For DENSO Authorized
ECD Service Dealer Only

Diesel Injection Pump

No. E-03-04

SERVICE MANUAL

Common Rail System for OPEL 4EE2 Type Engine

Operation

August, 2003

DENSO CORPORATION

00400028

FORWARD

To meet the high pressurization requirements for the engine to deliver cleaner exhaust gas emissions, lower fuel consumption and reduced noise, advanced electronic control technology is being adopted in the fuel injection system.

This manual covers the electronic control model Common Rail system with HP3 pump for the ISUZU 4EE2 type engine which is used to OPEL CORSA and MERIVA. Complex theories, special functions and components made by manufacturers other than DENSO are omitted from this manual.

This manual will help the reader develop an understanding of the basic construction, operation and system configuration of the DENSO manufactured components and brief diagnostic information.

TABLE OF CONTENTS

1. Product Application

1.1 Application

Vehicle Name	Vehicle Model	Engine Model	Exhaust Volume	Reference
Corsa	S-Car	4EE2	1.7L	Made in Germany
Meriva	S-Mono			

1.2 System Components Parts Number

Part Name	Vehicle Model		DENSO Part Number	Car Manufacturer Part Number
	Corsa	Meriva		
Supply Pump	O	O	HU294000-0071	97313 862
Rail	O	O	HU095440-0411	97313 863
Injector	O	O	HU095000-5082	97313 861
Engine ECU	O		112500-0151	97300 097
		O	112500-0161	97350 948
	Supply use		112500-0170	97364 132
Crankshaft Position Sensor	O	O	949979-1200	97321 620
Cylinder Recognition Sensor	O	O	949979-1200	97321 620
EGR Valve	O	O	HU135000-7040	97355 042

2. Outline

2.1 Outline of System

The common rail system was developed primarily to cope with exhaust gas regulations for diesel engines, and aimed for 1. further improved fuel economy; 2. noise reduction; and 3. high power output.

[1] System Characteristics

The common rail system uses a type of accumulation chamber called a rail to store pressurized fuel, and injectors that contain electronically controlled solenoid valves to spray the pressurized fuel into the cylinders. Because the engine ECU controls the injection system (including the injection pressure, injection rate, and injection timing), the injection system is unaffected by the engine speed or load. This ensures a stable injection pressure at all times, particularly in the low engine speed range, and dramatically decreases the amount of black smoke ordinarily emitted by a diesel engine during start-up and acceleration. As a result, exhaust gas emissions are cleaner and reduced, and higher power output is achieved.

(1) Injection pressure control

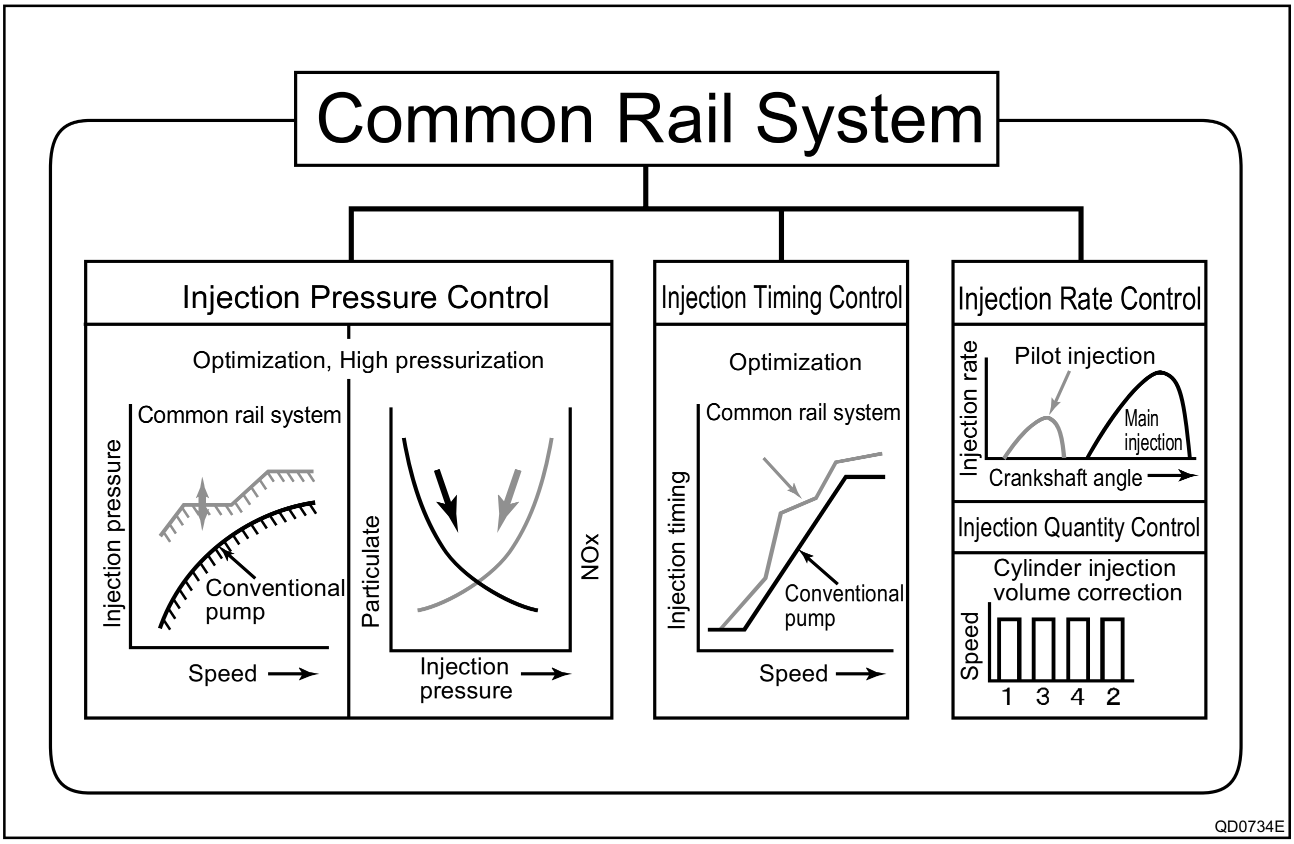
- Enables high-pressure injection even at low engine speeds.
- Optimizes control to minimize particulate matter and NOx emissions.

(2) Injection timing control

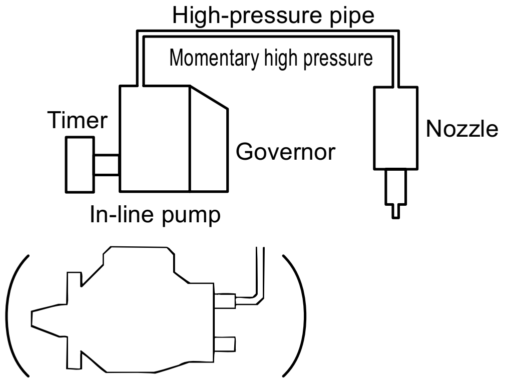
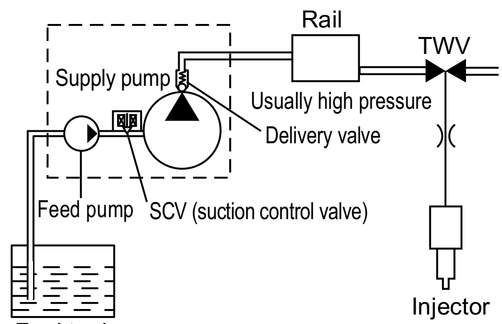
Enables finely tuned optimized control in accordance with driving conditions.

(3) Injection rate control

Pilot injection control sprays a small amount of fuel before the main injection.



[2] Comparison to the Conventional System

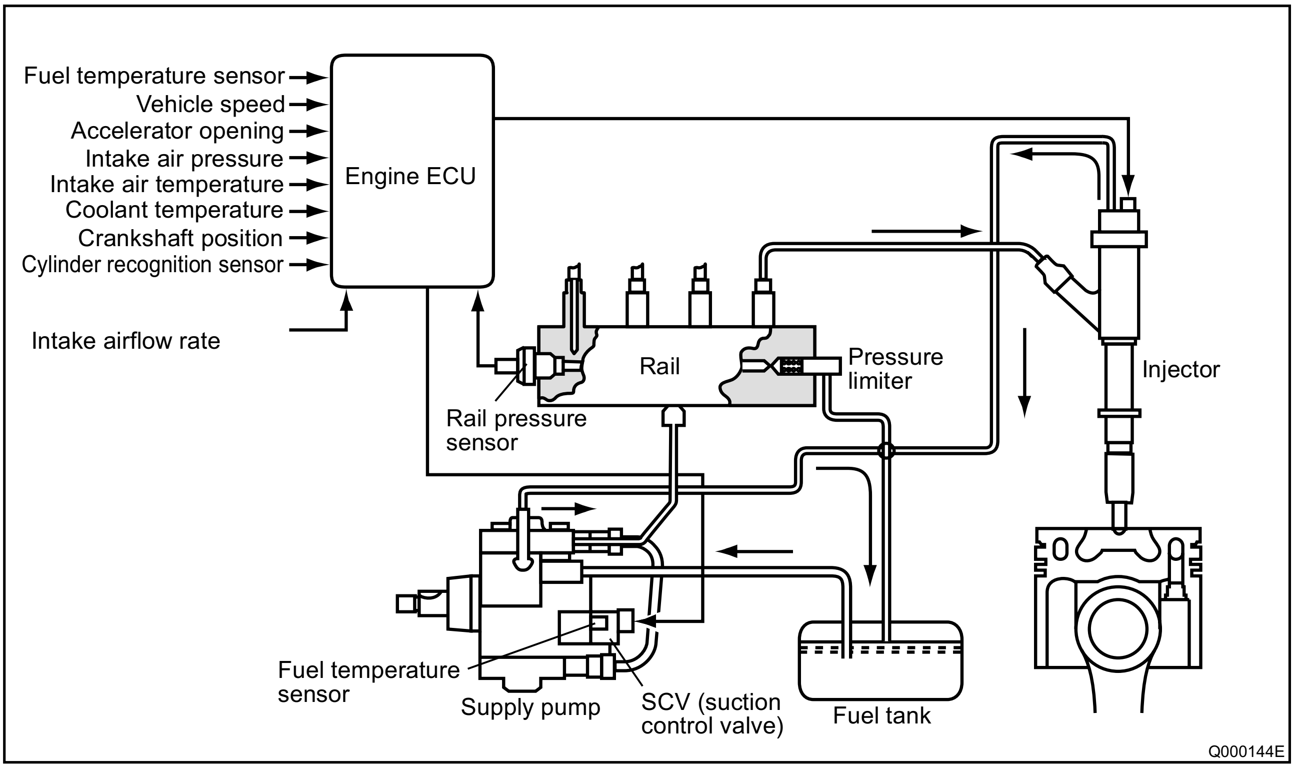
	In-line, VE Pump	Common rail system
System		
Injection quantity control	Pump (governor)	Engine ECU, injector (TWV)*1
Injection timing control	Pump (timer)	Engine ECU, injector (TWV)*1
Rising pressure	Pump	Engine ECU, supply pump
Distributor	Pump	Engine ECU, rail
Injection pressure control	Dependent upon speed and injection quantity	Engine ECU, supply pump (SCV)*2

*1 TWV: Two Way Valve *2 SCV： Suction Control Valve QD2341E

2.2 Outline of System

[1] Composition

The common rail system consists primarily of a supply pump, rail, injectors, and engine ECU.



[2] Operation

(1) Supply pump (HP3)

The supply pump draws fuel from the fuel tank, and pumps the high pressure fuel to the rail. The quantity of fuel discharged from the supply pump controls the pressure in the rail. The SCV (Suction Control Valve) in the supply pump effects this control in accordance with the command received from the ECU.

(2) Rail

The rail is mounted between the supply pump and the injector, and stores the high-pressure fuel.

(3) Injector

This injector replaces the conventional injection nozzle, and achieves optimal injection by effecting control in accordance with signals from the ECU. Signals from the ECU determine the length of time and the timing in which current is applied to the injector. This in turn, determines the quantity, rate and timing of the fuel that is injected from the injector.

(4) Engine ECU

The engine ECU calculates data received from the sensors to comprehensively control the injection quantity, timing and pressure, as well as the EGR (exhaust gas recirculation).

[3] Fuel System

This system comprises the route through which diesel fuel flows from the fuel tank to the supply pump, via the rail, and is injected through the injector, as well as the route through which the fuel returns to the tank via the overflow pipe.

[4] Control System

In this system, the engine ECU controls the fuel injection system in accordance with the signals received from various sensors. The components of this system can be broadly divided into the following three types: (1) Sensors; (2) ECU; and (3) Actuators.

(1) Sensors

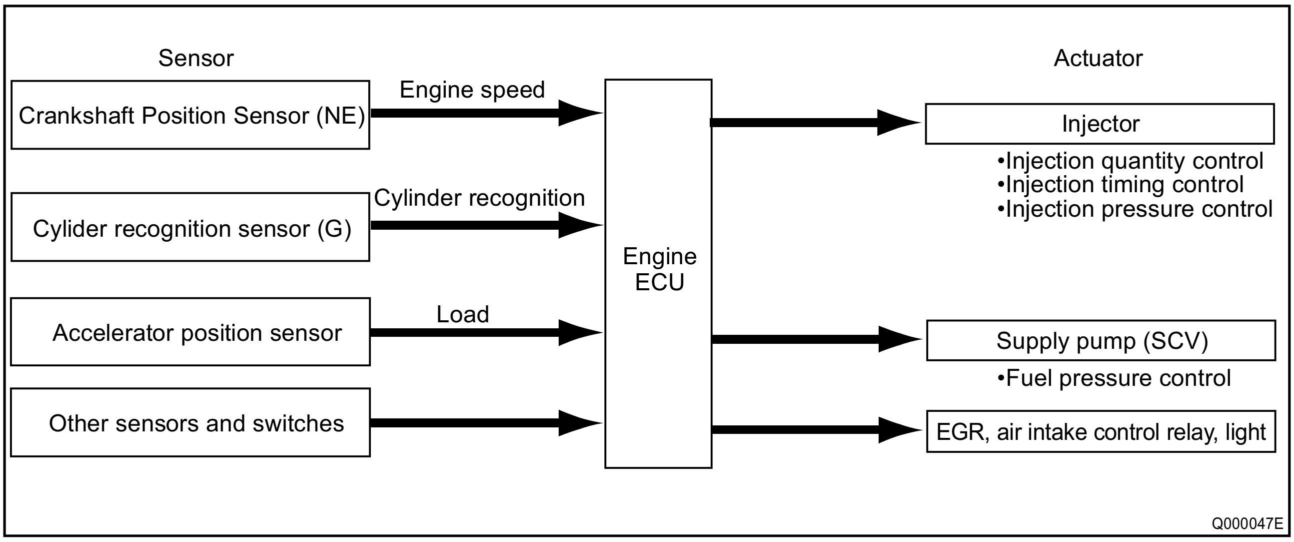
Detect the engine and driving conditions, and convert them into electrical signals.

(2) Engine ECU

Performs calculations based on the electrical signals received from the sensors, and sends them to the actuators in order to achieve optimal conditions.

(3) Actuators

Operate in accordance with electrical signals received from the ECU. Injection system control is undertaken by electronically controlling the actuators. The injection quantity and timing are determined by controlling the duration and the timing in which the current is applied to the TWV (Two-Way Valve) in the injector. The injection pressure is determined by controlling the SCV (Suction Control Valve) in the supply pump.



