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## **Combustion Particles Number Concentrations with Different Engines and Fuels**

# **Combustion particles number concentrations with different engines and fuels**

by

**Professor Jan Czerwinski**

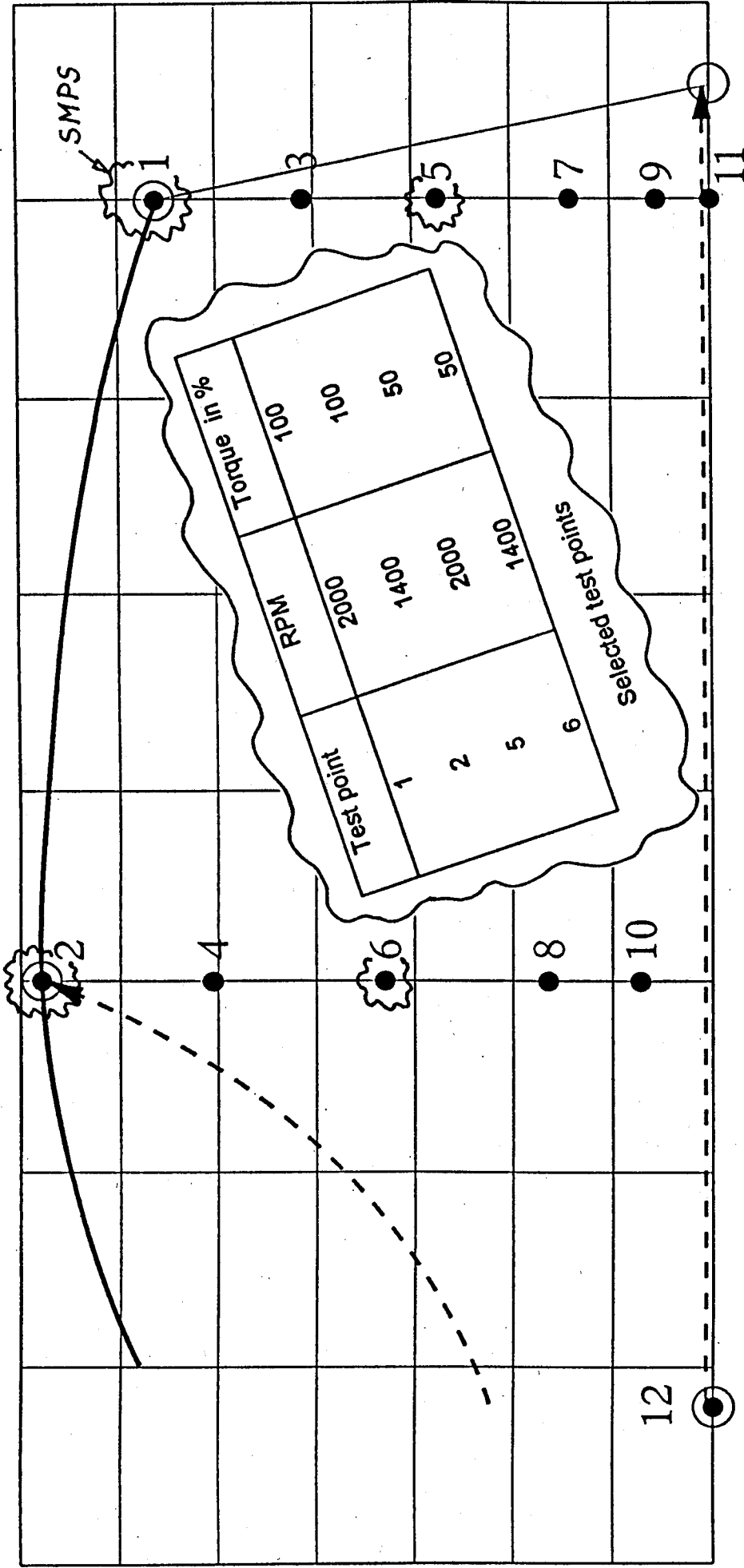
Head of the Laboratory for Internal Combustion Engines  
And Exhaust Emission Control  
Engineering College Biel/Bienne, Switzerland

Workshop „Particles Measurements“

ETH-Zurich, August 8, 1997

- Engine measurements program
- Engines & apparatus
- Comparison of results with standard fuels
- Influences of catalytic fuel additives
- Influences of special synthetic fuel

Last / Torque



# Drehzahl / RPM

- Testpunkte
- Feldmesspunkte
- ▶ Instat. Belastungen

## Caterpillar:

Manufacturer:	Caterpillar
Type:	3116
Displaced volume:	6.6 liters
Rated RPM:	2200
Rated power:	127 kW
Combustion:	Direct injection
Super-charging:	Turbo-charger without intercooling

