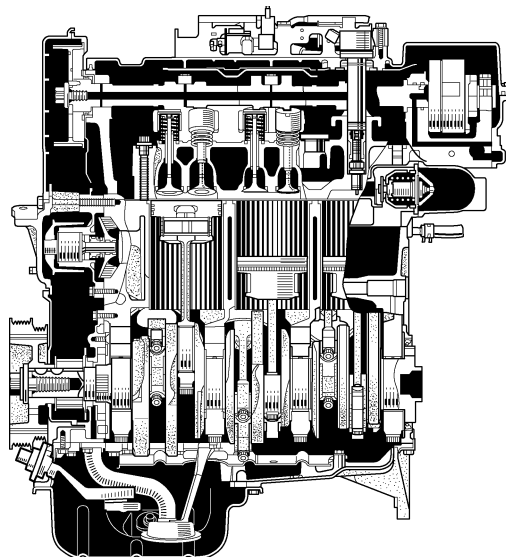


ENGINE

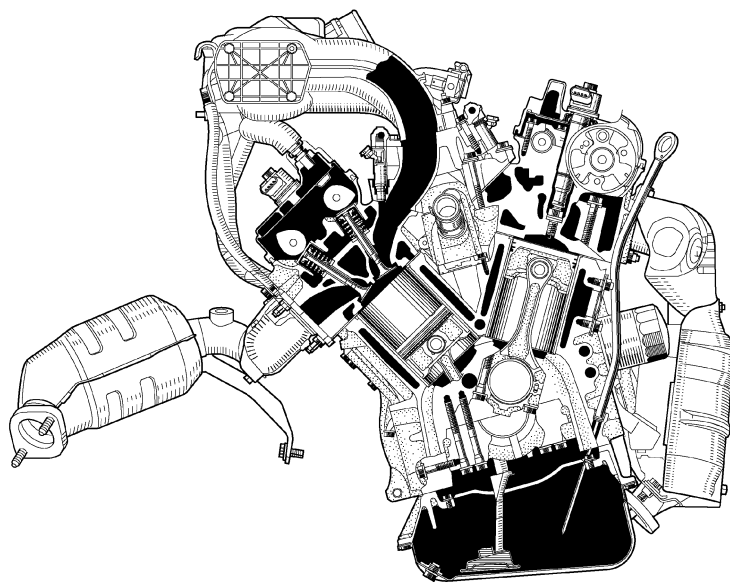
3MZ-FE ENGINE

■ DESCRIPTION

The RX400h uses the 3MZ-FE engine that has been newly developed for hybrid system application. It is a V6, 3.3-liter, 24-valve DOHC engine. It is based on the 3MZ-FE engine of the RX330. Furthermore, the VVT-i (Variable Valve Timing-intelligent) system and the ETCS-i (Electronic Throttle Control System-intelligent) system have been changed to suit the hybrid system.



277EG01



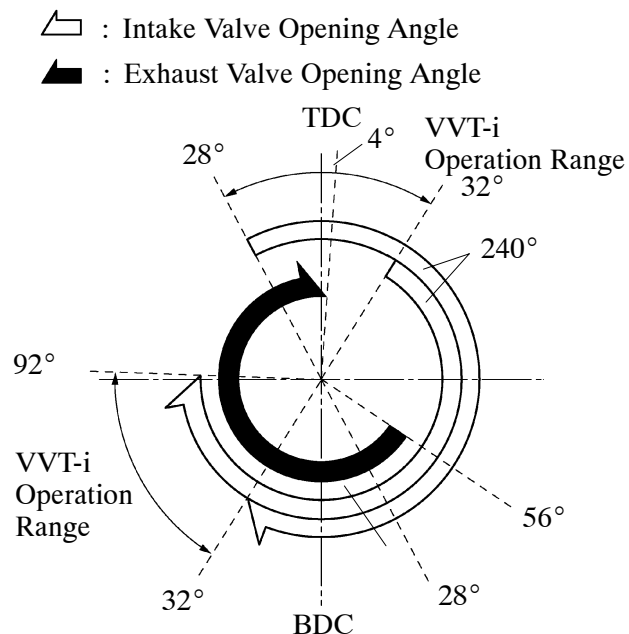
277EG02

► Engine Specifications ◀

Model			RX400h	RX330
Engine Type			3MZ-FE	3MZ-FE
No. of Cyls. & Arrangement			6-Cylinder, V Type	←
Valve Mechanism			24-Valve DOHC, Belt & Gear Drive (with VVT-i)	←
Combustion Chamber			Pentroof Type	←
Manifolds			Cross-Flow	←
Fuel System			EFI	←
Displacement cm ³ (cu. in.)			3,311 (202.1)	←
Bore × Stroke mm (in.)			92.0 × 83.0 (3.62 × 3.27)	←
Compression Ratio			10.8 : 1	←
Max. Output (EEC)			155 kw @ 5,600 rpm	172 kw @ 5,600 rpm
Max. Torque (EEC)			288 N·m @ 4,400 rpm	328 N·m @ 3,600 rpm
Valve Timing	Intake	Open	28°BTDC ~ 32° ATDC	56°BTDC ~ 4° ATDC
		Close	32°ABDC ~ 92° ABDC	4°ABDC ~ 64° ABDC
	Exhaust	Open	56° BBDC	←
		Close	4° ATDC	←
Firing Order			1-2-3-4-5-6	←
Research Octane Number			95 or higher	←
Engine Service Mass* (Reference) kg (lb)			160 (352)	←
Oil Grade			API, SJ, SL, EC or ILSAC	←
Tailpipe Emission Regulation			EURO IV	←
Evaporative Emission Regulation			EURO IV	←

*: Weight shows the figure with the oil and engine coolant fully filled.

► Valve Timing ◀



■ MAJOR DIFFERENCE

The major difference between the new 3MZ-FE engine on the RX400h and the 3MZ-FE engine on the RX330 are the following:

System	Features
Engine Proper	• A PVD(Physical Vapor Deposition) coating has been applied on the surface of No.1 compression ring. • An oil ring with a two-piece shape is used. • A wear resistant coating is used on the sliding surfaces of the crankshaft bearings for the No. 1 and No. 4 journals.
Valve Mechanism	The valve timing has been changed to achieve optimum hybrid control.
Cooling System	The engine radiator and condenser, inverter radiator have been integrated.
Intake and Exhaust System	• The material of and hoses has been changed to inhibit the permeation of fuel vapors. • An intake air connector made of aluminum alloy is used. • To reduce noise, resonators have been added to the following areas: inside the air cleaner, air cleaner hose, and the air inlet. • A material that provides the same level of high-temperature strength as stainless steel is used for the exhaust manifold. • A ceramic catalyst is used. • A large, 20.8-liter capacity muffler is used. • The intake air control valve and ACIS (Acoustic Control Induction System).
Charging System	The alternator has been discontinued.
Starting System	The starter motor has been discontinued. The starting system uses a motor generator (MG1).
Engine Mount	The shape of the front and rear engine mounts has been optimized and an absorber engine mount is used for the rear.
Serpentine Belt Drive System	The drive belt has been discontinued, along with the use of electric power steering and an electric inverter compressor.
Engine Control System	• Operates the engine intermittently depending on the driving conditions. • Calculates the load based on the accelerator position and the vehicle speed, in order to determine the throttle position. • The ACIS (Acoustic Control Induction System) has been discontinued. • An THS ECU is used with the hybrid system. Furthermore, the THS ECU and the engine ECU have been integrated. • The operating range of the VVT-i (Variable Valve Timing-intelligent) system has been changed.
Diagnosis	The diagnosis communication has been changed from serial communication (ISO9141) to CAN communication.

■ FEATURES OF 3MZ-FE ENGINE

The 3MZ-FE engine has been able to achieve the following through the use of the items listed below.

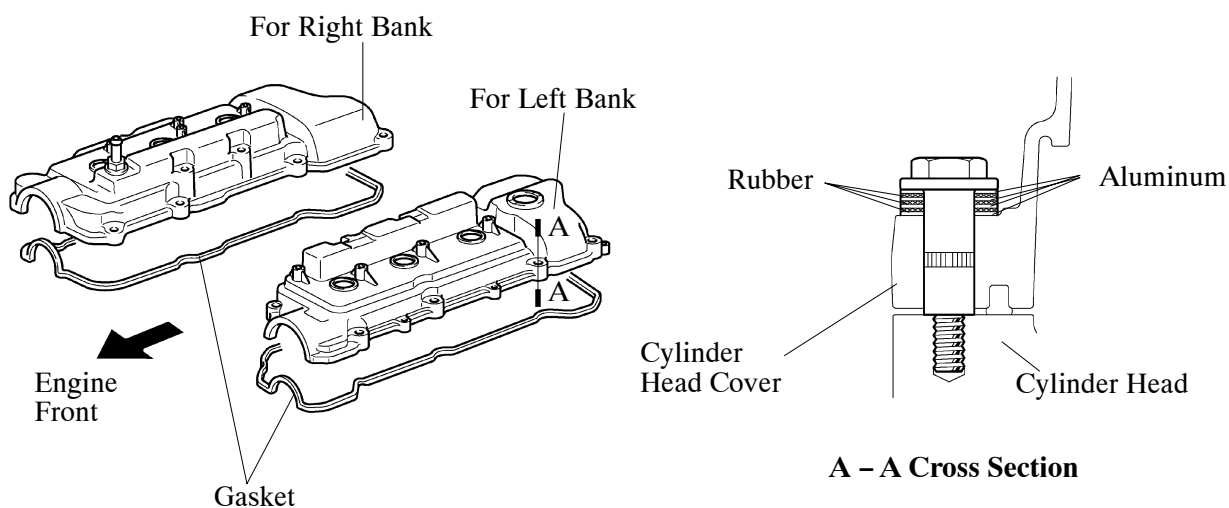
- (1) High performance and fuel economy
- (2) Low noise and vibration
- (3) Lightweight and compact design
- (4) Good serviceability
- (5) Clean emission

Item	(1)	(2)	(3)	(4)	(5)
The VVT-i system is used.	○				○
The ETCS-i is used.	○				
A cylinder block made of aluminum alloy is used.			○		
The intake air chamber made of plastics is used.			○		
Independent type DIS(Direct Ignition System) is used.	○			○	○
The fuel returnless system is used.			○	○	○
Quick connectors are used to connect the fuel hose with the fuel pipes.				○	
12-hole type fuel injectors with high atomizing performance is used.	○				○
Iridium-tipped spark plugs is used	○			○	
A 2-way exhaust control system is used.	○	○			
An absorber engine mount is used.		○			
A radiator integrated with a condenser, inverter radiator is used.			○		
The use of an air fuel ratio sensor allows precise control.					○

ENGINE PROPER

1. Cylinder Head Cover

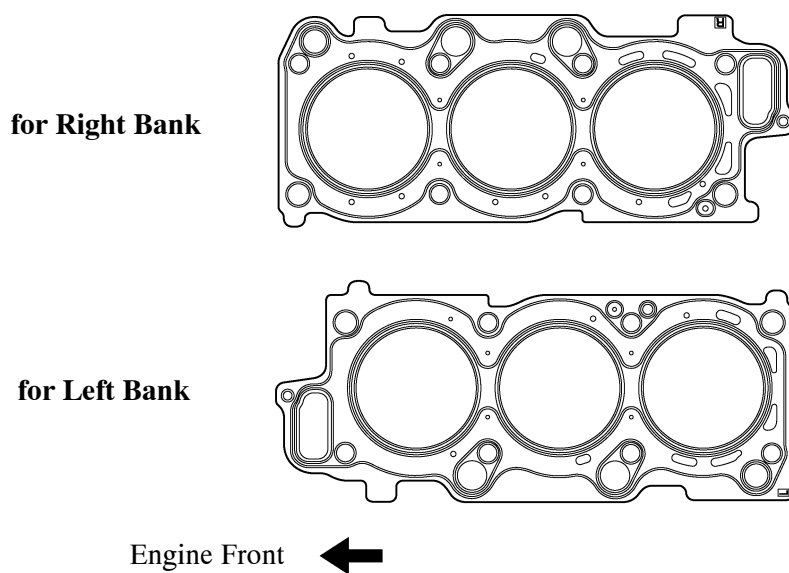
- Lightweight yet high-strength aluminum diecast cylinder head covers are used.
- An aluminum washer made of vibration-damping laminated aluminum sheet is used on the evenly spaced shoulder bolts which fasten the cylinder head covers.



209EG101

2. Cylinder Head Gasket

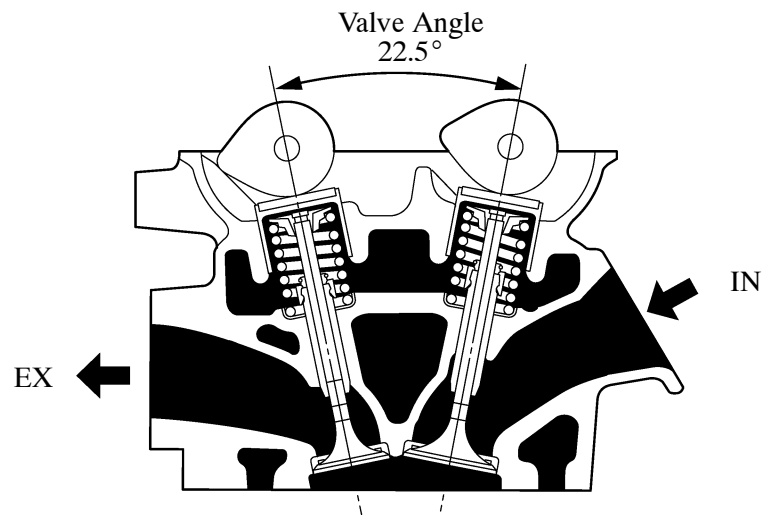
A metal type cylinder head gasket which offers superior pressure resistance and sealing performance is used.



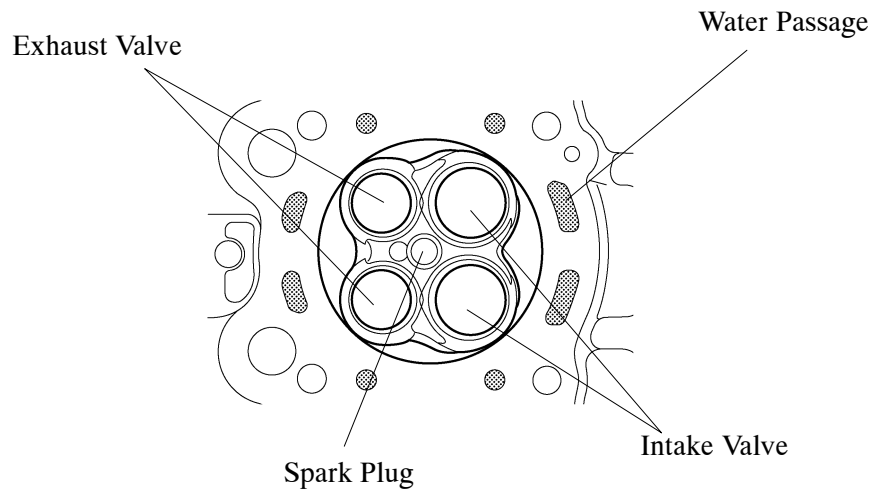
241EG05

3. Cylinder Head

- The cylinder head, which is made of aluminum, uses a pentroof-type combustion chamber. The spark plug has been located in the center of the combustion chamber in order to improve the engine's antiknocking performance.
- The angle of the intake and exhaust valves is narrowed and set at 22.5° to permit a compact cylinder head.
- Upright, small-diameter intake ports are used to improve the torque at low-to-medium speeds.
- In order to reduce intake and exhaust air resistance, the cross section of the protrusion of the valve guide into the intake port has been reduced by decreasing the valve stem diameter and the valve guide outer diameter.
- Plastic region tightening bolts are used for the cylinder head bolts for good axial tension.



187EG06

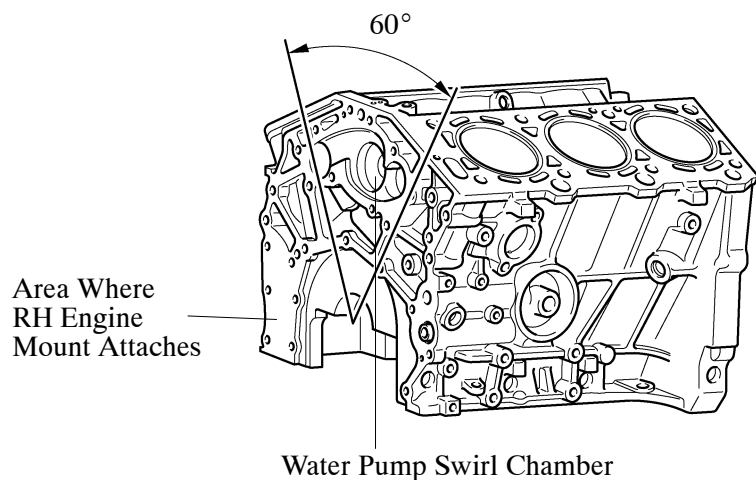


View of Back Side

277EG04

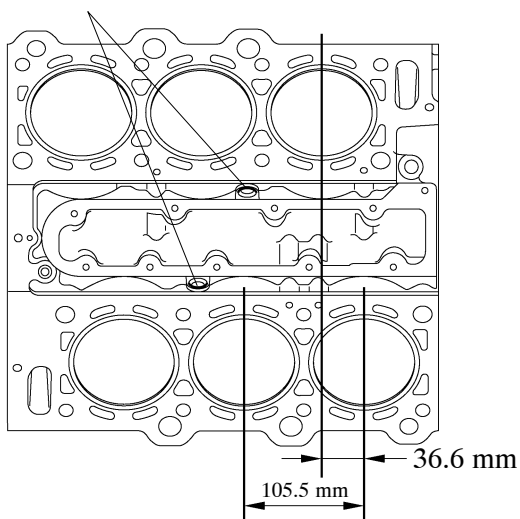
4. Cylinder Block

- The cylinder block has a bank angle of 60° , a bank offset of 36.6 mm (1.44 in.) and a bore pitch of 105.5 mm (4.15 in.), resulting in a compact block.
- Lightweight aluminum alloy is used for the cylinder block.
- A thin cast-iron liner is press-fit inside the cylinder to ensure an added reliability. This liner is thin, so that boring is not possible.
- A water pump swirl chamber and an inlet passage to the pump are provided in the V-bank to help make the engine compact.
- Knock sensor bosses are provided at 2 locations in V-bank.



198EG38

Knock Sensor Bosses



View of Top Side

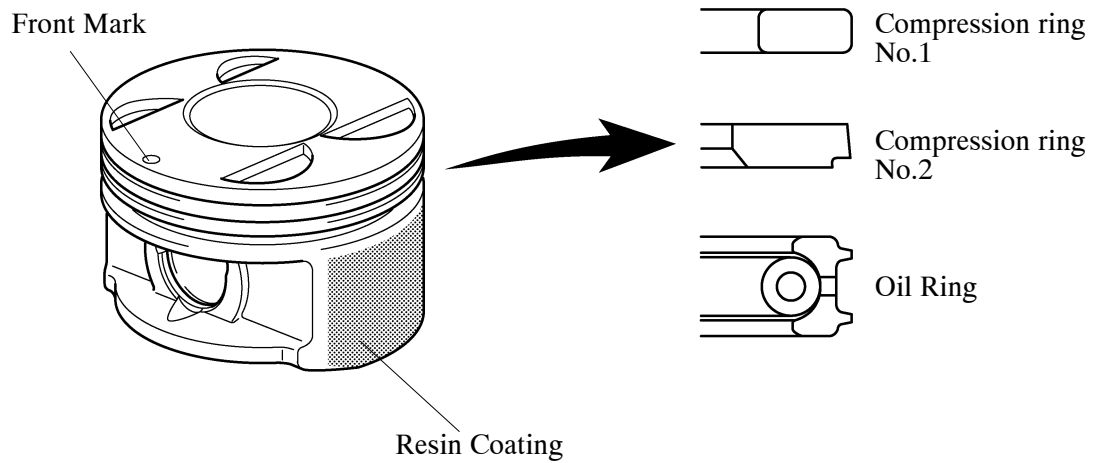
208EG63

5. Piston and Piston Ring

- The piston is made of aluminum alloy and skirt area is made compact and lightweight.
- The piston skirt has been coated with resin to reduce the friction loss.
- Full floating type piston pins are used.

