Weaknesses of the traditional approach to the Indoor Air Quality (IAQ)

Jan Czerwinski,
VERT, NanoCleanAir

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VERT Forum, METAS Bern, 19.03.2026

Experiences of VERT & NanoCleanAir

www.vert-certification.eu
www.nanocleanair.ch

The most important facts

- VERT working with anorganic NANOPARTICLES from engines since more than 30 years: highest filtration quality – NANOFILTRATION, metrology, research and…
- DPF in tunnelling and mining later all engines (still a lot to do…)
- Since 2011 first automotive legislation considering PN (particle number, EU, Diesel cars)
- Since 2020 (pandemy) NanoCleanAir works with infectious nano-aerosols

NANOFILTRATION = VIRUS FILTRATION

- Implementation in advanced ventilation systems
- AQ (in-& outdoor) lags behind the findings and clings to PM 2.5 (until today)

Events at the Beginning of the Pandemy March/April 2020

- December 2019 high number of infections (454) on the cruiser “Diamond Princess”
- Very high number of infections (1500) in meat processing company “Tönnies“, D
- Numerous infections in the meat processing companies in Switzerland

Conclusion:

The air conditioning and ventilation systems played a decisive role in the homogenization and distribution of the virus-enriched aerosol.

Important References

- WHO – Indoor Ventilation Guidelines – Covid-19 – 2021 **2020**
- AUVA – Luftfiltration Normen, Ausgabe 1-2018
- VDMA – Raumlufttechnische Anlagen in Zeiten von Covid-19, Apr.2020
- Max-Planck-Institut – Abluftanlage für Klassenräume, Nov. 2020
- GAeF – Gesellschaft für Aerosolforschung – Positionspapier Covid-19, 2020
- DIN EN 1822-1, High Efficiency Air Filters (EPA, HEPA and ULPA), Oct. 2019
- SIA 2023 Merkblatt – Lüftung in Wohnbauten
- Tappler, P: Corona und Lüftung(sanlagen); BauphysikerInnen Treffen 2020
- Diverse technisch-wissenschaftliche Publikationen, Präsentationen und Webinars zur Corona-Problematik (US EPA, US Academy of Sciences)

Filtration – Specifications and Ratings

- EPA … Efficient Particulate Air filter
- HEPA … High-Efficiency Particulate Air filter (down to 0.3 µm)
- ULPA … Ultra-Low Penetration Air filter (down to 0.12 µm)
- MERV … Minimum Efficiency Reporting Value (classification of the ASHARE … American Society of Heating Refrigerating and Air-Conditioning Engineers); MERV Ratings 13 to 20 (down to 0.3 µm)
- Classification Standard EN 1822
- Classification Standard EN ISO 14644-1 (Class 6: down to 0.1 µm)

The weaknesses are: *(example HVAC in Switzerland)*

2020

- no legal requirements for the filtration quality indoor,
- standards/norms are used as filter guidelines, no obligatory independent controls,
- the best filtration qualities that can be found in the standards apply to the size range down to 300 nm (which is not sufficient for virus filtration),
- the standards used were developed without the virus problem and without the limit values for the number of nanoparticles in the domain of air pollution control,
- the responsibilities for this problem are decentralized and do not lie with the federal government, but with the Cantons and the building technology associations,
- there are no public mechanisms to recommend, to guarantee and to control the improved indoor filtration quality,
- however, there are skills and technical means for nano-filtration and its quality control to be introduced (experience from vehicle technology),
- official issuance of recommendations, regulations and possible incentive measures is urgently recommendable.

Book: New Perspectives in Indoor Air Quality.

Elsevier, Paperback ISBN: 9780443266430, eBook ISBN: 9780443266447, 1st Edition - November 27, 2025.

75 scientific contributors from 19 countries

- "*Postpandemic, many indoor air scientists have advocated for mandatory IAQ standards for public buildings*" (p.10)
- Influencing IAQ-legislation: "*resources available for monitoring and enforcing IAQ standards, political factors, including ideologies and agendas*" (p.14)
- "*While public health practitioners may encourage stricter IAQ standards to protect human health, construction and manufacturing industries may encourage IAQ regulations that consider economic feasibility*" (p.14)
- Sources of UFP indoor: cooking, candles, incense, mosquito coil, smoking, laser-printers, cleaning activities (p.47)
- PN measurements in schools (p.52)
- Other pollutants: gases, mikro/nano plastics (chap.6), radition Radon 222Rn [attached to UFP] (chap.7)
- Primary biological aerosol particles PBAP [viruses, bacteris, pollens, fungi] (chap.14)
- Several independent confirmations of health effects (all chaps), SBS…sick building syndrome (chap.18)

