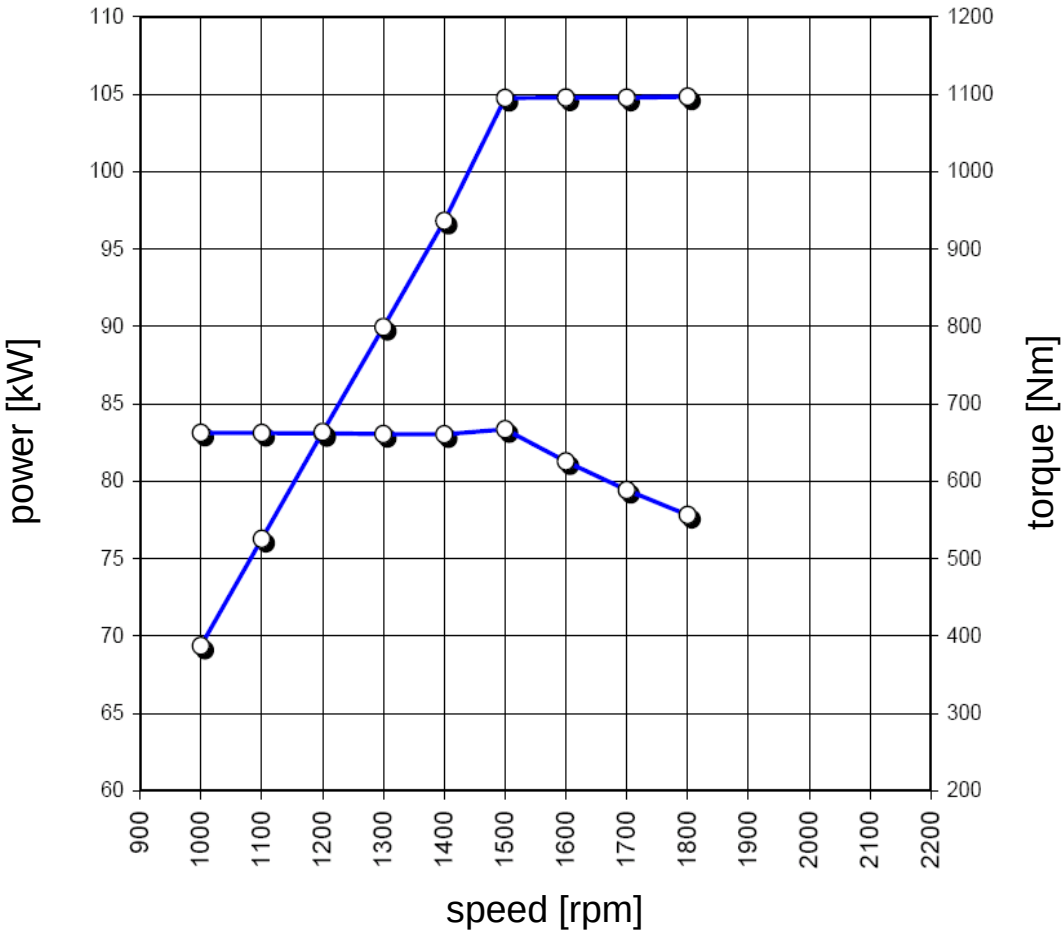
Test Engine

Liebherr Dieselmotor 934 S A6
4 Cylinders Turbodiesel,
intercooler, unit pump, EDC

Power :	105 kW at 2000 rpm
Displacement:	6,36 dm^3
Bore x stroke:	136 x 122 mm
Compression ratio:	17 : 1

Emission values according to:

97/68/EG	Stage IIIA
EPA / CARB	Tier 3
88/77/EWG	---



[Liebherr Machines Bulle SA]

