

10th ETH Conference on Combustion Generated Nanoparticles
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CUTEC GmbH Clausthal-Zellerfeld



A Modern Diesel Engine Operated with Pure Rapeseed Oil; Effects on the Emissions

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outline



- **Motivation and scope of examination**
- **Technical equipment and fuel properties**
- **Results**
 - **Gaseous and particulate emissions**
 - **PAH sampling**
- **summary**

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- **Due to present oil prices and tax policy the use of rapeseed oil as a fuel is very interesting, e.g. for agriculture.**
 - **Can the engines fulfil existing emission limits with rapeseed oil?**
 - **What happens to the unlimited emissions?**

scope of the examination

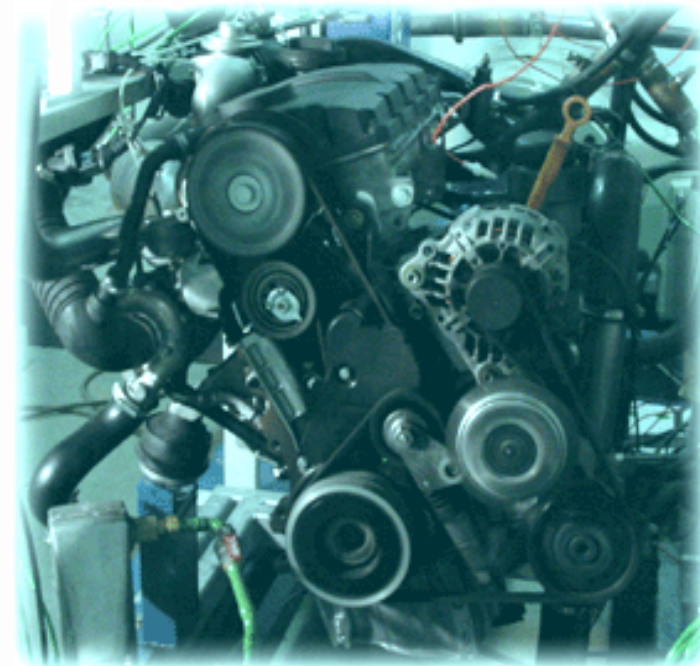
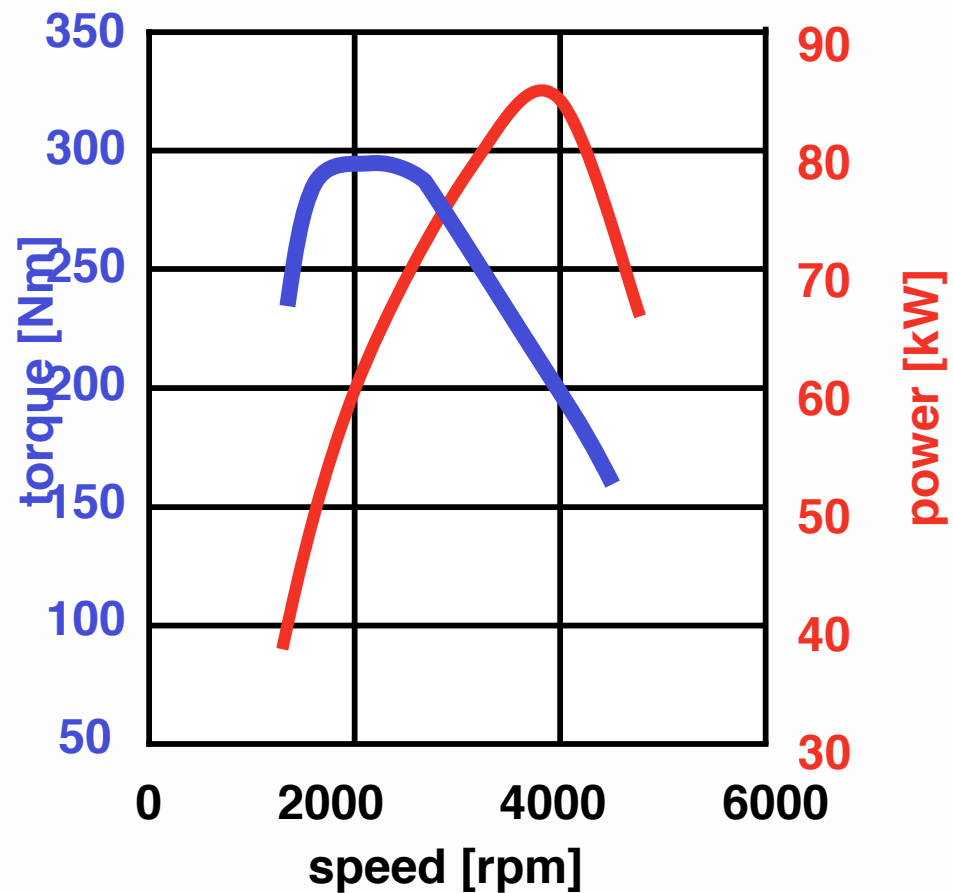
- The data were obtained as part of a preliminary examination of a pre-treatment system.
- The data indicate how a highly developed diesel engine reacts to a rather different fuel.
- It is not intended to show compliance with legal limits.



