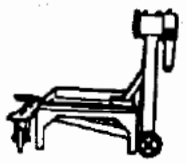
SPECIAL SERVICE TOOLS

Engine
Special service tools

0K130 990 007

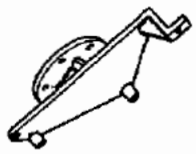
Engine stand



Used to disassemble and assemble engine.

0K410 101 004

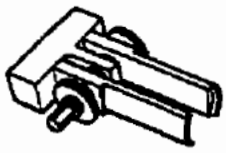
Hanger, engine stand



Used to disassemble and assemble engine.

0K993 120 004

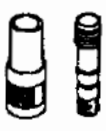
Pivot, valve spring lifter



Used to remove and install valve.

0K710 120 004

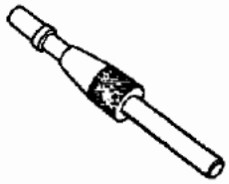
Installer, valve seal



Used to install valve seal.

0K130 160 010

Centering tool, clutch disc



Used to install clutch disc and clutch cover.

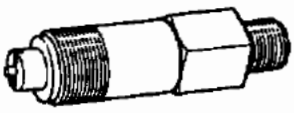
0K552 111 001

Holder, camshaft pulley

Used to install camshaft pulley.

0K552 131 002

Adapter, compression gauge



Used to measure compression pressure.

0K993 120 001

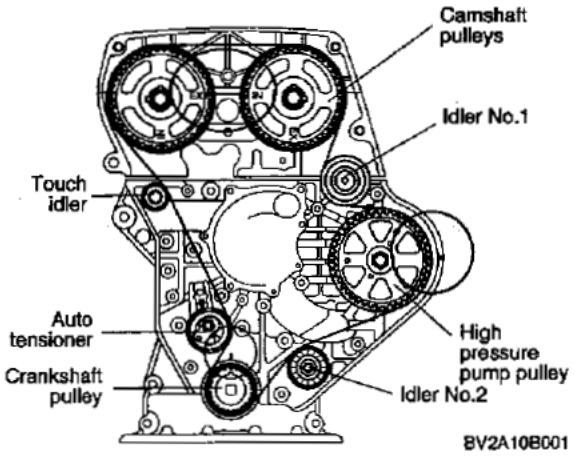
Arm, valve spring lifter

Used to remove and install valve.

Problem	Possible Cause	Action to be taken
White smoke out of exhaust	Usually caused by water vapor, which is a normal by product of combustion on cold days. Excessive white smoke with engine warmed up could be caused by a failed cylinder head or intake gasket, could also be cracked block, cylinder head or intake manifold.	None required Repair or replace
Black smoke out of exhaust	Malfunction of fuel system Malfunction of emission system	Refer to section FL, fuel system Refer to section EC, emission control system
Abnormal combustion	Sticking or burned valve Weak or broken valve spring Carbon accumulation in combustion chamber	Replace Replace Eliminate the carbon
Poor idling	Malfunction of fuel system Malfunction of emission system Uneven cylinder compression Poor valve to valve seat contact Broken valve spring Failed cylinder head gasket	Refer to section FL, fuel system Refer to section EC, emission control system Repair Repair or replace Repair Replace
Turbocharger noise	Contaminated air cleaner element Foreign material in intake duct or compressor housing Foreign material between intake manifold and compressor Foreign material in engine exhaust system Carbon deposit on turbine housing Interference between turbocharger rotating parts Loose connecting parts of intake and exhaust system	Replace Clean Clean Clean Clean Repair or replace Tighten
Engine knocks when hot and at idle **Slight noise at idle, becomes louder as engine speed is increased**	Loose or worn accessory drive belt/tensioner Improper oil viscosity Excessive piston pin clearance Connecting rod alignment Insufficient piston to bore clearance Faulty timing belt tensioner or guide Loose damper pulley Valve spring clicking on cap, off square or broken Excessive stem to guide clearance Excessive valve seat runout Holed exhaust pipe	Replace if necessary Install proper oil viscosity for expected temperature Install new piston pin and/or connecting rod Check and replace Hone and fit new pistons Replace Tighten or replace Repair or replace Repair Repair Replace
Engine knoks when cold	Excessive piston to wall clearance Loose or broken damper pulley	Replace Tighten or replace
Knock increase with torque	Excessive piston to bore clearance Bent connecting rod	Replace piston Replace
Engine has heavy knock when hot and torque is applied	Broken damper pulley Accessory belts too tight or damaged Belt tensioner damaged Flywheel cracked or loose clutch plate Excessive main bearing clearance Excessive rod bearing clearance	Replace Adjust or replace belt Replace Replace flywheel or clutch plate Repair Repair

Replacement

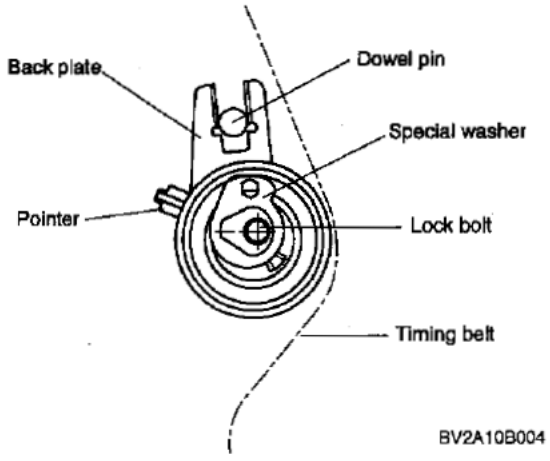
1. Check that timing mark on timing belt pulley, camshaft pulley and high pressure pump pulley is aligned with timing mark on engine.



