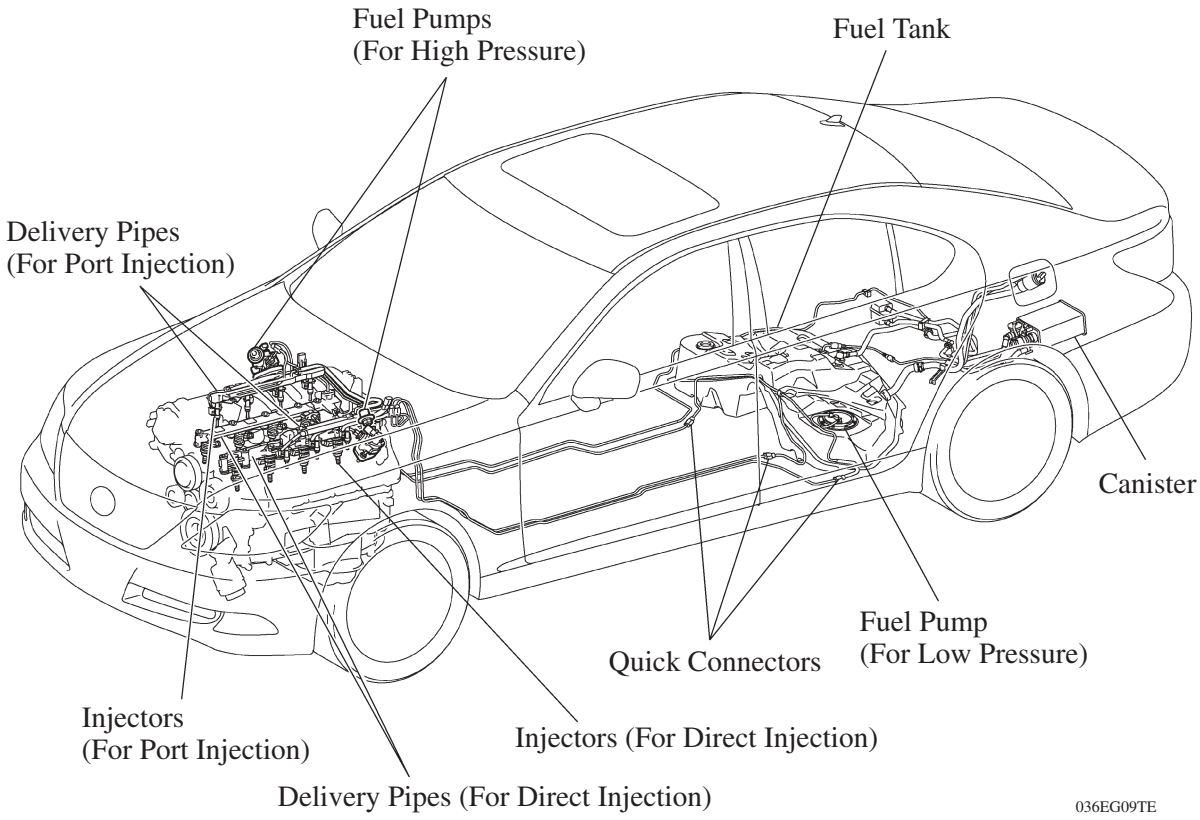
■FUEL SYSTEM

1. General

- The 1UR-FSE engine adopts a D-4S (Direct injection 4-stroke gasoline engine Superior version) system which has both direct and port types of injectors. This system optimally controls the 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, which controls the fuel pressure for the low pressure part of the fuel system using a pressure regulator installed in the fuel tank, is used. 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 (for low pressure) when an SRS airbag is deployed in a frontal, side, or rear side collision. For details, see page EG-97.
- In order to ensure excellent serviceability, quick connectors are used to connect the fuel pipe to the fuel hose.
- High-pressure injectors with double slit nozzles are used for direct injection.
- An evaporative emission control system is used. For details, see page EG-104.