Technical equipment and fuel properties

Engine

VW TDI-PUI 4 cylinder 1.9 L, 85 kW, 285 Nm@1900 rpm



EURO 3 norm

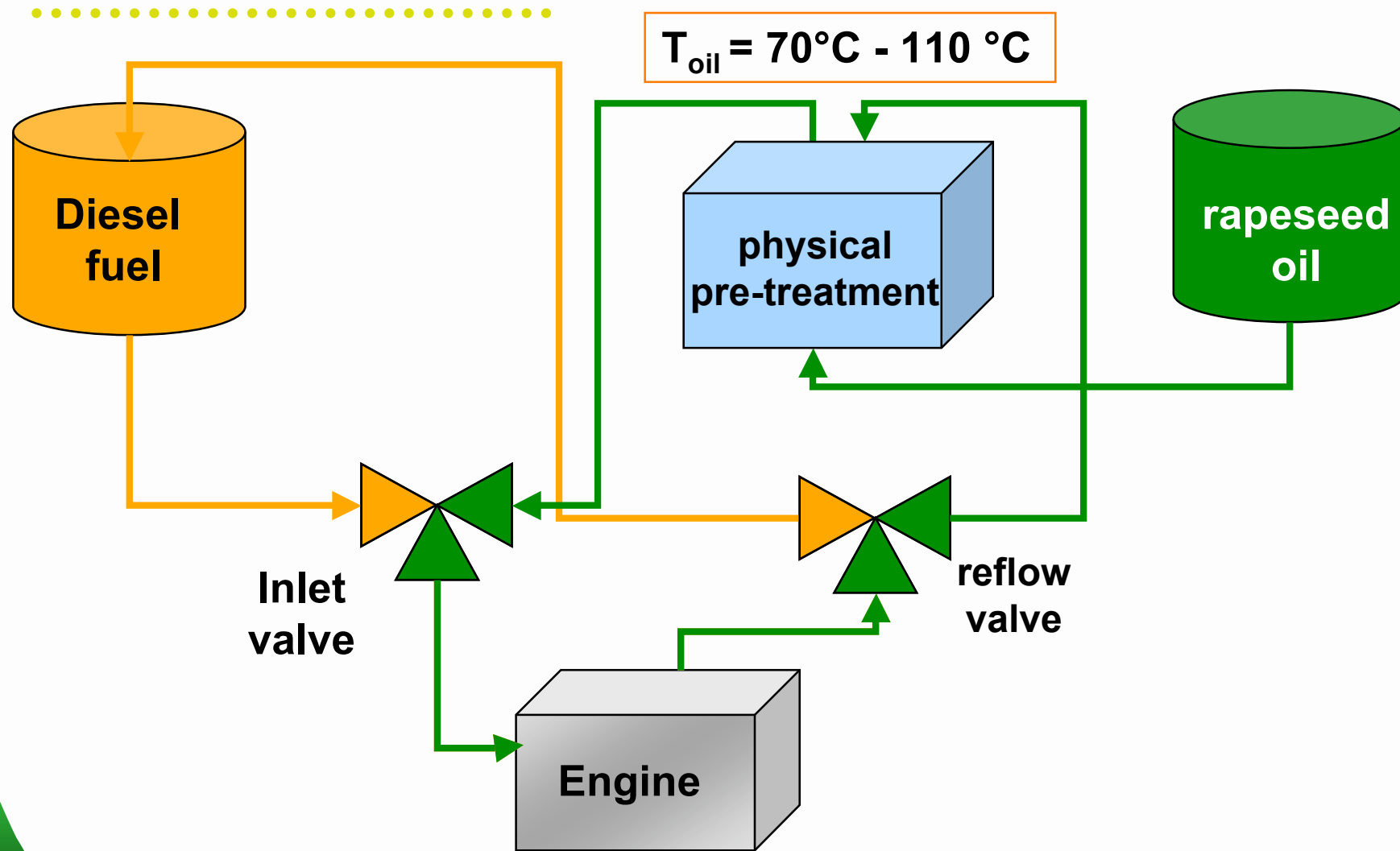
Physical properties of diesel fuel and pure rapeseed oil

parameter	diesel fuel (DIN EN 590)	rapeseed oil (*)
calorific value [MJ/kg]	46	39
Cetane number	51	39
Density (15°C) [kg/m ³]	0.83	0.92
Viscosity (40°C) [mm ² /s]	4	75

used rapeseed oil according to the Weihenstephan standard and DIN 5160, resp.

