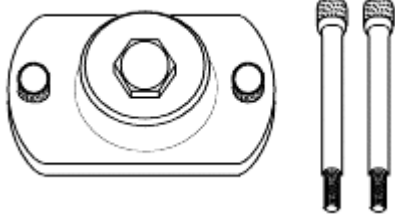




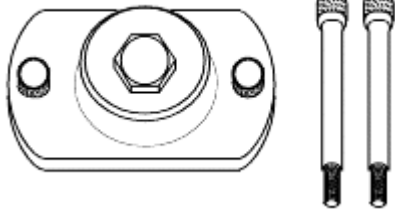
Fuel System

General Information

**Special service tools**

Tool (Number and name)	Illustration	Use
OK552 131 003 Puller, Injection pump pulley		Used to remove injection pump pulley.

Special service tools

Tool (Number and name)	Illustration	Use
OK552 131 003 Puller, Injection pump pulley		Used to remove injection pump pulley.



SPECIFICATIONS

Item		Engine	KJ 2.9 TCI DIESEL
Idle speed		rpm	800±20
Idle-up speed		rpm	850±20
Throttle position (TP) sensor	Accelerator pedal fully depressed	volt	0.6±0.25
	Accelerator pedal released	volt	4.4 ^{+0.25} _{-0.2}
Engine coolant temperature sensor	Resistance kΩ	-4°F(-20°C)	16.2±1.6
		68°F(20°C)	2.45±0.25
		176°F(80°C)	0.32±0.03
Idle-up solenoid valve	Resistance (at 68°F[20°C])	Ω	40
EGR solenoid valve	Resistance (at 68°F[20°C])	Ω	15.5
Air heater relay No.1 & No.2	Resistance (at 68°F[20°C])	Ω	37
Cooling fan relay No.1, No.2 & No.3	Resistance (at 68°F[20°C])	Ω	60
Water heater relay No.1 & No.2	Resistance (at 68°F[20°C])	Ω	37