— Main Changes from Current RX330 —

- A PVD (Physical Vapor Deposition) coating has been applied on the surface of No.1 compression ring.
- A two-piece type oil ring is used.



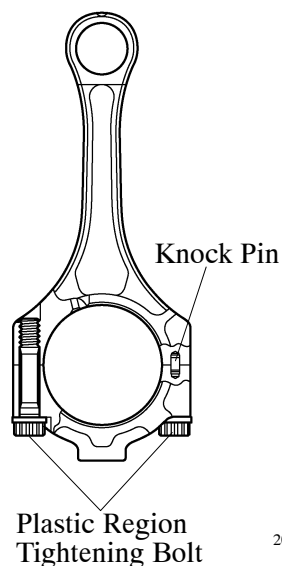
277EG05

► Piston Ring Specifications ◀

	Shape		Surface Treatment	
	RX400h	RX330	RX400h	RX330
Compression Ring No.1	Barrel	←	PVD	Zinc Phosphate
Compression Ring No.2	Tapered + Undercut	←	Zinc Phosphate	←
Oil Ring	Two-Piece	Three-Piece	Gas Nitriding	←

6. Connecting Rod

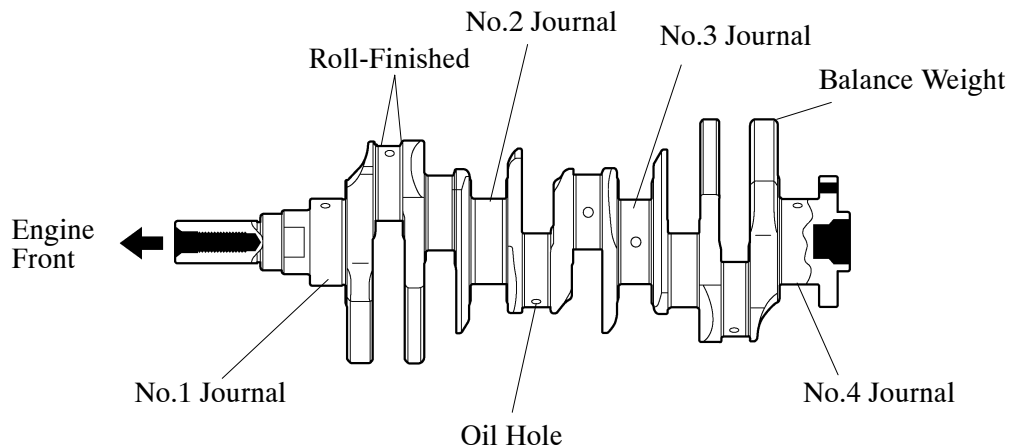
- Connecting rods that have been forged for high strength are used for weight reduction.
- An aluminum bearing with overlay is used for the connecting rod bearings.
- Plastic region tightening bolts are used.
- Knock pins are used at the mating surfaces of the bearing caps of the connecting rod to minimize the shifting of the bearing caps during assembly.



208EG106

7. Crankshaft

- The crankshaft is made of forged steel and has 4 journals and 9 balance weights.
- All pin and journal fillets are roll-finished to maintain adequate strength.
- The crankshaft bearings for the No.1 and No.4 journals are made wider to decrease noise and vibration, and the No.2 and No.3 journals are made narrower to reduce friction.



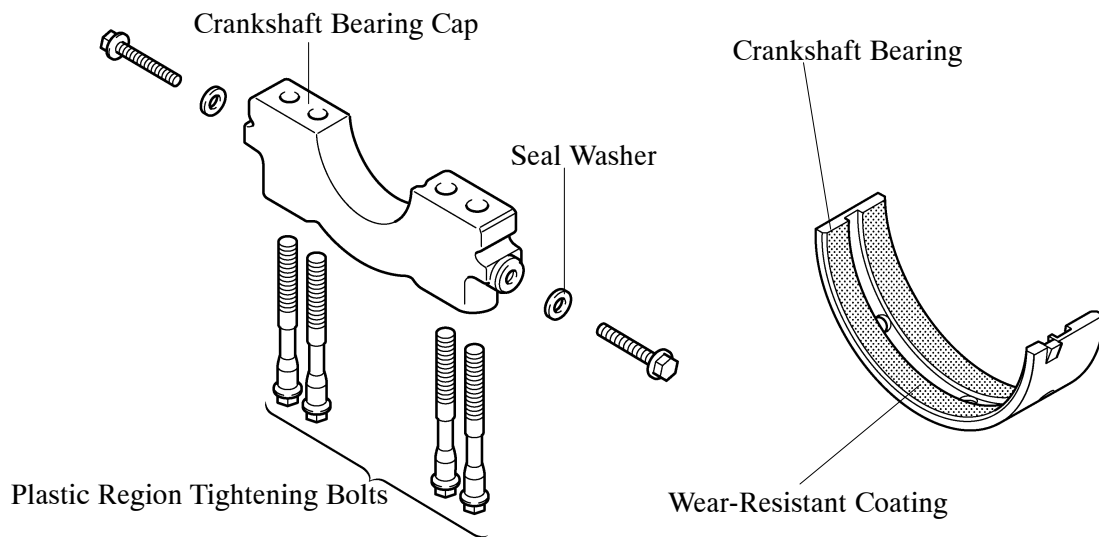
208EG72

8. Crankshaft Bearing and Bearing Cap

The crankshaft bearing caps are tightened using 4 plastic-region bolts for each journal. In addition, each cap is tightened laterally to improve reliability.

— Main Changes from Current RX330 —

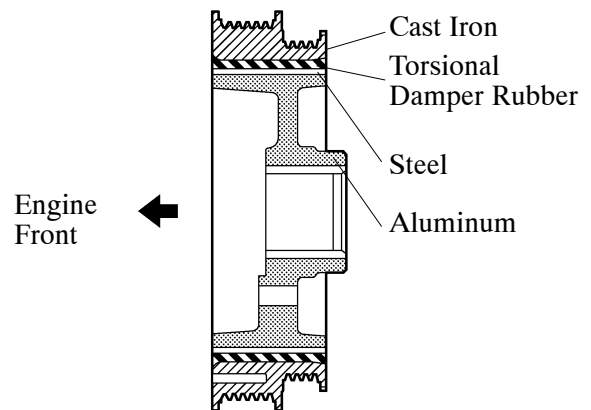
A wear resistant coating is used on the sliding surfaces of the crankshaft bearings for the upper and lower No. 1 and No. 4 journals.



EG

9. Crankshaft Pulley

- The crankshaft pulley hub is made of aluminum to reduce weight and vibration.
- The rigidity of the torsional damper rubber has been optimized to reduce noise.

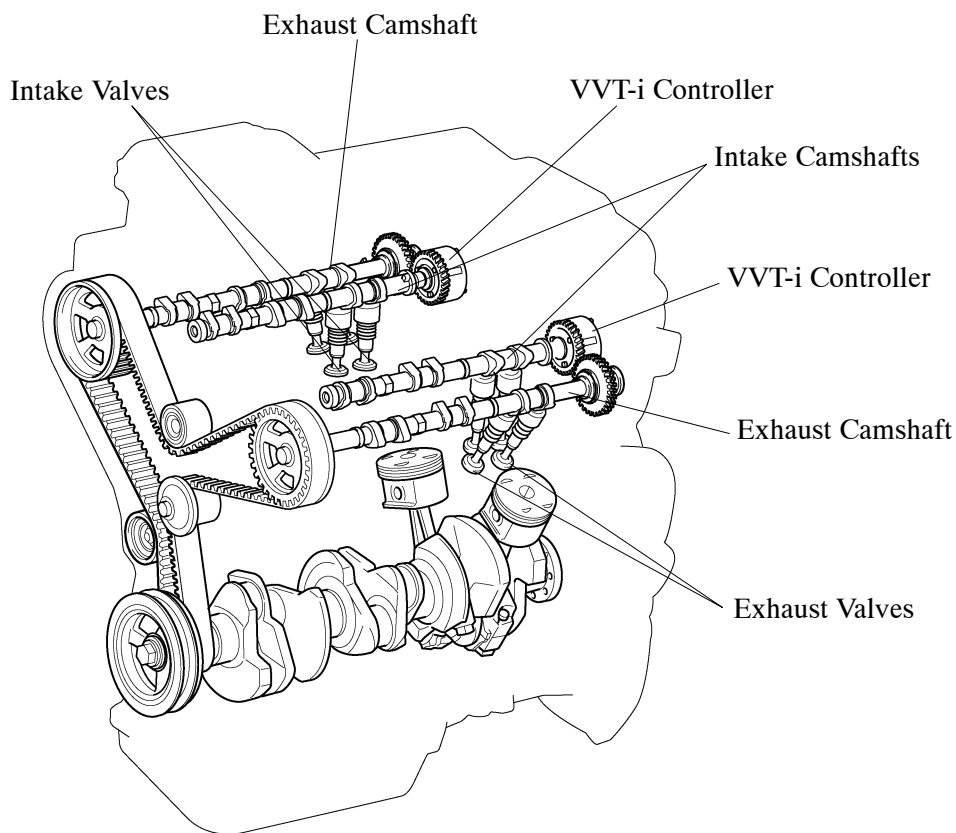


241EG09

■ VALVE MECHANISM

1. General

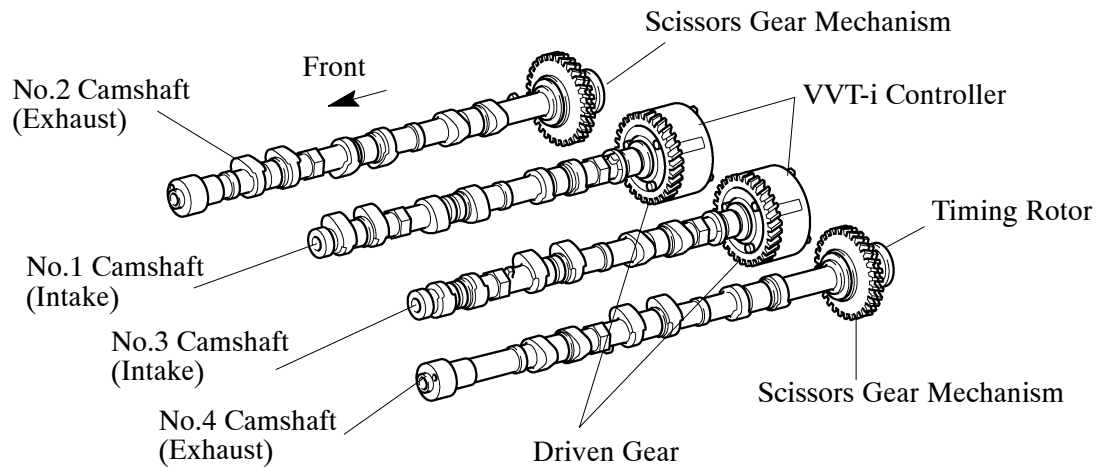
- The valves are directly opened and closed by 4 camshafts.
- The exhaust camshafts are driven by a timing belt, while the intake camshafts are driven through gears on the exhaust camshafts.
- The VVT-i system used for the intake camshaft provides excellent fuel economy, engine performance and reduce exhaust emissions. For details, refer to VVT-i System on [page EG-49](#).



211EG06

2. Camshafts

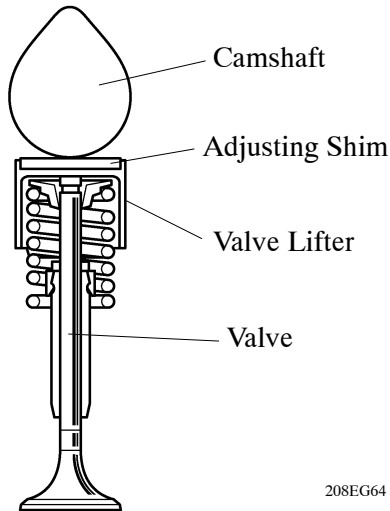
- The camshafts are made of cast iron alloy.
- In conjunction with the use of the VVT-i system, an oil passage is provided in the intake camshaft in order to supply engine oil to the VVT-i system.
- A VVT-i controller has been installed on the rear of the intake camshaft to vary the timing of the intake valves.
- The intake camshafts are driven by gears on the exhaust camshafts. The scissors gear mechanism is used on drive gear of the exhaust camshaft to control backlash and suppress gear noise.
- To detect the intake camshaft position, a timing rotor is provided in front of the VVT-i controller. This timing rotor, which is secured to the intake camshaft, is used by the VVT sensor to detect the actual position of the intake camshaft.



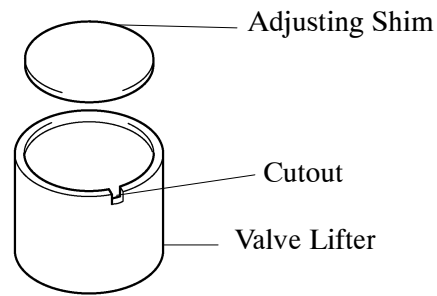
187EG15

3. Intake and Exhaust Valve and Valve Lifter

- Narrower valve stems are used to reduce the intake and exhaust resistance and to reduce weight.
- The adjusting shim has been located directly above the valve lifter. This construction allows the adjusting shim to be replaced without removing the camshaft, which improves the serviceability during valve clearance adjustment.
- A cutout is provided in the valve lifter to improve the serviceability of removing the adjusting shims.



208EG64



187EG17

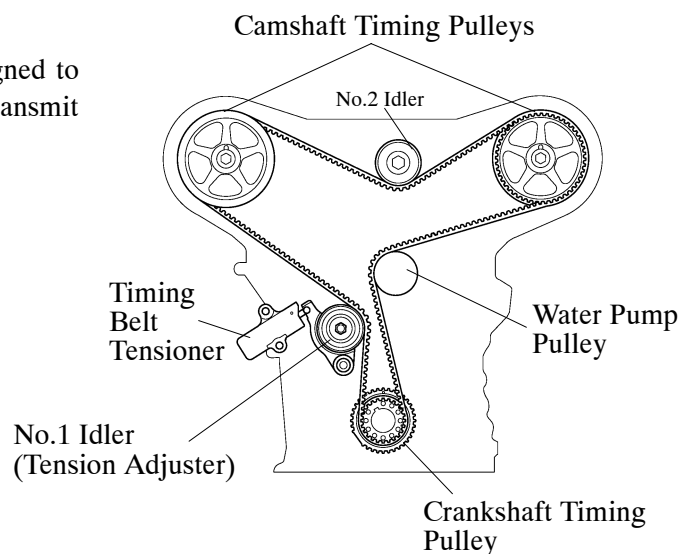
Service Tip

The adjusting shims are available in 17 sizes in increments of 0.05 mm (0.002 in.), from 2.50 (0.098 in.) to 3.30 (0.130 in.).

For details, refer to the LEXUS RX400h Repair Manual (Pub. No. RM1139E).

4. Timing Belt

The timing belt tooth configuration is designed to help to reduce noise and to enable the belt to transmit power under high load factors.



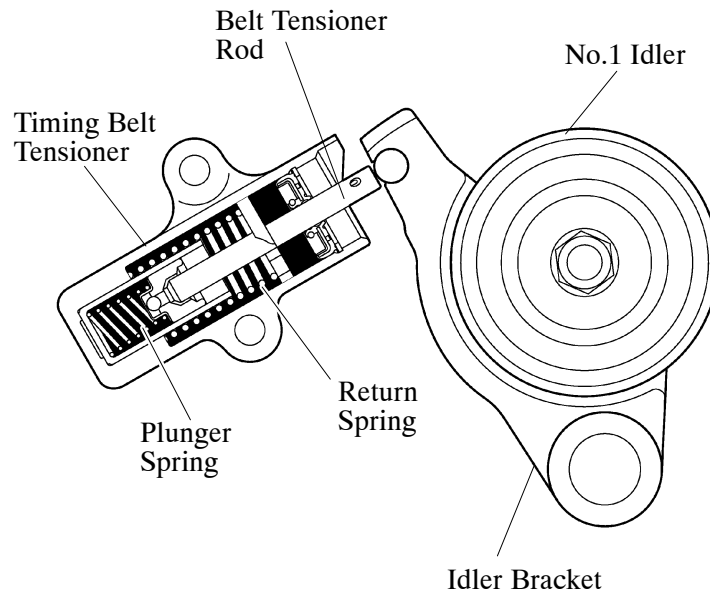
198EG40

Service Tip

The 3MZ-FE engine, the valves may come in contact with the pistons during the installation of the timing belt, depending on the position of the pistons. To prevent this contact, the procedure for installing the timing belt has been changed. Before locating the camshafts, the crankshaft must be turned counterclockwise so that the piston of the No. 1 cylinder is at 60° BTDC. This places all the pistons away from their TDC (Top Dead Center), which prevents the valves from coming in contact with the pistons. For details, refer to the LEXUS RX400h Repair Manual (Pub. No. RM1139E).

5. Timing Belt Tensioner

The timing belt tensioner uses a spring and silicon oil damper, and maintains proper timing belt tension at all times. The timing belt tensioner suppresses noise generated by the timing belt.

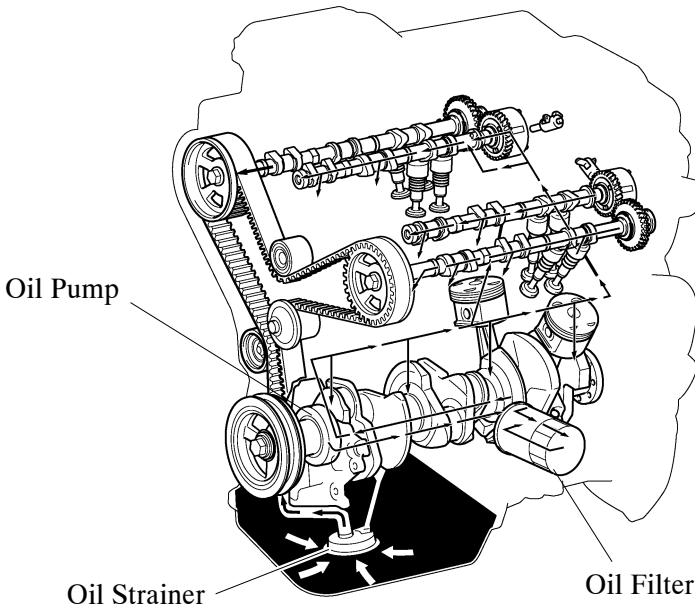


241EG10

LUBRICATION SYSTEM

1. General

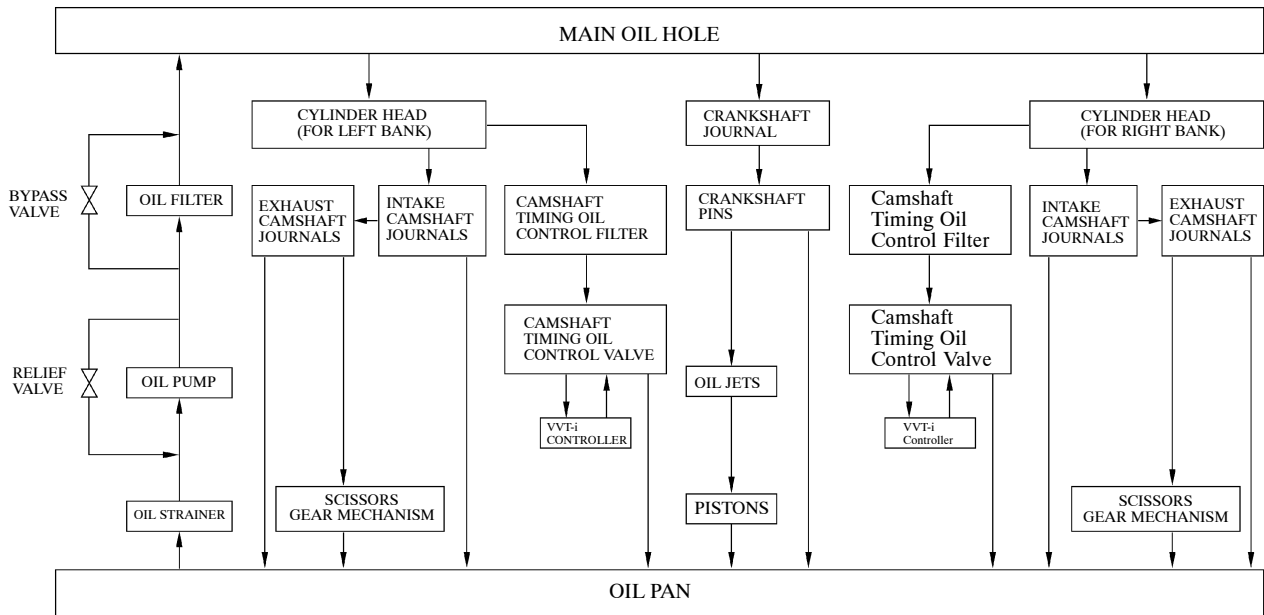
- The lubrication is fully pressurized and all oil passes through an oil filter.
- A trochoid gear type oil pump is directly driven by the crankshaft.



