OUTLINE

Engine Description

- Newly developed V6 gasoline engines, the 3GR-FE (3.0L gasoline) and the 3GR-FSE (3.0L gasoline) are used. The 3UZ-FE (4.3L gasoline) engine continues to be used, and the 2JZ-GE (3.0L gasoline) engine has been discontinued.
- The 3GR-FE engine complies with the EURO-IV exhaust regulations in Europe by realizing high performance/high power output and low fuel consumption/low emissions through the use of the following features: linkless electronic throttle system, Dual VVT-i (Dual Variable Valve Timing-intelligent = continuously variable intake and exhaust valve timing mechanism) system, electronic ACIS (Acoustic Control Induction System), long dual exhaust system, etc.
- The 3GR-FSE uses the D-4 (Direct injection 4-stroke gasoline engine) system to achieve efficient combustion. In addition, this engine complies with the EURO-IV exhaust regulations in Europe by realizing high performance/high power output and low fuel consumption/low emissions through the use of the following features: linkless electronic throttle system, Dual VVT-i (Dual Variable Valve Timing-intelligent = continuously variable intake and exhaust valve timing mechanism) system, electronic ACIS (Acoustic Control Induction System), electronic SCV (Swirl Control Valve), long dual exhaust system, etc.
- The 3UZ-FE engine on the '05 model GS430 is the same as on the '04 model GS430.
- This engine produces ample torque in all speed ranges, particularly in the low- to medium-speed range, through the use of the VVT-i (Variable Valve Timing-intelligent) system and the ACIS (Acoustic Control Induction System).
- This engine complies with the EURO-IV exhaust regulations in Europe through optimal combustion achieved through the use of air-assist type fuel injectors, as well as through reduced exhaust emissions achieved with a compact exhaust manifold made of stainless steel, and an ultra thin-wall, high cell density ceramic catalyst.

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Main Features of 3GR-FE

3GR-FE Engine Features List

Item	High Performance/ Fuel Economy	Compact/ Lightweight	Cleaner Exhaust Gas	Low Noise/ Low Vibration	Reliability	Serviceability
Dual VVT-i(Dual Variable Valve Timing-intelligent)	❍		❍			
Roller Rocker Arm	❍					
Lash Adjuster	❍					❍
Slanted Squish Combustion Chamber	❍		❍			
Cast Aluminum Alloy Hypereutectic Type Piston	❍	❍			❍	
High Precision Aluminum Alloy Cylinder Block		❍		❍		
Spiny Surface Cylinder Liner	❍	❍				
Water Jacket Spacer	❍					
Aluminum Alloy Oil Pan		❍		❍		
Replaceable Element Oil Filter						❍
Auxiliary Equipment Bracket Integrated with Engine Block		❍		❍	❍	
Single High-Strength Timing Chain Drive		❍			❍	
Alternator Pulley with Clutch	❍				❍	
Electronic ACIS (Acoustic Control Induction System)	❍				❍	
Plastic Surge Tank	❍	❍				
Single-Valve Electronically Controlled Throttle System	❍	❍				
Full Fabric Air Filter Element		❍				
Compact Plug-In Type Hot-Wire Airflow Meter	❍	❍				
Exhaust Manifold Integrated Three-Way Catalyst			❍			
Stainless Steel Exhaust Manifold		❍	❍			
Fuel Return Less System		❍				
Long-Reach Iridium Spark Plug	❍		❍			
DIS(Direct Ignition System)	❍	❍	❍		❍	
Liquid-Filled Double-Orifice Mount Insulator		❍		❍		
Oil Level Sensor					❍	
Air-Fuel Ratio Sensor	❍		❍		❍	
Diagnosis					❍	

High Performance/Fuel Economy

- Through the use of the Dual VVT-i system, optimal valve timing is set to suit the engine conditions in various speed ranges. Thus, high power output, high torque, and low emissions have been realized.
- The 4-valve DOHC cylinder head uses roller rocker arms, thus narrowing the angle between the intake and exhaust valves to 25.6 degrees. This results in a compact combustion chamber shape that offers a superior S/V* ratio. Furthermore, long-reach iridium spark plugs are used, enabling an optimal placement of the water jacket in the cylinder head. As a result, the knock threshold has been improved.
- The shapes of the intake ports have been optimized and slanted squish combustion chambers are used to increase the intake air volume, thus improving engine performance. In addition, the combustion chambers generate a tumble flow that is optimal for improving combustion.
- A thin-wall, cast aluminum intake manifold is used. The diameter, length, and shape of the ports are optimized to achieve a high torque and fuel economy in all operating ranges. In addition, the manifold pressure loss is minimized to improve engine performance.
- By optimizing the exhaust port and using a stainless steel exhaust manifold, the torque in the low- to medium-speed range has been improved.
- An electronic ACIS (Acoustic Control Induction System) is used. The length of the intake manifold and the capacity of the surge tank have been changed to increase the torque in all speed ranges.
- A clutch is provided on the alternetor pulley to lower the tension of the accessory belt and reduce friction, in order to improve fuel economy.
- To reduce the friction of the valve train and reciprocal movement parts, comprehensive measures have been taken: a roller rocker type of mechanism is used to open and close the valves, a new type of resin coat is applied to the pistons, low-tension piston rings are used, and a uniform bore wall temperature has been ensured by improving the roundness of the cylinder bore and using a water jacket spacer.

❖REFERENCE❖

* : S/V = combustion chamber surface/volume ratio. The lower the S/V ratio, the lesser the cooling loss, enabling the effective use of fuel.

Low Exhaust Emissions

- Each stainless steel (dual pipe) exhaust manifold has a built-in three-way catalyst. The warm-up performance of the catalyst has been improved by placing the catalyst directly below the engine and through the optimal use of precious metal. This improves exhaust emission performance immediately after the engine is started.

Lightweight and Compact

- The cylinder block is made of aluminum alloy for weight reduction.
- A serpentine drive system, which uses a single belt to drive the accessories, is used in order to shorten the overall length of the engine.
- The brackets for the accessories are integrated with the engine in order to reduce the number of parts and achieve a compact construction.
- The exhaust manifold is made of stainless steel, and the portion that mounts to the cylinder head is made of thin-wall stamped steel for weight reduction.

Low Vibration, Low Noise, and Quietness

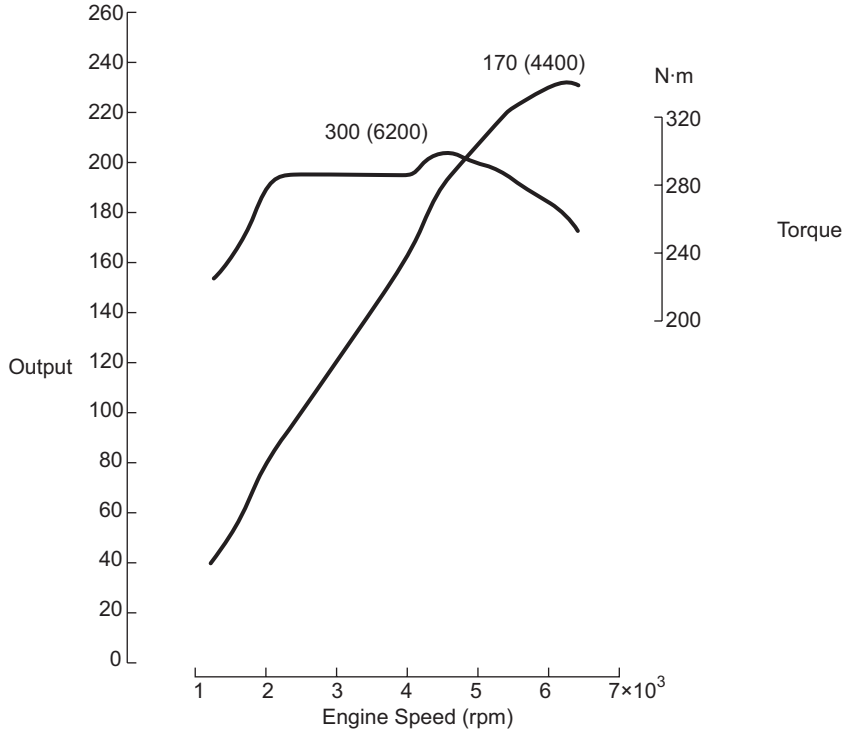
- A highly rigid, aluminum alloy oil pan with integrated stiffeners is used. By improving the joining rigidity between the oil pan and the power plant, low vibration and low noise have been achieved.
- A high strength, highly rigid forged steel crankshaft that has 4 journals and 5 balance weights is used. In addition to weight reduction, this crankshaft has achieved low vibration and noise due to the optimal allocation of balance weights.
- A liquid-filled, double-orifice mount insulator is used in the front engine mount to reduce vibration and noise.

Serviceability

- The maintenance interval has been extended through the use of iridium spark plugs.
- A replaceable element oil filter is used due to environmental concerns.
- Hydraulic lash adjusters are used, making valve clearance adjustments unnecessary.

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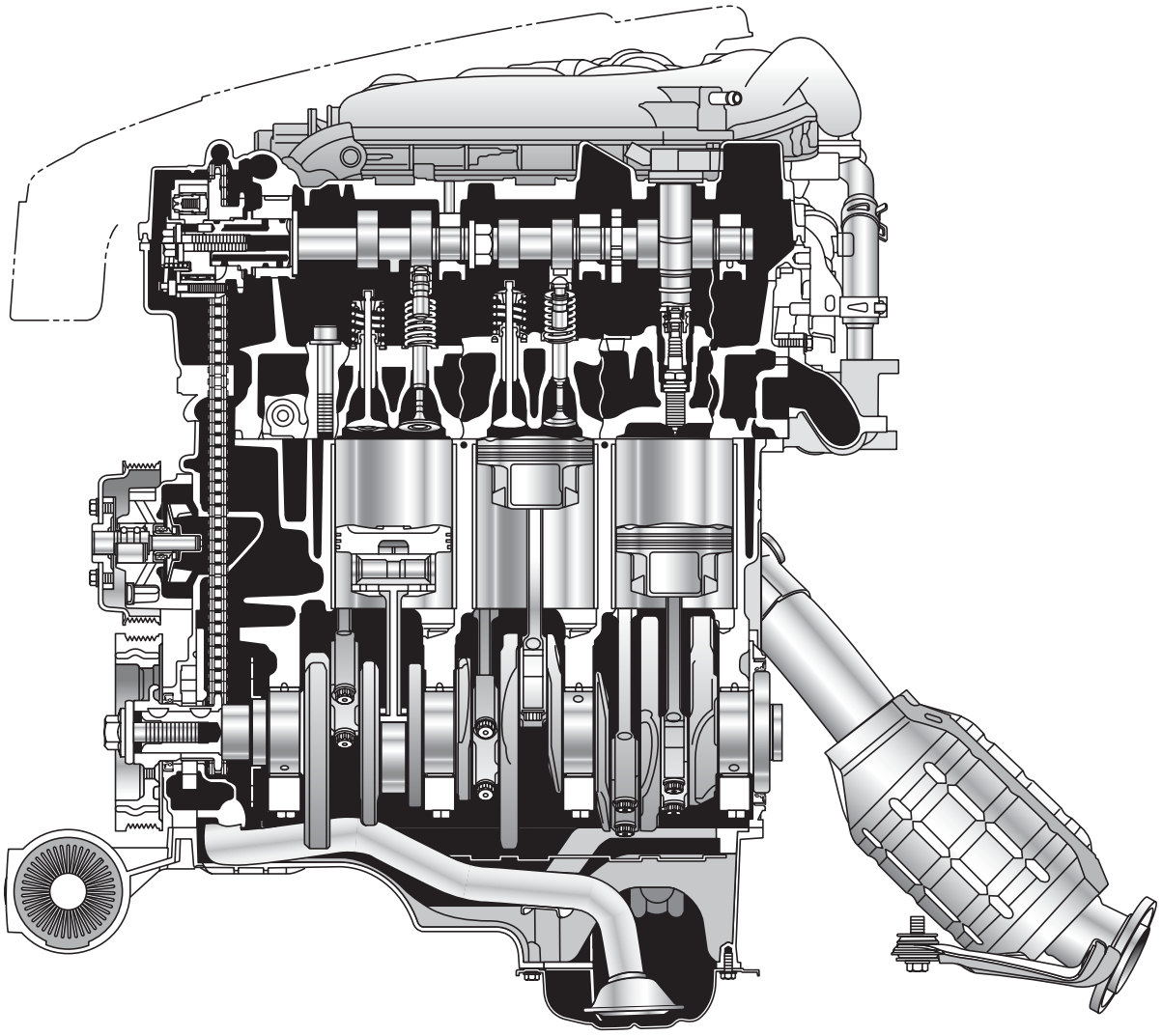
3GR-FE Engine Spec



3GR-FE

Displacement [cm^3 (cu.in.)]		2994 (182.7)
No. of Cyls. & Arrangement		6-Cylinder, V Type
Combustion Chamber		Pentroof Type
Valve Mechanism		24-Valve DOHC, Chain Drive
Bore × Stroke [mm (in.)]		87.5×83.0 (3.44×3.27)
Compression Ratio		10.5
Fuel System		EFI
Max. Output(SAE-NET) [kW](rpm)		170(6200)
Max. Torque(SAE-NET) [N·m](rpm)		300(4400)
Intake Valve Timing	Open	-3 ~ 37°BTDC
	Close	71 ~ 31°ABDC
Exhaust Valve Timing	Open	64 ~ 29°BBDC
	Close	0 ~ 35°ATDC
Firing Order		1-2-3-4-5-6
Research Octane Number		95 or higher
No-Load Speed (rpm)		650
Default Ignition Timing (BTDC°·rpm)		10·650
Weight [kg(lb)]		171 (377)

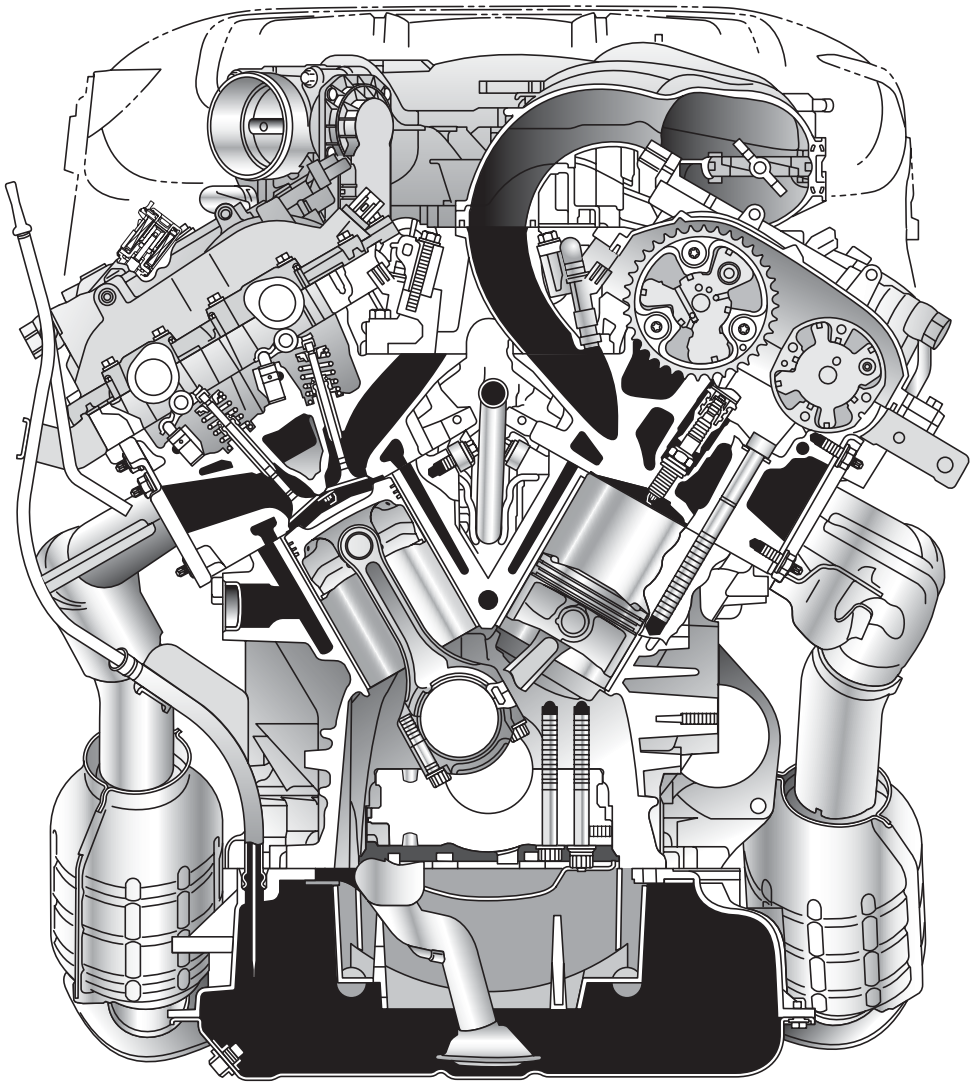
3GR-FE Engine Sectional View



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Engine Cross Section



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Main Features of 3GR-FSE

3GR-FSE Engine Features List

Item	High Performance/ Fuel Economy	Compact/ Lightweight	Cleaner Exhaust Gas	Low Noise/ Low Vibration	Reliability	Serviceability
Dual VVT-i(Dual Variable Valve Timing-intelligent)	❍		❍			
Roller Rocker Arm	❍					
Lash Adjuster	❍			❍		❍
Highly Efficient High Tumble Intake Port	❍		❍			
Slanted Squish Combustion Chamber	❍		❍			
Cast Aluminum Alloy Hypereutectic Type Piston	❍	❍			❍	
High Precision Aluminum Alloy Cylinder Block		❍		❍		
Spiny Surface Cylinder Liner	❍	❍				
Water Jacket Spacer	❍					
Aluminum Alloy Oil Pan		❍		❍		
Replaceable Element Oil Filter						❍
Auxiliary Equipment Bracket Integrated with Engine Block		❍		❍	❍	
Single High-Strength Timing Chain Drive		❍			❍	
Serpentine Drive System		❍				
Alternator Pulley with Clutch	❍				❍	
Electronic ACIS (Acoustic Control Induction System)	❍				❍	
Plastic Surge Tank	❍	❍				
Single-Valve Electronically Controlled Throttle System	❍	❍				
Electronic SCV (Swirl Control Valve) & Link Mechanism	❍	❍	❍			
Full Fabric Air Filter Element		❍				
Compact Plug-In Type Hot-Wire Airflow Meter	❍	❍				
Exhaust Manifold Integrated Three-Way Catalyst			❍			
Stainless Steel Exhaust Manifold		❍	❍			
D-4 (Direct injection 4-stroke gasoline engine)	❍		❍			
Fuel Return Less System (low pressure side)		❍				
Compact Highly Atomized Fuel Injector	❍	❍	❍			
Long-Reach Iridium Spark Plug (single tip, triple ground electrode)	❍		❍			
DIS(Direct Ignition System)	❍	❍	❍		❍	

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Item	High Performance/ Fuel Economy	Compact/ Lightweight	Cleaner Exhaust Gas	Low Noise/ Low Vibration	Reliability	Serviceability
EDU (Electronic Driver Unit)						❍
Liquid-Filled Double-Orifice Mount Insulator		❍		❍		
Oil Level Sensor					❍	
Air-Fuel Ratio Sensor	❍		❍		❍	
Diagnosis					❍	

High Performance/Fuel Economy

- The 3GR-FSE uses the D-4 (Direct injection 4-stroke gasoline engine) system. The intake cooling effect of the direct injection improves charging efficiency and improves knocking, making a higher compression ratio possible. As a result, the output performance and fuel economy have been improved.
- Through the use of the Dual VVT-i system, optimal valve timing is set to suit the engine conditions in various speed ranges. Thus, high power output, high torque, and low emissions have been realized.
- The 4-valve DOHC cylinder head uses roller rocker arms, thus narrowing the angle between the intake and exhaust valves to 25.6 degrees. This results in a compact combustion chamber shape that offers a superior S/V* ratio. Furthermore, long-reach iridium spark plugs (single tip, triple ground electrode) are used, enabling an optimal placement of the water jacket in the cylinder head. As a result, the knock threshold has been improved.
- Highly efficient, high tumble intake ports and slanted squish combustion chambers are used to increase the intake air volume, thus improving engine performance. In addition, the combustion chambers generate an optimal tumble flow to improve combustion.
- A thin-wall, cast aluminum intake manifold is used. The diameter, length, and shape of the ports are optimized to achieve a high torque and fuel economy in all operating ranges. In addition, the manifold pressure loss is minimized to improve engine performance.
- By optimizing the exhaust port and using a stainless steel exhaust manifold, the torque in the low- to medium-speed range has been improved.
- An electronic ACIS (Acoustic Control Induction System) is used. The length of the intake manifold and the capacity of the surge tank have been changed to increase the torque in all speed ranges.
- An electronic SCV (Swirl Control Valve) is used to stabilize combustion.
- A clutch is provided on the alternator pulley to lower the tension of the accessory belt and reduce friction, in order to improve fuel economy.
- To reduce the friction of the valve train and reciprocal movement parts, comprehensive measures have been taken: a roller rocker type of mechanism is used to open and close the valves, a new type of resin coat is applied to the pistons, low-tension piston rings are used, and a uniform bore wall temperature has been ensured by improving the roundness of the cylinder bore and using a water jacket spacer.

❖REFERENCE❖

* : S/V = combustion chamber surface/volume ratio. The lower the S/V ratio, the lesser the cooling loss, enabling the effective use of fuel.

Low Exhaust Emissions

- Each stainless steel (dual pipe) exhaust manifold has a built-in three-way catalyst. The warm-up performance of the catalyst has been improved by placing the catalyst directly below the engine and through the optimal use of precious metal. This improves exhaust emission performance immediately after the engine is started.

Lightweight and Compact

- The cylinder block is made of aluminum alloy for weight reduction.
- A serpentine drive system, which uses a single belt to drive the accessories, is used in order to shorten the overall length of the engine.
- The brackets for the accessories are integrated with the engine in order to reduce the number of parts and achieve a compact construction.
- The intake manifold is made of thin-wall cast aluminum for weight reduction.
- The exhaust manifold is made of stainless steel, and the portion that mounts to the cylinder head is made of thin-wall stamped steel for weight reduction.

Low Vibration, Low Noise, and Quietness

- A highly rigid, aluminum alloy oil pan with integrated stiffeners is used. By improving the joining rigidity between the oil pan and the power plant, low vibration and low noise have been achieved.
- A high strength, highly rigid forged steel crankshaft that has 4 journals and 5 balance weights is used. In addition to weight reduction, this crankshaft has achieved low vibration and noise due to the optimal allocation of balance weights.
- A liquid-filled, double-orifice mount insulator is used in the front engine mount to reduce vibration and noise.

Serviceability

- The maintenance interval has been extended through the use of iridium spark plugs.
- A replaceable element oil filter is used due to environmental concerns.
- Hydraulic lash adjusters are used, making valve clearance adjustments unnecessary.

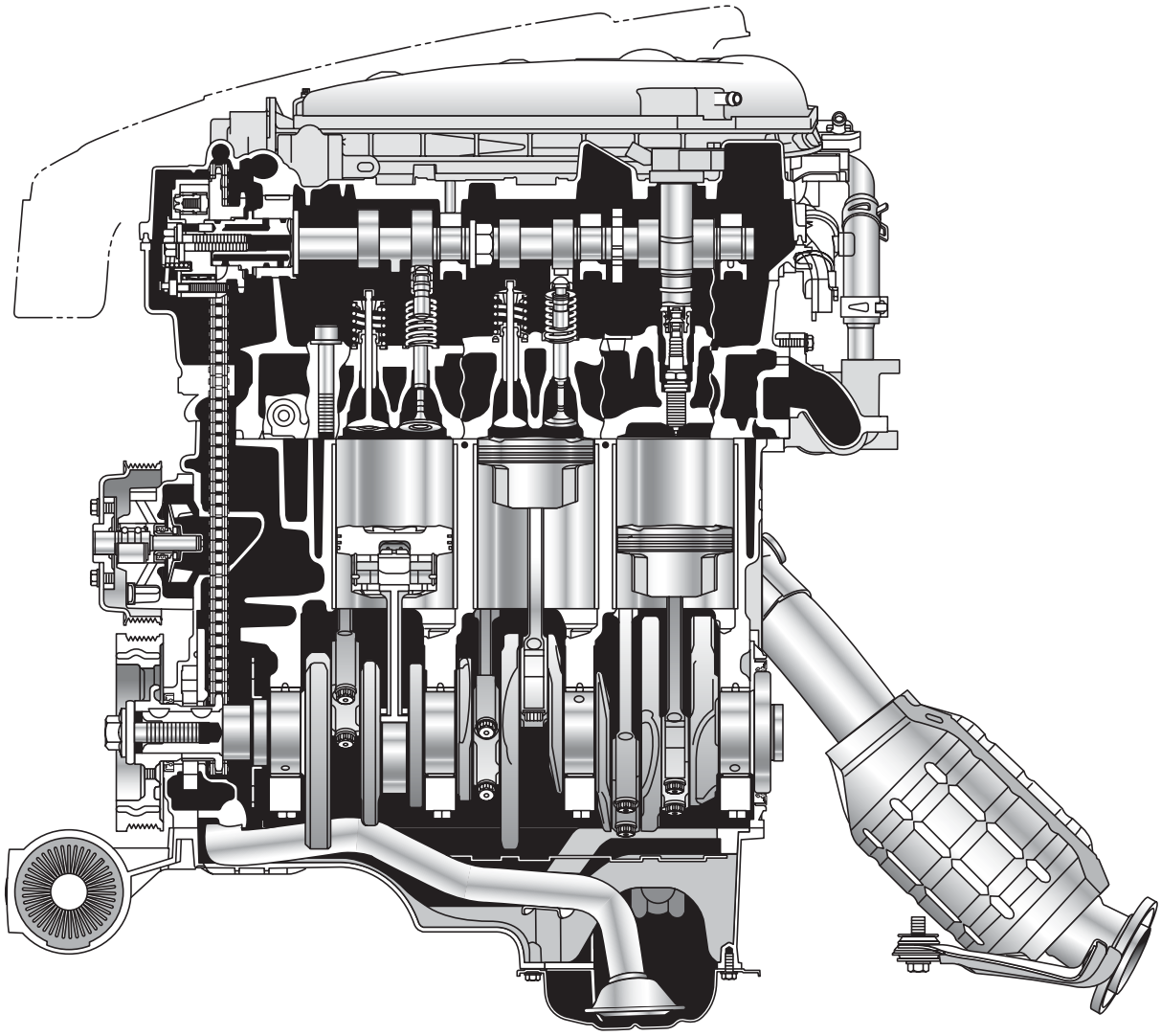
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3GR-FSE Engine Spec

3GR-FSE

Displacement [cm^3 (cu.in.)]		2995 (182.7)
No. of Cyls. & Arrangement		6-Cylinder, V Type
Combustion Chamber		Pentroof Type
Valve Mechanism		24-Valve DOHC, Chain Drive
Bore × Stroke [mm (in.)]		87.5×83.0 (3.44×3.27)
Compression Ratio		11.5
Fuel System		EFI·D-4
Intake Valve Timing	Open	-6 ~ 34°BTDC
	Close	70 ~ 30°ABDC
Exhaust Valve Timing	Open	57 ~ 22°BBDC
	Close	3 ~ 38°ATDC
Firing Order		1-2-3-4-5-6
Research Octane Number		95 or higher
No-Load Speed (rpm)		650
Default Ignition Timing (BTDC°·rpm)		10·650
Weight [kg(lb)]		174 (383)

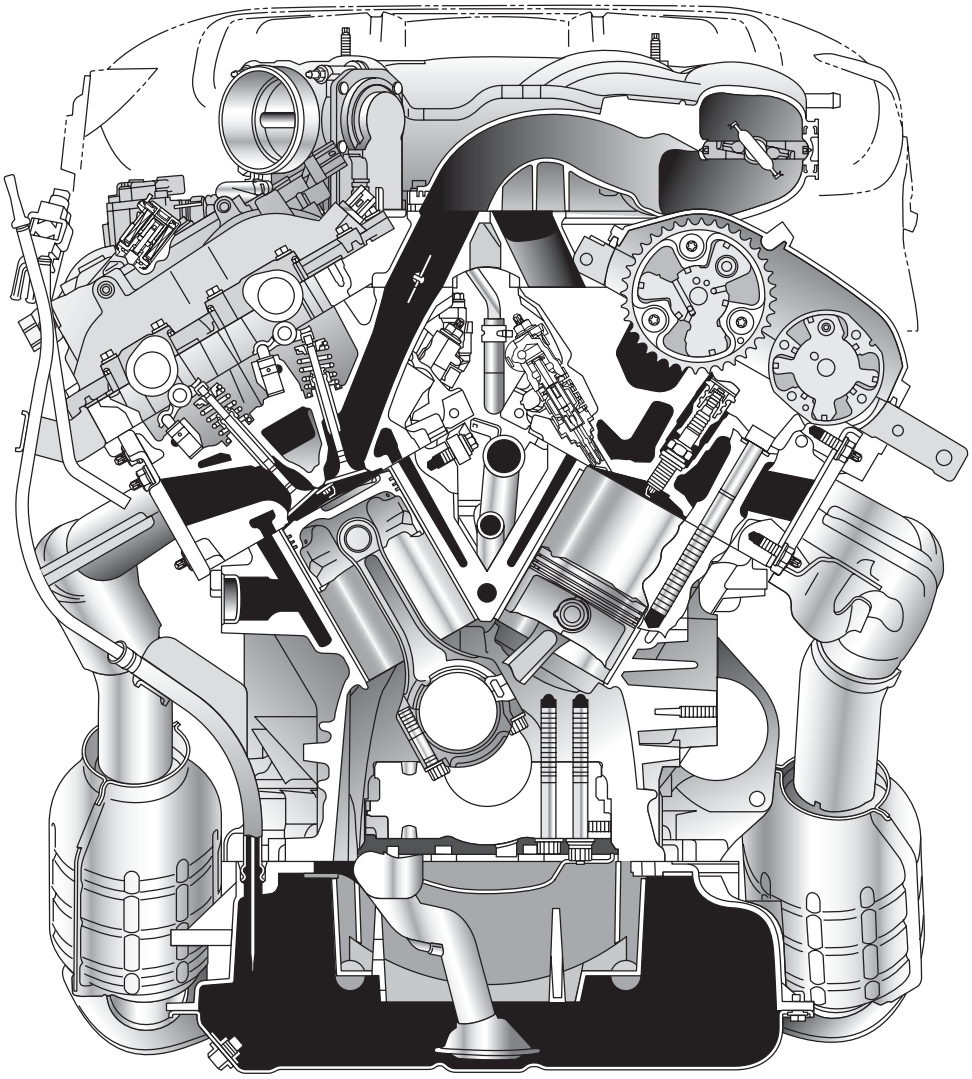
3GR-FSE Engine Sectional View



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Engine Cross Section



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Main Features of 3UZ-FE

● Torque in all speed ranges, particularly in the low- to medium-speed range, has been improved through the use of the VVT-i (Variable Valve Timing-intelligent) system and the ACIS (Acoustic Control Induction System). In addition, low exhaust emissions have been achieved through precision exhaust gas feedback using an air assist system and an O2 sensor, a stainless steel exhaust manifold, and an ultra thin-wall, high cell density ceramic catalyst that excels in catalyst warm-up performance.

3UZ-FE Engine Features List

Item	High Performance/Fuel Economy	Compact / Lightweight	Cleaner Exhaust Gas	Low Noise/ Low Vibration	Improved Reliability
VVT-i(Variable Valve Timing-intelligent)	❍		❍		
Plastic Engine Cover				❍	
Aluminum Alloy Cylinder Head	❍	❍			
Aluminum Alloy Cylinder Block	❍	❍			
Aluminum Alloy Oil Pan No. 1 Integrated with Stiffeners		❍		❍	
Vertical Intake Port	❍		❍		
Slanted Squish Combustion Chamber	❍		❍		
Three-Way Split Timing Belt Cover				❍	
Inner Shim Type Valve Lifter	❍				
Resin Coated Piston	❍				❍
Accessory Serpentine Drive	❍				❍
Electronically Controlled Cooling Fan	❍			❍	❍
Fuel Returnless System		❍	❍		
Air Assist Type Compact Fuel Injector		❍	❍		
ACIS(Acoustic Control Induction System)	❍				
Compact Plug-In Type Hot Wire Airflow Meter	❍	❍			
Full Fabric Air Filter Element		❍			
Single Valve Electronically Controlled Throttle Valve	❍	❍			
Long Port Intake Manifold	❍				
Stainless Exhaust Manifold		❍	❍	❍	
Exhaust Manifold Insulator with Vent Holes	❍				❍
Ultra Thin-Wall High Cell Density Ceramic Catalyst		❍	❍		
Large-Diameter Water Pump	❍				❍
Segment Conductor Type Alternator	❍	❍		❍	
DIS(Direct Ignition System)	❍			❍	❍
Iridium Center Core Spark Plug	❍				

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Item	High Performance/Fuel Economy	Compact / Lightweight	Cleaner Exhaust Gas	Low Noise/ Low Vibration	Improved Reliability
Liquid-Filled Engine Mount				❍	
Diagnosis					❍

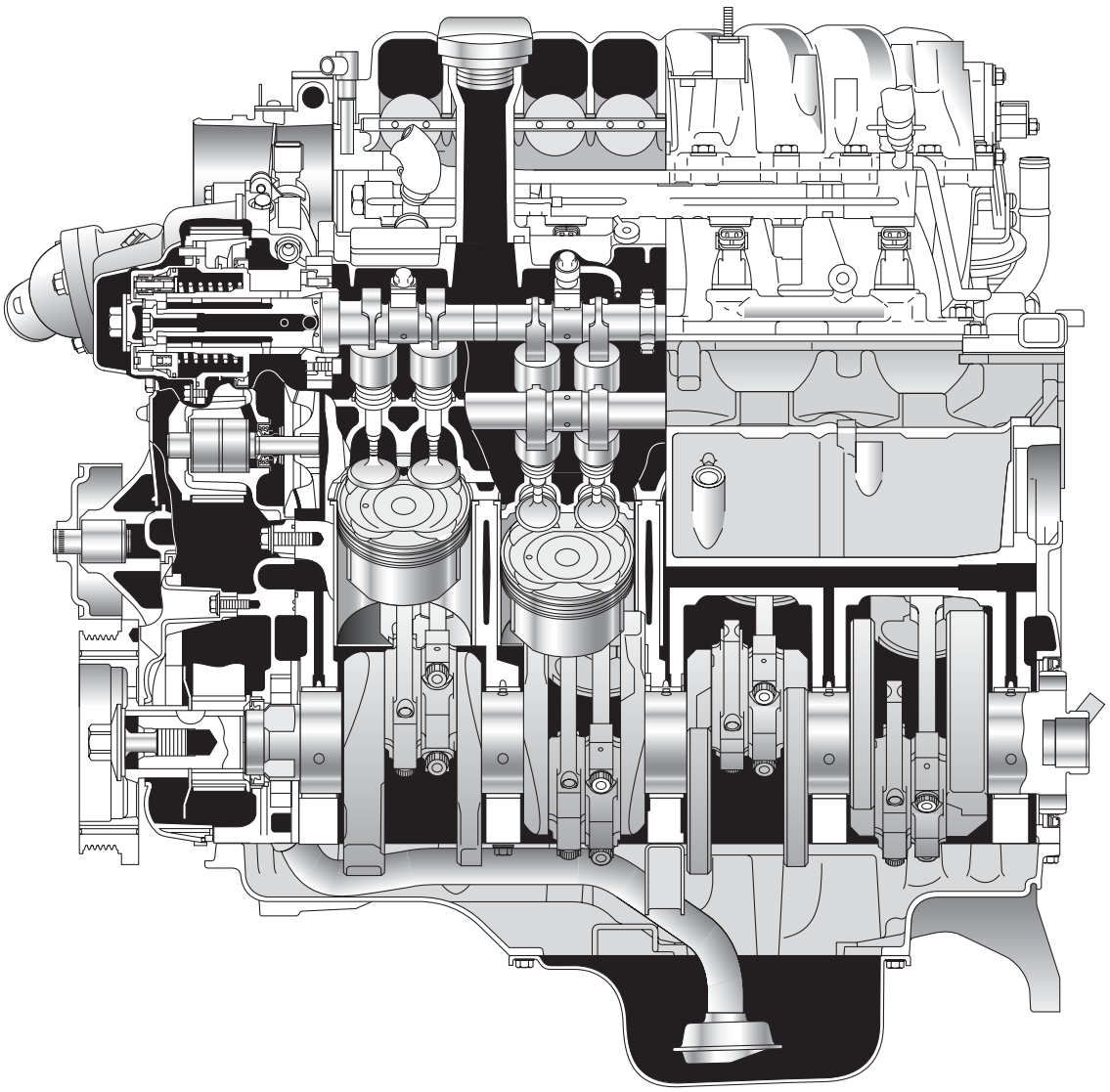
3UZ-FE Engine Spec

3UZ-FE

Displacement [cm^3 (cu.in.)]		4293 (261.9)
No. of Cyls. & Arrangement		8-Cylinder, V Type
Combustion Chamber		Pentroof Type
Valve Mechanism		32-Valve DOHC, Belt & Gear Drive
Bore × Stroke [mm (in.)]		91.0×82.5 (3.58×3.25)
Compression Ratio		10.5
Fuel System		EFI
Max. Output(SAE-NET) [kW](rpm)		208 (5600)
Max. Torque(SAE-NET) [N·m](rpm)		417 (3500)
Intake Valve Timing	Open	-14 ~ 31°BTDC
	Close	64 ~ 19°ABDC
Exhaust Valve Timing	Open	46°BBDC
	Close	3°ATDC
Firing Order		1 - 8 - 4 - 3 - 6 - 5 - 7 - 2
Research Octane Number		95 or higher
Weight [kg(lb)]		190 (419)

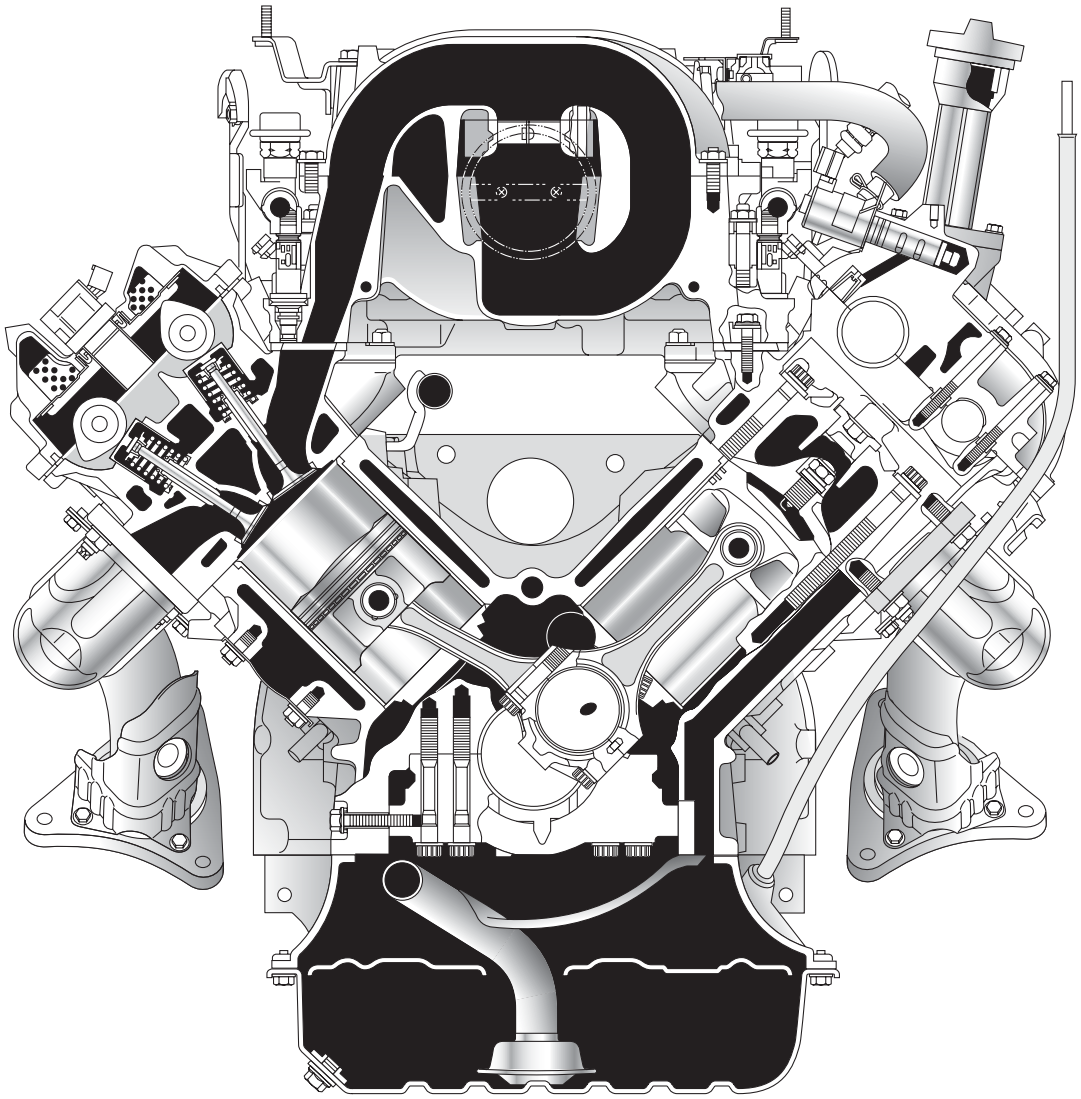
3UZ-FE Engine Sectional View

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Engine Cross Section



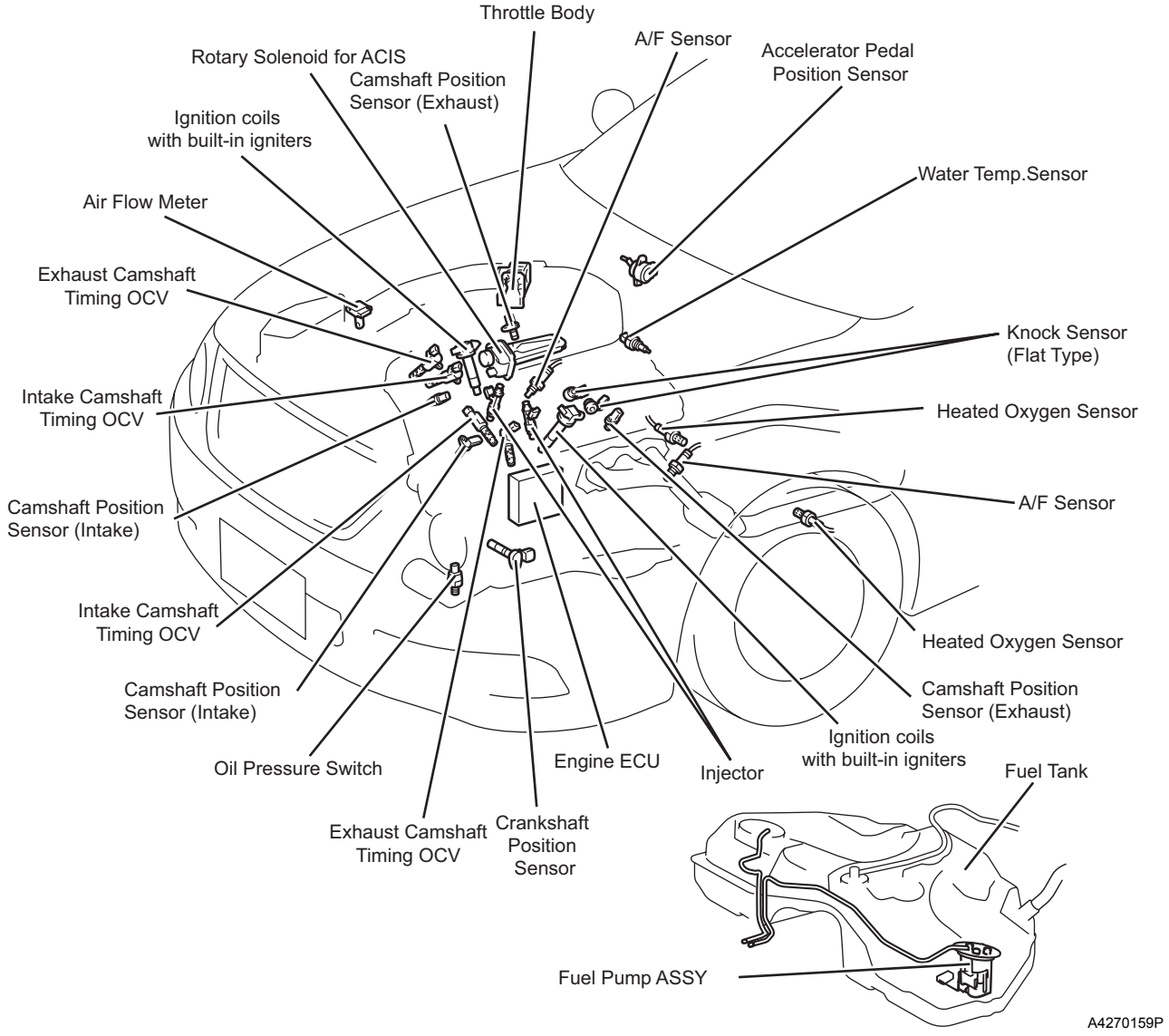
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3GR-FE ENGINE CONTROL SYSTEM

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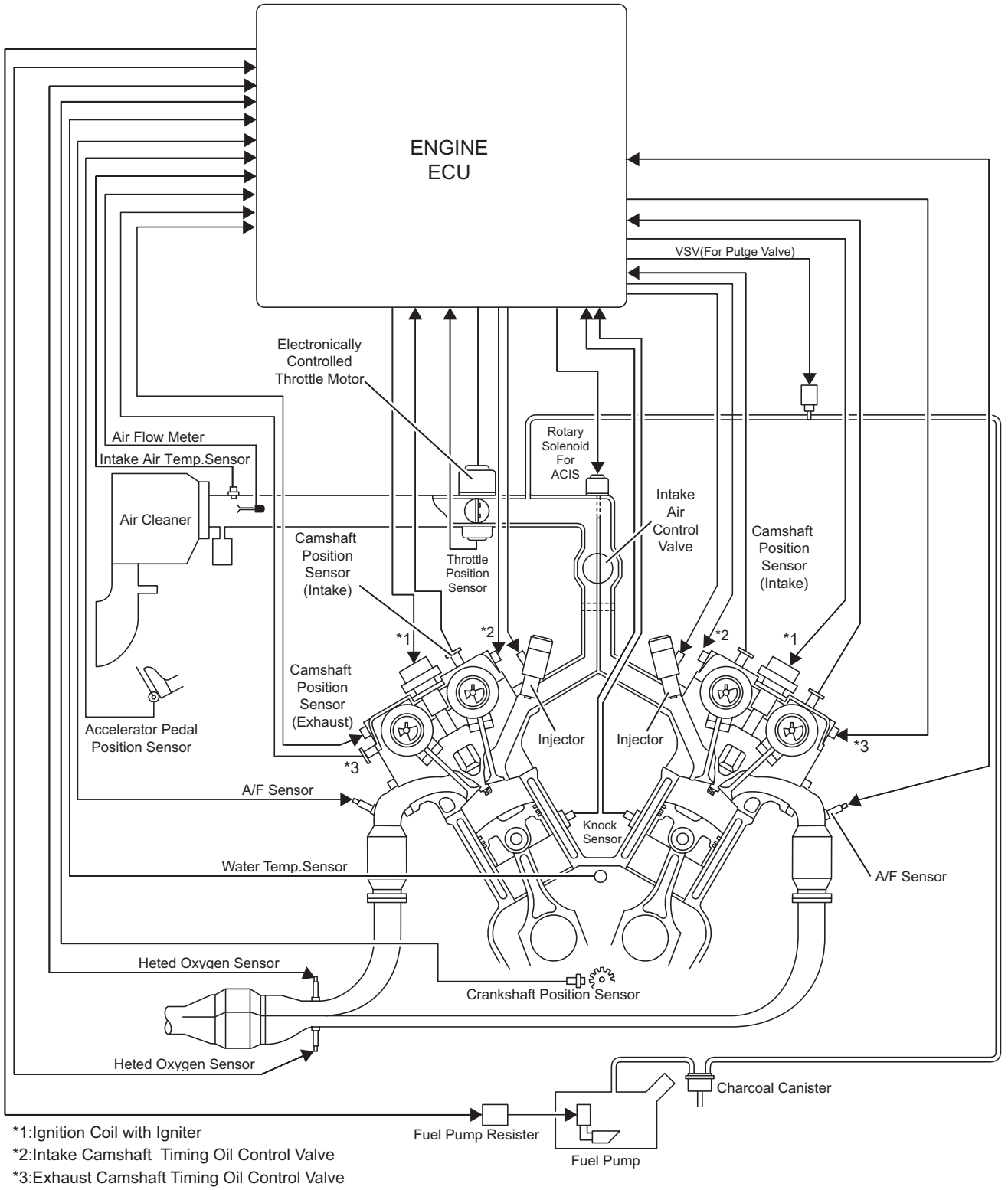
Engine Control System Description

- This engine controls the following systems in a highly accurate manner: Electronic Fuel Injection (EFI), Electronic Spark Advance (ESA), Electronic Throttle Control System-intelligent (ETCS-i), and Dual Variable Valve Timing-intelligent (Dual VVT-i). As a result, high performance, high power output, fuel economy, and improved exhaust emission performance have been achieved.
- CAN (Controller Area Network) communication is used to exchange data with other ECUs.
- The electronic ACIS (Acoustic Control Induction System) control generates high torque in the practical speed range.
- A diagnosis and a failsafe function are provided to ensure serviceability and safety.



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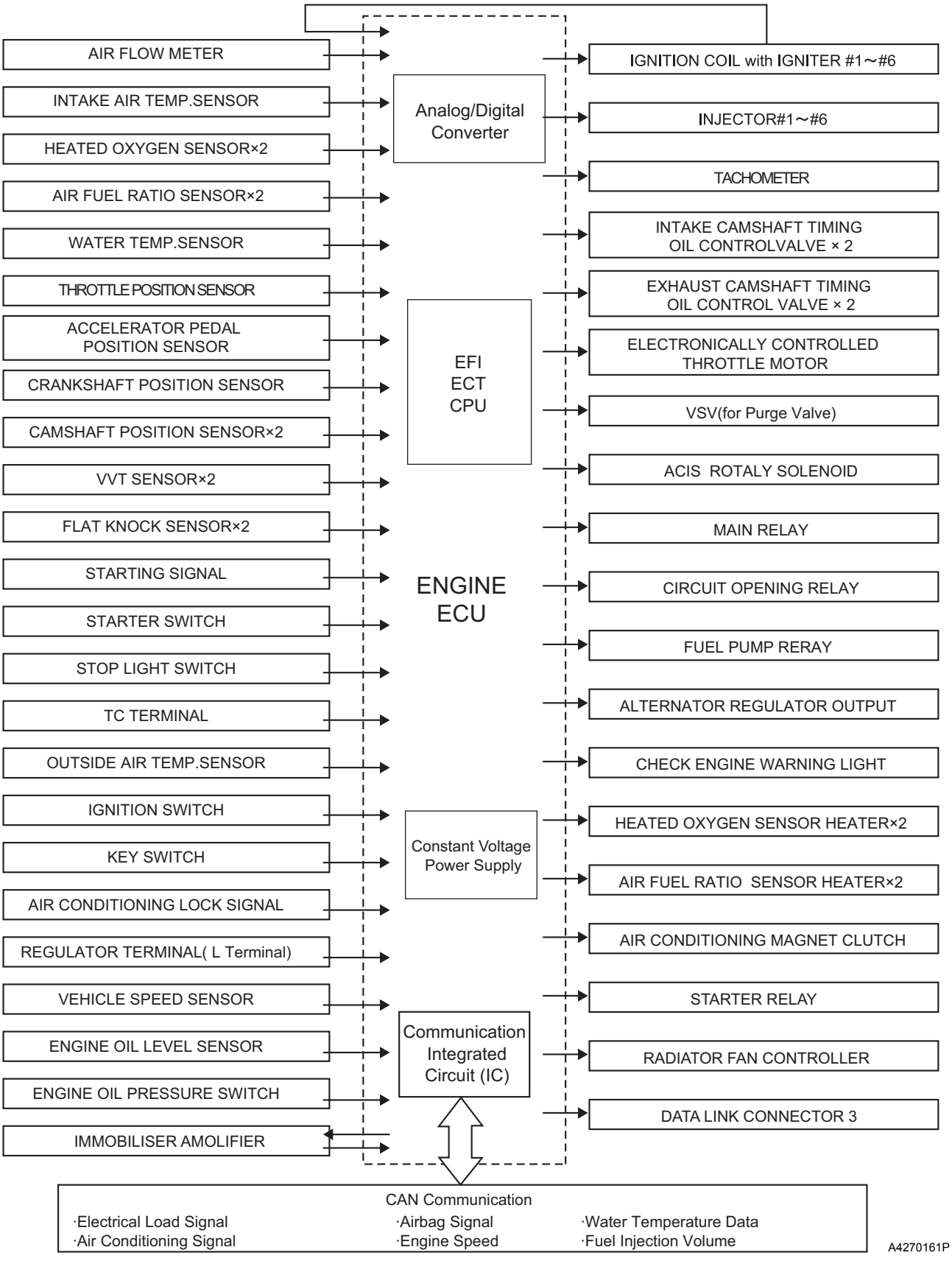
Engine Control System Diagram



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Construction



Control List

System	Outline	
EFI (Electronic Fuel Injection)	An L-type EFI system directly detects the intake air mass with a hot wire type mass air flow meter.	
ESA (Electronic Spark Advance)	Ignition timing is determined by the engine ECU based on signals from various sensors. Corrects ignition timing in response to engine knocking.	
	Knocking Judgment Control(KCS)	2 knock sensors are used to improve knock detection.
	ECT Shifting Torque Control	The torque control correction during gear shifting has been used to minimize the shift shock.
ETCS-i (Electronic Throttle Control System-intelligent)	Ignition timing is determined by the engine ECU based on signals from various sensors. Corrects ignition timing in response to engine knocking.	
	VSC Control	Controls the throttle valve position when the VSC is operating.
	Maximum Speed Control	When the vehicle speed reaches 240 km/h, this control closes the throttle valve to suppress the increase in vehicle speed.
	Idle Speed Control(ISC)	Controls the fast idle speed in accordance with the water temperature, and the idle speed after the engine has been warmed up. It controls the idle speed by regulating the fuel injection volume and the throttle position.
Dual VVT-i Control	Controls the optimal intake and exhaust valve timing in accordance with the conditions of the engine.	
ACIS (Acoustic Control Induction System) Control	Varies the intake manifold length to suit the conditions of the engine.	
Fuel Pump Control	Turns the fuel pump ON/OFF in accordance with the starter signal and the engine speed signal. Stops the operation of the fuel pump in accordance with the signals from the airbag ECU	
Cranking Hold Control	After the starter starts to crank the engine, this control continues to apply current to the starter until the engine starts. Thus, it prevents the failure of the engine to start when the driver inadvertently turns the ignition switch to OFF just before the engine fires.	
Air-Fuel Ratio Sensor Heater Control	Turns the air-fuel ratio sensor heater ON/OFF in accordance with the water temperature and the driving conditions.	
Heated Oxygen Sensor Heater Control	Maintains the temperature of the Heated Oxygen Sensor at an appropriate level to increase accuracy of detection of the oxygen concentration in the exhaust gas.	
Evaporative Emission Control	The engine ECU controls the purge flow of evaporative emissions (HC) in the charcoal canister in accordance with engine conditions.	
Air ConditioningCut-Off Control	By controlling the air conditioning compressor ON or OFF in accordance with the engine condition, drivability is maintained.	
Engine Immobiliser	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid ignition key.	
Function to communicate with multiplex communication system	Communicates with the meter ECU, A/C ECU, etc., on the body side, to input/output necessary signals.	

System	Outline
Diagnosis	Enables the accurate and detailed diagnosis of malfunctions through the use of the intelligent Tester II diagnostic tool to access the SAE-prescribed DTC (Diagnostic Trouble Code) and data, as well as to perform active tests.
Fail-Safe	When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in the memory.

■ **Service Tip** ■

The uses the CAN protocol for diagnostic communication. Therefore, a intelligent Tester II and a dedicated adapter [CAN VIM (Vehicle Interface Module)] are required for accessing diagnostic data. For details, see the 2005 Lexus GS430/300 Repair Manual(Pub. No. RM1168E)

Sensor List

Name	Function and Construction	EFI	ESA	ISC	VVT-i
Air Flow Meter	Detects the intake air volume.	❍	❍	❍	❍
Intake Air Temperature Sensor	Detects the intake air temperature.	❍	❍	❍	❍
Camshaft Position Sensor	Identifies the cylinder and detects the actual camshaft position.	❍	❍	❍	❍
Crankshaft Position Sensor	Detects the crankshaft position.	❍	❍	❍	❍
Accelerator Pedal Position Sensor	It is attached to the accelerator pedal to detect the accelerator pedal position.	❍	❍	❍	❍
Throttle Position Sensor	Detects the throttle valve position.	❍	❍	❍	❍
Water Temp.Sensor	Detects the water Ftemperature.	❍	❍	❍	❍
Air-Fuel Ratio Sensor	Detects the state of the air-fuel ratio in the exhaust gas.	❍			
Heated Oxygen Sensor	Detects the oxygen concentration in the exhaust gas.	❍			
Igniter	Sends the ignition verification signal.		❍		
Starter Signal	Sends the starter voltage in the form of a signal when the engine is started.	❍	❍	❍	❍
Neutral Start Switch	Detects the P, N, and D positions of the automatic transmission.	❍	❍	❍	❍
Knock Sensor	Detects the knocking of the engine by way of the resonance of the piezoelectric element.		❍		
Vehicle Speed Signal	Detects vehicle speed.	❍	❍	❍	❍

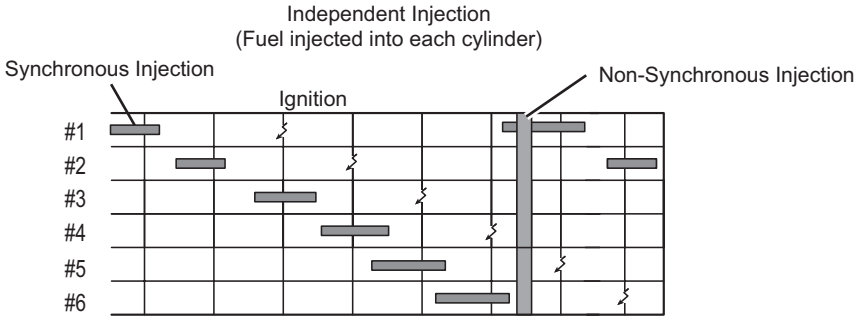
Actuator List

Name	Function and Construction
Main Relay	Supplies main power to the EFI, ESA system, etc
Circuit Opening Relay	Supplies power to the fuel pump system.
Fuel Injector	Injects an optimal volume of fuel at an optimal timing.
Air-Fuel Ratio Sensor Heater	Heats the air-fuel ratio sensor to promote feedback control when the engine is cold.

Name	Function and Construction
Heated Oxygen Sensor Heater	Heats the heated oxygen sensor to promote feedback control when the engine is cold.
Igniter	Turns the current to the ignition coil ON/OFF at an optimal timing.
Electronically Controlled Throttle Motor	Controls the position of the throttle valve in accordance with driving conditions.
Intake Camshaft Timing OCV	Controls the intake VVT-i at an optimal valve timing.
Exhaust Camshaft Timing OCV	Controls the exhaust VVT-i at an optimal valve timing.
Rotary Solenoid for ACIS	Opens and closes the ACIS valve in accordance with driving conditions.
Evaporative Purging VSV	Regulates the purge volume of the canister.

EFI (Electronic Fuel Injection) System

- An L-type EFI system directly detects the intake air mass with a hot wire type air flow meter.
- An independent injection system (in which fuel is injected once into each cylinder for each two revolutions of the crankshaft) has been adopted.
- There are two types of fuel injection: One is synchronous injection in which corrections based on the signals from the sensors are added to the basic injection time so that injection occurs always at the same position. The other is non-synchronous injection in which injection is effected by detecting the requests from the signals of the sensors regardless of the crankshaft angle. Furthermore, to protect the engine and improve fuel economy, the system effects fuel cutoff in which the injection of fuel is stopped temporarily in accordance with the driving conditions.

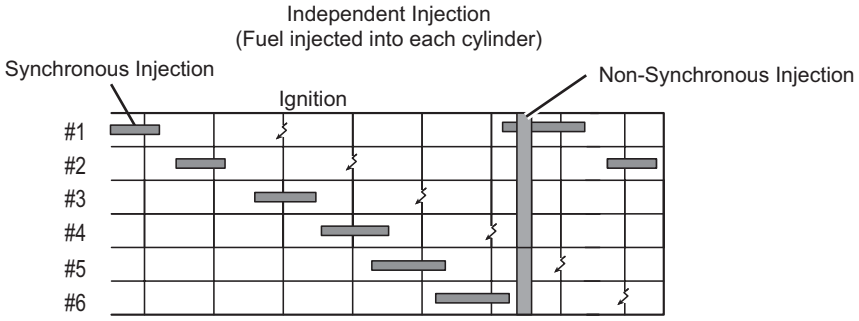


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Synchronous Injection

• The synchronous injection time can be expressed by the formula given below. During the starting of the engine, the injection time is determined in accordance with the engine speed, battery voltage, and the water temperature. To prevent excessive amounts of fuel from being injected during starting, the injection volume is regulated in accordance with the cranking time.

Synchronous Injection = A. Basic Injection Time + B. Correction Injection Time + C. Ineffective Injection Coefficient

A.Basic Injection Time	It is the basic injection time that is determined by the intake air volume and the engine speed.
B.Correction Injection	It is a coefficient that is used to achieve the air-fuel mixture that is appropriate for the engine condition at that time, in accordance with the signals from the sensors.
B-1 Intake Temperature Correction	Enriches the mixture when the intake air temperature is low because the air density is high.
B-2 Post-Warm-Up Enrichment Correction	Enriches the mixture when the water temperature is low to ensure drivability during cold operation.
B-3 Post-Start Enrichment Correction	Enriches the mixture after the engine is started in accordance with the water temperature and the engine speed in order to ensure a stable engine operation after starting. The enrichment is at the highest ratio immediately after the engine is started, and decreases gradually thereafter.
B-4 Transient Air-Fuel Ratio Correction	Enriches or leans the mixture in accordance with the acceleration or deceleration conditions determined by the changes in the intake air volume.
B-5 Wall Adhesion Correction	Correction is made by calculating the adhesion of fuel to the wall surface based on the water temperature, engine speed, and throttle valve opening.
B-6 High-Load Enrichment Correction	Prevents the exhaust temperature from rising by detecting the high-load driving conditions in accordance with the signals from the sensors and enriching the mixture.
B-7 Constant Fuel Pressure Control	Corrects the deviation of the fuel injection volume that results from the changes in the intake manifold pressure to achieve a constant pressure.
B-8 Air-Fuel Ratio Feedback Control	Controls the air-fuel ratio to a narrow range near the stoichiometric ratio (in which the cleaning performance of the three-way catalyst is at the highest level) by making corrections based on the signals from the heated heated oxygen sensor.
C.Ineffective Injection	Corrects the operation lag of the injectors.

Non-Synchronous Injection

• Apart from the normal (synchronous) fuel injection, this function simultaneously injects a prescribed volume of fuel to all the cylinders only immediately after the signals from the sensors are input, in order to ensure the proper startability and acceleration response.

• During synchronous injection, the injection time is extended for the amount of non-synchronous injection.

The following are the three types of non-synchronous injection

Starting Non-Synchronous Injection	Effects non-synchronous injection immediatelyafter the starter signal is input,thus improving startablility.
Acceleration Non-Synchronous Injection	Effects non-synchronous injection when the increased amount of the throttle valve opening is greater than the preset value, to improve response during acceleration.
Engine Speed Drop Non-SynchronousInjection	Effects non-synchronous injection when the engine speed drops suddenly during a fuel cutoff or when resuming from a fuel cutoff, thus ensuring the proper drivability.

Fuel Cut

• Temporarily stops the injection of fuel to protect the engine and improve fuel economy.

The following are the three types of fuel cutoff

Deceleration Fuel Cutoff	Stops the injection of fuel when the engine speed is higher than the specified value during deceleration (throttle OFF detected by engine ECU). This prevents the TWC (Three-Way Catalyst) from overheating due to misfiring and improves fuel economy. The fuel cutoff and resumption speeds are higher when the coolant temperature is low.
Engine Speed Fuel Cutoff	Stops the injection of fuel when the engine speed is higher than the specified value to prevent over-revolution.
N → D Shift Fuel Cutoff	Stops the injection of fuel for a prescribed length of time when shifting from N→ D, if the engine speed is higher than the specified value to reduce shift shock.

Fuel Cut Resumption Speed During Deceleration

While lockup control is operating	[rpm]	1000
While lockup control is not operating	[rpm]	1200

Fuel Cut Speed During High-Speed Operation

Engine Speed	[rpm]	6500

ESA (Electronic Spark Advance)

● 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. The ignition timing can be expressed by the formula given below. The default ignition timing is set to 5° BTDC.

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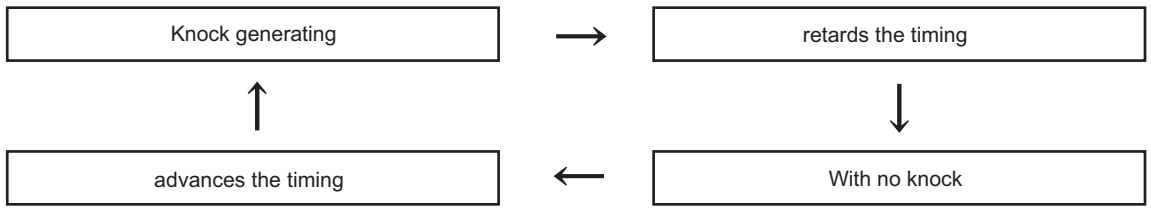
Calculation of ignition timing

❖REFERENCE❖
Ignition Timing = A. Default Ignition Timing or B. Basic Timing Advance + C. Correction Timing Advance

A.Fixed Timing Advance Characteristic	During the starting of the engine, the timing is fixed to 5° BTDC. If the throttle valve is turned OFF by shorting the service terminals, the timing becomes fixed to 10° BTDC.
B.Basic Timing Advance Characteristic	The optimal ignition timing is selected from the map based on the signals received from the sensors.
C.Correction Timing Advance Characteristic	Appropriately advances or retards the timing in accordance with the conditions of the engine based on the signals received from the sensors.
C-1 Warm-Up Timing Advance Characteristic	Advances the ignition timing in accordance with the driving conditions when the water temperature is low, in order to improve drivability.
C-2 Idle Stabilization Timing Advance Characteristic	Advances the ignition timing when the idle speed decreases, in order to stabilize the idle speed. Conversely, retards the timing if the idle speed increases.
C-3 Transient Correction Timing Retard	Retards the ignition timing during sudden acceleration when the water temperature is higher than 60°C, in order to prevent the engine from knocking.
C-4 Acceleration Timing Retard	Temporarily retards the ignition timing during acceleration in order to improve drivability.
C-5 Knock Correction Timing Retard	Corrects the ignition timing in accordance with the signals received from the knock sensor when knocking occurs. Depending on the extent of the knocking that is detected, this function retards the timing by a prescribed angle at a time until there is no more knocking. After no more knocking occurs, this function advances the timing by a prescribed angle at a time. If knocking occurs again while advancing the timing, it retards the timing again.

Knock Control System

- When the engine ECU detects the engine knocking, it retards the timing, depending on the extent of knocking, by one predetermined angle at a time until the engine stops knocking.
- When the engine stops knocking, the engine ECU advances the timing by one predetermined angle at a time. If the engine starts knocking again, the engine ECU retards the timing again.



Knocking Feedback Control

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Maximum and Minimum Timing Advance Characteristics

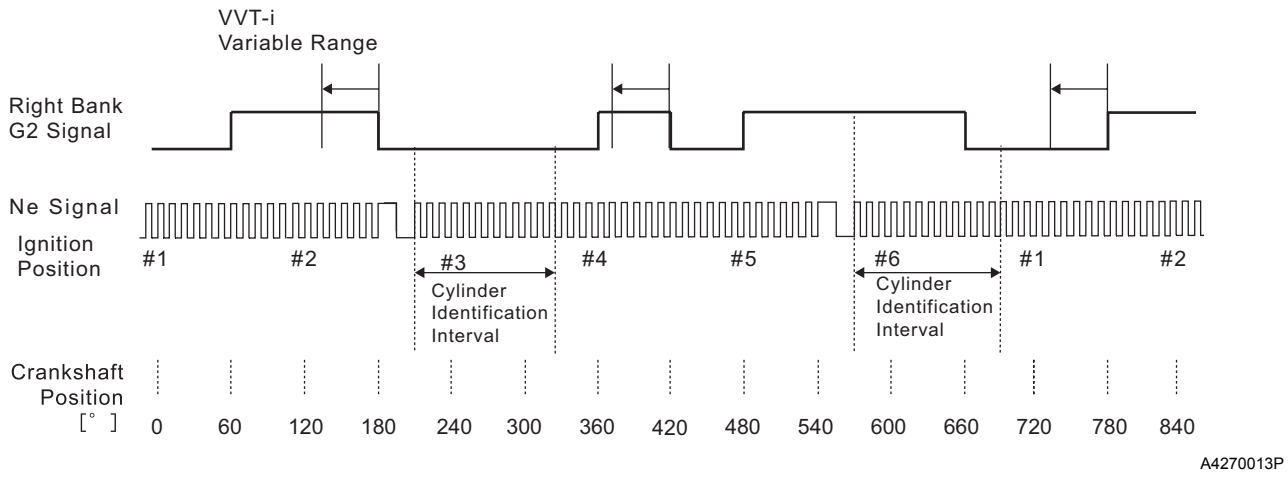
- The maximum and minimum timing advance angles are fixed because the engine can be adversely affected if the ignition timing advances or retards abnormally.

Maximum and Minimum Timing Advance Angles

Maximum Timing Advance Angle (BTDC)	49°
Minimum Timing Advance Angle (ATDC)	-10°

Calculation of ignition timing

- Based on the Ne and G2 signals, airflow meter signal, accelerator position signal, and water temperature signal, the engine ECU calculates the optimal ignition timing to suit the driving conditions. Then, the engine ECU sends an ignition signal to the ignition coil with a built-in igniter.



Idle Speed Control

● Controls the fast idle speed in accordance with the water temperature, and the idle speed after the engine has been warmed up. It controls the idle speed by regulating the fuel injection volume and the throttle position.

Idle Speed Control

Starting Control	When starting the engine, this control opens the throttle valve to increase the intake air volume, which improves the startability of the engine.
Forecast Control	When the system detects any one of the signals listed below, it controls the position of the throttle valve to suppress speed fluctuations.
	·A change in the idle speed has been forecasted.
	·A change occurred in the electrical load.
	·The air conditioning switch has been switched.
	·The shift lever has been shifted. (N → D, D → N)
Deceleration Control	This control increases the airflow volume by opening the throttle valve during deceleration, thus lowering the vacuum in the intake manifold. This decreases the volume of oil consumed through suction into the combustion chamber, prevents the engine from stalling through a sudden drop in engine speed, and improves drivability.
Feedback Control	While measuring the engine speed for a certain length of time, if there is a difference between the actual speed and the target speed, this control regulates the throttle valve position in order to bring the idle speed to the target speed.

Target Speed

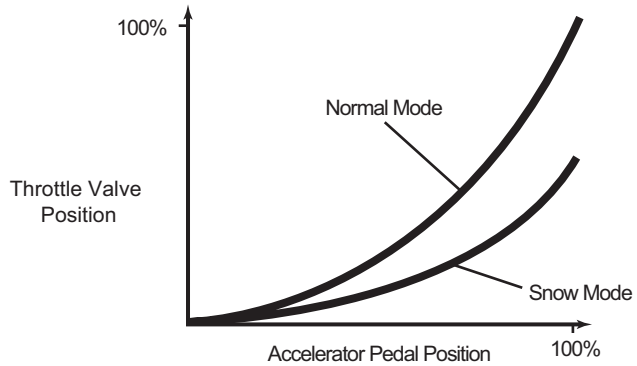
		3GR-FE		
		Europe	General countries	G.C.C.countries
No-load speed [rpm]		650	←	←
With an electrical load [rpm]		650	←	←
A/C ON [rpm]	Low load	650	675	←
	High load	800	←	875

ETCS-i (Electronic Throttle Control System-intelligent)

- In the conventional throttle body, the throttle valve opening is determined invariably by the amount of the accelerator pedal effort. In contrast, the ETCS-i uses the engine ECU to calculate the optimal throttle valve opening that is appropriate for the respective driving condition and uses a throttle control motor to control the opening.
- The functions of the ordinary throttle position control (nonlinear control), idle speed control (ISC), traction control (including VSC), and cruise control have been integrated in the single-valve electronically controlled throttle body.
- Excellent driving stability and comfort have been achieved by effecting integrated control with the power train, and vehicle stability has been ensured through cooperative control with the ECT and VSC systems.
- Two CPUs, one for the ETCS-i, and the other for the EFI control, monitor each other to ensure a reliable system.
- A dual system is used so that the vehicle can continue to operate in the event of a problem, thus ensuring reliability.

ETCS-i Control

Nonlinear Control	Normal-mode Control	Controls the throttle to an optimal throttle valve opening that is appropriate for the driving condition such as the amount of the accelerator pedal effort and the engine operating condition in order to realize excellent throttle control and comfort in all operating ranges.
	SNOW-mode Control	In situations in which low-μ surface conditions can be anticipated, such as when driving in the snow, the throttle valve can be controlled to help vehicle stability while driving over the slippery surface. This is accomplished by turning on the SNOW switch of the pattern select switch, which, in response to the amount of the accelerator pedal effort that is applied, reduces the engine output from that of the normal driving level.
ECT + EFI + ETCS-i Integrated Control (Shift Shock Reduction Control)		During the shifting of the ECT, this control regulates the throttle valve position in order to reduce the shift shock that occurs during shift up and down, and shorten the shifting duration.
Maximum Speed Control		When the vehicle speed reaches 240 km/h, this control closes the throttle valve to suppress the increase of vehicle speed.
TRC (VSC) + ETCS-i Cooperative Control (models equipped with VSC)		In order to bring the effectiveness of the VSC system control into full play, the throttle valve opening angle is controlled by effecting a coordination control with the skid control ECU.
Idle Speed Control		Controls the fast idle speed in accordance with the water temperature, and the idle speed after the engine has been warmed up. It controls the idle speed by regulating the fuel injection volume and the throttle position.



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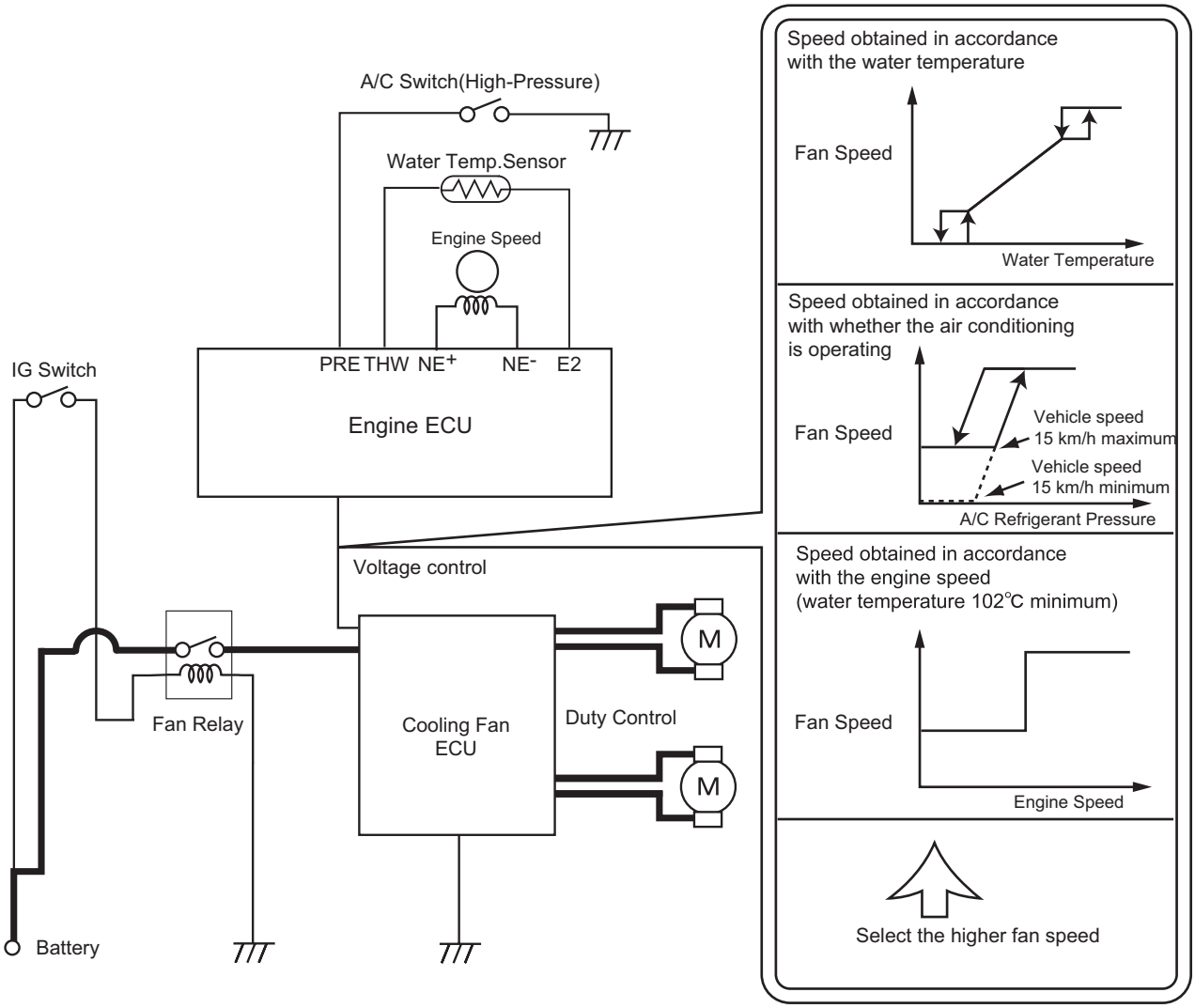
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VVT-i System

● This engine uses a Dual VVT-i (Variable Valve Timing-intelligent) system that continuously varies the phases of the camshafts. By regulating the timing of the intake and exhaust valves in accordance with the driving conditions, this system realizes fuel economy, high power output, and low exhaust emissions.

