

Описание двигателя

- Общие сведения

- V-образный 6-ти цилиндровый, угол развала блока 60° , рабочий объём 2.5 л, 24-клапана, система газораспределения DOHC с механизмом VVT-i, на впуске и выпуске, система ACIS электронный дроссель (система ETCS-i)

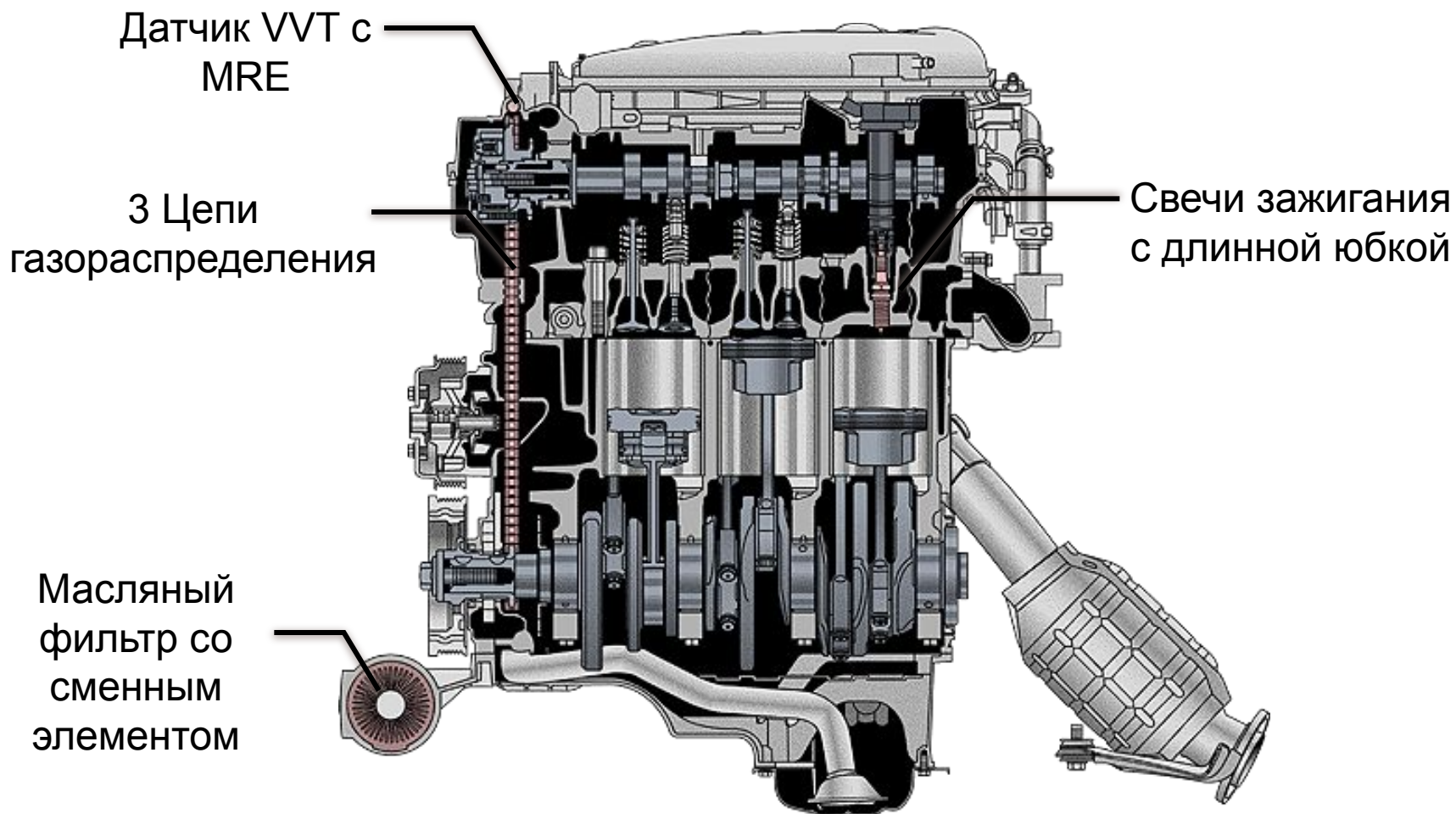


4GR-FSE

**Система D-4
[Непосредственное
впрыскивание]**

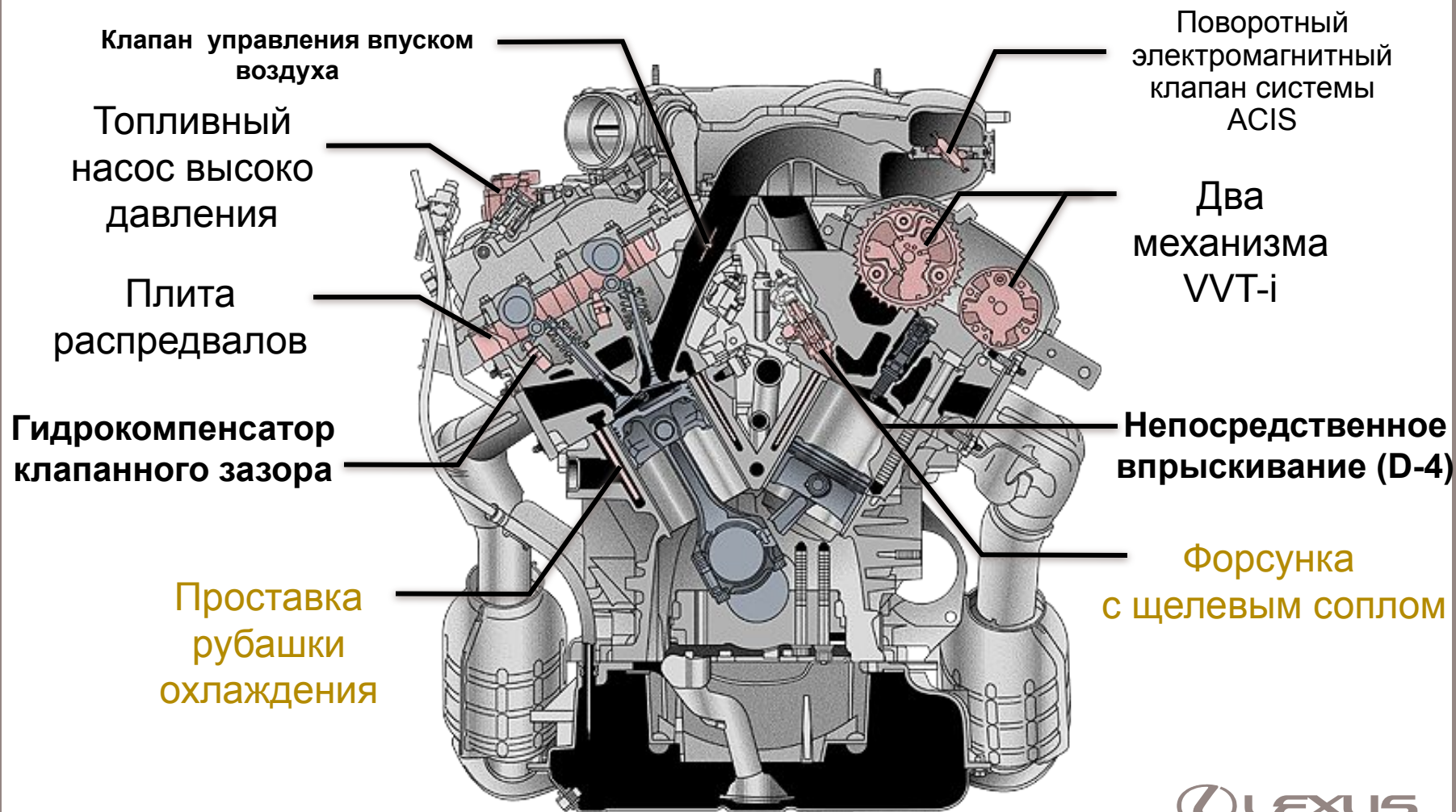
Описание двигателя

- Характеристики **4GR-FSE**



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Описание двигателя

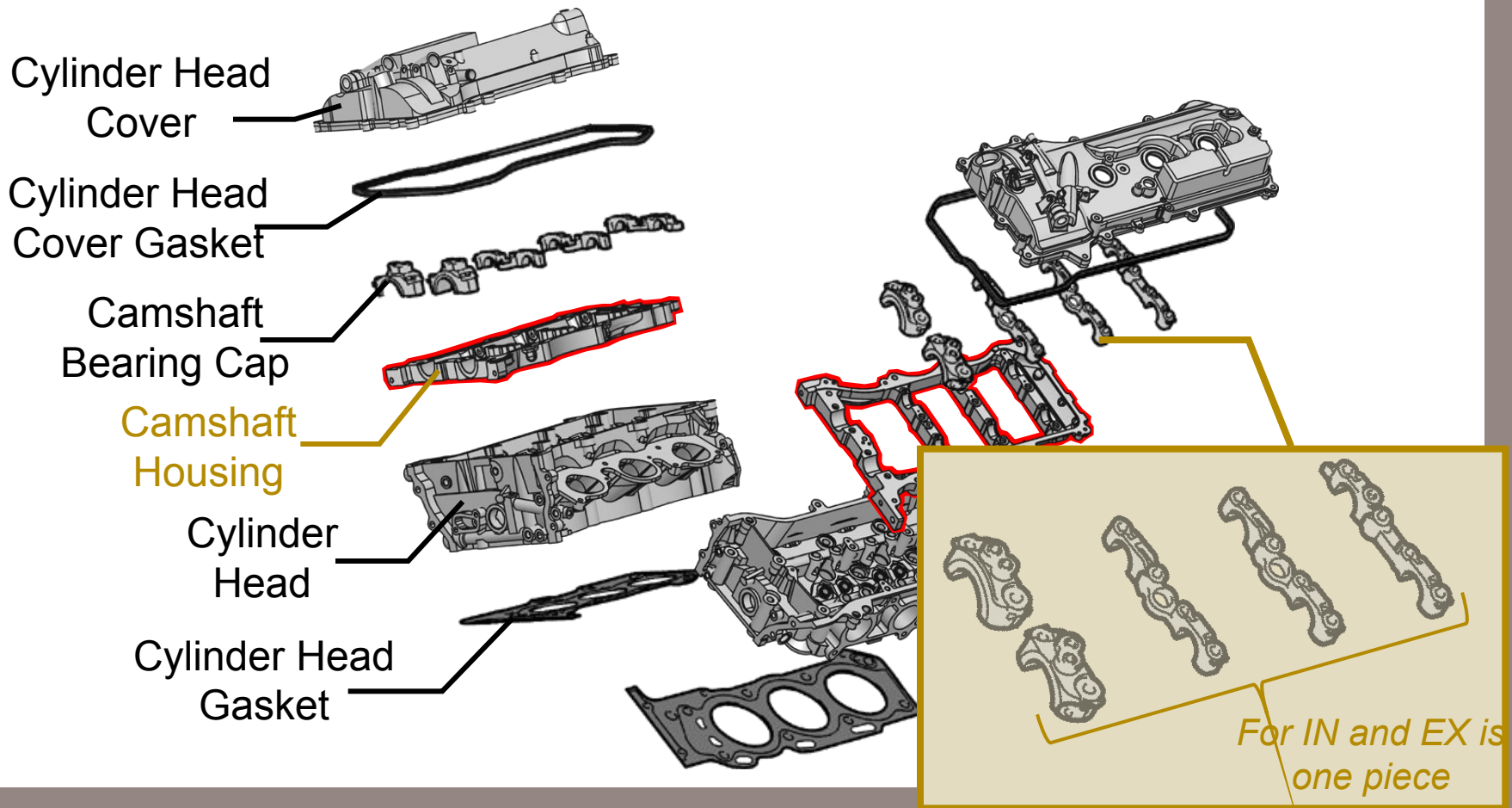
- Основные характеристики

	4GR-FSE
Число и расположение цилиндров	6, V-образно
Механизм газораспределения	24-клапана, DOHC, цепной привод, два VVT-i
Тип камеры сгорания	Шатровая
Раб. Объём, см ³	2499
Диаметр цилиндра x ход поршня mm	83.0 x 77.0
Степень сжатия	12.0
Макс. мощность кВт @ обор. (л.с. @ обор.)	152 @ 6,400 (204 @ 6,400)
Макс. кр. момент N·m @ обор.	250 @ 4,800

Engine Proper

- Cylinder Head

- Camshaft housing to simplify the cylinder head structure
- Camshaft bearing cap for IN and EX is one piece



Service Point (Engine Proper)

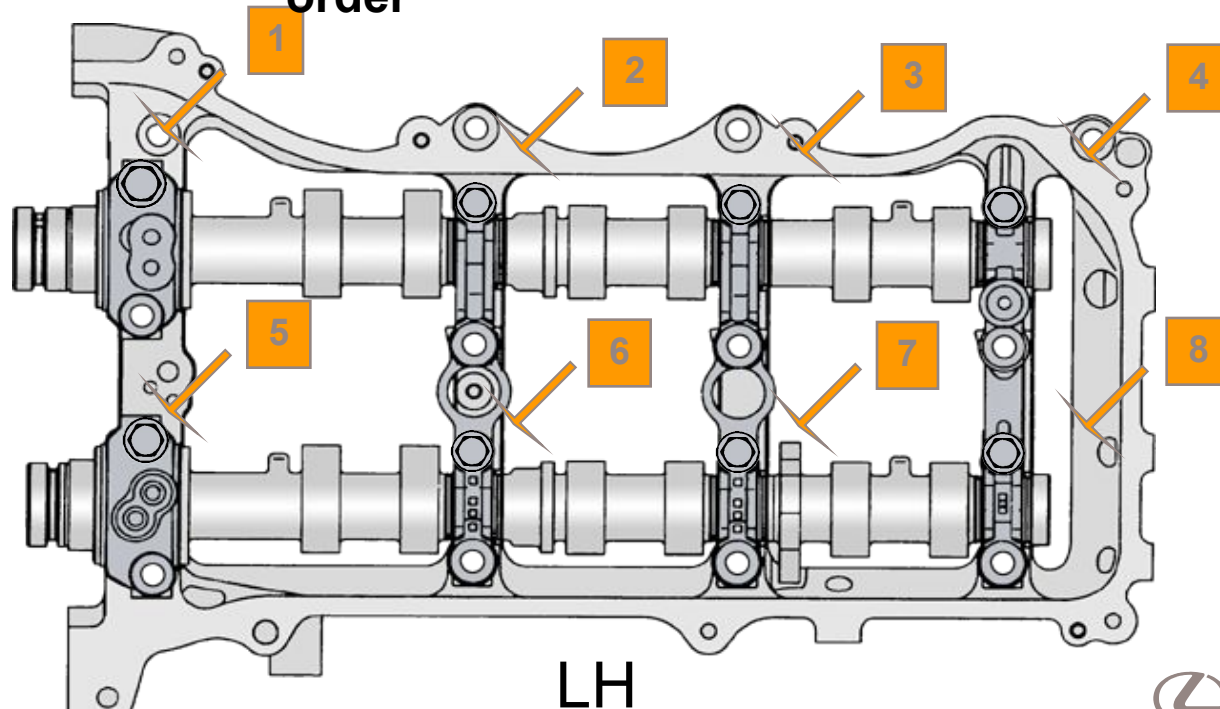
- Cylinder Head
 - Camshaft and camshaft housing installation

Step
1



: Temporary tighten (Torque: 10N·m
[102kgf·cm])

: Tightening
order



LH
Bank



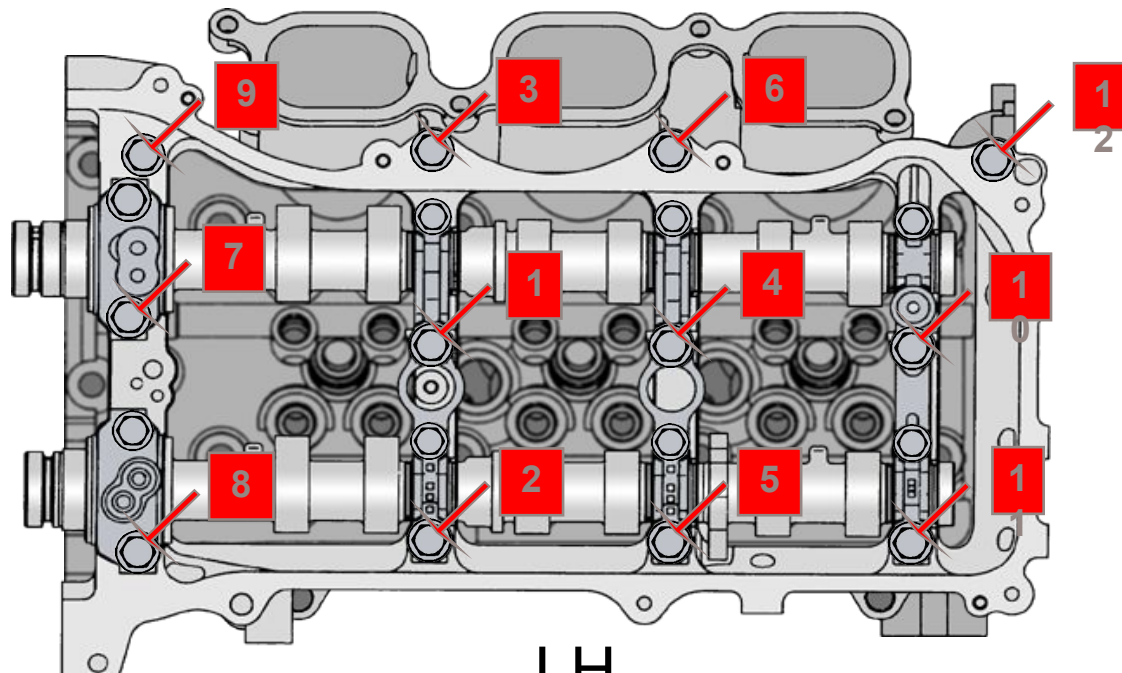
Service Point (Engine Proper)

- Cylinder Head
 - Camshaft and camshaft housing installation

Step
2



: Tighten (Torque: 28N·m
[286kgf·cm])
: Tightening
order



LH
Bank

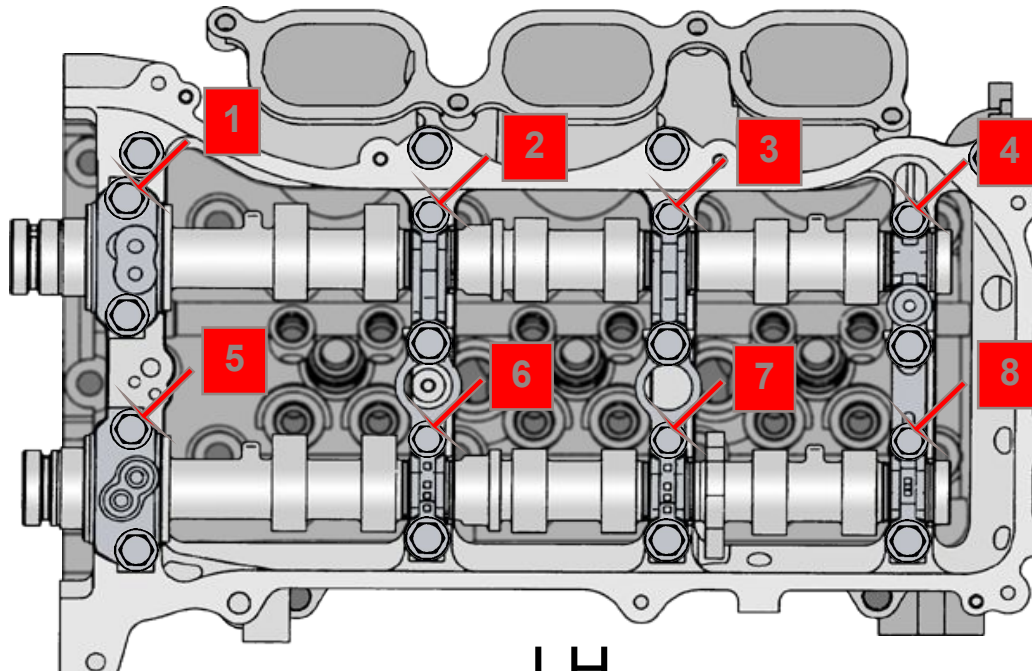
Service Point (Engine Proper)

- Cylinder Head
 - Camshaft and camshaft housing installation

Step
3



: Tighten (Torque: 16N·m
[163kgf·cm])
: Tightening
order

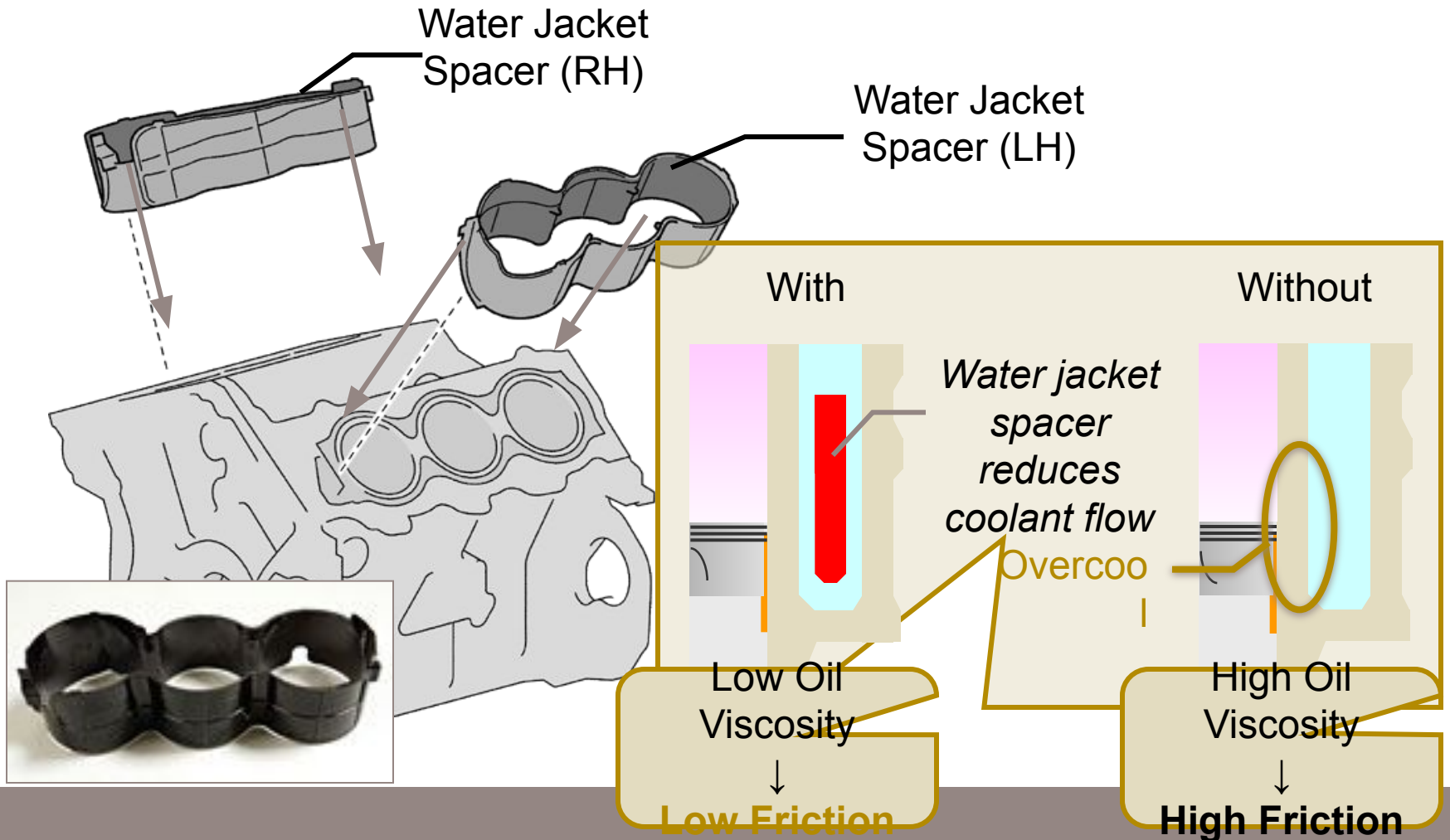


LH
Bank

Engine Proper

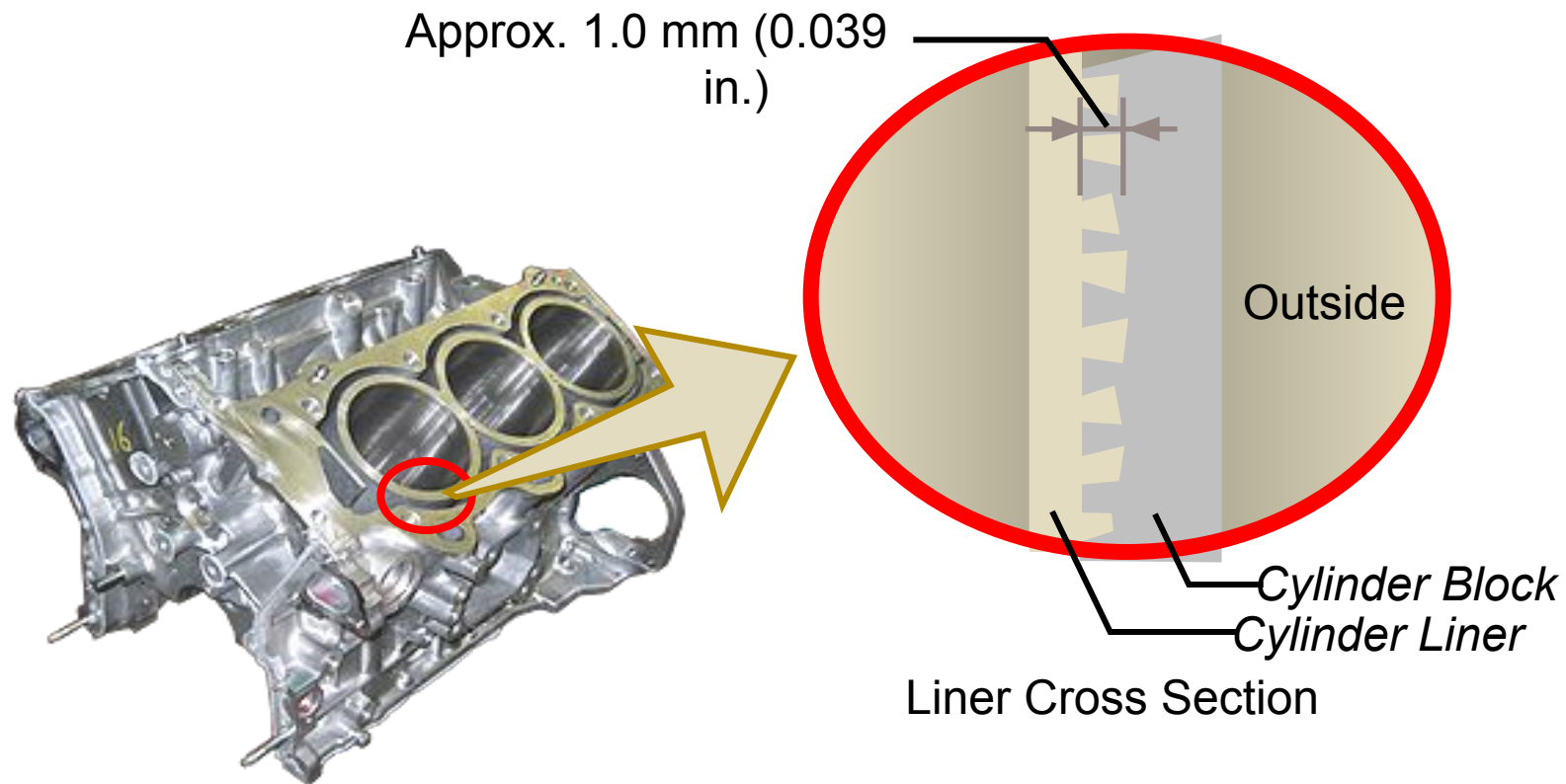
- Cylinder Block

- Water jacket spacer optimizes the cylinder bore temp. to reduce friction



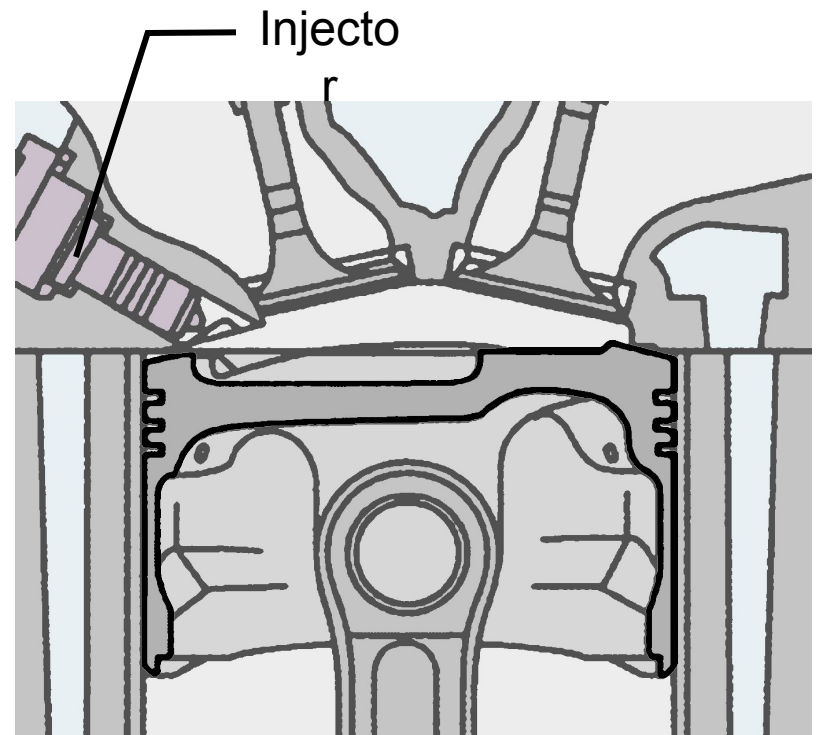
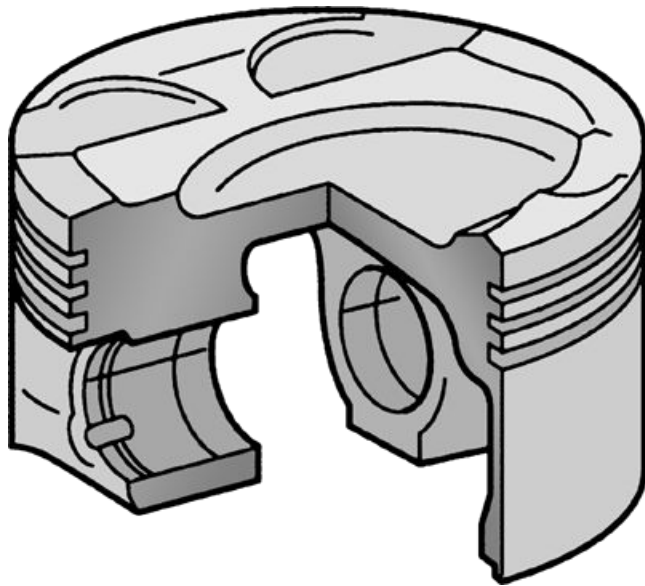
Engine Proper