*source: Birkner, M, Diss. Kaiserslautern 1995

Scheme of the fuel switching





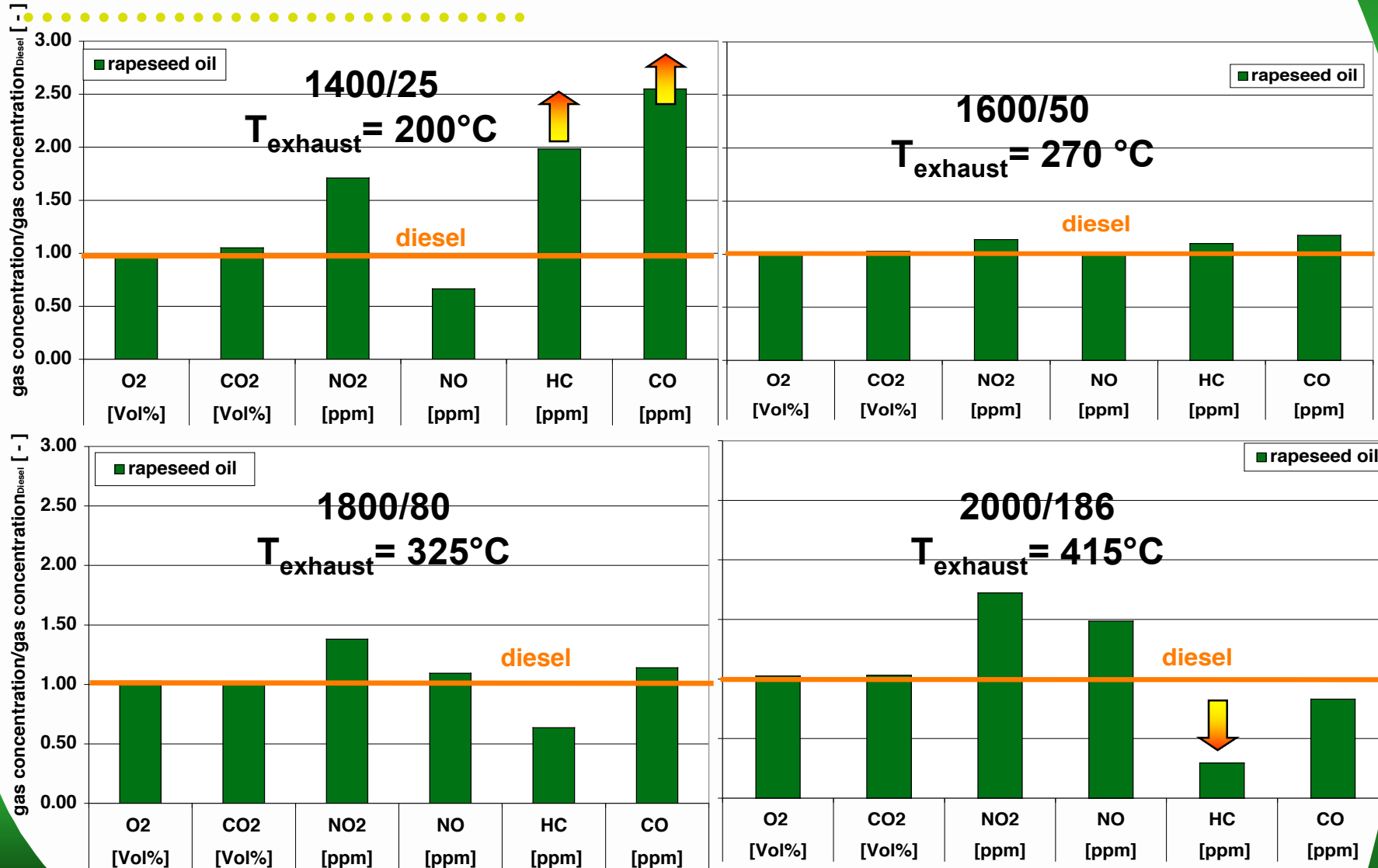
Gaseous and particulate emissions

Stationary engine settings and characteristic parameters

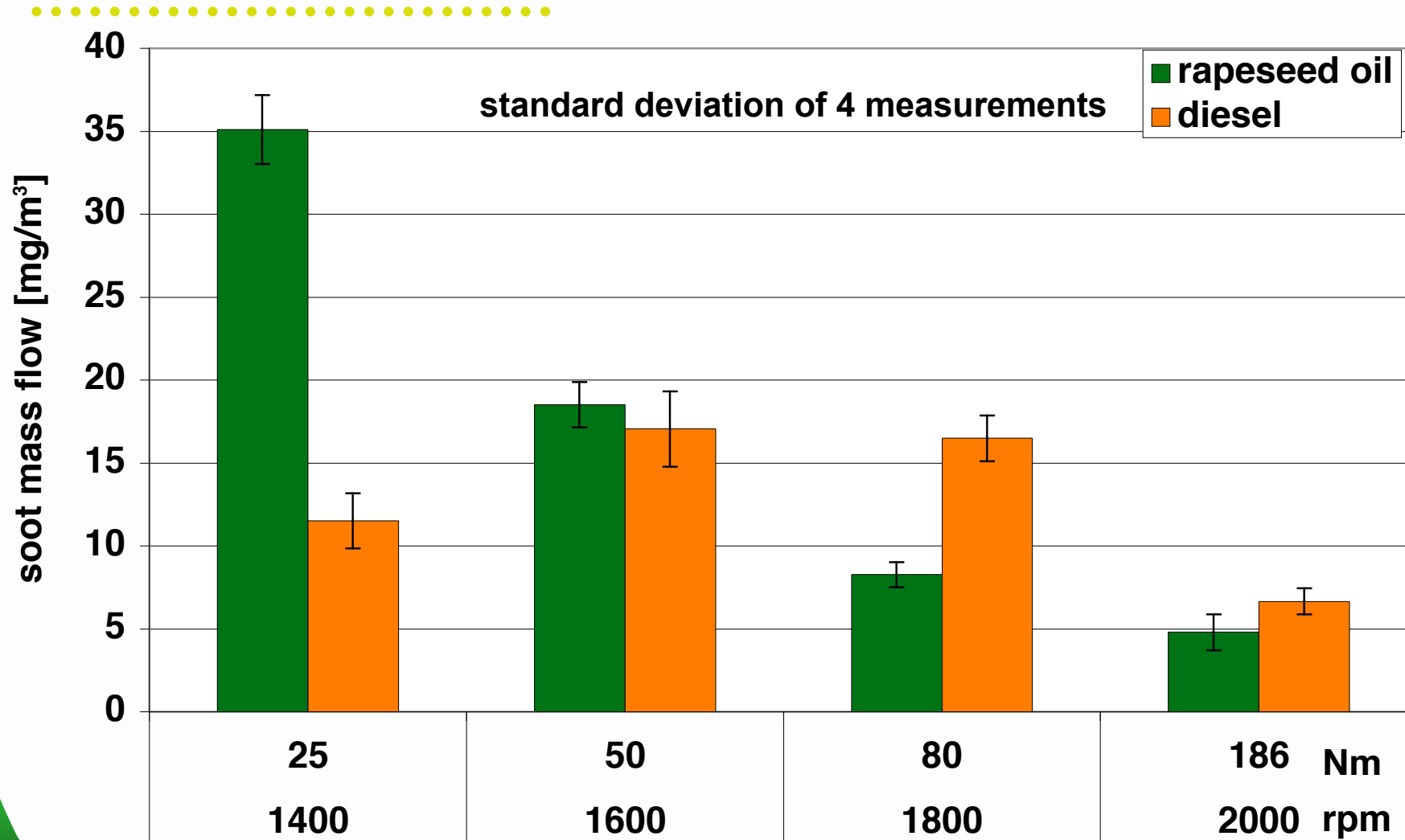
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speed	torque	power	BMEP	T_{diesel}
[rpm]	[Nm]	[kW]	[bar]	[°C]
1400	25	3.7	1.6	200
1600	50	8.4	3.2	270
1800	80	15	5	330
2000	186	39	12	420

