



DENSO

Diesel Injection Pump

SERVICE MANUAL

**KUBOTA M108X V3800 ENGINE
COMMON RAIL SYSTEM (CRS)**

OPERATION

February 2008

DENSO CORPORATION

00400610E

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Table of Contents

Operation Section

1. PRODUCT APPLICATION INFORMATION

1.1	Outline	1-1
1.2	Applicable Vehicle Model.	1-1
1.3	Specifications.	1-2
1.4	System Component Part Numbers	1-4
1.5	Configuration	1-5

2. SUPPLY PUMP

2.1	Outline	1-6
2.2	Suction Control Valve (SCV)	1-7

3. RAIL

3.1	Outline	1-8
3.2	Rail Pressure Sensor.	1-8
3.3	Pressure Limiter	1-9

4. INJECTOR

4.1	Outline	1-10
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5. CONTROL SYSTEM

5.1	Engine Control System Diagram	1-11
5.2	Engine ECU (Electronic Control Unit)	1-12
5.3	Description of Sensors	1-12

6. FUEL INJECTION CONTROL

6.1	Outline	1-16
6.2	Injection Pattern.	1-16
6.3	Other Controls	1-16

7. DIAGNOSTIC TROUBLE CODES (DTC)

7.1	DTC Table	1-17
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8. ATTACHED MATERIALS

8.1	Engine ECU External Wiring Diagram.	1-19
8.2	Connector Terminal Layout	1-21

1. PRODUCT APPLICATION INFORMATION

1.1 Outline

- The Common Rail System (CRS) has been newly introduced for the V3800 engine equipped in the Kubota Tractor M108X. This manual describes parts unique to the V3800 engine CRS. For basic information on the CRS described herein, refer to "General Edition Manual Common Rail System (Doc ID: 00400534E).
 - HP3 supply pump components and basic operation
 - G2 injector construction and operation
 - Outline for each of the following controls: Fuel injection quantity control, fuel injection timing control, fuel injection rate control, fuel injection pressure control

1.2 Applicable Vehicle Model

Vehicle Name	Engine Model	Engine Displacement	Line Off Period	Reference
M108X	V3800	3.8 L	January 2007	

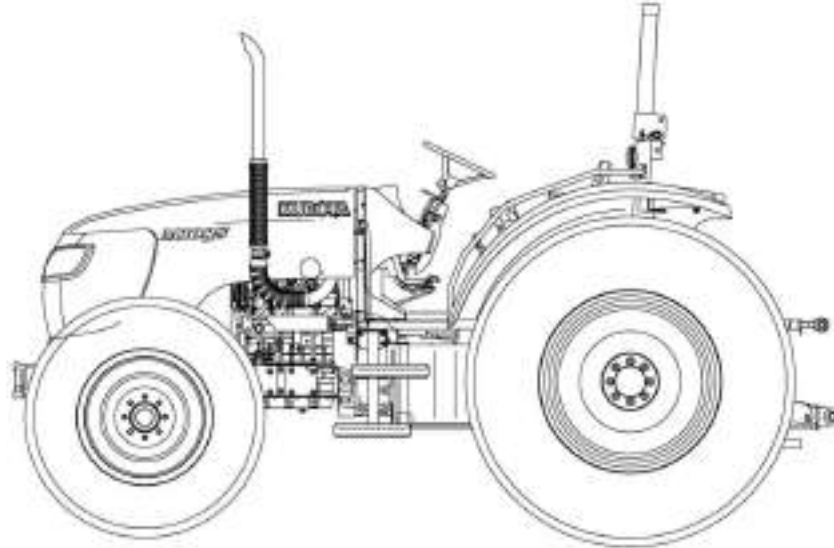
Vehicle External View



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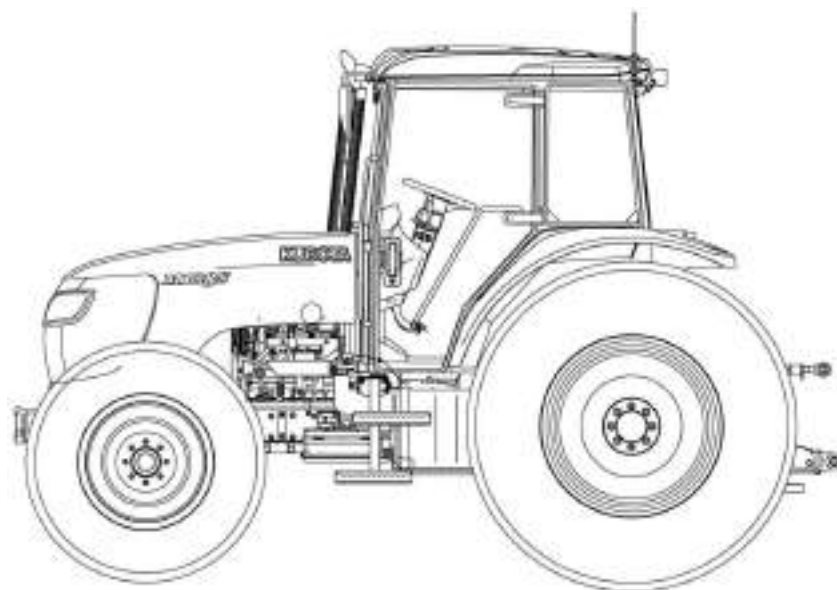
1.3 Specifications

(1) ROPS Model



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Model	M108S		M96S (not equipped with the CRS)	
	2WD	4WD	2WD	4WD
Model	V3800-CR-TI		V3800-DI-T	
Type	Vertical, water-cooled, 4-cycle diesel engine			
No. of Cylinders	4			
Total Displacement	3769 cm ³ (230.0 cu.in.)			
Net Power	80.6 kW (108 HP)* / 2600 min. ⁻¹ (rpm)		70.9 kW (95 HP)* / 2600 min. ⁻¹ (rpm)	
PTO Power *1 (Factory Observed)	71.6 kW (96 HP)*1 / 2600 min. ⁻¹ (rpm)		62.7 kW (84 HP)*1 / 2600 min. ⁻¹ (rpm)	
Maximum Torque	366.4 N•m (37.3 kgf•m, 270.2 lbf•ft) / 1400 to 1600 min. ⁻¹ (rpm)		314.8 N•m (32.1 kgf•m, 232.2 lbf•ft) / 1400 to 1600 min. ⁻¹ (rpm)	
Battery	12 V, RC, 160 min, CCA 900 A			

