EUROPEAN
TURBINE
NETWORK

Sub-Micron Aerosol Generation Research

A request to the European Turbine Network from ASHRAE GPC 35, February 2015

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Shaping Tomorrow's
Built Environment Today

Problem Statement

- Test dusts currently used in laboratory tests that are applied to filters or filter systems are not close to what actually perceived in urban/industrial environments
- This was also perceived as a gap by the ETN in a recent 2014 Air Filtration survey by at least one of the sectors (offshore/onshore)

ETN Survey Results

- The survey shows a gap on the test dust, and that ETN members surveyed generally do not believe laboratory testing performance data is adequate

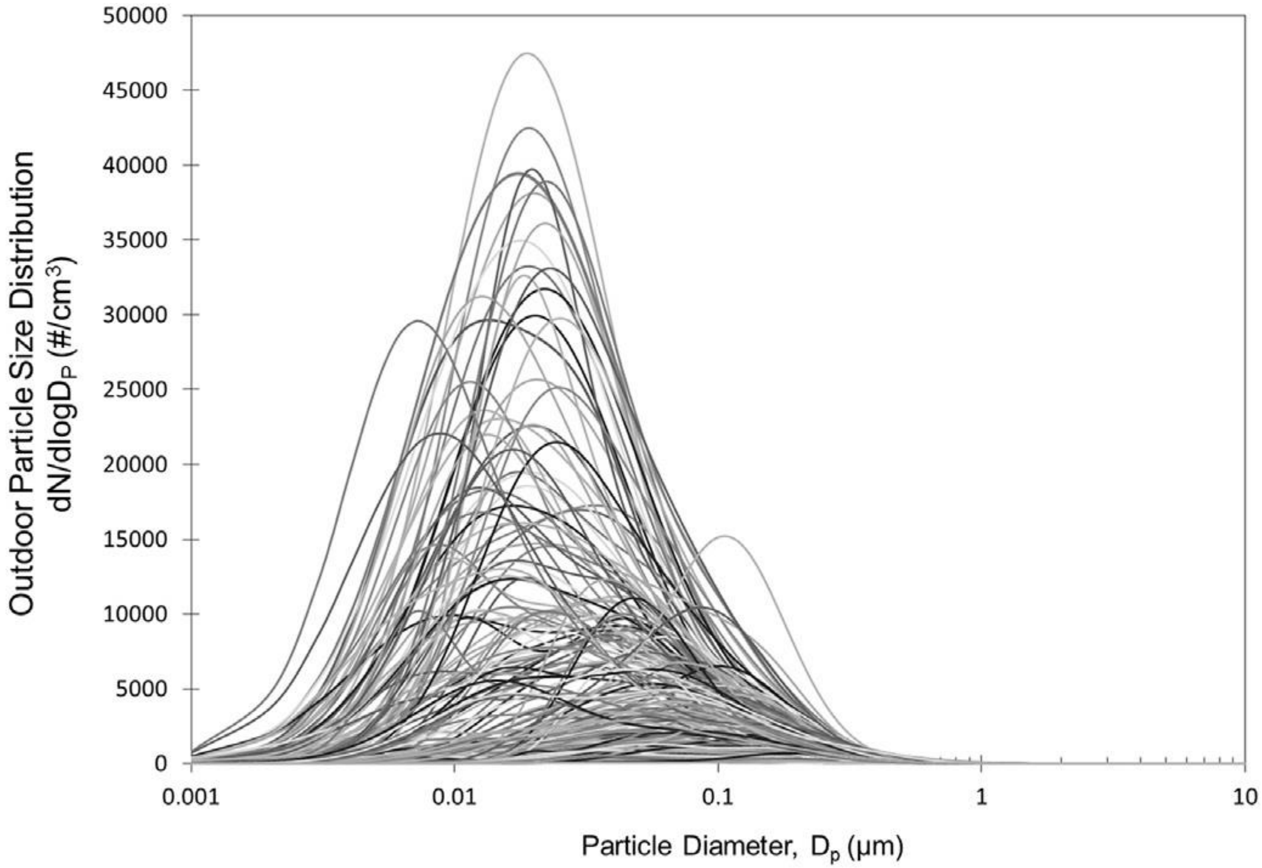
TOP 3 HIGHEST GAP (GAP : IMPORTANCE TO SATISFACTION)	Question	Q No.	GAP	Imp. Score
	1. Salt Retention	15	5.71	9.57
	2. Water Repellence	16	5.14	9.29
	3. Type of Test Dust	24	4.67	9.17

