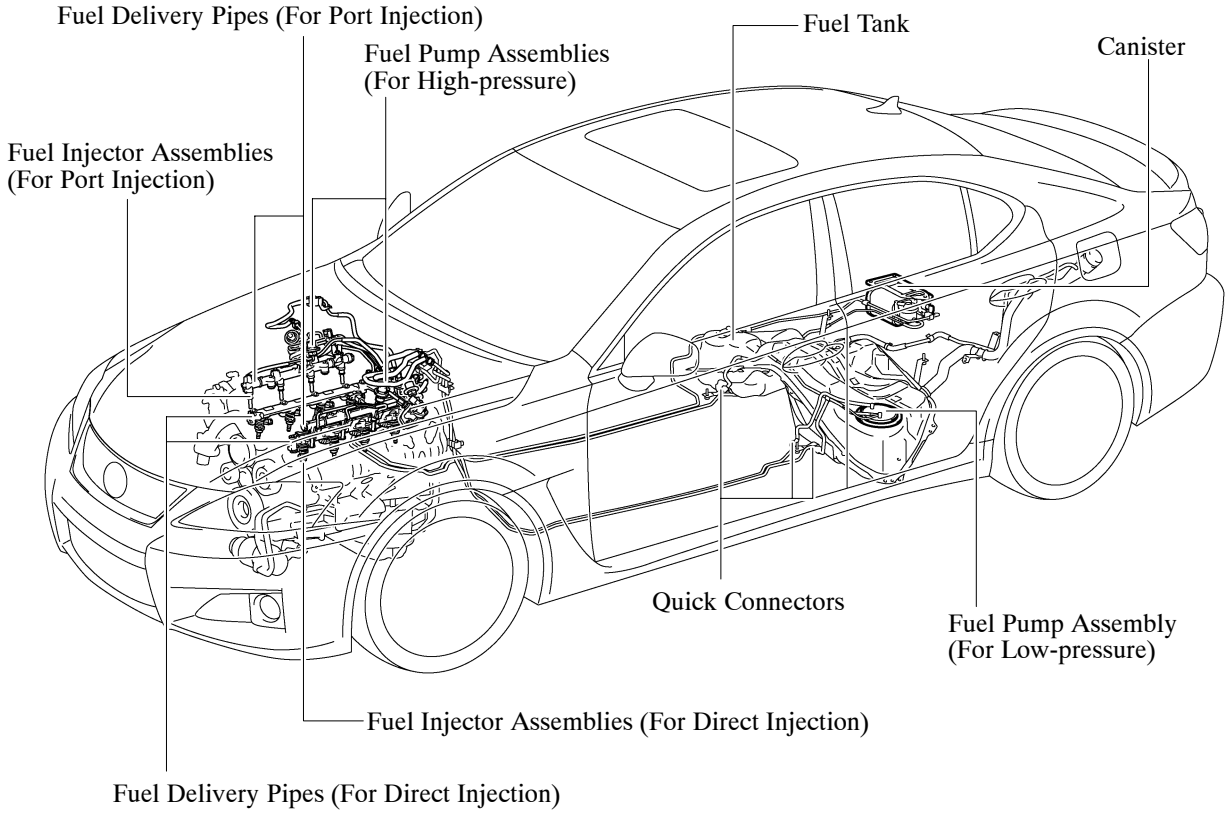
■FUEL SYSTEM

1. General

- The 2UR-GSE engine adopts the D-4S (Direct injection 4-stroke gasoline engine Superior version) system which has both direct and port types of fuel injectors. This system optimally controls the fuel injectors for direct injection and port injection according to engine load. The system achieves improved engine performance, fuel economy, and clean emissions.
- A fuel returnless system is used. This system controls the fuel pressure for the low-pressure part of the fuel system using a pressure regulator installed in the fuel tank. However, the unused fuel from the high-pressure fuel pump and the fuel from the relief valve return to the fuel tank.
- A fuel cut control is used to stop the fuel pump assembly (for low-pressure) when an SRS airbag is deployed in a frontal, side, or rear side collision. For details, see page EG-106.
- In order to ensure excellent serviceability, quick connectors are used to connect the fuel pipes to the fuel hoses.
- High-pressure fuel injectors with double slit nozzles are used for direct injection.
- An evaporative emission control system is used.



