



CAPABILITY ENHANCEMENT OF ELECTRONICS AND SOFTWARE

Module 2 - ACU related Sensors, Actuators and OBD Introduction

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I. Sensors

- a) Exhaust gas temperature sensor
- b) Delta pressure sensor
- c) Nox sensor
- d) Urea Level sensor
- e) Urea Quality sensor
- f) Urea Level sensor
- g) Ambient air temperature sensor

I. Actuators

- a) Urea Dosing System
- b) Hydrocarbon dosing system

II. On Board Diagnostics introduction

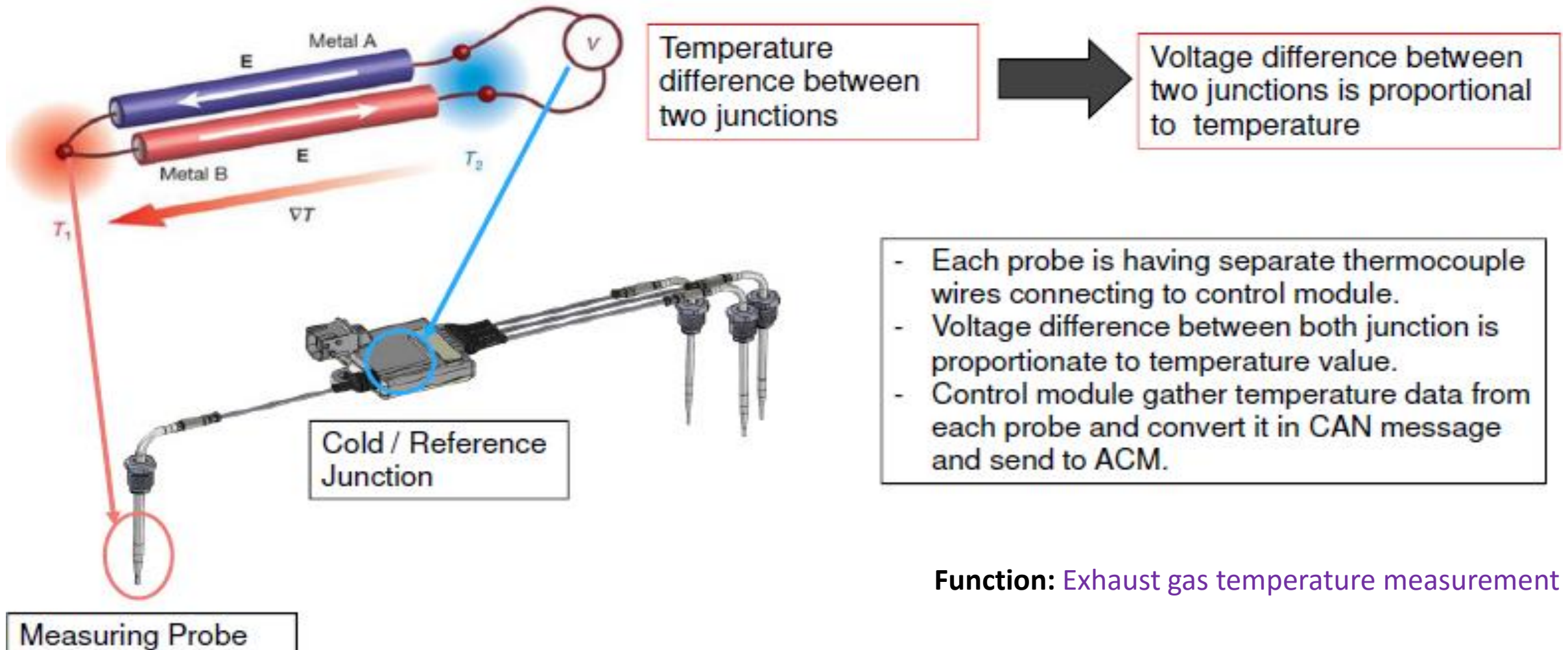
Sensors and Actuators



	Sensors			Actuators	
EATS	Exhaust Gas Temperature sensors	Delta pressure sensor	Nox Sensor		
DEF Tank unit	Urea Level Sensor	Urea Quality Sensor	Urea Temperature sensor		
DEF Tank Frame	Ambient air temperature sensor				
UDS	Urea pressure sensor	Air pressure sensor		Urea pump	Air regulator valve
HC Metering unit	Upstream pressure + Temperature	Downstream pressure sensor		Fuel shutoff valve	Dosing valve



Exhaust Gas Temperature sensor

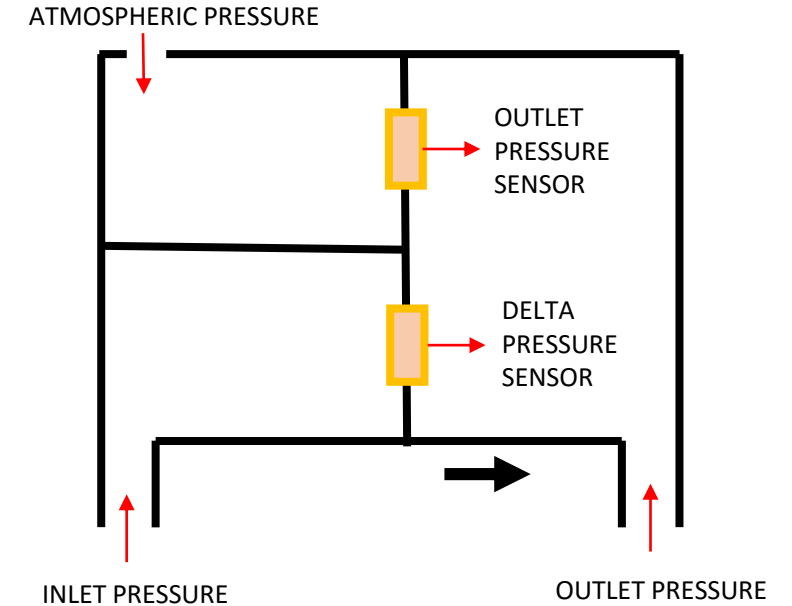
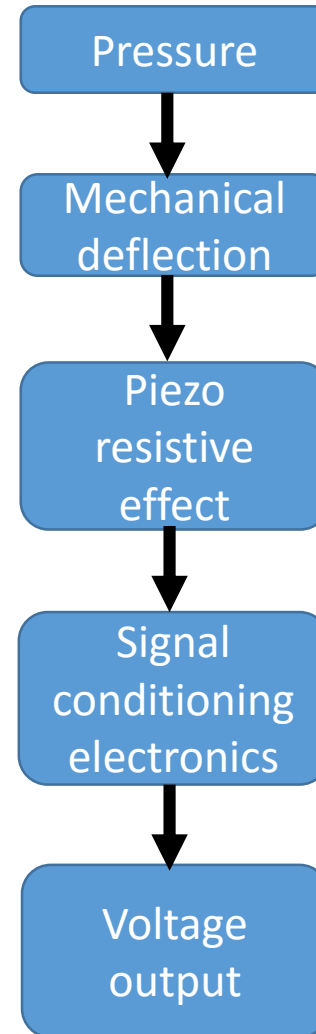


The **Thermocouple** consists of two dissimilar metals joined together to form two junctions (one end in sensor tip, another end in module). Difference in temperature between two junction creating voltage difference that is measured by the module and sends the output in terms of temperature

Delta pressure sensor



Working principle :Piezo resistive effect



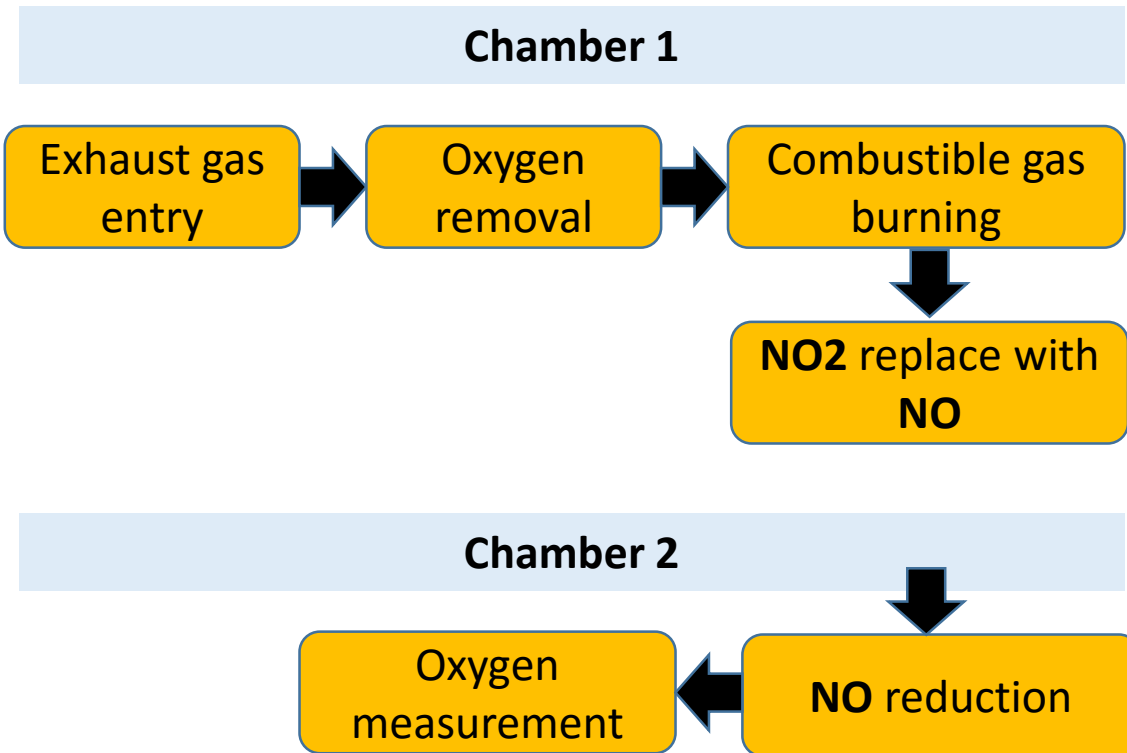
Function: To estimate the soot load inside DPF.