211EG07

Oil Capacity

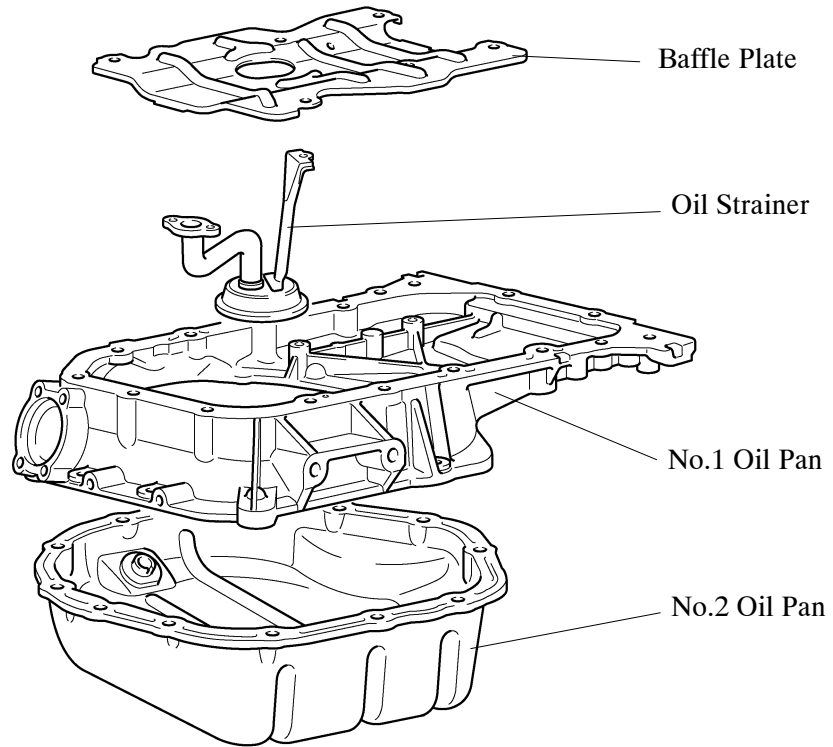
	liter (US qts, Imp. qts)
Dry	5.5 (5.8, 4.8)
with Oil Filter	4.7 (5.0, 4.1)
without Oil Filter	4.5 (4.8, 4.0)



187EG22

2. Oil Pan

- The oil pan is made up of 2 piece. No.1 oil pan is made of aluminum alloy and No.2 oil pan is made of steel sheet.
- No.1 oil pan is secured to the cylinder block and the transaxle housing and is increasing rigidity.



187EG23

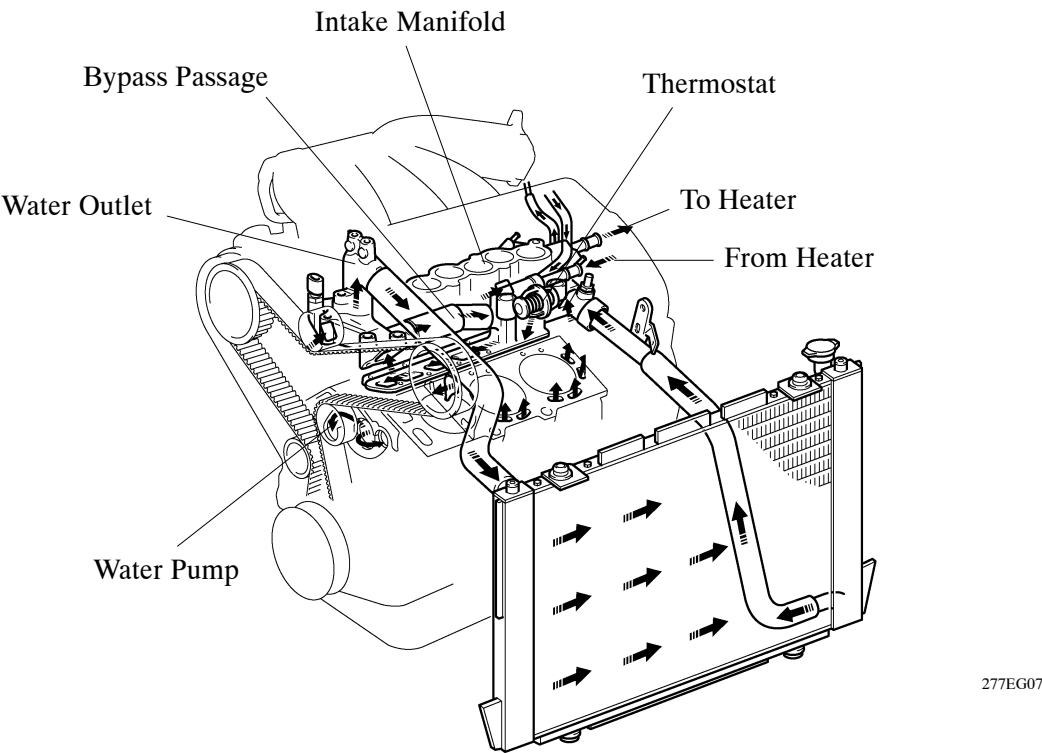
COOLING SYSTEM

1. General

- The cooling system uses a pressurized forced circulation system with open air type reservoir tank.
- A thermostat having a bypass valve is located on the water pump inlet side of the cooling circuit.
- The TOYOTA genuine super long life coolant (SLLC) is used. As a result, the maintenance interval has been extended.

— Main Changes from Current RX330 —

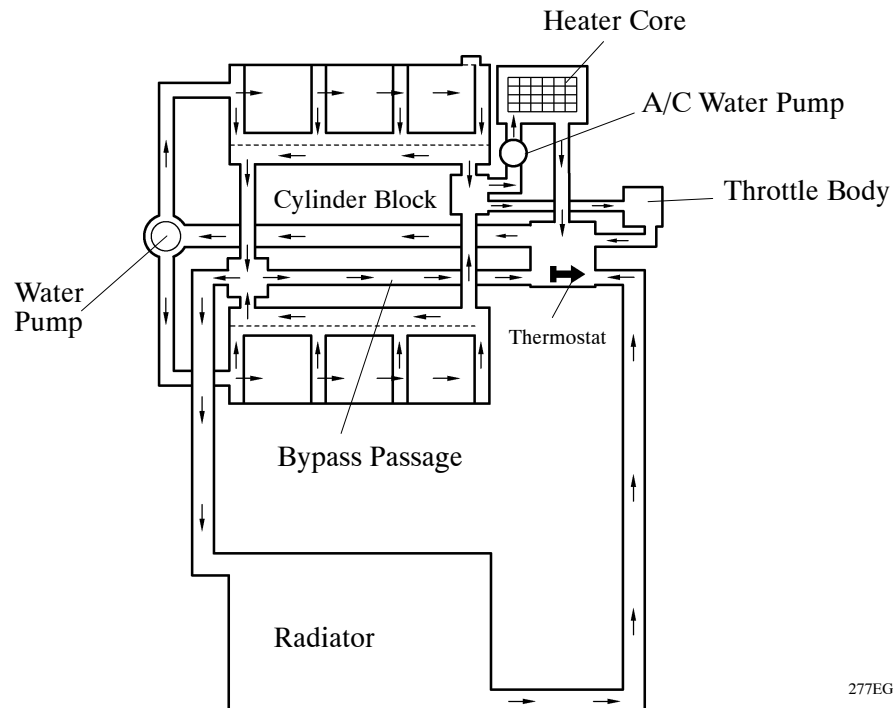
- An inverter radiator has been provided, with the hybrid system. The inverter radiator, condenser, and the engine radiator have been arranged parallel to each other, and integrated with brackets.
- The fan shroud and the radiator reserve tank have been integrated.
- An electric fan with ring-shaped blade tips is used.



► Specifications ◀

Engine Coolant	Capacity	liters (US qts, Imp. qts)	10.3 (10.9, 9.1)
	Type		TOYOTA Genuine Super Long Life Coolant (SLLC) or Equivalent
Thermostat	Opening Temperature	°C (°F)	77 - 82 (171 - 180)

► Water Flow Diagram ◀



277EG08

EG

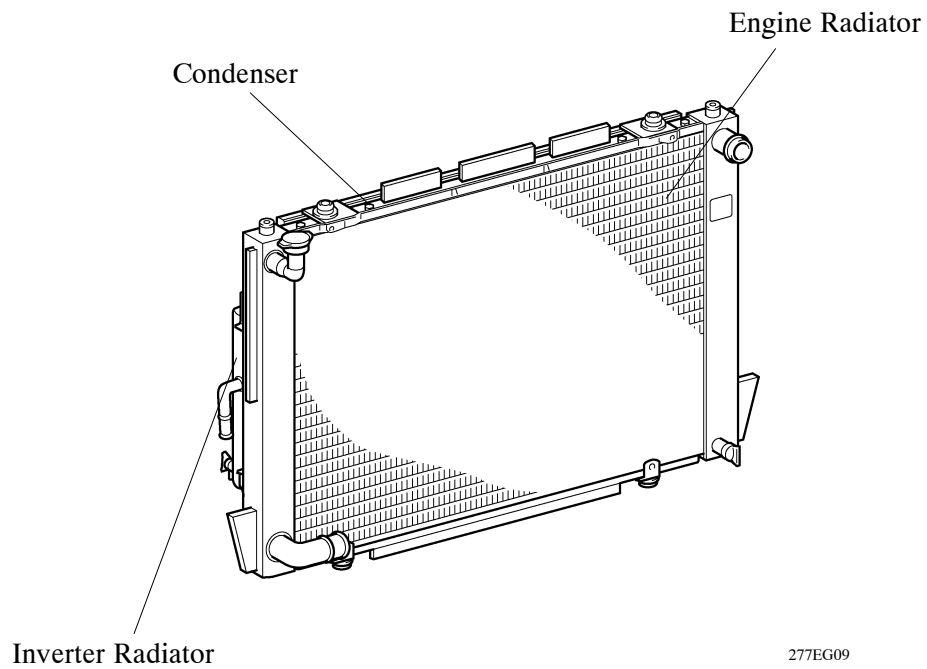
► Engine Coolant Specifications ◀

Engine Coolant Type		TOYOTA Genuine Super Long Life Coolant (SLLC) or Equivalent	TOYOTA Genuine Long Life Coolant (LLC) or Equivalent
Color		Pink	Red
Maintenance Intervals	First Time	160,000 km (100,000 mile)	Every 40,000 km (25,000 miles) or 24 months whichever comes first
	Subsequent	Every 80,000 km (50,000 mile)	

- SLLC is pre-mixed (50% coolant and 50% deionized water), so no dilution is needed when adding or replacing SLLC in the vehicle.
- If LLC is mixed with SLLC, the interval for LLC (every 40,000 km/25,000 miles or 24 months) should be used.
- You can also apply the new maintenance interval (every 80,000 km/50,000 miles) to vehicles initially filled with LLC (red-colored), if you use SLLC (pink-colored) for the engine coolant change.

2. Radiator

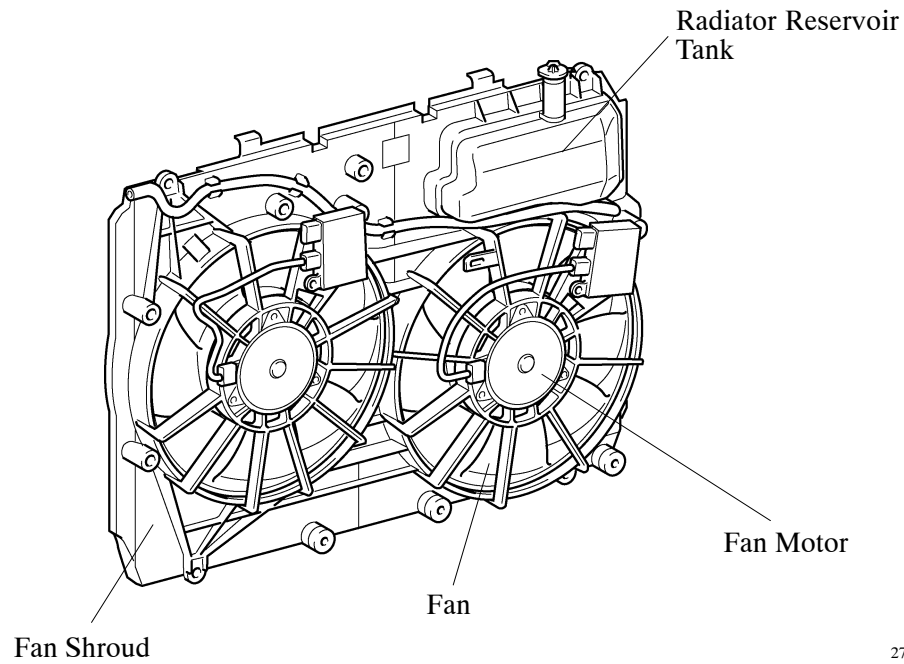
- The RX400h uses the same aluminum alloy radiator as the current RX330 for weight reduction and improved cooling performance.
- The inverter radiator and the condenser have been integrated with brackets to achieve a compact radiator.



277EG09

3. Cooling Fan and Fan Shroud

- The radiator reserve tank has been integrated to save space and reduce weight.
- A ring-shaped electric fan is used to ensure efficient cooling performance and quieter operation.



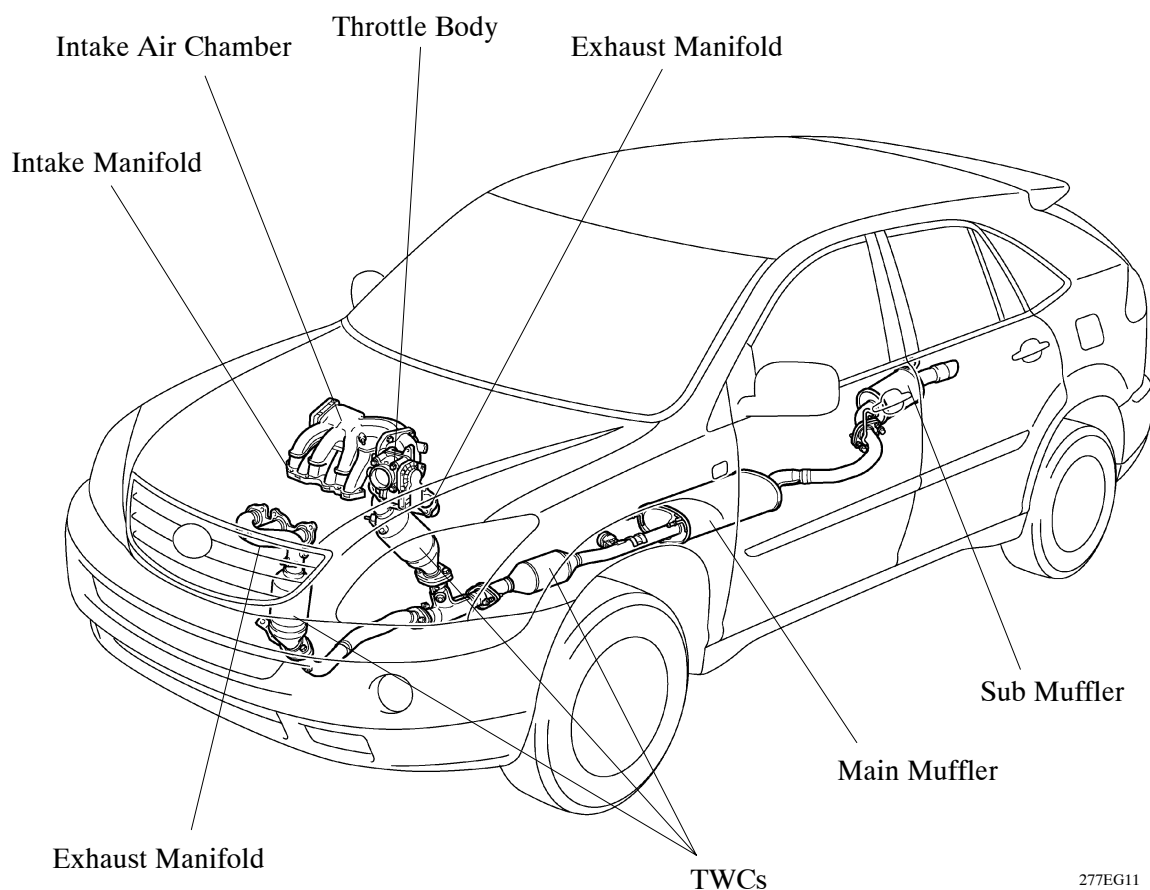
■ INTAKE AND EXHAUST SYSTEM

1. General

2-way exhaust control system is used in the main muffler to reduce noise and back pressure.

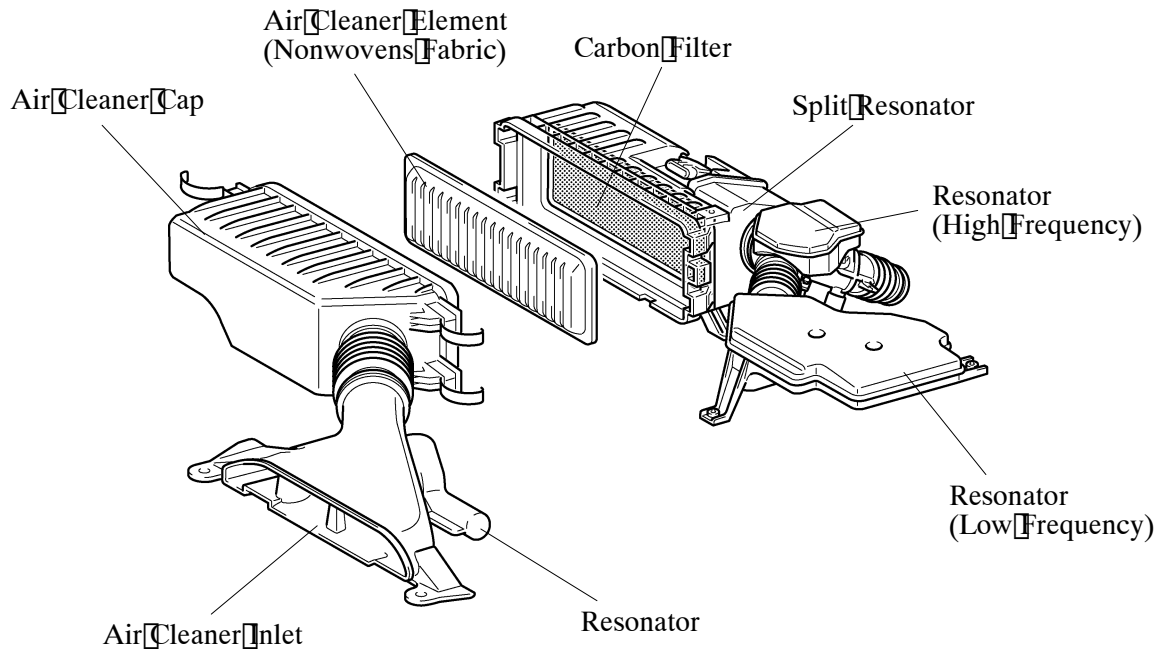
— Main Changes from Current RX330 —

- The intake air control valve has been discontinued, along with the discontinuance of the ACIS (Acoustic Control Induction System).
- The following are used with the hybrid system:
 - The air cleaner assembly has been relocated directly above the engine.
 - Resonators are used in various areas of the air cleaner assembly.
 - The intake port of the air cleaner has been relocated.
 - A large-capacity main muffler is used.
 - An intake air connector has been added, along with the relocation of the air cleaner assembly.