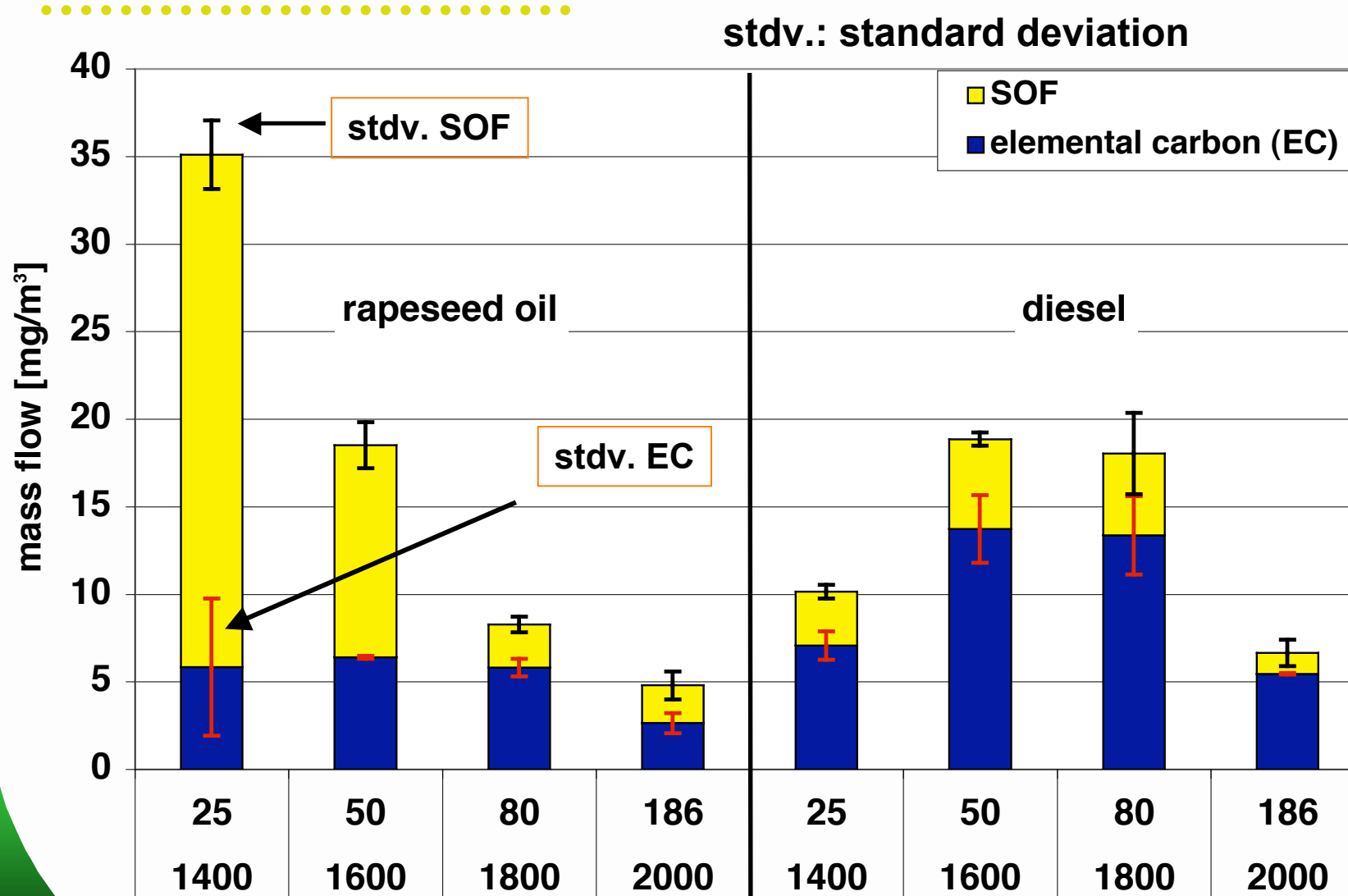
measured gas concentration with rapeseed oil: diesel as reference