Highlights:

- The performance of filters in challenging operating conditions (High moisture, humidity) and against difficult contaminants (hydrocarbons, salts etc.) is perceived to be barely satisfactory
- The performance data provided based on laboratory testing is not fully adequate
- Onshore operators are more satisfied with the total cost of their system

The Particle Challenge is Sub-Micron

Long-term average outdoor particle size distribution
for locations in Europe, USA, and Canada (number of particles per cm^3)



Data from eight studies that reported outdoor PSDs measured in duration of at least one year, leading to a total of 194 PSDs in more than 30 locations.

Locations include Canada, USA, and Europe.

Most distributions have a **peak number concentration between 8 and 40 nm**, as is typical for most outdoor environments (Seinfeld and Pandis, 2006).

Source: Azimi et al, Estimates of HVAC filtration efficiency for fine and ultrafine particles of outdoor origin, Atmospheric Environment September 2014

Needs

- Challenge: to understand how to generate sub-micron particles in high enough concentration to challenge filters in a repeatable laboratory environment
- This will allow us to better replicate urban/industrial pollutants in lab testing
- This will more accurately reflect what is challenging for example Gas Turbine Filter systems

Opportunity

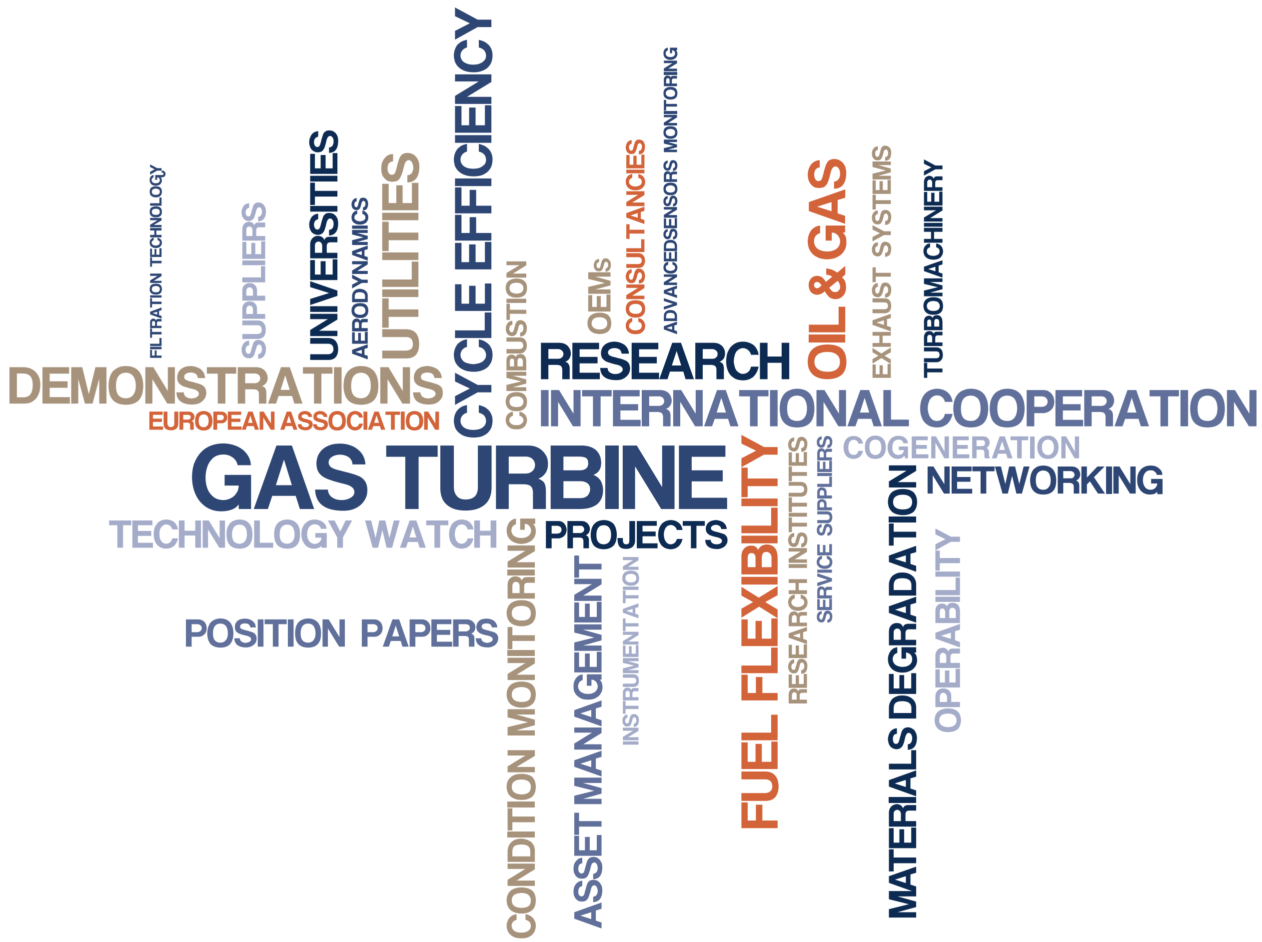
- ASHRAE is considering research to understand how to generate these particles. ETN can help sponsor this research, and in return:
  - Can help oversee this research
  - Use the published research to help shape testing standards that affect Gas Turbine filters
  - Use the research to educate others, as long as the ASHRAE copyright is cited
  - Will be cited as helping to sponsor the research
- The result of the work can be of support for the work that’s been addressed under ISO TC 142 Working Group 9 (ISO 29461 series of standards).

