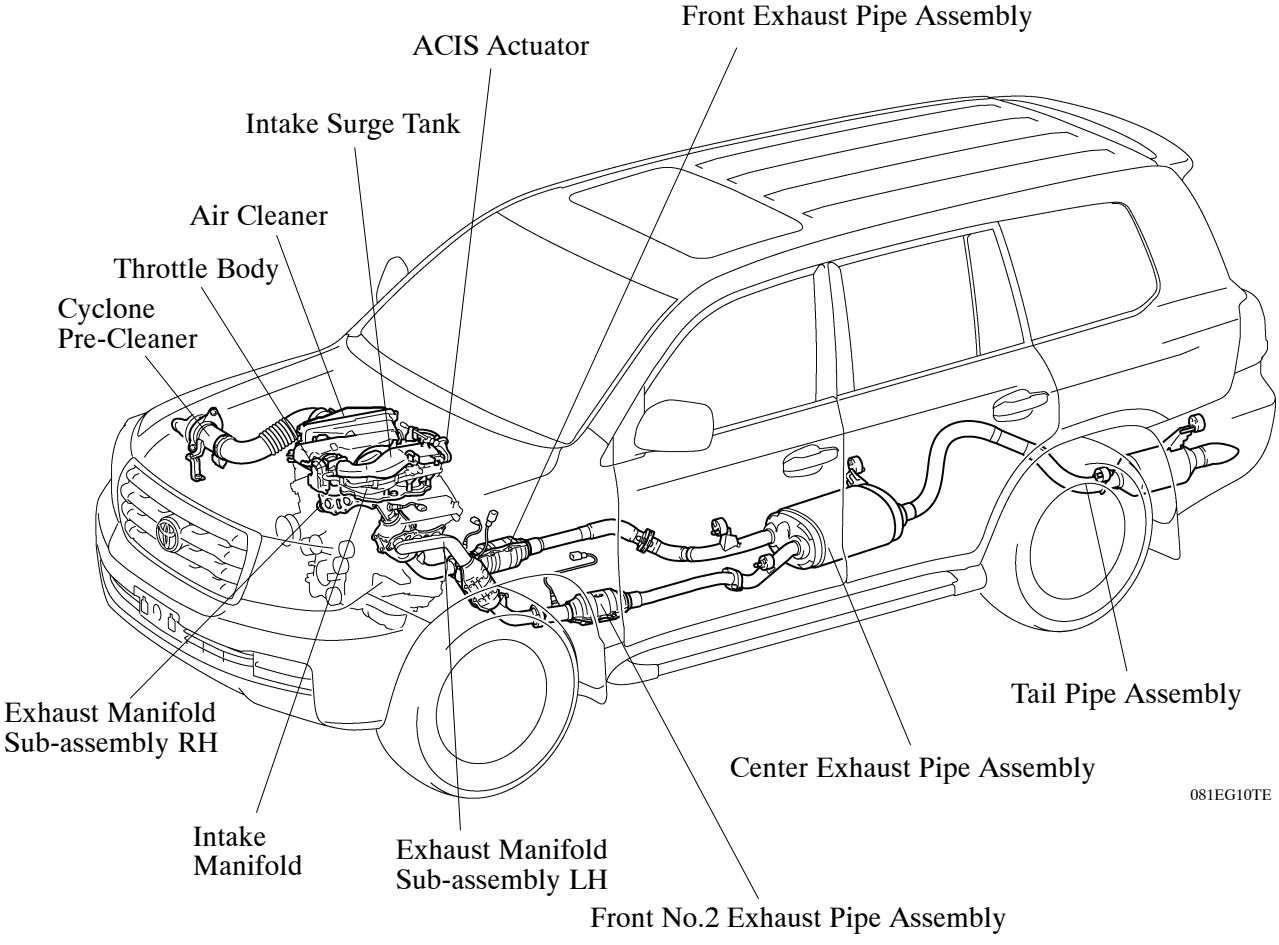
Type		TOYOTA Genuine SLLC or the equivalent*
Maintenance Intervals	First Time	160,000 km (100,000 miles)
	Subsequent	Every 80,000 km (50,000 miles)
Color		Pink

*: 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 consists of a combination of low phosphates and organic acids.)

■INTAKE AND EXHAUST SYSTEM

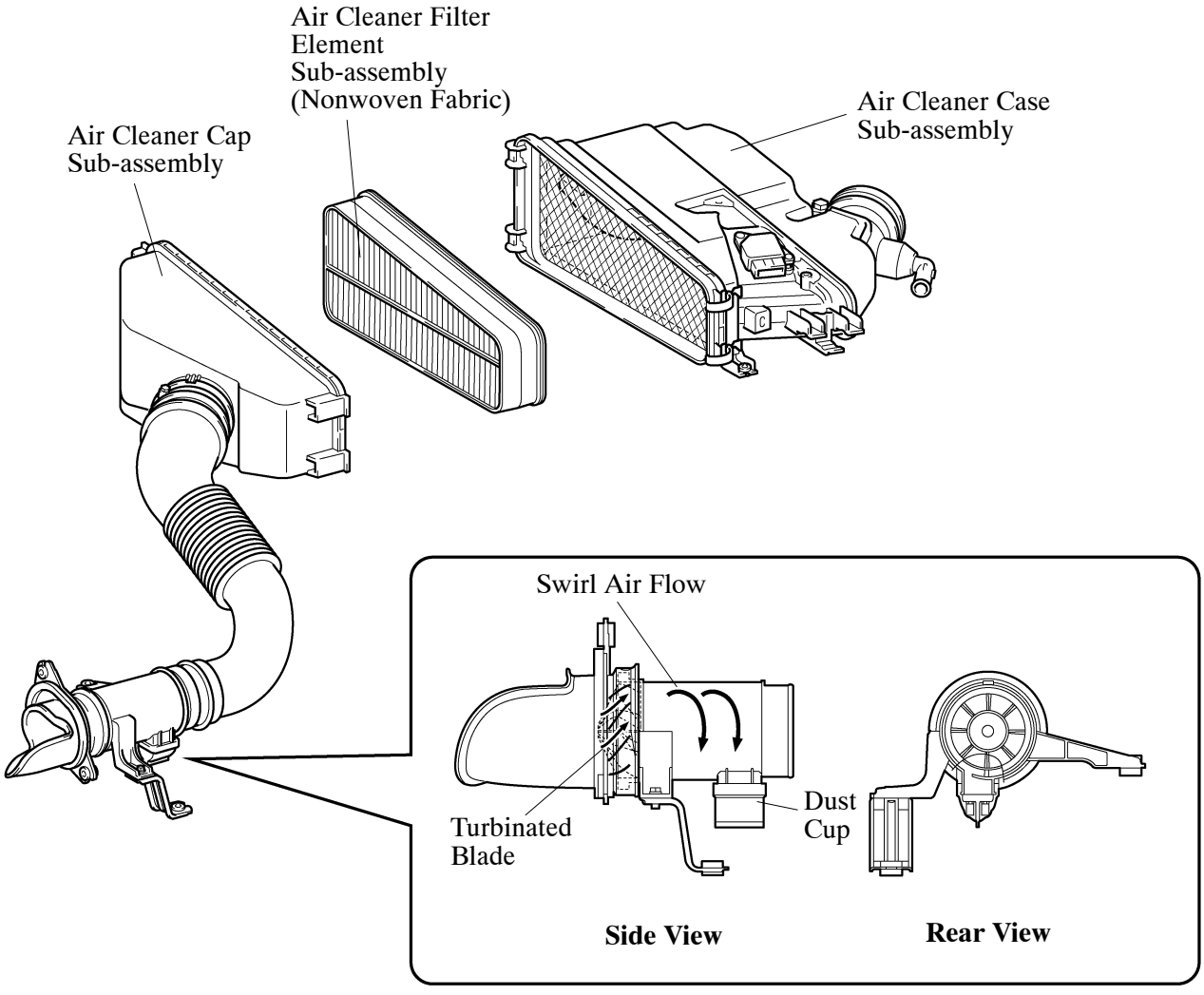
1. General

- A cyclone pre-cleaner has been provided in the air cleaner inlet.
- A link-less type throttle body is used and it realizes excellent throttle control.
- A plastic intake surge tank is used.
- Stainless steel exhaust manifolds and exhaust pipes are used.
- The ETCS-i (Electronic Throttle Control System-intelligent) is used to ensure excellent throttle control in all operating ranges. For details, see page EG-60.
- The ACIS (Acoustic Control Induction System) is used to improve the engine performance in all speed range. For details of ACIS control, see page EG-66.



2. Air Cleaner

- A nonwoven, full-fabric type air cleaner filter element is used.
- A resonator has been provided in the air cleaner case to reduce the amount of intake air sound.
- A cyclone pre-cleaner has been provided in the air cleaner inlet. This cyclone pre-cleaner has a screw shape (turbinated blade) and gathers dusts which has rather big size in a dust cup by swirling the inlet air. The dust cup is removable, so the dust gathered can be disposed.

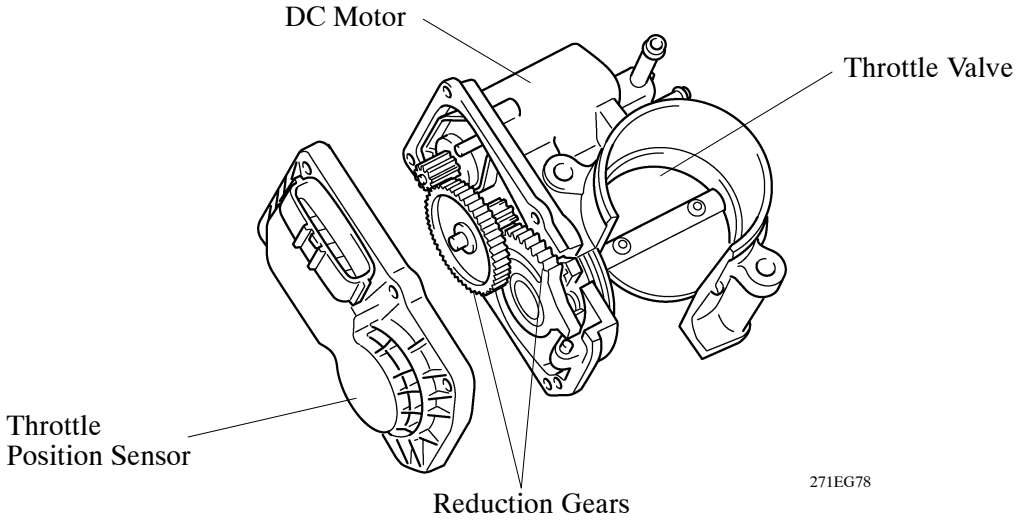


Cyclone Pre-cleaner

081EG11Y

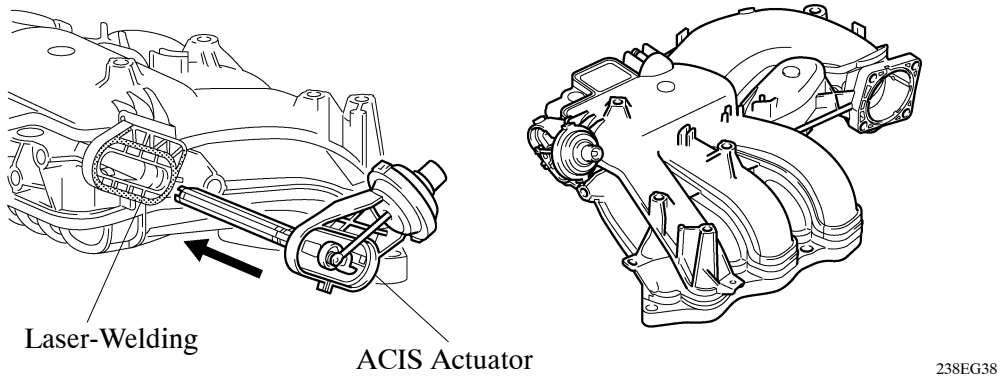
3. Throttle Body

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



4. Intake Surge Tank

- The intake surge tank is made of plastic to realize lightweight.
- The intake surge tank consists of upper and lower section and contains an intake air control valve. This valve is activated by ACIS (Acoustic Control Induction System) and is used to alter the intake pipe length to improve the engine performance in all speed range.
- The ACIS actuator is laser-welded onto the intake surge tank. Many of the components are made of plastic for weight reduction.



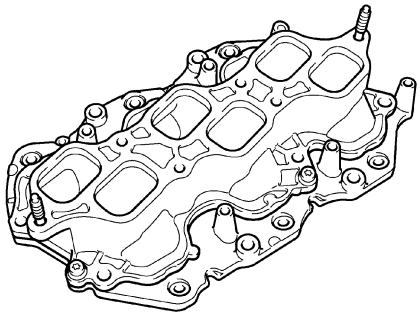
— REFERENCE —

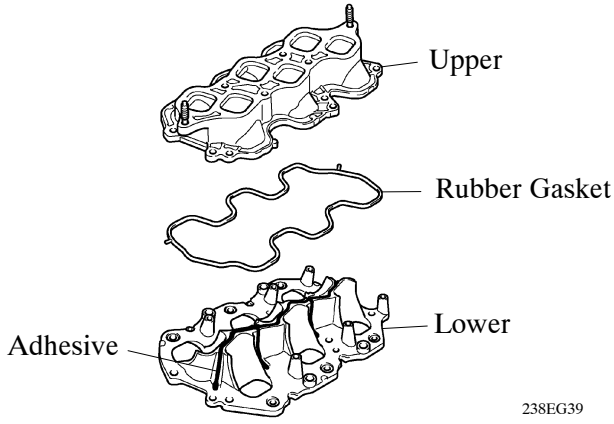
Laser-Welding:

In laser-welding, a laser-absorbing material (for the intake surge tank) 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.

5. Intake Manifold

- Light weight aluminum alloy is used for the intake manifold.
- This intake manifold consists of two pieces, the upper and lower, which are sealed with a rubber gasket and adhesive.

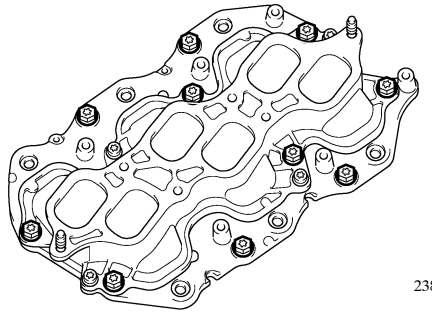




238EG39

Service Tip

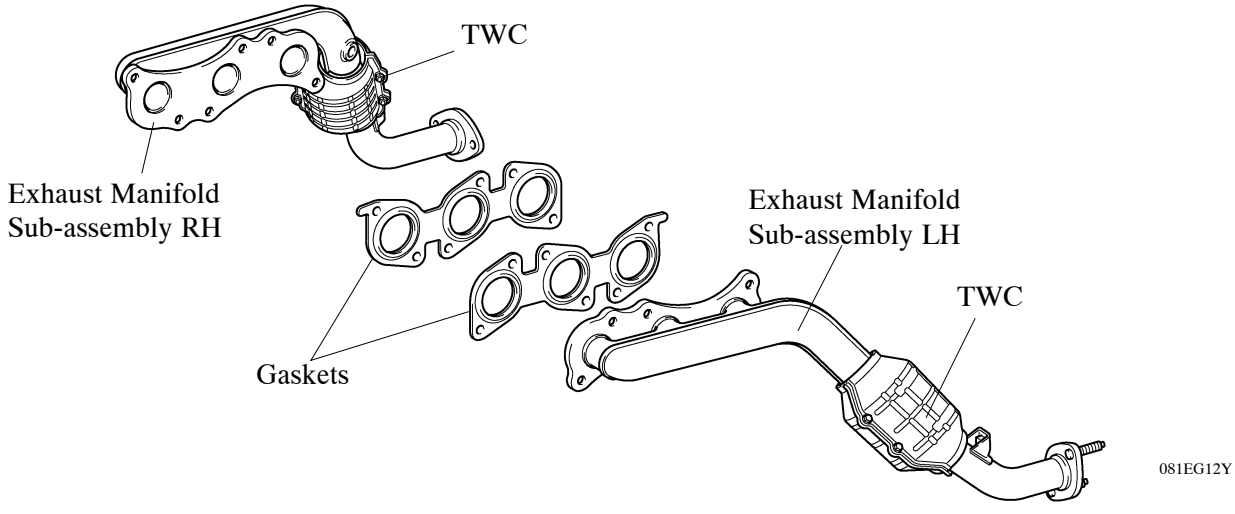
- Do not disassemble the upper and lower portions of the two-piece intake manifold, which are sealed with a rubber gasket and adhesive.
- To remove the intake manifold assembly, remove the 10 bolts that are shown in the illustration.
- These bolts have the head of hexagon shape.



238EG40

6. Exhaust Manifold

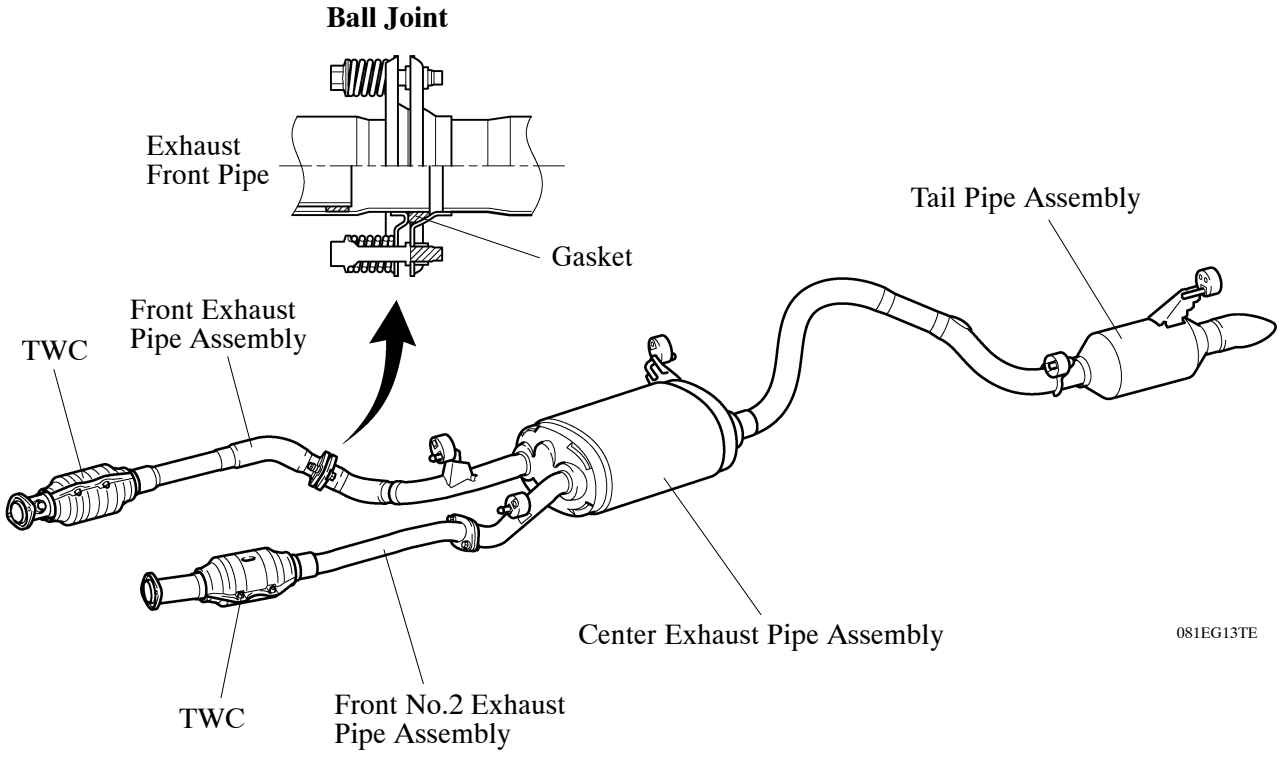
- The exhaust manifolds are made of stainless steel for weight reduction and rust resistance.
- A ceramic type TWC (Three-Way Catalytic Converter) is used. This TWC is incorporated on each of the right and left banks.



081EG12Y

7. Exhaust Pipe

- A stainless steel exhaust pipe is used for weight reduction and rust resistance.
- The ceramic type TWC is used.
- A ball joint is used to join the front exhaust pipe assembly and the center exhaust pipe assembly. As a result, a simple and reliable construction for reducing vibration has been realized.

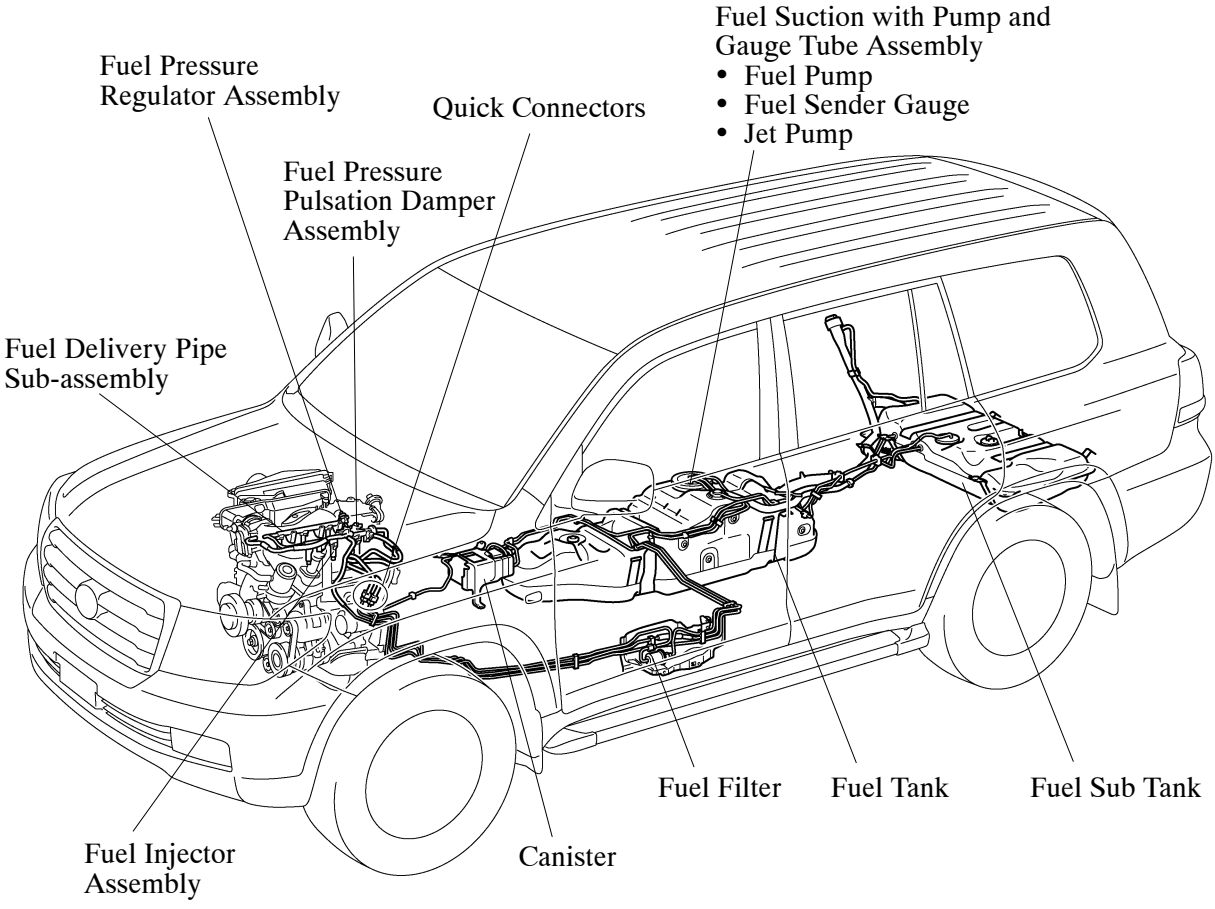


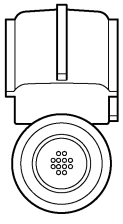
■FUEL SYSTEM

1. General

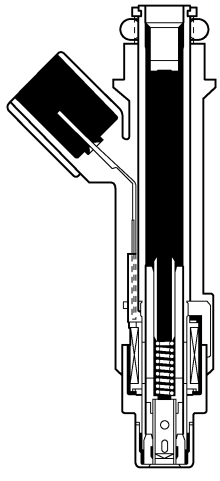
- A fuel cut control is used to stop the fuel pump when SRS airbags deploy in a frontal or side collision. For details, see page EG-68.
- Compact 12-hole type fuel injectors are used to improve the atomization of fuel.
- Quick connectors are used to connect the fuel lines for ease of serviceability.
- The dual fuel tank is comprised of a fuel tank and fuel sub tank and is provided as standard on Chinese and G.C.C. country models and as an option on general country models*.
- A multi-layer plastic fuel tank is used for the fuel tank. (The fuel sub tank however is made of steel.)

*: Provided as standard on package models for South Africa





View from Bottom Side



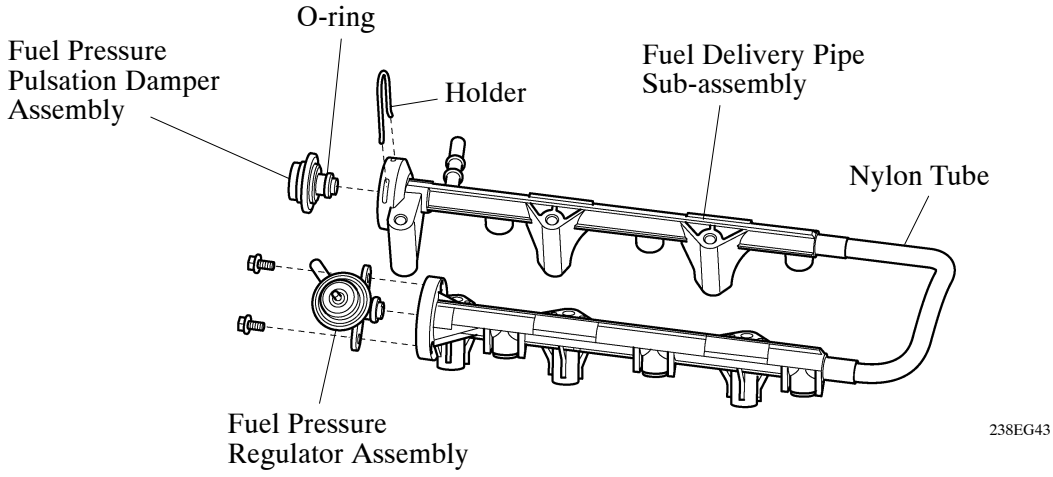
Injector Cross Section

081EG01H

Models with Dual Fuel Tank

2. Fuel Delivery Pipe

- The fuel delivery pipe is made of plastic to reduce weight.
- The right and left fuel delivery pipes are connected by a nylon tube.
- The pulsation damper is sealed with an O-ring and secured with a holder.



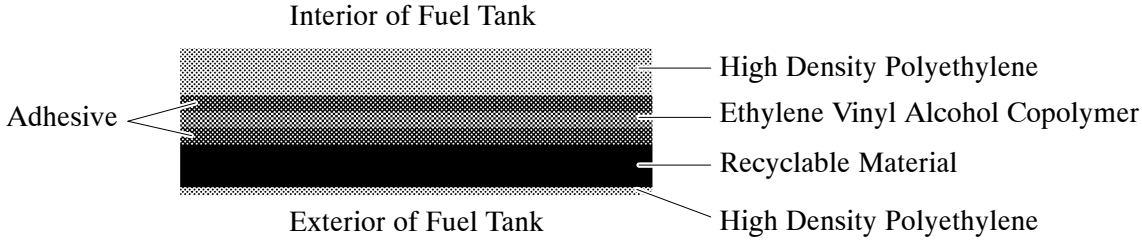
3. Fuel Tank

General

- A jet pump, which automatically transfers fuel from the fuel sub tank to the fuel tank, is provided in the fuel tank on models equipped with a dual fuel tank.
- The multi-layer plastic fuel tank consists of six layers of four types of materials, and one of those is a recyclable material to address environmental concerns.

▶ Fuel Tank Capacity ◀

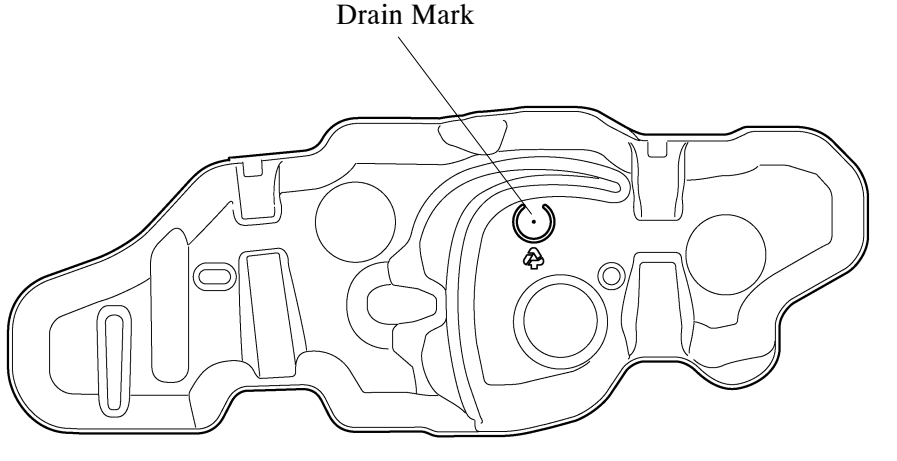
	Liters (US qts, Imp qts)
Models with Dual Fuel Tank	138 (145.8, 121.4)
Models with Single Fuel Tank	93 (98.3, 81.8)



Cross Section of Fuel Tank

Service Tip

Drain mark has been provided at the lowest position of the fuel tank. When dismantling (scraping) the vehicle, drain fuel by drilling holes at the drain mark.



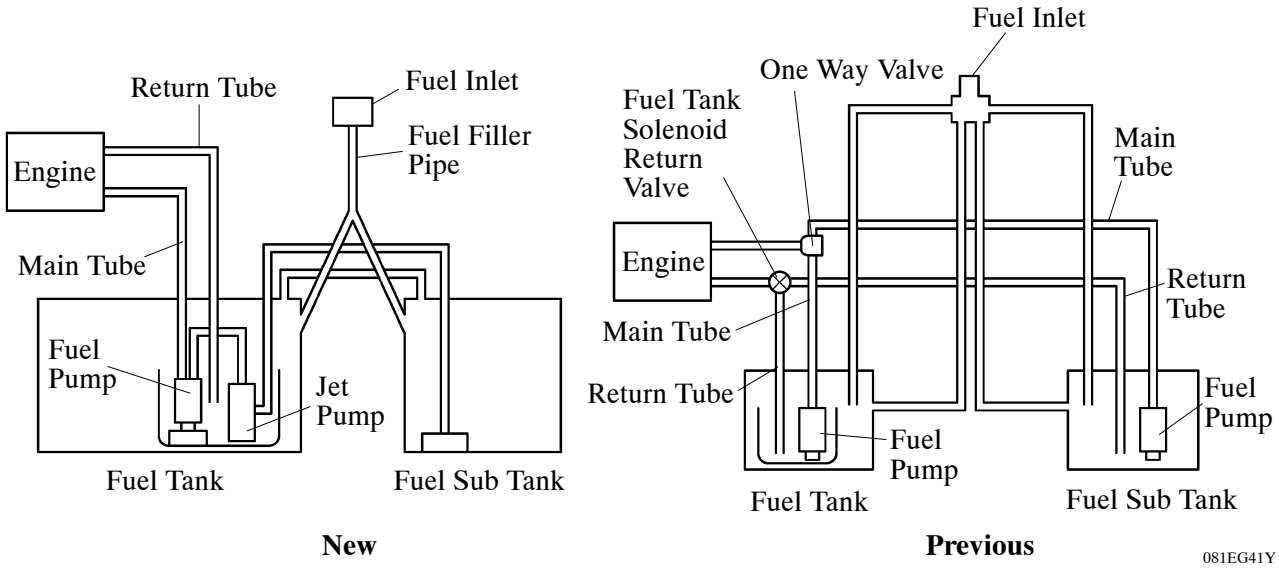
View from Bottom Side

Construction of Dual Fuel Tank

1) General

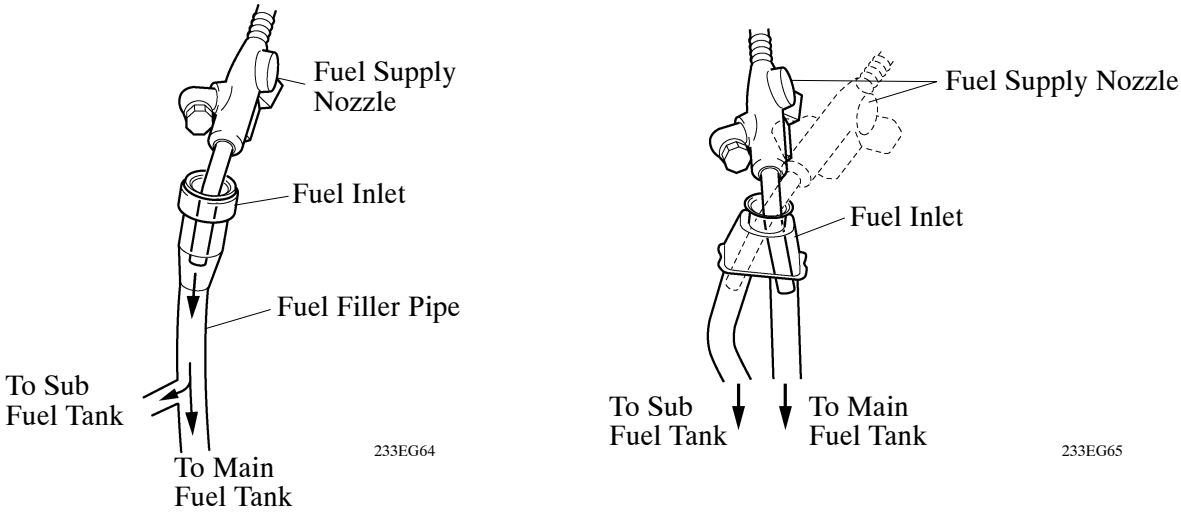
- On the previous model, either the fuel tank or fuel sub tank, from which fuel is supplied, is selected by operating the sub fuel tank switch. On the new model however, a jet pump is provided in the fuel tank in order to automatically transfer fuel from the fuel sub tank to the fuel tank.
- For the fuel filler pipe, the structure that is united right under the fuel inlet and forked into two in the middle has been adopted in its configuration. Therefore, the driver can refuel without the need to distinguish the fuel tank from the fuel sub tank.

▶ System Diagram ◀



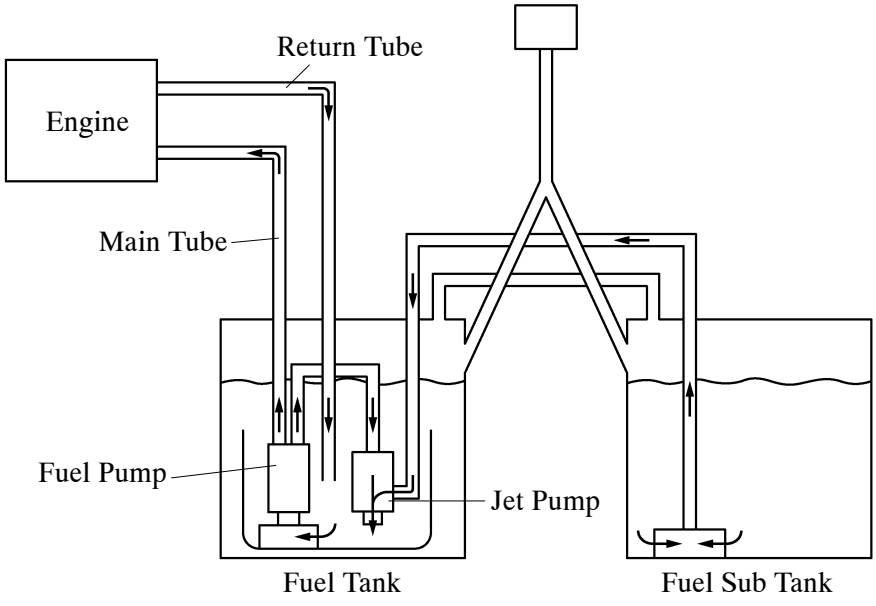
2) Fuel Inlet

- On the previous model, the fuel filler pipe has branched into two pipes directly below the fuel inlet. Therefore, the driver had to select whether to fill the main fuel tank or the sub fuel tank during refueling.
- On the new model, there is only one fuel filler pipe directly below the fuel inlet, which branches into two pipes at a midway point.



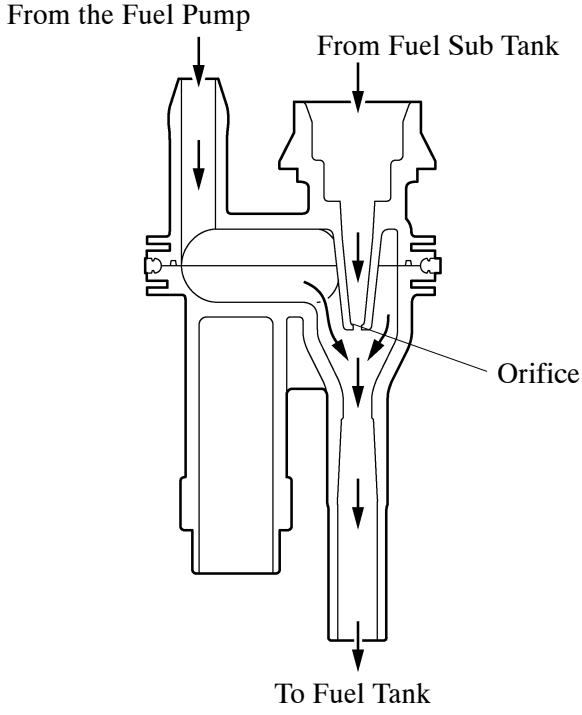
3) Operation

- The fuel from the fuel pump actuates the jet pump in the fuel tank, in order to draw fuel from the fuel sub tank to the fuel tank.



081EG42Y

- The fuel from the fuel pump passes through the orifice in the jet pump and returns to the fuel tank. Because the flow speed of the fuel from the fuel pump increases as it passes through the orifice, a vacuum is created near the exit of the orifice. This vacuum causes the fuel to be drawn from the fuel sub tank to the fuel tank.



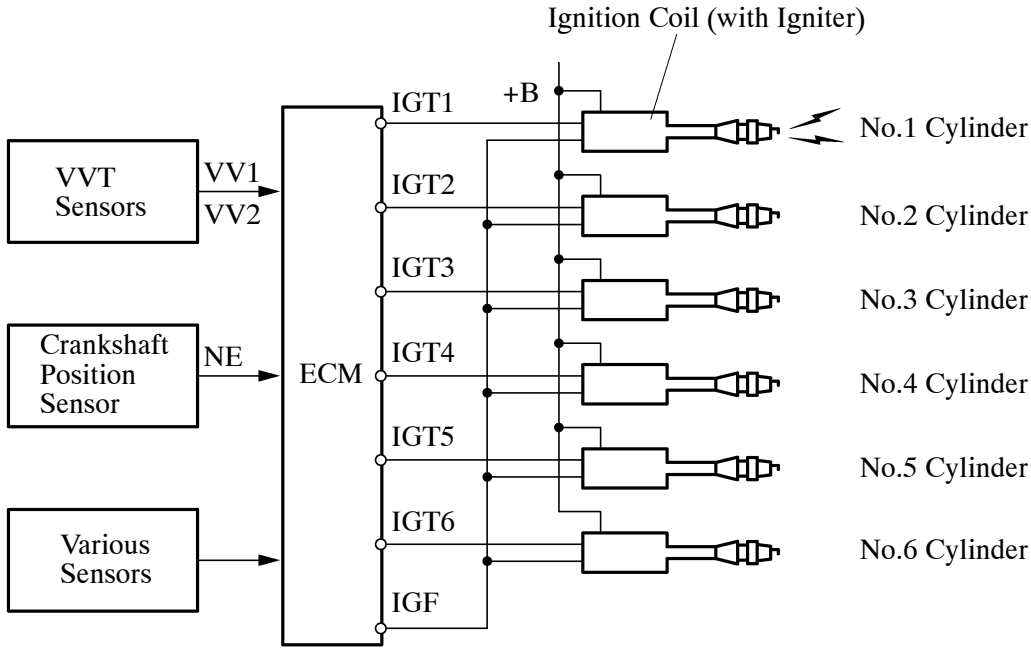
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Jet Pump

■IGNITION SYSTEM

1. General

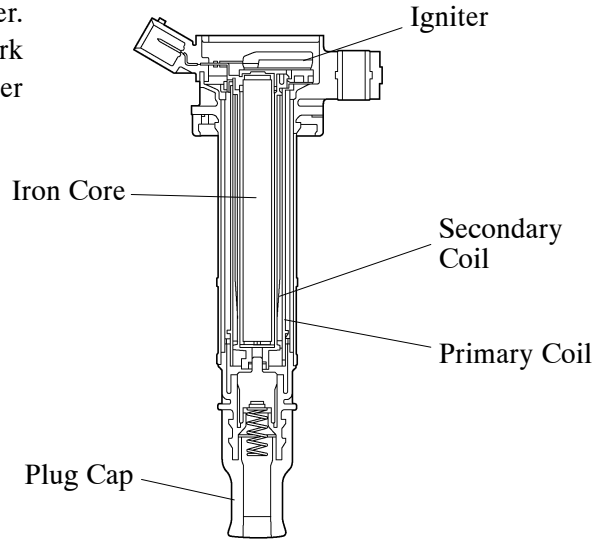
A DIS (Direct Ignition System) is used. The DIS improves the ignition timing accuracy, reduces high-voltage loss, and enhances the overall reliability of the ignition system by eliminating the distributor. The DIS in this engine is an independent ignition system, which has one ignition coil for each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



238EG68

2. Ignition Coil

The DIS provides 6 ignition coils, one for each cylinder. The spark plug cap, which provides contact to the spark plug, is integrated with the ignition coil. Also, the igniter is enclosed to simplify the system.

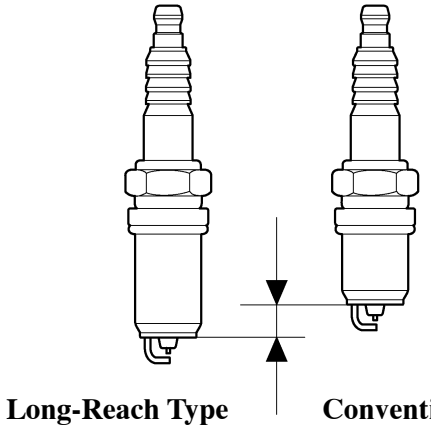


Ignition Coil Cross Section

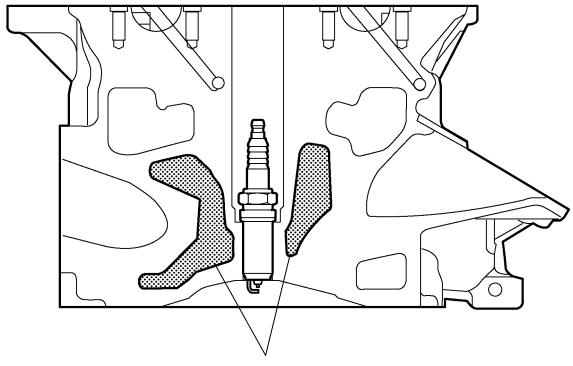
238EG69

3. Spark Plug

Long-reach type spark plugs are used. This type of spark plugs allows the area of the cylinder head to receive the spark plugs to be made thick. Thus, the water jacket can be extended near the combustion chamber, which contributes to cooling performance.



Long-Reach Type **Conventional Type**



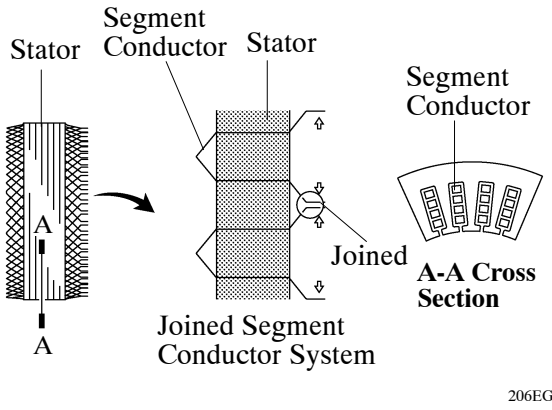
238EG46

▶ Specifications ◀

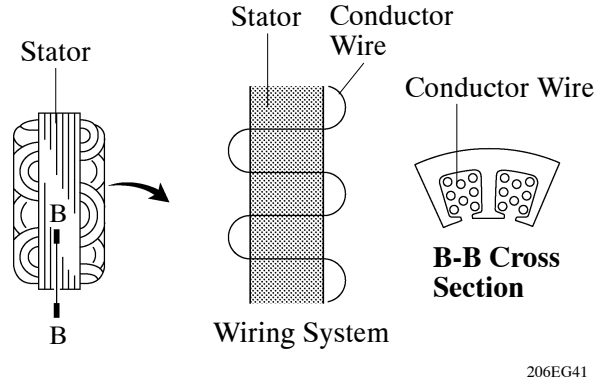
DENSO	K20HR-U11
NGK	LFR6C-11
Plug Gap mm(in.)	1.0 - 1.1 (0.0394 - 0.0433)

■CHARGING SYSTEM

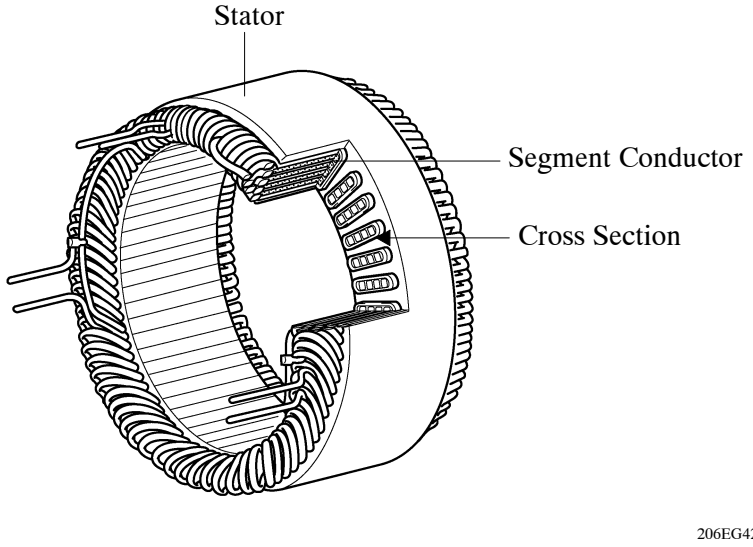
- A compact and lightweight segment conductor type generator is used. This type of generator generates a high amperage output in a highly efficient manner.
- This generator uses a joined segment conductor system, in which multiple segment conductors are welded together to the stator. Compared to the conventional winding system, the electrical resistance is reduced due to the shape of the segment conductors, and their arrangement helps to make the generator more compact.



Segment Conductor Type Generator



Conventional Type Generator

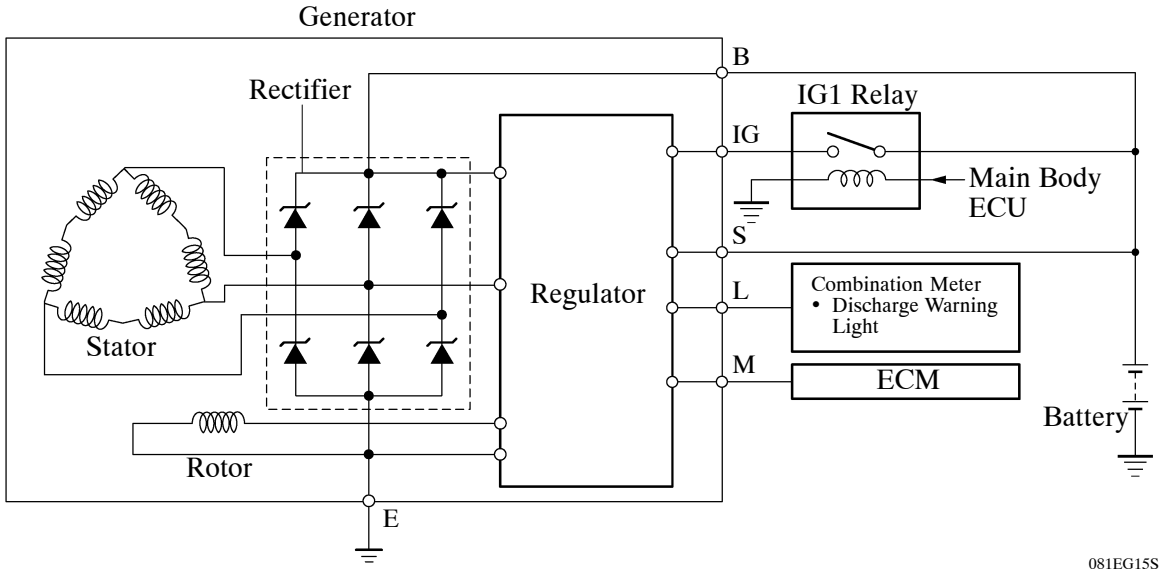


Stator of Segment Conductor Type Generator

▶ Specifications ◀

Type	SE0
Rated Voltage	12V
Output Rated	100 A

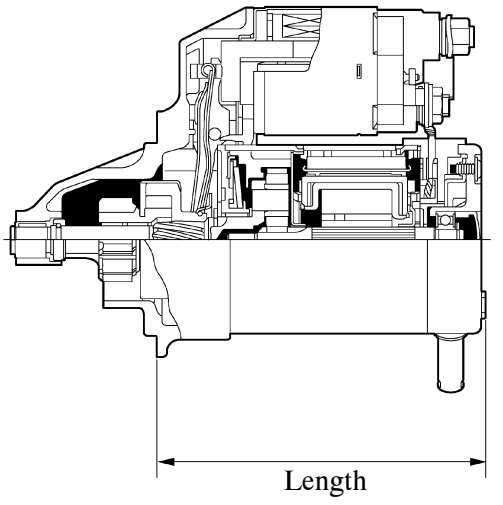
▶ Wiring Diagram ◀



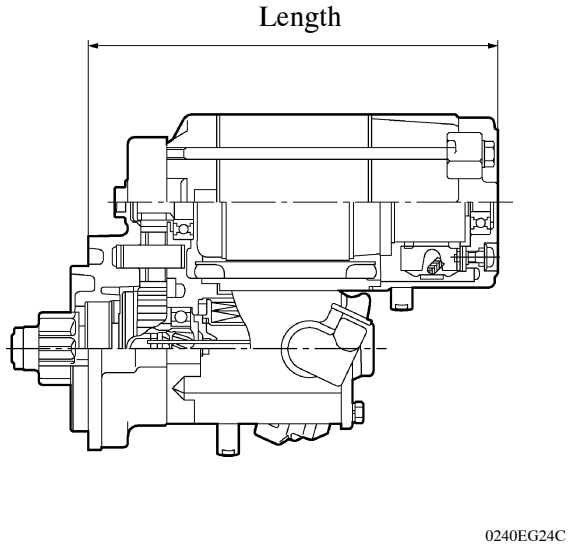
■STARTING SYSTEM

1. General

- A compact and lightweight PS (Planetary reduction-Segment conductor motor) type starter is used on models for general countries and G.C.C. countries.
- A reduction type starter is used on Chinese models and cold area specification models for general countries.



PS Type Starter



RA Type Starter

▶ Specifications ◀

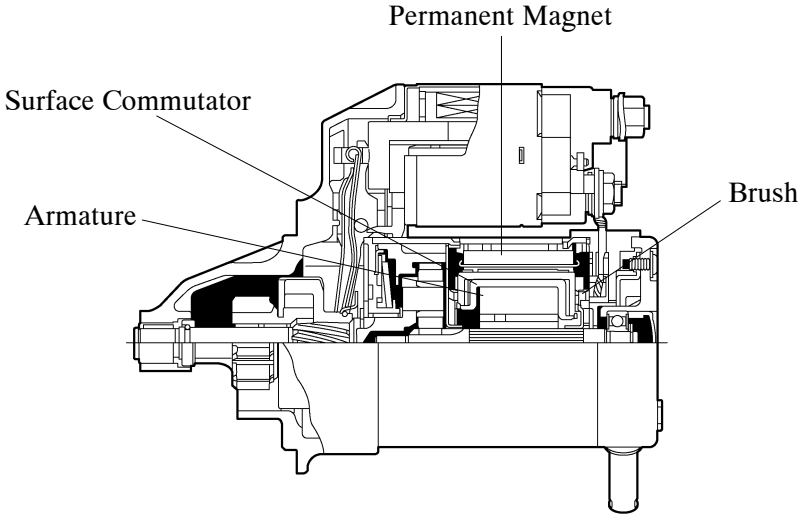
Starter Type		PS1.6	RA2.0
		PS type	Reduction type
Supplier		DENSO	←
Rating Output		1.6 kW	2.0 kW
Rating Voltage		12 V	←
Length*1	mm (in.)	126.4 (4.98)	185.3 (7.30)
Weight	g (lb)	2800 (6.2)	4700 (10.4)
Rotating of Direction*2		Clockwise	←

*1: Length from the mounted area to the rear end of the starter
*2: Viewed from Pinion Side

2. PS (Planetary reduction-Segment conductor motor) type Starter

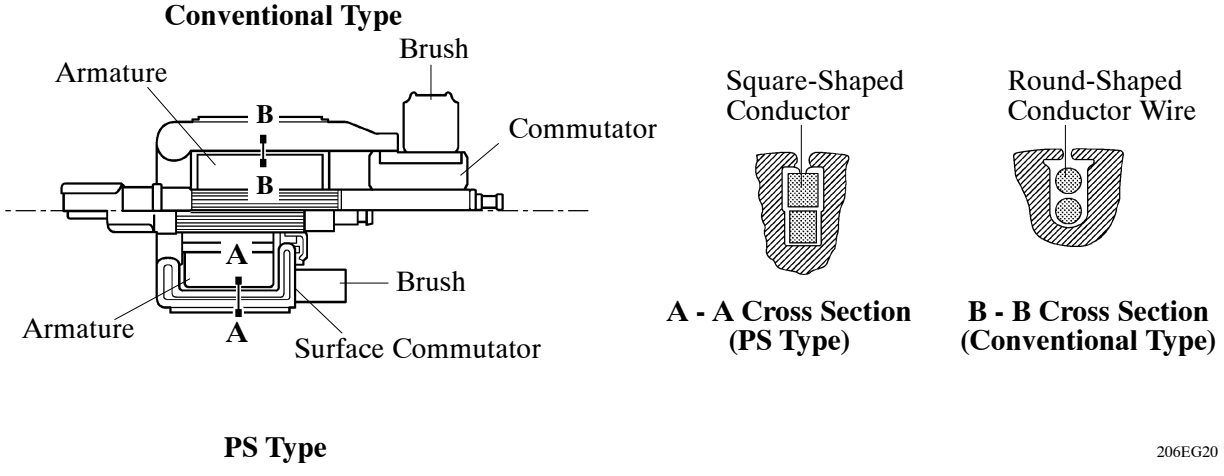
General

- The PS starter contains an armature that uses square-shaped conductors. The surface of the armature at one end functions as the commutator, resulting in improved output torque and overall length reduction.
- In place of the field coil used in the conventional starter, the PS starter uses two types of permanent magnets: main magnets and interpolar magnets. The main magnets and interpolar magnets have been efficiently arranged to increase the magnetic flux and to shorten the length of the yoke.

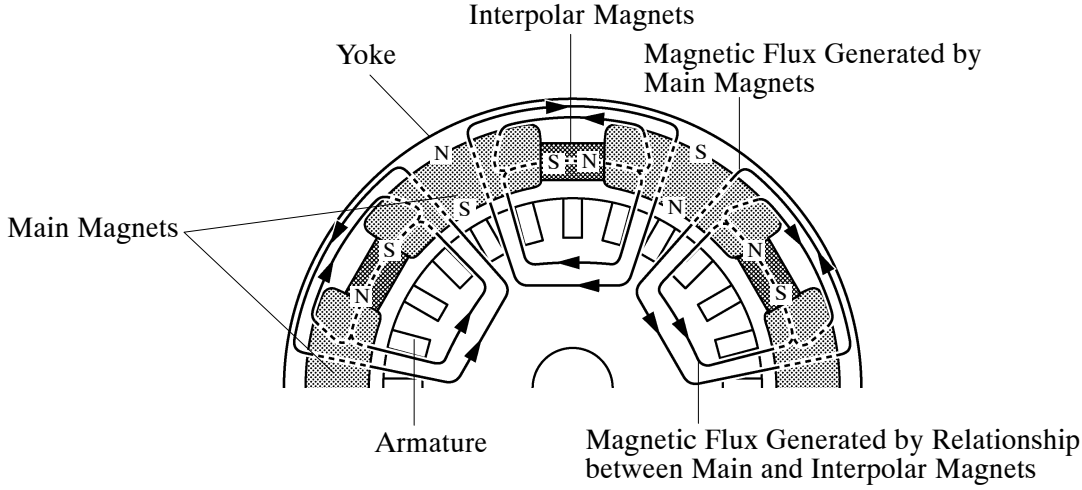


Construction

- Instead of the round-shaped conductor wires used in the conventional starter, the PS type starter uses square-shaped conductors. In this type of construction, square-shaped conductors can achieve the same conditions as those achieved by winding numerous round-shaped conductor wires, but without increasing the mass. As a result, the output torque is increased, and the armature coil is more compact.
- Because the surface of the square-shaped conductors that are used in the armature coil functions as a commutator, the overall length of the PS type starter has been shortened.



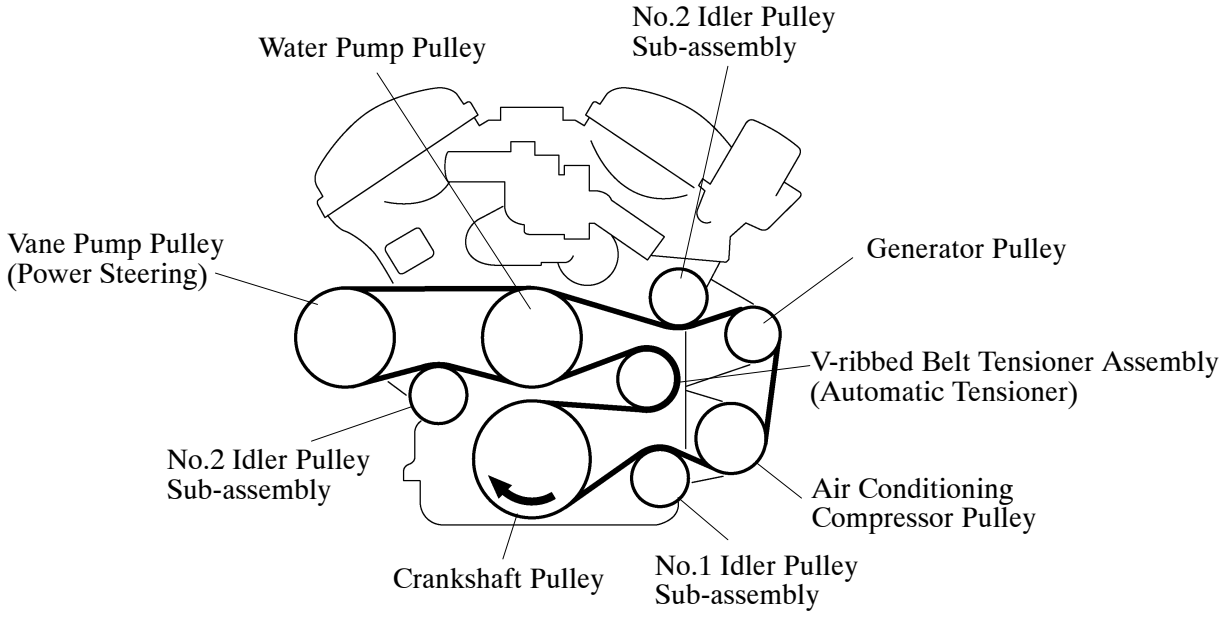
- Instead of the field coils used in the conventional type starter, the PS type starter has adopted two types of permanent magnets: the main magnets and the interpolar magnets. The main and interpolar magnets are arranged alternately inside the yoke, allowing the magnetic flux that is generated between the main and interpolar magnets to be added to the magnetic flux that is generated by the main magnets. In addition to increasing the amount of magnetic flux, this construction shortens the overall length of the yoke.



Cross Section of Yoke Portion

■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 number of engine parts.
- An automatic tensioner is used. This makes the tension adjustment unnecessary.



■ ENGINE CONTROL SYSTEM

1. General

The engine control system of the 1GR-FE engine has the following system.

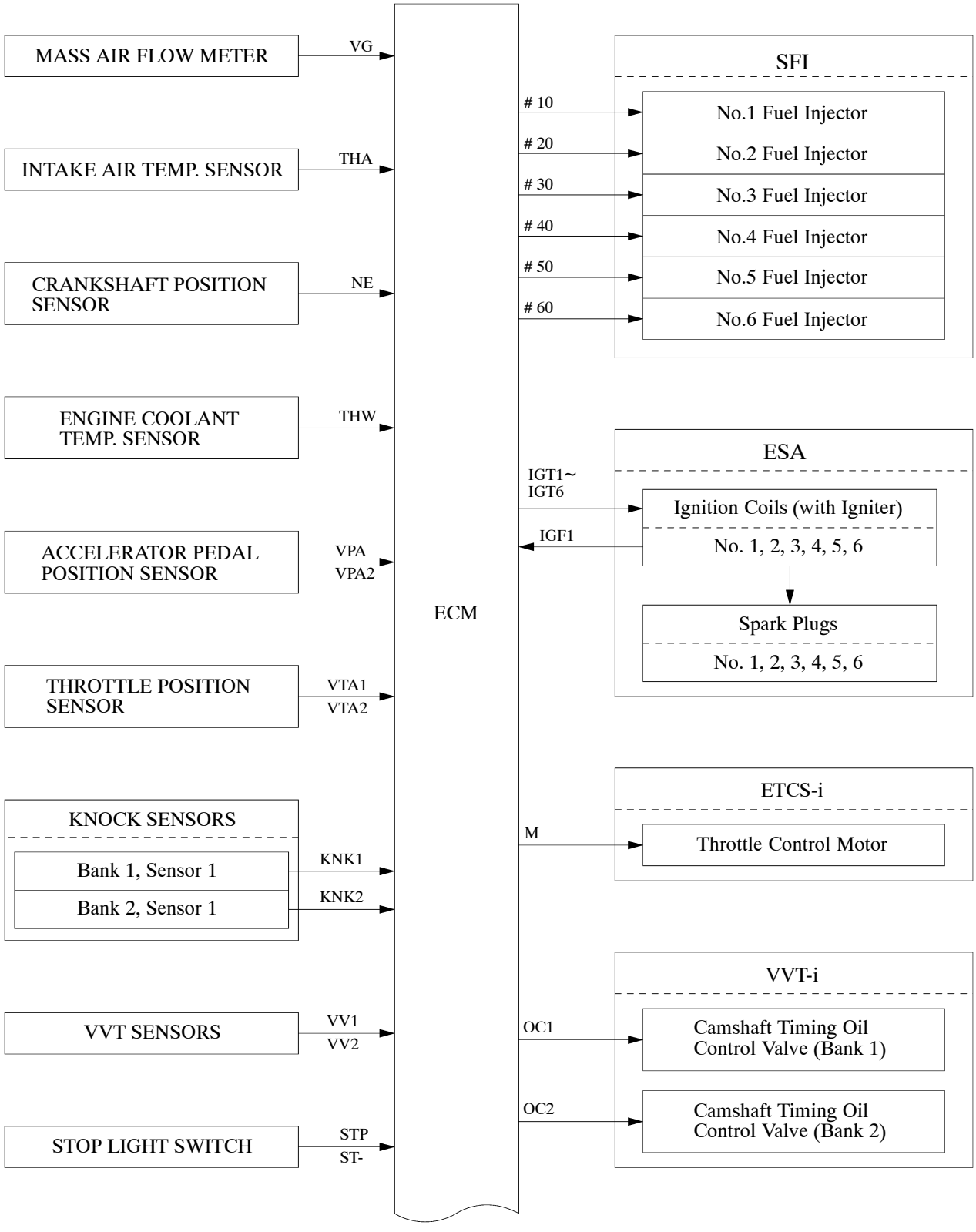
System	Outline
SFI (Sequential Multiport Fuel Injection)	• An L-type SFI system directly detects the intake air mass using a hot wire type air flow meter. • An independent injection system (in which fuel is injected once into each intake port for each two revolutions of the crankshaft) is used. • Fuel injection takes two forms: - Synchronous injection, in which injection always occurs at the same timing relative to the firing order. - The non-synchronous injection in which injection is effected regardless of the crankshaft angle. • This system performs group injection when the engine coolant temperature is extremely low and the engine is operating at a low speed.
ESA (Electronic Spark Advance)	• 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.
ETCS-i (Electronic Throttle Control System-intelligent) [See page EG-60]	Optimally controls the throttle valve opening in accordance with the amount of accelerator pedal effort and the condition of the engine and the vehicle.
VVT-i (Variable Valve Timing-intelligent) [See page EG-62]	Controls the intake camshaft to optimal valve timing in accordance with the engine condition.
ACIS (Acoustic Control Induction System) [See page EG-66]	The intake air passages are switched according to the engine speed and throttle valve opening angle to provided high performance in all speed ranges.
Fuel Pump Control [See page EG-68]	• Based on signals from the ECM, the fuel pump ECU controls the fuel pump to 3 stages. • The fuel pump is stopped when the SRS airbag is deployed in a frontal, side, or side rear collision.
Starter Control (Cranking Hold Function) [See page EG-70]	Once the engine switch is pushed, this control continues to operate the starter until the engine is started.
Air Fuel Ratio Sensor and Oxygen Sensor Heater Control	Maintains the temperature of the air fuel ratio sensors or oxygen sensors at an appropriate level to increase the detection accuracy of the exhaust gas oxygen concentration.

(Continued)

System	Outline
Air Conditioning Cut-off Control	By turning the air conditioning compressor ON or OFF in accordance with the engine condition, drivability is maintained.
Evaporative Emission Control	The ECM controls the purge flow of evaporative emission (HC) in the charcoal canister in accordance with engine conditions.
Engine Immobilizer	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid key.
Diagnosis [See page EG-72]	When the ECM detects a malfunction, the ECM records the malfunction and memorizes information related to the fault.
Fail-safe [See page EG-72]	When the ECM detects a malfunction, the ECM stops or controls the engine according to the data already stored in the memory.

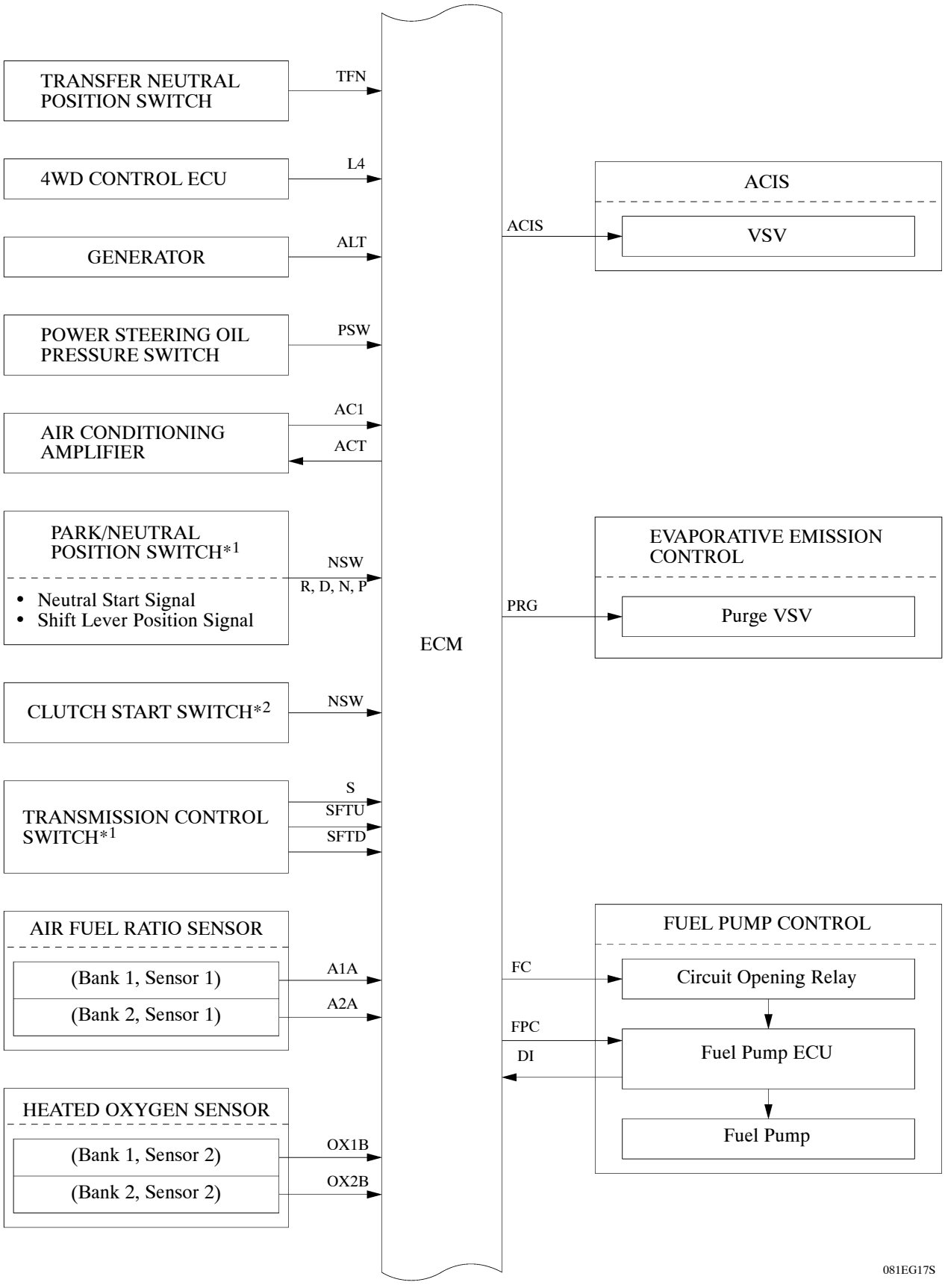
2. Construction

The configuration of the engine control system in the 1GR-FE engine is as shown in the following chart.