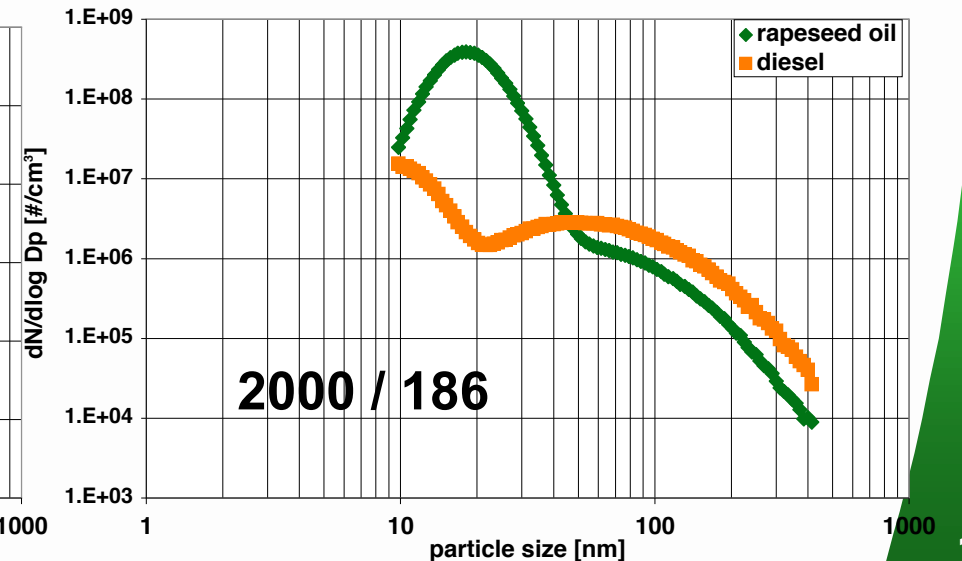
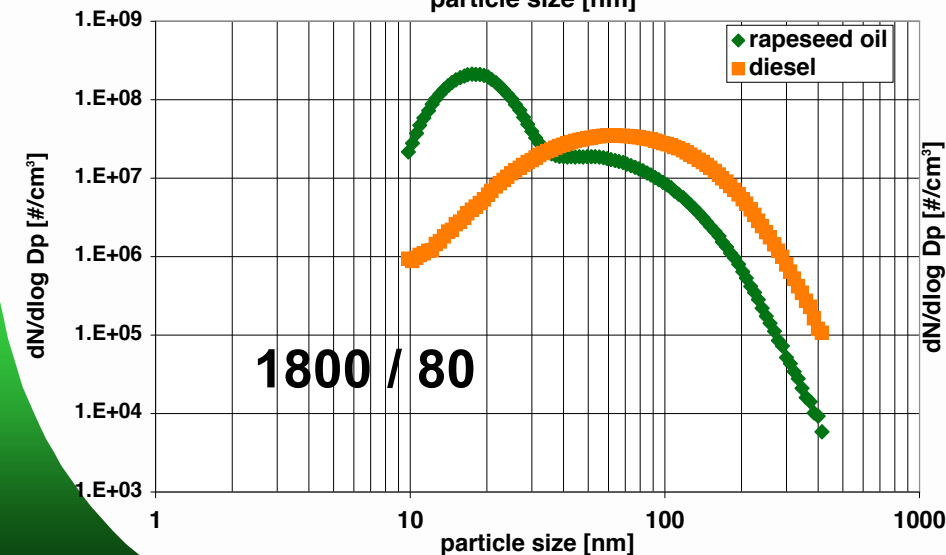
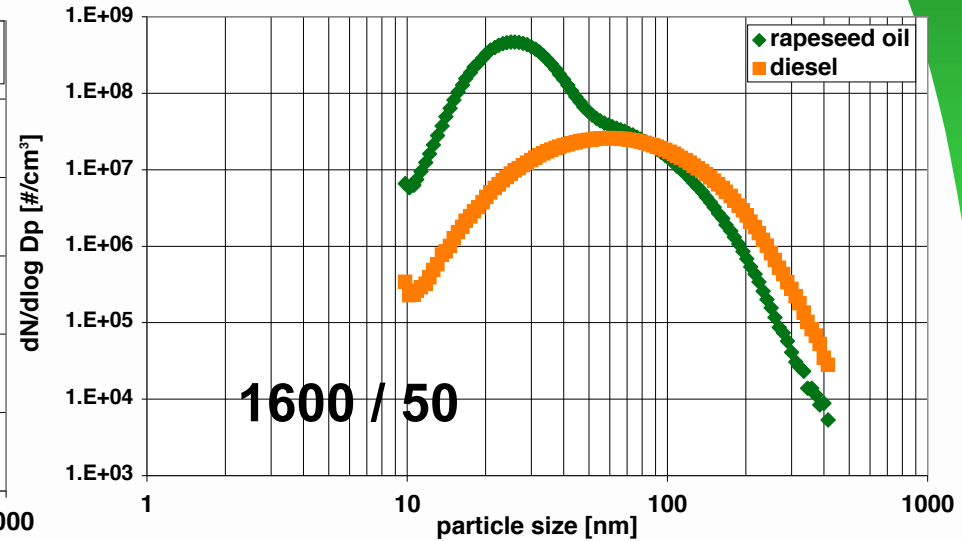
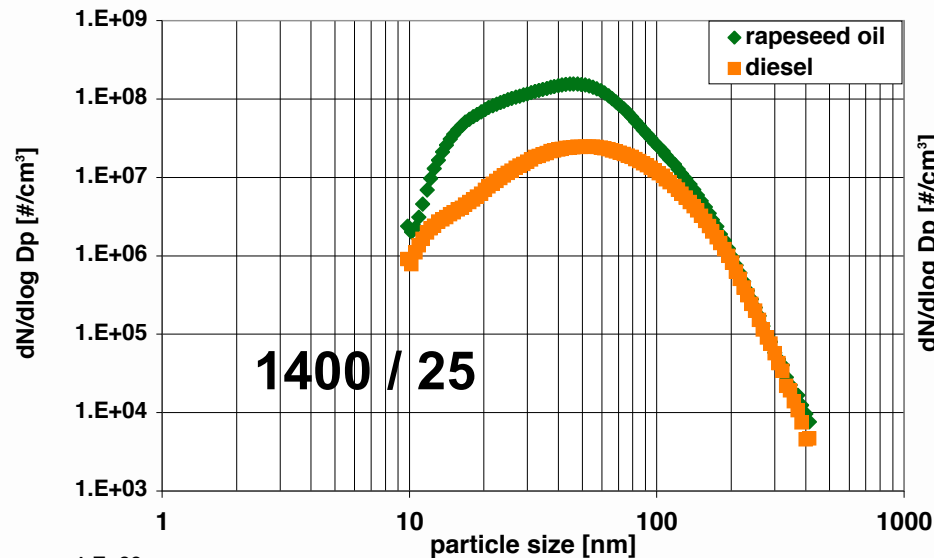
Total soot mass flow diesel and rapeseed oil