Timing and Cost

- The research work statement is currently being written by Paolo Tronville of the Politecnico di Torino *(RTAR 1734 – Reproducing the Typical Urban Atmospheric Aerosol in Laboratory for Air Filter Particulate Loading)*
- It is **due for submission by 8 March 2015**
- We would like to submit a concept of assistance from the ETN at that time
- A formal memorandum of understanding would have to be developed and agreed to by the ETN and ASHRAE
- Prior agreements have requested 50% of the funds available at the start of the research, and 50% upon delivery of the published research
- We expect the total cost of the research to be roughly **$250,000 and take two years to complete.**
- If the work statement is accepted, ASHRAE will send the research work statement out to bid for qualified researchers.

ETN

Thanks for your attention!



Appendix

ATMOSPHERIC AEROSOL SIZE DISTRIBUTION

By Sheldon K. Friedlander

From *Smoke, Dust, and Haze: Fundamentals of Aerosol Dynamics, Second Edition*

ATMOSPHERIC AEROSOL SIZE DISTRIBUTION

General Features

The size distribution of the atmospheric aerosol results from the action of the dynamic processes discussed in this book, on particles and gases introduced into the atmosphere from natural and man-made sources. Measurements of atmospheric size distributions at various California locations are shown in Fig. 13.1 as $dV/d\log d_p$ versus $\log d_p$. Plotted in this form, the aerosol mass in any size range is proportional to the area under the curve between the size range limits, assuming that particle density does not vary with particle size. Figure 13.1 shows that there are usually two modes in the mass distribution: the *coarse mode* corresponding to particles larger than 2 to 3 um in diameter and the *accumulation mode* between about 0.1 and 2.5 um.

Distributions of this form have been observed at many different geographical locations. This important generalization, due to K. T. Whitby, has had a profound effect on our understanding of the atmospheric aerosol. Particles smaller than about 0.1 um, the *ultrafine range*, sometimes appear in the form of an additional mode if freshly formed or emitted. Usually, however, the ultrafine mass distribution decreases monotonically with decreasing particle size. Aerosol number and volume concentrations in each size range can be grouped according to the type of atmospheric region.

Approximate values for these integral parameters are given in Table 13.1.

