DENSO

Diesel Injection Pump

# SERVICE MANUAL

## Common Rail System for The MITSUBISHI FUSO FIGHTER 6M60 Engine

### OPERATION

April, 2004

DENSO CORPORATION

00400071E

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# 1. GENERAL DESCRIPTION

## 1-1. Outline

- This manual describes the common rail system installed in the 6M60 engine of the Mitsubishi Fuso Fighter. The most significant difference to the conventional common rail system is that this system employs a compact and lightweight HP4 supply pump, and a G2 injector with better response. For more details on the common rail system, refer to service manual No. 00400041 "Common Rail System for HINO J05D/J08E Type Engine", issued in October 2003.

## 2. PRODUCT APPLICATION LIST

### 2-1. Vehicle Specifications

| Vehicle Name | Engine Model | Engine Displacement | Remarks |
|---|---|---|---|
| Mitsubishi Fuso Fighter | 6M60 | 7,545 cc | |

### 2-2. Component Part Numbers

| Part Name | DENSO P/N | Mitsubishi P/N | Remarks |
|---|---|---|---|
| Injector | 095000-5450 | ME302143 | |
| Rail | 095440-0570 | ME302292 | |
| Flow Damper | | ME743861 | Rail Component Parts |
| Pressure Limiter | | ME743862 | |
| Pc sensor | | ME743864 | |
| Supply Pump | 294050-0050 | ME302145 | 12V Specification |
| ECU | 275800-3401 | ME302751 | 6M60T1 |
| | 275800-3411 | ME302752 | 6M60T2 |
| | 275800-3451 | ME302986 | 6M60T1 (Allison AT) |
| Boost Pressure Sensor | 079800-5580 | MK369080 | |
| TDC (MRE) Sensor | 949979-1420 | ME301026 | |
| NE (MPU) Sensor | 029600-0570 | MC885578 | |
| Intake Air Temperature Sensor | 071500-2571 | ME352426 | |
| Fuel Temperature Sensor | 179730-0030 | MC885579 | |
| Accelerator Position Sensor | 198300-7030 | ME162376 | |

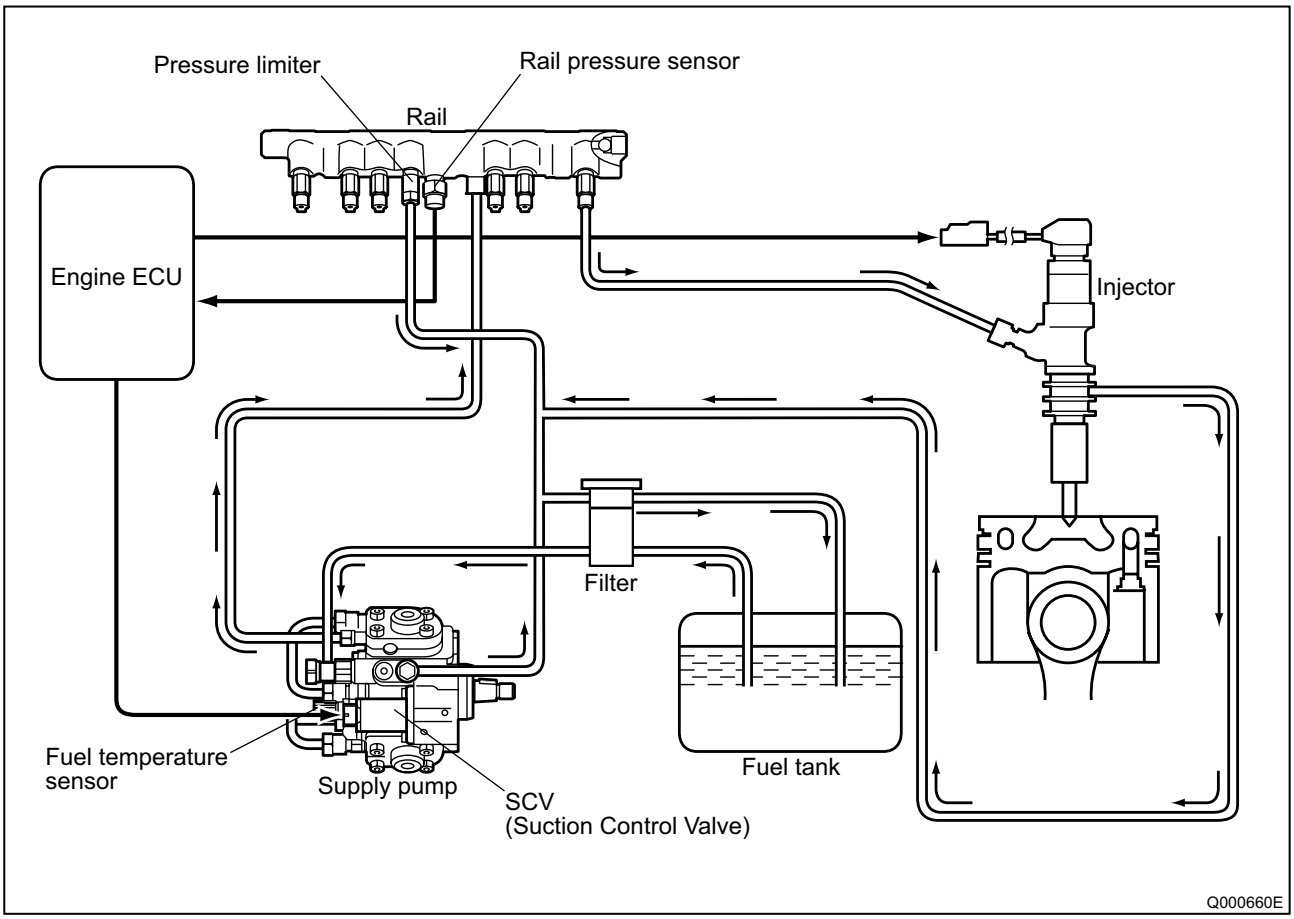
## 3. GENERAL DESCRIPTION OF MAIN NEW FEATURES

### 3-1. Common Rail Specifications and Engine Elements

| | | FK6 |
|---|---|---|
| Common Rail Specifications | Main Elements | HP-4 + G2 |
| | Pressure Used | 170MPa |
| Engine Elements | Model | L6, TI, 4 valves. |
| | Engine Displacement | 7.5L |
| | Output | 199kW/2700rpm |
| | Torque | 785N•m/1400rpm |

### 3-2. System Configuration

#### A. Overall System



# 4. MAIN FUNCTIONAL PARTS

## 4-1. Changes to the Main Functional Parts

- This section describes only the functional parts that have changed significantly.

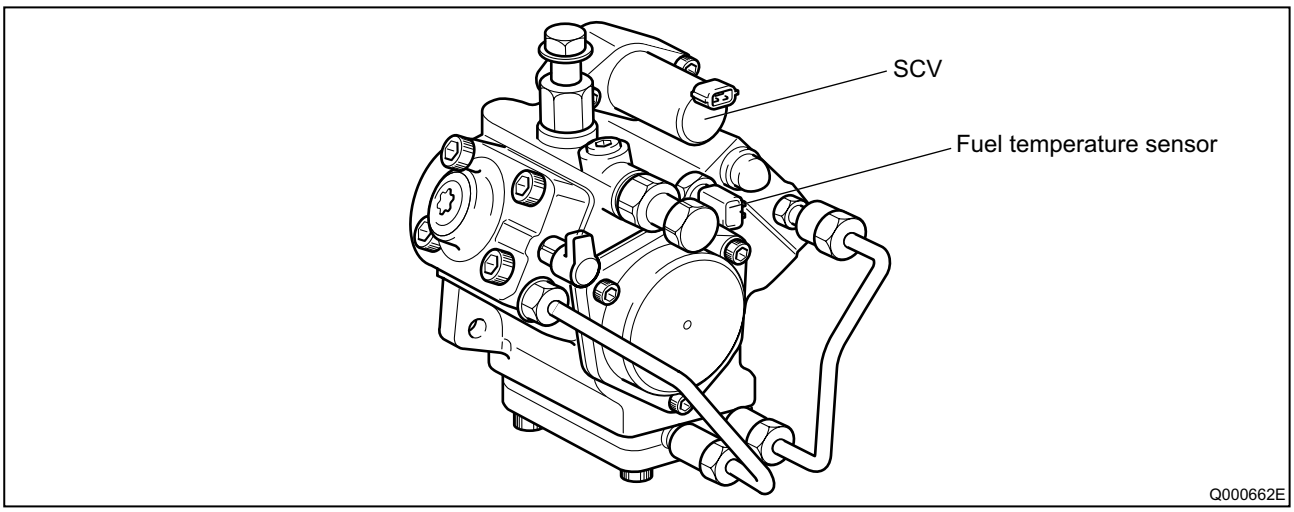
## 4-2. Supply Pump

### A. Changes

Significant changes are listed below.