2. Air Cleaner

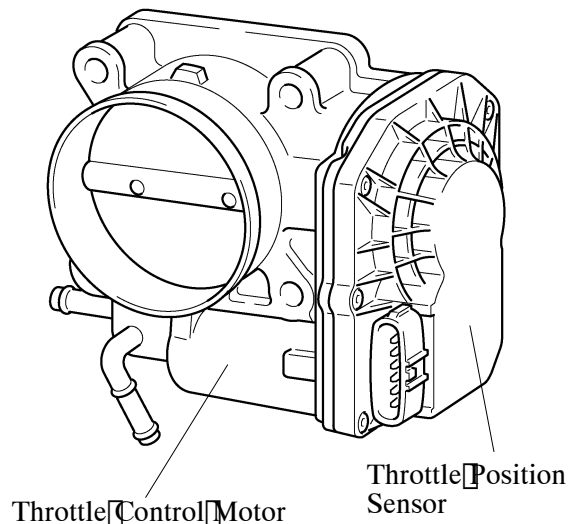
- A carbon filter, which adsorbs the HC that accumulates in the intake system when the engine is stopped, is used in the air cleaner cap in order to reduce evaporative emissions. This filter is maintenance-free.
- A split resonator is used inside the air cleaner. A low-frequency resonator and a high-frequency resonator are used in the vibrating area of the air cleaner hose. Furthermore, a resonator is used in the vibrating area of the air inlet. As a result, noise has been reduced and performance has been improved.
- An inlet port for the air cleaner has been located in the center of the upper radiator support to improve intake efficiency.



277EG12

3. Throttle Body

- A DC motor with excellent response and minimal power consumption is used for the throttle control motor. The HV 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.
- The link-less type throttle body is used for excellent throttle control.
For details, refer to ETCS-i on [page EG-46](#).

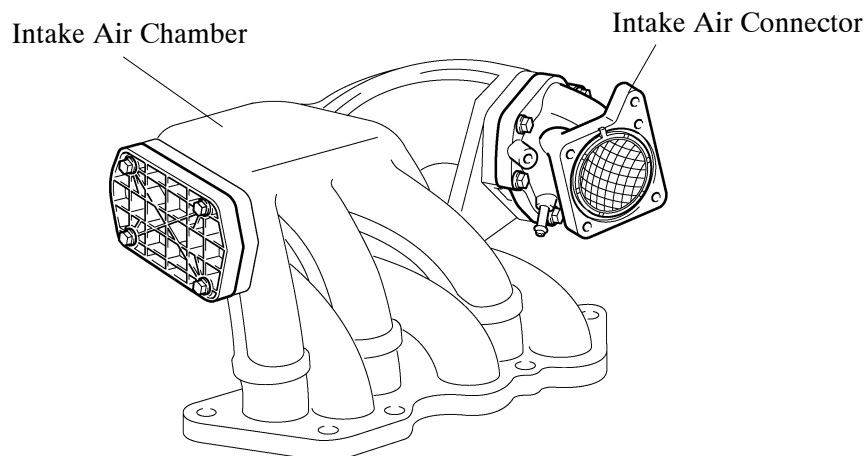


241EG15

4. Intake Air Chamber

The following measures have been taken to reduce the weight of the intake air chamber:

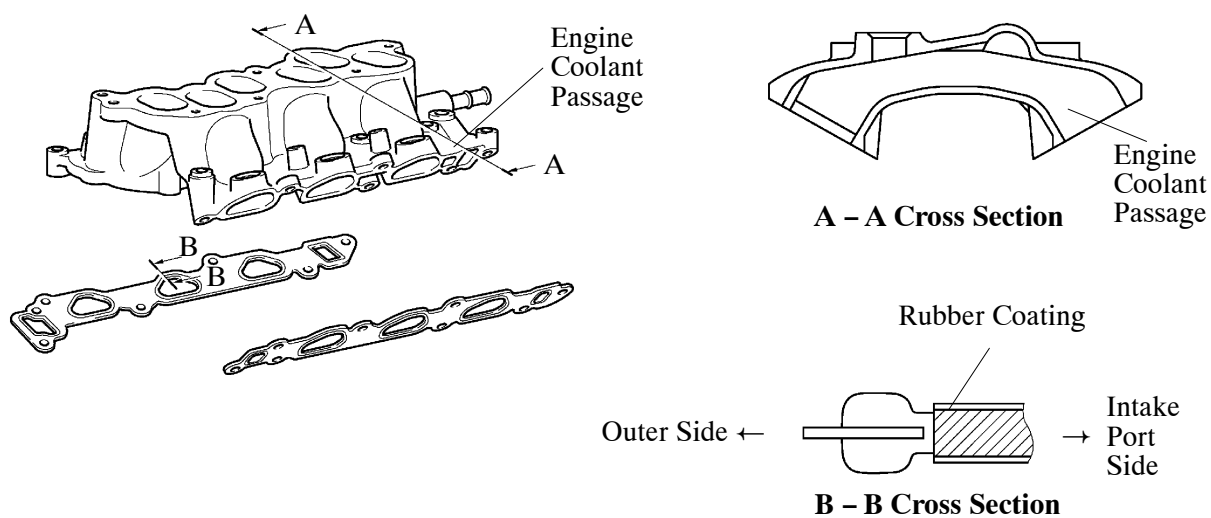
- The intake air connector is made of aluminum alloy
- The intake air chamber is made of plastic similar to the RX330



277EG13

5. Intake Manifold

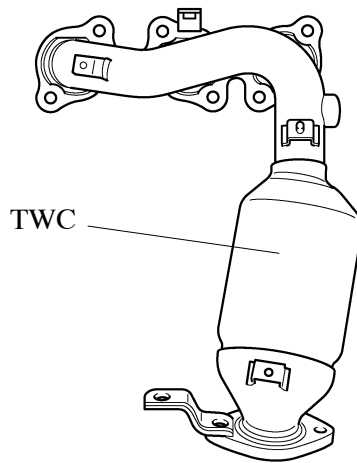
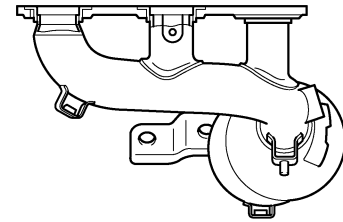
- The port diameter of the intake manifold and the port length have been optimized.
- An engine coolant passage connects the left and right banks at the rear end of the intake manifold.
- The intake manifold gaskets has rubber coating applied onto surface, and provide superior durability.



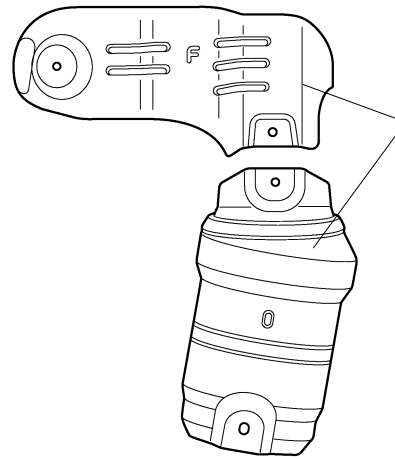
211EG35

6. Exhaust Manifold

- Air fuel ratio sensors are located on the exhaust manifolds.
- A high temperature resistant exhaust manifold with an integrated TWC (Three-Way Catalytic converter) is used.
- Ceramic type TWC is used. This TWC enables to improve exhaust emissions by optimizing the cells density.



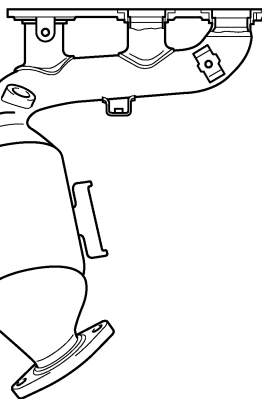
TWC



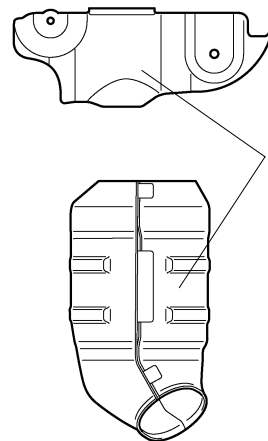
Heat Insulators

277EG14

for Left Bank

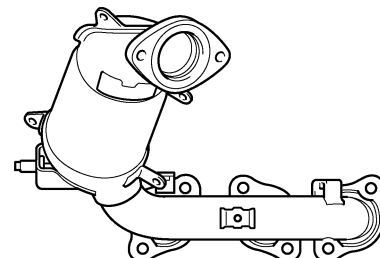


TWC



Heat Insulators

277EG15

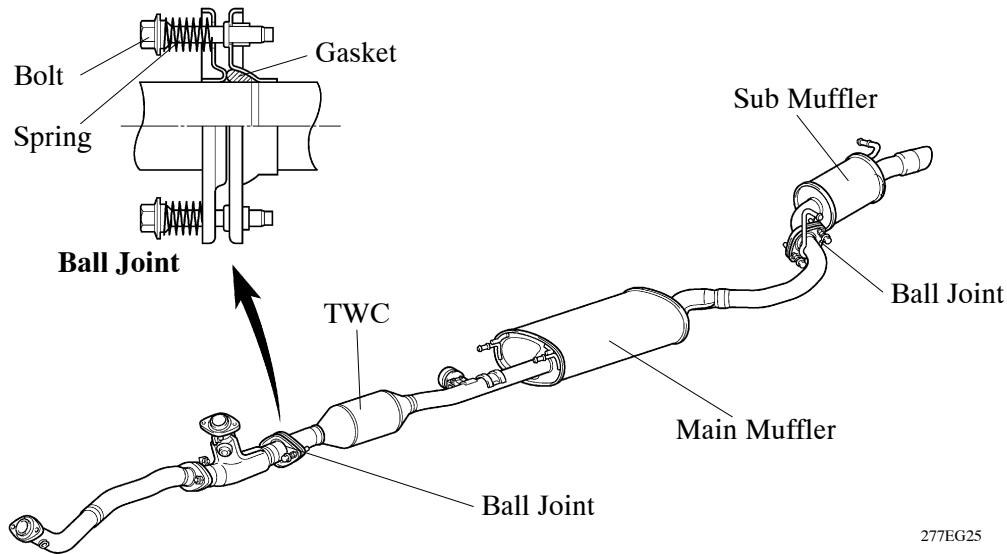


for Right Bank

7. Exhaust Pipe

General

- Ceramic type TWC is used. This TWC enables to improve exhaust emissions by optimizing the cells density.
- 2-way exhaust control system is provided to reduce noise and back pressure in the main muffler.
- A ball joint is used to join the exhaust front pipe, exhaust center pipe and exhaust tail pipe. As a result, a simple construction and improved reliability have been realized.
- A large-capacity, main muffler is used in the center of the vehicle to improve quietness.



277EG25

2-Way Exhaust Control System

- A 2-way exhaust control system is used.
- At lower engine speeds, this system enable a quieter operation with control valve close in main muffler.
- The valve opens steplessly in accordance with engine condition and this system reduce the back pressure at higher engine speeds.

1) Construction

The control valve is enclosed in the main-muffler. When the exhaust gas pressure overcomes the spring pressure, the control valve opens steplessly in accordance with the exhaust gas pressure.

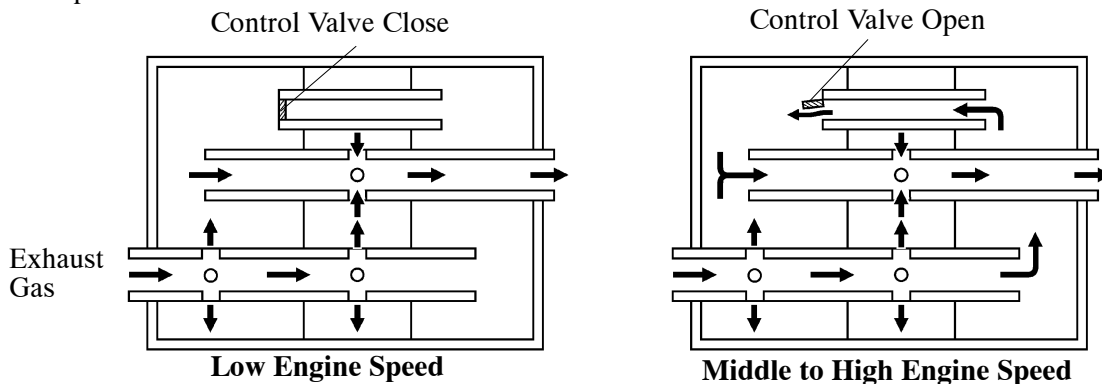
2) Operation

a. When Control Valve is Closed (low engine speed)

Since the pressure in the main muffler is low, the control valve is closed. Hence exhaust gas does not pass the bypass passage, and exhaust noise decreased by the main muffler.

b. When Control Valve is Open (middle to high engine speed)

The valve opens more as the engine speed and the back pressure in the muffler increase. This allows a large volume of exhaust gas to pass the bypass passage, thereby substantially decreasing the back pressure.



241EG19

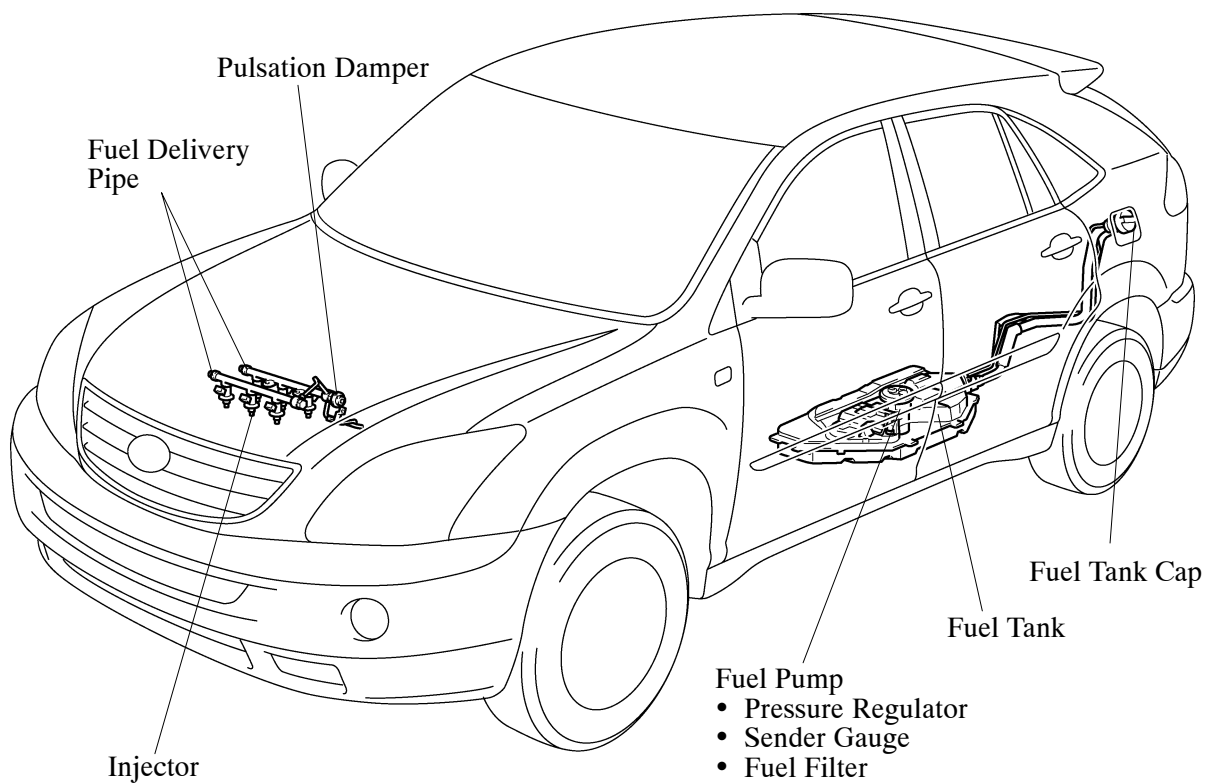
■ FUEL SYSTEM

1. General

- A compact fuel pump in which a fuel filter and pressure regulator are integrated in the module fuel pump assembly is used.
- A quick connectors are used to connect the fuel pipe with the fuel hose to improve serviceability.

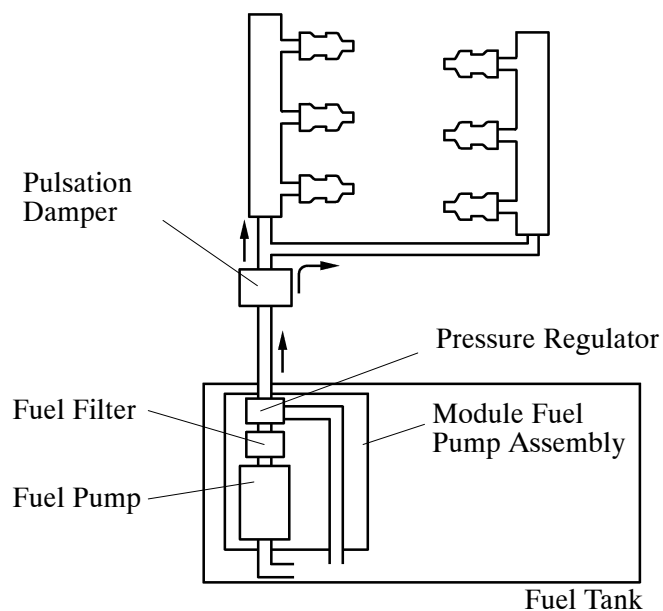
— Main Changes from Current RX330 —

The material of the fuel tank have been changed.

**EG**

2. Fuel Returnless System

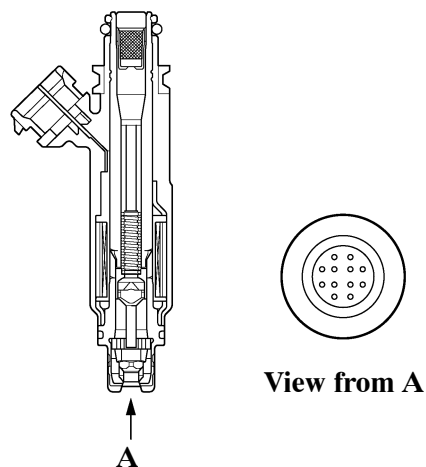
This type of fuel system is used to reduce the evaporative emission. As shown below, by integrating the fuel filter, pressure regulator, and fuel sender gauge with fuel pump assembly, the return of fuel from the engine area is discontinued and temperature rise inside the fuel tank is prevented.



208E117

3. Fuel Injector

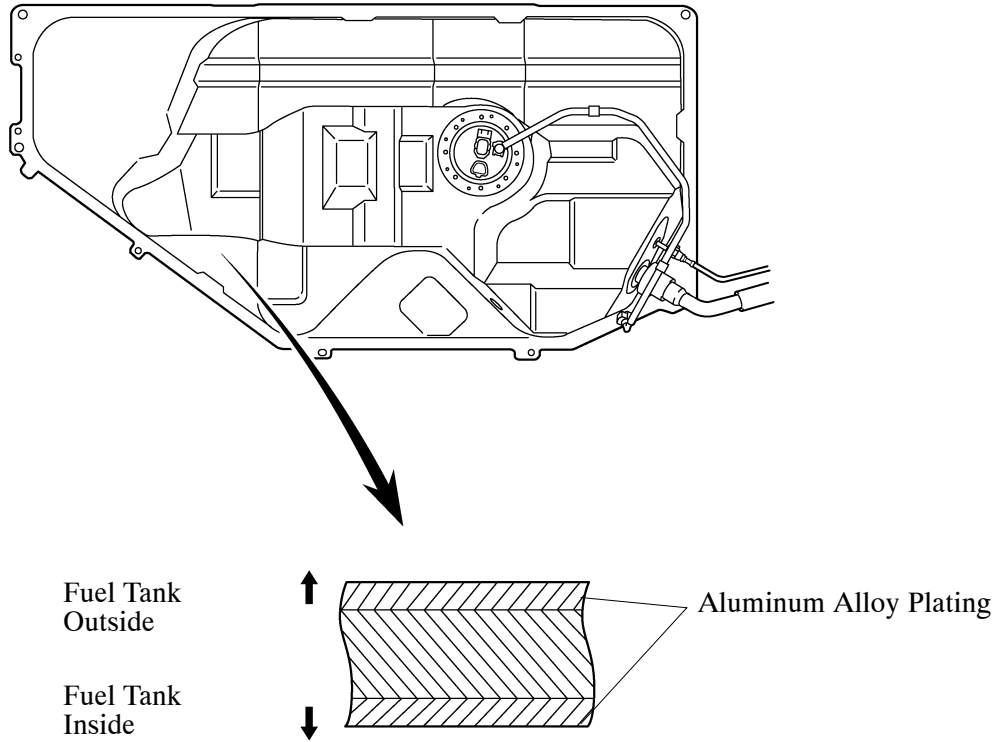
The 12-hole type injector is used to improve the atomization of fuel.