(2) CABIN Model

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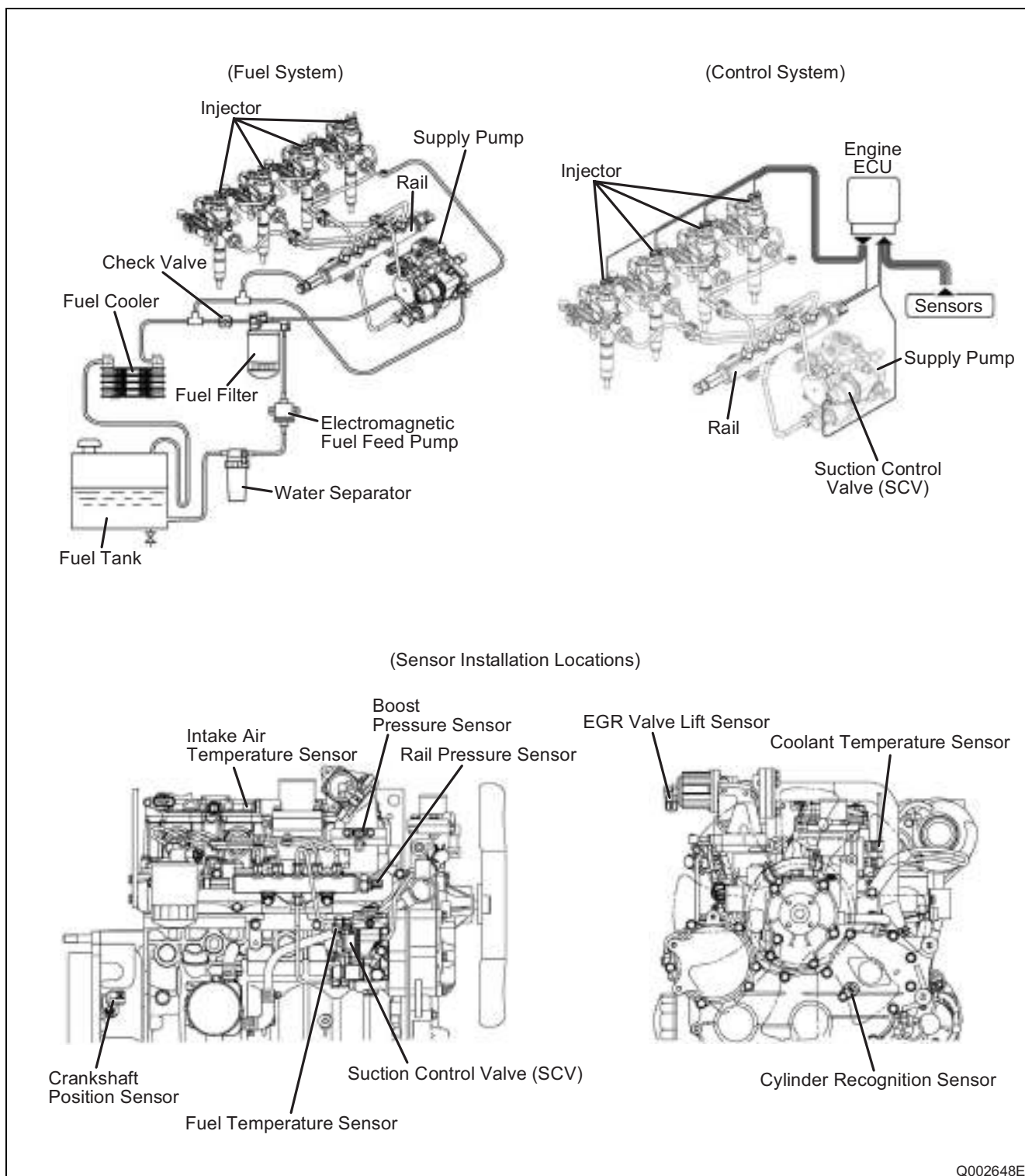
Model	M108S		M96S (not equipped with the CRS)
	2WD	4WD	4WD
Model	V3800-CR-TI		V3800-DI-T
Type	Vertical, water-cooled, 4-cycle diesel engine		
No. of Cylinders	4		
Total Displacement	3769 cm ³ (230.0 cu.in.)		
Net Power	80.6 kW (108 HP)* / 2600 min. ⁻¹ (rpm)		70.9 kW (95 HP)* / 2600 min. ⁻¹ (rpm)
PTO Power *1 (Factory Observed)	71.6 kW (96 HP)*1 / 2600 min. ⁻¹ (rpm)		62.7 kW (84 HP)*1 / 2600 min. ⁻¹ (rpm)
Maximum Torque	366.4 N•m (37.3 kgf•m, 270.2 lbf•ft) / 1400 to 1600 min. ⁻¹ (rpm)		314.8 N•m (32.1 kgf•m, 232.2 lbf•ft) / 1400 to 1600 min. ⁻¹ (rpm)
Battery	12 V, RC, 160 min, CCA 900 A		

1.4 System Component Part Numbers

Part Name	DENSO Part Number	Car Manufacturer Part Number	Remarks
Supply Pump	294000-069#	1J574-50501	HP3 type
Injector	095000-680#	1J574-53051	G2 type
Rail	095440-109#	1J574-50601	
Engine ECU	275800-722#	1J574-59053	
Accelerator Position Sensor	198300-719#	1J574-59701	
Cylinder Recognition Sensor	949979-186#	1J574-59711	MRE type
Crankshaft Position Sensor	949979-038#	1J574-59661	MRE type
Coolant Temperature Sensor	179700-022#	5H601-41941	
Boost Pressure Sensor	079800-559#	1J574-59671	
Intake Air Temperature Sensor	071500-249#	1J574-59681	

1.5 Configuration

- The CRS consists primarily of the following components. Additionally, the maximum injection pressure for this system is 130 MPa.

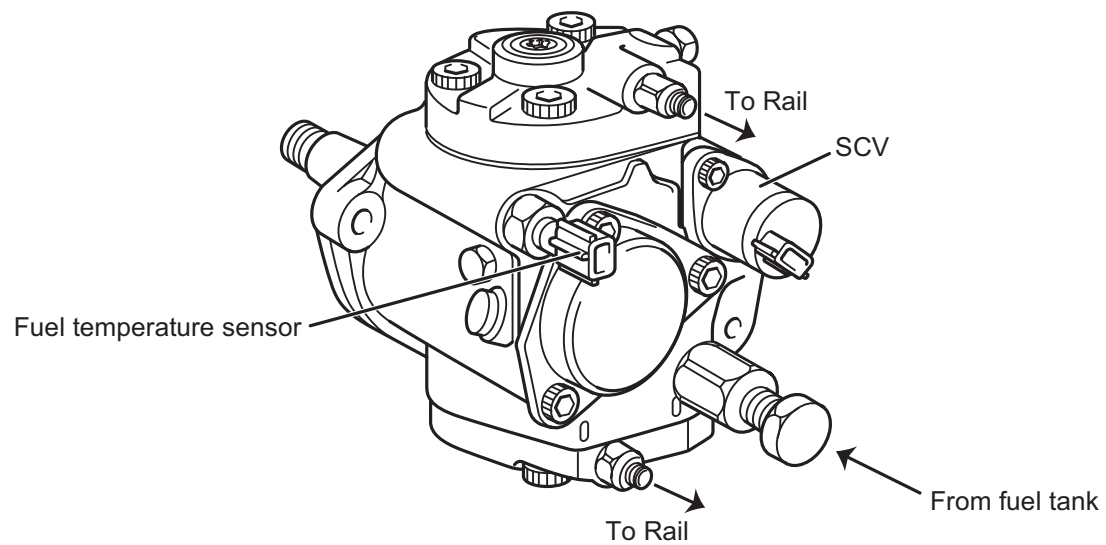


2. SUPPLY PUMP

2.1 Outline

- The V3800 engine CRS is equipped with an HP3 supply pump. The HP3 supply pump features a compact Suction Control Valve (SCV), and no connecting pipe.