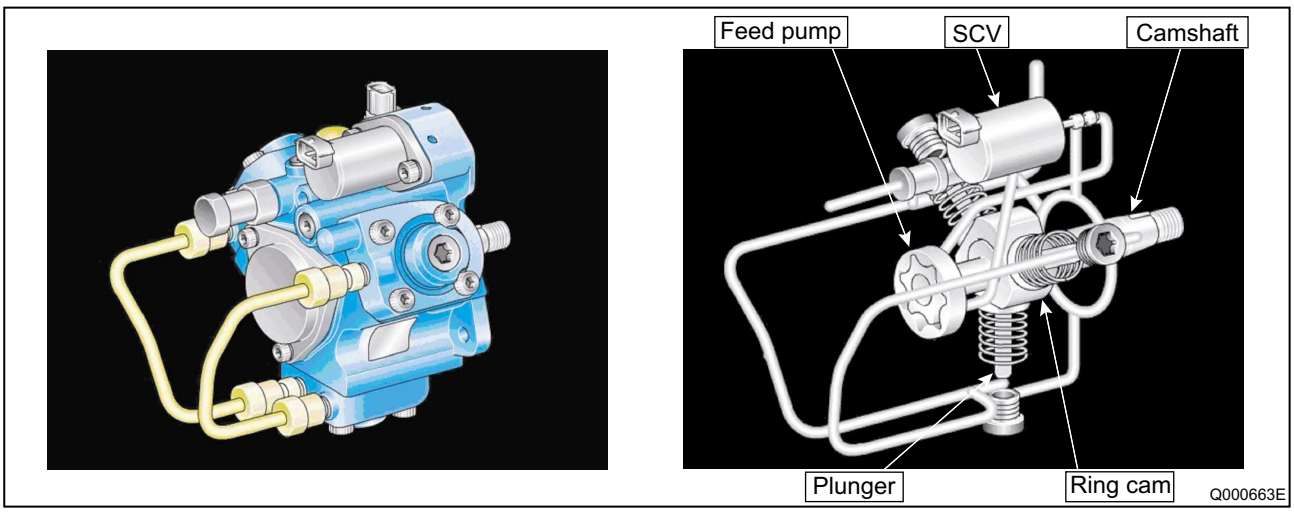
| | | | |
|---|---|---|---|
| Model | | | HP-4 |
| Rotation Ratio Np : Ne | | | 1 : 1 |
| Maximum Speed | | | 4000rpm |
| Direction of Rotation | | | Counter clockwise (viewed from actuating side). |
| Component Parts | Feed Pump | | Trochoid Type |
| | SCV | Rated Voltage | 12V |
| | | Type | Normally Open |
| | Plunger | Diameter × No. | φ8.5 × 3 |
| | | Lift Amount | 8.8mm |
| | Fuel Temperature Sensor | | 2.45 ± 0.24kΩ (20°C) |

### B. External View

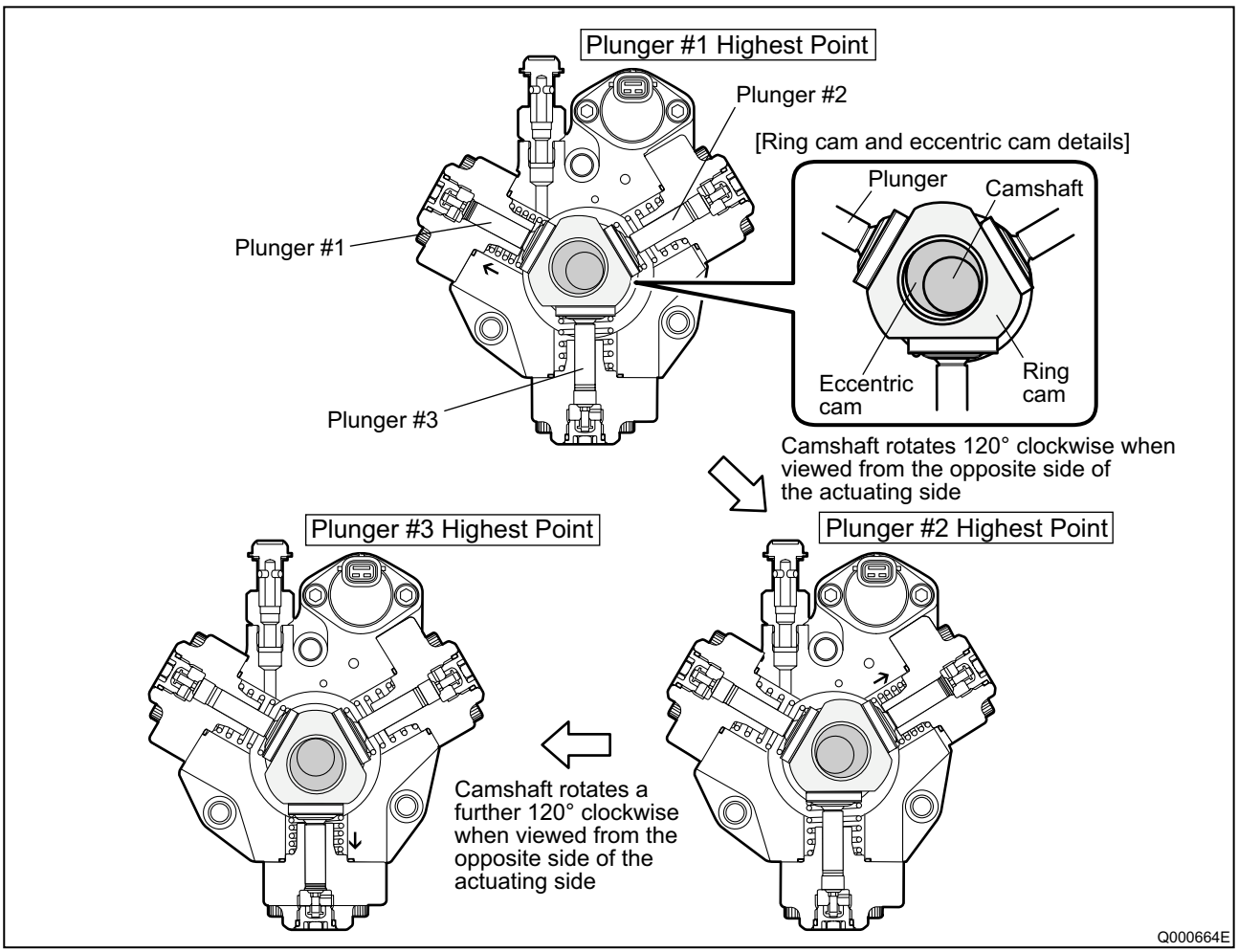



### C. Construction and Operation

- The ring cam is press fitted into an eccentric position relative to the cam shaft. The ring cam is a triple-lobed cam.

