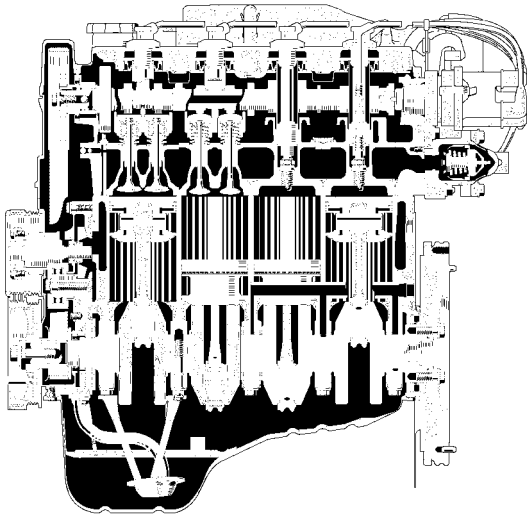
ENGINE

4A-FE ENGINE (STOICHIOMETRIC)

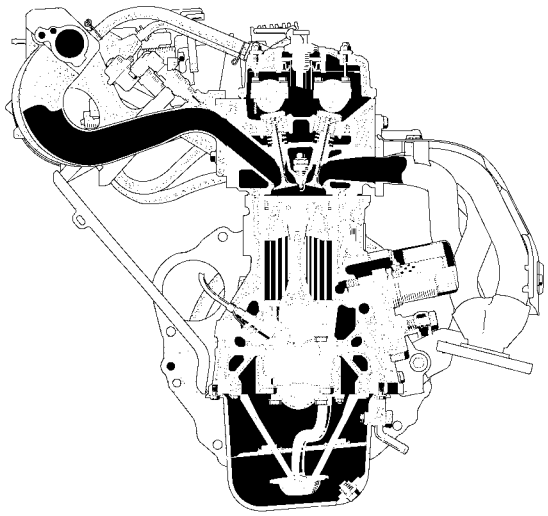
■ DESCRIPTION

The intake and exhaust systems of the 4A-FE engine for the Europe model have been revised to improve engine performance. In addition, the engine control system has been revised to reduce the exhaust emissions. The 4A-FE engine for General Countries has improved its torque in the low- to mid-speed range by revising its intake manifold.

▶ For Europe ◀

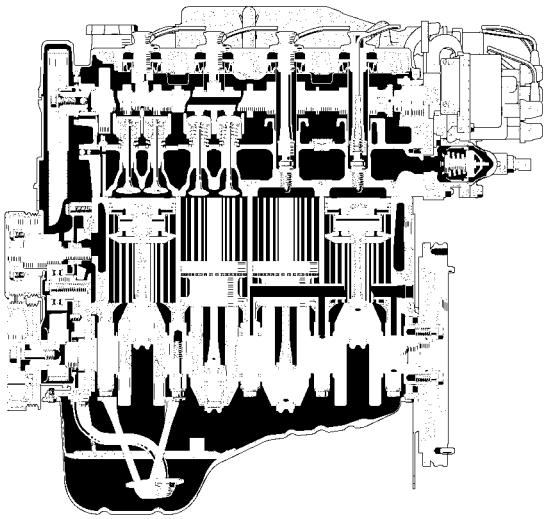


145EG01



145EG02

▶ For General Countries ◀



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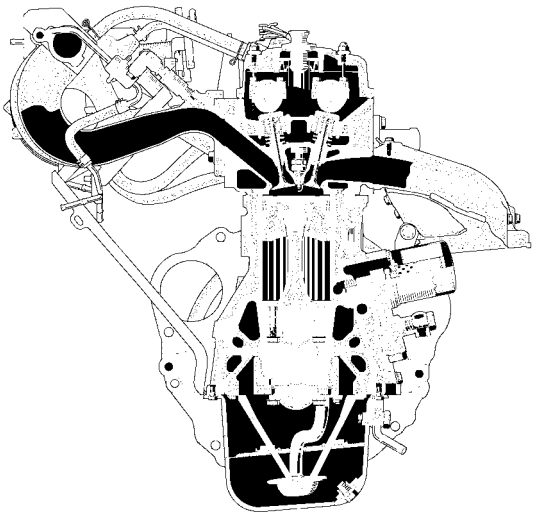


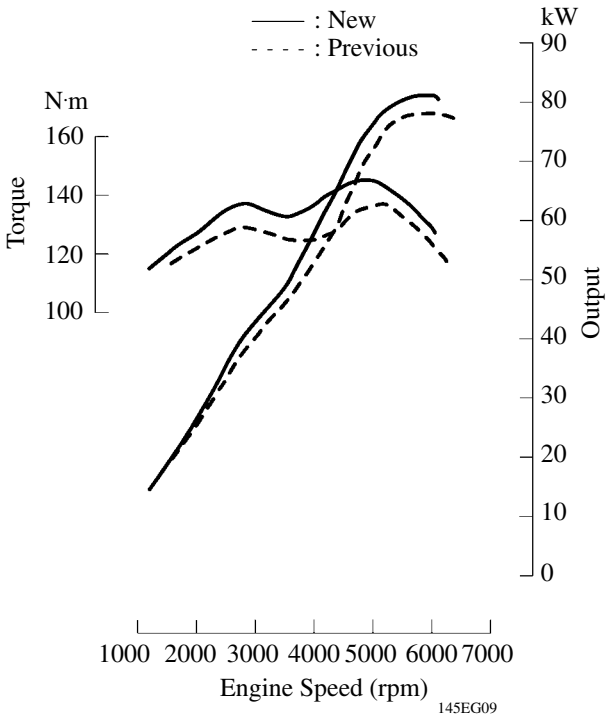
145EG04

■ENGINE SPECIFICATIONS AND PERFORMANCE CURVES

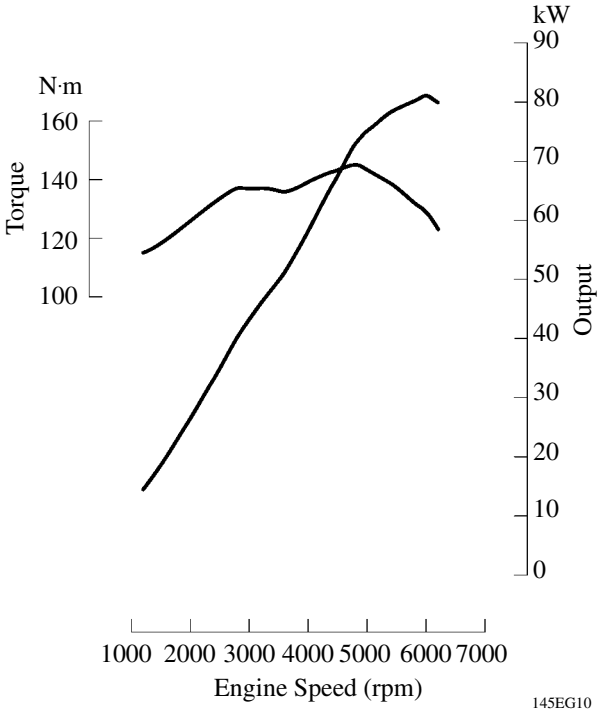
Item \ 4A-FE Engine			New	Previous
No. of Cyls. & Arrangement			4-Cylinder, In-Line	←
Valve Mechanism			16-Valve, DOHC, Belt & Gear Drive	←
Combustion Chamber			Pentroof Type	←
Manifold			Cross-Flow	←
Fuel System			EFI	←
Displacement cm³ (cu. in.)			1587 (96.8)	←
Bore x Stroke mm (in.)			81.0 x 77.0 (3.19 x 3.03)	←
Compression Ratio			9.5 : 1	←
Max. Output [EEC]			81 kW@6000 rpm	78 kW@6000 rpm*1 81 kW@6000 rpm*2
Max. Torque [EEC]			145 N·m@4800 rpm	137 N·m@4800 ~ 5400 rpm*1 142 N·m@4800 rpm*2
Valve Timing	Intake	Open	6°BTDC	←
		Close	46°ABDC	←
	Exhaust	Open	38°BBDC	←
		Close	6°ATDC	←
Fuel Octane Number (RON)			95*1, 90 or 95*2	←
Oil Grade			API SH EC-II, SJ EC or ILSAC	←

*1: Models for Europe
*2: Models for General Countries

▶ For Europe ◀



▶ For General Countries ◀



EG

■MAJOR DIFFERENCES

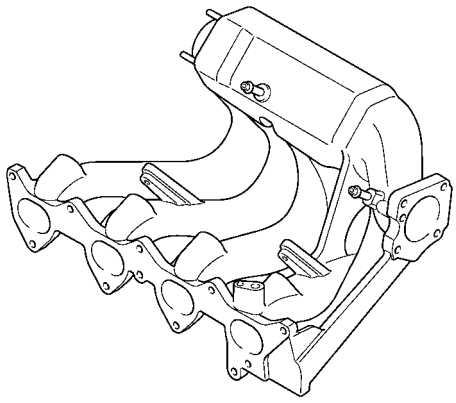
The following changes have been made to the 4A-FE Engine.

Item	Features	Europe	General Countries
Cooling System	An aluminum radiator core is used for weight reduction.	○	○
Intake and Exhaust System	The ports of the intake manifold have been extended to improve torque in the low-to mid-speed range.	○	○
	A dual exhaust manifold has been adopted to improve engine performance.	○	–
	● A ball joint has been adopted in the front exhaust pipe to reduce noise and vibration. ● The internal construction of the main muffler has been optimized to improve its quietness and reduce the exhaust pressure. ● The support of the main muffler has been changed from the 3-point to 2-point support to reduce the noise and vibration that are transmitted to the body.	○	○
Fuel System	A fuel returnless system has been adopted to reduce evaporative emissions.	○	–
Engine Control System	● The fuel injection system is changed from a 2-group injection type to sequential multiport fuel injection type. ● The power steering idle-up control has been changed from the system using an air control valve to the one using a pressure switch and an ISC valve. ● The radiator cooling fan is now controlled by the engine ECU. ● M-OBD (Multiplex On-Board Diagnosis) system is adopted.	○	–

■INTAKE AND EXHAUST SYSTEM

1. Intake Manifold

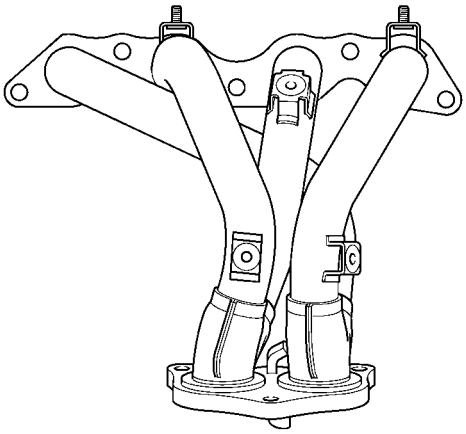
- The intake manifold has been integrated with the intake air chamber for weight reduction.
- The length of the intake port has been optimized to improve the torque in the low-to mid-range engine speed.



145EG13

2. Exhaust Manifold

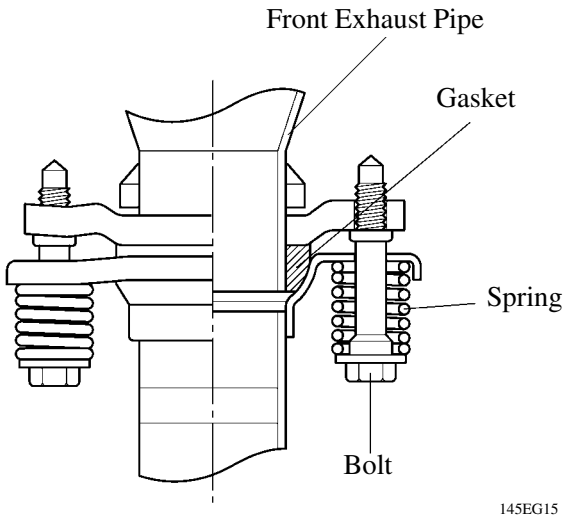
A dual exhaust manifold made of stainless steel has been adopted to improve engine performance.



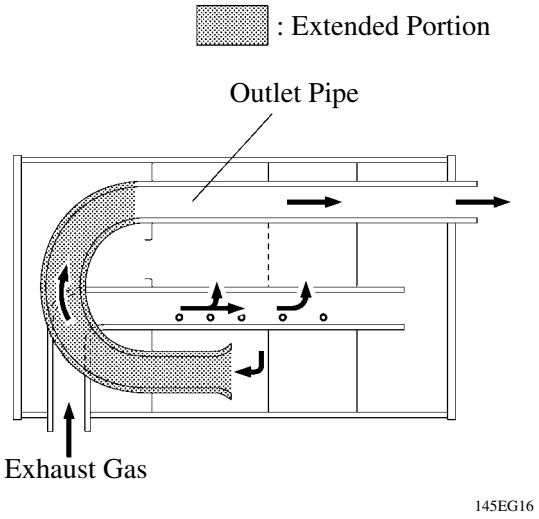
145EG14

3. Exhaust Pipe

- A ball joint has been adopted in the front exhaust pipe to reduce noise and vibration transmitted to the exhaust pipe.
- The outlet pipe in the main muffler has been extended and various components have been optimally located to improve quietness and reduce the exhaust pressure.



Ball Joint

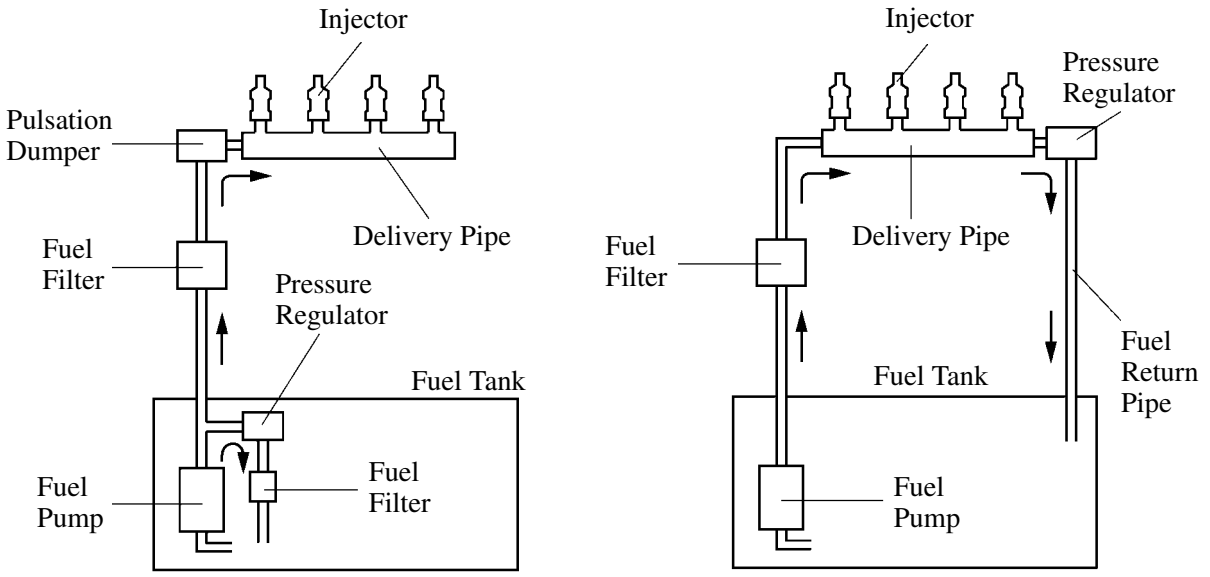


Main Muffler

■FUEL SYSTEM

1. Fuel Returnless System

The new Avensis has adopted a fuel returnless system to reduce evaporative emissions. With the pressure regulator housed inside the fuel tank, this system eliminates the return of fuel from the engine area.



New

Previous

■ENGINE CONTROL SYSTEM (BOSCH TYPE)

1. General

The (Bosch Type) engine control system of the 4A-FE engine for the Europe model has adopted the Sequential Multiport fuel injection system and the M-OBD (Multiplex On-Board Diagnosis) system.
The engine control system on the model for General Countries is basically the same as that of the previous model.
The engine control system (Bosch Type) of the new 4A-FE engine and previous 4A-FE engine are compered below.

System	Outline	New	Previous
EFI (Electronic Fuel Injection)	A D-type EFI system is used, which indirectly detects intake air volume by manifold pressure sensor signal.	○	○
	The fuel injection system is a sequential multiport fuel injection system.	○	–
	The fuel injection system is a 2-group type, each of which injects 2 cylinders simultaneously.	–	○
ESA (Electronic Spark Advance)	Ignition timing is determined by the engine ECU based on signals from various sensors.	○	○
	It retards ignition timing to suppress knocking when it occurs.	○	○
ISC (Idle Speed Control)	A rotary solenoid type ISC system is used to control the fast idle and idle speeds.	○	○
Fuel Pump Control	Fuel pump operation is controlled by signals from the engine ECU based on the engine speed signal (NE).	○	○
Engine Immobiliser	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid ignition key.	○	○
Air Conditioner Cut-Off Control	By controlling the air conditioner compressor in accordance with the throttle valve opening angle and the vehicle speed, driveability is maintained.	○	○
Cooling Fan Control	Radiator cooling fan operation is controlled by signals from engine ECU based on the water temperature sensor signal (THW).	○	–
Diagnosis	When the engine ECU detects a malfunction, the engine ECU diagnoses and memorizes the failed section.	○	○
	A newly developed diagnostic system which utilizes a high speed bi-directional communication line to provide extended diagnostic capabilities and features.	○	–
Fail-Safe	When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in memory.	○	○