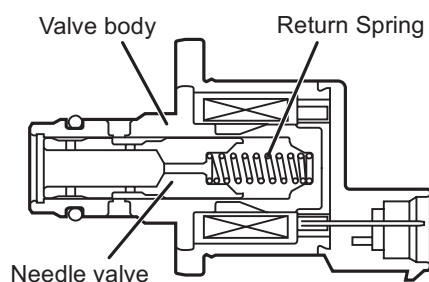
External View



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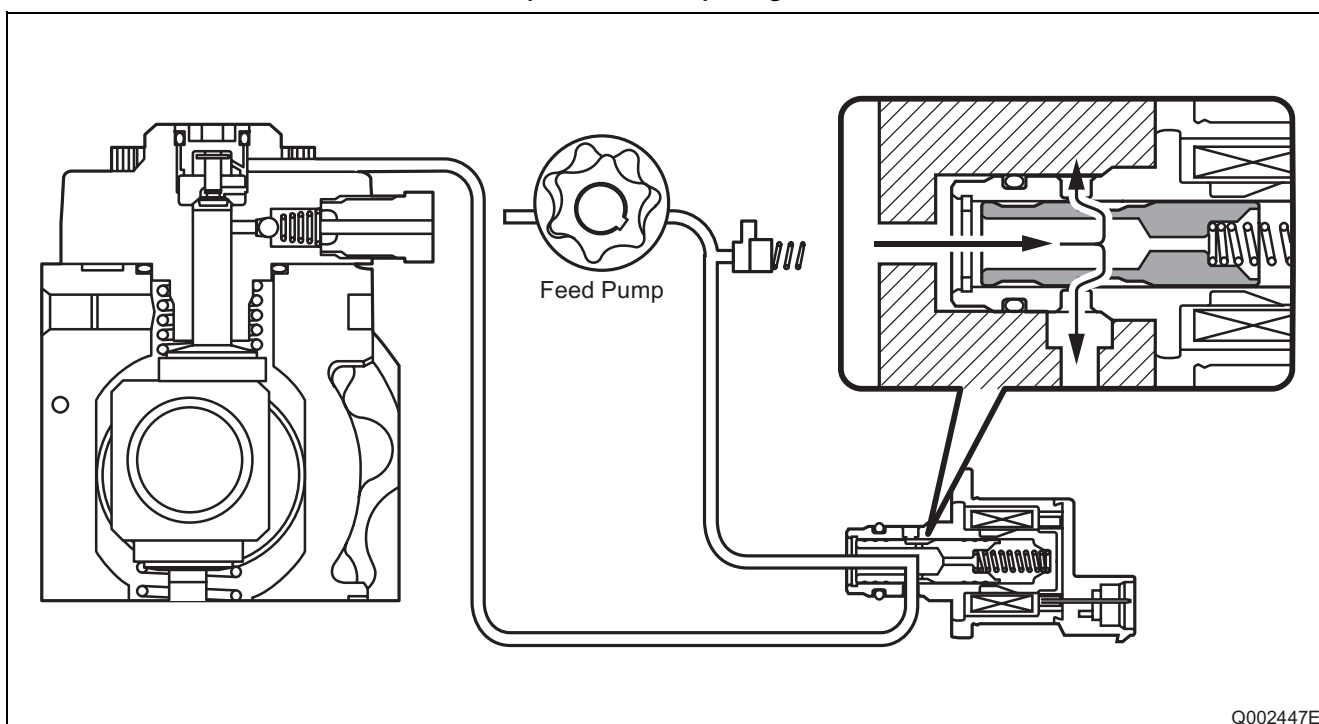
2.2 Suction Control Valve (SCV)

- The V3800 engine CRS is equipped with a compact SCV. The SCV is a normally opened type.



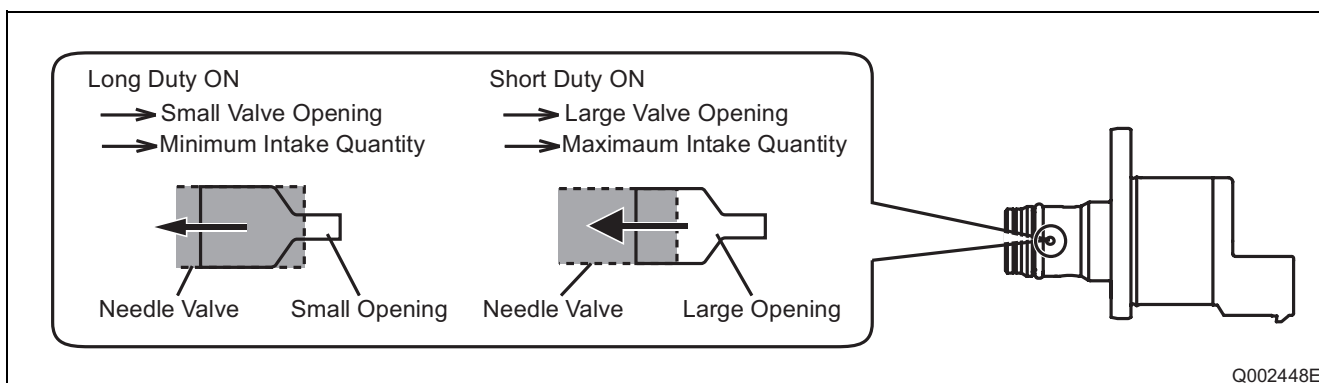
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Operation Concept Diagram



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Operation

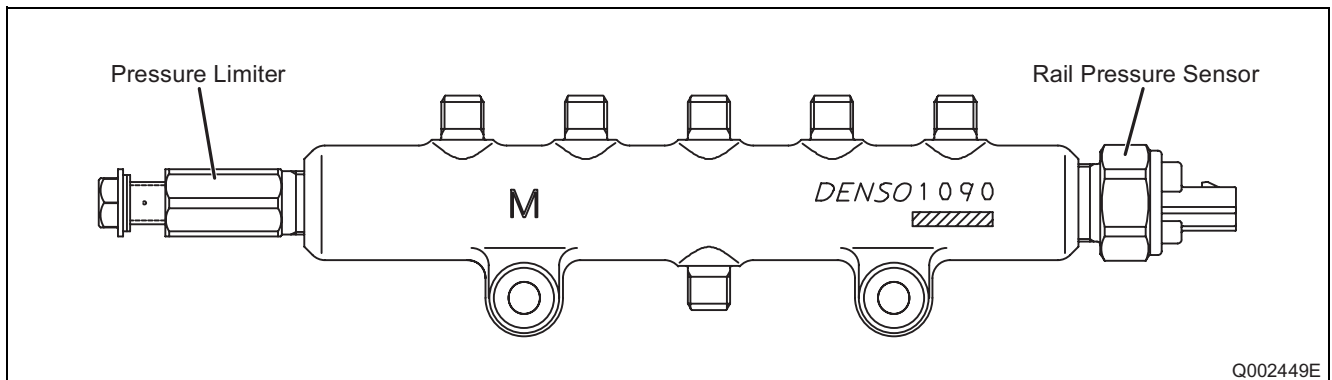


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3. RAIL

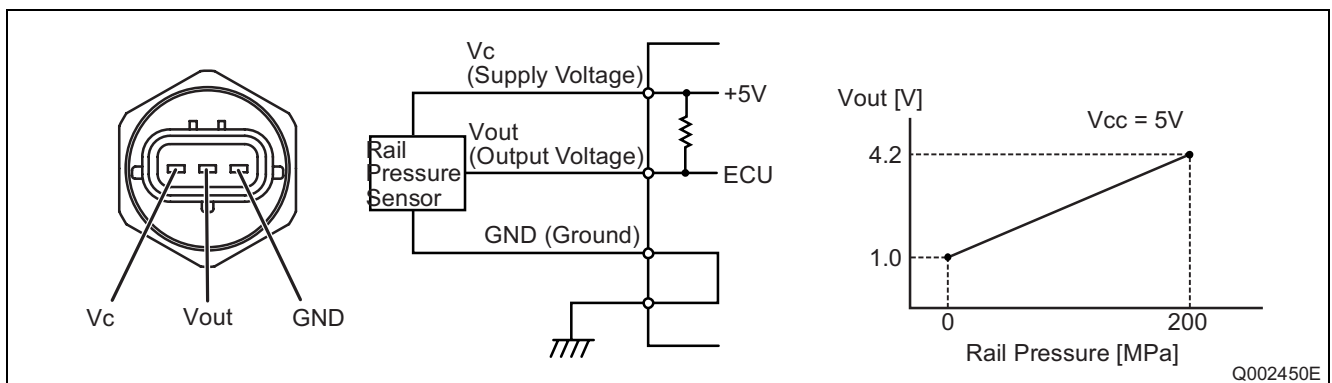
3.1 Outline

- The rail accumulates pressurized fuel (0 to 130 MPa) delivered from the supply pump for distribution to the injector for each cylinder. A rail pressure sensor, and pressure limiter are attached to the rail.
- The rail pressure sensor (Pc sensor) detects rail internal fuel pressure, and sends a signal to the engine ECU; the pressure limiter control excess pressure. These devices ensure optimum combustion and reduce combustion noise.