- Cylinder Block
 - Spiny liner is used to increase cooling performance



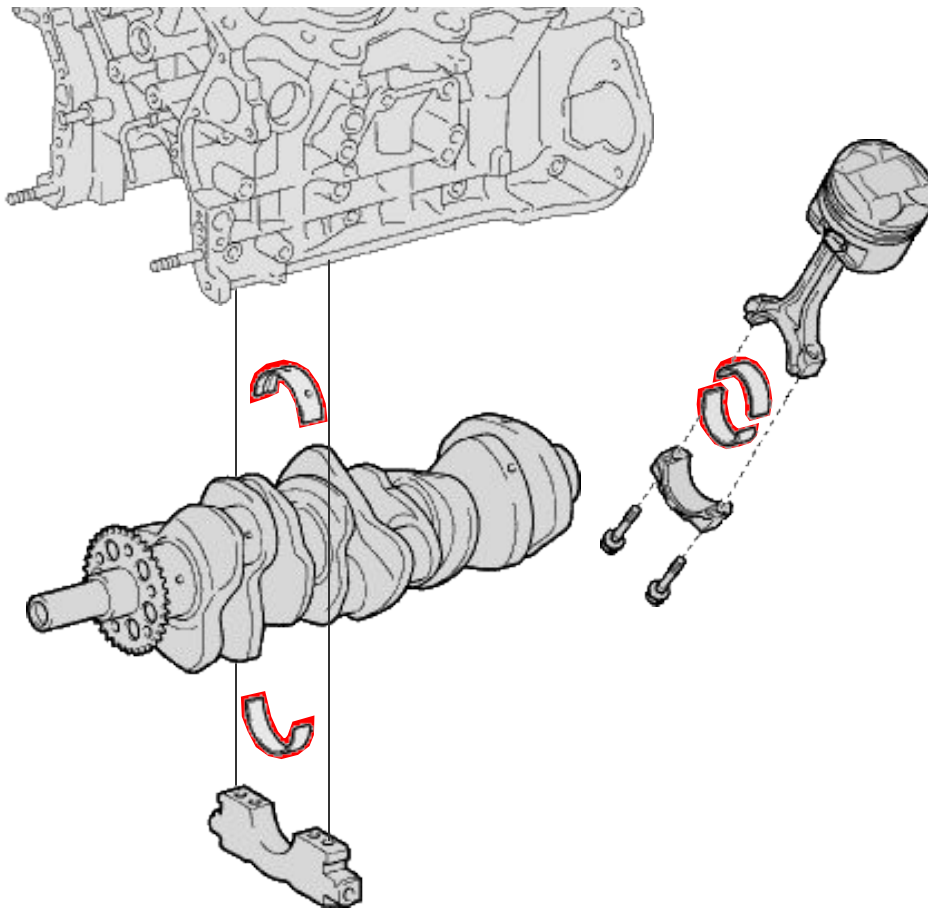
Engine Proper

- Piston
 - Optimal piston head shape to promote the mixture of fuel and air



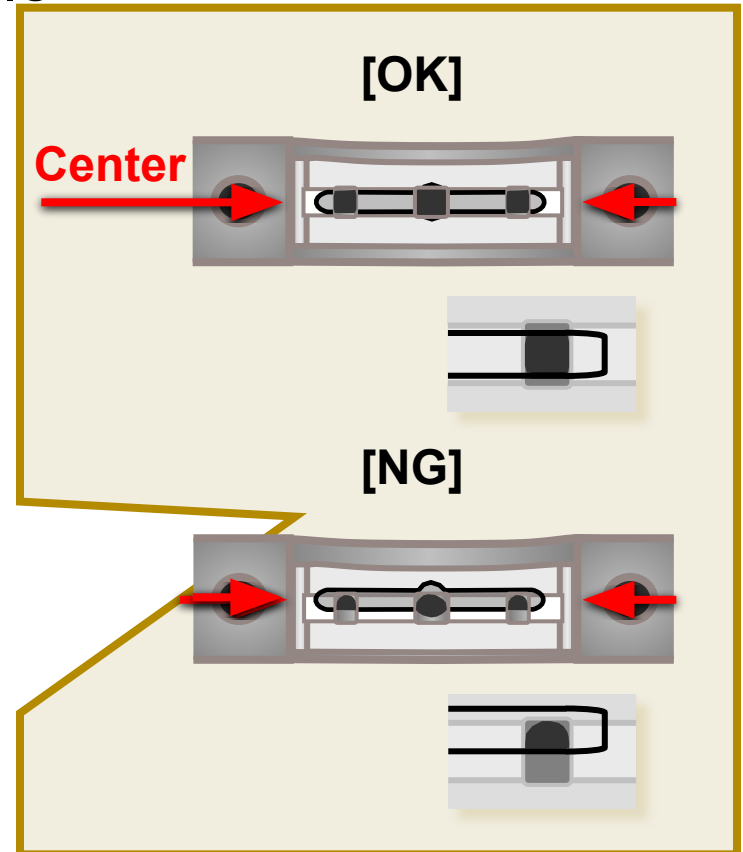
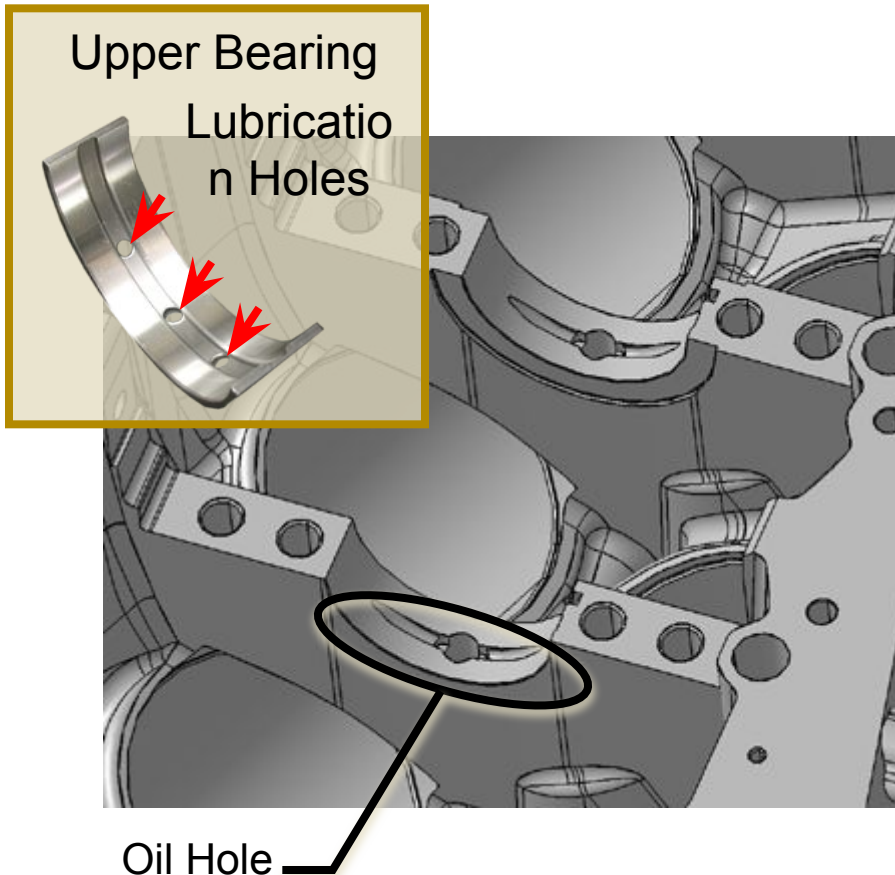
Engine Proper

- Bearing
 - Bearing without bearing claw is used for crankshaft bearings and connecting rod bearings



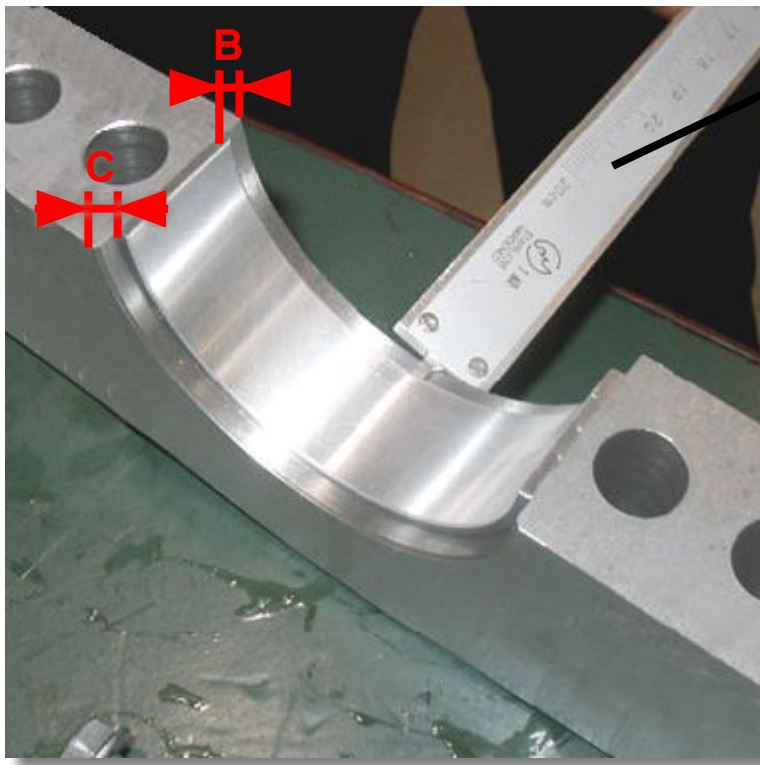
Service Point (Engine Proper)

- Installation of Crankshaft Upper Bearing
 - Bearing position should be centered to the cylinder block journal to align the oil hole

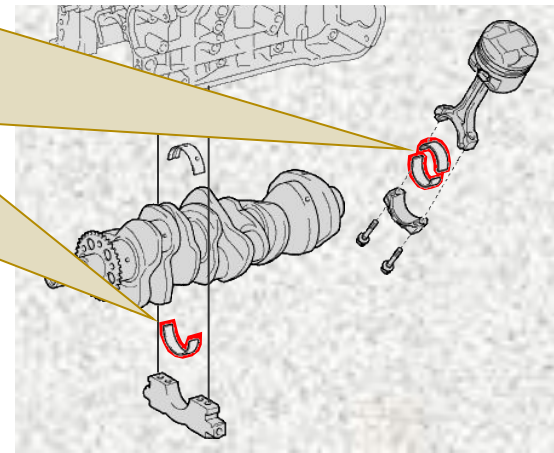


Service Point (Engine Proper)

- Installation of Crankshaft Lower Bearing, Connecting Rod Upper and Lower Bearings
 - Bearing should be positioned in center and measure the position
Difference Between “B” and “C”: **0.7 mm (0.028 in.) or less**

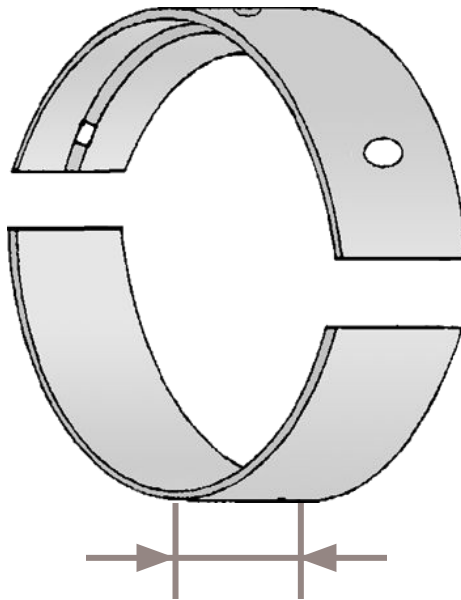


Vernier Caliper



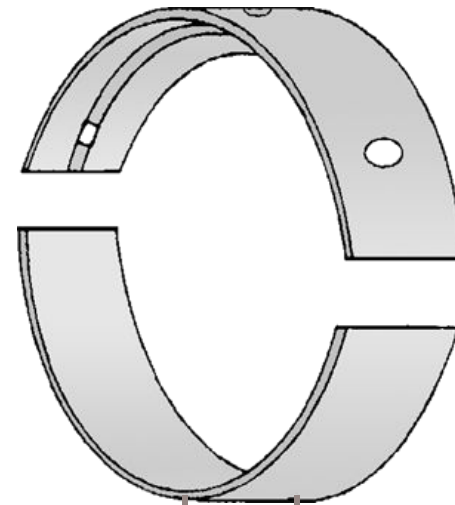
Service Point (Engine Proper)

- Crankshaft Bearing (upper and lower)
 - Combination of different width of the Bearings



21.0 mm
(0.827 in.)

No.1 and No.4 Journals



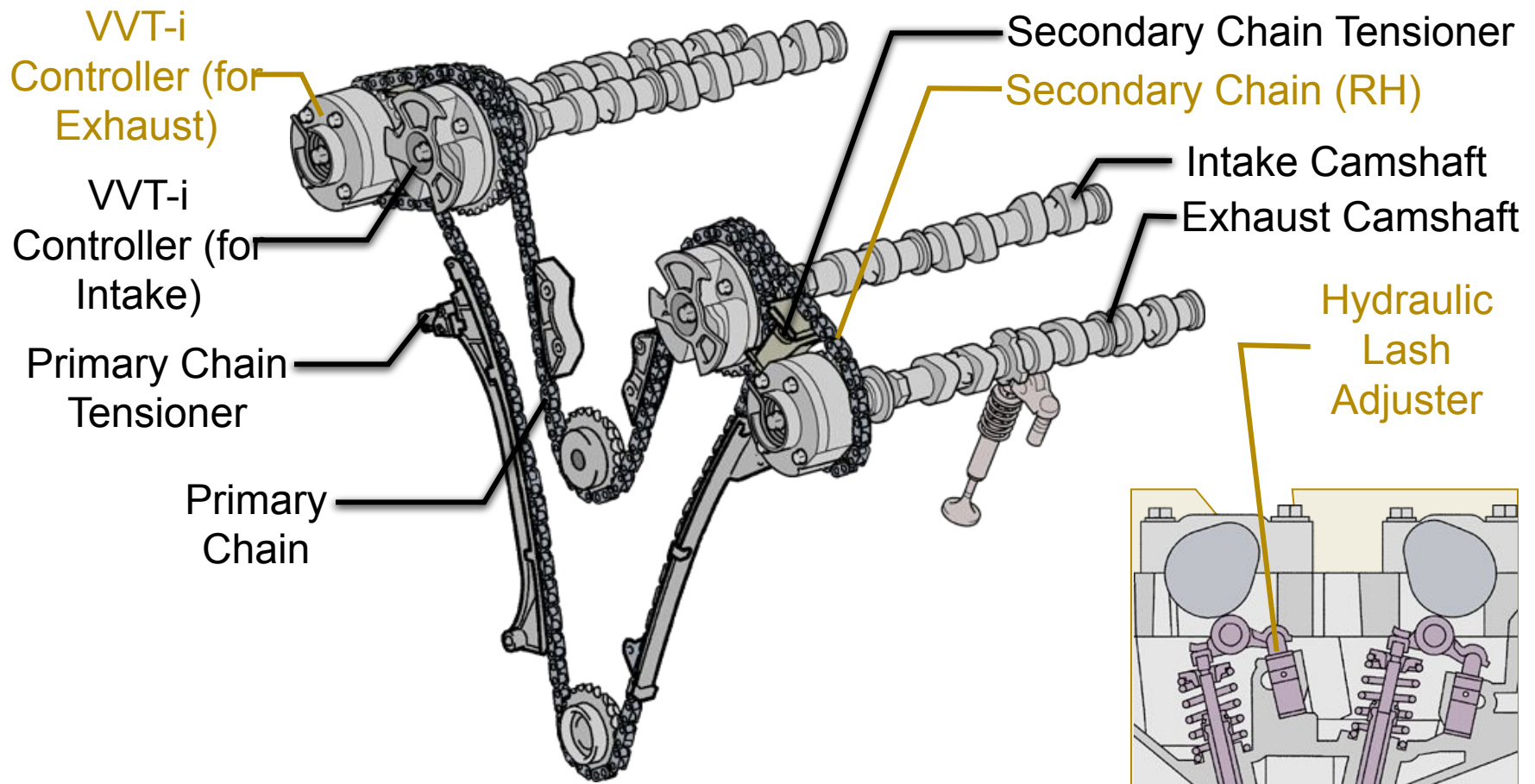
18.0 mm
(0.709

in.)
No.2 and No.3 Journals

Valve Mechanism

- General

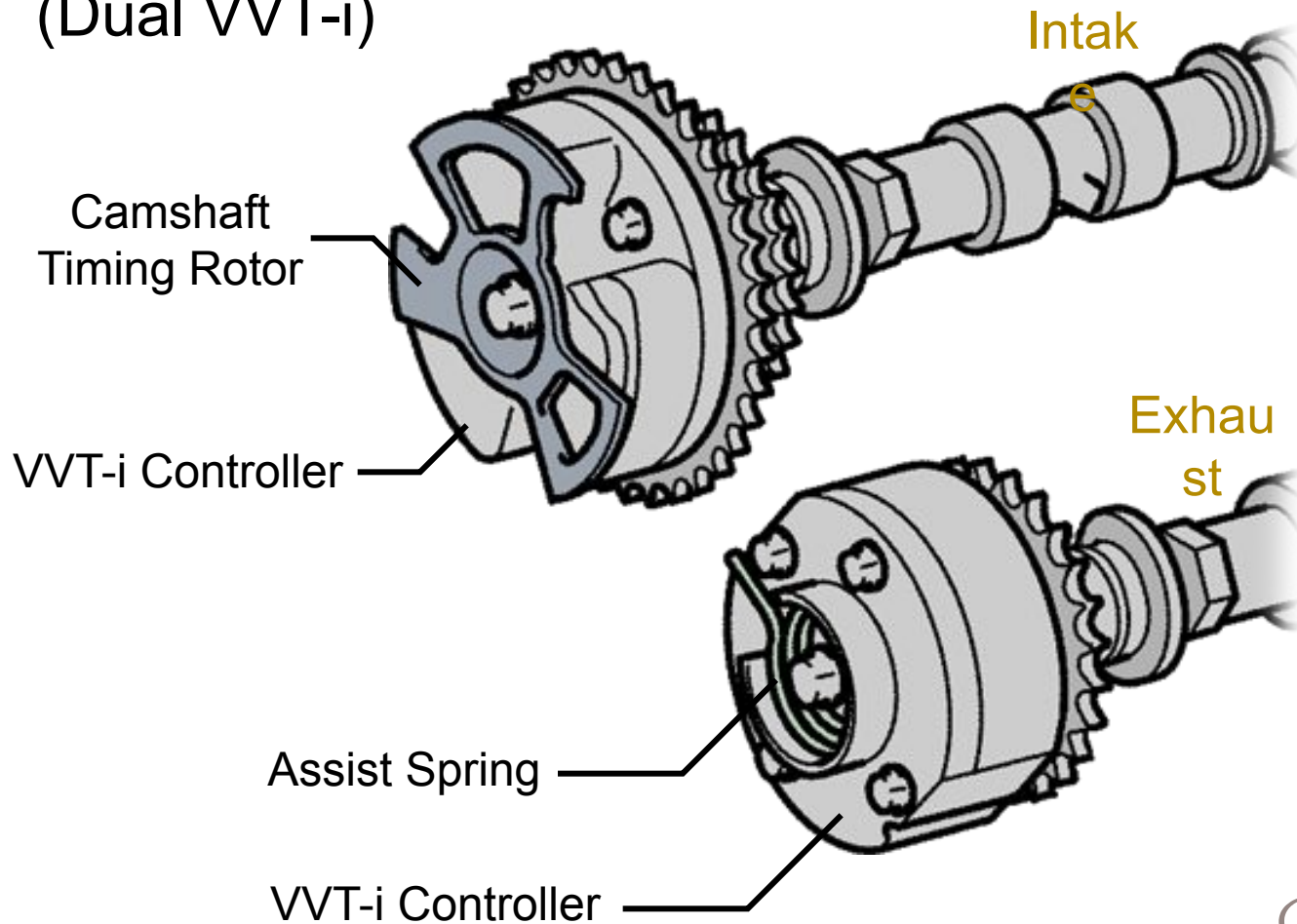
- Three timing chains to drive intake and exhaust camshafts of each bank



Valve Mechanism

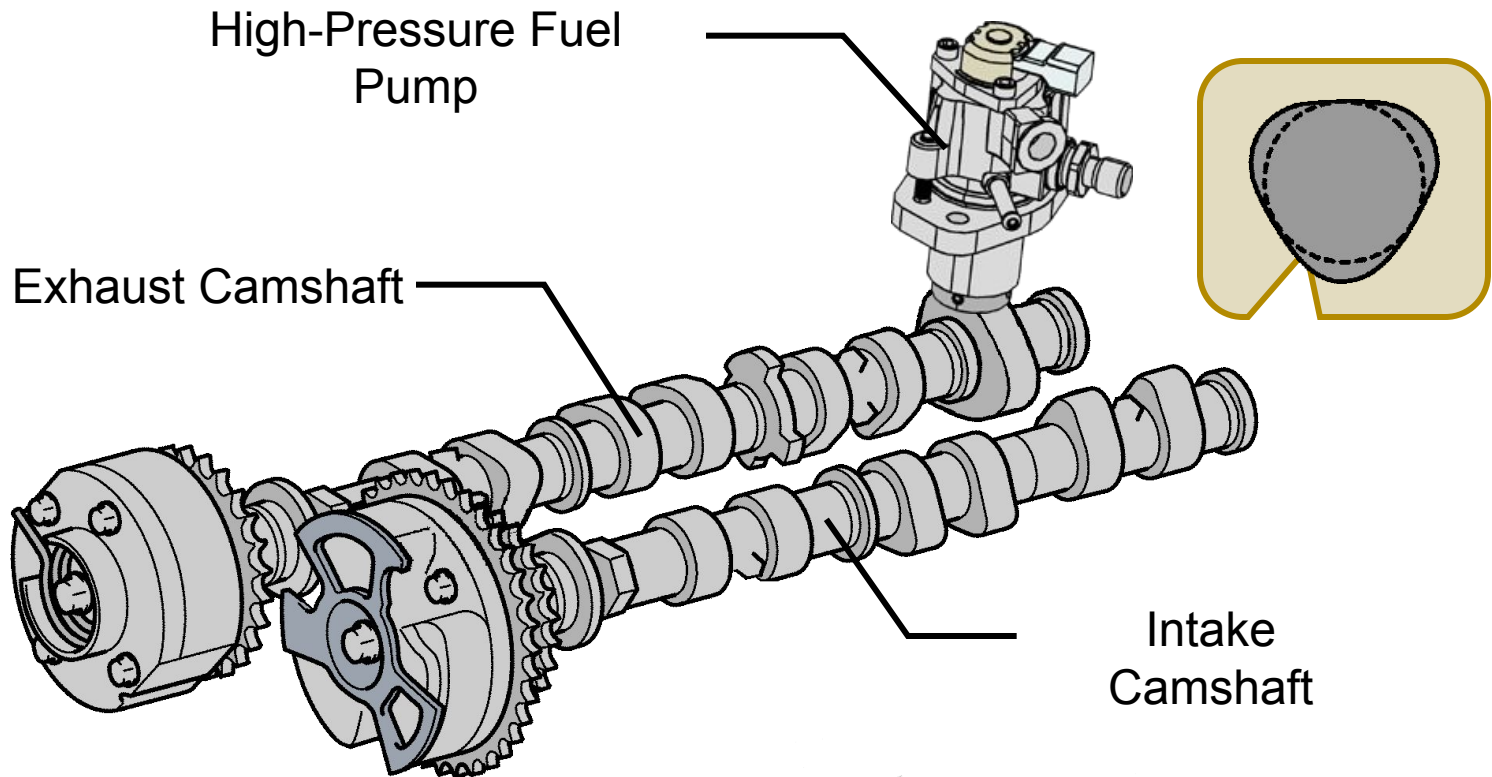
- Camshaft

- VVT-i system is used for intake & exhaust camshafts (Dual VVT-i)



Valve Mechanism

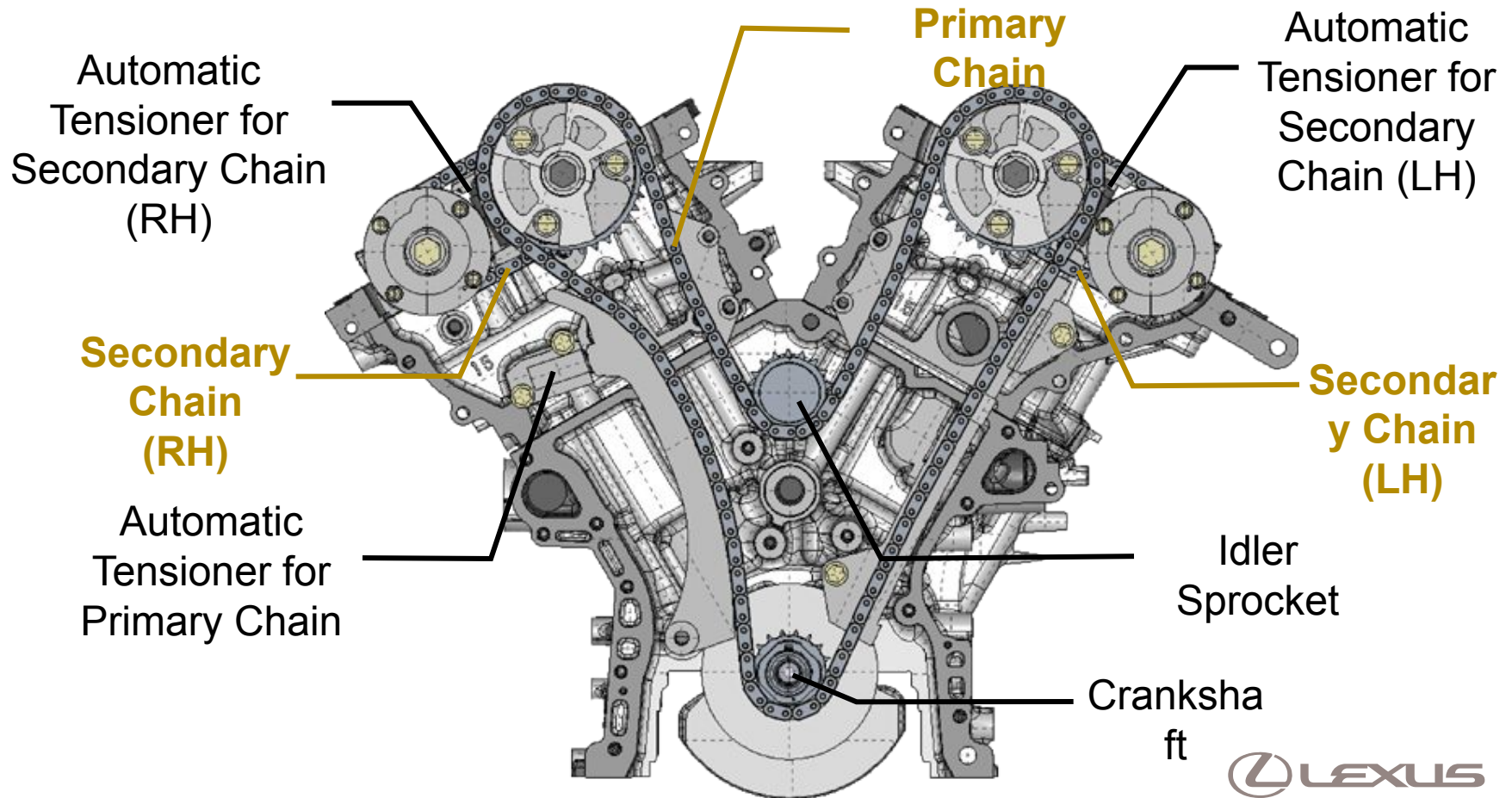
- Camshaft
 - RH bank exhaust camshaft is provided with the cam to drive the high-pressure fuel pump



RH
Bank

Valve Mechanism

- Timing Chain
 - Three timing chains to drive intake and exhaust camshafts of each bank



Valve Mechanism

- Chain Tensioner
 - Primary chain tensioner
 - Ratchet type non-return mechanism

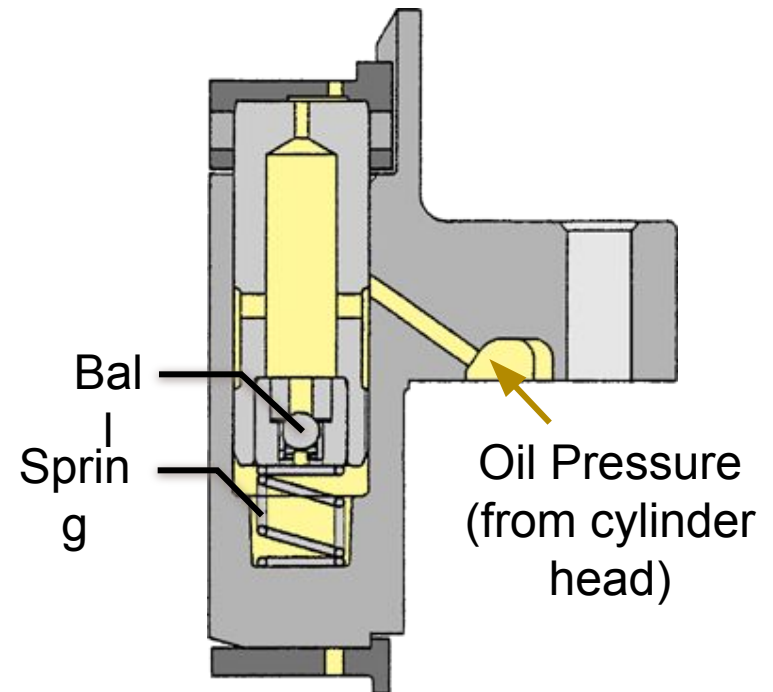
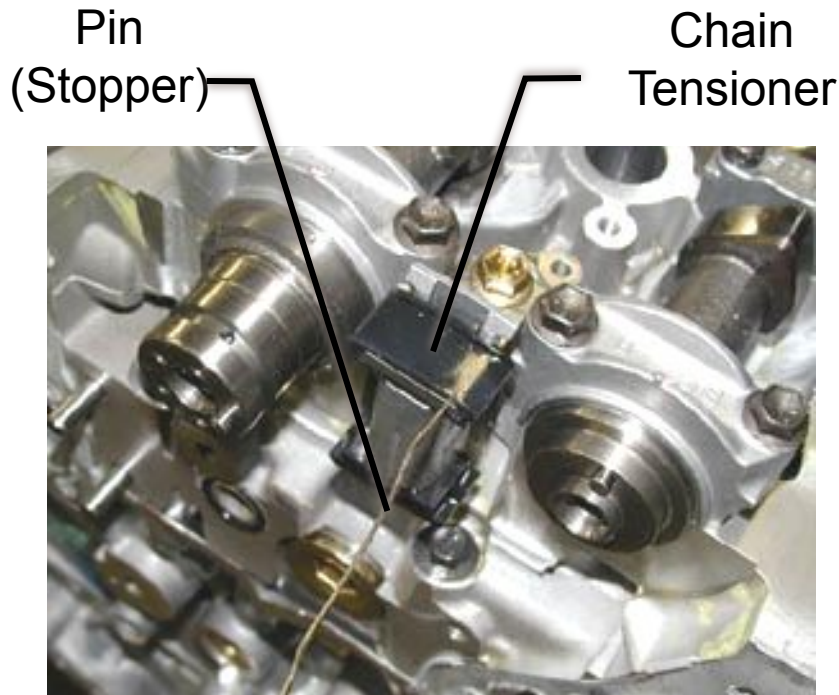


Service hall for
remove and replace



Valve Mechanism

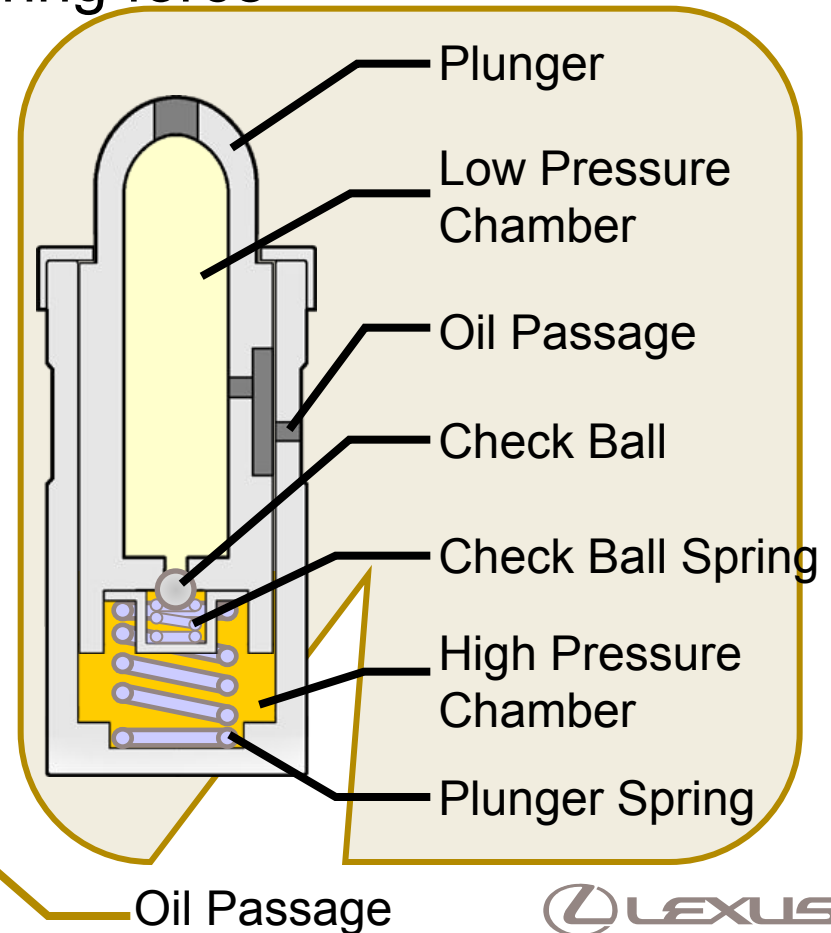
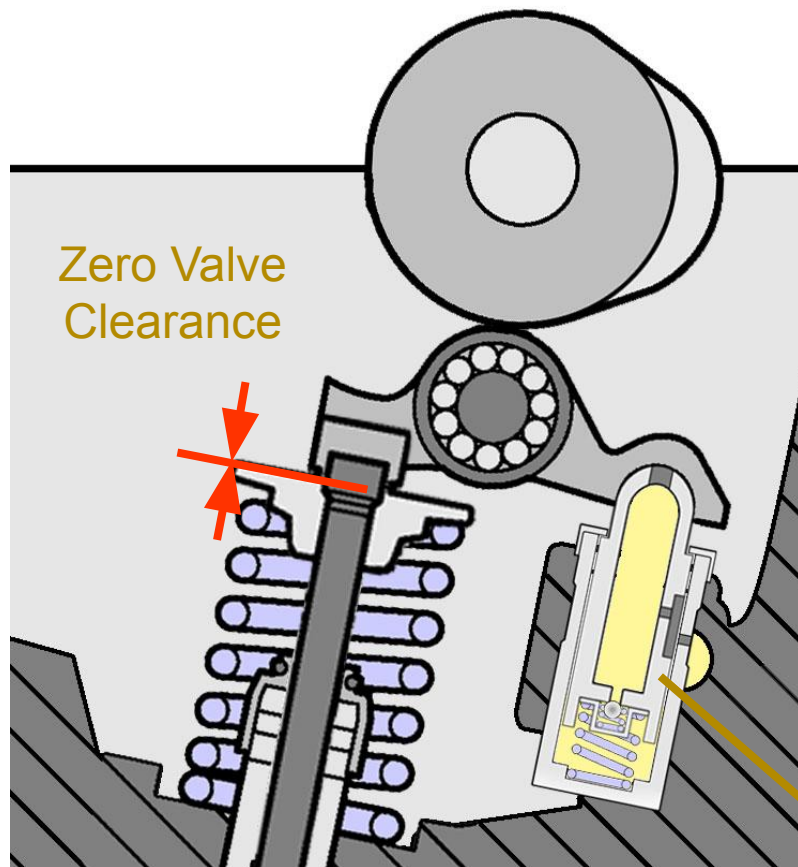
- Chain Tensioner
 - 2 secondary chain tensioners are used for left and right bank



