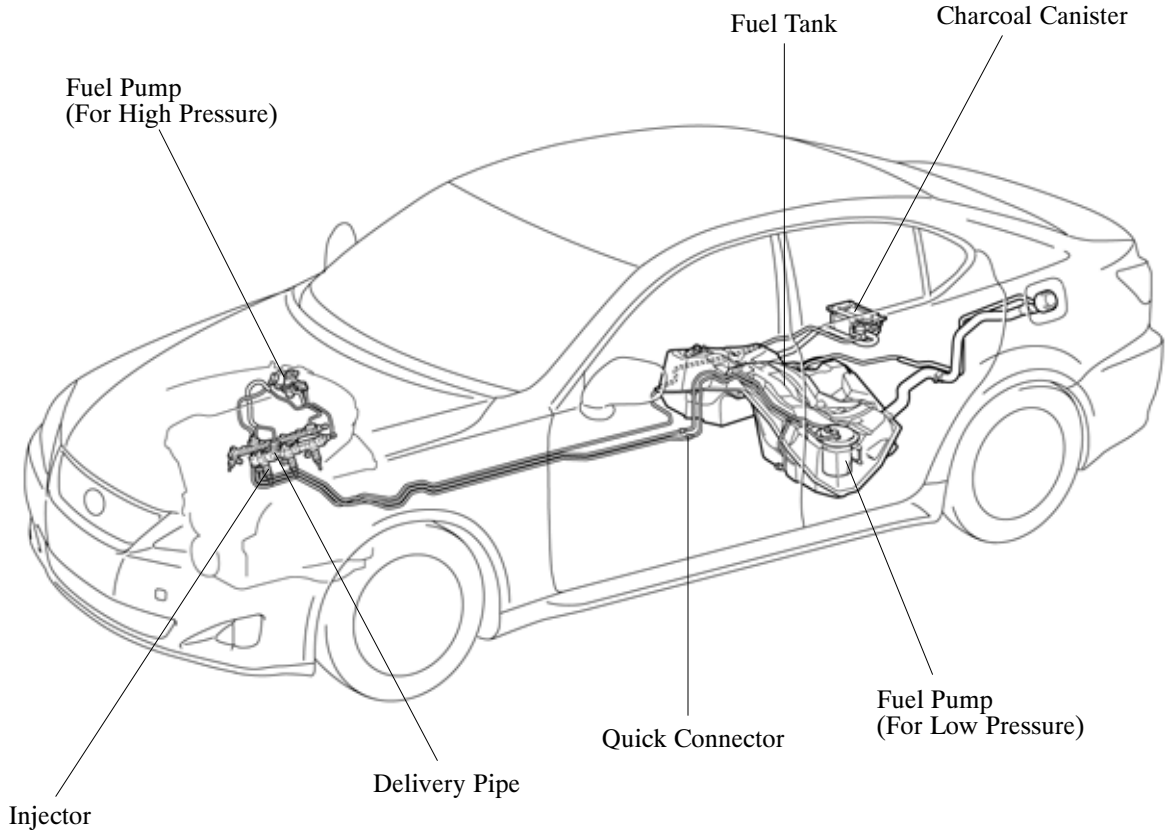
## ■FUEL SYSTEM

### 1. General

- The D-4 (Direct injection 4-stroke gasoline engine) system is used as the fuel system of the 4GR-FSE engine. This system effects comprehensive control of the fuel injection timing, air-fuel ratio, throttle valve position, etc., to realize both a high power output and low exhaust emissions.
- A fuel returnless system, which controls the fuel pressure for the low pressure side by way of a pressure regulator installed in the fuel tank, is used. However, the fuel from the high-pressure fuel pump spill control valve 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 or side collision. For details, see page EG-75.
- A quick connector is used to connect the fuel pipe with the fuel hose for excellent serviceability.
- A single-slit, high-pressure slit nozzle injector is used.