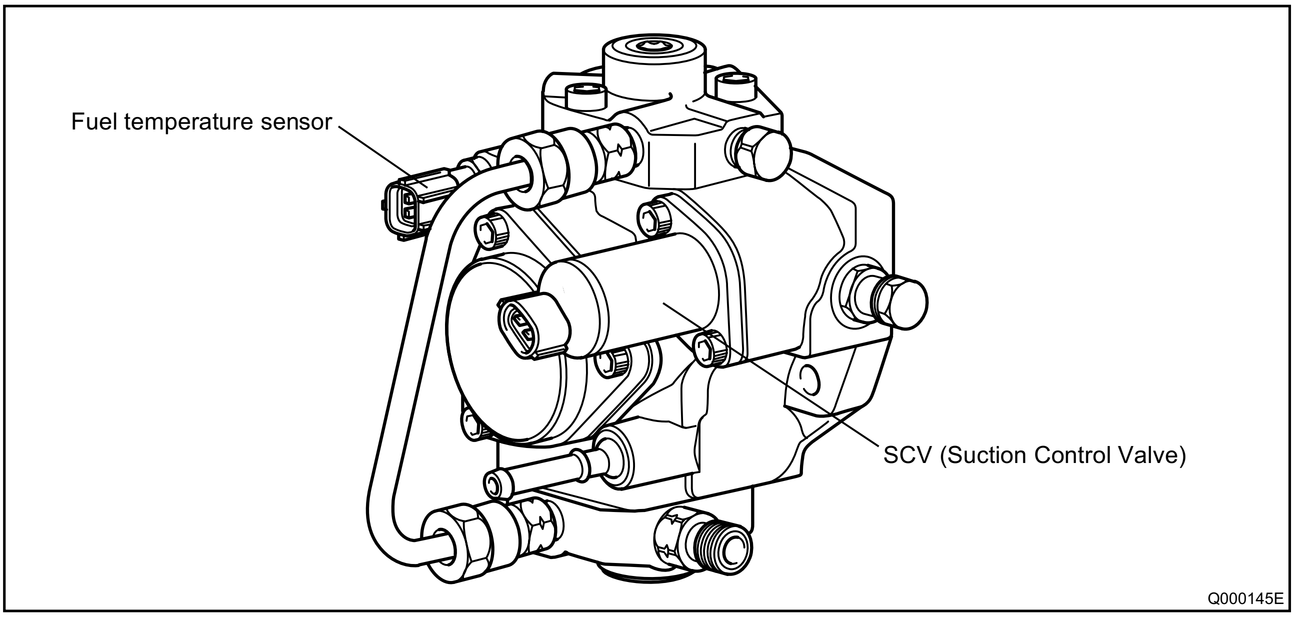
3. Construction and Operation

3.1 Description of Main Components

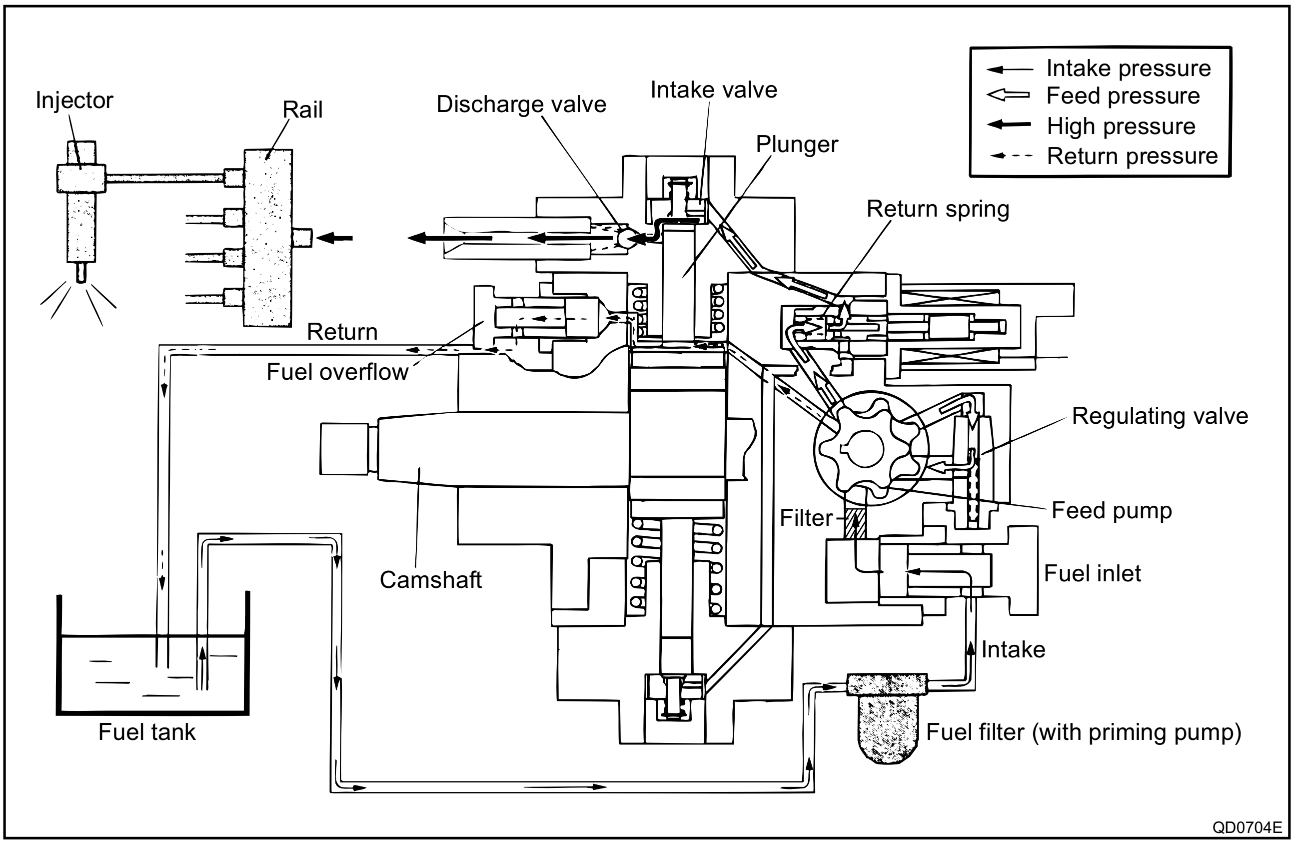
[1] Supply Pump (HP3)

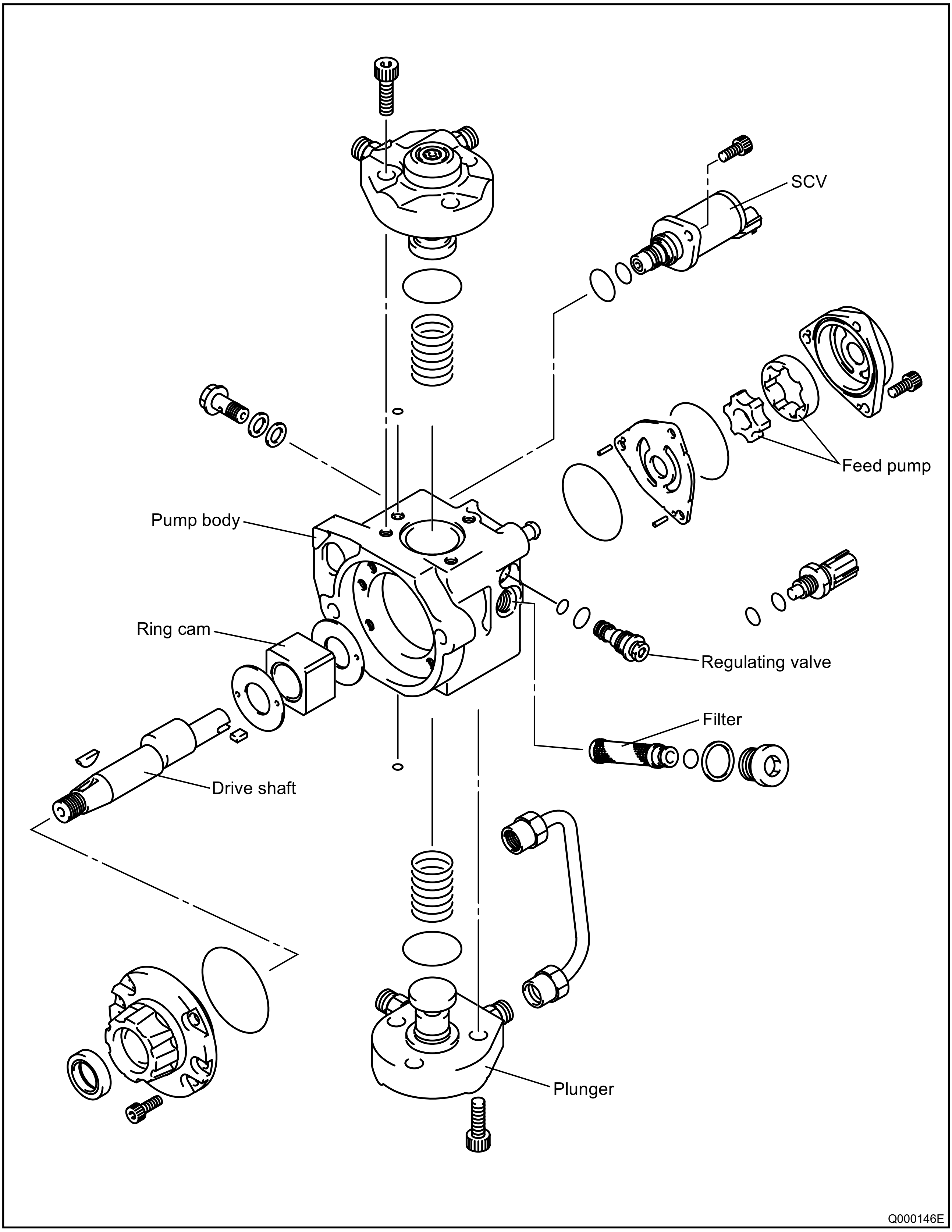
(1) Outline

- The supply pump consists primarily of the pump body (eccentric cam, ring cam, and plungers), SCV (Suction Control Valve), fuel temperature sensor, and feed pump.



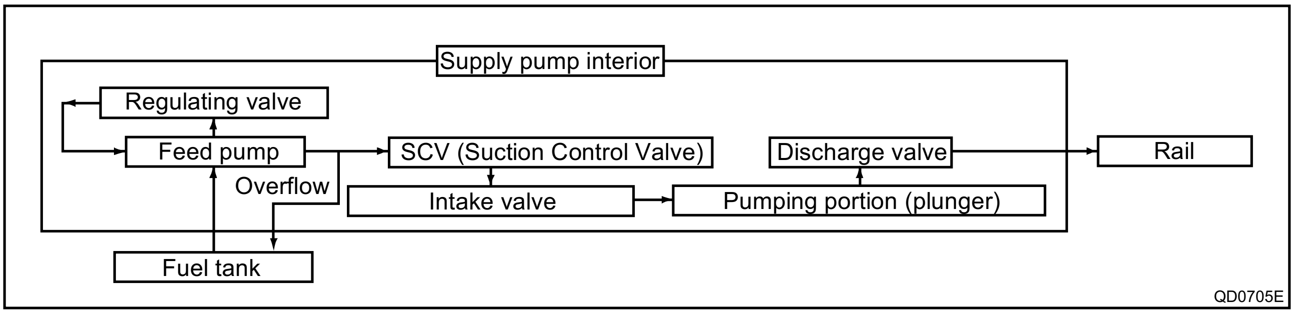
- The two plungers are positioned vertically on the outer ring cam for compactness.
- The engine drives the supply pump at a ratio of 1:2. The supply pump has a built-in feed pump (trochoid type), and draws the fuel from the fuel tank, sending it to the plunger chamber.
- The internal camshaft drives 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 opened type (the intake valve opens during de-energization).


Intake pressure
Feed pressure
High pressure
Return pressure
Injector
Rail
Discharge valve
Intake valve
Plunger
Return spring
Return
Fuel overflow
Regulating valve
Camshaft
Filter
Feed pump
Fuel inlet
Intake
Fuel tank
Fuel filter (with priming pump)
QD0704E


SCV
Feed pump
Pump body
Ring cam
Regulating valve
Filter
Drive shaft
Plunger
Q000146E

