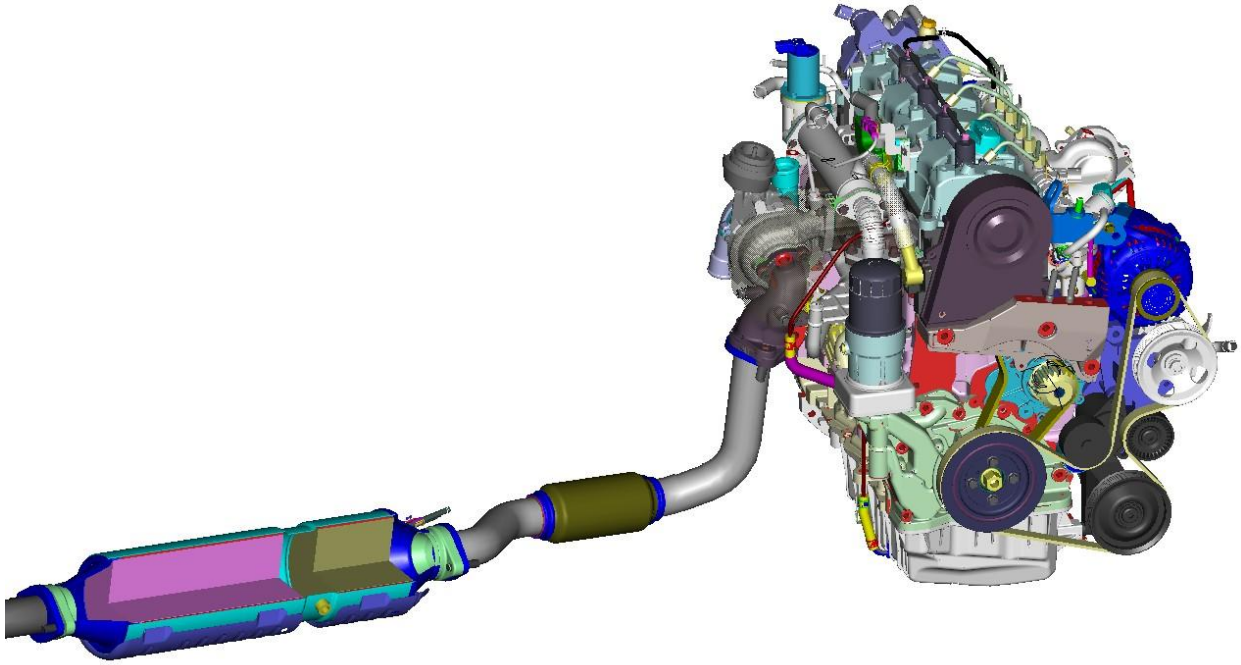
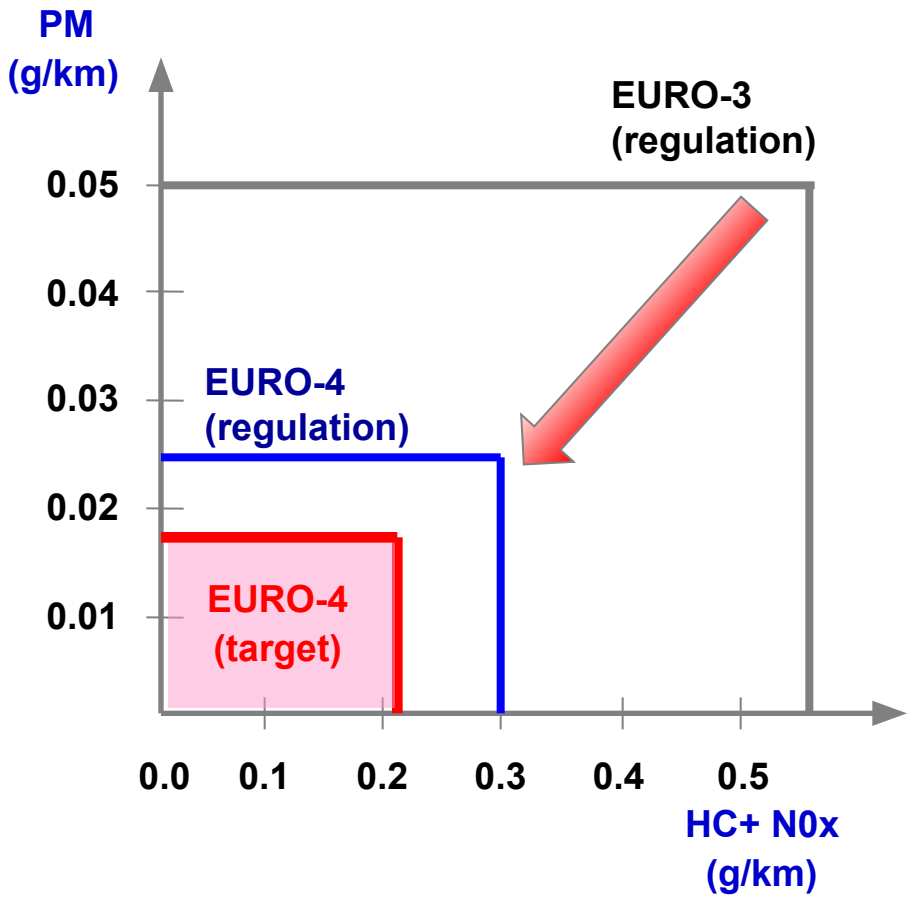
CM
D-2.2L Engine

(EURO-IV D-2.2L CRDi)



EURO III vs EURO IV

Developmental target for emission



① EURO-4 emission reduction potential compared with EURO-3

- PM : 50 % decrease
- NOx : 50 % decrease

② Developmental target

- 70 % of regulation

③ EURO-4 Availability

- New model : JAN.2005
- Existing vehicle : JAN.2006

EURO-IV corresponding technology

2nd GEN CRDi system
Injection Pressure : 1350 →1600 bar
ECU : 16 →32 bit

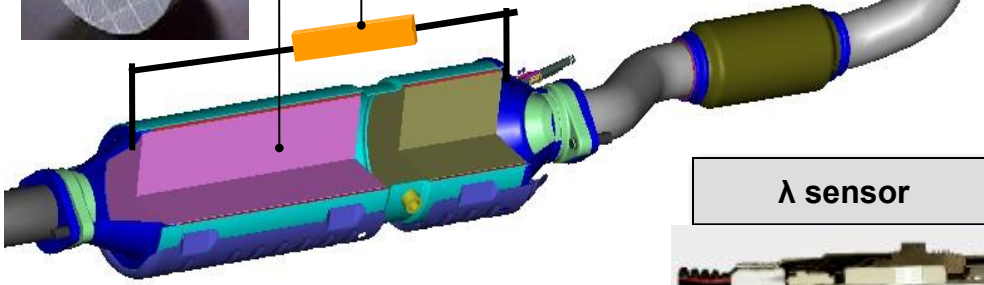
SCV(Swirl Control Valve)

ACV(Air Control Valve)

Water cooled EGR (electrical control)

CPF

Diff pressure & Temp sensor

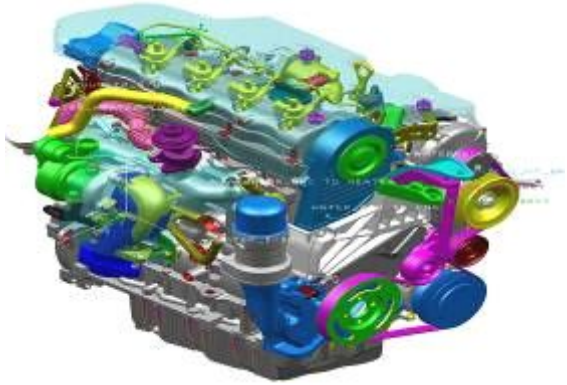


λ sensor

Comparative table (EURO-III vs EURO-IV)

Items		EURO-III	EURO-IV		Remark
Emission regulation	CO	0.64g/km	0.50g/km		
	Nox	0.50g/km	0.25g/km		
	HC	0.56g/km	0.30g/km		
	PM	0.05g/km	0.025g/km		
	soot	15%	10%		
ECM	Speed	16 bit CPU	32 bit CPU		
	Pins	121	154		
	Location	Internal	Engine room		Depending on vehicle
Λ(Oxygen) sensor		X	○		For EGR control
CPF(Catalyzed Particulary Filter)		X	U-Eng	-	Reduce PM
			D-Eng	○	
CPF Diff pressure & temp sensor		X	U-Eng	-	Detect internal pressure & temp
		X	D-Eng	○	
SCV(Swirl Control Valve)		X	○		Reduce smoke during low-mid
Fuel temp sensor		X	○		
Rail pressure control	MPROM	○	○		Inlet control – A, J Eng
	PCV(Pressure Control Valve)	X	○		Outlet control – D Eng
Injector	Multi-injection	1 Pilot, 1 Main	2 Pilot, 1 Main,2 Post		D-Eng: 2 Post injection
	Pressure	250~1350bar	250~1600bar		
	type	Classfied (C1,C2,C3)	7-code (IQA)		

D-2.0L vs D-2.2L

Engine	D-2.0 CRDi	D-2.2 CRDi
shape		
displacemnet	1,991 cc	2,188 cc
PS	125 PS	153 PS
Torque	29.0 kg·m	35.0 kg·m
Bore x stroke	83×92	87×92
Features	• BOSCH 1st GEN • Fuel pressure control - Outlet control - 1,350bar	• BOSCH 2nd GEN • Fuel pressure control - Inlet & outlet control - 1,600bar • Swirl Control Valve • Air Control Valve • Catalyzed Particulate Filter - Euro Ⅳ

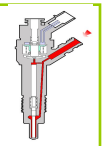
Input / output (EURO-III and EURO-IV)

- APS 1, 2
- Brake, clutch S/W
- CKPS & CMPS
- Boost pressure&temp sensor
- Fuel pressure sensor
- HFM5/HFM6
- Fuel temp sensor
- WTS, AFS
- Blower, A/C S/W
- A/C S/W
- λ sensor
- DPF diff & temp sensor

BOSCH ECM

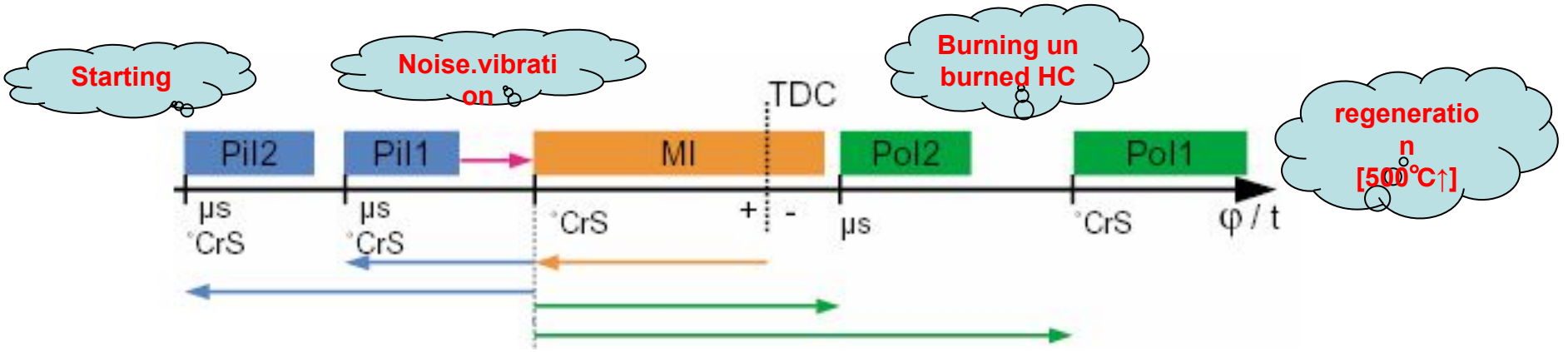
EURO-III

EURO-IV

- Injection 
- Rail pressure control
  - inlet
  - outlet
- EGR control
- SCV control
- Cooling fan control
- A/C comp relay
- PTC control
- Glow plug control
- ACV control
- CAN/K-line
- MIL/glow lamp

※ shadow=> EURO4

EURO-IV injection



type	Injection timing		Purpose
	Max advanced	Max retard	
Pilot2	BTDC 100º	SOE(Pil1)+150 μs + ET(Pil2)	starting
Pilot1	BTDC 100º	SOE(MI) + 150 μs + ET(Pil1)	Reducing smoke NVH
Main	BTDC 40º	ATDC 10º	Improving torque
Post2	SOE(MI) + ET(MI) + 150 μs	ATDC 40º	Increasing CPF temp
Post1	ATDC 40º	Next cylinder max. advanced	Activate oxidation catayst (burning soot)

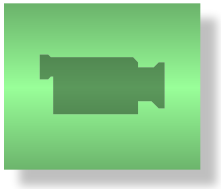
SOE (Start Of Energizing) ET (Energizing Time)

Burning procedure for diesel engine

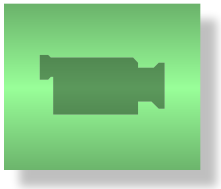
Flame depending on pilot injection or not

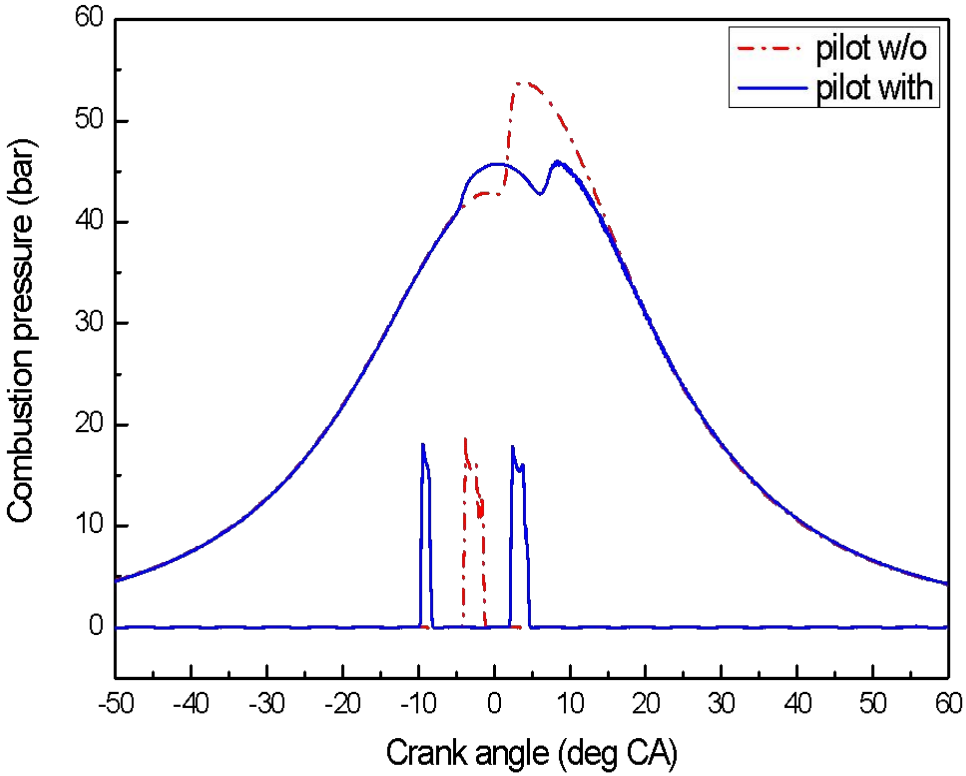
Injection volume : 7mg
Fuel pressure : 1000bar
RPM : 1000rpm
Injection timing : BTDC 22

Without pilot injection



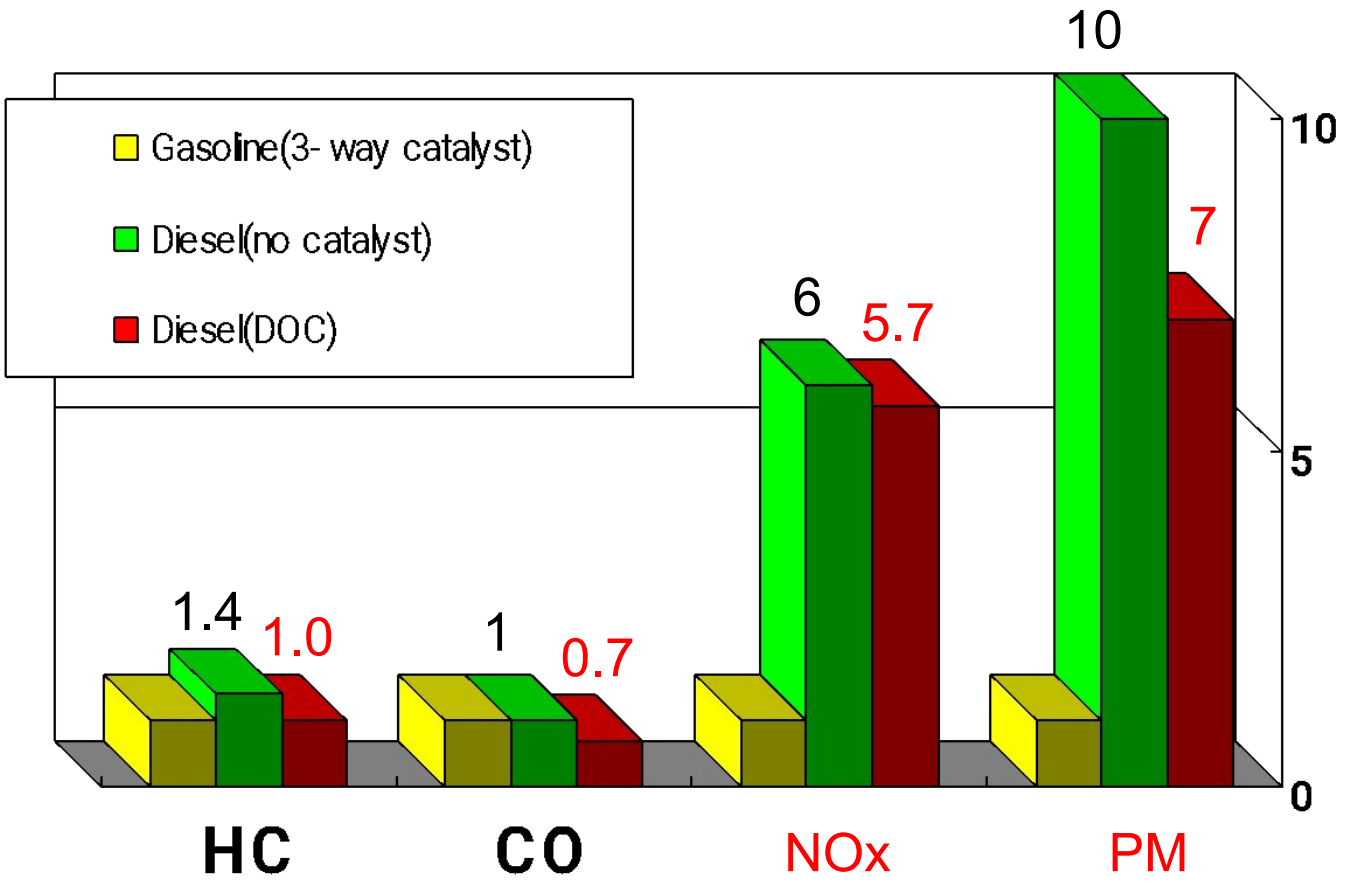
With pilot injection





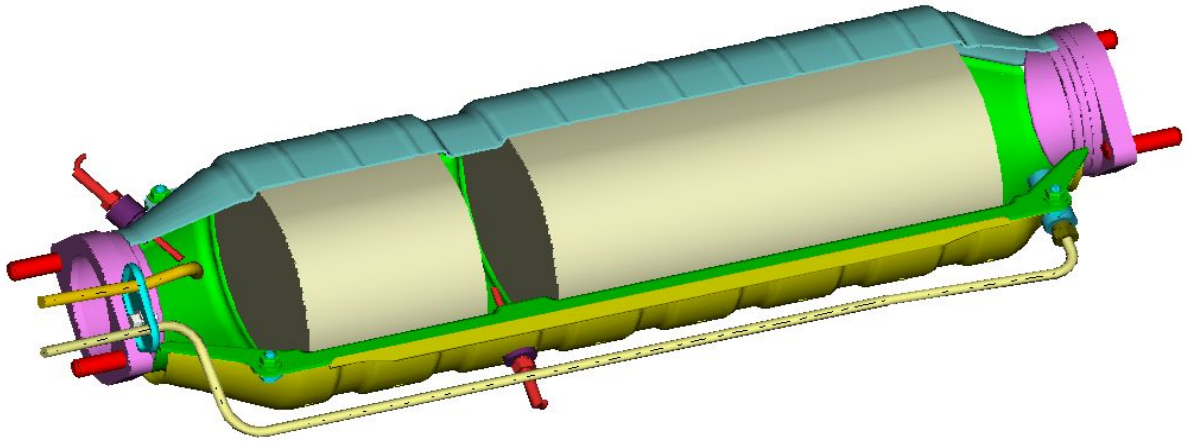
Diesel exhaust gas

* PM : Particulate Matter



- Heart of aftertreatment is reducing **Nox** & **PM**

CPF
(Catalyzed Particulate Filter)



What is PM (Particulate Material or Matter)

Specialty Definition: PARTICULATE MATTER

Energy

Unburned fuel particles that form smoke or soot and stick to lung tissue when inhaled. A chiefcomponent of exhaust emissions from heavy-duty diesel engines. (PM).