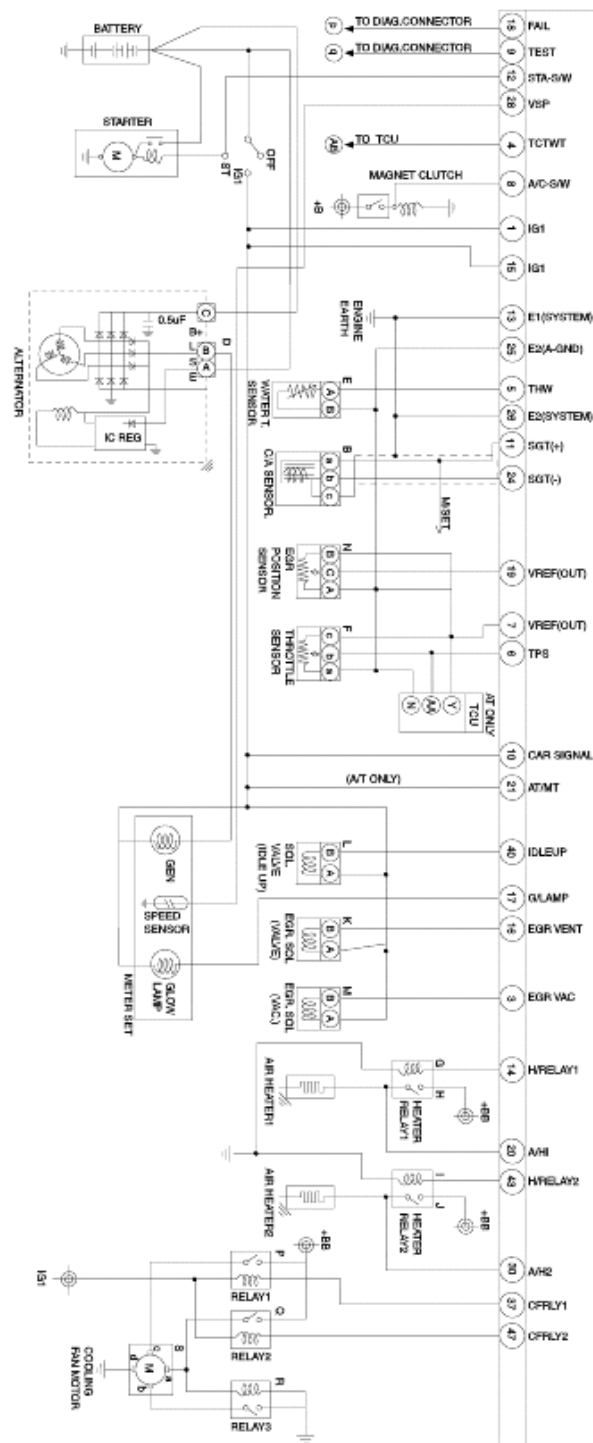


Fuel System

Engine Control System

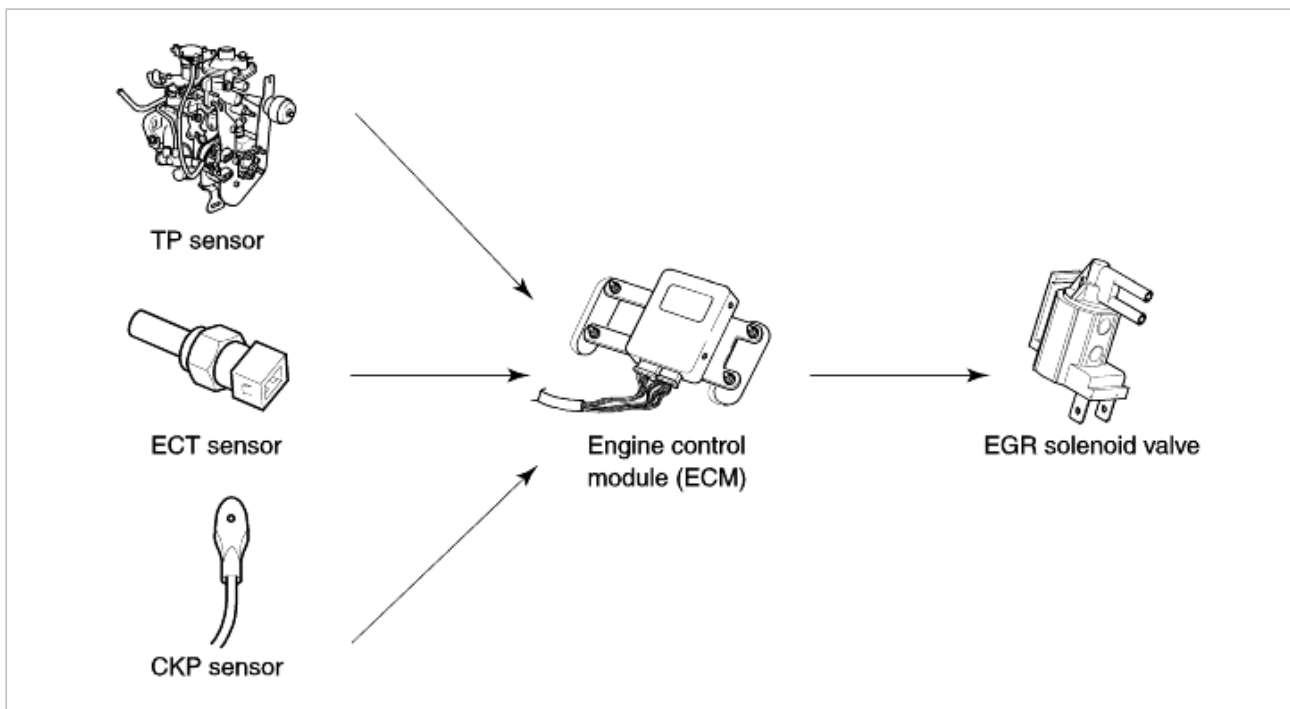


CIRCUIT DIAGRAM





Exhaust Gas Recirculation (EGR) system control



A EGR system recirculates a small amount of exhaust gas into engine to reduce the combustion temperature, and reduces the NOx emissions. It is difficult for diesel engine to use three-way catalytic converter for reducing NOx gas because the excess air ratio of the diesel engine is much higher than that of the gasoline engine.

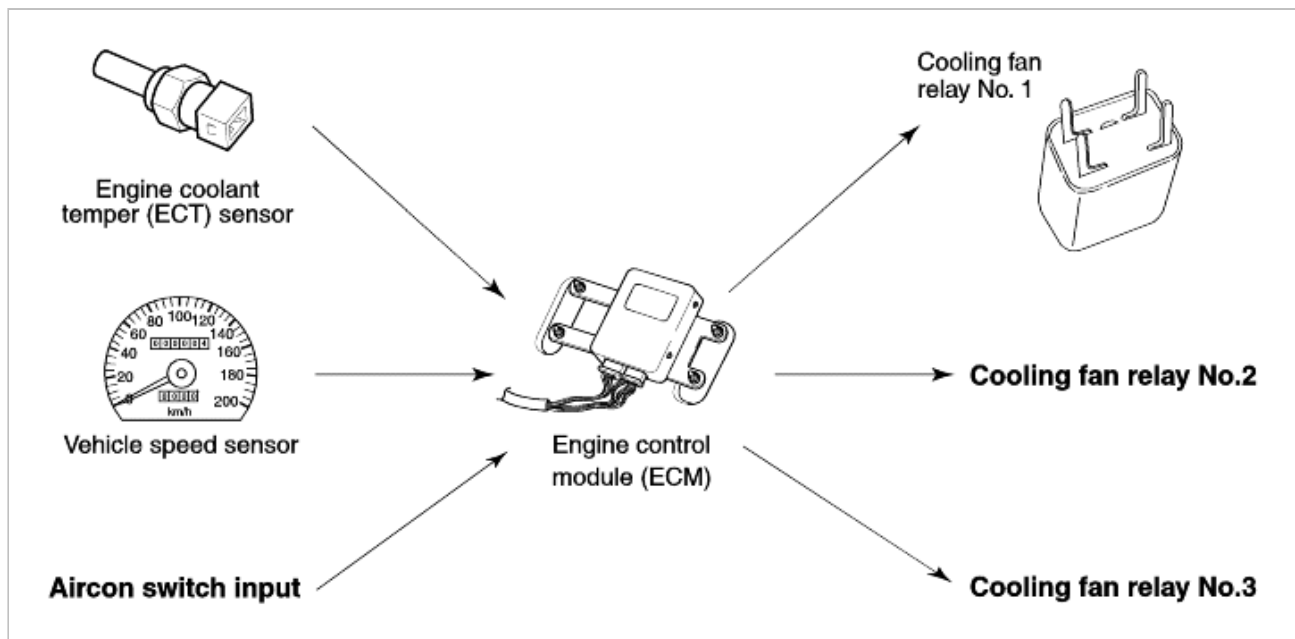
The EGR control is inhibited under the following conditions.

1. Engine coolant temperature is lower than 86°F(30°C).
2. Engine speed is lower than the specified rpm.
3. Engine starting.
4. Faulty ECT sensor, TP sensor, or CKP sensor.

The EGR solenoid valve is deactivated for 1.5 sec when the variation of throttle angle is higher than 2.75% per 30 m/sec and the throttle angle is between 30% and 100%.

The EGR solenoid valve is duty-controlled according to engine speed and throttle angle except above conditions.

Cooling fan control



A electric cooling fan is controlled by the ECM to prevent engine overheat.

The cooling fan operates at two speeds (LOW/HIGH) depending on various inputs from the vehicle speed sensor, air conditioner switch, and engine coolant temperature sensor.

The cooling fan is controlled by cooling fan relay according to the cooling fan speed as below table.