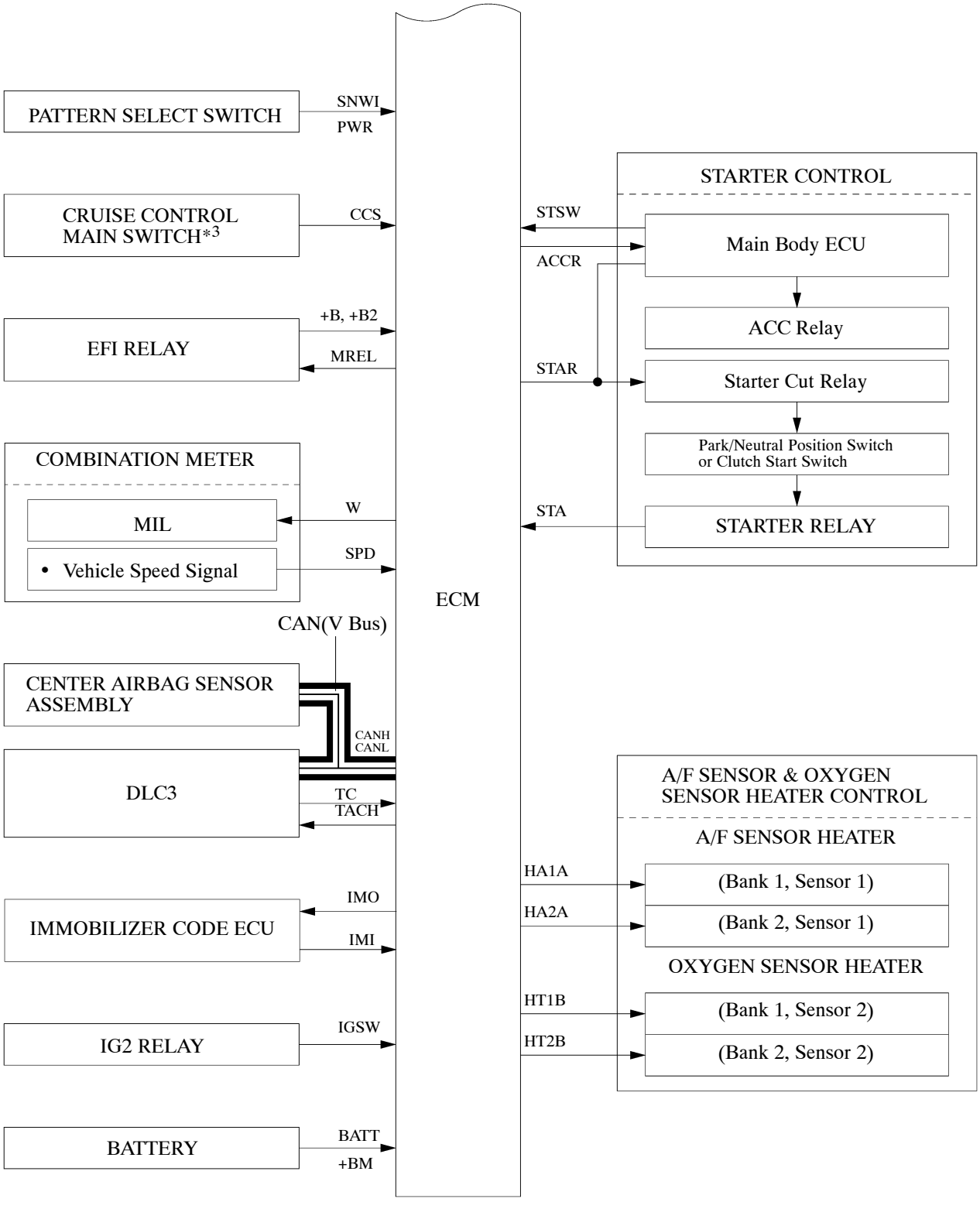


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(Continued)


TRANSFER NEUTRAL POSITION SWITCH
TFN
4WD CONTROL ECU
L4
GENERATOR
ALT
POWER STEERING OIL PRESSURE SWITCH
PSW
AIR CONDITIONING AMPLIFIER
AC1
ACT
PARK/NEUTRAL POSITION SWITCH*1
• Neutral Start Signal
• Shift Lever Position Signal
NSW
R, D, N, P
CLUTCH START SWITCH*2
NSW
TRANSMISSION CONTROL SWITCH*1
S
SFTU
SFTD
AIR FUEL RATIO SENSOR
(Bank 1, Sensor 1)
(Bank 2, Sensor 1)
A1A
A2A
HEATED OXYGEN SENSOR
(Bank 1, Sensor 2)
(Bank 2, Sensor 2)
OX1B
OX2B
ECM
ACIS
ACIS
VSV
EVAPORATIVE EMISSION CONTROL
PRG
Purge VSV
FUEL PUMP CONTROL
FC
Circuit Opening Relay
FPC
DI
Fuel Pump ECU
Fuel Pump
081EG17S

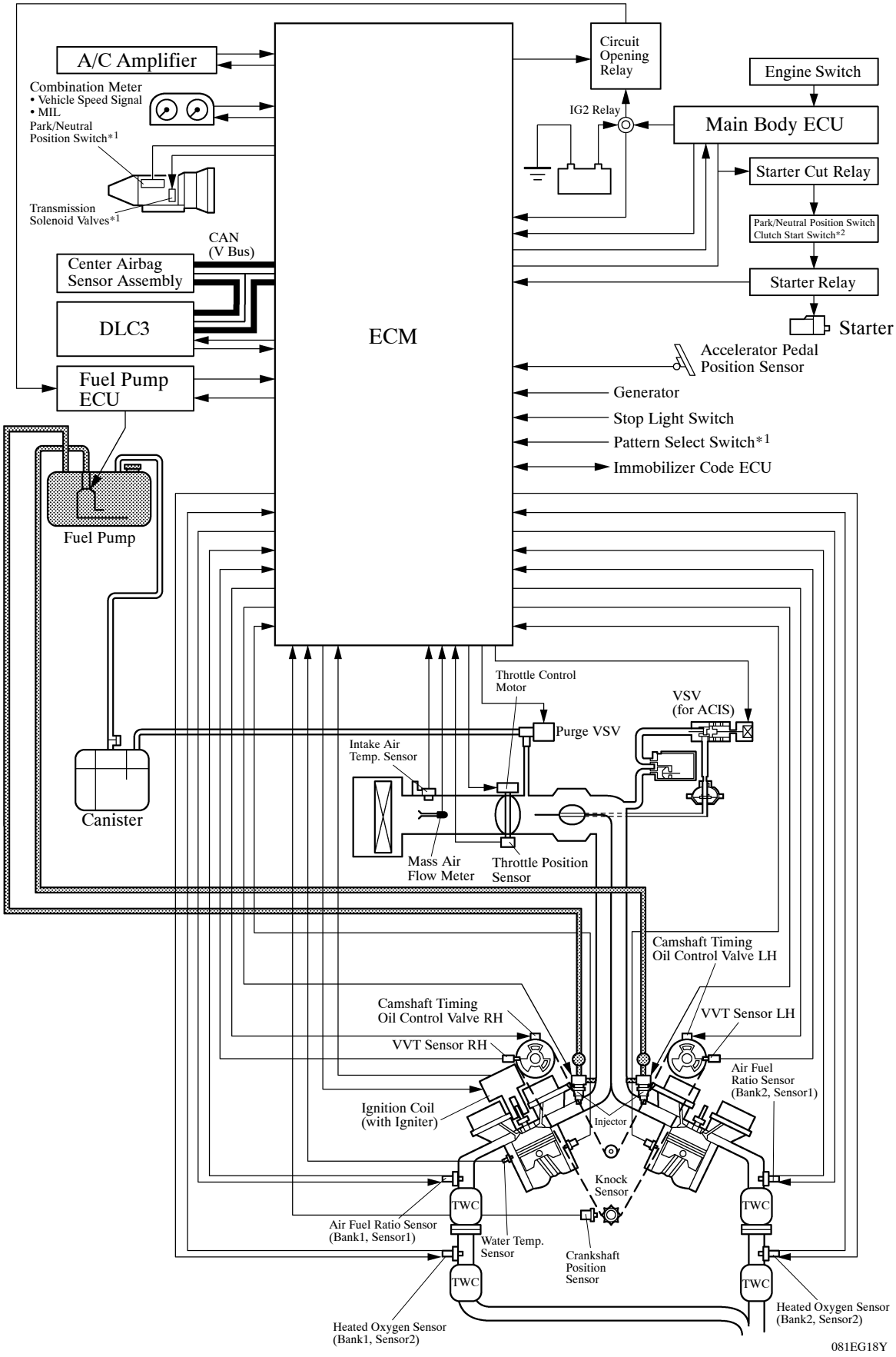
(Continued)



081EG22S

*1: Only for models with automatic transmission
*2: Only for models with manual transmission
*3: Only for models with cruise control system

3. Engine Control System Diagram

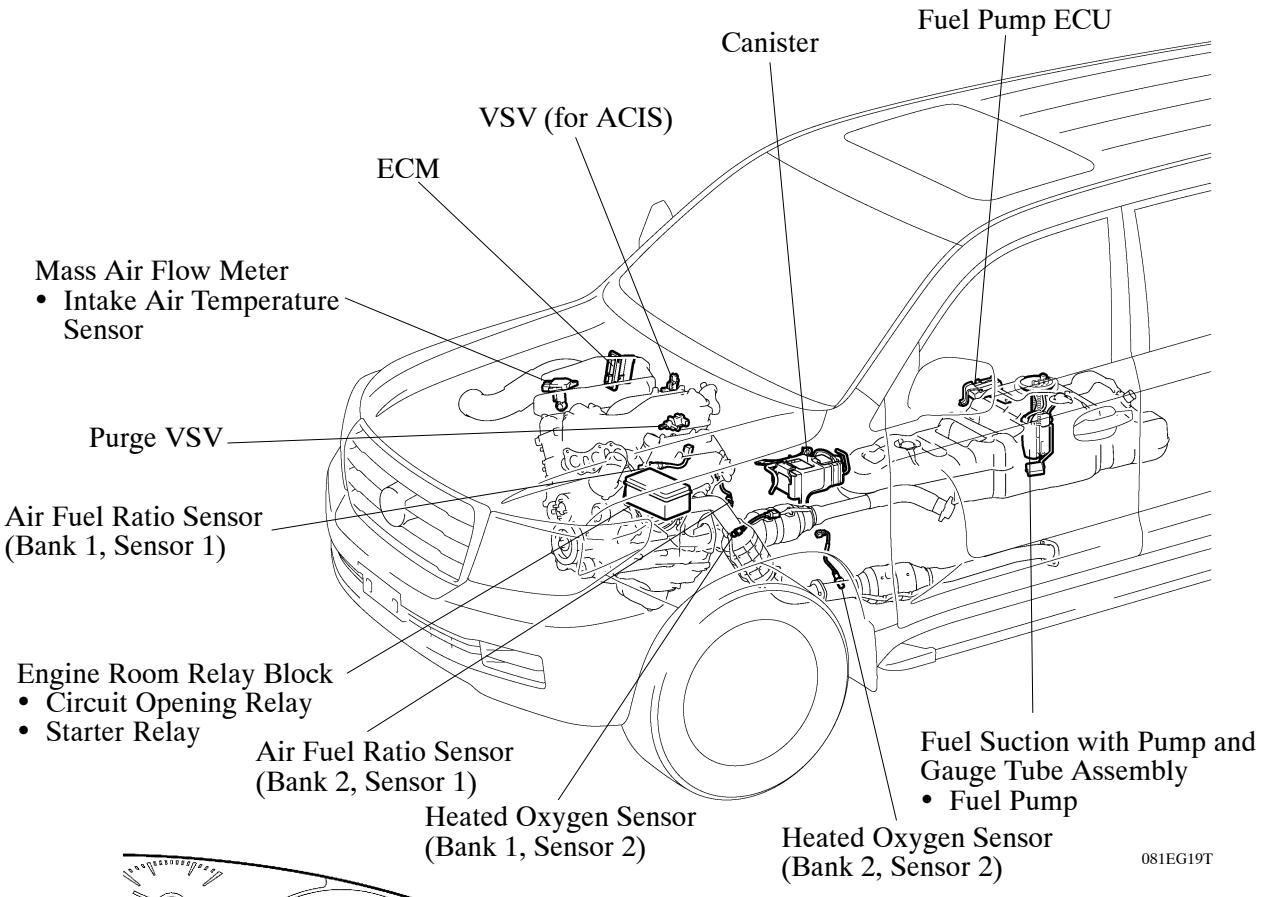


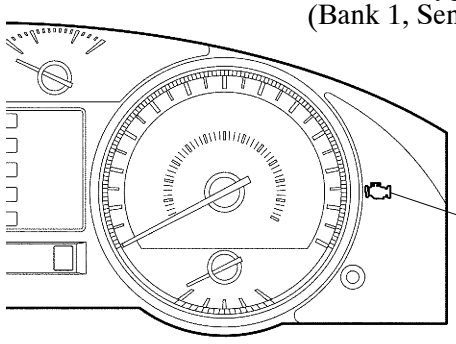
*1: Only for models with automatic transmission

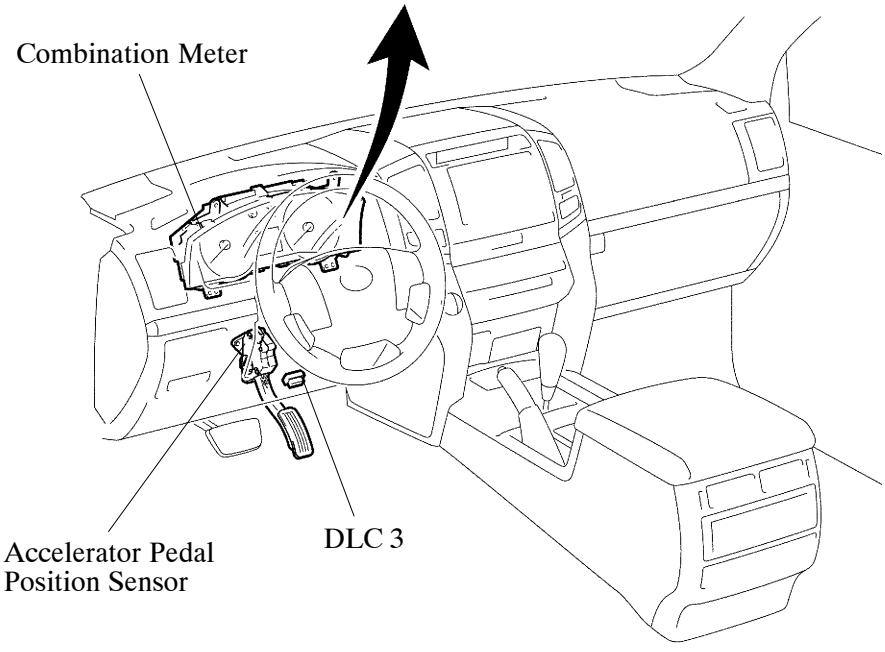
*2: Only for models with manual transmission

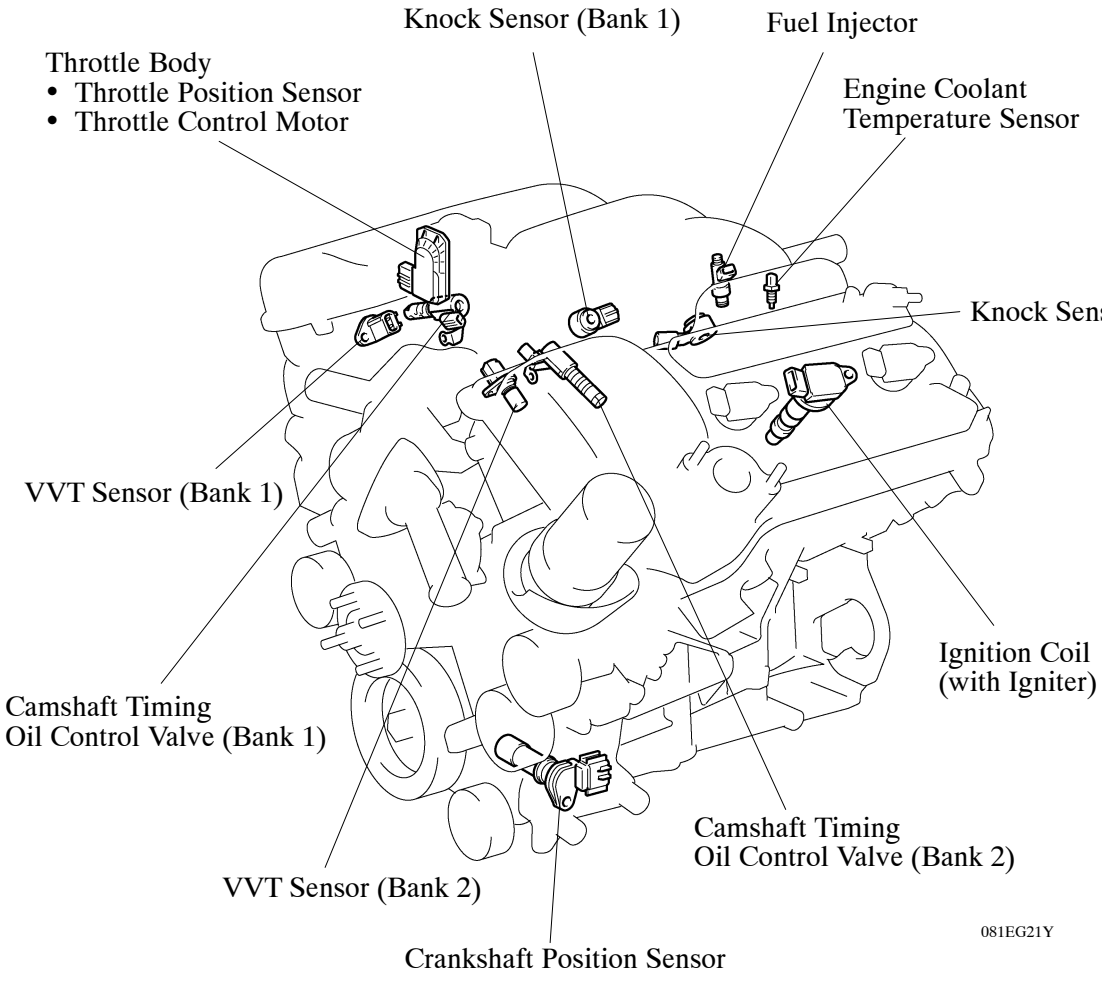
EG

4. Layout of Main Components








Knock Sensor (Bank 1)
Fuel Injector
Throttle Body
• Throttle Position Sensor
• Throttle Control Motor
Engine Coolant Temperature Sensor
Knock Sensor (Bank 2)
VVT Sensor (Bank 1)
Ignition Coil (with Igniter)
Camshaft Timing Oil Control Valve (Bank 1)
Camshaft Timing Oil Control Valve (Bank 2)
VVT Sensor (Bank 2)
Crankshaft Position Sensor
081EG21Y

5. Main Components of Engine Control System

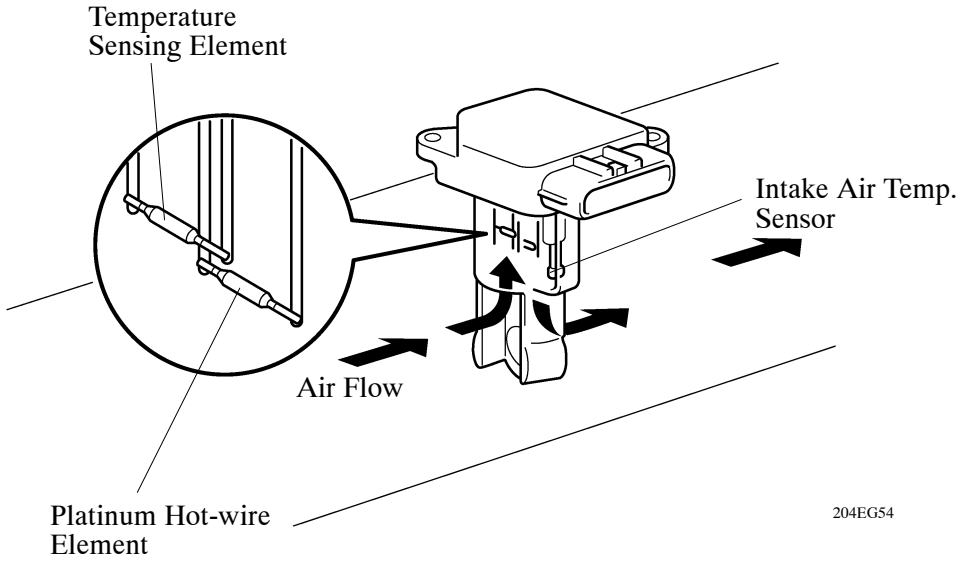
General

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

Components	Outline	Quantity	Function
ECM	32-bit CPU (DENSO)	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 [See page EG-51]	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.
Crankshaft Position Sensor [See page EG-52]	Pick-up Coil Type (Rotor Teeth /36-2)	1	This sensor detects the engine speed and performs the cylinder identification.
VVT Sensor [See page EG-52]	MRE Type (Rotor Teeth /3)	1 each bank	This sensor performs the cylinder identification.
Accelerator Pedal Position Sensor [See page EG-54]	No-contact Type	1	This sensor detects the amount of pedal effort applied to the accelerator pedal.
Throttle Position Sensor [See page EG-55]	No-contact Type	1	This sensor detects the throttle valve opening angle.
Knock Sensor [See page EG-56]	Built-in Piezoelectric Type (Flat Type)	1 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 [See page EG-58]	Cup Type with Heater	1 each bank	This sensor detects the oxygen concentration in the exhaust gas by measuring the electromotive force which is generated in the sensor itself.
Air Fuel Ratio Sensor [See page EG-58]	Planar Type with Heater	1 each bank	As with the oxygen sensor, this sensor detects the oxygen concentration in the exhaust gas. However, it detects the oxygen concentration in the exhaust gas linearly.
Engine Coolant Temperature Sensor	Thermistor Type	1	This sensor detects the engine coolant temperature by means of an internal thermistor.
Fuel Injector [See page EG-29]	12-Hole Type	6	This fuel injector contains an electro-magnetically operated nozzle to inject fuel into the intake port.
Camshaft Timing Oil Control Valve [See page EG-64]	Electro-Magnetic 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.

Mass Air Flow Meter

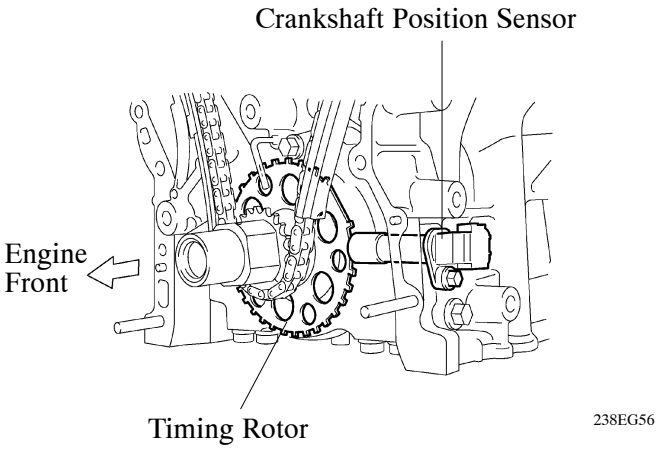
- This mass air flow meter, which is a plug-in type, allows a portion of the intake air to flow through the detection area. By directly measuring the mass and the flow rate of the intake air, the detection precision is improved and the intake air resistance is reduced.
- This mass air flow meter has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

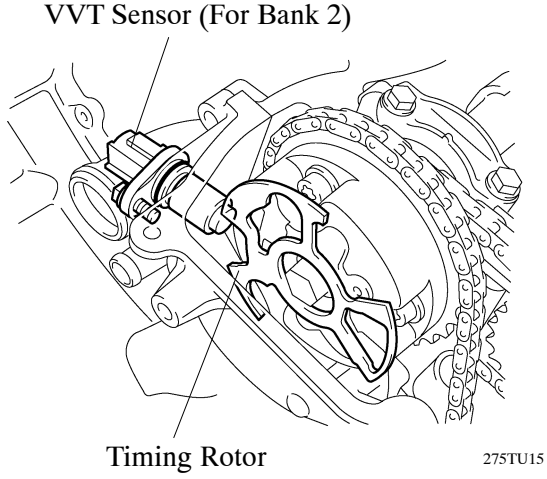


Crankshaft and VVT Sensors

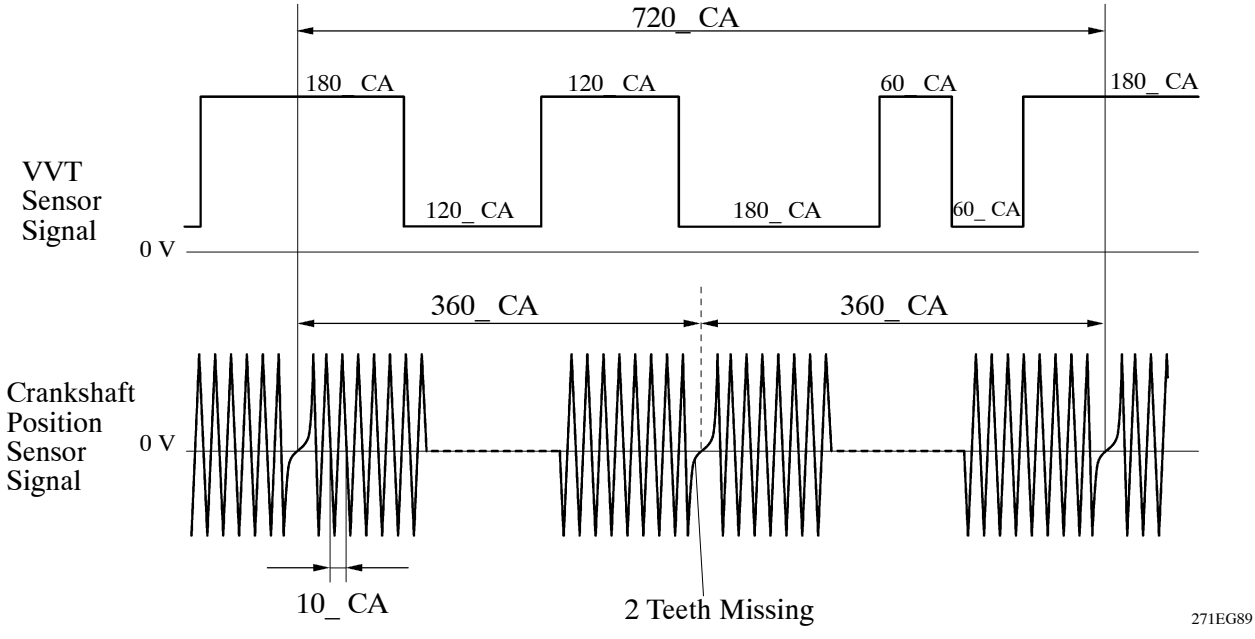
1) General

- Pick up coil type crankshaft position sensor is used. The timing rotor of the crankshaft consists of 34 teeth, with 2 teeth missing. The crankshaft position sensor outputs the crankshaft rotation signals every 10° and the missing teeth are used to determine the top-dead-center.
- MRE (Magnetic Resistance Element) type VVT sensor is used. To detect the camshaft position, a timing rotor that is secured to the camshaft in front of the VVT controller is used to generate 3 (3 Hi output, 3 Lo output) for every 2 revolutions of the crankshaft.





▶ Sensor Output Waveforms ◀

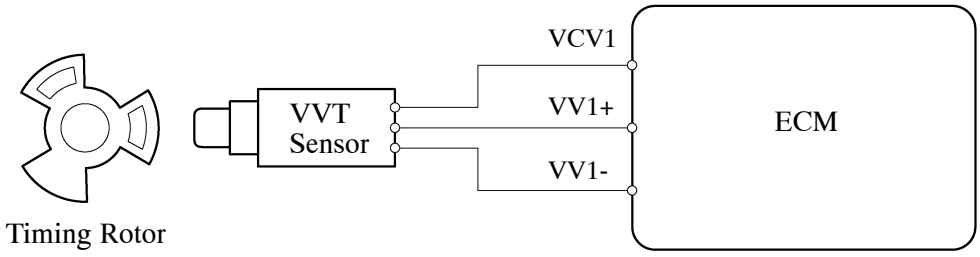


2) MRE type VVT Sensor

- The MRE type VVT sensor consists of an MRE, a magnet and a sensor. The direction of the magnetic field changes due to the different shapes (protruded and non-protruded 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 Hi or Lo. The ECM detects the camshaft position based on this output voltage.
- The differences between the MRE type VVT sensor and the pickup coil type VVT sensor used on the conventional model are as follows.

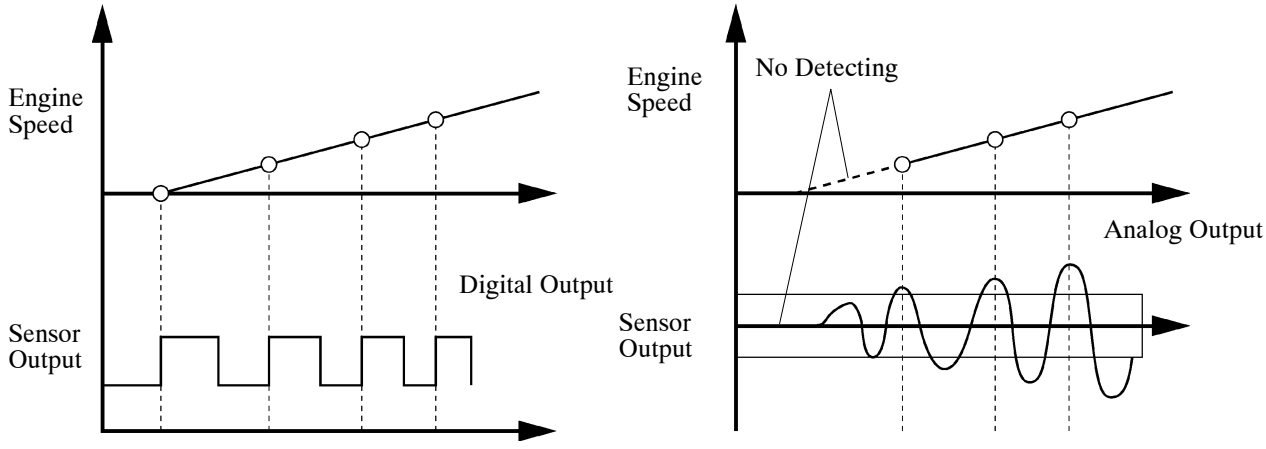
Item	Sensor Type	
	MRE	Pick up Coil
Signal Output	Constant digital output starts from low engine speeds	Analog output changes with the engine speed
Camshaft Position Detection	Detection based on the waveforms output throughout the timing rotor speed range	Detection based on the waveforms output as the protruded portion of the timing rotor passes

▶ Wiring Diagram◀



271EG160

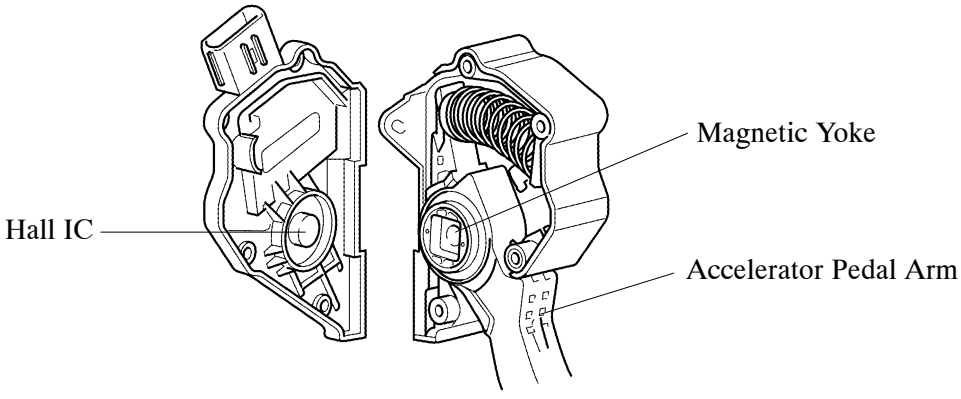
▶ MRE Type and Pickup Coil Type Output Waveform Image Comparison ◀



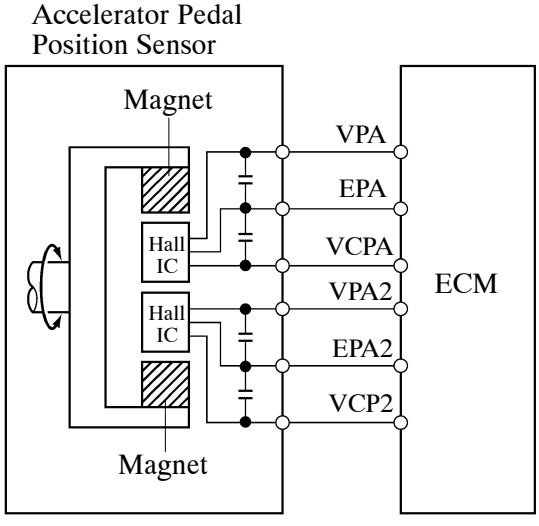
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Accelerator Pedal Position Sensor

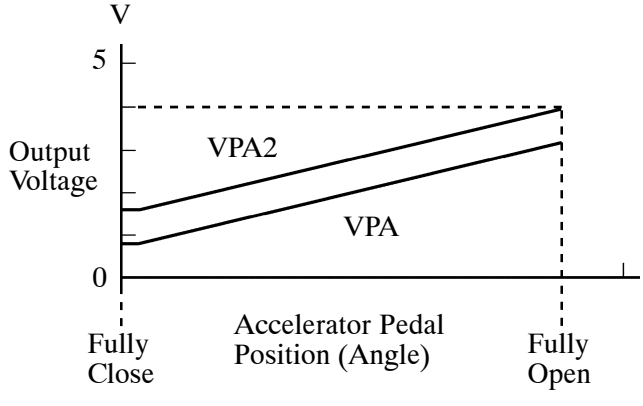
- The no-contact type accelerator pedal position sensor uses a Hall IC, which is mounted on the accelerator pedal arm.
- A magnetic yoke is mounted at the base of the accelerator pedal arm. This yoke rotates around the Hall IC in accordance with the amount of effort that is applied to the accelerator pedal. The Hall IC converts the changes that occur in the magnetic flux into electrical signals, and outputs them in the form of accelerator pedal position signals to the ECM.
- The Hall IC contains two circuits, one for the main signal, and one for the sub signal. It converts the accelerator pedal position (angle) into electric signals that have differing characteristics and outputs them to the ECM.



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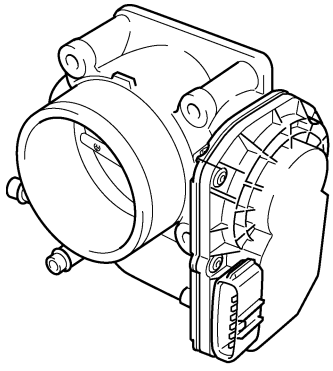
228TU24

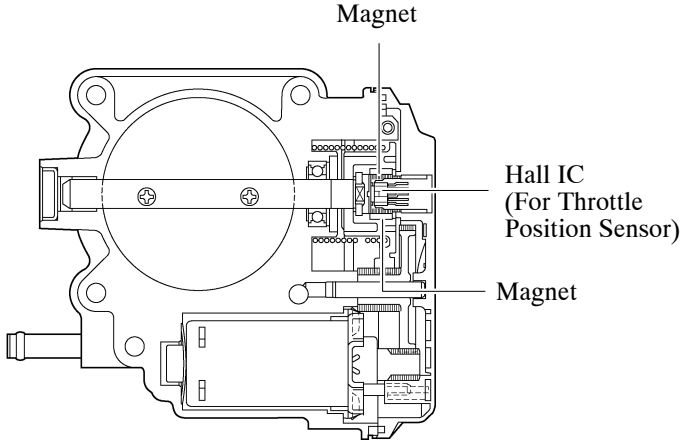


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Throttle Position Sensor

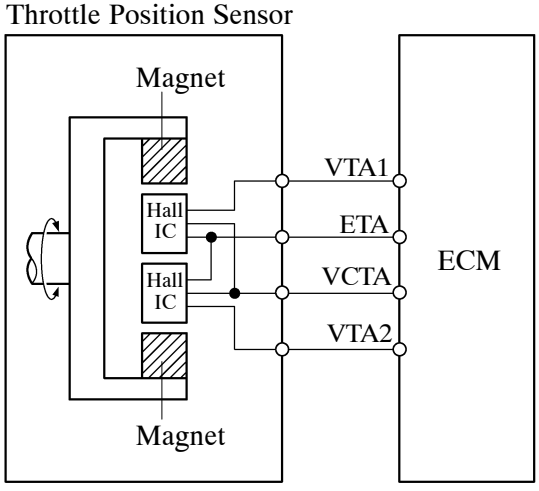
- The no-contact type throttle position sensor uses a Hall IC, which is mounted on the throttle body.
- The Hall IC is surrounded by a magnetic yoke. The Hall IC converts the changes that occur in the magnetic flux into electrical signals, and outputs them in the form of throttle valve position signals to the ECM.
- The Hall IC contains circuits for the main and sub signals. It converts the throttle valve opening angle into two electrical signals that have differing characteristics and outputs them to the ECM.

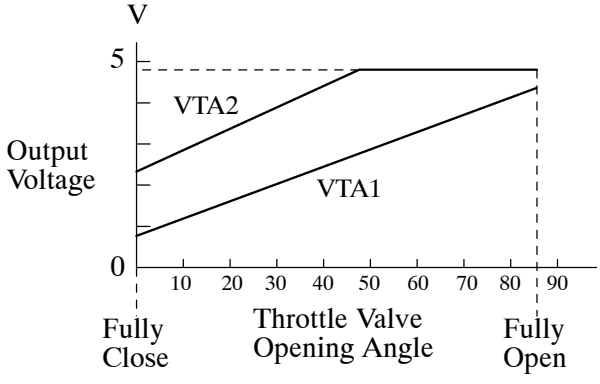




Cross Section

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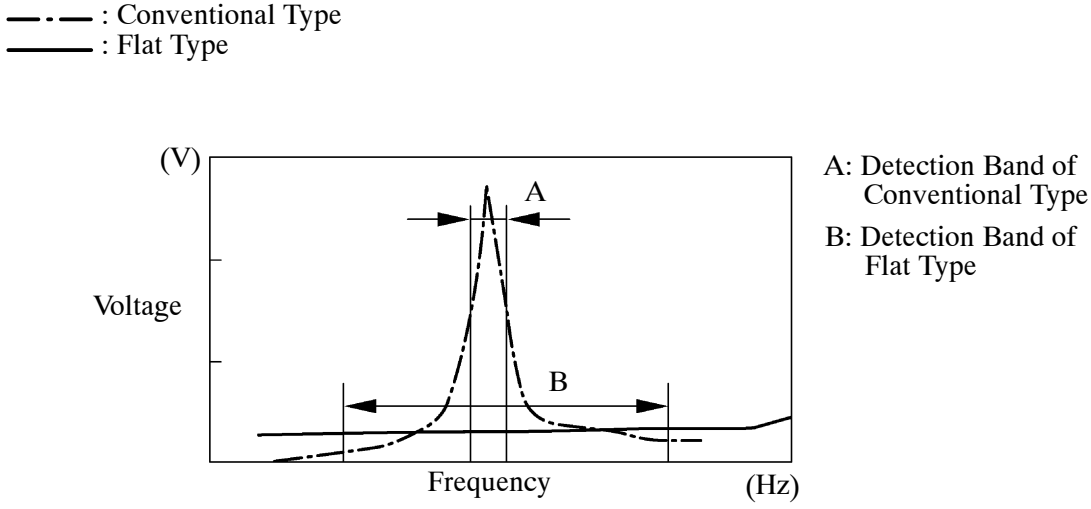
Knock Sensor (Flat Type)

1) 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.

On the other hand, a flat type knock sensor (non-resonant type) has the ability to detect vibration in a wider frequency band from about 6 kHz to 15 kHz, and has the following features:

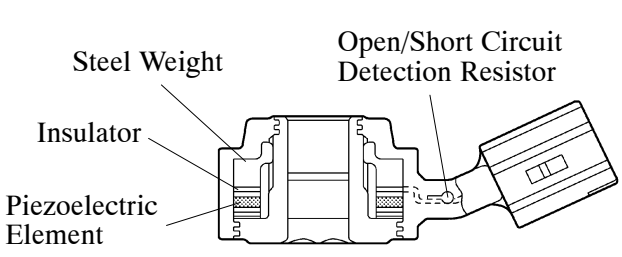
- The engine knocking frequency will change a bit depending on the engine speed. The flat type knock sensor can detect vibration even when the engine knocking frequency is changed. Thus the vibration detection ability is increased compared to the conventional type knock sensor, and a more precise ignition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



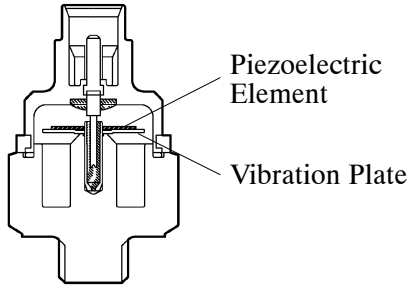
Characteristic of Knock Sensor 214CE04

2) 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 is running through in 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.



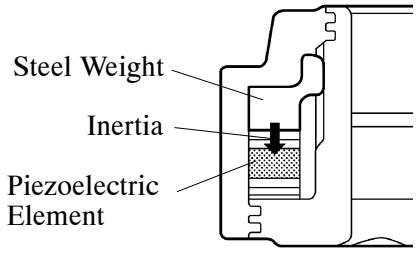
Flat Type Knock Sensor (Non-resonant Type) 214CE01



Conventional Type Knock Sensor (Resonant Type) 214CE02

3) Operation

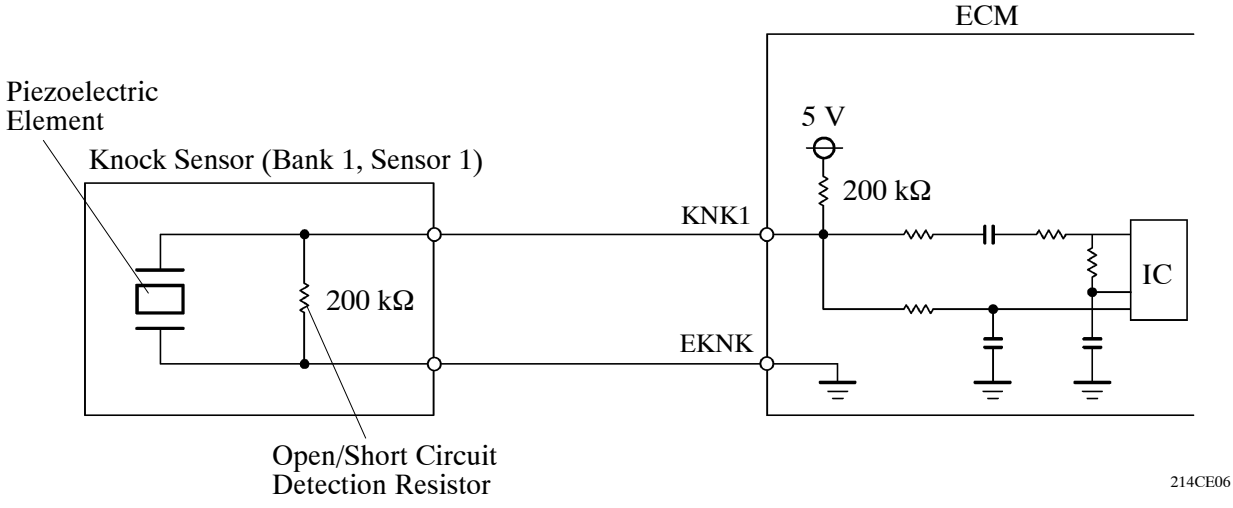
The knocking vibration is transmitted to the steel weight and its inertia applies pressure to the piezoelectric element. The action generates electromotive force.



214CE08

4) Open/Short Circuit Detection Resistor

During the power source is IG-ON, the open/short circuit detection resistor in the knock sensor and the resistor in the ECM keep the voltage at the terminal KNK1 of engine constant.
An IC (Integrated Circuit) in the ECM is always monitoring the voltage of the terminal KNK1. If the open/short circuit occurs between the knock sensor and the ECM, the voltage of the terminal KNK1 will change and the ECM detects the open/short circuit and stores DTC (Diagnostic Trouble Code).



214CE06

Service Tip

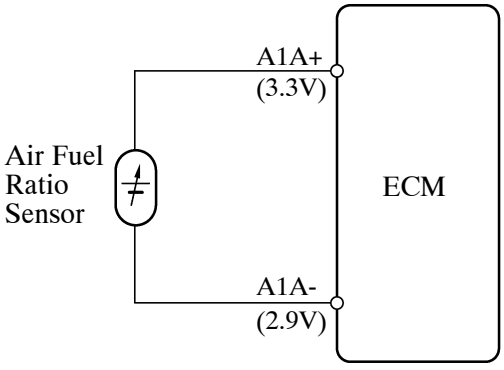
These knock sensors are mounted in specific directions at specific angles. To prevent the right and left bank wiring connectors from being interchanged, make sure to install each sensor in its prescribed direction. For details, refer to the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

EG

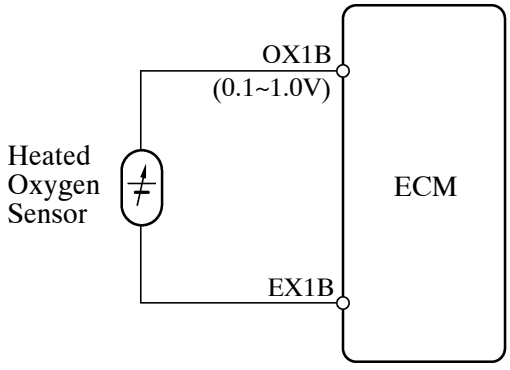
Air Fuel Ratio Sensor and Heated Oxygen Sensor

1) 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 0.4V 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 converts the changes in the output amperage into voltage in order to linearly detect the present air-fuel ratio.

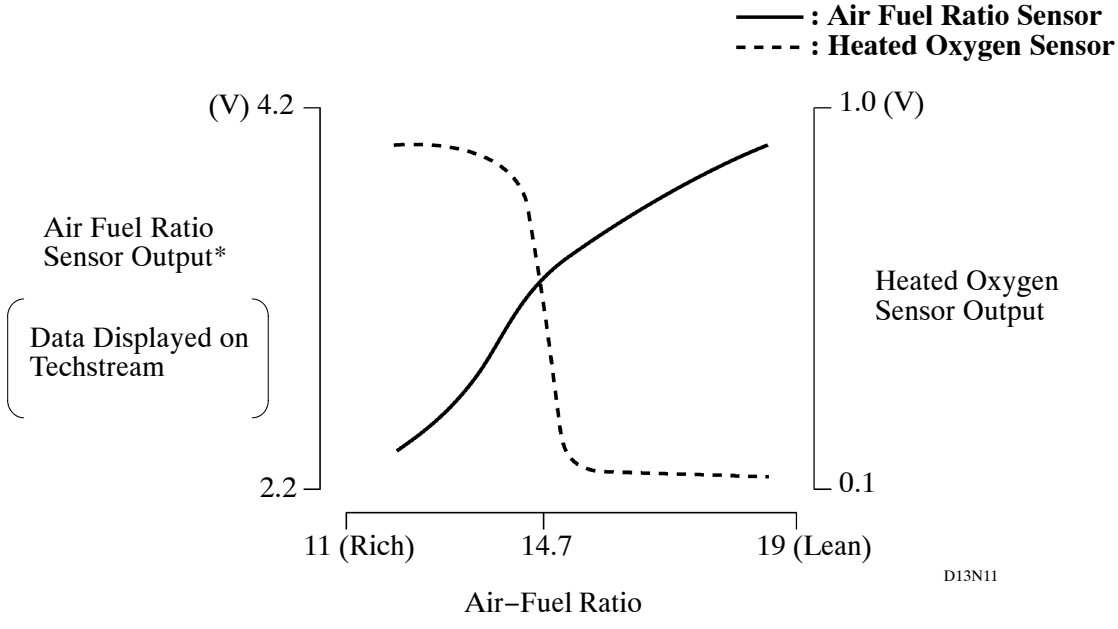


Air Fuel Ratio Sensor Circuit (Bank 1, Sensor 1)



Heated Oxygen Sensor Circuit (Bank 1, Sensor 2)

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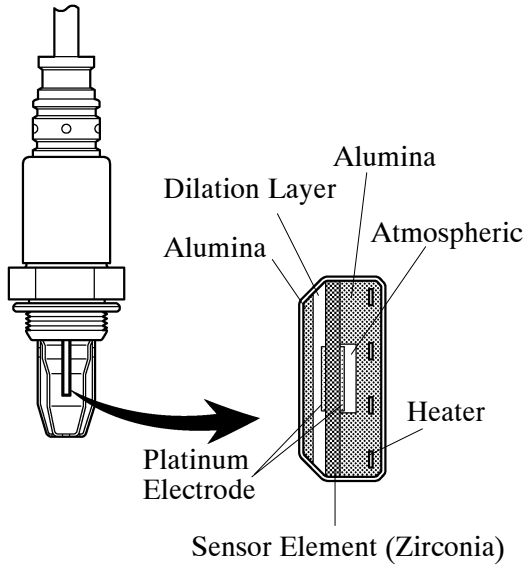


D13N11

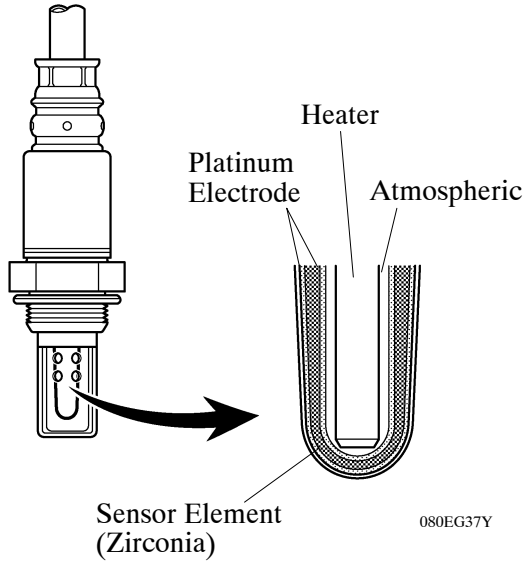
*: This calculation value is used internally in the ECM, and is not an ECM terminal voltage.

2) 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 a heater.
- The planar type sensor uses alumina, which excels in heat conductivity and insulation, to integrate a sensor element with a heater, thus improving the warm up performance of the sensor.



Air Fuel Ratio Sensor (Planar Type)*



Heated Oxygen Sensor (Cup Type)*

*: The illustrations above are intended to show the differences in the basic construction between the cup type sensor and the planner type sensor, so the illustrated sensor shapes may differ from the actual ones.

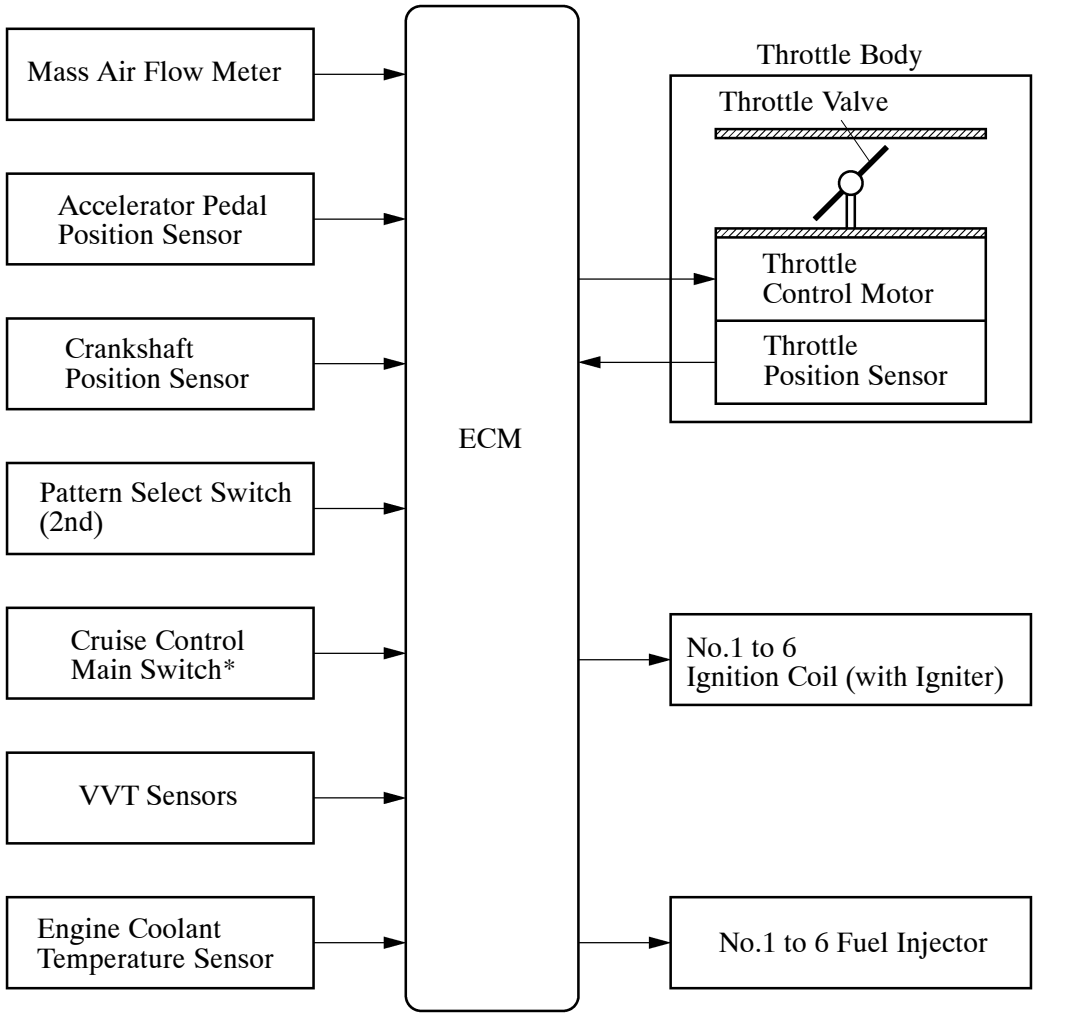
EG

6. ETCS-i (Electronic Throttle Control System-intelligent)

General

- In the conventional throttle body, the throttle valve angle is determined invariably by the amount of the 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. For details, see page EG-73.

▶ System Diagram ◀



*: Optional Equipment

Control

1) General

The ETCS-i consists of the following functions:
- Normal Throttle Control (non-linear control)
- ISC (Idle Speed Control)
- Cruise Control (optional equipment)

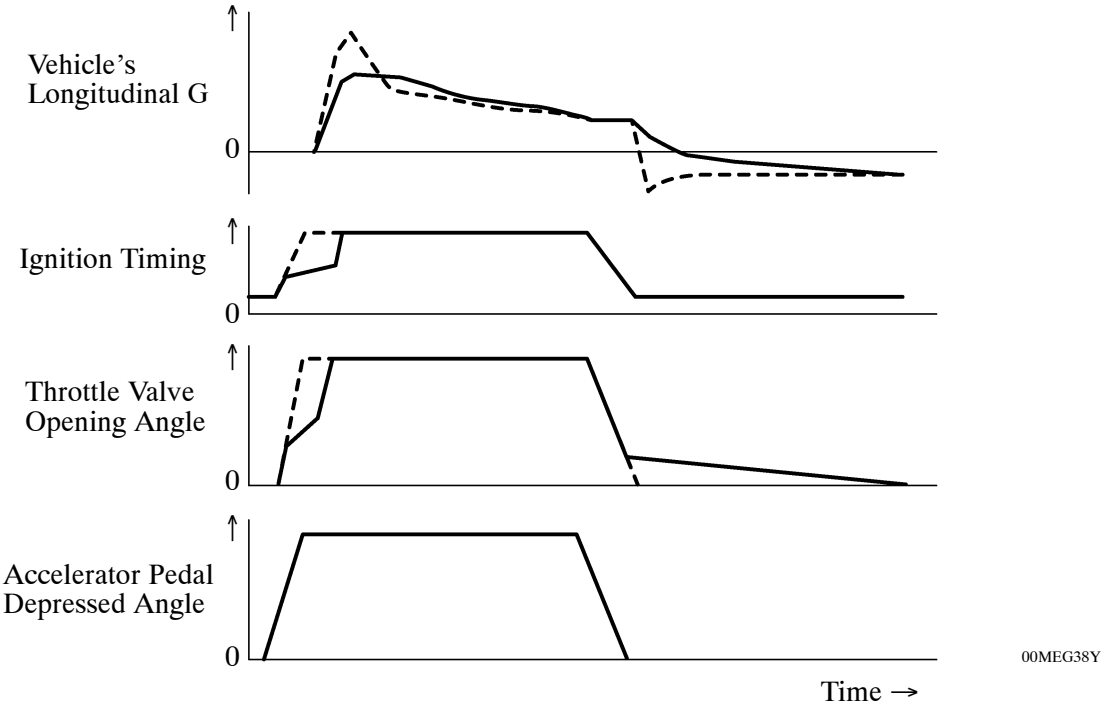
2) Normal Throttle Control (Non-linear Control)

a. General

Controls the throttle to an optimal throttle valve angle that is appropriate for the driving condition such as the amount of the accelerator pedal effort and the engine speed in order to realize excellent throttle control and comfort in all operating ranges.

▶ Conceptual Diagrams of Engine Control During Acceleration and Deceleration ◀

——— : With Control
- - - - : Without Control



b. 2nd Start Control (Only for models with Automatic Transmission)

In situations in which low-μ(low friction) road surface conditions can be anticipated, such as when driving in the snow, the rate of throttle valve opening can be controlled to help vehicle stability while driving on the slippery surface. This is accomplished by turning on 2nd start control. Pressing the 2nd side of the pattern select switch activates this control. This control modifies the relationship and reaction of the throttle to the accelerator pedal, and assists the driver by reducing the engine output from that of a normal level.

3) Idle Speed Control

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

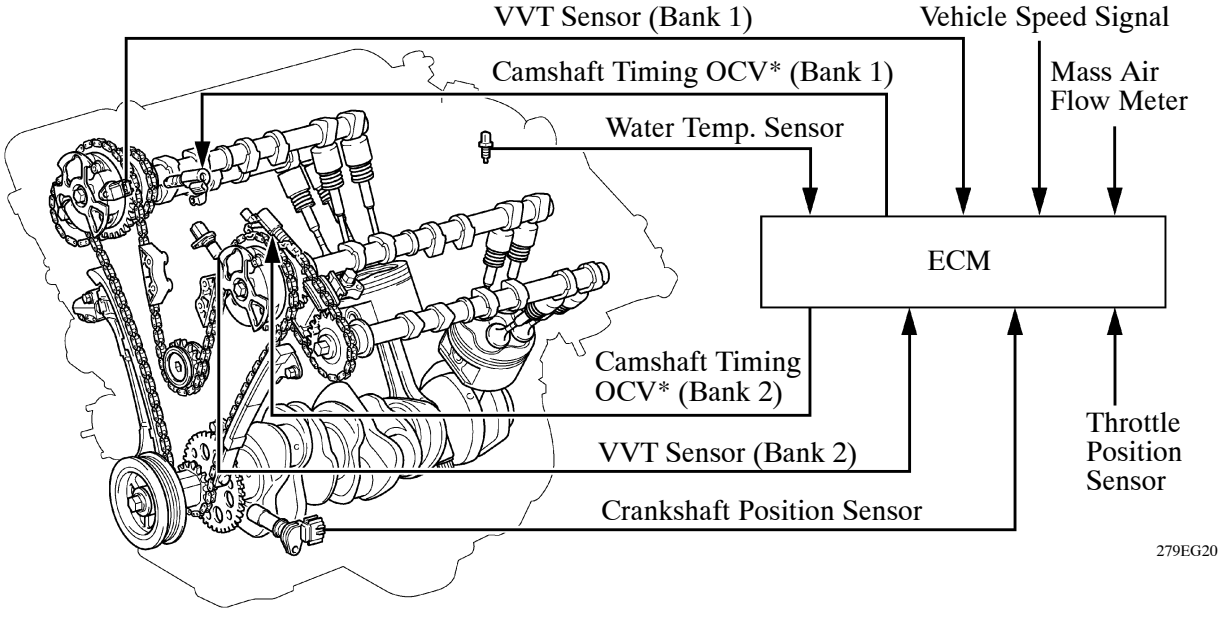
4) Cruise Control

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

7. VVT-i (Variable Valve Timing-intelligent) System

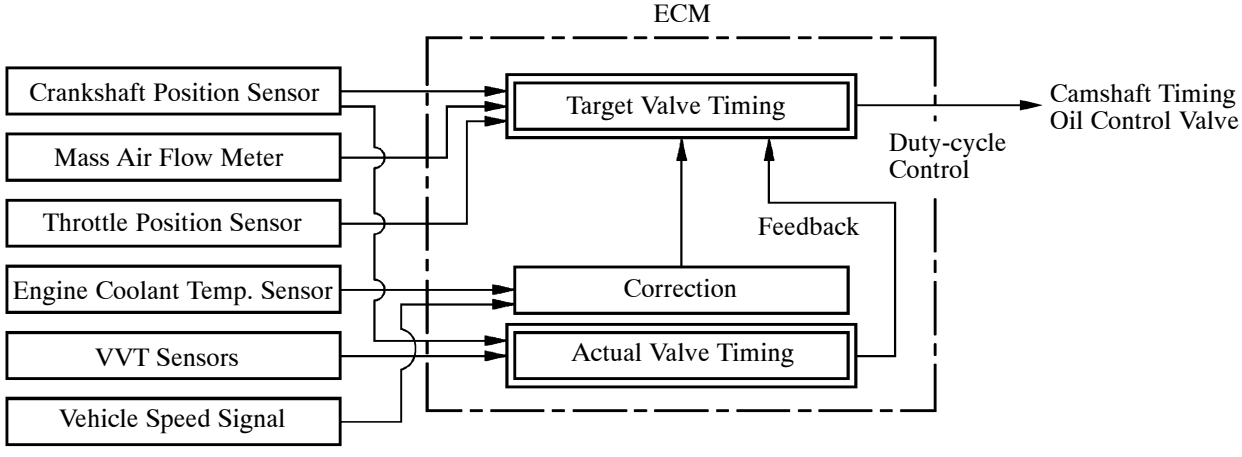
General

- The VVT-i system is designed to control the intake camshaft within a range of 50° (of Crankshaft Angle) to provide valve timing that is optimally suited to the engine condition. This improves torque in all the speed ranges as well as increasing fuel economy, and reducing exhaust emissions.

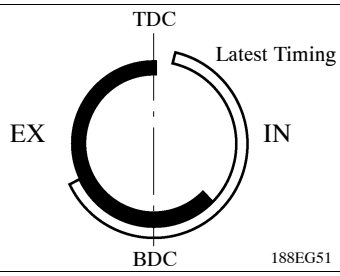
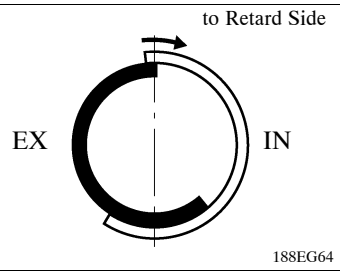
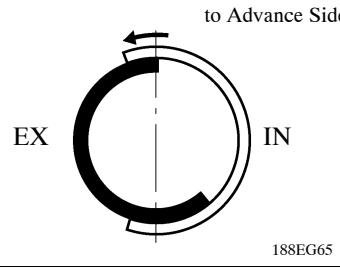
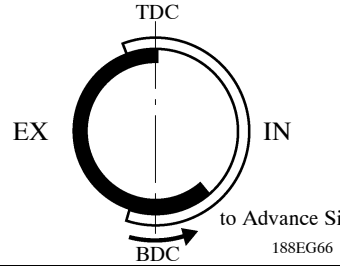
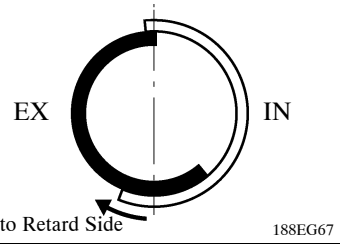
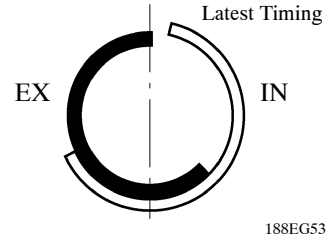
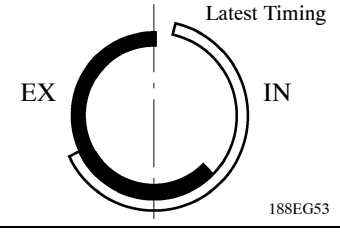


*: Oil Control Valve

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



Effectiveness of the VVT-i System

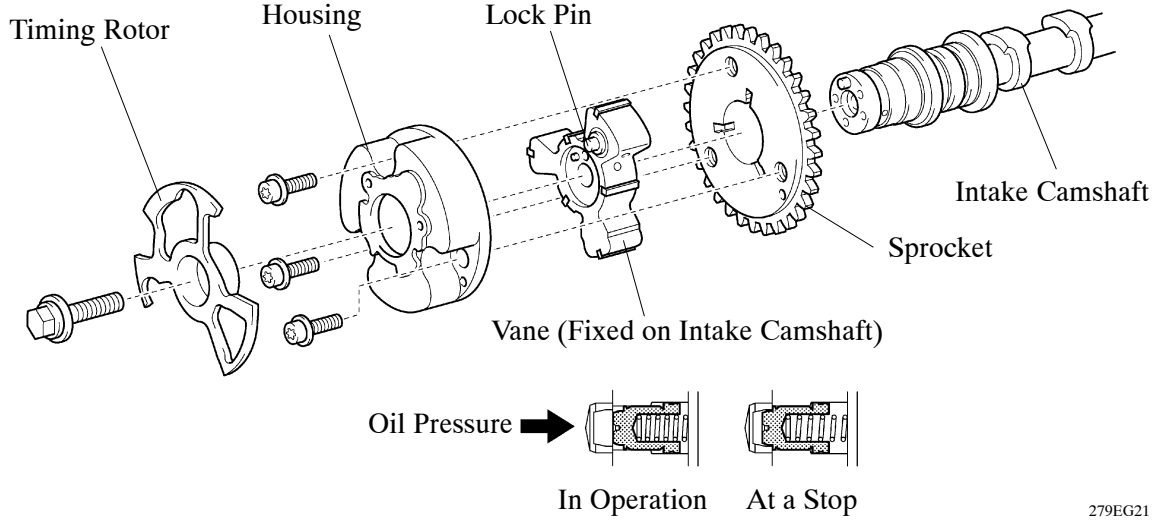
Operation State	Objective		Effect
During Idling		Eliminating overlap to reduce blow back to the intake side	• Stabilized idling rpm • Better fuel economy
At Light Load		Minimizing overlap to reduce blow back to the intake side.	Ensured engine stability
At Medium Load		Increasing overlap to increase internal EGR to reduce pumping loss	• Better fuel economy • Improved emission control
In Low to Medium Speed Range with Heavy Load		Advancing the intake valve close timing for volumetric efficiency improvement	Improved torque in low to medium speed range
In High Speed Range with Heavy Load		Retarding the intake valve close timing for volumetric efficiency improvement	Improved output
At Low Temperatures		Eliminating overlap to prevent blow back to the intake side and stabilizes the idling speed at fast idle.	• Stabilized fast idle rpm • Better fuel economy
• Upon Starting • Stopping the Engine		Eliminating overlap to reduce blow back to the intake side	Improved startability

EG

Construction

1) VVT-i Controller

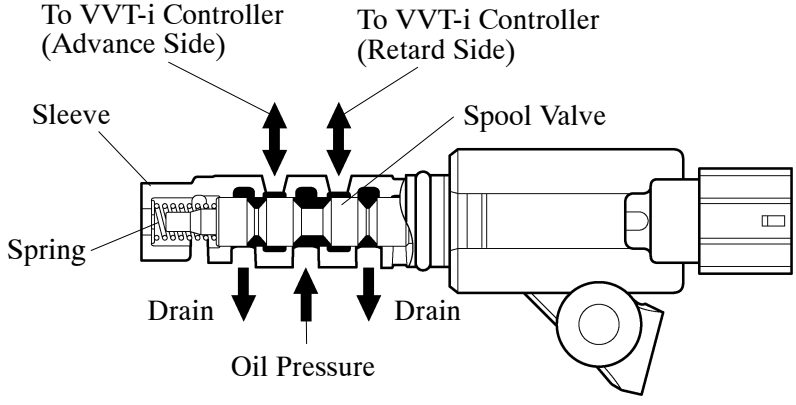
This controller consists of the housing driven from the timing chain and the vane coupled with the intake camshaft. The oil pressure sent from the advance or retard side path at the intake camshaft causes rotation in the VVT-i controller vane circumferential direction to vary the intake valve timing continuously. When the engine is stopped, the intake camshaft will be in the most retarded state to ensure startability. When hydraulic pressure is not applied to the VVT-i controller immediately after the engine has started, the lock pin locks the movement of the VVT-i controller to prevent a knocking noise. Thereafter, when hydraulic pressure is applied to the VVT-i controller, the lock pin is released.



Lock Pin

2) Camshaft Timing Oil Control Valve

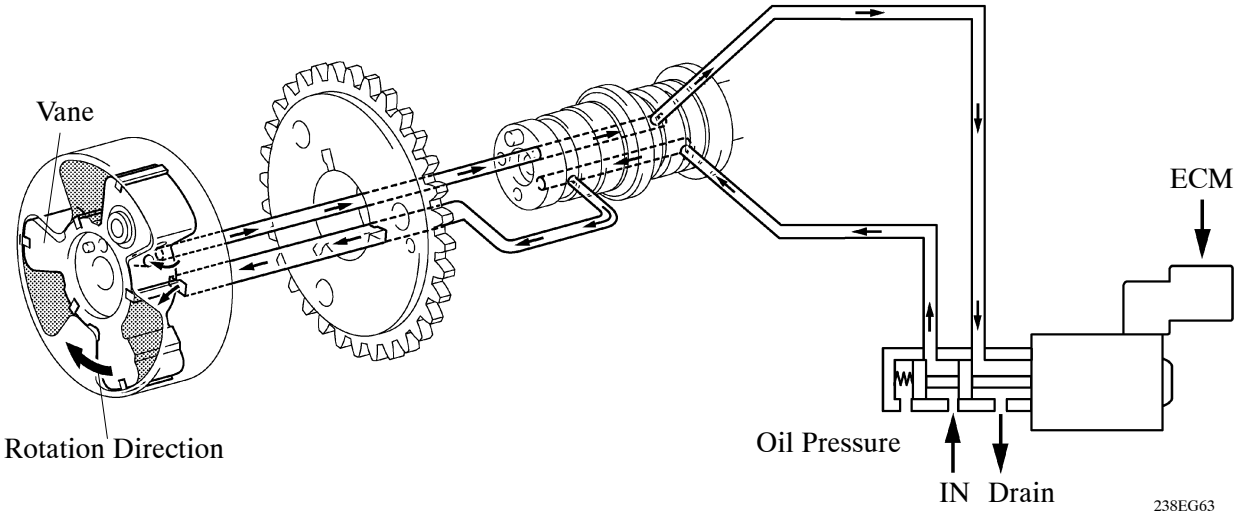
This camshaft timing oil control valve controls the spool valve using duty-cycle control from the ECM. This allows hydraulic pressure to be applied to the VVT-i controller advance or retard side. When the engine is stopped, the camshaft timing oil control valve is in the most retard position.



Operation

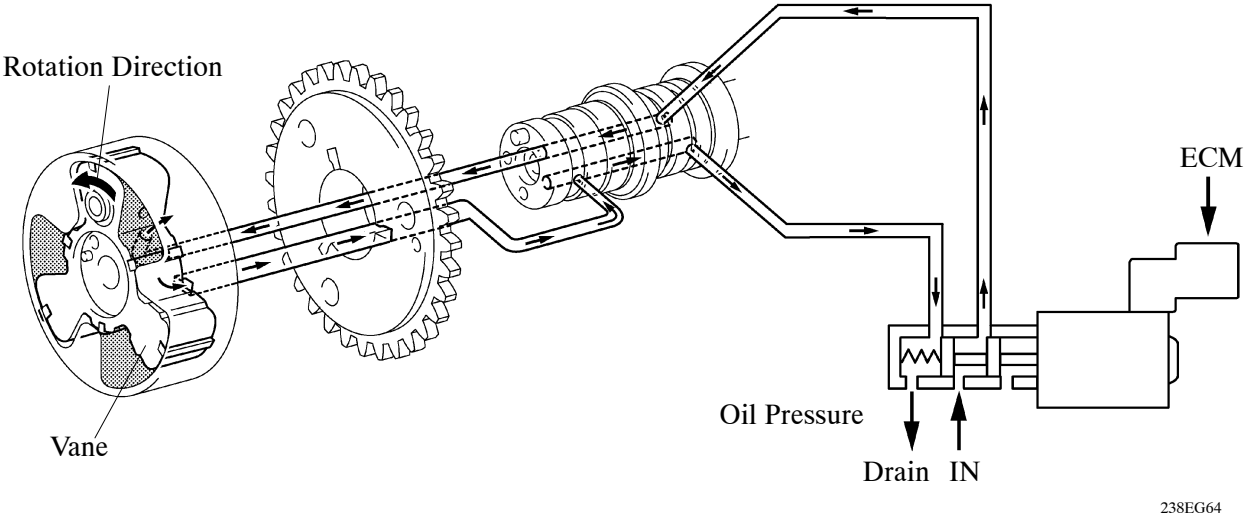
1) Advance

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.



2) 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.



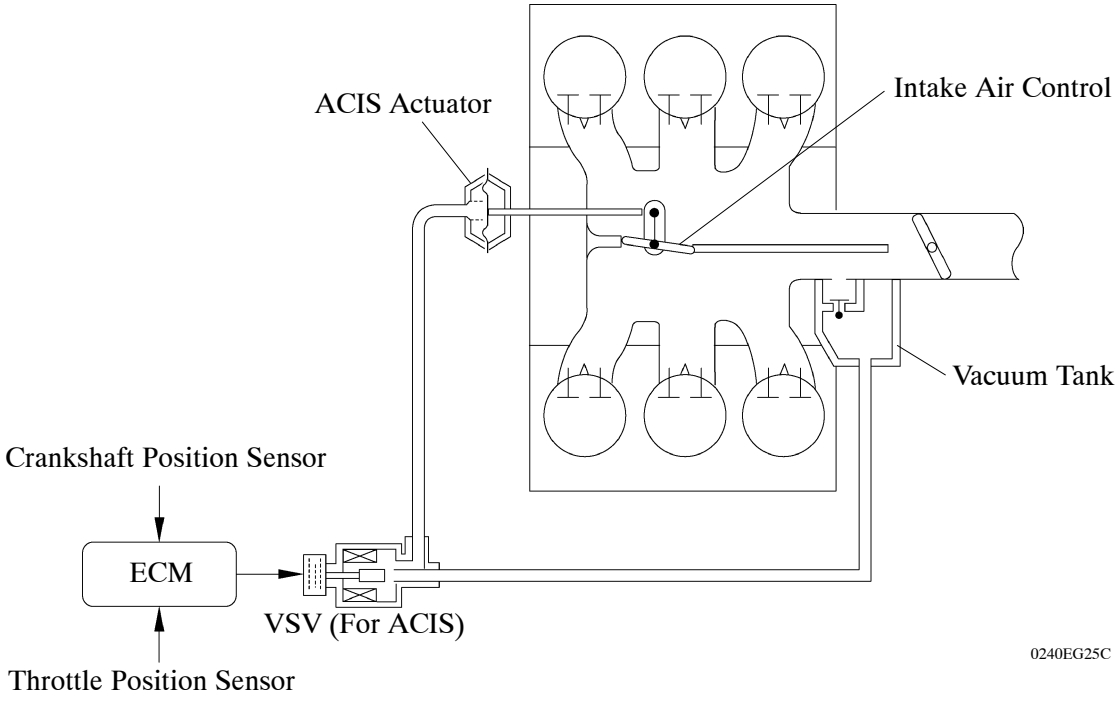
3) Hold

After reaching the target timing, the valve timing is held by keeping the camshaft timing oil control valve in the neutral position unless the traveling state changes.
This adjusts the valve timing at the desired target position and prevents the engine oil from running out when it is unnecessary.

8. ACIS (Acoustic Control Induction System)

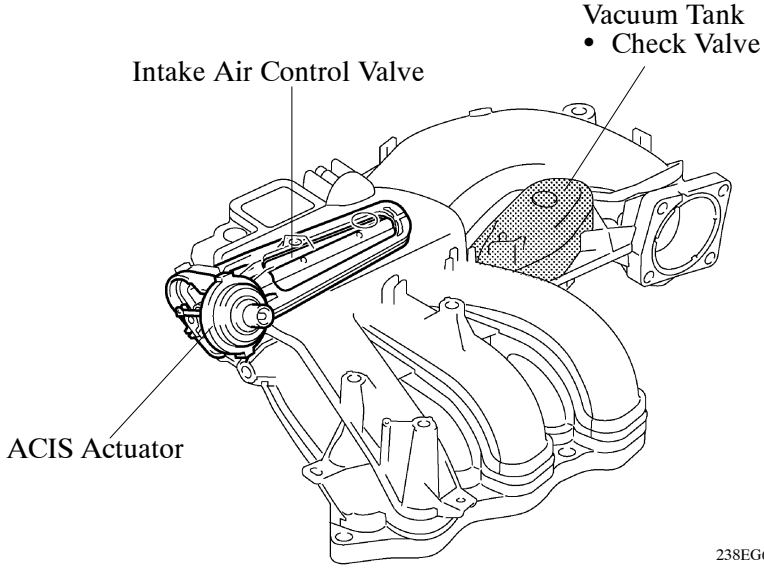
General

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



Intake Air Control Valve and Vacuum Tank

- The intake air control valve and the vacuum tank are installed in the intake surge tank.
- The intake air control valve opens and closes to make two effective lengths of the intake manifold possible.
- The vacuum tank is equipped with an internal check valve. The check valve stores the vacuum that is used for application of the ACIS actuator in order to maintain the intake air control valve fully closed even during low-vacuum conditions.

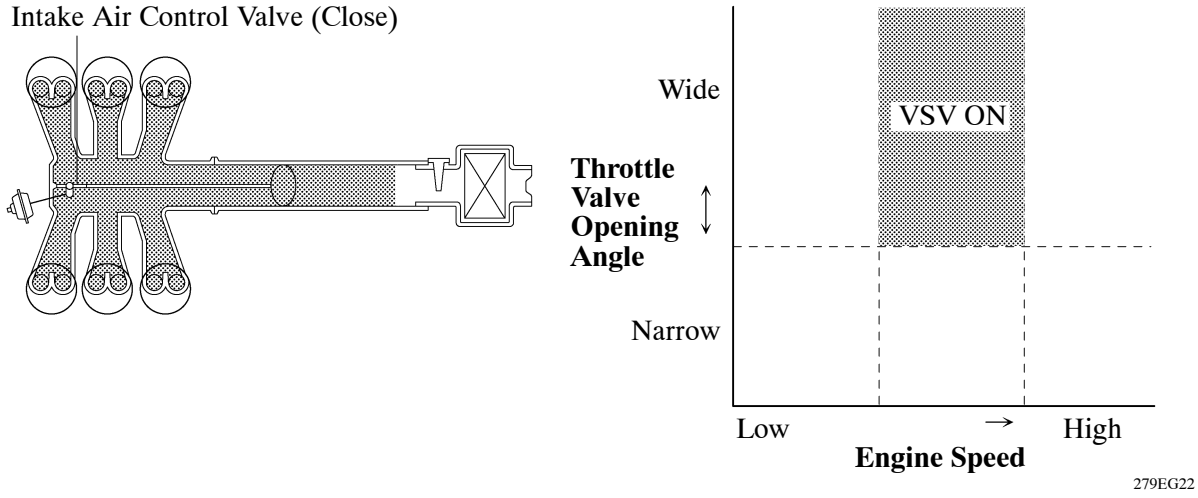


Operation

1) Intake Air Control Valve Close (VSV ON)

The ECM activates the VSV to match the longer pulsation cycle of the intake air charge. The vacuum from the VSV acts on the diaphragm chamber of the ACIS actuator. This closes the intake air control valve. As a result, the effective length of the intake manifold is increased and the intake efficiency in the medium speed range is improved due to the dynamic effect (inertia) of the intake air, thereby increasing power output in this engine speed range.

: Effective Intake Manifold Length

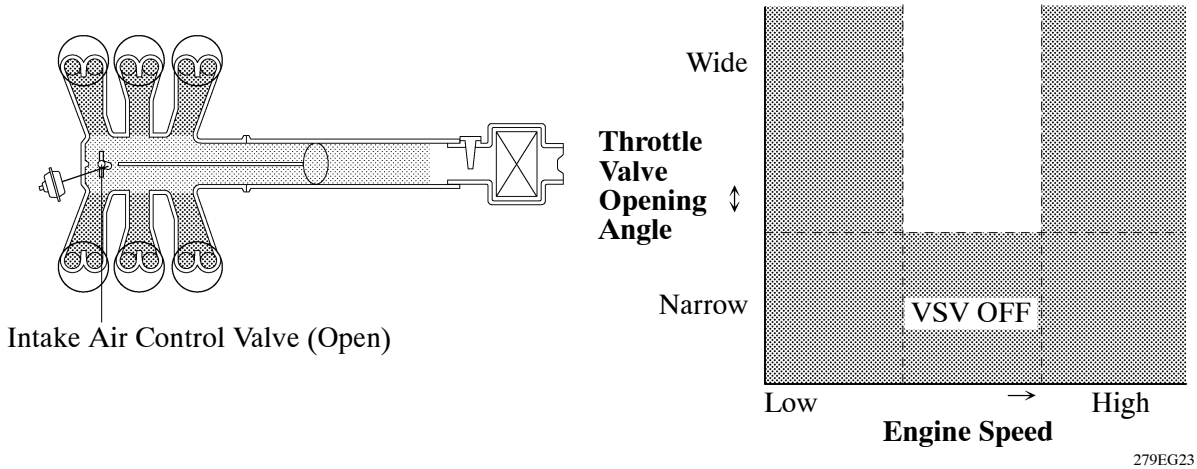


2) Intake Air Control Valve Open (VSV OFF)

The ECM deactivates the VSV to match the shorter pulsation cycle of the intake air. Deactivating the VSV allows atmospheric air into the diaphragm chamber of the ACIS actuator opening the intake air control valve. When the intake air control valve is open, the effective length of the intake air chamber is shortened and peak intake efficiency is shifted to the low-to-high engine speed range, thus providing greater output at low-to-high engine speeds.

: Effective Intake Manifold Length

: Effective Intake Air Chamber Length



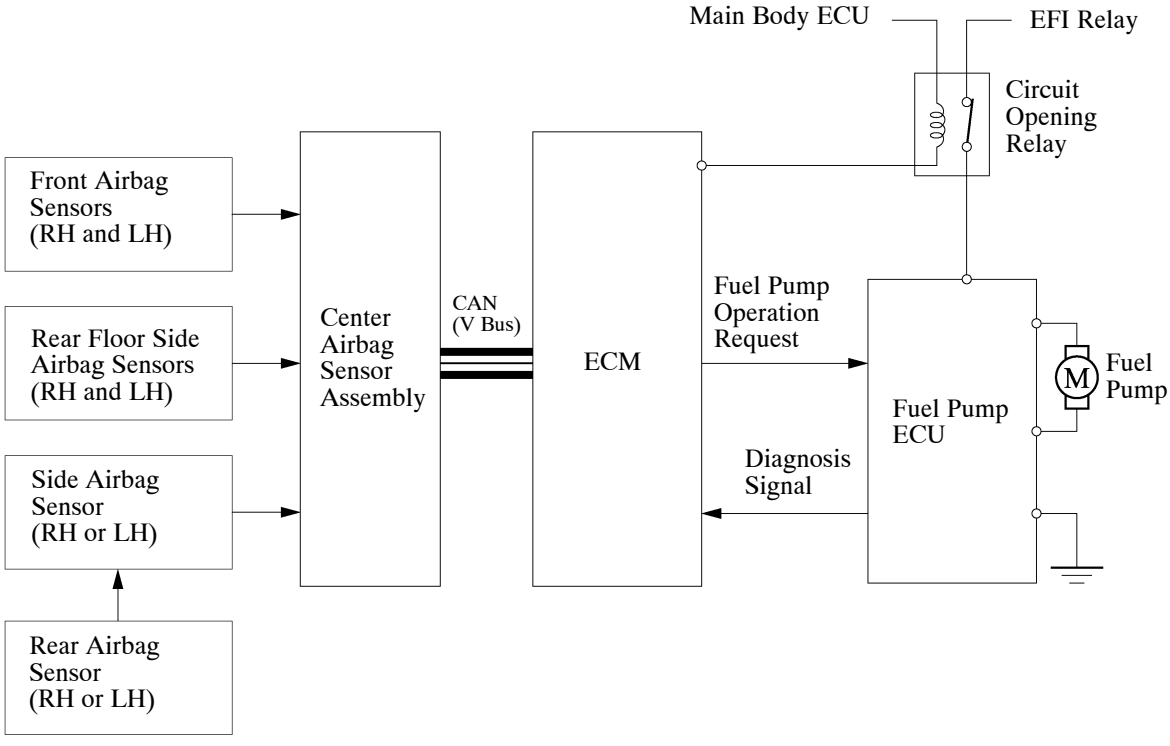
9. Fuel Pump Control

General

In this vehicle, there are 2 types of fuel pump control. The fuel pump is controlled to an optimum speed to match the engine operating conditions, and the fuel pump operation is cut 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 deploy. 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 fuel pump ECU is stopped, causing the fuel pump to stop operating. After the fuel cut control has been activated, turning the power source from OFF to IG-ON cancels the fuel cut control, and the engine can be restarted.

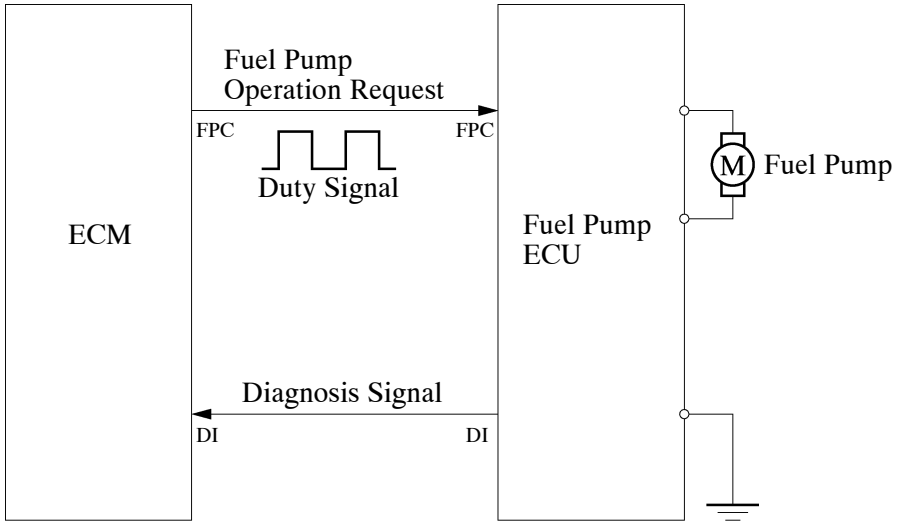
▶ System Diagram ◀



080EG27S

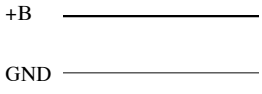
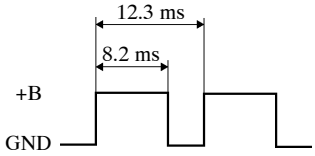
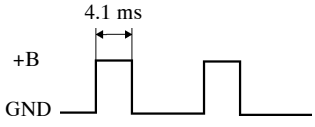
Fuel Pump ECU

- The fuel pump ECU controls fuel pump speed by receiving a duty cycle signal (FPC terminal input) from the ECM, control is performed to three 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.