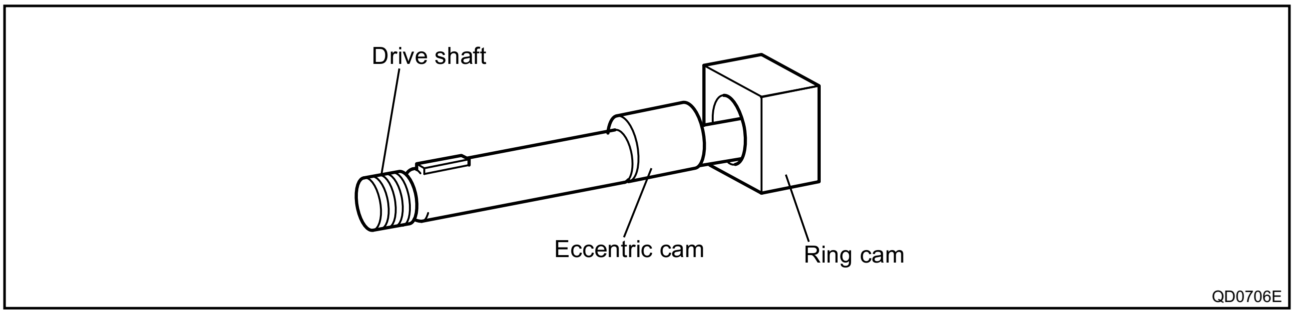
(2) Supply Pump Internal Fuel Flow

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

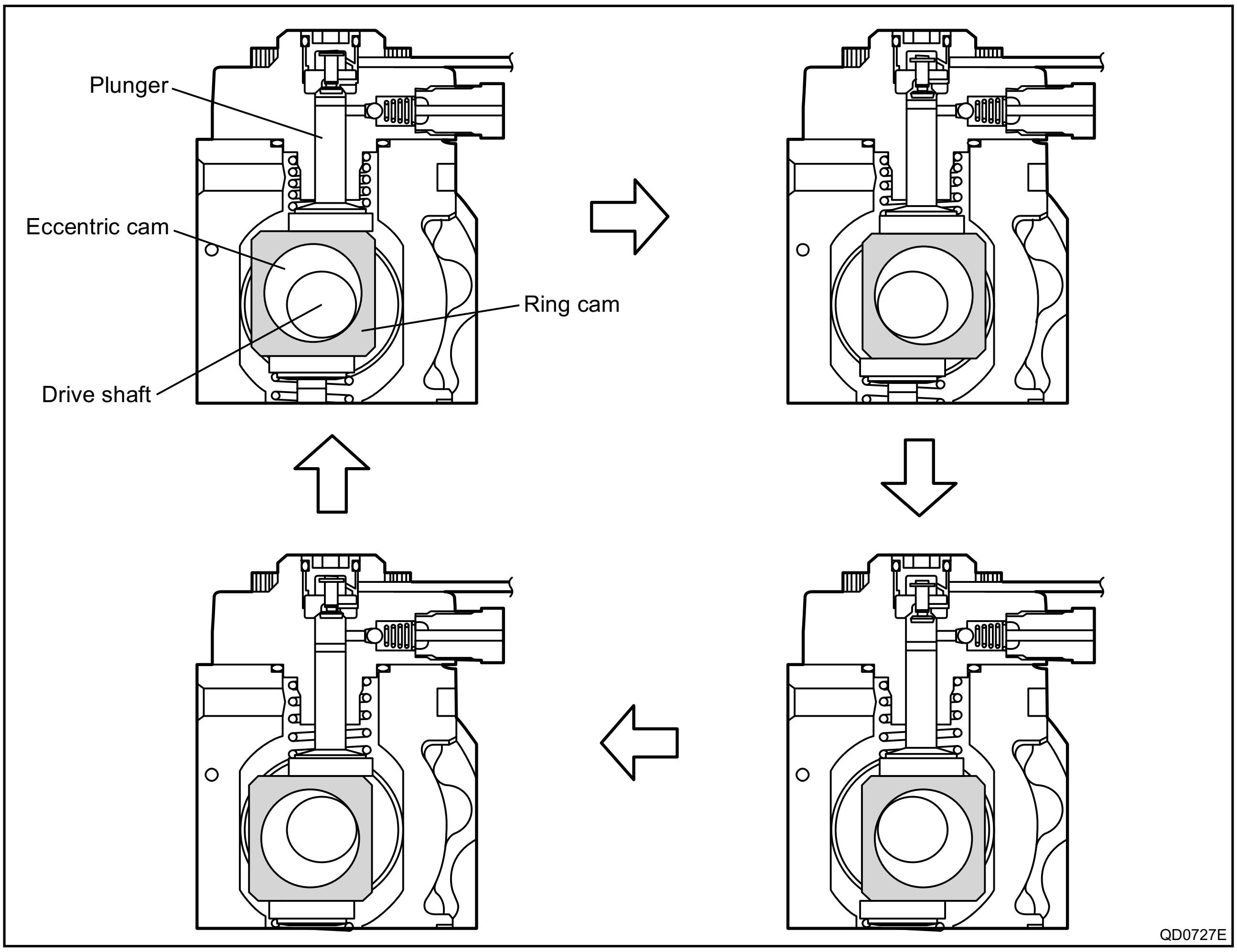


(3) Construction of Supply Pump

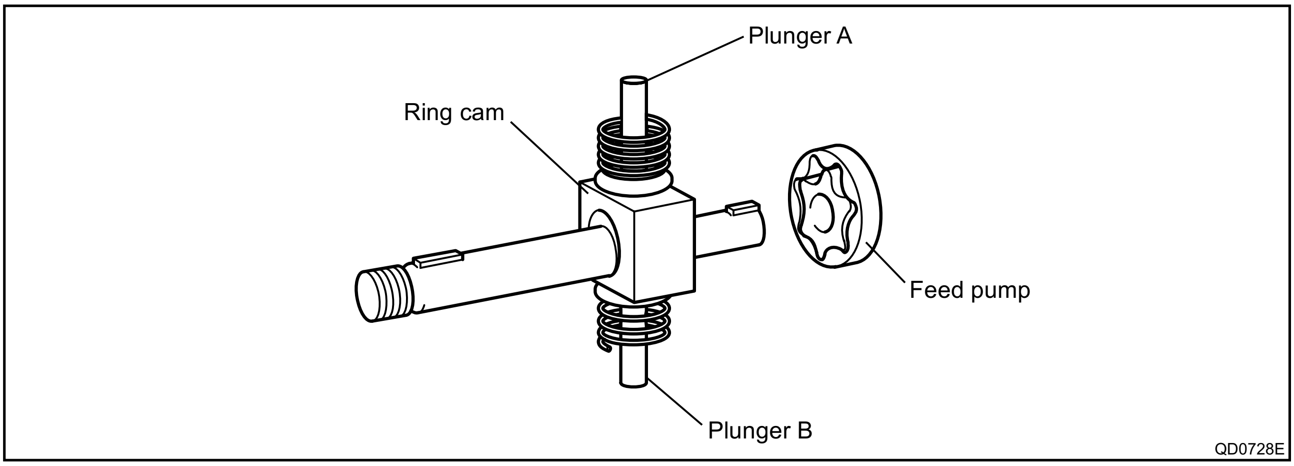
The eccentric cam is formed on the drive shaft. The ring cam is connected to the eccentric cam.



As the drive shaft rotates, the eccentric cam rotates in the eccentric state, and the ring cam moves up and down while rotating.

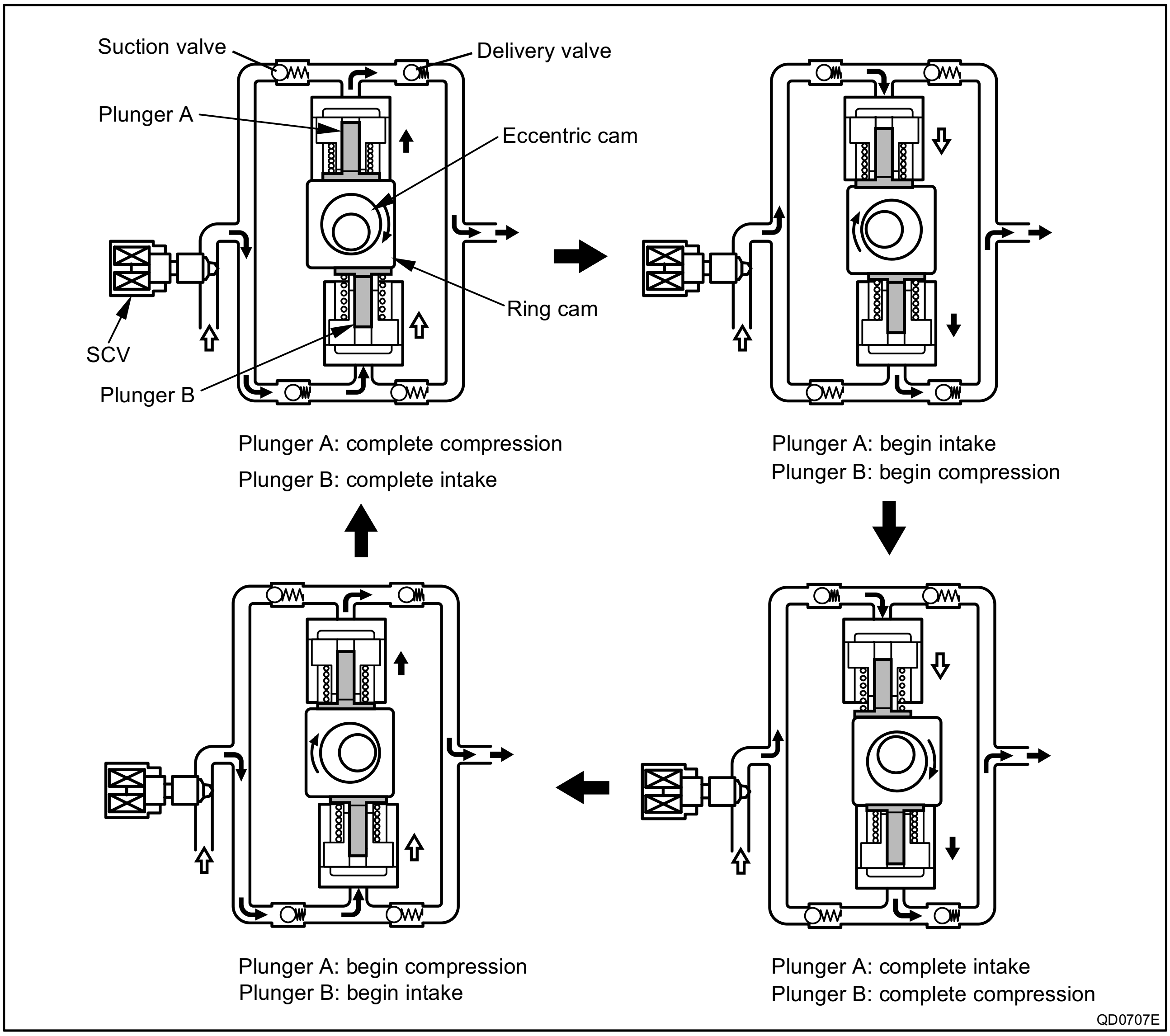


The plunger and the suction valve are mounted on top of the ring cam. The feed pump is connected to the rear of the drive shaft.



(4) Operation of the Supply Pump

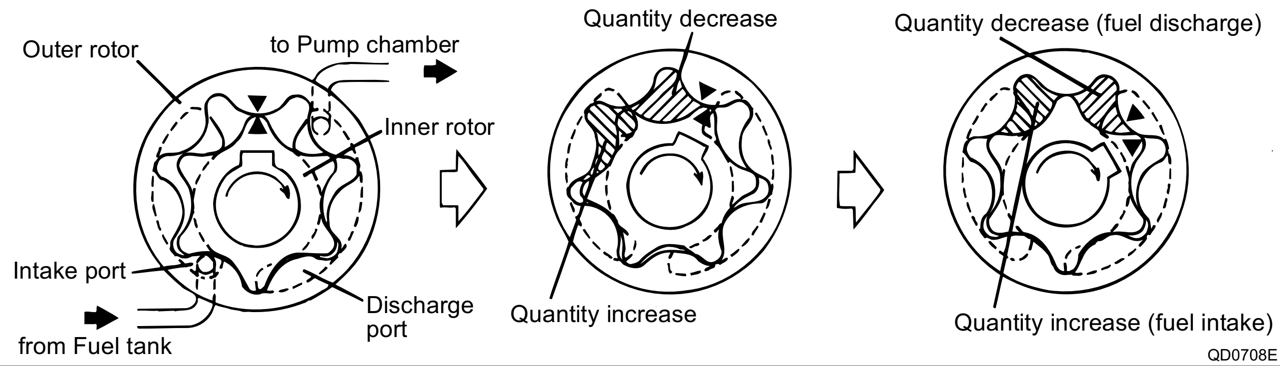
As shown in the illustration below, the rotation of the eccentric cam causes the ring cam to push Plunger A upwards. Due to the spring force, Plunger B is pulled in the opposite direction to Plunger A. As a result, Plunger B draws in fuel, while Plunger A pumps it to the rail.



[2] Description of Supply Pump Components

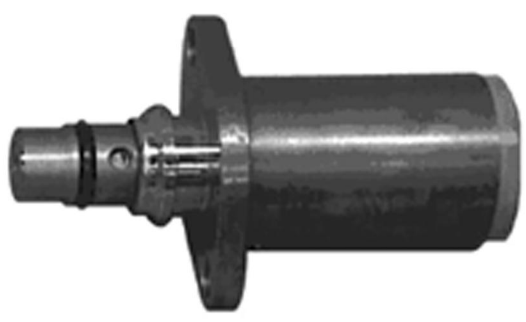
(1) Feed Pump

The trochoid type feed pump, which is integrated in 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 drive shaft. 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.

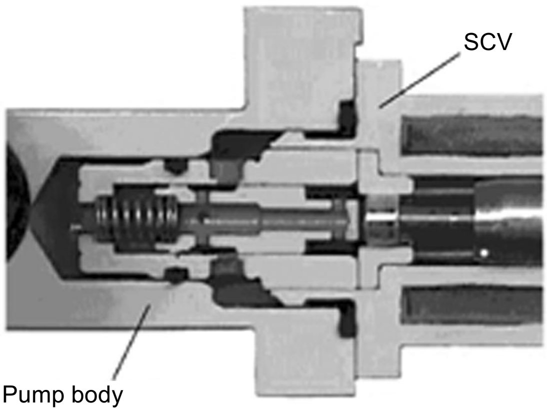


(2) SCV: Suction Control Valve

- A linear solenoid type valve has been adopted. The ECU controls the duty ratio (the length of time that the current is applied to the SCV), in order to control the quantity of fuel that is supplied to the high-pressure plunger.
- Because only the quantity of fuel that is required for achieving the target rail pressure is drawn in, the drive load of the supply pump decreases.
- When current flows to the SCV, variable electromotive force is created in accordance with the duty ratio, moving the armature to the left side. The armature moves the cylinder to the left side, changing the opening of the fuel passage and thus regulating the fuel quantity.
- With the SCV OFF, the return spring contracts, completely opening the fuel passage and supplying fuel to the plungers. (Full quantity intake and full quantity discharge)
- When the SCV is ON, the force of the return spring moves the cylinder to the right, closing the fuel passage (normally opened).
- By turning the SCV ON/OFF, fuel is supplied in an amount corresponding to the actuation duty ratio, and fuel is discharged by the plungers.