Cooling Fan System

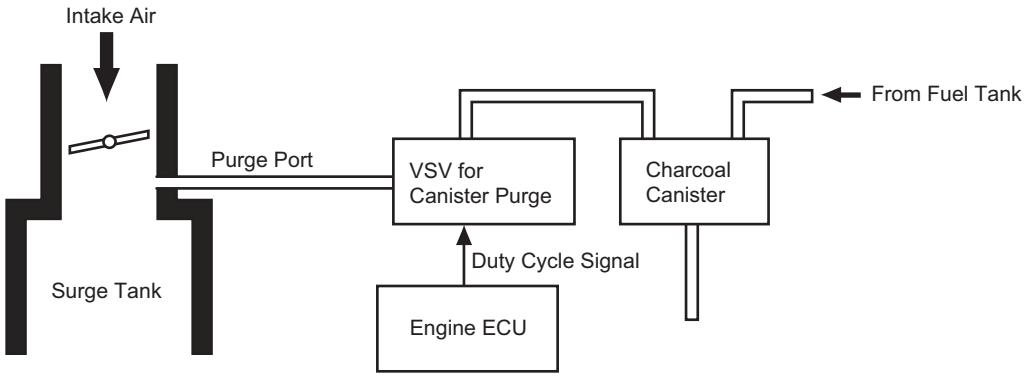
● To achieve an optimal fan speed in accordance with the engine coolant temperature, vehicle speed, engine speed, and air conditioning operating conditions, the engine ECU calculates the proper fan speed and sends the signals to the cooling fan ECU. Upon receiving the signals from the engine ECU, the cooling fan ECU actuates the fan motors. Also, the fan speed is controlled by engine ECU using the stepless control.



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Evaporative Emission Control System

- A single system purge flow path is provided in order to control the fuel evaporative gas that flows from the charcoal canister to the purge port in accordance with the conditions of the engine. Then, the fuel evaporative gas that has been absorbed by the canister is drawn into the engine, thus suppressing the discharge of fuel evaporative gas.
- The purge port, which is provided downstream of the throttle valve, draws the fuel evaporative gas into the intake manifold in accordance with the driving conditions. The engine ECU applies current to the VSV, which is provided midstream of the purge pipe, in order to control the purge to an optimal volume.

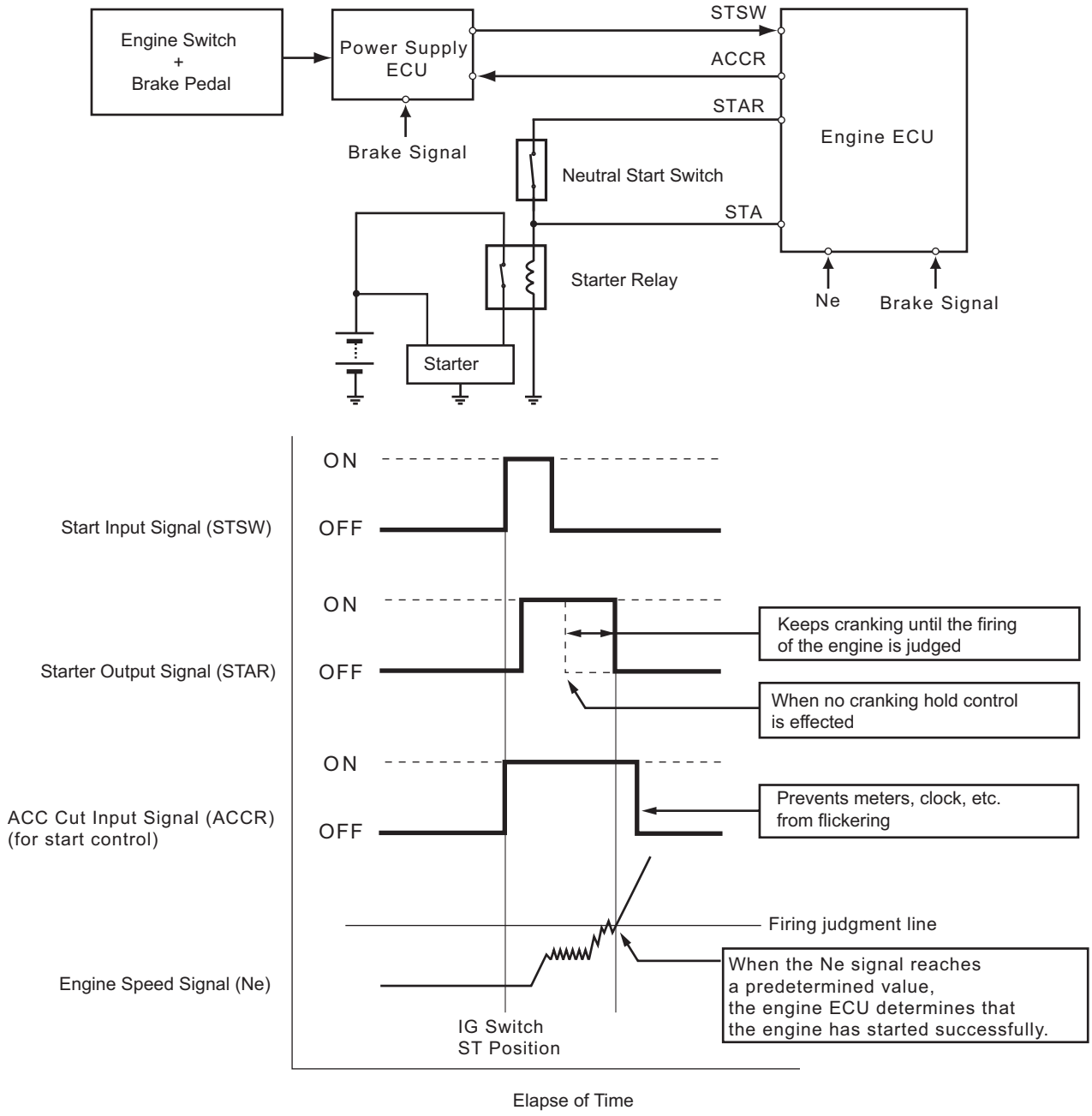


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Cranking Hold Control

- When a start signal (STSW) is input by the engine switch, the engine ECU sends a signal (STAR) to the starter relay via the Park/Neutral Position switch (to determine P or N position), in order to start the starter. At this time, the engine ECU turns ON the ACC cut (ACCR) switch to prevent the meters, clock, and audio unit from flickering.
- After the starter starts, the engine ECU continues to output a signal to the starter until it detects that the engine has fired. After cranking, when the engine speed becomes higher than a predetermined speed, the engine ECU determines that the engine has fired, and stops the signal that is output to the starter relay.

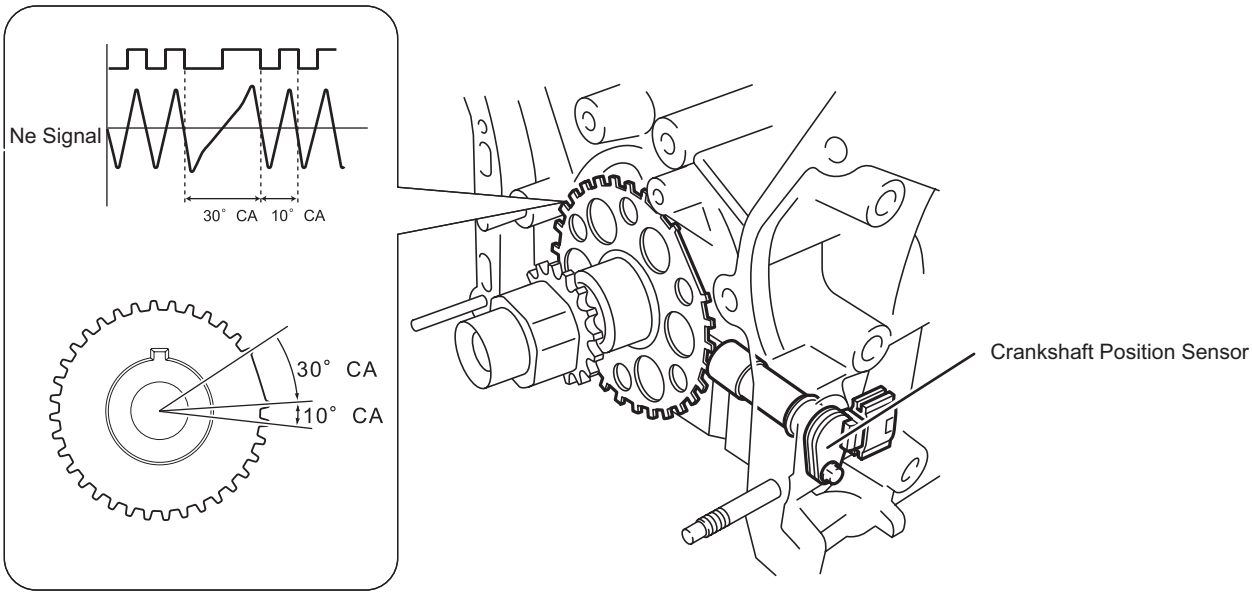


Cranking Hold Control Circuit Diagram (SMART ACCESS SYSTEM with PUSH-BUTTON START Type) and System Diagram

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Crankshaft Position Sensor

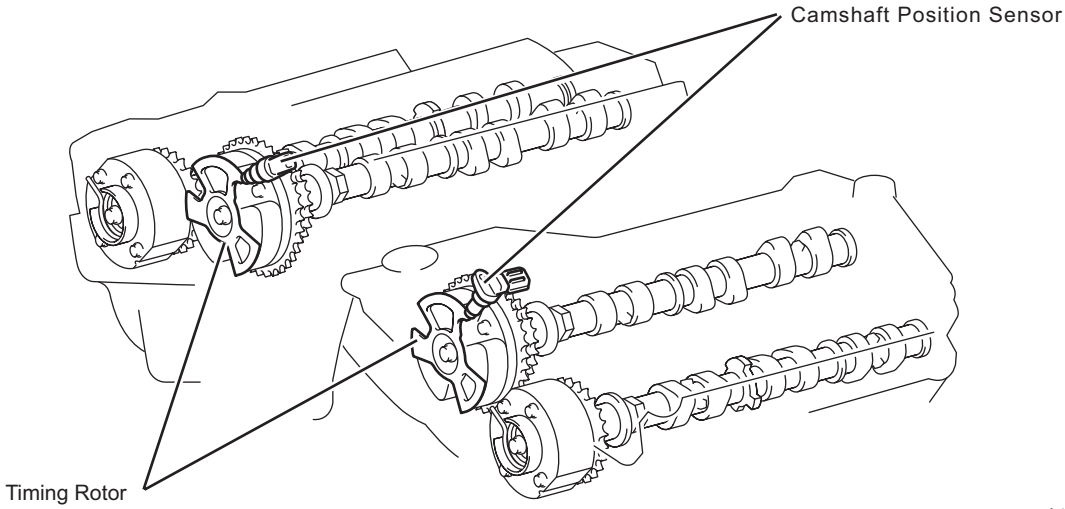
- The timing rotor of the crankshaft consists of 34 teeth, with 2 teeth missing. The crankshaft position sensor outputs the crankshaft rotation signals every 10°, and the missing teeth are used to determine the top-dead-center.
- This engine uses an electromagnetic pickup sensor that provides a high level of detection accuracy. When the crankshaft rotates, the air gap between the protrusion on the timing rotor and the crankshaft position sensor changes. This causes the magnetic flux that passes through the coil of the crankshaft position sensor to increase and decrease, causing the coil to generate an electromotive force. This electromotive force generates voltage in opposing directions, depending on whether the protrusion of the timing rotor approaches the crankshaft position sensor or withdraws from the sensor. Thus, the voltage appears in the form of alternating current voltage.



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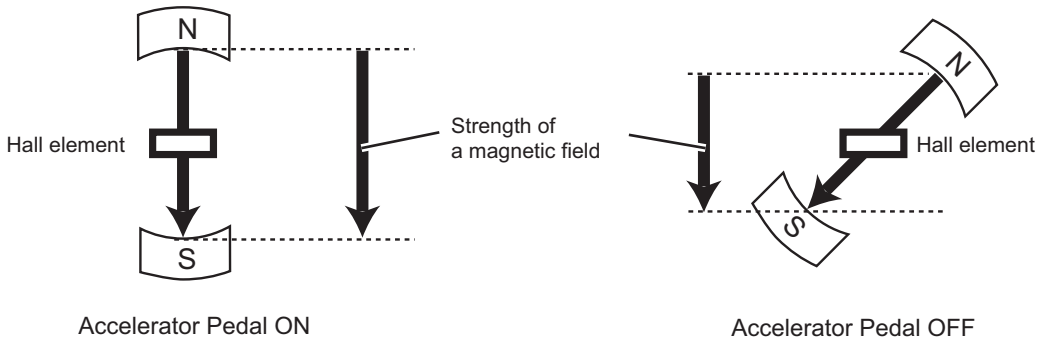
Camshaft Position Sensor

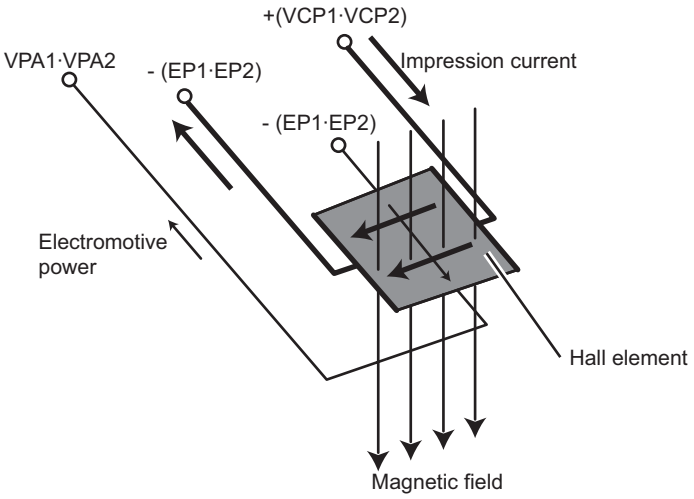
- These sensors are the MRE (Magnetic Resistance Element) type. The rotational movement of the timing rotor (which is provided in the VVT-i controller of the intake camshaft) causes a magnetic field to act on the magnetic resistance element in the sensor. The sensor utilizes the changes that occur in the direction of the magnetic field to detect the position of the timing rotor, which determines the position of the actual camshaft. The cylinders are identified by the input sequence of the Ne and G2 signals.

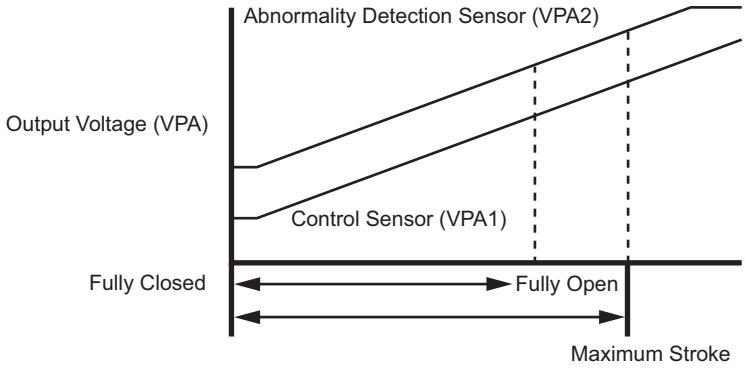


Accelerator Pedal Position sensor

● This sensor, which is mounted on the accelerator pedal, detects the amount of pedal effort applied to the accelerator. By using a Hall element, this electronic position sensor enables accurate control and ensures permanent reliability. When the amount of pedal effort applied to the accelerator changes, this sensor sends the angle of the magnetic field in relation to the flow of the applied current in the Hall element (VCP1 → EP1, VCP2 → EP2) in the form of an accelerator pedal effort signal to the engine ECU. In addition, this sensor consists of a dual system having different output characteristics to ensure reliability.







Accelerator Position Sensor Output Voltage Characteristics

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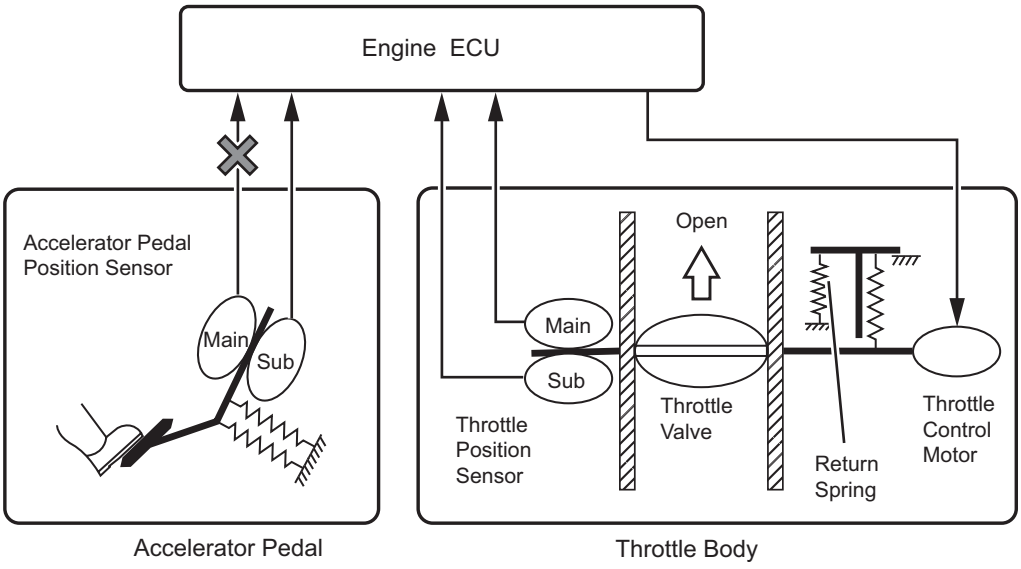
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Fail Safe

- The accelerator position sensor comprises two (main, sub) sensor circuits, to detect the pedal position. In case of an abnormal condition in the signal, the engine ECU switches to the failsafe driving mode.

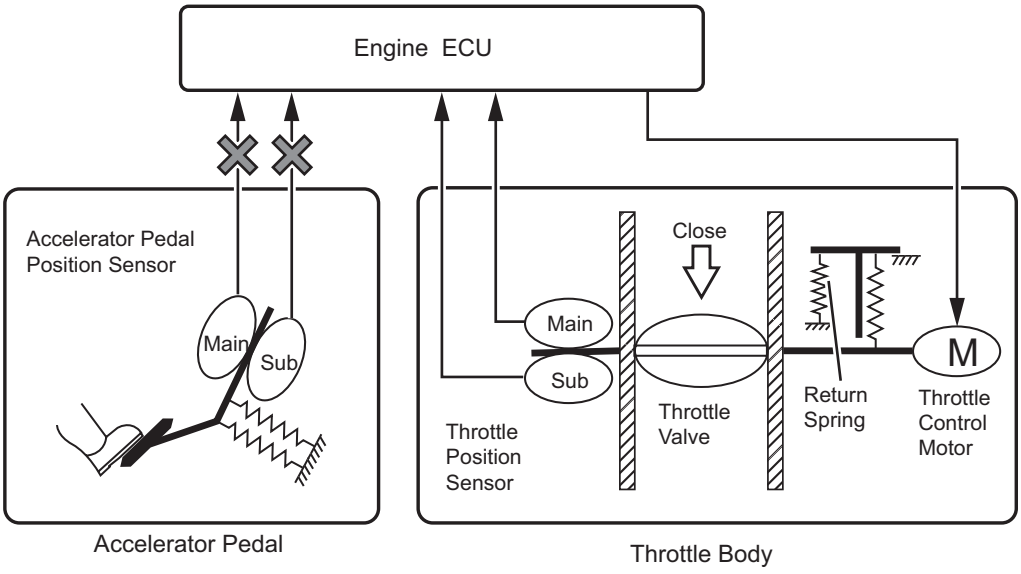
System 1 Failure

The accelerator pedal position sensor comprises two (main, sub) sensor circuits. If a malfunction occurs in either one of the sensor circuits, the engine ECU detects the abnormal signal voltage difference between these two sensor circuits and switches to the limp mode. In the limp mode, the remaining circuit is used to calculate the accelerator pedal opening, in order to operate the vehicle under limp mode control.



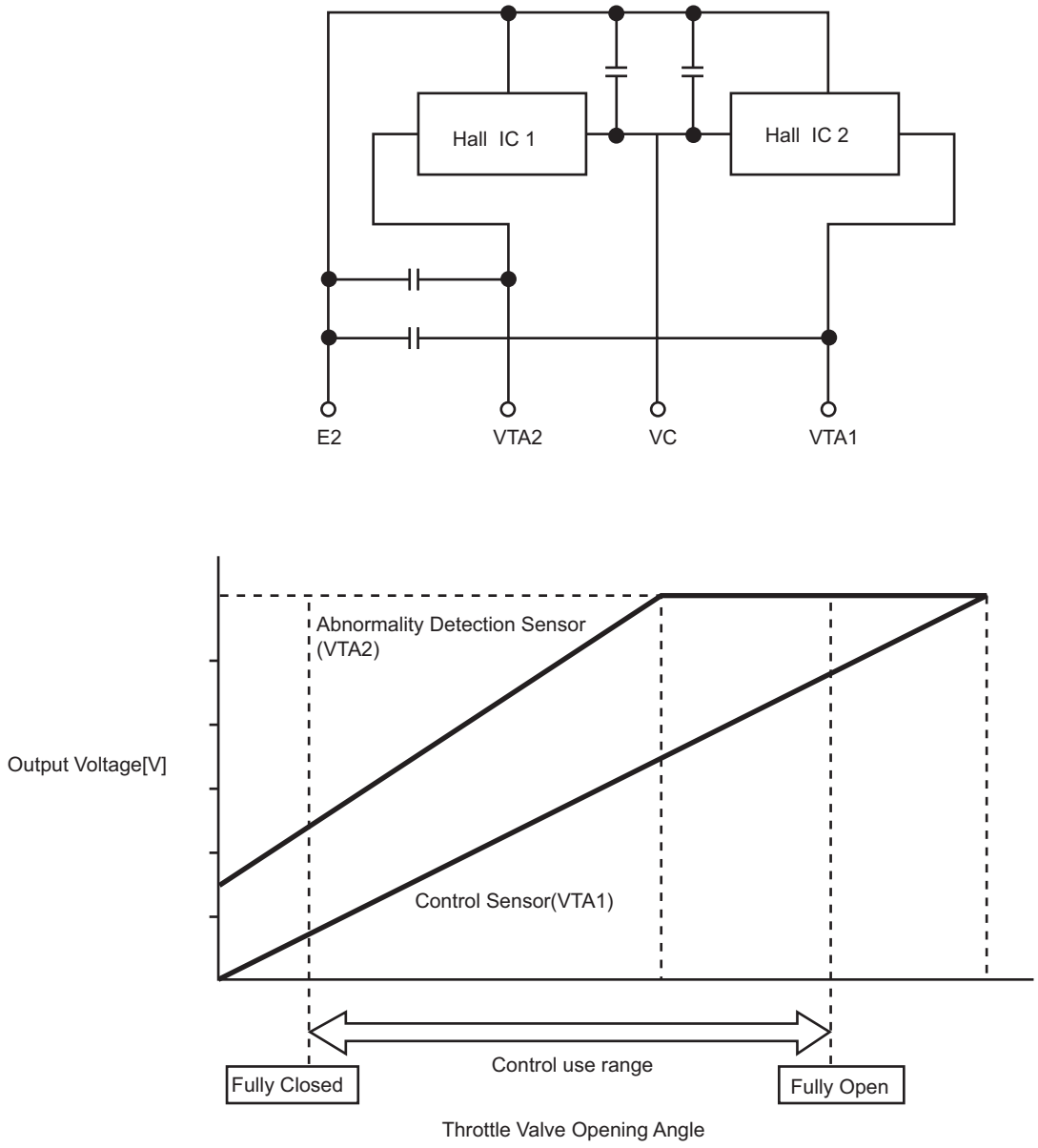
System 2 Failure

If both systems malfunction, the engine ECU detects the abnormal signal voltage between these two sensor circuits and regards that the opening angle of the accelerator pedal is fully opened and then continues the throttle control. At this time, the vehicle can be driven within its idling range.



Throttle Position Sensor

- This sensor, which is located in the throttle body, detects the position of the throttle valve. By using a Hall element, in the same way as the accelerator position sensor, this electronic position sensor enables accurate control and ensures permanent reliability. In addition, this sensor consists of a dual system having different output characteristics to ensure reliability.



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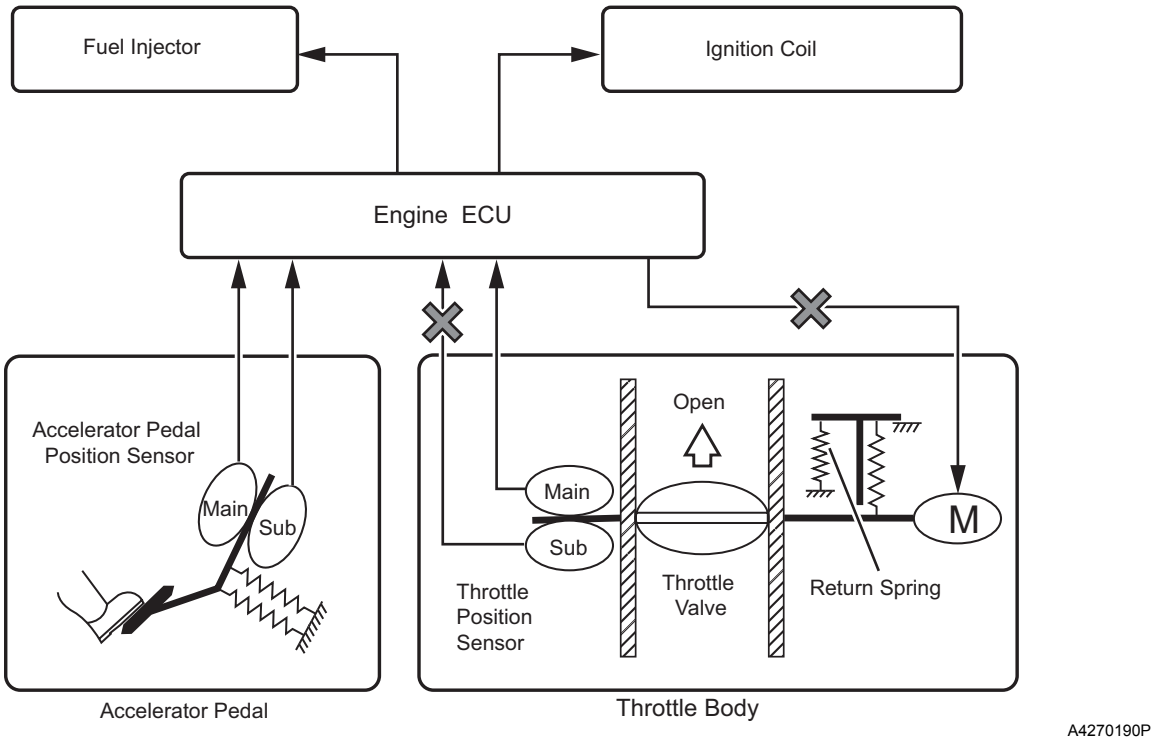
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Fail Safe

- The throttle position sensor comprises two (main, sub) sensor circuits, to detect the throttle position. In case of an abnormal condition in the signal, the engine ECU switches to the failsafe driving mode.

Failure Detection

The throttle position sensor comprises two (main, sub) sensor circuits. If a malfunction occurs in either one of the sensor circuits, the engine ECU detects the abnormal signal voltage difference between these two sensor circuits, cuts off the current to the throttle control motor, and switches to the limp mode. Then, the force of the return spring causes the throttle valve to return and stay at the prescribed opening. At this time, the vehicle can be driven in the limp mode while the engine output is regulated through the control of the fuel injection and ignition timing in accordance with the accelerator opening.

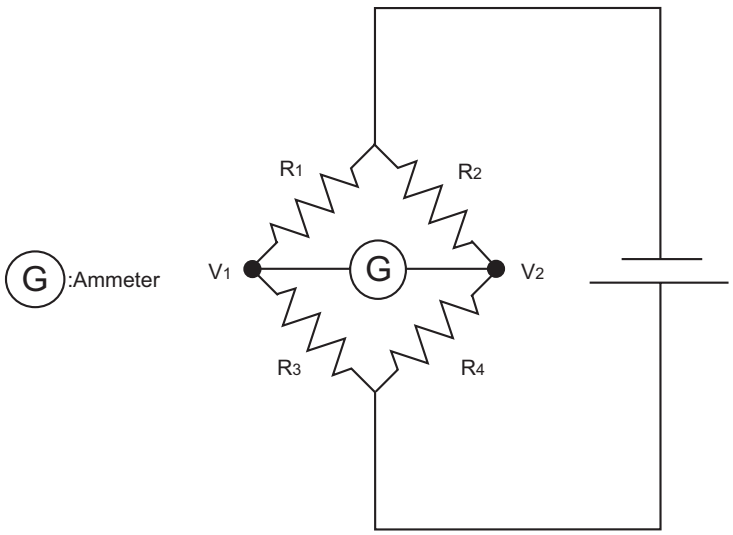


Air Flow Meter

- This 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 has been improved and the intake air resistance has been reduced.
- This air flow meter has a built-in intake air temperature sensor.
- This system measures the air flow in the bypass, which is less likely to be affected by the intake pulsations created by the air cleaner. Also, the flow path is constructed to minimize flow resistance, thus reducing flow loss. Therefore, this system can measure small to large airflow in a precise manner.

Hot Wire Type Air flow Meter Operation

- A hot-wire measurement portion measures the volume of the intake air that is partially routed through a bypass. The hot-wire, which uses a platinum filament, measures the intake air volume of the engine by comprising a bridge circuit that consists of an intake temperature measurement resistor and a heating resistor (heater). In principle, this airflow meter can directly measure the mass flow due to the nature of the hot-wire type air flow meter. Therefore, it does not require a density correction to counter the changes in the intake temperature. However, it does require intake temperature data in order to effect engine control such as in EFI (Electronic Fuel Injection). For this reason, the air flow meter contains a compact, thermistor type intake temperature sensor that detects the intake temperature.
- The bridge circuit is connected as shown in the diagram below. When R1 x R4 = R2 x R3 is established in this circuit, V1 becomes V2, causing the ammeter G to indicate 0.

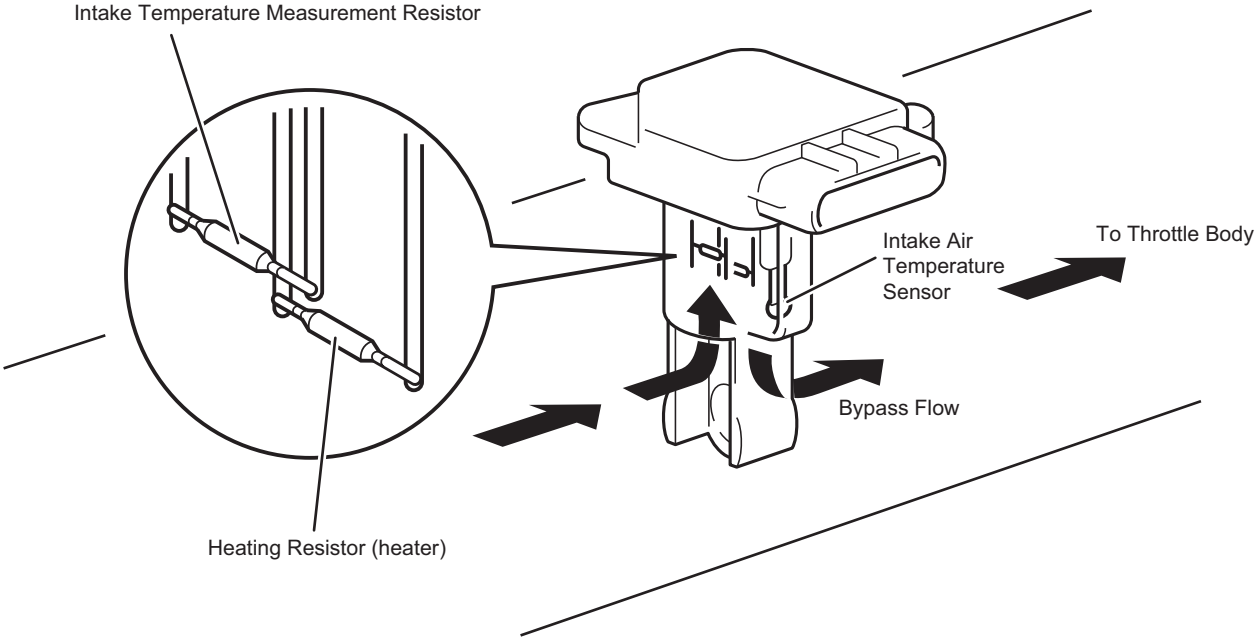


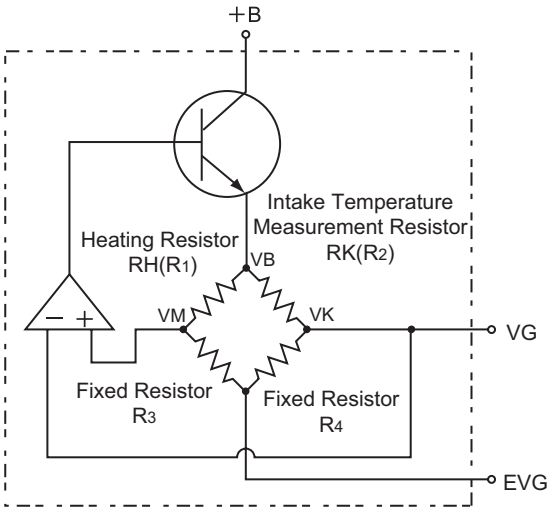
Bridge Circuit

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EG

- When the intake air volume changes, the bridge circuit in the hot-wire measurement portion effects feedback control to supply electricity to the heating resistor, in order to maintain a constant difference in temperature between the intake temperature measurement resistor and the heating resistor (heater). Then, it converts the supplied electricity into voltage and outputs it to the engine ECU. The engine ECU calculates the engine intake air volume based on a predetermined relationship between the air flow meter output voltage and the flow volume.
- The diagram below describes the configuration of the bridge circuit of the hot-wire type air flow meter. For example, if the intake volume that is drawn in increases, it cools the heating resistor and decreases the RH value, thus resulting in RH (R1) x R4 < RK (R2) x R3, VM≠VK. When the control unit detects this condition, it effects control to increase the amperage that flows from the power supply to VB (to heat RH), in order to result in RH (R1) x R4 = RK (R2) x R3, VM = VK.



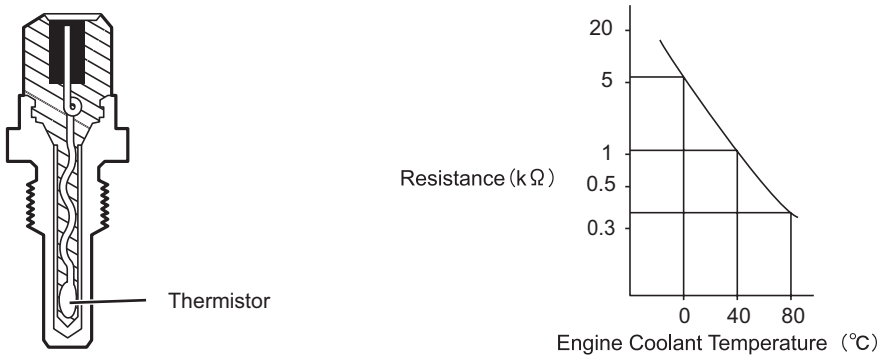


Bridge Circuit

A4270026P

Water Temp.Sensor

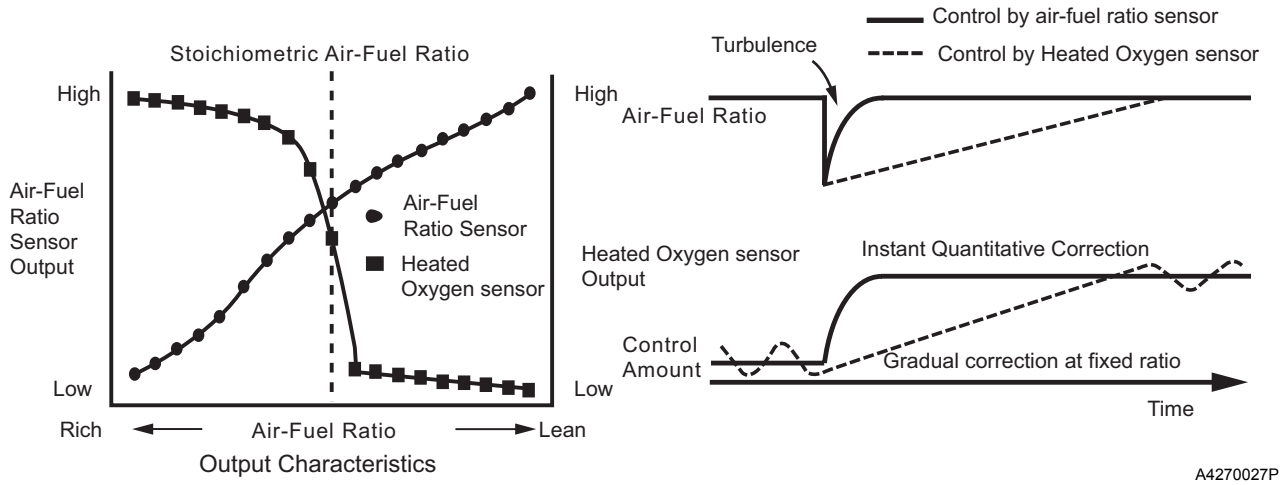
- This sensor detects the water temperature and sends a signal to the engine ECU.



A4270105P

Air Fuel Ratio Sensor

- An air-fuel ratio sensor is used to ensure the reliable feedback of the state of the air-fuel ratio in the exhaust gas. An heated oxygen sensor outputs a lean or rich signal bordering on the stoichiometric air-fuel ratio. In contrast, the air-fuel ratio sensor has output characteristics that are proportionate to the air-fuel ratio. Therefore, the engine ECU is able to effect a more precise control.
- As with the heated oxygen sensor, a heater is used to heat and maintain a constant temperature in the air-fuel ratio sensor, thus promoting the proper feedback control.



A4270027P

Heated Oxygen Sensor

- This sensor detects the oxygen concentration in the exhaust gas.

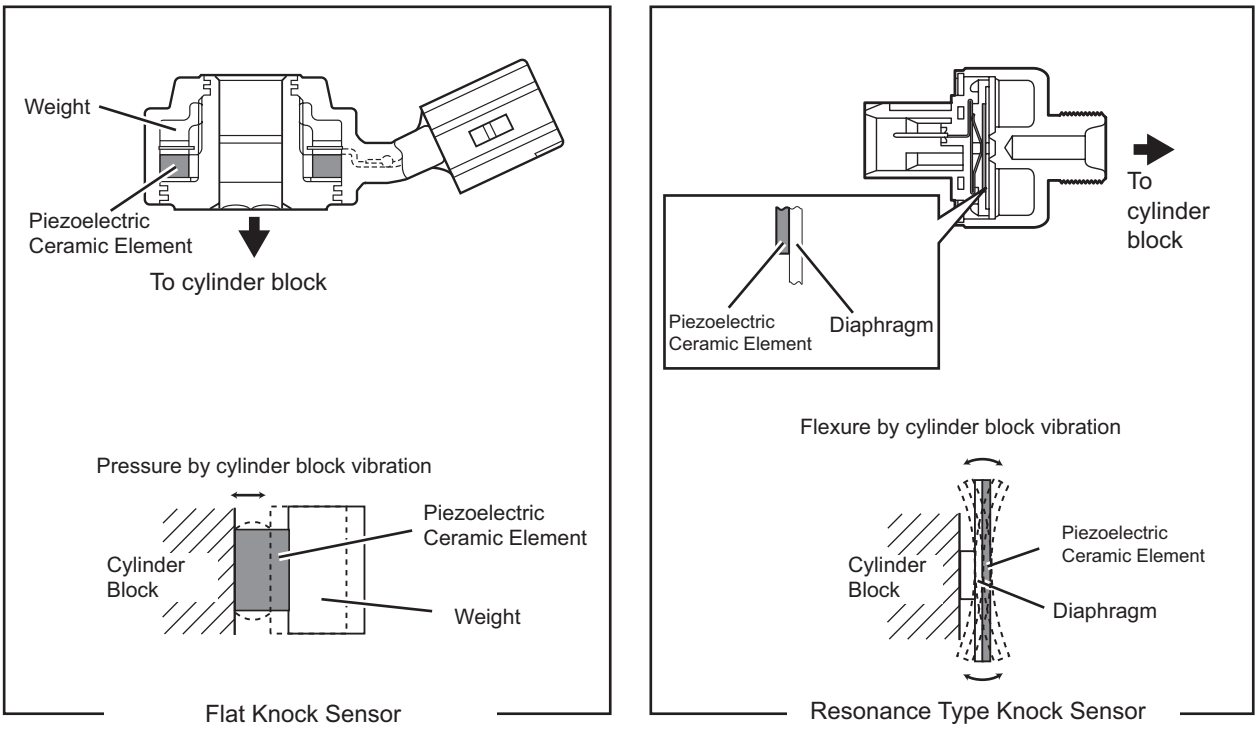
EG

Knock Sensor (Flat Type)

● When the conventional resonance type knock sensor receives vibrations from the cylinder block, a diaphragm on a piezoelectric ceramic element flexes along the area where it is mounted to the cylinder block acting as the fulcrum. This causes a pressure to act on the piezoelectric ceramic element, which generates a voltage. In contrast, when the flat (non-resonance type) knock sensor receives vibrations from the cylinder block, a delayed movement of the weight occurs in the sensor due to the inertial force of the weight. This causes a pressure to be applied to a piezoelectric ceramic element, which is provided between the cylinder block and the weight, thus generating a voltage.

Knock Sensor Operation

• In the conventional resonance type knock sensor, the diaphragm resonates at a certain frequency at which the engine knocks. Therefore, when the knock sensor generates an output, the engine ECU determines that knocking has occurred. In contrast, the flat (non-resonance type) knock sensor has practically constant output characteristics in all frequency ranges. Therefore, the engine ECU can detect a target frequency at which knocking occurs, enabling a more accurate knocking detection.



A4270028P

Camshaft Timing Oil Control Valve

- In accordance with the duty cycle signals received from the engine ECU, this OCV controls the position of the spool valve in order to constantly achieve optimal valve timing. When the engine is stopped, the force of a spring keeps the intake side of the spool valve in the most retarded state, and the exhaust side to the most advanced state, in order to ready the valves for the subsequent starting.
  (See page EG-63)

Injector

- Injectors with 4 orifices are used. They are mounted directly into the cylinder heads to shorten the distance to the combustion chambers, thus reducing the adhesion of fuel to the intake ports.
  (See page EG-76)

Fuel Pump

- A fuel pump assembly consisting of a fuel pump, fuel filter, and sender gauge is used.
  (See page EG-73)

Ignition Coil (with Igniter)

- Ignition coils with built-in igniters are used and placed directly over the spark plugs.
  (See page EG-95)

VSV (For EVAP)

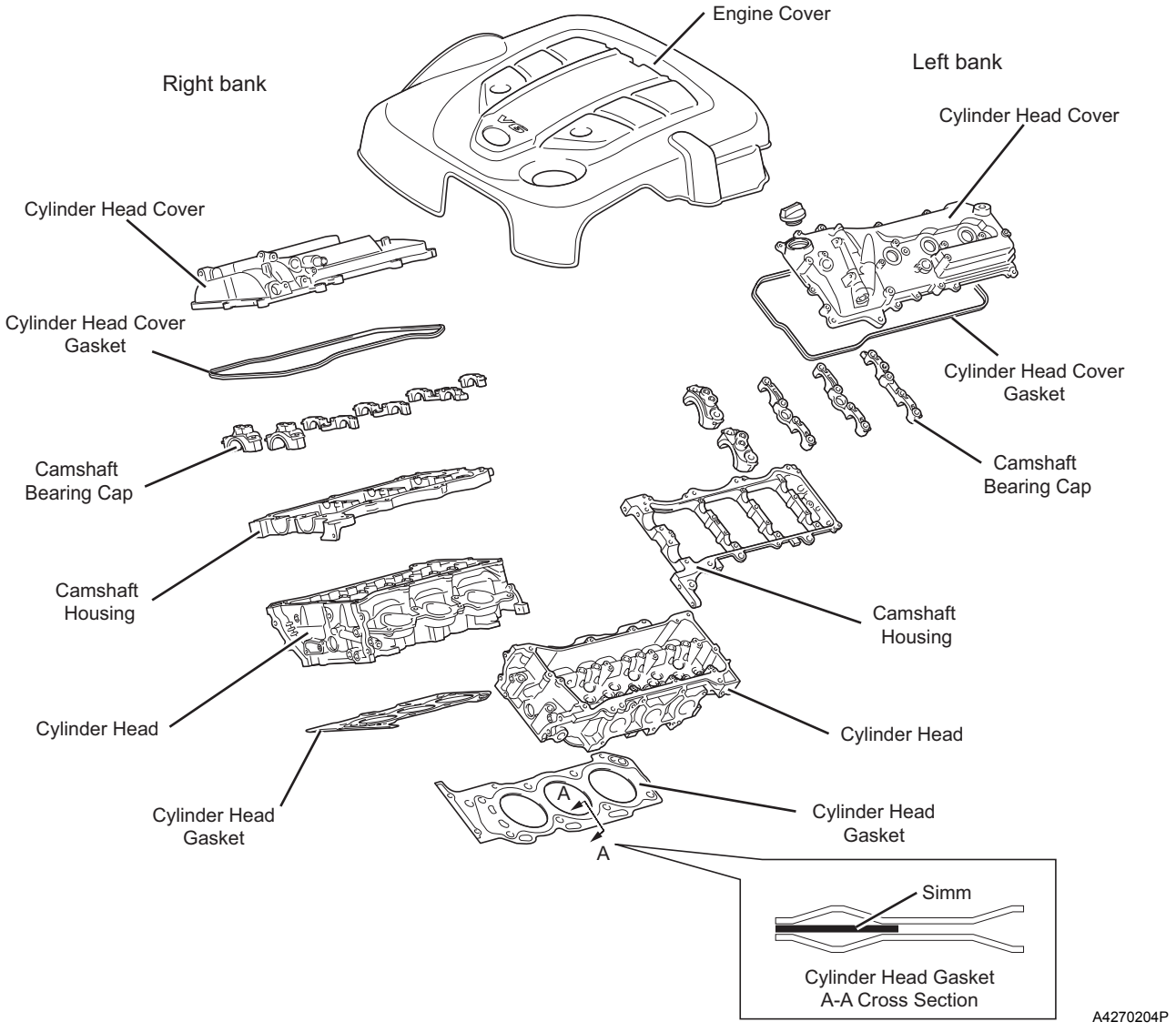
- Regulates the purge volume of the canister.

3GR-FE ENGINE MECHANICAL

EG

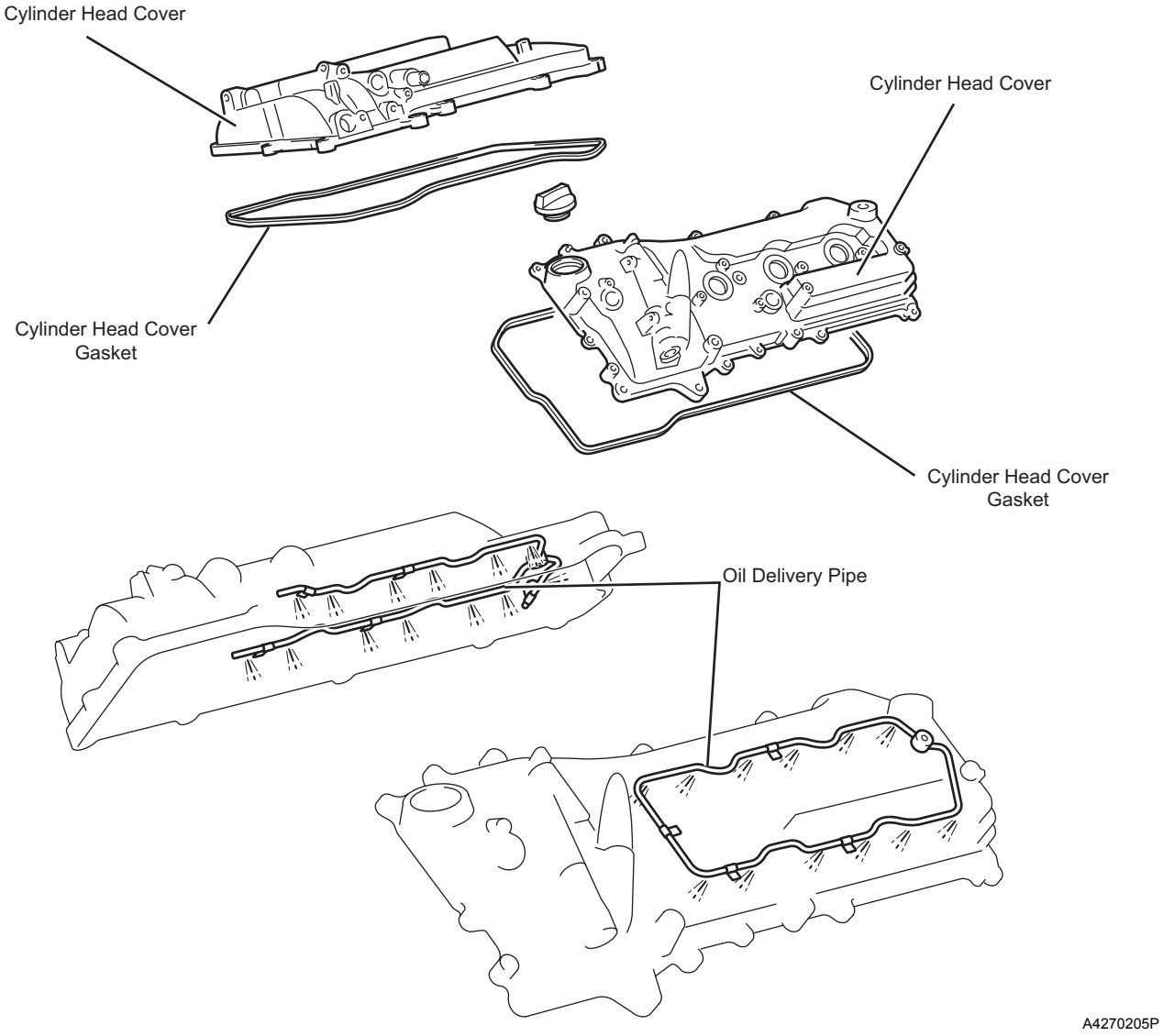
Cylinder Head Fitting Parts

- The cylinder heads are made of a lightweight and highly rigid aluminum alloy. Also, the VVT-i supply oil passage has been separated from the cylinder heads to simplify the oil passage in the cylinder heads.
- The cylinder head gaskets are the two-layer metal type. Shims are provided around the bores to ensure sealing performance and durability.
- The cylinder head covers are made of a lightweight aluminum alloy. They are tightened to the cylinder heads by way of fixed-dimension flanges along their periphery to ensure the proper sealing performance.
- OCVs (oil control valves) for Dual VVT-i are mounted on both the right and left cylinder head covers.
- The cylinder head cover gaskets are made of acrylic rubber, which excels in heat resistance and oil resistance.



Cylinder Head Cover

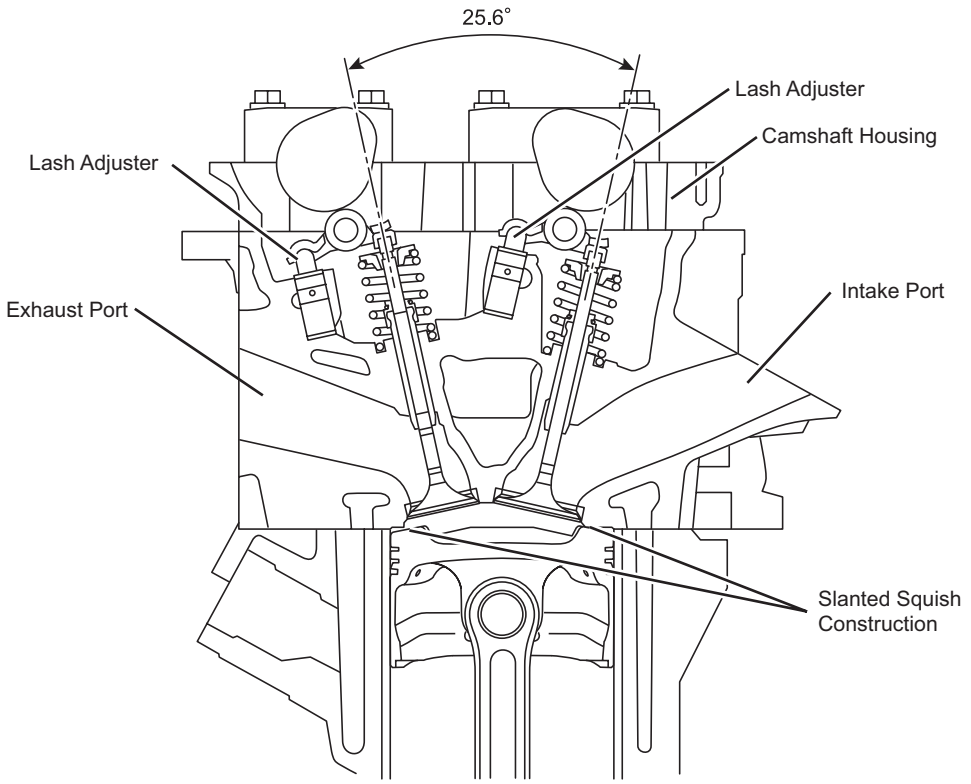
- Large baffle plates are built into the right and left head covers. By reducing the flow rate of blowby gas, these baffle plates remove oil droplets and oil mist, thus reducing the volume of oil taken away.
- Oil delivery pipes are provided to supply engine oil, in order to properly lubricate the sliding areas of the roller rocker arms, thus enhancing their reliability.



EG

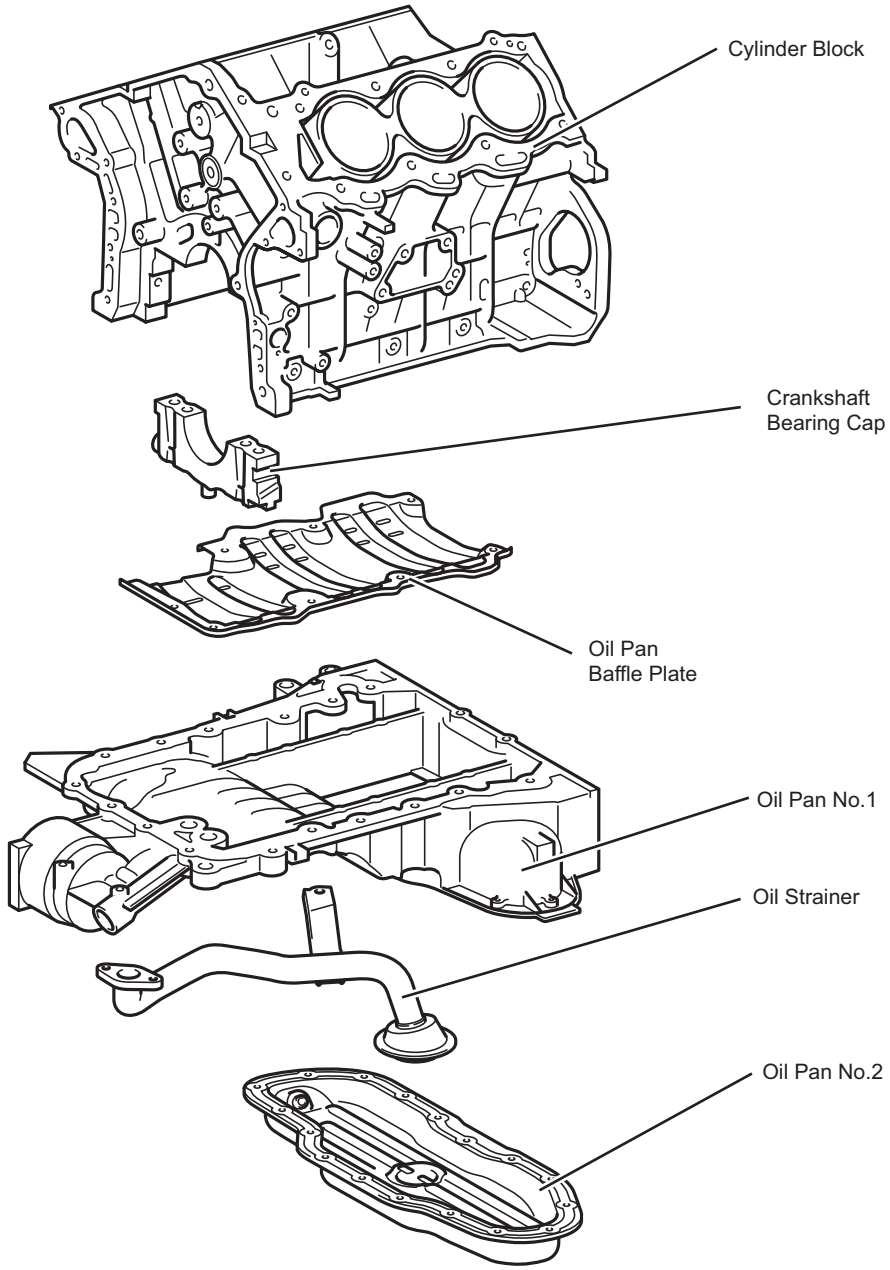
Cylinder Head

- By using a two-piece construction in which the portion that receives the cam journals is separate from the cylinder head proper, the configuration of the cylinder head proper has been simplified. This results in weight reduction and improved serviceability.
- Pentroof combustion chambers are used. A spark plug is located practically in the center of each combustion chamber to enhance combustion efficiency and knock resistance. Furthermore, the angle between the intake and exhaust valves has been narrowed to 25.6 degrees, thus making the combustion chamber compact.
- The port configuration is an efficient cross-flow type in which the intake ports face the inside of the V bank and the exhaust ports face the outside. The intake and exhaust ports have a Siamese construction. The intake port configuration has been optimized to realize high intake efficiency.
- The diameter of the valve stem and the outer diameter of the valve guide have been reduced to reduce intake resistance.
- The cylinder head bolts are tightened with the plastic region tightening method in order to stabilize the axial tension of the bolts.



Cylinder Block Fitting Parts

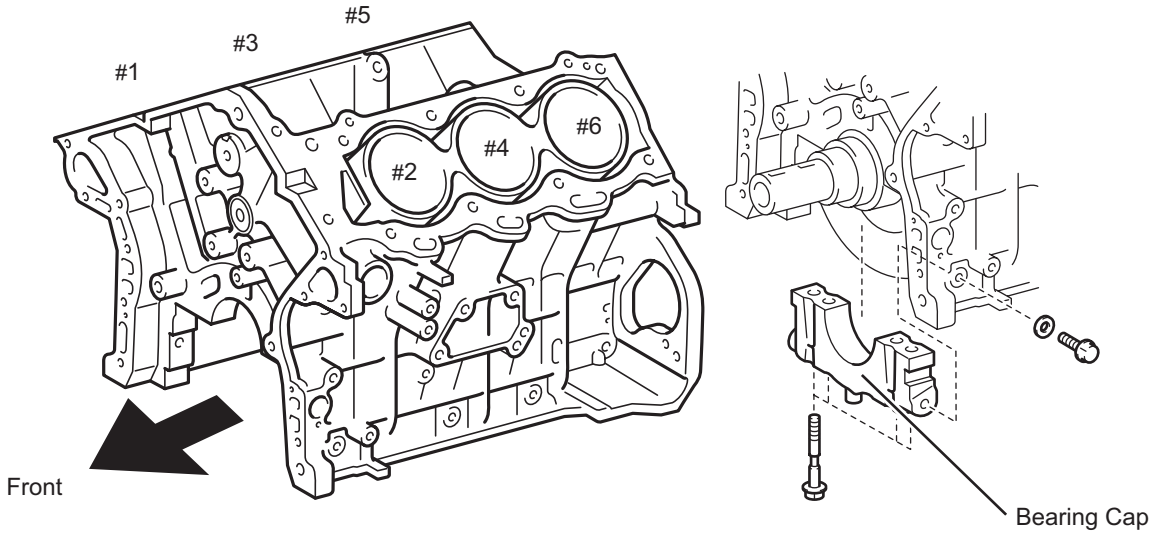
- The cylinder block is made of an aluminum alloy to realize a dramatic weight reduction. Furthermore, it has been made compact in terms of both overall length and width as follows: a 60° V6 bank angle, a 36.6mm(1.441in.) bank offset, and a 105.5mm(4.154in.) bore center distance.
- The oil pan consists of a two-piece construction. Oil pan No. 1 is made of an aluminum alloy, and oil pan No. 2 is made of stamped steel sheet. Oil pan No. 1 has built-in stiffeners that tighten the cylinder block and the transaxle case together. This increases the rigidity of the entire power plant, resulting in reduced vibration and weight reduction.
- Appropriate ribs are placed on the outer wall of the cylinder block to increase rigidity.
- An FIPG (Formed-In-Place Gasket), which excels in sealing performance, is used on the mating surfaces of the oil pan.



EG

Cylinder Block

- The cylinder liner is a centrifugal cast iron liner insert. Its outer spiny surface enhances contact with the aluminum block, thus improving heat dissipation. This lowers the temperature of the piston and suppresses the deformation of the bore.
- The outer walls of the block are curved and reinforcement ribs are provided on the end of the block that is coupled to the transmission in order to attain a high level of rigidity.
- The oil return holes from the cylinder heads and the blowby gas passages have been optimally arranged to ensure the smooth return of oil and heighten the rigidity of the side faces of the cylinder block.
- Drilled coolant passages are provided between the bores in order to positively cool the upper areas of the cylinder bores, which are easily affected by heat. Thus, a more uniform temperature distribution has been achieved in the circumferential direction of the bore wall surface. This improves knocking resistance and minimizes the heat deformation that occurs between the cylinder bores. Thus, an engine with low friction, high performance, and enhanced fuel economy has been achieved.
- A knock sensor is provided on both the right and left sides of the V bank, enabling optimal knock control.
- The crankshaft bearing caps are made of cast iron, and each is tightened with 4 bolts from the bottom, using the plastic region tightening method. Also, each bearing cap is tightened from both sides together with the cylinder block, which increases rigidity and decreases vibration and noise.



Bearing cap attachment appearance

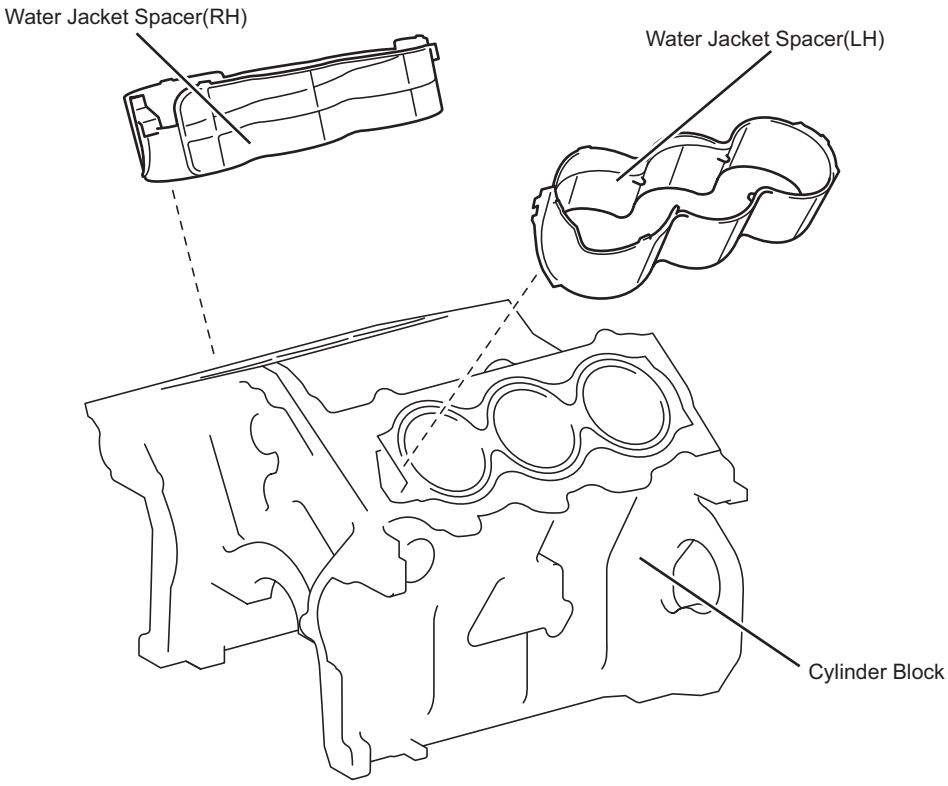
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Cylinder Block

Overall Length	[mm (in.)]	402.1 (15.831)
Overall Width	[mm (in.)]	408.0 (16.063)
Overall Height	[mm (in.)]	320.1 (12.606)
Bore Diameter	[mm (in.)]	87.5 (3.445)
Bore Center Distance	[mm (in.)]	105.5 (4.154)
Bank Offset	[mm (in.)]	36.6 (1.441)

Water Jacket Spacer

- A water jacket spacer made of plastic, which excels in heat resistance and forming precision, is provided in the water jacket of the cylinder block. This optimizes heat distribution along the cylinder bore wall and reduces friction.



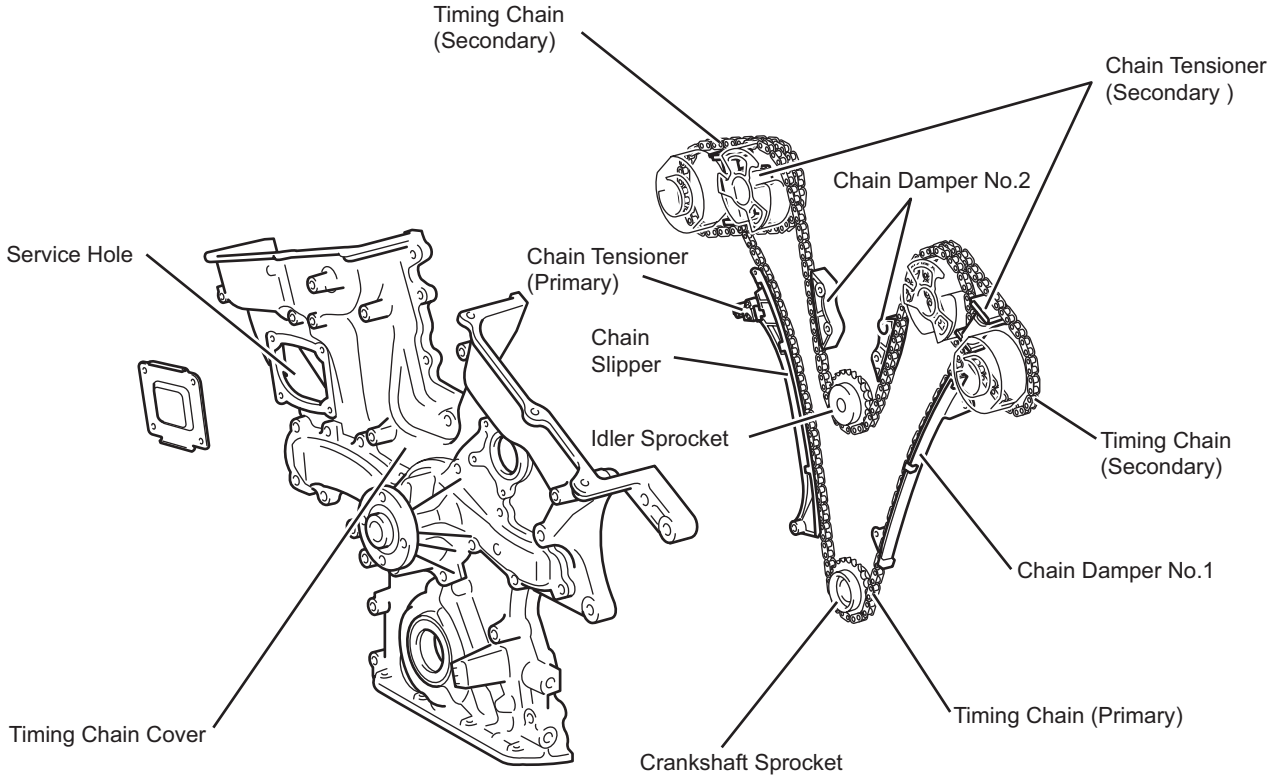
Function of Water Jacket Spacer

The water jacket spacer suppresses the water flow in the center of the water jacket. This increases the flow speed of the coolant along the upper part of the cylinder bore, thus improving the cooling of the upper area of the cylinder block and between the cylinder bores. Furthermore, the area near the center of the cylinder bore becomes less susceptible to the influences of the coolant, allowing the temperature along the wall surface to rise. These measures decrease the temperature differences along the surface of the cylinder bore wall and enable uniform thermal expansion. In addition, these measures lower the viscosity of the engine oil that adheres to the surface of the bore wall, thus reducing friction.

EG

Timing Chain

- The timing mechanism is a chain-driven system that is maintenance-free. Both the primary and secondary timing chains consist of 9.525mm (0.375in.)pitch, high-strength, single-row roller chains and compact sprockets, which contribute to making the engine compact.
- A two-stage chain system is used. It consists of a primary chain that enables the crankshaft to drive the right and left intake camshafts, and a secondary chain that enables the intake camshafts to drive the exhaust camshafts.
- The primary chain uses a check ball type chain tensioner with a ratchet mechanism that uses both engine oil pressure and a spring force. The secondary chain uses a compact tensioner that directly pushes on the chain by using engine oil pressure and a spring force. These tensioners constantly apply optimal tension to the timing chains in order to ensure a quiet and reliable operation.
- The timing chain cover is made of an aluminum alloy that is lightweight and excels in sound insulation capability. The one-piece cover seals the front of the cylinder block, camshaft housing, and cylinder head. The crankshaft sprocket is provided with a guide that prevents the chain links from jumping. This prevents the chain from being installed incorrectly during maintenance, as a result of the chain falling out. A service hole for the primary chain tensioner is provided in the timing chain cover to facilitate maintenance.
- The chain dampers and the tensioner shoes are made of a plastic material that excels in wear resistance.



A4270063P

Sprocket

	Number of Teeth
Crankshaft Sprocket	18
Idler Sprocket	18
Camshaft Sprocket (Primary)	36
Camshaft Sprocket (Secondary: IN)	24
Camshaft Sprocket (Secondary: EX)	24

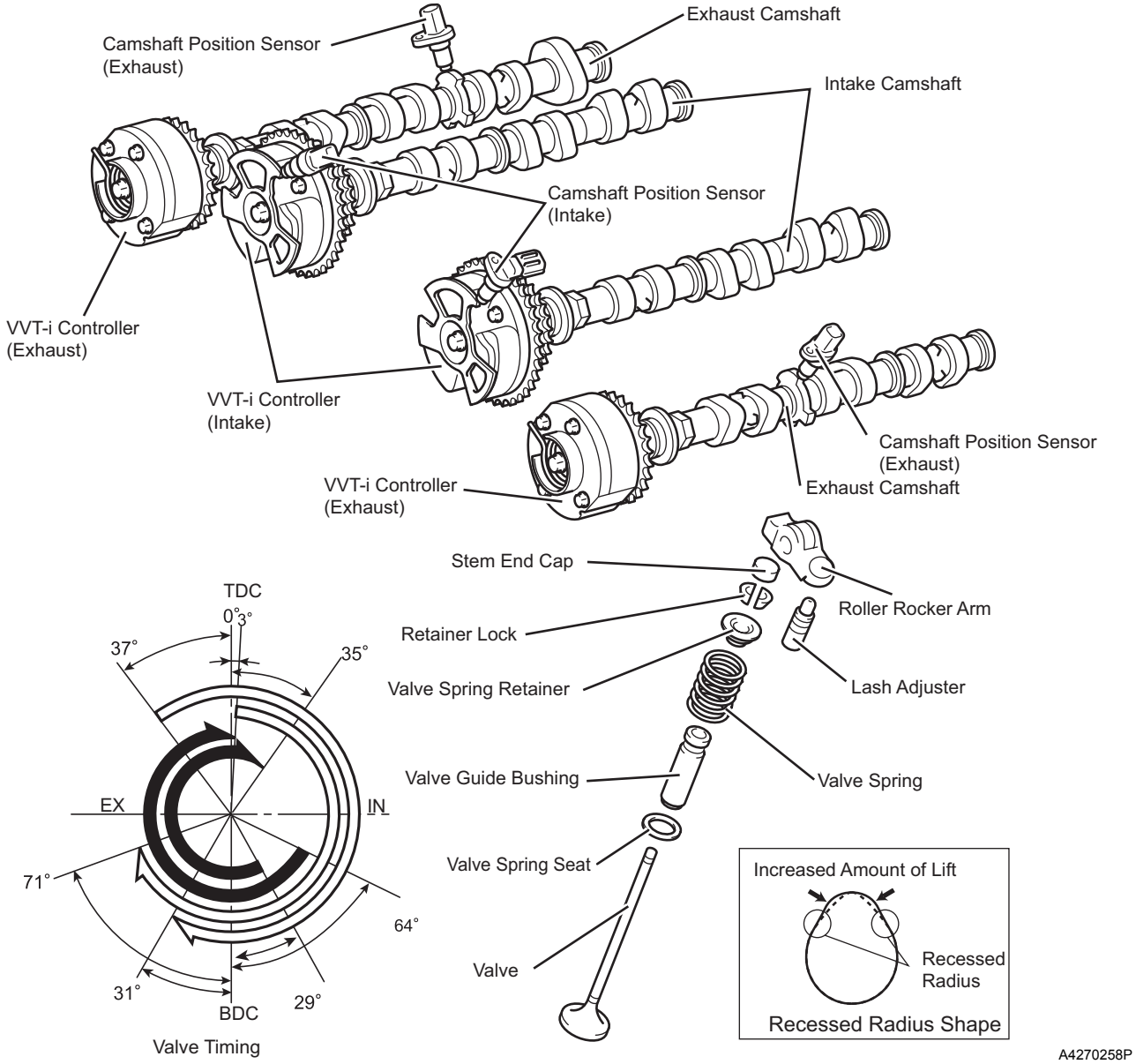
Timing Chain

	Number of Links
Timing Chain (Primary)	170
Timing Chain (Secondary)	46

EG

Valve Mechanism

- A Dual VVT-i (Dual Variable Valve Timing-intelligent : continuously variable intake and exhaust valve timing mechanism) system is used to control the intake camshaft and the exhaust camshaft to an optimal valve timing in accordance with the driving conditions.
- The camshafts are made of alloyed cast iron. Their cams are induction hardened and their surfaces are finished with a higher precision to improve wear resistance and reduce friction.
- Roller rocker arms are used in the valve train in order to dramatically reduce friction between the cams and the sliding surfaces to improve fuel economy. In addition, hydraulic lash adjusters are used, making valve clearance adjustments unnecessary and facilitating service.
- Along with the use of the roller rocker arms, the cam profile has been shaped with recessed radii. This increases the amount of valve lift near the beginning of the opening of the valve and near the end of the closing of the valve, in order to further increase power output.



Camshaft

	Intake	Exhaust
Cam Lift Amount [mm (in.)]	5.99 (0.236)	6.14 (0.241)
Cam Lobe Width [mm (in.)]	15.35 (0.604)	14.1 (0.555)

Valve

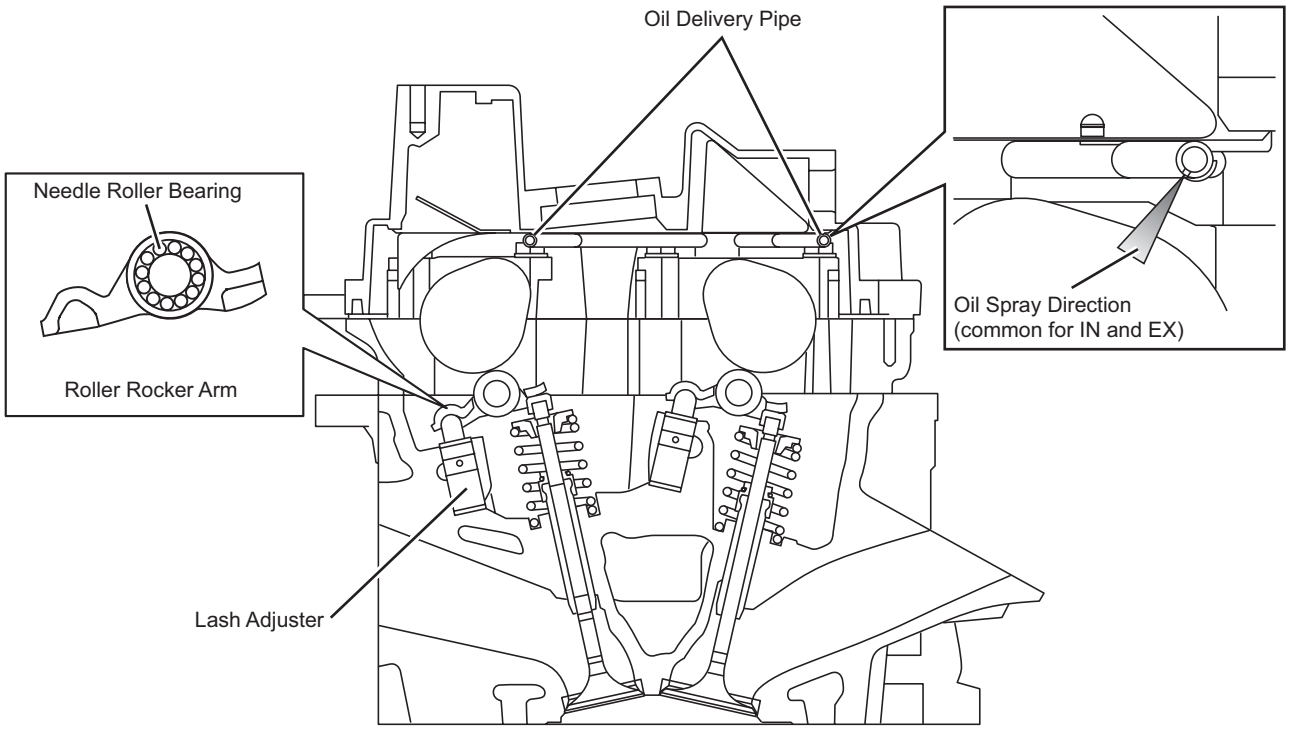
	Intake	Exhaust
Overall Length [mm (in.)]	105.65 (4.159)	111.5 (4.390)
Face Diameter [mm (in.)]	34.5 (1.358)	29.0 (1.142)
Stem Diameter [mm (in.)]	5.5 (0.217)	←

Valve Spring

Wire Diameter [mm (in.)]	3.3 (0.130)
Coil Inner Diamet [mm (in.)]	18.0±0.2 (0.709±0.008)
Free Length [mm (in.)]	46.51 (1.831)

Roller Rocker Arm

- The rocker arm is made compact and lightweight with a stamped steel arm with built-in needle bearings. The roller is supported by needle roller bearings that dramatically reduce friction at the sliding area, which contributes to fuel economy.
- An oil delivery pipe system is used for supplying oil to the roller rocker arms. This system positively supplies oil from above the camshaft to the lubrication area to ensure reliability.