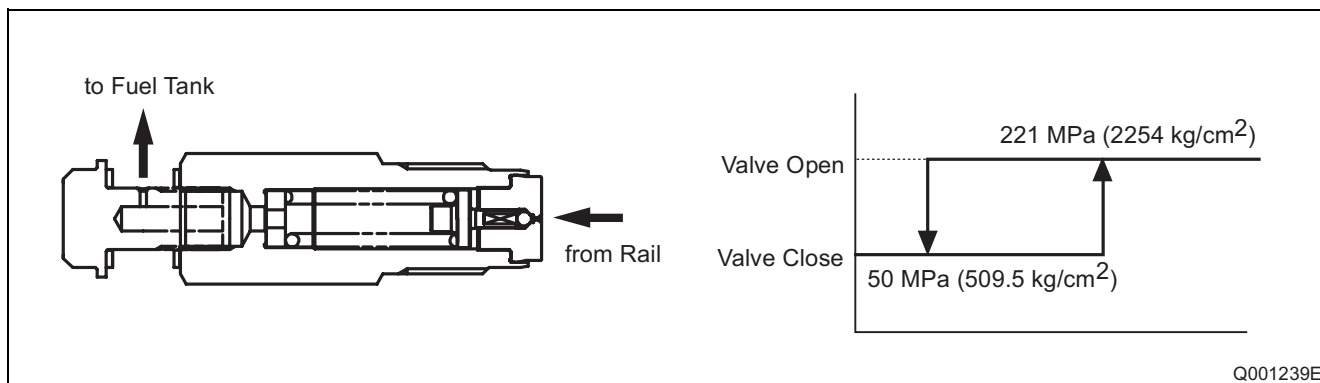
3.2 Rail Pressure Sensor

- The rail pressure sensor detects fuel pressure inside the rail, and sends a signal to the engine ECU. The rail pressure sensor is made from a semiconductor, and uses the "Piezoelectric Resistive Effect" to detect changes in electrical resistance based on the pressure applied to the elemental silicon. In comparison to the conventional rail pressure sensor, this sensor responds better to high pressure.



3.3 Pressure Limiter

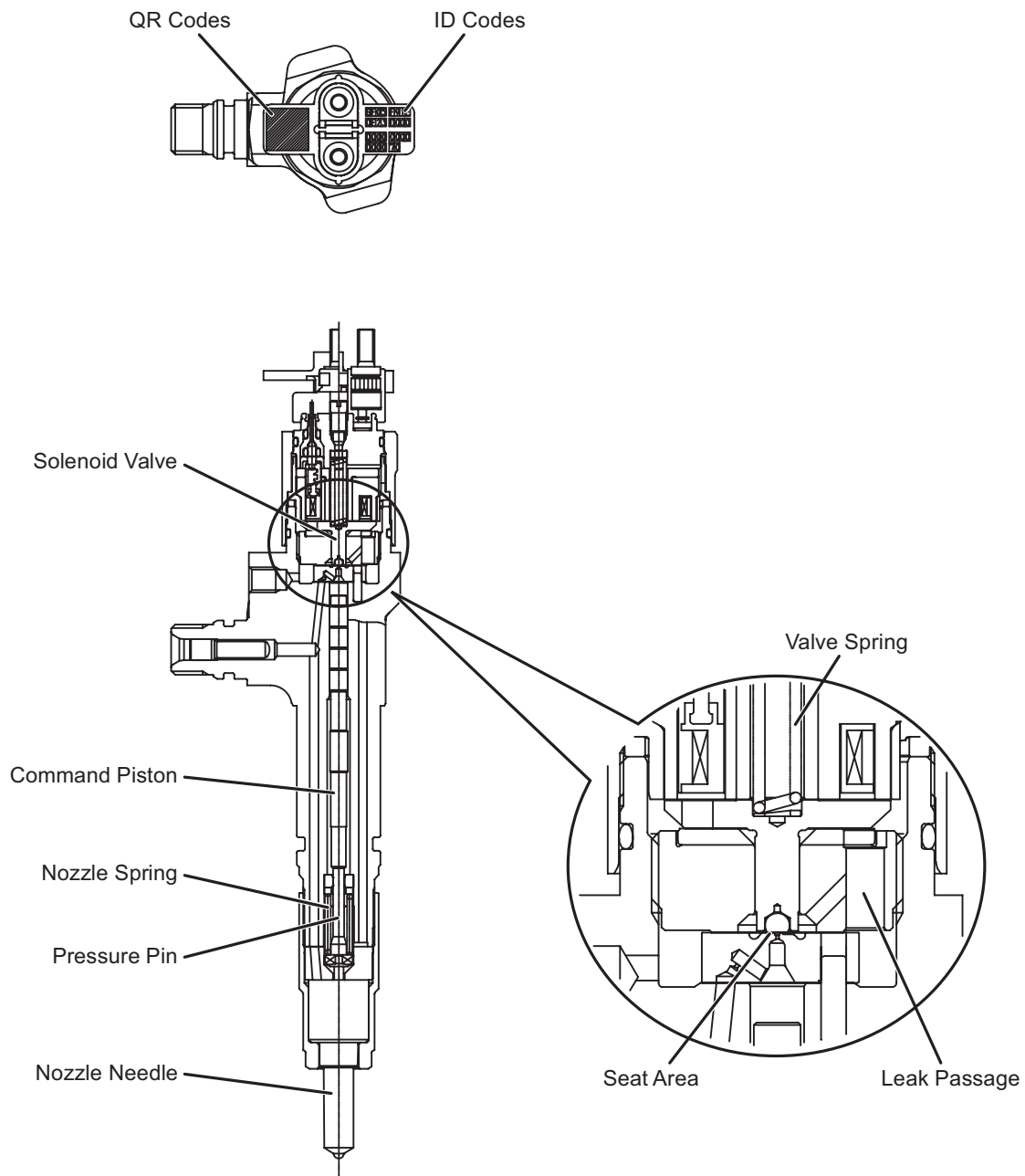
- The pressure limiter releases pressure when the rail internal pressure becomes abnormally high. The pressure limiter opens when internal pressure reaches approximately 221MPa (2254 kg/cm²), and closes when rail pressure reaches a given set pressure. Fuel released from the pressure limiter is returned to the fuel tank.



4. INJECTOR

4.1 Outline

- The V3800 engine CRS is equipped with G2 injectors.



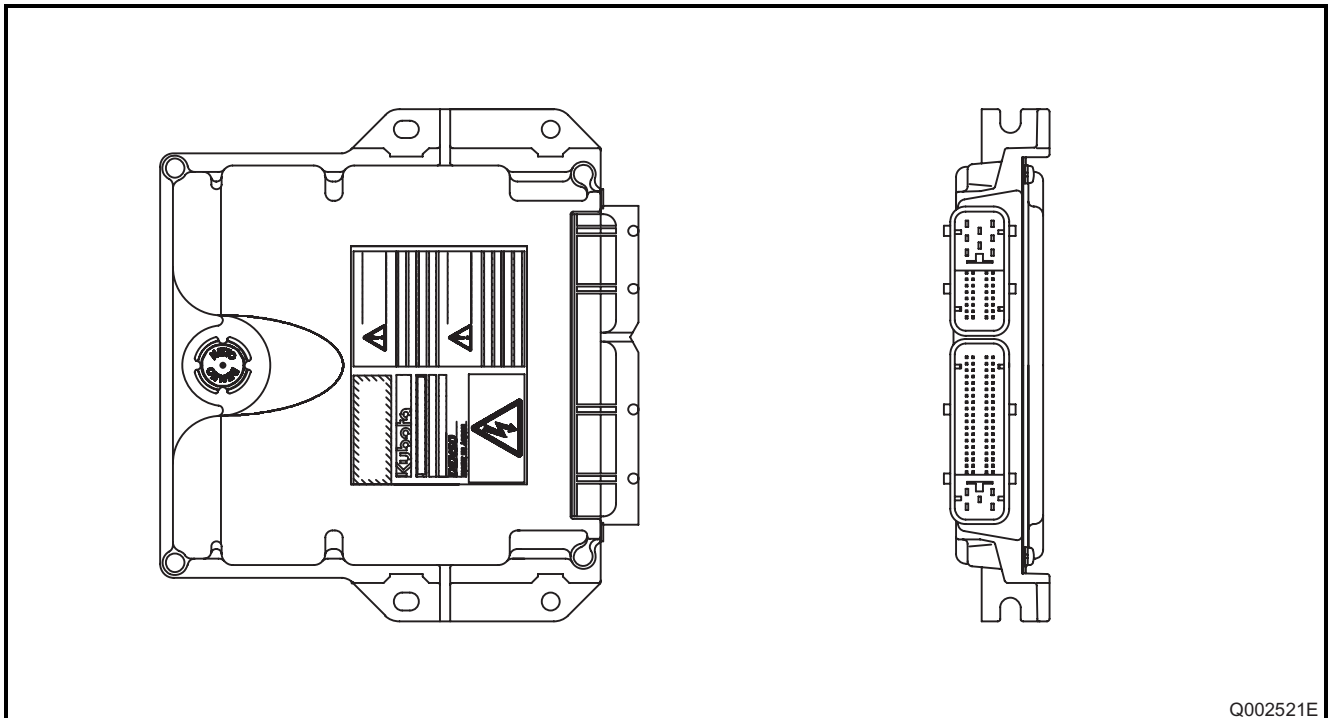
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5.1 Engine Control System Diagram



5.2 Engine ECU (Electronic Control Unit)

- The figure below is an external view of the engine ECU. For details on the connector terminal layout, refer to "8.2 Connector Terminal Layout".