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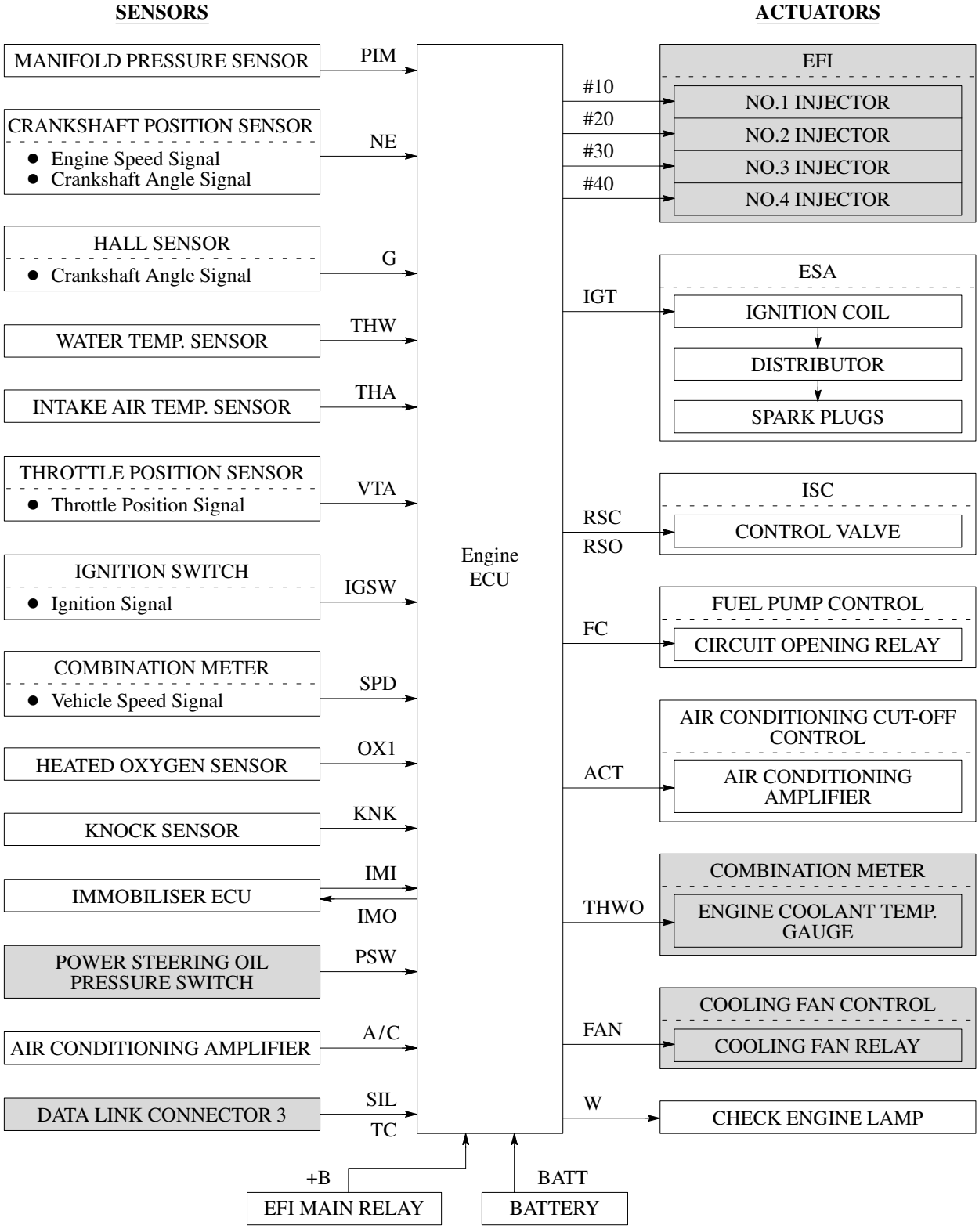
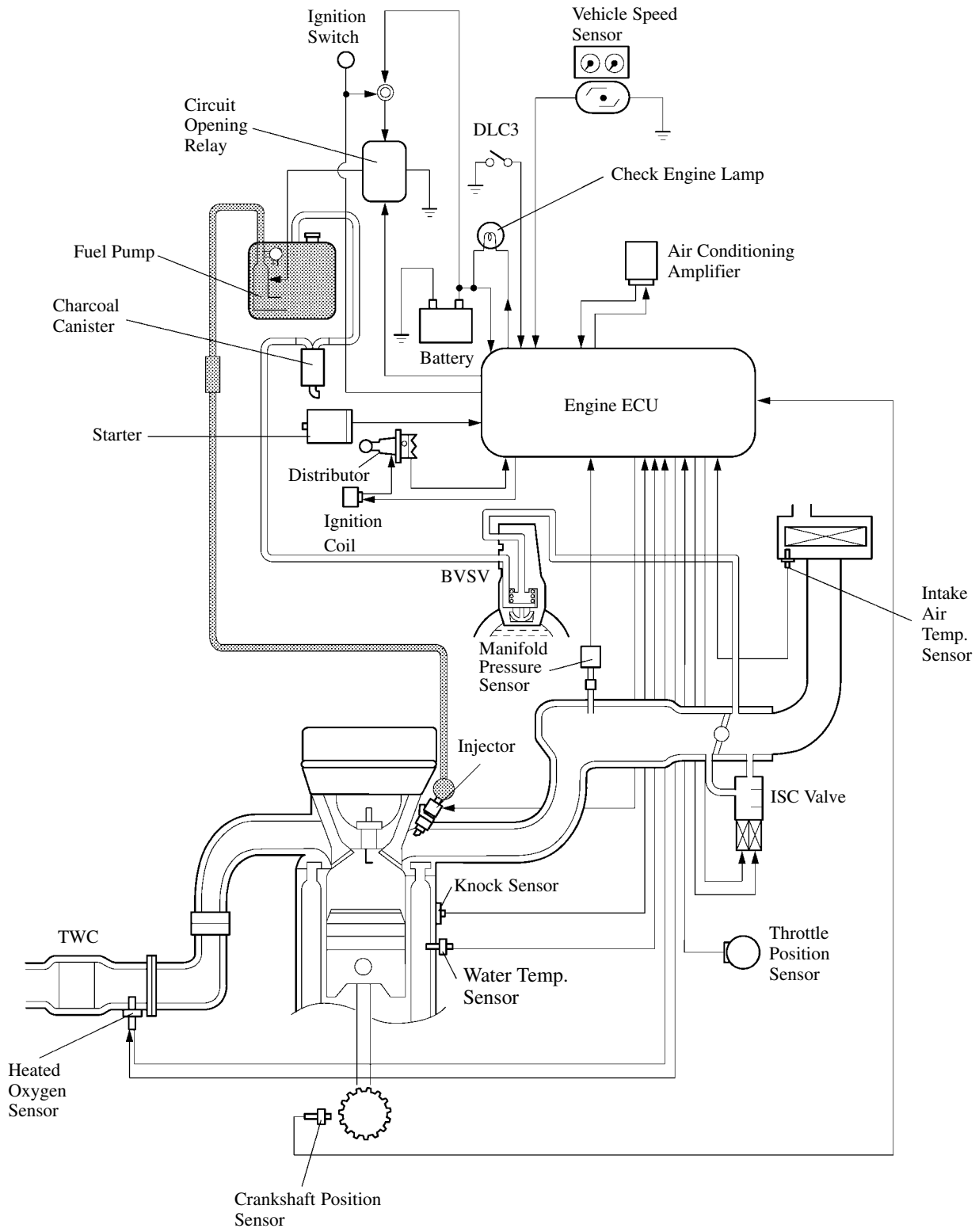
2. Construction

The configuration of the engine control system in the 4A-FE engine of the new AVENSIS is as shown in the following chart. Shaded portions ▭ differ from the 4A-FE engine of the previous model.



3. Engine Control System Diagram



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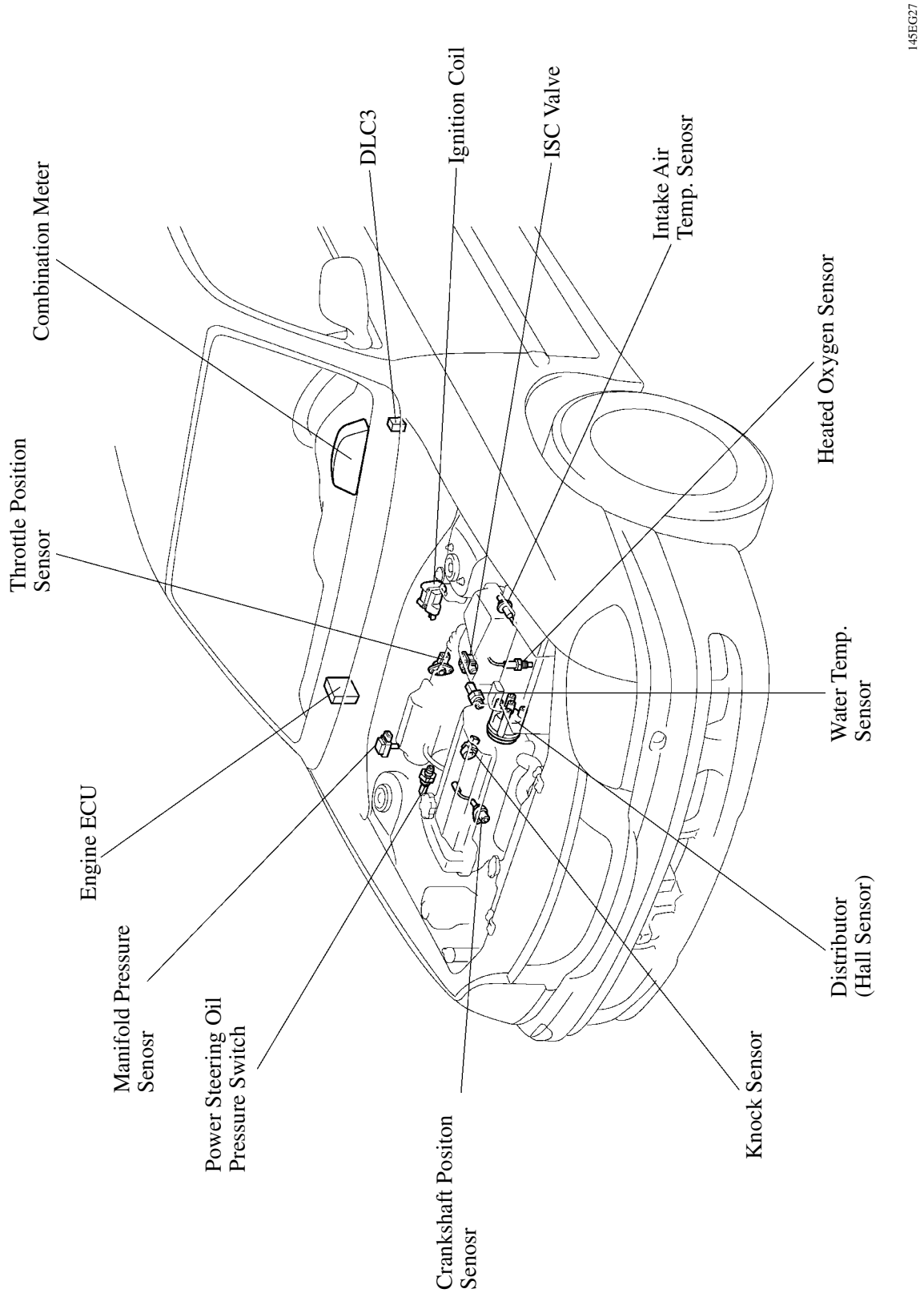
4. Layout of Components



5. Main Components of Engine Control System

General

The following table compares the main components of the 4A-FE engine in the new and previous model.

Component \ Model		New	Previous
Manifold Pressure Sensor		Semiconductor Type	←
Throttle Position Sensor		Linear Type	←
Crankshaft Position Sensor		Pick-Up Coil Type, 1	←
Distributor	Hall Sensor	Hall Element Type	←
Knock Sensor		Built-In Piezoelectric Element Type, 1	←
Oxygen Sensor		With Heater Type	←
Injector		2-Hole Type	←
ISC Valve		Rotary Solenoid Type	←

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6. EFI (Electronic Fuel Injection System)

The injection pattern has been changed from the previous 2-group injection type to the Sequential Multiport fuel injection type to improve the precision of the air-fuel ratio feedback control.

7. ISC (Idle Speed Control)

The power steering idle-up control has been changed from the system using an air control valve to the one using a pressure switch and an ISC valve.

8. Cooling Fan Control

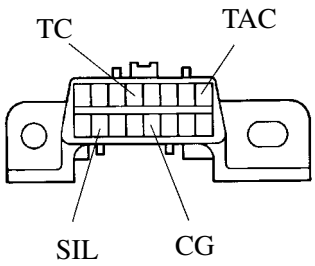
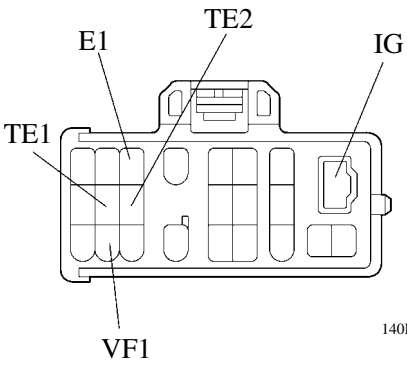
In the previous model, the operation of the cooling fan used to be controlled by the water temperature switch provided at the water inlet of the engine. In the new model, the cooling fan is controlled by the engine ECU based on the signal (THW) that is output by the water temperature sensor.

9. Engine Coolant Temperature Signal Output

In place of the temperature sender gauge used on the previous model, the engine ECU sends the engine coolant temperature signal to the engine coolant temperature gauge in the combination meter.

10. Diagnosis System

The M-OBD (Multiplex On-Board Diagnostic) system that has been adopted in the 4A-FE engine is the system that has been improved upon the previous diagnostic system in order to perform troubleshooting in a more efficient and accurate manner.
The functions of the M-OBD system can be fully utilized through the use of a hand-held tester.
The following table compares the M-OBD system and previous diagnostic system.

System / Item	M-OBD	Previous Diagnostic
Check Connector and Data Link Connector	The DLC3 (Data Link Connector 3) has been newly provided. In addition, the check connector terminals TE1, TE2, and IG have been discontinued. **▶ DLC3 ◀**  140EG127 CG: Chassis Ground SIL: Provides communication between the engine ECU and the hand-held tester. TAC: Outputs the engine speed signal. TC: Provides the same function as the previous TE1 terminal.	The check connector is provided. **▶ Check Connector ◀**  140EG39
Diagnostic Trouble Code Check Method	After connecting terminals TC and CG of the DLC3, displays the code on CHECK Engine Lamp in the combination meter.	After connecting terminals TE1 and E1 of the check connector, displays the code on CHECK Engine Lamp in the combination meter.
Output Engine ECU Date	The engine ECU's control data can be output by connecting the hand-held tester to the DLC3. Output Date Speed: 9.6 kbps	The engine ECU's control data can be output by connecting the hand-held tester to the check connector. Output Date Speed: 125 bps

Furthermore, on the M-OBD system, the functions listed below can be utilized by connecting the hand-held tester to the DLC3.

Function	Details
Diagnostic Trouble Code	The system can output 5-digit diagnostic trouble codes to the tester, which are more detailed than the previous 2-digit diagnostic trouble codes, thus making it easier to identify the location of the problem. Example: Code 28 (Oxygen Sensor) → P0130 (Oxygen Sensor) → P0135 (Oxygen Sensor Heater)
Freeze-Frame Data	The system can output freeze-frame data to the tester. This data (which depicts the condition of the engine control system and the vehicle) is stored in the engine ECU at the very moment when the engine ECU has detected its last data of malfunction.
Active Test	Through the use of the tester, the actuators (VSV, fuel pump, ISC valve etc.) can be activated to a desired state.
Trouble Code Clear	Through the use of the tester, trouble codes stored in the engine ECU can be cleared.

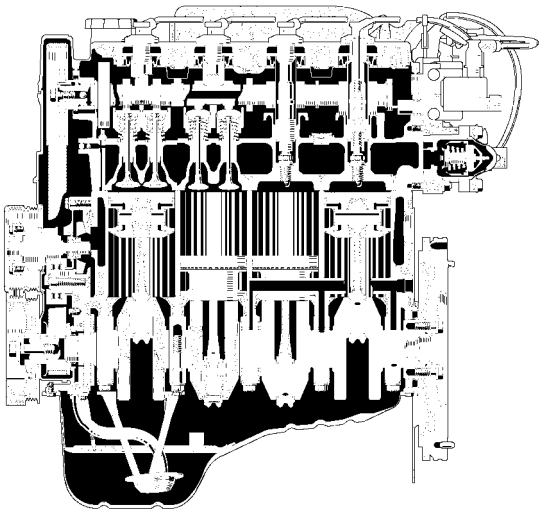
- For details of the diagnostic trouble codes, active test, etc. described above, refer to the 4A-F, -FE/7A-FE, Engine Repair Manual Supplement (Pub. No. RM611E).
- For details of the hand-held tester, refer to the Hand-Held Tester Operator's Manual.

4A-FE AND 7A-FE ENGINES (LEAN-BURN)

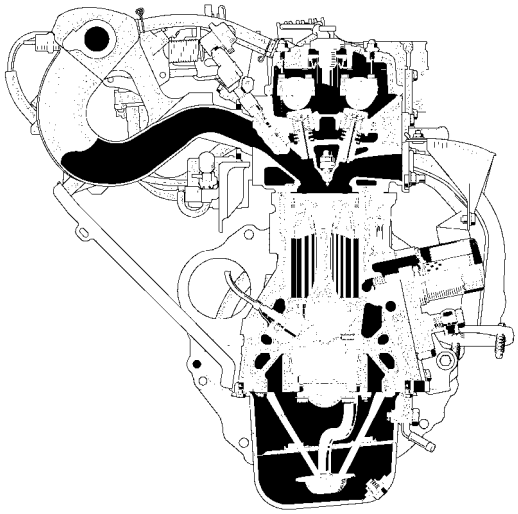
■ DESCRIPTION

The 4A-FE and 7A-FE engines realized improvement in torque in the low- to mid-speed range by changing the intake manifold and improvement in fuel economy by adopting resin-coated pistons.

▶ 4A-FE Engine ◀

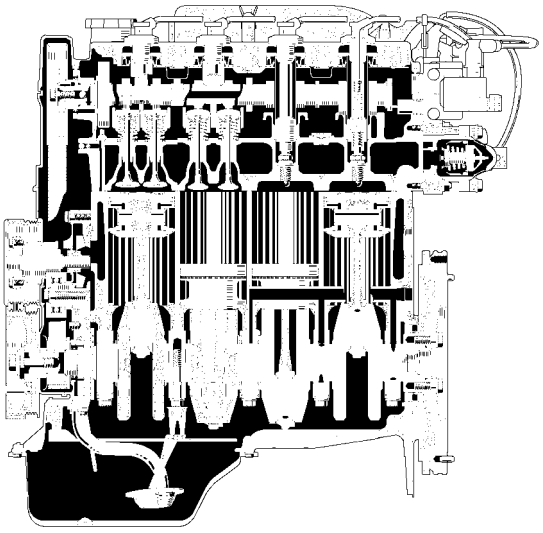


145EG05



145EG06

▶ 7A-FE Engine ◀



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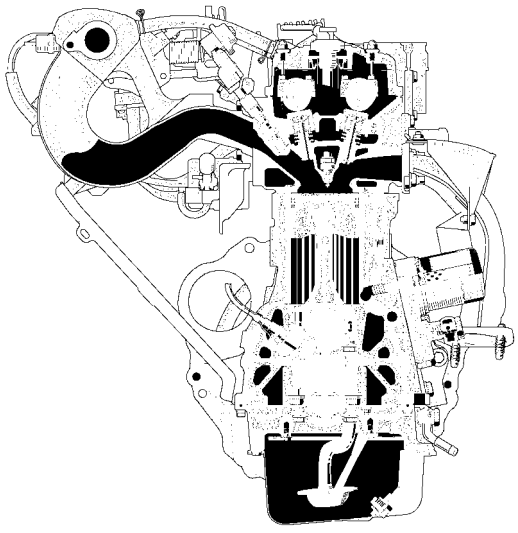
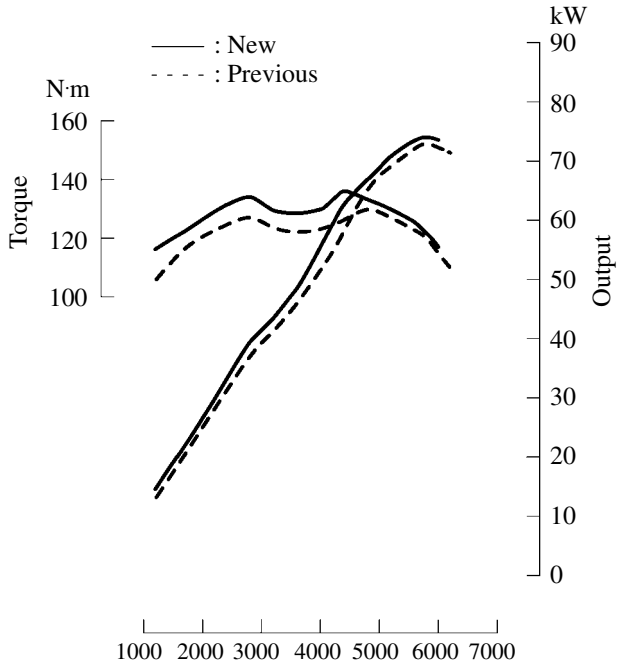


145EG08

■ENGINE SPECIFICATIONS AND PERFORMANCE CURVE (4A-FE ENGINE)

Item \ 4A-FE Engine			New	Previous
No. of Cyls. & Arrangement			4-Cylinder, In-Line	←
Valve Mechanism			16-Valve, DOHC, Belt & Gear Drive	←
Combustion Chamber			Pentroof Type	←
Manifold			Cross-Flow	←
Fuel System			EFI	←
Displacement cm³ (cu. in.)			1587 (96.8)	←
Bore x Stroke mm (in.)			81.0 x 77.0 (3.19 x 3.03)	←
Compression Ratio			9.5 : 1	←
Max. Output [EEC]			74 kW@5800 rpm	73 kW@5800 rpm
Max. Torque [EEC]			136 N·m@4400 rpm	130 N·m@4800 rpm
Valve Timing	Intake	Open	6°BTDC	←
		Close	38°ABDC	←
	Exhaust	Open	42°BBDC	←
		Close	2°ATDC	←
Fuel Octane Number (RON)			95	←
Oil Grade			API SH EC-II, SJ EC or ILSAC	←

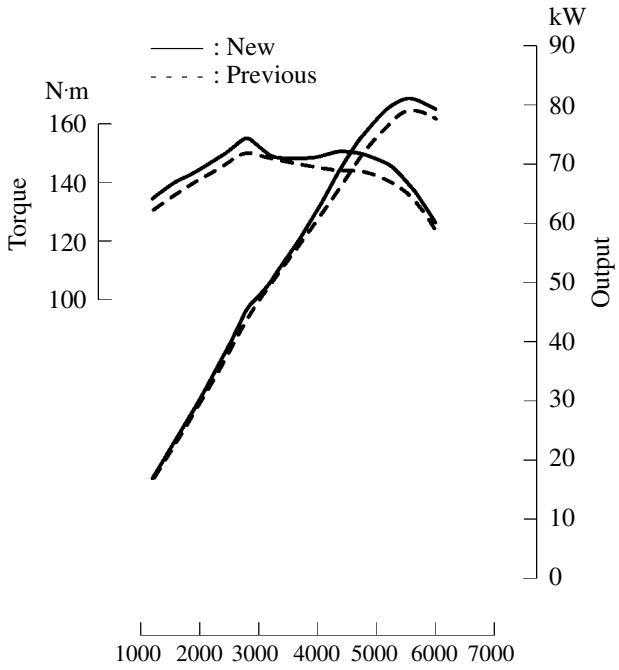


145EG11

EG

■ENGINE SPECIFICATIONS AND PERFORMANCE CURVE (7A-FE ENGINE)

Item \ 7A-FE Engine			New	Previous
No. of Cyls. & Arrangement			4-Cylinder, In-Line	←
Valve Mechanism			16-Valve, DOHC, Belt & Gear Drive	←
Combustion Chamber			Pentroof Type	←
Manifold			Cross-Flow	←
Fuel System			EFI	←
Displacement cm^3 (cu. in.)			1762 (107.5)	←
Bore x Stroke mm (in.)			81.0 x 85.5 (3.19 x 3.37)	←
Compression Ratio			9.5 : 1	←
Max. Output [EEC]			81 kW@5600 rpm	79 kW@5600 rpm
Max. Torque [EEC]			155 N·m@2800 rpm	150 N·m@2800 rpm
Valve Timing	Intake	Open	2°BTDC	←
		Close	42°ABDC	←
	Exhaust	Open	38°BBDC	←
		Close	6°ATDC	←
Fuel Octane Number (RON)			95	←
Oil Grade			API SH EC-II, SJ EC or ILSAC	←



145EG12

■MAJOR DIFFERENCES

The following changes have been made to the 4A-FE and 7A-FE Engines.