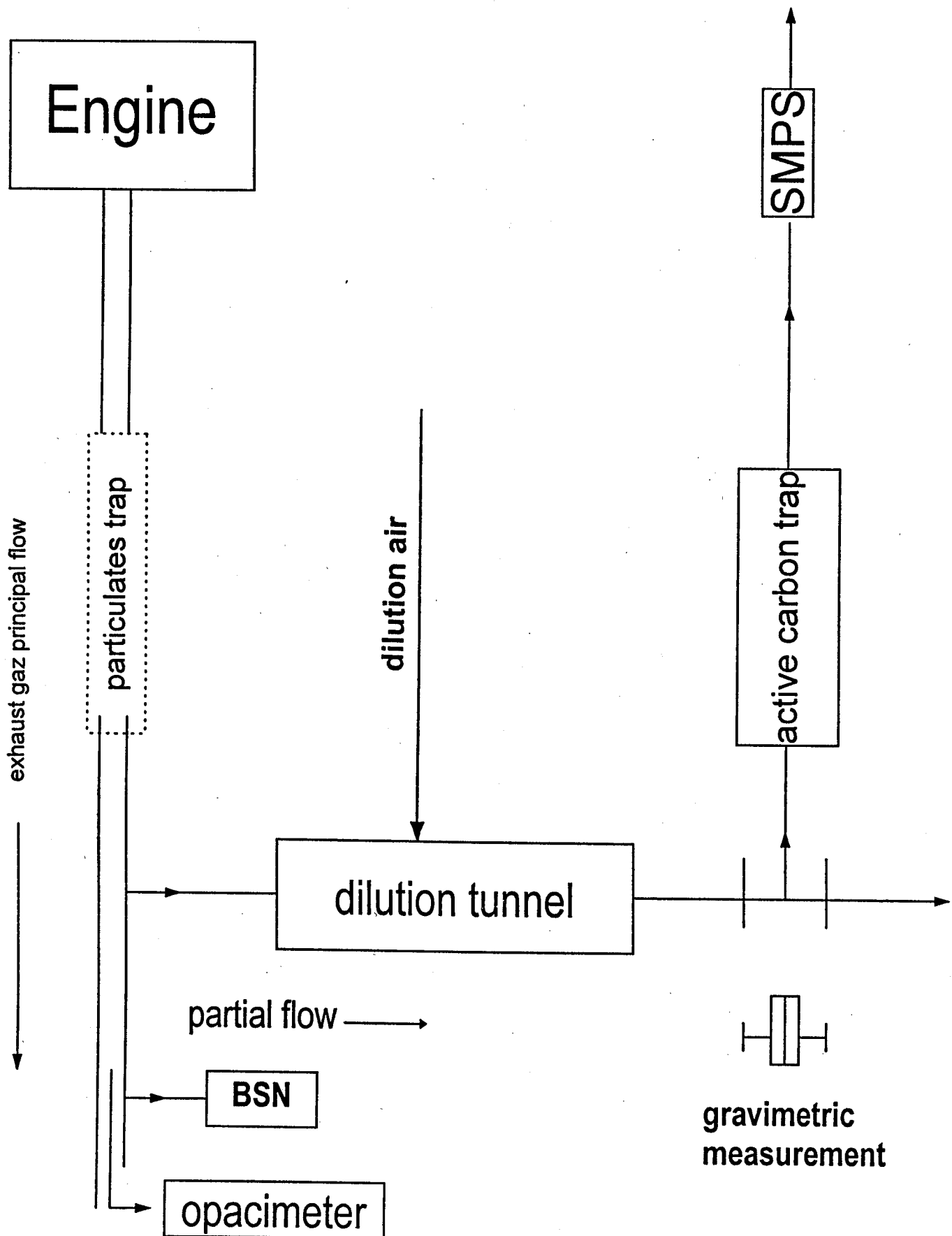
## Liebherr I:

Manufacturer:	Liebherr
Type:	941 T
Displaced volume:	6.11 liters
Rated RPM:	2000
Rated power:	105 kW
Combustion:	Direct injection
Super-charging:	Without intercooling

## Liebherr II:

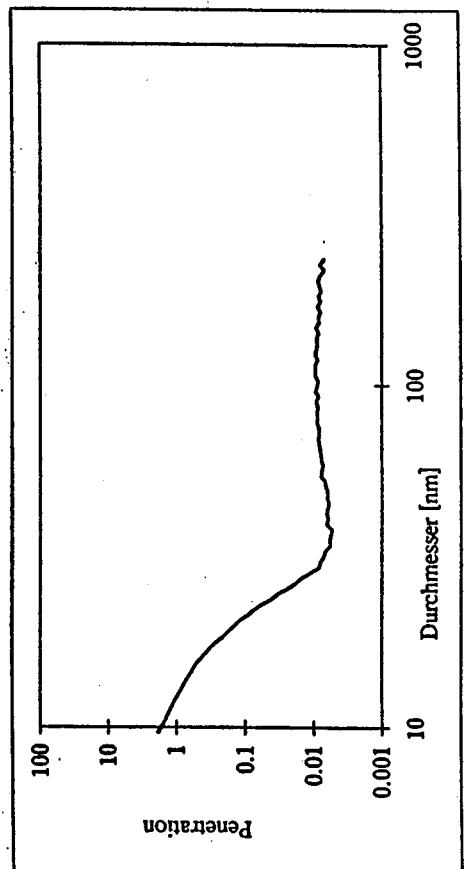
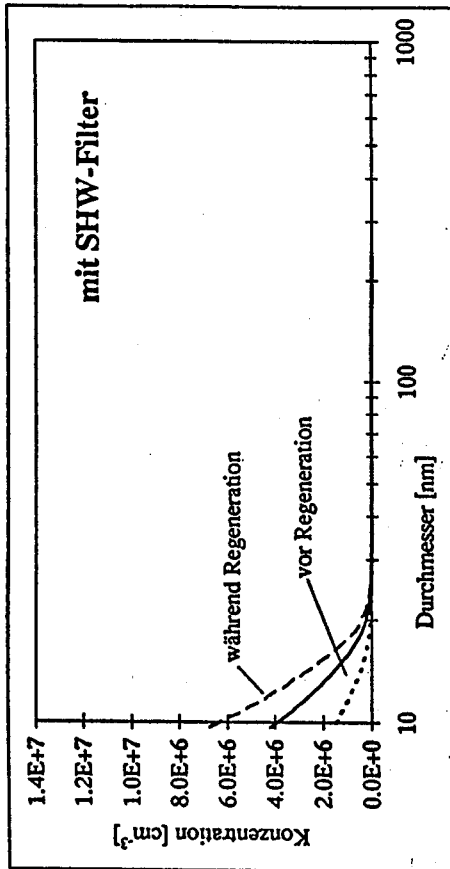
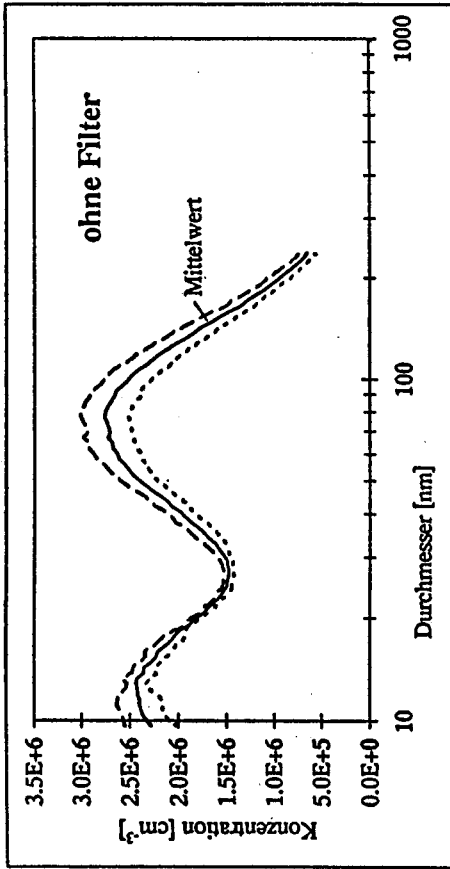
Manufacturer:	Liebherr
Type:	924 TI-E A2
Displaced volume:	6.64 l
Rated RPM:	2000 min <sup>-1</sup>
Rated power:	140 kW
Combustion:	Direct injection
Super-charging:	With intercooling

