Particulate and Gaseous Emissions Measurements From a PFI-SI Engine with Oxygenate Fuel Blends

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Outline

- Background and Objectives

- Experimental facilities and instruments used.

- Test Matrix

- Results: PM and HC Emissions variation with fuel composition a different values of AFR, load, ignition.

- Summary & Conclusions.

Introduction

Looking into the effect of oxygenated fuels on PM and gaseous emissions.

Hypothesis

Blending Oxygenates with ULG significantly changes the fuels properties. This might affect emissions.

Fuel Blends

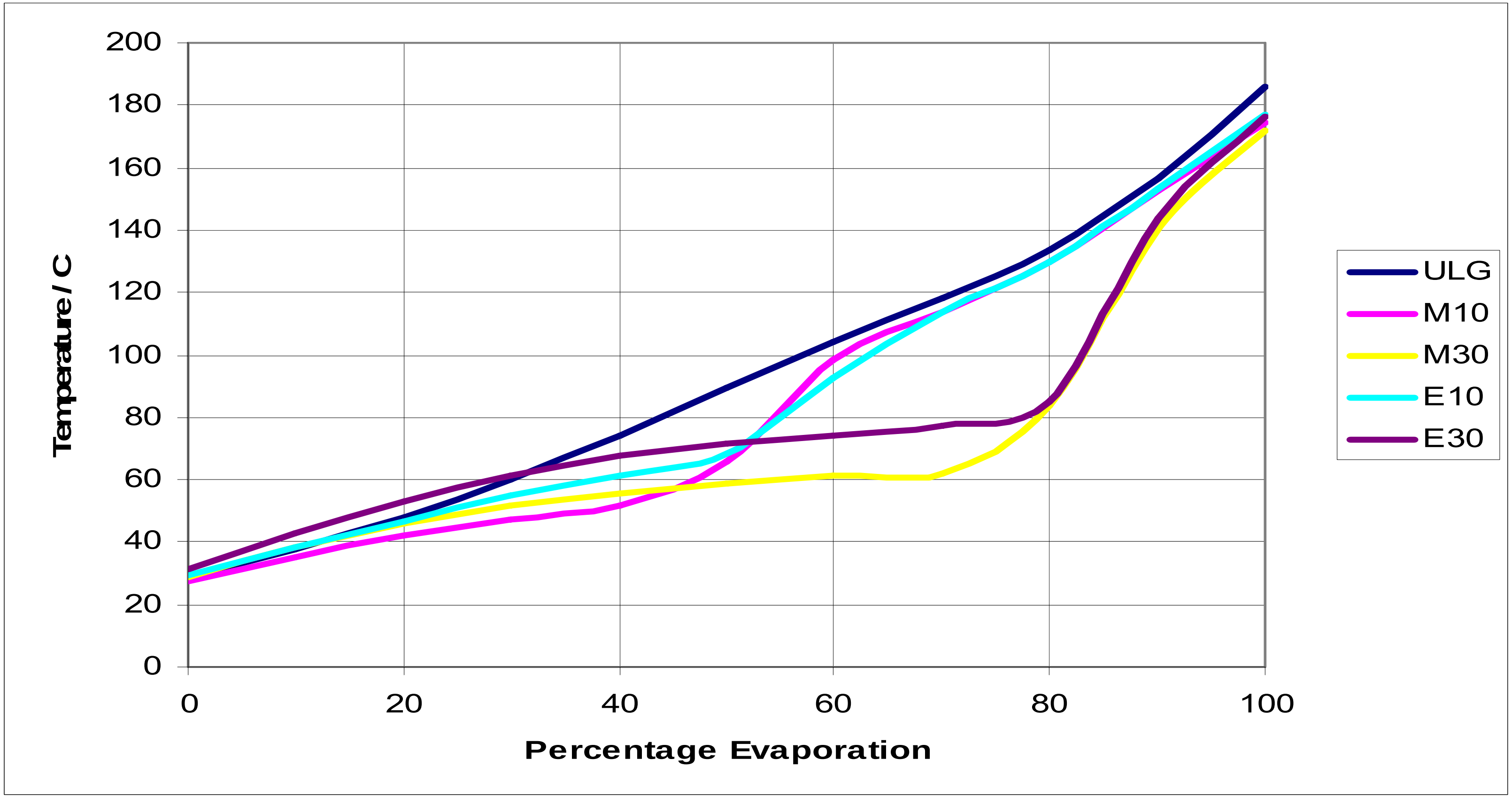