Exterior view of SCV



Cross-section of SCV

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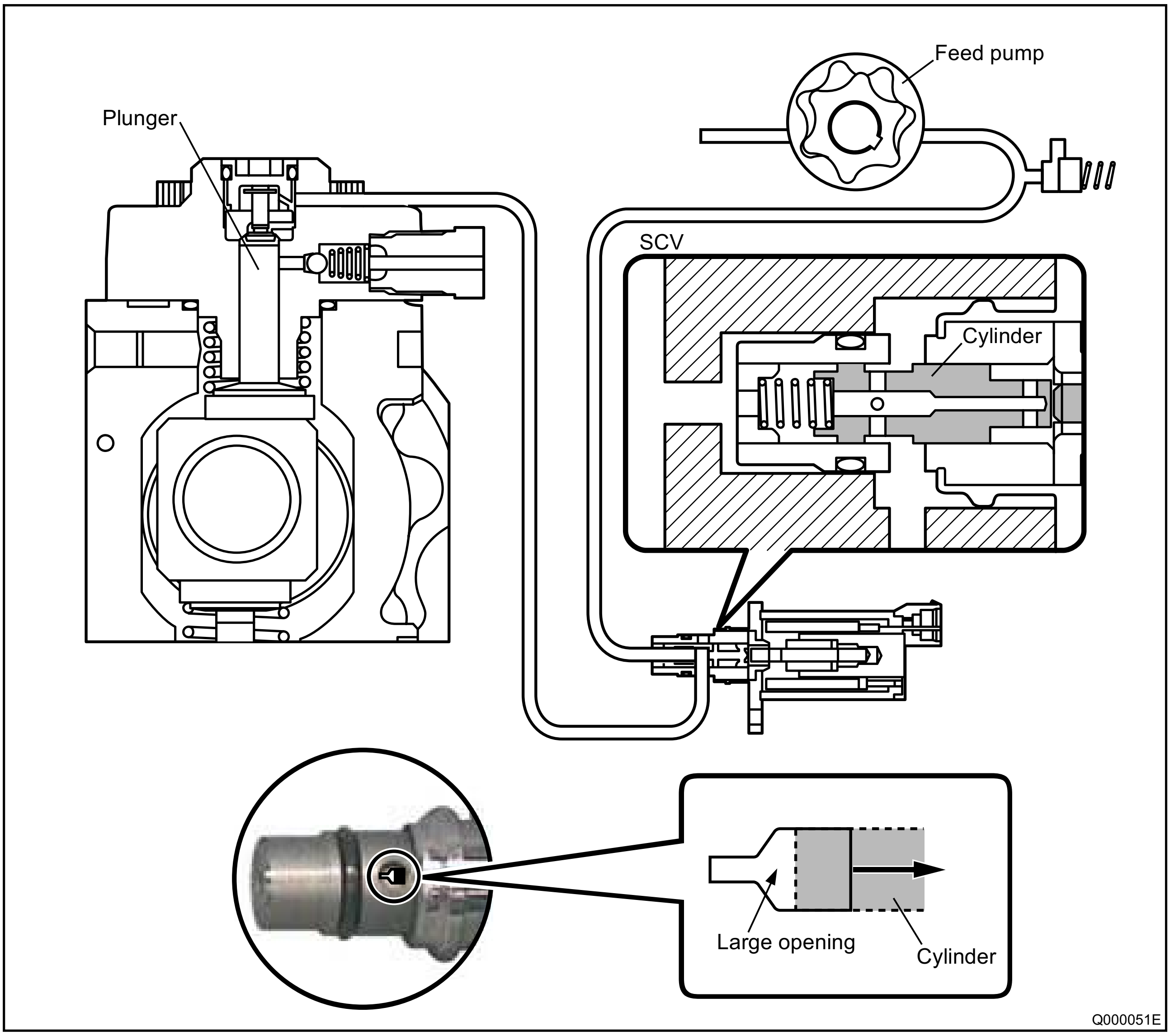
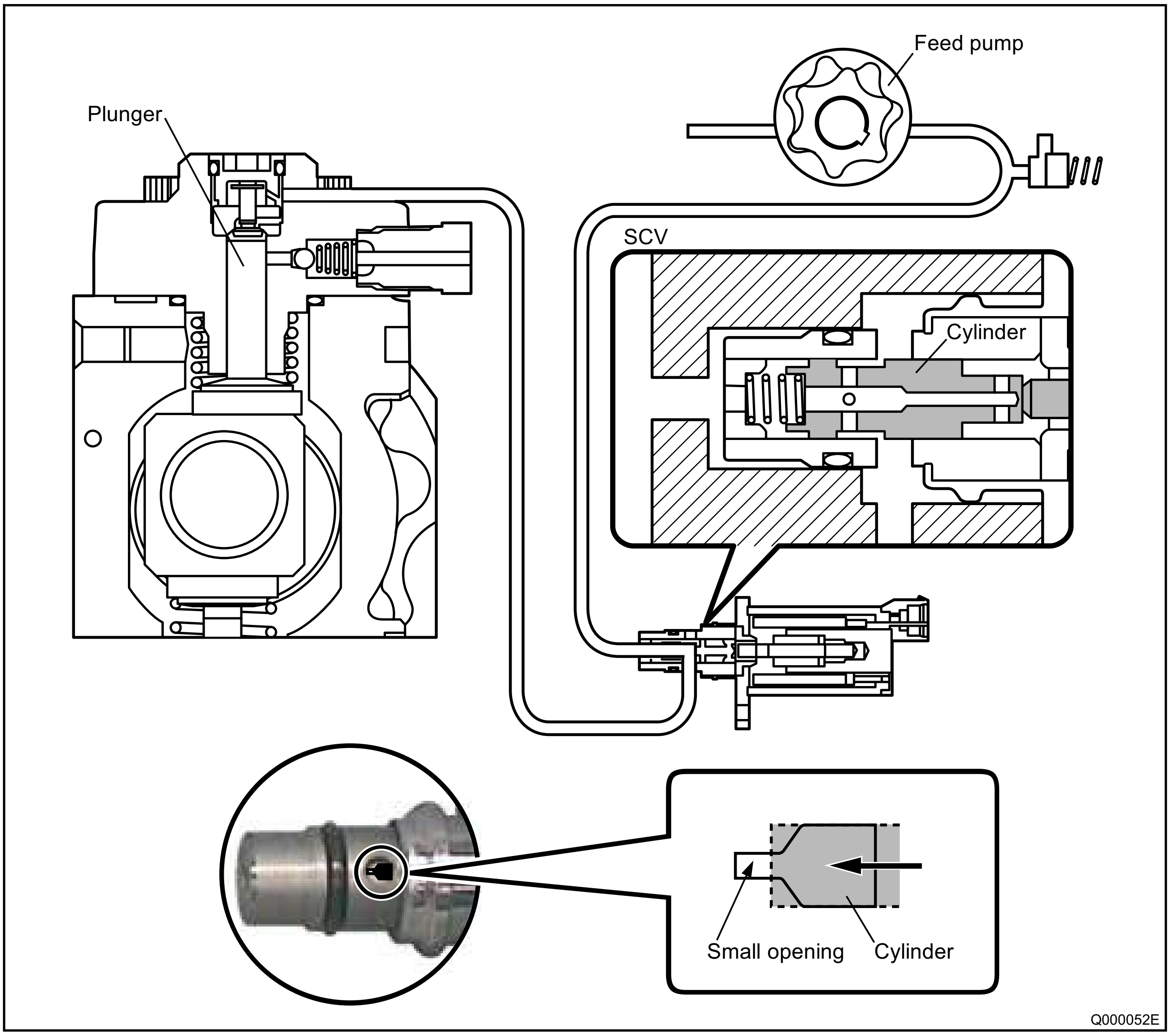
[In case of short duty ON]

Short duty ON → large valve opening → maximum intake quantity



[In case of long duty ON]

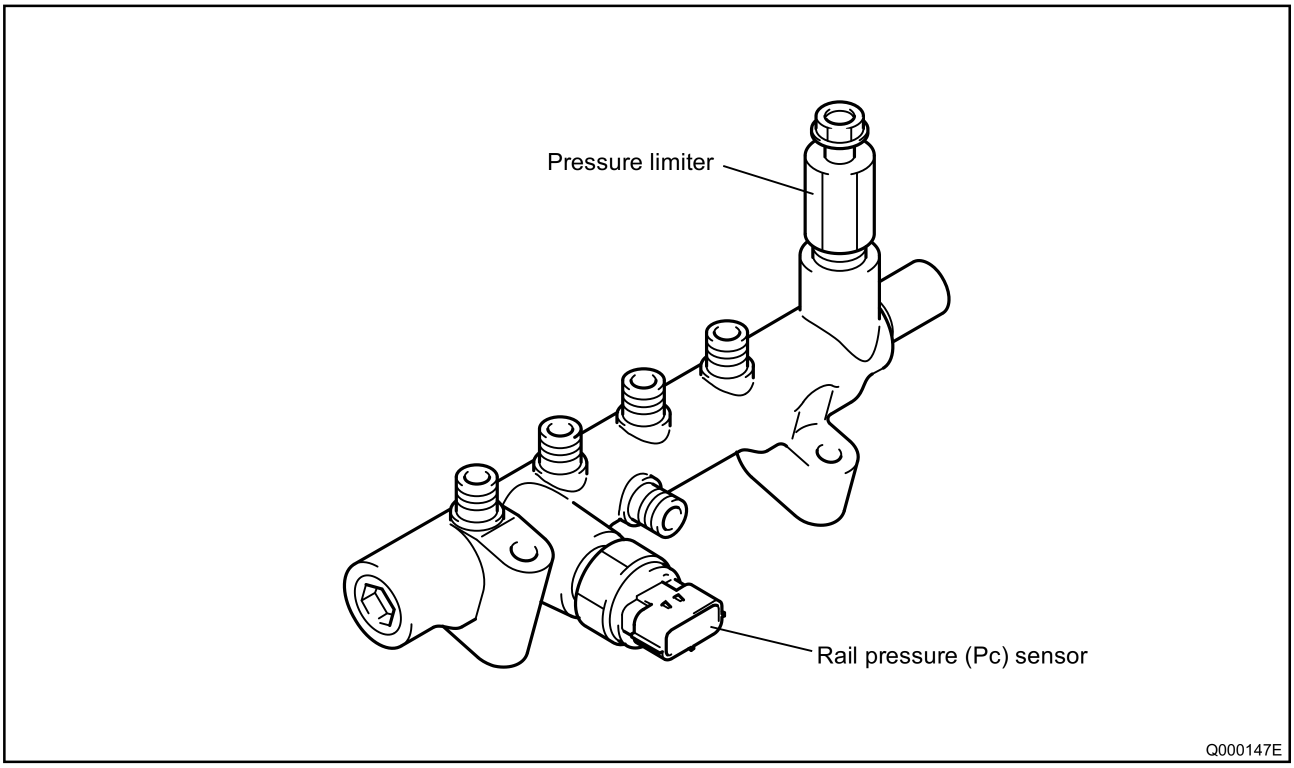
Long duty ON → small valve opening → minimum intake quantity



[3] Rail

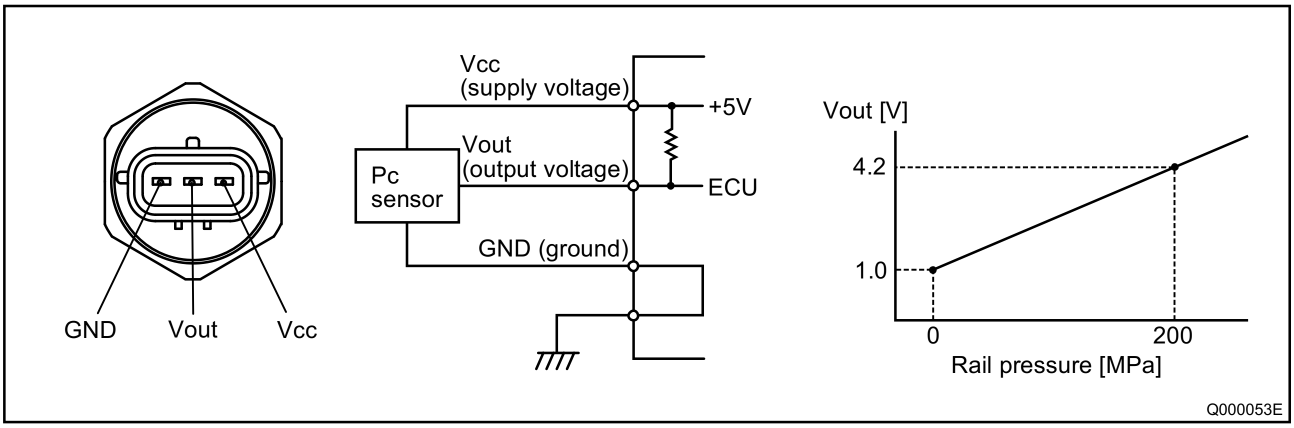
(1) Outline

- Stores pressurized fuel (0 to 180 MPa) that has been delivered from the supply pump and distributes the fuel to each cylinder injector. A rail pressure sensor and a pressure limiter are adopted in the rail.
- The rail pressure sensor (Pc sensor) detects the fuel pressure in the rail and sends a signal to the engine ECU, while the pressure limiter controls the fuel pressure in the rail.



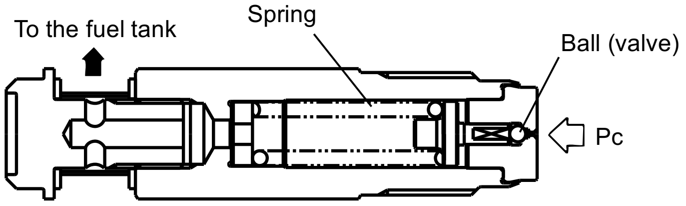
(2) Rail Pressure (Pc) Sensor

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



(3) Pressure Limiter

The pressure limiter relieves pressure by opening the valve if abnormally high pressure is generated. The valve opens when pressure in rail reaches approximately 230 MPa, and closes when pressure falls to approximately 50 MPa. Fuel leaked by the pressure limiter returns to the fuel tank.



[4] Injector

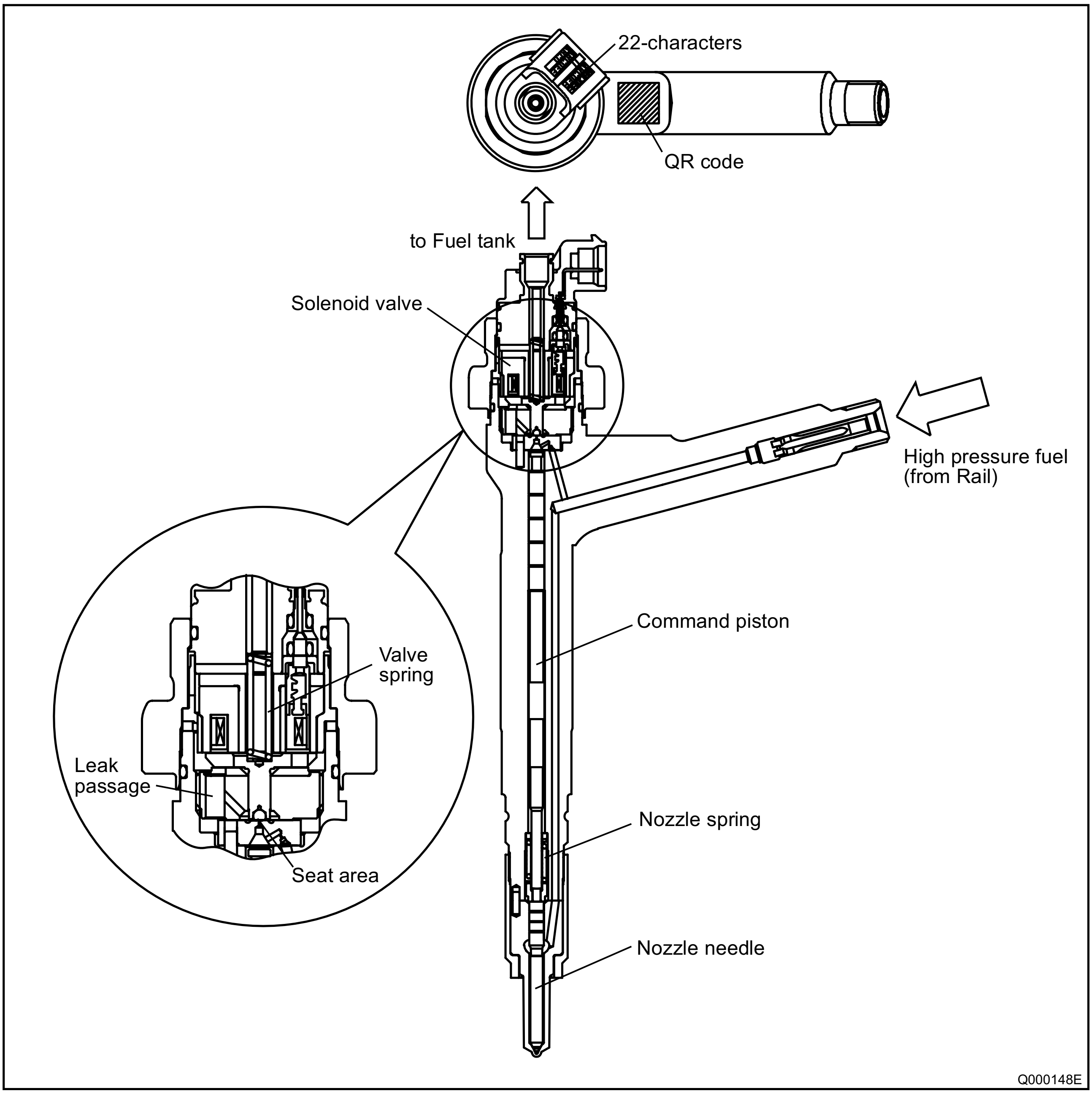
(1) Outline

The injectors inject the high-pressure fuel from the rail into the combustion chambers at the optimum injection timing, rate, and spray condition, in accordance with commands received from the ECU.

(2) Characteristics

- A compact, energy-saving solenoid-control type TWV (Two-Way Valve) injector has been adopted.
- QR codes displaying various injector characteristics are laser marked in the injector body, and ID codes showing these in numeric form (22 alphanumeric figures) are laser marked on the connector head.
- This system uses QR code information to optimize injection quantity control. When an injector is newly installed in a vehicle, it is necessary to input the ID codes in the ECU.

