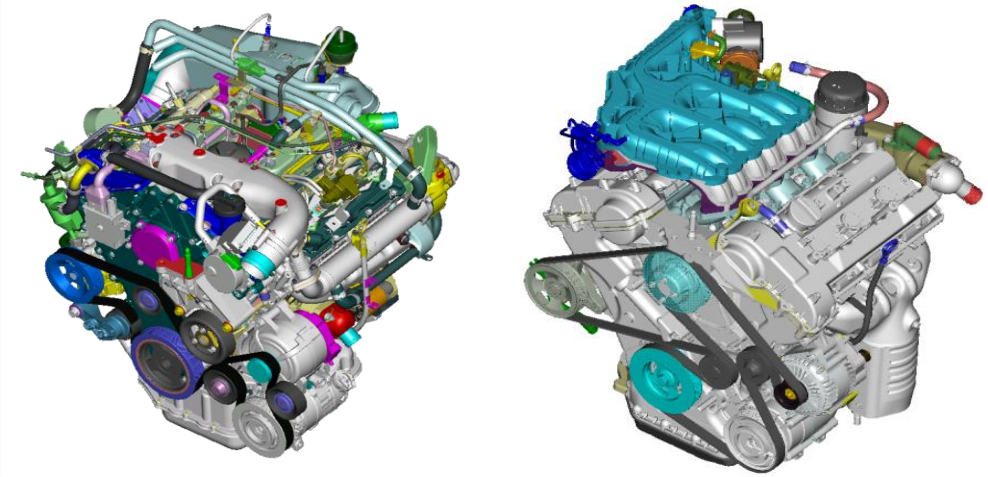
EN Engine

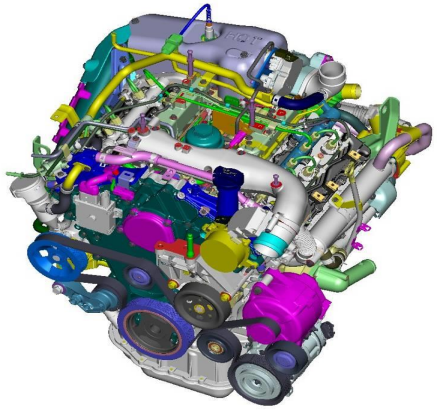
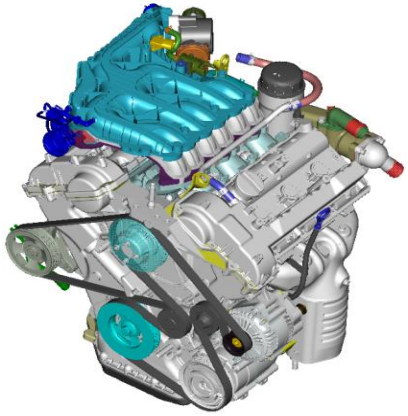


Power Train Variation

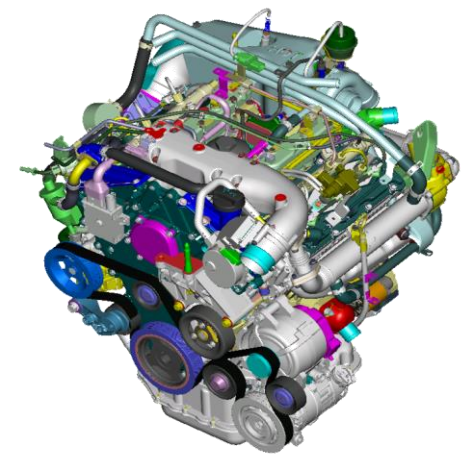
Engine		A/T	NAS	MES	GEN		
					Others	China	Chile
Lambda 3.8L		F21-450 (AISIN)	●	●	●	●	●
S-3.0 V6 VGT	EURO-2		-	-	●	-	-
	EURO-3		-	-	-	●	-
	EURO-4		-	-	-	-	●

3.0 L V6 Common rail diesel engine (S-engine) and 3.8 L V6 gasoline engine (Lambda) are used for EN. S-engine is the first used in HMC and Lambda engine is already used for NF, TG, CM.

Engine Line-Up

Item		S- V6 3.0 L	Lambda V6 3.8 L
Fuel Injection type		CRDi (1600bar)	MPI
Displacement		2,959	3,778
Bore x Stroke (mm)		84 x 89	96 x 87
Timing system		Chain	Chain
Performance	Output max.	233 ps	260 ps
	Torque max.	45kgfm	35kgfm
Appearance			

S-3.0 V6 E-VGT CRDi Diesel Engine

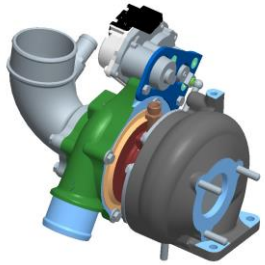


Specification

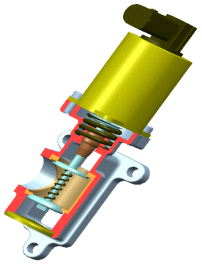
Item	Specification	Item	Specification
Replacement (cc)	2,959	Glow system	ISS (Instant Starting System)
Bore X Stroke	84 x 89	Injection order	1-2-3-4-5-6
Compression ratio	17.8	Fuel Injection type	CRDi(1,600 bar)
Max power (Ps/RPM)	238/4,000	Fuel pressure control	Inlet & Outlet
Max Torque (kgfm/RPM)	45/2,000	Injection type	Pilot 2, Pilot 1, Main
Idle rpm	750	Injector type	Piezo Injector
Max rpm	4800	EMS	EDC16CP (for piezo injector)

Main Feature

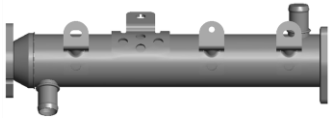
Items	Performance/ Fuel Economy	Emission	NVH	Durability	Starting
Compacted Graphite Iron (CGI)	●	●	●		
Electronic VGT	●	●			
Electronic E.G.R		●	●		
EGR Cooler		●			
Instant Starting System (ISS)		●			●
Variable Intake System	●	●			
Lambda Sensor		●			
Serpentine Belt			●	●	
Timing Chain				●	



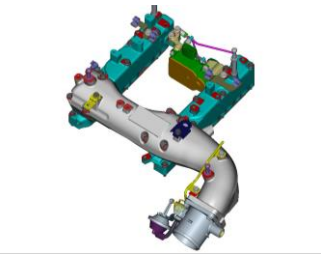
Electronic VGT



Electronic E.G.R



EGR Cooler



Variable Intake System

Timing Chain

Main Feature

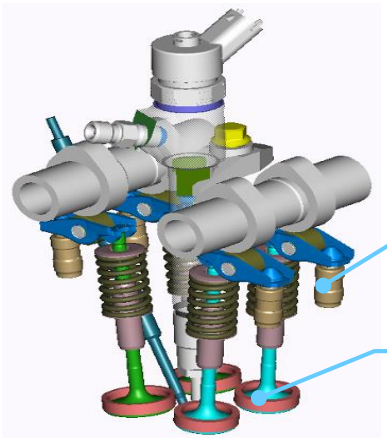
WCC

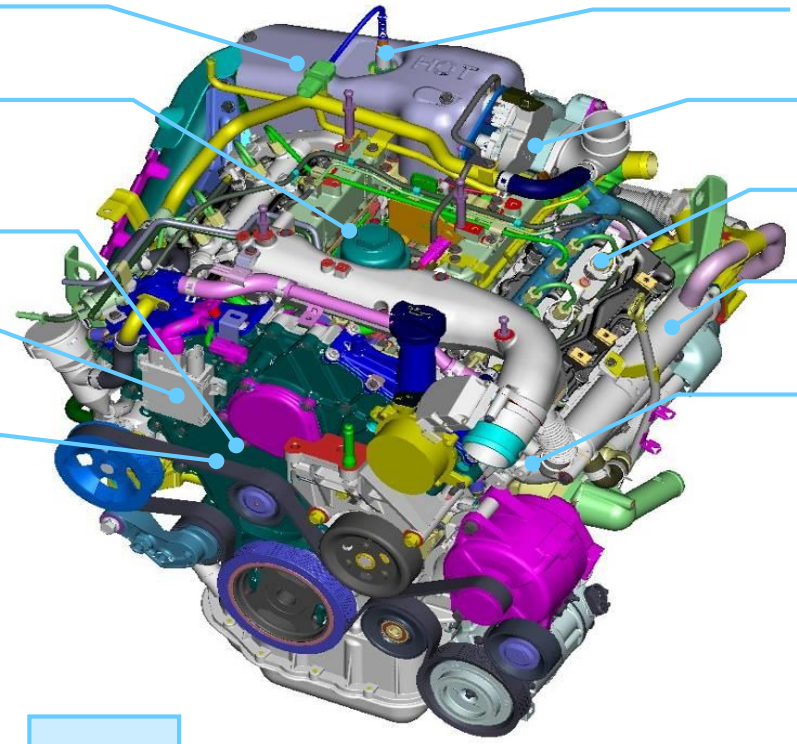
Swirl Control Valve (EURO-3/4)

Timing Chain

I.S.S

Serpentine Belt





Lambda Sensor(EUR3/4)

Electronic VGT

Piezo Injector

Electronic E.G.R

CGI Cylinder Block

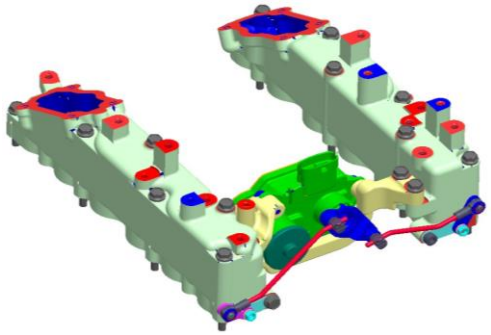
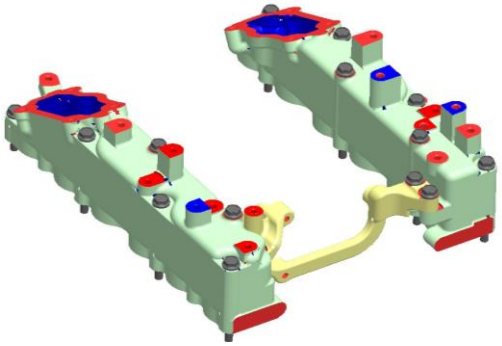
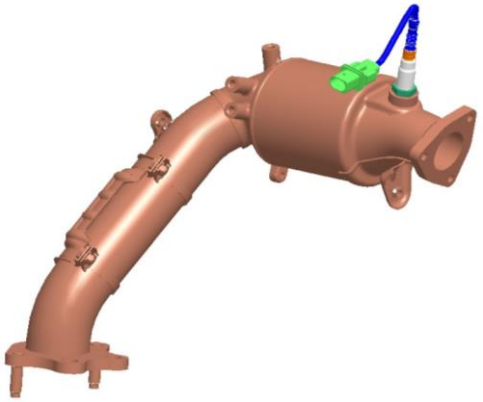
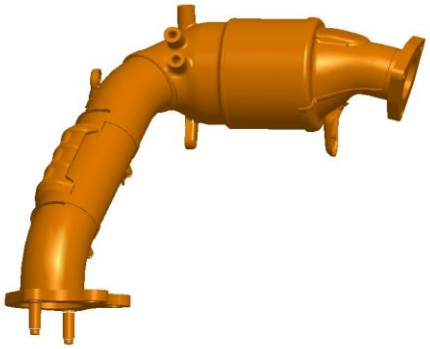
HLA

4 Valve DOHC

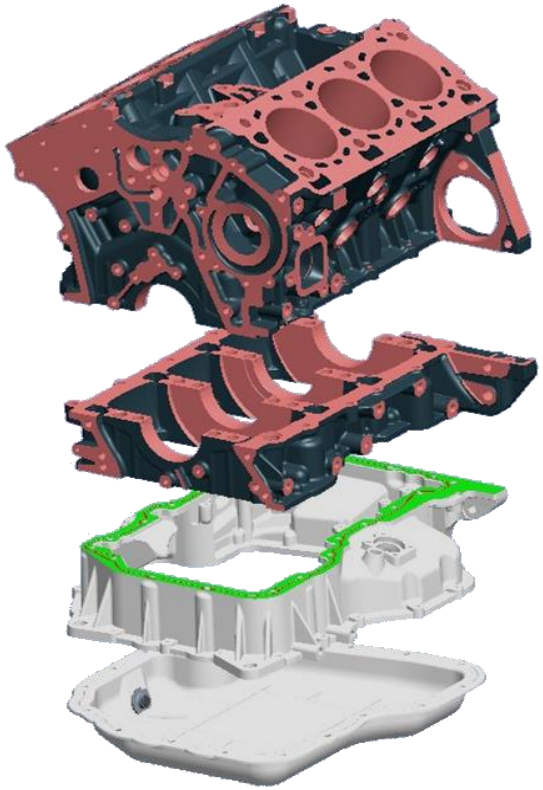
EDC16CP 32Bit (Piezo injector)

- ISS : Instant Starting System
- CGI : Compacted Graphite Iron
- WCC : Warm-up Catalytic Converter

EURO-2 vs. EURO-4

Item	Removed Parts	EURO-4	EURO-2
IN-MANI, LWR	Swirl control valve actuator & valve linkage		
WCC	Lambda sensor		

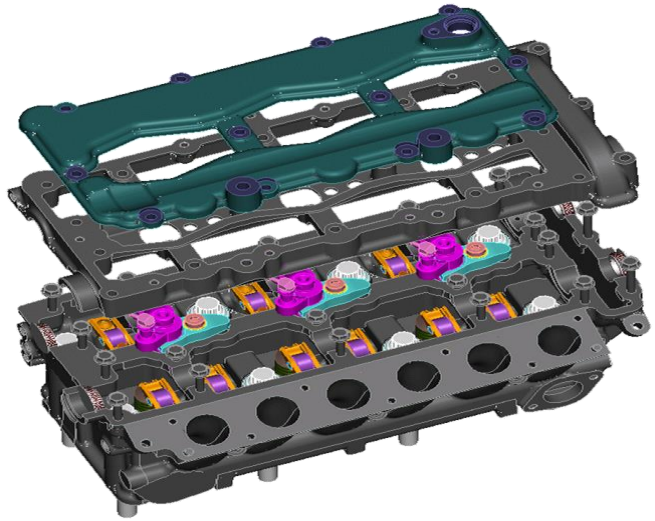
Cylinder Block

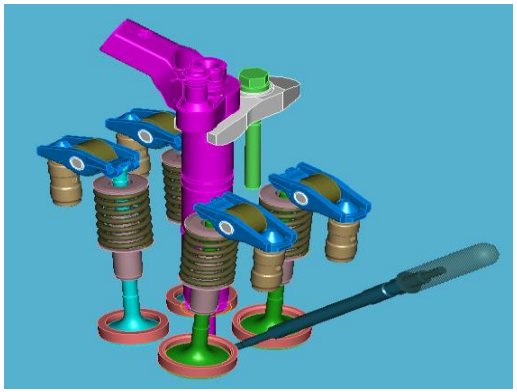
Item	Features	
Cylinder Block	• CGI (Compacted Graphite Iron) - Purpose : Engine power up & reduce CO2 level by Increasing max. combustion pressure (190bar) - Benefit : Reduced weight (10%) and engine length	
Bed Plate	-Improved NVH & durability -When replacing cylinder block, the bed plate should be replaced together (Bearing cap integrated)	
Upper Oil Pan	- Aluminum : Improved NVH	
Lower Oil Pan	- Steel plate	

Cylinder Block

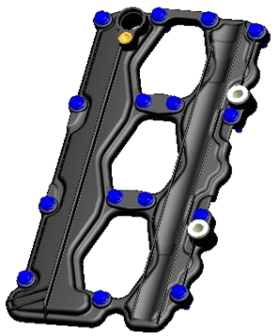
- Aluminum cylinder head
- V6, 4 valves DOHC
- Applied plastic head cover : weight is reduced
- Integrated cam cap (ladder type) : improved NVH
- Left and Right cylinder head gasket are different (3 grade gasket)
- Cylinder head bolt tightening torque :

  6.0kgf-m + 90˚ + 120˚

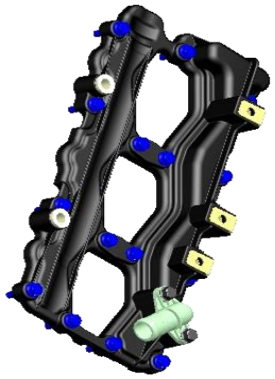




[Intake & Exhaust valve]



[Plastic cover (RH)]



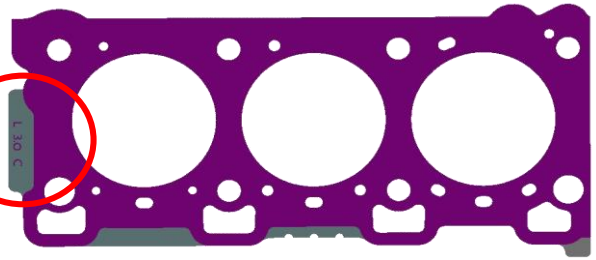
[Plastic cover (LH)]

Cylinder Head

L: LH, R: RH

Grade (A, B, C)

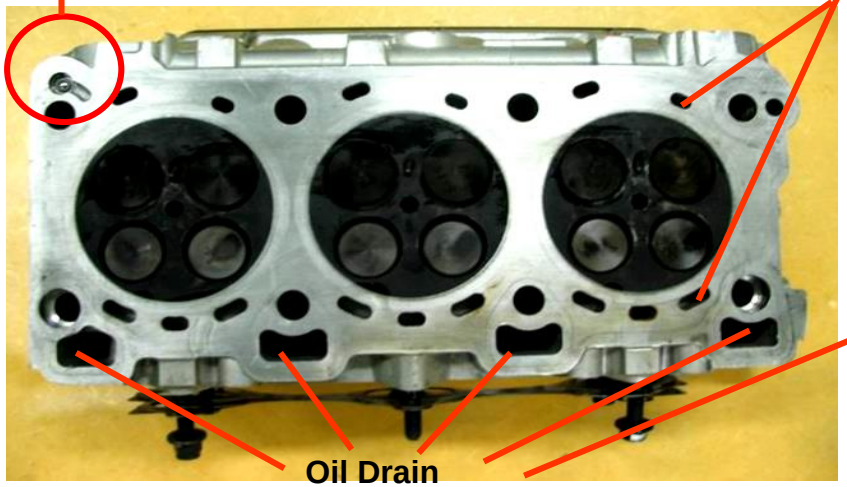
Engine displacement



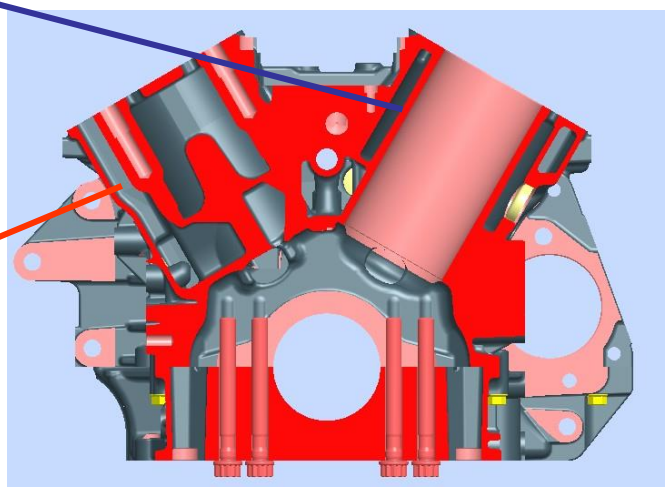
[Cylinder head gasket]

Lubrication hole for camshaft

Water Jacket

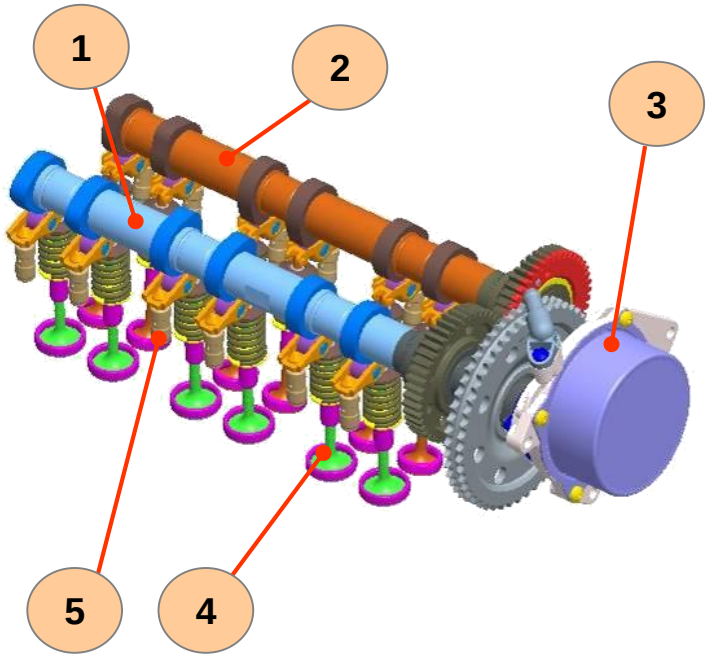


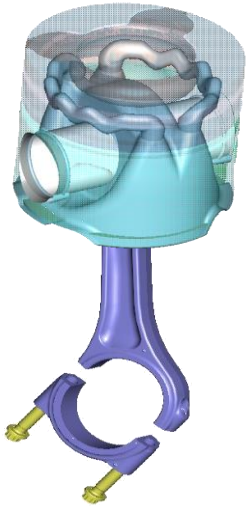
Oil Drain



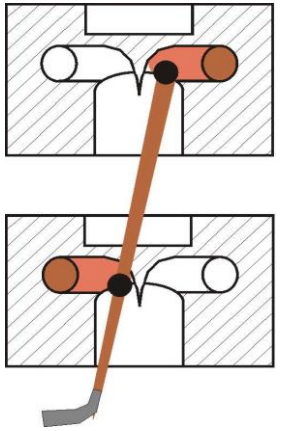
Moving System

- 4 Valve DOHC
- Hollow type camshaft
- Low-tension type piston ring
- Piston double wave cooling gallery and oil jet





Component of valve train

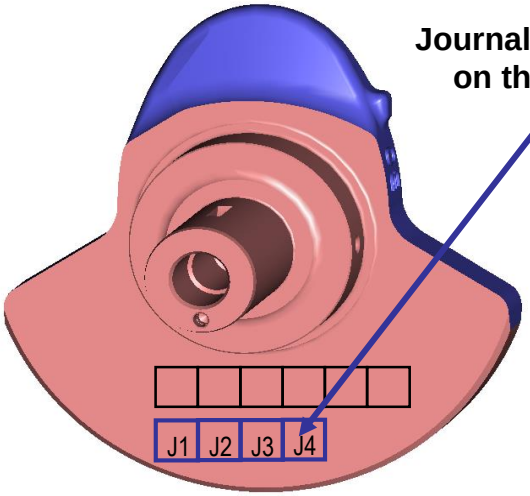


Oil Jet

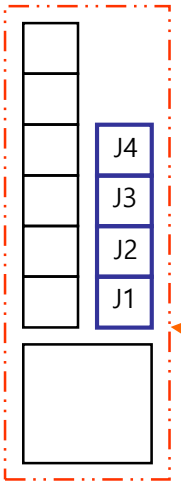
NO	component	Remarks
1	In. camshaft	Hollow type
2	Ex. Camshaft	
3	Vacuum pump	Capa : 260cc/rev
4	Valve	Dia. of valve: Φ6
5	HLA	