Left Bank

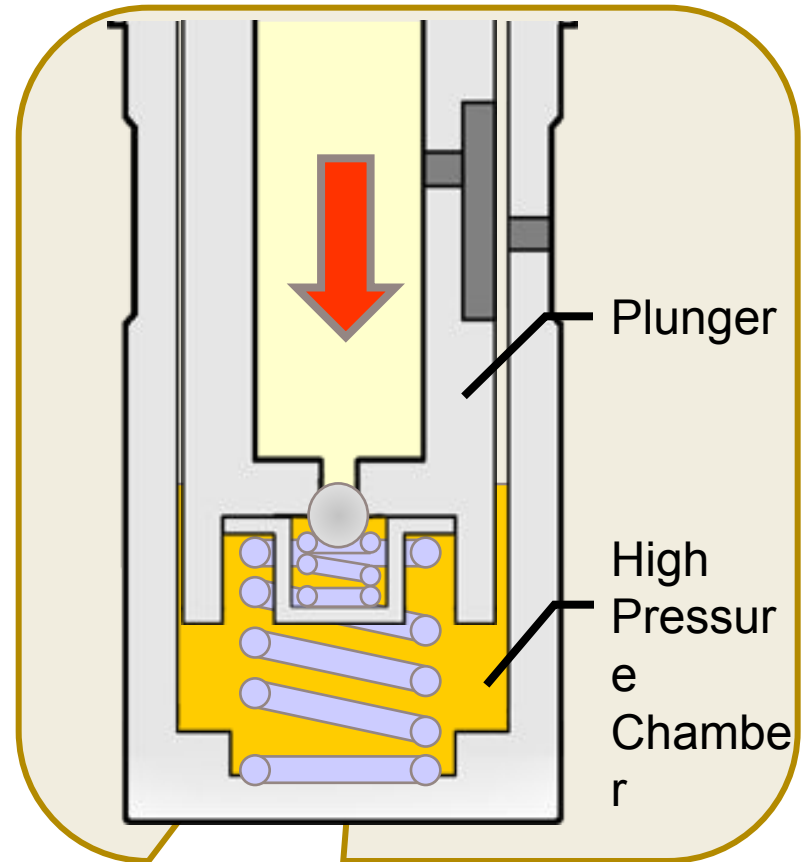
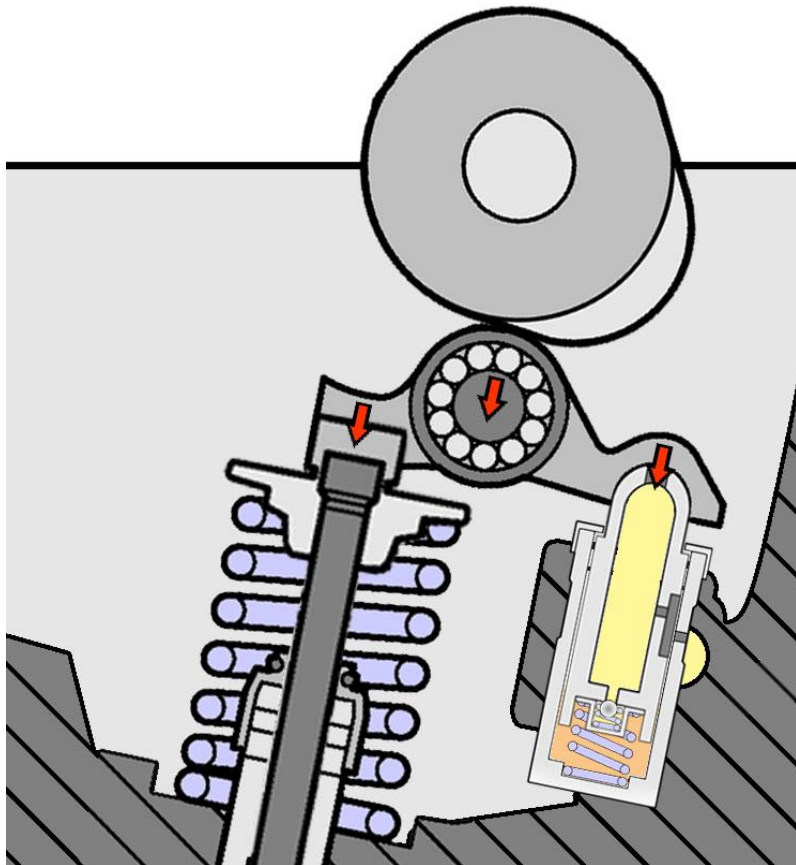
Reference (Valve Mechanism)

- Hydraulic Lash Adjuster
 - Maintaining a constant zero valve clearance through use of oil pressure and spring force



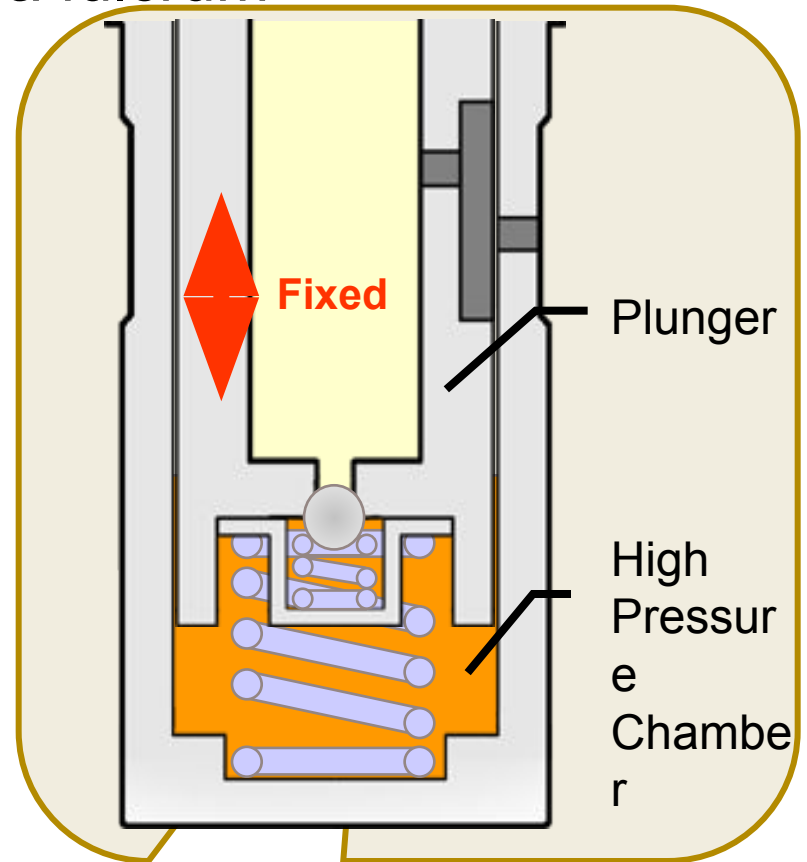
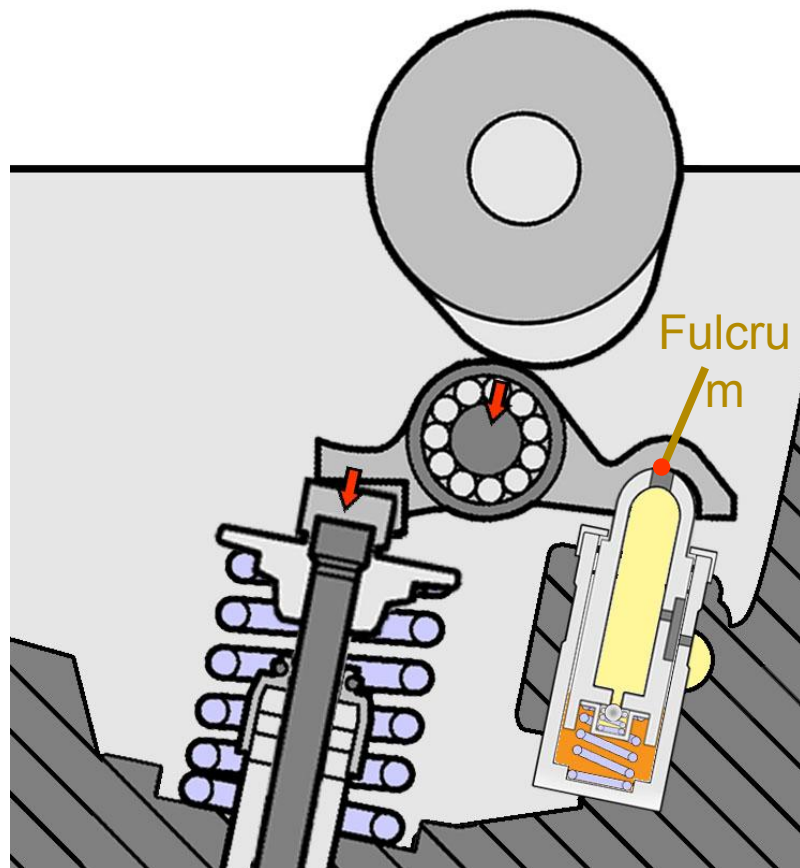
Reference (Valve Mechanism)

- Hydraulic Lash Adjuster
 - Start cam lift, plunger is pressed and oil in high pressure chamber is kept



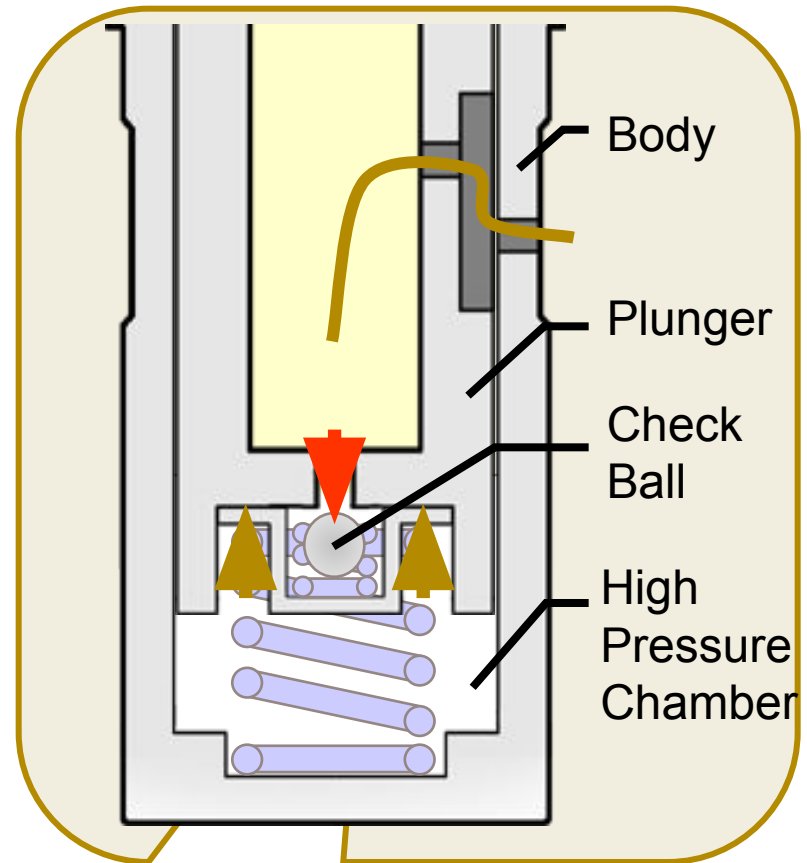
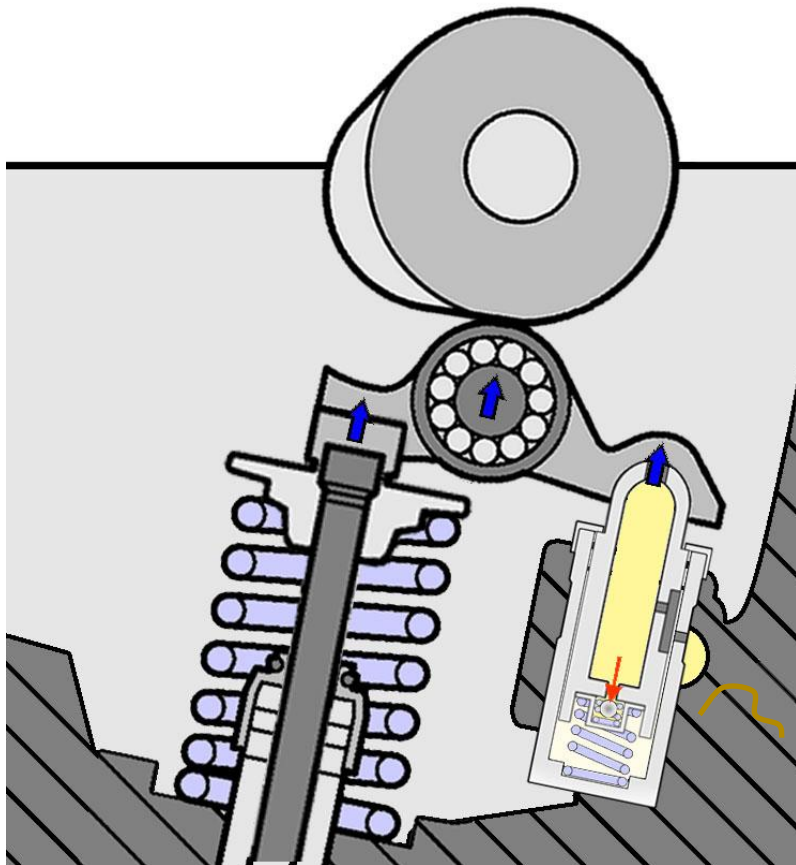
Reference (Valve Mechanism)

- Hydraulic Lash Adjuster
 - Then the rocker arm pushes the valve by using hydraulic lash adjuster as a fulcrum



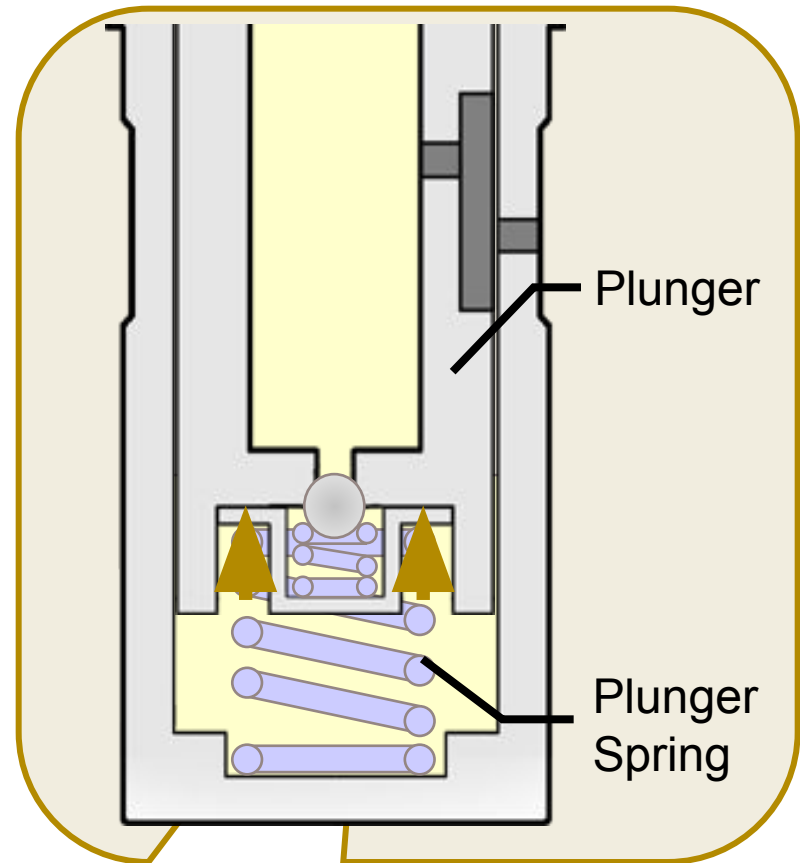
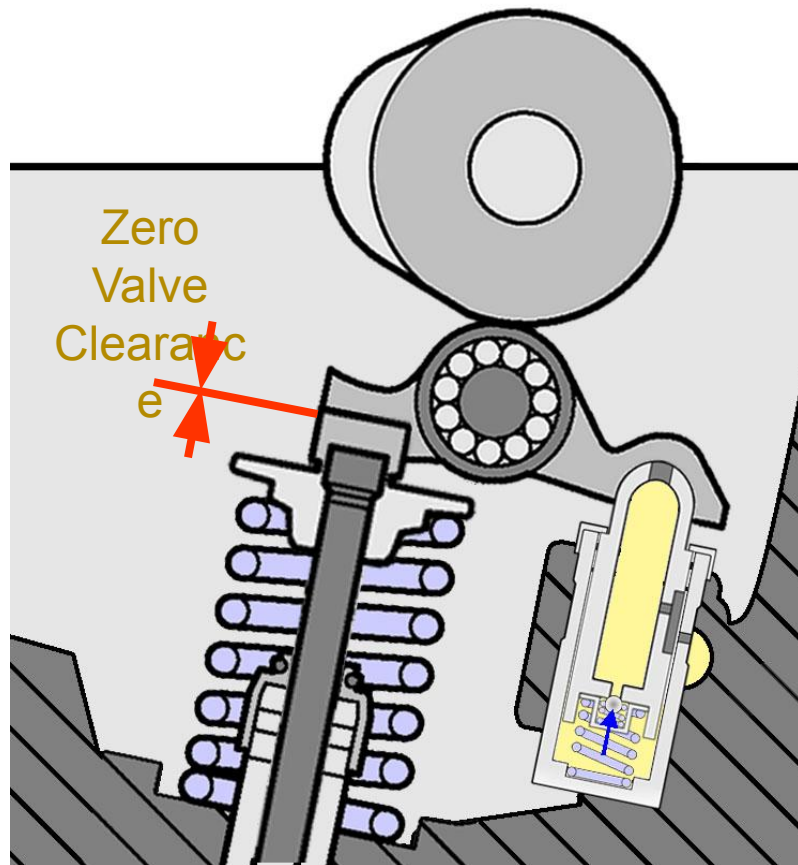
Reference (Valve Mechanism)

- Hydraulic Lash Adjuster
 - Plunger pushes back, check valve is opened and fills up oil



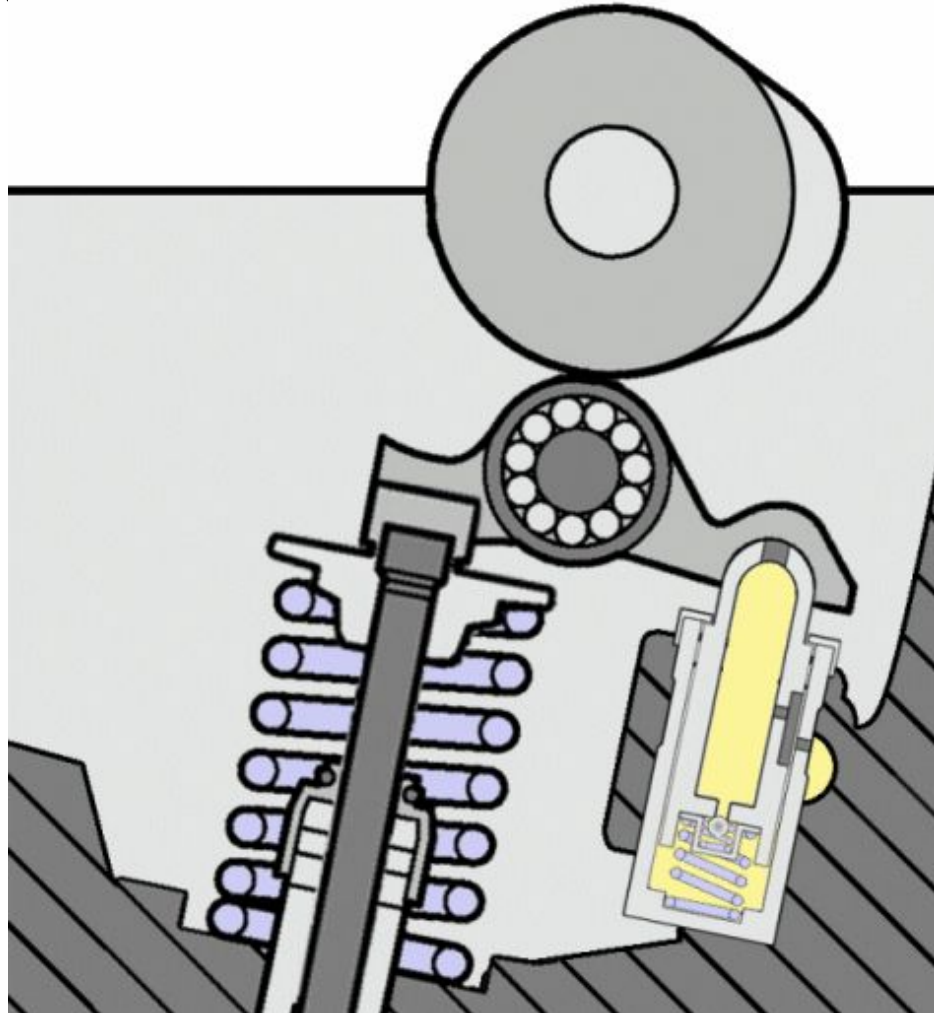
Reference (Valve Mechanism)

- Hydraulic Lash Adjuster
 - Plunger is pushed up, then, valve clearance is maintained at zero



Reference (Valve Mechanism)

- Hydraulic Lift
– Operation

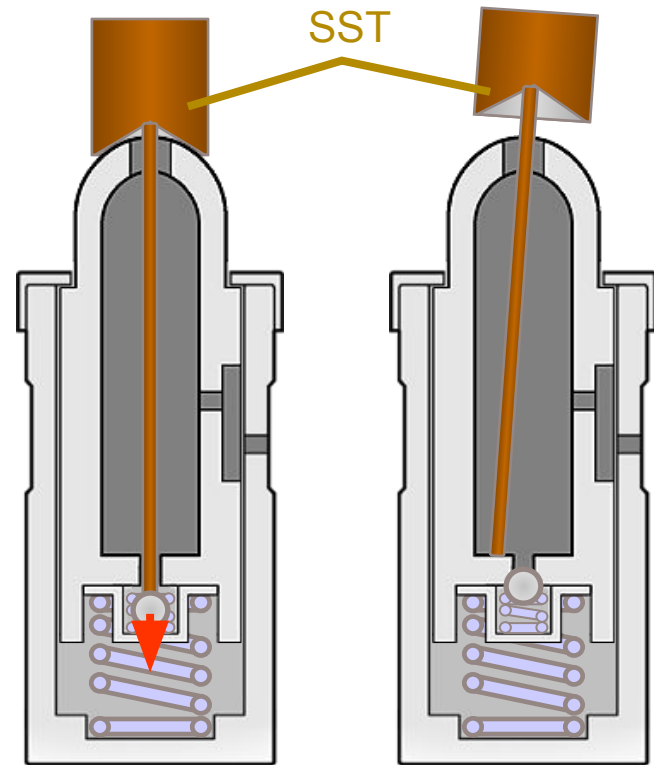


Service Point (Valve Mechanism)

- Hydraulic Lash Adjuster
 - Engine oil changing procedure
 - 1. Pushing check ball down by using SST



Hydraulic Lash Adjuster



Correct

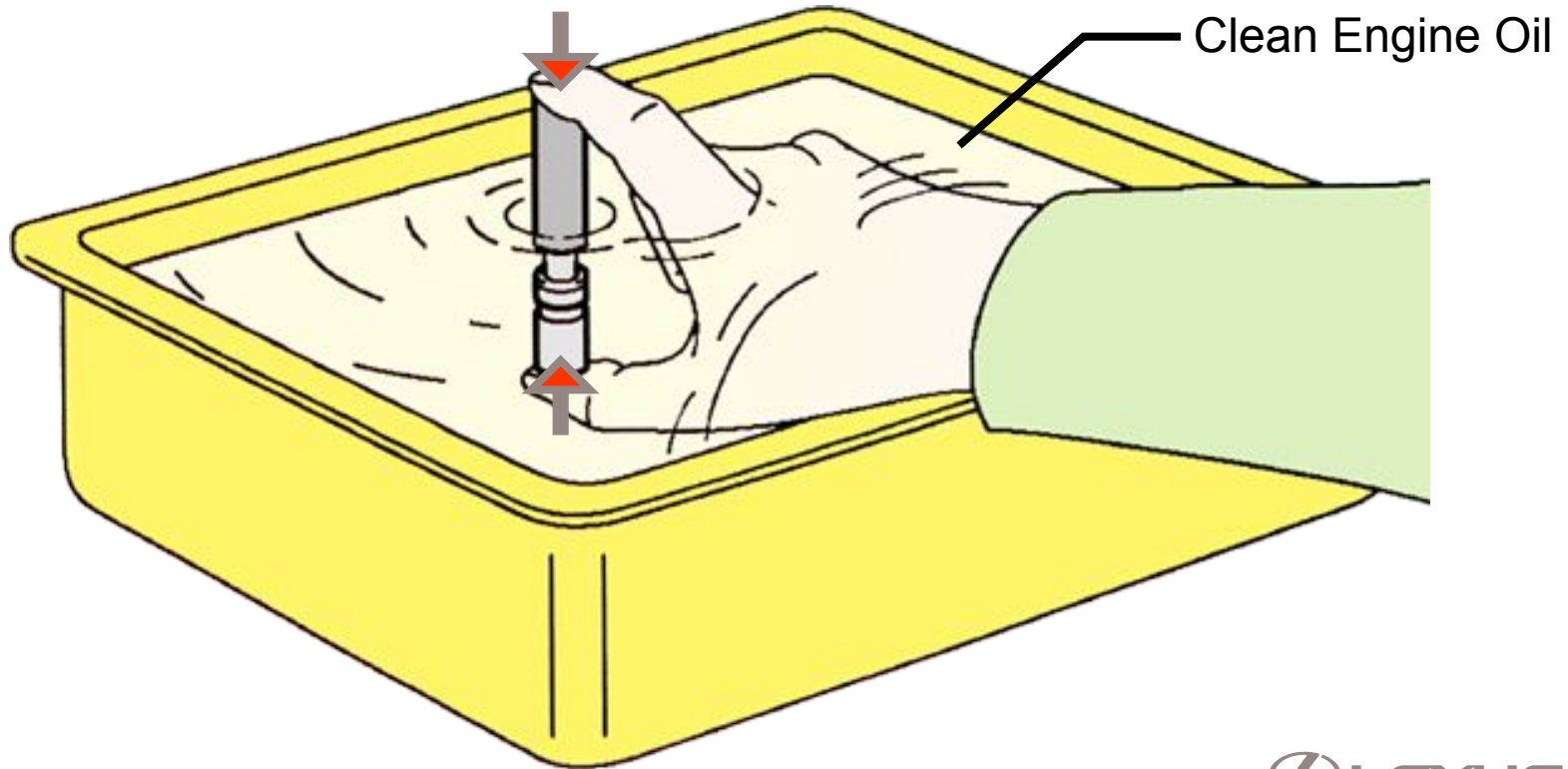
Incorrect

Service Point (Valve Mechanism)

- Hydraulic Lash Adjuster

- Engine oil changing procedure

- 2. Immerse hydraulic lash adjuster in clean engine oil, then compress and return the plunger with SST 5 to 6 times



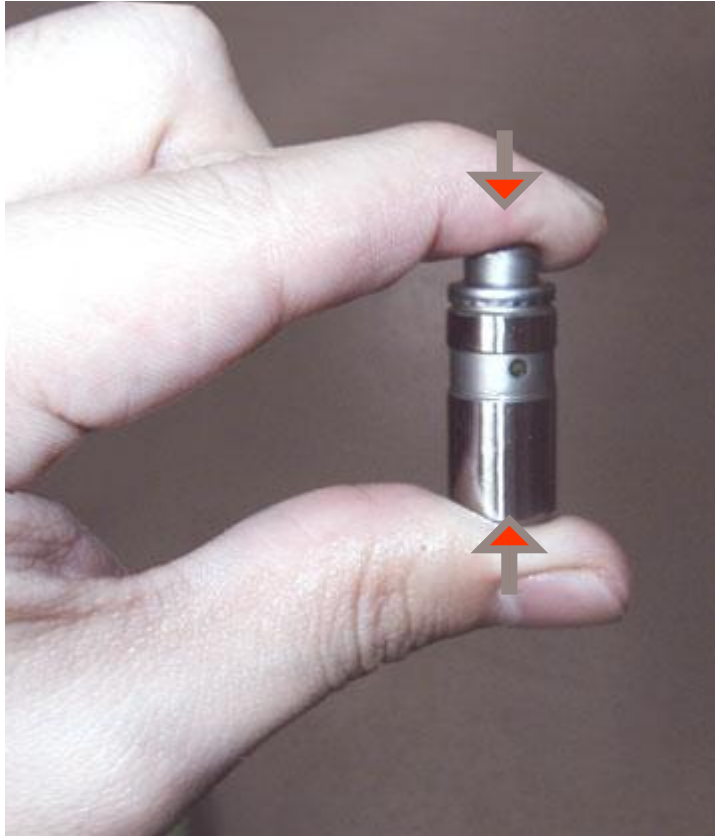
Service Point (Valve Mechanism)

- Hydraulic Assist Adjuster
 - Engine oil changing procedure
 - 3. Press the plunger by finger and check the blockage of plunger



Service Point (Valve Mechanism)

- Hydraulic Assist Adjuster
 - Engine oil changing procedure
 - If plunger is compressed after 3 times trial, replace to new one

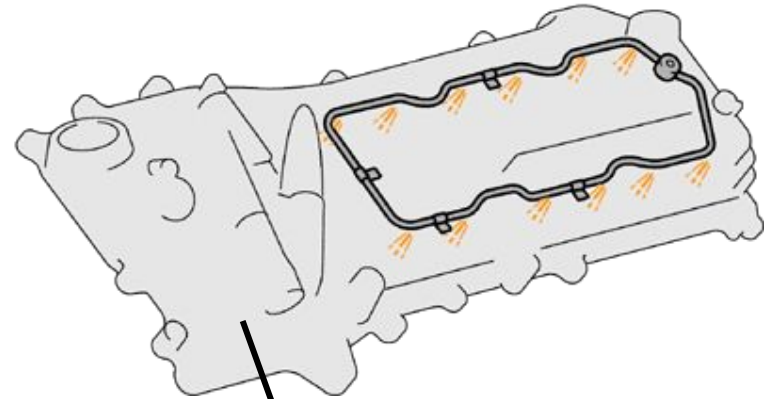
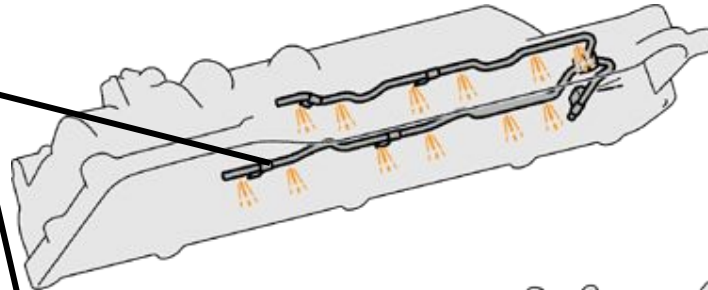
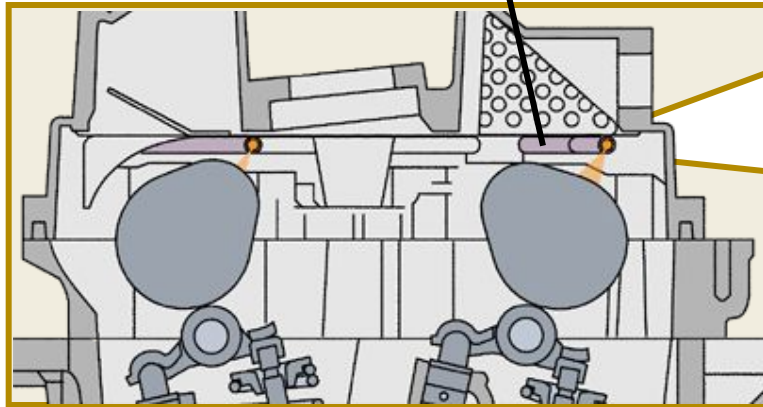


Lubrication System

- Oil Delivery Pipe

- Oil delivery pipe is used to lubricate cam and rocker arm

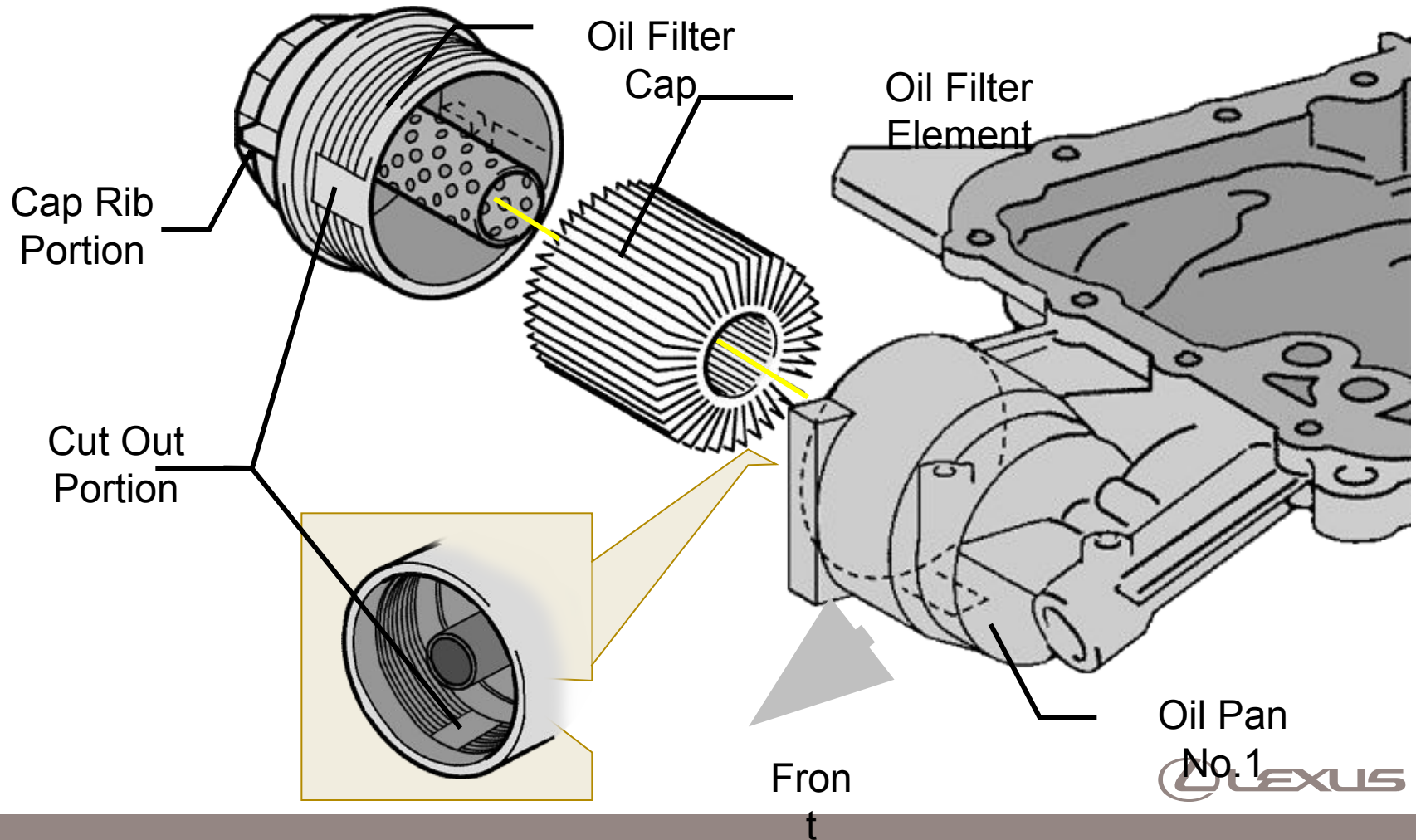
Oil Delivery
Pipe



Cylinder Head
Cover

Lubrication System

- Oil Filter (2WD)
 - Element replacing type oil filter is used

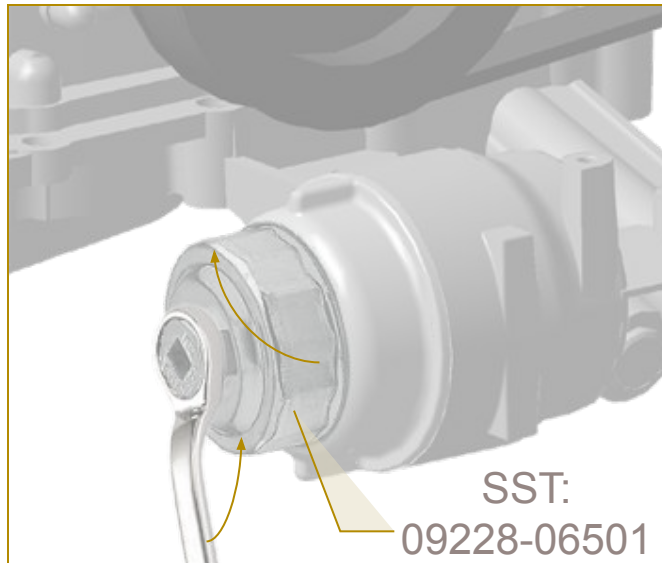


Service Point (Lubrication System)

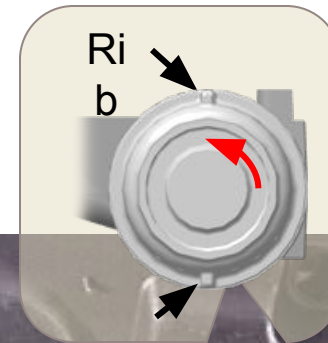
Oil Filter (4WD)

- Oil filter replacement
 - Removal

Remove filter element



Loosen the filter cap for approx. 4 rev.