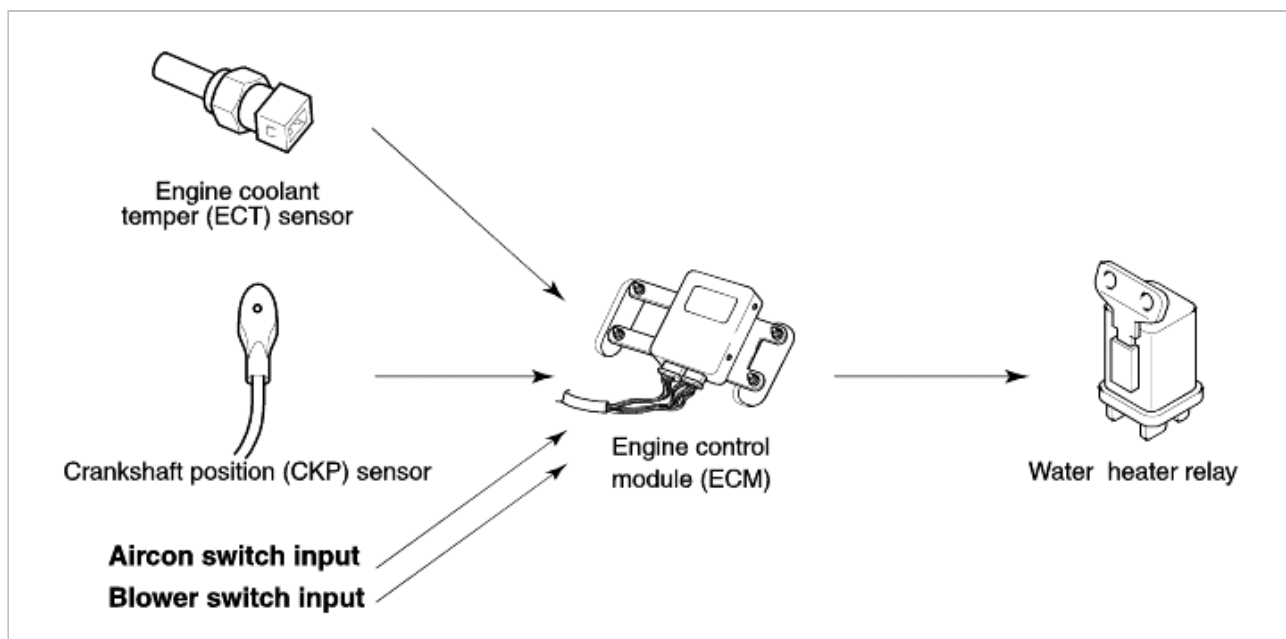
	Relay No.1	Relay No.2	Relay No.3
Low speed	ON	OFF	OFF
High speed	ON	ON	ON

The cooling fan operates at low speeds when the engine coolant temperature is higher than 203°F(95°C).

The cooling fan operates at high speeds under each following conditions.

1. The air conditioner is not operating and the engine coolant temperature is higher then 230°F(110°C).
2. The air conditioner is operating, the vehicle speed is lower than 5 km/h, and the engine coolant temperature is higher than 230°F(110°C).
3. The air conditioner is operating, the vehicle speed is between 5 km/h and 80 km/h, and the engine coolant temperature is higher than 219°F(104°C).
4. The air conditioner is operating, the vehicle speed is higher than 80 km/h, and the engine coolant temperature is higher than 230°F(110°C).

Water heater control



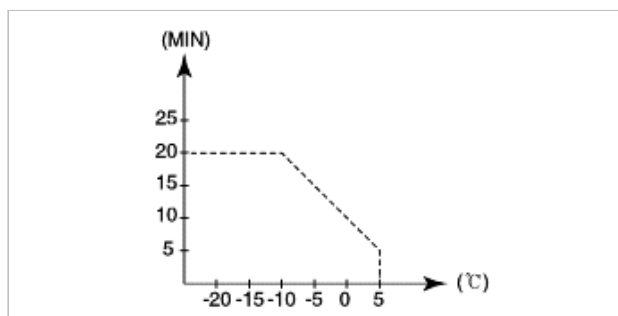
A water heater control system is designed to clear the frost away just after the engine star-up.

The water heater operates as followings.

1. When the engine coolant temperature is below 32°F(0°C) just after engine start-up;
2. The water heater operates during the setting time (T1) until the engine coolant is 149°F(65°C).with the air conditioner switch OFF.
3. When the engine coolant temperature is above 32°F(0°C) just after engine start-up;
The water heater operates during the setting time (T1) until the engine coolant is 149°F(65°C) with the blower switch ON and the air conditioner switch OFF.
4. When the water heater control is performed as above mentioned (1)or (2) operation and the air conditioner is turned from "ON" to "OFF".

The water heater operates during the maximum 20 minutes or until the engine coolant temperature is 113°F(45°C) with the blower switch ON and more than 5 km/h of vehicle speed.

The water heater control is prohibited when the air conditioner is turned ON, the engine coolant temperature is 149°F(65°C), the engine speed is below 500 rpm, or faulty ECT sensor, CKP sensor.