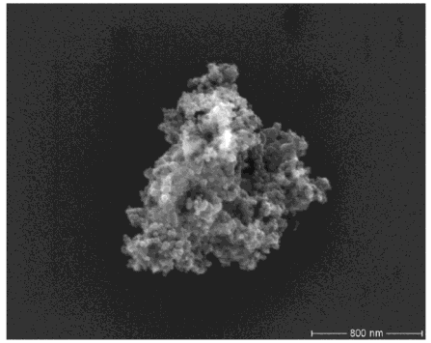
LASERPRINTER - TONER AND EMISSIONS

Healthy Indoor Air – The Lowest-Hanging Fruit For Public Health

nano-Control, International Foundation is advocating since 2008 for Stricter Regulations.

Over the past two decades, nano-Control has compiled more than 4,000 case reports from affected individuals, revealing consistent patterns of health effects linked to permanent exposure to ultrafine and nanoparticulate emissions.

Toner are mixtures of polymers, metals, and chemical additives. The printer emitted particles (PEPs) are released in the indoor air, billions by printing only one page. They accumulate in rooms, even in low doses but over prolonged periods. We are allowing them to penetrate biological barriers and reach multiple organs, including the brain.



Toner particle scale 0,8 µm

nano-Control, International Foundation, Hamburg, Foundation Board, www.nano-control.org
Member Bundesverband Deutscher Stiftungen · Cradle to Cradle e.V. · BBU e.V. · VERT® Association · GO AQS
Charity account: IBAN DE 34 2005 0550 1280 3874 89, BIC: HASPDEHHXXX, Hamburger Sparkasse

Examples from Canada & USA

Webinar: „Mitigation of Idoor Exposure to Fine Particulate Matter“
US Academy of Sciences,
April 28, 2021

