SERVICE MANUAL

FORD Puma Common Rail System
Functional Parts

OPERATION

February, 2006

DENSO CORPORATION
# Table of Contents

## Operation Section

### 1. ACCESSORY INFORMATION
1.1 Outline ........................................................................................................... 1-1
1.2 Functional Parts List .......................................................................................... 1-1

### 2. SUPPLY PUMP
2.1 Outline ............................................................................................................. 1-2
2.2 Construction ....................................................................................................... 1-3
2.3 Operation ........................................................................................................... 1-5

### 3. RAIL
3.1 Outline ............................................................................................................... 1-6

### 4. INJECTOR
4.1 Outline ............................................................................................................... 1-7
4.2 Construction ....................................................................................................... 1-7
4.3 Operation ........................................................................................................... 1-10

### 5. SUPPLY PUMP COMPONENT PARTS
5.1 Feed Pump .......................................................................................................... 1-11
5.2 SCV (Suction Control Valve) ............................................................................... 1-11
5.3 Fuel temperature sensor ...................................................................................... 1-13

### 6. RAIL COMPONENT PARTS
6.1 Rail Pressure Sensor ............................................................................................ 1-14
6.2 Pressure Limiter ................................................................................................... 1-14
1. ACCESSORY INFORMATION

1.1 Outline

- This publication details the common rail system for the FORD Puma. This common rail system includes the following DENSO functional parts: supply pump, rail and injectors. Only the functional parts are described here.

1.2 Functional Parts List

<table>
<thead>
<tr>
<th>Parts Name</th>
<th>DENSO Part Number</th>
<th>Manufacturer Parts Number</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply pump</td>
<td>HU294000-040#</td>
<td>6C1Q-9B395-AB</td>
<td>For 2.2L</td>
</tr>
<tr>
<td></td>
<td>HU294000-041#</td>
<td>6C1Q-9B395-BB</td>
<td>For 2.4L</td>
</tr>
<tr>
<td>Fuel temperature sensor</td>
<td>179730-010#</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCV (Suction Control Valve)</td>
<td>SM294200-010#</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rail</td>
<td>HU095440-073#</td>
<td>6C1Q-9D280-AB</td>
<td></td>
</tr>
<tr>
<td>Rail Pressure Sensor</td>
<td>HU294390-001#</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure Limiter</td>
<td>HU095420-033#</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injector</td>
<td>HU095000-580#</td>
<td>6C1Q-9K546-AB</td>
<td>For low output</td>
</tr>
<tr>
<td></td>
<td>HU095000-581#</td>
<td>6C1Q-9K546-BA</td>
<td>For high output</td>
</tr>
</tbody>
</table>
2. SUPPLY PUMP

2.1 Outline

- The supply pump consists primarily of the pump body (camshaft (eccentric cam), ring cam, and plungers), SCV (Suction Control Valve), fuel temperature sensor, and feed pump.
- The two plungers are positioned vertically on the outer ring cam for compactness.

- The engine drives the supply pump at a ratio of 1:2. The supply pump has a built-in feed pump (trochoid type), and draws the fuel from the fuel tank, sending it to the plunger chamber.
- The internal camshaft drives the two plungers, and they pressurize the fuel sent to the plunger chamber and send it to the rail. The quantity of fuel supplied to the rail is controlled by the SCV, using signals from the engine ECU. The SCV is a normally open type (the SCV opens during de-energization).
(1) Supply Pump Internal Fuel Flow

- Fuel drawn from the fuel tank passes through the route in the supply pump as illustrated, and is fed into the rail.

2.2 Construction

- The eccentric cam is formed on the camshaft and is attached to the ring cam.

- As the camshaft rotates, the eccentric cam rotates eccentrically, and the ring cam moves up and down while rotating.
- The plunger and the suction valve are mounted on top of the ring cam. The feed pump is connected to the rear of the camshaft.
2.3 Operation

As shown in the illustration below, the rotation of the eccentric cam causes the ring cam to push Plunger A upwards. Due to the spring force, Plunger B is pulled in the opposite direction to Plunger A. As a result, Plunger B draws in fuel while Plunger A pumps it to the rail.
3. RAIL

3.1 Outline

- The rail stores pressurized fuel that has been delivered from the supply pump and distributes it to each cylinder injector. A pressure sensor and a pressure limiter are adopted in the rail. The pressure sensor detects the fuel pressure in the rail and sends a signal to the ECU. The ECU controls the supply pump SCV and the fuel pressure in the rail based on this signal.
4. INJECTOR

4.1 Outline

- A compact, energy-saving solenoid-control type TWV (Two-Way Valve) injector has been adopted.

4.2 Construction
(1) Injector with QR Codes

**QR Code Location**

- **QR Codes (9.9mm)**
- **Sample**
- **ID Codes (16 base 16 characters)**
- **Base 16 characters nothing fuel injection quantity correction information for market service use.**
- **Sample Upper Side**

**QR Code Correction Points**

- **Injection volume Q**
- **QR code Sample**
- **Pressure parameters**
- **Actuating pulse width TQ**
(2) Service Instructions

- When replacing the injectors or the engine ECU, it is necessary to record the ID codes in the ECU using a diagnosis tool (available from the car manufacturer).

< CAUTION >

If the ID codes for the installed injectors are not registered correctly, engine failure such as rough idling and noise will result.