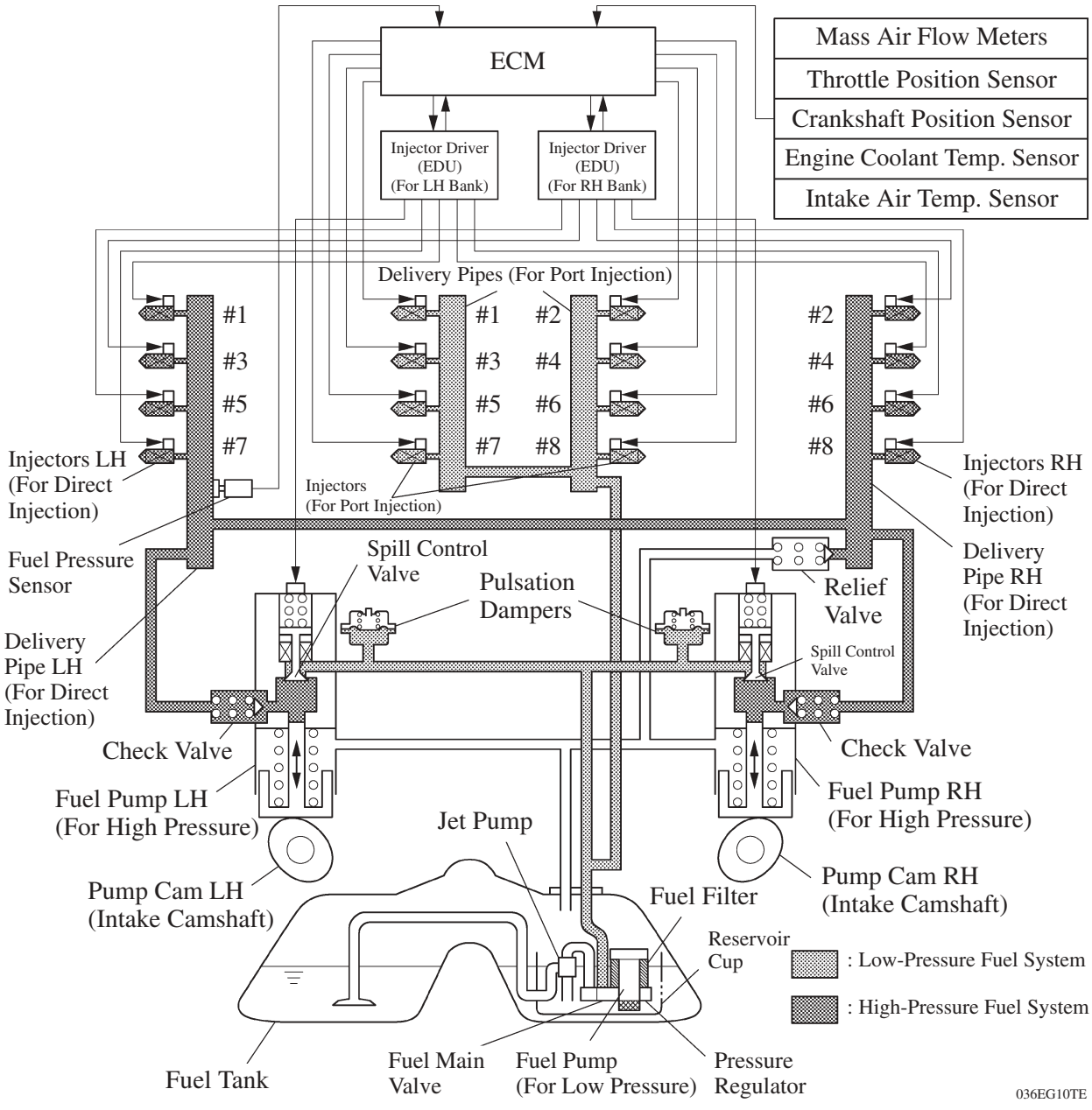


2. D-4S (Direct injection 4-stroke gasoline engine Superior version) System

General

- The D-4S system is based on two types of fuel injection systems: the direct injection system and the port injection system. 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 injectors (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 injectors (for direct injection) to the combustion chambers.
- The direct injection system mainly consists of the fuel pumps (for high pressure), delivery pipes (for direct injection), and injectors (for direct injection). In this system, the ECM controls the high pressure fuel pumps and direct injection injectors 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 injectors (for port injection). In this system, the ECM controls the port injection injectors based on signals from various sensors, thus optimally controlling injection volume and timing.

