

Table D.1 — Test report: data and description of test object

SNR 277205, Tab. D.1

Manufacturer of filter system	Physitron GmbH, Am Merzenborn 6 56422 Wirges, Germany	
Type / serial number	Physitron Physitec SiC-B / 08.35.06	
Designation of particle filter family	Physitron Physitec SiC	
Filter medium (particle filter element)		
Manufacturer of filter medium	LiqTech A/S	
Type	Wall flow filter	
External dimensions / weight	11.25" x 12" / -	
Material	100% RE SiC	
Porosity	[%]	43
Pore size	[μm]	12-15
Number of cells per square inch	[CPSI]	150
Wall thickness	[mm]	0.5
Maximum flow-through rate	[m^3/s]	1.2 @ 20°C, 1013.25 mbar / 0.42 *)
Maximum space velocity	[s^{-1}]	21.6 *)
Maximum operating temperature	[°C]	900
Storage capacity for soot/ash	[g/l]	18
Regeneration		
Regeneration procedure	Diesel burner	
With additive (FBC = fuel borne catalyst)		
Manufacturer and specification of additive		
Catalytically active substances		
Treat rate	recommended / standard for test	
Additizing procedure		
Specification of dosage device		
With catalytic coating		
Catalytically active elements / concentration of catalytically active substances		-
OBC (electronic on board control unit)		
Manufacturerer and specification	Physitron DNY ControlBox	
Serial number	20103	

*) in present tests

Table D.2 — Test report: visual inspection and control of functions

SNR 277205, Tab. D.2

Visual inspection (5.2)	
Description of cleaning and maintenance	<input checked="" type="checkbox"/> yes <input type="checkbox"/> no <input type="checkbox"/> not inspected
Presence of Identification plate with serial number, test number and indication of particle family	<input checked="" type="checkbox"/> yes <input type="checkbox"/> no <input type="checkbox"/> not inspected
Measurement access upstream of filter element	<input checked="" type="checkbox"/> yes <input type="checkbox"/> no <input type="checkbox"/> not inspected
Flow-through direction indicated by arrow	<input checked="" type="checkbox"/> yes <input type="checkbox"/> no <input type="checkbox"/> not inspected
Reversal of filter element prevented through structural measures	<input checked="" type="checkbox"/> yes <input type="checkbox"/> no <input type="checkbox"/> not inspected
Control of functions (5.6)	
Recording of pressure loss at intervals of 1 second	<input checked="" type="checkbox"/> yes <input type="checkbox"/> no <input type="checkbox"/> not inspected
Electronic storage of peak pressure loss levels at 1-minute intervals, with storage capacity for at least 1 month of operation	<input checked="" type="checkbox"/> yes <input type="checkbox"/> no <input type="checkbox"/> not inspected
Issue of warning if pressure loss exceeds 150 mbar for more than 5 seconds. Warning saved in alarm memory that cannot be overwritten and cannot be deleted.	<input checked="" type="checkbox"/> yes <input type="checkbox"/> no <input type="checkbox"/> not inspected
Issue of an alarm if pressure exceeds 200 mbar for more than 5 seconds. Alarm saved in alarm memory that cannot be overwritten and cannot be deleted.	<input checked="" type="checkbox"/> yes <input type="checkbox"/> no <input type="checkbox"/> not inspected
Issue of an alarm if (too low) counter-pressure is recorded that indicates damage to filter (e.g. leak to exterior or fissure/crack in filter element). Alarm saved in alarm memory that cannot be overwritten and cannot be deleted.	<input checked="" type="checkbox"/> yes <input type="checkbox"/> no <input type="checkbox"/> not inspected
Issue of alarm and switch-off of additive dosage in the event of filter damage	<input type="checkbox"/> yes <input type="checkbox"/> no <input type="checkbox"/> not inspected
Issue of alarm when minimum level in additive tank is reached	<input type="checkbox"/> yes <input type="checkbox"/> no <input type="checkbox"/> not inspected

Table D.3 — Test report: test engine data

SNR 277205, Tab. D.3

Manufacturer / type	Liebherr Machines Bulle S.A./ D 934 S
Maximum emission level (legal exhaust level)	97/68/EG step 3A; EPA/CARB Tier 3
Cylinder number and configuration	4 cylinders in-line
Bore / stroke	136 x 122 [mm]
overall displacement	6.36 [dm ³]
Compression ratio	17 [-]
Serial number / year of manufacture / operating hours	2005 03 1341 / 2005 / -
Cooling medium (air, water, etc.)	water
Combustion process (direct injection, prechamber, etc.)	direct injection
Fuel system type	unit pump Bosch
Speed governor	EDC
Method of air aspiration	turbocharging
Charge air cooling system	intercooler
Measures to reduce emissions	-
Rated power / Rated speed (present EDC setting)	111 [kW] @ 2000 [min ⁻¹]
Low idle speed / high idle speed	800 [min ⁻¹]; 2170 [min ⁻¹]