Working: The resistance of the strain sensitive piezo resistors varies proportional to the strain in the diaphragm. Placing the piezo resistors in Wheatstone bridge gives an output voltage proportional to the pressure change

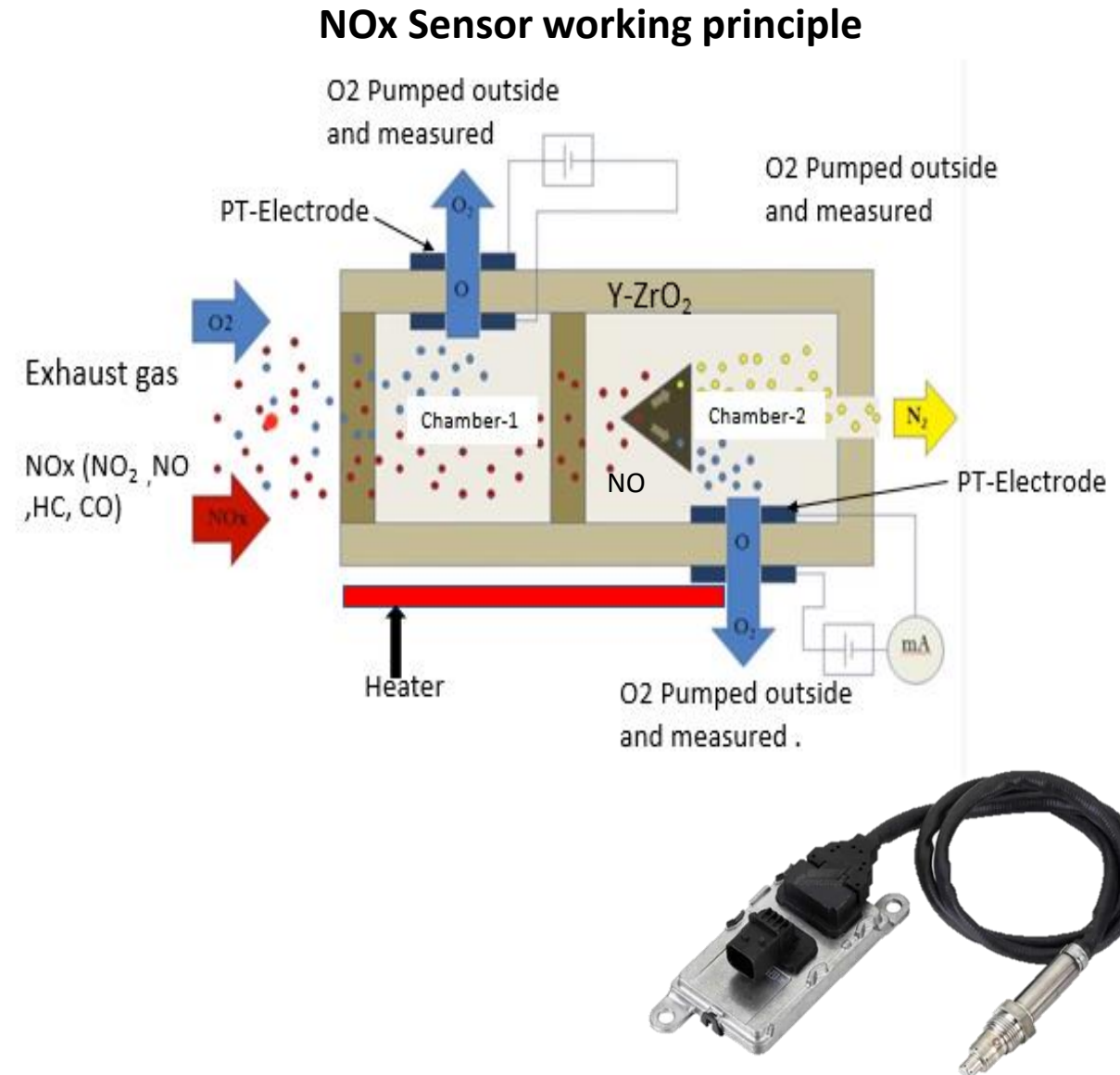


Nox sensor- Working principle

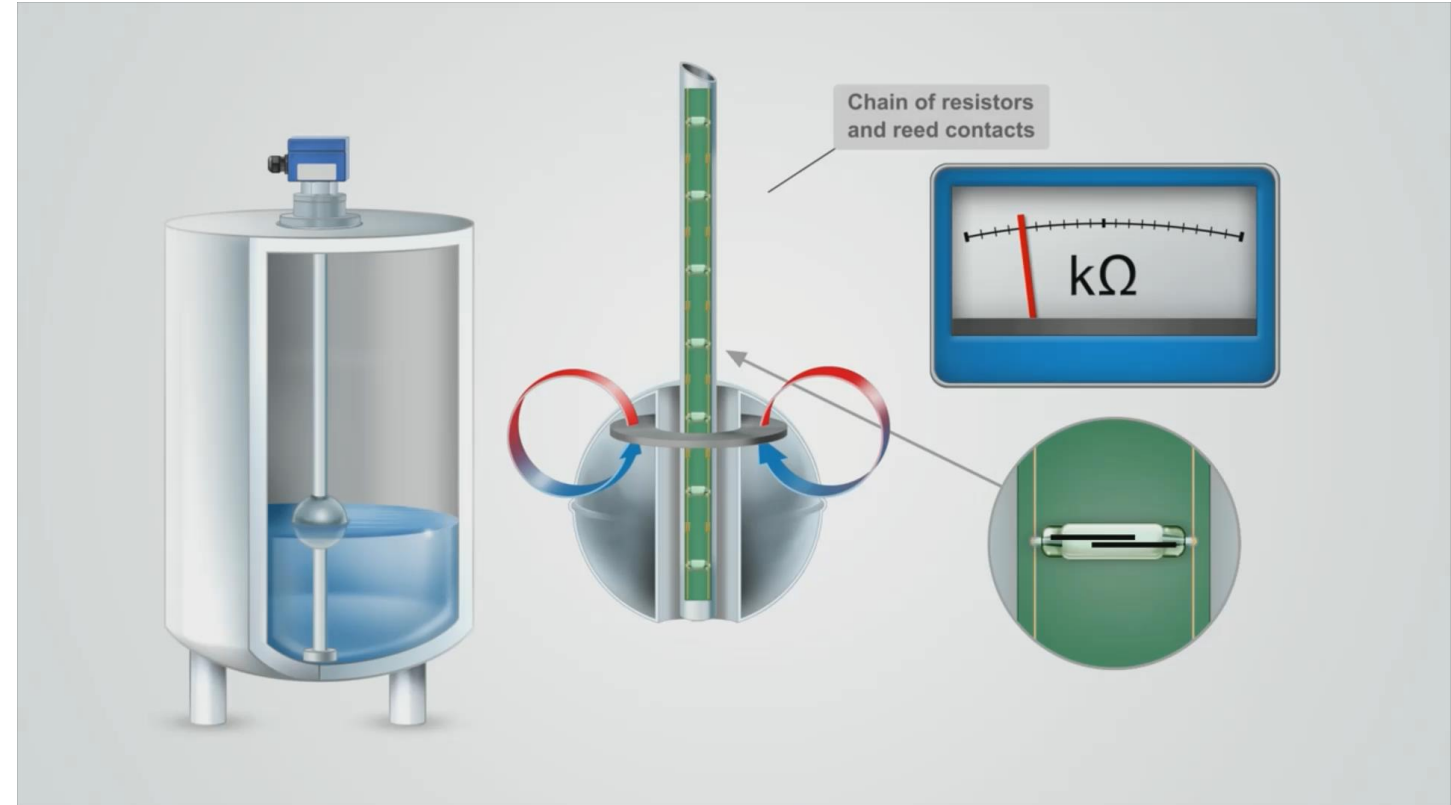
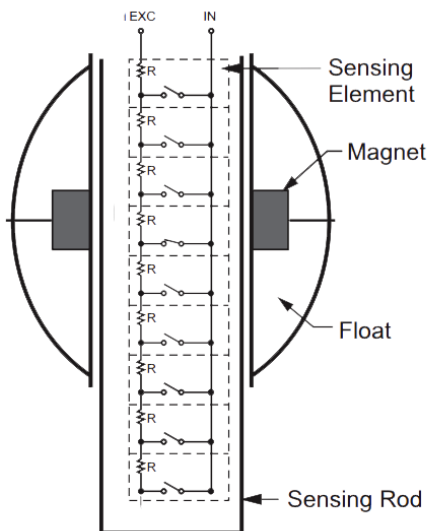
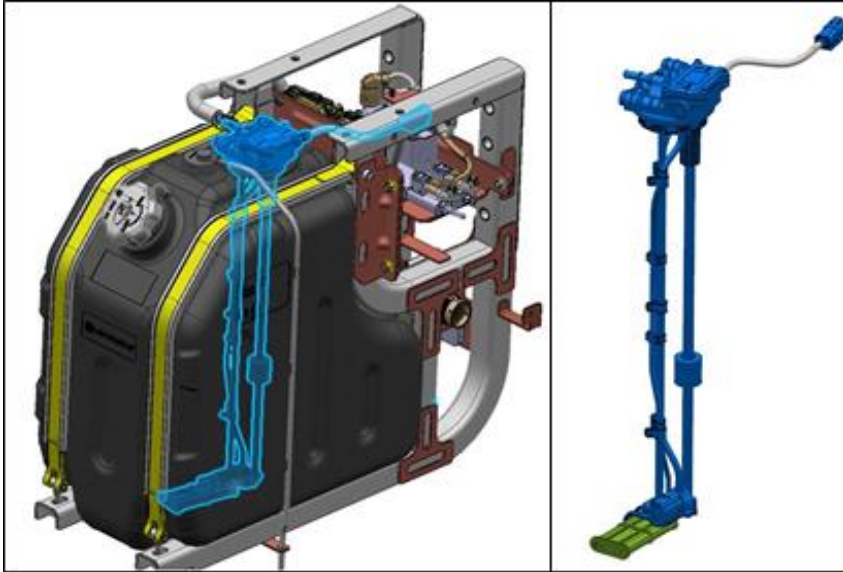
Function: Nox measurement from Exhaust gas