# Measuring apparatus for black smoke & particulates

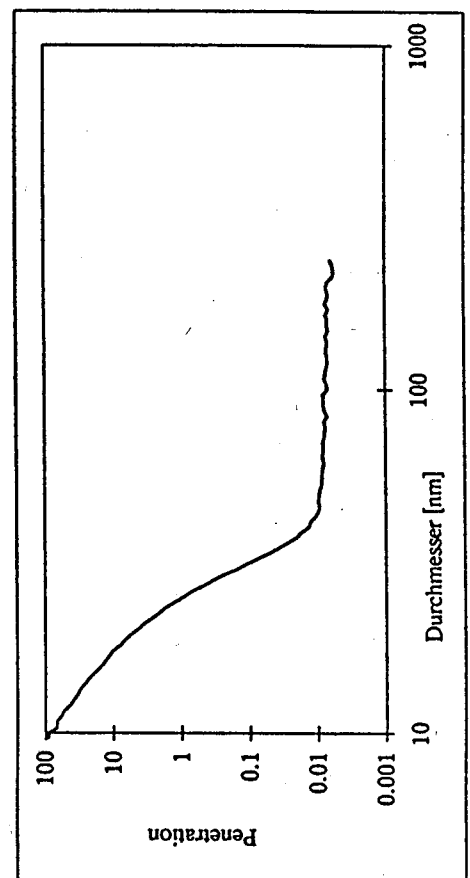
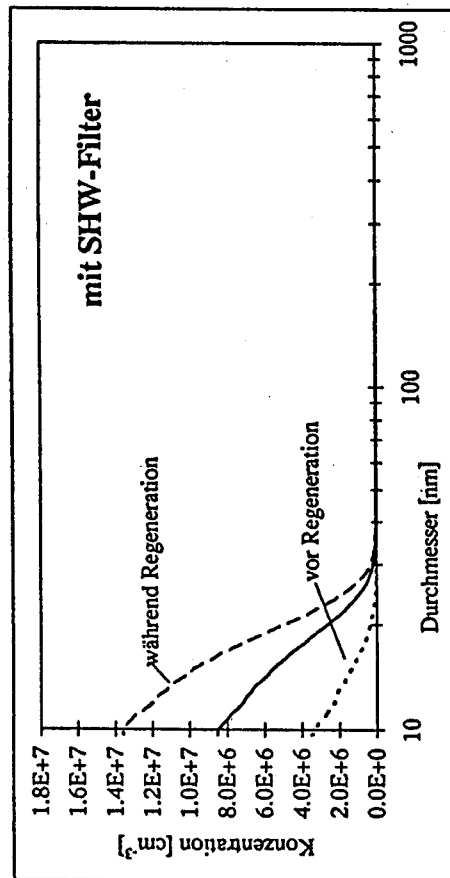
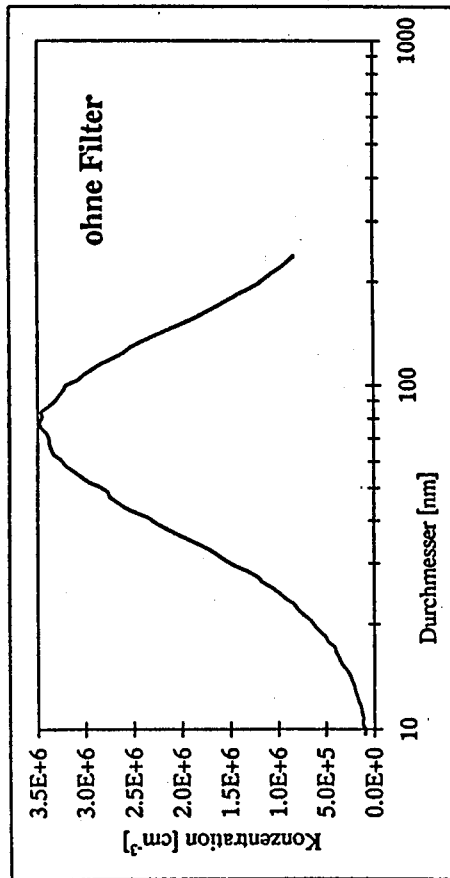