Main bearing size

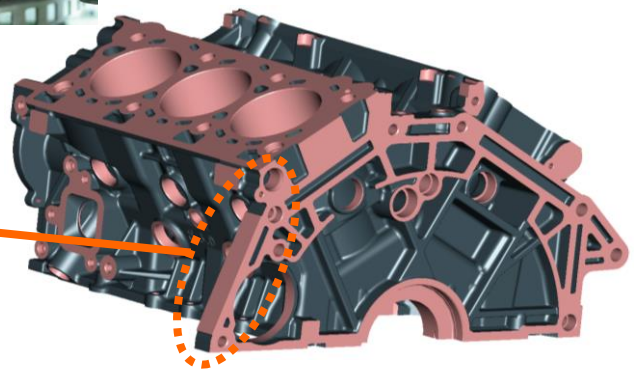
Crankshaft diameter	Bore size	Main bearing (Color)	Oil Clearance
A	A	E (Green)	0.030~0.048
	B	D (Yellow)	
	C	C (No mark)	
B	A	D (Yellow)	
	B	C (No mark)	
	C	B (Blue)	
C	A	C (No mark)	
	B	B (Blue)	
	C	A (Red)	



Journal diameter mark on the crankshaft



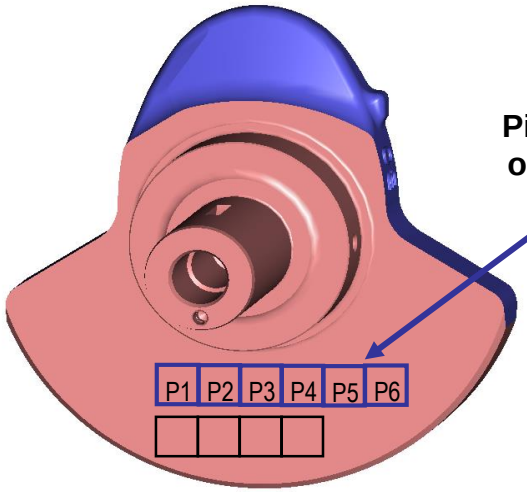
Journal diameter mark on the cylinder block



Connecting rod bearing size

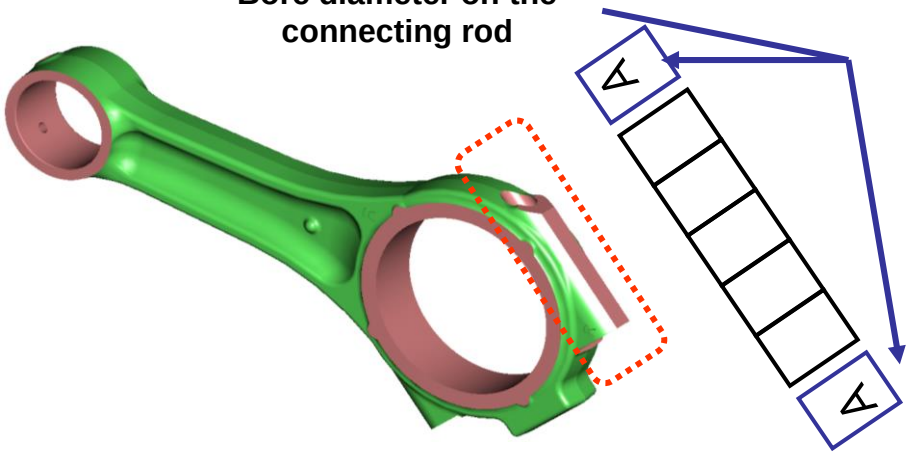
(Lower connecting rod bearing is one size)

Crankshaft diameter	Bore size	Bearing (Color)	Oil Clearance
A	A	C (Red)	0.024~0.050
	B	C (Red)	0.030 ~0.056
	C	B (Yellow)	0.026 ~0.052
B	A	C (Red)	0.030 ~0.056
	B	B (Yellow)	0.026 ~0.052
	C	B (Yellow)	0.032 ~0.058
C	A	B (Yellow)	0.026 ~0.052
	B	B (Yellow)	0.032 ~0.058
	C	A (Blue)	0.028 ~0.054



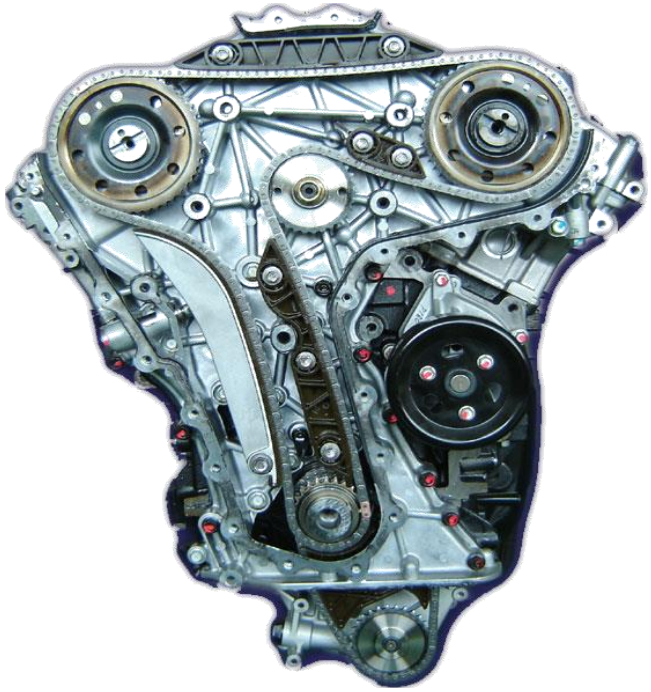
Pin diameter mark on the crankshaft

Bore diameter on the connecting rod



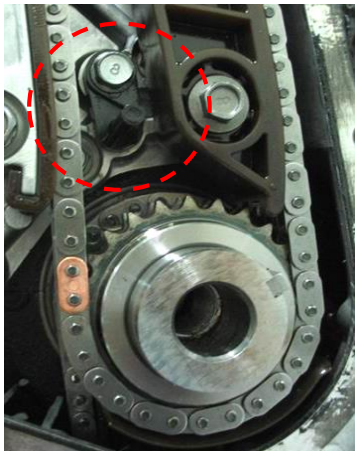
Timing System

- **Duplex bush timing chain** is used for S-engine.
- **Exhaust camshaft** is operated by scissors gears.
- **Hydraulic auto-tensioner** is used for timing chain.
- **Oil jet** is used for timing chain lubrication.
- **Mechanical type tensioner** is used for oil pump chain.



[Duplex bush chain]

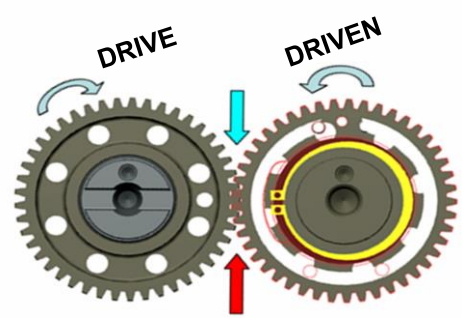
[Scissors gear]

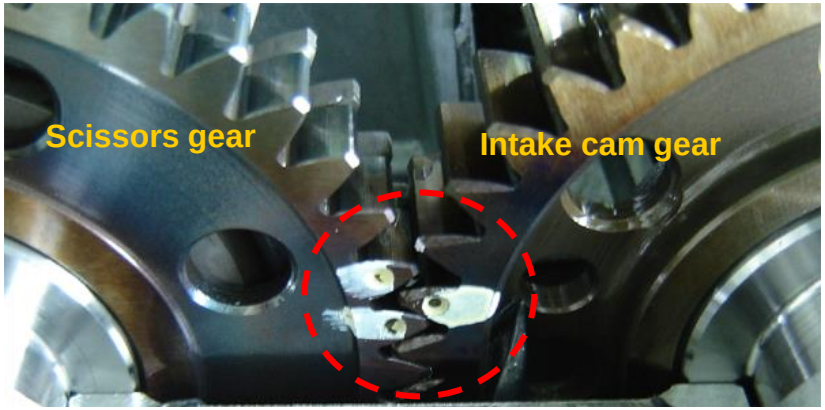


[Oil jet]

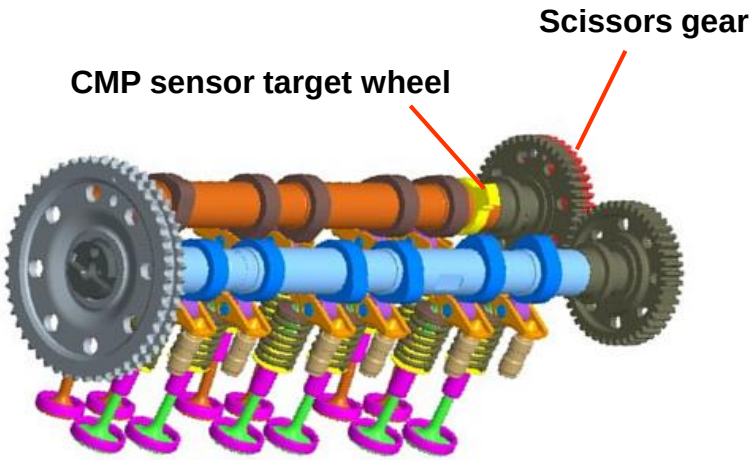
Scissors gear

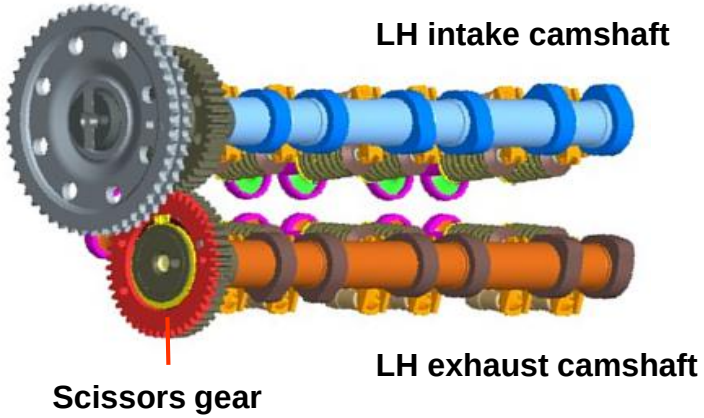
- Purpose : Little noise reduction
- It does not affect engine performance





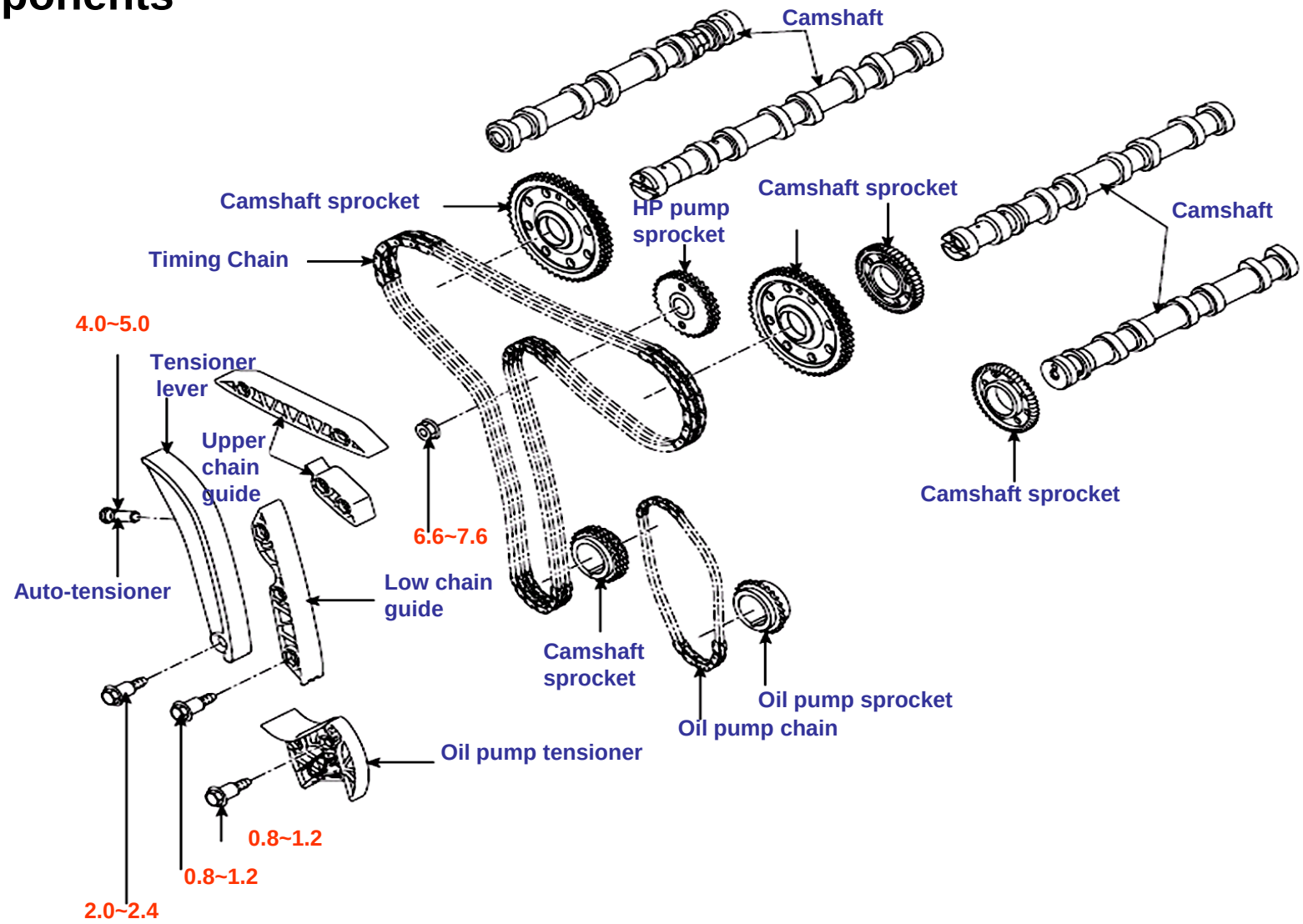
[Timing Mark]





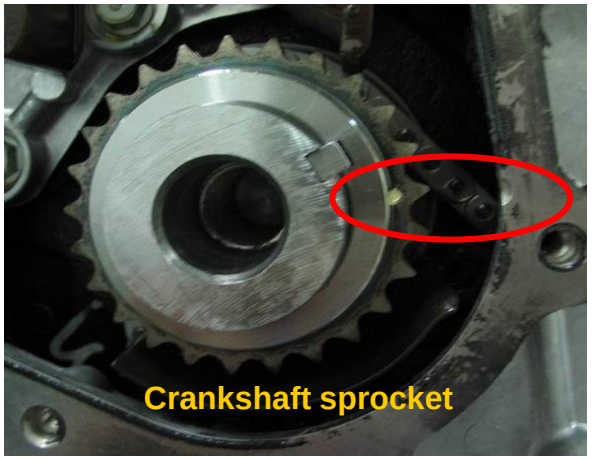
Timing Chain Installation

Components



Timing Chain Installation

Preparation



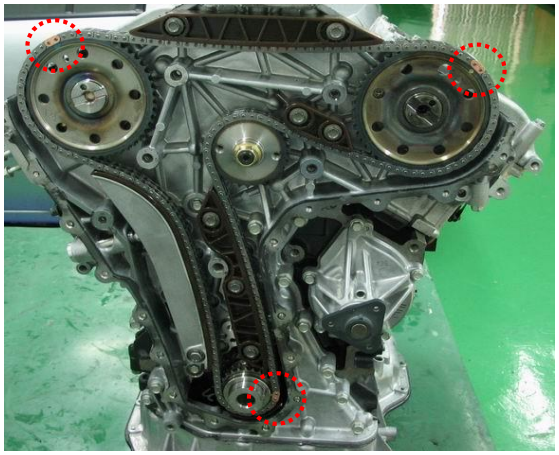
1. **Install the camshaft locking tools (09231-3A000).**
2. **Align the crankshaft timing position.**
3. **Install the upper & lower chain guides.**

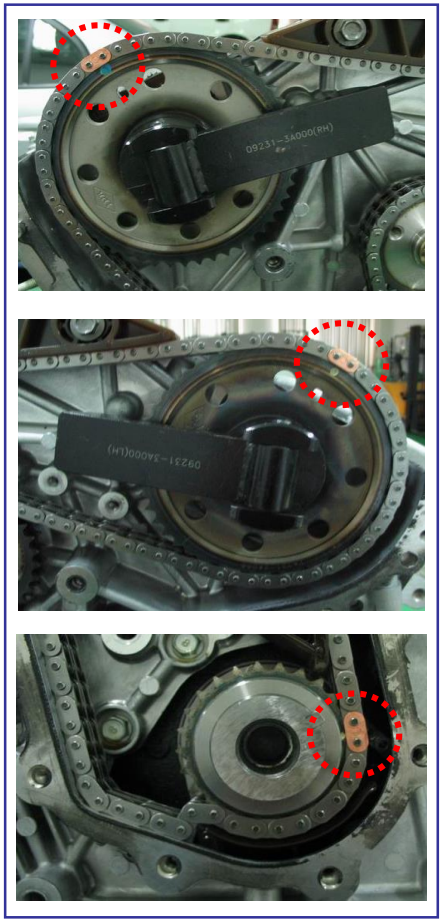
[Camshaft locking tool (09231-3A000)]

* This tool has two components with different size. One for LH sprocket (smaller), the other for RH sprocket (bigger).

Timing Chain Installation

Installation

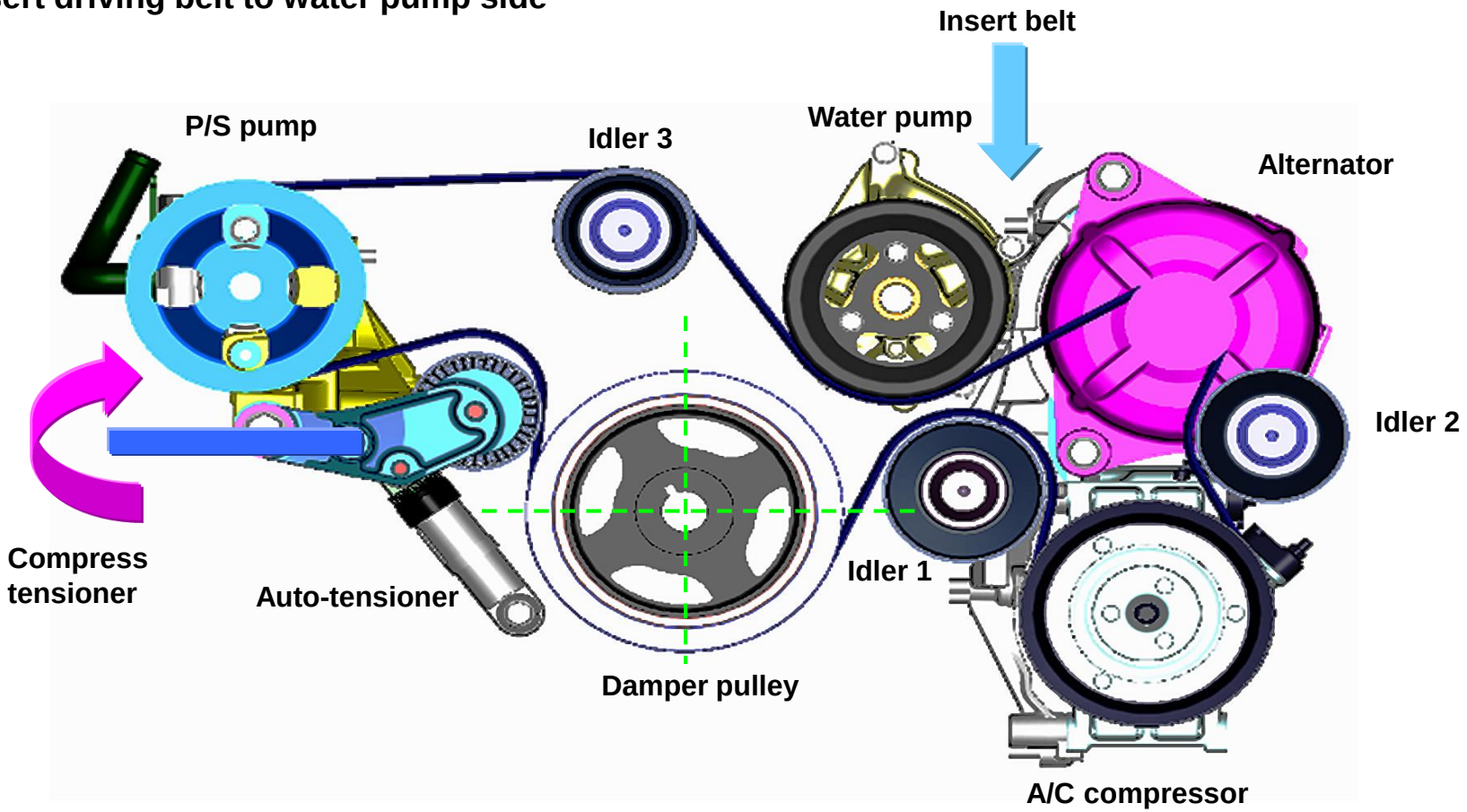




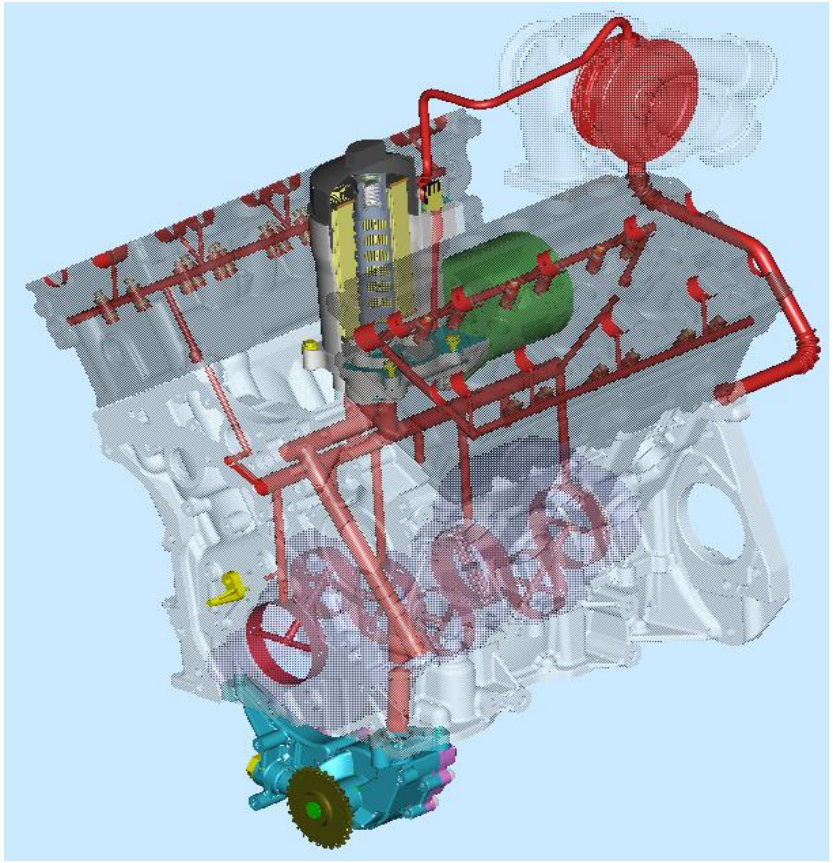
1. **Install the timing chain and aligns timing mark on the sprocket.**
   [Caution] The yellow color on the timing chain are for new part. However the color can be erased with mileage. Therefore ‘O’ mark can be used instead.
2. **Install the tensioner lever.**
3. **Install the hydraulic auto-tensioner.**
4. **Remove the sprocket locking tools.**