- Example-2NO $\text{N}_2 + \text{O}_2$



DEF Level sensor

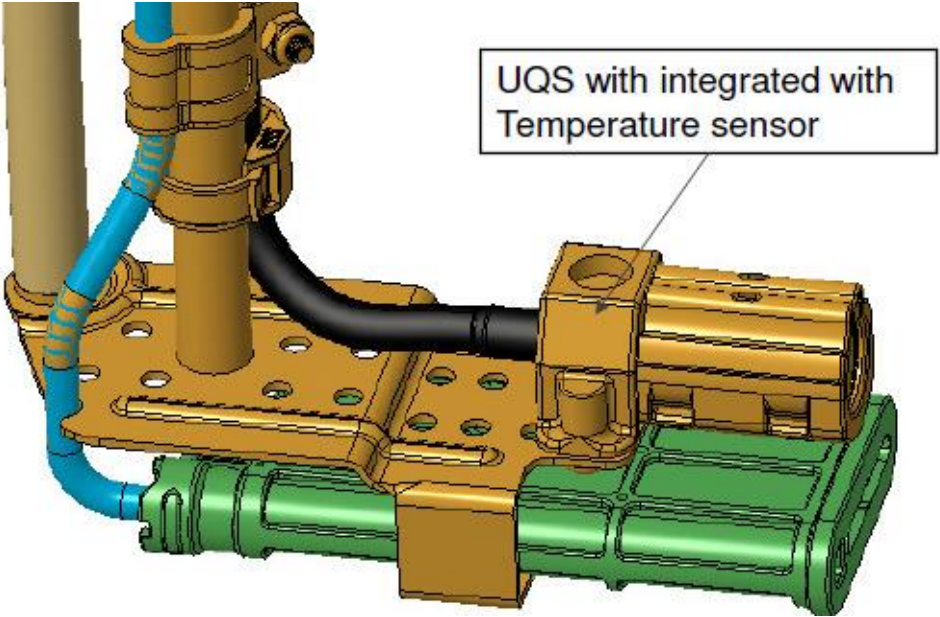


Working principle: **Magnetic float type**

Whenever float moves on tube, Switch will be closed due to Magnetic force. Which makes the circuit complete and voltage will be measured by Module.

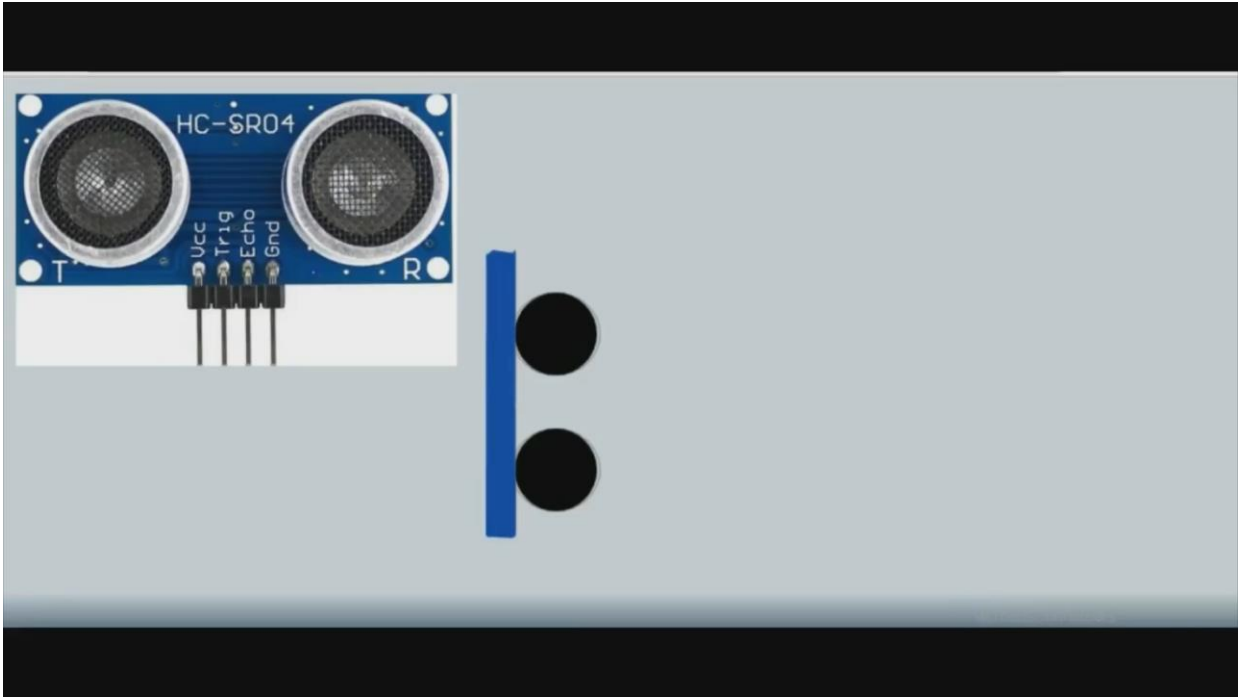
Function: Urea level sensing in the Tank

DEF/Urea Quality sensor



Working principle: With known fixed reflection distance, the ultrasonic wave speed could be calculated by measured by Time of Wave return, which varies according to different Urea Concentrations.

