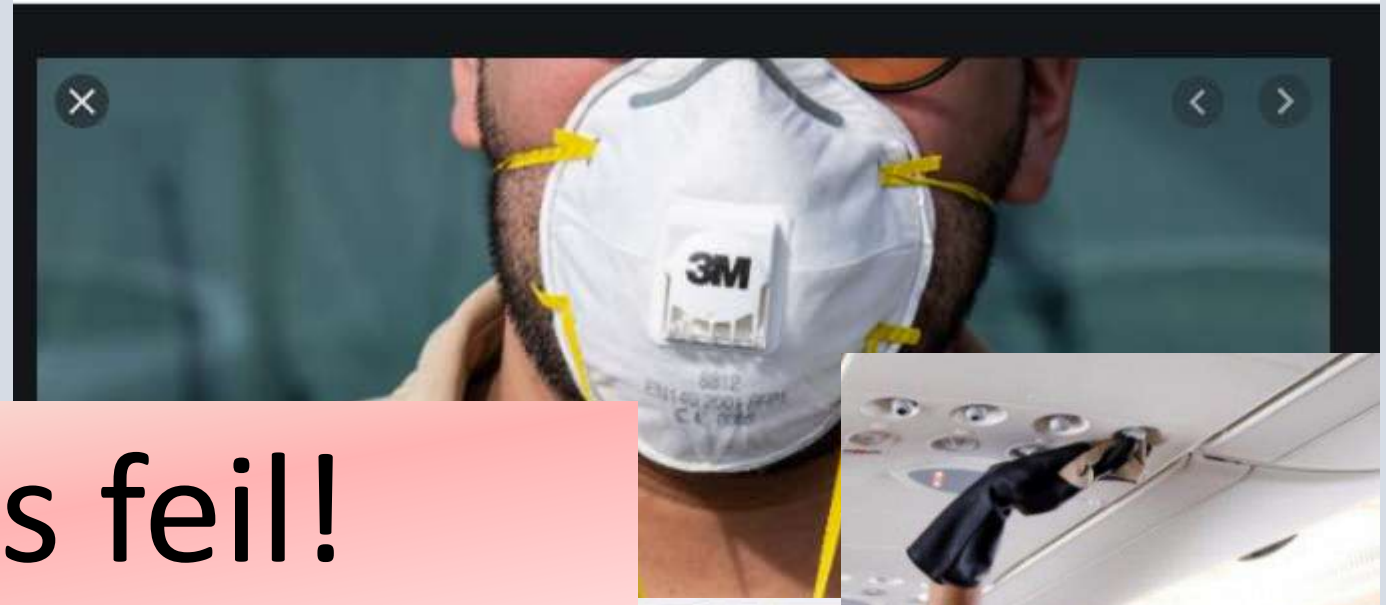
Informasjon til Sikkerhetsforum, 07.04.2020
www.ptil.no/trepartsamarbeid/sikkerhetsforum/

Åndedrettsvern i smittetider.

Litt faglig undelag for vurdering av risiko.

- Hva skal det beskyttes mot?
- Hvordan ser luftforurensningen ut?
- Hvordan opptrer luftforurensingen?
- Hvilke typer åndedrettsvern benyttes?
- Hva er beskyttesfaktor?
- Hvorfor er tetthetstesting helt nødvendig?

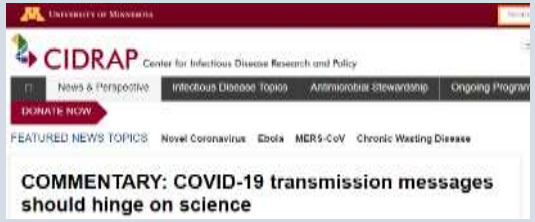
Halvor Erikstein
organisasjonssekretær/
yrkeshygieniker SYH
www.SAFE.no



Finn seks feil!

Støvmasker over skjegg eller bruk av munnbind er ikke åndedrettsvern!

Støvmaske gir ikke beskyttelse mot kjemikalier!