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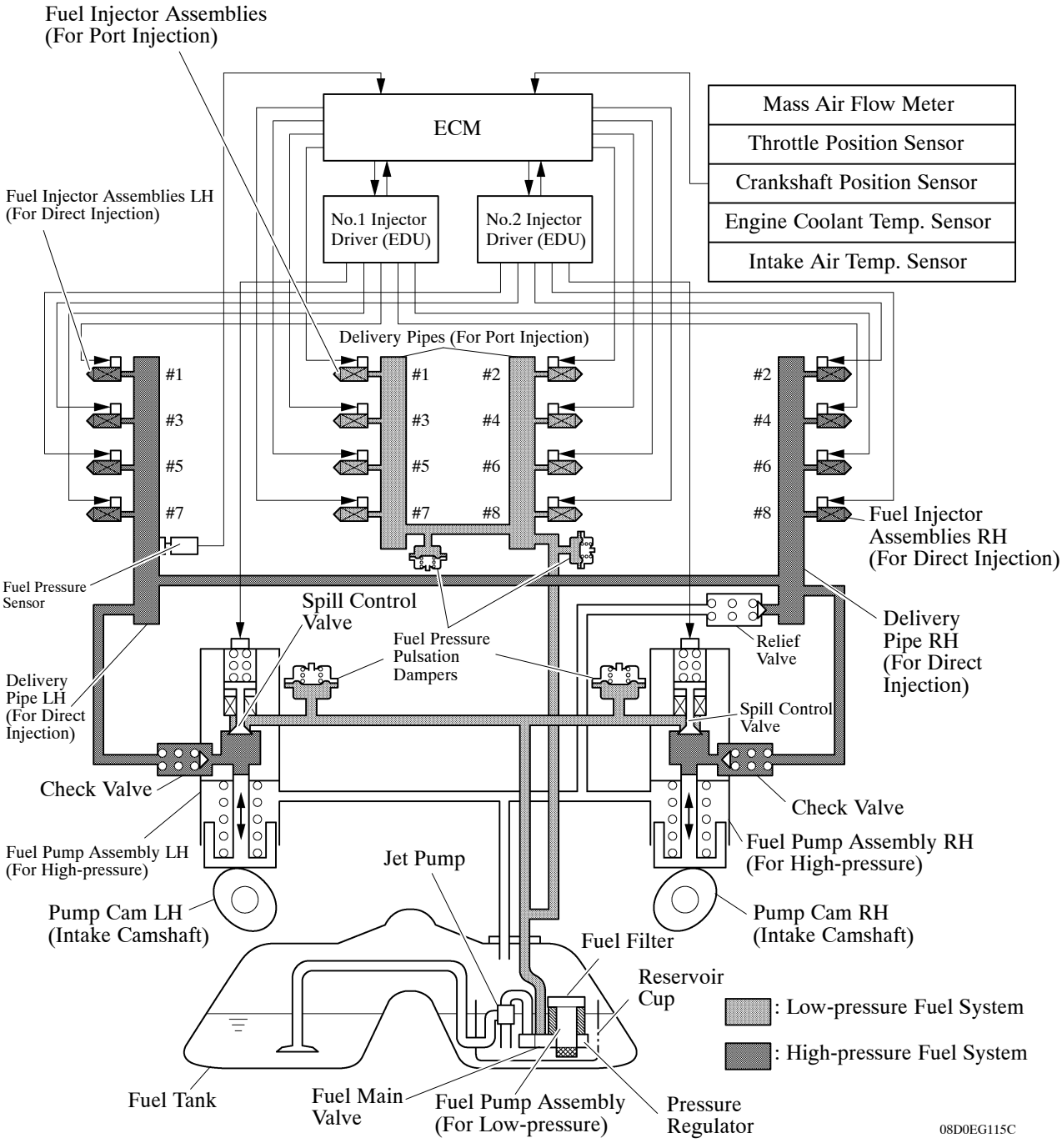
2. D-4S System

General

- The D-4S (Direct injection 4-stroke gasoline engine Superior version) system is based on two types of fuel injection systems: the direct injection system and the port injection system.
- The direct injection system mainly consists of the fuel pumps (for high-pressure), delivery pipes (for direct injection), and fuel injector assemblies (for direct injection). In this system, the ECM controls the high-pressure fuel pumps and fuel injector assemblies (for direct injection) via the injector drivers (EDUs : Electronic Driver Units) based on signals from various sensors, thus optimally controlling fuel pressure, injection volume, and injection timing.
- The port injection system mainly consists of the fuel pump (for low-pressure), delivery pipes (for port injection), and fuel injector assemblies (for port injection). In this system, the ECM controls the fuel injector assemblies (for port injection) based on signals from various sensors, thus optimally controlling injection volume and timing.
- Fuel sent from the fuel tank is delivered to the low-pressure and high-pressure fuel systems. The fuel delivered to the low-pressure fuel system is injected from the fuel injector assemblies (for port injection) to the intake ports.
- The fuel delivered to the high-pressure fuel system is pressurized by the high-pressure fuel pumps and injected from the fuel injector assemblies (for direct injection) to the combustion chambers.

