Contents

◨ **Engine General**

- Diesel Engine Basic

- A-2.5TCI Common Rail Direct Injection

- Sigma - 3.5

- Sirius Ⅱ - 2.4

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Diesel Engine

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Diesel Fuel Property

■ Comparison

Property / Fuel	Diesel	Gasoline
Heat Value(kcal/kg)	12,840	11,300
Specific Gravity	0.85~0.97	0.70~0.75
Flash Point(℃)	60~85℃	-40℃(below)
Ignition Point (℃)	350 (℃)	550 (℃)
Viscosity(Sec.)	Diesel > Gasoline	
Ignitibility(Knock)	Cetane No.	Octane No.
Fuel Consumption(g/ps)	150~240	230~300

※ Others : Sulfur content, Carbon number, Oxidation & water

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■ Cetane No. vs Carbon monoxide

Diesel Fuel Property
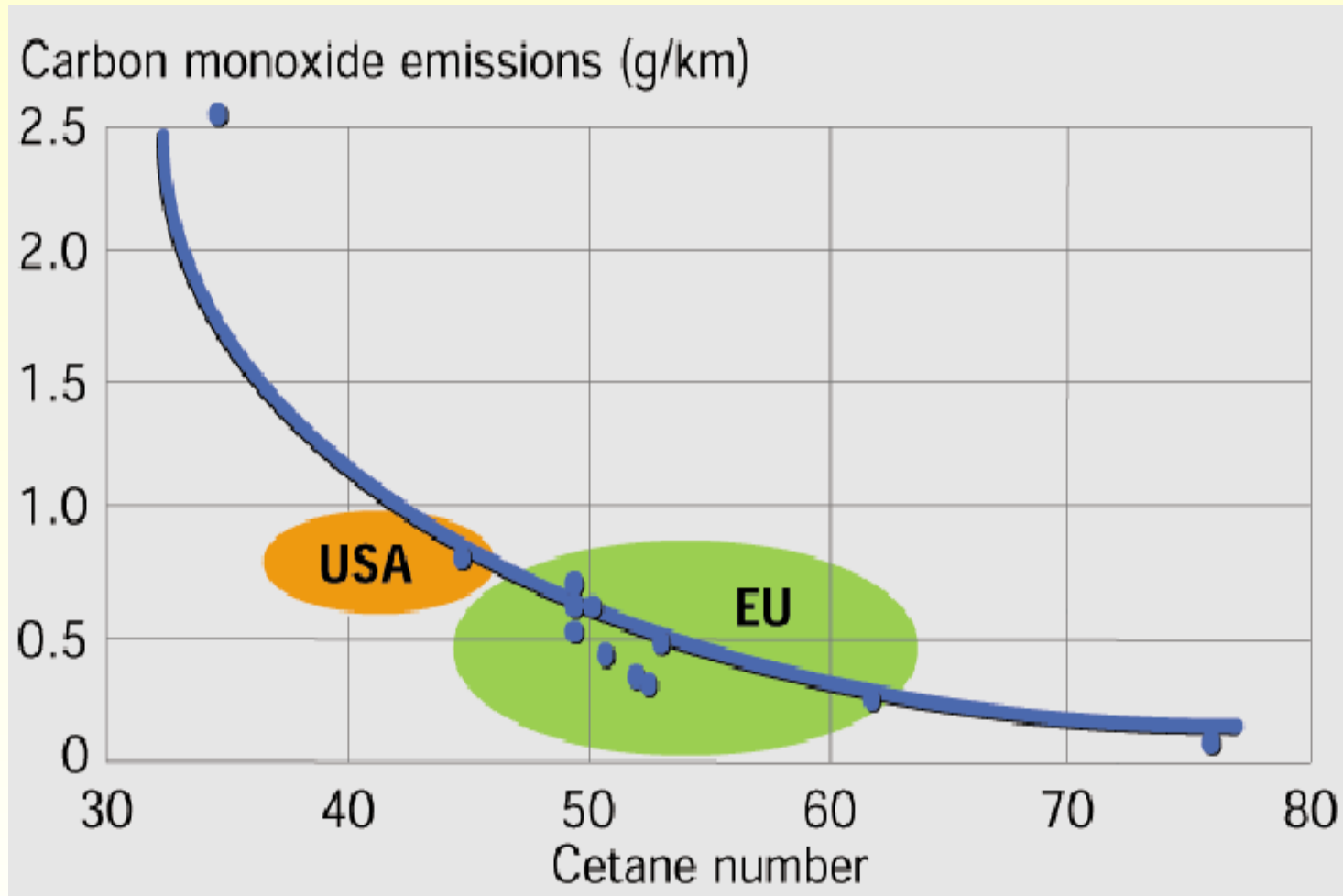
■ Diesel fuel's injection condition

1. Atomization :

- The atomized mist pressurized by high pressure (nearly 100 ~ 1500bar) pump

  is injected through small nozzle hole at the end of injector. This fuel mist has

  collisions with compressed air in the combustion chamber with high speed.

  The size of this injected mist needs to be atomized as smaller as possible so that its

  total surface contacted with air becomes larger. In this reason, the atomization is the

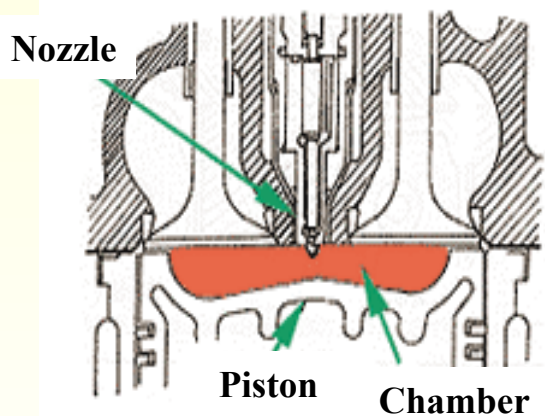 most important factor for ignition and perfect combustion.

2. Penetration :

- Even though the injected fuel is in good condition in atomization, it is difficult to meet

  fresh air in compressed combustion chamber if this mist hasn't enough power to go

  fast and quite a way off. Generally Atomization and Penetration can not be met

  together in normal situation since atomized mist has much more resistor for air.
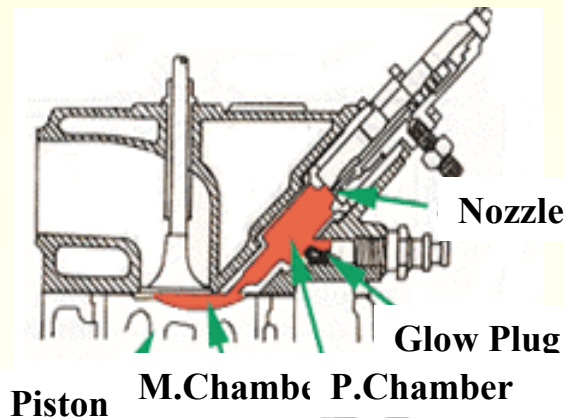
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3. Distribution :

- It is important for Injected fuel to have good distribution in combustion chamber for perfect combustion. Pre chamber combustion and swirl type was adapted to make gas pulsation be increased in the process of the distribution in combustion chamber.
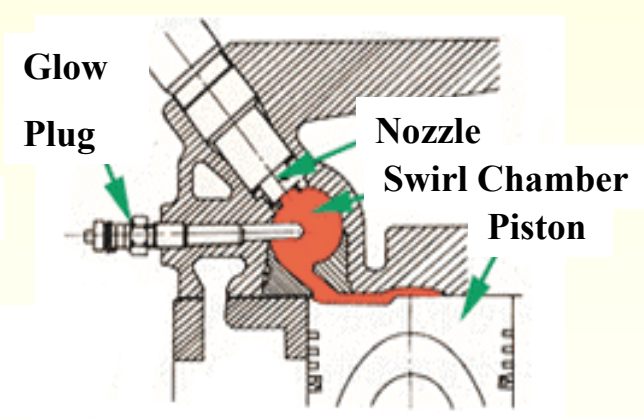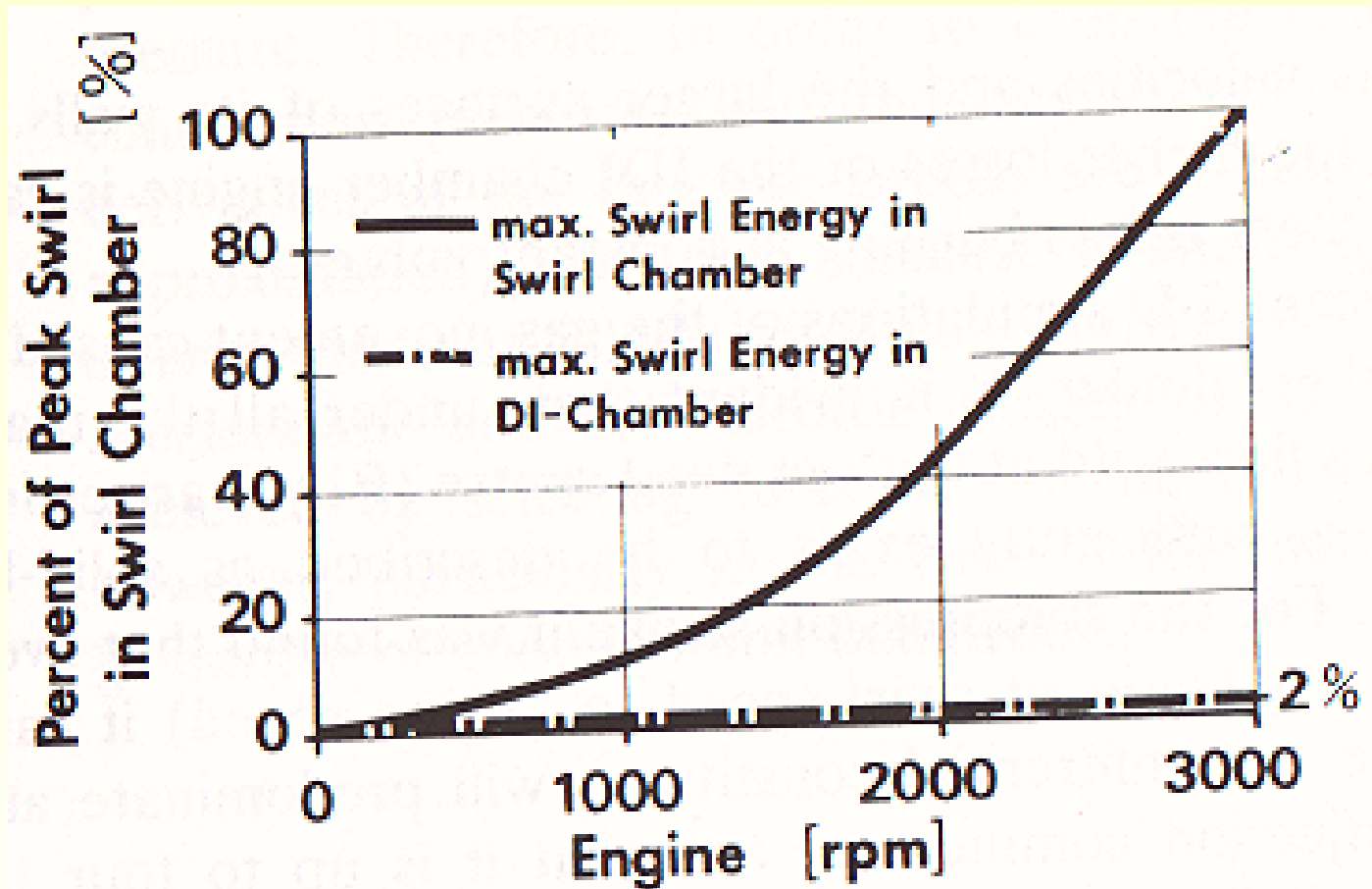
▽ **Direct Injection**   ▽ **Pre-combustion chamber**   ▽**Swirl Chamber**

Nozzle

Piston   Chamber

Nozzle

Glow Plug

Piston   M.Chamber P.Chamber
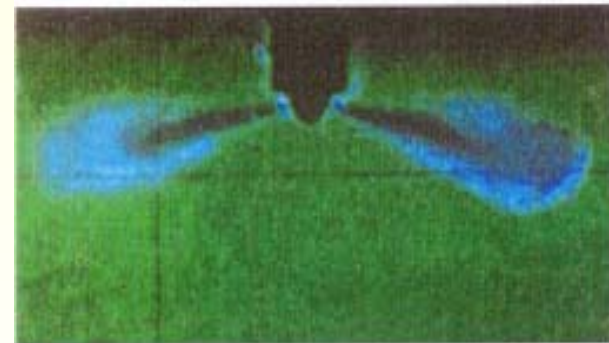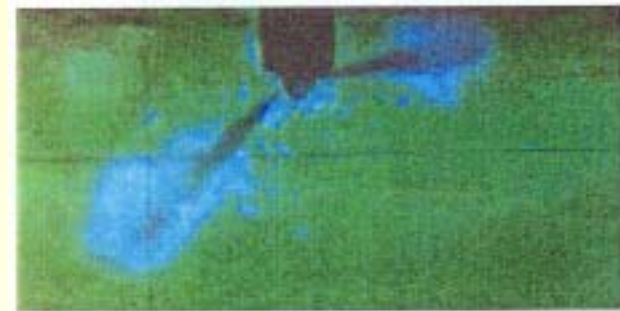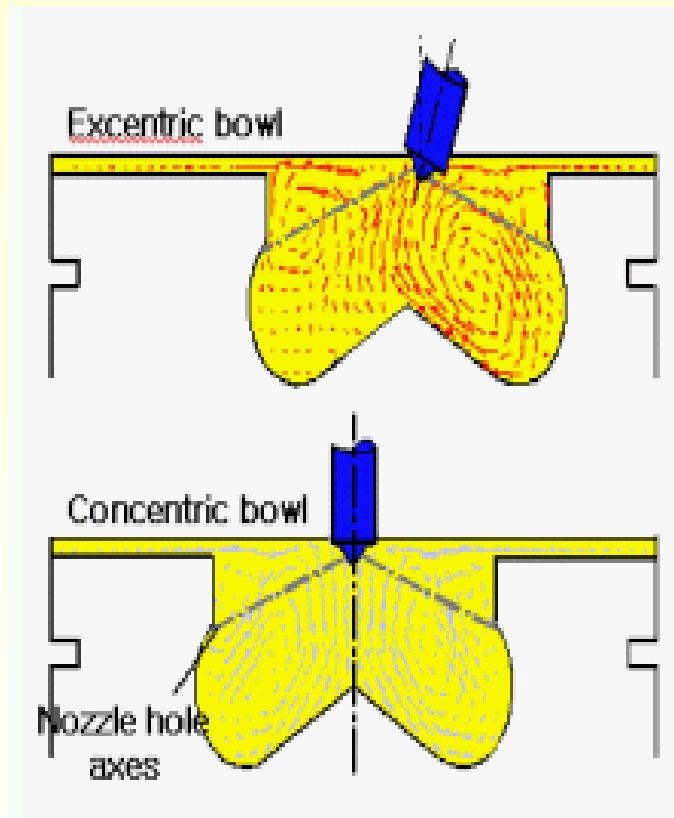
Glow Plug

Nozzle
Swirl Chamber
Piston

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Diesel Fuel Property

■ Swirl energy Comparison

Distribution difference ■ Distribution difference by injector install type

■ Soot and Nox formation theory
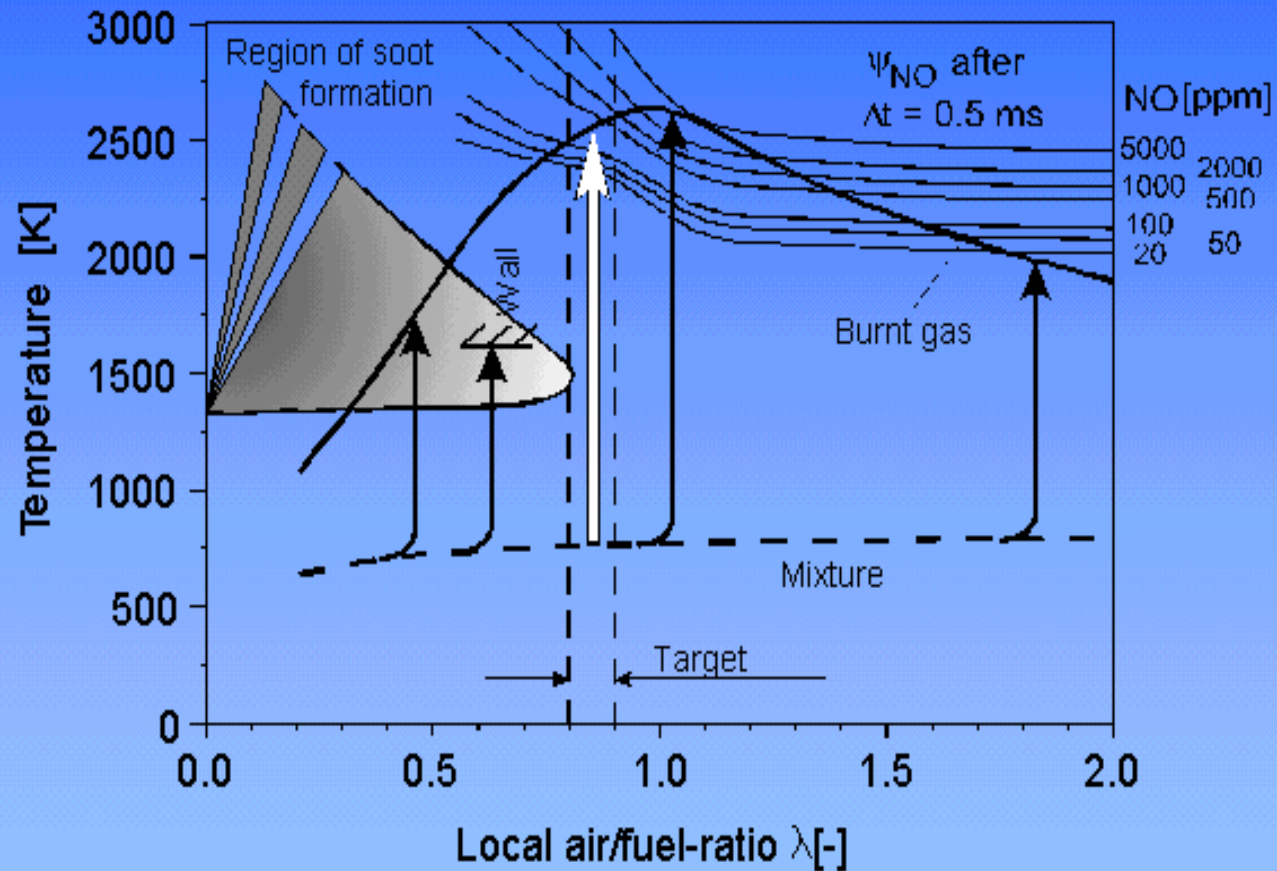
■ Internal Pressure Diagram in Combustion

A :   beginning of fuel delivery from pump

B :   beginning of fuel injection from nozzle

C :   beginning of combustion

T :   point of TDC

D :   fuel injection end

E :   after injection

F :   combustion end

A-C : Injection Lag

C-D : Explosive Combustion

D-E : Extensive Combustion

E-F : After Combustion

T ▶

C →

B →

A →

E ▶

F ▶

D →

After injection

-100°

0°

TDC

100°

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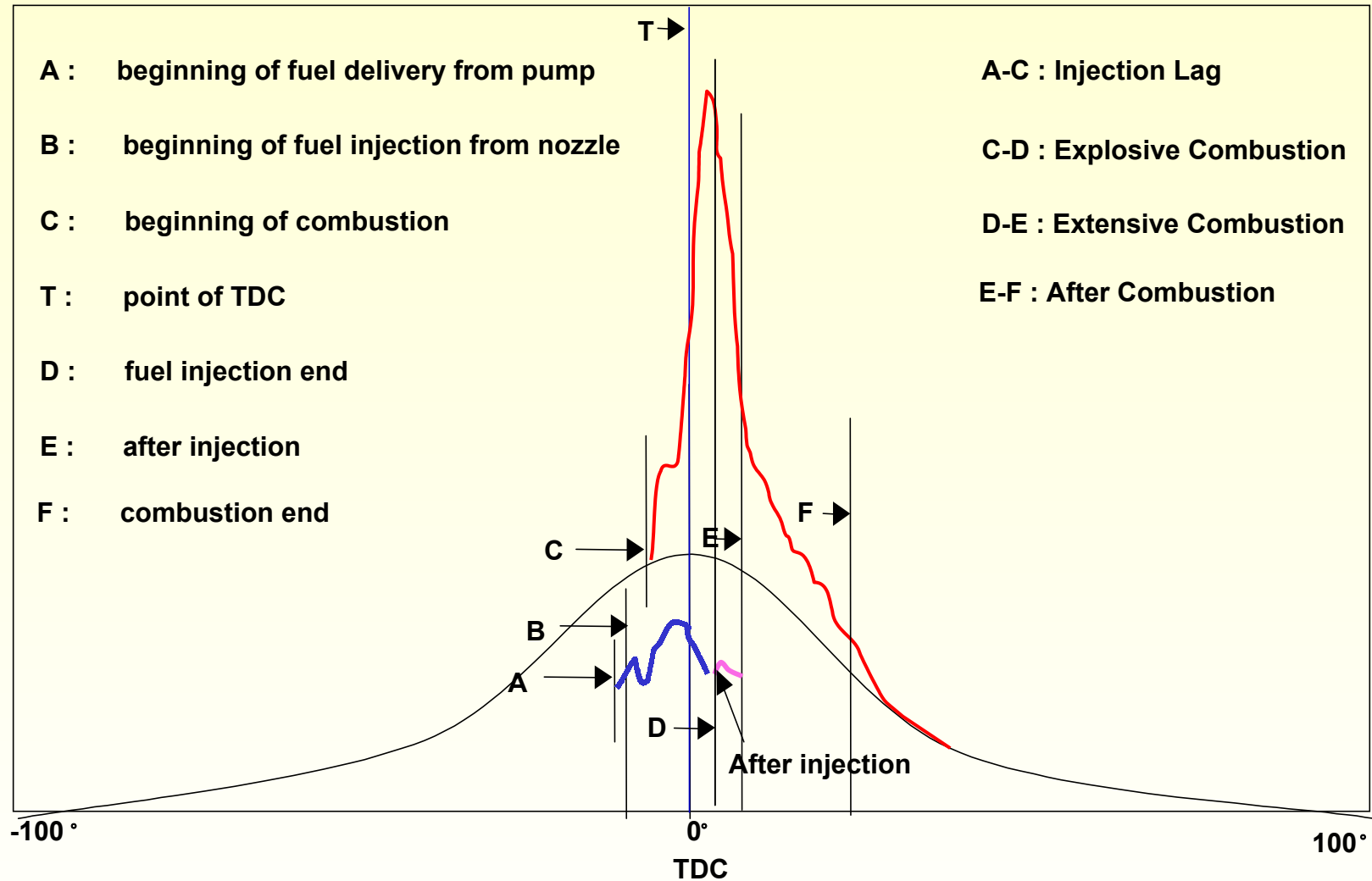
■ Ignition Lag :

- Diesel combustion process is a little different by several reasons compared

  to Gasoline's. The ignition in diesel happens in several points by heated air when

  atomized fuel mist is injected. In that reason, the fire deflection is affected by

  several things such as combustion pressure, fuel temperature, water coolant

  temperature, rpm and so on. The ignition lag in internal pressure diagram

  shows the connection among the mentioned items before. Generally in diesel

  engine this lag becomes about 3~ 7ms, but it's different by conditions.

  If Ignition lag becomes longer, the detonation, diesel knock easily happens.

  The way to shorten this lag is :

- Using High compression rate   - High Centan No. fuel

- Retard the injection time   - Using swirl to increase deflection speed

- Turbocharger with intercooler   - Small nozzle size

- appropriate working temperature in fuel, water coolant and air intake

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■ Dynamic of diesel development
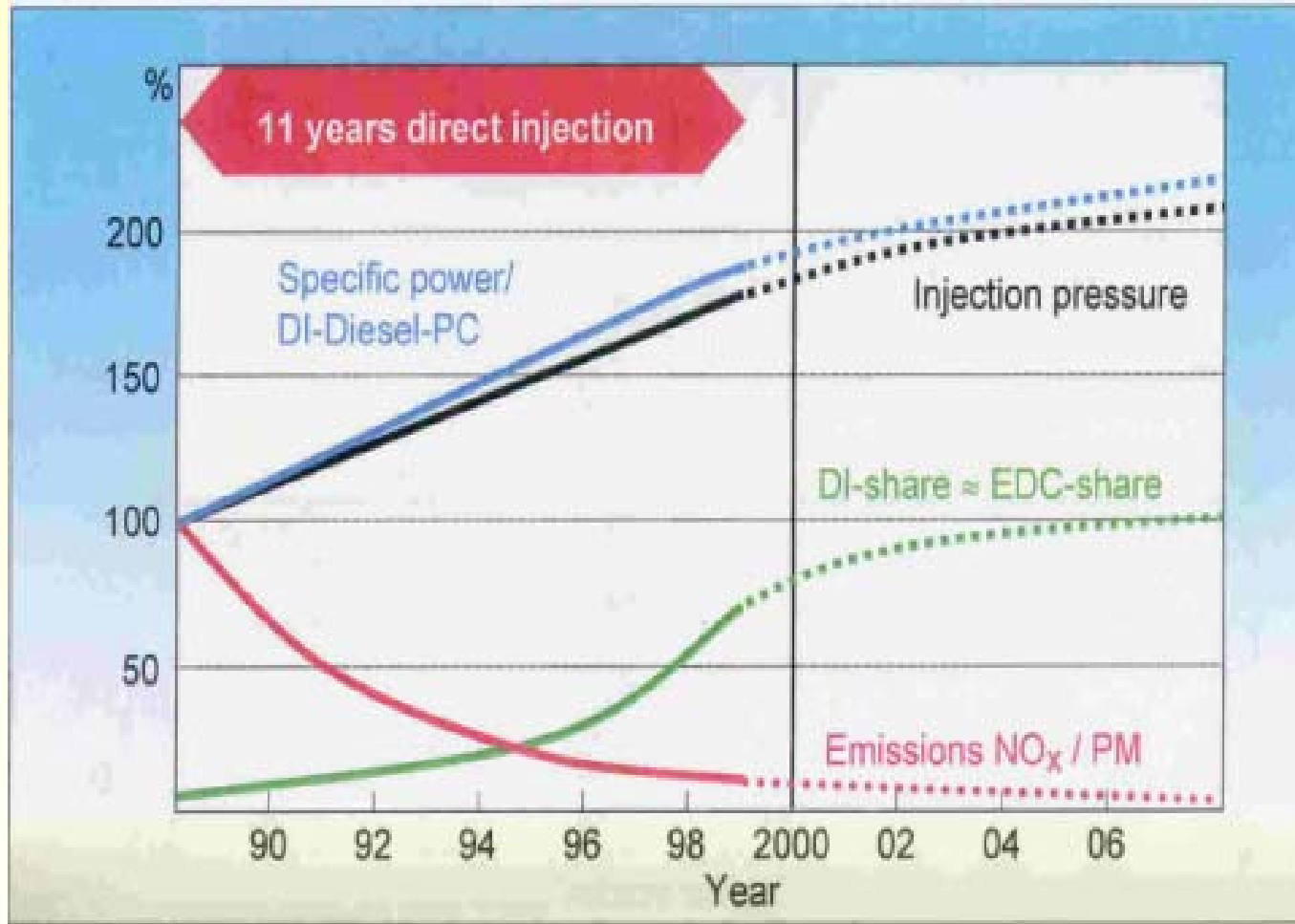
■ System Comparison

Items / Fuel	Diesel	Gasoline
Mixture(A/F)	Irregular	Regular
Ignition	Heat of Compression	Electrical Spark
Compression ratio	16~23:1(only air)	8~11:1(A:F)
Fuel Efficiency(%)	35~40	25~35
Explosion Pressure	120~160kg/cm^2	50~70kg/cm^2
Max. rpm	4500	7500
Load Control	Fuel	A/F Mixture
Exhaust Temp.	Low	High

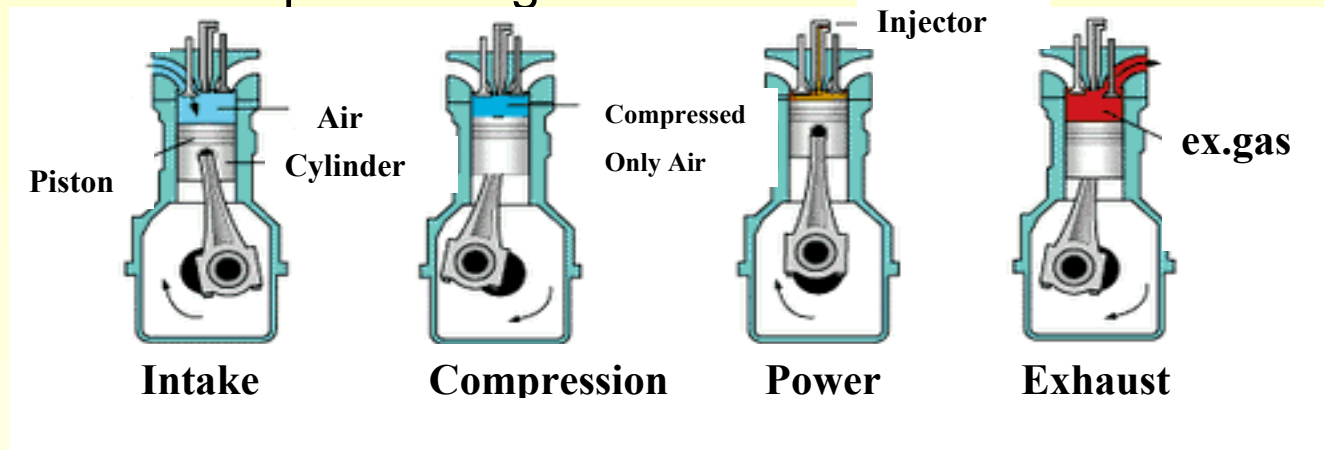# Diesel System Advantage and Disadvantage

■ Advantage

- Using cheaper fuel (Generally)

- Using the heat of compression to ignite ⇒ It makes system simple.

- High efficiency at light loads and idle speeds

- High compression ratio ⇒ good fuel consumption

- Fuel efficiency is higher (by 15%)
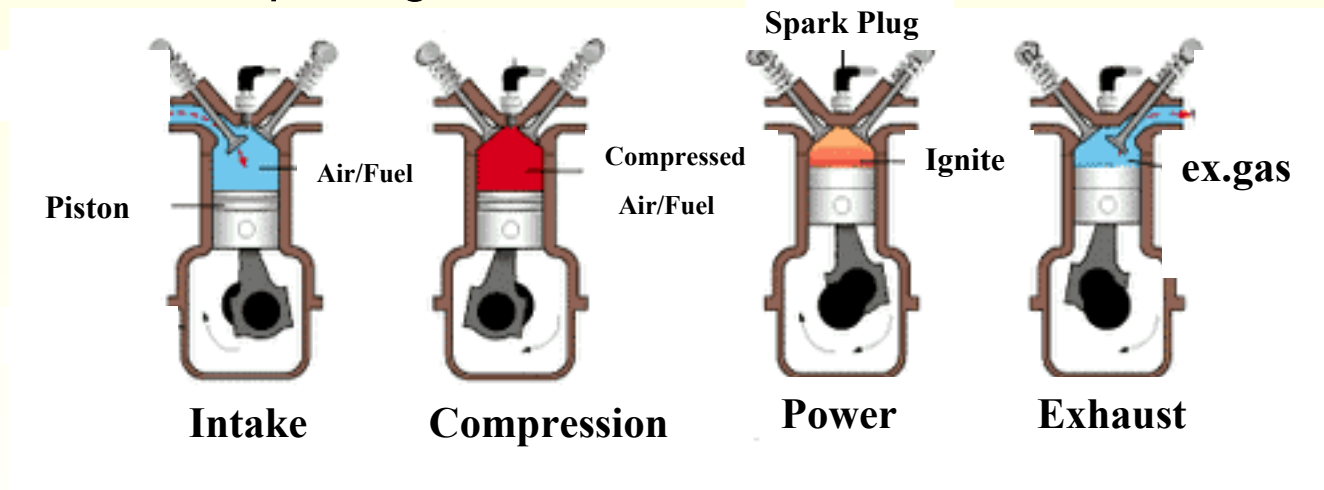
- Components' durability

■ **Disadvantage**

- Precise in injection system and durability ⇒ these make them more

  expensive to build

- Output torque range is shorter than gasoline's

- Harmful emission gas ⇒ soot-laden(particles), sulfur content,

- Detonation is easy to occur

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■ Diesel : Compression ignition

Injector

Air
Cylinder

Compressed
Only Air

ex.gas

Piston

Intake **Compression** **Power** **Exhaust**

■ Gasoline : Spark Ignition

Spark Plug

Air/Fuel

Compressed
Air/Fuel

Ignite

ex.gas

Piston

Intake **Compression** **Power** **Exhaust**

■ Subject : Common Rail System

1. Discuss by party what the common rail system is

   - Concept, main components, the difference verse IDI system,

   - Your country's situation in commercial diesel vehicle

   - Advantage or disadvantage etc.

2. Present each party's output

   - Use 5 minutes for presentation

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Common Rail Direct Injection (CRDI)

■ CRDI System Overview

- Over the years, a wide variety of different requirements in diesel engine, such as severe exhaust gas regulation, high power output at any range, and easy installation at any vehicle types from small sized passenger cars to heavy truck, have led to the using CRDI system which is met all of requirements.

- Compared to conventional cam-driven mechanical injection system, the CRDI fuel injection system provides for considerably higher flexibility in the adaptation of the injection system to the engine.

- The main advantage to a common-rail system is that there is no relationship between engine speed and injector pressure. In traditional fuel-injection systems, you can get only limited pressure at low engine speeds. In addition, high-speed engines offer reduced time for fuel/air mixture formation, so injection pressure is key to move the combustion along at a fast pace. In addition, it can generate almost 1,000 bars of pressure already at an engine speed of only 1,500 rpm, which was previously impossible.
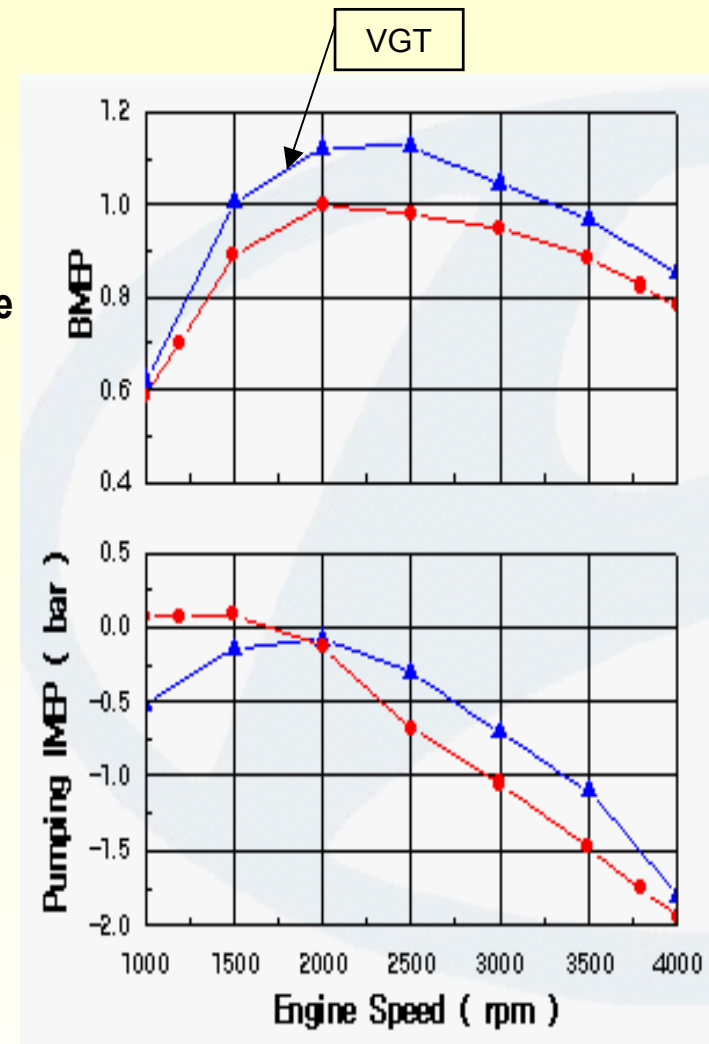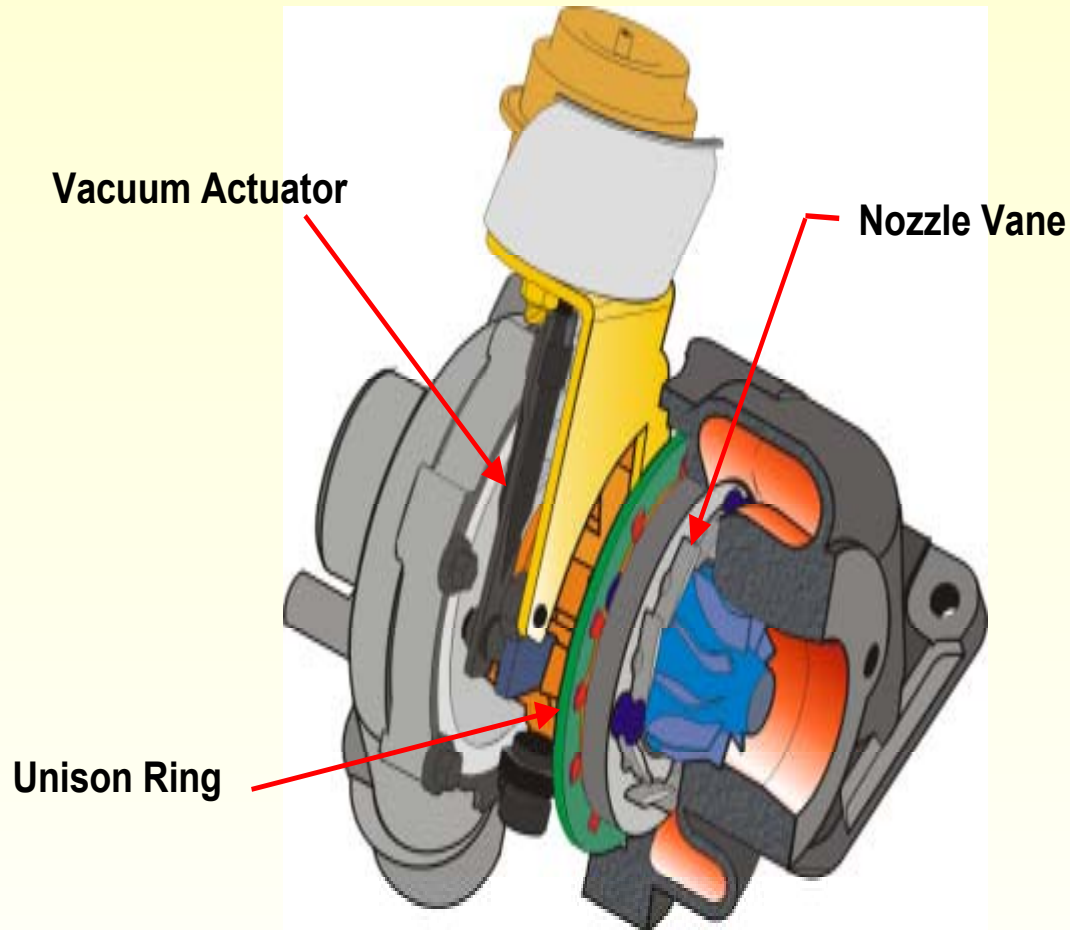
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-The diesel common-rail systems embody the same concept as gasoline-engine rails, which feature an accumulator connected with tubes to the injectors. The basic difference between them is the injector pressure. In a common-rail diesel, it reaches 1,300 to 1,600 bars of pressure. In a gasoline rail system, the pressures are much less than 3 or 4 bars

■ Main Features

- Extensive area of application

- High injection pressures of up to approx. 1400bar

- Variable start of injection

- Possibility of pilot injection, main injection and post injection
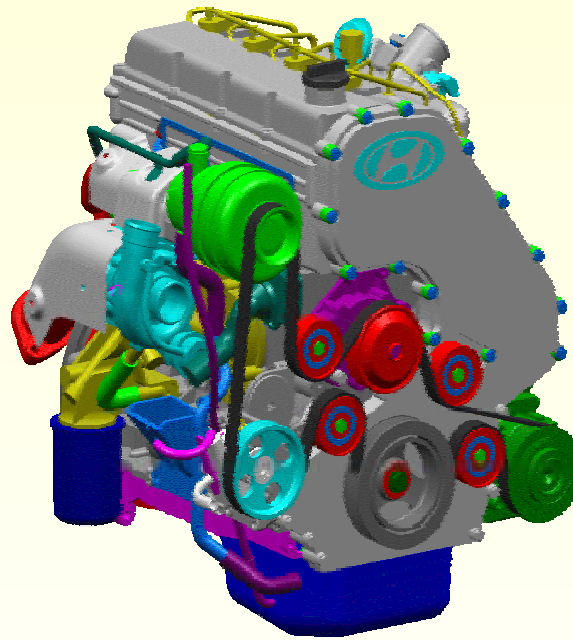
- Matching of injection pressure to the operating mode

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■ VGT (Variable Geometry Turbo)

Vacuum Actuator

Nozzle Vane

Unison Ring

VGT

BMEP

Pumping IMEP (bar)

Engine Speed (rpm)

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A-2.5 TCI Mechanical system

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A-2.5 TCI

■ Increasing specific power and fuel consumption

- DOHC 4 valve with swing roller arm

- Turbocharger with intercooler

- State-of-the-art Electronic Diesel Control(EDC)

  by Bosch with Common Rail

- Electronically controlled high precise injectors

  installed in the center of the combustion chamber

- High injection pressure up to approx. 1,350 bar

■ Low emission and NVH decreased

- Pilot injection prior to main injection

- Balance shafts

- EGR system with oxidation catalytic converter

- Cam carrier and ladder frame type bed plate

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■ A-2.5 TCI
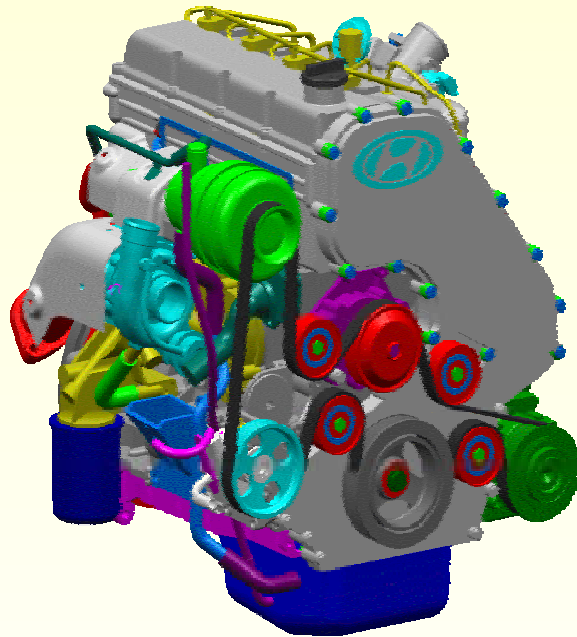
Items	A-Eng.
EMS	Bosch
Available Vehicle	Sorento
Displacement(cc)	2,497
High Pressure Pump Drive	Timing Chain
Injector Control	Pull-in currency (20A) by EMS
Fuel Injection	Pilot Injection Main Injection
Max. Fuel Pressure	1350bar
Fuel Pressure Control	Inlet Control
Heating Device	Glow plug Water coolant heater Fuel Heater
Valve Clearance	HLA

■ J-3 2.9ℓ C/R
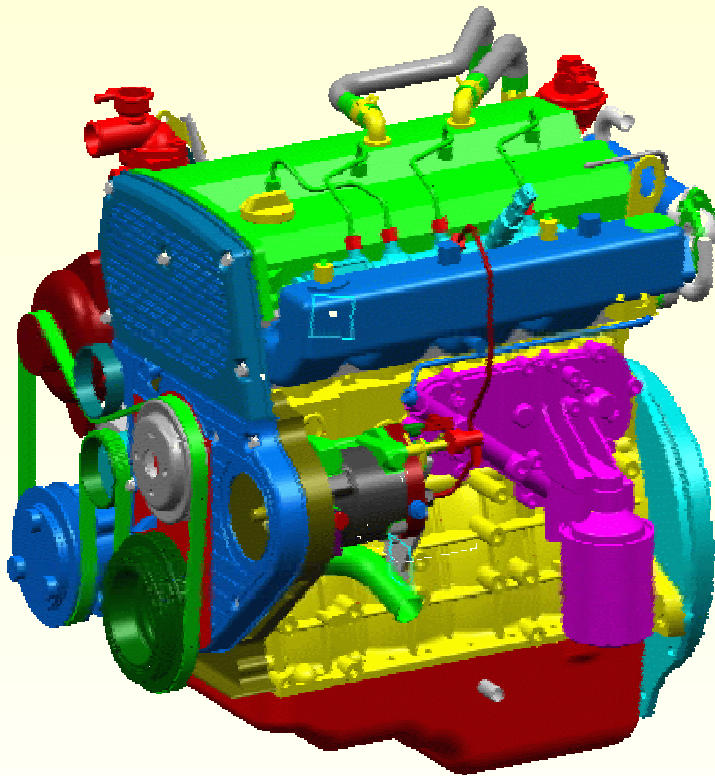
| Items	J Ⅲ-Eng
EMS	Delphi
Available Vehicle	Carnival
Displacement(cc)	2,902
High Pressure Pump Drive	Timing belt
Injector Control	Pull-in currency (10A) by EMS
Fuel Injection	Pre Injection Main Injection
Max. Fuel Pressure	1400bar
Fuel Pressure Control	Inlet Control
Heating Device	Air Heater Fuel Heater Water Coolant Heater
Valve Clearance	HLA

■ HTI D-2.0ℓ Eng.
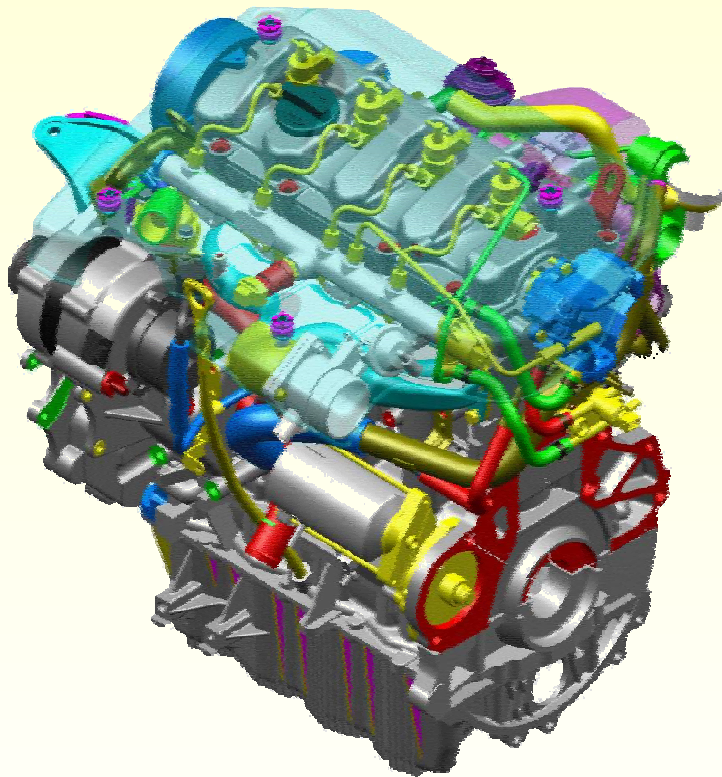
Items	D-Eng
EMS	Bosch
Available Vehicle	Carens
Displacement(cc)	2.0ℓ
High Pressure Pump Drive	Camshaft Driven Gear
Injector Control	Pull-in currency (20A) by EMS
Fuel Injection	Pre Injection Main Injection
Max. Fuel Pressure	1350bar
Fuel Pressure Control	Outlet Control
Heating Device	Glow plug Fuel Heater Water Coolant Heater
Valve Clearance	HLA

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TEST MODE : JIS 82 NET
ENGINE : D4CB(A2.5 TCI)

※ **Sorento's highest torque produces in 2000 rpm. Considering the fuel consumption curve with best torque it's recommended to drive in this rpm range.**

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A-2.5 TCI (CDRI) – Wastegate
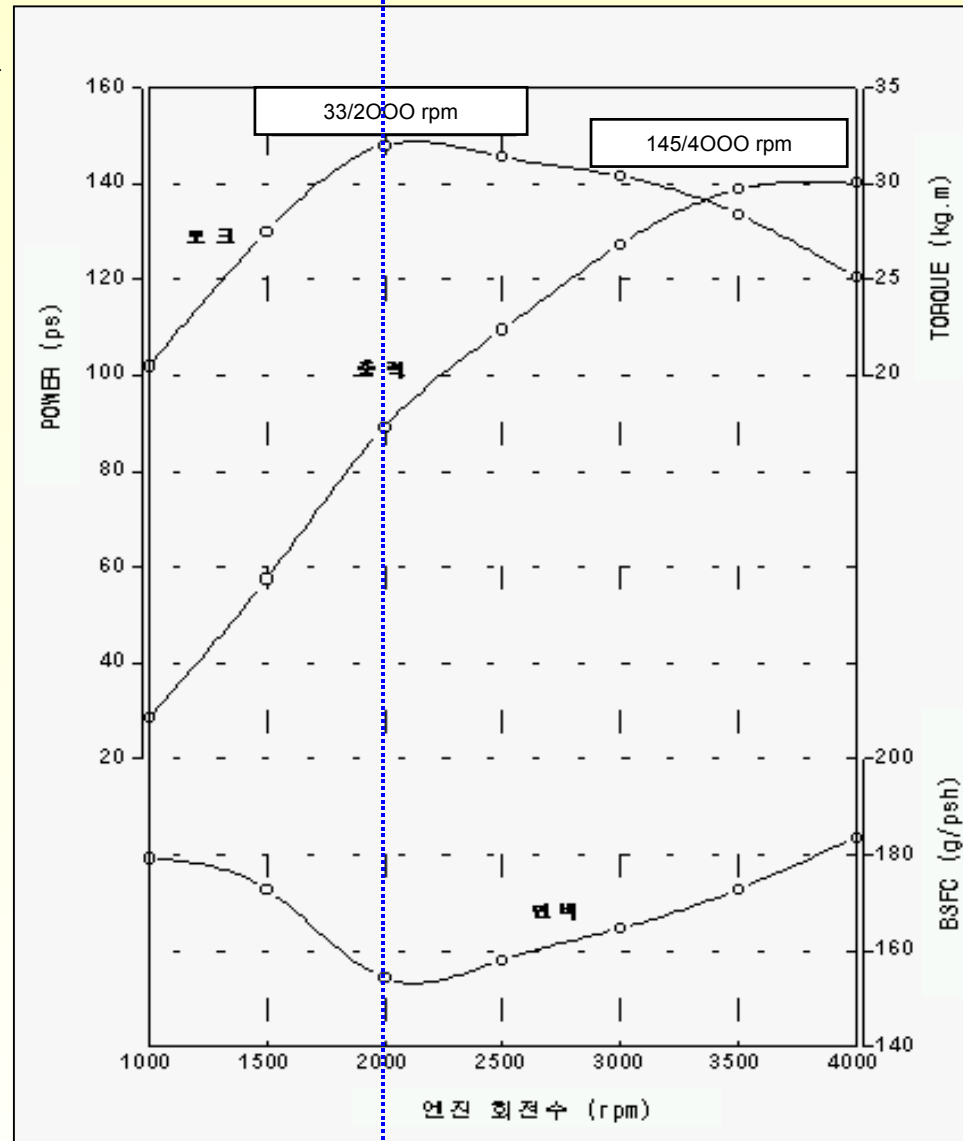
■ Wastegate

A bypass valve (wasrte / regulator) allows the turbo system to develop peak charge-air pressure for maximum engine boost response while eliminating the chance of excessive manifold pressure (overboost) at high speed.
The wastegate is precisely calibrated and opens to direct some exhaust gas flow around the turbine wheel. This limit shaft speed which in turn control boost pressure.

