Instytut Badań Stosowanych
POLITECHNIKI WARSZAWSKIEJ SP. Z O.O.

OPINION

ON FILTRATION EFFICIENCY

AIM AND SCOPE:

The opinion has been prepared in response to an order from **Oxygen City Sp. z o.o.** The objective of this opinion was to assess the efficiency of air purification, in particular from particles present in the outside air. The efficiency of air filtration from pollutants was assessed on the basis of documentation provided by the Ordering Party and other data available in the literature. A comparison was also carried out with alternative solutions used to remove dusts from polluted air streams.

AUTHORS:

Piotr Kępa, Ph.D., Artur Badyda, Ph.D. Eng.

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Instytut Badań Stosowanych Politechniki Warszawskiej Sp. z o.o.

Adres biura:
ul. Rektorska 4, 00-614 Warszawa

tel.: 22 234 7052
e-mail: biuro.ibs@pw.edu.pl

Siedziba:
ul. St. Noakowskiego 18/20, 00-668 Warszawa

Sąd Rejonowy dla Miasta Stołecznego Warszawy
XII Wydział Gospodarczy, KRS: 0000440779
REGON: 146402159, NIP: 7010360620
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In accordance with the technical documentation provided by the Ordering Party, the device is equipped with 16 electrostatic filters, selected in filtration class EU7 (Table 1). In the technical data sheet it is stated that the filters used require regular cleaning, at least every 6 months.

Table 1. Filter classes, their efficiency and example use (sy-klone.com)

Comparison of EU Standards to ASHRAE 52.1, 52.2 (MERV Ratings)

Standard European Filter Classification

Filter	General properties	Class	Effect	Applications
Basis filters	In general: - produced in synthetic fibers - efficient for particles > 4-5 mm - air speed < 2.5 m/s - start pressure drop approximately 50 Pa - final pressure drop approximately 150 Pa	EU1	Protects against insects and fibers. Limited effect against larger pollen (<70%) Ineffective against smoke and blacking particles	Window units Heat exchangers Air heaters Fiber filters in textile industry
		EU2	Effective against larger pollen (>85%) and larger atmospheric dust. Limited effect against dust and blacking particles	Heating and cooling units in electrical transformers garages industrial halls offices in industry
		EU3	Effective against larger pollen (>85%) and larger atmospheric dust. Limited effect against dust and blacking particles	Heating and cooling units in electrical transformers garages industrial halls offices in industry
		EU4	Limited effect against dust and blacking particles	In addition to EU3 kitchens and spray paint work shops
Fine filters	In general: - produced in glass fibers - efficient for particles > 0.1 mm - air speed < 2- 3 m/s - start pressure drop approximately 50-100 Pa - final pressure drop approximately 200 -250 Pa	EU5	Effective against pollen and finer atmospheric dust Considerable effect against smoke. No effect against tobacco smoke	Churches, sport halls, department stores, schools, hotels Food stores
		EU6	As EU5	As EU5
		EU7	Effective against pollen and blacking dust	As EU6 and food industry, laboratories, theatres, hospital rooms, data rooms
		EU8	Very effective against particles and blacking. Very effective against microbes. Effective against tobacco smoke.	Operating theatres, production rooms for fine optics and electronics. Hospital examination rooms.
		EU9	As EU8	As EU8

In accordance with the data presented in Table 1, EU7 class filters are fine filters, effective in removing particles of >0.1 micrometer size. Filters of this class are used, among others, in laboratories, server rooms, hospital rooms or production halls. The standard airflow rate is 2-3 [m/s] (in the analyzed case it is 2.5 [m/s]). Selection of this filter class for the device to be used as a city air purifier seems to be fully justified.