Measured values

n	rpm	engine speed
M	Nm	torque
G_{air}	kg/h	air mass flow
V_{fuel}	l/h	fuel flow
t_{SS}	s	time of particulates sampling
PM_{filter}	mg	particle mass on the filter
t_{water}	°C	cooling water temperature
t_{oil}	°C	oil temperature
t_{room}	°C	temperature in the testing room
t_1	°C	temperature on air filter
t_2	°C	temperature before compressor
t_3	°C	temperature after compressor
t_4	°C	temperature after intercooler
t_5	°C	temperature before turbine
t_6	°C	temperature after turbine
t_7	°C	temperature before particle trap
t_8	°C	temperature after particle trap
p_{wv}	mbar	partial pressure of the water vapor
p_{atm}	mbar	atmospheric pressure in the testing room
p_2	mbar	rel. pressure before compressor
p_3	mbar	rel. pressure after compressor
p_4	mbar	rel. pressure after intercooler
p_5	mbar	rel. pressure before turbine
p_6	mbar	rel. pressure after turbine
p_7	mbar	rel. pressure before particle trap
p_8	mbar	rel. pressure after particle trap
CO	ppm	volumetric concentration of the emissions
$HC3_{FID}$	ppm	
$HC6_{IR}$	ppm	
NO	ppm	
NO_2	ppm	
NO_X	ppm	
$CO_{2\ high}$	%	high: exhaust
$CO_{2\ low}$	%	low: diluted sample (smart sampler)
$CO_{2\ room}$	%	CO_2- concentration in the testing room
O_2	%	
BSN	-	Bosch smoke number
R_{room}	%	rel. humidity in the testing room