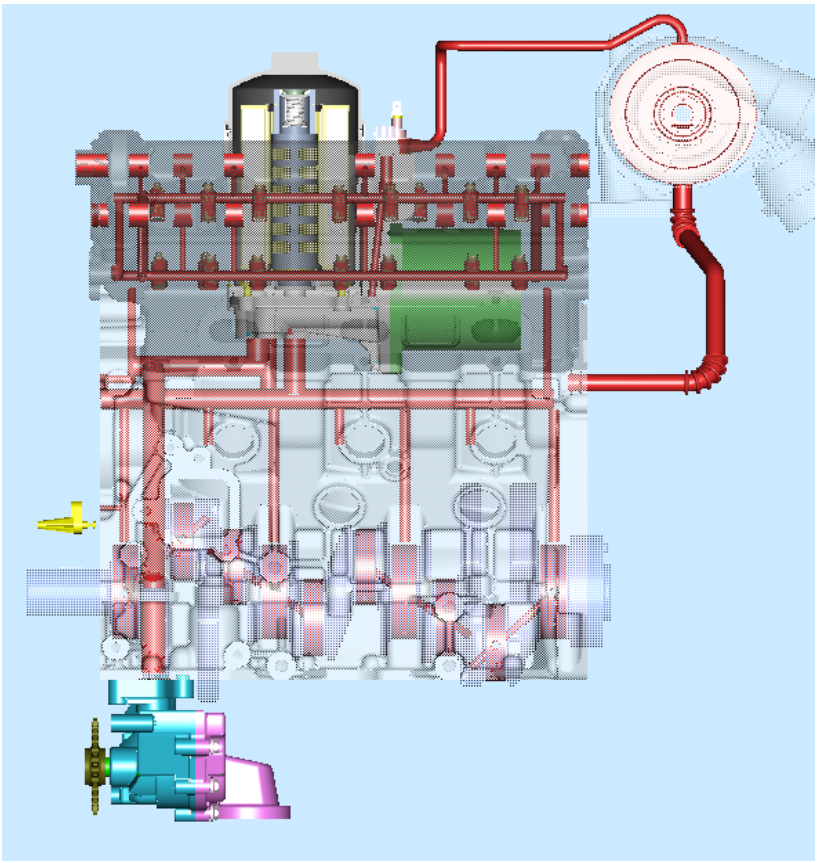
Driving Belt

- Serpentine belt
- Compress auto-tensioner (turn to clockwise)
- Insert driving belt to water pump side

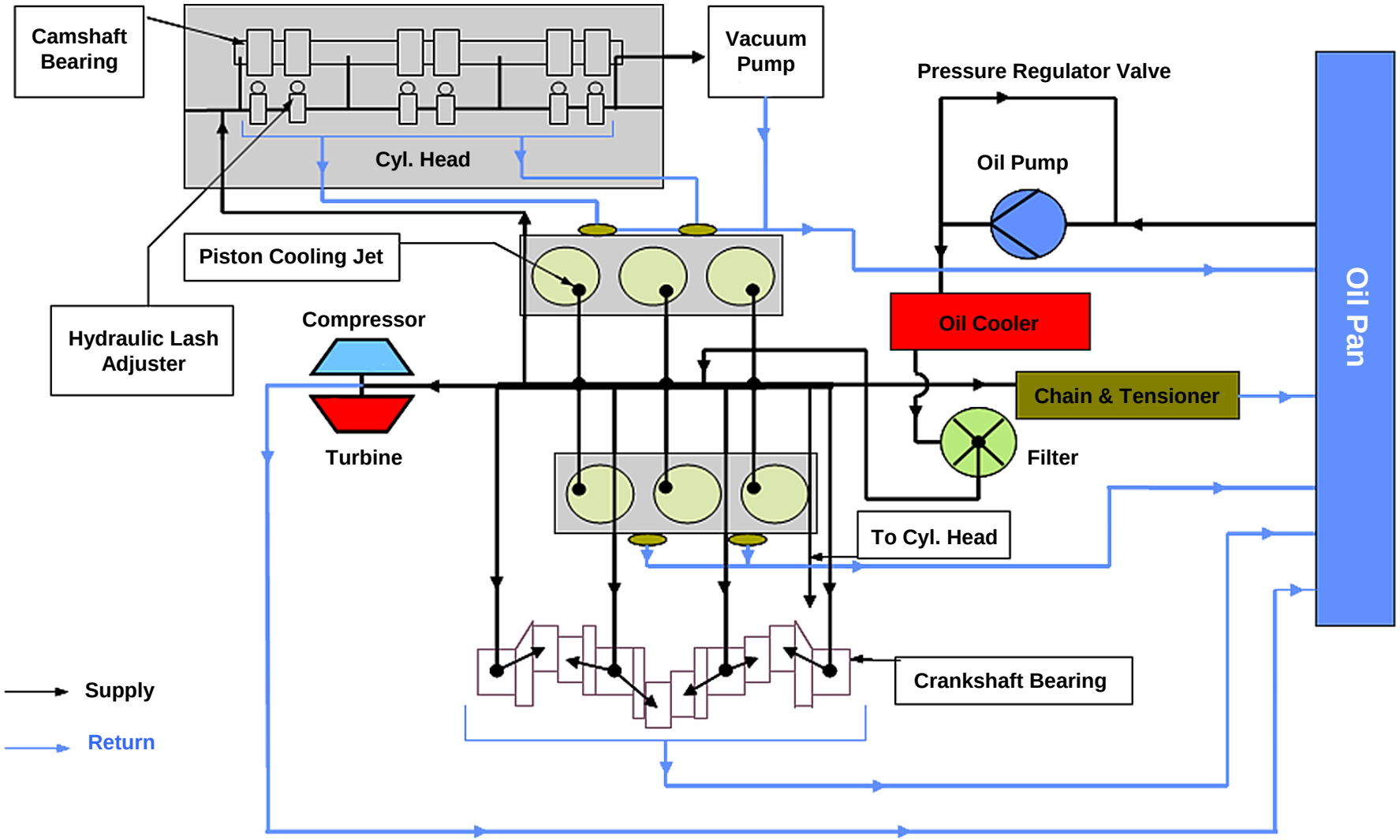


Oil gallery



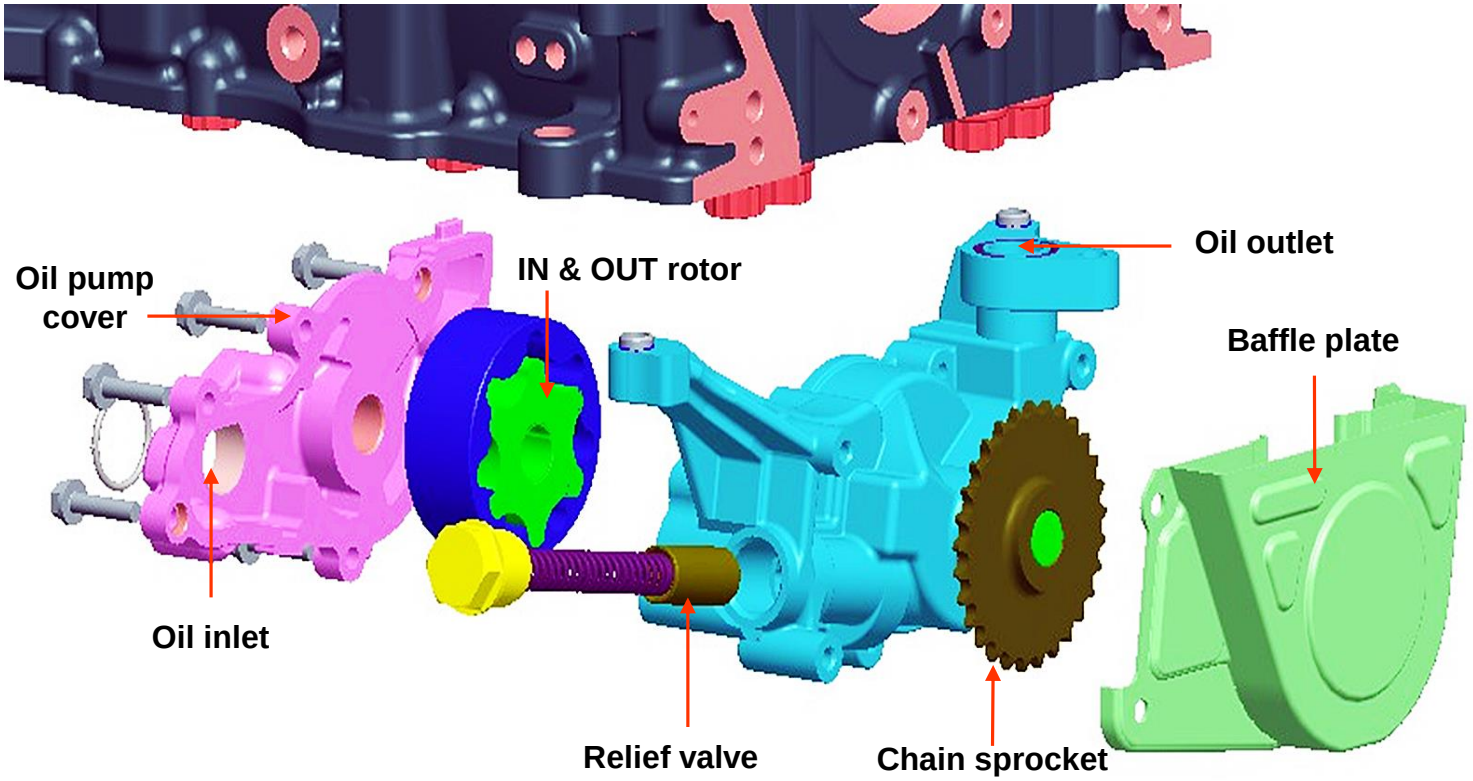


Oil supply circuit

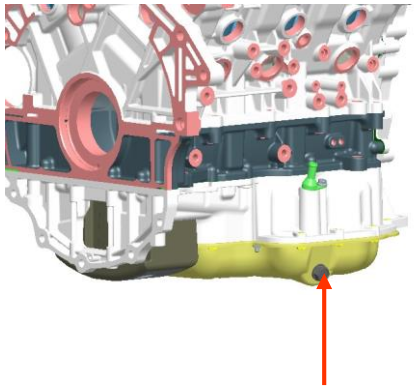


Oil pump

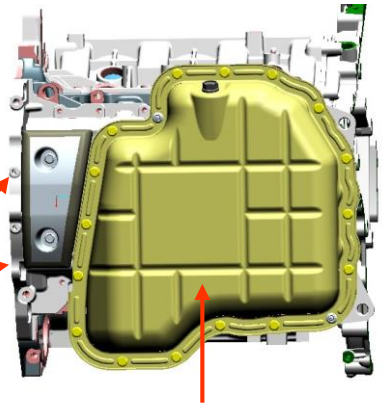
- Oil pump : Rotary type
- Relief pressure : 5.8 ± 0.5bar



Oil pump replacement

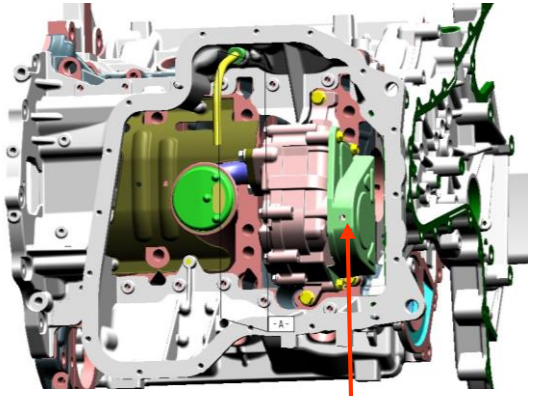


Oil drain plug

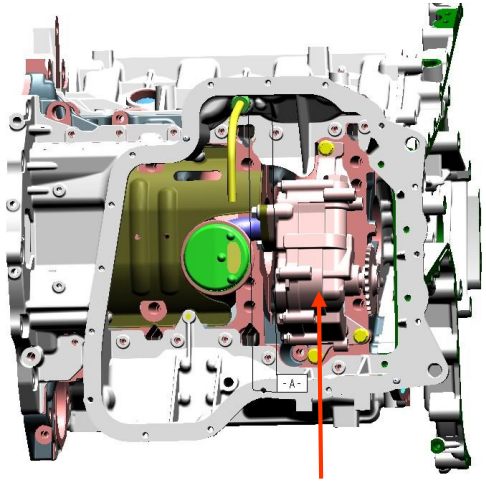


Acoustic shield cover

Lower oil pan



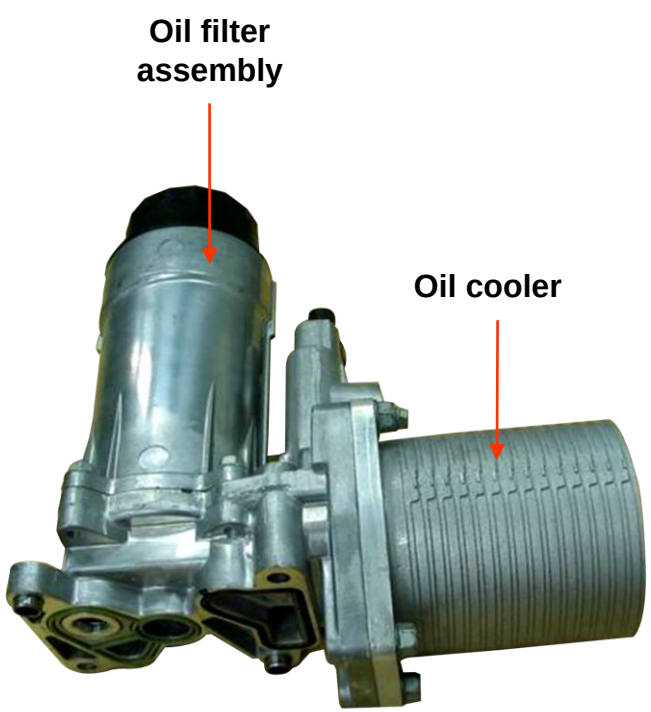
Baffle plate

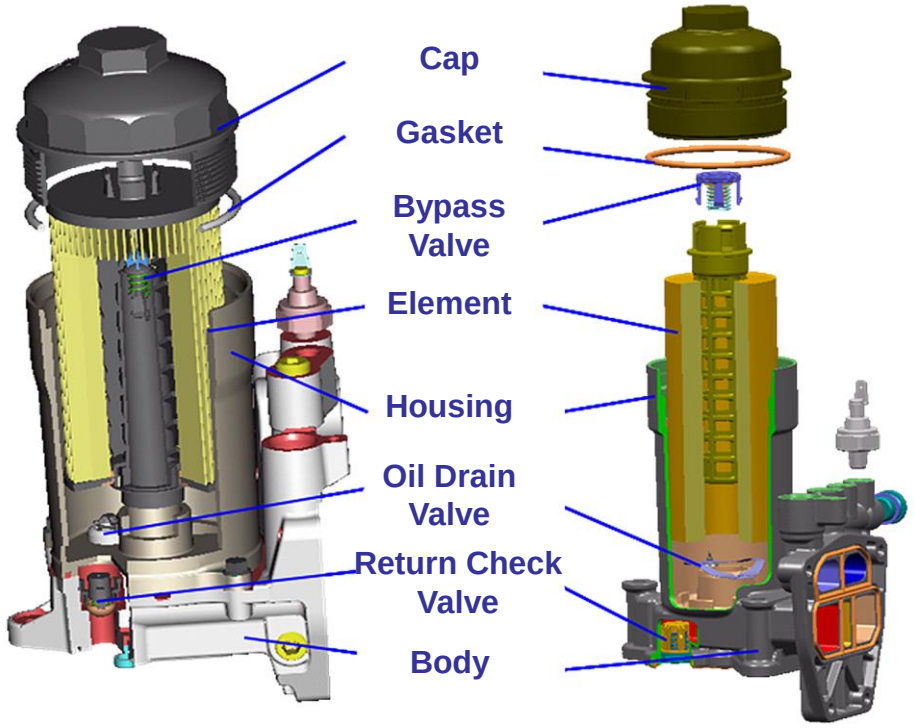


Oil pump

- Remove the oil drain plug.
- Remove the acoustic shield cover.
- Remove the lower oil pan.
- Remove the baffle plate.
- Remove the oil pump.

Oil filter assembly

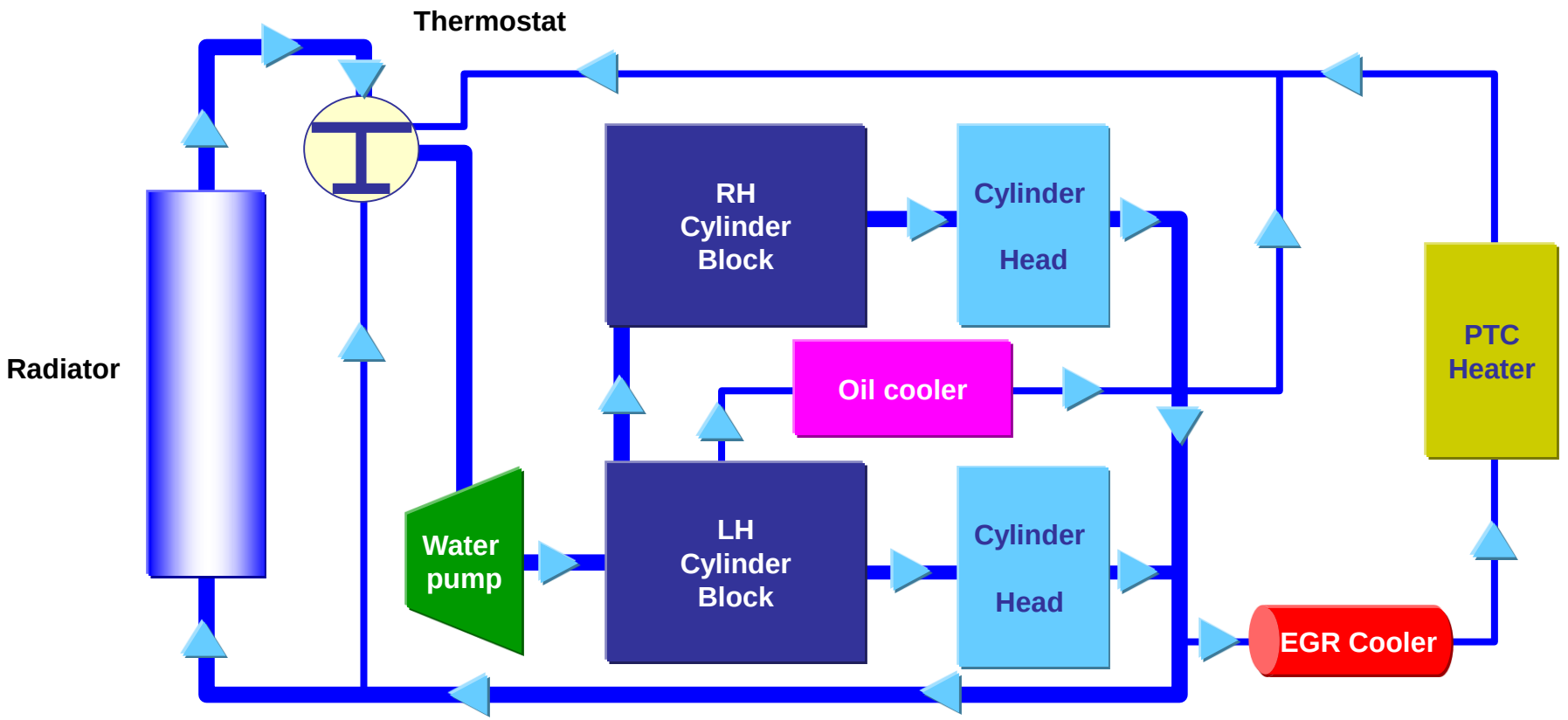




Oil filter replacement

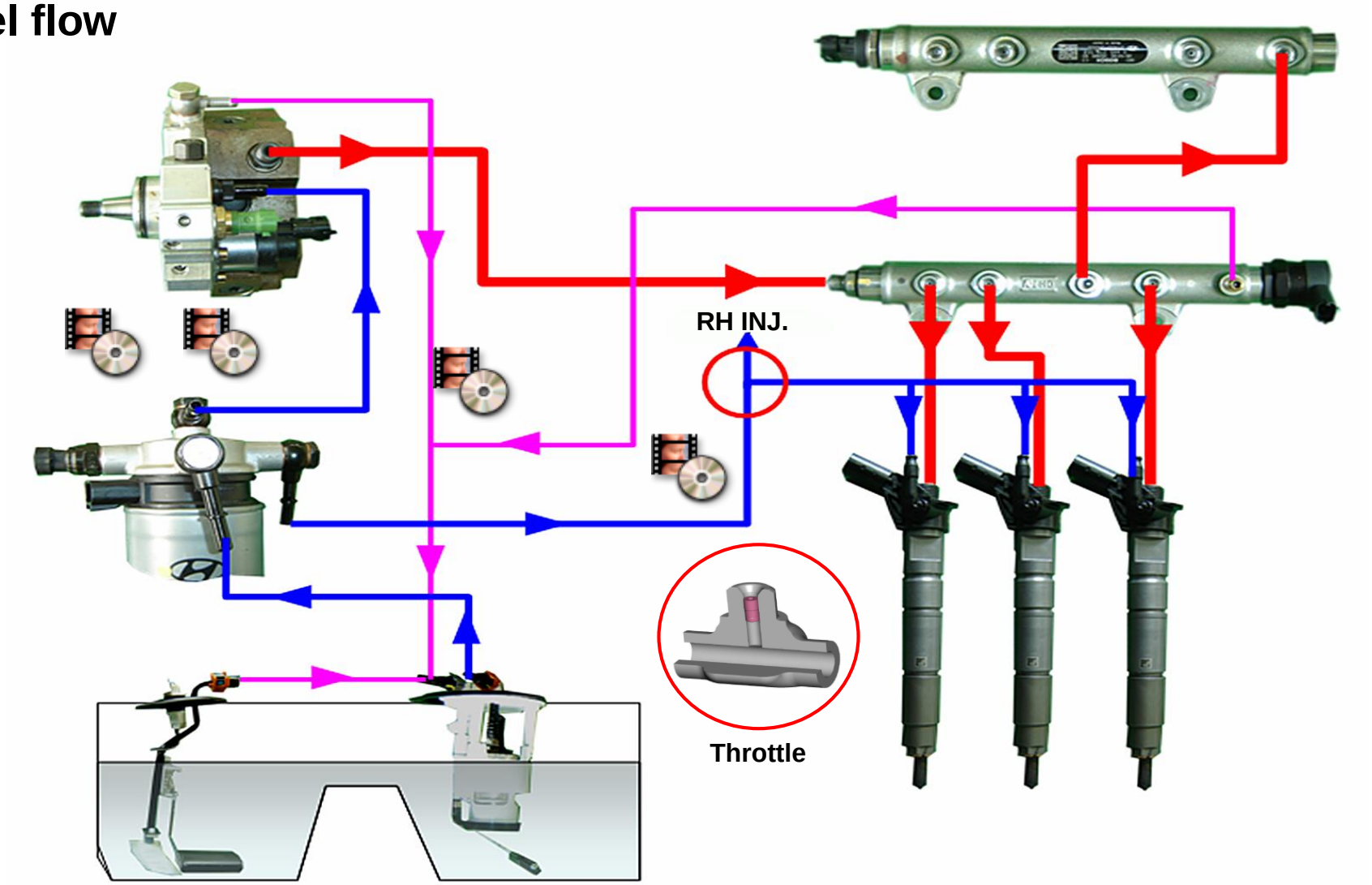
- Remove the Oil filter cap with a 32mm wrench.
- Move up the cap and hold it for oil drain.
- Replace the filter element service kit.
- Install oil filter cap. (Torque: 2.5kgfm)