Kan vi få en bedre forståelse av hvordan virus opptrer og forurenser arbeidsmiljøet?
Hvordan kan de som arbeider i miljøer med virus bli beskyttet av åndedrettsvern?

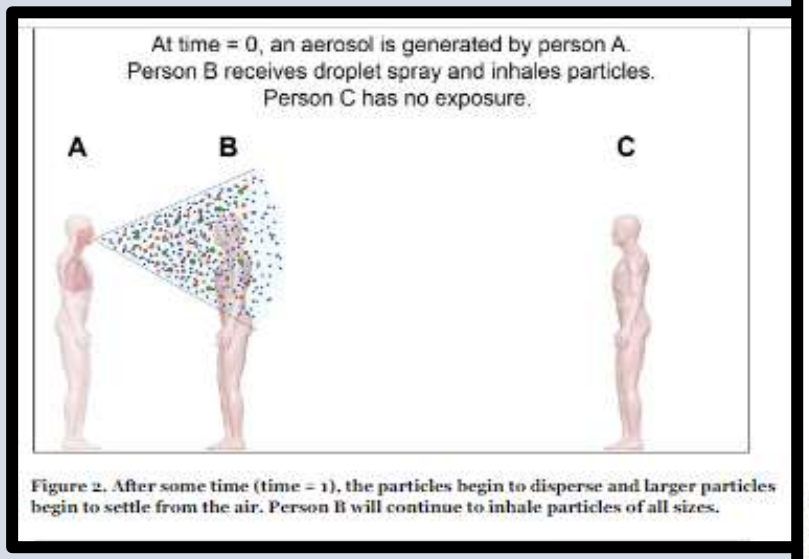


Figure 2. After some time (time = 1), the particles begin to disperse and larger particles begin to settle from the air. Person B will continue to inhale particles of all sizes.

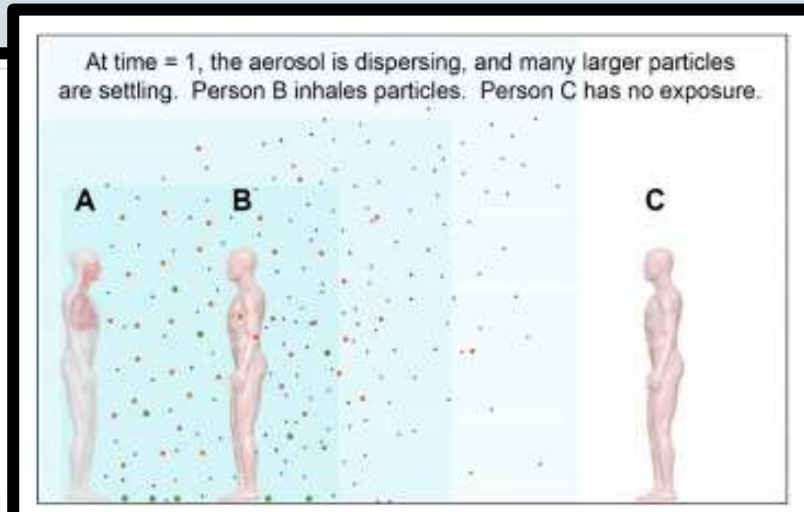


Figure 3. After more time (time = 2), the small particles are uniformly dispersed and more of the larger particles have settled from the air. Persons B and C will inhale particles that are generally smaller, have a smaller size range, and are at a lower concentration than at time = 0.

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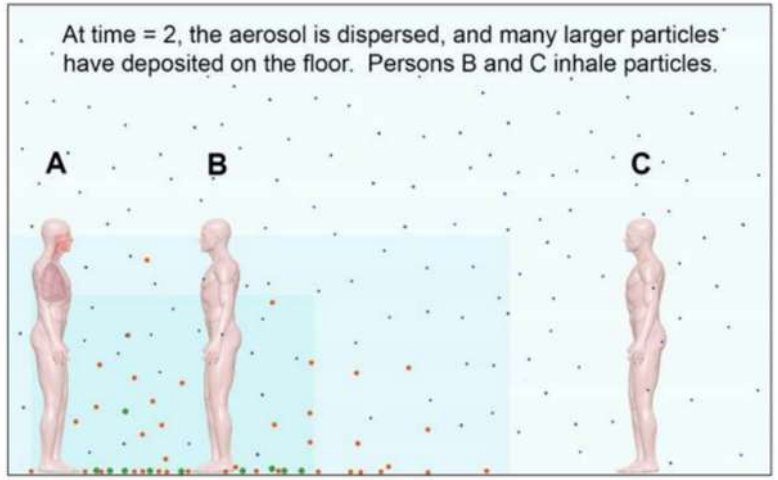