Environment

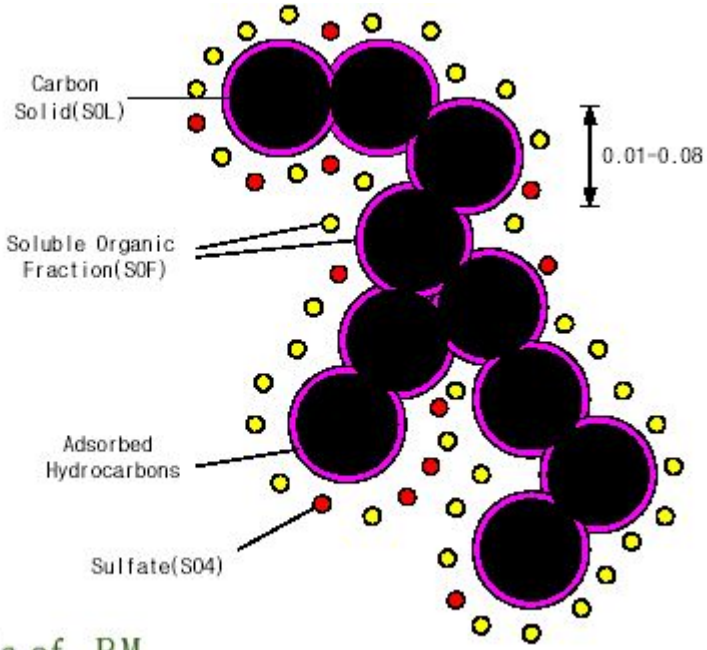
Dust, soot, other tiny bits of solid materials that are released into and move around in the air.

Weather

(PM) Solid particles or liquid droplets suspended or carried in the air (e.g., soot, dust, fumes, mist) . Very small pieces of solid or liquid matter, such as particles of soot, dust, aerosols, fumes, or mists.

Components of PM

The main component of PM is the unburned carbon solid particleof 15-30nm diameter, gas phase-from fuel and partly from lubricant, and all named as fines, dust, soot, mist, fog, and smog are a part of PM.



Components of PM

SOL (Solid fraction) *: elemental carbon / ash*

SOF (soluble organic fraction) *: organic material from engine oil and fuel*

Absorbed Hydrocabons

Sulfate *: sulfate acid / water*

Soot(carbon material)

Catalystic converter terms

- **Kinds of catalystic converter depending on location**
  - MCC (Manifold Catalytic Converter)
  - CCC (Close-Coupled Catalytic Converter)
  - WCC (Warm-up Catalytic Converter)
  - UCC (Under-floor Catalytic Converter)

- **Components of catalystic converter**
  - **Washcoat :** coating material including catalyst. Mainly Al_2O_3 is used.
  - **Substrate :** honeycomb shape which is coated by washcoat.

    Exhaust gas pass through this. Effect of reducing exhaust gas is different depending on shape or thickness of substrate.
  - **Support :** support the substrate by using STS wire or matt.

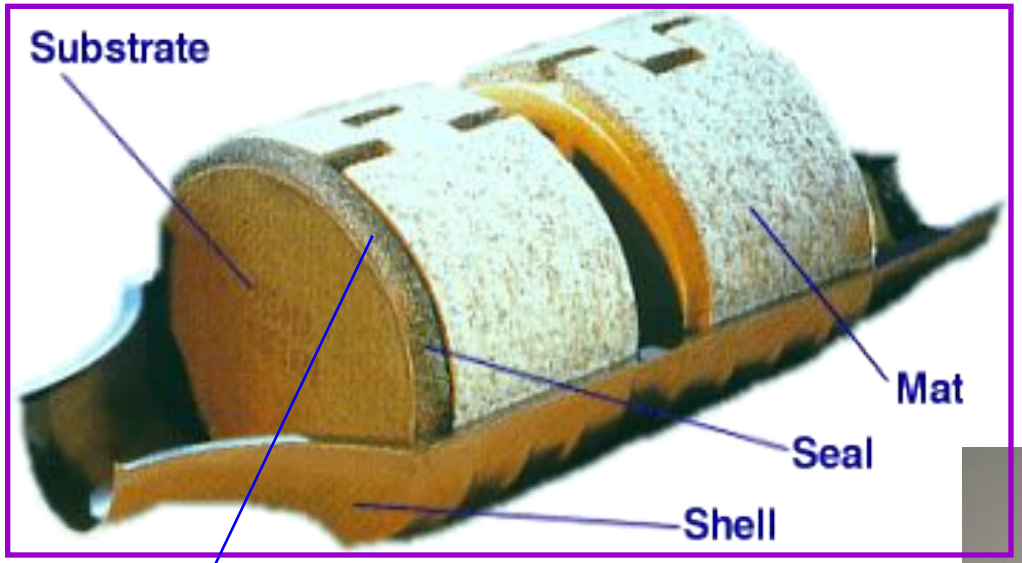
MCC

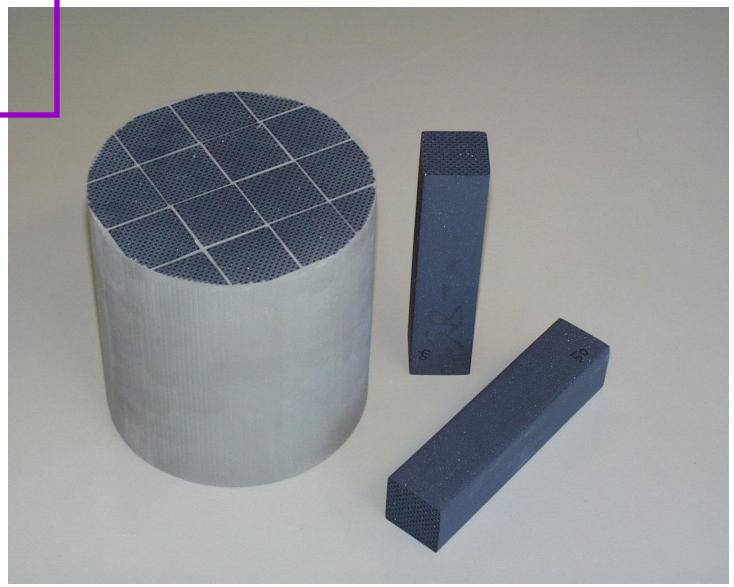
CCC

WCC

UCC

Catalystic converter terms

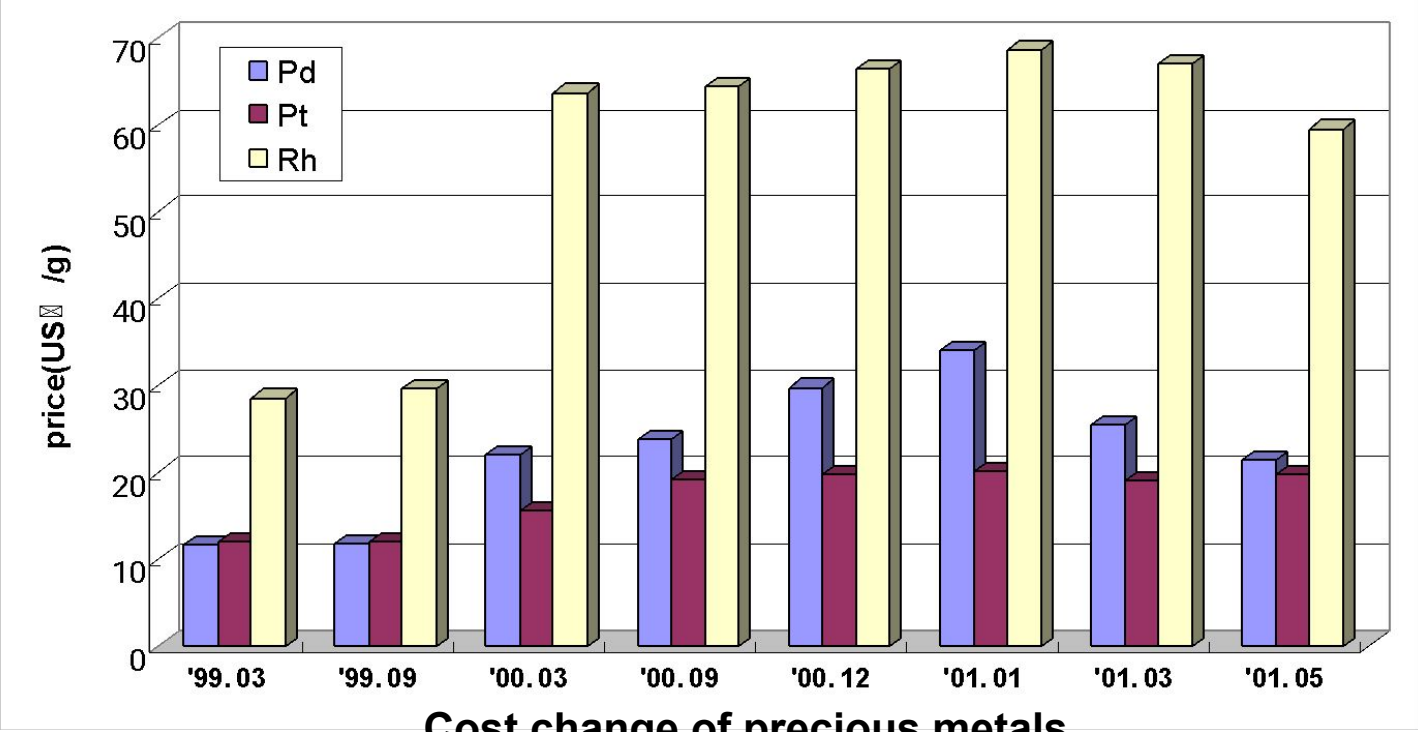




Substrate

Precious metals for vehicle

- **Pd :** Purify HC mainly. Thermal resistance is good. Using in CCC
  using as Pd only or Pd-Rh
- **Pt :** Purify CO, Nox mainly. Thermal resistance is lower than Pd□ using in UCC
  using as Pt-Rh or Pd-Pt-Rh
- **Rh :** purify Nox mainly.price is much higher than Pd, Pt



Cost change of precious metals

Catalyst Deactivation Mechanism

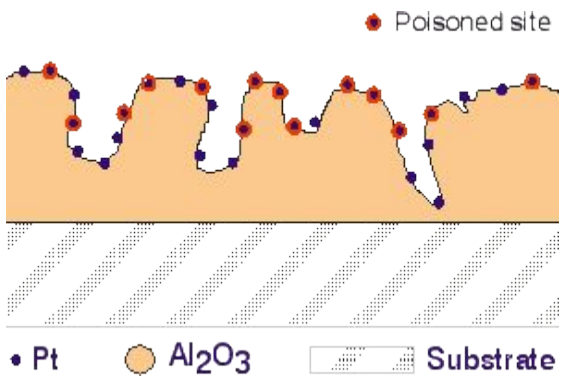
- **Poisoning**

Selective Catalyst Poisoning

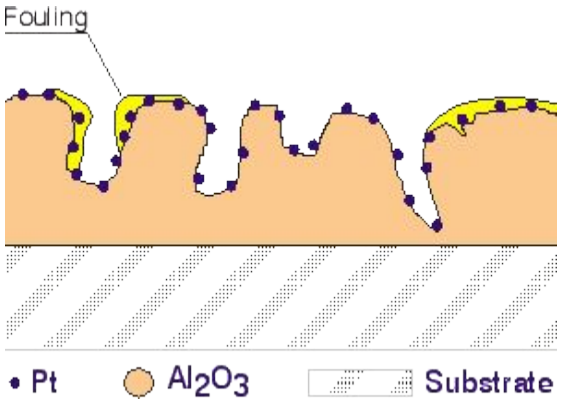
- poisoning by Pb, Hg, Cd
- deactivation by SO_2
- recovery by thermal treatment, washing

Catalyst Fouling

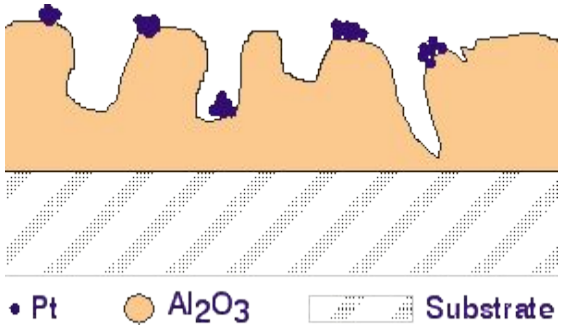
- nonselective poisoning, masking
- by P (engine oil)



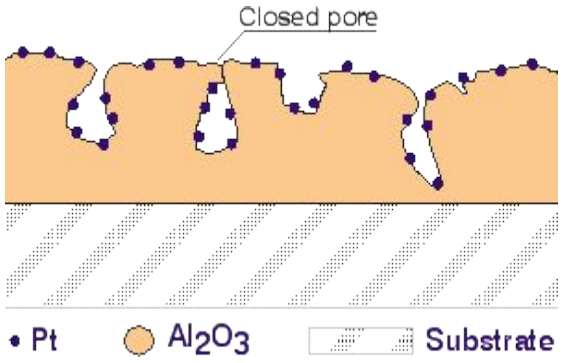
Selective Catalyst Poisoning



Catalyst Fouling



Catalyst Sintering



Washcoat Sintering

- **Thermal Deactivation**

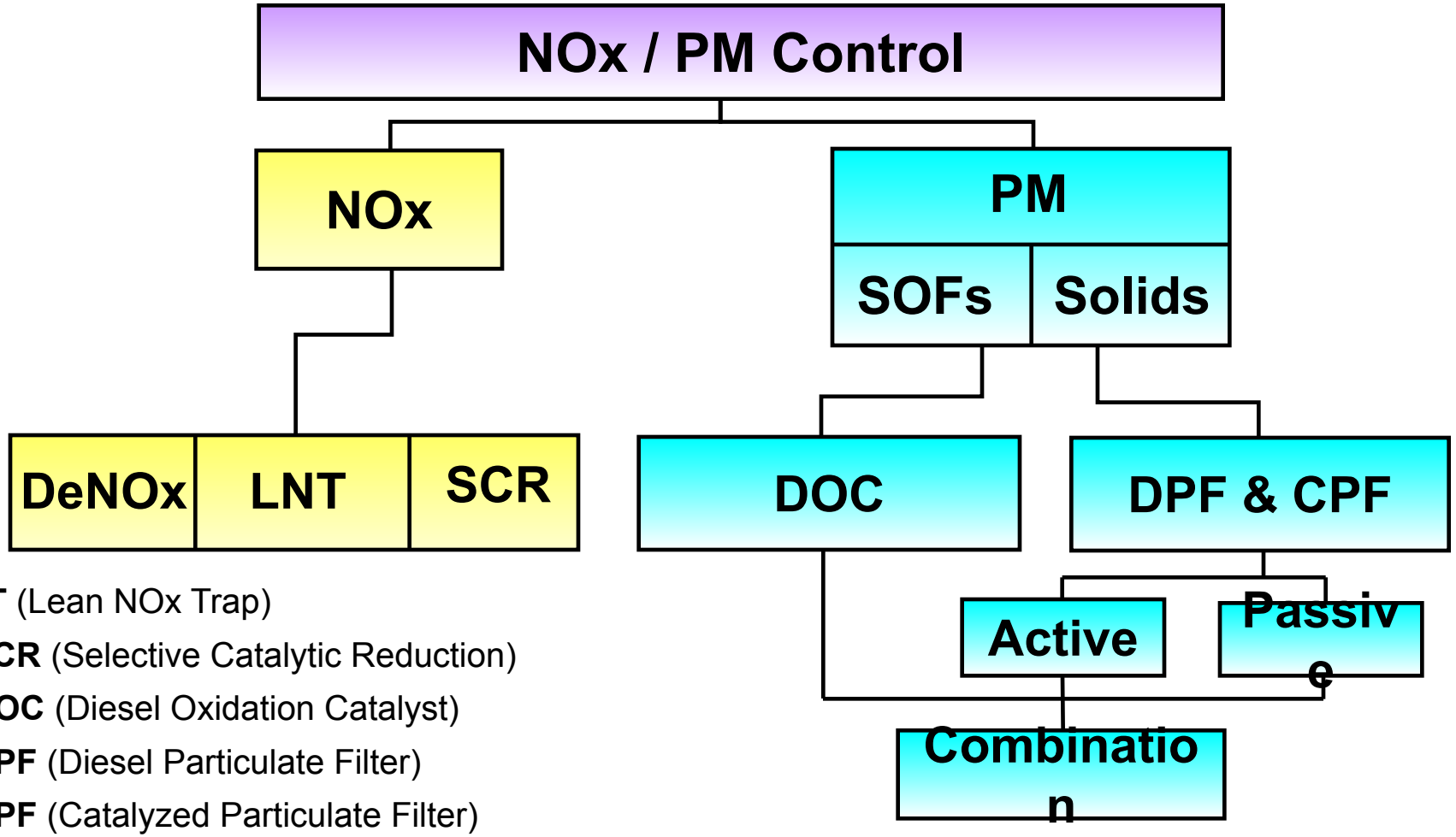
Catalyst Sintering

- sintering, cohesion of precious metals
- using Stabilizer CeO_2, La_2O_3

Washcoat Sintering

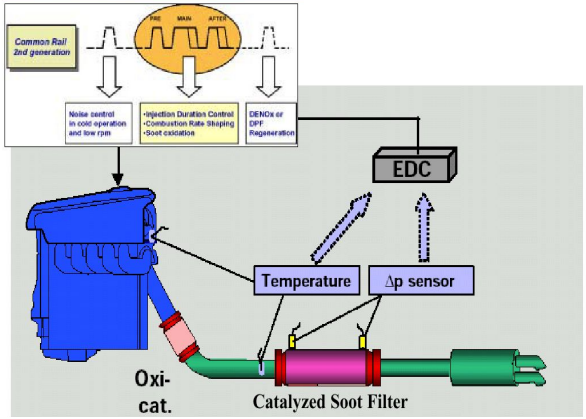
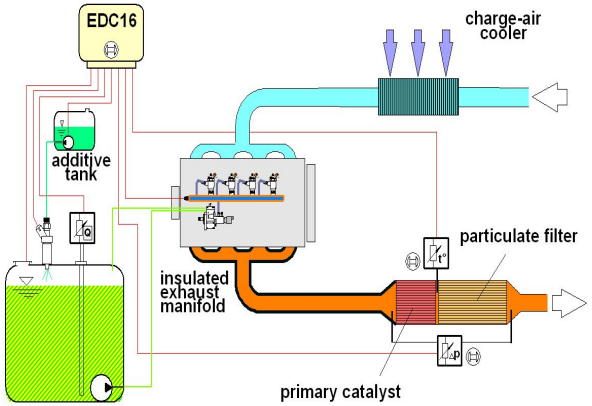
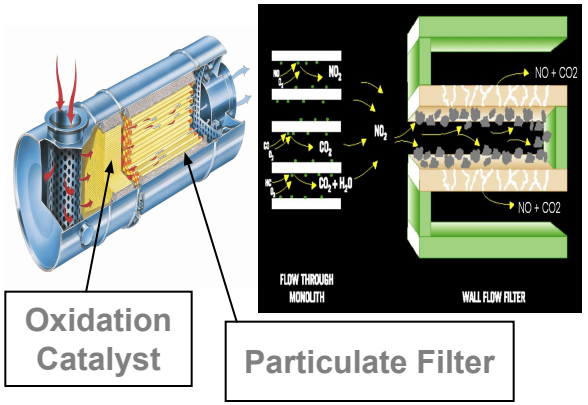
- using Stabilizer BaO, La_2O_3, SiO_2, ZrO_2