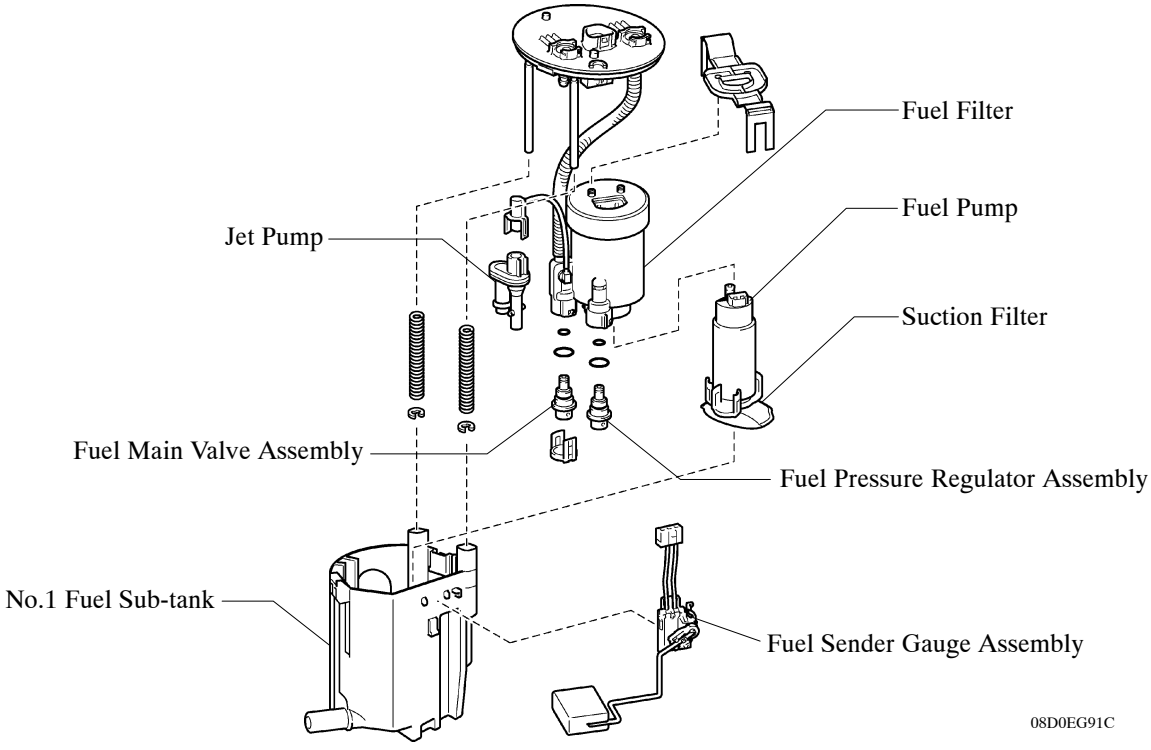
System Diagram



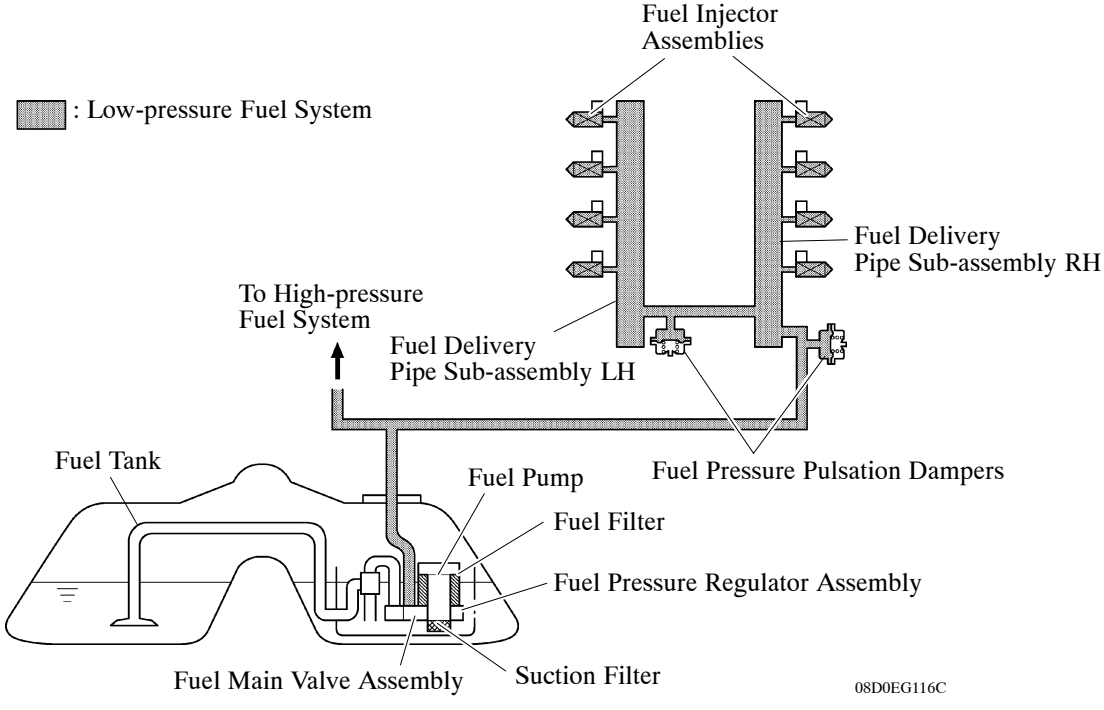
Construction and Operation

1) Fuel Pump (For Low-pressure)

- A fuel pump assembly (for low-pressure) that has an integrated fuel filter and sender gauge is used.
- The low-pressure fuel pump is located in the fuel tank. This pump pressurizes fuel to 400 kPa in order to send the fuel from the fuel tank to the high- and low-pressure fuel systems.
- A low-current fuel pump is used to minimize power consumption and improve fuel economy.



▶ Low-pressure Fuel System Diagram ◀

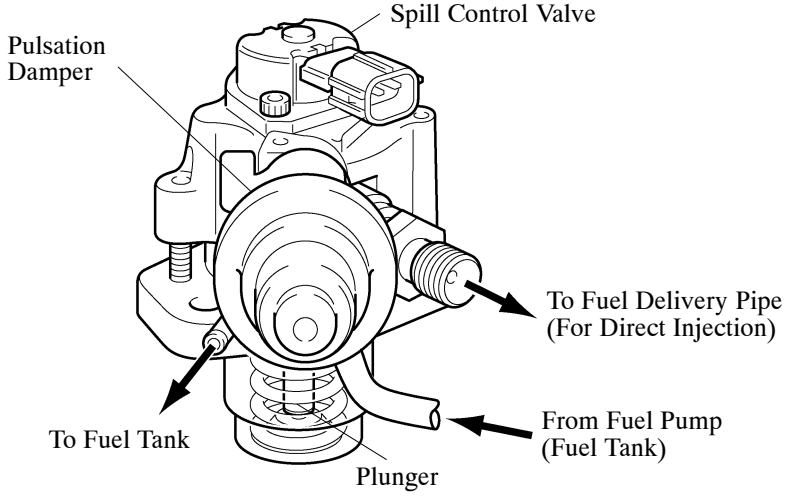


2) Fuel Pump (For High-pressure)