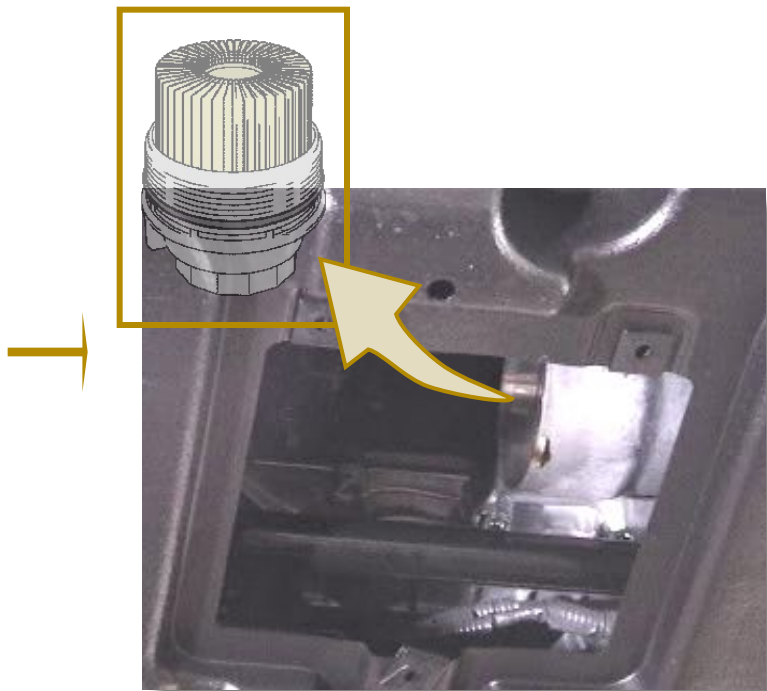


Align the cap rib vertically and drain oil

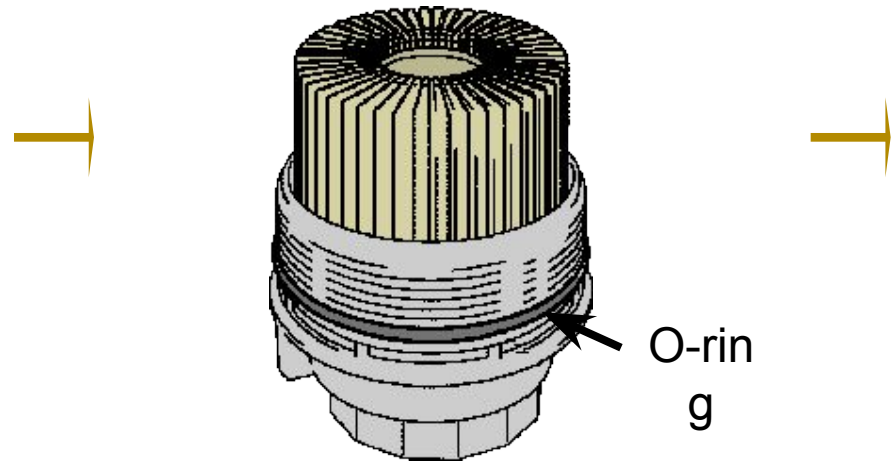
Service Point (Lubrication System)

Oil filter (4WD)

- Oil filter replacement
 - Removal



Remove oil filter cap and filter element



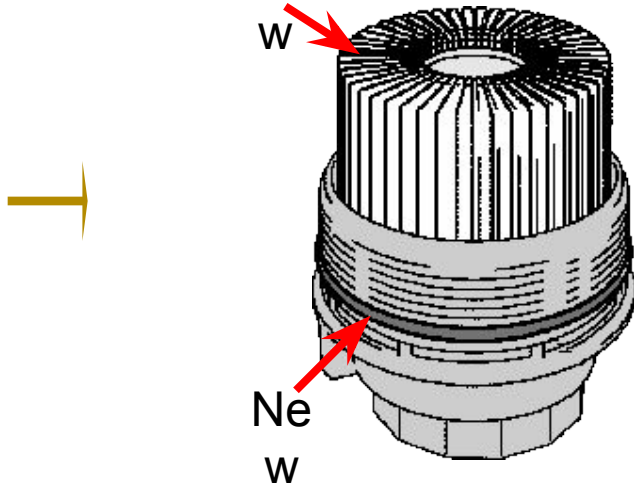
Remove filter element and O-ring from filter cap

Service Point (Lubrication System)

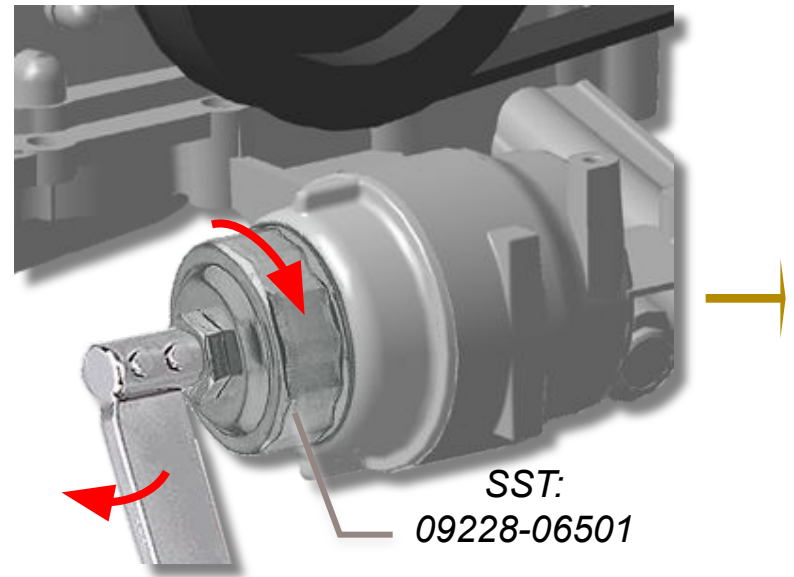
Oil Filter (2WD)

- Oil filter replacement
 - Installation

Install filter element
Ne
w



Set new filter element and
O-ring



Install filter cap using
SST

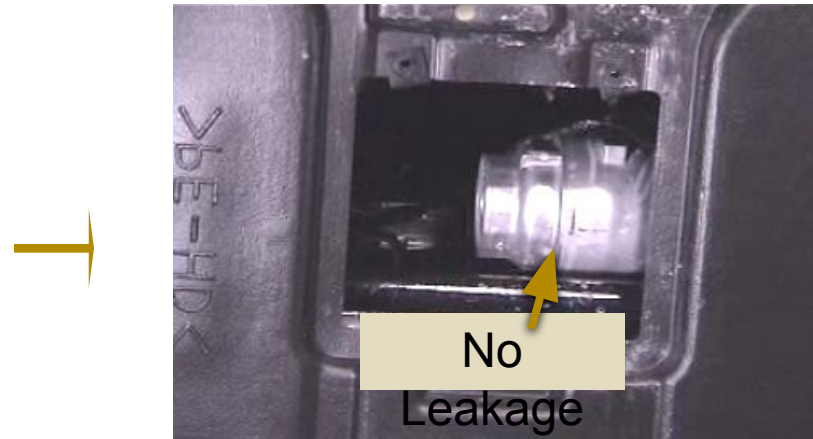
Service Point (Lubrication System)

Oil filter (4WD)

- Oil filter replacement
 - Installation



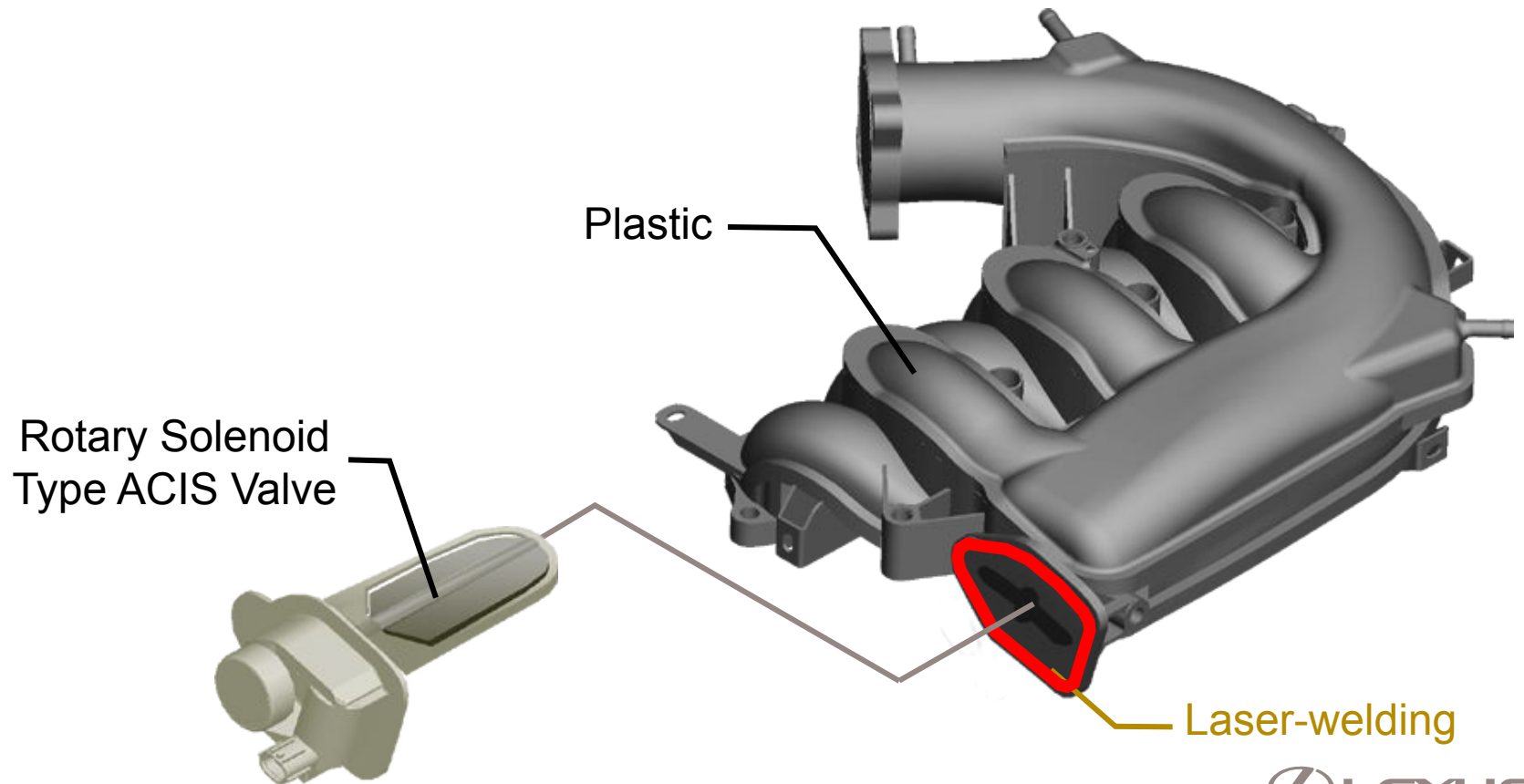
Refill engine oil



Run the engine and check oil leakage

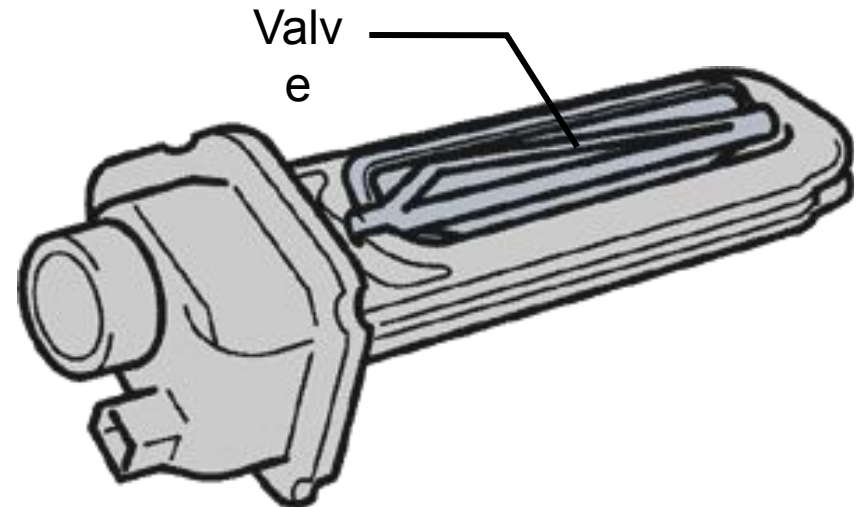
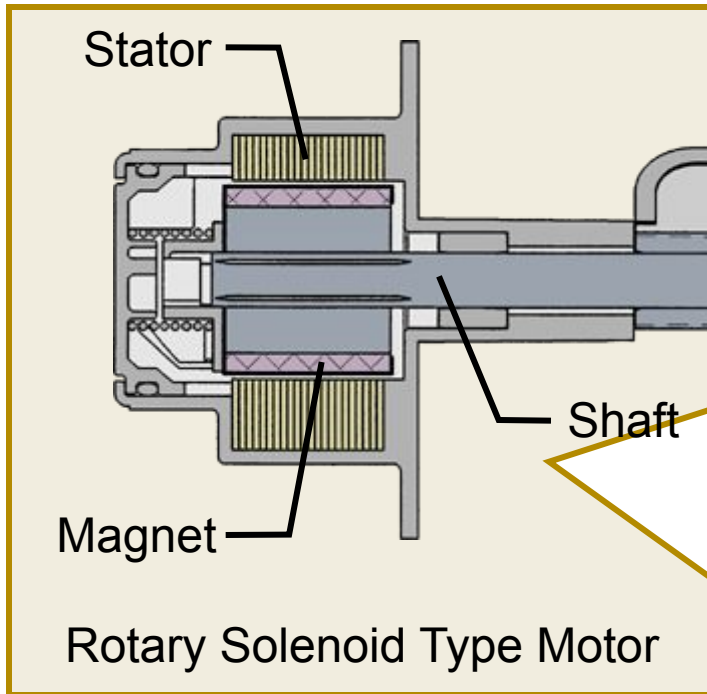
Intake and Exhaust System

- ACIS Valve
 - Rotary solenoid type ACIS valve is used
 - ACIS valve is unified by laser-welding



Reference (Intake & Exhaust System)

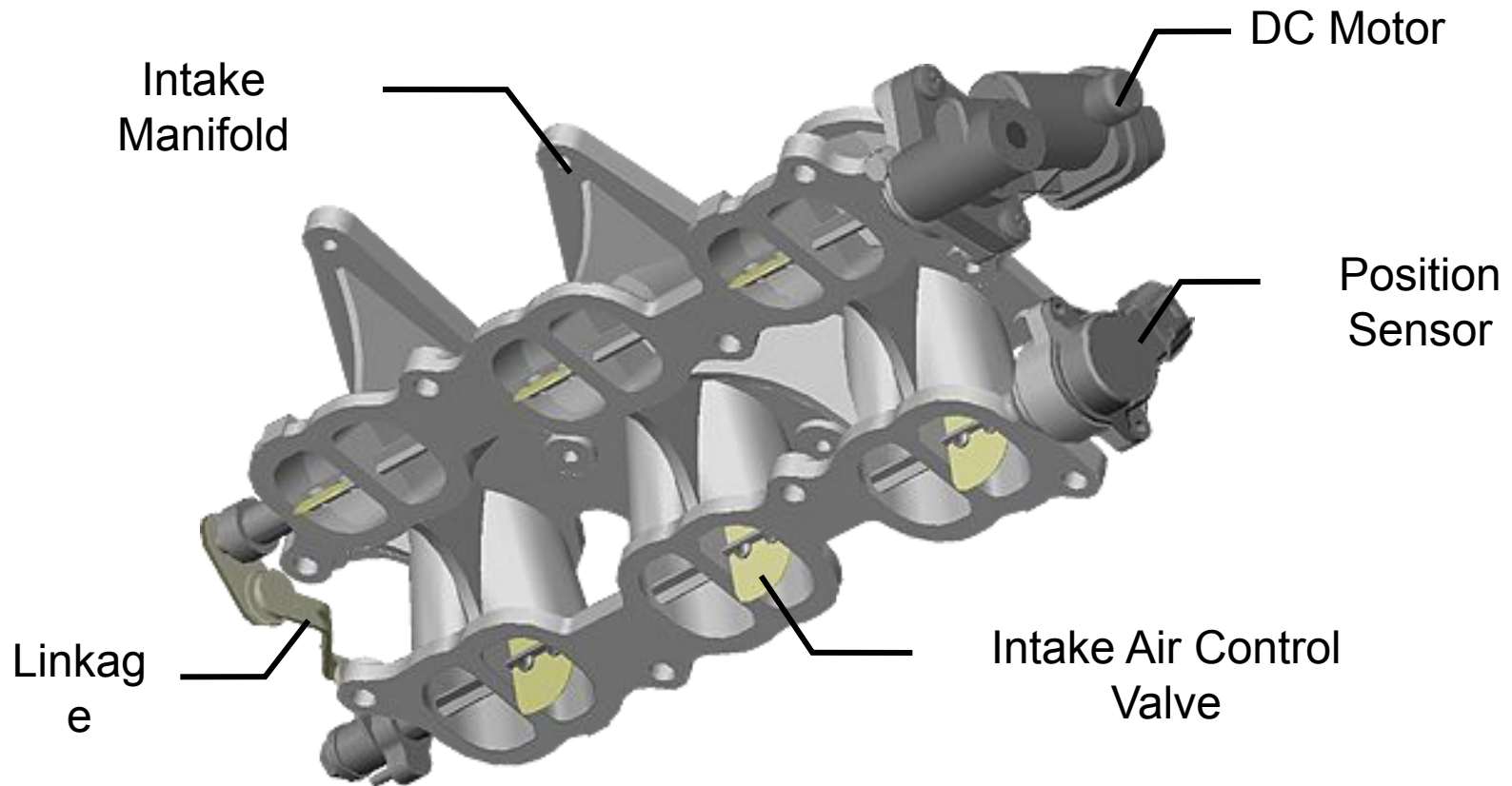
- Rotary solenoid type ACIS valve is used



ACIS
Valve

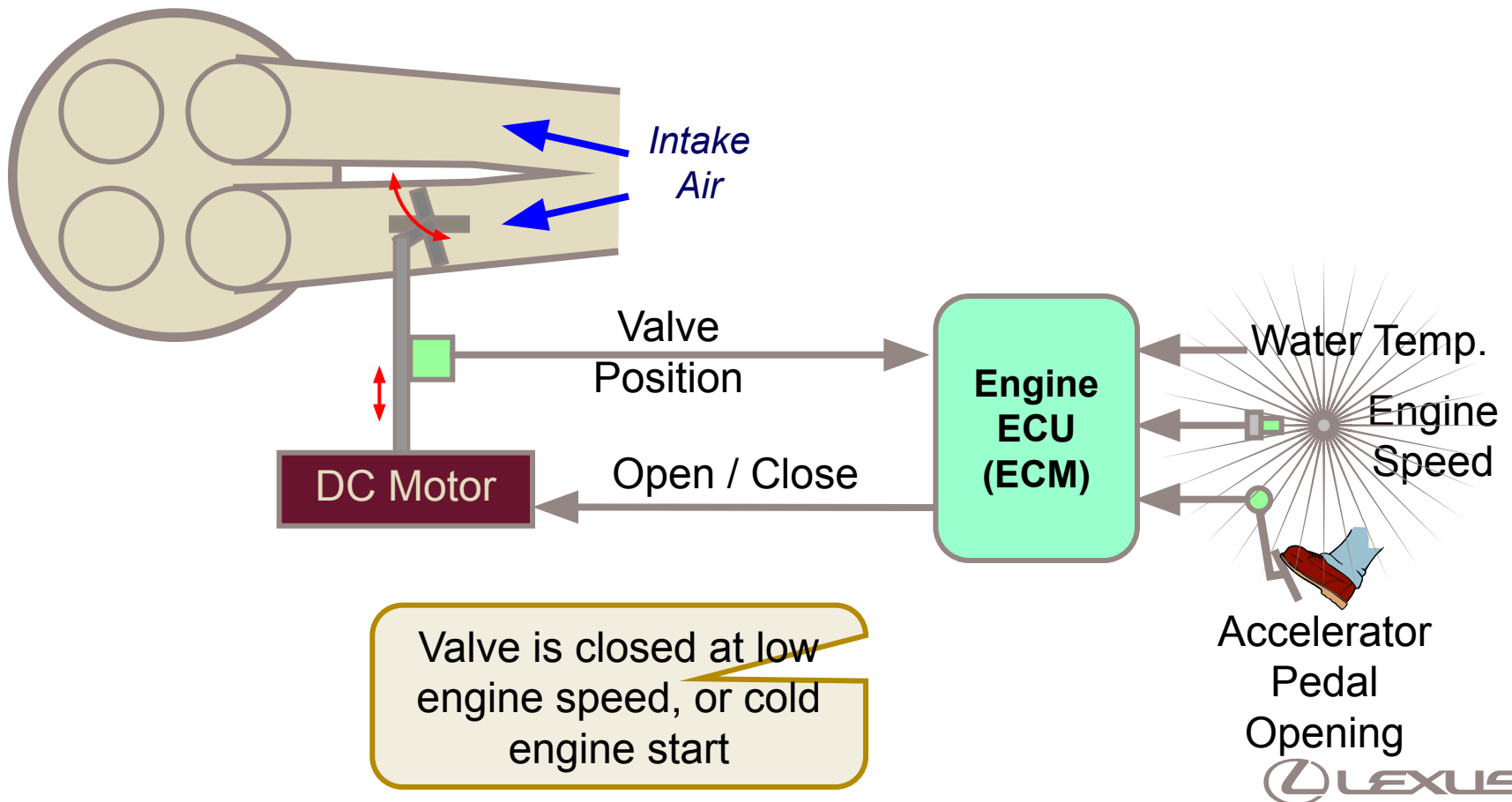
Intake and Exhaust System

- Intake Air Control Valve
 - Intake air control valve is operated by DC motor



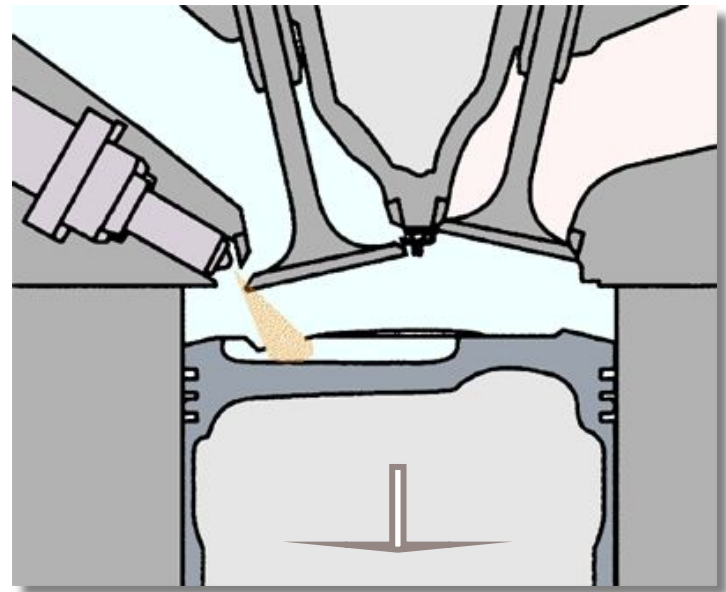
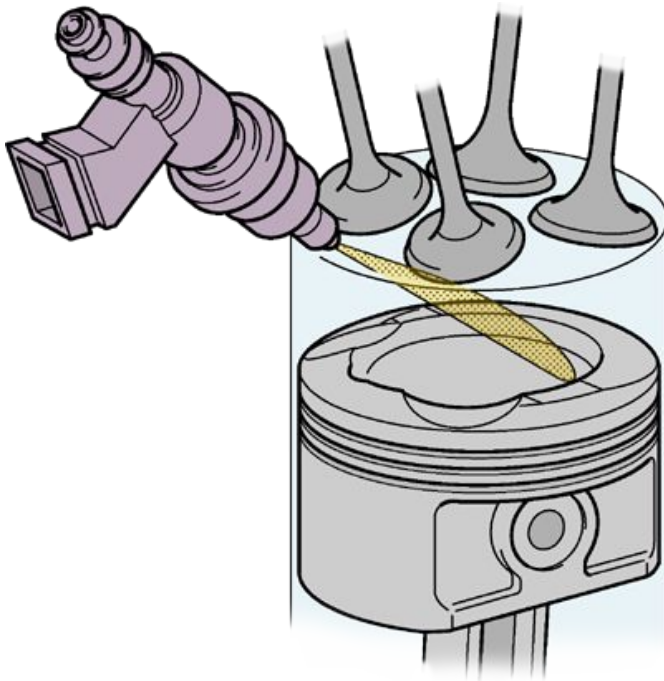
Intake and Exhaust System

- Intake Air Control Valve
 - Operation



D-4 System

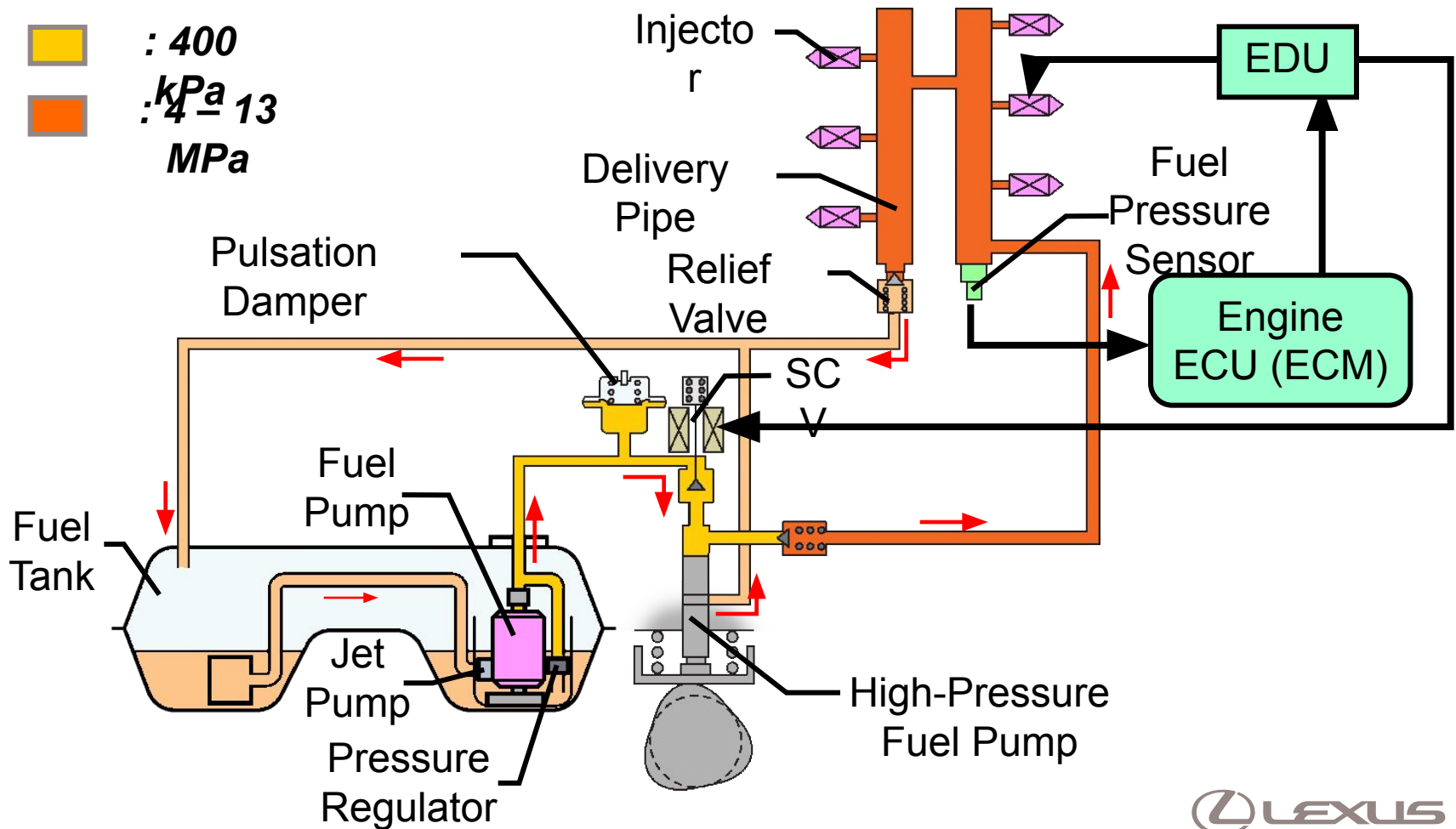
- General
 - 4GR-FSE engine uses D-4 System



D-4 (Direct injection 4-stroke gasoline engine)