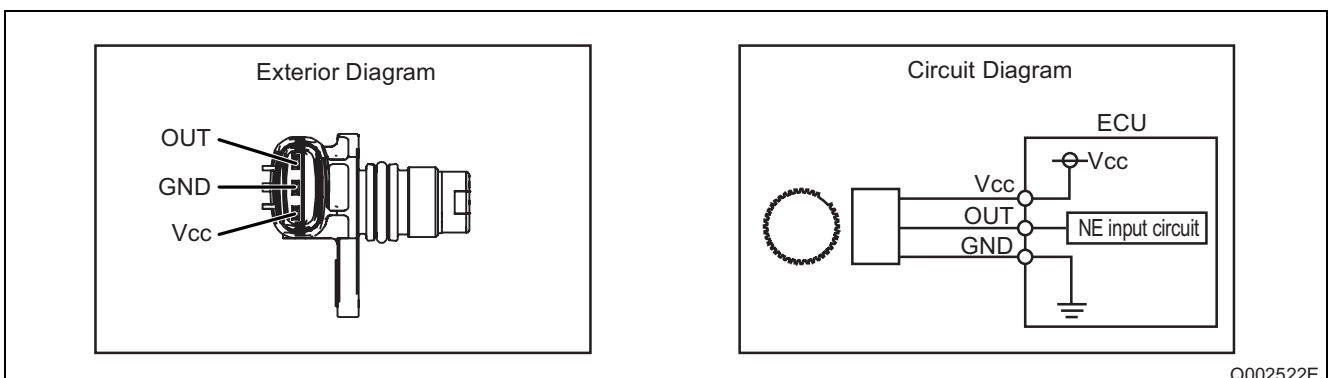


5.3 Description of Sensors

(1) Crankshaft position sensor (NE sensor) and cylinder recognition sensor (G)

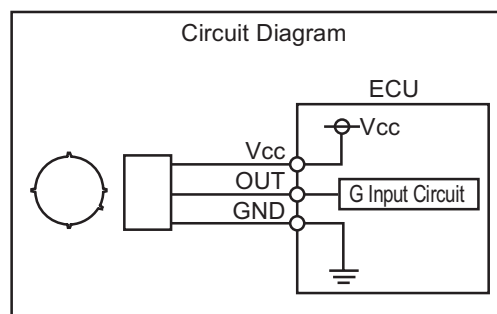
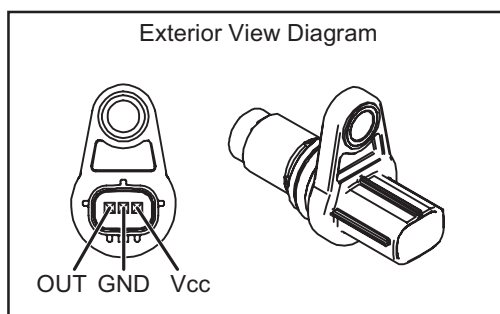
Crankshaft Position Sensor (NE)

- The crankshaft position sensor is installed near the flywheel pulsar gear on the flywheel to detect the crankshaft angle, and output the engine speed signal. The sensor unit is an MRE (Magnetic Resistance Element) type. The pulsar gear has 56 pulses.



Cylinder recognition sensor (G)

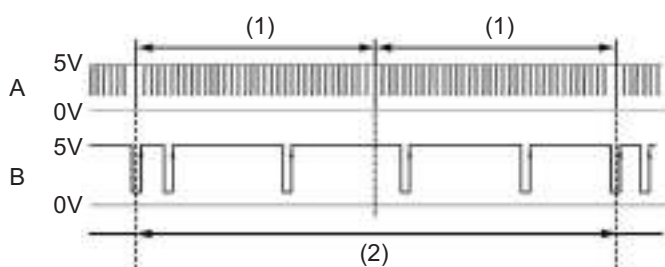
- The cylinder recognition sensor is installed near the camshaft pulsar gear to identify each cylinder. The sensor unit is an MRE type. The pulsar gear has five pulses.



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Pulse chart

- This figure below shows the pulse chart for both the crankshaft position sensor output signal, and cylinder recognition sensor output signal. The cylinder recognition gear rotates once for every two rotations of the crankshaft pulsar gear (12.56 rad (720°) crank angle). There is also a gearless section on the crankshaft pulsar gear. The ECU determines Top Dead Center (TDC) when the cylinder recognition sensor signal is detected due to the gearless section passing the crankshaft position sensor.



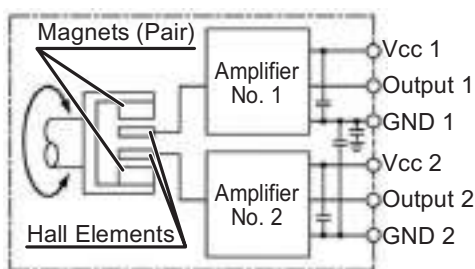
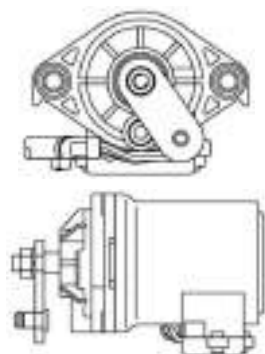
A : Crankshaft Position Sensor Output Voltage
B : Camshaft Position Sensor Output Voltage

- (1) 56 Pulses (6.28 rad (360°) Crank Angle)
(2) 5 Pulses (12.56 rad (720°) Crank Angle)

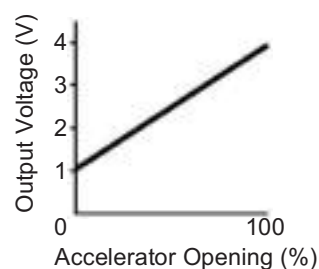
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(2) Accelerator position sensor

- The accelerator position sensor is a Hall element type sensor. Accelerator position is converted to an electrical signal that is output to the engine ECU.