Function: Urea Quality monitoring

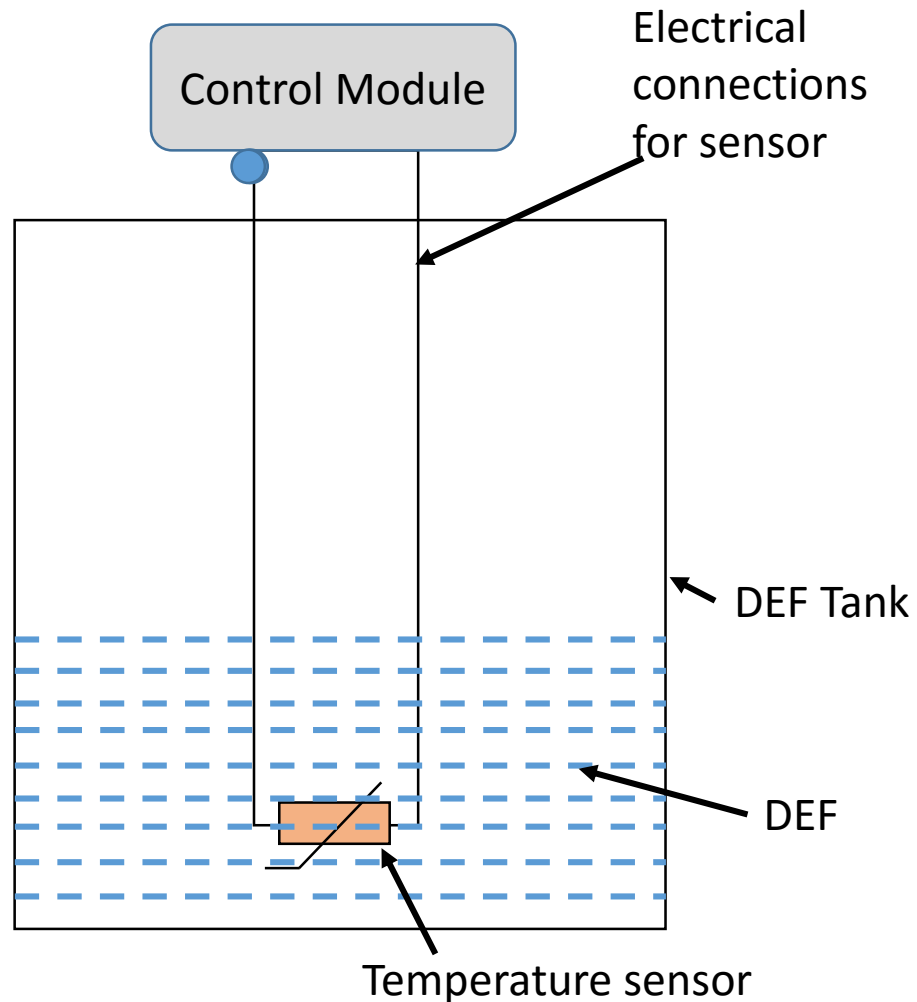


Example for
Concentration
estimation



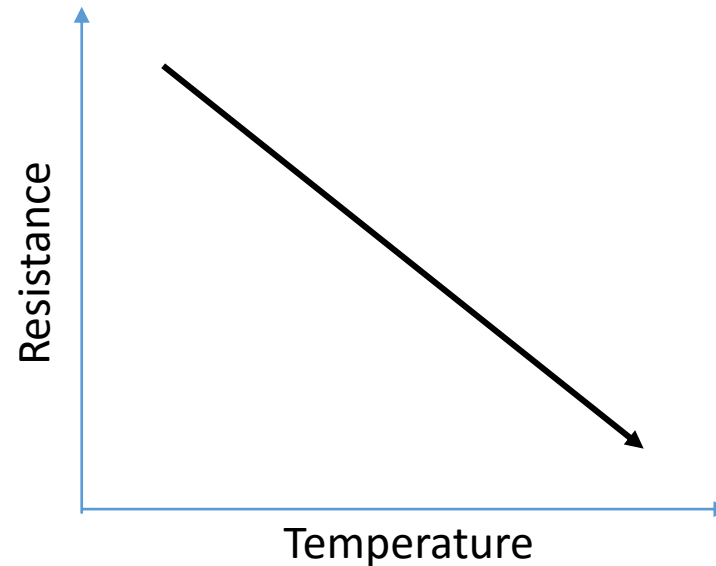
Urea Concentration	Time
32.5%	T1
25%	T2
20%	T3
15	T4

DEF Tank Temperature Sensor



Working principle: NTC - Negative Temperature Coefficient thermistor.

The resistance decreases with increasing temperature.



Function: Urea temperature in tank monitoring



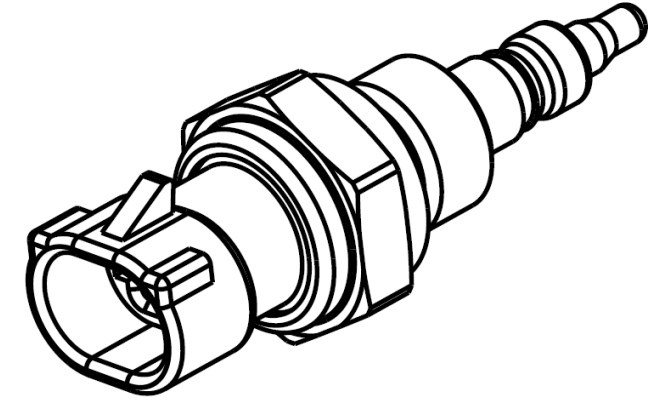
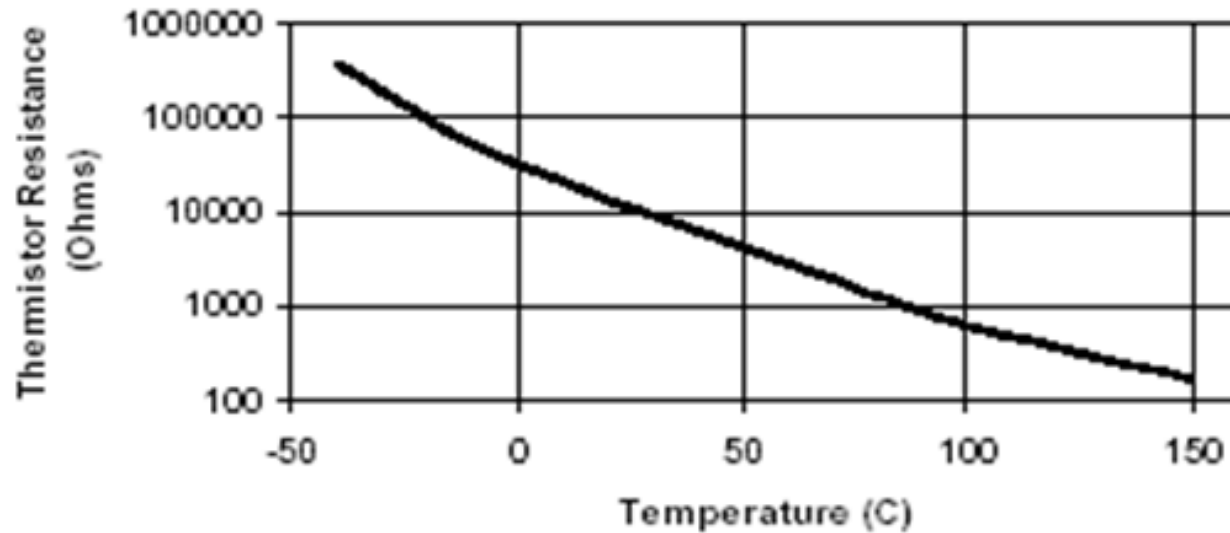


Ambient Air Temperature sensor

Working principle: NTC - Negative Temperature Coefficient Thermistor.

The resistance decreases with increasing temperature.

Typical NTC Thermistor Curve



Function: Ambient air temperature monitoring



Actuators



Urea Dosing System- Albonair

1. Urea Pump

- Suction of urea from the urea tank and Delivers into the SCR system channels through Transfer lines and Urea Nozzle.
- A diaphragm based reciprocating pump which controls the delivery of urea based on the request from system.

