Understanding of Sub-23 nm Particle Emissions from PFI/DI SI engines fueled with gasoline, ethanol and blend

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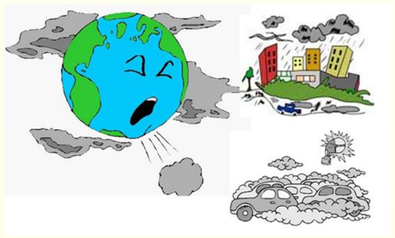
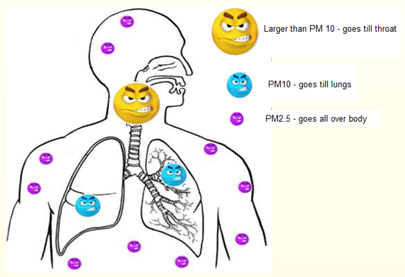
Environmental Issues

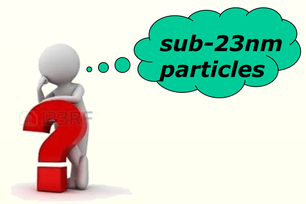


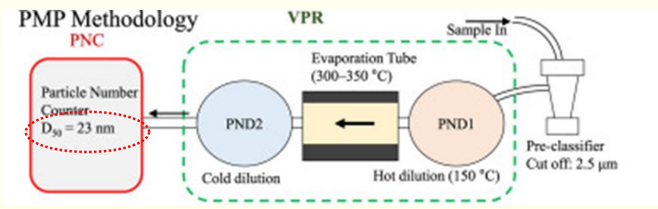
Human Health



Emission standard EURO6

Stage	Date	CO	HC	HC+NOx	NOx	PM	PN
		g/km					#/km
Positive Ignition (Gasoline)							
Euro 6	2014.09	1	0.1	-	0.06	0.005	6.0×10^{11}
Compression Ignition (Diesel)							
Euro 6	2014.09	0.5	-	0.17	0.08	0.005	6.0×10^{11}



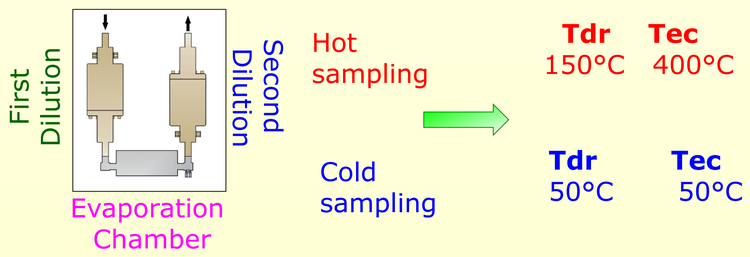


To properly define a measurement procedure for sub-23 nm particles emitted from internal combustion engines it has to be better understood their nature.

*Characterization of the nature of **sub-23 nm particles** emitted from **DI** and **PFI SI** engines by means the analysis of the effect of the temperature of sampling*

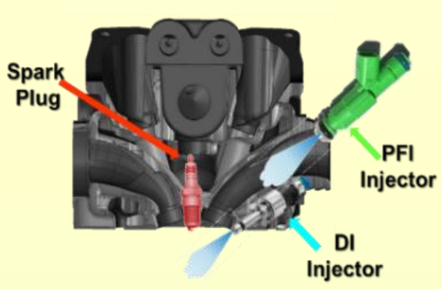
Temperature of dilution ***Temperature of evaporation chamber***

Methodology



$$\alpha VOF\ (\%) = (N_{10\text{-}23}(Cold) - N_{10\text{-}23}(Hot)) / N_{10\text{-}23}(Hot) * 100$$

Engines

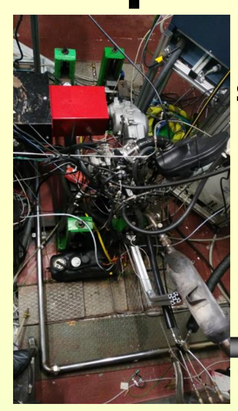


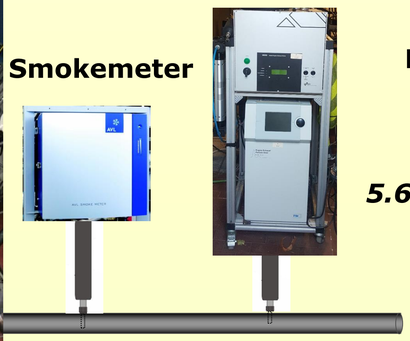
Engine type	4-stroke single cylinder	
Displacement [cm^3]	250	
Bore [mm]	72	
Stroke [mm]	60	
Compression ratio	10.5:1	
Maximum Torque [Nm]	20 Nm @ 5500 rpm	
Maximum Power [kW]	16 kW @ 8000 rpm	
Injector Type	**PFI** Commercial	**DI** Prototypal
Number of Nozzle Holes	3	6
P_{inj} [bar]	3	100