2. Install the timing belt.
   1) The timing belt is installed in sequence crank shaft pulley, idler No.2, high pressure pump pulley, idler No.1 and camshaft pulley.

✱ *Notice*
   a) The auto-tensioner must be mounted onto the engine after the timing belt is installed.
   b) Keep the tension of timing belt when install timing belt.

3. Install the auto-tensioner.
   1) Install the auto-tensioner as shown illust. The dowel pin has to be located between the tensioner fork (back plate).



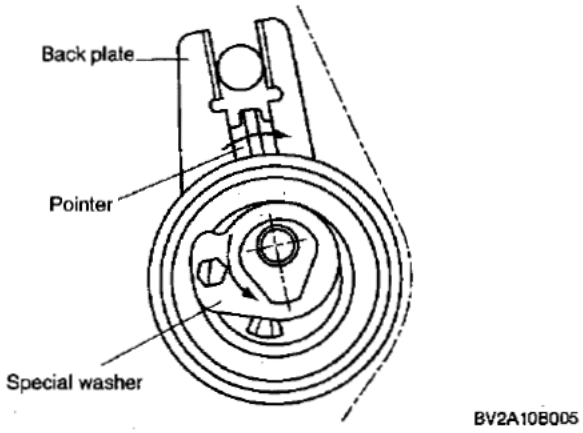
   2) Pretighten the auto-tensioner.

Tightening torque:
2.9lb-ft (3.9N•m , 0.4kg-m)

✱ *Notice*
   a) Oil must not get in contact with the tensioner. The tensioner has to be replaced by a new one, if it is oily.
   b) The positions of the pointer, the back plate and the special washer are in accordance to the illust.

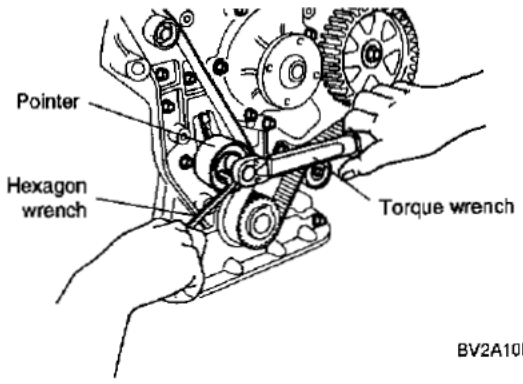
4. Check again if the alignment marks of camshafts, crankshaft and high pressure pump are aligned with the marks on the timing case.

5. Adjust the auto-tensioner, and then tighten it.
   1) Align the pointer to the back plate by rotating the special washer in counter-clockwise using the hexagon wrench as shown illust.



   2) Tighten the auto-tensioner lock bolt with holding the special washer by the hexagon wrench when the pointer is aligned with the back plate.

Tightening torque :
17.4lb-ft (23.5N•m , 2.4kg-m)



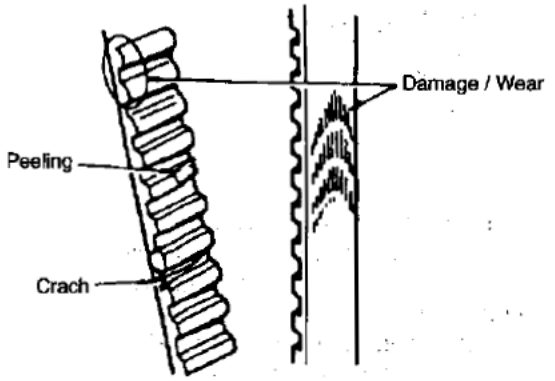
   3) Remove the hexagon wrench.

Inspection

Front timing belt

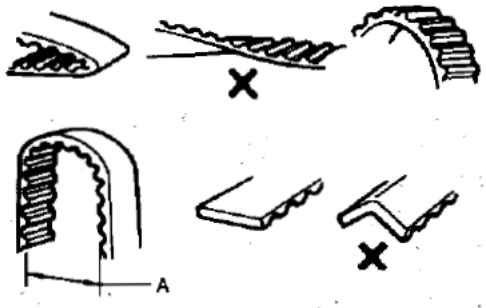
✱ *Notice*
a) Never forcefully twist, turn inside out or bend timing belt.
b) Do not allow oil or grease to come in contact with timing belt.

1. Replace timing belt if it is contaminated with oil or grease.
2. Check timing belt for uneven wear, fraying, peeling, cracking and hardening. Replace timing belt if necessary.



ABT010217

3. Bend timing belt into a "U" shapes as shown in figure. Distance "A" must be at least 1.0 in (25 mm).



ABT010216

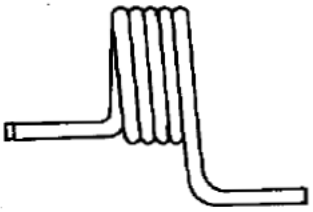
Camshaft pulleys and timing belt pulley

✱ *Notice*
Do not clean pulleys with cleaning fluids. If needed, use a soft cloth to wipe them clean, and avoid scratching the pulleys as it will affect integrity of the timing belt.