- ULG, M10, M30, E10, E30

Background – Oxygenated fuel blends

	h_{fg} kJ/kg	CV MJ/kg fuel	Boiling point °C	RON	C/H	Adiabatic Flame Temperature °C
ULG	310	42	25 – 175	95	1.8	c2315
Methanol	1170	20	65	106	4	2243
Ethanol	850	26.9	78.5	107	3	2258

Shell Distillation Curves

- Adding oxygenates increases the percentage evaporation of the fuel blend
- 30% fuel blends significantly increase the percentage evaporation
- Due to decrease in enthalpy of vaporisation and an increase in the enthalpy of mixing

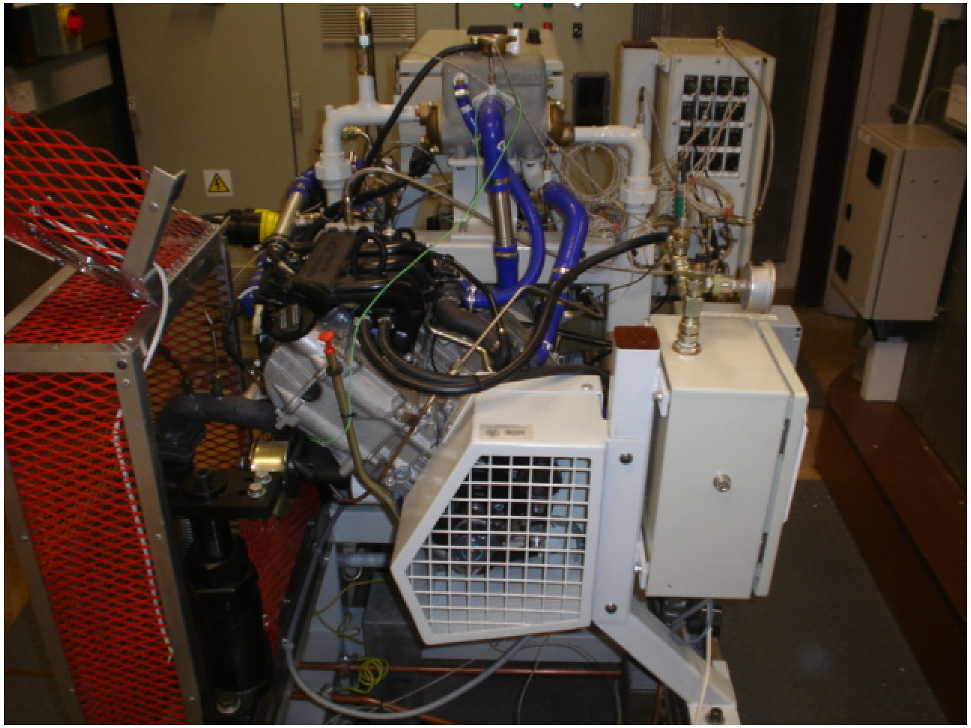


- Calculated by Dr Harold Walmsley at Royal Dutch Shell using activity coefficient method