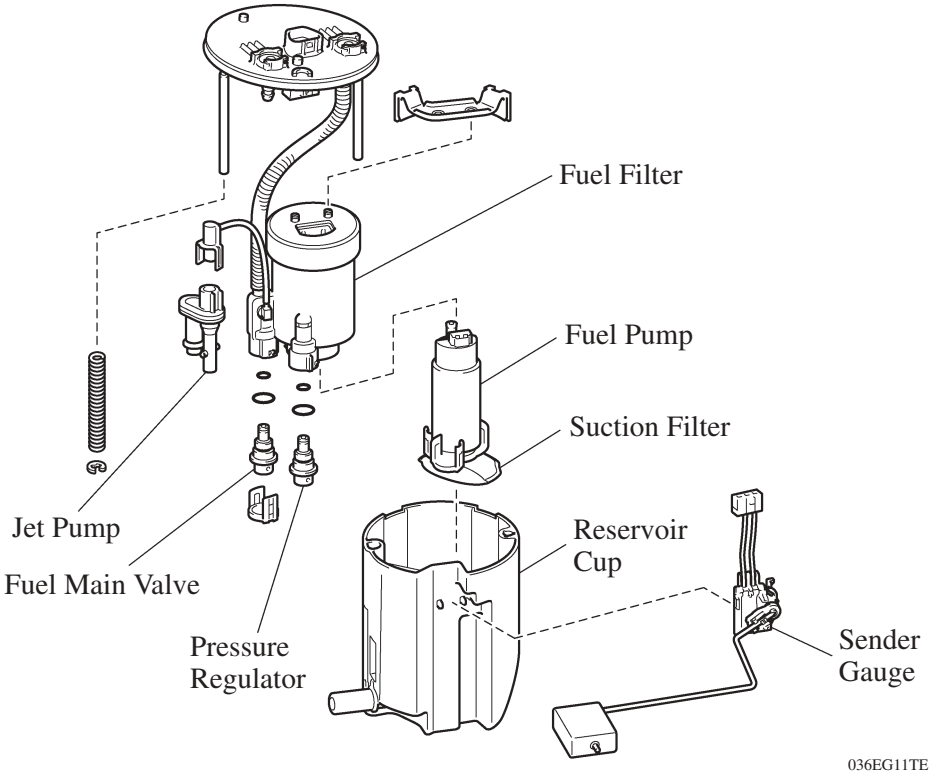
▶ System Diagram ◀



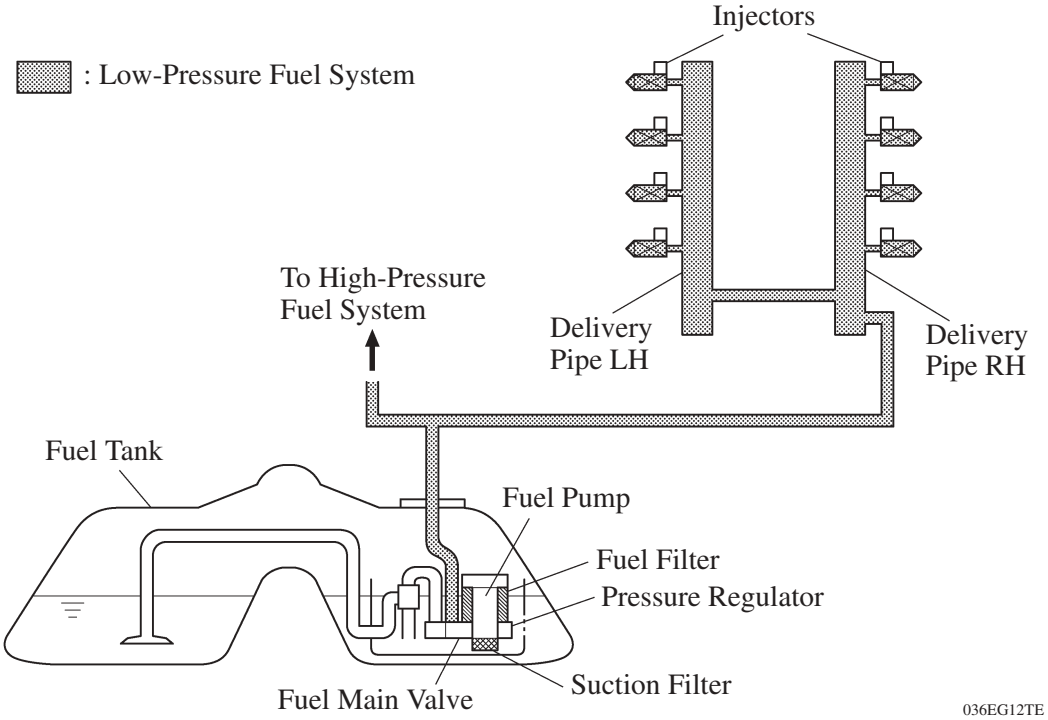
Construction and Operation

1) Fuel Pump (For Low Pressure)

- A fuel pump (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 ◀

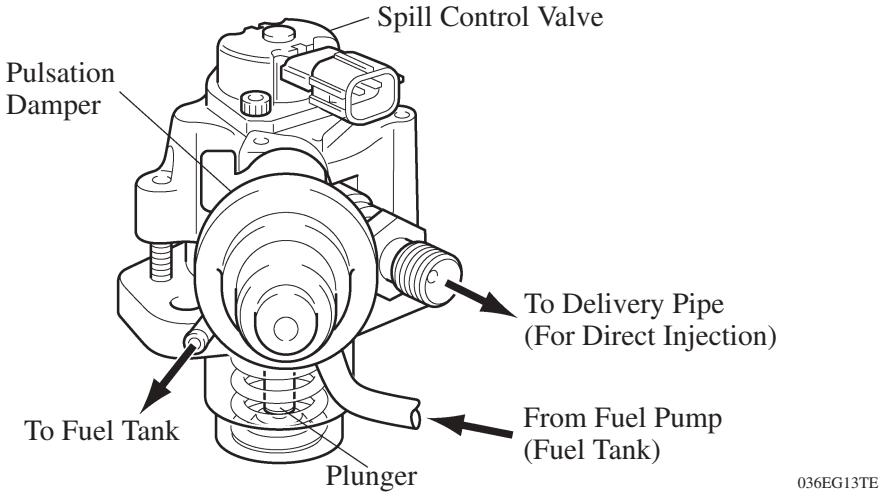


2) Fuel Pump (For High Pressure)