Item	Features
Engine Proper	● The cylinder head intake port has been changed in shape to improve engine performance and fuel economy. ● The pistons have been coated with resin to reduce friction loss and improve fuel economy.
Valve Mechanism	The spring tension of the valve springs are reduced to reduce friction loss.
Cooling System	An aluminum radiator core is used for weight reduction.
Intake and Exhaust System	● The ports of the intake manifold have been extended to improve torque in the low- to mid-speed range. ● A ball joint has been adopted in the front exhaust pipe to reduce noise and vibration. For details, see page 34. ● The internal construction of the main muffler has been optimized to improve its quietness and reduce the exhaust pressure. For details, see page 34. ● The support of the main muffler has been changed from the 3-point to 2-point support to reduce the noise and vibration that are transmitted to the body.
Fuel System	● 4-hole type fuel injectors have been adopted to improve the atomization of fuel. ● A fuel returnless system has been adopted to reduce evaporative emissions. For details, see page 34.
Ignition System	● The DIS (Direct Ignition System) is used to enhance the reliability of the ignition system. ● Iridium-tipped spark plugs have been adopted to improve ignition.
Engine Control System	● The ESA system of the 4A-FE engine has adopted a knocking correction function.* ● 1 Coil type ISC valve has been adopted. ● The power steering idle-up control has been changed from the system using an air control valve to the one using a pressure switch and an ISC valve. ● The radiator cooling fan is now controlled by the engine ECU. ● M-OBD (Multiplex On-Board Diagnosis) system is adopted. For detail, see page 40.

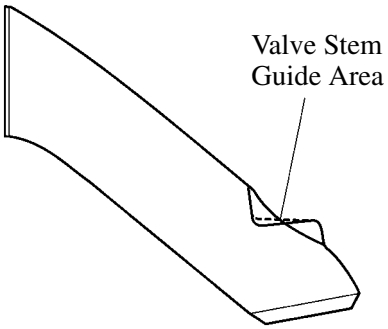
*: This function had already been adopted on the 7A-FE engine.

■ENGINE PROPER

1. Cylinder Head

The cylinder head intake port (helical, straight) has been improved to improve engine performance and fuel economy.

- The shape of the valve stem guide area of the helical port has been changed to improve the swirl ratio without reducing the intake air volume to stabilize the lean-burn performance.
- The straight port diameter has been increased and the inside of the port has been made smoother to improve the volumetric efficiency during high-load conditions.
- The area of the port communication passage has been reduced to optimize the fuel distribution to the helical and straight ports.



Helical Port

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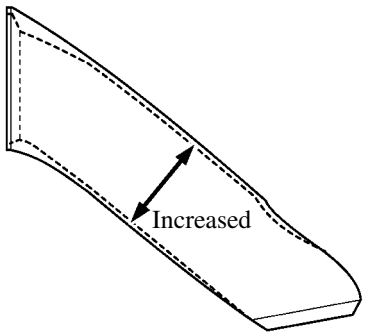
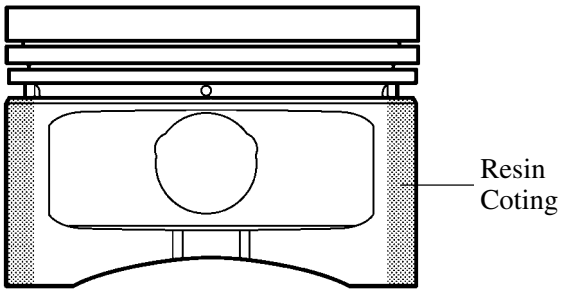


Straight Port

145EG20

2. Piston

The piston skirt has been coated with resin to reduce friction loss.

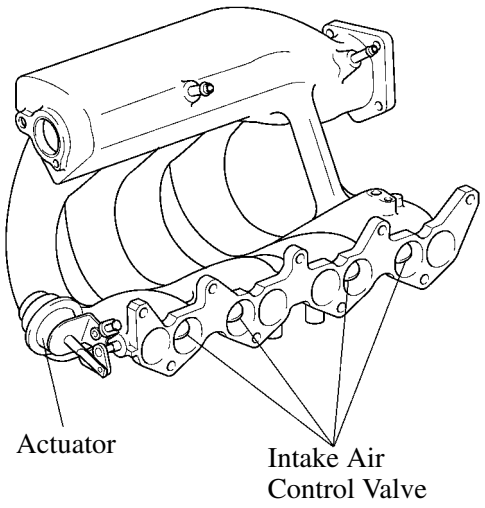


145EG22

■INTAKE AND EXHAUST SYSTEM

1. Intake Manifold

- The intake manifold has been integrated with the intake air chamber for weight reduction.
- The length of the intake port has been optimized to improve the torque in the low- to mid-range engine speed.
- The intake air control valve and actuators have been integrated with the intake manifold.



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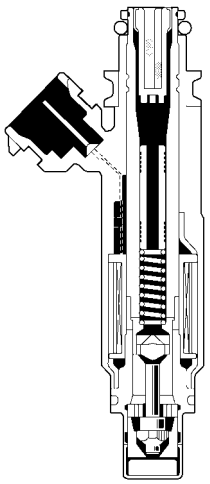
■FUEL SYSTEM

1. Injector

A 4-hole type fuel injector has been adopted to improve the atomization of fuel.

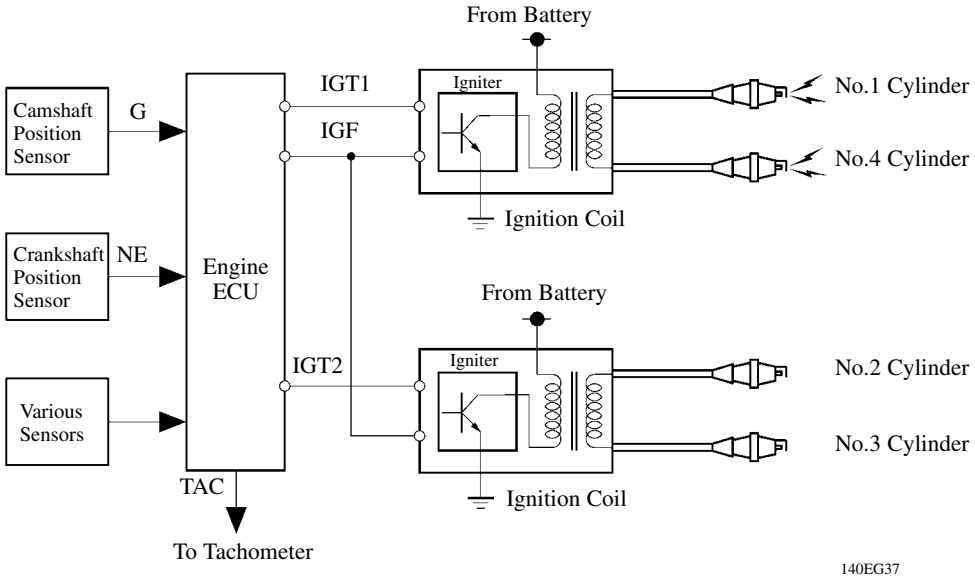


141EG12

■IGNITION SYSTEM

1. General

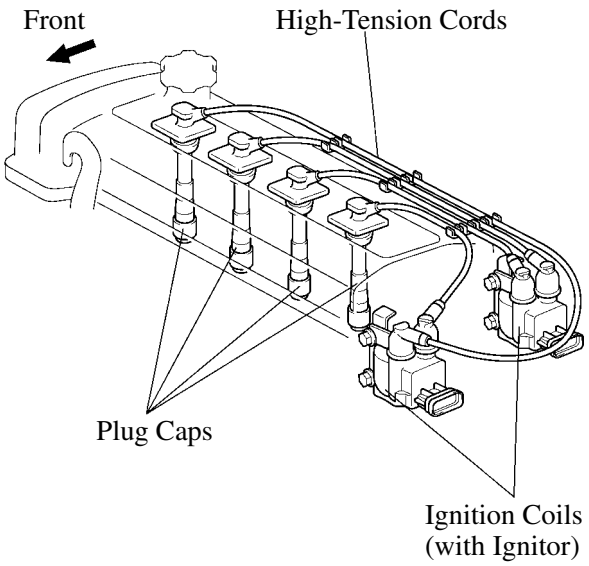
A DIS (Direct Ignition System) has been adopted in the new 4A-FE and 7A-FE engines. The DIS improves the ignition timing accuracy, reduces high-voltage loss, and enhances the overall reliability of the ignition system by eliminating the distributor.
The DIS in new 4A-FE and 7A-FE engines are a 2-cylinder simultaneous ignition system which ignites 2-cylinders simultaneously with one ignition coil.

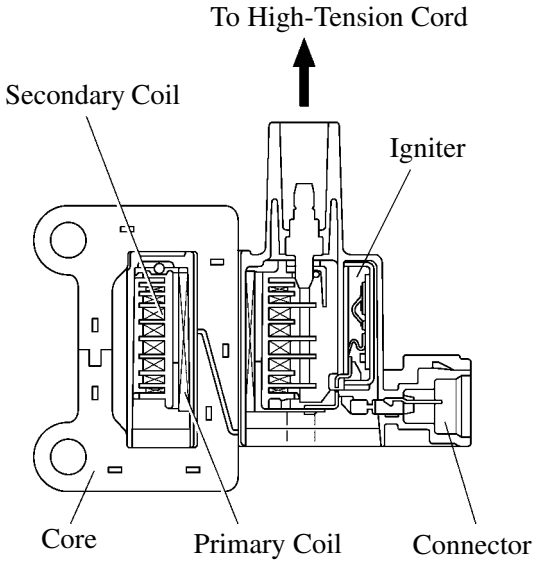


2. Ignition Coil

Construction

Construction the DIS system of the 4A-FE and 7A-FE engines consists of 2 sets of ignition coils integrated with igniter and with the high-tension cords attached directly onto the ignition coil.

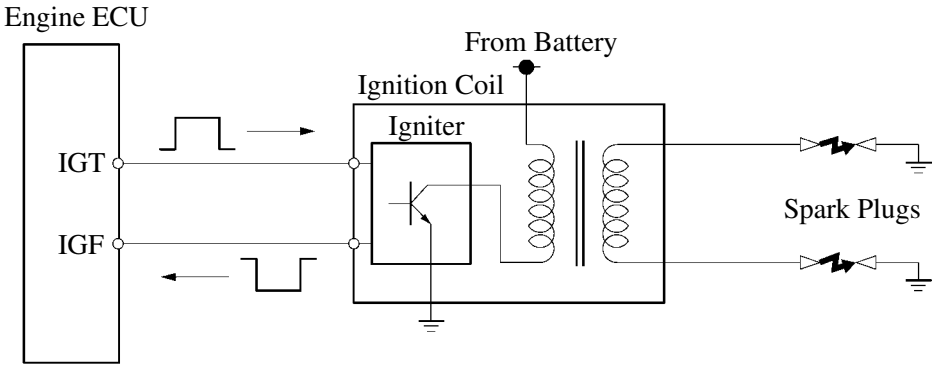




Ignition Coil Cross Section

Operation

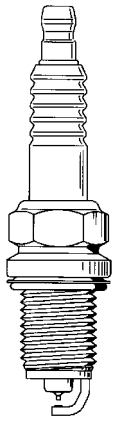
Prompted by the IGT signal received from the engine ECU, the power transistors in the igniter cuts off the current to the primary coil in the ignition coil. Accordingly, the high voltage generated in the secondary coil is supplied simultaneously to the two spark plugs via the high-tension cords that are connected to the both ends of the secondary coil. At the same time, the igniter also sends an ignition confirmation signal (IGF) as a fail-safe function to the engine ECU.

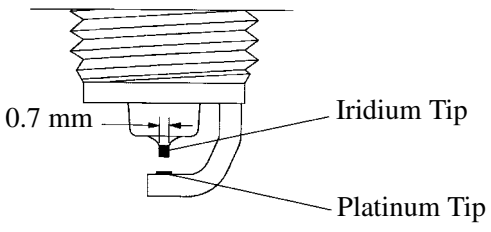


141EG06

3. Spark Plugs

Iridium-tipped spark plugs have been adopted. Their center electrode is made of iridium, which excels in wear resistance. As a result, the center electrode is made with a smaller diameter and improved the ignition performance.





151EG39

▶ Recommended Spark Plugs ◀

DENSO	SK20R-P13
Plug Gap	1.2 – 1.3 mm (0.047 – 0.051 in.)

■ENGINE CONTROL SYSTEM

1. General

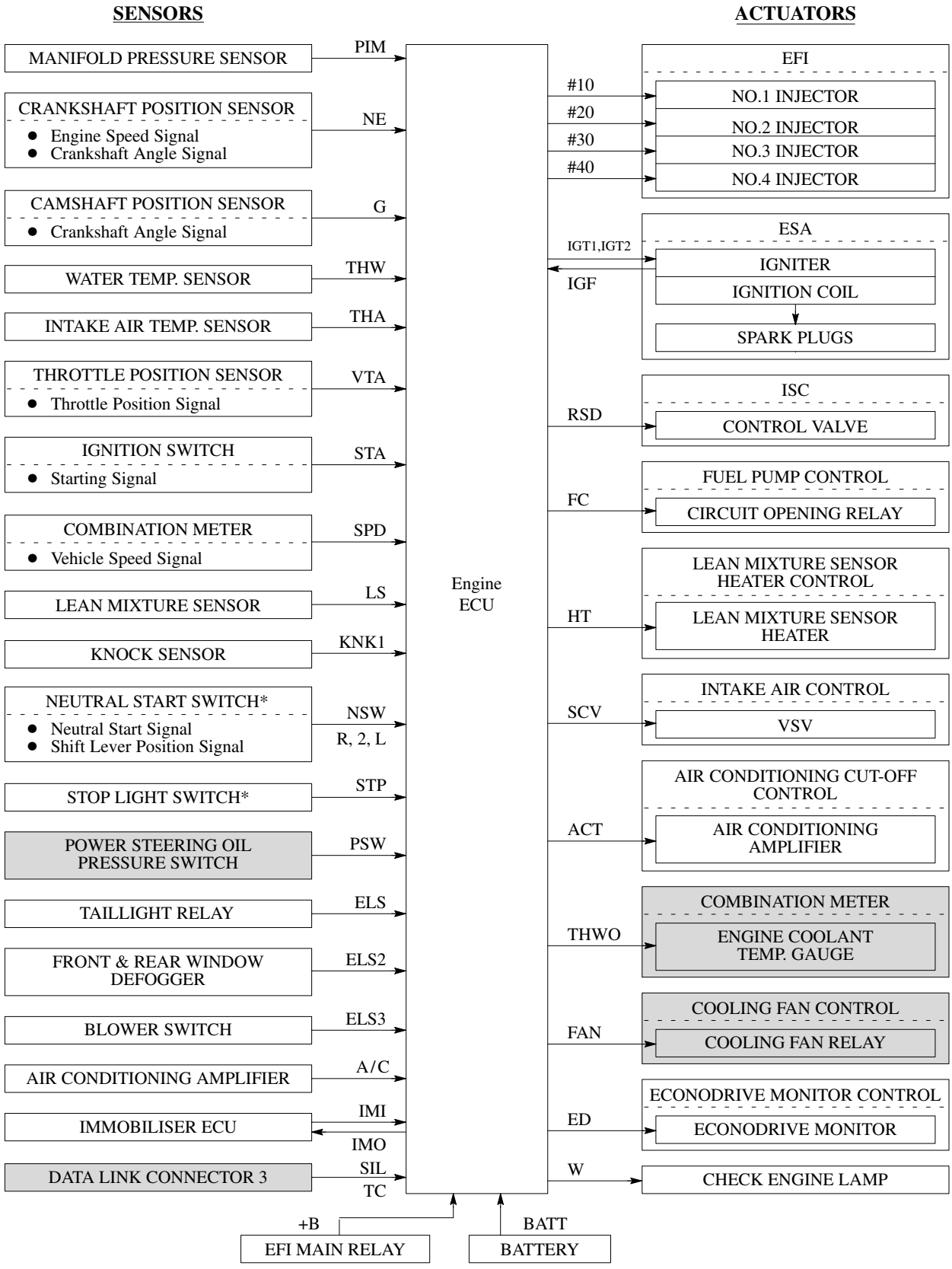
In addition to newly adopting the knocking correction function in the ESA system of the 4A-FE engine, the engine control system for all models has adopted a cooling fan control system and M-OBD (Multiplex On-Board Diagnosis) system.
The engine control system of the new engines and previous engines are compered below.