1. Check pulley teeth for wear, deformities and other damage. Replace pulleys if necessary.

Tensioner spring

1. Check the tensioner spring. Replace tensioner spring if necessary.

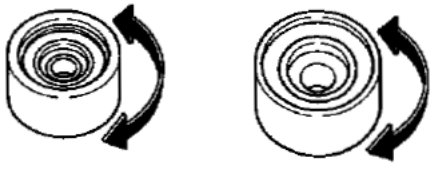


AV2A10B083

Tensioner and idler

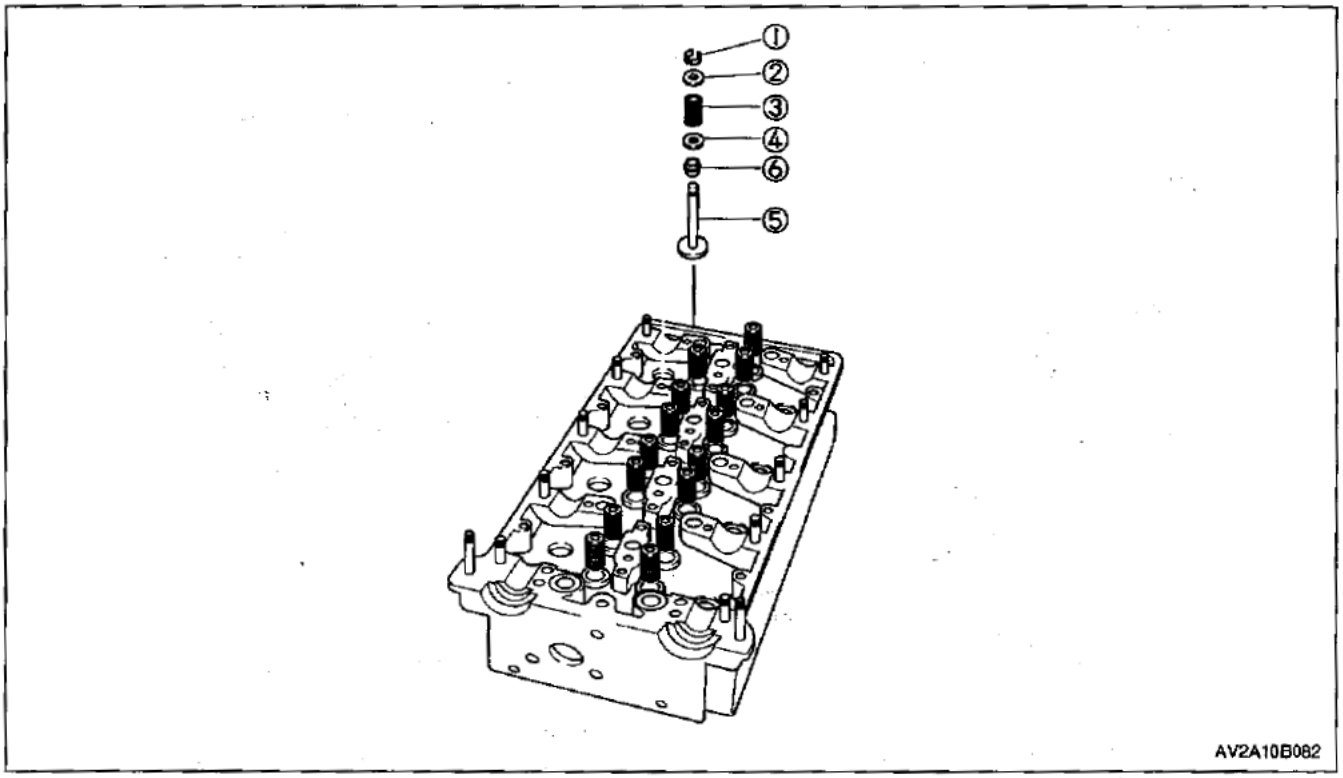
✱ *Notice*
Do not clean tensioner pulley or idler pulley with cleaning fluids. If needed, use a soft rag to wipe them clean. Avoid scratching tensioner pulley or idler pulley as it can affect integrity of timing belt.

1. Check tensioner pulley and idler pulley for smooth rotation and proper sound. Replace tensioner pulley and idler pulley if necessary.



AV2A10B064

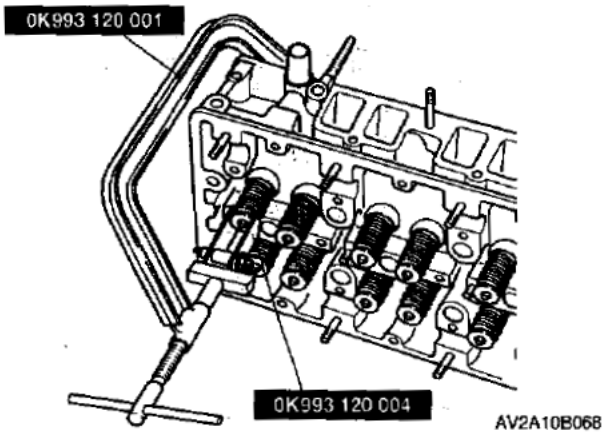
Cylinder head



(1) Valve cotter
(2) Valve spring upper seat
(3) Valve spring
(4) Valve spring lower seat
(5) Valve
(6) Valve seal