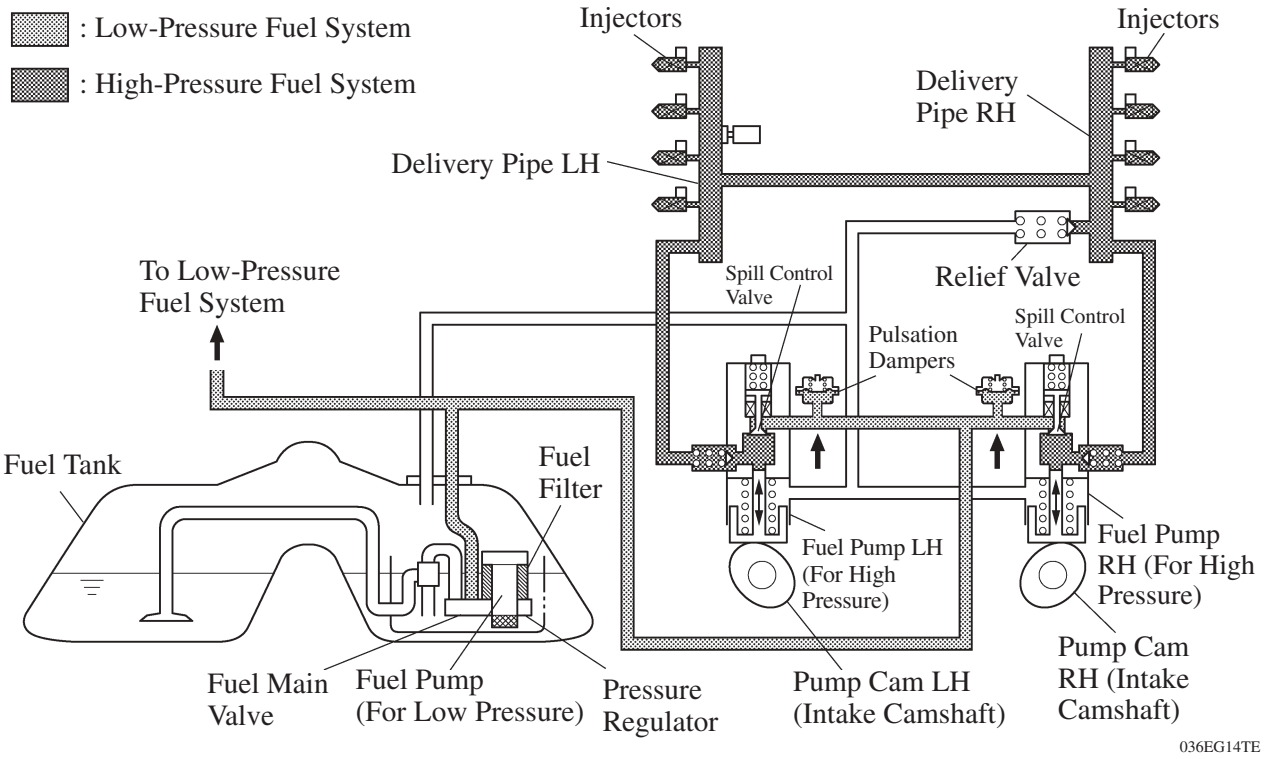
a. Construction

The fuel pump consists of a plunger, spill control valve, and check valve. A pulsation damper is also installed at the fuel inlet. It pressurizes the fuel that is sent by the low-pressure fuel pump to a pressure ranging from 4 to 13 MPa, and sends it to the high-pressure 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 delivery pipe (minimum pressure to open the check valve is 60 kPa).