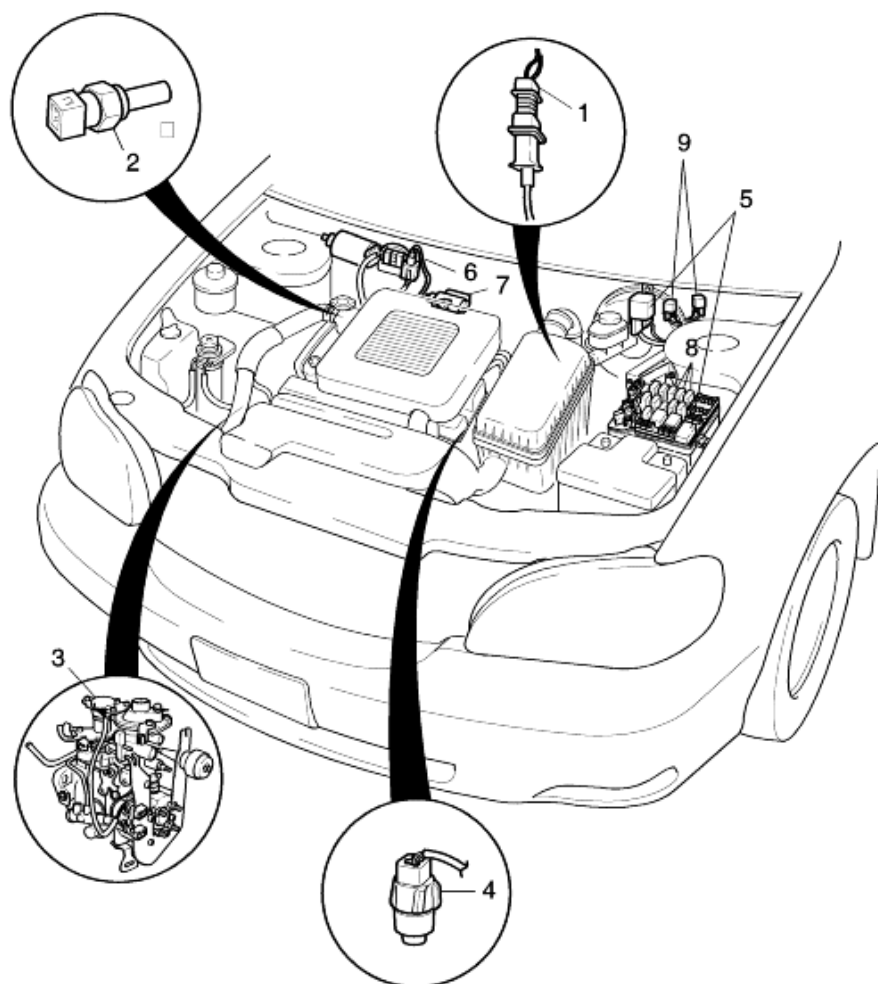
Diagnostic trouble codes

MIL function

Test switch	Test switch	
	No fault code	Fault code
OFF(Open)	OFF	ON
ON(GND)	OFF after LED open inspection function	Fault code display after LED open inspection function



Underhood engine control components

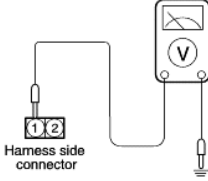
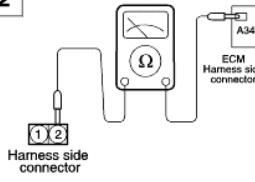
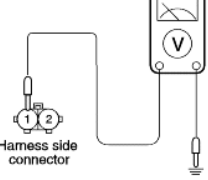
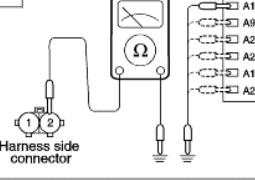
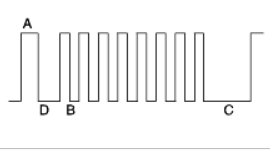


1. Crankshaft position (CKP) sensor
2. Engine coolant temperature (ECT) sensor
3. Throttle position (TP) sensor
4. Vehicle speed sensor
5. Air heater relay

6. Idle-up solenoid valve
7. EGR valve
8. Cooling fan relay
9. Water heater relay



Diagnostic trouble code

Fault code	Items	Diagnosis	Fault code output		Limp home
02	Crankshaft position (CKP) sensor circuit malfunction	The engine speed is lower than 60 rpm when the engine starts	1 	Measure the power supply voltage. o Connector: Disconnected. o Ignition switch: ON. o Voltage (V) : Battery voltage. OK → 2 NG → Repair the harness.	The after-heat of air heater, W/Heater control and EGR control are inhibited
09	Engine coolant temperature (ECT) sensor circuit malfunction	- The engine coolant temperature is lower than -40°F(-40°C) - The engine coolant temperature is higher than 302°F(150°C)	2 	Check for an open circuit or short circuit between the evaporative emission canister purge solenoid valve and the ECM. o Engine ECM connector: Disconnected. o Evaporative emission canister purge solenoid valve connector: Disconnected OK → END NG → Repair the harness.	The following controls are inhibited - W/Heater control - After-heat of air heater - EGR - Idle-up The cooling fan operates at low speeds Engine coolant temperature signal (to TCM) is commanded ON
12	Throttle position (TP) sensor circuit malfunction	- The throttle angle is lower than 5% - The throttle angle is higher than 95%	1 	Measure the power supply voltage. o Connector: Disconnected. o Ignition switch : ON. o Voltage (V) : Battery voltage OK → 2 NG → Repair the harness.	The after-heating of air heater and EGR control are inhibited
36	Air heater relay No.1 circuit malfunction	- The voltage of air heater relay is lower than 1V when air heater relay is turned ON - The voltage of air heater relay is higher than 4V when air heater relay is turned OFF	2 	Check for an open circuit, or a short circuit to ground between the powertrain control module and the injector. o ECM connector : Disconnected o Injector connector : Disconnected OK → END ! NG → Repair the harness.	The air heater relay No.1 & No.2 are deactivated (except engine starting) Glow lamp flashing
18	Air heater relay No.2 circuit malfunction	The voltage of air heater relay is lower than 1V when air heater relay is turned ON. The voltage of air heater relay is higher than 4V when air heater relay is turned OFF.			The air heater relay No.1 & No.2 are deactivated (except engine starting) Glow lamp flashing

Fault code	Items	diagnosis	Time	Limp home
02	Crankshaft position sensor circuit malfunction	The engine speed is lower than 60rpm when the engine starts.	3 sec	Inhibition of after-heat of air heater Inhibition of EGR

09	Engine coolant temperature sensor circuit malfunction	Engine coolant temperature is lower than -40°C. Engine coolant temperature is higher than 150°C.	2 sec	Inhibition of after heat of air heater Inhibition of EGR Inhibition of idle up
12	Throttle position sensor circuit malfunction Throttle angle is lower than 5%. Throttle angle is higher than 90%.	-	1sec	Inhibition of after heat of air heater Inhibition of EGR
16	EGR position sensor circuit malfunction	-	1sec	Inhibition of EGR
18	Air heater relay 2 circuit malfunction	The voltage of air heater relay is lower than 1V when air heater relay is turned ON The voltage of air heater relay is higher than 4V when air heater relay is turned OFF.	1sec	Air heater relay 1 and 2 are deactivated (except engine start). Glow lamp is flashing.
36	Air heater relay 1 circuit malfunction	The voltage of air heater relay is lower than 1V when air heater relay is turned ON The voltage of air heater relay is higher than 4V when air heater relay is turned OFF.	1sec	Air heater relay 1 and 2 are deactivated (except engine start). Glow lamp is flashing.



Injection timing

Inspection

1. Remove the battery negative cable and the fuel cut solenoid valve connector.
2. Remove intake hose.
3. Remove the fuel injection pipes from the injection pump.
4. Slowly rotate the crankshaft one revolution clockwise and rotate the crankshaft one revolution counterclockwise.
5. Align to TDC by slightly rotating the crankshaft in left and right.
6. After removing the cover of hydraulic part of injection pump and install measuring device (dial gauge) into the plug hole on the hydraulic head, and install the dial gauge so that its indicator can touches the plunger of pump.
7. Release wax cold start device from fuel injection pump.
 - A. Apply battery voltage (B+) to wax cold start device terminal and battery ground (B-) to fuel injection pump body.
 - B. Wait for 3 ~5 minutes until completely melting wax.
 - C. Verify that the cold start device lever contacts stop lever.
8. Slowly rotate the crankshaft pulley counterclockwise (in the reverse direction of engine revolution) until the indicator of dial gauge does not move.