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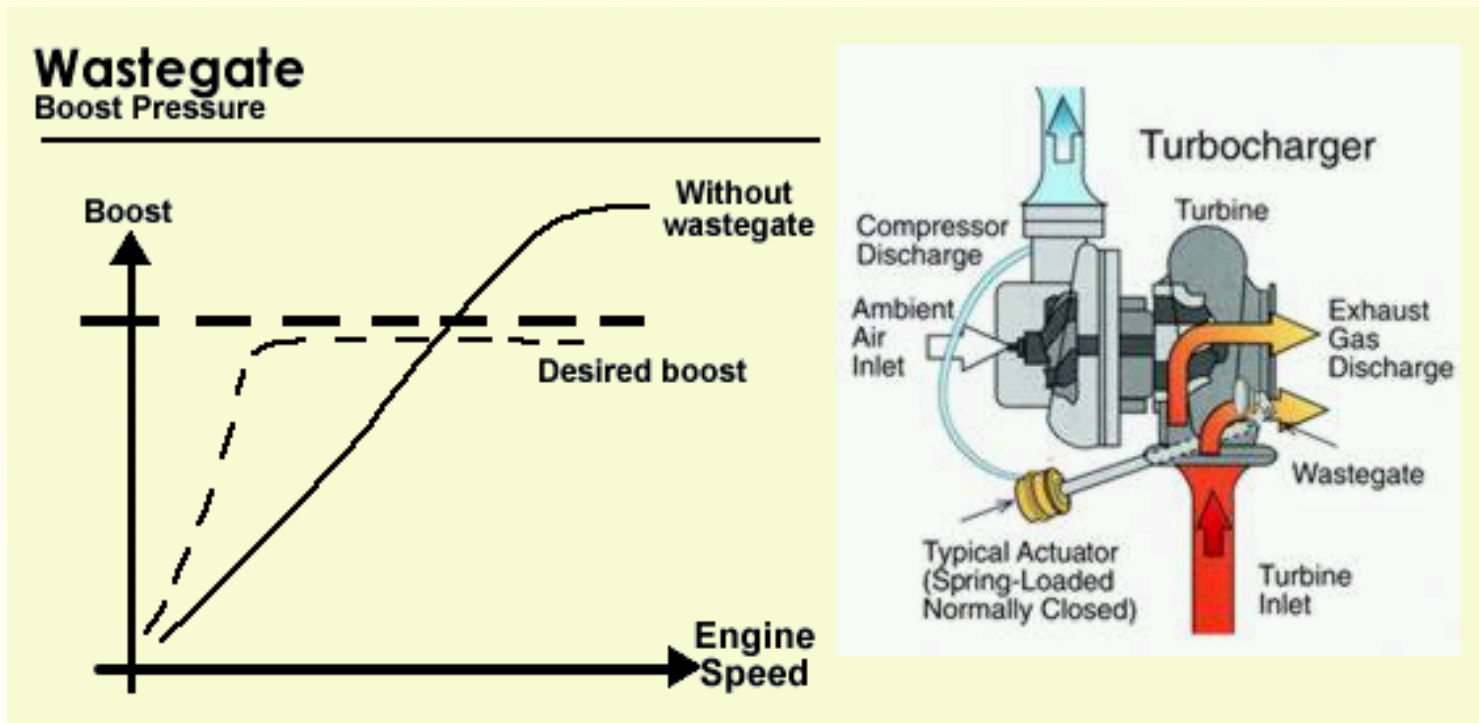
■ Boost pressure at intercooler outlet

● Check point
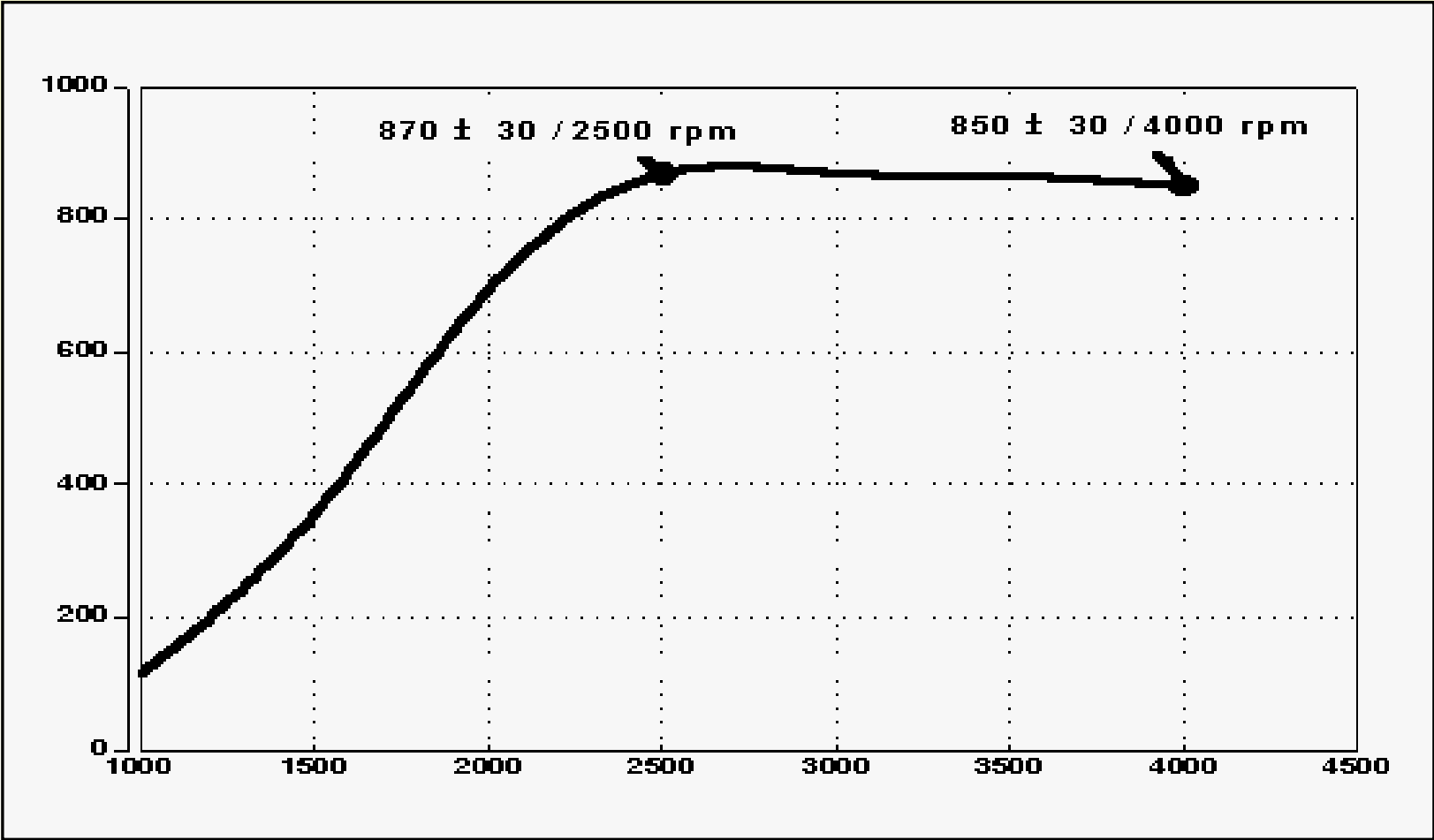
■ Intercooling

Intercooling is a process whereby an air cooler, called the intercooler, reduces the temperature of the compressed air intake, making it denser with a higher concentration of oxygen per cubic air volume. Coupled with turbocharging, an even higher level of combustion is achieved, thereby releasing an additional 15% engine power. The Sorento uses a front ahead type intercooler.
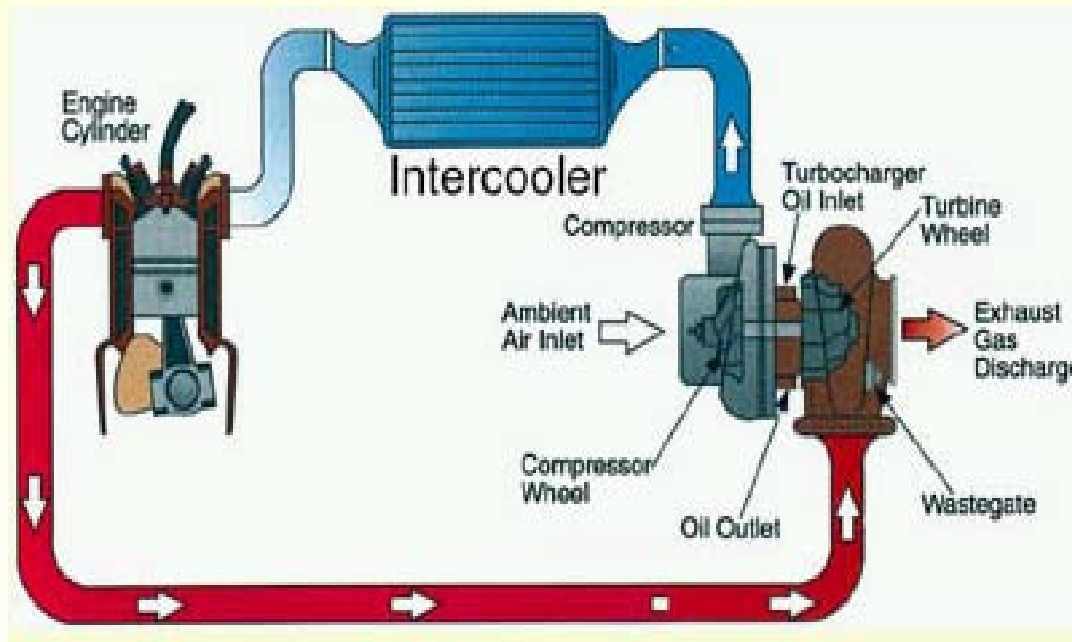
Sorento Intercooler

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■ Intercooler outlet temperature

● Check point

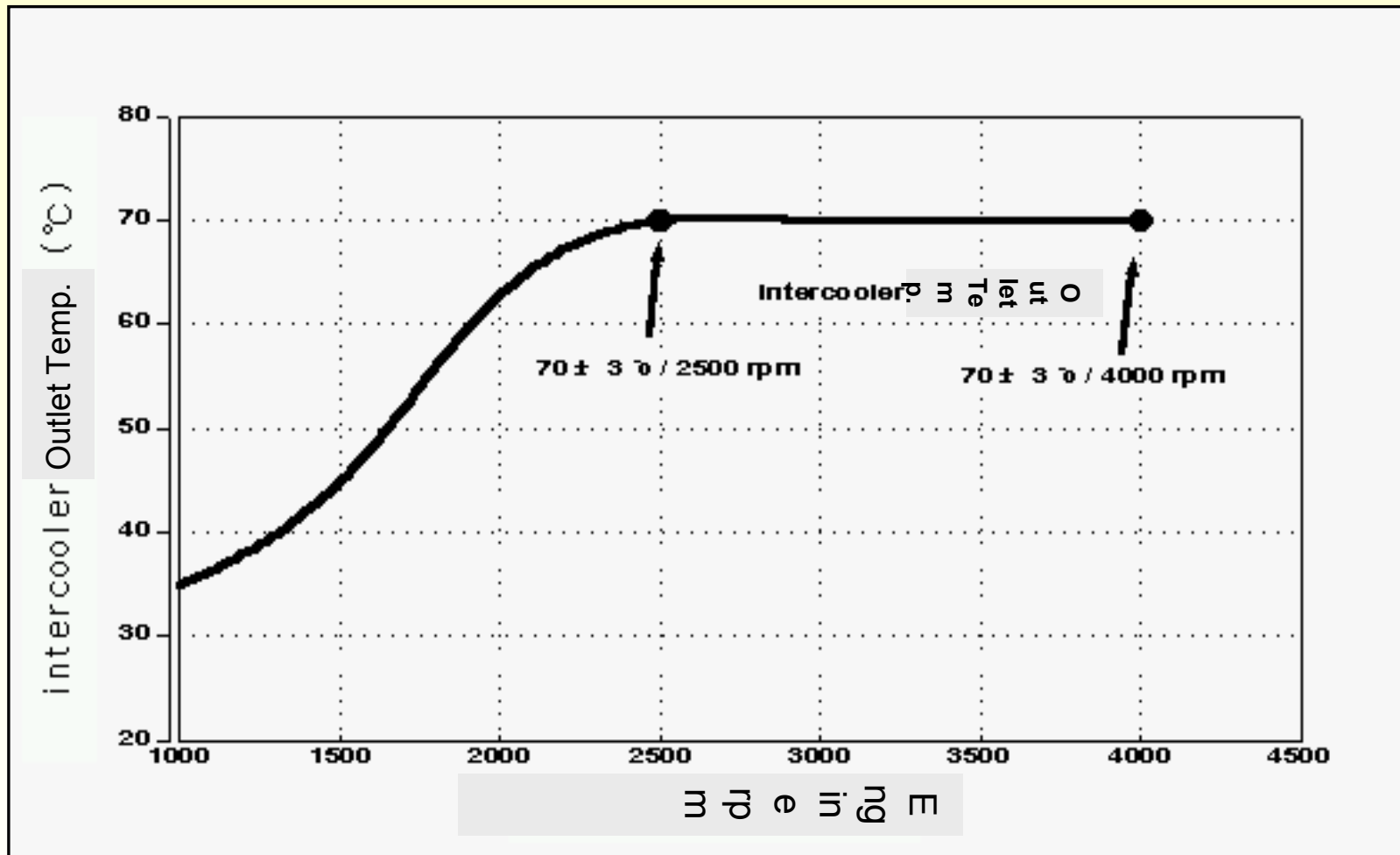■ System Layout – CP3
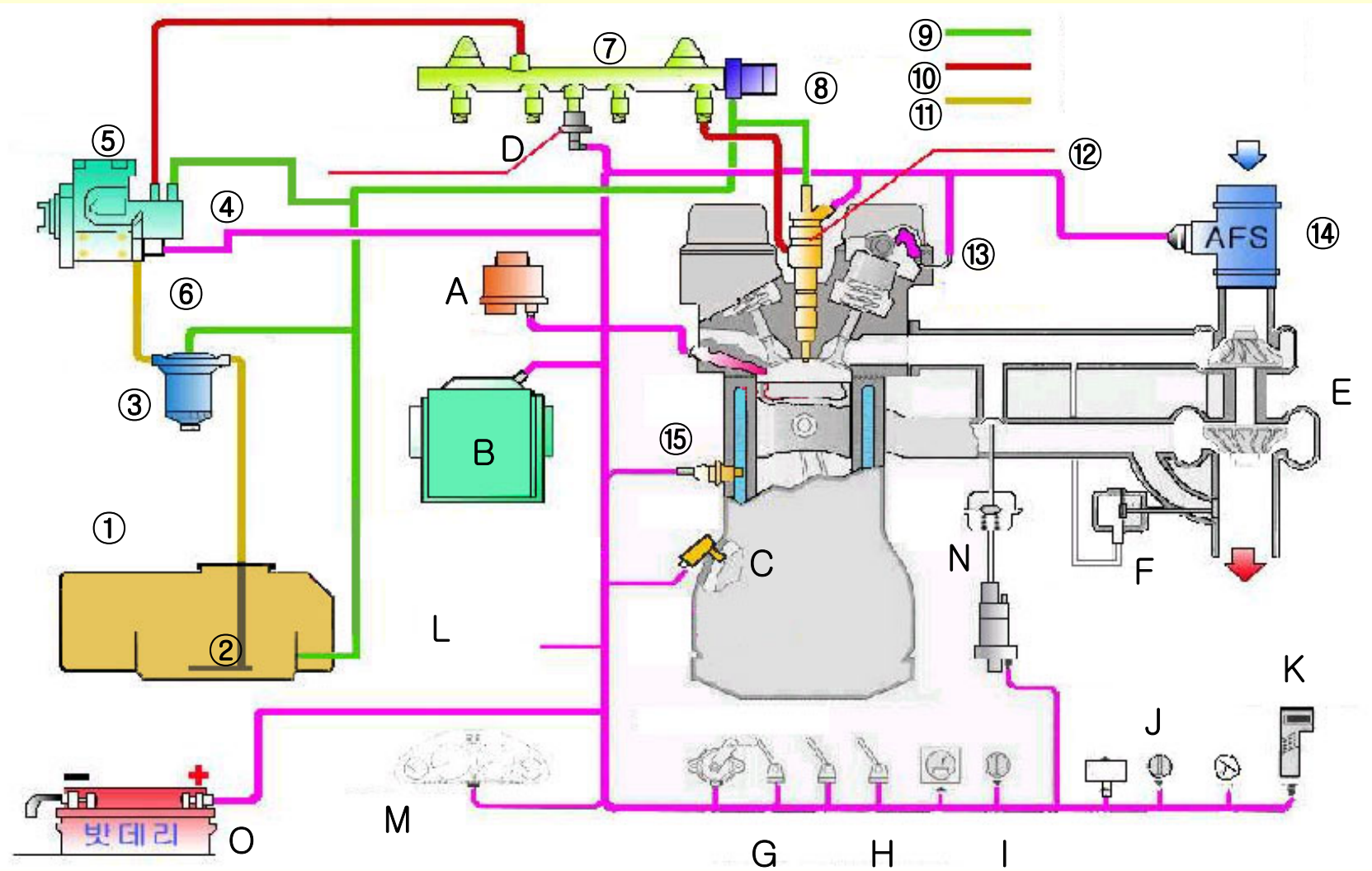
■ **Components Descriptions**

- ① : Fuel Tank
- ② : Pre-filter
- ③ : Fuel filter
- ④ : Low pressure pump
- ⑤ : High pressure pump
- ⑥ : Pressure control valve
- ⑦ : Common rail
- ⑧ : Pressure limiter valve
- ⑨ : Fuel return line
- ⑩ : High pressure line
- ⑪ : Low pressure line
- ⑫ : Injector

- ⑬ : CMP sensor
- ⑭ : Air flow sensor
- ⑮ : WTS
- A : Glow plug relay
- B : ECM
- C : CKP sensor
- D : Rail pressure sensor
- E : Turbocharger
- F : Wastegate
- G : Accelerator pedal sensor
- H : Brake switch
- I : Clutch switch

- J : Air-con switch
- K : Diagnostic connect
- L : Can Bus
- M : Cluster
- N : Vacuum Modulator
       for EGR
- O : Battery

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■ Cleanliness

The high pressure required by the common rail injection system makes it necessary to have much smaller holes and much tighter adjustments than those found in conventional injection systems.

It is therefore absolutely essential to ensure impeccable cleanliness whenever work is being done on a common rail type injection system.

Injector Hole

hair
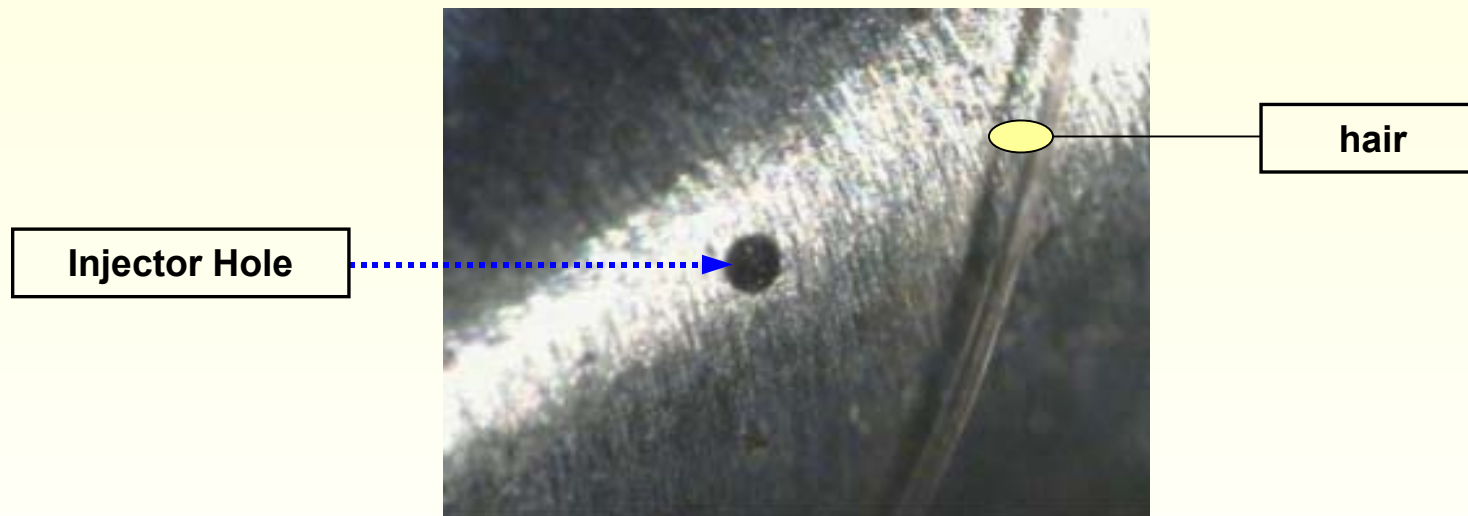
Air Flow Sensor

EGR Valve

High Pressure Pump

Intercooler

Condenser Fan

Alternator

Auto Tensioner

Timing Chain "C"

High Pressure Pump

Viscous coupling clutch

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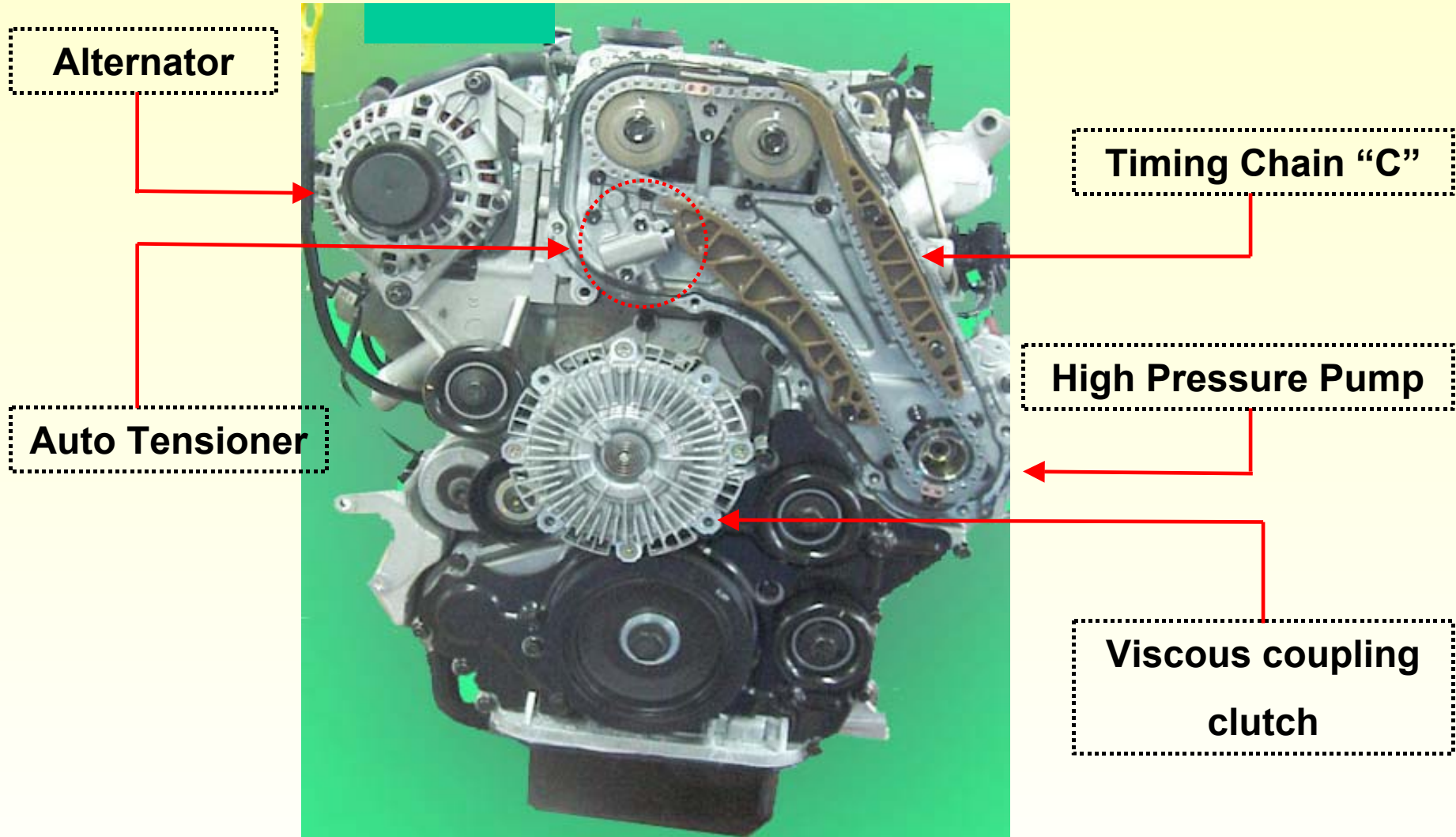
■ Viscous coulping

When you start the engine, the fluid is cold and watery in consistency, so although the fan turns there isn't a very strong bond between the fan and the engine. This allows the fan to be stopped with little effort and the engine to reach optimum temperature. When your engine reaches this temperature the fluid in the coupling is hotter and has a thicker consistency. The thicker consistency causes the bond between the engine and the fan speed to improve causing the fan to run faster at higher speeds.

One Driving Belt

Glow plug

CKP Sensor

Turbocharger

Oil Cooler

Air-Con.

Compressor

Oil Filter

Steel Oil Fan

Ladder Frame

Injectors

Pressure Limiter Valve

Common Rail

Rail Pressure Sensor
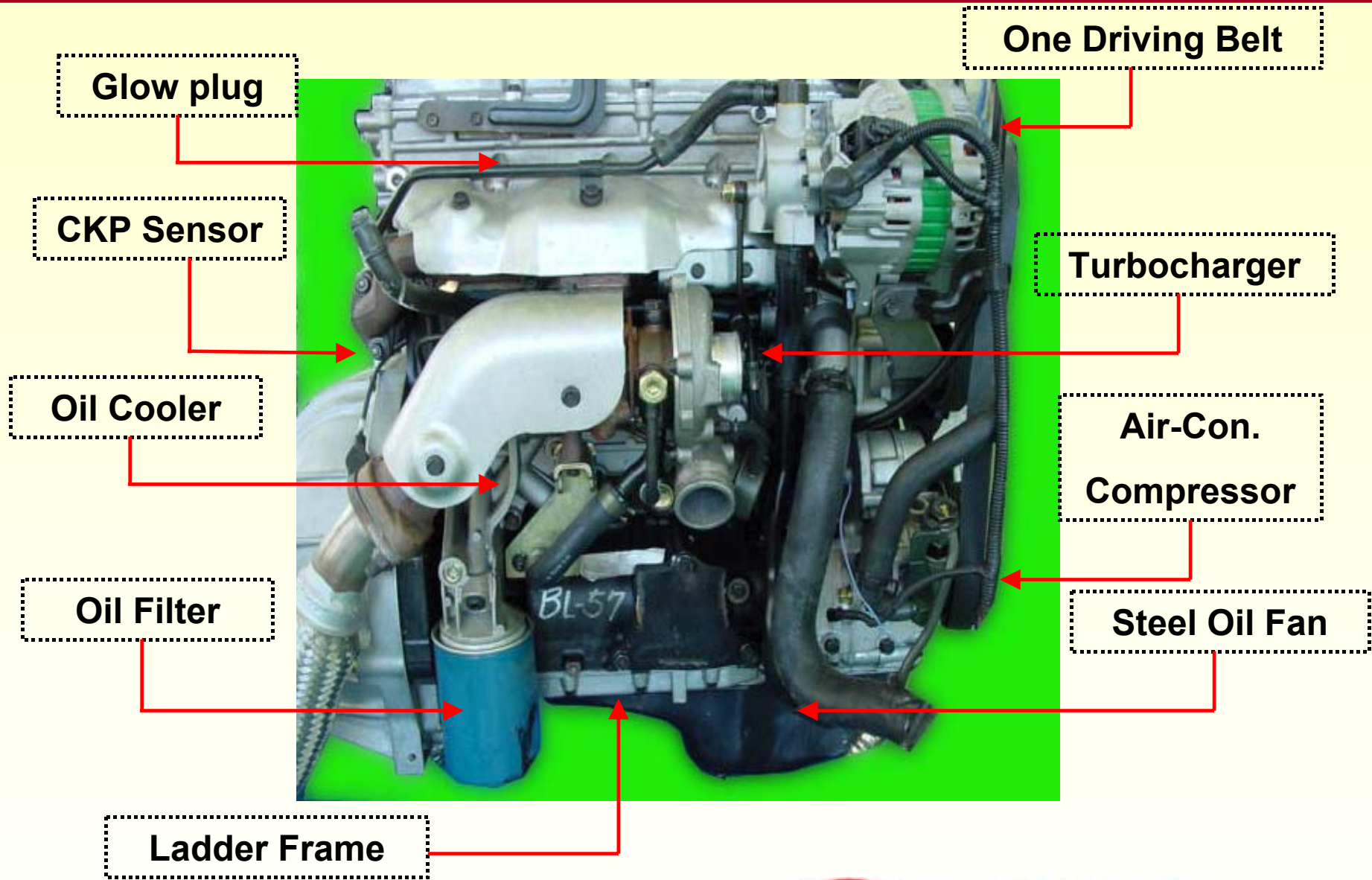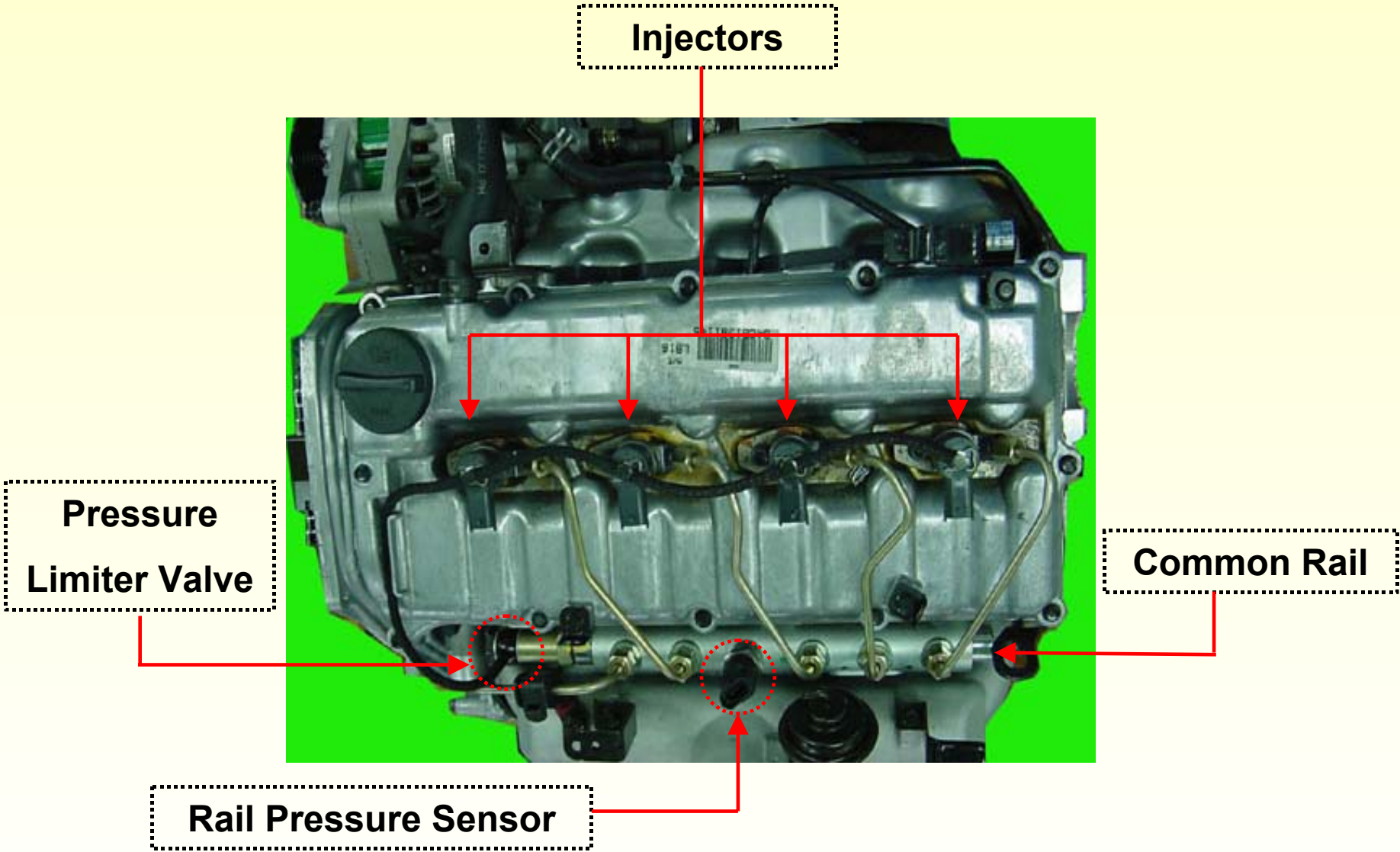
■ Turbocharger

- water cooled turbochager

- water cooled bearing housing

- wastegate(bypass)

- front ahead type intercooler

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■ Components description

Serpentine drive belt

Over running Alternator

Idler

Water Pump

A/con.

Power Steering

Tension

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■ Components Descriptions

Camshaft

Cam carrier
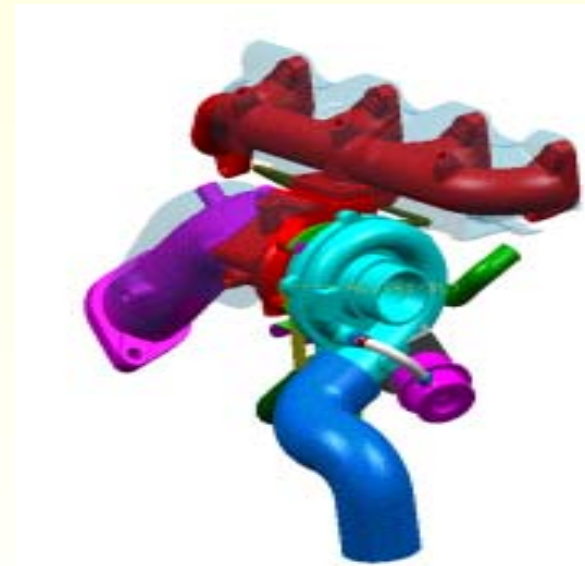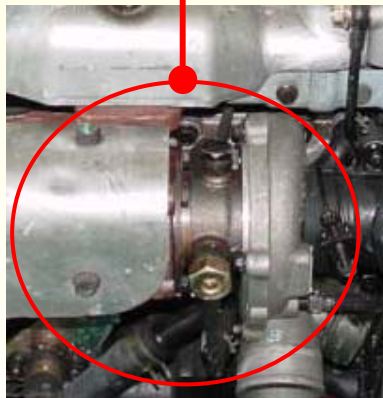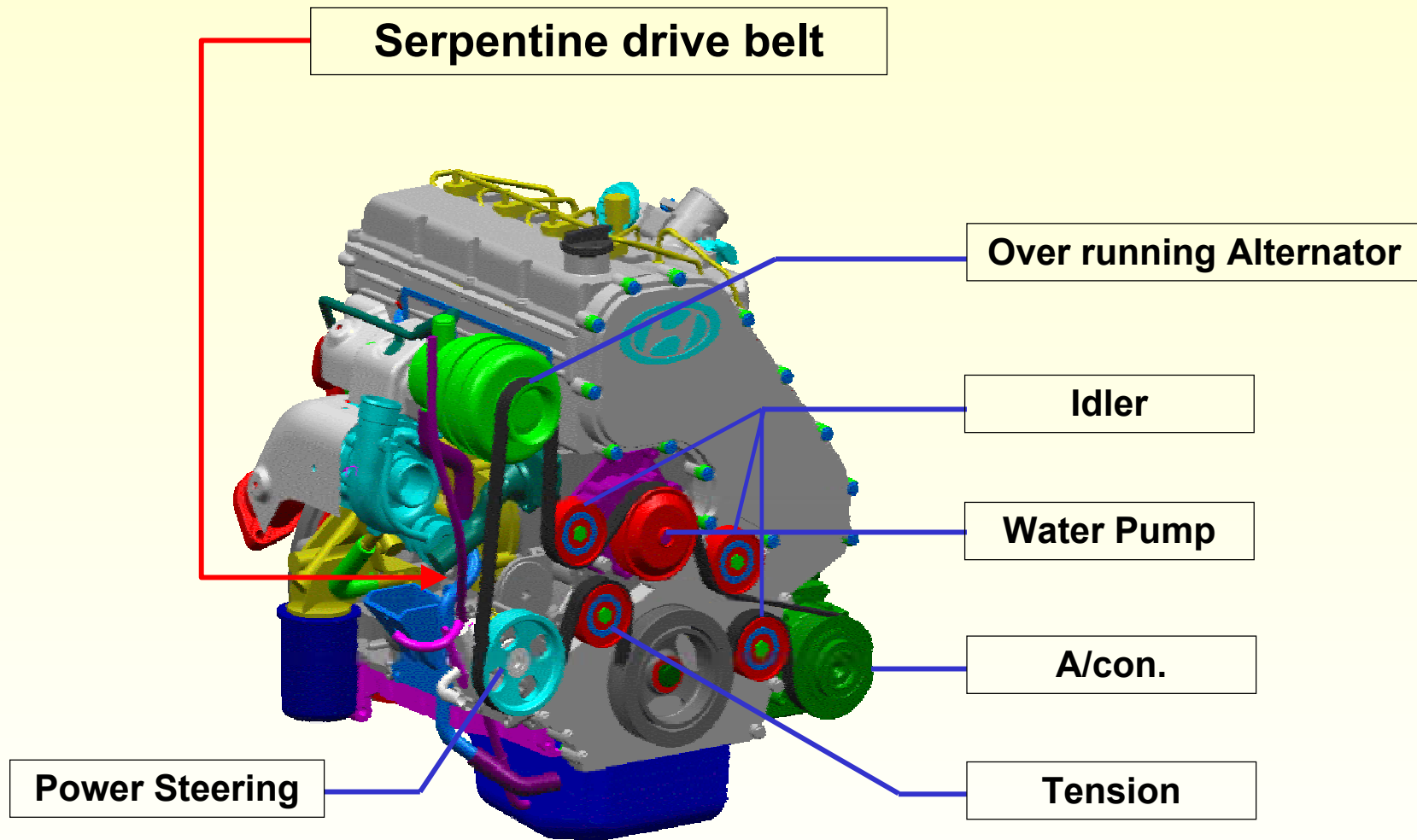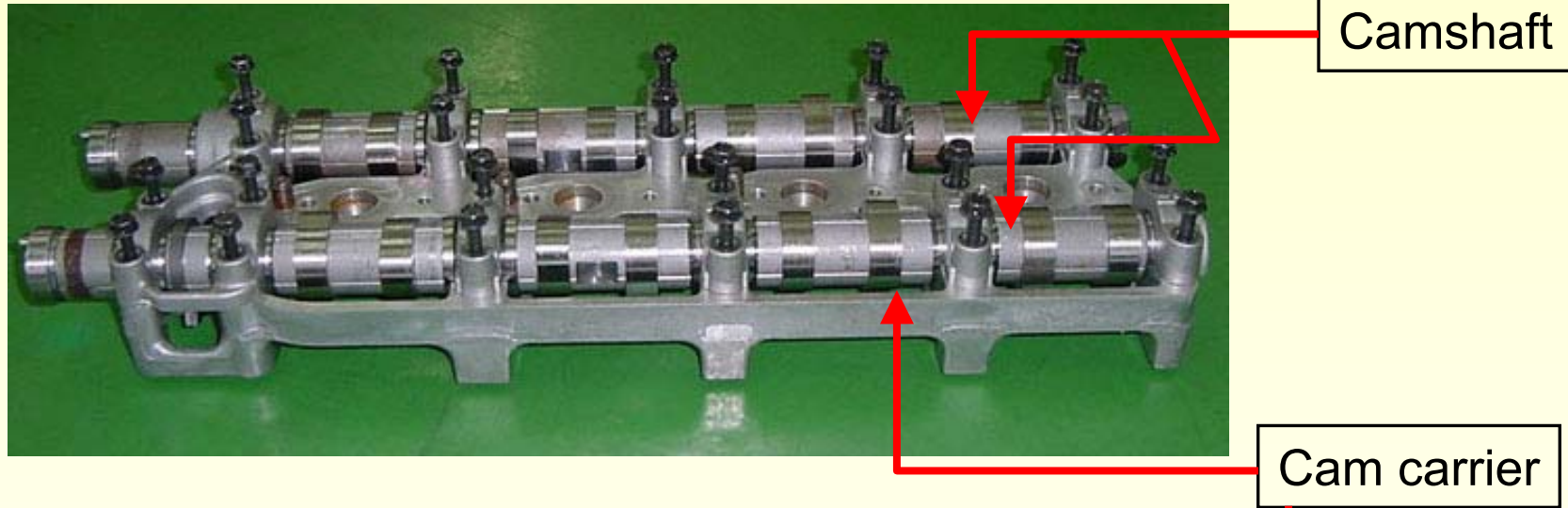
Using camshaft carrier, Sorento can decrease the engine's noise and vibration .
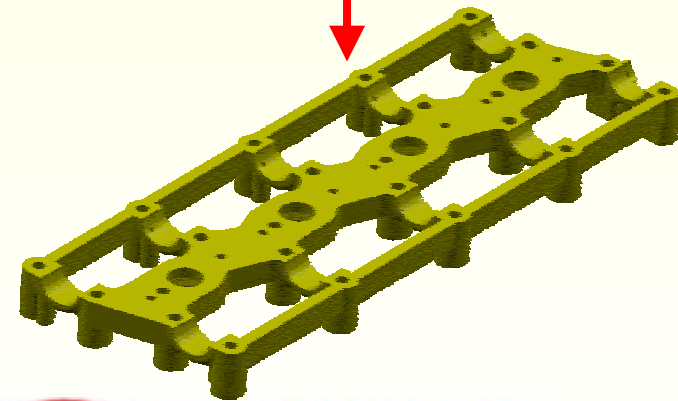
■ Components Descriptions

- 4 valve DOHC with HLA(end-pivot type)
- swing roller arm
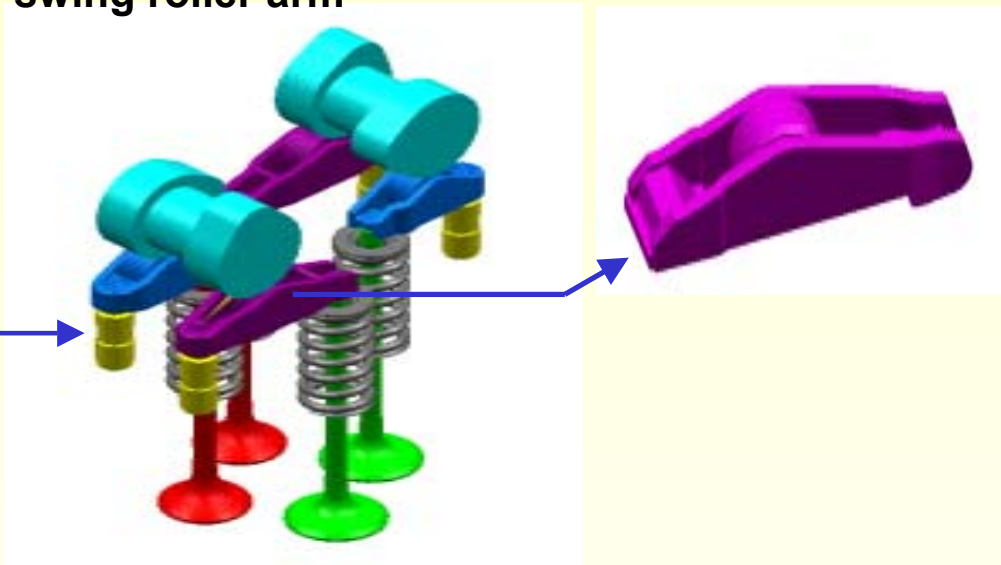
- Hollow camshaft

Hydraulic lash adjustment(HLA)
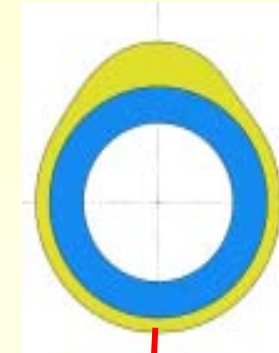
■ Components Descriptions

- **Piston cooling :**
  oil passage gallery
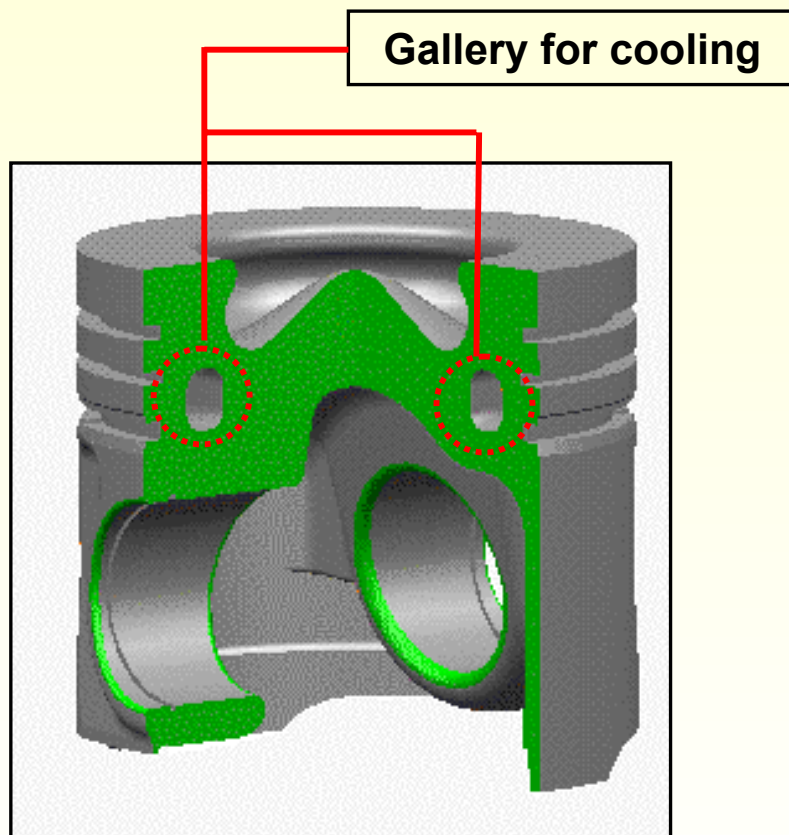
- **Connecting rod tightening torque :**
  ① **6.0kg-m tightening**
  ② **release**
  ③ **3.5kg-m re-tightening**
  ④ **60~64 degree using angle method**

Gallery for cooling

Torque-to - Angle method

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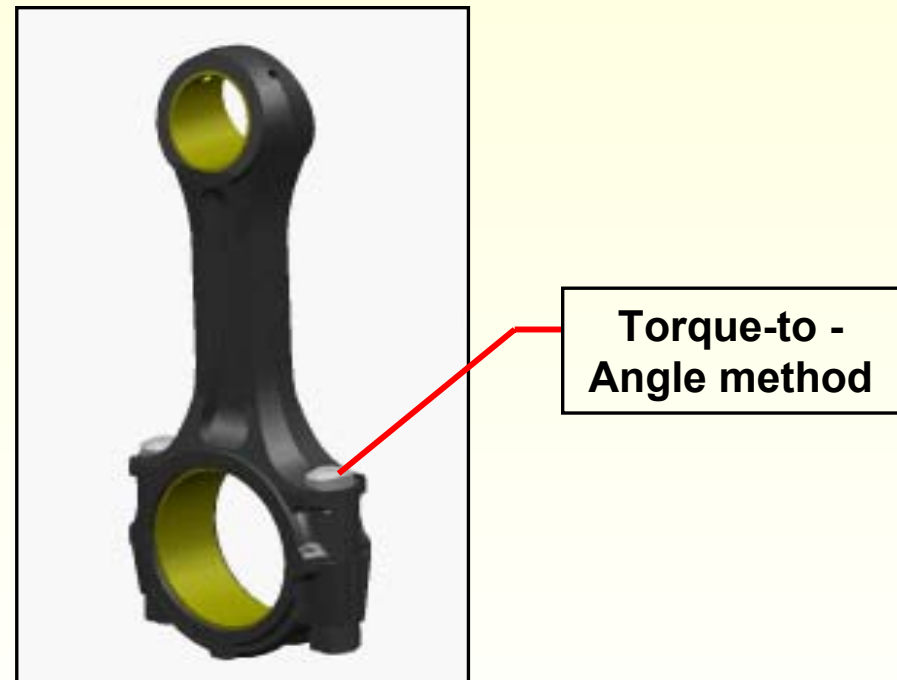
■ Tightening torque methods :

- There are three types of cylinder head bolts (in some case connecting rod cap bolts
  included) tightening procedures in modern vehicle.
    1) Traditional torque method
    2) Torque-to-yield
    3) Torque-to-angle

- Traditional torque method fastens each bolt to its yield point calculated by its
  elasticity. The one demerit of this method is not able to compensate for variations
  in each bolt's thread friction. The other one is each bolt is easy to retract to its
  original length when the axial and torsional force is relieved by combined heating
  and cooling action of the engine.