Test points of motor in accordance with ISO 8178-4, test cycle C1				
	Rated speed		Intermediate speed	
Test phase	1	3	5	7
Speed [min ⁻¹]	2000	2000	1400	1400
Torque [Nm]	500	250	680	340
Power [kW]	104.7	52.3	99.6	49.8

Table D.4 — Test report: fuel and lubricating oil data

SNR 277205, Tab. D.4

Base fuel (without additive)			
Type	Diesel fuel Swiss market quality		
Manufacturer	BP		
Property	Method	Unit	
Density (at 15°C)	ISO 3675	kg/l	0.820 – 0.845
Viscosity (at 40°C)	ISO 3104	mm ² /s	2.2 – 2.8
Cetane number	ISO 5165	-	52 - 54
Cetane index	ISO 4264	-	49 - 51
Sulphur content	ISO 4260 / 8754	mg / kg	max. 10
Cloud point	ISO 3015	°C	max. -10
Pour point (CFPP)	ISO 3016	°C	max. -20
Flash point	ISO 2719	°C	min. 62
Heating value		MJ/kg	min. 42.5
Aromatic hydrocarbons	ISO 3837	% vol	max. 2
Conradson at 10% test residue			max. 0.02 g/100g
Boiling analysis (at 1013 mbar, 340°C)			min. 98 vol%

Lubricating oil

Lubrizol research oil OS No. 165108, blue, 15W/40

Property		
Viscosity kin 40°C	-	mm ² /s
Viscosity kin 100°C	13.98	mm ² /s
Viscosity index	-	(--)
Density 20°C	-	kg/m ³
Pourpoint	-25	°C
Flamepoint	-	°C
Total Base Number TBN	8.4	mg KOH/g
Sulfur ashes	10'770	mg/kg
Sulfur	3'360	mg/kg
Mg	< 10	mg/kg
Zn	1'200	mg/kg
Ca	2'630	mg/kg
P	1'110	mg/kg

Table D.5 — Test report: results of filtration test (5.3)

Filtration efficiency in stationary operation

SNR 277205, Tab. D.5

Filter status	Particle size range [nm]	Test-cycle	Particle count concentration before filter	Particle count concentration after filter	Penetration [-]	Filtration efficiency [%]	Pressure loss of filter [mbar]	
before regeneration	Integrated	op 5					99.80	
	20 - 30		3.253E+06	4.439E+03	1.365E-03	99.86		
	30 - 40		3.289E+06	5.357E+03	1.629E-03	99.84		
	40 - 50		2.933E+06	5.431E+03	1.852E-03	99.81		
	50 - 60		2.633E+06	5.256E+03	1.996E-03	99.80		
	60 - 80		4.135E+06	9.687E+03	2.343E-03	99.77		
	80 - 190		8.024E+06	2.034E+04	2.536E-03	99.75		
	190 - 300		1.301E+06	2.767E+03	2.126E-03	99.79	40	
	Integrated	op 7					99.89	
	20 - 30		2.997E+06	2.875E+03	9.593E-04	99.90		
	30 - 40		2.914E+06	3.251E+03	1.116E-03	99.89		
	40 - 50		2.558E+06	3.059E+03	1.196E-03	99.88		
	50 - 60		2.230E+06	2.439E+03	1.094E-03	99.89		
	60 - 80		3.378E+06	3.920E+03	1.160E-03	99.88		
	80 - 190		5.645E+06	6.723E+03	1.191E-03	99.88		
	190 - 300		5.405E+05	6.284E+02	1.163E-03	99.88	13	
	Integrated	op 3					99.89	
	20 - 30		5.863E+06	6.471E+03	1.104E-03	99.89		
	30 - 40		5.438E+06	6.060E+03	1.114E-03	99.89		
	40 - 50		4.369E+06	4.993E+03	1.143E-03	99.89		
	50 - 60		3.538E+06	3.964E+03	1.120E-03	99.89		
	60 - 80		4.726E+06	5.238E+03	1.108E-03	99.89		
	80 - 190		5.546E+06	6.490E+03	1.170E-03	99.88		
	190 - 300		1.976E+05	1.392E+02	7.041E-04	99.93	41	
	Integrated	op 1					99.90	
	20 - 30		4.338E+06	4.128E+03	9.516E-04	99.90		
	30 - 40		3.885E+06	3.633E+03	9.352E-04	99.91		
	40 - 50		3.044E+06	2.998E+03	9.851E-04	99.90		
50 - 60	2.428E+06		2.445E+03	1.007E-03	99.90			
60 - 80	3.299E+06		3.390E+03	1.028E-03	99.90			
80 - 190	4.170E+06		4.444E+03	1.066E-03	99.89			
190 - 300	2.559E+05		3.361E+02	1.313E-03	99.87	85		
Integrated	op 5 (r.)					99.89		
20 - 30		3.196E+06	3.067E+03	9.599E-04	99.90			
30 - 40		3.186E+06	3.525E+03	1.106E-03	99.89			
40 - 50		2.839E+06	2.973E+03	1.047E-03	99.90			
50 - 60		2.578E+06	2.807E+03	1.088E-03	99.89			
60 - 80		4.086E+06	4.422E+03	1.082E-03	99.89			
80 - 190		7.794E+06	9.522E+03	1.222E-03	99.88			
190 - 300		1.268E+06	1.250E+03	9.856E-04	99.90	41		
average filtration efficiency of all operation points						99.87		