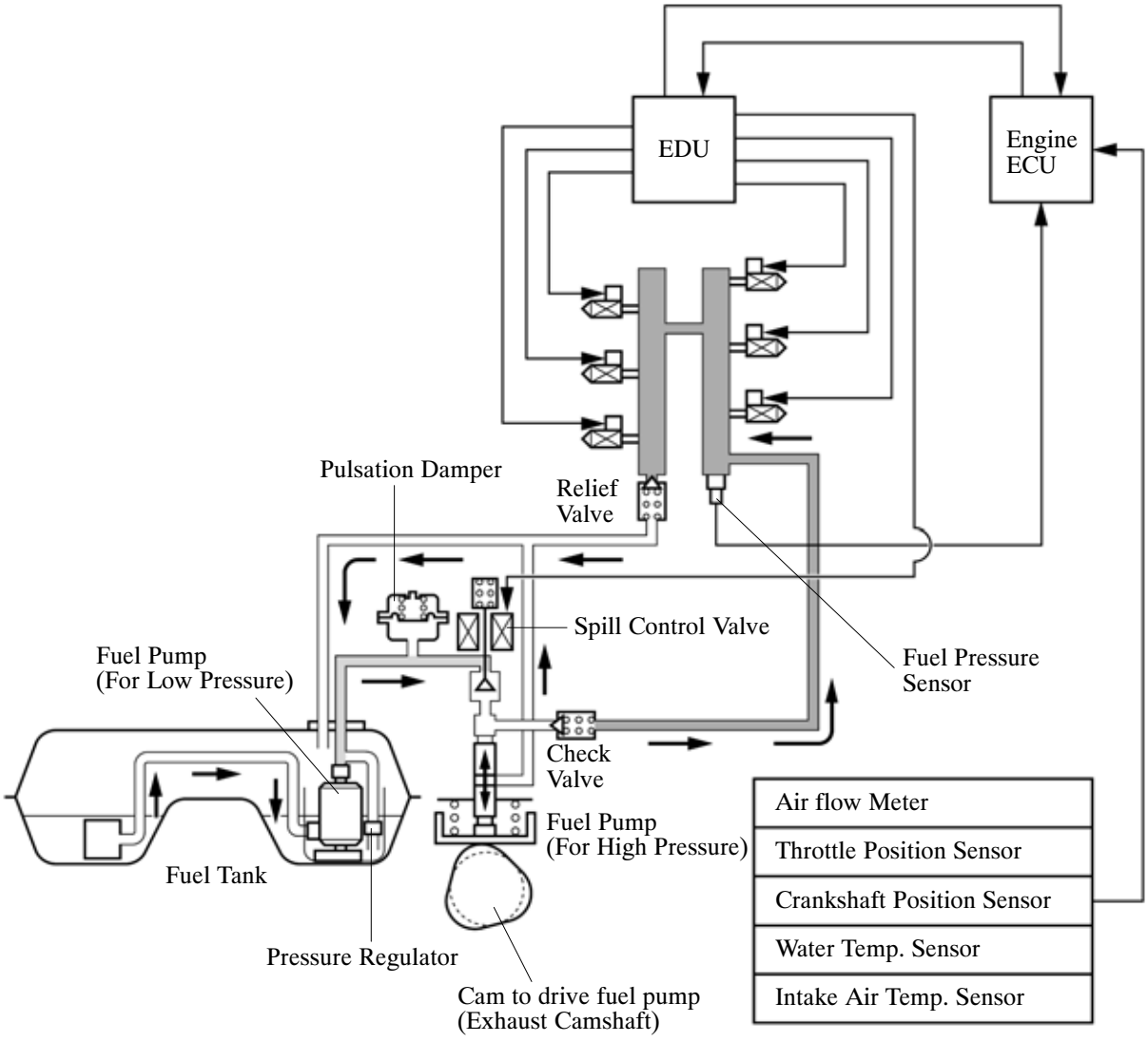
## 2. D-4 (Direct Injection 4-stroke Gasoline Engine) System

### General

Mainly consisting of a fuel pump (high pressure), delivery pipe, and slit nozzle type injectors, this system effects optimal control for combustion by controlling the fuel pressure, injection volume, and the injection timing via the Engine ECU and EDU (Electronic Driver Unit).