2021

CANADIAN CENTRE FOR BUILDING EXCELLENCE

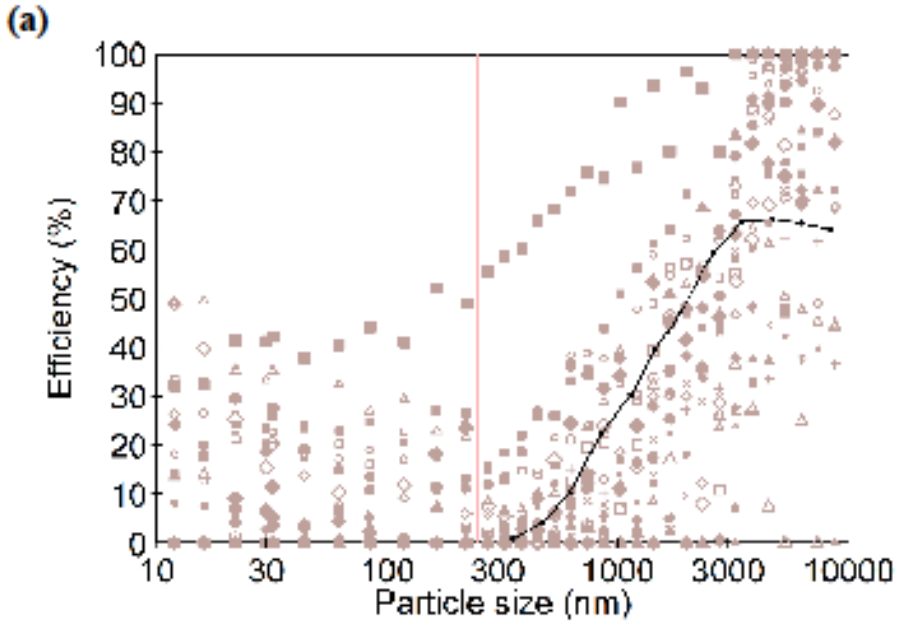
Engineering Health and Efficiency

Fine particulate matter filtration and air cleaning in residential environments

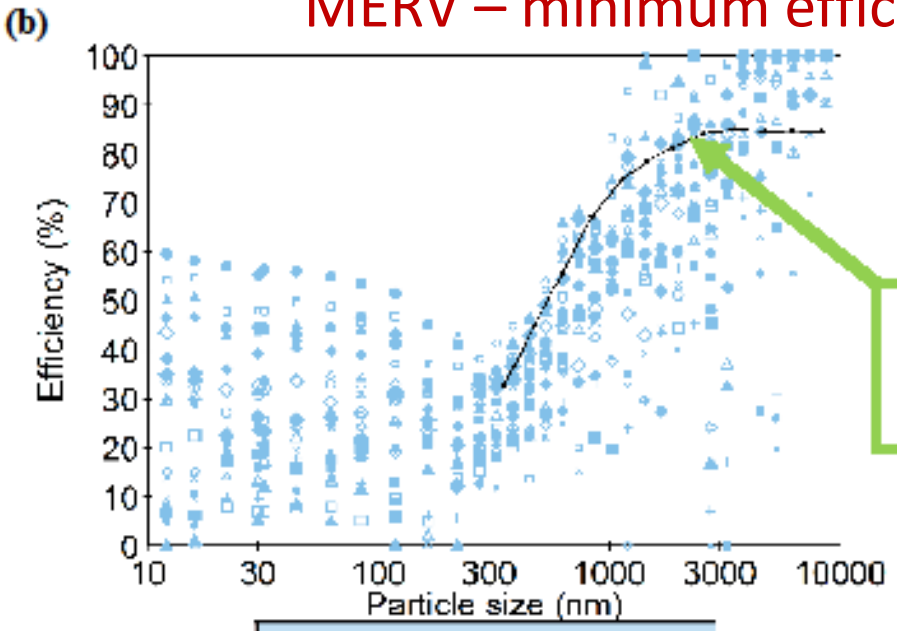
Jeffrey Siegel, jeffrey.siegel@utoronto.ca