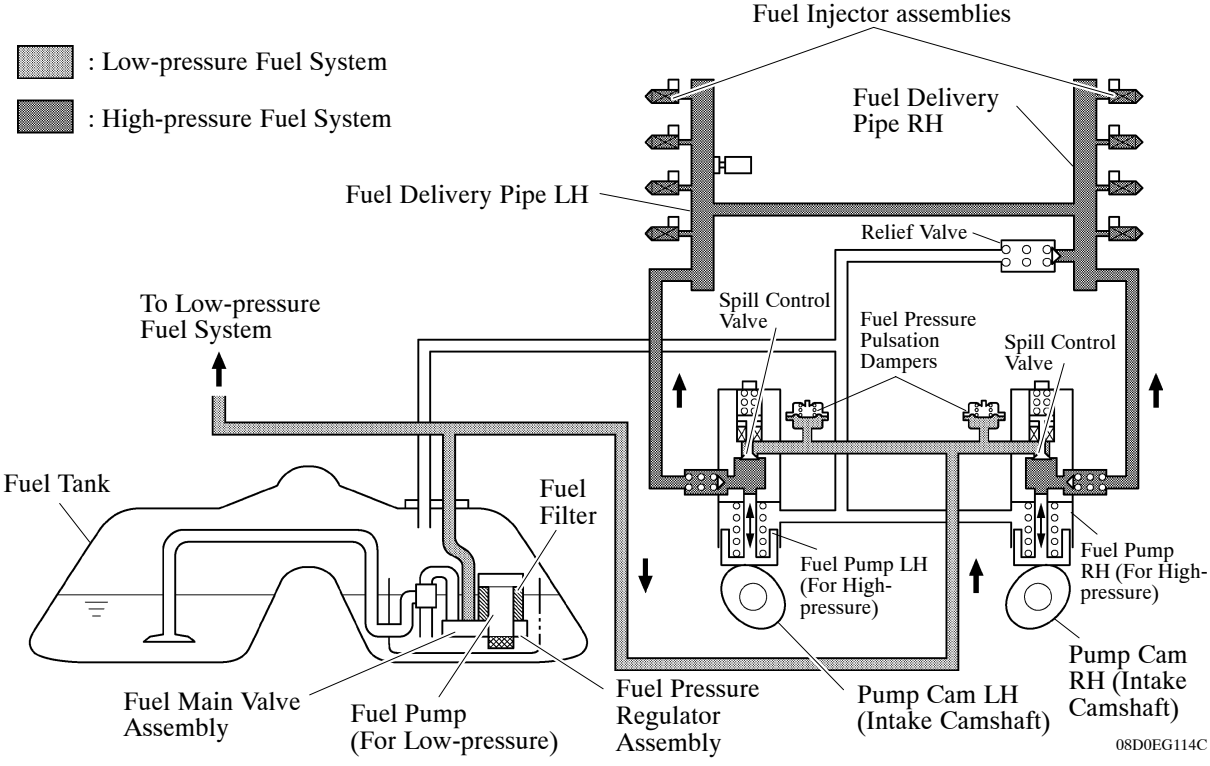
a. Construction

The fuel pump assembly consists of a plunger, spill control valve, and check valve. A fuel pressure pulsation damper is also installed at the fuel inlet. It pressurizes the fuel that is sent by the fuel pump assembly (for low-pressure) to a pressure ranging from 4 to 13 MPa, and sends it to the high-pressure fuel delivery pipe.

- A pump cam that is fitted on the intake camshaft moves the plunger vertically. This pump cam has an oval shape, allowing the plunger to make two strokes for every revolution of the camshaft.
- A spill control valve is used to control the pump discharge pressure. The spill control valve is located in the inlet passage of the pump. It is electrically opened and closed by the injector driver (EDU), based on instructions from the ECM.
- A check valve is present in the outlet of the pump. As the pressure in the outlet of the pump rises, and becomes high enough to push the check valve off its seat, fuel will begin to flow to the fuel delivery pipe (minimum pressure to open the check valve is 60 kPa).



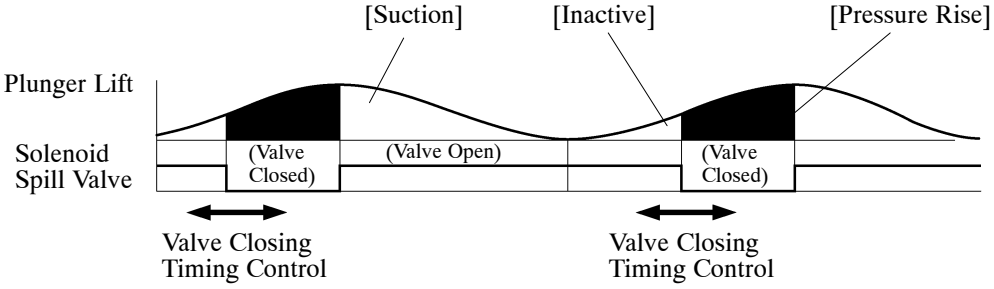
▶ High-pressure Fuel System Diagram ◀

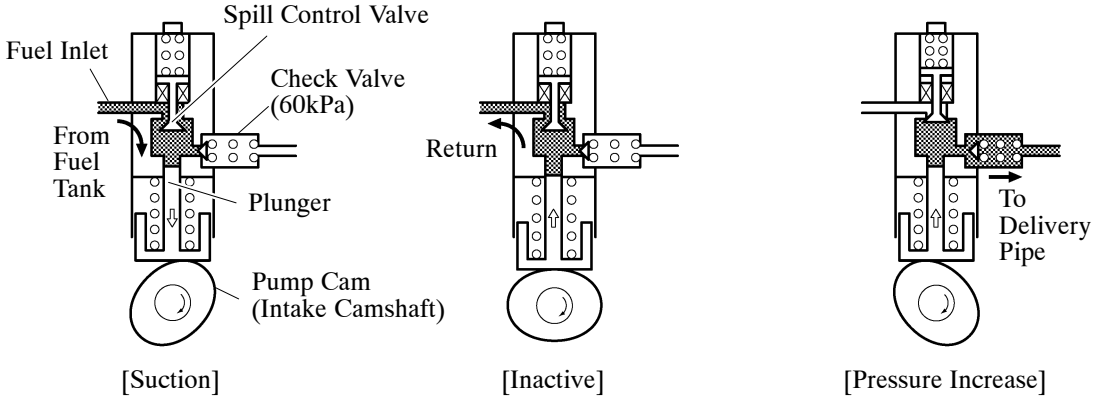


b. Operation

During the intake portion of the pump cycle, the spill control valve is opened, and the pump plunger (piston) is moved downward by a spring force. This allows fuel to be drawn in to the cylinder of the pump. If the spill control valve has not been closed yet, when the cam forces the plunger to move upward, the fuel in the pump cylinder (this fuel is not pressurized) will be pushed back to the pump inlet (fuel tank side).