Diesel aftertreatment

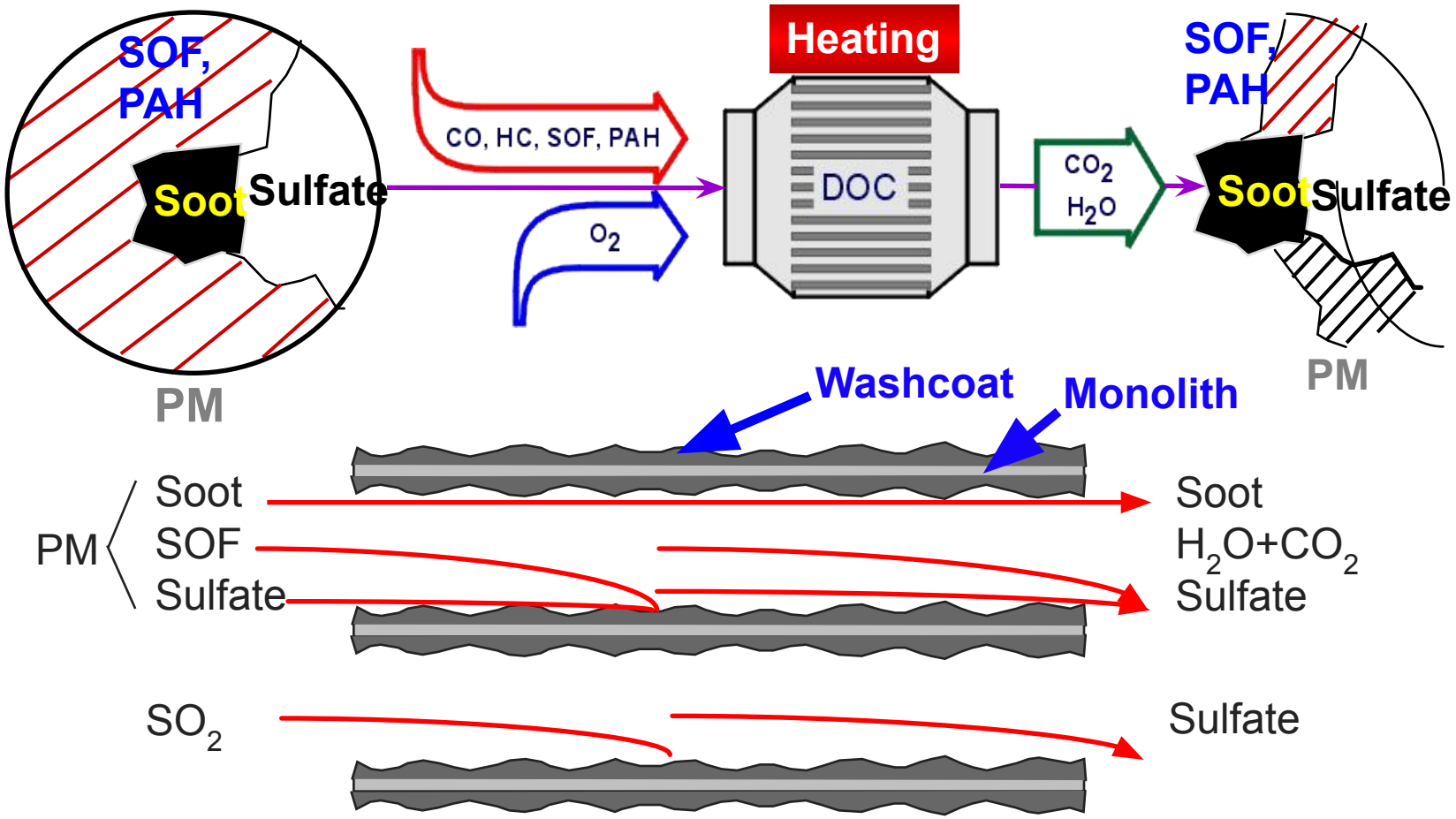


- **LNT** (Lean NOx Trap)
  SCR (Selective Catalytic Reduction)
  DOC (Diesel Oxidation Catalyst)
  DPF (Diesel Particulate Filter)
  CPF (Catalyzed Particulate Filter)
  SOF(Soluble Organic Fraction)

PM reducing device

PM reducing device		
CPF (Catalyzed Particulate Filter)	**DPF+Additive (Diesel Particulate Filter)**	**CRT (Continuously Regenerating Trap)**
		
▸ Burning a soot by post injection & oxidating a soot by using activation of coated catalyst (using NO_2) ▸ Simple system (no special fuel adding device) ▸ **need a strategy of controlling regeneration temp.** ▸ Problem (recovery of waste DPF & cleaning)	▸ Burning the soot by post injection & cerium-based additive(around 450℃, at every 500km forced regeneration) ▸ sophistcated system(fuel adding device) ▸ **Problem (lots of** CO emission)	▸ Burning the soot continuously by oxidated NO_2(through DOC), without post injection ▸ On the testing at bus(LONDON) ▸ impossible to adapt to passenger vehicle (exhaust gas temp is too low)
▸ adapted to almost European passenger diesel	▸ Peugeot, Volkswagen, FORD	▸ adapted to commercial diesel

DOC (Diesel Oxidation Catalyst)



- **Efective to reduce CO/HC and SOF**
  (SO2 is changed to sulfate))

** **SOF**(Soluble Organic Fraction)

PAH(polycyclic aromatic hydrocarbon)

WHAT IS CPF?

□ CPF (Catalyzed Particulate Filter)

● Principle

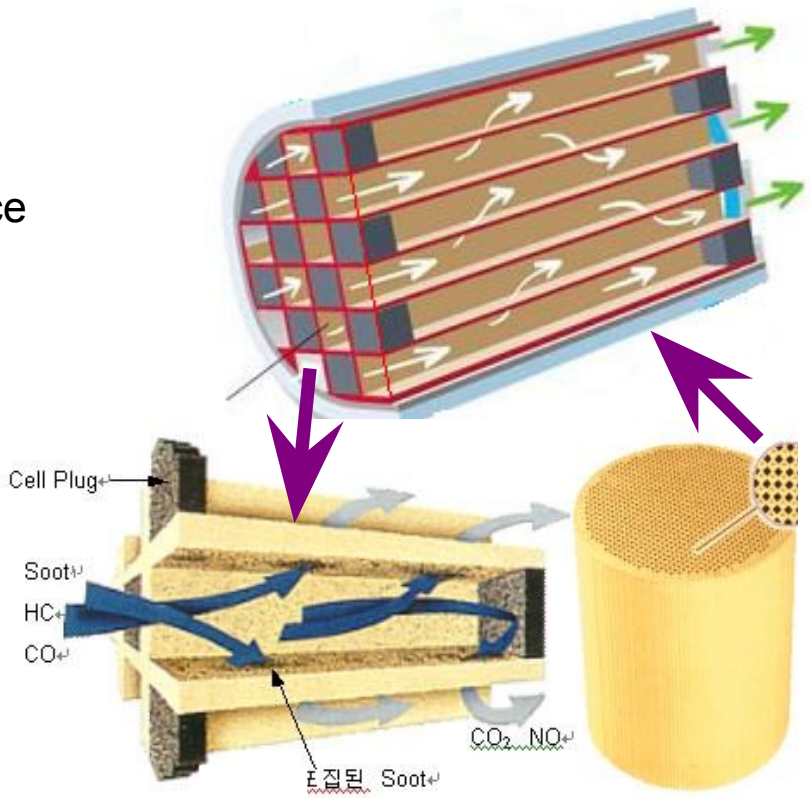
(1) Trapping the PM(Particulate Material)

(2) Burnig the trapped PM at regular driving distance (Increasing a PM burning temp. over 550℃)

(3) Ash is accumulated in a filter

Some maker have a separate Service strategy

(Peugeot 607 : repairing the filter from peugeot company at 80,000km free of charge



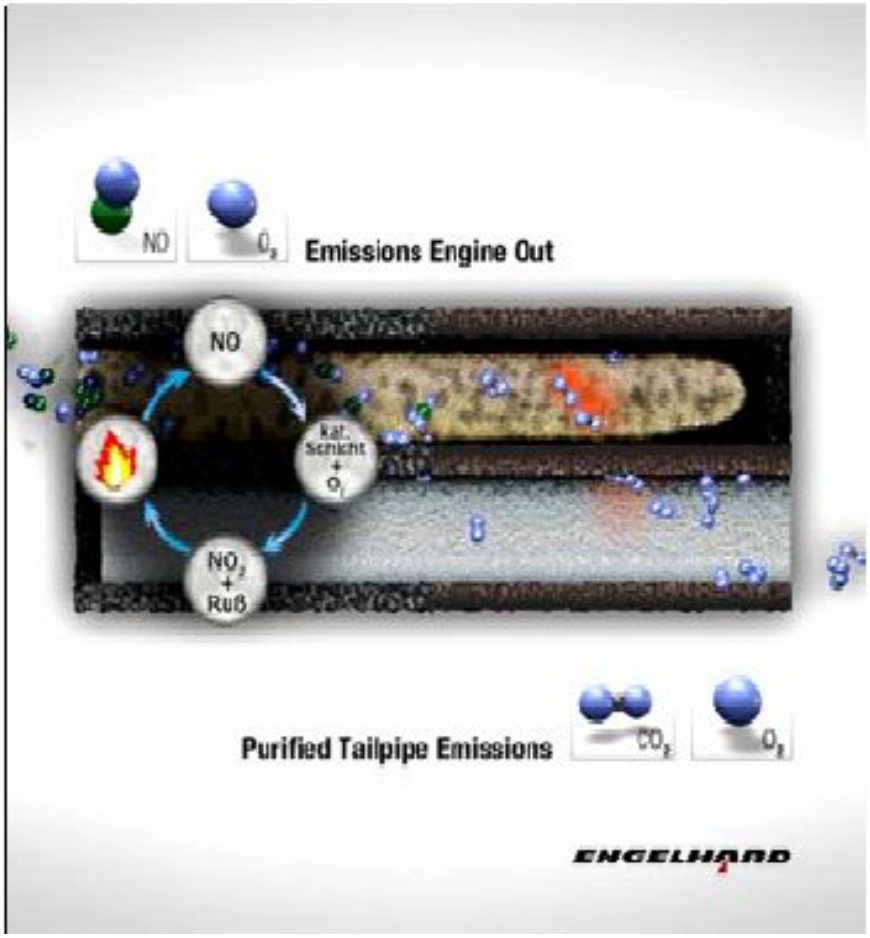
● Developmental background

(1) Correspond to EURO- 4 emission regulation

Reducing Nox : by electrical EGR & EGR cooler

Reducing PM : by DOC & filter

CPF passive soot regeneration



$C(soot) + NO_2 \rightarrow CO/CO_2 + NO$

$NO + O_2 \rightarrow NO_2$

NO_2 turn over :

(by using NO_2 □ 2~4 C burning)

$C(Particulate) + O \rightarrow CO/CO$

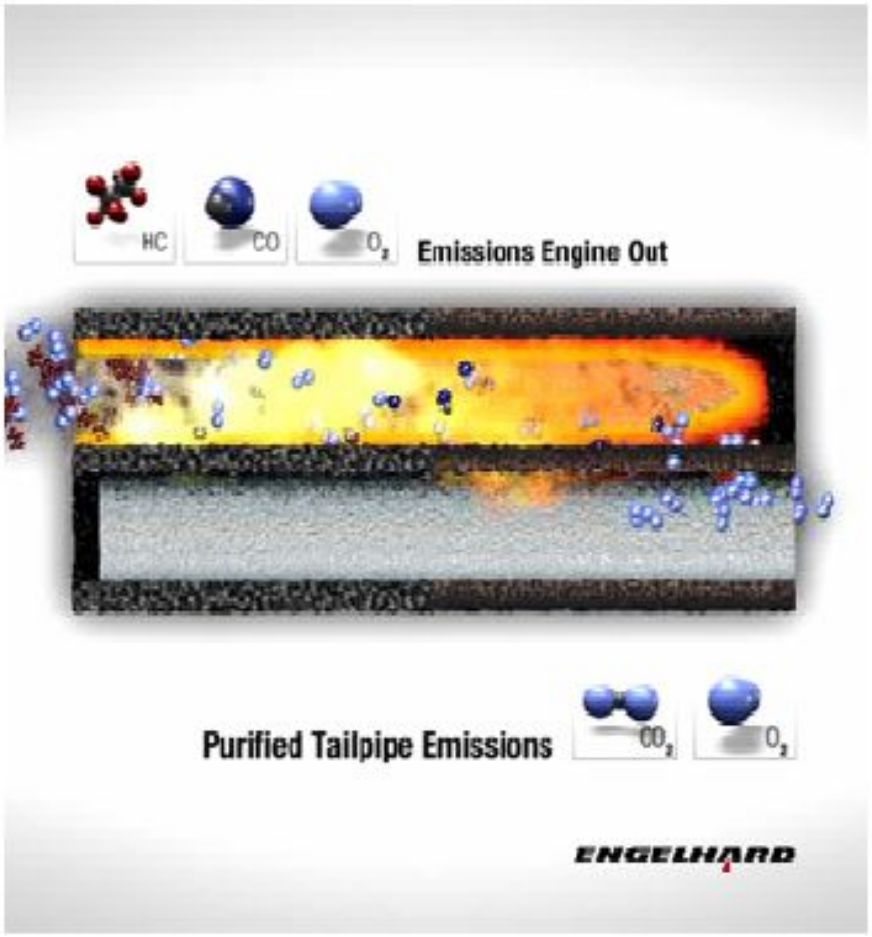
$CO + O_2 \rightarrow CO_2$ *(CO from soot)*

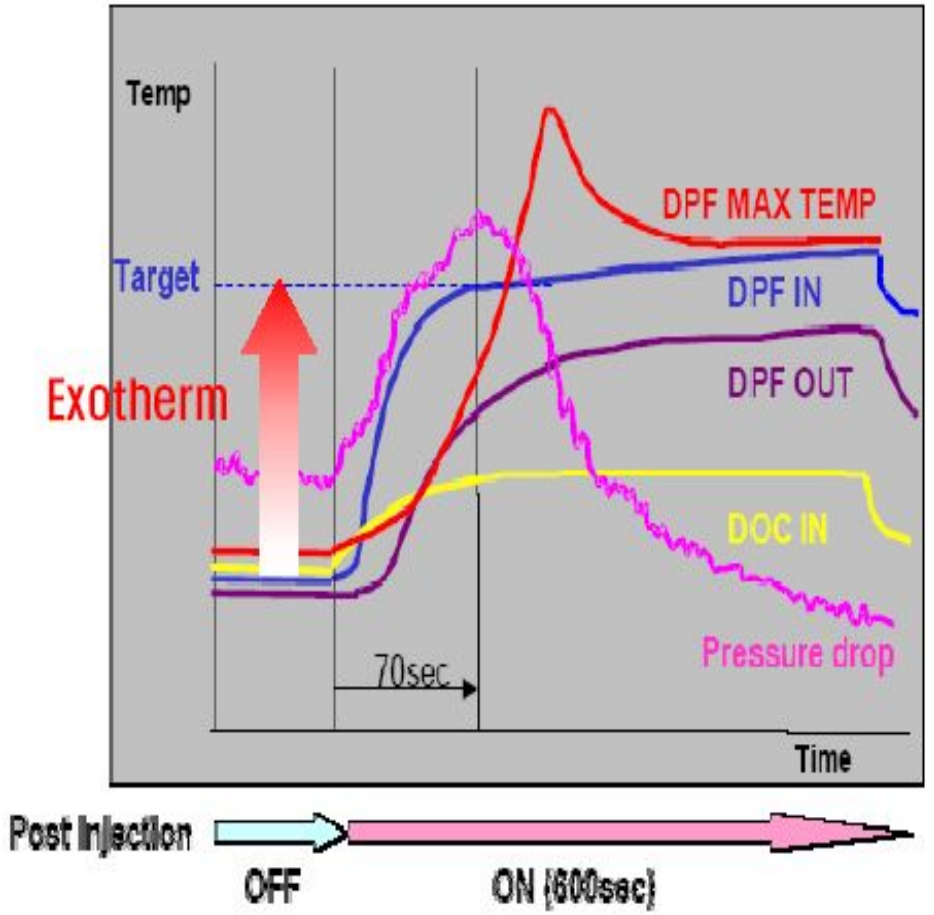
$HC,CO + O_2 \rightarrow CO_2 + H_2O$
(residual gaseous HC,CO)

** Passive : without any additive mechanism

Active : with additive mechanism (post injection)

CPF active soot regeneration





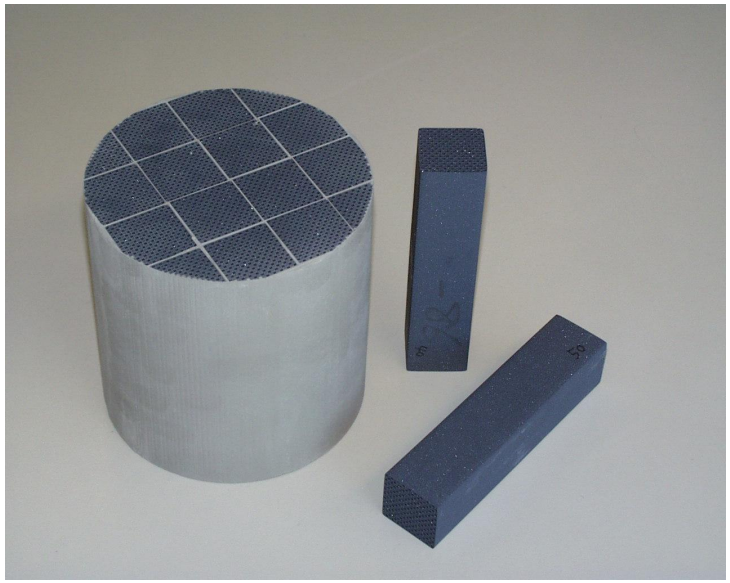
- Increasing temp. of exhaust gas through post injection and DOC □ burning soot