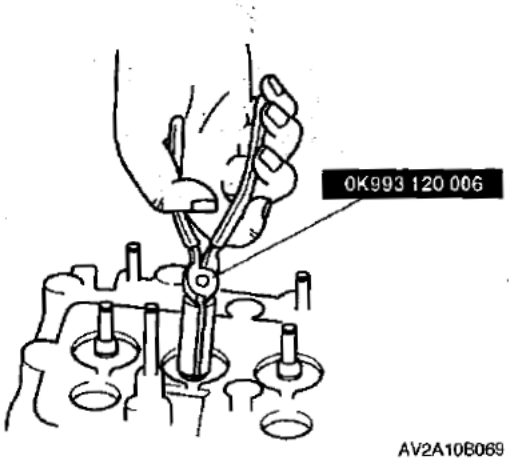
Disassembly

1. Remove the valve cotter by using the **SST (0K993 120 001 / 0K993 120 004)**.



2. Remove the valve spring upper seat, valve spring, valve spring lower seat and valve.

3. Pull the valve seal out by using the **SST (0K993 120 006)**.

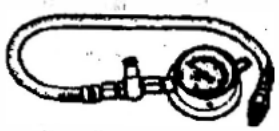


SPECIAL SERVICE TOOL

Lubrication system
Special service tool

0K670 140 015

Oil pressure gauge



Used to inspect oil pressure.

SYMPTOM-RELATED DIAGNOSTIC PROCEDURE

Lubrication system
Diagnostic chart

Problem	Possible Cause	Action
Engine hard starting	Improper engine oil Insufficient engine oil	Replace Add oil
Excessive oil consumption	Internal engine wear Oil leak	*Refer to Section EM* Repair
Oil pressure drop	Insufficient oil Oil leakage Worn and/or damaged oil pump gear Worn plunger (inside oil pump) or weak spring Clogged oil strainer Excessive main bearing or connecting rod bearing clearance	Add oil Repair Replace Replace Clean *Refer to Section EM*
Warning lamp illuminates while engine is running	Oil pressure drop Malfunction of oil pressure switch Malfunction of electrical system	As described above *Inspect oil pressure switch* *Inspect electrical system*

COMMON RAIL ACCUMUALTOR FUEL-INJECTION SYSTEM

Field of application

The in-line fuel-injection pump's main area of application is still in all sizes of commercial-vehicle diesel engines, stationary diesel engines, locomotives and ships. Injection pressures of up to approx. 1600 bar are used to generate output powers of up to about 160 kW per cylinder.
Over the years, a wide variety of different requirements, such as the installation of direct-injection (DI) engines in small delivery vans and passenger cars, have led to the development of various diesel fuel-injection systems which are aligned to the requirements of a particular application. Of major importance in these developments are not only the increase in specific power, but also the demand for reduced fuel consumption, and the call for lower noise and exhaust-gas emissions. Compared to conventional cam-driven systems, the Delphi "Common Rail" fuel-injection system for direct-injection (DI) diesel engines provides for considerably higher flexibility in the adaptation of the injection system to the engine, for instance:

- Extensive area of application (for passenger cars and light commercial vehicles with output powers of up to 30kW/cylinder, as well as for heavy-duty vehicles, locomotives, and ships with outputs of up to approx. 200kW/cylinder,
- High injection pressures of up to approx. 1400 bar.
- Variable start of injection,
- Possibility of pilot injection, main injection, and post injection,
- Matching of injection pressure to the operating mode.

Funtions

Pressure generation and fuel injection are completely decoupled from each other in the "Common Rail" accumulator injection system. The injection pressure is generated independent of engine speed and injected fuel quantity. The fuel is stored under pressure in the high-pressure accumulator (the "Rail") ready for injection. The injected fuel quantity is defined by the driver, and the start of injection and injection pressure are calculated by the ECU on the basis of the stored maps. The ECU then triggers the solenoid valves so that the injector (injection unit) at each engine cylinder injects accordingly. The ECU and sensor stages of such a CR fuel-injection system comprise:

- ECU,
- Crankshaft angle sensor,
- Phase sensor,
- Accelerator-pedal sensor,
- Rail-pressure sensor,
- Water temperature sensor and,
- Air-flow sensor.

Using the input signals from the above sensors, the ECU registers the driver's requirements (accelerator-pedal setting) and defines the instantaneous operating performance of the engine and the vehicle as a whole. It processes the signals which have been generated by the sensors and which it receives via data lines. On the basis of this information, it can then intervene with open and closed-loop controlling action at the vehicle and particularly at the engine. The engine speed is measured by the crankshaft-Angle sensor, and the phase sensor and the phase sensor determines the firing sequence (phase length). The electrical signal generated across a potentiometer in the accelerator-pedal module informs the ECU about how far the driver has depressed the pedal, in other words about his (her) torque requirement.
The ari-flow sensor meter provides the ECU with data on the instantaneous air flow in order that combustion can be adapted so as to comply with the emissions regulations.

DESIGN AND FUNCTION OF THE COMPONENTS

Low-pressure stage

The low-pressure stage provides enough fuel for the high-pressure section. The most important components are:

- Fuel tank,
- Lift pump(integrated in HP-pump),
- Low-pressure fuel lines for supply and return,
- Fuel filter and
- Low-pressure area of the high-pressure pump.