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Camshaft

	Intake	Exhaust
Cam Lift Amount [mm (in.)]	5.99 (0.236)	6.14 (0.241)
Cam Lobe Width [mm (in.)]	15.35 (0.604)	14.1 (0.555)

Valve

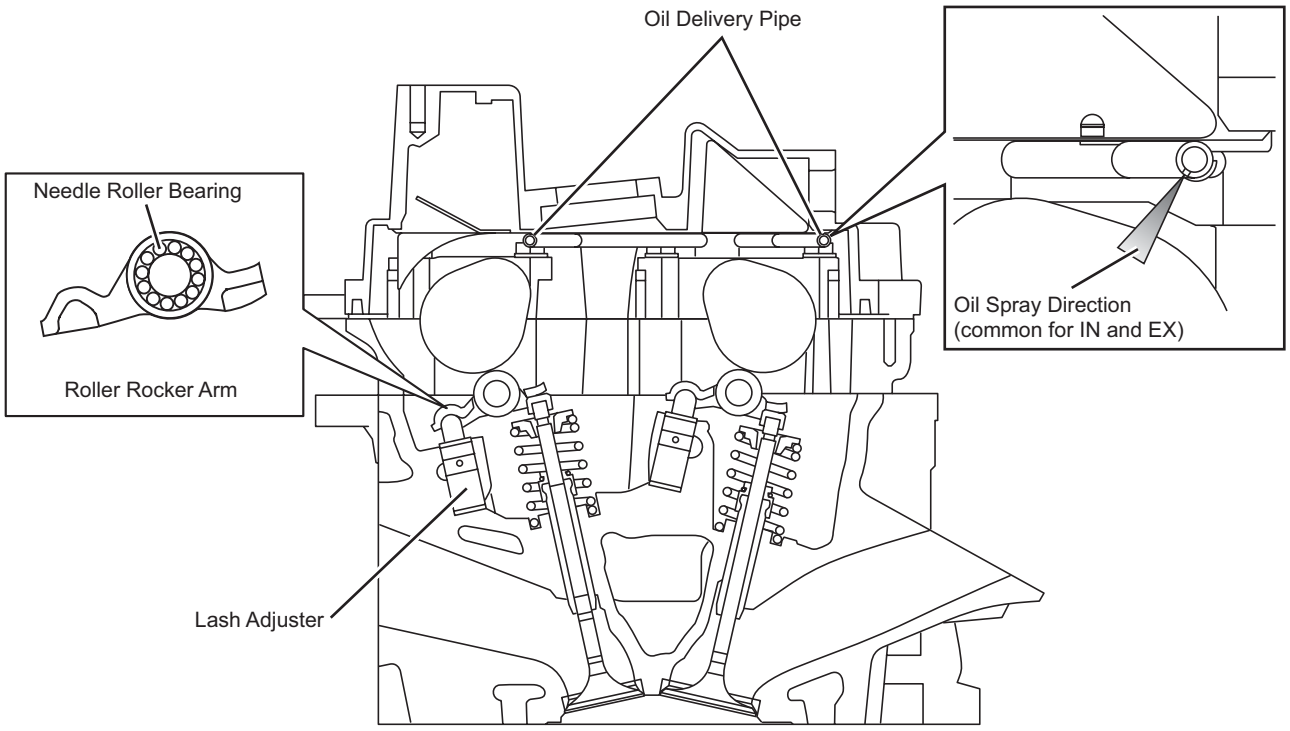
	Intake	Exhaust
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- An oil delivery pipe system is used for supplying oil to the roller rocker arms. This system positively supplies oil from above the camshaft to the lubrication area to ensure reliability.



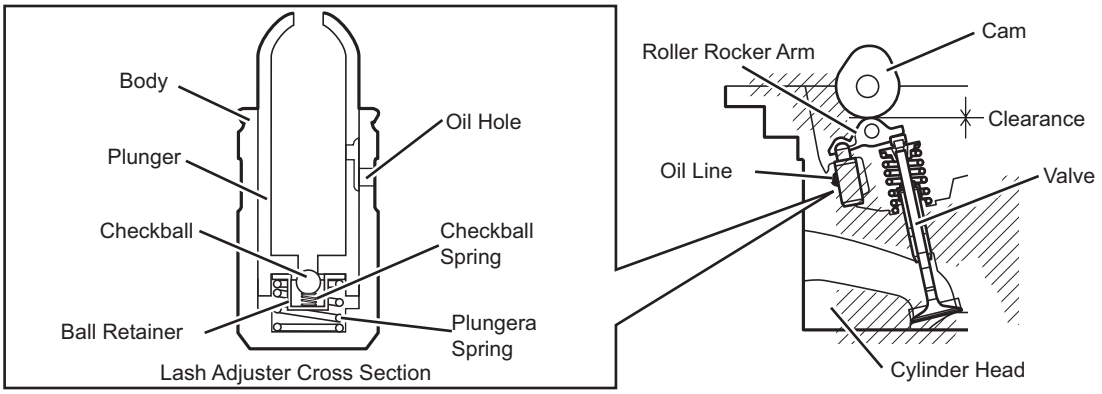
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EG

Lash Adjuster

Lash Adjuster Construction

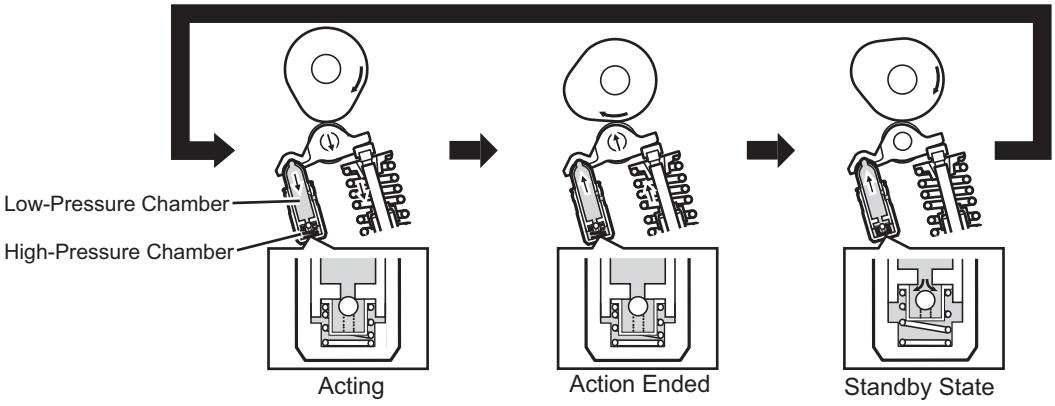
- Compact, hydraulic lash adjusters are used to constantly eliminate the gap (clearance) between the cams and rocker arms, thus enhancing the quiet performance of the engine.
- The lash adjuster is placed at the fulcrum of the rocker arm at the opposite end of the valve, and uses the oil that is supplied by the cylinder head as the operating fluid. The plunger in the lash adjuster body slides vertically due to the repulsion of the plunger spring or the hydraulic force in order to adjust the clearance.



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Lash Adjuster Operation

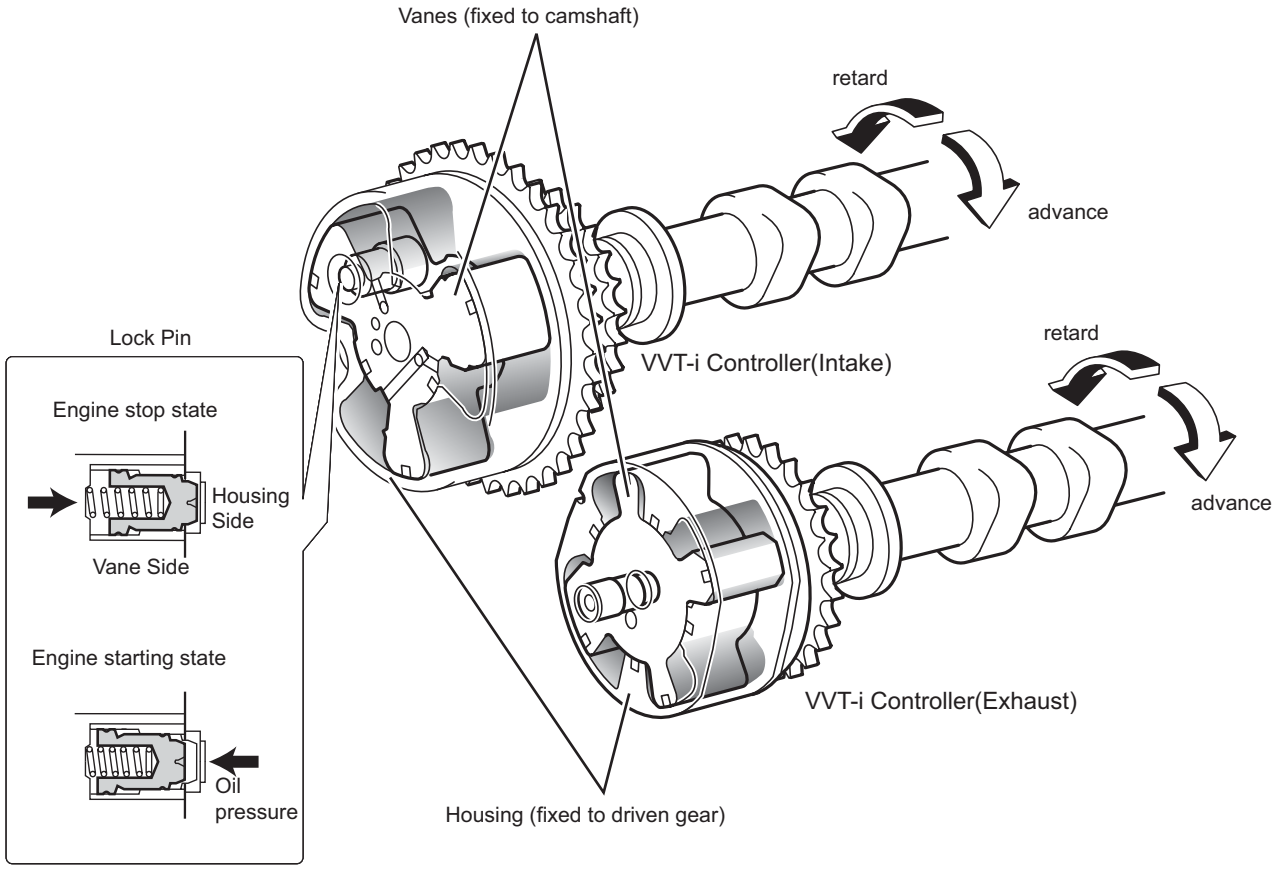
- The camshaft rotates clockwise, causing the cam to push on the rocker arm (acting), and a load is applied to both the valve and the plunger. At this time, the plunger almost gets pushed in, but because the check ball closes, the plunger stops. This allows the rocker arm to tilt in the clockwise direction, using the top of the plunger as the fulcrum, thus pushing the valve down.
- When the cam gets past the apex, the force of the valve spring causes the rocker arm to start ascending. However, because the force of the valve spring also acts on the lash adjuster, the high pressure chamber maintains its hydraulic pressure.
- When the valve closes (action ended), the oil in the high-pressure chamber is released from the pressurized state. At this time, a valve clearance is about to be created. However, the force of the plunger spring causes the plunger to push the rocker arm upward in order to maintain a constant zero valve clearance. At the same time, the capacity of the high-pressure chamber increases, creating a pressure difference between the high-pressure and low-pressure chambers. When this pressure difference becomes greater than the force of the check ball spring, the check ball moves downward to provide an oil passage. This allows the oil to flow from the low-pressure chamber to the high-pressure chamber in preparation for the next movement (standby state).



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Dual VVT-i Controller

- The VVT-i controller is a vane type that has low friction and is highly efficient while it is being driven.
- The VVT-i controller for the intake is a 3-vane type, and a 4-vane type for the exhaust. When the engine is stopped, a lock pin locks the vanes for the intake in the most retarded position and the vanes for the exhaust in the most advanced position.
- The VVT-i for the exhaust is provided with an advance assist spring that provides a torque assist in the advance direction so that the lock pin engages securely when the engine is stopped.
- Based on the signals provided by the sensors, the ECM controls the hydraulic pressure that acts on the advance chamber and retard chamber in the VVT-i controller, via an OCV (Oil Control Valve) that is mounted on the cylinder head cover. Thus, it continuously varies the phases of the intake and exhaust camshafts.



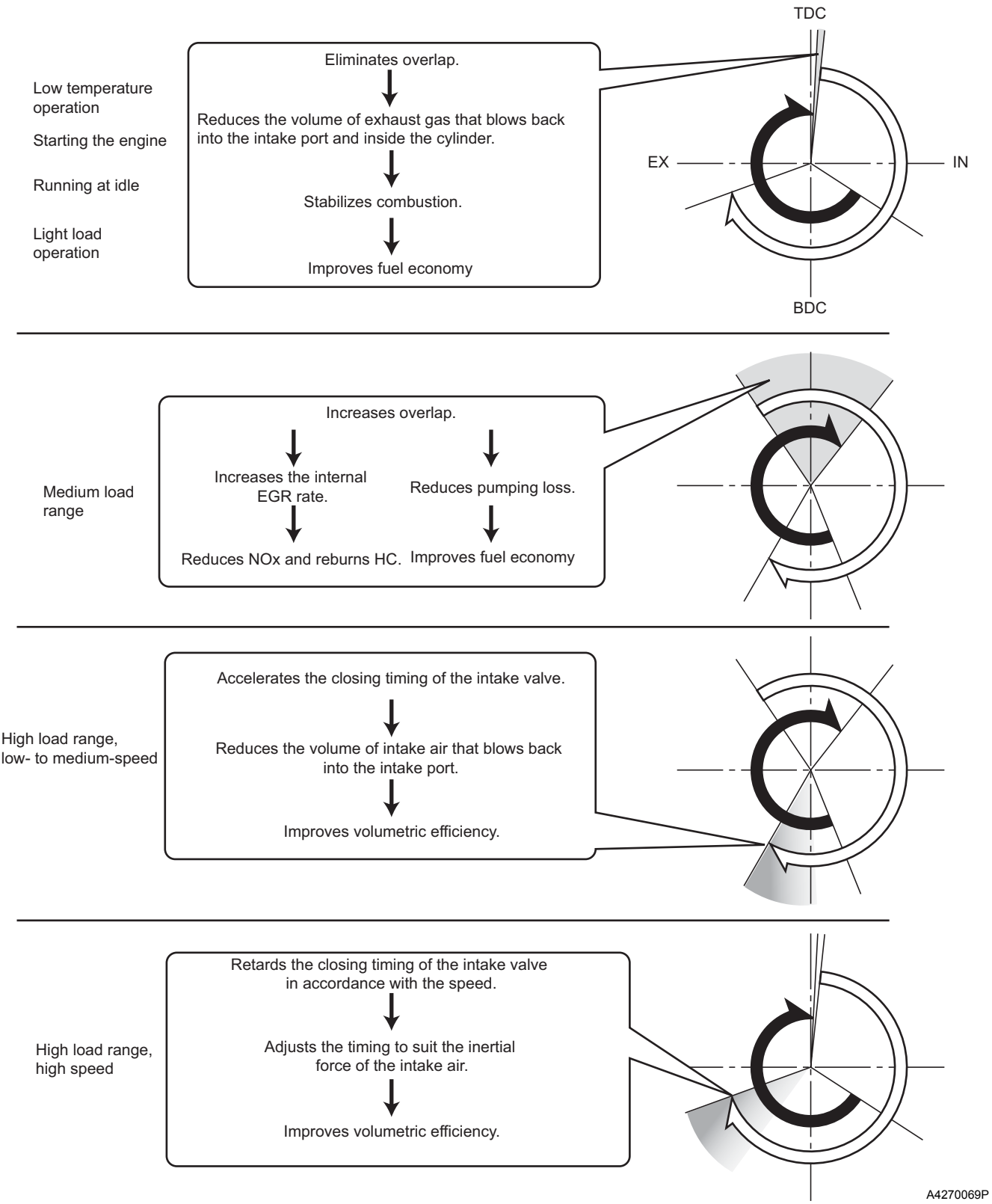
*The drawing shows the VVT-i controller for the intake in the retarded state and the VVT-i controller for the exhaust in the advanced state.

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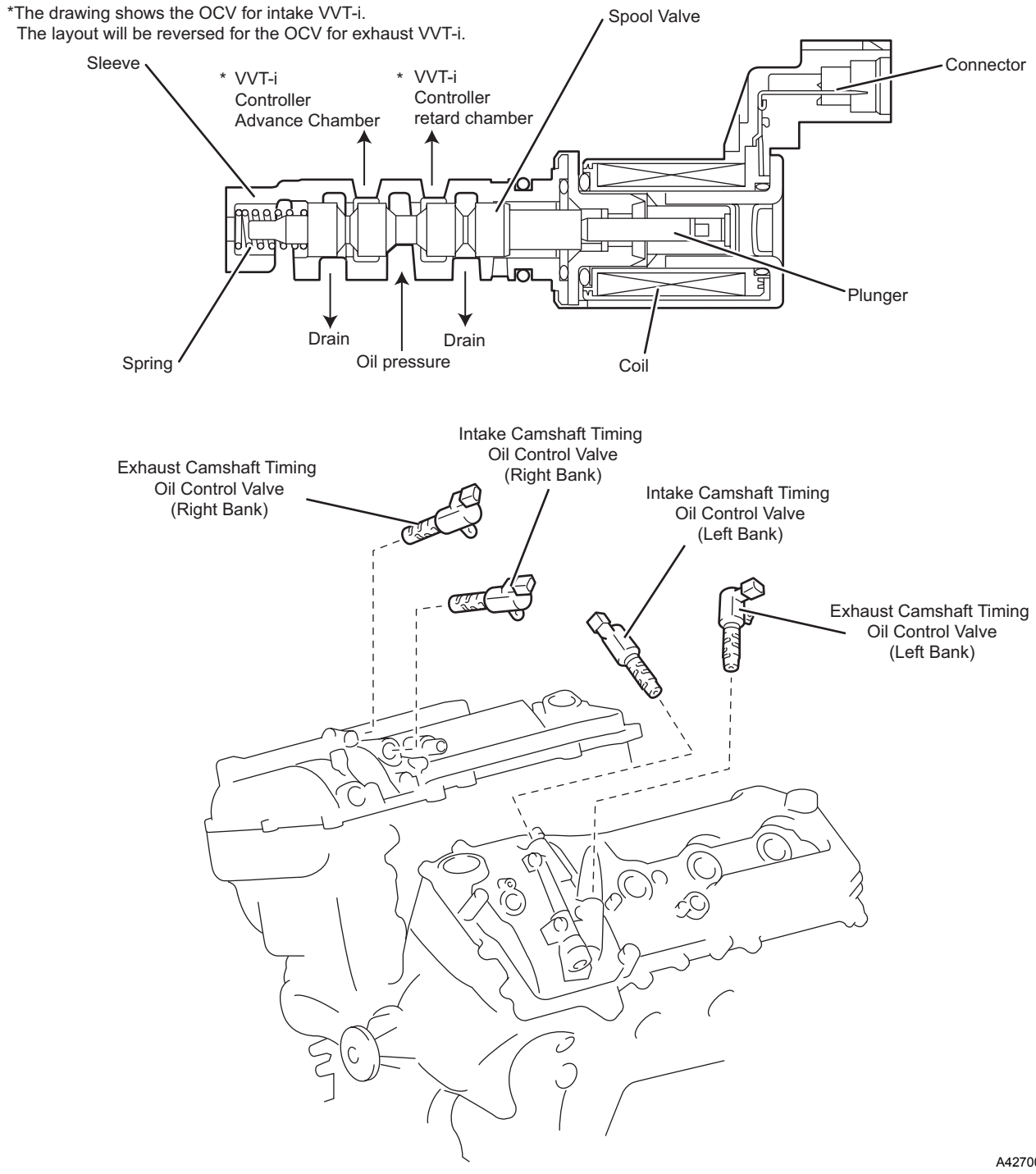
Effects of Dual VVT-i

• By advancing and retarding the intake and exhaust valves, the Dual VVT-i provides the following effects.



Camshaft Timing Oil Control Valve

- In accordance with the duty cycle signals received from the engine ECU, this OCV controls the position of the spool valve in order to constantly achieve optimal valve timing. When the engine is stopped, the force of a spring keeps the intake side of the spool valve in the most retarded state, and the exhaust side to the most advanced state, in order to ready the valves for the subsequent starting.



EG

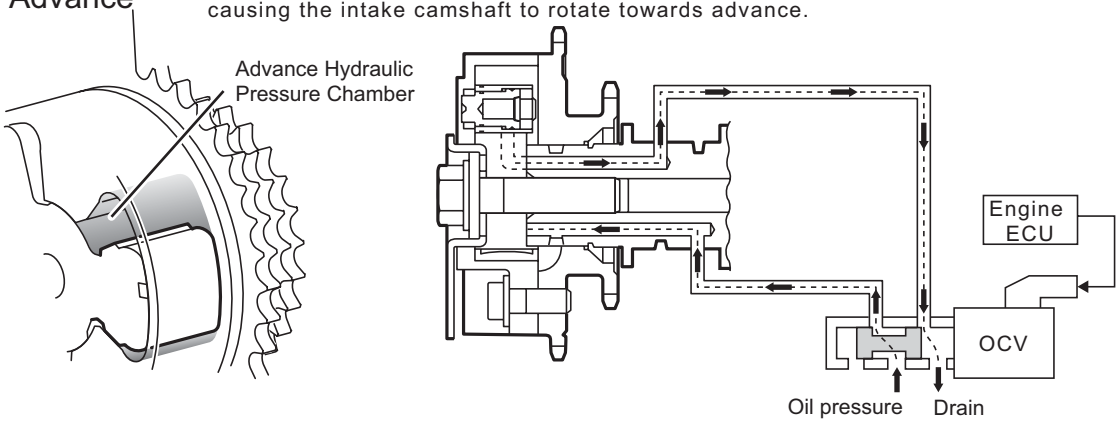
Dual VVT-i Operation

• The Dual VVT-i controls the advance, retard, and holding states as illustrated below, in accordance with the driving conditions.

Outline of Intake VVT-i Operation

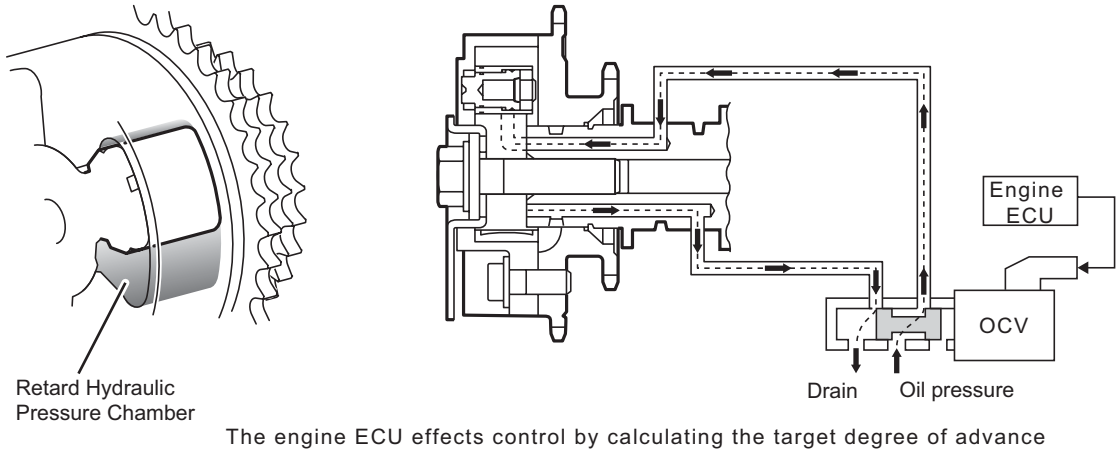
The spool valve of the OCV reaches the position shown in the drawing, as a result of receiving a signal from the engine ECU. Then, hydraulic pressure is applied to the hydraulic pressure chamber for advance, causing the intake camshaft to rotate towards advance.

Advance



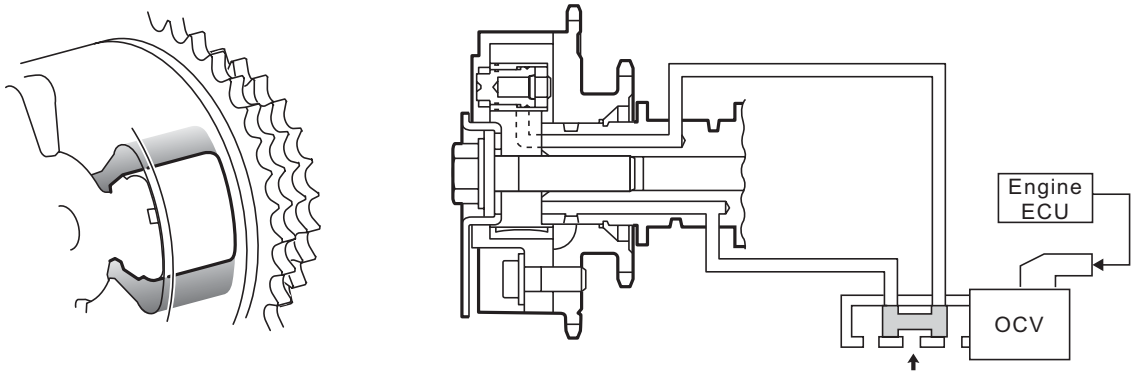
The spool valve of the OCV reaches the position shown in the drawing, as a result of receiving a signal from the engine ECU. Then, hydraulic pressure is applied to the hydraulic pressure chamber for retard, causing the intake camshaft to rotate towards retard.

Retard



The engine ECU effects control by calculating the target degree of advance in accordance with the driving conditions. After reaching the target timing, the engine ECU maintains the timing by setting the OCV to neutral, provided that the driving conditions do not change. As a result, the valve timing can be set to any target position. At the same time, the engine oil is prevented from flowing out needlessly.

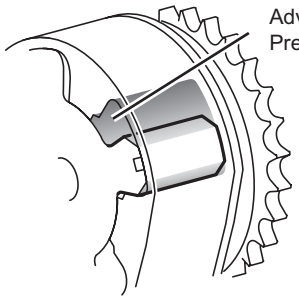
Hold

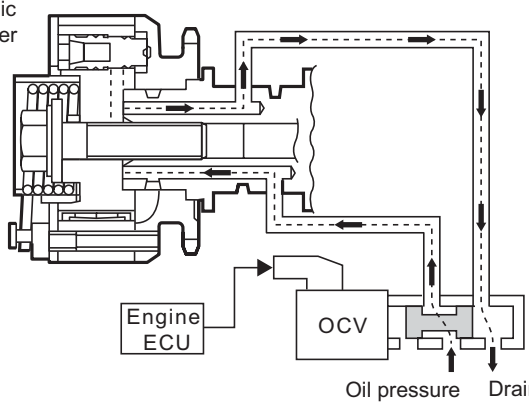


Outline of Exhaust VVT-i Operation

Advance

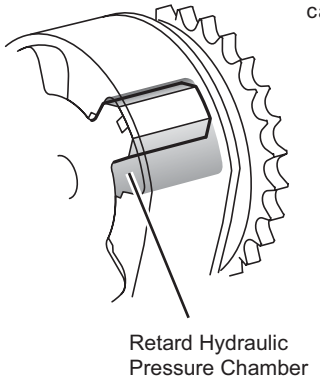
The spool valve of the OCV reaches the position shown in the drawing,
as a result of receiving a signal from the engine ECU.
Then, hydraulic pressure is applied to the hydraulic pressure chamber for advance,
causing the exhaust camshaft to rotate towards advance.

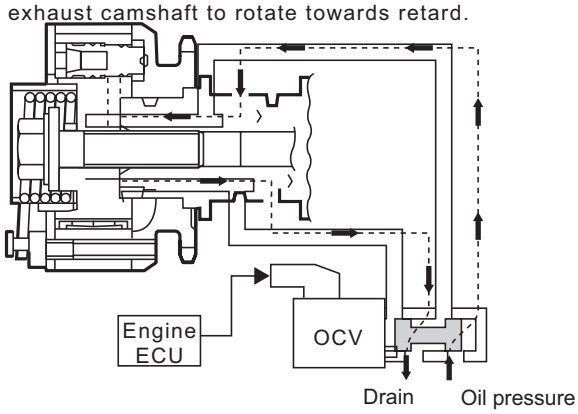




Retard

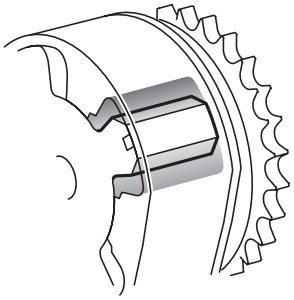
The spool valve of the OCV reaches the position shown in the drawing,
as a result of receiving a signal from the engine ECU.
Then, hydraulic pressure is applied to the hydraulic pressure chamber for retard,
causing the exhaust camshaft to rotate towards retard.

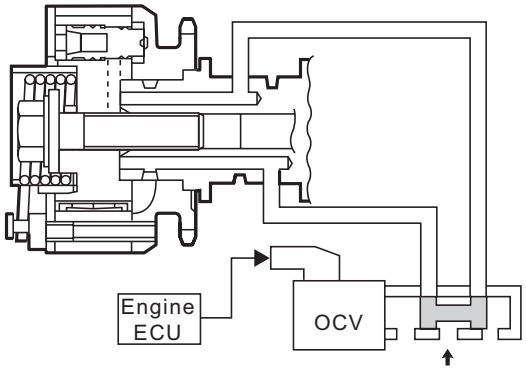




Hold

The engine ECU effects control by calculating the target degree of advance
in accordance with the driving conditions. After reaching the target timing,
the engine ECU maintains the timing by setting the OCV to neutral,
provided that the driving conditions do not change. As a result,
the valve timing can be set to any target position.
At the same time, the engine oil is prevented from flowing out needlessly.



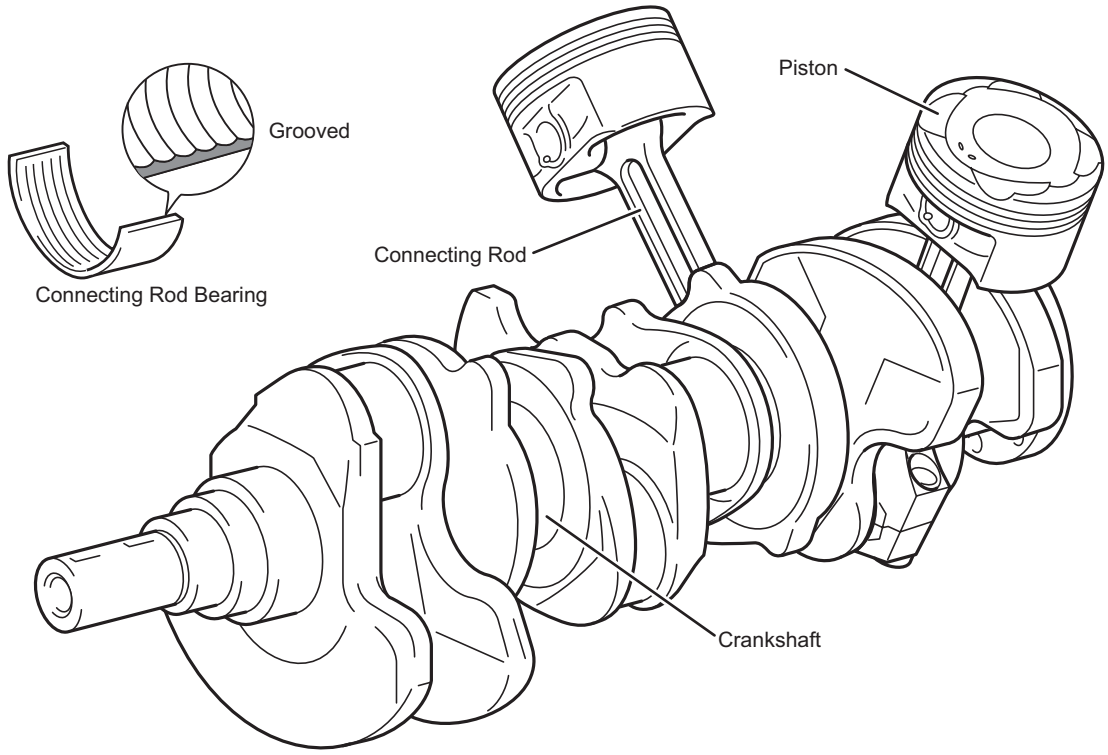


A4270256P

EG

Piston and Crankshaft

- The pistons are made of a lightweight and highly rigid aluminum alloy.
- The connecting rods are made of highly rigid, sintered forged steel that ensures a high level of reliability.
- The crankshaft, which is made of forged steel, is a type that has 4 journals and 5 balance weights. It is lightweight and the balance weights are placed optimally to reduce vibration and noise. The crank pin width and the journal fillet have been made narrower to shorten the length of the crankshaft, in order to realize both high rigidity and low friction. The fillets have been induction hardened to ensure ample strength.
- The connecting rod bearings and the crankshaft bearings have been made narrower to reduce friction. The bearing lining is made of an aluminum alloy to realize both wear resistance and seizure resistance.
- The crankshaft pulley is provided with a torsional damper to reduce vibration and noise.



A4270210P

Connecting Rod

Big End Inner Diameter	[mm (in.)]	56.0 (2.204)
Small End Inner Diameter	[mm (in.)]	22.0 (0.866)
Center Distance Between Big and Small Ends	[mm (in.)]	147.5 (5.807)

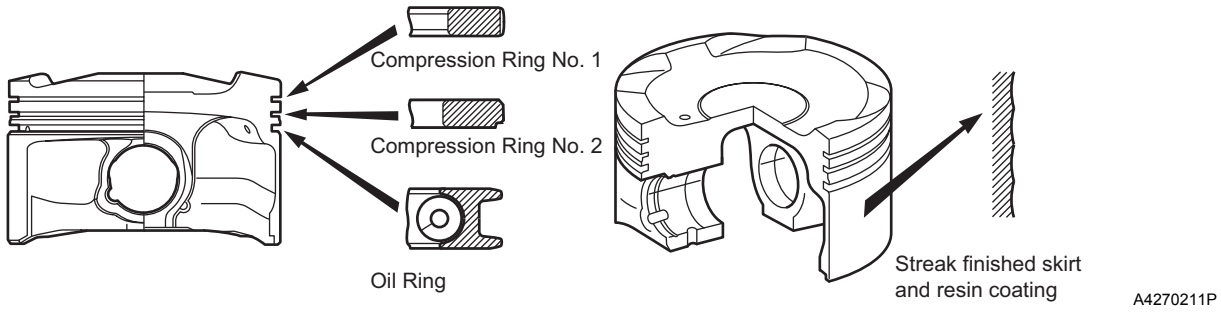
Crankshaft

Journal Diameter	[mm (in.)]	61.0 (2.402)
Crank Pin Diameter	[mm (in.)]	53.0 (2.087)
Crank Pin Stroke Radius	[mm (in.)]	41.5 (1.634)

EG

Piston

- The pistons have been made lightweight with a short compression height and a short skirt. The piston skirt has a streak finish and a plastic coating that excel in seizure resistance, in order to reduce noise and friction.
- A compact combustion chamber is provided on top of the piston to realize stable combustion. Together with the pentroof type combustion chamber on the cylinder head, this realizes a high compression ratio, resulting in both high performance and fuel economy.
- Each piston ring is made thinner and with low tension to reduce friction.



Piston

Basic Diameter [mm (in.)]	87.465 (3.444)
Pin Hole Offset [mm (in.)]	0.5 (0.020)
Compression Height [mm (in.)]	31.05 (1.222)

Piston Pin

Outer Diameter [mm (in.)]	22.0 (0.87)
Inner Diameter [mm (in.)]	12.7 (0.5)
Length [mm (in.)]	56.0 (2.2)

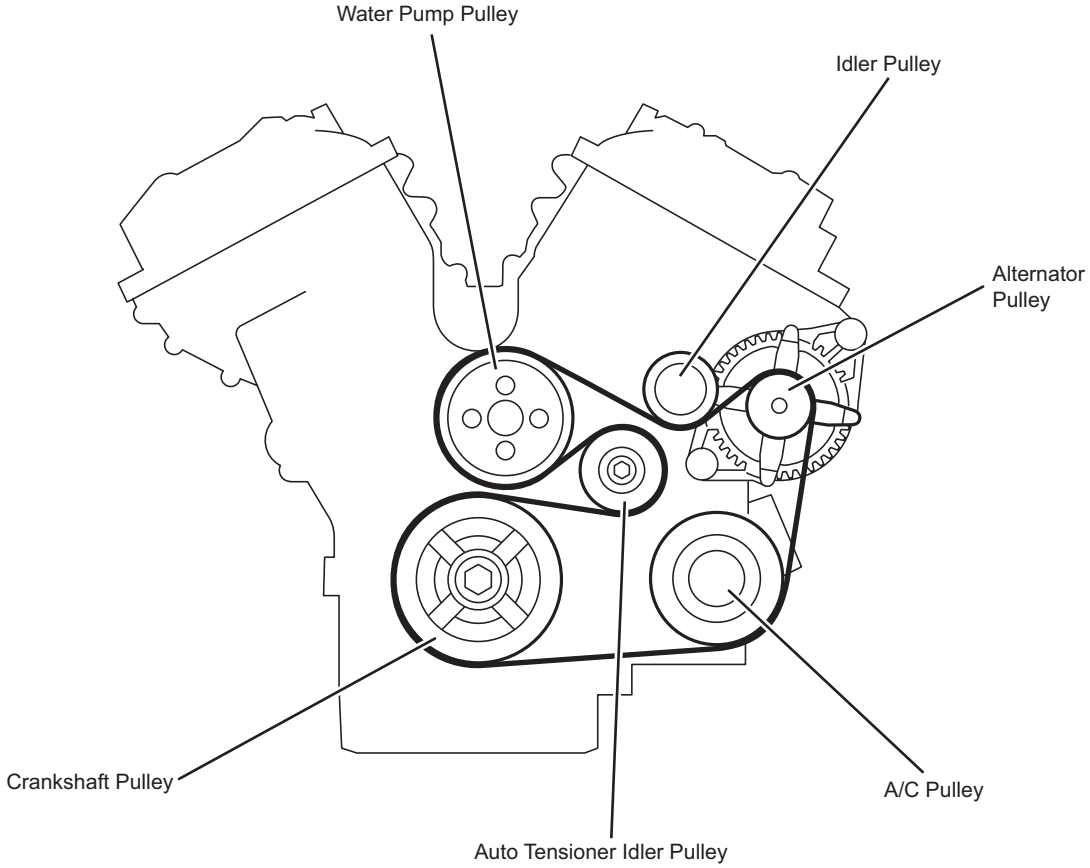
Piston Ring

	Compression Ring No. 1	Compression Ring No. 2	Oil Ring
Material	Stainless Steel	Steel	Steel
Shape	Barrel Face	Tapered Face + Undercut	Combination
Width [mm (in.)]	1.2 (0.047)	1.2 (0.047)	2.0 (0.079)
Thickness[mm (in.)]	2.7 (0.106)	2.7(0.106)	2.75 (0.108)
Surface Treatment	PVD (Physical Vapor Deposition) (Periphery)	Anti-Corrosion	Gas Nitriding

EG

Serpentine Belt Drive System

- A serpentine drive system, which uses a single V-ribbed belt to drive all accessories, is used in order to shorten the overall length of the engine and make it lightweight.
- An auto tensioner is used for the V-ribbed belt to ensure the long life of the belt and accessories, make them maintenance free, and improve serviceability by facilitating the removal and reinstallation of the belt.



Pulley Specifications

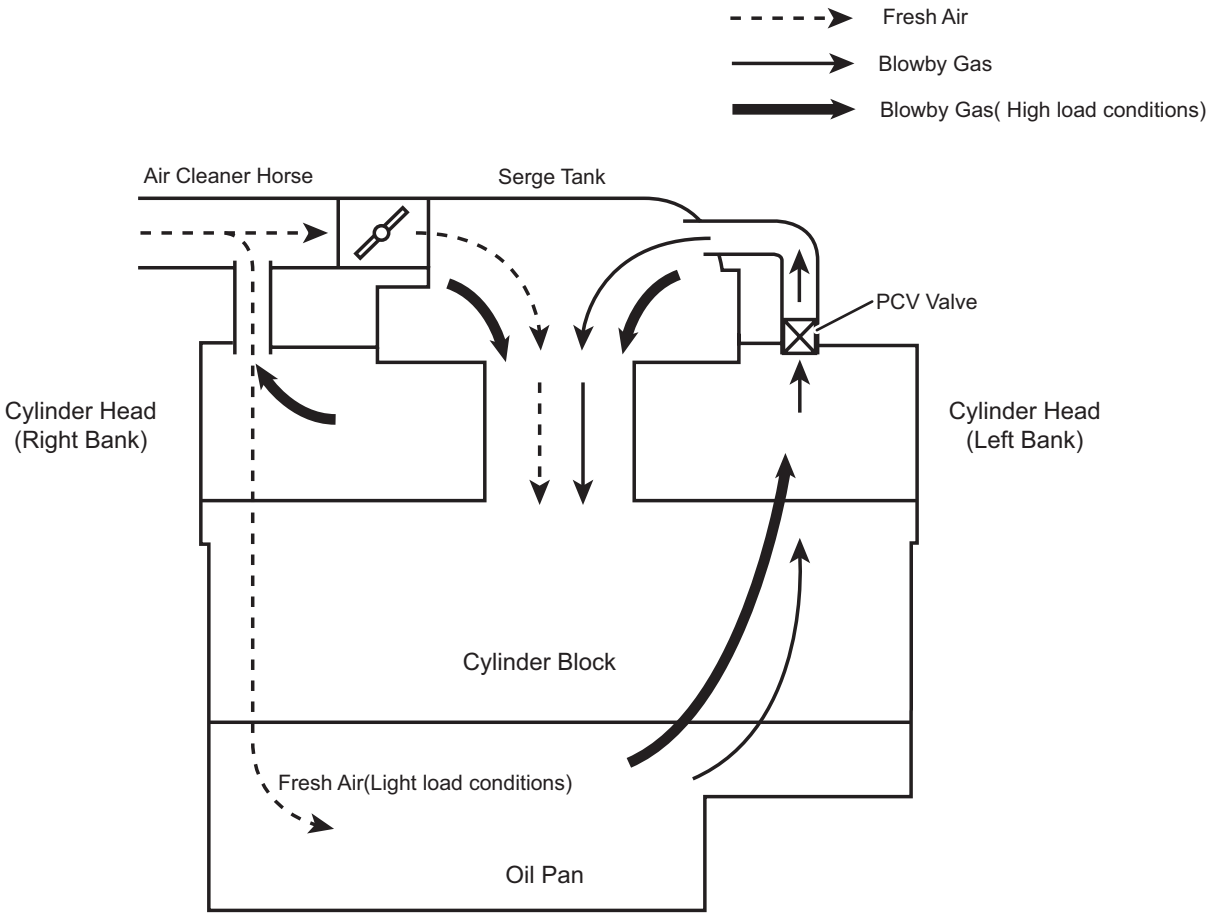
	Pulley Diameter [mm (in.)]
Crankshaft Pulley	140 (5.512)
Auto Tensioner Idler Pulley	70 (2.756)(driven from back face)
A/C Pulley	115 (4.528)
Idler Pulley	70 (2.756)(driven from back face)
Water Pump Pulley	120 (4.724)
Alternator Pulley	52.5 (2.067)

V Ribbed Belt Specifications

Width [mm (in.)]	24.92 (0.981)
Length [mm (in.)]	1550 (61.024)
Number of Ribs	7

Blowby Gas Reduction System

- A PCV hose and a PCV valve are provided to forcefully feed the blowby gas into the intake system for combustion, in order to prevent the blowby gas, which includes a large amount of HC, from being discharged into the atmosphere. A new air circulating system is used wherein fresh air from the air cleaner hose is introduced via the right bank head cover and the blowby gas is discharged into the surge tank via the left bank head cover.
- Under light load conditions, the intake manifold vacuum causes the blowby gas to be drawn via the PCV valve into the intake manifold, to be combusted. The internal pressure is regulated in the crankcase, where fresh air is introduced from the cylinder head cover.
- Under high load conditions, the intake manifold vacuum forcefully introduces the blowby gas into the intake system, where it is combusted. This prevents the blowby gas, which contains a large amount of HC, from being released to the atmosphere.
- A dedicated oil return passage and a blowby gas passage are provided in the cylinder block and the cylinder head to enhance the oil return function and minimize the volume of oil that is taken away.



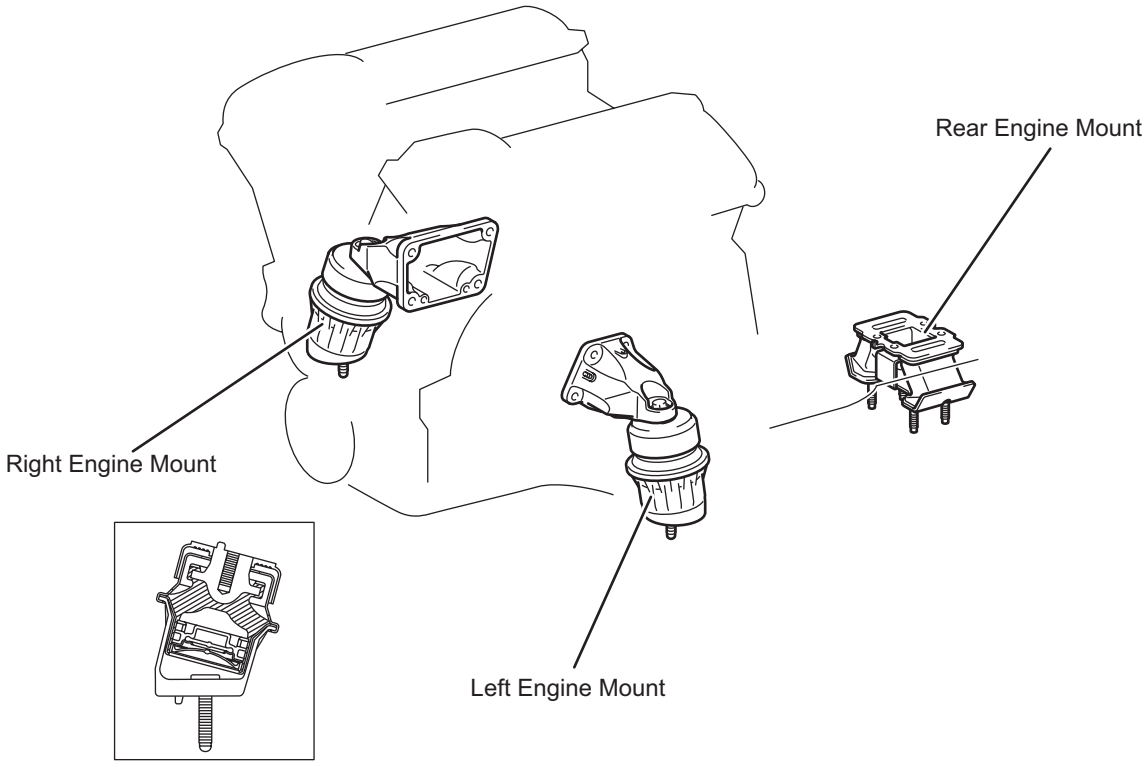
Conceptual operation image of the blowby reduction system

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EG

Engine Mounts

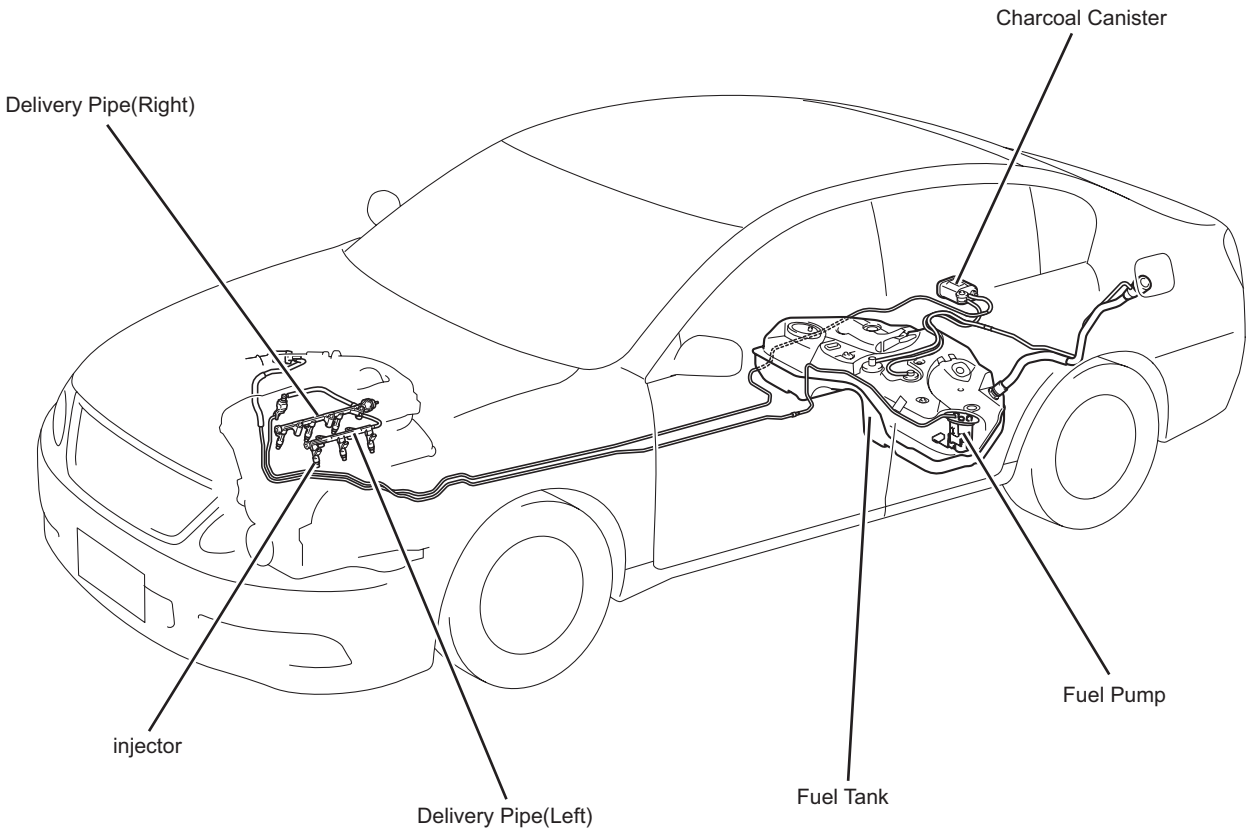
- The front engine mounts are installed on the upper area of the cylinder block where the vibration is minimal. In addition, the brackets have been angled more moderately to reduce vibration and noise in all operating ranges. The brackets are made of cone-shaped aluminum alloys to reduce weight, vibration, and noise.
- The front engine mount uses a liquid-filled double-orifice mount insulator to reduce vibration and noise in the operating range of the engine.
- The die shape for the rear engine mount has been optimized to reduce vibration in the operating range.



3GR-FE FUEL

General

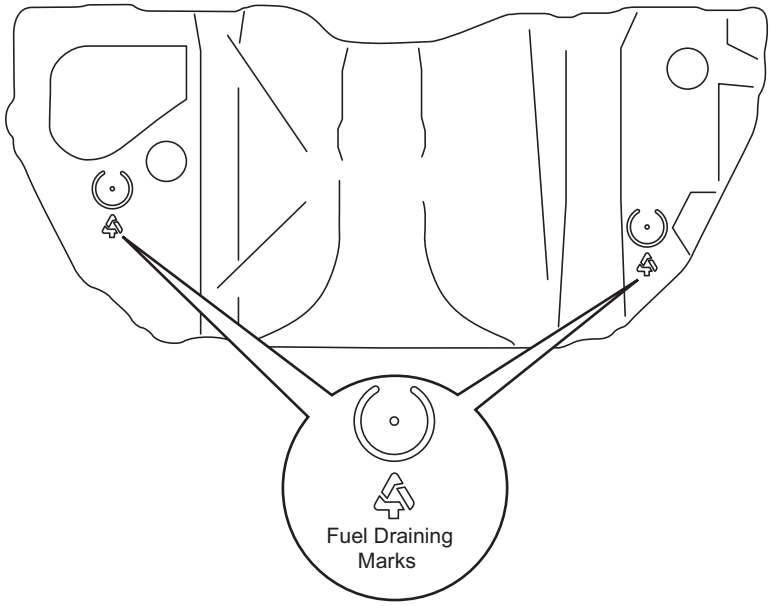
- A fuel returnless system has been used to reduce evaporative emissions.
- To prevent fuel from leaking during a collision (in which air bags are deployed), a system that turns OFF the circuit opening relay is used to ensure safety.



A4270192P

Fuel Tank

- The fuel tank is mounted in the center of the vehicle, forward of the rear axle. It has a capacity of 71.0 liters.
- The fuel tank adopts a saddle shape to allow the propeller shaft to pass through its center portion.
- Two sender gauges (main, sub), fuel pump, fuel filter, pressure regulator, and jet pump have been integrated.
- Fuel draining marks have been provided on the bottom of the fuel tank. These marks clearly indicate the position for aligning the fuel draining device during dismantling, and simplify and ensure the reliable draining of fuel.

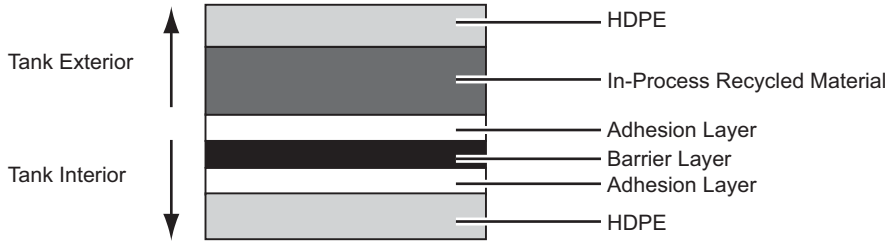


Fuel Tank Bottom View

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Plastic Fuel Tank

• A fuel tank made of plastic is used for weight reduction. It consists of six layers of plastic to ensure the long life of the tank and the low permeation of fuel.



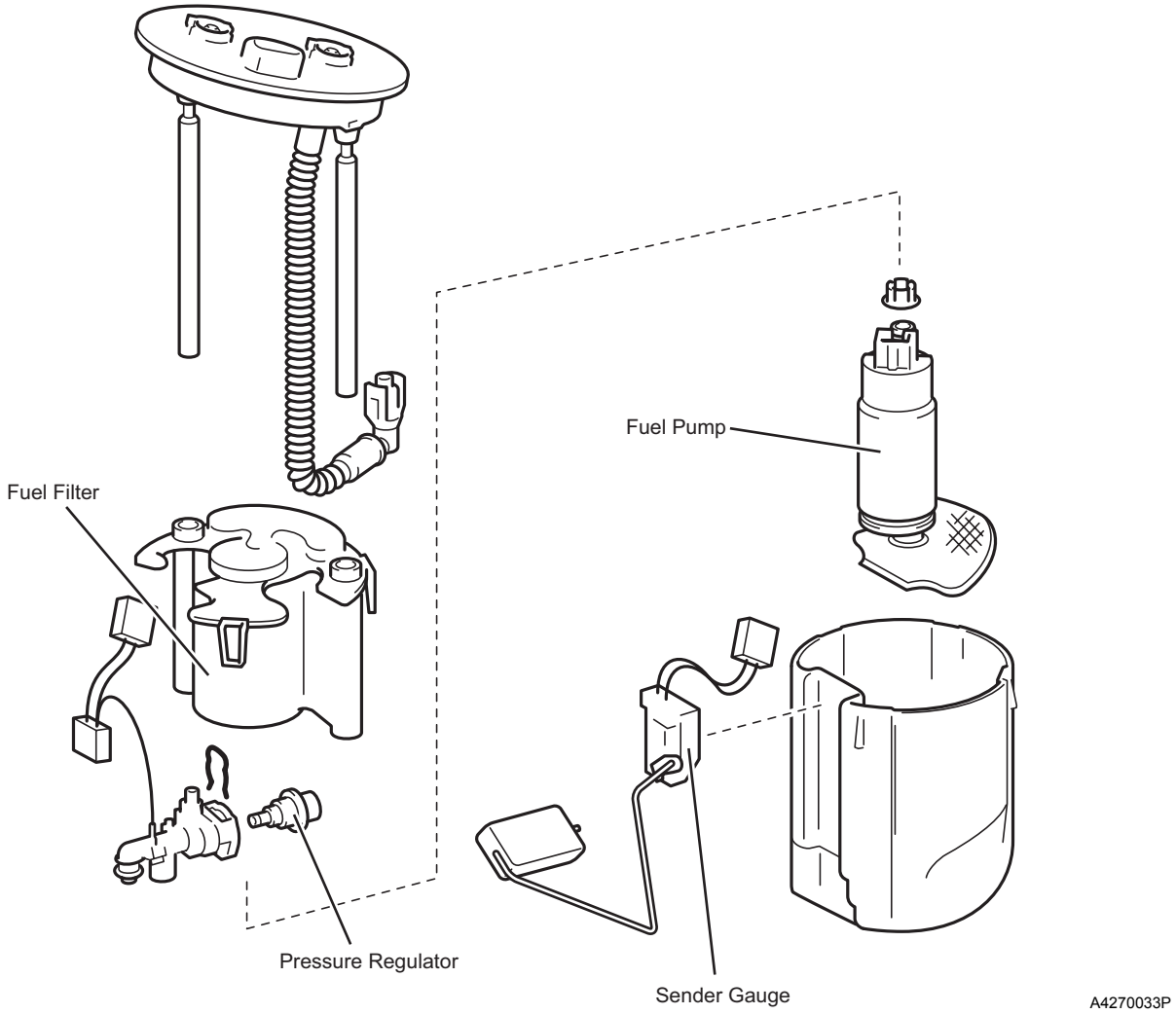
*HDPE(High Density Polyethylene):High Density Polyethylene It is lightweight, high strength,and excels in water and solvent resistance.

Layer Composition of Fuel Tank

A4270048P

Fuel Pump

- A fuel pump assembly consisting of a fuel pump, fuel filter, and sender gauge is used.
- To prevent fuel from leaking during a collision (in which air bags are deployed), a system that turns OFF the circuit opening relay, in accordance with a signal from the airbag ECU, is used to ensure safety.



Fuel Pump

Discharge Pressure [kPa]	324
Discharge Volume [L·h]	150 Minimum

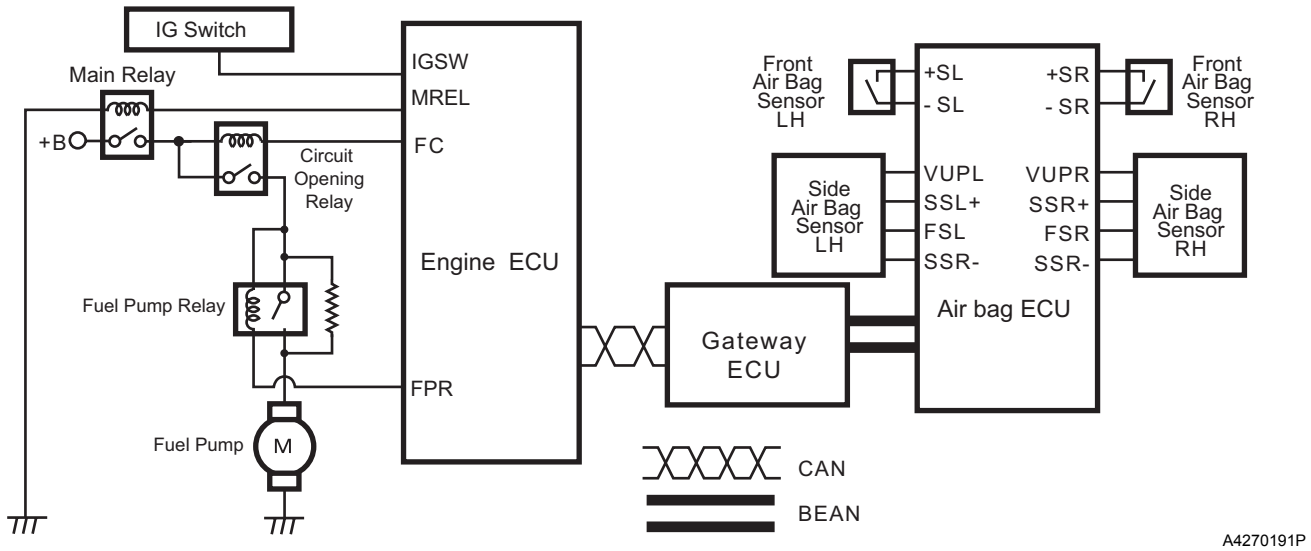
Fuel Filter

Filter System	Paper Filter Type
Filtering Surface Area [cm2]	1550

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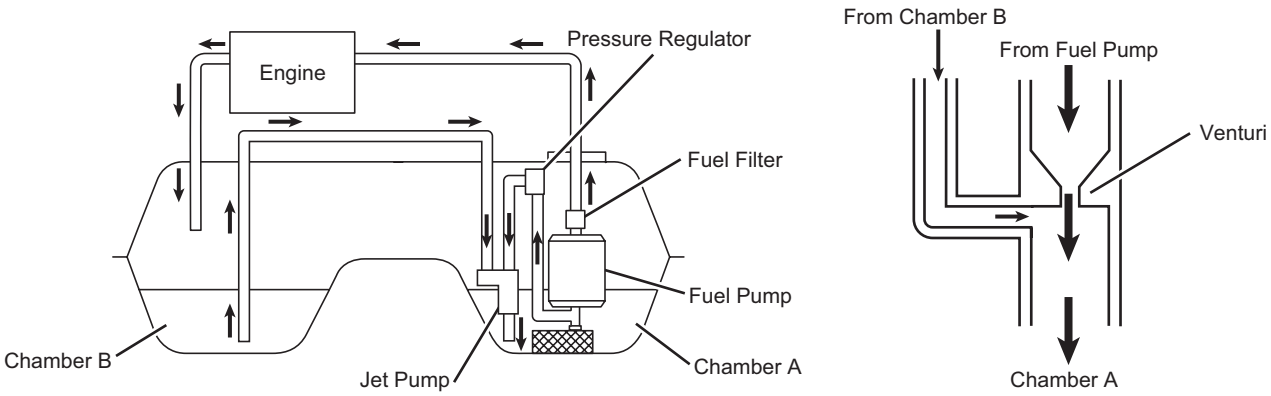
Fuel Pump Control

- When the starter signal is ON and the engine speed signal is input continuously for 2 seconds or longer, the circuit opening relay turns ON to actuate the fuel pump.
- A fuel cut control is adopted to stop the fuel pump when the airbag is deployed at the front or side collision. In this system, the airbag deployment signal from the airbag sensor assembly is detected by the engine ECU, which turns OFF the circuit opening relay.
- After the fuel cut control has been activated, turning the ignition switch from OFF to ON cancels the fuel cut control, thus engine can be restarted.



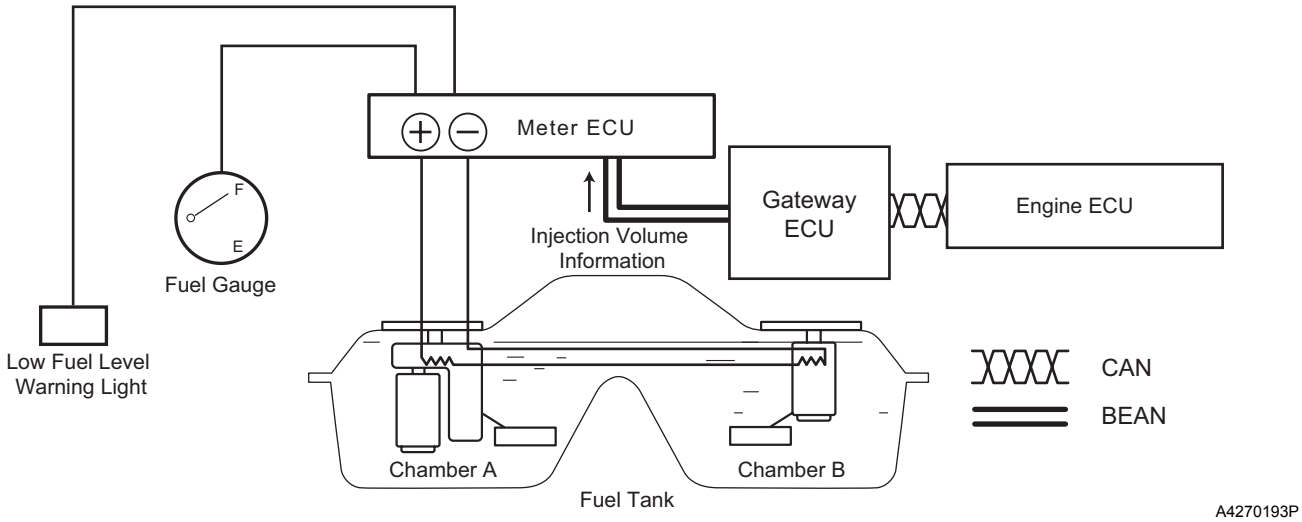
Jet Pump

- The jet pump operates as described below.
- A jet pump is adopted in the fuel tank. Since the propeller shaft is located below its center bottom, the fuel tank of the GS430 is shaped as indicated below.
- A fuel tank with such a shape tends to cause the fuel to be dispersed into both chamber A and chamber B when the fuel level is low, stopping the fuel in chamber B from being pumped out. To prevent this from occurring, a jet pump has been provided to transfer the fuel from chamber B to chamber A.
- This is accomplished by utilizing the flow of the fuel, so that the vacuum created by the fuel, as it passes through the venturi is used to suck the fuel out of chamber B and send it to chamber A.



Fuel Sender Gauge

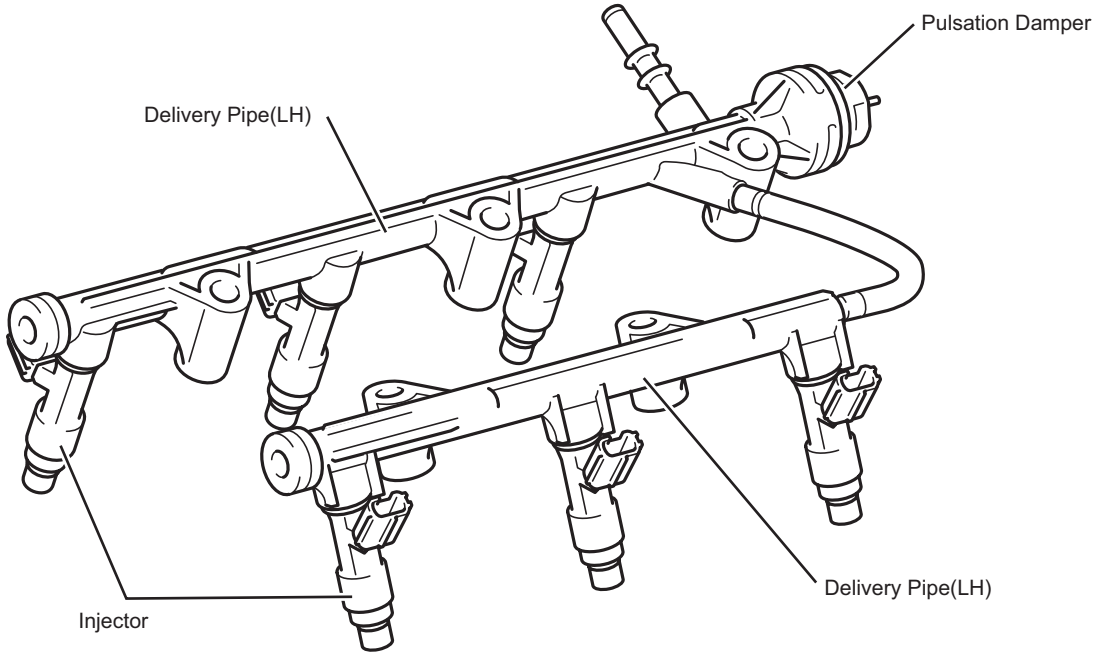
- To accurately inform the driver of the residual fuel volume in the saddle-shaped tank, inline sender gauges are provided in the two chambers, A and B. These sender gauges output the residual fuel volume of both chambers to the meter ECU.
- Based on the signals received from the two sender gauges and the EFI control information received from the engine ECU, the meter ECU calculates the residual fuel volume, and activates the fuel gauge.



EG

Delivery Pipe

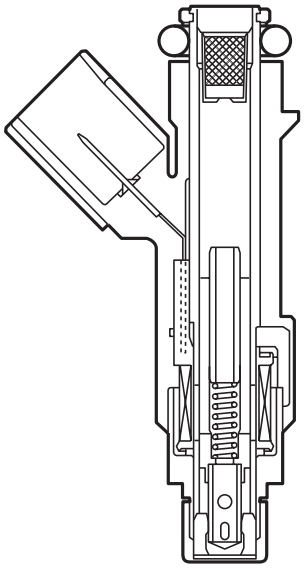
- A fuel delivery pipe made of an aluminum alloy is used.
- A pulsation damper is provided to reduce the pulsation and noise of the fuel.



A4270194P

Injector

- Injectors with 4 orifices are used. They are mounted directly into the cylinder heads to shorten the distance to the combustion chambers, thus reducing the adhesion of fuel to the intake ports.



Fuel Injector Cross-Sectional Diagram

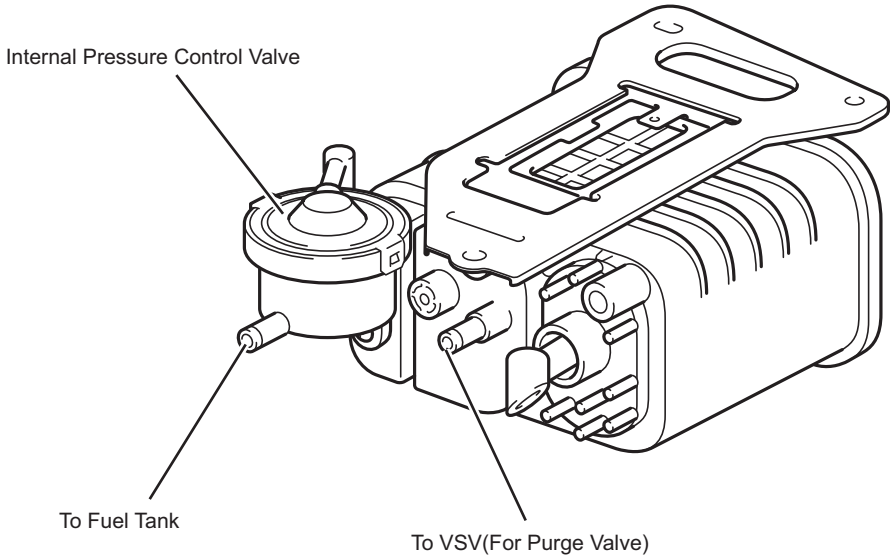
A4270195P

Fuel Injector

Number of Orifices	4
Orifice Dimensions [mm (in.)]	0.34 (0.013)

Charcoal Canister

- Canister purge control is used to draw the fuel evaporative gas created in the fuel tank into the intake port, to be burned during combustion.
- The charcoal canister is mounted behind the fuel tank.
- An internal pressure control valve is provided at the fuel passage inlet from the fuel tank in order to maintain the proper pressure in the fuel tank.



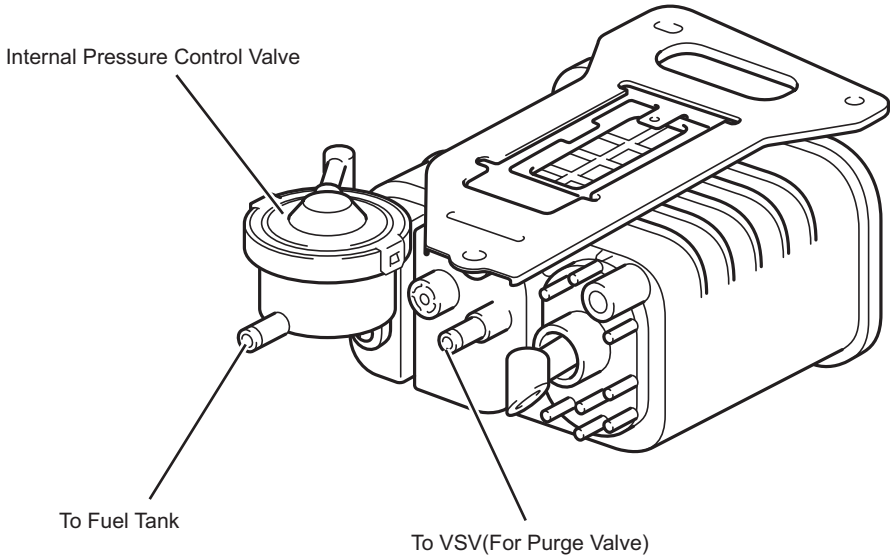
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Fuel Injector

Number of Orifices	4
Orifice Dimensions [mm (in.)]	0.34 (0.013)

Charcoal Canister

- Canister purge control is used to draw the fuel evaporative gas created in the fuel tank into the intake port, to be burned during combustion.
- The charcoal canister is mounted behind the fuel tank.
- An internal pressure control valve is provided at the fuel passage inlet from the fuel tank in order to maintain the proper pressure in the fuel tank.