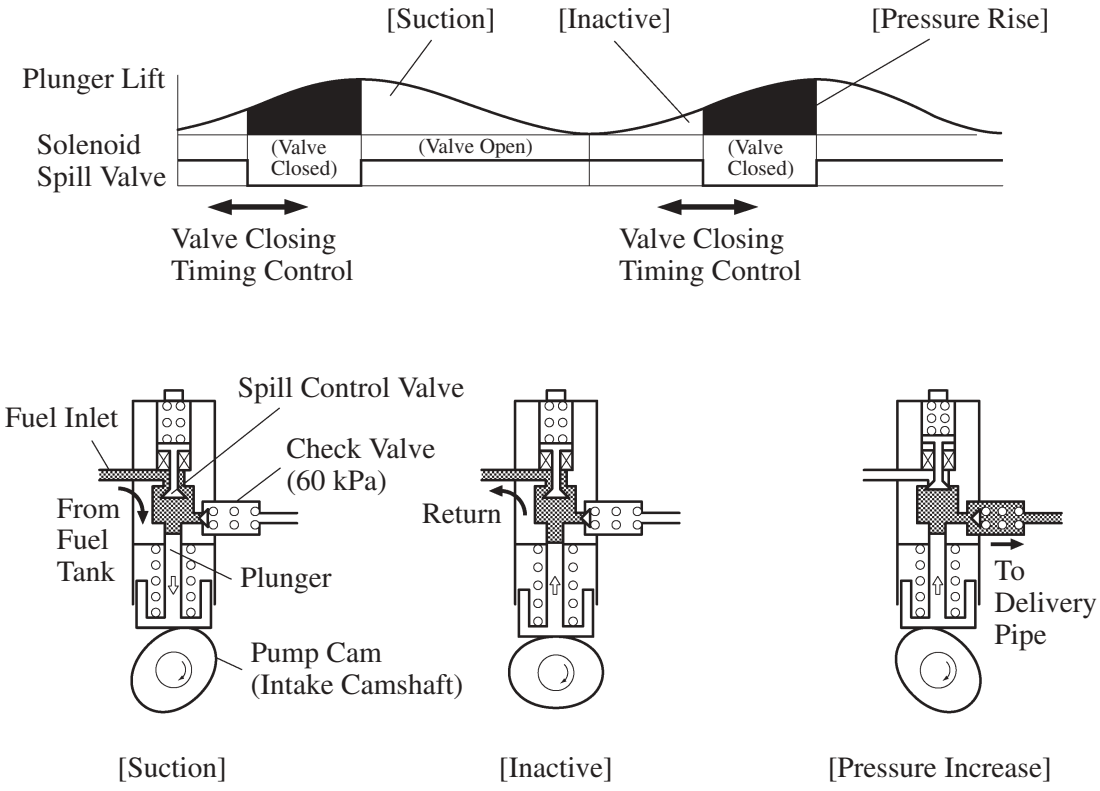
▶ High-Pressure Fuel System Diagram ◀



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 delivery pipe, whichever is higher), the fuel will begin to flow to the 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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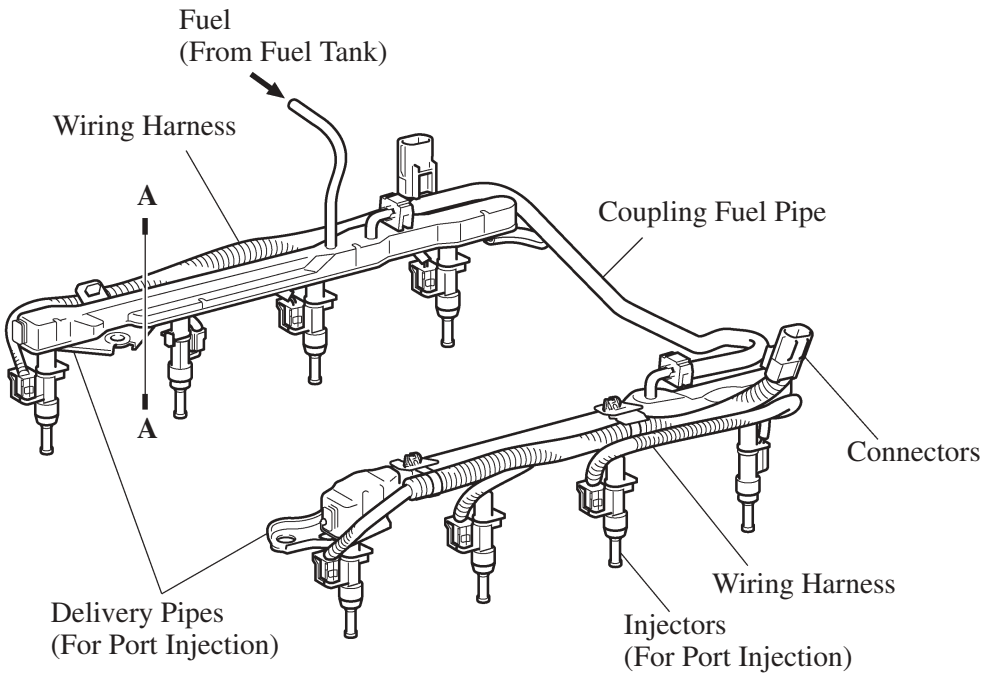
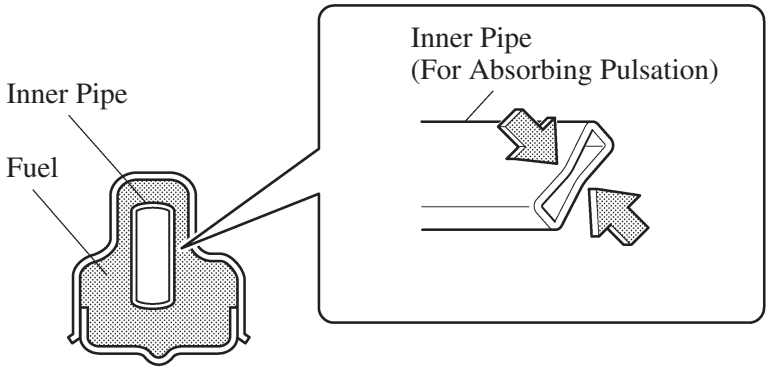
3) Delivery Pipe (For Port Injection)

- Stamped steel delivery pipes are used (for port injection) to deliver low-pressure fuel to the fuel injectors (for port injection).
- An inner pipe inside the delivery pipe is used to absorb fuel pulsations. This eliminates the use of the pulsation damper provided on conventional models, making the fuel system more compact and lightweight. When fuel pulsates, the shape of the inner pipe changes with the pulsation, thus changing the internal capacity of the delivery pipe. This change in capacity absorbs the fuel pulsations.
- The wiring harnesses that connect to the injectors (for port injection) are combined into a single strand at each bank. Furthermore, they connect to the ECM at a single connector for improved serviceability.