System	Outline	New	Previous
EFI (Electronic Fuel Injection)	A D-type EFI system is used, which indirectly detects intake air volume by the manifold pressure sensor signal.	○	○
	The fuel injection system is a sequential multiport fuel injection system.	○	○
ESA (Electronic Spark Advance)	Ignition timing is determined by the engine ECU based on signals from various sensors.	○	○
	It retards ignition timing to suppress knocking if knocking occurs.	○	○
	In vehicles equipped with automatic transaxle, torque control compensation during gear shifting is used to minimize the shift shock.	○*	○*
ISC (Idle Speed Control)	A rotary solenoid type ISC system is used, which controls the fast idle and idle speeds.	○	○
Intake Air Control	When the engine is under a light load and engine speed is below predetermined level fuel economy is improved by closing the intake air control valve.	○	○
Fuel Pump Control	Fuel pump operation is controlled by signals from the engine ECU based on the engine speed signal (NE).	○	○
Lean Mixture Sensor Heater Control	Maintains the temperature of the lean mixture sensor at an appropriate level to increase accuracy of detection of the oxygen concentration in the exhaust gas.	○	○
Air Conditioning Cut-Off Control	By turning the air conditioning compressor ON or OFF in accordance with the engine condition, drivability is maintained.	○	○
Cooling Fan Control	Radiator cooling fan operation is controlled by signals from engine ECU based on the water temperature sensor signal (THW).	○	–
Engine Immobiliser	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid ignition key.	○	○
Diagnosis	When the engine ECU detects a malfunction, the engine ECU diagnoses and memorizes the failed section.	○	○
	A newly developed diagnostic system which utilizes a high speed bi-directional communication line to provide extended diagnostic capabilities and features.	○	–
Fail-Safe	When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in memory.	○	○
Econodrive Monitor Control	Turns ON the indicator to inform the driver that the engine is operating at the lean-burn air-fuel ratio.	○	○

*: 7A-FE Engine Only

2. Construction

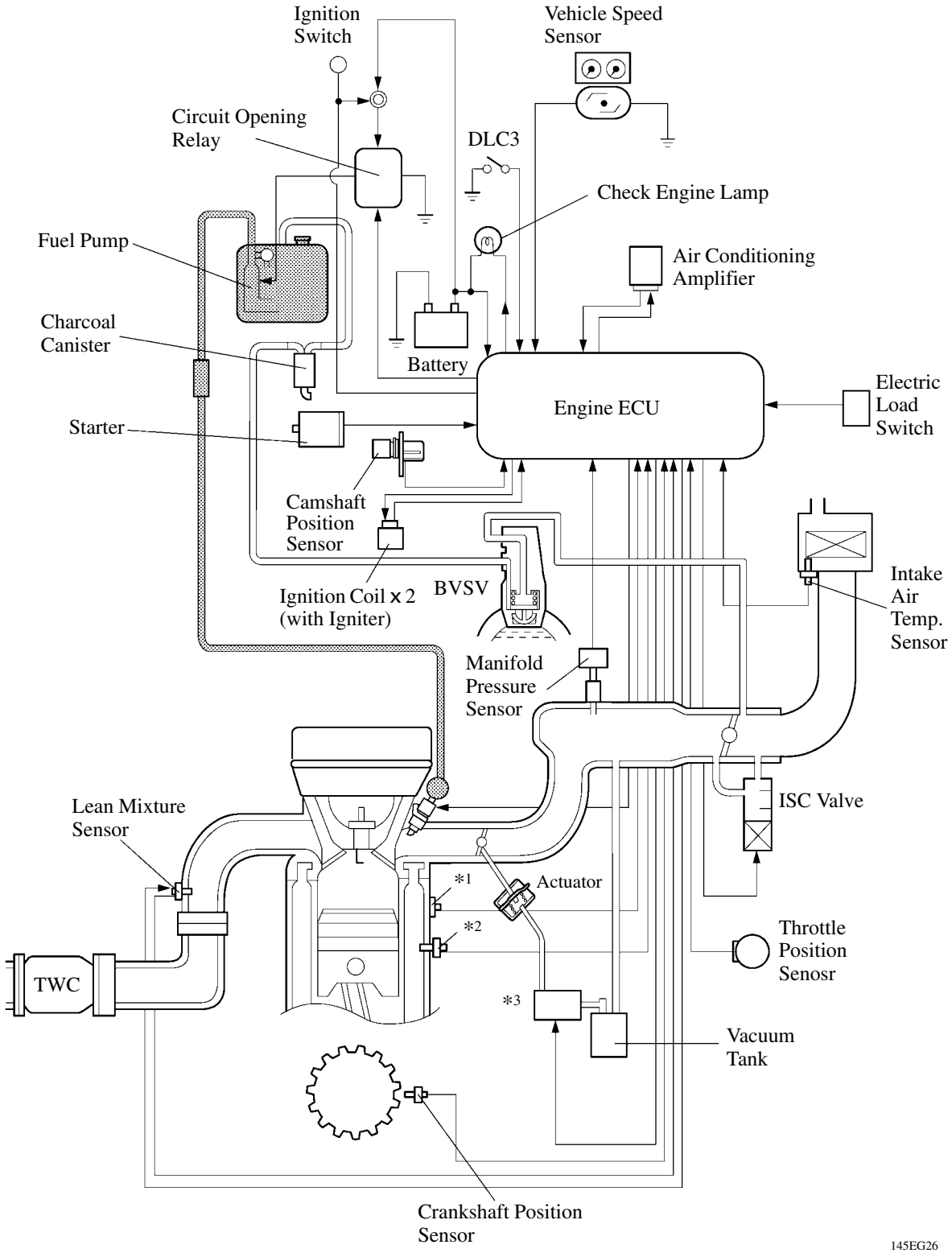
The configuration of the engine control system in the new 4A-FE and 7A-FE engines is as shown in the following chart. Shaded portions ▭ differ from the previous 4A-FE and 7A-FE engines.



*: Applicable only to the automatic transaxle model.

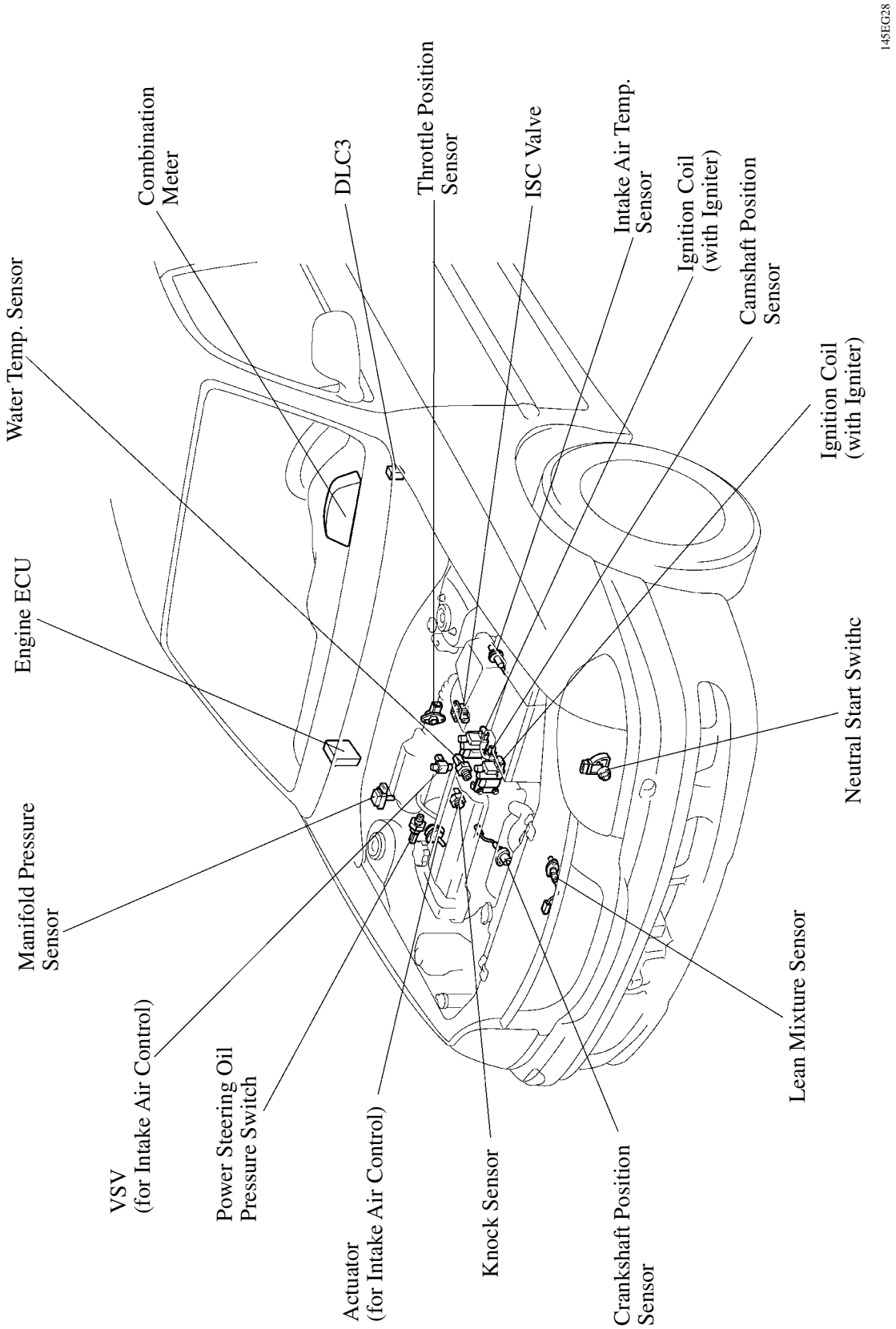
EG

3. Engine Control System Diagram



*1: Knock Sensor
*2: Water Temp. Sensor
*3: VSV (for Intake Air Control)

4. Layout of Components



EG

5. Main Components of Engine Control System

General

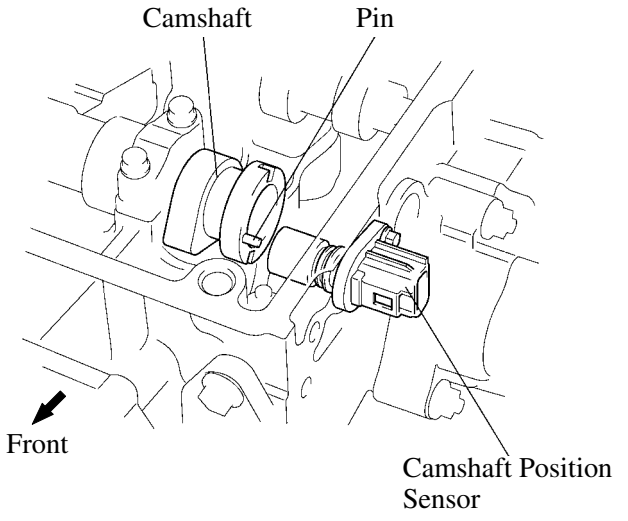
The following table compares the main components of the 4A-FE and 7A-FE engines in the new and previous model.

Component \ Model		New	Previous
Manifold Pressure Sensor		Semiconductor Type	←
Throttle Position Sensor		Linear Type	←
Crankshaft Position Sensor		Pick-Up Coil Type, 1	–
Camshaft Position Sensor		Pick-Up Coil Type, 1	–
Distributor	Crankshaft Position Sensor	–	2 Pick-Up Coils in Series
	Camshaft Position Sensor	–	Pick-Up Coil Type, 1
Knock Sensor		Built-In Piezoelectric Element Type, 1	Built-In Piezoelectric Element Type, 1*
Lean Mixture Sensor		With Heater Type	←
Injector		4-Hole Type	2-Hole Type
ISC Valve		Rotary Solenoid Type (1-Coil Type)	Rotary Solenoid Type (2-Coil Type)

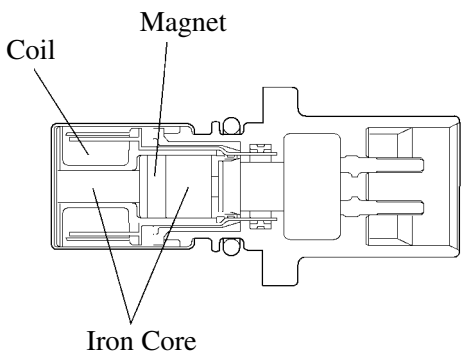
*: 7A-FE Engine Only

Camshaft Position Sensors

The camshaft position sensor consists of a magnet, coil and iron core, and it is mounted onto the right side of the cylinder head.
Each time when the camshaft rotates, the distance between the camshaft position sensor and the pin installed on the camshaft is varied. This causes the magnetic flux passing through the coil in the camshaft sensor to increase and decrease and to generate an electromotive force. Since the voltage generated when the pin on the camshaft approaches the pickup coil is the opposite of when it departs, an alternating electrical current is produced.



145EG34

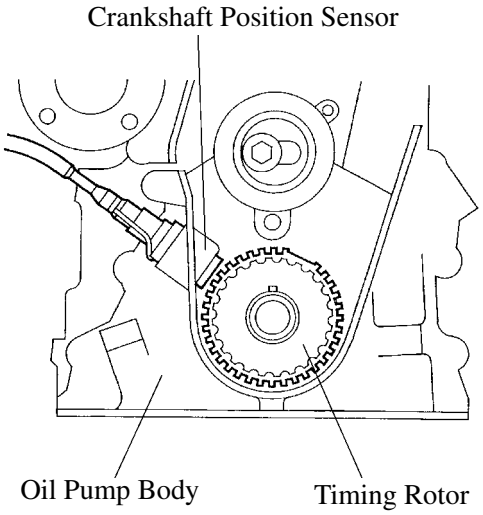


Camshaft Position Sensor Cross Section

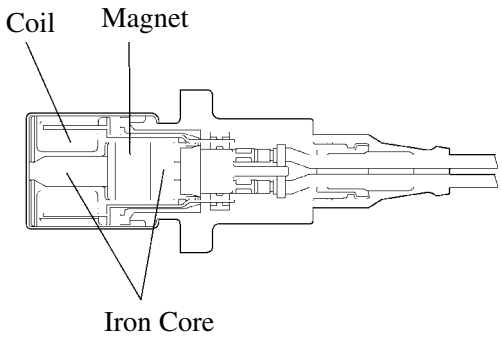
145EG35

Crankshaft Position Sensor

The crankshaft position sensor also consists of a magnet, coil and iron core, and it is mounted on the oil pump body as illustrated below.
The timing rotor is integrated with the crankshaft pulley. The rotor's teeth are spaced 10° apart according to crankshaft angle, but since there are 2 teeth missing, as illustrated below, there is a total of 34 teeth. Accordingly, the engine ECU can detect the crankshaft angle in addition to the crankshaft speed.



145EG37

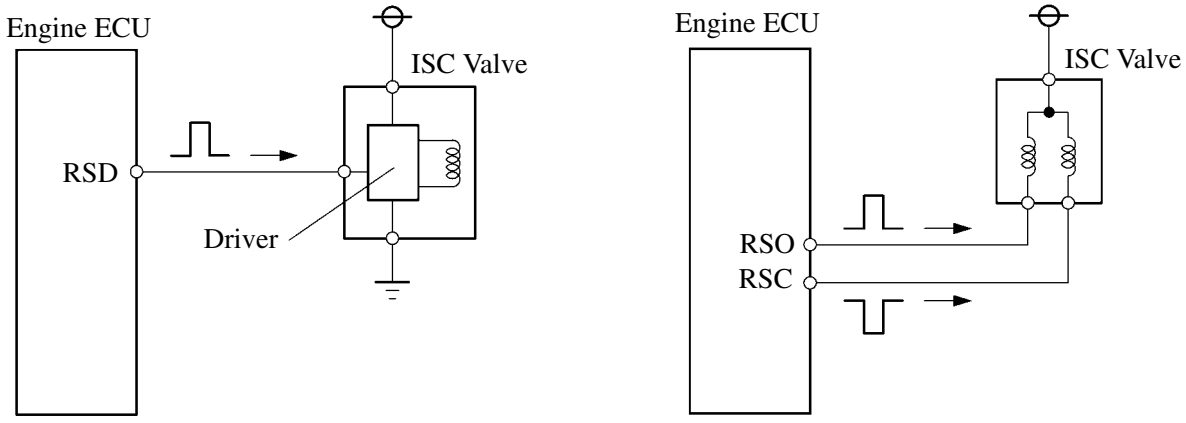


Crankshaft Position Sensor Cross Section

145EG36

ISC Valve

As on the previous model, a rotary solenoid type ISC valve is used to control the idle speed. However, instead of the 2 coils used on the previous model, the new model uses 1 coil to simplify its system.



New **Previous**

141EG30

7. ISC (Idle Speed Control)

The power steering idle-up control has been changed from the system using an air control valve to the one using a pressure switch and an ISC valve.

8. Cooling Fan Control

In the previous model, the operation of the cooling fan used to be controlled by the water temperature switch provided at the water inlet of the engine. In the new model, the cooling fan is controlled by the engine ECU based on the signal (THW) that is output by the water temperature sensor.

9. Engine Coolant Temperature Signal Output

In place of the temperature sender gauge used on the previous model, the engine ECU sends the engine coolant temperature signal to the engine coolant temperature gauge in the combination meter.

3S-FE ENGINE

■DESCRIPTION

The 3S-FE engine has improved its torque in the low- to mid-speed range by changing the intake manifold and has adopted the DIS (Direct Ignition System) for its ignition system.

■ENGINE SPECIFICATIONS AND PERFORMANCE CURVES

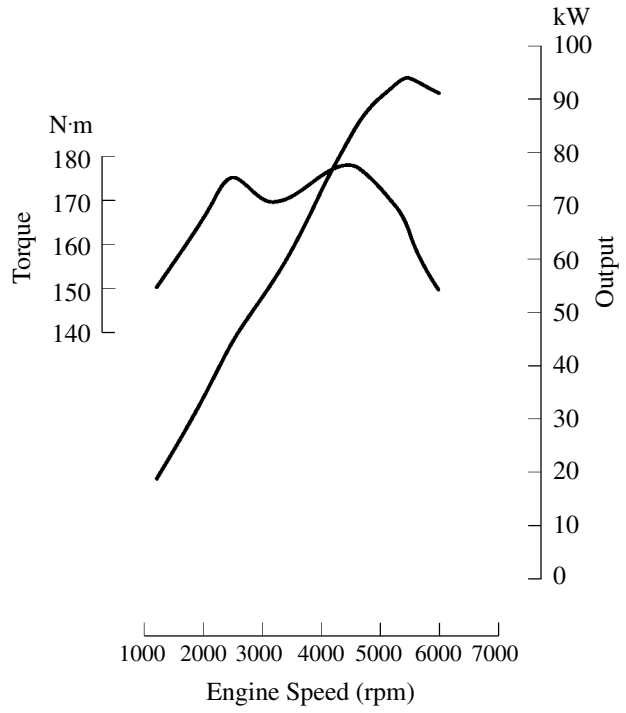
Item \ Engine			New	Previous
No. of Cyls. & Arrangement			4-Cylinder, In-Line	←–
Valve Mechanism			4-Valve DOHC, Belt & Gear Drive	←–
Combustion Chamber			Pentroof Type	←–
Manifold			Cross-Flow	←–
Fuel System			EFI	←–
Displacement cm^3 (cu. in.)			1998 (121.9)	←–
Bore x Stroke mm (in.)			86.0 x 86.0 (3.39 x 3.39)	←–
Compression Ratio			9.8 : 1*1, 9.5 : 1*2	←–
Max. Output [EEC]		Europe	94 kW@5400 rpm	93 kW@5600 rpm
		General Countries	91 kW@5400 rpm	95 kW@5600 rpm
Max. Torque [EEC]		Europe	178 N·m@4400 rpm	178 N·m@4400 ~ 4800 rpm
		General Countries	178 N·m@4400 rpm	182 N·m@4400 rpm
Valve Timing	Intake	Open	3°BTDC	←–
		Close	43°ABDC	←–
	Exhaust	Open	45°BBDC	←–
		Close	3°ATDC	←–
Fuel Octane Number RON			95*1, 90 or 95*2	←–
Oil Grade			API SH EC-II, SJ EC ILSAC	←–

*1: For Europe Model

*2: For General Countries Model

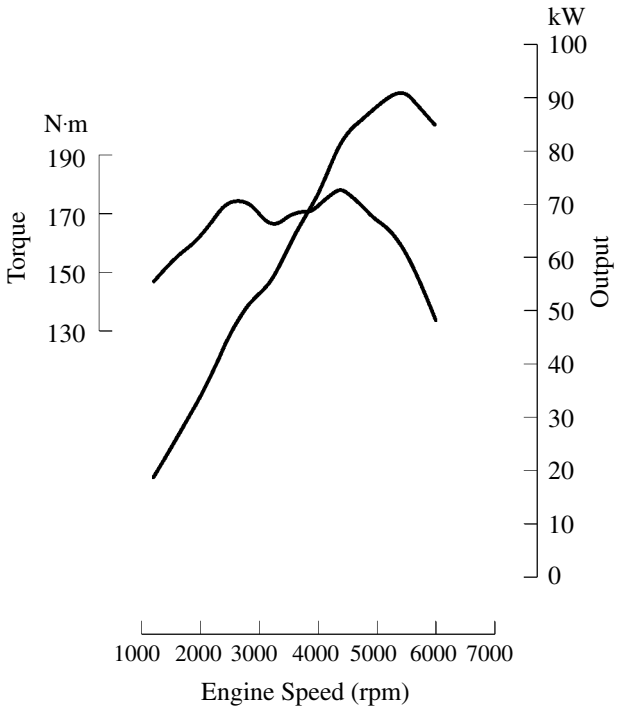
EG

▶ For Europe ◀



145EG45

▶ For General Countries ◀



145EG46

■MAJOR DIFFERENCES

The following changes have been made to the 3S-FE Engine.