Civil & Mineral Engineering
UNIVERSITY OF TORONTO

MERV – minimum efficiency reporting value

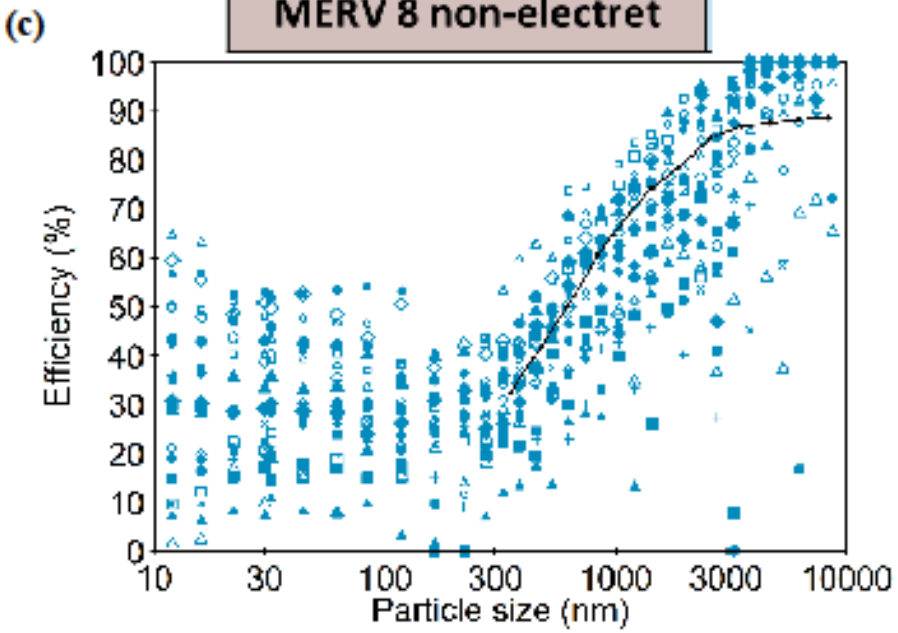


MERV 8 non-electret

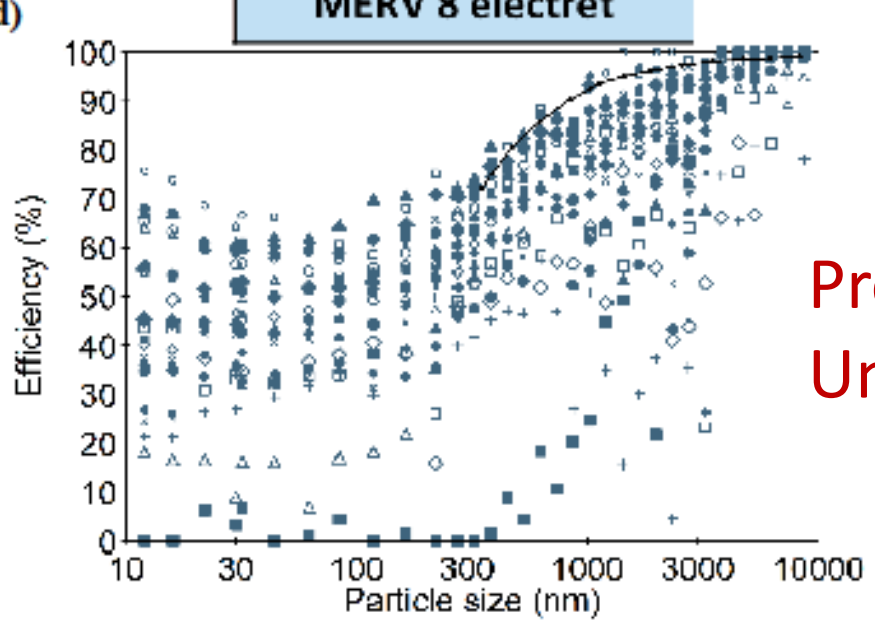


MERV 8 electret

ASHRAE 52.2
initial test



MERV 11 electret



MERV 14 Electret

Prof. Jeffrey Siegel,
University of Toronto

Li and Siegel (2020), *Indoor Air*

Efficiency: Standard 52.2

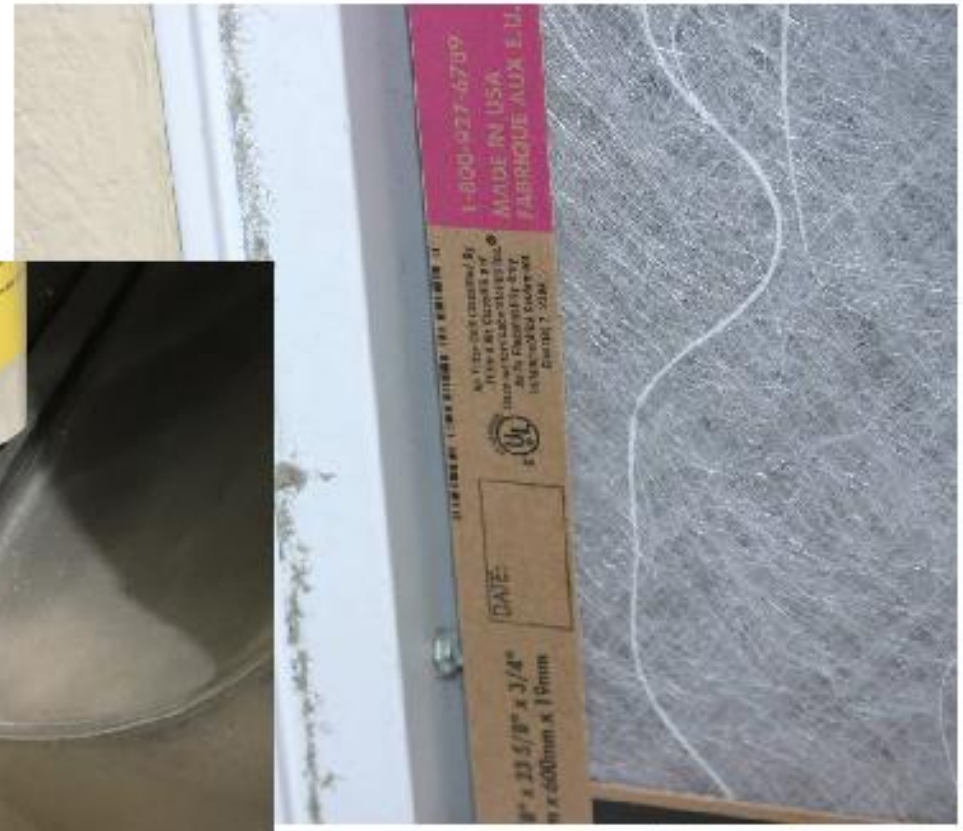
Prof. Jeffrey Siegel, University of Toronto