# Caterpillar 3116 T

Messungen mit Additiv bei 2200min-1 / Vollast



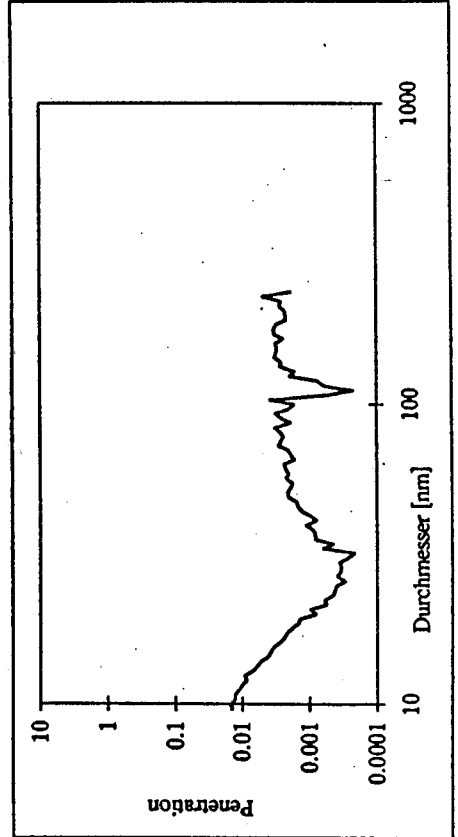
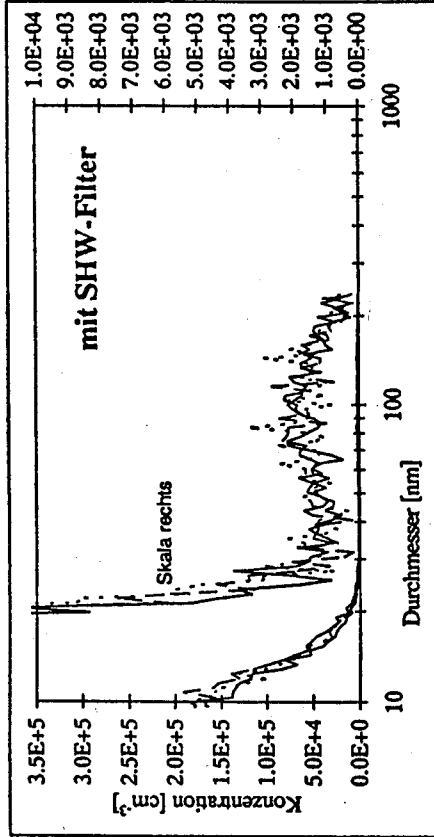
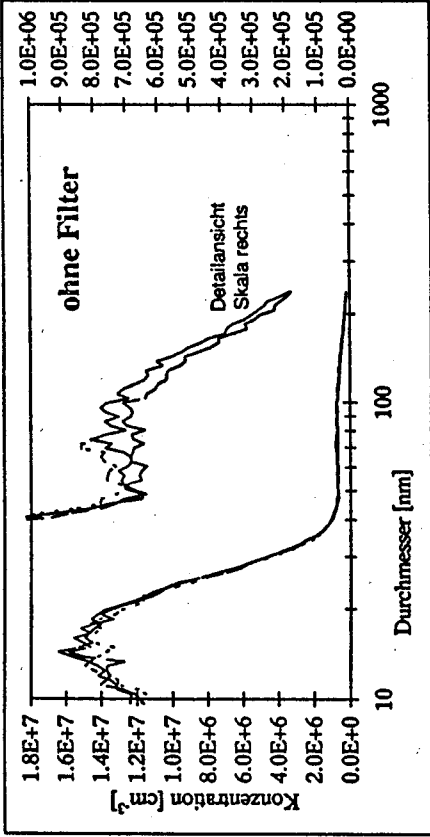
Messungen ohne Additiv bei 2200min-1 / Vollast



# Liebherr II

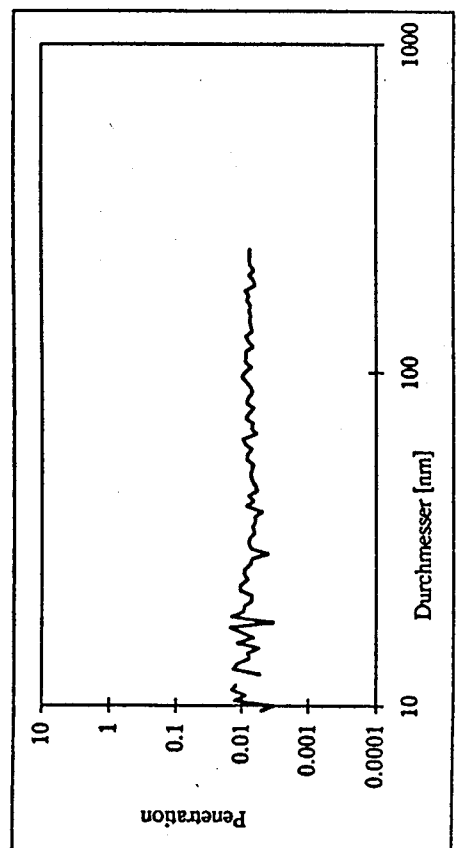
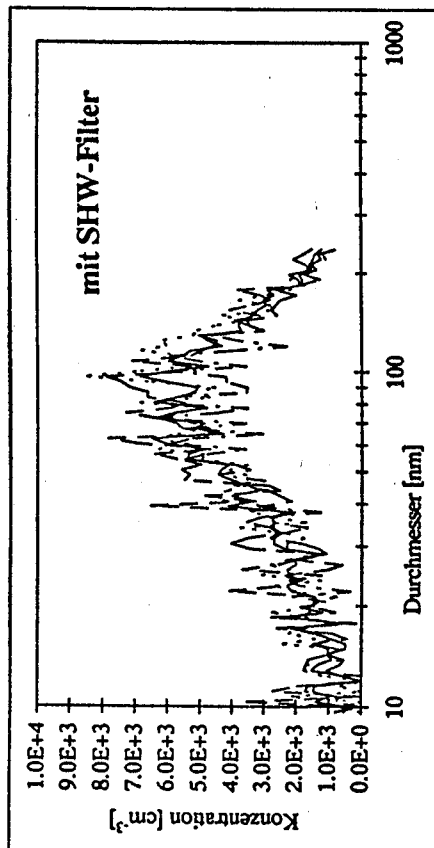
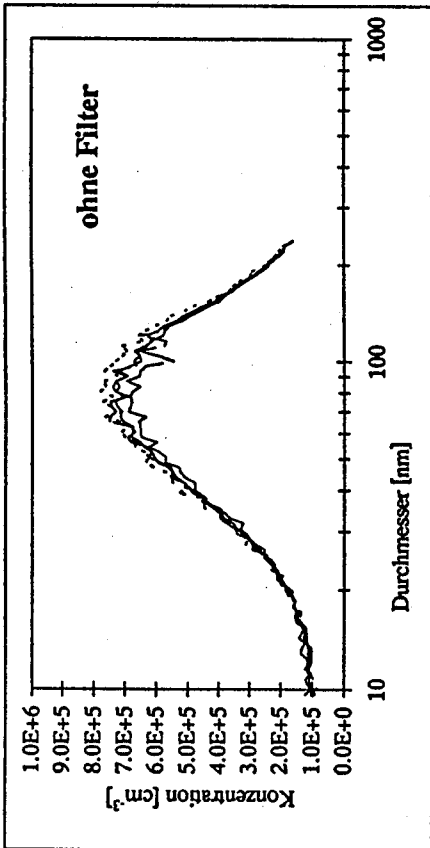
## Liebherr D924 TI-E