Cooling System



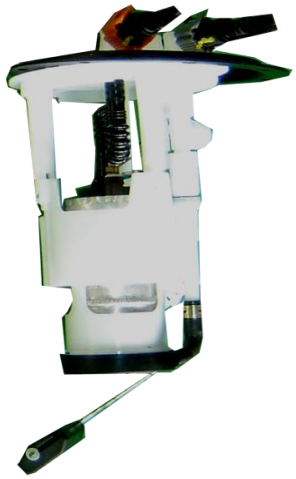
Coolant capacity	5ℓ	**Thermostat fully open temp.**	95℃
Thermostat type	Wax pallet type	**Control type**	Inlet control
Thermostat opening temp.	82℃	**Cooling fan control**	LOW,HIGH

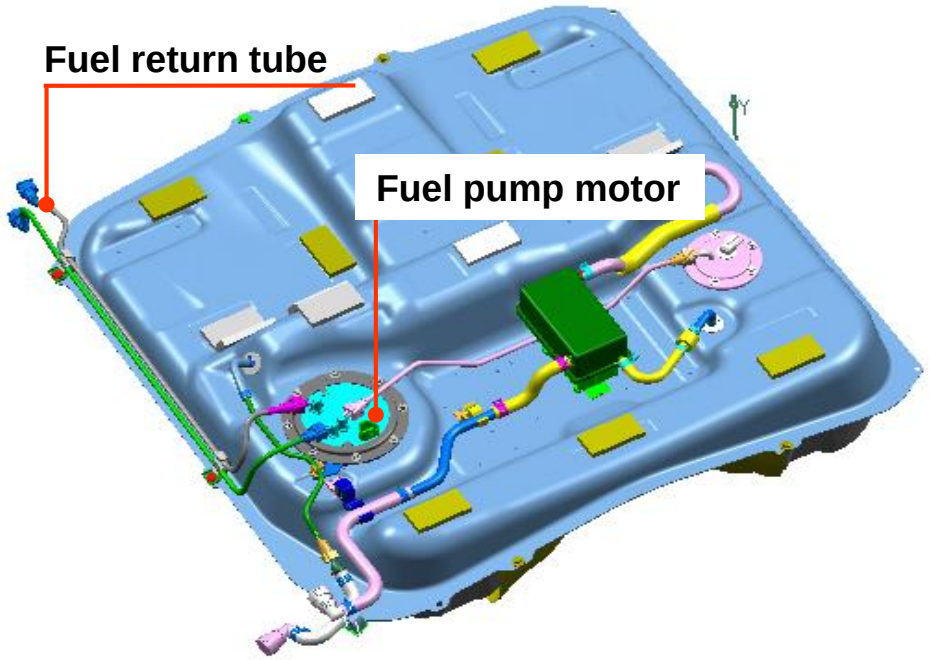
Fuel flow



Fuel tank

Items	Specification
Fuel Tank (Steel)	78 L
Fuel Pressure	4.5 kg/㎠
Fuel Pump	Electric motor

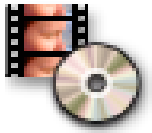




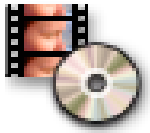
Fuel pressure

Fuel Pressure at Idle [Fuel filter → HP pump, Fuel filter → Injector return line]

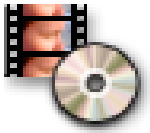
Fuel Pressure at Idle [HP pump → Fuel filter]



IG ON (filter → Pump)

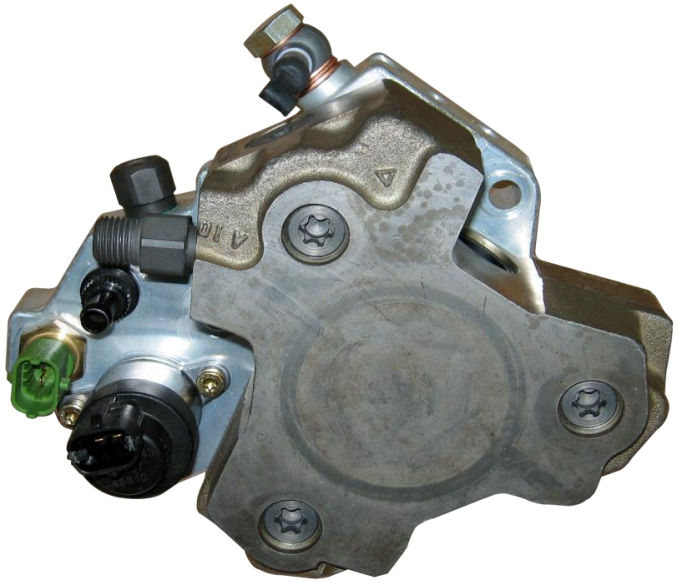
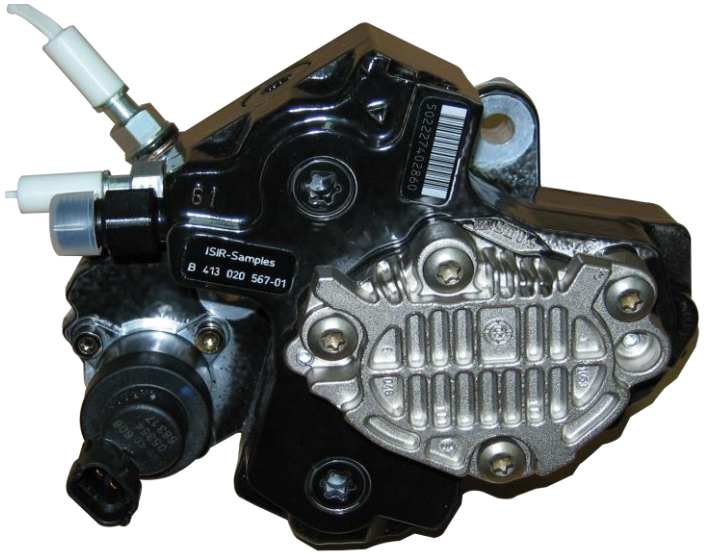


Engine ON (Filter → Pump)



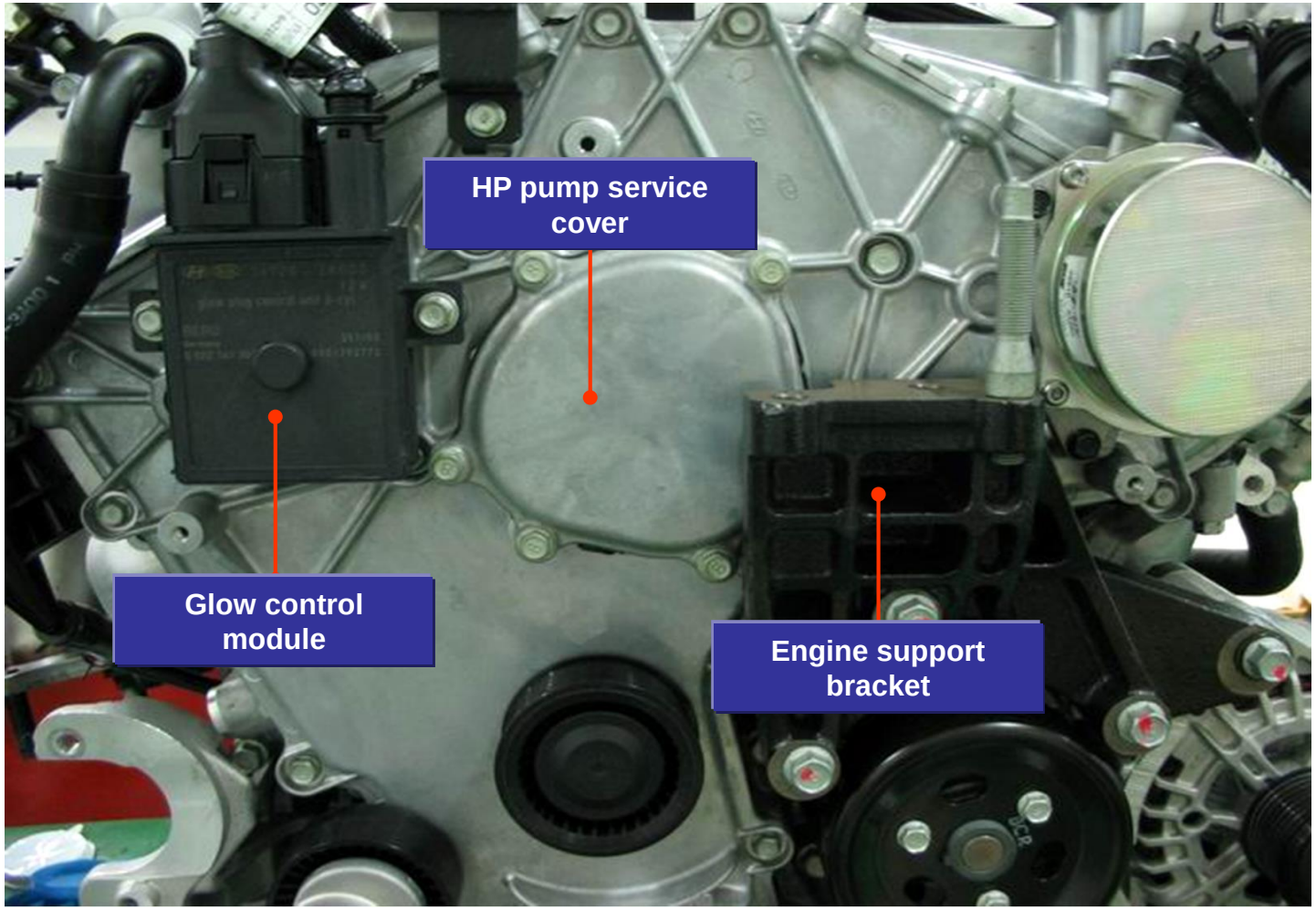
Engine ON (Pump → Filter)

High Pressure Pump

S-engine : CP3.2+	U-engine : CP3.2
Capacity : 866 mm3/rev Max pressure : 1600 bar Fuel temperature sensor is adapted. Gear pump is not adapted.	Capacity : 677 mm3/rev Max pressure : 1600 bar No fuel temperature sensor Gear pump is integrated.
	

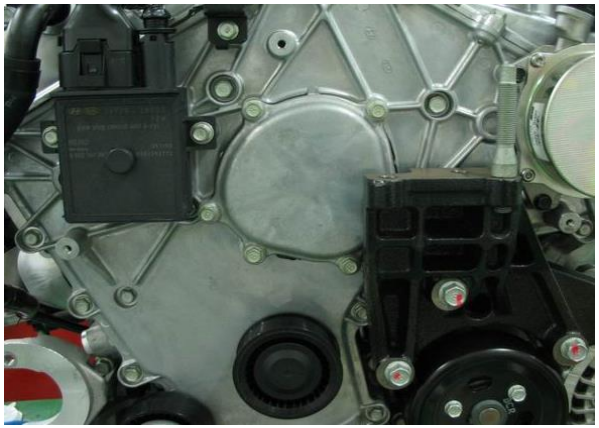
High Pressure Pump Removal

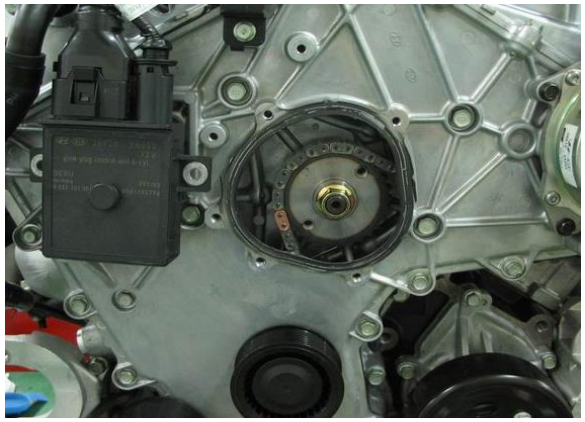
Preparation



High Pressure Pump Removal

Preparation



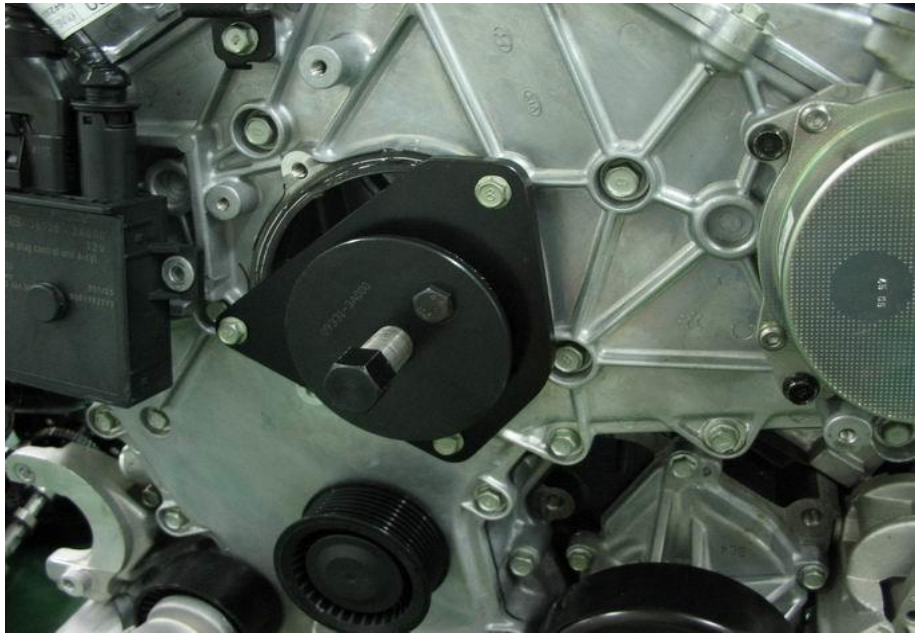


1. Remove the engine support bracket.
2. Remove the glow control module mounting bolts.
3. Remove the HP pump service cover
4. Remove the HP pump sprocket lock nut.

High Pressure Pump Removal

Preparation

5. **Install the HP pump puller. (09331-3A000)**

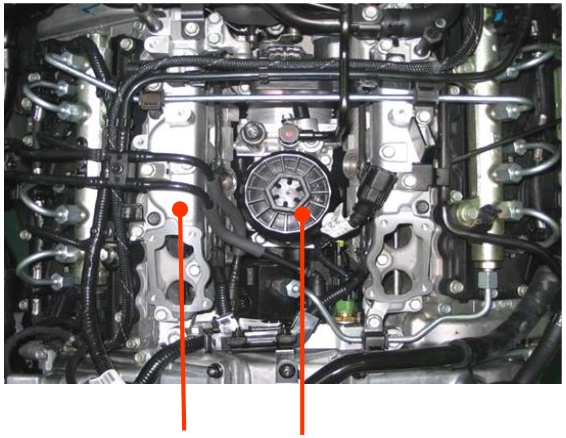


HP pump puller. (09331-3A000)

High Pressure Pump Removal

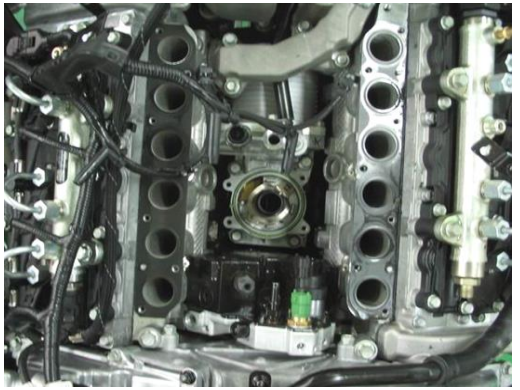
Removal

Inlet upper manifold

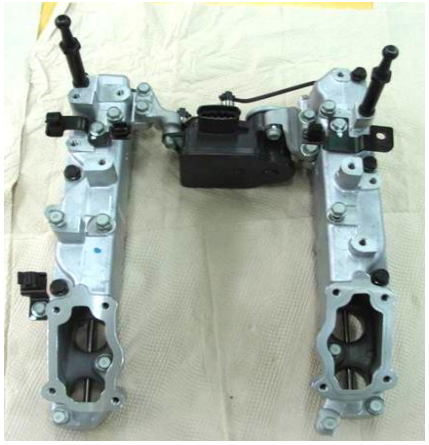


Inlet lower manifold

Oil filter



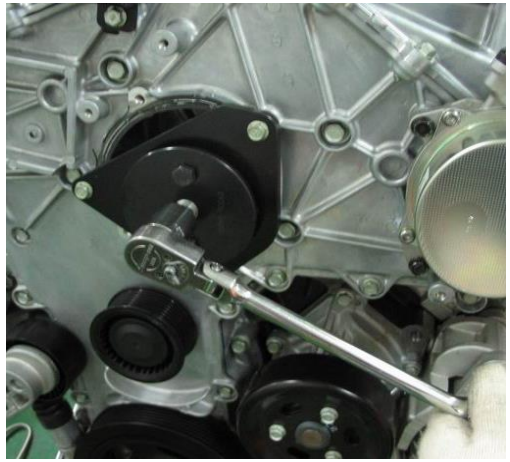
1. Remove the inlet upper manifold.
2. Remove the oil filter.
3. Remove the inlet lower manifold.
4. Remove the HP pump mounting bolts.

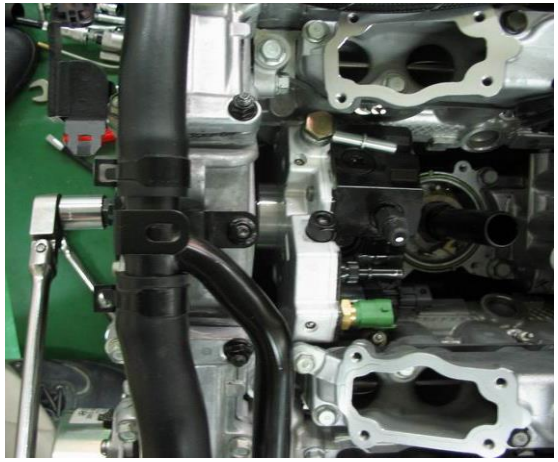


[Inlet lower manifold assembly]

High Pressure Pump Removal

Removal



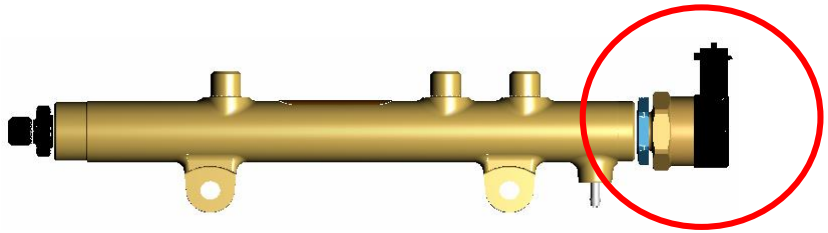


4. Tighten the screw of the HP pump puller.
5. Remove the HP pump.

[HP pump assembly]

Dual Pressure Control

Components

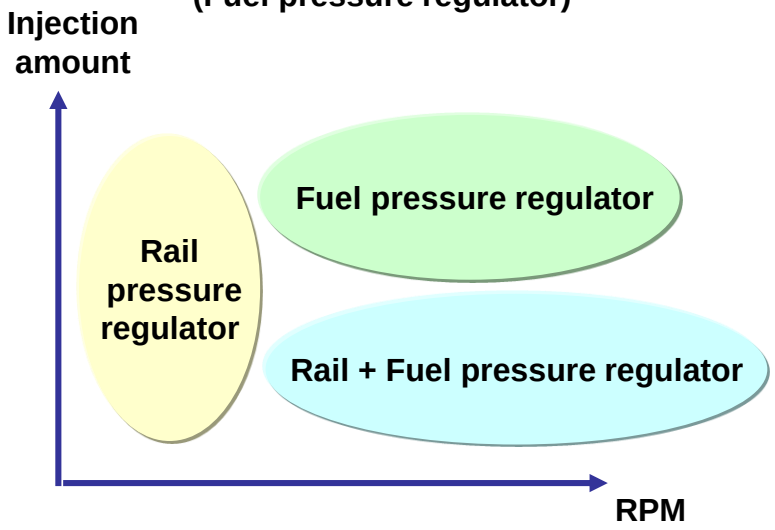


Pressure Control Valve
(Rail pressure regulator)

Inlet Metering Valve
(Fuel pressure regulator)

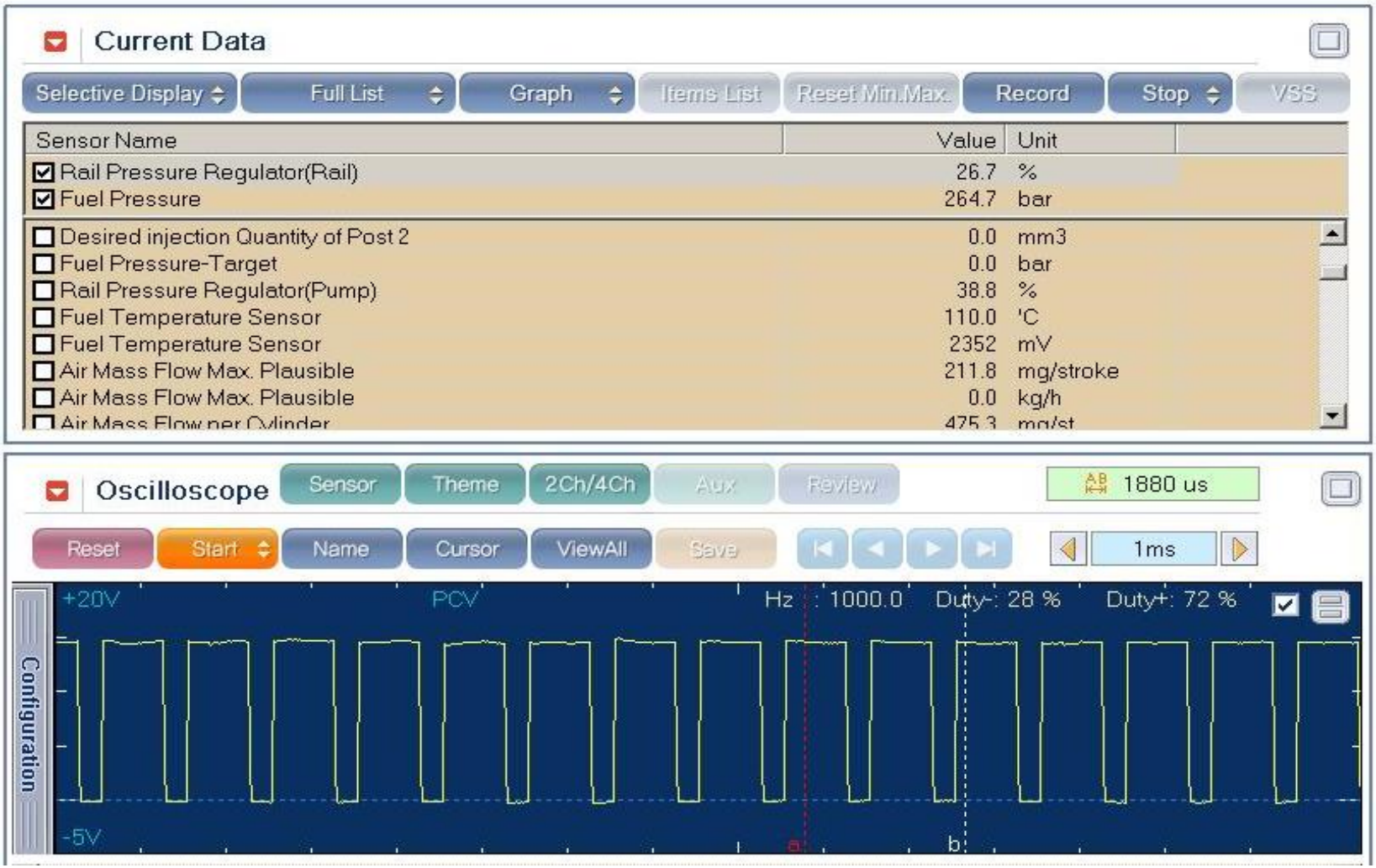
Operation

Condition	Pressure valve	
	Pump side	Rail side
Starting	OPEN	CLOSED
Low speed	OPEN	Control
Middle speed ~	Control	Control
Failsafe	Limp-home	OPEN