04E0EG24C

▶ FPC Terminal Input ◀

FPC Input Signal (Duty Signal)	Fuel Pump Speed
 04E0EG25C	Hi
 04E0EG26C	Middle
 04E0EG27C	Low
 04E0EG28C	Stop

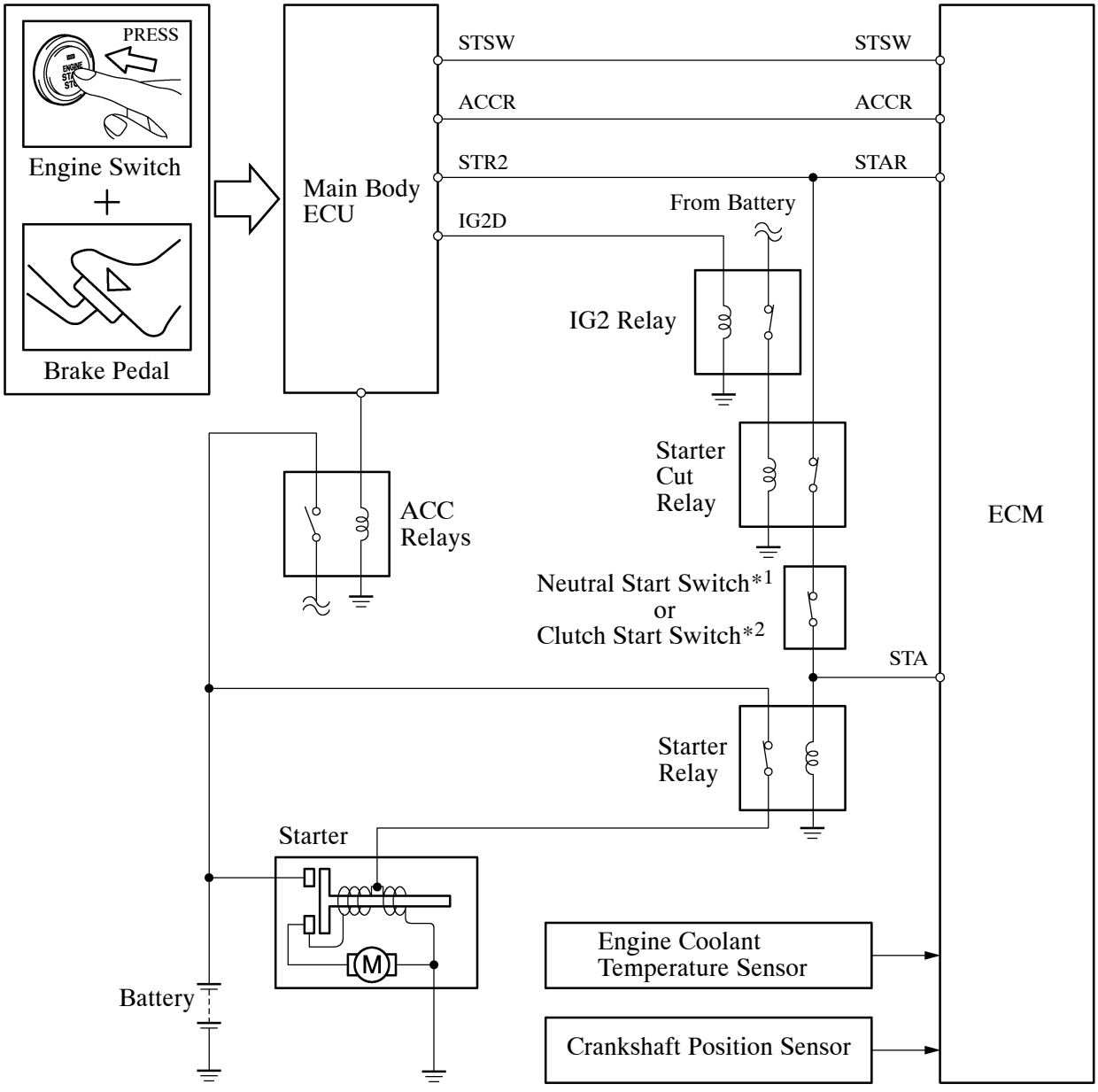
EG

10. Cranking Hold Function

General

- Once the engine switch is pressed, this function continues to operate the starter until the engine has started, provided that the brake pedal (A/T) or clutch pedal (M/T) is depressed. This prevents starting failure and the engine from being cranked after it has started.
- When the ECM detects a start signal from the main body ECU, this system monitors the engine speed (NE signal) and continues to operate the starter until it has determined that the engine has started. Furthermore, even if the ECM detects a start signal from the main body ECU, this system will not operate the starter if the ECM has determined that the engine has already started.

▶ System Diagram ◀

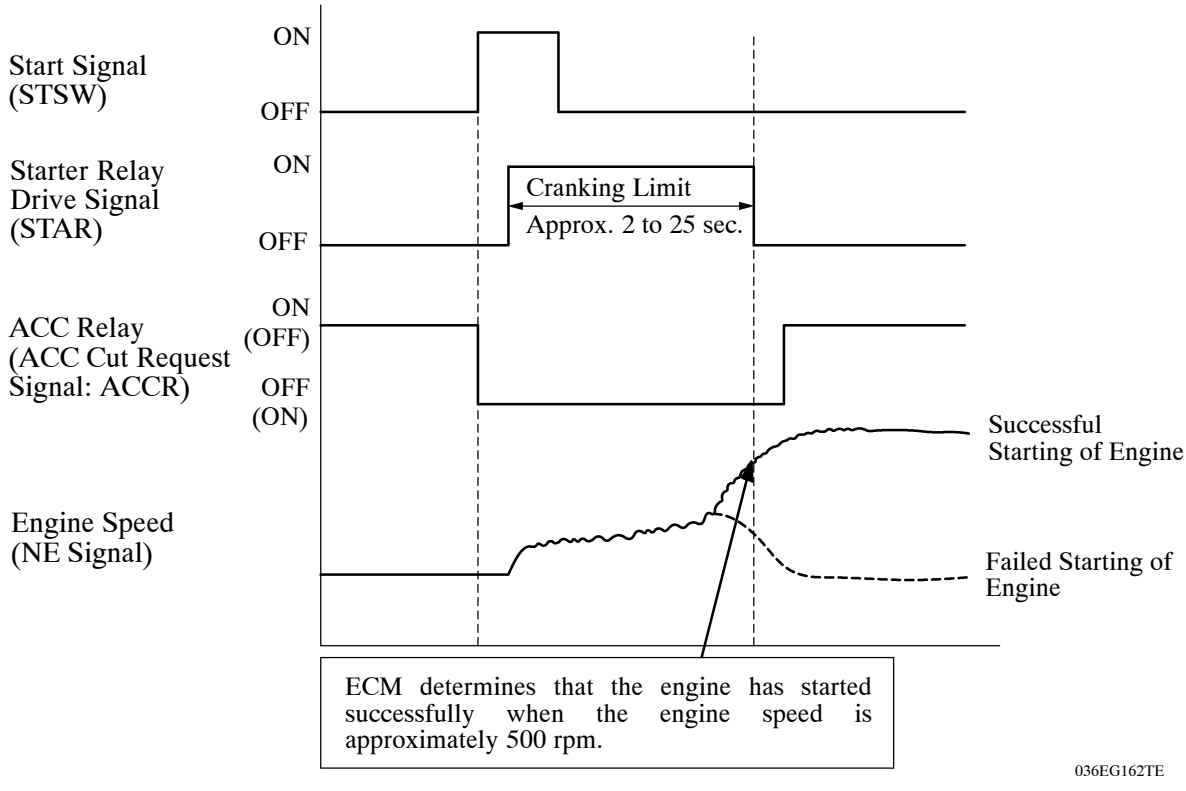


*1: Models with Automatic Transmission
*2: Models with Manual Transmission

Operation

- As indicated in the below timing chart, when the ECM detects a STSW signal (start signal) from the main body ECU, the ECM outputs STAR signal (starter relay drive signal) through the starter cut relay to the starter relay and actuates the starter. The ECM also outputs ACCR signal (ACC cut request signal) to the main body ECU. Thus, the main body ECU will not energize the ACC 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 output of the STAR signal to the starter relay and the output of ACCR signal to the main body ECU. Thus, the starter operation stops and the main body ECU energize the ACC relay.
- If the engine has any failure and does not start, the starter operates as long as its maximum continuous operation time and stops automatically. The maximum continuous operation time is approximately 2 seconds through 25 seconds depending on the engine coolant temperature condition. When the engine coolant temperature is extremely low, it is approximately 25 seconds and when the engine is warmed up sufficiently, it is approximately 2 seconds.
- 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 that is associated with the cranking of the engine.
- This system has following protection features:
  - While the engine is running normally, the starter does not operate.
  - Even if the driver keeps pressing the engine switch, the ECM stops the output of the STAR and ACCR signals when the engine speed becomes higher than 1200 rpm. Thus, the starter operation stops and the main body ECU energize the ACC relay.
  - In case the driver keeps pressing the engine switch and the engine does not start, the ECM stops the output of the STAR and ACCR signals after 30 seconds have elapsed. Thus, the starter operation stops and the main body ECU energize the ACC relay.
  - In case the ECM cannot detect an engine speed signal while the starter is operating, the ECM will immediately stop the output of the STAR and ACCR signals. Thus, the starter operation stops and the main body ECU energize the ACC relay.

▶ Timing Chart ◀



11. Diagnosis

- When the ECM detects a malfunction, the ECM makes a diagnosis and memorizes the failed section. Furthermore, the check engine warning light in the combination meter illuminates or blinks to inform the driver.
- The ECM will also store the DTC (Diagnostic Trouble Code) of the malfunctions. The DTC can be accessed by using the intelligent tester II.
- For details, refer to the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

Service Tip

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

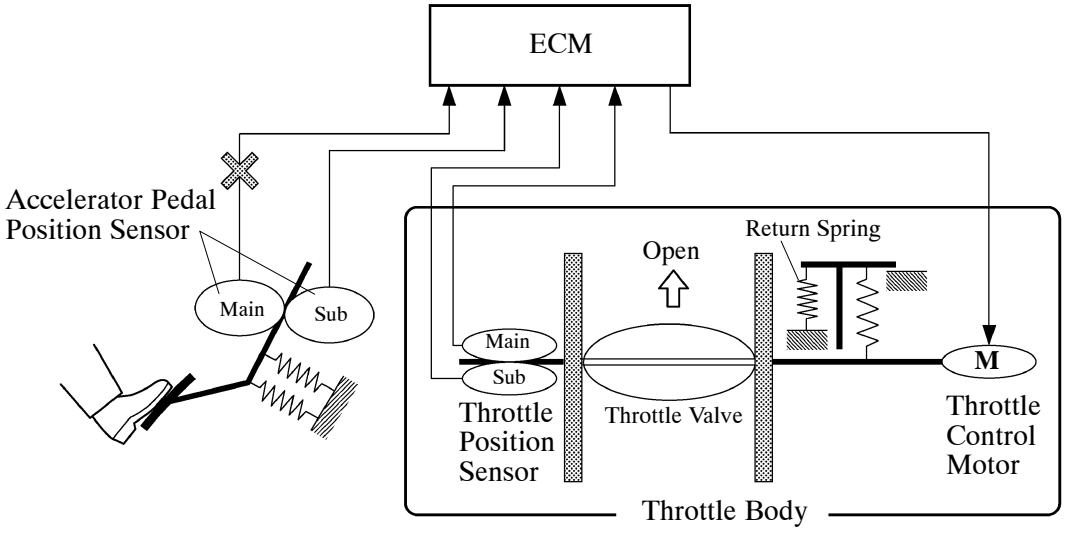
12. Fail-safe

General

When a malfunction is detected at any of the sensors, there is a possibility of an engine or other malfunction occurring if the ECM were to continue 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 Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

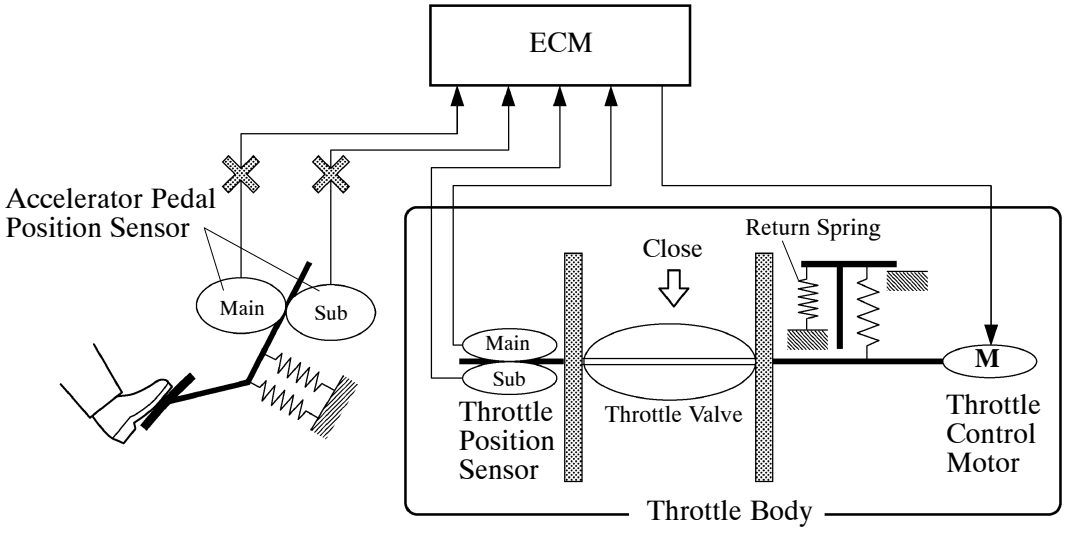
Fail-safe Operation due to Accelerator Pedal Position Sensor Trouble

- The accelerator pedal position sensor comprises two (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.



D13N08

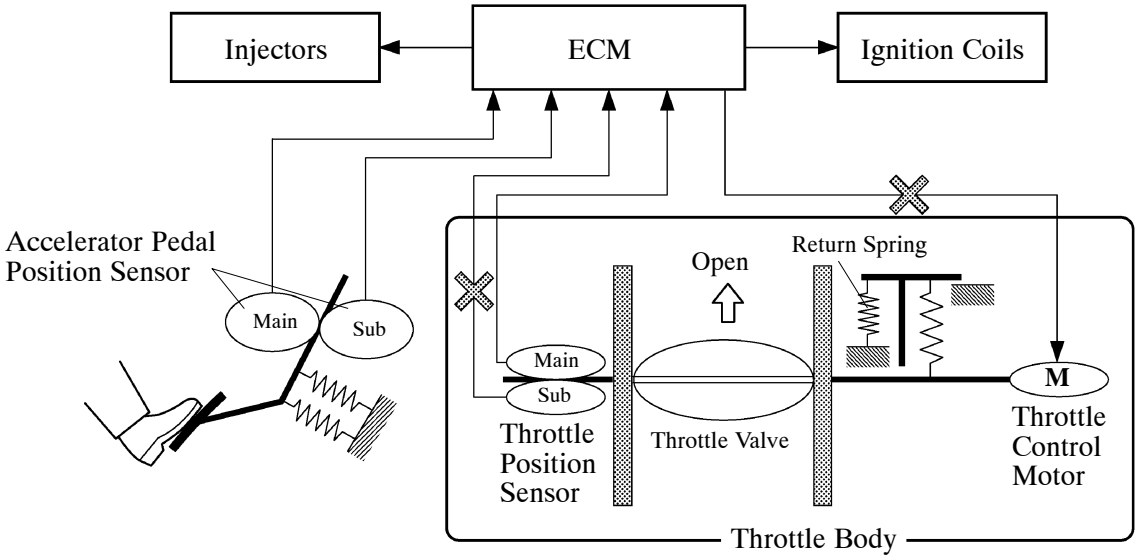
- If both circuits malfunction, the ECM detects the abnormal signal voltage from these two sensor circuits and discontinues the throttle control. At this time, the vehicle can be driven within its idling range.



D13N09

Fail-safe Operation due to Throttle Position Sensor Trouble

- The throttle position sensor comprises two (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, 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.



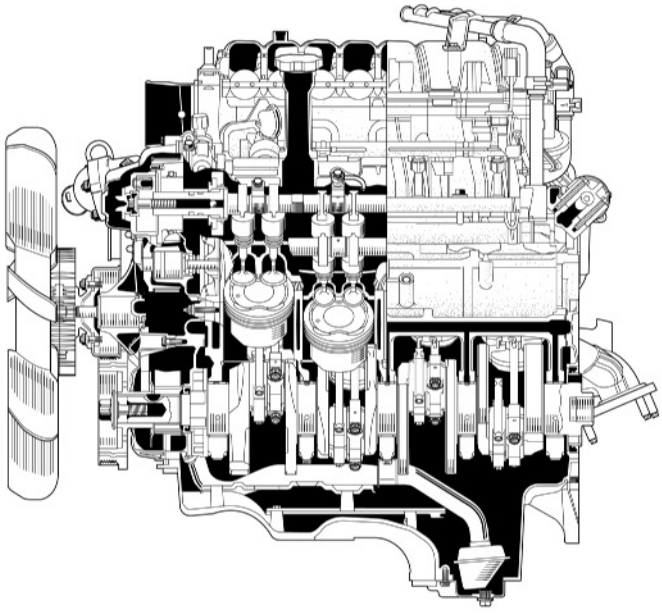
D13N10

2UZ-FE ENGINE

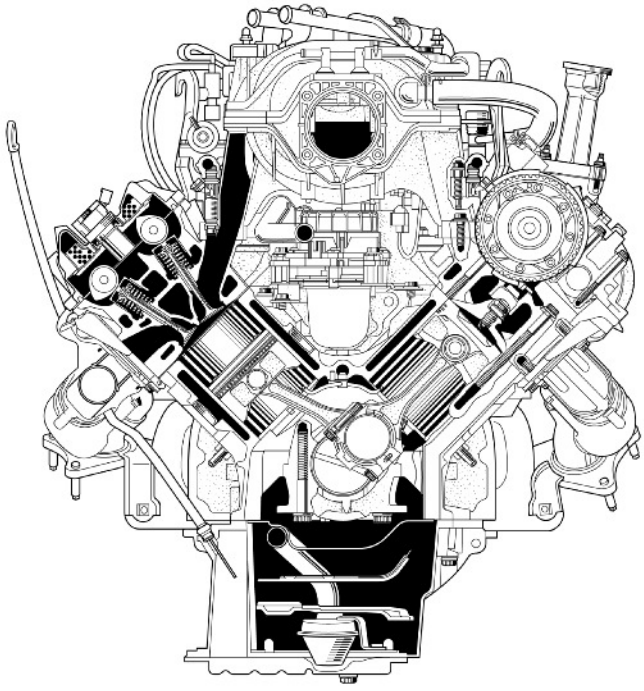
■ DESCRIPTION

The 2UZ-FE engine is a V8 4.7-liter, 32-valve DOHC. This engine is added the VVT-i (Variable Valve Timing-intelligent) system, ACIS (Acoustic Control Induction System), and Air Injection system* to achieve high performance and reduce exhaust emissions.

*: Only for European, Australian and Chinese models



081EG24Z



081EG25Z

▶ Engine Specifications ◀

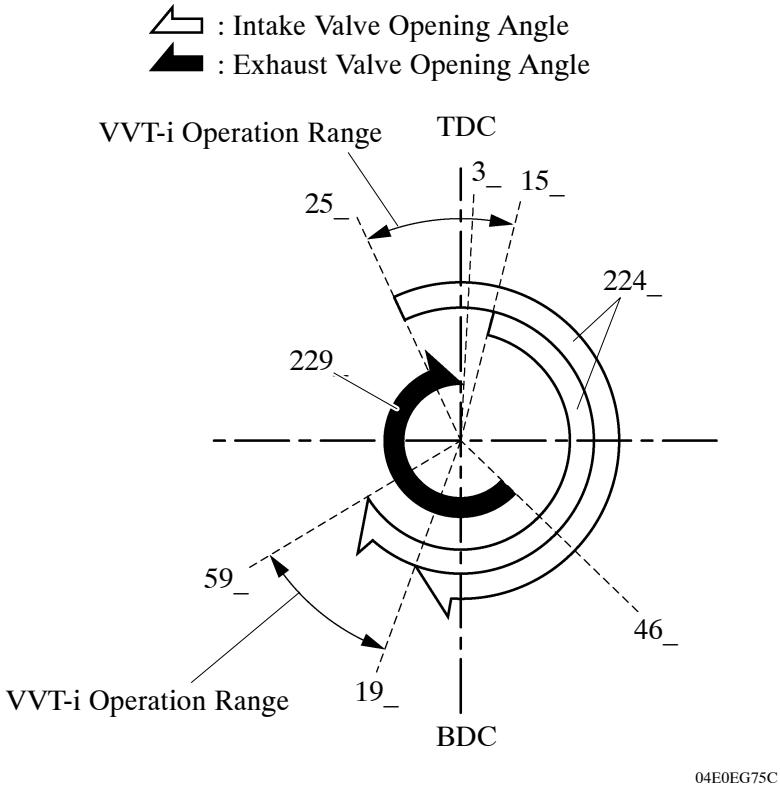
No. of Cyls. & Arrangement			8-Cylinder, V Type
Valve Mechanism			32-Valve DOHC, Belt & Gear Drive (with VVT-i)
Combustion Chamber			Pentroof Type
Manifolds			Cross-flow
Fuel System			EFI
Ignition System			DIS
Displacement cm^3 (cu. in.)			4664 (284.5)
Bore × Stroke mm (in.)			94.0 × 84.0 (3.70 × 3.31)
Compression Ratio			10.0 : 1
Max. Output	Europe	[ECE]	212 kW @ 5400 rpm
	Except Europe*1	[SAE-NET]	202 kW @ 5400 rpm
Max. Torque	Europe	[ECE]	445 N·m @ 3400 rpm
	Except Europe*1	[SAE-NET]	410 N·m @ 3400 rpm
Valve Timing	Intake	Open	25° BTDC to 15° ATDC
		Close	19° ABDC to 59° ABDC
	Exhaust	Open	46° BBDC
		Close	3° ATDC
Firing Order			1-8-4-3-6-5-7-2
Oil Grade			API grade SL "Energy-Conserving", SM "Energy-Conserving" or ILSAC
Research Octane Number (RON)		Europe	95 or higher*3
		Except Europe*1	91 or higher
Emission Regulation		G.C.C. Countries	EURO III
		General Countries	
		Europe	EURO IV
		Australia	
		China	
Engine Service Mass*2 (Reference) kg (lb)		Models with Air Injection System	239 (527)
		Models without Air Injection System	235 (518)

*1: European models equipped with a pre-cleaner are included.

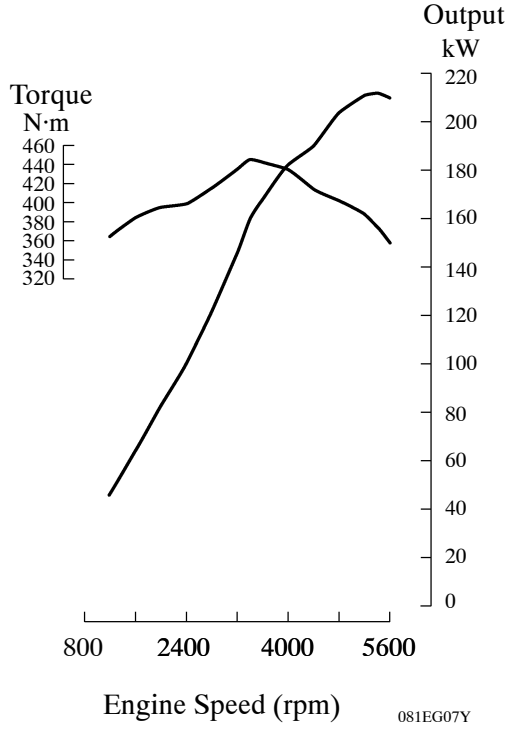
*2: The figure shown is the weight of the part without coolant and oil.

*3: Premium unleaded gasoline with a Research Octane Number 95 or higher required for optimum engine performance. If 95 octane cannot be obtained, you may use unleaded gasoline with a Research Octane Number as low as 91. Use of unleaded fuel with a Research Octane Number lower than 95 may result in engine knocking and significantly reduced performance. Persistent knocking can lead to engine damage and should be corrected by refueling with higher octane unleaded gasoline.

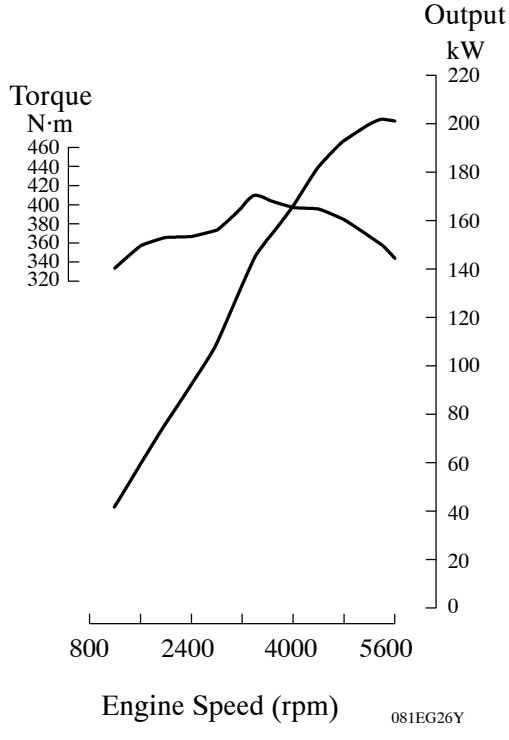
▶ Valve Timing ◀



▶ Performance Curve ◀



European Models



Except European Models*

*: European models equipped with a pre-cleaner are included.

■ FEATURES OF 2UZ-FE ENGINE

The 2UZ-FE engine has been able to achieve the following performance through the adoption of the items listed below.

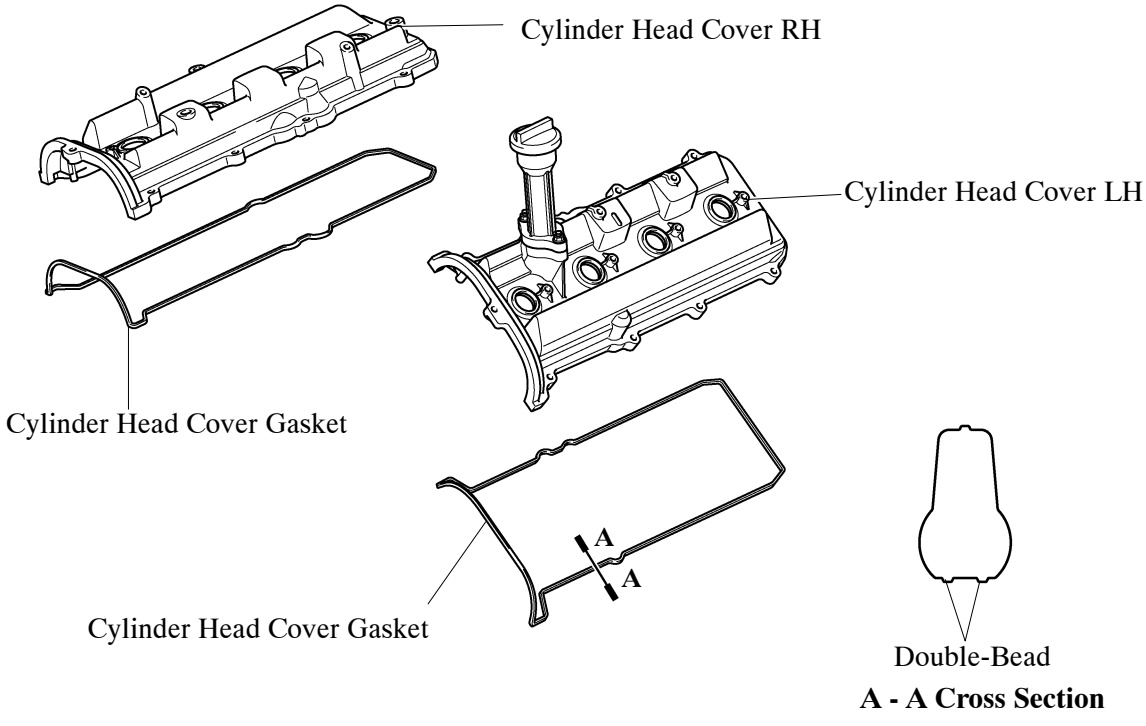
(1) High performance and reliability
(2) Low noise and vibration
(3) Lightweight and compact design
(4) Good serviceability
(5) Clean emission and fuel economy

Item		(1)	(2)	(3)	(4)	(5)
Engine Proper	An upright intake port is used.	○		○		
	A taper squish shape is used for combustion chamber.	○				○
	The piston skirt is coated with resin.	○	○			
	No.1oil pan sub-assembly made of aluminum alloy is used.		○	○		
Lubrication System	A water-cooled type engine oil cooler is used.	○				
Cooling System	TOYOTA Genuine SLLC (Super Long Life Coolant) is used as the engine coolant.				○	
Intake and Exhaust System	A long port intake manifold made of plastic is used.	○		○		
	The link-less type throttle body is used.			○	○	
	Stainless steel exhaust manifolds are used.			○		
	Ceramic type TWCs (Three Way catalytic Converters) are used.					○
Fuel System	4-hole type fuel injectors are used to improve the atomization of fuel.	○				○
Ignition System	The DIS (Direct Ignition System) makes ignition timing adjustment unnecessary.	○			○	○
Charging System	Segment Conductor type generator is used.	○		○		
Serpentine Belt Drive System	A serpentine belt drive system is used.			○	○	
Engine Control System	MRE (Magnetic Resistance Element) type camshaft position sensor is used.	○				
	The ETCS-i (Electronic Throttle Control System- intelligent) is used.	○				○
	The VVT-i (Variable Valve Timing-intelligent) system is used.	○				○
	The ACIS (Acoustic Control Induction System) is used.	○				○
	An air injection system is used. (Only for European, Australian and Chinese models)					○
	The cranking hold function is used.	○				

■ENGINE PROPER

1. Cylinder Head Cover

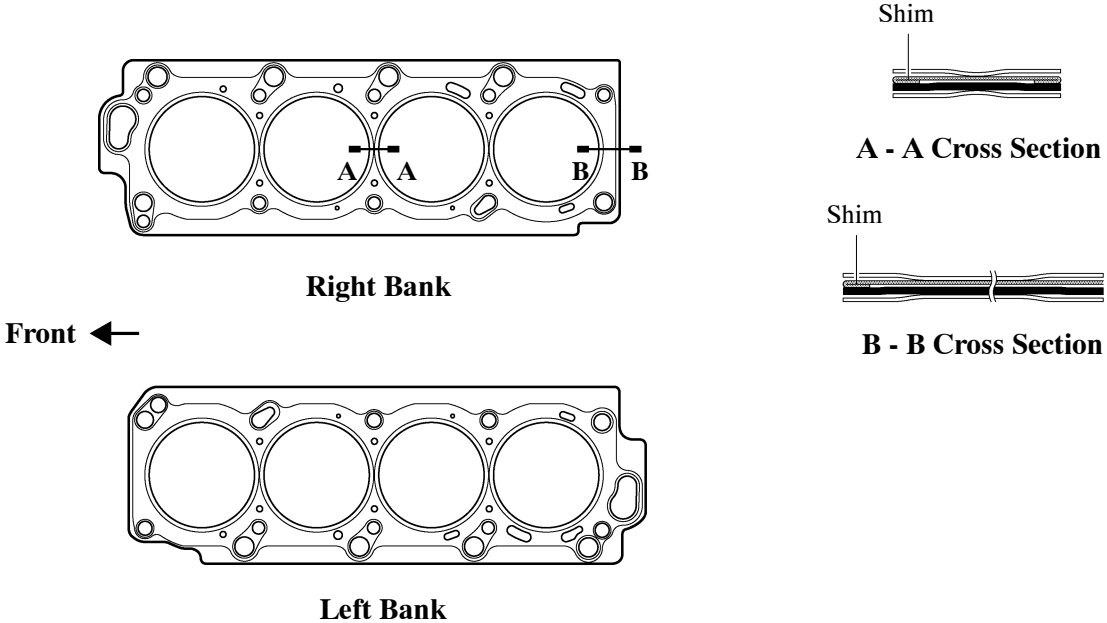
- Lightweight yet high-strength aluminum cylinder head cover sub-assemblies are used.
- An oil filler extension housing is provided on the cylinder head cover sub-assembly LH for use when filling the engine oil to improve serviceability.
- The cylinder head cover gaskets use a double-bead cross-sectional construction to improve their reliability.



081EG27Y

2. Cylinder Head Gasket

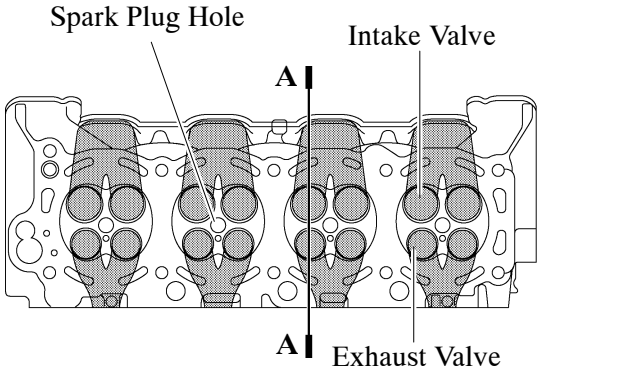
4-layer Steel-laminate type cylinder head gaskets are used. A shim is used around the cylinder bore of each gasket to help enhance sealing performance and durability.



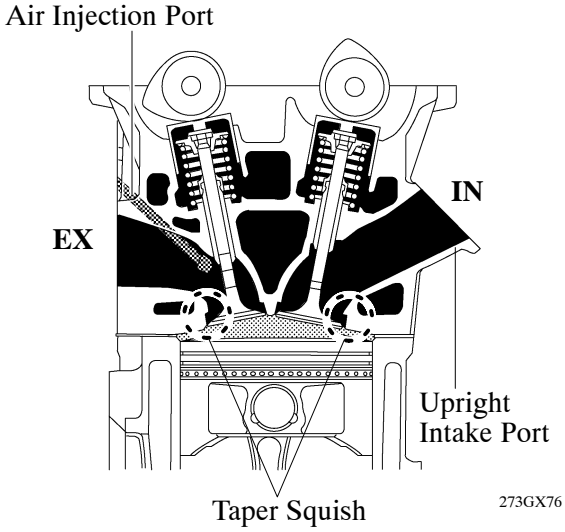
04E0EG38C

3. 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.
- Upright intake ports are used to improve the intake efficiency.
- A taper squish combustion chamber is used to improve anti-knocking performance and intake efficiency. In addition, engine performance and fuel economy are improved.
- A lead-free valve seat is used for environmental purposes.
- Plastic region tightening bolts are used for the cylinder head to ensure good axial tension.
- The air injection port is provided for the air injection system.



View from Button Side 04E0EG68C

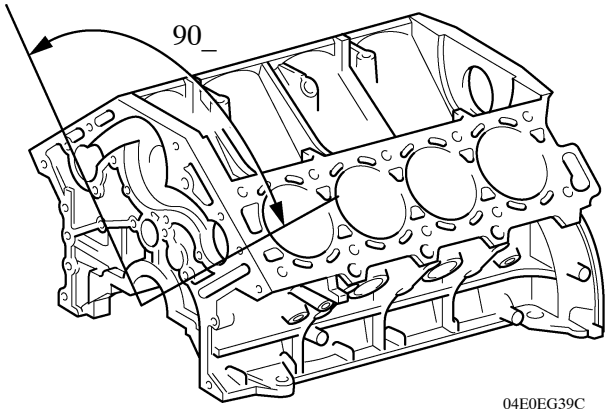


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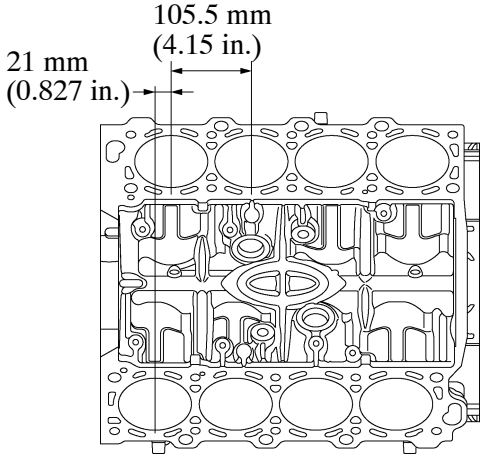
A - A Cross Section

4. Cylinder Block

- The cylinder block is made of cast iron 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.
- Part of the volute chamber of the water pump is incorporated into the cylinder block to shorten the engine length.
- Installation bosses of the two knock sensors are located on the inner side of left and right banks.



04E0EG39C

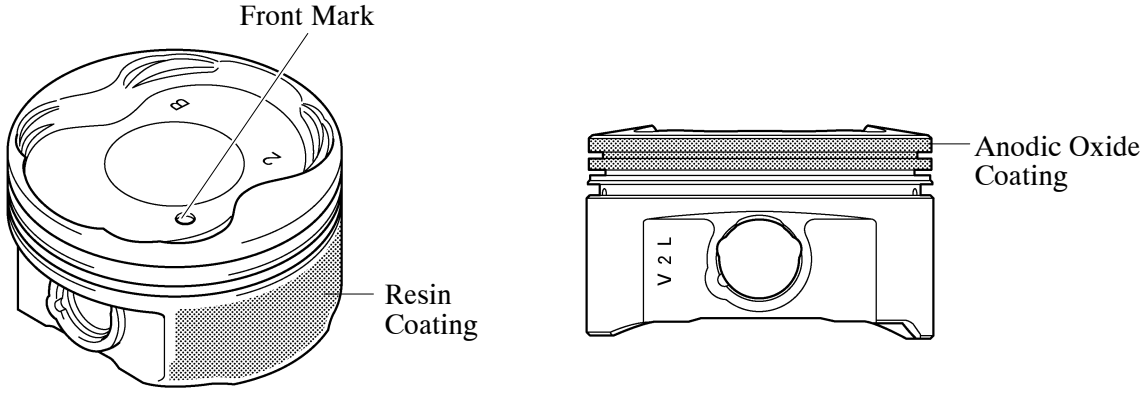


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View of Top Side

5. Piston

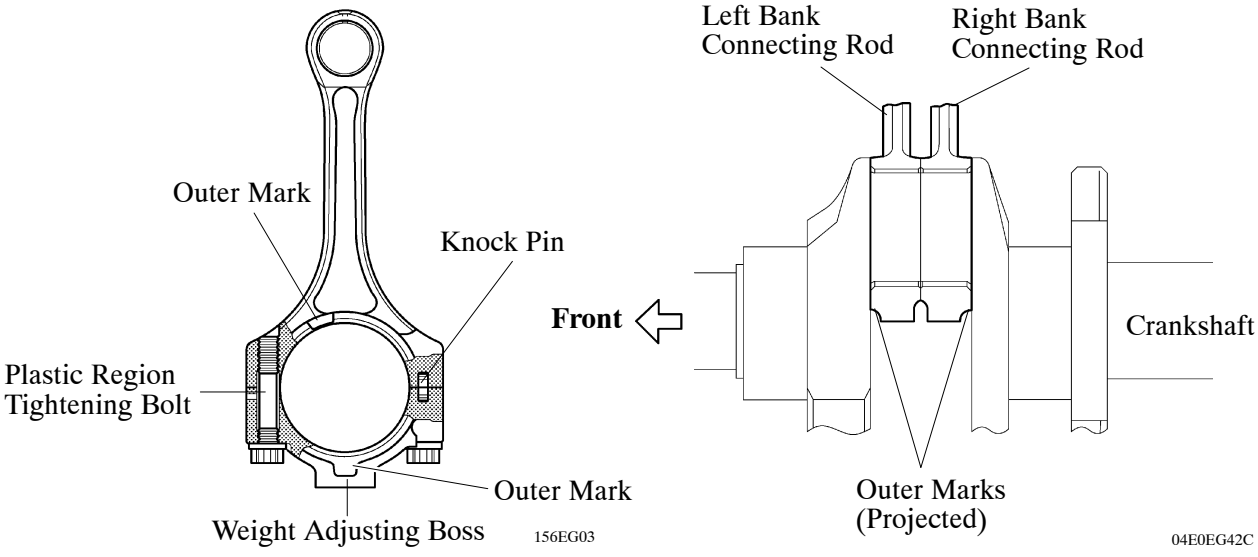
- The pistons are made of aluminum alloy.
- The piston head portion uses a taper squish shape to accomplish fuel combustion efficiency.
- The piston skirt is coated with resin to reduce friction losses.
- The groove of the piston ring is coated with anodic oxide to improve wear resistance and corrosion resistance.
- Full floating type piston pins are used.



081EG28Y

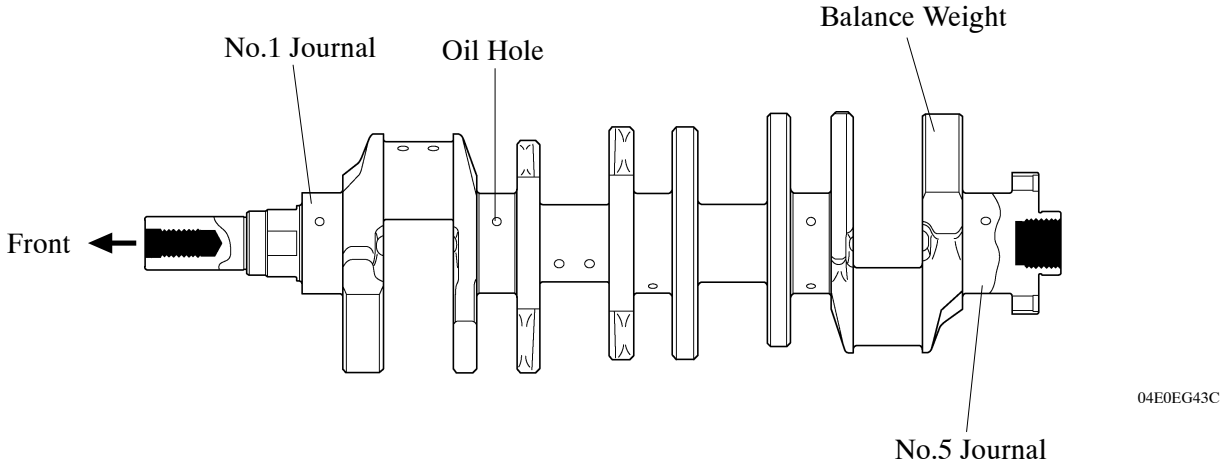
6. Connecting Rod and Connecting Rod Bearing

- The sintered and forged connecting rod is very rigid and has little weight fluctuation.
- A weight-adjusting boss is provided at the bearing caps to reduce fluctuation of weight and balance the engine.
- The connecting rods for the right and left banks are placed in opposite directions with the outer marks facing the crankshaft.
- 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.
- Aluminum bearings are used for the connecting rod bearings.

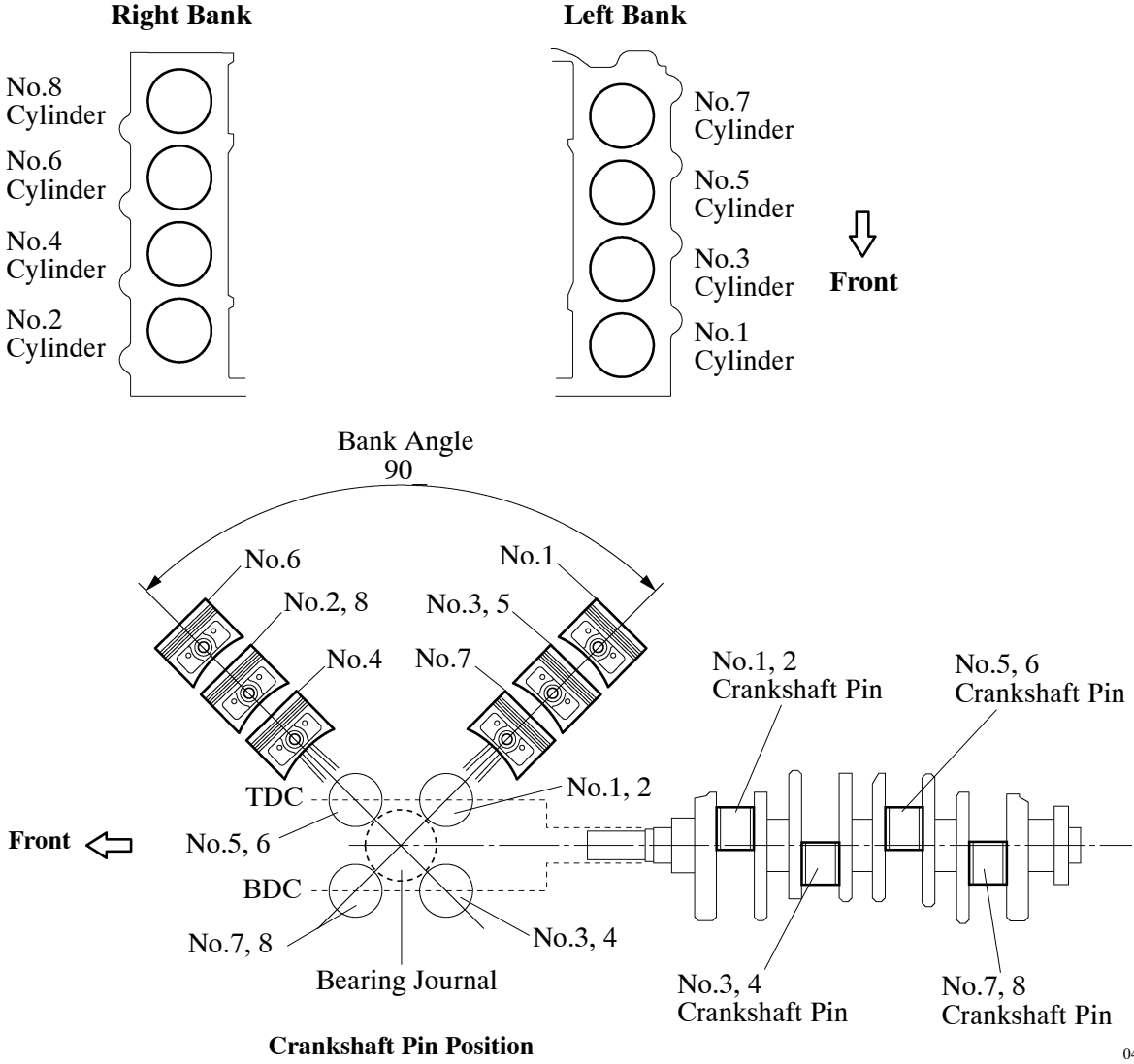


7. Crankshaft and Crankshaft Bearing

- A crankshaft made of steel, which excels in rigidity and wear resistance, is used.
- The crankshaft has 5 main bearing journals, 4 crankshaft pins and 8 balance weights.
- The crankshaft bearings are made of aluminum alloy.

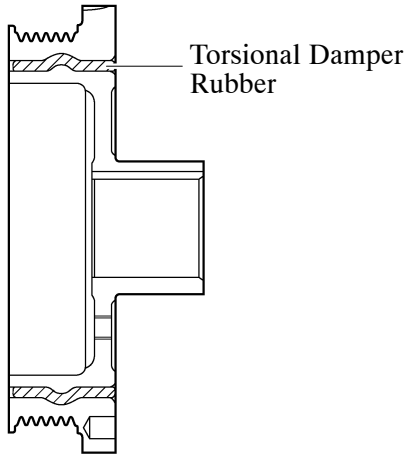


NOTE: The positions of the crankshaft pins and pistons are illustrated below.



8. Crankshaft Pulley

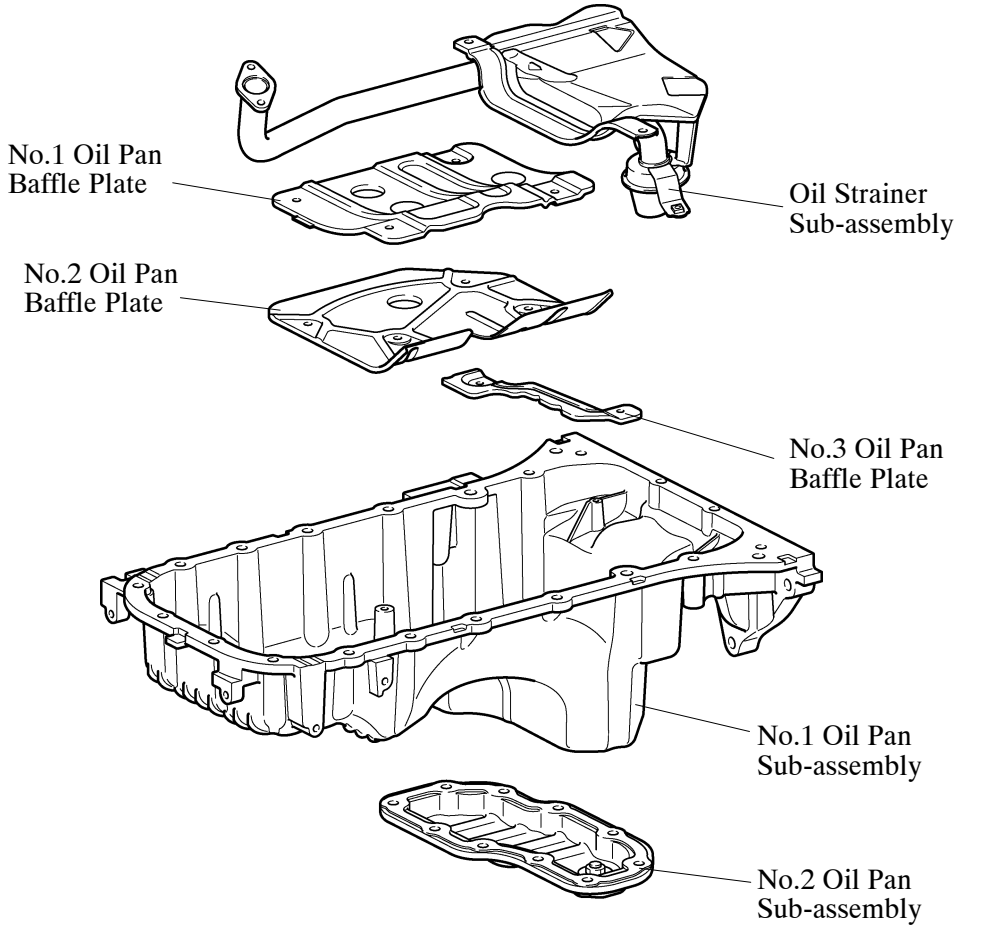
The rigidity of the torsional damper rubber has been optimized to reduce noise.



232EG26

9. Oil Pan

- The No.1 oil pan sub-assembly is made of aluminum alloy.
- The No.2 oil pan sub-assembly is made of steel.
- The No.1 oil pan sub-assembly is secured to the cylinder block and the transmission housing to increase rigidity.

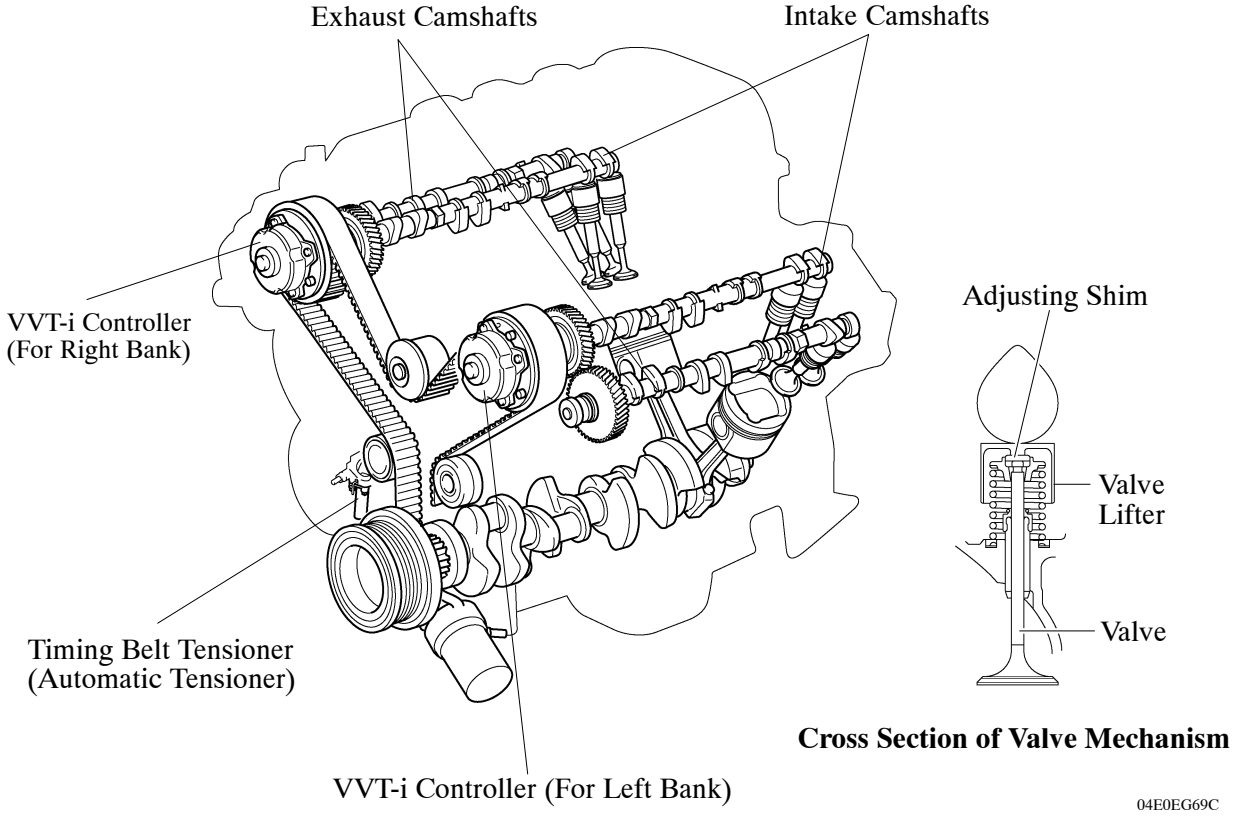


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■VALVE MECHANISM

1. General

- Each cylinder has 2 intake valves and 2 exhaust valves. Intake and exhaust efficiency is increased by means of the larger total port areas.
- The valves are directly opened and closed by 4 camshafts.
- The intake camshafts are driven by a timing belt, while the exhaust camshafts are driven through gears on the intake camshafts.
- A VVT-i controller is installed on the front of each intake camshaft to vary the timing of the intake valves.
- Inner shim type adjusting shims, which allow a greater amount of valve lift, are used.

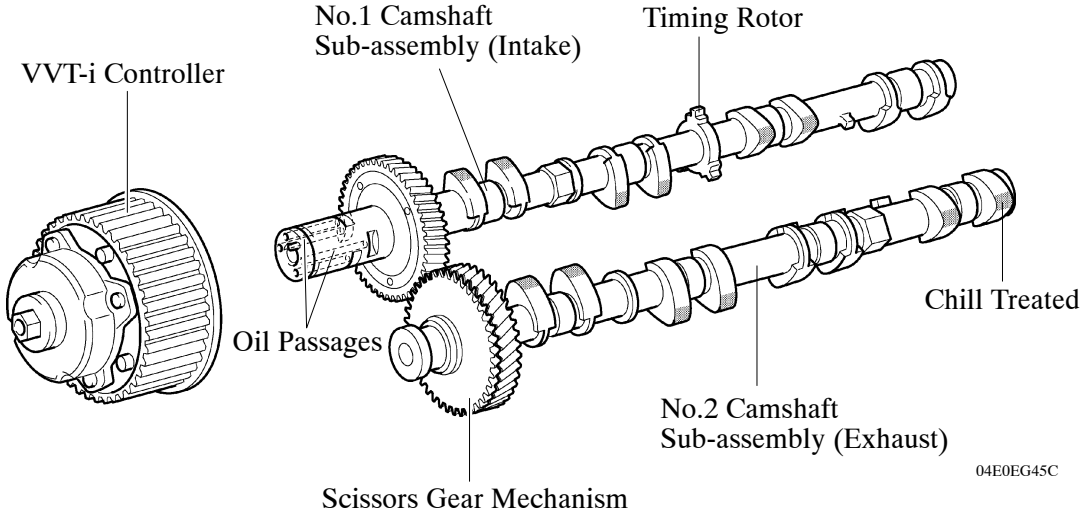


Cross Section of Valve Mechanism

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2. Camshaft

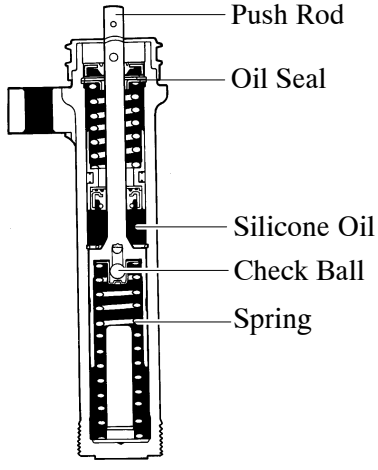
- The camshafts are made of a cast iron alloy. The cam lobes have been chill treated to increase abrasion resistance.
- An oil passage is provided in the intake camshaft in order to supply engine oil to the VVT- i controller.
- A timing rotor for the VVT-i sensor is provided on the intake camshaft to detect the actual position of the intake camshaft.
- The exhaust camshafts are driven by gears on the intake camshafts. The scissors gear mechanism is used on the exhaust camshaft to control backlash and suppress gear noise.



Right Bank

3. Automatic Tensioner

The automatic tensioner is made up of a spring and oil damper, and maintains proper timing belt tension at all time. The automatic tensioner suppresses noise generated by the timing belt.

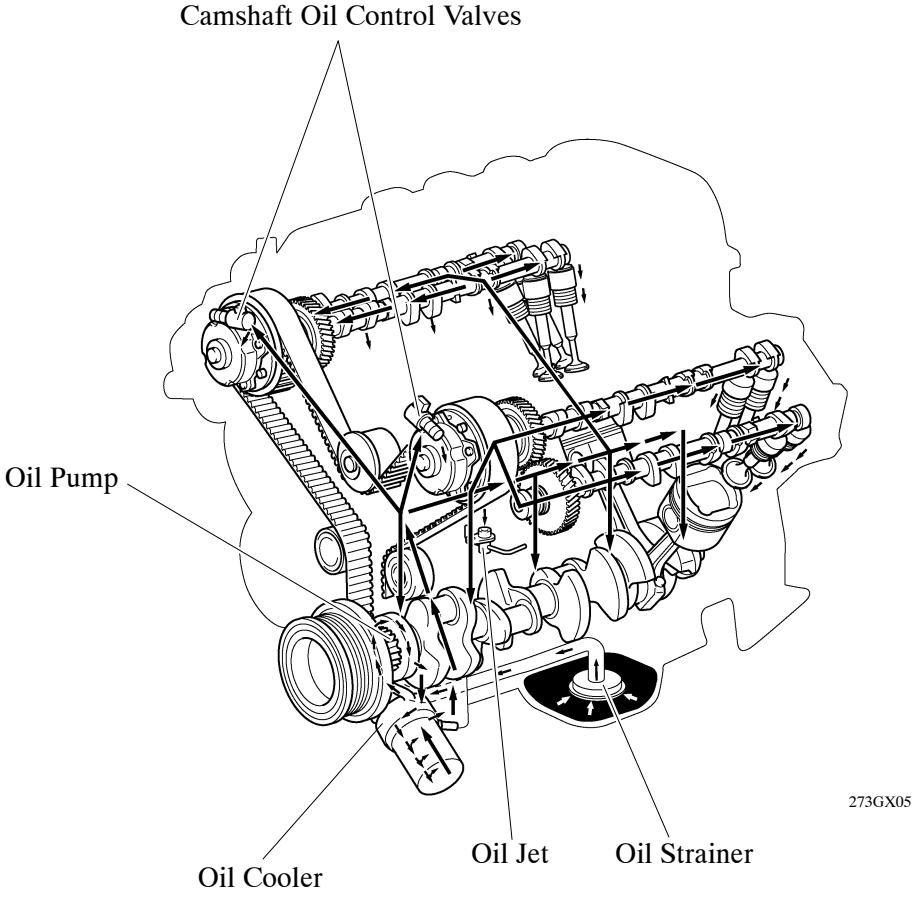


Timing Belt Tensioner (Automatic Tensioner)

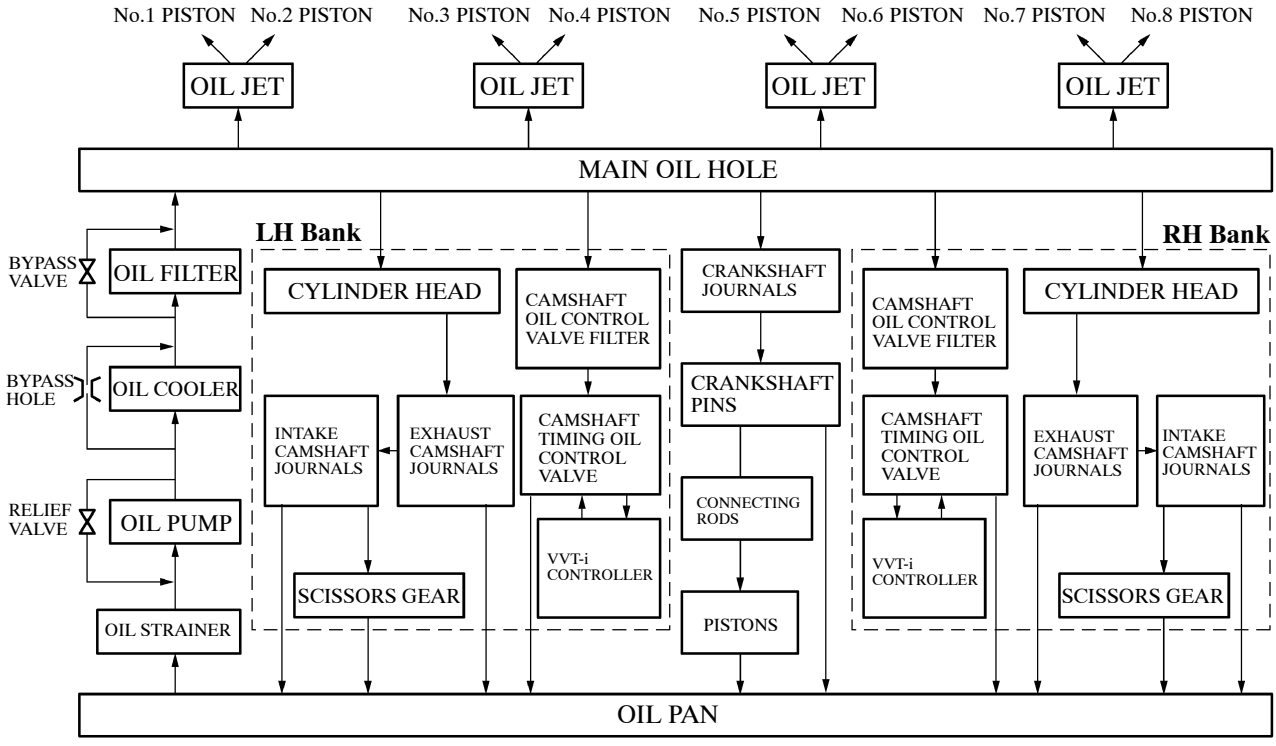
■ LUBRICATION SYSTEM

1. General

- The lubrication circuit is fully pressurized and oil passes through an oil filter.
- A trochoid gear type oil pump is used. This pump is directly driven by the crankshaft.
- A water-cooled type engine oil cooler is used.



▶ Oil Circuit ◀



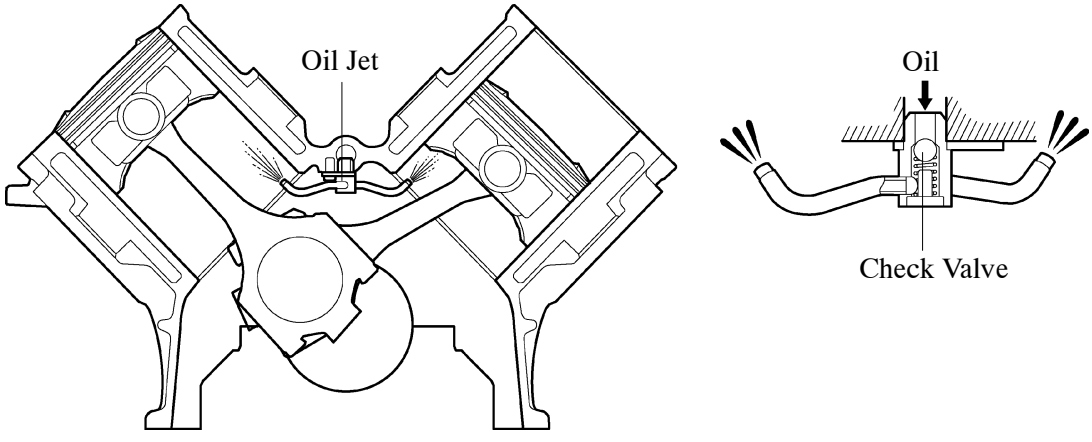
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▶ Oil Capacity ◀

Oil Capacity [Liters (US qts, Imp. qts)]	Dry	7.1 (7.5, 6.2)
	with Oil Filter	6.2 (6.6, 5.5)
	without Oil Filter	5.7 (6.0, 5.0)

2. Oil Jet

- Four 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.

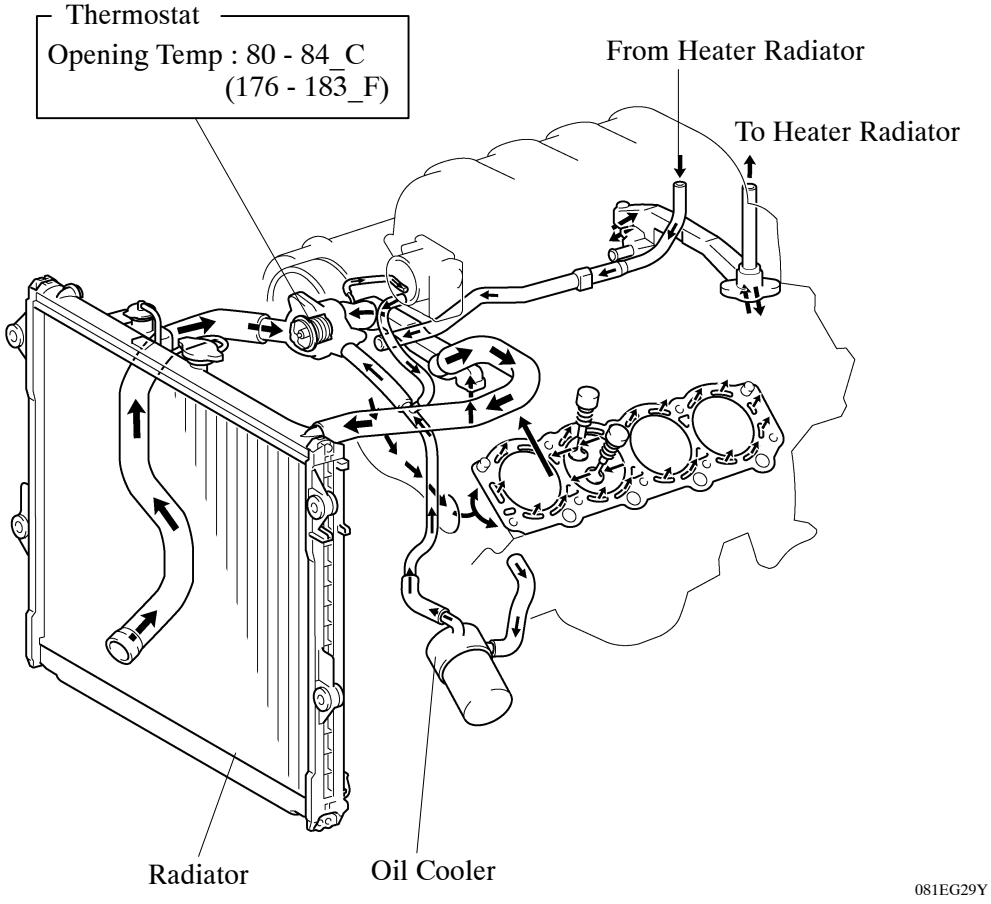


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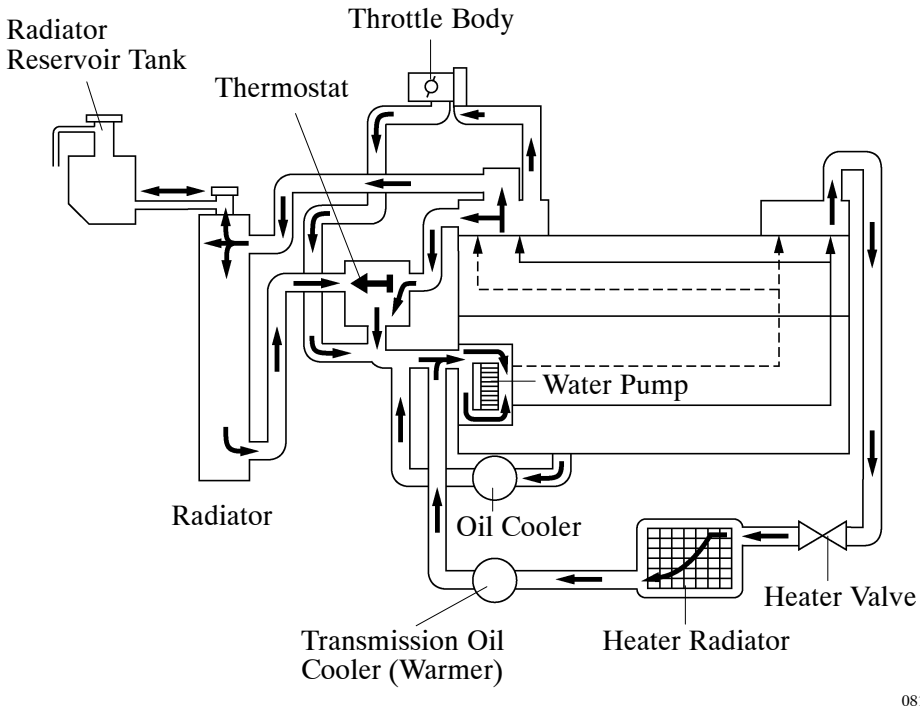
■COOLING SYSTEM

1. General

- The cooling system uses a pressurized forced circulation system with open air type reservoir tank.
- A thermostat with a bypass valve is located on the water inlet housing 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 started to minimize fan noise.
- TOYOTA genuine SLLC (Super Long Life Coolant) is used as the engine coolant.



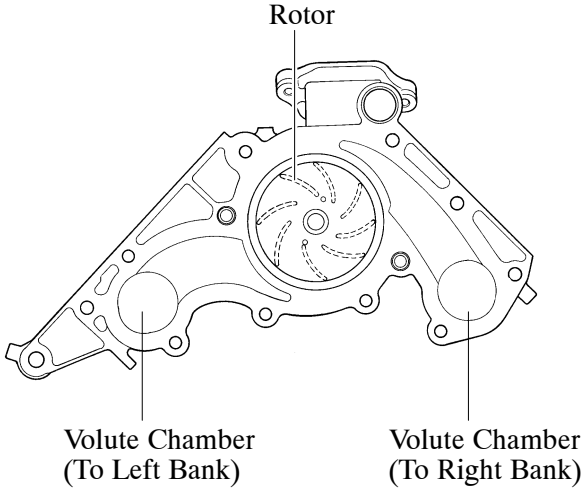
▶ System Diagram ◀



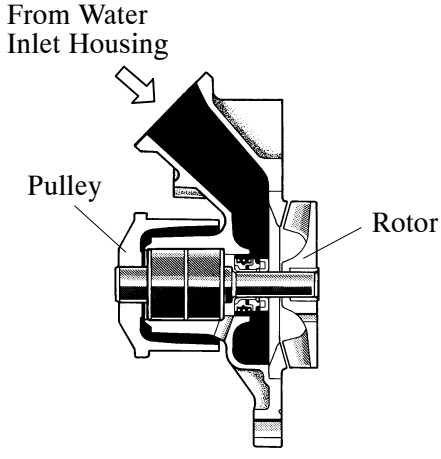
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2. Water Pump

- The water pump assembly has two volute chambers, and coolant circulates uniformly to the left and right banks of the cylinder block.
- The water pump is driven by the timing belt.
- The rotor is made of resin.



156EG13



156EG14

3. Engine Coolant

- TOYOTA genuine SLLC (Super Long Life Coolant) is used.
- SLLC is pre-mixed (50 % coolant and 50 % deionized water), so no dilution is needed when adding or replacing SLLC in the vehicle.
- Maintenance intervals are as shown in the table below:

Type		TOYOTA Genuine SLLC or the equivalent*
Maintenance Intervals	First Time	160,000 km (100,000 miles)
	Subsequent	Every 80,000 km (50,000 miles)
Color		Pink

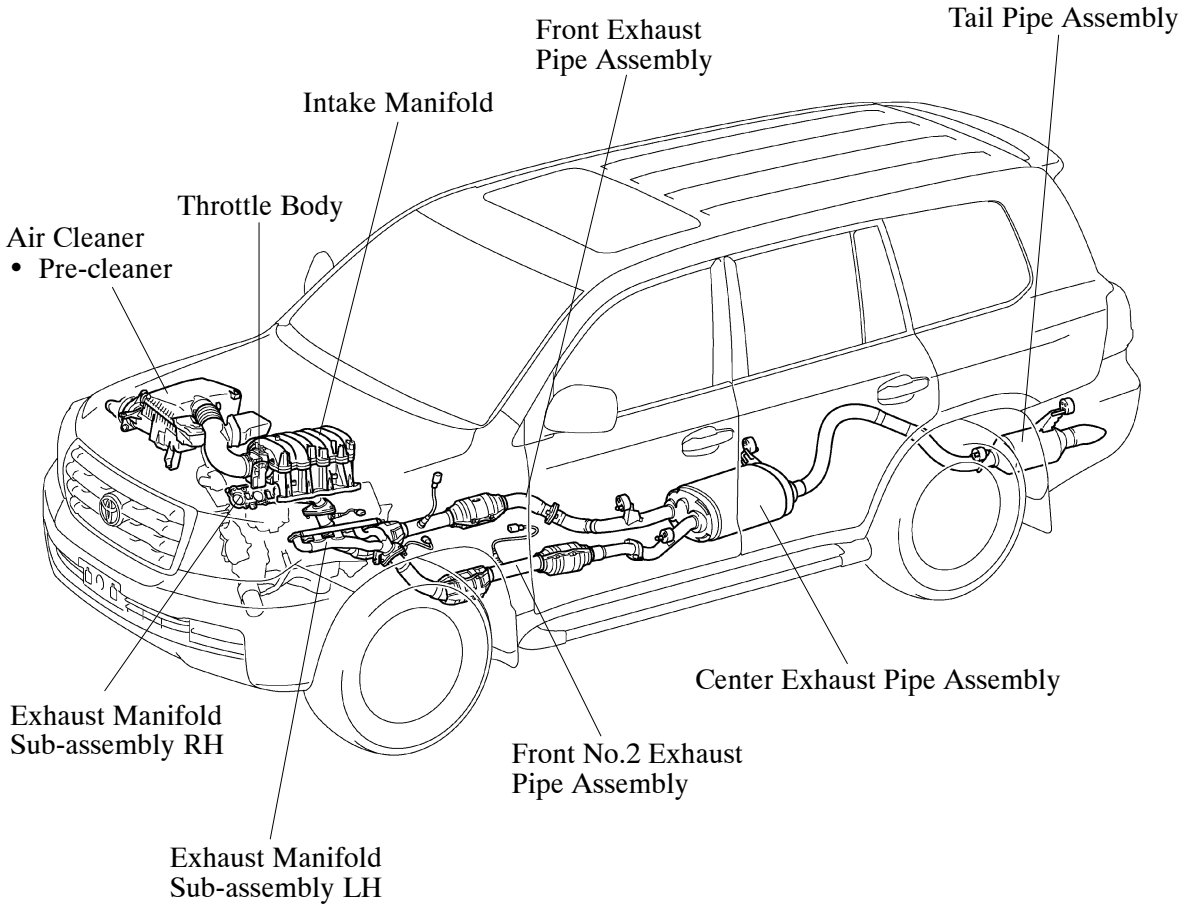
*: Similar high quality ethylene glycol based non-silicate, non-amine, non-nitrite, and non-borate coolant with long-life hybrid organic acid technology. (Coolant with long-life hybrid organic acid technology consists of a combination of low phosphates and organic acids.)

■INTAKE AND EXHAUST SYSTEM

1. General

- A cyclone pre-cleaner is provided on all models except European models*.
- A link-less type throttle body is used and it realizes excellent throttle control.
- A plastic intake manifold is used.
- Stainless steel exhaust manifolds and exhaust pipes are used.
- The ETCS-i (Electronic Throttle Control System-intelligent) is used to ensure excellent throttle control in all operating ranges. For details, see page EG-116.
- The ACIS (Acoustic Control Induction System) is used to improve the engine performance in all speed range. For details of ACIS control, see page EG-123.

*: European models other than package models for South Africa, New Caledonia, Russia and Central America



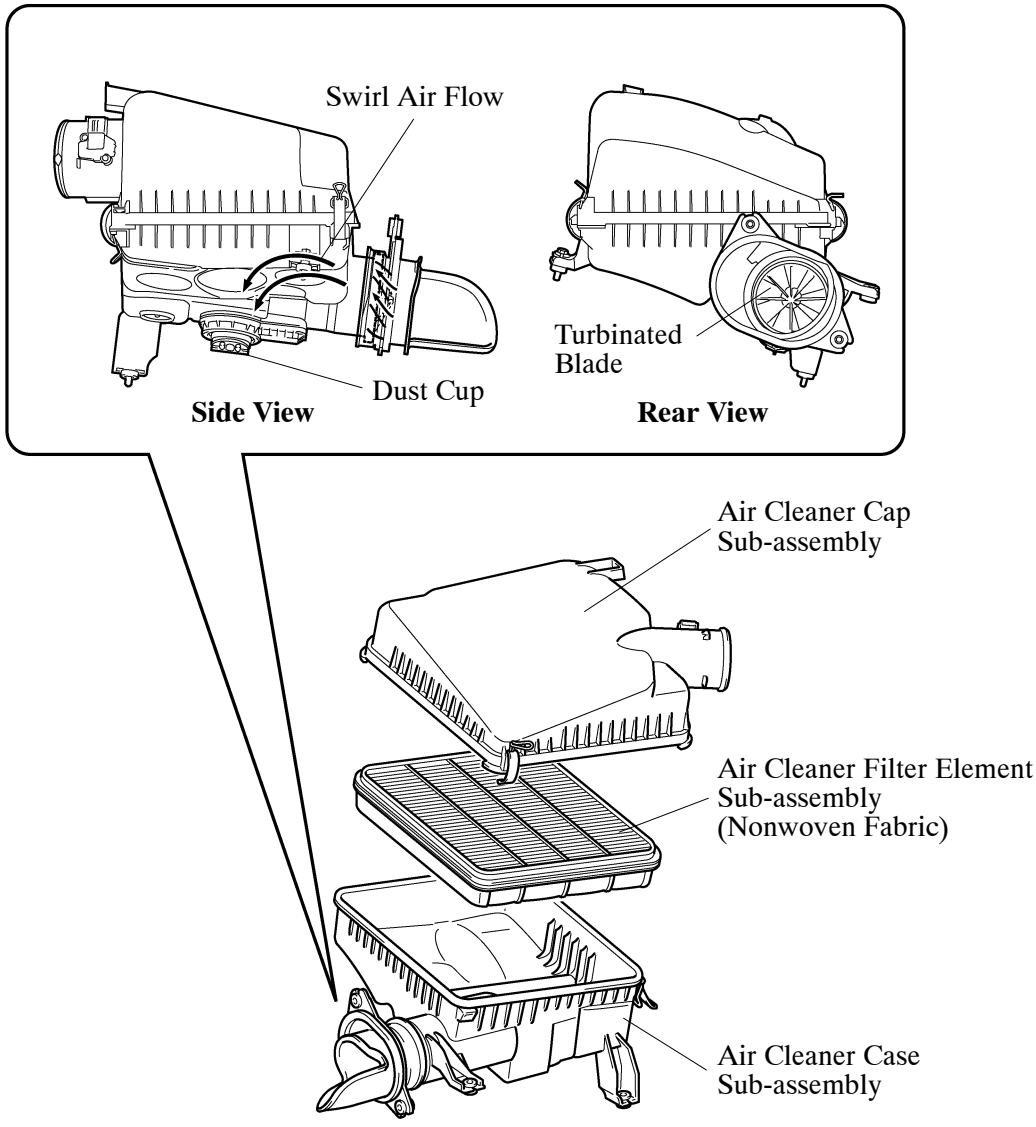
081EG31TE

Models with Cyclone Pre-cleaner

2. Air Cleaner

- A nonwoven, full-fabric type air cleaner filter element is used.
- A cyclone pre-cleaner has been provided in the air cleaner case. This cyclone pre-cleaner has a screw shape (turbinated blade) and gathers dusts which has rather big size in a dust cup by swirling the inlet air. The dust cup is removable, so the dust gathered can be disposed.