**▶ System Diagram ◀**



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## Component of Function

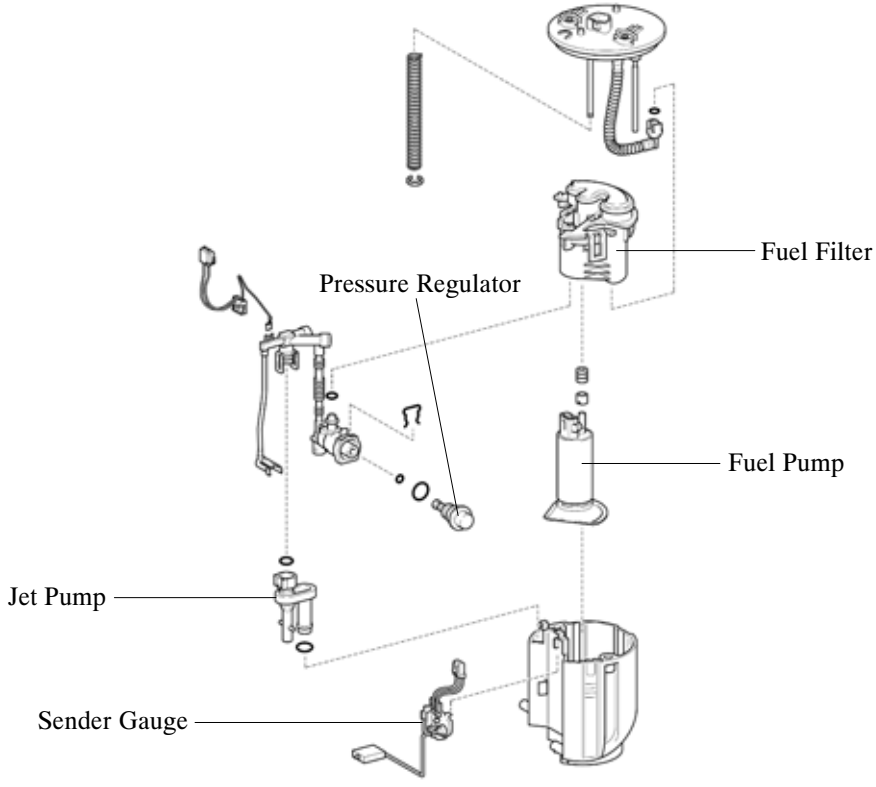
The direct injection system has following components and functions.

| Component | Outline |
|---|---|
| Fuel Pump (For Low Pressure) | Sends fuel (400 kPa) from the fuel tank to the fuel pump (for high pressure). |
| Fuel Pump (For High Pressure) | To pressurize the fuel from the fuel pump (for low pressure) from 4 to 13 MPa and send it to the delivery pipe. |
| Delivery Pipes | To deliver the high pressure fuel to the injectors. |
| Fuel Pressure Sensor | The fuel pressure sensor senses the fuel pressure and outputs the signal to the Engine ECU. |
| Relief Valve | When the pressure in the delivery pipe is abnormally high, the relief valve discharges the excess fuel to the fuel tank to reduce pressure. |
| Injector | To inject a calculated (by the Engine ECU) quantity of high pressure fuel directly into the combustion chamber. |
| EDU (Electronic Driver Unit) | The EDU drives the injectors and the spill control valve at high speed. |
| Engine ECU | Depending on the vehicle condition, and based on signals from various sensors, the Engine ECU calculates the optimal injection timing and volume, and controls the injectors and high pressure fuel pump. |

## 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 fuel pump (for low pressure) is located in the fuel tank. This fuel pump pressurizes the fuel from the fuel tank and sends the fuel to the high-pressure fuel pump.

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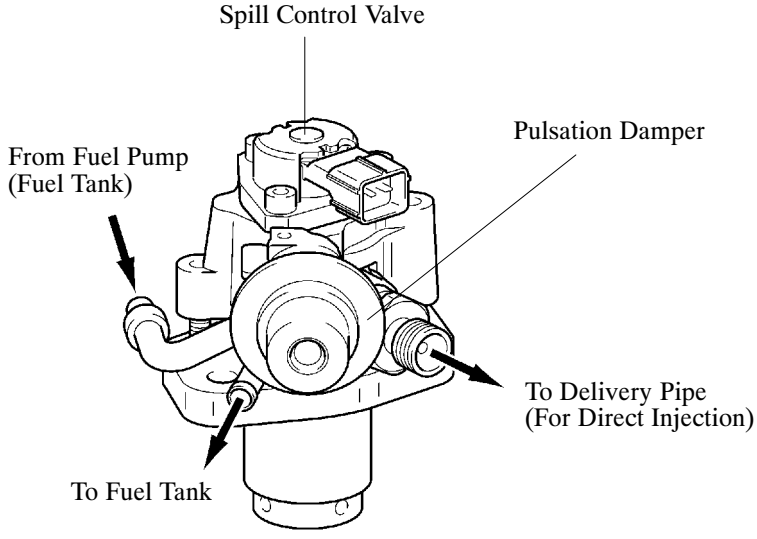
**2) Fuel Pump (For High Pressure)**

**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.

- The plunger is moved up and down by a lobe that is located at the rear end of the exhaust camshaft on the right bank of the engine. This lobe causes three strokes of the pump piston to occur for each camshaft revolution (three protrusions exist 120degrees from each other on the same camshaft "lobe")
- 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 EDU, based on instructions from the engine Engine ECU.
- 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).