All of the particle sizes in a typical cough or sneeze aerosol are inhalable. The larger particles will deposit in the nose, while smaller particles deposit in the lungs, where cell receptors for many infectious respiratory viruses are typically located.

http://www.cidrap.umn.edu/news-perspective/2020/03/commentary-covid-19-transmission-messages-should-hinge-science

Bioaerosoler.
Mikroorganismer og størrelser.

- Underlag for vurdering av risiko:
  - Aerosoler og størrelse
  - Spredning
  - Dråper og levetid
  - Fordampning
  - Maskelekkasje
  - Skjegg
  - Beskyttelsesfaktor
  - Tetthetstetsting

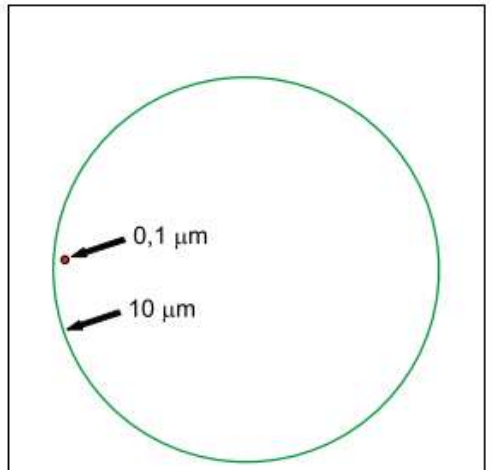
https://www.youtube.com/watch?v=h0xTKxbIElU

Luftbårne partikler

Luftforurensning, astma og allergi – betydningen av ulike partikler.
Heidi Ormstad, Martinus Løvik.

Tabell 1 Definisjoner og størrelsesinndeling av luftbårne partikler

Svevestøv	Støvpartikler som holder seg svevende i en viss tid (partikler mindre enn 75 µm i aerodynamisk diameter).
Nedfallstøv	Større partikler som ikke svever i luften mer enn noen minutter før de sedimenterer (større enn omtrent 75 µm i aerodynamisk diameter)
PM_{10}	Partikler i svevestøv med en aerodynamisk diameter mindre enn 10 µm
Inhalerbar fraksjon	Samme definisjon som PM_{10}
Grovfraksjon	Partikler i svevestøv med en aerodynamisk diameter mellom 2,5 µm og 10 µm
$PM_{2,5}$	Partikler i svevestøv med en aerodynamisk diameter mindre enn 2,5 µm
Finfraksjon	Samme definisjon som $PM_{2,5}$
Ultrafine partikler	Partikler i svevestøv med en aerodynamisk diameter mindre enn 0,1 µm (100 nanometer)
Nanopartikler	Noe ulike definisjoner, men oftest brukt om partikler i svevestøv med en aerodynamisk diameter mindre enn 10 eller 50 nanometer
Respirabel fraksjon	Partikler i svevestøv med en aerodynamisk diameter mindre enn 5 µm
Sot	Svarte partikler i svevestøv som i hovedsak består av elementært karbon, stammer fra forbrenning av fossilt materiale. Et eksempel er dieseleksospartikler
Aerosoler	Faste partikler eller dråper med liten nok diameter til å holde seg svevende i luften



Figur 1 *Forholdet mellom en partikkel med diameter på 0,1 µm (om lag som en dieseleksospartikkel) og en partikkel på 10 µm (for eksempel piggdekkstøv)*