- To reduce these disadvantages mentioned before, new modern vehicles require
  torque-to-yield or torque-to-angle methods by need.
  The bolt which is tightened by both these methods stretches beyond elasticity to
  what's called the "yield point".
  It stays stretched and won't come back to its original length when loosened. Once
  this point is reached, re-torque won't increase clamping force very much.

- In any case using both torque-to-yield and torque-to-angle each bolt is recommended not to reuse, since you don't know how much or how often it has been tightened in the past, regardless of the possibility of reusing a certain number of times.

- For proper installation in the torque-to-angle methods, an indicator gauge is required more than one torquing sequence. This results in more accurate installation than using only a torque wrench and the 'eyeball estimate' method.

- *Connecting rod cap bolt torquing procedure in Sorento :*
  ① 6.0kg-m tighten
    ※ Torque the bolts in the proper sequence
  ② Release
  ③ 3.5kg-m re-tighten
  ④ 60~64 degree of rotation (needed a torque-to-angle indicator gauge)

■ Components Descriptions

8 weight balanced crankshaft
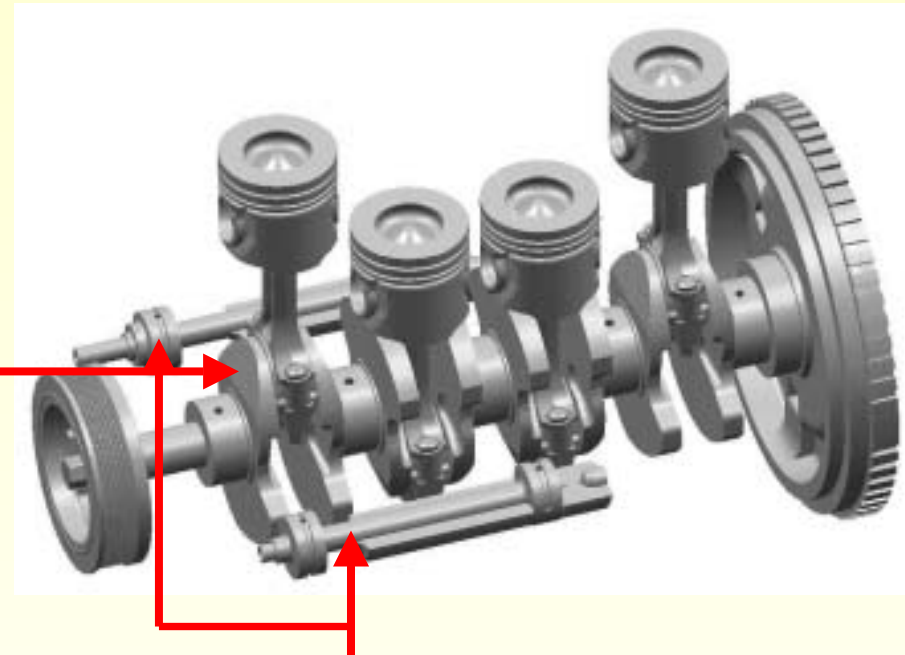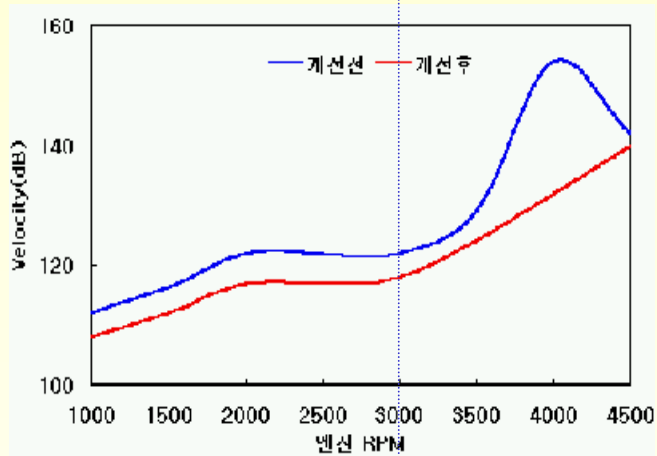
Balance(silence) shaft

※ **To check proper installation of balance shaft, insert the screwdriver into the plug hole and check whether it slides more than 60mm.**

■ Components Descriptions

- Bed plate(ladder frame type) installed

Bed Plate
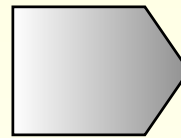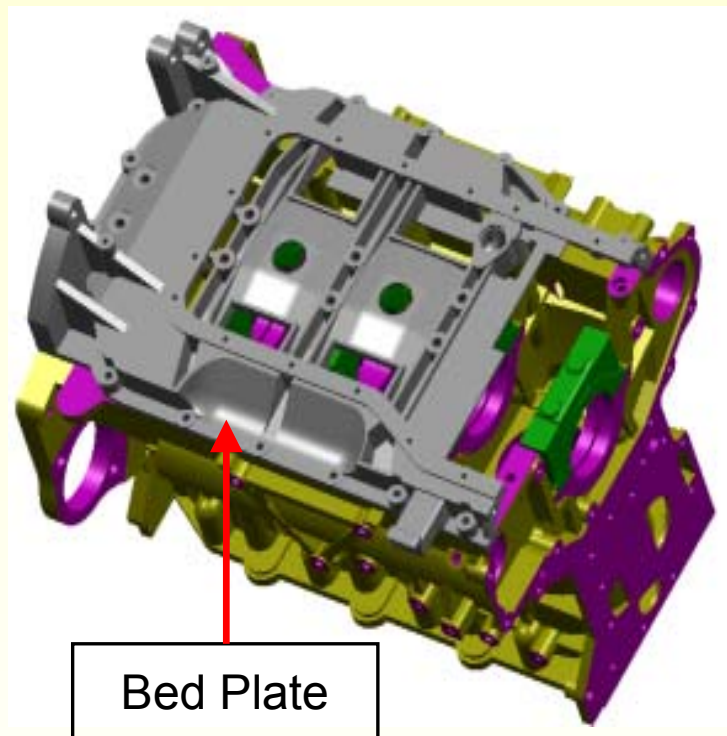
■ Components Descriptions

- Oil pump is installed in inside of the oil pan
- In-direct driven type by timing chain "B" can make overall engine length shorter
- Available engine oil : <u>CE grade 10W30</u>
- Responsible for lubrication of engine moving parts, timing chain and HLA

Oil Pump

Bed Plate
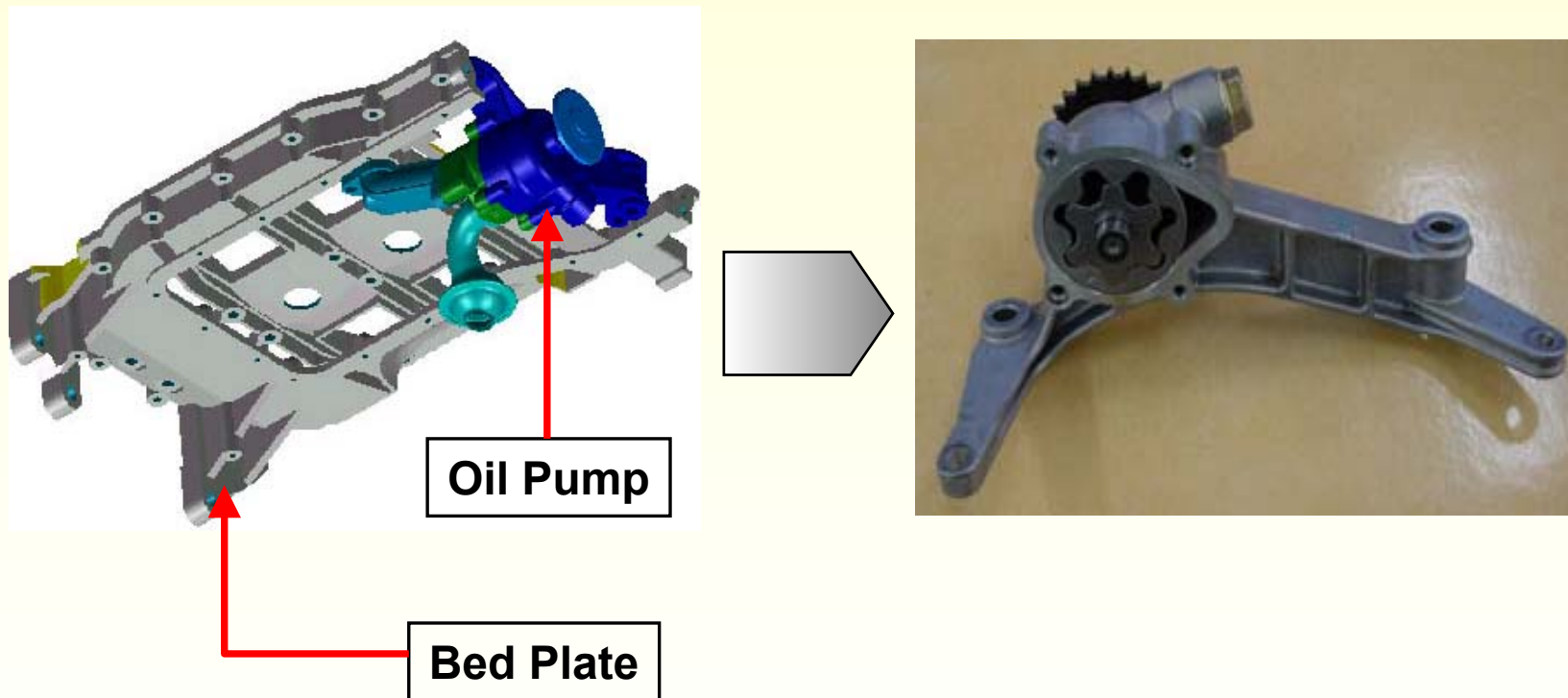
■ Components Descriptions

- Maintenance free timing chain and chain guide adapted
- Composed by 3 chains : A, B and C
- Shorten engine length

Timing Chain

Timing Chain "C"

Tensioner

Chain guide
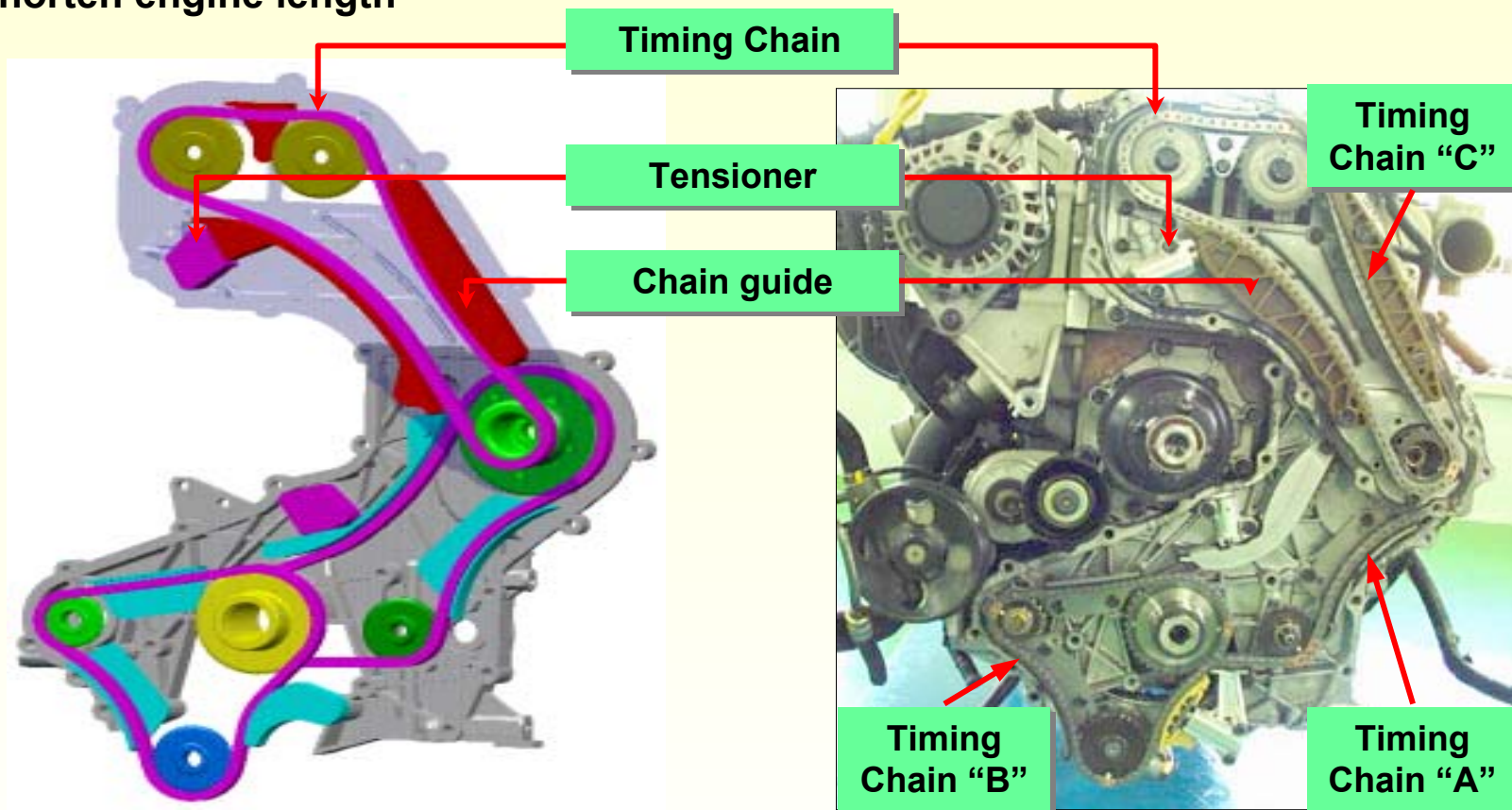
Timing Chain "B"

Timing Chain "A"

■ Components Descriptions

- **Drive crankshaft pulley, high pressure pump and RH balance shaft**
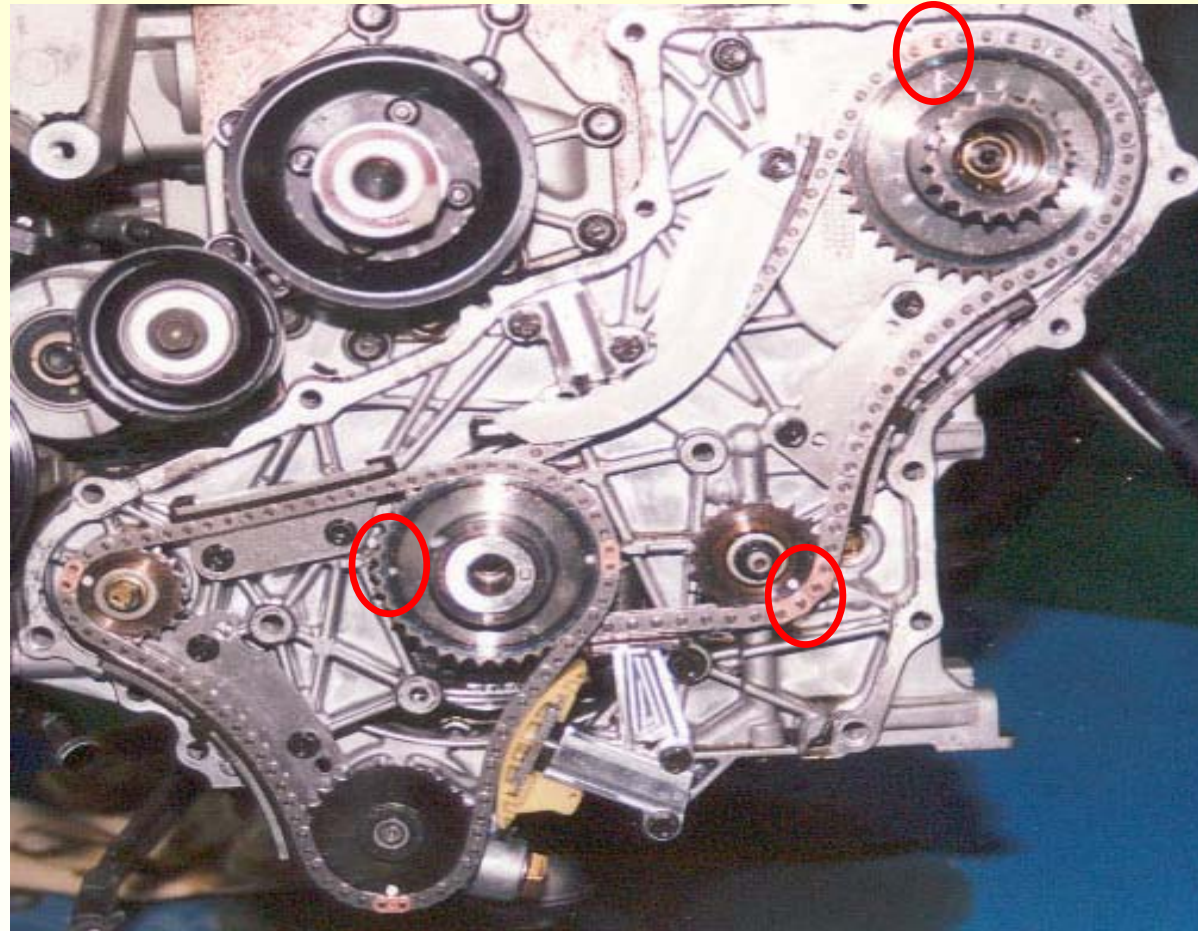
■ Components Descriptions

- Drive Crankshaft pulley, oil pump and LH balance shaft pulley
- Aligned all timing mark together in initial installation
- Proper lubrication for timing chain and chain guide

Tensioner

15 teeth

13 teeth

12 teeth

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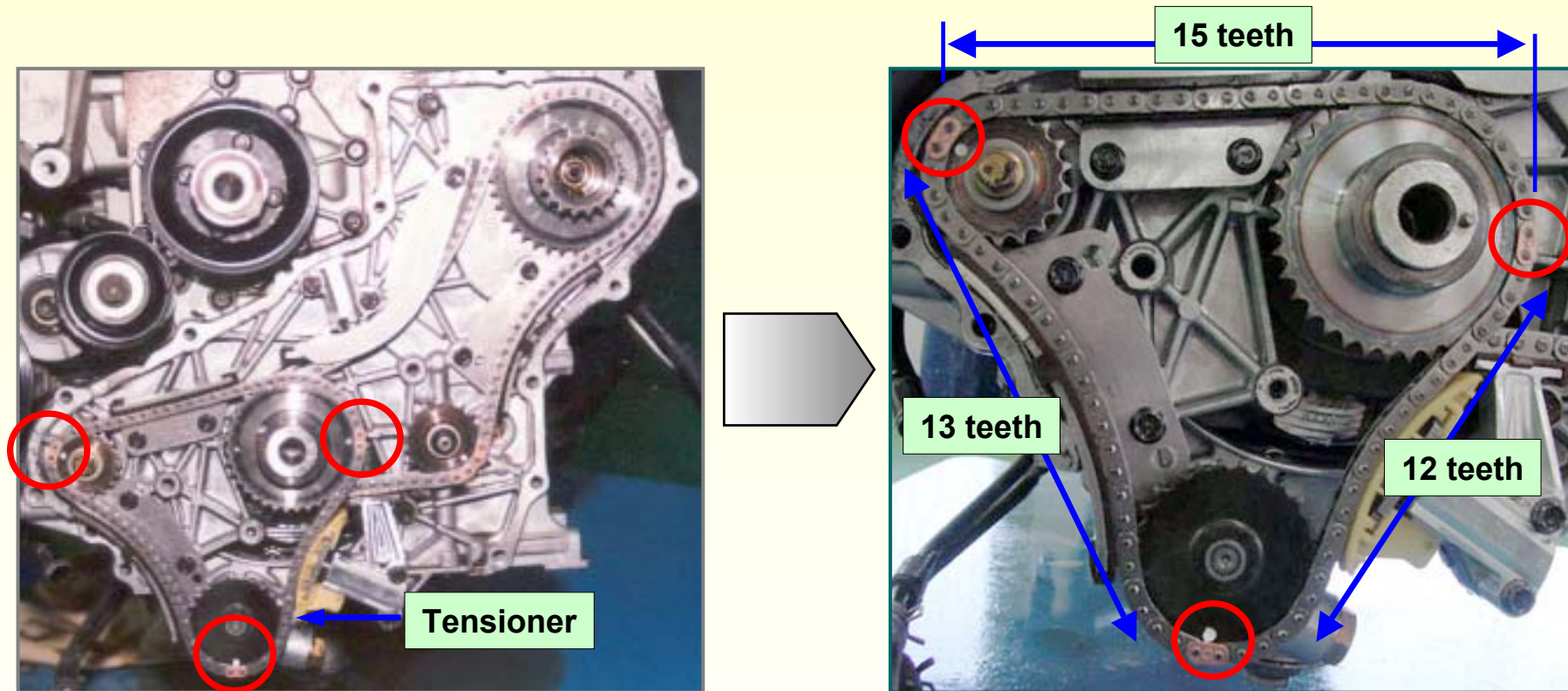
Timing Chain "C"

■ Components Descriptions

- Drive high pressure pump intake and exhaust cam sprocket

5teeth
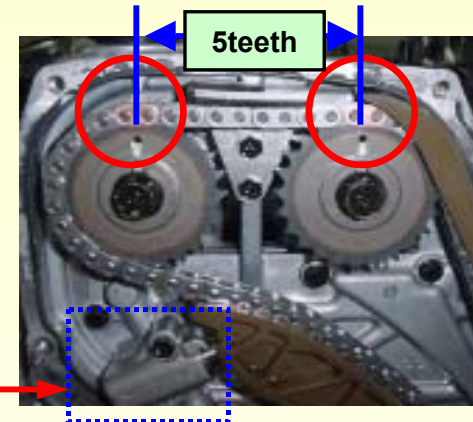
Auto Tensioner

High Pressure
Pump sprocket

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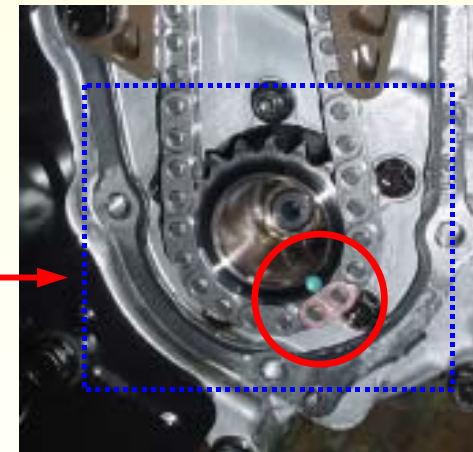
■ Reference

- Replacing work for timing chain A and B is not possible in condition of engine installation while timing chain C is possible.
- Alignment between each sprocket and timing belt should be in spec. especially in timing chain "C".
- There are 3 types of high pressure pump sprocket supplied related to high pressure pump. Every time when you are in replacing work, you have to check the clearance between high pressure pump end and pump sprocket end and choose the right size of sprocket for proper installation.

Cylinder Block

HP Pump
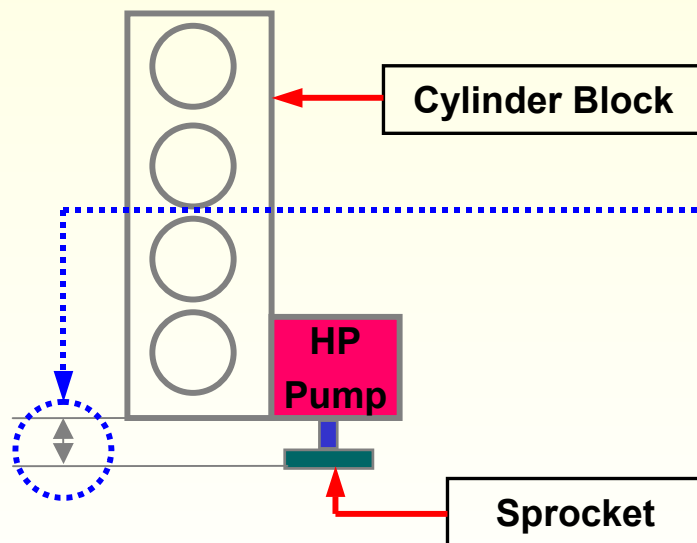
Sprocket

Color	Thickness (mm)	Sprocket
Blue	34.2-35.0	A
White	33.4-34.2	B
Red	35.0-35.8	C

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Fuel System

High pressure line

Rail pressure sensor

Pressure limiter valve

Common Rail

Low pressure line

Fuel return line

Injector

High pressure Pump

Pressure control valve

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Fuel system – Low Pressure Line

Low pressure line comprises

Pressure limiter valve

HP pump

Common rail

Rail pressure sensor

Injector

Pressure control valve
(MP RCP)

LP pump
(F/pump)

Supply pressure
(4-6bar)

Suction Pressure
(0.5-1bar)

Fuel filter
- water separator
- fuel pre-heater

Pre-filter
(600$\mu\ell$)

Fuel tank

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■ Components Descriptions

- Fuel tank is located under the second passenger seat
- Capacity of fuel tank is 72ℓ
- Cut-off valve(located right under air filter) : prevent fuel
  flow from tank to canister in emergency

Fuel return
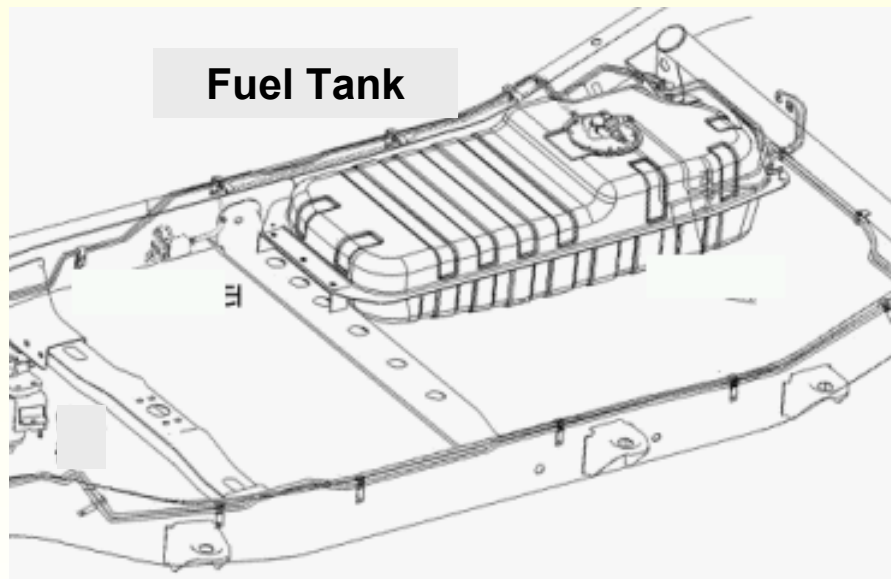
Connector for fuel level change

Fuel Tank

Air filter

Fuel supply
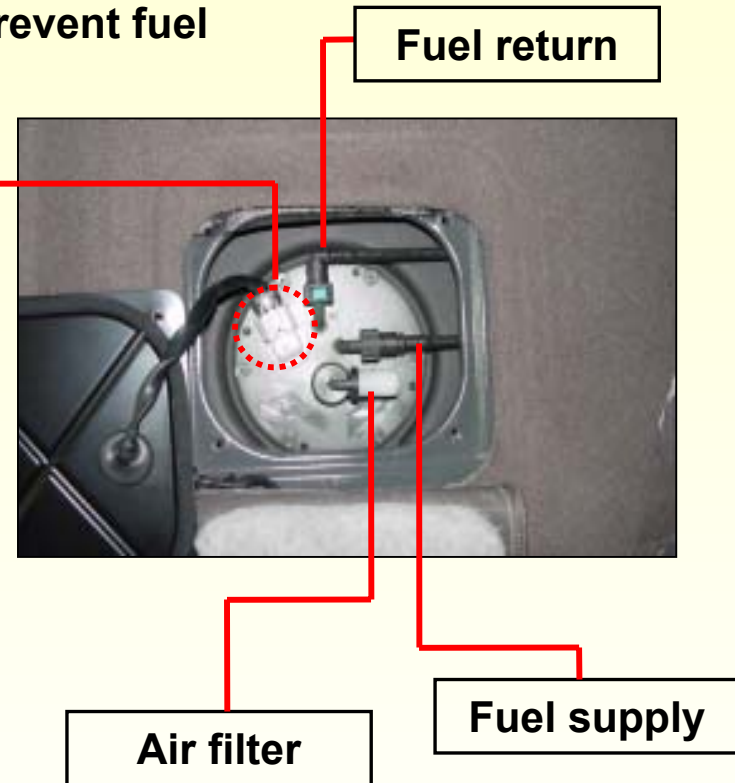
- Fuel level gauge : Detect the fuel level by rotary type potentiometer and signal to cluster

- Low fuel warning lamp : The same function as fuel gauge is used. But when the output potentiometer data reaches in specified range of low fuel warning lamp and lasts enough time of 60 ± 20 Seconds, low fuel warning lamp is on.

Warning lamp relay

※ Resistor value by floater position

Floater Position	Top	3/4	1/2	Warning Lamp on	Empty
Resistor Value(Ω)	3 ± 1	18.5 ± 1	32.5 ± 1.5	83 ± 2	110 ± 2
Tank Capacity(ℓ)	72	54	36	12	8

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■ Components Descriptions

- Common rail diesel system needs much more purified fuel than conventional diesel system by several reasons.
- Water and solid contaminants especially in cold weather can result in wear, erosion, filter blocking, surface pitting ,pressure loss and eventual poor lubrication in HP pump side.
- To reduce these potential problems, Sorento is installed Bosch fuel filter along with water separator and fuel pre-heater.

- Main components :

① Main filter
② Fuel temperature switch
③ Water separator sensor
④ Fuel pre-heater
⑤ Air bleeding pump

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■ System Descriptions

- **Purpose : to prevent diesel fuel from waxing (solidifying propriety in cold temperature of diesel fuel) formation.**
- **Working temperature :**
  on : below -5℃
  off : over 3℃

Fuel temperature Switch

Pre-heater

■ System diagram

Fuse box

Battery

Heater relay

Pre-heater

IG

Fuel temperature switch

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Low Pressure Line – Feed Pump(Supply Pump)
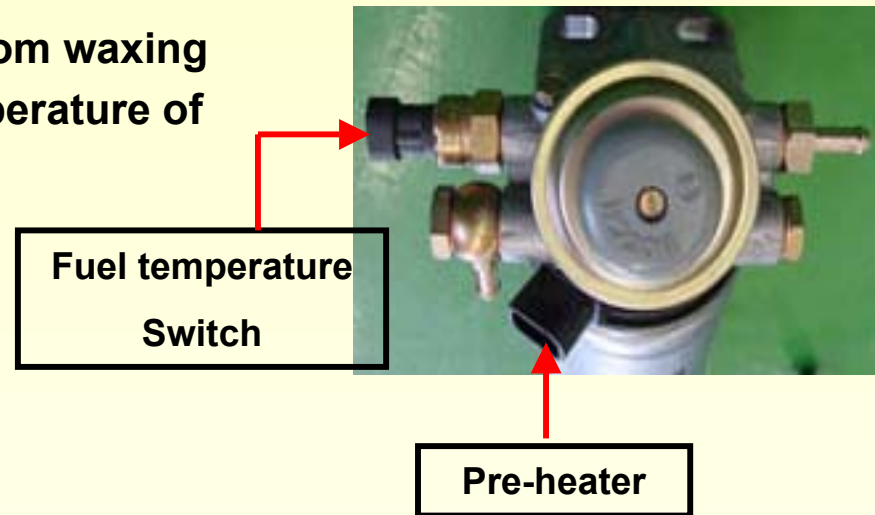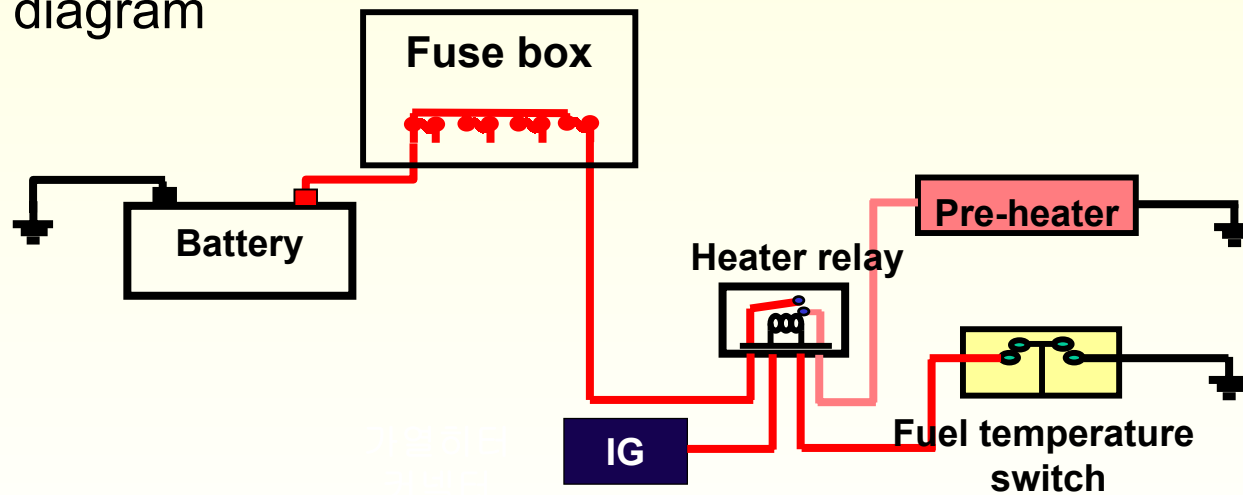
■ Components Descriptions

- Main job : maintaining an adequate fuel supply to the high pressure pump
- Type : Mechanically driven gear type and integrated in the high pressure
  pump with which it shares a common drive
- Main features :
    ① Delivered fuel quantity is practically proportional to the engine speed
    ② Maintenance-free
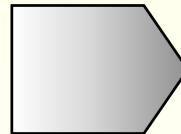
■ Components Descriptions

- Suction pressure : 0.5 ~ 1 bar
- Feed pressure : 4.5 bar

※ Capacity

Feed quantity	2798rpm	1.03ℓ/min
Feed pressure	2798rpm	4.5bar
Max. feed quantity	80ℓ/hr	

Pressure limiter valve

High pressure line comprises

HP pump

Common rail

Fuel filter
- water separator
- fuel pre-heater

LP pump
(F/pump)

Rail pressure sensor

Suction Pressure
(0.5-1bar)

Pre-filter
(600$\mu\ell$)

Injector

Supply pressure
(4-6bar)

Pressure control valve
(MP ROP)

Fuel tank
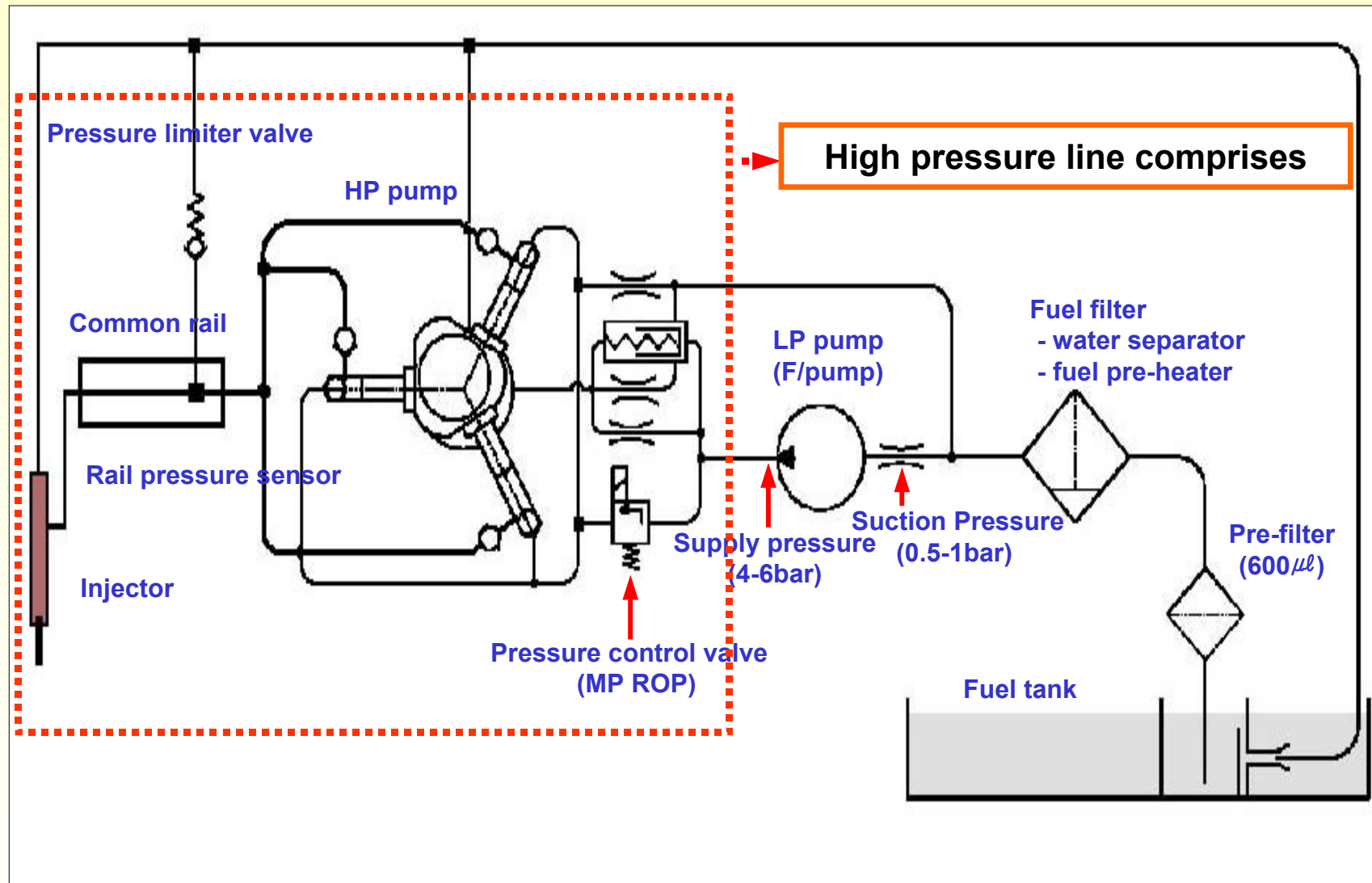
■ Components Descriptions

- **Main function : To control the injection pressure to the engine's requirements which are calculated according to engine speed and load.**

   ① **Engine speed and load are high** : **The degree of turbulence in combustion chamber is very great so the highly pressurized fuel has to optimize combustion.**

   ② **Engine speed and load are low** : **If injection pressure is too high in low load stage, the nozzle's 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.**

- **Pressure control process :**

   ① **Measure the current rail pressure by rail pressure sensor**
   ② **Signal to EDC(Electronic Diesel Control)**
   ③ **Calculate the adequate fuel demand by engine speed and load**
   ④ **Control the "pressure control valve to reach the required value by PWM (Pulse-width modulation)**

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■ Components Descriptions

- Types :
  ① Outlet control : located at the end of accumulator line and control the output pressure from H/P pump by increasing or decreasing the total return fuel quantity
  ② Inlet control : integrated with H/P pump and control the fuel quantity from feed pump to high pressure pump

  ※ Merit of outlet control type
     ⓐ minimize the increasing fuel temperature only supplying optimized fuel volume
     ⓑ driving torque is decreased by 3~4kg-m

  Demerit
     ⓐ difficult to release unneeded rail pressure in sudden deceleration condition

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■ Components Descriptions

- Sorento uses the **inlet control type**
  pressure control valve.

Pressure control valve

Feed Pump

H/P pump

■ Components Descriptions

- **Pressure control valve non-energized** :
  The fuel pressurized from feed pump
  exceeds the spring force so that the
  control valve remains open.

  The small fuel is used for pump
  lubrication and last of fuel goes through
  the pressure control valve and pressurized
  by high pump.

From feed pump

To h/p pump

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■ Components Descriptions

- **Pressure-control valve energized** :
 When the pressure control valve is energized
 it remains closed until equilibrium is reached
between the high pressure forces and spring
force with energized electromagnet force

The fuel from feed pump side can not go
through the pressure control valve and only
return through the return passage inside
of the pump.

The electromagnet's forces are proportional
to its energizing current which is varied by
pwm(pulse-width modulation) pulsing.

From feed pump

To h/p pump

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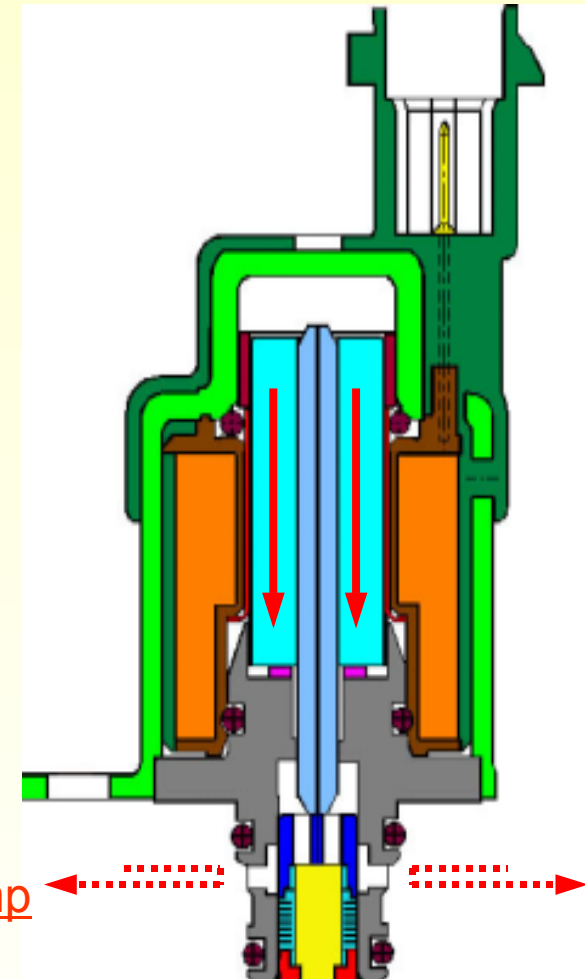
High Pressure Line – Pressure Control Valve

■ Components Descriptions

- Idle (800rpm) :
    Close duty ≒ 45%
    Rail pressure ≒ 270bar

- loaden condition (4500rpm):
    Close duty ≒ 35%
    Rail pressure ≒ 1350bar
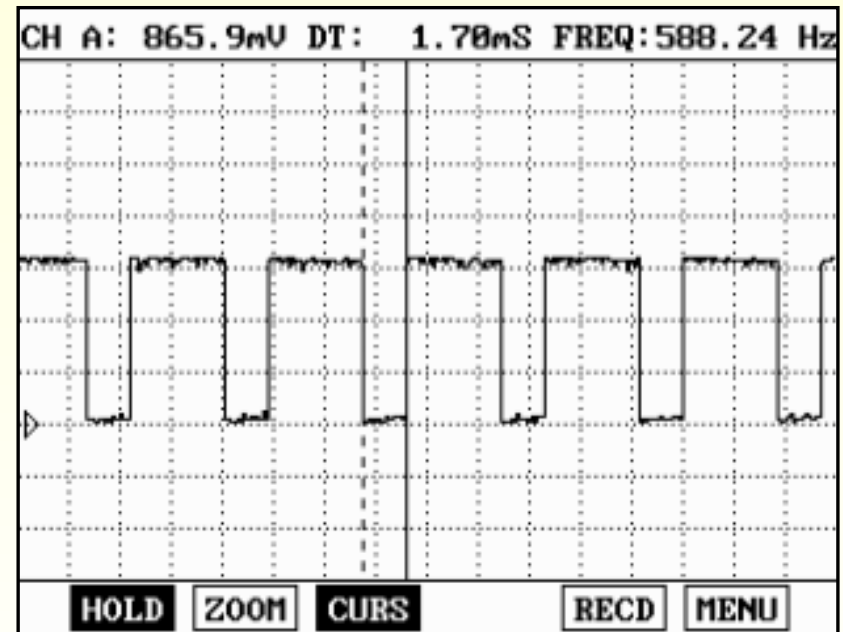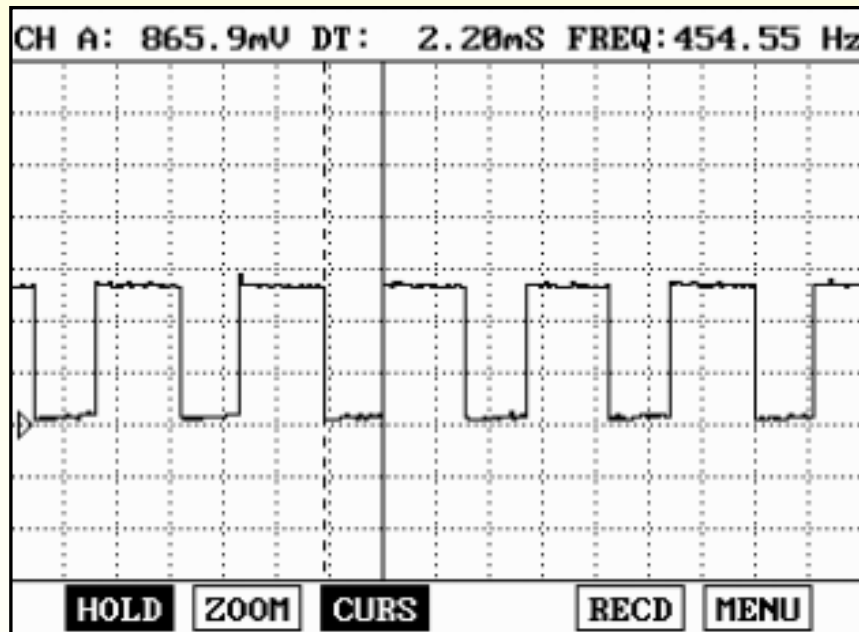
■ Components Descriptions

- **Main functions :**

   The high pressure pump is the interface between the low pressure and the high pressure stages. It is responsible to generate adequate high pressure under all operating conditions.