Table 12-1 Minimum Efficiency Reporting Value (MERV) Parameters

Standard 52.2 Minimum Efficiency Reporting Value (MERV)	Composite Average Particle Size Efficiency, % in Size Range, µm		
	Range 1 0.30 to 1.0	Range 2 1.0 to 3.0	Range 3 3.0 to 10.0
1	N/A	N/A	$E_3 < 20$
2	N/A	N/A	$E_3 < 20$
3	N/A	N/A	$E_3 < 20$
4	N/A	N/A	$E_3 < 20$
5	N/A	N/A	$20 \le E_3$
6	N/A	N/A	$35 \le E_3$
7	N/A	N/A	$50 \le E_3$
8	N/A	$20 \le E_2$	$70 \le E_3$
9	N/A	$35 \le E_2$	$75 \le E_3$
10	N/A	$50 \le E_2$	$80 \le E_3$
11	$20 \le E_1$	$65 \le E_2$	$85 \le E_3$
12	$35 \le E_1$	$80 \le E_2$	$90 \le E_3$
13	$50 \le E_1$	$85 \le E_2$	$90 \le E_3$
14	$75 \le E_1$	$90 \le E_2$	$95 \le E_3$
15	$85 \le E_1$	$90 \le E_2$	$95 \le E_3$
16	$95 \le E_1$	$95 \le E_2$	$95 \le E_3$

ASHRAE Standard 52.2-2017

- Test approach
  - In a lab
  - Perfectly installed
  - At a fixed flow rate
  - Potassium chloride aerosol
  - With successive dust loadings
  - Optional conditioning step
- Notes
  - Not a residential standard
  - Not an in-situ standard
  - Only addresses 0.3-10 µm particles



Ward & Siegel (2005) *ASHRAE Trans.*
Siegel et al. (2008) *Indoor Air Conf.*
Chojnowski et al. (2009) *ASHRAE Trans.*
VerShaw et al. (2009) *ASHRAE Trans.*

Mitigation of fine particulate matter exposures in schools

Indoor Exposure to Fine Particulate Matter and Practical Mitigation Approaches

Workshop on Mitigation of Indoor Exposure to Fine Particulate Matter

National Academies of Science and Engineering

Dr. Elliott T. Gall, Ph.D.