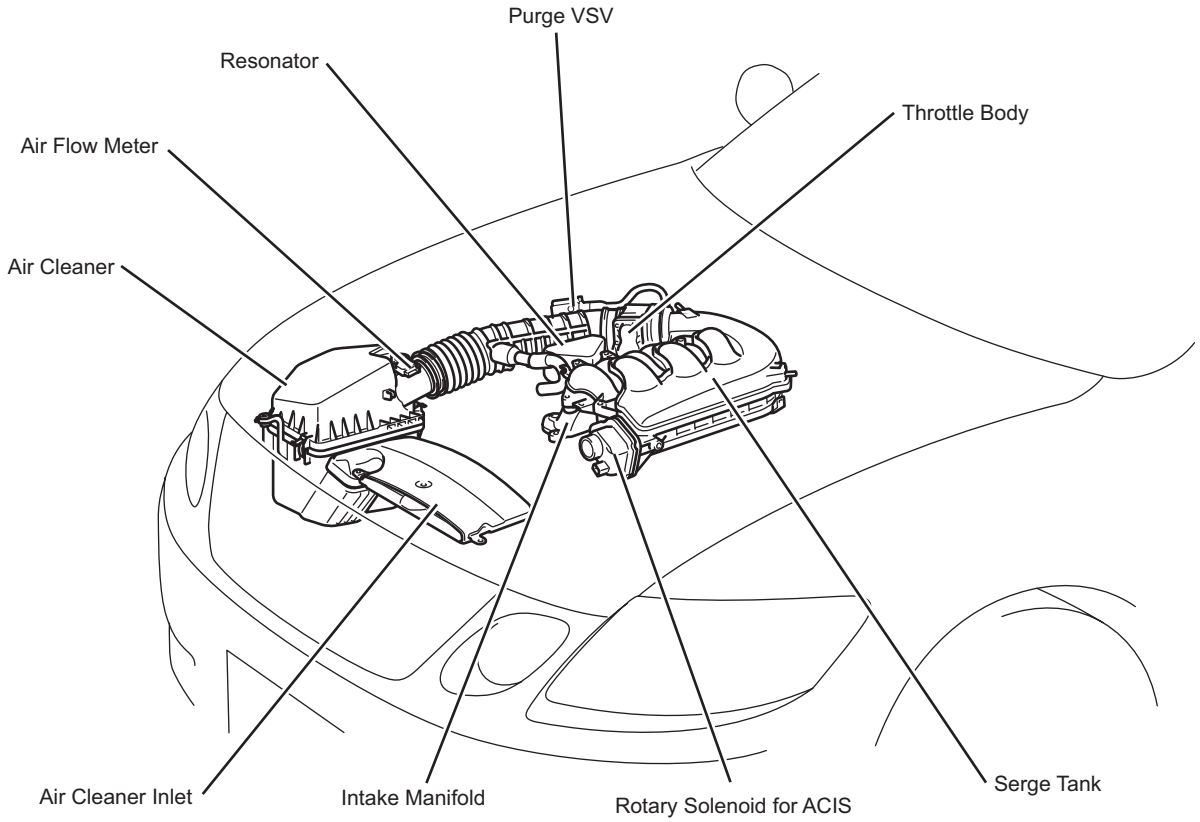
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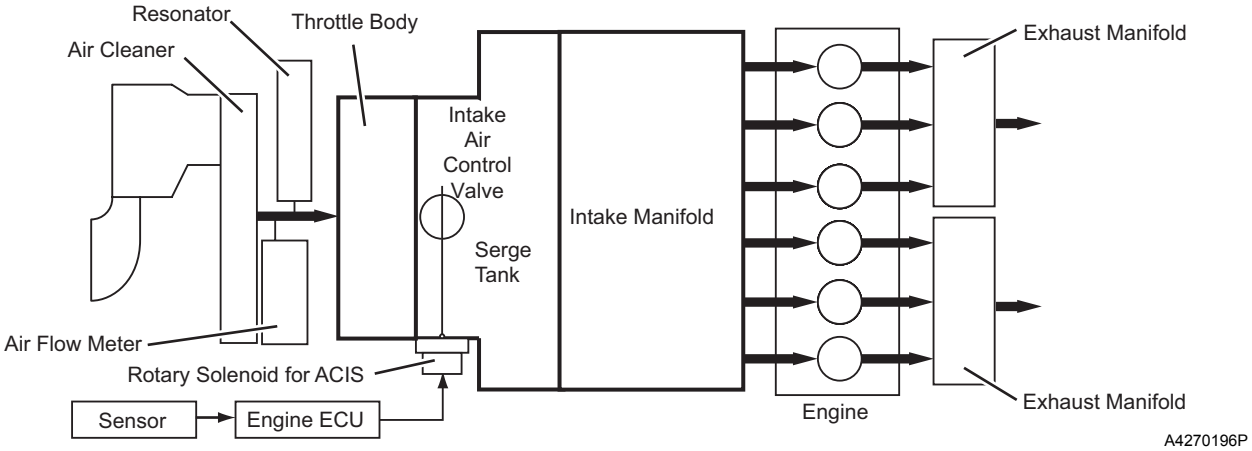
3GR-FE INTAKE

EG

General

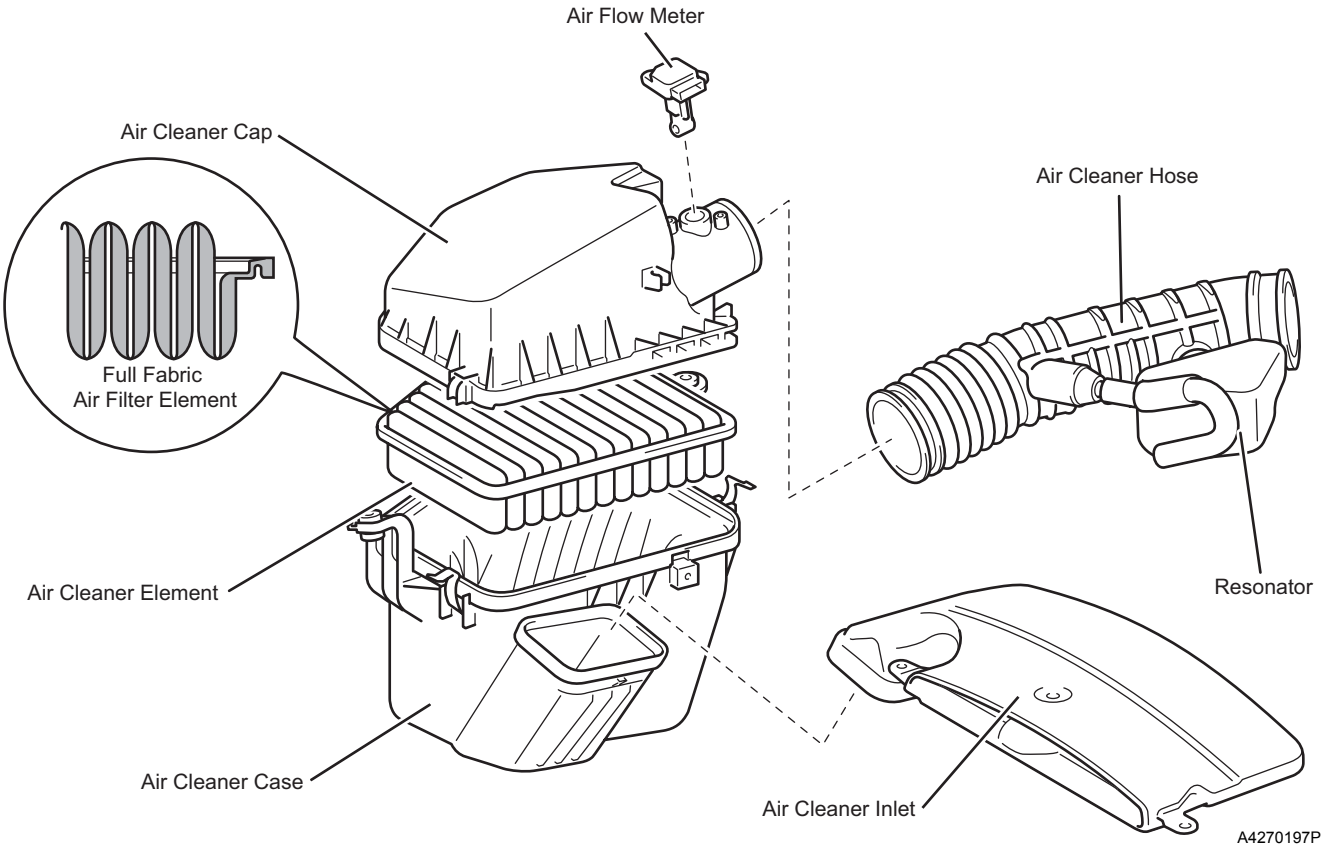
- A surge tank with a built-in ACIS (Acoustic Control Induction System) is used.
- A hot-wire type airflow meter (with a built-in intake air temperature sensor) is provided in the air cleaner cap.
- The ETCS-i system is used and a single-valve, electronically controlled throttle body is installed.





Air Cleaner

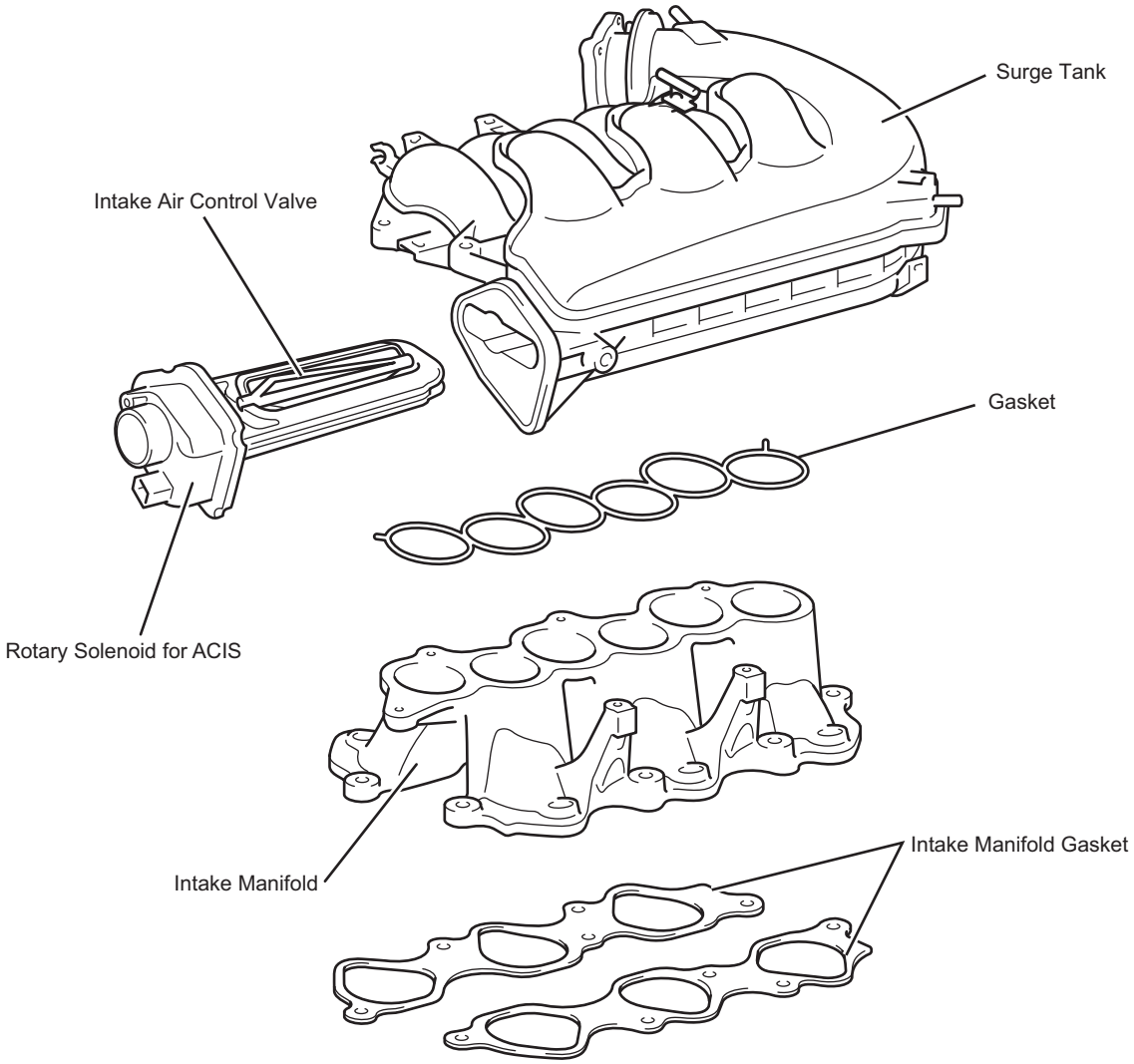
- A removable cap type air cleaner case is used for enhanced serviceability. Also, an airflow meter (with a built-in intake air temperature sensor) is provided in the air cleaner cap.
- A dry type air cleaner element is used and provided with an ample filtering surface area
- A compact resonator is provided in the air cleaner hose to reduce intake noise.
- A full fabric air filter element, which does not contain an outer frame or rubber seal, is used. As a result, the case could be made compact, with recyclability in mind.



EG

Intake Manifold

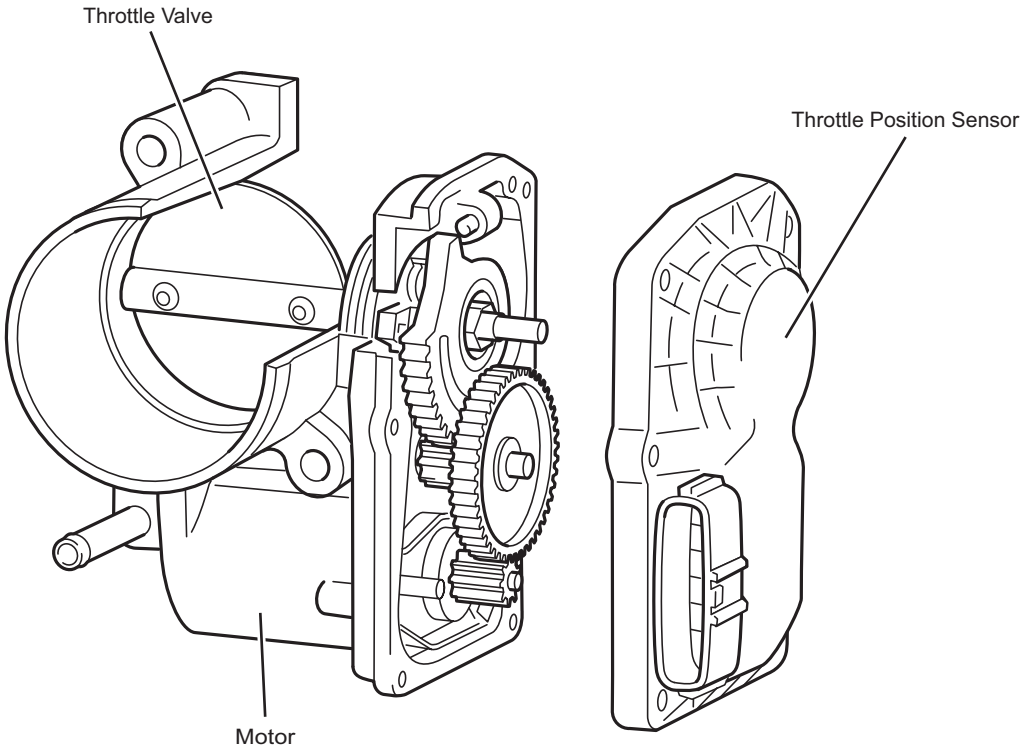
- An intake system with an ACIS (Acoustic Control Induction System) consisting of independent ports is used. The port diameter and length have been optimized to strike a balance between high torque in all driving ranges and fuel economy performance.
- A plastic surge tank is used for weight reduction. An ACIS (Acoustic Control Induction System) is used to vary the effective length of the intake manifold, thus increasing the torque in all ranges.



A4270198P

Throttle Body

- The adoption of the ETCS-i has realized excellent throttle control.
- The accelerator pedal position sensor is attached to the accelerator pedal.
- A link-less type throttle body has been adopted.
- The accelerator position sensor, which is provided on the accelerator pedal, transmits the operation by the driver (amount of pedal effort on the accelerator) to the engine ECU. The engine ECU determines the throttle position that suits the driving conditions and actuates the throttle motor. Then, the throttle position sensor gives feedback regarding the throttle valve position to the engine ECU.
- A motor with excellent response and minimal power consumption is used for the throttle control motor. The engine ECU performs the duty ratio control of the direction and the amperage of the current that flows to the throttle control motor in order to regulate the opening angle of the throttle valve.
- Both the accelerator position sensor and the throttle position sensor consist of two internal circuits (main, sub), in order to constantly monitor the system for malfunctions.
- If a malfunction is detected, the system illuminates a warning light in the combination meter to alert the driver, and cuts the current to the motor. The throttle valve return spring returns the throttle valve to a predetermined position. Thus, by cutting the fuel injection off and retarding the ignition timing, the system regulates the engine power output in accordance with the accelerator position to enable the vehicle to continue driving.



Air Flow Meter

- This 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 has been improved and the intake air resistance has been reduced.
- This air flow meter has a built-in intake air temperature sensor.
- This system measures the air flow in the bypass, which is less likely to be affected by the intake pulsations created by the air cleaner. Also, the flow path is constructed to minimize flow resistance, thus reducing flow loss. Therefore, this system can measure small to large airflow in a precise manner.

(See page EG-45)

Accelerator Pedal Position sensor

- This sensor, which is mounted on the accelerator pedal, detects the amount of pedal effort applied to the accelerator. By using a Hall element, this electronic position sensor enables accurate control and ensures permanent reliability. When the amount of pedal effort applied to the accelerator changes, this sensor sends the angle of the magnetic field in relation to the flow of the applied current in the Hall element (VCP1 → EP1, VCP2 → EP2) in the form of an accelerator pedal effort signal to the engine ECU. In addition, this sensor consists of a dual system having different output characteristics to ensure reliability.

(See page EG-41)

Throttle Position Sensor

- This sensor, which is located in the throttle body, detects the position of the throttle valve. By using a Hall element, in the same way as the accelerator position sensor, this electronic position sensor enables accurate control and ensures permanent reliability. In addition, this sensor consists of a dual system having different output characteristics to ensure reliability.

(See page EG-43)

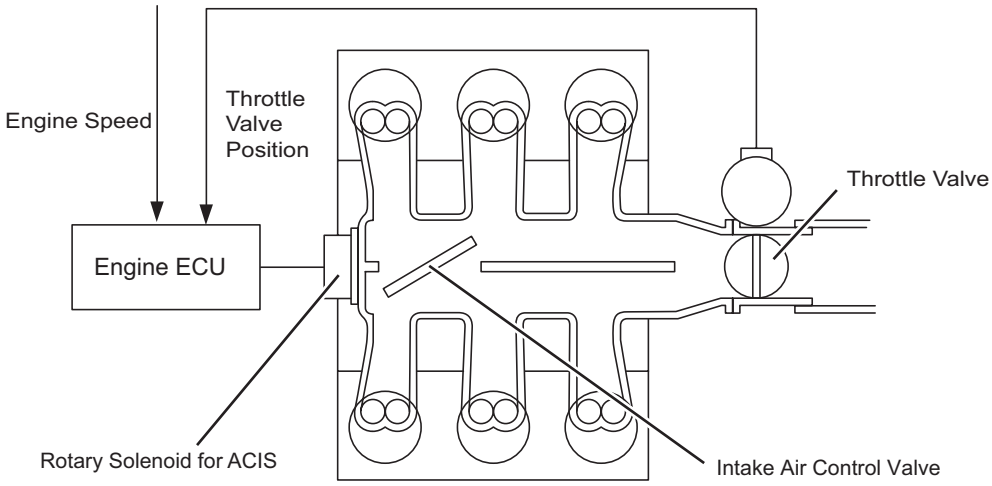
ETCS-i (Electronic Throttle Control System-intelligent)

- In the conventional throttle body, the throttle valve opening is determined invariably by the amount of the accelerator pedal effort. In contrast, the ETCS-i uses the engine ECU to calculate the optimal throttle valve opening that is appropriate for the respective driving condition and uses a throttle control motor to control the opening.
- The functions of the ordinary throttle position control (nonlinear control), idle speed control (ISC), traction control (including VSC), and cruise control have been integrated in the single-valve electronically controlled throttle body.

(See page EG-35)

Electronic ACIS (Acoustic Control Induction System)

- Pressure fluctuations are indirectly created in the intake manifold by the intake stroke. The influence exerted on the subsequent intake stroke by the pressure fluctuations remaining in the intake manifold, even after the intake valve has closed, is called a pulsation effect. When the pressure fluctuations that remain after the intake valve has closed coincides with the subsequent intake stroke, the pressure increases at the time the valve opens, the intake air volume increases, and the torque increases.
- To proactively utilize this pulsation effect, the Acoustic Control Induction System changes the effective intake manifold length in accordance with the cycle of the pulsation flow that changes with the engine speed, in order to increase the torque in all ranges.



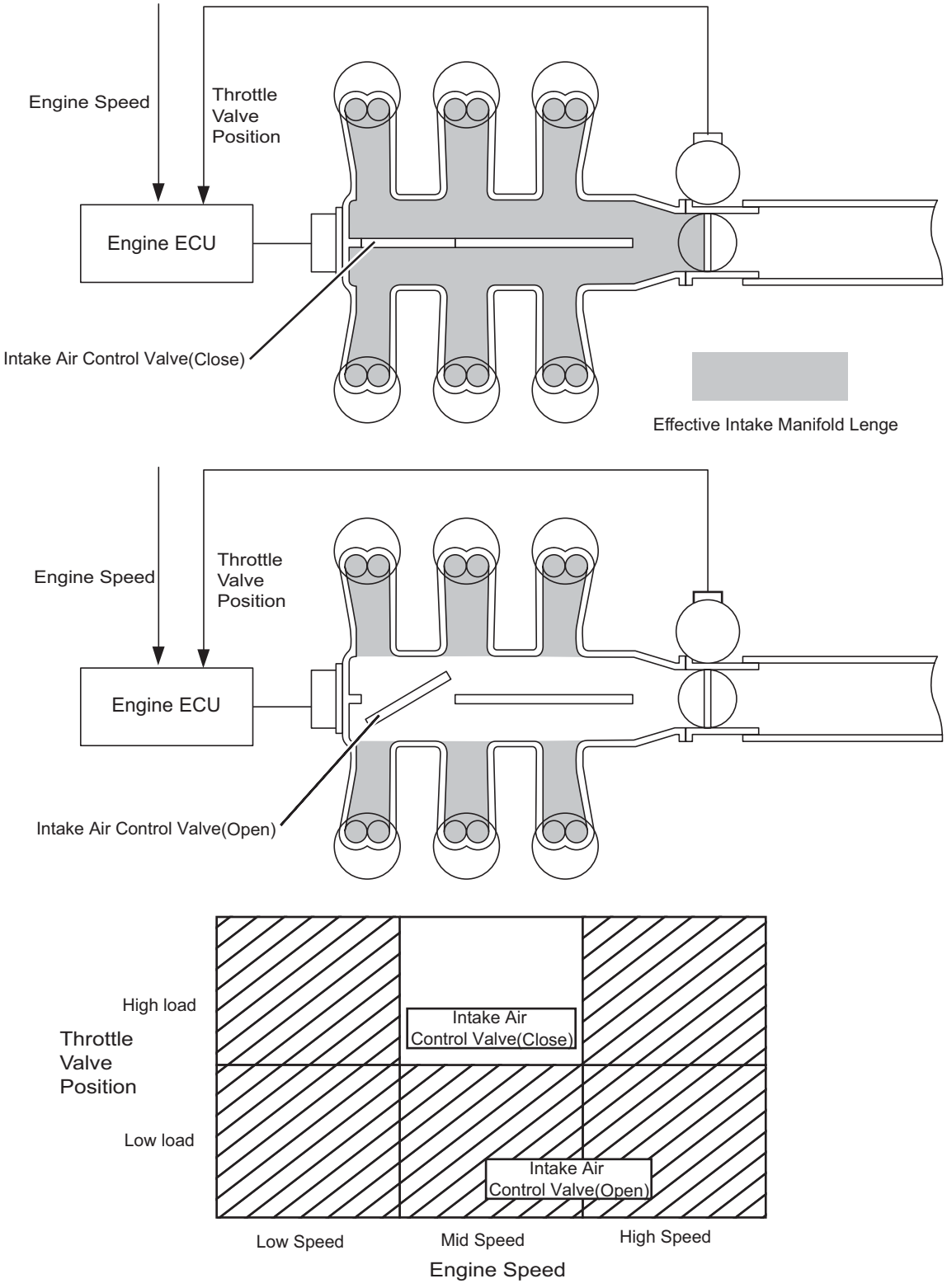
List of Functions

Device Name	Function
Crankshaft Position Sensor	Detects engine speed.
Throttle Position Sensor	Detects throttle valve position.
Intake Air Control Valve	Opens and closes the valve to switch the effective intake manifold length in two stages.
Rotary Solenoid for ACIS	Opens and closes the intake Air control valve under the command of the engine ECU.
Engine ECU	Sends a signal to the ACIS rotary solenoid at an appropriate timing in accordance with the signals received from the sensors.

EG

Electronic ACIS Operation

- The engine ECU opens and closes the intake air control valve in accordance with the engine speed and the throttle valve position, in order to enhance the torque in all ranges, particularly in the medium-speed range.

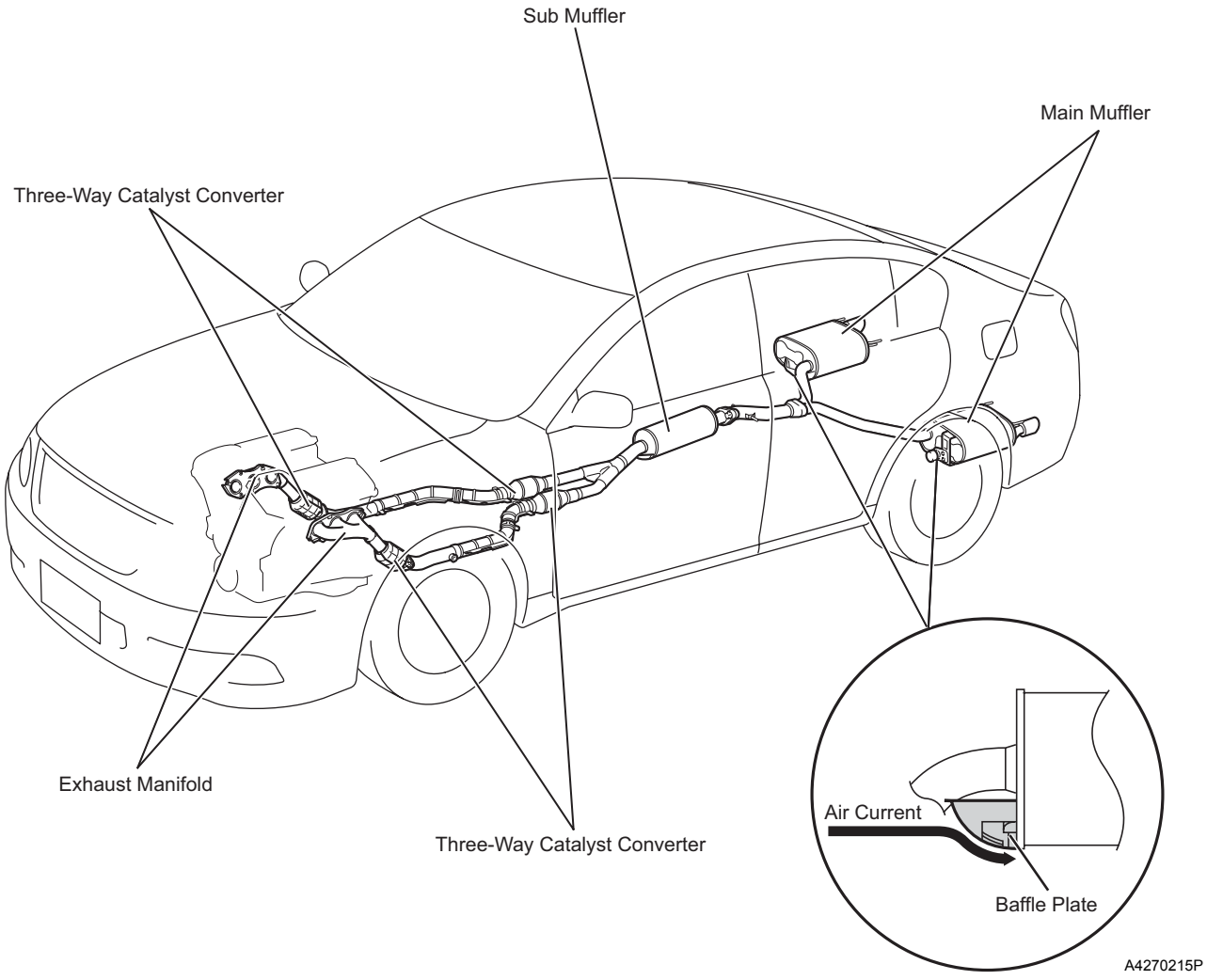


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3GR-FE EXHAUST

General

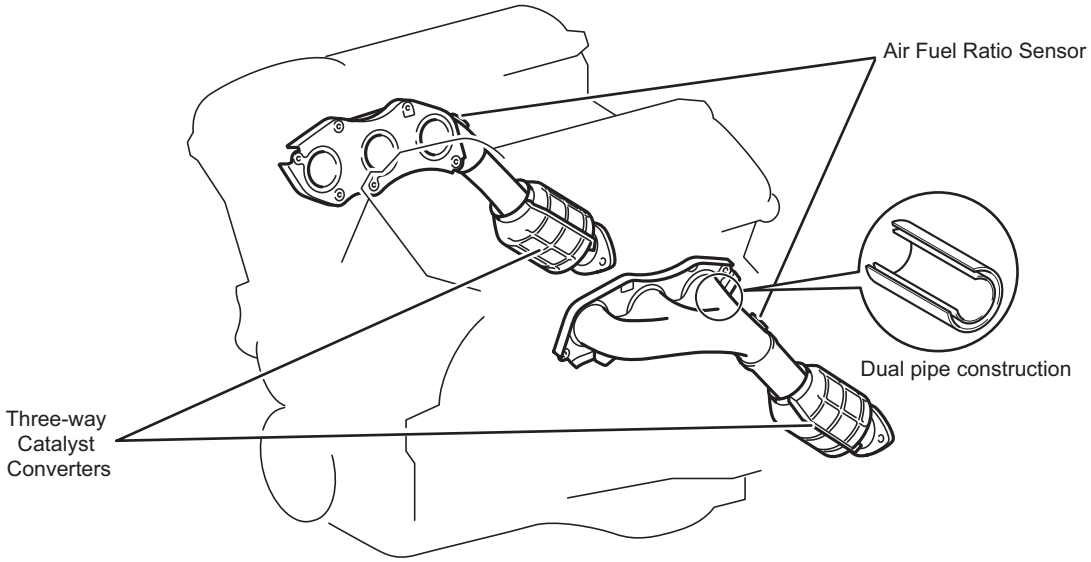
- The entire exhaust system from the exhaust manifold to the tail pipe is made of stainless steel to realize weight reduction and improve corrosion resistance.
- Three-way catalysts are placed directly below the exhaust manifold and in the front pipes to ensure ample emission reduction performance, in order to comply with the Step IV European Tailpipe Emission Regulations.
- An exhaust manifold with a built-in Three-way catalyst Converter is placed directly below each bank of the engine to ensure low exhaust emissions immediately after the engine is started.
- The exhaust pipe diameter has been optimized to reduce exhaust loss and optimize engine power output.
- A baffle plate is provided in front of the main muffler to straighten the airflow under the floor, thus improving dynamic performance.
- An air-fuel ratio sensor is provided upstream of the Three-way catalyst Converter in each exhaust manifold. An heated oxygen sensor is provided downstream of the Three-way catalyst Converter in each exhaust manifold. These sensors enable precise control of the air-fuel ratio.



EG

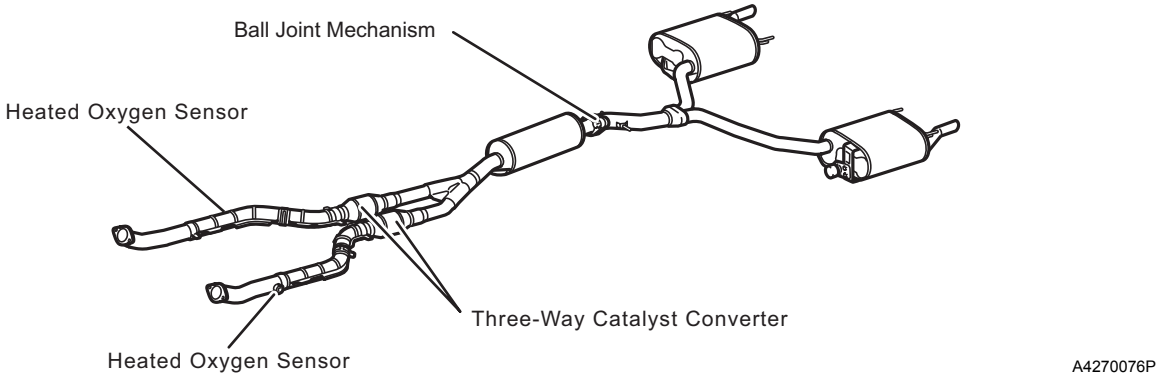
Exhaust Manifold

- The exhaust manifolds are made of dual pipe construction stainless steel to reduce noise and enhance heat resistance. Also, they accelerate the warm-up of the catalysts immediately after the engine is started, thus reducing exhaust emissions.
- Built into each exhaust manifold, the three-way catalyst converter consists of an ultra thin-wall, high-cell density ceramic catalyst in which precious metals are optimally used. It accelerates the warm-up of the catalytic converter, thus improving exhaust emission performance immediately after the engine is started.
- The flow of the exhaust gases has been optimized and the exhaust gas pressure loss has been reduced to produce a higher power output.



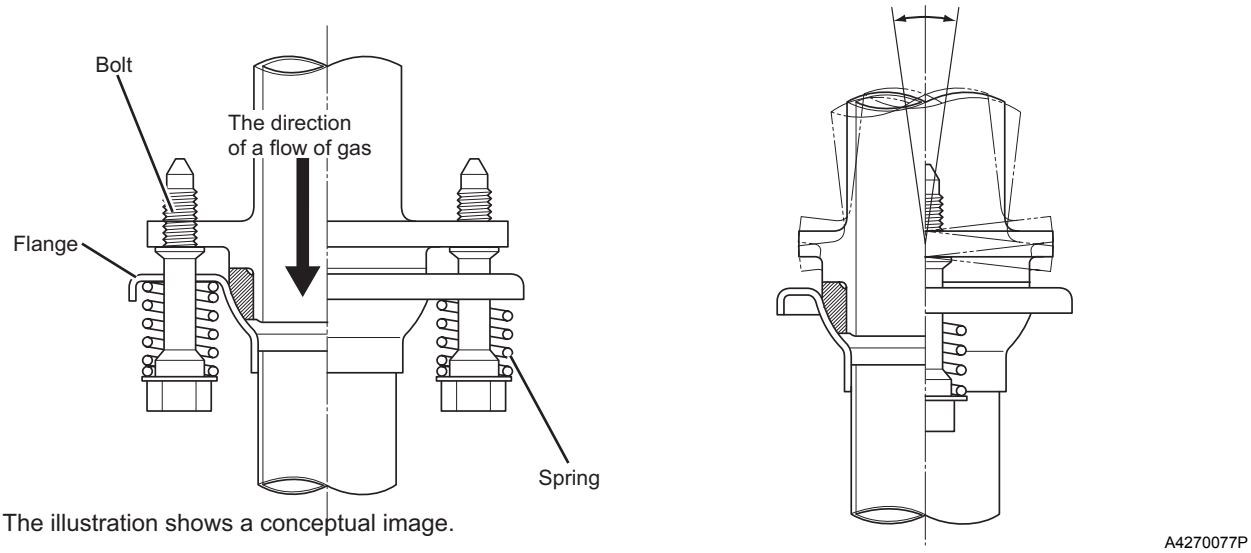
Exhaust Pipe

- Long, dual construction exhaust pipes are used from the exhaust manifolds to the front pipe junction. By optimizing the lengths of the exhaust pipes and utilizing the fluctuation of the exhaust pressure, exhaust gases are discharged effectively to improve the torque in the low- to medium-speed range.
- Ball joint mechanism is used to join the front pipe to the tail pipe in order to reduce the droning sound and vibration in the cabin and reduce weight. The ball joint mechanism consists of a spherical flange, and a bolt and a spring to support the sealing area of the gasket. The ball joint (the spherical areas of the flange and the gasket) absorbs the vibration of the engine as well as the vibration of the exhaust pipe in order to reduce the droning sound and vibration in the cabin.



Ball Joint Mechanism

- The ball joint mechanism consists of a spherical flange, a bolt, and a spring to support the sealing area of the gasket. This is more compact than a flexible pipe, and can be installed in an optimal position to counter vibrations.
- The ball joint (the spherical areas of the flange and the gasket) absorbs the vibration of the engine as well as the vibration of the exhaust pipe in order to reduce the droning sound and vibration in the cabin.

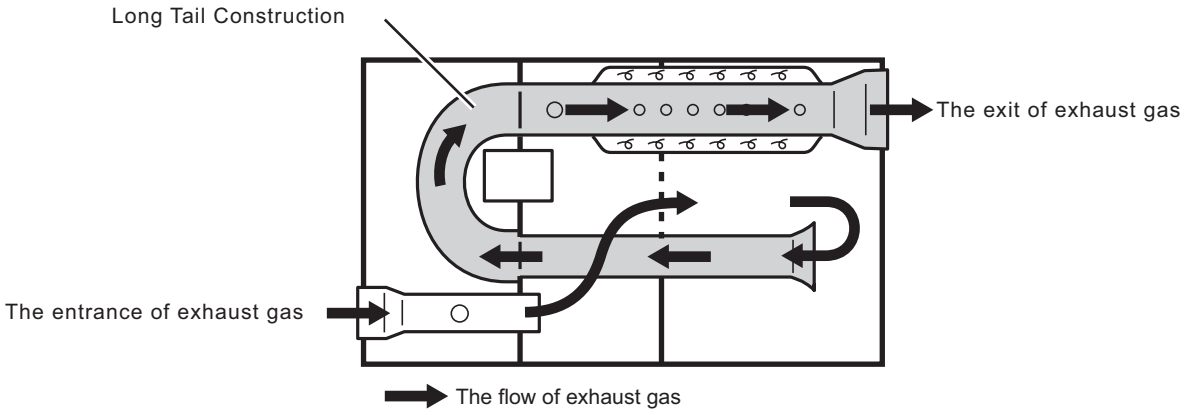


* The illustration shows a conceptual image.

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Muffler

● Dual main mufflers are provided to reduce back pressure, which improves the power output of the engine. A long tail construction is used inside the main muffler to suppress the low-frequency exhaust sounds, thus reducing the sounds in the cabin.



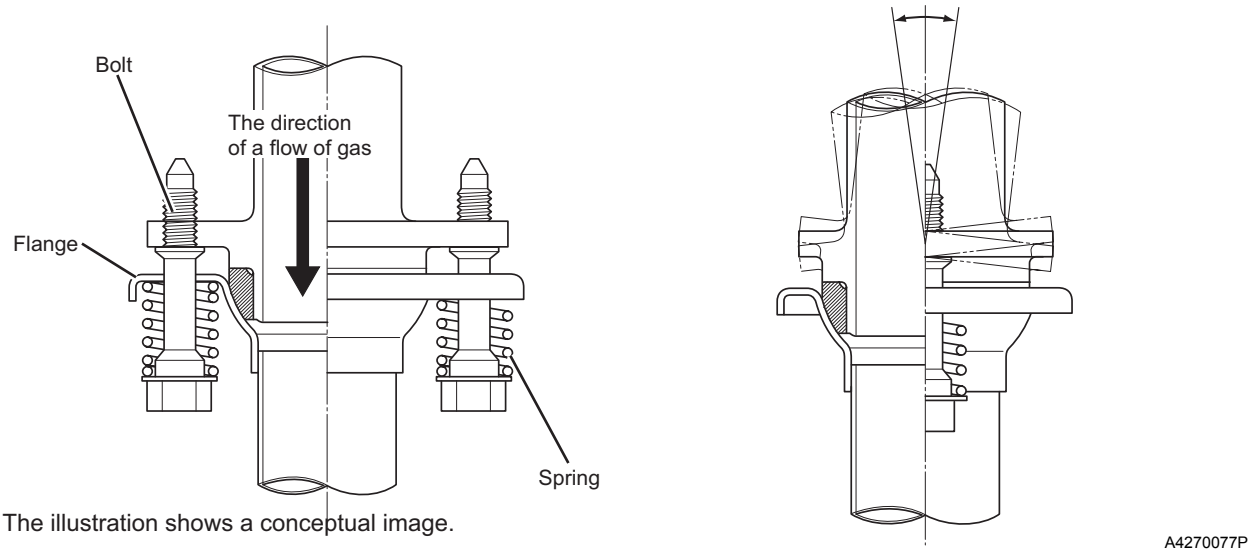
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Three Way Catalytic Converter

● An ultra thin-wall, high cell density ceramic catalyst with an optimized amount of precious metals held is placed directly below each exhaust manifold and in each front pipe. These catalysts ensure a high level of warm-up performance immediately after the engine is started, thus reducing exhaust emissions and complying with the Step-IV European Tailpipe Emission Regulations.

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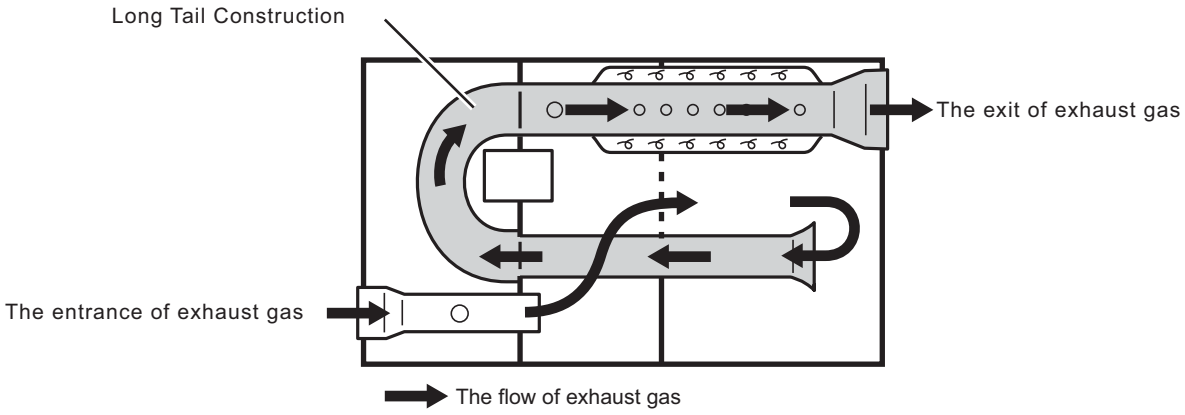


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A4270077P

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Three Way Catalytic Converter

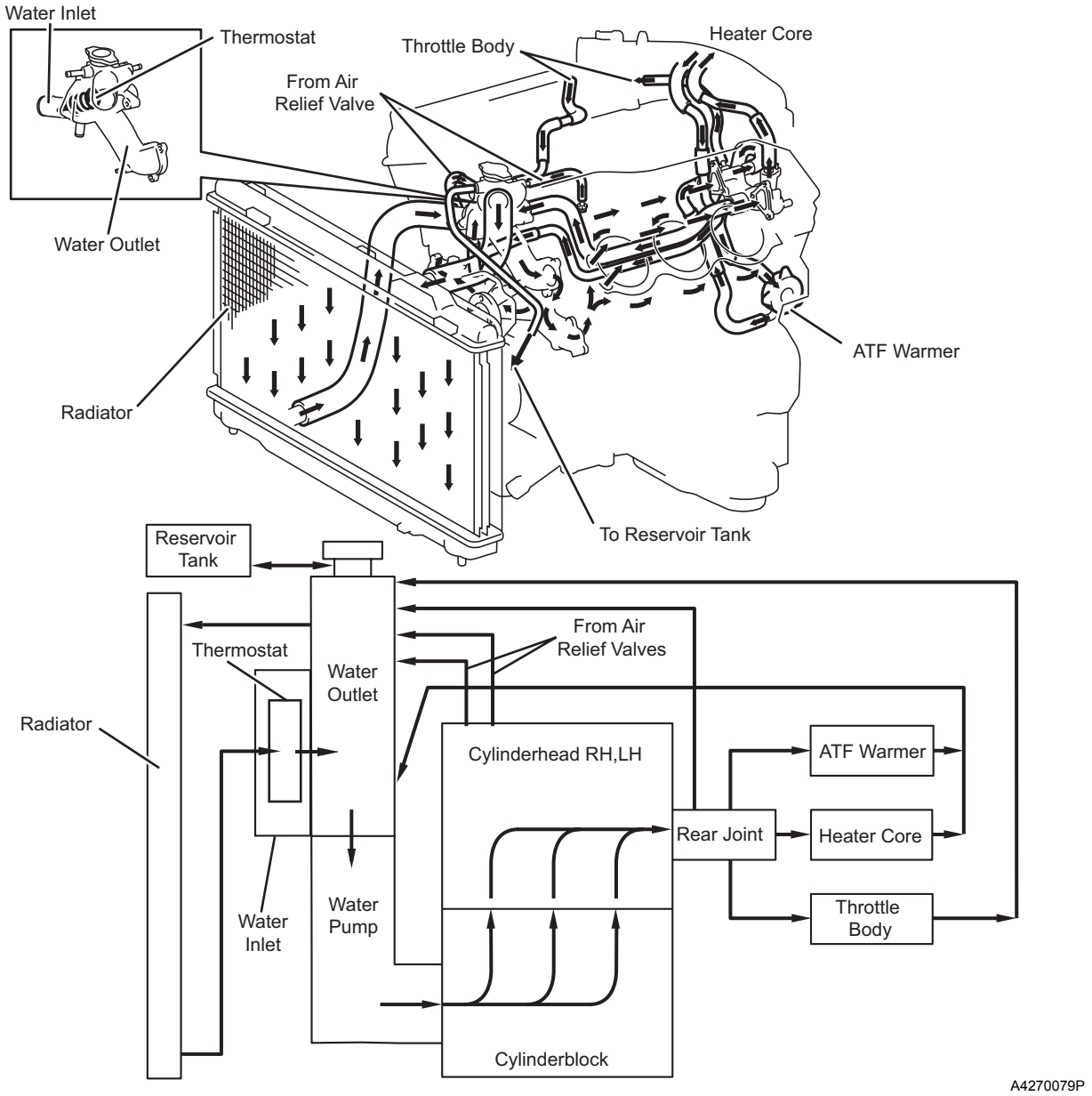
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3GR-FE COOLING

EG

General

- The cooling system is a water-cooled, forced-pressure circulation type in which a bypass valve type thermostat is integrated in the water inlet housing. The thermostat is the bottom bypass type.
- In this system, the engine ECU turns the cooling fan ON-OFF and controls the fan speed.
- To reduce the formation of air pockets in the cylinder head, air relief valves are provided in the right and left cylinder heads.
- An ATF warmer is provided to accelerate the warm-up speed, thus reducing the friction of the automatic transmission.



Radiator

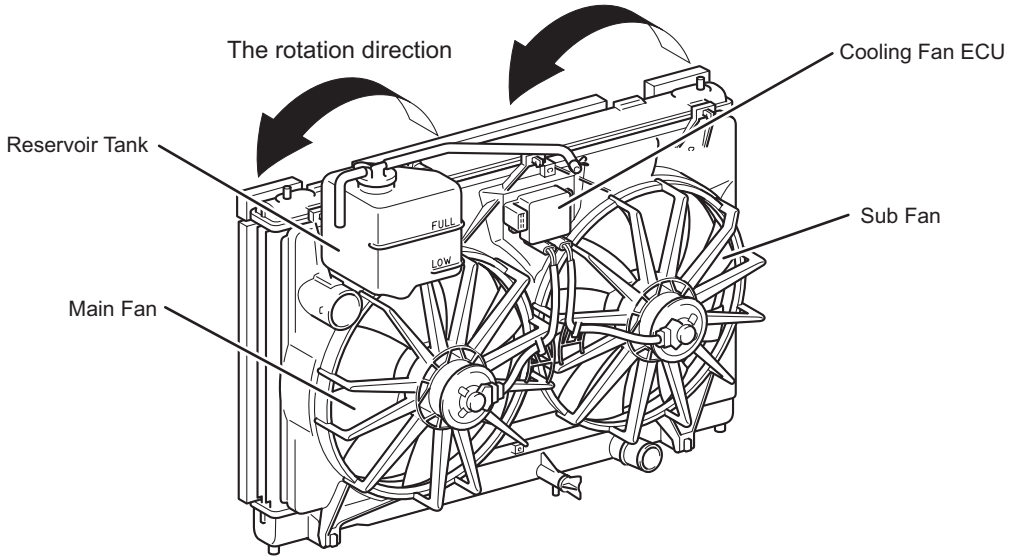
- A lightweight, high-performance aluminum core radiator is used to improve cooling performance and reduce weight.

Radiator

Core Type	Corrugated Fin
Fin Pitch [mm (in.)]	2.5 (0.098)/2
Core Dimensions (width x height x thickness) [mm (in.)]	709.0×399.2×27 (27.913×15.717×1.063)
Dry Weight [kg]	3.59

Cooling Fan

- The fan shroud is secured to the radiator without bolts.
- Ring fans, which are provided with band-shaped rings around them are used, which enhance rigidity and realize a lightweight and compact construction.
- The engine ECU outputs a signal to the cooling fan ECU, which steplessly controls the speed of the two fans in accordance with the engine conditions, driving conditions, and whether the air conditioner is operating. Through optimally controlled speeds, the fans operate significantly quieter and improve cooling performance.



Cooling fan

	Main Fan	Sub Fan
Outer Diameter [mm (in.)]	340 (13.386)	←
Number of blades	5	7

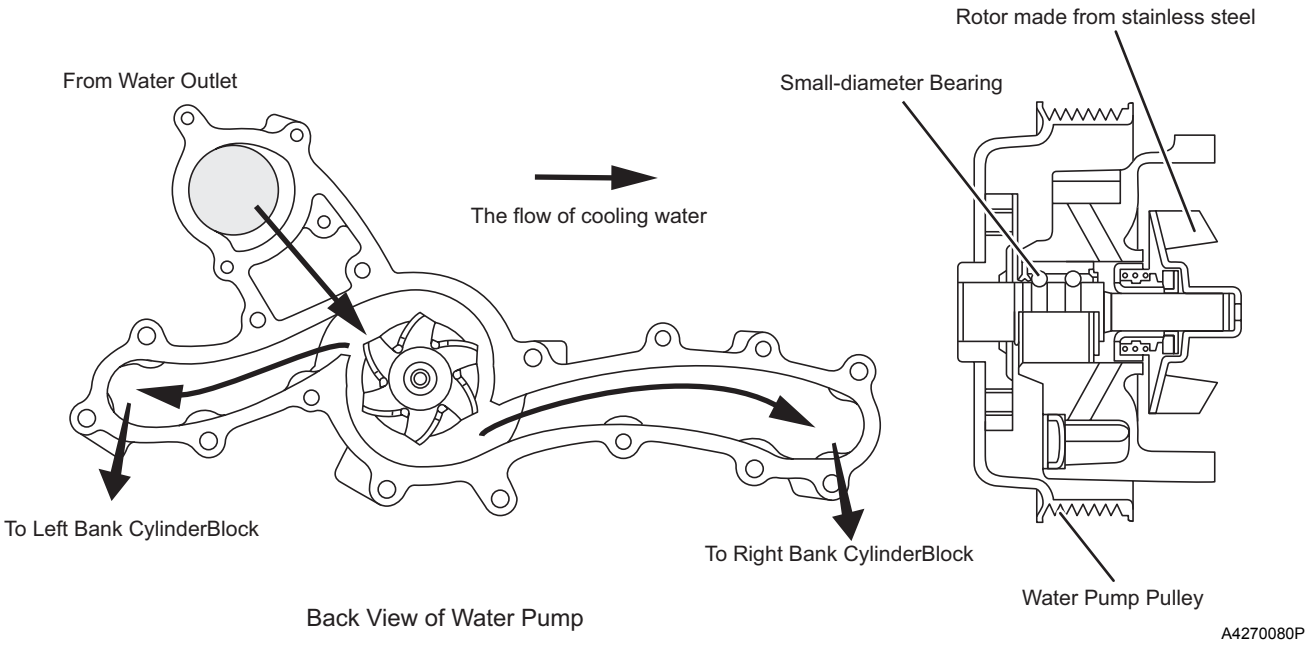
Cooling Fan motor

	Main Fan Motor	Sub Fan Motor
Rated voltage [V]	12	←
Rated Output [W]	160	←

EG

Water Pump

- The water pump uses a V ribbed belt driven system.
- It uses a small-diameter bearing to achieve a compact construction.
- The rotor is made of stainless steel to improve corrosion resistance and ensure reliability.



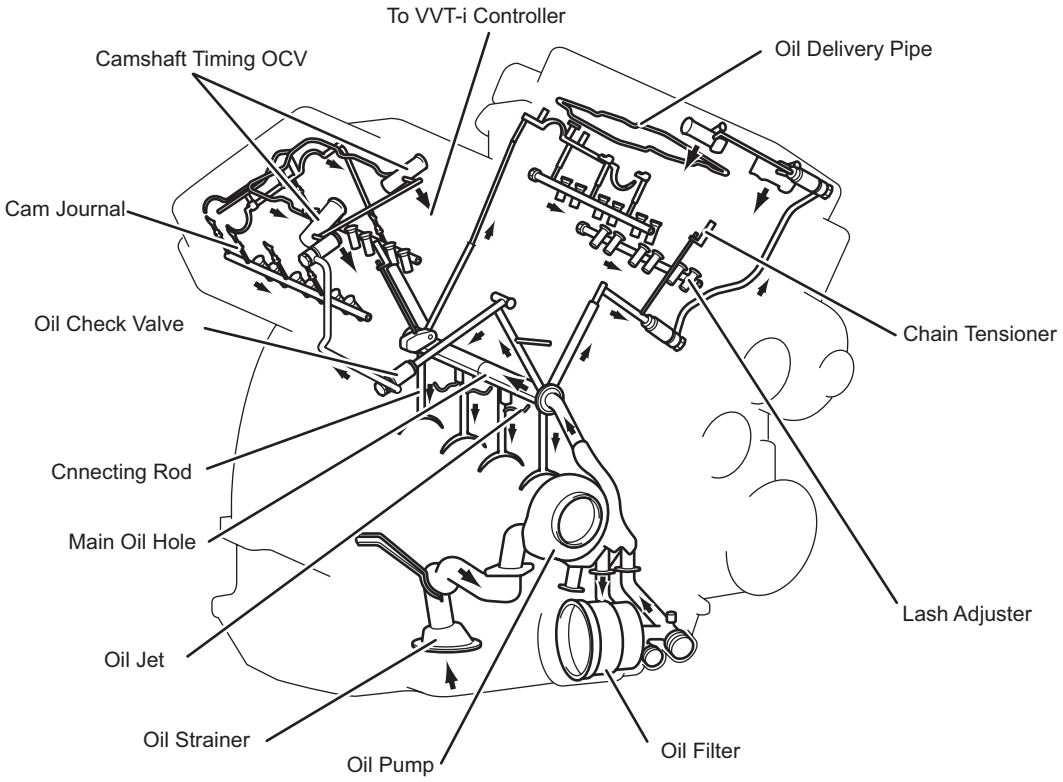
Water Pump

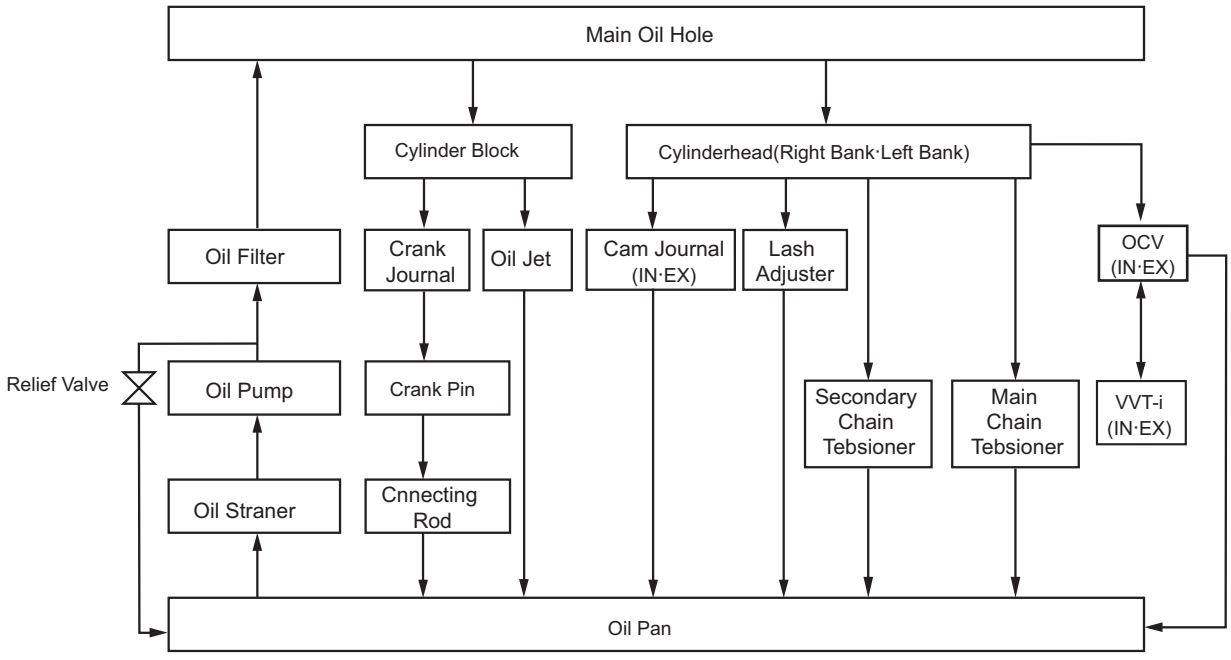
Drive System	V Ribbed Belt Driven
Rotor Diameter [mm (in.)]	60.0 (2.362)
Bearing Diameter [mm (in.)]	30.0 (1.181)
Number of Blades	6
Discharge Performance [L/min](at 80 ± 2°C, 4,000 rpm)	46

3GR-FE LUBRICATION

General

- A full-pumping, full-filtering lubrication system is used.



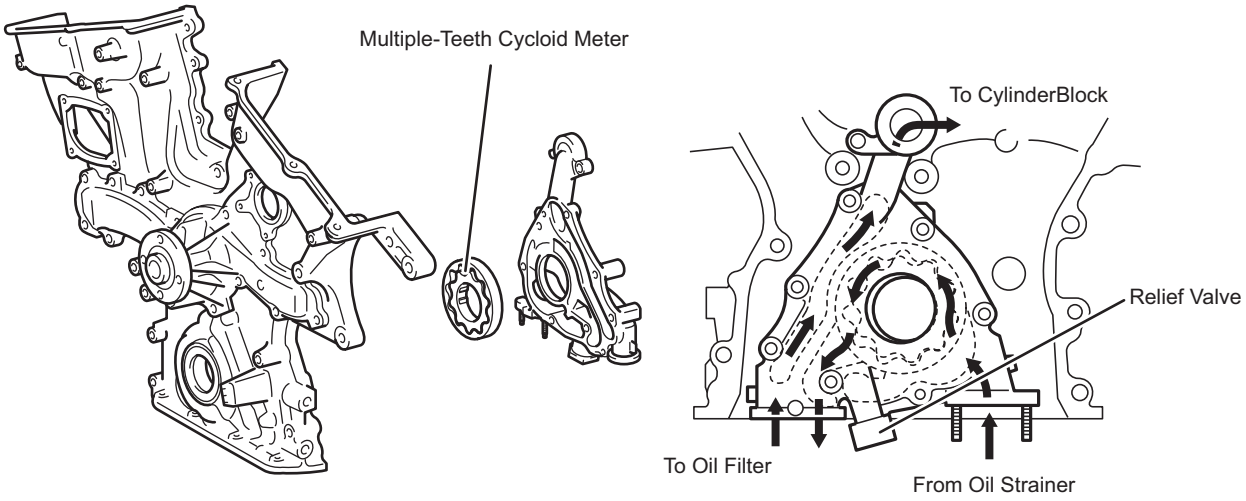


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EG

Oil Pump

- The oil pump consists of a compact, highly efficient, and multiple-teeth cycloid rotor that is driven directly by the crankshaft. The drive rotor is a flangeless type, which enables the use of a driven rotor with a small diameter, thus reducing friction.
- An internal oil relief system is used to circulate the relief oil through the suction passage in the oil pump. This suppresses the oil level fluctuations in the oil pan, reduces friction, and reduces the rate of mixing air bubbles in the oil.



The oil passage in an oil pump

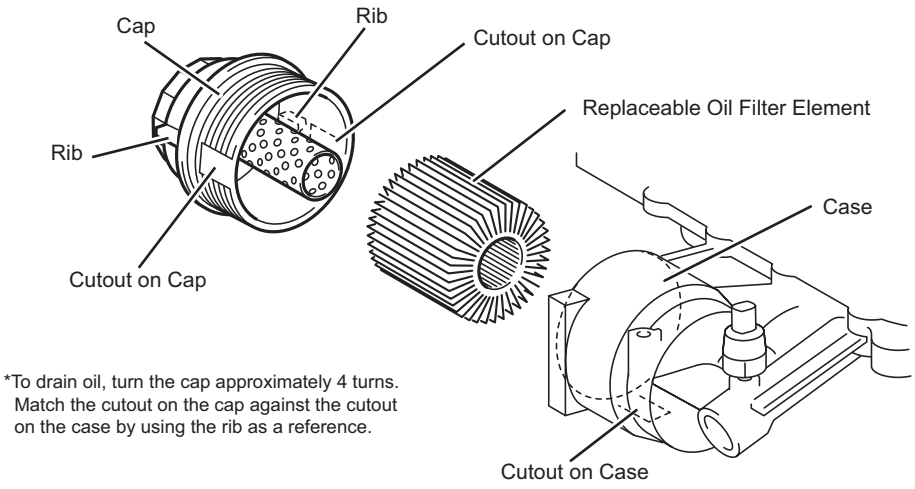
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Oil Pump

Pump Speed [rpm]	600	2000	6400
Discharge Volume [L/min]	6.0 Minimum	—	89.6 Minimum
Discharge Pressure [kPa]	100	—	290
Relief Valve Opening Pressure [kPa]	—	490	—

Oil Filter

- A newly developed oil filter with a replaceable element is used. The element uses high-performance filter paper that ensures ample filtering performance, and is made completely burnable.
- The cap is made of an aluminum alloy for a long life.
- A drain construction is provided to suppress the splashing of the oil during the replacement of the oil filter element. Oil can be drained by matching the thread cutout on the cap against the thread cutout on the case.



Drain construction

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■ **Service Tip** ■

To replace the oil filter, turn the cap approximately 4 turns, match the cutout on the cap against the cutout on the case, and drain the oil. Use the rib on the cap as a reference for matching the cutout on the cap against the cutout on the case. For details, refer to the GS430/300 Repair Manual(Pub. No. RM1168E)

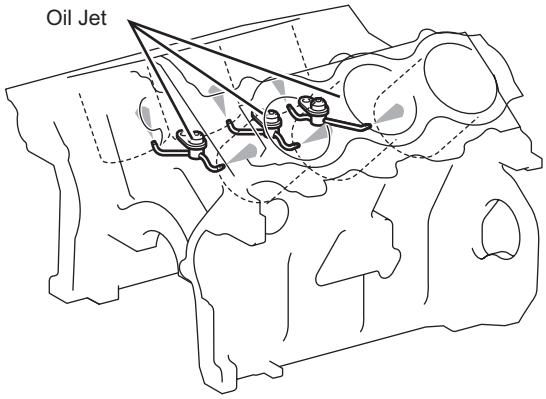
Oil Filter

Type		Full-flow
Filtration area	[cm^2]	1260
Outer diameter×Height	[mm (in.)]	82.1×70.5 (3.232×2.776)
Relief Valve Opening Pressure	[kPa]	100

EG

Oil Jet

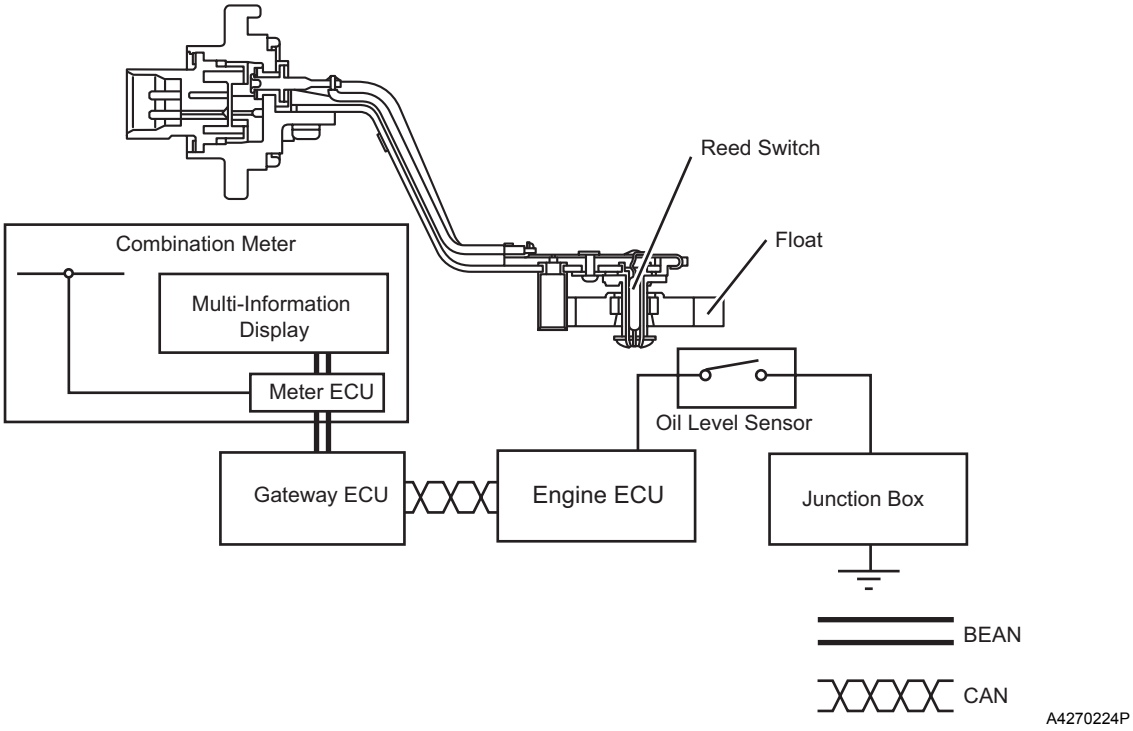
- Oil jets are provided in the cylinder block. These jets spray oil into the cylinders to reduce friction and suppress the increase in temperature. As a result, they improve the durability of the pistons and prevent them from knocking.



A4270084P

Oil Level Sensor

- The oil level sensor consists of a reed switch, which turns ON and OFF with the vertical movement of the float. When the engine oil level decreases, the system informs the driver of it in the following manner. On the multi-information display in the combination meter, a warning appears on the multi-information display. In addition, the system is provided with a 40-second delay circuit to prevent the display from indicating improperly as a result of biased behavior of the oil while the vehicle is in motion.
- A warning appears when the float descends as a result of a reduction in the engine oil level (when the reed switch is OFF).

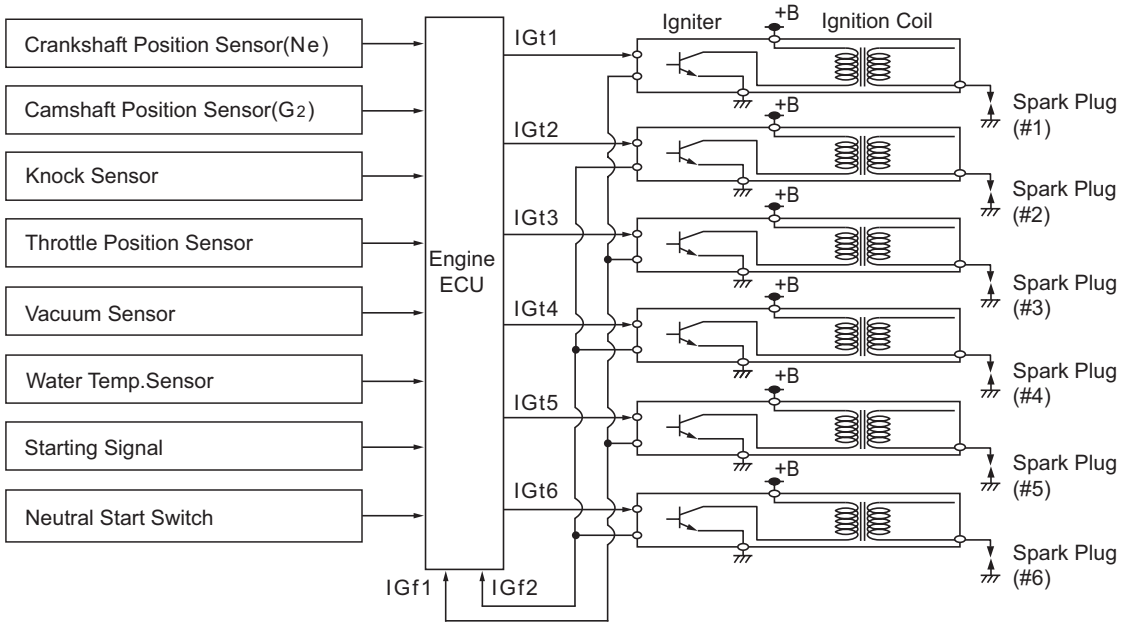


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3GR-FE IGNITION

General

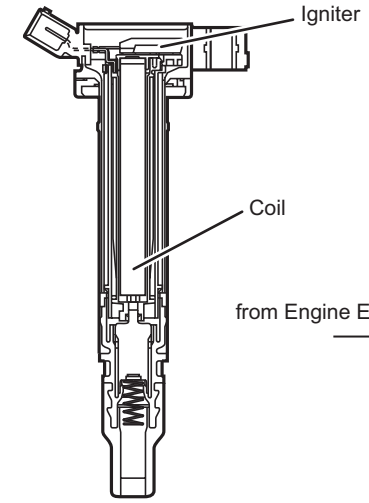
- The Direct Ignition system(DIS) is used, in which an ignition coil with a built-in igniter is provided for every cylinder. This system enhances the ignition timing control precision and makes the ignition timing completely adjustment-free.
- Independent ignition coils are provided to each of the cylinders #1 to #6, thus making a distributor or high tension cord unnecessary. This reduces the power loss associated with high-voltage areas, improves reliability, and reduces electro-magnetic interference.



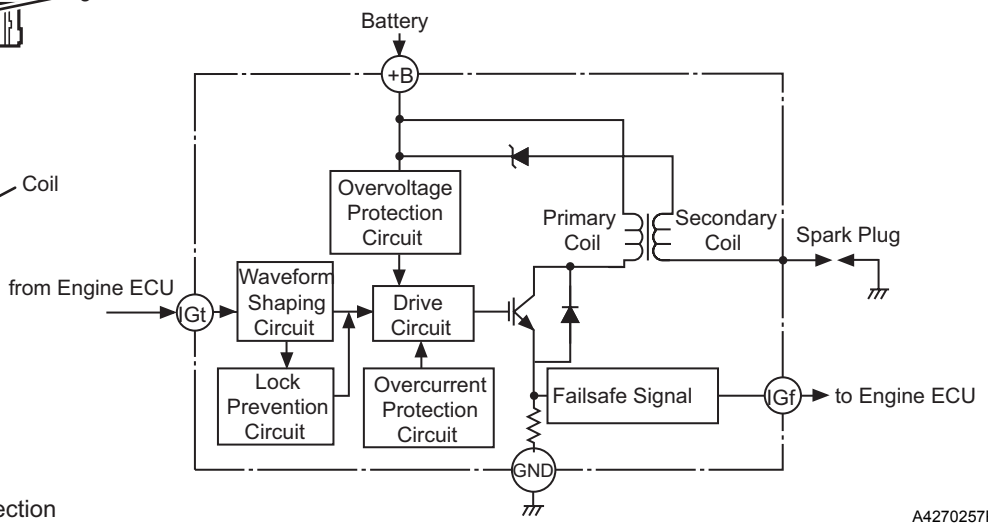
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Ignition Coil (with Igniter)

- Ignition coils with built-in igniters are used and placed directly over the spark plugs.



Ignition Coil Cross Section

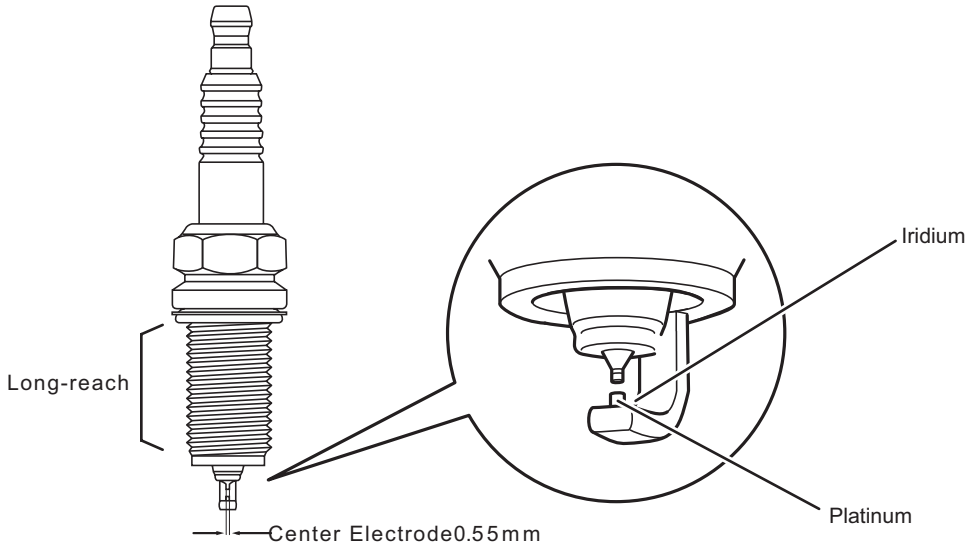


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EG

Spark Plug

- Long-reach spark plugs are used to improve the cooling performance of the cylinder heads.
- They are iridium spark plugs that use an iridium alloy in their center electrode. Because the iridium alloy has extremely superior wear resistance, the center electrode can be made with a small diameter. This produces reliable ignition while improving durability.



Spark Plug

DENSO	FK20HR11
NGK	ILFR6D11
Plug Gap [mm (in.)]	1.0 ~ 1.1 (0.0394~ 0.043)

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.
(See page EG-39)

Camshaft Position Sensor

- These sensors are the MRE (Magnetic Resistance Element) type. The rotational movement of the timing rotor (which is provided in the VVT-i controller of the intake camshaft) causes a magnetic field to act on the magnetic resistance element in the sensor. The sensor utilizes the changes that occur in the direction of the magnetic field to detect the position of the timing rotor, which determines the position of the actual camshaft. The cylinders are identified by the input sequence of the Ne and G2 signals.
(See page EG-40)

3GR-FE STARTING

Starter

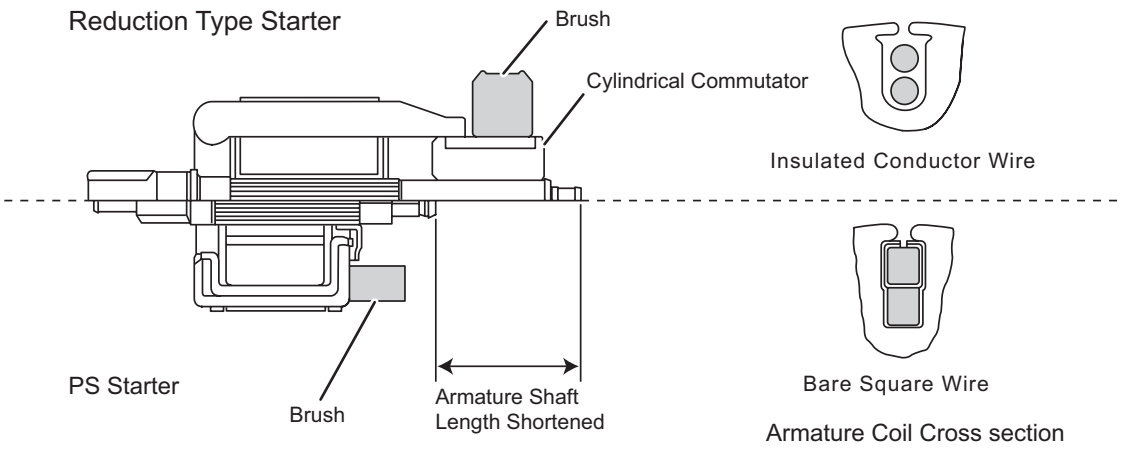
- A compact, lightweight, high power output, and highly efficient PS (Planetary reduction - Segment conductor motor) starter is used.
- A square conductor armature coil is used to achieve a compact and lightweight construction.

Starter

	Standard	For China
Type	PS Type	←
Rated Voltage [V]	12	←
Rated Output [kW]	1.3	1.7

Armature Coil

- The armature coil consists of bare square wire, which improves the space factor, and improves the torque of the starter.
- The cylindrical commutator has been discontinued to shorten the length of the armature shaft.

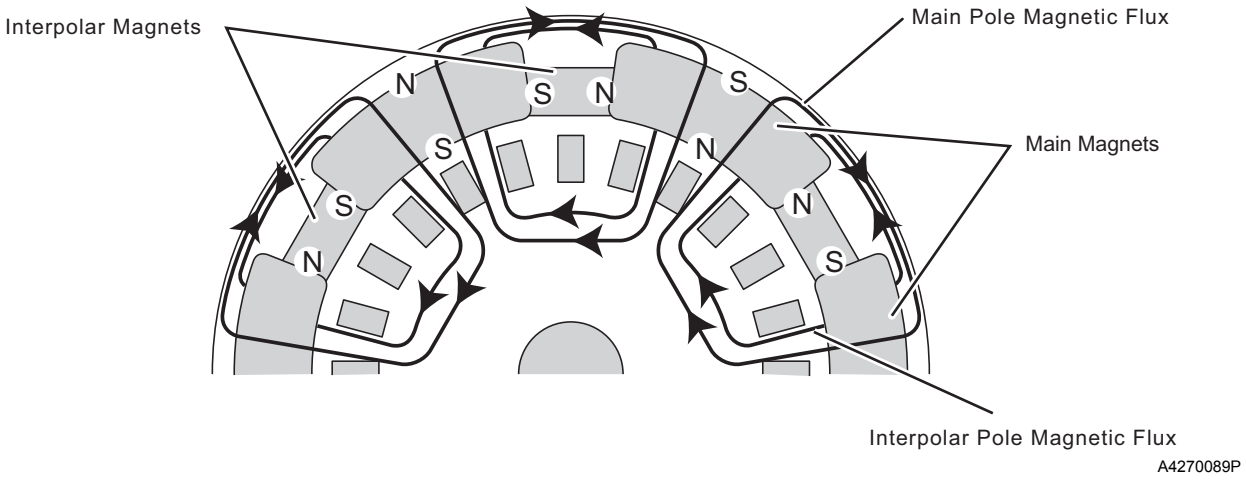


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EG

Field Coil

• Interpolar magnets are used between the field coils. This improves the magnetic circuit and increases the amount of magnetic flux. Because the same amount of magnetic flux as the conventional type can be attained with a compact construction, the length of the yoke shaft has been shortened.



3GR-FE CHARGING

Alternator

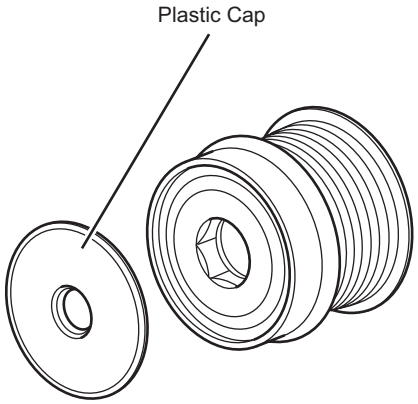
- A compact, lightweight, high power output, and highly efficient segment conductor type alternator is used.
- A clutch is provided in the alternator pulley. By reducing friction on the accessory belt, this clutch contributes to fuel economy.

Alternator

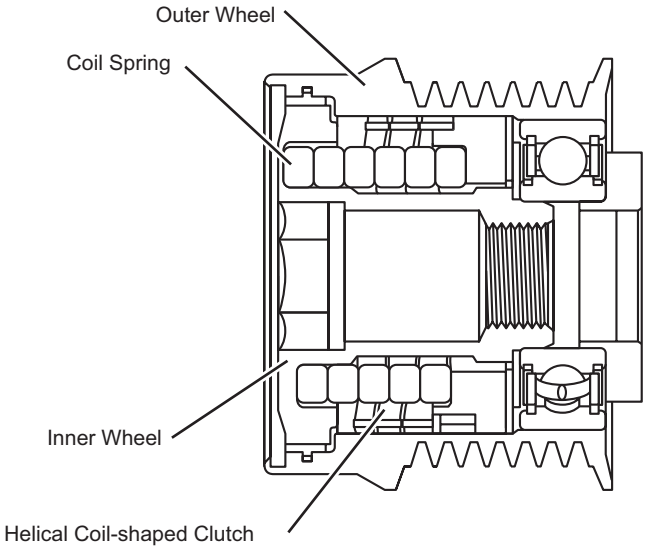
	Standard	For China
Rated Voltage [V]	12	12
Rated Output [A]	130	150
Regulator Setting Voltage [V](5000rpm,10A,25°C)	12.1 ~ 15.4	←
Permissible Max Speed [rpm]	18000	←

Alternator Pulley

- A helical coil-shaped clutch, which is located between the inner and outer wheels of the pulley, transmits power to the alternator only in the forward rotational direction of the engine. Thus, it reduces the load that acts on the accessory belt.
- The pulley is made compact by shaping the inner wheel together with the nut used for tightening the alternator shaft.
- A plastic cap that covers the interior is provided in front of the pulley. This prevents mud from entering, thus ensuring reliability under poor environmental conditions.