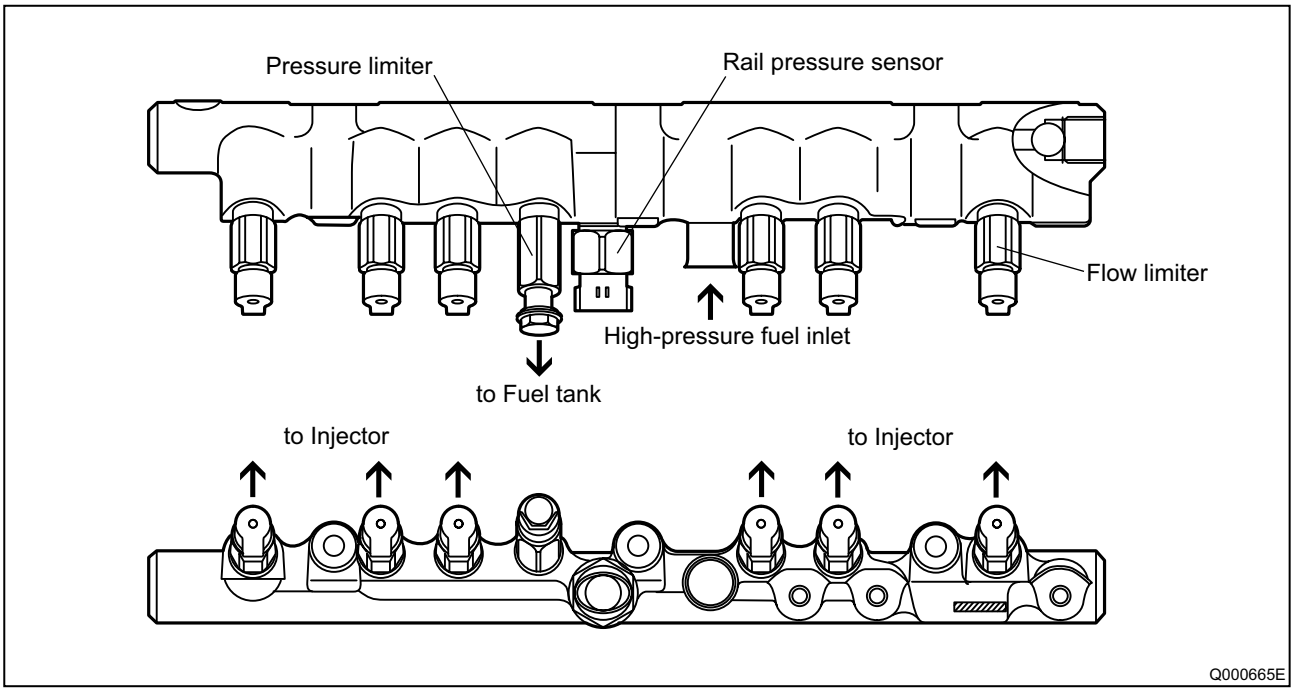


- As the camshaft makes one rotation, the positional relationship between the ring cam and the plunger remains unchanged. Each plunger makes a single reciprocal movement to pump the fuel. Fuel is drawn in by the feed pump, and the suction quantity is adjusted by the SCV (Suction Control Valve).



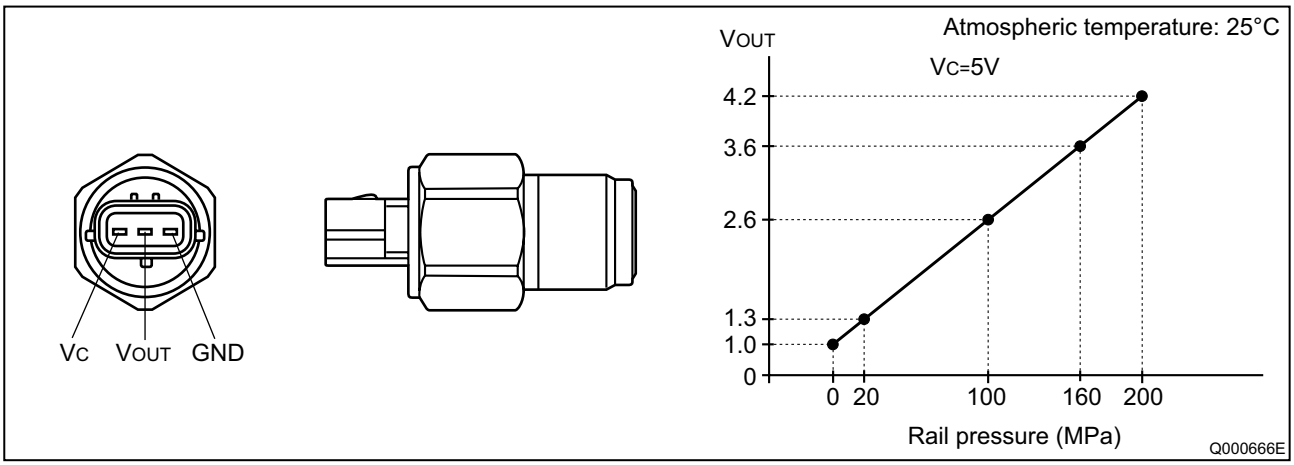

4-3. Rail

A. External View



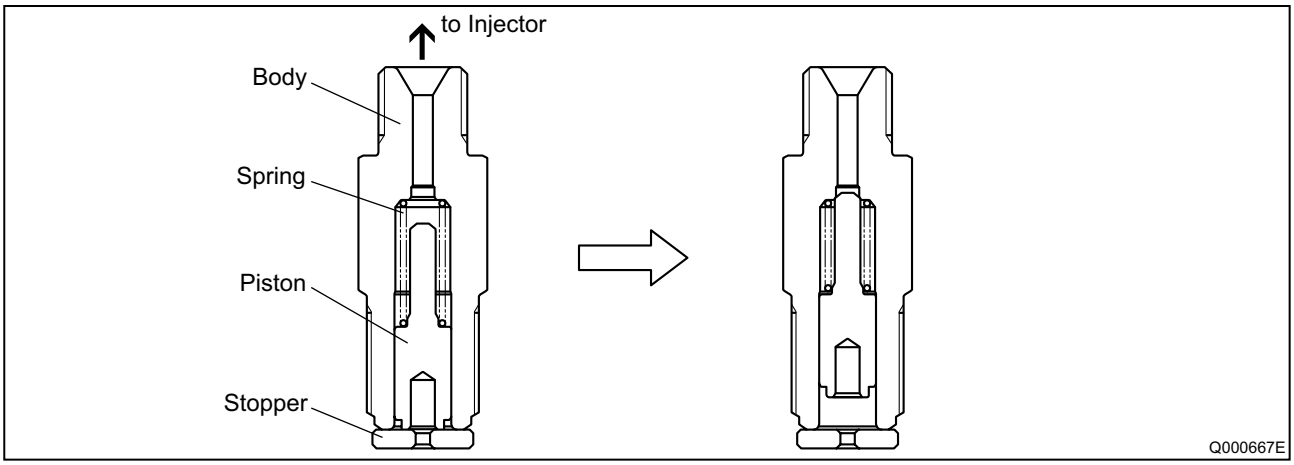
B. Rail Pressure Sensor

The basic principles and construction are the same as for the conventional model. The pressure detection range has been changed to accommodate the increase in pumping pressure from the supply pump.