In order to close the spill control valve as the piston is moving upward, the ECM sends a signal to the valve via the injector driver (EDU). When the spill control valve is closed, and the plunger is moving upward, the pressure in the pump cylinder will rise. As this pressure rises above 60 kPa (or the pressure of the fuel delivery pipe, whichever is higher), the fuel will begin to flow to the fuel delivery pipe. The ECM calculates the target fuel pressure based on driving conditions. The ECM controls the pressure by operating the spill control valve via the injector driver (EDU). The timing and duration of the spill control valve closing is varied to cause the pump pressure to meet the target pressure.





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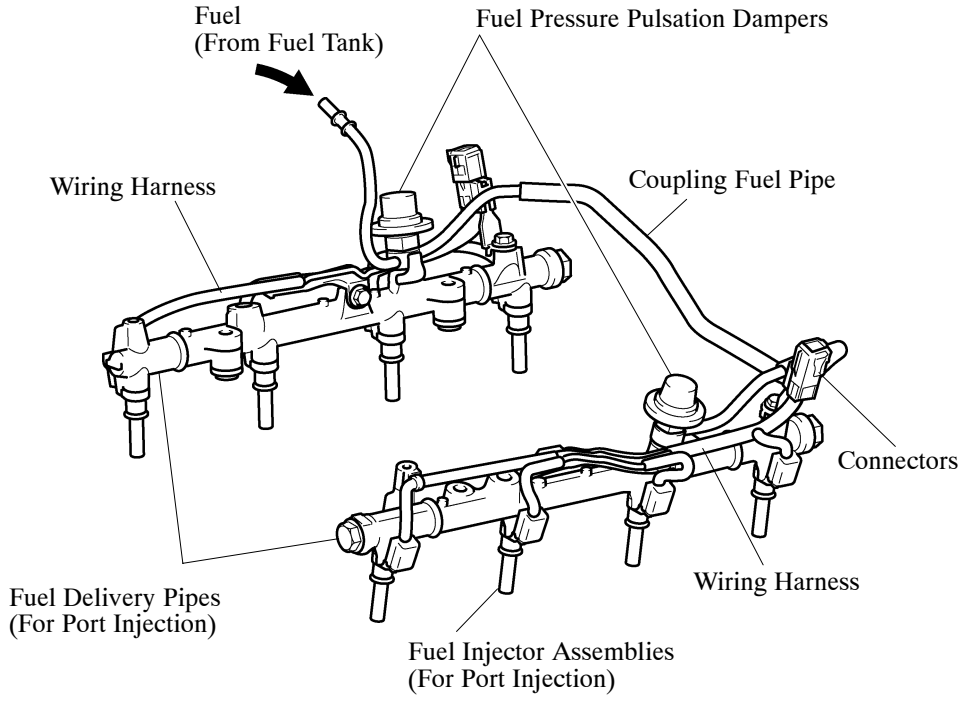
3) Fuel Delivery Pipe (For Port Injection)

- Cast aluminum delivery pipes are used (for port injection) to deliver low-pressure fuel to the fuel injector assemblies (for port injection).
- The wiring harnesses that connect to the fuel injector assemblies (for port injection) are combined into a single strand at each bank. Furthermore, they each connect to the ECM at a single connector for improved serviceability.



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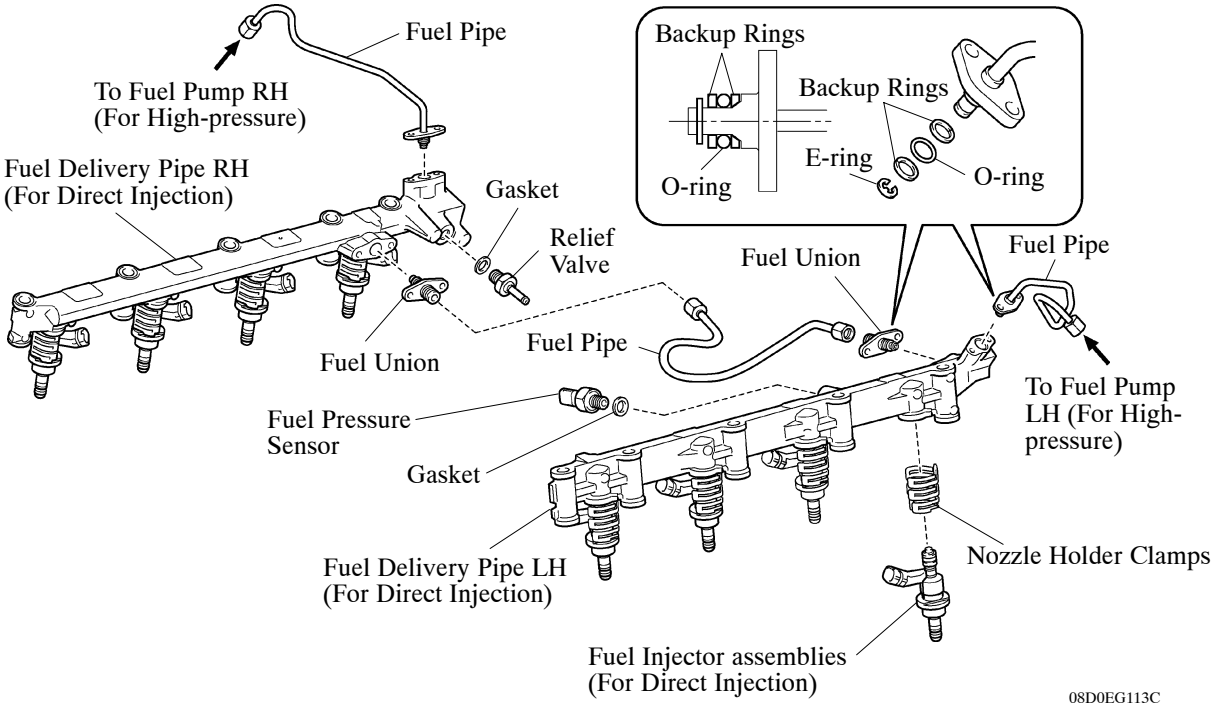
4) Fuel Delivery Pipe (For Direct Injection)