SNR 277205, Tab. D.5

Filter status	Particle size range [nm]	Test-cycle	Particle count concentration before filter	Particle count concentration after filter	Penetration [-]	Filtration efficiency [%]	Pressure loss of filter [mbar]	
after regeneration	Integrated	op 5				98.10		
	20 - 30		3.253E+06	1.488E+04	4.573E-03	99.54		
	30 - 40		3.289E+06	3.241E+04	9.853E-03	99.01		
	40 - 50		2.933E+06	4.518E+04	1.540E-02	98.46		
	50 - 60		2.633E+06	5.508E+04	2.092E-02	97.91		
	60 - 80		4.135E+06	1.059E+05	2.560E-02	97.44		
	80 - 190		8.024E+06	2.514E+05	3.134E-02	96.87		
	190 - 300		1.301E+06	3.300E+04	2.535E-02	97.46	38	
	Integrated	op 7				99.84		
	20 - 30		2.997E+06	2.463E+03	8.216E-04	99.92		
	30 - 40		2.914E+06	3.000E+03	1.029E-03	99.90		
	40 - 50		2.558E+06	3.678E+03	1.438E-03	99.86		
	50 - 60		2.230E+06	3.834E+03	1.719E-03	99.83		
	60 - 80		3.378E+06	6.895E+03	2.041E-03	99.80		
	80 - 190		5.645E+06	1.258E+04	2.228E-03	99.78		
	190 - 300		5.405E+05	8.763E+02	1.621E-03	99.84	13	
	Integrated	op 3				99.93		
	20 - 30		5.863E+06	3.249E+03	5.540E-04	99.94		
	30 - 40		5.438E+06	3.154E+03	5.800E-04	99.94		
	40 - 50		4.369E+06	2.658E+03	6.083E-04	99.94		
	50 - 60		3.538E+06	2.456E+03	6.942E-04	99.93		
	60 - 80		4.726E+06	3.611E+03	7.640E-04	99.92		
	80 - 190		5.546E+06	4.377E+03	7.894E-04	99.92		
	190 - 300		1.976E+05	1.784E+02	9.025E-04	99.91	41	
	Integrated	op 1				99.93		
	20 - 30		4.338E+06	1.968E+03	4.537E-04	99.95		
	30 - 40		3.885E+06	2.125E+03	5.471E-04	99.95		
	40 - 50		3.044E+06	1.939E+03	6.370E-04	99.94		
	50 - 60		2.428E+06	1.747E+03	7.196E-04	99.93		
	60 - 80		3.299E+06	2.703E+03	8.196E-04	99.92		
	80 - 190		4.170E+06	3.586E+03	8.601E-04	99.91		
	190 - 300		2.559E+05	1.983E+02	7.751E-04	99.92	85	
	Integrated	op 5 (r.)				99.93		
20 - 30	3.196E+06		1.769E+03	5.536E-04	99.94			
30 - 40	3.186E+06		2.051E+03	6.437E-04	99.94			
40 - 50	2.839E+06		1.770E+03	6.234E-04	99.94			
50 - 60	2.578E+06		1.774E+03	6.882E-04	99.93			
60 - 80	4.086E+06		2.770E+03	6.779E-04	99.93			
80 - 190	7.794E+06		5.809E+03	7.453E-04	99.93			
190 - 300	1.268E+06		1.127E+03	8.888E-04	99.91	41		
average filtration efficiency of all operation points						99.55		