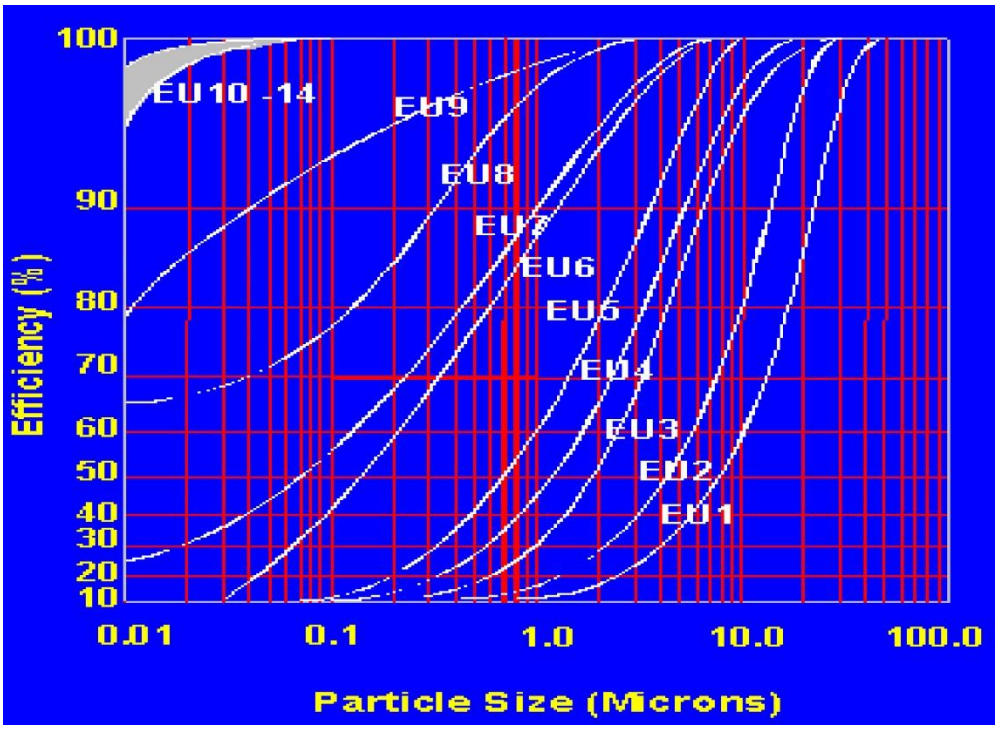

Figure 1. Filter class efficiency and particle size (sy-clone.com)

Based on the data shown in Figure 1, it is possible to determine the filter/absorption efficiency of particles depending on their size and the class of filter used. The efficiency of EU7 class filter for particles with 0.1 ⍰⍰m equivalent aerodynamic diameter is 55-65%. This efficiency increases along with increasing particle sizes.

The expertise of ILH Berlin (Figure 2) shows that filters used in the device can achieve a total filtration efficiency comparable to that of E11-H13, achieving a total efficiency of 98.24% to 99.96%. Filters of E11-H13 class are used, among others, in hospitals, pharmaceutical industry, air purifiers and other cases where significant air purity is required. The total particle separation through the filter is achievable for:

- Low flow velocity;
- Serial location of filters;
- In relation to particles >0,3-0,9 µm;
- With minimal or constant pressure drop in the filter.

INSTITUT FÜR LUFTHYGIENE

Prof. Dr. med. H. Rüden
Dr.-Ing. M. Möritz (GbR)

Kluckstraße 35
D - 10785 Berlin

ILH BERLIN

Expertise on Hygiene

(reduction)

Of efficiency of the HI-TECH NATURE SYSTEM (HTNS) of the Company EXPANSION ELECTRONIC Srl, Via delle Industrie 18, 36050 Cartigliano (VI), Vicenza, Italy for the abatement of living particles (microorganisms) and nonliving ones (dust) from air.

Content of the report

On behalf of the Company EXPANSION ELECTRONIC Srl it was made a survey to test the efficiency of the HTNS of the Company EXPANSION ELECTRONIC S rl, on abatement of living particles (microorganisms) and nonliving ones (dust) from the air. For the realization of tests it was made available by the principal, a sample of the machine type HI-TECH NATURE SYSTEM (HTNS), model 115 / 3D Oil.