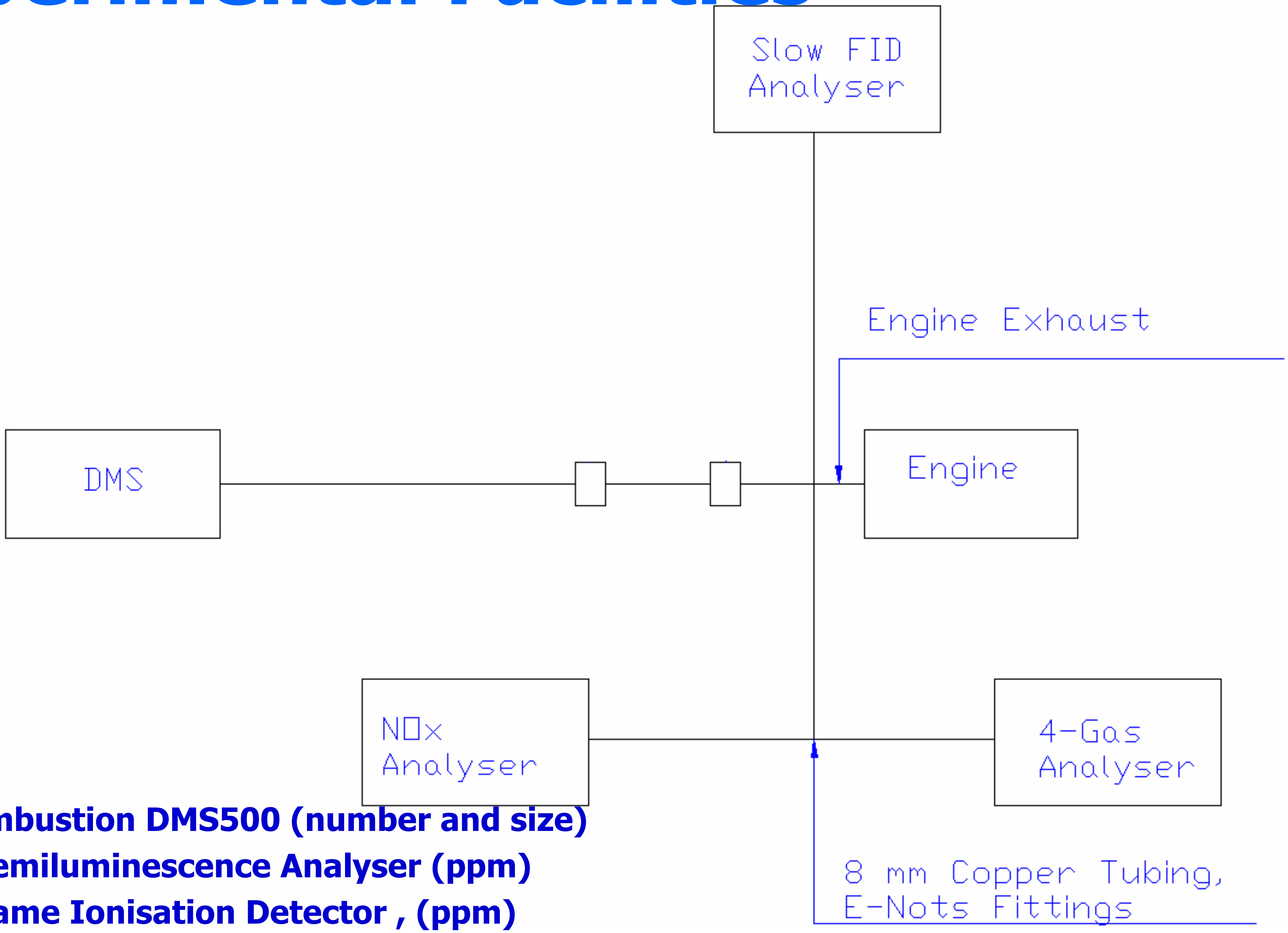
Experimental Facilities

PFI Spark Ignition in line 3 cylinder turbocharged Engine

- Bore x Stroke: 66.5mm * 67mm
- Compression Ratio: 9:1
- Swept Volume: 698 cm^3



Experimental Facilities



PM – Cambustion DMS500 (number and size)

NO_x - Chemiluminescence Analyser (ppm)