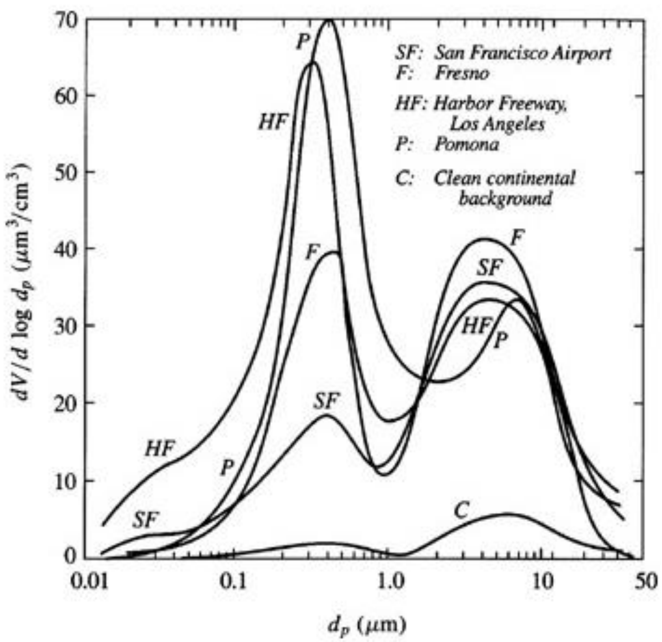
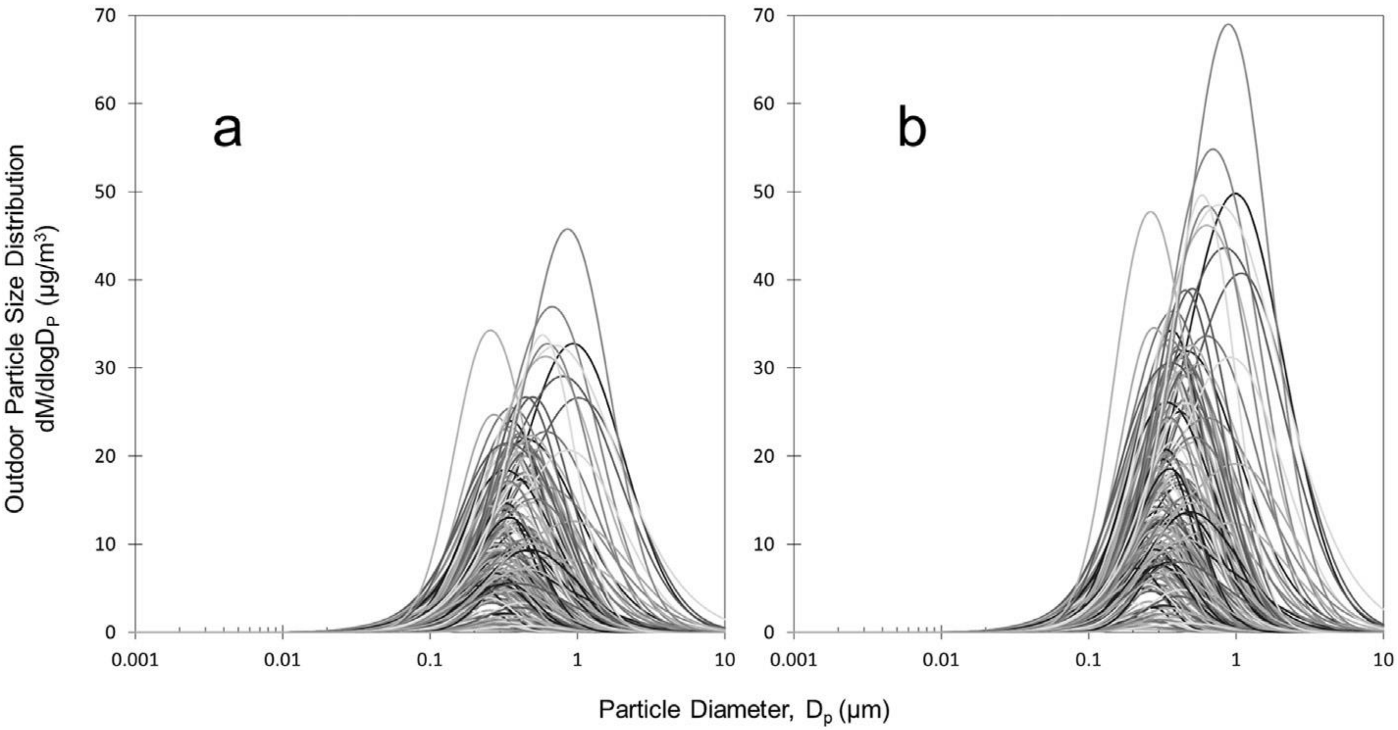


Figure 13.1: Atmospheric aerosol size distributions measured at various locations...

Outdoor Particle Mass Distribution, Mass (µg) per m^3



Data from eight studies that reported outdoor PSDs measured in duration of at least one year, leading to a total of 194 PSDs in more than 30 locations.