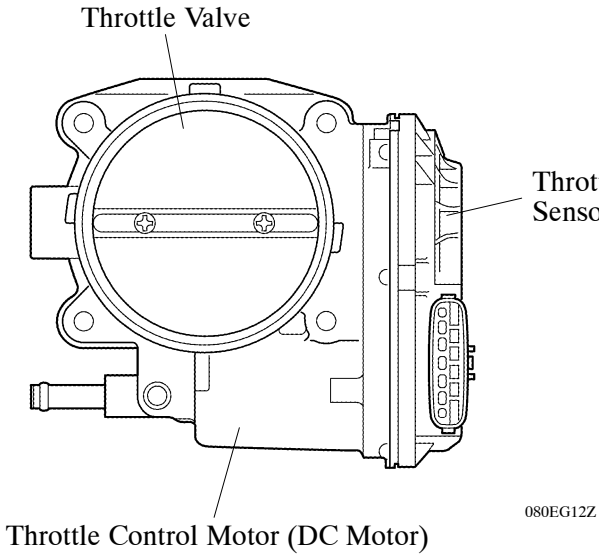
Cyclone Pre-cleaner



Models with Cyclone Pre-cleaner

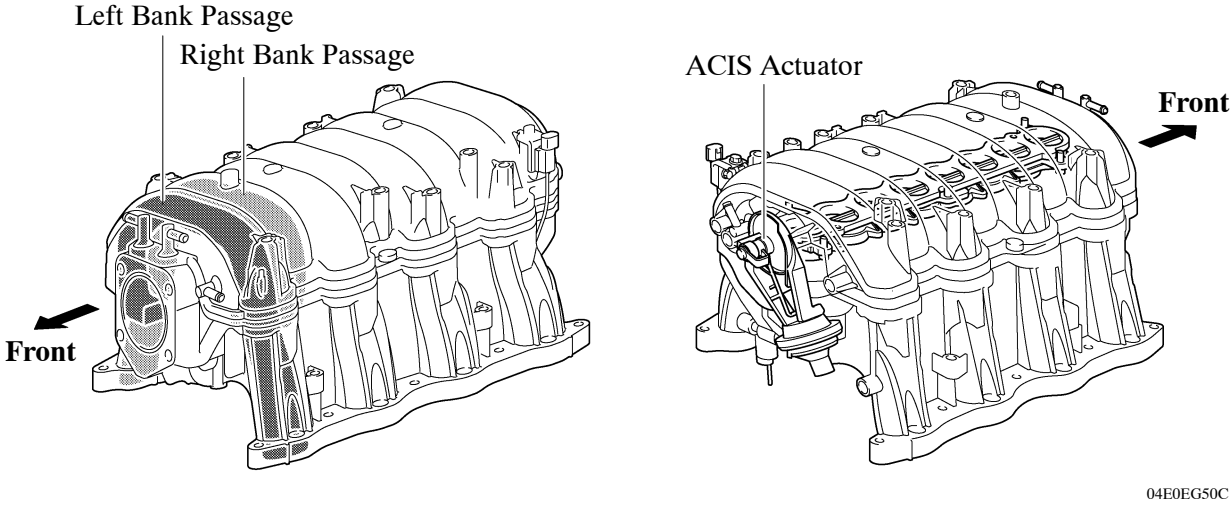
3. Throttle Body

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



4. Intake Manifold

- A plastic intake manifold is used for weight reduction.
- The low-to-mid speed range torque is improved by increasing the length of the intake manifold port.
- The intake manifold contains valves for the ACIS (Acoustic Control Induction System), and the actuator is laser-welded to the intake manifold.



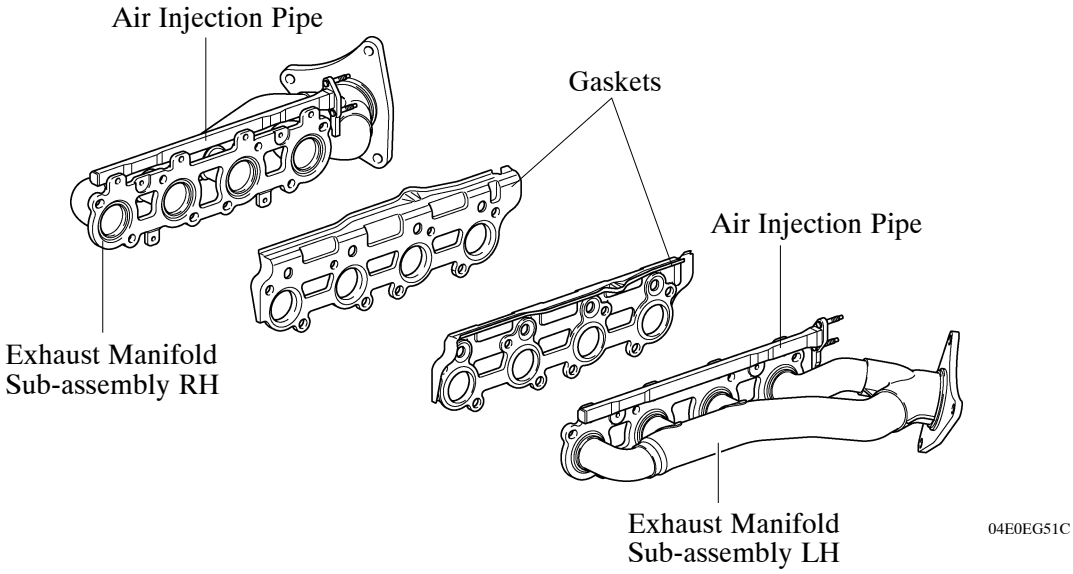
— REFERENCE —

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.

5. Exhaust Manifold

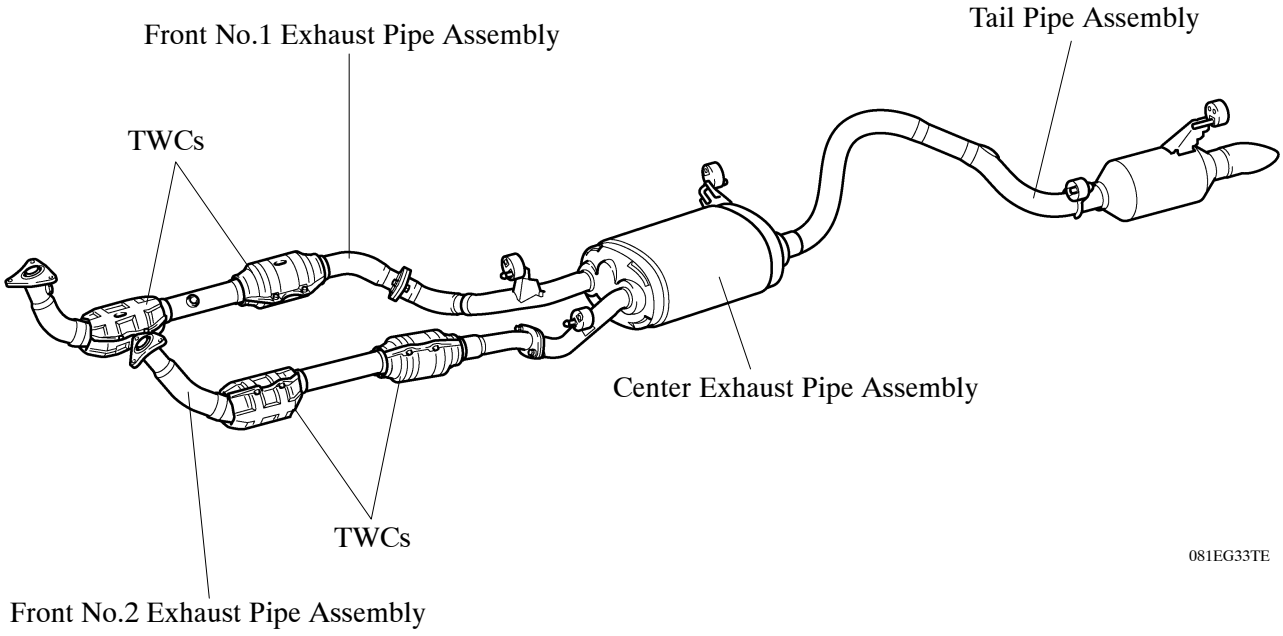
- A stainless steel exhaust manifold is used for weight reduction and rust resistance.
- On models with the air injection system, air injection pipes are provided for the right and left bank exhaust manifolds.



Models with Air Injection System

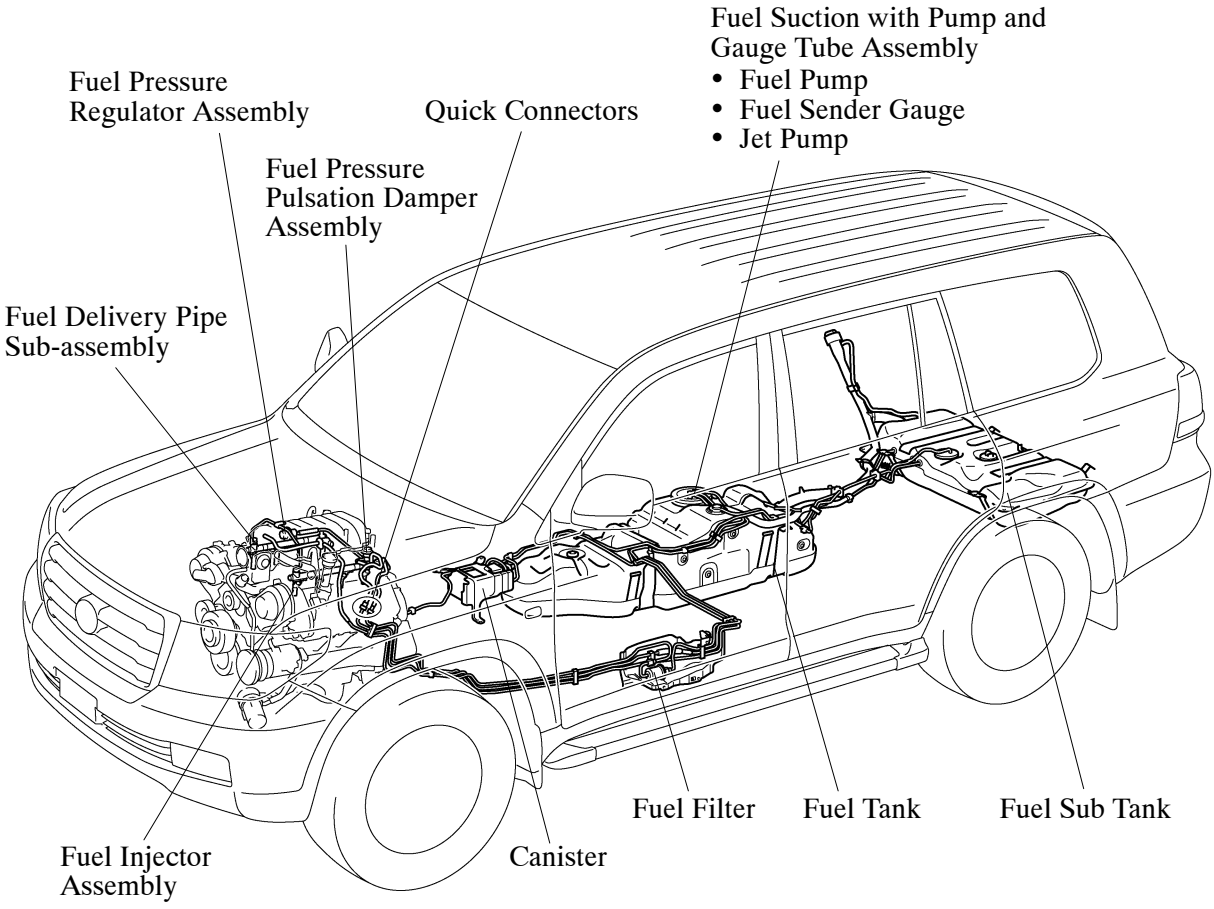
6. Exhaust Pipe

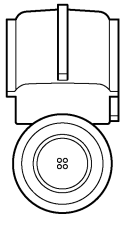
- A stainless steel exhaust pipe is used for weight reduction and rust resistance.
- The ceramic type TWC is used.



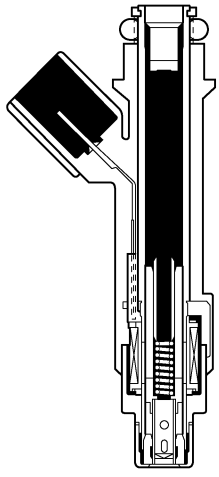
■ FUEL SYSTEM

- A fuel cut control is used to stop the fuel pump when SRS airbags deploy in a frontal or side collision. For details, refer to the 1GR-FE engine Engine Control System Section on page EG-68.
- Compact 4-hole type fuel injectors are used to improve the atomization of fuel.
- Fuel delivery pipes made of aluminum alloy are used to realize weight savings.
- Quick connectors are used to connect the fuel lines for ease of serviceability.
- The dual fuel tank comprising a fuel tank and fuel sub tank is provided as standard on all models except European models. A multi-layer plastic fuel tank is used for the fuel tank. (The fuel sub tank however is made of steel.) For details, refer to the 1GR-FE engine Fuel System Section on page EG-31.





View from Bottom Side



Injector Cross Section

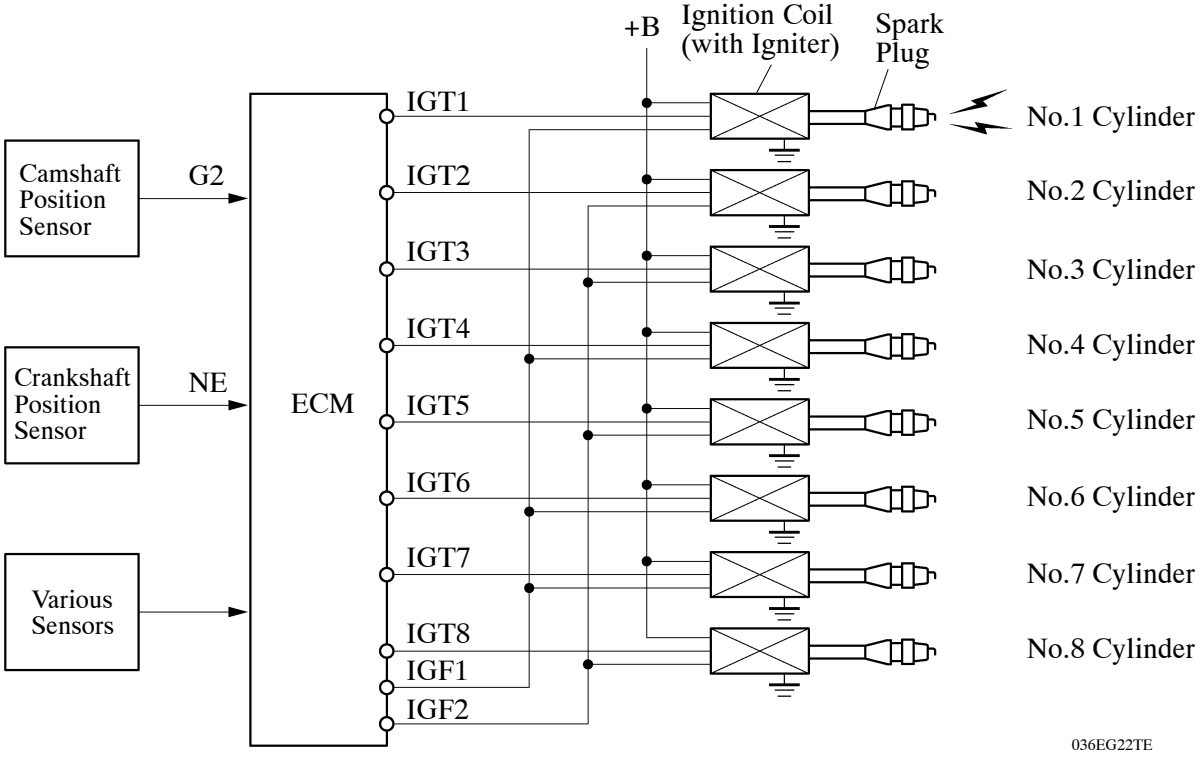
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Models with Dual Fuel Tank

■IGNITION SYSTEM

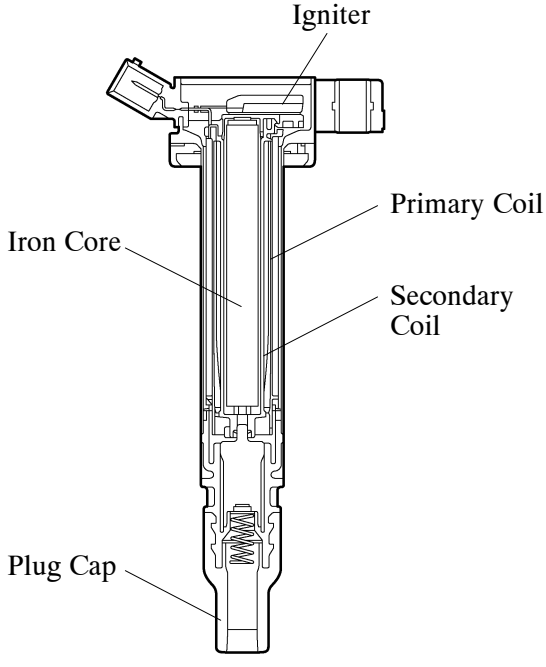
1. General

A DIS (Direct Ignition System) 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.



2. 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.



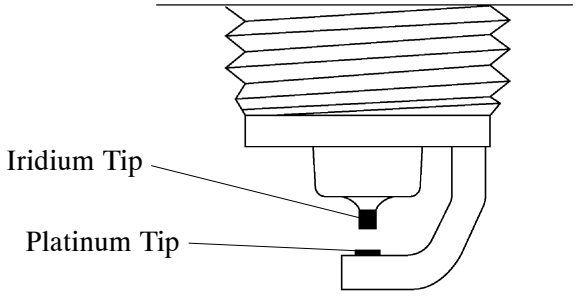
Ignition Coil Cross Section

05AEG39TE

EG

3. Spark Plug

Iridium-tipped spark plugs are used to achieve a 100000 km (60000 mile) maintenance interval. By adopting an iridium center electrode, ignition performance that is superior to that of platinum-tipped spark plugs is achieved and durability is increased.



208EG70

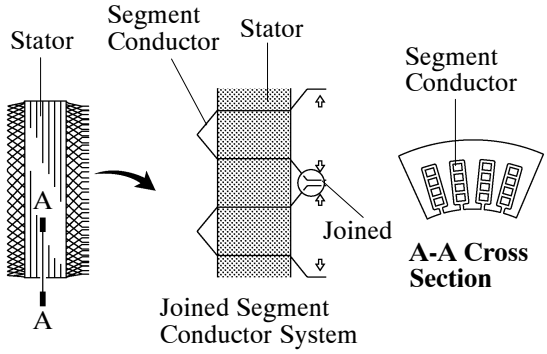
▶ Specifications ◀

DENSO	SK20R11
NGK	IFR6A11
Plug Gap mm (in.)	1.0 - 1.1 (0.0394 - 0.0433)

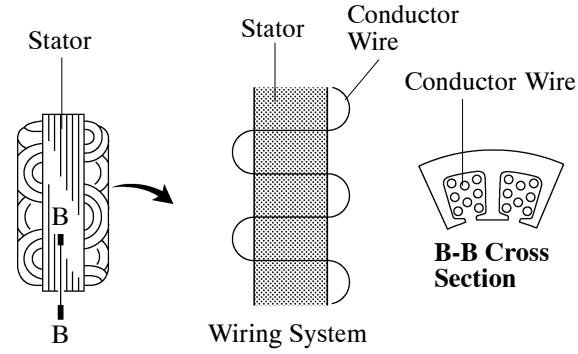
■CHARGING SYSTEM

1. General

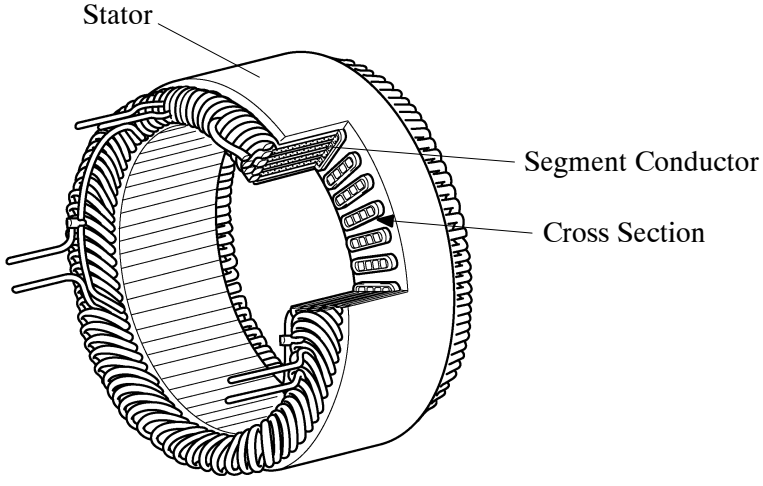
- A compact and lightweight segment conductor type generator is used. This type of generator generates a high amperage output in a highly efficient manner.
- This generator uses a joined segment conductor system, in which multiple segment conductors are welded together to the stator. Compared to the conventional winding system, the electrical resistance is reduced due to the shape of the segment conductors, and their arrangement helps to make the generator more compact.



Segment Conductor Type Generator



Conventional Type Generator



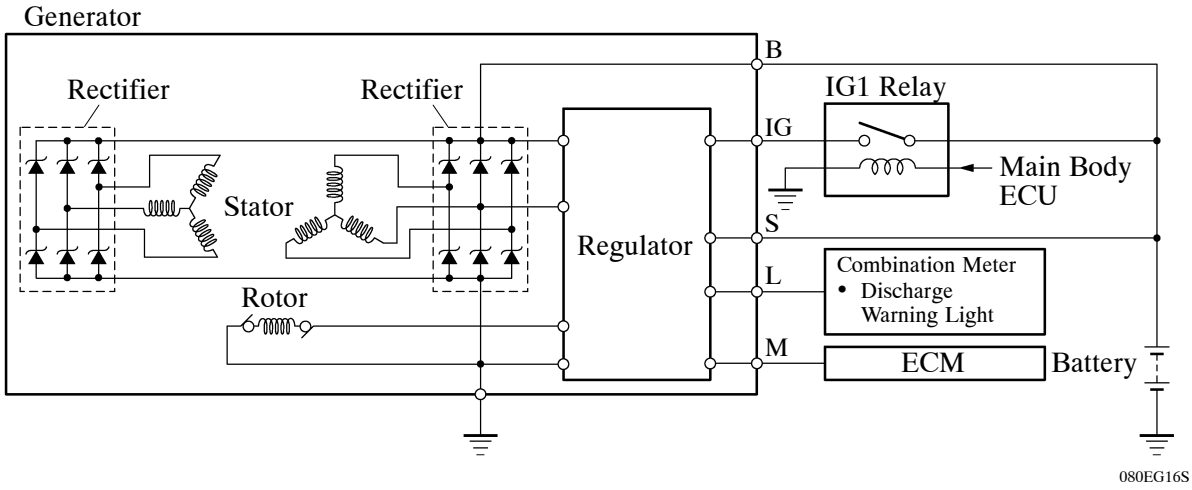
Stator of Segment Conductor Type Generator 206EG42

▶ Specifications ◀

Type	SC1		SC2		
Destination	Australia*1	Europe and General Countries*2	Australia*3	Europe and General Countries*4	G.C.C. Countries and China
Rated Voltage	12V		←		
Output Rated	130 A		150A		

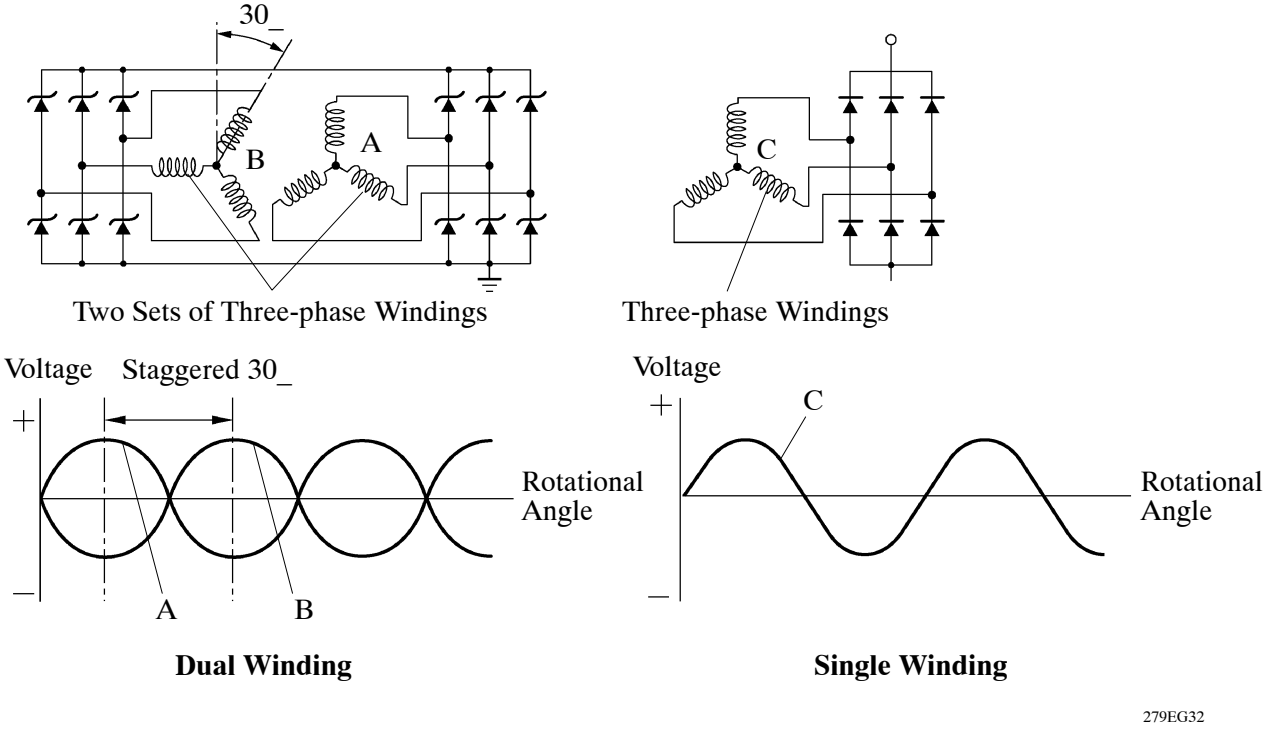
*1: Only for models without multi-display
*2: Only for models without towing package
*3: Only for models with multi-display
*4: Only for models with towing package

▶ Wiring Diagram ◀



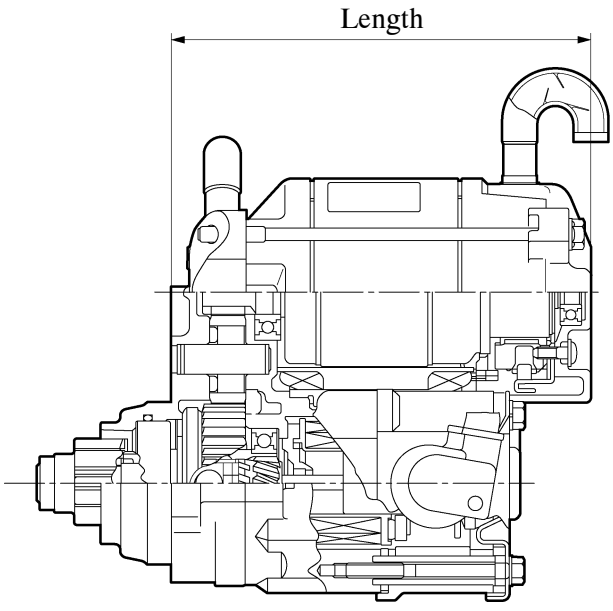
2. Dual Winding System

A dual winding system is used. This system consists of two sets of three-phase windings whose phases are staggered 30_. This system results in the reduction of both electrical noise (ripple and spike), and magnetic noise (a hum that is heard as generator load is increased). This system significantly suppresses noise at the source (generator). Because the waves that the respective windings generate have opposite polarities, magnetic noise is reduced. The magnetic noise is significantly reduced, but the electrical power generated does not cancel itself out due to the use of separate rectifiers. The opposite polarities that are generated can be seen below.



■STARTING SYSTEM

Reduction type starter is used on all models



RA1.4 Type

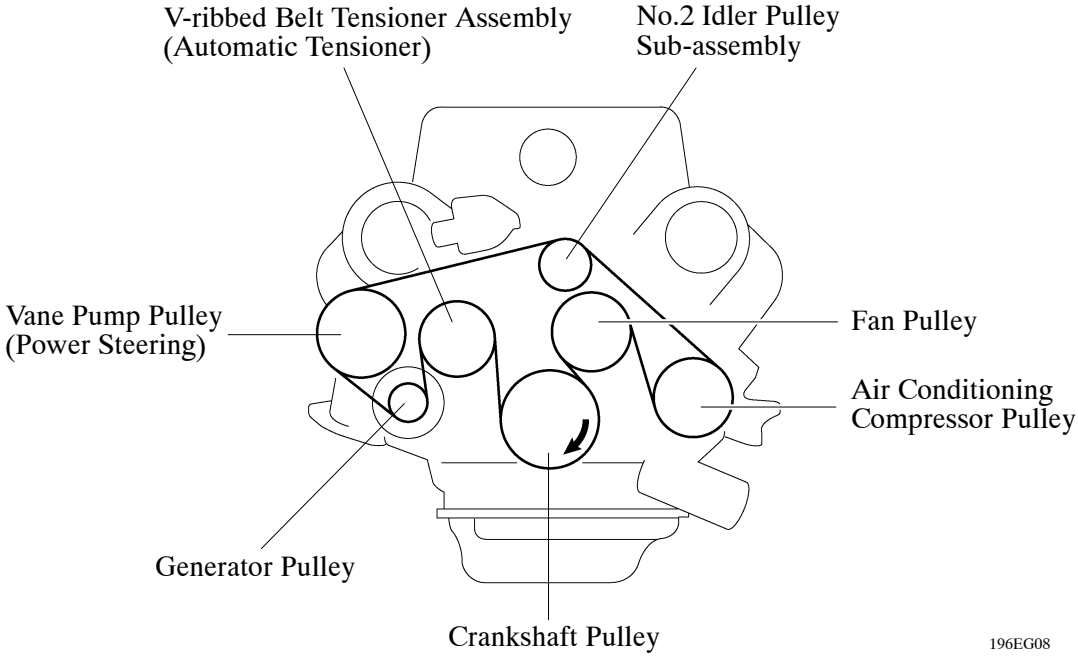
▶ Specifications ◀

Starter Type	RA1.4	RA2.0
	Reduction type	←
Destination	General Countries, G.C.C. Countries and Australia	Europe and China
Supplier	DENSO	←
Rating Output	1.4 kW	2.0 kW
Rating Voltage	12 V	←
Length*1 mm (in.)	142.3 (5.60)	174.5 (6.87)
Weight g (lb)	3740 (8.2)	4660 (10.3)
Rotating of Direction*2	Clockwise	←

*1: Length from the mounted area to the rear end of the starter
*2: Viewed from Pinion Side

■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 number of engine parts.
- An automatic tensioner is used. This makes the tension adjustment unnecessary.



■ENGINE CONTROL SYSTEM

1. General

The engine control system of the 2UZ-FE engine has the following system.

System	Outline
SFI (Sequential Multiport Fuel Injection)	• 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 two revolutions of the crankshaft) is used. • Fuel injection takes two forms: - Synchronous injection, in which injection always occurs at the same timing relative to the firing order. - The non-synchronous injection in which injection is effected regardless of the crankshaft angle.
ESA (Electronic Spark Advance)	• 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.
ETCS-i (Electronic Throttle Control System-intelligent) [See page EG-116]	Optimally controls the throttle valve opening in accordance with the amount of accelerator pedal effort and the condition of the engine and the vehicle.
VVT-i (Variable Valve Timing-intelligent) [See page EG-119]	Controls the intake camshaft to optimal valve timing in accordance with the engine condition.
ACIS (Acoustic Control Induction System) [See page EG-123]	The intake air passages are switched according to the engine speed and throttle valve opening angle to provided high performance in all speed ranges.
Fuel Pump Control	• Based on signals from the ECM, the fuel pump ECU controls the fuel pump to 3 stages. • The fuel pump is stopped when the SRS airbag is deployed in a frontal, side, or side rear collision. • The basic construction and operation of the fuel pump control are the same as in the 1GR-FE engine. For details, see page EG-68.
Air Injection Control* [See page EG-125]	The ECM controls the air injection time based on the signals from the crankshaft position sensor, engine coolant temp. sensor, mass air flow meter and air pressure sensor.
Starter Control (Cranking Hold Function)	• Once the engine switch is pushed, this control continues to operate the starter until the engine started. • The basic construction and operation of the starter control are the same as in the 1GR-FE engine. For details, see page EG-70.
Air Fuel Ratio Sensor and Oxygen Sensor Heater Control	Maintains the temperature of the air fuel ratio sensors or oxygen sensors at an appropriate level to increase the detection accuracy of the exhaust gas oxygen concentration.

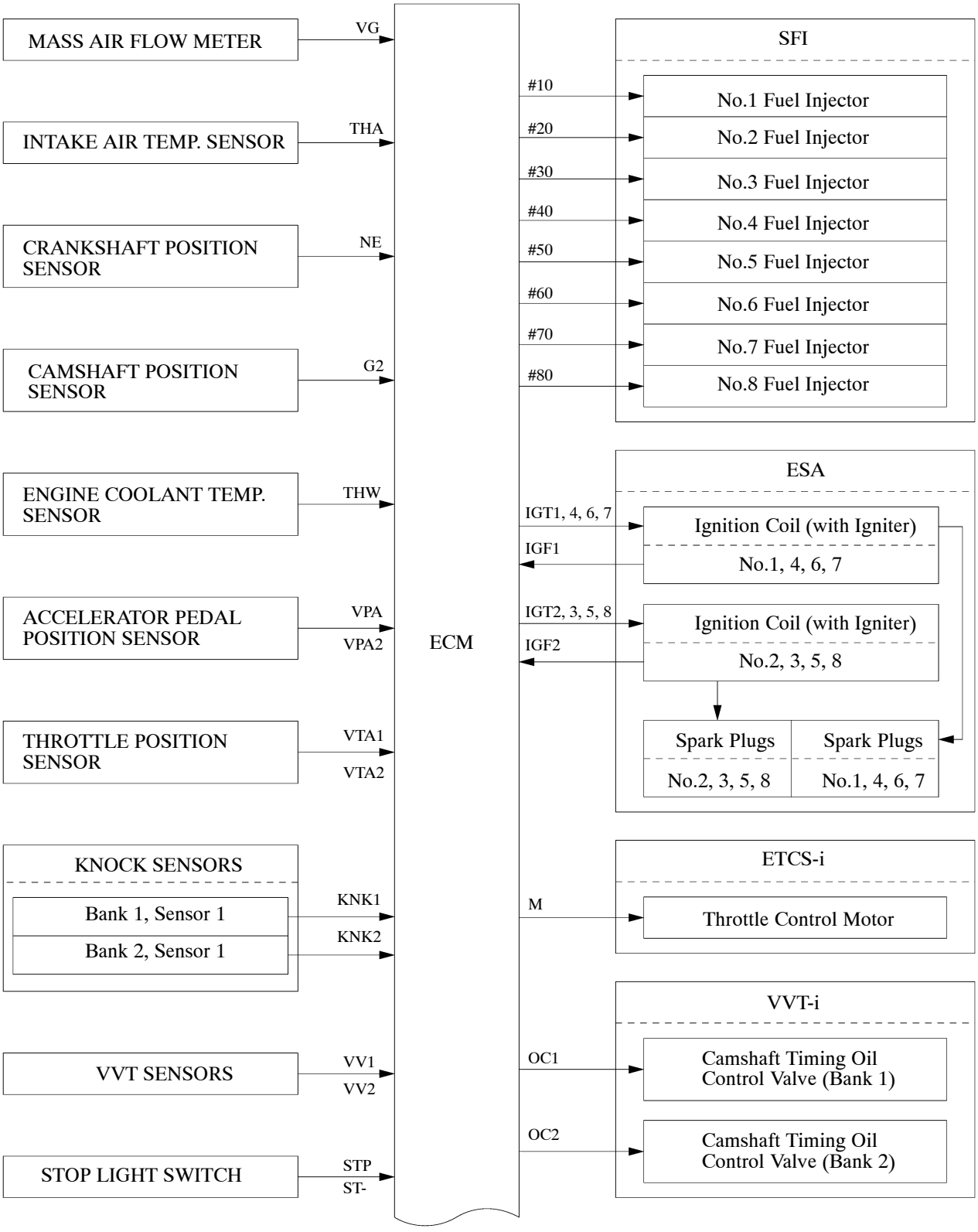
(Continued)

System	Outline
Air Conditioning Cut-off Control	By turning the air conditioning compressor ON or OFF in accordance with the engine condition, drivability is maintained.
Evaporative Emission Control	The ECM controls the purge flow of evaporative emission (HC) in the charcoal canister in accordance with engine conditions.
Engine Immobilizer	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid key.
Diagnosis [See page EG-130]	When the ECM detects a malfunction, the ECM records the malfunction and memorizes information related to the fault.
Fail-safe [See page EG-130]	When the ECM detects a malfunction, the ECM stops or controls the engine according to the data already stored in the memory.

*: Only for European, Australian and Chinese models

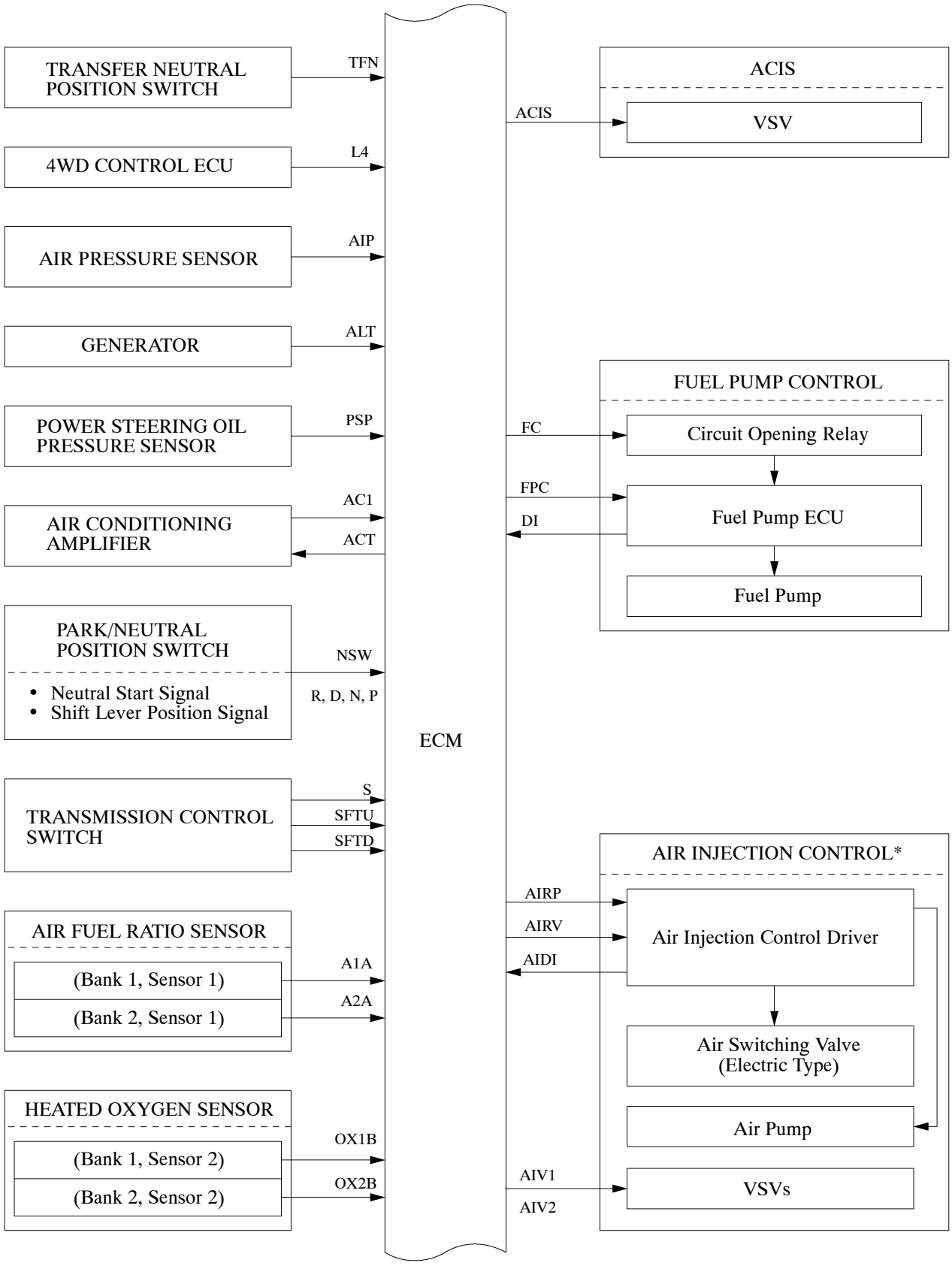
2. Construction

The configuration of the engine control system in the 2UZ-FE engine is as shown in the following chart.



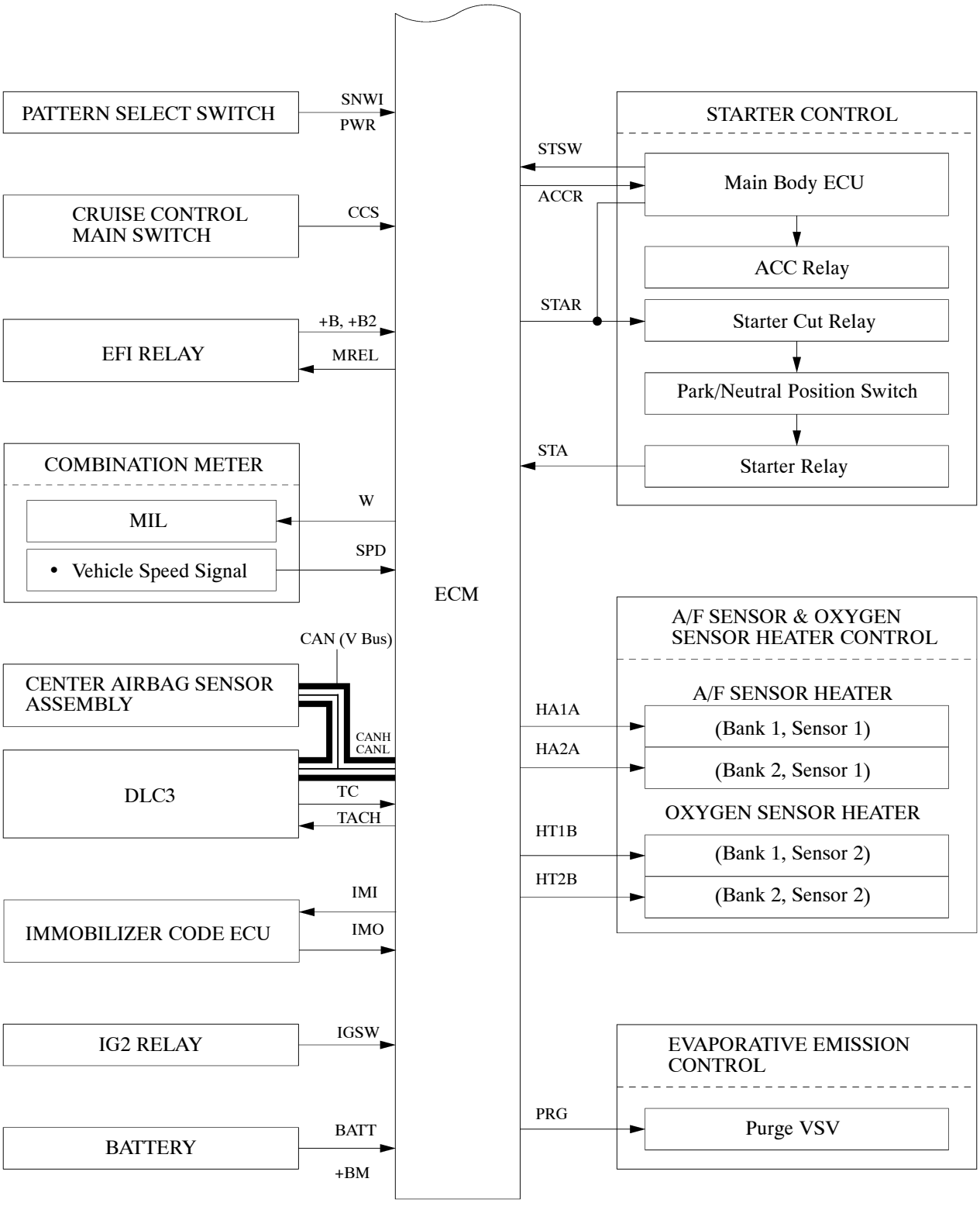
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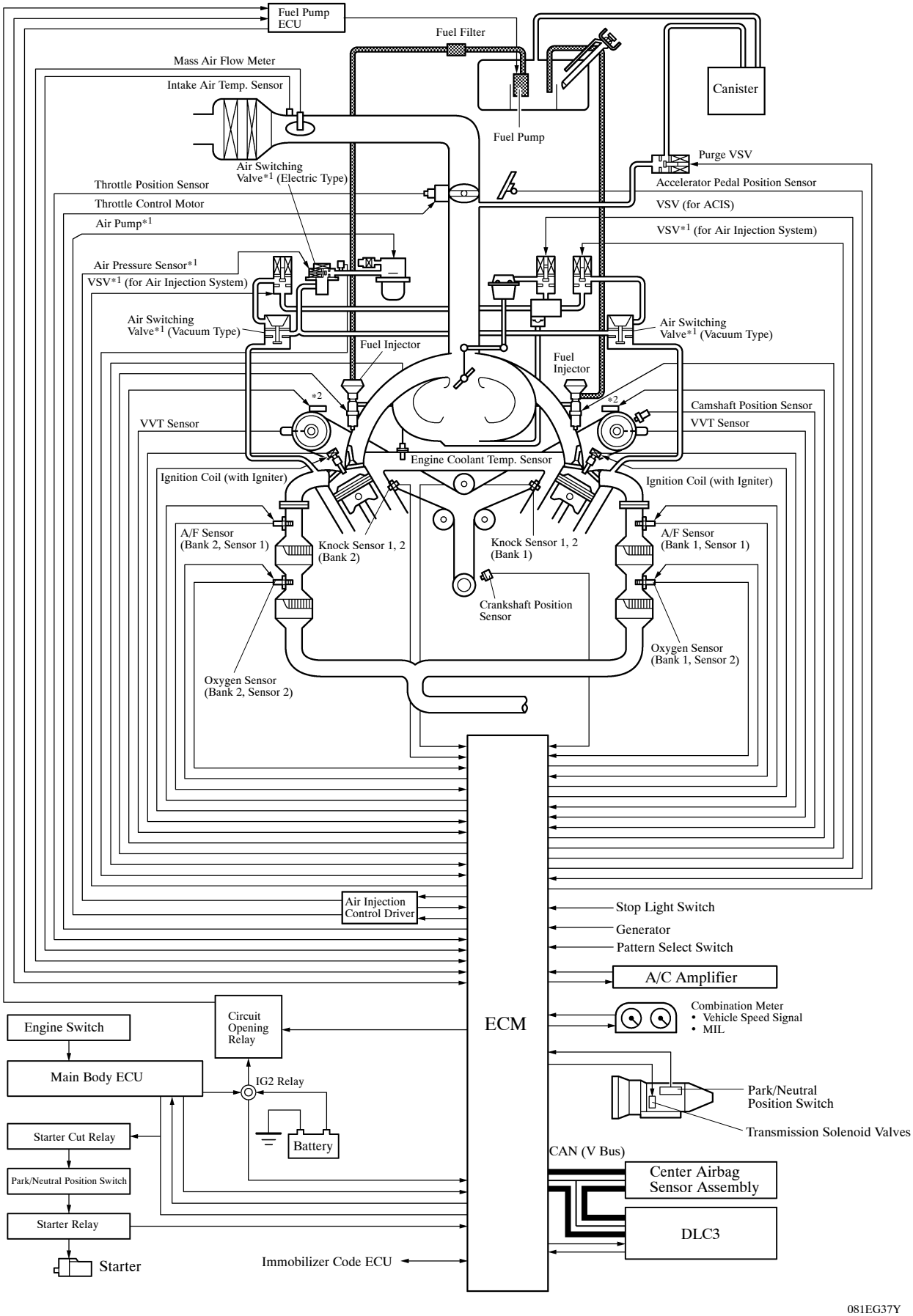


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*: Only for European, Australian and Chinese models

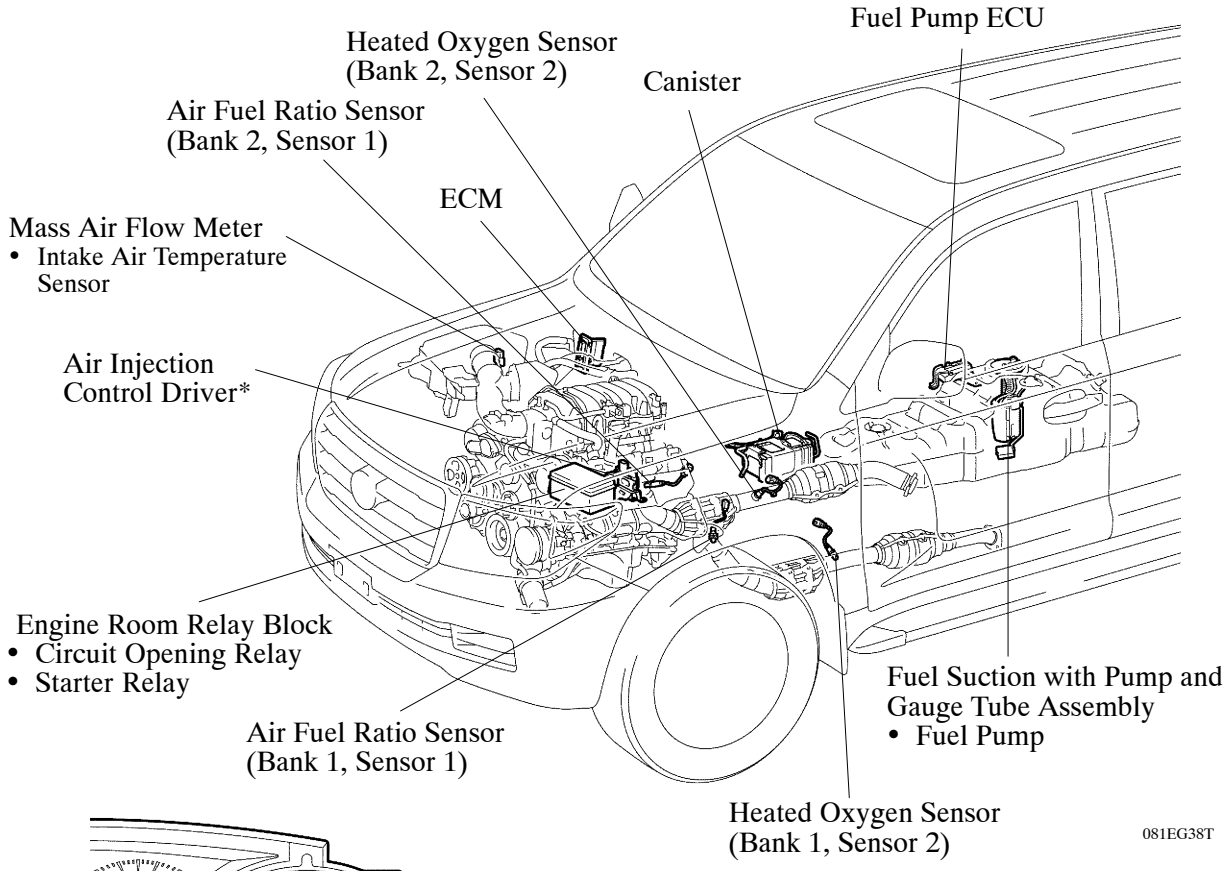
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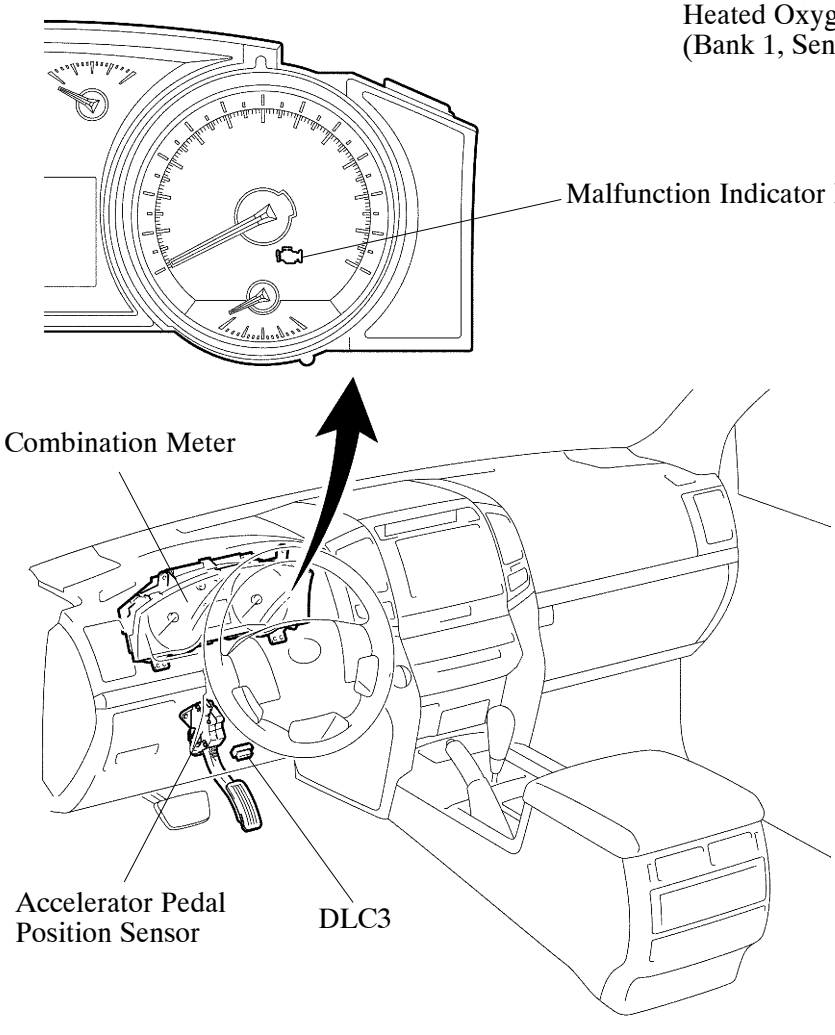
3. Engine Control System Diagram



*1: Only for European, Australian and Chinese models
*2: Camshaft Timing Oil Control Valve

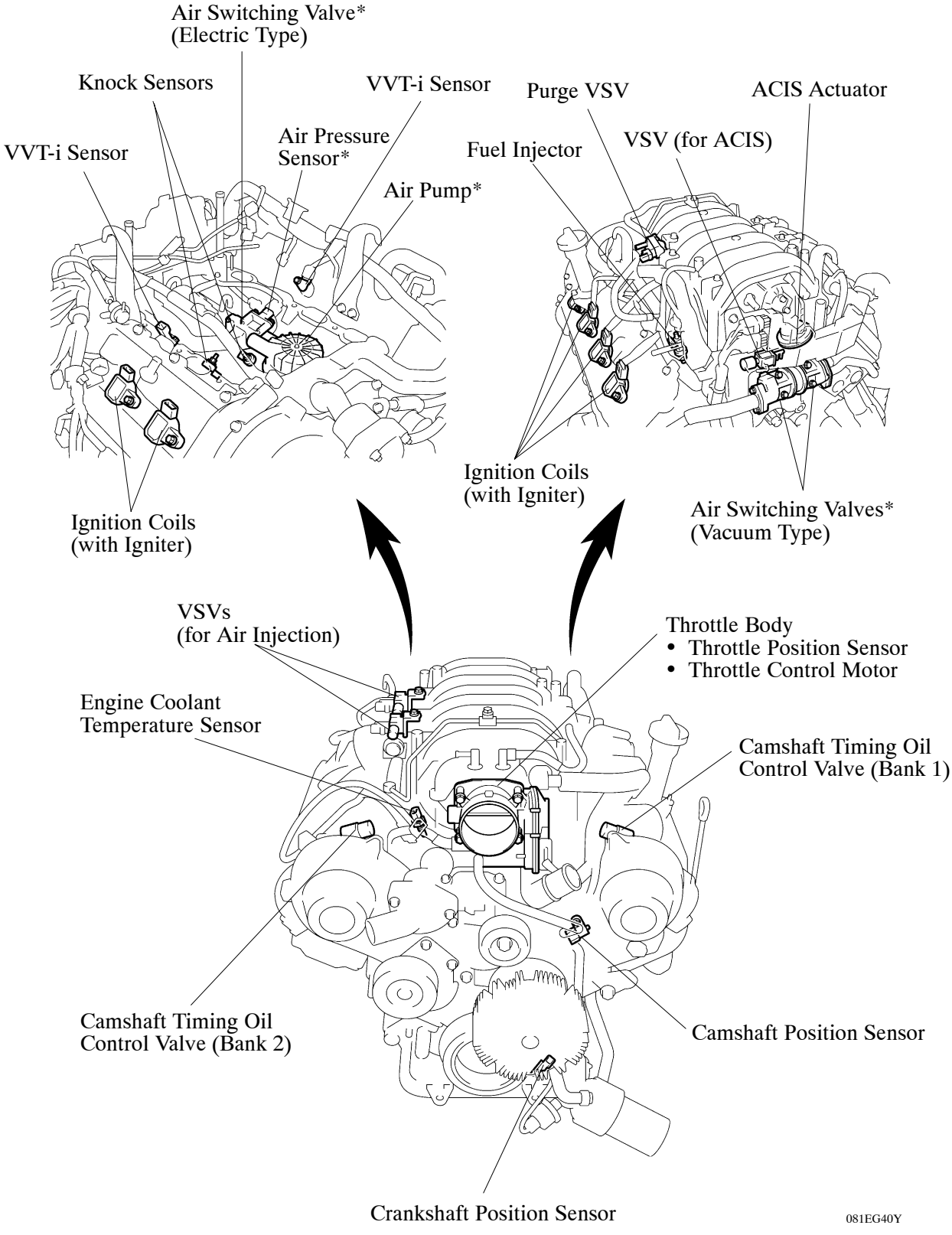
4. Layout of Main Components





*: Only for European, Australian and Chinese models

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*: Only for European, Australian and Chinese models

5. Main Components of Engine Control System

General

The main components of the 2UZ-FE engine control system are as follows:

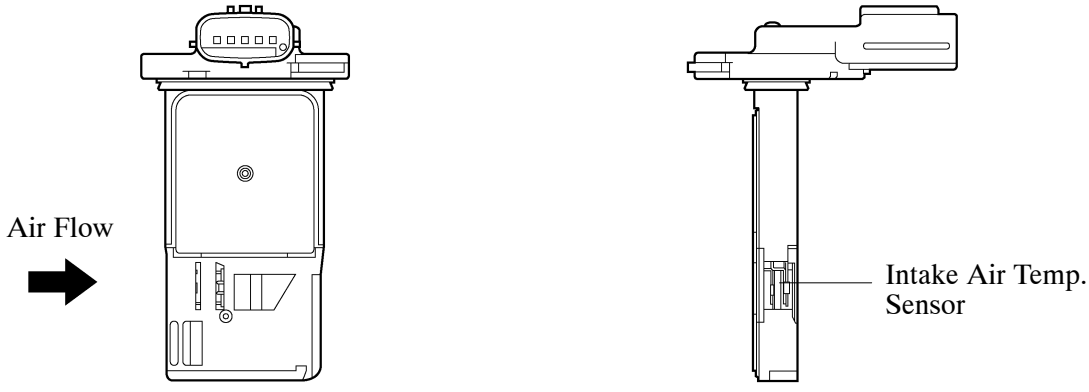
Components	Outline	Quantity	Function
ECM	32-bit CPU (DENSO)	1	The ECM optimally controls the SFI, ESA and ISC to suit the operating conditions of the engine in accordance with the signals provided by the sensors.
Mass Air Flow Meter [See page EG-112]	Hot-wire Type	1	This sensor has a built-in hot-wire 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.
Crankshaft Position Sensor [See page EG-113]	Pick-up Coil Type (Rotor Teeth /36-2)	1	This sensor detects the engine speed and the crankshaft position.
Camshaft Position Sensor [See page EG-113]	MRE Type (Rotor Teeth /3)	1	This sensor detects the camshaft position and performs the cylinder identification.
VVT Sensor [See page EG-115]	Pick-up Coil Type (Rotor Teeth /3)	1 each bank	This sensor detects the actual valve timing.
Accelerator Pedal Position Sensor	No-contact Type	1	• This sensor detects the amount of pedal effort applied to the accelerator pedal. • The basic construction and operation of this sensor are the same as in the 1GR-FE engine. For details, see page EG-54.
Throttle Position Sensor	No-contact Type	1	• This sensor detects the throttle valve opening angle. • The basic construction and operation of this sensor are the same as in the 1GR-FE engine. For details, see page EG-55.
Knock Sensor	Built-in Piezoelectric Type (Flat Type)	1 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. • The basic construction and operation of this sensor are the same as in the 1GR-FE engine. For details, see page EG-56.
Heated Oxygen Sensor	Cup Type with Heater	1 each bank	• This sensor detects the oxygen concentration in the exhaust gas by measuring the electromotive force which is generated in the sensor itself. • The basic construction and operation of this sensor are the same as in the 1GR-FE engine. For details, see page EG-58.

(Continued)

Components	Outline	Quantity	Function
Air Fuel Ratio Sensor	Planar Type with Heater	1 each bank	• As with the oxygen sensor, this sensor detects the oxygen concentration in the exhaust gas. However, it detects the oxygen concentration in the exhaust gas linearly. • The basic construction and operation of this sensor are the same as in the 1GR-FE engine. For details, see page EG-58.
Engine Coolant Temperature Sensor	Thermistor Type	1	This sensor detects the engine coolant temperature by means of an internal thermistor.
Fuel Injector [See page EG-96]	4-Hole Type	8	This fuel injector contains an electro-magnetically operated nozzle to inject fuel into the intake port.
Camshaft Timing Oil Control Valve [See page EG-121]	Electro-Magnetic 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.

Mass Air Flow Meter

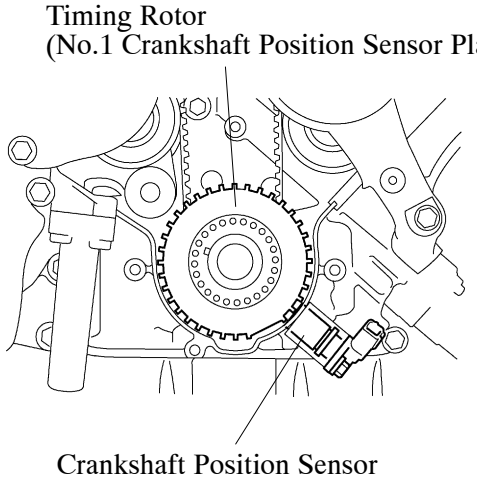
- This mass air flow meter, which is a slot-in type, allows a portion of the intake air to flow through the detection area. By directly measuring the mass and the flow rate of the intake air, the detection precision is improved and the intake air resistance is reduced.
- This mass air flow meter has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



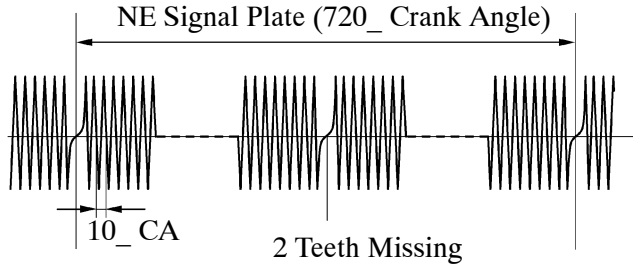
273GX15

Crankshaft Position Sensor

The timing rotor of the crankshaft consists of a 34 tooth plate with 2 teeth missing. The crankshaft position sensor outputs a crankshaft rotation signal every 10_ of crankshaft rotation, and the change of the signal due to the missing teeth is used to determine top-dead-center.



151EG18



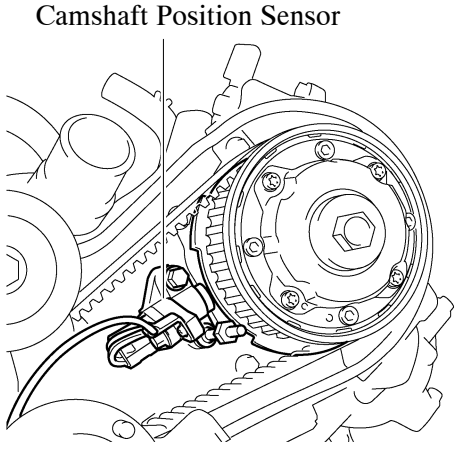
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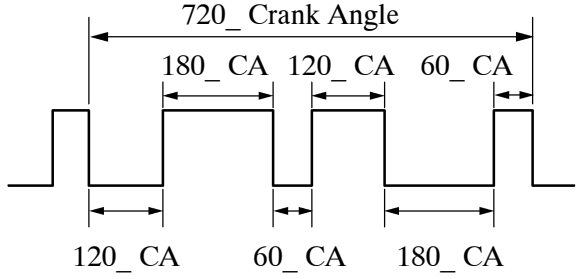
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Camshaft Position Sensor

1) General

The camshaft position sensor uses a timing rotor that is provided on the VVT-i controller of the left bank. Based on the timing rotor, the sensor outputs camshaft position signals consisting of 3 (3 Hi output, 3 Lo output) pulses for every 2 revolutions of the crankshaft.





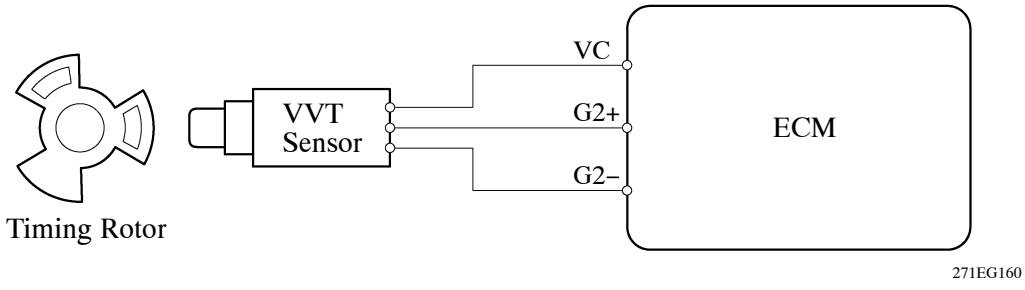
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2) Construction and Operation

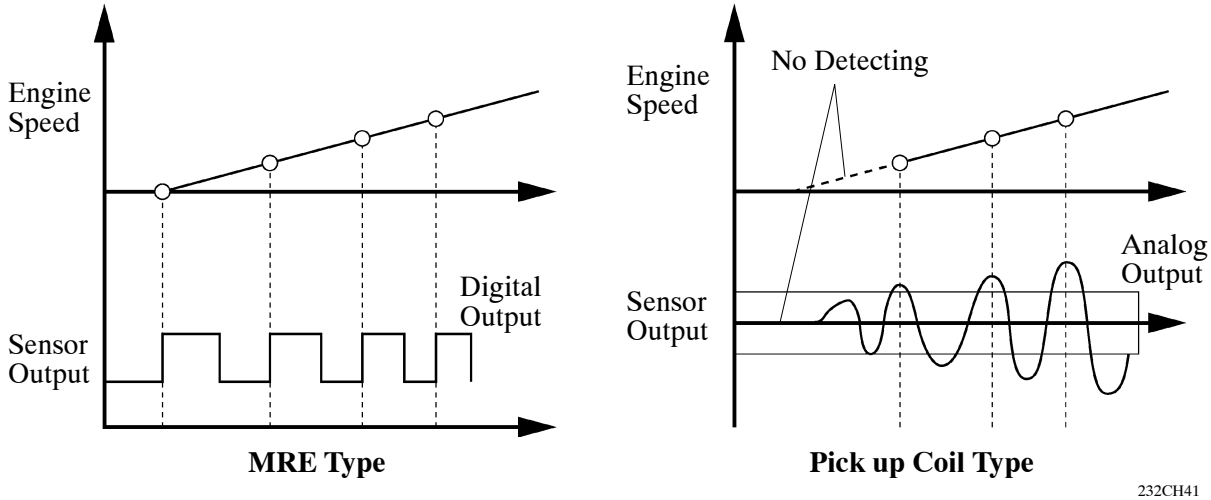
- The MRE type camshaft position sensor consists of an MRE, a magnet and a sensor. The direction of the magnetic field changes due to the different shapes (protruded and non-protruded portions) of the timing rotor, which passes by the sensor. As a result, the resistance of the MRE changes, and the output voltage to the ECM changes to Hi or Lo. The ECM detects the camshaft position based on this output voltage. The ECM compares the camshaft position sensor signal and crankshaft position sensor signals to detect the camshaft position and identify the cylinder.
- The differences between the MRE type camshaft position sensor and the pickup coil type camshaft position sensor used on the conventional model are as follows.

Item	Sensor Type	
	MRE	Pick up Coil
Signal Output	Constant digital output starts from low engine speeds	Analog output changes with the engine speed
Camshaft Position Detection	Detection based on the waveforms output throughout the timing rotor speed range	Detection based on the waveforms output as the protruded portion of the timing rotor passes

▶ Wiring Diagram ◀

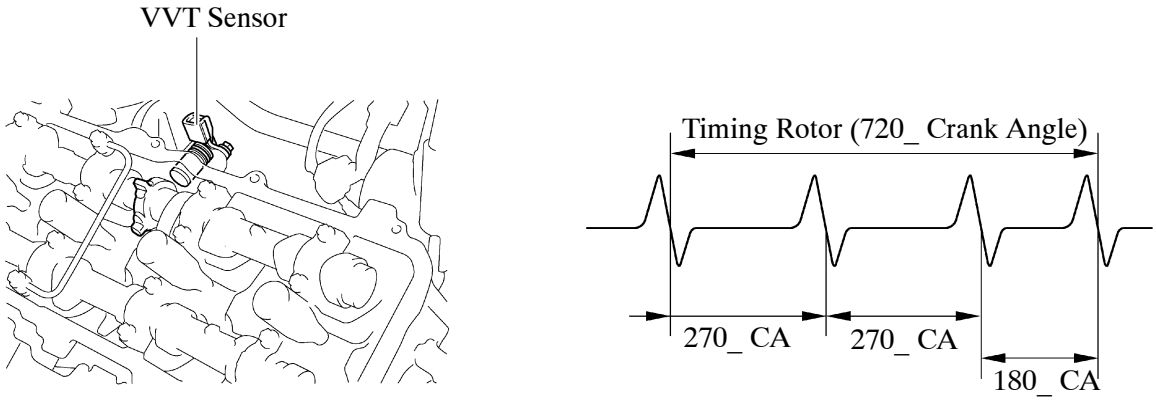


▶ MRE Type and Pickup Coil Type Output Waveform Image Comparison ◀



VVT Sensor

A VVT sensor is mounted on the intake side of each cylinder head. To detect the camshaft position, a timing rotor that is provided on the intake camshaft is used to generate 3 pulses for every 2 revolutions of the crankshaft. The ECM compares these VVT sensor signals and the crankshaft position sensor signal to detect the actual valve timing.



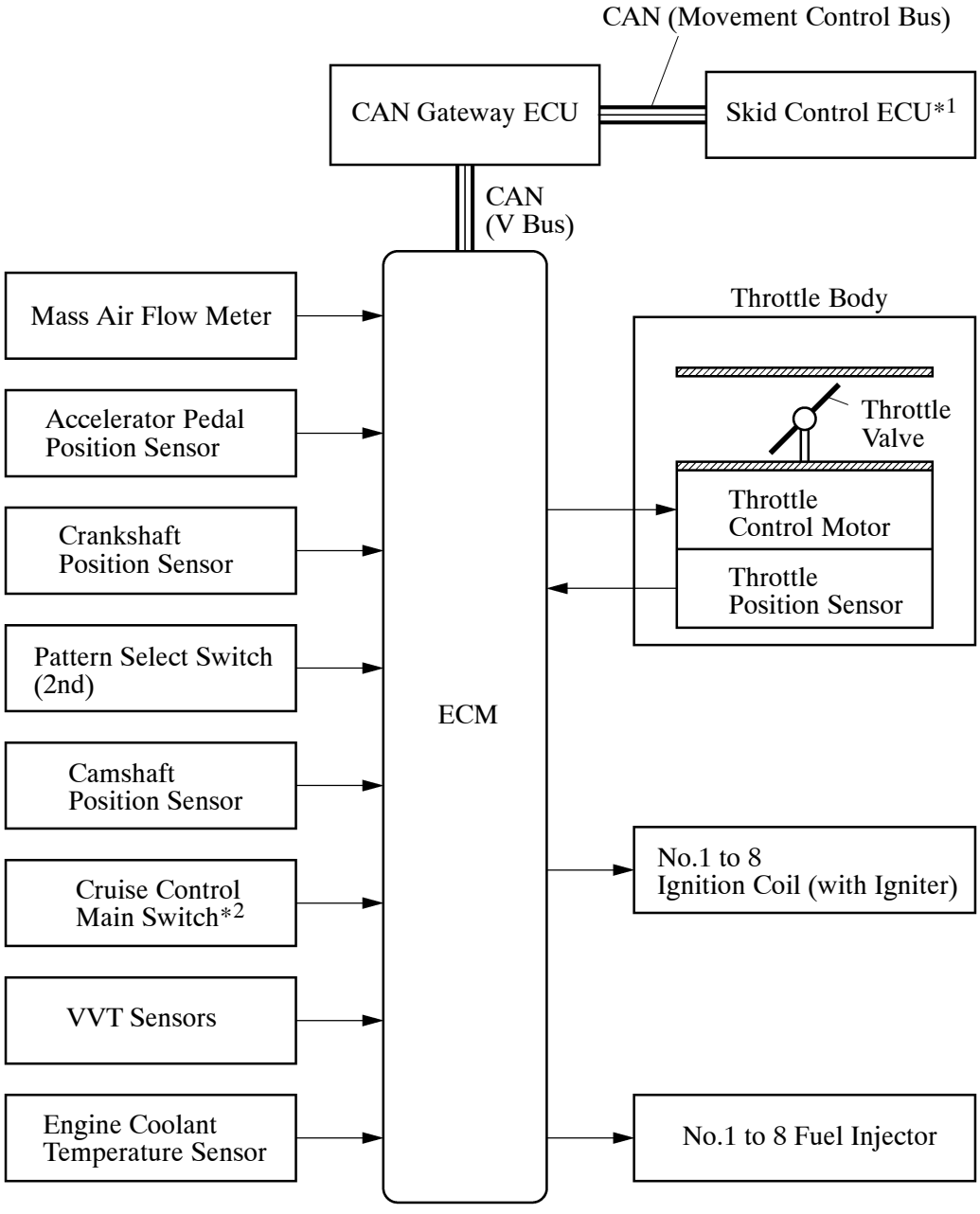
199EG38

6. ETCS-i (Electronic Throttle Control System-intelligent)

General

- In the conventional throttle body, the throttle valve angle is determined invariably by the amount of the 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. For details, see page EG-131.

▶ System Diagram ◀



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*1: Only for models with brake control system (Multi-terrain ABS with EBD, brake assist, A-TRC, VSC, hill-start assist control and CRAWL)
*2: Only for models with cruise control system

Control

1) General

The ETCS-i consists of the following functions:

- Normal Throttle Control (non-linear control)
- ISC (Idle Speed Control)
- A-TRC (Active Traction Control)*1
- VSC (Vehicle Stability Control) Coordination Control*1
- CRAWL (Crawl Control) Coordination Control*1
- Cruise Control*2

*1: Only for models with brake control system (Multi-terrain ABS with EBD, brake assist, A-TRC, VSC, hill-start assist control and CRAWL)

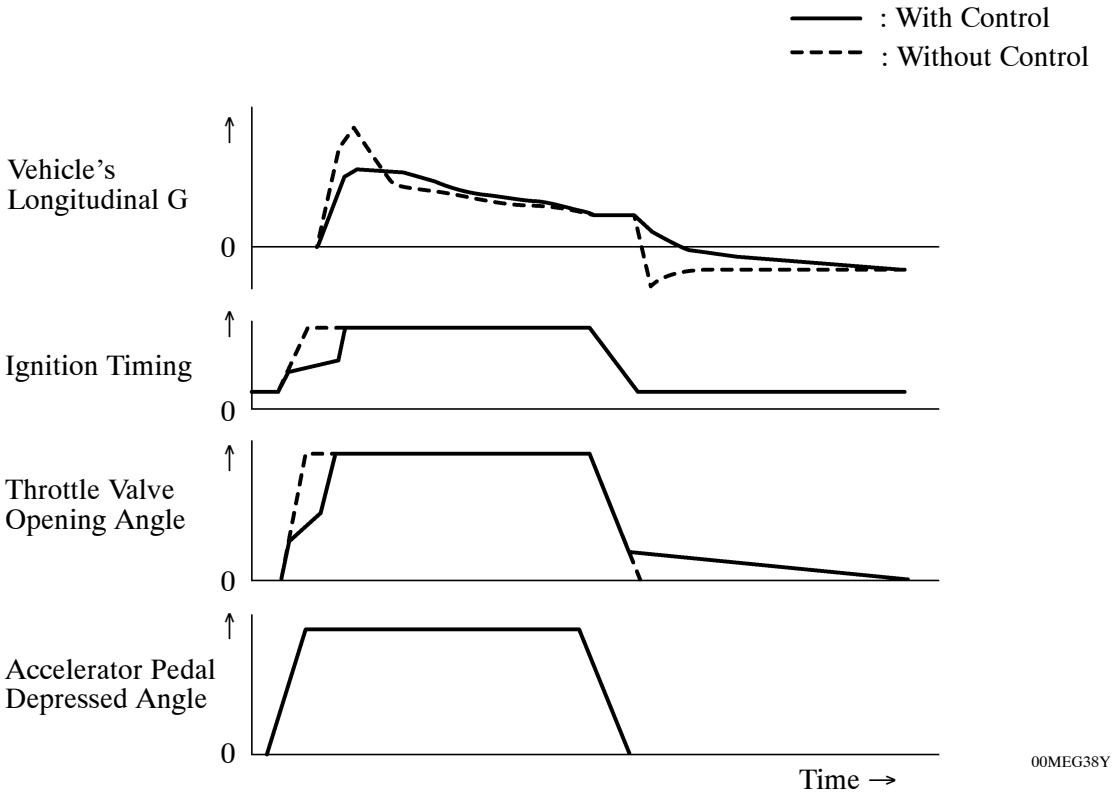
*2: Only for models with cruise control system

2) Normal Throttle Control (Non-linear Control)

a. General

Controls the throttle to an optimal throttle valve angle that is appropriate for the driving condition such as the amount of the accelerator pedal effort and the engine speed in order to realize excellent throttle control and comfort in all operating ranges.

▶ Conceptual Diagrams of Engine Control During Acceleration and Deceleration ◀



b. 2nd Start Control

In situations in which low-μ (low friction) road surface conditions can be anticipated, such as when driving in the snow, the rate of throttle valve opening can be controlled to help vehicle stability while driving on the slippery surface. This is accomplished by turning on 2nd start control. Pressing the 2nd side of the pattern select switch activates this control. This control modifies the relationship and reaction of the throttle to the accelerator pedal, and assists the driver by reducing the engine output from that of a normal level.

3) Idle Speed Control

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

4) A-TRC

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

5) 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 with the skid control ECU.

6) CRAWL Coordination Control

While the CRAWL is operating, the throttle valve is regulated through a coordination control with the skid control ECU.