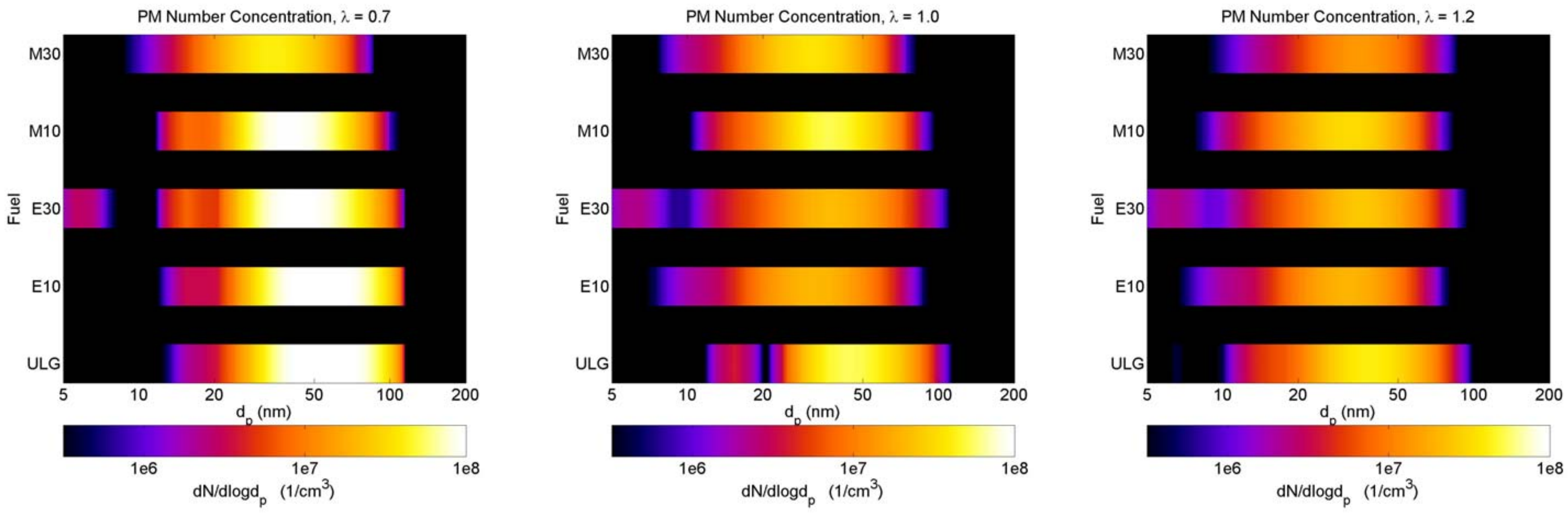
UHC – Flame Ionisation Detector , (ppm)