The determination of efficiency of abatement of HTNS was simultaneously performed by determining the concentration of microorganisms (Micrococcus luteus, Rhodotorula Rubra, mold, natural spectrum of outdoor air) and particles in the air before and after the electrostatic filtration unit, after each single emitter and the exit of the inlet jets (after neutralizers and revitalizer). As air to be tested, it was used outside air. Tests were led with different air speeds and with different relative air humidity.

Conclusion of test results

The HTNS is capable of eliminating from the air to be filtered airborne bacteria (M. luteus), yeasts (R. rubra) and molds with an efficiency that ranges from 98.53% to> 99.96% which depends on the type of germs and the relative humidity. Against airborne particles was determined with an efficiency between 98.24% and 99.48%. The HTNS produces hygienic, energetic and economic benefits and is recommended in a large number of applications, particularly as the second level of filtration in the following sectors: agri-food, pharmaceutical, clean room, hospital, textile production, printing and paper, tobacco production and ventilation and air conditioning systems in places with high air pollution (compares extended expertise).

From the results obtained in tests with the application of HTNS it's possible to signal the following advantages compared to traditional filters in extende d surface (pockets, cells or boxes of glass fibers, synthetic or celluloses):

1. Higher efficiency of electrostatic filtr ation unit (comparable to H11 -H13 according to DIN EN 1882);

2. As a result of (1): the cleaning of the air ducts (the respect of the norm VDI 6022 is sure, Sheet 1 (7/98) which considers 10 g / m^2 of dust thickness);

3. Using pocket filters and bag ones there is a possible formation and release of toxic microbial products from decomposition such as endotoxins, while through the use of HTNS in electrostatic filters t his is not to be expected, but in a negligible amount; this according to the results of the tests performed;

4. The reduction of electrostatic cell depends substantially on the diameter of the particles and by their ability to receive the electric charge. Since the size of the particles of Legionella and the M. luteus are in the same order of dimension, it is concluded that the removal of Legionella by the filter cell of HTNS as high as the Micrococcus luteus;

5. Minimum and almost constant pressure drops;

6. It musts be expected for lower maintenance costs due to the multiple regenerability of electrostatic cells.

Berlin, 18/06/2010

Geprüfte Hygiene-merkmale
ILH Berlin
geprüft nach VDI 6022, Blatt 1
Institut für Lufthygiene

(Dr.-Ing. M. Möritz) (Dr.-Ing. H. Peters)

Figure 2. Expertise on filters by ILH Berlin

Figure 3 shows a comparison of the separation capacity of airborne particles using different dust collectors. Number 5 indicates electrostatic dust collectors, which are capable of separating particles from 0.01 µm to 100 µm.

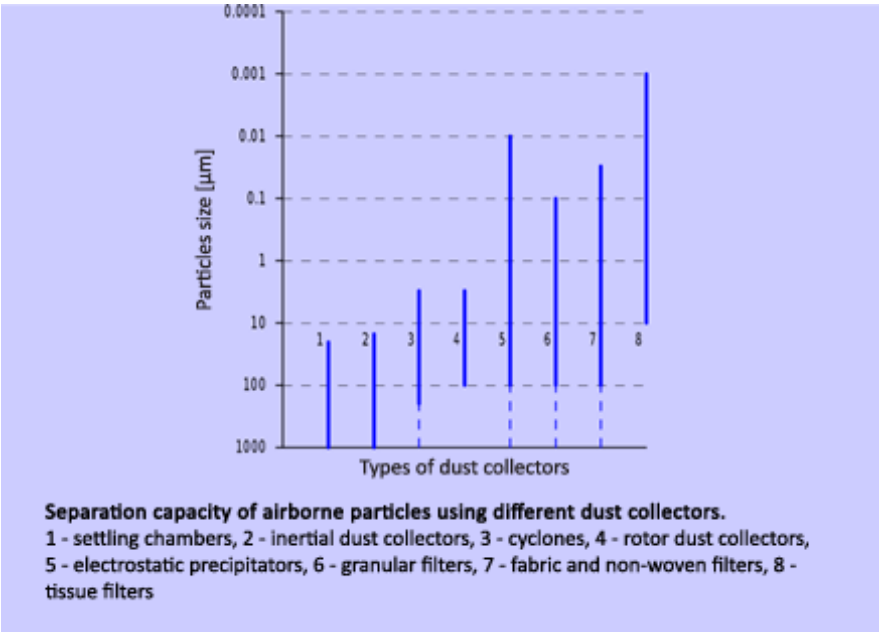

Figure 3. Comparison of dust collector types with particle separation (Prof. K. Badyda, ITC PW)