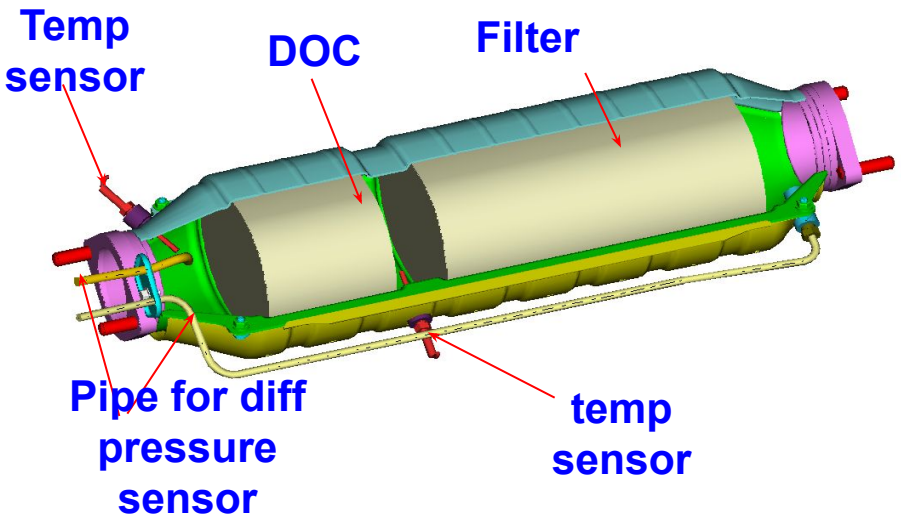
Shape & structure

- **Filter**

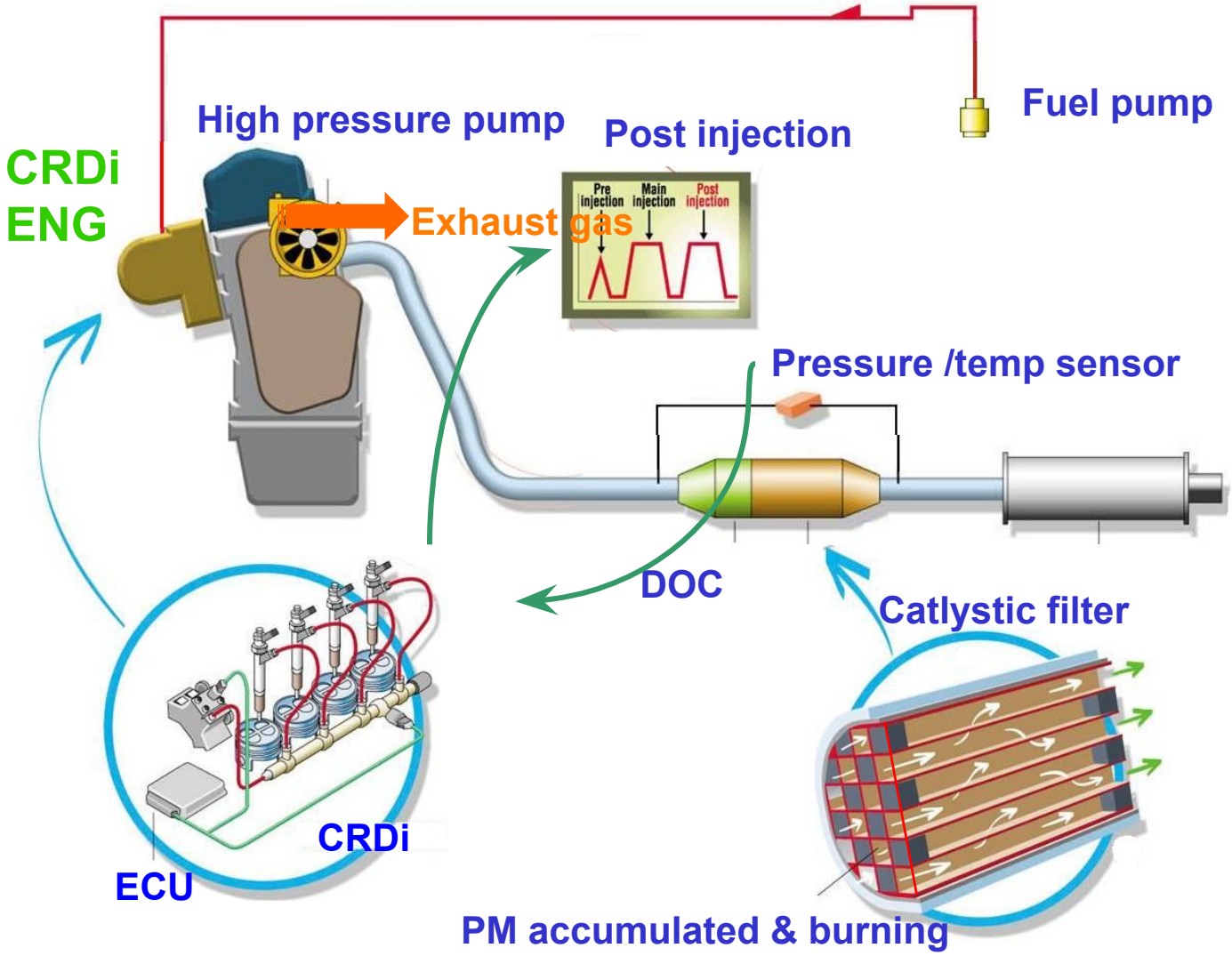
  Squre pillar

- ✔Filter: Trapping & regeneration
- ✔DOC: Improve condition of PM regeneration
- ✔Temp sensor: checking the temp for regeneration
- ✔Diff pressure sensor: decide a regeneration (detecting the loss pressure)



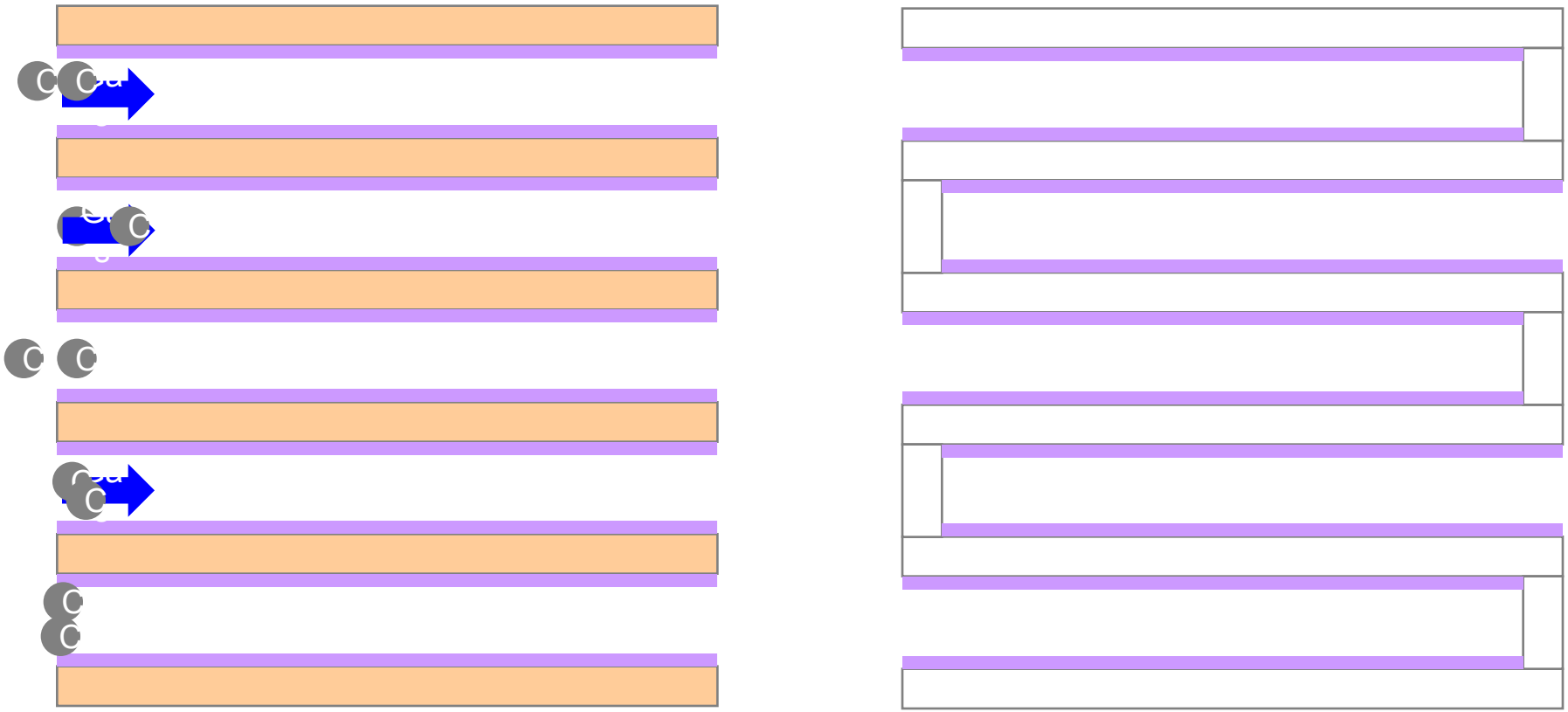


System overview



Regeneration procedure

1. Accumulating ash



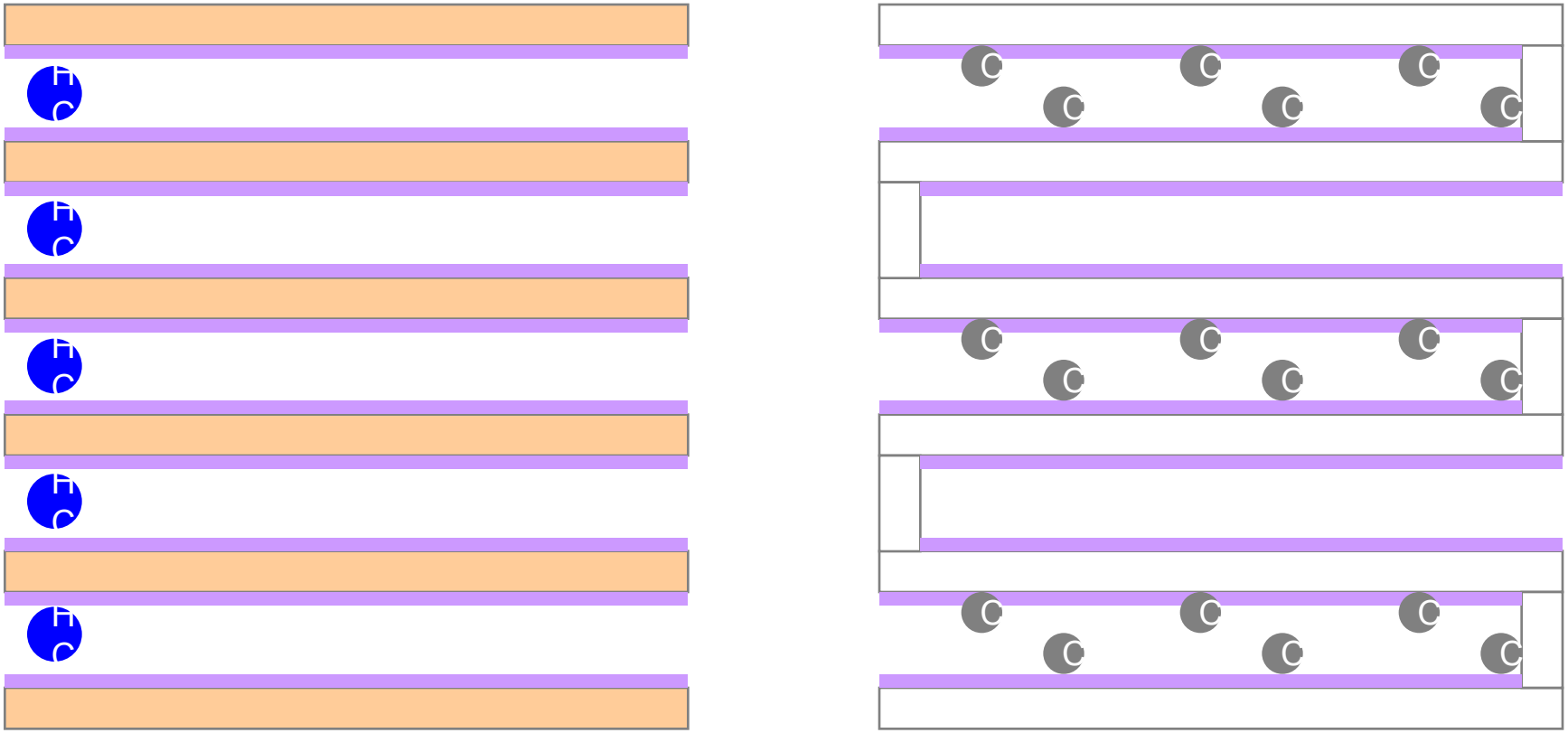
DOC

Catlalys t coating

Catlayst filter

Regeneration procedure

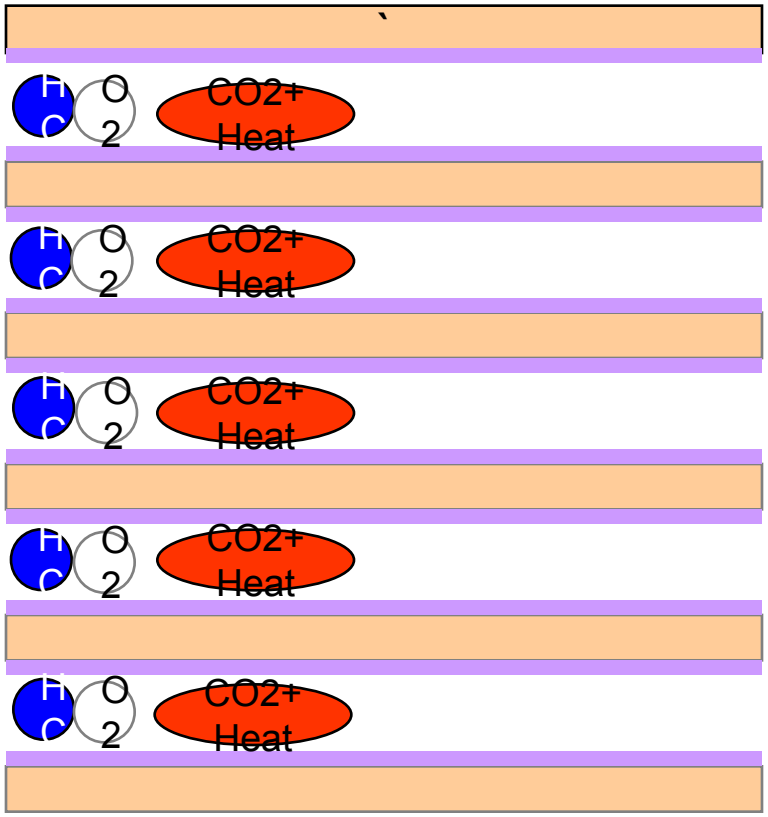
2. Increasing exhaust pressure & post injection

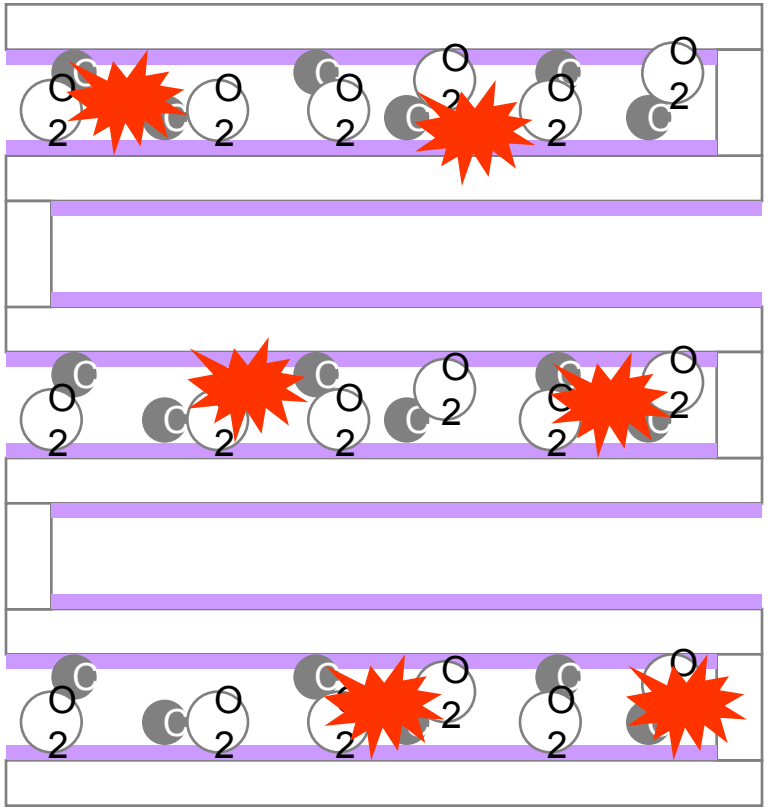


sens or → ECU → INJ pump

Regeneration procedure

3. PM regeneration

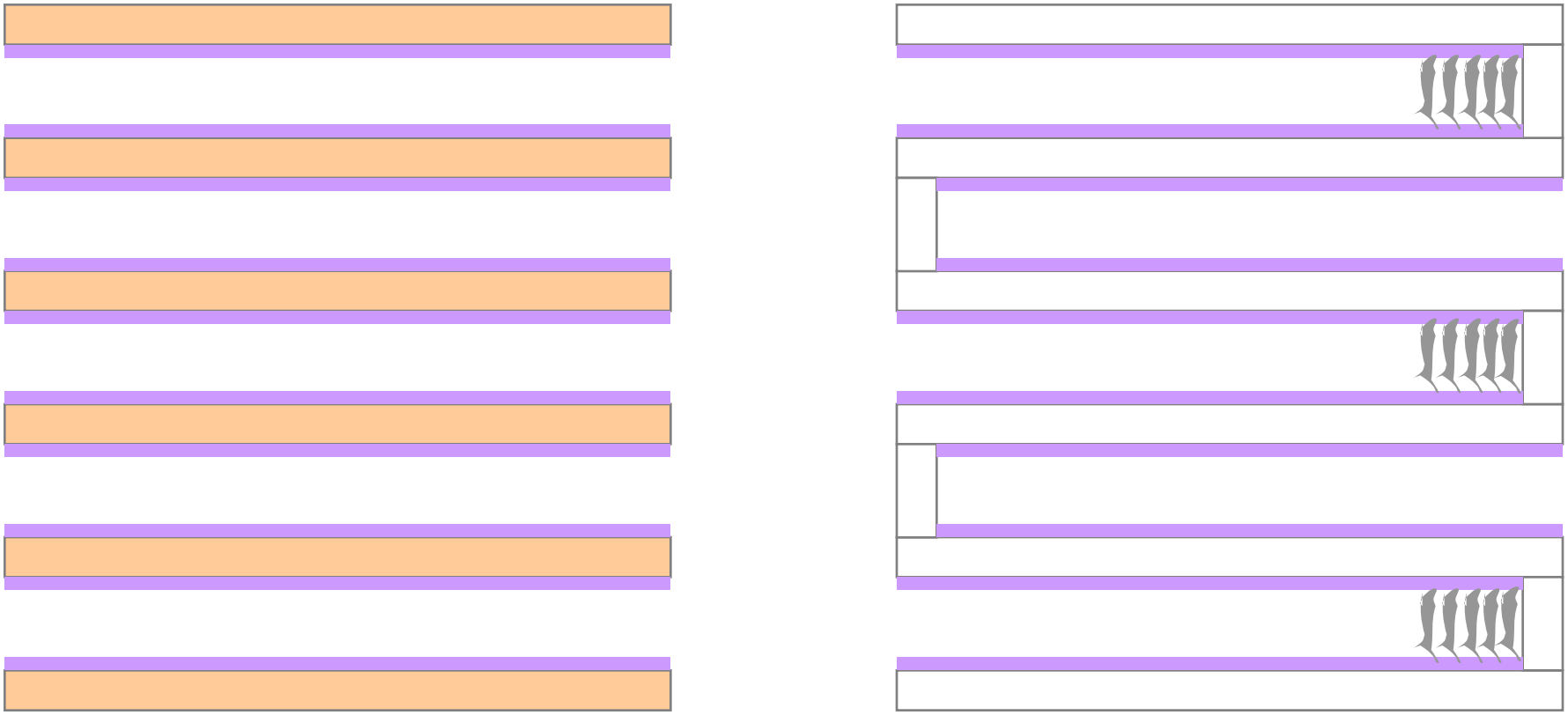




- Exhaust temp is increased by post injection
- DOC adjust the exhaust temp (regeneration temp)
- PM is regenerated and filter temp is increasing