A – A Cross Section (Delivery Pipe)

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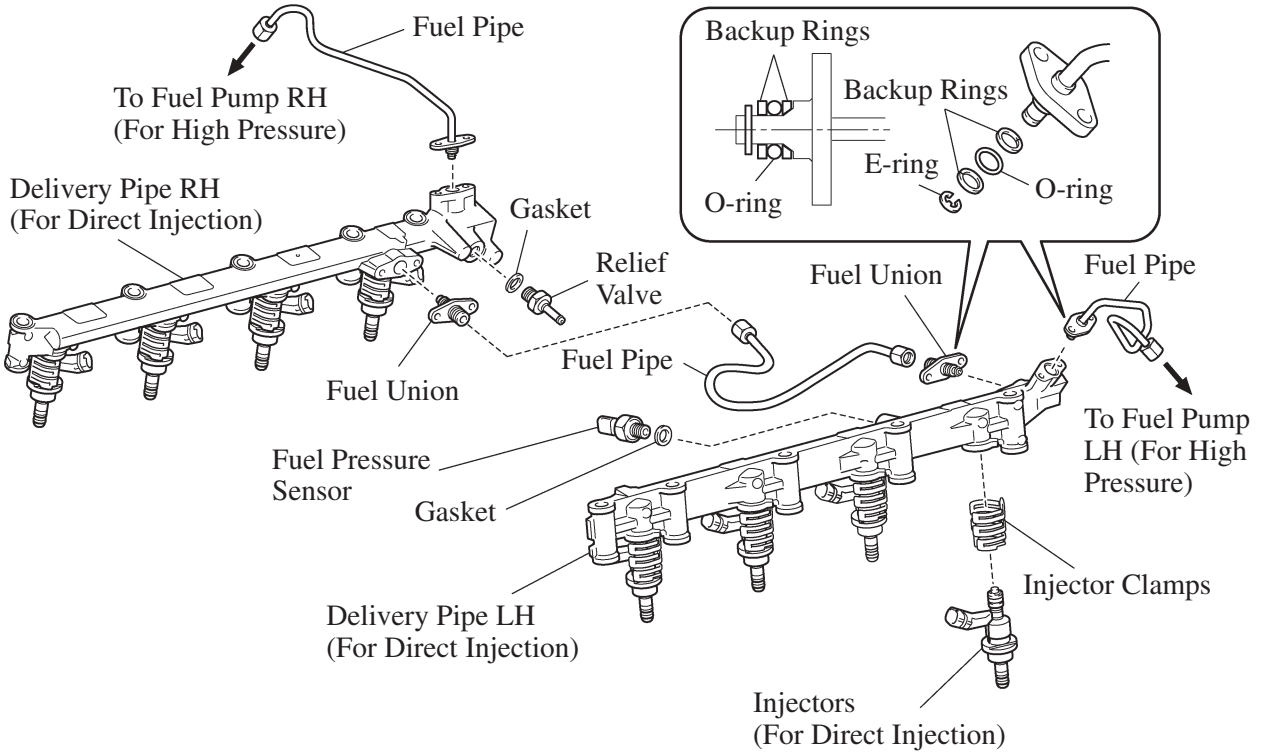
4) Delivery Pipe (For Direct Injection)

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



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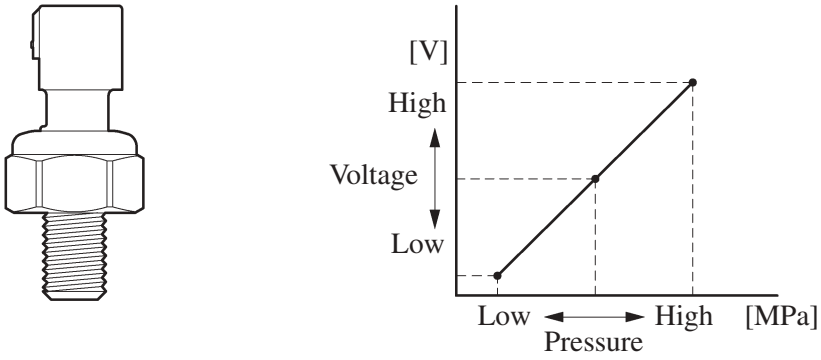
Service Tip

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 delivery pipe, outputs a signal to the ECM that represents the fuel pressure in the delivery pipe in order to allow the constant regulation of the fuel at an optimal pressure.