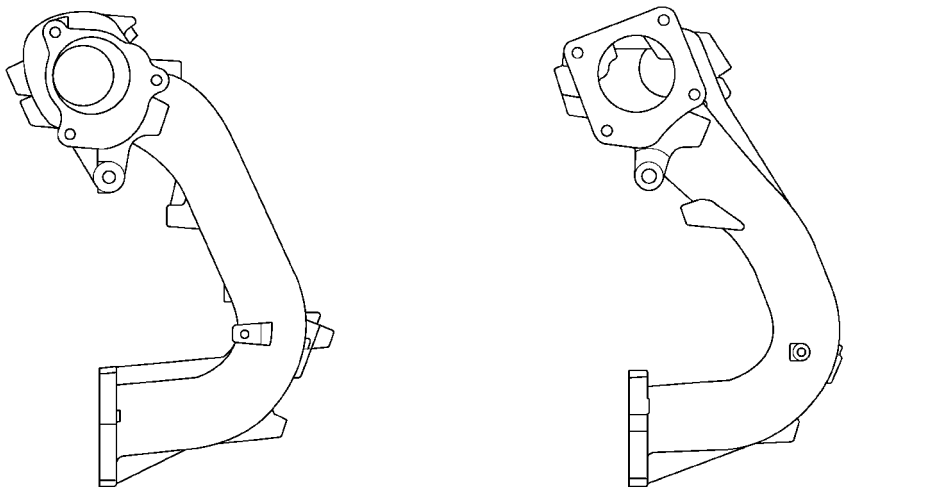
Item	Features
Cooling System	An aluminum radiator core is used for weight reduction.
Intake and Exhaust System	● The ports of the intake manifold have been extended to improve torque in the low- to mid-speed range. ● A ball joint has been adopted in the front exhaust pipe to reduce noise and vibration. ● The internal construction of the main muffler has been optimized to improve its quietness and reduce the exhaust pressure. For details, see page 34. ● The support of the main muffler has been changed from the 3-point to 2-point support to reduce the noise and vibration that are transmitted to the body.
Fuel System	A fuel returnless system has been adopted to reduce evaporative emissions*. For details, see page 34.
Ignition System	● The DIS (Direct Ignition System) is used to enhance the reliability of the ignition system.
Engine Control System	● The fuel injection system is changed from a 2-group injection type to sequential multiport fuel injection type. ● The power steering idle-up control has been changed from the system using an air control valve to the one using a pressure switch and an ISC valve. ● The radiator cooling fan is now controlled by the engine ECU. ● M-OBD (Multiplex On-Board Diagnosis) system is adopted. For details, see page 40.

*: Only for Europe Model

■INTAKE AND EXHAUST SYSTEM

1. Intake Manifold

The low- to mid-speed range torque has been improved by increasing the diameter and the length of the intake manifold port and by reducing the intake air chamber capacity.



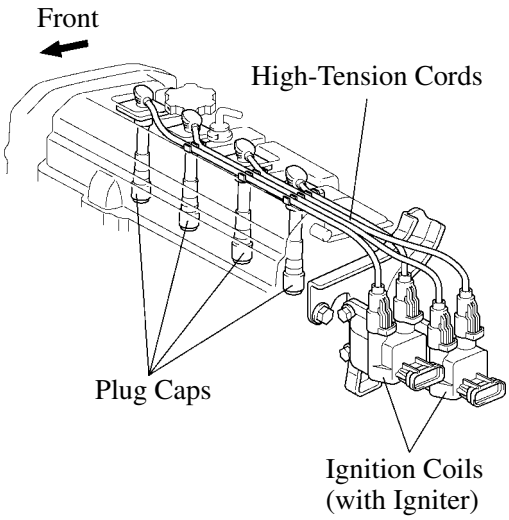
150EG64

New **Previous**

■IGNITION SYSTEM

1. General

Similar to the 4A-FE engine, the DIS (Direct Ignition System) has been adopted to improve the reliability of the ignition system.



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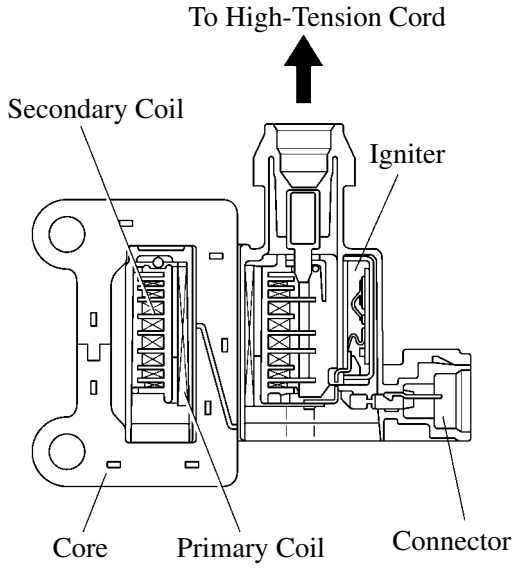
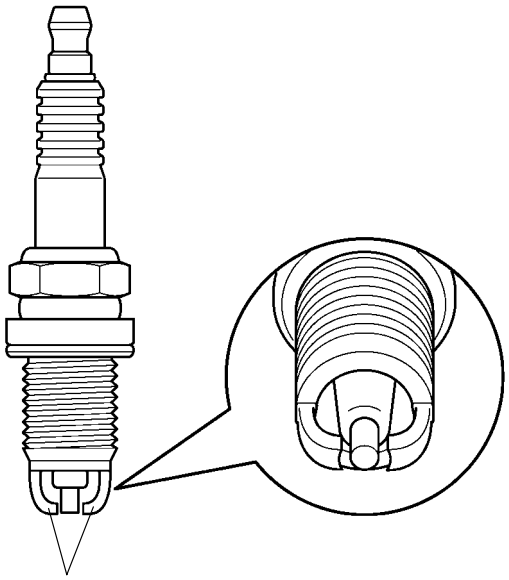


Ignition Coil Cross Section

141EG07

2. Spark Plugs

Twin ground electrode spark plugs are used on the 3S-FE engine. Due to the adoption of the DIS system, the number of sparks produced is double that produced in the conventional ignition system. To maintain spark plug durability, the ground electrodes have been made bipolar.



141EG08

▶ Recommended Spark Plugs ◀

DENSO	K20TR11
NGK	BKR6EKB11
Plug Gap	1.0 – 1.1 mm (0.039 – 0.043 in.)

■ENGINE CONTROL SYSTEM

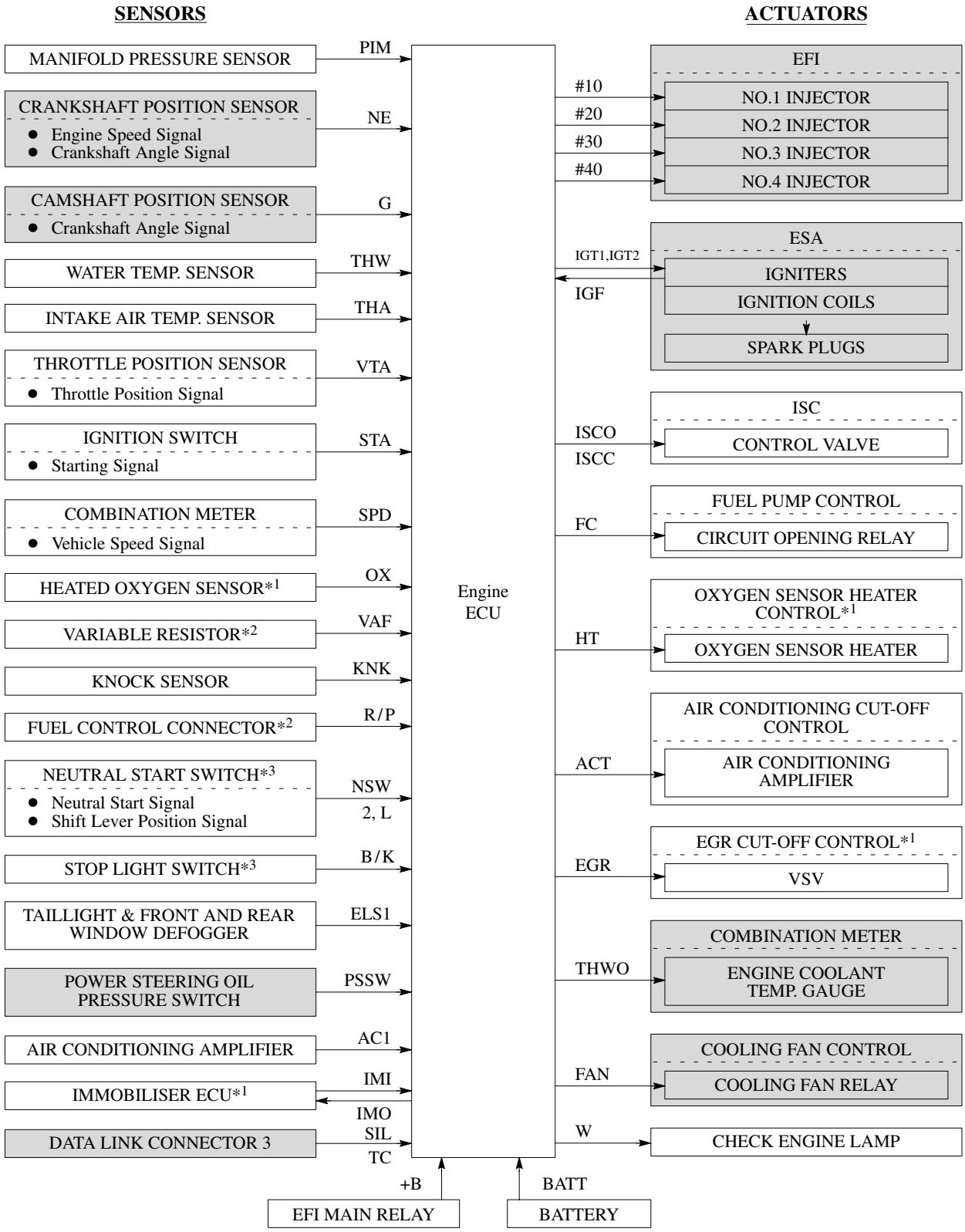
1. General

The 3S-FE engine has adopted the sequential multiport fuel injection system for its engine control system as well as an M-OBD (Multiplex On-Board Diagnosis) system.
The engine control system of new 3S-FE engine and previous 3S-FE engine are compared below.

System	Outline	New	Previous
EFI (Electronic Fuel Injection)	A D-type EFI system is used, which indirectly detects intake air volume by manifold pressure sensor signal.	○	○
	The fuel injection system is a sequential multiport fuel injection system.	○	–
	The fuel injection system is a 2-group type, each of which injects 2 cylinders simultaneously.	–	○
ESA (Electronic Spark Advance)	Ignition timing is determined by the engine ECU based on signals from various sensors.	○	○
	It retards ignition timing to suppress knocking if it occurs.	○	○
	In vehicles equipped with automatic transaxle, torque control compensation during gear shifting is used to minimize the shift shock.	○	○
ISC (Idle Speed Control)	A rotary solenoid type ISC valve is used, which controls the fast idle and idle speeds.	○	○
Fuel Pump Control	Fuel pump operation is controlled by signal from the engine ECU.	○	○
Oxygen Sensor Heated Control	Maintains the temperature of the oxygen sensor at an appropriate level to increase accuracy of detection of the oxygen concentration in the exhaust gas.	○	○
EGR Cut-Off Control	The EGR is cut off under light engine loads or low temperature conditions to maintain driveability.	○	○
Air Conditioning Cut-Off Control	By controlling the air conditioning compressor in accordance with the throttle valve opening angle and the vehicle speed, driveability is maintained.	○	○
Cooling Fan Control	Radiator cooling fan operation is controlled by signals from engine ECU based on the water temperature sensor signal (THW).	○	–
Diagnosis	When the engine ECU detects a malfunction, the engine ECU diagnoses and memorizes the failed section.	○	○
	A newly developed diagnostic system which utilizes a high speed bi-directional communication line to provide extended diagnostic capabilities and features.	○	–
Fail-Safe	When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in memory.	○	○

2. Construction

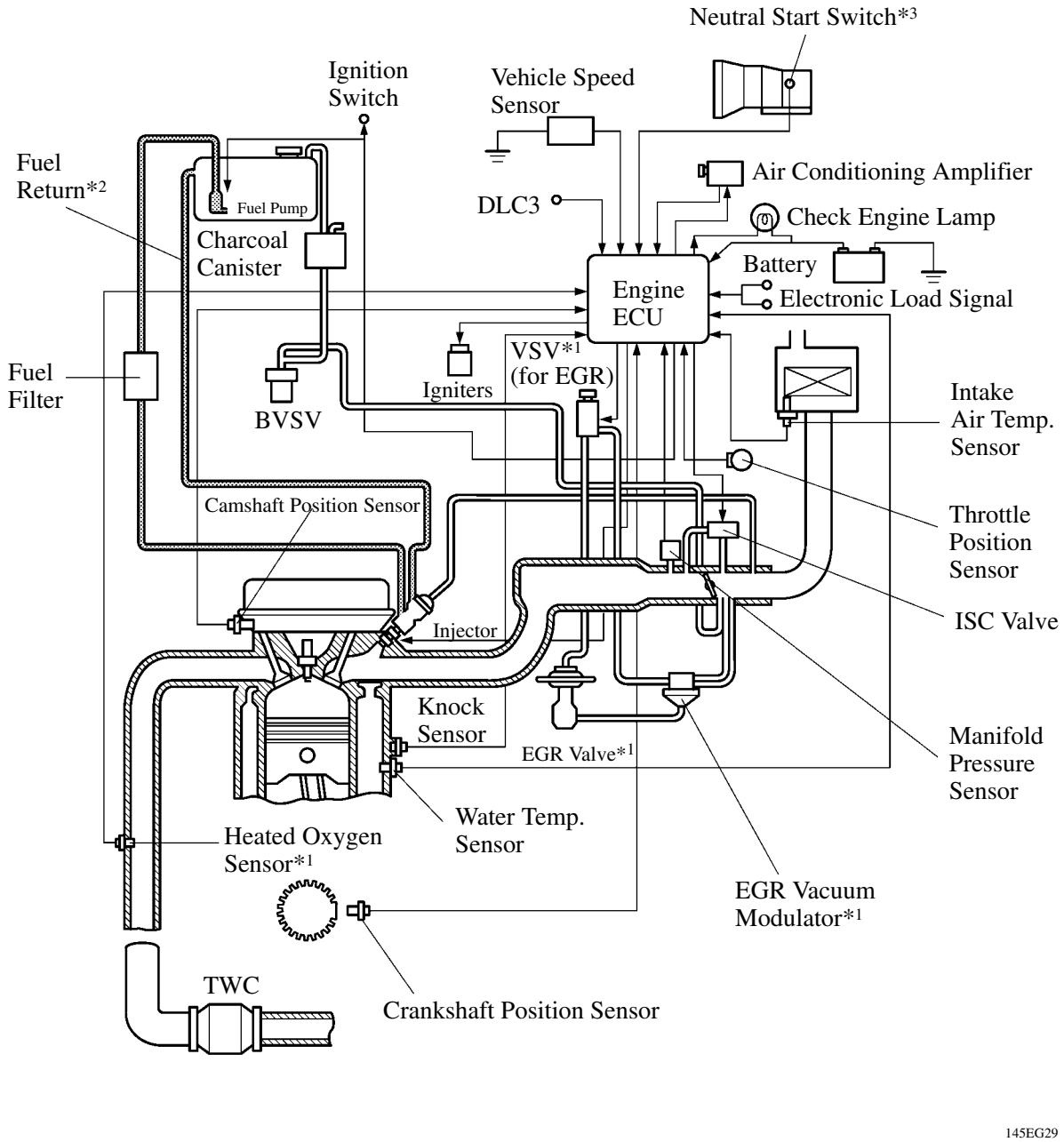
The configuration of the engine control system in the new 3S-FE engine is as shown in the following chart. Shaded portions [ ] differ from the previous 3S-FE engine.



*1: Only for Europe Model
*2: Only for General Countries Model
*3: Applicable only to the Automatic Transaxle Model.

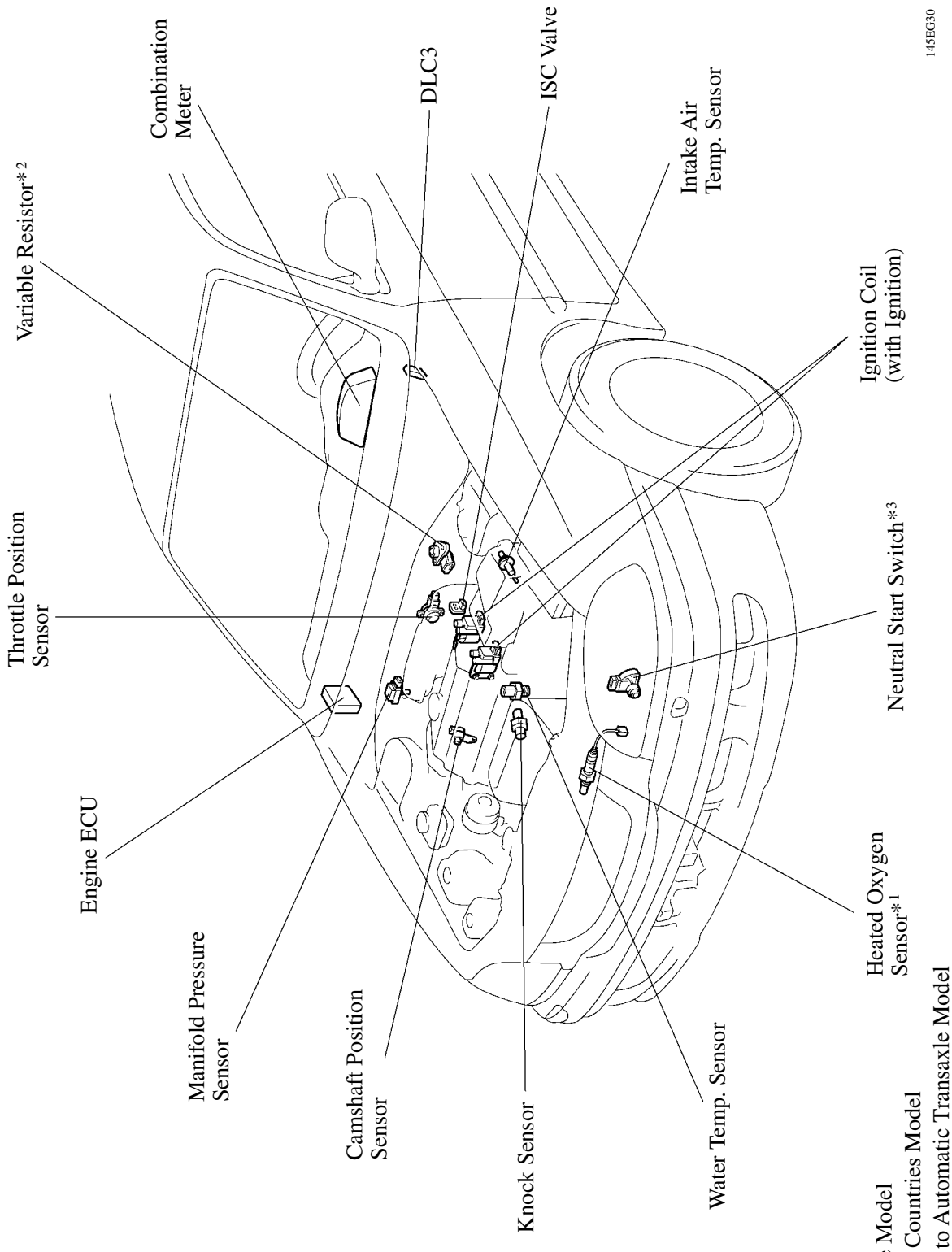
EG

3. Engine Control System Diagram



*1: Only for Europe Model
*2: Only for General Countries Model
*3: Automatic Transaxle Model Only

4. Layout of Components



*1 : Only for Europe Model
*2 : Only for Genral Countries Model
*3 : Applicable only to Automatic Transaxle Model

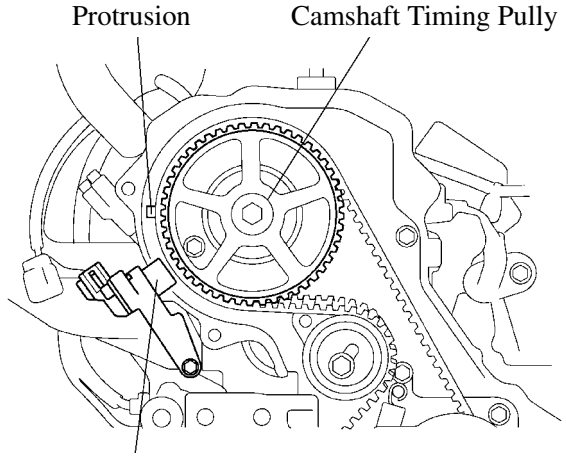
5. Main Components of Engine Control System

The following table compares the main components of the 3S-FE engine in the new and previous model.