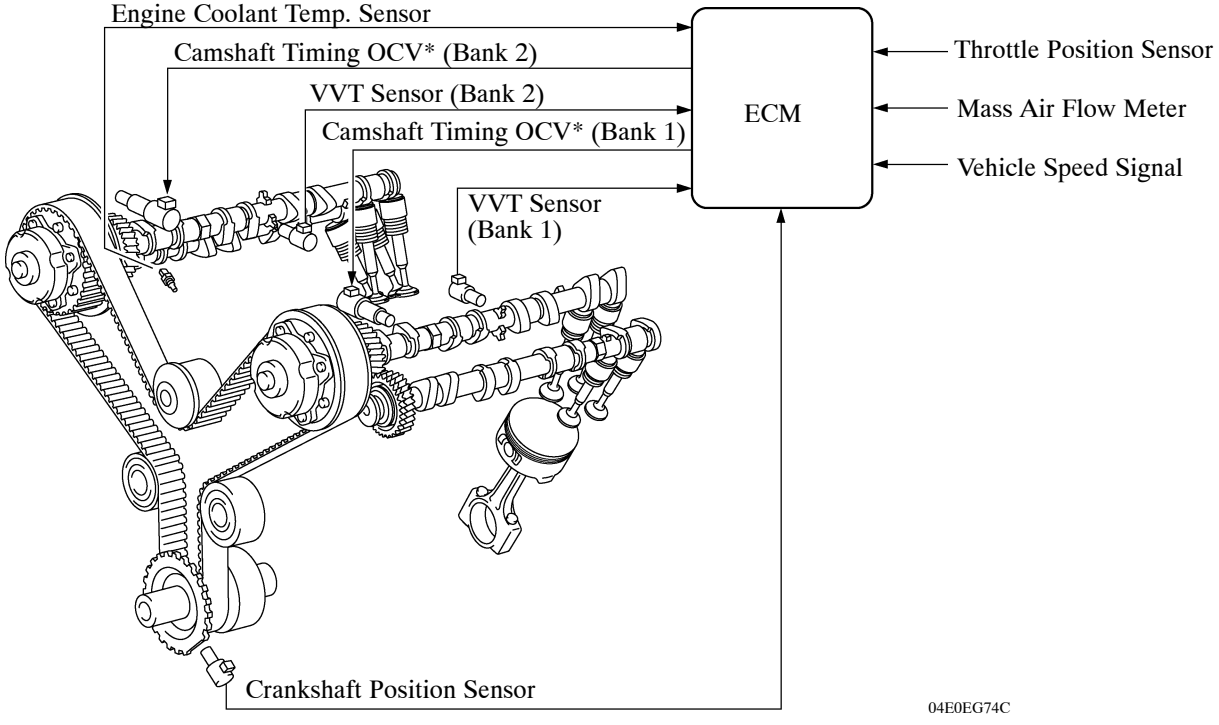
7) Cruise Control

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

7. VVT-i (Variable Valve Timing-intelligent) System

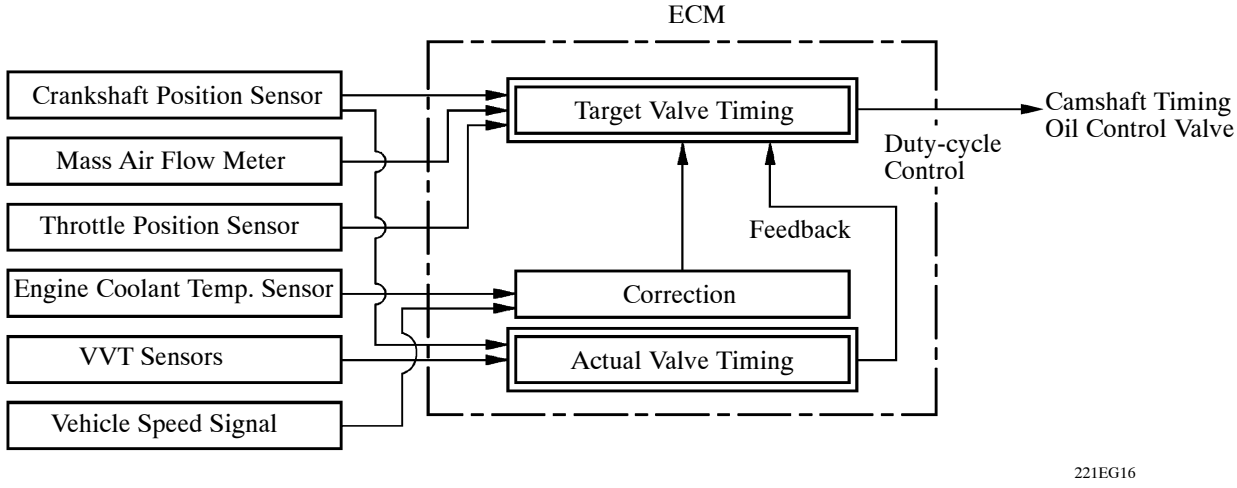
General

- The VVT-i system is designed to control the intake camshaft within a range of 40_ (of Crankshaft Angle) to provide valve timing that is optimally suited to the engine condition. This improves torque in all the speed ranges as well as increasing fuel economy, and reducing exhaust emissions.



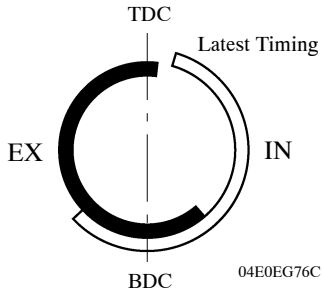
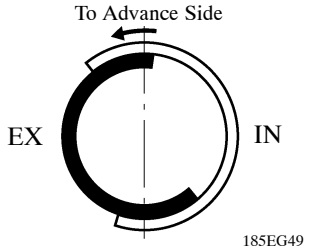
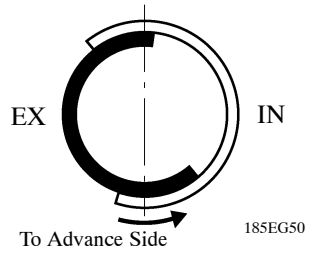
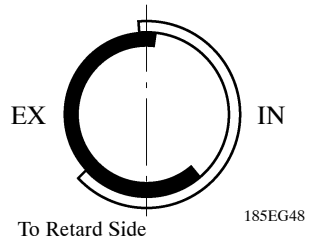
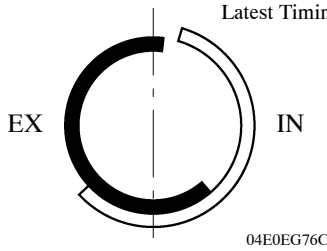
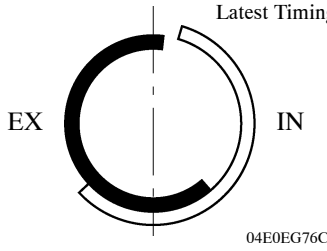
*: Oil Control Valve

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



EG

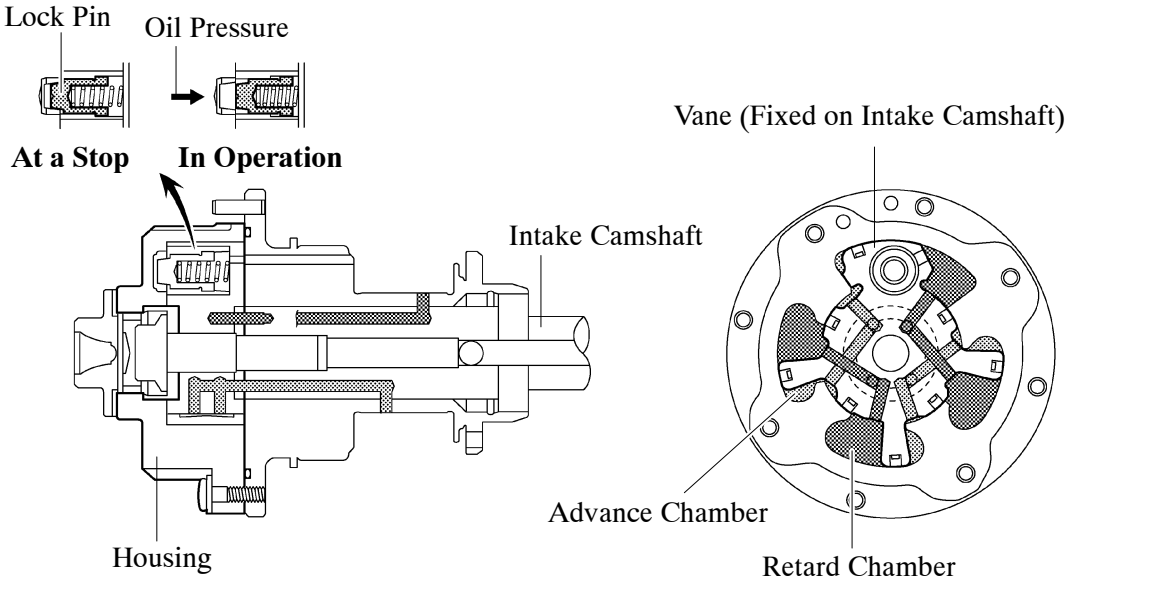
Effectiveness of the VVT-i System

Operation State	Objective	Effect
• During Idling • At Light Load	 Eliminating overlap to reduce blow back to the intake side	• Stabilized idling rpm • Better fuel economy
At Medium Load	 Increasing overlap to increase internal EGR to reduce pumping loss	• Better fuel economy • Improved emission control
In Low to Medium Speed Range with Heavy Load	 Advancing the intake valve close timing for volumetric efficiency improvement	Improved torque in low to medium speed range
In High Speed Range with Heavy Load	 Retarding the intake valve close timing for volumetric efficiency improvement	Improved output
At Low Temperatures	 Eliminating overlap to prevent blow back to the intake side and stabilizes the idling speed at fast idle.	• Stabilized fast idle rpm • Better fuel economy
• Upon Starting • Stopping the Engine	 Eliminating overlap to reduce blow back to the intake side	Improved startability

Construction

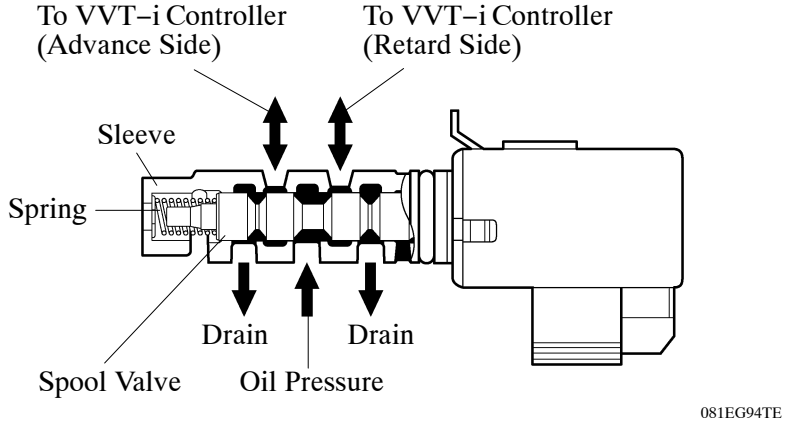
1) VVT-i Controller

VVT-i controller consists of the housing, four vanes, and a lock pin. The oil pressure sent from the advance or retard side path of the intake camshaft causes rotation in the VVT-i controller vane circumferential direction to vary the intake valve timing continuously. When the engine is stopped, the intake camshaft will be in the most retarded state to ensure startability. When hydraulic pressure is not applied to the VVT-i controller immediately after the engine has started, the lock pin locks the movement of the VVT-i controller to prevent a knocking noise. Thereafter, when hydraulic pressure is applied to the VVT-i controller, the lock pin is released.



2) Camshaft Timing Oil Control Valve

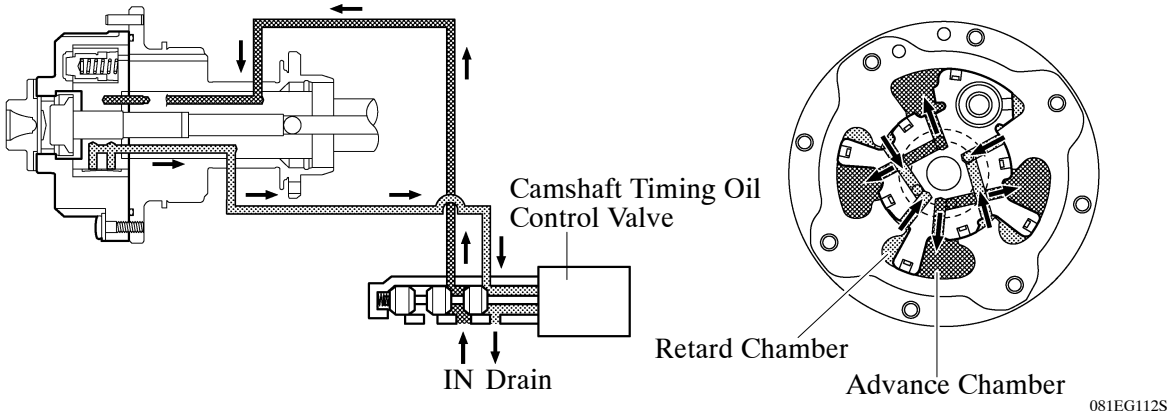
This camshaft timing oil control valve controls the spool valve using duty-cycle control from the ECM. This allows hydraulic pressure to be applied to the VVT-i controller advance or retard side. When the engine is stopped, the camshaft timing oil control valve is in the most retard position.



Operation

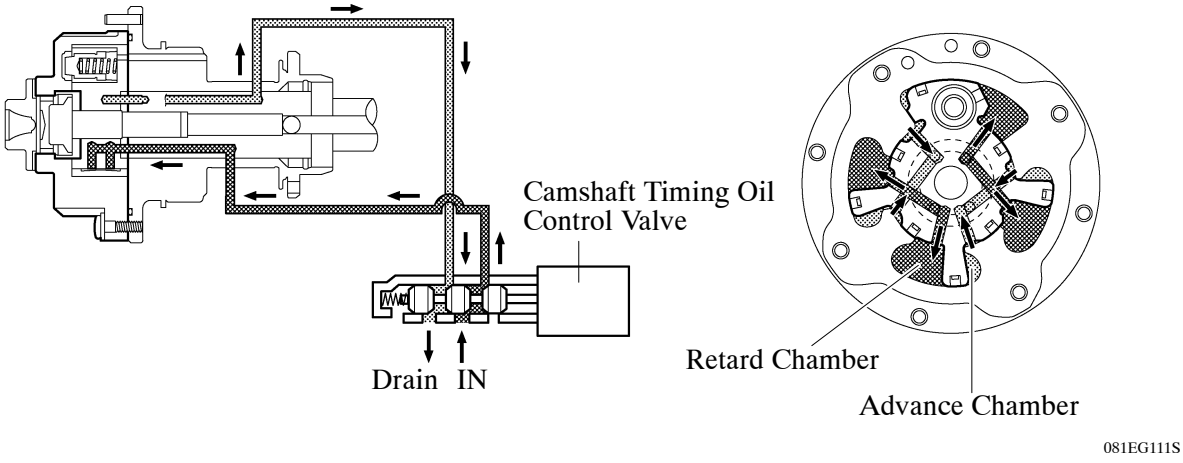
1) Advance

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.



2) 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.



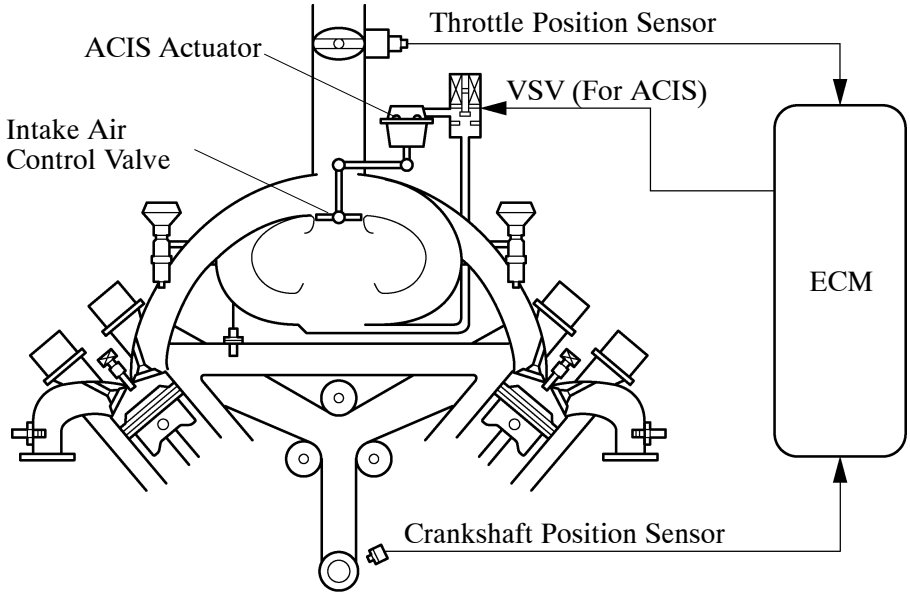
3) Hold

After reaching the target timing, the valve timing is held by keeping the camshaft timing oil control valve in the neutral position unless the traveling state changes.
This adjusts the valve timing at the desired target position and prevents the engine oil from running out when it is unnecessary.

8. ACIS (Acoustic Control Induction System)

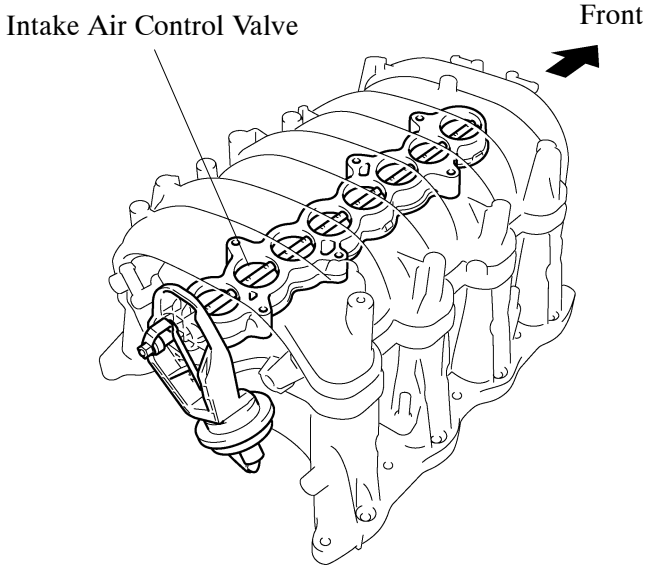
General

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



Intake Air Control Valve and Actuator

- The intake air control valve and actuator are integrated with the intake manifold.
- The intake air control valve opens and closes to make two effective lengths of the intake manifold possible.

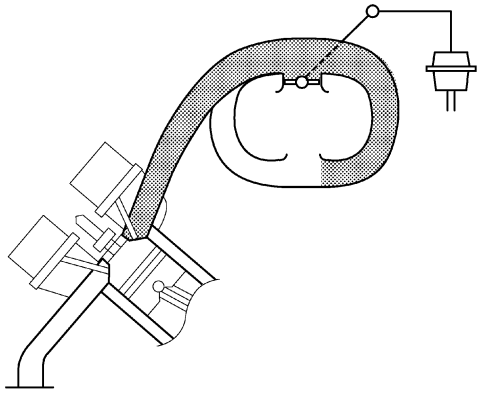


Operation

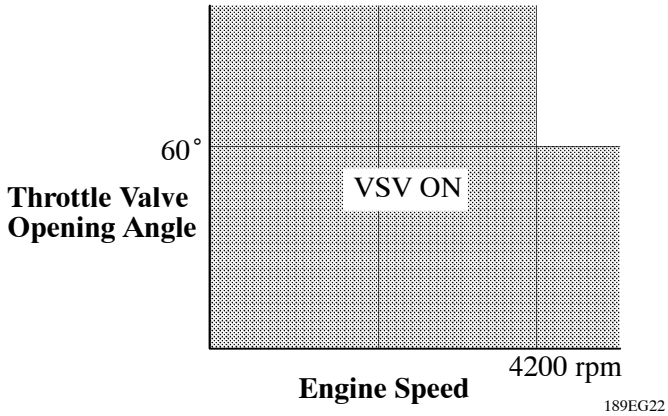
1) Intake Air Control Valve Close (VSV ON)

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

: Effective Intake Manifold Length



273GX23

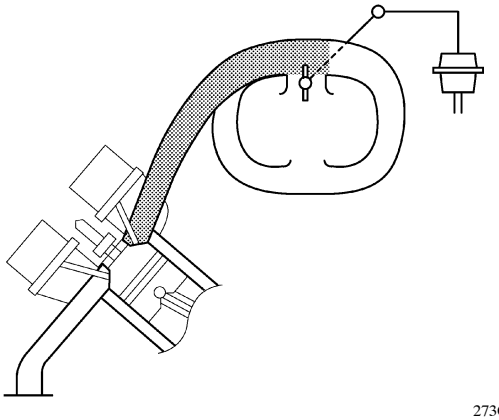


189EG22

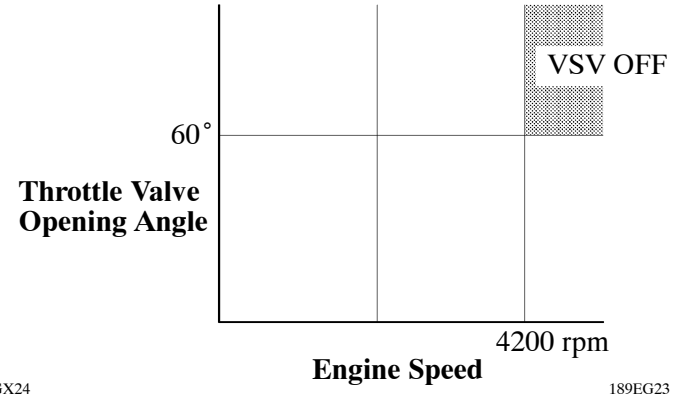
2) Intake Air Control Valve Open (VSV OFF)

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

: Effective Intake Manifold Length



273GX24



189EG23

9. Air Injection System (Only for European, Australian and Chinese Models)

General

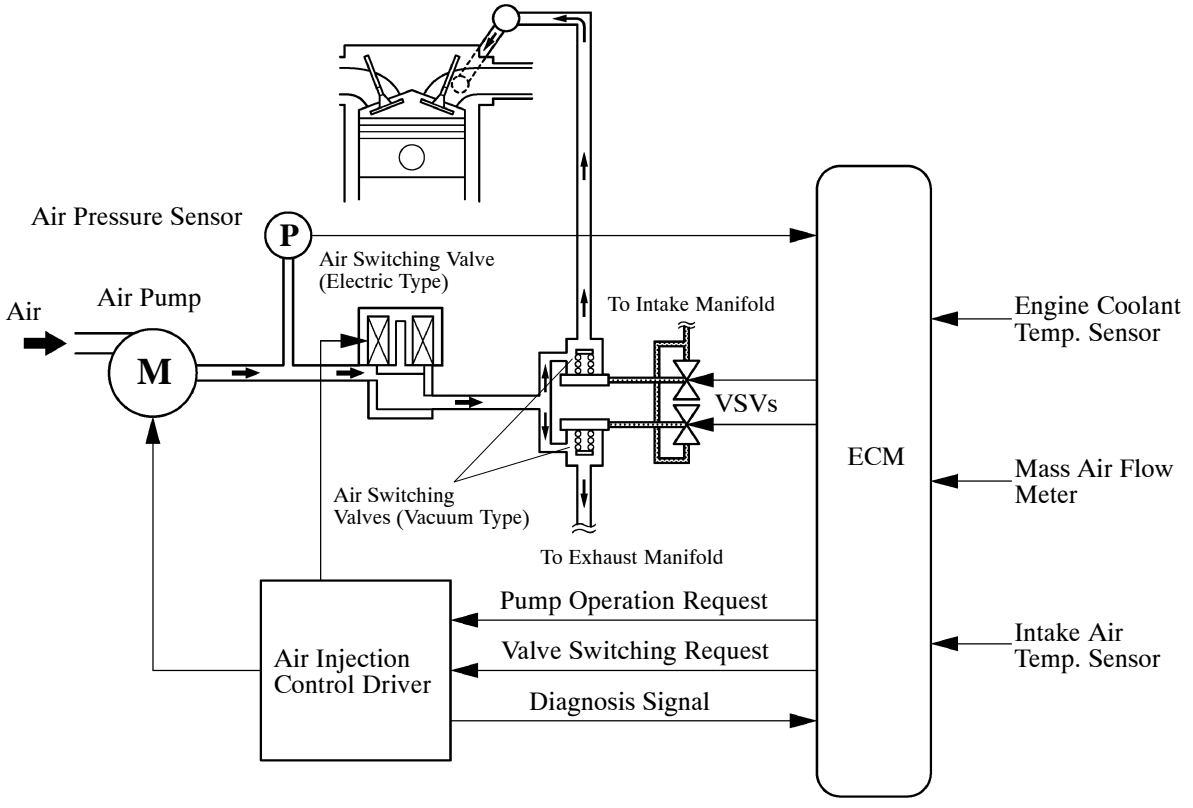
To ensure the proper warm-up performance of the TWC (Three-Way catalytic Converter) when starting a cold engine, an air injection system is used.

- This system consists of an air pump, an air injection control driver, two air switching valves (vacuum type), an air switching valve (electric type), and two VSVs.
- The ECM estimates the amount of the air injected to the TWC based on the 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 Temp.	5 to 45 _C (41 to 113 _F)
Intake Air Temp.	5 _C (41 _F) or more

▶ System Diagram ◀



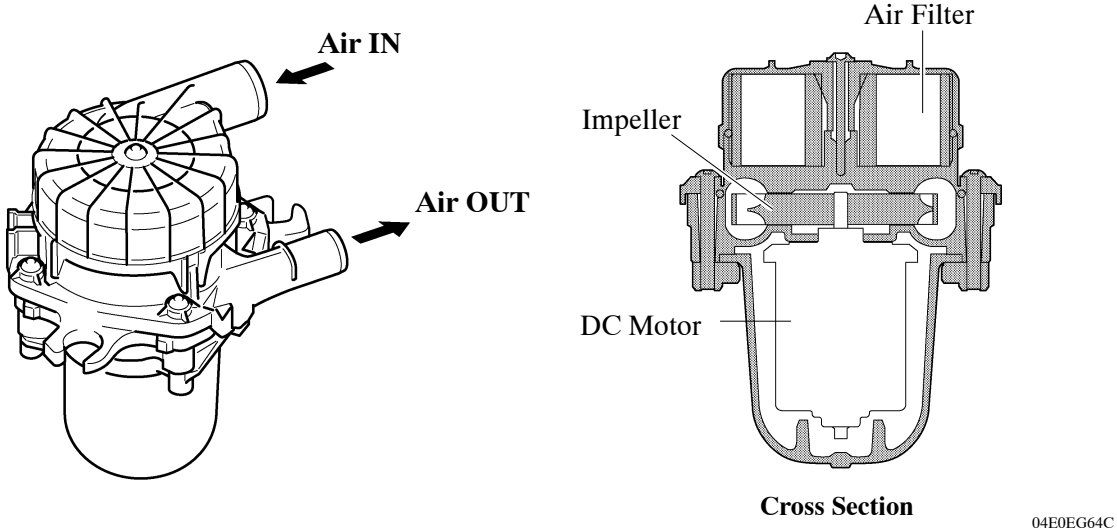
273GX25

Construction and Operation

1) Air Pump

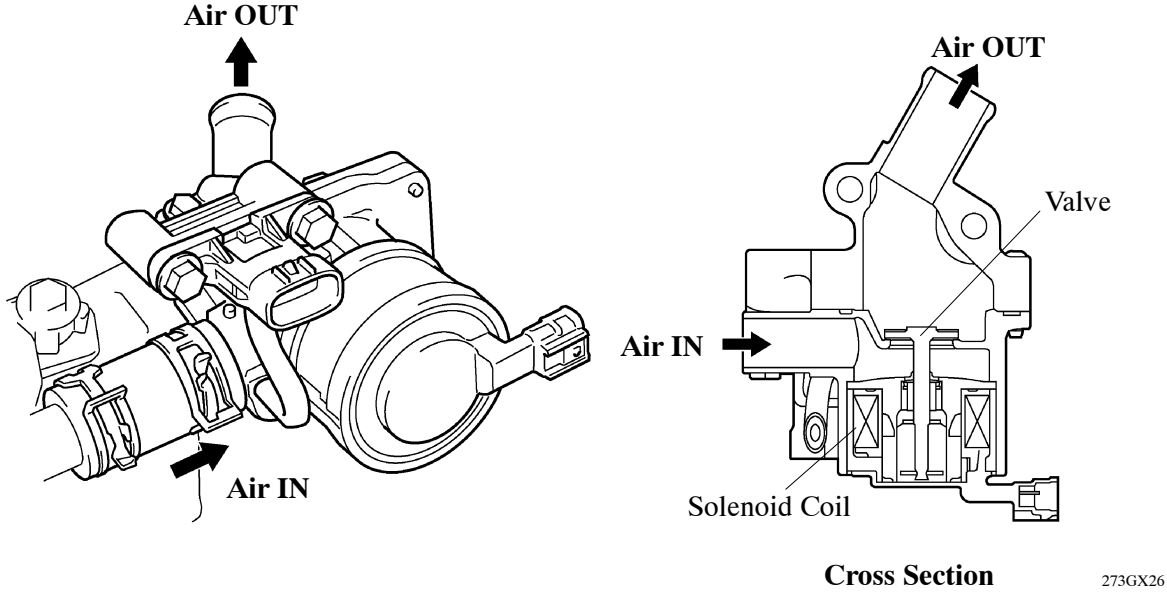
An air pump consists of a DC motor, an impeller and an air filter.

- The pump supplies air into an air switching valve (electric type) using its impeller.
- The air filter is maintenance-free.



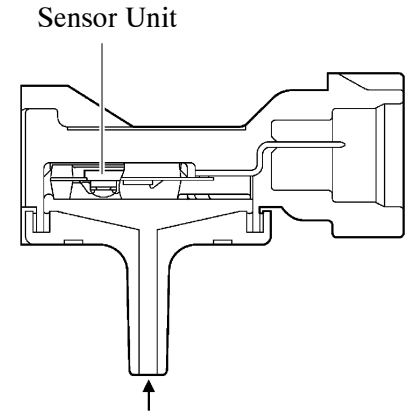
2) Air Switching Valve (Electric Type)

The air switching valve (electric type) is operated by a solenoid coil to control air injection and prevent back-flow of exhaust gas. Opening timing of the valve is synchronized with operation timing of the electric air pump.

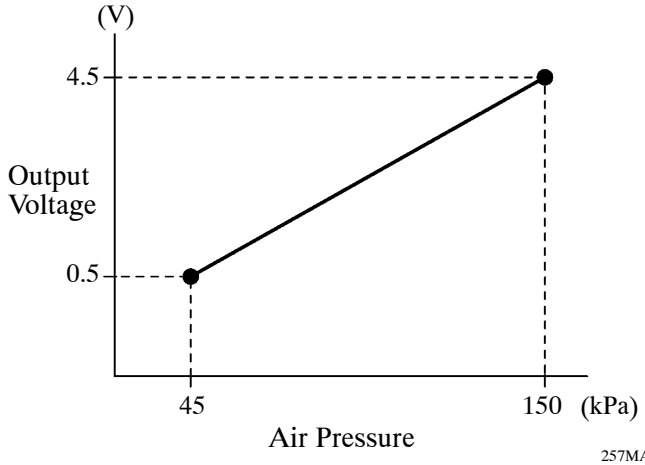


3) Air Pressure Sensor

The air pressure sensor consists of a semiconductor, which utilizes the characteristics of 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.



257MA21

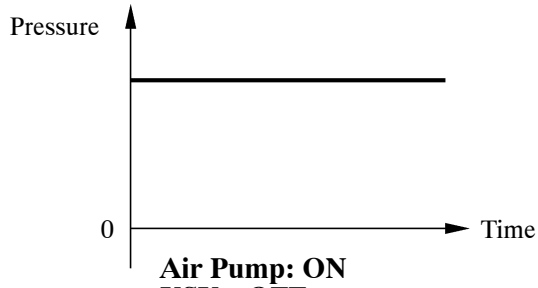


257MA22

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

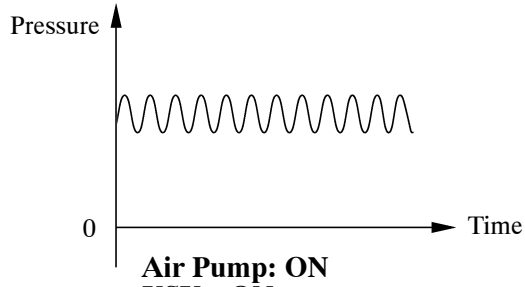
1) When the air pump is ON and the VSVs are OFF, the pressure is constant.
2) When the VSVs are turned ON with the air pump ON and all air switching valves open, the pressure drops slightly and becomes unstable because of exhaust-pulse.
3) When the air pump is OFF and the VSVs are OFF, the pressure remains 0.
4) When the VSVs are turned ON with the air pump OFF and all air switching valves open, the pressure drops below 0 and becomes unstable because of exhaust-pulse.

Example: 1



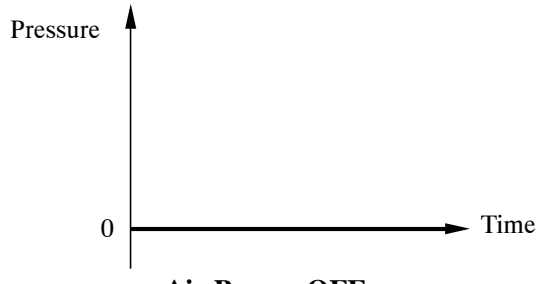
Air Pump: ON
VSVs: OFF

Example: 2



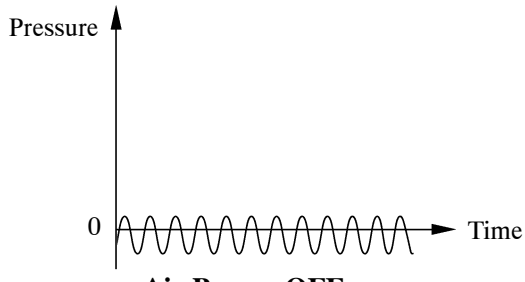
Air Pump: ON
VSVs: ON

Example: 3



Air Pump: OFF
VSVs: OFF

Example: 4



Air Pump: OFF
VSVs: ON

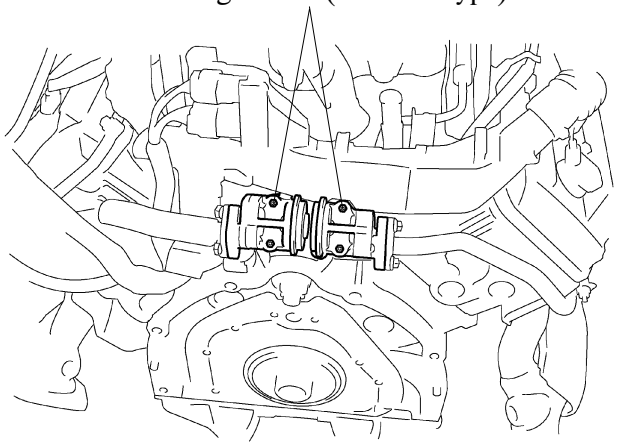
273GX81

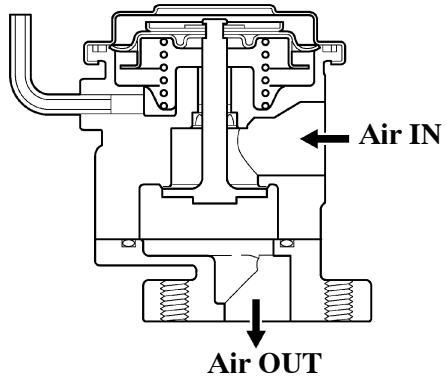
EG

4) Air Switching Valve (Vacuum Type)

The air switching valve (vacuum type) switches according to the vacuum pressure introduced by VSV.

Air Switching Valves (Vacuum Type)

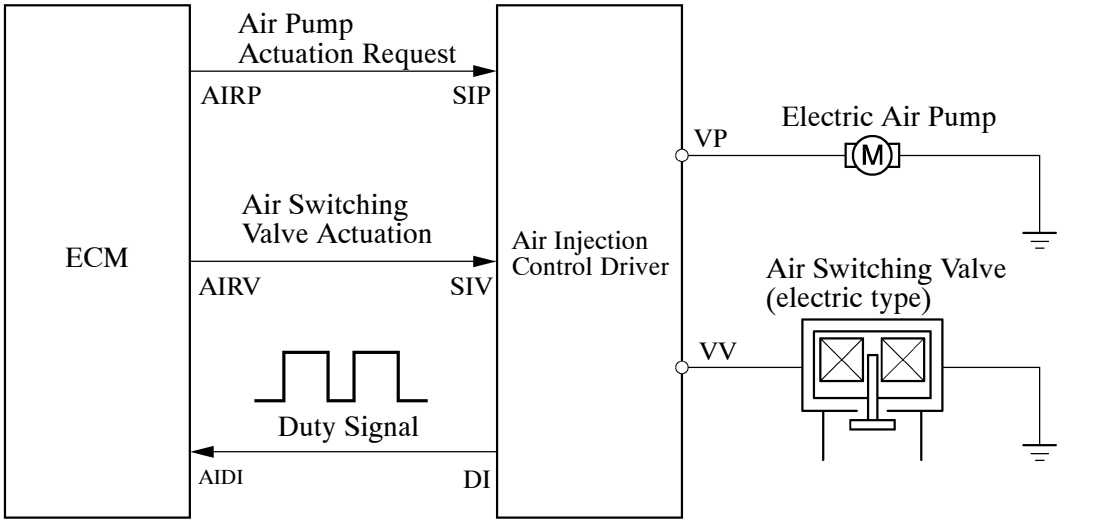




273GX27

5) 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 (electric type).
- 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.



▶ DI Terminal Output ◀

Condition	AIRP	AIRV	Output (Duty 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 GND 273GX30
Output failure at air injection control driver. (Failure in air switching valve actuation circuit)	—	—	GND 273GX31
Overheat failure of air injection control driver.	—	—	GND 273GX32
Normal	ON	ON	GND 273GX33
	OFF	OFF	GND 273GX29
	ON	OFF	
	OFF	ON	

10. Diagnosis

- When the ECM detects a malfunction, the ECM makes a diagnosis and memorizes the failed section. Furthermore, the check engine warning light in the combination meter illuminates or blinks to inform the driver.
- The ECM will also store the DTC (Diagnostic Trouble Code) of the malfunctions. The DTC can be accessed by using the intelligent tester II.
- For details, refer to the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

Service Tip

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

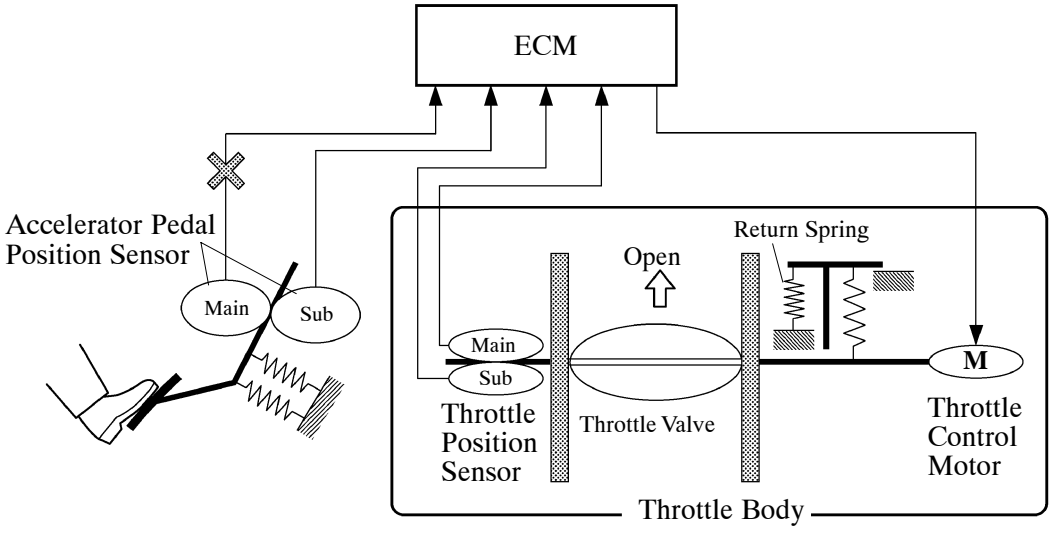
11. Fail-safe

General

When a malfunction is detected at any of the sensors, there is a possibility of an engine or other malfunction occurring if the ECM were to continue 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 Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

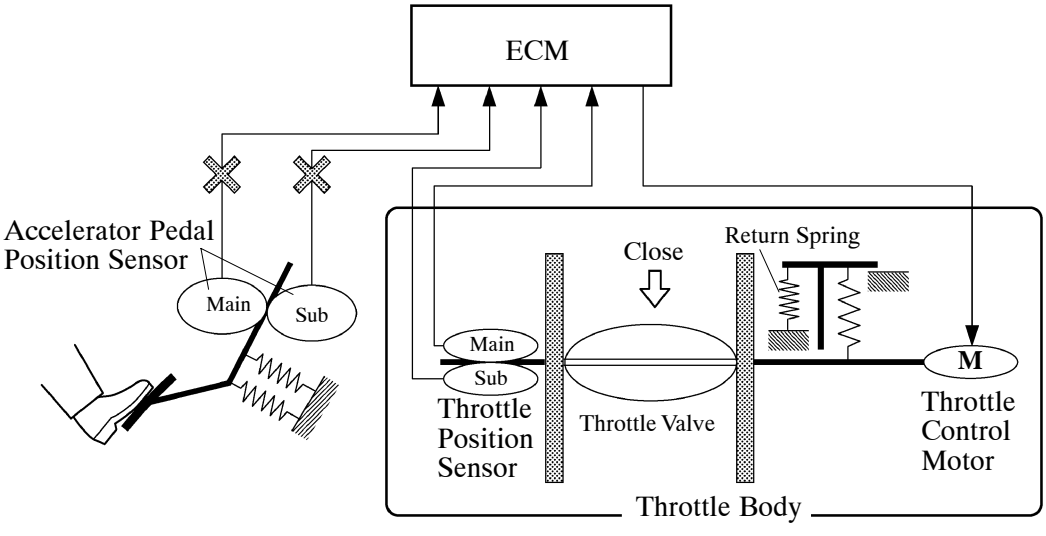
Fail-safe Operation due to Accelerator Pedal Position Sensor Trouble

- The accelerator pedal position sensor comprises two (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.



D13N08

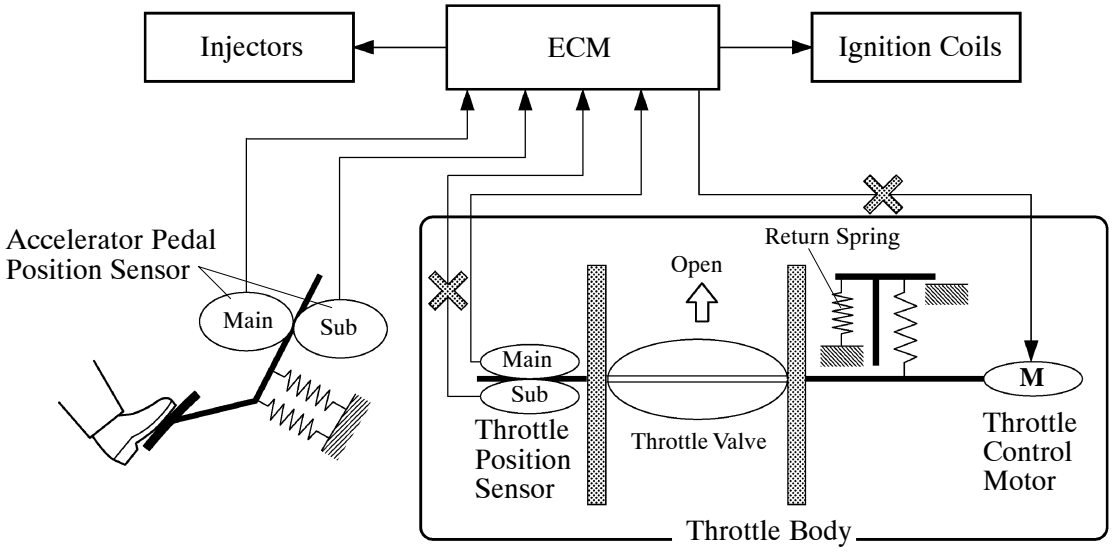
- If both circuits malfunction, the ECM detects the abnormal signal voltage from these two sensor circuits and discontinues the throttle control. At this time, the vehicle can be driven within its idling range.



D13N09

Fail-safe Operation due to Throttle Position Sensor Trouble

- The throttle position sensor comprises two (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, 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.

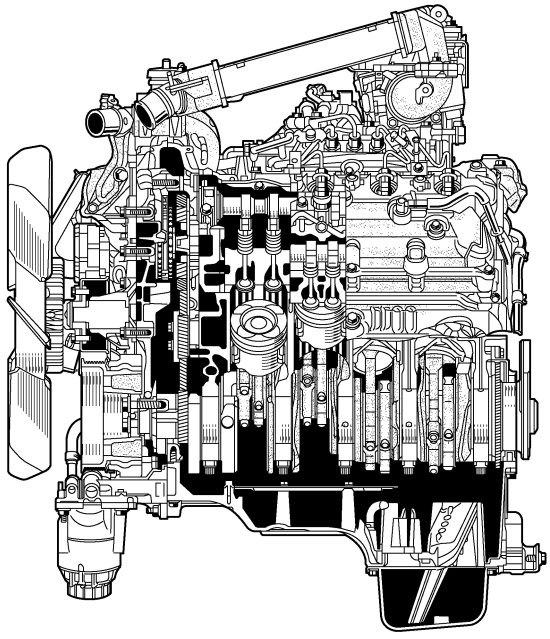


D13N10

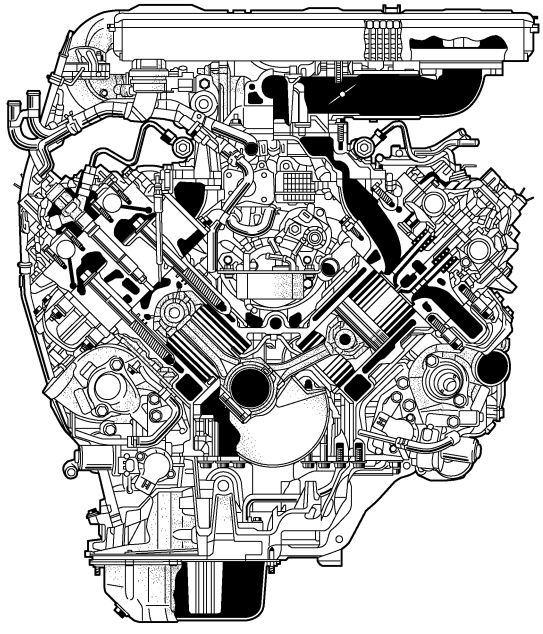
1VD-FTV ENGINE

■ DESCRIPTION

The 1VD-FTV engine is newly provided. The 1VD-FTV TOYOTA D-4D (Direct injection 4 stroke common-rail Diesel engine) is V8 4.5 liter, 32-valve DOHC, turbocharged diesel engine with intercooler. This engine uses direct injection system and common-rail system to realize high performance, clean emission, low noise and low vibration.



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081EG05Y

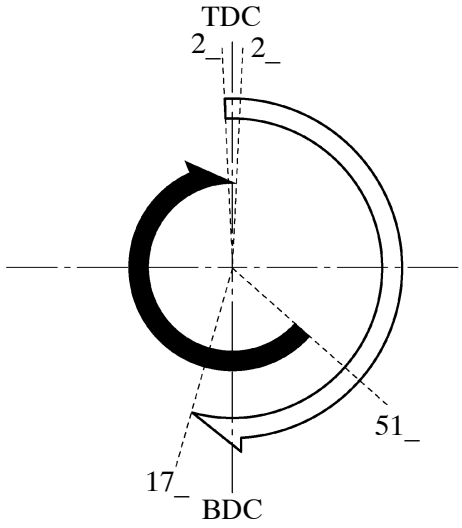
▶ Engine Specifications ◀

No. of Cyls. & Arrangement			8-Cylinder, V Type
Valve Mechanism			32-valve, DOHC, Chain & Gear Drive
Combustion Chamber			Direct Injection Type
Manifolds			Cross-flow
Fuel System			Common-rail Type
Displacement cm^3 (cu. in.)			4461 (272.2)
Bore × Stroke mm (in.)			86.0 × 96.0 (3.39 × 3.78)
Compression Ratio			16.8 : 1
Max. Output [ECE]	Europe		210 kW @ 3600 rpm
	Australia and Europe (Models with pre-cleaner)		195 kW @ 3400 rpm
	G.C.C. Countries and General Countries	A/T	173 kW @ 3200 rpm
		M/T	162 kW @ 3600 rpm
Max. Torque [ECE]	Europe		650 N·m @ 1600 to 2800 rpm
	Australia and Europe (Models with pre-cleaner)		650 N·m @ 1600 to 2600 rpm
	G.C.C. Countries and General Countries	A/T	615 N·m @ 1800 to 2200 rpm
		M/T	430 N·m @ 1200 to 3600 rpm
Valve Timing	Intake	Open	2_ BTDC
		Close	17_ ABDC
	Exhaust	Open	51_ BBDC
		Close	2_ ATDC
Firing Order			1-2-7-3-4-5-6-8
Oil Grade	Europe		ACEA B1, API CF-4 or CF
	Except Europe		G-DLD-1, API CF-4 or CF
Fuel Cetane Number	Europe		48 or higher
	Except Europe		50 (Cetane Index 45) or higher
Emission Regulation	Europe		EURO IV
			EURO III*1
	Australia		EURO IV
	G.C.C. Countries		—
	General Countries		EURO III*2
			EURO II*3
			—
Engine Service Mass*4 (Reference) kg (lb)	Models with EGR	A/T	325 (717)
		M/T	340 (750)
	Models without EGR	A/T	320 (705)
		M/T	334 (736)

*1: Russian package models
*2: Package models for South Africa, Argentina and Papua New Guinea
*3: Package models for Philippines and Vietnam
*4: The figure shown is the weight of the part without coolant and oil.

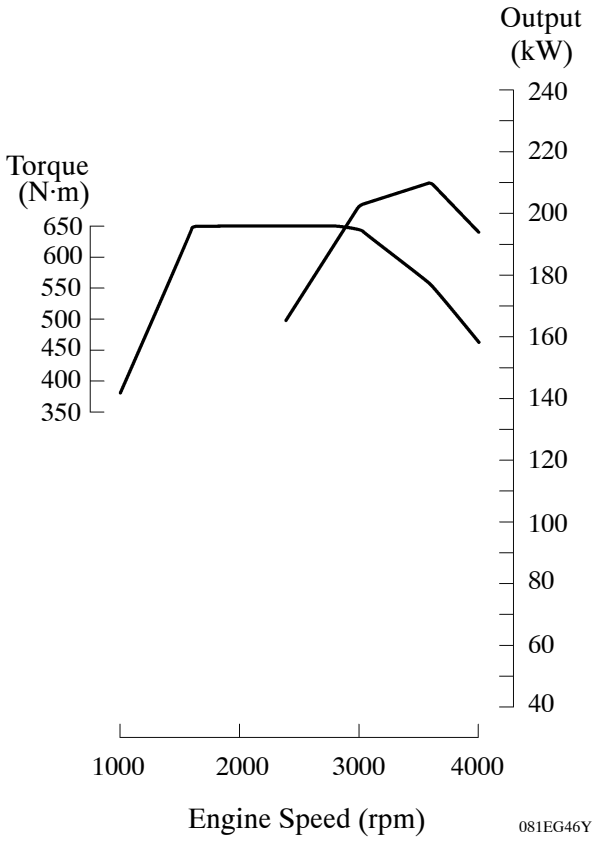
▶ Valve Timing ◀

: Intake Valve Opening Angle
: Exhaust Valve Opening Angle

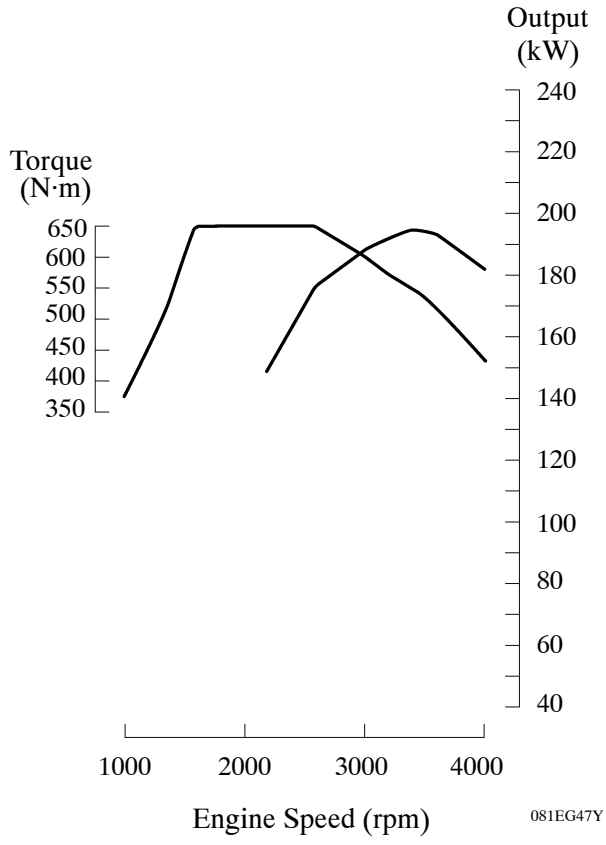


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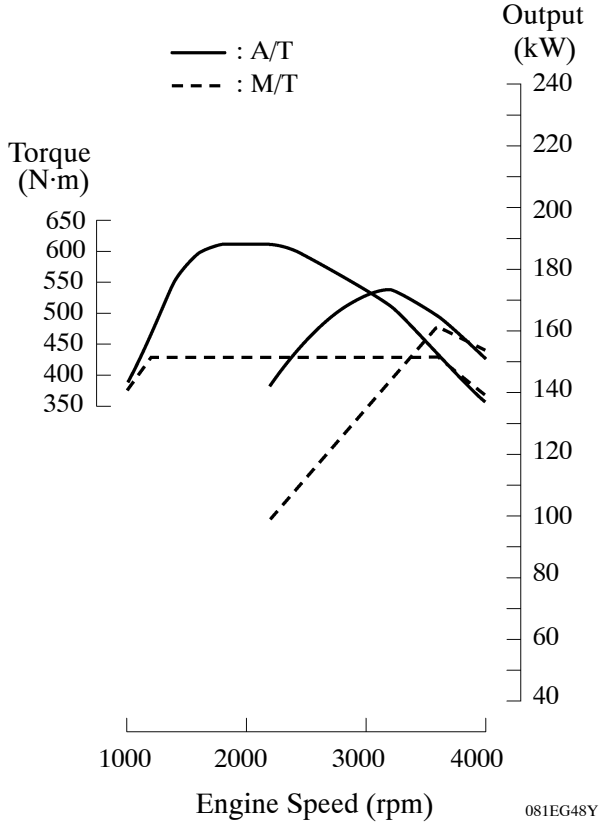
▶ Performance Curve ◀



Europe



**Australia and
Europe (Models with pre-cleaner)**



G.C.C. Countries and General Countries

■ FEATURES OF 1VD-FTV ENGINE

The 1VD-FTV engine has been able to achieve the following performance through the adoption 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	Cylinder head cover is made of plastic and cylinder head is made of aluminum alloy.	○		○		
	A cylinder block made of compact graphite iron is used.		○	○		
	Piston provided in combustion chamber is used in conjunction with the adoption of direct injection.	○				○
	The piston skirt is coated with resin.	○				○
	The passage for the EGR system is provided in the cylinder head. (Only on models with EGR)			○		○
	Crankshaft pulley uses an inertial weight.		○			
	A No.1 oil pan sub-assembly made of aluminum alloy is used.		○			
Valve Mechanism	A camshaft is driven by a timing chain and gear.	○	○	○		
	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 engine oil cooler is used.	○				
	A scavenging pump is used.	○				
Cooling System	TOYOTA Genuine SLLC (Super Long Life Coolant) is used as the engine coolant.				○	
Intake and Exhaust System	The rotary solenoid type diesel throttle motor and a non-contact throttle position sensor are used in the diesel throttle body.					○
	A variable nozzle vane type turbocharger driven by a DC motor is used in each bank.	○		○		○
	An air-cooled type intercooler is used.	○				○
	The linear solenoid type EGR valve is used. (Only on models with EGR)					○
	A water-cooled type EGR cooler is used. (Only on models with EGR)					○
	Oxidation catalytic converter is used. (Only on models complying with the emission regulations*)					○

(Continued)

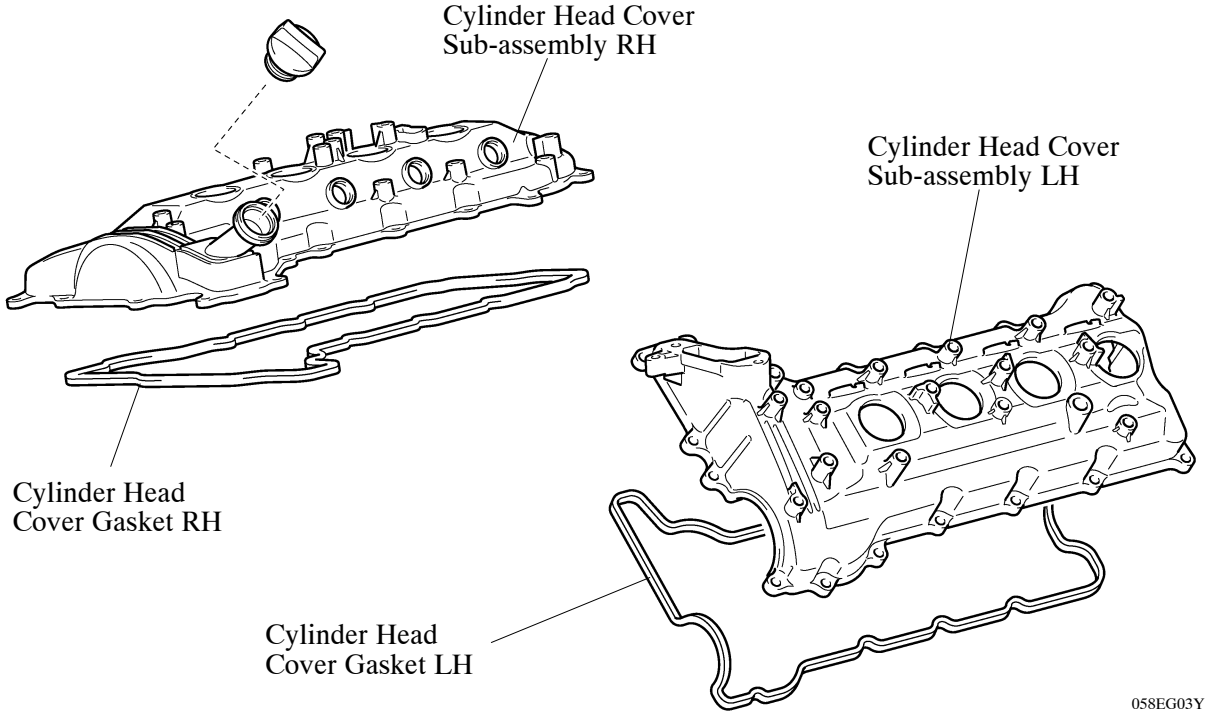
Item		(1)	(2)	(3)	(4)	(5)
Fuel System	3-plunger type fuel supply pump is used.	○	○			
	A common-rail type fuel injection system is used.	○	○			○
	Solenoid type fuel injectors on which compensation value and QR (Quick Response) code are printed are used.	○	○			○
	A fuel filter, in which the fuel filter element alone can be replaced, is used.				○	
	A fuel filter warning switch that detects the clogging of the fuel filter is used.	○			○	
	Water-cooled and air-cooled type fuel coolers are used.	○				○
Charging System	Segment conductor type generator is used.			○		
Engine Mount	The electrical hydraulic type engine mountings are used.		○			
Serpentine Belt Drive System	A serpentine belt drive system is used.			○	○	
Engine Control System	A pilot injection control is used.	○	○			○
	A fuel pump control, which has the fuel transfer function, is used. (Only on models with dual fuel tank)					○
	The cranking hold function is used.	○				
	An oil maintenance management system is used. (Only on European models complying with EURO IV)				○	

*: Except automatic transmission models complying with EURO II

■ENGINE PROPER

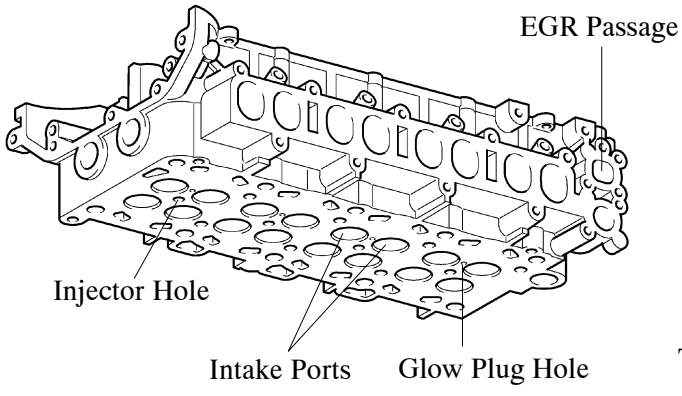
1. Cylinder Head Cover

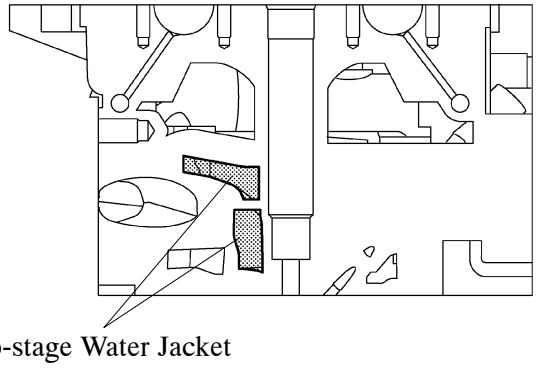
- The cylinder head cover sub-assemblies are made of plastic to reduce weight and noise.
- Acrylic rubber, which excels in heat resistance and reliability, is used for the cylinder head cover gaskets.



2. Cylinder Head

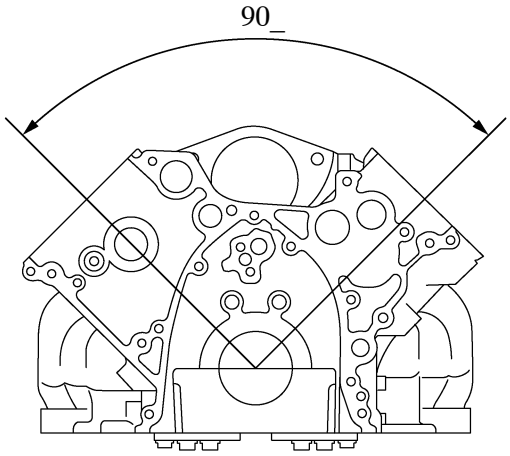
- The cylinder head is made of aluminum alloy.
- The fuel injector has been located in the center of the combustion chamber in order to improve engine performance and clean emission.
- The passage for the EGR is provided in the cylinder head. By cooling the exhaust gas, the great amount of exhaust gas can recirculate.
- A vertical two-stage construction is used for the water jacket to improve cooling performance.
- A glow plug is placed between the intake ports of each cylinder to ensure startability.

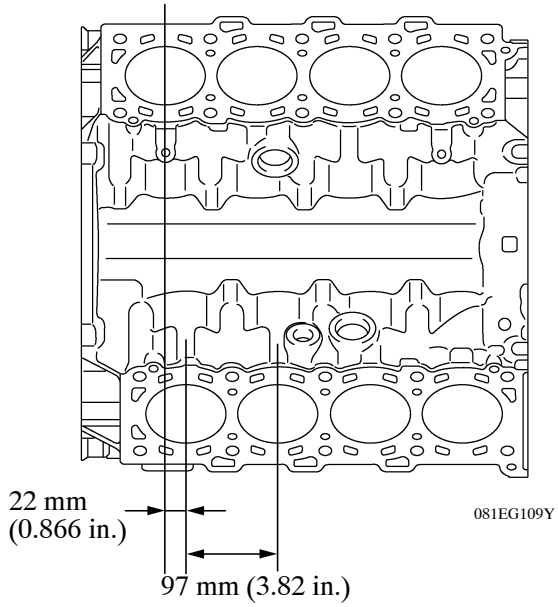




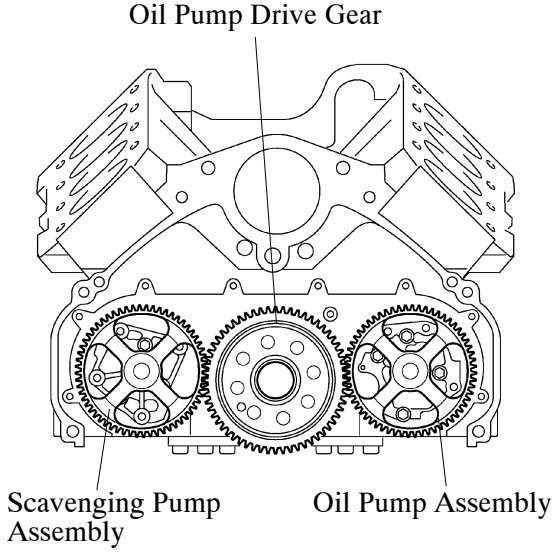
3. Cylinder Block

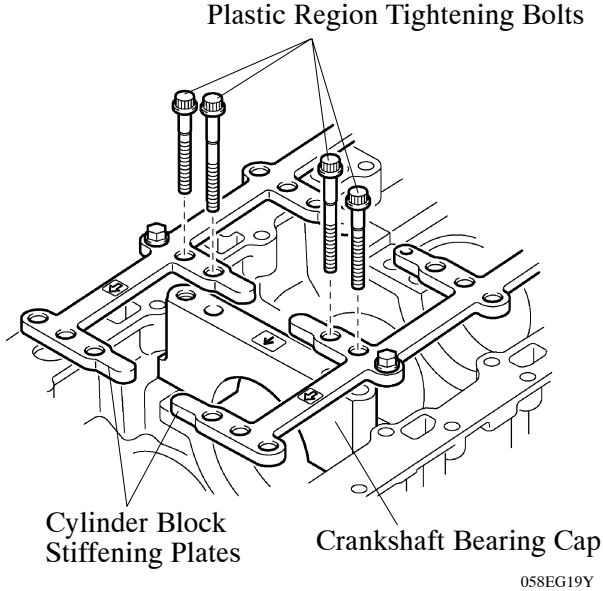
- Lightweight compact graphite iron is used for the cylinder block.
- The cylinder block has a bank angle of 90_, a bank offset of 22 mm (0.866 in.) and a bore pitch of 97 mm (3.82 in.), resulting in a compact block in its length and width even for its displacement.





- The oil pump drive gear at the rear end of the cylinder block drives the oil pump and the scavenging pump in order to achieve a compact engine. For details of the scavenging pump, see page EG-150.
- Four plastic region tightening bolts are used to tighten the crankshaft bearing caps together with the cylinder block stiffening plates in order to reduce vibrations.

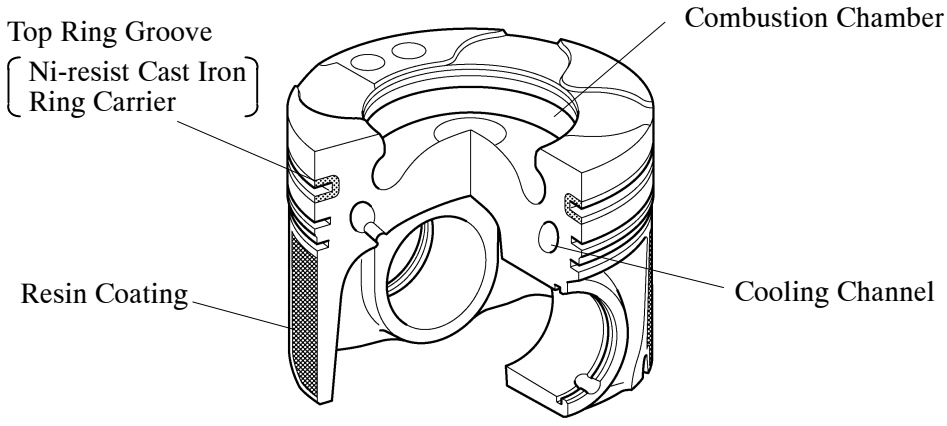




4. Piston

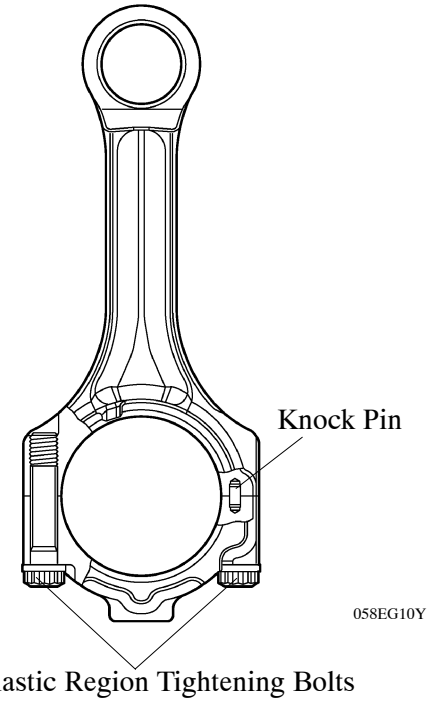
- The piston is made of aluminum alloy.
- In conjunction with the adoption of direct injection, the piston provided with combustion chamber is used.
- A cooling channel is provided to realize excellent piston performance.
- The top ring groove uses a Ni-resist cast iron ring carrier to improve wear resistance.
- The piston skirt is coated with resin to reduce friction loss and improve initial seizure resistance.
- On G.C.C. countries models, general countries models and some European models*, a PVD (Physical Vapor Deposition) coating has been applied to the surface of the No.1 compression ring, to improve its wear resistance.

*: Russian package models



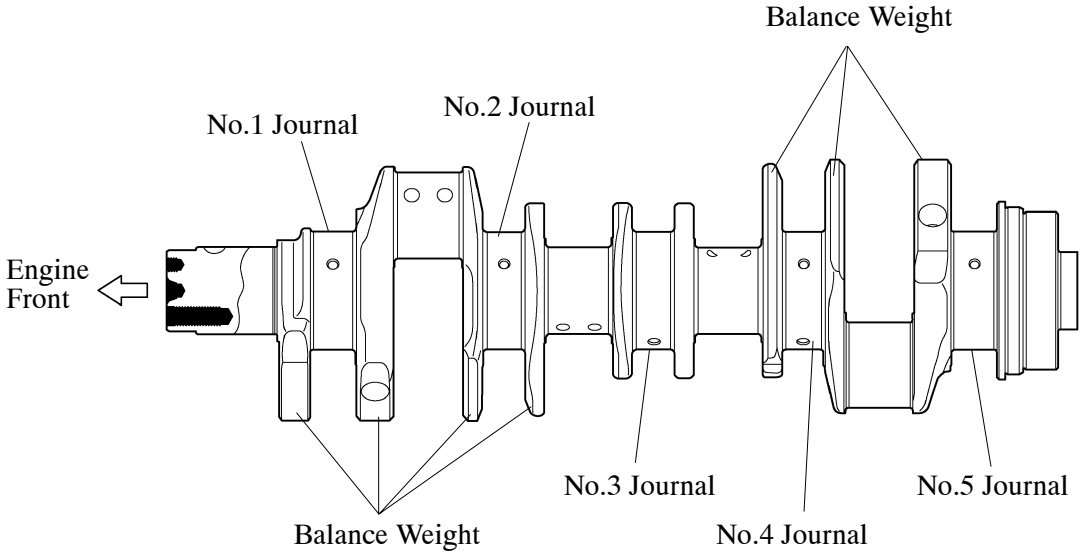
5. Connecting Rod

- The connecting rods and caps are made of high-strength material to ensure the proper strength.
- 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.
- Nutless type plastic region tightening bolts are used.
- The connecting rod bearings are reduced in width to reduce friction.



6. Crankshaft

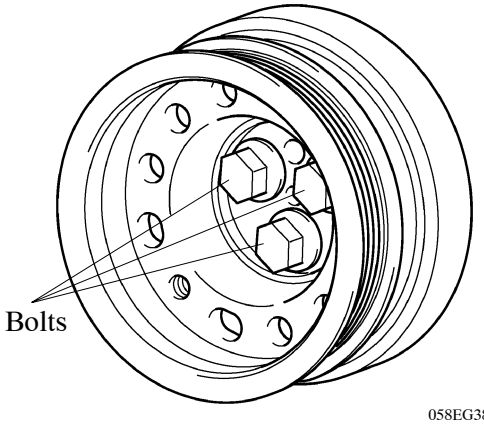
- A crankshaft made of forged steel, which excels in rigidity and wear resistance, is used.
- The crankshaft has 5 journals and 7 balance weights.
- All pins and journal fillets are IH (Induction Hardening)-finished to maintain adequate strength.
- An aluminum bearing is used for the crankshaft bearings.



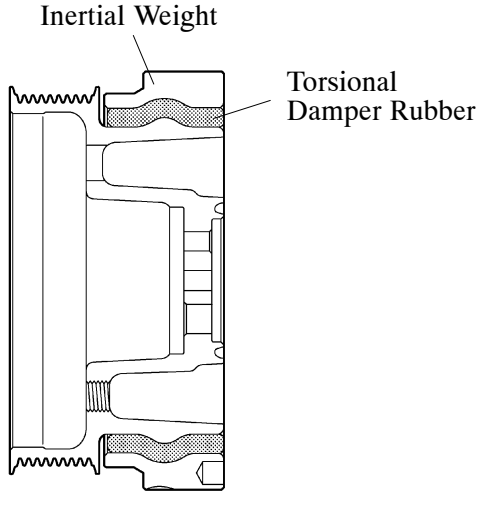
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7. Crankshaft Pulley

- Three bolts tighten the crankshaft pulley onto the crankshaft to reduce the tightening torque and improve serviceability.
- An inertial weight is installed via a torsional damper rubber to reduce vibrations.



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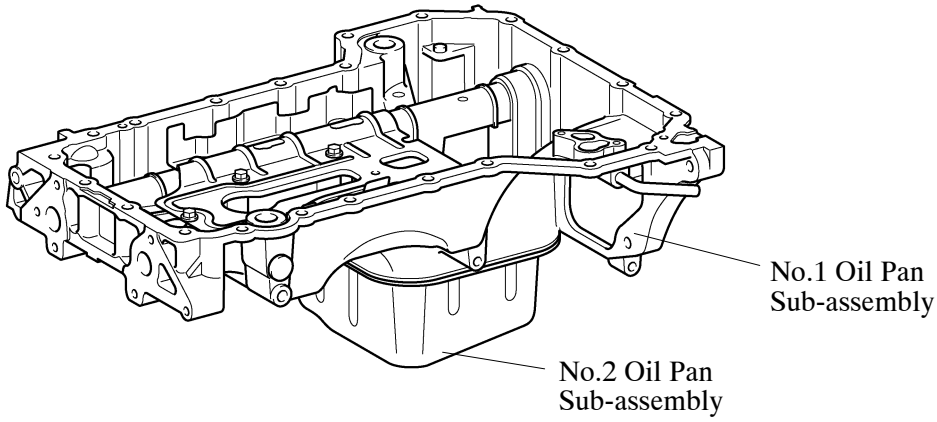
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Cross Section

Models without Viscous Heater

8. Oil Pan

- The No.1 oil pan sub-assembly is made of aluminum alloy.
- The No.2 oil pan sub-assembly is made of steel.
- The No.1 oil pan sub-assembly is secured to the cylinder block and the transmission housing to increase rigidity.

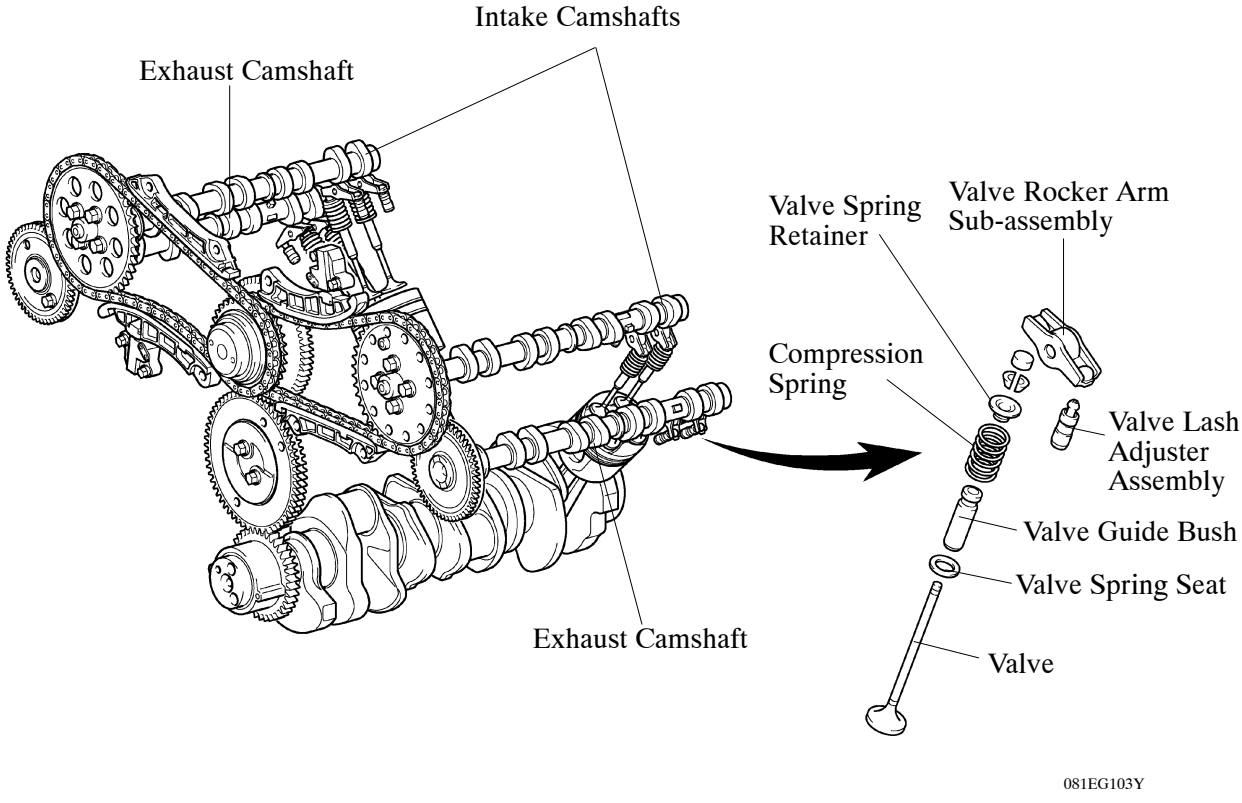


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■VALVE MECHANISM

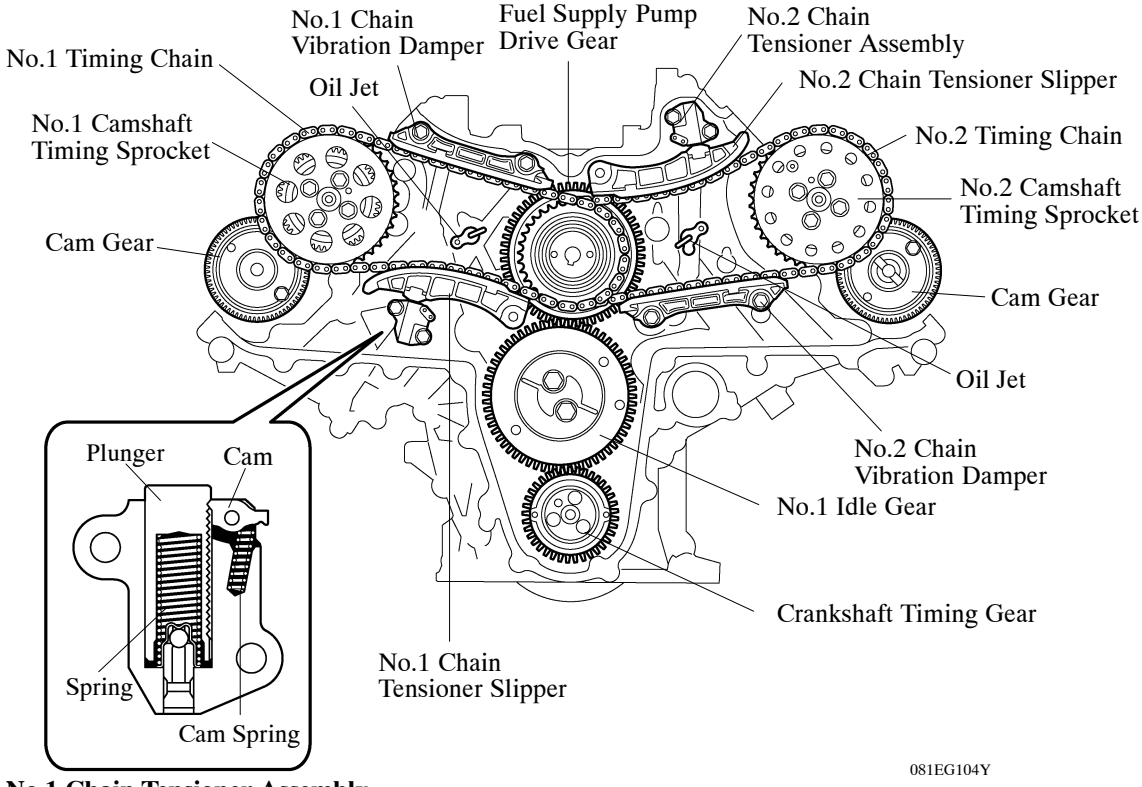
1. General

- Each cylinder has 2 intake valves and 2 exhaust valves. Intake and exhaust efficiency is increased by means of the larger total port areas.
- The timing gear train uses a combination of gears and a timing chain.
- This engine uses roller rocker arms with built-in needle bearings. This reduces the friction that occurs between the cams and the areas (roller rocker arms) that push the valves down, thus improving fuel economy.
- Valve lash adjuster assemblies, which maintain a constant zero valve clearance through the use of oil pressure and spring force, are used.