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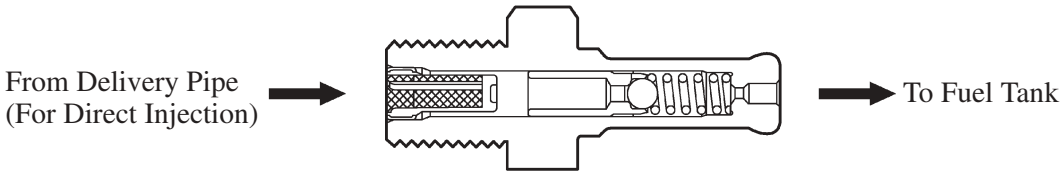
6) Relief Valve

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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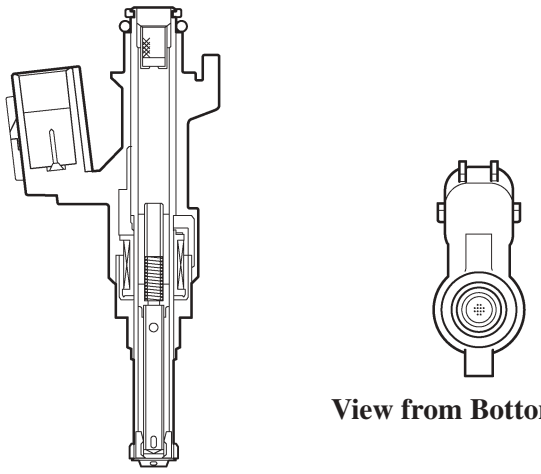
7) Injector (For Port Injection)

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



View from Bottom Side

Cross Section

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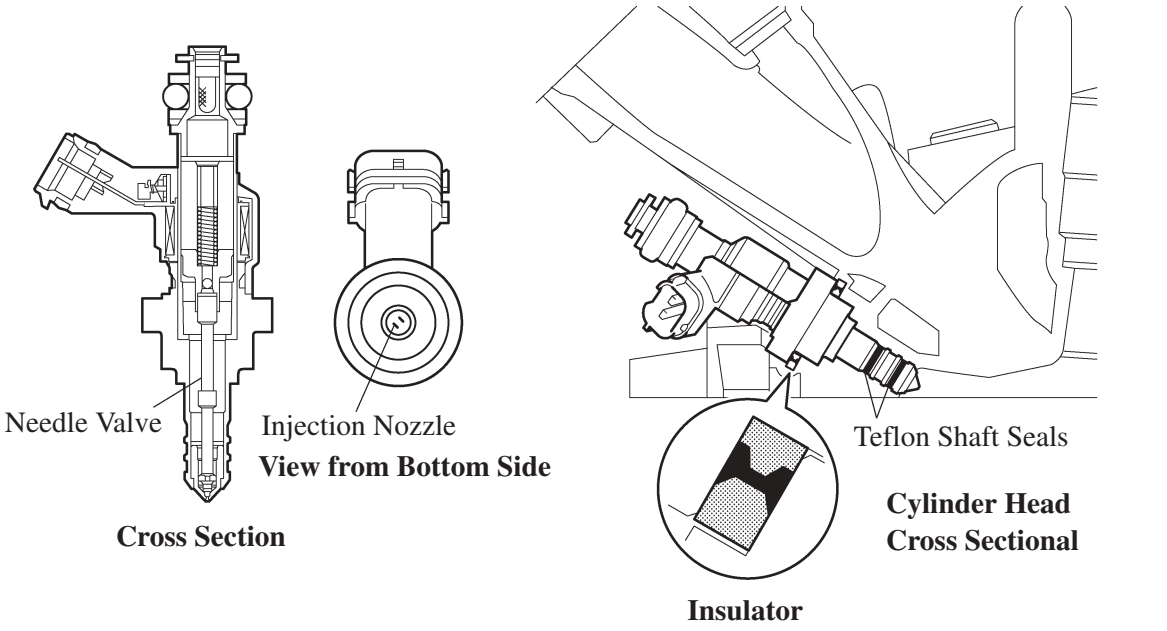
8) Injector (For Direct Injection)

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

- Each injector, 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 injector 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.
- Each injector is 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 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 1UR-FSE engine is provided with two injector drivers (EDUs : Electronic Driver Units) to control the injectors. One injector driver (EDU) controls the injectors (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 injectors (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 use of a DC/DC converter that converts 12 V into 50 V enables the injector drivers (EDUs) 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.

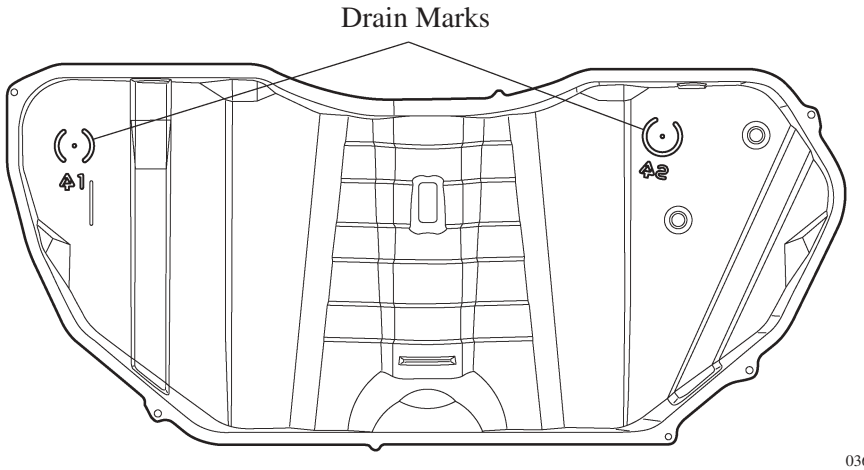
3. Fuel Tank

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.