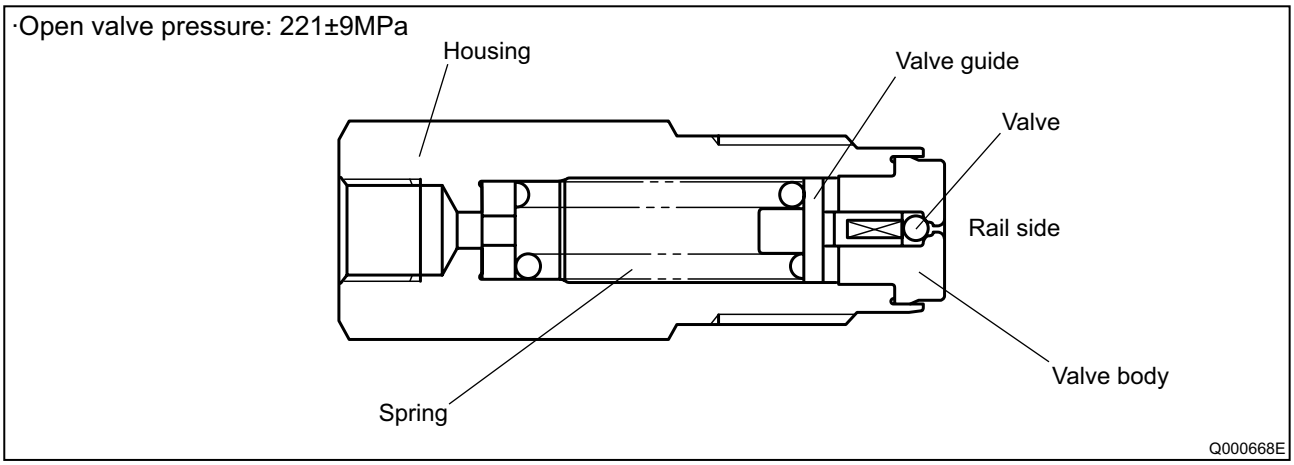

C. Flow Limiter

A flow limiter is employed instead of a flow damper. As with the flow damper, the flow limiter closes the fuel passage to prevent further flow of fuel in the event of an excessive fuel flow. If an abnormal flow occurs, the high pressure forces the piston up. This closes the fuel passage leading to the seat.




D. Pressure Limiter

The construction and operating principles are the same as for the conventional model. The operating pressure has changed.

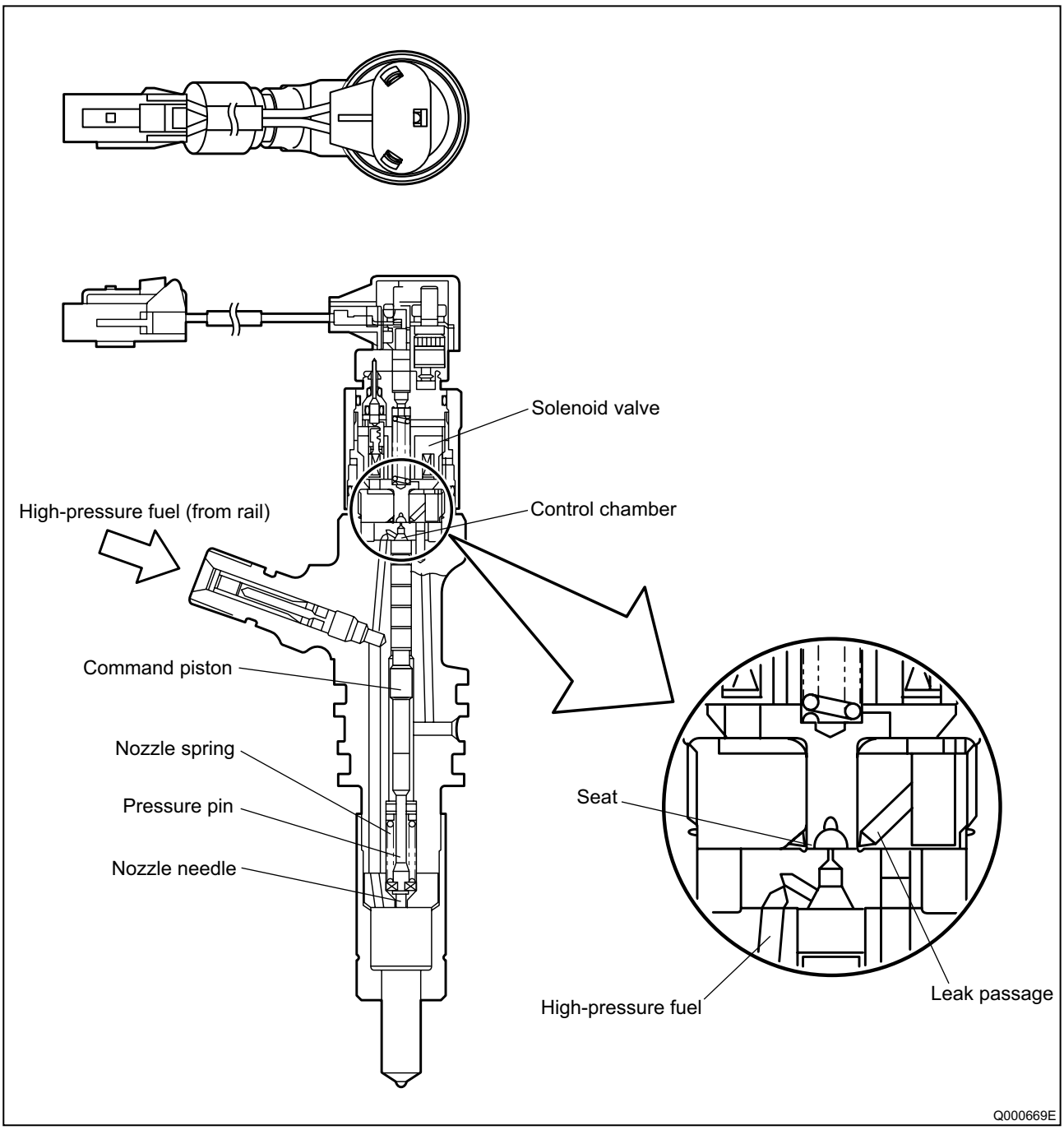


4-4. Injector

A. Outline

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

B. Construction



C. 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.

a. Non-Injection

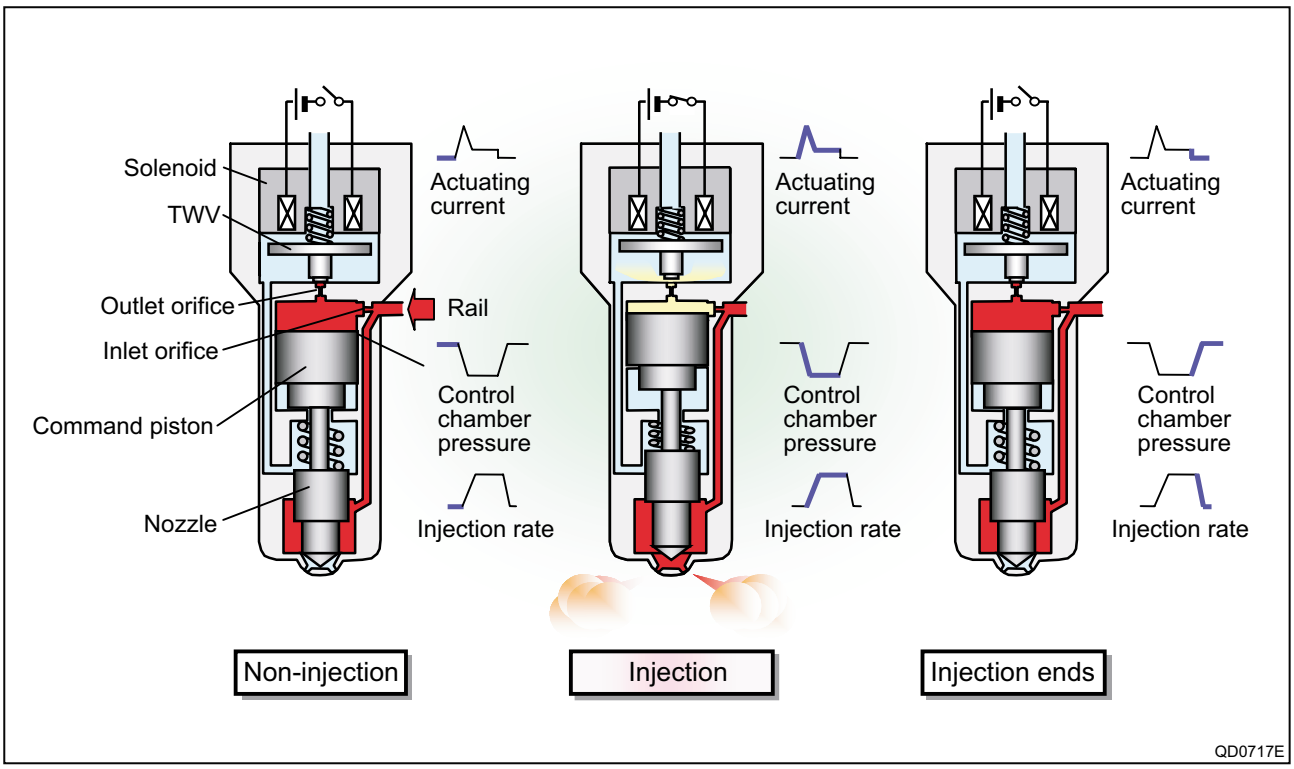
When no current is supplied to the solenoid, the TWV (solenoid valve) is pushed downward by the spring, closing the outlet orifice. This equalizes the control chamber pressure forcing the command piston down and the pressure forcing the nozzle needle up. A state of non-injection results because the nozzle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

b. 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.