2. Timing Gear Train

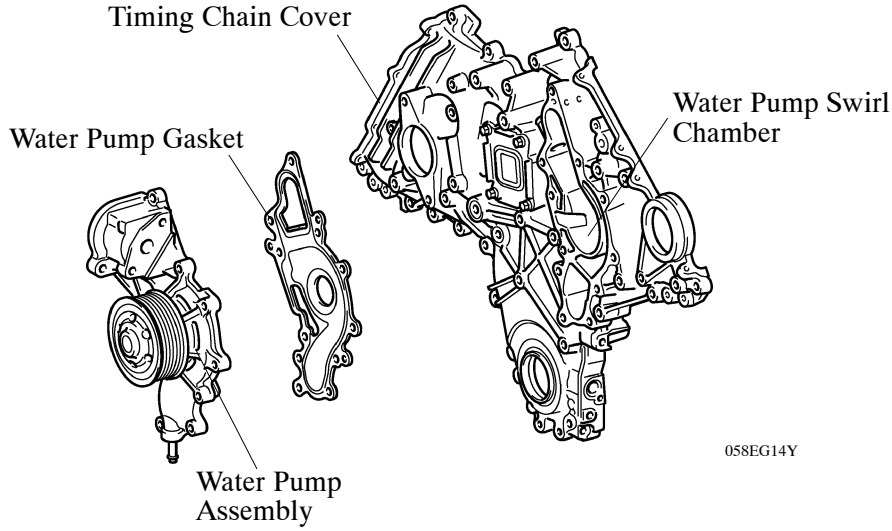
- An intake camshaft is driven by gears and a timing chain, and the exhaust camshaft is driven by a cam gear attached to the intake camshaft.
- Timing chains use bush chains with a pitch of 9.525mm (0.375 in.).
- The timing chains are lubricated by an oil jet.
- Chain tensioners use a spring and oil pressure to maintain proper chain tension at all times. They suppress noise generated by the timing chains
- The chain tensioners are the ratchet type with a non-return mechanism.
- The No.1 Idle gear and cam gear are constructed with a scissors gear to reduce noise.



No.1 Chain Tensioner Assembly

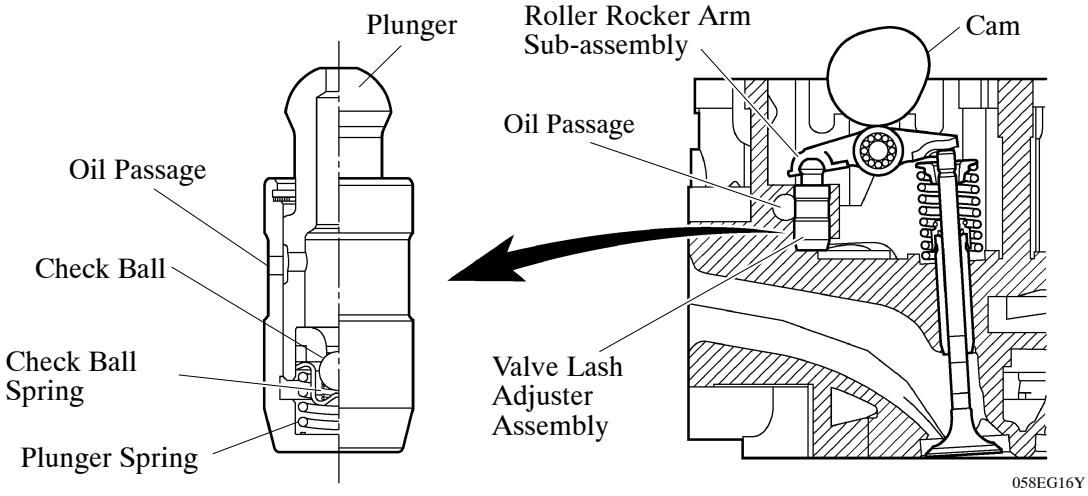
3. Timing Chain Cover

The timing chain cover has an integrated construction consisting of the cooling system (water pump and water passage). Thus, the number of parts has been reduced for weight reduction.



4. Hydraulic Lash Adjuster

- The valve lash adjuster assembly, which is located at the fulcrum of the roller rocker arm sub-assembly, consists primarily of a plunger, plunger spring, check ball, and check ball spring.
- The engine oil that is supplied by the cylinder head and the built-in spring actuates the valve lash adjuster assembly. The oil pressure and the spring force that act on the plunger push the roller rocker arm sub-assembly against the cam, in order to adjust the valve clearance that is created during the opening and closing of the valve. As a result, engine noise is reduced.



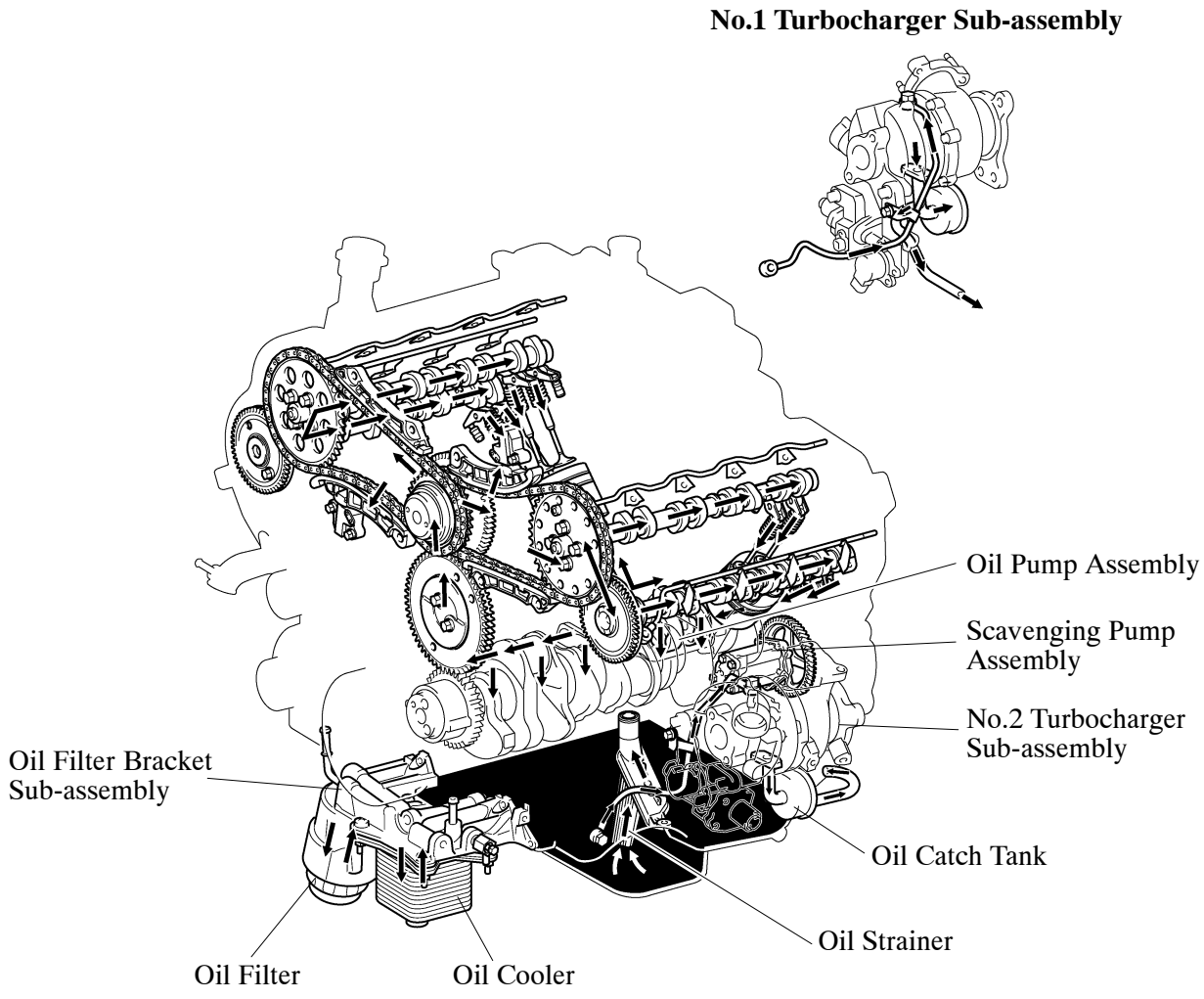
Service Tip

Valve clearance adjustment is not necessary because a valve lash adjusters are used in this model.

■LUBRICATION SYSTEM

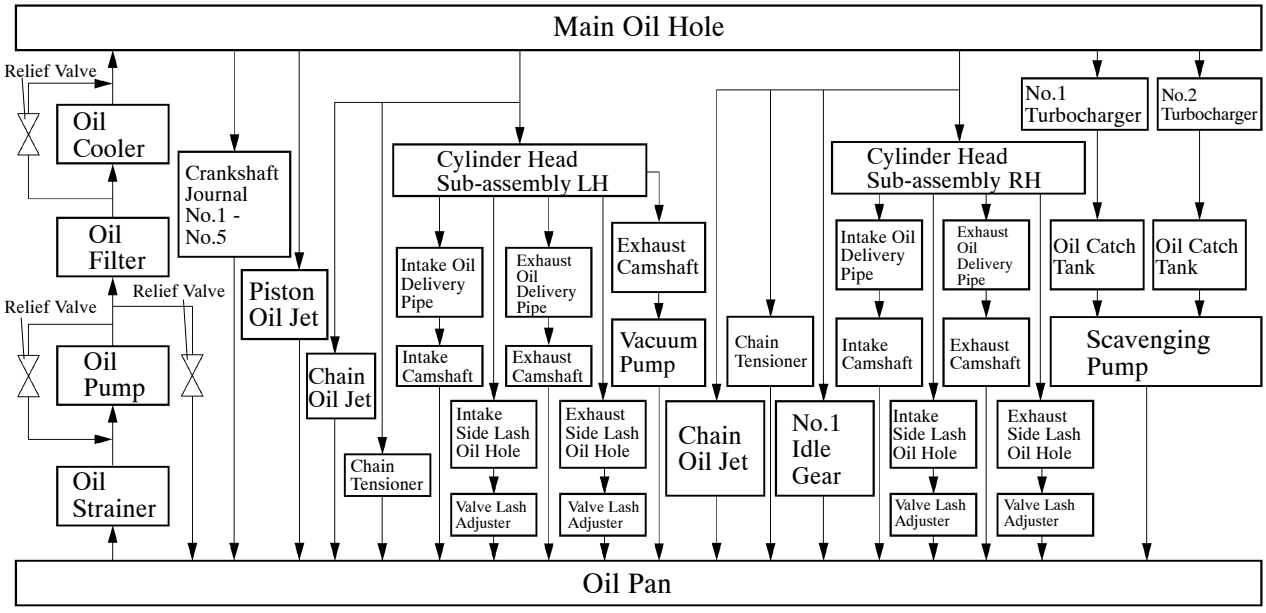
1. General

- The lubrication circuit is fully pressurized and all oil passes through an oil cooler and oil filter.
- A trochoid gear type oil pump, which uses 2 oil pump gears, is provided.
- A scavenging pump is used to suppress the accumulation of oil in the turbocharger while driving on a slope.
- A water-cooled type oil cooler is installed on oil filter bracket.



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▶ Oil Circuit ◀



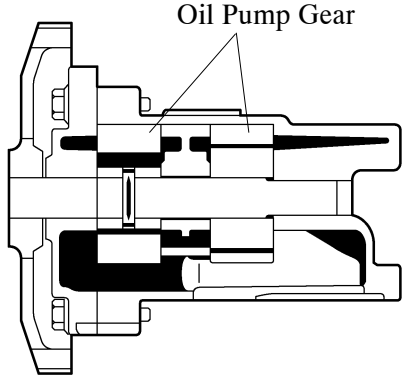
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▶ Oil Capacity ◀

Oil Capacity [Liters (US qts, Imp. qts)]	Dry	9.7 (10.3, 8.5)
	with Oil Filter	9.0 (9.5, 7.9)
	without Oil Filter	8.0 (8.5, 7.0)

2. Oil Pump

A trochoid gear type oil pump is used. The oil pump uses 2 oil pump gears and is driven by a gear engaged with the crankshaft.



Oil Pump Cross Section

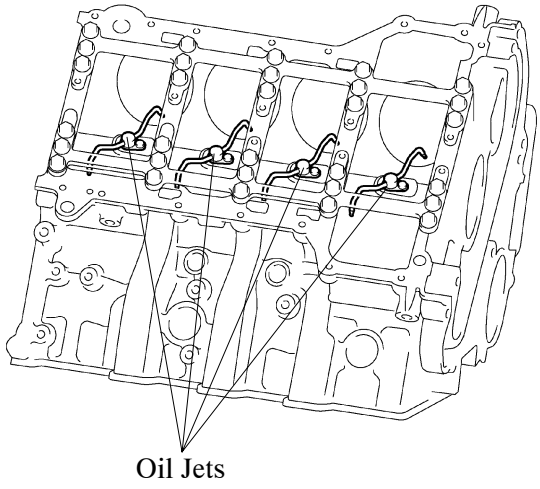


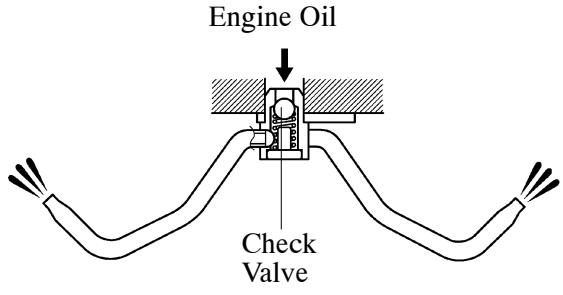
Oil Pump Gear Cross Section

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3. Oil Jet

- Oil jets are provided at the bottom of the cylinder block to spray oil to the piston's cooling channel, thus further cooling and lubricating the pistons.
- 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.

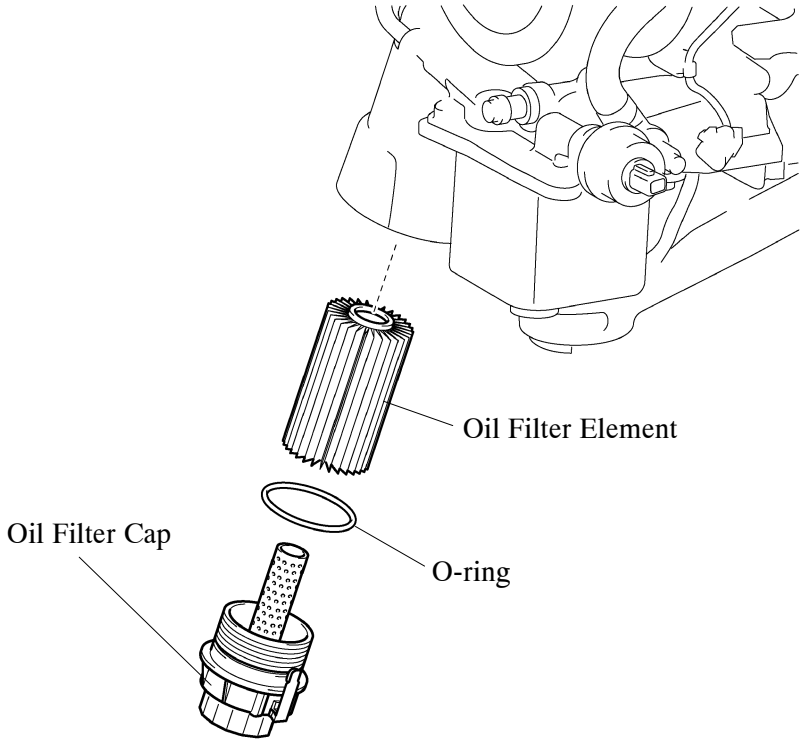




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4. Oil Filter

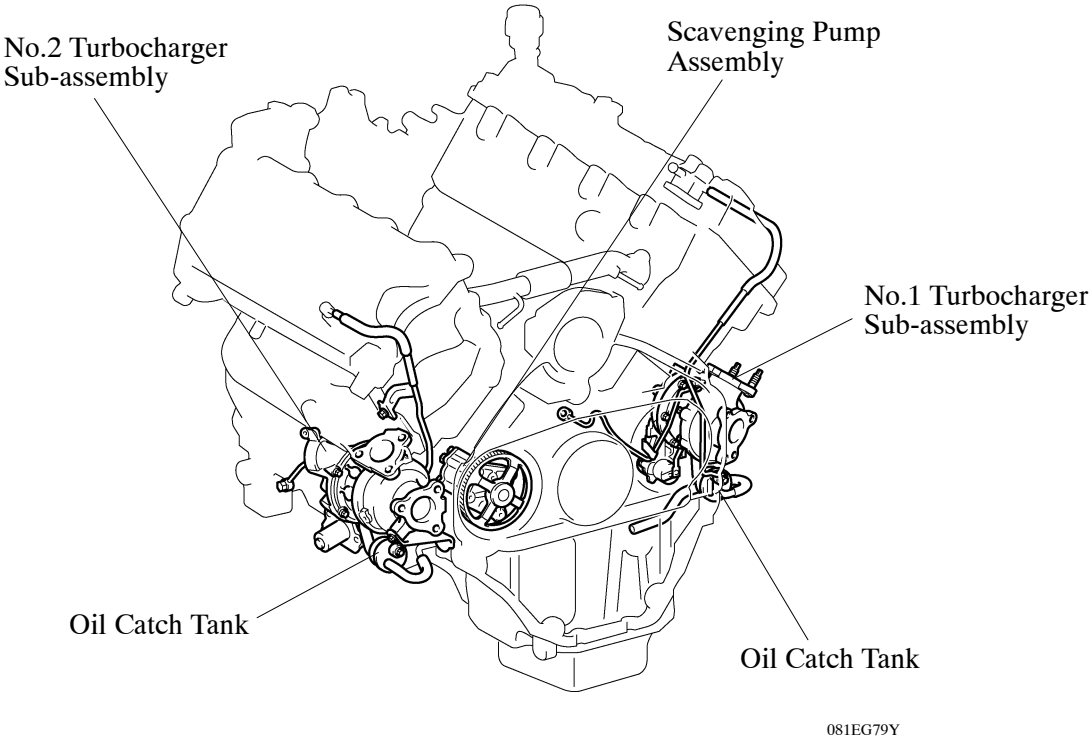
- An oil filter with a replaceable element is used. The oil filter element uses a high-performance filter paper to improve filtration performance. It is also combustible for environmental protection.
- A plastic oil filter cap is used.

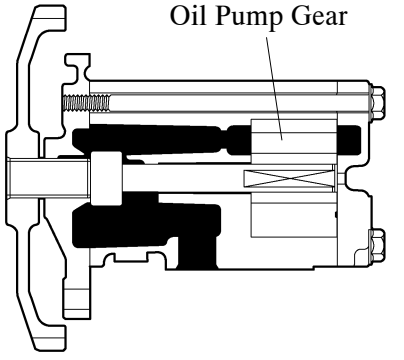


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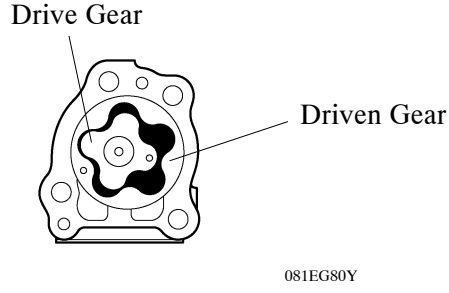
5. Scavenging Pump

- The scavenging pump, which is located at the back end of the cylinder block, is driven by the crankshaft via gears.
- After the turbocharger discharges the oil, the scavenging pump returns the oil from the oil catch tank through a forced suction and discharges it to the oil pan.





Scavenging Pump Cross Section

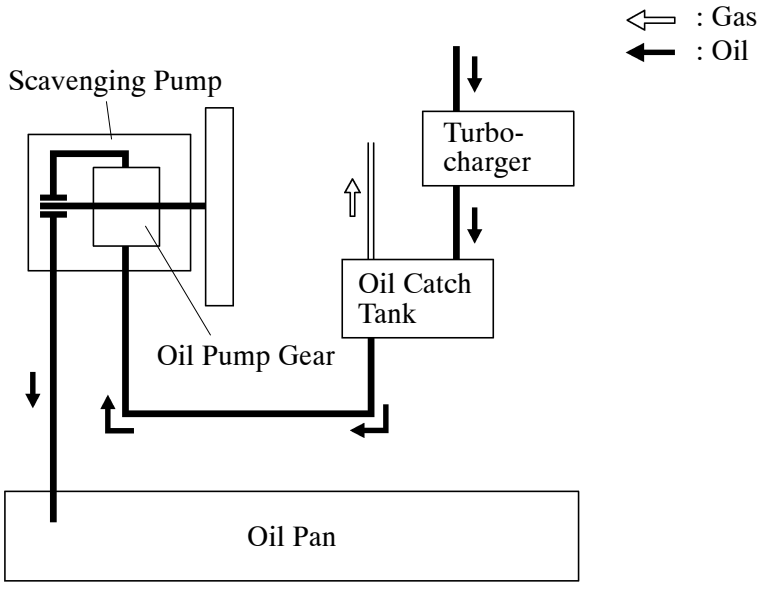


Scavenging Pump Gear Cross Section

▶ Pump Components and Functions ◀

Component	Function
Oil Catch Tank	The oil catch tank separates the oil discharged by the turbocharger into gas and liquid.
Scavenging Pump	Returns the oil from the oil catch tank by suction, and discharges it to the oil pan.

▶ System Diagram ◀

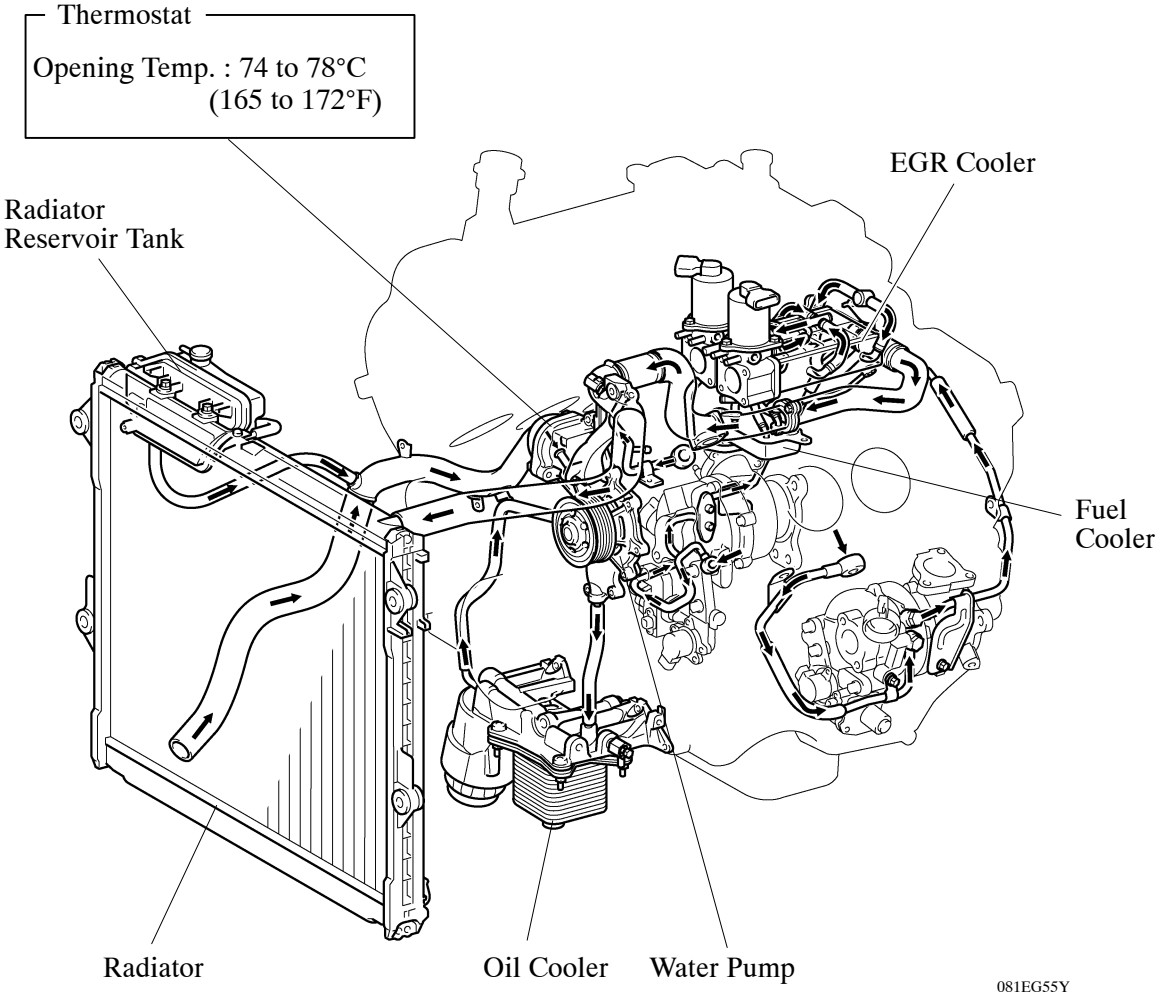


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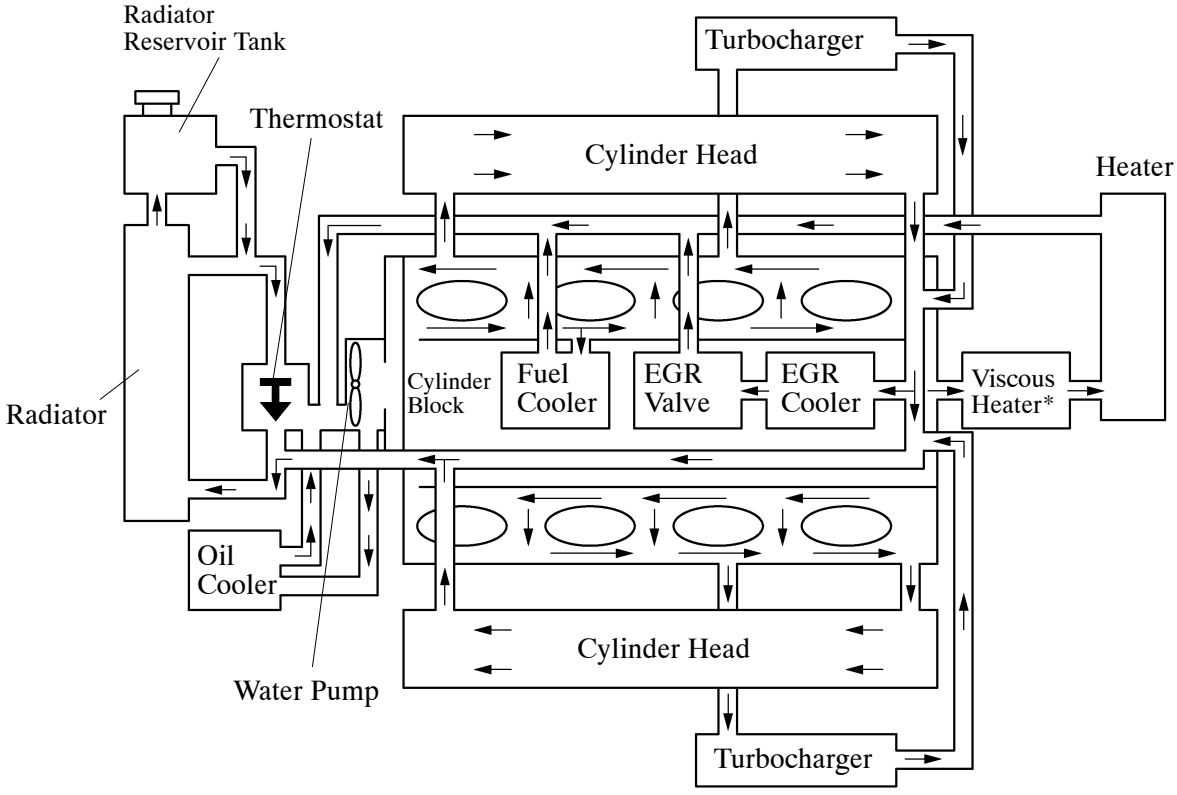
■COOLING SYSTEM

1. General

- The cooling system uses a pressurized forced-circulation system with pressurized reservoir tank.
- A pressurized reservoir tank is used to prevent the engine coolant from deteriorating upon contact with external air.
- A thermostat with a bypass valve is located on the water inlet housing 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 started to minimize fan noise.
- TOYOTA genuine SLLC (Super Long Life Coolant) is used as the engine coolant.



▶ System Diagram ◀



*: Only on European models

081EG56Y

2. Engine Coolant

- TOYOTA genuine SLLC (Super Long Life Coolant) is used.
- SLLC is pre-mixed (50 % coolant and 50 % deionized water), so no dilution is needed when adding or replacing SLLC in the vehicle.
- Maintenance intervals are as shown in the table below:

Type		TOYOTA Genuine SLLC or the equivalent*
Maintenance Intervals	First Time	160,000 km (100,000 miles)
	Subsequent	Every 80,000 km (50,000 miles)
Color		Pink

*: 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 consists of a combination of low phosphates and organic acids.)

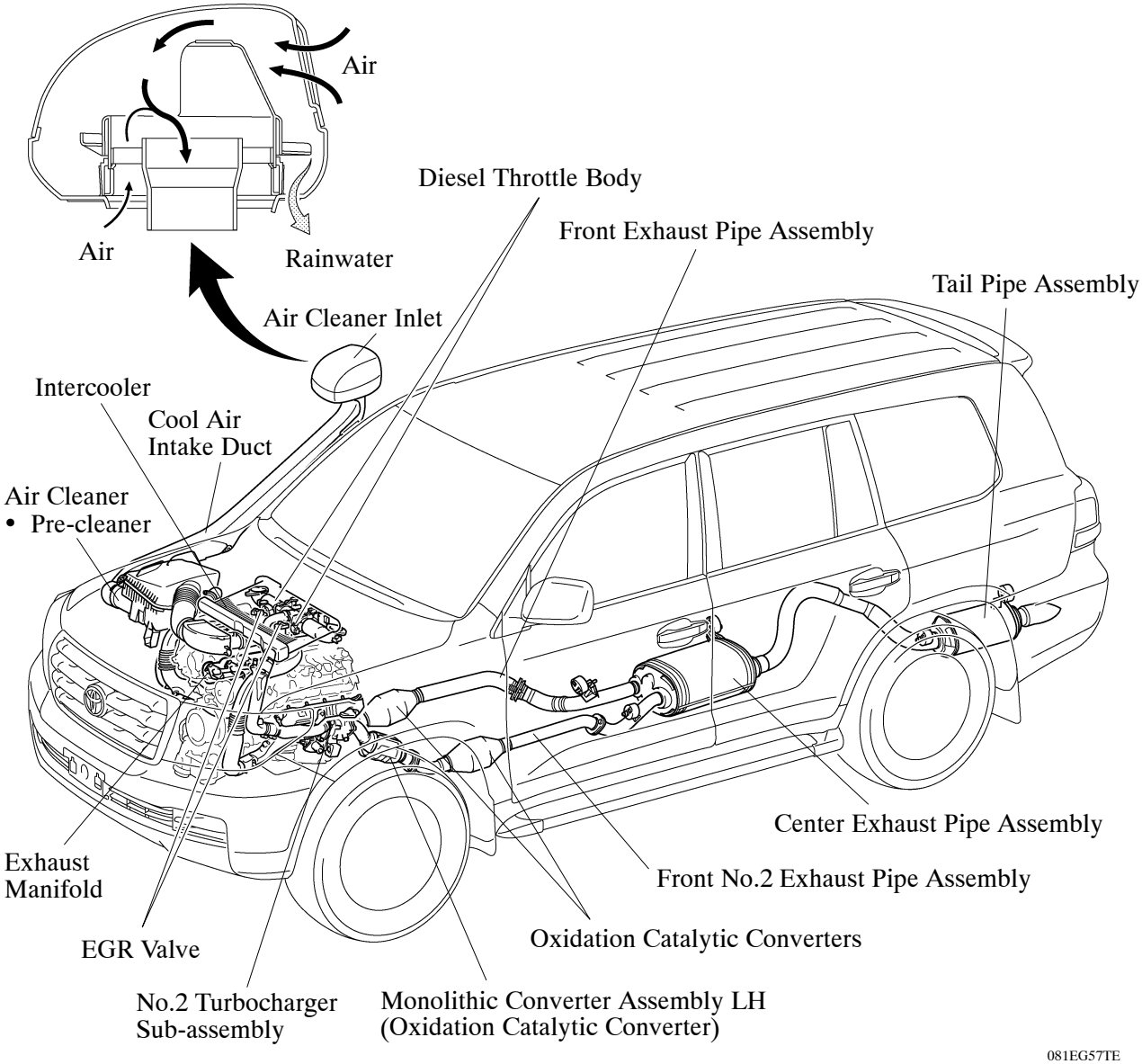
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■INTAKE AND EXHAUST SYSTEM

1. General

- A cyclone pre-cleaner is provided on all models except European models*1.
- A snorkel air cleaner is available as an option on Australian and general country models. The cool air intake duct of the snorkel air cleaner uses an air cleaner inlet designed to prevent rainwater entry.
- A diesel throttle body equipped with a rotary solenoid type diesel throttle control motor is used.
- An air-cooled intercooler is used.
- An EGR system is used on the models complying with the emission regulations (EURO II, EURO III, EURO IV). For details of EGR control, see page EG-206.
- A variable nozzle vane type turbocharger driven by a DC motor is used in each bank.
- A stainless steel exhaust pipe is used for weight reduction and improved rust resistance.
- An oxidation catalytic converter is used on models complying with the emission regulations (EURO II*2, EURO III and EURO IV).

*1: European models other than package models for Russia, Turkey, Sweden, Finland and Norway
*2: Except automatic transmission models

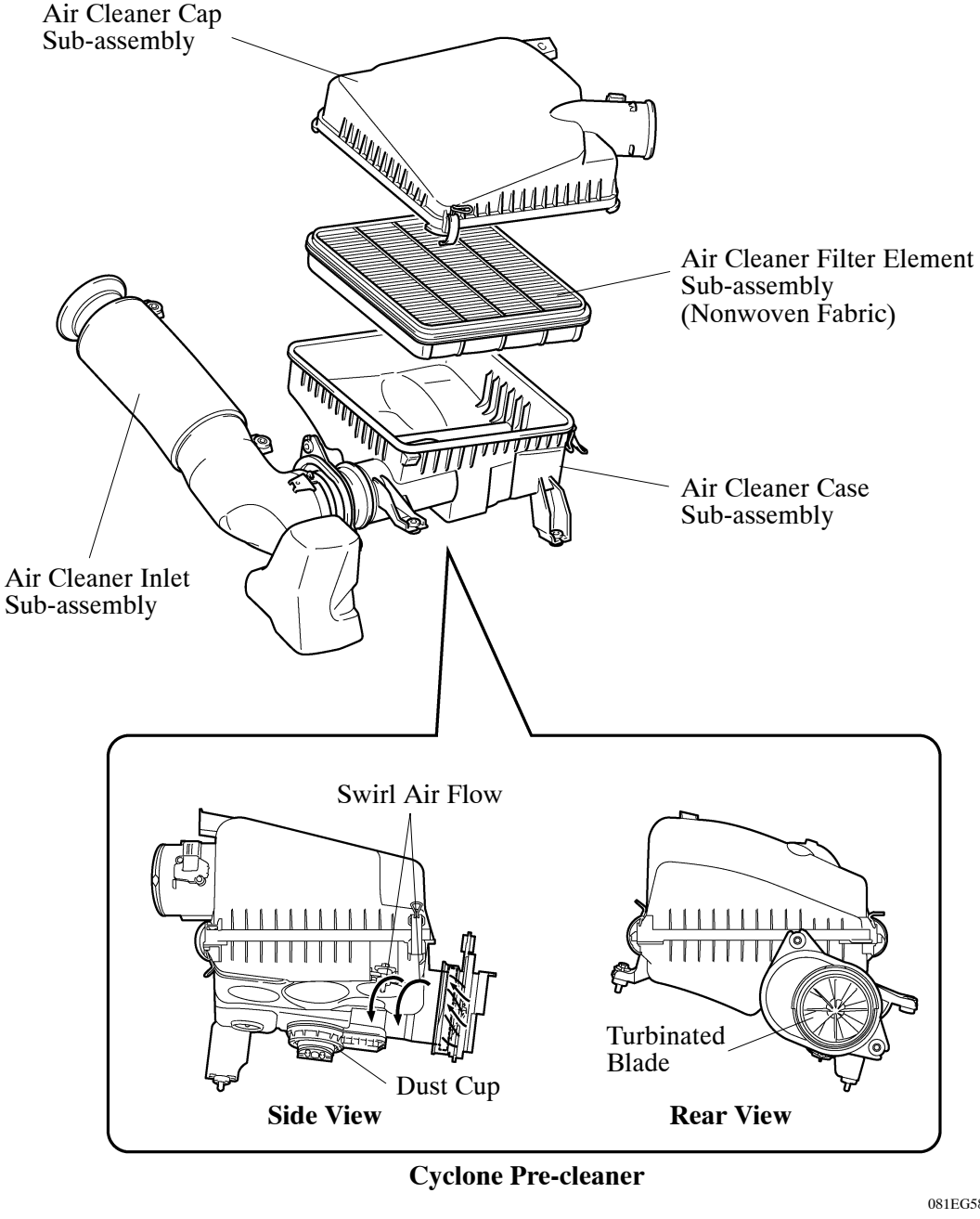


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Australian Models with Snorkel Air Cleaner

2. Air Cleaner

- A nonwoven, full-fabric type air cleaner filter element is used.
- A cyclone pre-cleaner has been provided in the air cleaner case. This cyclone pre-cleaner has a screw shape (turbinated blade) and gathers dusts which has rather big size in a dust cup by swirling the inlet air. The dust cup is removable, so the dust gathered can be disposed.

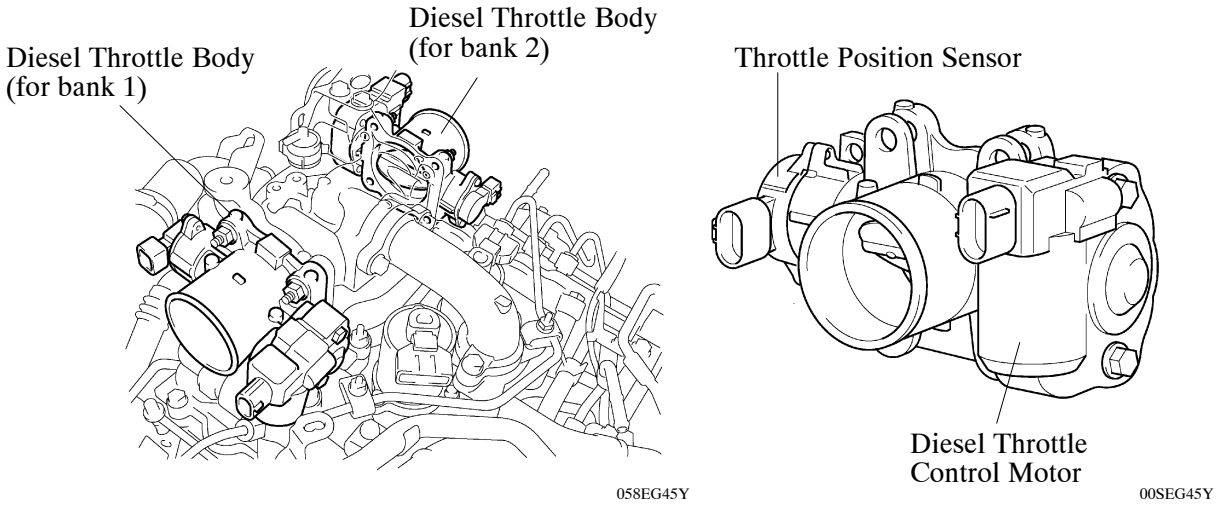


Cyclone Pre-cleaner

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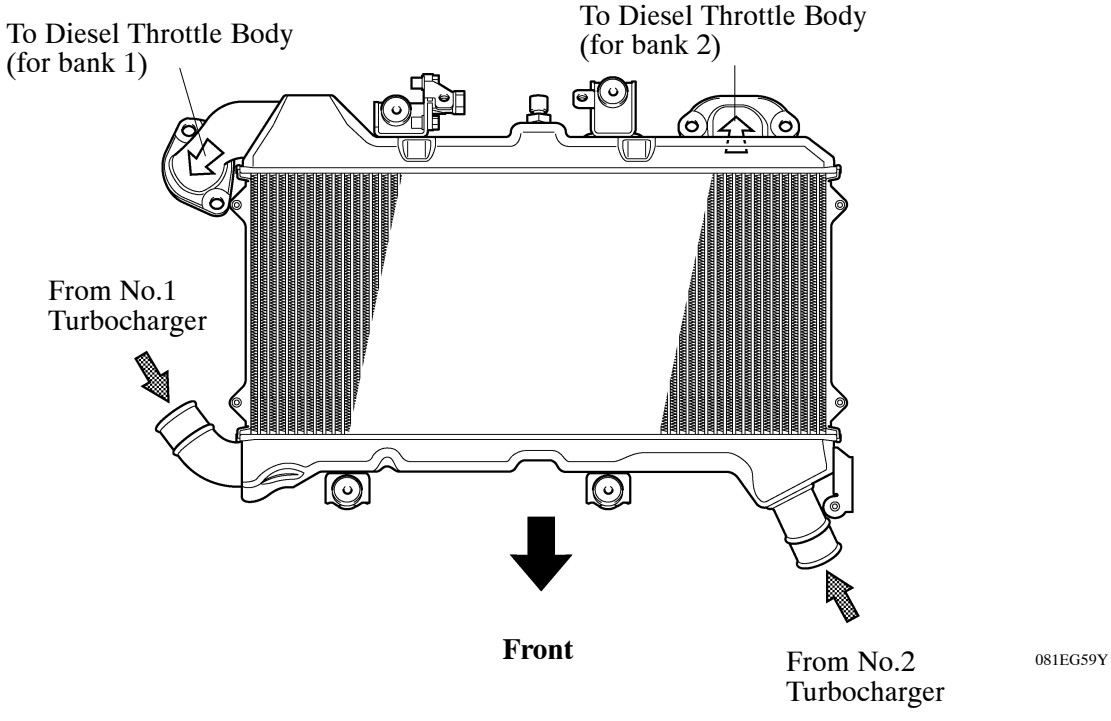
3. Diesel Throttle Body

- Two link-less type diesel throttle bodies in which the diesel throttle control motor and the throttle position sensor are integrated are used.
- In the diesel throttle control motor, a torque motor (rotary solenoid type) is used to control intake throttle.
- A non-contact type throttle position sensor is used in the throttle body. For details, see page EG-191.



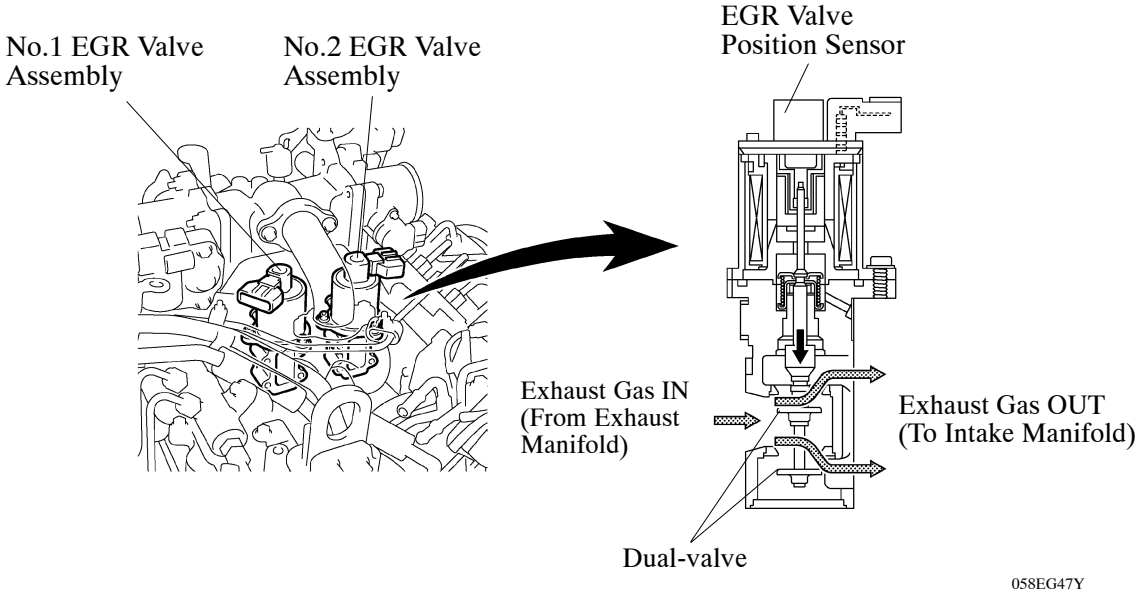
4. Intercooler

An air-cooled intercooler is used in order to lower the intake air temperature, improve engine performance, and to realize cleaner exhaust gas emissions. It is located directly on top of the engine.



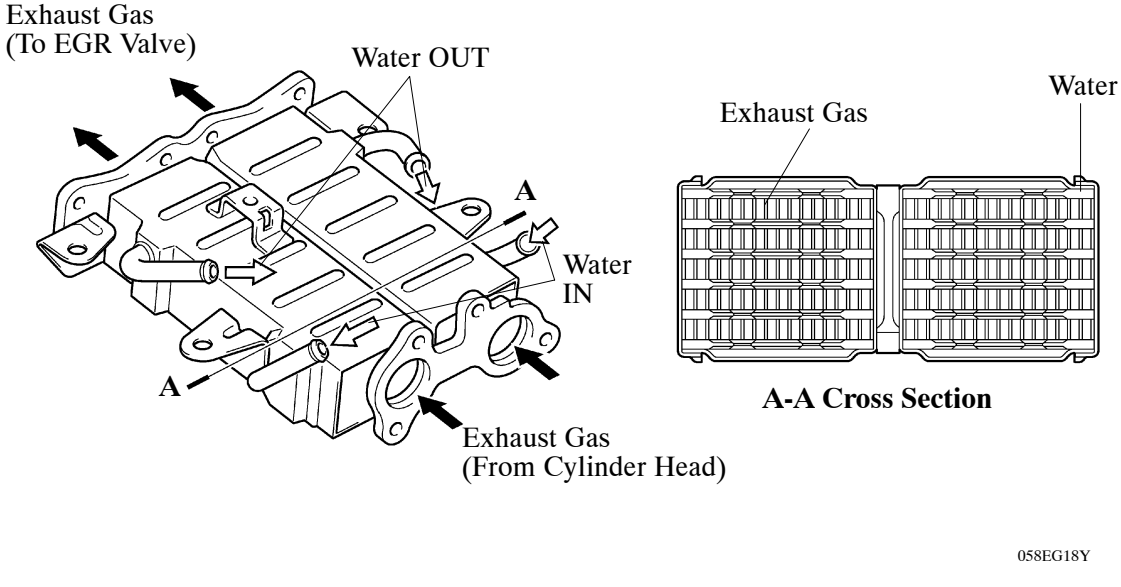
5. EGR Valve

- Two linear solenoid type EGR valves are used. Also, a dual-valve mechanism is used to cancel the effects of the exhaust pressure during actuation, in order to realize quick response.
- An EGR valve position sensor is provided in the EGR valve. This sensor enables EGR valve control at a higher level of precision by detecting the amount of lift of the EGR valve.



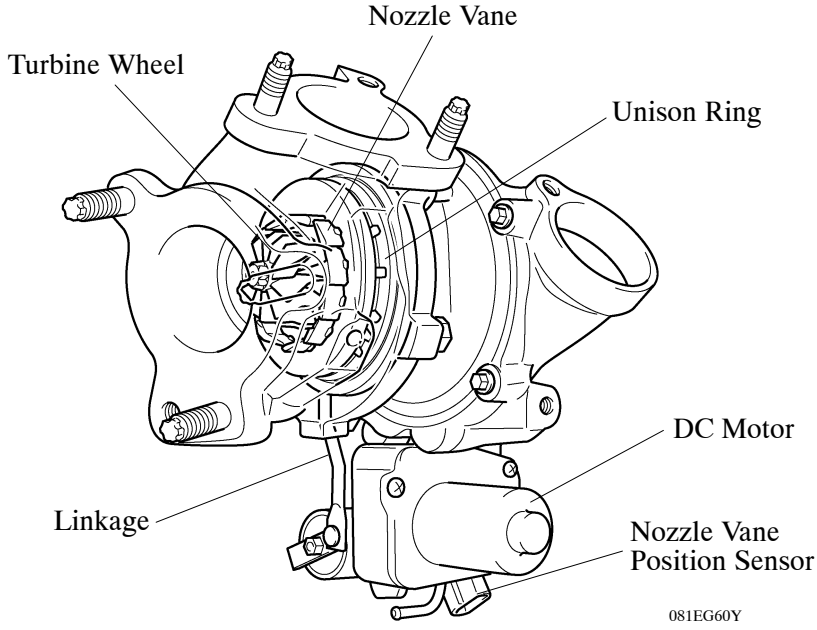
6. EGR Cooler

- A water-cooled type EGR cooler is used. That lowers the exhaust gas temperature to recirculate the great amount of exhaust gas, realizing the reduction of NOx.
- In the water-cooled type EGR cooler, water flows the five-layered gas passage to cool down.



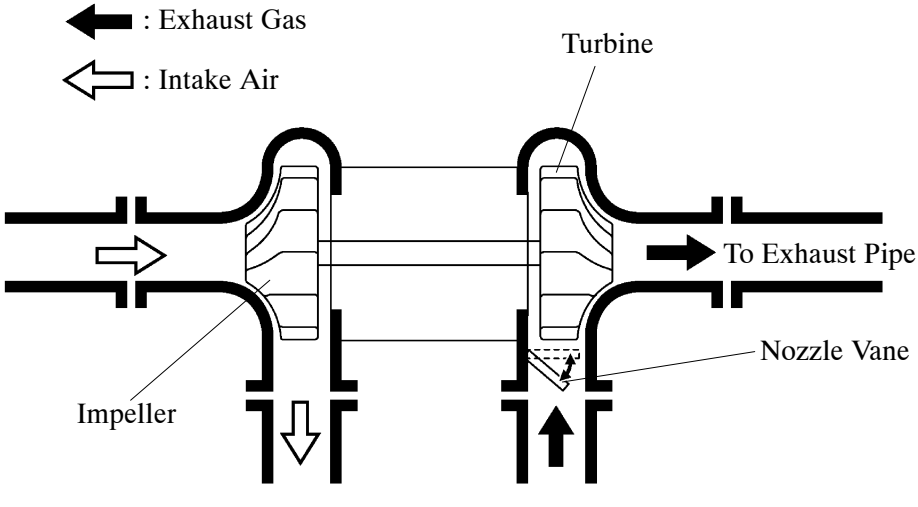
7. Turbocharger

- Variable nozzle vane type turbocharger consists primarily of a compressor wheel, turbine wheel, nozzle vane, unison ring, DC motor and nozzle vane position sensor.
- This turbocharger has realized great improvements in low-speed torque, maximum output, fuel consumption, and emission reduction. These improvements have been accomplished through variable control of the nozzle vane position, and an optimal velocity of the exhaust gas inflow to the turbine at all times in response to the engine condition.
- The ECM outputs a signal to the turbo motor driver, which actuates the DC motor, to control the nozzle vane position. For details on the turbocharger control, see page EG-201.



No.1 Turbocharger Sub-assembly (for bank 1)

- The exhaust gas from the exhaust manifold goes through the nozzle vane inside the turbo charger housing, and flows to the exhaust pipe through the turbine wheel. The speed of the turbine wheel (supercharging pressure) differs depending on the flow velocity of the exhaust gas going through the turbine wheel and the flow velocity of the exhaust gas is controlled by the opening. In such a time like idling, when the exhaust gas is less, the nozzle vane is almost fully closed, but as there is a slight clearance between the vanes, the exhaust gas flows through this clearance to the exhaust pipe. Therefore, there is no bypass.

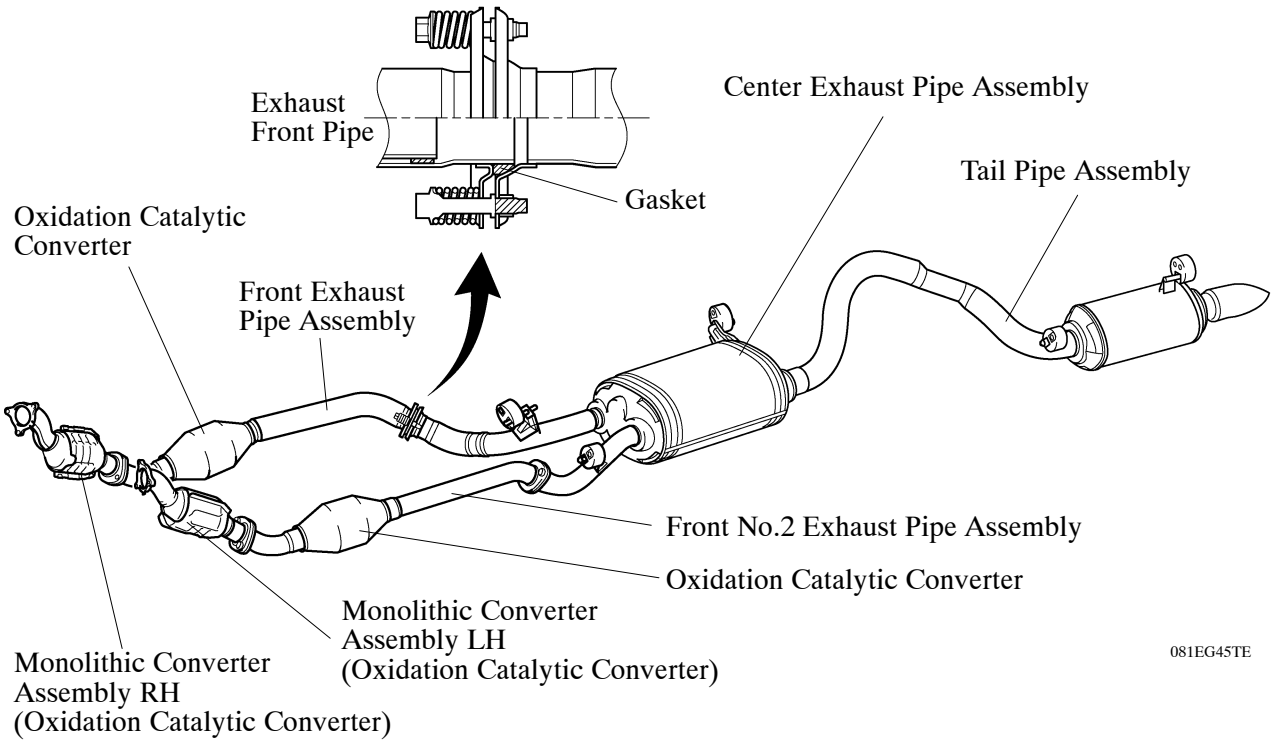


8. Exhaust Pipe

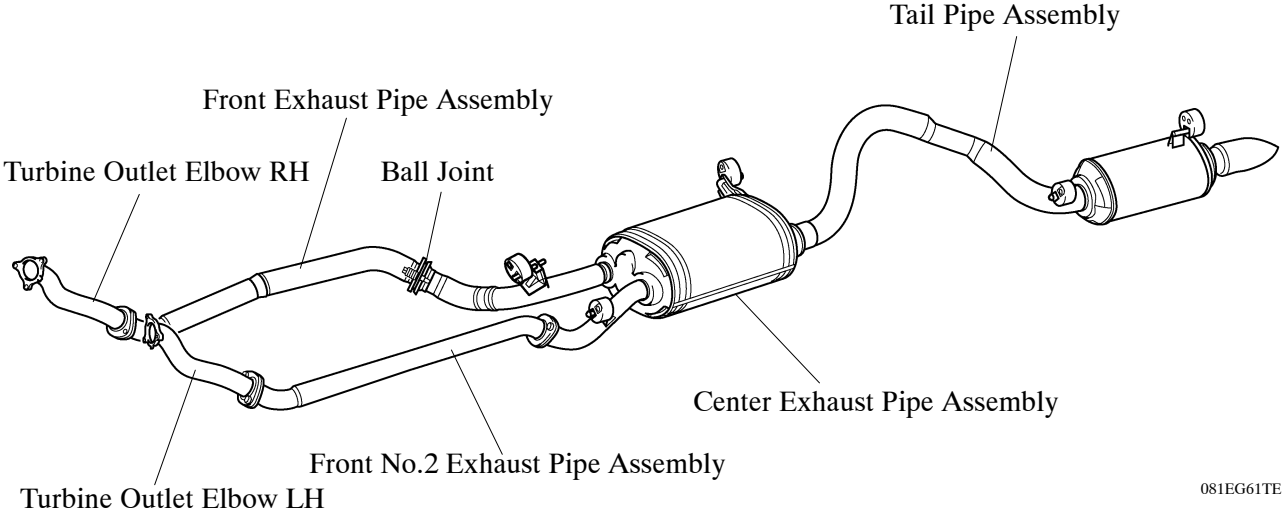
- A stainless steel exhaust pipe is used for weight reduction and rust resistance.
- On models complying with the emission regulations (EURO IV), 4 oxidation catalytic converters are used on the front exhaust pipe to clean the exhaust gas particulates, HC and CO.
- On models complying with the emission regulations (EURO II* and EURO III), 2 oxidation catalytic converters are used on the front exhaust pipe to clean the exhaust gas particulates, HC and CO.
- A ball joint is used to join the front exhaust pipe assembly and the center exhaust pipe assembly. As a result, a simple and reliable construction for reducing vibration has been realized.

*: Except automatic transmission models

Ball Joint



Models Complying with EURO IV



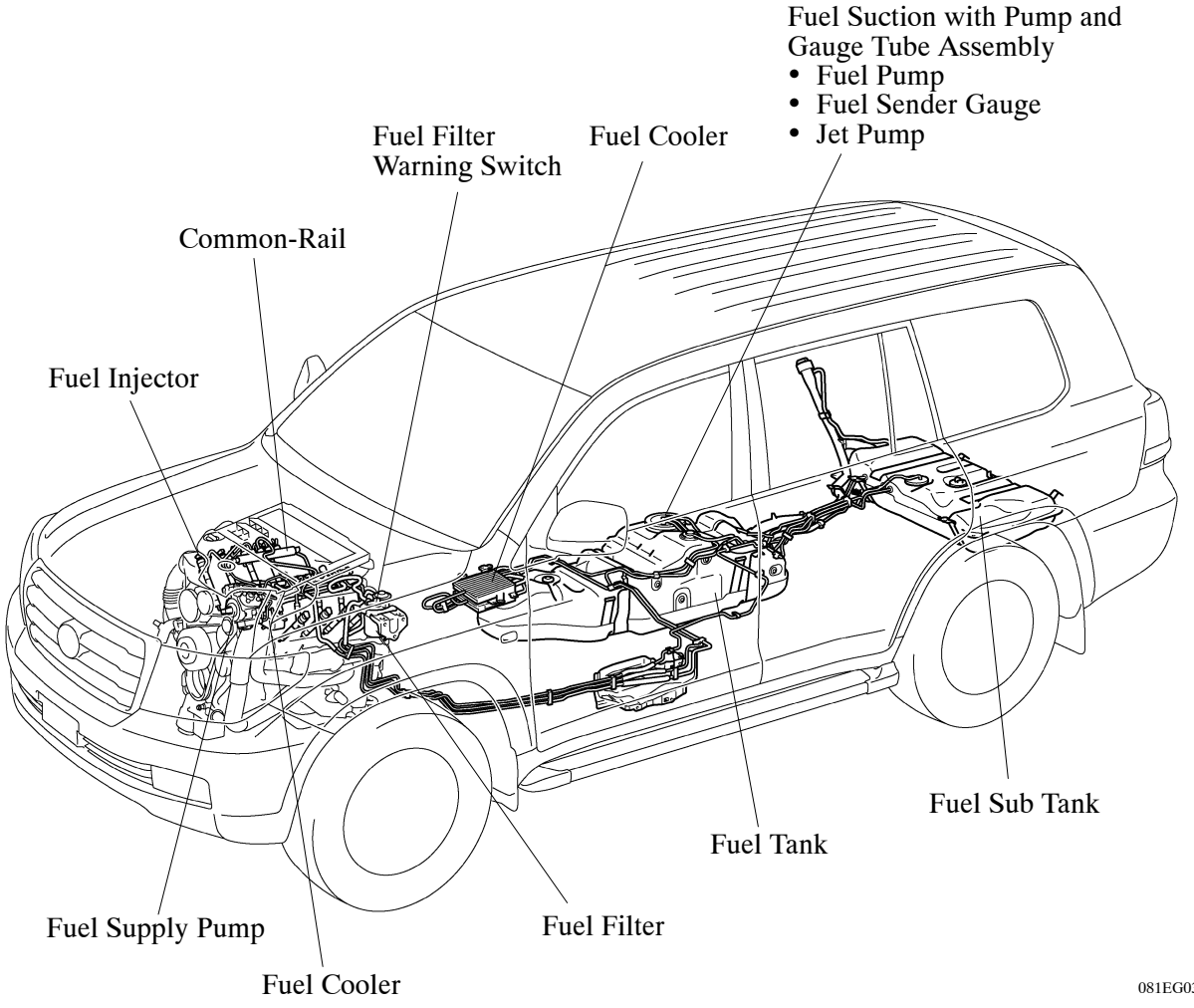
Models not Complying with Emission Regulations and Automatic transmission models complying with Euro II

■ FUEL SYSTEM

1. General

- A common-rail system is used in the fuel injection system.
- 3-plunger type (HP4 type) fuel supply pump, which is compact and lightweight, is used.
- An injector compensation value and a QR code are printed on the fuel injector to realize high-precision control.
- A new type of fuel filter, in which the fuel filter element alone can be replaced, is used.
- A fuel filter warning switch is provided in the fuel filter.
- A recirculation type fuel heater is provided in the fuel filter as standard on European models and as an option on general country models.
- 2 fuel coolers are used in the fuel return path.
- Quick connectors are used to connect the fuel lines for ease of serviceability.
- The dual fuel tank comprising a fuel tank and fuel sub tank is provided as standard on Australian* and G.C.C. country models and as an option on general country models. A multi-layer plastic fuel tank is used for the fuel tank. (The fuel sub tank however is made of steel.)
- A fuel pump and jet pump are provided in the fuel tank on models equipped with a dual fuel tank to transfer fuel from the fuel sub tank to the fuel tank.

*: On VX grade models, a single fuel tank is available as an option.



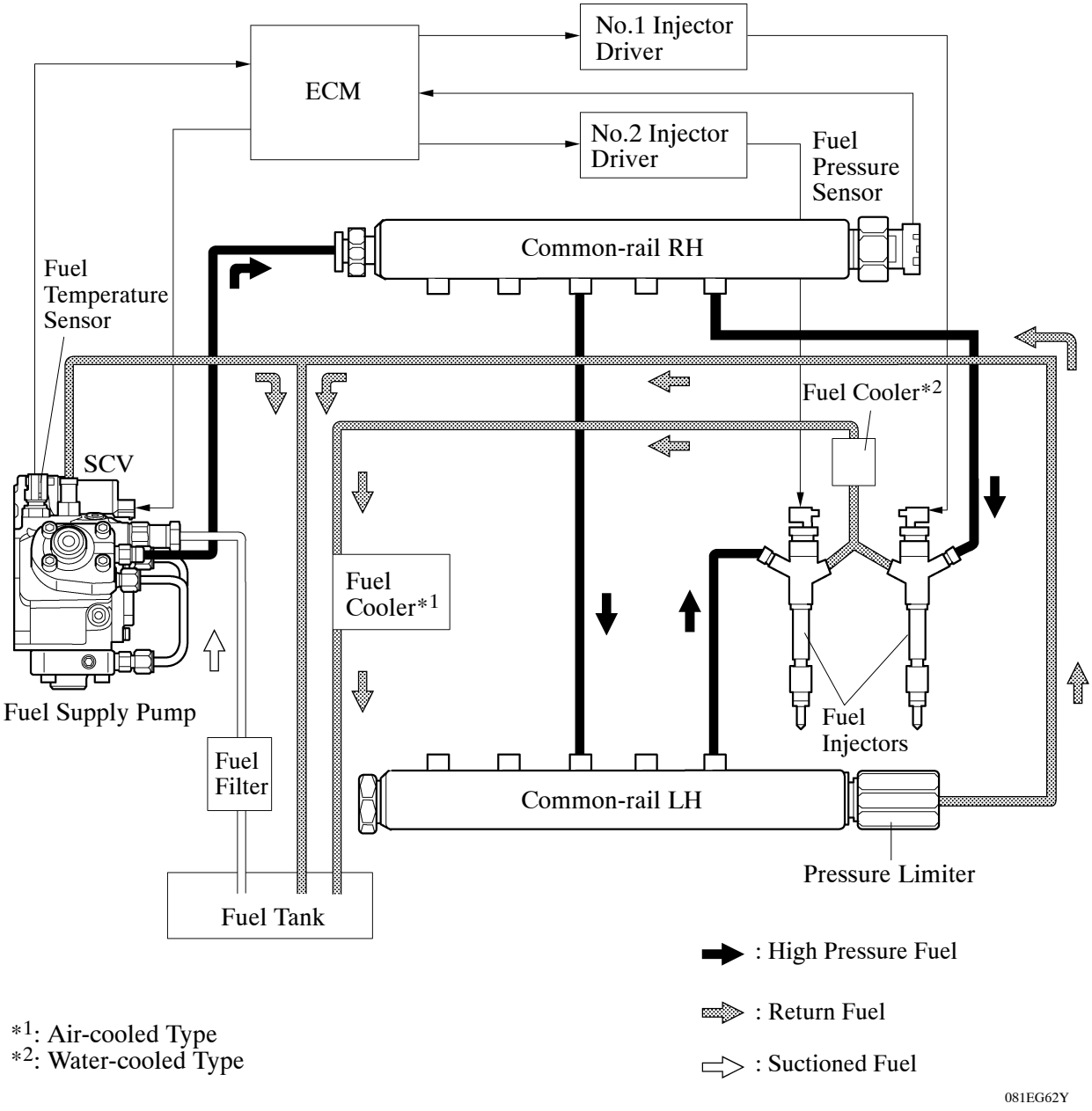
Models with Dual Fuel Tank

2. Common-rail System

General

In this system, the high-pressurized fuel that is supplied by the fuel supply pump is stored in the common-rail, and the ECM sends signals to the injectors via the injector driver in order to control the injection timing and injection volume. For details of this control, see page EG-192.

▶ System Diagram ◀



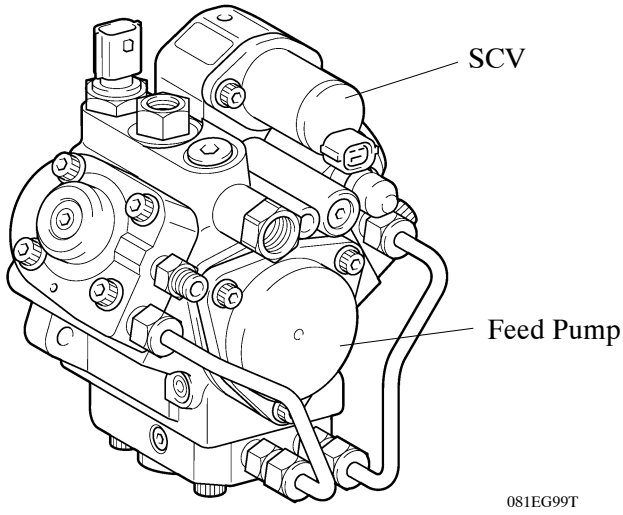
Models without Fuel Heater

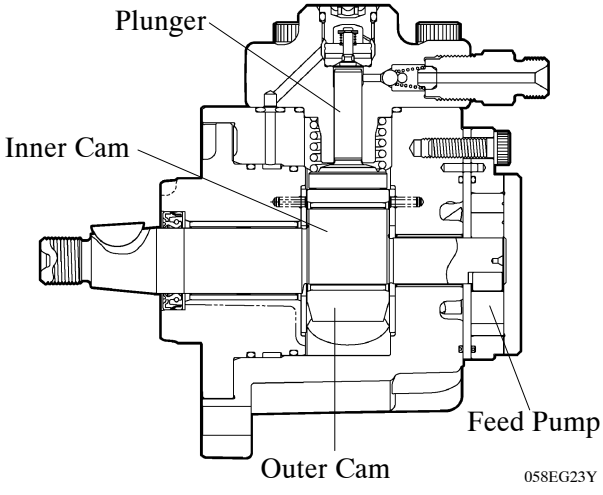
EG

Fuel Supply Pump

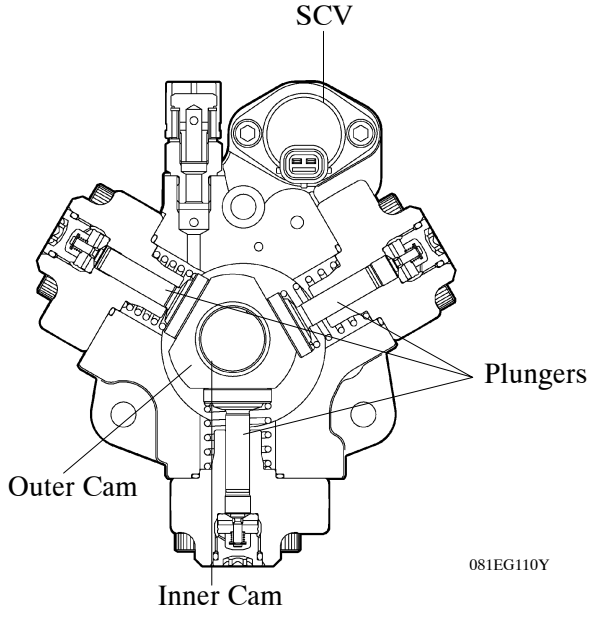
1) General

The fuel supply pump consists of an inner cam (eccentric cam), outer cam (polygon ring), and 3 plungers, SCV (Suction Control Valve), and a feed pump. Each plunger is placed outside of the outer cam.





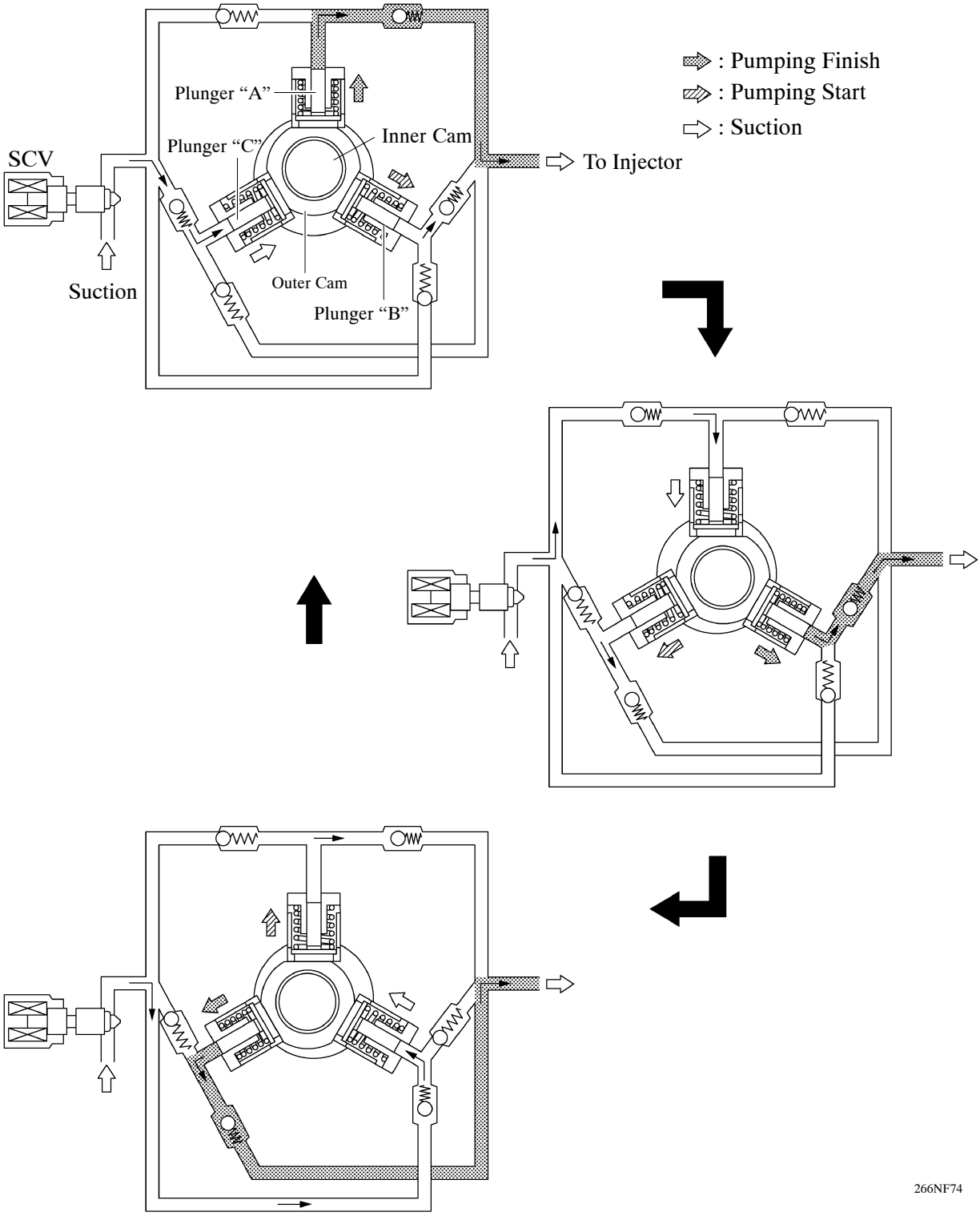
Cross Section



Cross Section

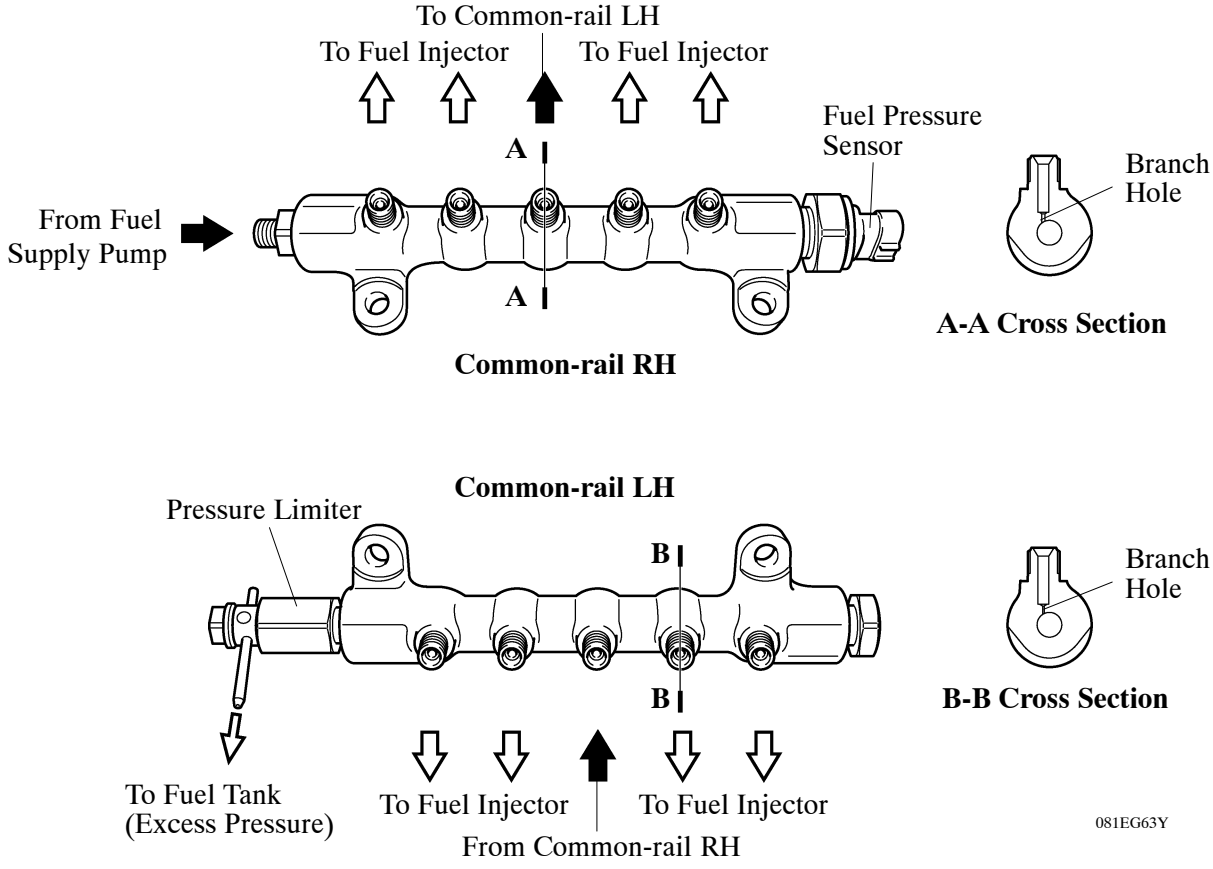
2) Operation

- Due to the rotation of the inner cam (eccentric cam), the outer cam pushes plunger “A” upward as illustrated below. The force of the spring pulls plungers “B” and “C”. As a result, plungers “B” and “C” draw fuel in, and plunger “A” pumps fuel at the same time.
- The SCV controls the volume of fuel that is drawn into the plungers in accordance with the signals from the ECM.



Common-rail

- The function of the common-rail is to store the fuel that has been pressurized by the fuel supply pump. The common-rail is provided with a fuel pressure sensor, which detects the fuel pressure in the common-rail, and a pressure limiter that mechanically relieves the pressure in case the internal pressure of the common-rail rises abnormally.
- Internally, the common-rail contains a main hole and five branch holes that intersect the main hole. Each branch hole functions as an orifice that dampens the fluctuation of the fuel pressure.



Service Tip

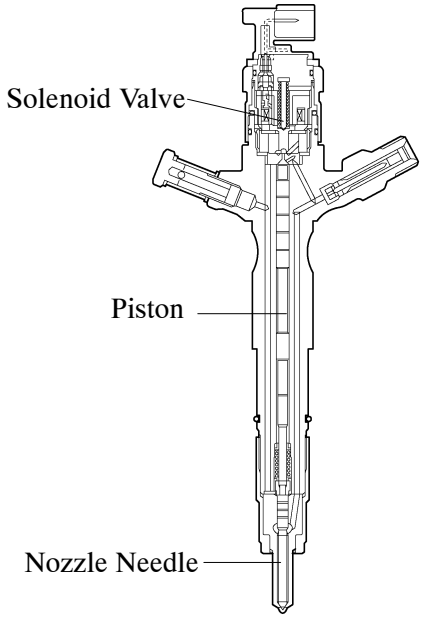
- Fuel pressure sensor has its sealing portion plastic-deformed in order to keep sealing performance, so do not reuse it after disassembling.
- The fuel pressure sensor and pressure limiter are supplied as a set with the common-rail.
- Do not disassemble the pressure limiter.
- If parts that affect the alignment have been changed, make sure to replace the pipe with a new one as well. The parts that require the replacement of a pipe are listed below.
  Injection Pipe: Fuel Injector, Common-rail, Cylinder Head and Intake Manifold
  Fuel Inlet Pipe: Fuel Supply Pump, Common-rail, Cylinder Head and Intake Manifold

For details, refer to the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

Fuel Injector

1) General

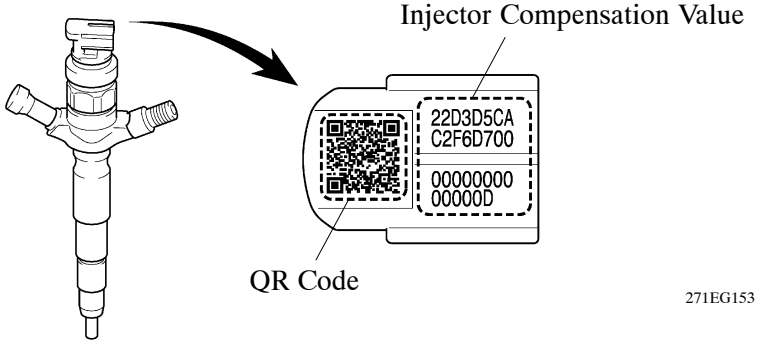
- The fuel injector consists of a nozzle needle, piston, and solenoid valve.
- An injector compensation value and QR (Quick Response) code containing encoded characteristics of the fuel injector are printed on each fuel injector.
- The injector compensation value and QR code contain various pieces of information regarding the fuel injector, such as model code, injection volume correction, and injection timing correction values.