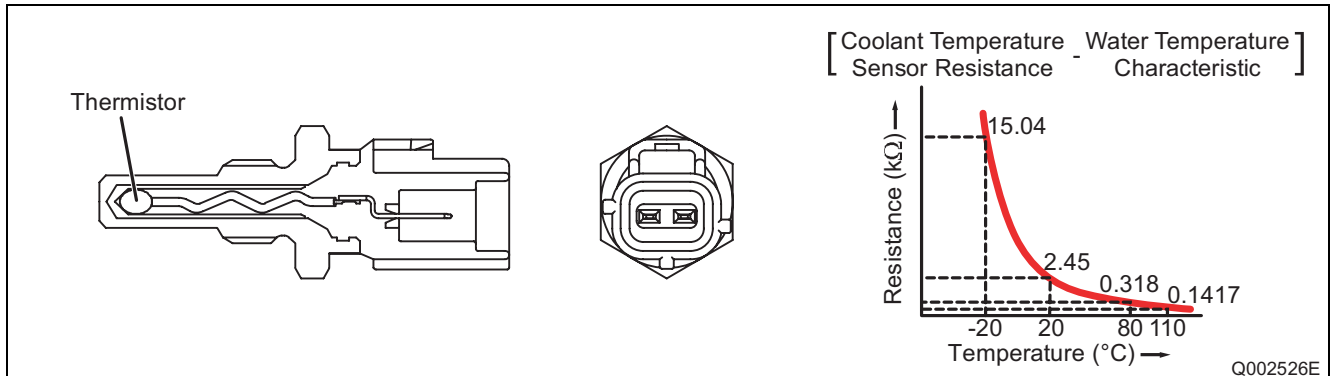
Output Voltage - Operating Characteristic



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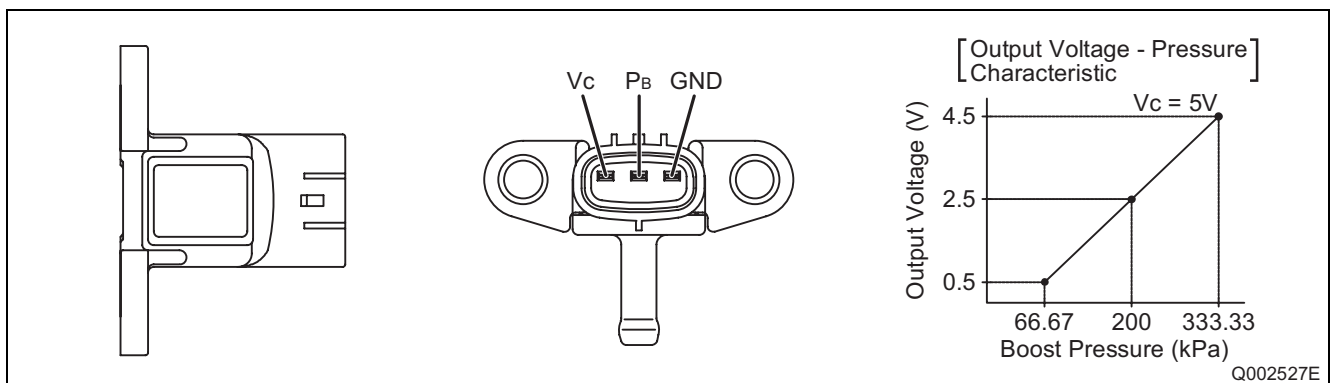
(3) Coolant temperature sensor

- The coolant temperature sensor detects engine coolant temperature. The coolant sensor contains a built-in thermistor that undergoes changes in resistance according to the temperature of the coolant. Any change in coolant temperature is detected using the change in the thermistor resistance value.



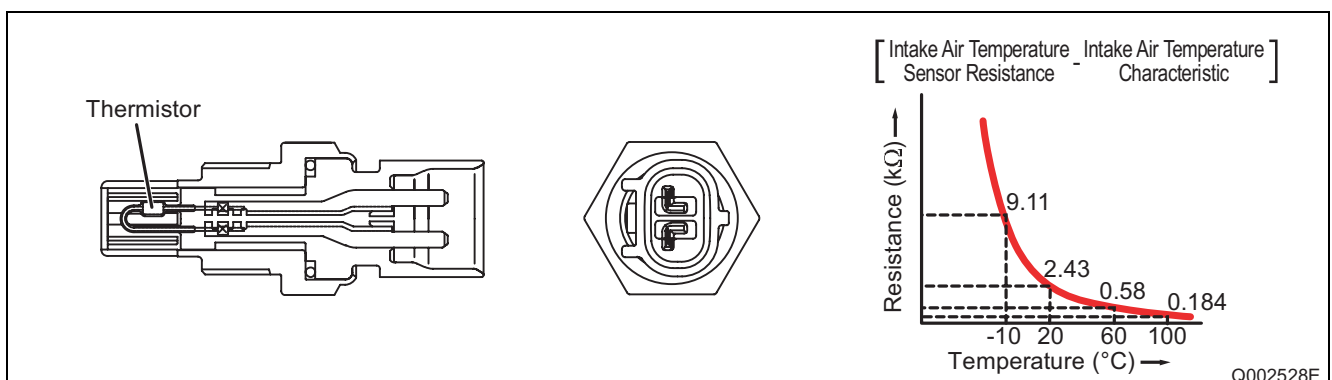
(4) Boost pressure sensor

- The boost pressure sensor is identical to the conventional sensor in construction and operational characteristics. The boost pressure sensor uses the "Piezoelectric Resistive Effect" to detect air pressure inside the intake manifold. Under the "Piezoelectric Resistive Effect", changes in electrical resistance accompany changes in voltage applied to the silicon element inside the sensor.



(5) Intake air temperature sensor

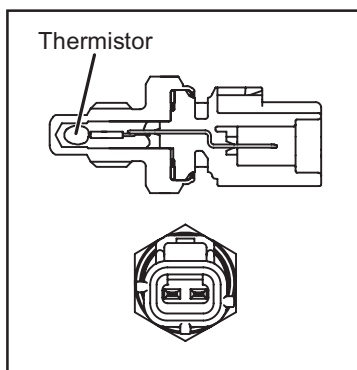
- The intake air temperature sensor detects the temperature of the intake air that has passed through the turbocharger. The sensor portion of the unit that detects the temperature contains a thermistor. The electrical resistance of the thermistor changes with temperature to detect the intake air temperature.



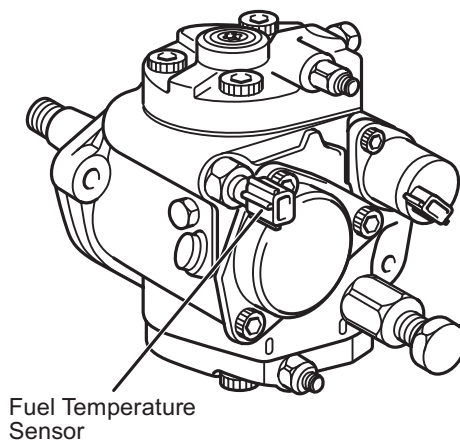
(6) Fuel temperature sensor

- The fuel temperature sensor is a conventional sensor. The table below shows sensor resistance values in relation to fuel temperature.

Resistance Value Characteristics



Temperature (°C)	Resistance Value (kΩ)
-30	(25.4)
-20	15.0 ^{+1.29} _{-1.20}
-10	(9.16)
0	(5.74)
10	(3.70)
20	2.45 ^{+0.14} _{-0.13}
30	(1.66)
40	(1.15)
50	(0.811)
60	(0.584)
70	(0.428)
80	0.318±0.008
90	(0.240)
100	(0.1836)
110	0.1417±0.0018
120	(0.1108)



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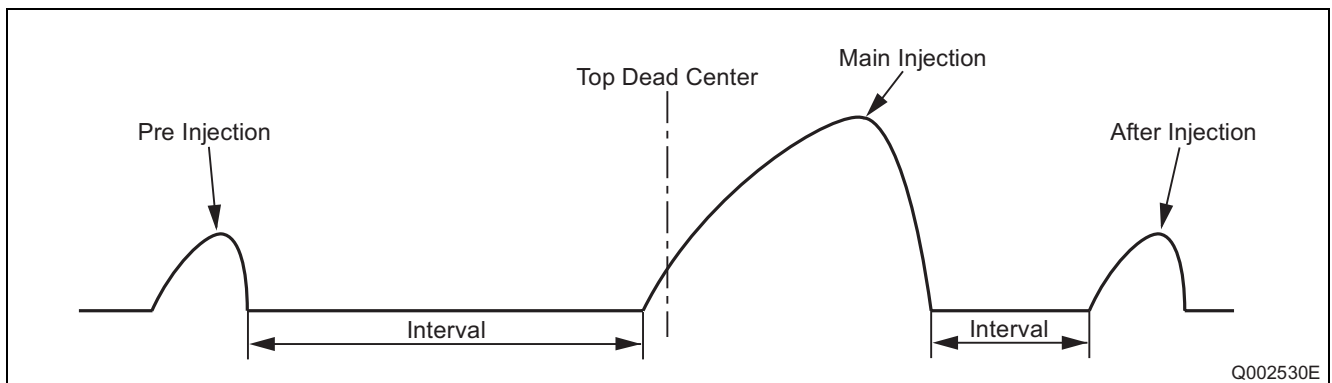
6. FUEL INJECTION CONTROL

6.1 Outline

- The following conventional controls are used to adjust fuel injection: fuel injection quantity control, fuel injection timing control, fuel injection rate control, fuel injection pressure control. The proceeding section explains controls unique to the V3800 engine CRS.