Fuels

Gasoline
Ethanol
E25

Experimental Layout

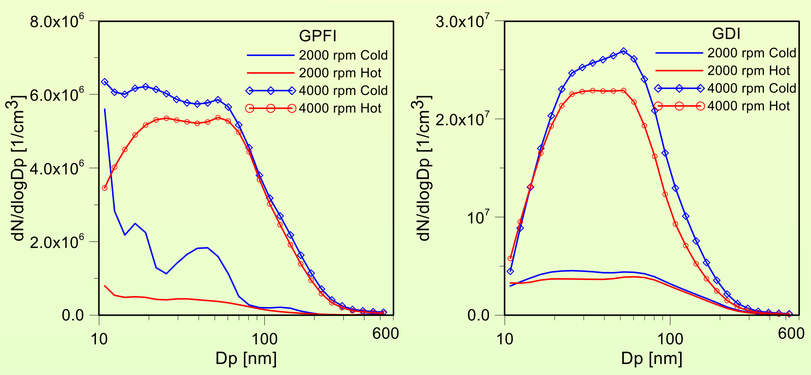




Sub-23 particles VOF Evaluation vs Fuels

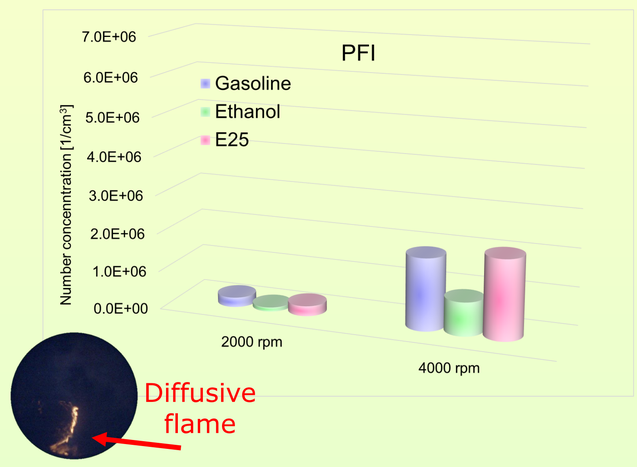
PDSF Hot-Cold Sampling

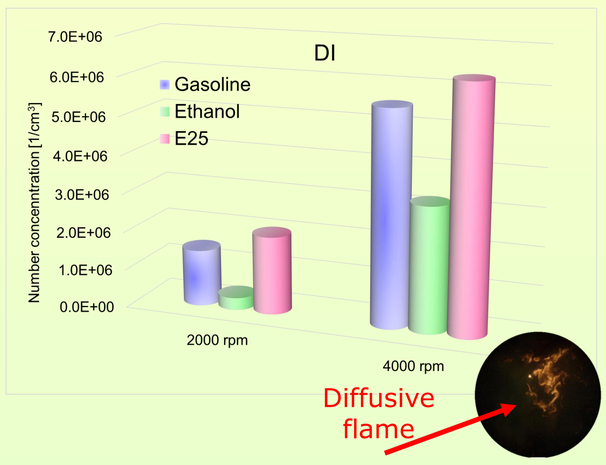
Gasoline



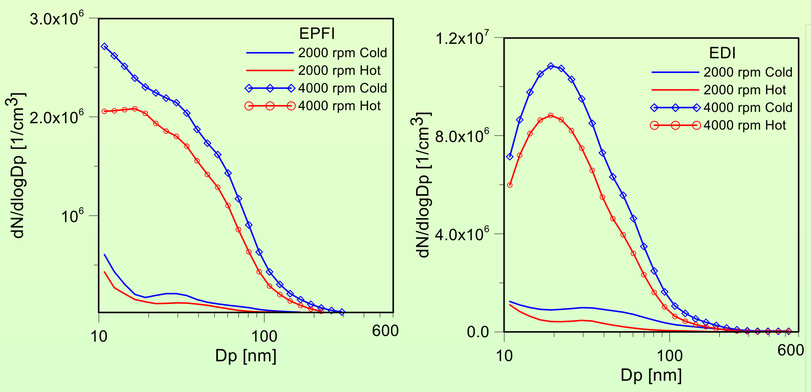
PM emissions at Raw Exhaust

Test case	2000 rpm		4000 rpm	
	Hot	Cold	Hot	Cold
GPFI	0.07	0.07	0.78	0.81
E25PFI	0.02	0.01	0.14	0.18
EPFI	0.03	0.04	0.35	0.30
GDI	1.52	1.52	3.42	3.27
E25DI	11.48	12.5	0.94	1.18
EDI	0.26	0.23	0.06	0.06

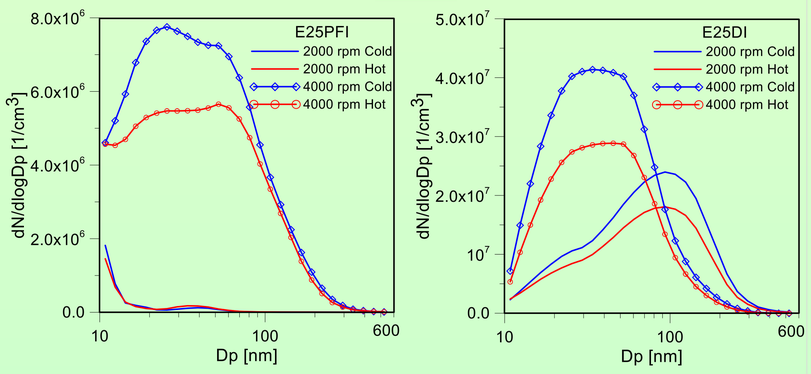




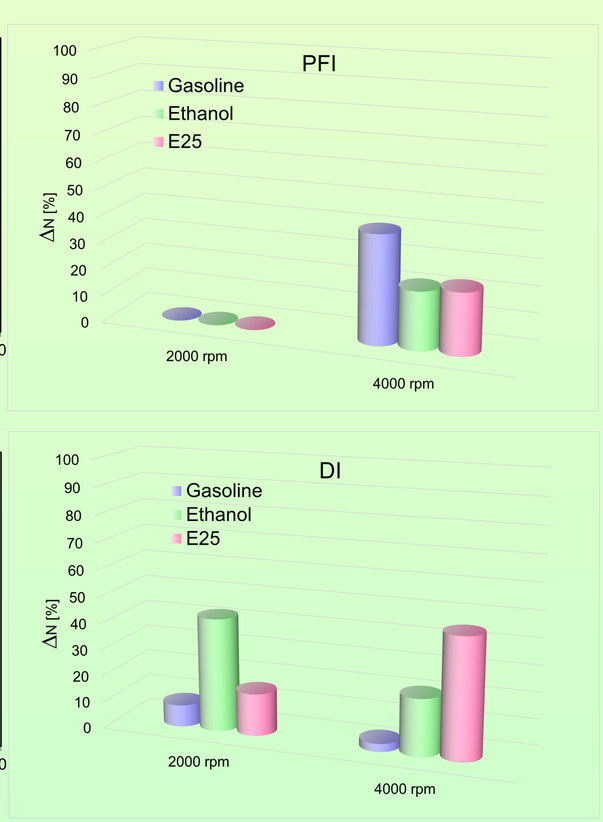
Ethanol



E25



VOF Evaluation



PFI vs DI

Sub-23 nm particle emission is larger for DI.

Ethanol

Easier evaporation: lower presence of liquid fuel and rich zone;
Lower aromatic content: reduced soot precursor formation;
Larger oxygen content: more complete combustion and oxidation.

E25

Addition of gasoline affects the evaporation of ethanol.

Sub-23 nm particles survive at T_{ec} 400°C and are mainly composed of ***VOF.***

Volatile Organic Fraction is strongly affected by:

- Engine configuration;
- Engine operating condition;
- Fuels.

Sub-23 nm particles measure is strongly affected by sampling condition:
VOF condensation/nucleation enhanced at low temperature.