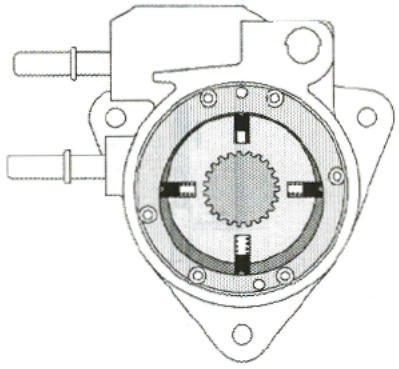
Lift pump(Transfer pump)

Description

The lift pump is included in the housing of the HP pump. The lift pump is of the volumetric blade type pump: and consists of the following components:

- A rotor turned by the shaft of the HP pump. The connection is provided by splines.
- An eccentric liner fixed to the housing of the HP pump by 6 Torx bolts. The liner is positioned by two off-set pins in order to prevent any assembly errors.
- A plate provided with two oblong holes.
- The inlet and outlet orifice.
- Four blades set at 90°. Each blade is held against the liner by a coil spring.(Fig. 1)

[Fig. 1] Lift pump (Transfer pump, feed pump)



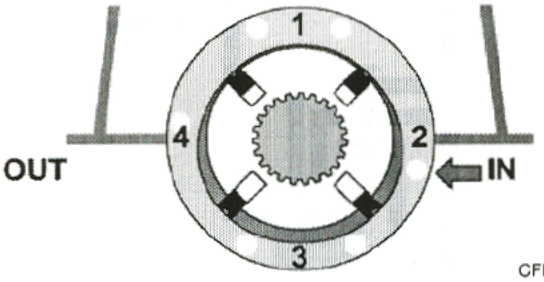
CFL0FL065

Principle of operation

Consider the chamber between the rotor, the liner and two successive blades. (Fig. 2)

- When the chamber is in position 1, the volume of the chamber is minimal. The changes in volume according to the angle of rotation of the rotor are small.
- The rotor makes a quarter turn clockwise.
  The previous chamber is now in position 2. The inlet orifice is uncovered. The volume contained in the chamber quickly rises. The pressure inside the chamber drops sharply. Fuel is drawn into the chamber.
- The rotor continues to rotate It is now in position 3. The inlet and outlet orifices are now sealed off.
  The volume area controlled by the rotor, the liner and the two blades is at the maximum. The changes in volume according to the angle of rotation of the rotor are small.
- The rotor continues to rotate. It is finally in position 4. The outlet orifice is uncovered. The volume area controlled by the rotor, the liner and the blades decreases quickly. The pressure inside the chamber rises sharply. The fuel is expelled under pressure.
  The depression caused by the transfer pumpis rotation is sufficient to draw in diesel fuel through the filter. The transfer pump is driven by the shaft of the HP pump, transfer pressure thus rises with engine speed.

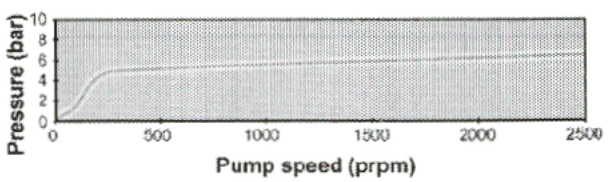
[Fig. 2] Principle of operation



CFL0FL066

A regulating valve allows the transfer pressure to be maintained at a practically constant level (about 6 bar) throughout the whole range of engine operations by returning some of the fuel to the pump inlet.

[Fig. 3]



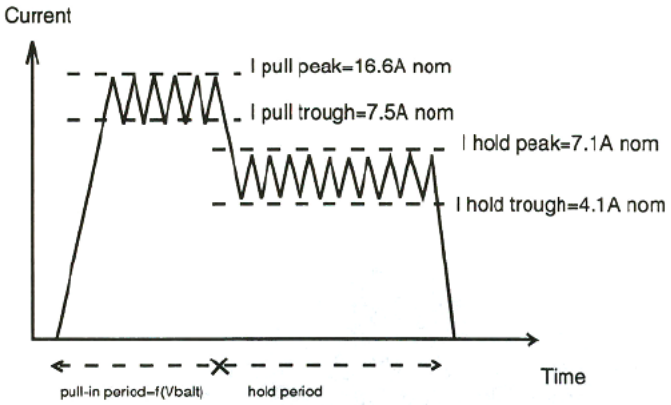
CFL0FL067

Injector drive current definition

The injector definition allows for low drive currents:

- I pull mean = ~10.5 A at 12V
- I hold mean = ~5A at 12V

[Fig.3]



Power dissipation

•The maximum injectors drive dissipation is 4.5W worse case with a EURO IV regulation scenario.
•The maximum estimated dissipation is 14.2W worse case for the complete Control unit.

Electrical limits

The ECU supply is the voltage between the ECU supply and ground pins.
The voltage drop inside the wires from the battery to the ECU supply must be as low as possible.

Nominal voltage at Control Unit: 12V
Nominal system functionalities: 10 to 16V
Limited system functionnalities: 6 to 10V
Derated functionalities: 16 to 18V (18V for 1 hour max)
No damage: 24V during 2 minutes

INJECTION CONTROL

PRESSURE CONTROL

Pressure control consists of two principal modules:

- The first determines the rail pressure demand value as a function of the engineís operating conditions.
- The second is responsible for controlling the IMV to ensure that the rail pressure reaches the required value.