Component \ Model		New	Previous
Manifold Pressure Sensor		Semiconductor Type	←
Throttle Position Sensor		Linear Type	←
Crankshaft Position Sensor		Pick-Up Coil Type, 1	–
Camshaft Position Sensor		Pick-Up Coil Type, 1	–
Distributor	Crankshaft Position Sensor	–	Pick-Up Coil Type, 1
	Camshaft Position Sensor	–	Pick-Up Coil Type, 1
Knock Sensor		Built-In Piezoelectric Element Type, 1	←
Oxygen Sensor		With Heater Type	←
Injector		4-Hole Type	2-Hole Type
ISC Valve		Rotary Solenoid Type	←

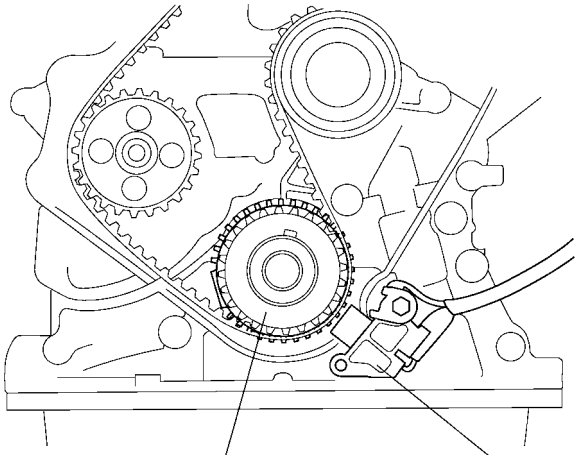
Camshaft Position Sensor

The camshaft position sensor is mounted onto the cylinder head. Using the protrusion that is provided on the timing pulley, the sensor generates 1 signal for every revolution.
This signal is then sent to the engine ECU as a crankshaft angle signal.



Crankshaft Position Sensor

The crankshaft position sensor is mounted on the oil pump body.
The timing rotor is integrated with the crankshaft pulley. The rotor's teeth are spaced 10° apart according to crankshaft angle but since there are 2 teeth missing, as illustrated below, there is a total of 34 teeth. Accordingly, the engine ECU can detect the crankshaft angle in addition to the crankshaft speed.



6. EFI (Electronic Fuel Injection System)

The injection pattern has been changed from the previous 2-group injection type to the Sequential Multiport fuel injection type to improve the precision of the air-fuel ratio feedback control.

7. ISC (Idle Speed Control)

The power steering idle-up control has been changed from the system using an air control valve to the one using a pressure switch and an ISC valve.

8. Cooling Fan Control

In the previous model, the operation of the cooling fan used to be controlled by the water temperature switch provided at the bottom of the radiator lower tank. In the new model, the cooling fan is controlled by the engine ECU based on the signal (THW) that is output by the water temperature sensor.

9. Engine Coolant Temperature Signal Output

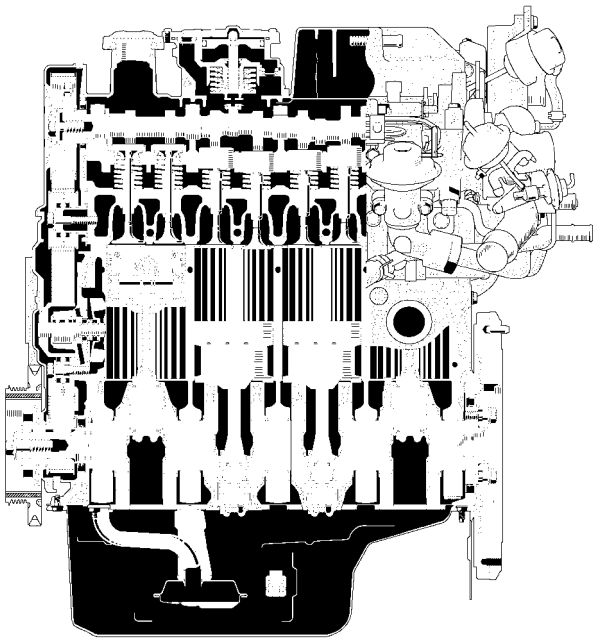
In place of the temperature sender gauge used on the previous model, the engine ECU sends the engine coolant temperature signal to the engine coolant temperature gauge in the combination meter.

2C-T AND 2C-TE ENGINES

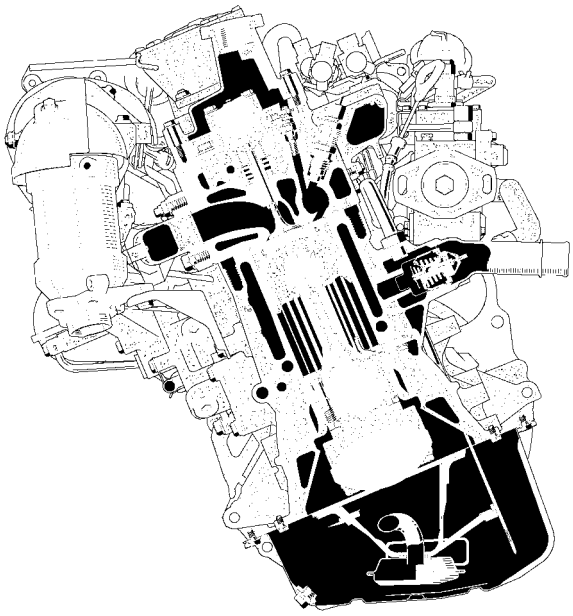
■ DESCRIPTION

Based on the 2C-T engine, the 2C-TE provides improved engine performance through the use of an intercooler, as well as improved driveability and reduced exhaust emissions through the use of an electronically controlled injection pump.

In the 2C-T engine, the distance between the intake and exhaust valves in the cylinder head has been increased to improve the cooling performance between the valves.



145EG18

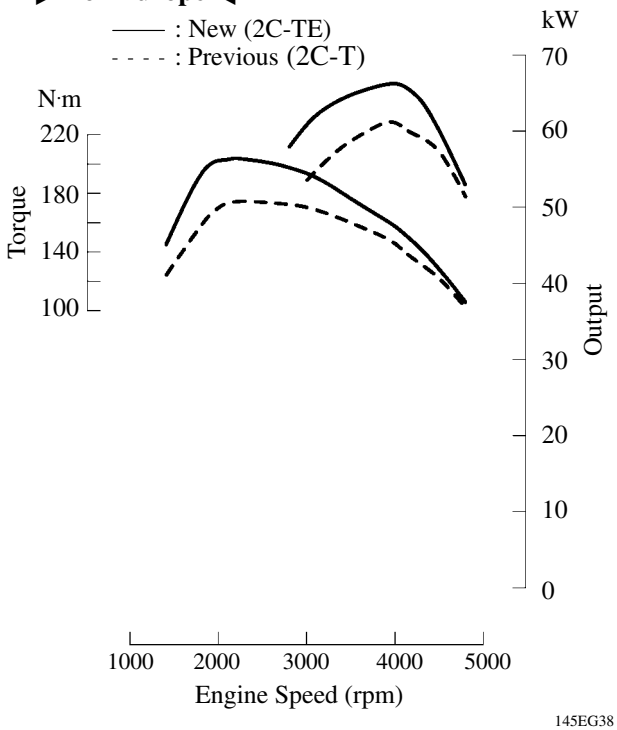


145EG19

■ENGINE SPECIFICATIONS AND PERFORMANCE CURVES

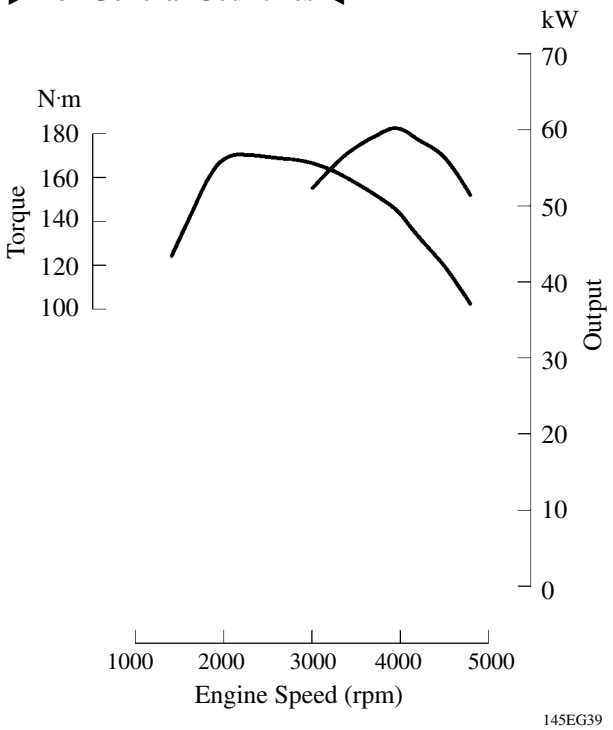
Model / Engine / Item			New		Previous
			2C-TE	2C-T	2C-T
No. of Cyls. & Arrangement			4-Cylinder, In-Line		←
Valve Mechanism			8-Valve, OHC, Belt Drive		←
Combustion Chamber			Swirl Type		←
Manifolds			Cross-Flow		←
Fuel System			Distributor Type (Electronically Controlled)	Distributor Type (Mechanically Controlled)	←
Displacement cm³ (cu. in.)			1975 (120.5)		←
Bore x Stroke mm (in.)			86.0 x 85.0 (3.39 x 3.35)		←
Compression Ratio			23.0 : 1		←
Max. Output [EEC]		Europe	66 kW@4000 rpm	60 kW/4000 rpm	61kW@4000 rpm
		General Countries	–	60 kW/4000 rpm	61 kW@4000 rpm
Max. Torque [EEC]		Europe	203 N·m@2200 rpm	170 N·m@2000～3000 rpm	174 N·m@2000～3000 rpm
		General Countries	–	170 N·m@2000～3000 rpm	174 N·m@2000～3000 rpm
Valve Timing	Intake	Open	7°BTDC		←
		Close	35°ABDC		33°ABDC
	Exhaust	Open	56°BBDC		←
		Close	5°ATDC		←
Fuel Cetane Number			48 or higher		←
Oil Grade			CF-4		API CD or Better

▶ For Europe ◀



145EG38

▶ For General Countries ◀



145EG39

EG

■ MAJOR DIFFERENCES

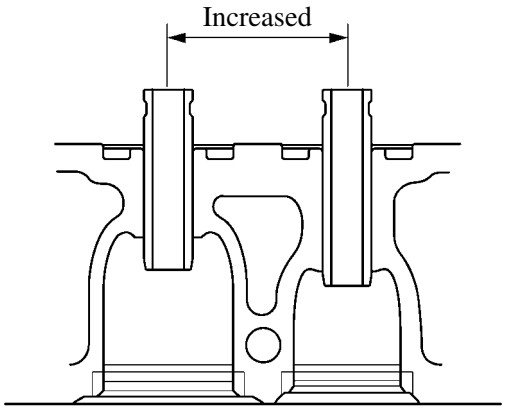
The following changes have been made to the 2C-TE and 2C-T engine.

Item	Features	2C-TE	2C-T
Engine Proper	● The distance between the intake and exhaust valves in the cylinder head has been increased to improve the cooling performance. ● The shape of the combustion chamber has been optimized to improve the torque in the low- to mid-speed range.	○	○
Intake and Exhaust System	● A diesel throttle has been adopted to reduce intake air noise and vibration. ● An intercooler has been adopted to improve engine performance. ● The exhaust manifold adopts a two-part construction to improve its reliability.	○	–
	● The internal construction of the main muffler has been optimized to improve its quietness and reduce the exhaust pressure. ● The support of the main muffler has been changed from the 3-point to 2-point support to reduce the noise and vibration that are transmitted to the body.	○	○
Turbocharger System	The size of the vanes and the clearance between various parts have been optimized to improve the turbocharging efficiency.	○	–
Cooling System	An aluminum radiator core is used for weight reduction.	○	○
Fuel System	An electronically controlled injection pump is used.	○	–
Engine Control System	● An electronic fuel injection system has been adopted. ● M-OBD (Multiplex On-Board Diagnosis) system is adopeted.	○	–

■ENGINE PROPER

1. Cylinder Head

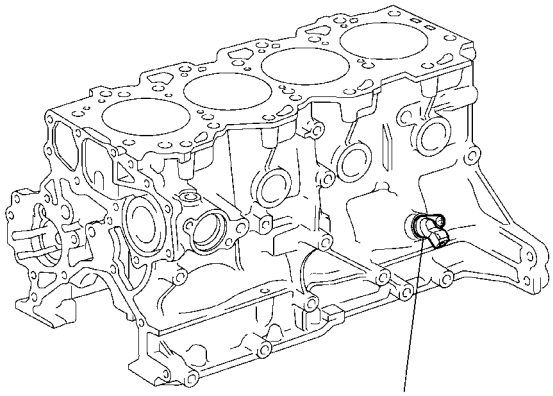
The distance between the intake and exhaust valves has been increased to improve the cooling performance.



145EG40

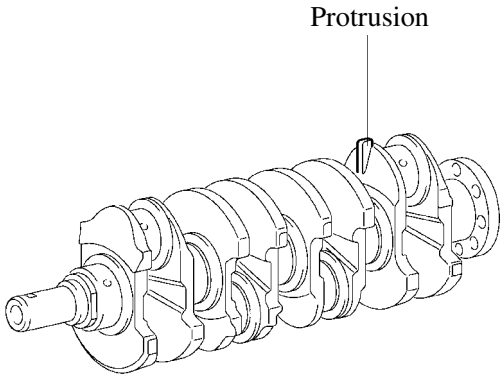
2. Cylinder Block and Crankshaft (Only for 2C-TE ENGINE)

Along with the adoption of the engine control system, a crankshaft position sensor has been provided in the cylinder block, and a protrusion has been provided on the crankshaft to generate a signal.



Cylinder Block

141EG21



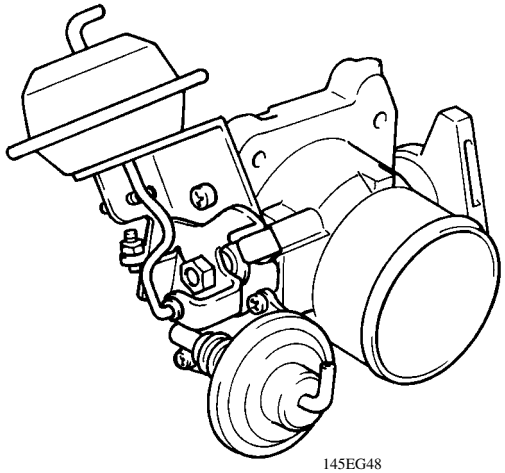
Crankshaft

141EG22

■INTAKE AND EXHAUST SYSTEM

1. Diesel Throttle (Only for 2C-TE Engine)

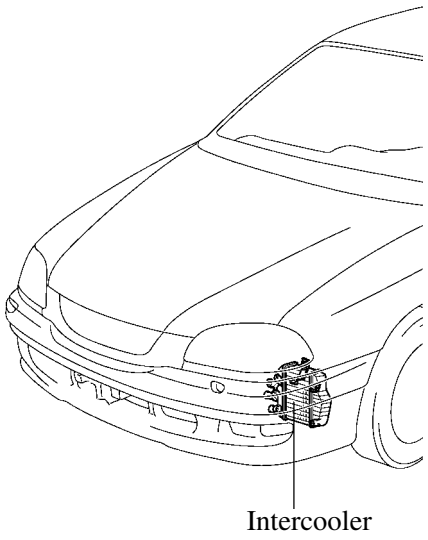
- The throttle valve that is not linked directly to an accelerator pedal has been adopted to reduce the noise and vibration during idling, deceleration, and when the engine is stopped.
- The throttle valve opening is controlled by the engine ECU in accordance with the engine condition, in the following 3 stages: wide open, idle opening, and fully closed.



145EG48

2. Intercooler (Only for 2C-TE Engine)

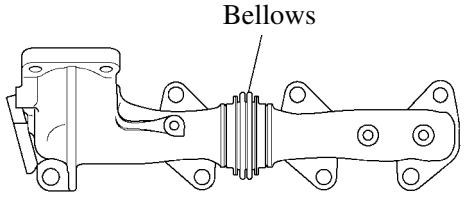
An intercooler has been adopted to improve engine performance.
The intercooler is provided in the left side of the front bumper.



145EG41

3. Exhaust Manifold (Only for 2C-TE Engine)

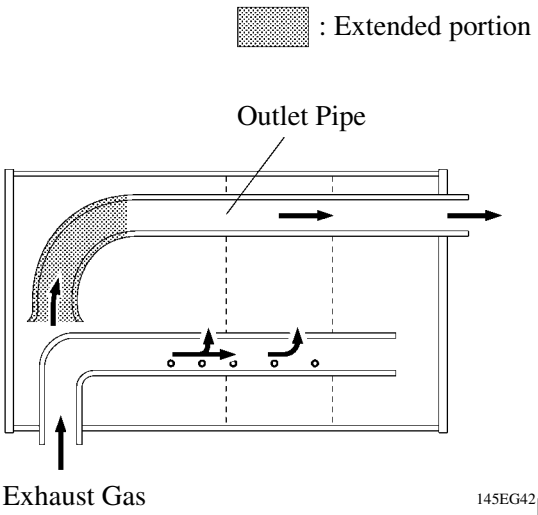
The exhaust manifold adopts a two-part construction in which the two parts are connected by a bellows to improve the manifold's reliability.



145EG53

3. Exhaust Pipe

The outlet pipe in the main muffler has been extended and various components have been optimally located to improve quietness and reduce the exhaust pressure.

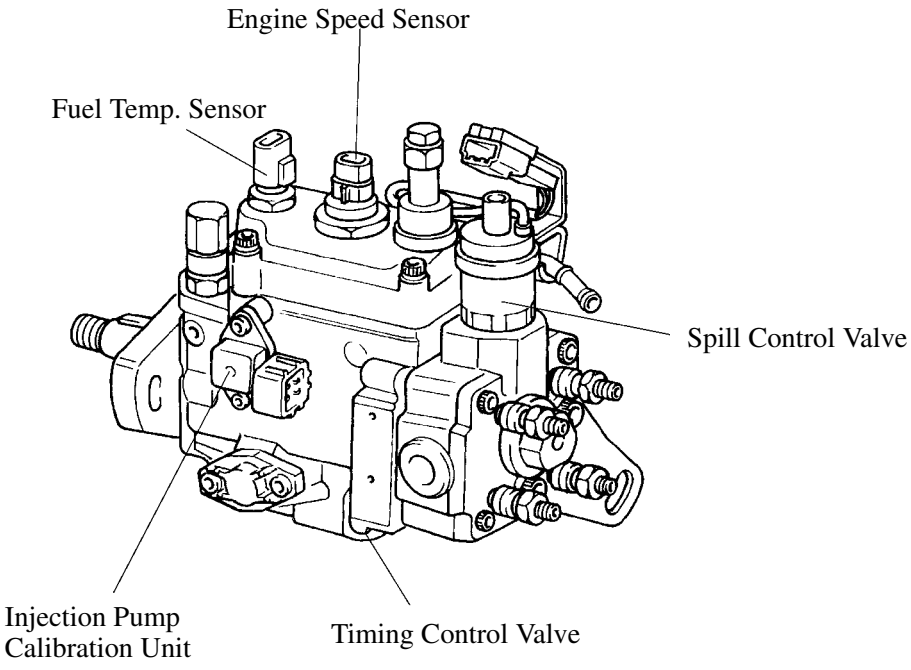


EG

■FUEL SYSTEM

1. Injection Pump (Only for 2C-TE Engine)

Along with the adoption of the engine control system, a spill control valve, timing control valve, fuel temperature sensor, engine speed sensor, and injection pump calibration unit have been provided.