Alternator Pulley



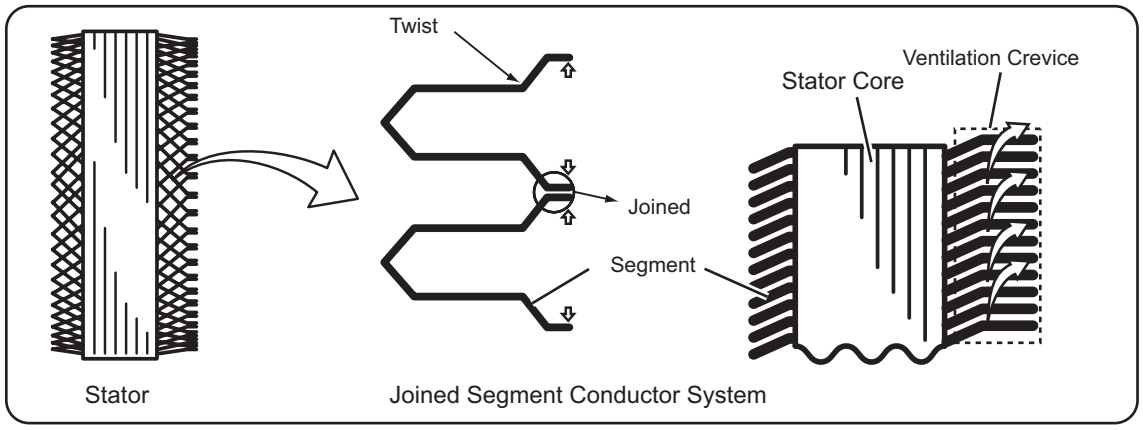
Alternator Pulley Cross Section

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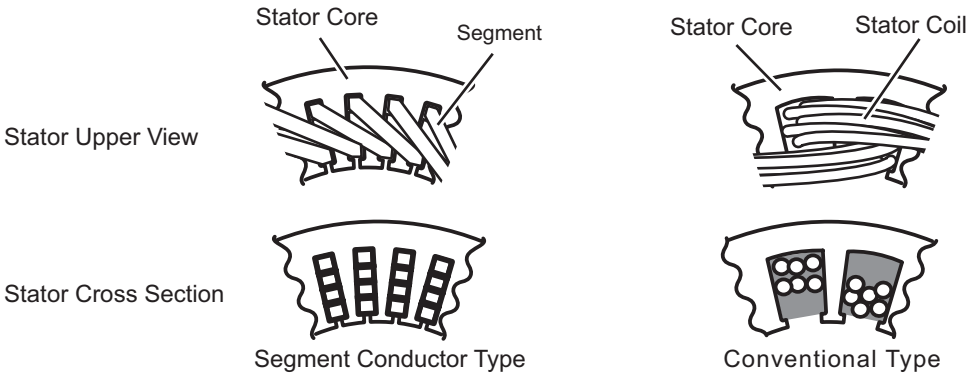
EG

Stator Coil

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



〈Segment Conductor Type Alternator〉

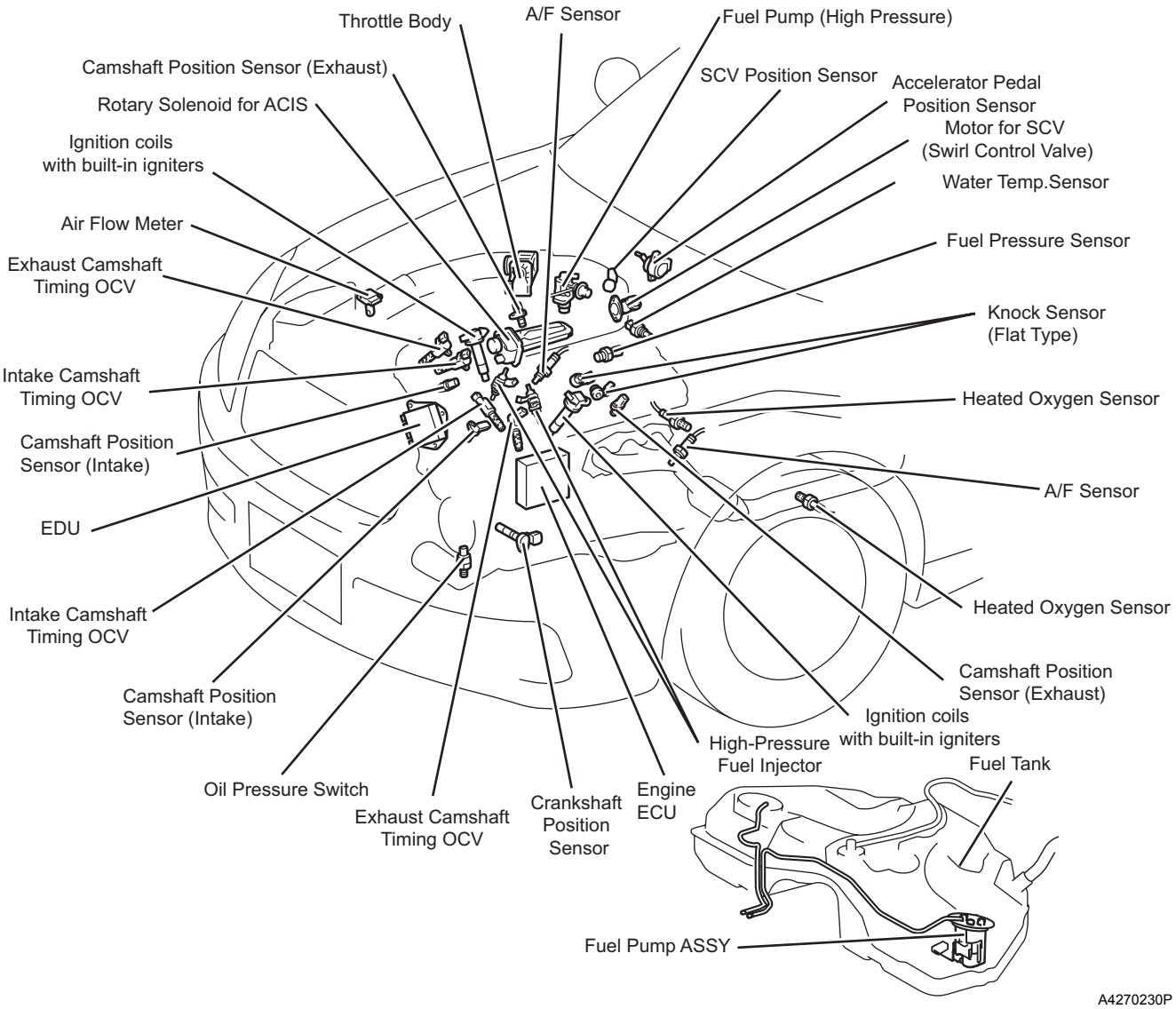


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3GR-FSE ENGINE CONTROL SYSTEM

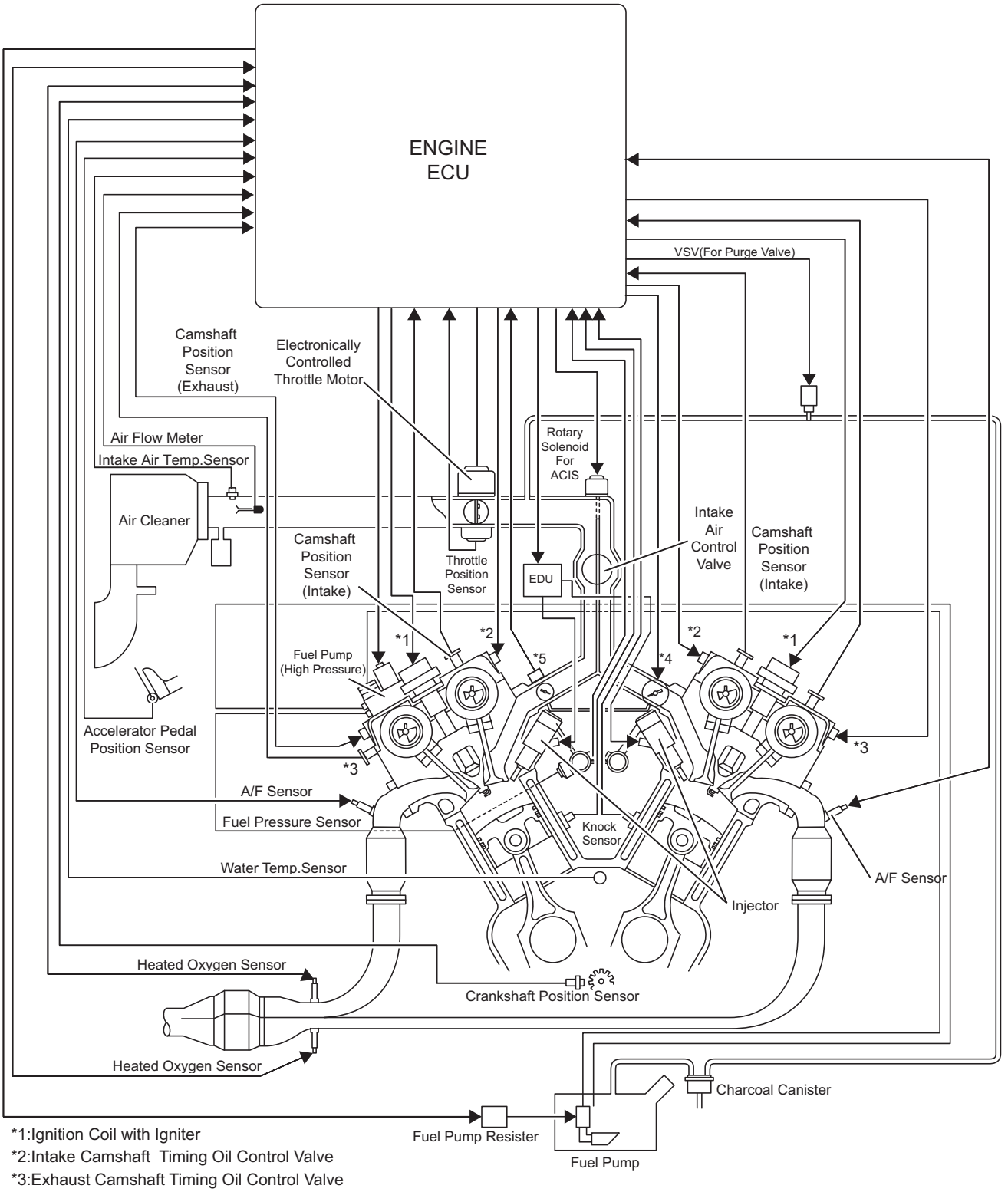
Engine Control System Description

- This engine controls the following systems in a highly accurate manner: Electronic Fuel Injection (EFI), Electronic Spark Advance (ESA), Electronic Throttle Control System-intelligent (ETCS-i), and Dual Variable Valve Timing-intelligent (Dual VVT-i). As a result, high performance, high power output, fuel economy, and improved exhaust emission performance have been achieved.
- A D-4 (Direct injection 4-stroke gasoline engine) system is used. The engine ECU effects centralized control to achieve an optimal state of combustion that suits the driving conditions, in order to realize fuel economy and a high power output in the practical range.
- CAN (Controller Area Network) communication is used to exchange data with other ECUs.
- The electronic SCV (Swirl Control Valve) control stabilizes combustion when the water temperature is low, and the electronic ACIS (Acoustic Control Induction System) control generates high torque in the practical speed range.
- A diagnosis and a failsafe function are provided to ensure serviceability and safety.



EG

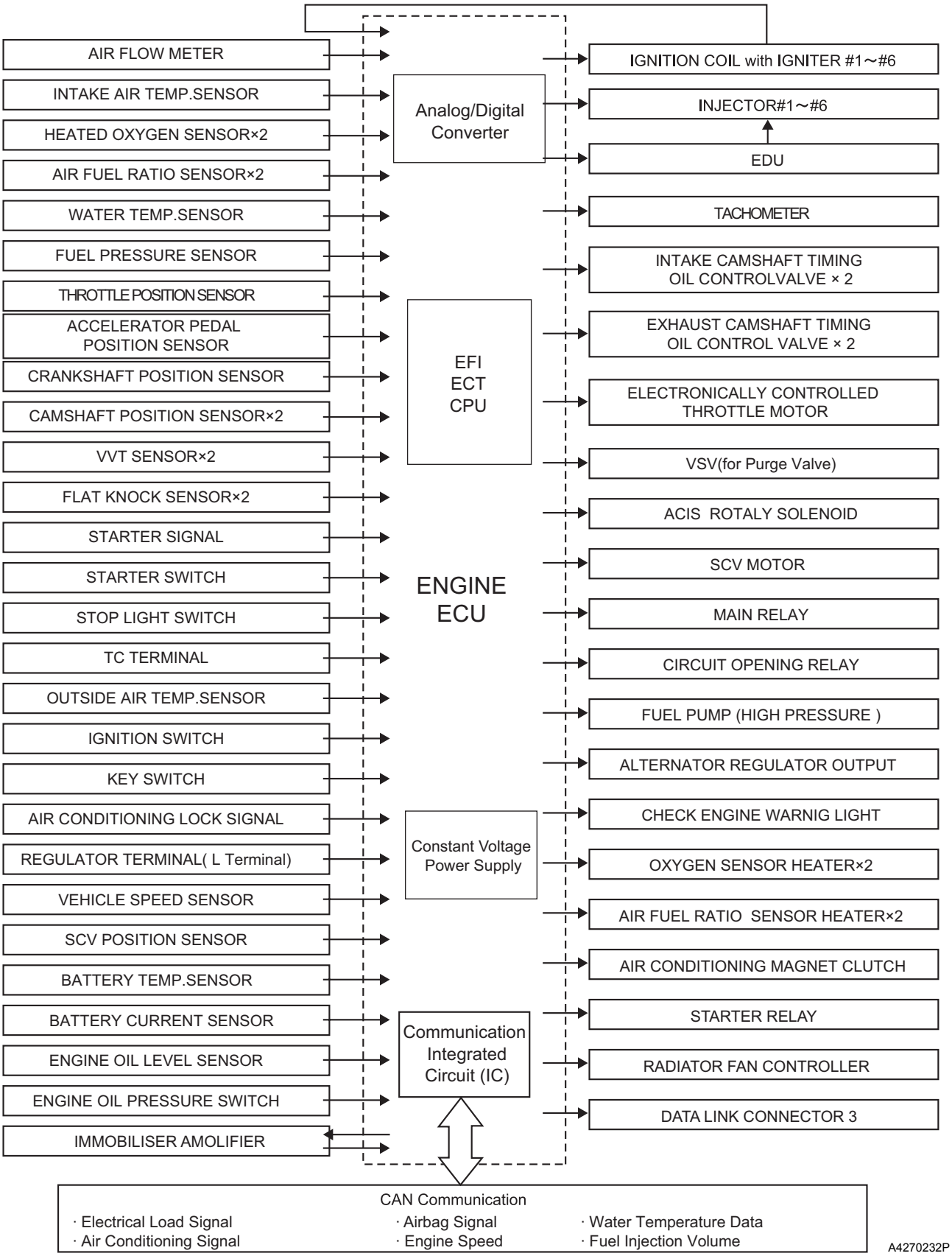
Engine Control System Diagram



*1:Ignition Coil with Igniter
*2:Intake Camshaft Timing Oil Control Valve
*3:Exhaust Camshaft Timing Oil Control Valve
*4:SCV(Swirl Control Valve) Motor
*5:SCV Position Sensor

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Construction



A4270232P

Control List

System	Outline	
D-4 EFI (Electronic Fuel Injection)	An L-type EFI system directly detects the intake air mass with a hot wire type mass air flow meter.	
ESA (Electronic Spark Advance)	An L-type EFI system directly detects the intake air mass with a hot wire type mass air flow meter.	
	Ignition timing is determined by the engine ECU based on signals from various sensors. Corrects ignition timing in response to engine knocking.	
	Knocking Judgment Control(KCS)	2 knock sensors are used to improve knock detection.
ETCS-i (Electronic Throttle Control System-intelligent)	Based on the signals provided by the sensors, this system applies corrections to the throttle position that has been calculated in accordance with the condition of the engine, in order to achieve an appropriate throttle position.	
	VSC Control	Controls the throttle valve position when the VSC is operating.
	Maximum Speed Control	When the vehicle speed reaches 240 km/h, this control closes the throttle valve to suppress the increase in vehicle speed.
	Idle Speed Control(ISC	Controls the fast idle speed in accordance with the water temperature, and the idle speed after the engine has been warmed up. It controls the idle speed by regulating the fuel injection volume and the throttle position.
Dual VVT-i Control	Controls the optimal intake and exhaust valve timing in accordance with the conditions of the engine.	
SCV(Swirl Control Valve) Control	Optimally controls the air current in the combustion chamber by closing one of the independent intake ports in accordance with the water temperature and engine condition, in order to stabilize the combustion and improve performance.	
ACIS (Acoustic Control Induction System) Control	Varies the intake manifold length to suit the conditions of the engine.	
Fuel Pump Control (For High Pressure Side)	Controls the discharge pressure of the high-pressure fuel pump in accordance with the conditions of the engine.	
Fuel Pump Control	Turns the fuel pump ON/OFF in accordance with the starter signal and the engine speed signal. Stops the operation of the fuel pump in accordance with the signals from the airbag ECU.	
Alternator Charging Control	Controls the charging voltage of the alternator in accordance with the driving conditions, thus reducing the charging load and contributing to fuel economy.	
Cranking Hold Control	After the starter starts to crank the engine, this control continues to apply current to the starter until the engine starts. Thus, it prevents the failure of the engine to start when the driver inadvertently turns the ignition switch to OFF just before the engine fires.	
Air-Fuel Ratio Sensor Heater Control	Turns the air-fuel ratio sensor heater ON/OFF in accordance with the water temperature and the driving conditions.	
Heated Oxygen Sensor Heater Control	Maintains the temperature of the heated oxygen sensor at an appropriate level to increase accuracy of detection of the oxygen concentration in the exhaust gas.	
Evaporative Emission Control	The engine ECU controls the purge flow of evaporative emissions (HC) in the charcoal canister in accordance with engine conditions.	

System	Outline
Air ConditioningCut-Off Control	By controlling the air conditioning compressor ON or OFF in accordance with the engine condition, drivability is maintained.
Engine Immobiliser	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid ignition key.
Function to communicate with multiplex communication system	Communicates with the meter ECU, A/C ECU, etc., on the body side, to input/output necessary signals.
Diagnosis	Enables the accurate and detailed diagnosis of malfunctions through the use of the intelligent Tester II diagnostic tool to access the SAE-prescribed DTC (Diagnostic Trouble Code) and data, as well as to perform active tests.
Fail-Safe	When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in the memory.

■ **Service Tip** ■

The uses the CAN protocol for diagnostic communication. Therefore, a intelligent Tester II and a dedicated adapter [CAN VIM (Vehicle Interface Module)] are required for accessing diagnostic data. For details, see the 2005 Lexus GS430/300 Repair Manual(Pub. No. RM1168E)

Sensor List

Name	Function and Construction	EFI	ESA	ISC	VVT-i
Air Flow Meter	Detects the intake air volume.	❍	❍	❍	❍
Intake Air Temperature Sensor	Detects the intake air temperature.	❍	❍	❍	❍
Camshaft Position Sensor	Identifies the cylinder and detects the actual camshaft position.	❍	❍	❍	❍
Crankshaft Position Sensor	Detects the crankshaft position.	❍	❍	❍	❍
Accelerator Pedal Position Sensor	It is attached to the accelerator pedal to detect the accelerator pedal position.	❍	❍	❍	❍
Throttle Position Sensor	Detects the throttle valve position.	❍	❍	❍	❍
SCV Position Sensor	Detects the SCV position.				
Water Temp.Sensor	Detects the water Ftemperature.	❍	❍	❍	❍
Fuel Pressure Sensor	It is mounted on the fuel delivery pipe to detect fuel pressure.	❍			
Air-Fuel Ratio Sensor	Detects the state of the air-fuel ratio in the exhaust gas.	❍			
Heated Oxygen Sensor	Detects the oxygen concentration in the exhaust gas.	❍			
Igniter	Sends the ignition verification signal.		❍		
Starter Signal	Sends the starter voltage in the form of a signal when the engine is started.	❍	❍	❍	❍
Neutral Start Switch	Detects the P, N, and D positions of the automatic transmission.	❍	❍	❍	❍
Knock Sensor	Detects the knocking of the engine by way of the resonance of the piezoelectric element.		❍		

Name	Function and Construction	EFI	ESA	ISC	VVT-i
Vehicle Speed Signal	Detects vehicle speed.	❍	❍	❍	❍

Actuator List

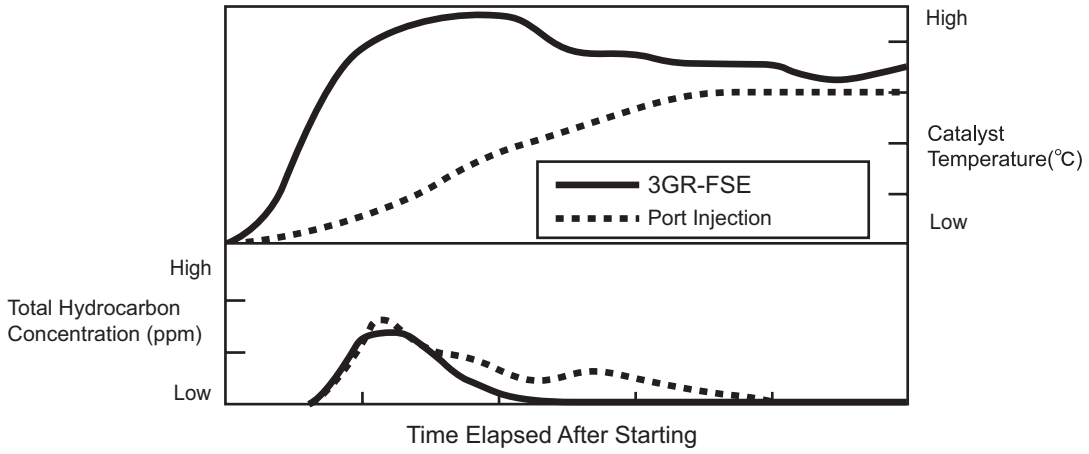
Name	Function and Construction
Main Relay	Supplies main power to the EFI, ESA system, etc.
Circuit Opening Relay	Supplies power to the fuel pump system.
High-Pressure Fuel Pump	Pressurizes fuel.
Fuel Injector	Injects an optimal volume of fuel at an optimal timing.
Air-Fuel Ratio Sensor Heater	Heats the air-fuel ratio sensor to promote feedback control when the engine is cold.
Heated Oxygen Sensor Heater	Heats the heated oxygen sensor to promote feedback control when the engine is cold.
Igniter	Turns the current to the ignition coil ON/OFF at an optimal timing.
Electronically Controlled Throttle Motor	Controls the position of the throttle valve in accordance with driving conditions.
Intake Camshaft Timing OCV	Controls the intake VVT-i at an optimal valve timing.
Exhaust Camshaft Timing OCV	Controls the exhaust VVT-i at an optimal valve timing.
Rotary Solenoid for ACIS	Opens and closes the intake air control valve in accordance with driving conditions.
Motor for SCV (Swirl Control Valve)	Opens and closes the swirl control valve in accordance with driving conditions.
Evaporative Purging VSV	Regulates the purge volume of the canister.
EDU(Electronic Driver Unit)	Converts the injection request signal from the engine ECU into a high voltage, high amperage injector actuation signal in order to actuate the high-pressure fuel injector.

D-4 EFI (Electronic Fuel Injection) System

- The D-4 (Direct Injection 4-Stroke Gasoline Engine) consists of a high-pressure fuel injector that is installed directly in the combustion chamber in order to precisely and optimally control the fuel injection timing in accordance with the driving conditions.
- Uses an airflow meter to detect the intake air volume in order to control the fuel injection volume.
- Based on the signals obtained from various sensors, the engine ECU controls the injection volume and injection timing to suit the engine speed and the engine load, in order to achieve an optimal state of combustion.
- Unlike an ordinary gasoline engine, the fuel injection system simultaneously controls the injection timing and injection volume in order to inject fuel directly into the cylinders. In addition, asynchronous injection that takes place in an ordinary gasoline engine does not exist in this engine.
- To promote the warm-up of the catalyst during cold starting, this system effects lean-burn control through weak stratification combustion.

Weak Stratification Combustion

- The system injects fuel during the latter half of the compression stroke immediately after the engine is cold-started, to effect a weak stratification combustion. This raises the combustion temperature, promotes the warm-up of the catalyst, and dramatically improves exhaust emission performance.



The effect of reducing the total hydrocarbon concentration by injecting fuel during the compression stroke during cold starting

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Homogeneous Combustion

• By injecting fuel during the first half of the intake stroke, the engine creates a more homogeneous air-fuel mixture. In addition, by utilizing the heat of evaporation of the injected fuel to cool the compressed air, the engine has increased its charging efficiency and produces a higher power output.

Air-Fuel Ratio Control

Air-Fuel Ratio Control	The system determines the fuel injection volume based on the engine speed and the intake air volume (which is detected by the airflow meter). After the engine is started, feedback control is effected on the air-fuel ratio based on signals from the air-fuel ratio sensor.

Control and Combustion Classification

		State of Combustion	Injection Timing	Control Condition
(1)	Lean Air-Fuel Ratio Control	weak stratification combustion	compression stroke	At the time of starting between the colds
(2)	Stoichiometric Air-Fuel Ratio Control	homogeneous combustion	intake stroke	Except (1) and (3)
(3)	Air-Fuel Ratio Feedback Control Prohibition	homogeneous combustion	intake stroke	High load driving (large)
				At the time of low engine coolant temperature

Fuel Cut

• The system temporarily stops the injection of fuel to protect the engine and improve fuel economy.

The following are the three types of fuel cutoff

Deceleration Fuel Cutoff	Stops the injection of fuel when the engine speed is higher than the specified value during deceleration (throttle OFF detected by ECM). This prevents the TWC (Three-Way Catalyst) from overheating due to misfiring and improves fuel economy. The fuel cutoff and resumption speeds are higher when the coolant temperature is low.
Engine Speed Fuel Cutoff	Stops the injection of fuel when the engine speed is higher than the specified value to prevent over-revolution.
N → D Shift Fuel Cutoff	Stops the injection of fuel for a prescribed length of time when shifting from N→ D, if the engine speed is higher than the specified value to reduce shift shock.

Fuel Pump Control (For High Pressure Side)

● The system varies the high fuel pressure between 4 and 13 MPa to suit the driving conditions, in order to reduce friction loss.

● When the engine is started, the solenoid spill valve opens, allowing the fuel to be sent to the delivery pipe at the pressure regulator pressure (400 kPa).

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ESA (Electronic Spark Advance)

● 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. The ignition timing can be expressed by the formula given below. The default ignition timing is set to 5° BTDC.

Calculation of ignition timing

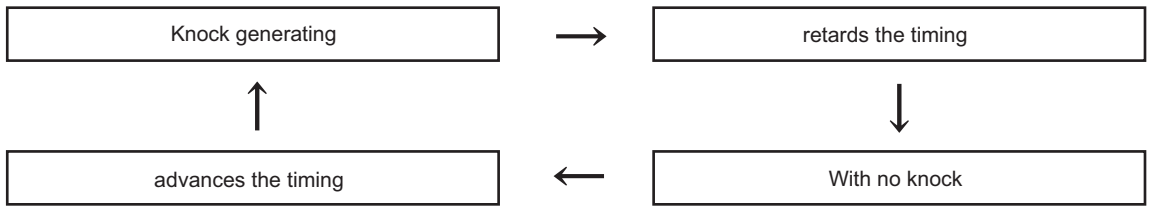
❖REFERENCE❖

Ignition Timing = A. Default Ignition Timing or B. Basic Timing Advance + C. Correction Timing Advance

A.Fixed Timing Advance Characteristic	During the starting of the engine, the timing is fixed to 5° BTDC. If the throttle valve is turned OFF and shorting the service terminals, the timing becomes fixed to 10° BTDC.
B.Basic Timing Advance Characteristic	The optimal ignition timing is selected from the map based on the signals received from the sensors.
C.Correction Timing Advance Characteristic	Appropriately advances or retards the timing in accordance with the conditions of the engine based on the signals received from the sensors.
C-1 Warm-Up Timing Advance Characteristic	Advances the ignition timing in accordance with the driving conditions when the engine coolant temperature is low, in order to improve drivability.
C-2 Idle Stabilization Timing Advance Characteristic	Advances the ignition timing when the idle speed decreases, in order to stabilize the idle speed. Conversely, retards the timing if the idle speed increases.
C-3 Transient Correction Timing Retard	Retards the ignition timing during sudden acceleration when the water temperature is higher than 60°C, in order to prevent the engine from knocking.
C-4 Acceleration Timing Retard	Temporarily retards the ignition timing during acceleration in order to improve drivability.
C-5 Knock Correction Timing Retard	Corrects the ignition timing in accordance with the signals received from the knock sensor when knocking occurs. Depending on the extent of the knocking that is detected, this function retards the timing by a prescribed angle at a time until there is no more knocking. After no more knocking occurs, this function advances the timing by a prescribed angle at a time. If knocking occurs again while advancing the timing, it retards the timing again.

Knock Control System

- When the engine ECU detects the engine knocking, it retards the timing, depending on the extent of knocking, by one predetermined angle at a time until the engine stops knocking.
- When the engine stops knocking, the engine ECU advances the timing by one predetermined angle at a time. If the engine starts knocking again, the engine ECU retards the timing again.



Knocking Feedback Control

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Maximum and Minimum Timing Advance Characteristics

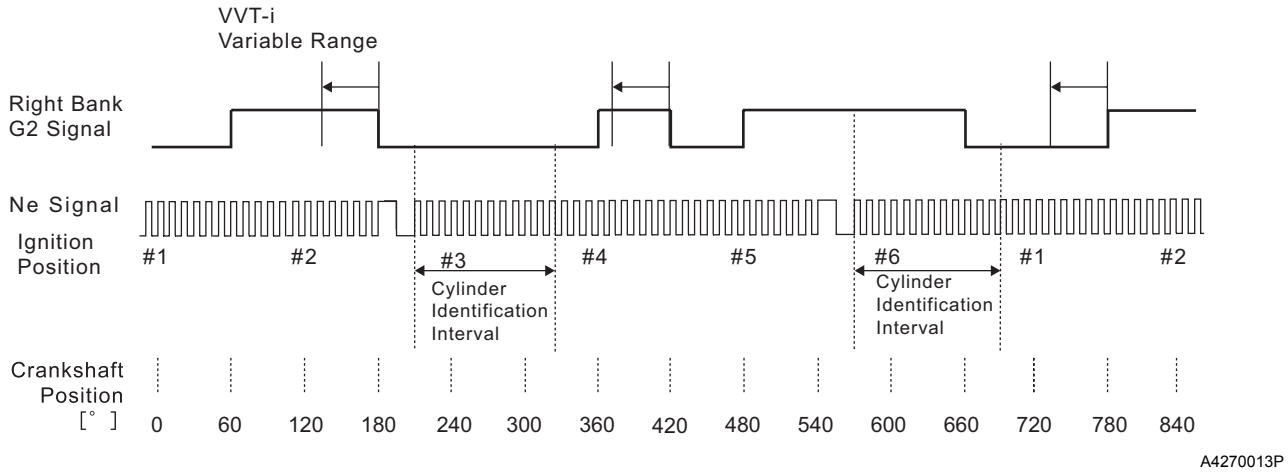
• The maximum and minimum timing advance angles are fixed because the engine can be adversely affected if the ignition timing advances or retards abnormally.

Maximum and Minimum Timing Advance Angles

Maximum Timing Advance Angle (BTDC)	49°
Minimum Timing Advance Angle (ATDC)	-20°

Calculation of ignition timing

• Based on the Ne and G2 signals, airflow meter signal, accelerator position signal, and water temperature signal, the engine ECU calculates the optimal ignition timing to suit the driving conditions. Then, the engine ECU sends an ignition signal to the ignition coil with a built-in igniter.



Idle Speed Control

● Controls the fast idle speed in accordance with the engine coolant temperature, and the idle speed after the engine has been warmed up. It controls the idle speed by regulating the fuel injection volume and the throttle position.

Idle Speed Control

Starting Control	When starting the engine, this control opens the throttle valve to increase the intake air volume, which improves the startability of the engine.
Forecast Control	When the system detects any one of the signals listed below, it controls the position of the throttle valve to suppress speed fluctuations.
	·A change in the idle speed has been forecasted.
	·A change occurred in the electrical load.
	·The air conditioning switch has been switched.
	·The shift lever has been shifted. (N → D, D → N)
Deceleration Control	This control increases the airflow volume by opening the throttle valve during deceleration, thus lowering the vacuum in the intake manifold. This decreases the volume of oil consumed through suction into the combustion chamber, prevents the engine from stalling through a sudden drop in engine speed, and improves drivability.
Feedback Control	While measuring the engine speed for a certain length of time, if there is a difference between the actual speed and the target speed, this control regulates the throttle valve position in order to bring the idle speed to the target speed.

Target Speed

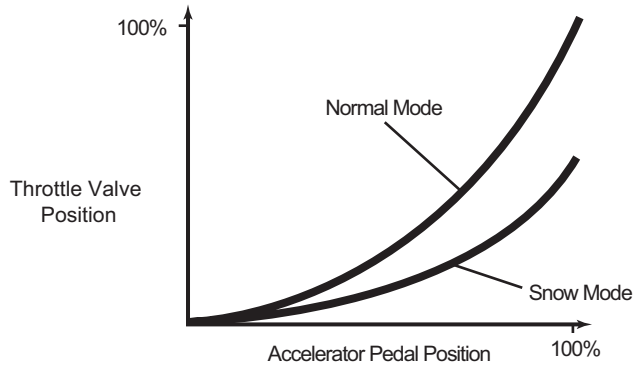
		3GR-FSE
No-load speed [rpm]		650
With an electrical load [rpm]		650
A/C ON [rpm]	Low load	650
	High load	800

ETCS-i (Electronic Throttle Control System-intelligent)

- In the conventional throttle body, the throttle valve opening is determined invariably by the amount of the accelerator pedal effort. In contrast, the ETCS-i uses the engine ECU to calculate the optimal throttle valve opening that is appropriate for the respective driving condition and uses a throttle control motor to control the opening.
- The functions of the ordinary throttle position control (nonlinear control), idle speed control (ISC), traction control (including VSC), and cruise control have been integrated in the single-valve electronically controlled throttle body.
- Excellent driving stability and comfort have been achieved by effecting integrated control with the power train, and vehicle stability has been ensured through cooperative control with the ECT and VSC systems.
- Two CPUs, one for the ETCS-i, and the other for the EFI control, monitor each other to ensure a reliable system.
- A dual system is used so that the vehicle can continue to operate in the event of a problem, thus ensuring reliability.

ETCS-i Control

Nonlinear Control	Normal-mode Control	Controls the throttle to an optimal throttle valve opening that is appropriate for the driving condition such as the amount of the accelerator pedal effort and the engine operating condition in order to realize excellent throttle control and comfort in all operating ranges.
	SNOW-mode Control	In situations in which low-μ surface conditions can be anticipated, such as when driving in the snow, the throttle valve can be controlled to help vehicle stability while driving over the slippery surface. This is accomplished by turning on the SNOW switch of the pattern select switch, which, in response to the amount of the accelerator pedal effort that is applied, reduces the engine output from that of the normal driving level.
ECT + EFI + ETCS-i Integrated Control (Shift Shock Reduction Control)		During the shifting of the ECT, this control regulates the throttle valve position in order to reduce the shift shock that occurs during shift up and down, and shorten the shifting duration.
Maximum Speed Control		When the vehicle speed reaches 240 km/h, this control closes the throttle valve to suppress the increase of vehicle speed.
TRC (VSC) + ETCS-i Cooperative Control (models equipped with VSC)		In order to bring the effectiveness of the VSC system control into full play, the throttle valve opening angle is controlled by effecting a coordination control with the skid control ECU.
Idle Speed Control		Controls the fast idle speed in accordance with the water temperature, and the idle speed after the engine has been warmed up. It controls the idle speed by regulating the fuel injection volume and the throttle position.



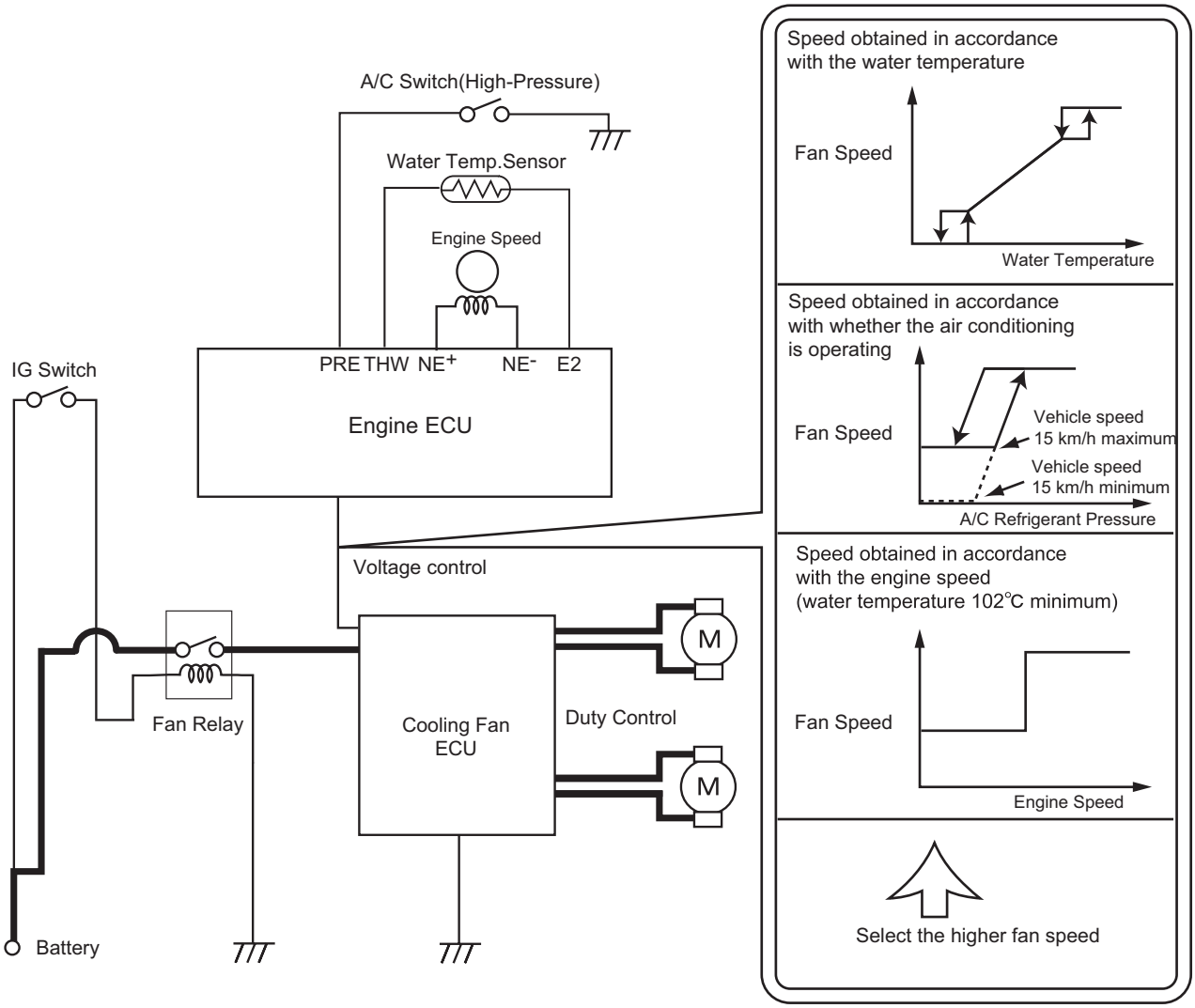
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VVT-i System

- This engine uses a Dual VVT-i (Variable Valve Timing-intelligent) system that continuously varies the phases of the camshafts. By regulating the timing of the intake and exhaust valves in accordance with the driving conditions, this system realizes fuel economy, high power output, and low exhaust emissions.

Cooling Fan System

- To achieve an optimal fan speed in accordance with the engine coolant temperature, vehicle speed, engine speed, and air conditioning operating conditions, the engine ECU calculates the proper fan speed and sends the signals to the cooling fan ECU. Upon receiving the signals from the engine ECU, the cooling fan ECU actuates the fan motors. Also, the fan speed is controlled by engine ECU using the stepless control.

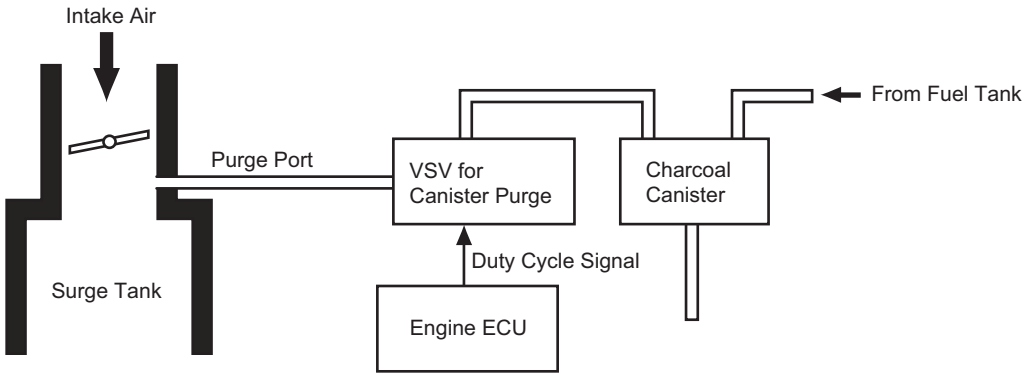


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Evaporative Emission Control System

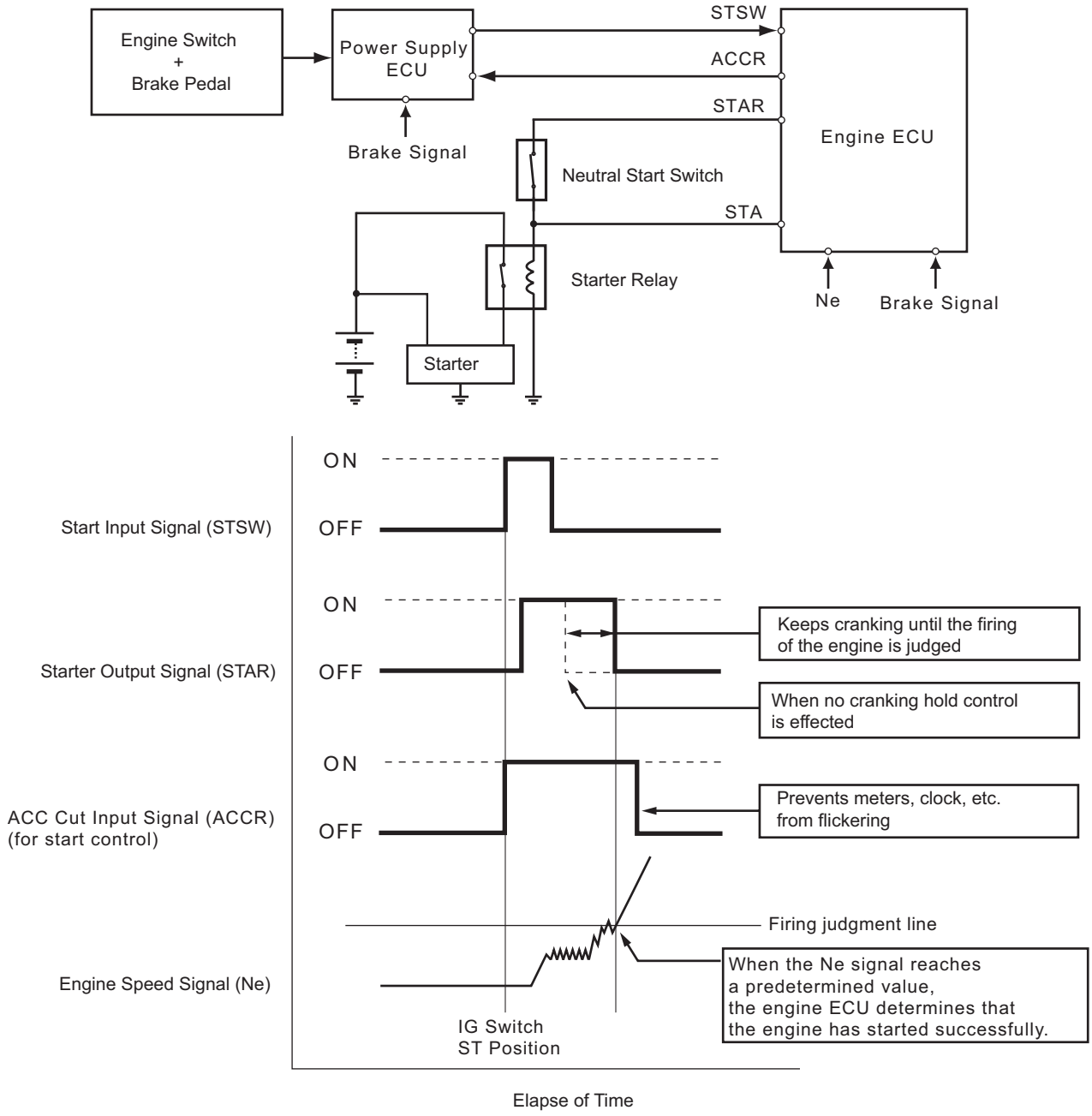
- A single system purge flow path is provided in order to control the fuel evaporative gas that flows from the charcoal canister to the purge port in accordance with the conditions of the engine. Then, the fuel evaporative gas that has been absorbed by the canister is drawn into the engine, thus suppressing the discharge of fuel evaporative gas.
- The purge port, which is provided downstream of the throttle valve, draws the fuel evaporative gas into the intake manifold in accordance with the driving conditions. The engine ECU applies current to the VSV, which is provided midstream of the purge pipe, in order to control the purge to an optimal volume.



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Cranking Hold Control

- When a start signal (STSW) is input by the engine switch, the engine ECU sends a signal (STAR) to the starter relay via the Park/Neutral Position switch (to determine P or N position), in order to start the starter. At this time, the engine ECU turns ON the ACC cut (ACCR) switch to prevent the meters, clock, and audio unit from flickering.
- After the starter starts, the engine ECU continues to output a signal to the starter until it detects that the engine has fired. After cranking, when the engine speed becomes higher than a predetermined speed, the engine ECU determines that the engine has fired, and stops the signal that is output to the starter relay.



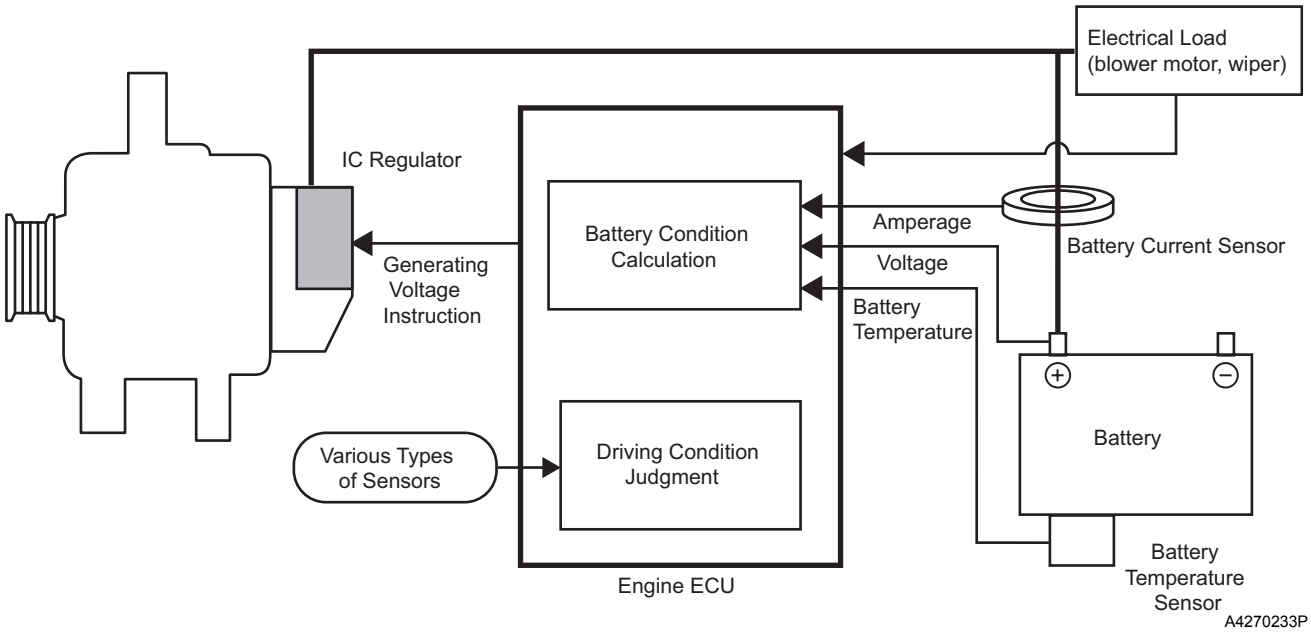
Cranking Hold Control Circuit Diagram (SMART ACCESS SYSTEM with PUSH-BUTTON START Type) and System Diagram

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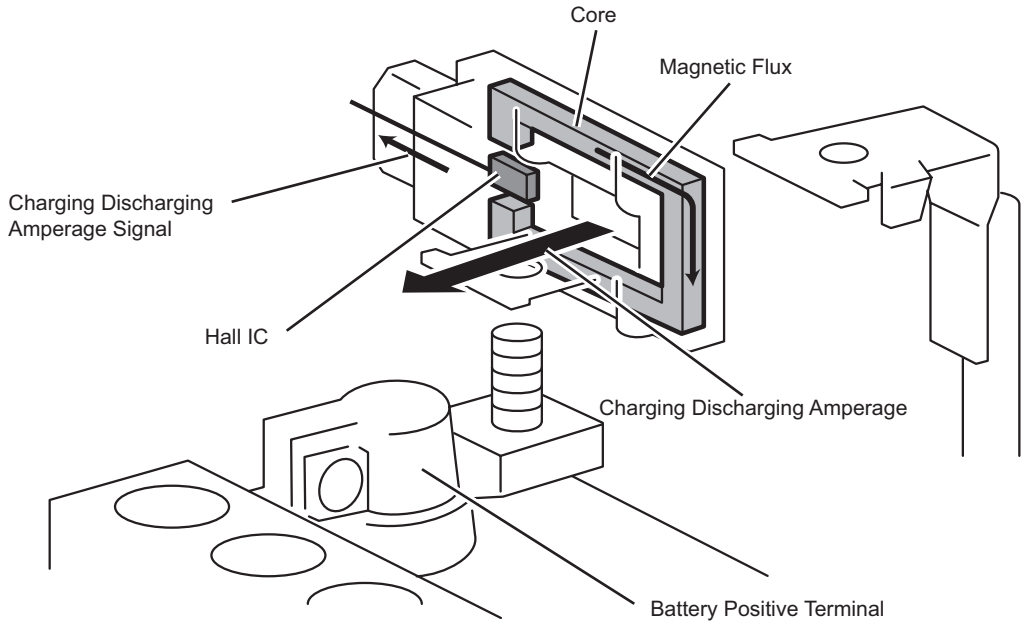
Charging Control System

- This system lowers the generating voltage when the vehicle is idling or is being driven at a constant speed, and raises the generating voltage when the vehicle is decelerating. This reduces the load on the engine as a result of the electric generation of the alternator, thus contributing to the fuel economy of the engine. During acceleration, this system regulates the generating voltage in order to place the amperage estimation value* close to the target value.



Battery Current Sensor

• Installed on the positive terminal of the battery, this sensor detects the amount of charging and discharging amperage of the battery and sends a signal to the engine ECU. Based on this signal, the engine ECU calculates the battery capacity. A Hall IC is used for detecting the amount of charging and discharging amperage. The changes that occur in the magnetic flux density in the core as a result of the charging and discharging amperage of the battery are converted and output as voltage.

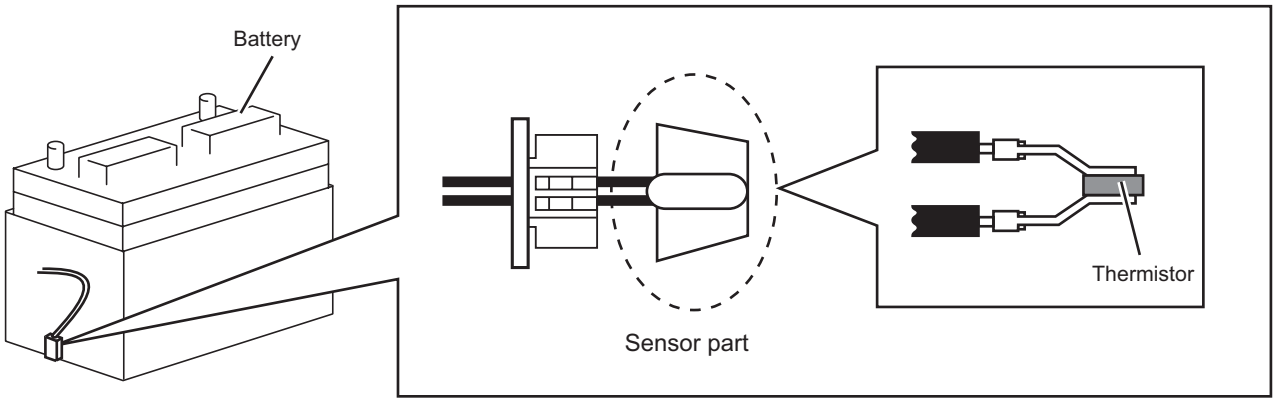


*The illustration shows a conceptual image.

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Battery Temperature Sensor

• A battery fluid temperature that is too low or too high can accelerate the deterioration of the battery or cause the battery to become discharged. In addition, the characteristics of the battery to accept current changes with the temperature of the battery fluid. For these reasons, the battery temperature sensor detects the battery fluid temperature and sends a signal to the engine ECU, in order to protect the battery. This sensor is installed on the side of the battery insulator.



*The illustration shows a conceptual image.

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Fail Safe

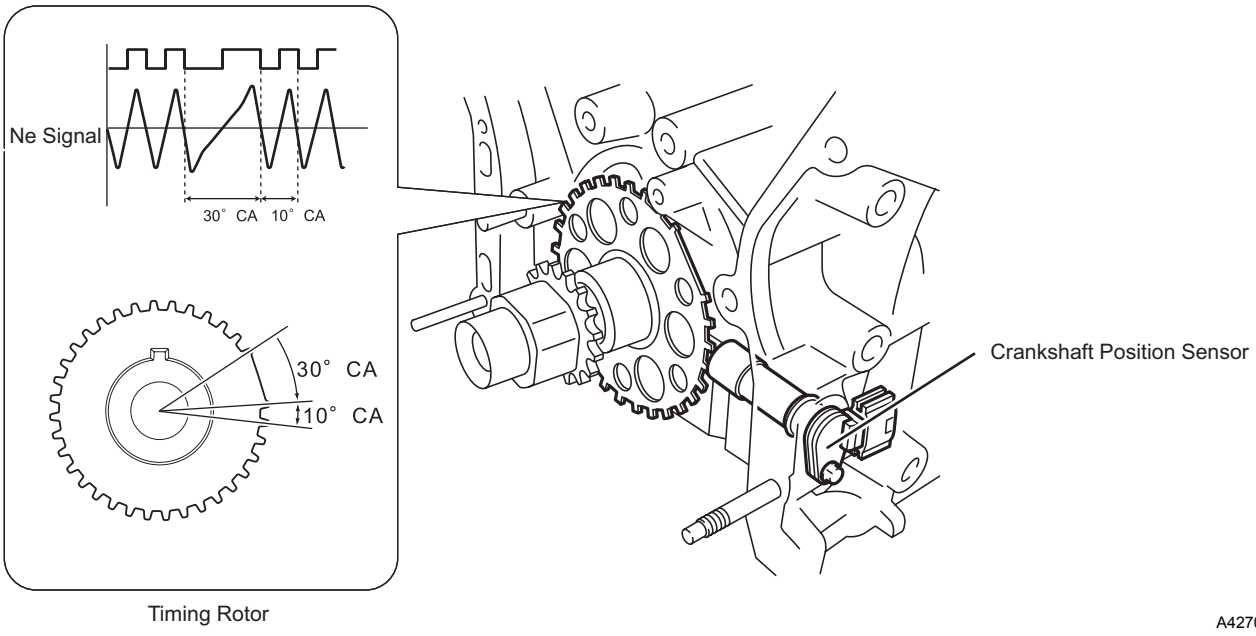
- Due to a failure in the sensors, the condition of the battery, or the operating state of electrical loads, the engine ECU may determine the necessity of performing a failsafe operation. Then, the engine ECU stops the alternator charging control and transfers the operation to the constant voltage generation mode.

Conditions for Transferring to Failsafe Mode

Condition	Control
Low battery capacity	The engine ECU determines the state of charge of the battery through its capacity or fluid temperature. If the battery is excessively charged or discharged, the engine ECU stops the charging control to protect the battery, as well as to prevent the capacity from dropping
Low or high battery temperature	
Wipers operating or blower motor operating at high load	When a particular electrical load is operating, the engine ECU stops the changes in voltage through charging control, in order to prevent the unpleasant operation of the electrical load due to the fluctuations in voltage.
Malfunction detected in the following sensors and switches: current sensor, temperature sensor, throttle position sensor, vehicle speed sensor, crankshaft position sensor, stoplight switch, or shift position switch	During a failure of a sensor system, the engine ECU stops the charging control to prevent the battery capacity from dropping.

Crankshaft Position Sensor

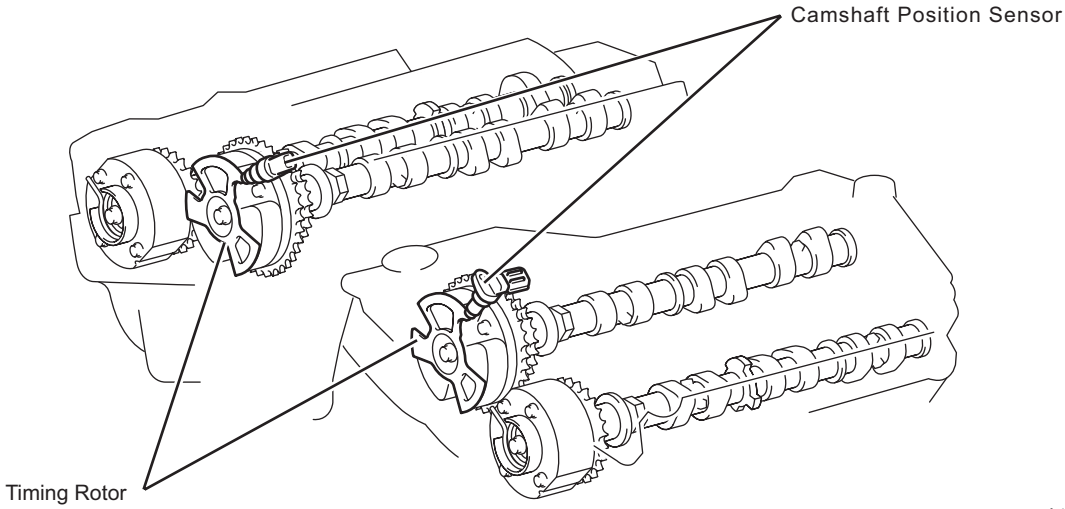
- The timing rotor of the crankshaft consists of 34 teeth, with 2 teeth missing. The crankshaft position sensor outputs the crankshaft rotation signals every 10°, and the missing teeth are used to determine the top-dead-center.
- This engine uses an electromagnetic pickup sensor that provides a high level of detection accuracy. When the crankshaft rotates, the air gap between the protrusion on the timing rotor and the crankshaft position sensor changes. This causes the magnetic flux that passes through the coil of the crankshaft position sensor to increase and decrease, causing the coil to generate an electromotive force. This electromotive force generates voltage in opposing directions, depending on whether the protrusion of the timing rotor approaches the crankshaft position sensor or withdraws from the sensor. Thus, the voltage appears in the form of alternating current voltage.



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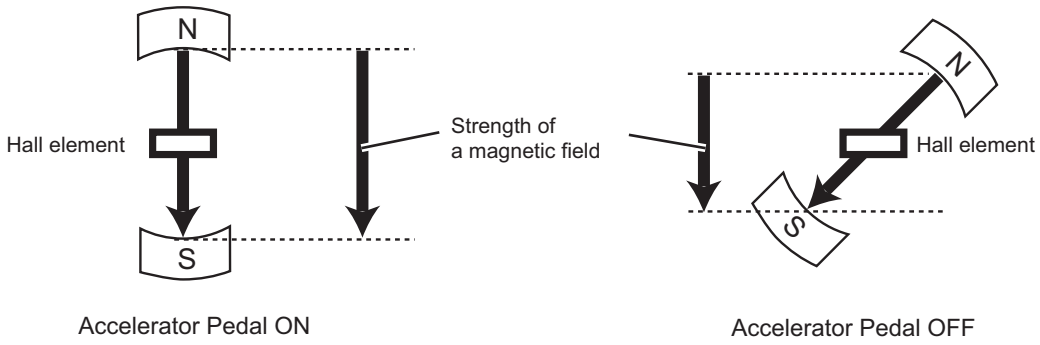
Camshaft Position Sensor

- These sensors are the MRE (Magnetic Resistance Element) type. The rotational movement of the timing rotor (which is provided in the VVT-i controller of the intake camshaft) causes a magnetic field to act on the magnetic resistance element in the sensor. The sensor utilizes the changes that occur in the direction of the magnetic field to detect the position of the timing rotor, which determines the position of the actual camshaft. The cylinders are identified by the input sequence of the Ne and G2 signals.



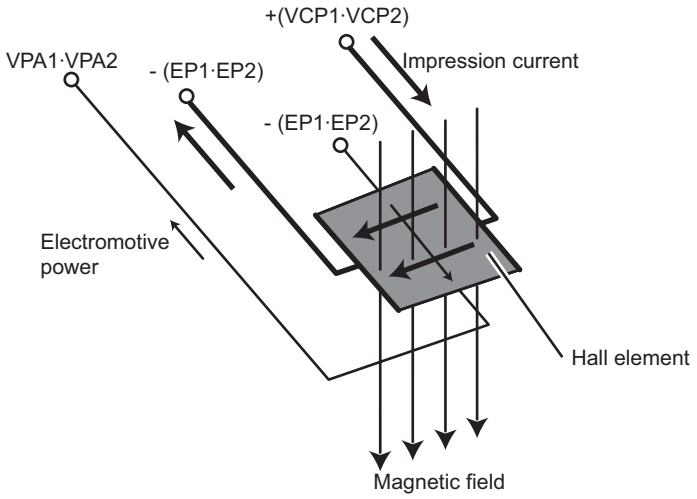
Accelerator Pedal Position sensor

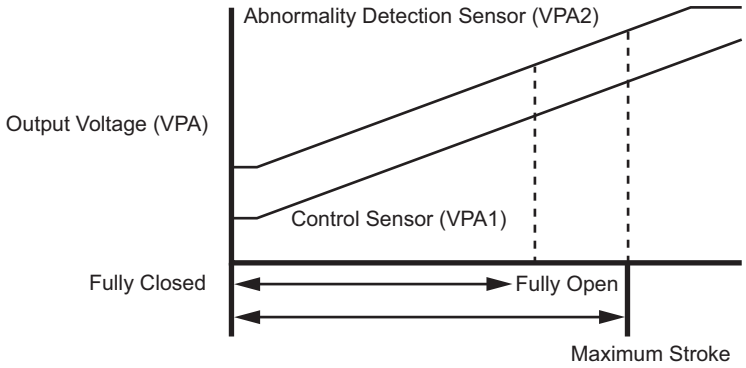
- This sensor, which is mounted on the accelerator pedal, detects the amount of pedal effort applied to the accelerator. By using a Hall element, this electronic position sensor enables accurate control and ensures permanent reliability. When the amount of pedal effort applied to the accelerator changes, this sensor sends the angle of the magnetic field in relation to the flow of the applied current in the Hall element (VCP1 → EP1, VCP2 → EP2) in the form of an accelerator pedal effort signal to the engine ECU. In addition, this sensor consists of a dual system having different output characteristics to ensure reliability.



Accelerator Pedal ON

Accelerator Pedal OFF





Accelerator Position Sensor Output Voltage Characteristics

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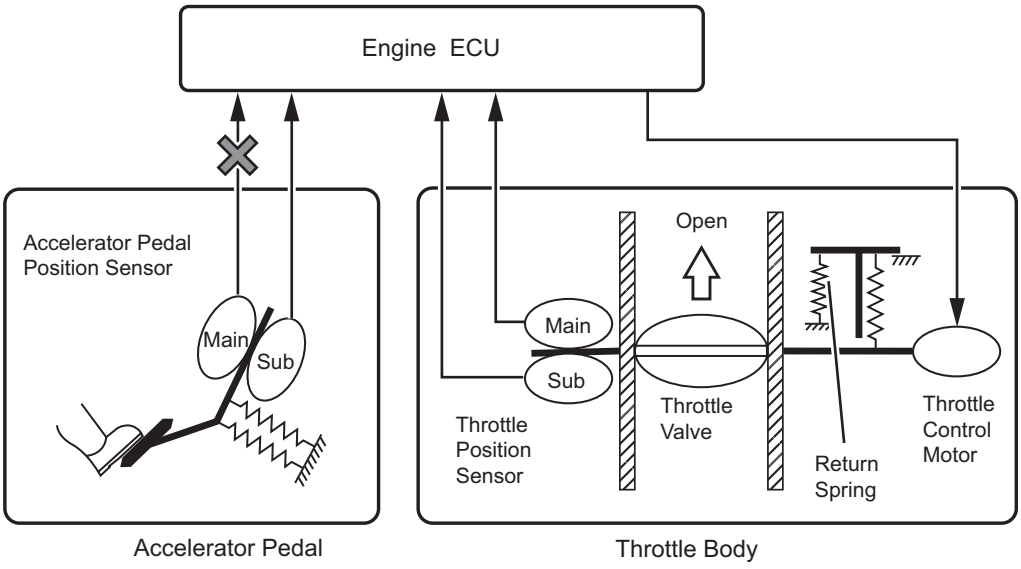
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Fail Safe

- The accelerator position sensor comprises two (main, sub) sensor circuits, to detect the pedal position. In case of an abnormal condition in the signal, the engine ECU switches to the failsafe driving mode.

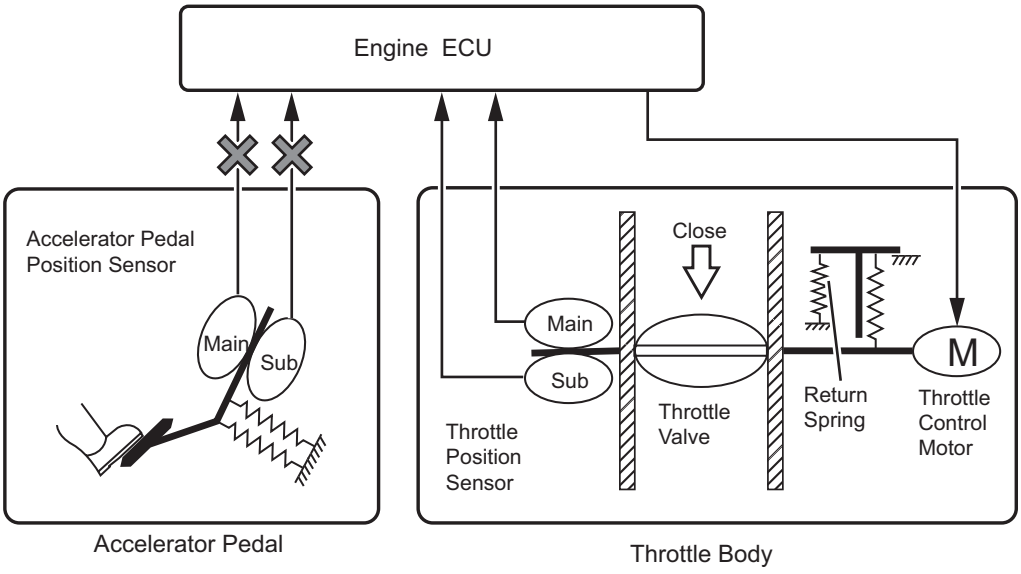
System 1 Failure

The accelerator pedal position sensor comprises two (main, sub) sensor circuits. If a malfunction occurs in either one of the sensor circuits, the engine ECU detects the abnormal signal voltage difference between these two sensor circuits and switches to the limp mode. In the limp mode, the remaining circuit is used to calculate the accelerator pedal opening, in order to operate the vehicle under limp mode control.



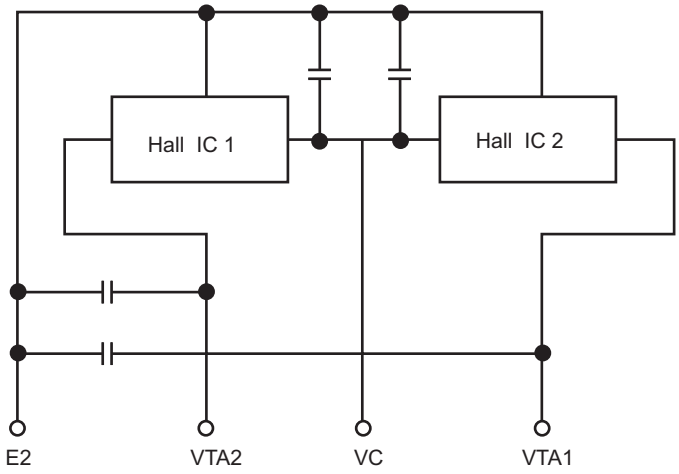
System 2 Failure

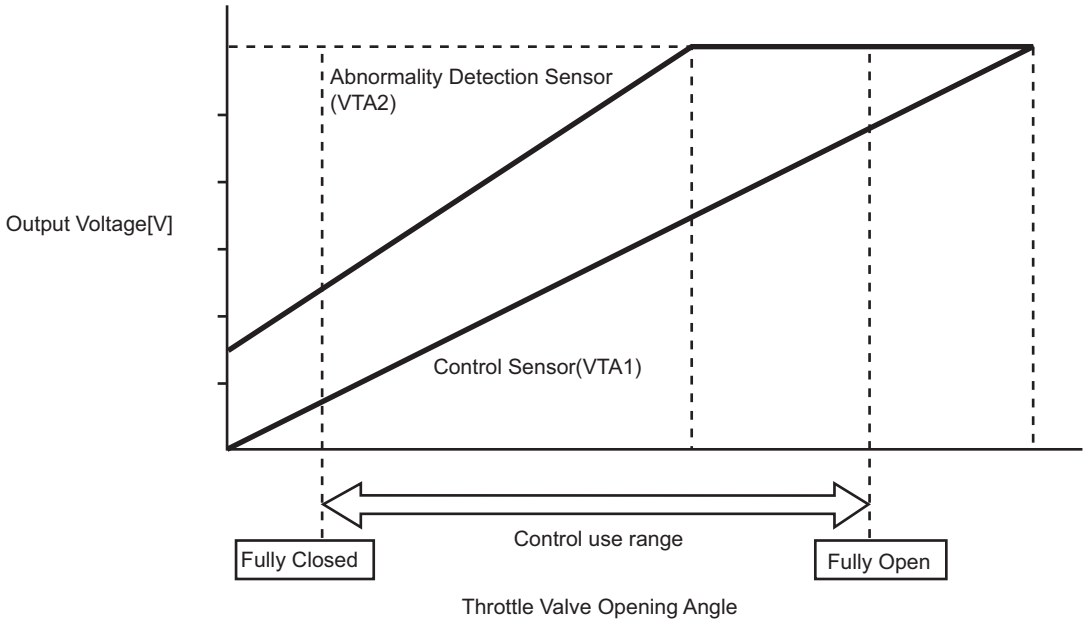
If both systems malfunction, the engine ECU detects the abnormal signal voltage between these two sensor circuits and regards that the opening angle of the accelerator pedal is fully opened and then continues the throttle control. At this time, the vehicle can be driven within its idling range.



Throttle Position Sensor

- This sensor, which is located in the throttle body, detects the position of the throttle valve. By using a Hall element, in the same way as the accelerator position sensor, this electronic position sensor enables accurate control and ensures permanent reliability. In addition, this sensor consists of a dual system having different output characteristics to ensure reliability.





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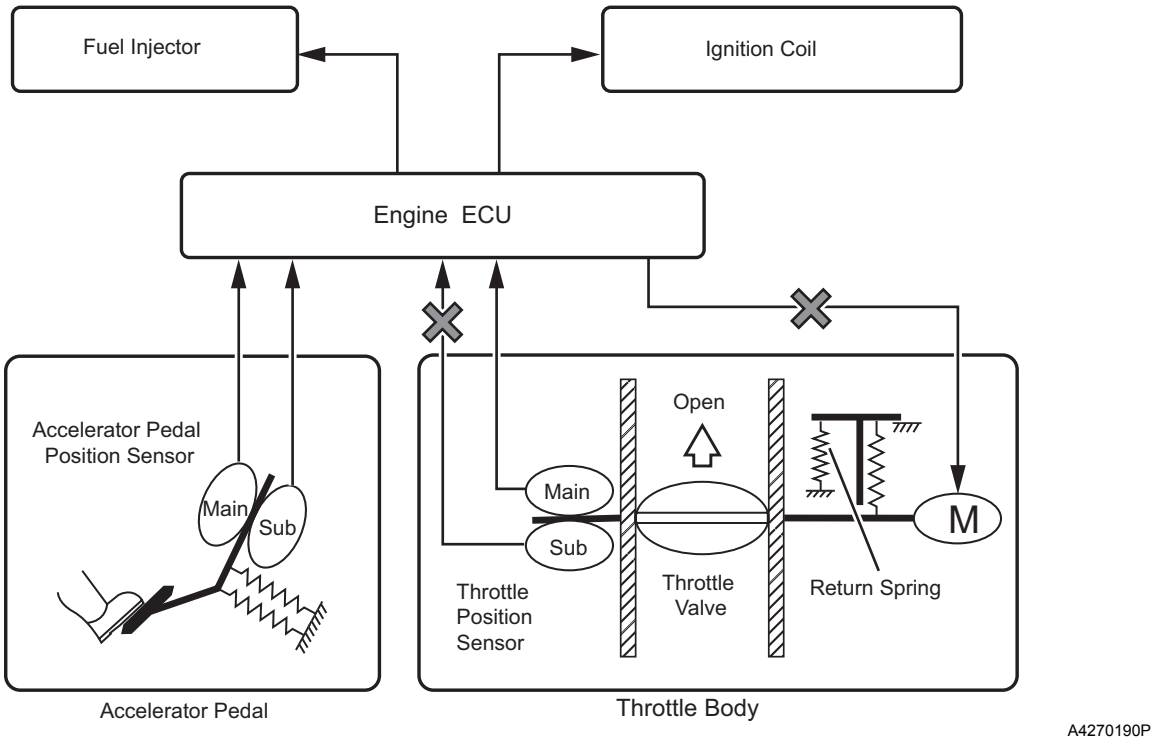
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Fail Safe

- The throttle position sensor comprises two (main, sub) sensor circuits, to detect the throttle position. In case of an abnormal condition in the signal, the engine ECU switches to the failsafe driving mode.

Failure Detection

The throttle position sensor comprises two (main, sub) sensor circuits. If a malfunction occurs in either one of the sensor circuits, the engine ECU detects the abnormal signal voltage difference between these two sensor circuits, cuts off the current to the throttle control motor, and switches to the limp mode. Then, the force of the return spring causes the throttle valve to return and stay at the prescribed opening. At this time, the vehicle can be driven in the limp mode while the engine output is regulated through the control of the fuel injection and ignition timing in accordance with the accelerator opening.

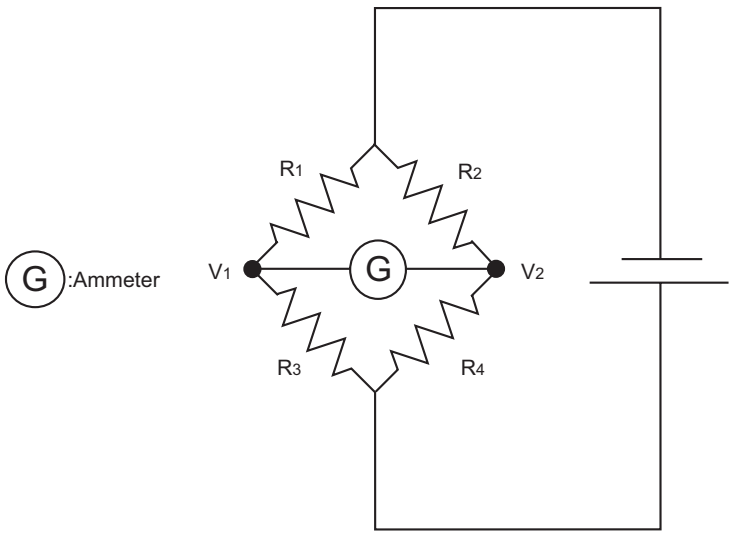


Air Flow Meter

- This 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 has been improved and the intake air resistance has been reduced.
- This air flow meter has a built-in intake air temperature sensor.
- This system measures the air flow in the bypass, which is less likely to be affected by the intake pulsations created by the air cleaner. Also, the flow path is constructed to minimize flow resistance, thus reducing flow loss. Therefore, this system can measure small to large airflow in a precise manner.

Hot Wire Type Air flow Meter Operation

- A hot-wire measurement portion measures the volume of the intake air that is partially routed through a bypass. The hot-wire, which uses a platinum filament, measures the intake air volume of the engine by comprising a bridge circuit that consists of an intake temperature measurement resistor and a heating resistor (heater). In principle, this airflow meter can directly measure the mass flow due to the nature of the hot-wire type air flow meter. Therefore, it does not require a density correction to counter the changes in the intake temperature. However, it does require intake temperature data in order to effect engine control such as in EFI (Electronic Fuel Injection). For this reason, the air flow meter contains a compact, thermistor type intake temperature sensor that detects the intake temperature.
- The bridge circuit is connected as shown in the diagram below. When R1 x R4 = R2 x R3 is established in this circuit, V1 becomes V2, causing the ammeter G to indicate 0.