6.2 Injection Pattern

- Injection patterns for the V3800 engine CRS system are indicated in the figure below. Pre-injection is performed in nearly all regions, while after injection occurs following engine warm-up when engine rotational speed has reached 1400 rpm, and there is at least a moderate engine load. Under injection timing control, once the main injection timing is determined, each individual interval is controlled.



6.3 Other Controls

- The V3800 engine CRS also includes the following controls:
 - Limit maximum injection quantity
 - Fuel cutoff
 - EGR
 - Glow plug relay (option)

7. DIAGNOSTIC TROUBLE CODES (DTC)

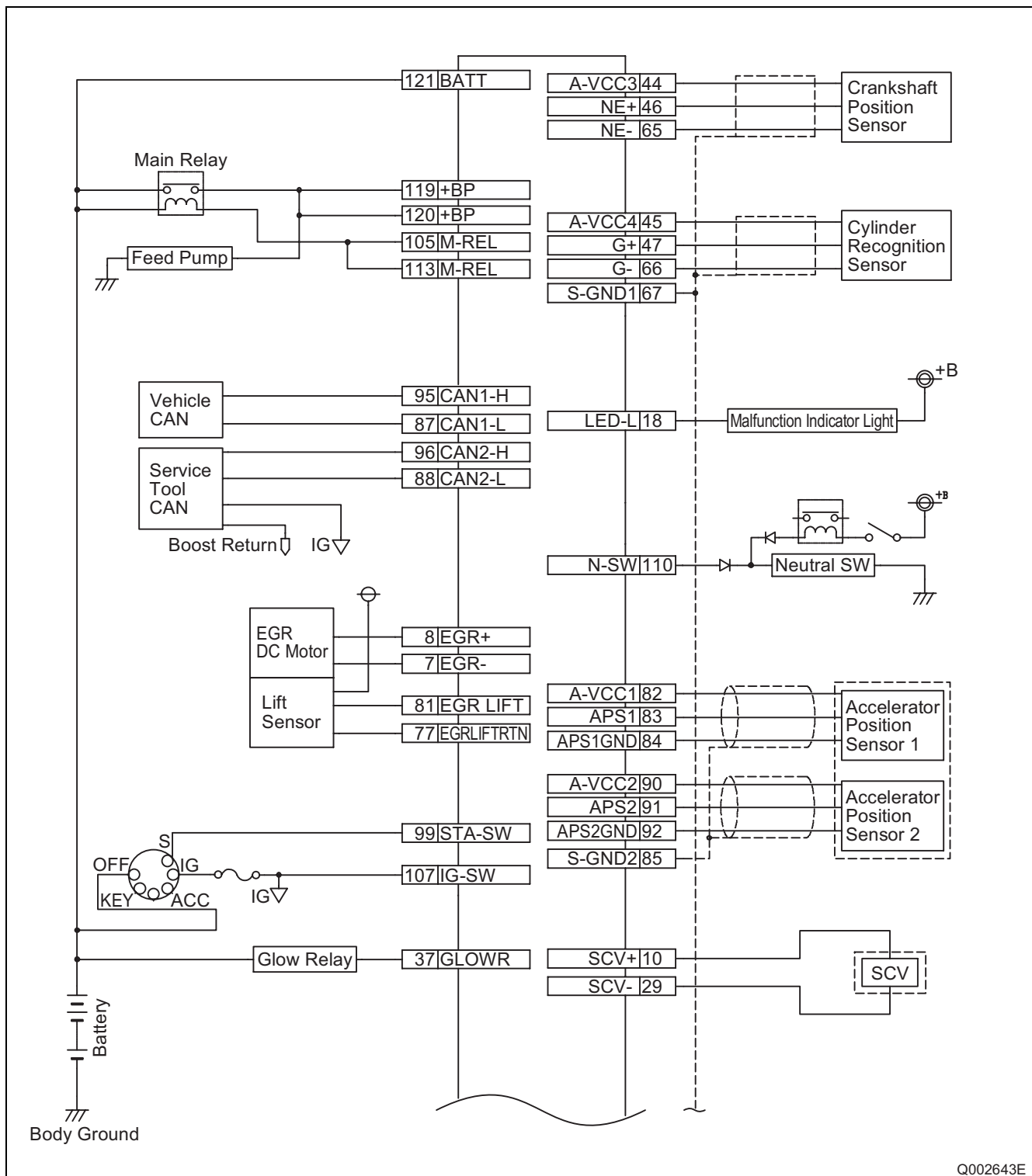
7.1 DTC Table

DTC	Detection Item
P0016	Crankshaft position sensor (NE) - cylinder recognition sensor (G) phase gap
P0087	Pressure limiter opening abnormality
P0088	High rail pressure abnormality
P0089	SCV stuck
P0093	Fuel leak
P0112	Intake air temperature sensor abnormality
P0113	
P0117	Coolant temperature sensor abnormality
P0118	
P0182	Fuel temperature sensor abnormality
P0183	
P0192	Rail pressure sensor abnormality
P0193	
P0200	Overcharge
P0201	TWV 1 actuation system open circuit
P0202	TWV 2 actuation system open circuit
P0203	TWV 3 actuation system open circuit
P0204	TWV 4 actuation system open circuit
P0217	Overheat
P0219	Overrun
P0237	Intake air pressure sensor abnormality
P0238	
P0263	Non-injection abnormality (rotational fluctuation abnormality)
P0266	
P0269	
P0272	
P0335	Crankshaft position sensor (NE sensor) abnormality
P0336	
P0340	Cylinder Recognition Sensor (G sensor) abnormality
P0341	
P0380	Air heater relay actuation abnormality (optional specifications)
P0380	
P0400	EGR feedback abnormality
P0404	EGR DC motor estimated temperature abnormality