■ENGINE CONTROL SYSTEM (ONLY FOR 2C-TE ENGINE)

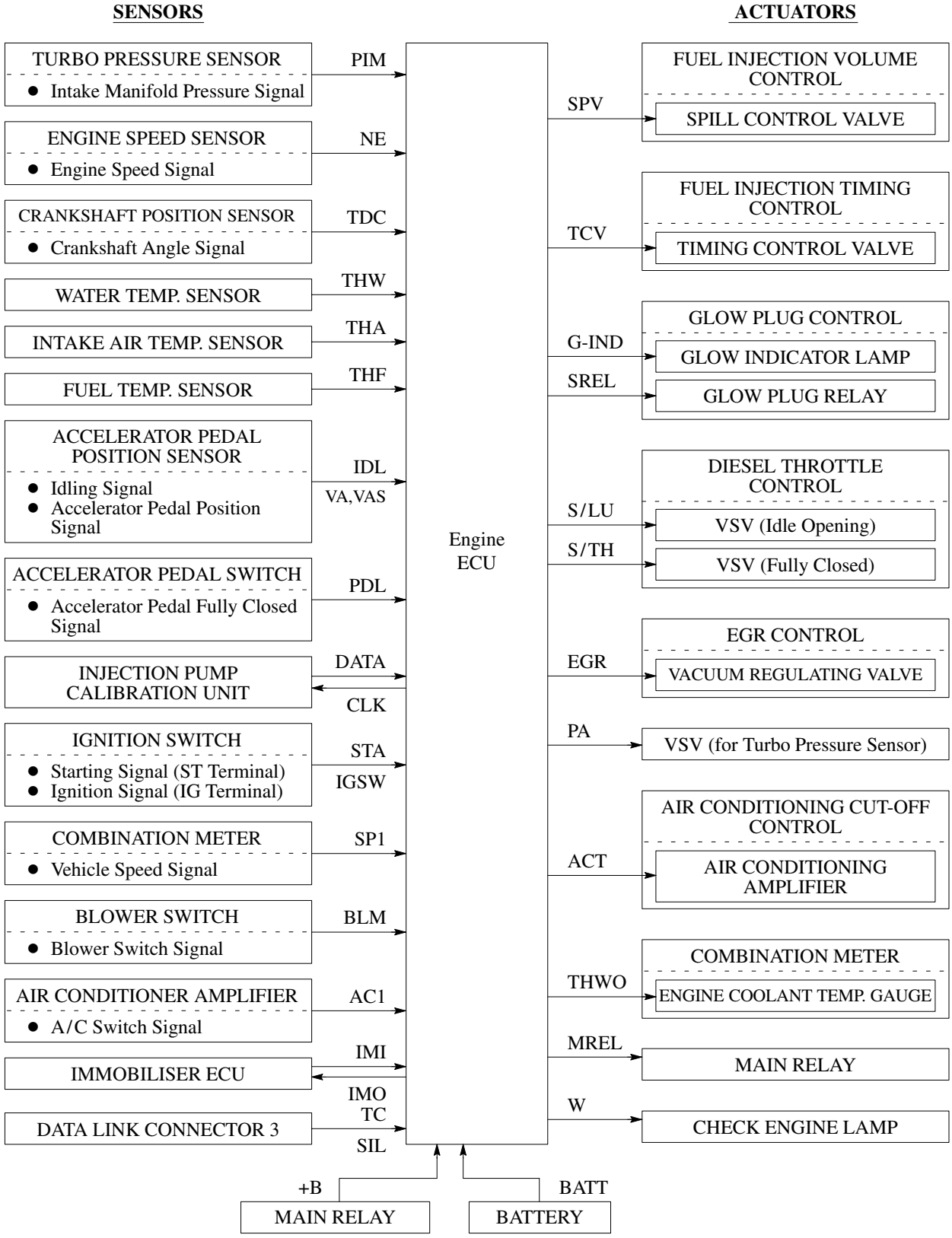
1. General

To operate the engine is an optimal condition. The engine control system of the 2C-TE engine have general control of the following functions: fuel injection volume control, fuel injection timing control and idle speed control. In addition, a diagnosis function has been added to improve the serviceability of the engine.

System	Outline
Fuel Injection Volume Control	Based on the signals received from the sensors, the engine ECU determines the fuel injection volume in accordance with the engine condition.
Fuel Injection Timing Control	Based on the signals received from the sensors, the engine ECU determines the fuel injection timing in accordance with the engine condition.
Idle Speed Control	The engine ECU determines the idle speed in accordance with the engine condition, and controls the fuel injection volume in order to achieve the target idle speed.
Stable Idling Control	Corrects the fuel injection volume that is directed to each cylinder during idling, thus reducing engine vibration.
Diesel Throttle Control	Controls the throttle valve opening in 3 stages in accordance with the engine condition.
Glow Plug Control	Controls the length of time when the current is applied to the glow plugs in accordance with the coolant temperature.
EGR Control	Controls the engine EGR volume in accordance with the engine condition.
Air Conditioning Cut-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 if an attempt is made to start the engine with an invalid ignition key.
Diagnosis	● When the engine ECU detects a malfunction, the engine ECU diagnoses and memorizes the failed section. ● A newly developed diagnostic system which utilizes a high speed bi-directional communication line to provide extended diagnostic capabilities and features.
Fail-Safe	When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in memory.

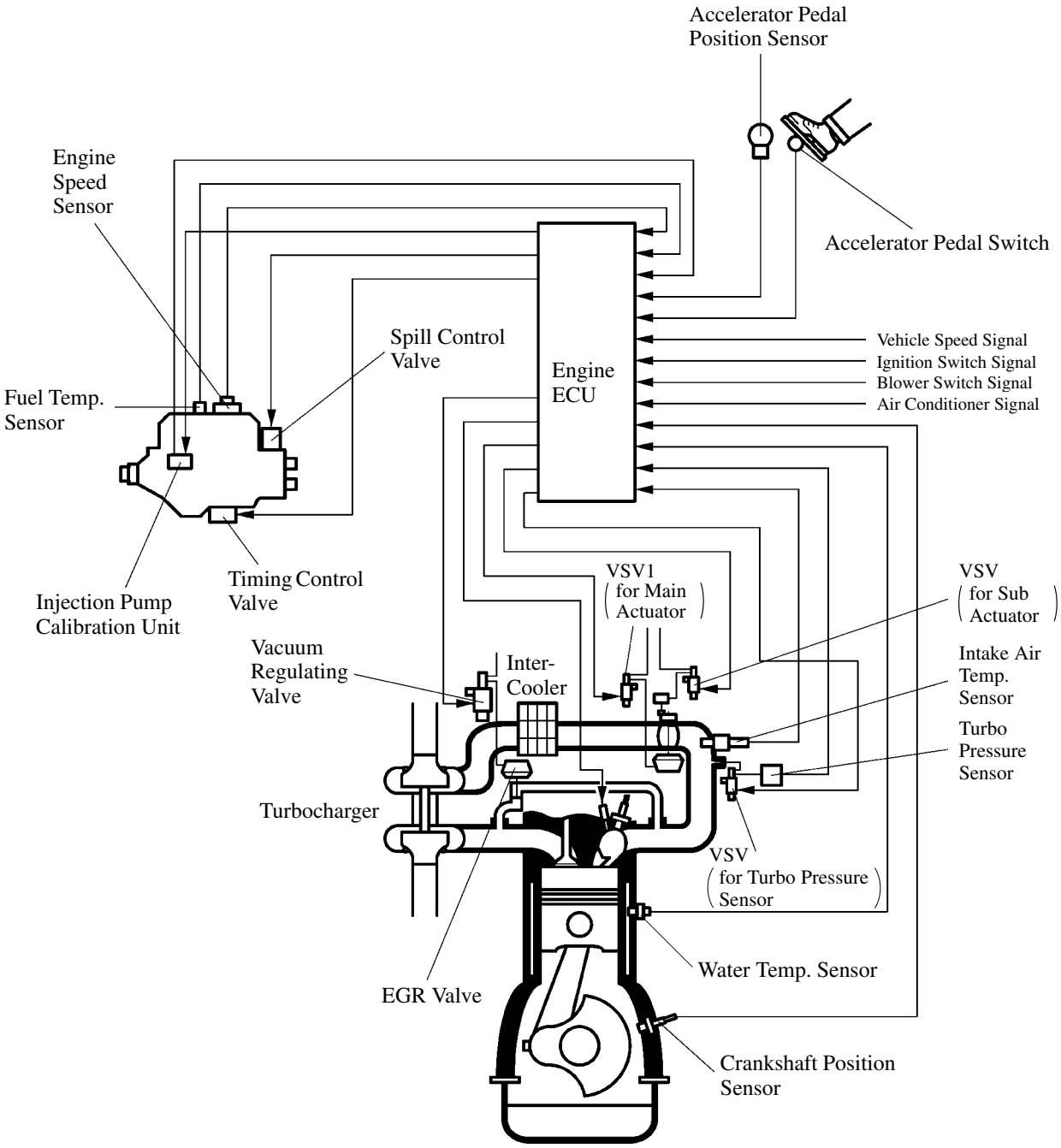
2. Construction

The configuration of the engine control system which can be broadly divided into three groups: the engine ECU, the sensors and the actuators, is shown in the following chart.

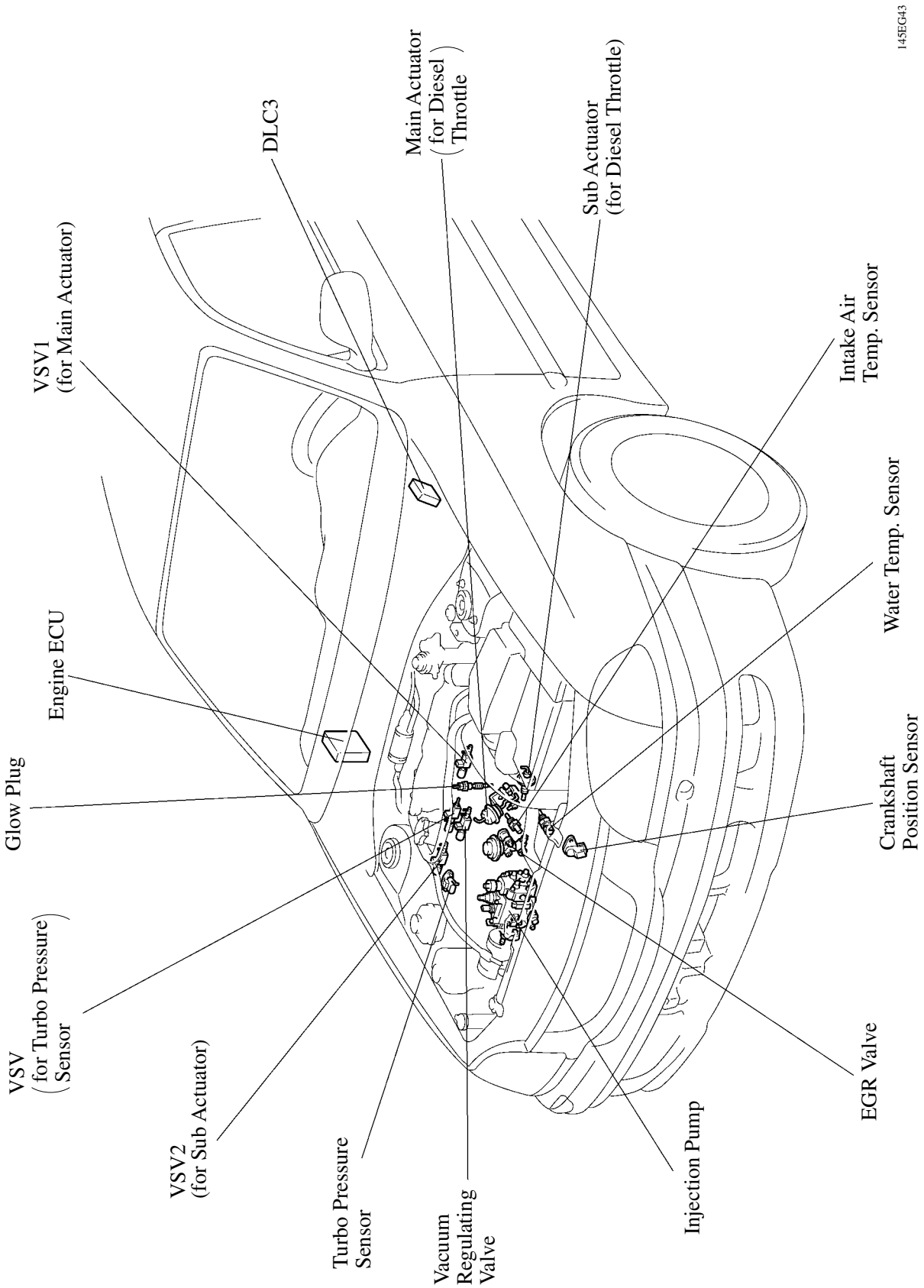


EG

3. Engine Control System Diagram



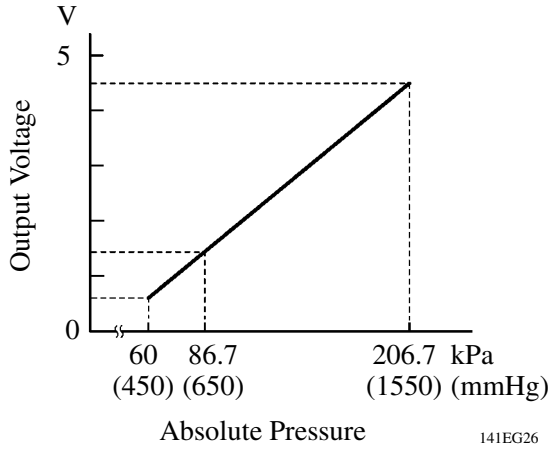
4. Layout of Components



5. Main Components of Engine Control System

Turbo Pressure Sensor

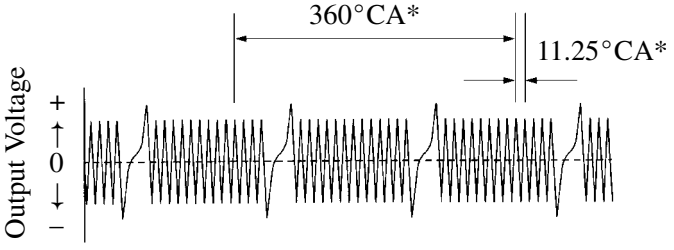
The turbo pressure sensor consists of a semiconductor which utilizes the characteristic of a silicon chip that changes its electrical resistance when pressure is applied to it. The sensor converts the intake air pressure into an electrical signal, and sends it to the engine ECU in an amplified form.
In addition, the atmospheric pressure can be detected by switching the piping passage through the operation of the VSV.

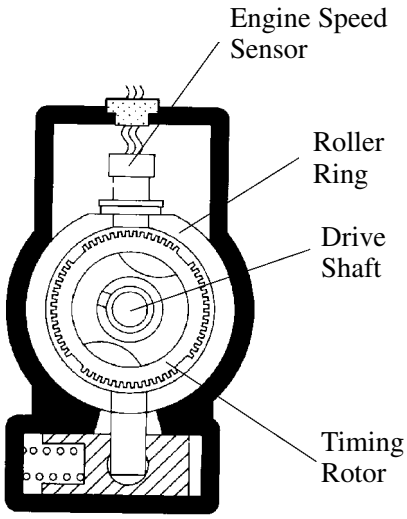


Turbo Pressure Sensor Output Characteristics

Engine Speed Sensor

The engine speed sensor is attached to the roller ring in the injection pump to detect the engine speed. The timing rotor is attached to the drive shaft. Missing 2 teeth at each of the 4 locations, the timing rotor generates a signal every 11.25° (crankshaft angle) with its 56 teeth.

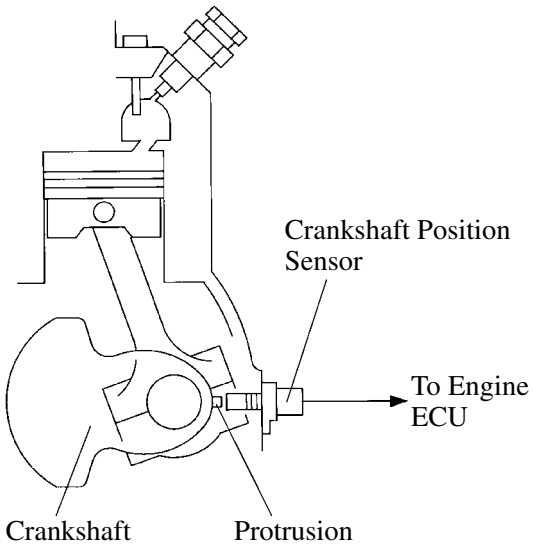




*: CA (Crankshaft Angle)

Crankshaft Position Sensor

The crankshaft position sensor is attached to the cylinder block. Using the protrusion that is provided on the crankshaft, the sensor generates 1 signal for every revolution. This signal is then sent to the engine ECU as a crankshaft position signal.



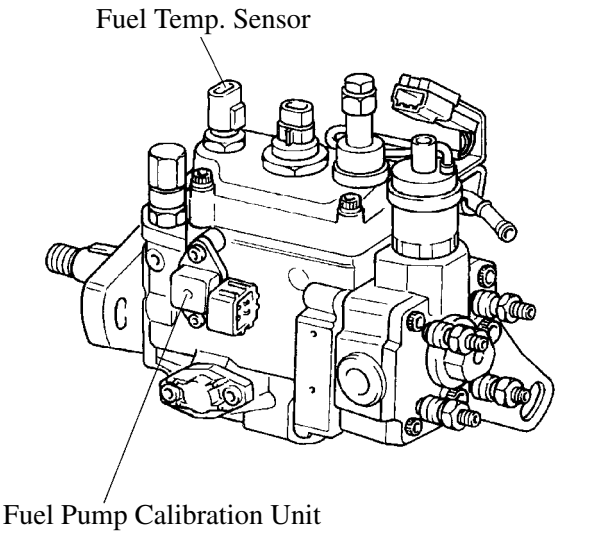
141EG46

Fuel Temperature Sensor

The fuel temperature sensor is attached to the injection pump, and uses an internal thermistor to detect the fuel temperature.

Fuel Pump Calibration Unit

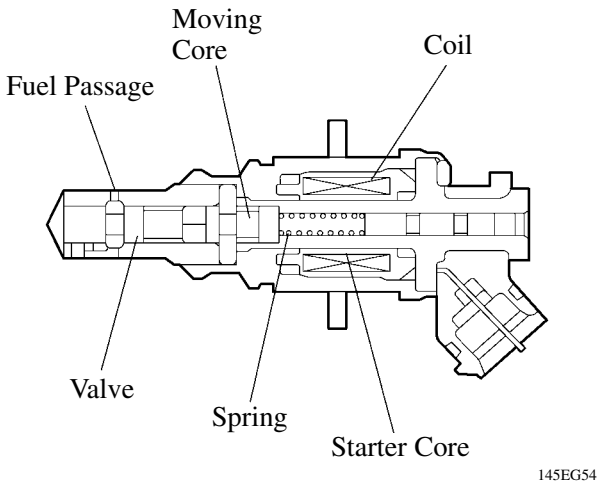
To compensate for the shift in injection volume and injection timing caused by the variances in the injection pump itself, a correction is made by using the data that is stored in the ROM in the fuel pump calibration unit.



145EG47

Timing Control Valve

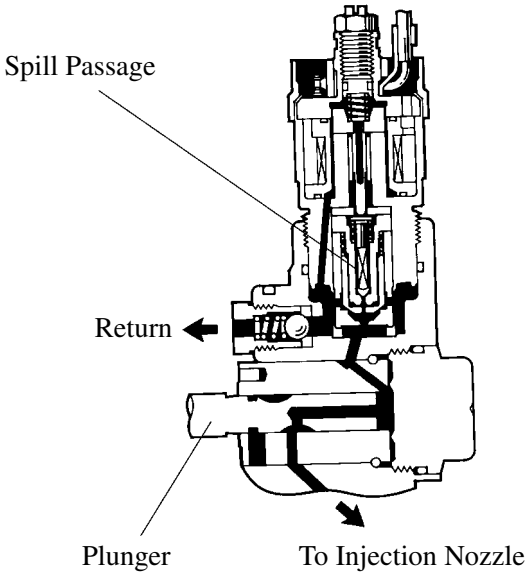
The timing control valve is attached to the injection pump. In accordance with the signals from the engine ECU, it opens the valve in the fuel passage between the high-pressure chamber and the low-pressure chamber, thus controlling the injection timing.
When the current flows to the coil of the timing control valve, the starter core becomes an electromagnet to push and compress the spring. This causes the moving core to retract and open the fuel passage.