Figure 4 shows the size ranges of various particles that may be present in the air. Electrostatic filters are capable of absorbing particles from 0.01 µm to 100 µm. Taking this into account, it seems to be fully justified to use electrostatic filters in urban air purification. Electrostatic filters can effectively stop dust floating in the air (including the vast majority of PM10 or $PM_{2.5}$ particles).

Such filters can also be effective in absorbing particles corresponding to the size of a vast majority of bacteria.

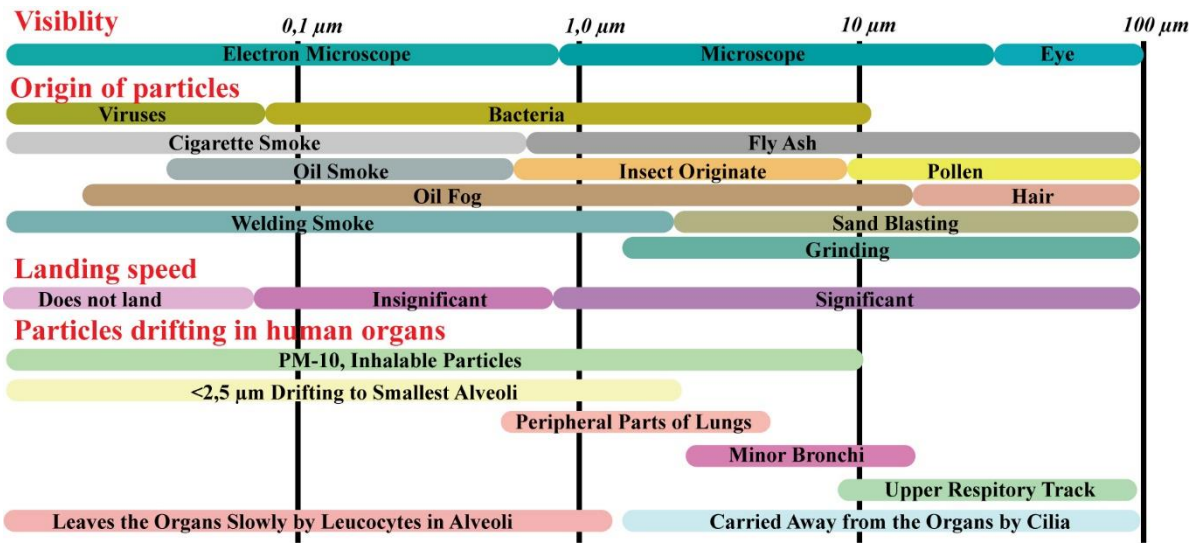

Figure 4. Types and sizes of particles in the air (Prof. K. Badyda, ITC PW)

The use of electrostatic filters in the analyzed device has specific advantages compared to other types of filters. The most important advantages of electrostatic filters include:

- Wide range of removed particle sizes;

  From 0.01 µm to 100 µm, i.e. dimensions in which the vast majority of particles present in urban conditions occur.

- Electrostatic filters do not need to be replaced, but rather cleaned;

  This is a big advantage compared to filters, e.g. HDPE, which need to be replaced after a certain quantity of particulate matter has been captured. When properly operated and cleaned, electrostatic filters have a longer service life, which reduces operating costs and the emission of pollutants and other environmental costs associated with the disposal of used filters. The frequency of cleaning the electrostatic filters depends of course on the concentrations of pollutants present in the filtered air.