c. End of Injection

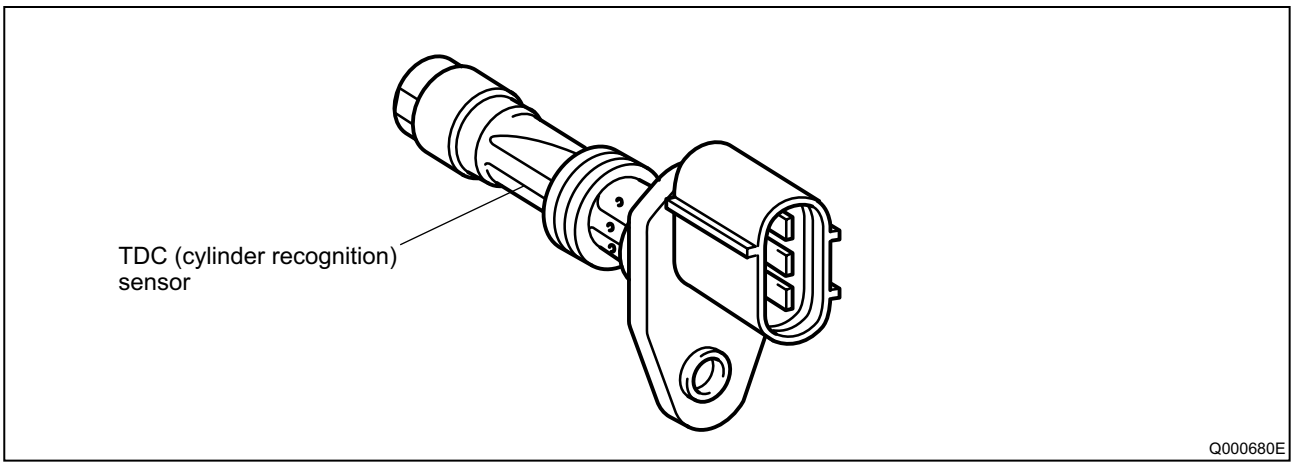
When current continues to be applied to the solenoid, the nozzle reaches its maximum lift, where the injection rate is also at the maximum level. When current to the solenoid is turned OFF, the TWV (solenoid valve) falls and closes the orifice. Fuel then flows into the control chamber via the inlet orifice,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



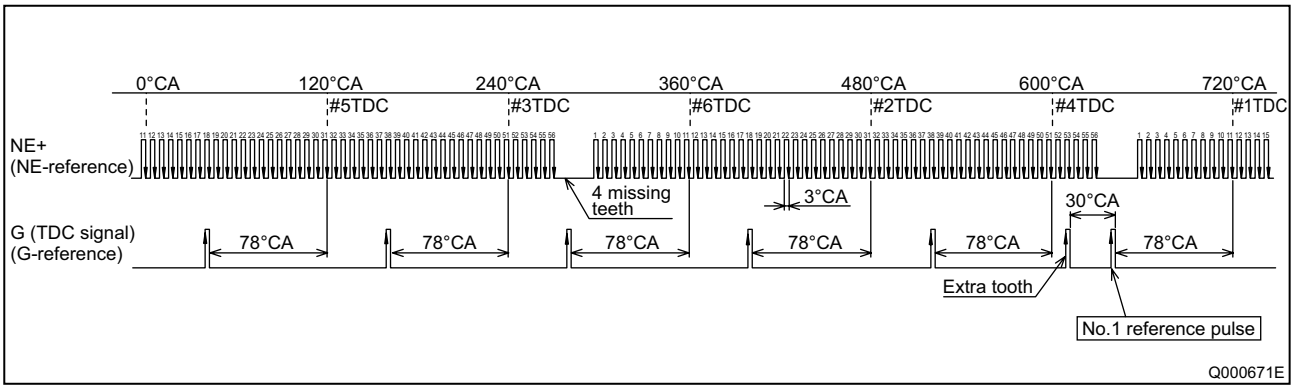
## 4-5. Sensor Additions and Changes

### A. Cylinder Recognition Sensor (TDC Sensor)

- The cylinder recognition sensor is an MRE (Magneto Resistive Element) type. As the teeth in the cylinder recognition sensor pass the sensor, the magnetic resistance in the sensor changes. The change in the voltage generated is converted into a rectangular wave pulse in the IC circuit, and this signal is output to the engine ECU. A cylinder recognition pulsar is installed to the engine camshaft gear, and it outputs the cylinder recognition signal.

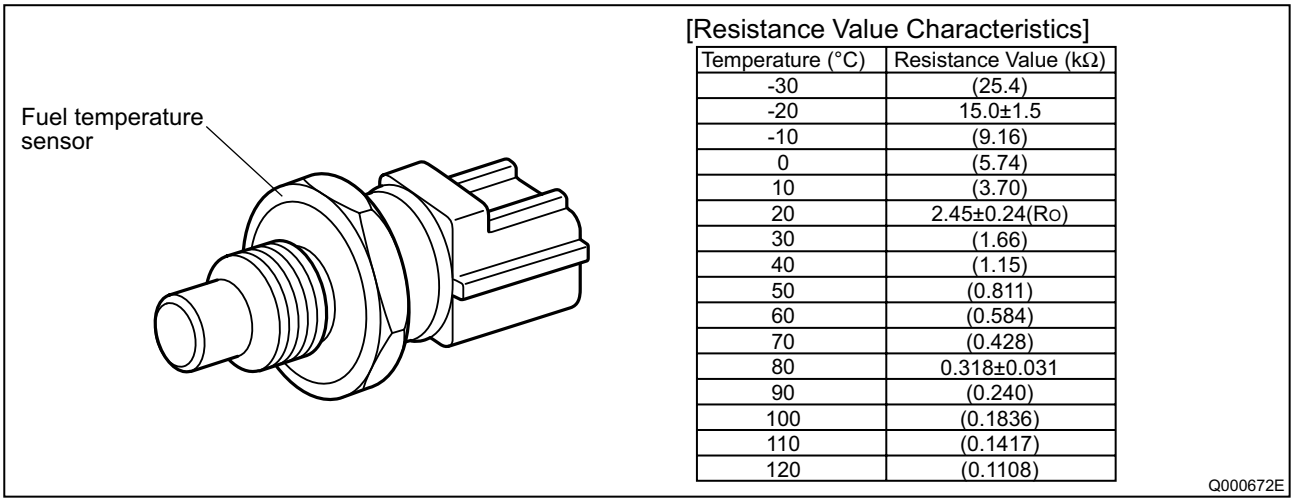



- The No. 1 cylinder is located 78°CA from the No. 1 TDC reference signal following the irregular pulse. The interval between each cylinder is the same degree.




### B. Fuel Temperature Sensor

The fuel temperature sensor is installed on the supply pump. It detects the fuel temperature and sends a signal to the engine ECU. The detection component utilizes a thermistor in which the internal resistance changes according to the temperature. The temperature versus resistance characteristics are shown in the diagram below.