Tabell 2 Relativt overflateareal og antall for en gitt vektmengde kuleformede partikler med ulik diameter

Diameter (µm)	Relativ overflate	Relativt antall
0,1	100	1 000 000
1,0	10	1000
2,5	4	64
10	1	1

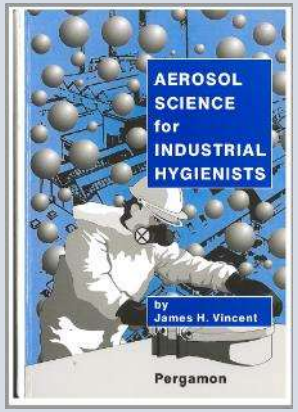
Størrelse av aerosoler

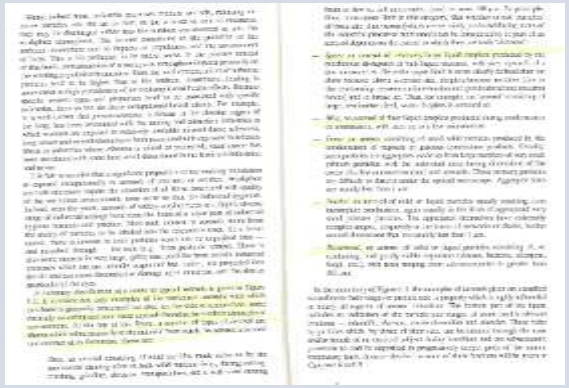
- En person kan med blottet, normalt øye se enkeltpartikler ned til ca. 50 mikrometer.
- Mindre partikler er kun synlig i sterkt lys.
- Partikler mindre enn 10 mikrometer sees som tåke.

Basisbog i teknisk arbejdshygiejne, Thomas Schneider, 1986, side 36

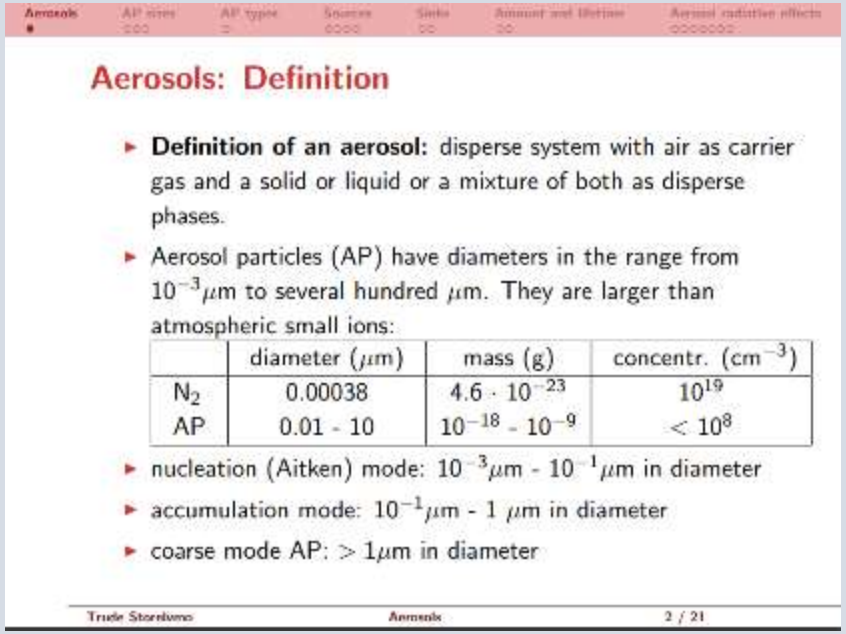
https://tidsskriftet.no/2002/08/aktuelt-problem/luftforurensning-astma-og-allergi-betydningen-av-ulike-partikler