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

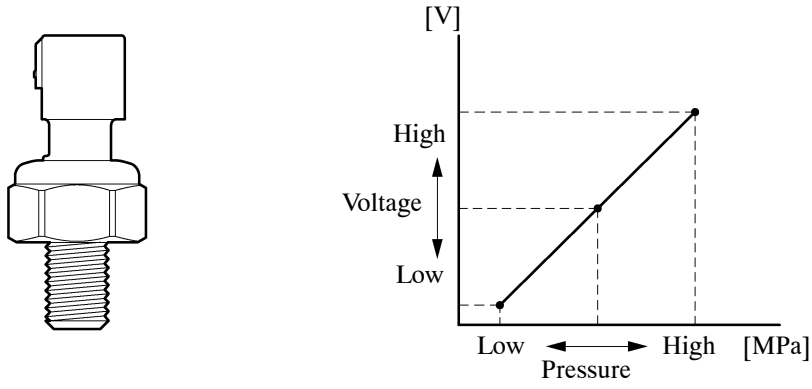


Service Tip

The backup rings are provided to securely support the rubber O-ring which is exposed to high fuel pressure. During assembly, make sure to install them in the correct position and orientation.

5) Fuel Pressure Sensor

The fuel pressure sensor, which is mounted on the fuel delivery pipe, outputs a signal to the ECM that represents the fuel pressure in the fuel delivery pipe in order to allow the constant regulation of the fuel at an optimal pressure.



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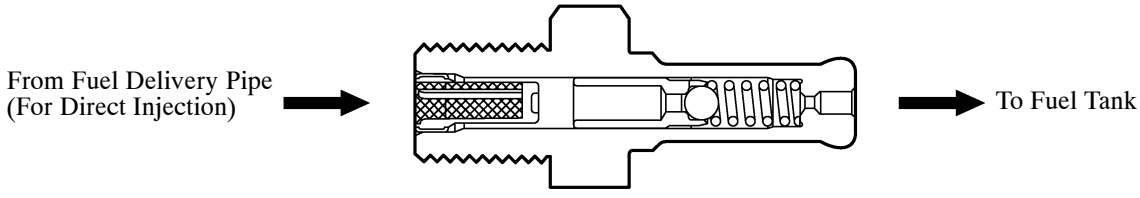
6) Relief Valve

A relief valve is provided in the fuel delivery pipe. When the fuel pressure in the fuel delivery pipe rises above (15.3 MPa), the relief valve limits the pressure by returning fuel to the fuel tank.



Cross Section

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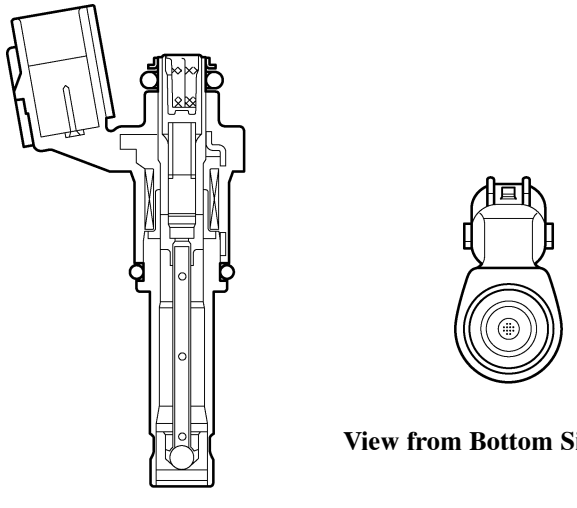
7) Fuel Injector Assembly (For Port Injection)

Compact and lightweight 12-hole type injectors are used as fuel injector assemblies for port injection.