Table D.6 — Test report: results of filtration test (5.3)**Exhaust opacity before*)/after filter with free acceleration**

SNR 277205, Tab. D.6

Cooling medium temperature	80 [°C]
Lubricating oil temperature	90 [°C]

Test no.	Max. exhaust opacity [m ⁻¹]	
	Exhaust opacity before (or without) filter	Exhaust opacity after filter
1	0.74	0.02
2	0.72	0.02
3	0.81	0.02
4	0.77	0.02
5	0.78	0.02
6	0.79	0.02
7		
8		
9		
10		
Average of last four consecutive readings within scatter band of 0.25 m ⁻¹	0.79	0.02

*) or without filter

Table D.7 — Test report: results of regeneration test (5.4)

Maximum pressure loss of filter during regeneration cycle	- [kPa]
Exhaust temperature at balance point (BP)	- [°C]

Emissions during regeneration cycle

CO

Load level		without DPF	with DPF	
[%]	[Nm]	CO [ppm]	CO [ppm]	K _{CO} [%]
10				
20				
30				
40	200	154	129	16
50	250	113	90	20
60	300	84	70	17
70	350	63	53	15
80	400	50	42	16
90	450	42	36	13
100	500	37	31	16
Integral		77	65	16

HC

SNR 277205, Tab. D.7

Load level		without DPF	with DPF	
[%]	[Nm]	HC [ppm]	HC [ppm]	K _{HC} [%]
10				
20				
30				
40	200	21	18	11
50	250	19	16	14
60	300	16	15	9
70	350	14	13	7
80	400	12	11	13
90	450	11	9	13
100	500	11	8	24
Integral		15	13	13

NO_x

Load level		without DPF	with DPF	
[%]	[Nm]	NO _x [ppm]	NO _x [ppm]	K _{NO_x} [%]
10				
20				
30				
40	200	216	233	-8
50	250	233	250	-8
60	300	253	270	-7
70	350	273	293	-7
80	400	298	316	-6
90	450	314	338	-8
100	500	339	358	-6
Integral		275	294	-7

NP

Load level		without DPF	with DPF	
[%]	[Nm]	NP [µgEC/m ³]	NP [µgEC/m ³]	K _{NP} [%]
10				
20				
30				
40	200	99799	2	100.00
50	250	139095	9	99.99
60	300	160435	14	99.99
70	350	160364	16	99.99
80	400	143365	16	99.99
90	450	123810	20	99.98
100	500	99576	20	99.98
Integral		132349	14	99.99

$$K_x = \frac{X_{without\ DPF} - X_{with\ DPF}}{X_{without\ DPF}}$$

K_x ...reduction rate of component "X"

X ...exhaust gas component (CO, HC, NO_x, NP)

NP ...nanoparticle

Table D.8.1 — Test report: results of NO₂/NO_x-emissions (5.5.1)

SNR 277205, Tab. D.8.1

Load level		Measurement without DPF				Measurement with DPF					
at rated speed 2000 rpm level M		t _{exhaust}	NO ₂	NO _x	NO ₂ /NO _x	t _{exhaust}	NO ₂	NO _x	NO ₂ /NO _x	ΔNO ₂	ΔNO ₂ /NO _x ^{*)}
[%]	[Nm]	[°C]	[ppm]	[ppm]	[%]	[°C]	[ppm]	[ppm]	[%]	[ppm]	[%]
40	200	269	28	216	13.2	277	10	233	4.2	19	9
50	250	292	23	233	9.7	300	4	250	1.7	18	8
60	300	312	18	253	7.0	322	2	270	0.7	16	6
70	350	330	14	273	5.1	343	1	293	0.3	13	5
80	400	349	12	298	4.0	361	1	316	0.2	11	4
90	450	366	11	314	3.5	381	0	338	0.1	10	3
100	500	382	10	339	3.0	398	0	358	0.1	10	3

$$\Delta \text{NO}_2 = \text{NO}_2 \text{ without DPF} - \text{NO}_2 \text{ with DPF}$$

$$*) \Delta \text{NO}_2 / \text{NO}_x \text{ without DPF}$$