Definisjoner - aerosoler





- **Dust**, an aerosol consisting of solid particles made airborne by mechanical desintegration of bulk solid material (e.g., during cutting, crushing, grinding, abrasion, transportation etc.) with sizes ranging from a low as sub-micrometre to over 100 micro.
- **Spray**, aerosol of relatively large liquid droplets products by the mechanical disruption of bulk liquid material, with sizes upwards of a few micrometre
- **Mist**, an aerosol of finer liquid droplets produced during condensation or atomisation, with sizes up to a few micrometres.
- **Fume**, an aerosol consisting of small particles produces by the condensation of vapours or gaseous combustion products. Usually such particles are aggregates made up from large numbers of very small primary particles, with the individual units dimensions of the order if a few nanometres and upwards. Aggregate sizes are usually less than 1 micrometre.
- **Smoke**, an aerosol of solid or liquid particles usually resulting from incomplete combustion, again usually in form of aggregated very small primary particles. The aggregates themselves have extremely complex shapes, frequently in form of network or chains, having overall dimensions that ae usually less than 1 micrometre.
- **Bioaerosol**, an aerosol of solid or liquid particles consisting of, or containing, biologically-viable organisms (virus, bacteria, allergens, fungi, etc.), with sizes ranging from sub-micrometre to greater than 100 micrometre



http://folk.uio.no/truds/aerosols_large_Feb2018.pdf

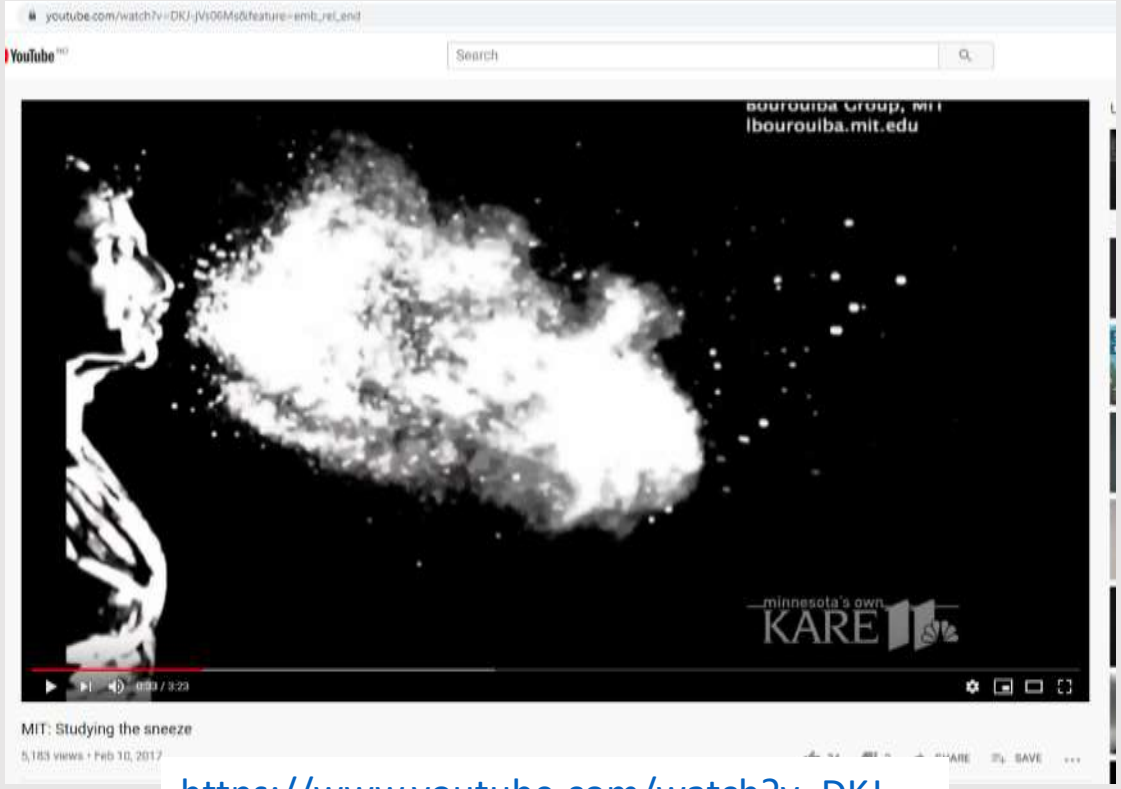
Nysing - smittespredning

https://www.nature.com/news/polopoly_fs/1.19996!/menu/main/topColumns/topLeftColumn/pdf/534024a.pdf?origin=ppub

https://www.youtube.com/watch?v=ARCoKoy_BRE&feature=emb_rel_end

Nysing - smittespredning

https://math.mit.edu/~bush/?p=1873



https://www.youtube.com/watch?v=DKJ-jVs06Ms&feature=emb_rel_end

Nysing – spredning av partikler

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Enhanced spread of expiratory droplets by turbulence in a cough jet