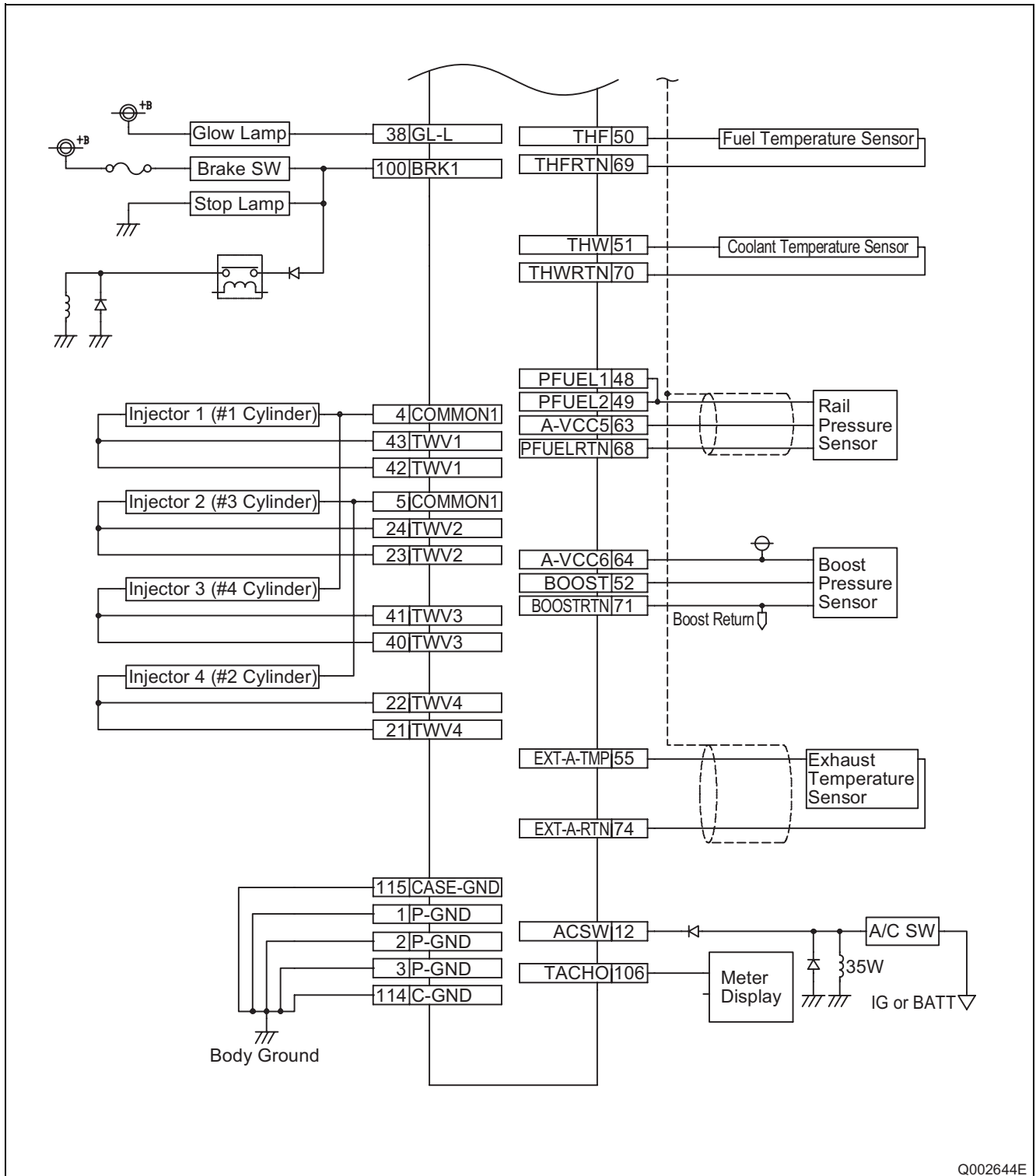
DTC	Detection Item
P0405	EGR lift sensor abnormality
P0406	
P0501	Vehicle speed sensor abnormality
P0503	
P0561	Battery voltage abnormality
P0562	
P0563	
P0602	QR abnormality
P0605	ECU Flash - ROM abnormality
P0606	CPU abnormality
P0611	Low charge
P0616	Starter switch abnormality
P0617	
P0628	SCV abnormality
P0629	
P0642	Sensor voltage 1 abnormality
P0643	
P0652	Sensor voltage 2 abnormality
P0653	
P0687	Main relay abnormality
P1274	Pump protection failure flag
P1275	Pump replacement failure flag
P2122	Accelerator position sensor 1 abnormality
P2123	
P2127	Accelerator position sensor 2 abnormality
P2128	
P2146	Common 1 system open circuit
P2147	Common 1 TWV actuation system ground short
P2148	Common 1 TWV actuation system +B short
P2149	Common 2 system open circuit
P2227	Atmospheric pressure sensor abnormality
P2228	
P2229	

8. ATTACHED MATERIALS

8.1 Engine ECU External Wiring Diagram

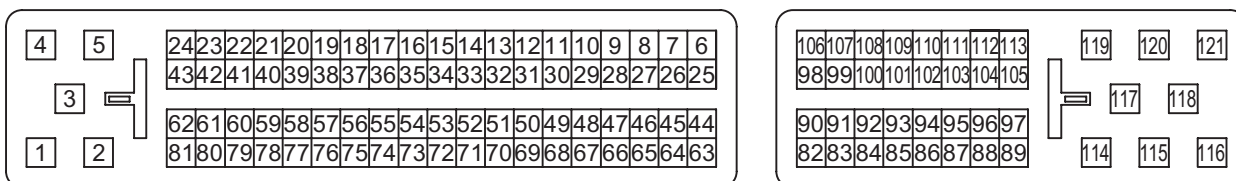


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8.2 Connector Terminal Layout



Q002645E

No.	Terminal Name	Terminal Description
1	P-GND	Power Ground
2	P-GND	Power Ground
3	P-GND	Power Ground
4	COMMON1	Injection Common
5	COMMON1	Injection Common
6	—	
7	EGR-	EGR DC Motor-
8	EGR+	EGR DC Motor+
9	—	
10	SCV+	Suction Control Valve
11	—	
12	ACSW	Air Conditioner Switch
13	—	
14	—	
15	—	
16	—	
17	—	
18	LED-L	Malfunction Indicator Light
19	—	
20	—	
21	TWV4	Injection Drive 4
22	TWV4	Injection Drive 4
23	TWV2	Injection Drive 2
24	TWV2	Injection Drive 2
25	—	
26	—	
27	—	
28	—	
29	SCV-	Suction Control Valve
30	—	

No.	Terminal Name	Terminal Description
31	—	
32	—	
33	—	
34	—	
35	—	
36	—	
37	GLOWR	Glow Relay
38	GL-L	Glow lamp
39	—	
40	TWV3	Injection Drive 3
41	TWV3	Injection Drive 3
42	TWV1	Injection Drive 1
43	TWV1	Injection Drive 1
44	A-VCC3	Sensor (Power Supply)
45	A-VCC4	Sensor (Power Supply)
46	NE+	Crankshaft Position Sensor+
47	G+	Cylinder Recognition Sensor+
48	PFUEL	Rail Pressure Sensor
49	PFUEL	Rail Pressure Sensor
50	THF	Fuel Temperature Sensor
51	THW	Coolant Temperature Sensor
52	BOOST	Boost Pressure Sensor
53	—	
54	—	
55	EXT-A-TMP	Exhaust Temperature Sensor
56	—	
57	—	
58	—	
59	—	
60	—	
61	—	
62	—	
63	A-VCC5	Sensor (Power Supply)
64	A-VCC6	Sensor (Power Supply)
65	NE-	Crankshaft Position Sensor-
66	G-	Cylinder Recognition Sensor-
67	S-GND1	Shield Ground
68	PFUELRTN	Sensor Ground
69	THFRTN	Fuel Temperature Sensor Return
70	THWRTN	Coolant Temperature Sensor Return
71	BOOSTRTN	Boost Pressure Sensor Return

No.	Terminal Name	Terminal Description
72	—	
73	—	
74	EXT-A-RTN	Exhaust Temperature Sensor Return
75	—	
76	—	
77	EGR LIFT RTN	EGR Lift Sensor Return
78	—	
79	—	
80	—	
81	EGR LIFT	EGR Lift Sensor
82	A-VCC1	Sensor (Power Supply)
83	APS1	Accelerator Position Sensor1
84	APS1GND	Sensor Ground
85	S-GND2	Shield Ground
86	—	
87	CAN1-L	CAN1 Communication
88	CAN2-L	CAN2 Communication
89	—	
90	A-VCC2	Sensor (Power Supply)
91	APS2	Accelerator Position Sensor2
92	APS2GND	Sensor Ground
93	—	
94	—	
95	CAN1-H	CAN1 Communication
96	CAN2-H	CAN2 Communication
97	SPD	Speed Sensor
98	—	
99	STA-SW	Starter Switch
100	BRK1	Brake Switch 1
101	—	
102	—	
103	—	
104	—	
105	M-REL	Main Relay
106	TACHO	Tachometer Pulse
107	IG-SW	Ignition Switch
108	—	
109	—	
110	N-SW	Neutral Switch
111	—	
112	—	

No.	Terminal Name	Terminal Description
113	M-REL	Main Relay
114	C-GND	Signal Ground
115	CASE-GND	Case-Ground
116	—	
117	—	
118	—	
119	+BP	Battery+ (Main Relay)
120	+BP	Battery+ (Main Relay)
121	BATT	Battery+

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Service Department

1-1 Showa-cho, Kariya, Aichi Prefecture, Japan