2. Air Regulator Valve(ARV)

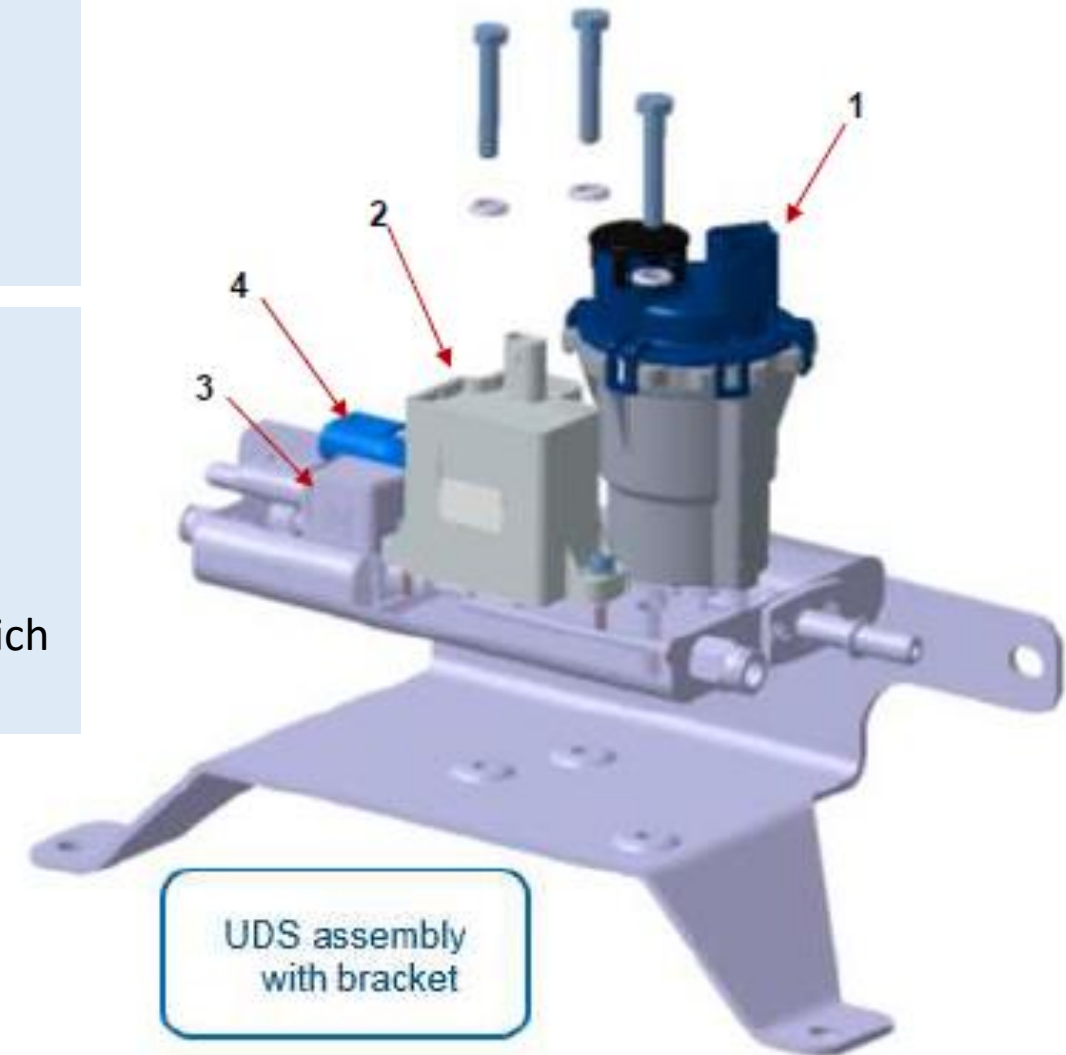
- Supplies Air pressure to the Urea nozzle for urea injection through Air transfer line.
- It is an electronic controlled valve which is capable of dispense the required amount of Air pressure based on the system demand.
- Air pressure supply is getting from Auxiliary Air tank in the vehicle which charges from the vehicle air pressure lines

4. Urea Pressure Sensor

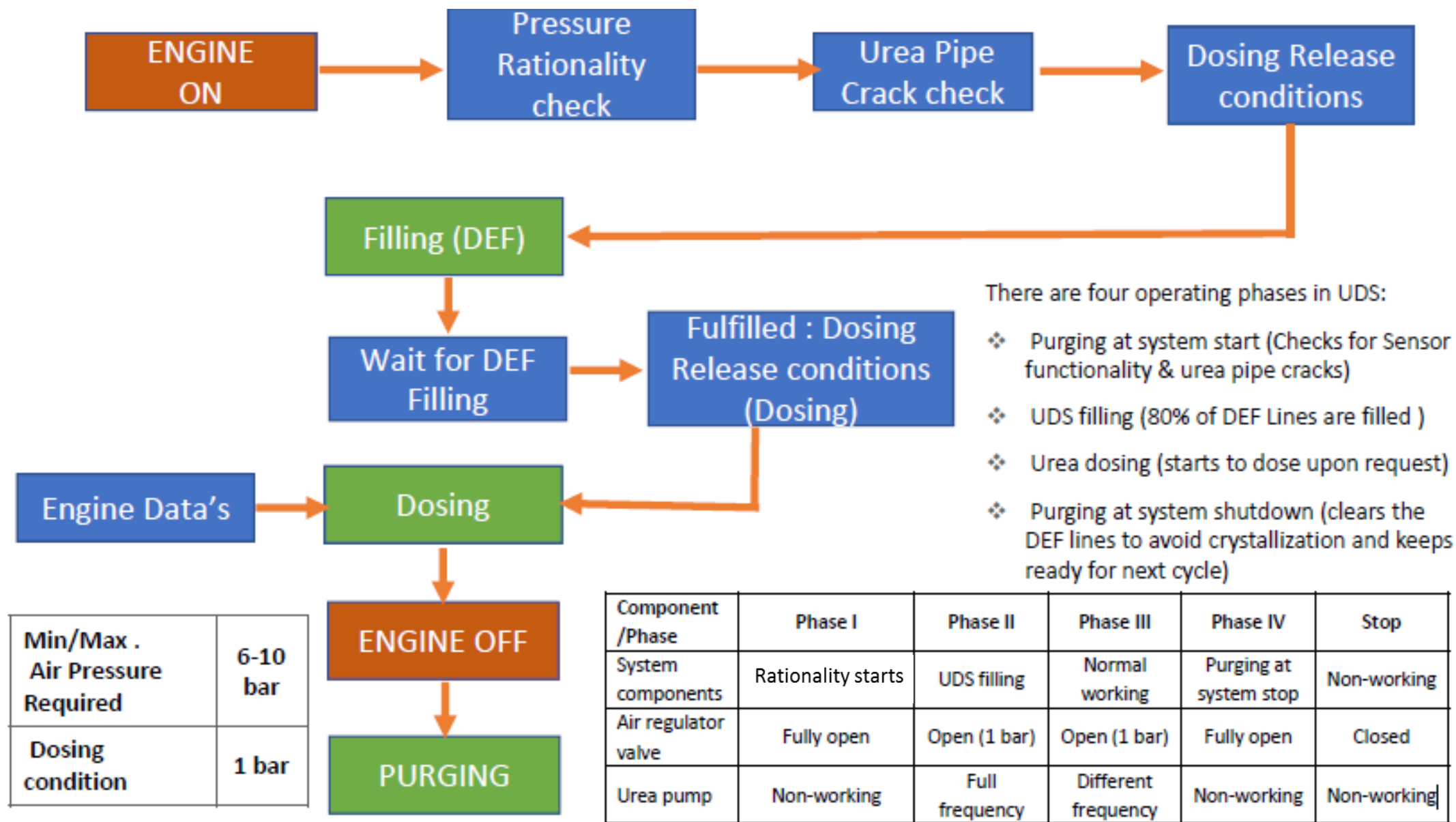
- Measures the Urea pressure of Urea transfer line- After Urea pump and Before urea injector (Piezo resistive sensor)

4. Air Pressure Sensor

- Measures the Air pressure of Air transfer line- After ARV and Before urea injector (Piezo resistive sensor)