Pressure demand

Pressure demand is determined according to engine speed and load on the engine. The aim is to adapt the injection pressure to the engineís requirements:

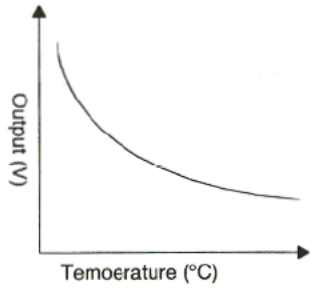
- When engine speed and load are high, the degree of turbulence is very great and the fuel can be injected at very high pressure in order to optimise combustion.
- At low load or low engine speed, the filling is slower and the degree of turbulence is low. If injection pressure is too high, the nozzleís penetration will be excessive and part of the fuel will be sprayed directly onto the sides of the cylinder, causing the formation of smoke and unburned hydrocarbons and perhaps eventually damaging the piston.

Pressure demand is corrected according to air temperature, water temperature and atmospheric pressure and to take account of the added ignition time caused by cold running or by high altitude driving.
A special pressure demand is necessary in order to obtain the additional flow required during starts.
This demand is determined according to injected fuel and water temperature.
The pressure demand is limited as a function of fuel temperature. In fact, not all of the fuel compressed by the HP pump is injected into the engine. Part of the compressed fuel is sent back to the fuel tank through the back leak circuit. The reduction in pressure of the fuel from rail pressure to atmospheric pressure causes a large amount of heat to be released into the fuel tank.

Trouble symtoms / Check items	Engine overrun, Accel.	White/Blue smoke	Clouds of black smoke	Engine overheating	Can not shut off with IG key	Diagnosis lamp not go out or flickers	AC cannot be switched on	RAD. Fan constantly in operation
Rail Pressure Sensor								
Accel. Position Sensor	3						6	
Mechanical fault in accel.	2							
EGR			3					
HFM5 (Air Flow Meter)			5					
Air filter clogged			2					
Vacuum system leaking			4					
Turbocharger defective	4							
Waste-gate valve connection	5							
Fuel Temp. Sensor	9							
Checking belt tension								
Clutch switch								
Brake switch								
Vehicle speed signal								
Checking oil level		7						
Radiator fan				4				
Radiator defective or clogged				5				
IG switch defective					2			
AC compress. SW							4	2
AC SW							3	
Plug contacts								
Connection between turbo. and Intake manifold. Leaking								

Features of IAT output

For the measure feature of the IAT at malfunction, if the coolant temperature is normal, the intake air substitution value is 0°C when the coolant temperature is below 69.75°C while the value is 60°C when the coolant temperature is over 69.75°C. The substitution value should be 60°C when the engine coolant temperature sensor is failed simultaneously.



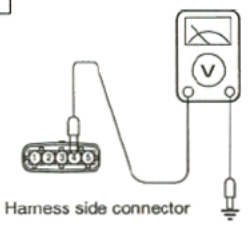
P-38

Using voltmeter

Item to check	Data output	Condition to check	Intake air temp.	Resistance
Intake air temp. sensor	Intake air temp.	Ignition switch: ON or starting	-40°C	33.85~61.20 kΩ
			20°C	2.22~2.82 kΩ
			80°C	0.299~0.375 kΩ

Harness inspection (MAFS)

1



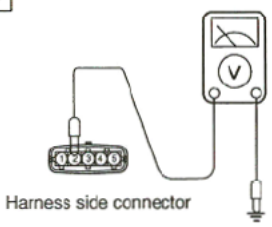
Meaure the reference power supply voltage.
- Connector : Disonnected
- Ignition switch : ON
- Power(V) : 4.8~5.2

OK ⇒ 2

NG ⇒ Repair the harness

KFW5240A

2



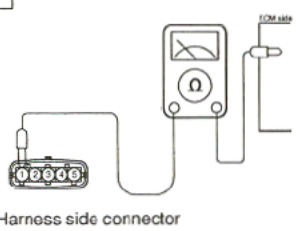
Measure the voltage of power supply for sensor.
- Connector : Disonnected
- Ignition switch : ON
- Voltage (V) : B+

OK ⇒ 3

NG ⇒ Repair the harness

KFW5241A

3



Check for an open or short circuit between ECM and IAT signal circuit.
- ECM connector : Disconnected.
- IAT sensor connector : Disconnected