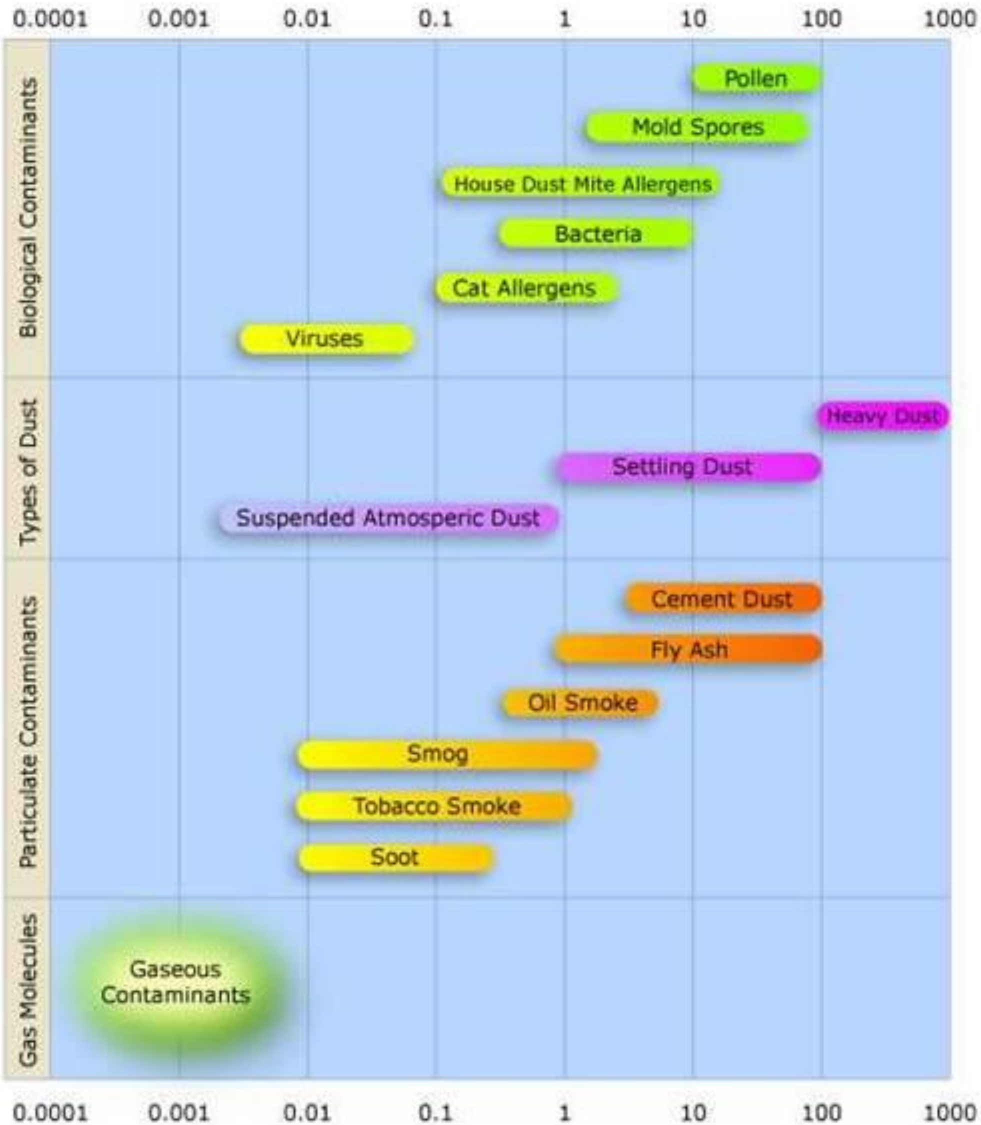
Locations include Canada, USA, and Europe.

The **mass distributions peak between 0.2 and 2 µm** for all outdoor scenarios, consistent with literature on many outdoor environments.