(3) Construction



(4) Operation

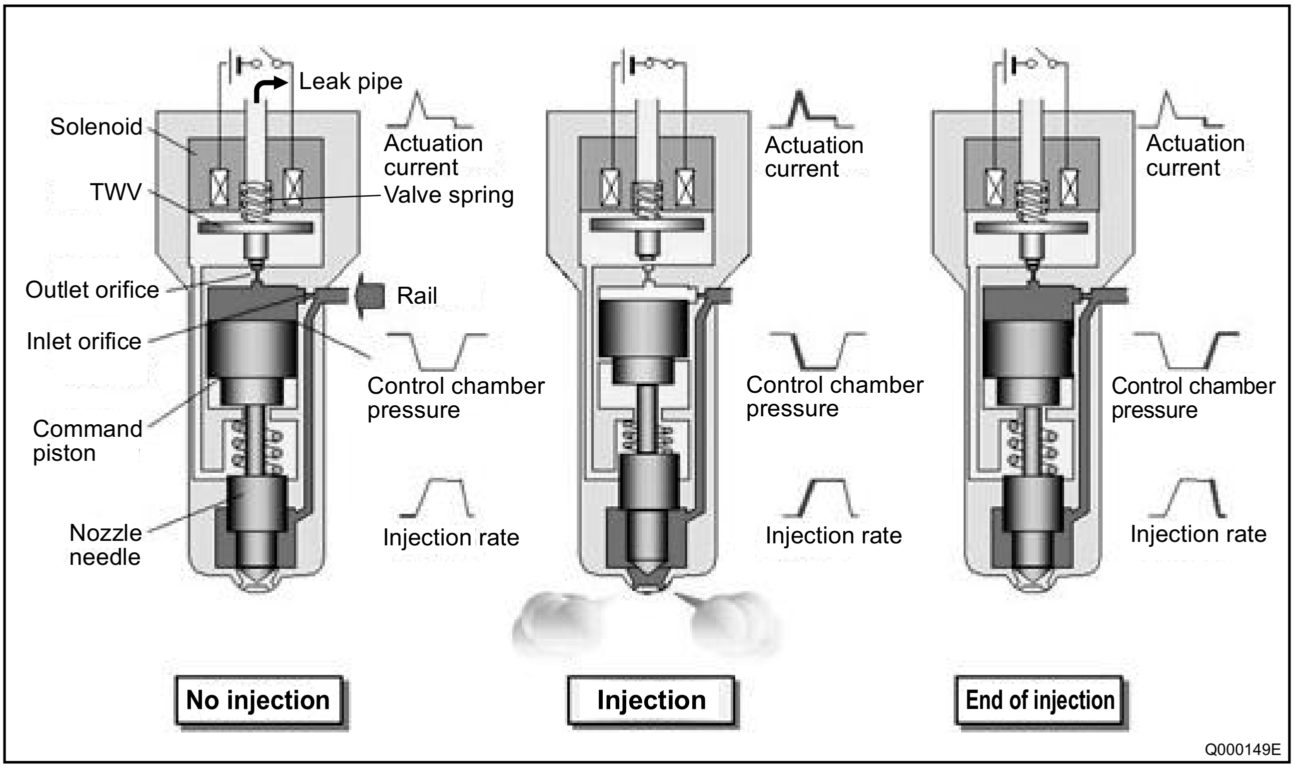
The TWV valve opens and closes the outlet orifice to control the hydraulic pressure in the control chamber, and the start and the end of injection.

[No injection]

- When no current is supplied to the solenoid, the valve spring force is stronger than the hydraulic pressure in the control chamber. Thus, the TWV is pushed downward, effectively closing the outlet orifice. For this reason, the hydraulic pressure in the control chamber is applied to the command piston causes the nozzle spring to compress. This closes the nozzle needle, and as a result, fuel is not injected.

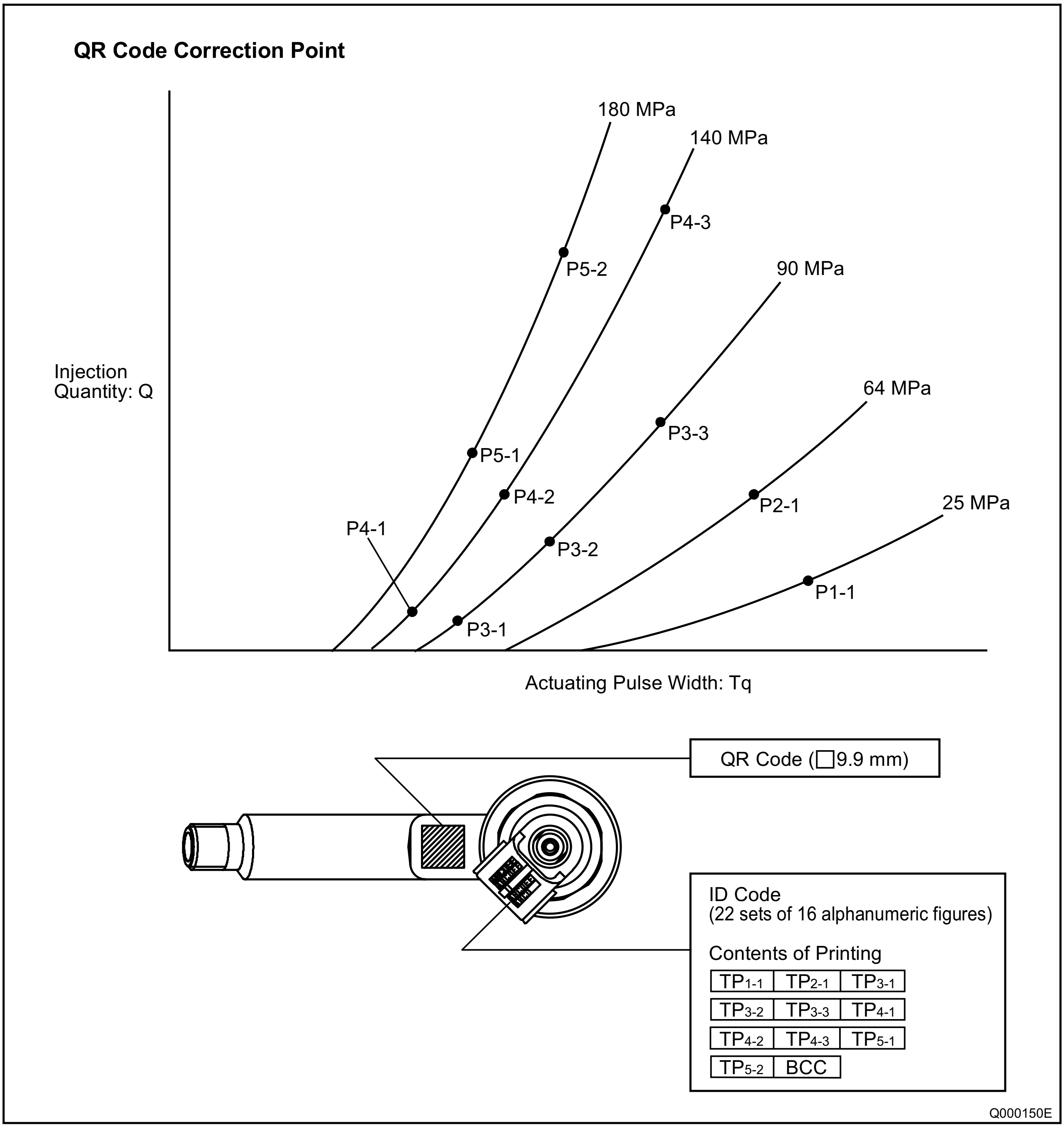
[Injection]

- When the current is initially applied to the solenoid, the attraction of the solenoid pulls the TWV up, effectively opening the outlet orifice and allowing the fuel to flow out of the control chamber. After the fuel flows out, the hydraulic pressure in the control chamber decreases pulling the command piston up. This causes the nozzle needle to rise and injection to start.
- The fuel that flows past the outlet orifice flows to the leak pipe and below the command piston. The fuel that flows below the nozzle needle lifts the it upward, which helps to improve the nozzle's opening and closing response.
- 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 falls, causing the nozzle needle to close immediately and the injection to stop.



(5) QR Code

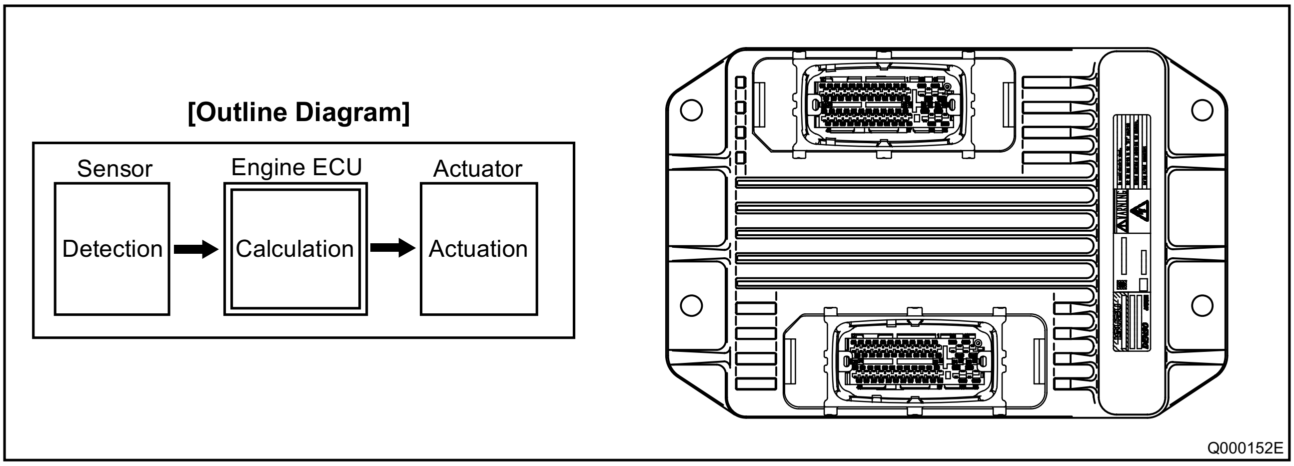
QR (Quick Response) codes have been adopted to enhance the injection quantity precision of the injectors. The adoption of QR codes enables injection quantity dispersion control throughout all pressure ranges, contributing to improvement in combustion efficiency, reductions in exhaust gas emissions and so on.



3.2 Description of Control System Components

[1] ECU (Electronic Control Unit)

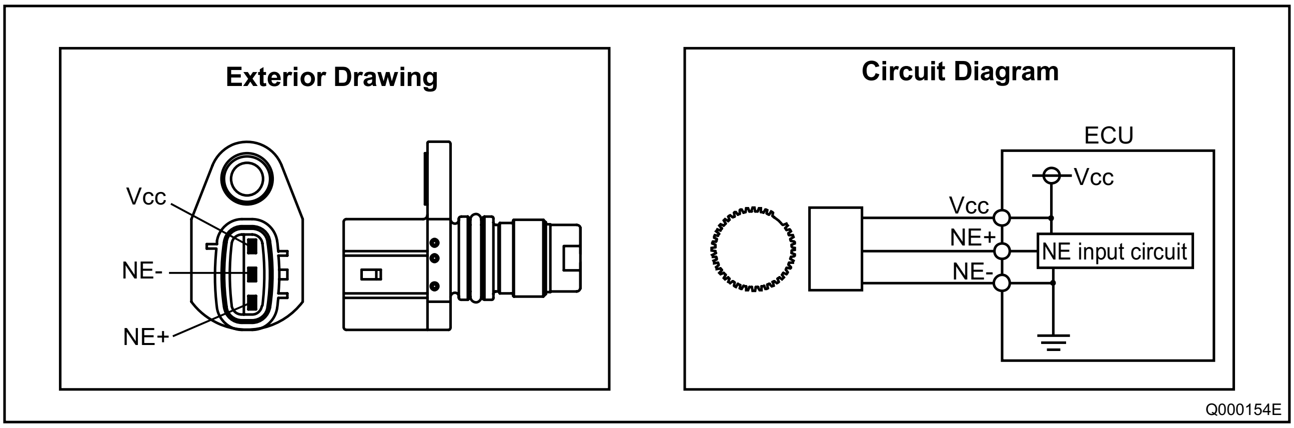
This is the command center that controls the fuel injection system and engine operation in general.



[2] Description of Sensors

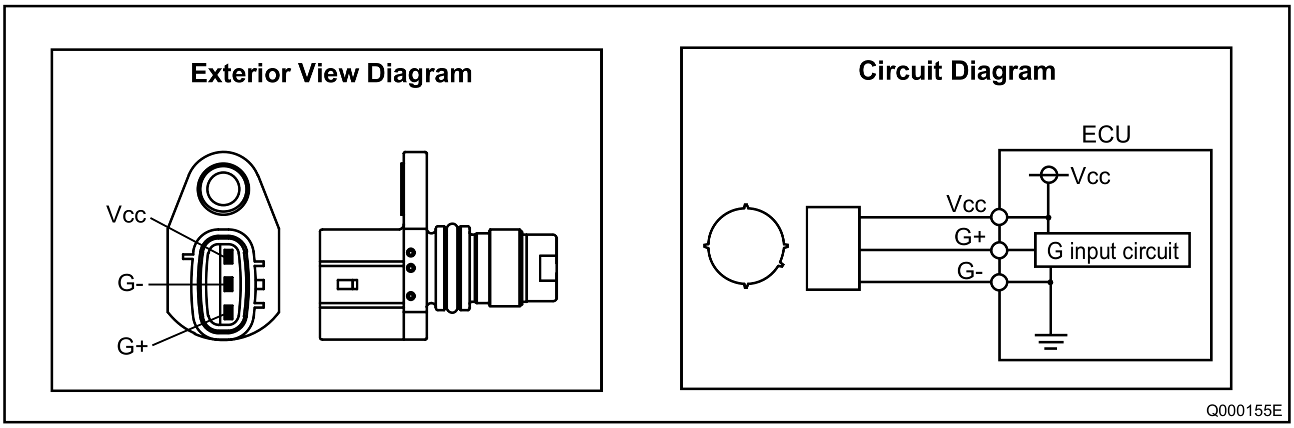
(1) Crankshaft Position Sensor (NE sensor)

The NE sensor is an MRE (Magnetic Resistance Element) type sensor. It is positioned above the crankshaft to detect the crankshaft position. The pulsar gear is composed of 56 gears with 4 gears missing (per 1 revolution), and the sensor outputs 56 pulses for each 1 revolution of the crankshaft (360°CA).



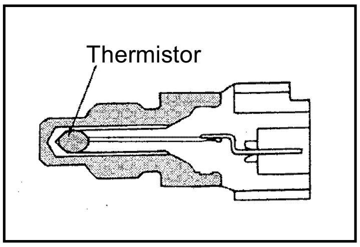
(2) Cylinder Recognition Sensor (G sensor)

The cylinder recognition sensor (G sensor) is an MRE (Magnetic Resistance Element) type sensor. It detects the engine cylinders, and outputs 5 pulses for every two revolutions of the engine (720°CA).