OK ⇒ 4

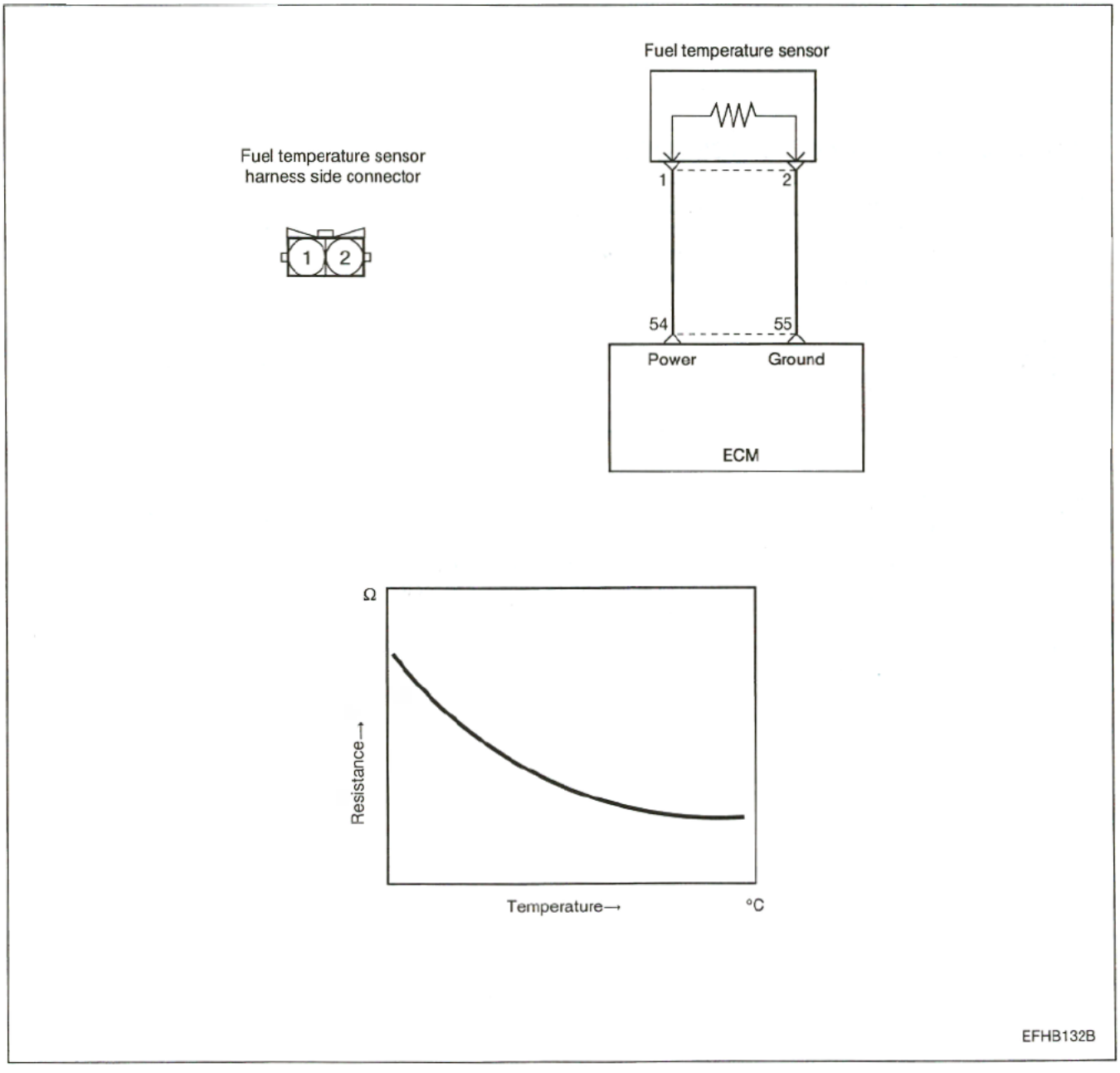
NG ⇒ Repair the harness

KFW5244A

FUEL TEMPERATURE SENSOR (FTS)

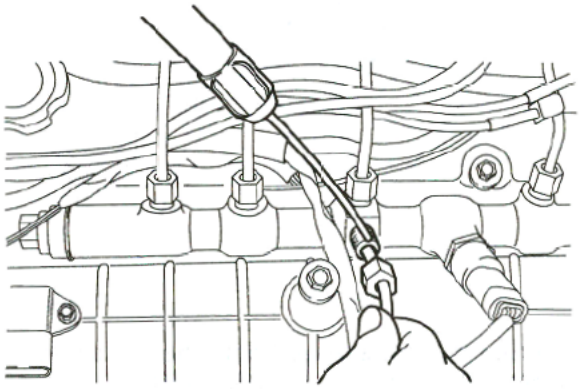
The fuel temperature sensor is equipped with a temperature-dependent resistor with a negative temperature coefficient (NTC) which is part of a voltage-divider circuit across which 5V are applied.
The voltage drop across the resistor is inputted into the ECM through an analog-to-digital converter (ADC) and is a measure for the temperature. A characteristic curve is stored in the ECM microcomputer which defines the temperature as a function of the given voltage value.

[CIRCUIT DIAGRAM]



- Move th nut along the pipe, keeping the olive in contact with the cone of the HP inlet of the rail and vacuum up the particles in the area of contact between the olive and the cone with the aid of the pneumatic suction device (Figure 23).
- Carry out the same operation on the pump side.

[Fig.23]



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- Remove the clip of the rail/pump HP pipe.
- Remove the rail/pump HP pipe.
- Vacuum up the particles inside the cone of the rail HP inlet using the pneumatic suction device.
- Carry out the same operation on the pump side.
- Immediately seal the HP inlet of the rail and the HP outlet of the pump with the recommended plugs.

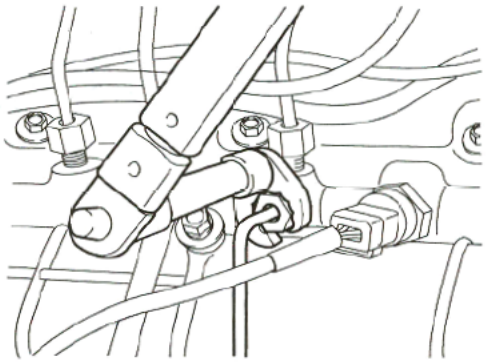
Reassembly fo rail/pump pipe

- Take the new pipe out of its packing just before fitting it.

⚠ WARNING
IT IS PROHIBITED TO RE-USE AN OLD PIPE.