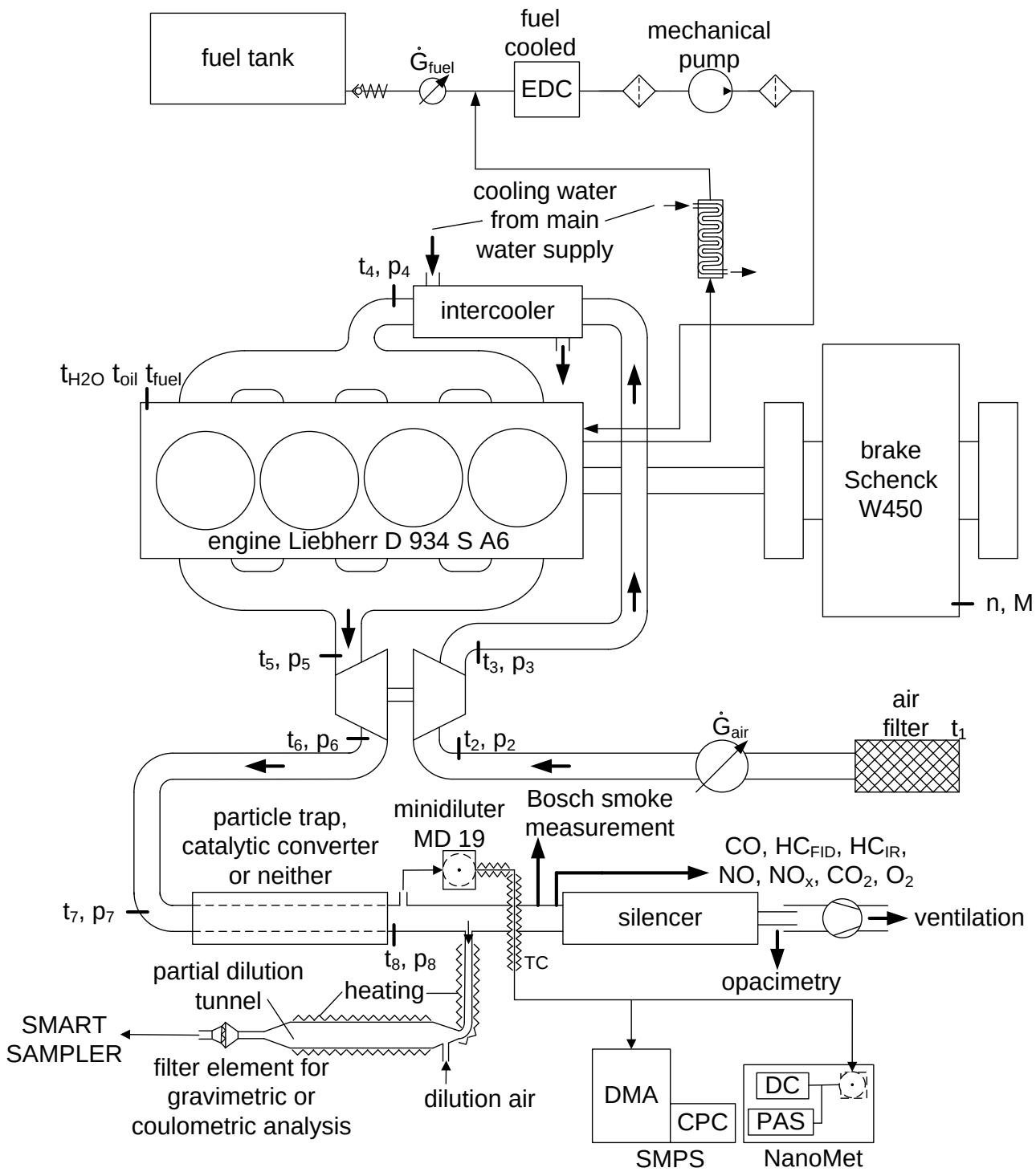
Calculated values

P_e	kW	power
p_{me}	bar	mean effectiv pressure
G_{fuel}	kg/h	fuel mass flow
b_e	g/kWh	specific fuel consumption
η_e	-	effective efficiency
β	mm^3/stroke	injection quantity
λ	-	global equivalence ratio
G_{exh}	kg/h	exhaust mass flow
PM_{engine}	g/h	particle mass emission
PM	g/kWh	specific emissions
CO	g/kWh	
HC	g/kWh	
NO_X	g/kWh	
DF	-	dilution factor (dilution tunnel)

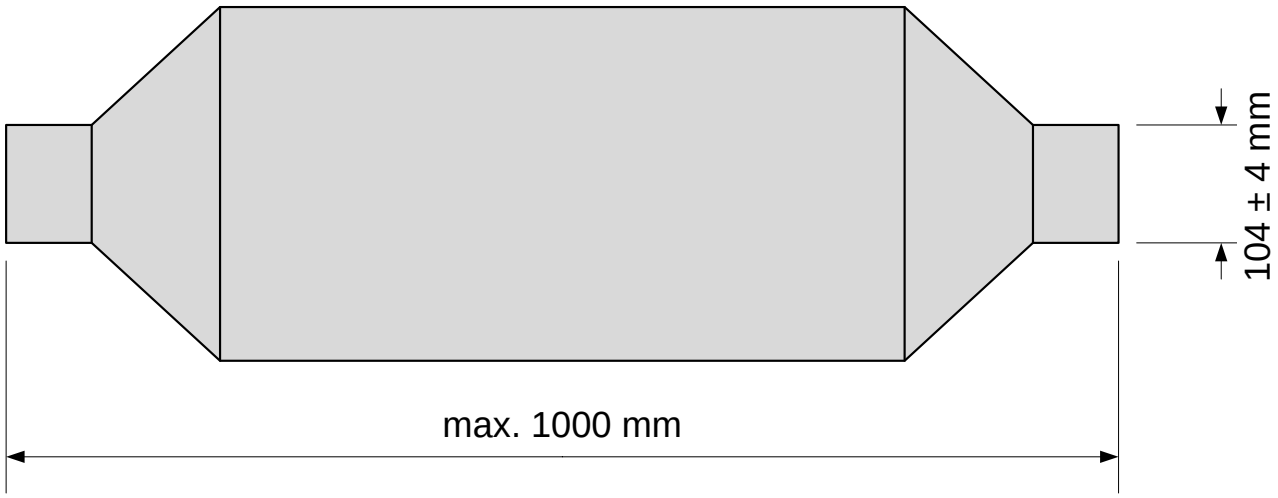
Abbreviations

BSN	Bosch smoke number
CPC	condensation particle counter
DC	diffusion charging sensor
DMA	differential mobility analyser
DPF	diesel particle filter
EC	elemental carbon
ECFE	elemental carbon filtration efficiency
INSOF	insoluble fraction
MD19	heated minidiluter
NanoMet	nanoparticle summary surface analyser (PAS, DC and MD19)
NP	nanoparticulates
OC	organic carbon
PAK, PAH	polycyclic aromatic hydrocarbons
PAS	photoelectrical aerosol sensor
PM	particulate matter, particle mass
PMFE	particulate mass filtration efficiency
PC	particle count
PCFE	particulate counts filtration efficiency (20 – 300 nm)
SOF	soluble organic fraction
SMPS	scanning mobility particles sizer (DMA + CPC)
TC	total carbon