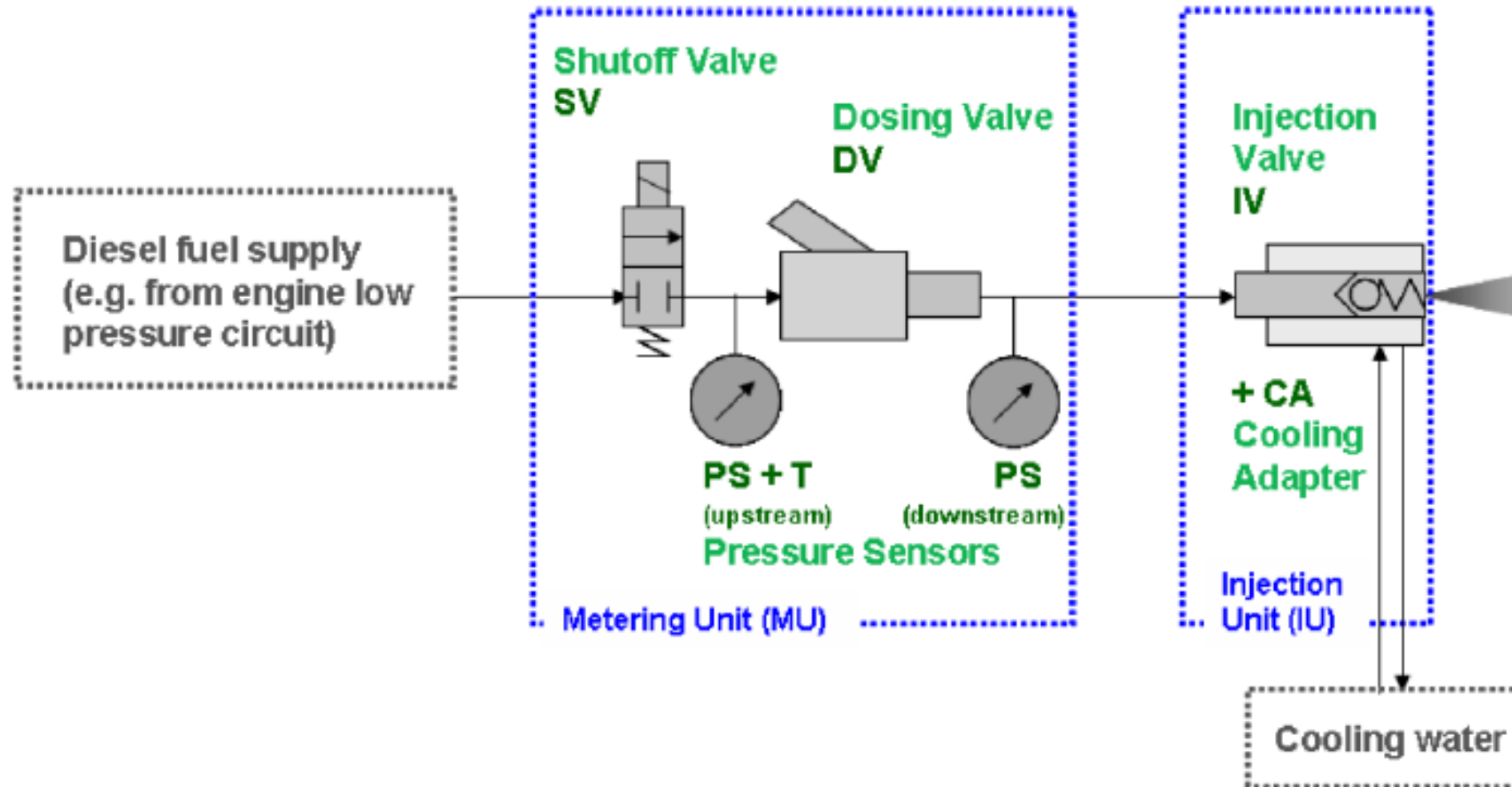


UDS Functionality



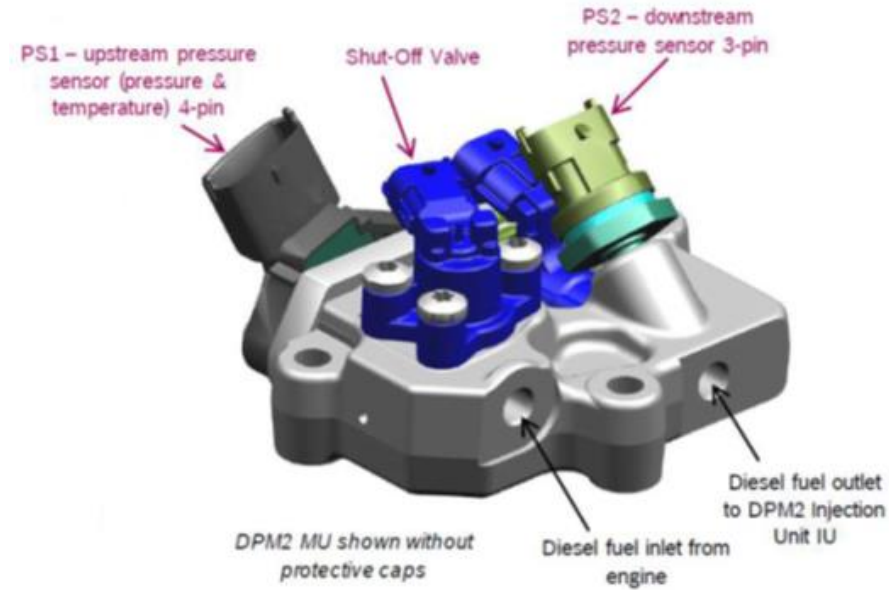


HC Dozer- Metering unit and Injector- Schematic diagram

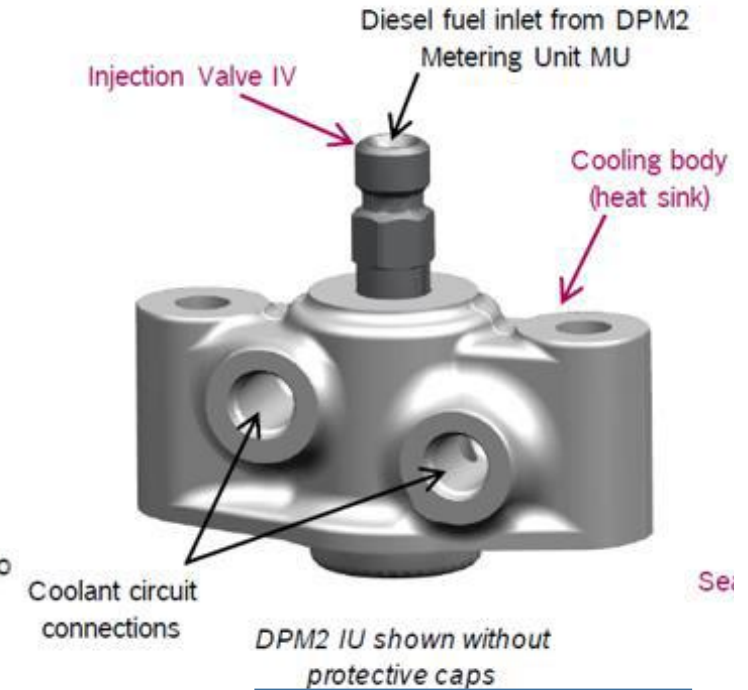
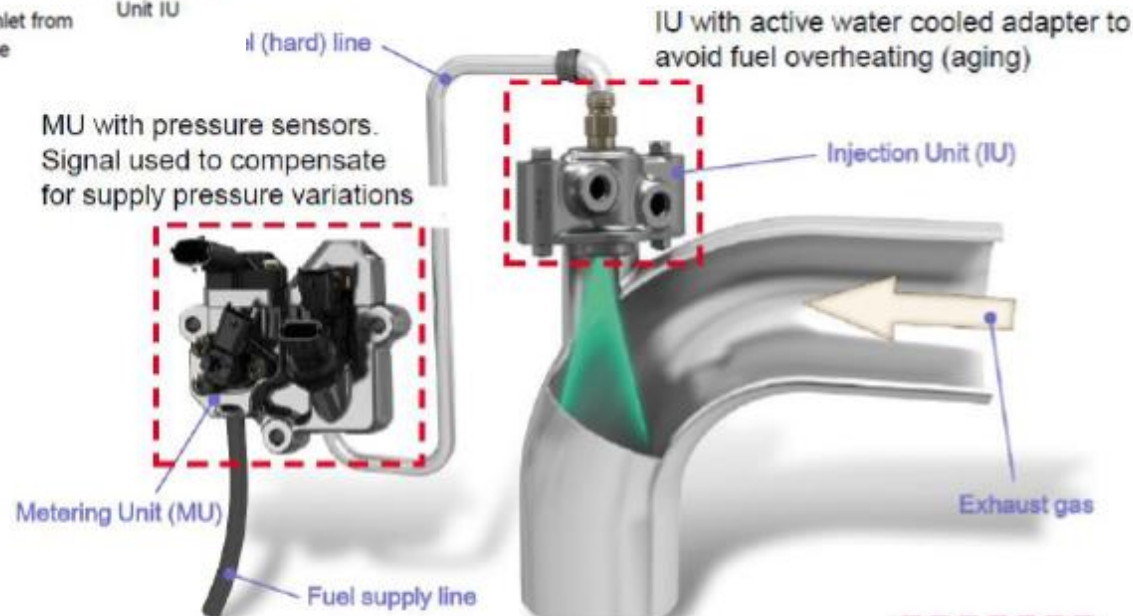