145EG54

Spill Control Valve

The spill control valve is attached to the injection pump to control the fuel injection volume in a accordance with the signals received from the engine ECU. When the current applied to the spill control valve is shut off, the valve in the spill control valve opens by the difference in pressures. Thus, the pressure in the plunger decreases causing the injection nozzle to stop injection fuel.
The length of time till the spill control valve is turned OFF becomes the fuel injection time. Thus, the fuel injection volume is controlled by increasing or decreasing the length of time till the spill control valve is turned OFF.



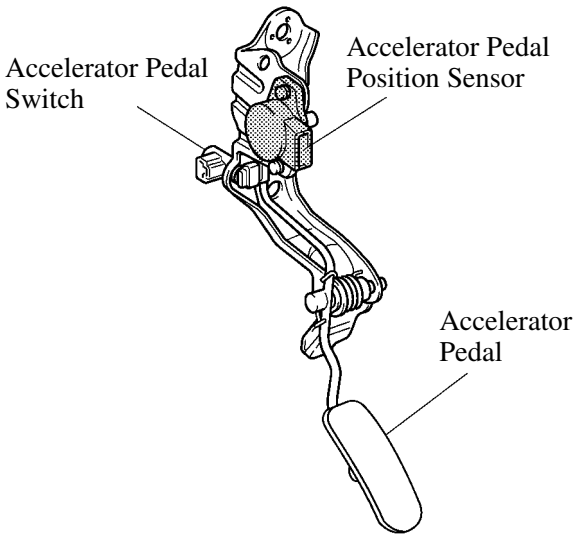
141EG48

Accelerator Pedal Position Sensor

- The accelerator pedal position sensor uses a hall element that outputs voltage that changes linearly in relation to the amount of pedal effort that is applied to the accelerator pedal. The accelerator pedal position sensor uses a duplex system to ensure its reliability.
- An idle switch that detects the fully closed condition of the accelerator pedal is enclosed in the accelerator pedal position sensor.

Accelerator Pedal Switch

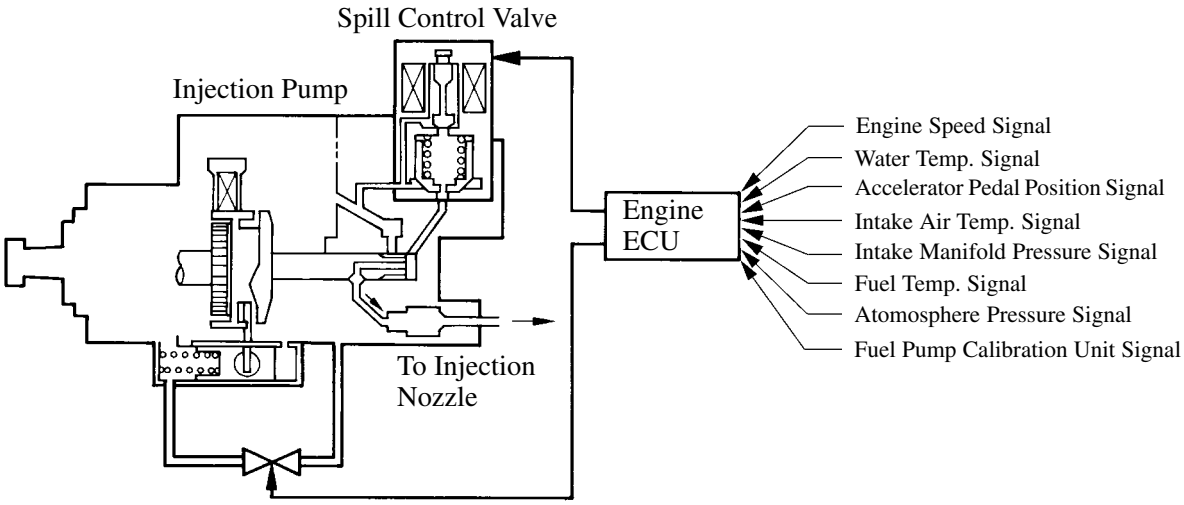
Detects the fully closed condition of the accelerator pedal.



145EG50

6. Fuel Injection Volume Control

Based on sensor signals, the engine ECU controls the fuel injection volume by calculating the fuel injection volume that is appropriate for the engine condition.



Function of Engine ECU

The engine ECU calculates the basic injection volume based on the throttle opening and engine speed, and the maximum injection volume for the engine condition. The two injection volumes are then compared, and the lesser of the two is selected. A correction value, which is obtained via the correction resistors, is added to that injection volume, thus determining the final injection volume.

1) Basic Injection Volume

Determined in accordance with the throttle opening and the engine speed.

2) Maximum Injection Volume

Based on the signals received from the sensors, correction values are added to the theoretically required injection volume (basic maximum injection volume) to determine the maximum injection volume during engine operation.

a. Basic Maximum Injection Volume

Determined in accordance with the engine speed.

b. Intake Manifold Pressure Correction

Corrects the basic maximum injection volume in accordance with the intake manifold pressure. The higher the intake manifold pressure becomes, the larger the injection volume becomes.

c. Intake Air Temperature Correction

Corrects the variance in the air-fuel ratio that is created by the difference in the density of the intake air in accordance with the intake air temperature. The higher the intake air temperature becomes, the smaller the injection volume becomes.

d. Fuel Temperature Correction

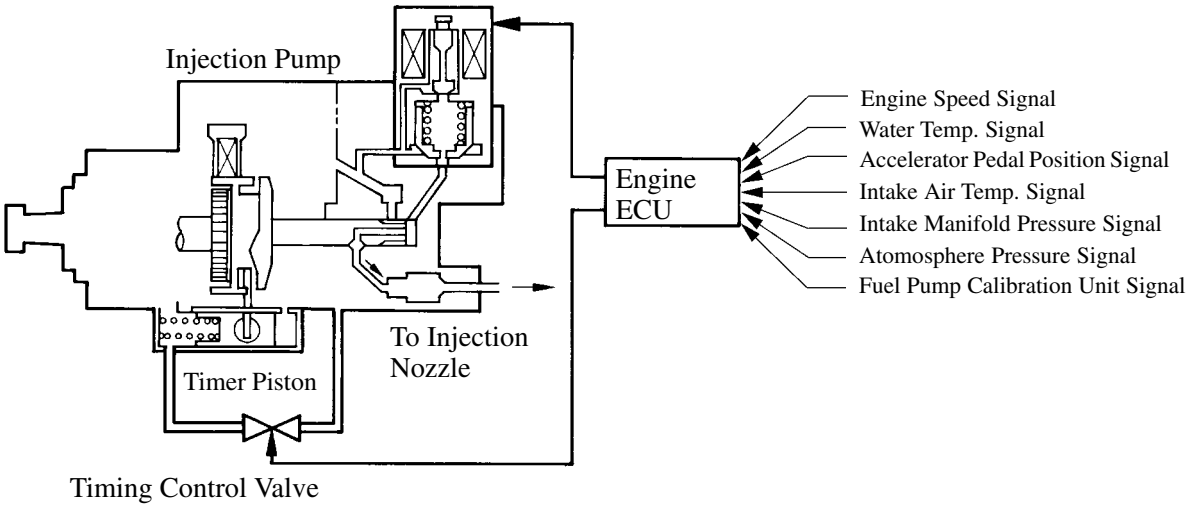
Corrects the variance in the injection volume that is created by the difference in the density of the fuel in accordance with the fuel temperature. The higher the fuel temperature becomes, the larger the injection volume becomes.

3) Starting Injection Volume Control

Determines the fuel injection volume during starting in accordance with the starting signal and the water temperature signal. When the engine is cold, the lower the coolant temperature becomes, the larger the injection volume becomes.

7. Fuel Injection Timing Control

Based on the signals received from the sensors, the engine ECU calculates and controls the fuel injection timing to be optimal for the engine condition.



Function of Engine ECU

The engine ECU adds the corrections from the sensor signals to the basic fuel injection timing to calculate the fuel injection timing that is optimal for the engine condition.

1) Basic Injection Timing

The basic injection timing is determined in accordance with the injection volume and the engine speed.

2) Injection Timing Correction

a. Intake Manifold Pressure Correction

Corrects the basic fuel injection timing in accordance with the intake air pressure. The injection timing is advanced when the intake air pressure is low in such the case as of high altitude areas.

b. Water Temperature Control

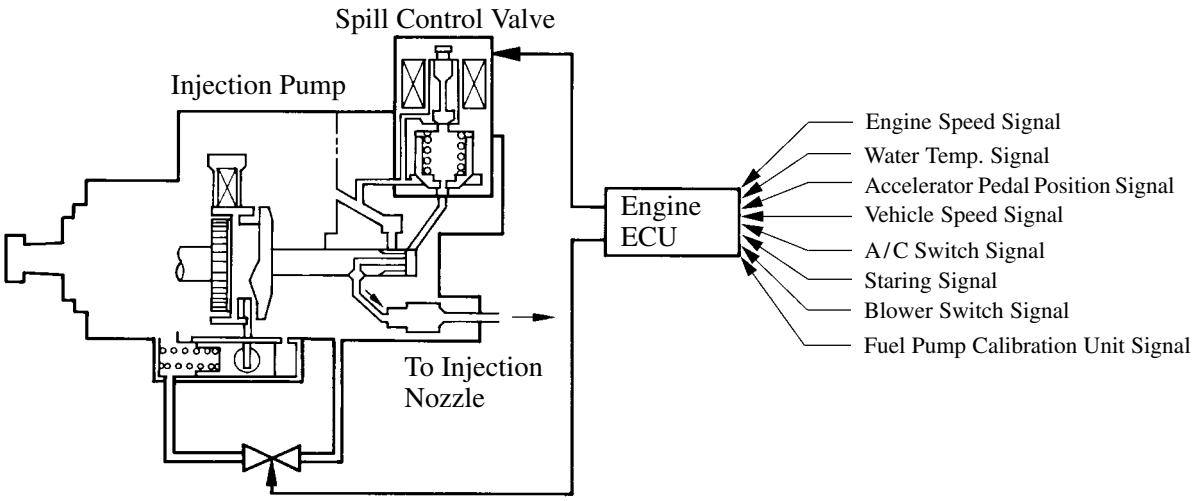
Corrects the basic fuel injection timing in accordance with the water temperature. The injection timing is advanced when the water temperature is low.

3) Starting Injection Timing Control

The starting injection timing is determined in accordance with the starting signal, water temperature signal, and engine speed. The injection timing is advanced when the water temperature is low and engine speed is high.

8. Idle Speed Control

- In this system, the engine ECU calculates the target engine speed in accordance with the engine condition, and determines the fuel injection volume, thus controlling the idle speed rpm.
- During cold operation, the idle is increased by turning ON the blower switch, thus improving the heating performance of the heater.



141EG50

Function of Engine ECU

1) Feedback Control

During idling, the feedback control controls the injection volume to achieve the target idle speed, if there is a difference between the target idle speed calculated by the engine ECU and the actual idle speed.

2) Warm-Up Control

Controls the injection volume during warm-up to achieve an optimal fast idle speed in accordance with water temperature.

3) Engine Speed Change Estimate Control

Immediately after the air conditioning switch is engaged, the idle speed can be affected by the change in the load that is applied to the engine. To prevent this symptom, the engine speed-change estimate control increases or decreases the injection volume before the idle speed changes.

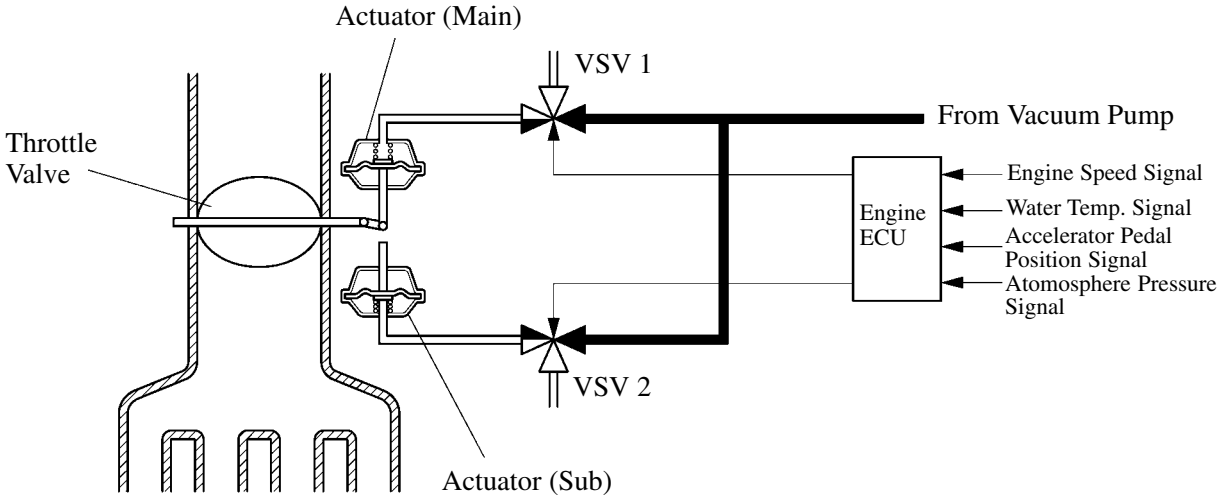
9. Stable Idling Control

Immediately after the air conditioning switch is turned ON or OFF, the load applied to the engine changes, causing the idle speed to fluctuate. To prevent this symptom, the engine speed-change estimate control increases or decreases the injection volume before the idle speed fluctuates.

10. Diesel Throttle Control

The opening of the throttle valve that is installed on the intake manifold is controlled by the engine ECU in accordance with the engine condition, in the following 3 stages: wide open, idle opening, and fully closed. As a result, the noise that is generated during idling and deceleration, as well as the noise and vibration that are generated when the engine is stopped, have been reduced.

▶ System Diagram ◀



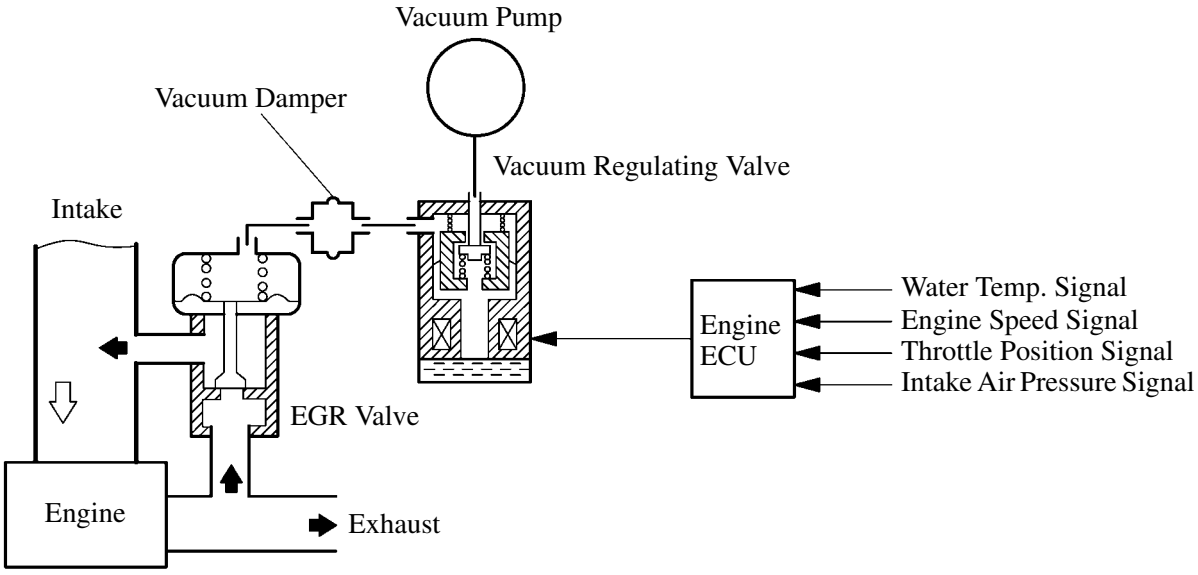
145EG49

VSV / Throttle Valve	VSV 1	VSV 2
Wide Open	OFF	OFF
Idle Opening	ON	OFF
Fully Closed	ON	ON

11. EGR Control

In the EGR control system, the engine ECU controls the vacuum regulating valve to recirculate an appropriate amount of exhaust gas to the combustion chamber in accordance with the engine condition. This results in slower combustion rate, lower combustion temperature, and reduced NOx emissions.

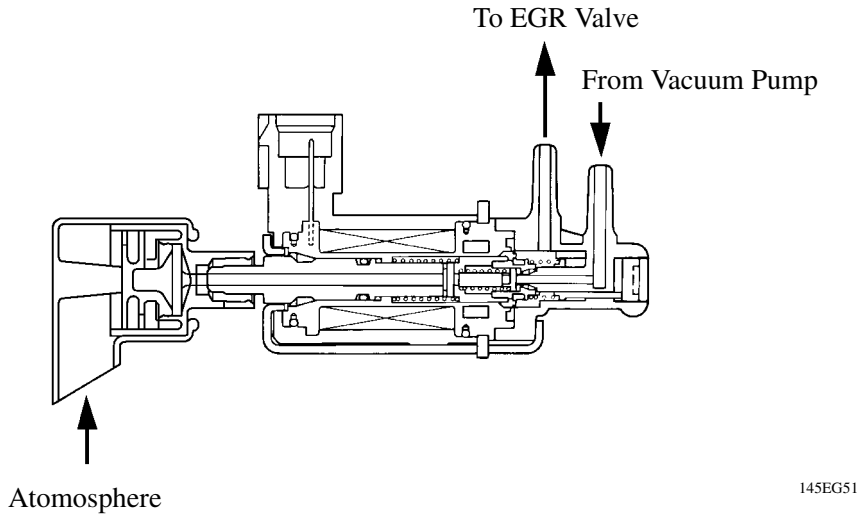
▶ System Diagram ◀



Construction

1) Vacuum Regulating Valve

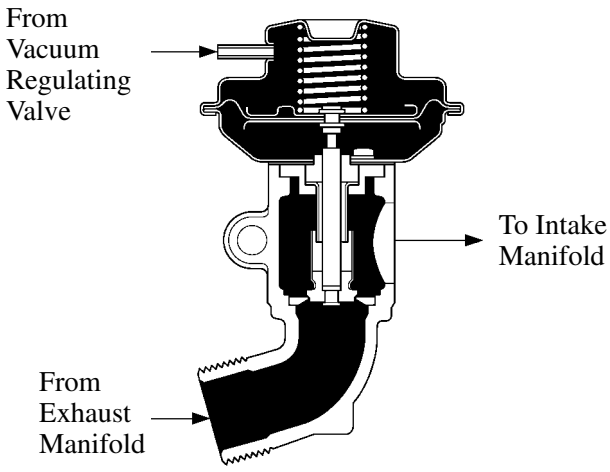
Controls the vacuum that is applied by the vacuum pump to the EGR valve in accordance with the signals from the engine ECU.



EG

2) EGR Valve

Using the vacuum from the vacuum regulating valve, the EGR valve opens and closes the valve to introduce exhaust gas into the intake manifold.



Operation

1) Based on the signals from the sensors, the engine ECU applies duty control to the current that is applied to the vacuum regulating valve, thus regulating the vacuum that is applied to the EGR valve. Thus, the EGR valve opening is controlled to provide the volume of EGR gas that is appropriate for the engine condition.
2) The EGR function is stopped under the conditions given below to ensure drivability and to reduce diesel smoke.

- The water temperature is below 60°C (140°F).
- The vehicle is driven under high load condition.
- During decelecration (The EGR operates at idle)

11. Engine Immobiliser System

The engine immobiliser system has been designed to prevent the vehicle from being stolen. This system uses a transponder key computer that stores the ID code of the authorized ignition key. If an attempt is made to start the engine using an unauthorized key, the transponder key computer emits a signal to the engine ECU to prohibit fuel delivery effectively in order to disable the engine. For details, see page 151 in the Engine Immobiliser system section.

12. Diagnosis

- If the engine ECU detects any problem with a sensor or an electrical circuit, it turns ON the CHECK ENGINE lamp in the combination meter to inform the driver. In addition, the malfunction code will be stored in memory.
- An M-OBD (Multiplex On-Board Diagnostic) System has been adopted to improve serviceability. For details, see page 40.