Carbon mass flow classified in SOF and EC



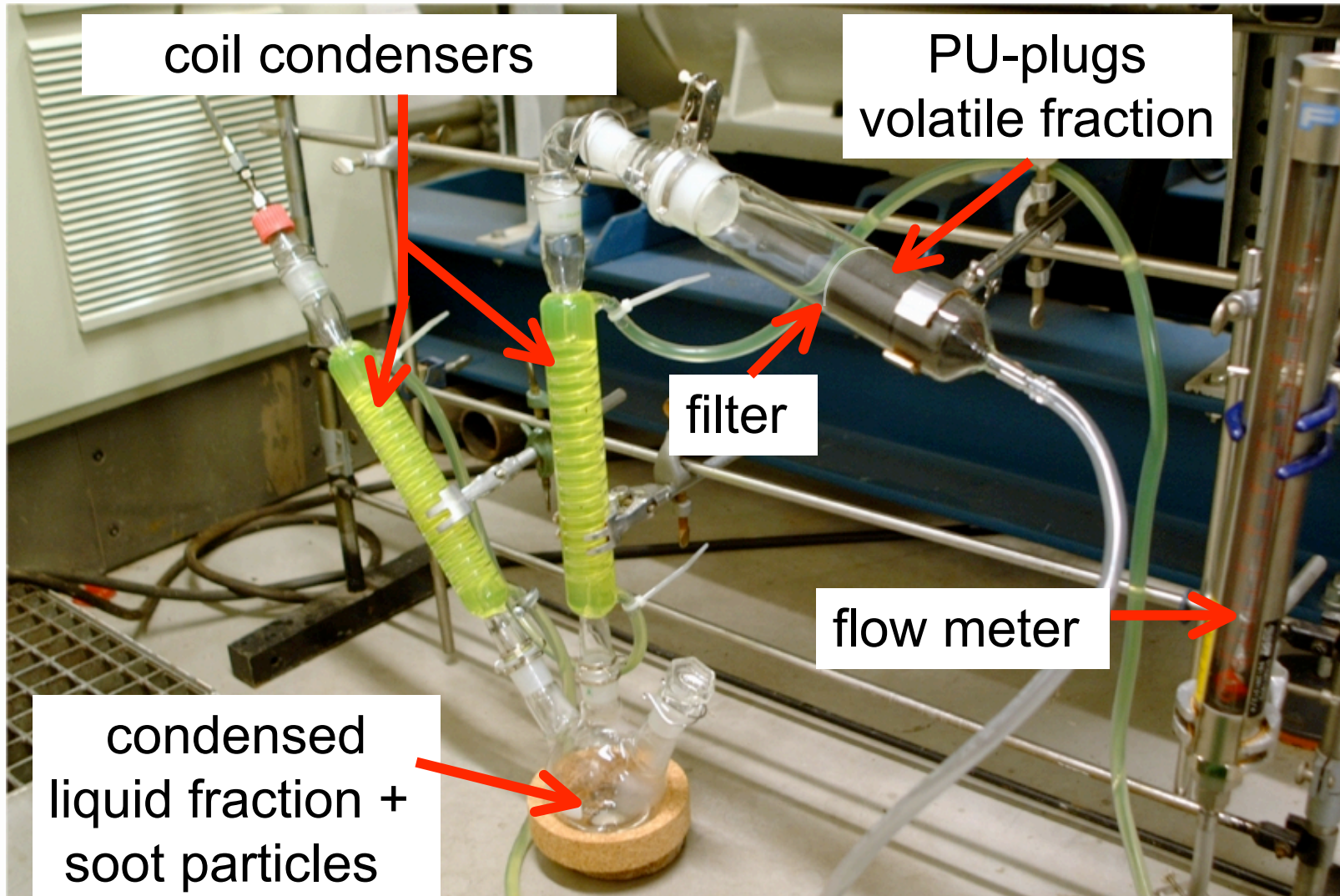
Particle number distribution for different fuels and engine operation points