Messungen mit Additiv bei 2000min-1 / Vollast



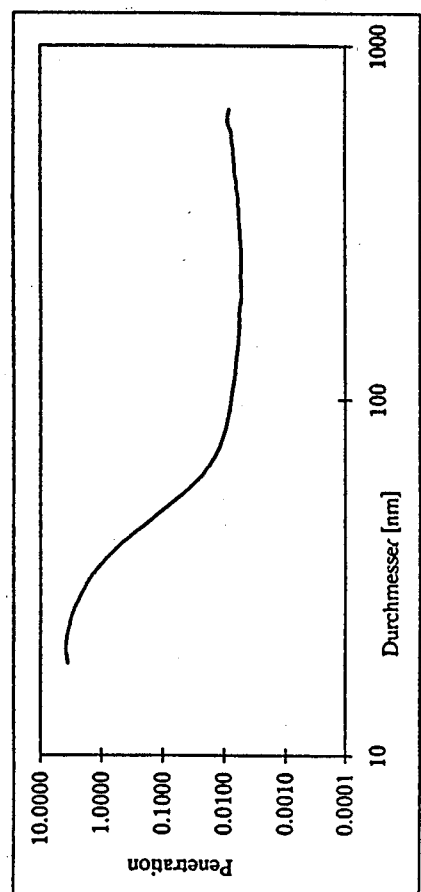
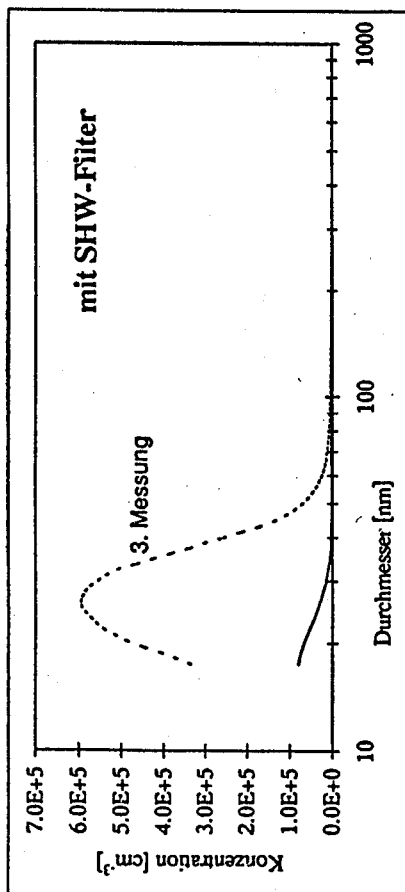
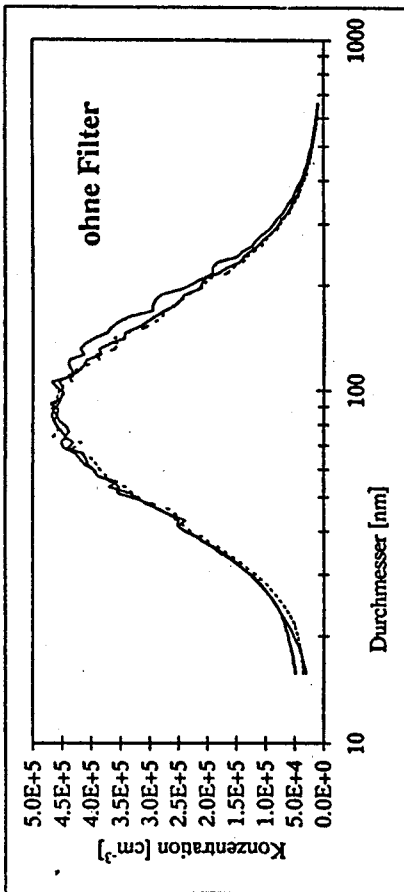
## Liebherr D924 TI-E