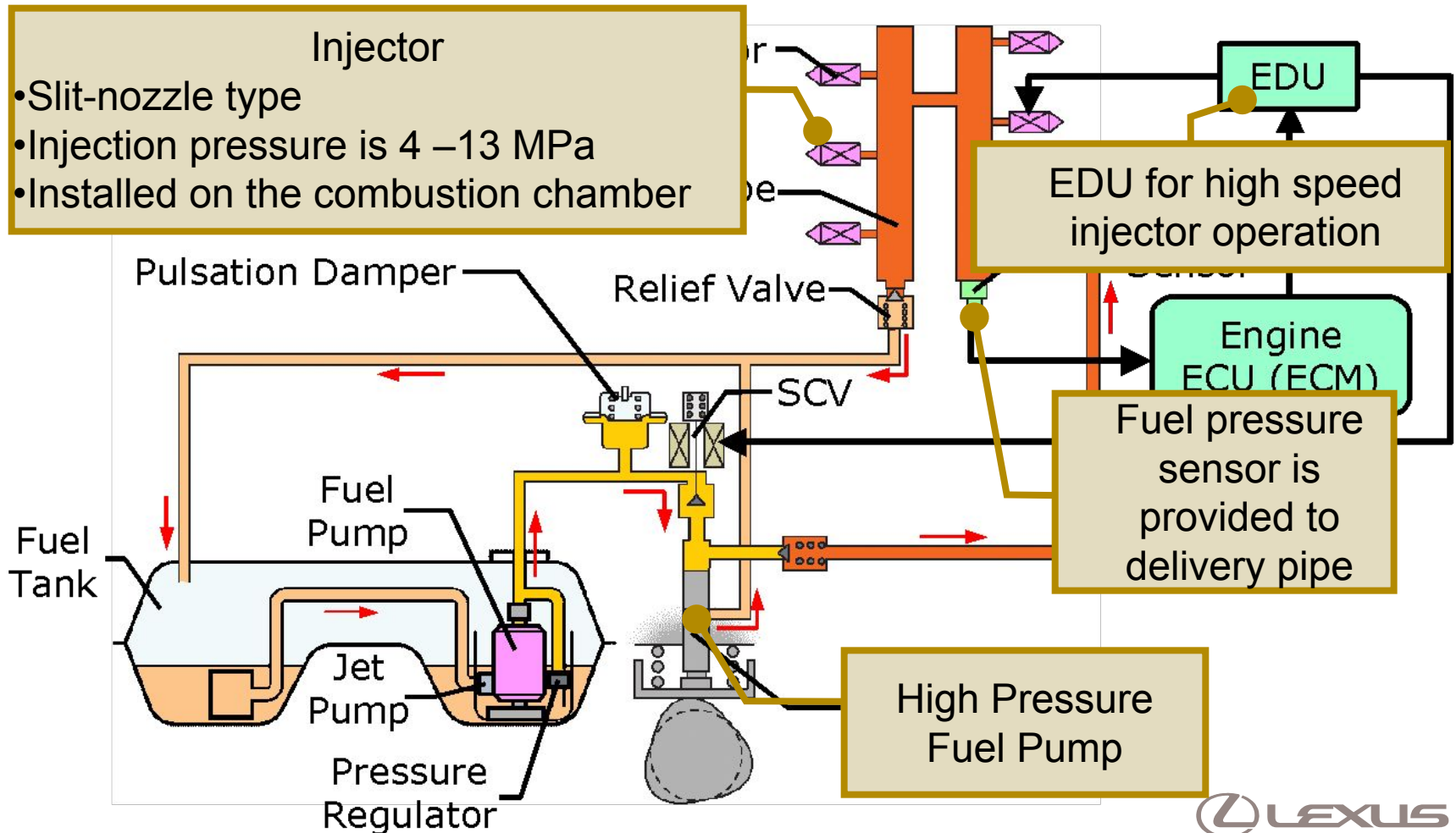
D-4 System

- System Diagram



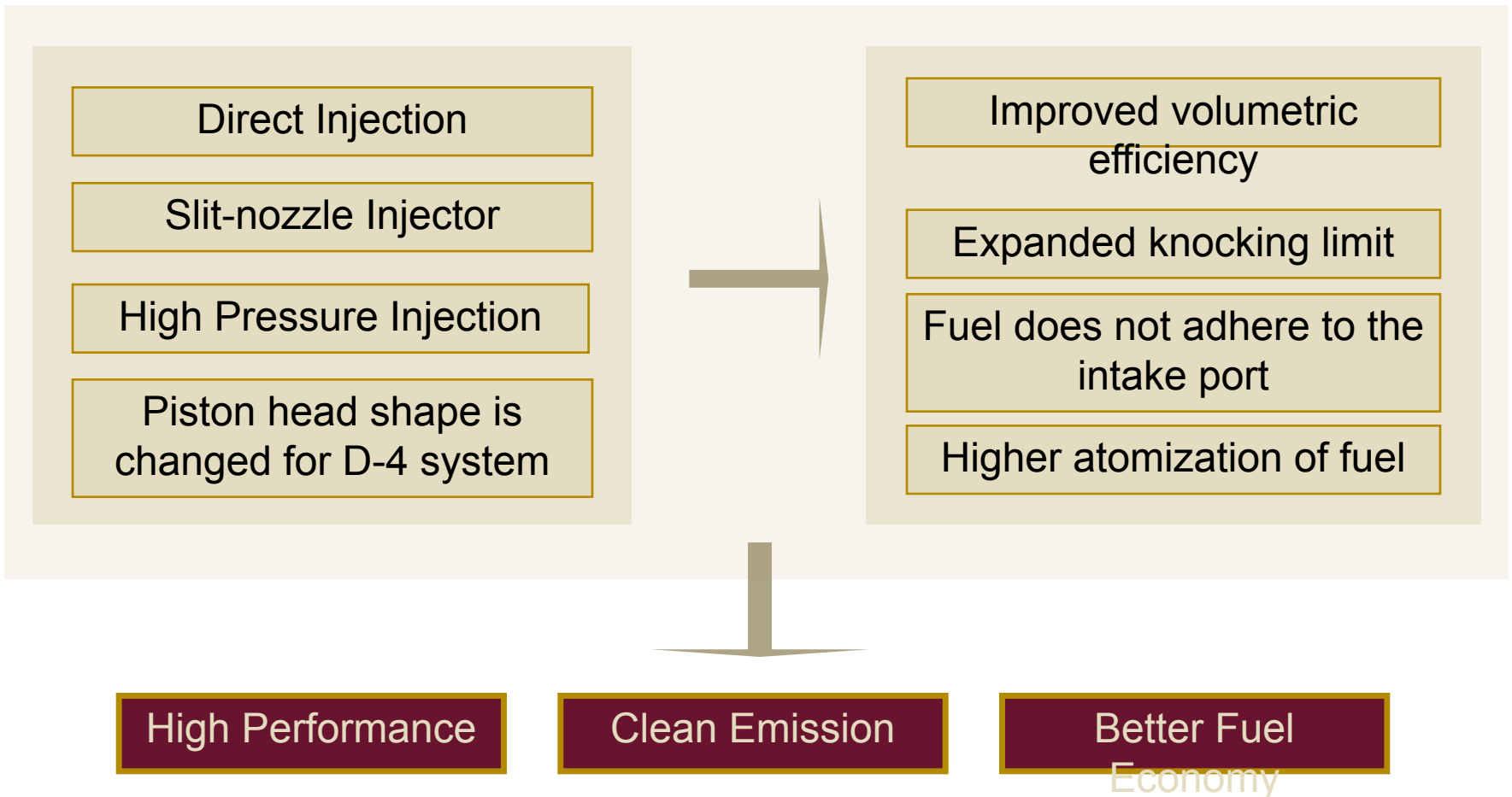
D-4 System

- Difference from usual gasoline EFI



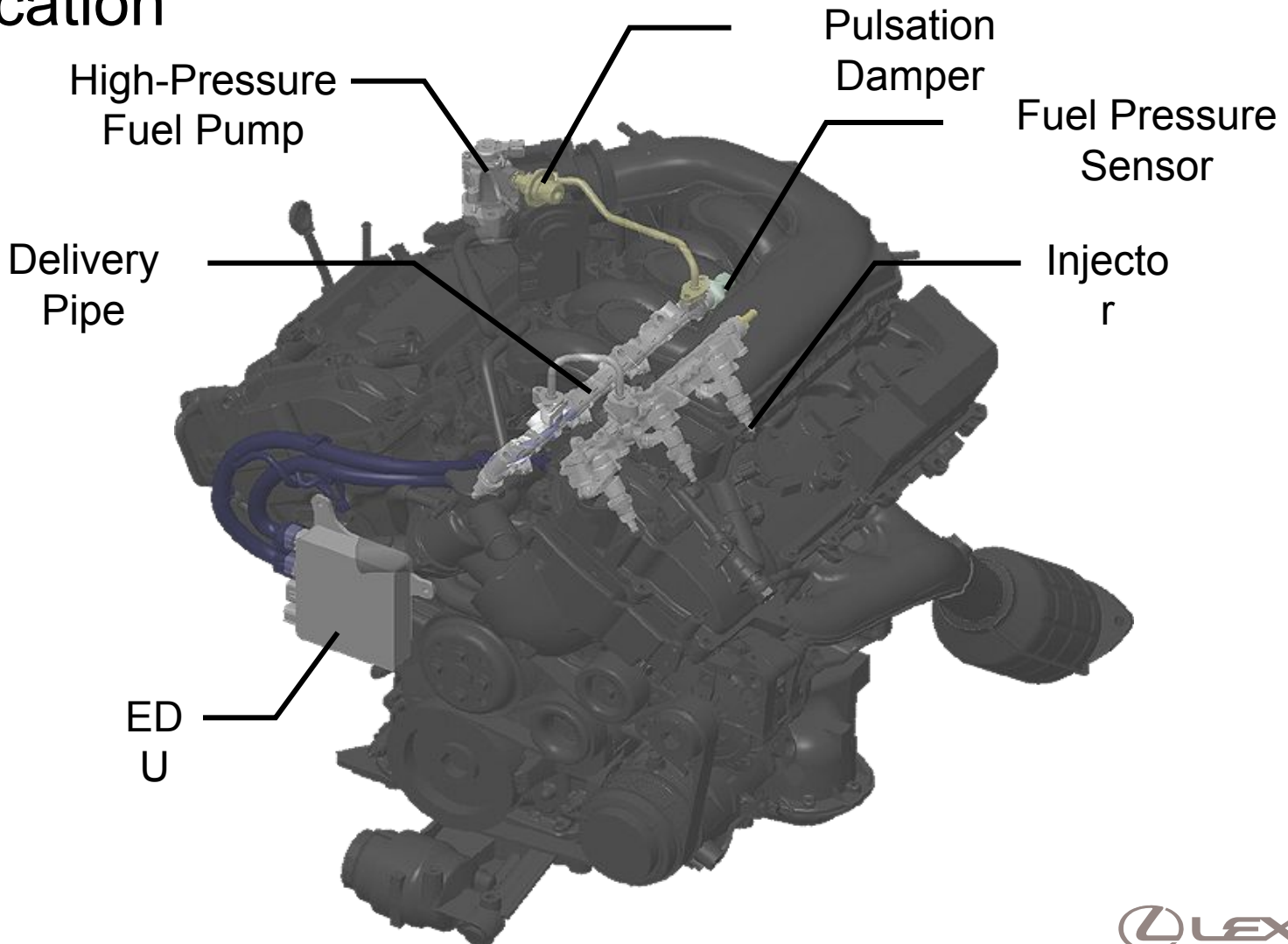
Reference

- Features of D-4 System



D-4 System

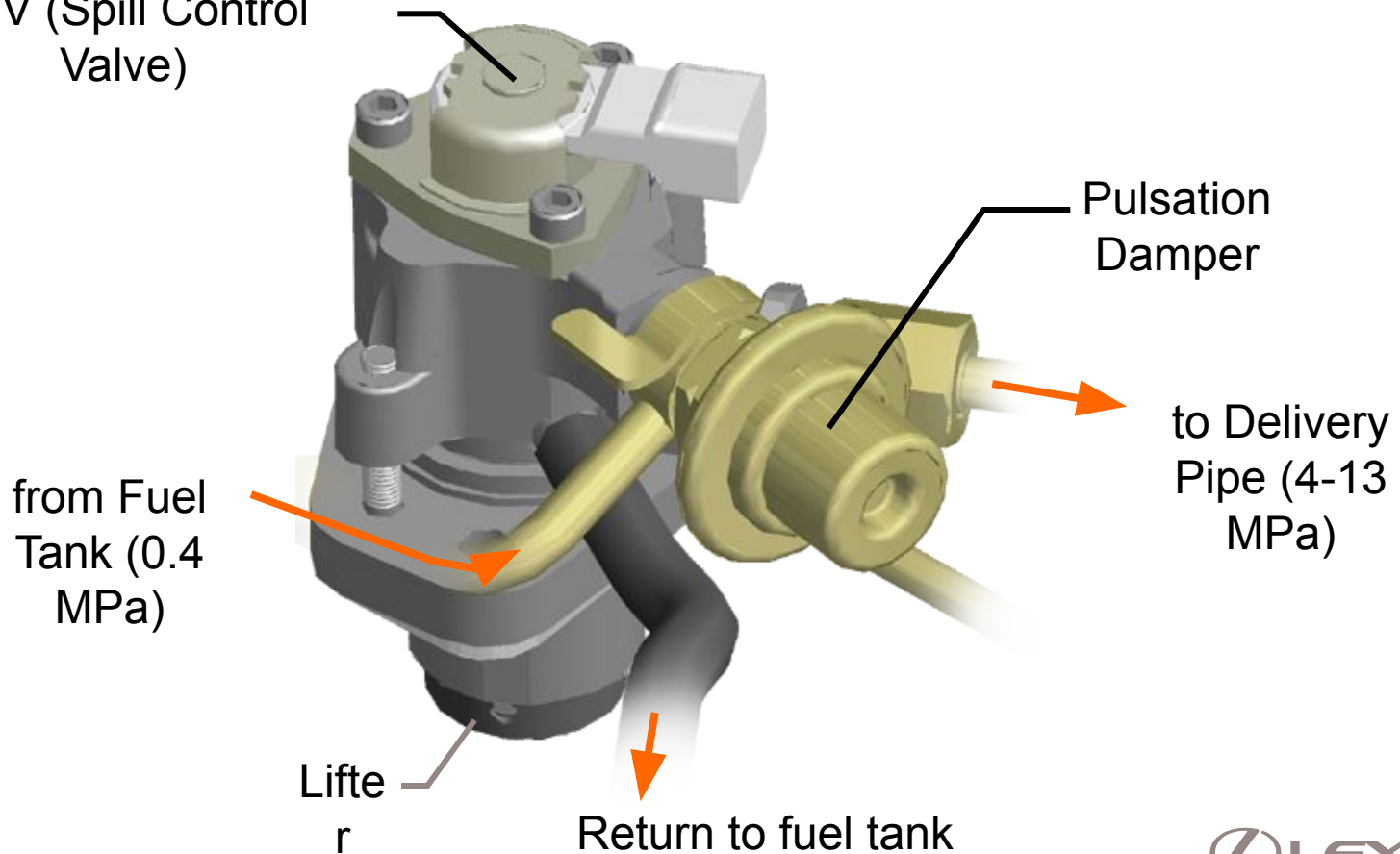
- Location



D-4 System

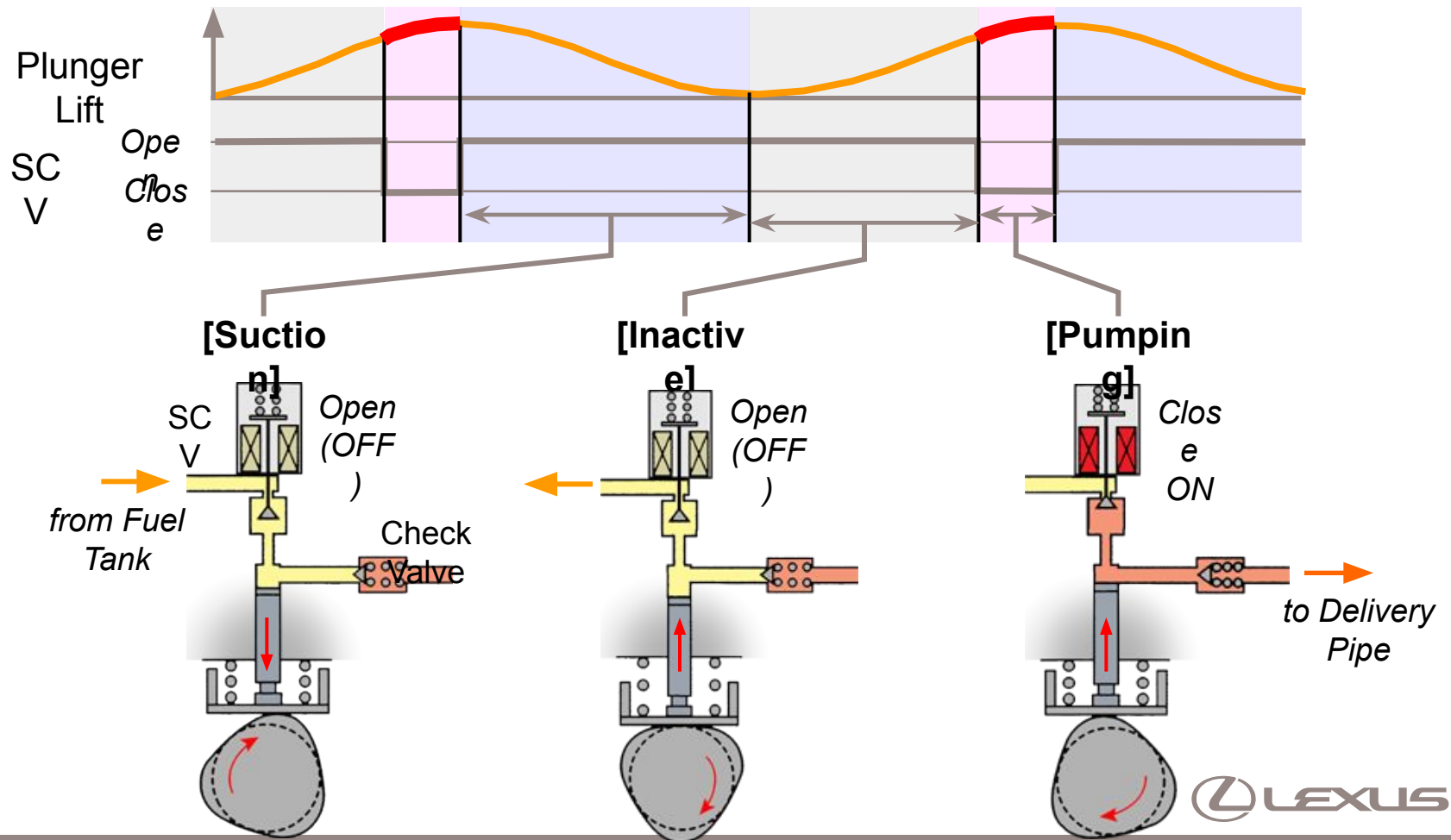
- High-Pressure Fuel Pump
 - Supplies the high pressure fuel to the delivery pipe

SCV (Spill Control Valve)



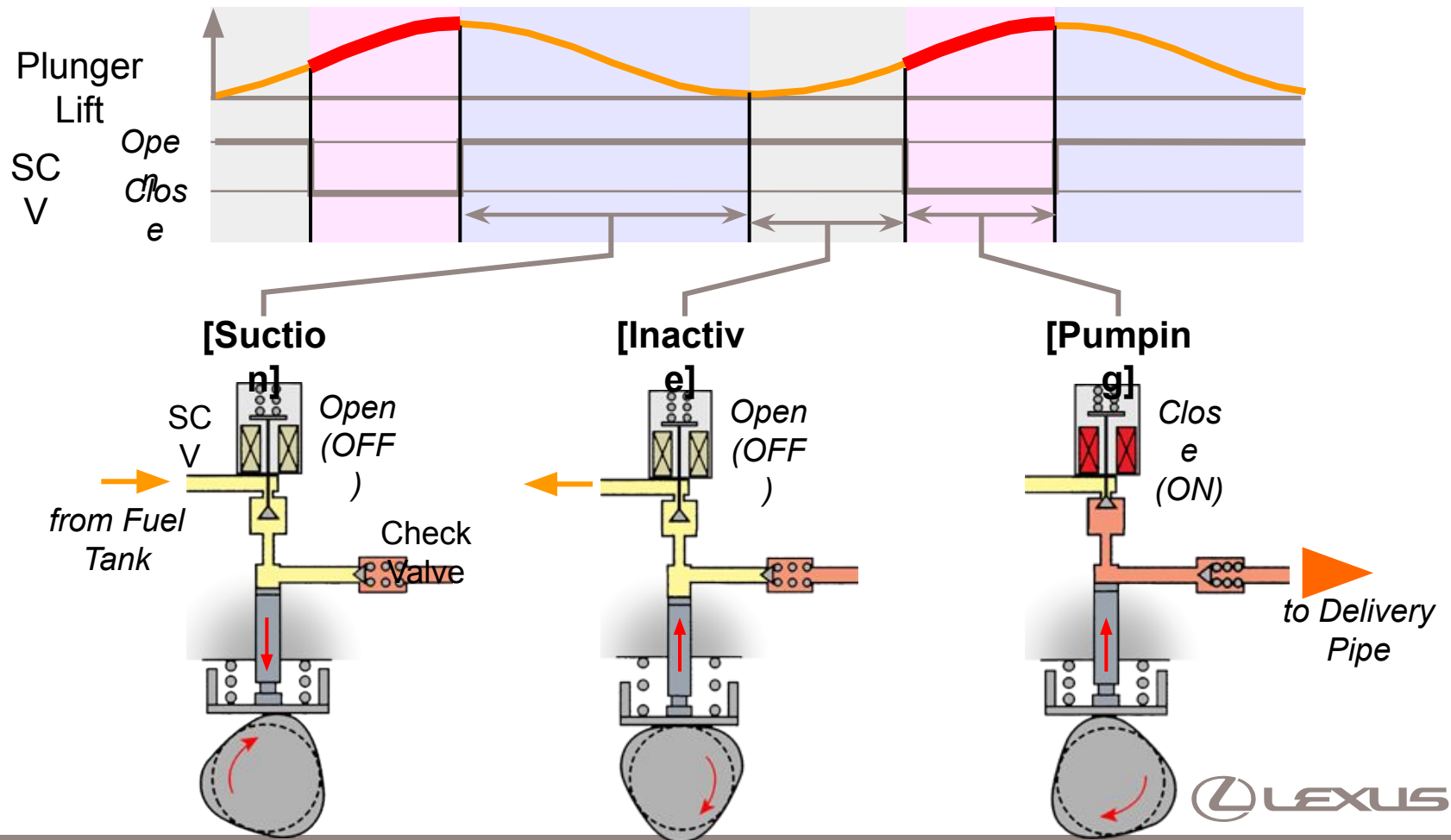
D-4 System

- High-Pressure Fuel Pump
 - Fuel control operation (SCV close timing is **late**)



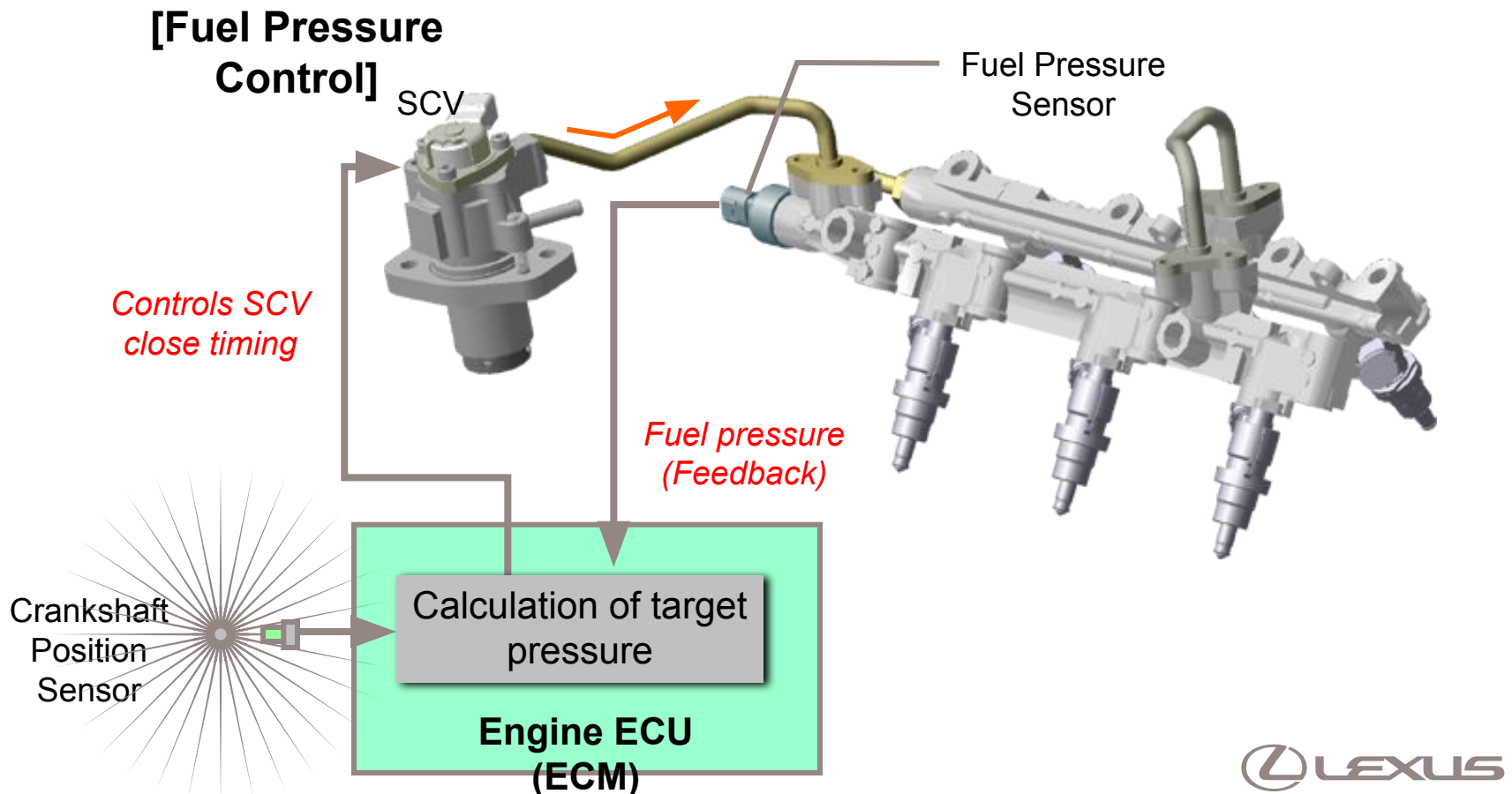
D-4 System

- High-Pressure Fuel Pump
 - Fuel control operation (SCV close timing is **early**)



D-4 System

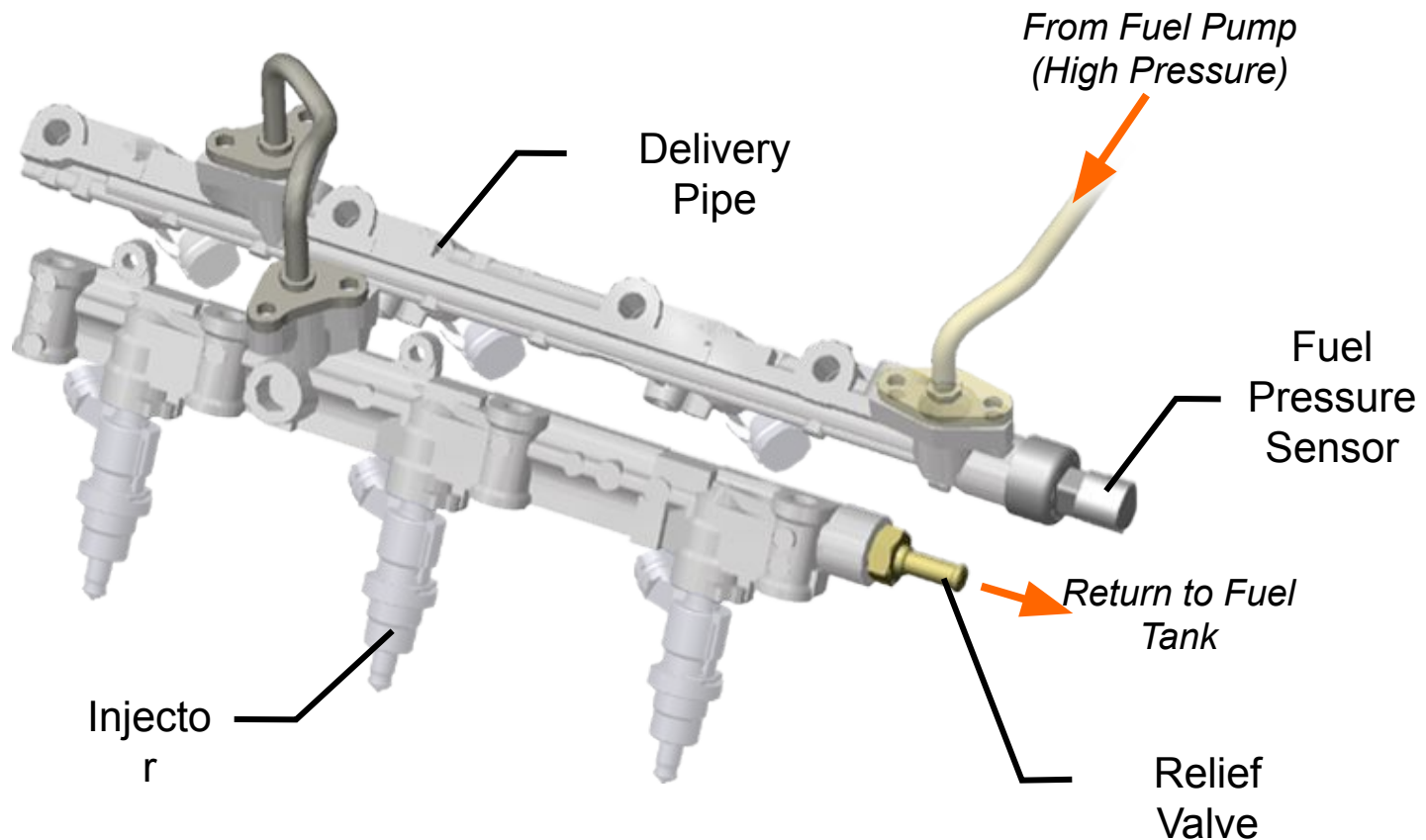
- High-Pressure Fuel Pump
 - The SCV close timing regulates the pumping volume to control fuel pressure



D-4 System

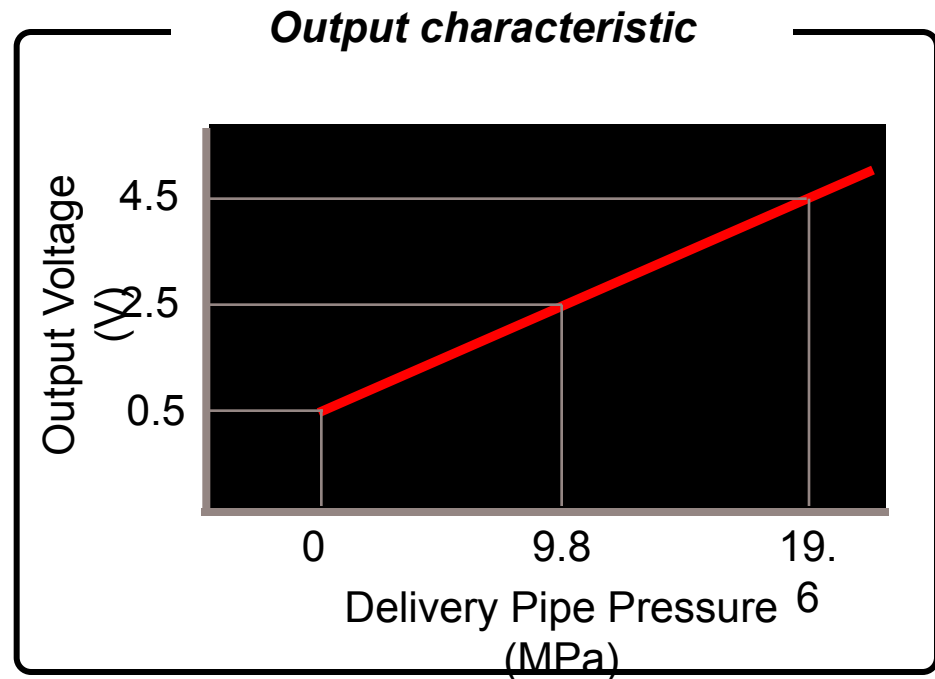
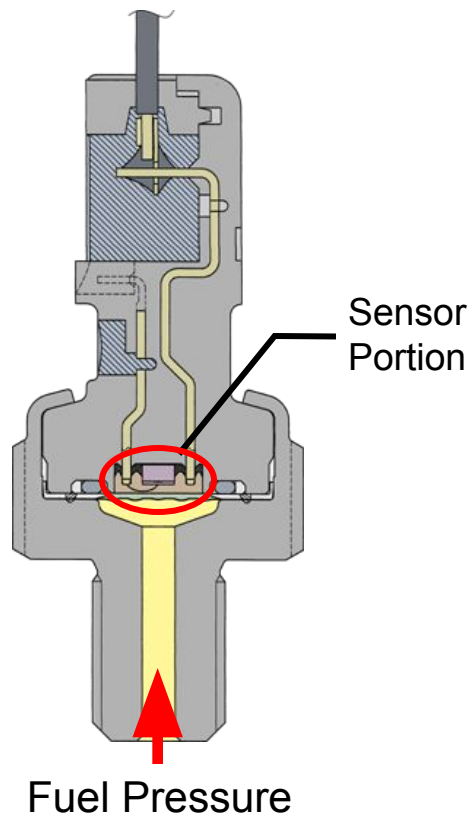
- Delivery Pipe

- Stores high-pressure fuel (4 – 13 MPa) produced by high-pressure fuel pump



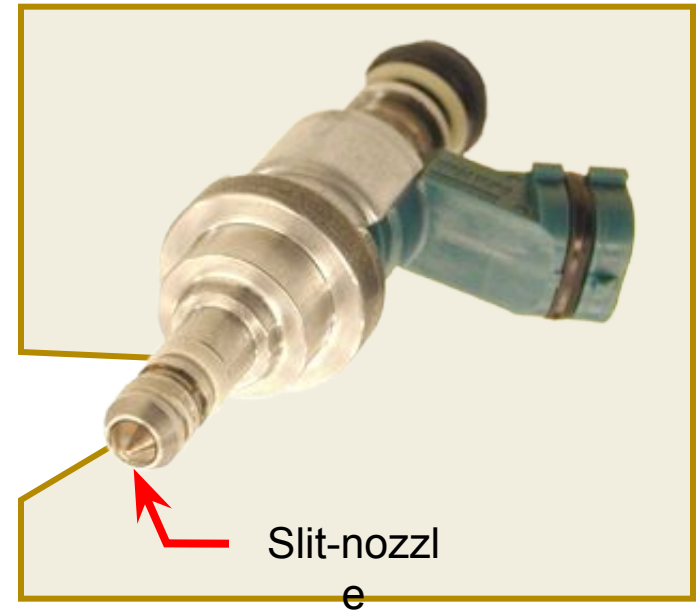
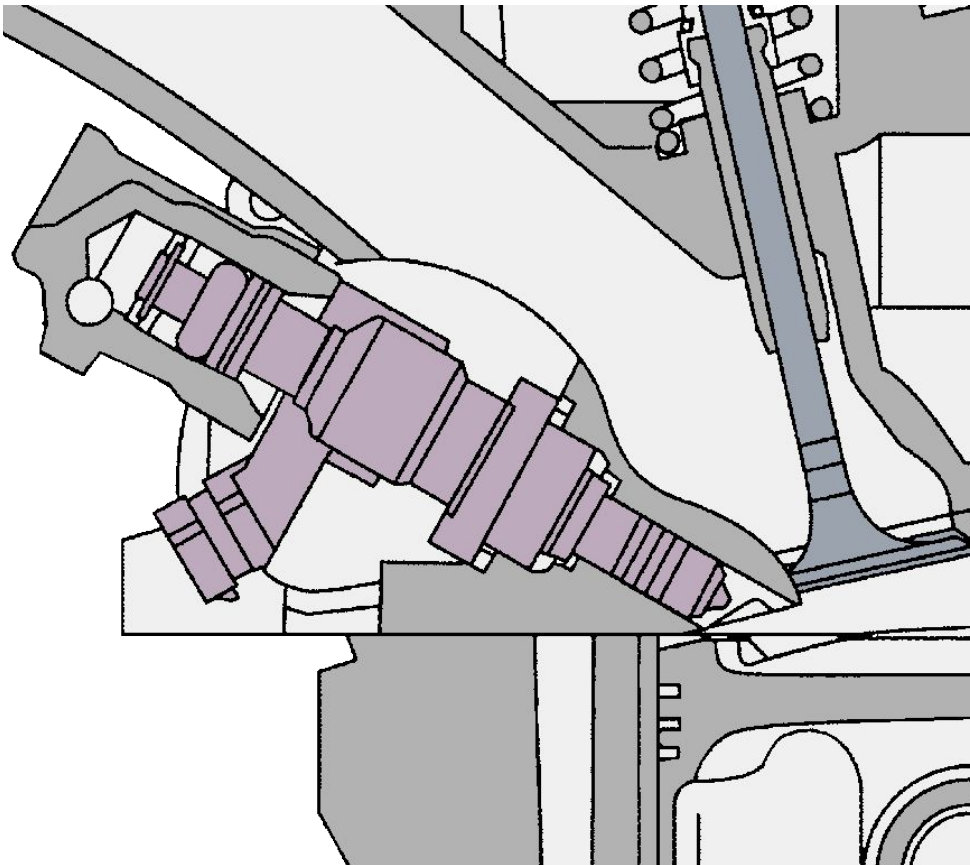
D-4 System