271EG152

Service Tip

- If the ECM is replaced, use the intelligent tester II and input the injector compensation values of all 8 injectors. If one of the fuel injectors is replaced, input the injector compensation value of the replaced fuel injector. Then, the proper compensation will be made so that the injection volume precision prior to the replacement will remain unchanged. For details, refer to the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).
- The QR code, which requires a special scan tool, is not used at TOYOTA dealers.



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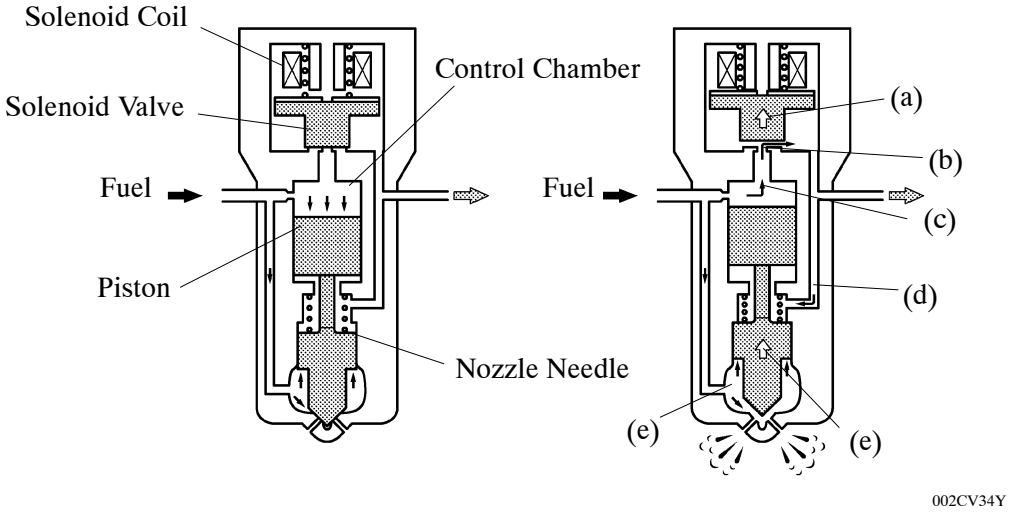
— REFERENCE —

What is QR (Quick Response) Code?

- *QR code, a matrix symbology consisting of an array of nominally square cells, allows omni-directional, high-speed reading of large amounts of data.*
- *QR code encodes many types of date such as numeric, alphanumeric, kanji, kana and binary code. A maximum of 7,089 characters (numeric) can be encoded.*
- *QR code (2D code) contains information in the vertical and horizontal direction, whereas a bar code contains data in one direction only. QR code (2D code) holds a considerably greater volume of information than a bar code.*

2) Operation

(a) When electrical current is applied to the solenoid coil, it pulls the solenoid valve up.
(b) The orifice of the control chamber opens, allowing the fuel to flow out.
(c) The fuel pressure in the control chamber drops.
(d) Simultaneously, fuel flows from the orifice to the bottom of the piston and raises the piston up (to enhance response).
(e) As a result, the piston raises the nozzle needle to inject fuel.



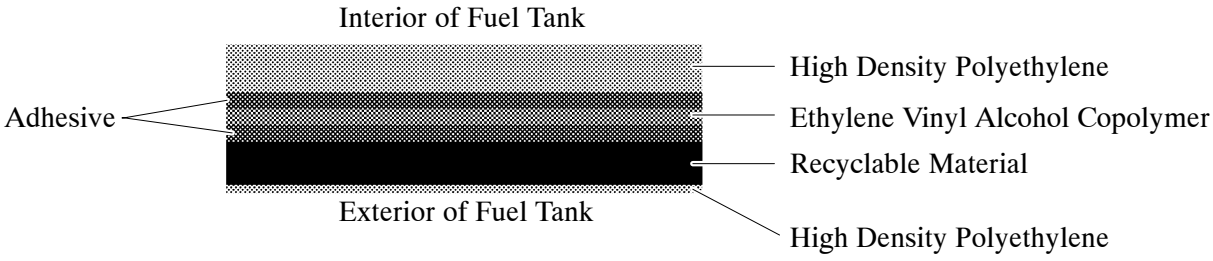
3. Fuel Tank

General

- A jet pump, which automatically transfers fuel from the fuel sub tank to the fuel tank, and a fuel pump, which drives the jet pump, are provided in the fuel tank on models equipped with a dual fuel tank.
- The multi-layer plastic fuel tank consists of six layers of four types of materials, and one of those is a recyclable material to address environmental concerns.

▶ Fuel Tank Capacity ◀

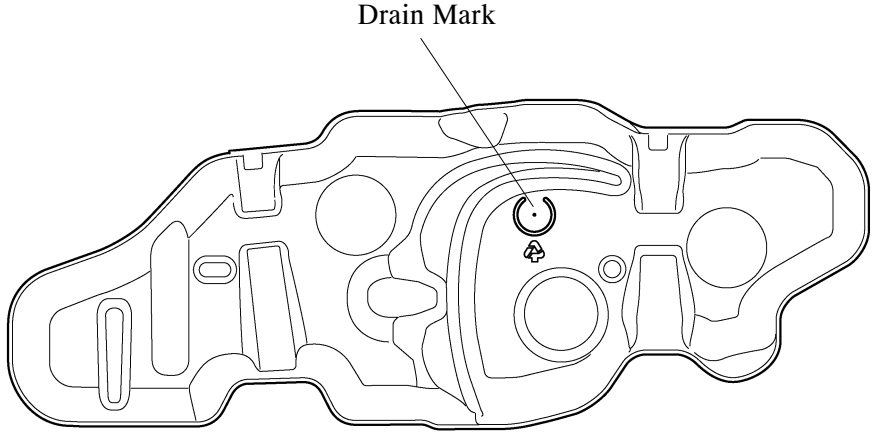
	Liters (US qts, Imp qts)
Models with Dual Fuel Tank	138 (145.8, 121.4)
Models with Single Fuel Tank	93 (98.3, 81.8)



Cross Section of Fuel Tank D13N27

Service Tip

Drain marks have been provided at the lowest position of the fuel tank. When dismantling (scraping) the vehicle, drain fuel by drilling holes at the drain mark.



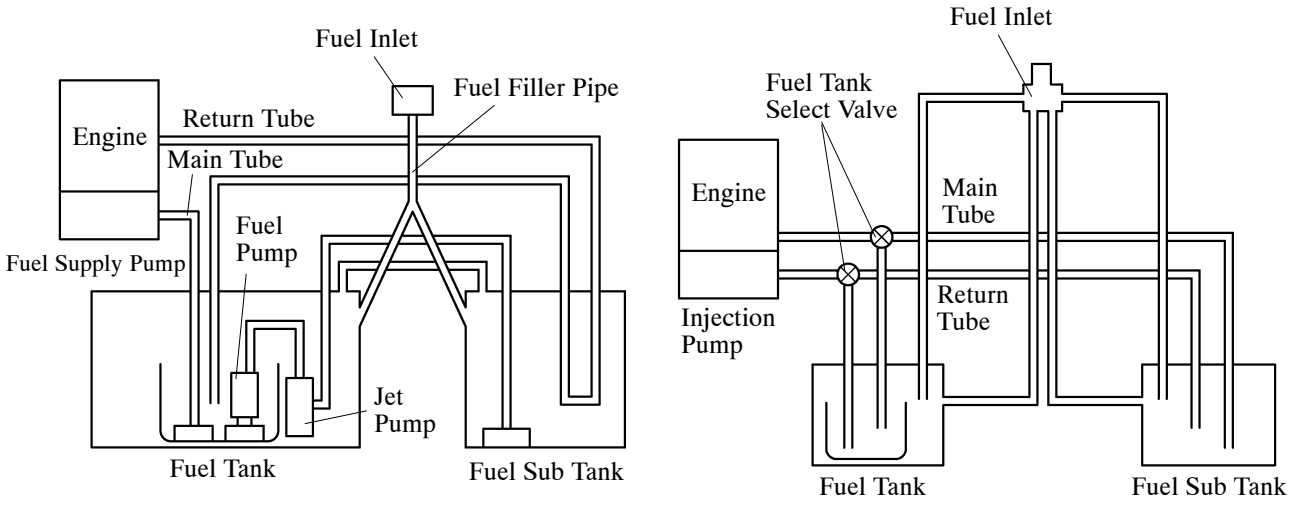
View from Bottom Side 080EG14TE

Construction of Dual Fuel Tank

1) General

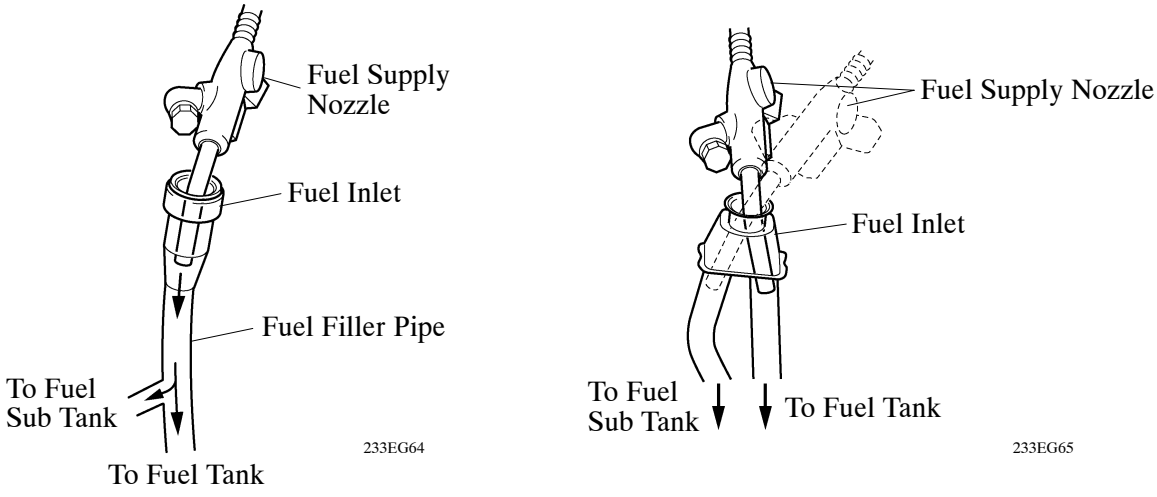
- On the previous model, either the fuel tank or fuel sub tank, from which fuel is supplied, is selected by operating the sub fuel tank switch. On the new model however, a jet pump and fuel pump are provided in the fuel tank in order to automatically transfer fuel from the fuel sub tank to the fuel tank.
- Fuel pump operation is controlled by the ECM in accordance with the actual fuel amount in the fuel tanks. For details on fuel pump control, see page EG-205.
- For the fuel filler pipe, the structure that is united right under the fuel inlet and forked into two in the middle is used in its configuration. Therefore, the driver can refuel without the need to distinguish the fuel tank from the fuel sub tank.

▶ System Diagram ◀



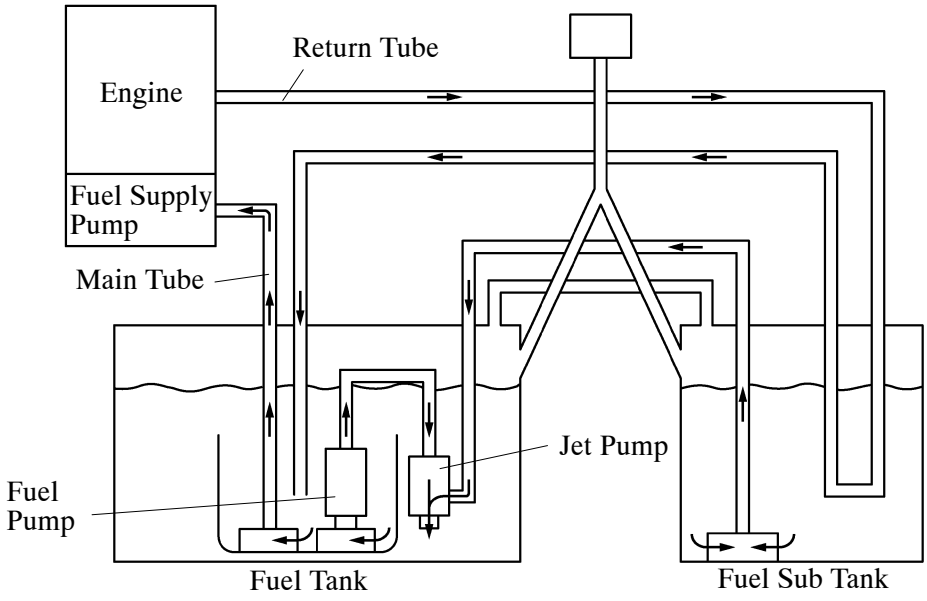
2) Fuel Inlet

- On the previous model, the fuel filler pipe has branched into two pipes directly below the fuel inlet. Therefore, the driver had to select whether to fill the fuel tank or the fuel sub tank during refueling.
- On the new model, there is only one fuel filler pipe directly below the fuel inlet, which branches into two pipes at a midway point.

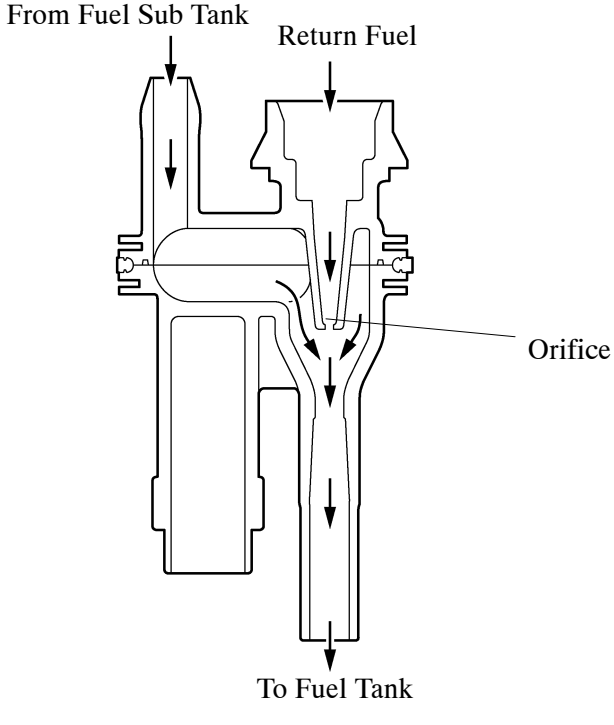


3) Operation

- The fuel from the fuel pump actuates the jet pump in the fuel tank, in order to draw fuel from the fuel sub tank to the fuel tank.



- The fuel from the fuel pump passes through the orifice in the jet pump and returns to the fuel tank. Because the flow speed of the fuel from the fuel pump increases as it passes through the orifice, a vacuum is created near the exit of the orifice. This vacuum causes the fuel to be drawn from the fuel sub tank to the fuel tank.



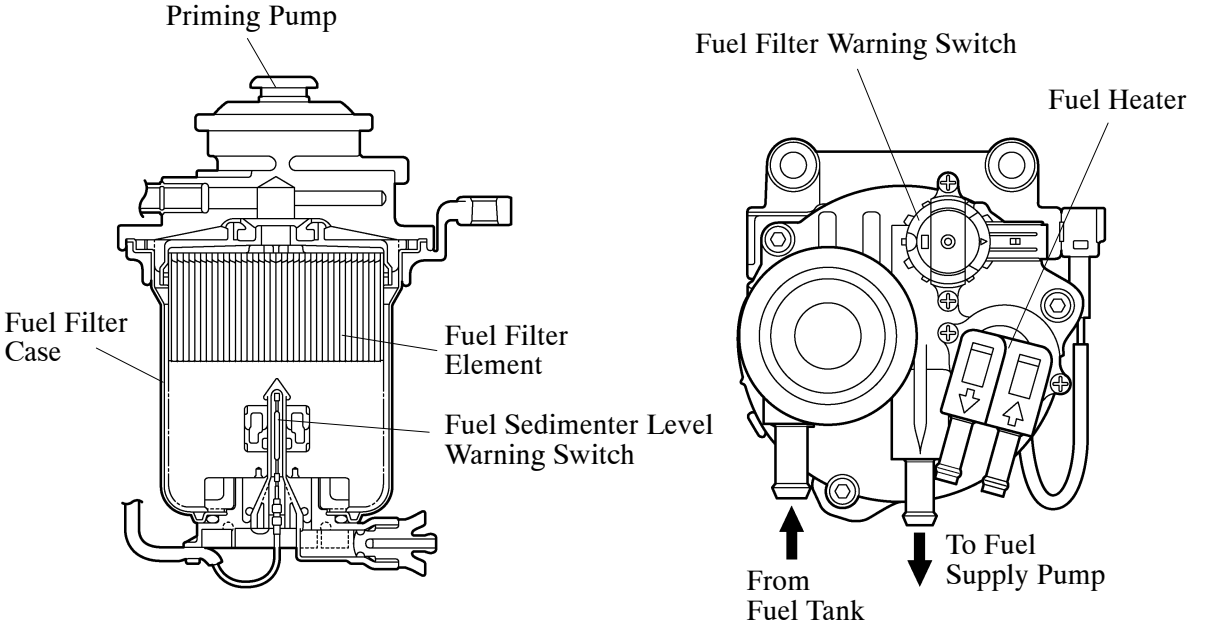
Jet Pump

EG

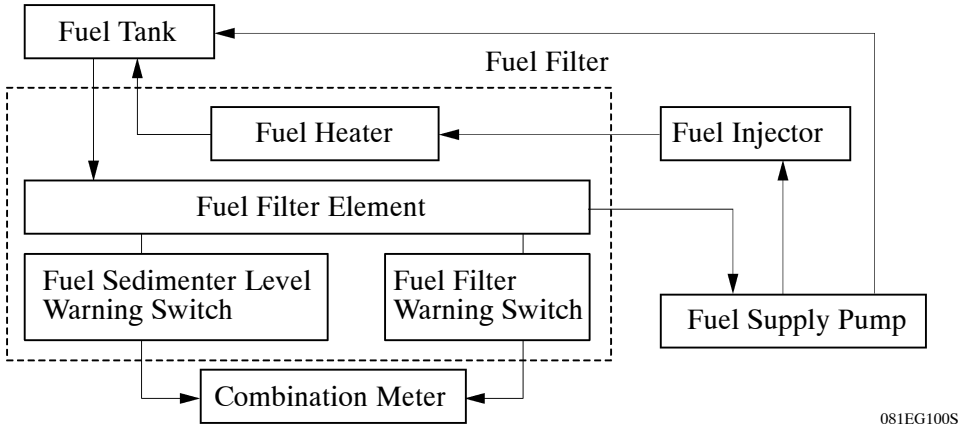
4. Fuel Filter

General

- While the fuel filter element of the conventional fuel filter has been integrated with the fuel filter case, the new fuel filter consists of a separate fuel filter element and fuel filter case. A paper filter element that offers high filtering efficiency and captures the minutest particles is used.
- A fuel filter warning switch, which turns ON/OFF when the internal vacuum of the filter increases, is provided in the fuel filter.
- Instead of the electrical type fuel heater used on the conventional model, a recirculation type fuel heater is provided as standard on European models and as an option on general country models, in order to improve the fuel heating performance.]



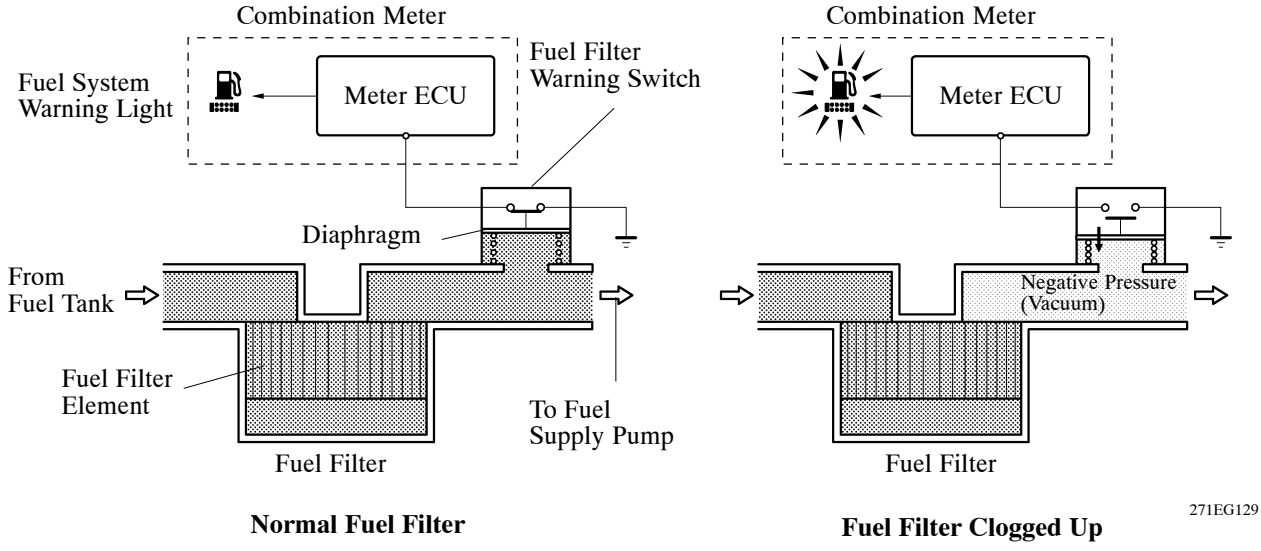
▶ System Diagram ◀



Fuel Filter Warning Switch

- A fuel filter warning switch, which turns ON/OFF when the internal vacuum of the filter increases, is provided in the fuel filter. This switch, which turns OFF when the internal vacuum of the fuel filter increases to a predetermined level, is connected by wire to the meter ECU.
- When the meter ECU detects that the internal vacuum of the fuel filter has increased (by way of the fuel filter warning switch OFF signal), it determines that the fuel filter has become clogged. Then it illuminates the fuel system warning light*1 (or displays a message on the multi-information display*2) on the combination meter to urge the driver to replace the fuel filter. For details on fuel filter warning light control, see page BE-48.

*1: Only on models with analog type combination meter
*2: Only on models with optitron display type combination meter



Normal Fuel Filter **Fuel Filter Clogged Up**

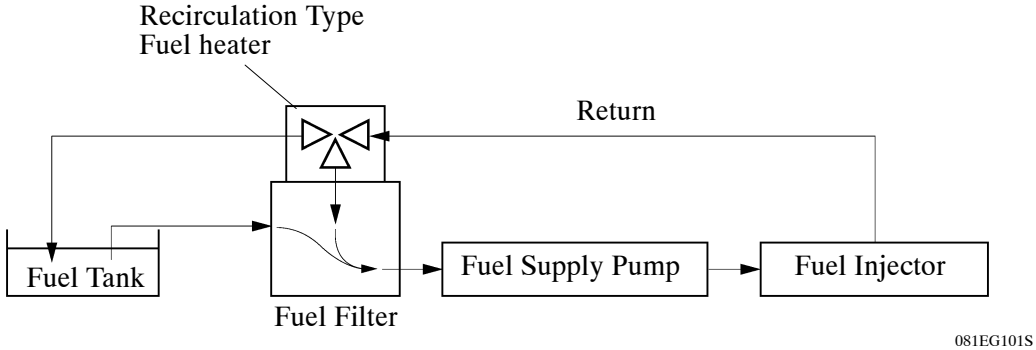
Fuel Sedimenter Level Warning Switch

- When the water in the sedimenter section reaches a certain amount, the level warning switch comes ON and the fuel system warning light in the combination meter blinks*1 (or a message is displayed on the multi-information display*2).
- On models except for Europe, when the fuel system warning light blinks, the buzzer in the combination meter sounds.
- For details on fuel filter warning light control, see page BE-48.

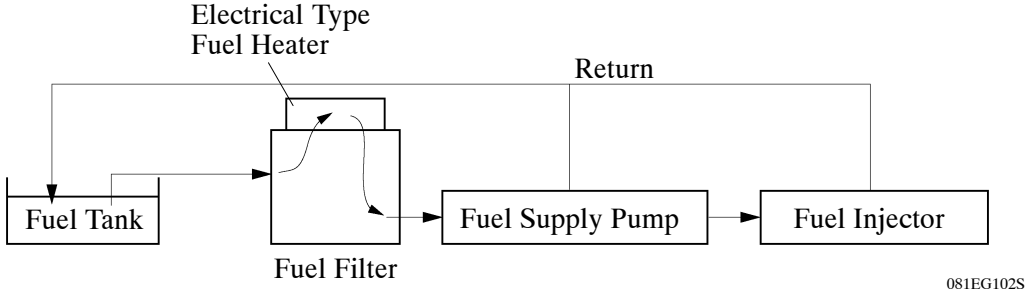
*1: Only on models with analog type combination meter
*2: Only on models with optitron display type combination meter

Fuel Heater

- This heater heats the fuel by recirculating the returned fuel, which becomes to have a high temperature by the fuel pumping of the fuel supply pump, to the fuel filter.
- The fuel heater uses a recirculation valve (bimetal), which is mounted on the fuel return line and opens and closes in accordance with the fuel temperatures to draw return fuel to the fuel filter.
- While the engine is cold, the recirculation valve inside the fuel heater will open due to the bimetal action, so the return fuel will return to the fuel filter and the fuel tank.
- While the engine is warm, the recirculation valve will close due to the bimetal action, so all the return fuel will return to the fuel tank.



New

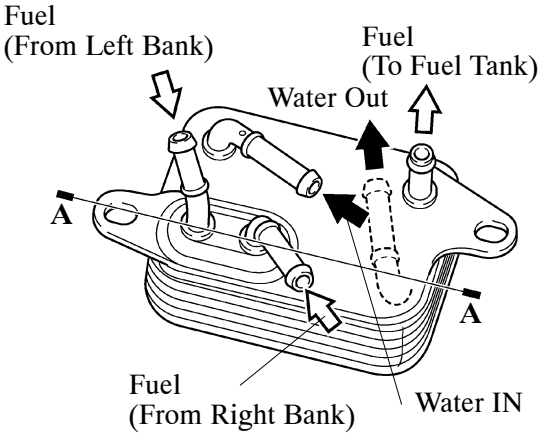


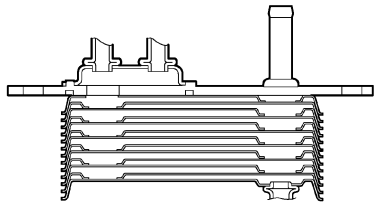
Conventional

5. Fuel Cooler

The two types of the fuel coolers are used; one is the water-cooled type, and the other is the air-cooled type. These fuel coolers, which are provided in the fuel return path, cool the return fuel that has reached a high temperature as a result of the pumping of the fuel supply pump. This prevents the reduction in fuel viscosity that is caused by the rise in fuel temperature, and improves the reliability of the fuel system.

▶ Water-cooled Type Fuel Cooler ◀

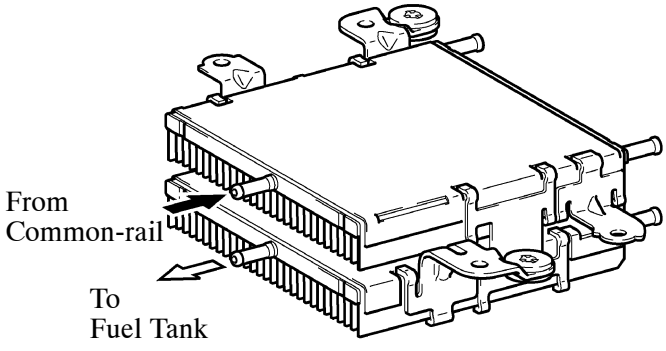


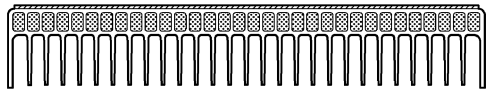


A - A Cross Section

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▶ Air-cooled Type Fuel Cooler ◀





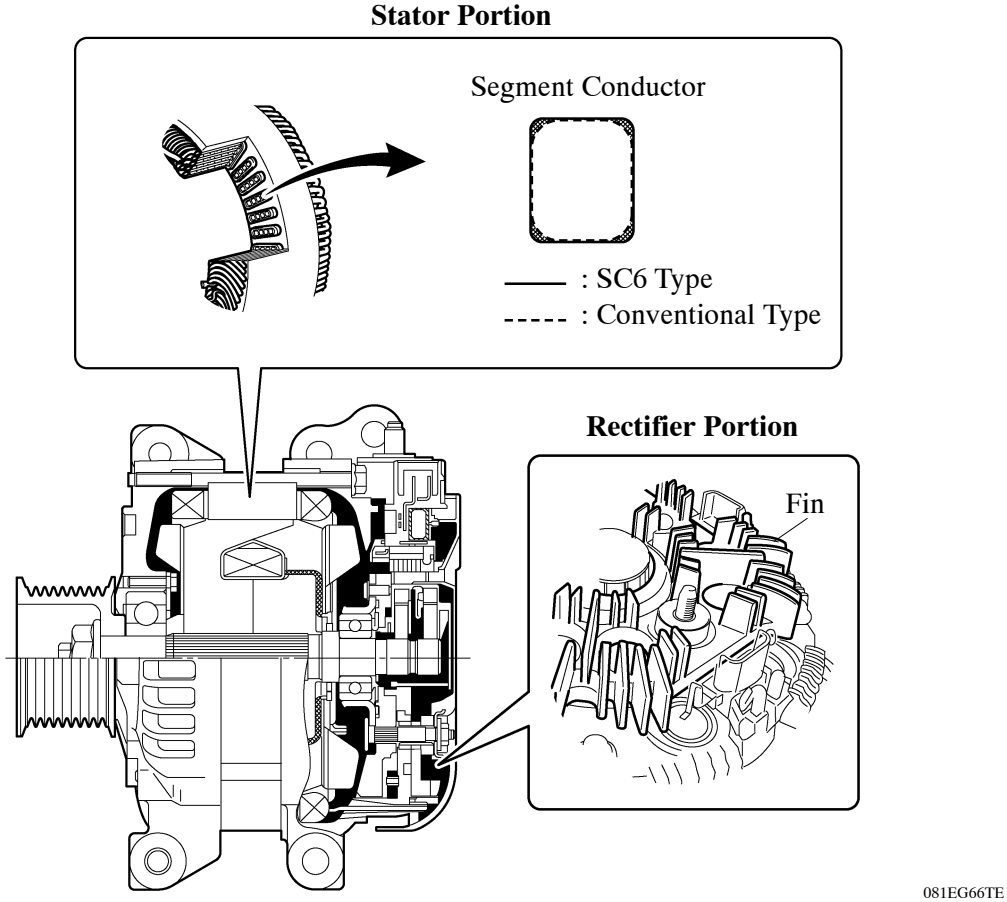
Fuel Cooler Cross Section

081EG65TE

■CHARGING SYSTEM

1. General

- A compact and lightweight segment conductor type generator is used on all models.
- A SC6 type generator is provided on European models with the towing package. The cross sectional area of the segment conductors on a stator in this generator has been increased, which reduces the electrical resistance of the stator, generates high power output, and achieves a higher efficiency. This type uses an aluminum die-casting rectifier unit and also provides fins on the rectifier to improve heat dissipation.



Generator Cross Section

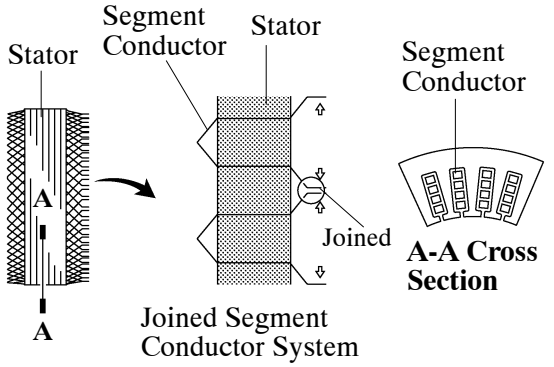
▶ Specifications ◀

Type	SC1	SC2	SC6
Destination	G.C.C. Countries	Europe*2	Europe*4
		Australia	
	General Countries*1	General Countries*3	
Rated Voltage	12V	←	←
Output Rated	130A	150A	180A

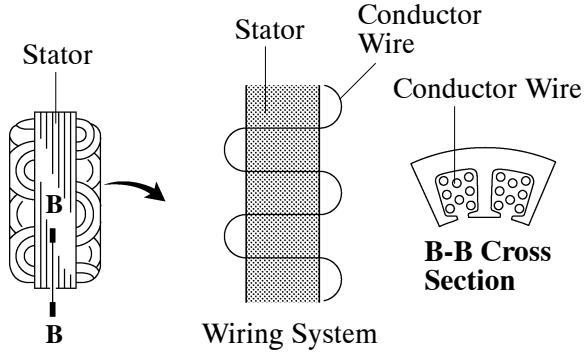
*1: Except for VX grade models
*2: European models without the towing package except cold area specifications
*3: Only on VX grade models
*4: Only on models with towing package

2. Construction and Operation

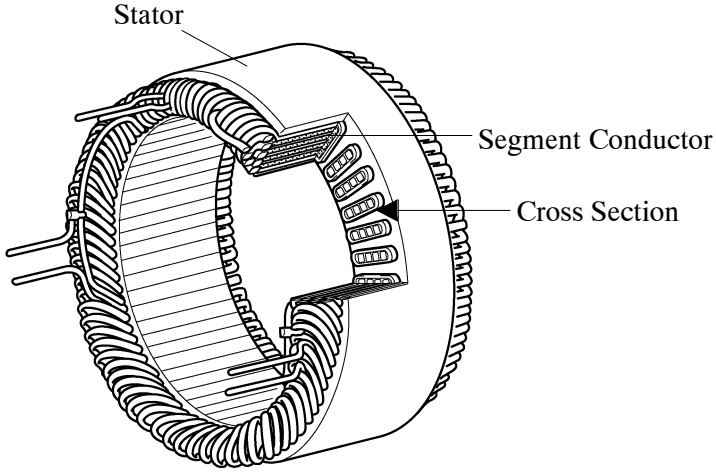
This generator uses a joined segment conductor system, in which multiple segment conductors are welded together at the stator. Compared to the conventional winding system, the electrical resistance is reduced due to the shape of the segment conductors, and their arrangement helps to make the generator more compact.



Segment Conductor Type generator 206EG40

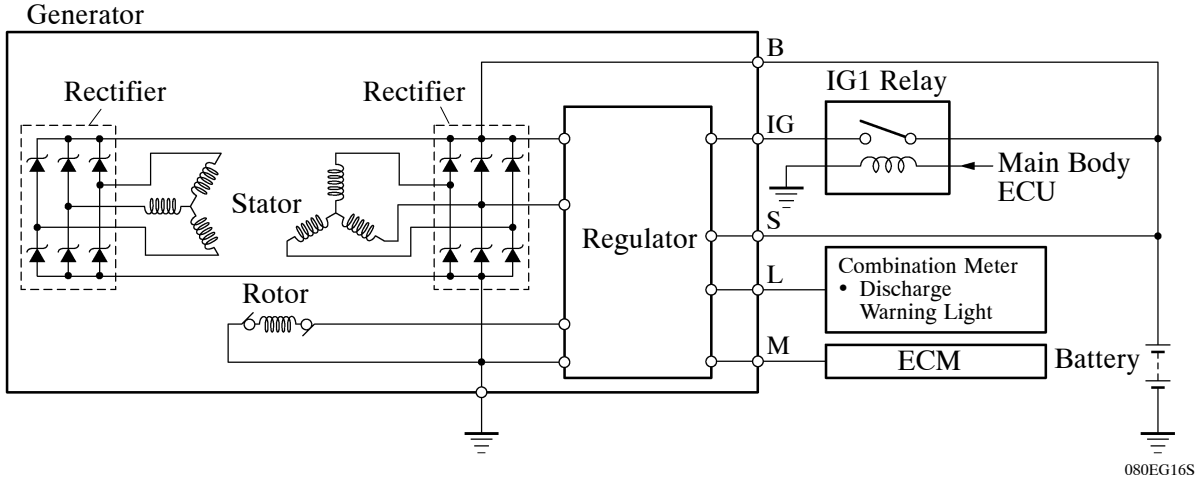


Conventional Type Generator 206EG41



Stator of Segment Conductor Type Generator 206EG42

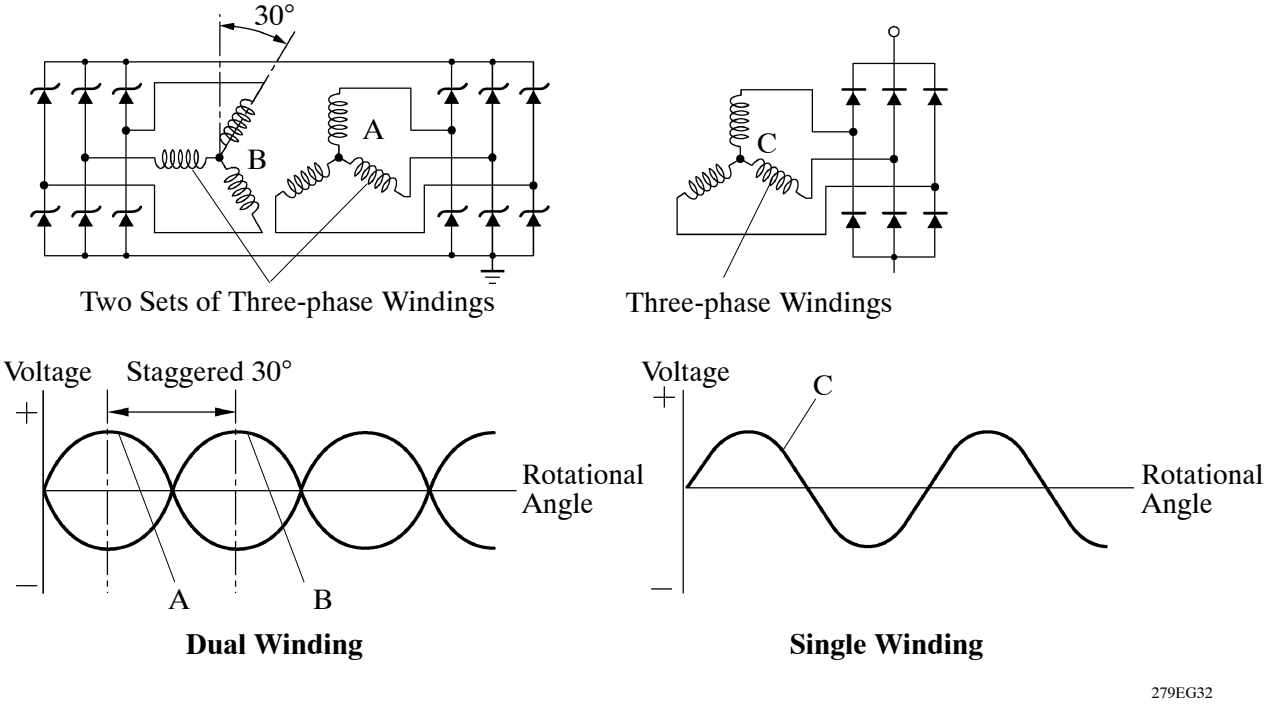
▶ Wiring Diagram ◀



080EG16S

3. Dual Winding System

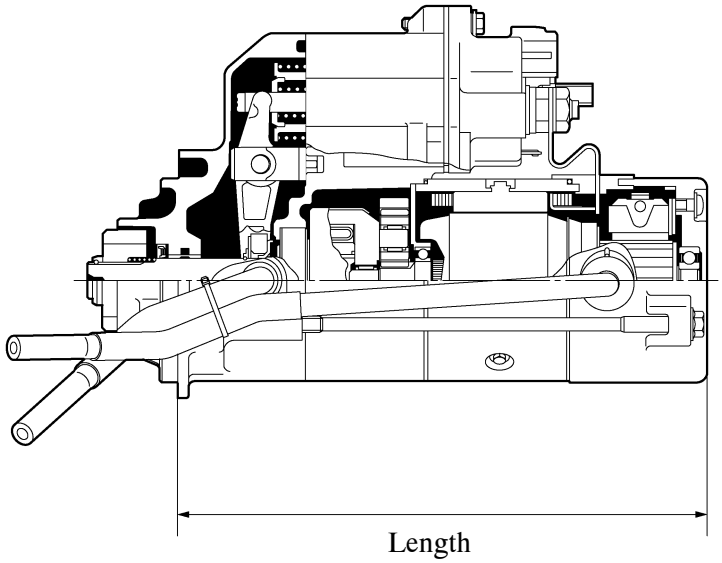
A dual winding system is used. This system consists of two sets of three-phase windings whose phases are staggered 30_. This system results in the reduction of both electrical noise (ripple and spike), and magnetic noise (a hum that is heard as alternator load is increased). This system significantly suppresses noise at the source (alternator). Because the waves that the respective windings generate have opposite polarities, magnetic noise is reduced. The magnetic noise is significantly reduced, but the electrical power generated does not cancel itself out due to the use of separate rectifiers. The opposite polarities that are generated can be seen below.



279EG32

■STARTING SYSTEM

Planetary reduction type starter is used.



081EG67TE

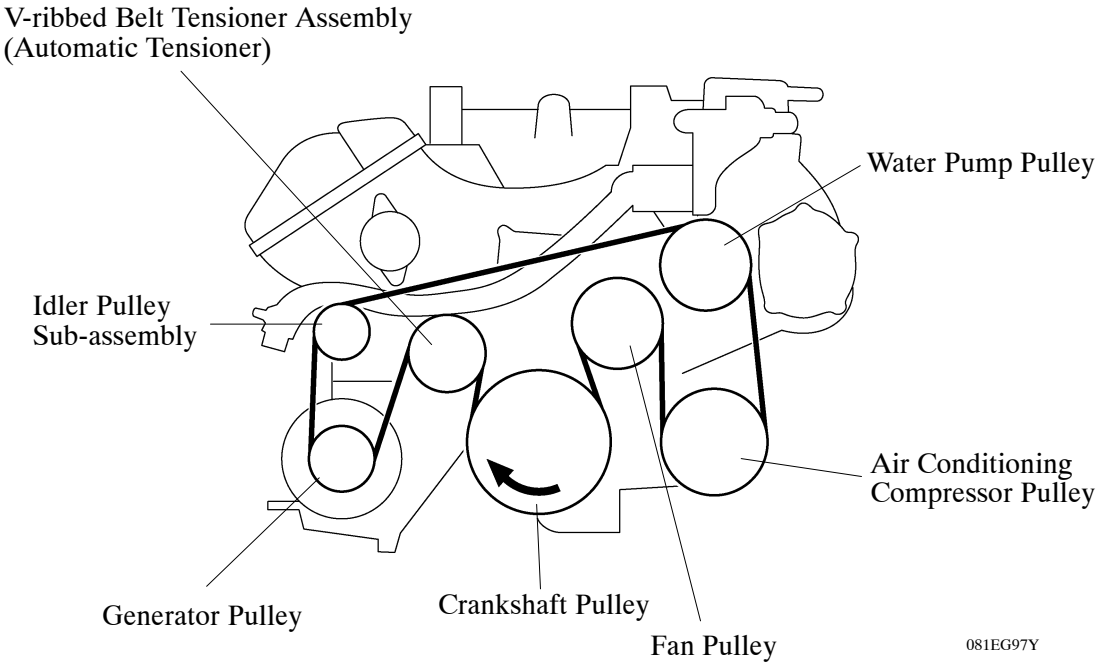
▶ Specifications ◀

Type		PA90S
		Planetary reduction type
Rating Output	kW	2.7
Rating Voltage	V	12
Length*1	mm (in.)	237.5 (9.35)
Weight	g (lb)	7500 (16.5)
Rotating Direction		Clockwise*2

*1: Length from the mounted area to the rear end of the starter
*2: Viewed from Pinion Side

■SERPENTINE BELT DRIVE SYSTEM

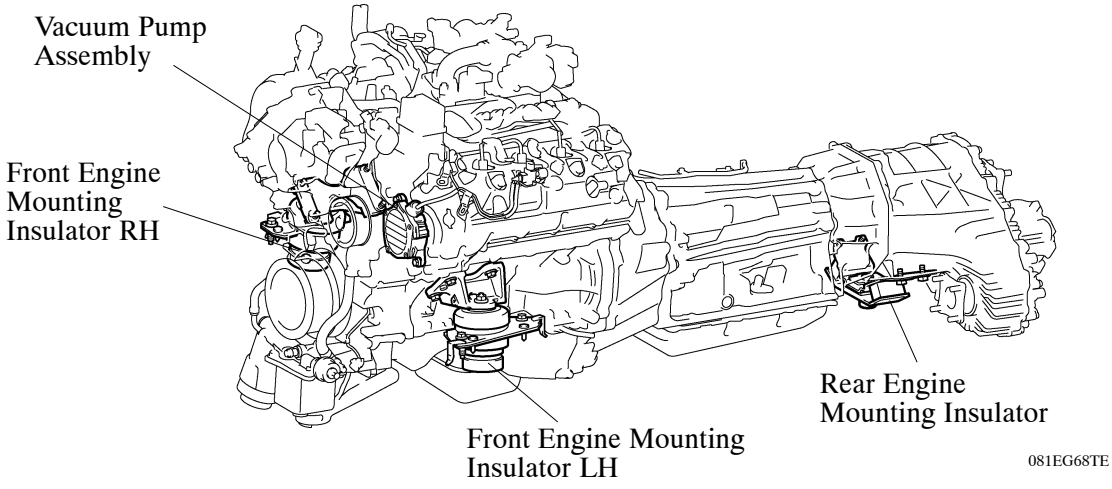
- A serpentine belt drive system, which drives all accessory components by a single V-ribbed belt, is used. It reduces the overall engine length, weight and number of engine parts.
- An automatic tensioner is used. This makes the tension adjustment unnecessary.



■ENGINE MOUNTING

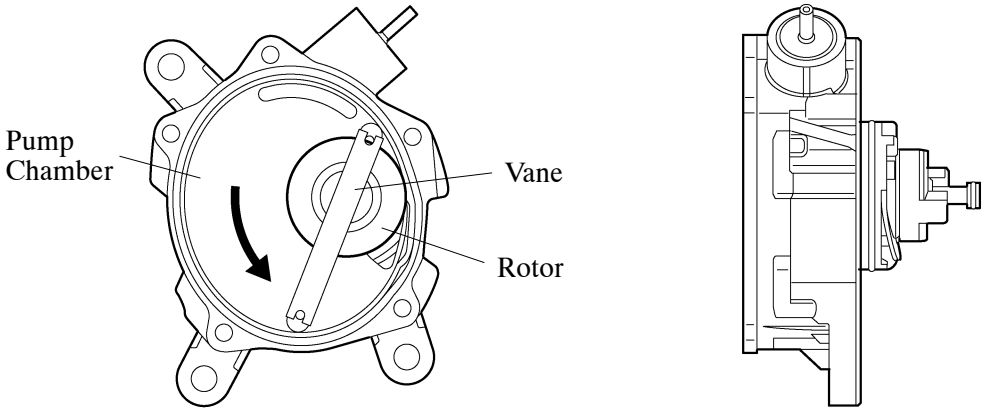
1. General

- Two front engine mountings on each side of the engine and one rear engine mounting at the back of the transmission are provided.
- Electrical hydraulic type engine mountings are used for the front engine mounting. These mountings are operated by the vacuum which is generated by the vacuum pump that is used to control engine mountings. For details on engine mounting control, see page EG-207.



2. Vacuum Pump

A compact and lightweight vane type vacuum pump with 1 blade is used.



Cross Section

Service Tip

The maintenance interval (replacement) of the vacuum pump is every 200000 km. For details, refer to the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

■ENGINE CONTROL SYSTEM

1. General

The engine control system of the 1VD-FTV engine has the following system.

System	Outline
Fuel Injection Volume Control (See page EG-192)	Based on the signals received from the sensors, the ECM determines the fuel injection volume in accordance with the engine condition.
Fuel Injection Timing Control (See page EG-193)	Based on the signals received from the sensors, the ECM determines the fuel injection timing in accordance with the engine condition.
During Starting Control (See page EG-194)	To facilitate startability, the ECM optimally controls the injection volume and injection timing during starting.
Idle Speed Control (See page EG-195)	The ECM determines the idle speed in accordance with the engine condition, and controls the fuel injection volume in order to maintain the target idle speed.
Fuel Pressure Control (See page EG-196)	Based on the signals received from the sensors, the ECM controls fuel pressure using the SCV (Suction Control Valve) according to the engine condition.
Pilot Injection Control (See page EG-199)	Based on the signals received from the sensors, the ECM determines pilot injection volume/timing, and interval (between pilot injection and main injection) in accordance with the engine condition.
Glow Plug Control	Controls the length of time when the current is applied to the glow plugs, in accordance with the engine coolant temperature.
Throttle Control (See page EG-200)	• Based on the signals received from the various sensors, the ECM determines throttle valve position in accordance with the engine condition. • Fully close the throttle valve in order to reduce the vibration when the engine is stopped.
Turbocharger Control (See page EG-201)	Based on the signals received from the sensors, the ECM controls the actuator via the turbo motor driver in accordance with the engine conditions.
Fuel Pump Control*1 (See page EG-205)	Based on the signals from the sensors, the ECM operates the fuel pump to optimally control the transfer of the fuel from the fuel sub tank to the fuel tank.
EGR Control*2 (See page EG-206)	Based on the signals received from the sensors, the ECM determines the EGR volume via EGR valve and throttle valve in accordance with the engine condition.
Engine Mounting Control (See page EG-207)	When the engine speed and the vehicle speed are low, this control utilizes vacuum to soften the engine mounting characteristics in order to restrain the engine vibration.
Oil Maintenance Management*3 (See page EG-210)	When the ECM determines engine oil deterioration, the engine oil change reminder light turns on to inform the driver.

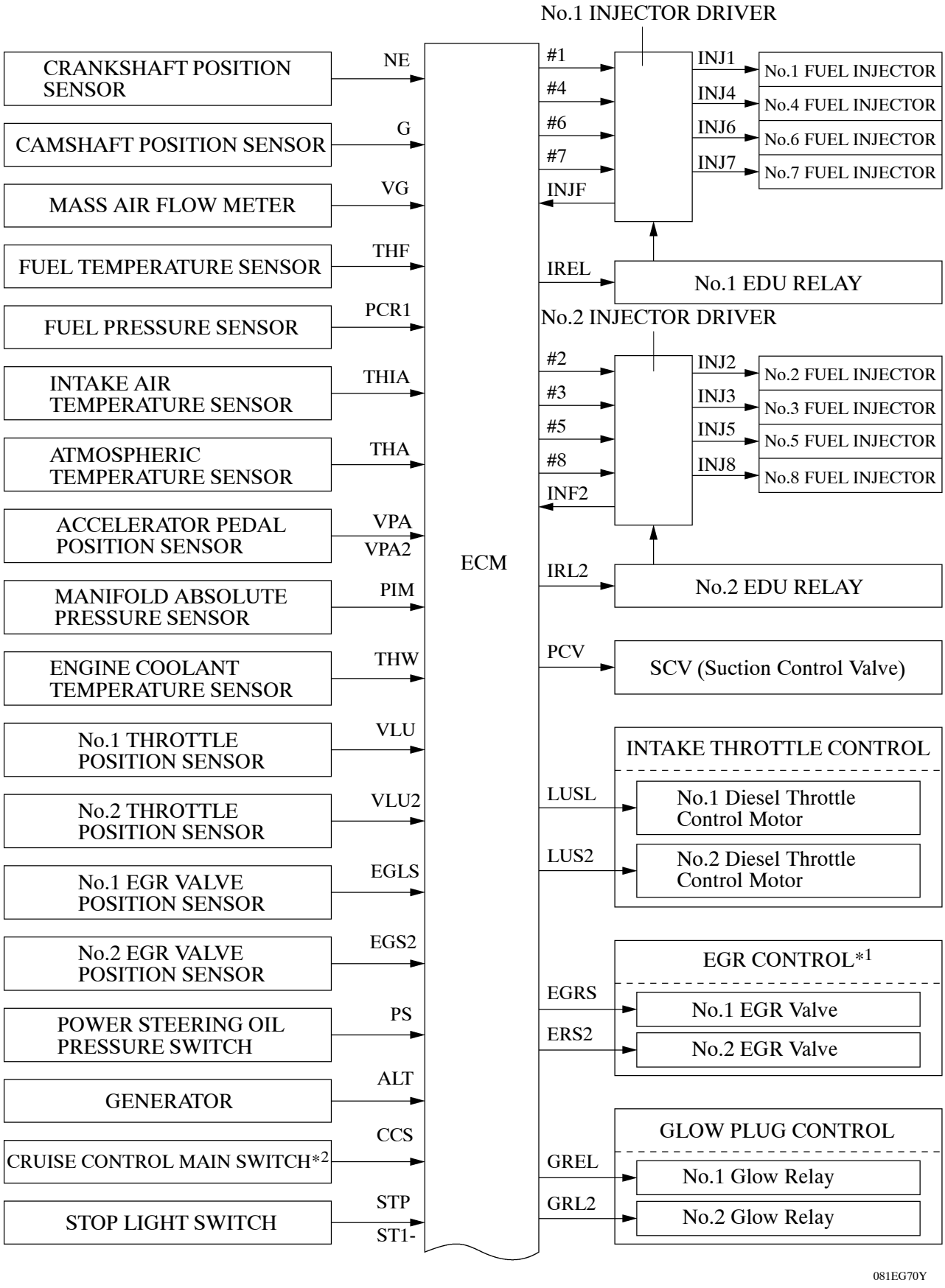
(Continued)

System	Outline
Starter Control (Cranking Hold Function)	• Once the engine switch is pushed, this control continues to operate the starter until the engine is started. • The basic construction and operation of the starter control are the same as in the 1GR-FE engine. For details, see page EG-70.
Air Conditioner Cut-off Control	By controlling the air conditioner compressor ON or OFF in accordance with the engine condition, drivability is maintained.
Engine Immobilizer	Prohibits fuel injection if an attempt is made to start the engine with an invalid key.
Diagnosis [See page EG-212]	When the ECM detects a malfunction, the ECM records the malfunction and memorizes information related to the fault.
Fail-safe [See page EG-212]	When the ECM detects a malfunction, the ECM stops or controls the engine according to the data already stored in the memory.

*1: Only on models with dual fuel tank
*2: Only on models complying with emission regulations (EURO II, EURO III, EURO IV)
*3: Only on European models complying with EURO IV

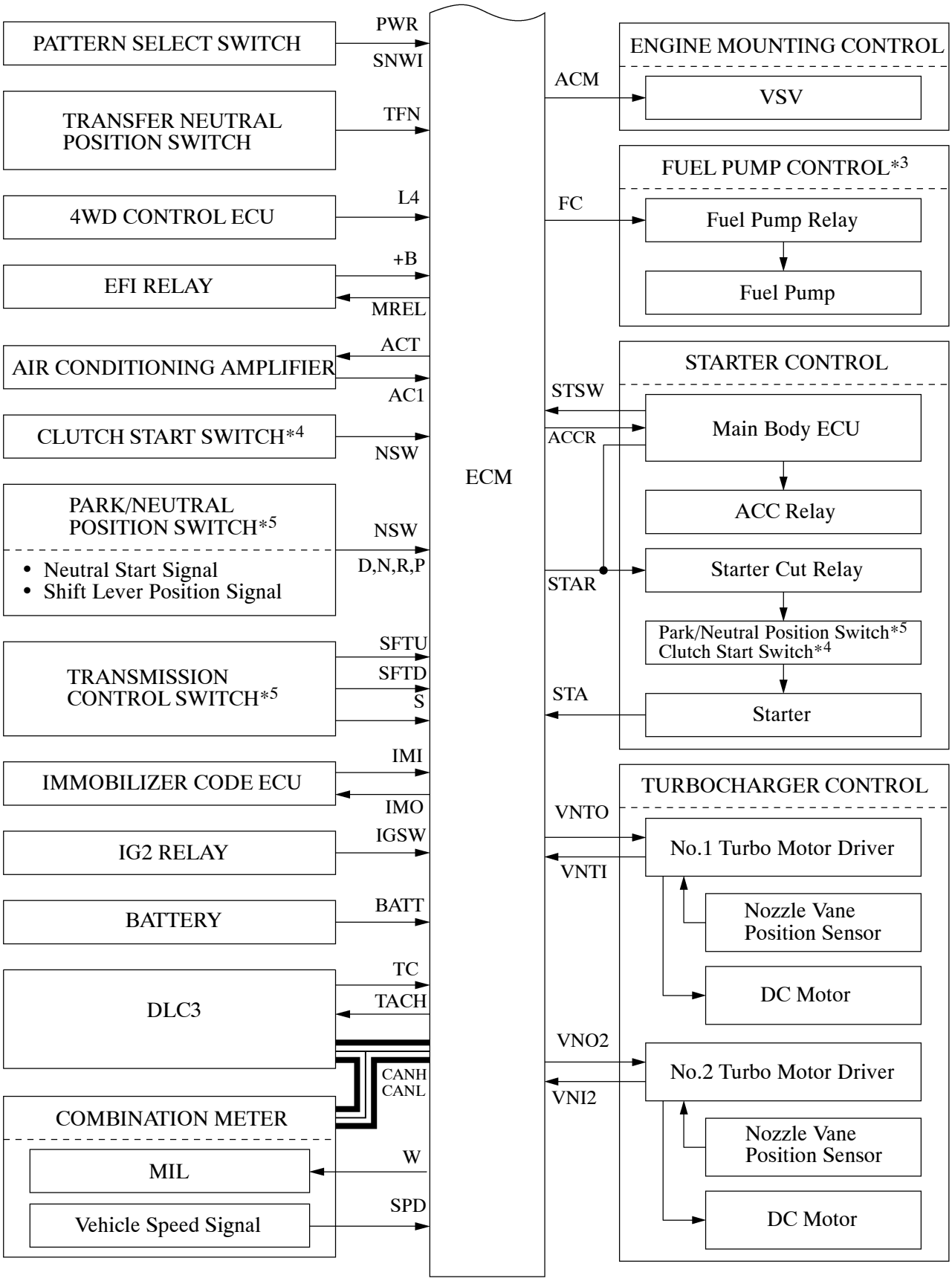
2. Construction

The configuration of the engine control system in the 1VD-FTV engine is as shown in the following chart.



081EG70Y

(Continued)

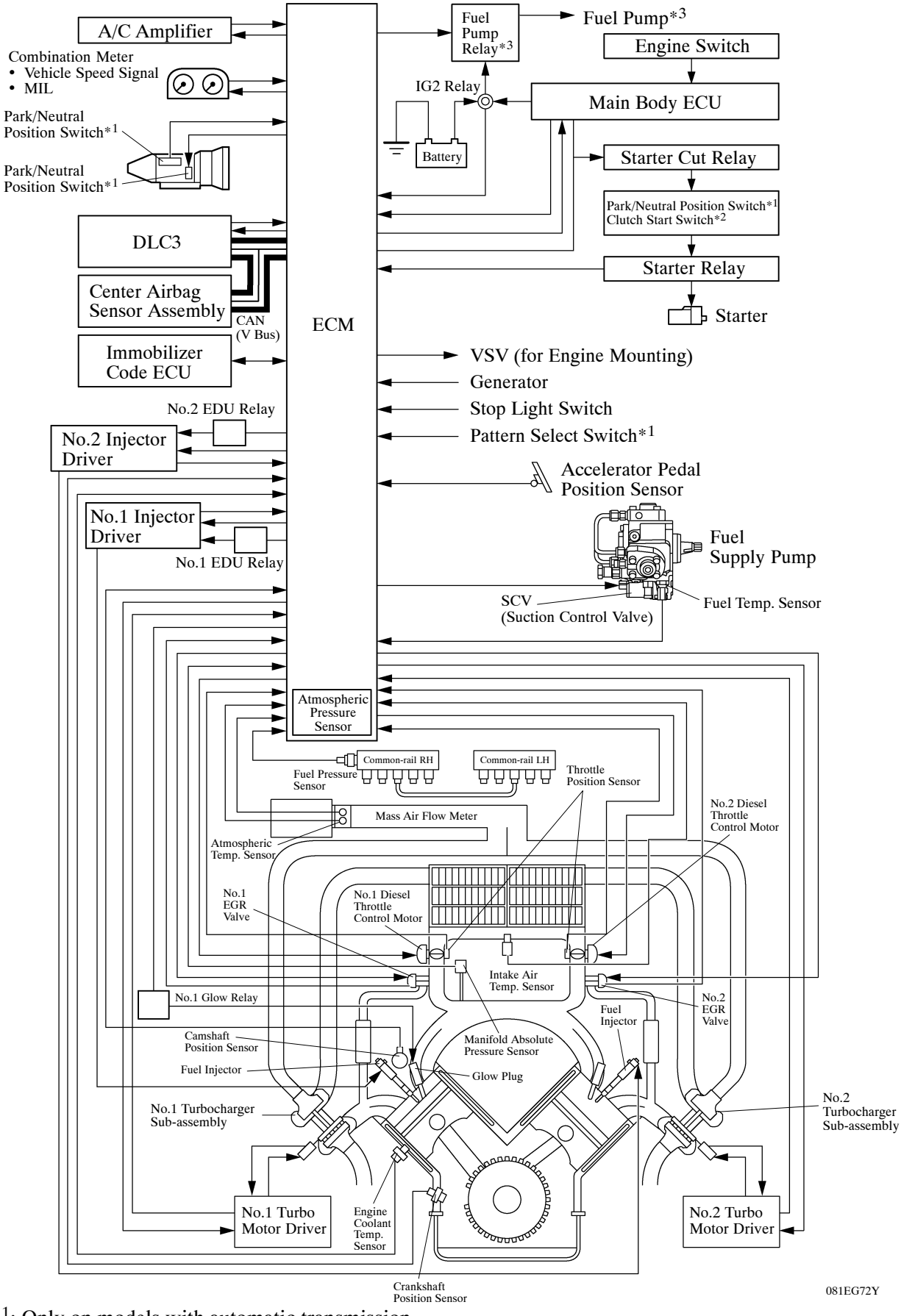


081EG71Y

*1: Only on models complying with the emission regulations
*2: Only on models with cruise control system
*3: Only on models with dual fuel tank
*4: Only on models with manual transmission
*5: Only on models with automatic transmission

EG

3. Engine Control System Diagram

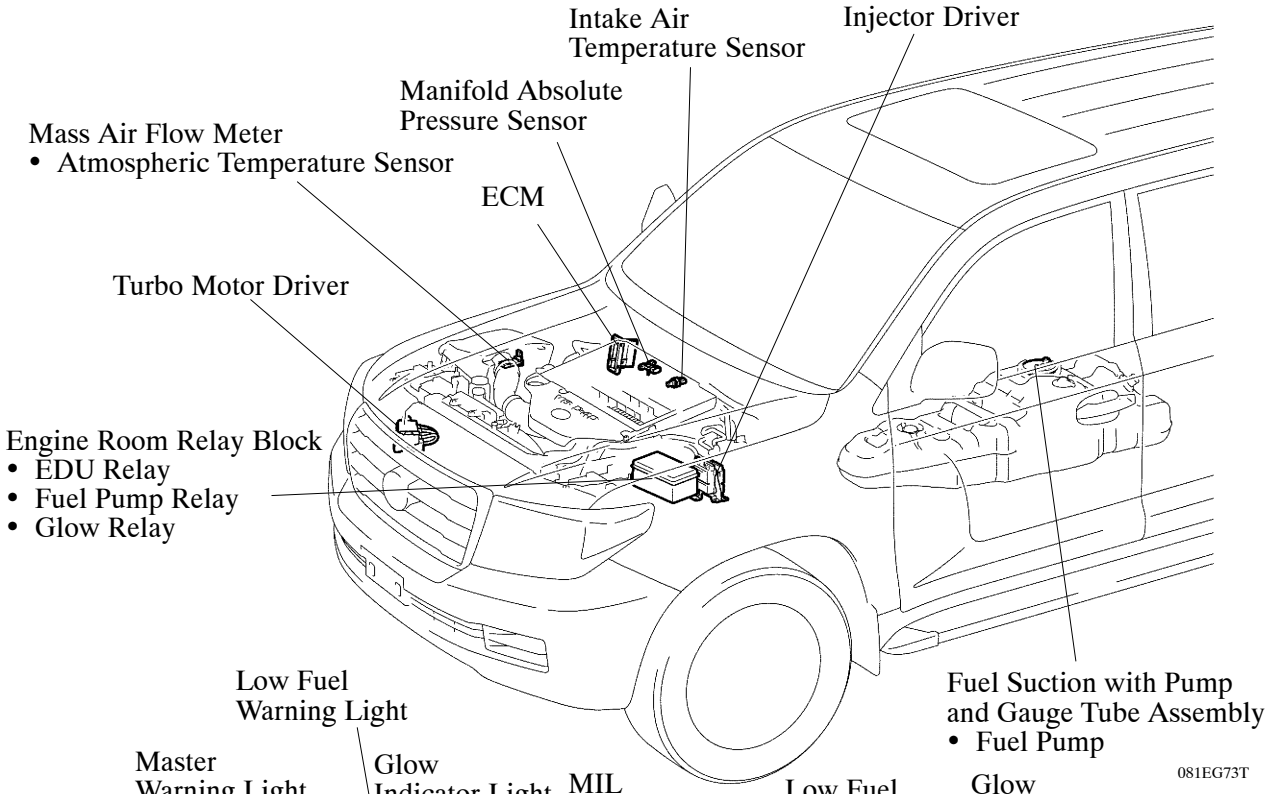


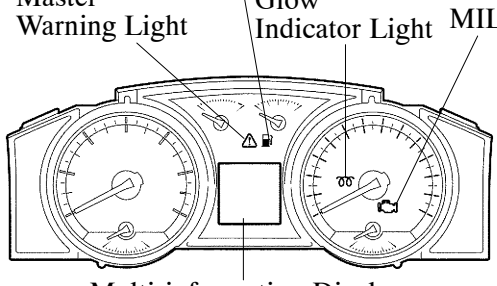
*1: Only on models with automatic transmission

*2: Only on models with manual transmission

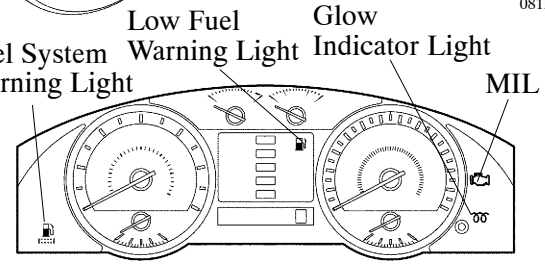
*3: Only on models with dual fuel tank

4. Layout of Main Components

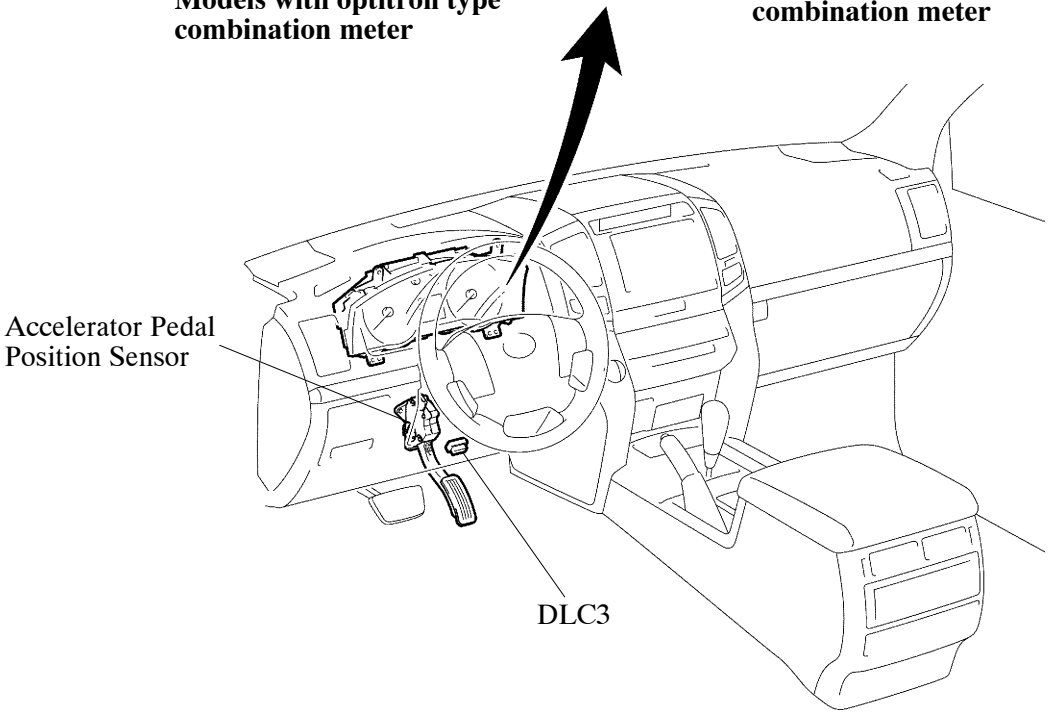




Models with optitron type combination meter



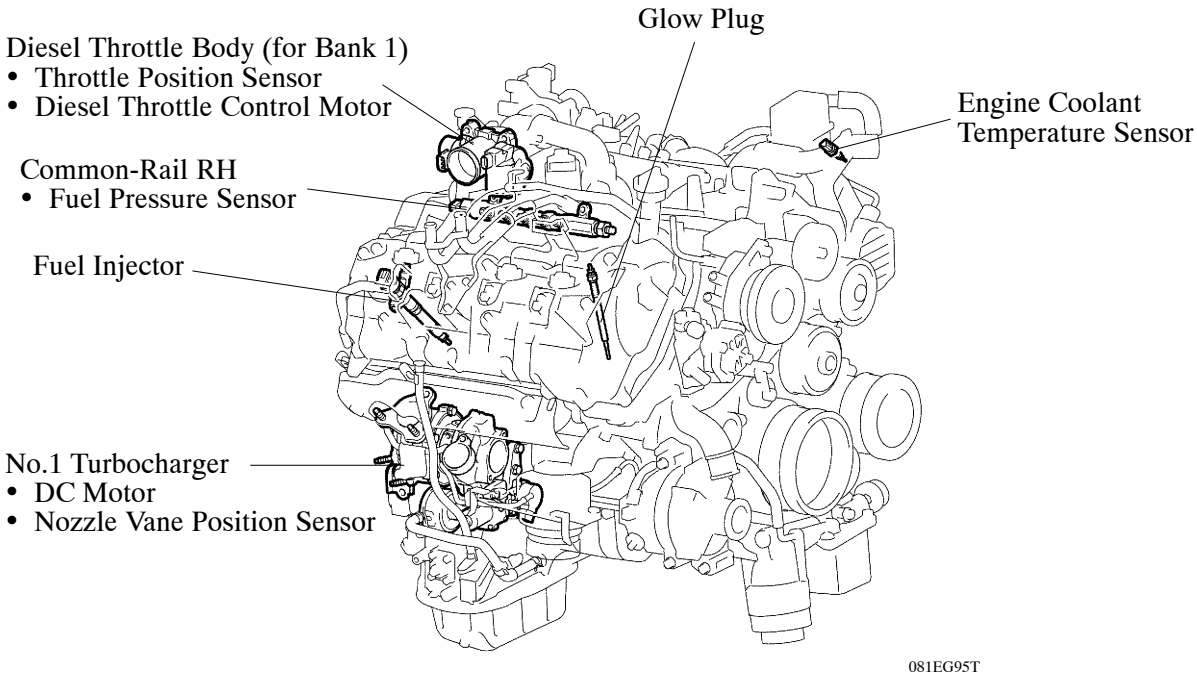
Models with analog type combination meter

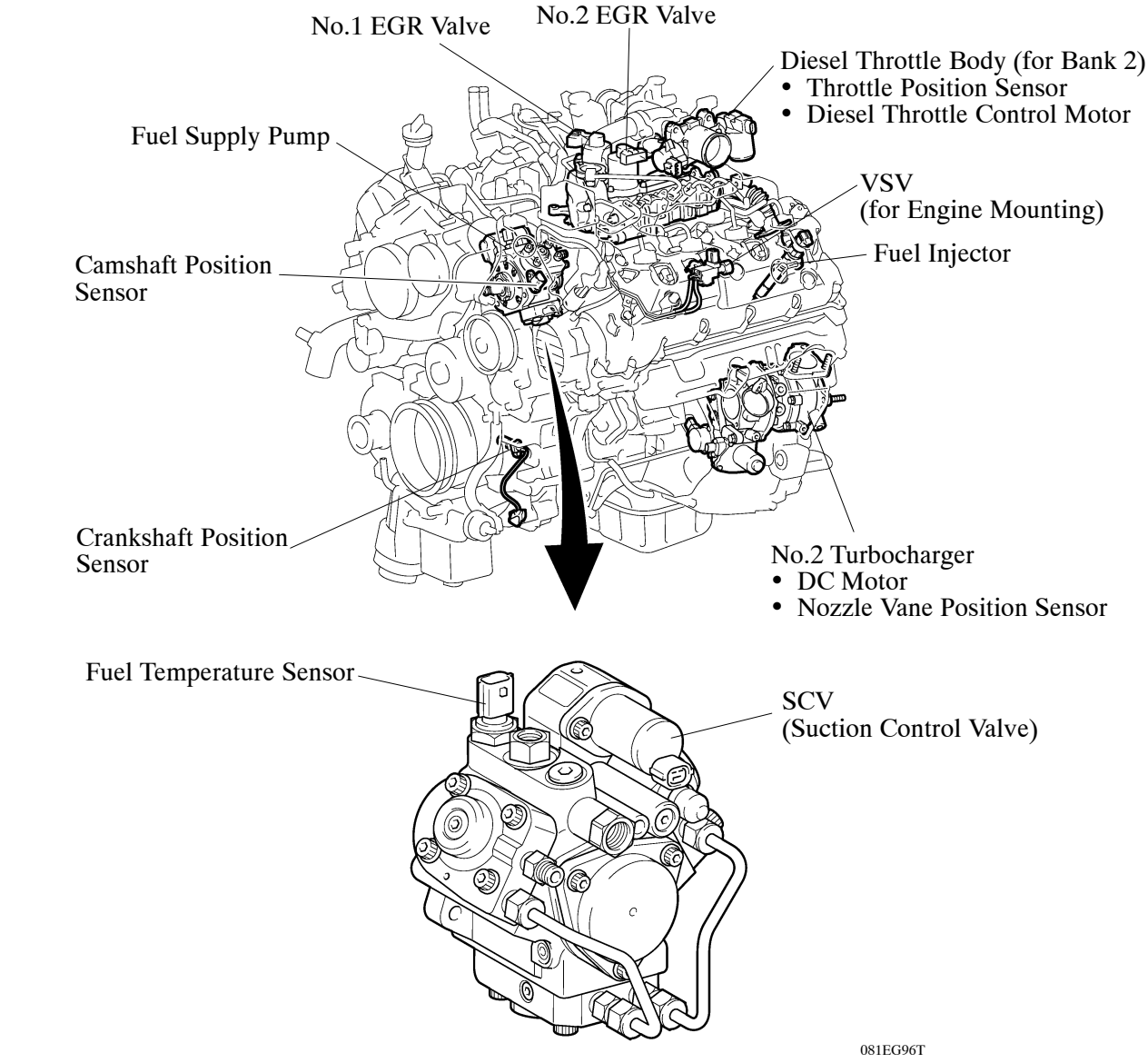


LHD Models with Dual Fuel Tank

081EG74T

EG


Glow Plug
Diesel Throttle Body (for Bank 1)
• Throttle Position Sensor
• Diesel Throttle Control Motor
Engine Coolant Temperature Sensor
Common-Rail RH
• Fuel Pressure Sensor
Fuel Injector
No.1 Turbocharger
• DC Motor
• Nozzle Vane Position Sensor
081EG95T


No.1 EGR Valve
No.2 EGR Valve
Diesel Throttle Body (for Bank 2)
• Throttle Position Sensor
• Diesel Throttle Control Motor
Fuel Supply Pump
VSV
(for Engine Mounting)
Camshaft Position Sensor
Fuel Injector
Crankshaft Position Sensor
No.2 Turbocharger
• DC Motor
• Nozzle Vane Position Sensor
Fuel Temperature Sensor
SCV
(Suction Control Valve)
081EG96T

5. Main Components of Engine Control System

General

The main components of the 1VD-FTV engine control system are as follows:

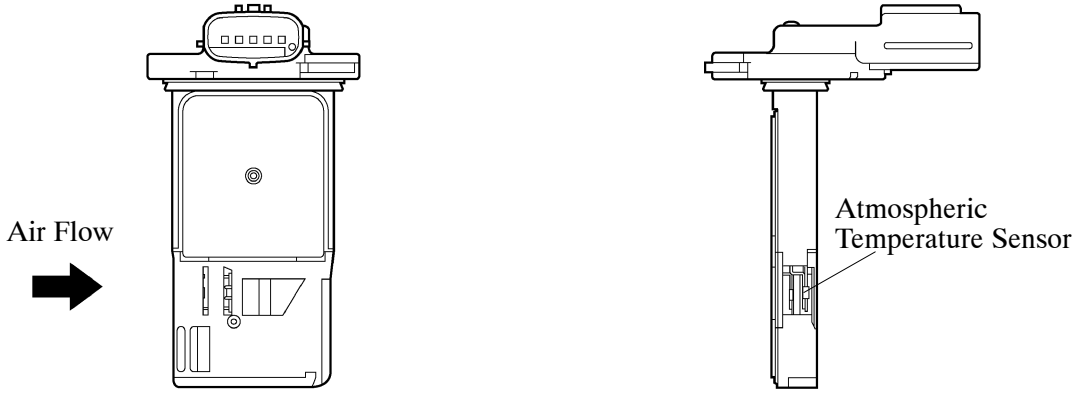
Components	Outline	Quantity	Function
ECM	32-bit CPU (DENSO)	1	The ECM effects overall control of the engine control system to suit the operating conditions of the engine in accordance with the signals provided by the sensors.
Injector Driver	DC/DC Converter	2	The injector driver is used to drive the fuel injector at high speeds. The injector driver has realized high-speed driving under high fuel pressure conditions through the use of a DC/DC converter that provides a high voltage, quick-charging system.
Mass Air Flow Meter [See page EG-188]	Hot-wire Type	1	This sensor uses a built-in hot-wire to directly detect the intake air mass and flow rate.
Atmospheric Temperature Sensor	Thermistor Type	1	This sensor detects the atmospheric temperature by means of an internal thermistor.
Fuel Pressure Sensor [See page EG-189]	Semiconductor Strain Gauge Type	1	This sensor uses built-in semiconductors to detect the internal pressure of the common-rail.
Manifold Absolute Pressure Sensor [See page EG-189]	Semiconductor Silicon Chip Type	1	This sensor uses built-in semiconductors to detect the intake manifold pressure.
Atmospheric Pressure Sensor	Semiconductor Silicon Chip Type	1	This sensor, which is built into the ECM, uses semiconductors to detect the atmospheric pressure.
Crankshaft Position Sensor [See page EG-190]	Pick-up Coil Type (Rotor Teeth /36-2)	1	This sensor detects the engine speed and performs the cylinder identification.
Camshaft Position Sensor [See page EG-190]	Pick-up Coil Type (Rotor Teeth /1)	1	This sensor performs the cylinder identification.
Throttle Position Sensor [See page EG-191]	Non-contact Type	2	This sensor detects the throttle valve opening angle.
Accelerator Pedal Position Sensor	No-contact Type	1	• This sensor detects the amount of pedal effort applied to the accelerator pedal. • The basic construction and operation of this sensor are the same as in the 1GR-FE engine. For details, see page EG-54.
Engine Coolant Temperature Sensor	Thermistor Type	1	This sensor detects the engine coolant temperature by means of an internal thermistor.
Intake Air Temperature Sensor	Thermistor Type	1	This sensor detects the intake air temperature after the intercooler.

(Continued)

Components	Outline	Quantity	Function
Fuel Temperature Sensor	Thermistor Type	1	This sensor detects the fuel temperature in the supply pump by means of an internal thermistor.
SCV (Suction Control Valve)	Linear Solenoid Valve	1	The SCV position is controlled by the signals from the ECM, and a fuel volume that suits the SCV position is drawn into the pumping portion (plunger portion).
Fuel Injector [See page EG-165]	9-hole Type	8	The fuel injector contains a solenoid valve that opens and closes to increase or decrease the pressure in the control chamber. This causes the nozzle needle to open and close the valve, which results in fuel injection.