CO, CO_2 and UHC – NDIR Gas Analyser; O_2 – Chemical Cell

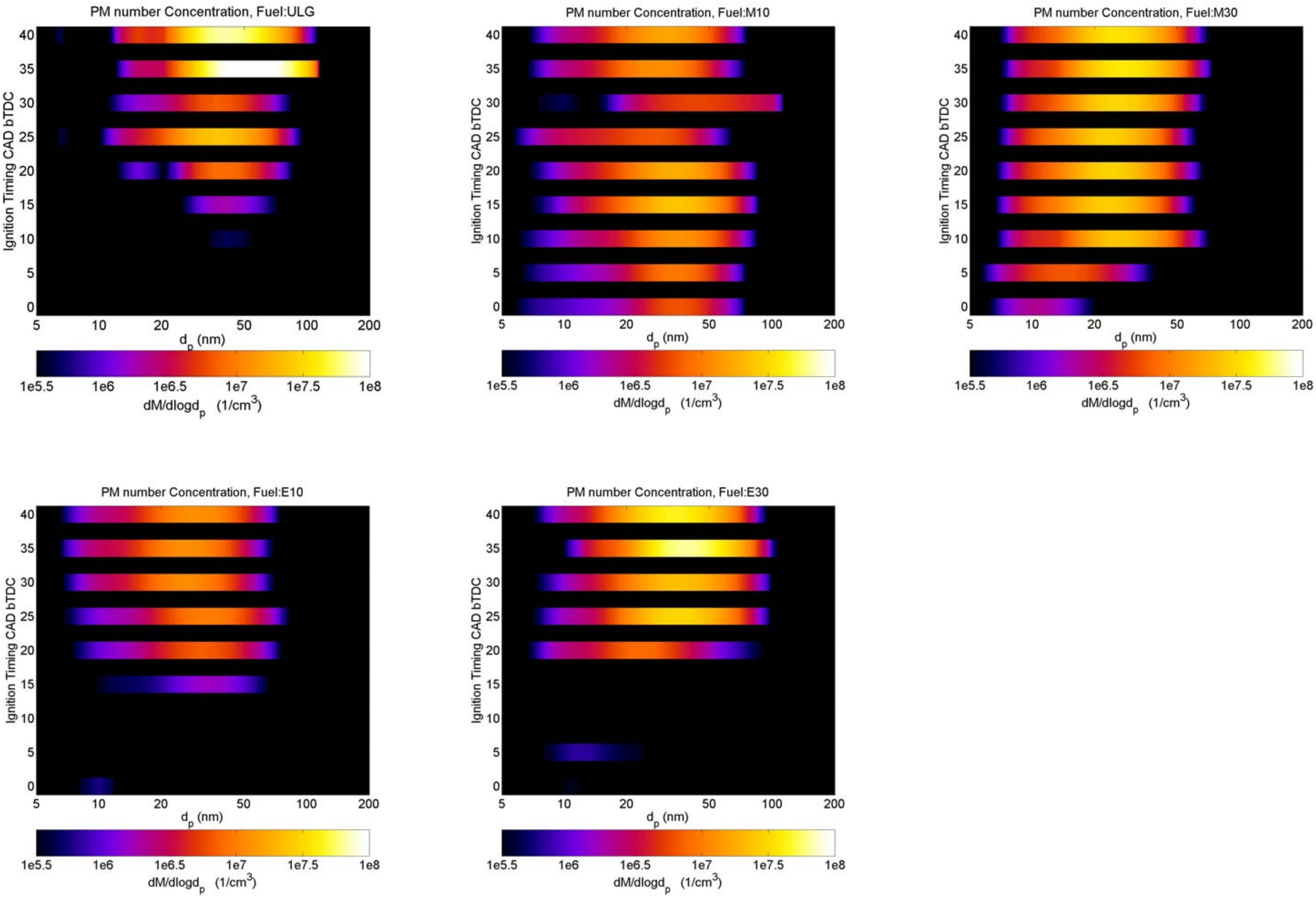
Test Matrix (All at 2000 rpm)

		ULG	M10	M30	E10	E30
AFR Sweep	λ 0.7					
	.	8.6% Throttle, 20 CAD bTDC				
	.					
	.					
	λ 1.2					
Ignition Timing Sweep (CAD bTDC)	0					
	.	8.6% Throttle, λ = 1				
	.					
	.					
	40					
Load (MAP) Sweep (mbar)	400					
	.	λ = 1, MBT				
	.					
	.					
	1230					