- Delivery Pipe
 - Fuel pressure sensor



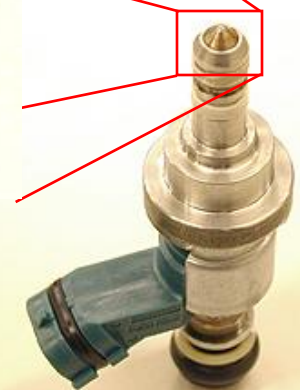
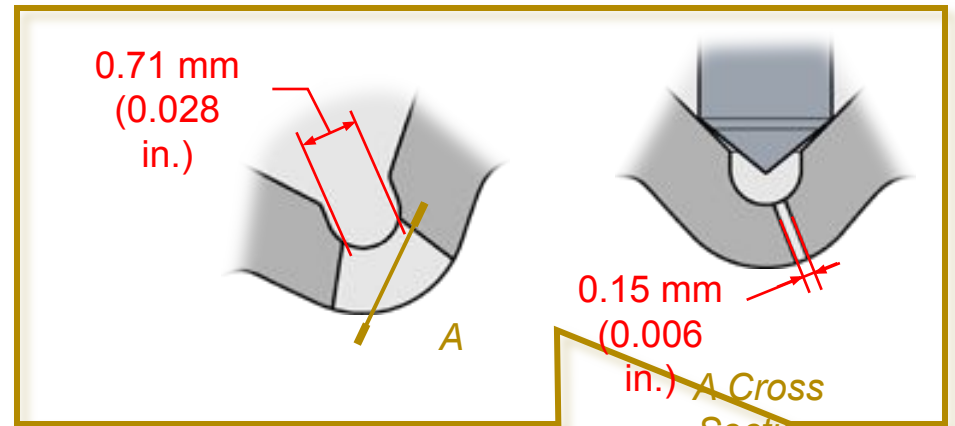
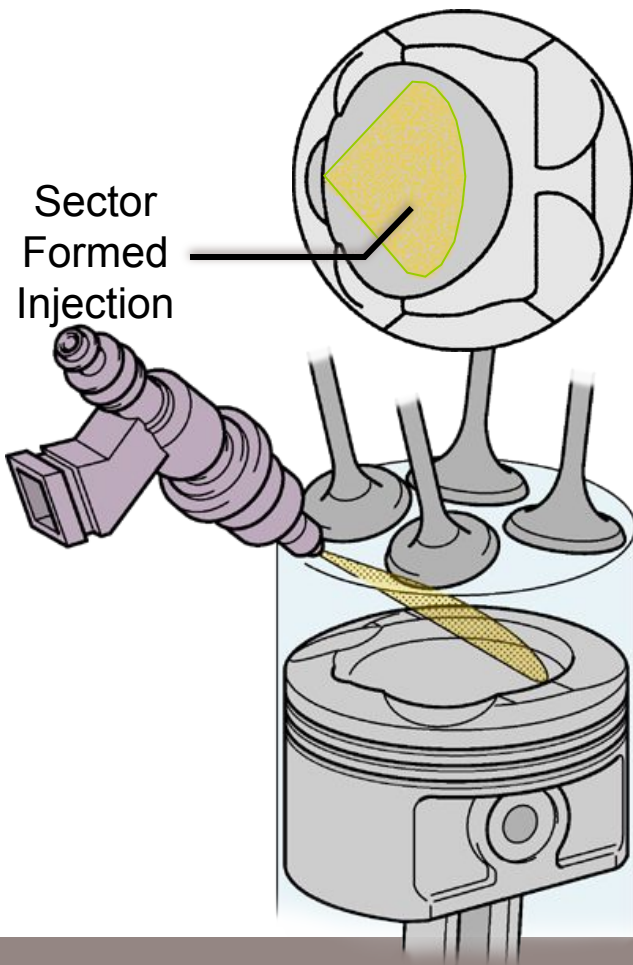
D-4 System

- Injector
 - High pressure, slit-nozzle type injector



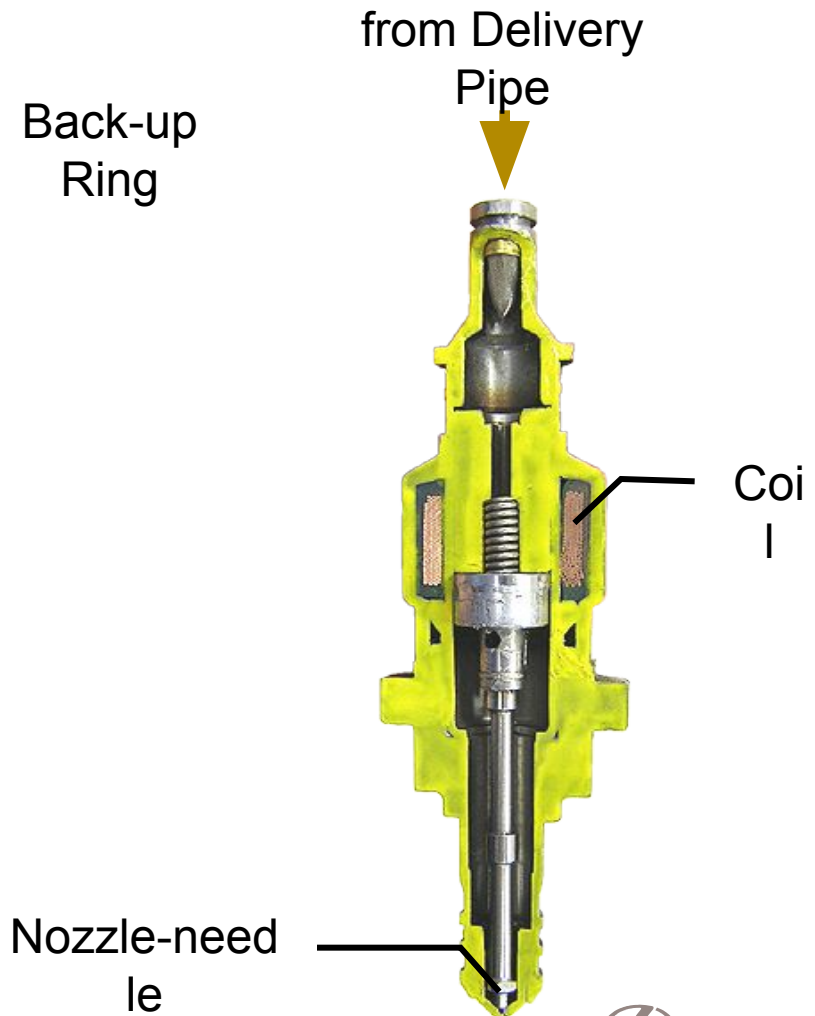
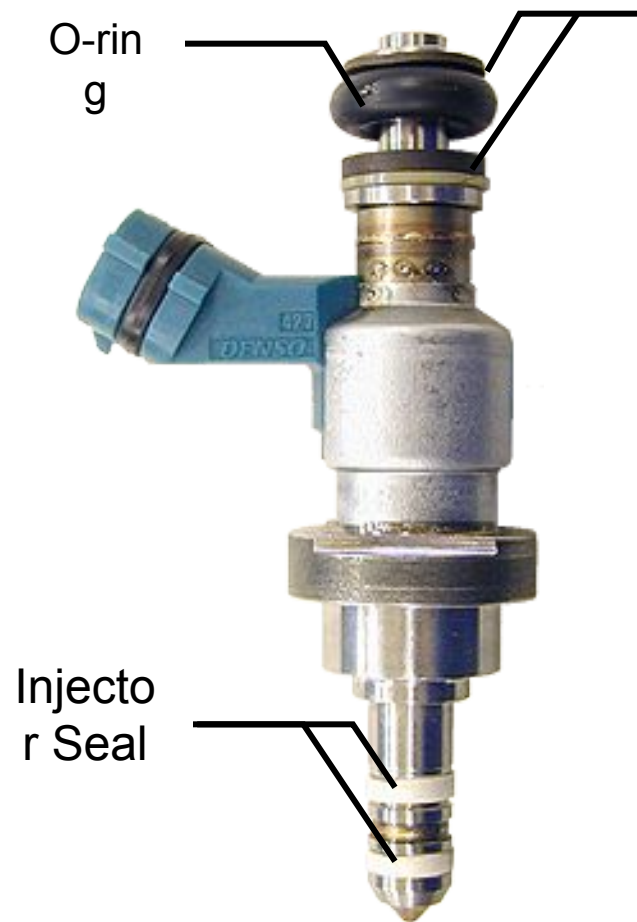
D-4 System

- Injector
 - Slit-nozzle makes sector formed injection



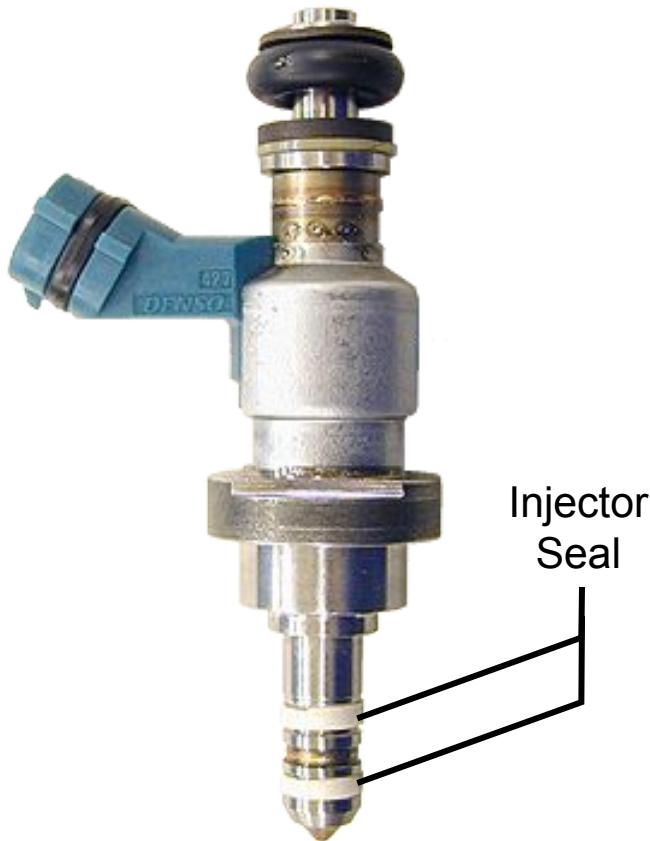
D-4 System

- Injector
 - Construction



Service Point (D-4 System)

- Injector
 - When remove the injector from cylinder head, replace the injector seal using new SST



Injector Seal Guide
(09268-03020)

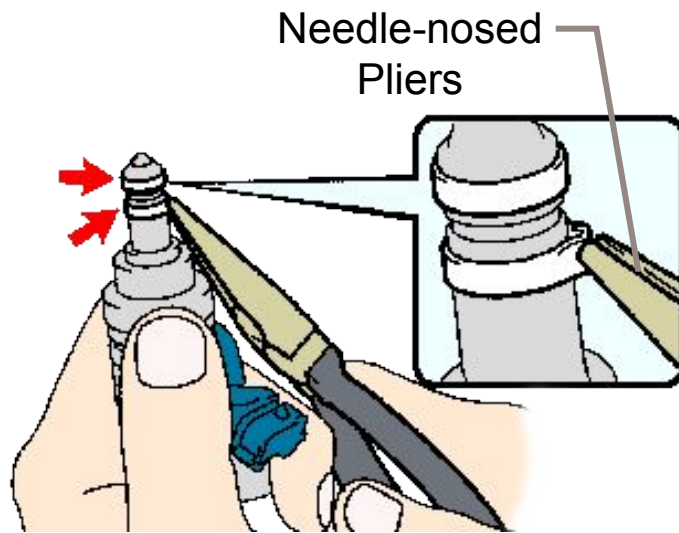


Injector Seal Holder
(09268-03010)

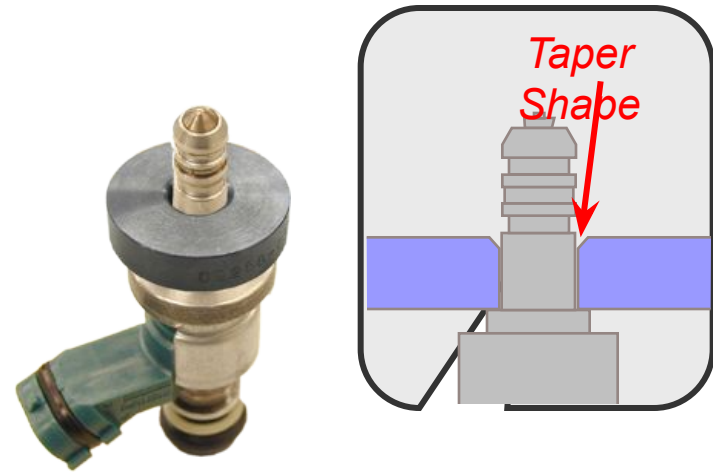
SST
09260-39015

Service Point (D-4 System)

- Injector
 - Replacement of injector seals (using SST)



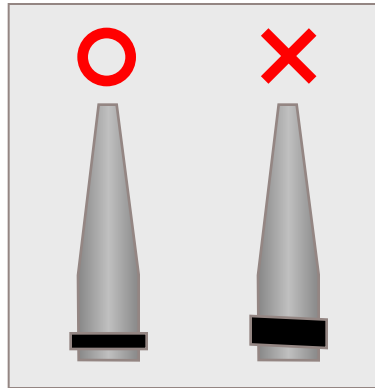
1. Remove injector seals



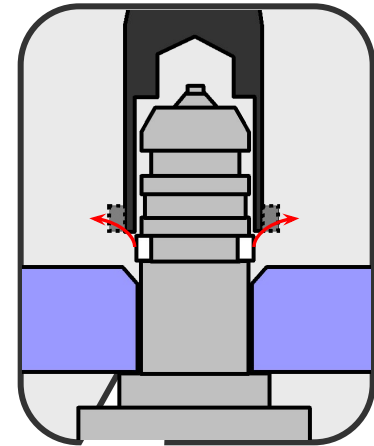
2. Attach the guide (SST)

Service Point (D-4 System)

- Injector
 - Replacement of injector seals (using SST)



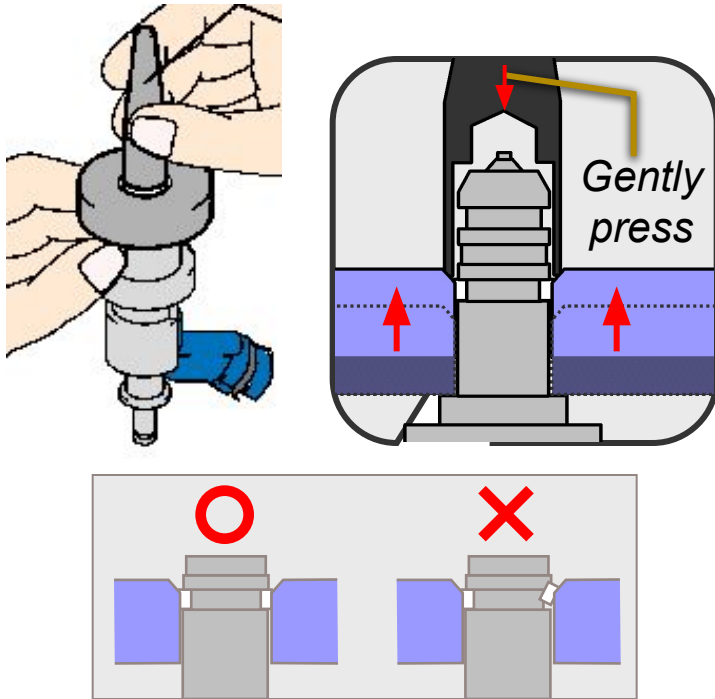
3. Install a new injector



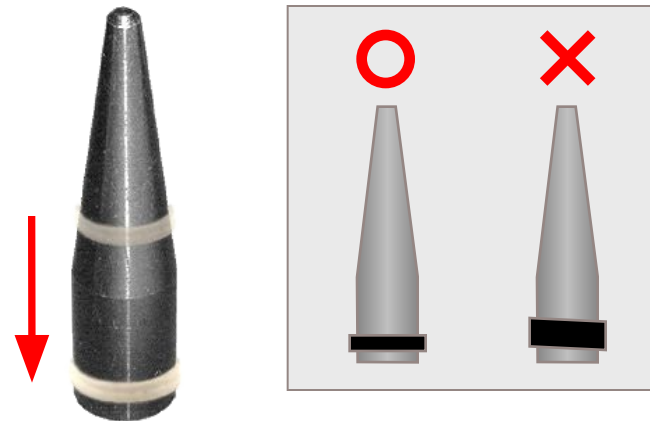
4. Slide the the injector seal into the injector groove

Service Point (D-4 System)

- Injector
 - Replacement of injector seals (using SST)



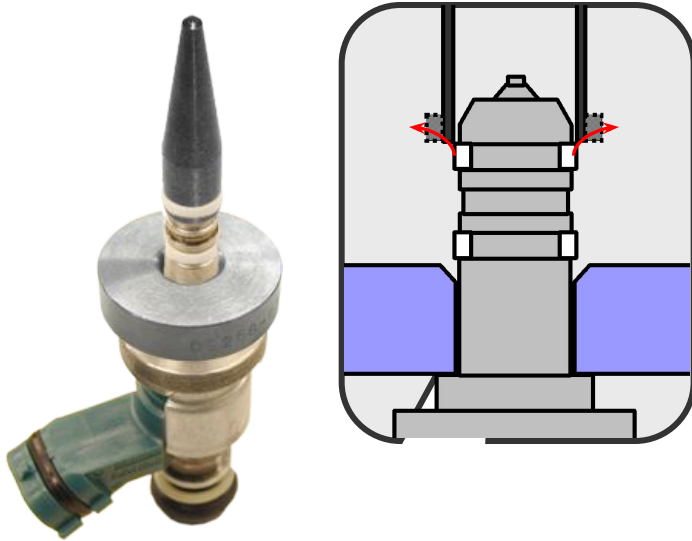
5. Settle the injector seal



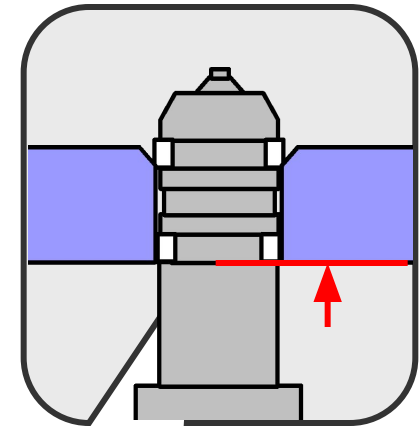
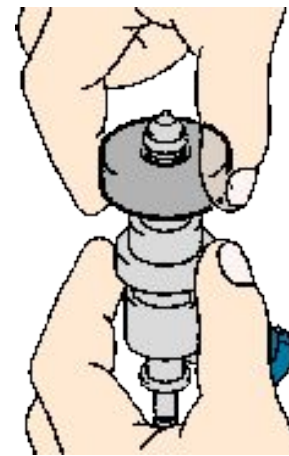
6. Install a new injector seal

Service Point (D-4 System)

- Injector
 - Replacement of injector seals (using SST)



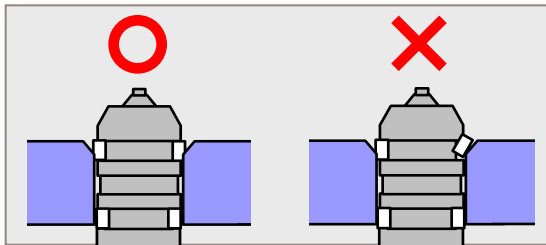
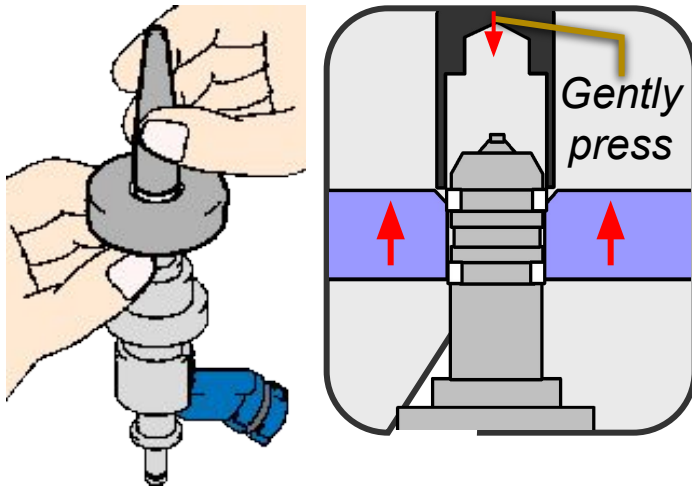
7. Slide the injector seal into the injector groove



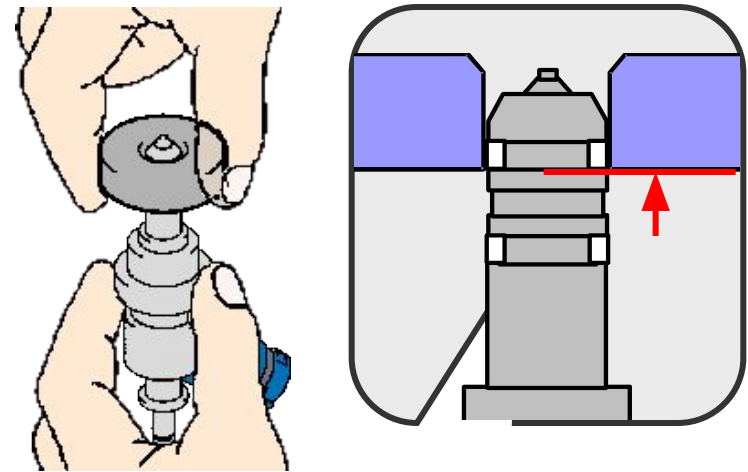
8. Fully align the injector seal

Service Point (D-4 System)

- Injector
 - Replacement of injector seals (using SST)



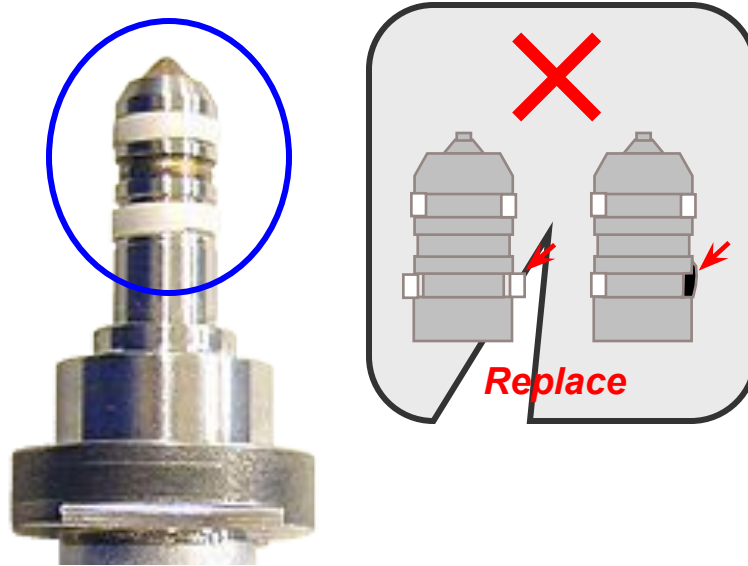
9. Settle the injector seal



10. Fully align the injector seal

Service Point (D-4 System)

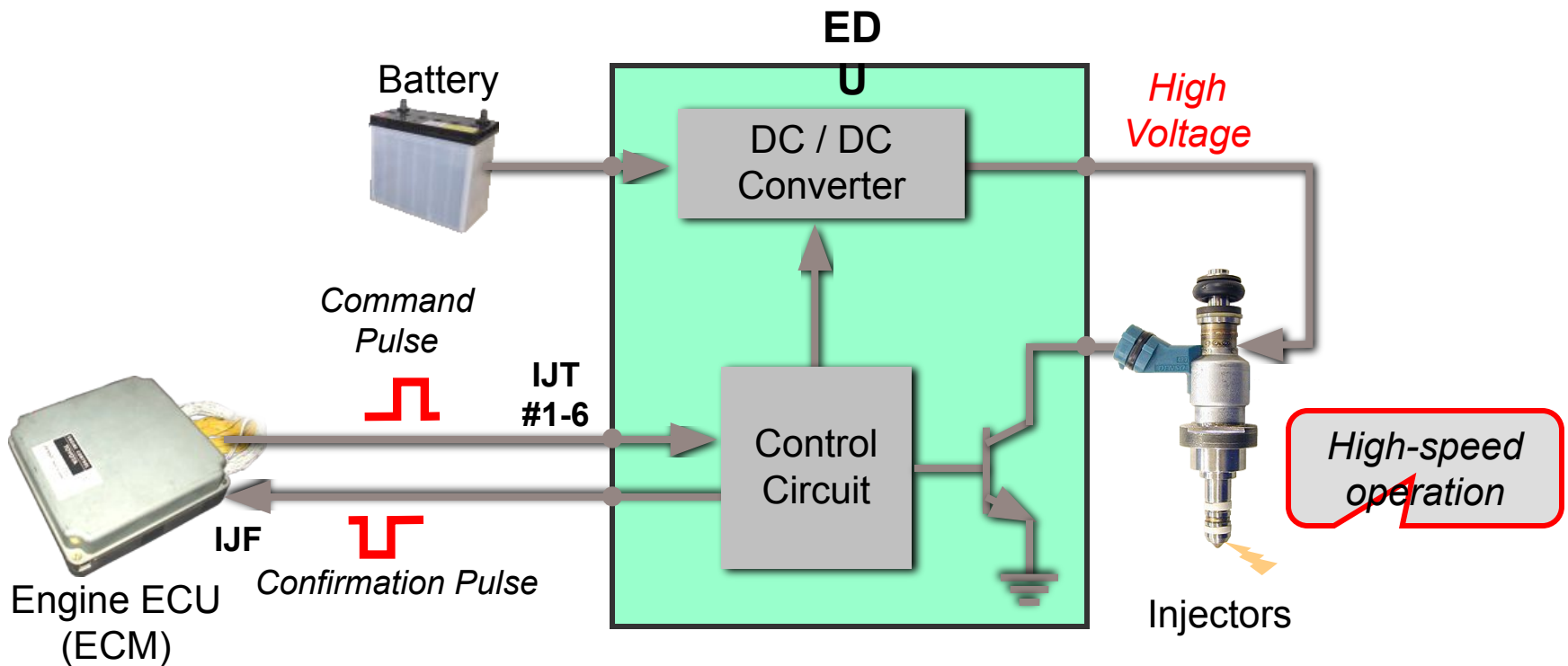
- Injector
 - Replacement of injector seals (using SST)



11. Check the injector seals

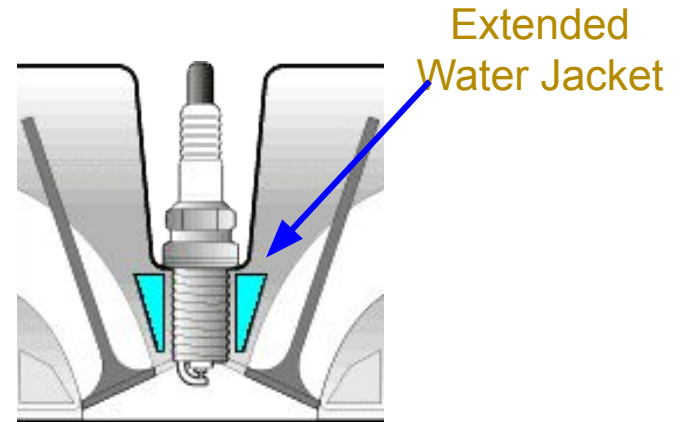
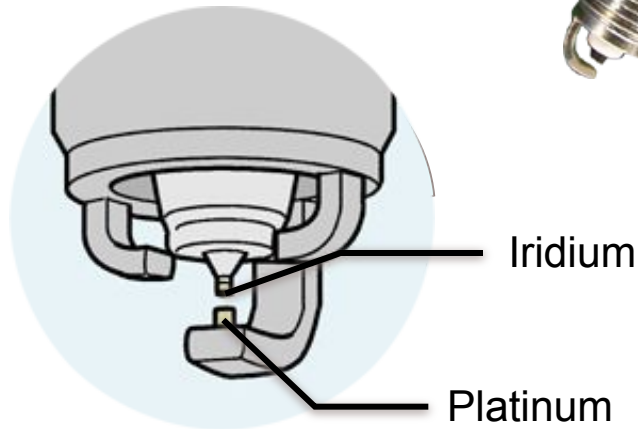
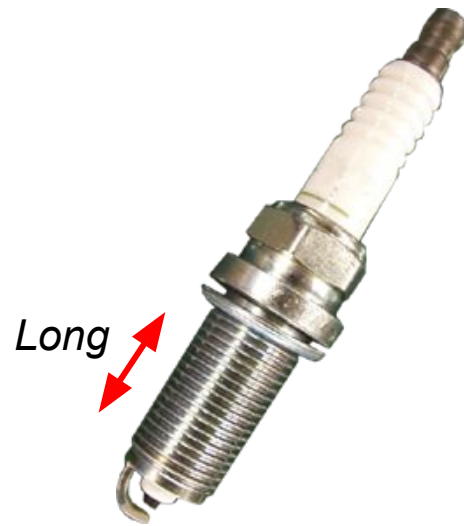
D-4 System

- EDU (Electronic Driver Unit)
 - Drives the injectors at high speed

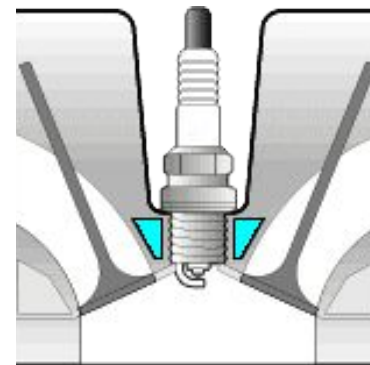


Ignition System

- Spark Plug
 - Long-reach type spark plug to improve cooling performance on cylinder head



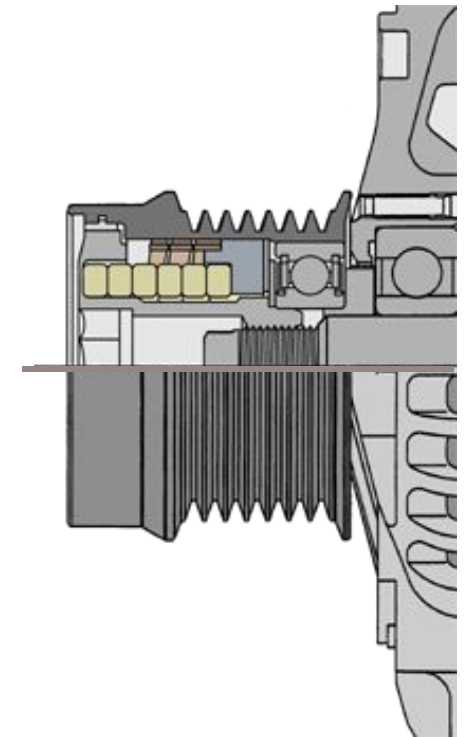
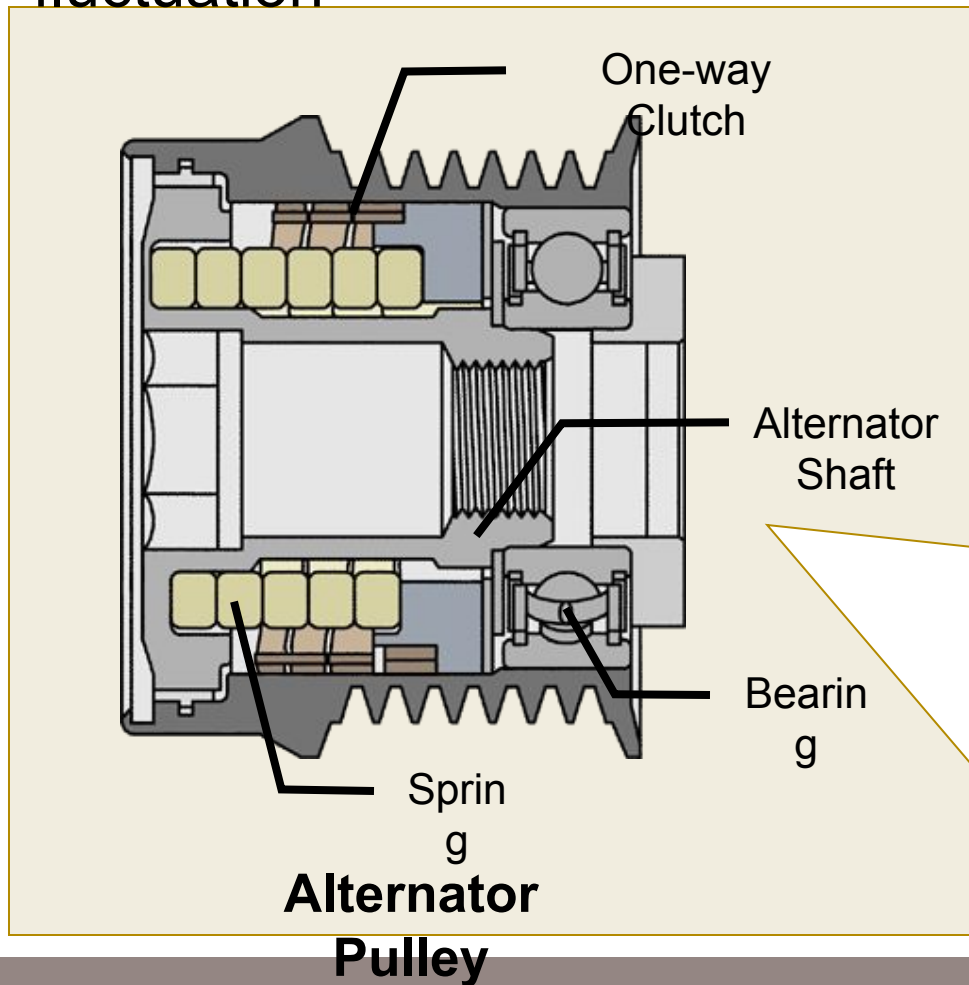
Long-reach Type



Normal Type

Charging System

- Alternator Pulley
 - One-way clutch is used in the pulley to absorb engine fluctuation



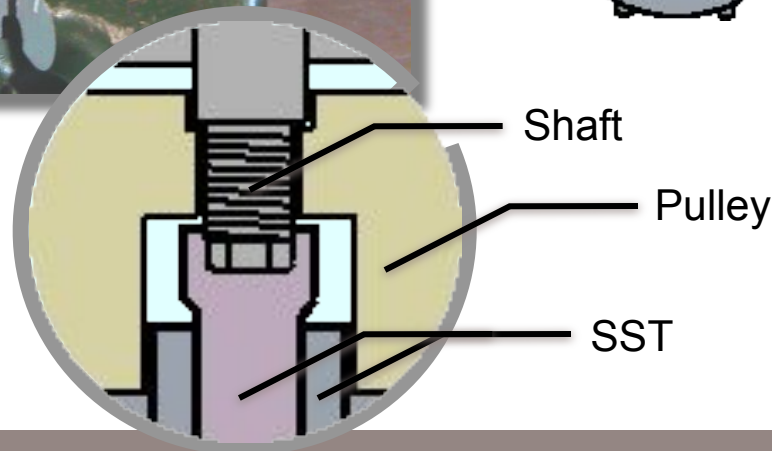
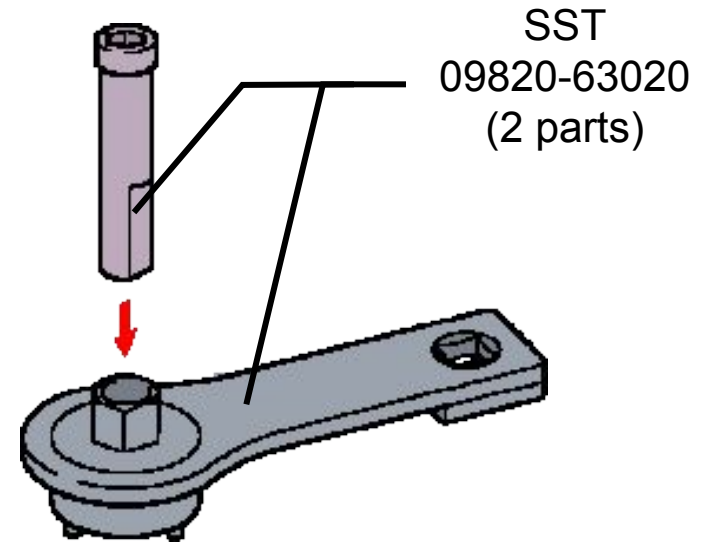
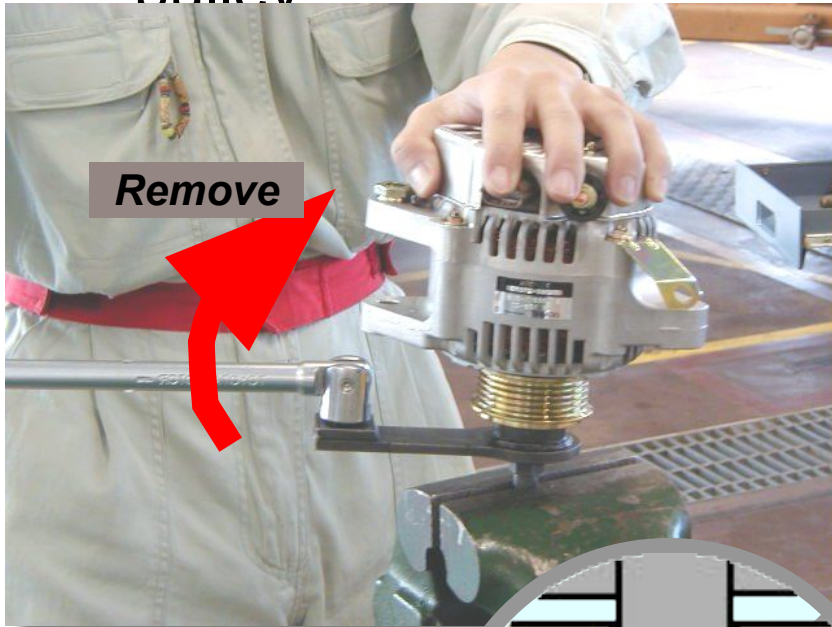
Alternator