NOTICE

The indicator of dial gauge stops when the crankshaft is turned approximately BTDC 30°~50°

9. Align the indicator of dial gauge to 0 by rotating the crankshaft pulley in left and right and then verify that the position of indicator.

NOTICE

After aligning the indicator of dial gauge to "0", verify that the indicator of dial gauge is not moved from "0" by slightly rotating the alternator pulley in left and right.

10. After rotating the crankshaft pulley clockwise at that the timing mark can be aligned with the indicator pin, verify that the indicator of dial gauge indicated.
 $0.7 \pm 0.05 \text{ mm}$ ($0.0276 \pm 0.02 \text{ in}$) when the timing mark (TDC 0°) can be aligned with the indicator pin.

Specification: $0.7 \pm 0.05 \text{ mm}$ ($0.0276 \pm 0.02 \text{ in}$)

11. If the dial gauge reading is not within the specification, slant the top of fuel injection to engine or the outside of engine so that dial gauge indicates
 $0.7 \pm 0.05 \text{ mm}$ ($0.0276 \pm 0.02 \text{ in}$) at TDC 0°
12. Tighten the three flange nuts of fuel injection pump.

Tightening torque
 $18.6 \sim 26.5 \text{ Nm}$ ($1.9 \sim 2.7 \text{ kg-m}$, $13.7 \sim 19.5 \text{ lb-ft}$)

13. Tighten the three flange nuts of fuel injection pump bracket.
14. Verify that the indicator of dial gauge is within $0.7 \pm 0.05 \text{ mm}$ ($0.0276 \pm 0.02 \text{ in}$) at TDC 0°. If the indicator is not within the specification, repeat the step 11~ step 13.
15. Remove measuring device for injection pump.

16. Install cap after inserting a new gasket.

Tightening torque

13.7~19.6Nm (1.4~2.0 kg-m, 10.0~14.5 lb-ft)

17. Tighten the injection pipe temporarily and tighten the four nuts on pump side.

Tightening torque

24.5~29.4Nm (2.5~3.0 kg-m, 18.1~21.7 lb-ft)

18. Connect fuel cut solenoid valve connector and wax cold start device connector.

19. After starting, check if there is any fuel leakage.

NOTICE

Perform the air bleeding after adjusting injection timing.

Glow lamp control

1. Glow lamp is controlled as following conditions:

A. ON condition (AND)

1. Water temperature $\leq 100^{\circ}\text{C}$
2. Within the time of glow lamp ON
3. Engine speed $\leq 500\text{RPM}$

B. OFF condition

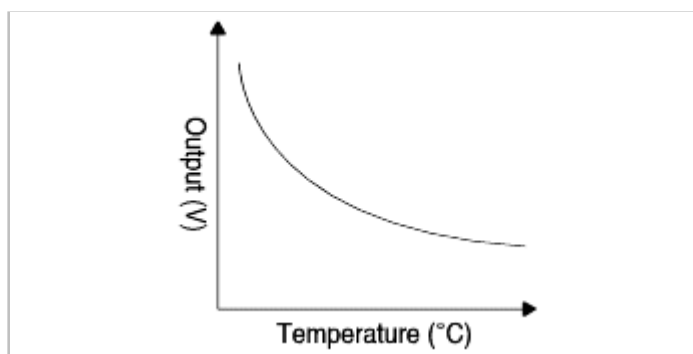
1. Glow lamp is always turned OFF without ON condition but glow lamp is not illuminated on condition of ON conditions after OFF conditions.

C. Forced OFF condition (OR)

1. Ignition switch OFF
2. START ON
3. At shutting off overvoltage

2. The time of glow lamp illumination is defined by engine coolant temperature (the time is set whenever ignition switch is turned to ON).

3. Glow lamp operation at heater relay fault if air heater relay is faulty, glow lamp flashes as following:



Glow relay control

1. Glow relay is controlled as following conditions:

A. Condition (AND)

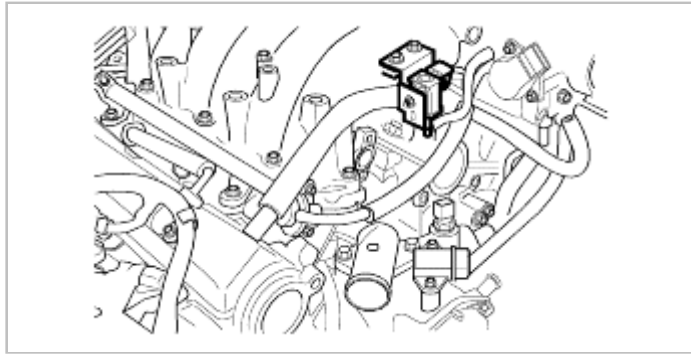
1. Ignition switch ON
2. None status of shutting off overvoltage
3. No faulty

4. Following condition (OR)
 - START ON
 - Engine coolant temperature $\leq 34^{\circ}\text{C}$ and at preheating
 - Engine coolant temperature $\leq 41^{\circ}\text{C}$ and at after-heating

Pre-heating

After-heating

1. After-heating is controlled as following conditions
 - A. Start condition (AND)
 1. Engine coolant temperature $\leq 41^{\circ}\text{C}$
 2. No fault
 3. Engine speed ≤ 500 RPM
 4. START OFF
 - B. Completion condition
 1. Timeout of after-heating (after completion condition, after-heating is not always operating on condition of start condition)
2. The time of glow lamp illumination is set according to engine coolant temperature (the time is set whenever ignition switch is turned ON).
3. For after-heating, air heater relay 1 & 2 are alternately operating by ten seconds as following diagram:

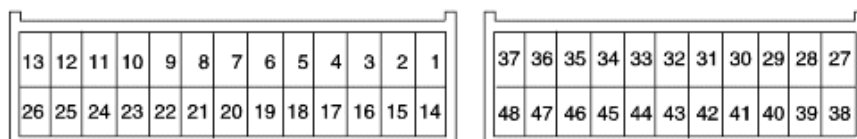


Operating time

Temperature (C)	Glow lamp	Preheating	After-heating
90	2	0	0
76	2	0	0
61	2	0	0
50	2	0	0
41	2	0	0
34	2	0	30
27	3	5	40
20	7	12	60
13	7	12	120
7	7	12	180
-8	11	16	240
-18	17	22	300
-32	17	22	300