208EG118

4. Fuel Tank

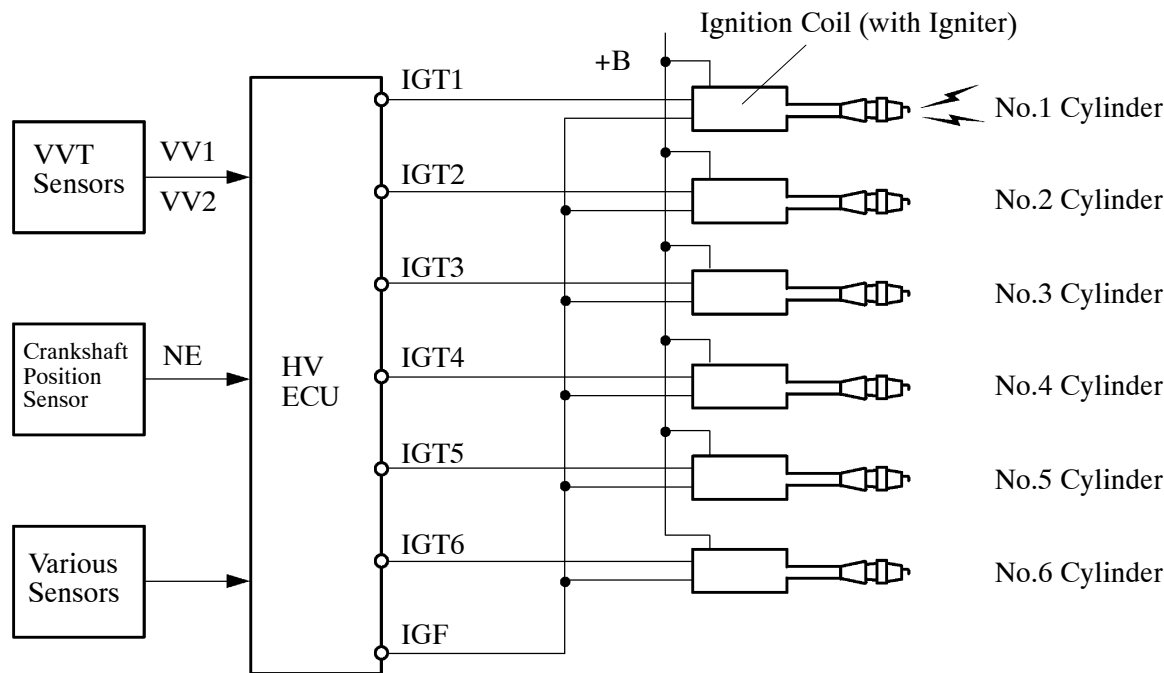
The fuel tank is used plated with aluminum for improved rust resistance.

**EG**

■ IGNITION SYSTEM

1. General

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



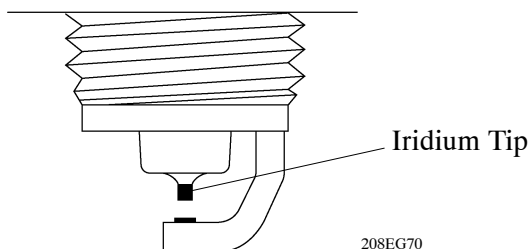
161EG43

2. Ignition Coil

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

3. Spark Plug

Iridium-tipped spark plugs are used to realize a 193,000 km (120,000 mile) maintenance-free operation. By making the center electrode of iridium, the same ignition performance as of the platinum-tipped spark plug and further improvement of durability have been realized.



208EG70

► Specifications ◀

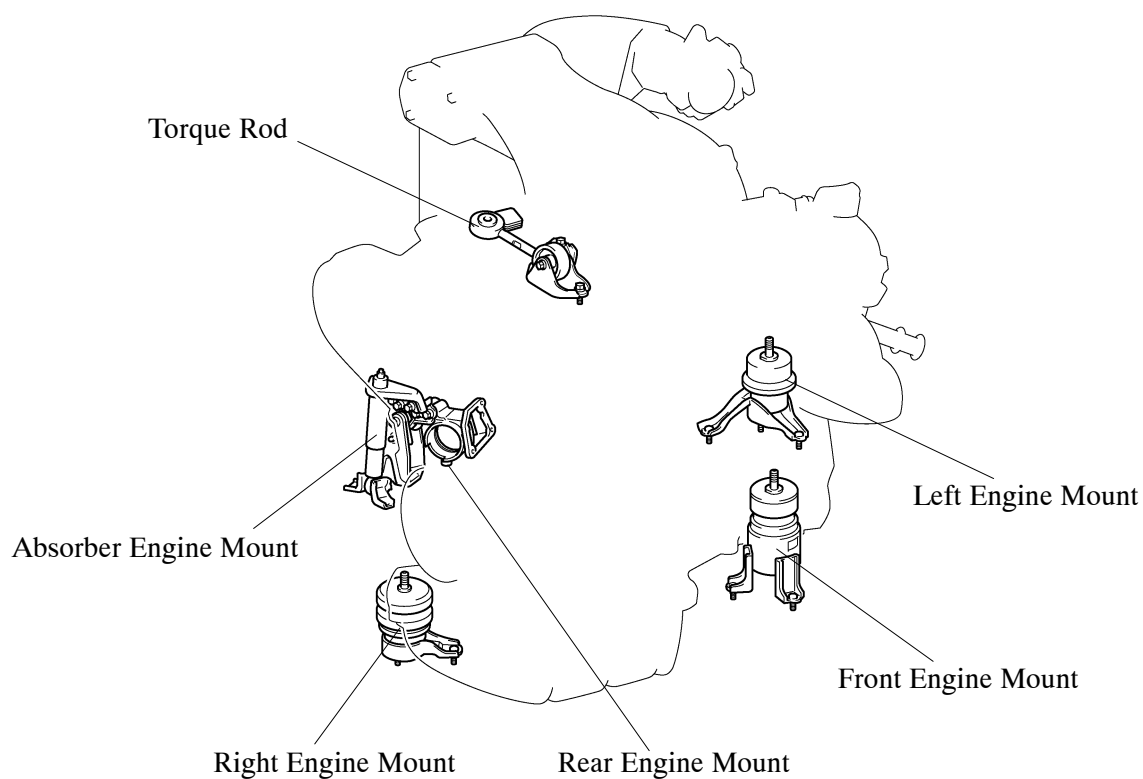
DENSO	SK20R11
NGK	IFR6A11
Plug Gap	1.0 - 1.1 mm (0.039 - 0.043 in.)

■ ENGINE MOUNT

A 4-point support on the front sub-frame are used.

— Main Changes from Current RX330 —

- The front and rear engine mounts have been relocated.
- An absorber engine mount is used for the rear.
- The engine absorber mount is used on the rear engine mount and a hydraulic engine mounts are used on the right and left sides to realize low noise and vibration and to achieve high levels of both riding comfort and drivability.



ENGINE CONTROL SYSTEM

1. General

- The engine is controlled by the THS ECU. The THS ECU determines the motive force required by the driver in accordance with the pedal effort applied by the driver on the accelerator. Then, the THS ECU determines the driving conditions of the vehicle in accordance with the vehicle speed, vehicle load, and various sensor signals. Furthermore, the THS ECU starts and stops the engine in accordance with the motive force required by the driver, regardless of the driving conditions, and generates the required engine motive force.
- The engine control system of the 3MZ-FE engine on the RX400h has following system.

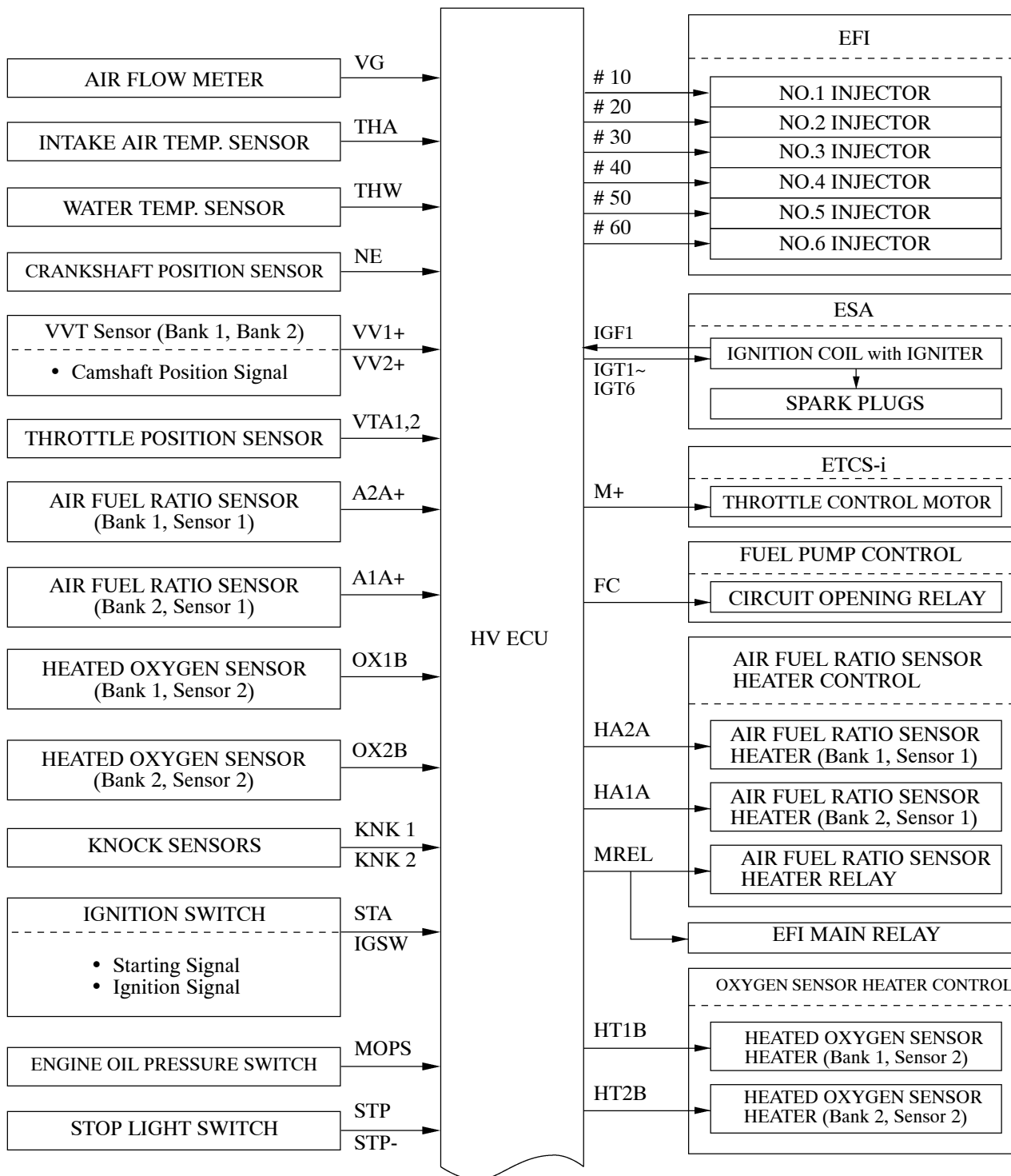
System	Outline	RX400h THS ECU	RX330 ECM
EFI (Electronic Fuel Injection)	• An L-type FI system directly detects the intake air mass with a hot wire type air flow meter. • The fuel injection system is a sequential multiport fuel injection system. • Fuel injection takes two forms: Synchronous injection, which always takes place with the same timing in accordance with the basic injection duration and an additional correction based on the signals provided by the sensors. Non-synchronous injection, which takes place at the time an injection request based on the signals provided by the sensors is detected, regardless of the crankshaft position. • Synchronous injection is further divided into group injection during a cold start, and independent injection after the engine is started.	○	○
ESA (Electronic Spark Advance)	• Ignition timing is determined by the THS ECU/ECM based on signals from various sensors. The THS ECU/ECM corrects ignition timing in response to engine knocking. • This system selects the optimal ignition timing in accordance with the signals received from the sensors and sends the (IGT) ignition signal to the igniter.	○	○
ETCS-i (Electronic Throttle Control System-intelligent (See page EG-46))	• Optimally controls the throttle valve opening in accordance with the amount of accelerator pedal effort and the condition of the engine and the vehicle. • A link-less type is used, without an accelerator cable. • An accelerator pedal position sensor is provided on the accelerator pedal. • A no-contact type throttle position sensor and accelerator pedal position sensor are used.	○	○
VVT-i (Variable Valve Timing-intelligent (See page EG-49))	• Controls the intake camshaft to an optimal valve timing in accordance with the engine conditions and the control request received from the THS ECU/ECM.	○	○
	• The maximum retard closing timing of the intake valve has been changed from 64° to 92° ABDC (After Bottom-Dead-Center). As a result, the cold-starting performance of the engine has been improved.	○	-
Air Fuel Ratio Sensor, Oxygen Sensor Heater Control	Maintains the temperature of the air fuel ratio sensor or oxygen sensor at an appropriate level to increase accuracy of detection of the oxygen concentration in the exhaust gas.	○	○

(Continued)

System	Outline	RX400h THS ECU	RX330 ECM
Cooling Fan Control (See page EG-53)	The THS ECU/ECM steplessly controls the speed of the fans in accordance with the engine coolant temperature, vehicle speed, engine speed, and air conditioning operating conditions. As a result, the cooling performance has been improved.	○	○
Fuel Pump Control	- Fuel pump operation is controlled by signal from the THS ECU/ECM. - A fuel cut control is used to stop the fuel pump when the airbag is deployed during front or side collision.	○	○
Evaporative Emission Control	The THS ECU controls the purge flow of evaporative emission (HC) in the charcoal canister in accordance with engine conditions.	○	○
THS Immobilizer	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid ignition key.	○	-
Diagnosis (See page EG-55)	- When the THS ECU/ECM detects a malfunction, the THS ECU/ECM diagnoses and memorizes the failed section. - All the DTCs (Diagnostic Trouble Codes) have been made to correspond to the SAE controlled codes.	○	○
Fail-Safe (See page EG-55)	When the THS ECU/ECM detects a malfunction, the THS ECU/ECM stops or controls the engine according to the data already stored in the memory.	○	○

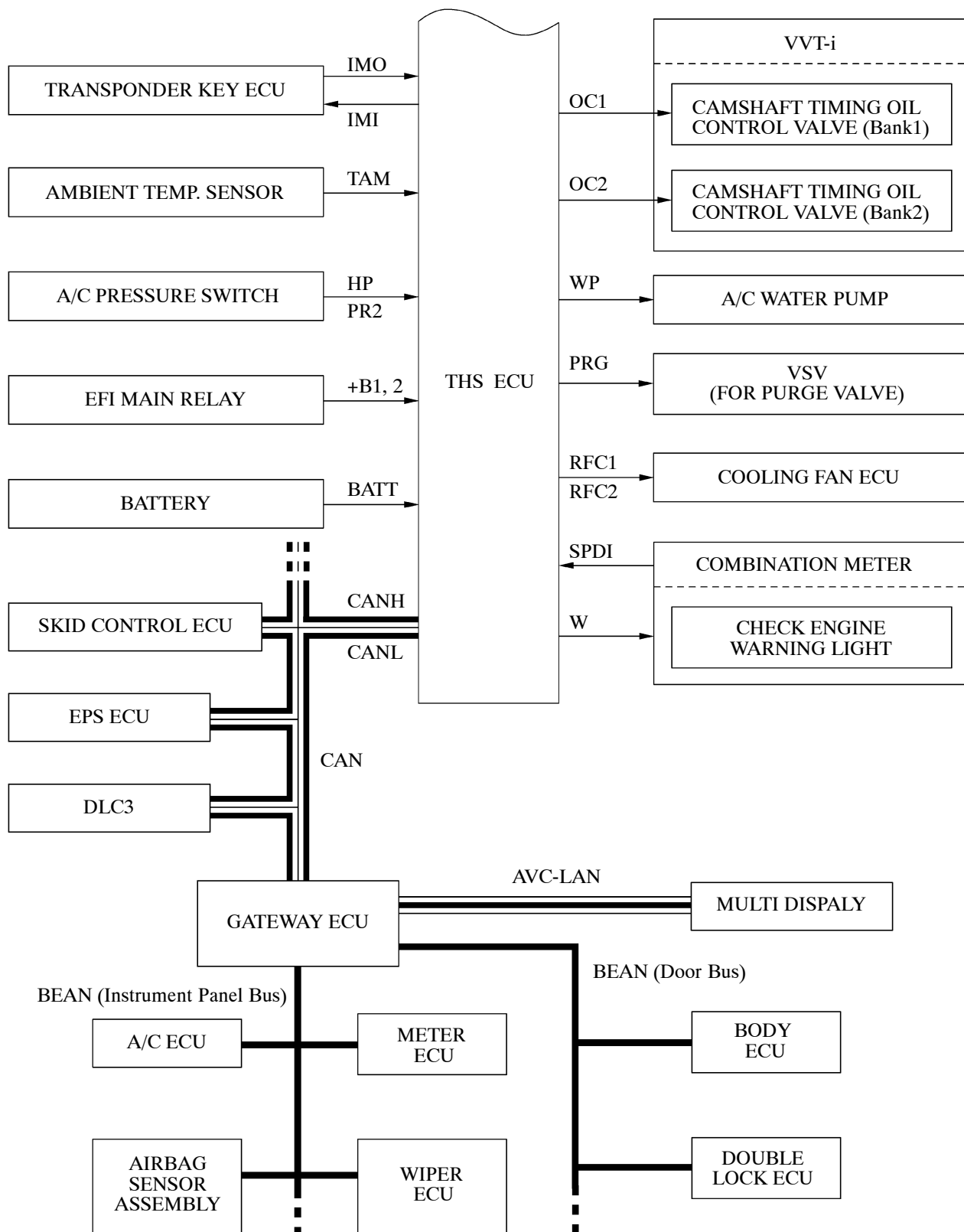
2. Construction

The configuration of the engine control system in the 3MZ-FE engine on the RX400h is as shown in the following chart.