- **Type :**

   ① **Volumetric blade type driven by timing chain.**

   ② **Installed at the same point as a conventional distributor pump.**

H/P pump

Pressure control valve

Feed pump

Low pressure inlet

Low pressure return

High pressure supply

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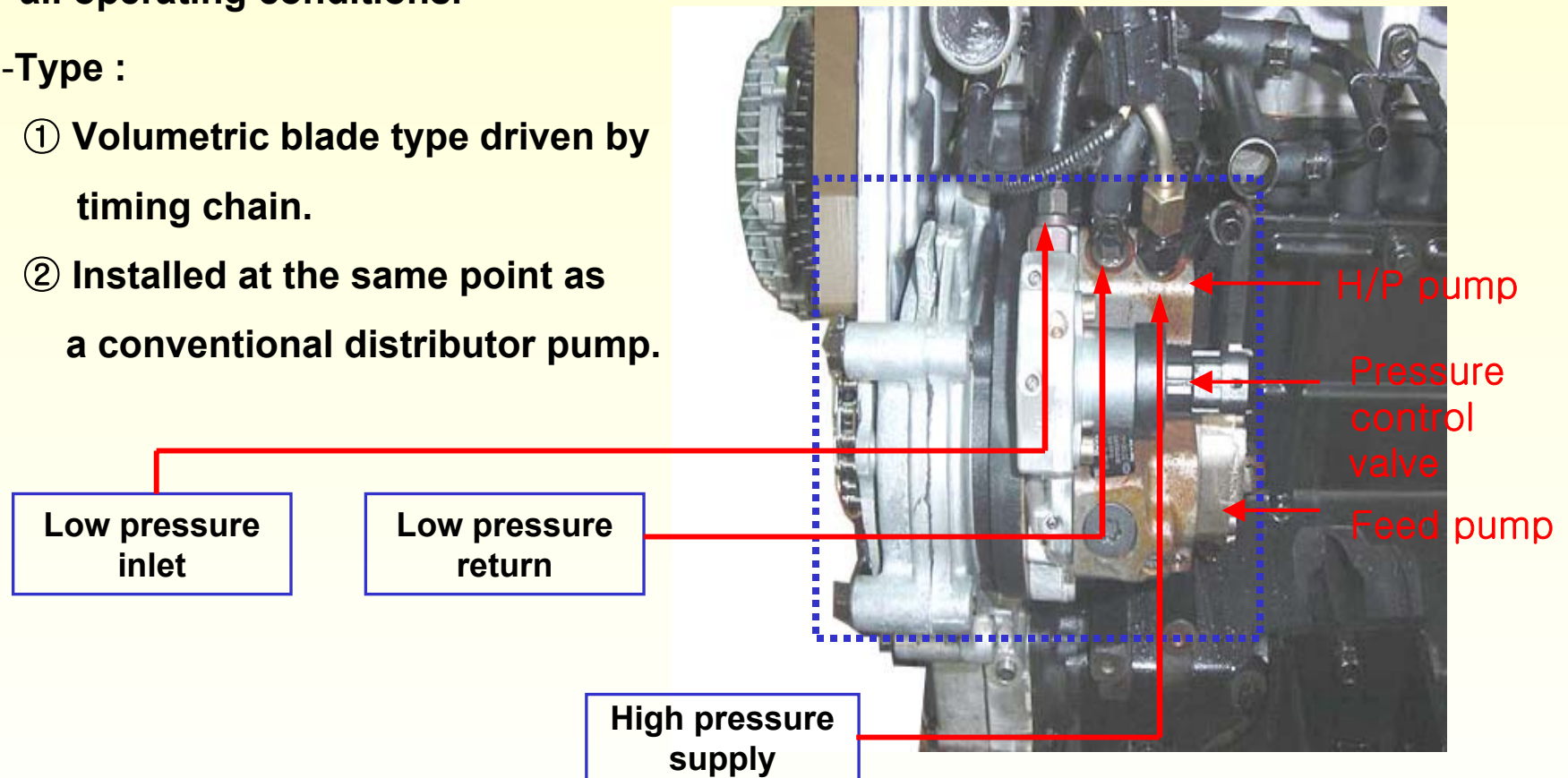
■ Components Descriptions

- **Main components :**
  ① **drive shaft**
  ② **Eccentric cam.**
  ③ **Pumping element with pump piston**
  ④ **Inlet valve**
  ⑤ **Outlet valve**

Inlet valve
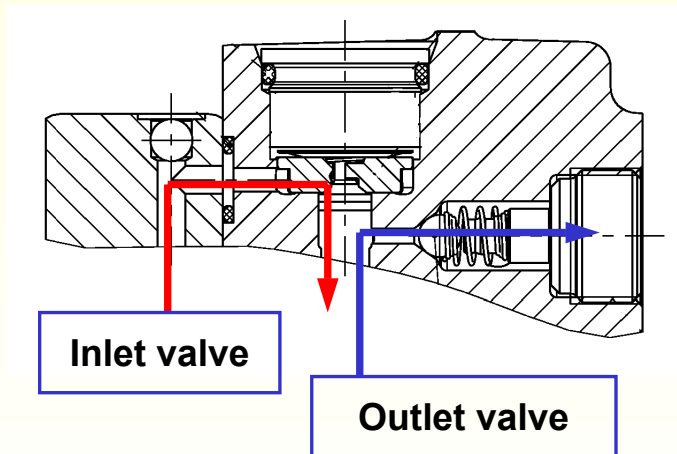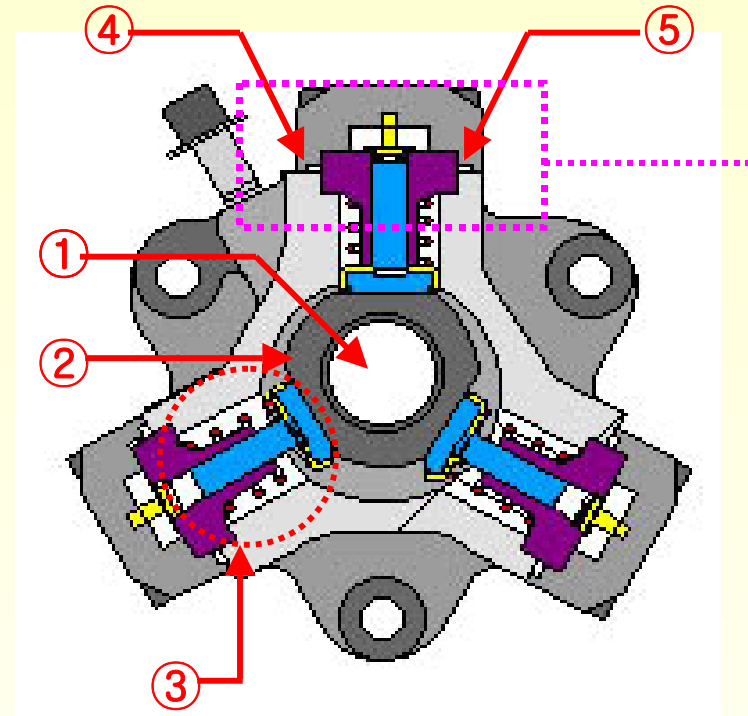
Outlet valve

■ Components Descriptions

- **Operation :**

① **The feed pump pumps fuel from the tank to the high pressure pump.**

② **The drive shaft with its eccentric cam moves the three pump plungers up and down in accordance with the shape of the cam.**

③ **The inlet valve closes when the pump piston passes through BDC.**

④ **The increasing pressure in the pumping element chamber opens the outlet valve.**

⑤ **The compressed fuel enters the high pressure circuit.**

- **Specifications :**

Items	Data	Items	Data
Output quantity	0.677㎤/rev	**Max. rev. Speed**	4600rpm
Output pressure	1600bar	**Working pressure**	1350bar
Gear ratio	0.67	**Drive torque**	24~28Nm

■ Components Descriptions

- Main functions :

The high pressure accumulator, generally speaking common rail, stores the fuel at high pressure. Even when large quantities of fuel are extracted, the common rail maintains its inner pressure practically constant.

- Components :

① Rail

② Inlet from the high pressure pump

③ Rail pressure sensor

④ Pressure limiter valve

⑤ Line to the injector
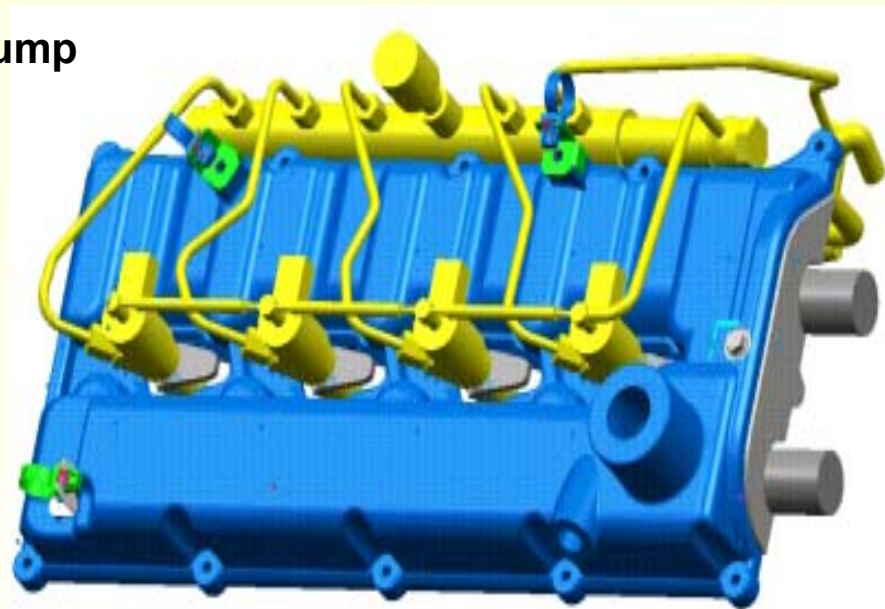
■ Components Descriptions

- **Main functions :**

  ① **the same job as an overpressure valve.**

  ② **In case of excessive pressure in common rail,**
     the pressure limiter valve limits the rail pressure
     by opening an escape passage.

  ③ **Defined opening rail pressure : 1,750 bar**

- **Components :**

  ① **High pressure connection**

  ② **Flow passage**

  ③ **Plunger**

  ④ **Spring**

  ⑤ **Fuel return**

- **As soon as the maximum system pressure is**
  exceeded, the plunger is forced up by the rail
  pressure against the force of the spring. When the
  plunger is up, fuel leaves the rail so that the rail
  pressure drops.

⑤ ④ ③ ② ①

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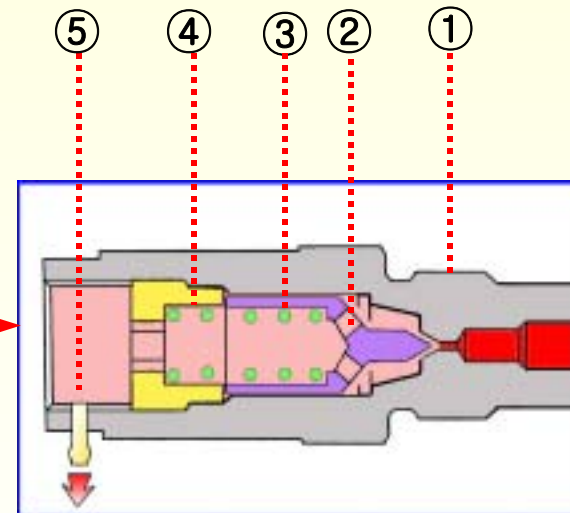
■ Components Descriptions

- Main function :

The central-vertically located injector injects the correct amount of fuel into the combustion chamber at the right time. To do so, it is designed :

① to be fully electronically controlled

② to allow multiple injections with short intervals between each injection

The solenoid valve block

The hydraulic servo-system block

The hole-type nozzle block
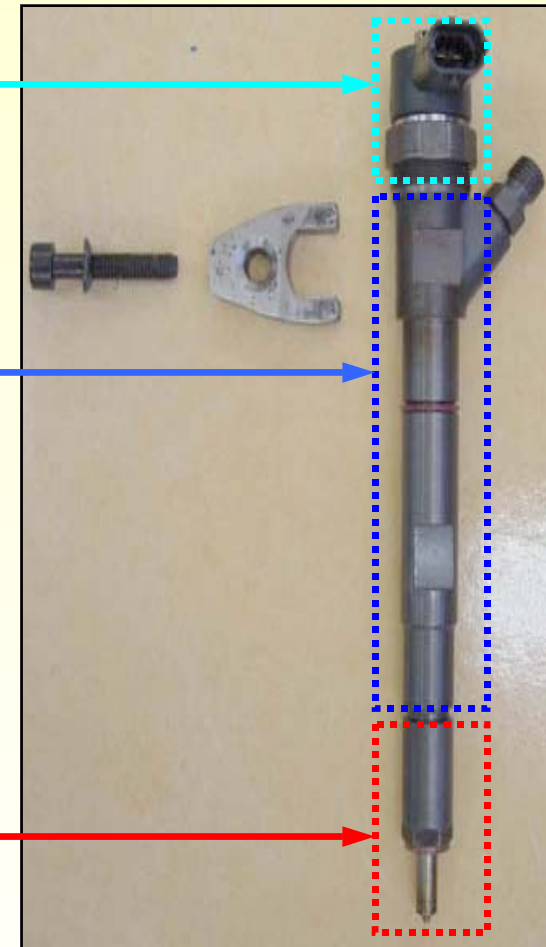
※ Initial operating currency : 80V/20A

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■ Components Descriptions

Closed   **Opened**

- Components :

① **Fuel return**

② **Electrical connection**

③ **Solenoid valve**

④ **Fuel inlet**

⑤ **Valve ball**

⑥ **Bleed orifice**

⑦ **Feed orifice**

⑧ **Valve control chamber**

⑨ **Valve control plunger**

⑩ **Feed passage**

⑪ **Nozzle needle**

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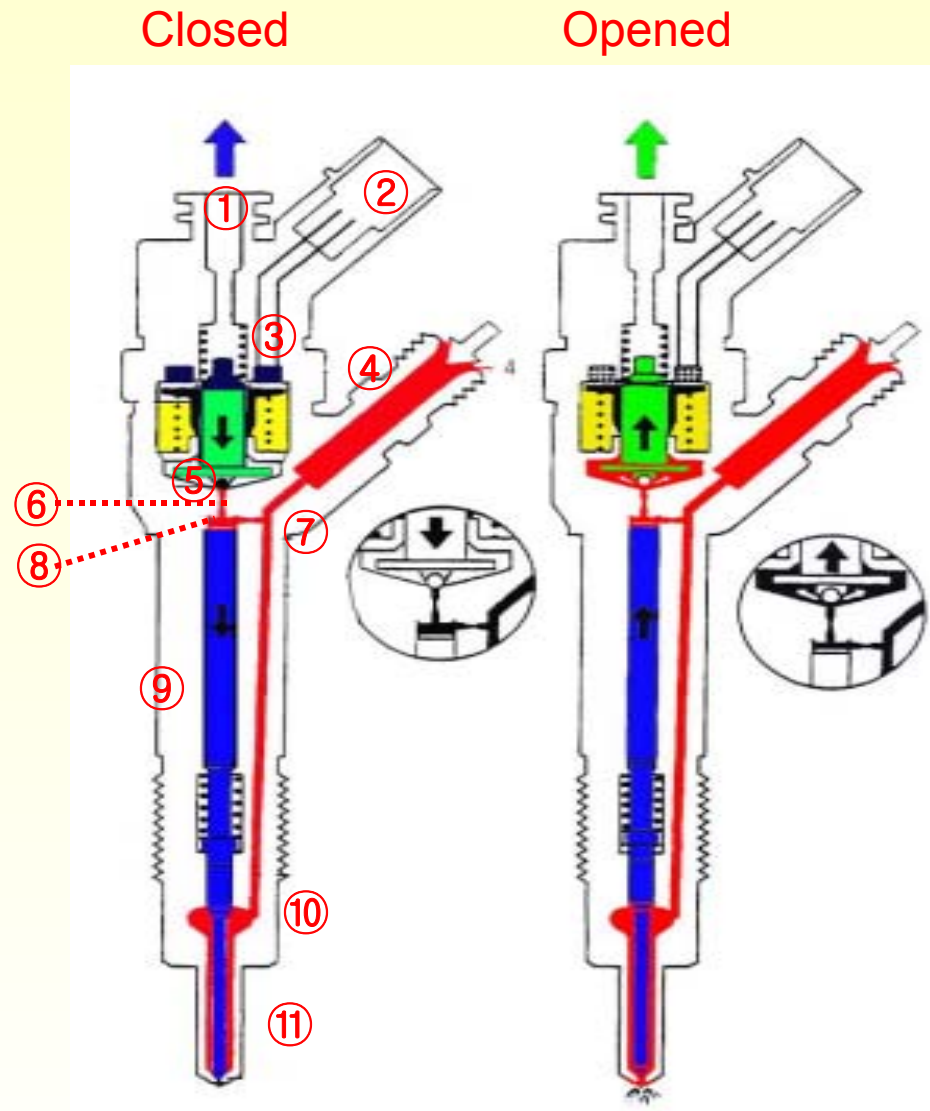
■ Components Descriptions :

- **Operation :**

① **Injector closed (at-rest status) :**

The solenoid valve is not energized and the bleed orifice closed. The valve spring forces

the valve ball to the bleed orifice seat. The same pressure is present between in the valve

control chamber and in the nozzle chamber.

② **Injector opens(start of injection) :**

The solenoid valve is energized with the pick-up current and the applied force exceeds that

of the valve spring which opens the bleed orifice. When the bleed orifice opens, fuel can

flow from the valve control chamber to the fuel tank via the fuel return. This makes pressure

unbalance between the valve control chamber and the nozzle chamber. The reduced pressure

in the valve control chamber lets the nozzle needle opens as a result and injection starts.

③ **Injector closed (end of injection) :**

As soon as the solenoid valve is no longer energized, the valve spring forces the armature

downwards and the valve ball closes the bleed orifice. Closing the bleed orifice leads to

pressure buildup in the control chamber. Consequently this pressure buildup makes pressure

balance between in the valve control chamber and in the nozzle chamber and the nozzle needle

closes.

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■ Components Descriptions :

- Injection time sequence :

A = Control current

B = Stroke in mm

C = High pressure

D = Injection rate

a = Control current for solenoid coil

b = Valve lift stroke

c1 = Pressure in the control chamber

c2 = P. in the needle lift chamber

d   = Injection
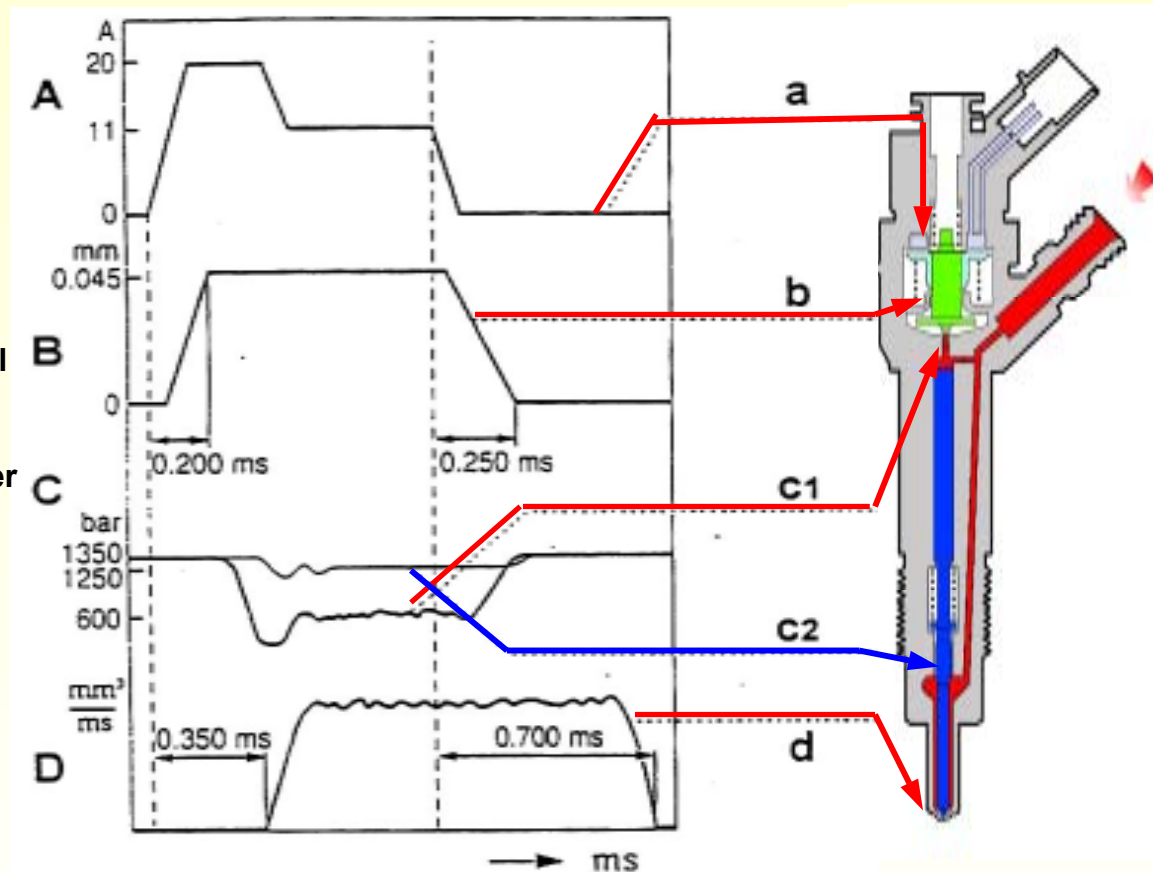
■ Components Descriptions :

- Injector control :

1 Capacitor disharge

2 Injector pull in current

3 Capacitor charge

4 Injector holding current

5 Capacitor charge

(PST off)

6 Regulated holding current

(free-wheeling)

7 Regulated holding current

(power stage on)

■ Components Descriptions :

- **Pilot-injection :**
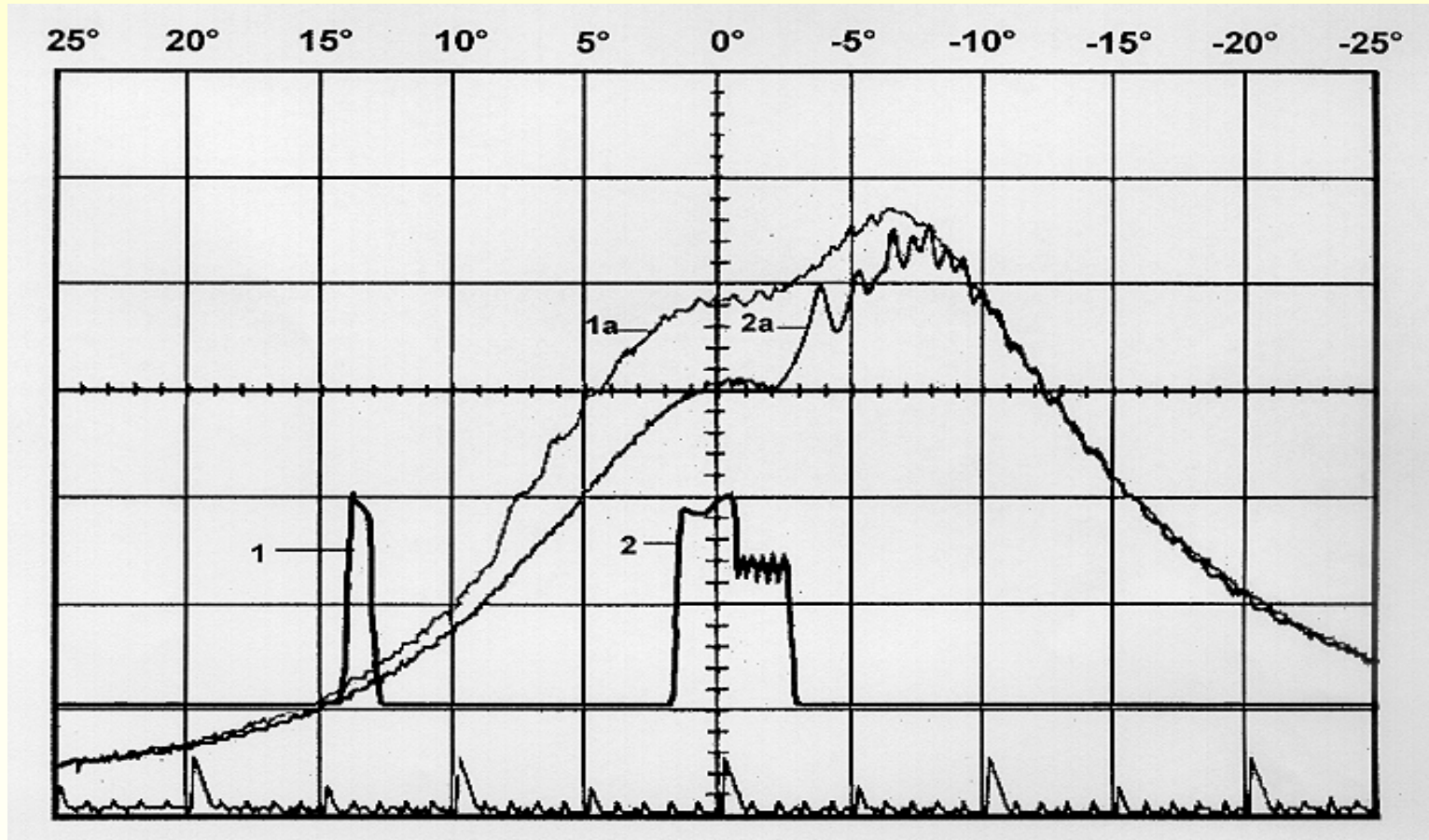
1 = Pilot-injection   1a = Combustion pressure with pilot-injection

2 = Main injection   2a = Combustion pressure without pilot-injection

High Pressure Line – Injector

■ Components Descriptions :

- Aim of pre-injection :

Reduction in Combustion noise

① Combustion noise

② HC Emissions

③ Fuel consumption (late injection start)

- Working condition :

Idling and operation under partial load

- Principle :

In a diesel engine, combustion does not start immediately after the fuel has been

Injected into the cylinder. It makes severe combustion noise when ignition happens.

To reduce combustion noise and to make idle combustion, it is necessary to reduce

the ignition time by increasing both the vaporisation and the chemical formation.

This increase can be brought about by injecting a small quantity before the start of

the main injection. This is termed pre-injection.

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■ Components Descriptions :

- Injector installation :

High pressure fuel inlet

- Tightening torque : 2.5~2.9kg-m

Clamp bolt and washer

- Tightening torque : 3.1±0.3kg-m

- Over tightening torque problems :

① Uneven fuel distribution

② Performance down

③ Shorten durability

Electronic Diesel Control

(EDC)

Input

Output

Input box:

1. Air-mass Sensor

2. ECT Sensor

3. IAT Sensor

4. CKP Sensor

5. CMP Sensor

6. Rail Pressure Sensor

7. Accel. Pedal Sensor

8. S/W Inputs

   - Brake

   - Clutch

   - A/con

9. Vehicle Speed Sensor

ECM

Output box:

1. Injector

2. Rail control valve

3. Relays

   - Main

   - Glow Plug

   - Cooling Fan

   - A/con. Fan

4. VAC Modulator for EGR

5. Pre-heater(Coolant)

6. CAN

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■ Components descriptions :

- Fault code erasing :

When the fault code occurs and stored in the ECM, only Hi-scan pro can erase the fault memory in the ECM.

- Self identification function :

Since Sorento uses the same ECM regardless of the M/T or A/T specifications , it is necessary to identify the ECM whether the ECM is M/T spec. or A/T spec. through the Hi-Scan Pro.

Sorento ECM connector

PLUG "K"   PLUG "M"

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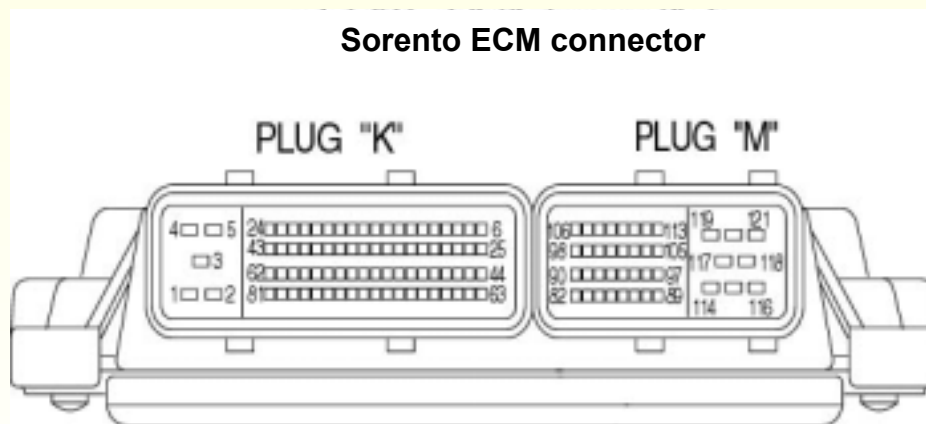
- Limp home mode :

The ECM switches to limp home mode in the event of failure of important input/

output signals. This can result in

① Reduced power

② Lower maximum speed

③ No EGR (It depends on items)

- Emergency shut off

For safety reasons, the ECM effects emergency shut off of the engine if the

following system components fail :

① Injectors

② CKP sensor

③ Pressure control valve

④ Fuel leakage

- Attention : Never work on injection system with engine running or with in 30 Sec.

after shutting off the engine.

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■ Components Descriptions :

- The hot-film sensor principle is based on the transfer of heat from a heated

  sensor element to the air mass flow. Unlikely that of gasoline engine, diesel

  engine's air flow sensor is mainly used to comply with the exhaust-gas limits,

  EGR(Exhaust Gas Recalculation). Intake air temperature sensor is integrated.

- Functions :

  ① EGR feed back control

  ② Fuel correction in sudden acceleration or deceleration

Air flow sensor

ECM

AFS Output (V)   5

89

B+(12V)   2

Reference (V)   4

97

IAT Output (V)   1

86

Ground   3

88

ANS

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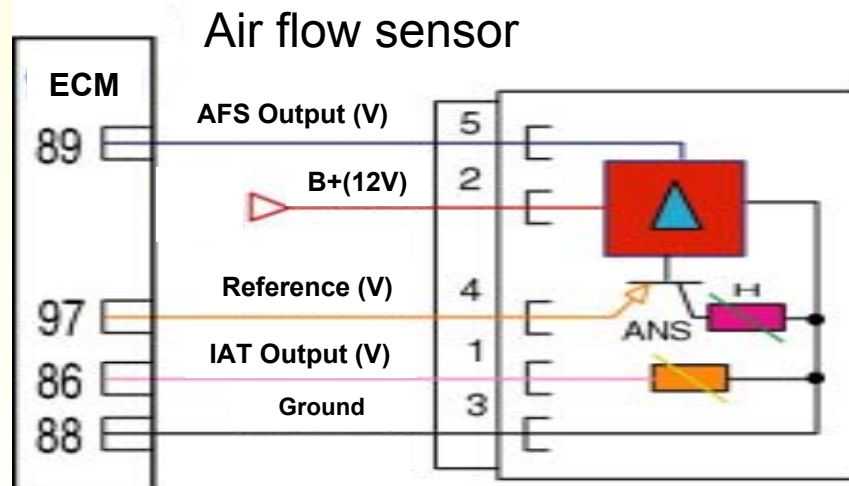
- **Failure symptom : Limp-Home function - <u>rpm limit by 2250rpm</u>**

Characteristic U = f (ṁ)


```
FR    CH A 5.0 V   0.2 mS     CH B 1.0 V
MIN:      4.4 V AVE:     4.6 V   MAX:    5.0 V
FREQ:       8.33 KHz      DUTY:  49 %
```

```
HOLD  ZOOM  CURS        RECD  MENU
```
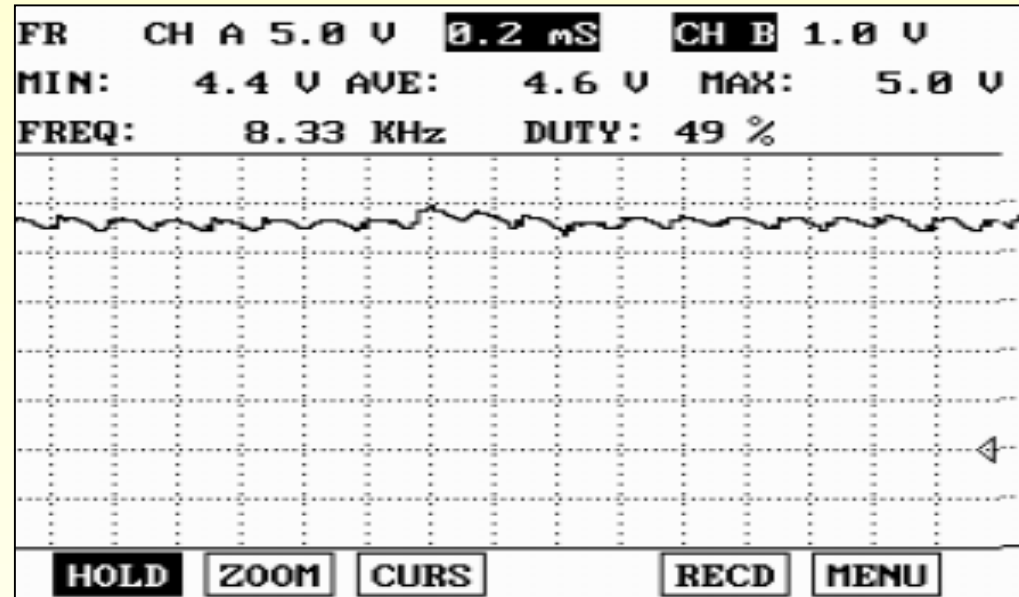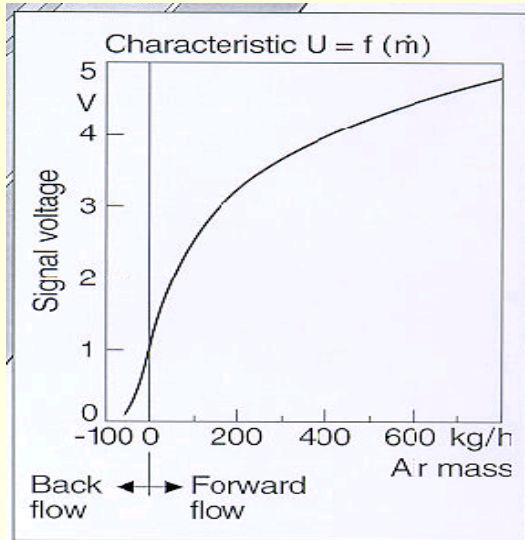
| Code | | Detail Description | Symptoms | | | | Check Condition |
DTC	CC		Fuel = 0	EGR off	Fuel Limit	MIL On	
0100	C001	Signal below lower limit(Air mass <-20kg/h)					Eng. Run
	C002	Signal above upper limit(Air mass>800kg/h)		Y	Y		
	C003	General Error(Reference Volt> 4.7~5.1)					

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■ Components Descriptions :

- Accelerator-pedal sensor is designed to detect the driver's acceleration or deceleration intension and to transmit this signal to the ECM. The ECM uses this signal to determined the injection volume and right time. There are two sensors in APS(Accelerator-pedal sensor), both APS 1 and APS 2. APS 1 is the main sensor to signal the driver's intension to the ECM. APS 2 is to monitor APS 1's malfunction in rationality check. APS 2 has the half of APS 1's output value.

Signal	ECM
APS1 Reference	78
APS1 Signal	77
APS1 Ground	76
APS2 Reference	81
APS2 Signal	80
APS2 Ground	79

- Failure symptom :

When the malfunction happens in one of both sensors, <u>rpm fix on 1250rpm</u>

Code		Detail Description	Symptoms				Check Condition
DTC	CC		Fuel = 0	EGR off	Fuel Limit	MIL On	
0120	C001	Signal below lower limit(Signal <68.4mV)		Y	Y		IG On
	C002	Signal above upper limit(Air mass>4.9V)					
	C003	General error(Reference Volt>1.7~5.1)					
	C004	Plausibility error with brake signal					
0220	C001	Signal below lower limit(Signal <68.4mV)		Y	Y		IG On
	C002	Signal above upper limit(Air mass>2.45V)					
	C003	General error(Reference Volt>1.7~5.1)					
	C004	Plausibility error (APS 1 and APS 2)					

- Plausibility error with brake signal (0120-C004) :

When the driver presses the accelerator pedal more than 1% and simultaneously presses the brake pedal (brake switch on), the ECM consider this condition as an abnormal accelerator pedal working ,kind of accelerator pedal's stuck in not-idle position. Other purpose to utilize this plausibility check is to prevent from sudden unintended acceleration of pedal misapplication by driver.

- Plausibility error between APS 1 and APS 2 (0220-C004) :

When the result of compared difference from APS 1 and APS 2 is over than set value, for example the press rate of accelerator pedal is 1.8 ~ 6% : 308mV

　　　　　　 the press rate of accelerator pedal is 7%　　 : 406mV

the ECM considers this as a fault of APS 1 or APS 2 in the name of rationality check.

EDC – Accelerator-pedal sensor(APS)
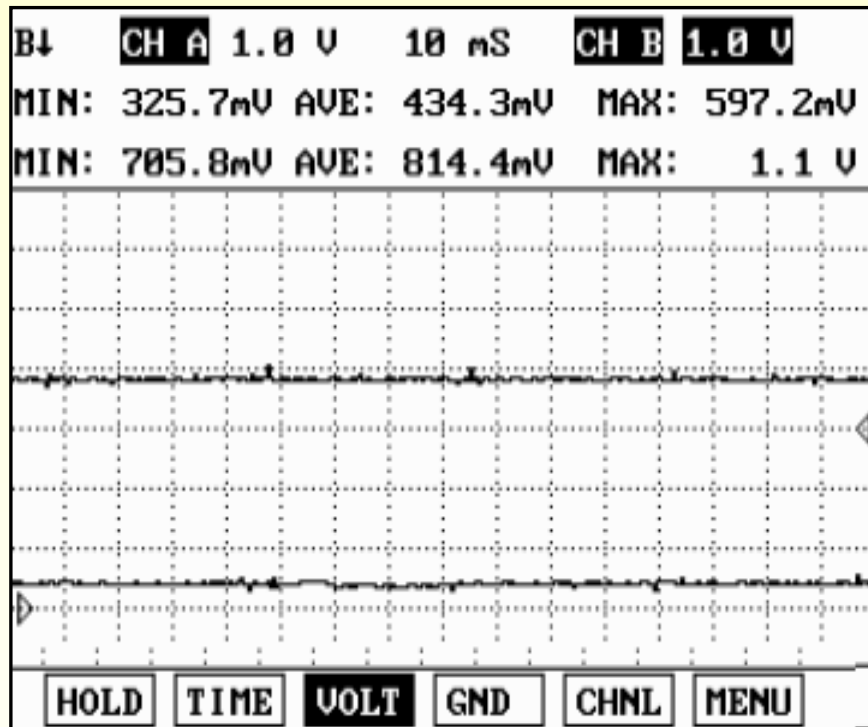
- Idle :   **- Full Load :**
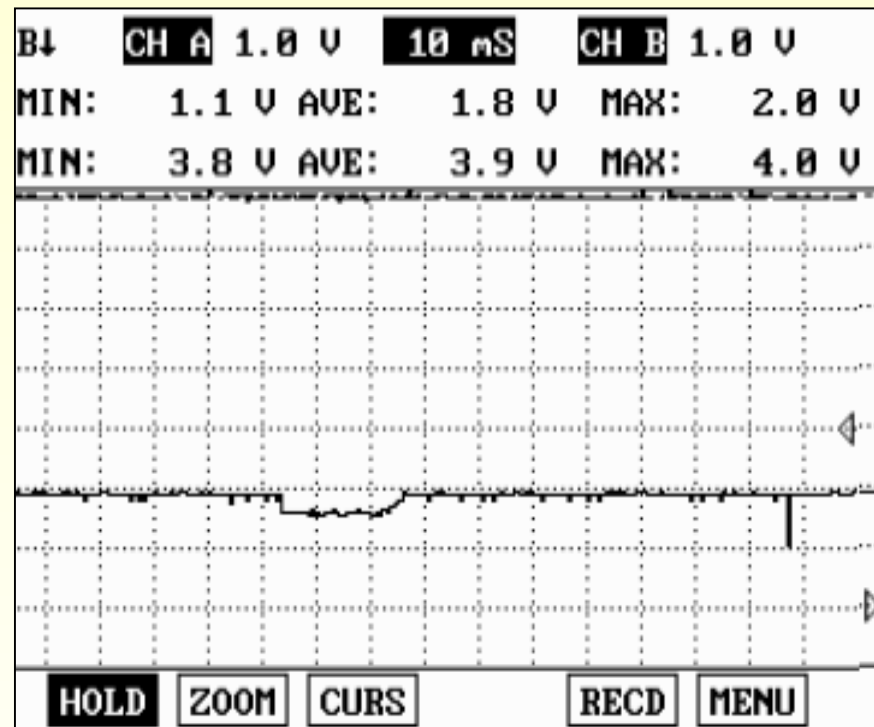
■ Components Descriptions :

- Crankshaft Position Sensor(CKP) :

The crankshaft position sensor, technically speaking CKP, is designed to detect and count the tooth on target wheel(60-2) and provides ECM with the information of the each piston's position in the combustion chamber to define the exact start of injection. This important information is calculated in the ECM using the signal from the inductive crankshaft position sensor(CKP).
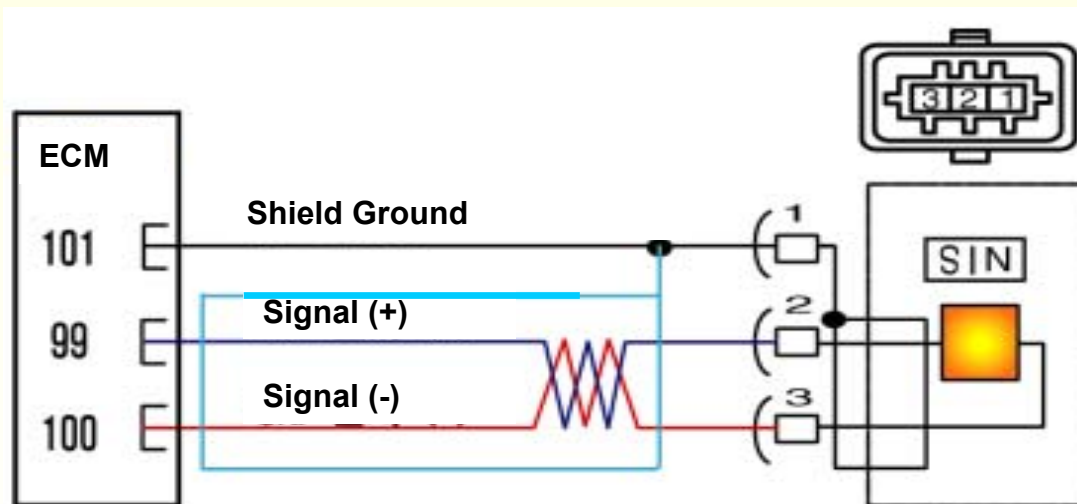
- Failure symptom : immediately engine shut-off and no re-starting

Sensor motion direction

Reference point of the target used by EMS to synchronize the engine

Air gap=1±0.5mm

Crankshaft Mechanical Target Wheel

ECM

ON≤1.8

OFF≥4,2V

1 tooth = 6°

OFF = 5V

Above4.7V

Output sensor Electrical signal

ON = 0V

Below0.8V

Tolerance = +/- 0.45 ° crankshaft
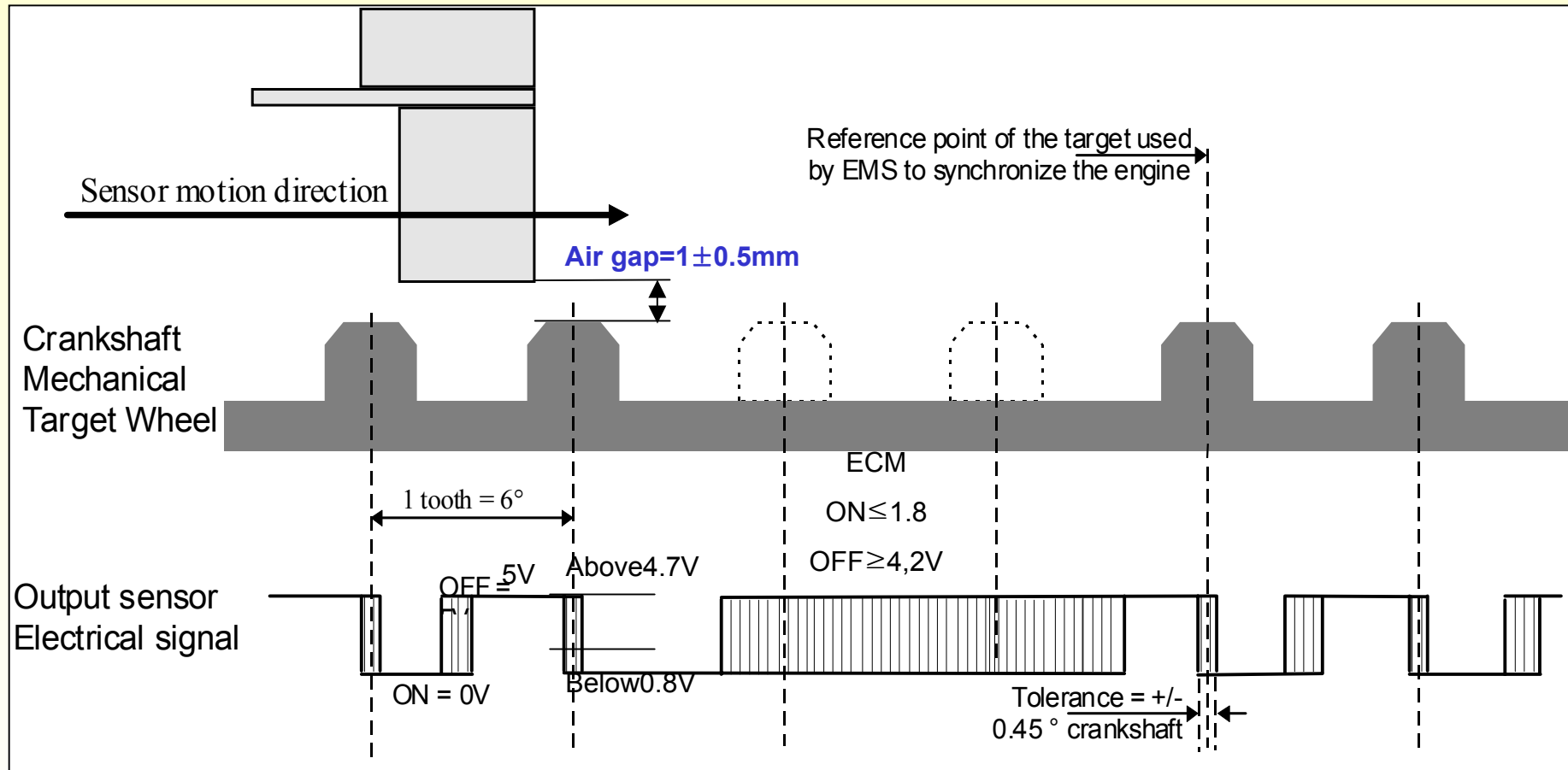
■ Components Descriptions :

- Camshaft Position Sensor(CMP) :