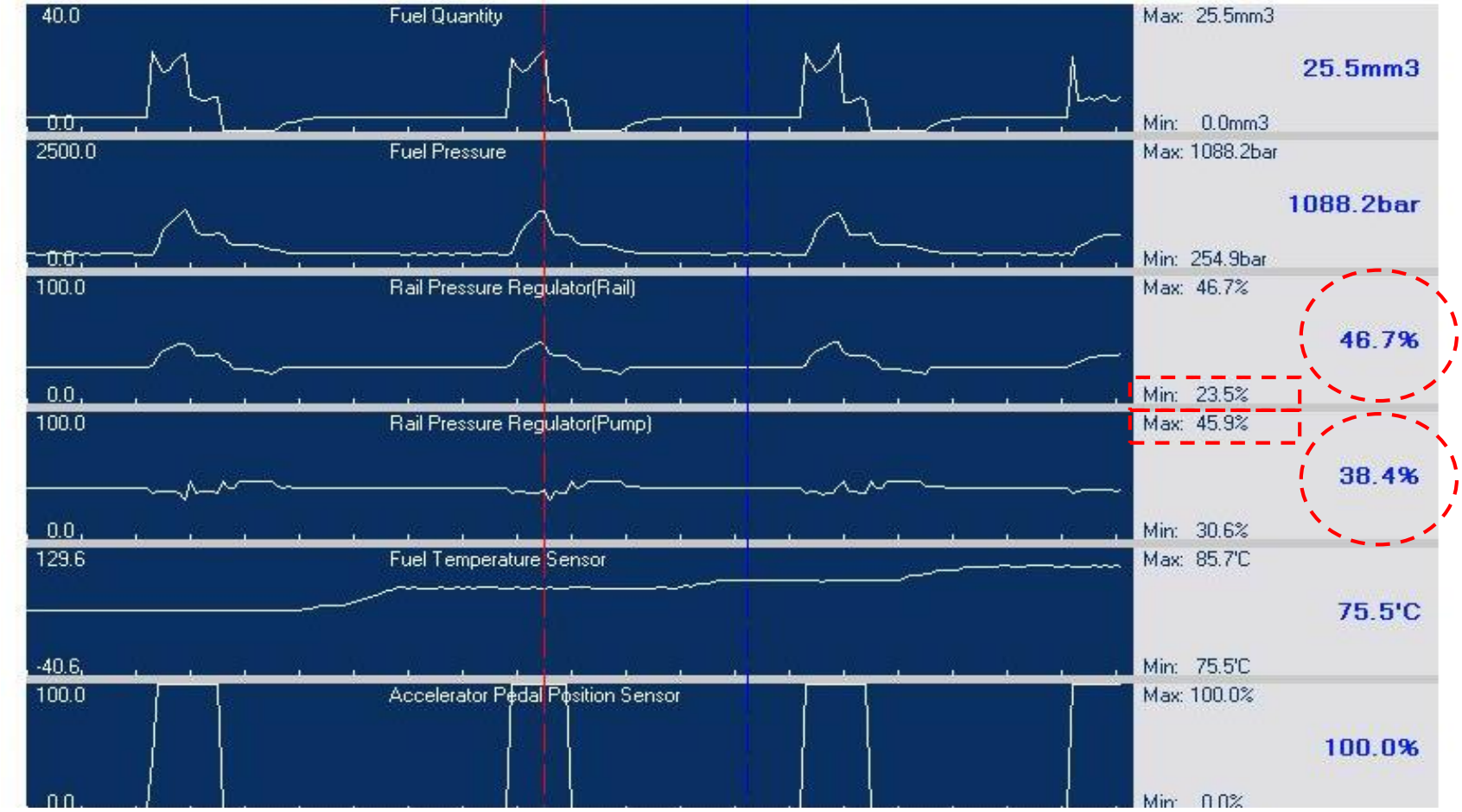
Dual Pressure Control

Output signal



Dual Pressure Control

Current data



Piezo Injector

- Advantage : Engine power up & lower emission due to enhanced injection response time
  Reduced injector size & weight (490g → 270g)

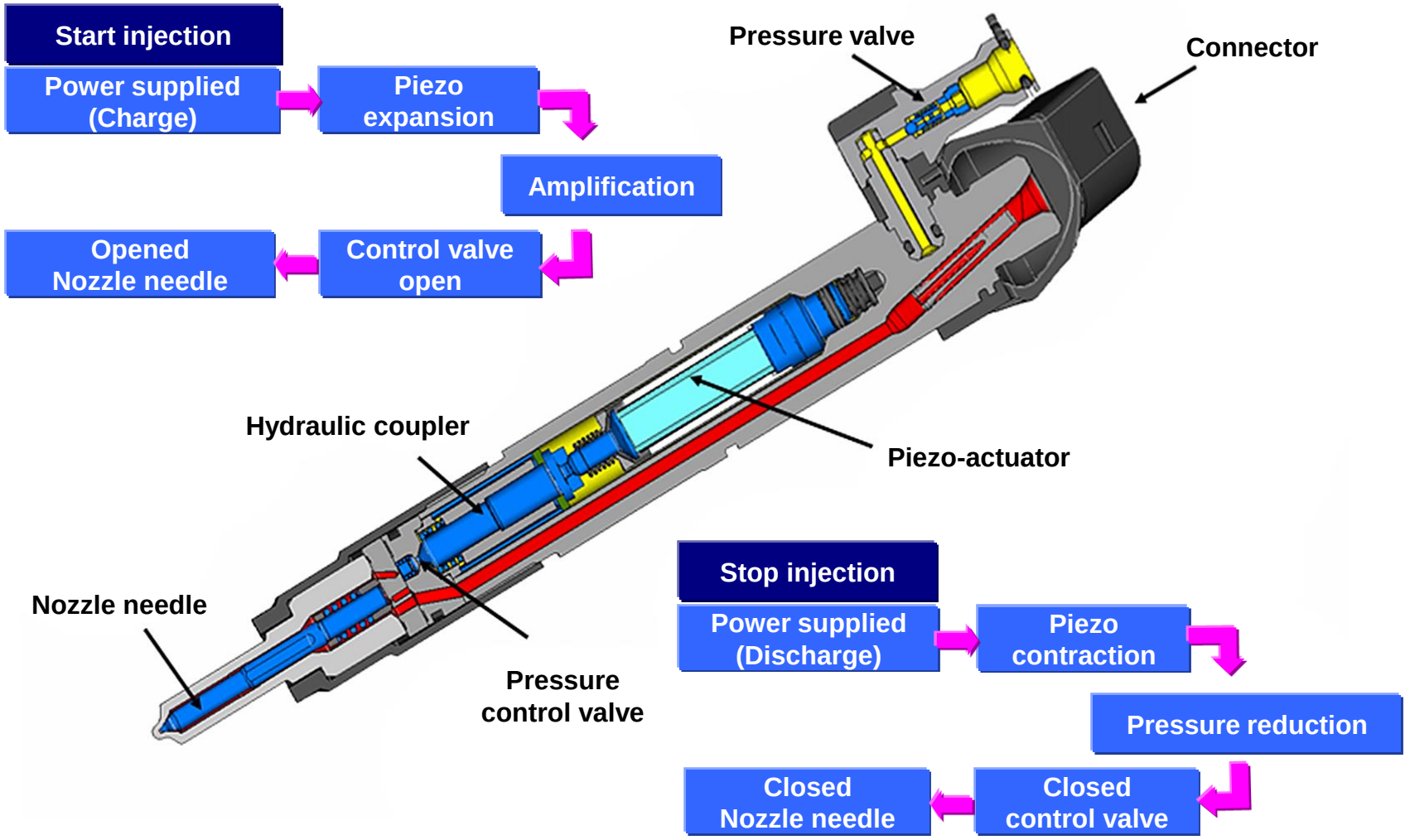
- Disadvantage : Maximum operating voltage is 200V. If an injector is short to ground,
  be careful of electric shock.

[Solenoid injector]

[Piezo injector]

Piezo Injector

Construction



Concept of piezo actuator

- Piezo effect : piezo generates voltage by external force

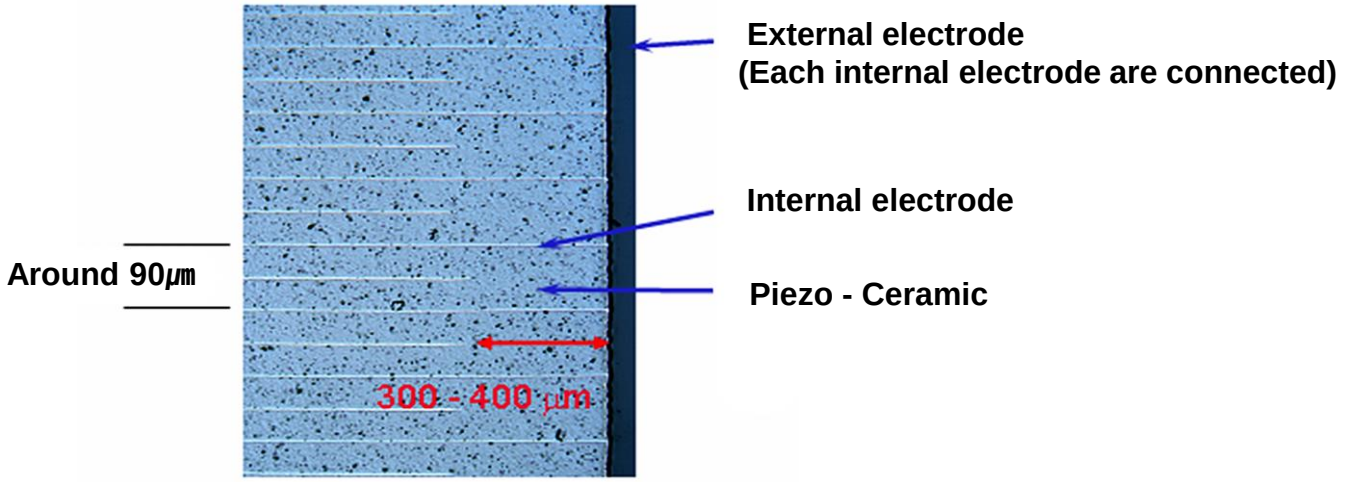
  (ex. pressure sensor, map sensor).

- Polarization : piezo deforms certain direction by voltage.

- The piezo stack connected parallel functions like capacitor.

- The length of a 90㎛ piezo stack extends to 1.5~2% by maximum 200V.
  (current : less than 20A, minimum voltage applying time : 125 μs)

- Stroke of actuator depends on the number of piezo stacks



Piezo Injector

Process of polarization of the piezo actuator

before polarization

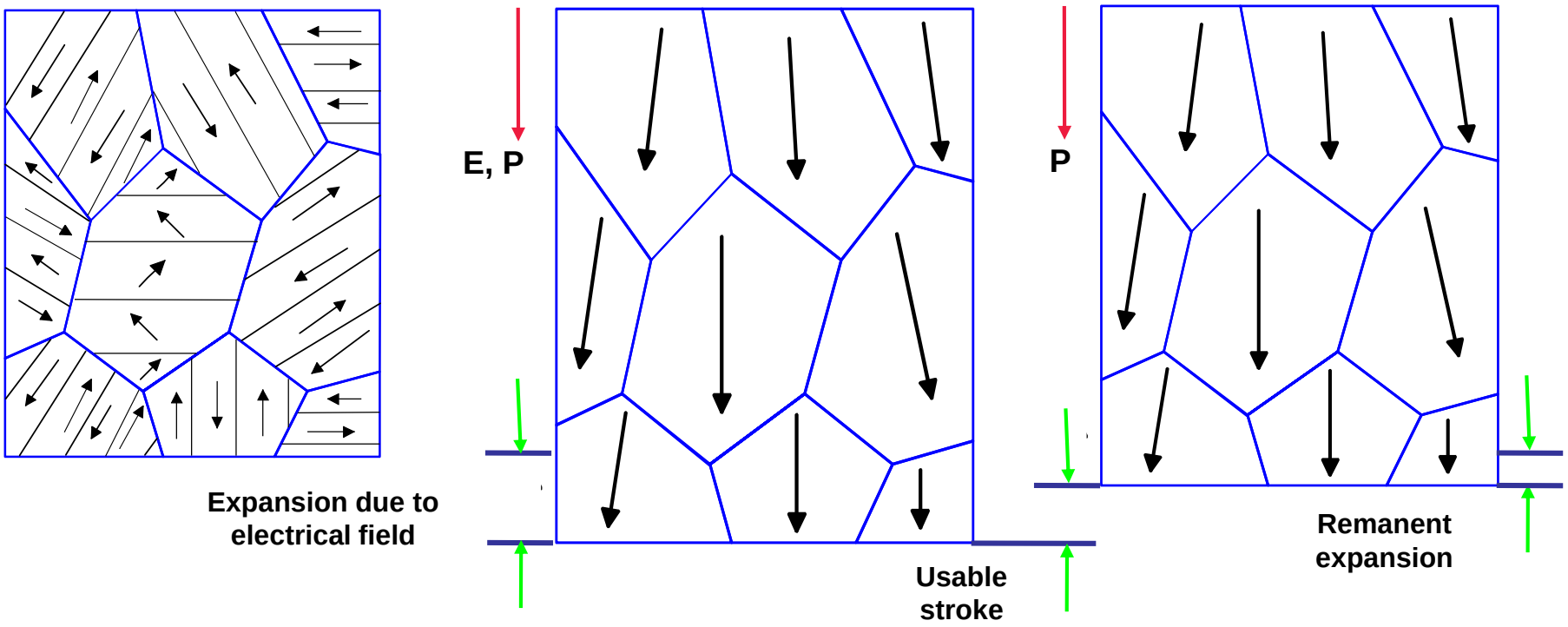
no preferred direction of domains, piezo electrically inactive

during polarization

alignment of domains

after polarization

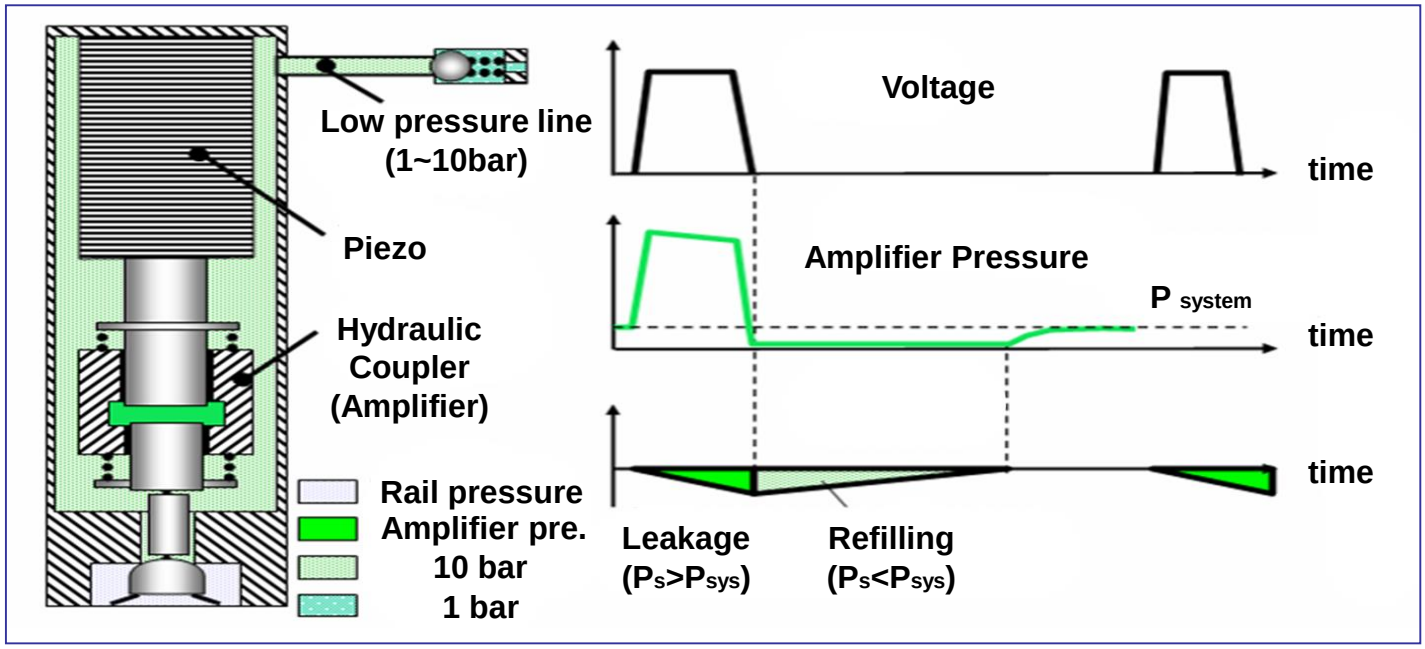
mostly remaining alignment of domains



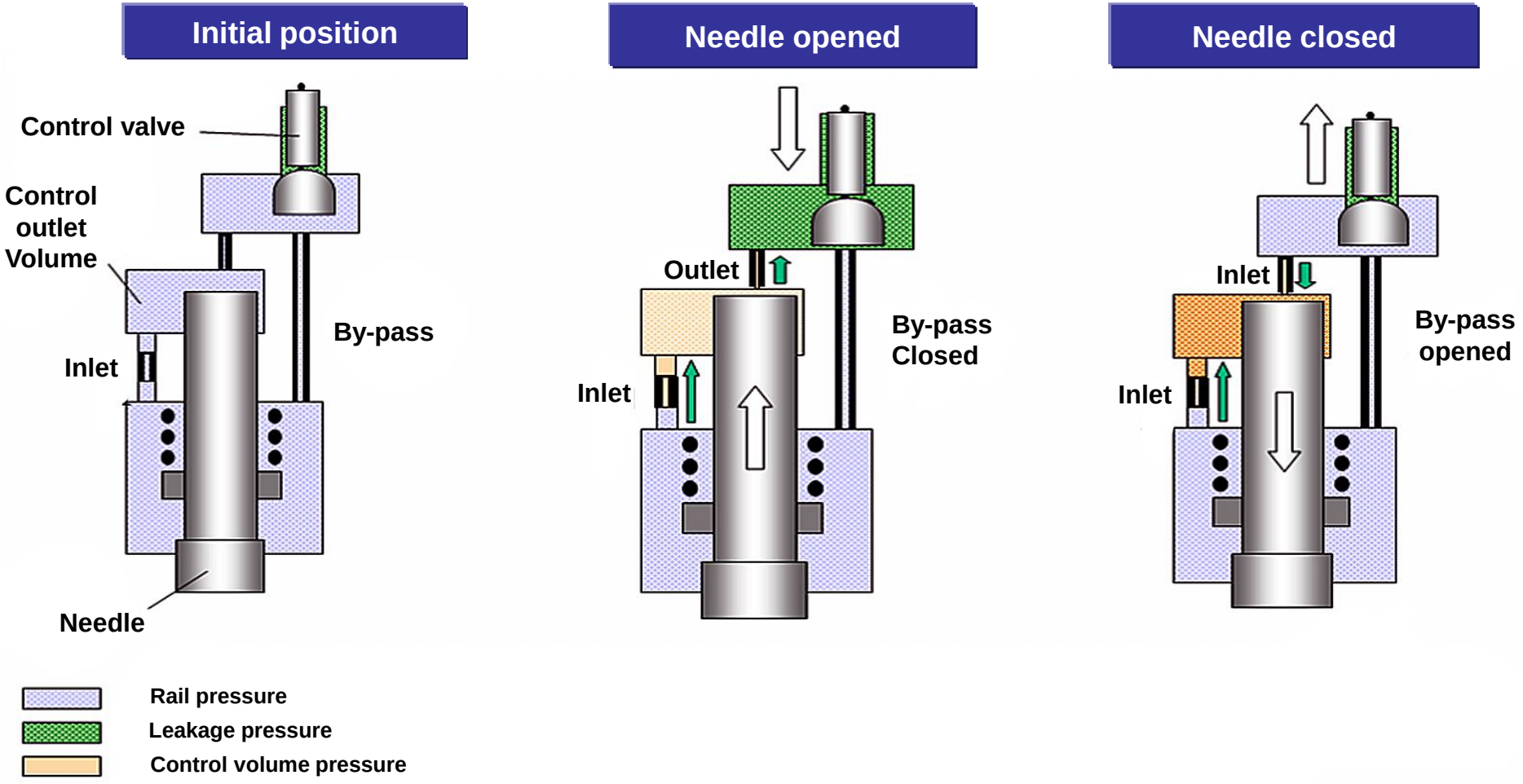
Operating principle (hydraulic coupler)

- Hydraulic piston inside the hydraulic coupler amplifies the operating force from piezo actuator as much as the surface difference of upper piston & lower piston and increase the operating stroke.

- For normal operation of the coupler, 1~10bar remains on the fuel return line (low pressure line).

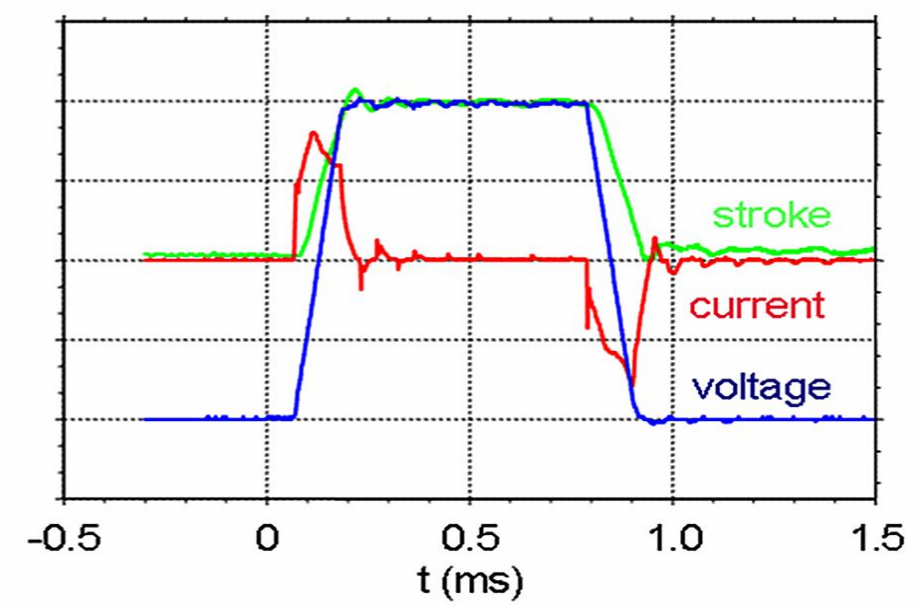


Operating principle (pressure control part)

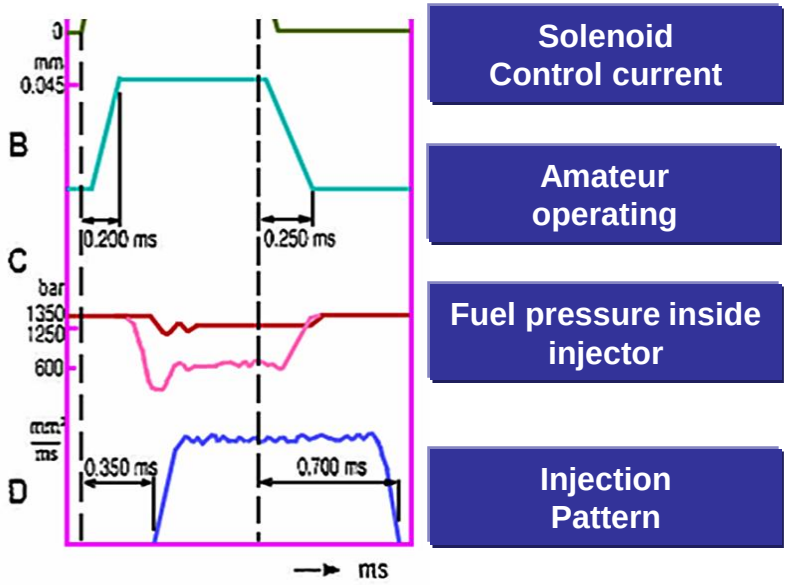


Piezo injector vs. Solenoid injector

- **Injector response :** no delay time between the voltage and the stroke
- **Control current :** only controls injection starting current and ending current.