---

Replacing the Injector

"As no correction resistance used, the fuel injection correction data cannot be detected electrically"

Replaced injector

* Injector ID code must be registered with the engine ECU

Replacing the Engine ECU

"As no correction resistance used, the fuel injection correction data cannot be detected electrically"

Vehicle injectors

* Injector ID code must be registered with the engine ECU
4.3 Operation

- The TWV (Two-Way Valve) solenoid valve opens and closes the outlet orifice passage to control both the pressure in the control chamber, and the start and end of injection.

(1) No injection

- When no current is supplied to the solenoid, the TWV (solenoid valve) is pushed downward by the spring, closing the outlet orifice. This equalizes the control chamber pressure forcing the command piston down, and the pressure forcing the nozzle needle up. A state of no injection results because the nozzle needle closes due to the nozzle spring force and the difference in areas to which pressure is being applied.

(2) Injection

- When current is initially applied to the solenoid, the attraction of the solenoid pulls the TWV (solenoid valve) up, opening the outlet orifice and allowing fuel to flow out of the control chamber. After the fuel flows out, pressure in the control chamber decreases, pulling the command piston up. This causes the nozzle needle to rise and injection to start.

(3) Injection Ends

- When current continues to be applied to the solenoid, the nozzle reaches its maximum lift where the injection rate is also at the maximum level. When current to the solenoid is turned OFF, the TWV (solenoid valve) falls and closes the orifice. Fuel then flows into the control chamber via the inlet orifice, increasing pressure and causing the nozzle needle to close immediately and injection to stop.
5. SUPPLY PUMP COMPONENT PARTS

5.1 Feed Pump

- The trochoid type feed pump integrated into the supply pump, draws fuel from the fuel tank and feeds it to the two plungers via the fuel filter and the SCV (Suction Control Valve). The feed pump is driven by the camshaft. With the rotation of the inner rotor, the feed pump draws fuel from its suction port and pumps it out through the discharge port. This is done in accordance with the space that increases and decreases with the movement of the outer and inner rotors.

5.2 SCV (Suction Control Valve)

- A linear solenoid type valve has been adopted. The ECU controls the duty ratio (the duration in which current is applied to the SCV), in order to control the quantity of fuel that is supplied to the high-pressure plunger.
- The supply pump drive load decreases because intake fuel quantity is controlled to achieve the target rail pressure.
- When current flows to the SCV, the internal armature moves in accordance with the duty ratio. The fuel quantity is regulated by the cylinder, which moves in connection with the armature to block the fuel passage.
- With the SCV OFF, the return spring pushes the cylinder, completely opening the fuel passage and supplying fuel to the plungers. (Full quantity intake => full quantity discharge.)
- When the SCV is ON, the return spring contracts and closes the fuel passage.
- By turning the SCV ON/OFF, fuel is supplied in an amount corresponding to the drive duty ratio and then discharged by the plungers.
(1) When the SCV Energized Duration (Duty ON Time) is Short

- Short duty ON => large valve opening => maximum intake quantity

(2) When the SCV Energized Duration (Duty ON Time) is Long

- Long duty ON => small valve opening => minimum intake quantity
(3) Relationship Between the Drive Signal and Current (Magnetomotive Force)

Drive Signal and Current (Magnetomotive Force) Relational Diagram

5.3 Fuel temperature sensor

- The fuel temperature sensor is used in rail pressure and injection quantity control. This sensor is installed on the fuel intake side and utilizes the characteristics of a thermistor in which the electric resistance changes with the temperature in order to detect the fuel temperature.

Initial Resistance Value Characteristics

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Resistance Value (kΩ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-30</td>
<td>(25.4)</td>
</tr>
<tr>
<td>-20</td>
<td>15.04 ±1.20</td>
</tr>
<tr>
<td>-10</td>
<td>(9.16)</td>
</tr>
<tr>
<td>0</td>
<td>(5.74)</td>
</tr>
<tr>
<td>10</td>
<td>(3.70)</td>
</tr>
<tr>
<td>20</td>
<td>2.45 ±0.14</td>
</tr>
<tr>
<td>30</td>
<td>(1.66)</td>
</tr>
<tr>
<td>40</td>
<td>(1.15)</td>
</tr>
<tr>
<td>50</td>
<td>(0.811)</td>
</tr>
<tr>
<td>60</td>
<td>(0.584)</td>
</tr>
<tr>
<td>70</td>
<td>(0.428)</td>
</tr>
<tr>
<td>80</td>
<td>0.318±0.008</td>
</tr>
<tr>
<td>90</td>
<td>(0.240)</td>
</tr>
<tr>
<td>100</td>
<td>(0.1836)</td>
</tr>
<tr>
<td>110</td>
<td>0.1417±0.0018</td>
</tr>
<tr>
<td>120</td>
<td>(0.1108)</td>
</tr>
</tbody>
</table>
6. RAIL COMPONENT PARTS

6.1 Rail Pressure Sensor

- This sensor detects fuel pressure in the rail and sends a signal to the engine ECU. It is a semi-conductor piezo resistance type pressure sensor that utilizes the characteristic whereby electrical resistance changes when pressure is applied to a metal diaphragm.

![Diagram of Rail Pressure Sensor]

6.2 Pressure Limiter

- When pressure in the rail is abnormally high, the pressure limiter opens the valve to relieve the pressure. It reopens when pressure in the rail drops to approximately 200 MPa, and resumes operation when pressure drops to below the specified level. Fuel leaked by the pressure limiter returns to the fuel tank.

![Diagram of Pressure Limiter]

Opening pressure: 200 ± 9MPa