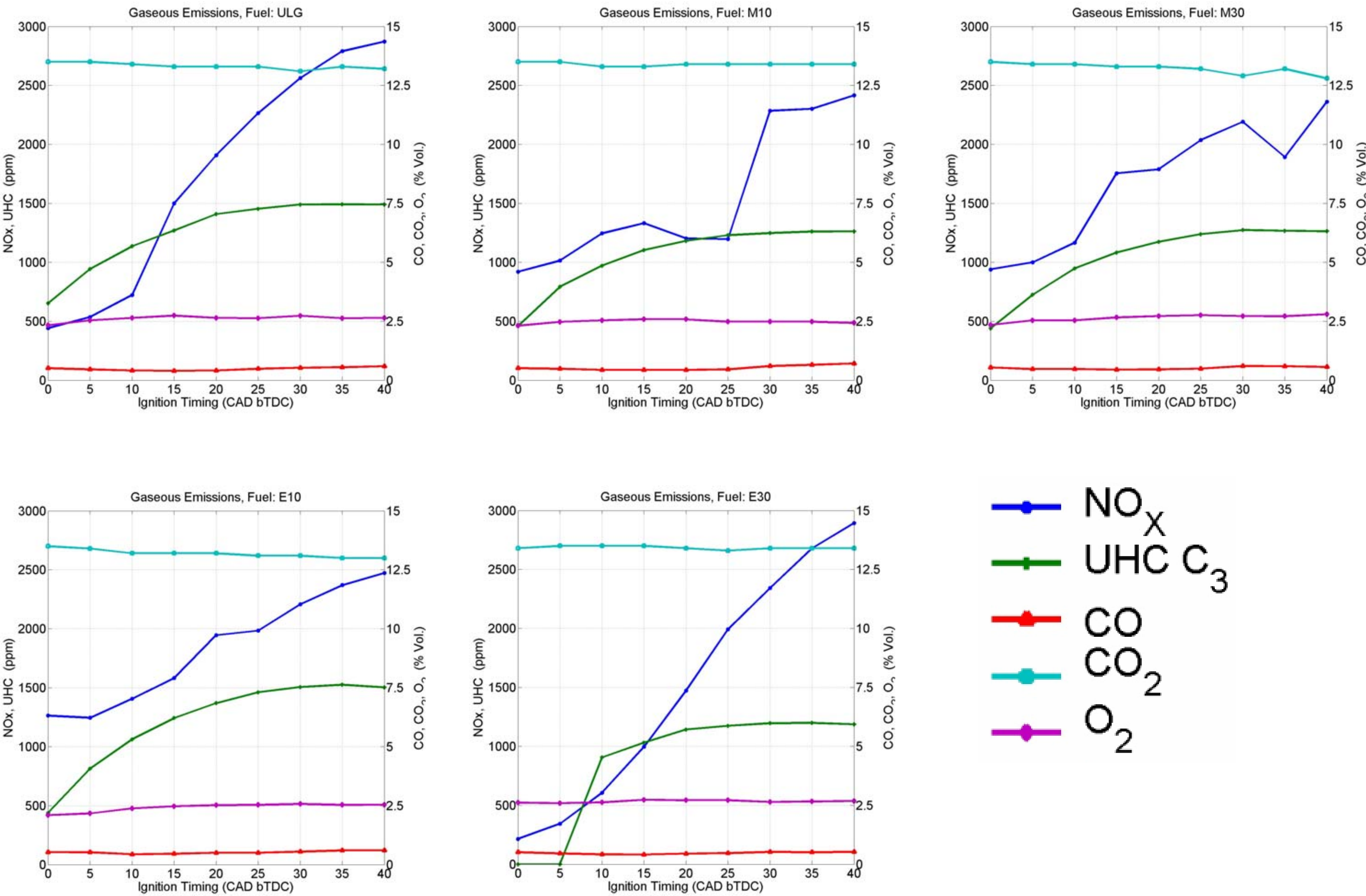
PM Results – AFR, MBT, c400 mbar



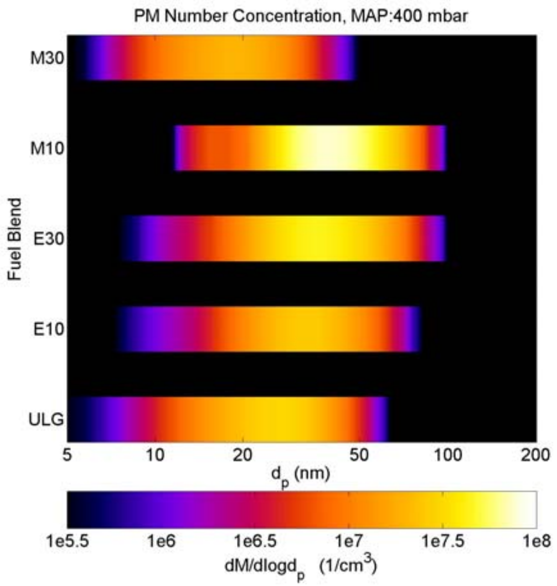
PM Results – Ignition Timing, λ = 1, c400 mbar