Cross Section

View from Bottom Side

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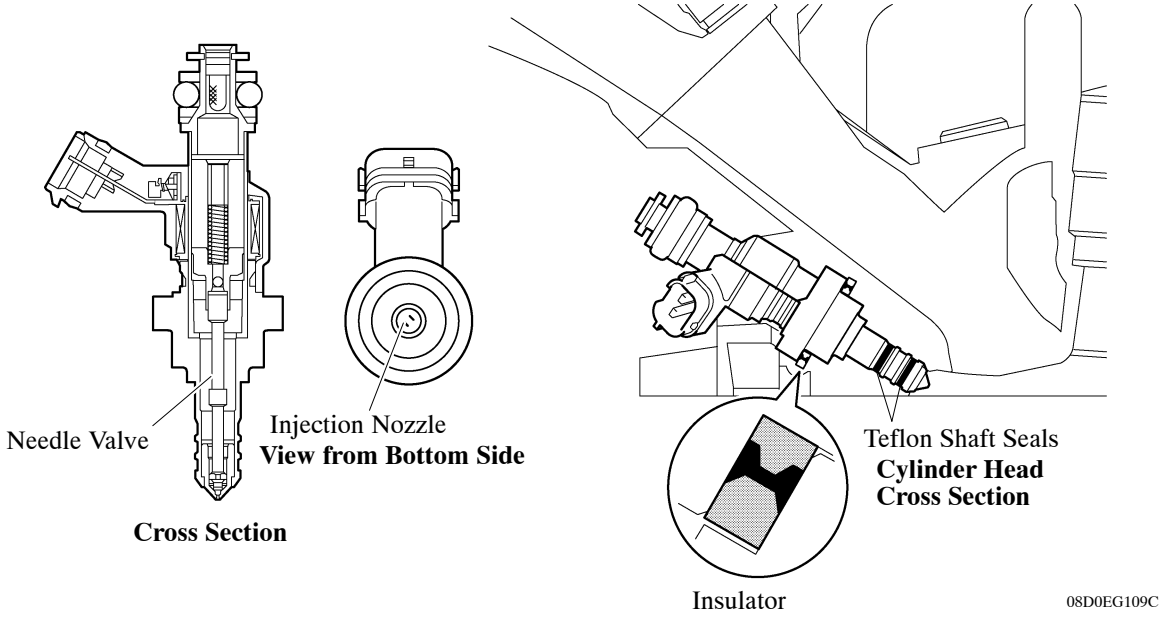
8) Fuel Injector Assembly (For Direct Injection)

Double slit-nozzle type fuel injectors which have two slit-shaped injection orifices are used as fuel injectors for direct injection.

- Each fuel injector assembly, based on signals from the ECM, meters the flow of high-pressure fuel. The fuel is injected directly to the combustion chamber as a fine-atomized mist in a fan shaped pattern via a slit type nozzle.
- An insulator is used in the area where the fuel injector assembly (for direct injection) contacts the cylinder head, and Teflon shaft seals are used to seal the injector against the combustion pressure in the cylinder. This is done in order to reduce vibration and noise and to enhance sealing performance.
- Each nozzle tip is coated to reduce the adhesion of deposits.
- The fuel injector assemblies are actuated by the injector drivers (EDUs). Based on signals received from the ECM, the injector drivers (EDUs) apply an initial high voltage of 50 V and high current of 9.7 A to the injectors in order to open the needle valves quickly. Once the fuel injectors are open, the injector drivers (EDUs) apply a constant voltage of 12 V and current of 2 A, in order to maintain the open state efficiently. This control allows the injectors to inject high-pressure fuel in a short amount of time.



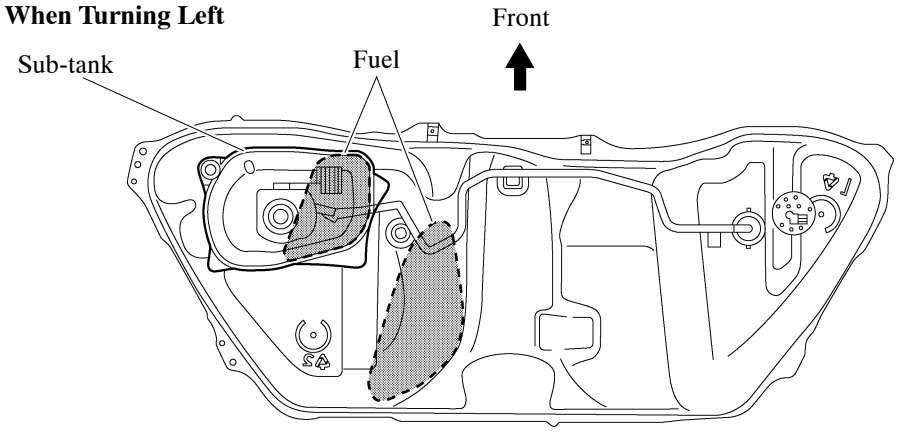
9) Injector Driver (EDU)

- The 2UR-GSE engine is provided with two injector drivers (EDU: Electronic Driver Units) to control the injectors. One injector driver (EDU) controls the fuel injector assemblies (for direct injection) of the number 1, 4, 6, and 7 cylinders and the fuel pump spill control valve (for high-pressure) on the left bank. The other injector driver (EDU) controls the fuel injector assemblies (for direct injection) of the number 2, 3, 5, and 8 cylinders and the fuel pump spill control valve (for high-pressure) on the right bank.
- The injector drivers (EDUs) each use an internal DC/DC converter that converts 12 V into 50 V enabling them to operate the fuel injectors under high-pressure conditions. The DC/DC converter provides the injector drivers (EDUs) with a high-voltage, quick-charging system (the “quick-charging system” refers to the ability of the injector drivers (EDUs) to “recharge” their internal high-voltage power source).
- The ECM constantly monitors the injector drivers (EDUs) and stops the engine in the event an abnormal condition is detected.

3. Fuel Tank

General

- A fuel tank made of steel is used.
- The fuel tank adopts a saddle shape to allow the propeller shaft to pass under the center portion of the tank. Also, a jet pump is used to transfer the fuel from the side of the tank without the fuel pump to the side with the fuel pump.
- Due to the adoption of a sub-tank, the movement of fuel to one side during high speed turns is reduced, preventing engine hesitation and stalling.