- Lower airflow resistance during filter operation with accumulated dirt;

  Electrostatic filters are characterized by a very low efficiency drop that occurs with the filter lifetime. In electrostatic filters, a 4% drop in efficiency is observed, while in HEPA filters made of high density polyethylene, the drop in efficiency may even exceed 20%. https://www.lakeair.com/hepa-vs-electrostatic/

- High efficiency of electrostatic precipitators compared to other types of filters;

  Dust extraction rate (efficiency) with the use of electrostatic precipitators, with the appropriate selection of the type of cleaner and its dimensions reaches – depending on the size of particles – value of up to 99.99%, without the need to replace filters and decreases in efficiency (Directions of improvements of modern electrostatic precipitators P.TRACZ L.BIAŁY K.WACŁAWIAK)

- High efficiency of electrostatic precipitators , at high flow velocity (using 3 electrostatic precipitators connected in series);

  The efficiency level of electrostatic precipitators , depending on the airflow velocity through the filter, is shown in Table 2.

Table 2. Efficiency of FE600 filters depending on the airflow velocity

EN 1822-5: DETERMINING THE EFFICIENCY OF FILTER ELEMENTS

EN1822-5: Particle measurements

Air filter: FE600, 3 filters in series

Test No: SP201504171

Test Aerosol: DEHS

Air flow rate: 850 - 4250m^3/h

Particle size				Efficiency %									
Interval µm			Mean µm	850 m^3/h		1700 m^3/h		2550 m^3/h		3400 m^3/h		4250 m^3/h	
				E	$E_{95\%min}$	E	$E_{95\%min}$	E	$E_{95\%min}$	E	$E_{95\%min}$	E	$E_{95\%min}$
0.10	-	0.12	0.11	99.991	99.990	99.977	99.975	99.69	99.68	96.76	96.68	90.83	90.66
0.12	-	0.14	0.13	99.992	99.991	99.974	99.972	99.57	99.55	95.77	95.66	89.10	88.88
0.14	-	0.16	0.15	99.992	99.991	99.973	99.971	99.50	99.48	95.34	95.22	88.53	88.30
0.16	-	0.18	0.17	99.991	99.990	99.970	99.968	99.43	99.41	94.97	94.84	87.73	87.48
0.18	-	0.20	0.19	99.991	99.990	99.968	99.965	99.39	99.37	94.91	94.77	87.30	87.03
0.20	-	0.22	0.21	99.991	99.990	99.970	99.967	99.39	99.36	94.73	94.59	87.42	87.15
0.22	-	0.24	0.23	99.990	99.989	99.968	99.966	99.37	99.35	94.91	94.76	87.38	87.10
0.24	-	0.26	0.25	99.992	99.99	99.970	99.967	99.39	99.37	94.98	94.84	87.44	87.15
0.26	-	0.28	0.27	99.990	99.989	99.970	99.967	99.39	99.37	95.30	95.16	87.76	87.47
0.28	-	0.30	0.29	99.991	99.990	99.971	99.968	99.43	99.40	95.48	95.33	87.98	87.67
0.30	-	0.32	0.31	99.991	99.990	99.971	99.968	99.49	99.47	95.65	95.49	88.71	88.38
0.32	-	0.35	0.33	99.990	99.989	99.976	99.974	99.54	99.51	96.00	95.87	89.10	88.84
0.35	-	0.45	0.40	99.992	99.991	99.978	99.977	99.68	99.67	97.03	96.97	90.86	90.72
0.45	-	0.60	0.52	99.992	99.991	99.982	99.980	99.85	99.84	98.14	98.08	93.78	93.64
0.60	-	0.75	0.67	99.992	99.990	99.985	99.981	99.91	99.90	98.74	98.66	95.95	95.78
0.75	-	1.00	0.87	99.991	99.989	99.987	99.984	99.93	99.92	99.32	99.26	96.81	96.65
1.00	-	1.50	1.22	99.995	99.992	99.985	99.979	99.96	99.94	99.59	99.52	97.90	97.71

E Efficiency, %

$E_{95\%min}$ Efficiency as lower limit value for the 95% level of confidence, %