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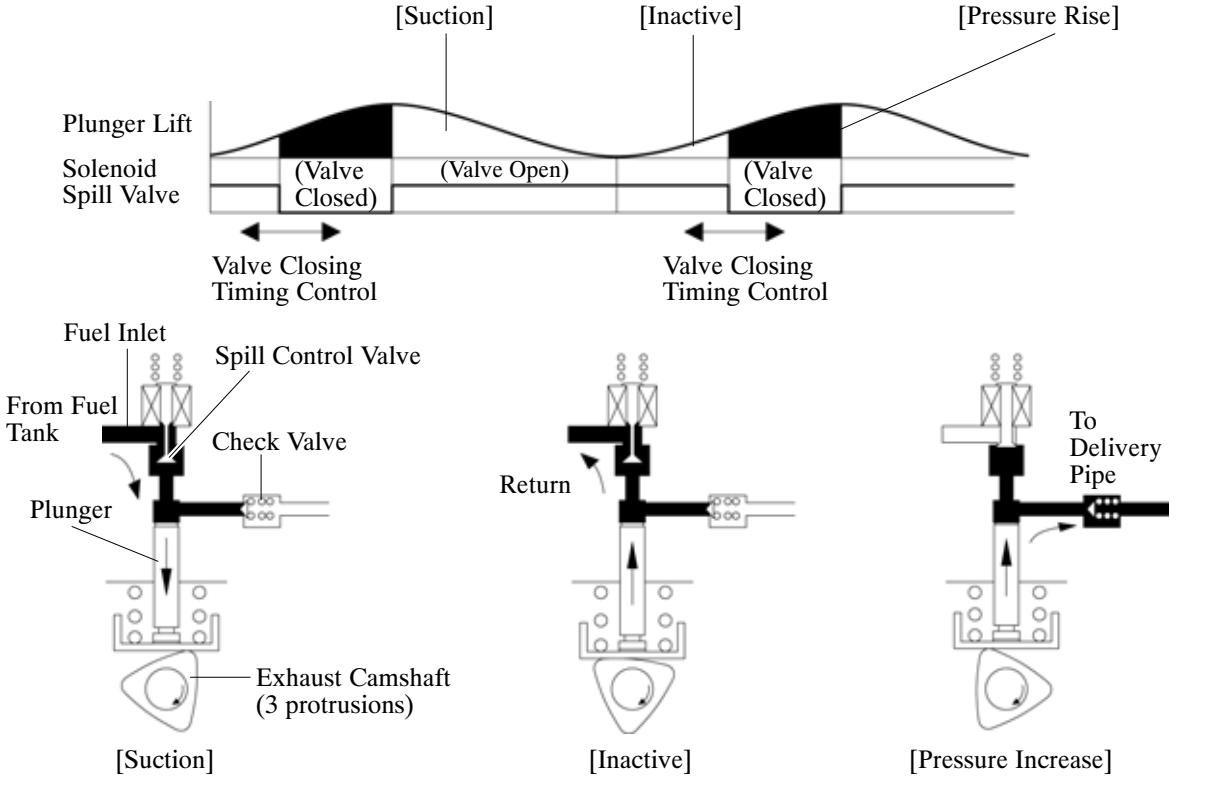
**b. Operation**