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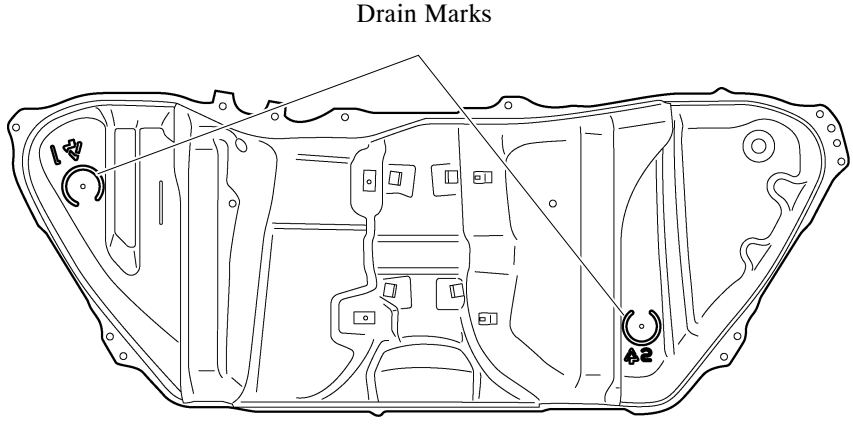
Service Tip

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



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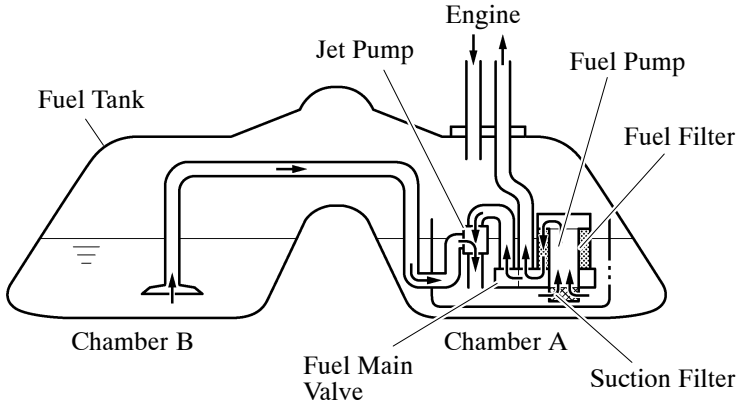
Jet Pump

A jet pump is used in the fuel tank. The propeller shaft is located below the raised center of the bottom of the fuel tank. The fuel tank is shaped as indicated below.
A fuel tank with such a shape tends to cause fuel to be present in both chamber A and chamber B when the fuel level is low. This stops the fuel in chamber B from being pumped out. To prevent this from occurring, a jet pump has been provided to transfer the fuel from chamber B to chamber A.
This is accomplished by utilizing the flow of the fuel through the jet pump, so that the pressure difference created by the fuel as it passes through the venturi, is used to suck the fuel out of chamber B and send it to chamber A.



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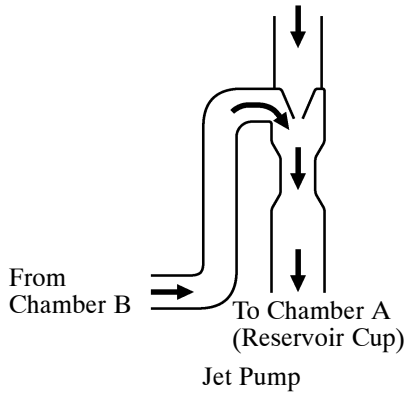

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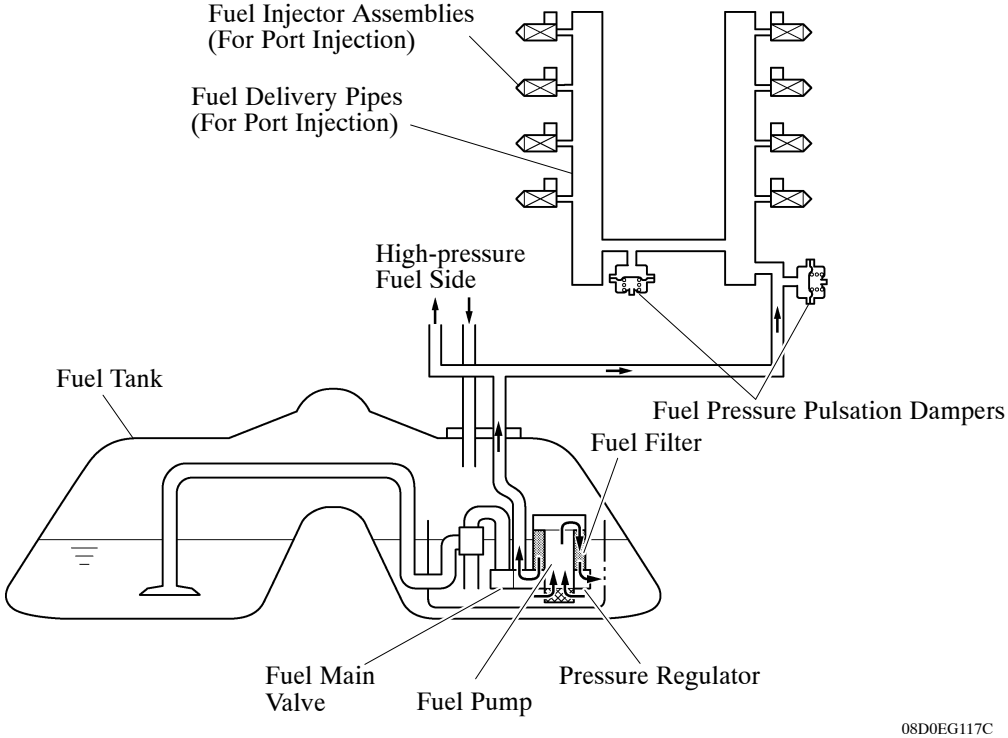
Fuel Returnless System (For Low-pressure Side)

This fuel returnless system is used to reduce evaporative emissions. As shown below, if the fuel filter, pressure regulator are integrated with the fuel pump assembly (for low-pressure), it possible to discontinue the return of fuel from the engine area and reduce the consequent temperature rise inside the fuel tank.



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