[Piezo- Injector]



[Solenoid Injector]

IVA (Injector Voltage Adjustment)

*** IVA (Injector Voltage Adjustment) : Characteristics of piezo injector**

- Function : Calibration of actuator/control valve stroke at the factory

- Reason : Injector individual voltage demand caused by mechanical margin deviation of actuator and injector.

(ex. Seat diameter of control valve, piston friction, relationship of voltage and stroke)

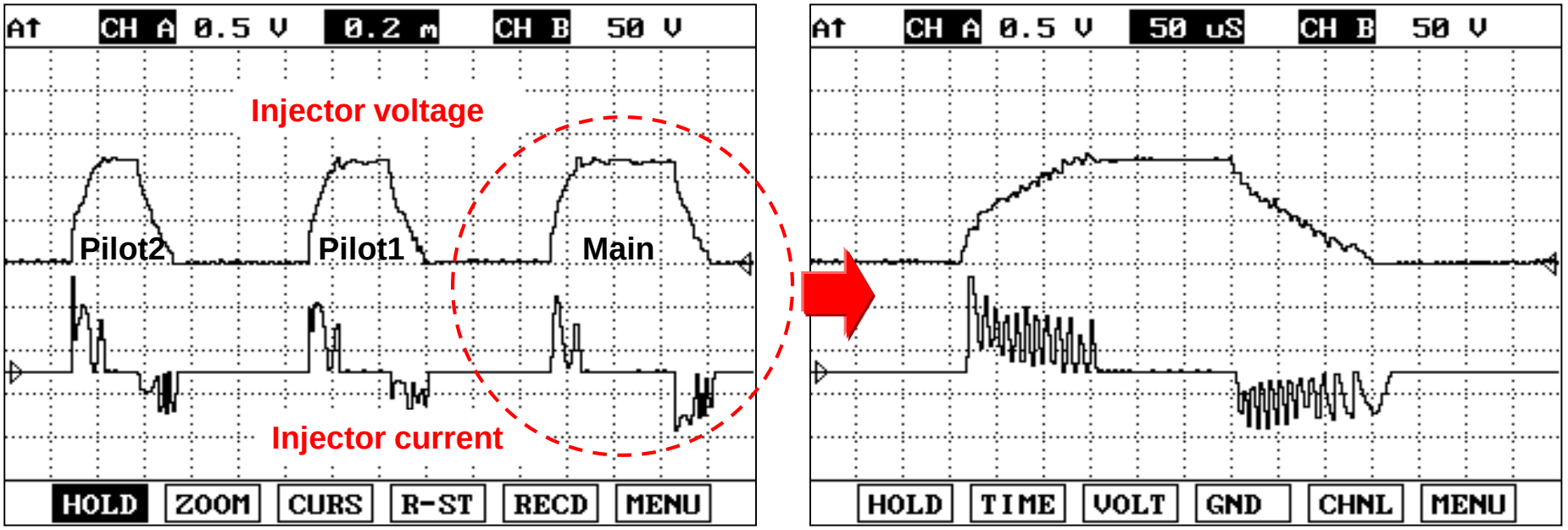
- Class : 1st ~ 15th class according to operating voltage

*** Injector code = IQA + IVA**

AIAK8NG

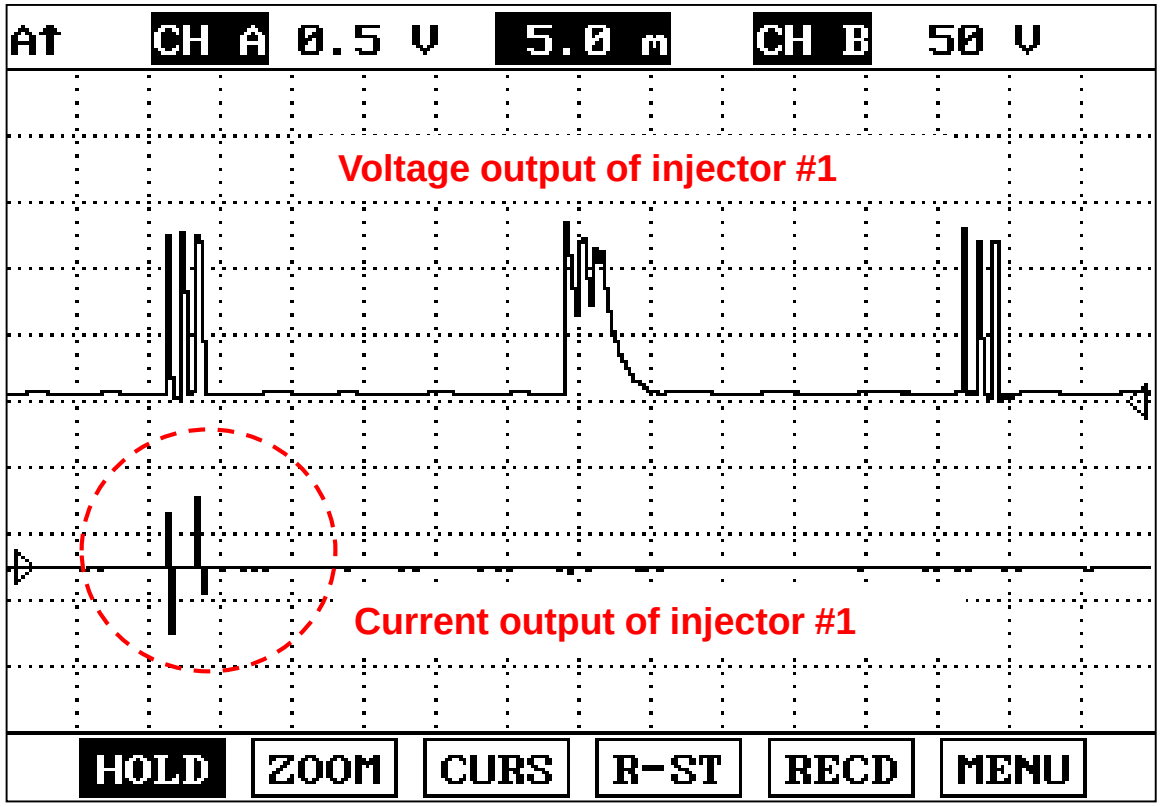
*** IQA : Injector Quantity Adjustment**

Output signal

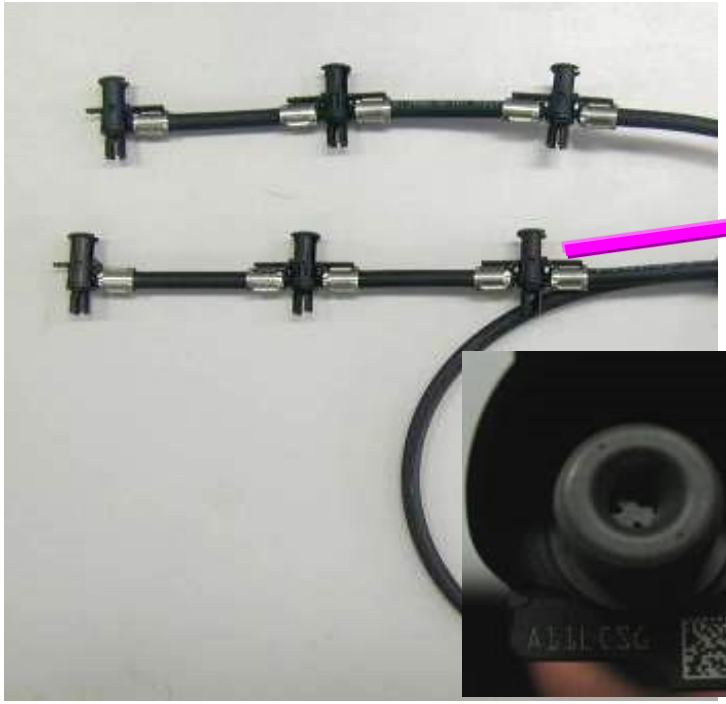


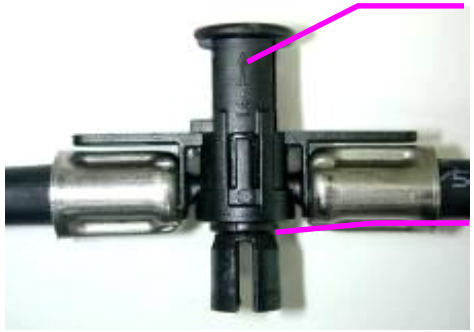
Piezo Injector

Output signal



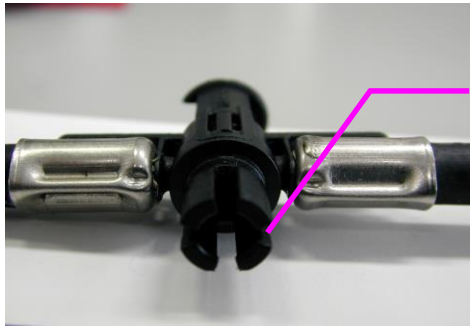
Back-leak Rail Installation & Removal





Plug Bush

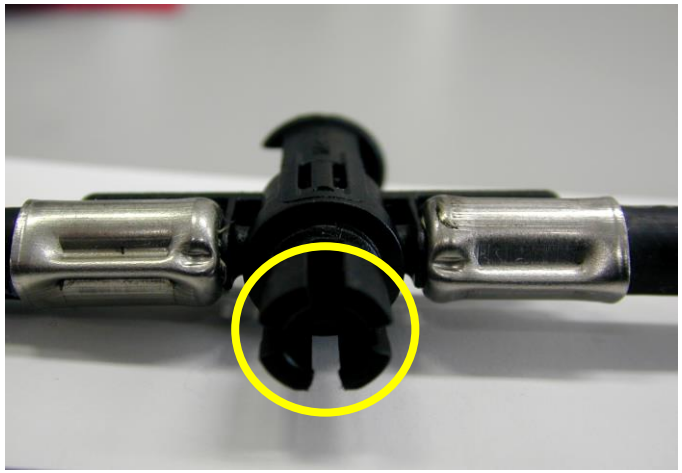
Plug



Plug fixing (4EA)

Back-leak Rail Installation & Removal

Installation

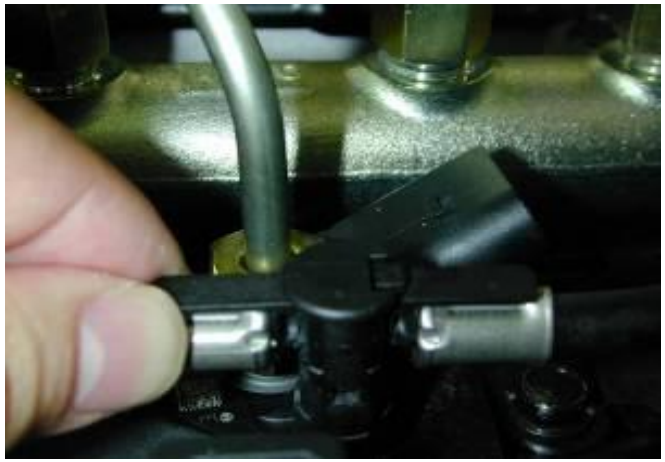


Before assembling the return line, confirm plug fixing condition and plug bush is lifted.

Push the plug to vertical direction until make clicker sound from injector nipple

Back-leak Rail Installation & Removal

Installation



Confirm installed condition by moving plug

Install plug bush until hear click sound

Back-leak Rail Installation & Removal

Removal

Press both knob and lift up plug bush

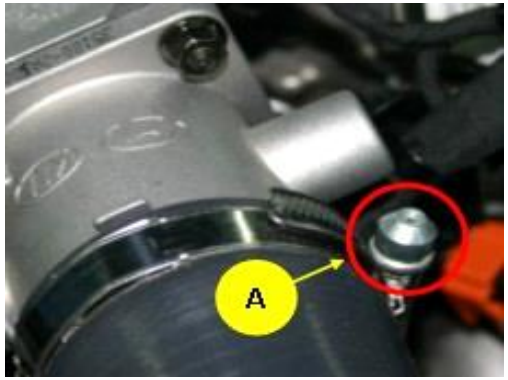
Lift up plug vertical direction from injector nipple at lifted plug bush

Back-leak Rail Installation & Removal

Case study

- Cause : One plug fixing is broken. Because of excessive installation without the plug bush fully up.
- Symptom : Fuel leaks from the injector nipple

Clamp Cap Information

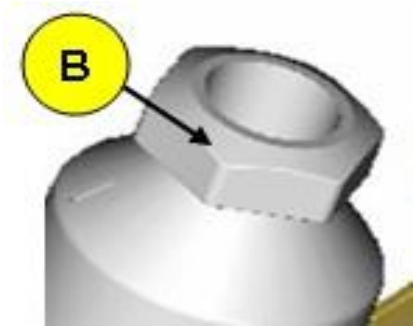
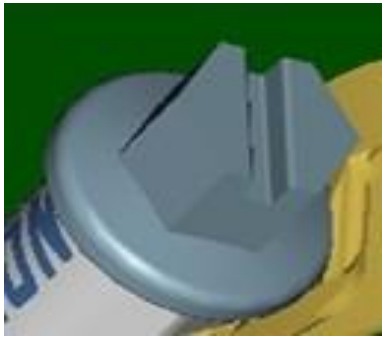


For S-engine, U-engine and J-engine s below table, the intake manifold hose clamp is covered with the cap (A) and the cap head (B).

When tightening torque of the clamp cap head reaches its specification (0.5~0.7 kgf-m(3.6~5.1 lbf-ft)), the clamp cap head is broken out.

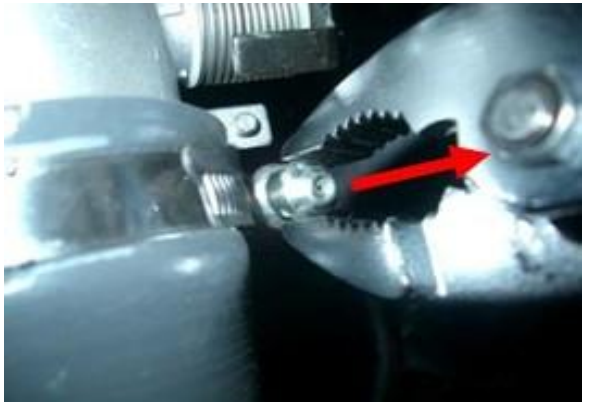
The purpose of this clamp cap head type is to have the recommended tightening torque for the intake manifold hose clamp in production line.

- **A : Clamp cap**
- **B : Torque control cap**

S/U/J Engine		
		
Before torque	After torque	After removing the cap

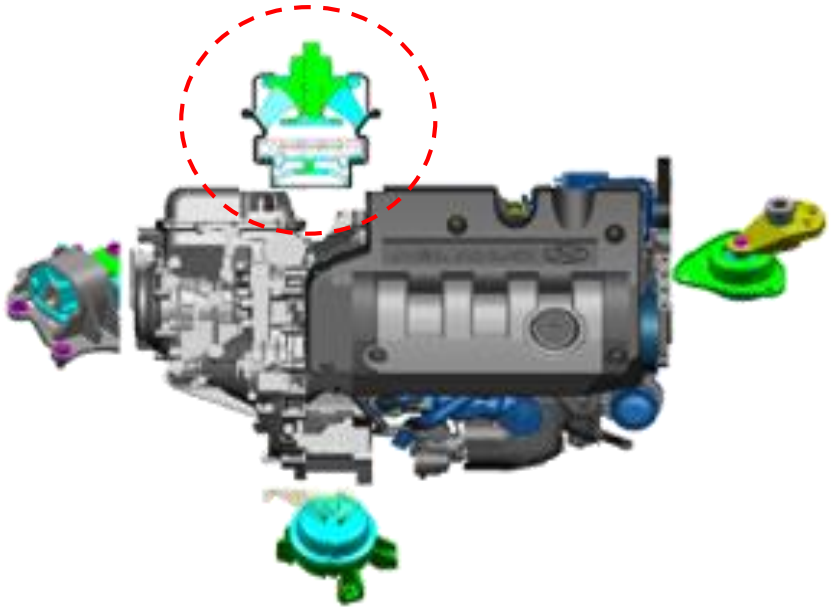
Clamp Cap Information

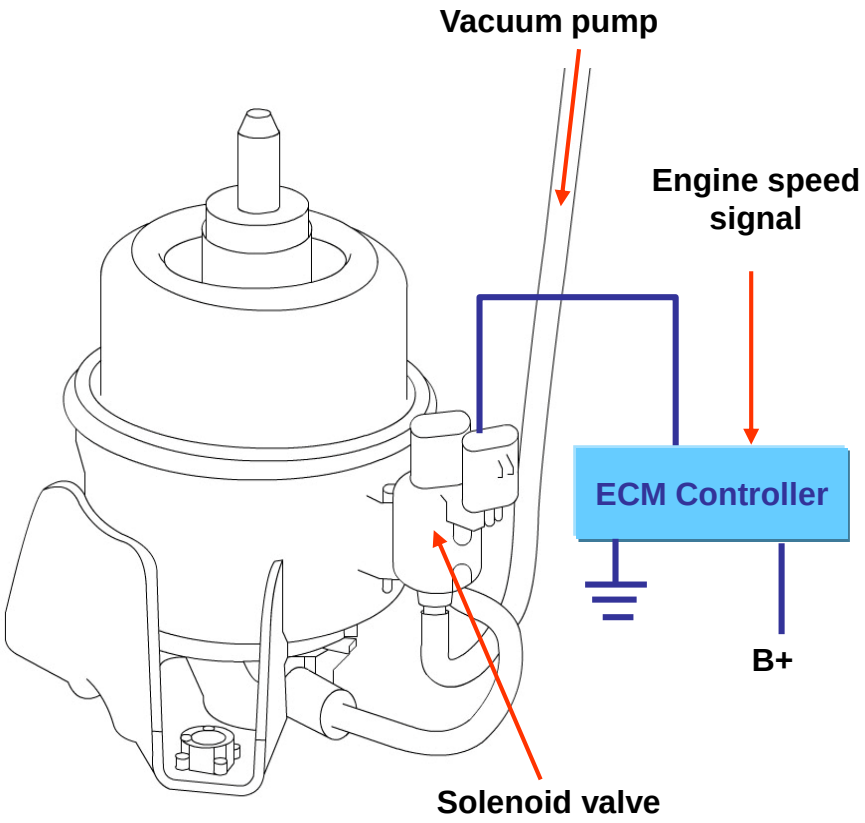
Service procedure

1) Plier out the intake manifold clamp cap.	
2) Tighten or loosen the clamp using a flat head screwdriver.	

Semi Active Mounting

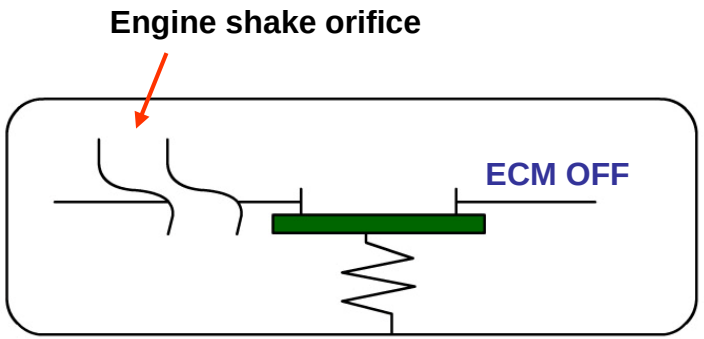
- Only for Front Roll Stopper
- Improved idle vibration by 5~10dB
- Solenoid valve is controlled by ECM control module
  (not engine ECM but independent one)





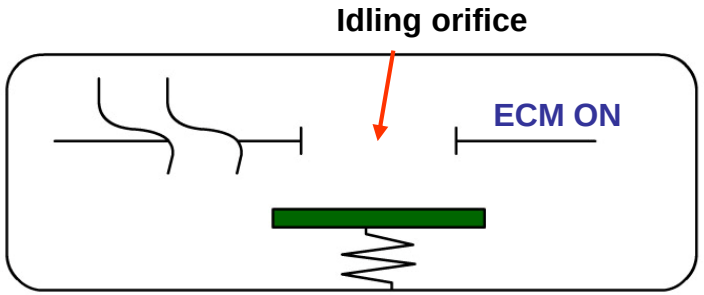
Operation

1) Except idle condition – High damping



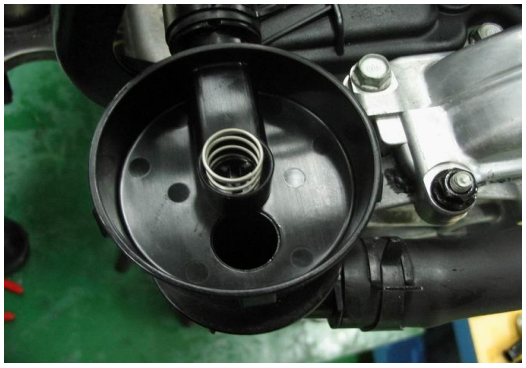
Operating condition		Solenoid valve
Engine ON	~ 920 RPM	ON (Idle)
	920 ~ 1000 RPM	Previous condition
	1000 RPM ~	OFF (Driving)
Engine OFF		OFF

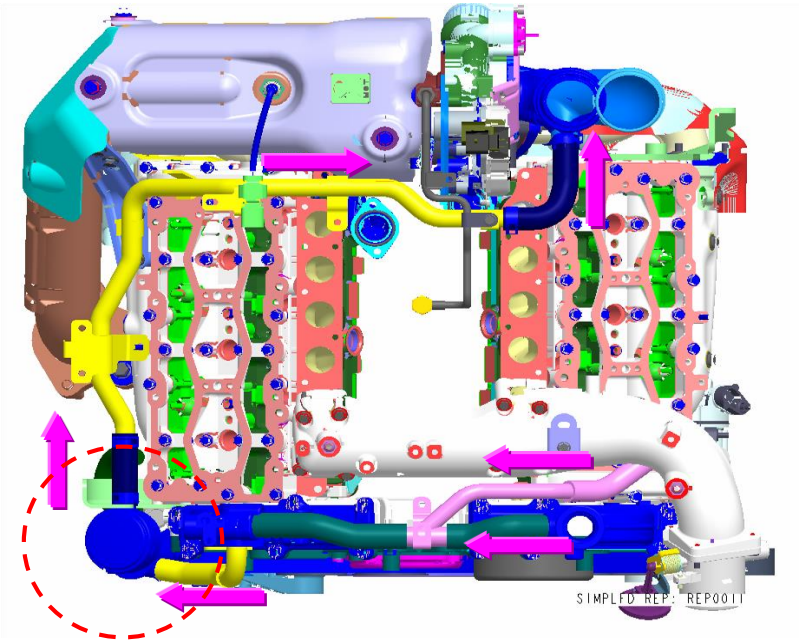
2) Idle condition – Low dynamic stiffness