Regeneration procedure

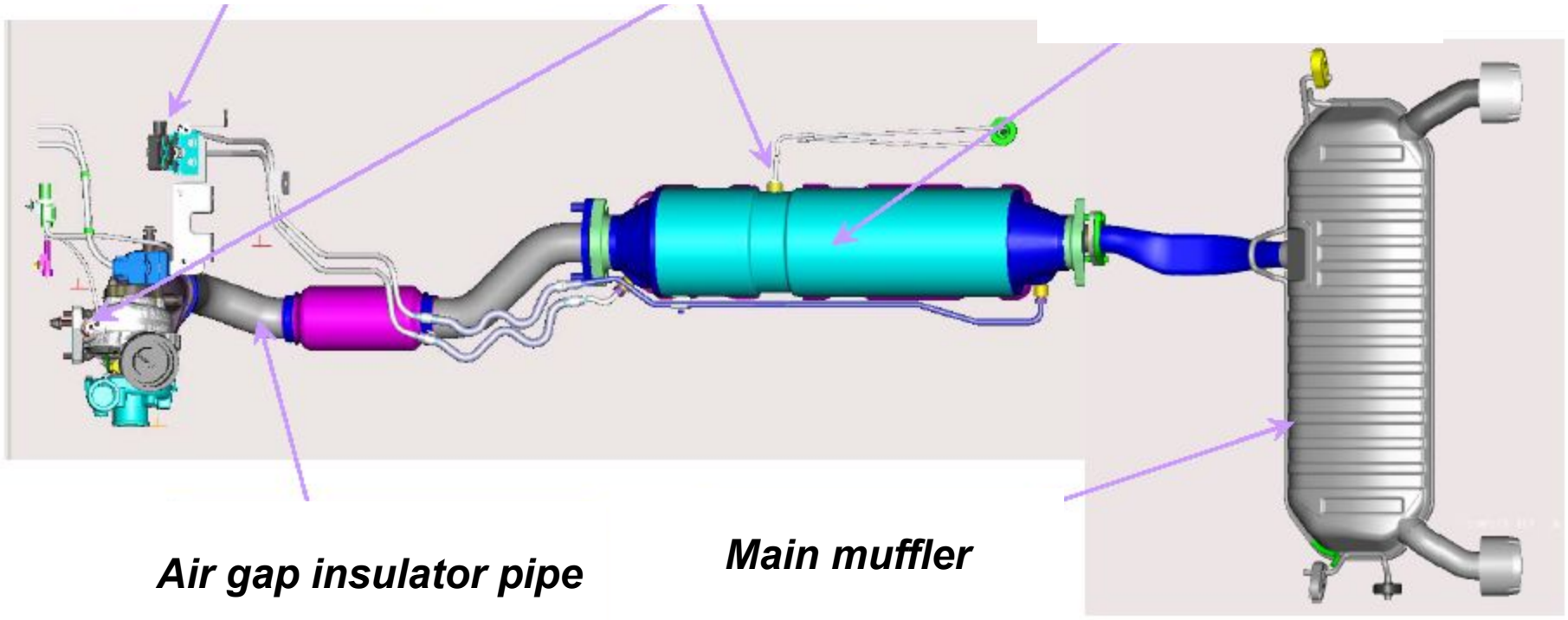
4. re-accumulating ash



Ash is accumulated by unburned fuel/oil

How fast ash is accumulated in the filter that is point

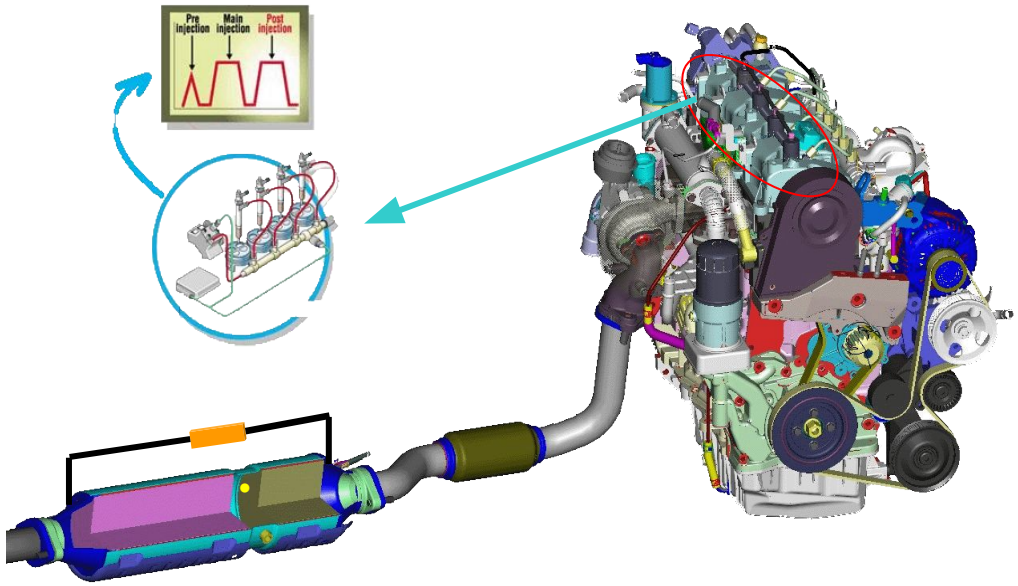
KM & JM exhaust system overview



CPF regeneration condition

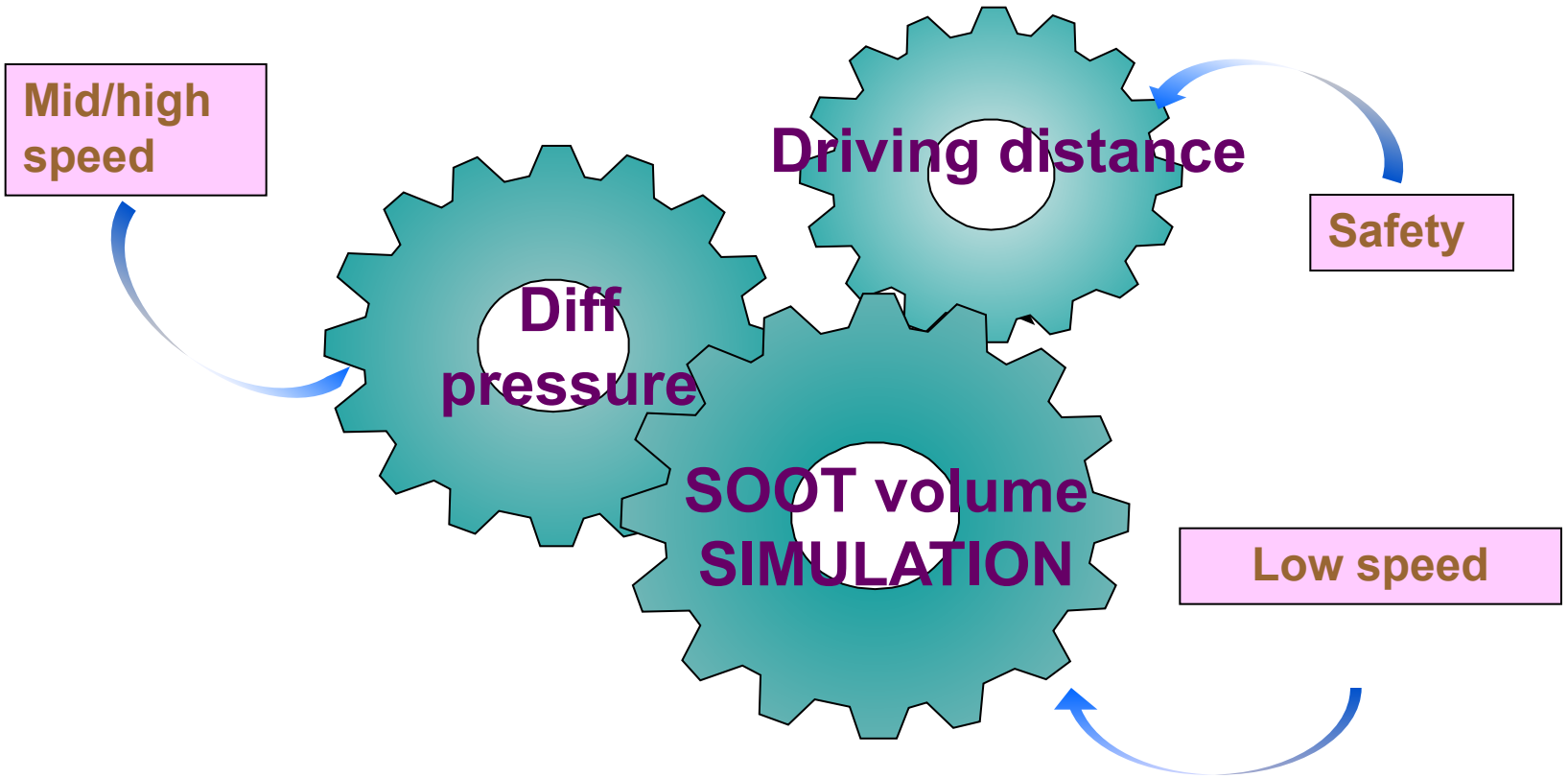
Regeneration mode condition

- Drving distance: every 1,000km
- Engine RPM: 1,000RPM ~ 4,000RPM
- Engine load: around 0.7bar(over 8mg/st)
- Vehicle speed : over 5km/h
- Water temp : over 40℃



Notice) shock or noise may occurred by changing torque during regeneration

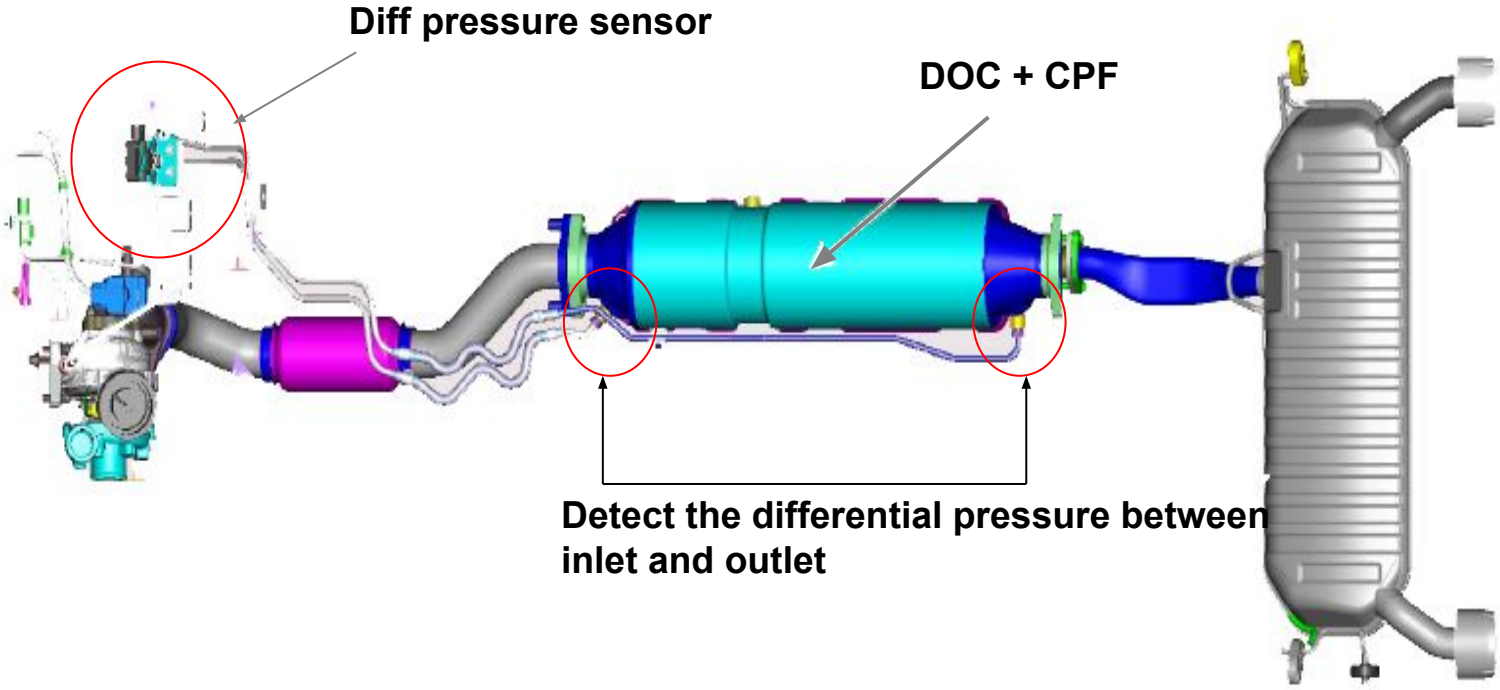
Regeneration method



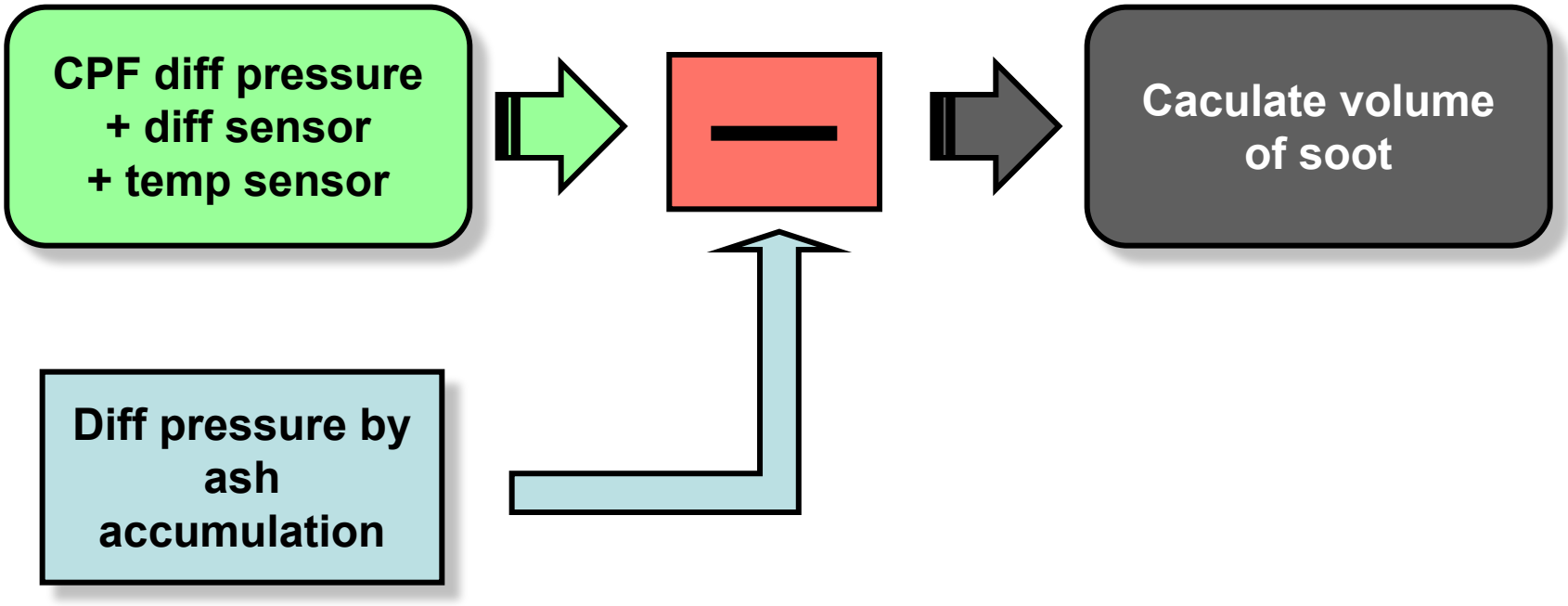
CPF aftertreatment procedure

Judgement regeneration - 1

- Using CPF diff pressure □ caculate volume of PM
  - Diff pressur: when PM is stored □ make a differential pressure
  - ECU decide time of regeneration



Differential pressure model

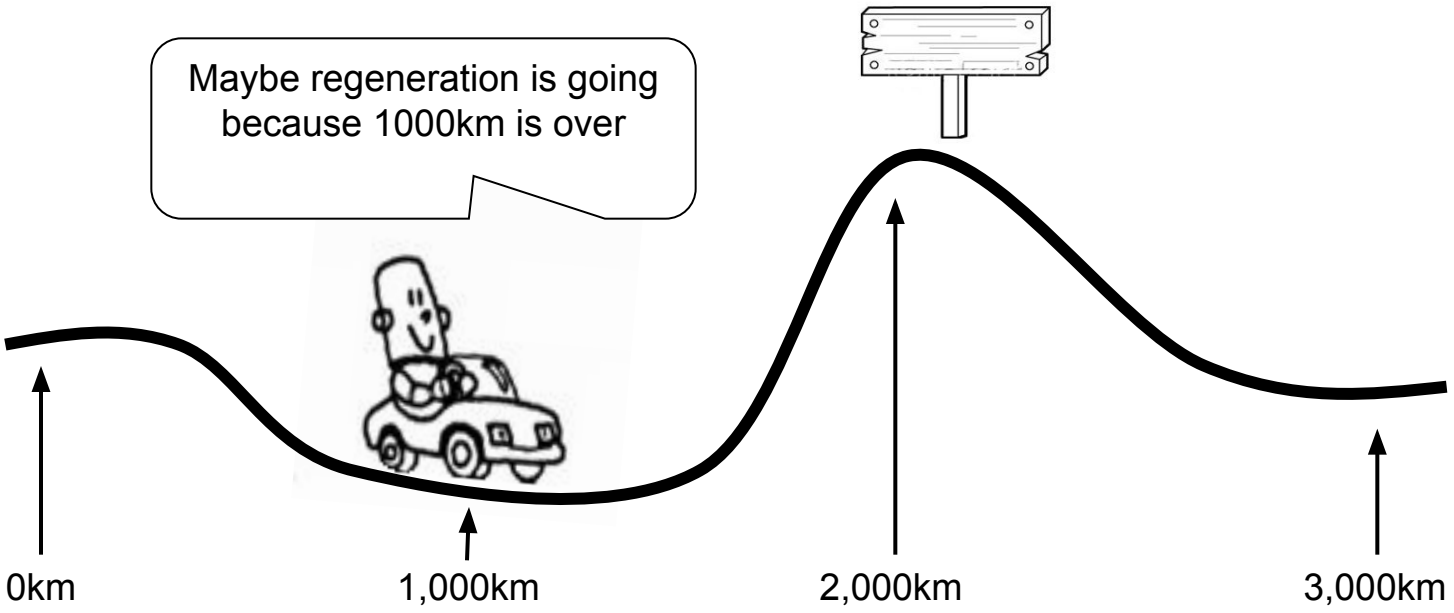


CPF aftertreatment procedure

Judgement regeneration - 2

- Judge by driving distance

  - Every 1,000km , ECU decide regeneration

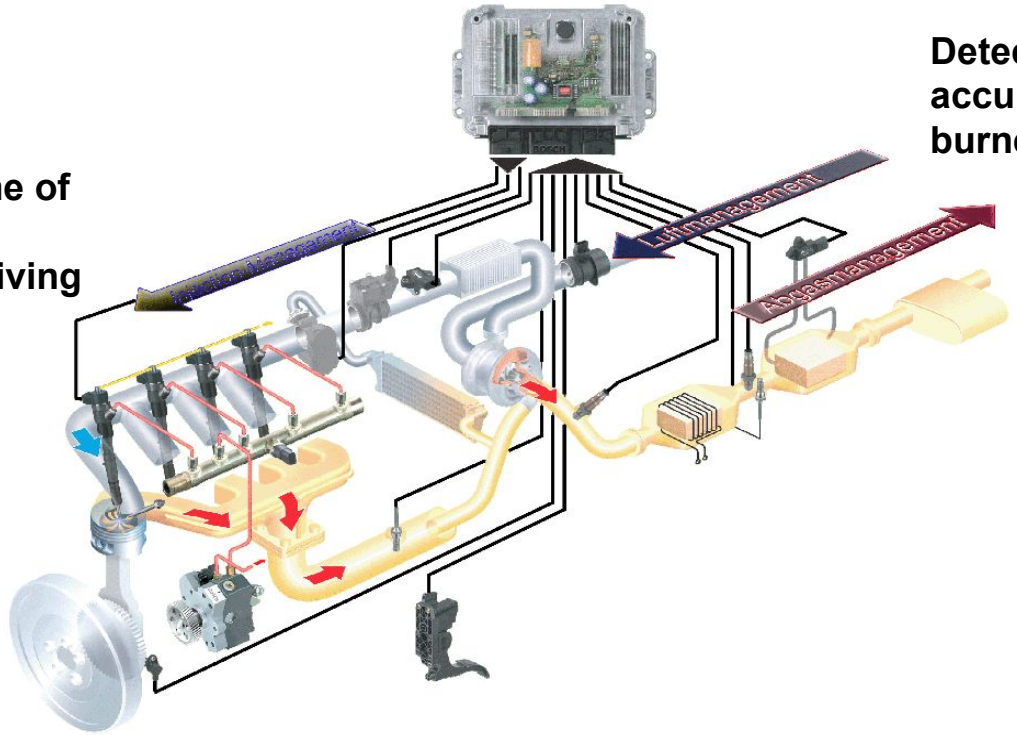


CPF aftertreatment procedure

Judgement regeneration - 3

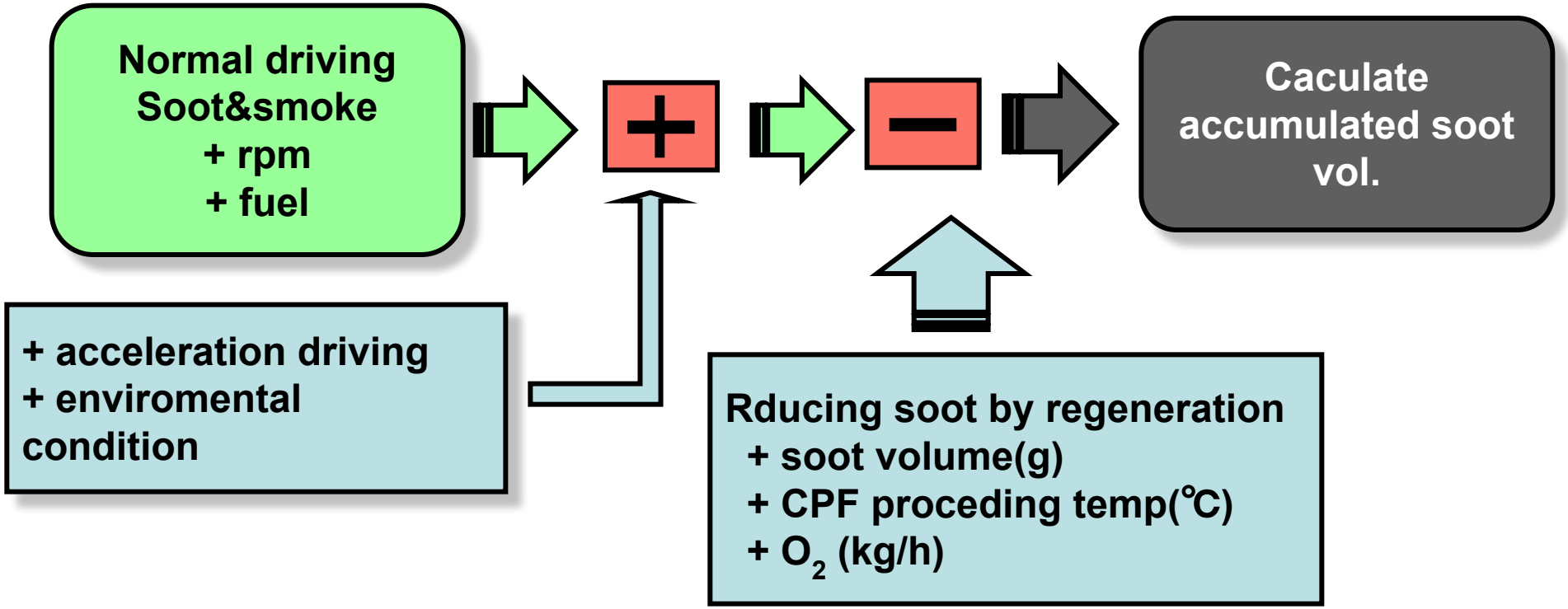
- Predict the volume of PM by using simulation