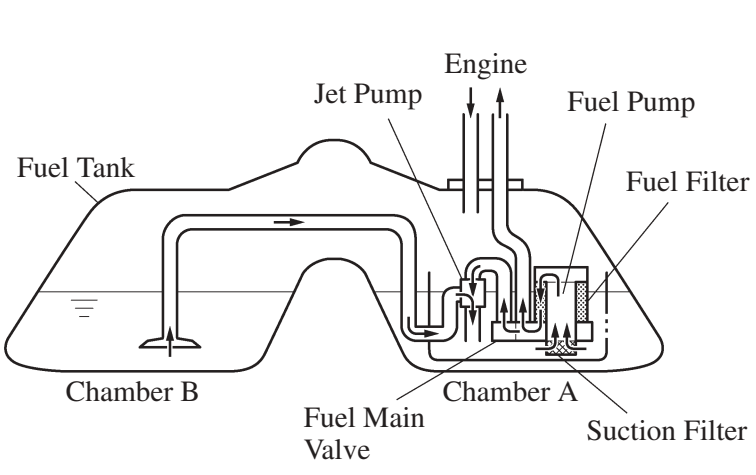
Service Tip

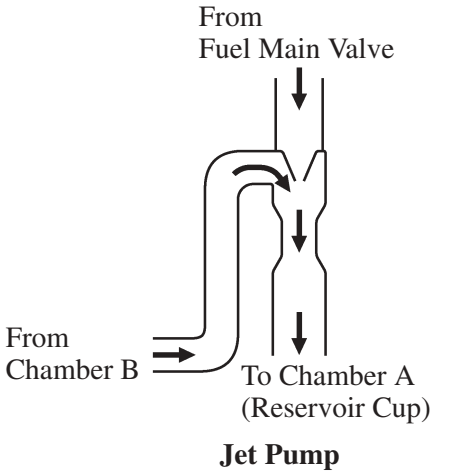
Drain marks have been provided at the lowest position of the fuel tank. When dismantling (scraping) the vehicle, drain fuel by drilling holes at the drain mark.



Jet Pump

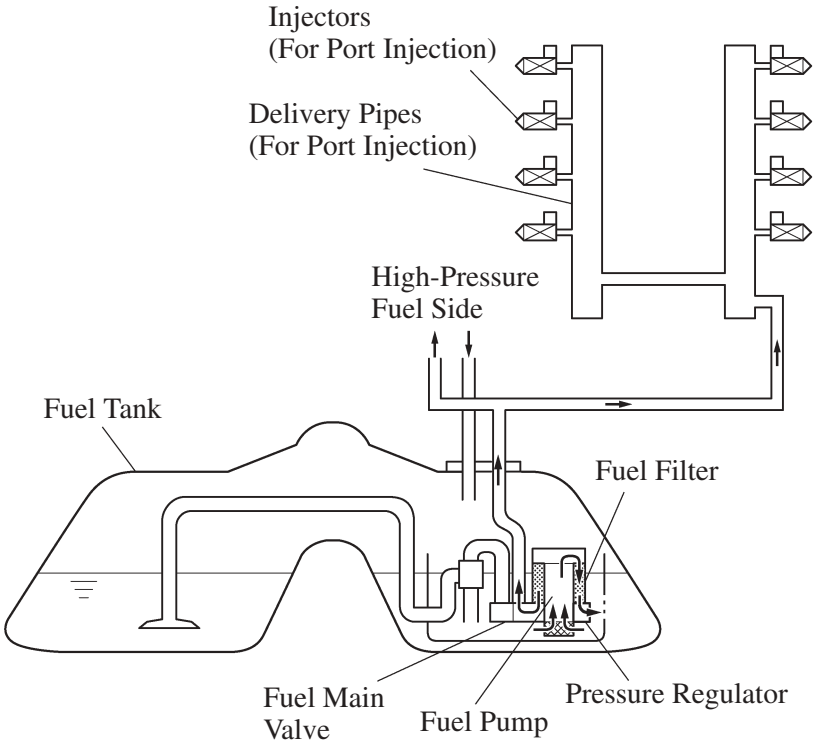
A jet pump is used in the fuel tank. The propeller shaft is located below the raised center of the bottom of the fuel tank. The fuel tank is shaped as indicated below.
A fuel tank with such a shape tends to cause fuel to be present in both chamber A and chamber B when the fuel level is low. This stops 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.





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, 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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