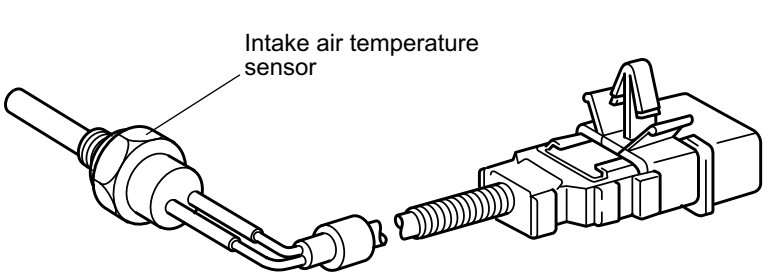



[Resistance Value Characteristics]

| Temperature (°C) | Resistance Value (kΩ) |
|---|---|
| -30 | (25.4) |
| -20 | 15.0±1.5 |
| -10 | (9.16) |
| 0 | (5.74) |
| 10 | (3.70) |
| 20 | 2.45±0.24(Ro) |
| 30 | (1.66) |
| 40 | (1.15) |
| 50 | (0.811) |
| 60 | (0.584) |
| 70 | (0.428) |
| 80 | 0.318±0.031 |
| 90 | (0.240) |
| 100 | (0.1836) |
| 110 | (0.1417) |
| 120 | (0.1108) |

C. Intake Air Temperature Sensor

This sensor is used to detect the intake air temperature in order to correct the injection quantity, injection timing and injection pressure. Similar to the other temperature sensors, it uses a thermistor. The temperature versus resistance characteristics are shown in the diagram below.




[Temperature - Resistance Characteristics]

| Temperature (°C) | Resistance Value (kΩ) |
|---|---|
| (-30) | (26.758) |
| (-20) | (16.2) |
| -10 | 5.88±0.588 |
| 20 | 2.45±0.245 |
| 80 | 0.322±0.0483 |
| (120) | (0.1058) |

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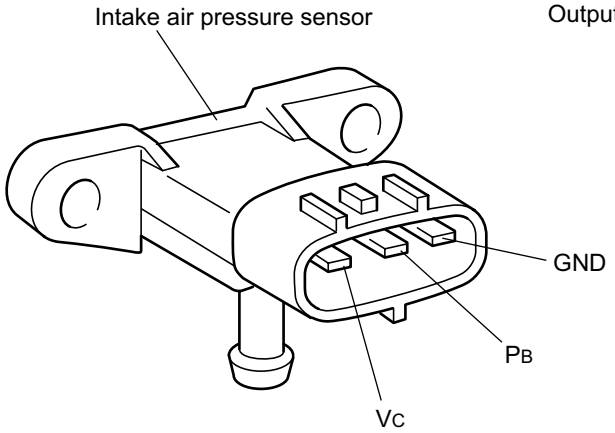
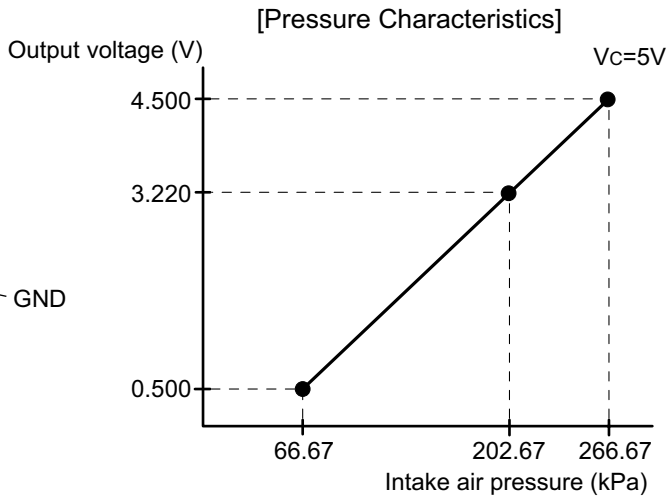
D. Intake Air Pressure Sensor (PIM)

This is a type of semi-conductor pressure sensor. It utilizes the characteristic whereby electrical resistance changes when pressure is applied to silicon crystal. The intake air pressure sensor is used to correct the full load injection quantity data programmed in the engine ECU. The relationship between pressure and output voltage is shown in the diagram below.

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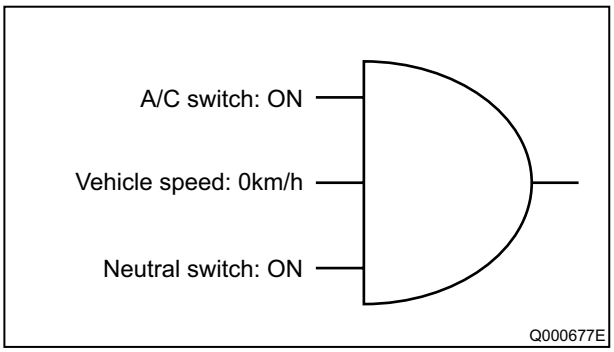
## 5. CONTROL OPERATION CHANGES

### 5-1. Idle-Up

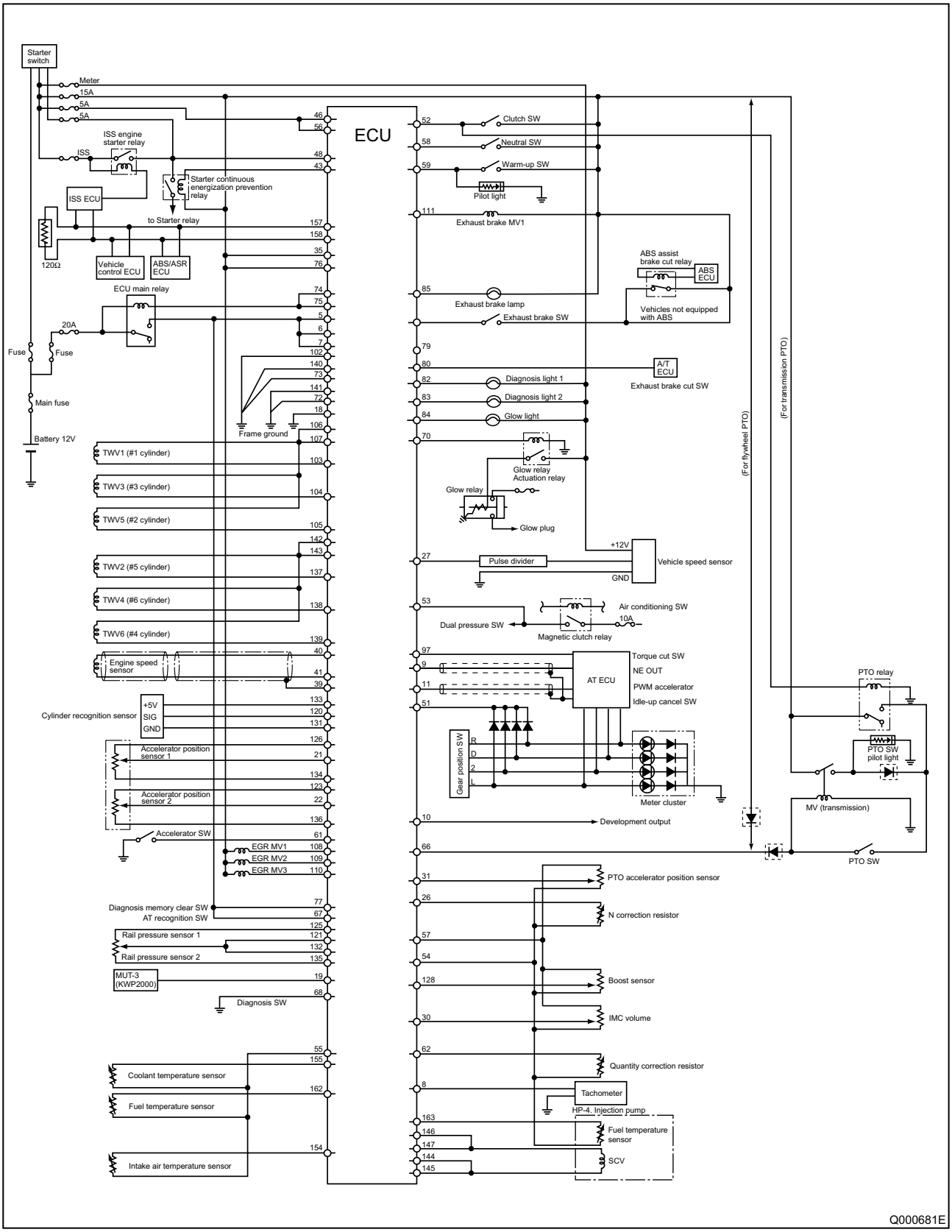
- If the conditions shown in the diagram on the right overlap, the idling speed is set to a fixed value.