Messungen ohne Additiv bei 2000min-1 / Vollast



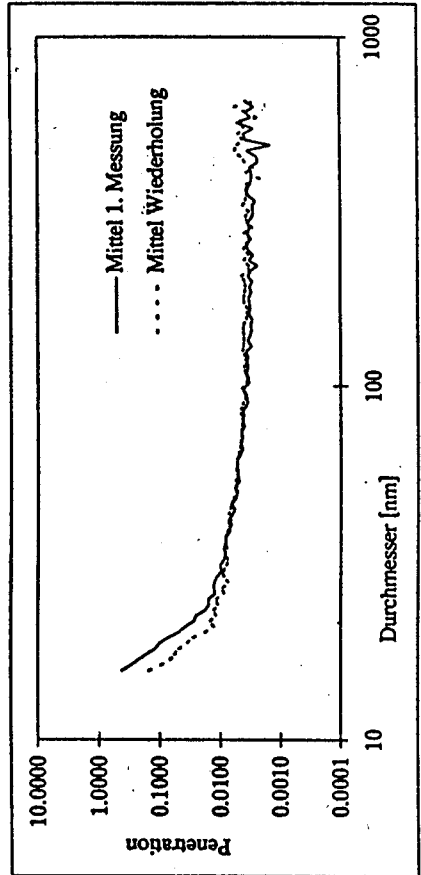
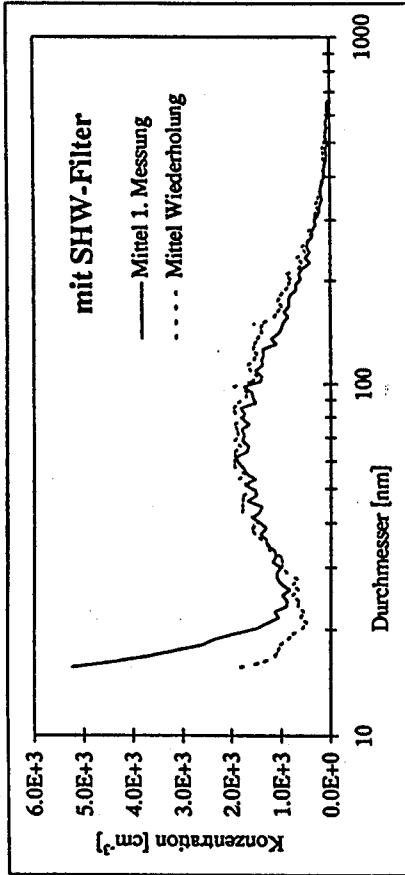
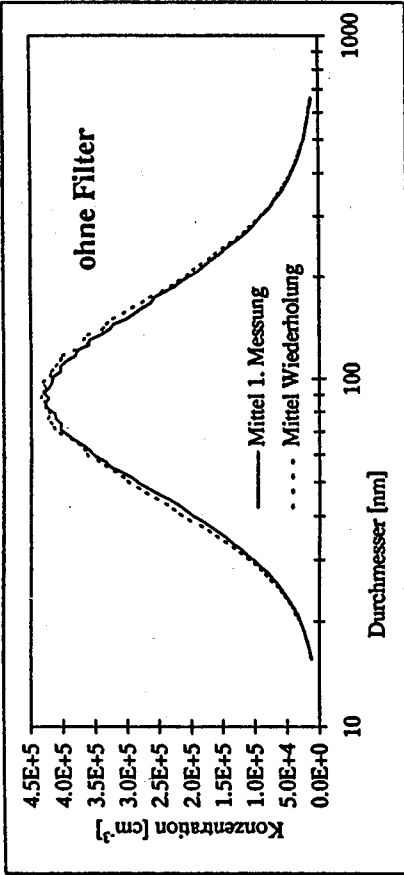
Liebherr I

Messungen mit standard Diesel bei 2000min<sup>-1</sup> / Vollast



Liebherr I

Messungen mit standard Diesel bei 1400min<sup>-1</sup> / Vollast





Particulates mass-emission and maximum number for different engines and fuels

**Standard fuel**

Caterpillar	Betr.punkt	PM	PZ max
	[n / M]		
	2200 / VL	19.77	3.50
	1400 / VL	41.69	6.30
	1400 / 50 %	7.88	1.30
Average		23.11	3.70

**DEA fuel**

Liebherr I	Betr.punkt	PM	PZ max
	[n / M]		
	2000 / VL	11.61	4.60
	2000 / 50 %	8.05	7.00
	1400 / VL	7.95	4.20
	1400 / 50 %	2.49	1.80
Average		6.16	4.33

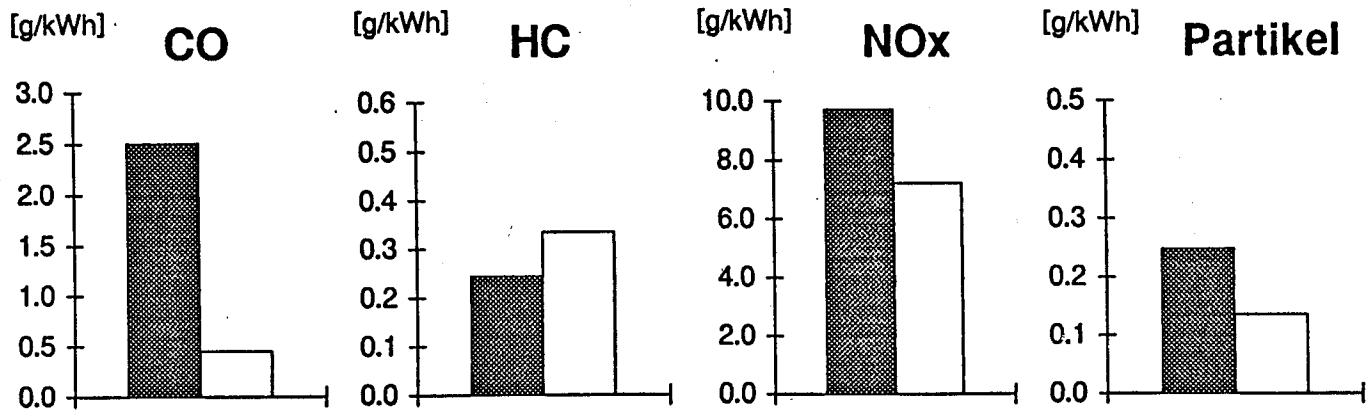
Liebherr II	Betr.punkt	PM	PZ max
	[n / M]		
	2000 / VL	16.24	8.20
	2000 / 50 %	13.26	9.00
	1400 / VL	10.44	6.90
	1400 / 50 %	6.31	6.20
Average		10.00	7.37