ECM TERMINAL LAYOUT



Terminal	Signal	I/O	Connected to	Value
1	IG1	I	Ignition switch	B+ at ignition switch ON
2	-	-	-	-
3	EGR solenoid valve (Vacuum) control	O	EGR solenoid valve	32±3Ω at 20°C (68°F) ON-OFF control
4	Engine coolant temperature signal output	O	TCU	- -
5	Engine coolant temperature signal	I	Engine coolant temperature sensor	-
6	Throttle position sensor signal input	I	Throttle position sensor	0.3~0.9V at idle 4.0~4.4V at full open
7	Reference voltage	O	EGR position sensor Throttle position sensor	5V
8	A/C switch signal	I	Air conditioner switch	ON: B+ OFF: 0V
9	Test switch	I	Diagnosis connector	ON: GND
10	Vehicle signal	I	Ignition switch	Carnival: B+
11	Crankshaft position sensor signal (SGT+)	I	Crankshaft position sensor	4 pulse/1revolution
12	Starter switch signal	I	starter	B+ at cranking
13	Ground 1	I	Chassis ground	-
14	Air heater relay 1 control	O	Air heater relay 1	37Ω at 20°C (68°F) ON-OFF control
15	IG1	I	Ignition switch	B+ at ignition switch ON
16	EGR solenoid valve (vent) control	O	EGR solenoid valve (vent)	32±3Ω at 20°C (68°F) ON-OFF control
17	Glow lamp control	O	Glow lamp	3.4W
18	MIL control	O	MIL	LED
19	EGR position sensor signal	I	EGR position sensor	5KΩ at 20°C (68°F)
20	Air heater relay 1 signal	I	Air heater relay 1	B+ at activating relay
21	AT/MT signal input	I	AT/MT conversion	A/T: B+ MT: OPEN
22	-	-	-	-
23	-	-	-	-
24	Crankshaft position sensor signal (SGT-)	I	Crankshaft position sensor	-
25	Sensor ground	I	Engine coolant temperature sensor Throttle position sensor EGR position sensor	-

26	Ground 2	I	Chassis ground	-
27	-	-	-	-
28	Vehicle speed sensor signal	I	Instrument cluster	-
29	-	-	-	-
30	Air heater relay 2 signal	I	Air heater relay 2	B+ at activating relay
31	-	-	-	-
32	-	-	-	-
33	-	-	-	-
34	-	-	-	-
35	-	-	-	-
36	-	-	-	-
37	Cooling fan relay 1 control	O	Cooling fan relay 1	60Ω at 20°C(68°F)
38	-	-	-	-
39	-	-	-	-
40	Idle up solenoid valve control	O	Idle up solenoid valve	40Ω at 20°C(68°F)
41	-	-	-	-
42	-	-	-	-
43	Air heater relay 2 control	O	Air heater relay 2	37Ω at 20°C(68°F)
44	-	-	-	-
45	-	-	-	-
46	-	-	-	-
47	Cooling fan relay 2 control	O	Cooling fan relay 2	60Ω at 20°C(68°F)
48	-	-	-	-

Fuel System

Engine Control System - Engine Control
Module (ECM)



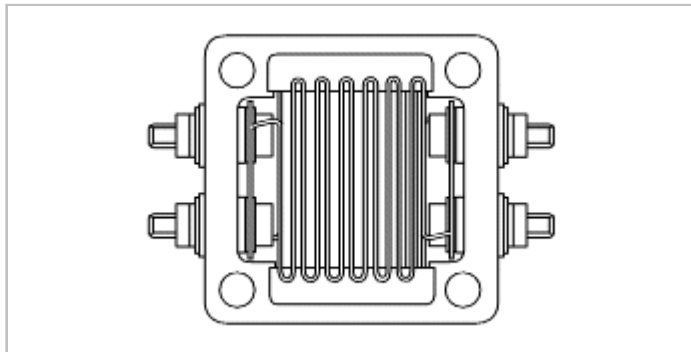
Air heater

Inspection

1. Disconnect both air heater connectors.
2. Use an ohmmeter to check continuity between both terminals of air heater.
3. If there is no continuity, replace air heater.
4. Clean air heater if there is carbon, dust or any other foreign material in it.
5. Replace gaskets on both sides of heater when installing.

CAUTION

Make sure gaskets are installed in correct direction (as shown).



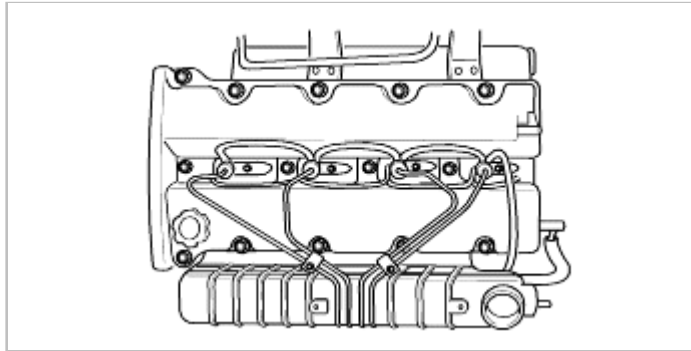
Fuel System

Mechanical Injection Pump



Removal

1. Disconnect battery negative cable.
2. Remove injection pipe.
3. Remove fuel return pipe.
4. Remove injector nozzle holder.
5. Remove injector nozzle holder gasket.



Installation

1. Install in the reverse order of removal.

CAUTION

- 1) Do not reuse the washer and the corrugated gasket.
- 2) When installing the corrugated gasket, the red-painted surface should be faced to the injection nozzle.
- 3) Keep the specified torque when installing the injection nozzle.
- 4) Bleed air when installing the injection nozzle.