(Continued)

278EG03

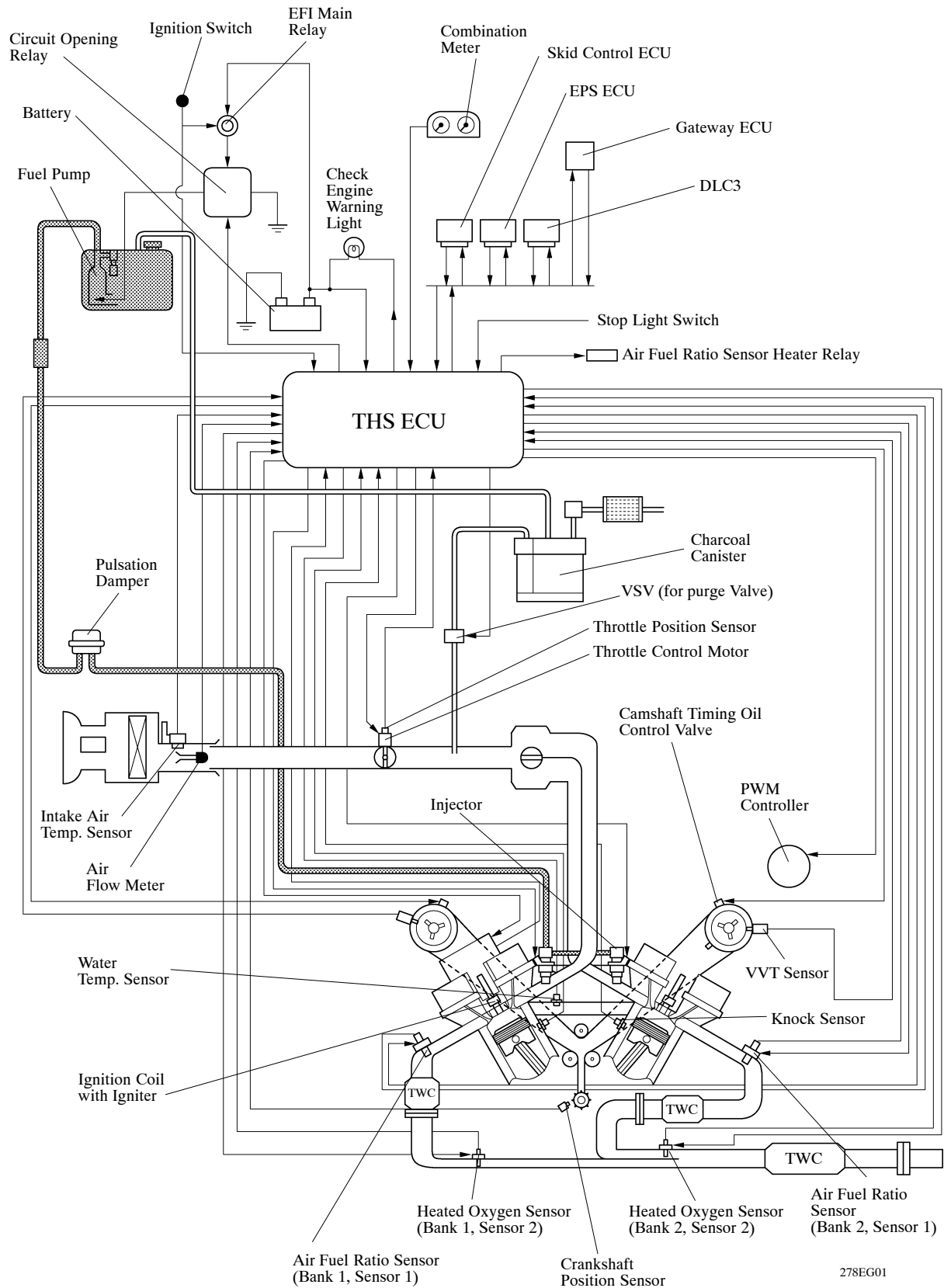


EG

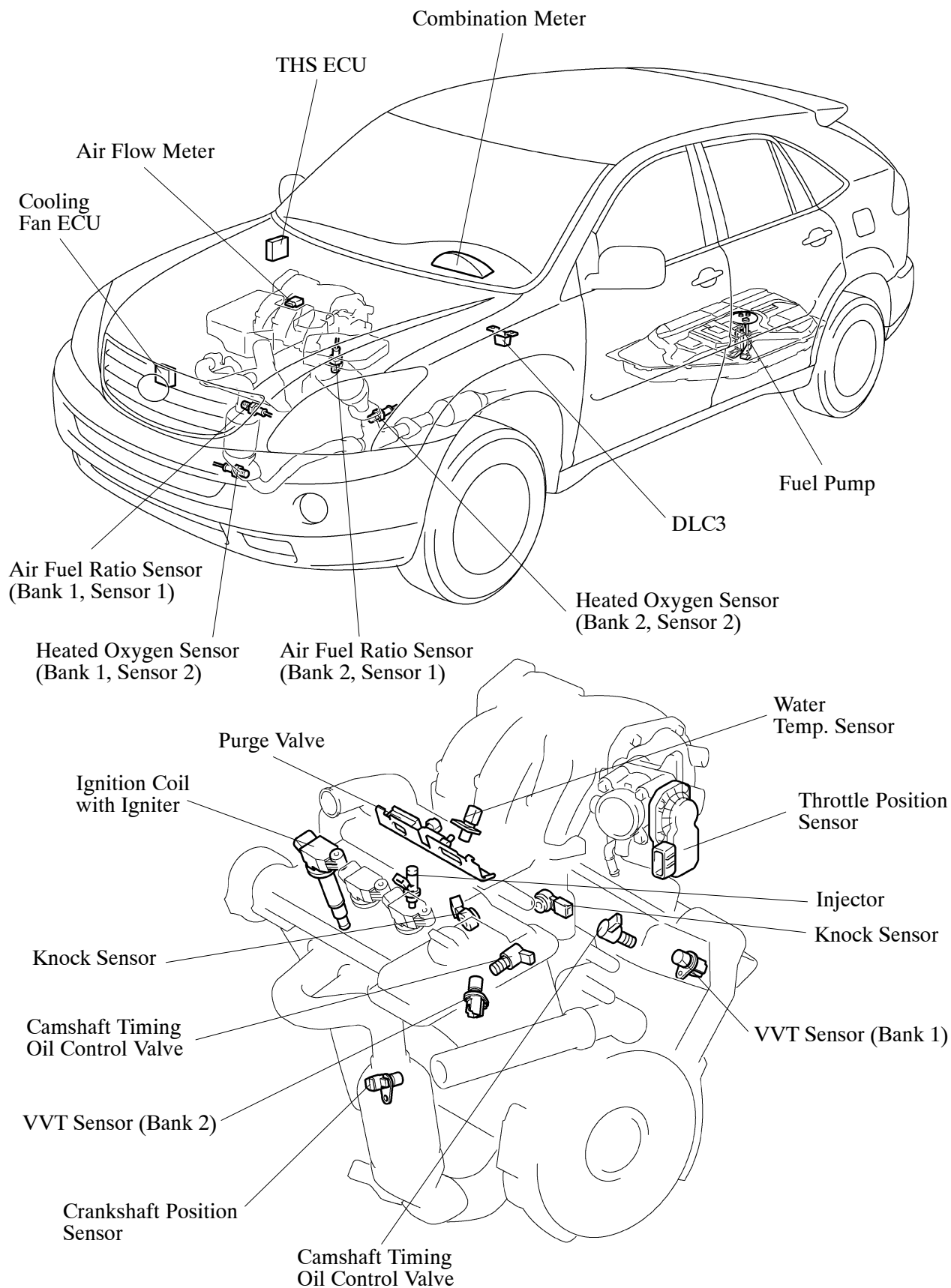
► MPX Communication ◀

Type	ECU	Signals Exchanged with ECU	
		Transmission Signals	Reception Signals
CAN	Skid Control ECU	—	• Engine speed • Ambient Temp. sensor
	EPS ECU	—	• Test mode • Engine speed
BEAN (Instrument Panel Bus)	A/C ECU	—	• Water Temp. sensor • Engine speed • Ambient Temp. sensor
	Airbag Sensor Assembly	—	• Test mode • Engine speed
	Wiper ECU	—	• Engine speed
	Meter ECU	Fuel Sender Gauge Level	• Water Temp. sensor • Engine speed • Fuel injection volume • Engine oil pressure switch • Test mode • Fuel lid sensor
BEAN (Door Bus)	Double Lock ECU	—	• Engine speed • Test mode
	Body ECU	—	• Engine speed • Test mode
AVC-LAN	Multi Display	—	• Water Temp. sensor • Engine oil pressure switch • Test mode

3. Engine Control System Diagram



4. Layout of Main Components



LHD Model

278EG02

5. Main Components of Engine Control System

General

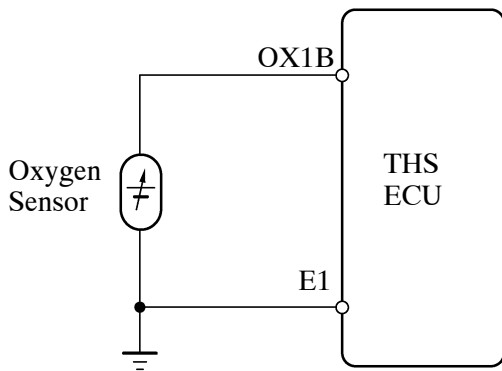
The main components of the 3MZ-FE engine control system are as follows:

Components	Outline	Quantity	Function	RX400h	RX330
THS ECU	32-bit CPU	1	The THS ECU optimally controls the EFI and ESA to suit the operating conditions of the engine in accordance with the signals provided by the sensors.	○	-
Oxygen Sensor (Bank 1, Sensor 2) (Bank 2, Sensor 2)	with Heater Type (Cup Type)	2	This sensor detects the oxygen concentration in the exhaust emission by measuring the electromotive force which is generated in the sensor itself.	○	○
Air Fuel Ratio Sensor (Bank 1, Sensor 1) (Bank 2, Sensor 1)	with Heater Type (Planar Type)	2	As with the oxygen sensor, this sensor detects the oxygen concentration in the exhaust emission. However, it detects the oxygen concentration in the exhaust emission linearly.	○	○
Air Flow Meter	Hot-wire Type	1	This sensor has a built-in hot-wire to directly detect the intake air volume.	○	○
Crankshaft Position Sensor (Rotor Teeth)	Pick-up Coil Type (36-2)	1	This sensor detects the engine speed and performs the cylinder identification.	○	○
VVT Sensor LH, RH (Rotor Teeth)	Pick-up Coil Type (3)	2	This sensor performs the cylinder identification.	○	○
Water Temperature Sensor	Thermistor Type	1	This sensor detects the water temperature by means of an internal thermistor.	○	○
Intake Air Temperature Sensor	Thermistor Type	1	This sensor detects the intake air temperature by means of an internal thermistor.	○	○
Knock Sensor 1,2	Built-in Piezoelectric Type (Flat Type)	2	This sensor detects an occurrence of the engine knocking indirectly from the vibration of the cylinder block caused by the occurrence of engine knocking.	○	○
Throttle Position Sensor	No-contact Type	1	This sensor detects the throttle valve opening angle.	○	○
Injector	12-Hole Type	6	The injector is an electromagnetically-operated nozzle which injects fuel in accordance with signals from the THS ECU.	○	○

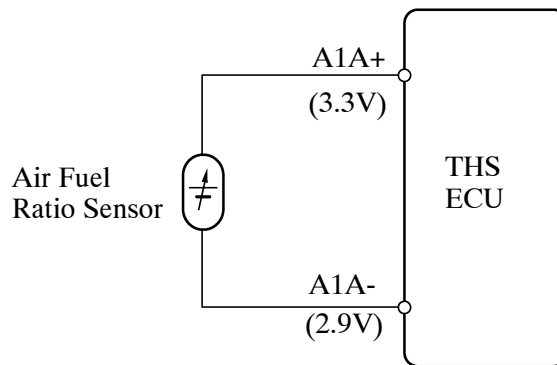
Oxygen Sensor and Air Fuel Ratio Sensor

1) General

- The oxygen sensor and the air fuel ratio sensor differ in output characteristics.
- The output voltage of the oxygen sensor changes in accordance with the oxygen concentration in the exhaust emission. The THS ECU uses this output voltage to determine whether the present air-fuel ratio is richer or leaner than the stoichiometric air-fuel ratio.
- Approximately 0.4V is constantly applied to the air-fuel ratio sensor, which outputs an amperage that varies in accordance with the oxygen concentration in the exhaust emission. The THS ECU converts the changes in the output amperage into voltage in order to linearly detect the present air-fuel ratio.

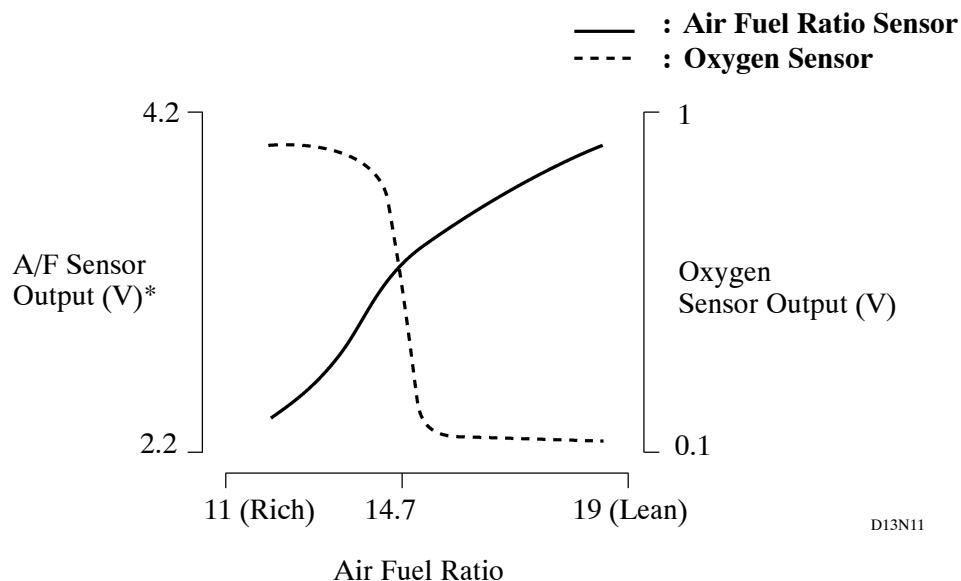


Oxygen Sensor Circuit



Air Fuel Ratio Sensor Circuit

271EG44

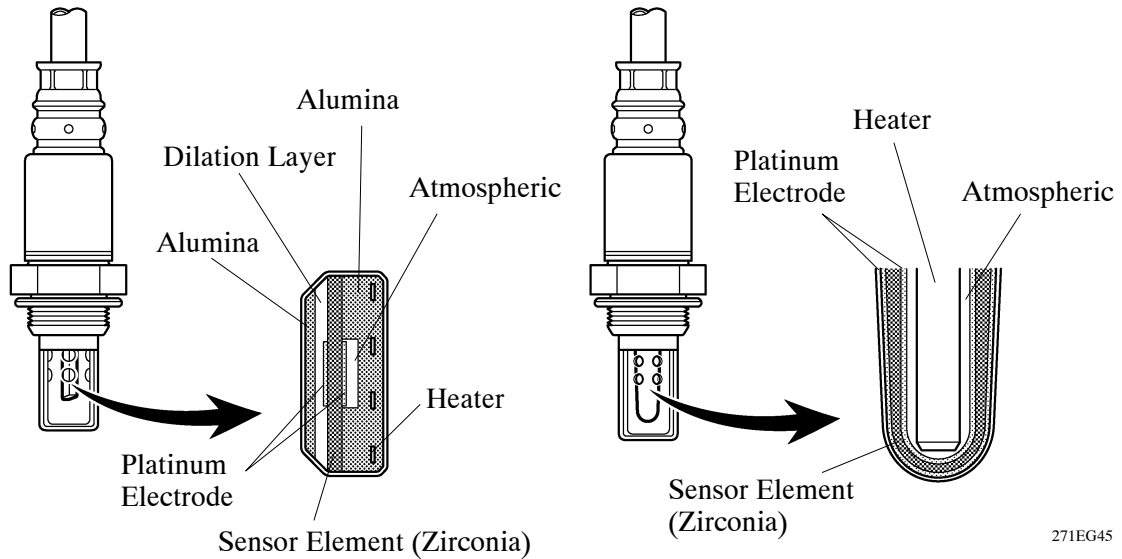


D13N11

*: This calculation value is used internally in the THS ECU, and is not a THS ECU terminal voltage.

2) Construction

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



Planer Type Air Fuel Ratio Sensor

Cup Type Oxygen Sensor

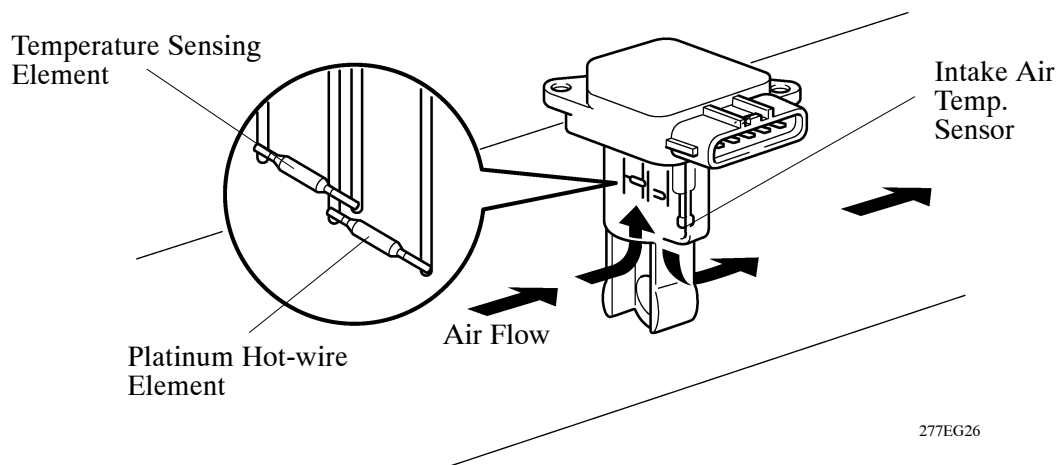
271EG45

► Warm-up Specification ◀

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

Air Flow Meter

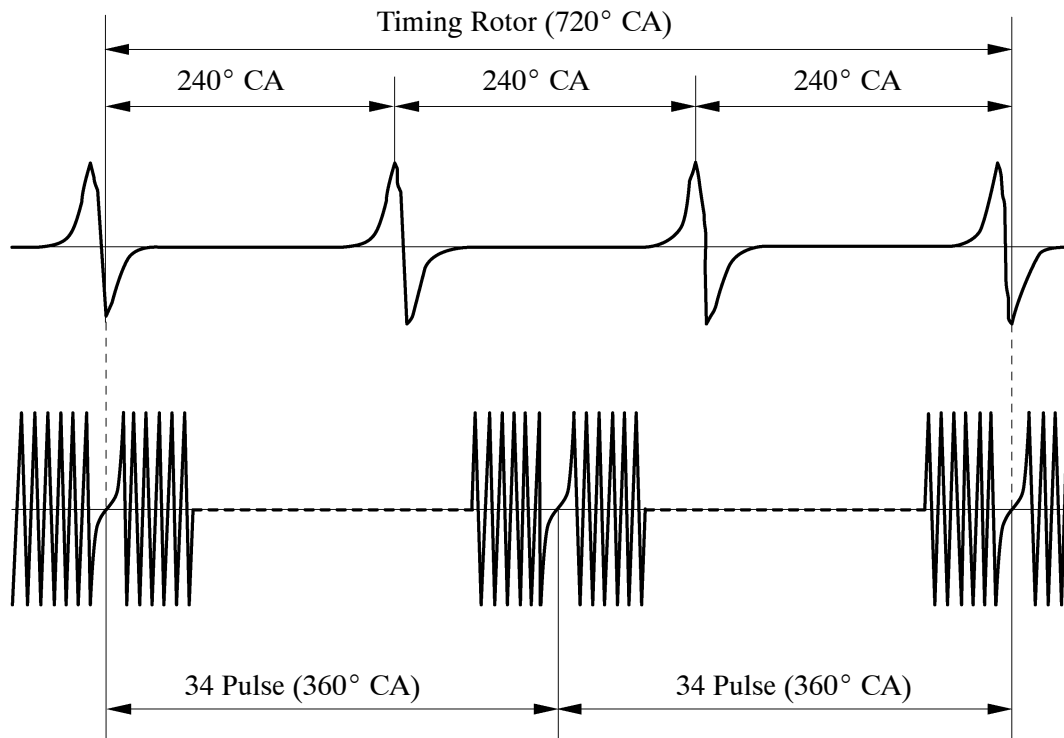
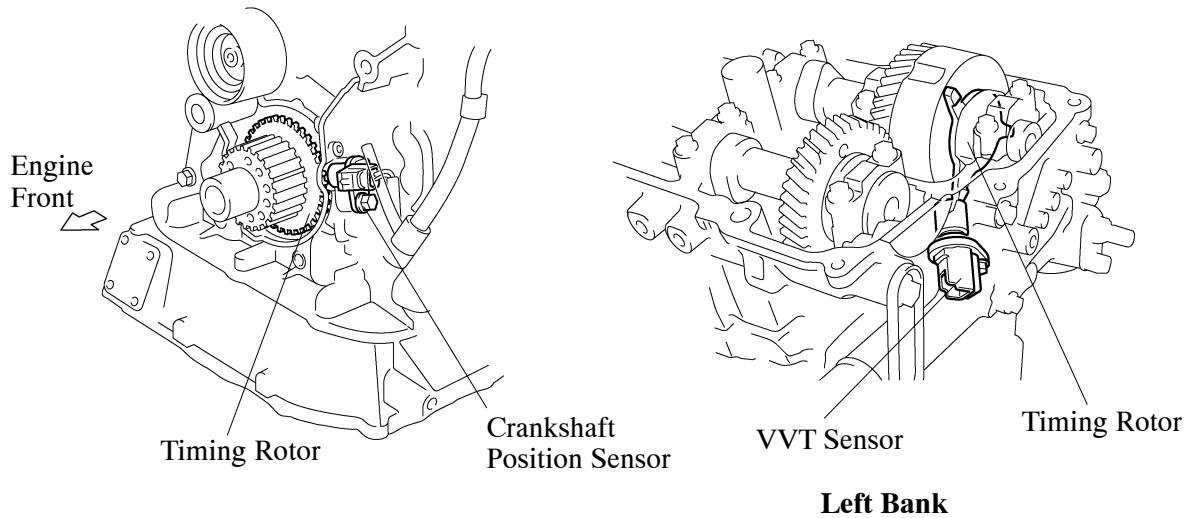
- This air flow meter, which is a plug-in type, allows a portion of the intake air to flow through the detection area. By directly measuring the mass and the flow rate of the intake air, the detection precision has been improved and the intake air resistance has been reduced.
- This air flow meter has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



277EG26

Crankshaft Position and VVT 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.
- The VVT sensors are mounted on the right and left banks of the cylinder heads. To detect the camshaft position, these sensors pick up the protrusion of the timing rotor that is secured to the camshaft in front of the VVT controller. In addition, each sensor generates 3 pulses for every 2 revolutions of the crankshaft.