Service Point (Charging System)

Alternator Pulley

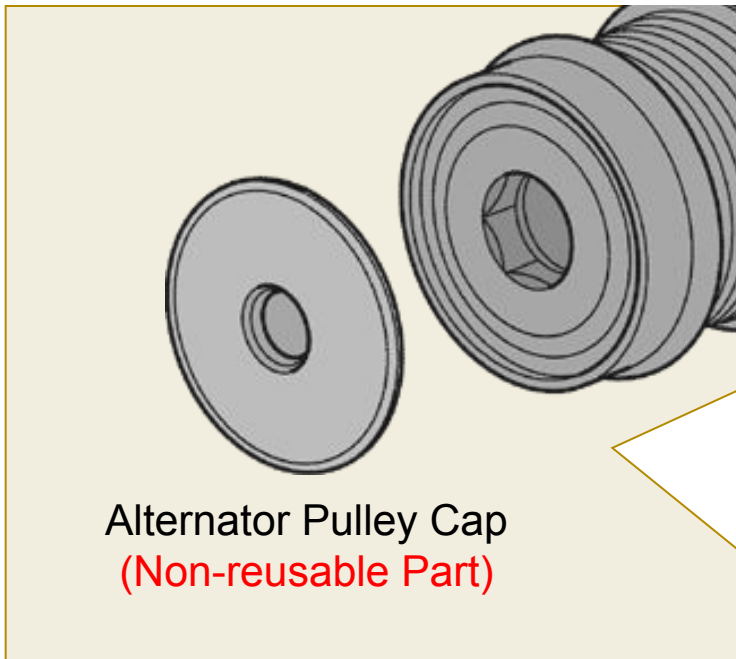
- Using a SST, when remove or install the alternator pulley



Service Point (Charging System)

• Alternator Pulley

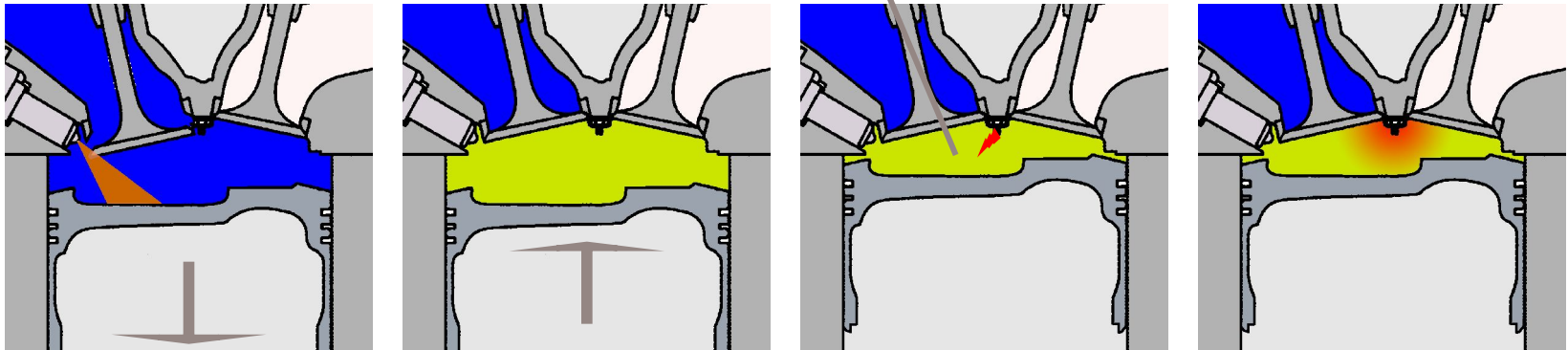
- Alternator pulley cap is non-reusable part



Engine Control System

- D-4 EFI Control (for 4GR-FSE)
 - D-4 EFI conducts the injection volume control and injection timing control simultaneously

*Stoichiometric
Air-fuel Ratio*

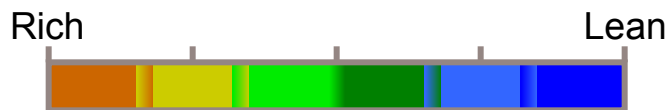


Intake
(Injection)

Compression

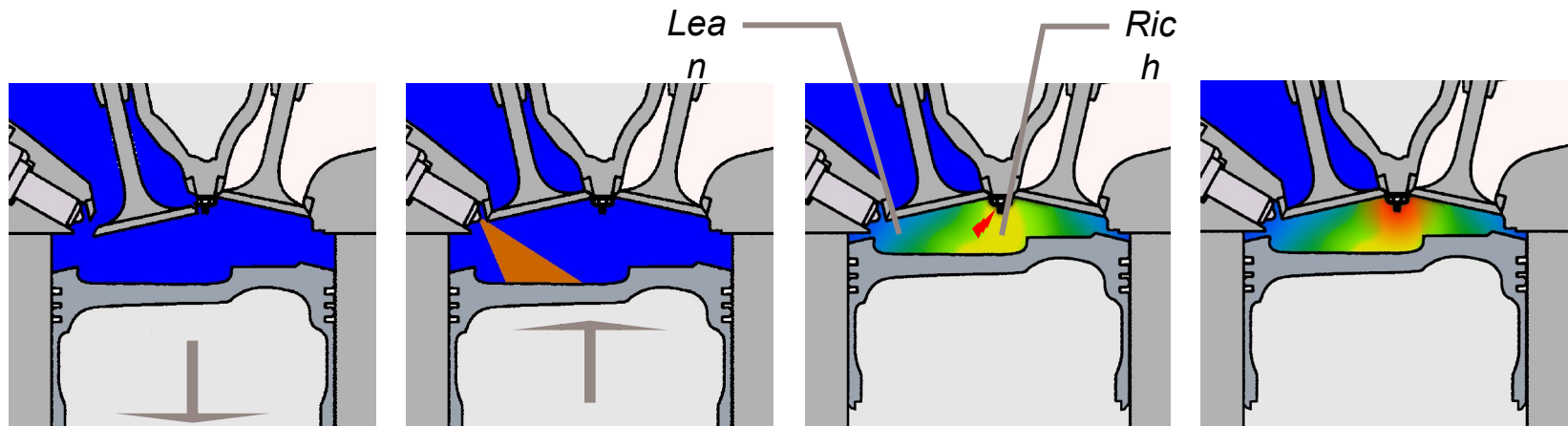
Sparking

Combustion



Engine Control System

- D-4 EFI Control (for 4GR-FSE)
 - At cold start, weak stratification combustion to improve TWC warm-up performance

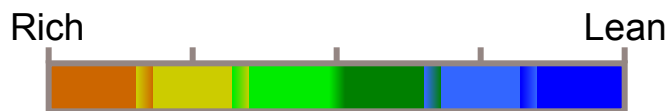


Intake

Compression
(Injection)

Sparking

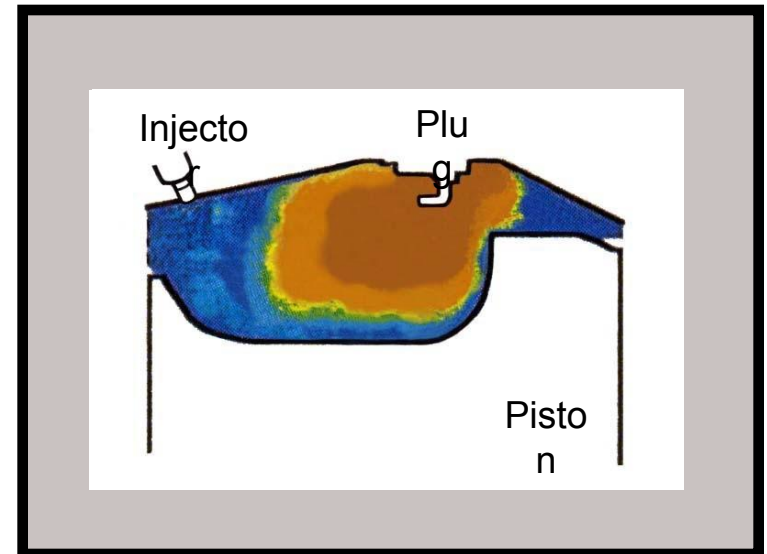
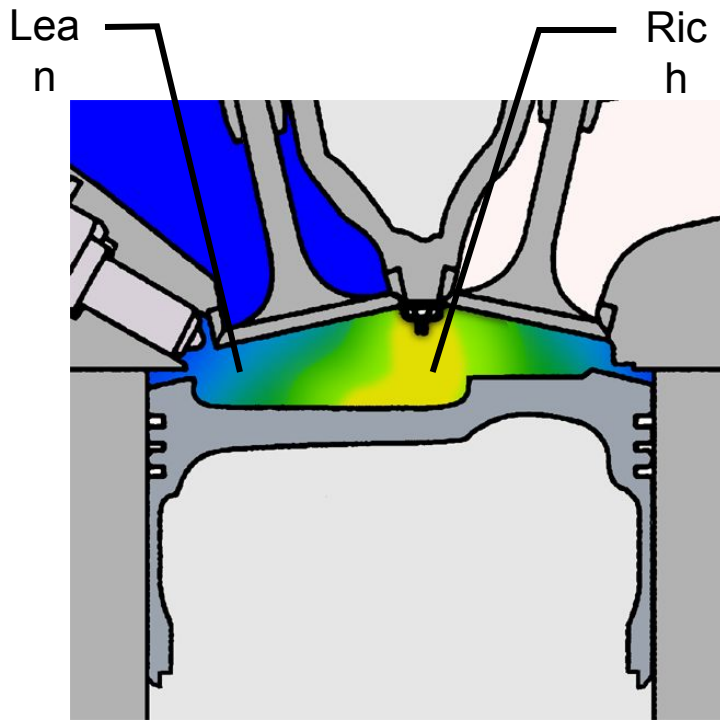
Combustion



Reference (Engine Control System)

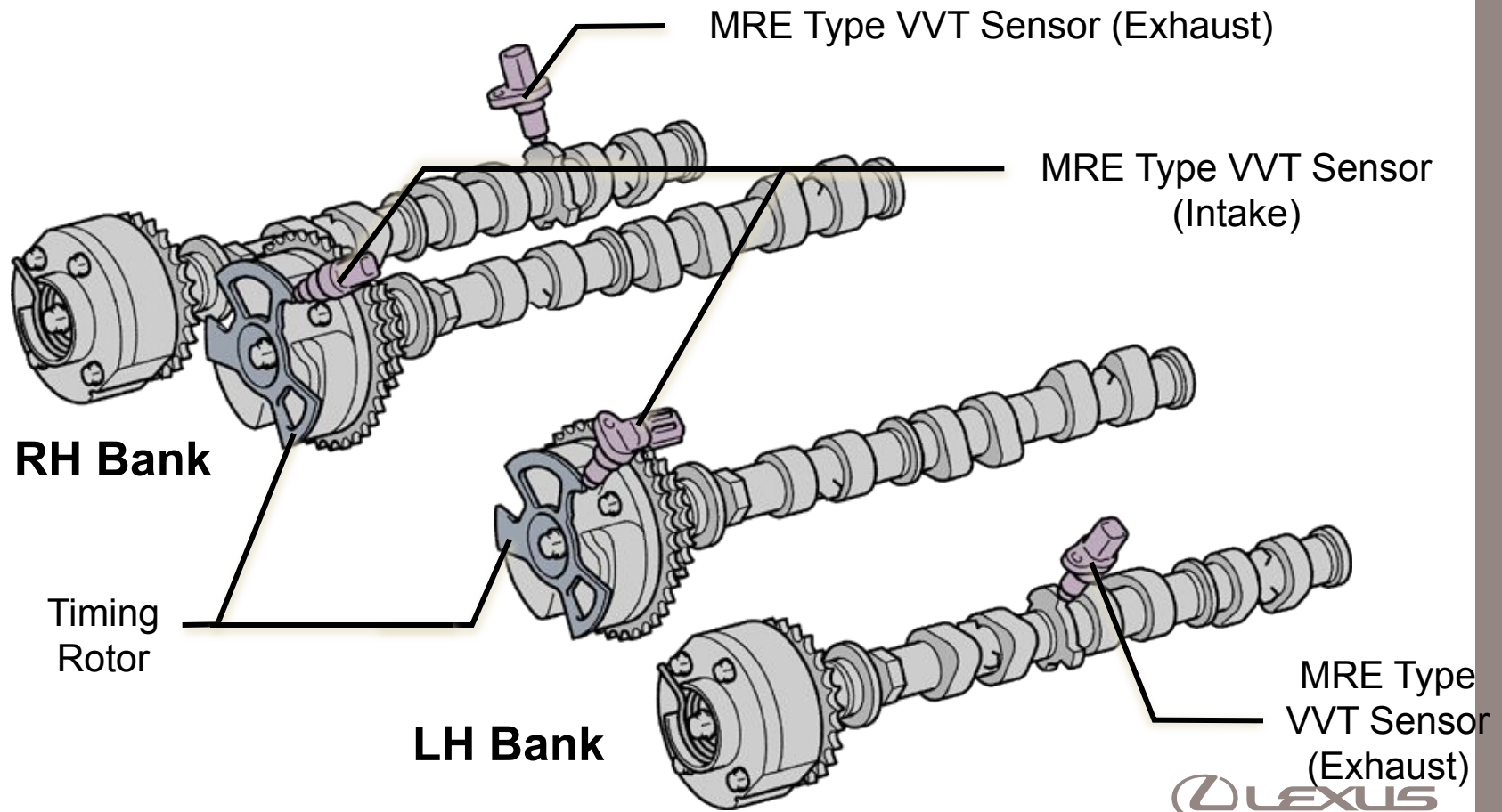
• System control (for 4GR-FSE)

- Weak stratification combustion
 - Creates rich and lean portions of air-fuel mixture within the combustion chamber



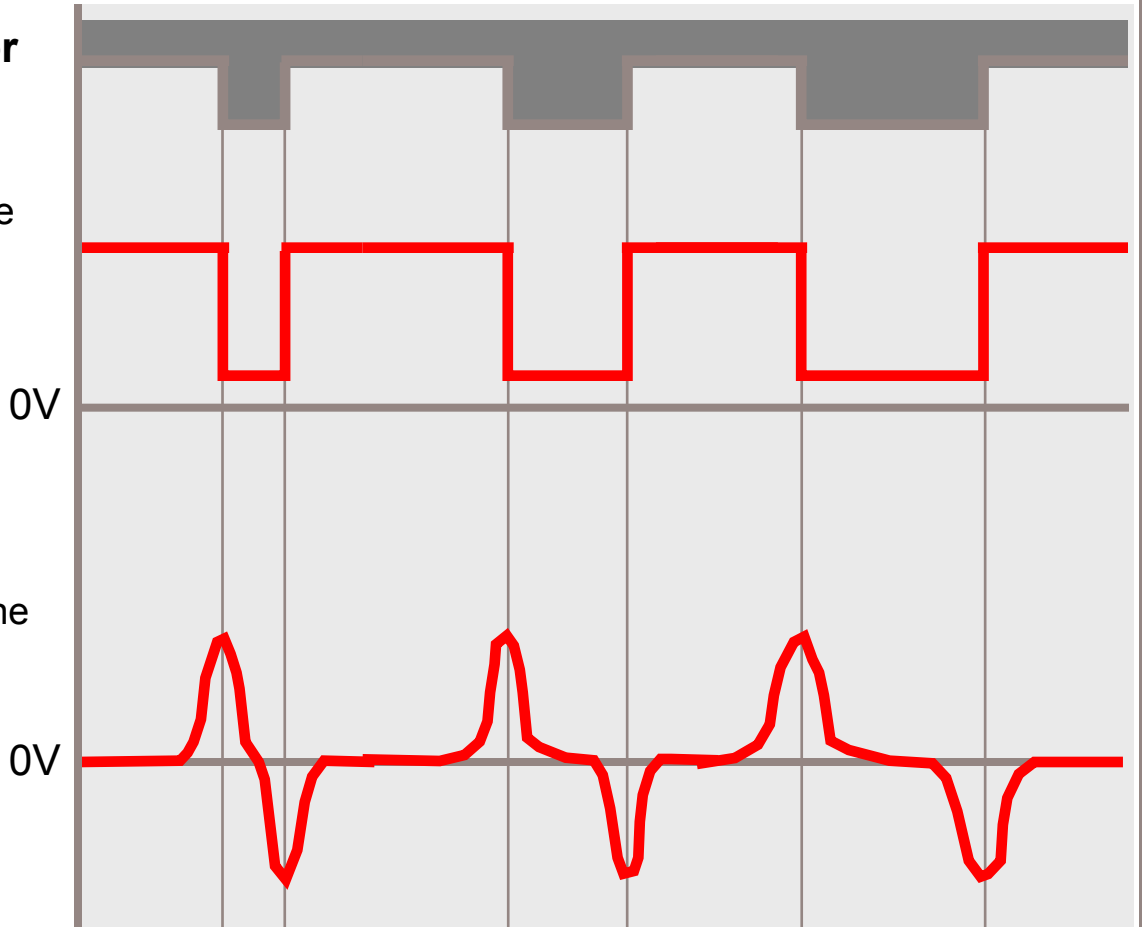
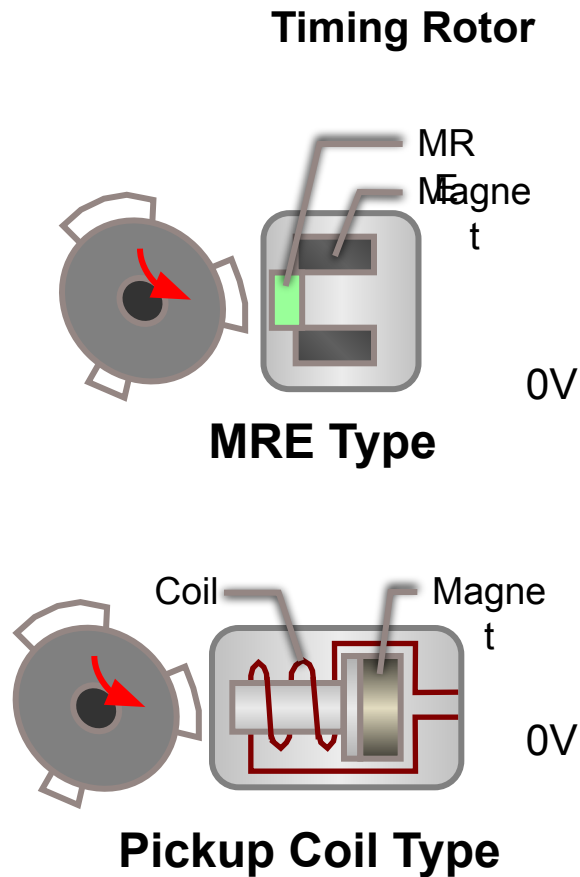
Engine Control System

- VVT Sensor
 - 4 MRE type VVT sensors are used for intake and exhaust camshaft of each bank



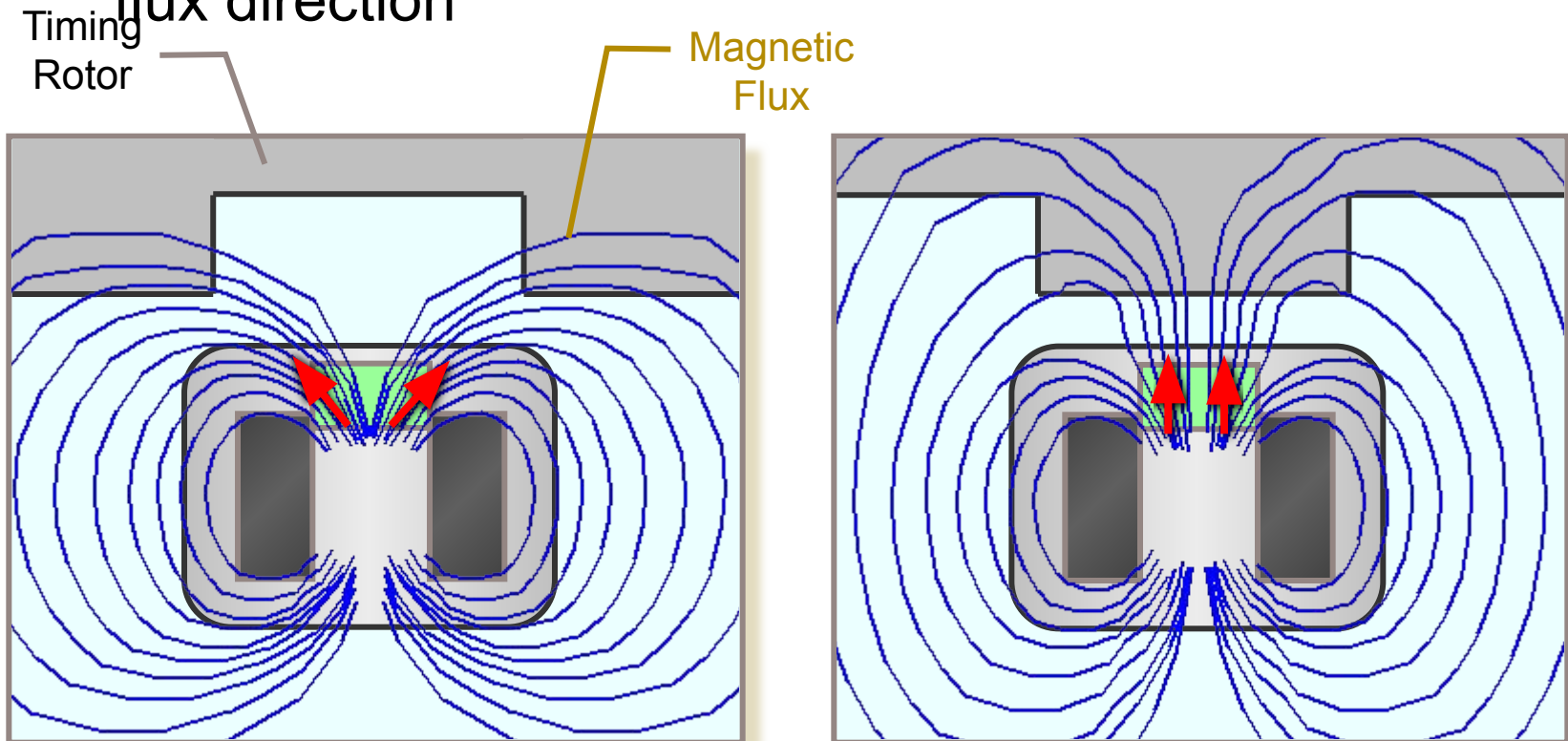
Reference (Engine Control System)

- Output signal is digital waveform



Reference (Engine Control System)

- The resistance of MRE is changed by the magnetic flux direction



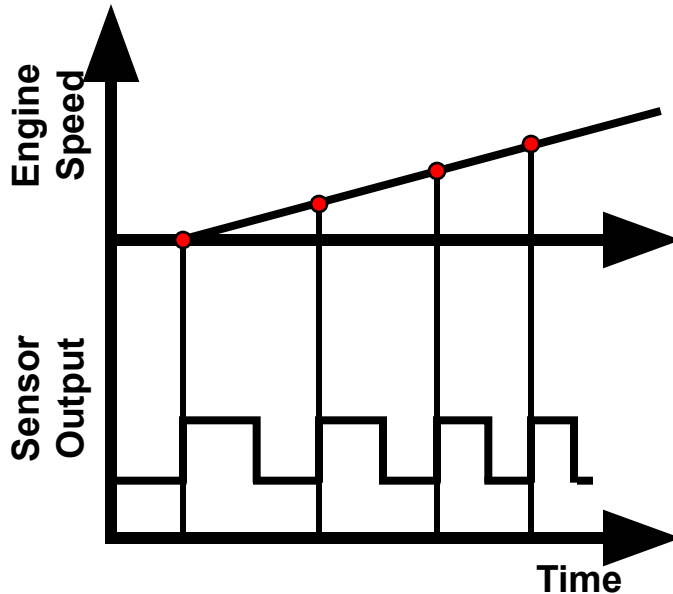
Sensor Output
"High"

Sensor Output
"Low"

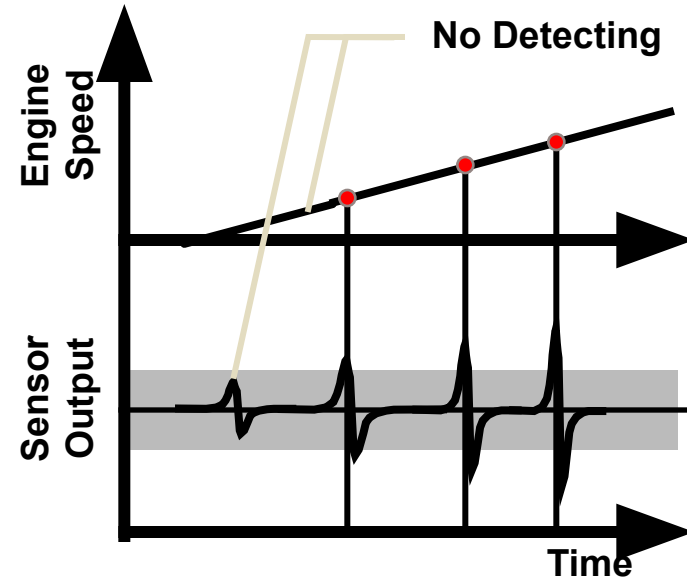
Reference (Engine Control System)

- Signal output at extremely low speed rotation can be ensured

MRE Type

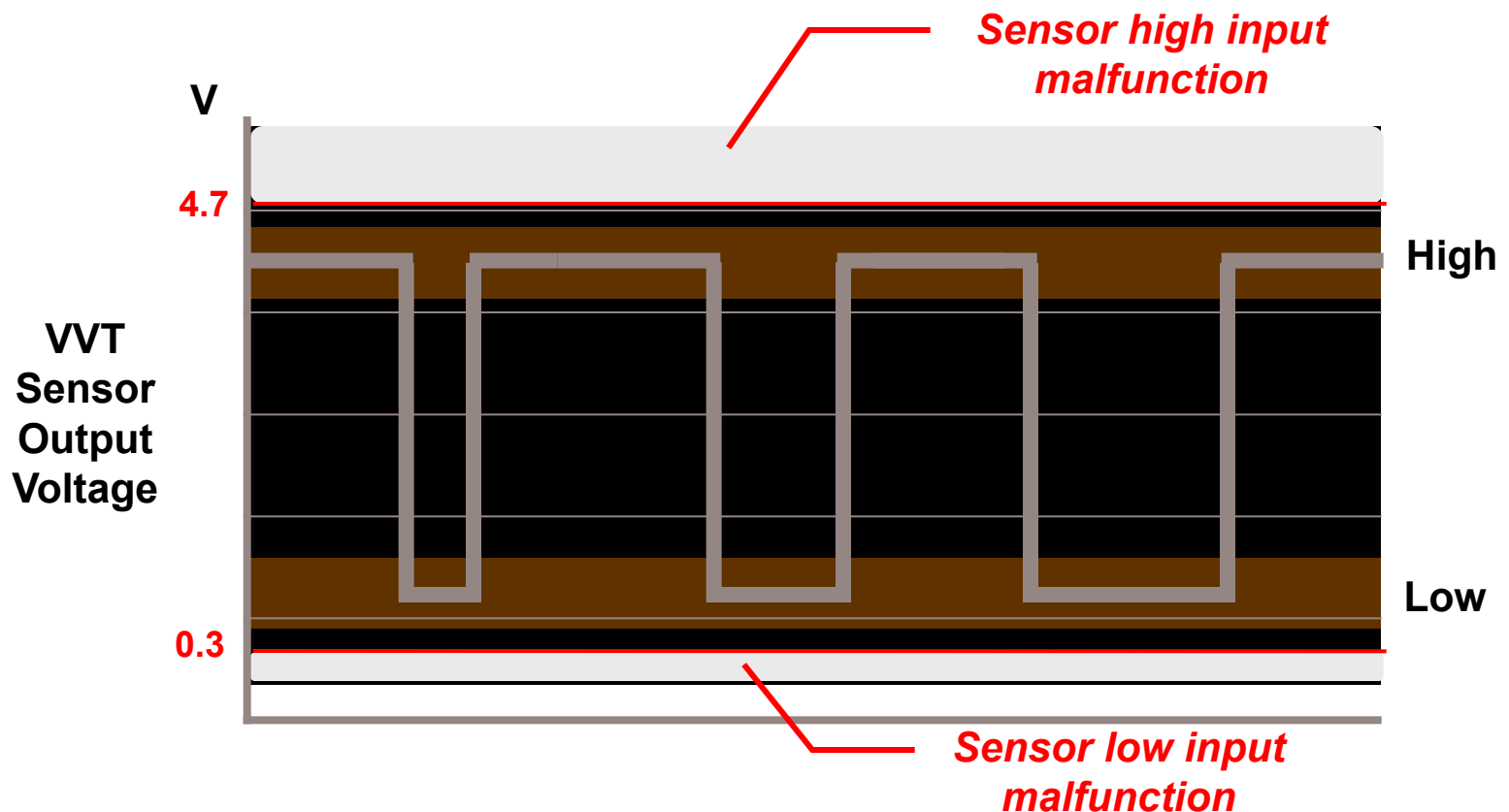


Pickup Coil Type



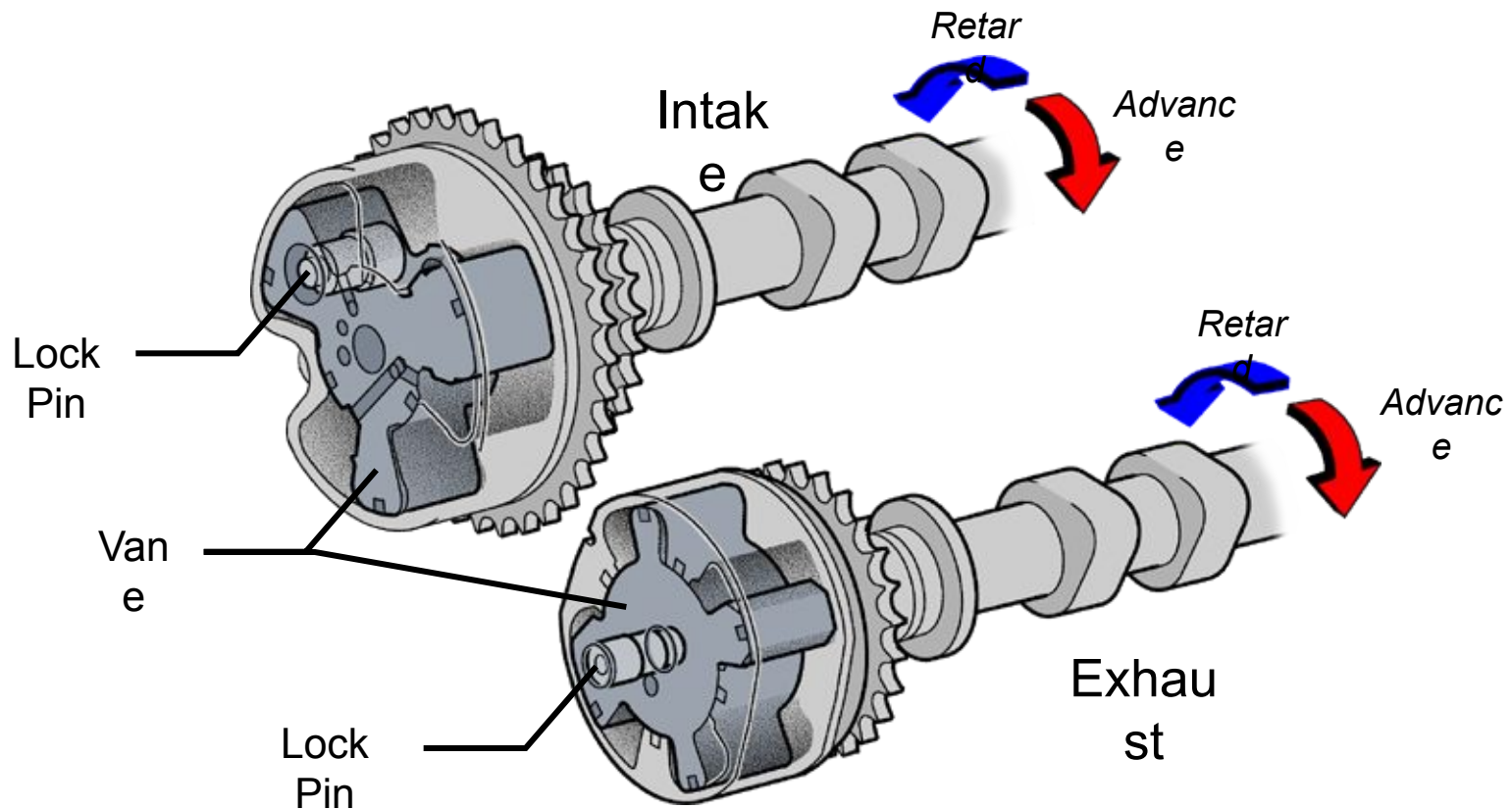
Reference (Engine Control System)