Tightening torque:

43.4~50.6 lb-ft (59~69 N·m, 6~7 kg-m)

Inspection

NOTICE

Inspect the fuel injection nozzle by using diesel fuel at about 20°C(68°F)

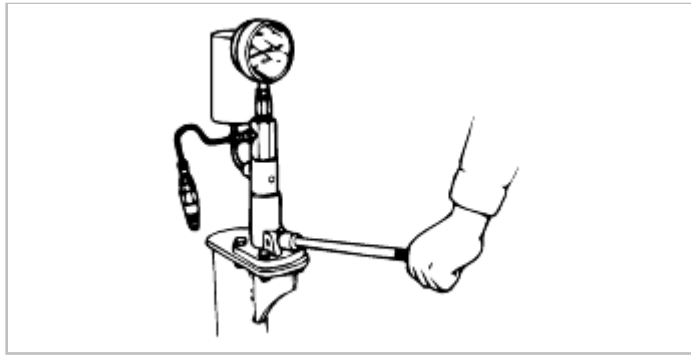
Injection starting pressure

1. Set the injection nozzle tester and bleed air by pumping handle several times.
2. Slowly push down the handle of nozzle tester and check injection starting pressure.

Injection starting pressure:

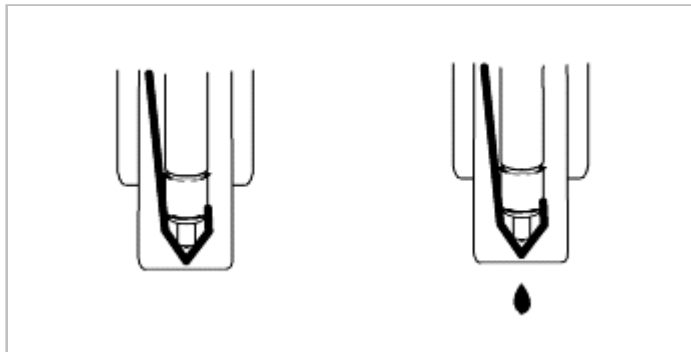
20,600 kPa (210 kg/cm², 2,986 psi)

: 2 stage opening pressure



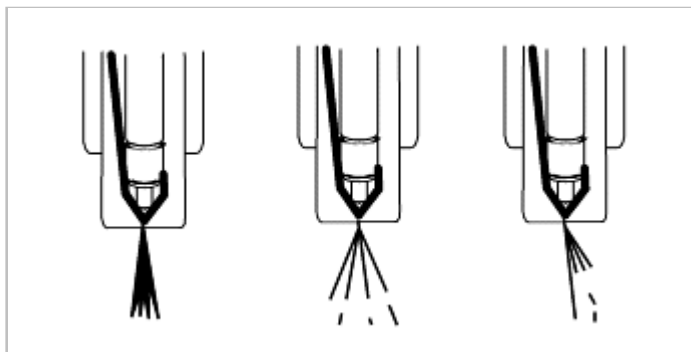
Valve seat

1. Apply a certain pressure 11,270 kPa (115 kg/cm², 1,634 psi) and check if fuel leaks from the injection nozzle hole. If fuel leaks, disassemble, clean and check injection nozzle again, or replace it.



Atomizing condition (Spray pattern)

1. Set the nozzle on the nozzle tester and bleed air by pumping handle several times.
2. In condition that pressure is not applied to nozzle, push handle several times quickly (push handle as quickly as possible so that a pulsation noise can be heard) and check atomizing condition.
 - (1) Fuel should be sprayed uniformly and finely.
 - (2) Injection angle and direction should be normal.
3. If atomizing condition is abnormal, disassemble, clean and check injection nozzle again, or replace it.

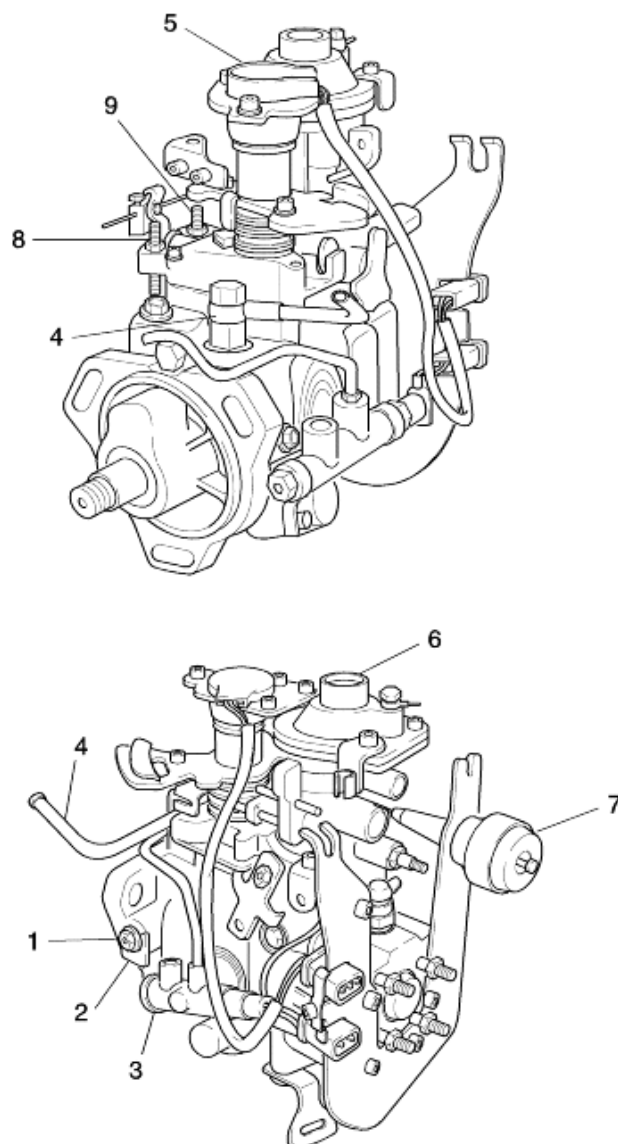


Fuel System

Fuel Delivery System - Fuel Pump



Injection pump

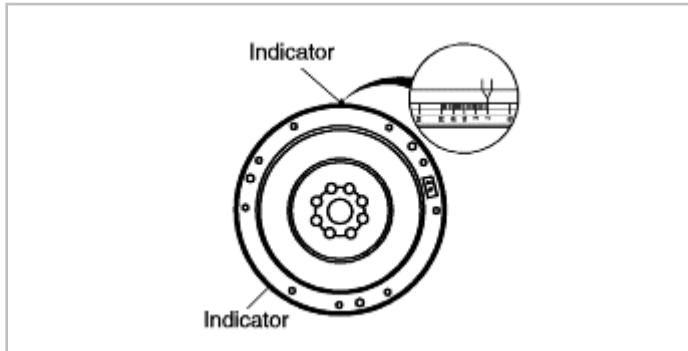


- | | |
|--|--|
| 1. Locking bolt | 6. LDA(Boost pressure compensation device) |
| 2. Locking plate | 7. PLA(Load compensation actuator) |
| 3. KSB | 8. Idle speed adjusting screw (A/C ON) |
| (Injection timing advancing during cold engine starting) | 9. Idle speed adjusting screw (A/C OFF) |
| 4. Fuel pipe | |
| 5. TP sensor | |