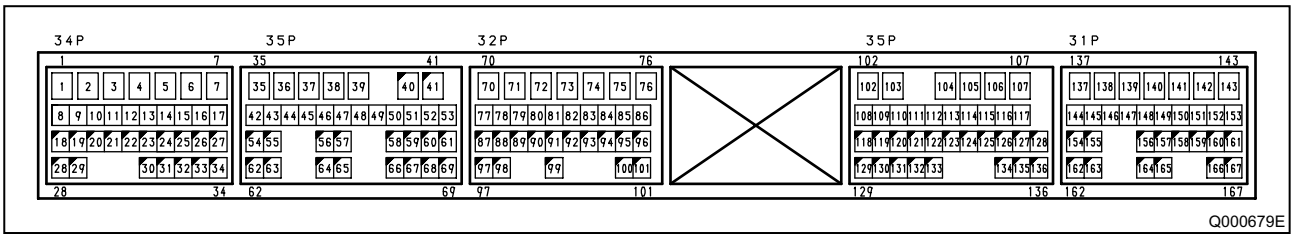
# 6. ECU RELATED

## 6-1. External Wiring Diagram

*1: For the 6M60T1 engine.



## 6-2. Terminal Layout




## 6-3. Terminal Symbol Explanation

### A. Terminals No. 1 to 34

| No. | Terminal Name | Signal Name | No. | Terminal Name | Signal Name |
|---|---|---|---|---|---|
| 1 | - | - | 18 | CASEGND | Case ground |
| 2 | - | - | 19 | KWP2000 | MUT-3 |
| 3 | - | - | 20 | - | - |
| 4 | - | - | 21 | AD1 | Accelerator position sensor 1 |
| 5 | +B | +VB | 22 | AD2 | Accelerator position sensor 2 |
| 6 | +B | +VB | 23 | - | - |
| 7 | +B | +VB | 24 | - | - |
| 8 | TAC1 | Tachometer signal | 25 | AD19 | Temperature sensor 4 for after-treatment (following EGR merging). |
| 9 | TAC2 | NE OUT | 26 | AD20 | N correction resistor |
| 10 | POUT1 | Development output (Q-OUT) | 27 | VS1 | Vehicle speed sensor |
| 11 | POUT2 | PWMACC | 28 | - | - |
| 12 | - | - | 29 | - | - |
| 13 | - | - | 30 | AD14 | IMC volume |
| 14 | - | - | 31 | AD15 | PTO accelerator position sensor |
| 15 | - | - | 32 | - | - |
| 16 | - | - | 33 | - | - |
| 17 | - | - | 34 | - | - |

### B. Terminals No. 35 to 69

| No. | Terminal Name | Signal Name | No. | Terminal Name | Signal Name |
|---|---|---|---|---|---|
| 35 | +BF | SURGE OUT 1 | 53 | SW7 | Air conditioning switch |
| 36 | - | - | 54 | A-GND4 | Sensor GND4 |
| 37 | - | - | 55 | A-GND5 | Sensor GND5 |
| 38 | - | - | 56 | SW1 | Key switch |
| 39 | NE-SLD | NE-SLD | 57 | A-VCC4 | Sensor power supply 4 |
| 40 | NE+ | Engine speed sensor + | 58 | SW8 | Neutral switch |
| 41 | NE- | Engine speed sensor - | 59 | SW10 | Warm-up switch |
| 42 | - | - | 60 | - | - |
| 43 | OUT2 | Relay to prevent continuous starter energization. | 61 | SW17 | Accelerator switch |

| No. | Terminal Name | Signal Name | No. | Terminal Name | Signal Name |
|---|---|---|---|---|---|
| 44 | - | - | 62 | AD21 | Quantity correction resistor |
| 45 | - | - | 63 | - | - |
| 46 | SW1 | Key switch | 64 | - | - |
| 47 | - | - | 65 | - | - |
| 48 | SW2 | Starter switch | 66 | SW9 | PTO switch |
| 49 | SW3 | Exhaust brake switch | 67 | SW11 | AT recognition switch |
| 50 | - | - | 68 | SW16 | Diagnosis switch |
| 51 | SW5 | Idle-up cancel switch | 69 | - | - |
| 52 | SW6 | Clutch switch 1 | | | |

C. Terminals No. 70 to 101

| No. | Terminal Name | Signal Name | No. | Terminal Name | Signal Name |
|---|---|---|---|---|---|
| 70 | OUT19 | Glow relay actuation relay | 86 | - | - |
| 71 | - | - | 87 | - | - |
| 72 | GND | ECU analog GND | 88 | - | - |
| 73 | GND | ECU analog GND | 89 | - | - |
| 74 | OUT17 | ECU main relay | 90 | - | - |
| 75 | OUT18 | ECU main relay | 91 | - | - |
| 76 | +BF | SURGE OUT 2 | 92 | - | - |
| 77 | SW27 | Diagnosis memory clear switch | 93 | - | - |
| 78 | - | - | 94 | - | - |
| 79 | - | - | 95 | - | - |
| 80 | SW15 | Exhaust brake cut switch | 96 | - | - |
| 81 | - | - | 97 | - | - |
| 82 | S-OUT1 | Diagnosis light 1 (red) | 98 | - | - |
| 83 | S-OUT2 | Diagnosis light 2 (orange) | 99 | - | - |
| 84 | S-OUT3 | Glow light | 100 | - | - |
| 85 | S-OUT4 | Exhaust brake light | 101 | - | - |

D. Terminals No. 102 to 136

| No. | Terminal Name | Signal Name | No. | Terminal Name | Signal Name |
|---|---|---|---|---|---|
| 102 | P-GND | POWER GND | 120 | G | G sensor + |
| 103 | TWV1 | Injector drive signal 1 | 121 | AD4 | Rail pressure sensor 1 |
| 104 | TWV3 | Injector drive signal 3 | 122 | - | - |
| 105 | TWV5 | Injector drive signal 5 | 123 | A-VCC3 | Sensor power supply 3 |
| 106 | COMMON1 | Injector drive power supply 1-1 | 124 | - | - |
| 107 | COMMON1 | Injector drive power supply 1-2 | 125 | A-VCC2 | Sensor power supply 2 |
| 108 | - | - | 126 | A-VCC1 | Sensor power supply 1 |
| 109 | - | - | 127 | - | - |

| No. | Terminal Name | Signal Name | No. | Terminal Name | Signal Name |
|---|---|---|---|---|---|
| 110 | - | - | 128 | AD3 | Boost sensor |
| 111 | OUT12 | Exhaust brake MV1 | 129 | - | - |
| 112 | - | - | 130 | - | - |
| 113 | - | - | 131 | G-GND | G sensor |
| 114 | - | - | 132 | AD5 | Rail pressure sensor 2 |
| 115 | - | - | 133 | G-VCC | CAM ANGLE VCC (5V) |
| 116 | - | - | 134 | A-GND1 | Sensor GND1 |
| 117 | - | - | 135 | A-GND2 | Sensor GND2 |
| 118 | - | - | 136 | A-GND3 | Sensor GND3 |
| 119 | - | - | | | |