The camshaft position sensor utilizes the hall effect when establishing the camshaft position. A tooth of ferromagnetic material is attached to the camshaft and rotates with it. When this tooth passes the camshaft position sensor, its magnetic field diverts the electrons in the semiconductor wafers at right angles to the direction of the current flowing through the wafers. This results in a brief voltage signal(hall voltage) which informs the ECM with the information of piston and cylinder that cylinder no. 1 has just entered the compression phase.
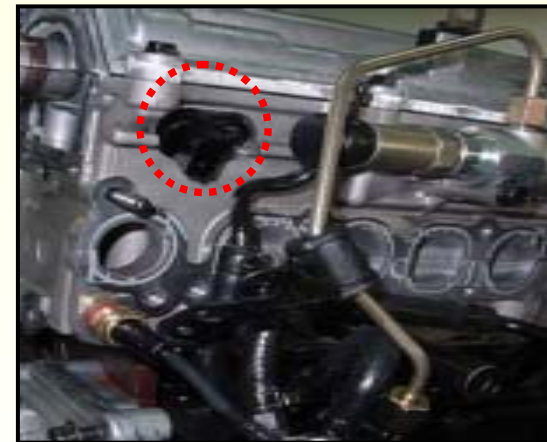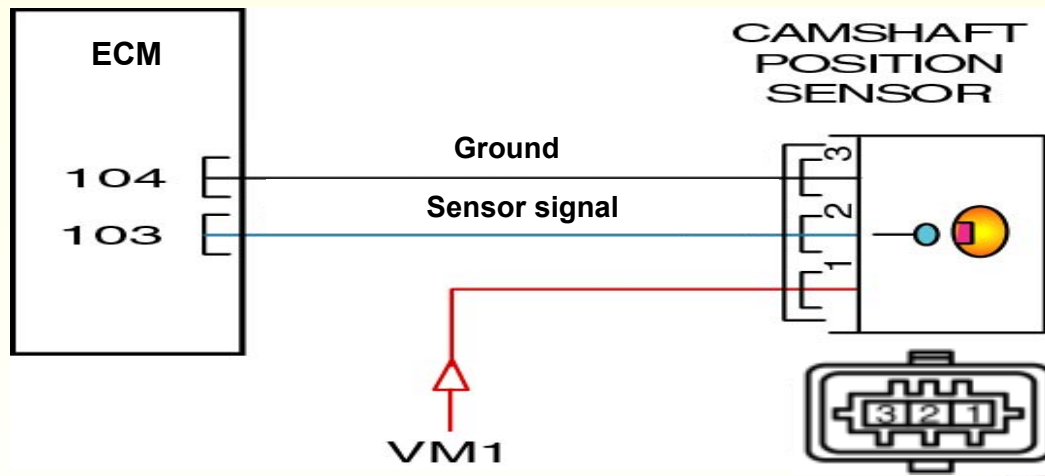
- CMP failure symptom : No start of the engine

| FR | CH A 5.0 V | 2.0 mS | CH B 2.0 V |

| HOLD | ZOOM | CURS | | RECD | MENU |
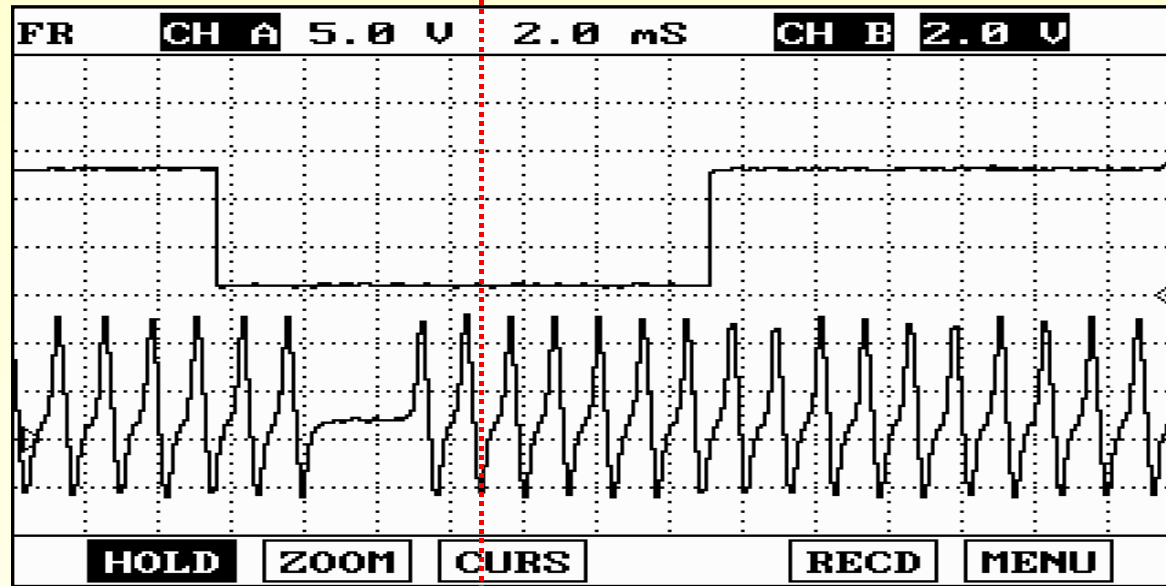
Code		Detail Description	Symptoms				Check Condition
DTC	CC		Fuel = 0	EGR off	Fuel Limit	MIL On	
0340	C001	CMP signal below lower limit(No signal)	No START			Y	Eng. Run
	C002	CMP Signal above upper limit					
	C003	CKP&CMP General error (Rationality check)	Y				
	C004	CKP Plausibility error					

■ Components Descriptions :

- **Rail Pressure Sensor(RPS) :**

The main role of rail pressure sensor is to measure the instantaneous pressure in the rail and to signal the ECM with output voltage which corresponds to the applied pressure. In order to have the tight tolerance which apply to the rail pressure sensor during pressure measurement, RPS must keep adequate accuracy with quick response.
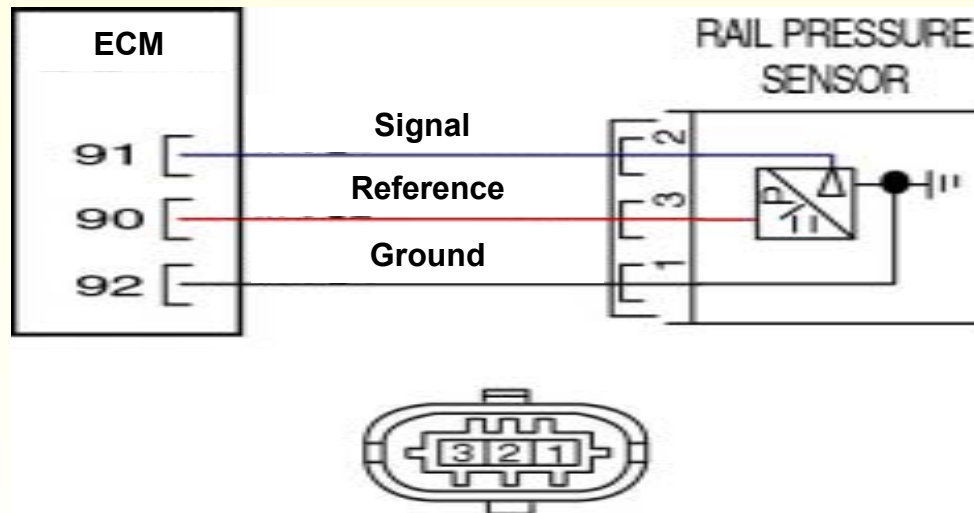
- Failure symptom : immediately engine shut-off and no re-starting

```
CH B:    4.1 V DT:    2.63S FREQ:    0.38 Hz
```


HOLD ZOOM CURS   RECD MENU
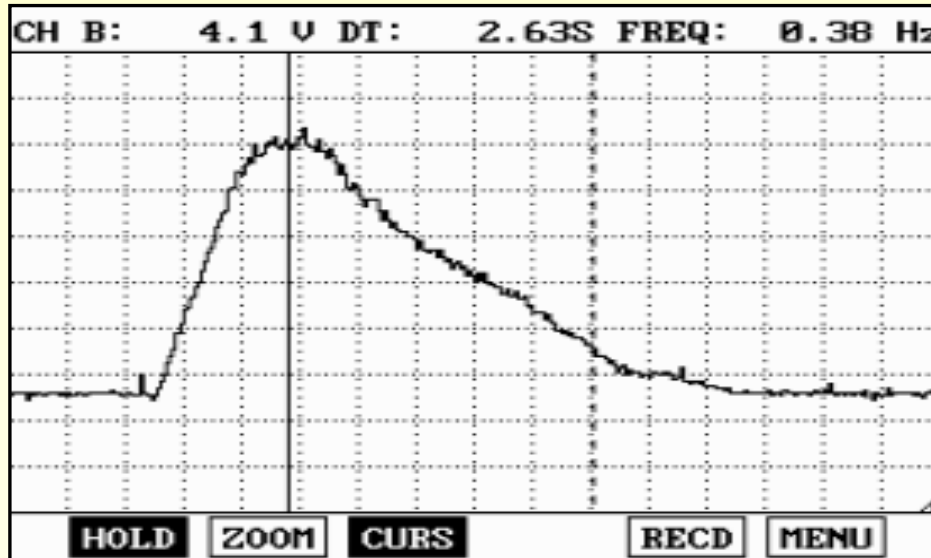
Cracking : 0.5→1.3V(≒250bar)

Idle   : 1.3V(≒250~260bar)

WOT   : 4.1V(≒1350bar)

- sensor monitoring

| Code | | Detail Description | Symptoms | | | | Check Condition |
DTC	CC		Fuel = 0	EGR off	Fuel Limit	MIL On	
	C001	Signal below lower limit(Signal <180mV)					
0190	C002	Signal above upper limit(Signal>4.8V)	Y		Y	Y	Eng.Run
	C003	General Error(Reference Volt> 4.7~5.1)					

KIA KIA MOTORS

- Pressure monitoring : only conduct more than 700 rpm condition

Code		Detail Description	Symptoms				Check Condition
DTC	CC		Fuel = 0	EGR off	Fuel Limit	MIL On	
1181	C005	Maximum pressure exceed(pressure >1480bar)	Y		Y	Y	Eng. Run
	C006	* Pressure lower limit by rpm					
	C008	* Pressure target value check(Negative deviation)					
	C010	* Pressure target value check (Positive deviation)					

※ **Pressure lower limit by rpm :**

  120bar / 800rpm, 180bar / 2000rpm, 230bar / 3000rpm, 270bar / 4000rpm

※ **Pressure target value check : (RPS stuck, wiring problem)**

  350bar / 800rpm, 300bar / 2000rpm, 250bar / 3000rpm

※ **Pressure target value check : (fuel leakage, failure from feed pump or high pump)**

  300bar / 800rpm, 250bar / 2000rpm

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■ Components Descriptions :

- **Engine Coolant Temperature sensor(ECT) :**
  The engine coolant temperature sensor is located in the engine coolant passage of the cylinder head. It detects the engine coolant temperature and relays signals to the ECM. It employs a thermistor, which is sensitive to changes in temperature. The electric resistance of a thermistor decreases in response to temperature rise. The ECM utilizes this signal to control the injection time and to limit idle rpm by ECT output. Also the ECM decreases the fuel volume when the ECT set value is over the mapping value in the ECM.

Heat gauge unit

ECM

Ground

Signal

85

84

3
2
1

[Characteristic curve]
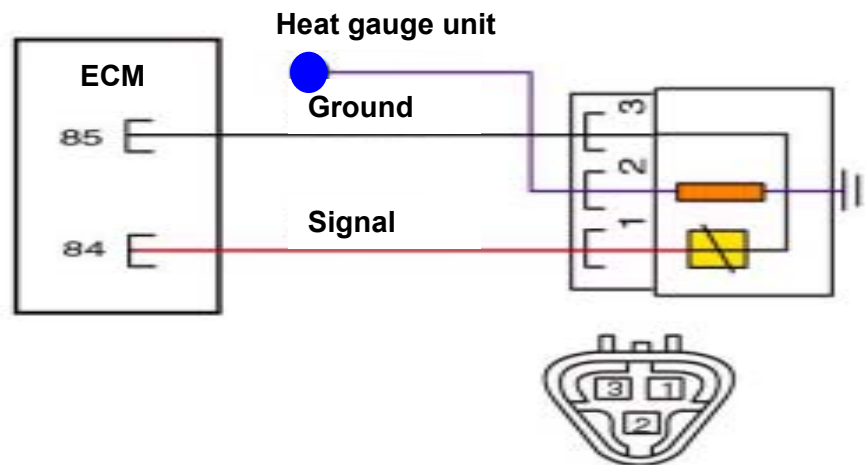
- Failure symptom :

① **Air-con operation and pre-heater prohibited,**

   cooling fan constantly on.

② **Limp-home : After cranking : 80℃ set**

                    Before cranking : -20℃ set
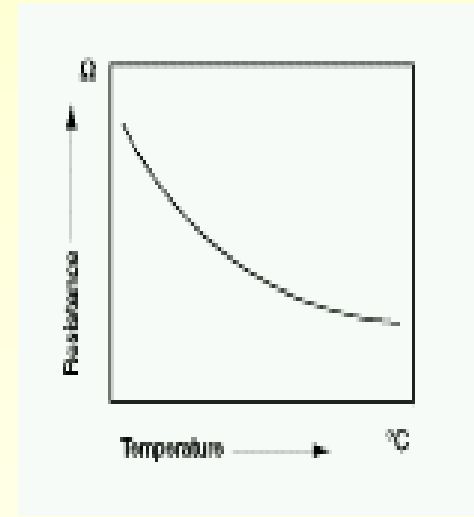
Code		Detail Description	Symptoms				Check Condition
DTC	CC		Fuel = 0	EGR off	Fuel Limit	MIL On	
C0115	C001	Signal below lower limit(Signal <225mV)					IG. On
	C002	Signal above upper limit(Signal>4.9V)					

■ Components Descriptions :

- Brake switch :

There are two brake switch for safety reason. Every time when the driver

depresses the brake, it signals the ECM with on or off information of brake system.

When the brake switch 1 is on condition, the brake switch 2 should be off position

in signal. Through this contrary output in signals, the ECM is capable of checking

each switch's plausibility.
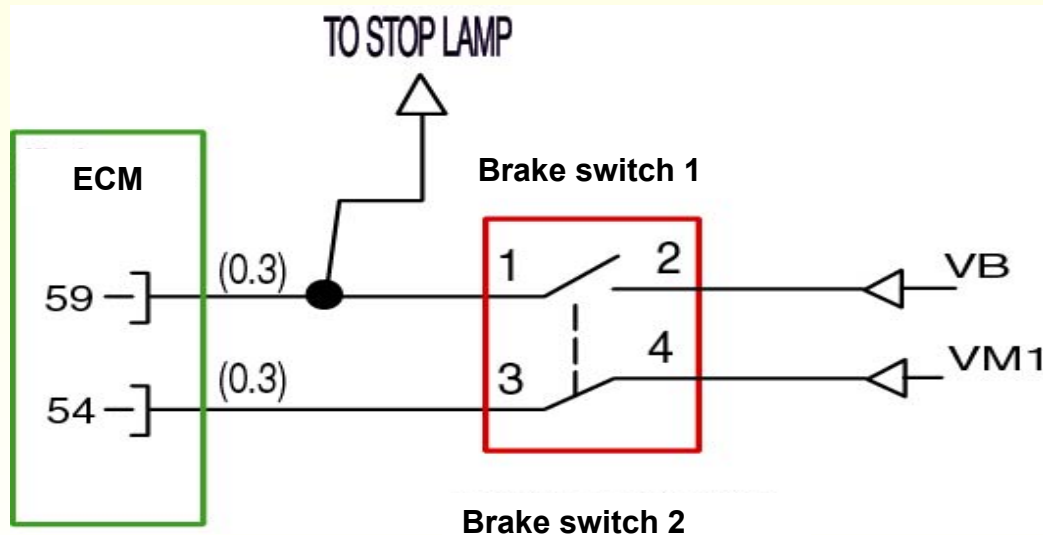
TO STOP LAMP

ECM

Brake switch 1

59 — (0.3)

1   2   VB

54 — (0.3)

3   4   VM1

Brake switch 2

EDC – Brake Switch

- **Failure symptom : normal driving prohibited**

Code		Detail Description	Symptoms				Check Condition
DTC	CC		Fuel = 0	EGR off	Fuel Limit	MIL On	
0703	C004	Plausibility error (comparing switch 1& 2)					IG On

KIA MOTORS

■ Components Descriptions :

- Clutch switch (M/T) only :

① Smoke reduce control in gear changing

② Cruise control
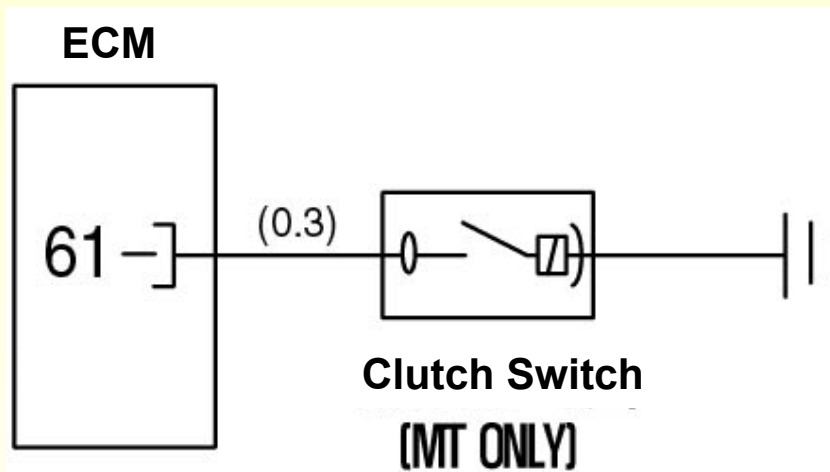
ECM

Clutch Switch

(MT ONLY)

- Failure symptom : normal driving prohibited

Code		Detail Description	Symptoms				Check Condition
DTC	CC		Fuel = 0	EGR off	Fuel Limit	MIL On	
0704	C004	Plausibility error (No signal within 80km/h)					IG On

KIA KIA MOTORS

■ Components Descriptions :

- Injector :

Special injectors with hydraulic servo system and electrical triggering element are used in the Sorento.   Pick-up current : 20A±1A, Hold-in current : 12A±1A

ECU

| 114 | 119 | 117 | 120 | 121 | 118 |

No. 1 Ground

No. 4 Ground

Power supply

No. 3 Ground

No. 2 Ground

Power supply

TWIST WIRE

to ecu inj 1

to ecu inj 4

to ecu inj 3

to ecu inj 2
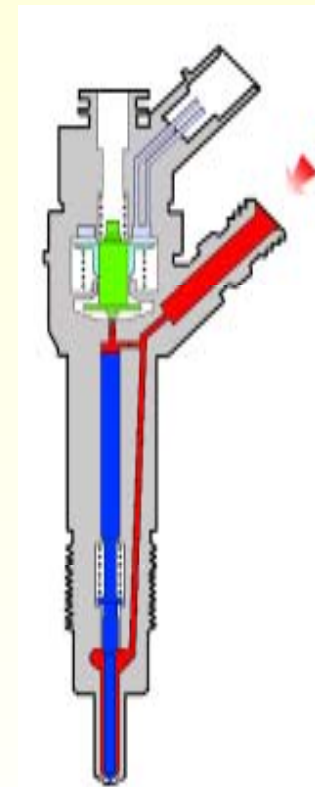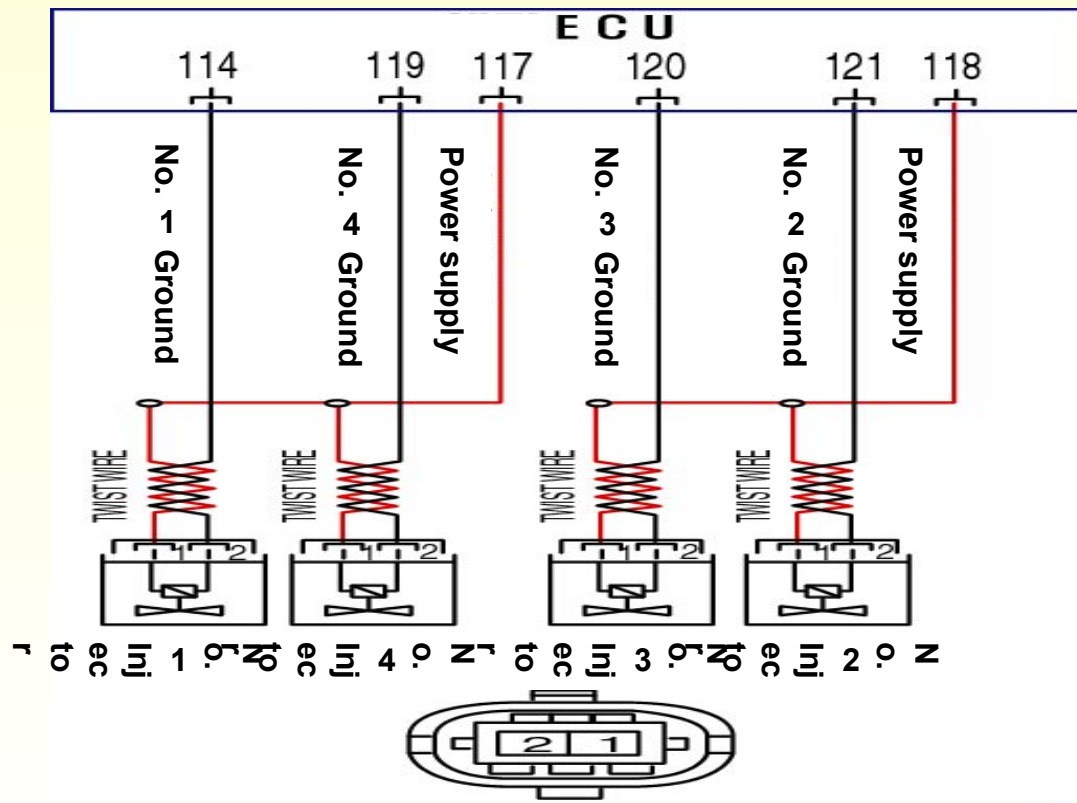
- Failure symptom : When failure occurs more than two injectors together, the engine immediately shuts off.
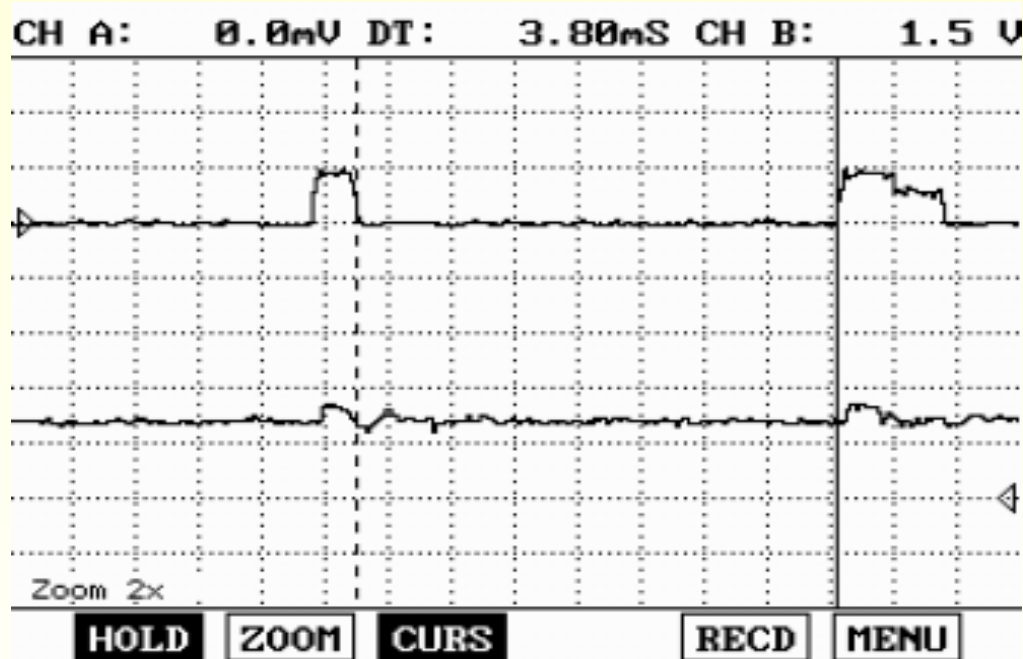
[Characteristic curve]

CH A: 0.0mV DT: 3.80mS CH B: 1.5 V

Zoom 2x

HOLD   ZOOM   CURS   RECD   MENU

A
20
Current
11
0
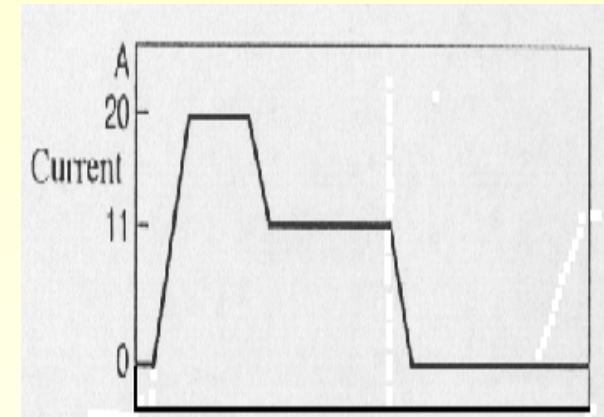
| Code | | Detail Description | Symptoms | | | | Check Condition |
DTC	CC		Fuel = 0	EGR off	Fuel Limit	MIL On	
0201 0202 0203 0204	C018	Low side Line short circuit(current>29.5~34A) High side line short circuit(current>28~36A)			Y	Y	Eng. Run
	C019	Line open circuit					

※ 0201 : Injector No. 1   0202 : Injector No. 2

   0203 : Injector No. 3   0204 : Injector No. 4

※ C018 possible causes of trouble :

   - Short circuit of high side line to B(+)

   - Short circuit of low side line to GND

   - Injectors & Injector voltage (ECM side) trouble

※ C019 possible causes of trouble :

   - High side line broken / low side line broken

   - contact resistance

   - Injectors & Injector voltage (ECM side) trouble

KIA KIA MOTORS

■ Components descriptions :

- The glow system :

The glow system is responsible for ensuring

efficient cold starting. It also shortens the

warm-up period, a fact which is highly relevant

for exhaust emissions.

Glow Relay

Glow Plug

- The glow time is calculated with the coolant temperature and engine rpm.

- There are three modes in glow system by operation ;

① **Pre glow :**

Coolant Temp.(℃)	-20℃	-10 ℃	20 ℃	50 ℃
Glow time (Sec.)	12	8	3	0.7

② **Start glow :** In case of no engine starting after finishing the pre glow situation. When the coolant temperature value is less than 60℃, the maximum glow time lasts 30 seconds. If the coolant temperature value reaches 60℃ within 30 Sec. the start glow is suspended.

③ **Post glow :** In case of after starting but the engine rpm is less than 2500 and the injection fuel volume is less than 75cc/min.

Coolant Temp.(℃)	-20℃	-10 ℃	20 ℃	40 ℃
Glow time (Sec.)	40	25	10	0

④ **Intermediate glow :** In case the engine rpm is less than 20, the coolant temperature value is less than 40℃ and the injection volume is less than 10cc/min, to prevent the combustion chamber from getting cold down.

KIA KIA MOTORS

- **Failure symptoms : Glow plug indicator lamp only lights on briefly (self-test function) when IG. Is on condition. Other case of glow plug indicator lamp flashing is from the ECM(M/T or A/T setting) Check sign.**

Code		Detail Description	Symptoms				Check Condition
DTC	CC		Fuel = 0	EGR off	Fuel Limit	MIL On	
1325, 1629	C018	Short circuit to Bat(+)					IG. On
	C019	Short circuit to GND					

※ **1325 : Glow plug relay problem**

1629 : Glow plug indicator lamp problem

KIA KIA MOTORS

■ Components descriptions :
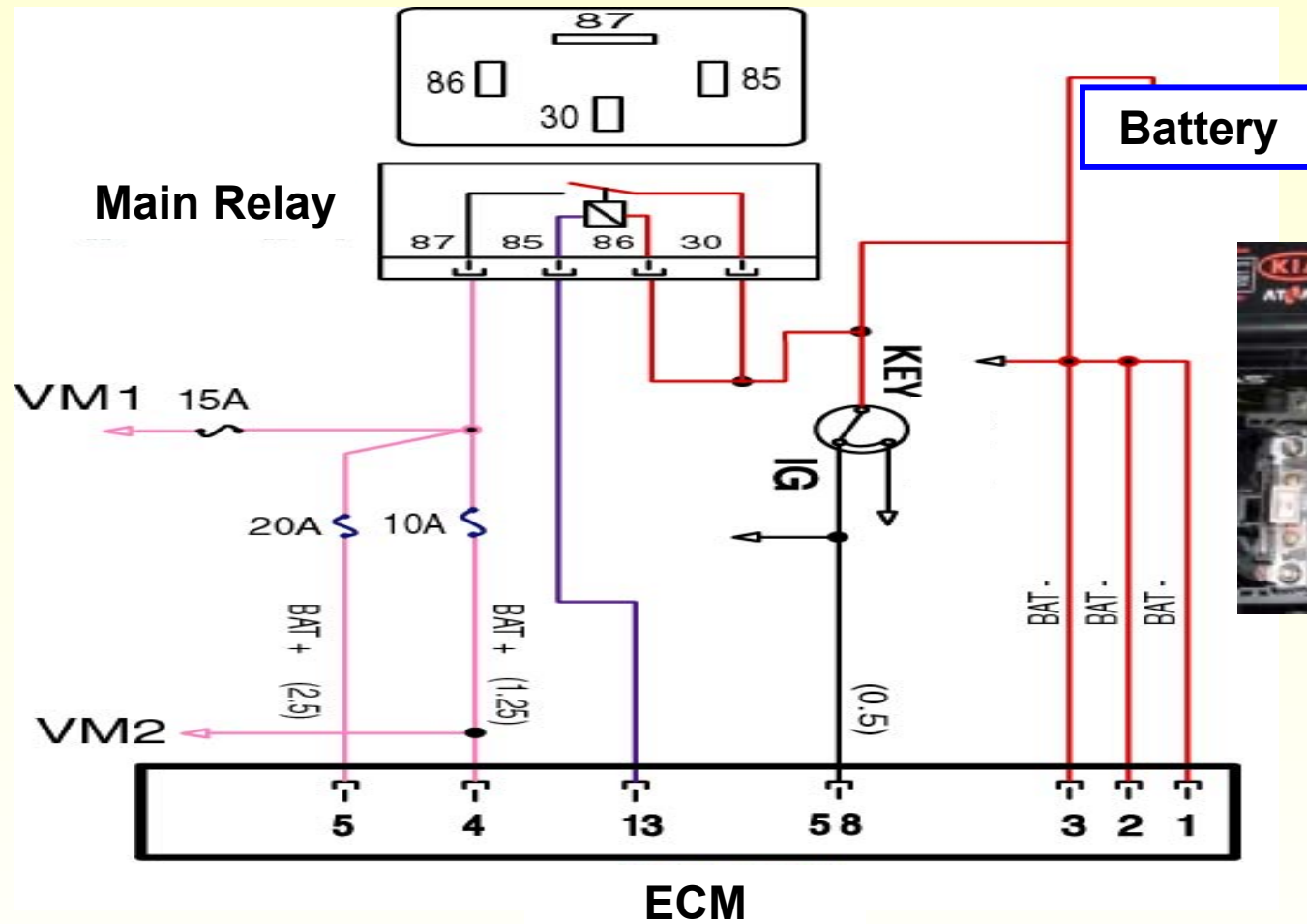
| Code | | Detail Description | Symptoms | | | | Check Condition |
DTC	CC		Fuel = 0	EGR off	Fuel Limit	MIL On	
1616	C004	Plausibility Error(IG signal comparison)					IG. On

KIA MOTORS

■ Components descriptions :

- The pre-heater :

The pre-heater unit is located in between the heater unit and the engine coolant passage.

This serves to increase the coolant temperature in the heater unit so that the heater

system is able to be activated by driver's need as soon as possible.

Sorento uses the heating plug type and there are three heating plugs controlled by the

ECM. Each plug has 300W capacity respectively and totally it becomes 900W.

Three heating plugs
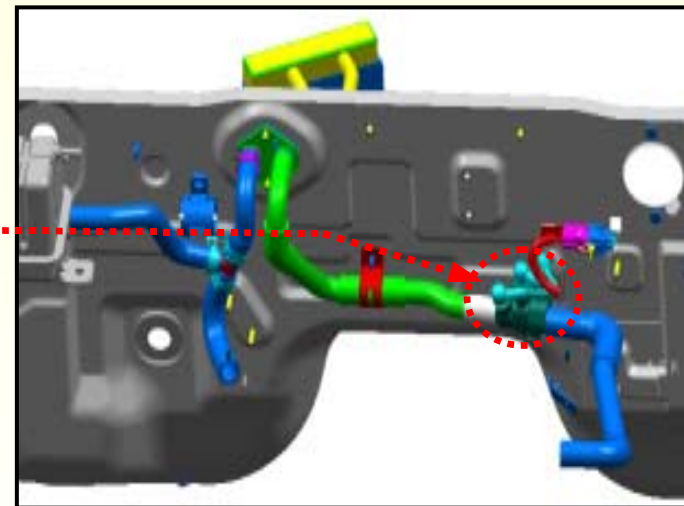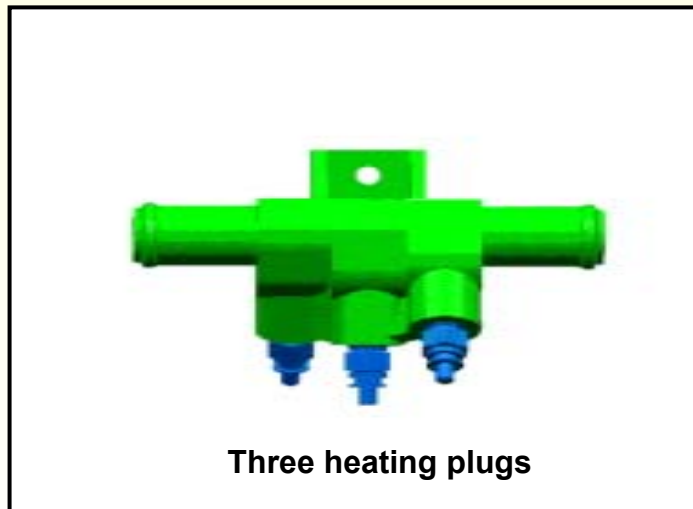
■ Components descriptions :

- The EGR system :

With exhaust gas recirculation(EGR), a portion of the exhaust gas is led into the engine's intake. Up to a certain degree, an increasing portion of the residual exhaust gas has a positive effect upon energy conversion and upon the exhaust gas emissions.

The EGR solenoid valve is controlled by the ECM using the PWM signal generated by the control circuit.
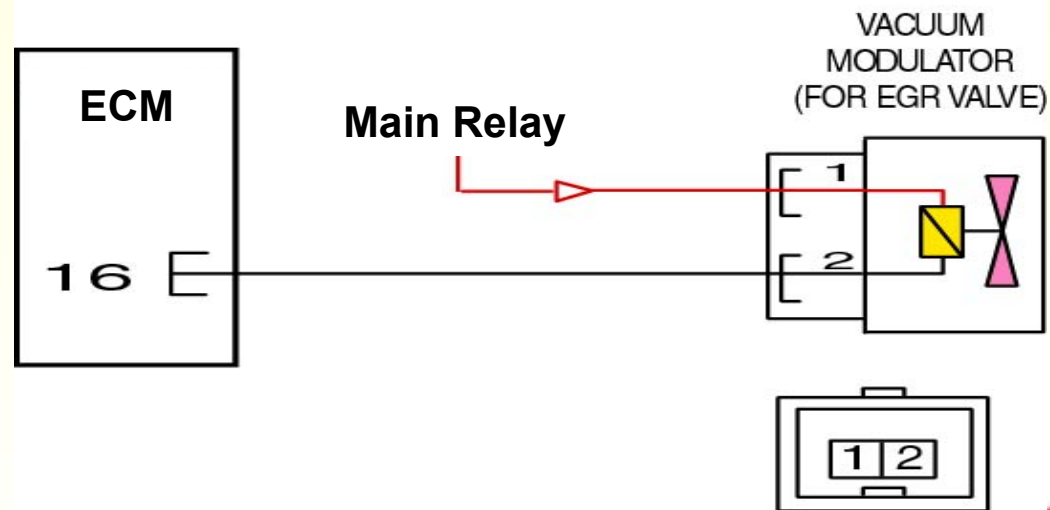
Solenoid Valve

EGR Valve

ECM

Main Relay

VACUUM
MODULATOR
(FOR EGR VALVE)

1

2

16

1 2

- EGR system overview :

Turbine

AFS

air intake

AFS signal
(EGR feed back control)

Ex. Manifold

ENGINE

In. Manifold

EGR Valve

Inter-Cooler

Vacuum Pump

PWM (Duty)

Feed back EGR

ECM

Target EGR

APS   rpm

Controlled Vac. Pressure

air intake

Vac. Pressure

Input Signal

Exhaust Gas

EGR Gas

KIA **KIA MOTORS**
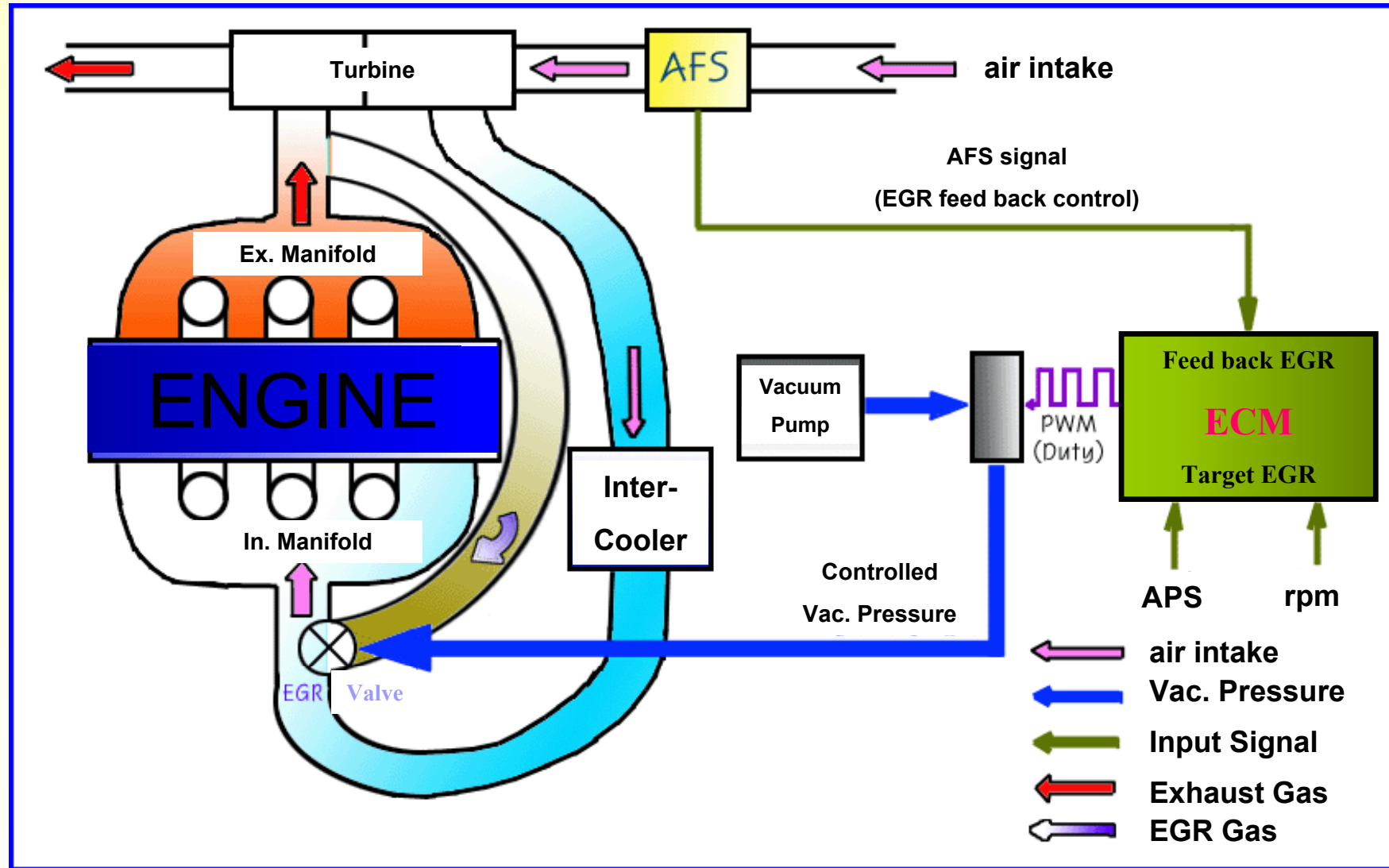
- Failure symptoms :

Code		Detail Description	Symptoms				Check Condition
DTC	CC		Fuel = 0	EGR off	Fuel Limit	MIL On	
0403	C018	Short circuit to Bat(+)		Y			IG. On
	C019	Short circuit to GND					

Engine

Contents

- Sigma(Σ) Engine Hardware

- Sigma(Σ) Engine Management System

KIA MOTORS

■ **Sigma(Σ)3.5ℓ Development concept**

☐ **Lay-out**

  - Σ 3.5 Dohc FF (already installed in Carnival) → FR Design

☐ **Performance**

  - Low-middle range torque up --- VIS

☐ **Emission**

  - Korean Domestic 2000, LEV, Euro - Ⅲ

☐ **NVH**

  - HLA, Beam Bearing Cap, Engine Cover

☐ **Long Durability**

KIA KIA MOTORS

Sigma(Σ) 3.5ℓ Eng. – Engine Concept

Sys.	BL Σ-3.5 FR	Remark
Lubrication	· Oil Level Stability of Up/Downhill at 35 Degree and Fast Turning	
Cooling	· Cooling & Air-Vent Sys. Design for Engine Install(5′ incline in fornt side)	
Intake & Exhaust	· Added Vacuum Type VIS and Aerodynamic Port Design for Low-MiddlePerformance · Added MCC and Minimized Exhaust Gas Resistance for LEV	
Accessory	· Optimization of Aux. Drive Belt Lay-out Design	
Moving	· Improved HC EM & Blow-by Gas	

KIA KIA MOTORS

Sigma(Σ) 3.5ℓ Eng. – Main component comparison

■ Comparison

Part Name	Σ3.5 ENG			
	GQ3.5	BL3.5	MAKER	REMARK
	Part No.	Part No.		
Water Temp Sensor & Heat Gage Unit	39220–38020 39220–38030	←	ELEC. KOREA INSI	
Ignition Coil	27300–39050	27300–39800	DENSO PUNGSONG	– Small different shape – Same performance – Integrated Power_Tr
Ignition Failure Sensor	27370–38000	←	Hyundai Autonet	
Spark Plug	18817–11051(PFR5N–11) 27410–37100(RC10PYPB4)	←	WOOJIN SERIM	– Pt alloy, Gap: 1.0~1.1 – Cu–Ni/Pt, Gap: 1.0~1.1
Air flow sensor	28100–39400 28100–39450	←	BOSCH BOSCH KOREA	– Hot Film Type
Air Temp. Sensor	Integrated in AFS	←	–	
Crank Angle Sensor (CAS)	39310–39010	39310–39800	VDO HALRA	– Hall IC
Cam position Sensor(CPS)	39310–39110	39318–39800	VDO HALRA	– Hall IC
ECU	39110–39600	39110–39420	KEFICO	– GQ : PCU(ECU+TCU) – BL : ECU (separated TCU)
Throttle Body Assy	35100–39610	35100–39600	DEASONG	– Small different shape
Throttle Position Sensor*	incorporated in TH/B	←		– Same Sp – with idle switch

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Part Name	Σ 3.5 ENG			
	GQ3.5	BL3.5	MAKER	REMARK
	Part No.	Part No.		
Idle Speed Actuator*	incorporated in TH/B	←		– Same Sp – Stepping Motor
Fuel injector ass'y	35310–38010	←	KEFICO	
Fuel pressure regulator	35301–39600	35301–39410	INZI	– Same press.control 　(3.35 ± 0.05Kgf/㎠) – Different shape
Knock sensor	39320–35561	39510–39810	INZI	– Same Spec 　(resonance–type : 11.0KHz) – Different L/Wire
MAP sensor	39300–38100 39300–38200	←	KEFICO	– 20~106.7KPa abs
O2 sensor (Bank1–Up)	39210–39800	39210–39820	WOOJIN	– FLO Type (+ Heated type) – Different L/Wire
O2 sensor (Bank1–Down)	39210–39650	39210–39550	WOOJIN	– Heated type – Different L/Wire
O2 sensor (Bank2–Up)	39210–39600	39210–39820	WOOJIN	– FLO Type (+ Heated type) – Different L/Wire
O2 sensor (Bank2–Down)	39210–39025	39210–39500	WOOJIN	– Heated type – Different L/Wire
Purge solenoid valve	39460–38650	←	KEFICO	– 60L
Case assy catalyst(MCC)	28530–39675(LH) 28530–39685(RH)	28530–39410		
Converter assy catalyst(UCC)	28950–39671	28950–38610		

KIA KIA MOTORS

■ Throttle Body

Water-In

Water-Out
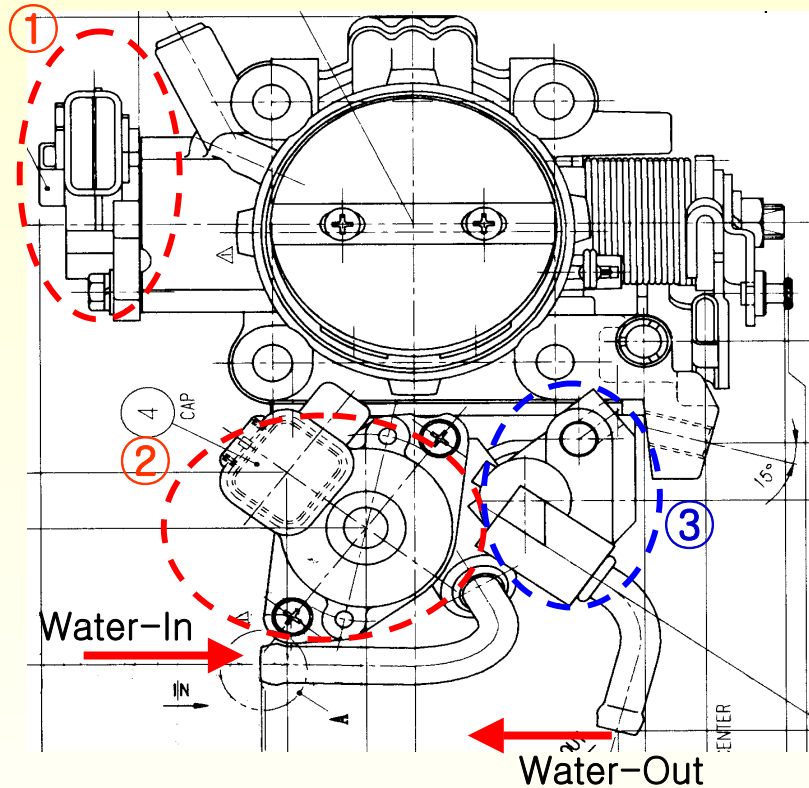
1) TPS (Throttle Position Sensor)

- With Idle Switch

2) Idle Speed Control Motor

- Stepping Motor

- Control Range (0 ~ 120 Step)

- Initial Position : 80 Step

- After IG-Key Off,

  Stop-position is initialized by

  ECU during power latch time.

3) Thermo. WAX

- Operating according to water temp.