Detect the volume of accumulated PM depending on driving condition



Detect the volume of accumulated PM and burned PM

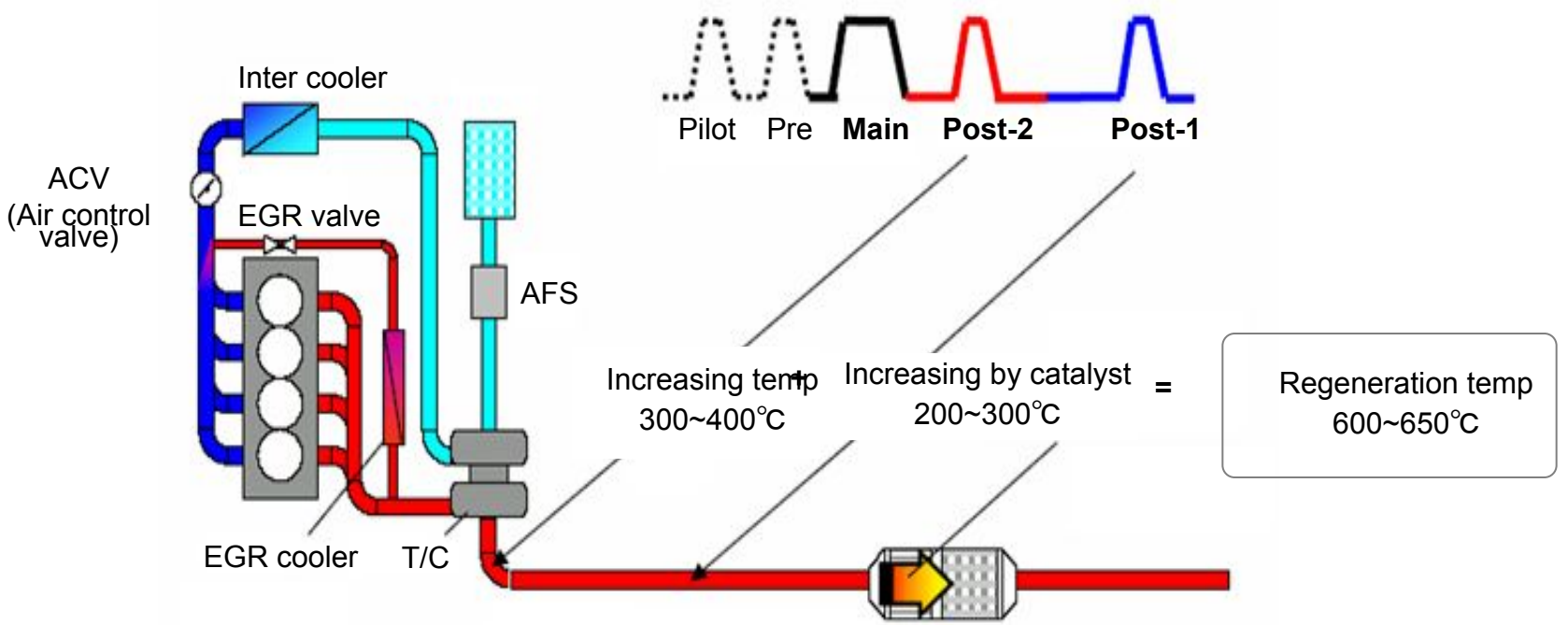
Simulation model



CPF aftertreatment procedure

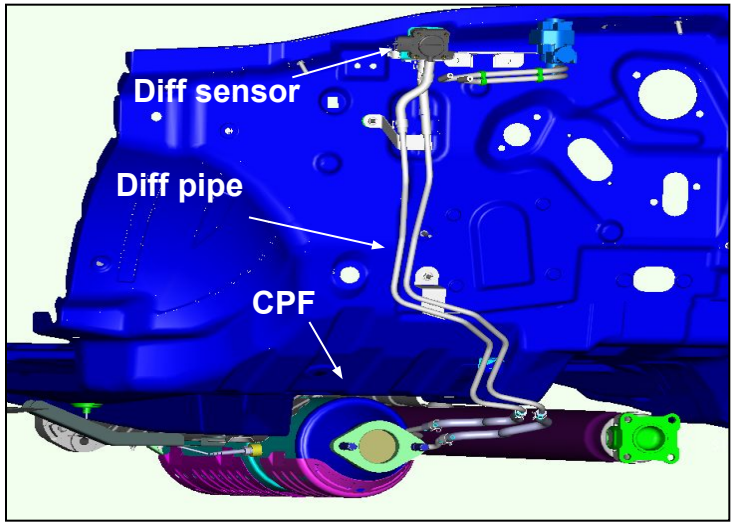
Regeneration

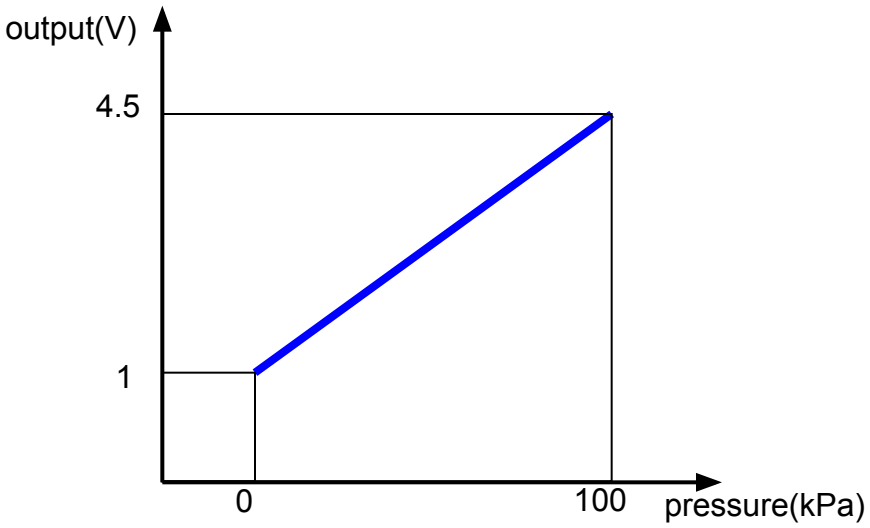
- Burning PM by increasing temp up to 550℃~600℃
- Increasing exhaust temp by post-injection



Differential pressure sensor

- Detect the diff pressure between CPF inlet(upstream) and outlet(downstream)
- Diff pressure 20~30kPa(200~300mbar) □ regeneration start
- Output voltage: 1V ~ 4.5 V

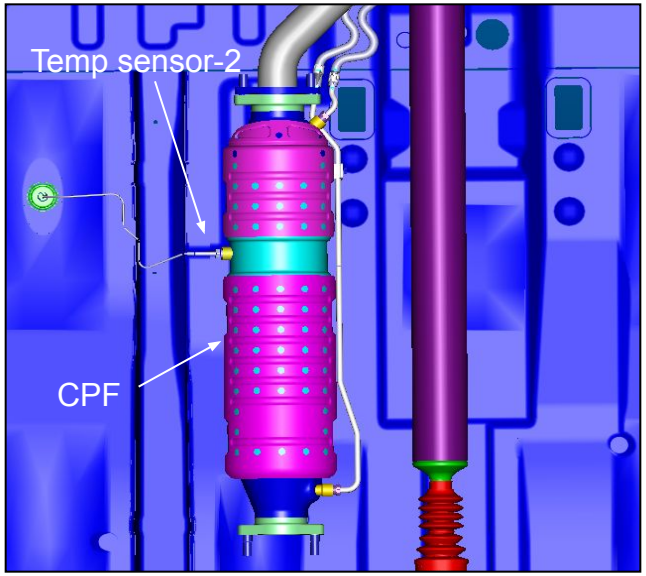


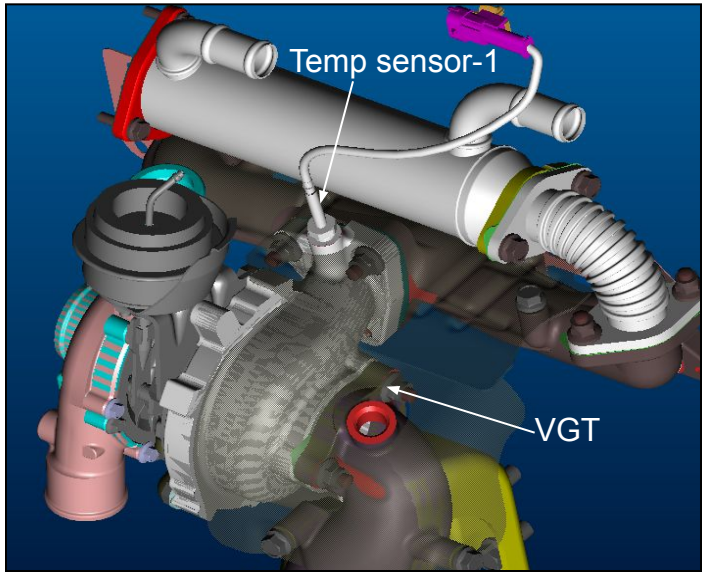


CPF component

Exhaust temp sensor

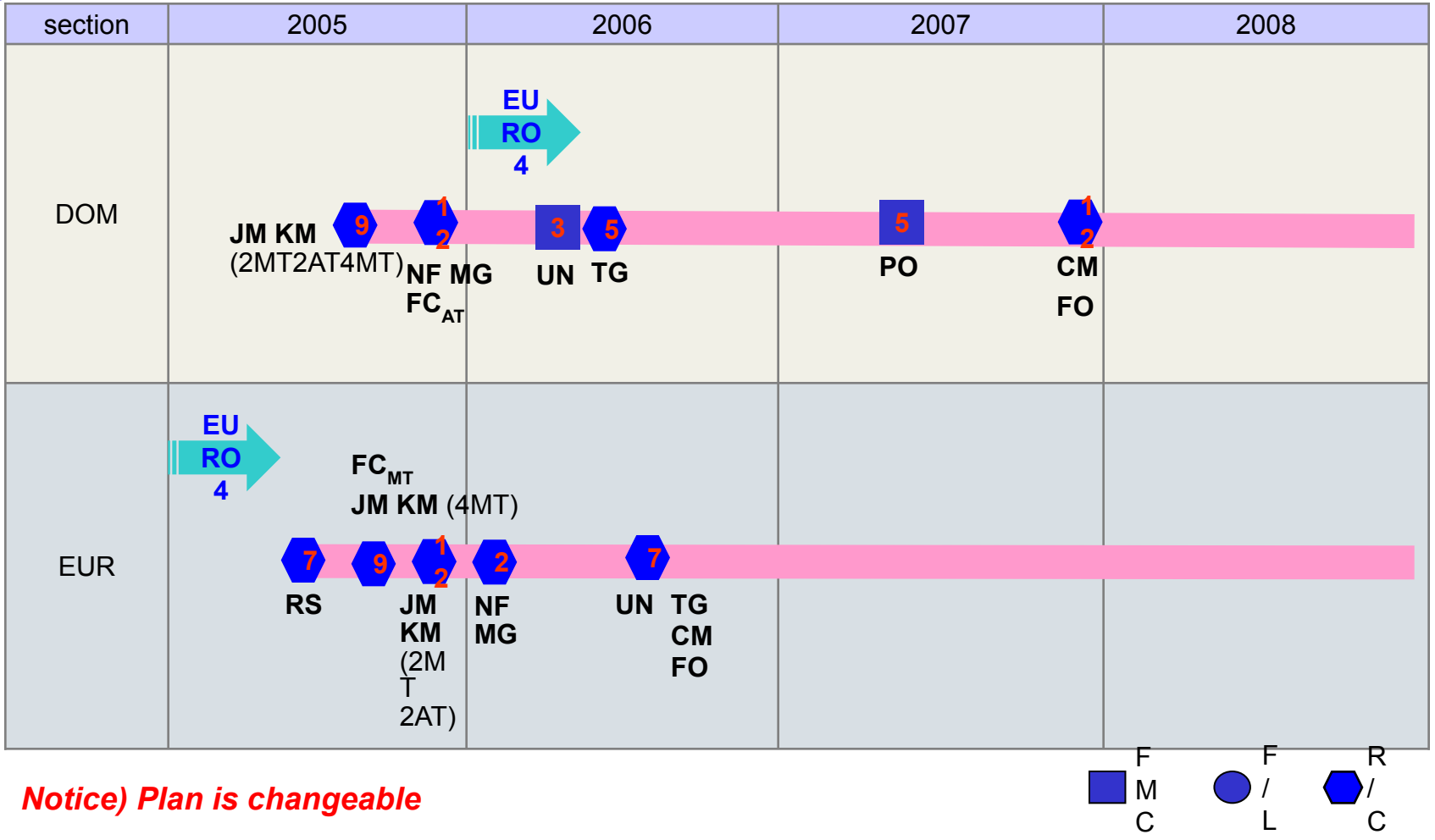
- Monitoring the regeneration temp.(Obtain ignition temperature in particulate filter)
- Temp sensor-1: protect VGT , located in exhaust gas
- Temp sensor-2: feedback for regeneration





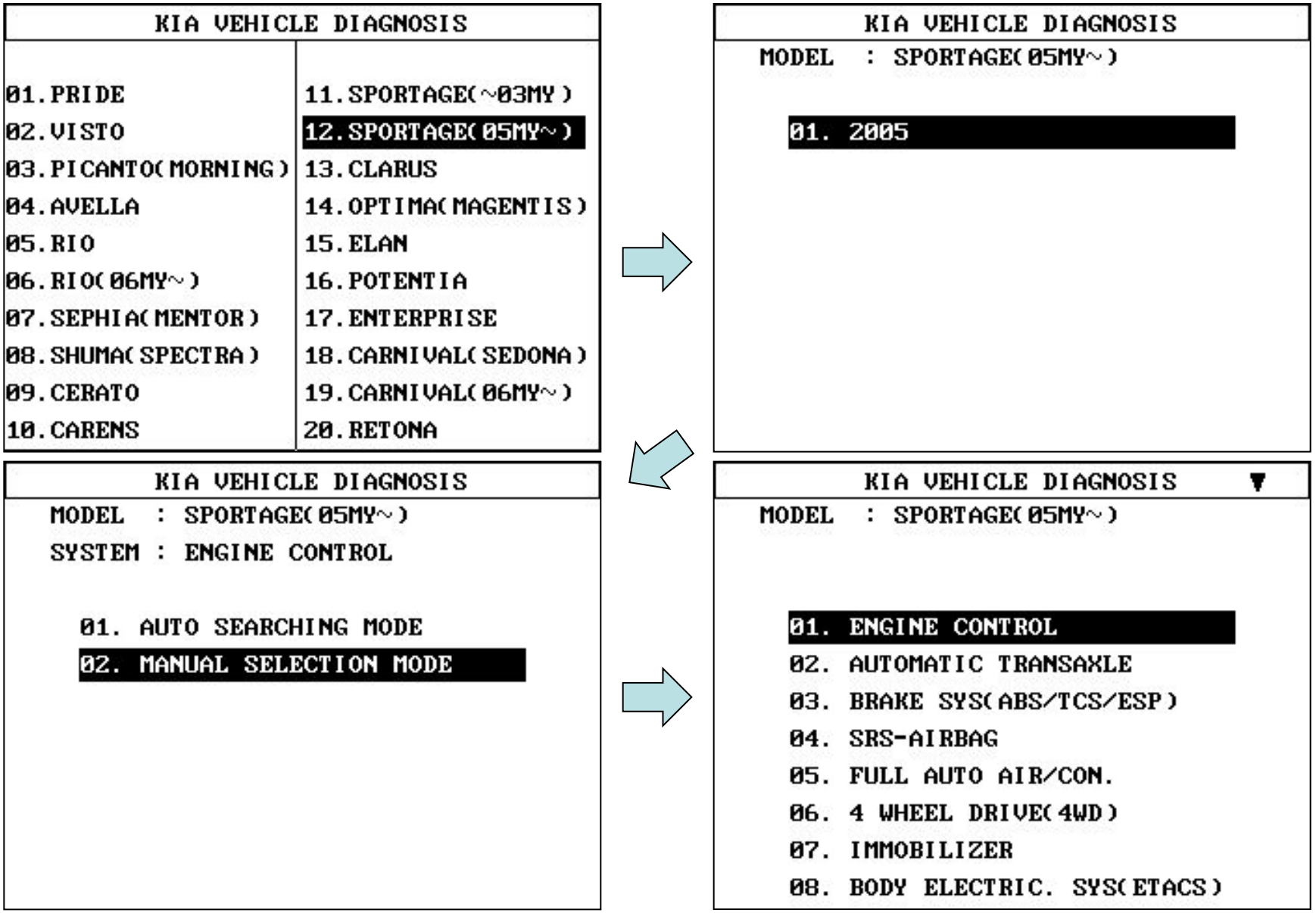
Plan for CPF

Adapted vehicle : D-RS, D-JM, D-KM, D-NF, D-MG, D-UN, D-CM$_{AT}$, D-TG$_{AT}$, D-FO, U-FC$_{AT}$