Schema of measuring setup



Maximal dimensions for particulate filter



VERT Secondary Emission Test - measured and calculated values

customer:	-	particle trap:	-	date:	**10.11.2014**	t_{room} [°C]:	24
fuel:	**ulsd**	additive:	-	engine:	**Liebherr D934 S A6**	R_{room} [%]:	36
equipment:	**Lubrizol "yellow" 5W30**	measurement:	**Reference**			p_{atm} [mbar]:	958

pt.	n	M	period	G_{air}	V_{fuel}	BSN	CO_2	CO	$HC3_{FID}$	$HC6_{IR}$	O_2	NO (hot)	NO_x (hot)	NO_2/NO_x
	[rpm]	[Nm]	[min]	[kg/h]	[l/h]	[-]	[%]	[ppm]	[ppm]	[ppm]	[%]	[ppm]	[ppm]	[%]
1	2000	507	15	827	30	-	6	50	19	4	12	373	391	4
2	2000	376	15	727	23	-	6	60	17	3	13	309	330	6
3	2000	251	15	624	17	-	5	113	26	3	14	238	272	12
4	2000	52	10	471	7	-	3	328	61	5	17	174	229	24
5	1400	692	10	525	25	-	8	127	31	5	9	755	764	1
6	1400	512	10	446	19	-	8	97	23	4	10	693	703	1
7	1400	341	10	378	14	-	6	88	25	4	12	598	622	4
8	850	2	15	158	1	-	1	188	55	4	19	131	165	21

pt.	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_{water}	t_{fuel}	p_2	p_3	p_4	p_5	p_6	p_7	p_8
	[°C]	[°C]	[°C]	[°C]	[°C]	[°C]	[°C]	[°C]	[°C]	[mbar]	[mbar]	[mbar]	[mbar]	[mbar]	[mbar]	[mbar]
1	13	125	31	511	384	368	360	77	30	-15	1243	1180	1340	-	53	-
2	14	106	28	454	355	343	337	77	31	-12	952	897	1029	-	42	-
3	13	81	23	382	307	297	290	76	30	-9	649	600	747	-	30	-
4	13	46	17	227	196	193	191	77	28	-6	238	199	397	-	17	-
5	13	98	23	561	449	419	407	76	26	-7	958	928	695	-	27	-
6	14	79	21	506	427	402	393	76	25	-5	655	630	506	-	20	-
7	14	57	18	415	360	341	331	76	24	-4	381	360	352	-	15	-
8	14	23	12	119	128	130	132	76	20	-2	10	9	87	-	7	-

pt.	P_e	p_{me}	G_{fuel}	$G_{exh\ DRY}$	CO_2	CO	HC_{FID}	$NO_{x\ (hot)}$	$G_{exh\ WET}$	b_e	β	λ	V_{exh}	CO	HC_{FID}	$NO_{x\ (hot)}$
	[kW]	[bar]	[kg/h]	[g/h]	[g/kWh]	[g/kWh]	[g/kWh]	[g/kWh]	[kg/h]	[g/kWh]	[mm³/H]	[-]	[m³/min]	[g/h]	[g/h]	[g/h]
1	106	10	26	804	753	0	0	5	853	242	126	2	26	39	23	517
2	79	7	20	709	818	1	0	5	747	250	96	3	22	41	18	384
3	53	5	14	612	892	1	0	5	639	272	70	3	18	67	24	273
4	11	1	6	465	1924	14	4	16	477	565	30	5	11	147	42	175
5	102	14	21	506	648	1	0	6	546	205	146	2	18	62	24	636
6	75	10	16	432	704	1	0	7	463	216	113	2	15	40	15	498
7	50	7	12	367	746	1	0	7	389	233	82	2	12	31	14	374
8	0	-	1	157	-	-	-	-	159	-	14	9	3	29	12	42

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