Assistant Professor

Department of Mechanical and Materials Engineering

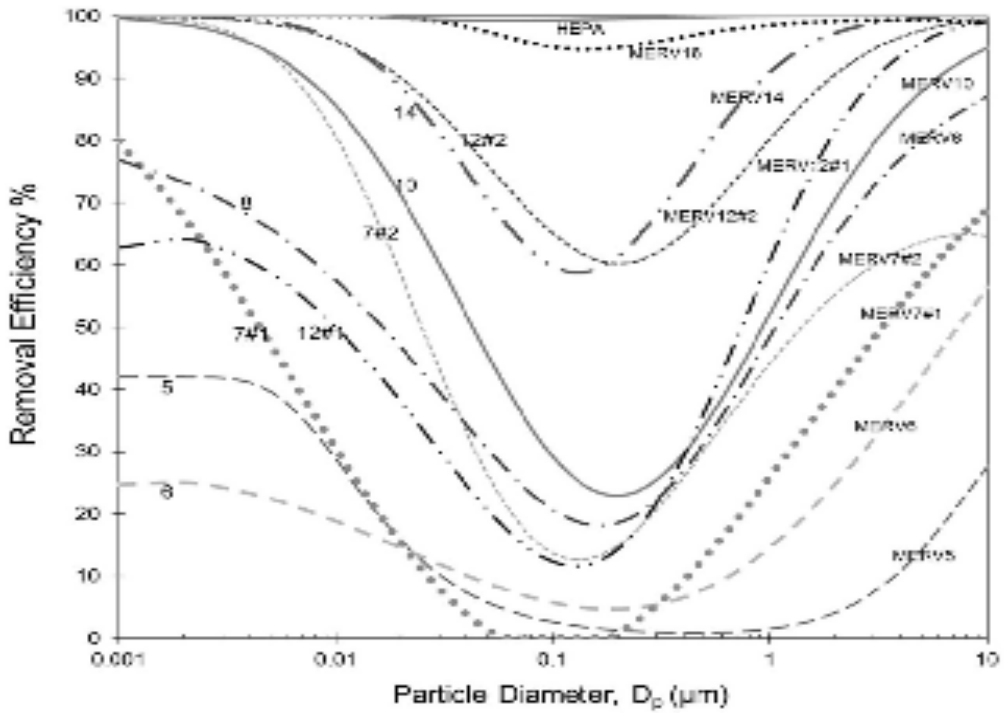
Healthy Buildings Research Lab

Portland State UNIVERSITY

Healthy Buildings Research Lab

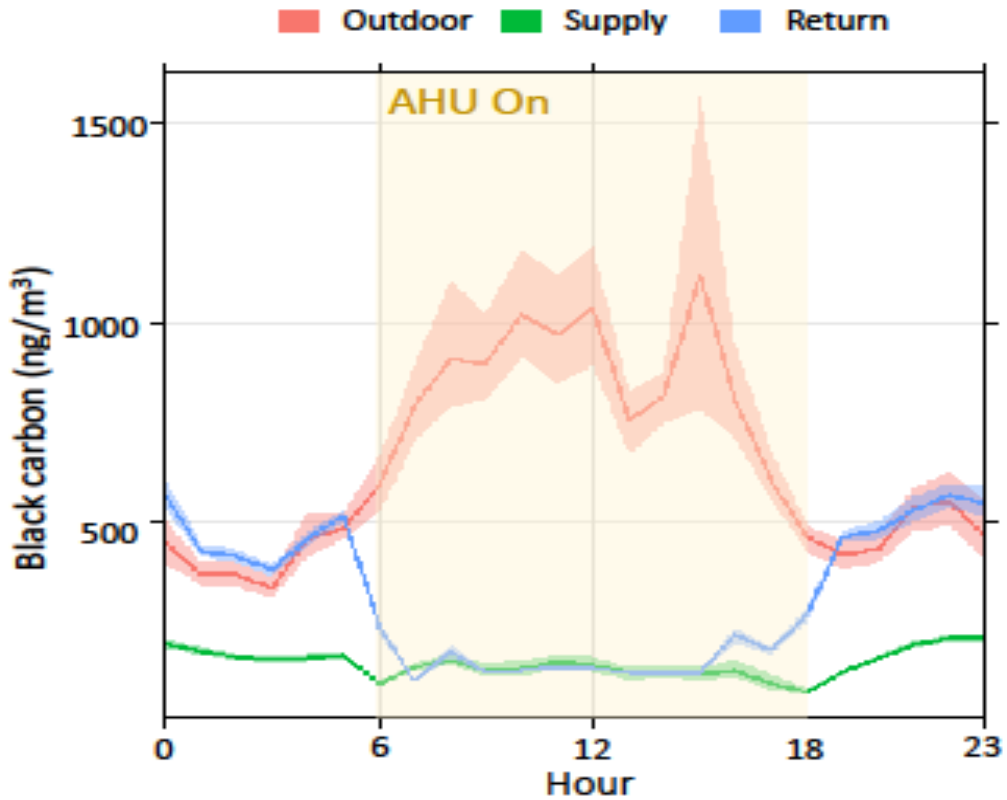
Efficacy of high-efficiency air cleaning

Predictions of size-resolved removal efficiency vs. MERV rating[1,2]



>84% removal efficiency of fine particulate matter achievable, f(MERV, d_p)

1-week at near-roadway middle school[3], w/ MERV 8 + 16



Blue line: Indoor BC levels avg. 150 ng/m³ w/ air cleaning; **effectiveness of ~85%**

[1]Azimi et al. Atm. Env. 98:337-47; [2]Hecker, R.; Hofacre, K. C. Development of Performance Data for Common Building Air Cleaning Devices Report No. EPA/600/R-08/013; U.S. EPA; [3]Laguerre et al., 2020, ES&T 54(19):11798-11808

Conclusions of the Examples from Canada & USA

Conclusions:

- The ASHARE standards (MERV / HEPA) check and guarantee the filtration efficiency of the filter material up to a minimum of 300 nm; below this size spectrum there is a scatter in the degree of efficiency between 0 and about 60%;
- In practice there are damages and assembly errors of the filters, periodic maintenance and checks are necessary;
- Continuous monitoring of the filtration and personal exposure with the help of appropriate sensors is possible;
- It is recommended to carefully and professionally examine various alternative systems offered on the market;
- PM 2.5 and more rarely Black Carbon BC are still used as legal parameters in air quality;
- In the case of indoor pollution, outdoor air pollution must also be taken into account.

Webinar: „Mitigation of Idoor Exposure to Fine Particulate Matter“ US Academy of Sciences, April 28, 2021

Answer of several school directions in CH,

if PN-monitoring would be possible…???

In our school everything is OK !

No measurements are necessary !

Answer of an authority for public buildings in CH,

if PN-monitoring would be possible…???

For us the UFP is at moment no topic !

Frequent answers (if any) from building construction branch, if we could discuss about the vent-systems…???

We are working according to the Norms and everything is OK!

Clean rooms? Too expensive!!!