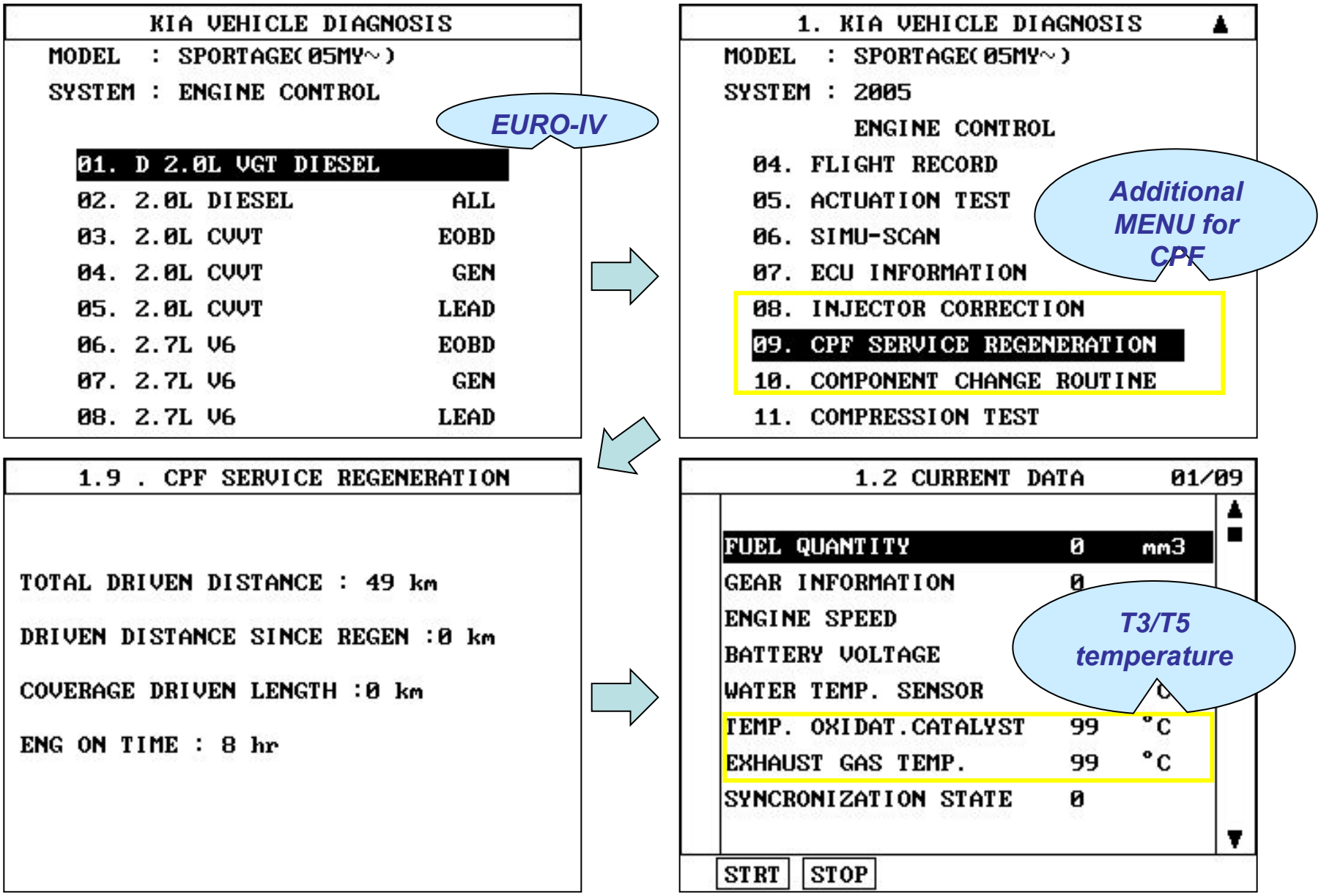


Notice) Plan is changeable

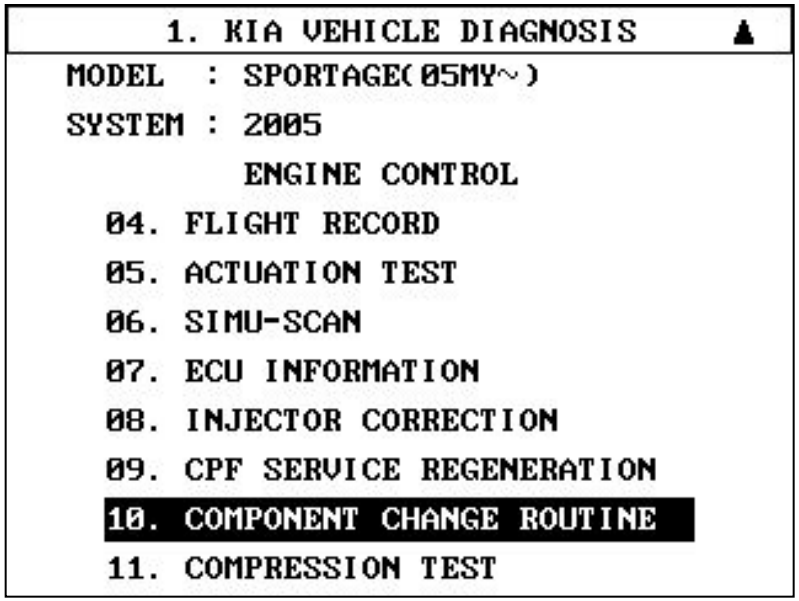
CPF service regeneration by Hi-scan

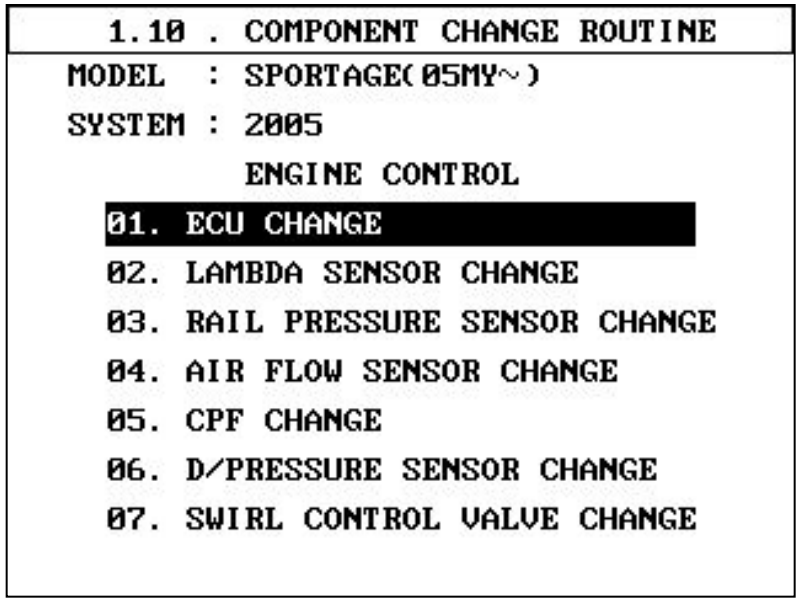


CPF service regeneration by Hi-scan



Component change routine (ECU change)





Notice) If you change some parts related CPF you should do this procedure.

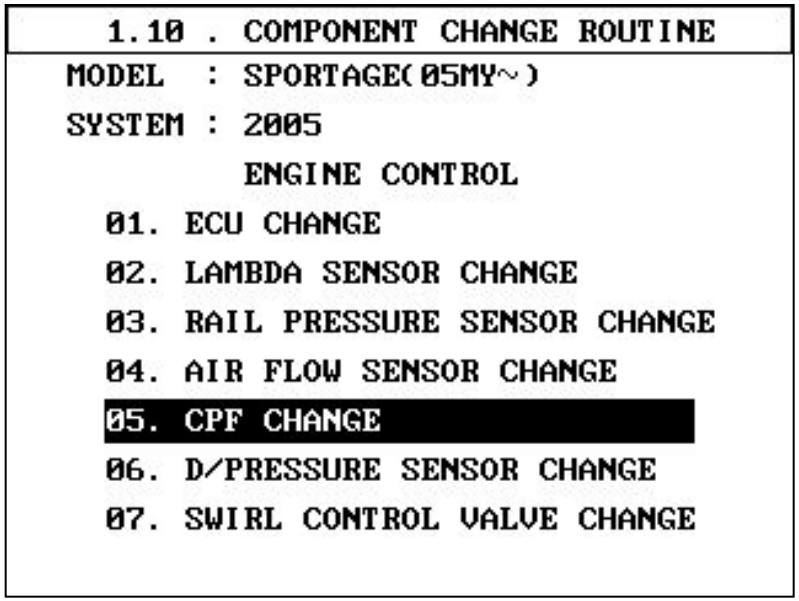
INPUT THE CURRENT ODO VALUES IN CLUSTER TO COUNT THE DRIFT SOOT VALUE INFORMATION OF CPF.

000000 km

REFER TO PREVIOUS MENU TO SEE INJECTOR INFORMATION.

PRESS [ENTER] KEY.

Component change routine (CPF change)

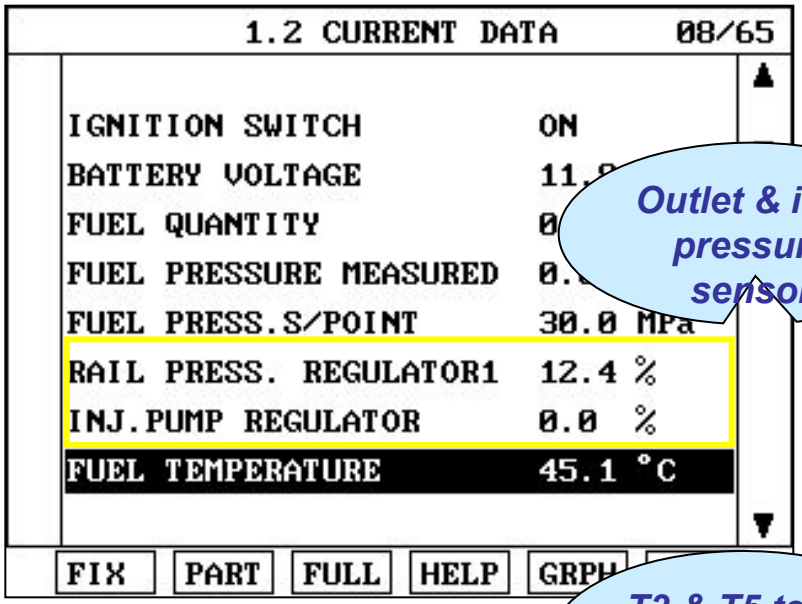


IN THIS MODE, CAN RESET THE DISTANCE OF LAST CHANGED CPF AND OTHERS RELATED PARAMETERS.

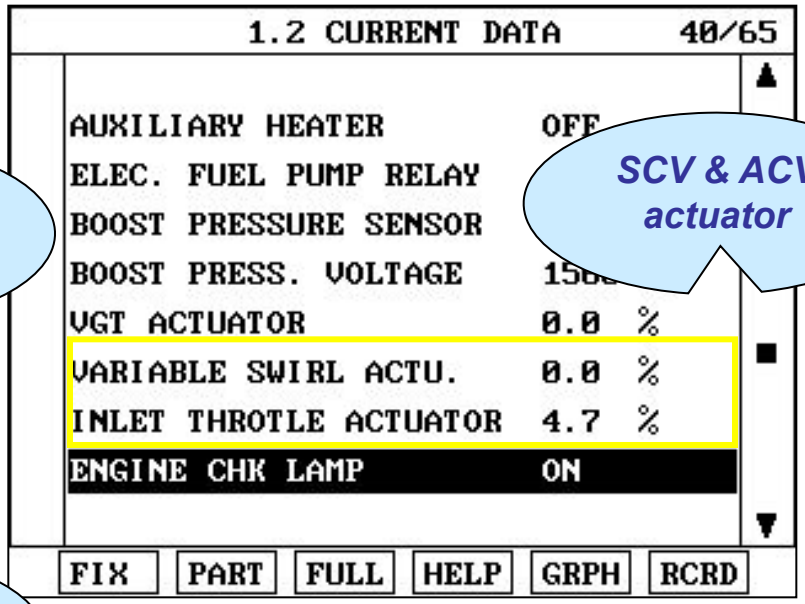
PRESS [ENTER] KEY.

Notice) If you change the CPF then should reset the distance of last changed CPF. Other related parts are same procedure(Lambda sensor , RPS, AFS, Diff sensor SCV).