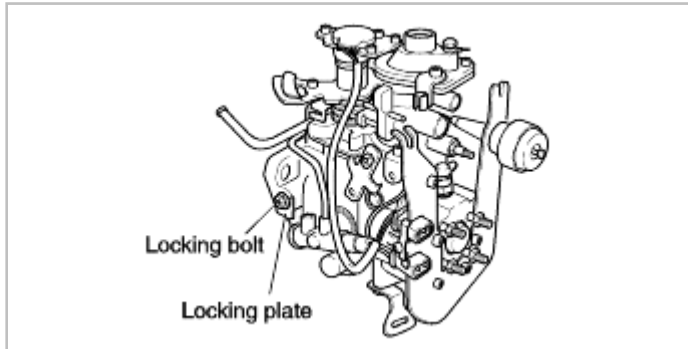


Removal

1. Rotate crankshaft slowly and align yellow marking on crankshaft pulley with indicator on the timing belt cover.



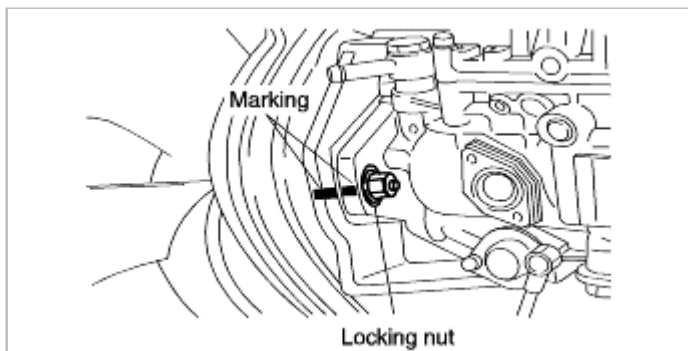
2. Remove injection pipe between injection pump and injection nozzle.
3. Remove locking plate of injection pump and assemble locking bolt.



4. Remove injection pump pulley.



5. Mark as shown figure for installing injection pump and loosen locking nut and stay bolt.



6. Remove injection pump.

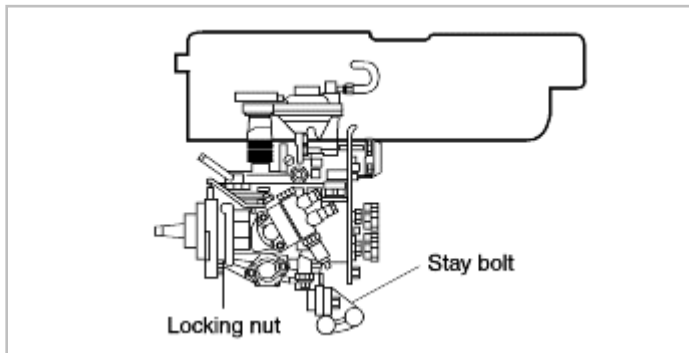
Installation

1. Position injection pump and install injection pump pulley loosely.

Tightening torque: 3.0 kg-m

2. Inspect the injection pump for injection timing.
3. Install injection pump locking nut and stay bolt.

Tightening torque: 1.9 kg-m



4. Loosen locking bolt and reinstall and install locking plate.
5. Install injection pump pulley.
6. Install injection pipe between injection pump and injection nozzle.

Fuel System

Fuel Delivery System - Fuel Filter



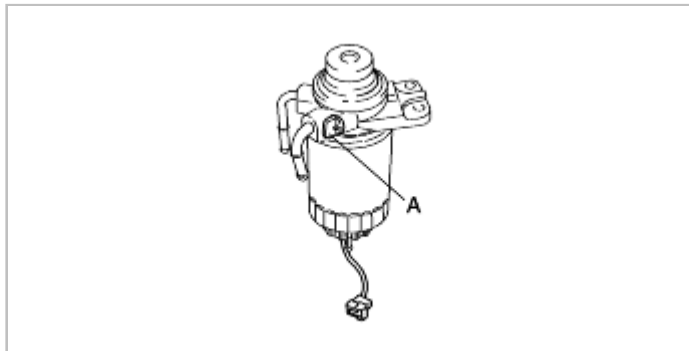
Fuel filter (Built-with sedimentor)

Air bleeding

CAUTION

In case that air is present in the injection system because of lack of fuel during engine operation, or the injection pump is replaced, air bleeding should be performed according to the following procedures, and then start engine and verify if fuel is not leaked.

1. Remove the fuel filter air bleeding plug A.
2. Depress and release repeatedly the head of fuel filter until only fuel flows out.
3. Install the air bleeding plug while depressing the head of fuel filter.



CAUTION

Please refill with fuel before the engine has run out of fuel

Since the presence of air in the fuel system anywhere between the fuel tank and injector will cause a no start, always the bleed air from the system when the engine has run out of fuel.

If the engine is stopped due to fuel empty, please start the engine by following procedures.

1. Refill with diesel fuel before you begin the following procedures.
2. Bleed the air from the fuel filter.
Loosen the air bleed screw at the top of fuel filter body and operate the manual handle of the lift pump until the air bubbles completely expel in the fuel following from the filter, re-tighten the screw.
3. Bleed the air from the fuel line (line from the filter to the injection pump)
Loosen the nipples on the injector side, and crank engine. When no more bubbles appear in the fuel following from the end of the injection pipe, re-tighten the nipple.

Draining water

NOTICE

If the sedimentor warning light is lit, drain the water in the steps as shown below.

1. Remove the drain plug, and then drain the water while depressing and releasing repeatedly the head of fuel filter.
2. After draining the water, do air bleeding for the fuel filter.

Detector

1. Remove the detector from the sedimentor.
2. Do the continuity test and verify that it is closed if the detector is moved upward and opened if downward.

CAUTION

After installing the detector, air bleeding should be done.