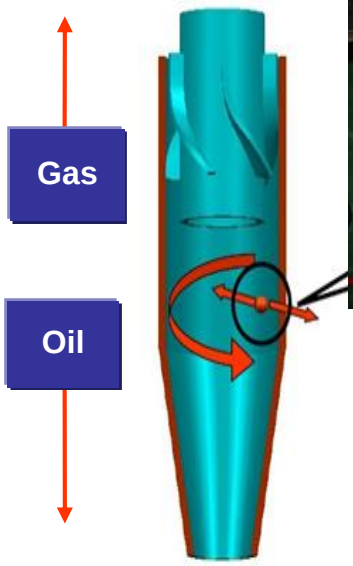


Alternator 'L' voltage	Solenoid valve
9V ~	ON
2~9V	Previous condition
~ 2V	OFF

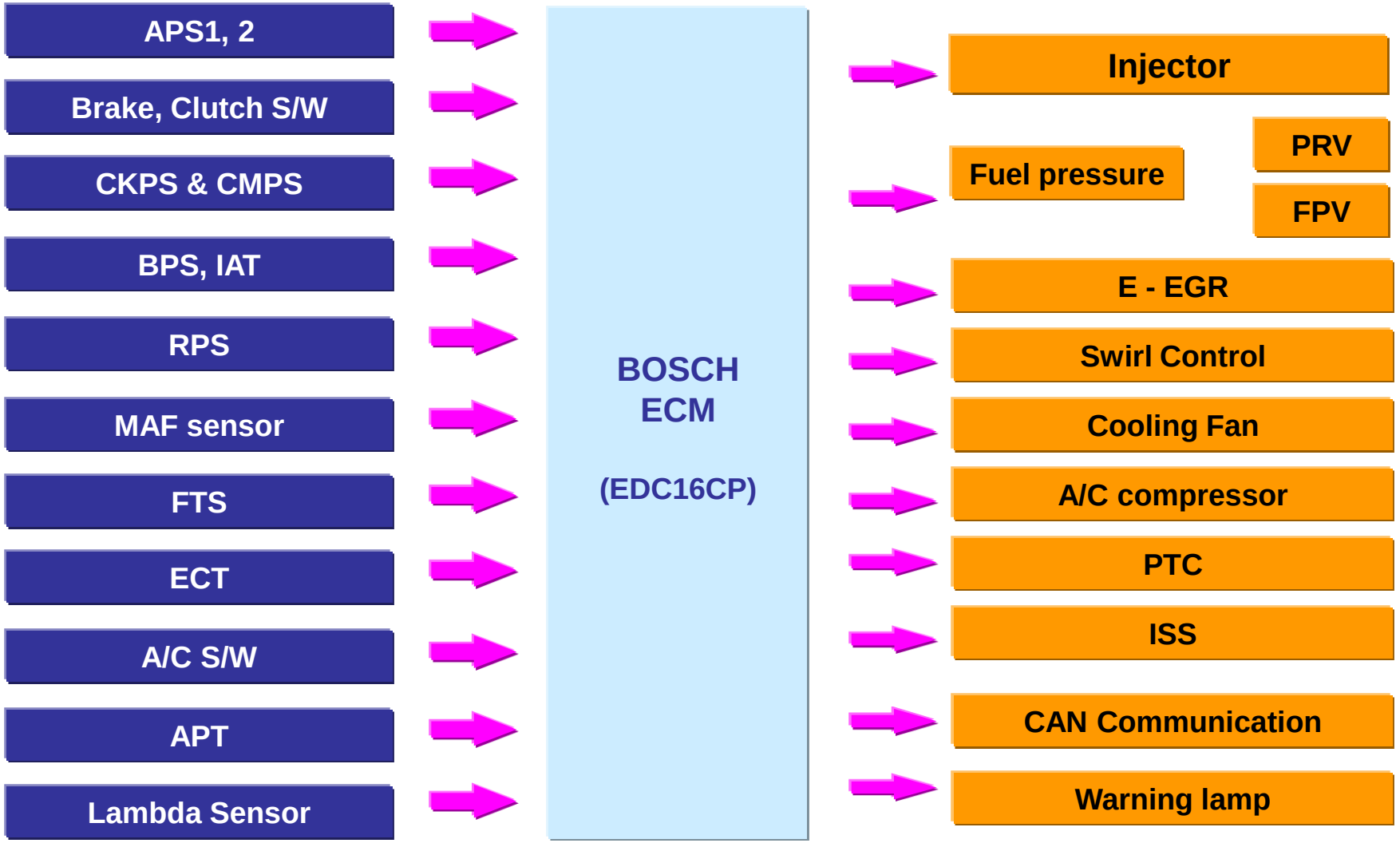
Oil Separator





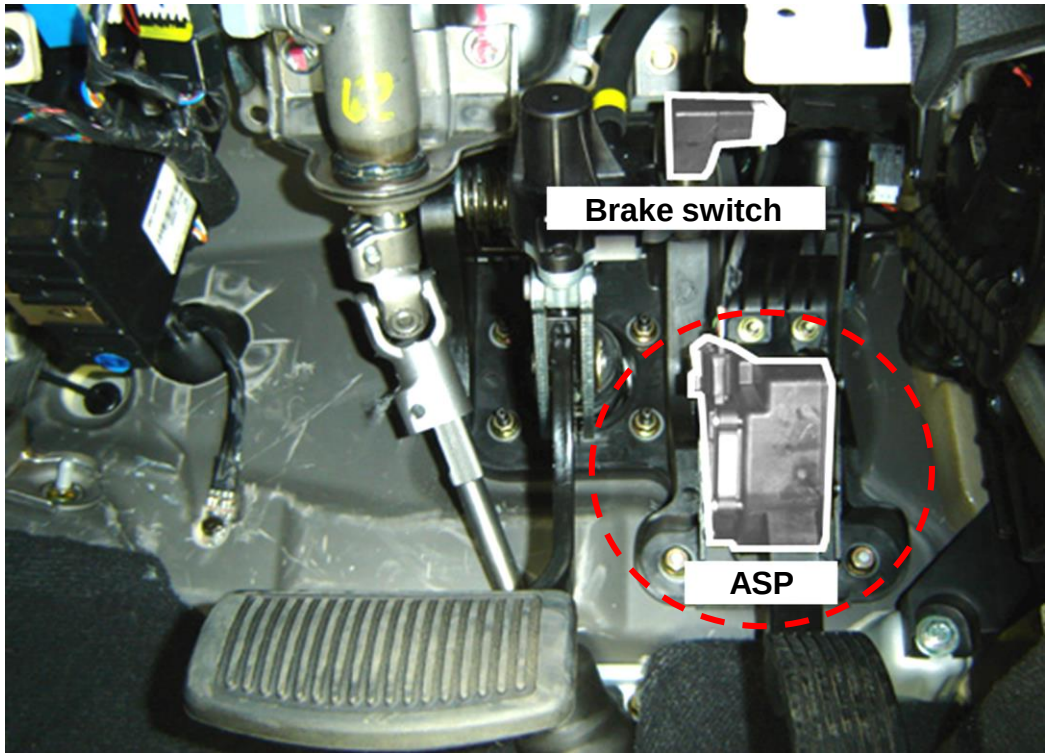


Inputs & Outputs



Acceleration Position Sensor 1,2

- Sensor 1 : For injection amount and timing (torque request signal)
- Sensor 2 : Sensor 1 monitoring, preventing sudden starting
- Failsafe : 1,250 rpm fix



Rail Pressure Sensor

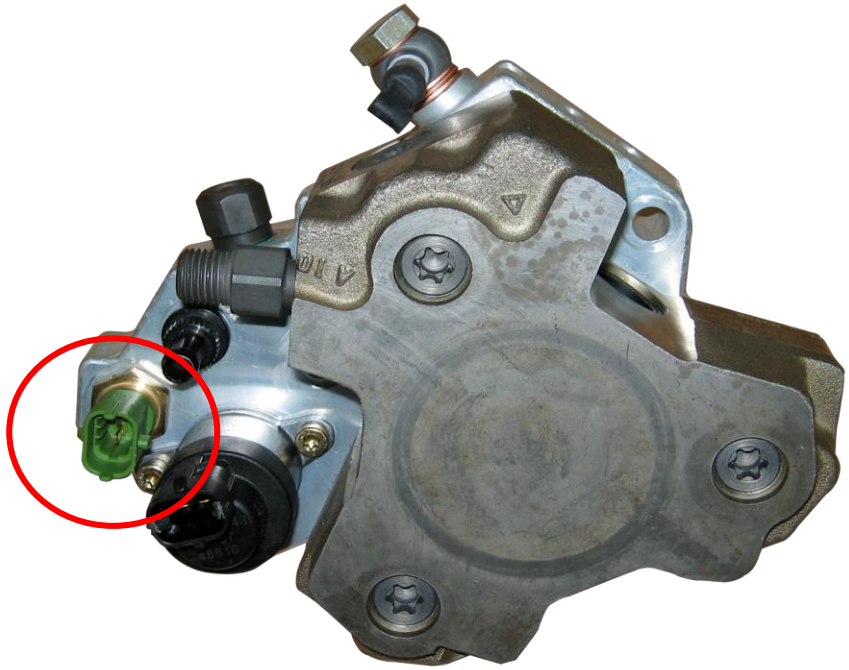
- Failsafe : Rail pressure 360bar (36MPa) fix

Engine speed limitation - 3000 rpm

Fuel Temperature Sensor

- Function : Detects the fuel inlet temperature at high pressure pump

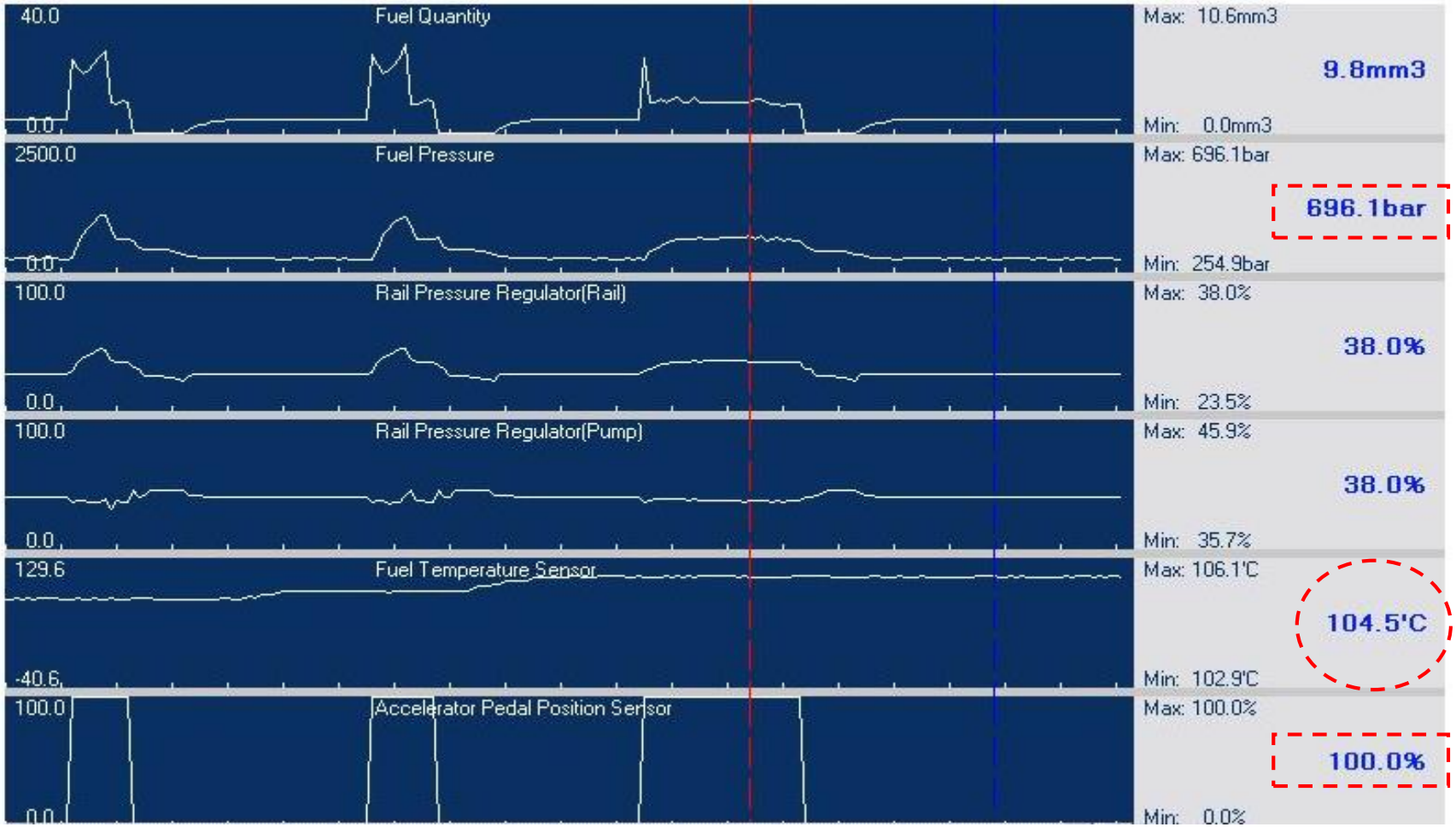
If the fuel temperature is over 80 ℃, max. engine rpm is limited 3000rpm



Temperature (℃)	Resistance (kΩ)
-20	13.4 ~ 17.7
-10	8.24 ~ 10.66
0	5.23 ~ 6.62
20	2.26 ~ 2.76
40	1.08 ~ 1.28
60	0.56 ~ 0.64
80	0.3 ~ 0.34
120	0.11 ~ 0.12

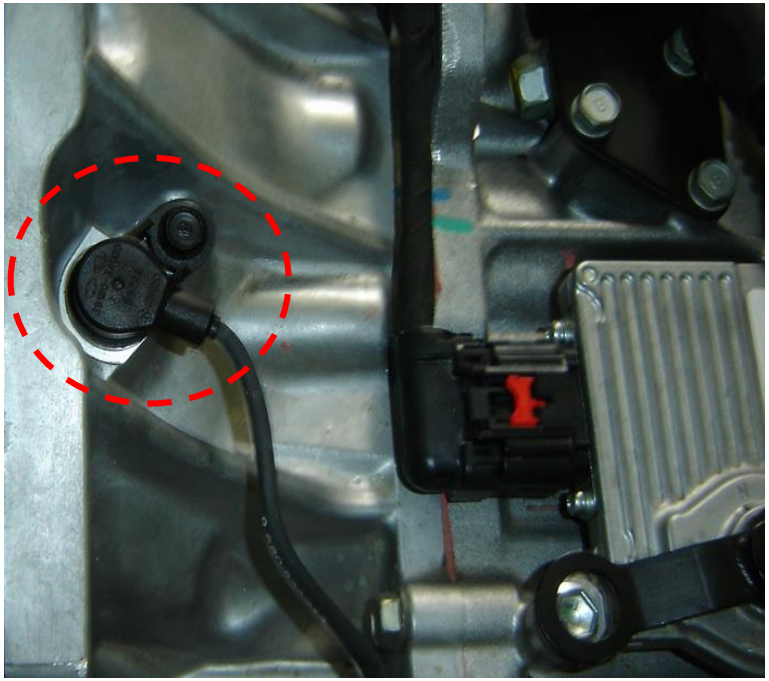
Fuel Temperature Sensor

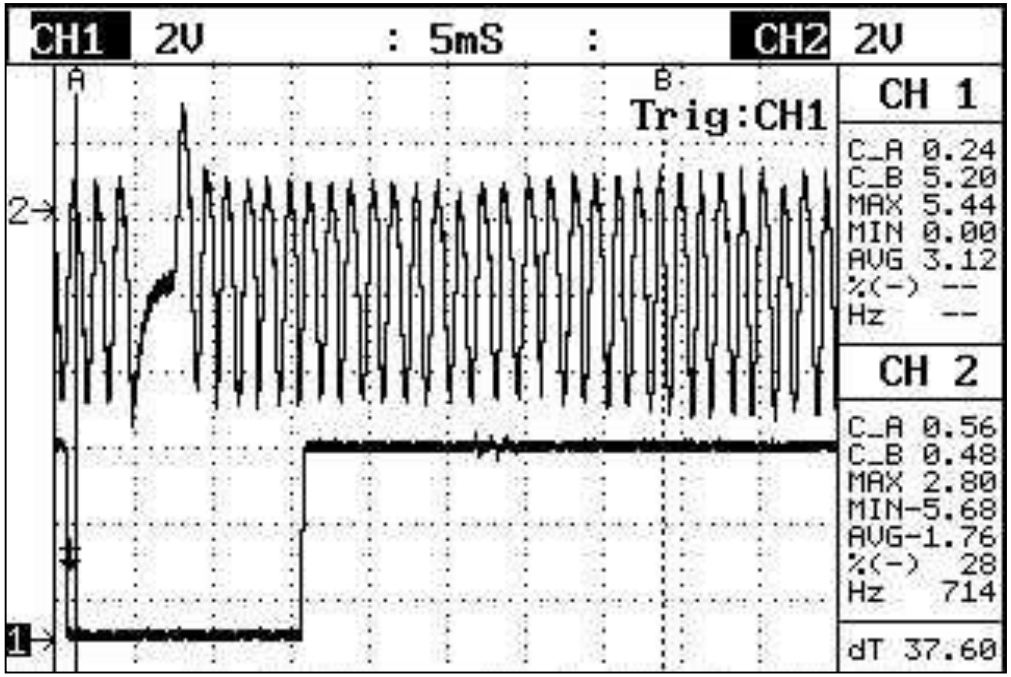
Current data



Crankshaft Position Sensor

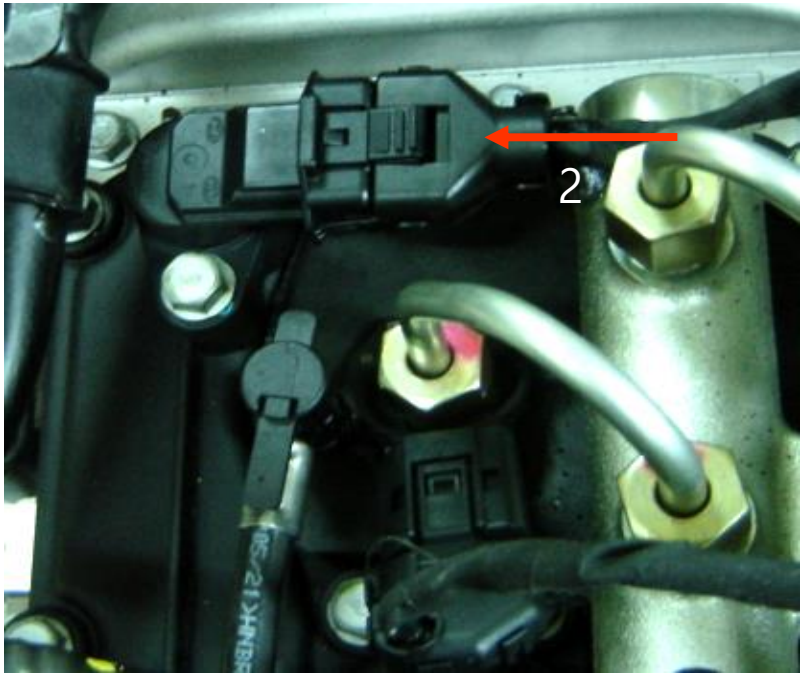
- Inductive type
- Information of engine speed and injection timing
- Engine off if fails (cannot restart)

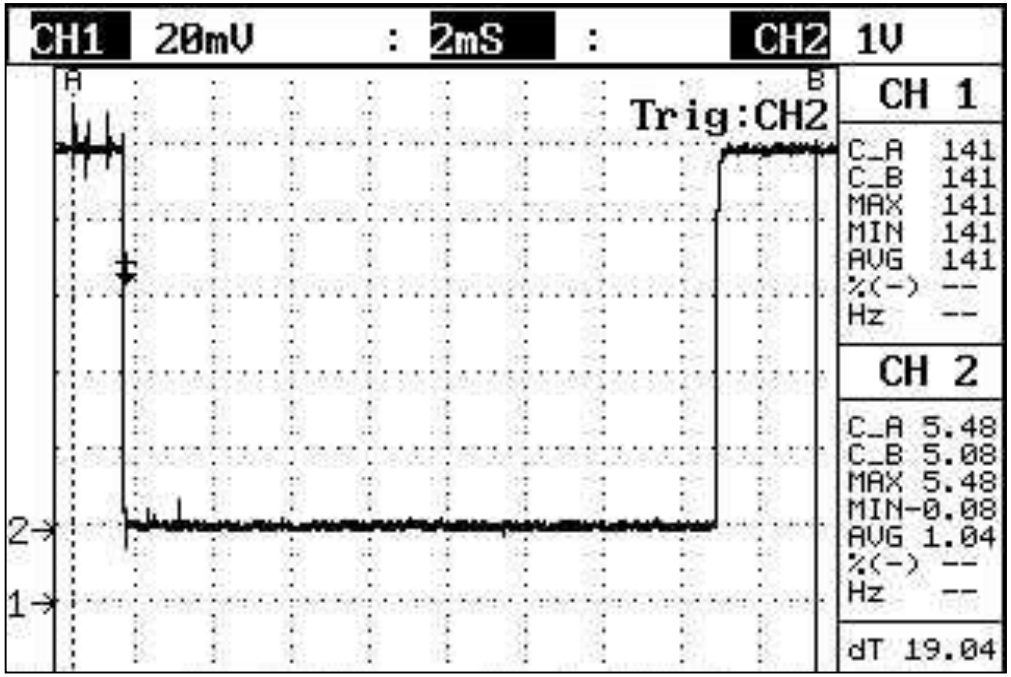




Crankshaft Position Sensor

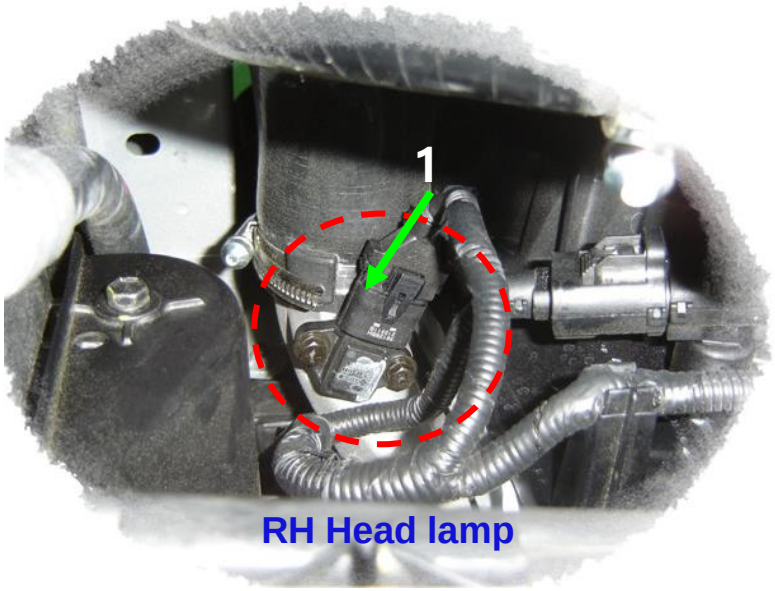
- Hall IC type
- Information of engine speed and injection timing
- Limp-home function starts if fails while driving but cannot restart