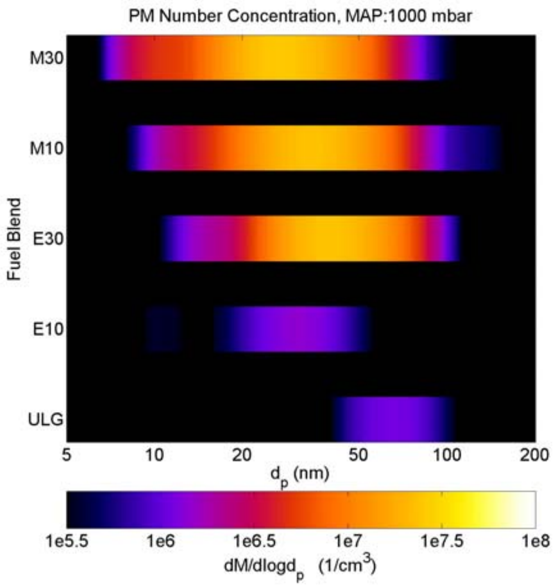


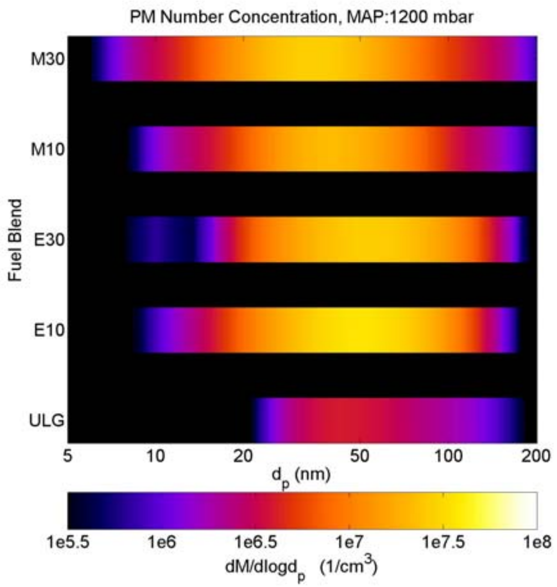
Gaseous Results - Load



PM Results – Load, λ = 1, MBT







- **UHC Decrease with oxygenated fuel blends, shown at 400, 1000, 1200 mbar.**
- **At Low Load, NO_x increases with oxygenated fuel blends.**
- **At High Load, NOx, decreases with oxygenated fuel blends.**

Conclusions - General

- AFR Sweep : Changing λ from rich to lean leads to a decrease in both the number concentration and d_p.
- Ignition Timing Sweep: Advancing θ increases the number concentration and the NO_x this is due to an increase in the adiabatic flame temperature. UHC Increase due to a lower post flame temperature and hence less post flame oxidation
- Load Sweep: High Methanol blends beneficial at low loads. High loads oxygenated blends increase the geometric standard deviation.