Liebherr I	PM	PZ max
	10.81	6.70
	6.37	6.90
	6.35	5.30
	2.43	2.30
	5.05	4.83

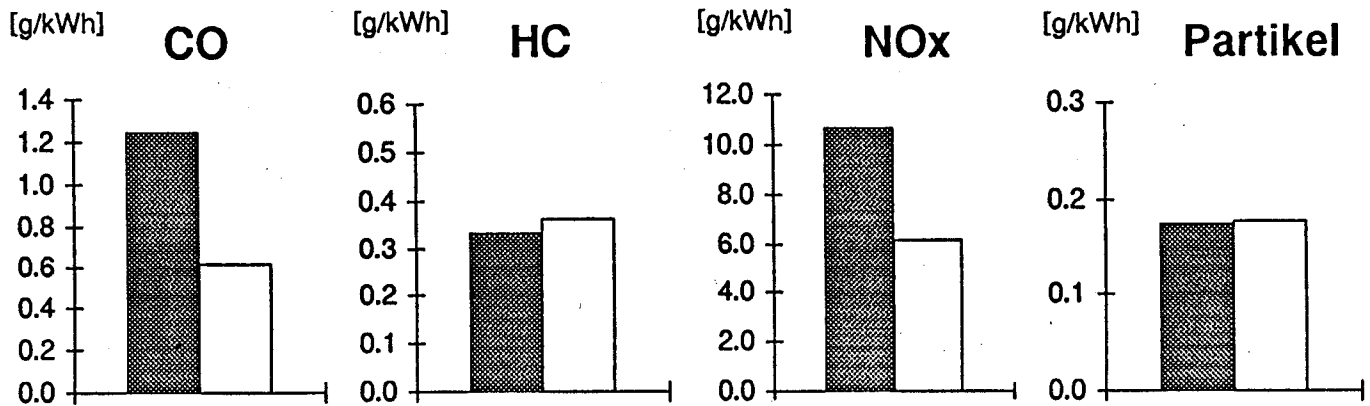
Liebherr II	PM	PZ max
	11.90	7.50
	10.93	9.70
	7.89	6.30
	4.55	6.00
	7.79	7.33

## Vergleich der Emissionswerte bei den Stufentests

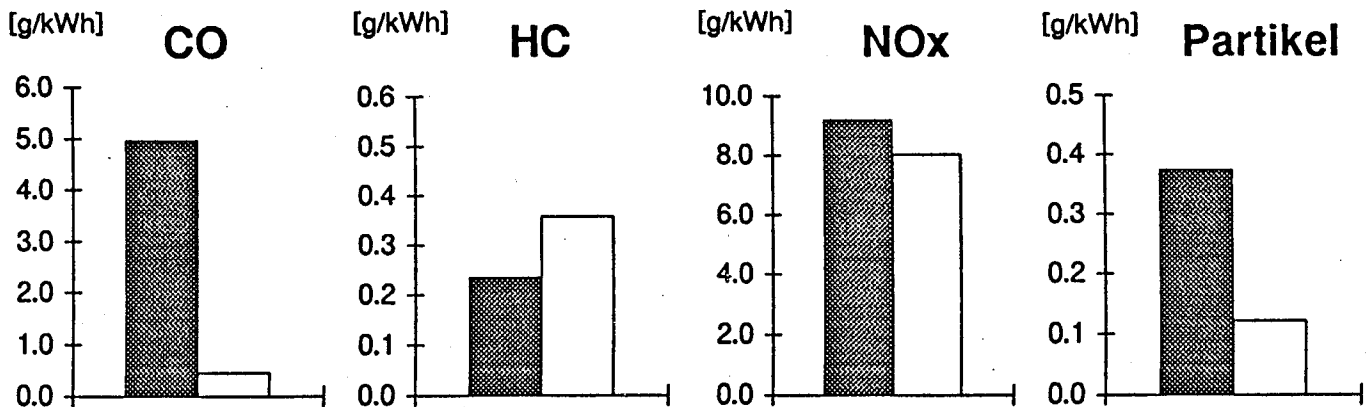
### C1 8-Pkt.