- By the adoption of MRE type VVT sensor, ECM can detect the sensor low input or high input malfunction



Engine Control System

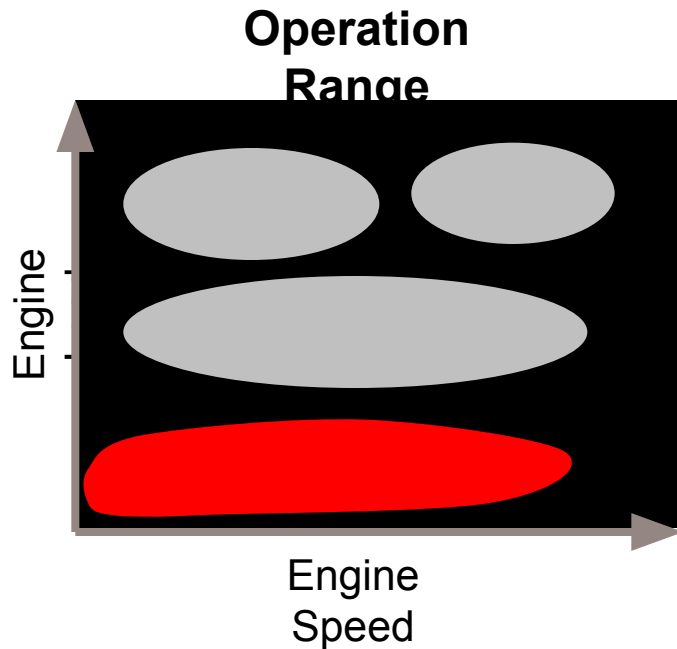
- Dual VVT-i (Variable Valve Timing – intelligent)
 - VVT-i is used for intake and exhaust camshafts



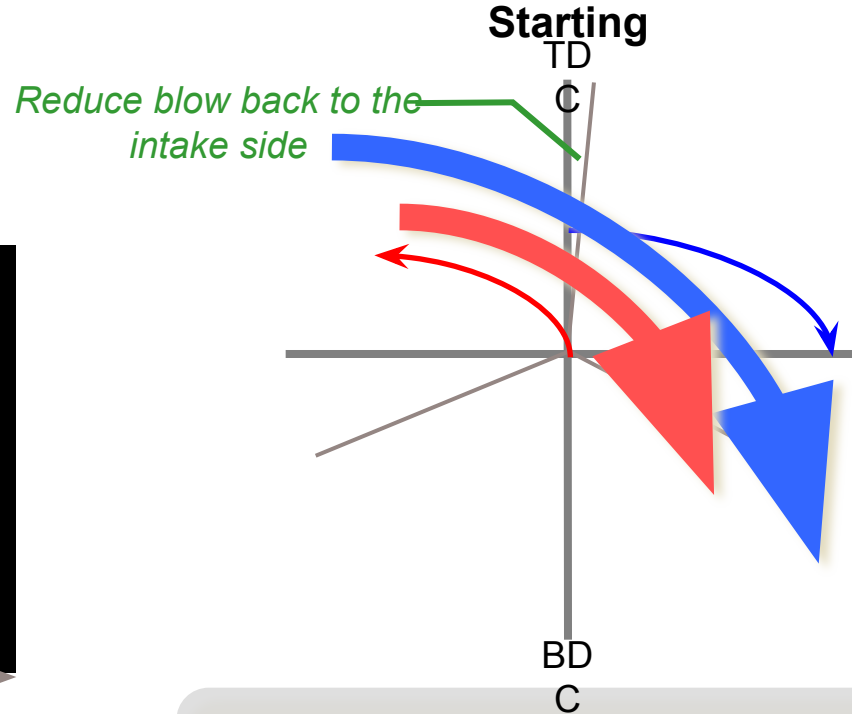
**Dual VVT-i for LH
Bank**

Reference (Engine Control System)

Operation



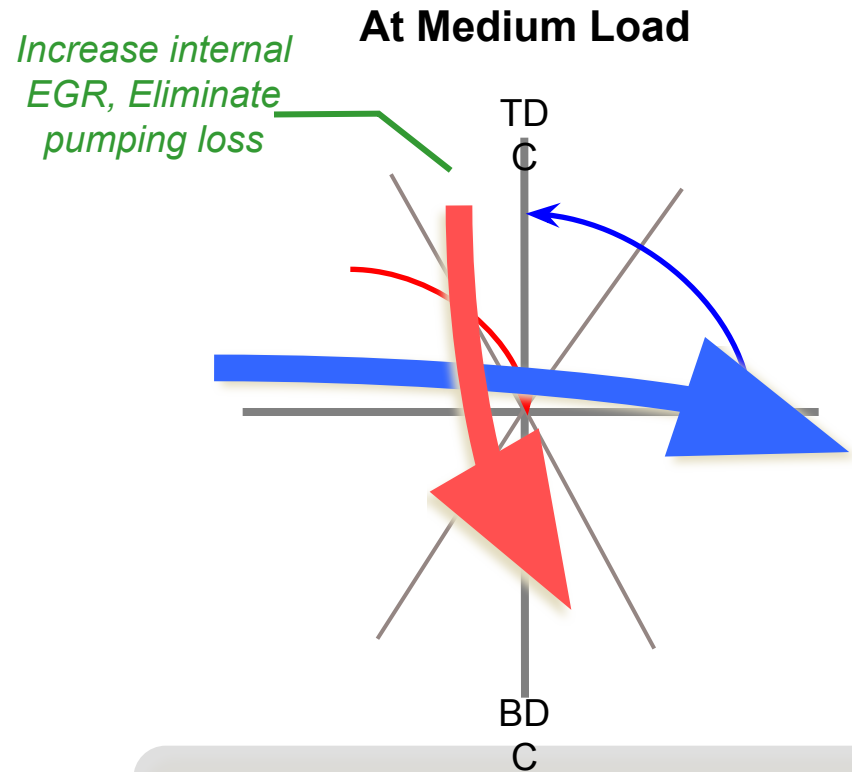
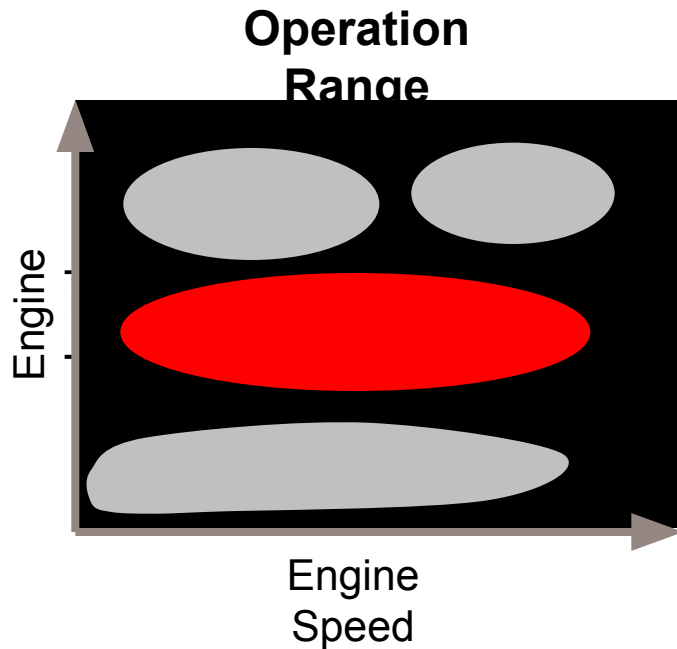
At Idle, Light Load, Low Temp. and Starting



-
- Effect Stable Combustion for fuel economy
-

Reference (Engine Control System)

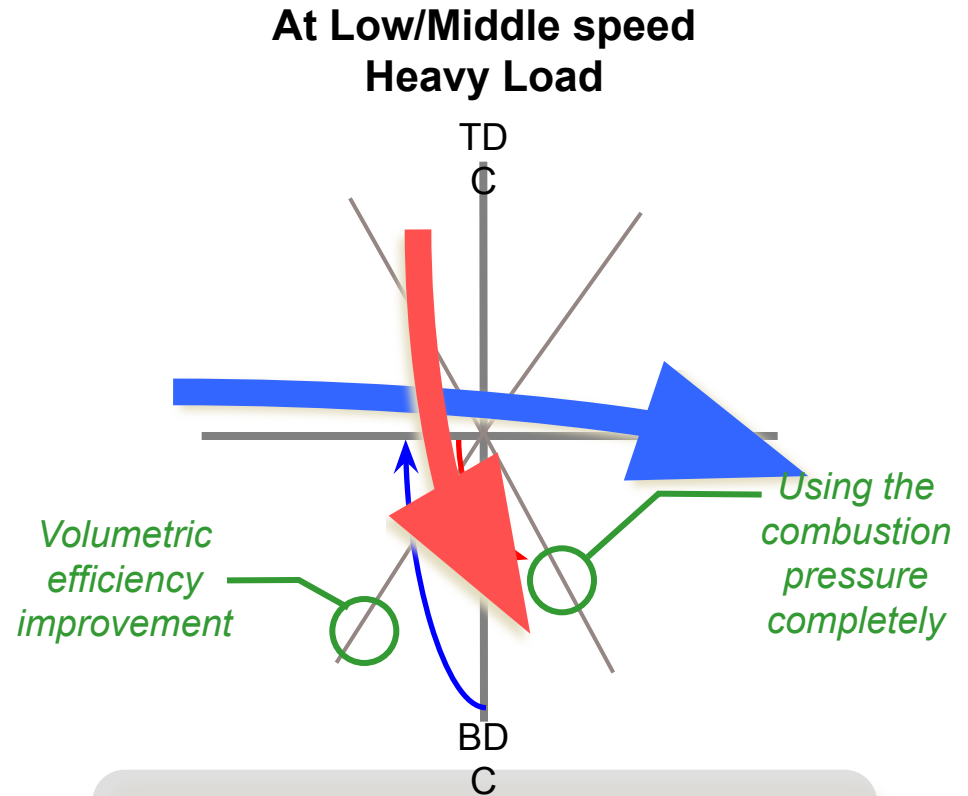
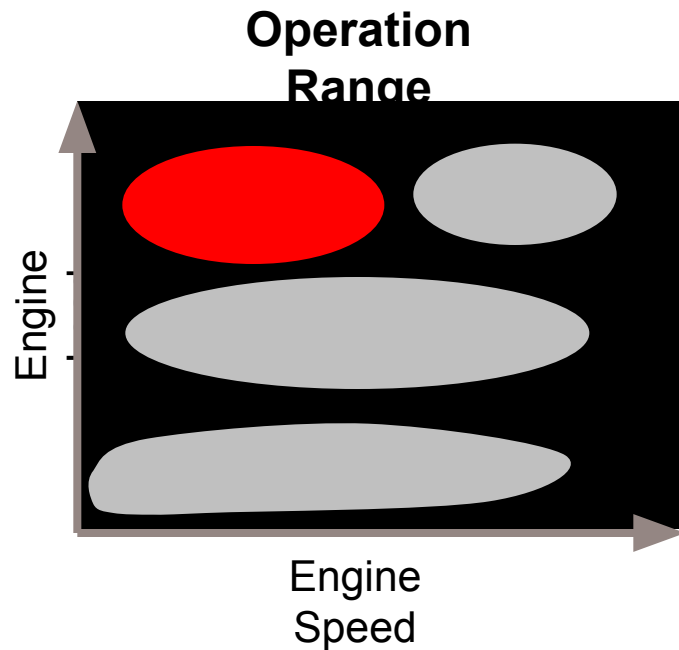
Operation



- Effect
- Improved emission control
 - Better fuel economy

Reference (Engine Control System)

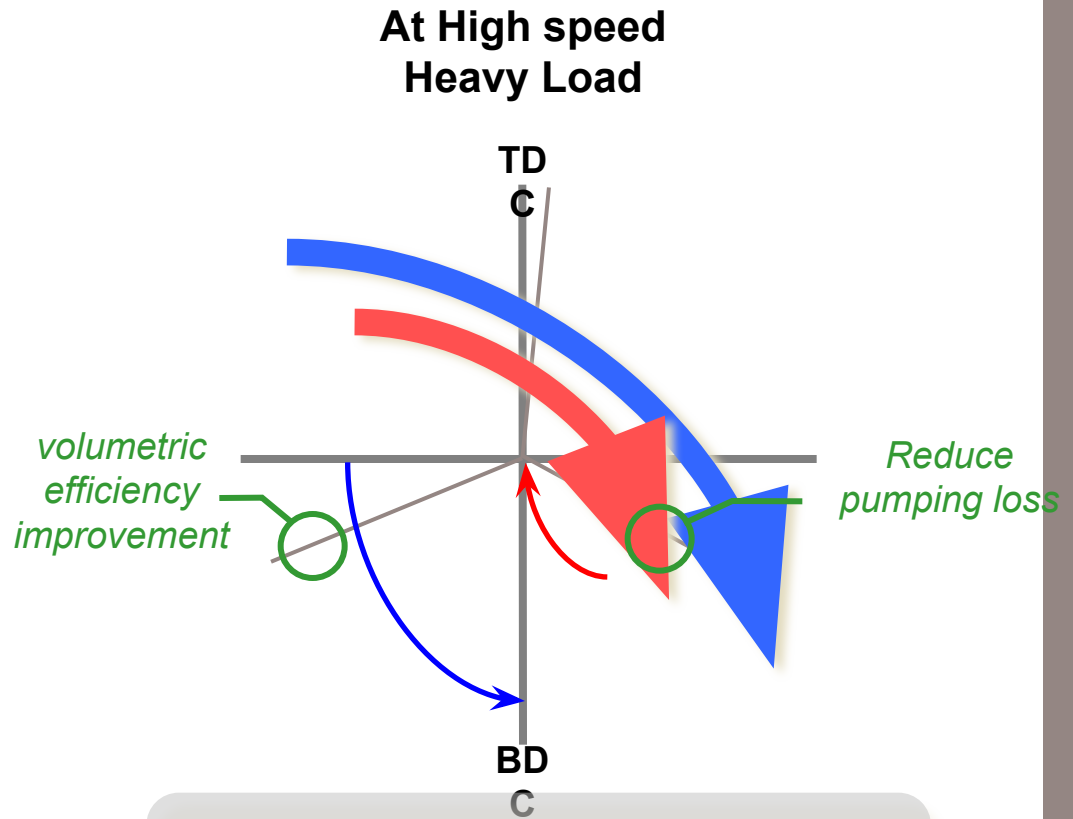
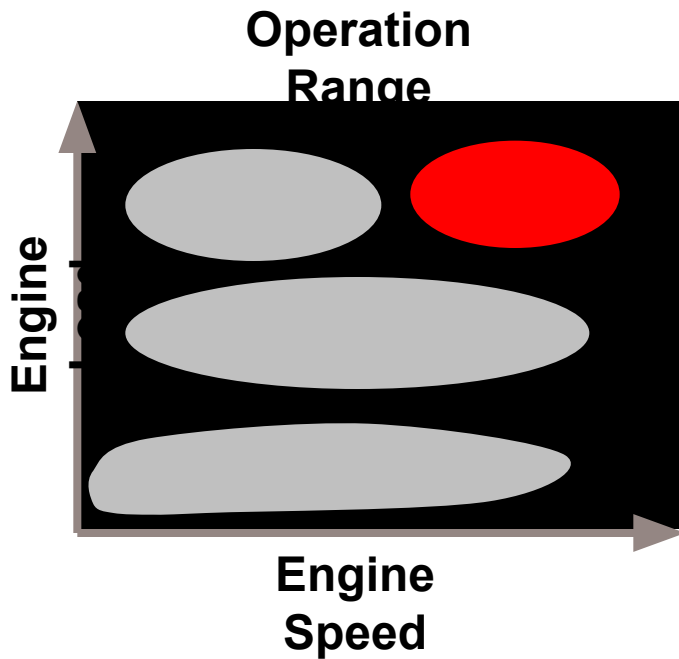
Operation



-
- Effect Improved torque/output
-

Reference (Engine Control System)

Operation



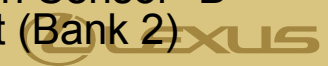
-
- Effect Improved output
-

Service Point (Engine Control System)

• System

– Following 14 DTCs are added by adoption of exhaust VVT-i

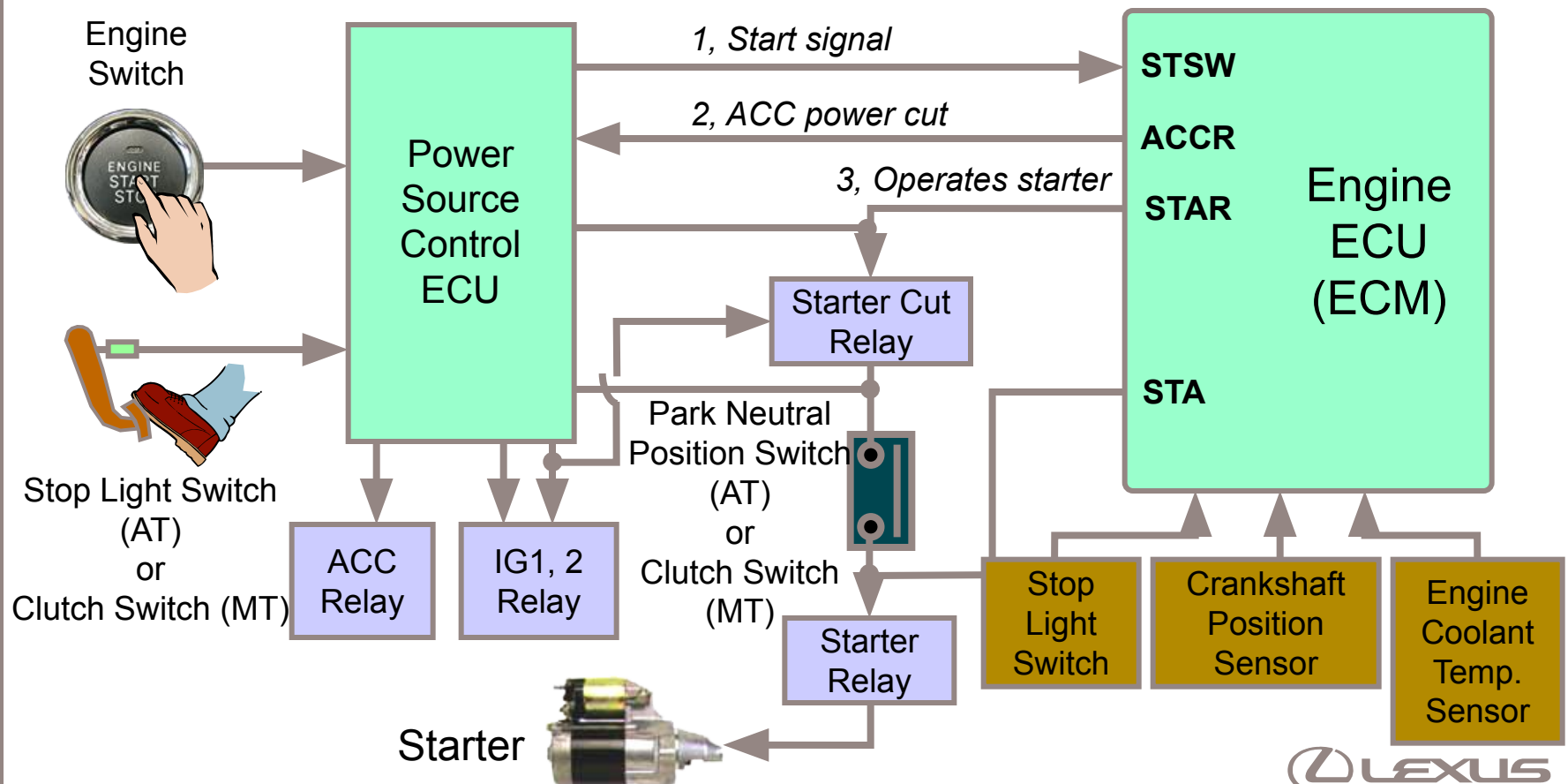
DTC No.	Detection Item	DTC No.	Detection Item
P0013	Camshaft Position "B" Actuator Circuit (Bank 1)	P0025	Camshaft Position "B" - Timing Over-Retarded (Bank 2)
P0014	Camshaft Position "B" - Timing Over-Advanced or System Performance (Bank 1)	P0365	Camshaft Position Sensor "B" Circuit (Bank 1)
P0015	Camshaft Position "B" - Timing Over-Retarded (Bank 1)	P0367	Camshaft Position Sensor "B" Circuit Low Input (Bank 1)
P0017	Crankshaft Position - Camshaft Position Correlation (Bank 1 Sensor B)	P0368	Camshaft Position Sensor "B" Circuit High Input (Bank 1)
P0019	Crankshaft Position - Camshaft Position Correlation (Bank 2 Sensor B)	P0390	Camshaft Position Sensor "B" Circuit (Bank 2)
P0023	Camshaft Position "B" Actuator Circuit (Bank 2)	P0392	Camshaft Position Sensor "B" Circuit Low Input (Bank 2)
P0024	Camshaft Position "B" - Timing Over-Advanced or System Performance (Bank 2)	P0393	Camshaft Position Sensor "B" Circuit High Input (Bank 2)



Engine Control System

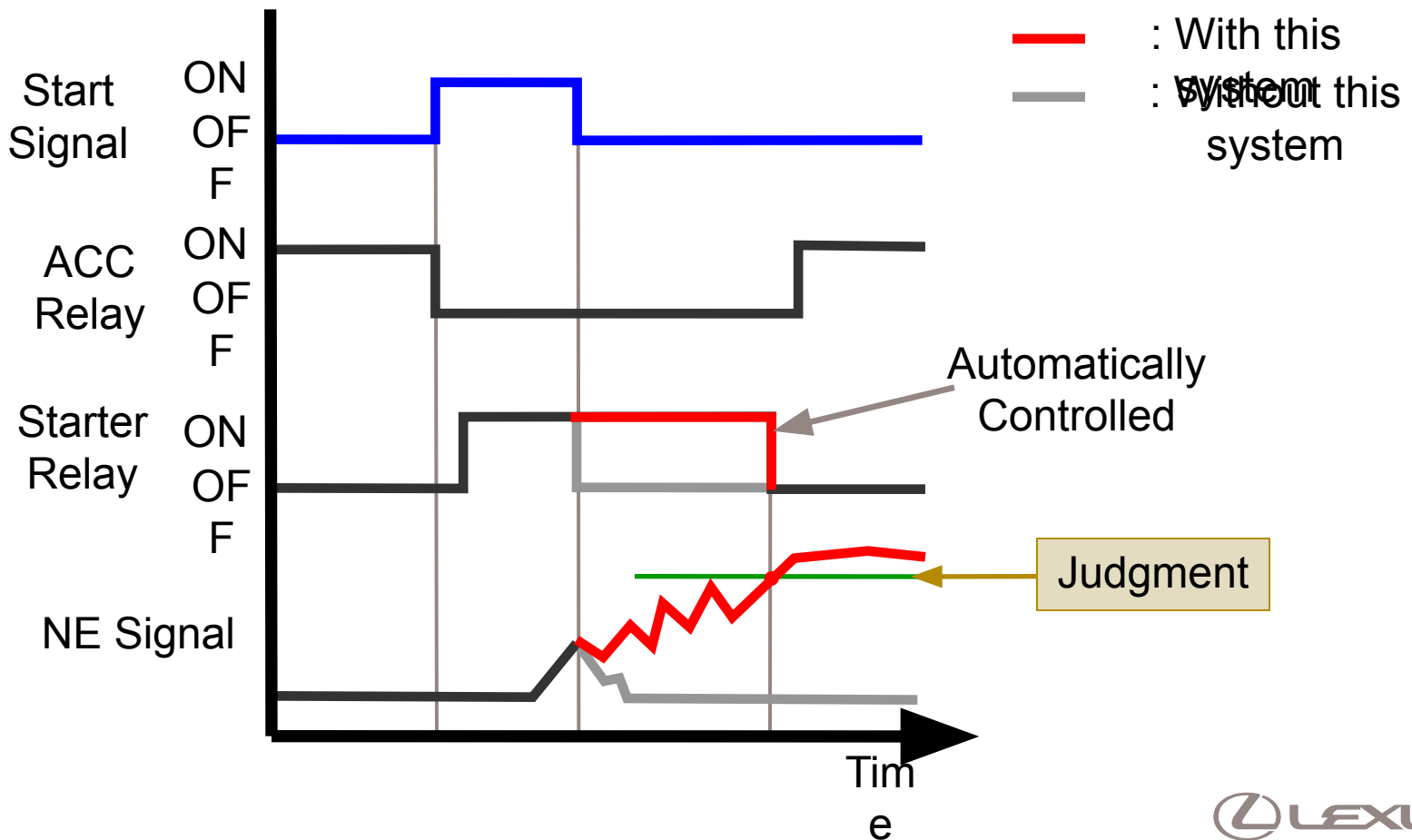
- Cranking Hold Function

- Once the power mode is turned to “Engine Starting”, starter operates until engine starting



Reference (Engine Control System)

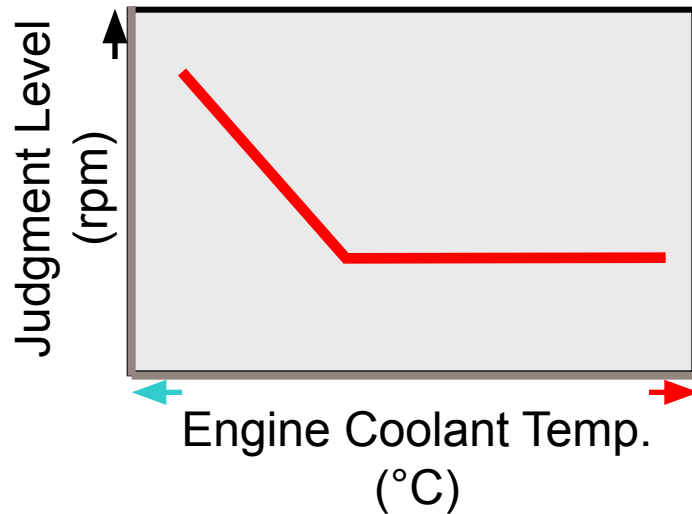
- Overriding Hold Function - Operation



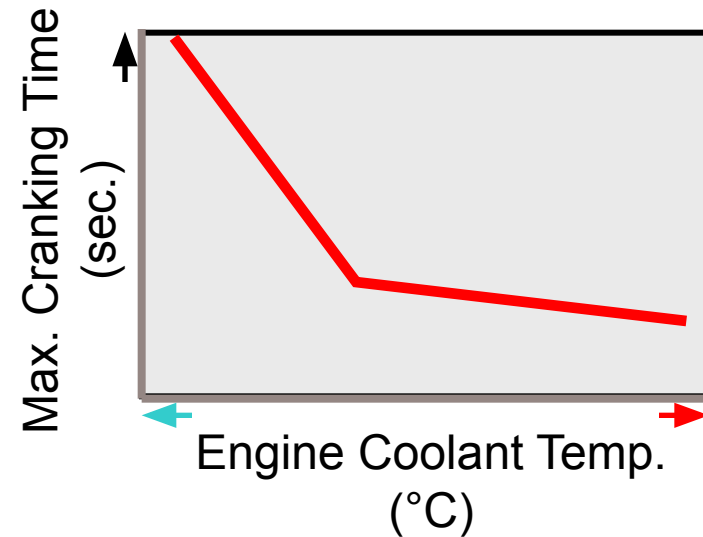
Reference (Engine Control System)

Starting Hold Function

- Judgment of the engine firing
- Maximum cranking time



Judgment of the engine firing



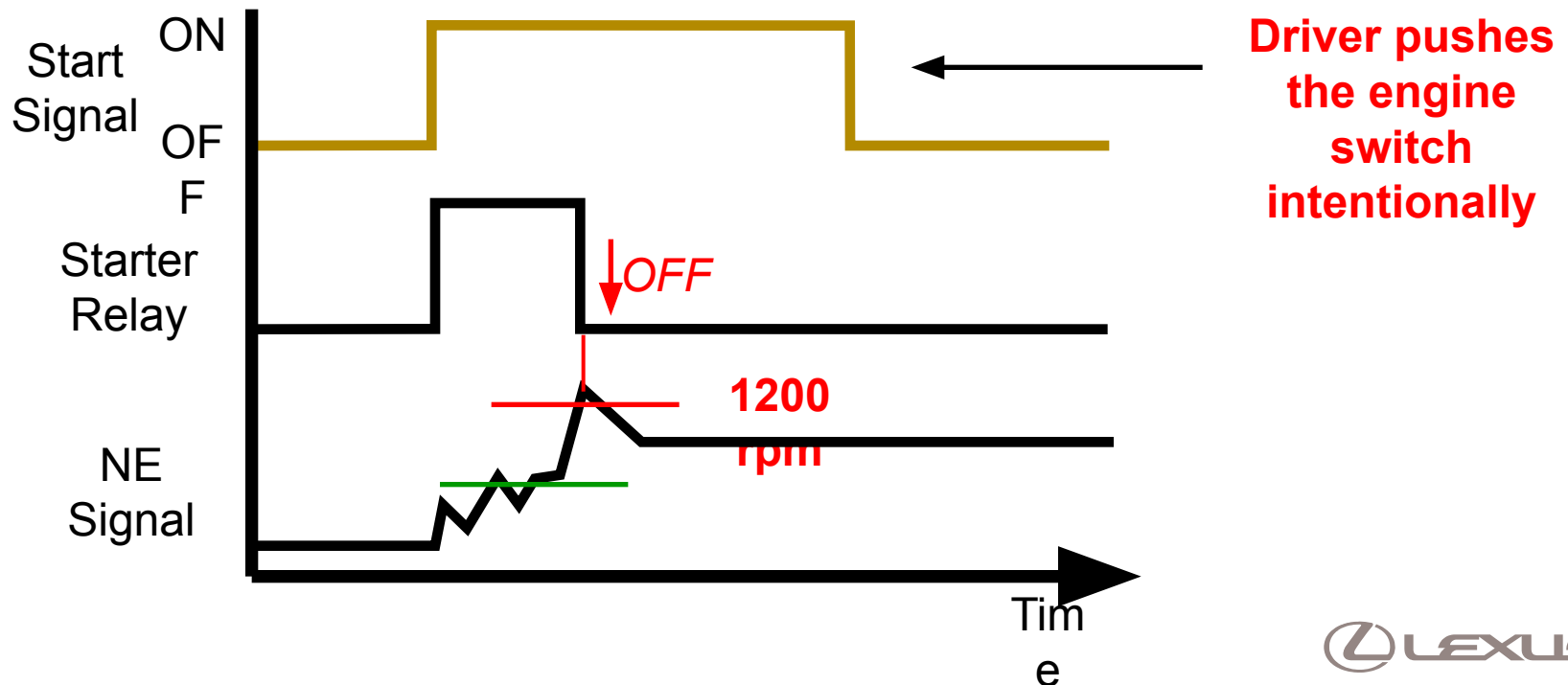
Maximum cranking time
(When engine does not start by some abnormalities)

Reference (Engine Control System)

Start Hold Function

- Protection during engine starting

If the engine speed becomes 1200 rpm or more while cranking, engine ECU (ECM) stops starter to prevent starter overrun

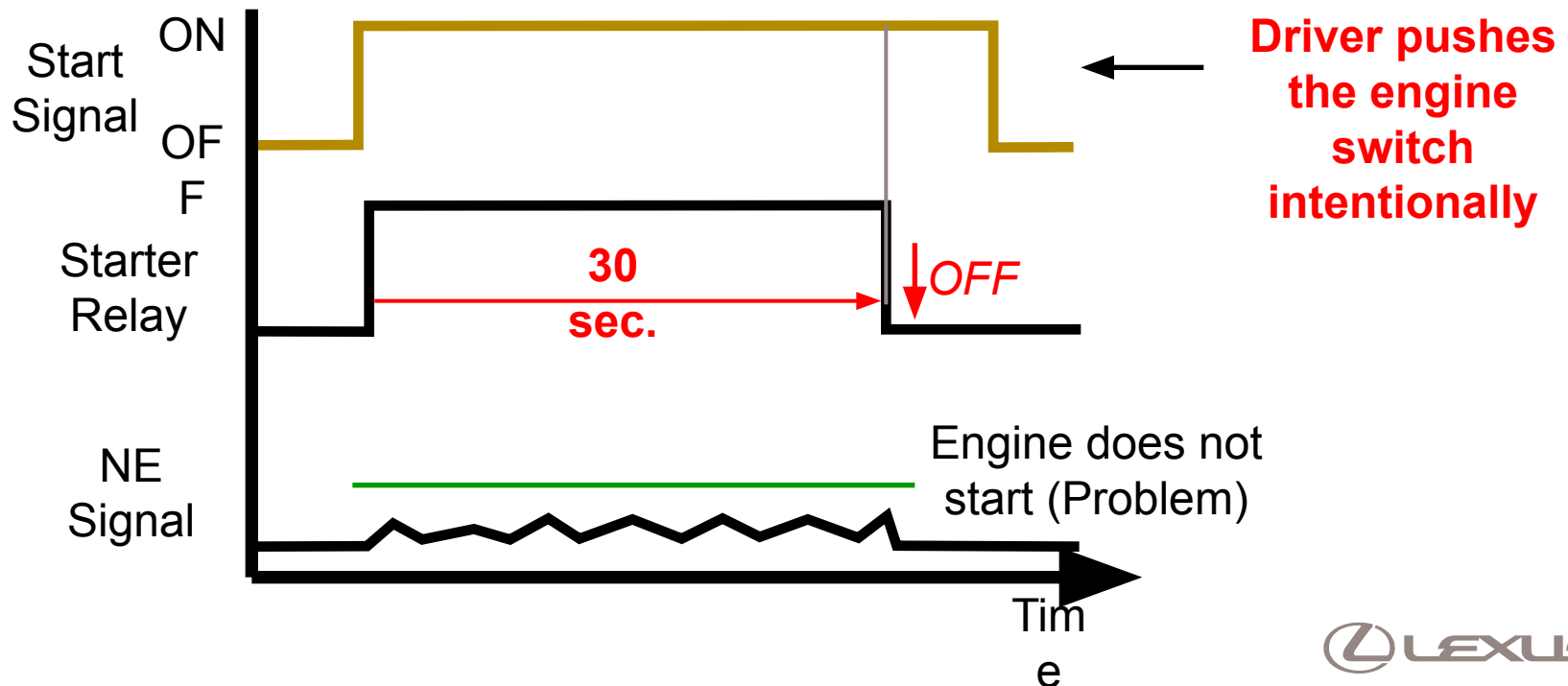


Reference (Engine Control System)

Starter Hold Function

- Protection during engine starting

Starter overheating protection operates starter max.30 sec. with intentional starter operation



Engine Control System

- Communication
 - CAN (Controller Area Network) communication for DLC3 and other ECUs