Summary

- Viruses = Nanoparticles ⟶ **Viruses**-Filtration = Nano-Filtration **(+ everything else)**
- The standardised approach to assessing indoor air quality is purely theoretical and is currently based on voluntary practice.
- There are no public mechanisms to recommend, to guarantee and to control the improved indoor filtration quality. **Quality Control & Consumer Protection.**
- However, there are skills and technical means for nano-filtration and its quality control to be introduced (experiences from vehicle technology).
- Official issuance of recommendations, regulations and possible incentive measures is urgently recommendable. **Regulatory Precautions.**

Remark of one honourable project partner:

In a democratic system there is a SPREAD of RESPONSIBILITIES!

Who is responsible if there is no regulation in place???

Deadly fire at Swiss nightclub **caused by illegal sparklers**, similar to Station nightclub fire in Massachusetts.
(Internet USA 17.Jan.2026 …2 weeks ago)

Desaster:

- **On 1 January 2026, 1.26h a devastating fire broke out at the “Le Constellation” bar in the Swiss ski resort of Crans-Montana (Canton of Valais).**
- **The fire claimed the lives of 40 people, most of them teenagers and young adults. Another 119 people were injured, many of them seriously with life-threatening burns.**
- **According to initial investigations, sparklers (spray fountains) on champagne bottles ignited the flammable foam insulation on the ceiling. This led to a so-called ‘flashover’ (sudden full-scale fire) within a very short time.**
- **Investigations are underway to determine the extent to which fire safety regulations were disregarded, as the building did not have a sprinkler system or efficient emergency exits.**

What‘s about EMISSIONS?
What‘s about VENTILATION?

Who is responsible?
Who is to blame for this?

Remark of another honourable project partner:

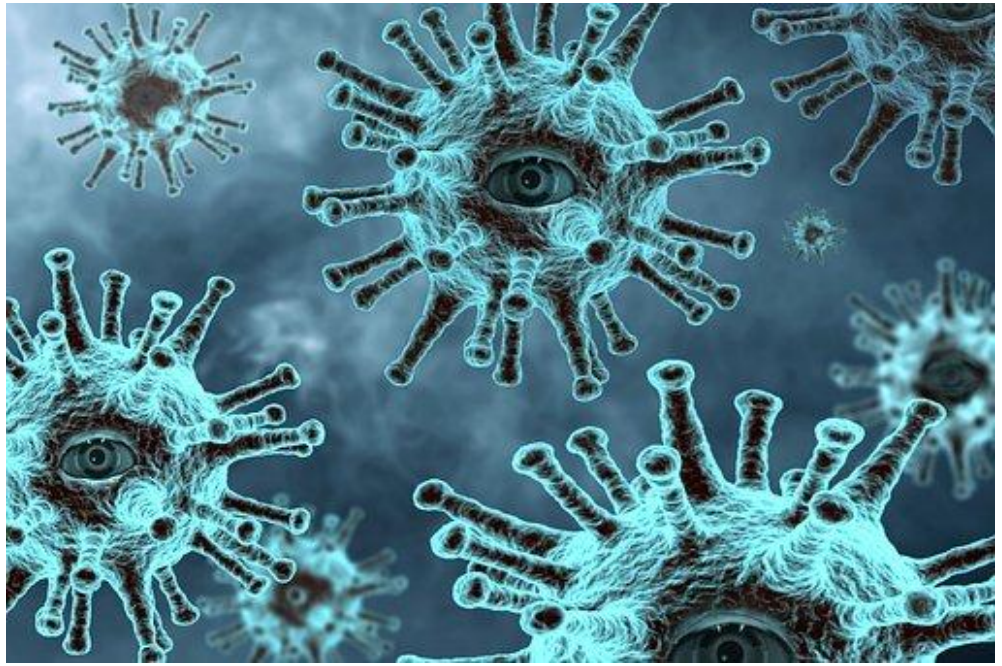
There is no simple solution for a complex problem!

We must take a didactic approach.

With joint efforts - through improvements and quality assurance of indoor filtration and flow control - the risk of health damage can be significantly reduced or eliminated.

Thank you for your attention !