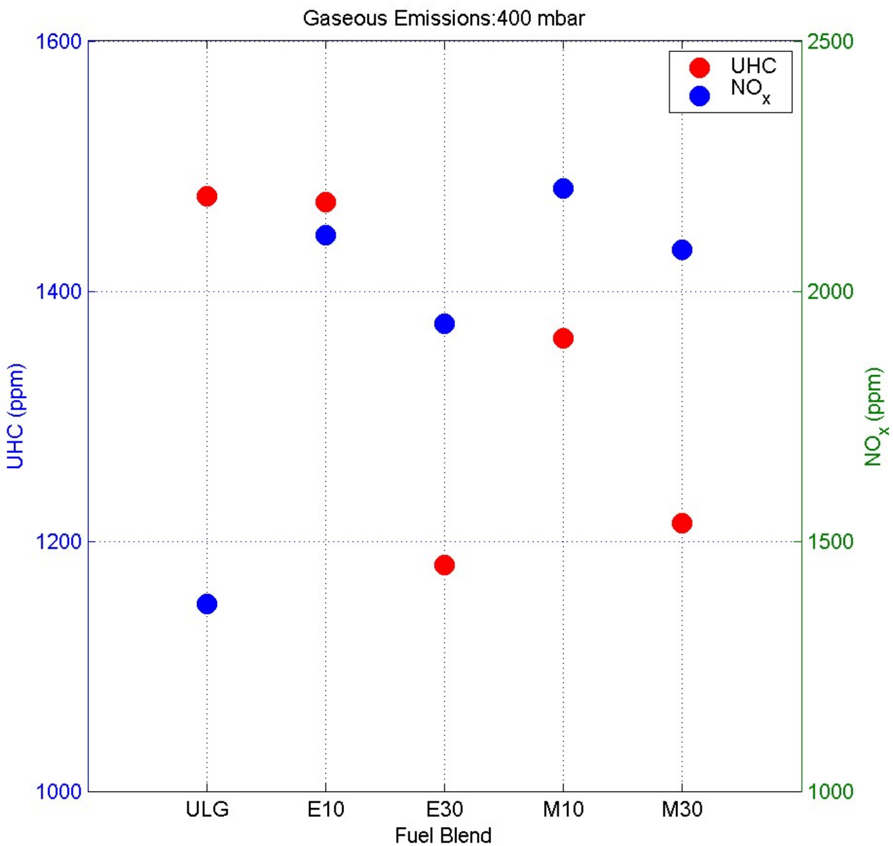
Conclusions – Effects of Oxygenates

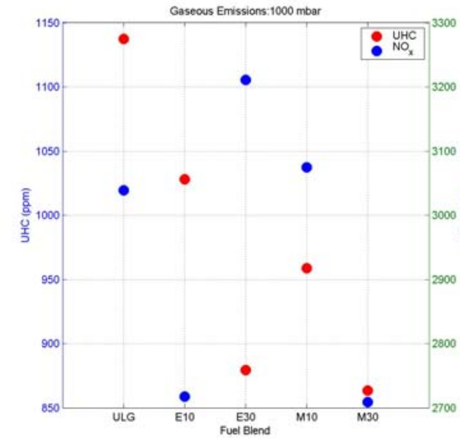
- Decrease in NO_x due to lower adiabatic flame temperature of alcohols
- Increase in UHC in comparison to ULG due to less post flame oxidation
- At MBT and retarded ignition timing methanol increases the PM number concentration and diameter. Ethanol is less sensitive
- Operating at rich conditions oxygenates lead to a reduction in PM and d_p

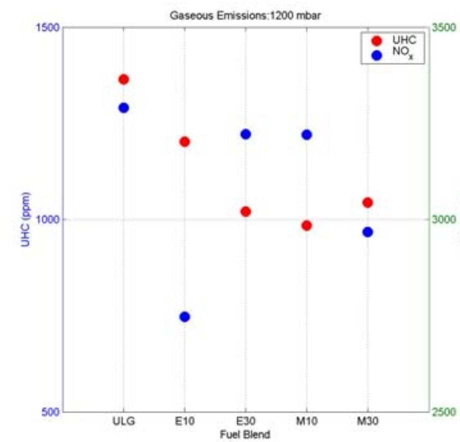
Questions ?

- Particle diameter d_p is reduced but the concentration is increased when using methanol blends,
- Methanol blends have increased particle number concentration when the ignition was advaded.
- When operating rich, oxygenated blends reduce both the number concentration and the mean diameter.
- When operating at lean both the particle diameter and the number concentration are lower than at rich

- High Methanol blends have beneficial effects at low load
- At high load methanol blends increase the geometric standard deviation
- Oxygenated blends decrease the concentration of NO_x, this is due to the lower adiabatic flame temperature.


Gaseous Emissions:400 mbar
UHC
NOx
1600
1400
1200
1000
2500
2000
1500
1000
UHC (ppm)
NOx (ppm)
ULG
E10
E30
M10
M30
Fuel Blend


Gaseous Emissions:1000 mbar
UHC
NOx
1150
1100
1050
1000
950
900
850
3300
3200
3100
3000
2900
2800
2700
UHC (ppm)
NOx (ppm)
ULG
E10
E30
M10
M30
Fuel Blend


Gaseous Emissions:1200 mbar
UHC
NOx
1500
1000
500
3500
3000
2500
UHC (ppm)
NOx (ppm)
ULG
E10
E30
M10
M30
Fuel Blend