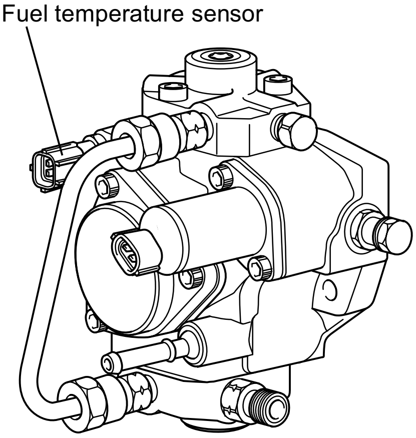
(3) Fuel temperature sensor (THF)

Detects the fuel temperature and sends a corresponding signal to the engine ECU. Based on this information, the engine ECU calculates the injection volume correction that is appropriate for the fuel temperature.



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
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)



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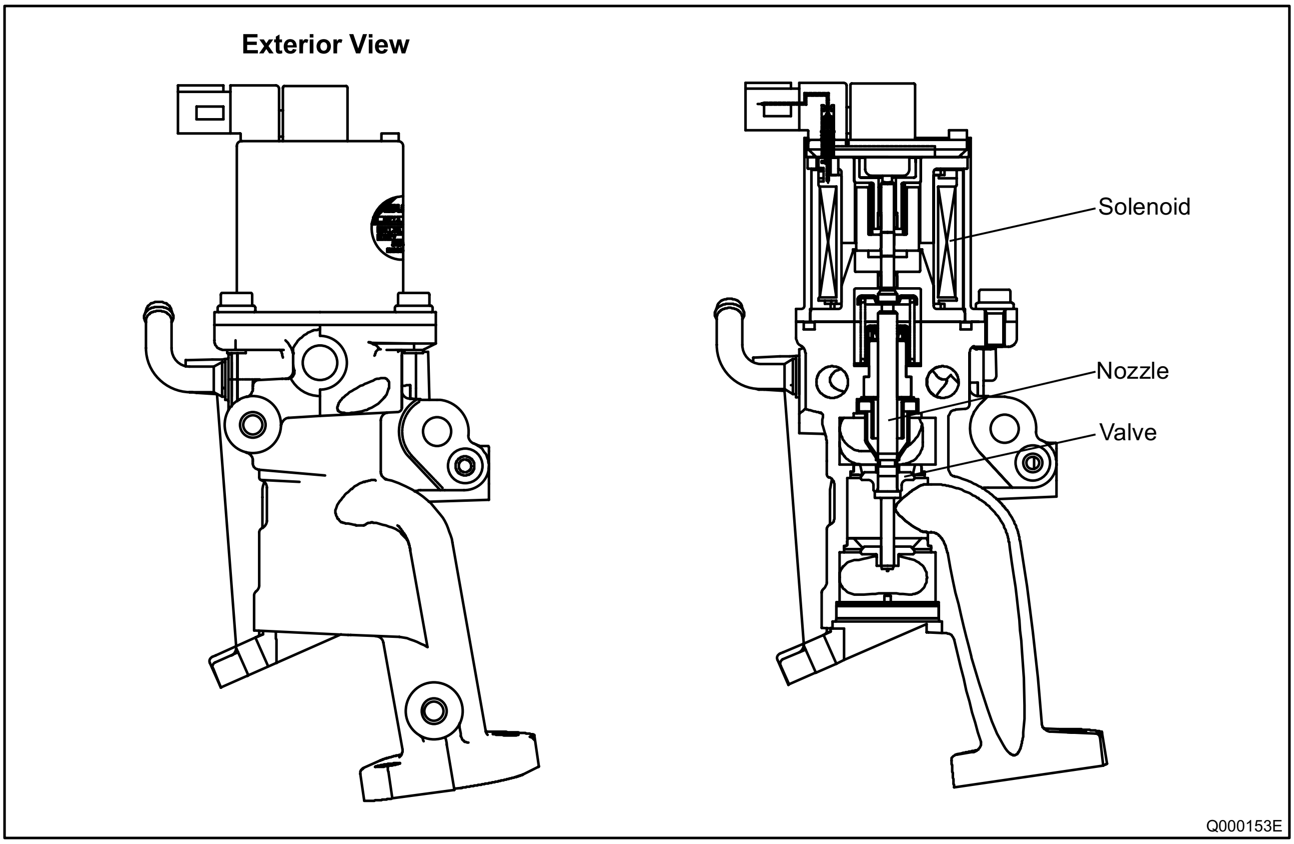
[3] EGR Valve (Exhaust Gas Recirculation Valve)

(1) EGR Valve Construction

An EGR valve is utilized as the system actuator for the electric exhaust gas recirculation (E-EGR) system. It is constructed of an upper section and a lower section. The upper section receives output signals from the engine ECU, and contains a solenoid that generates electromagnetic force. The lower section is constructed of a nozzle that moves up and down in response to the electromagnetic force, and a valve with an opening that alters in response to the nozzle position.

(2) EGR Valve Operation

The E-EGR system electronically controls the EGR. The EGR system reduces NOx by lowering the combustion temperature. This is done recirculating a portion of the exhaust gases through the intake manifold. Because this system also reduces the engine output and affects driveability, the E-EGR system effects computer control to achieve an optimal EGR volume in accordance with the driving conditions.



3.3 Various Types of Controls

[1] Outline

This system effects fuel injection quantity and injection timing control more appropriately than the mechanical governor and timer used in the conventional injection pump.The engine ECU performs the necessary calculations in accordance with the sensors installed on the engine and the vehicle. It then controls the timing and duration of time in which current is applied to the injectors, in order to realize both optimal injection and injection timing.

(1) Fuel Injection Quantity Control Function

The fuel injection quantity control function replaces the conventional governor function. It controls the fuel injection to an optimal injection quantity based on the engine speed and accelerator position signals.

(2) Fuel Injection Timing Control Function

The fuel injection timing control function replaces the conventional timer function. It controls the injection to an optimal timing based on the engine speed and the injection quantity.

(3) Fuel Injection Rate Control Function

Pilot injection control injects a small amount of fuel before the main injection.

(4) Fuel Injection Pressure Control Function (Rail Pressure Control Function)

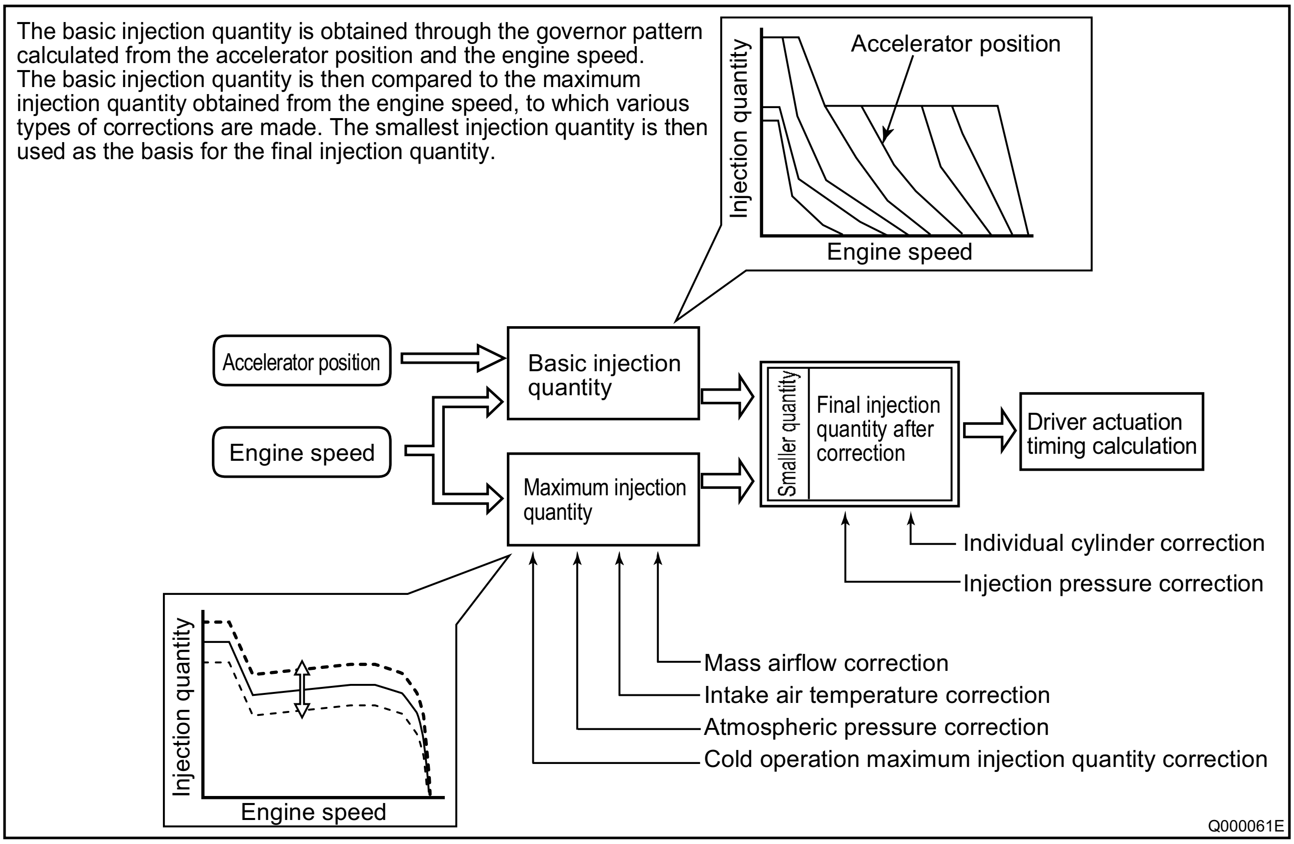
The fuel injection pressure control function (rail pressure control function) controls the discharge volume of the pump by measuring the fuel pressure at the rail pressure sensor and feeding it back to the ECU. It effects pressure feedback control so that the discharge volume matches the optimal (command) value set in accordance with the engine speed and the injection quantity.

[2] Fuel Injection Quantity Control

(1) Outline

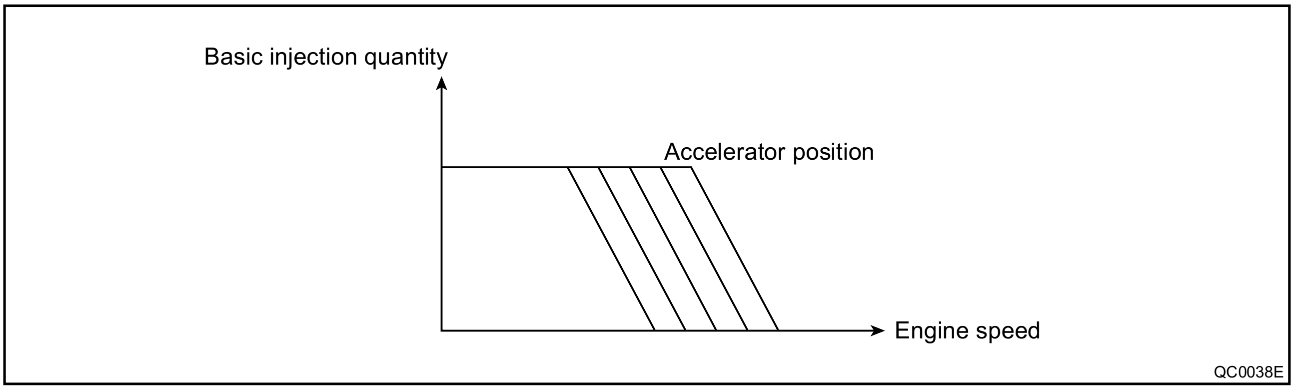
This control determines the fuel injection quantity by adding coolant temperature, fuel temperature, intake air temperature, and mass airflow corrections to the basic injection quantity is calculated by the engine ECU, based on the engine operating conditions and driving conditions.

(2) Injection Quantity Calculation Method



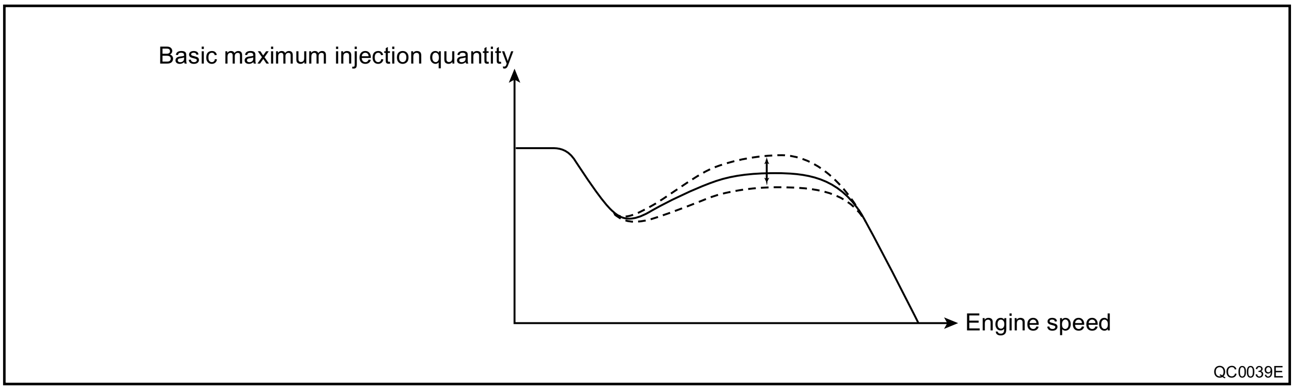
(3) Basic Injection Quantity

The basic injection quantity is determined by the engine speed (NE) and the accelerator position. The injection quantity is increased when the accelerator position signal is increased while the engine speed remains constant.



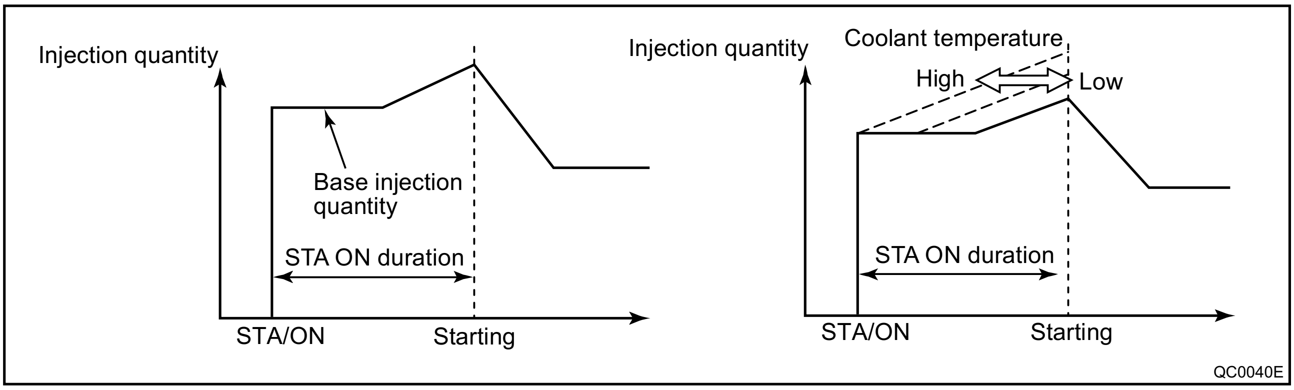
(4) Maximum Injection Quantity

The maximum injection quantity is calculated by adding the mass airflow correction, intake air temperature correction, atmospheric pressure correction and the cold operation maximum injection quantity correction to the basic maximum injection quantity that is determined by the engine speed.



(5) Starting Injection Quantity

When the starter switch is turned ON, the injection quantity is calculated in accordance with the starting base injection quantity and the starter ON time. The base injection quantity and the inclination of the quantity increase/decrease change in accordance with the coolant temperature and the engine speed.