Metering unit and Nozzle asseble

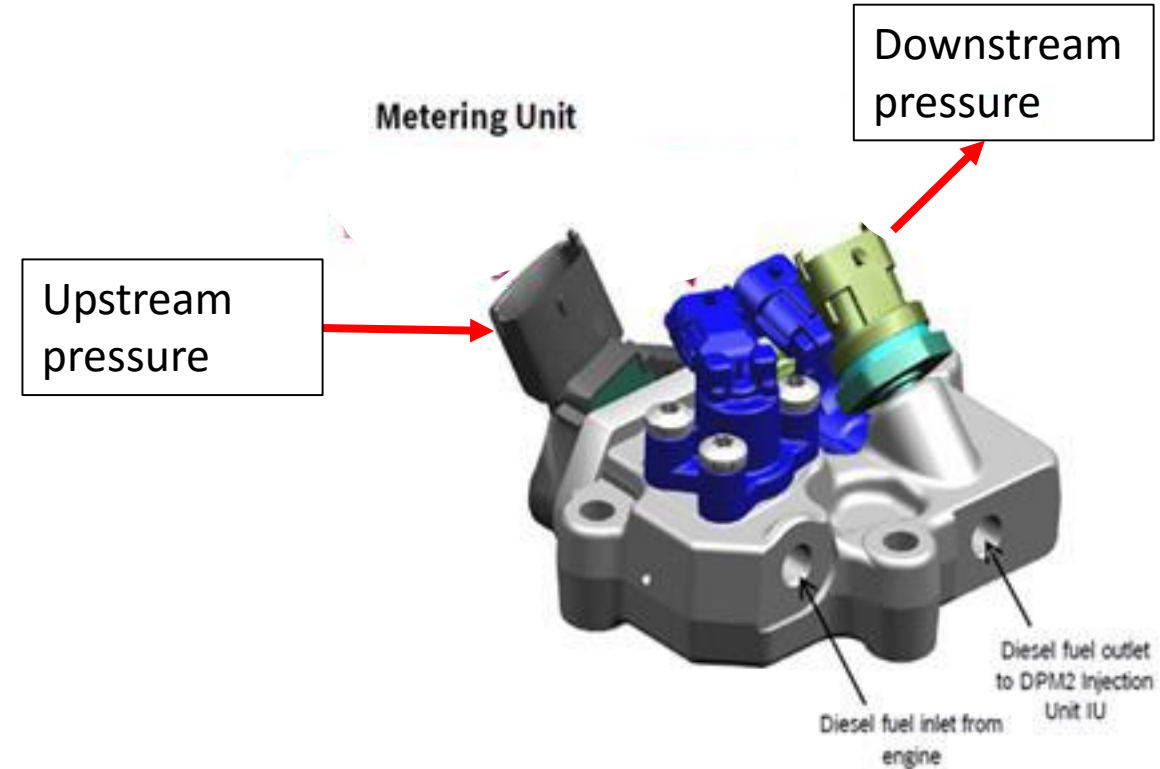
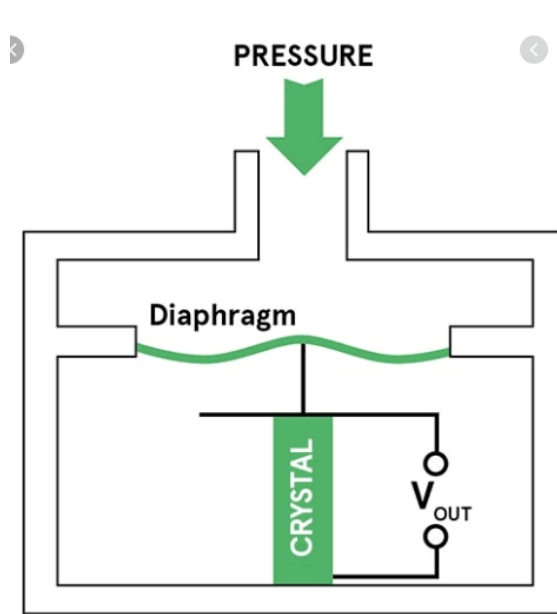


Metering unit



Nozzle

Upstream pressure & Downstream pressure sensor



Working principle– piezo resistive type

- The housing of the sensing probe contains a silicon chip which is exposed to a reference vacuum and sealed.
- Pressure acting the chip creates resistance change in piezo resistive material.
- This is converted as a signal voltage



On-Board Diagnostics-OBD

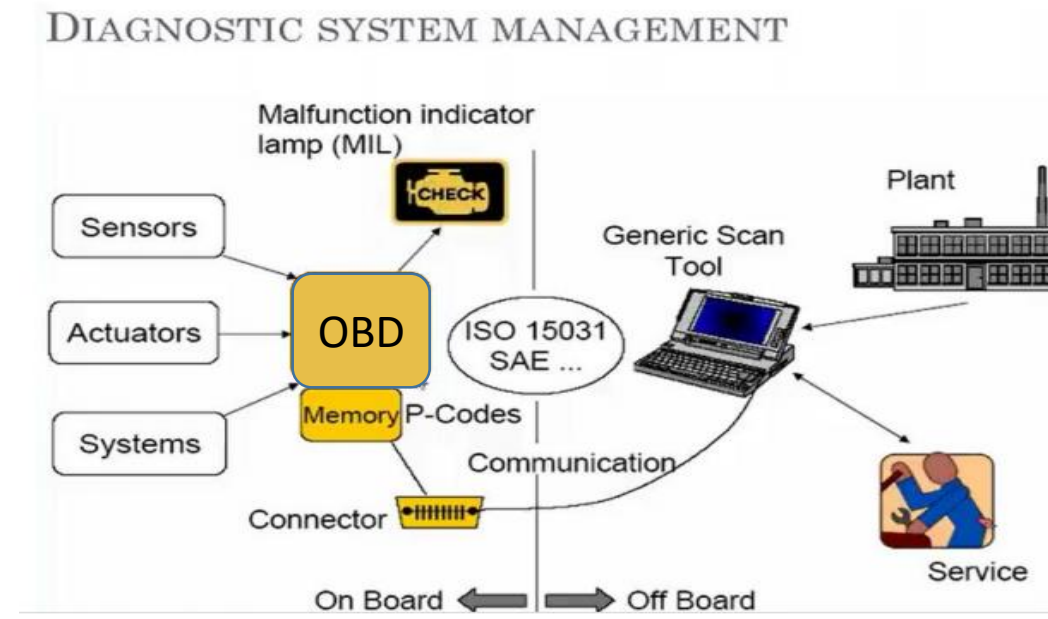
On- Board Diagnostics(OBD)



- ❑ ECU and ACU contain a built in self-diagnosis system which detect faults within the system and store the failure code associated with the detected failure.
- ❑ The purpose of OBD is to facilitate efficient repair of emission related failures during vehicle operation

Why OBD??

1. Component monitoring
 - Electrical circuit failure
 - Rationality failure
 - Functionality failure
2. Performance threshold monitoring
3. Emission threshold monitoring





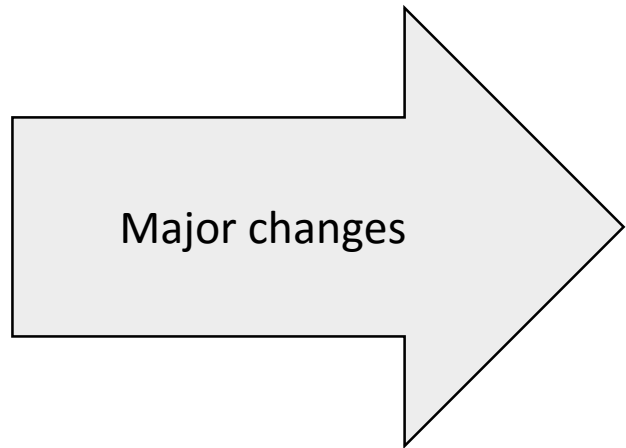
BSVI OBD Stage II - Change details

BSVI- OBD Stage 1 and Stage 2: Requirements

	BSVI OBD Stage-1	BSVI OBD Stage-2
Introduction cutoff	1-Apr-2020	1-Apr-2023
Nox- OBD limit	1500mg/kwhr	1200mg/kwhr
PM- OBD limit (Monitoring)	Not available	25mg/kwhr
Nox emission limit due to Urea Concentration(Reagent Quality)	900mg/kwhr	Will be optimized
IUPR (In Use Performance Ratio)	Not available	IUPR>0.1 for all OBD diagnostics

- **OBD**- On Board diagnostics
- **PM**- Particular matter(soot)
- **IUPR**- In Use Performance Ratio

No hardware changed are involved in OBD Stage 2 migration. The OBD-2 limits are will be achieved through Calibration changes only



- 1. Nox Conversion efficiency diagnostics thresholds modification**
 - ❑ NOx OBD threshold reduced from 1500mg/kwhr to 1200mg/kwhr
- 2. PM(Soot) OBD threshold limit introduced for DPF monitoring.**
 - ❑ The thresholds of DPF filtration efficiency will be changed detect the condition.
- 4. IUPR calculation and monitoring logic introduction in Calibration.**



Type approval and IUPR (In Use Performance Ratio)

Type approval process

BSVI- OBD Stage I

- ☐ Type approval based on performance in Test bed level- various emission test cycles

BSVI- OBD Stage II

- ☐ Type approval based on performance in Test bed level- various emission test cycles
- ☐ IUPR Data submission of field vehicles

IUPR- In Use performance ratio

- ☐ The conformity of in-service vehicles or engines of an engine family shall be demonstrated by testing vehicles on the road operated over their normal driving patterns, conditions and payloads.
- ☐ The in-service conformity test shall be representative for vehicles operated on their real driving routes

IUPR- In Use performance ratio

- ☐ Ratio that checks the performance of Diagnostic (OBD related- as grouped by PD under IUPR) monitors of vehicle in-use.
- ☐ IUPR to check how often the diagnosis runs under practical driving conditions (Not only in defined duty cycle also for normal vehicle operation)