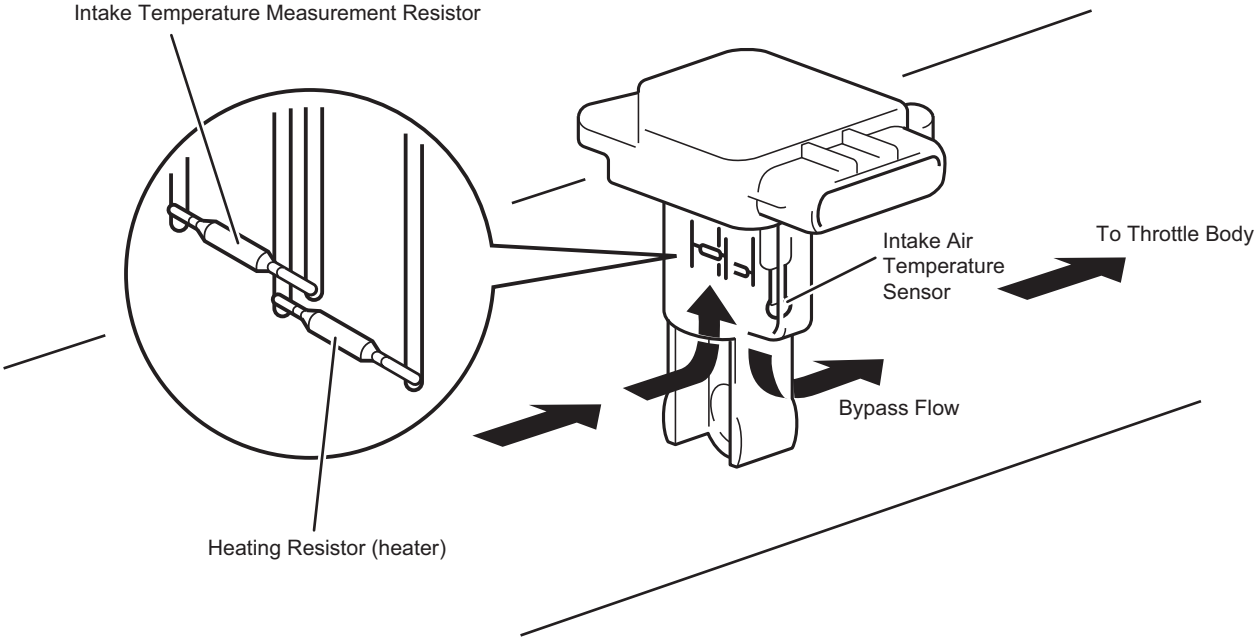


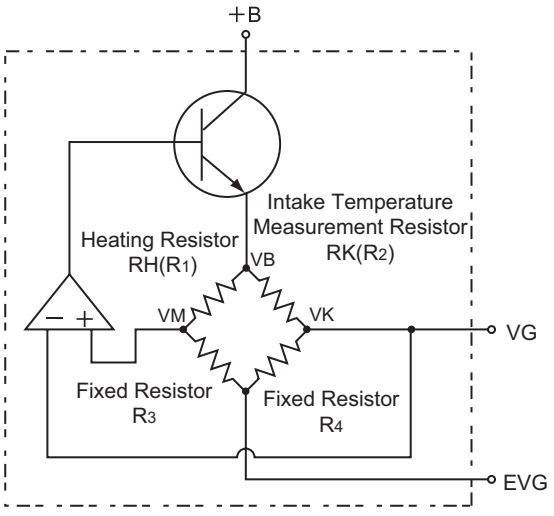
Bridge Circuit

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- When the intake air volume changes, the bridge circuit in the hot-wire measurement portion effects feedback control to supply electricity to the heating resistor, in order to maintain a constant difference in temperature between the intake temperature measurement resistor and the heating resistor (heater). Then, it converts the supplied electricity into voltage and outputs it to the engine ECU. The engine ECU calculates the engine intake air volume based on a predetermined relationship between the air flow meter output voltage and the flow volume.
- The diagram below describes the configuration of the bridge circuit of the hot-wire type air flow meter. For example, if the intake volume that is drawn in increases, it cools the heating resistor and decreases the RH value, thus resulting in RH (R1) x R4 < RK (R2) x R3, VM≠VK. When the control unit detects this condition, it effects control to increase the amperage that flows from the power supply to VB (to heat RH), in order to result in RH (R1) x R4 = RK (R2) x R3, VM = VK.





Bridge Circuit

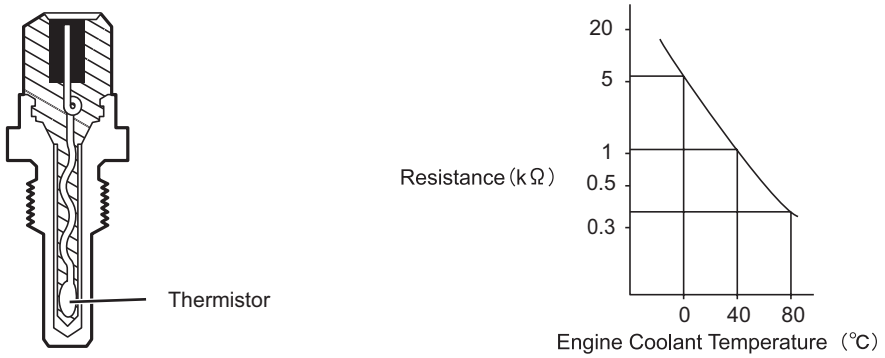
A4270026P

Fuel Pressure Sensor

- This sensor is installed on the fuel delivery pipe to detect fuel pressure.

Water Temp.Sensor

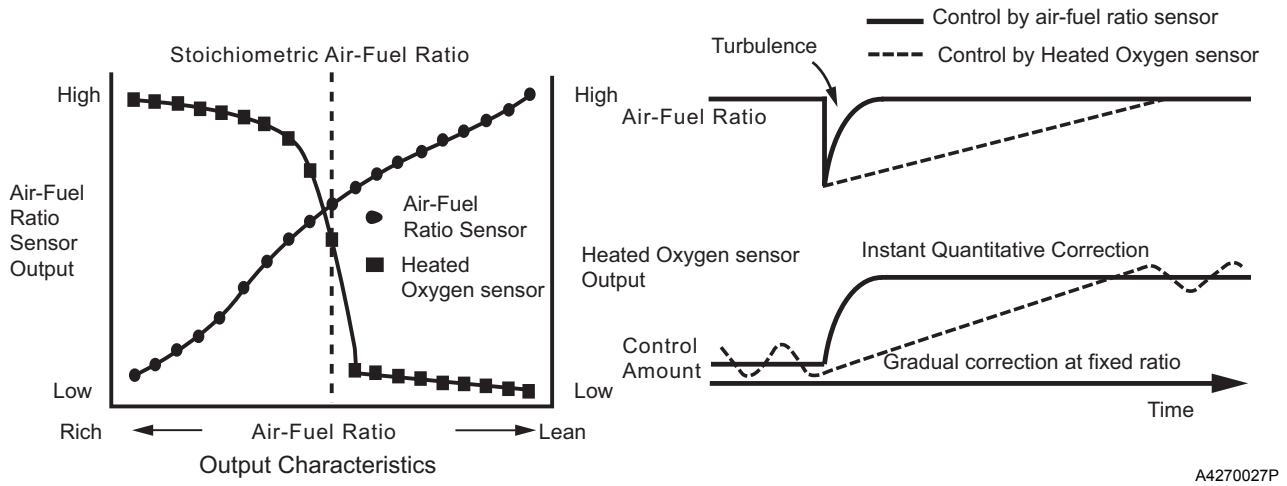
- This sensor detects the water temperature and sends a signal to the engine ECU.



A4270105P

Air Fuel Ratio Sensor

- An air-fuel ratio sensor is used to ensure the reliable feedback of the state of the air-fuel ratio in the exhaust gas. An heated oxygen sensor outputs a lean or rich signal bordering on the stoichiometric air-fuel ratio. In contrast, the air-fuel ratio sensor has output characteristics that are proportionate to the air-fuel ratio. Therefore, the engine ECU is able to effect a more precise control.
- As with the heated oxygen sensor, a heater is used to heat and maintain a constant temperature in the air-fuel ratio sensor, thus promoting the proper feedback control.



A4270027P

Heated Oxygen Sensor

- This sensor detects the oxygen concentration in the exhaust gas.

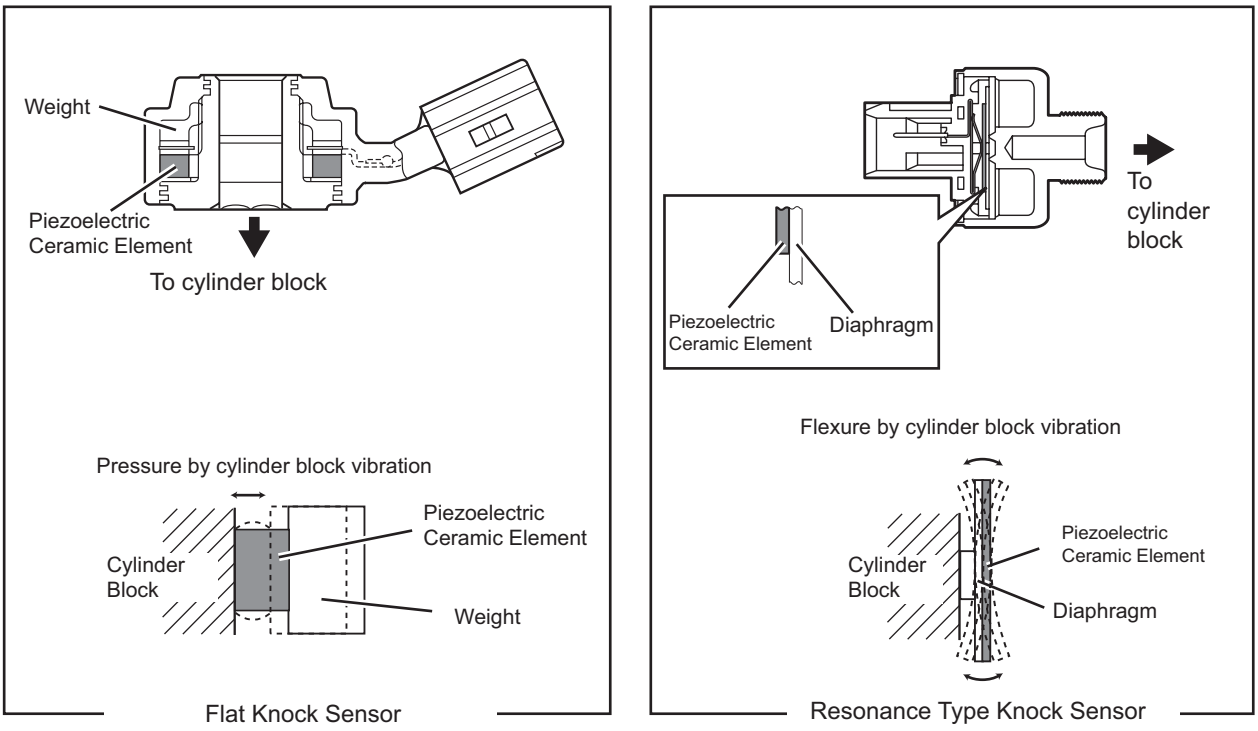
EG

Knock Sensor (Flat Type)

● When the conventional resonance type knock sensor receives vibrations from the cylinder block, a diaphragm on a piezoelectric ceramic element flexes along the area where it is mounted to the cylinder block acting as the fulcrum. This causes a pressure to act on the piezoelectric ceramic element, which generates a voltage. In contrast, when the flat (non-resonance type) knock sensor receives vibrations from the cylinder block, a delayed movement of the weight occurs in the sensor due to the inertial force of the weight. This causes a pressure to be applied to a piezoelectric ceramic element, which is provided between the cylinder block and the weight, thus generating a voltage.

Knock Sensor Operation

• In the conventional resonance type knock sensor, the diaphragm resonates at a certain frequency at which the engine knocks. Therefore, when the knock sensor generates an output, the engine ECU determines that knocking has occurred. In contrast, the flat (non-resonance type) knock sensor has practically constant output characteristics in all frequency ranges. Therefore, the engine ECU can detect a target frequency at which knocking occurs, enabling a more accurate knocking detection.



A4270028P

Camshaft Timing Oil Control Valve

- In accordance with the duty cycle signals received from the engine ECU, this OCV controls the position of the spool valve in order to constantly achieve optimal valve timing. When the engine is stopped, the force of a spring keeps the intake side of the spool valve in the most retarded state, and the exhaust side to the most advanced state, in order to ready the valves for the subsequent starting.
  (See page EG-143)

Injector

- A single-orifice, high-pressure slit nozzle injector is used.
  (See page EG-160)

Fuel Pump

- A fuel pump assembly consisting of a fuel pump, fuel filter, and sender gauge is used.
- To prevent fuel from leaking during a collision (in which air bags are deployed), a system that turns OFF the circuit opening relay, in accordance with a signal from the airbag ECU, is used to ensure safety.
  (See page EG-154)

Ignition Coil (with Igniter)

- Ignition coils with built-in igniters are used and placed directly over the spark plugs.
  (See page EG-183)

VSV (For EVAP)

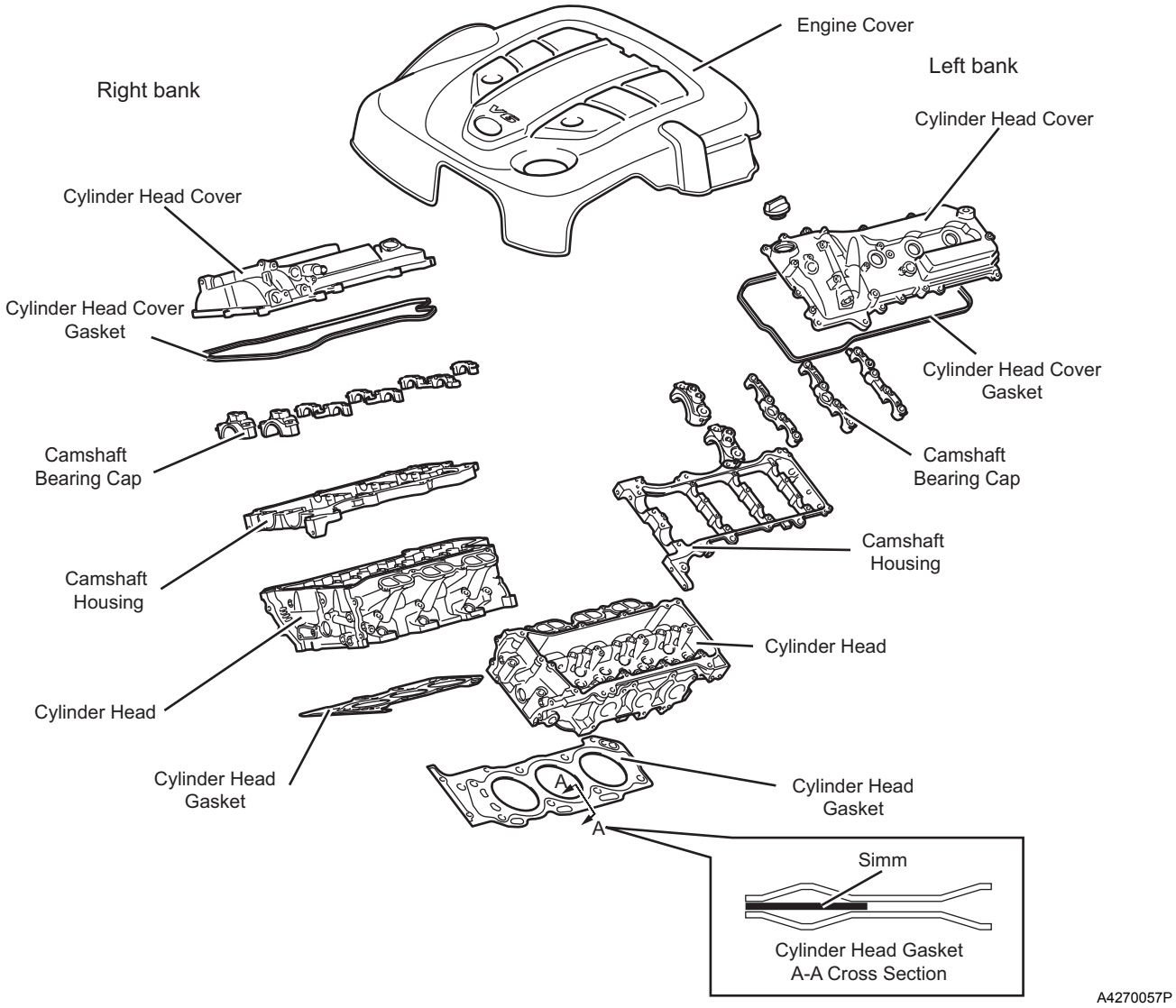
- Regulates the purge volume of the canister.

3GR-FSE ENGINE MECHANICAL

EG

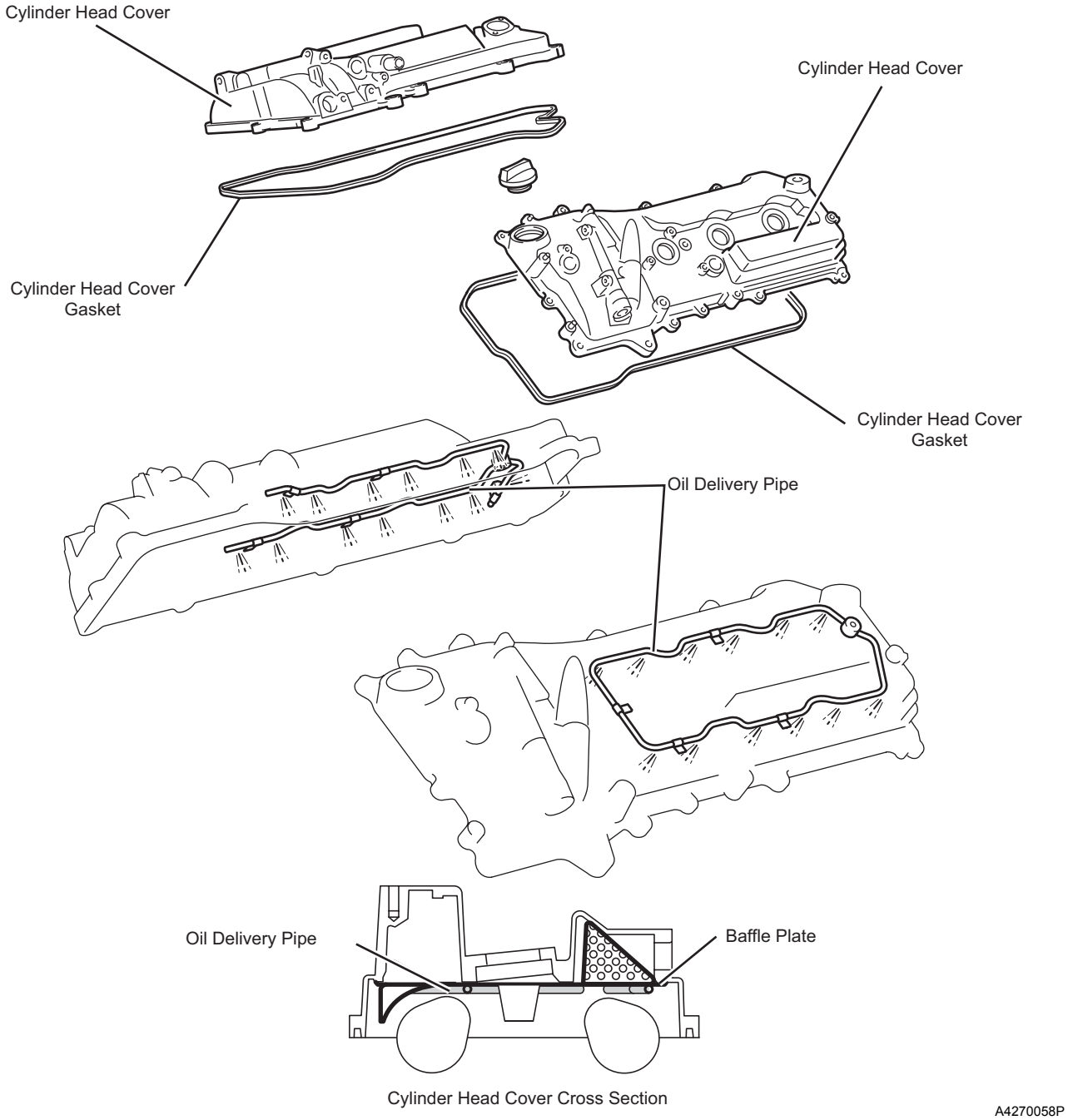
Cylinder Head Fitting Parts

- The cylinder heads are made of a lightweight and highly rigid aluminum alloy. Also, the VVT-i supply oil passage has been separated from the cylinder heads to simplify the oil passage in the cylinder heads.
- The cylinder head gaskets are the two-layer metal type. Shims are provided around the bores to ensure sealing performance and durability.
- The cylinder head covers are made of a lightweight aluminum alloy. They are tightened to the cylinder heads by way of fixed-dimension flanges along their periphery to ensure the proper sealing performance.
- OCVs (oil control valves) for Dual VVT-i are mounted on both the right and left cylinder head covers.
- The cylinder head cover gaskets are made of acrylic rubber, which excels in heat resistance and oil resistance.



Cylinder Head Cover

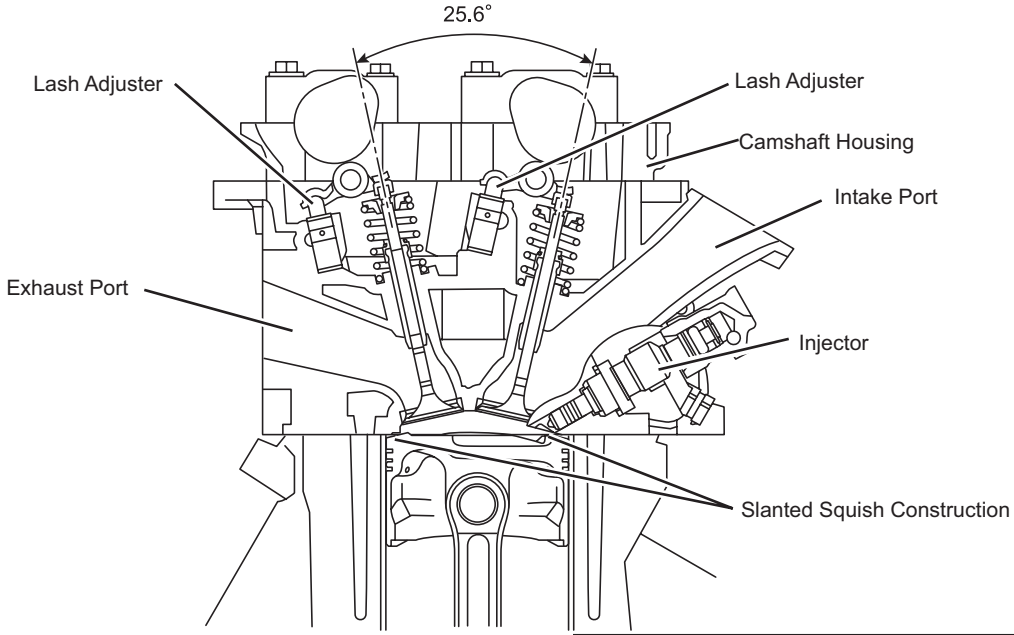
- Large baffle plates are built into the right and left head covers. By reducing the flow rate of blowby gas, these baffle plates remove oil droplets and oil mist, thus reducing the volume of oil taken away.
- Oil delivery pipes are provided to supply engine oil, in order to properly lubricate the sliding areas of the roller rocker arms, thus enhancing their reliability.



EG

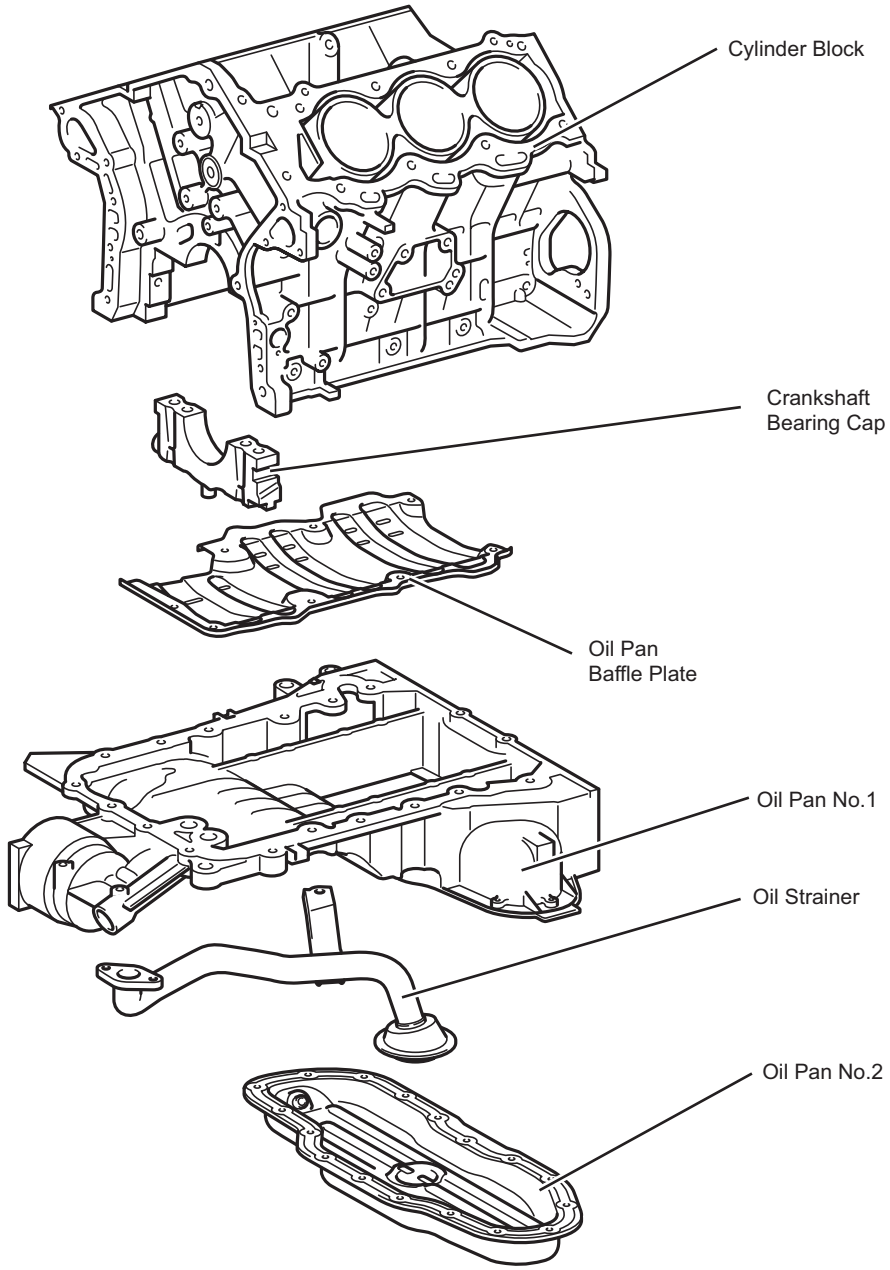
Cylinder Head

- By using a two-piece construction in which the portion that receives the cam journals is separate from the cylinder head proper, the configuration of the cylinder head proper has been simplified. This results in weight reduction and improved serviceability.
- Pentroof combustion chambers are used. A spark plug is located practically in the center of each combustion chamber to enhance combustion efficiency and knock resistance. Furthermore, the angle between the intake and exhaust valves has been narrowed to 25.6 degrees, thus making the combustion chamber compact.
- The port configuration is an efficient cross-flow type in which the intake ports face the inside of the V bank and the exhaust ports face the outside. The intake ports have an independent, narrow-diameter construction and the exhaust ports have a Siamese construction to enhance low- to medium-speed torque. The intake ports are the vertical type that has a cutout and an edge at the bottom of each port outlet to realize a high tumble and high intake efficiency.
- The diameter of the valve stem and the outer diameter of the valve guide have been reduced to reduce intake resistance.
- The cylinder head bolts are tightened with the plastic region tightening method in order to stabilize the axial tension of the bolts.



Cylinder Block Fitting Parts

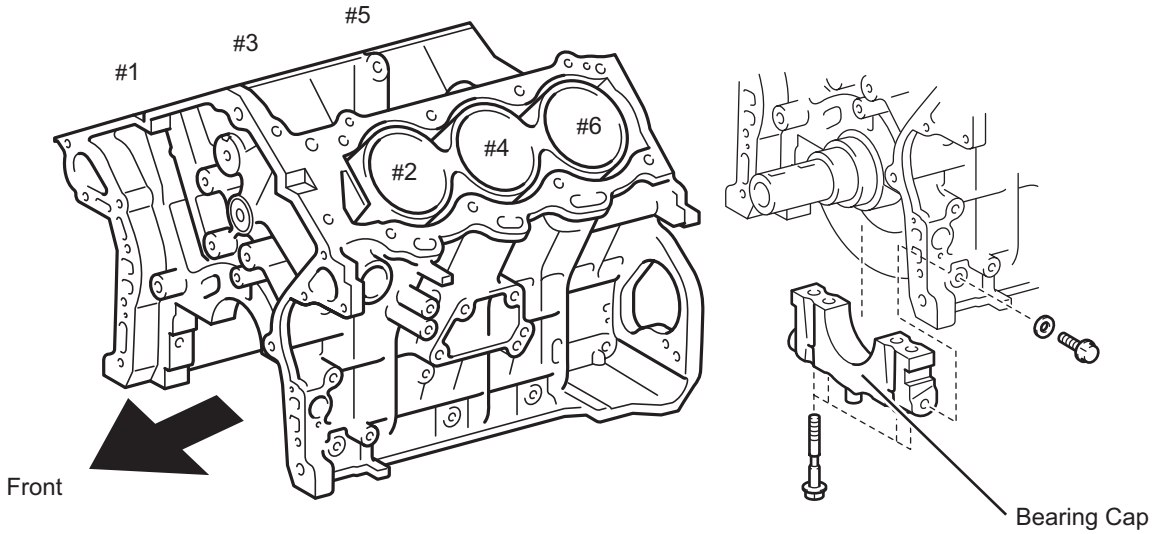
- The cylinder block is made of an aluminum alloy to realize a dramatic weight reduction. Furthermore, it has been made compact in terms of both overall length and width as follows: a 60° V6 bank angle, a 36.6mm(1.441in.) bank offset, and a 105.5mm(4.154in.) bore center distance.
- The oil pan consists of a two-piece construction. Oil pan No. 1 is made of an aluminum alloy, and oil pan No. 2 is made of stamped steel sheet. Oil pan No. 1 has built-in stiffeners that tighten the cylinder block and the transaxle case together. This increases the rigidity of the entire power plant, resulting in reduced vibration and weight reduction.
- Appropriate ribs are placed on the outer wall of the cylinder block to increase rigidity.
- An FIPG (Formed-In-Place Gasket), which excels in sealing performance, is used on the mating surfaces of the oil pan.



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Cylinder Block

- The cylinder liner is a centrifugal cast iron liner insert. Its outer spiny surface enhances contact with the aluminum block, thus improving heat dissipation. This lowers the temperature of the piston and suppresses the deformation of the bore.
- The outer walls of the block are curved and reinforcement ribs are provided on the end of the block that is coupled to the transmission in order to attain a high level of rigidity.
- The oil return holes from the cylinder heads and the blowby gas passages have been optimally arranged to ensure the smooth return of oil and heighten the rigidity of the side faces of the cylinder block.
- Drilled coolant passages are provided between the bores in order to positively cool the upper areas of the cylinder bores, which are easily affected by heat. Thus, a more uniform temperature distribution has been achieved in the circumferential direction of the bore wall surface. This improves knocking resistance and minimizes the heat deformation that occurs between the cylinder bores. Thus, an engine with low friction, high performance, and enhanced fuel economy has been achieved.
- A knock sensor is provided on both the right and left sides of the V bank, enabling optimal knock control.
- The crankshaft bearing caps are made of cast iron, and each is tightened with 4 bolts from the bottom, using the plastic region tightening method. Also, each bearing cap is tightened from both sides together with the cylinder block, which increases rigidity and decreases vibration and noise.



Bearing cap attachment appearance

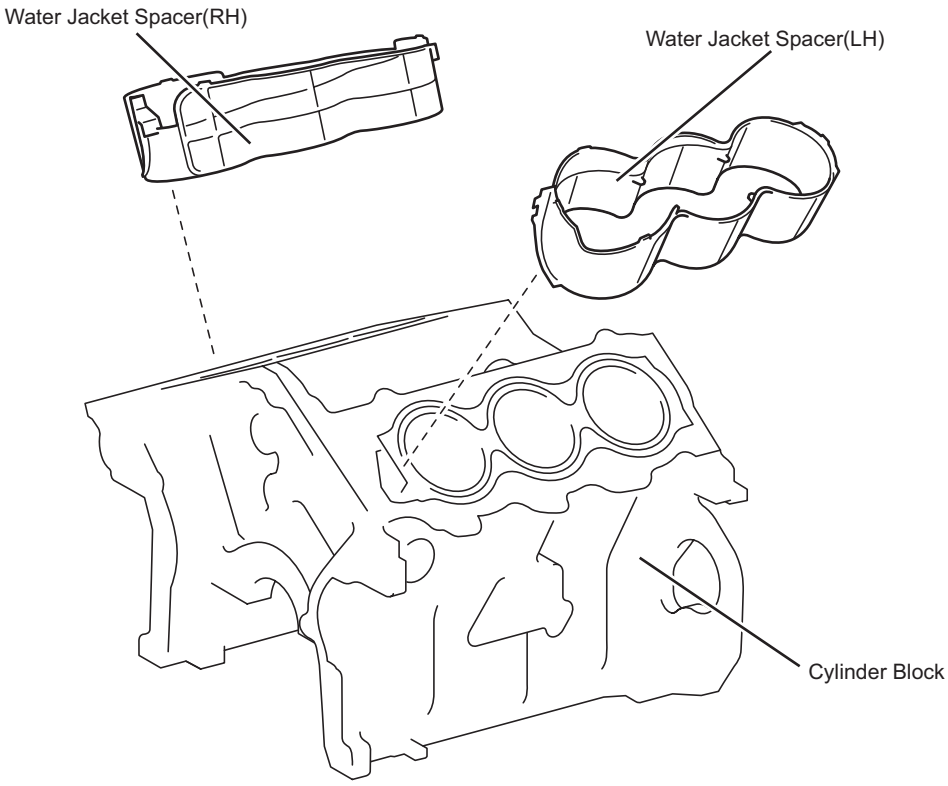
A4270061P

Cylinder Block

Overall Length	[mm (in.)]	402.1 (15.831)
Overall Width	[mm (in.)]	408.0 (16.063)
Overall Height	[mm (in.)]	320.2 (12.606)
Bore Diameter	[mm (in.)]	87.5 (3.445)
Bore Center Distance	[mm (in.)]	105.5 (4.154)
Bank Offset	[mm (in.)]	36.6 (1.441)

Water Jacket Spacer

- A water jacket spacer made of plastic, which excels in heat resistance and forming precision, is provided in the water jacket of the cylinder block. This optimizes heat distribution along the cylinder bore wall and reduces friction.



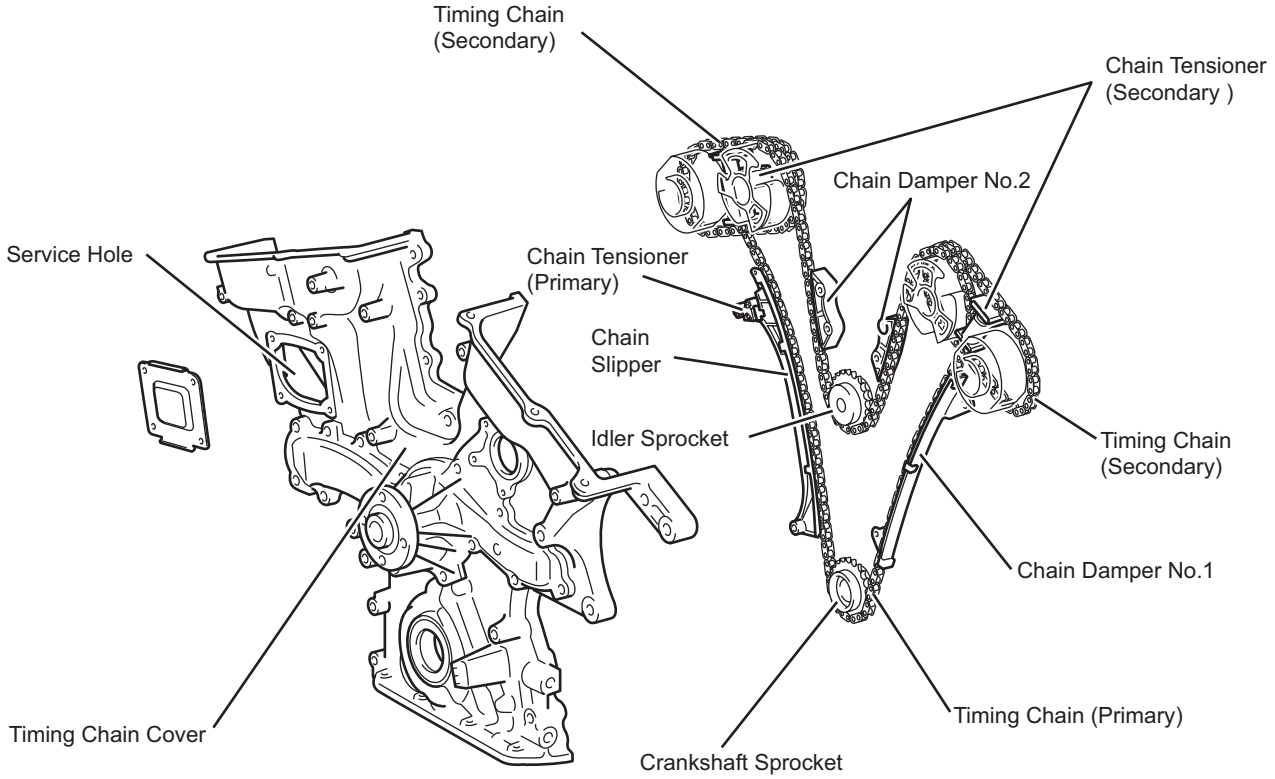
Function of Water Jacket Spacer

The water jacket spacer suppresses the water flow in the center of the water jacket. This increases the flow speed of the coolant along the upper part of the cylinder bore, thus improving the cooling of the upper area of the cylinder block and between the cylinder bores. Furthermore, the area near the center of the cylinder bore becomes less susceptible to the influences of the coolant, allowing the temperature along the wall surface to rise. These measures decrease the temperature differences along the surface of the cylinder bore wall and enable uniform thermal expansion. In addition, these measures lower the viscosity of the engine oil that adheres to the surface of the bore wall, thus reducing friction.

EG

Timing Chain

- The timing mechanism is a chain-driven system that is maintenance-free. Both the primary and secondary timing chains consist of 9.525mm(0.375in.) pitch, high-strength, single-row roller chains and compact sprockets, which contribute to making the engine compact.
- A two-stage chain system is used. It consists of a primary chain that enables the crankshaft to drive the right and left intake camshafts, and a secondary chain that enables the intake camshafts to drive the exhaust camshafts.
- The primary chain uses a check ball type chain tensioner with a ratchet mechanism that uses both engine oil pressure and a spring force. The secondary chain uses a compact tensioner that directly pushes on the chain by using engine oil pressure and a spring force. These tensioners constantly apply optimal tension to the timing chains in order to ensure a quiet and reliable operation.
- The timing chain cover is made of an aluminum alloy that is lightweight and excels in sound insulation capability. The one-piece cover seals the front of the cylinder block, camshaft housing, and cylinder head. The crankshaft sprocket is provided with a guide that prevents the chain links from jumping. This prevents the chain from being installed incorrectly during maintenance, as a result of the chain falling out. A service hole for the primary chain tensioner is provided in the timing chain cover to facilitate maintenance.
- The chain dampers and the tensioner shoes are made of a plastic material that excels in wear resistance.



A4270063P

Sprocket

	Number of Teeth
Crankshaft Sprocket	18
Idler Sprocket	18
Camshaft Sprocket (Primary)	36
Camshaft Sprocket (Secondary: IN)	24
Camshaft Sprocket (Secondary: EX)	24

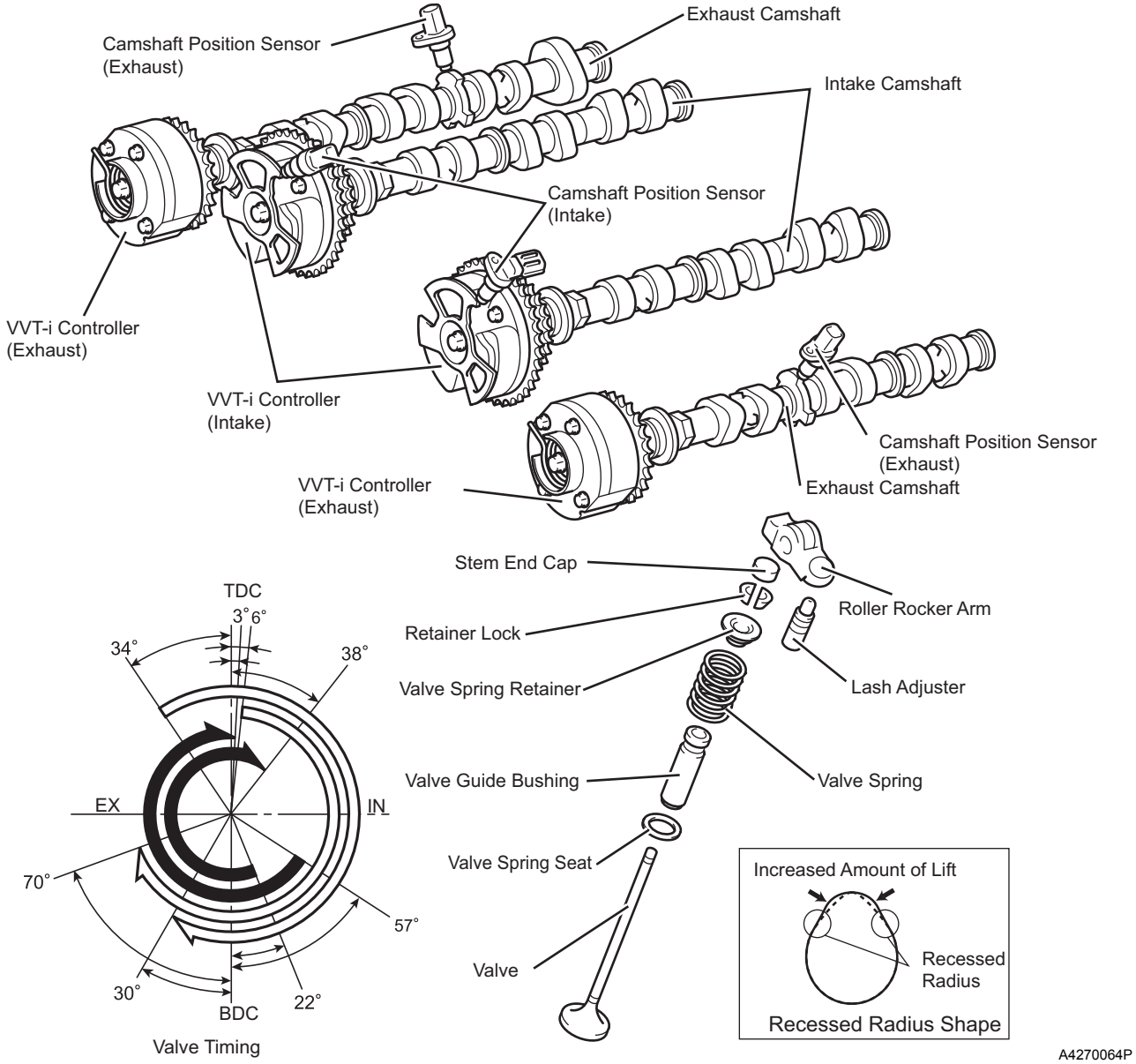
Timing Chain

	Number of Links
Timing Chain (Primary)	170
Timing Chain (Secondary)	46

EG

Valve Mechanism

- A Dual VVT-i (Dual Variable Valve Timing-intelligent : continuously variable intake and exhaust valve timing mechanism) system is used to control the intake camshaft and the exhaust camshaft to an optimal valve timing in accordance with the driving conditions.
- The camshafts are made of alloyed cast iron. Their cams are induction hardened and their surfaces are finished with a higher precision to improve wear resistance and reduce friction.
- Roller rocker arms are used in the valve train in order to dramatically reduce friction between the cams and the sliding surfaces to improve fuel economy. In addition, hydraulic lash adjusters are used, making valve clearance adjustments unnecessary and facilitating service.
- Along with the use of the roller rocker arms, the cam profile has been shaped with recessed radii. This increases the amount of valve lift near the beginning of the opening of the valve and near the end of the closing of the valve, in order to further increase power output.



Camshaft

	Intake	Exhaust
Cam Lift Amount [mm (in.)]	5.99 (0.236)	6.14 (0.242)
Cam Lobe Width [mm (in.)]	15.35 (0.604)	14.1 (0.555)

Valve

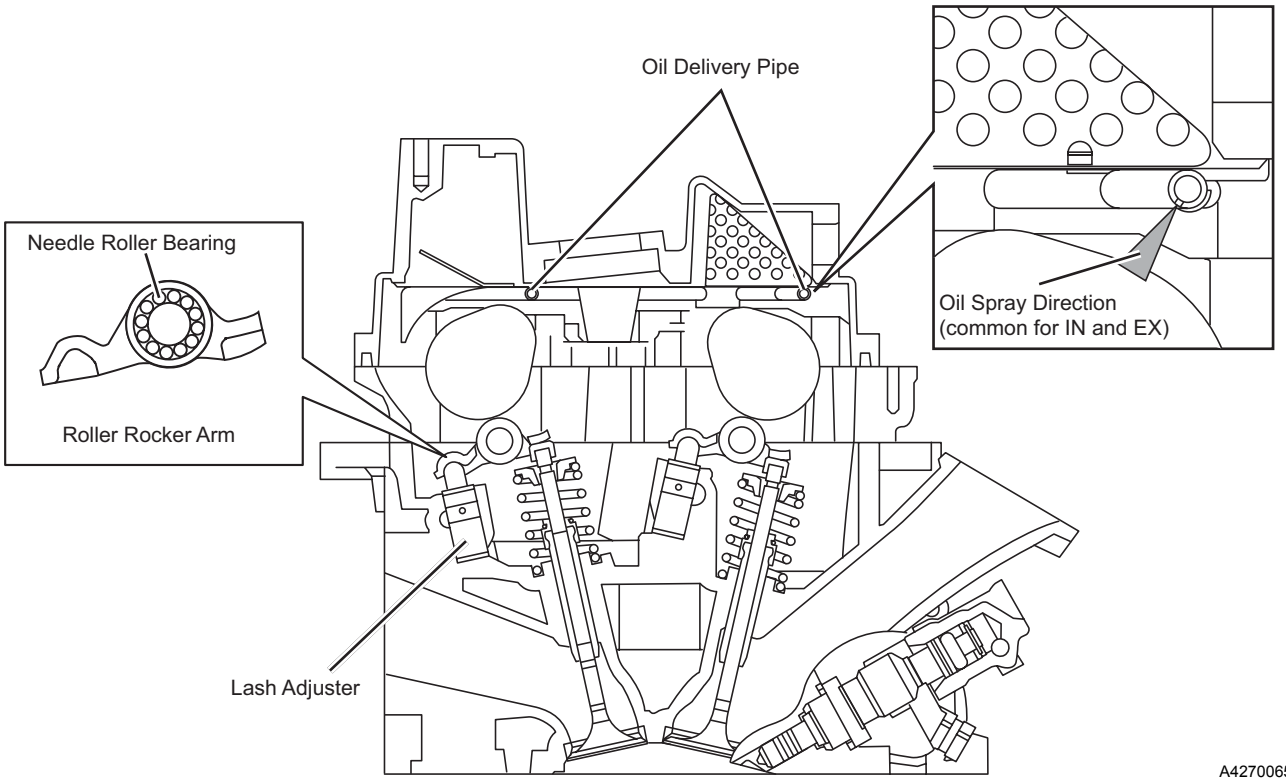
	Intake	Exhaust
Overall Length [mm (in.)]	105.65 (4.159)	111.5 (4.390)
Face Diameter [mm (in.)]	34.5 (1.358)	29.0 (1.142)
Stem Diameter [mm (in.)]	5.5 (0.216)	←

Valve Spring

Wire Diameter [mm (in.)]	3.3 (0.130)
Coil Inner Diamet [mm (in.)]	18.0±0.2 (0.709±0.08)
Free Length [mm (in.)]	46.51 (1.831)

Roller Rocker Arm

- The rocker arm is made compact and lightweight with a stamped steel arm with built-in needle bearings. The roller is supported by needle roller bearings that dramatically reduce friction at the sliding area, which contributes to fuel economy.
- An oil delivery pipe system is used for supplying oil to the roller rocker arms. This system positively supplies oil from above the camshaft to the lubrication area to ensure reliability.



Camshaft

	Intake	Exhaust
Cam Lift Amount [mm (in.)]	5.99 (0.236)	6.14 (0.242)
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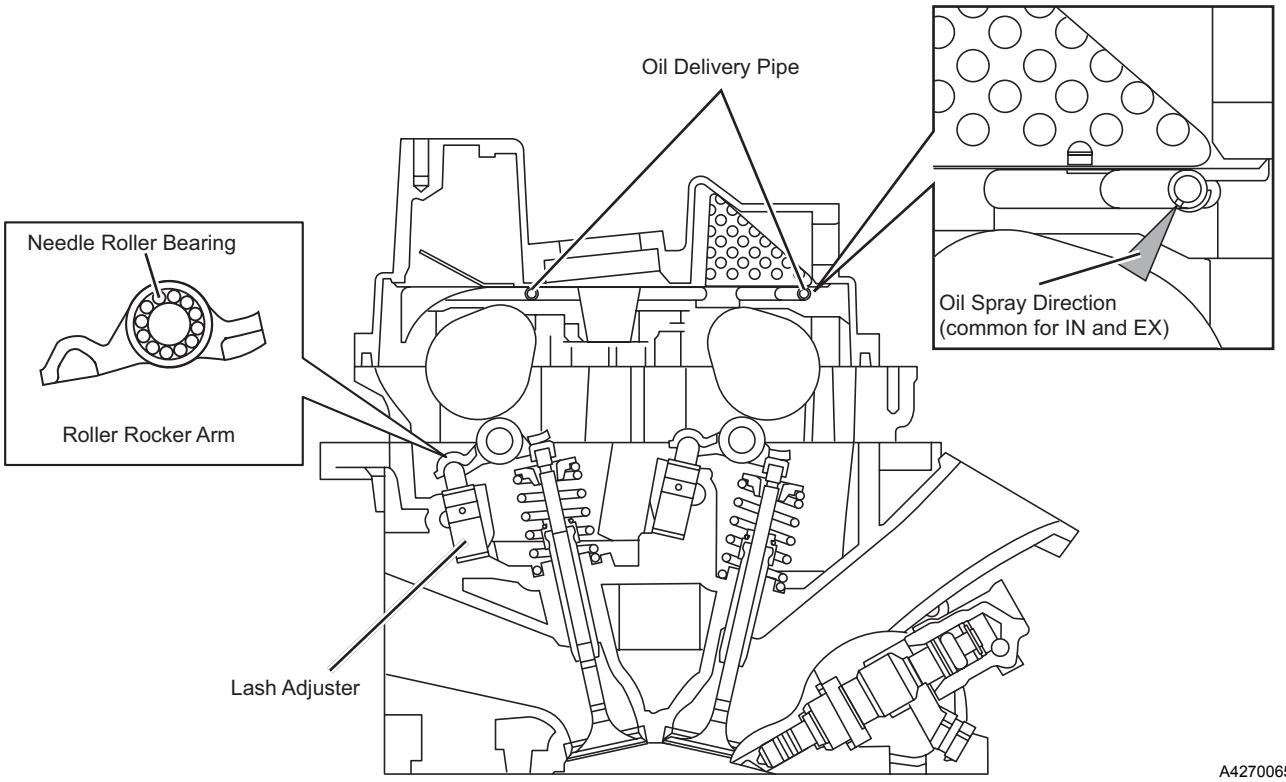
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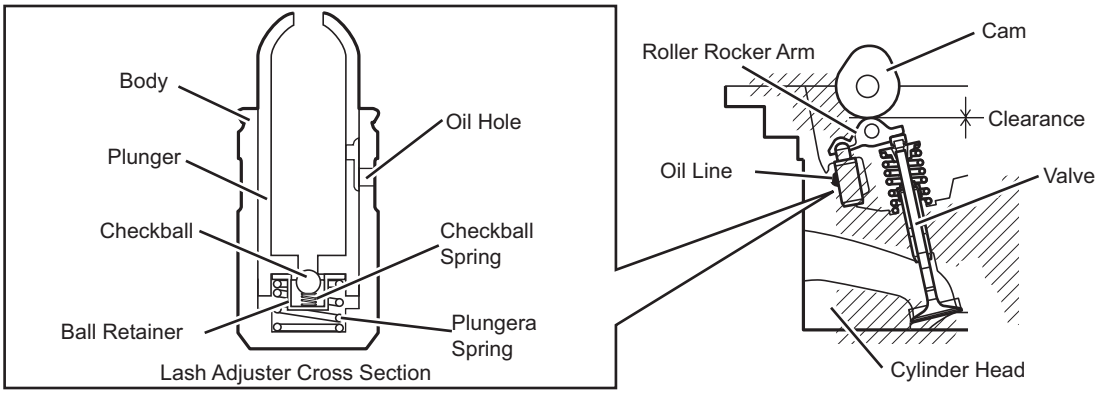


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Lash Adjuster

Lash Adjuster Construction

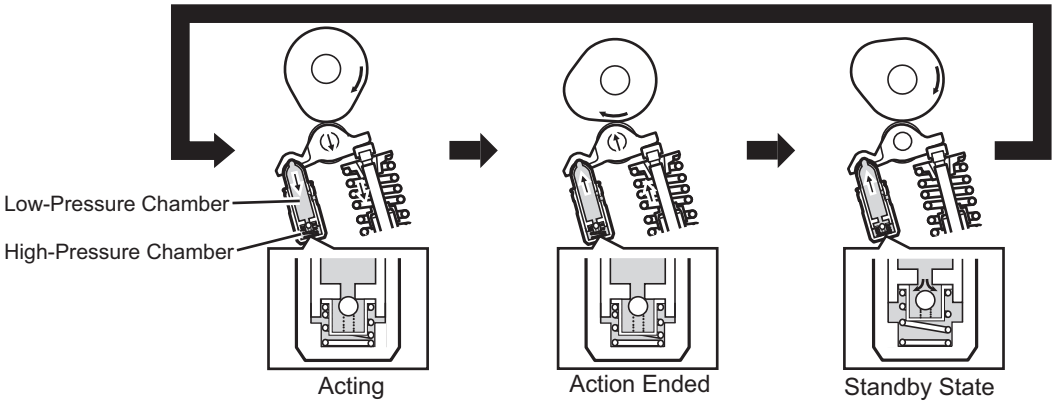
- Compact, hydraulic lash adjusters are used to constantly eliminate the gap (clearance) between the cams and rocker arms, thus enhancing the quiet performance of the engine.
- The lash adjuster is placed at the fulcrum of the rocker arm at the opposite end of the valve, and uses the oil that is supplied by the cylinder head as the operating fluid. The plunger in the lash adjuster body slides vertically due to the repulsion of the plunger spring or the hydraulic force in order to adjust the clearance.



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Lash Adjuster Operation

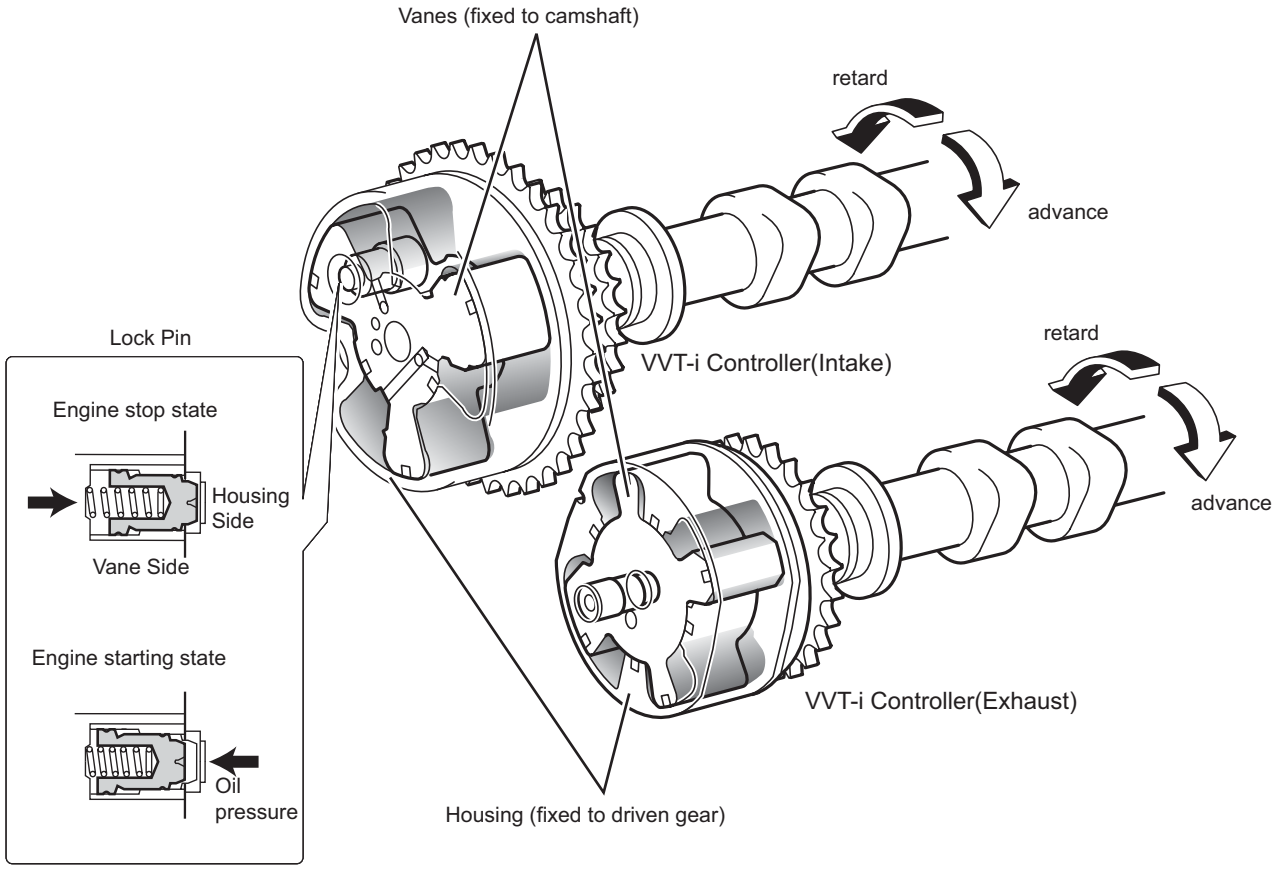
- The camshaft rotates clockwise, causing the cam to push on the rocker arm (acting), and a load is applied to both the valve and the plunger. At this time, the plunger almost gets pushed in, but because the check ball closes, the plunger stops. This allows the rocker arm to tilt in the clockwise direction, using the top of the plunger as the fulcrum, thus pushing the valve down.
- When the cam gets past the apex, the force of the valve spring causes the rocker arm to start ascending. However, because the force of the valve spring also acts on the lash adjuster, the high pressure chamber maintains its hydraulic pressure.
- When the valve closes (action ended), the oil in the high-pressure chamber is released from the pressurized state. At this time, a valve clearance is about to be created. However, the force of the plunger spring causes the plunger to push the rocker arm upward in order to maintain a constant zero valve clearance. At the same time, the capacity of the high-pressure chamber increases, creating a pressure difference between the high-pressure and low-pressure chambers. When this pressure difference becomes greater than the force of the check ball spring, the check ball moves downward to provide an oil passage. This allows the oil to flow from the low-pressure chamber to the high-pressure chamber in preparation for the next movement (standby state).



A4270067P

Dual VVT-i Controller

- The VVT-i controller is a vane type that has low friction and is highly efficient while it is being driven.
- The VVT-i controller for the intake is a 3-vane type, and a 4-vane type for the exhaust. When the engine is stopped, a lock pin locks the vanes for the intake in the most retarded position and the vanes for the exhaust in the most advanced position.
- The VVT-i for the exhaust is provided with an advance assist spring that provides a torque assist in the advance direction so that the lock pin engages securely when the engine is stopped.
- Based on the signals provided by the sensors, the engine ECU controls the hydraulic pressure that acts on the advance chamber and retard chamber in the VVT-i controller, via an OCV (Oil Control Valve) that is mounted on the cylinder head cover. Thus, it continuously varies the phases of the intake and exhaust camshafts.



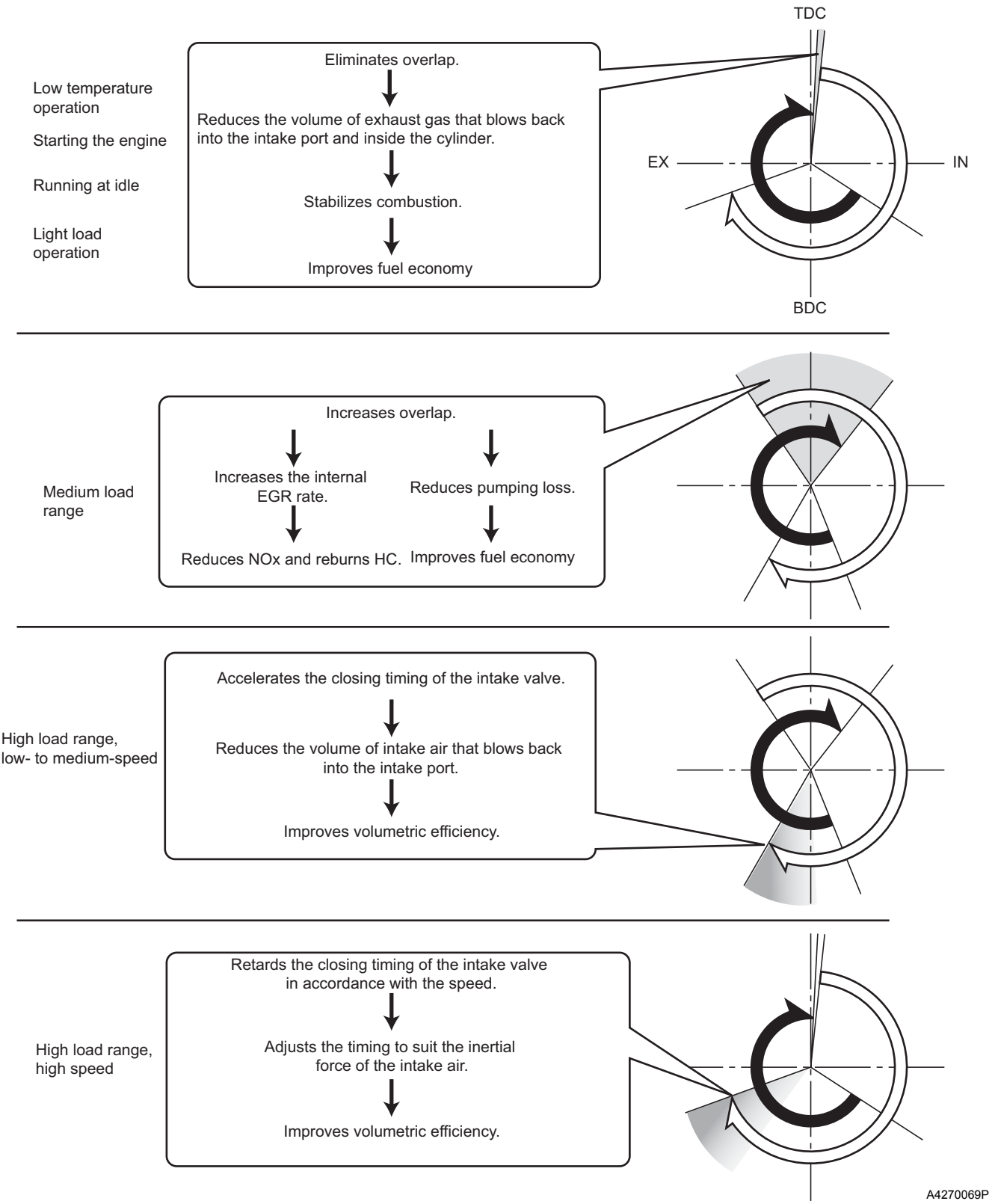
*The drawing shows the VVT-i controller for the intake in the retarded state and the VVT-i controller for the exhaust in the advanced state.

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EG

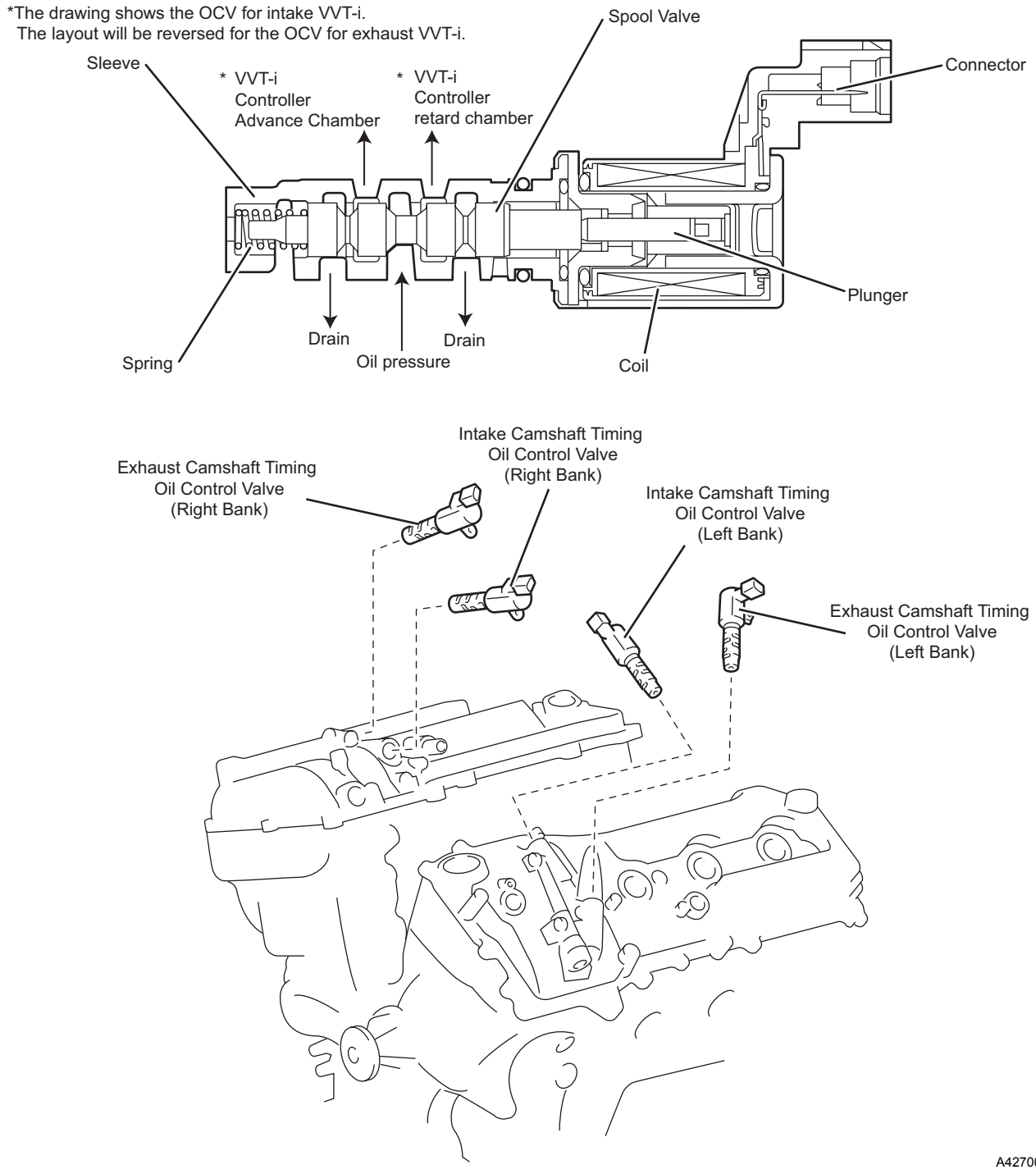
Effects of Dual VVT-i

• By advancing and retarding the intake and exhaust valves, the Dual VVT-i provides the following effects.



Camshaft Timing Oil Control Valve

- In accordance with the duty cycle signals received from the engine ECU, this OCV controls the position of the spool valve in order to constantly achieve optimal valve timing. When the engine is stopped, the force of a spring keeps the intake side of the spool valve in the most retarded state, and the exhaust side to the most advanced state, in order to ready the valves for the subsequent starting.



EG

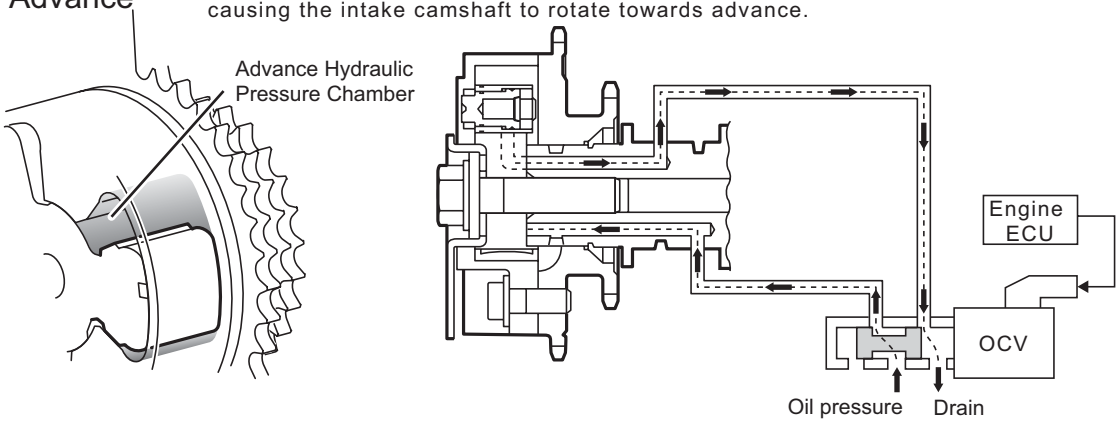
Dual VVT-i Operation

• The Dual VVT-i controls the advance, retard, and holding states as illustrated below, in accordance with the driving conditions.

Outline of Intake VVT-i Operation

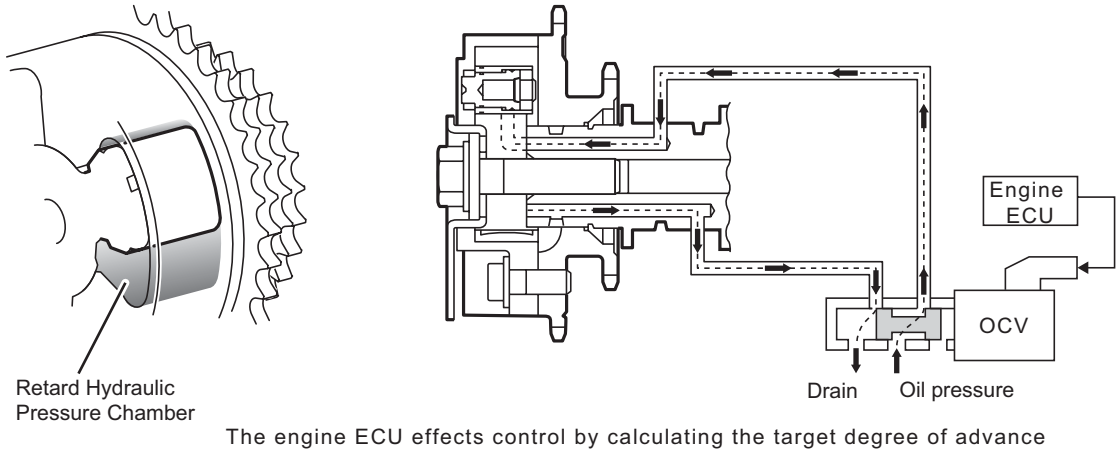
The spool valve of the OCV reaches the position shown in the drawing,
as a result of receiving a signal from the engine ECU.
Then, hydraulic pressure is applied to the hydraulic pressure chamber for advance,
causing the intake camshaft to rotate towards advance.

Advance



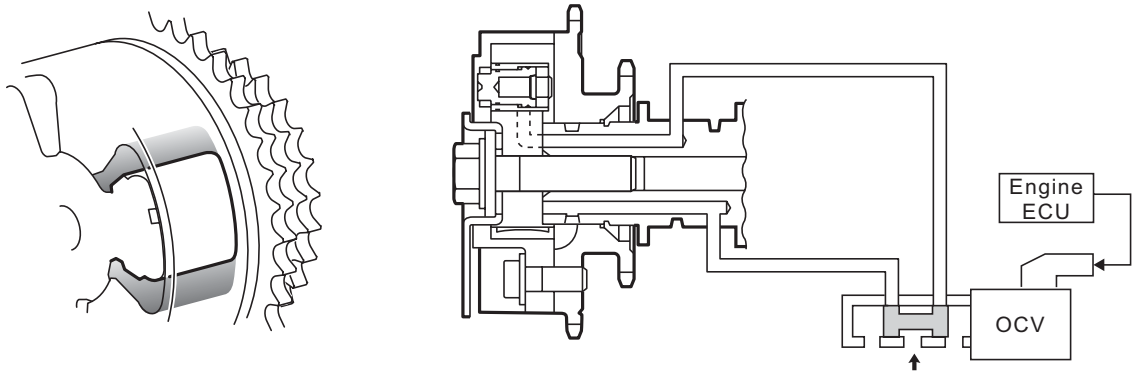
The spool valve of the OCV reaches the position shown in the drawing,
as a result of receiving a signal from the engine ECU.
Then, hydraulic pressure is applied to the hydraulic pressure chamber for retard,
causing the intake camshaft to rotate towards retard.

Retard



The engine ECU effects control by calculating the target degree of advance
in accordance with the driving conditions. After reaching the target timing,
the engine ECU maintains the timing by setting the OCV to neutral,
provided that the driving conditions do not change. As a result,
the valve timing can be set to any target position.
At the same time, the engine oil is prevented from flowing out needlessly.

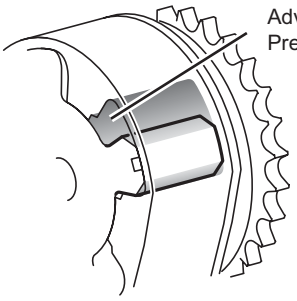
Hold

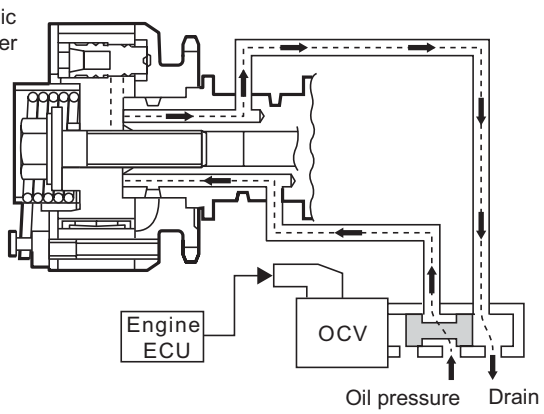


Outline of Exhaust VVT-i Operation

Advance

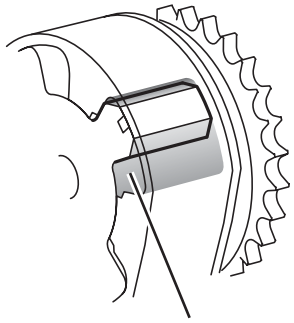
The spool valve of the OCV reaches the position shown in the drawing,
as a result of receiving a signal from the engine ECU.
Then, hydraulic pressure is applied to the hydraulic pressure chamber for advance,
causing the exhaust camshaft to rotate towards advance.

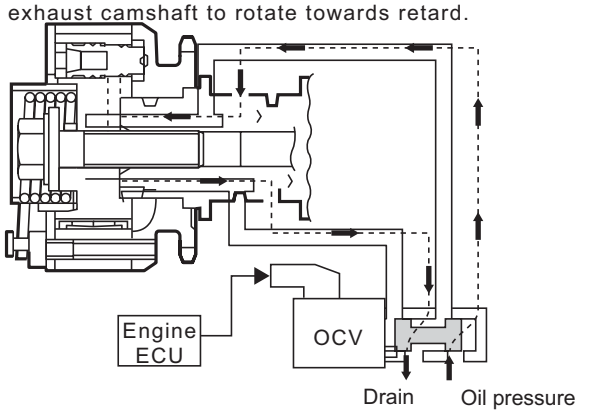




Retard

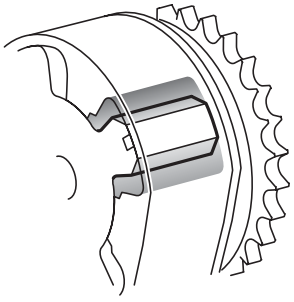
The spool valve of the OCV reaches the position shown in the drawing,
as a result of receiving a signal from the engine ECU.
Then, hydraulic pressure is applied to the hydraulic pressure chamber for retard,
causing the exhaust camshaft to rotate towards retard.

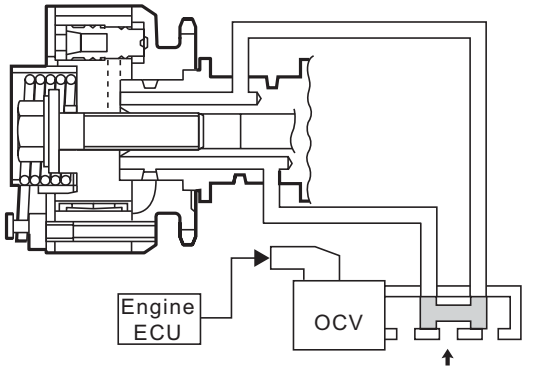




Hold

The engine ECU effects control by calculating the target degree of advance
in accordance with the driving conditions. After reaching the target timing,
the engine ECU maintains the timing by setting the OCV to neutral,
provided that the driving conditions do not change. As a result,
the valve timing can be set to any target position.
At the same time, the engine oil is prevented from flowing out needlessly.