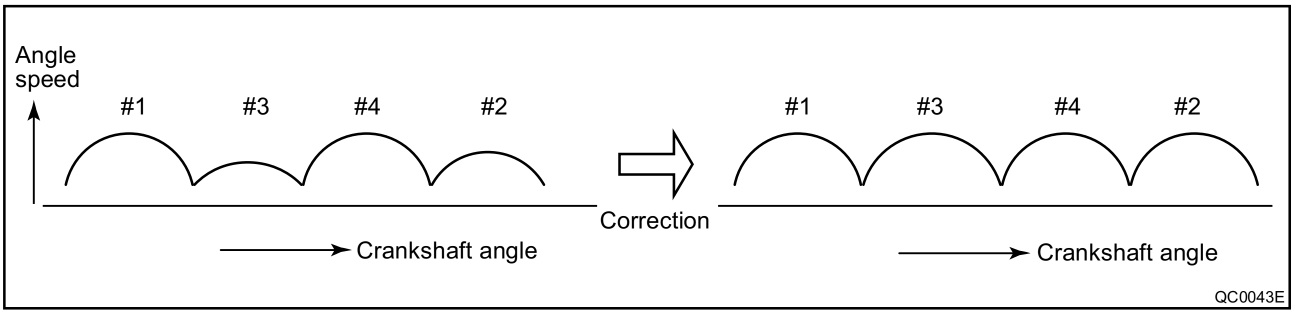
(6) Idle Speed Control (ISC) System

This system controls the idle speed by regulating the injection quantity in order to match the actual speed to the target speed that is calculated by the engine ECU.

The target speed varies according to the type of transmission (manual or automatic), whether the air conditioner is ON or OFF, the shift position, and the coolant water temperature.

(7) Idle Vibration Reduction Control

To reduce engine vibrations during idle, this function compares the angle speeds (times) of the cylinders and regulates the injection quantity for the individual cylinders if there is a large the difference, in order to achieve a smooth engine operation.



[3] Fuel Injection Timing Control

(1) Outline

Fuel injection timing is controlled by varying the timing in which current is applied to the injectors.

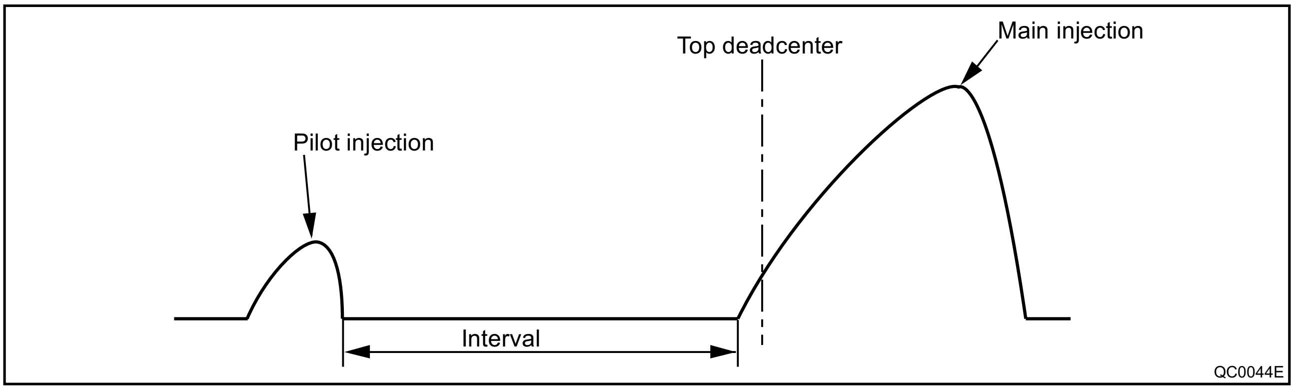
(2) Main and Pilot Injection Timing Control

[Main Injection Timing]

The engine ECU calculates the basic injection timing based on the engine speed the final injection quantity, and adds various types of corrections in order to determine the optimal main injection timing.

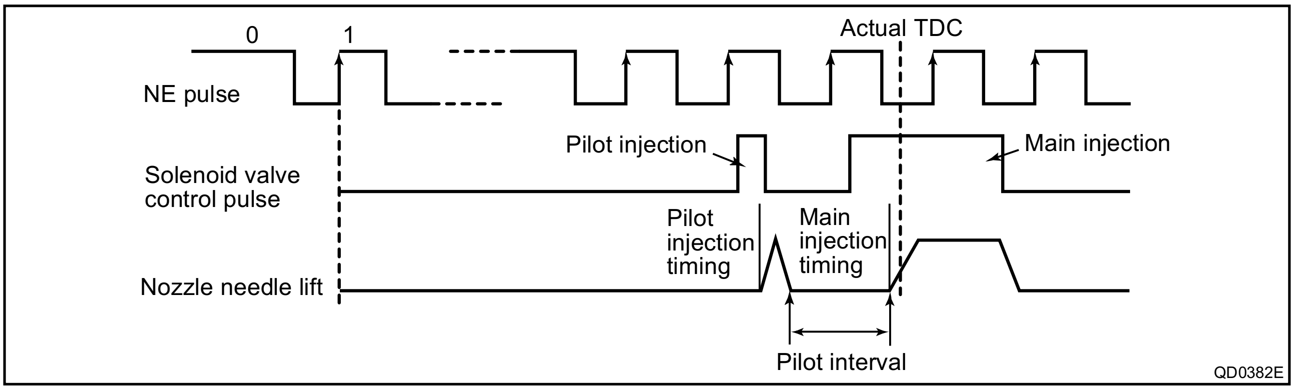
[Pilot Injection Timing (Pilot Interval)]

Pilot injection timing is controlled by adding a pilot interval to the main injection timing. The pilot interval is calculated based on the final injection quantity, engine speed, coolant temperature (map correction). The pilot interval at the time the engine is started is calculated from the coolant temperature and speed.

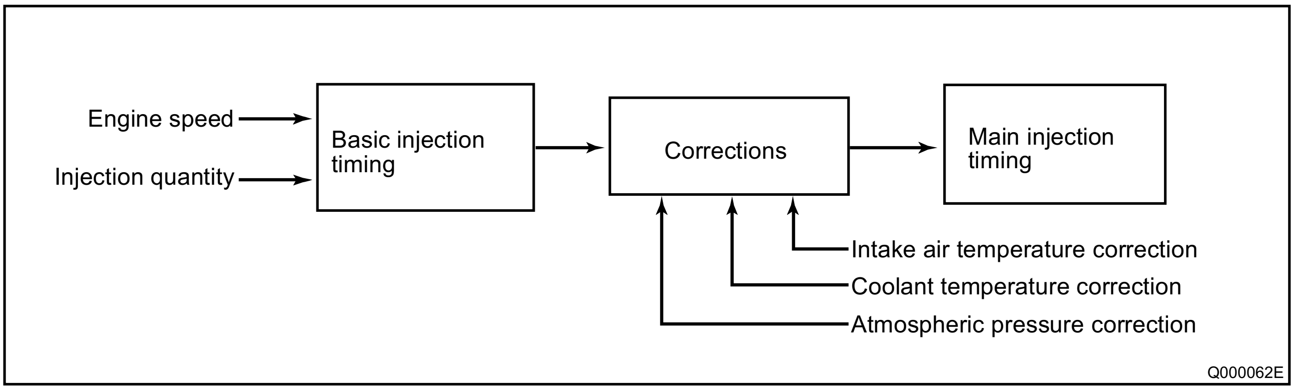


(3) Injection Timing Calculation Method

[Outline of Control Timing]

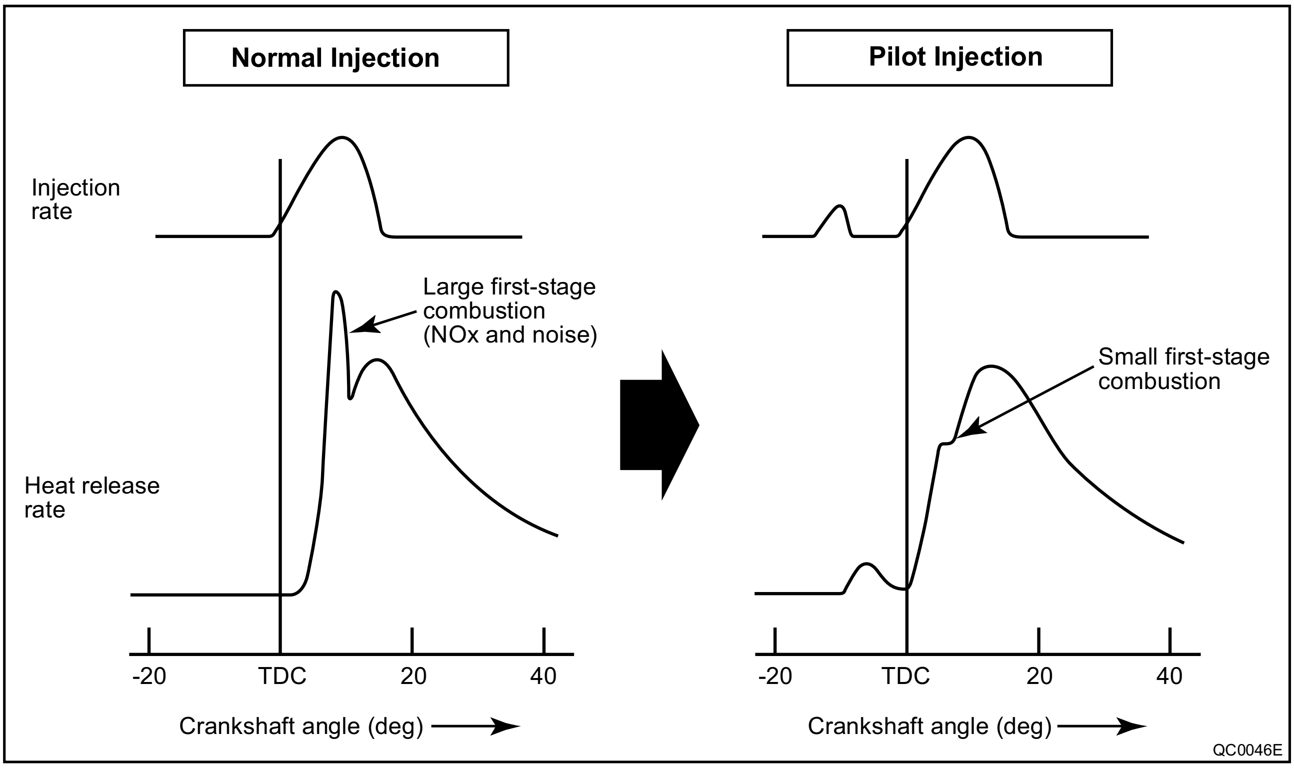


[Injection Timing Calculation Method]



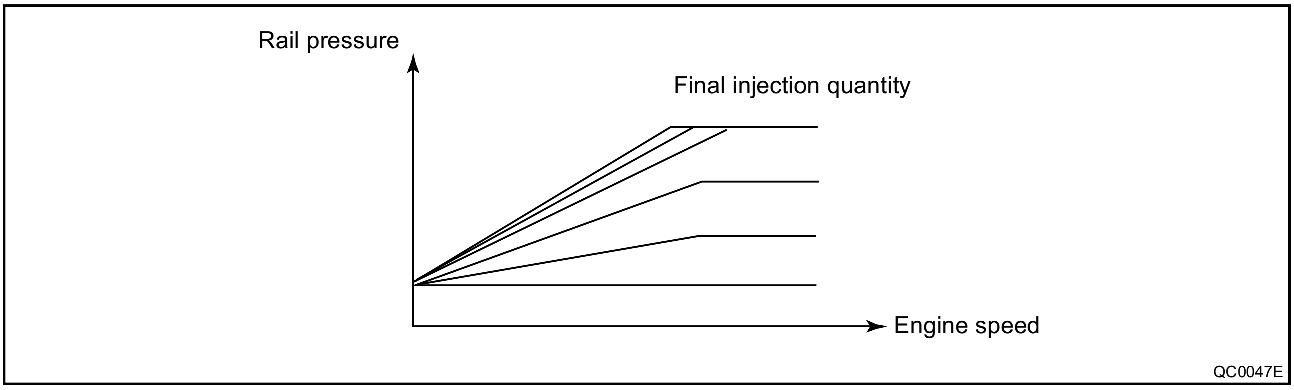
[4] Fuel Injection Rate Control

While the injection rate increases with the adoption of high-pressure fuel injection, the ignition lag, which is the delay from the start of injection to the beginning of combustion, cannot be shortened to less than a certain value. As a result, the quantity of fuel that is injected until main ignition occurs increases, resulting in an explosive combustion at the time of main ignition. This increases both NOx and noise. For this reason, pilot injection is provided to minimize the initial injection rate, prevent the explosive first-stage combustion, and reduce noise and NOx.



[5] Fuel Injection Pressure Control

A value that is determined by the final injection quantity, the water temperature and the engine speed is calculated. During the starting of the engine, the calculation is based on the water temperature and the atmospheric pressure.