- Closed about 60 ℃ (water temp)

KIA KIA MOTORS
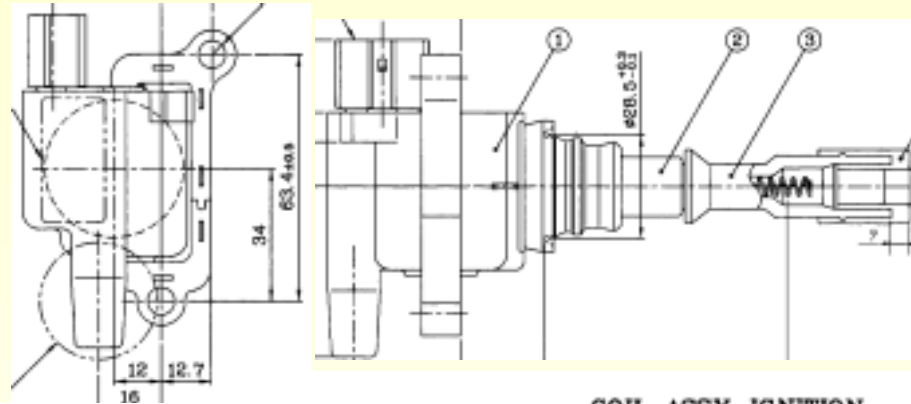
■ Ignition coil

- – Integrated Power_TR (IGNITOR)
- – 2– Cyl. Simultaneous Ignition

COIL ASSY-IGNITION

TO BAT. 전원

IGNITER

1차 2차

TO S/PLUG

TO ECU 점화입력신호

IGNITION COIL

EARTH (접지)

CIRCUIT DIAGRAM

KIA MOTORS

■ Ignition failure sensor

Ignition Failure Sensor

ECM

VB

IGf

Comparator

Pulse
Generator

IG+   Coil #1   Coil #2,3

Coil (Power TR included)

G

IB

G
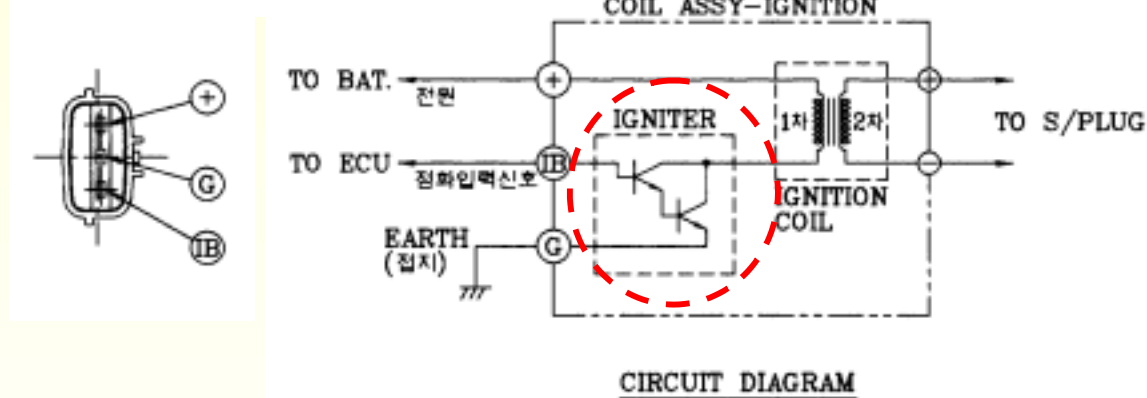
Tachometer
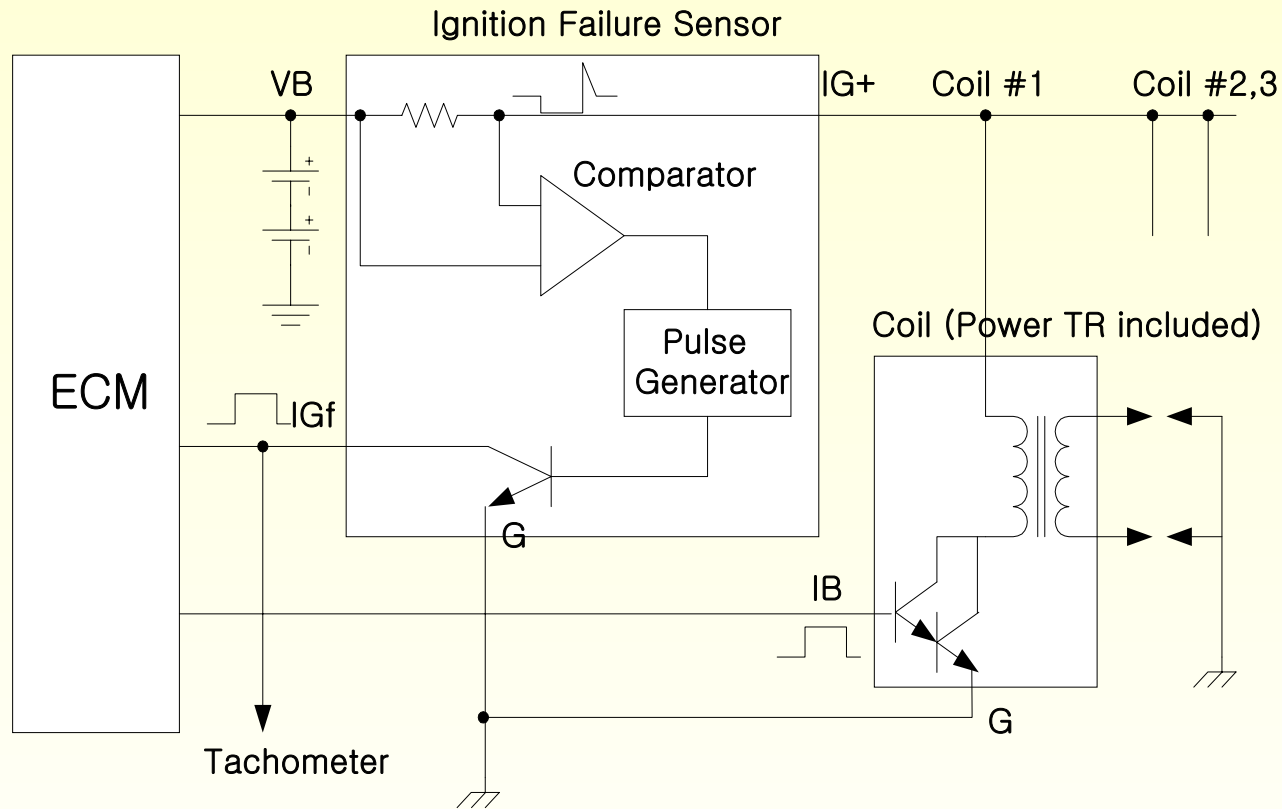
IG Coil Primary Circuit Wave form
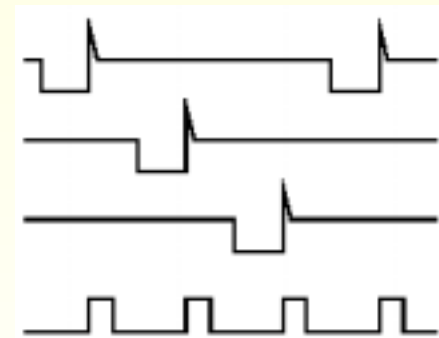
Ignition Failure Sensor Output

■ Sigma(Σ) Engine

- General

The Delta engine is a compact V6 DOHC engine, light in weight due to the use of aluminum engine parts with high torque output in low and medium speeds. This engine incorporates only one timing belt .This has resulted in a reduction of noise and increase in serviceability.

The Sigma engine is designed and manufactured by Hyundai Motor Company.

Items	Sigma 3.5L	Items	Sigma 3.5L
Displacement(cc)	3,497	Injector Type	4Hole 2 Spray
Bore X Stroke(mm)	93 X 85.8	Injection Timing	BTDC17.5°
Compression Ratio	10:1	Spark Plug	PFR6.1-11
Firing Order	1-2-3-4-5-6	Spark Plug Gap(mm)	1.0mm
Basic IG. Timing(°)	BTDC10° ± 2°	Oxygen Sensor	ZrO2
Idle RPM	700 ± 100	Coolant Control	Inlet Control
HLA	End Pivot Type	Air Flow Sensor	Hot Film
Fuel Pres.(Kgf/㎠)	3.33 ~ 3.35	EMS	Melco

Item	GQ Σ-3.5 FF	BL Σ-3.5 FR	Remark
Engine Instl.	FF	FR	
Engine Code	G6CU	←	
Dis. (CC)	3,497	←	
B×S (mm)	93.0 x 85.8	←	
Compression Ratio	10.0	←	
Valve System Type	DOHC 4 Valve	←	
Firing Order	1-2-3-4-5-6	←	
Aspiration	NA	←	
Vis Type	Electronic	Vacuum	
EGR	Yes	No	
Eng. Weight (DRY, Kg)	193.6	209.8	
Eng. Size (LxWxH, mm)	746×758×733	608×658×780	

KIA **KIA MOTORS**

Sigma(Σ) 3.5ℓ Eng.

■ Sigma(Σ)3.5ℓ-Engine Hardware

- The sorento is equipped with the Sigma 3.5 Liter Engine with 195 hp @ 5500rpm and torque30 @ 3500rpm. The intake manifold features a variable intake system which extends the torque curve by selecting designated intake runners to improve performance.
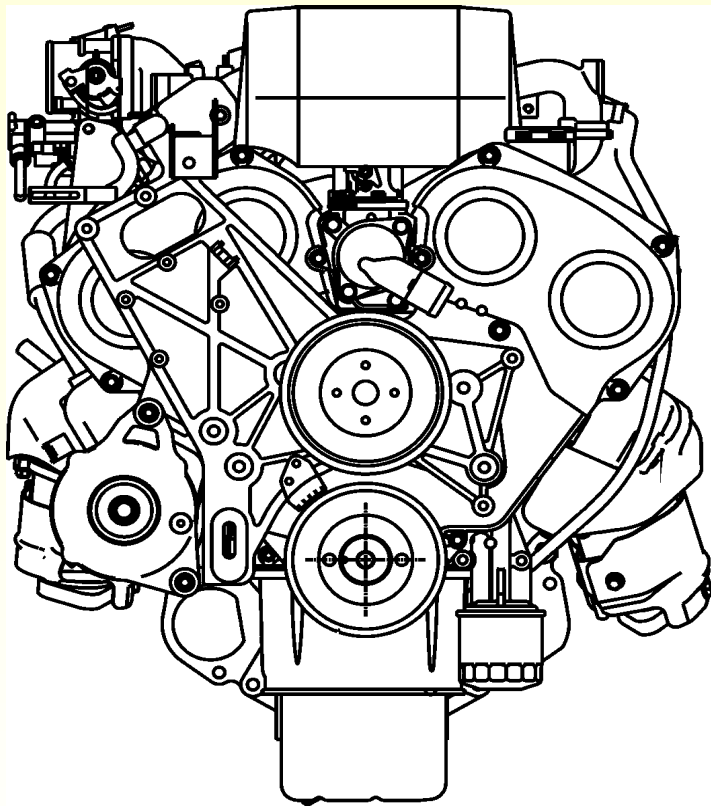
The block is made of cast iron. The cylinder heads and upper oil pan are aluminum. Hydraulic Lash Adjusters(HLA) eliminate the need for valve lash adjustments. There are three drive belts on the Sigma 3.5ℓ engine with mechanical tensioners. The timing belt turns all four cam sprockets with an hydraulic timing belt tensioner.

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■ Performance Curve

SYSTEM	MAX. POWER (Ps/rpm)	MAX. TORQUE (Kg.m/rpm)
BL	195	30.0
XG	197	29.8

KIA **KIA MOTORS**
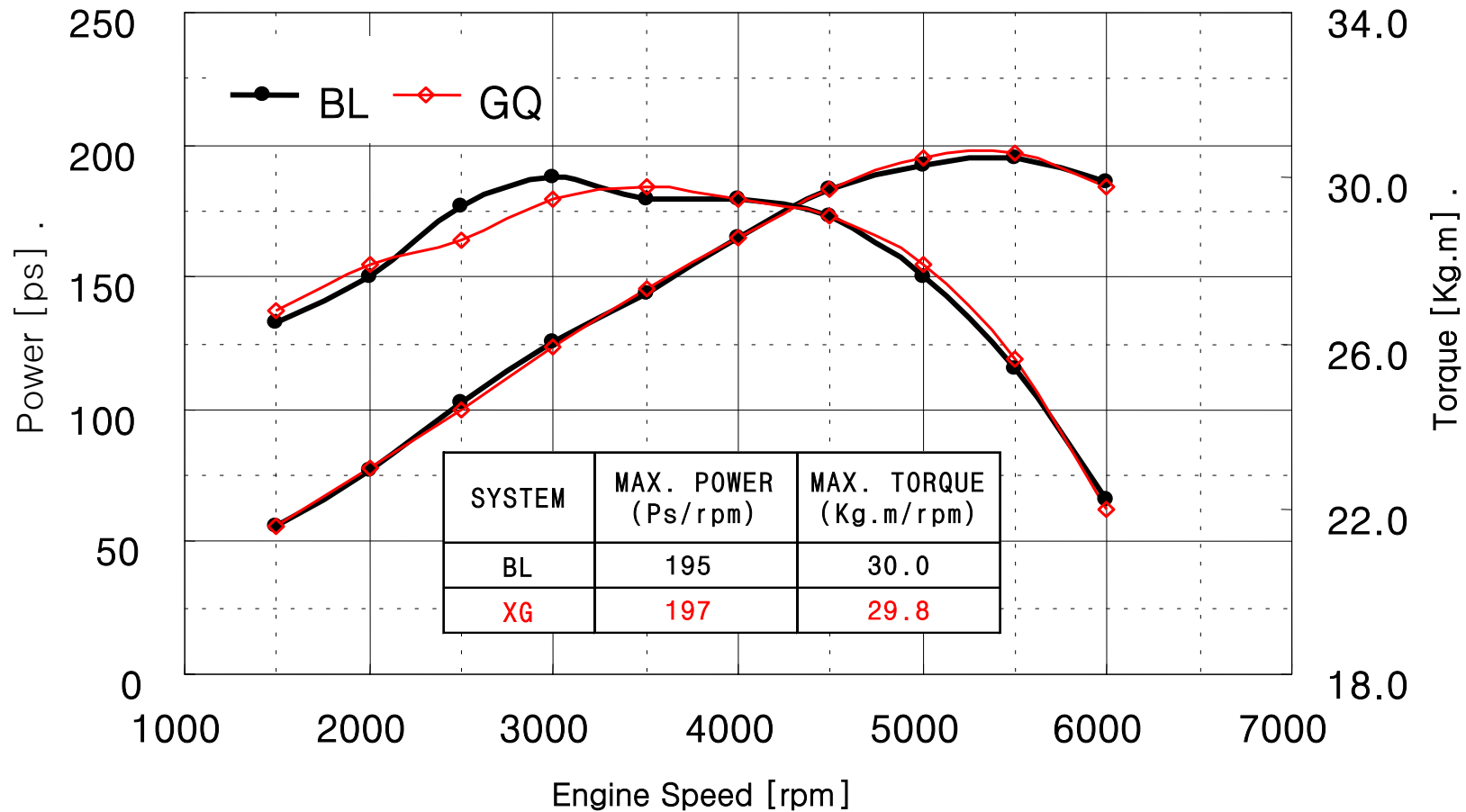
■ Section View
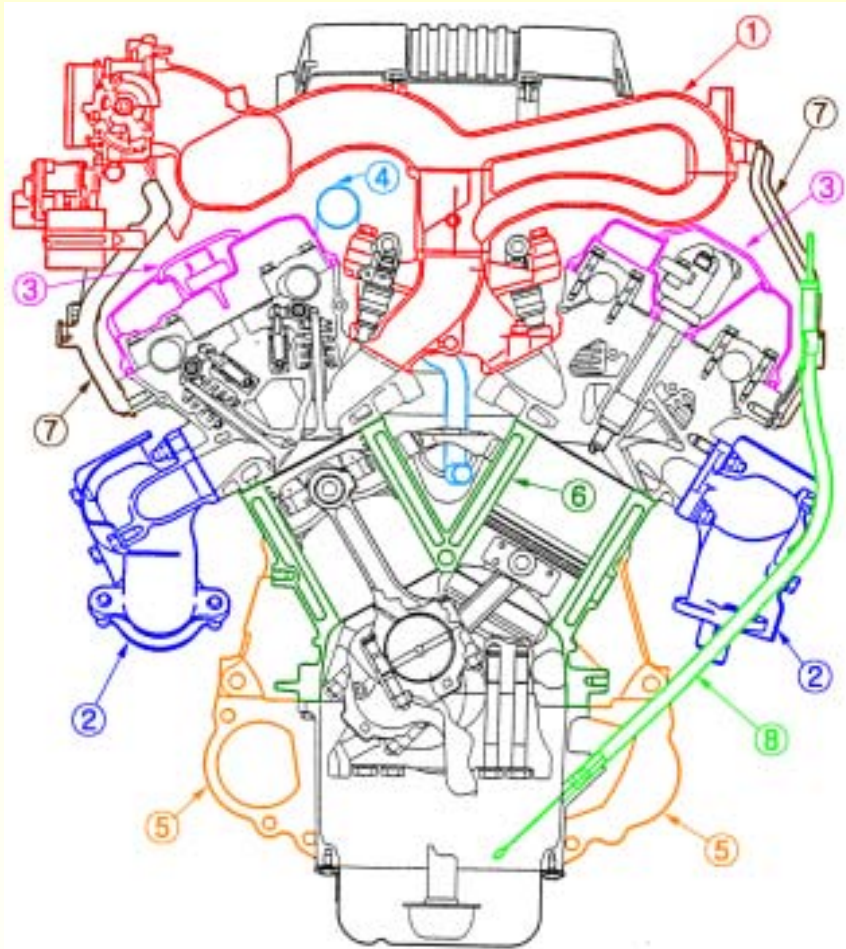
- End Pivot Type HLA

- Dry type liner

- Steel Cylinder block

- AL material Upper oil pan

Sigma(Σ) 3.5ℓ Eng. – Cooling System

132

■ Cooling System

TO TH/BODY

FROM TH/BODY

FROM HEATER

WATER OUTLET PIPE

TO HEATER

W/OUTLET FITT'G

THERMOSTAT HOUS'G

BYPASS FITT'G, RH

WATER PASSAGE

FROM RADIATOR

TO RADIATOR

KIA KIA MOTORS

■ Intake System

GQ Σ-3.5 FF	BL Σ-3.5 FR

■ Drive Belt

GQ Σ-3.5 FF	BL/HP Σ-3.5 FR
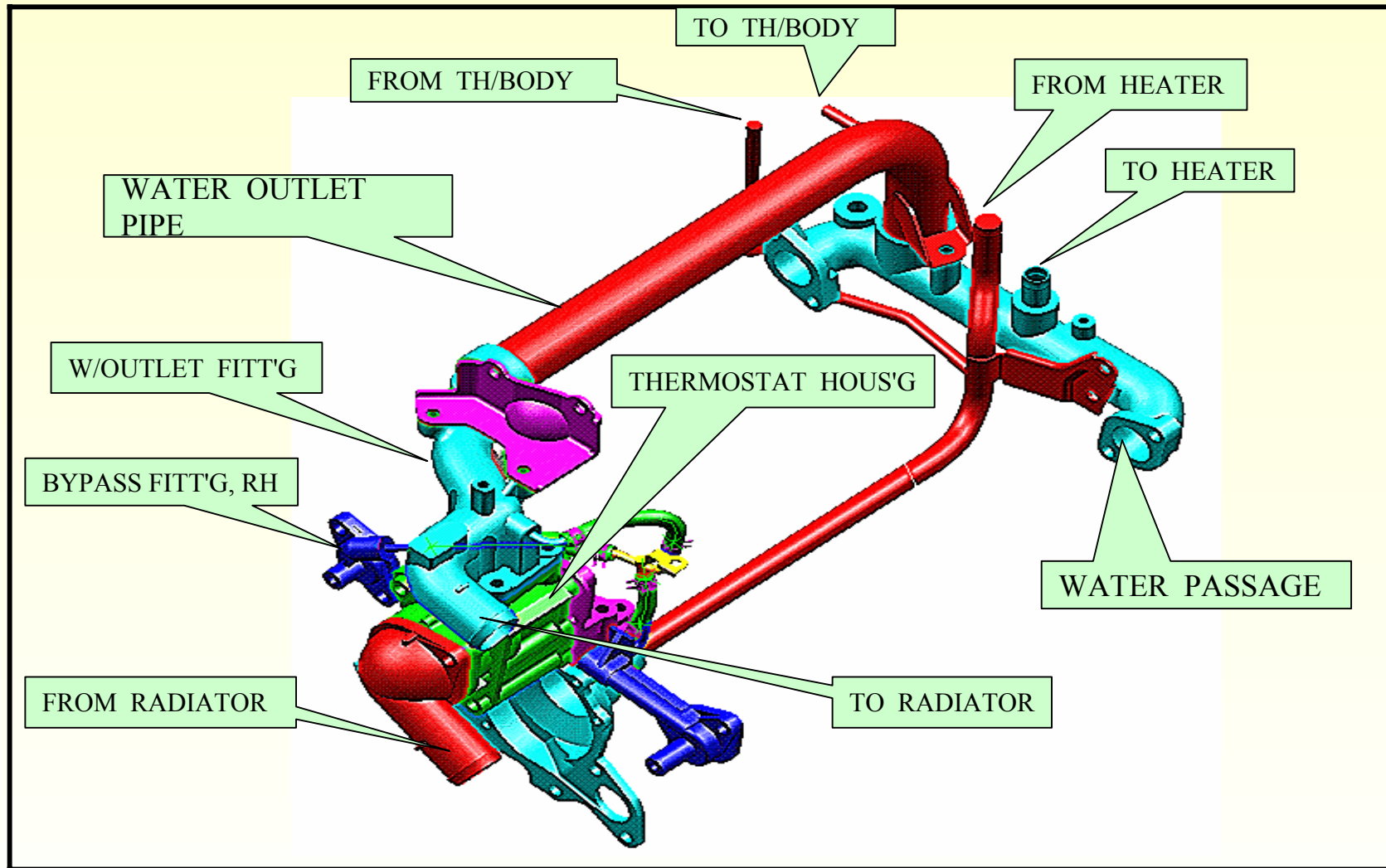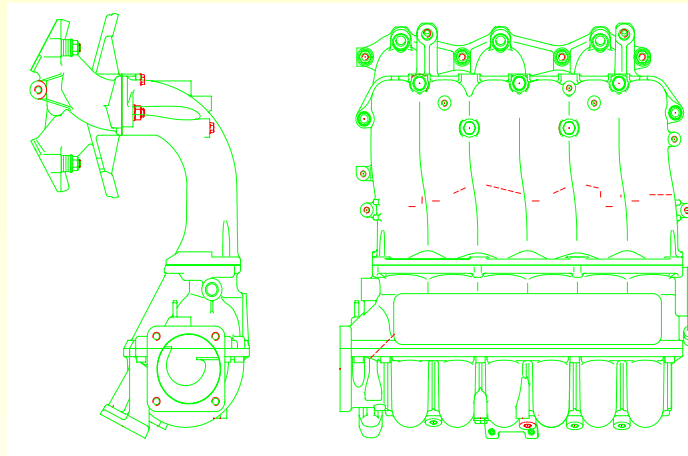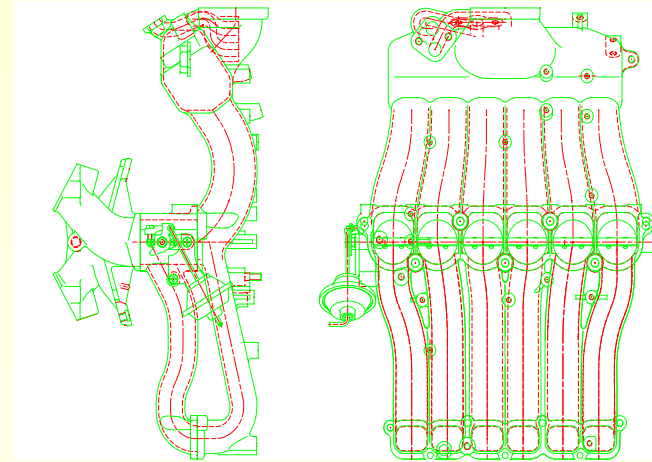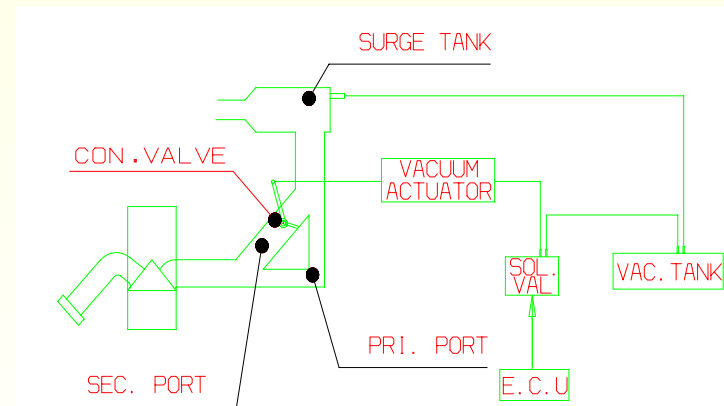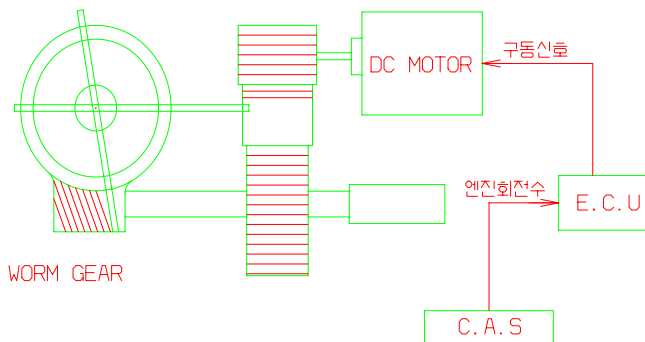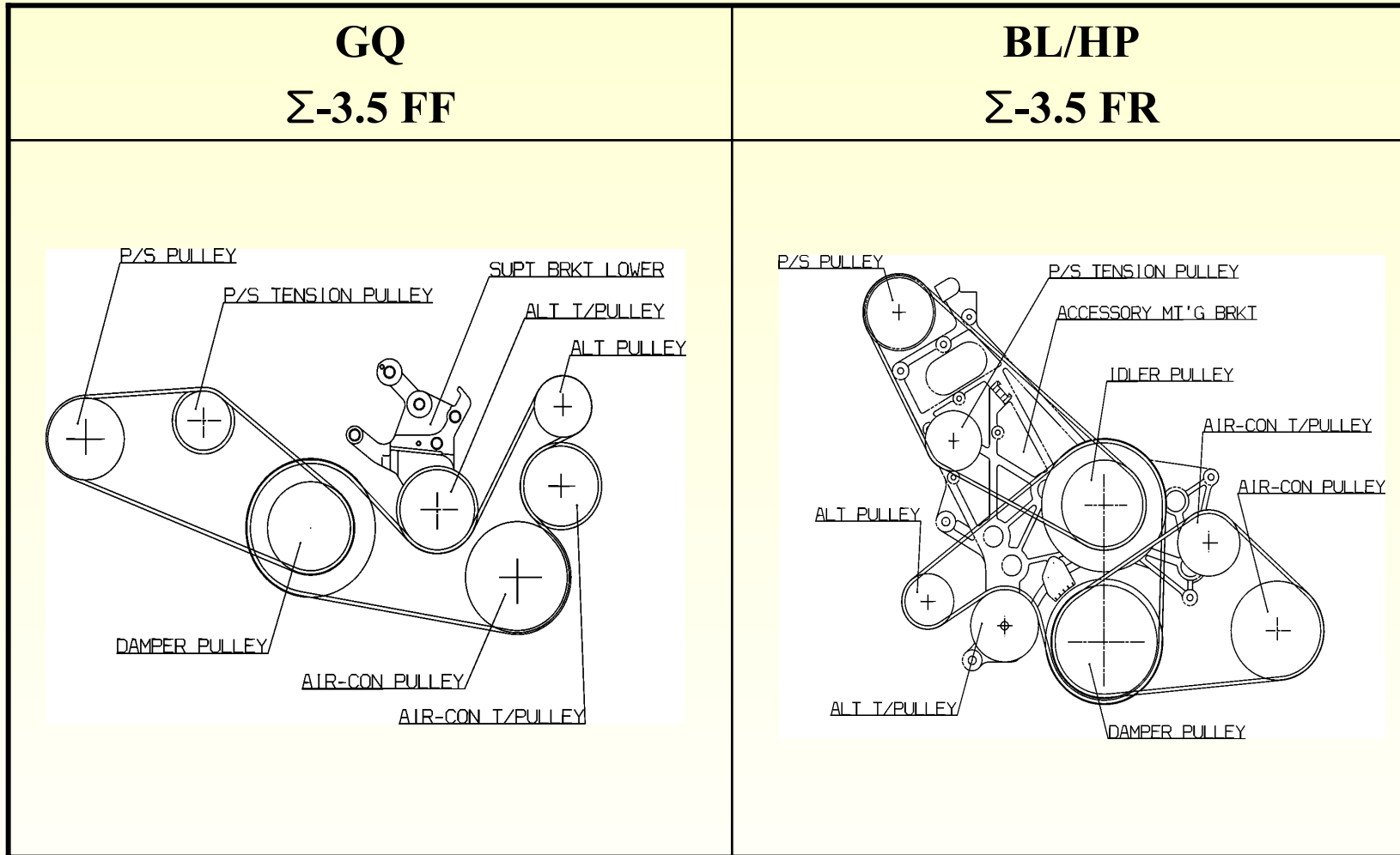
-Three mechanical drive belt tension adjuster

■ Timing Belt

- Hydraulic auto timing belt tensioner :

One cogged-tooth timing belt, that turns all four camshafts and the water pump.
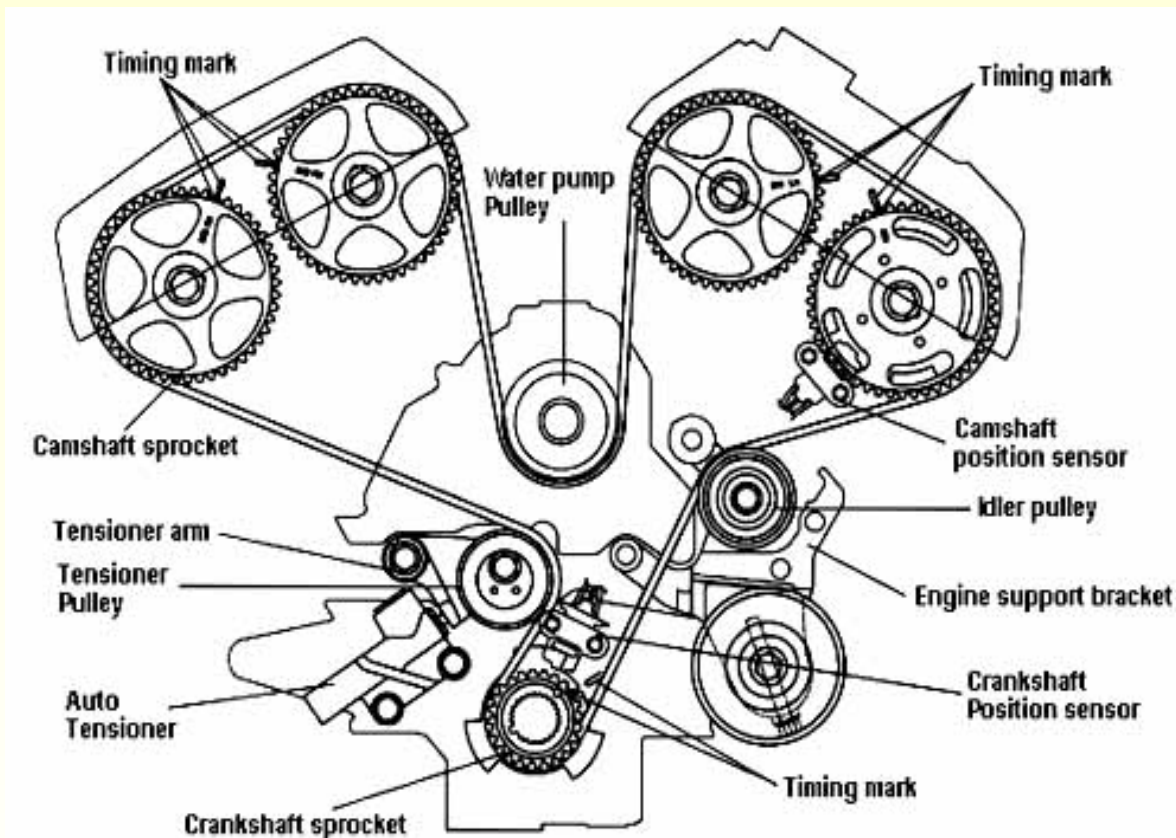
■ Cylinder Block

-Torque - Angle Method

 Connecting Rod Cap(33~37Nm+90~94˚)

-Torque tightening

 Main bearing Cab bolts(70~80Nm)

Piston and connecting rod assembly

Connecting rod upper bearing

Connecting rod lower bearing

Connecting rod cap

Oil pump cover

Oil pump outer rotor

Oil pump inner rotor

Oil pump case

Crankshaft position sensing blade

Crankshaft sprocket

Relief valve plunger

Relief valve spring

Relief valve plug

Oil pressure switch

Oil filter

Upper baffle plate

Gasket

Oil screen

Lower baffle plate

Upper oil pan

Drain plug

Lower oil pan

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Sigma(Σ) 3.5ℓ Eng. – Engine Feature

■ Cylinder Head

- Torque Tightening

  Cylinder head bolts(105~115Nm)

- Hydraulic Lash Adjuster

  End Pivot type HLA

  Air bleeding method
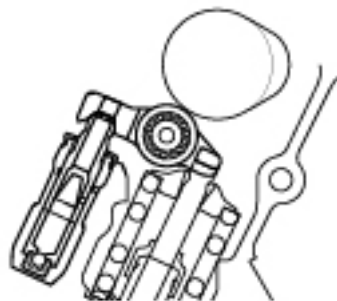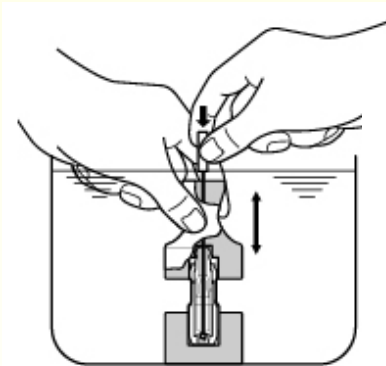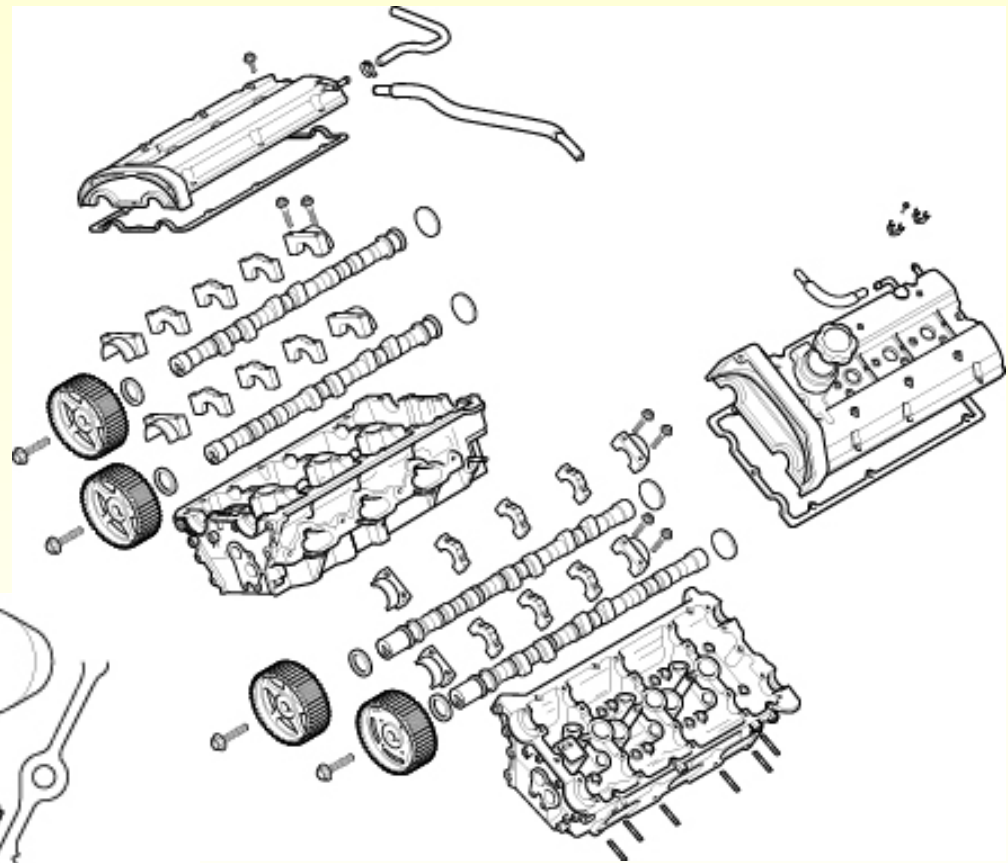
■ Checking condition

- Normal Operating Engine Temperature(80~95℃).

- No electrical load

- Neutral of Transaxle

- No operation of Steering wheel

4	3

2	1

12

20
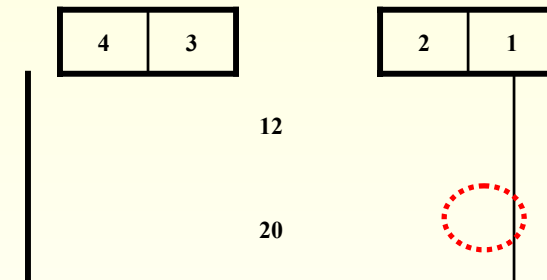
① Ground the No.3 pin(Ignition timing checking terminal) of DLT.

② Check the timing on crankshaft pulley with timing light.

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■ Checking condition

- Normal Operating Engine Temperature(80~95℃).

- No electrical load

- Neutral of Transaxle

- No operation of Steering wheel

Idle Speed Adjust Screen
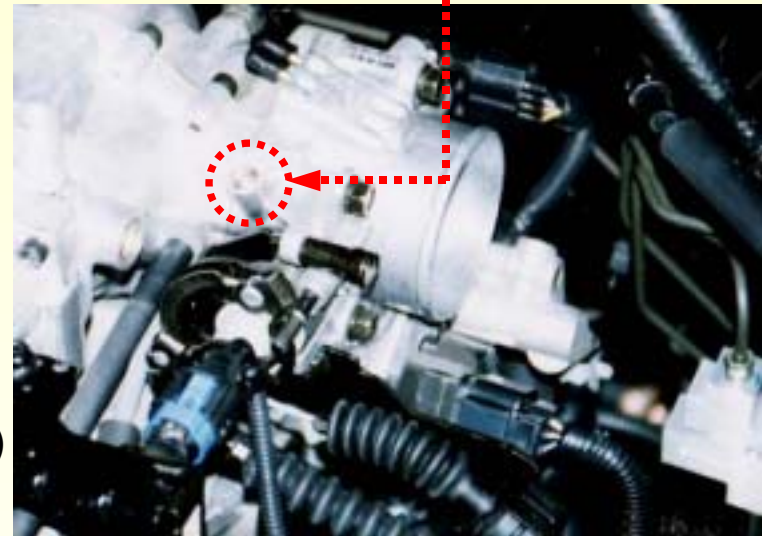
① Connect Hi-scan Pro to DLC(L-line Grounded)

② Ground the Ignition timing check terminal.

(To make engine stable, Ignition timing is controlled. ECM goes into Idle speed

adjusting mode)

③ Check idle RPM(700±100rpm). If beyond the specification, adjust it through Idle

speed adjust screw.

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■ Location

Fuel Pump Module

Fuel Filter

※ **Recommended replacement intervals : 100,000 mile / 10Years**

KIA KIA MOTORS

Sigma(Σ)-engine

Engine Management System

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Contents

- System Configuration

- System Description

- ECM Input/Output

- OBD2 Functions

- Diagnostic Trouble Code

- ECM Wiring circuit

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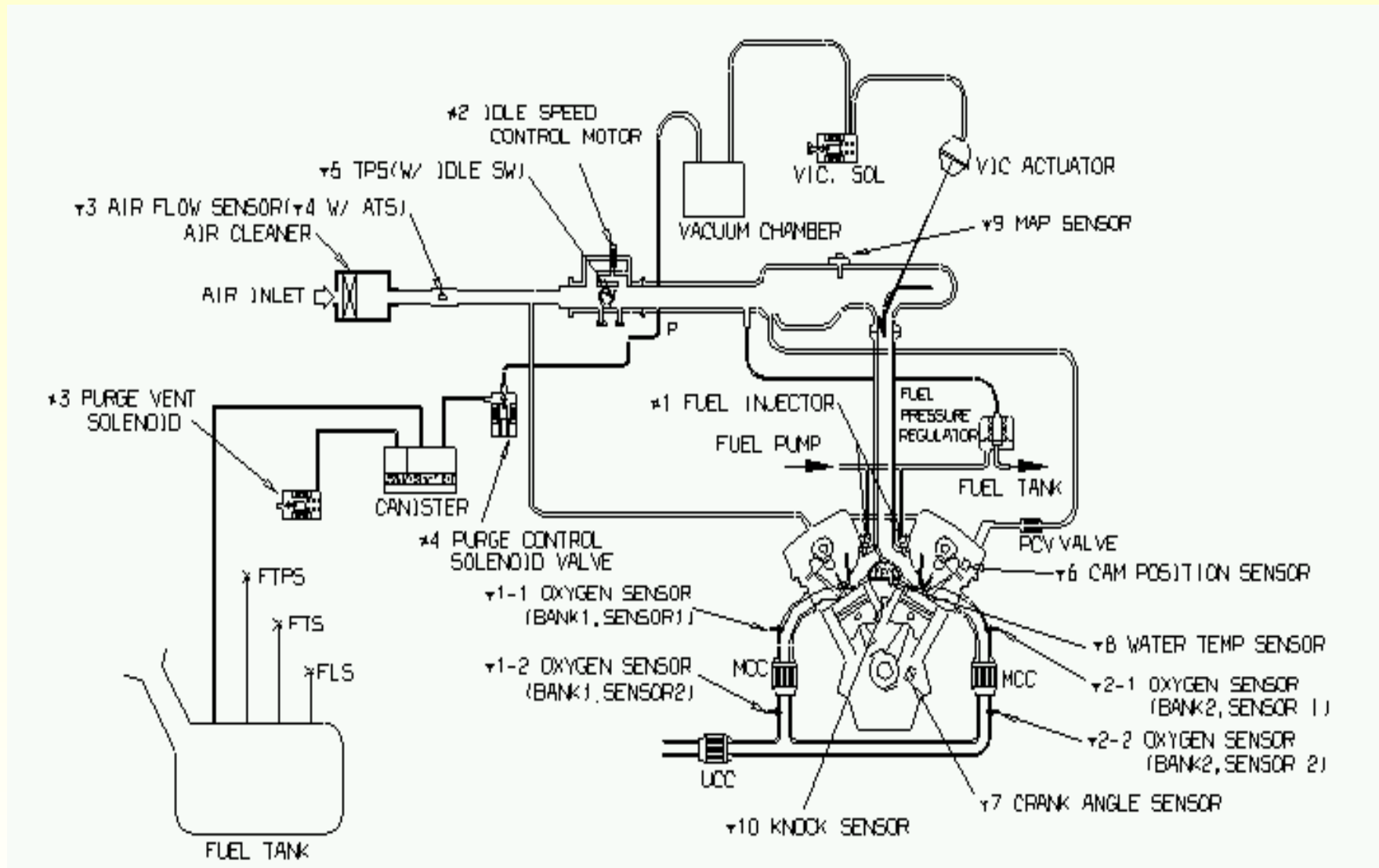
■ General descriptions :

  - The Sorento utilizes a Mitsubishi Electronics Company Engine Management System

    (MELCO). The MELCO system features a single 32 bit Powertrain Control Module

    (PCM) to control engine management as well as all automatic transaxle functions.

    Serial communication is used to transmit data between the engine and transaxle

    sections of the PCM. A sequential Multiport Fuel Injection system (SFI) is

    incorporated, along with a distributorless ignition system.

  - The ignition system of Sorento Sigma 3.5ℓ engine is very similar to previous

    ignition systems used on Kia vehicles since 1998 with the exception of having an

    additional coil for the 2 extra cylinders and and ignition failure sensor.

  - Engine management system monitoring functions are conducted in compliance

    with OBD-Ⅱ regulations. An EGR system is not employed in the Sorento.

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Sigma(Σ) 3.5ℓ Eng. – System Description

■ System Description

Engine		V6 3.5L DOHC
Emission Standard		LEV (0.130 NMOG)
Evaporative System		New EVAP/ ORVR
PCM		MELCO
Microprocessor		MH8305F(32bit)
Frequency		32 MHz
Memory Size		512Kbyte
Monitoring Functions	Catalyst	MCC Monitoring
	O2 sensor	Yes
	Misfire	Yes
	Fuel System	Yes
	Evap System	0.02in Leakage Monitoring
	Thermostat	Yes
	Comprehensive Component	Yes

▶ **MCC = Manifold Catalytic Converter**

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■ rpm by load

			VEHICLE
			BL3.5 NAS
VEHICLE	IGNITION TIMMING		**BTDC 10° ± 2°**
	P,N RANGE RPM	A/CON OFF	**800 ± 100**
		A/CON ON	**900 ± 100**
	D RANGE RPM	A/CON OFF	**750 ± 100**
		A/CON ON	**750 ± 100**
	OVERRUN F/CUT RPM	P/N	**4000**
		D	**6198**

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■ ECM Input/Output

| Input | | ECM | | Output |

Input

Oxygen Sensor(Bank1, Sensor1)   Manifold Differential Press. Sensor

Oxygen Sensor(Bank1, Sensor2)   Knock Sensor

Oxygen Sensor(Bank2, Sensor1)   Fuel Level Sensor

Oxygen Sensor(Bank2, Sensor2)   Fuel Tank Press. Sensor

Air Flow Sensor   Fuel Temp. Sensor

Air Temp. Sensor   Ignition Detect Signal

T.P.S.   Vehicle Speed Sensor

C.M.P   Power Steering Sensor

C.K.P.   Ignition Switch

W.T.S   Battery Voltage

Output

Ignition

Injector

Idle Speed Cont. Motor

Main Relay Control

Fuel Pump Control

Cooling Fan Control

Diagnosis(OBD)

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■ Mass Air Flow Sensor(MAF)

The air flow sensor installed between the air cleaner assembly and the throttle body assembly integrates Intake Air Temperature Sensor. Air flow sensing part consists of the heater device for keeping the constant relative temperature difference and the sensor device for measuring the air flow rate, and detect the balance of heat loss on hot film as circuit current increment. The ECM can calculate the mass air flow rate to engine, and this is *the most basic and important value for engine control in injection duration and ignition timing calculation*.

Electric Circuit
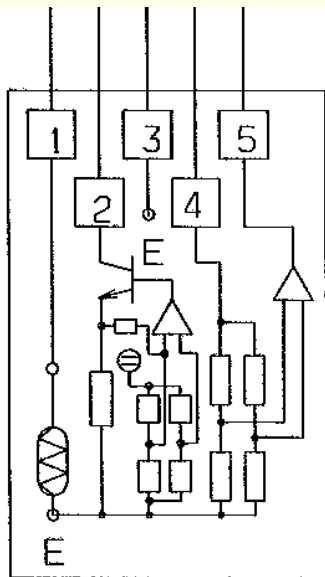
1: Air Temp. Signal

2: Vb

3: GND

4: Vref

5: Air Flow Signal

-HFM5

Location

Sensor Signal

KIA KIA MOTORS
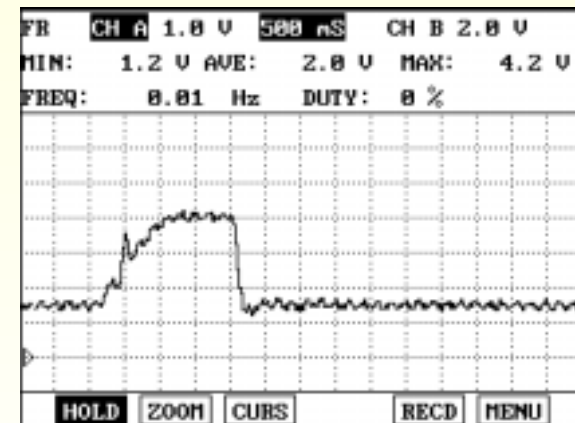
■ Throttle Position Sensor(TPS)

This is a rotary potentiometer having idle switch mounted on throttle body assembly.

This sensor provides throttle angle information to the ECM to be used for the *detection of engine status such as idle, part load, full throttle condition and anti-jerk condition and acceleration fuel enrichment correction.*

Electric Circuit

1: GND

2: Idle Sig.

3: TPS Sig.