### D2 5-Pkt.

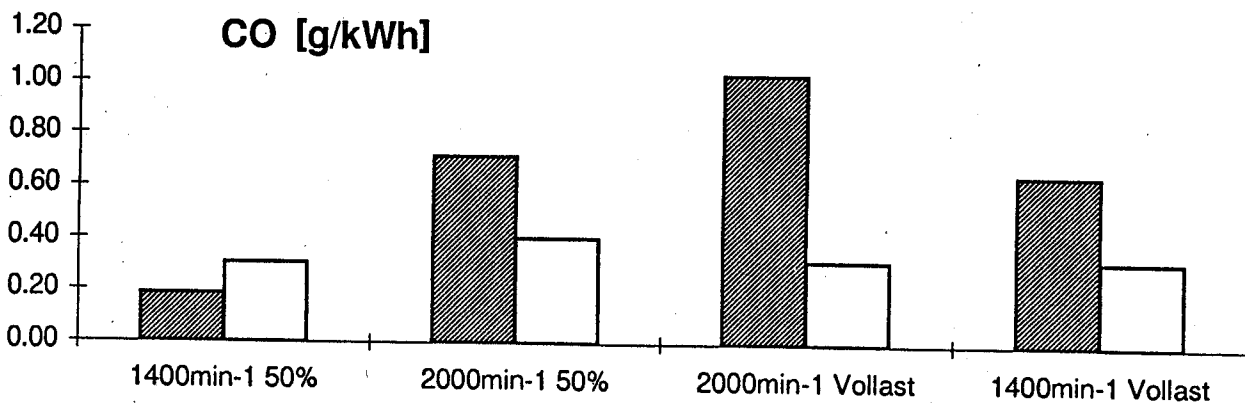
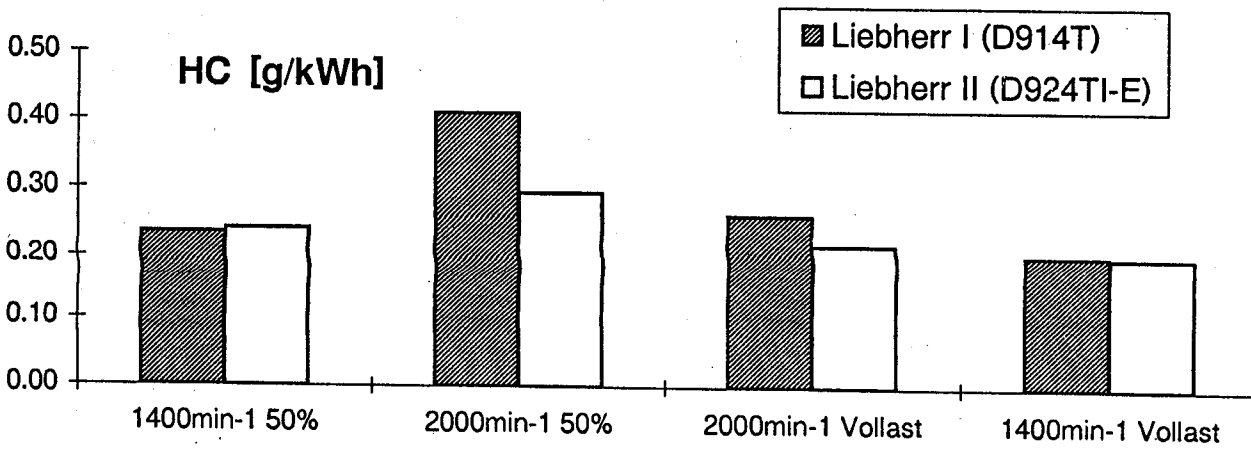
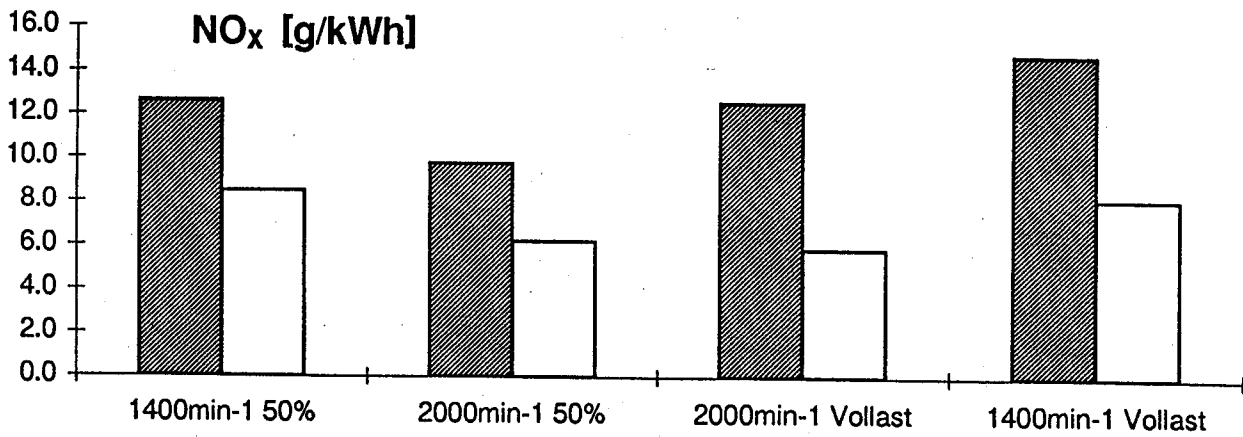
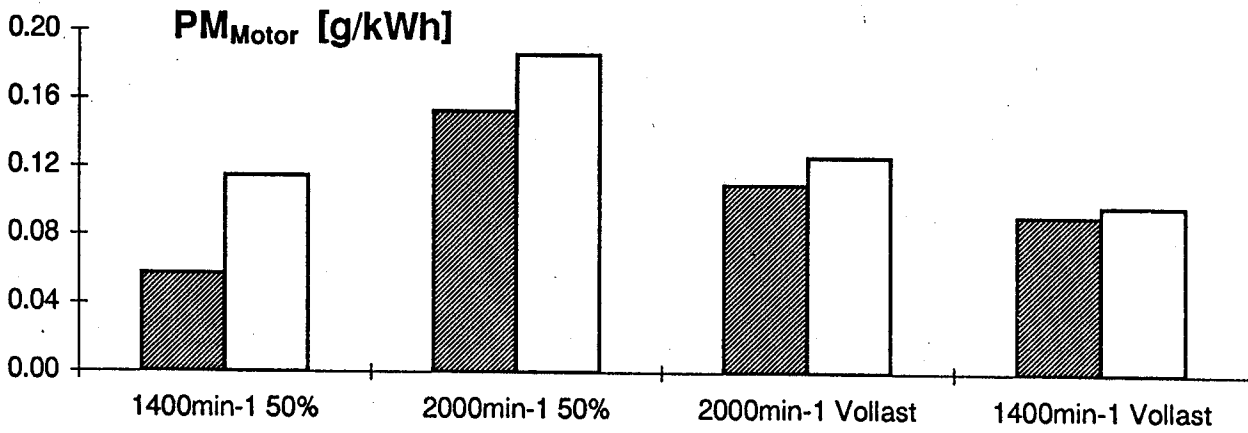


### ECE 13-Pkt.



■ Caterpillar 3116 DIT  
□ Liebherr D924 TI-E

## Vergleich der Emissionswerte zwischen Liebherr I und II



**Integrierte Partikelzahlen im Grössenbereich 20 bis 500 nm**

**Liebherr I, Additiv**