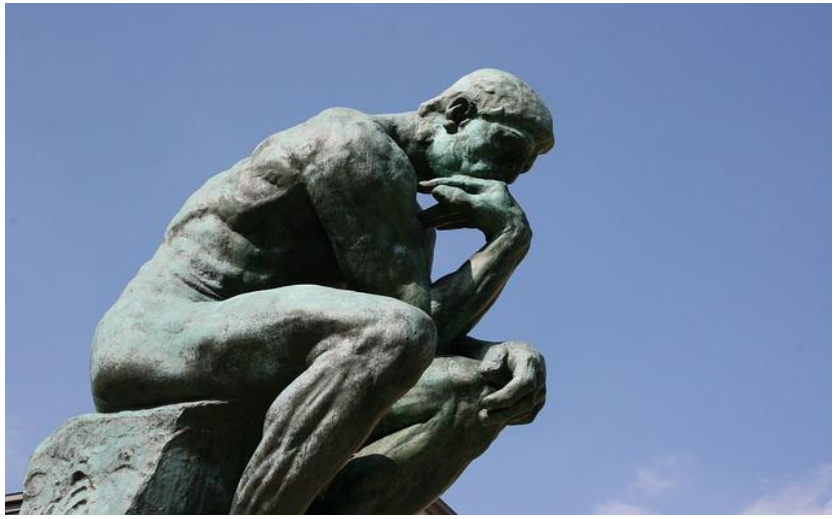
www.vert-certification.eu
www.nanocleanair.ch
www.nano-control.org



Further ideas, or infos:

What to do, or not to do….

- High-performance monitoring
- Be careful with other cleaning technologies
- Bottleneck analysis
- Paradigm Shifts
- Further Remarks
- Partial truths, or mistakes of consideration
- Vehicle Cabins – a working place



Research Needs #1

- In-situ effective filtration performance test with low-cost monitors
- Continuous performance monitoring
- Personal monitoring to assess exposure reduction

ISO 29462:2013

Field testing of general ventilation filtration devices and systems for in situ removal efficiency by particle size and resistance to airflow

Prof. Jeffrey Siegel, University of Toronto

Comparison of Test Methods for Determining the Particle Removal Efficiency of Filters in Residential and Light-Commercial Central HVAC Systems

Stephens & Siegel (2012) *Aerosol Sci Tech*

Other Air Cleaning Technologies

Image ref: Allergy Cosmos

- Photocatalytic oxidation, plasma, ionization, sprays
  - These are **not** terms with firm definitions
- There is not independent evidence of efficacy – many (most?) don't work/have low performance
- There is evidence of **harm** (ozone emission, ion concentration, byproduct formation)

This is a suitable place to give a most earnest warning against the use of so-called secret remedies and patent medicines.... Pettenkofer (1883)

Prof. Jeffrey Siegel,
University of Toronto

Bottleneck analysis

Paradigm Shift #3: Quality Control & Consumer Protection

- Proof and control of the filtration quality is possible with the portable PN measuring devices from the propulsion technology.
- There are specialized laboratories on this subject.
- Inspection and maintenance (I&M) of the filter systems is very important and should be publicly organized for important systems (similar to the control of the heaters, or control of cars).
- Damages, material- or assembly errors can destroy the effectiveness of the best filter systems.
- Public information about nano-filtration should be promoted (the mere naming of HEPA, or the marketing information is insufficient).

Conclusion:

Nano-filtration is: very important, measurable, controllable and little understood by the public.

Paradigm Shift #4: regulatory precautions

- Establish and / or update responsibilities for indoor air quality on federal and cantonal levels.
- Institutional uniform information for the construction industry and the public about filtration.
- Recommendations, regulations.
- Incentive measures such as: the subsidy contributions linked to the filtration quality, or opening and event conditions.

Conclusion:

The official introduction and quality control of nano-filtration is crucial.
Experience from the introduction of DPF has shown that market forces alone cannot achieve this satisfactorily.

Further Remarks

- Nanofiltration not only affects viruses and nanoparticles, but also bacteria, fungi, germs, allergens and other organic and inorganic air pollution.

- Nanofiltration and its maintenance cause additional costs and can increase the energy of the fans, can, however, reduce the use of outside air in air conditioning / heating systems and thereby reduce energy loss – need for further clarification and research.

- The viruses deposited in the filter are about 95% deactivated after 24 h and completely deactivated after 48 h (last research results).

- acknowledging this history— Covid-19—will allow good ventilation to emerge as a central pillar of public health policy, a development that would not just hasten the end of this pandemic but beat back future ones. [https://www.wired.com/story/the-teeny-tiny-scientific-screwup-that-helped-covid-kill/]

Partial truths, or mistakes of consideration

- More outside air
- More air mixing
- PM 2.5
- HEPA / MERV filtration sufficient
- No Quality Procedures

Vehicle Cabins – a working place