4: Vref

Location

TPS &
Idle SW
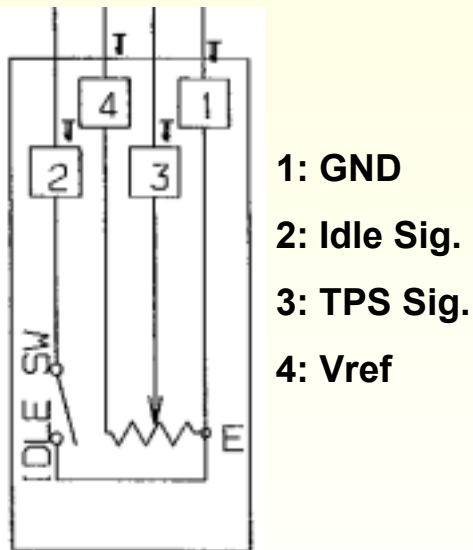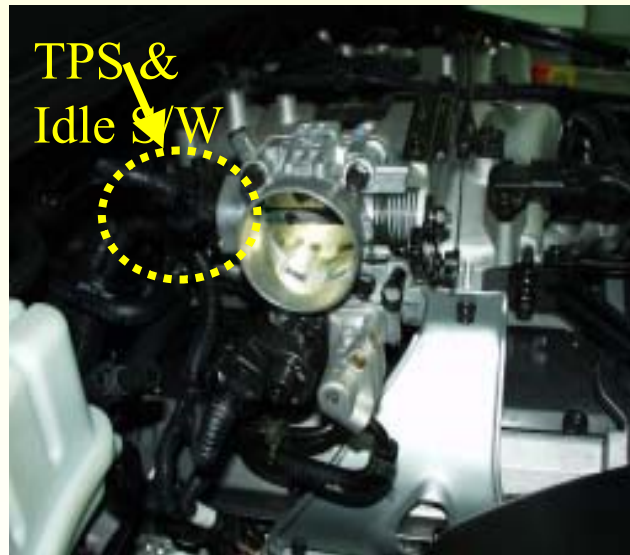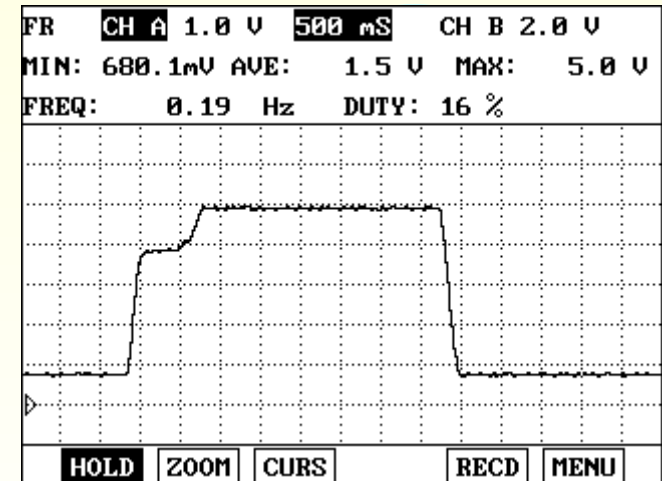
Sensor Signal

■ Throttle Position Sensor(TPS)

- Sensor Signal

[At idle → fuel cut]　　　　　　　　　　　　[At idle → running]
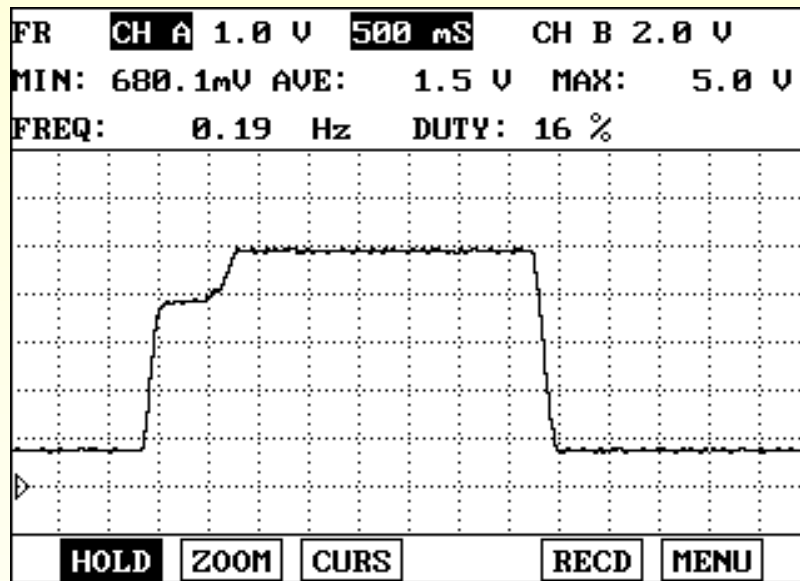
```
FR    CH A 1.0 V   500 mS    CH B 2.0 V
MIN: 680.1mV AVE:    1.5 V   MAX:    5.0 V
FREQ:     0.19  Hz    DUTY: 16 %




HOLD  ZOOM  CURS      RECD  MENU
```

```
FR    CH A 1.0 V   500 mS    CH B 2.0 V
MIN:- 11.6mV AVE:    1.2 V   MAX:    4.6 V
FREQ:     0.01  Hz    DUTY:  0 %




HOLD  ZOOM  CURS      RECD  MENU
```

KIA KIA MOTORS
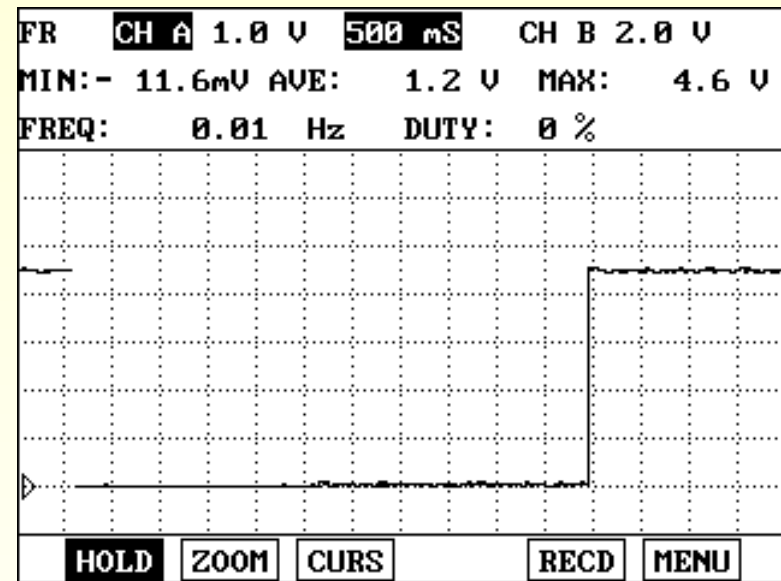
■ Engine Coolant Temperature Sensor (ECT)

The engine coolant temperature sensor integrated heat gauge is installed in the thermostat housing. This sensor having gold coated terminals provides information of coolant temperature to the ECM for controlling ;

- *Injection time and ignition timing during cranking & warm-up & hot condition*

- *ISC Motor to keep nominal idle engine speed*

- *Cooling & condenser fan etc.*

Electric Circuit
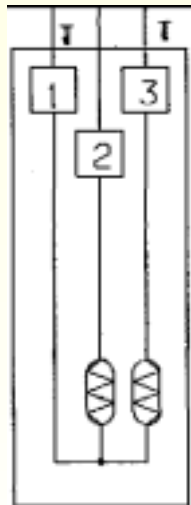
1: GND

2: Heat gauge

3: WTS Sig.

Location

WTS

Sensor Signal

KIA MOTORS
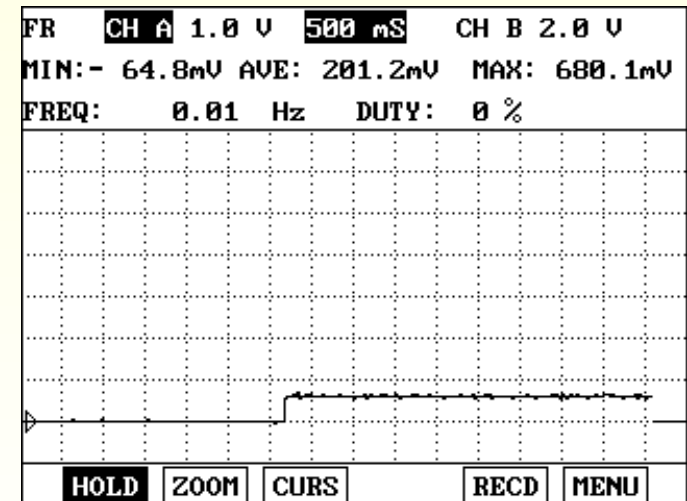
■ Heated Oxygen Sensors (HO2S)

There are four O2 sensors in a vehicle, two of them are installed in the upstream and the others are installed downstream of each bank of manifold catalyst.

The O2 sensors is consists of *Zirconia type* sensing element and heater. *The sensing element produces voltage* according to the richness of exhaust gas, and this voltage to reference in ECM reflect lean or rich status.

For each bank(1/2), ECM can control the fuel injection rate separately with the feedback of each front O2 sensor signals, and the desired air/fuel ratio which provide the best conversion efficiency is achieved.

The rear O2 sensors also inform ECM of lean or rich status of exhaust gas existing the closed-coupled catalyst.

The rear O2 sensor signals are used not only for the richness correction to control NOx emission effectively but for the determination of catalyst deterioration factor to monitor the catalyst converter.

And, the O2 sensor tip temperature is controlled to 750deg.C to get reliable sensor signal output by already programed *O2 heater control function*.

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■ Heated Oxygen Sensors (HO2S)

Electric Circuit

Location

Sensor Signal

HO2S Rear

HO2S Front
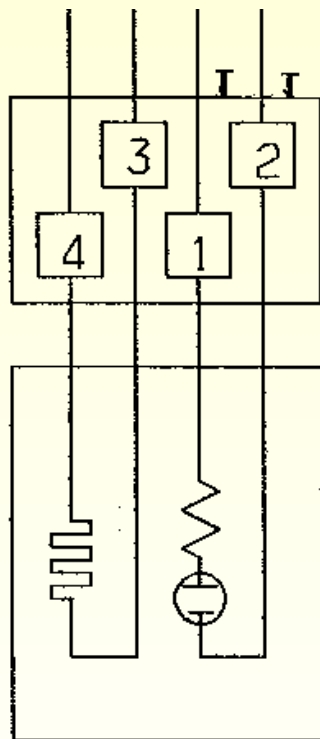
1: Sensor Sig.

2: Sensor GND

3: Heater Sig.

4: Vb
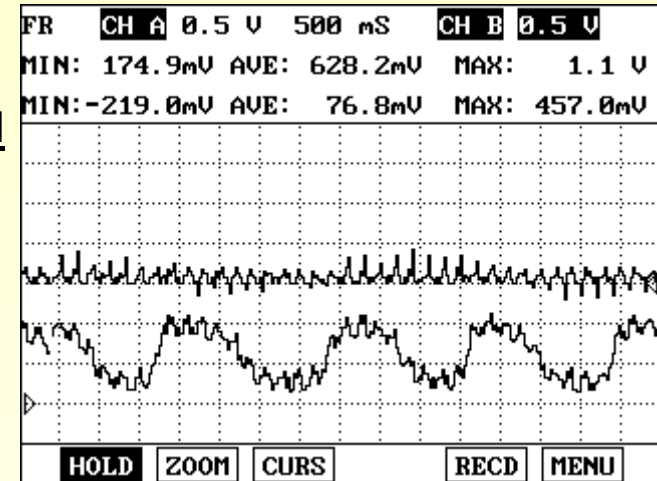

```
FR   CH A 0.5 V   500 mS   CH B 0.5 V
MIN: 174.9mV AVE: 628.2mV   MAX:   1.1 V
MIN:-219.0mV AVE:   76.8mV  MAX: 457.0mV
```

HOLD ZOOM CURS RECD MENU

FR. Sensor, RE. Sensor

```
FR   CH A 1.0 V   100 mS   CH B 5.0 V
MIN: 380.2mV AVE:   9.8 V   MAX:  13.8 V
FREQ:   18.18  Hz   DUTY: 72 %
```

HOLD ZOOM CURS RECD MENU

FR. Sensor Heater

KIA MOTORS
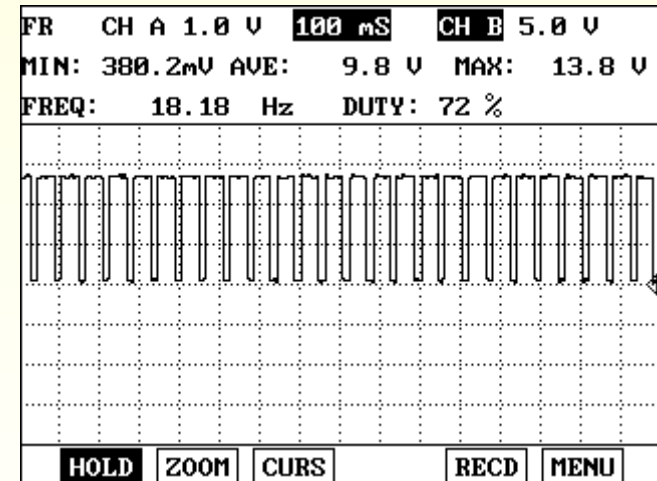
■ Crankshaft Position Sensor (CKP)

The crankshaft position sensor detects and counts the tooth on teeth target wheel(3) and provides ECM with the information on the current position of crank angle and cylinder, and also the duration of each tooth and segment. So _injection and ignition could be activated exactly in desired crank angle and current engine speed could be calculated also. The Sigma 3.5ℓ engine will not run if CKP sensor circuit failure conditions exist._ The CKP is located adjacent to the crankshaft pulley (similar to 2.4 Optima).

Electric Circuit

Location

1: GND.

2: Sensor Sig.

3: Vb

-Hall effect type sensor

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■ Crankshaft Position Sensor (CKP)

Sensor Signal
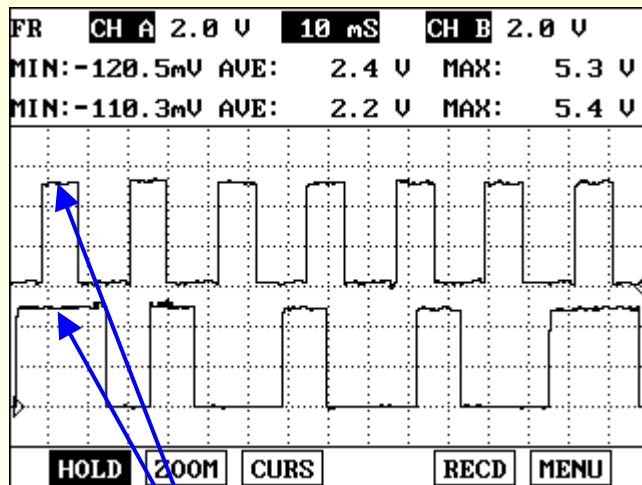
Synchronization with CMP
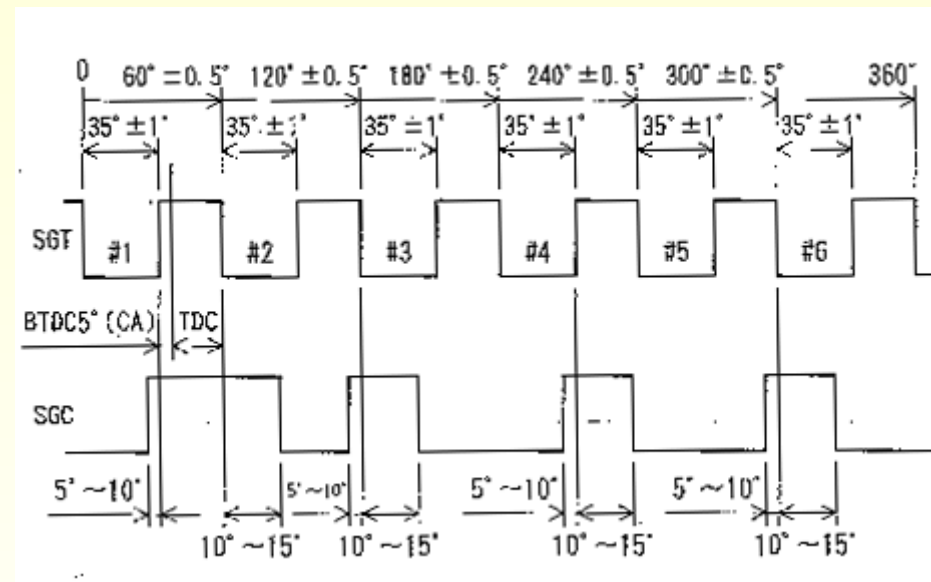
No.1 Cylinder TDC when both signals are at high.

■ Camshaft Position Sensor (CMP)

The Hall effect camshaft position sensor detects the teeth target wheel(Irregular four teeth) and provides ECM with the information on the current position of piston and cylinder, and also the duration of each tooth and segment. So *injection and ignition could be activated exactly in desired TDC of each cylinder.* The CMP is installed near the exhaust camshaft sprocket on the left cylinder bank. The target wheel is on the exhaust camshaft, behind the sprocket.

Electric Circuit

1: GND.

2: Sensor Sig.

3: Vb

-Hall effect type sensor

Location

CMP

Sensor Signal

FR CH A 2.0 V 10 mS CH B 0.5 V
MIN:-120.5mV AVE: 2.4 V MAX: 5.2 V
FREQ: 29.85 Hz DUTY: 42 %

Zoom 1x

HOLD ZOOM CURS RECD MENU
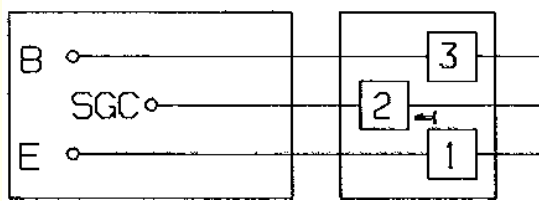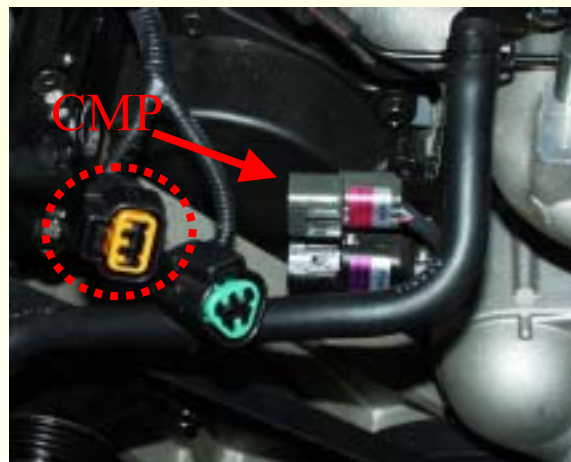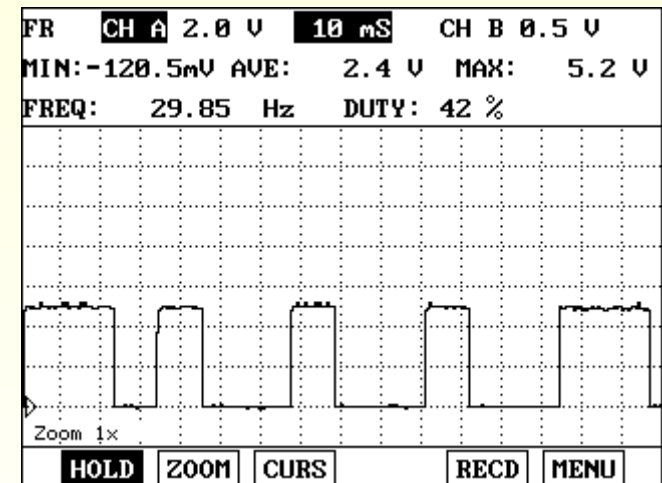
■ Knock Sensor

The knock sensor is installed to detect knock occurrence of each individual cylinders. The knock sensor signal is processed with filtering, signal noise level calculation and final decision of knock by comparing the noise level with calculated noise level threshold.

When knock is detected, ignition timings of corresponding cylinder are retarded by defined value, different engine operating conditions, and advanced again with delay and increment slop.

Location

Sensor Signal

Electric Circuit

2

1
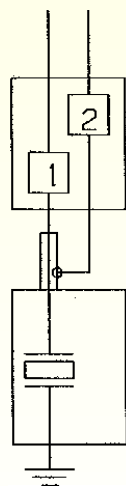
1: Sensor Sig.

2: Shield GND.

-Piezo type sensor

FR	CH A 1.0 V	50 mS	CH B 0.2 V
MIN:	17.0mV	AVE: 124.5mV	MAX: 296.6mV
FREQ:	57.14 Hz	DUTY: 36 %	

HOLD ZOOM CURS   RECD MENU

At idle

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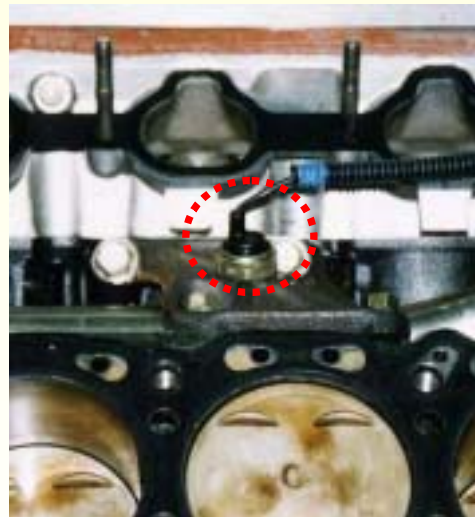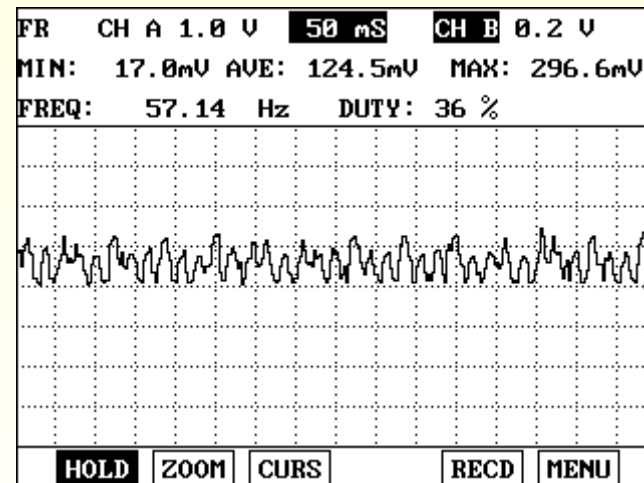
■ Idle Speed Control Motor (ISC)

Step Motor is installed to control the proper intake air amount to keep nominal idle engine speed and to avoid uncompleted combustion in closed throttle condition.
The ISC Motor opening value is concluded by Engine load(A/C,   Fans, Drive, ...), Altitude etc.
ECM sends a signal to each coils of step motor in series to open or close the by-pass passage of throttle body. The idle speed actuator has four coils.

Electric Circuit
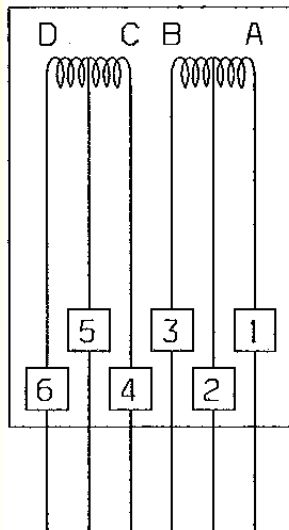
1: Control Sig. A

2: Vb.

3: Control Sig. B

4: Control Sig. C

5: Vb

6: Control Sig. D

-Coil type

Location

SAS

ISC STM
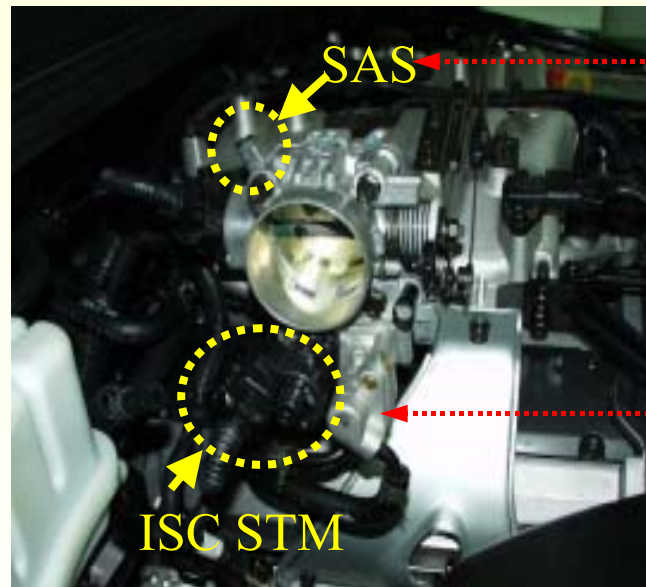
Idle Speed Adjust Screw(SAS)

FIAV(Fast Idle Air Valve) for cold condition

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■ Idle Speed Control Motor (ISC)

Output Characteristic

FR	CH A 5.0 V	200 mS	CH B 5.0 V
MIN:- 56.6mV	AVE:	8.5 V	MAX: 18.7 V
MIN:- 38.9mV	AVE:	1.2 V	MAX: 16.5 V

| HOLD | ZOOM | CURS | RECD | MENU |

FR	CH A 5.0 V	200 mS	CH B 5.0 V
MIN:- 56.6mV	AVE:	986.7mV	MAX: 32.9 V
MIN:- 38.9mV	AVE:	7.3 V	MAX: 29.1 V

| HOLD | ZOOM | CURS | RECD | MENU |

Tek Stop: 2.50kS/s   14 Acqs

Ch1 10.0 V   Ch2 10.0 V   M20.0ms Ch1 ∫   3.4 V   7 Jul 1999
Ch3 10.0 V   Ch4 10.0 V   12:14:26
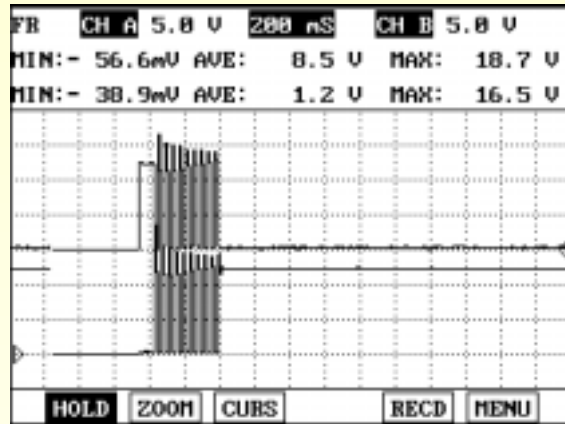
A & B at the moment A/C Off → On   **C & D**

Details →

Activation Order

	A	○			○
	B		○	○	
	C	○	○		
	D			○	○
Valve Moving	a	→			
	b	←			
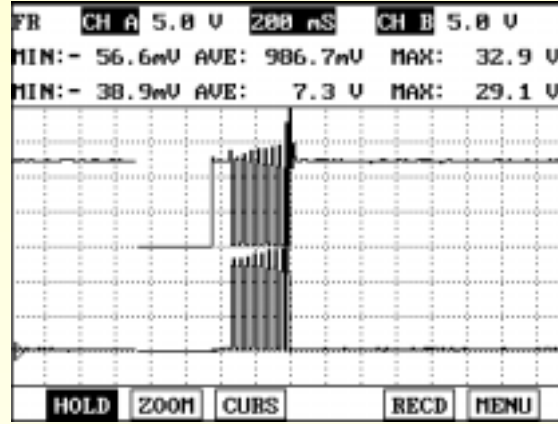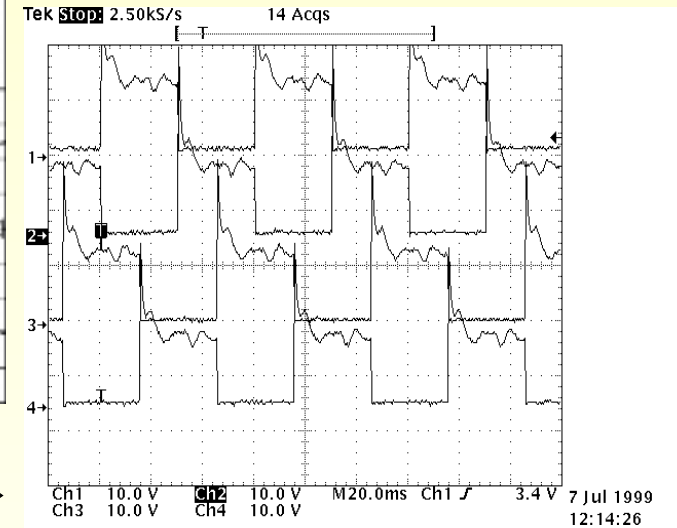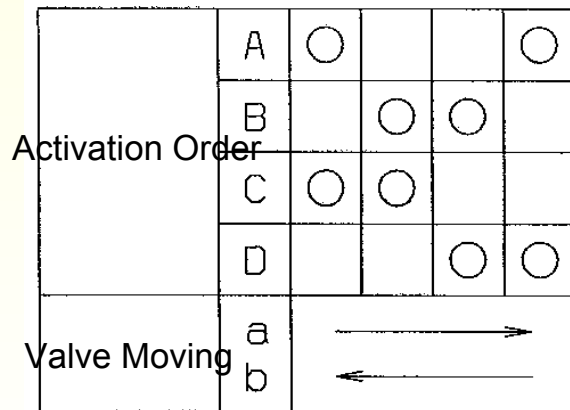
a : Valve Closing
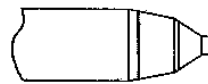
b : Valve Opening

Operation Order

KIA MOTORS

Sigma(Σ) 3.5ℓ Eng. – ECM Input/Output
160

■ Fuel Injectors

The six fuel injectors are sequentially activated by the PCM using ground controlled circuits. Each injector has four individual spray ports. The pulse signal from ECM actuates injector coil to open, thus inject a defined amount of fuel. The start and end of injection is controlled by ECM according to engine operating conditions.

Electric Circuit

Location

1: Control Sig.

2: Vb.

-Coil type

KIA MOTORS
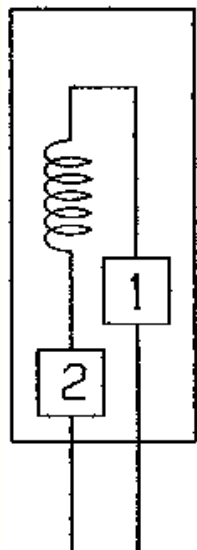
■ Fuel Injectors

Output Characteristic

#1, #2 Cylinder Injection at starting
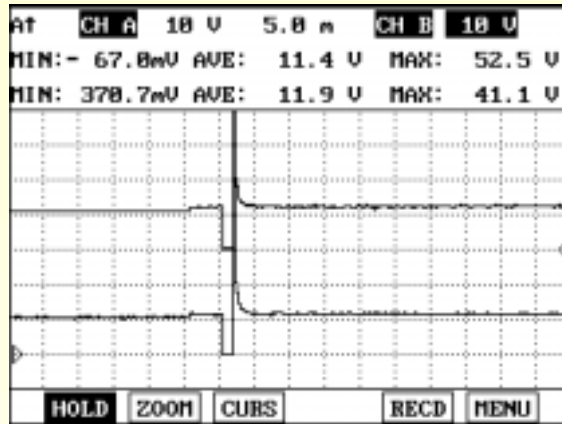
#1, #2 Cylinder Injection at idle
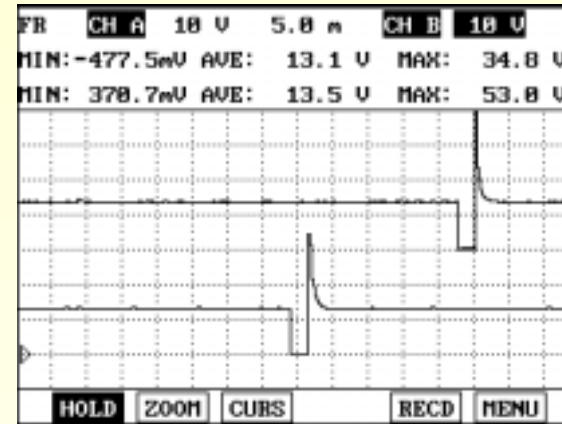
CKP

CMP

#1 Injection

#2 Injection
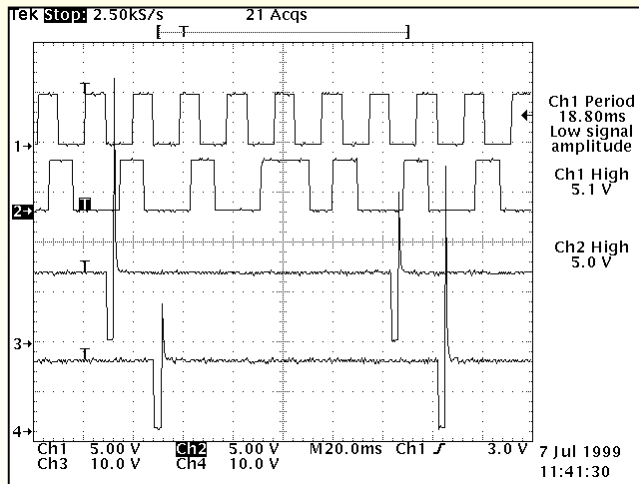
CKP

CMP

#3 Injection

#4 Injection

KIA **KIA MOTORS**
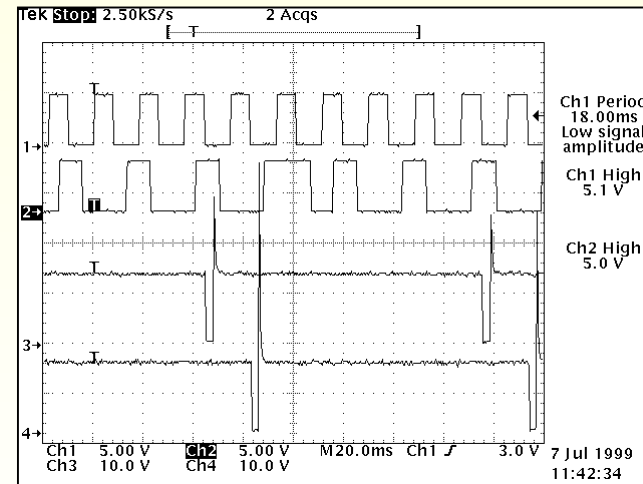
■ Purge Control Solenoid Valve

20Hz pulse duty signal is sent from ECM to purge accumulated fuel in the canister charcoal. The Purge control valve is open or closed when OBD-II leakage monitoring is performed. The pulse duty to purge the canister is calculated according to engine operating condition(Engine speed, Mass air flow)

Flow rate

Pressure difference

Electric Circuit

Location

1: Control Sig.

2: Vb.

-Coil type

1

2

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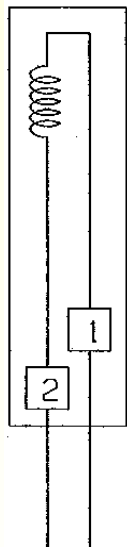
■ Fuel Tank Pressure Sensor (FTPS)

This sensor,installed on the fuel tank, measures the pressure of fuel tank to detect leakage or malfunction of related component during *the leakage monitoring of evaporative emission control system.*

Sensor Characteristic & Signal

Electric Circuit
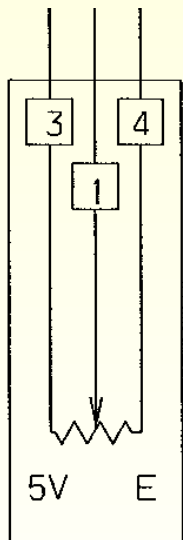
Location

1: Sensor Sig.

3: Vref.

4: Sensor GND.

-Resistance type with Diaphram

At the moment IG. Off → On

2.5kpa

0

-2.5kpa

0.7V   2.5V   4.5V

```
FR    CH A 1.0 V    500 mS    CH B 1.0 V
MIN:- 11.6mV AVE:    1.2 V    MAX:    2.4 V
FREQ:    0.01  Hz    DUTY:    0 %
```

HOLD ZOOM CURS   RECD MENU

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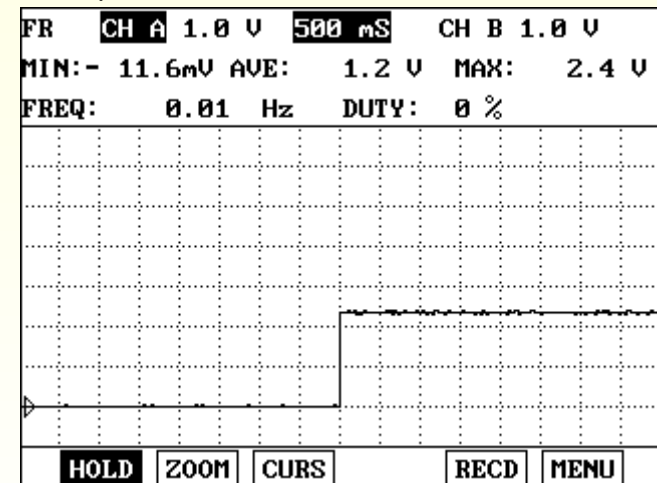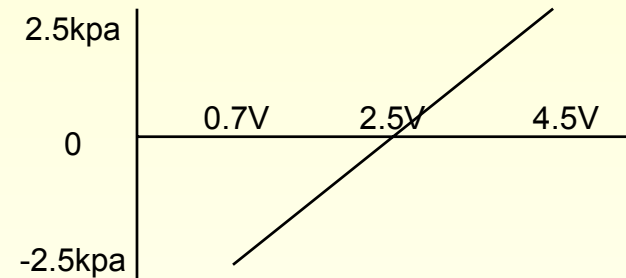
■ Fuel Level Sensor (FLS), Fuel Temperature Sensor (FTS)

For engine management purposes, the Fuel Level Sensor(FLS) is also used as a supplementary device to assist with evaporative monitoring. The Fuel Temperature Sensor (FTS) is also incorporated for this purpose.

Location
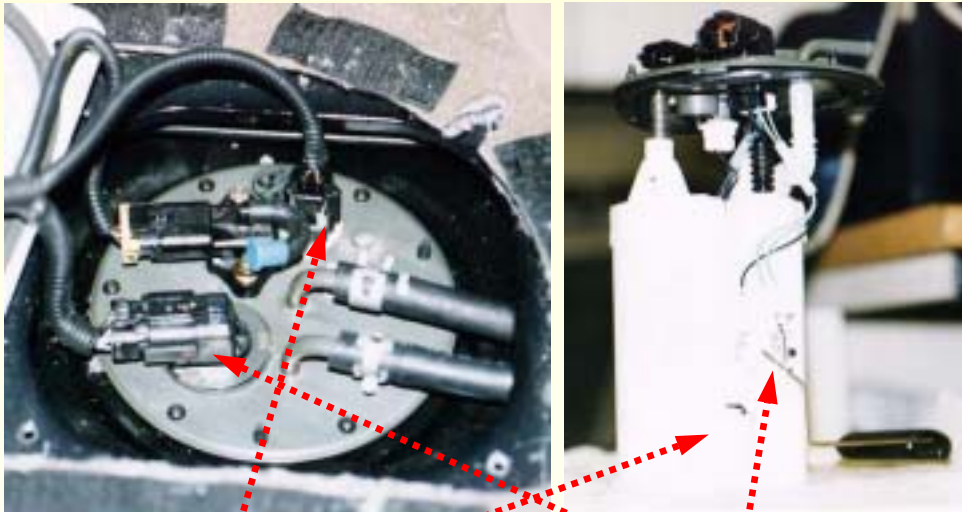
Sensor Signal

Fuel Temp. Sensor   Fuel Level Sensor

FR   CH A 1.0 V   500 mS   CH B 2.0 V
MIN:- 11.6mV AVE: 839.7mV   MAX: 3.7 V
FREQ: 0.01 Hz   DUTY: 0 %

HOLD ZOOM CURS   RECD MENU

FLS at IG.
Off → On

FR   CH A 1.0 V   500 mS   CH B 2.0 V
MIN:- 64.8mV AVE: 1.2 V   MAX: 2.3 V
FREQ: 0.01 Hz   DUTY: 0 %

HOLD ZOOM CURS   RECD MENU

FTS at IG.
Off → On

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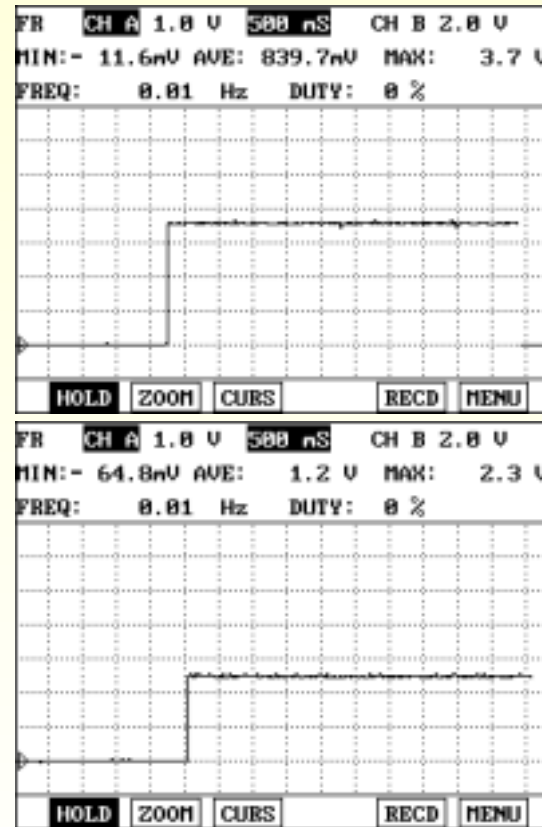
■ Canister Close Solenoid Valve (CCV) – NA only

The Canister Close Solenoid Valve (CCV) is normally open ; the ECM closes the valve to seal the evaporative emissions system for OBD-II leakage monitoring purposes. The CCV is located on the evap canister.

Electric Circuit

Location

1: Control Sig.

2: Vb.
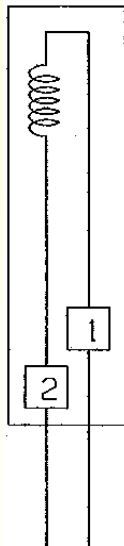
-Coil type
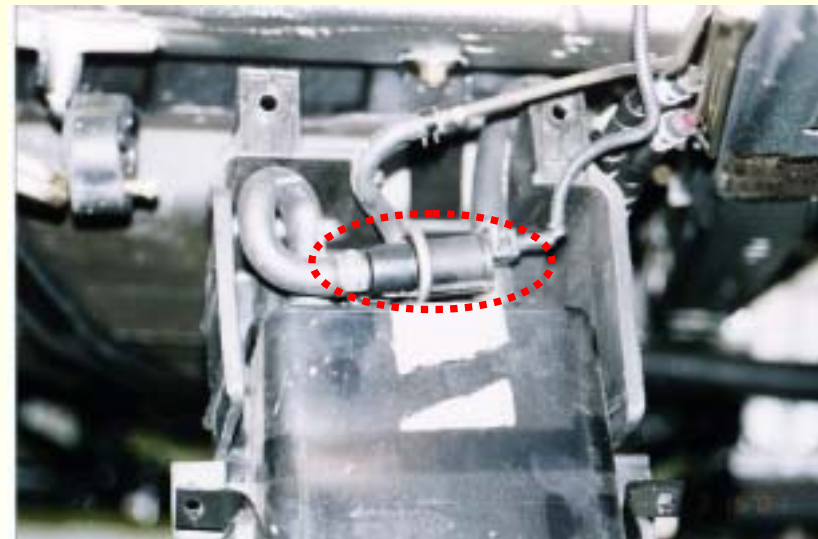
■ Manifold Absolute Pressure Sensor (MAP)

This sensor is installed at intake surge tank to adapt fuel system for the altitude of vehicle(by detecting atmosphere pressure).

Electric Circuit   **Location**   **Sensor Signal**
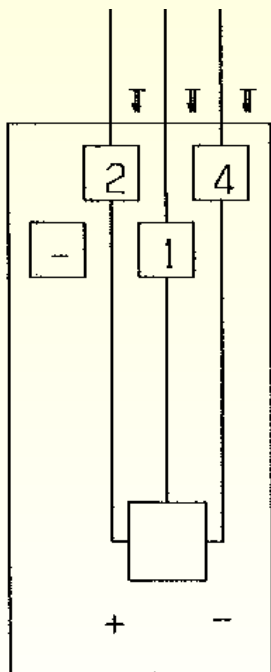
1: Sig.
2: Vref.
4: GND
-Piezo type sensor

MAP Sensor

FR CH A 0.5 V 500 mS CH B 5.0 V
MIN: 45.4mV AVE: 153.3mV MAX: 304.4mV
FREQ: 6.67 Hz DUTY: 47 %

HOLD ZOOM CURS RECD MENU
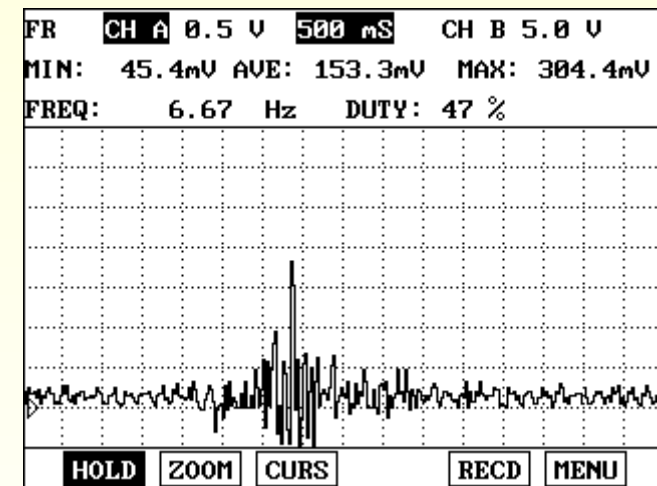
At idle → Acceleration

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■ Ignition Failure Sensor

The ignition failure sensor is employed for the purposes of detecting ignition system Malfunctions. The three ignition coil primary circuits are connected through the ignition failure sensor. The ECM monitors the sensor output signal to determine if a failure condition exists. (The tachometer is also supplied with the ignition detect signal.)

Electric Circuit

1: Body GND.

2: Vref.

3: Vb Output

4: Vb Input

-IC type sensor

Location

IFS
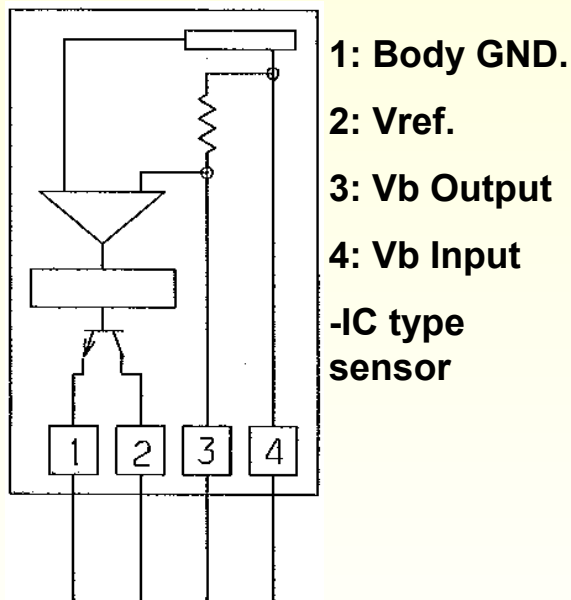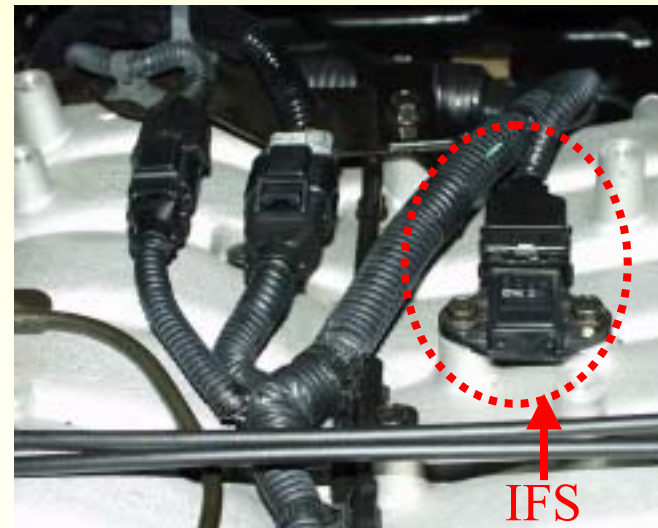
■ Ignition Failure Sensor

CKP

CMP

IG. #1&#4

IG. #2&#5

Tek Stop: 2.50kS/s   19 Acqs

Ch1 Period
28.00ms
Low signal
amplitude

Ch1 High
5.1 V

Ch3 Period
84.00ms
Low signal
amplitude

Ch3 High
3.80 V
Unstable
histogram

Ch1 5.00 V   Ch2 5.00 V   M20.0ms Ch1 ⌐   3.0 V   7 Jul 1999
Ch3 2.00 V   Ch4 2.00 V   11:45:47

CKP

CMP

IG. #3&#6

IG. Fail. sensor

Tek Stop: 2.50kS/s   223 Acqs

Ch1 Period
26.40ms
Low signal
amplitude

Ch1 High
5.1 V

Ch4 Period
26.44ms
Low signal
amplitude

Ch4 High
3.28 V
Unstable
histogram

Ch1 5.00 V   Ch2 5.00 V   M20.0ms Ch1 ⌐   3.0 V   7 Jul 1999
Ch3 2.00 V   Ch4 2.00 V   11:49:33

The signal from IG. Failure Sensor is a kind of monitoring signal for the activation of each primary IG. Coil.

