REPORT

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Air cleaner test - Clean Air Delivery Rate (CADR)

(3 appendices)

On behalf of Nanopas AB SP has evaluated an air cleaner system were the reduction of particles in a chamber was studied. The output is a calculation of CADR and a graph of the reduction. Two tests were performed, one of the purposes was to study the difference in reduction between larger particles (> 0.3 µm) and ultrafine particles (mainly < 0.1 µm).

Items tested

Nanopas AB, model Nanopas Premium, the model name was provided by Nanopas on March 7, 2016. A total of three units were included in the tests.

Pictures of the air cleaner units are presented in appendix 1.

The air cleaners were brought to SP by Nanopas AB on March 3, 2016, and were without visible defects.

Place and date of testing

The tests were carried out at SPs laboratory for Energy and Bioeconomy in Borås between March 3-4, 2016.

Test methods and test procedure

Clean Air Delivery Rate (CADR, also known as the Equivalent cleaning rate, ECR) tests were performed in accordance with SP-method 2378. The test procedure is based on Nordtest method NT VVS 106 Approved 1995-05 and standard ANSI/AHAM AC-1-2006.

The tests were carried out in a test chamber having dimensions of 3.5 m x 3.0 m x 2.5 m, the walls were covered with polyethylene sheet. The air cleaners were placed on different locations in the chamber, mainly on different heights, approximate 70 cm, 120 cm and 160 cm. The particle counter sampling probe was mounted at a height of 1.5 m above floor level in the test chamber. By using a HEPA filter the test chamber air was cleaned. When a suitable background particle level was achieved the HEPA filter fan was turned off. Tea candles were used as particle source. Four circulation fans were turned on to mix the air in the chamber.

When the tea candles had provided a required initial particle concentration in the chamber, they were extinguished. The level of the particle concentration in the chamber was adapted to fit the particle concentration limits of the optical particle counter, including a diluter, used for the tests. The air in the chamber was mixed for 2-3 minutes after the initial concentration was reached. The circulation fans were switched off, the concentration was stabilized, and the air cleaner was started.

The measurement started two minutes after starting the air cleaner. Temperature and humidity was measured before the test was started, the relative humidity was adjusted with help of a humidifier. The natural rate of particle decay in the test chamber, i.e. without the air cleaner being in operation, was also measured.

Two different setups were performed, were two different types of particle counters were used. In the first setup particles > 0.3 µm were measured (during approximate 1 h). For the second setup, the concentration of ultrafine particles was measured (during approximate 25 min).

The calculation of decay rate is based on the following formula:

$$C_t = C_i \cdot e^{-k \cdot t}$$

Where:

C_t = Concentration at time
C_i = Initial concentration
k = Decay rate constant [1/m^3]
t = Time [h]

The decay rate constant is obtained using the linear regression on lnC_t and t

The calculation of the effective cleaning rate is:

$$CADR = V \cdot (k_e - k_n)$$

Where:

$CADR$ = Clean air delivery rate [m^3/h]
V = Room volume [m^3]
k_e = Total decay rate constant
k_n = Natural decay rate constant

CADR was measured during the first half hour of measurement.

The operating voltage was 230 V.

The energy consumption was measured during the test.

Results

The results are presented in table 1, table 2 (CADR) and in appendix 1 (Reduction of particles). CADR are presented in the range of 0.3-0.5 µm, 0.5-1, 1-5 µm, total amount of particles above 0.3 µm (table 1) and for Ultrafine particles (table 2).

Table 1. CADR, Particles > 0.3 µm

T	RH	P_{tot}	CADR			
°C	%	mbar	m^3/h			
			0.3-0.5 µm	0.5-1 µm	1-5 µm	> 0.3 µm
22.5-22.9	51.8 - 53.5	982.5	28.0	29.8	32.1	29.2

Table 2. CADR, ultrafine particles

T	RH	P_{tot}	CADR
°C	%	mbar	m^3/h
			UFP
22.5-22.9	51.8 - 53.5	983.2	190.5

T = Temperature
RH = Relative humidity
P_{tot} = Atmospheric pressure

The energy consumption was measured to 5.72 – 6.04 W.

Note that the results given in this report relate only to the actual specific item tested.

Measurement equipment

Temperature- and humidity meter, Testo 635	SPs inventory number 900 066
Multimeter, Metrahit	SPs inventory number 901 452
Diluter, Topas Dil 550	SPs inventory number 202 486
Particle counter Lasair II 310A	SPs inventory number 201 389

TSI, P-Trak, model 8525, calibrated on November 25th. The instrument was brought by Nanopas AB and it is owned by Karolinska Institutet, Stockholm.