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 Engine ECU sends a signal to the valve via the 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 Engine ECU calculates the target fuel pressure based on driving conditions. The Engine ECU controls the pressure by operating the spill control valve via the 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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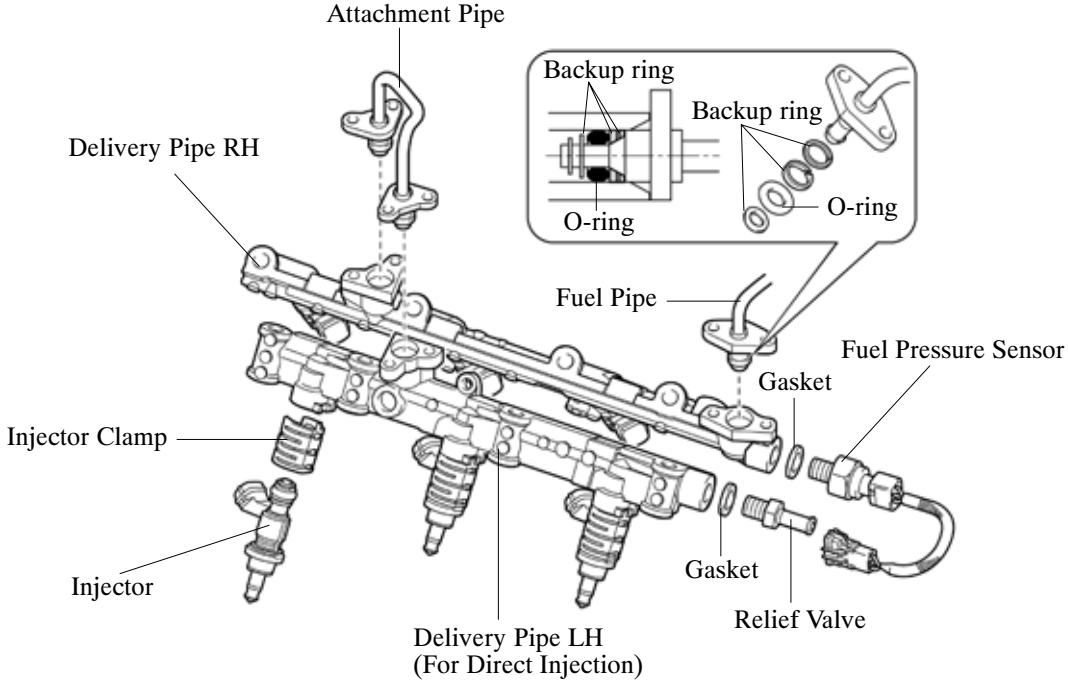
### 3) Delivery Pipe

- An aluminum alloy fuel delivery pipe is used.
- 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.
- O-rings and backup rings are used in the areas in which the high-pressure fuel injectors and high-pressure fuel delivery pipes are joined. This reduces the transmission of the operating sounds of the high-pressure fuel injectors, enhances quiet operation, and ensures the sealing performance of the joined areas.



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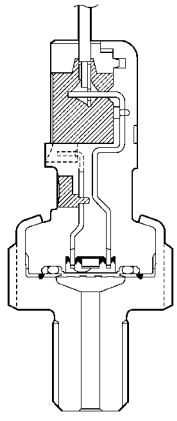
**Service Tip**

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

### 4) Fuel Pressure Sensor

The fuel pressure sensor, which is mounted on the delivery pipe, outputs a signal to the Engine ECU 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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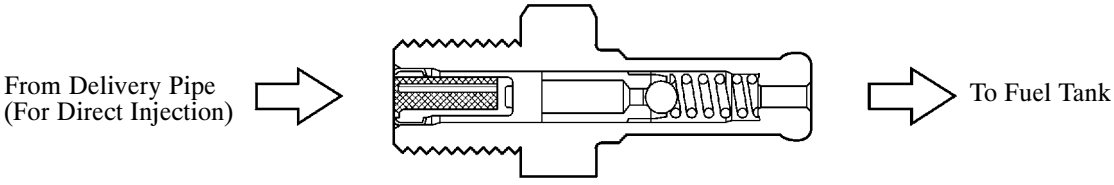
**5) Relief Valve**

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.

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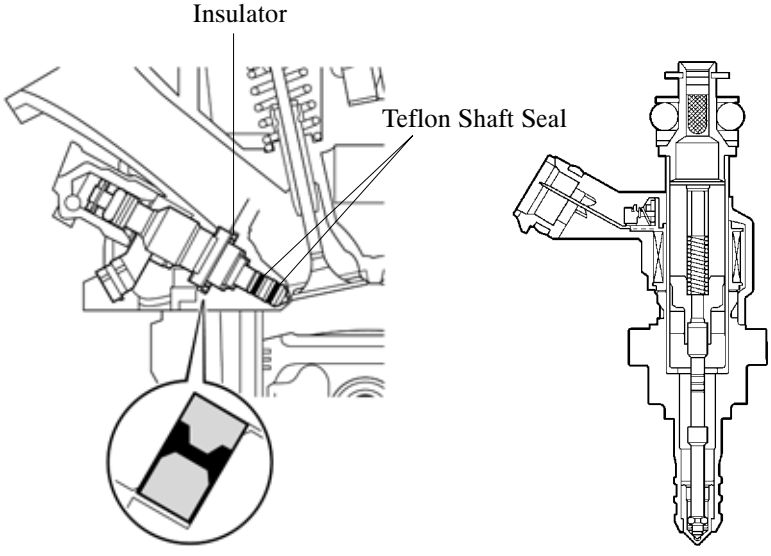
**6) Injector**

High-pressure, slit-nozzle type injectors are used in conjunction with the adoption of the D-4 (Direct injection, 4-stroke gasoline engine).