When each primary coil signal falls, the signal of IG. Failure Sensor rises.

ECM can monitor the primary IG. Coil signal at ECM outside with this signal and compares this signal with the each primary IG. Coil signal of ECM inside.

The frequency of both signal should be same. If there are any difference, ECM regards it misfire for the cylinder.

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■ Ignition Coil

There are three ignition coils-#1/#4, #2/#5 and #3/#6. Each ignition coil is integrated its own power transistor.

Electric Circuit

Location

Signal

1: Vb.

2: Body GND

3: Signal

-IG. Coil integrated TR
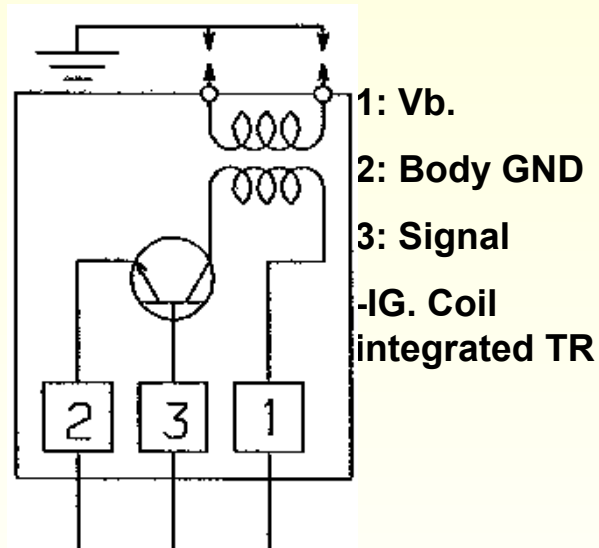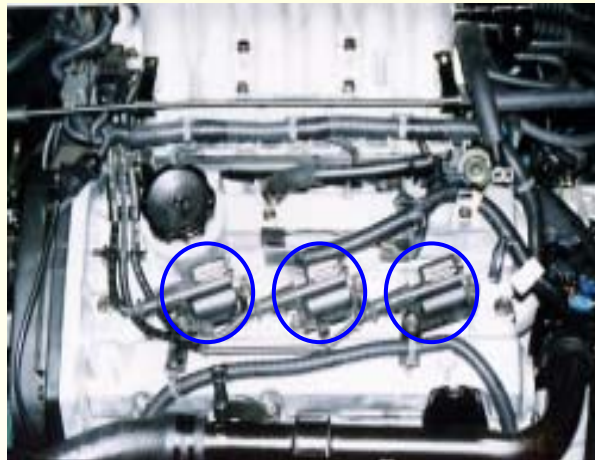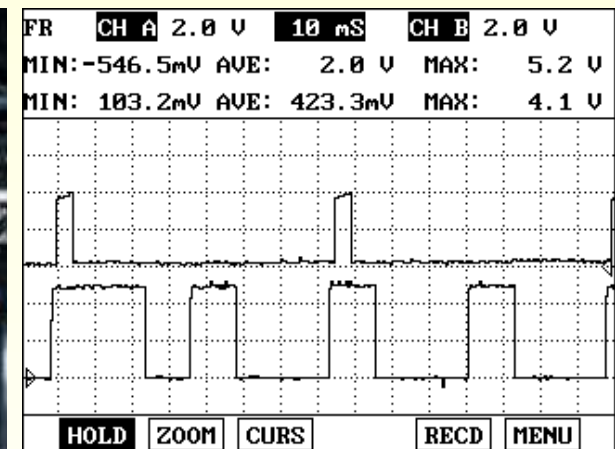
IG.#1&#4 & CMP

■ Variable Intake Manifold

Low to medium speed torque is boosted through the use of a Variable Intake Manifold. Intake manifold path is variable through the operation of VI vacumn according to the engine RPM. (≒3500rpm, on and off type)

Flow   **Location**

V.I Sol. Valve

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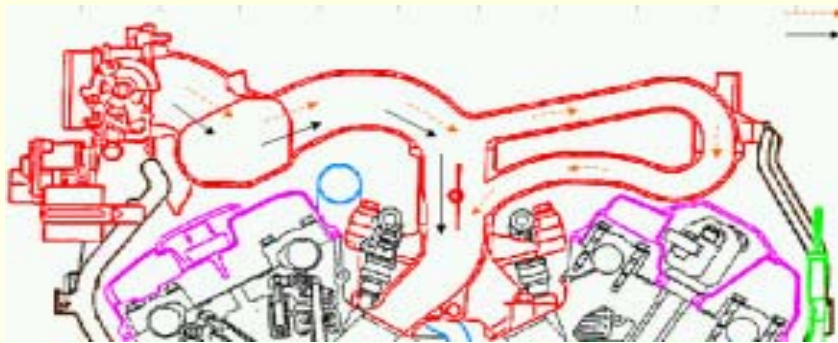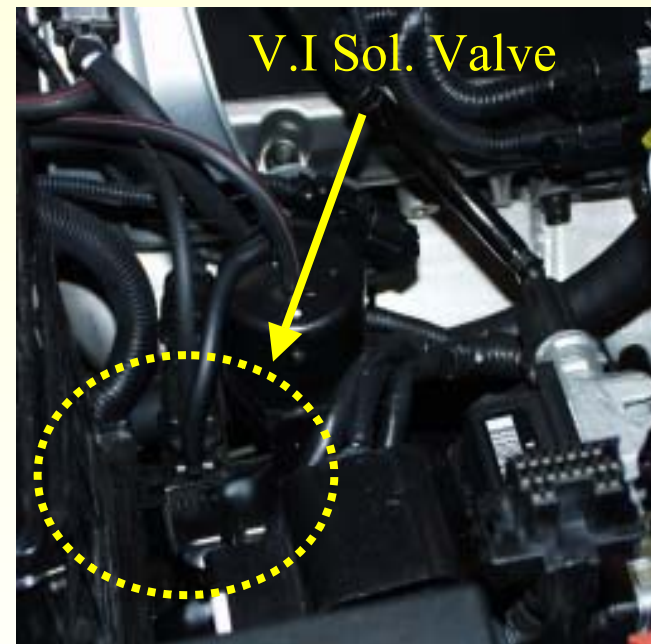
■ Main Relay

The voltage after main relay is used to supply power to the sensors and actuators.
ECM controls the Main Relay and its remains ON at Key off in order to store the adaptation values and fault status to the memory.

Electric Circuit
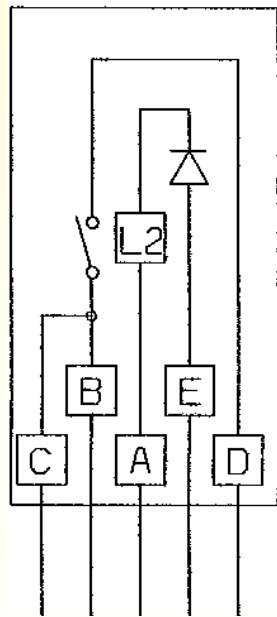
A: Control Sig.

B,C: Output Vb.

E,D: Input Vb

-Coil type

Location

Output Characteristic

IG. KEY ON	
	IG. KEY OFF

Around 10 sec

M/RELAY ON	
	M/RELAY OFF
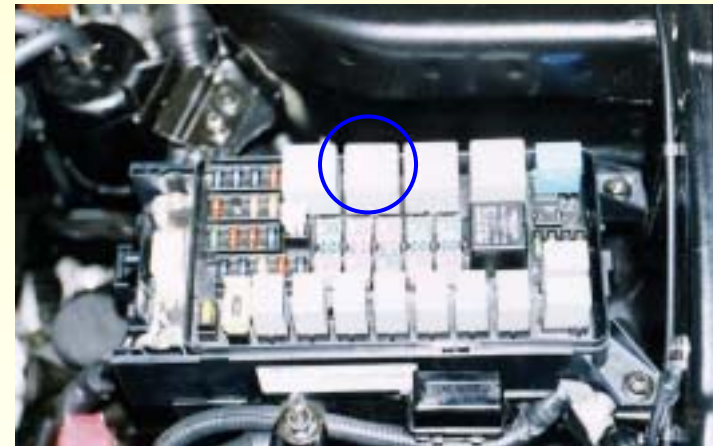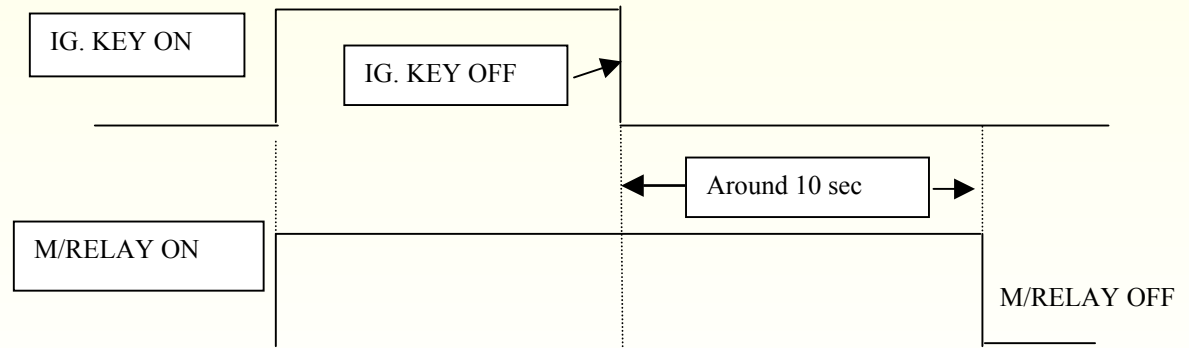
■ Catalyst Efficiency Monitoring

The signal from the O_2 sensor upstream from the monitored catalyst and the associated monitoring oxygen sensor downstream from the catalyst are used to estimate the Oxygen storage capability:

–If a catalyst has good conversion properties, the oxygen fluctuations upstream from the catalyst, generated by the lambda controller, are smoothed by the Oxygen storage capacity of the catalyst.

–If the conversion provided by the catalyst is low due to ageing, poisoning or misfiring, then the fluctuations upstream from the catalyst exist also downstream from the catalyst.

–Calculate a frequency ratio of output signals from the front and rear oxygen sensors according to the following equation.

Rf= Frequency of Rear Oxygen / Frequency of Front Oxygen

if Rf > R0(Threshold value), determine the catalyst malfunction.

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Sigma(Σ) 3.5ℓ Eng. – OBD2 Functions

■ Misfire Monitoring

Misfire induces a decrease of the engine speed, therefore a variation in the segment period. The misfiring detection is based on the observation of this variation of segment period.
As a result, ECM monitor the fluctuation of crank angular acceleration. If the crank angular acceleration is out of specification, ECM determines misfire on engine.

<u>Main causes of misfiring:</u>
- injector shut-off
- fuel pressure problems
- fuel combustion problems
- ignition cut-off…

<u>Carb. A error:</u>
- •Check recurrence: 200CKP revolution
- •Target: to avoid cataylist damage

<u>Carb. B error:</u>
- •Check recurrence: 1000CKP revolution
- •Emission decrease

<u>Misfire fade-out conditions:</u>
- •Min. engine rpm
- •Max. engine rpm(6500)
- •Min. engine load(0)
- •Max. air mass gradient
- •Max throttle gradient
- •Max. ignition angle gradient
- •Aircon compressor activation
- •Cylinder shut-off
- •Rough road detection
- •Crankshaft oscilation.
- •Shift change
- •Sudden deceleration

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■ O2 Sensor Monitoring

The fluctuation of O2 signal characteristics is significant to perform properly lambda feedback control. And, too slow sensing response of O2 signal can cause the increment of exhaust emission.

- Response time monitoring
Detect the response time (TLR, TRL) of oxygen sensor output signals when air-fuel ratio is changed intentionally from lean to rich (TLR) or rich to lean (TRL) under the hot steady state condition.
If T_{LR} > T1 or T_{RL} > T2 (T1, T2 : threshold value), determine the oxygen sensor malfunction.
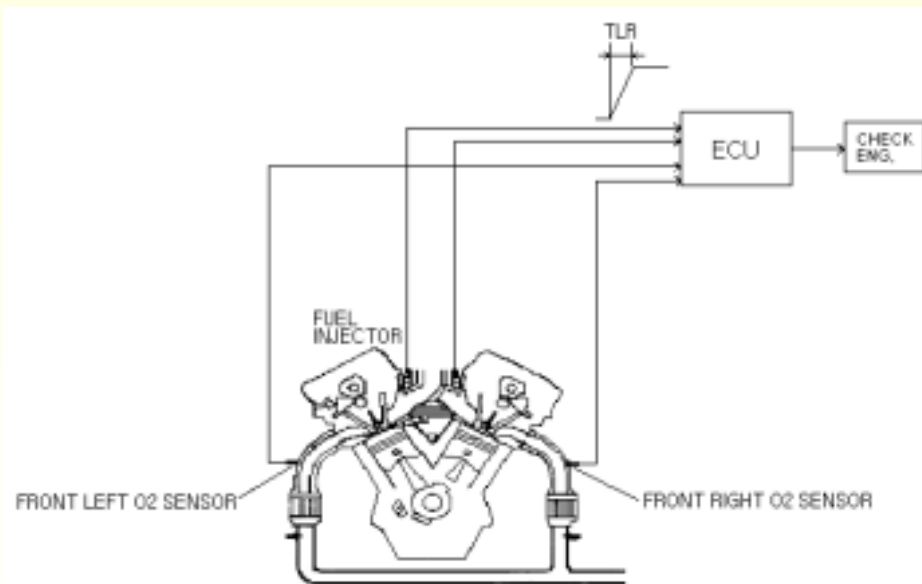
■ Fuel System Monitoring

A/F feedback compensation value (A/F learning value and Integral value of A/F feedback) is monitored. Injection time (T) is conceptually defined as follows ;

$$T = TB \times (KLRN + KI + 1.0)$$ TB : Base injection time

KI is determined to achieve A/F ratio stoichiometric for short-term trim and KLRN for long-term trim.
If KLRN > K0 and KI > K1 or KLRN < K2 and KI < K3(K0, K1, K2, K3 : threshold value), determine the fuel system malfunction.

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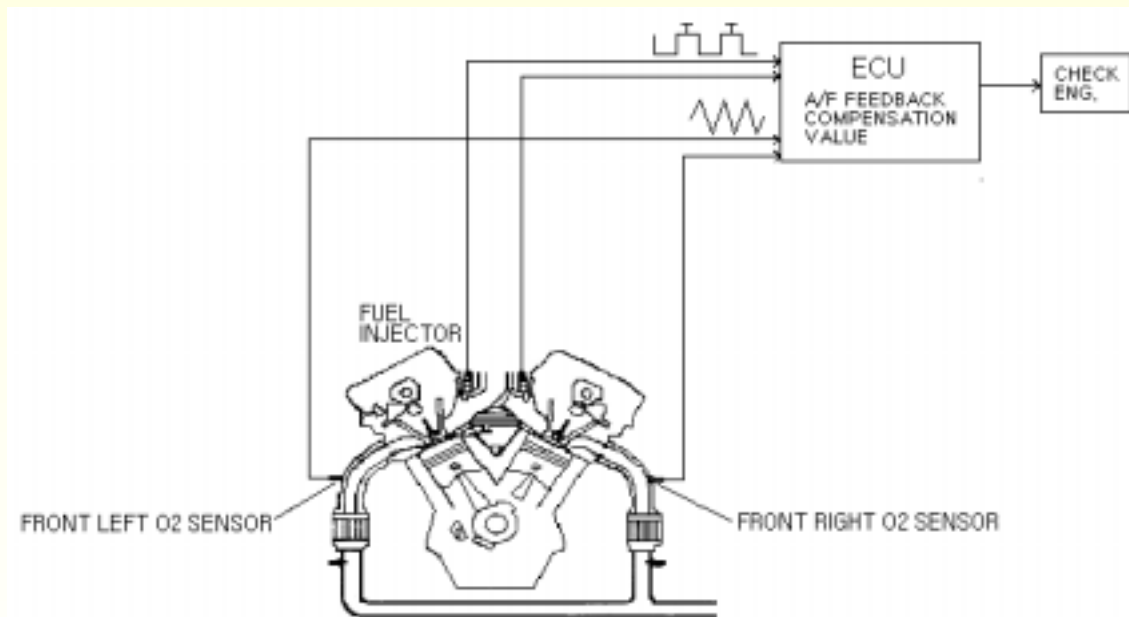
■ Evaporative System Monitoring

At driving condition, the fuel tank pressure gradient and the duration to reach to certain tank pressure are monitored after vacuuming the evaporative system to use the throttle body vacuum through the purge solenoid valve and canister close valve. If the evaporative system has a small leakage such as Φ1mm leakage hole, the pressure gradient will be above a certain threshold map value which consists of △P, △T.

At idle condition, if the evaporative system has a small leakage such as Φ0.5mm leakage hole, the pressure gradient will be above a certain threshold map value which consists of fuel temperature (FTMP), fuel level(FLVL).

-△P ≥ Threshold map value (△P, △T) or, Threshold map value (FTMP, FLVL)

where, △P = (PREAL - P3) - (P2 - P1), △T = T(P2') - T(P2)

-P2REAL > Threshold value
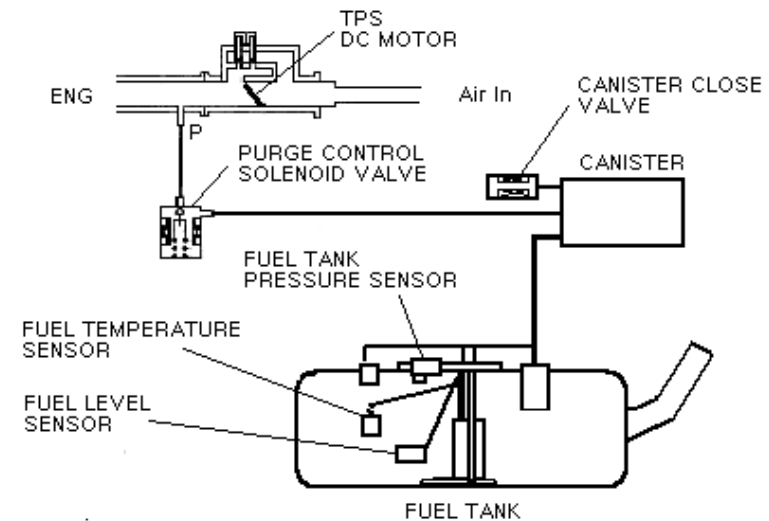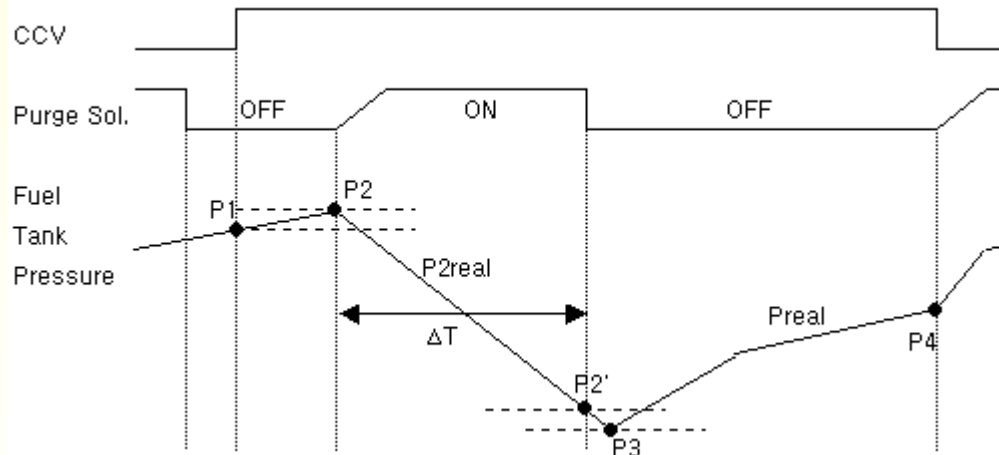
■ Thermostat Monitoring

Engine coolant temperature from the sensor voltage is monitored. For thermostat monitoring, three Malfunction criteria (TWTFL_H, TWTFL_M, TWTFL_L) according to intake air flow are reduced per 500msec. Malfunction decision is performed when the counter of malfunction criteria is zero in the case of the engine coolant temperature is over thermostat regulating temperature.

Malfunction Condition
Coolant temperature at start : 5 ~ 60℃
Coolant temperature at start - Intake air temperature at start < 10℃
Intake air temperature at start - Intake air temperature < 5℃
The integrated time of low air flow(TWOAFS) ≤ 200sec
The integrated time of high air flow(TWOAFS_H) ≤ 100sec

Malfunction Criteria
The counter of malfunction criteria(TWTFL_H, TWTFL_M, TWTFL_L) is changed.
intake average air flow(Qave).
Qave > 19.2g/sec   ⇒   TWTFL_H
19.2g/sec > Qave > 11.52 g/sec   ⇒   TWTFL_M
Qave ≤ 11.52g/sec   ⇒   TWTFL_L

COMPONENT SYSTEM	FAULT CODE	MONITOR STRATEGY DESCRIPTION	MALFUNCTION CRITERIA	THRESHOLD VALUE	SECONDARY PARAMETERS	ENABLE CONDITIONS	TIME REQUIRED	MIL ILLUM.
Catalyst (Bank 1)	P0421	Frequency ratio (Rf) of front and rear oxygen sensor used. Bank 1	FTP emission > 1.75 * emission standard	> 0.801	Closed loop		150sec once per driving cycle	2 Driving cycles
					Load value	25% ~ 70%		
					Engine speed	< 2500rpm		
					Idle switch	off		
					Vehicle speed	> 15KPH		
Catalyst (Bank 2)	P0431	Frequency ratio (Rf) of front and rear oxygen sensor used. Bank 2	FTP emission > 1.75 * emission standard	> 0.801	Closed loop		150sec once per driving cycle	2 Driving cycles
					Load value	25% ~ 70%		
					Engine speed	< 2500rpm		
					Idle switch	off		
					Vehicle speed	> 15KPH		
Misfire	P0300(Multi) P0301(#1 Cyl) P0302(#2 Cyl) P0303(#3 Cyl) P0304(#4 Cyl) P0305(#5 Cyl) P0306(#6 Cyl)	Fluctuation of crank angular acceleration is monitored	FTP emission > 1.5 * emission standard	> 2.2%	Engine speed	500~6250rpm	1000revs. Continuous	2 Driving cycles
					Load value	11% ~ 100%		
			Catalyst temp. > 950?	> 5 ~ 20% within 200revs.	No running on rough road		200 revs. Continuous	
					No shift change			
					No sudden deceleration			
Canister close valve	P0446	Surge voltage is monitored	Surge voltage, Vps	< Vb + 2V	Battery voltage	≥ 10V	Continuous	2 Driving cycles
		Clogging is monitored	Preal	< -200mmAq	FTPS voltage	1.0 V ~ 3.5V		
					Purge Duty	≥ 20%		

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System	Code	Monitoring	Measurement	Threshold	Condition	Value	Detection	Driving cycles
Evap. Purge system	P0456	0.02inch leakage of evap. System is monitored	ΔP = (Preal-P3) -(P2-P1)	≥ Threshold value(ΔP, FTMP, FLVL)	Idle switch	on	90sec once per driving cycle	2 Driving cycles
					Fuel temp.	< 45?		
					Vehicle speed	< 10KPH		
	P0442	0.04inch leakage of evap. System is monitored		≥ Threshold value(ΔP, ΔT)	Engine speed	> 1500rpm	50sec once per driving cycle	
					Load value	25 ~ 70%		
					Engine coolant	> 60?		
	P0455	Big leakage (fuel cap missing)	P2real between detecting P2 and detecting P3	> -180mmAq	Intake air temp.	< 70?		
					P/S pressure s/w	off		
					Vehicle speed	≥ 30KPH		
Purge sol. Valve	P0441	Evap. Pressure is monitored	Preal	< -157mmAq	↑	↑		2 Driving cycles
	P0443	Surge voltage is monitored	Surge voltage, Vps	< Vb + 2V	Battery voltage	≥ 10V	Continuous	2 Driving cycles
Fuel tank pressure sensor	P0453	Output voltage of tank pressure sensor is monitored	Purge Duty	≥ 100% and	Intake air temp.	> 5?	Continuous	2 Driving cycles
			Intake air temperature	< 45? and	Load value	25% ~ 70%		
			Sensor output voltage	> 3.5V	Engine speed	> 1440rpm		
	P0452	Output voltage of tank pressure sensor is monitored	Purge Duty	= 0% and	Vehicle speed	≥ 29.75KPH		
			Sensor output voltage	< 1.0V				
	P0451	(P1=pressure with full tank)	Oscillation between max. & min. voltage	>Mean value+P1 <Mean value-P1	Vehicle speed	< 2.5KPH	90sec Continuous	
					Idle switch	on		
Fuel Level Sensor	P0463	Change in output voltage(ΔVFLS) and output voltage(VFLS) are monitored	ΔVFLS	< 0.039V	Time during vehicle speed ? 0	> 600sec	Continuous	No MIL ON
	P0462		and VFLS	> 4.9V				
	P0460			< 1.0V				
				1.0<VFLS<4.9V				
Fuel temperature sensor	P0181	Output voltage is monitored.	Output voltage, VFTMP	< 0.1V or	Time after start	> 2sec	Continuous	2 Driving cycles
				> 4.6V				
	P0183	Rationality Check	| Fuel temp. at start - water temp. at start |	> 15?	Water temp at start - air temp. at start	< 5?		

Fuel system (Bank 1)	P0171(Too lean)	A/F learning value(KLRN) & integral value of A/F feedback compensation(KI) are monitored	Idle	KLRN	> +12.5%	Closed loop		Continuous	2 Driving cycles
				KI	> +25%				
			Part load	KLRN	> +12.5%				
				KI	> + 15.2%				
	P0172(Too rich)	A/F learning value(KLRN) & integral value of A/F feedback compensation(KI) are monitored	Idle	KLRN	< -12.5%				
				KI	< -30%				
			Part load	KLRN	< -12.5%				
				KI	< -10.9%				
	P0174(Too ean)	A/F learning value(KLRN) & integral value of A/F feedback compensation(KI) are monitored	Idle	KLRN	> +12.5%	Closed loop		Continuous	2 Driving cycles
				KI	> +25%				
			Part load	KLRN	> +12.5%				
				KI	> + 15.2%				
	P0175(Too rich)	A/F learning value(KLRN) & integral value of A/F feedback compensation(KI) are monitored	Idle	KLRN	< -12.5%				
				KI	< -30%				
			Part load	KLRN	< -12.5%				
				KI	< -10.9%				
Oxygen Sensor (Bank 1, front)	P0133	Response time from lean to rich (TLR) & from rich to lean (TRL) are monitored when A/F is intentionally changed.	From lean to rich (TLR)	> 1.1sec	Closed loop		8sec Continuous	2 Driving cycles
					Engine coolant	> 35?		
			From rich to lean (TRL)	> 0.95sec	Load value	25~60%		
					Engine speed	1375~3000rpm		
	P0132	Circuit voltage(Vf) is monitored.	Circuit voltage after applying 5V to sensor	≥ 4.5V	Engine coolant	> 77?	Continuous	2 Driving cycles
					Engine speed	> 1200rpm		
Oxygen Sensor (Bank 1, rear)	P0136	Circuit voltage(Vf) is monitored.	Circuit voltage after applying 5V to sensor	≥ 4.5V	Load value	> 25%		
					Sensor voltage	<0.2V for 180s		
	P0140	Circuit voltage is monitored when A/F is made to be rich 15% during 10sec	Circuit voltage Vf	≥ 0.5V	Engine coolant	> 70?	Continuous	2 Driving cycles
			Circuit voltage Vr	< 0.1V				
	P0139	Rationality Check	Response Rate, TRL	≥ 1sec	Engine coolant	> 82?	3sec Continuous	2 Driving cycles
					Fuel Cut	on		

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Sensor	Code	Description	Parameter	Threshold	Condition	Value	Time	Cycles
Oxygen Sensor (Bank 2, front)	P0150	Response time from lean to rich (TLR) & from rich to lean (TRL) are monitored when A/F is intentionally changed.	From lean to rich (TLR)	> 1.1sec	Closed loop		8sec Continuous	2 Driving cycles
					Engine coolant	> 35?		
			From rich to lean (TRL)	> 0.95sec	Load value	25~60%		
					Engine speed	1375~3000rpm		
	P0152	Circuit voltage(Vf) is monitored.	Circuit voltage	≥ 4.5V	Engine coolant	> 77?	Continuous	2 Driving cycles
					Engine speed	> 1200rpm		
Oxygen Sensor (Bank 2, rear)	P0156	Circuit voltage(Vf) is monitored.	Circuit voltage	≥ 4.5V	Load value	> 25%	Continuous	2 Driving cycles
	P0160	Circuit voltage is monitored when A/F is made to be rich 15% during 10sec	Circuit voltage Vf	≥ 0.5V	Engine coolant	> 70?	Continuous	2 Driving cycles
			Circuit voltage Vr	< 0.1V				
	P0159	Rationality Check	Response Rate, TRL	≥ 1sec	Engine coolant	> 82?	3sec Continuous	2 Driving cycles
					Fuel Cut	on		
Oxygen Sensor Heater (Bank 1)	P0135(front) P0141(rear)	Heater circuit current(AH) is monitored.	Circuit current, AH	< 200mA or ≥ 3.5A	Heater	on	Continuous	2 Driving cycles
Oxygen Sensor Heater (Bank 2)	P0155(front) P0161(rear)	Heater circuit current(AH) is monitored.	Circuit current, AH	< 200mA or ≥ 3.5A	Heater	on	Continuous	2 Driving cycles
Throttle position sensor	P0122	Output voltage is monitored.	Output voltage, VTPS	< 0.2V or ≥ 2V	Idle switch	on	Continuous	2 Driving cycles
	P0123	Output voltage is monitored.	Output voltage, VTPS	> 4.6V	Load value	< 30%		
					Engine speed	< 3000rpm		
	P0121	Rationality Check	Output voltage, VTPS	> Th1(rpm,load) < Th2(rpm,load)	Engine coolant	> 81?		
Cam position sensor	P0340	Change in output voltage (ΔVcam) is monitored.	ΔVcam	0			Continuous	2 Driving cycles
Crank angle sensor	P0335	Change in output voltage (ΔVcrank) is monitored.	ΔVcrank	0	Cranking switch	on	Continuous	2 Driving cycles
		Patterns of the signal combinations of the crank angle sensor signal & cam position sensor signal are monitored every 2sec continuously.						

Sensor	Code	Description	Parameter	Condition	Parameter	Condition	Monitoring	Driving
Air flow sensor	P0102	Output voltage is monitored.	Output voltage, VAFS	< 1.055V	Engine speed	> 3000rpm	Continuous	2 Driving cycles
	P0103	Output voltage is monitored.	Output voltage, VAFS	≥ 4.5V	Engine speed	≤ 2000rpm		
					TPS	≤ 2V		
	P0101	Rationality Check	Output voltage, VAFS	0.957V ~ 1.055V	Cranking switch	on		
			ΔVAFS	≤ 0.039V				
			Load value	> Th1(rpm,tps)	Engine coolant	> 81?		
				< Th2(rpm,tps)	Intake air temp.	5 < AT < 45?		
Coolant temperature sensor	P0115	Resistance of sensor(Rcts) is monitored	Resistance, Rcts	< 50Ω or / ≥ 72kΩ	Time after start	> 60sec	Continuous	2 Driving cycles
	P0125	Time(Tfbi) from engine starting to the reaching engine coolant temp. of F/B on	Tfbi	>300sec@-8?	AFS voltage	> 1.7V	300sec after engine start	2 Driving cycles
				>110sec@20?	Engine coolant	≥ -10?		
				>60sec@82?	Air temperature	≥ -10?		
				>300sec@-8?	AFS voltage	≤ 1.7V		
				>200sec@20?	Engine coolant	≥ -10?		
				>60sec@82?	Air temperature	≥ -10?		
	P0116	Time(Tdf) is monitored (elapsed time under 40? after over 40? once)	Tdf	> 300sec			300sec Continuous	2 Driving cycles
		Temperature shifting is monitored	| Wtmax - Wtmin |	< 1?	Engine speed	> 1500rpm	300sec Continuous	
					Load value	> 25%		
					coolant at start	> 7?		
					Air temperature	< 60?		
Intake air temp. sensor	P0112	Resistance of sensor(Rats) is monitored	Resistance, Rats	< 0.09kΩ	Time after start	> 2sec	Continuous	2 Driving cycles
	P0113		Resistance, Rats	≥ 50kΩ				
Idle speed control	P0506	Real engine speed & target engine speed are monitored.	Real engine speed	< Target-100rpm	ISC Feedback	on	Continuous	2 Driving cycles
	P0507		Real engine speed	> Target+200rpm	Engine coolant	≥ 77?		

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Idle switch	P0510	Condition of idle switch is monitored.	Idle switch is not made "on" for at least once during 1 driving cycle		Engine speed	< 812rpm	Continuous	2 Driving cycles
Fuel injector	P0201	Surge voltage(Vinj) at injector drive is monitored.	Surge voltage, Vinj	< Vb + 2V Vb : Battery V	Engine speed	< 1000rpm	Continuous	2 Driving cycles
	P0202							
	P0203				TPS voltage	< 1.16V		
	P0204							
	P0205							
	P0206							
Air fuel ratio feedback (Bank 1)	P0134	O2 sensor staying time(TFB2) below or under the reference voltage to decide rich/lean is monitored.	Time, TFB2	> 15sec	Engine coolant	> 70?	15sec Continuous	2 Driving cycle
					Engine speed	1400~3000rpm		
					Load value	25% ~ 62%		
Air fuel ratio feedback (Bank 2)	P0154	O2 sensor staying time(TFB2) below or under the reference voltage to decide rich/lean is monitored.	Time, TFB2	> 15sec	Engine coolant	> 70?	15sec Continuous	2 Driving cycle
					Engine speed	1400~3000rpm		
					Load value	25% ~ 62%		
Power steering pressure switch	P1521	Signal of power steering pressure switch is monitored.	P/S pressure switch signal	on	Engine speed	> 2500rpm	Continuous	No MIL ON
					Load value	> 55%		
					Engine coolant	> 20?		
Manifold absolute pressure sensor	P0106	Output voltage(Vmap) is monitored.	Output voltage, Vmap	< 0.1V or > 4.6V	Engine coolant	> 45?	Continuous	2 Driving cycles
					Intake air temp.	> 5?		
					Load value	30% ~ 55%		
	P0108			> 4.2V	Load value	< 30%		
	P0107			< 1.8V	Load value	> 70%		
Knock sensor	P0325	Signal at current segment is compared to previous one.	Amount of change	< 0.06V	Time after start	> 2sec	Continuous	No MIL ON
					Engine speed	≥ 2500rpm		
					Load value	≥ 30%		

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Thermostat	P0128	After given time (function or mass air flow, vehicle speed, engine speed) has elapsed, engine coolant temperature is monitored.	Engine coolant temperature after given time has elapsed.	< 77?	Engine coolant at start	5? ~ 60?	10~30min. depending on mass air flow, vehicle speed, engine speed	2 Driving cycles
					Intake air temp. decrease after start	< 5?		
					Engine coolant at start - intake air temp. at start	< 10?		
Battery backup line	P0560	VB backup voltage is monitored.	VB backup voltage	< 2V	Battery voltage	≥ 10V	Continuous	1 Driving cycle
					Duration	10sec		
Ignition coil	P0350	Current through ignition coil is monitored.	No current of 1 or 2 IG coil group at the 3 IG coil group	During 48 ignitions	Engine speed	< 4000rpm	Continuous	2 Driving cycle
Ignition failure sensor	P0320	Current through ignition coil is monitored.	No current at the 3 IG coil group	During 32 ignitions	Engine speed	< 4000rpm	Continuous	No MIL ON

Sirius2-Engine

Contents

- General Description

- Engine Feature

- Timing Belt

- Engine Tightening Torque

- ECM Overview

- ECM Input/Output

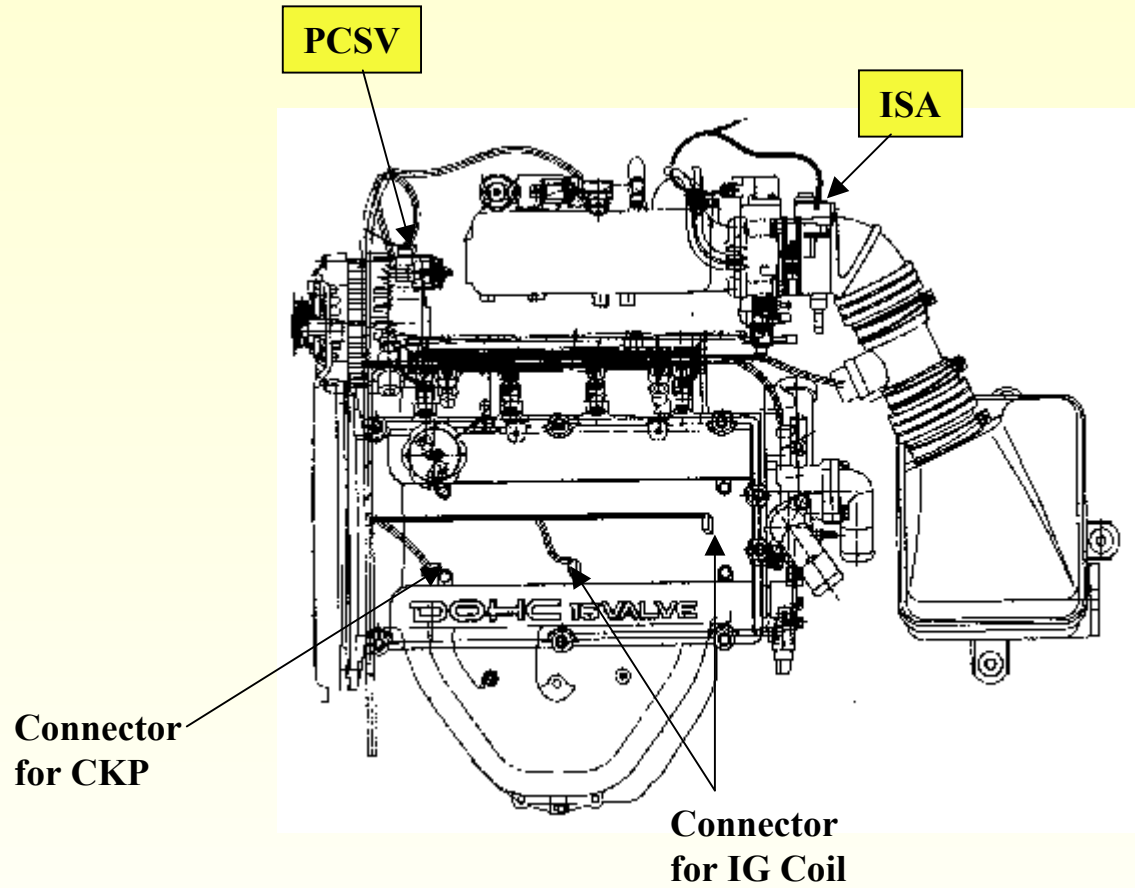**KIA MOTORS**

■ Sirius2 Engine

The Sirius2 engine is In-line 4 Cylinder DOHC engine adopted aluminium oil pan, inlet type cooling system, DLI type ignition coil integrated Power Transistor, and a ignition failure sensor added to detect ignition problems to increase serviceability.

Also, hall type CKP and CMP sensors are installed. This engine incorporates only one timing belt.

The Sirius2 engine is designed by Mitsubishi Motor company and manufactured by Hyundai Motor Company.

Item	Sirius Ⅱ 2.4 DOHC
Capacity(cc)	2351
Engine type	In line 4 cylinder MPI DOHC
Bore× Stroke	86.5 × 100
Compression ratio	10:01
Max. Power(PS/RPM)	140/5500
Max. Torque(Kgm/RPM)	20.2/3000
Ignition Timing	BTDC 5˚ ± 2˚
Idle RPM	800± 50RPM
Valve Clearance	0(HLA)
Fuel Pressure(Kg/㎠)	3.06
Ignition Order	1→ 3→ 4→ 2

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■ Top View

PCSV

ISA

Connector
for CKP

Connector
for IG Coil

■ Timing Belt

CAMSHAFT
SPROCKET

6~8 mm

AUTO
TENSIONER

CRANKSHAFT
SPROCKET

OIL PUMP SPROCKET

1. ALIGN TIMING MARKS

2. INSTALL TIMING BELT

3. REMOVE SET'G PIN

4. TURN THE CRANK-
   SHAFT SPROCKET
   2 REVOLUTION

5. CHECK THE CLEARANCE
   OF AUTO TENSIONER

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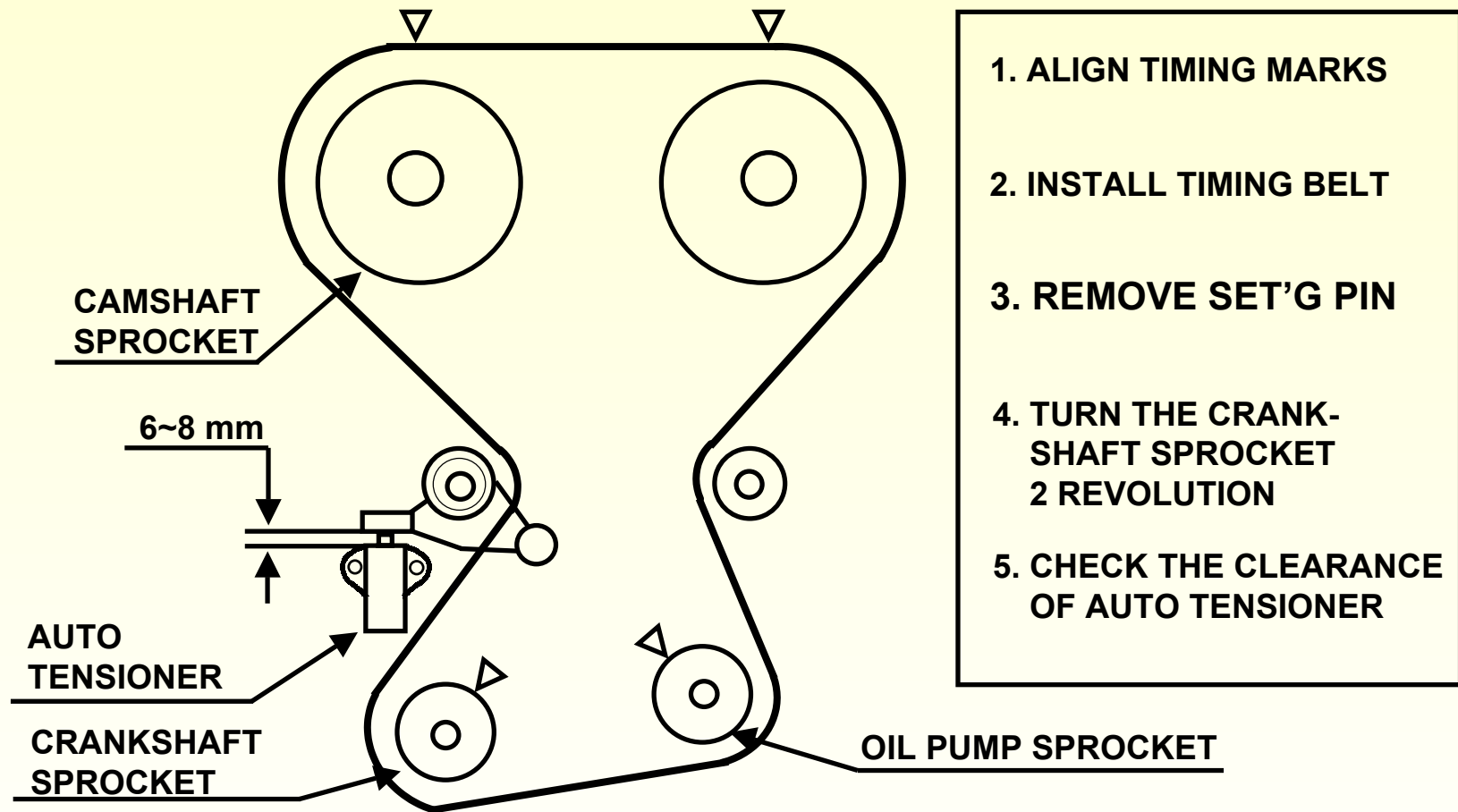
■ **Tightening Torque**

CAMSHAFT BEARING CAP: 19~21Nm

CONNECTING ROD BEARING CAP BOLT: 18~22Nm + 90~94°

MAIN BEARING CAP BOLT: 25Nm + 90~94°

CYLINDER HEAD BOLT:
       OVERHAUL WITHOUT REPLACE:
           20N.m + 90~94° + 90~94°
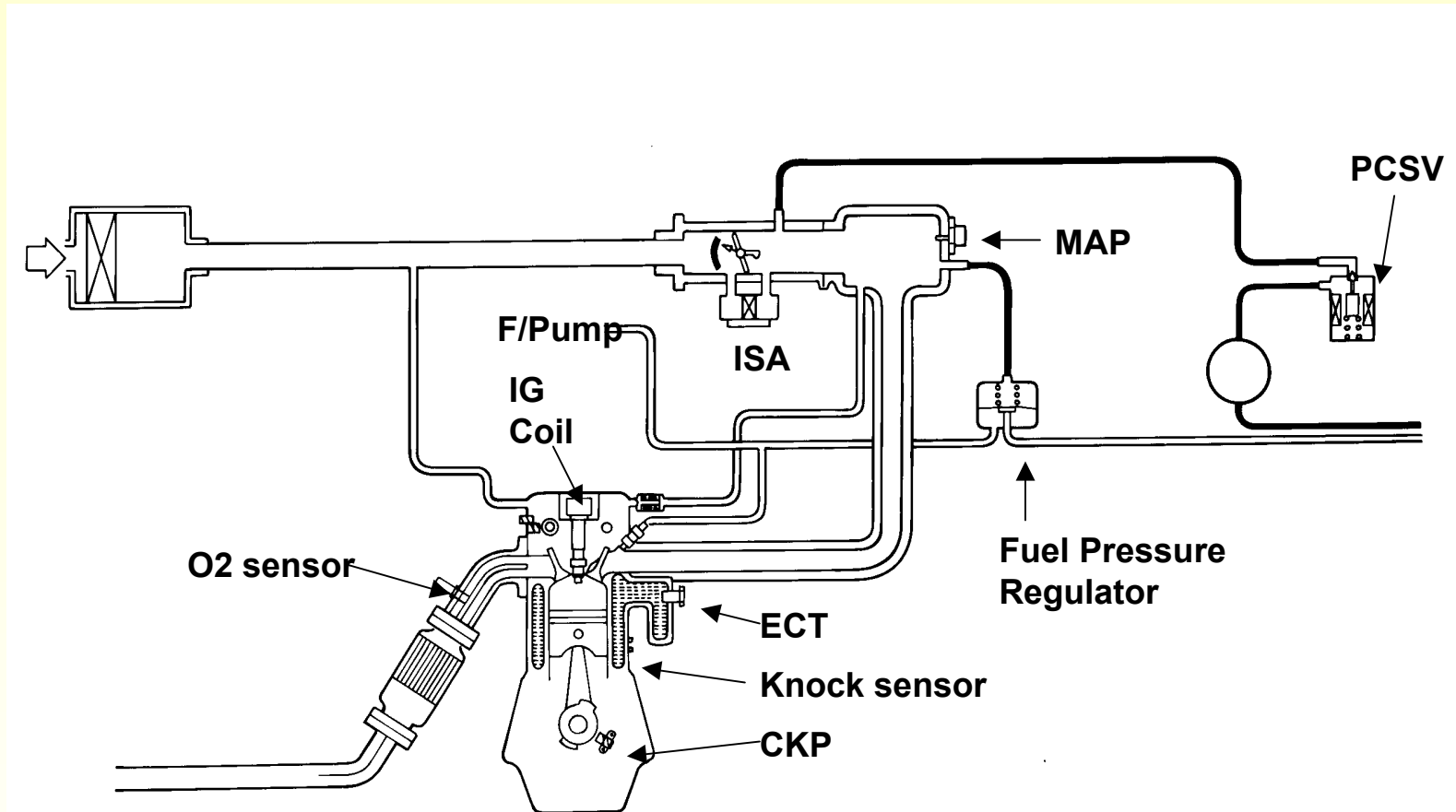   REPLACE GASKET:
           80N.m, LOOSE, 20N.m + 90~94° + 90~94°
       REPLACE HEAD BOLT:
           20N.m + 180~184° , LOOSE, 20N.m + 90~94° + 90~94°

■ **ECM Overview**

■ **ECM Input/Output**

Inputs	ECM	Outputs
MAP	**ECM MELCO**	Fuel control
Oxygen sensor		Ignition control
CKP		Knocking control
CMP		Idle speed control
ECT		Purge control
IAT		Cooling fan control
Knock sensor		A/C COMP.control
VSS		C/Relay control
Various switches		Alt. current control

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