Estimated uncertainties of measurement

Relative humidity ± 3 %-RH
Temperature ± 1 °C
Voltage ± 0.5 %
Energy consumption ± 5 %
CADR < 10 %

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Appendices
1. Reductions of airborne particles.
2. Picture of the test item.

Appendix 1

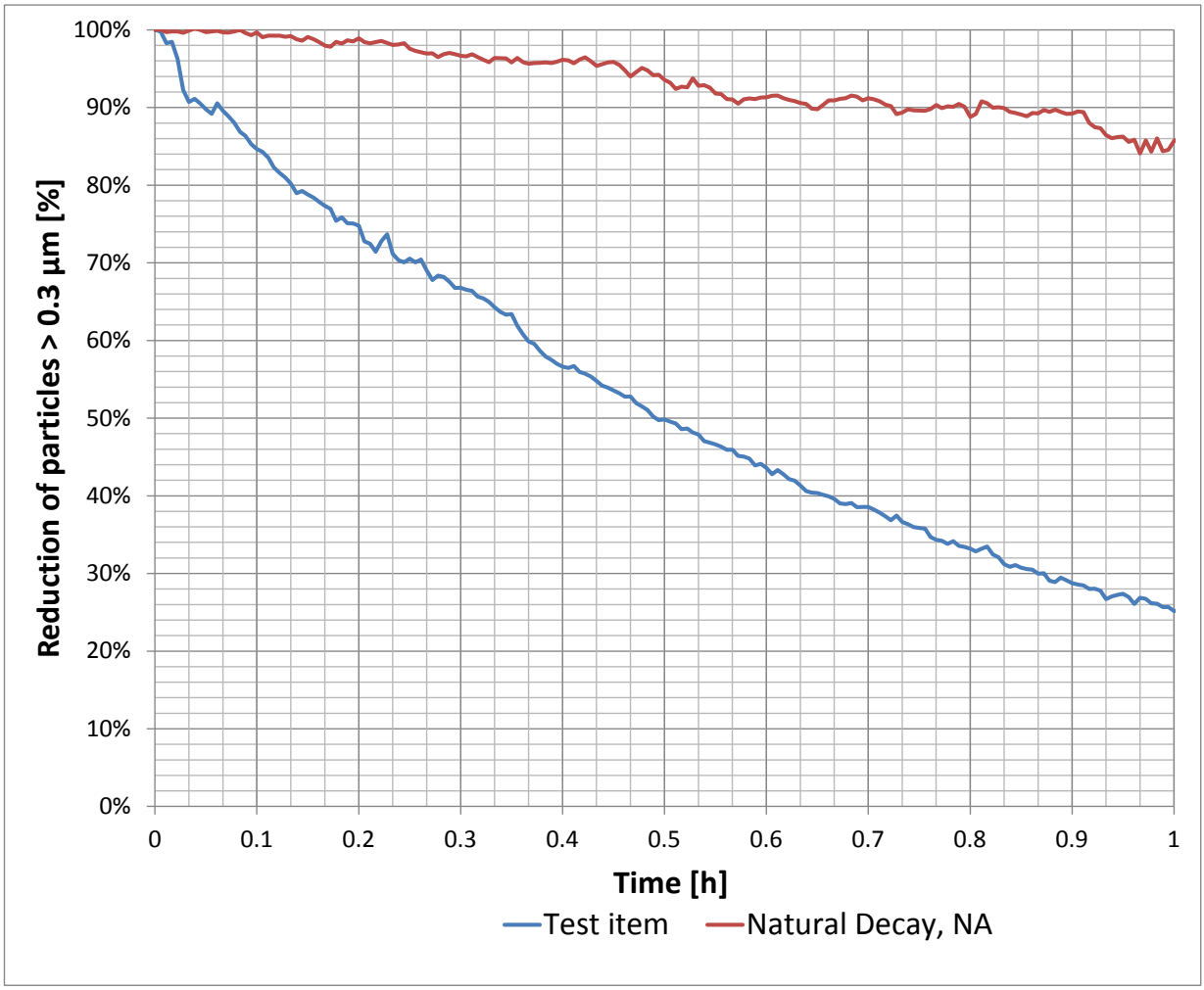

Fig 1. Reduction of particles > 0.3 µm, approximate 60 minutes.