Current data

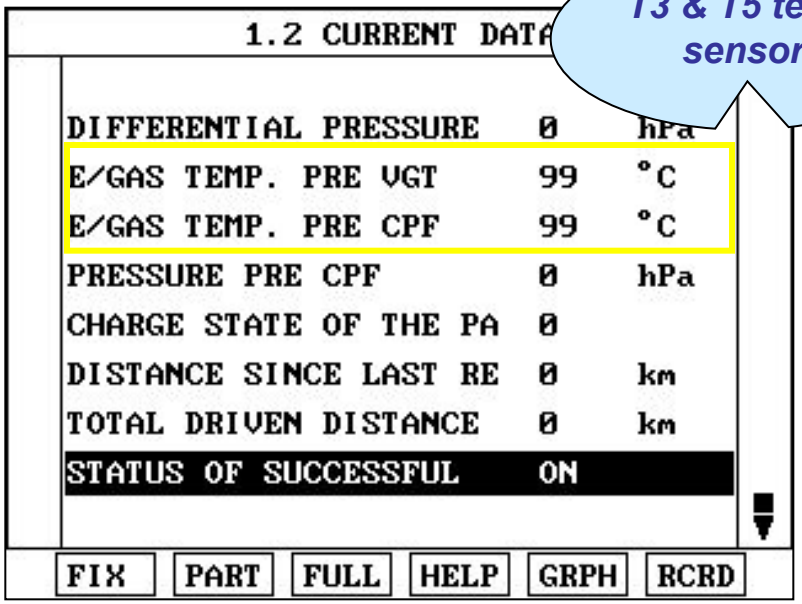


Outlet & inlet pressure sensor

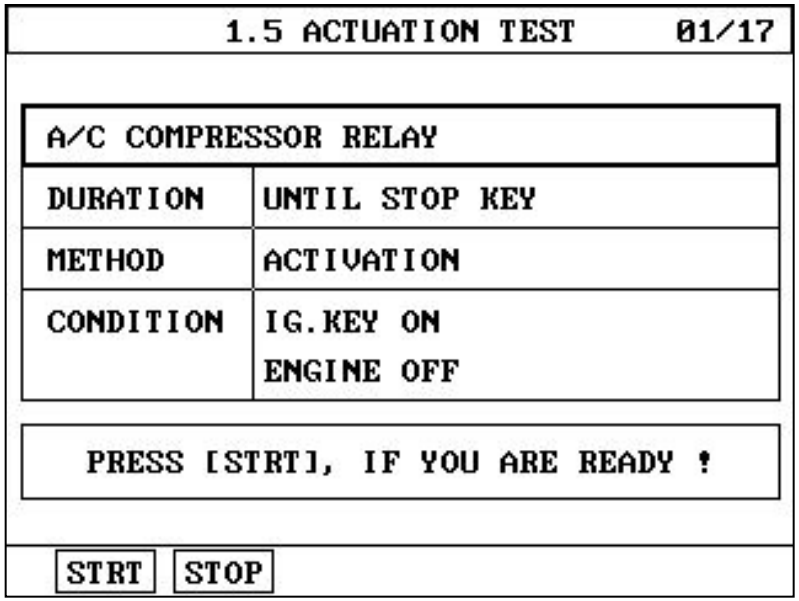


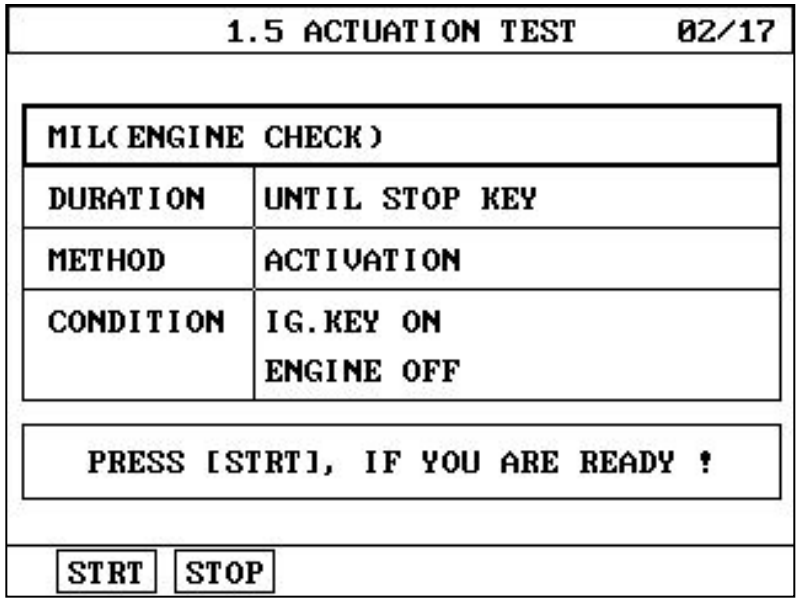
SCV & ACV actuator

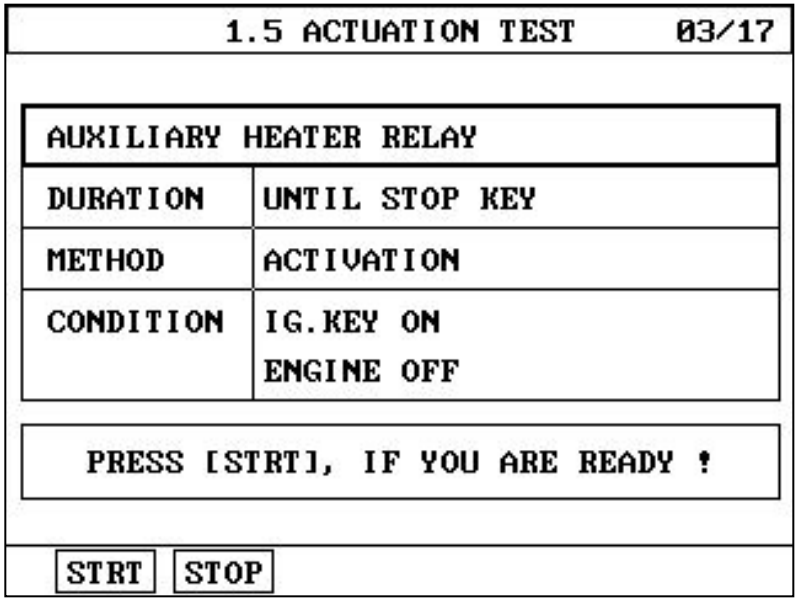
T3 & T5 temp sensor

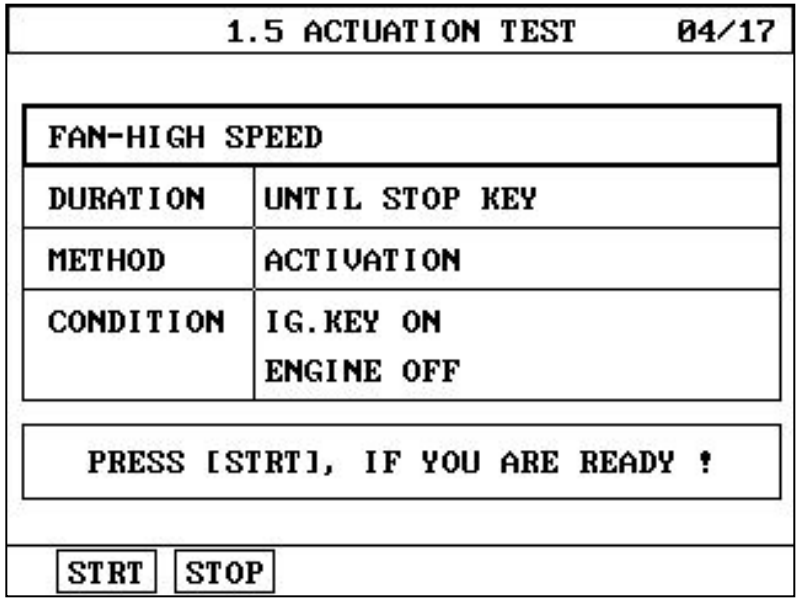


Actuation test

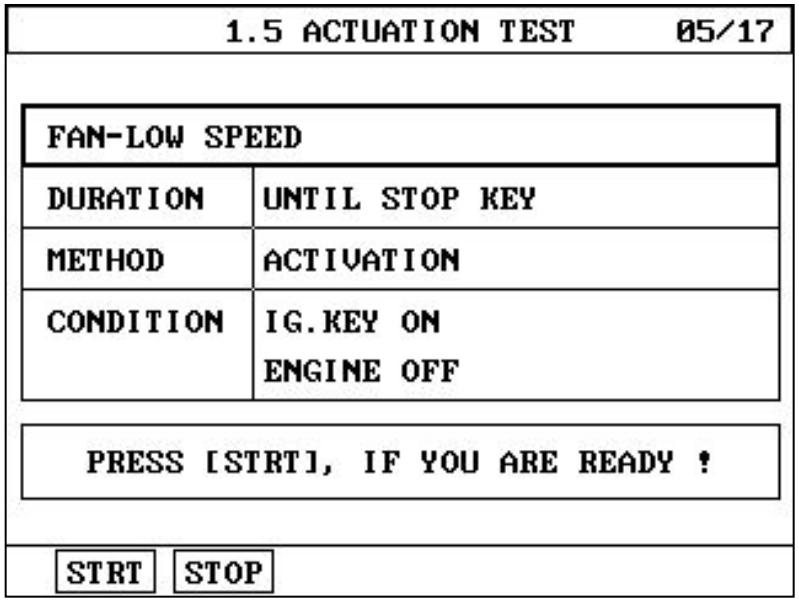


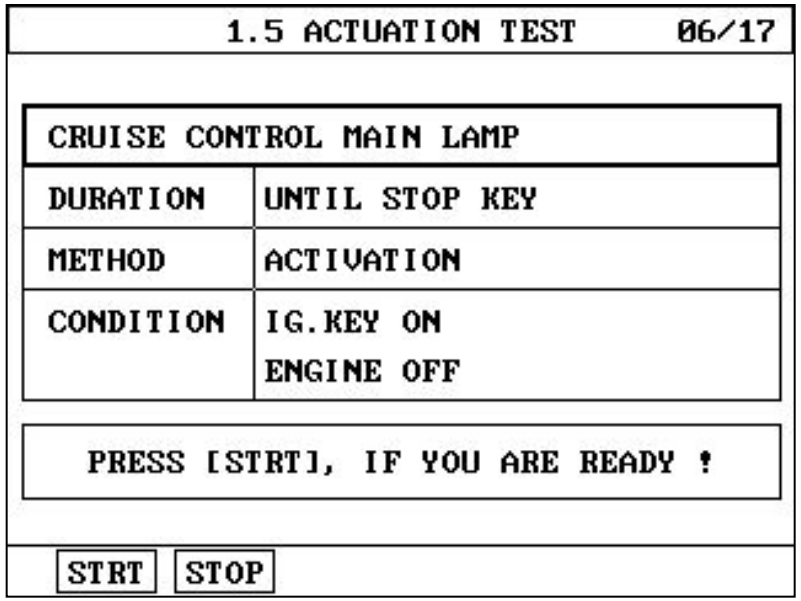


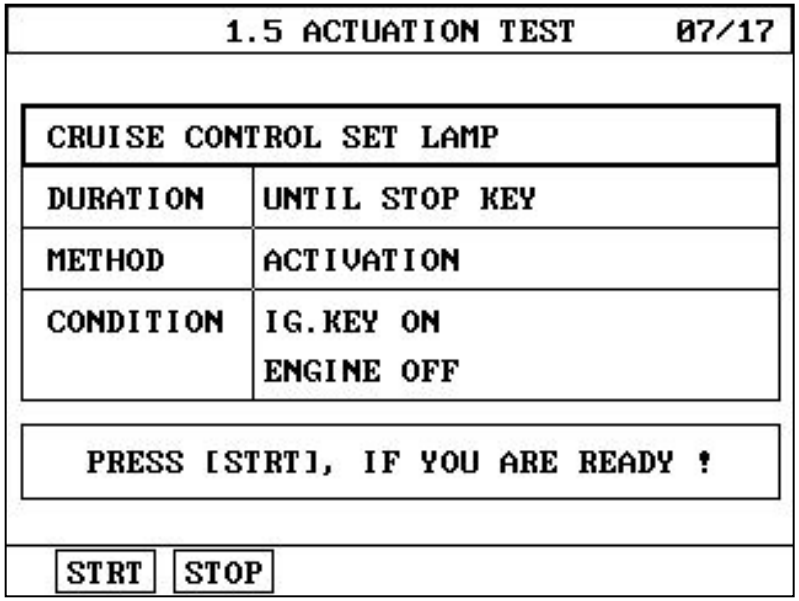


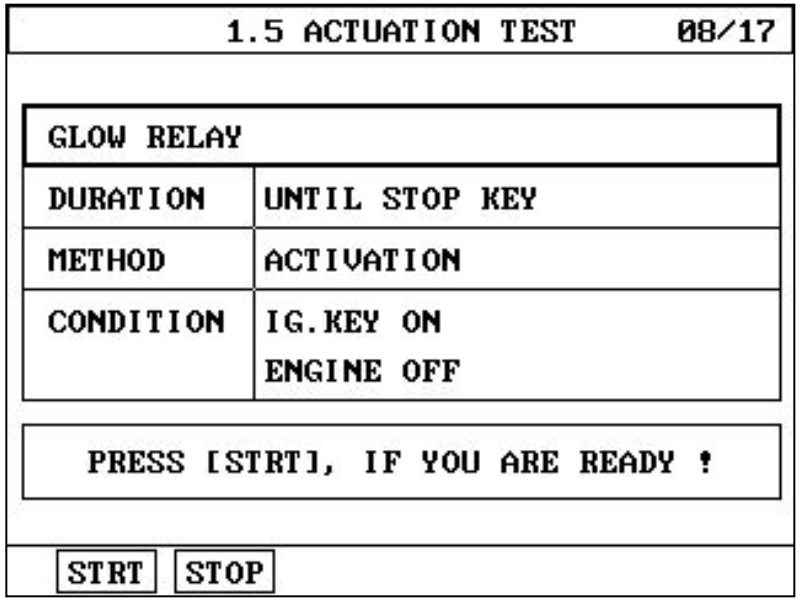


Actuation test

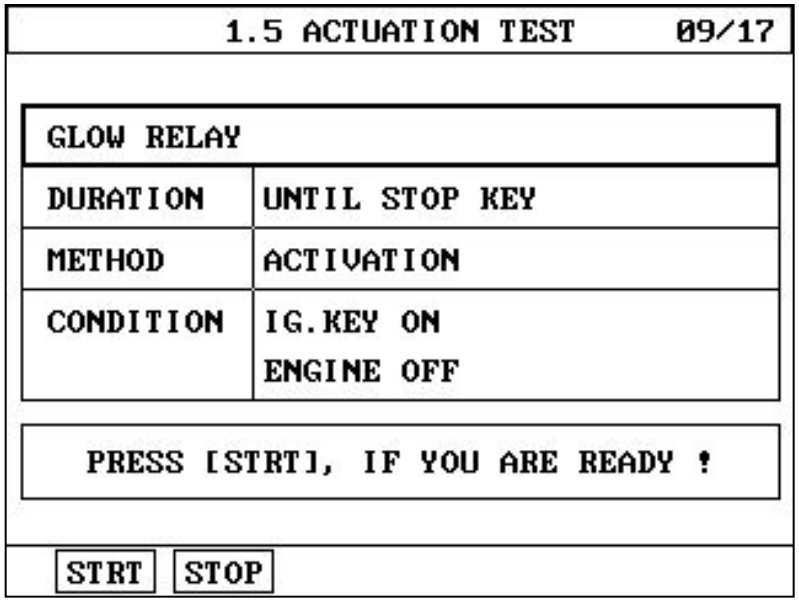


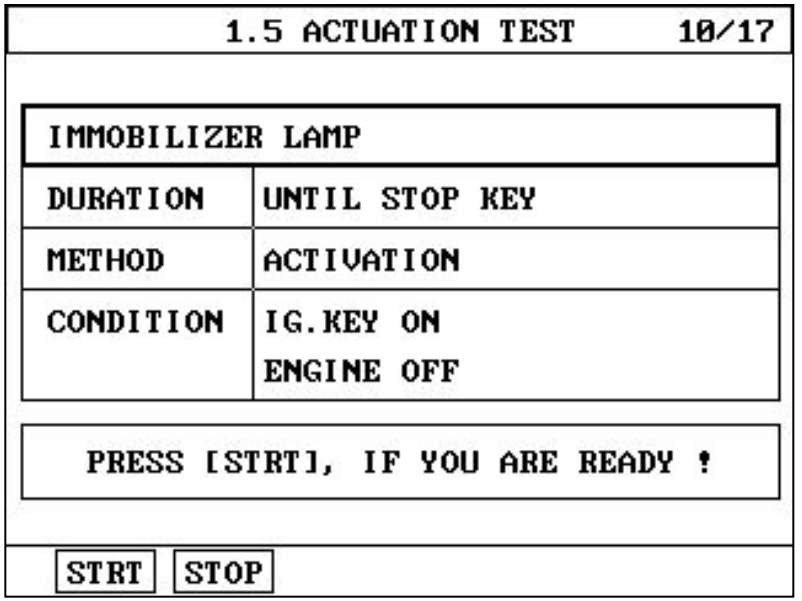


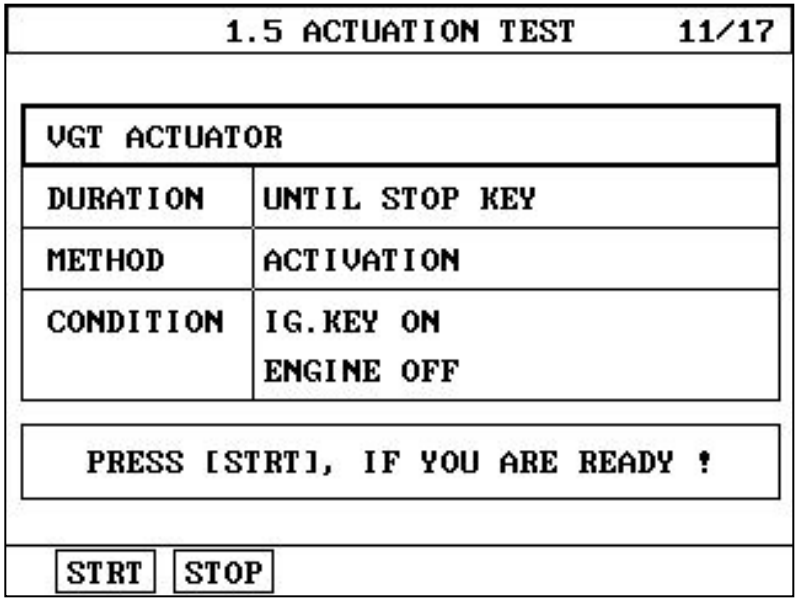


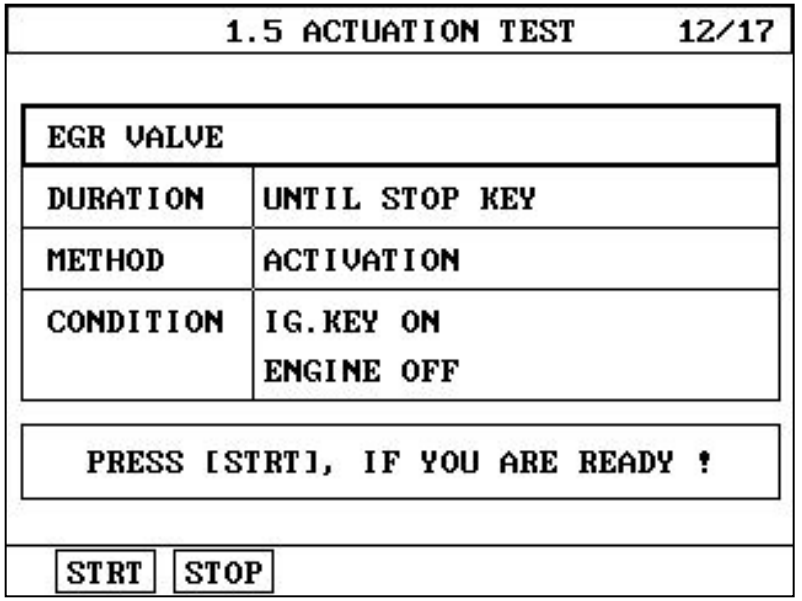


Actuation test

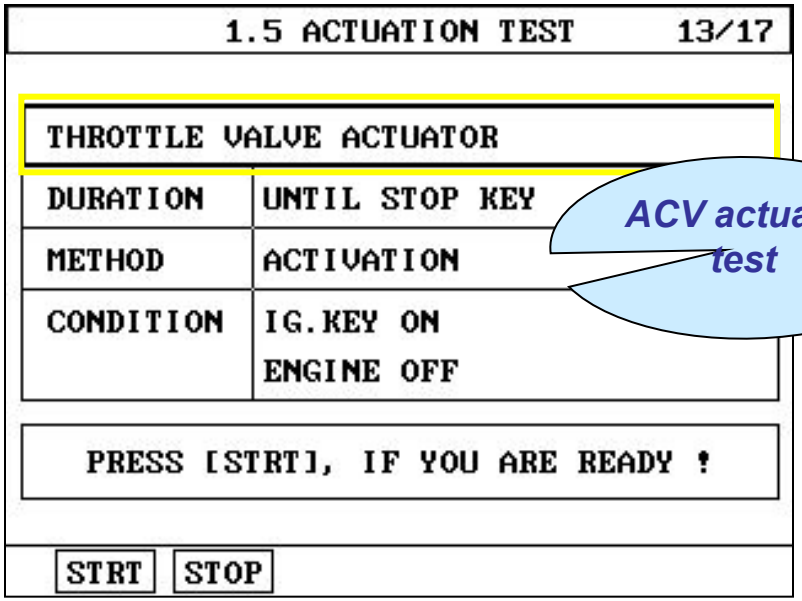




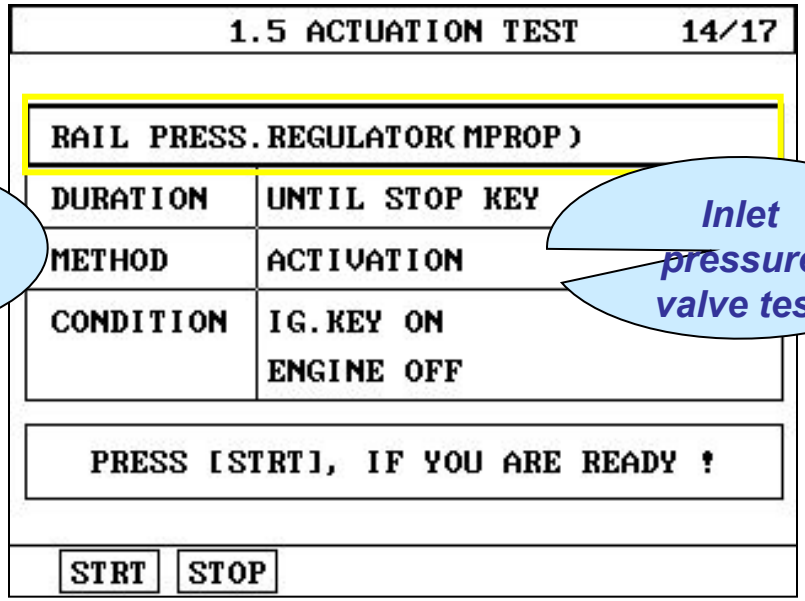




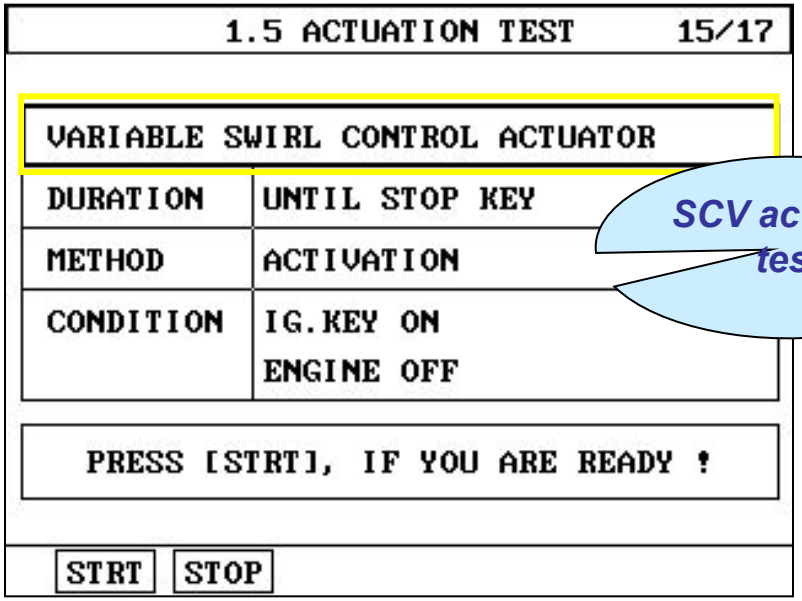
Actuation test



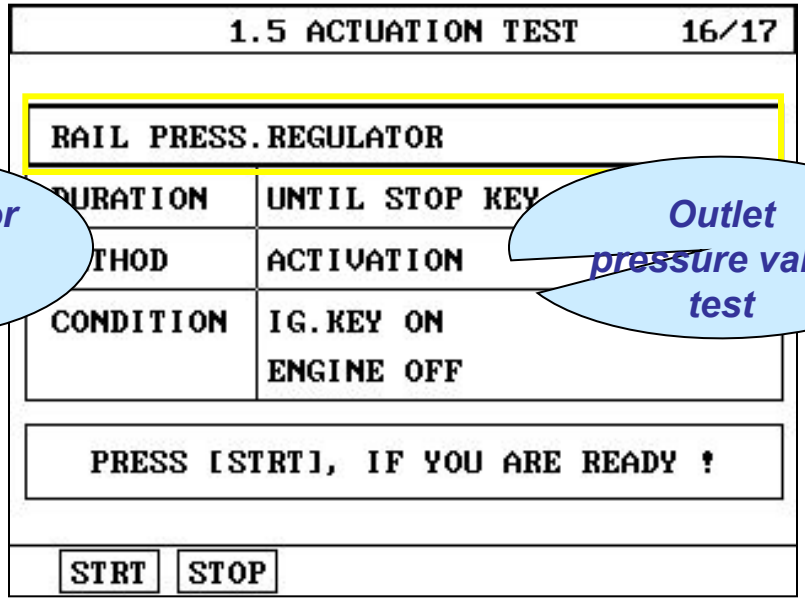
ACV actuator test



Inlet pressure valve test

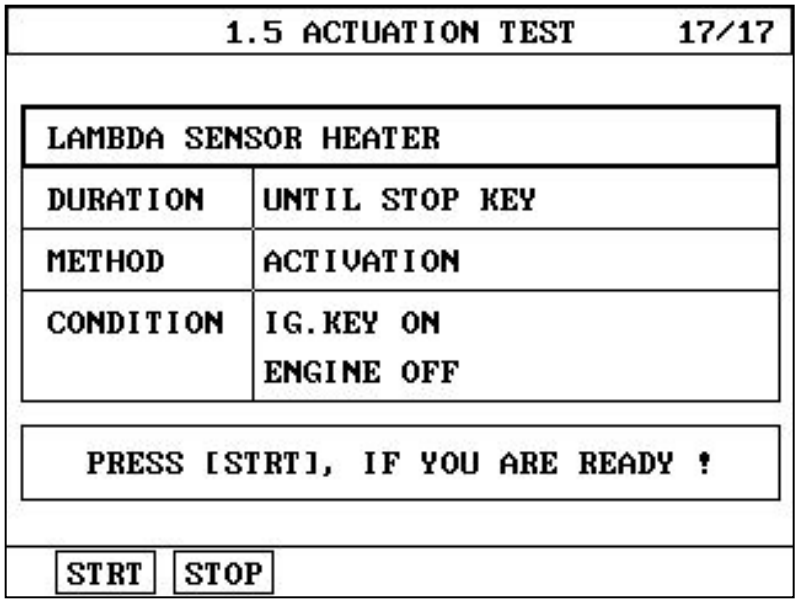


SCV actuator test

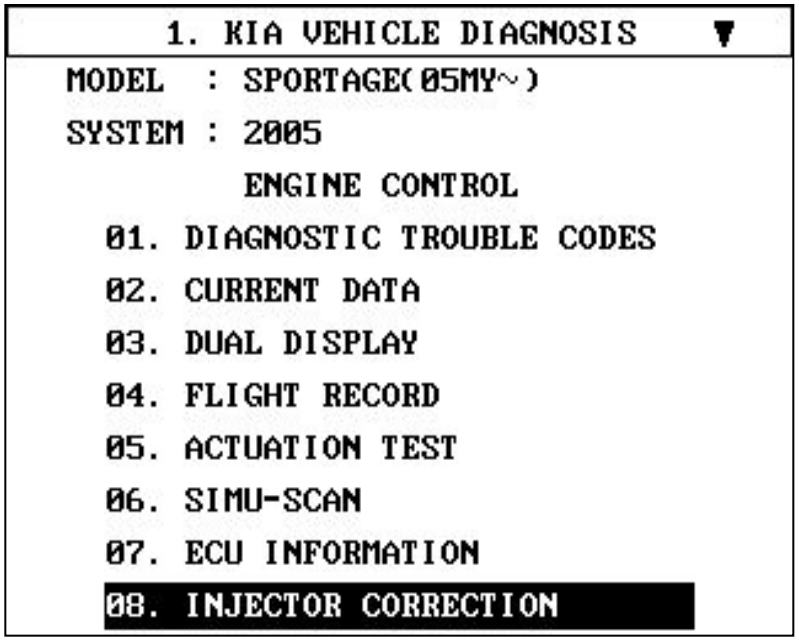


Outlet pressure valve test

Actuation test



Injection correction (IQA)



- CONDITION:IG.KEY ON(ENGINE STOP)

1. IF THE INJ IS CHANGED, THE INJ CORRECTION FUNC. SHOULD BE PERFORM TO CONTROL. THE NORMAL FUEL INJ.
2. TO INPUT THE INJECTOR NUMBER,PRESS SHIFT KEY AND SELECT THE CYL. BY ARROW KEY AT THE SAME TIME, AND INPUT THE INJ DATA BY [F1]~[F6], DIGIT KEY. AND THEN PRESS [ENTER].
3. AFTER COMPLETE, TURN THE IG.KEY OFF AND RECHECK THE SYSTEM AFTER 10 SEC.

Enter the 7-digit code

IQA (Injection Quantity Adaption) injector