E. Terminals No. 137 to 167

| No. | Terminal Name | Signal Name | No. | Terminal Name | Signal Name |
|---|---|---|---|---|---|
| 137 | TWV2 | Injector drive signal 2 | 153 | - | - |
| 138 | TWV4 | Injector drive signal 4 | 154 | AD6 | Intake air temperature sensor (before |
| 139 | TWV6 | Injector drive signal 6 | 155 | AD7 | Coolant temperature sensor |
| 140 | P-GND | POWER GND | 156 | - | - |
| 141 | P-GND | POWER GND | 157 | CAN1H | CAN1 HIGH |
| 142 | COMMON2 | Injector drive power supply 2-1 | 158 | CAN1L | CAN1 LOW |
| 143 | COMMON2 | Injector drive power supply 2-2 | 159 | - | - |
| 144 | SCVLO | HP3 and HP4 suction control valve drive signal 1 | 160 | - | - |
| 145 | SCVLO | HP3 and HP4 suction control valve drive signal 2 | 161 | - | - |
| 146 | SCVHI | HP3 and HP4 suction control valve power supply 1 | 162 | AD8 | Fuel temperature sensor 1 (leak side) |
| 147 | SCVHI | HP3 and HP4 suction control valve power supply 2 | 163 | AD9 | Fuel temperature sensor 2 |
| 148 | - | - | 164 | - | - |
| 149 | - | - | 165 | - | - |
| 150 | - | - | 166 | - | - |
| 151 | - | - | 167 | - | - |
| 152 | - | - | | | |

## 7. DIAGNOSTIC TROUBLE CODES (DTC)

### 7-1. DIAGNOSTIC TROUBLE CODES LIST

| DG Code | Source | Malfunction Outline |
|---|---|---|
| P0107 | Atmospheric pressure sensor | Output from the atmospheric pressure sensor is too low. |
| P0108 | Atmospheric pressure sensor | Output from the atmospheric pressure sensor is too high. |
| P0112 | Intake air temperature sensor | Output from the intake air temperature sensor is too low. |
| P0113 | Intake air temperature sensor | Output from the intake air temperature sensor is too high. |
| P0117 | Coolant temperature sensor | Output from the coolant temperature sensor is too low. |
| P0118 | Coolant temperature sensor | Output from the coolant temperature sensor is too high. |
| P0121 | Accelerator position sensor | Output from accelerator position sensors No. 1 and No. 2 is inconsistent. |
| P0122 | Accelerator position sensor No. 1 | Output from the accelerator position sensor is too low. |
| P0123 | Accelerator position sensor No. 1 | Output from the accelerator position sensor is too high. |
| P0187 | Fuel temperature sensor | Output from the fuel temperature sensor is too low. |
| P0188 | Fuel temperature sensor | Output from the fuel temperature sensor is too high. |
| P0191 | Rail pressure sensor | Output from the rail pressure sensor is fixed at a middle value. |
| P0192 | Rail pressure sensor | Output from the rail pressure sensor is too low. |
| P0193 | Rail pressure sensor | Output from the rail pressure sensor is too high. |
| P0200 | Injector COM1 | COM1 is open or short circuited; or TWV1, TMV3 or TWV5 is open or short circuited. |
| P0201 | Injector TWV | Open circuit in the TWV1 wiring or injector coil. |
| P0202 | Injector TWV | Open circuit in the TWV5 wiring or injector coil. |
| P0203 | Injector TWV | Open circuit in the TWV3 wiring or injector coil. |
| P0204 | Injector TWV | Open circuit in the TWV6 wiring or injector coil. |
| P0205 | Injector TWV | Open circuit in the TWV2 wiring or injector coil. |
| P0206 | Injector TWV | Open circuit in the TWV4 wiring or injector coil. |
| P0219 | Overrun | Engine is overrunning. |
| P0222 | Accelerator position sensor No. 2 | Output from the accelerator position sensor is too low. |
| P0223 | Accelerator position sensor No. 2 | Output from the accelerator position sensor is too high. |
| P0227 | PTO accelerator position sensor | Output from the PTO accelerator position sensor is too low. |
| P0228 | PTO accelerator position sensor | Output from the PTO accelerator position sensor is too high. |
| P0234 | Abnormally boost pressure | Boost pressure is excessive or insufficient. |
| P0237 | Intake air pressure sensor | Output from the intake air pressure sensor is too low. |
| P0238 | Intake air pressure sensor | Output from the intake air pressure sensor is too high. |
| P0251 | Fuel leak | Fuel leak in the injection system or fuel system. |
| P0252 | Pressure limiter | Pressure limiter is operating. |
| P0253 | Abnormally high pressure 2 | Output from the rail pressure sensor is over the higher upper limit. |
| P0254 | Abnormally high pressure 1 | Output from the rail pressure sensor is over the lower upper limit. |
| P0255 | Supply pump | Rail pressure exceeds the specified duration or is over the specified value. (Specified speed range.) |
| P0256 | Supply pump | Rail pressure exceeds the specified duration or is over the specified value (lower pressure and longer duration than PO255). (Medium to high speed range.) |

| DG Code | Source | Malfunction Outline |
|---|---|---|
| P0257 | Supply pump | Poor pumping in the supply pump No. 1 cylinder. |
| P0335 | Engine speed sensor | No signal output from the engine speed sensor. |
| P0340 | TDC sensor | No signal output from the TDC sensor. |
| P0380 | Glow relay | BATT short in the output to the glow relay. Open or GND short in the glow relay output. |
| P0500 | Vehicle speed sensor | Open or short circuit in the vehicle speed sensor; frequency is too high; no output. |
| P0506 | IMC volume | IMC volume signal is too low. |
| P0507 | IMC volume | IMC volume signal is too high. |
| P0510 | IDLE switch | IDLE switch is seized closed. |
| P0600 | SLD system | Communication error between the vehicle speed control ECU and engine ECU or vehicle speed sensor. |
| P0605 | CPU (in the engine ECU) | Main CPU malfunction or watchdog malfunction. |
| P0616 | Starter prohibition relay | BATT short in the output to the starter prohibition relay. |
| P0617 | Starter prohibition relay | Open circuit (external) or GND short in the output to the starter prohibition relay. |
| P1121 | Intake throttle valve | Open circuit, GND short or BATT short in the output to valve MV1. |
| P1171 | Injection correction resistance value | Injection correction resistance value is too low. |
| P1172 | Injection correction resistance value | Injection correction resistance value is too high. |
| P1176 | Maximum speed adjusting resistor | Adjusting resistor value is too low. |
| P1177 | Maximum speed adjusting resistor | Adjusting resistor value is too high. |
| P1185 | Engine stop switch | Engine stop switch is seized closed. |
| P1200 | Injector COM2 | COM2 is open or short circuited; or TWV2, TWV4 or TWV6 is open or short circuited. |
| P1210 | Capacitor charging circuit (ECU) | Malfunction in the injector drive power supply circuit (overcharging or insufficient charging). |
| P1240 | Fuel system 1 | Large momentary fluctuations in No. 1 cylinder speed. |
| P1241 | Fuel system 5 | Large momentary fluctuations in No. 5 cylinder speed. |
| P1242 | Fuel system 3 | Large momentary fluctuations in No. 3 cylinder speed. |
| P1243 | Fuel system 6 | Large momentary fluctuations in No. 6 cylinder speed. |
| P1244 | Fuel system 2 | Large momentary fluctuations in No. 2 cylinder speed. |
| P1245 | Fuel system 4 | Large momentary fluctuations in No. 4 cylinder speed. |
| P1255 | Output to SCV | Open circuit (external) in ECU terminal SCV+ or SCV-, GND short, or open circuit in SCV coil. |
| P1256 | Output to SCV | BATT short in ECU terminal SCV+ or SCV-. |
| P1257 | SCV | SCV seizure. |
| P1262 | Exhaust brake MV1 | Open circuit or GND short in the output to MV1. |
| P1263 | Exhaust brake MV1 | BATT short in the output to MV1. |
| P1605 | ECU | Malfunction in the flash memory. |
| P1930 | Power retarder relay | Open circuit, GND short or BATT short in the output to the retarder relay. |