- Each injector, based on signals from the Engine ECU, meters the flow of high pressure fuel. The fuel is injected as a fine-grained mist in a fan shaped pattern, directly to the combustion chamber, via a slit type nozzle.
- An insulator is used in the area in which the injector comes in contact with the cylinder head, and a Teflon shaft seal is used to seal the injector against the combustion pressure in the cylinders in order to reduce vibration and noise and to enhance sealing performance.
- Each nozzle hole is coated to reduce the adhesion of deposits.
- The injectors are actuated by the EDU using high-voltage and a constant-current control based on instructions from the Engine ECU. This control allows the injectors to inject high-pressure fuel in a short time.

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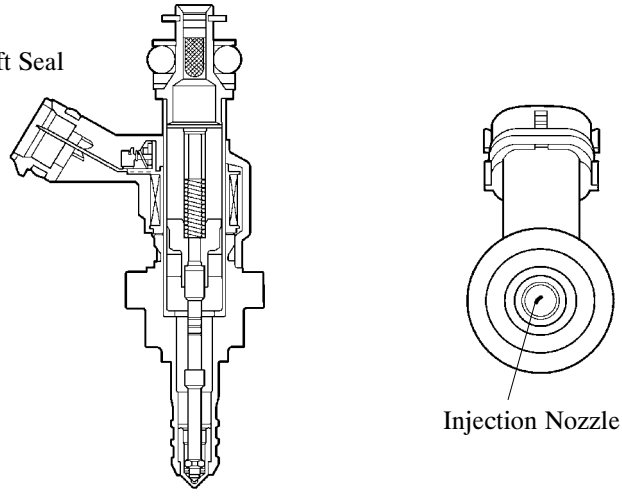


**Slit-nozzle Type injector Cross-Section**

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**7) EDU (Electronic Driver Unit)**

- The EDU is used to drive the injectors at high speeds. The EDU has the ability to operate the fuel injectors under high fuel pressure conditions through the use of a DC/DC converter that provides a high-voltage, quick-charging system. (“quick charging system” refers to the ability of the EDU to “recharge” its internal high voltage power source).
- The engine ECU constantly monitors the EDU and stops the engine in the event an abnormal condition is detected.

## 3. Fuel Tank

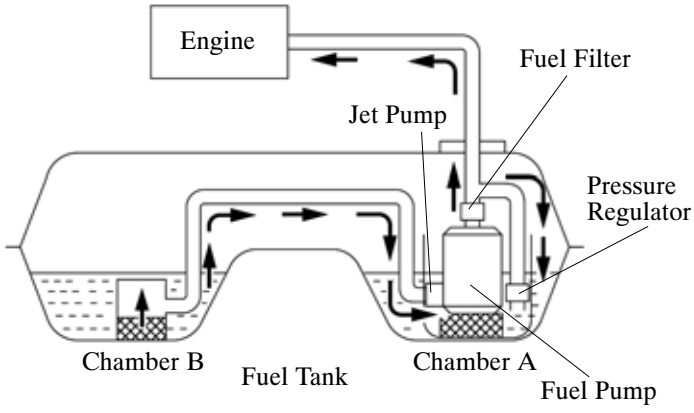
### General

- 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.

### 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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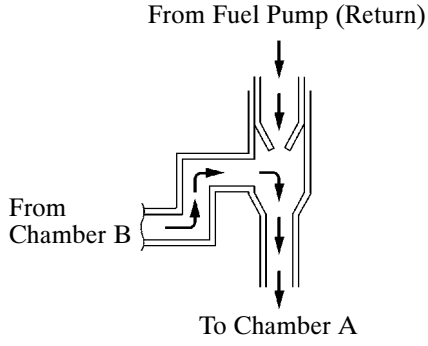


**Jet Pump**

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