Knock Sensor (Flat Type)

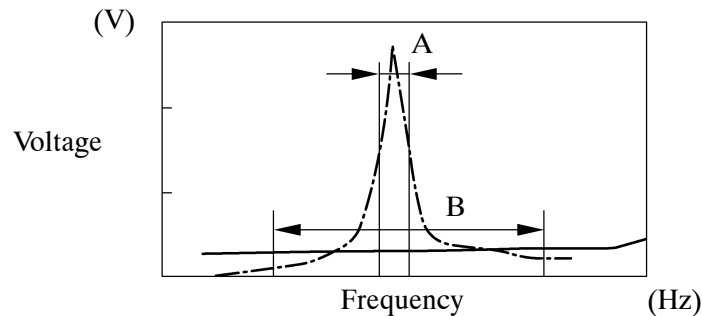
1) General

- In the conventional type knock sensor (resonant type), a vibration plate which has the same resonance point as the knocking frequency of the engine is built in and can detect the vibration in this frequency band.

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

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

— · — : Resonance Characteristic of Conventional Type
 — : Resonance Characteristic of Flat Type



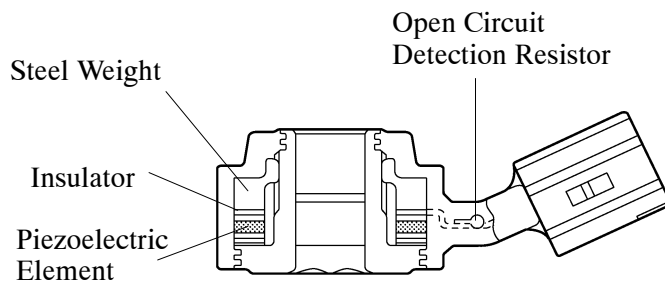
A: Detection Band of Conventional Type
 B: Detection Band of Flat Type

Characteristic of Knock Sensor

214EG04

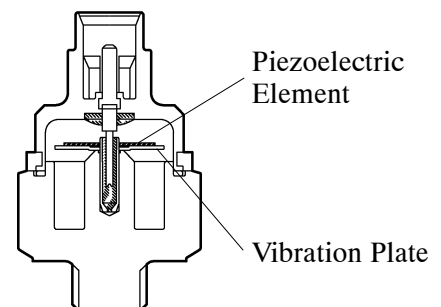
2) Construction

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



Flat Type Knock Sensor
(Non-Resonant Type)

214CE01

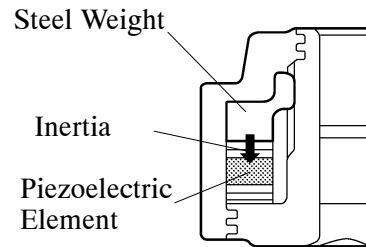


Conventional Type Knock Sensor
(Resonant Type)

214CE02

3) Operation

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

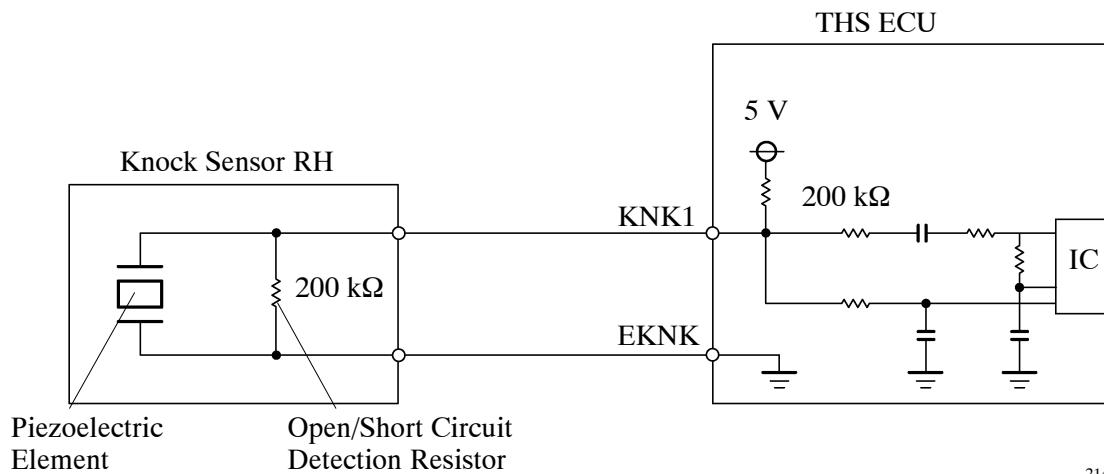


214CE08

4) Open/Short Circuit Detection Resistor

During the ignition is ON, the open/short circuit detection resistor in the knock sensor and the resistor in the THS ECU keep the voltage at the terminal KNK1 of engine constant.

An IC (Integrated Circuit) in the THS ECU is always monitoring the voltage of the terminal KNK1. If the open/short circuit occurs between the knock sensor and the THS ECU, the voltage of the terminal KNK1 will change and the THS ECU detects the open/short circuit and stores DTC (Diagnostic Trouble Code).



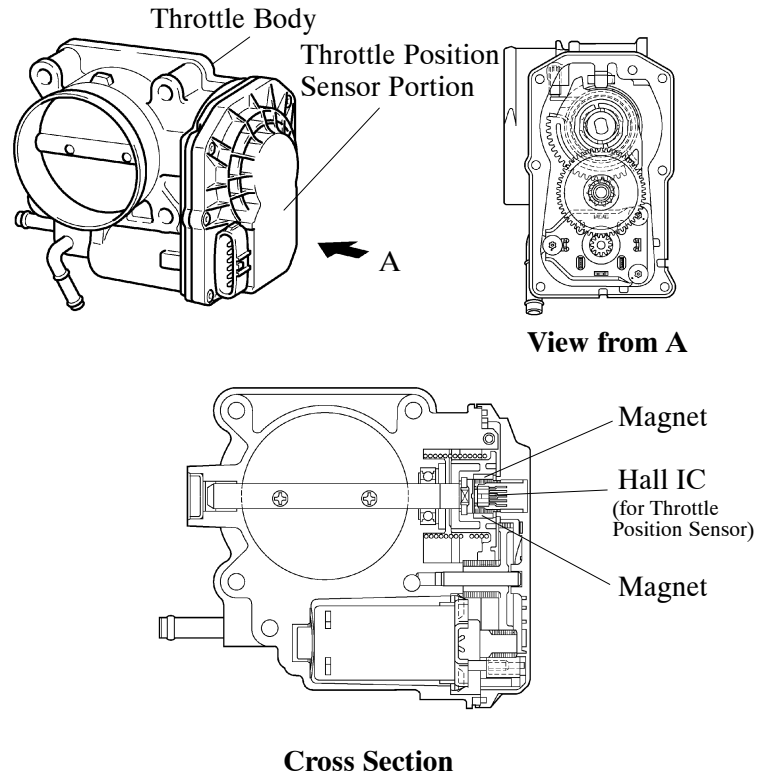
214CE06

Service Tip

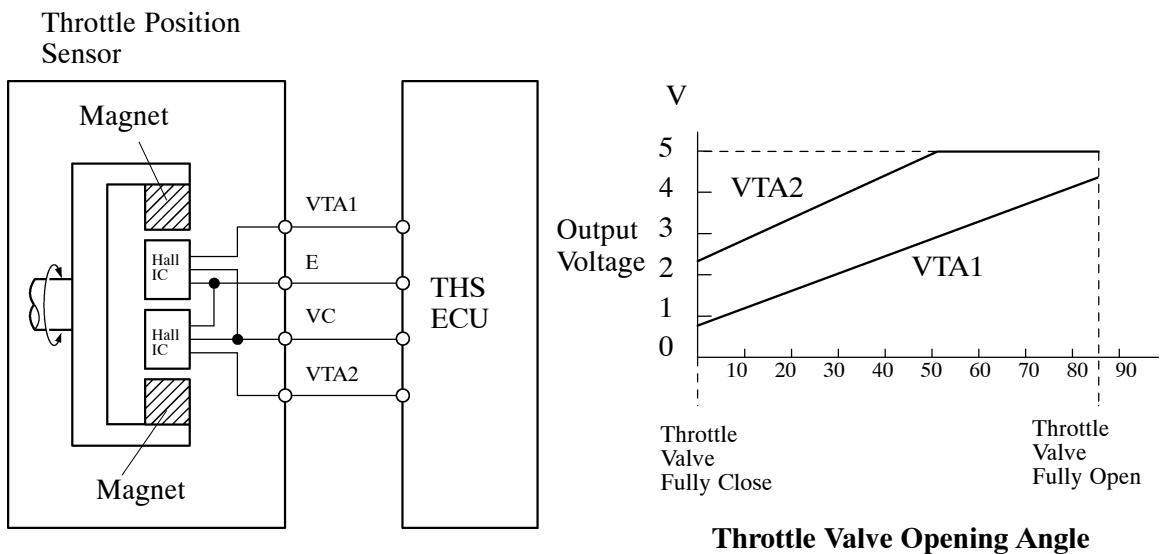
In accordance with the use of open/short circuit detection resistor, the inspection method for the sensor has been changed. For details, refer to LEXUS RX400h Repair Manual (Pub. No. RM1139E).

Throttle Position Sensor

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



241EG28



230LX12

238EG79

Service Tip

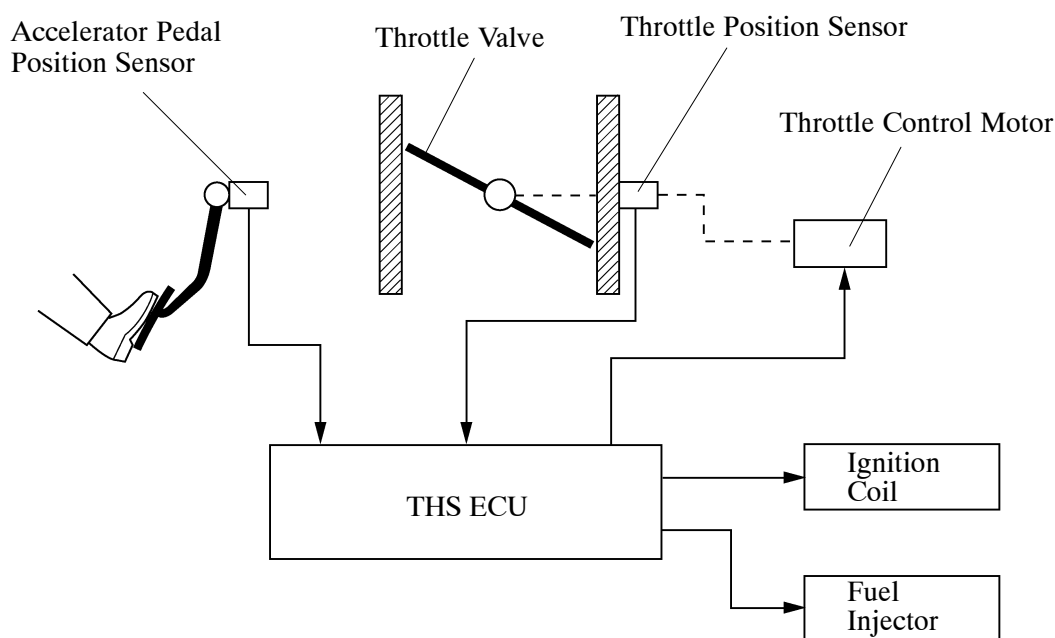
The inspection method differs from the conventional throttle position sensor because this sensor uses a Hall IC. For details, refer to the LEXUS RX400h Repair Manual (Pub. No. RM1139E.)

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

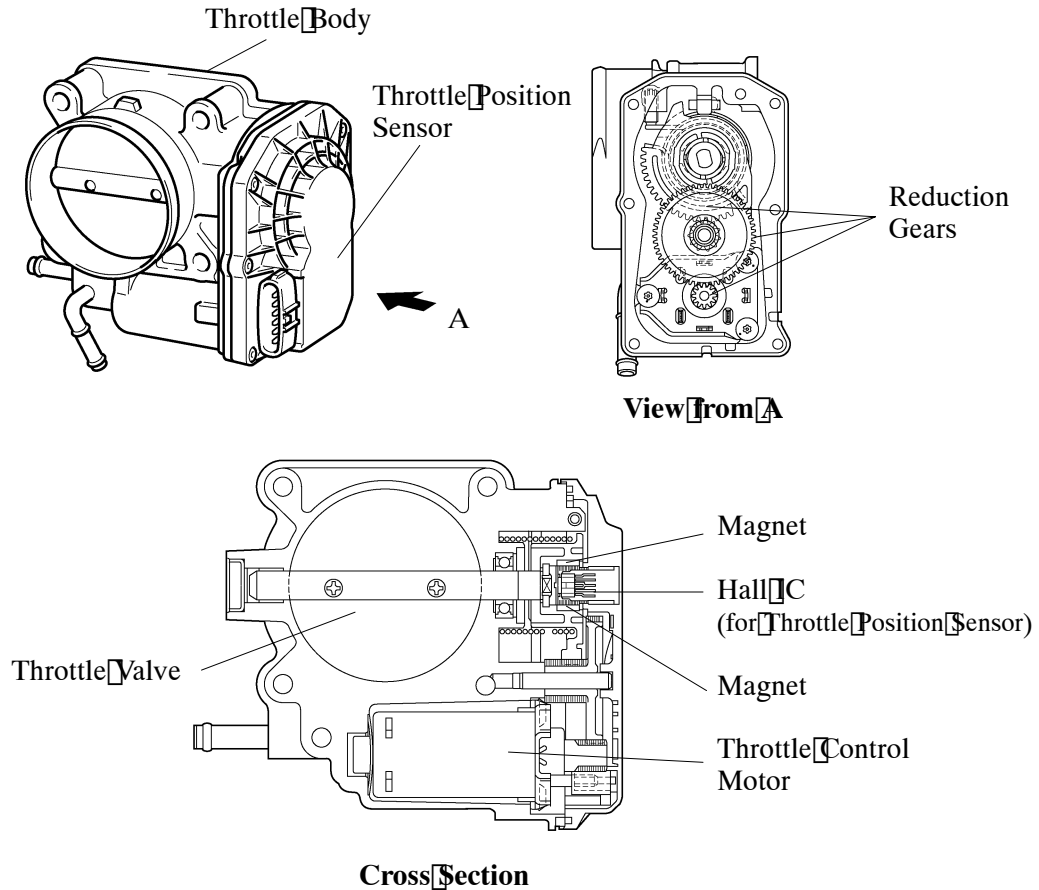
General

- The ETCS-i is used, providing excellent throttle control in all the operating ranges.
- In the conventional throttle body, the throttle valve opening is determined by the amount of the accelerator pedal effort. In contrast, the ETCS-i uses the THS 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.
- In case of an abnormal condition, this system transfers to the limp mode.

► System Diagram ◀



Construction



241EG28

1) Throttle Position Sensor

The throttle position sensor is mounted on the throttle body, to detect the opening angle of the throttle valve. For details, refer to Main Components of Engine Control System on [page 45](#).

2) Throttle Control Motor

A DC motor with excellent response and minimal power consumption is used for the throttle control motor. The THS 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 of the throttle valve.

Operation

1) General

The THS ECU drives the throttle control motor by determining the target throttle valve opening in accordance with the respective operating condition.

- a) Idle Speed Control
- b) VSC Coordination Control and TRC Throttle Control
- c) Cruise Control

a) Idle Speed Control

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

b) VSC Coordination Control and TRC Throttle Control

The effectiveness of VSC Coordination Control and TRC Throttle Control, are controlled by the throttle valve opening angle and the skid control ECU.

c) Cruise Control

A THS ECU with an integrated cruise control ECU directly actuates the throttle valve operation of the cruise Control.

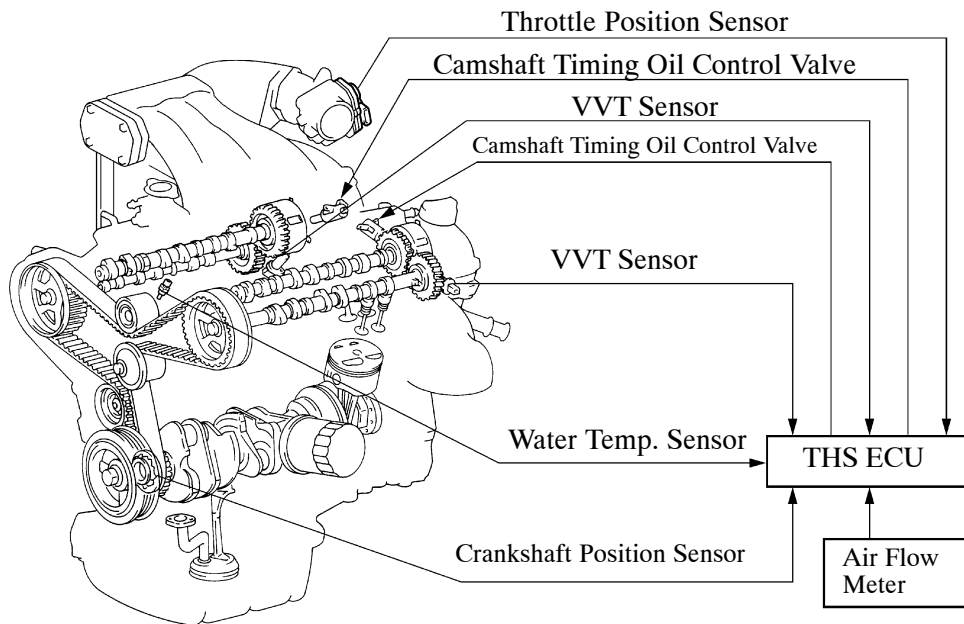
7. VVT-i (Variable Valve Timing-intelligent) System

General

The VVT-i system is designed to control the intake camshaft within a range of 60° (of Crankshaft Angle) to provide valve timing that is optimally suited to the engine condition. This improves torque in all the speed ranges as well as increasing fuel economy, and reducing exhaust emissions.