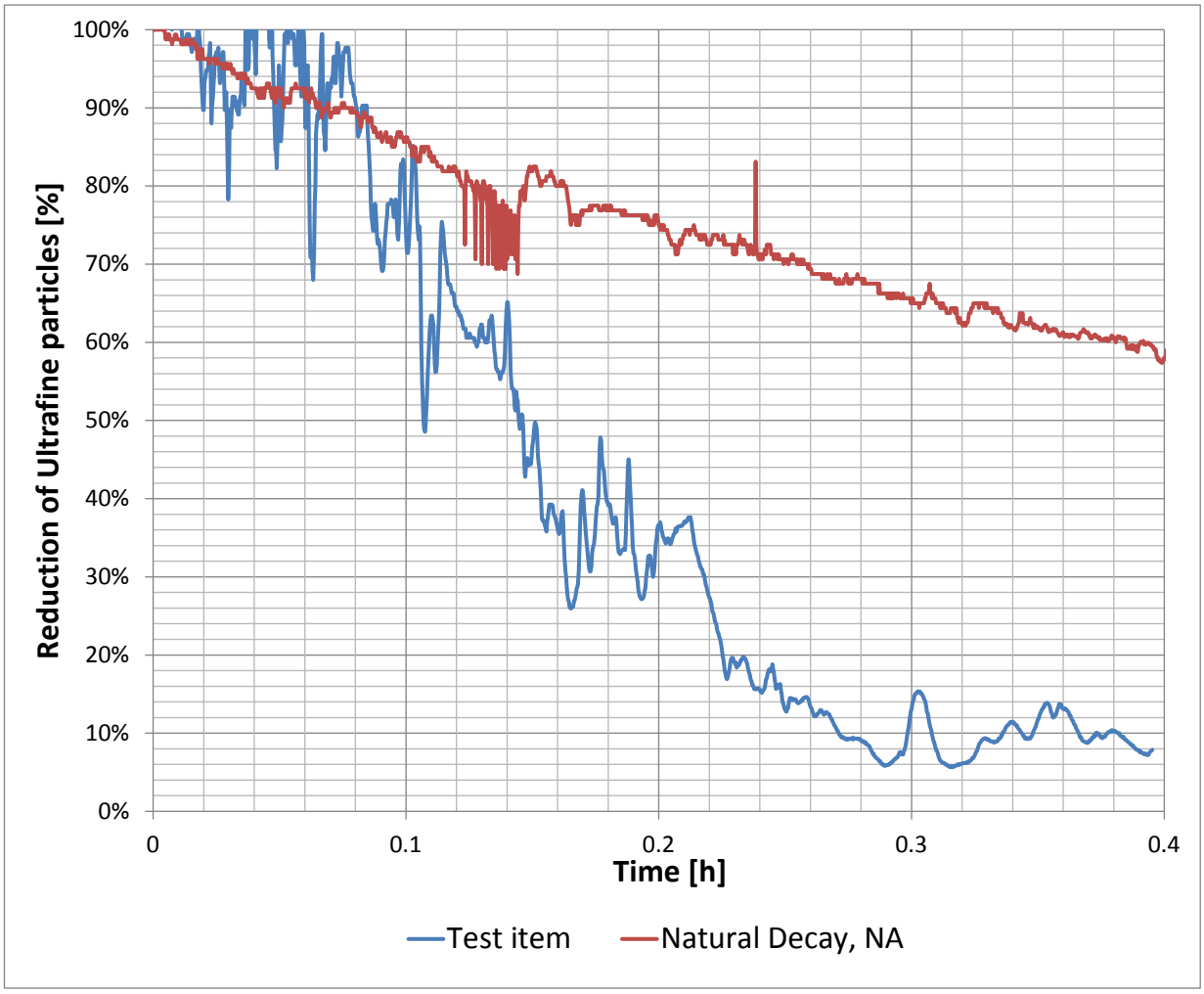

Fig 2. Reduction of ultrafine particles, approximate 25 minutes.