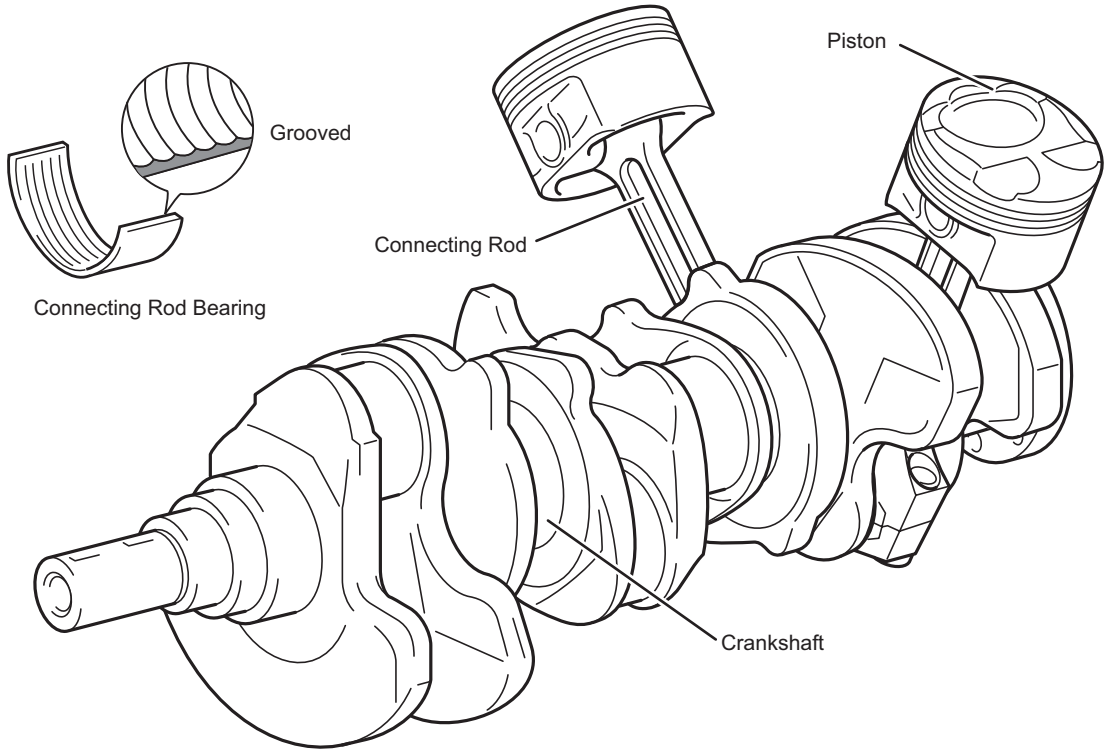


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EG

Piston and Crankshaft

- The pistons are made of a lightweight and highly rigid aluminum alloy.
- The connecting rods are made of highly rigid, sintered forged steel that ensures a high level of reliability.
- The crankshaft, which is made of forged steel, is a type that has 4 journals and 5 balance weights. It is lightweight and the balance weights are placed optimally to reduce vibration and noise. The crank pin width and the journal fillet have been made narrower to shorten the length of the crankshaft, in order to realize both high rigidity and low friction. The fillets have been induction hardened to ensure ample strength.
- The connecting rod bearings and the crankshaft bearings have been made narrower to reduce friction. The bearing lining is made of an aluminum alloy to realize both wear resistance and seizure resistance.
- The crankshaft pulley is provided with a torsional damper to reduce vibration and noise.



A4270152P

Connecting Rod

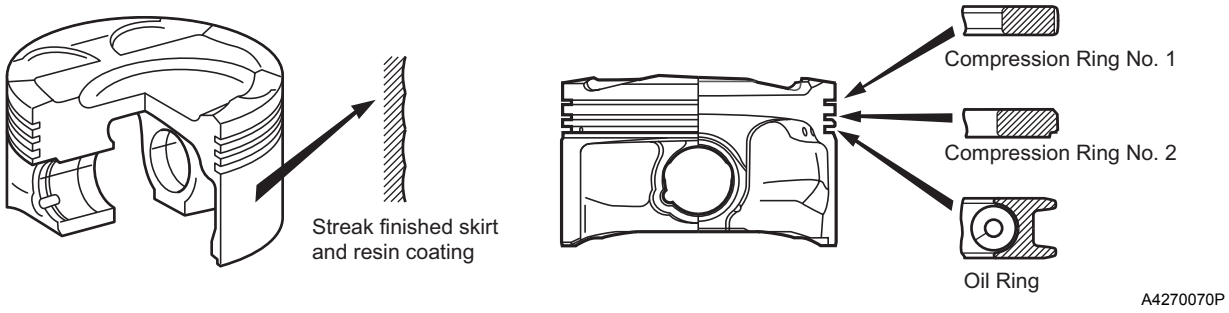
Big End Inner Diameter	[mm (in.)]	56.0 (2.205)
Small End Inner Diameter	[mm (in.)]	22.0 (0.866)
Center Distance Between Big and Small Ends	[mm (in.)]	147.5 (5.807)

Crankshaft

Journal Diameter	[mm (in.)]	61.0 (2.402)
Crank Pin Diameter	[mm (in.)]	53.0 (2.087)
Crank Pin Stroke Radius	[mm (in.)]	41.5 (1.634)

Piston

- The pistons have been made lightweight with a short compression height and a short skirt. The piston skirt has a streak finish and a plastic coating that excel in seizure resistance, in order to reduce noise and friction.
- A compact combustion chamber is provided on top of the piston to realize stable combustion. Together with the pentroof type combustion chamber on the cylinder head, this realizes a high compression ratio, resulting in both high performance and fuel economy.
- Each piston ring is made thinner and with low tension to reduce friction.



Piston

Basic Diameter	[mm (in.)]	87.465 (3.444)
Pin Hole Offset	[mm (in.)]	0.5 (0.020)
Compression Height	[mm (in.)]	31.05 (1.222)

Piston Pin

Outer Diameter	[mm (in.)]	22.0 (0.866)
Inner Diameter	[mm (in.)]	12.7 (0.5)
Length	[mm (in.)]	56.0 (2.205)

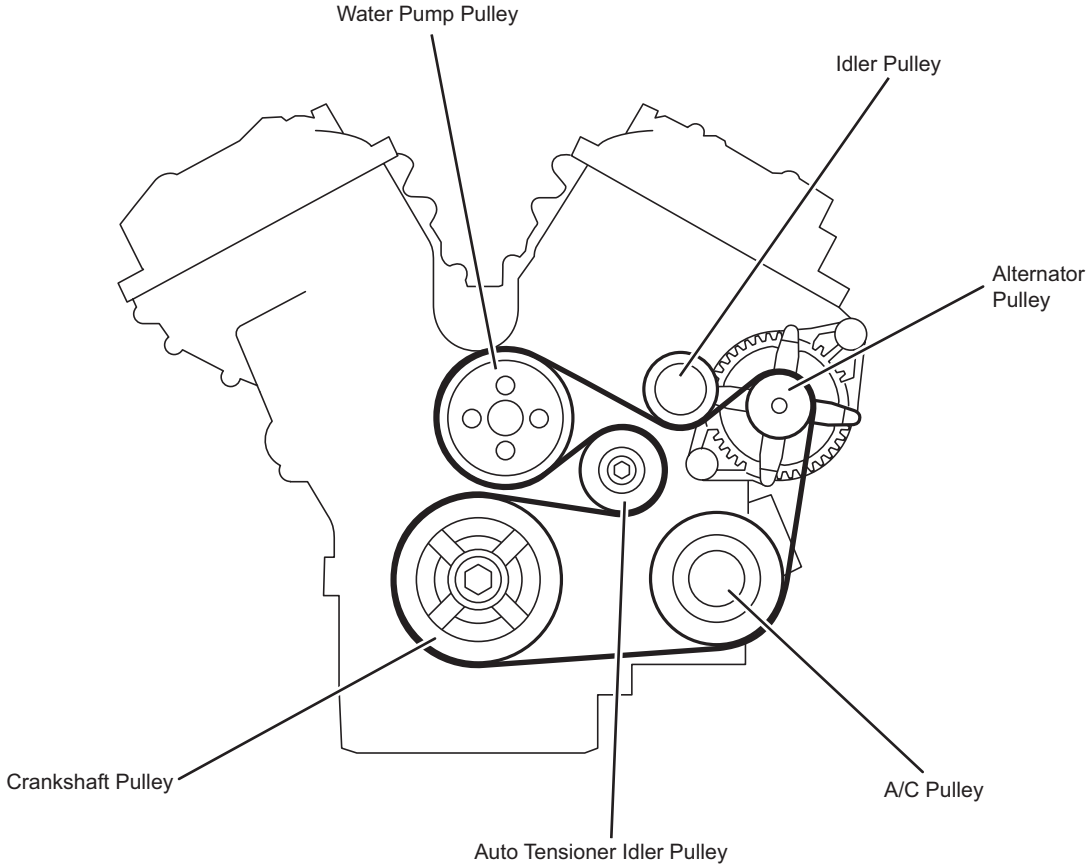
Piston Ring

	Compression Ring No. 1	Compression Ring No. 2	Oil Ring
Material	Stainless Steel	Steel	Steel
Shape	Barrel Face	Tapered Face + Undercut	Combination
Width [mm (in.)]	1.2 (0.047)	1.2 (0.047)	2.0 (0.079)
Thickness [mm (in.)]	2.7 (0.106)	2.7 (0.106)	2.75 (0.108)
Surface Treatment	PVD (Physical Vapor Deposition) (Periphery)	Anti-Corrosion	Gas Nitriding

EG

Serpentine Belt Drive System

- A serpentine drive system, which uses a single V-ribbed belt to drive all accessories, is used in order to shorten the overall length of the engine and make it lightweight.
- An auto tensioner is used for the V-ribbed belt to ensure the long life of the belt and accessories, make them maintenance free, and improve serviceability by facilitating the removal and reinstallation of the belt.



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Pulley Specifications

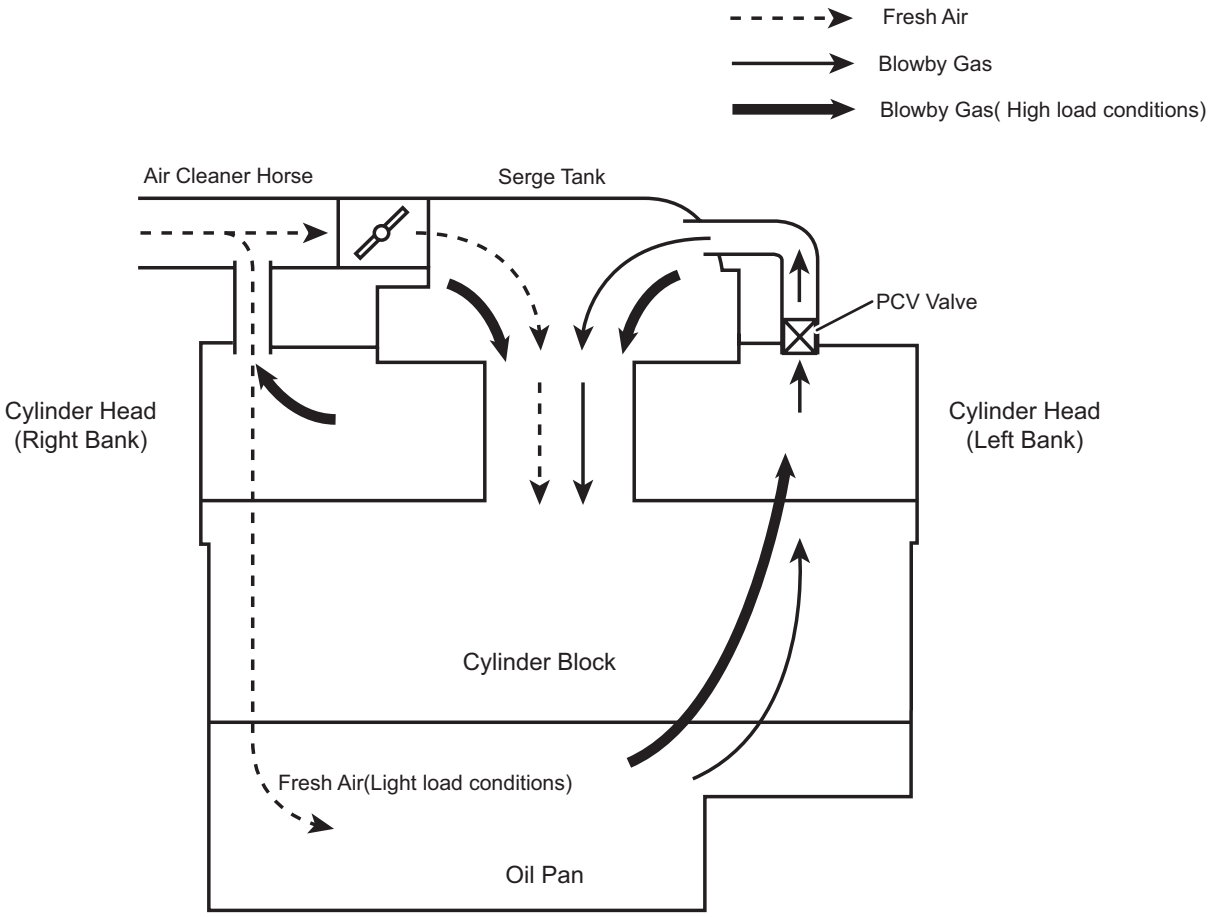
	Pulley Diameter [mm (in.)]
Crankshaft Pulley	140 (5.512)
Auto Tensioner Idler Pulley	70 (2.756)(driven from back face)
A/C Pulley	115 (4.528)
Idler Pulley	70 (2.756)(driven from back face)
Water Pump Pulley	120 (4.724)
Alternator Pulley	52.5 (2.067)

V Ribbed Belt Specifications

Width [mm (in.)]	24.92 (0.981)
Length [mm (in.)]	1550 (61.024)
Number of Ribs	7

Blowby Gas Reduction System

- A PCV hose and a PCV valve are provided to forcefully feed the blowby gas into the intake system for combustion, in order to prevent the blowby gas, which includes a large amount of HC, from being discharged into the atmosphere. A new air circulating system is used wherein fresh air from the air cleaner hose is introduced via the right bank head cover and the blowby gas is discharged into the surge tank via the left bank head cover.
- Under light load conditions, the intake manifold vacuum causes the blowby gas to be drawn via the PCV valve into the intake manifold, to be combusted. The internal pressure is regulated in the crankcase, where fresh air is introduced from the cylinder head cover.
- Under high load conditions, the intake manifold vacuum forcefully introduces the blowby gas into the intake system, where it is combusted. This prevents the blowby gas, which contains a large amount of HC, from being released to the atmosphere.
- A dedicated oil return passage and a blowby gas passage are provided in the cylinder block and the cylinder head to enhance the oil return function and minimize the volume of oil that is taken away.



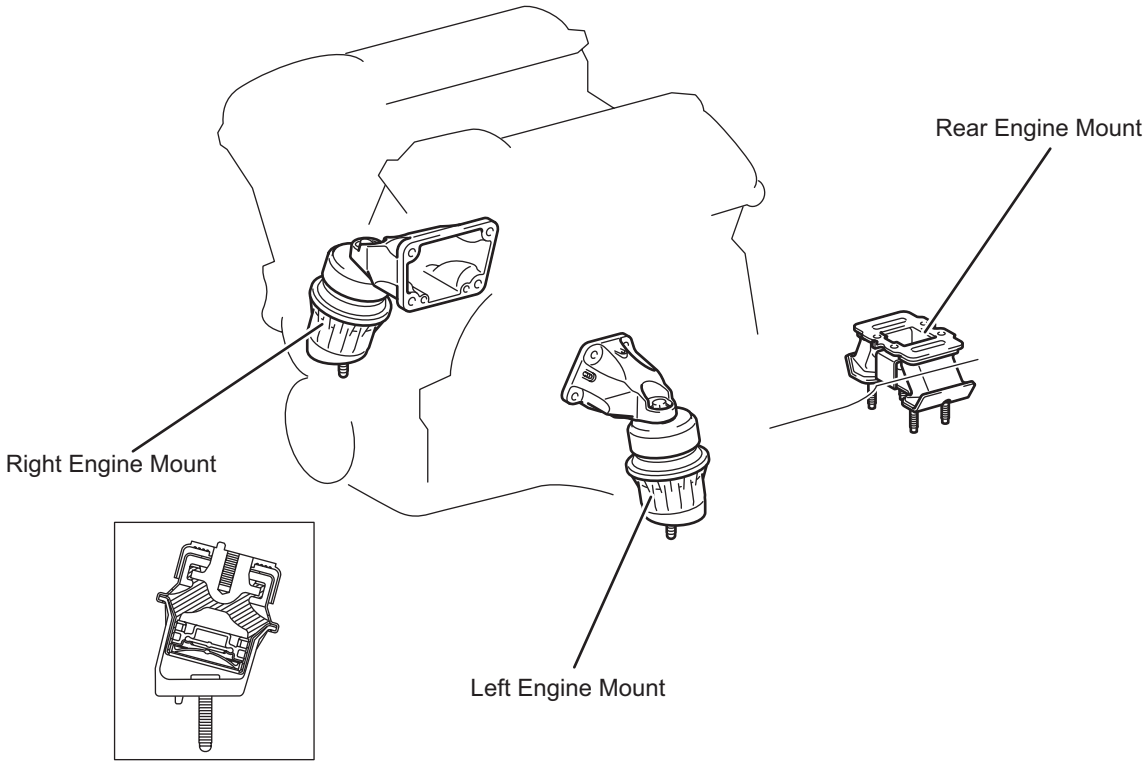
Conceptual operation image of the blowby reduction system

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EG

Engine Mounts

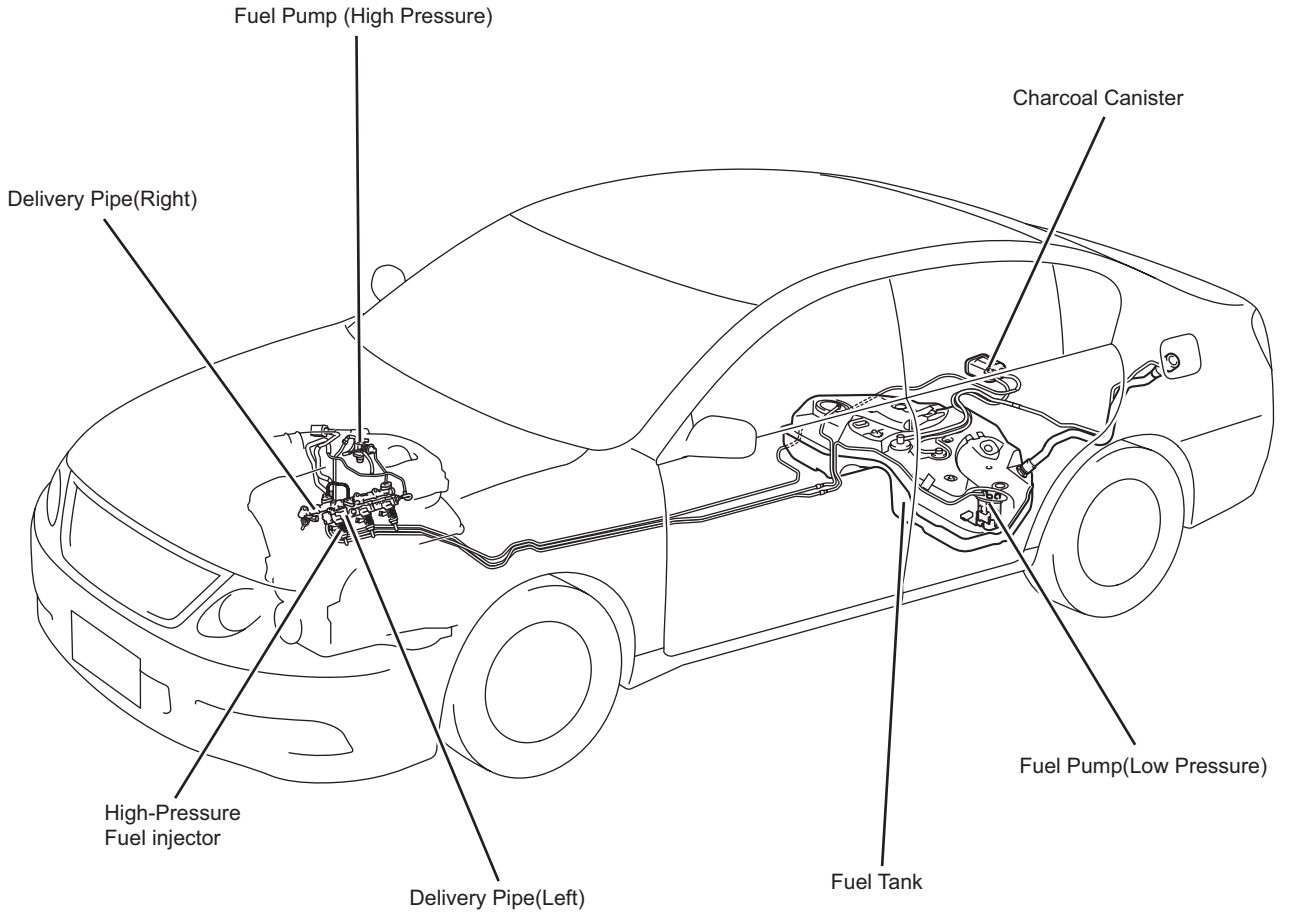
- The front engine mounts are installed on the upper area of the cylinder block where the vibration is minimal. In addition, the brackets have been angled more moderately to reduce vibration and noise in all operating ranges. The brackets are made of cone-shaped aluminum alloys to reduce weight, vibration, and noise.
- The front engine mount uses a liquid-filled double-orifice mount insulator to reduce vibration and noise in the operating range of the engine.
- The die shape for the rear engine mount has been optimized to reduce vibration in the operating range.



3GR-FSE FUEL

General

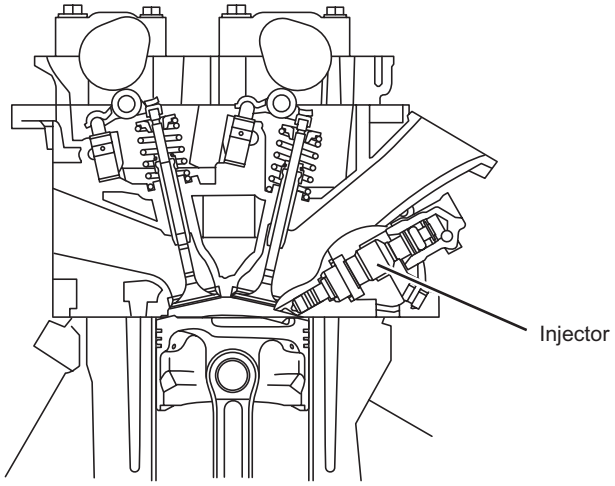
- This engine uses the D-4 (Direct injection 4-stroke gasoline engine) system. A (low pressure) fuel pump located inside the fuel tank pumps fuel to the high-pressure fuel pump located in the cylinder head cover. Then, the fuel is boosted to a pressure between 4 and 13 MPa in accordance with the driving conditions, and sent to the high-pressure fuel injectors.
- A fuel returnless system, which controls the fuel pressure for the low pressure side by way of a pressure regulator installed in the fuel tank, is used. However, the leak fuel from the high-pressure fuel pump and the fuel from the relief valve return to the fuel tank.
- To prevent fuel from leaking during a collision (in which air bags are deployed), a system that turns OFF the circuit opening relay is used to ensure safety.



EG

Direct injection 4-stroke Gasoline Engine (D-4)

- The D-4 (Direct injection 4-stroke gasoline engine) directly injects highly pressurized fuel into the cylinders. This engine effects comprehensive control of the fuel injection timing, air-fuel ratio, throttle valve position, etc., to realize both a high power output and low exhaust emissions.
- The high-pressure slit nozzle injector atomizes fuel into a fine mist while expanding it to form a large, fan-shaped pattern. Then, the fuel mist enters the combustion chamber while drawing in a large volume of air. The fuel mist that is sprayed at high-pressure expands into the combustion chamber on its own energy, without depending on the air current. Thus, it mixes efficiently with the intake air in order to achieve ideal combustion in all driving ranges.

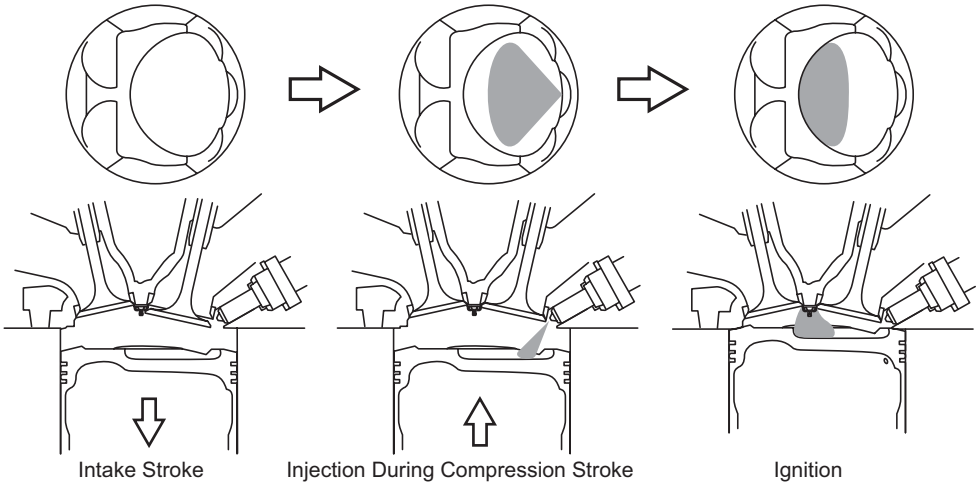


Direct injection 4-stroke Gasoline Engine(D-4)

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Air Fuel Ratio Control

- One of the two independent straight ports contains an SCV (Swirl Control Valve), which opens and closes to enhance both charging efficiency and combustion efficiency.
- When the engine is operating at low speed and low load conditions, the SCV remains fully closed. Thus, only one port is used for intake, in order to promote the mixture of air and fuel. This also accelerates the intake flow speed, which enhances combustion and improves fuel economy.
- When the engine is operating at high load conditions, the SCV opens to allow the intake of air through both straight ports. This increases the intake air volume and improves charging efficiency. At the same time, this creates a vertical swirl current (tumble current) in the combustion chamber to promote the mixture of air and fuel, thus improving performance.
- Fuel is injected during the compression stroke immediately after cold-starting. This enables the catalyst to warm up quickly, resulting in a dramatic reduction in exhaust emissions.



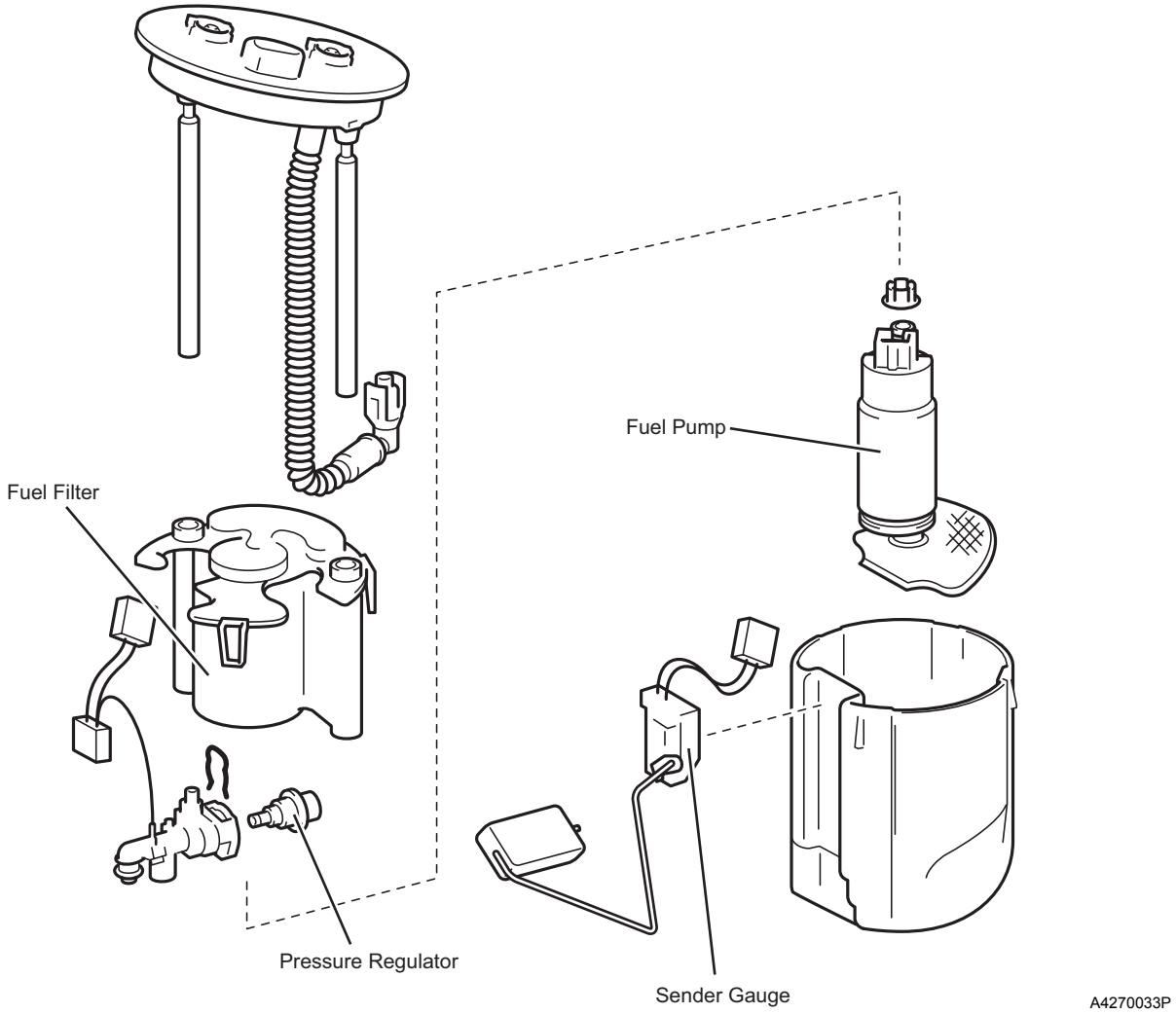
Conceptual image of fuel injection during cold starting

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EG

Fuel Pump

- A fuel pump assembly consisting of a fuel pump, fuel filter, and sender gauge is used.
- To prevent fuel from leaking during a collision (in which air bags are deployed), a system that turns OFF the circuit opening relay, in accordance with a signal from the airbag ECU, is used to ensure safety.



Fuel Pump

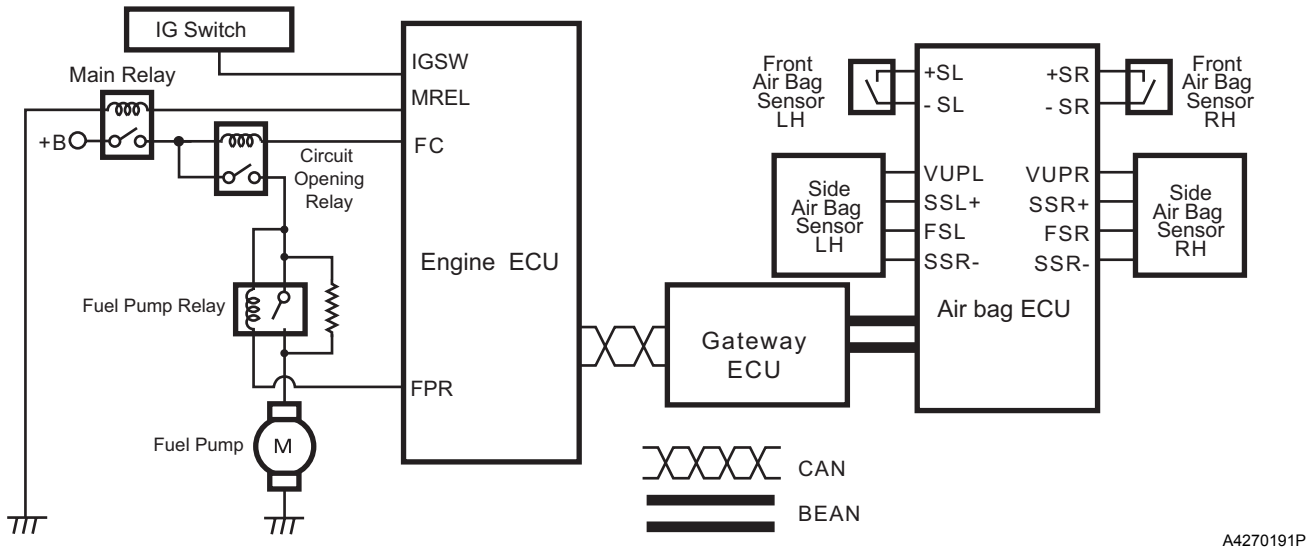
Discharge Pressure [kPa]	400
Discharge Volume [L·h]	190 Minimum

Fuel Filter

Filter System	Paper Filter Type
Filtering Surface Area [cm2]	1550

Fuel Pump Control

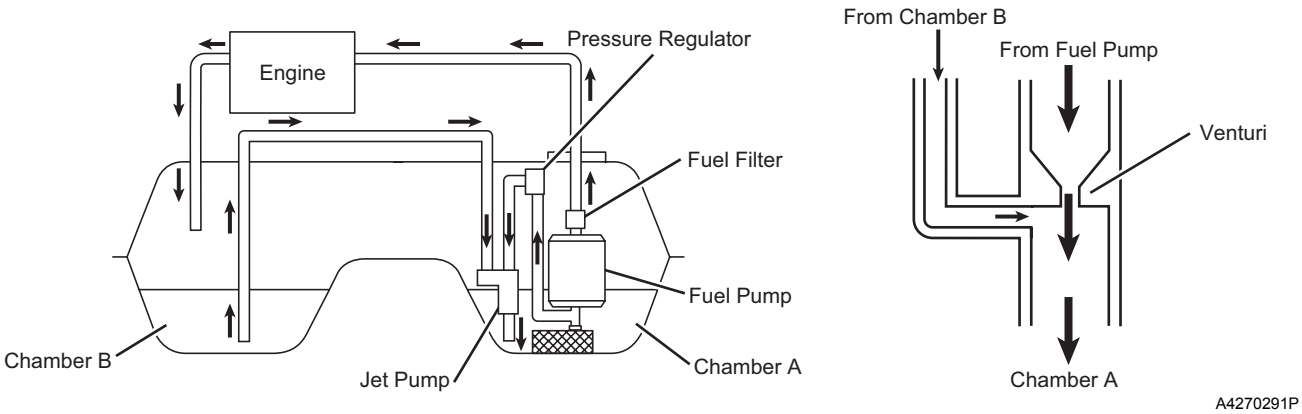
- When the starter signal is ON and the engine speed signal is input continuously for 2 seconds or longer, the circuit opening relay turns ON to actuate the fuel pump.
- A fuel cut control is adopted to stop the fuel pump when the airbag is deployed at the front or side collision. In this system, the airbag deployment signal from the airbag sensor assembly is detected by the engine ECU, which turns OFF the circuit opening relay.
- After the fuel cut control has been activated, turning the ignition switch from OFF to ON cancels the fuel cut control, thus engine can be restarted.



EG

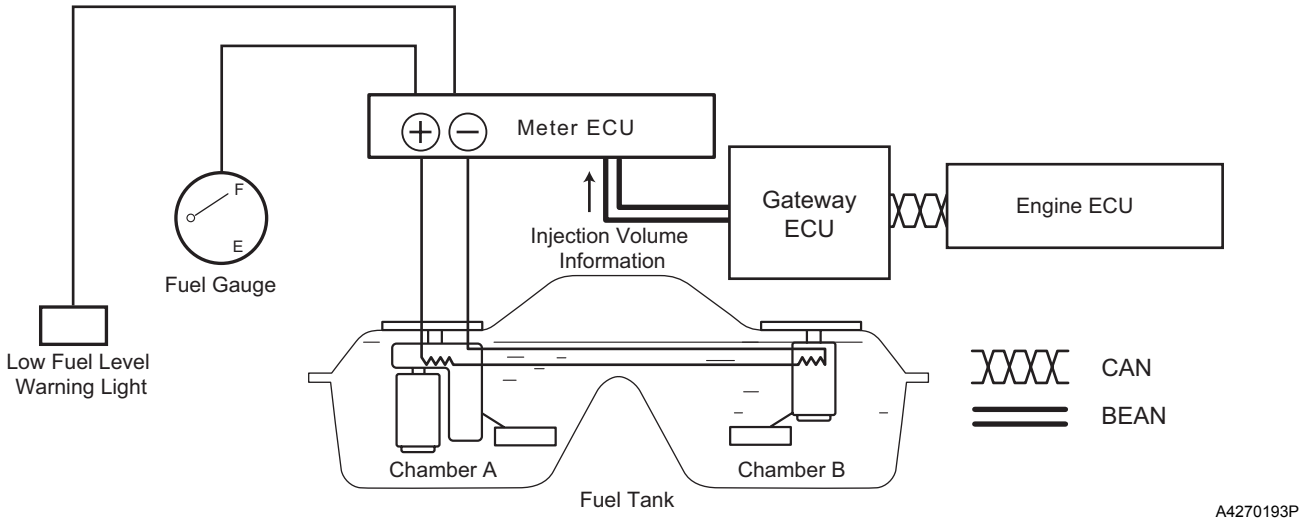
Jet Pump

- The jet pump operates as described below.
- A jet pump is adopted in the fuel tank. Since the propeller shaft is located below its center bottom, the fuel tank of the GS430 is shaped as indicated below.
- A fuel tank with such a shape tends to cause the fuel to be dispersed into both chamber A and chamber B when the fuel level is low, stopping the fuel in chamber B from being pumped out. To prevent this from occurring, a jet pump has been provided to transfer the fuel from chamber B to chamber A.
- This is accomplished by utilizing the flow of the fuel, so that the vacuum created by the fuel, as it passes through the venturi is used to suck the fuel out of chamber B and send it to chamber A.



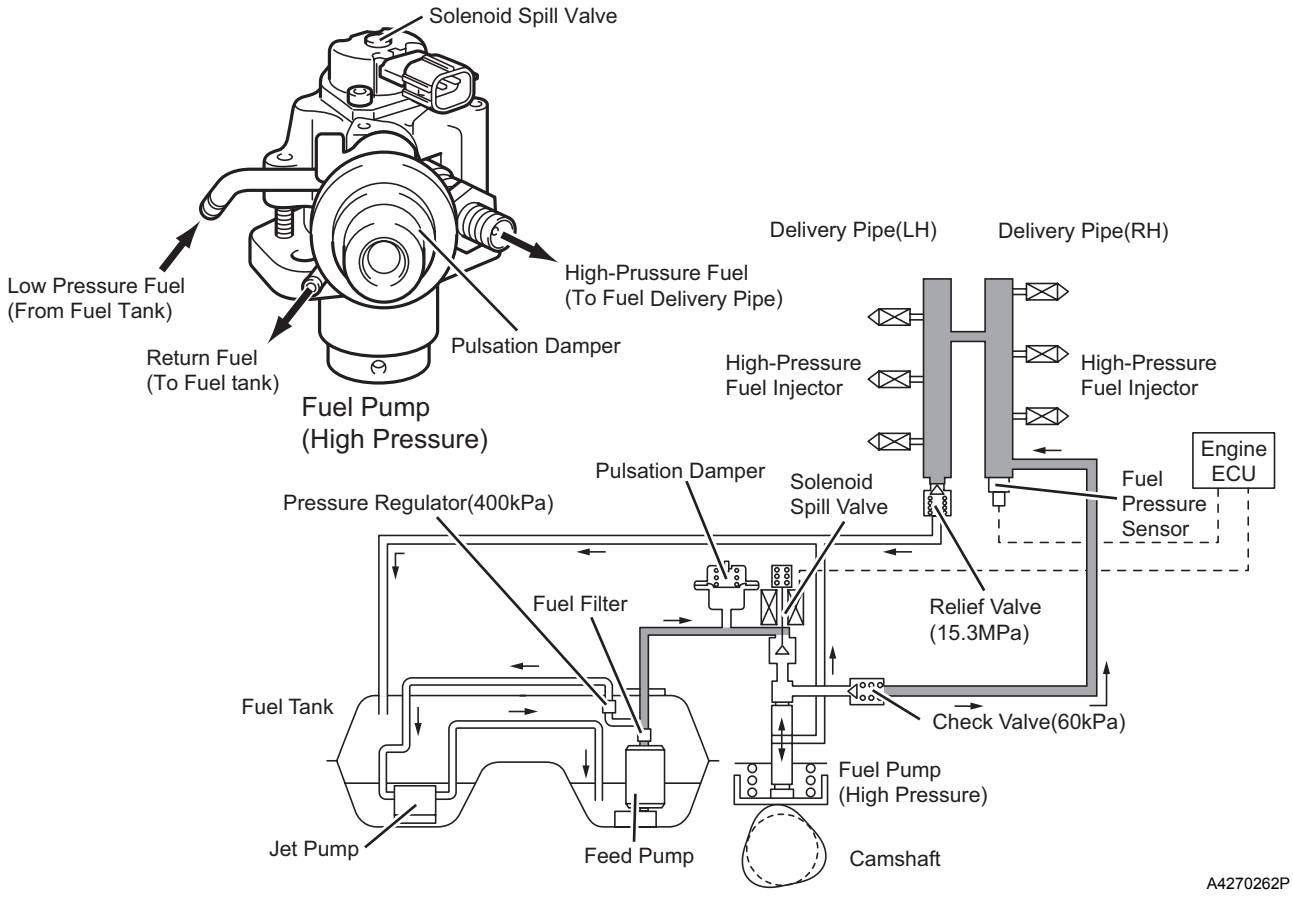
Fuel Sender Gauge

- To accurately inform the driver of the residual fuel volume in the saddle-shaped tank, inline sender gauges are provided in the two chambers, A and B. These sender gauges output the residual fuel volume of both chambers to the meter ECU.
- Based on the signals received from the two sender gauges and the EFI control information received from the engine ECU, the meter ECU calculates the residual fuel volume, and activates the fuel gauge.



Fuel Pump (High Pressure)

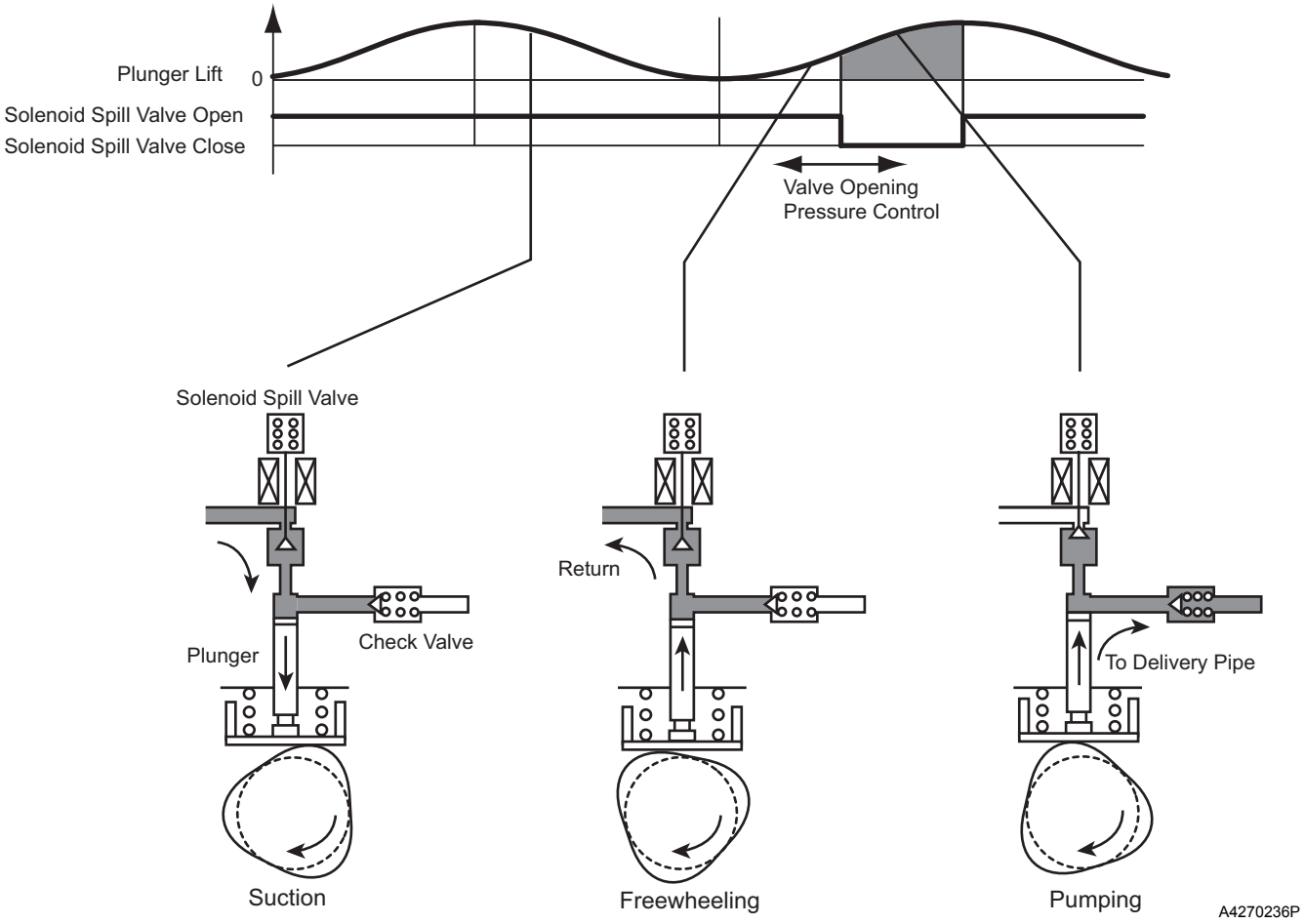
- This fuel pump is a highly efficient, single-plunger type in which the drive torque has been reduced. In addition, a solenoid spill valve and a check valve have been integrated to achieve a lightweight and compact system. Also, a pulsation damper has been installed at the low-pressure fuel inlet.
- Mounted on the cylinder head cover, this fuel pump is driven by a cam that is provided at the rear end of the exhaust camshaft on the right bank of the engine. A heat insulator is provided on the surface of the fuel pump that mounts to the cylinder head cover in order to suppress the increase in fuel temperature.
- The engine ECU variably controls the fuel to a high-pressure that suits the driving conditions. Because this system uses a solenoid spill valve to control and discharge only the necessary volume of fuel, the drive torque and noise have been reduced.
- A fuel pressure sensor, which is provided in the fuel delivery pipe, gives feedback to the engine ECU in order to maintain an optimal fuel pressure at all times. This system varies the high fuel pressure between 4 and 13 MPa to suit the driving conditions, in order to reduce friction loss.
- A tapered seal metal joint is used for joining the high-pressure fuel delivery pipes.
- It consists of a solenoid spill valve that regulates the discharge volume of high-pressure fuel, a plunger that is driven by the camshaft and pressurizes fuel, and a check valve that mechanically opens and closes the passage to the fuel delivery pipe.
- A pulsation damper is provided at the low-pressure fuel inlet from the fuel tank, in order to reduce the pulsation of fuel.



EG

High Pressure Fuel Pump Operation

- The plunger in the pump moves up and down to pressurize fuel. The solenoid spill valve, which is provided at the suction side of the pump, closes at an optimal timing during the compression stroke in order to control the fuel to the required pressure and volume. If the solenoid spill valve closes at an early timing, the effective stroke of the plunger becomes longer, thus pressurizing the fuel to an even higher pressure.
- The fuel that has been pressurized by the plunger pushes open the check valve (60 kPa), flows into the fuel delivery pipe, and is controlled to a pressure between 4 and 13 MPa (approximately 40 to 130 bars).
- The fuel pressure sensor that is provided on the fuel delivery pipe detects the fuel pressure and gives feedback to the engine ECU, enabling the engine ECU to control the fuel to a target pressure.

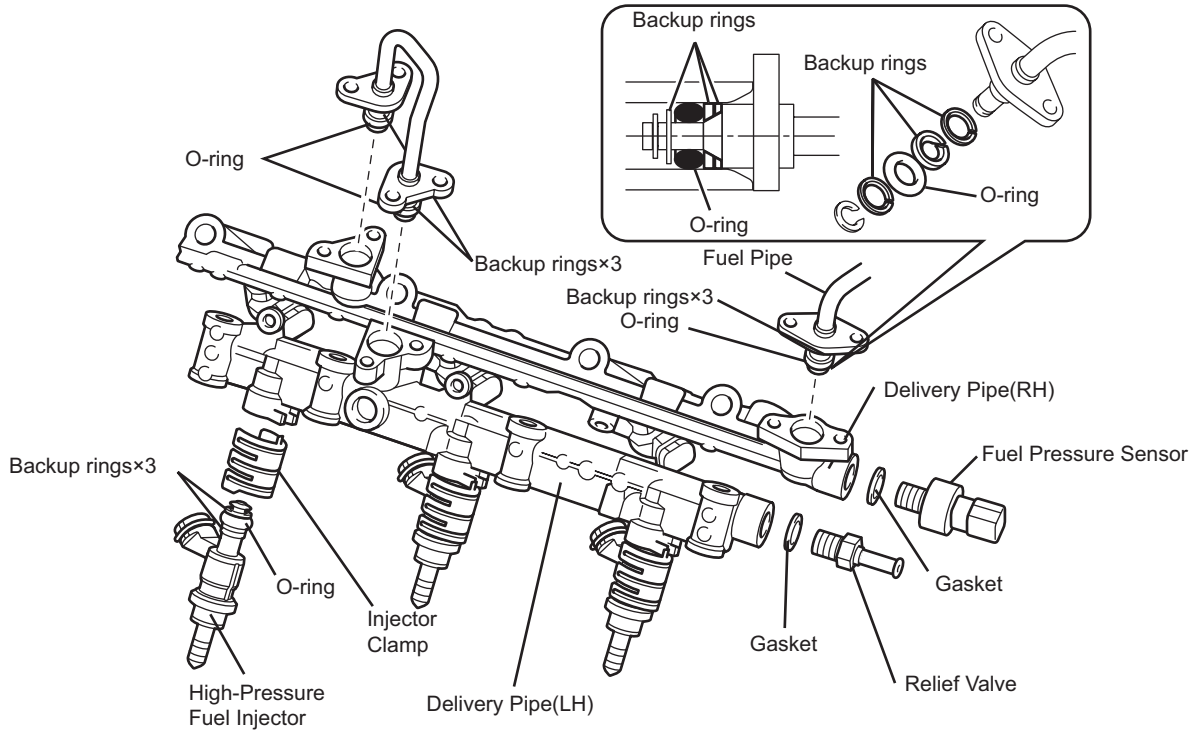


Delivery Pipe

- An aluminum alloy fuel delivery pipe is used.
- A fuel pressure sensor and a relief valve are provided on the fuel delivery pipe.
- An injector clamp is provided to each area of the fuel delivery pipe where a high-pressure fuel injector is installed. This clamp applies a constant spring force to the injector to prevent the injector from moving when the combustion pressure is applied to the injector while the engine is being started, during which the fuel pressure is low. As a result, it increases the sealing performance of the injector, while reducing vibration and noise.
- O-rings and backup rings* are used in the areas in which the high-pressure fuel injectors and high-pressure fuel delivery pipes are joined. This reduces the transmission of the operating sounds of the high-pressure fuel injectors, enhances quiet operation, and ensures the sealing performance of the joined areas.

❖REFERENCE❖

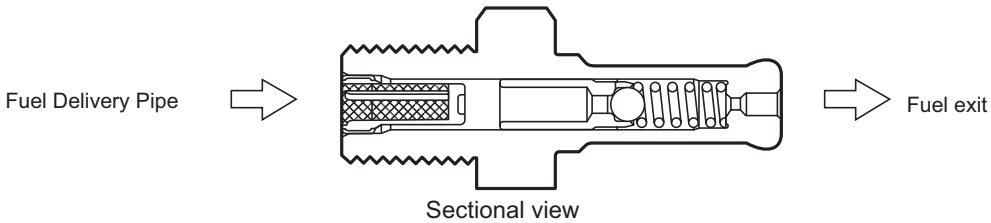
* : The backup ring is provided to securely support the rubber O-ring, which is exposed to high fuel pressure. During assembly, make sure to install it with the correct position and orientation.



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Relief Valve

- A relief valve is provided in the fuel delivery pipe. When the fuel in the fuel delivery pipe increases to a predetermined pressure (15.3 MPa), the relief valve returns the fuel to the fuel tank.

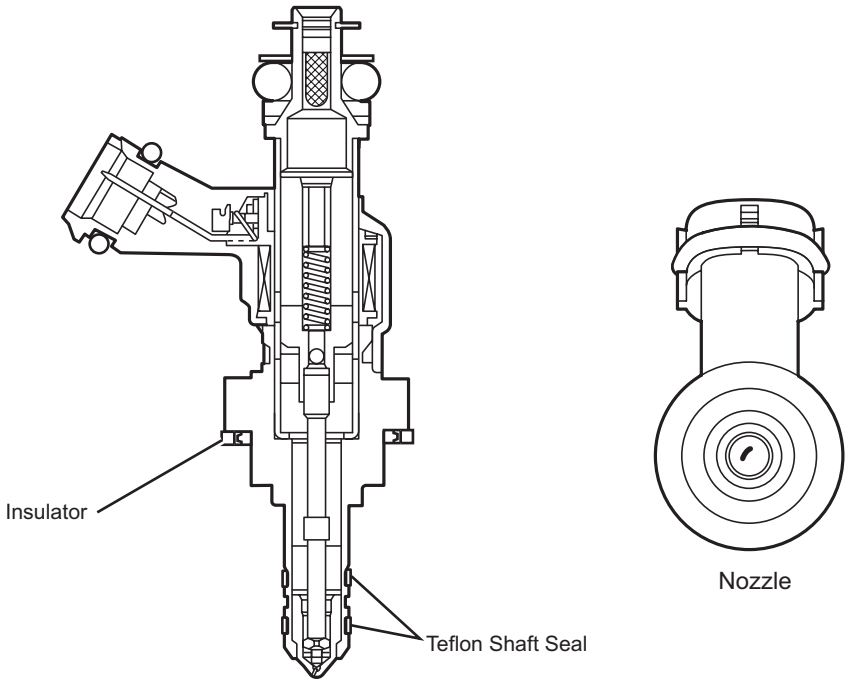


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EG

Injector

- A single-orifice, high-pressure slit nozzle injector is used.
- The injector atomizes fuel into a fine mist and expands it to form a large, fan-shaped pattern. Then, the fuel mist enters the combustion chamber while drawing in a large volume of air. This increases the intake air volume and improves charging efficiency. Furthermore, the intake air forms a vertical swirl current (tumble current) in the combustion chamber to promote the mixture of air and fuel, thus achieving high performance and a high power output.
- Because the injector is exposed inside the combustion chamber, a special coating has been applied to the nozzle in order to suppress the adhesion of carbon deposits created by the combustion gas.
- An insulator is used in the area in which the injector comes in contact with the cylinder head, and a Teflon shaft seal is used for sealing the injector against the cylinder pressure in order to reduce vibration and noise and enhance sealing performance.
- An EDU (Electronic Driver Unit) is used in order to operate the high-pressure fuel injectors speedily and precisely.



High-Pressure Fuel Injector Cross-Sectional Diagram

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Fuel Injector

Number of Orifices	1
Orifice Dimensions [mm (in.)]	0.15 × 0.71 (0.006 × 0.028)
Injection Pressure [MPa]	4 ~ 13

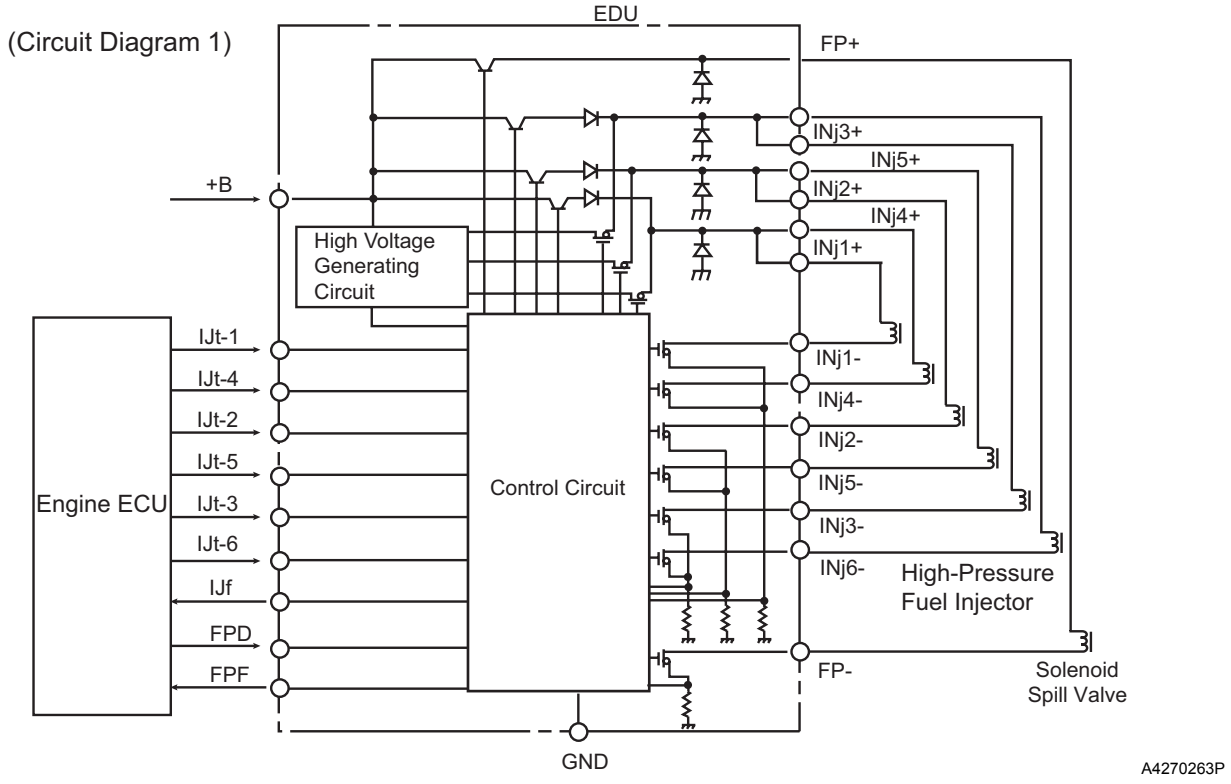
EDU(Electronic Driver Unit)

An EDU to operate the high-pressure fuel injectors at high speedsis placed in the engine compartment. The engine EDU converts theinjection request signal received from the engine ECU into high-voltage,high-amperage injector actuation signals, in order to actuate thehigh-pressure fuel injectors.

EDU Operation

EDU Operation (Circuit Diagram 1)

- When the engine ECU sends injection signals (IJt-1 to IJt-6) to the EDU, the COM terminal outputs a high voltage for actuating the injectors. When the injectors open the voltage switches to 12V to keep the injectors open. The current will flow from INj#+ to INj#- and to GND, in order to actuate the high-pressure fuel injectors.
- The control circuit constantly monitors the actuating state of the injectors, and sends an IJf fail signal to the engine ECU when the INj-# is actuated normally.

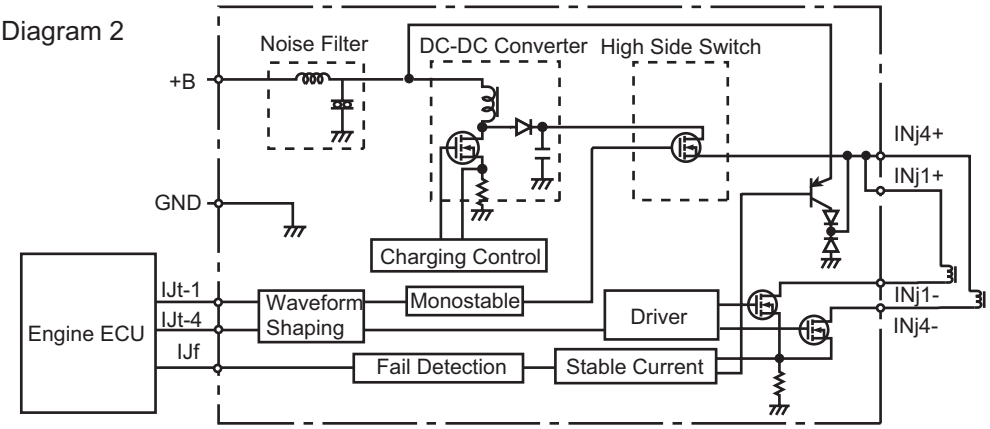


EG

Example of IJt-1 Actuation (Circuit Diagram 2)

- The fuel injection request signal IJt-1 from the engine ECU passes through the waveform shaping circuit, and separates into the monostable circuit - high side switch and the driver circuit. Then, the high side switch applies the high voltage boosted by the DC-DC converter, in accordance with the fuel injection request signal, from the INj1+ and INj4+ terminal to the INj1- and INj4- terminals (injectors #1 and #4).
- In accordance with a signal received from the waveform shaping circuit, the driver circuit grounds the INj1- terminal in a timely manner, in order to control the fuel injection volume and injection timing of injector #1.

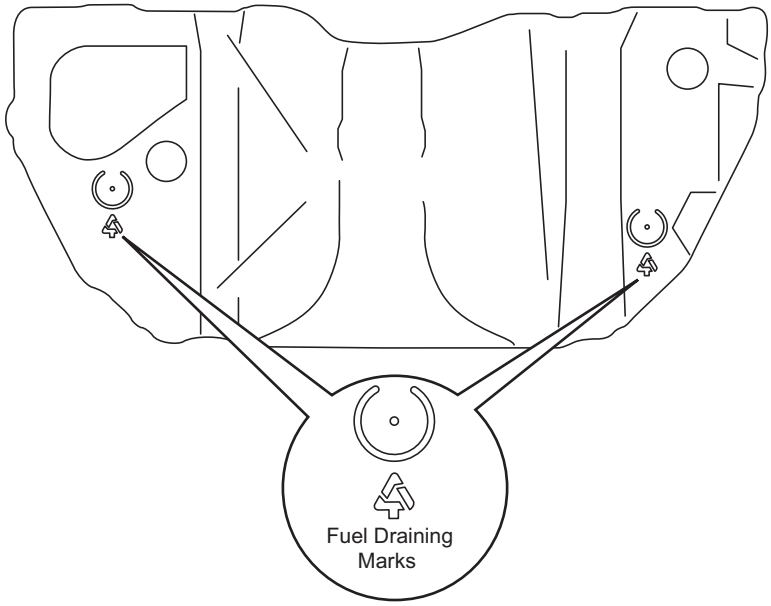
Circuit Diagram 2



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Fuel Tank

- The fuel tank is mounted in the center of the vehicle, forward of the rear axle. It has a capacity of 71.0 liters.
- The fuel tank adopts a saddle shape to allow the propeller shaft to pass through its center portion.
- Two sender gauges (main, sub), fuel pump, fuel filter, pressure regulator, and jet pump have been integrated.
- Fuel draining marks have been provided on the bottom of the fuel tank. These marks clearly indicate the position for aligning the fuel draining device during dismantling, and simplify and ensure the reliable draining of fuel.

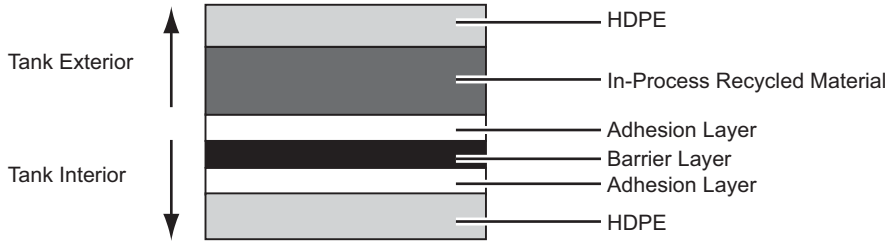


Fuel Tank Bottom View

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Plastic Fuel Tank

• A fuel tank made of plastic is used for weight reduction. It consists of six layers of plastic to ensure the long life of the tank and the low permeation of fuel.



*HDPE(High Density Polyethylene):High Density Polyethylene It is lightweight, high strength,and excels in water and solvent resistance.

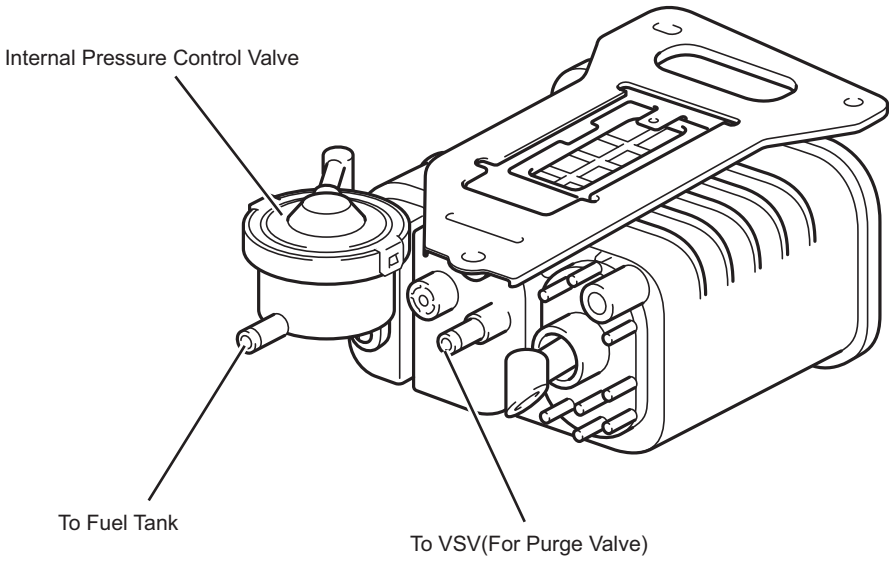
Layer Composition of Fuel Tank

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EG

Charcoal Canister

- Canister purge control is used to draw the fuel evaporative gas created in the fuel tank into the intake port, to be burned during combustion.
- The charcoal canister is mounted behind the fuel tank.
- An internal pressure control valve is provided at the fuel passage inlet from the fuel tank in order to maintain the proper pressure in the fuel tank.

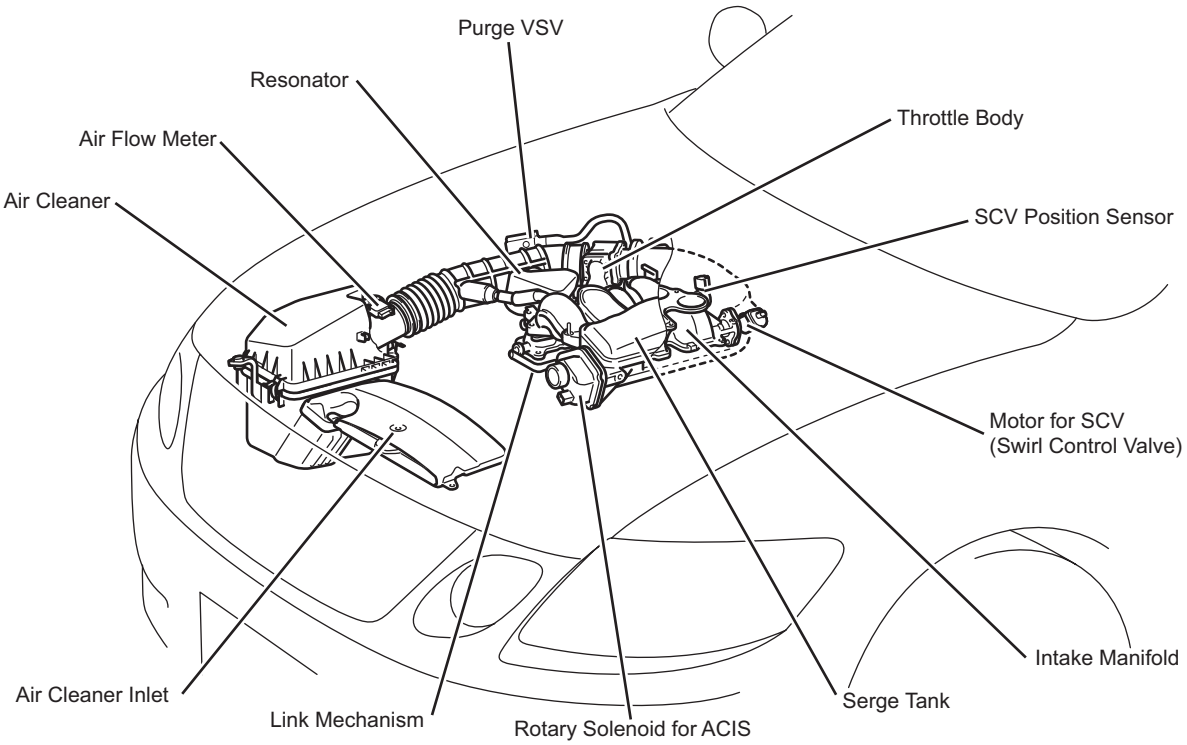


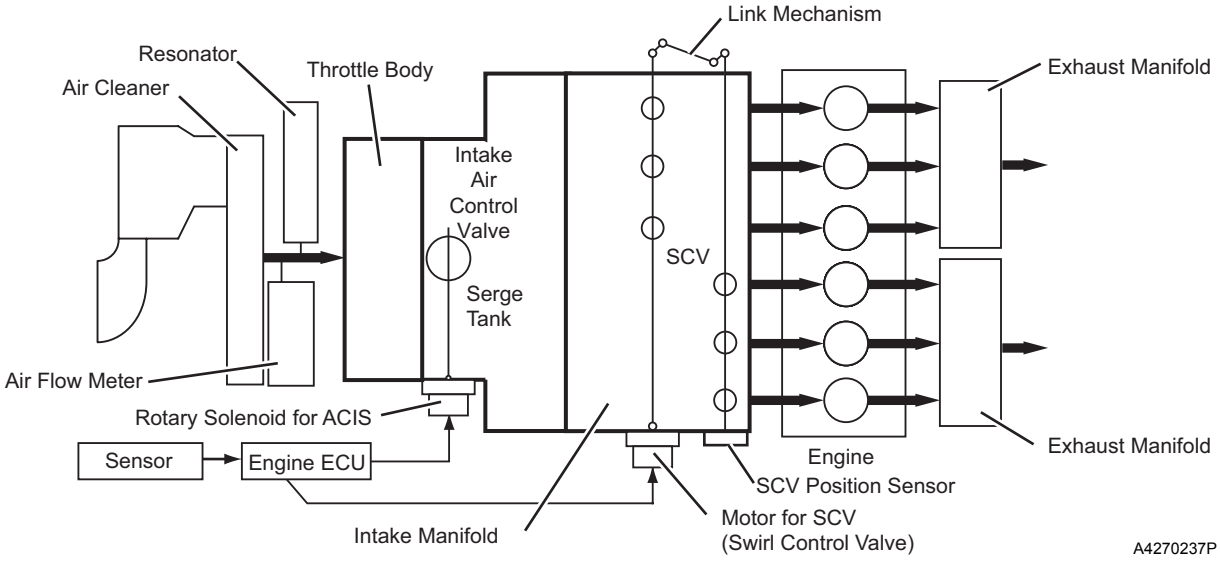
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3GR-FSE INTAKE

General

- A surge tank with a built-in ACIS (Acoustic Control Induction System) and an intake manifold with a built-in SCV (Swirl Control Valve) are used.
- A hot-wire type airflow meter (with a built-in intake air temperature sensor) is provided in the air cleaner cap.
- The ETCS-i system is used and a single-valve, electronically controlled throttle body is installed.

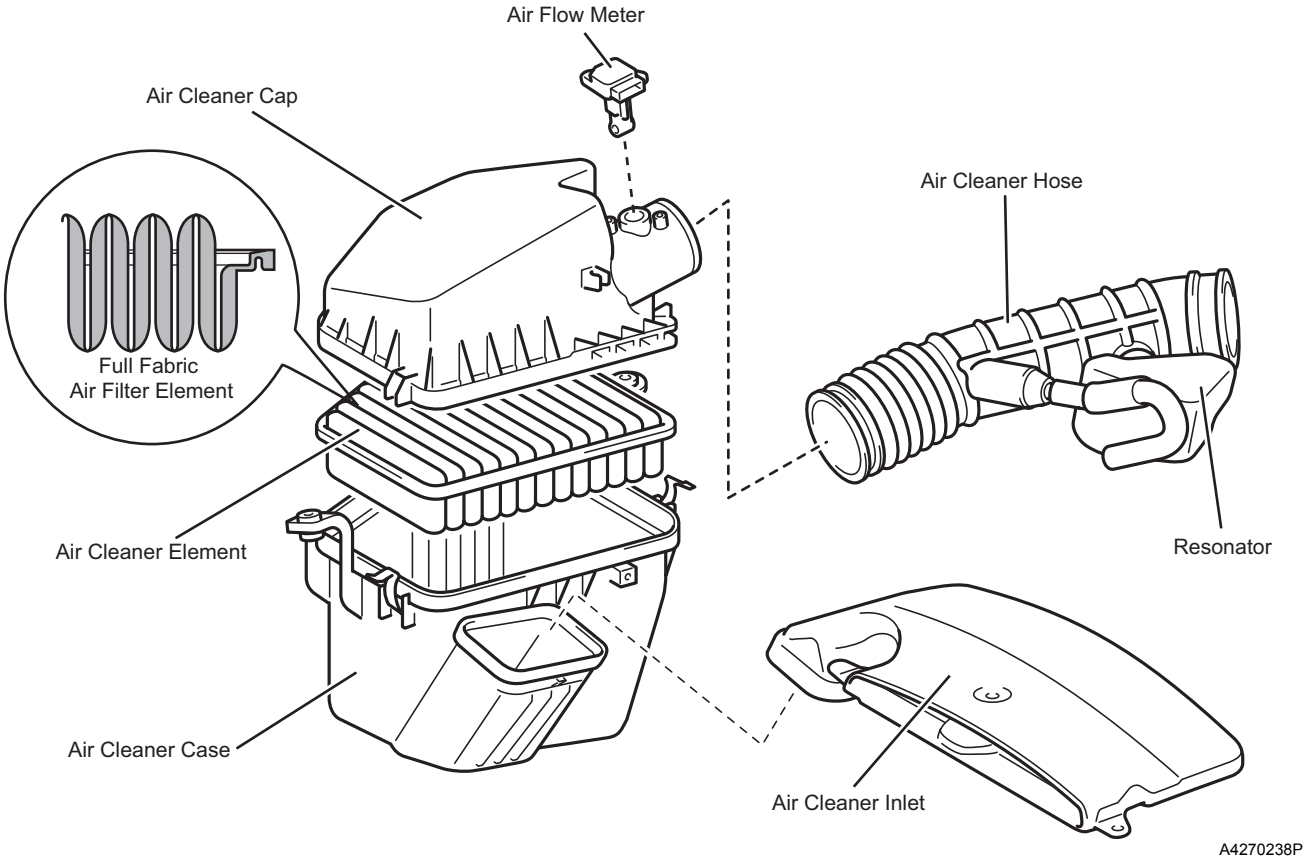




EG

Air Cleaner

- A removable cap type air cleaner case is used for enhanced serviceability. Also, an airflow meter (with a built-in intake air temperature sensor) is provided in the air cleaner cap.
- A dry type air cleaner element is used and provided with an ample filtering surface area.
- A compact resonator is provided in the air cleaner hose to reduce intake noise.
- A full fabric air filter element, which does not contain an outer frame or rubber seal, is used. As a result, the case could be made compact, with recyclability in mind.



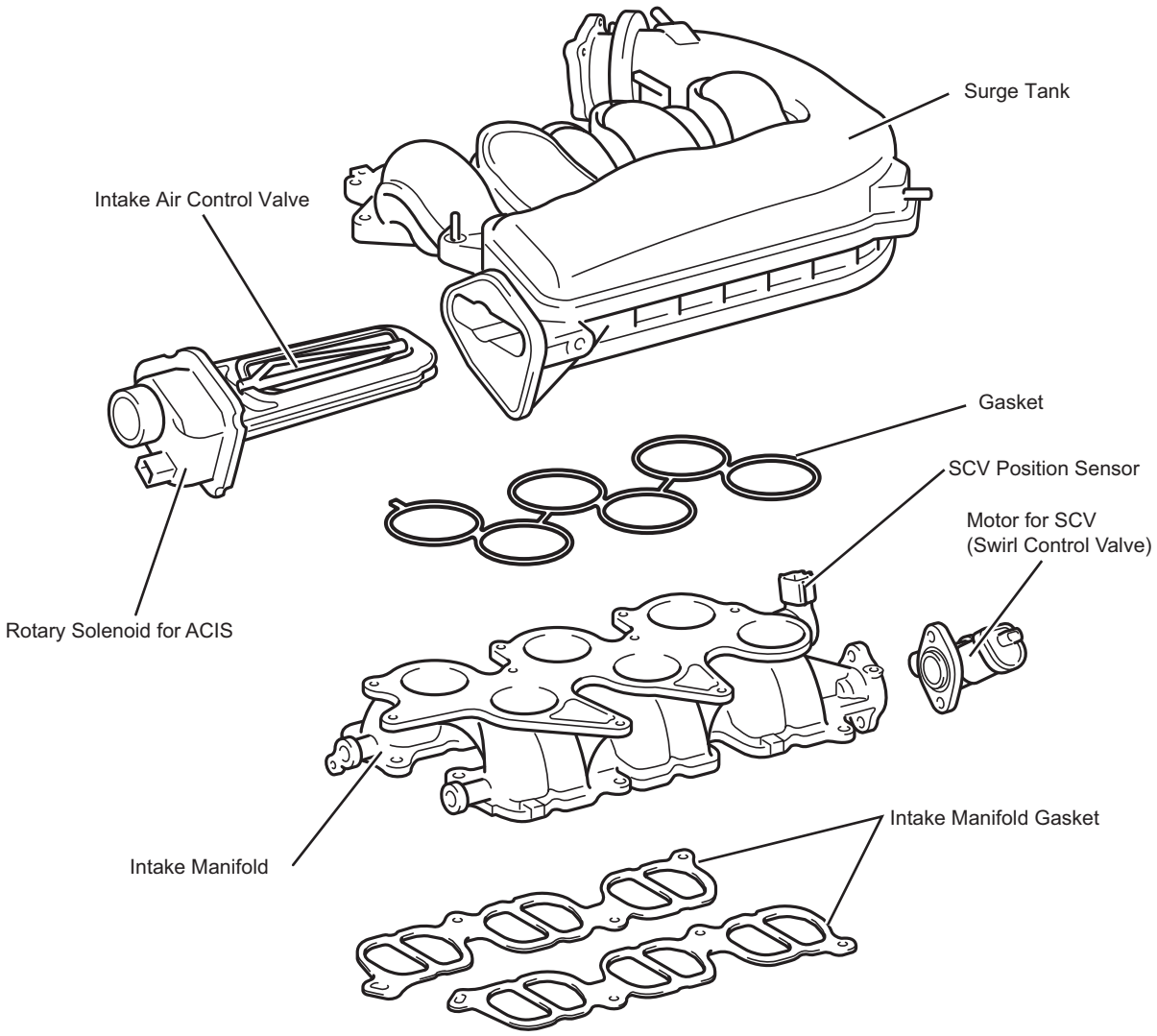
Air Flow Meter

- This 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 has been improved and the intake air resistance has been reduced.
- This air flow meter has a built-in intake air temperature sensor.
- This system measures the air flow in the bypass, which is less likely to be affected by the intake pulsations created by the air cleaner. Also, the flow path is constructed to minimize flow resistance, thus reducing flow loss. Therefore, this system can measure small to large airflow in a precise manner.