[6] Other Controls

a: Limit maximum injection quantity

b: Gradual acceleration injection quantity

c: Gradual deceleration injection quantity

d: Post-acceleration damping injection quantity

e: Reference injection quantity

f: Fuel cutoff

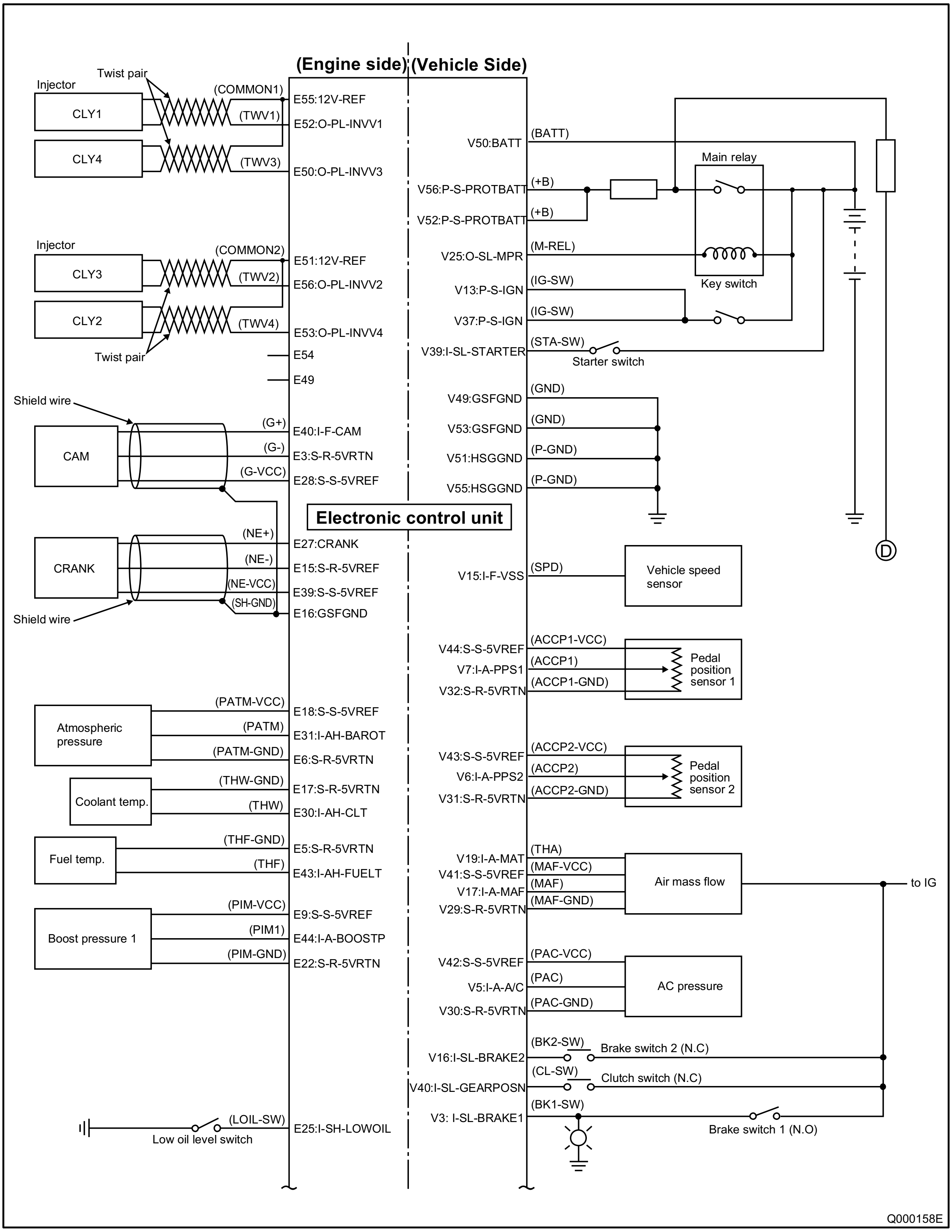
g: Turbo control

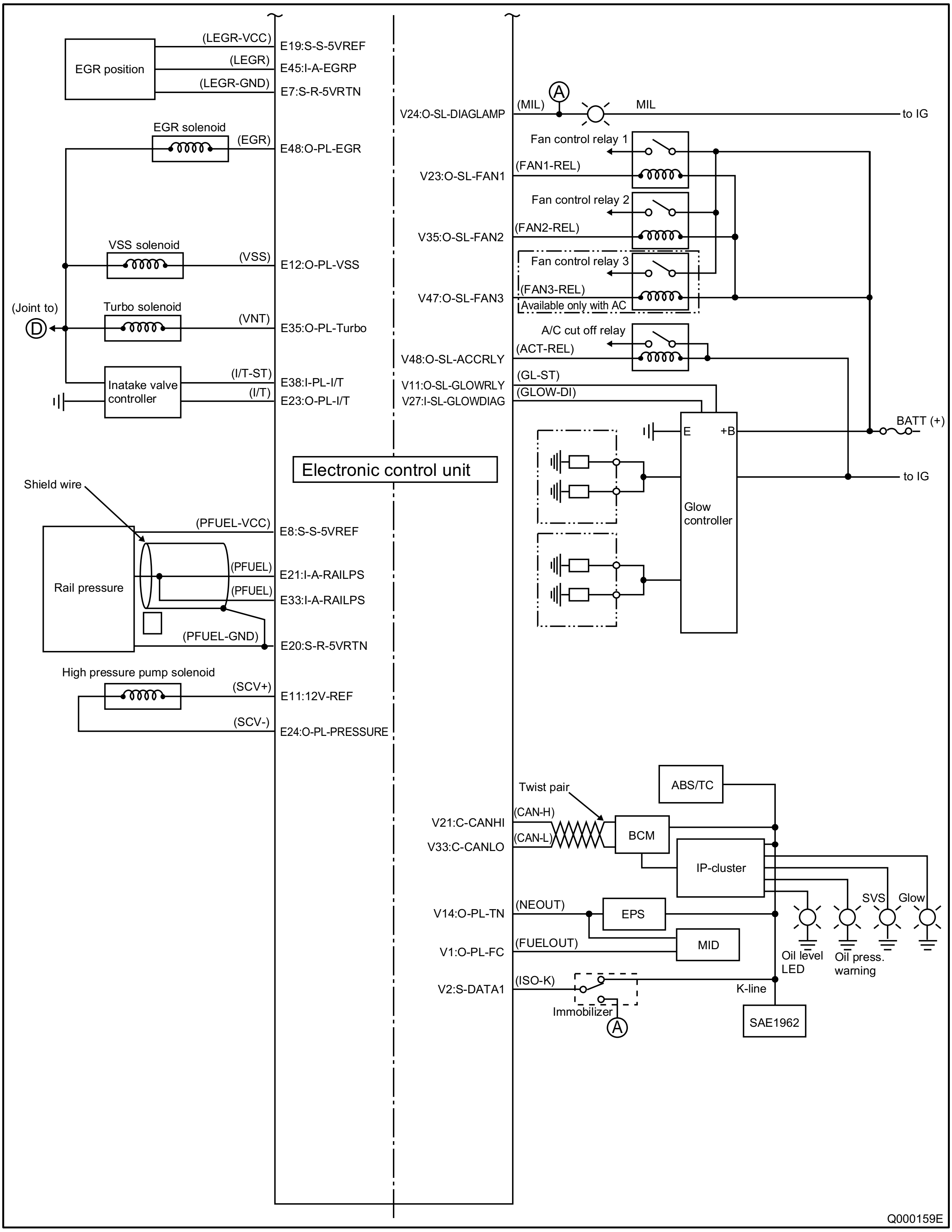
h: Glow plug relay

i: EGR control

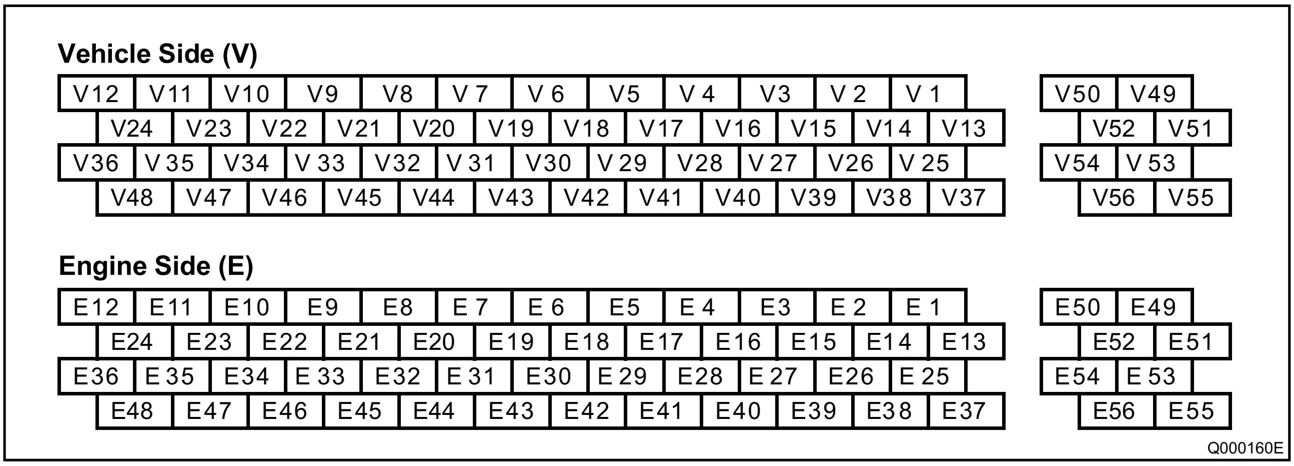
4. External Wiring Diagram

4.1 ECU External Wiring Diagram




(LEGR-VCC)
E19:S-S-5VREF
(LEGR)
E45:I-A-EGRP
EGR position
(LEGR-GND)
E7:S-R-5VRTN
EGR solenoid
(EGR)
E48:O-PL-EGR
VSS solenoid
(VSS)
E12:O-PL-VSS
(Joint to)
D
Turbo solenoid
(VNT)
E35:O-PL-Turbo
Inatake valve controller
(I/T-ST)
E38:I-PL-I/T
(I/T)
E23:O-PL-I/T
Electronic control unit
Shield wire
(PFUEL-VCC)
E8:S-S-5VREF
Rail pressure
(PFUEL)
E21:I-A-RAILPS
(PFUEL)
E33:I-A-RAILPS
(PFUEL-GND)
E20:S-R-5VRTN
High pressure pump solenoid
(SCV+)
E11:12V-REF
(SCV-)
E24:O-PL-PRESSURE
A
V24:O-SL-DIAGLAMP
(MIL)
MIL
to IG
Fan control relay 1
V23:O-SL-FAN1
(FAN1-REL)
Fan control relay 2
V35:O-SL-FAN2
(FAN2-REL)
Fan control relay 3
V47:O-SL-FAN3
(FAN3-REL)
Available only with AC
A/C cut off relay
V48:O-SL-ACCRLY
(ACT-REL)
V11:O-SL-GLOWRLY
(GL-ST)
V27:I-SL-GLOWDIAG
(GLOW-DI)
BATT (+)
E
+B
to IG
Glow controller
Twist pair
ABS/TC
V21:C-CANHI
(CAN-H)
BCM
V33:C-CANLO
(CAN-L)
IP-cluster
SVS
Glow
V14:O-PL-TN
(NEOUT)
EPS
V1:O-PL-FC
(FUELOUT)
MID
Oil level LED
Oil press. warning
V2:S-DATA1
(ISO-K)
K-line
Immobilizer
A
SAE1962
Q000159E

4.2 ECU Connector Diagram
[1] ECU Connector Terminal Layout



[2] Terminal Connections
(1) Vehicle Side (V)

Pin	Pin Name (ISUZU)	Pin Name (DENSO)	Wire Cross-section (proposal)	Pin	Pin Name (ISUZU)	Pin Name (DENSO)	Wire Cross-section (proposal)
V1	O-PL-FC	FUELOUT	$0.75mm^2$	V29	S-R-5VRTN	MAF-GND	$0.75mm^2$
V2	S-DATA1	ISO-K	$0.75mm^2$	V30	S-R-5VRTN	PAC-GND	$0.75mm^2$
V3	I-SL-BRAKE1	BK1-SW	$0.75mm^2$	V31	S-R-5VRTN	ACCP2-GND	$0.75mm^2$
V4				V32	S-R-5VRTN	ACCP1-GND	$0.75mm^2$
V5	I-A-A/C	PAC	$0.75mm^2$	V33	C-CANLO	CAN-L	$0.75mm^2$
V6	I-A-PPS2	ACCP2	$0.75mm^2$	V34			
V7	I-A-PPS1	ACCP1	$0.75mm^2$	V35	O-SL-FAN2	FAN2-REL	$0.75mm^2$
V8				V36			
V9				V37	P-S-IGN	IG-SW	$0.75mm^2$
V10				V38			
V11	O-SL-GLOWRLY	GL-ST	$0.75mm^2$	V39	I-SL-STARTER	STA-SW	$0.75mm^2$
V12	O-SL-WTGLOW1	HEAT1-REL	$0.75mm^2$	V40	I-SL-GEARPOSN	CL-SW	$0.75mm^2$
V13	P-S-IGN	IG-SW	$0.75mm^2$	V41	S-S-5VREF	MAF-VCC	$0.75mm^2$
V14	O-PL-TN	NEOUT	$0.75mm^2$	V42	S-S-5VREF	PAC-VCC	$0.75mm^2$
V15	I-F-VSS	SPD	$0.75mm^2$	V43	S-S-5VREF	ACCP2-VCC	$0.75mm^2$
V16	I-SL-BRAKE2	BK2-SW	$0.75mm^2$	V44	S-S-5VREF	ACCP1-VCC	$0.75mm^2$
V17	I-A-MAF	MAF	$0.75mm^2$	V45			
V18				V46			
V19	I-A-MAT	THA	$0.75mm^2$	V47	O-SL-FAN3	FAN3-REL	$0.75mm^2$
V20				V48	O-SL-ACCRLY	ACT-REL	$0.75mm^2$
V21	C-CANHI	CAN-H	$0.75mm^2$	V49	GSFGND	GND	$1.5mm^2$
V22				V50	BATT	BATT	$1.5mm^2$
V23	O-SL-FAN1	FAN1-REL	$0.75mm^2$	V51	HSGGND	P-GND	$1.5mm^2$
V24	O-SL-DIAGLAMP	MIL	$0.75mm^2$	V52	P-S-PROTBATT	+B	$1.5mm^2$
V25	O-SL-MPR	M-REL	$0.75mm^2$	V53	GSFGND	GND	$1.5mm^2$
V26				V54			
V27	I-SL-GLOWDIAG	GLOW-DI	$0.75mm^2$	V55	HSGGND	P-GND	$1.5mm^2$
V28				V56	P-S-PROTBATT	+B	$1.5mm^2$

(2) Engine Side (E)

Pin	Pin Name (ISUZU)	Pin Name (DENSO)	Wire Cross-section (proposal)	Pin	Pin Name (ISUZU)	Pin Name (DENSO)	Wire Cross-section (proposal)
E1				E29			
E2				E30	I-AH-CLT	THW	0.75mm2
E3	S-R-12VRTN	G-	$0.75mm^2$	E31	I-AH-BAROT	PATM	0.75mm2
E4				E32			
E5	S-R-5VRTN	THF-GND	$0.75mm^2$	E33	I-A-RAILPS	PFUEL	0.75mm2
E6	S-R-5VRTN	PATM-GND	$0.75mm^2$	E34			
E7	S-R-5VRTN	LEGR-GND	$0.75mm^2$	E35	O-PL-Turbo	VNT	0.75mm2
E8	S-S-5VREF	PFUEL-VCC	$0.75mm^2$	E36			
E9	S-S-5VREF	PIM-VCC	$0.75mm^2$	E37			
E10				E38	I-PL-I/T	I/T-ST	$0.75mm^2$
E11	12V-REF	SCV+	$0.75mm^2$	E39	S-S-5VREF	NE-VCC	$0.75mm^2$
E12	O-PL-VSS	VSS	$0.75mm^2$	E40	I-F-CAM	G+	$0.75mm^2$
E13				E41			
E14				E42			
E15	I-F-CRANK Lo	NE-	$0.75mm^2$	E43	I-AH-FUELT	THF	$0.75mm^2$
E16	GSFGND	SH-GND	$0.75mm^2$	E44	I-A-BOOSTP	PIM1	$0.75mm^2$
E17	S-R-5VRTN	THW-GND	$0.75mm^2$	E45	I-A-EGRP	LEGR	$0.75mm^2$
E18	S-S-5VREF	PATM-VCC	$0.75mm^2$	E46			
E19	S-S-5VREF	LEGR-VCC	$0.75mm^2$	E47			
E20	S-R-5VRTN	PFUEL-GND	$0.75mm^2$	E48	O-PL-EGR	EGR	$0.75mm^2$
E21	I-A-RAILPS	PFUEL	$0.75mm^2$	E49			
E22	S-R-5VRTN	PIM-GND	$0.75mm^2$	E50	O-PL-INVV3	TWV3	$1.5mm^2$
E23	O-PL-I/T	I/T	$0.75mm^2$	E51	12V-REF	COMMON2	$1.5mm^2$
E24	O-PL-PRESSURE	SCV-	$0.75mm^2$	E52	O-PL-INVV1	TWV1	$1.5mm^2$
E25	I-SH-LOWOIL	LOIL-SW	$0.75mm^2$	E53	O-PL-INVV4	TWV4	$1.5mm^2$
E26				E54			
E27	I-F-CRANK Hi	NE+	$0.75mm^2$	E55	12V-REF	COMMON1	$1.5mm^2$
E28	S-S-5VREF	G-VCC	$0.75mm^2$	E56	O-PL-INVV2	TWV2	$1.5mm^2$