Mass Air Flow Meter

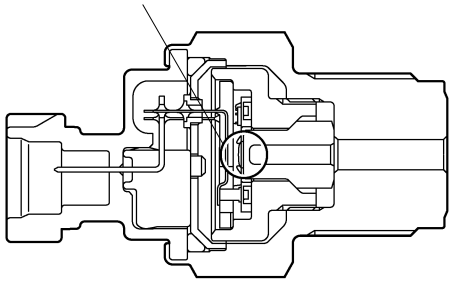
- The mass air flow meter of diesel engine uses precise fuel injection volume control and EGR control to realize clean emission.
- This mass air flow meter, which is a slot-in type, allows a portion of the intake air to flow through the detection area. By directly measuring the mass and the flow rate of the intake air, the detection precision is improved and the intake air resistance is reduced.
- The mass air flow meter has a built-in atmospheric temperature sensor.



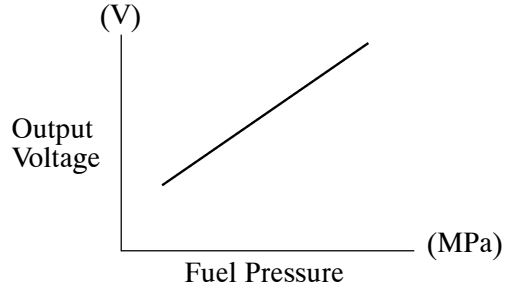
273GX15

Fuel Pressure Sensor

The fuel pressure sensor consists of a semiconductor which utilizes the characteristic of a silicon chip that changes its electrical resistance when pressure is applied to it. This sensor is mounted on the common-rail, outputs a signal that represents the fuel pressure in the common-rail to the ECM, in order to constantly regulate the fuel at an optimal pressure.



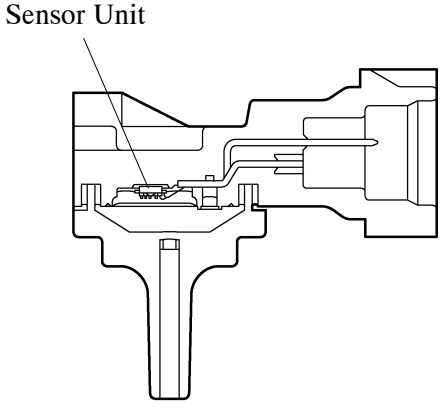
▶ Output Characteristic ◀



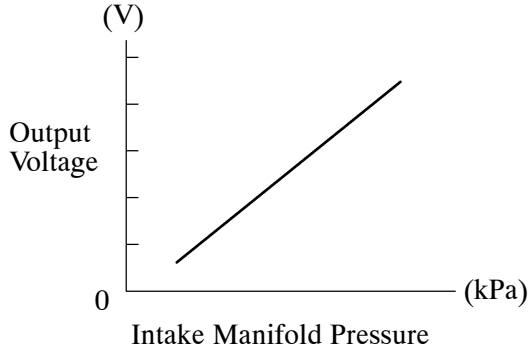
058EG64Y

Manifold Absolute Pressure Sensor

The manifold absolute pressure sensor consists of a semiconductor which utilizes the characteristic of a silicon chip that changes its electrical resistance when pressure is applied to it. The sensor converts the intake air pressure into an electrical signal, and sends it to the ECM in an amplified form.



▶ Output Characteristic ◀

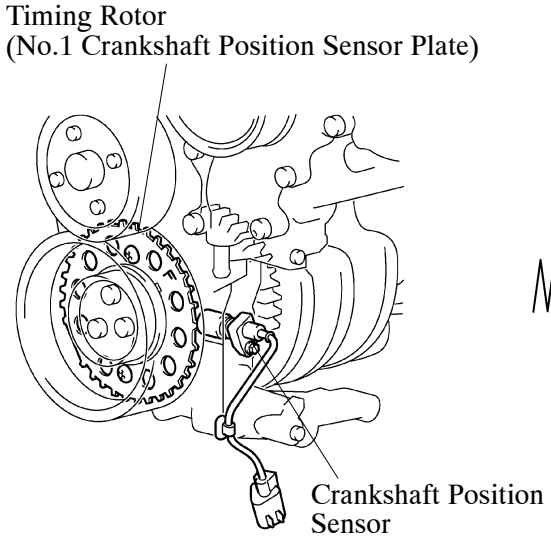


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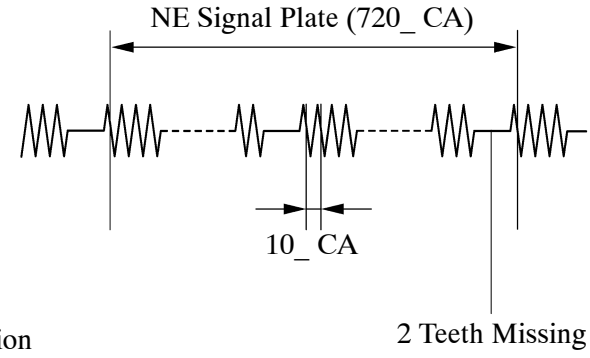
EG

Crankshaft Position Sensor

The timing rotor of the crankshaft consists of 34 teeth, with 2 teeth missing. The crankshaft position sensor outputs the crankshaft rotation signals every 10_, and the missing teeth are used to determine the top-dead-center.



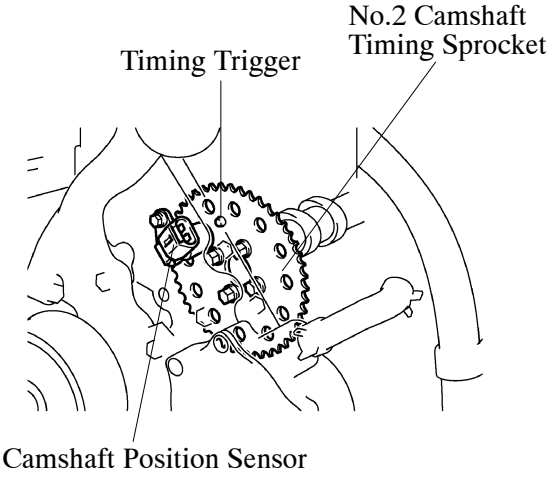
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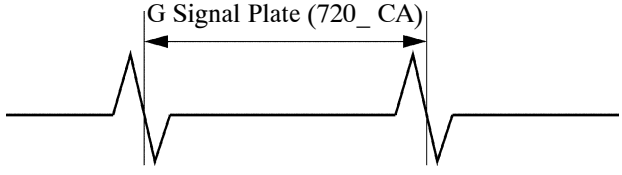
240EG90

Camshaft Position Sensor

The camshaft position sensor generates one signal in every two revolutions of the crankshaft by using the timing trigger of the No.2 camshaft timing sprocket.



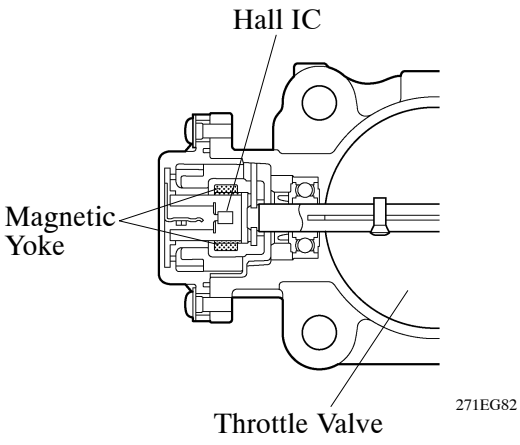
058EG57Y



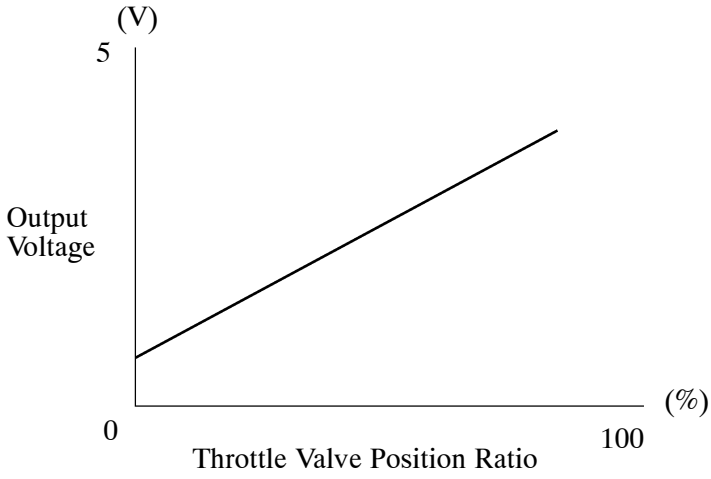
288EG95C

Throttle Position Sensor

The throttle position sensor is mounted on the diesel throttle body, to detect the opening angle of the throttle valve. The throttle position sensor converts the magnetic flux density that changes when the magnetic yoke (located on the same axis as that of the throttle valve shaft) rotates around the Hall IC into electric signals to operate the diesel throttle control motor.



▶ Output Characteristic ◀

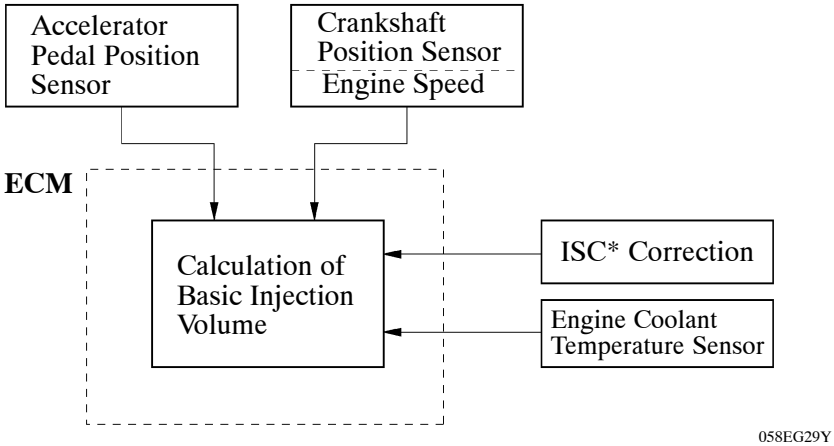


EG

6. Fuel Injection Volume Control

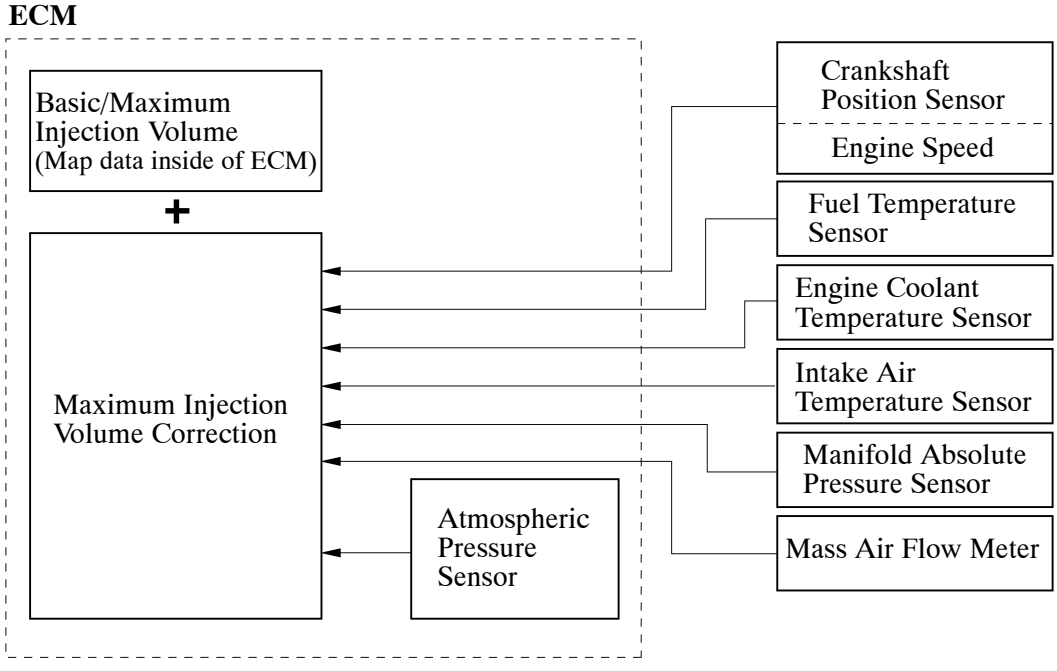
The ECM calculates two types of values: the basic injection volume and the maximum injection volume. Then, the ECM compares the basic and maximum injection volumes, and determines a smaller calculated value to be the final injection volume.

▶ Basic Injection Volume ◀

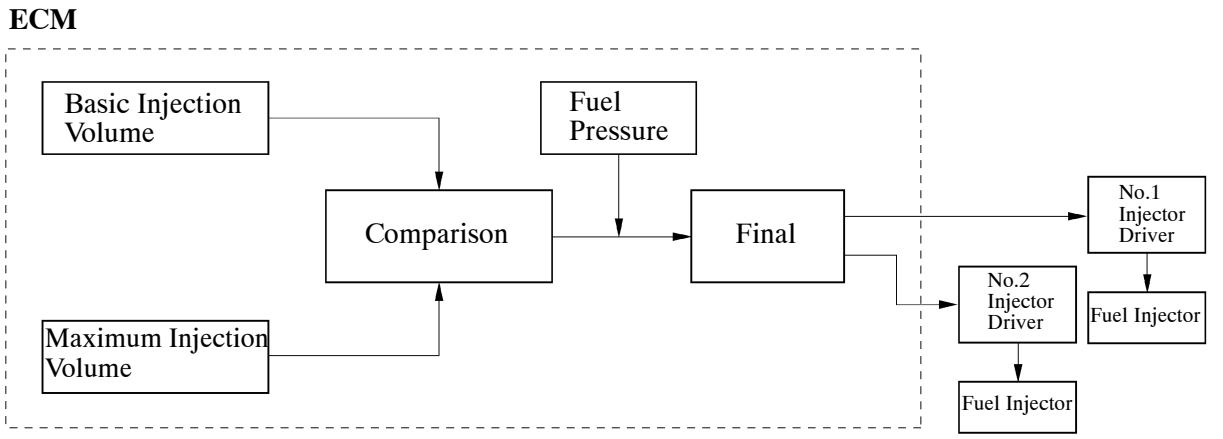


*: Idle Speed Control

▶ Maximum Injection Volume ◀



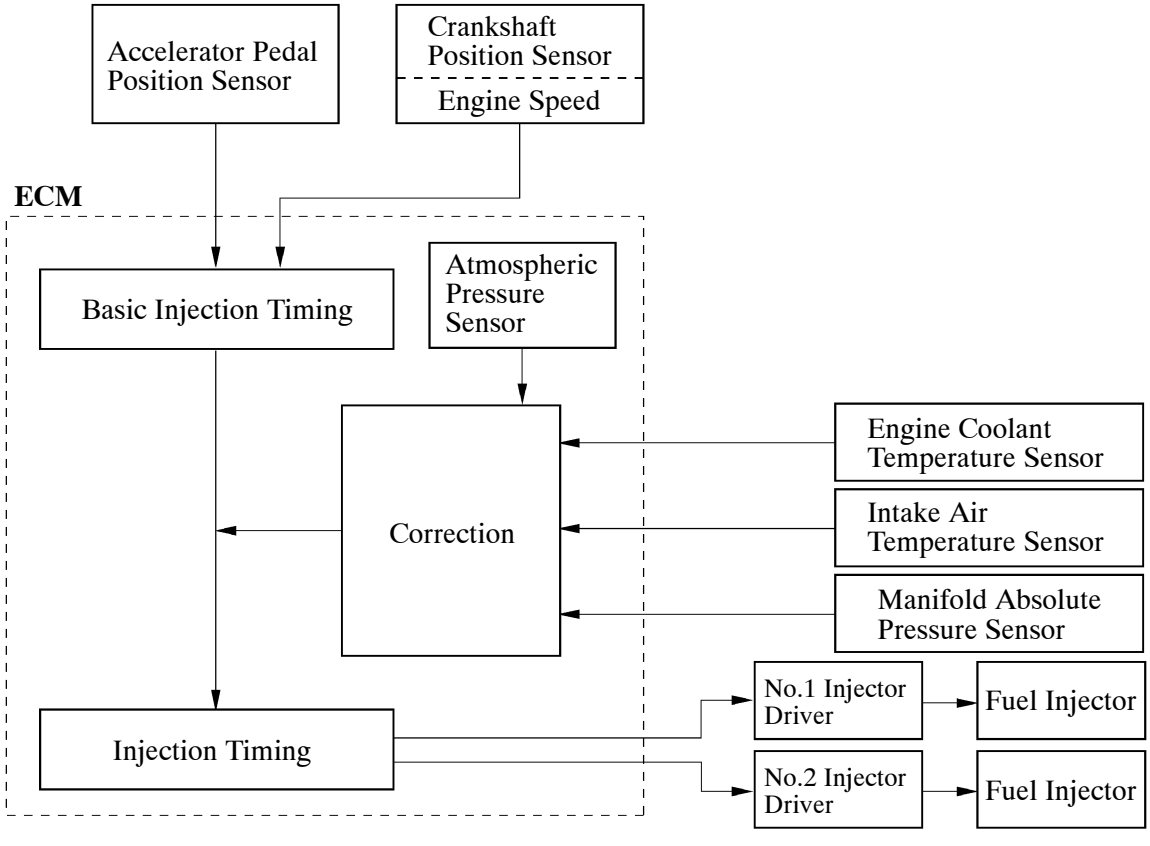
▶ Final Injection Volume Decision ◀



058EG31Y

7. Fuel Injection Timing Control

Fuel injection timing is controlled as shown below.



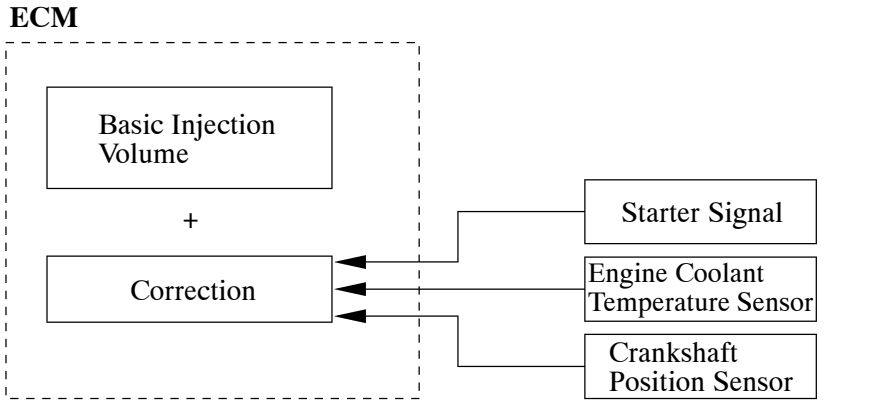
058EG32Y

EG

8. During Starting Control

Injection Volume Control

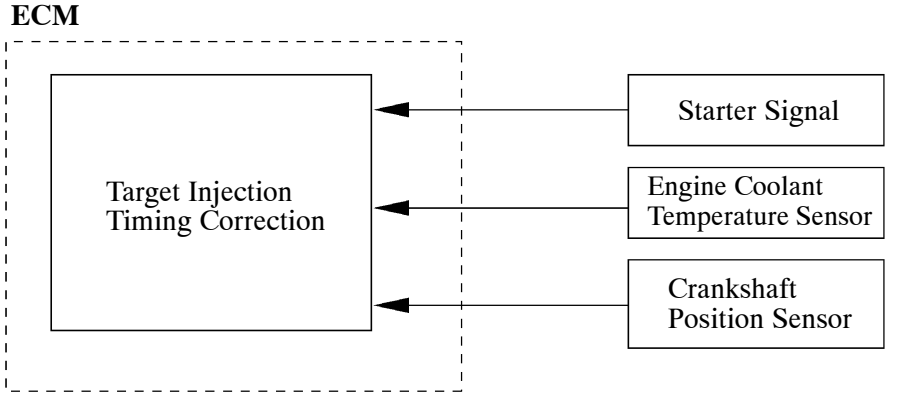
The starting injection volume is determined by adjusting the basic injection volume in accordance with the starter ON signals (ON time), engine coolant temperature sensor signals and engine speed signal. When the engine is cold, the engine coolant temperature will be lower and the injection volume will be greater.



224EG50

Injection Timing Control

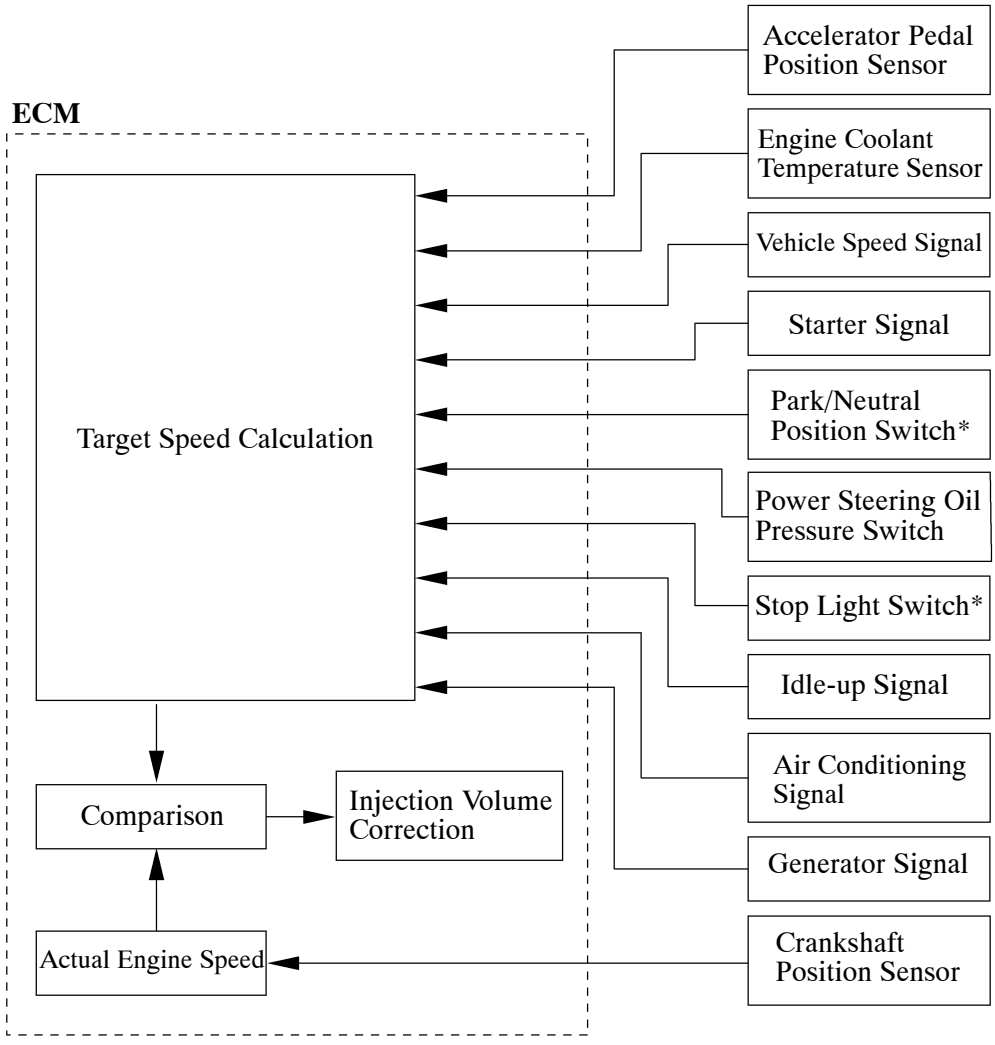
To determine the starting injection timing, the target injection timing is corrected in accordance with the starter signals, engine coolant temperature, and engine speed. When the engine coolant temperature is low, if the engine speed is high, the injection timing is advanced.



224EG51

9. Idle Speed Control

Fuel injection volume is controlled as shown below.



081EG106Y

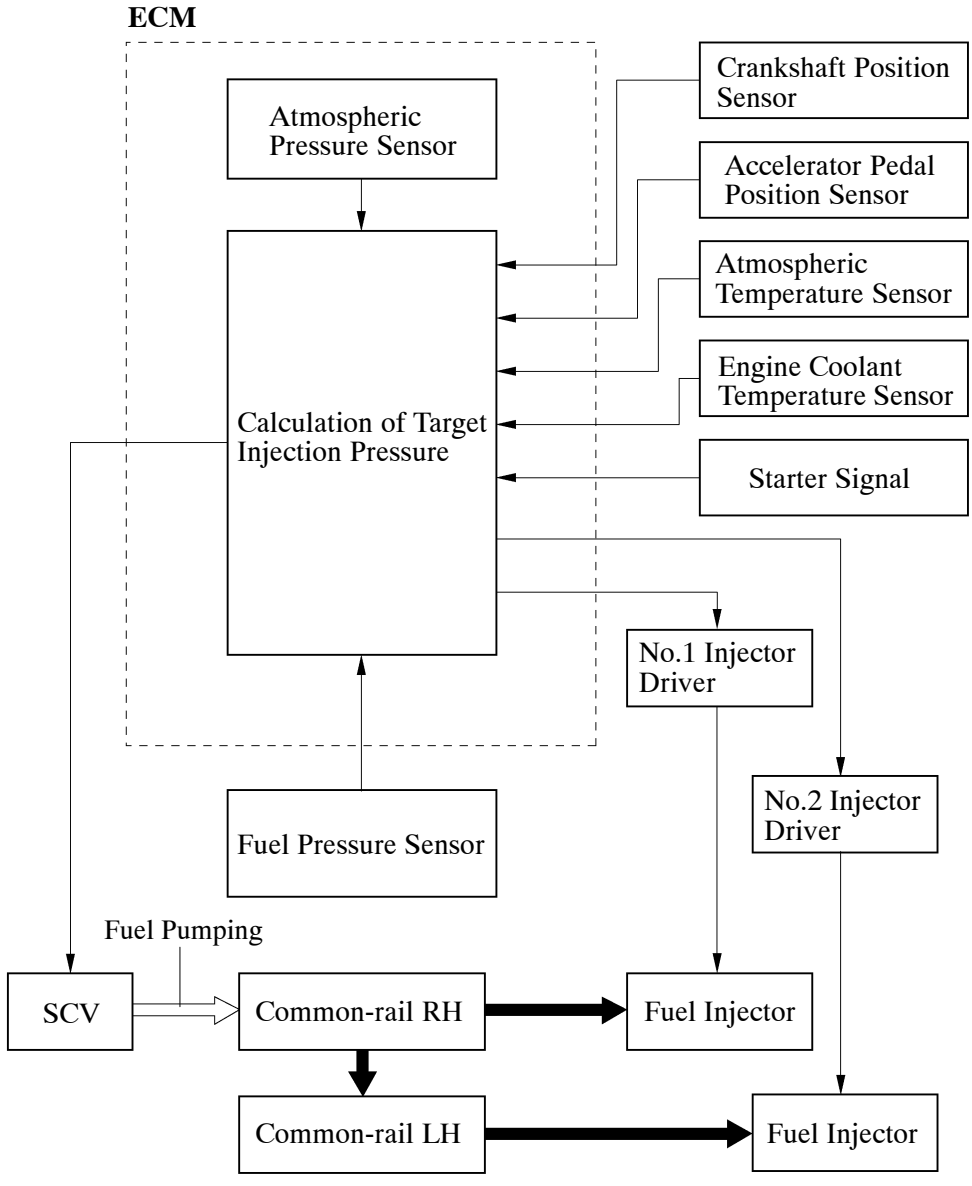
*: Models with Automatic Transmission

10. Fuel Pressure Control

General

The ECM calculates the target injection pressure (25 - 175 MPa*1, 25-129MPa*2) based on the engine conditions, that are the signals from the accelerator pedal position sensor and the crankshaft position sensor. To control fuel pressure, signals sent to SCV (Suction Control Valve) of the fuel supply pump regulate the pumping volume, so that the pressure detected by the fuel pressure sensor matches the target injection pressure.

*1: Models complying with EURO IV
*2: Models not complying with EURO IV



081EG107Y

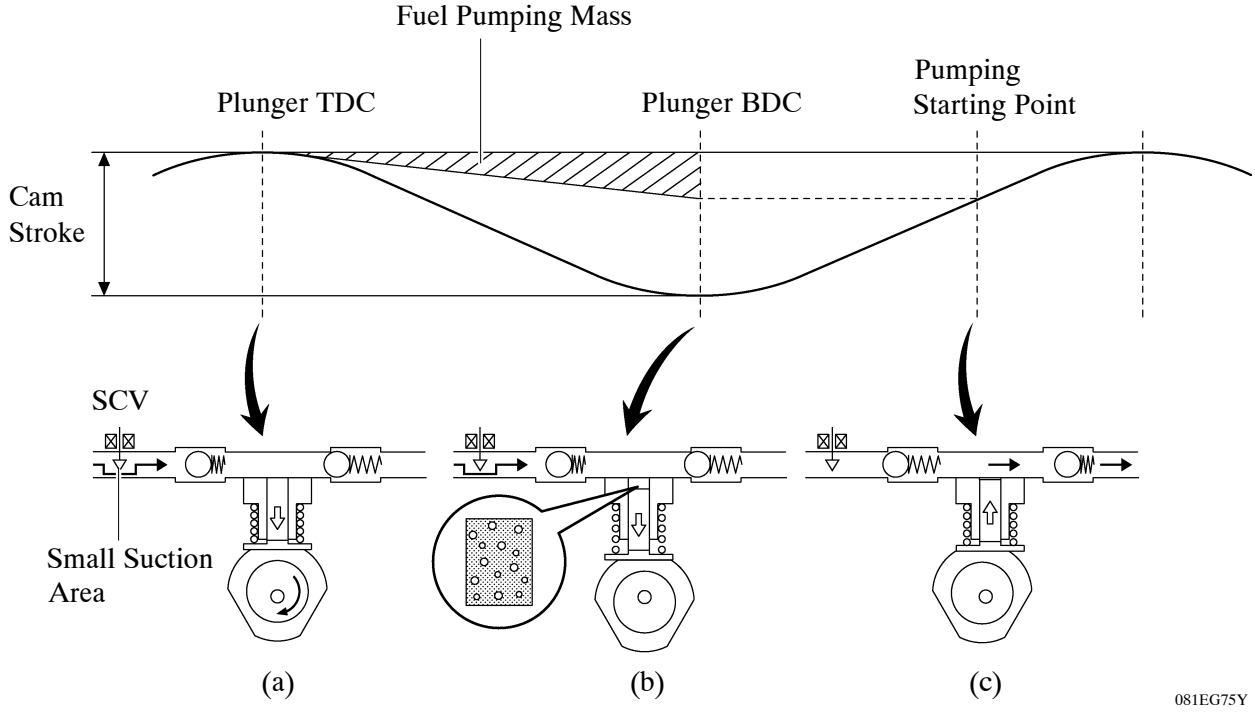
System Operation

1) General

The ECM controls the opening of the SCV (Suction Control Valve) in order to regulate the volume of fuel that is pumped by the fuel supply pump to the common-rail. Consequently, the fuel pressure in the common-rail is controlled to the target injection pressure.

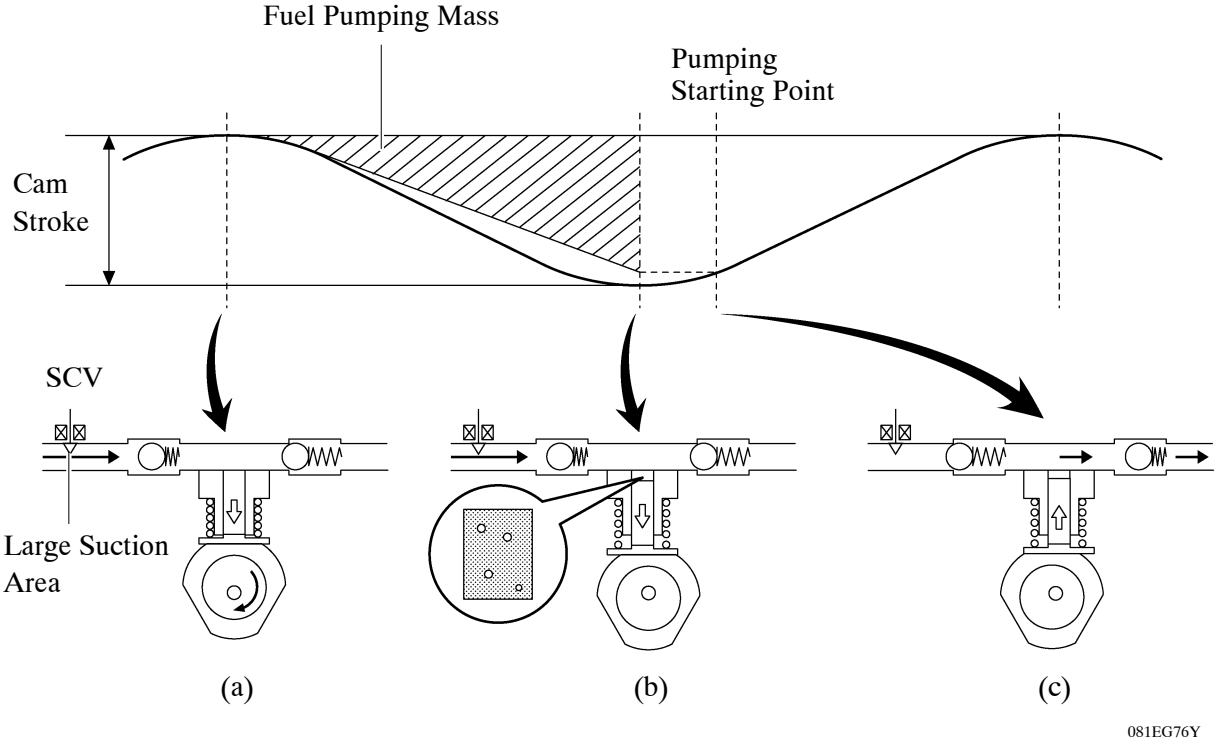
2) SCV Opening Small

(a) When the opening of the SCV is small, the fuel suction area is kept small, which decrease the transferable fuel quantity.
(b) The plunger strokes fully, however, the suction volume becomes small due to the small suction area. Therefore, the difference of the volume between the geometry volume and the suction volume is in vacuum condition.
(c) Pumping will start at the time when the fuel pressure has become higher than the common-rail pressure.



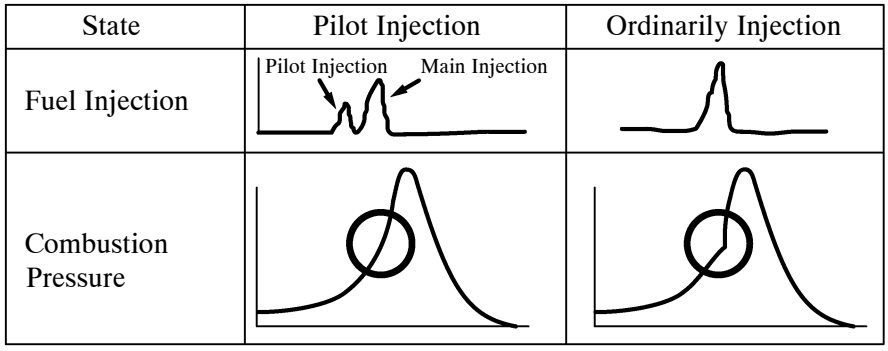
3) SCV Opening Large

(a) When the opening of the SCV is large, the fuel suction area is kept large, which increase the transferable fuel quantity.
(b) If the plunger strokes fully, the suction volume will increase because the suction area is large.
(c) Pumping will start at the time when the fuel pressure has become higher than the common-rail pressure.

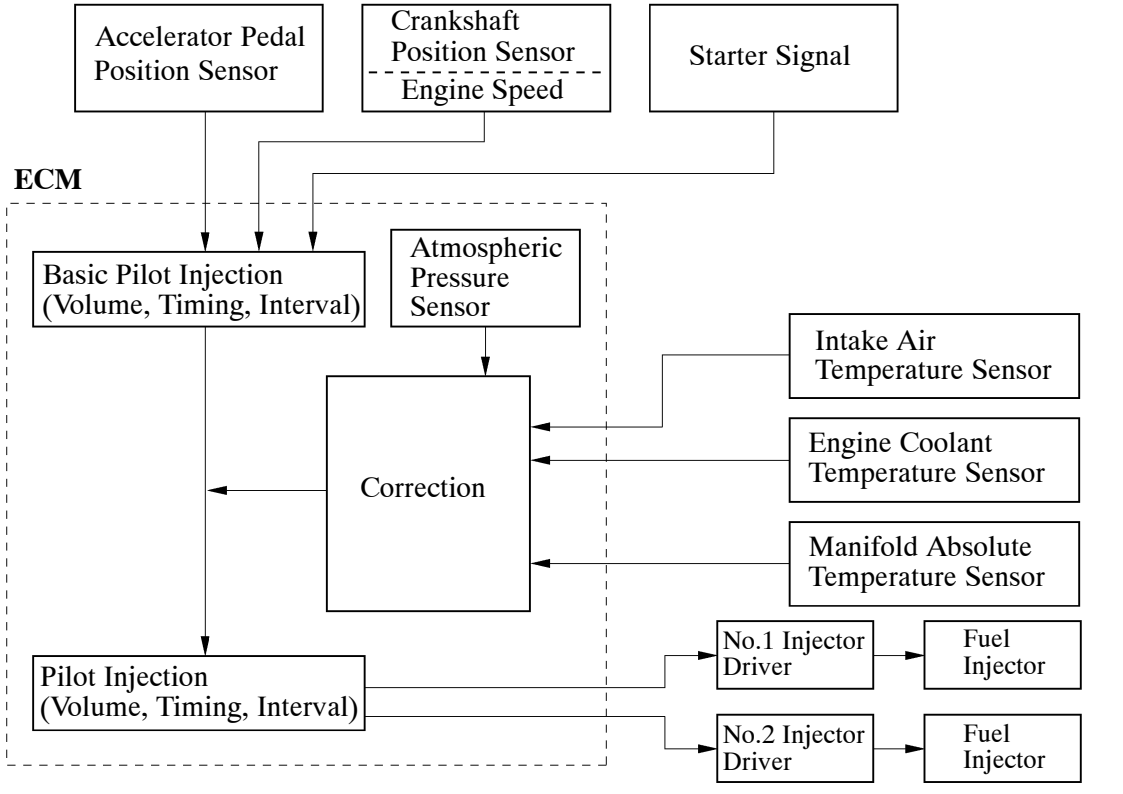


11. Pilot Injection Control

- Pilot injection is a method that provides auxiliary fuel injection before the main injection takes place. The purpose of pilot injection is to gently start the combustion of the fuel of the main injection in order to reduce combustion noise.



- During pilot injection, the pilot injection volume, timing, and interval (between pilot injection and main injection) are controlled as shown below.

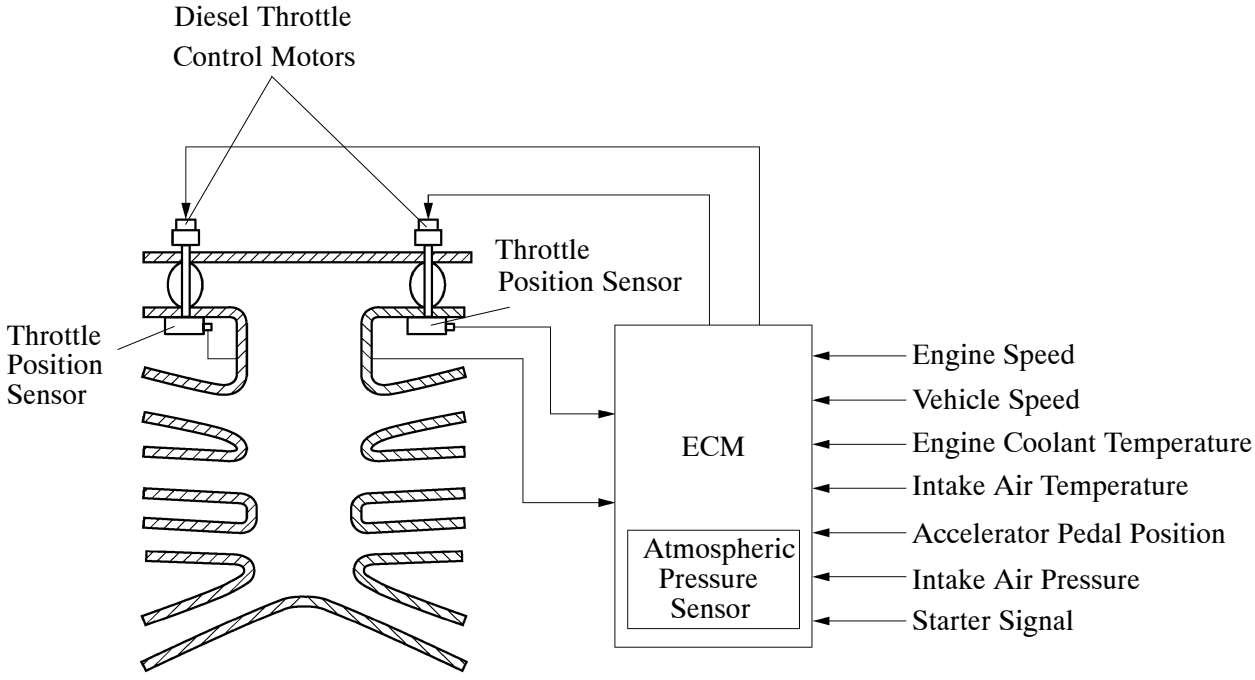


EG

12. Throttle Control

The opening of the throttle valve is controlled by the ECM in accordance with engine conditions.
As a result, the noise that is generated during idling and deceleration, as well as the noise and vibration that are generated when the engine is stopped, have been reduced.

▶ System Diagram ◀



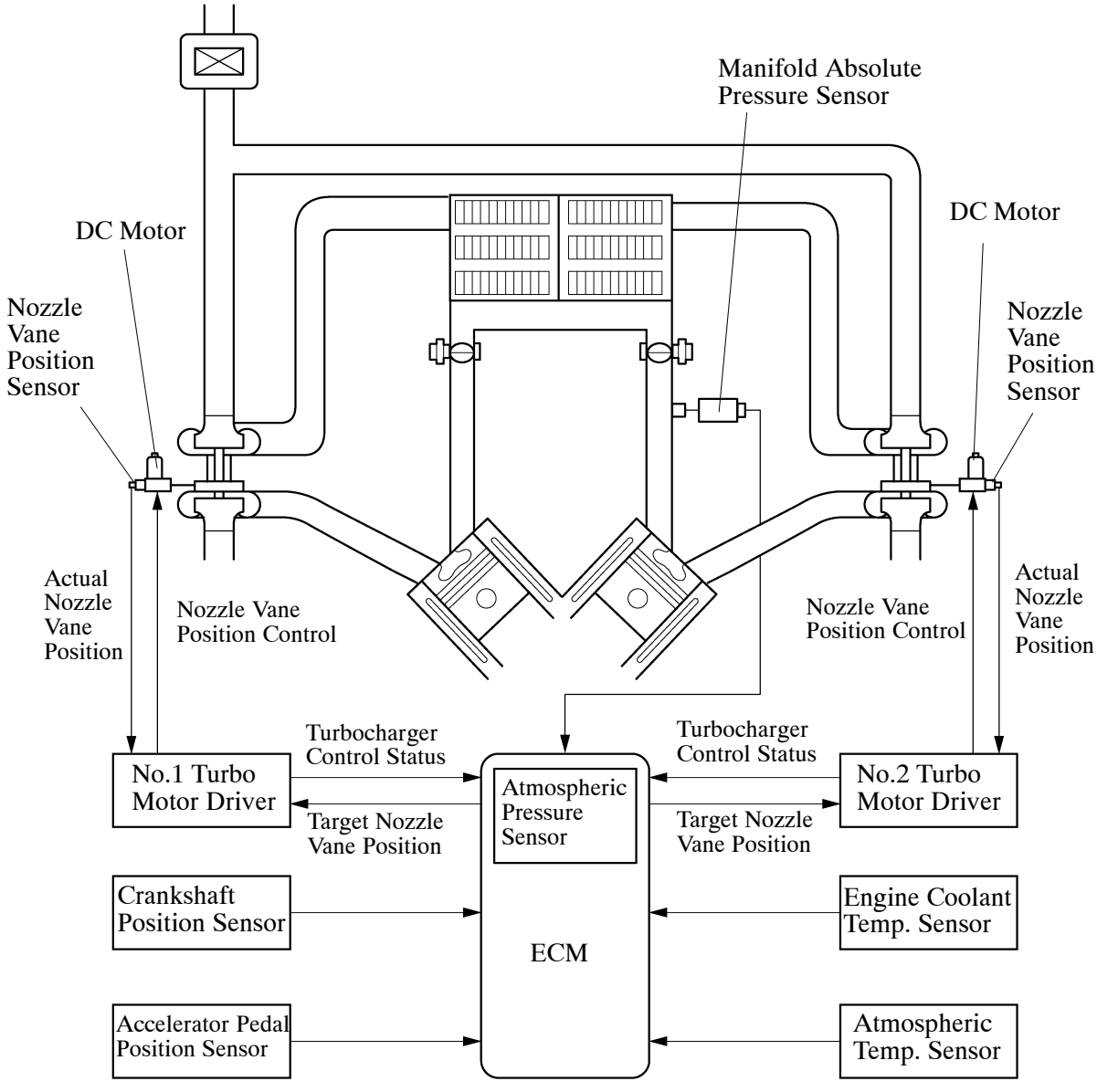
081EG77Y

13. Turbo Charger Control

General

- The ECM controls nozzle vane positions in the turbochargers on each bank via the turbo motor drivers in order to obtain the calculated target turbo pressure appropriate to the engine operation conditions.
- The ECM calculates the optimal nozzle vane position in accordance with the driving conditions (such as engine speed, injection volume, atmospheric pressure and engine coolant temperature), and sends a target nozzle vane position signal to each turbo motor driver. The turbo motor driver controls the nozzle vane position in accordance with this signal and the actual nozzle vane position signal provided by the nozzle vane position sensor.

▶ System Diagram ◀

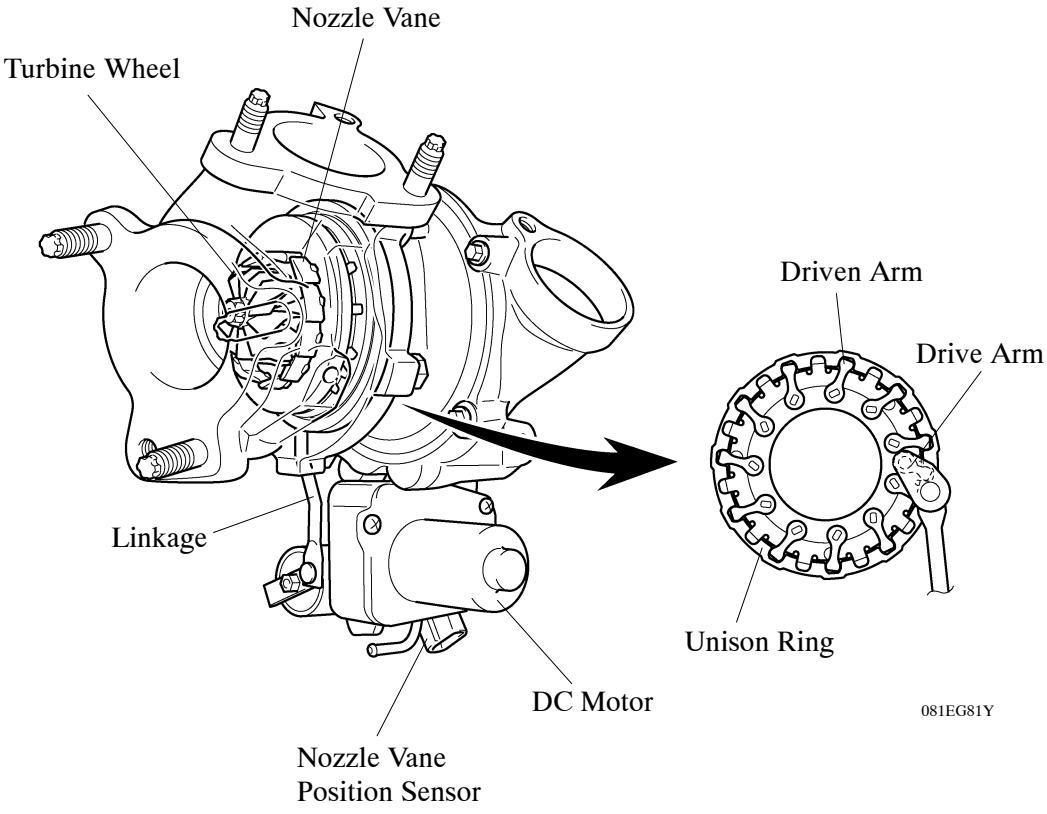


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Construction

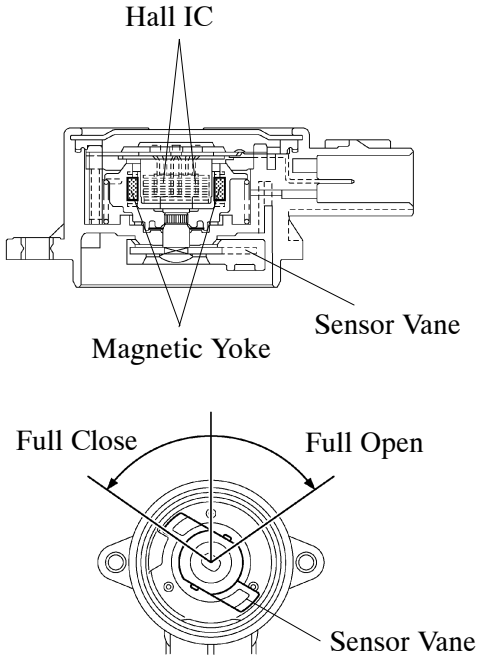
1) General

Variable nozzle vane device is established on the turbine wheel (exhaust) side, and consisted of a DC motor, nozzle vane position sensor, linkage, drive arm, unison ring, driven arms and nozzle vanes.

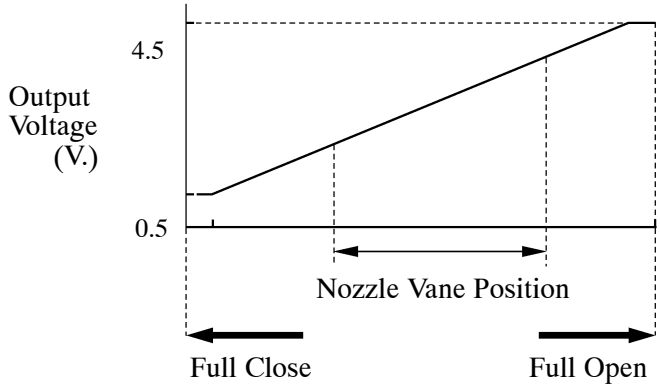


2) Nozzle Vane Position Sensor

The nozzle vane position sensor consists of a Hall IC and a magnetic yoke that rotates in unison with the movement of the linkage that actuates the nozzle vane. The nozzle vane position sensor converts the changes in the magnetic flux that are caused by the rotation of the DC motor (hence, the rotation of the magnetic yoke) into electric signals, and outputs them to the turbo motor driver. The turbo motor driver determines the actual nozzle vane position from the electric signals in order to calculate the target nozzle vane position.

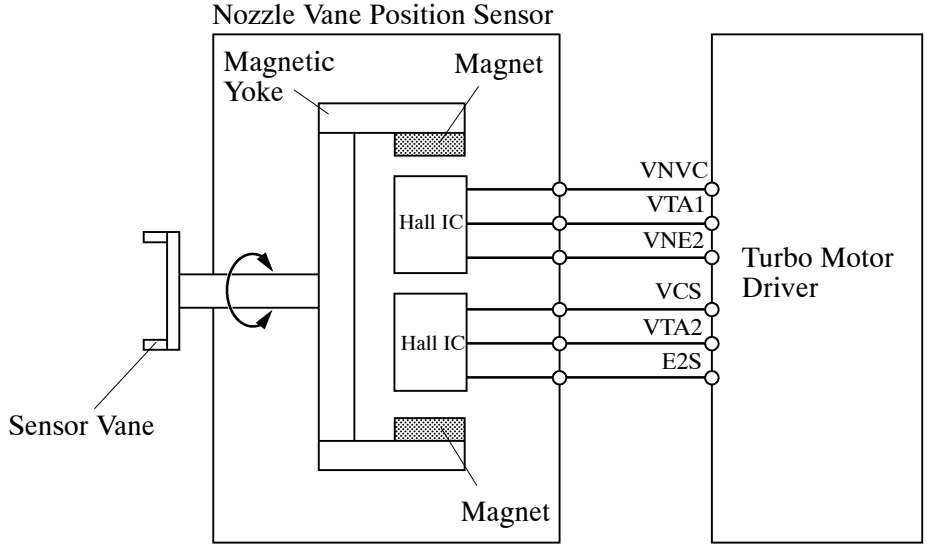


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271EG148

▶ System Diagram ◀

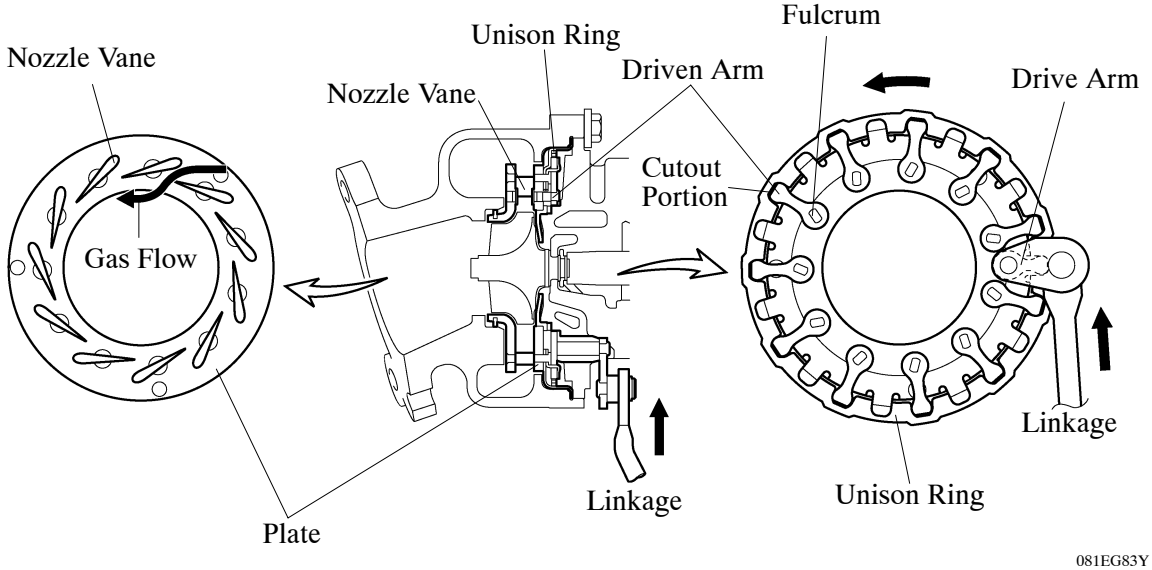


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Operation

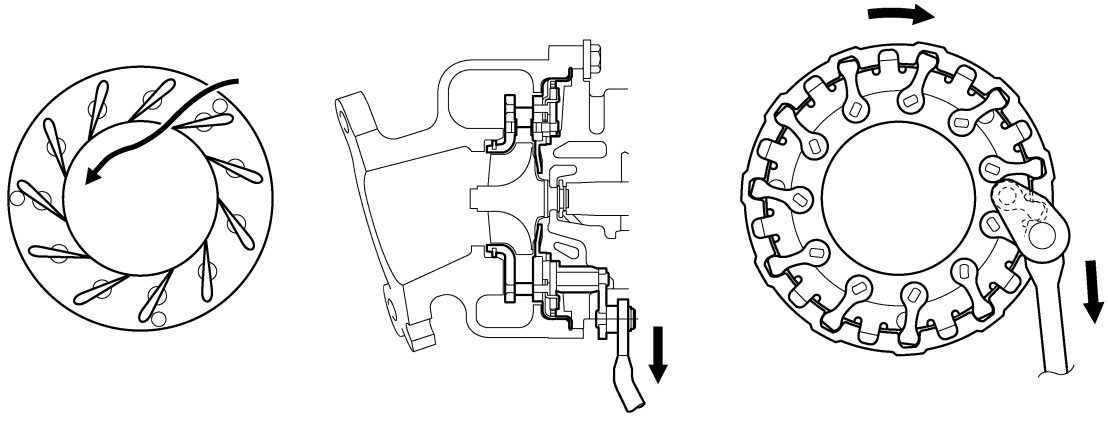
1) At Engine Low Speed Range

When the engine is running in a low speed range, the DC motor pulls up the linkage by a signal from the turbo motor driver. The tip of the linkage rotates the unison ring counterclockwise through a drive arm. The unison ring contains a driven arm, which is placed through the cutout portion of the unison ring. This driven arm also moves in the direction of the rotation of the unison ring. The fulcrum of the driven arm is an axis that is integrated with the nozzle vane behind the plate. When the driven arm moves counterclockwise, the nozzle vane moves toward the closing direction. This results in increasing the velocity of the exhaust gas flowing to the turbine, as well as the speed of the turbine. As a result, torque is improved when the engine is running at low speeds.



2) At Engine Medium-to-High Speed Range

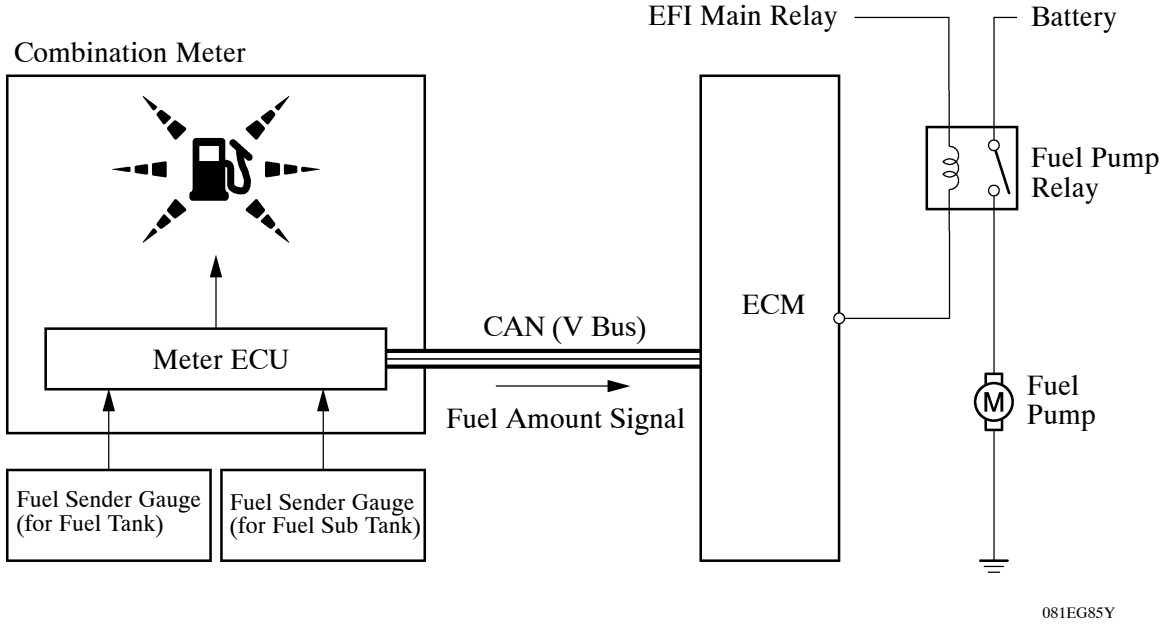
When the engine is running in a medium-to-high speed range, the DC motor presses down the linkage by a signal from the turbo motor driver. With this, the driven arm moves clockwise and this opens the nozzle vane and holds the specified supercharging pressure. Thus, lowering the back pressure and improving the output and fuel consumption.



14. Fuel Pump Control

- The ECM operates the fuel pump in accordance with signals from the meter ECU, which indicate the fuel amount in the fuel tanks (calculated by signals from fuel sender gauges in each fuel tank), to transfer fuel from the sub fuel tank to the main fuel tank using the jet pump for fuel transfer.
- The meter ECU determines if the fuel pump control system is malfunctioning based on the fuel amount in the main fuel tank and sub fuel tank. When the meter ECU detects that the fuel amount in the main fuel tank is small (20.7 liters [21.9 US qts, 18.2 Imp. qts] or less) and the amount in the sub fuel tank is large (7.8 liters [8.2 US qts, 6.9 Imp. qts] or more), it determines that fuel has not been transferred from the sub fuel tank to the main fuel tank. The meter ECU then blinks the low fuel warning light in the combination meter to inform the driver of the fuel pump control system malfunction. In addition, the master warning light comes on, the buzzer sounds and the warning message (Check Fuel System) is displayed on the multi-information display on models with optitron display type combination meter.

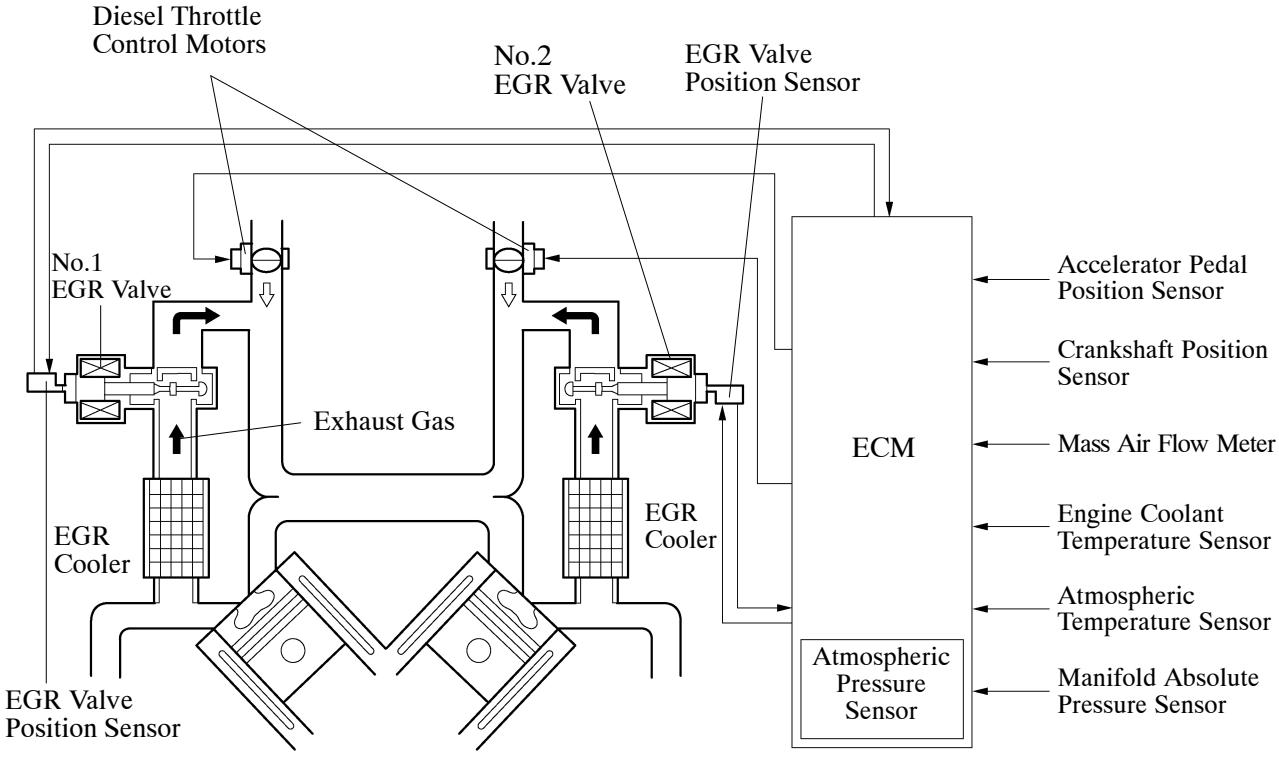
▶ System Diagram ◀



15. EGR Control

- This system is designed to reduce and control NOx formation due to a slight reduction of peak temperature in the engine combustion chamber, which is accomplished by introducing a small amount of inert gas into intake manifold.
- By sensing the engine driving conditions and actual amount of the EGR valve opening, the ECM operates the EGR valve and diesel throttle control motor, and regulates the amount of exhaust gas.

▶ System Diagram ◀

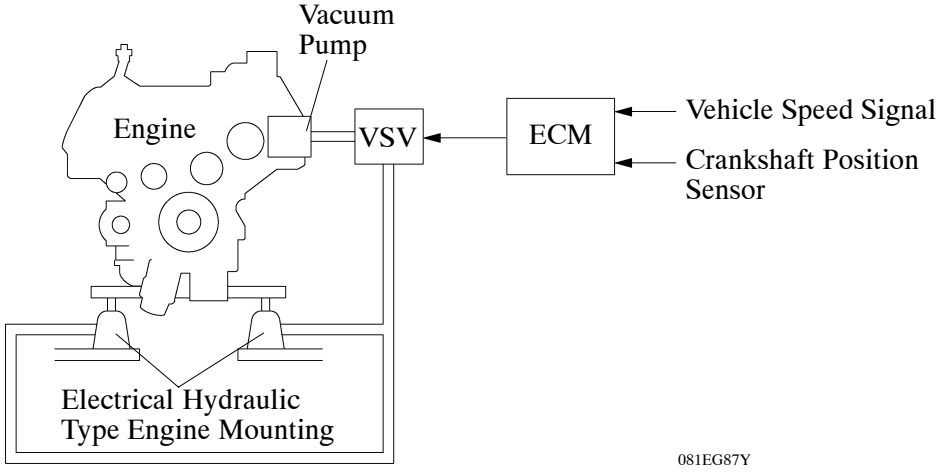


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16. Engine Mounting Control

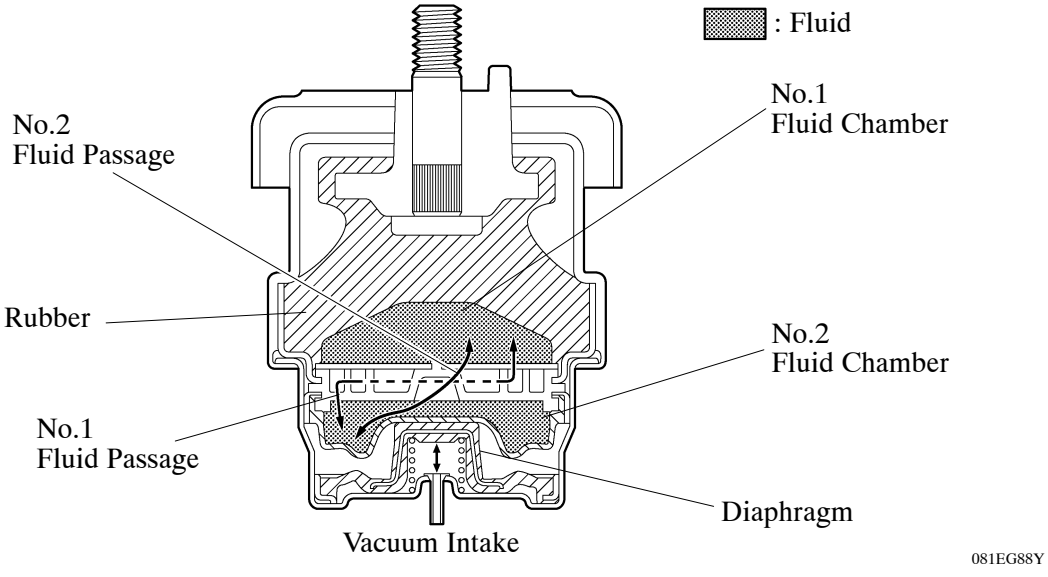
General

When the engine speed and the vehicle speed are low, this engine mounting utilizes the vacuum from the vacuum pump to move the diaphragm inside the mount, which switches the passage for the fluid sealed in the fluid chambers. By softening the damping characteristics of the mounting in this manner, the mounting restrains the engine vibration.



Construction

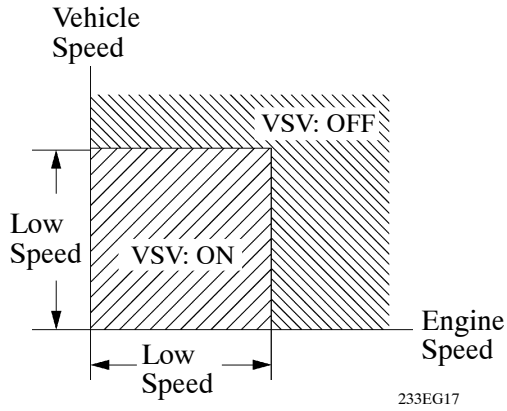
- This engine mounting consists primarily of the rubber portion, No.1 fluid chamber, No.2 fluid chamber, and diaphragm. Fluid is sealed in the No.1 and No.2 fluid chambers.
- This engine mounting obtains a vacuum from the vacuum pump via the VSV. It utilizes the vacuum to pull the diaphragm down in order to open or close the passages that connect the No.1 and No.2 fluid chambers.
- The No.1 and No.2 fluid chambers use two fluid passages: the No.1 fluid passage that is always connected regardless of whether the diaphragm is open or closed; and the No.2 fluid passage that is connected only when the diaphragm is open. The fluid flows back and forth between the No.1 and No.2 fluid chambers through these two passages in order to restrain the vibration.



Operation

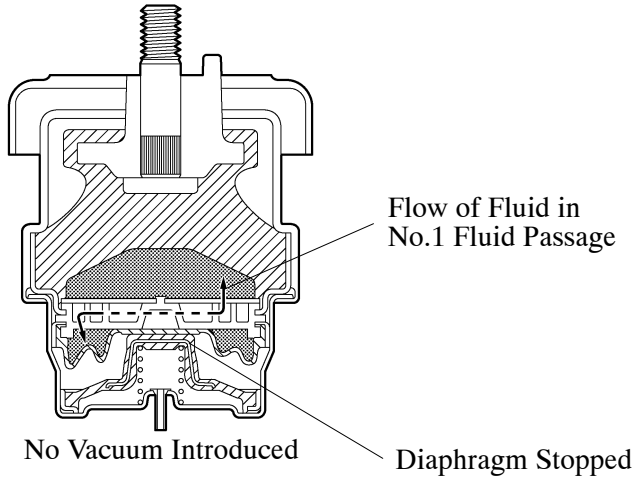
1) General

- When the ECM determines that the engine speed and the vehicle speed are low, it controls the introduction of vacuum from the vacuum pump to the engine mounting by turning the VSV ON or OFF.
- A hysteresis is provided for both the engine speed and the vehicle speed at the point in which the VSV switches from ON to OFF.
- While the engine is cranking, the VSV is OFF.



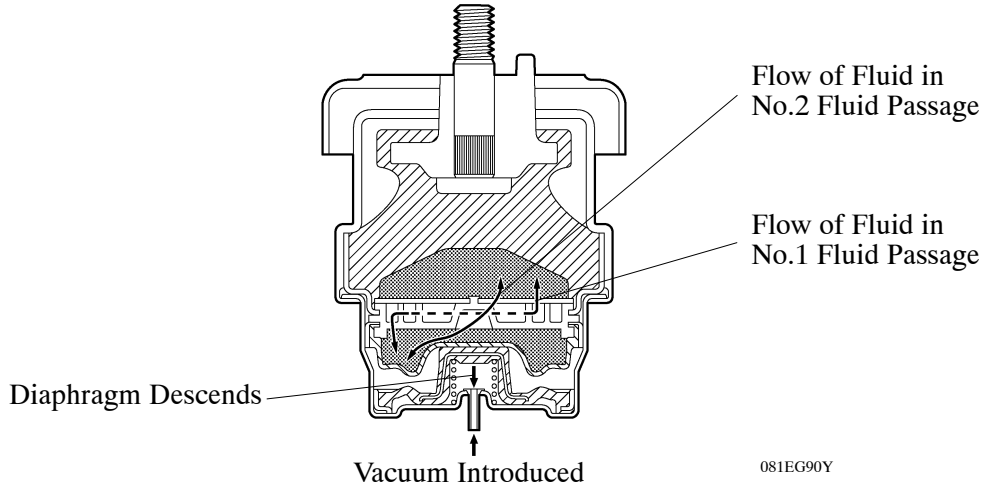
2) When the VSV is OFF

- When the ECM determines that the engine speed and vehicle speed exceed the specified value, it stops the introduction of vacuum into the engine mounting by turning the VSV OFF.
- When no vacuum is introduced into the engine mounting, the diaphragm does not move, so the No.1 fluid passage remains closed. In this state, the fluid passes only through the No.1 fluid passage in order to flow back and forth between the No.1 and No.2 fluid chambers.



3) When the VSV is ON

- When the ECM determines that the engine speed and the vehicle speed are equal to or less than the specified value, it turns the VSV ON to introduce vacuum into the engine mounting.
- When a vacuum is introduced into the engine mounting, it pulls the diaphragm down, causing the No.2 fluid passage to open. As a result, a large volume of fluid flows back and forth between the No.1 and No.2 fluid chambers, thus minimizing the fluid resistance and softening the engine mounting characteristics.

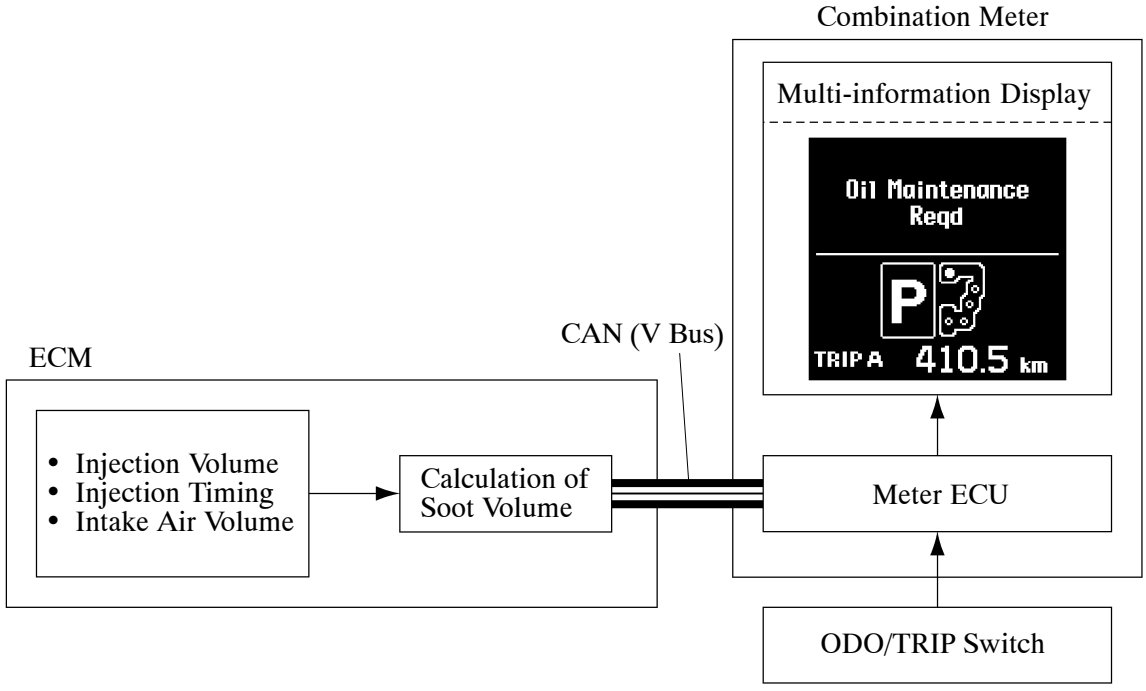


17. Oil Maintenance Management System

General

- In this oil maintenance management system, the soot volume in the engine oil is calculated based on the engine operating conditions. Based on the calculated soot volume, the ECM displays an "Oil Maintenance Reqd" warning on the multi-information display to inform the driver when it is necessary to change the engine oil.
- The ECM calculates soot volume from the injection volume, injection timing and intake air volume in order to operate this system.

▶ System Diagram ◀



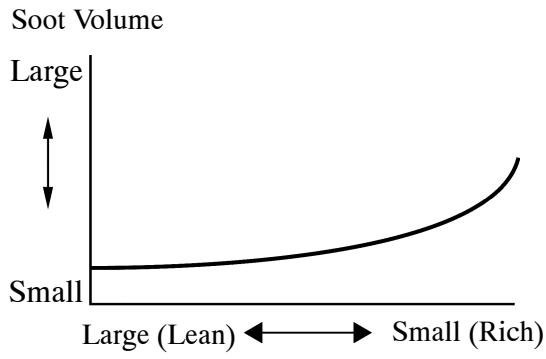
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Service Tip

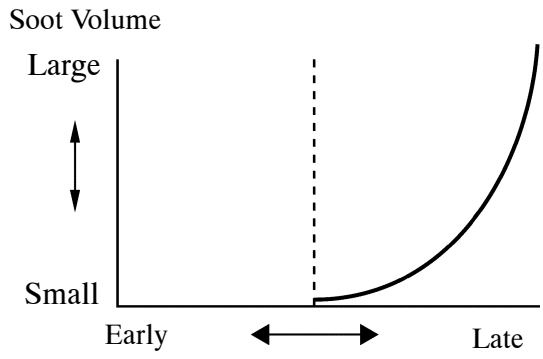
Since this system is controlled based on engine operating conditions, the "Oil Maintenance Reqd" warning may be displayed before driving 30,000 km (the maximum travel distance after oil maintenance). If the "Oil Maintenance Reqd" warning is displayed, immediately replace the oil and oil filter.

Soot Volume Calculation Method

The soot volume largely depends on injection ending timing and air-fuel ratio. The ECM calculates soot volume from this information as shown in the graphs below.



Calculation of Air-Fuel Ratio 288EG63C



Injection Ending Timing 288EG64C

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Service Tip

The accumulated soot volume memorized in ECM can be reset using the following procedures.

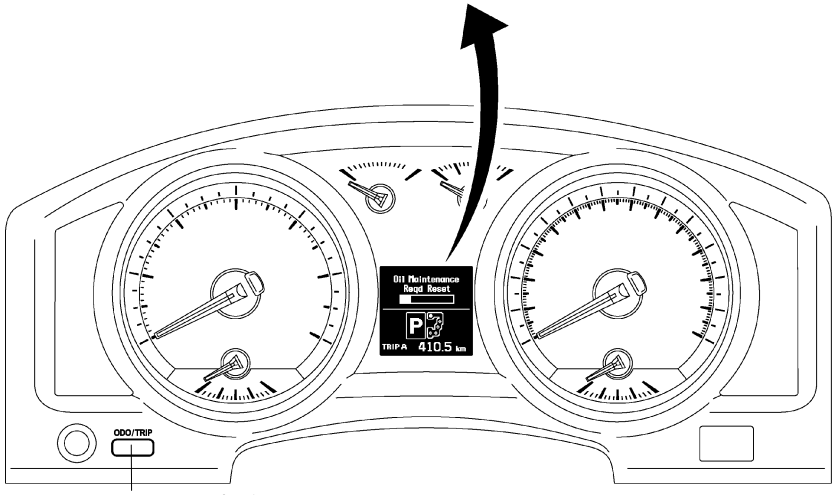
1) Switch the power source to IG-ON. Then, use the ODO/TRIP switch to turn ON the "TRIP A" display on the multi-information display.
2) Switch the power source to OFF. While pushing the ODO/TRIP switch, switch the power source to IG-ON.
3) With the power source in the IG-ON mode, keep holding the ODO/TRIP switch (for at least five seconds) with the multi-information display counting down as shown below.
4) When the resetting is completed, the multi-information display will display "COMPLETE" for one second and the buzzer built into the combination meter will sound.



5 seconds before | 4 seconds before | 3 seconds before



2 seconds before | 1 second before | Reset complete



ODO/TRIP Switch 081EG92H

18. Diagnosis

- When the ECM detects a malfunction, the ECM makes a diagnosis and memorizes the failed section. Furthermore, the check engine warning light in the combination meter illuminates or blinks to inform the driver.
- The ECM will also store the DTC (Diagnostic Trouble Code) of the malfunctions. The DTC can be accessed by using the intelligent tester II.
- For details, refer to the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

Service Tip

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

19. 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 were to continue 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 Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).