(See page EG-125)

Intake Manifold

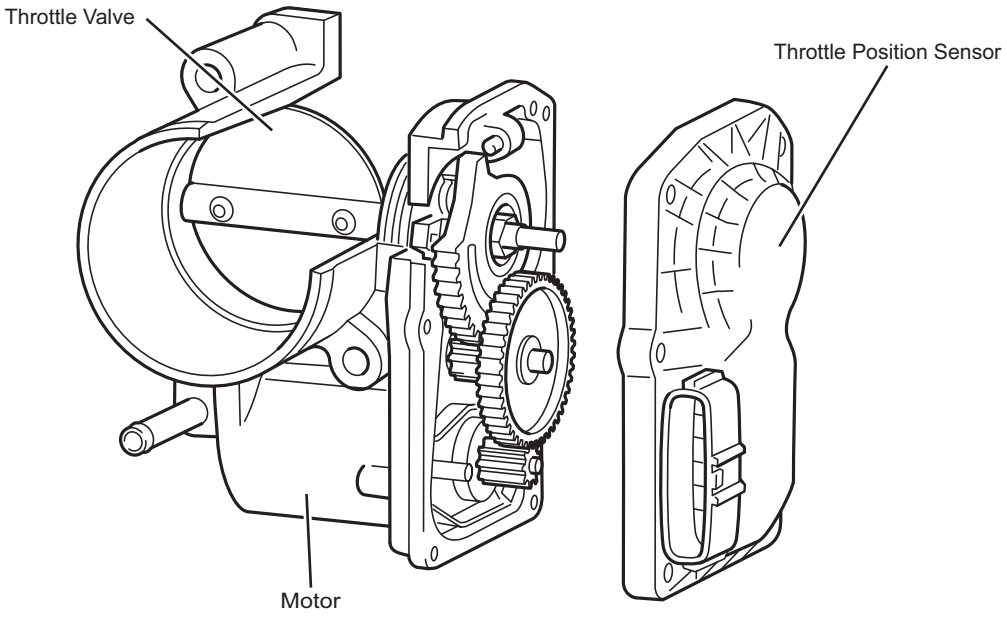
- An ACIS (Acoustic Control Induction System) with independent ports and an intake system with a swirl control valve (SCV) are used. The port diameter and length have been optimized to strike a balance between high torque in all driving ranges and fuel economy performance.
- A swirl control valve (SCV) is provided in the intake manifold to stabilize combustion while the water temperature is low, and open-close control is effected to achieve a higher torque at low engine speeds.
- A plastic surge tank is used for weight reduction. Also, an ACIS (Acoustic Control Induction System) is used, and the intake manifold length has been made variable to increase the torque in all ranges.



EG

Throttle Body

- The adoption of the ETCS-i has realized excellent throttle control.
- The accelerator pedal position sensor is attached to the accelerator pedal.
- A link-less type throttle body has been adopted.
- The accelerator position sensor, which is provided on the accelerator pedal, transmits the operation by the driver (amount of pedal effort on the accelerator) to the engine ECU. The engine ECU determines the throttle position that suits the driving conditions and actuates the throttle motor. Then, the throttle position sensor gives feedback regarding the throttle valve position to the engine ECU.
- A motor with excellent response and minimal power consumption is used for the throttle control motor. The engine ECU performs the duty ratio control of the direction and the amperage of the current that flows to the throttle control motor in order to regulate the opening angle of the throttle valve.
- Both the accelerator position sensor and the throttle position sensor consist of two internal circuits (main, sub), in order to constantly monitor the system for malfunctions.
- If a malfunction is detected, the system illuminates a warning light in the combination meter to alert the driver, and cuts the current to the motor. The throttle valve return spring returns the throttle valve to a predetermined position. Thus, by cutting the fuel injection off and retarding the ignition timing, the system regulates the engine power output in accordance with the accelerator position to enable the vehicle to continue driving.



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Accelerator Pedal Position sensor

- This sensor, which is mounted on the accelerator pedal, detects the amount of pedal effort applied to the accelerator. By using a Hall element, this electronic position sensor enables accurate control and ensures permanent reliability. When the amount of pedal effort applied to the accelerator changes, this sensor sends the angle of the magnetic field in relation to the flow of the applied current in the Hall element (VCP1 → EP1, VCP2 → EP2) in the form of an accelerator pedal effort signal to the engine ECU. In addition, this sensor consists of a dual system having different output characteristics to ensure reliability.
  (See page EG-121)

Throttle Position Sensor

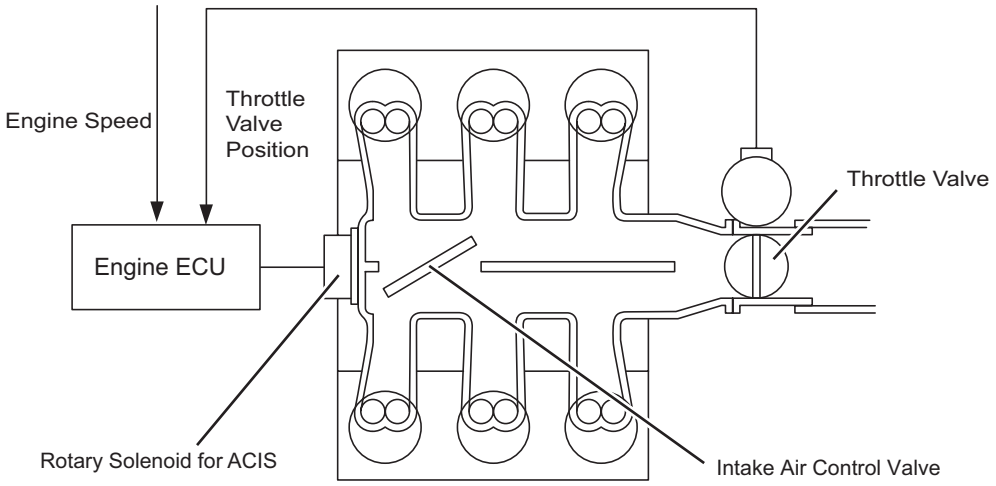
- This sensor, which is located in the throttle body, detects the position of the throttle valve. By using a Hall element, in the same way as the accelerator position sensor, this electronic position sensor enables accurate control and ensures permanent reliability. In addition, this sensor consists of a dual system having different output characteristics to ensure reliability.
  (See page EG-123)

ETCS-i (Electronic Throttle Control System-intelligent)

- In the conventional throttle body, the throttle valve opening is determined invariably by the amount of the accelerator pedal effort. In contrast, the ETCS-i uses the engine ECU to calculate the optimal throttle valve opening that is appropriate for the respective driving condition and uses a throttle control motor to control the opening.
- The functions of the ordinary throttle position control (nonlinear control), idle speed control (ISC), traction control (including VSC), and cruise control have been integrated in the single-valve electronically controlled throttle body.
- Excellent driving stability and comfort have been achieved by effecting integrated control with the power train, and vehicle stability has been ensured through cooperative control with the ECT and VSC systems.
- Two CPUs, one for the ETCS-i, and the other for the EFI control, monitor each other to ensure a reliable system.
- A dual system is used so that the vehicle can continue to operate in the event of a problem, thus ensuring reliability.
  (See page EG-112)

Electronic ACIS (Acoustic Control Induction System)

- Pressure fluctuations are indirectly created in the intake manifold by the intake stroke. The influence exerted on the subsequent intake stroke by the pressure fluctuations remaining in the intake manifold, even after the intake valve has closed, is called a pulsation effect. When the pressure fluctuations that remain after the intake valve has closed coincides with the subsequent intake stroke, the pressure increases at the time the valve opens, the intake air volume increases, and the torque increases.
- To proactively utilize this pulsation effect, the Acoustic Control Induction System changes the effective intake manifold length in accordance with the cycle of the pulsation flow that changes with the engine speed, in order to increase the torque in all ranges.



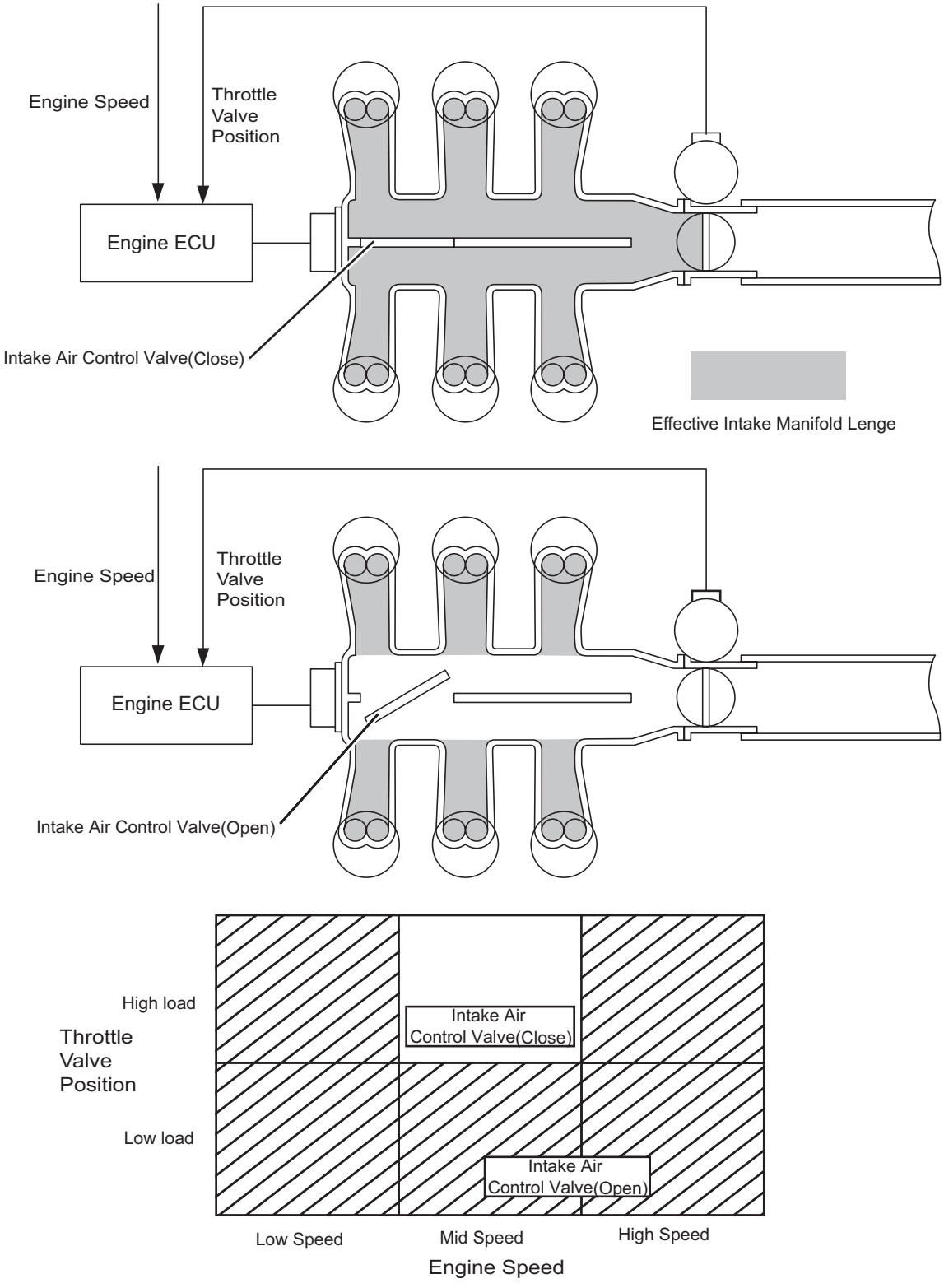
List of Functions

Device Name	Function
Crankshaft Position Sensor	Detects engine speed.
Throttle Position Sensor	Detects throttle valve position.
Intake Air Control Valve	Opens and closes the valve to switch the effective intake manifold length in two stages.
Rotary Solenoid for ACIS	Opens and closes the intake Air control valve under the command of the engine ECU.
Engine ECU	Sends a signal to the ACIS rotary solenoid at an appropriate timing in accordance with the signals received from the sensors.

EG

Electronic ACIS Operation

- The engine ECU opens and closes the intake air control valve in accordance with the engine speed and the throttle valve position, in order to enhance the torque in all ranges, particularly in the medium-speed range.

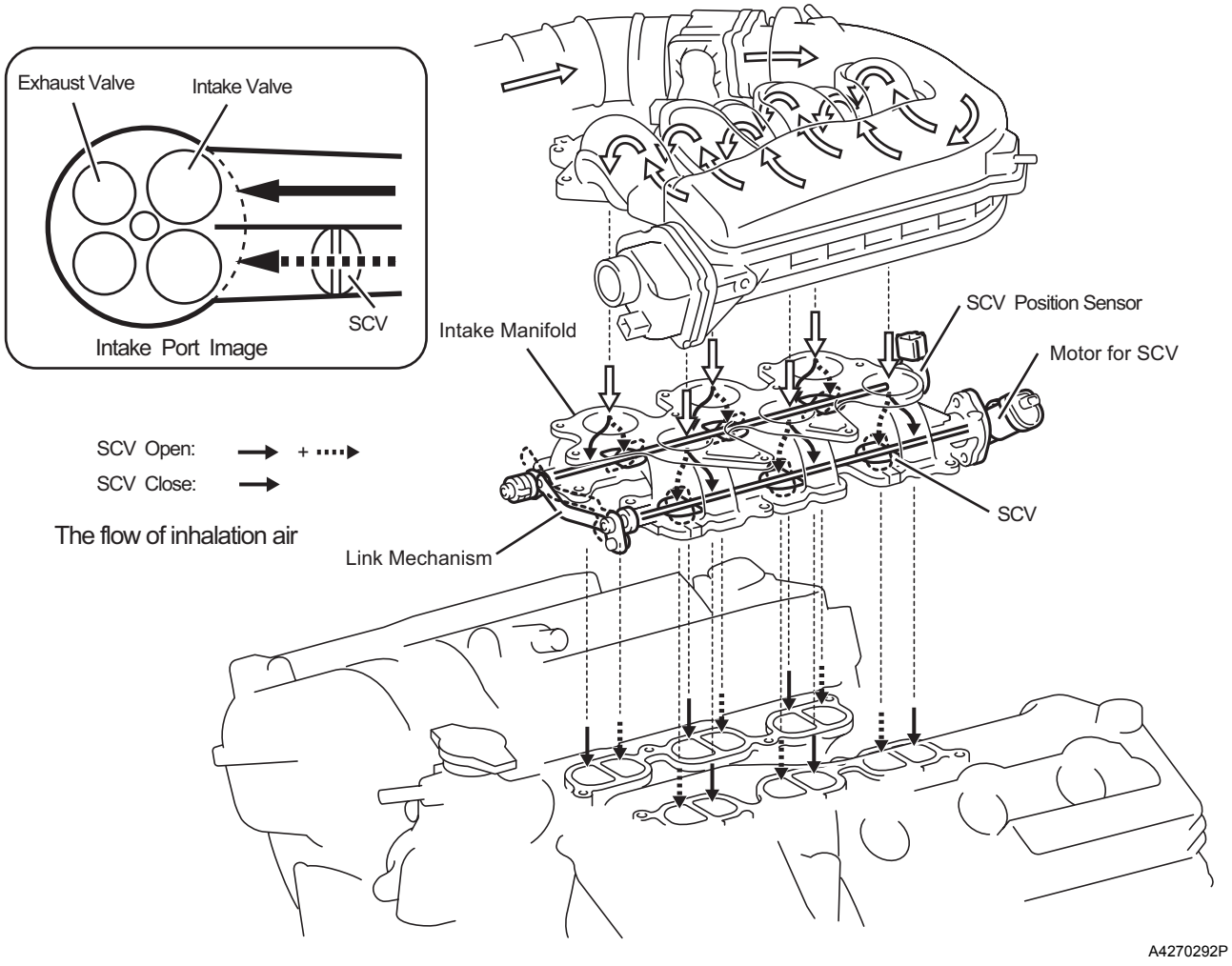


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EG

Electronic SCV (Swirl Control Valve)

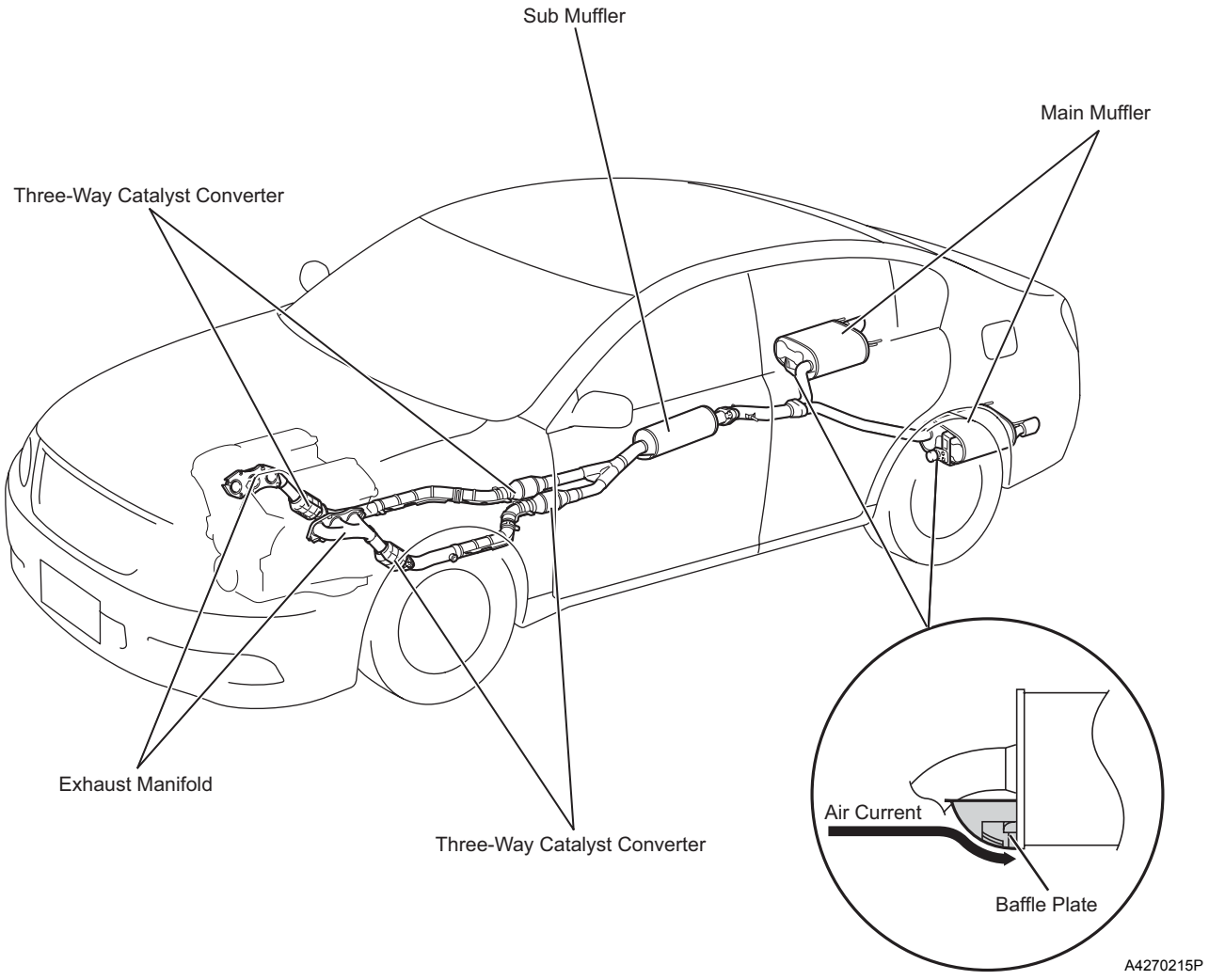
- The SCVs on the right and left banks are connected with a linkage mechanism, enabling both SCVs to be actuated with a single, compact motor, thus realizing a lightweight and compact construction.
- An SCV, which is provided at one of the two independent intake ports, opens and closes under the control signals received from the engine ECU.
- Closing one of the ports accelerates the speed of the intake air that flows through the other port, and strengthens the lateral turbulence in the combustion chamber. This results in promoting the atomization of fuel when the water temperature is low, thus stabilizing combustion. In addition, this improves combustion efficiency in the low-speed, light load range, resulting in improved fuel economy.
- Based on the engine speed, water temperature, and load signals, the engine ECU actuates the motor of the SCV in order to open and close the valve.



3GR-FSE EXHAUST

General

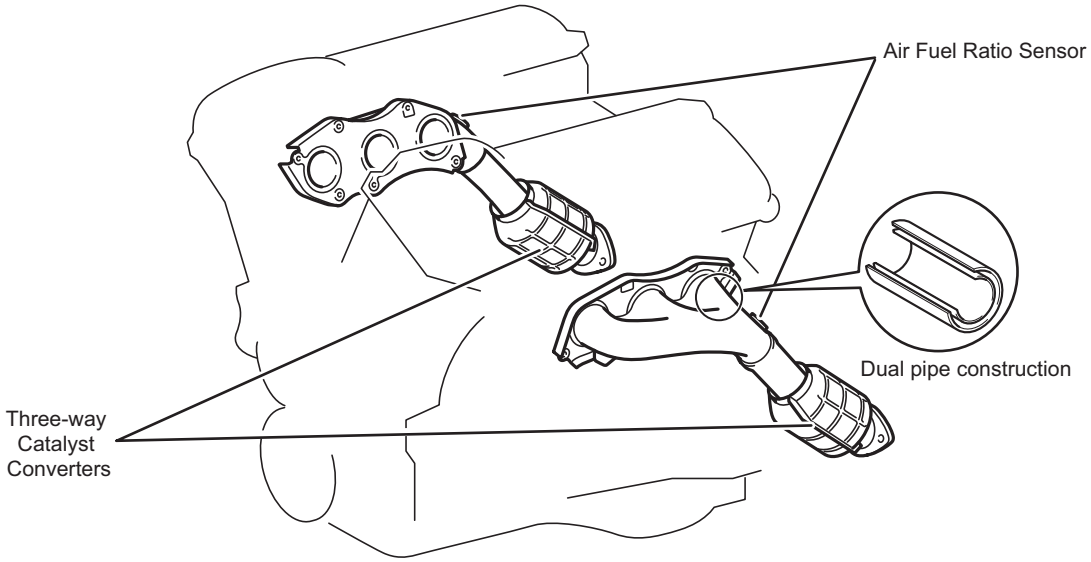
- The entire exhaust system from the exhaust manifold to the tail pipe is made of stainless steel to realize weight reduction and improve corrosion resistance.
- Three-way catalysts are placed directly below the exhaust manifold and in the front pipes to ensure ample emission reduction performance, in order to comply with the Step IV European Tailpipe Emission Regulations.
- An exhaust manifold with a built-in Three-way catalyst Converter is placed directly below each bank of the engine to ensure low exhaust emissions immediately after the engine is started.
- The exhaust pipe diameter has been optimized to reduce exhaust loss and optimize engine power output.
- A baffle plate is provided in front of the main muffler to straighten the airflow under the floor, thus improving dynamic performance.
- An air-fuel ratio sensor is provided upstream of the Three-way catalyst Converter in each exhaust manifold. An heated oxygen sensor is provided downstream of the Three-way catalyst Converter in each exhaust manifold. These sensors enable precise control of the air-fuel ratio.



EG

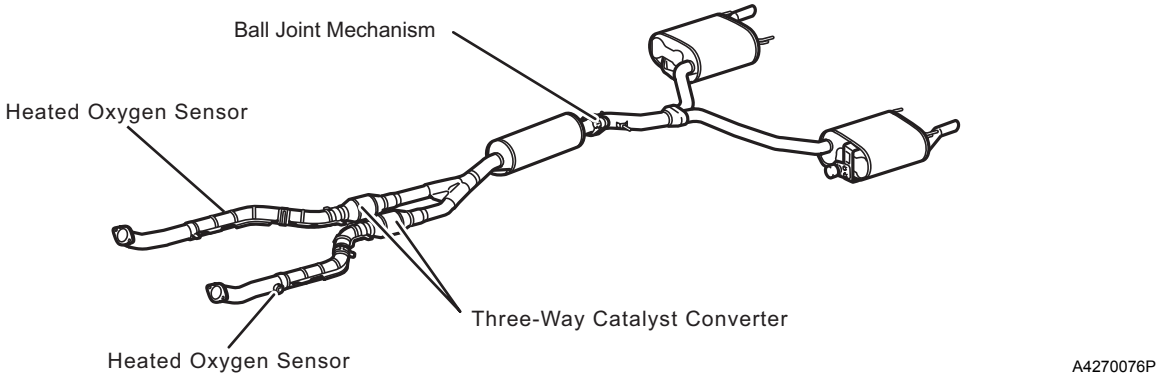
Exhaust Manifold

- The exhaust manifolds are made of dual pipe construction stainless steel to reduce noise and enhance heat resistance. Also, they accelerate the warm-up of the catalysts immediately after the engine is started, thus reducing exhaust emissions.
- Built into each exhaust manifold, the three-way catalyst converter consists of an ultra thin-wall, high-cell density ceramic catalyst in which precious metals are optimally used. It accelerates the warm-up of the catalytic converter, thus improving exhaust emission performance immediately after the engine is started.
- The flow of the exhaust gases has been optimized and the exhaust gas pressure loss has been reduced to produce a higher power output.



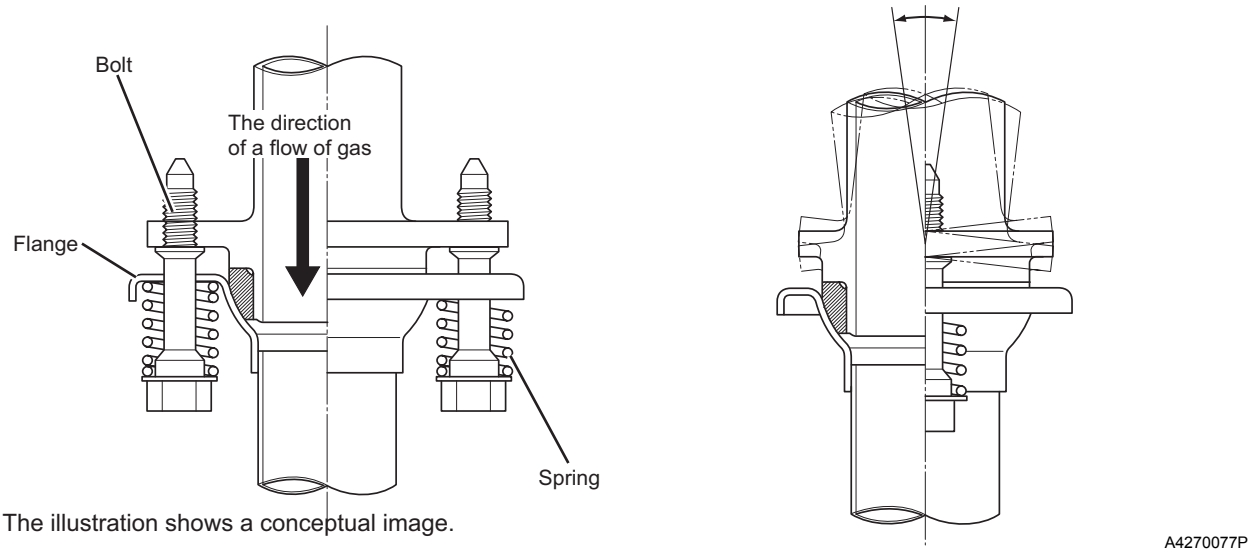
Exhaust Pipe

- Long, dual construction exhaust pipes are used from the exhaust manifolds to the front pipe junction. By optimizing the lengths of the exhaust pipes and utilizing the fluctuation of the exhaust pressure, exhaust gases are discharged effectively to improve the torque in the low- to medium-speed range.
- Ball joint mechanism is used to join the front pipe to the tail pipe in order to reduce the droning sound and vibration in the cabin and reduce weight. The ball joint mechanism consists of a spherical flange, and a bolt and a spring to support the sealing area of the gasket. The ball joint (the spherical areas of the flange and the gasket) absorbs the vibration of the engine as well as the vibration of the exhaust pipe in order to reduce the droning sound and vibration in the cabin.



Ball Joint Mechanism

- The ball joint mechanism consists of a spherical flange, a bolt, and a spring to support the sealing area of the gasket. This is more compact than a flexible pipe, and can be installed in an optimal position to counter vibrations.
- The ball joint (the spherical areas of the flange and the gasket) absorbs the vibration of the engine as well as the vibration of the exhaust pipe in order to reduce the droning sound and vibration in the cabin.

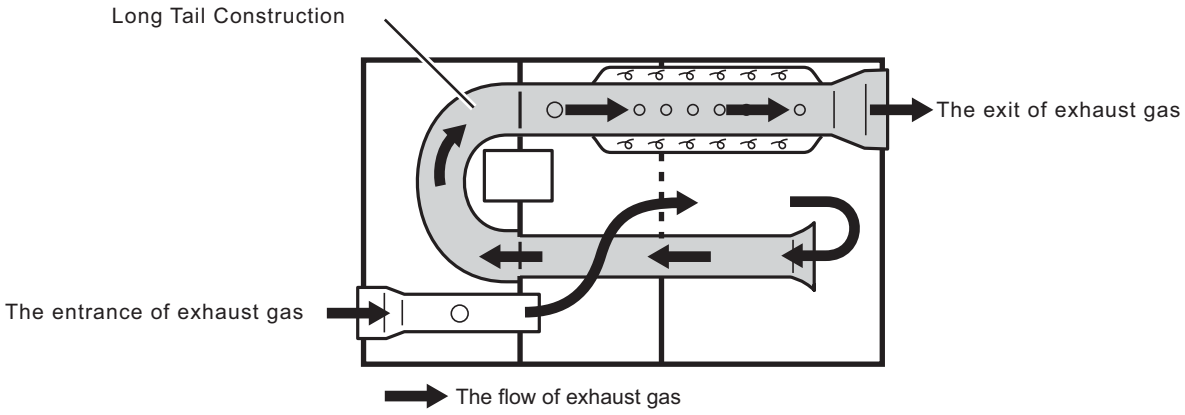


* The illustration shows a conceptual image.

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Muffler

- Dual main mufflers are provided to reduce back pressure, which improves the power output of the engine. A long tail construction is used inside the main muffler to suppress the low-frequency exhaust sounds, thus reducing the sounds in the cabin.



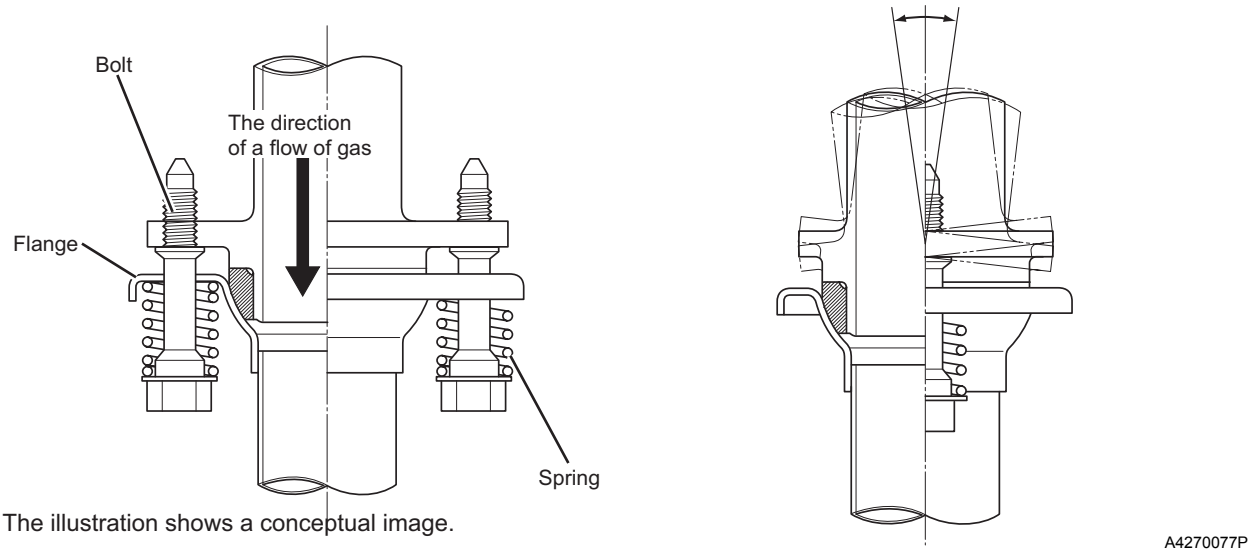
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Three Way Catalytic Converter

- An ultra thin-wall, high cell density ceramic catalyst with an optimized amount of precious metals held is placed directly below each exhaust manifold and in each front pipe. These catalysts ensure a high level of warm-up performance immediately after the engine is started, thus reducing exhaust emissions and complying with the Step-IV European Tailpipe Emission Regulations.

Ball Joint Mechanism

- The ball joint mechanism consists of a spherical flange, a bolt, and a spring to support the sealing area of the gasket. This is more compact than a flexible pipe, and can be installed in an optimal position to counter vibrations.
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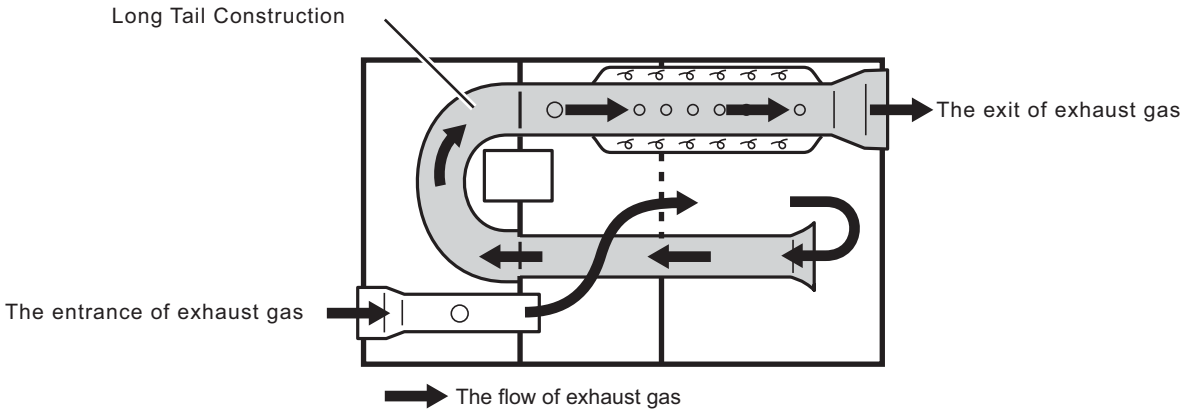


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Three Way Catalytic Converter

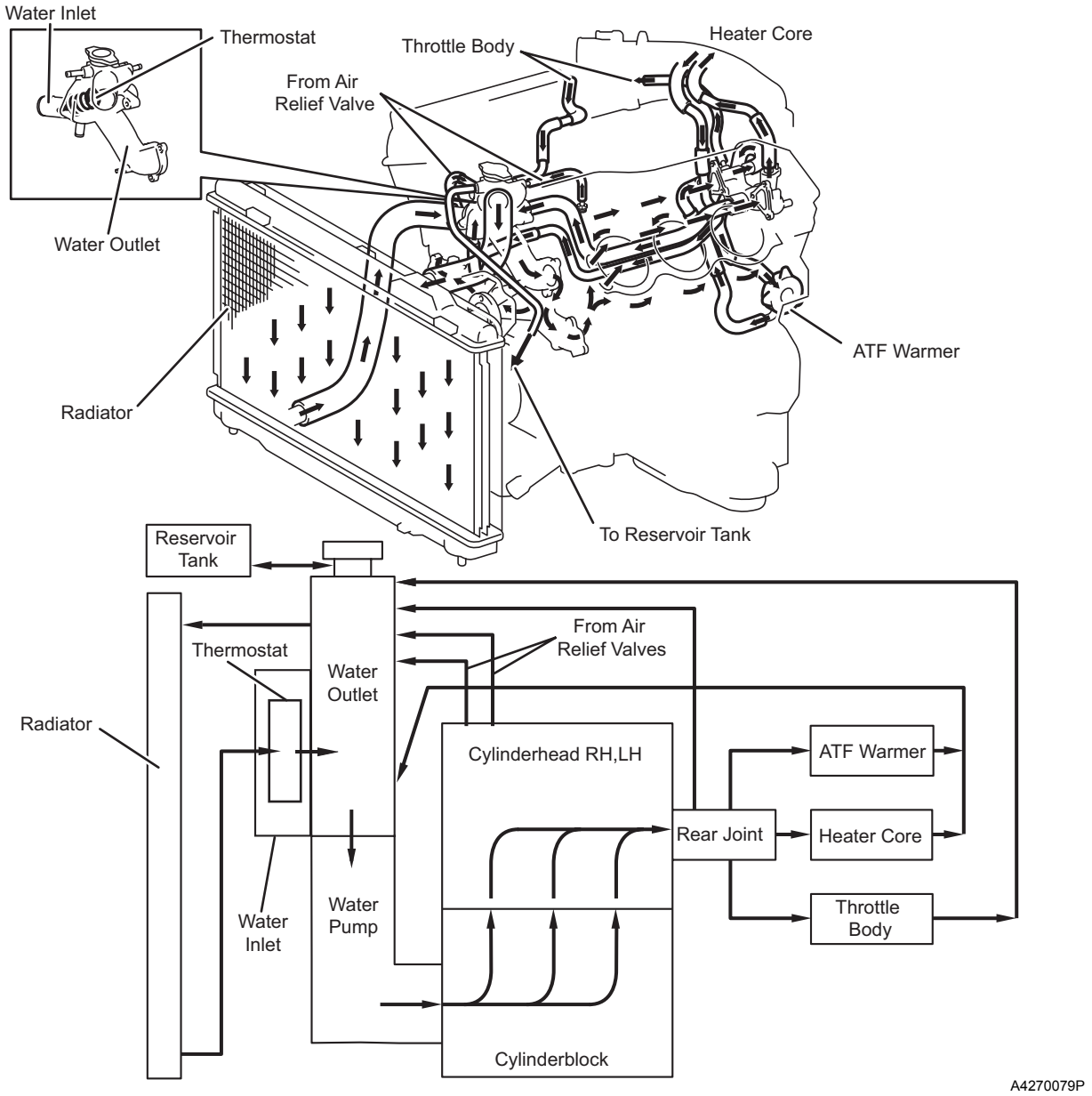
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3GR-FSE COOLING

EG

General

- The cooling system is a water-cooled, forced-pressure circulation type in which a bypass valve type thermostat is integrated in the water inlet housing. The thermostat is the bottom bypass type.
- In this system, the engine ECU turns the cooling fan ON-OFF and controls the fan speed.
- To reduce the formation of air pockets in the cylinder head, air relief valves are provided in the right and left cylinder heads.
- An ATF warmer is provided to accelerate the warm-up speed, thus reducing the friction of the automatic transmission.



Radiator

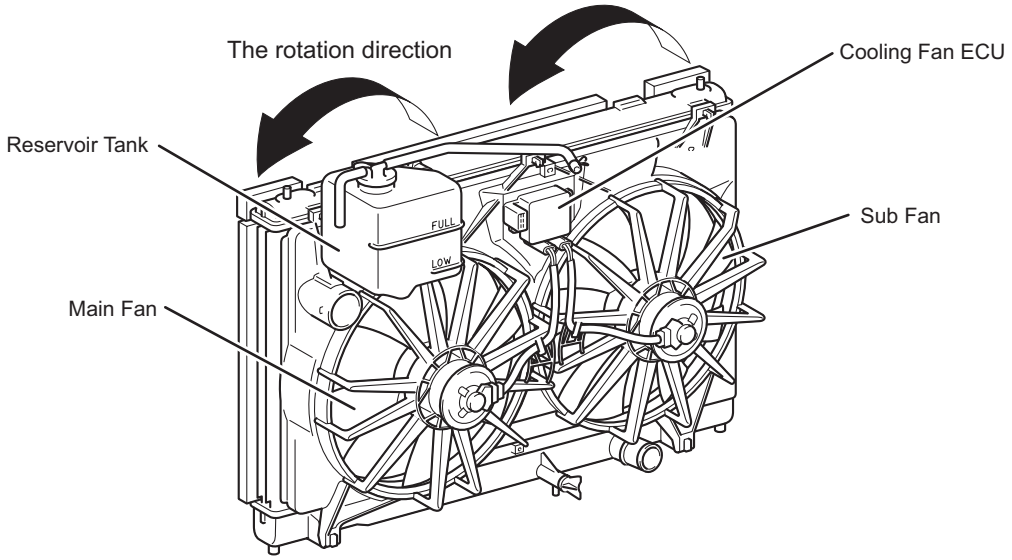
- A lightweight, high-performance aluminum core radiator is used to improve cooling performance and reduce weight.

Radiator

Core Type	Corrugated Fin
Fin Pitch [mm (in.)]	2.5 (0.098)/2
Core Dimensions (width x height x thickness) [mm (in.)]	709.0 × 399.2 × 16 (27.913 × 15.717 × 0.630)
Dry Weight [kg]	2.55

Cooling Fan

- The fan shroud is secured to the radiator without bolts.
- Ring fans, which are provided with band-shaped rings around them are used, which enhance rigidity and realize a lightweight and compact construction.
- The engine ECU outputs a signal to the cooling fan ECU, which steplessly controls the speed of the two fans in accordance with the engine conditions, driving conditions, and whether the air conditioner is operating. Through optimally controlled speeds, the fans operate significantly quieter and improve cooling performance.



Cooling fan

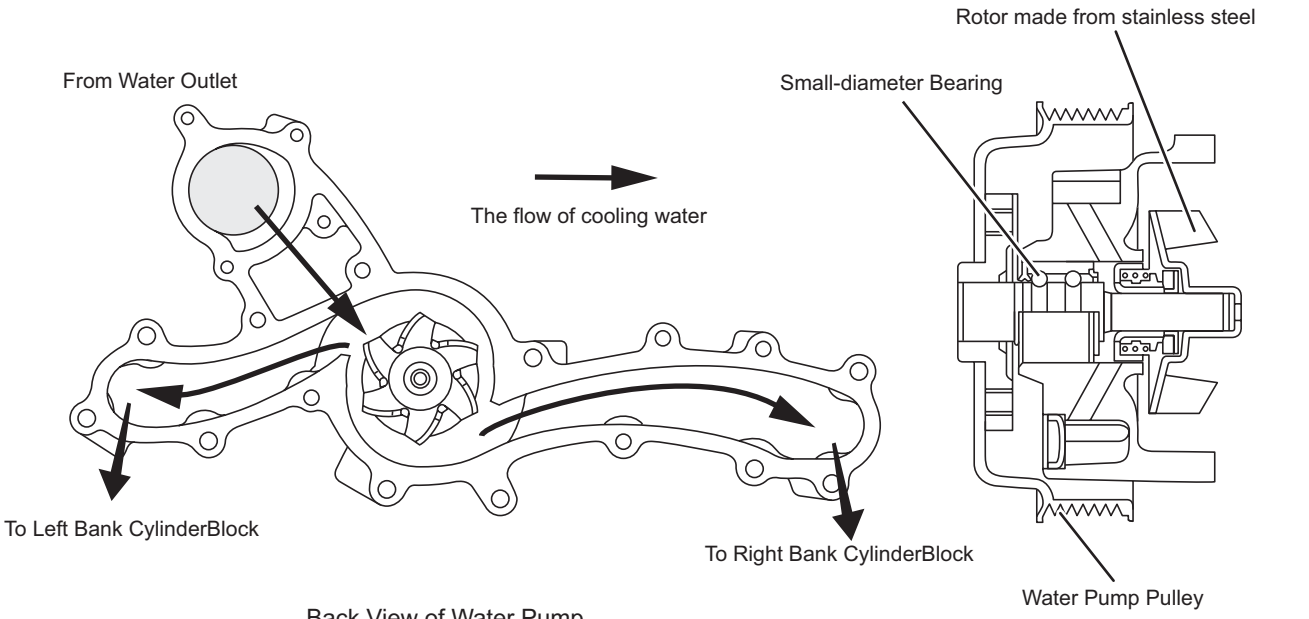
	Main Fan	Sub Fan
Outer Diameter [mm (in.)]	340 (13.386)	←
Number of blades	5	7

Cooling fan

	Main Fan Motor	Sub Fan Motor
Rated voltage [V]	12	←
Rated Output [W]	100	←

Water Pump

- The water pump uses a V ribbed belt driven system.
- It uses a small-diameter bearing to achieve a compact construction.
- The rotor is made of stainless steel to improve corrosion resistance and ensure reliability.



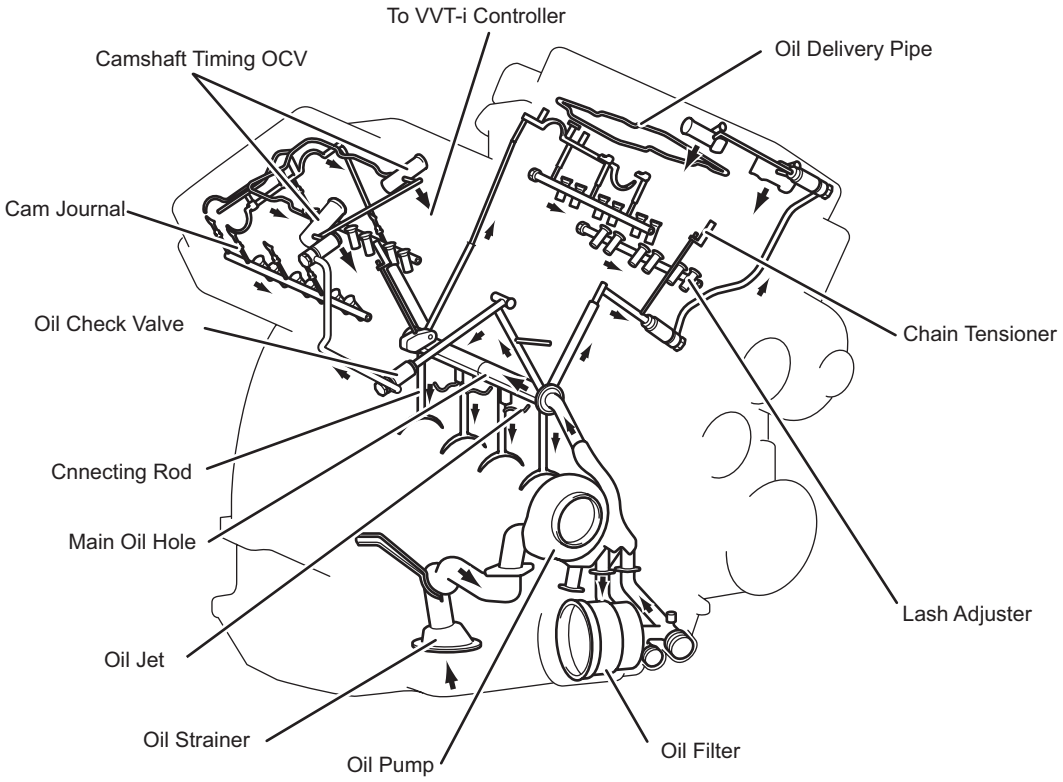
Water Pump

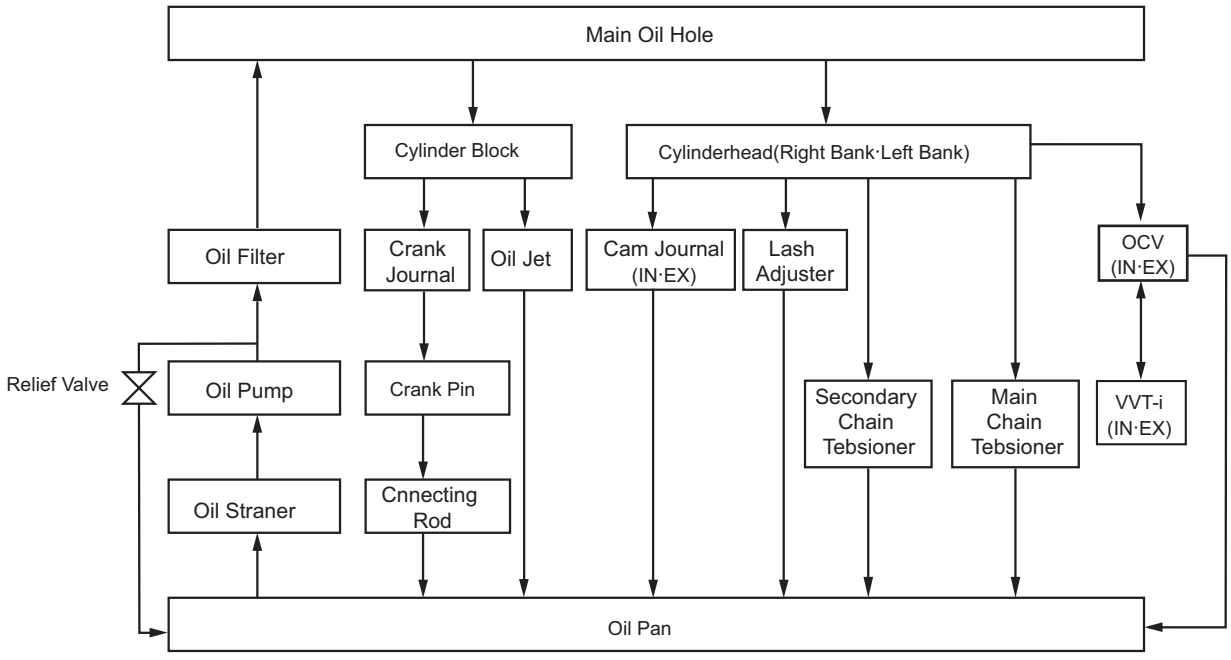
Drive System	V Ribbed Belt Driven
Rotor Diameter [mm (in.)]	60.0 (2.362)
Bearing Diameter [mm (in.)]	30.0 (1.181)
Number of Blades	6
Discharge Performance [L/min] (at 80 ± 2°C, 4,000 rpm)	46

3GR-FSE LUBRICATION

General

- A full-pumping, full-filtering lubrication system is used.



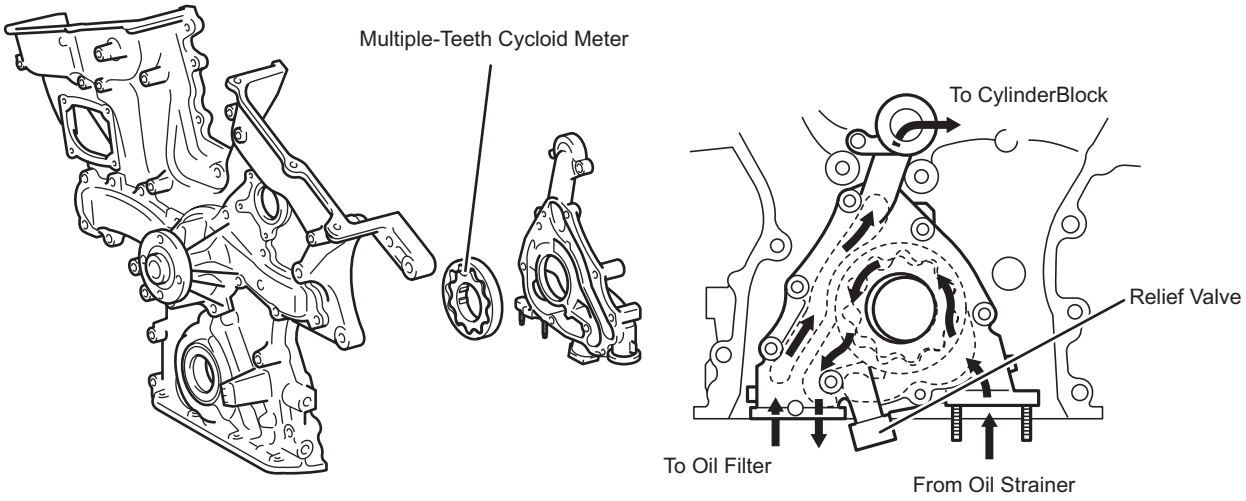


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EG

Oil Pump

- The oil pump consists of a compact, highly efficient, and multiple-teeth cycloid rotor that is driven directly by the crankshaft. The drive rotor is a flangeless type, which enables the use of a driven rotor with a small diameter, thus reducing friction.
- An internal oil relief system is used to circulate the relief oil through the suction passage in the oil pump. This suppresses the oil level fluctuations in the oil pan, reduces friction, and reduces the rate of mixing air bubbles in the oil.



The oil passage in an oil pump

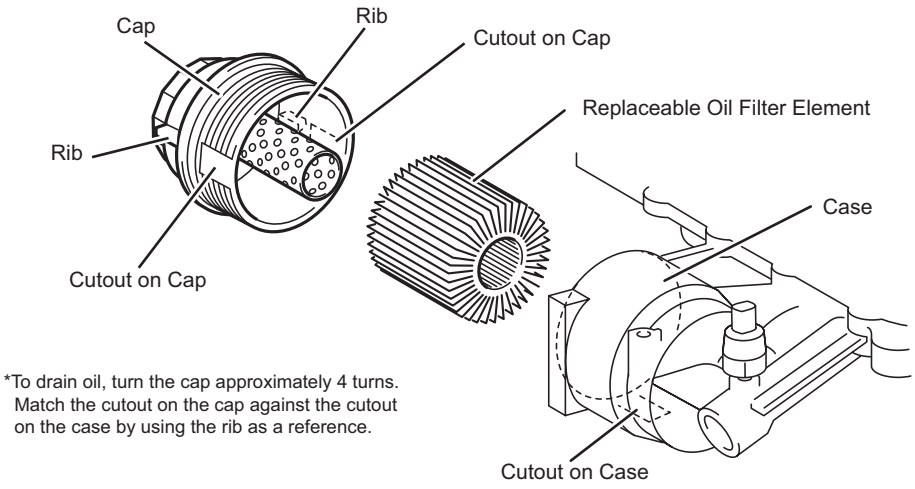
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Oil Pump

Pump Speed [rpm]	600	2000	6400
Discharge Volume [L/min]	6.0 Minimum	—	89.6 Minimum
Discharge Pressure [kPa]	100	—	290
Relief Valve Opening Pressure [kPa]	—	490	—

Oil Filter

- A newly developed oil filter with a replaceable element is used. The element uses high-performance filter paper that ensures ample filtering performance, and is made completely burnable.
- The cap is made of an aluminum alloy for a long life.
- A drain construction is provided to suppress the splashing of the oil during the replacement of the oil filter element. Oil can be drained by matching the thread cutout on the cap against the thread cutout on the case.



Drain construction

A4270222P

■ **Service Tip** ■

To replace the oil filter, turn the cap approximately 4 turns, match the cutout on the cap against the cutout on the case, and drain the oil. Use the rib on the cap as a reference for matching the cutout on the cap against the cutout on the case. For details, refer to the GS430/300 Repair Manual(Pub. No. RM1168E)

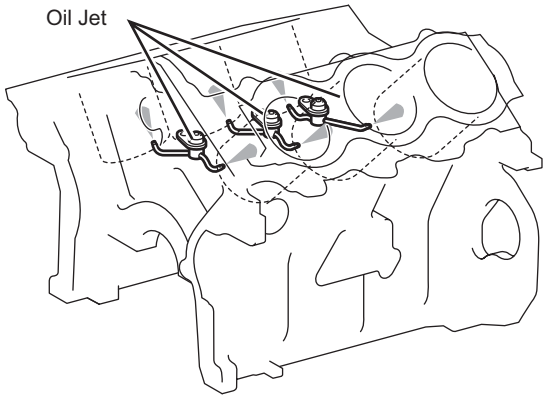
Oil Filter

Type	Full-flow
Filtration area [cm^2]	1260
Outer diameter×Height [mm (in.)]	82.1 × 70.5 (3.232 × 2.776)
Relief Valve Opening Pressure [kPa]	100

EG

Oil Jet

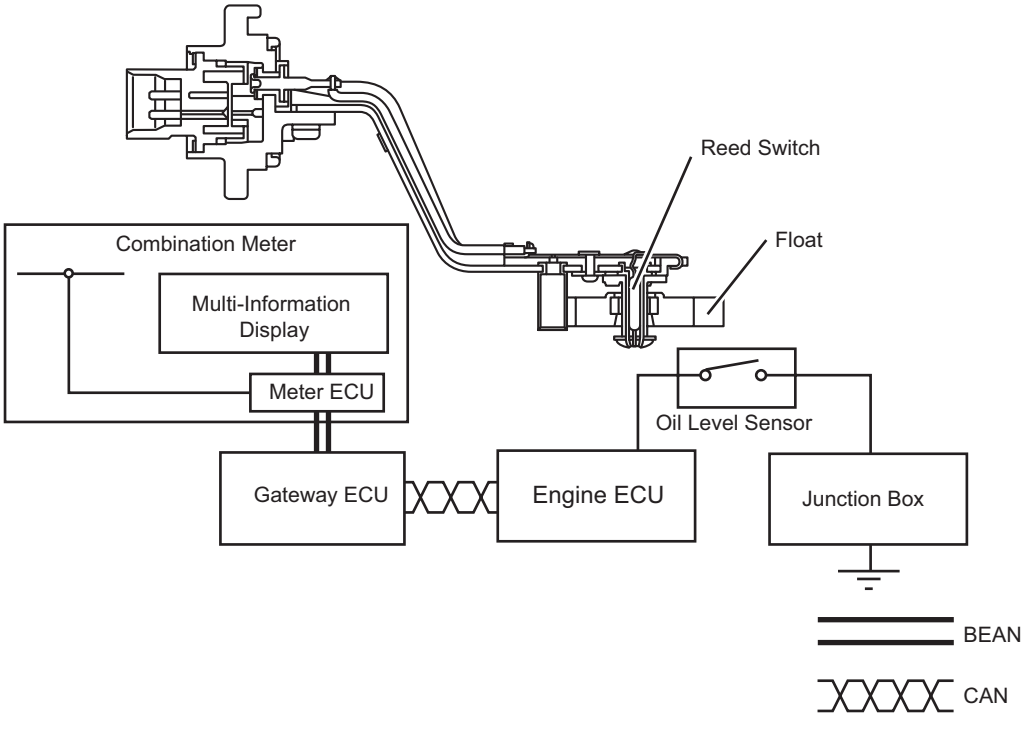
- Oil jets are provided in the cylinder block. These jets spray oil into the cylinders to reduce friction and suppress the increase in temperature. As a result, they improve the durability of the pistons and prevent them from knocking.



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Oil Level Sensor

- The oil level sensor consists of a reed switch, which turns ON and OFF with the vertical movement of the float. When the engine oil level decreases, the system informs the driver of it in the following manner. On the multi-information display in the combination meter, a warning appears on the multi-information display. In addition, the system is provided with a 40-second delay circuit to prevent the display from indicating improperly as a result of biased behavior of the oil while the vehicle is in motion.
- A warning appears when the float descends as a result of a reduction in the engine oil level (when the reed switch is OFF).



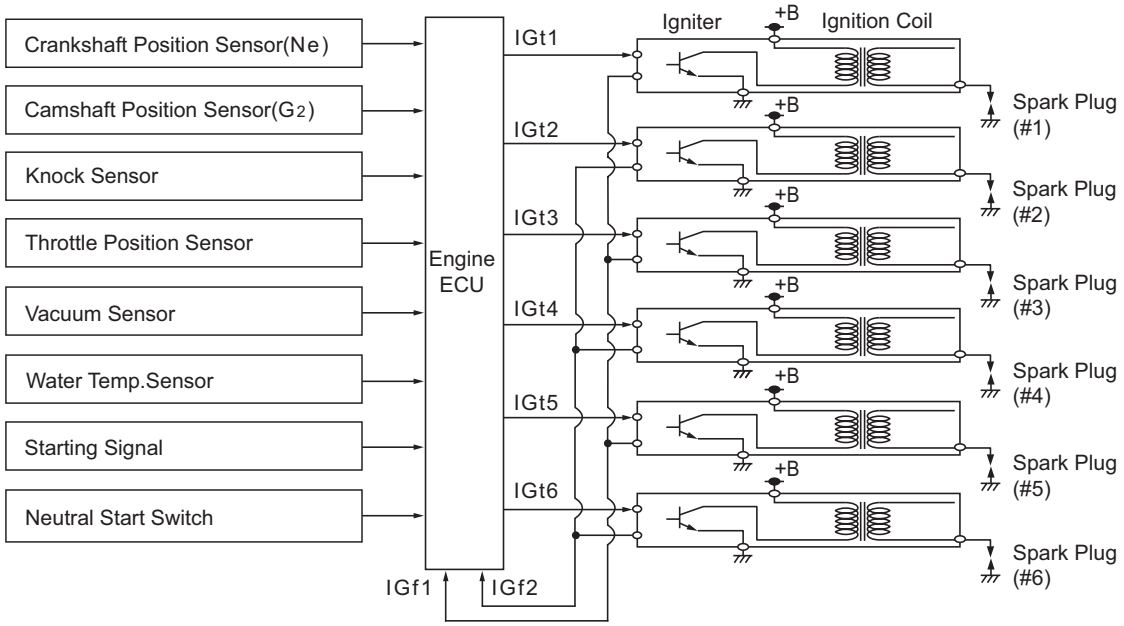
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3GR-FSE IGNITION

EG

General

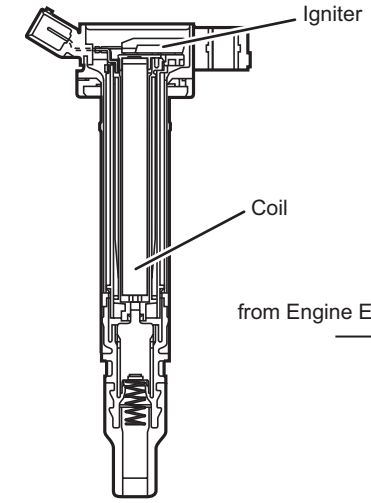
- The Direct Ignition system(DIS) is used, in which an ignition coil with a built-in igniter is provided for every cylinder. This system enhances the ignition timing control precision and makes the ignition timing completely adjustment-free.
- Independent ignition coils are provided to each of the cylinders #1 to #6, thus making a distributor or high tension cord unnecessary. This reduces the power loss associated with high-voltage areas, improves reliability, and reduces electro-magnetic interference.



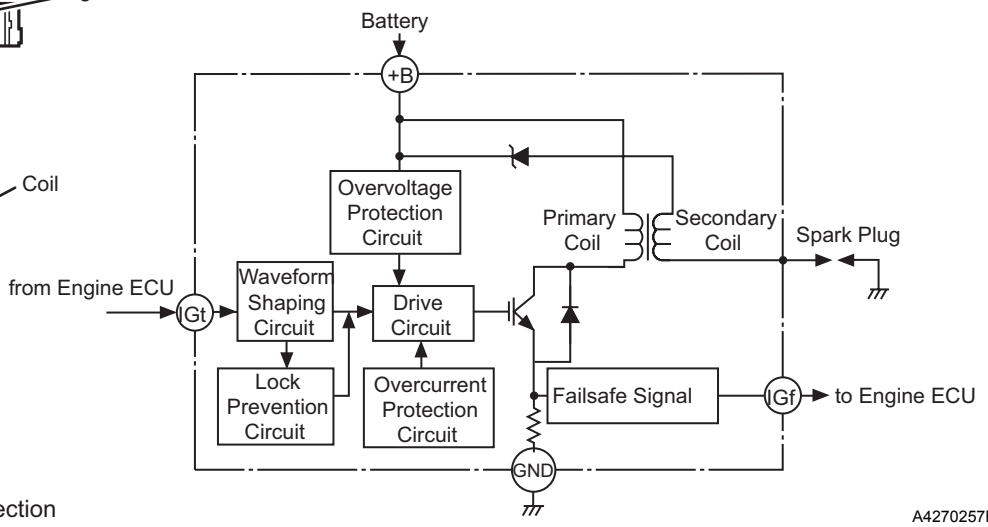
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Ignition Coil (with Igniter)

- Ignition coils with built-in igniters are used and placed directly over the spark plugs.



Ignition Coil Cross Section

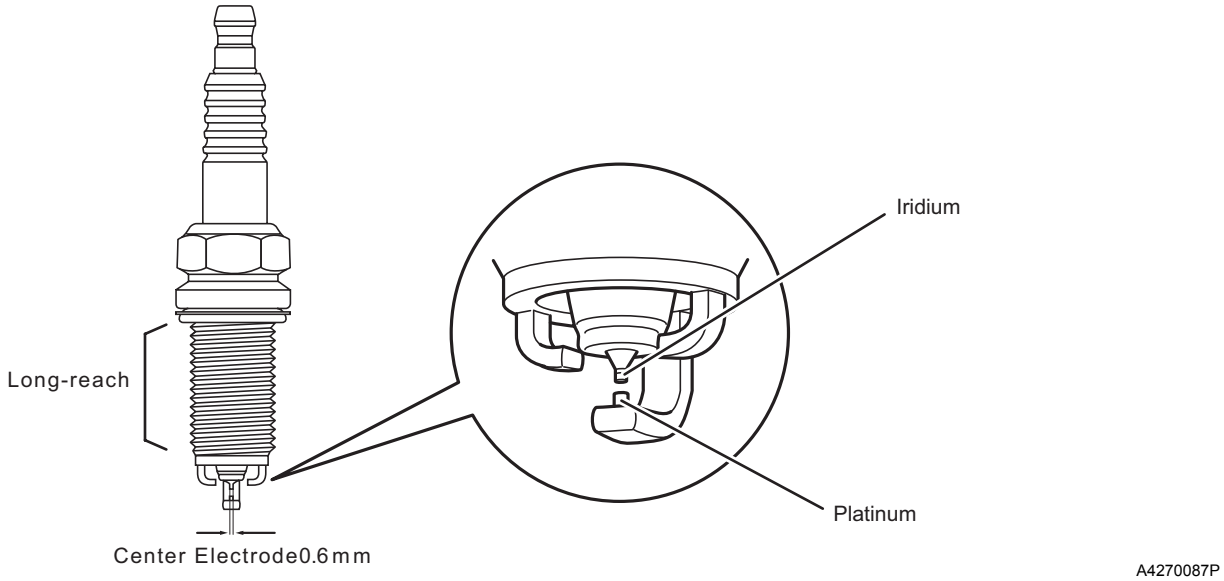


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Spark Plug

- Long-reach spark plugs are used to improve the cooling performance of the cylinder heads.
- The spark plug is the triple ground electrode type that uses an iridium alloy in its center electrode. Because the iridium alloy has extremely superior wear resistance, the center electrode can be made with a small diameter. This produces reliable ignition while improving durability. Furthermore, two ground electrodes have been added to further improve ignitability, wear resistance, and fouling resistance.



Spark Plug

DENSO	FK20HBR11
NGK	ILFR6D11T
Plug Gap [mm (in.)]	1.0 ~ 1.1 (0.0394 ~ 0.043)

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.
(See page EG-119)

Camshaft Position Sensor

- These sensors are the MRE (Magnetic Resistance Element) type. The rotational movement of the timing rotor (which is provided in the VVT-i controller of the intake camshaft) causes a magnetic field to act on the magnetic resistance element in the sensor. The sensor utilizes the changes that occur in the direction of the magnetic field to detect the position of the timing rotor, which determines the position of the actual camshaft. The cylinders are identified by the input sequence of the Ne and G2 signals.
(See page EG-120)

3GR-FSE STARTING

Starter

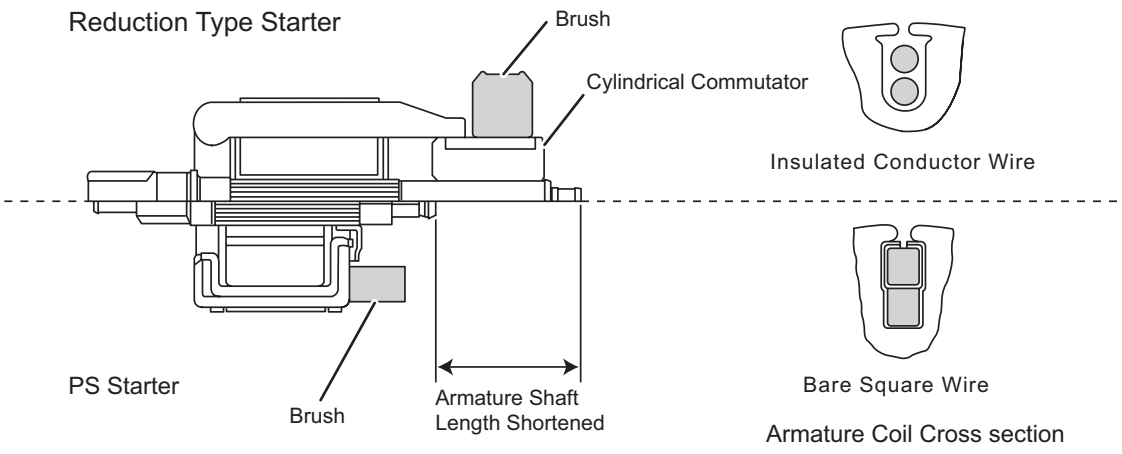
- A compact, lightweight, high power output, and highly efficient PS (Planetary reduction - Segment conductor motor) starter is used.
- A square conductor armature coil is used to achieve a compact and lightweight construction.

Starter

Type	PS Type
Rated Voltage [V]	12
Rated Output [kW]	1.7

Armature Coil

- The armature coil consists of bare square wire, which improves the space factor, and improves the torque of the starter.
- The cylindrical commutator has been discontinued to shorten the length of the armature shaft.

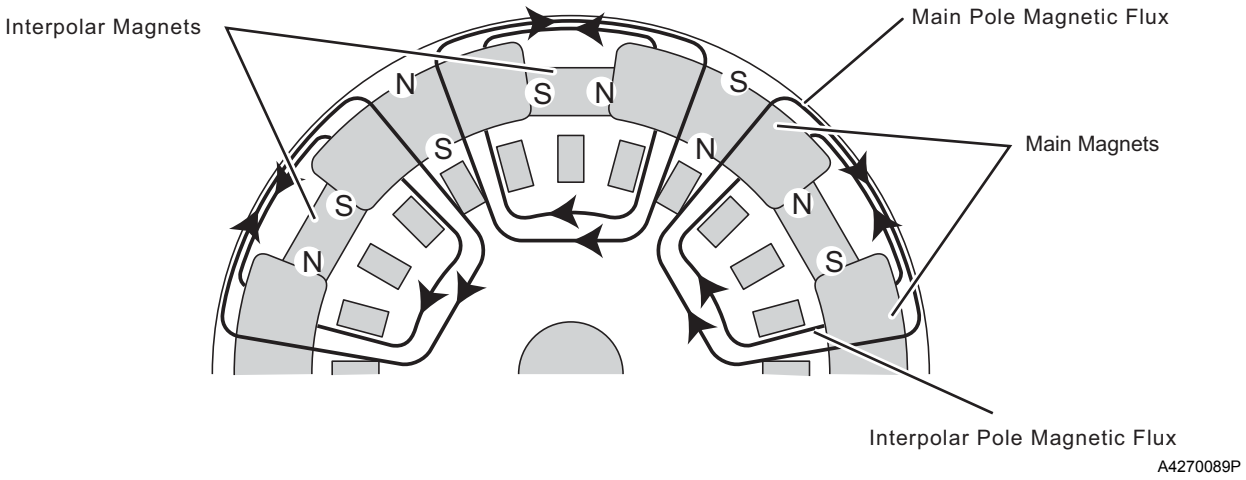


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Field Coil

• Interpolar magnets are used between the field coils. This improves the magnetic circuit and increases the amount of magnetic flux. Because the same amount of magnetic flux as the conventional type can be attained with a compact construction, the length of the yoke shaft has been shortened.



3GR-FSE CHARGING

Alternator

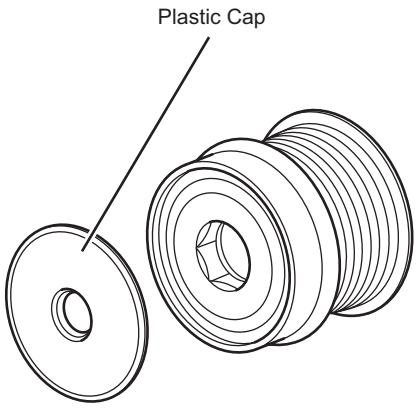
- A compact, lightweight, high power output, and highly efficient segment conductor type alternator is used.
- A charging control system is used. This system controls the generating load of the alternator in accordance with the driving conditions of the engine. By optimally controlling the generating voltage, this system contributes to fuel economy.
- A clutch is provided in the alternator pulley. By reducing friction on the accessory belt, this clutch contributes to fuel economy.

Alternator

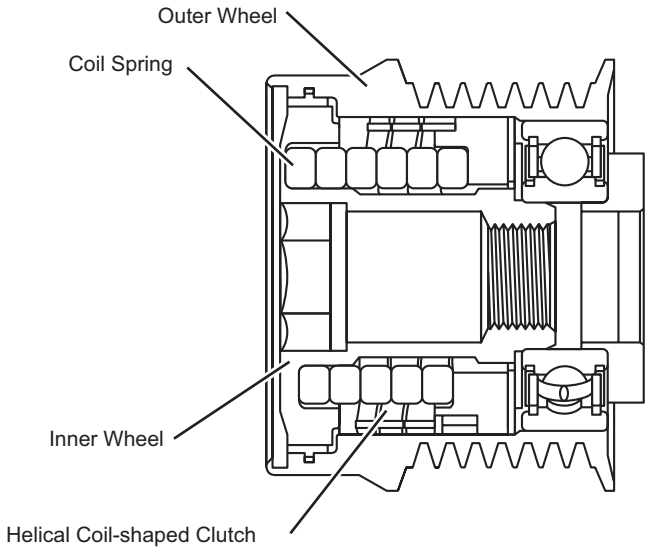
Rated Voltage [V]	12
Rated Output [A]	130
Regulator Setting Voltage [V] (5000rpm,10A,25°C)	12.1 ~ 15.4
Permissible Max Spee [rpm]	18000

Alternator Pulley

- A helical coil-shaped clutch, which is located between the inner and outer wheels of the pulley, transmits power to the alternator only in the forward rotational direction of the engine. Thus, it reduces the load that acts on the accessory belt.
- The pulley is made compact by shaping the inner wheel together with the nut used for tightening the alternator shaft.
- A plastic cap that covers the interior is provided in front of the pulley. This prevents mud from entering, thus ensuring reliability under poor environmental conditions.



Alternator Pulley



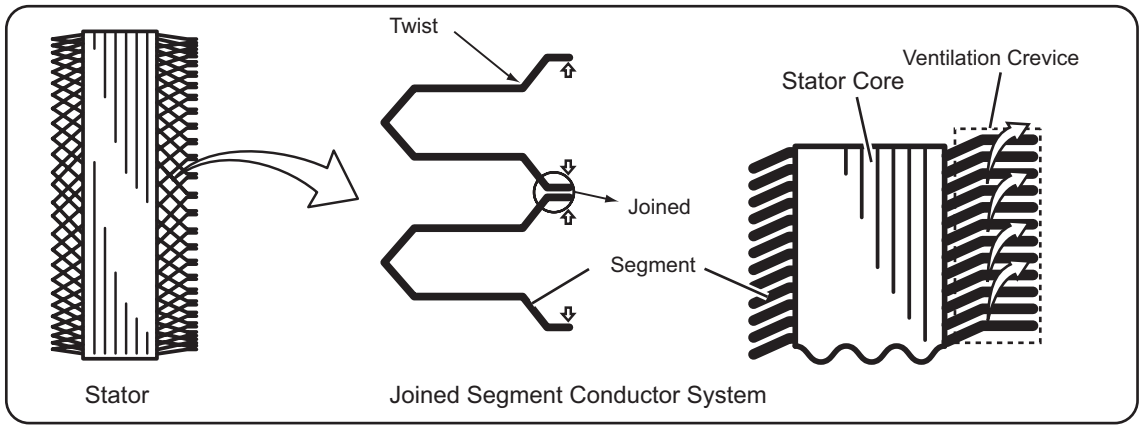
Alternator Pulley Cross Section

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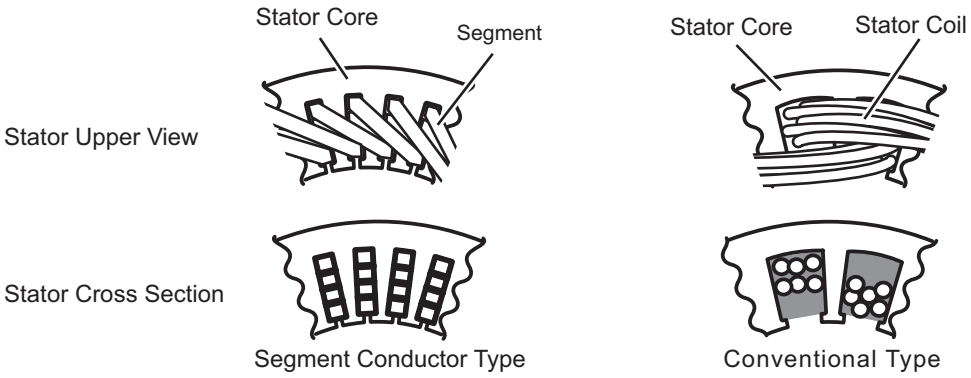
EG

Stator Coil

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



〈Segment Conductor Type Alternator〉



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