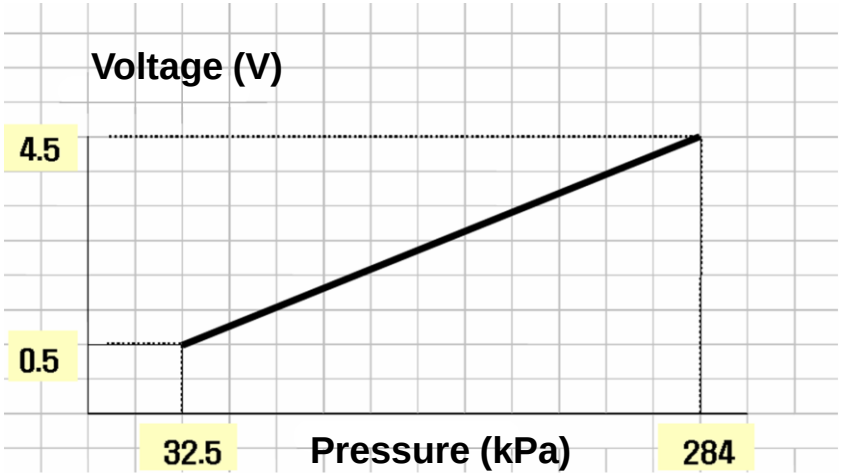




Boost Pressure Sensor (BPS)

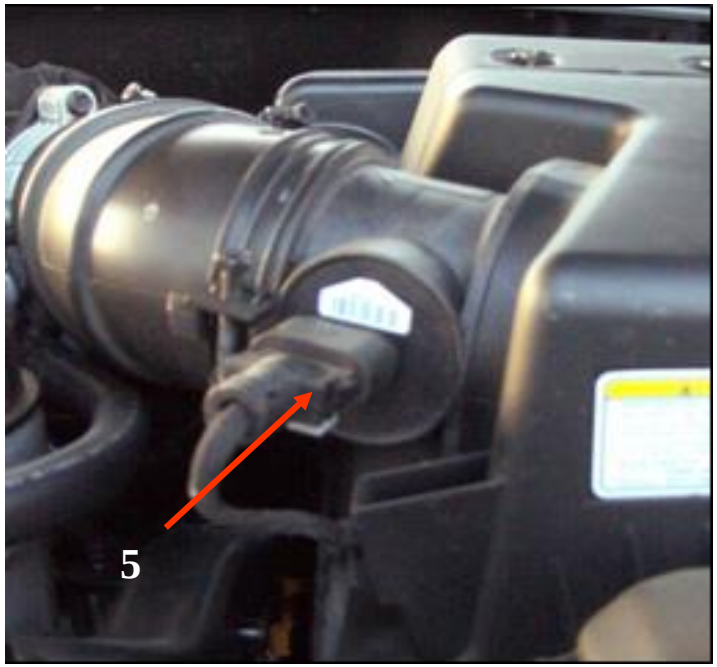
- BPS is installed on surge tank to measure the absolute intake manifold pressure.
- Used for control for E-VGT (Electrical Variable Geometry Turbocharger)
- Failsafe : Limp-home (limited injection)



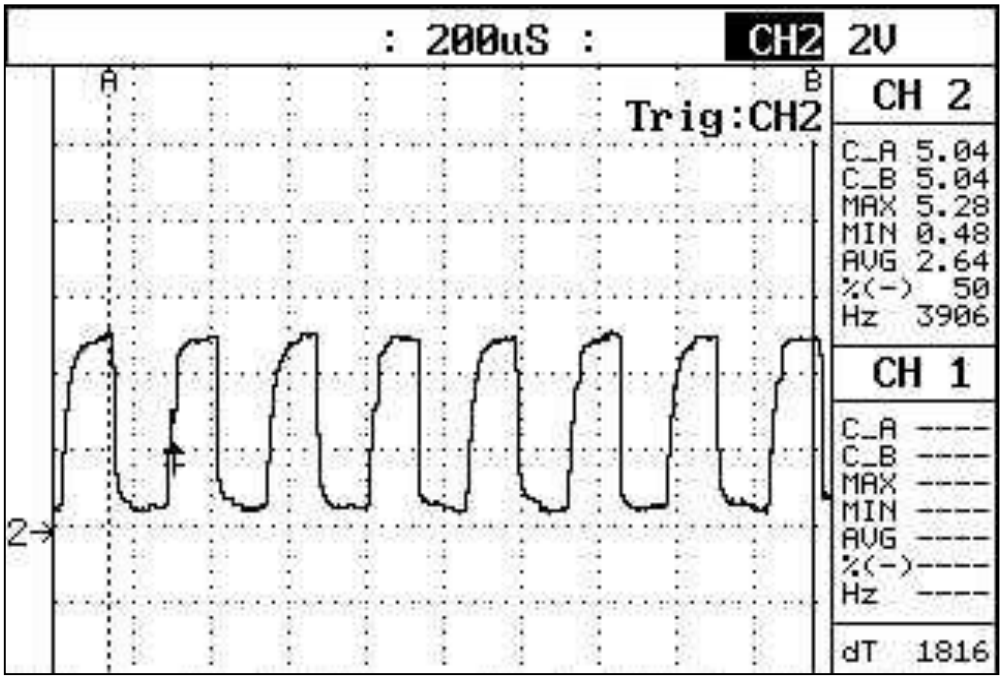


Air Flow Sensor

- Type : Hot-film type
- Used for injection amount and EGR amount control
- Failsafe : Limp-home (limited injection)



[Location]

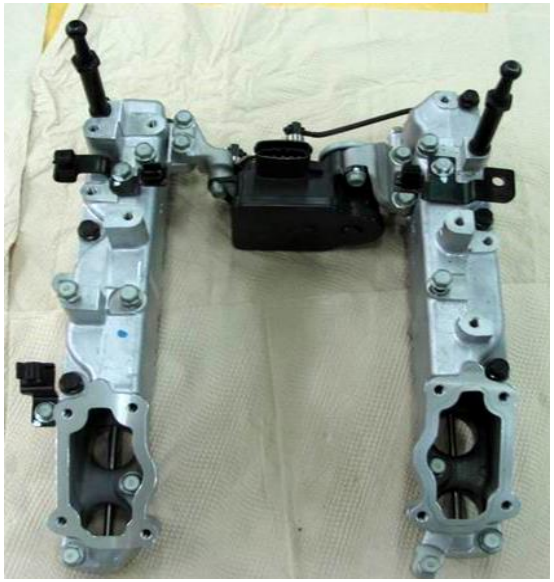


[Sensor output]

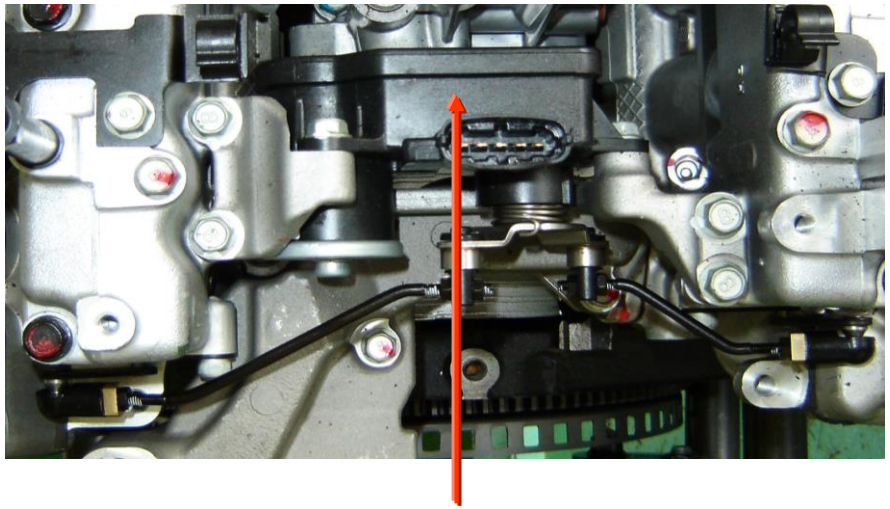
Lambda Sensor (EURO-4)

- Detects oxygen density of exhaust gas
- Accurate EGR control
- Injection amount correction
- Reduction of injection amount at engine full load condition to reduce smoke caused rich air-fuel mixture at high engine load condition.
- Failsafe : no EGR control, no injection amount correction

Swirl Control Valve (EURO-3/4)



[Replace as a set]



SCV Actuator

- Optimize intake air swirl condition according to engine load
- At low/Mid speed + low engine load : Increase the swirl for optimal combustion
  Increase EGR rate
  (valve closed → increasing swirl → reducing exhaust gas/power up/better fuel economy)
- At other engine conditions : valve opened → increasing inlet air flow → increasing torque

Swirl Control Valve (EURO-3/4)

- Valve flap : Normally open type

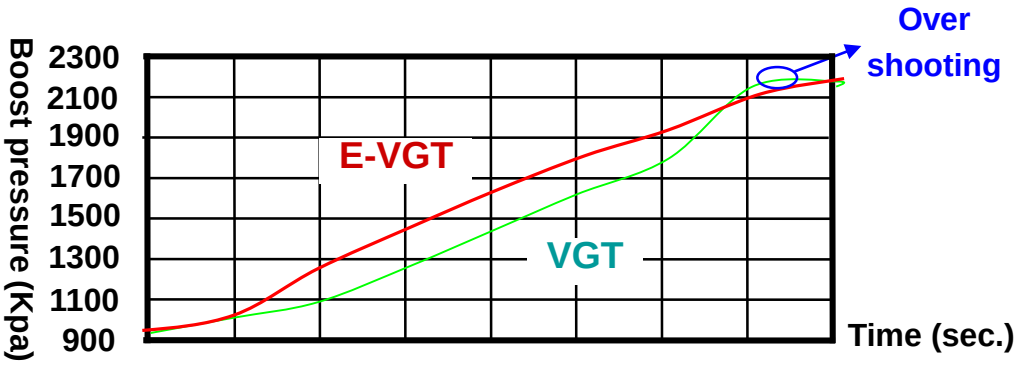
- Working ECT : over 70 degree celsius

- Initialization : for cleaning and learning of the max. & min. position

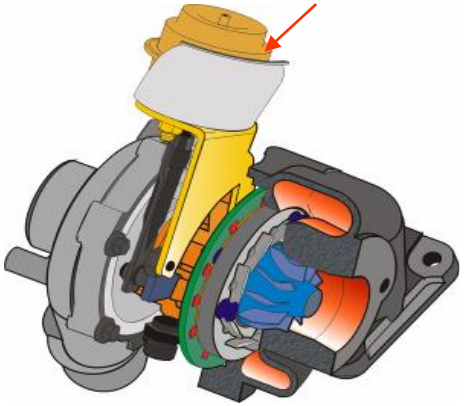
  Key off : Fully open ←→ Close (2~3 times)

Electronic VGT

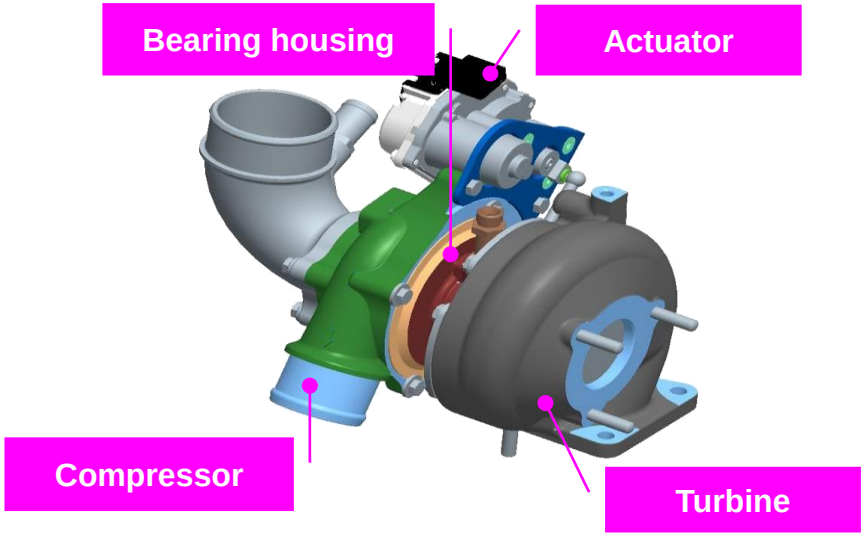
- Maker : Borg Warner (Actuator : Siemens VDO)
- Benefit : Stable intake air control (Less hysteresis)



Vane Control Actuator



[Vacuum type VGT]



[S-3.0 Engine EVGT]

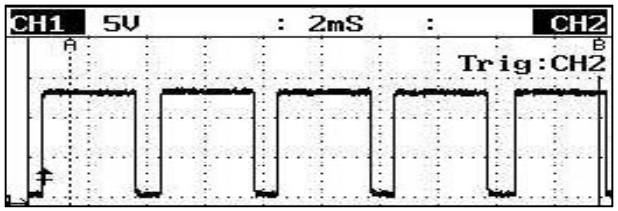
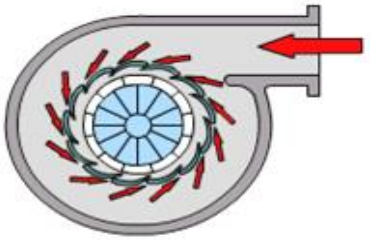
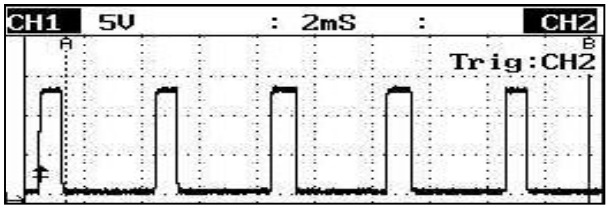
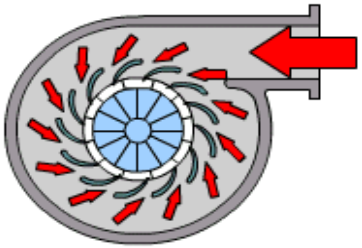
Electronic VGT

Operation

VGT is operated by control actuator. ECM decide target boost pressure by input data (engine RPM, APS, Boost pressure sensor, ECT, VSS), and control electronic motor actuator valve by PWM.

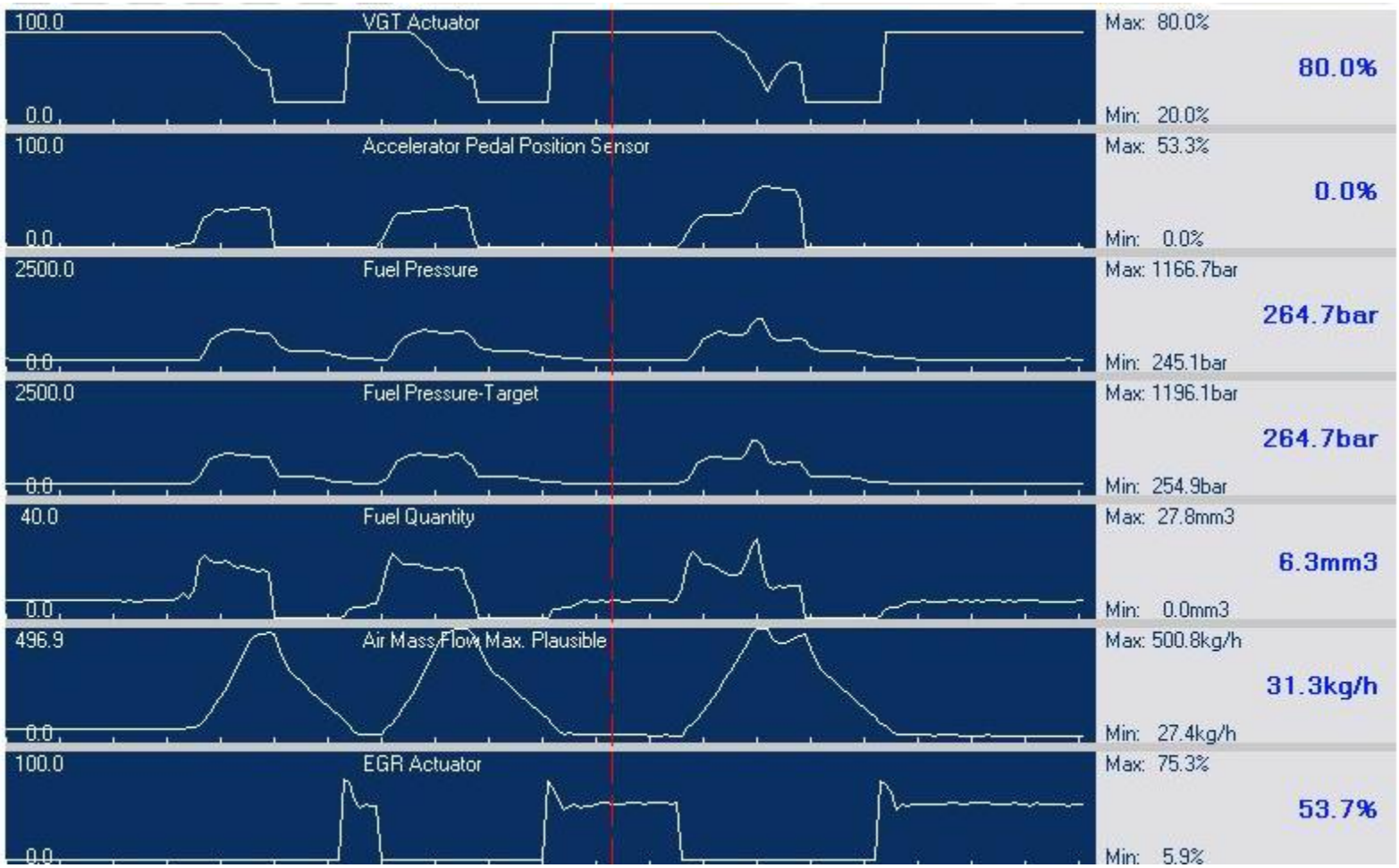
- Low speed : reduced exhaust passage → maximized speed energy (Remove turbo lag)

- High speed : exhaust passage is expansion → reduced exhaust pressure

Condition	Solenoid valve duty (+)	Actuator	Vane
Low speed Low load	80% 	Pull the rod	 Increased speed
High speed High load	20% 	Push the rod	 Increased quantity

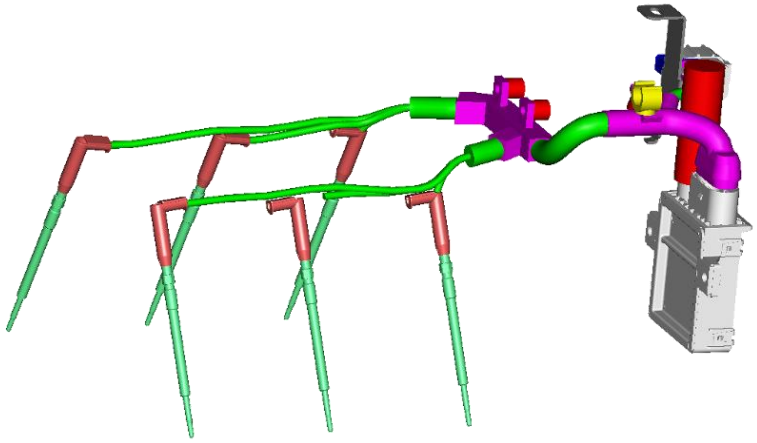
Electronic VGT

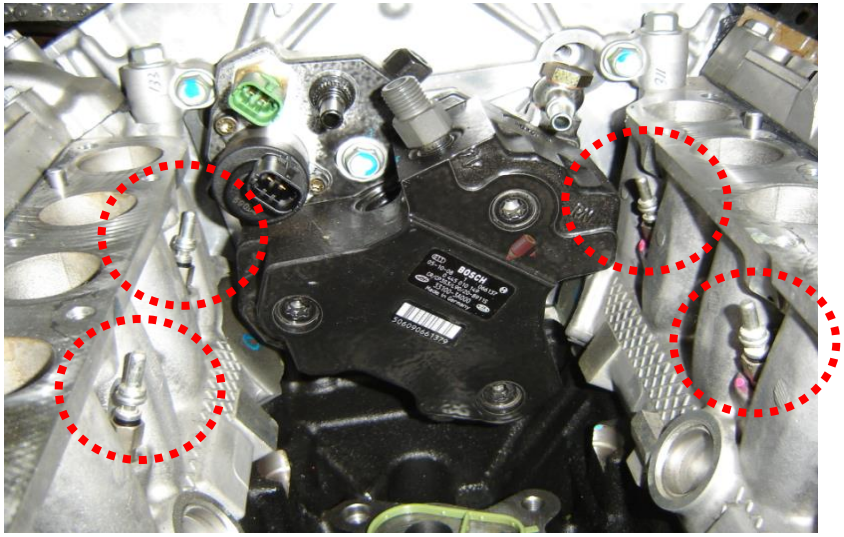
Current data



Glow System (ISS : Instant Starting System)

- Reduced Glow time : 2~3 seconds to 1000℃
- Glow time is decided by engine coolant temperature
- Self diagnosis function for each glow plug
- GCU (Glow Control Unit) can use CAN communication
- PWM control



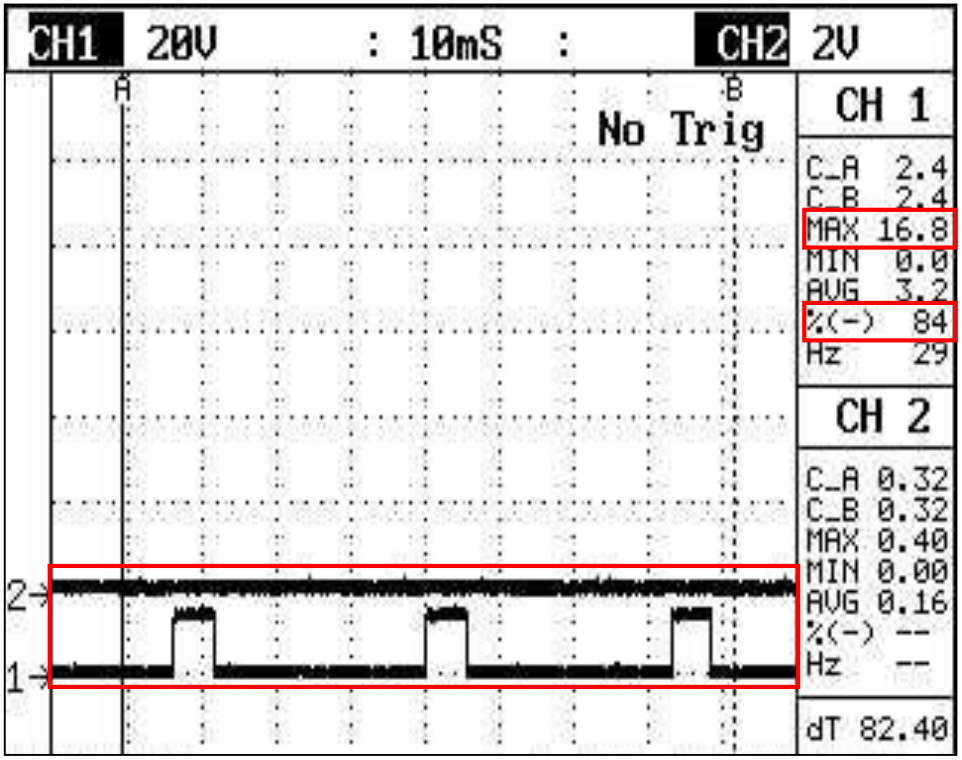


Glow System (ISS : Instant Starting System)

System comparison

Items		ISS	Conventional Type
Hardware	Heating time (1000℃)	Within 2 sec	Within 10 sec
	Operating voltage	4V ~ 12V	12V
	Power consumption	41W	97W
	At low battery voltage	Stable	Reduced performance
Software	Active control according to engine speed/load	Yes	No
	Communication with ECM	CAN	Relay
	Protect overheat function	G/P and GCU control	G/P control

Output signal



Glow System (ISS : Instant Starting System)