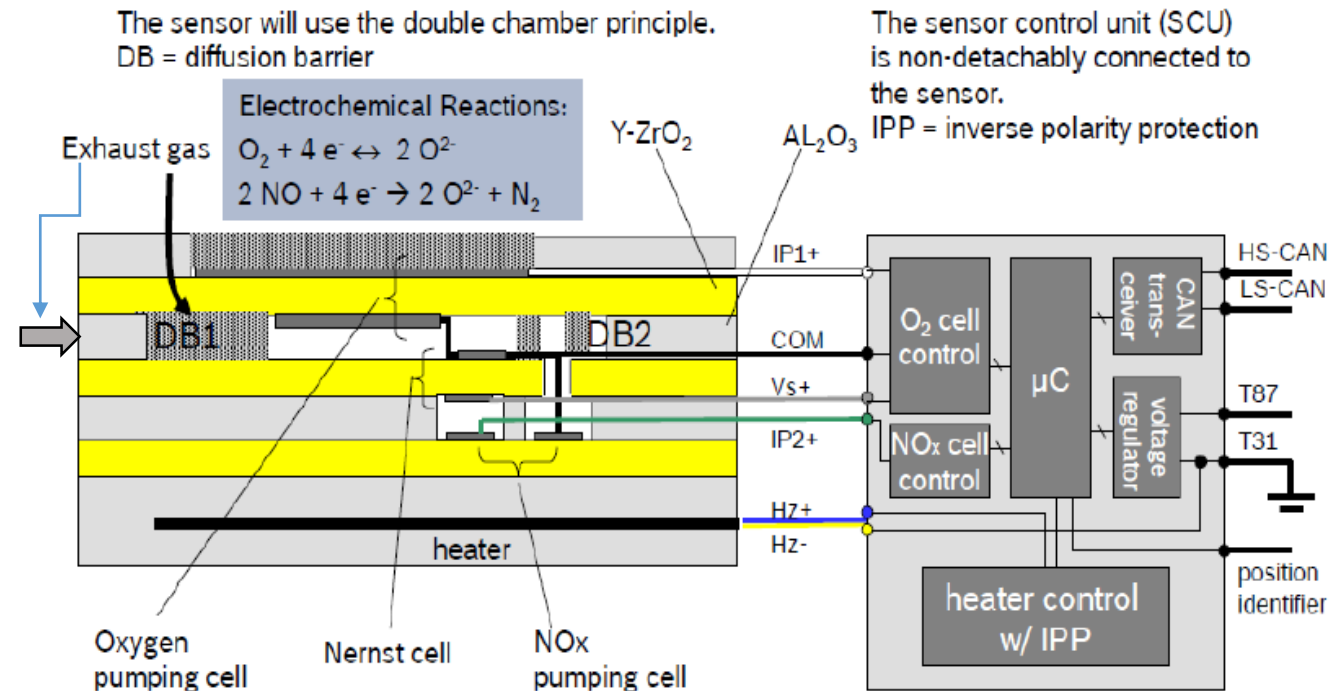


Thank You



Nox sensor- Working principle

- When exhaust gases flow into the first chamber, the first cell electrochemically pumps O₂ out of the sample. So that it does not interfere with the NO_x measurement.
- This cell electrochemically reduces the O₂ and removes it by pumping O⁼ ions out. This occurs by applying a bias voltage (mV), negative bias is necessary to supply the O₂ with electrons so that they reduce to form ions.
- The current is proportional to O₂ concentration and is diffusion-limited.
- Remaining gases diffuse into an adjacent chamber, where a reduction catalyst causes the NO to decompose into N₂ and O₂.
- A bias of voltage (mV) applied to the electrode of the sensing cell causes the O₂ to dissociate, and then get removed electrochemical pumping.
- This diffusion limited current is proportional to the amount of oxygen that arrives at the electrode from the dissociated NO_x.
- An additional electrochemical cell, a Nernstian lambda gauge (potentiometric oxygen sensor), may also be present to assist the control of the NO sensing cell.

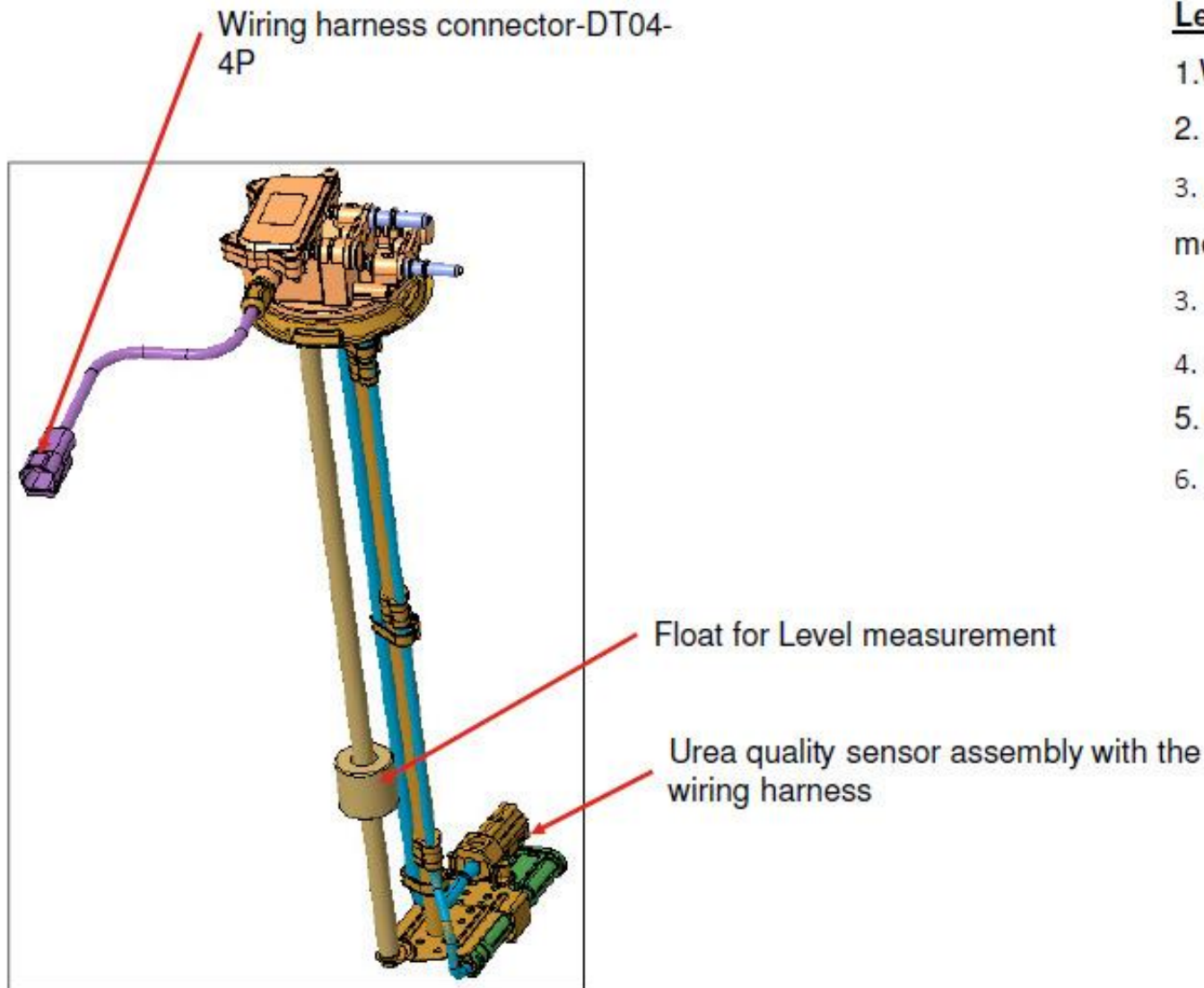




Dew point calibration

- NOx sensor required to reach working temperature of $800 \pm 20^{\circ}\text{C}$ by internally built in heater in minimum possible time . The sensor is made out of ceramic material which has been well protected by metallic sensor housing.
- Although the ceramic sensor elements are protected by a metallic sensor housing consisting of protection tubes with bores for gas inflow, the sensor elements are prone to be damaged by condensed water or water droplets (water splash) during engine cold start. Condensation occurs in the exhaust tube wall, in the sensor housing, and on the sensor element itself. If condensed water come in contact with the heated ceramic sensor element it resulting in thermal stress & may lead to sensor failures.
- In order to protect the sensor from damage by moisture, NOx sensor should come in action when there is no moisture content in the exhaust gas .
- This has been ensured by measuring the exhaust gas temperature at DOC inlet which is 200°C for NOx-In sensor to start working and 200°C at SCR inlet temp for NOx-Out sensor for start functioning.

DEF Level sensor- Working principle



Level Sensor :

1. Working Principle → Float Type
2. Location - → placed above the quality sensor.
3. capability → Shall sense 0%, 10% & 100% level (Continuous monitoring)
3. Sensor tolerance → $\pm 5\text{mm}$
4. Operating temp range → $(-10^{\circ}\text{C}$ to 70°C
5. Operating temp range-External air → $(-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$
6. Response time → 60 seconds

Temperature Sensor

1. Working Principle → NTC
2. Location - → placed above the quality sensor.
3. Accuracy → $\pm 1^{\circ}\text{C}$
3. Sensor tolerance → $(\pm) 1\%$
4. Operating temp range → $(-10^{\circ}\text{C}$ to 70°C
5. Operating temp range-External air → $(-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$
6. Response time → 60 seconds