PAH sampling and results

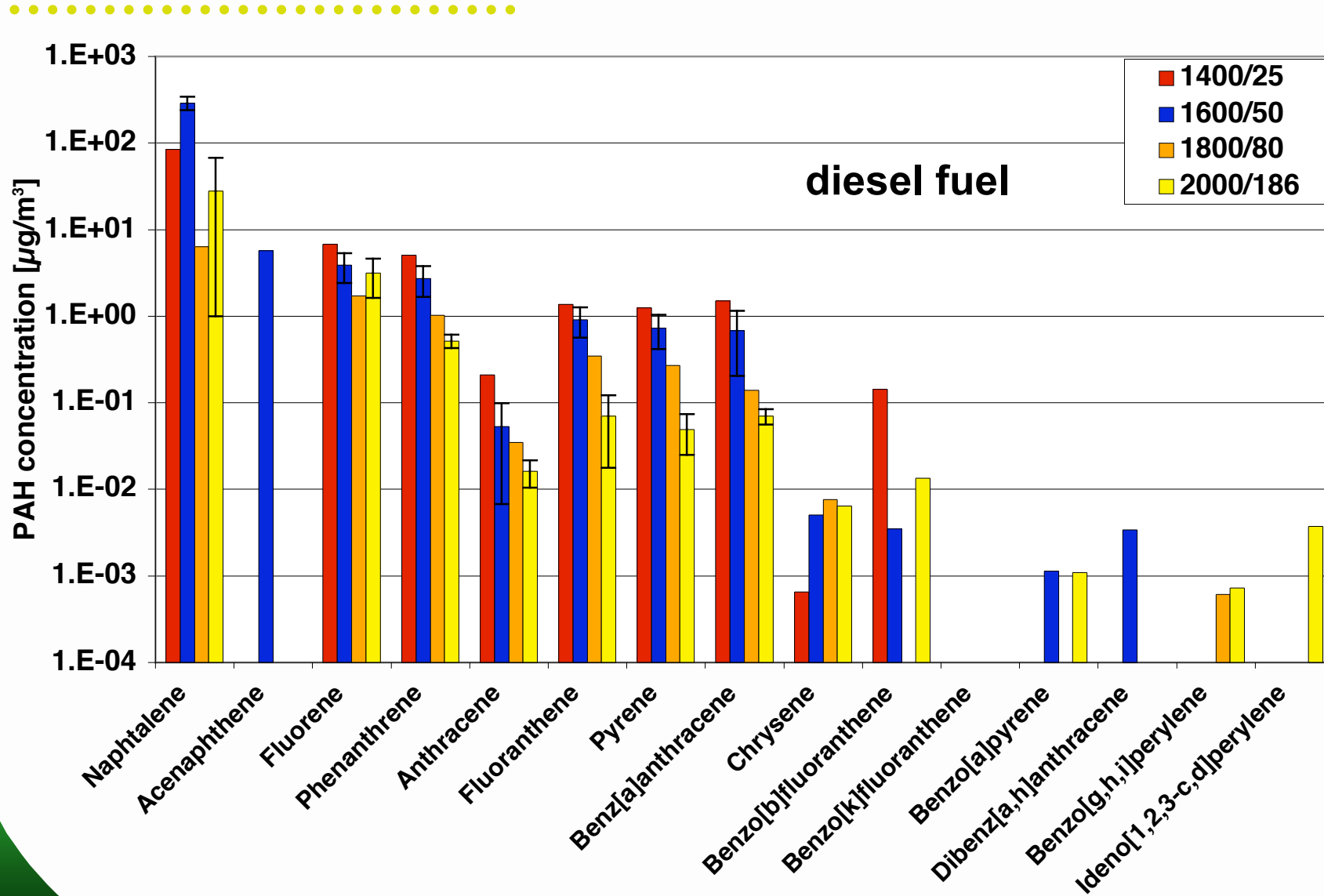
PAH sampling system



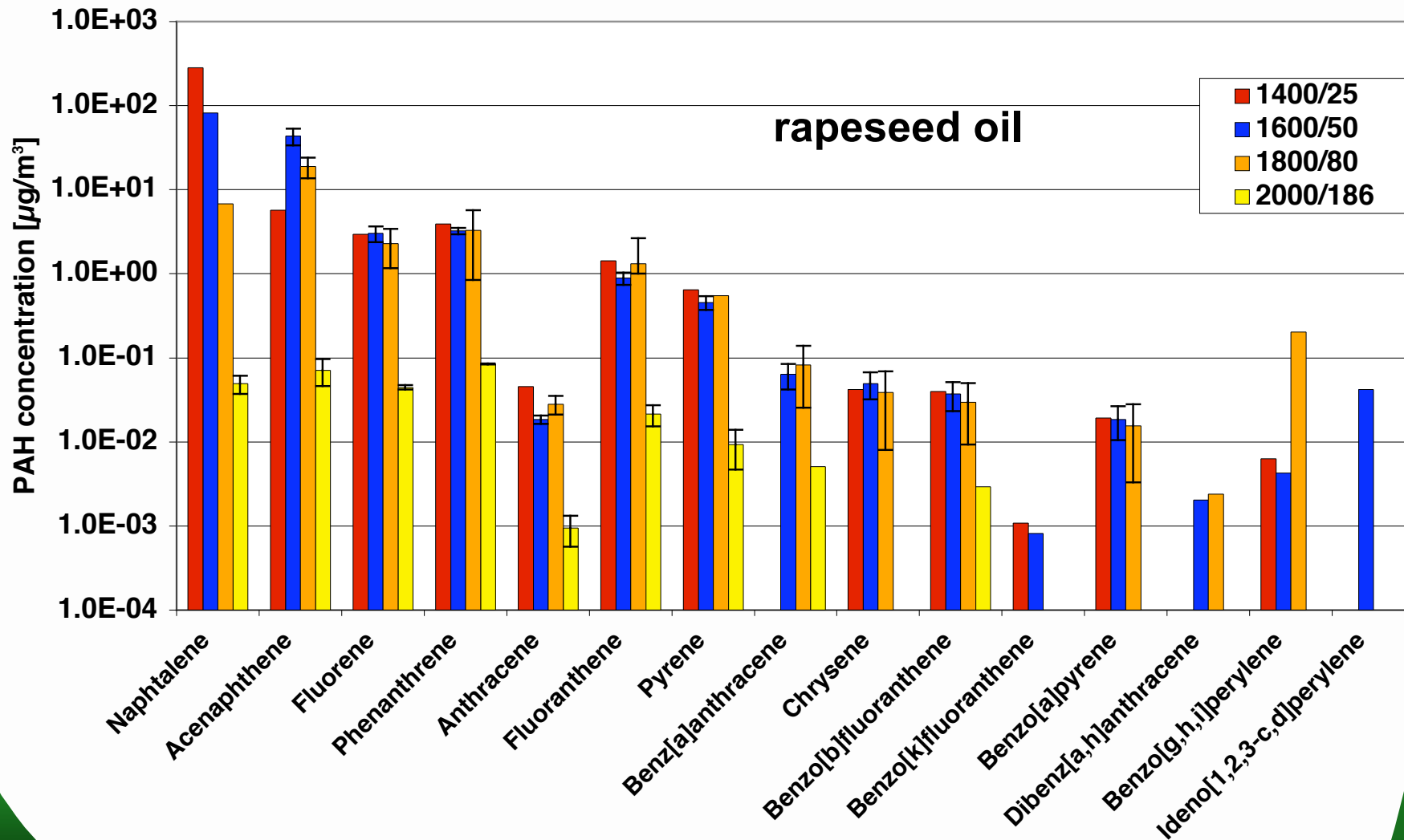
Procedure of PAH sampling and PAH analysing according to VDI Richtline 3872