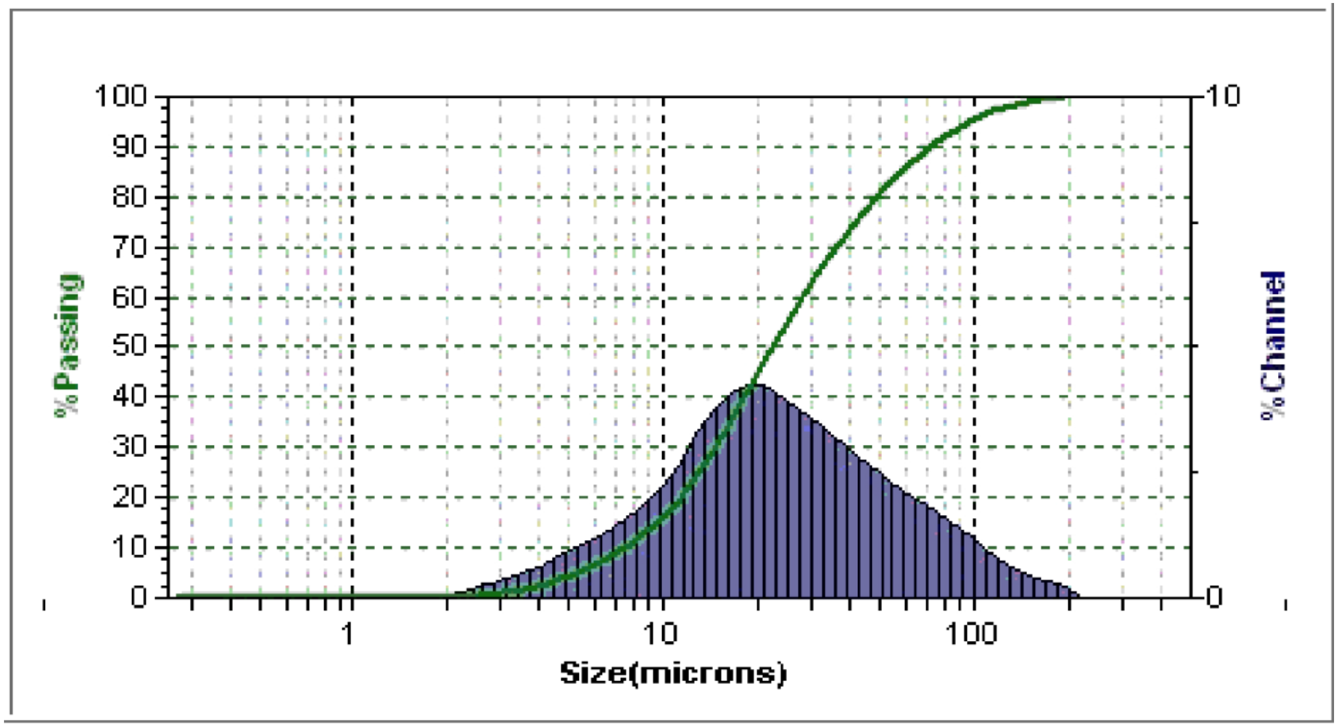
Long-term average outdoor particle mass distributions for all 194 locations assuming (a) constant unit density and (b) density varies with particle size.

Source: Azimi et al, Estimates of HVAC filtration efficiency for fine and ultrafine particles of outdoor origin, Atmospheric Environment September 2014

Typical Airborne Contaminants by Particle Size



Particle Size Distribution, ASHRAE Test Dust



ASHRAE Test Dust *starts* at 2 µm particles, and has a peak at 20 µm particles. It contains no submicron particles, and the bulk of it is well within the settling dust range.

Particle Size Distribution, ISO-Specified Test Dusts

ETN

4 Particle size distribution

Particle size distribution is determined using a Coulter[1)] Multisizer IIe™ particle size analyser. Table 2 specifies cumulative volume particle size limits for ISO-specified test dusts made from Arizona desert sand.

Table 2 — Particle size distribution

Size µm	**Maximum volume fraction, %**			
	A1 ultrafine	A2 fine	A3 medium	A4 coarse
1	1 to 3	2,5 to 3,5	1 to 2	0,6 to 1
2	9 to 13	10,5 to 12,5	4,0 to 5,5	2,2 to 3,7
3	21 to 27	18,5 to 22,0	7,5 to 9,5	4,2 to 6,0
4	36 to 44	25,5 to 29,5	10,5 to 13,0	6,2 to 8,2
5	56 to 64	31 to 36	15 to 19	8,0 to 10,5
7	83 to 88	41 to 46	28 to 33	12,0 to 14,5
10	97 to 100	50 to 54	40 to 45	17,0 to 22,0
20	100	70 to 74	65 to 69	32,0 to 36,0
40	—	88 to 91	84 to 88	57,0 to 61,0
80	—	99,5 to 100	99 to 100	87,5 to 89,5
120	—	100	100	97,0 to 98,0
180	—	—	—	99,5 to 100
200	—	—	—	100

The finest dust, ISO A1 Ultrafine, starts at 1-3% of 1 µm particles, and only gets bigger. All of this is within settling dust range.