- Remove the plugs inserted at each end of the pipe.
- Lubricate the threads of the nuts with the lubricant supplied in the kit.
- Remove the protective plugs from the rail HP inlet and the pump HP outlet.
- Fit the pipe olive into the cone of the rail HP inlet and tighten the nut by hand.
- Reassembly the clip of the rail/pump HP pipe and partially tighten it.
- Fit the pipe olive into the cone of the pump HP outlet and tighten the nut by hand.
- Tighten the nut on the rail side to a torque of 40Nm(29.5 lb-ft)(Figure 24).
- Tighten the nut on the pump side to a torque of 40Nm(29.5 lb-ft)(Figure 25).
- Fully tighten the clip fo the rail/pump HP pipe (Figure 26).

[Fig.24]



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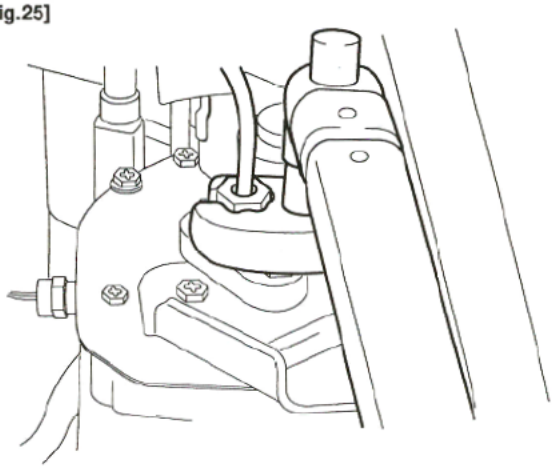
[Fig.25]



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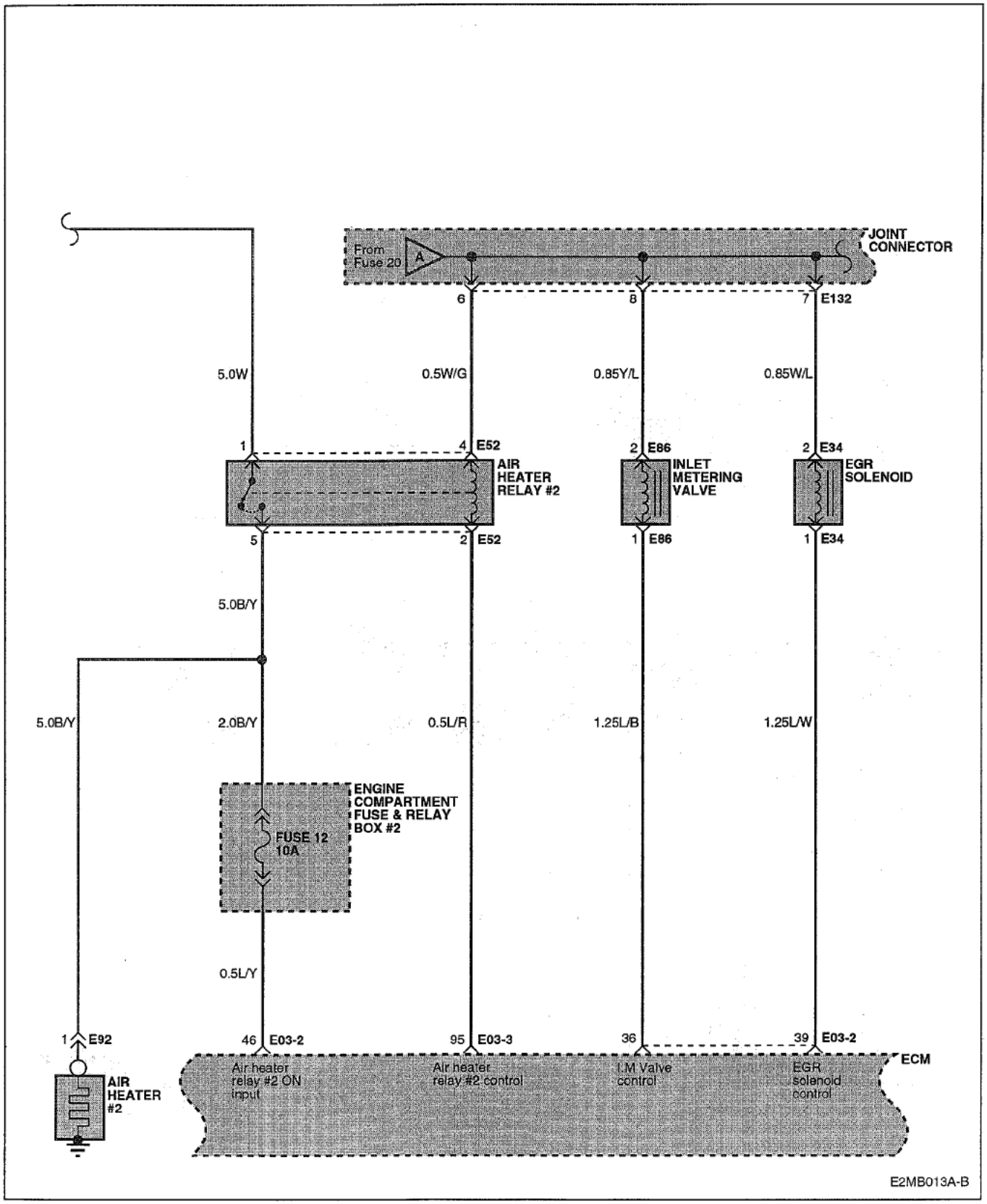
MFI CONTROL SYSTEM (2)



COMPONENT LOCATION INDEX