Appendix 2

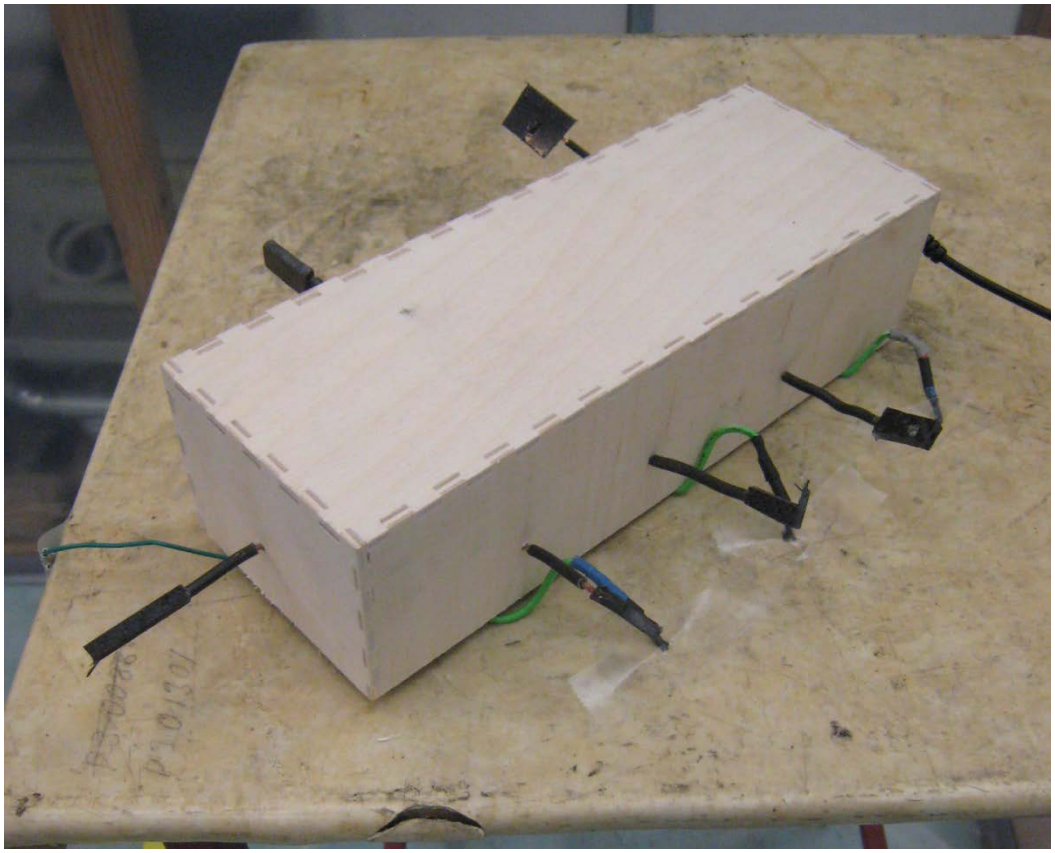

Fig 1. Unit one, overview.

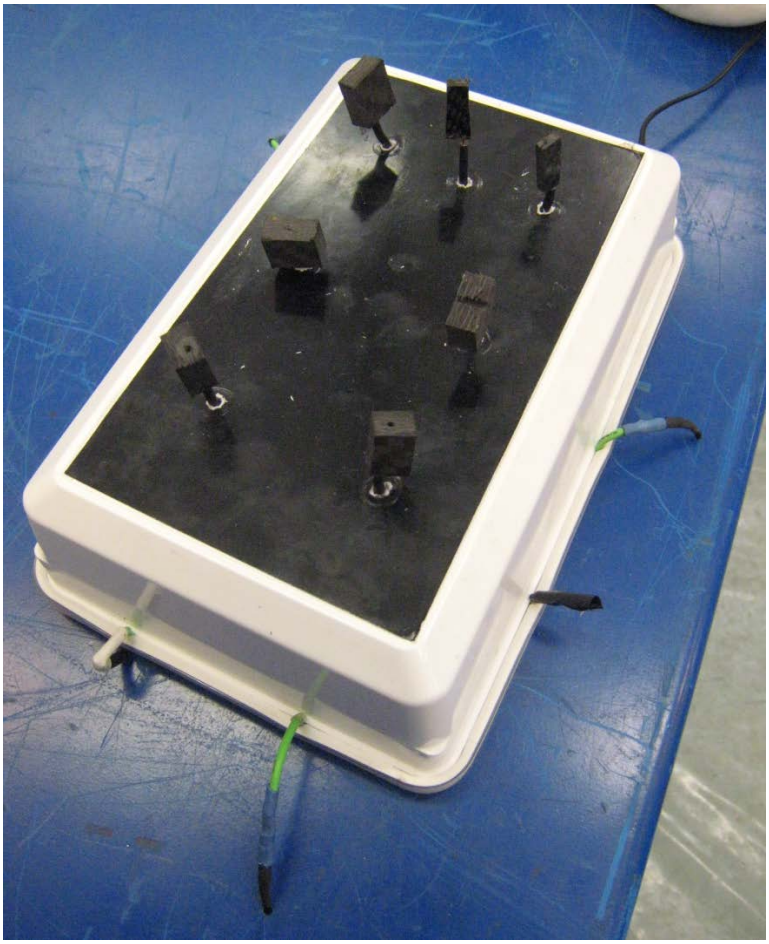

Fig 2. Unit two, overview.

Appendix 2

Fig 3. Unit 3, overview.