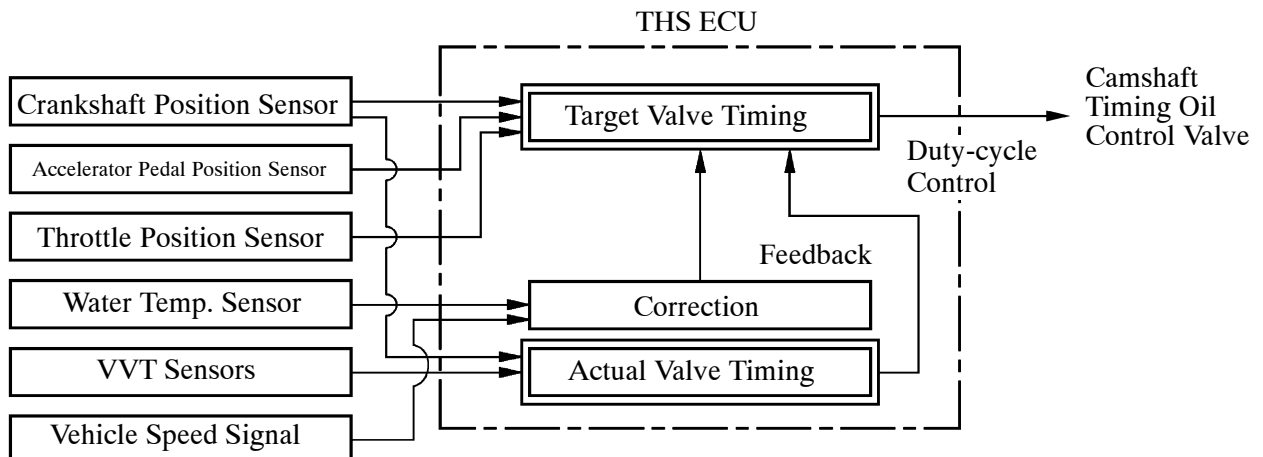
— Main Changes from Current RX330 —

The maximum closing timing of the intake valve has been retarded from 64° to 92° ABDC (After Bottom-Dead-Center). This reduces the effective cylinder capacity and temporarily lowers the combustion pressure, thus reducing the vibrations created during the start of the engine.



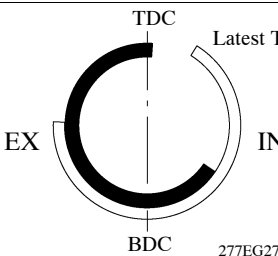
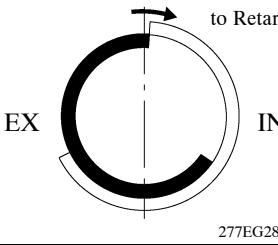
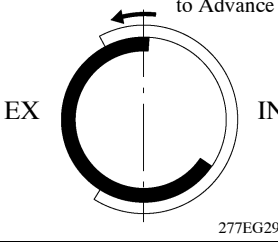
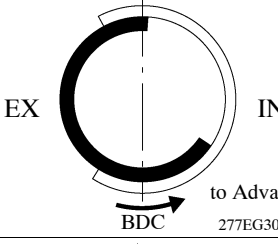
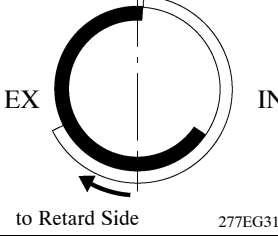
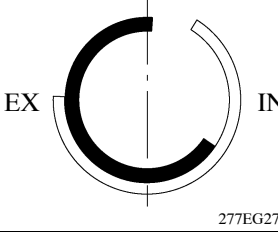
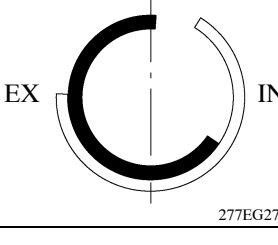
277EG33

- Using the engine speed, intake air volume, throttle position and water temperature, the THS ECU can calculate optimal valve timing for each driving condition and controls the camshaft timing oil control valve. In addition, the THS ECU uses signals from the camshaft position sensor and the crankshaft position sensor to detect the actual valve timing, thus providing feedback control to achieve the target valve timing.



221EG16

Effectiveness of the VVT-i System

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

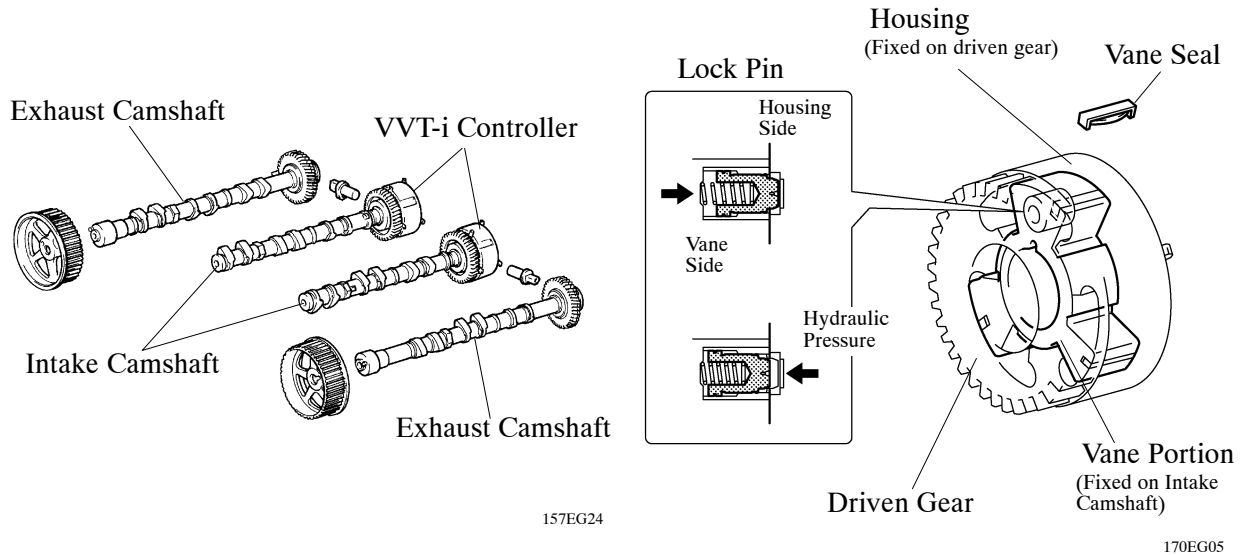
Construction

1) VVT-i Controller

This controller consists of the housing driven from the exhaust camshaft and the vane coupled with the intake camshaft.

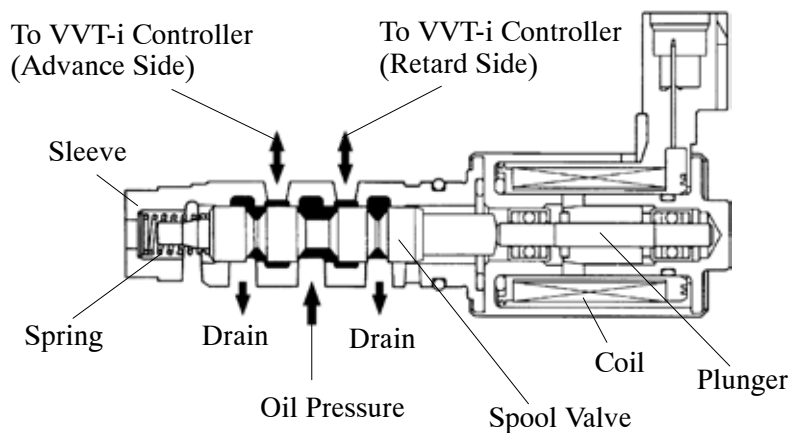
The oil pressure sent from the advance or retard side path at the intake camshaft causes rotation in the VVT-i controller vane circumferential direction to vary the intake valve timing continuously.

When the engine is stopped, the intake camshaft will be in the most retarded state to ensure startability. When hydraulic pressure is not applied to the VVT-i controller immediately after the engine has been started, the lock pin locks the movement of the VVT-i controller to prevent a knocking noise.



2) Camshaft Timing Oil Control Valve

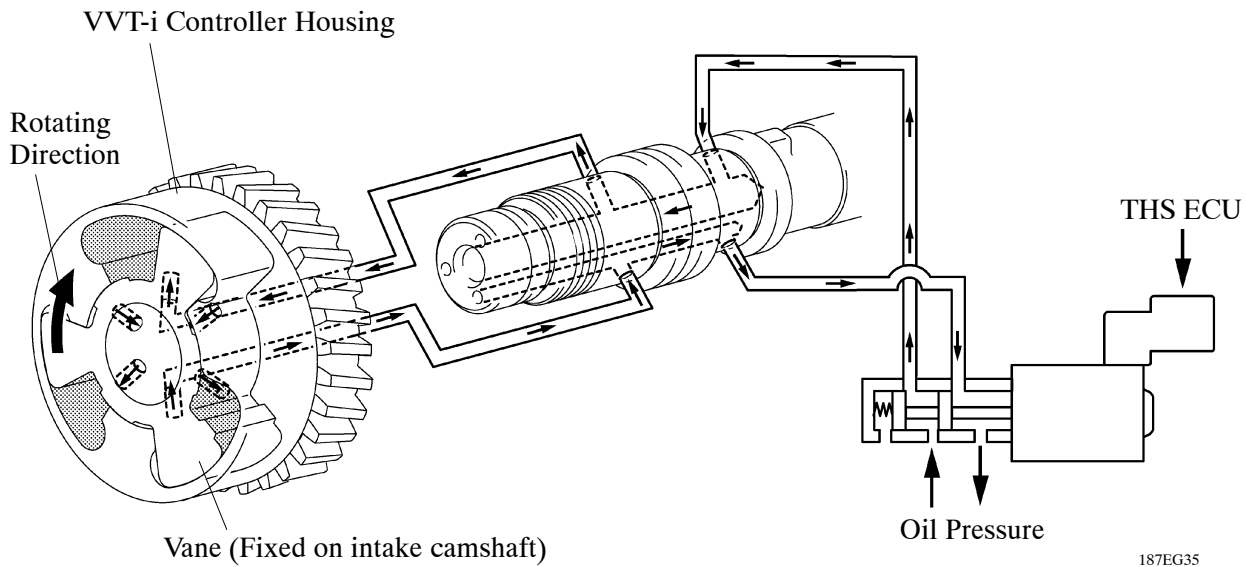
This camshaft timing oil control valve controls the spool valve position in accordance with the duty-cycle control from the THS ECU. This allows hydraulic pressure to be applied to the VVT-i controller advance or retard side. When the engine is stopped, the camshaft timing oil control valve is in the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



Operation

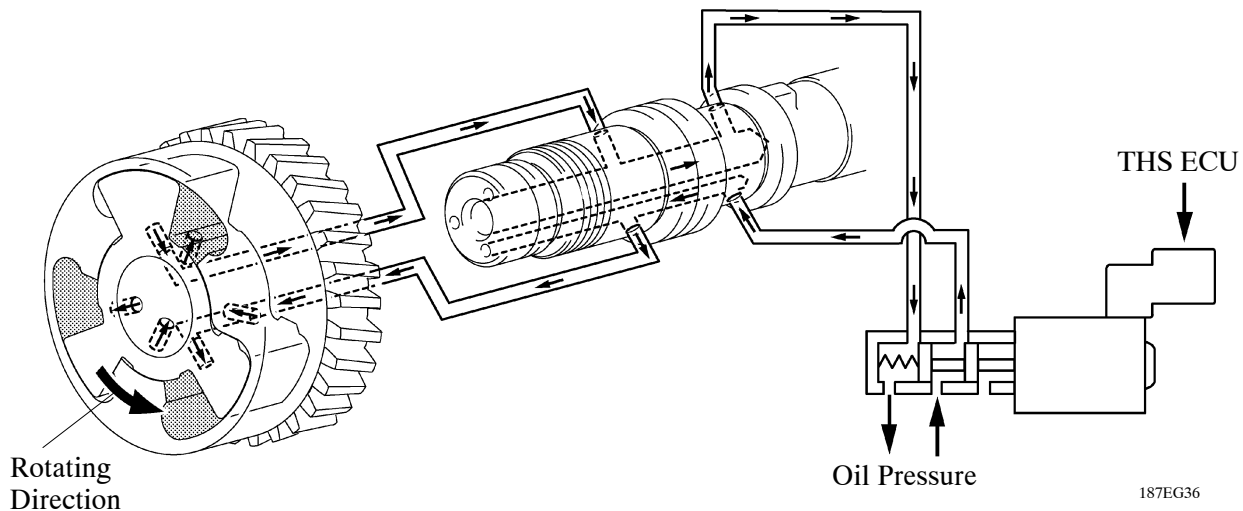
1) Advance

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



2) Retard

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



3) Hold

After reaching the target timing, the valve timing is held by keeping the camshaft timing oil control valve in the neutral position unless the traveling state changes.

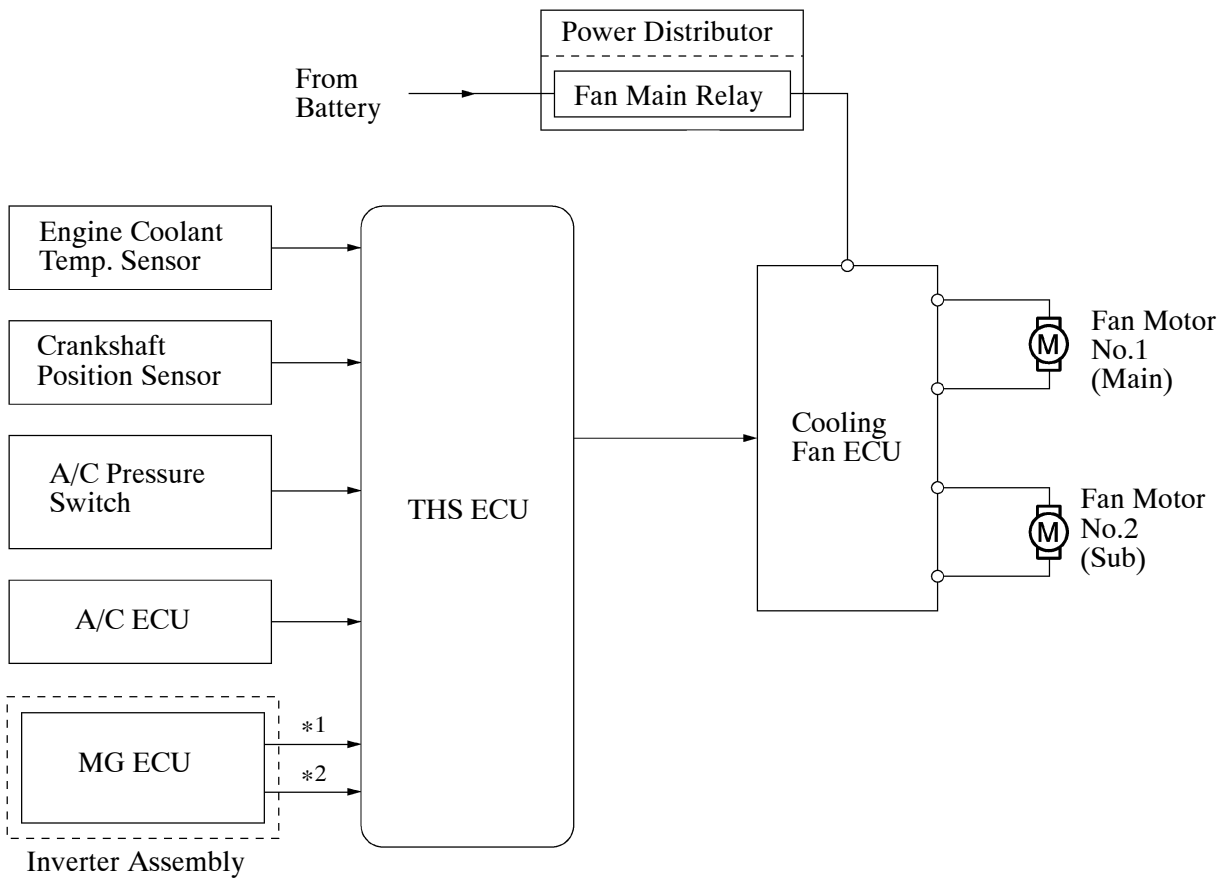
This adjusts the valve timing at the desired target position and prevents the engine oil from running out when it is unnecessary.

8. Cooling Fan Control System

General

A cooling fan control system is used on the 3MZ-FE engine of the RX400h. To achieve an optimal fan speed in accordance with the engine coolant temperature, vehicle speed, engine speed, and air conditioning operating conditions, the THS ECU calculates the proper fan speed and sends the signals to the cooling fan ECU. Upon receiving the signals from the THS ECU, the cooling fan ECU actuates the fan motors. Also, the fan speed is controlled by the THS ECU using a stepless control.

► System Diagram ◀



*1: Inverter Water Temperature

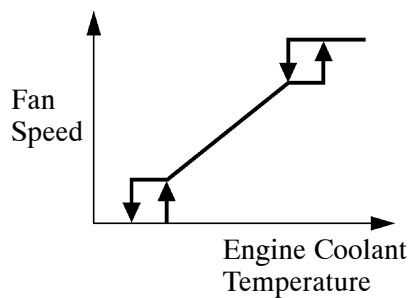
*2: Inverter Temperature

277EG67

Operation

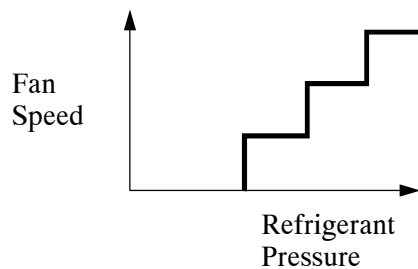
As illustrated below, the THS ECU determines the required fan speed by selecting the fastest fan speed from among the following:

(A) The fan speed required by the engine coolant temperature, (B) the fan speed required by the air conditioning refrigerant pressure, (C) the fan speed required by the inverter temperature and inverter water temperature.



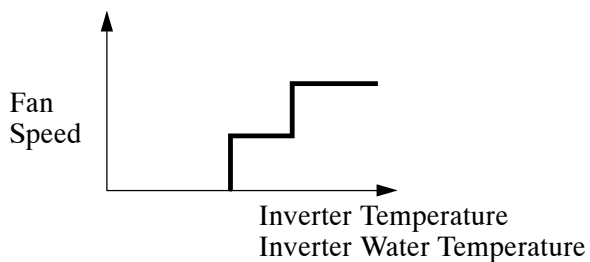
(A) Fan speed required by
Engine coolant temperature

189EG13



(B) Fan speed required by air
conditioning refrigerant
pressure

277EG79



(C) Fan speed required by
Inverter temperature and
Inverter water temperature

277EG80

9. Diagnosis

- When the THS ECU detects a malfunction, the THS ECU makes a diagnosis and memorizes the failed section.
Furthermore, the check engine warning light in the combination meter illuminates or blinks to inform the driver.
- The THS ECU will also store the DTCs of the malfunctions.
- The diagnosis communication has been changed from serial communication (ISO9141) to CAN communication. Accordingly, a newly adopted Intelligent Tester II is required for reading the DTCs of the engine ECU. For details, refer to the LEXUS RX400h Repair Manual (Pub. No. RM1139E).
- All the DTCs (Diagnostic Trouble Codes) have been made to correspond to the SAE controlled codes. Some of the DTCs have been further divided into smaller detection areas than in the past, and new DTCs have been assigned to them. For details, refer to the LEXUS RX400h Repair Manual (Pub. No. RM1139E).

Service Tip

To clear the DTC that is stored in the HV ECU, use a Intelligent Tester II or disconnect the battery terminal or remove the EFI fuse for 1 minute or longer.

EG

10. Fail-Safe

When a malfunction is detected by any of the sensors, there is a possibility of an engine or other malfunction occurring if the ECU were to continue to control the engine control system in the normal way. To prevent such a problem, the fail-safe function of the ECU either relies on the data stored in memory to allow the engine control system to continue operating, or stops the engine if a hazard is anticipated. For details, refer to the LEXUS RX400h Repair Manual (Pub. No. RM1139E).