- isokinetic sampling
- rinse the sampling system with Acetone
- evaporation of Acetone and change of solvent
- soxhlet extraction
- drying water residua with sodium sulphate
- filtration of the soot particles
- concentration and clean up of the samples
- measurement by HPLC

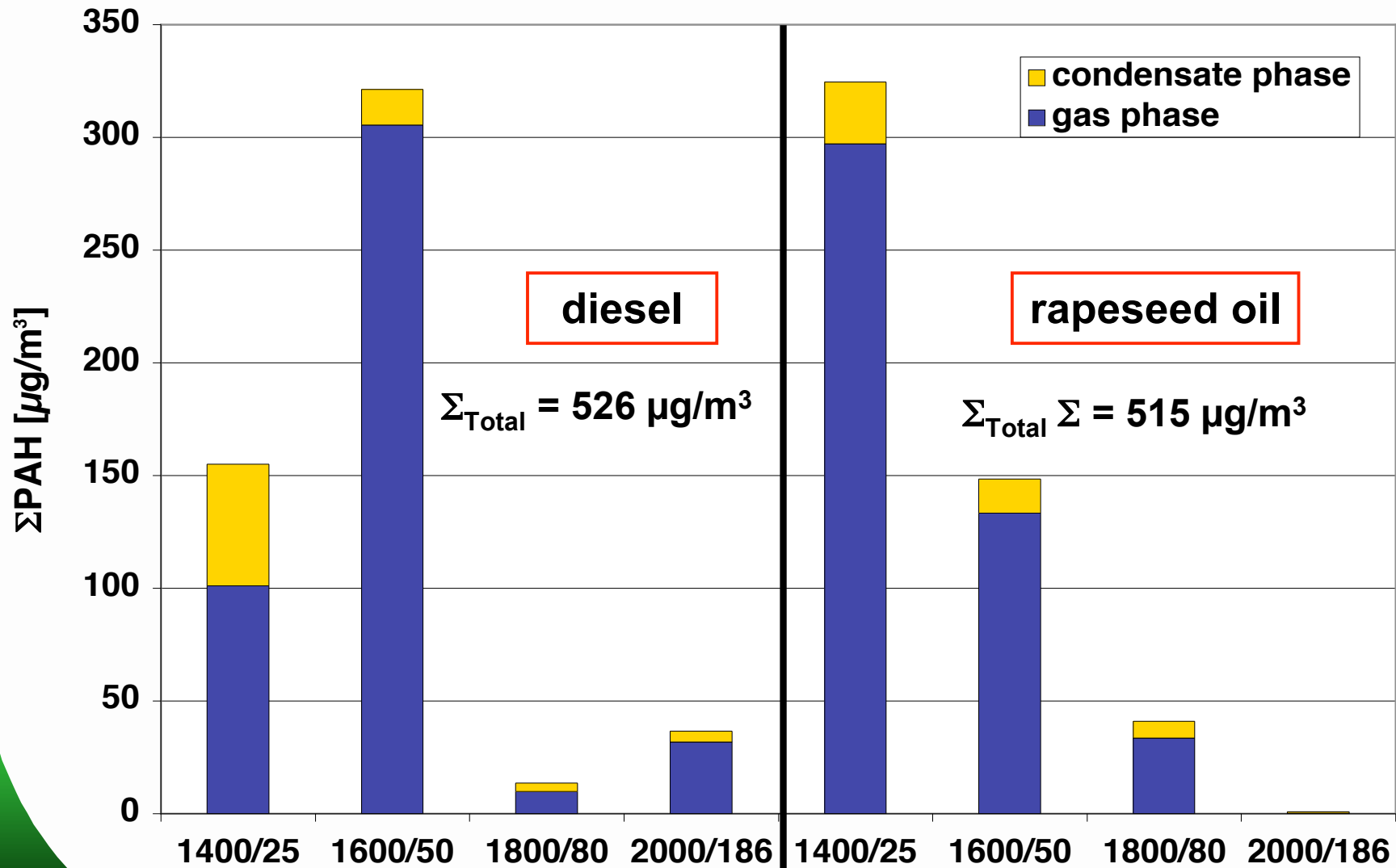
PAH species detected into the gas phase for different engine operating points (diesel fuel)




PAH species detected into the gas phase for different engine operating points (rapeseed oil)



Sum of detected PAH for different engine operating points



detected PAH species and their ring numbers



species	Number of rings
Naphtalene	2
Acenaphthene, Fluorene, Phenanthrene, Anthracene	3
Fluoranthene, Pyrene, Benz[a]anthracene, Chrysene	4
Benzo[b]fluoranthene, Benzo[k]fluoranthene, Benzo[a]pyrene, Dibenz[a,h]anthracene	5
Benzo[g,h,i]perylene	6
Ideno[1,2,3-c,d]perylene	7

Sum of PAH divided into rings for both fuels

PAH	Σ PAH diesel [$\mu\text{g}/\text{m}^3$]	Σ PAH rapeseed oil [$\mu\text{g}/\text{m}^3$]
2-ring*	456	384
3-ring ⁺	54	113
4-ring ⁺	17	16
5-ring ⁺	0.2	0.7
6-ring*	0.002	0.4
7-ring*	0.004	0.09



not valid values

*one species

⁺ four species

summary 1

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Database only 4 stationary points

- **Expectation:**

- **Physical properties of rapeseed oil differ in most cases by 10 to 20 *percent* from diesel.**
- **Viscosity is higher by a *factor* of 20.**
 - ⇒ **different flow regime and spray formation**
 - ⇒ **different combustion**

summary 2

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- **Observed (with pre-treatment):**

- **Gaseous emissions in the range 0.25 up to 2.5 of diesel**
- **SOF lightly higher but lower amount of elemental carbon**
- **PAH average correspond with diesel**

- **Further research**

- **NEUDC test cycle**
- **Effects on after-treatment system**

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Thank you for your attention !

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