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ABSTRACT

Coughing has been confirmed as a significant vector for transmitting respiratory diseases. It can be modelled physically as a turbulent jet to study the dispersion of expiratory droplets. The discrete random walk model for particle tracking is employed to study the effect of turbulence fluctuation on dispersion of particles and/or droplets. The concept of reach probability is proposed to characterise the streamwise spread distance. Our study shows that jet-like cough airflow turbulence prompts the wide spread of particles and expiratory droplets, and that the effect of evaporation on medium droplets (50 μm) is most significant. When turbulence fluctuations are considered for the 100 μm particles, there is a four-fold increase in the dispersion range in the streamwise direction, and a thirteen-fold increase in the transverse direction compared to that without fluctuation. Small particles are found to follow the airflow closely, dispersing in the whole jet region, while only 1% of large particles exceed 2 m in the streamwise direction; nearly 10% of medium particles travel 4.0 m (initial u_0 = 10 m/s, mouth diameter D = 2 cm). Droplets evaporate after being exhaled, but fates of small droplets with initial diameter d_{p0} = 30μm as well as large droplets with d_{p0} = 100μm are little affected by relative humidity (RH). The 30 μm droplets evaporate in seconds and behave similarly to the 10 μm particles. The spread distance of large droplets is mainly determined by the jet outlet diameter and velocity. In contrast, the medium droplets are found to be very sensitive to RH under humid conditions (RH ≥ 80%).

1. Introduction

Many respiratory diseases can be transmitted via direct spray of droplets, long- and short-range airborne routes, and/or by indirect contact. The precise transmission mode(s) for some diseases remains controversial, e.g. influenza. The literature review by Brankston et al. [1] concluded that influenza infection generally occurs over short rather than long distances. On the other hand, a literature review by Tellier [2], concluded that aerosol transmission occurs at considerable rates, while Weber & Stilianakis [3] found contact, large droplet and small droplet (aerosol) transmission all to be potentially important modes of transmission for the influenza virus. These in-depth reviews also revealed the importance of studying exposure of expiratory droplets/droplet nuclei among people, as it is a prerequisite for transmission of respiratory diseases.

The formation mechanisms of expiratory droplets have been studied, including the instability and break up of mucus during coughing and sneezing [4–6], and rupture of liquid film at thermal airways [7,8]. A number of droplet generation measurements have found that the majority of exhaled droplets during breathing are in the sub-micron range, while coughing and sneezing can produce large droplets [7,9–13]. Wells [14] first defined large droplets as those over 100 μm in aerodynamic diameter. The mechanism of droplet formation and origin is also associated with virus and bacteria load in droplets, as pathogens are usually limited to certain areas of the body [7]. Lindsley et al. [15] used the quantitative polymerase chain reaction (qPCR) to measure the influenza virus in aerosol particles from human coughs. Some 35% of the detected influenza RNA was contained in particles >4 μm in diameter, 23% in particles of 1–4 μm, and 42% in particles <1 μm, showing not only that coughing by patients emits aerosols containing the influenza virus, but also that much of the viral RNA is contained within particles in the respirable size range.

The fate of expiratory droplets in the indoor environment, or more specifically, how far they travel, is associated with exposure and subsequent infection/disease. The travel distance and dispersion of droplets is itself a complex phenomenon, which is affected by the sub-micron-scale evaporation of droplets [16–18], room ventilation and obstacles [19–21], thermal plume around and

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http://dx.doi.org/10.1016/j.buildenv.2015.06.018
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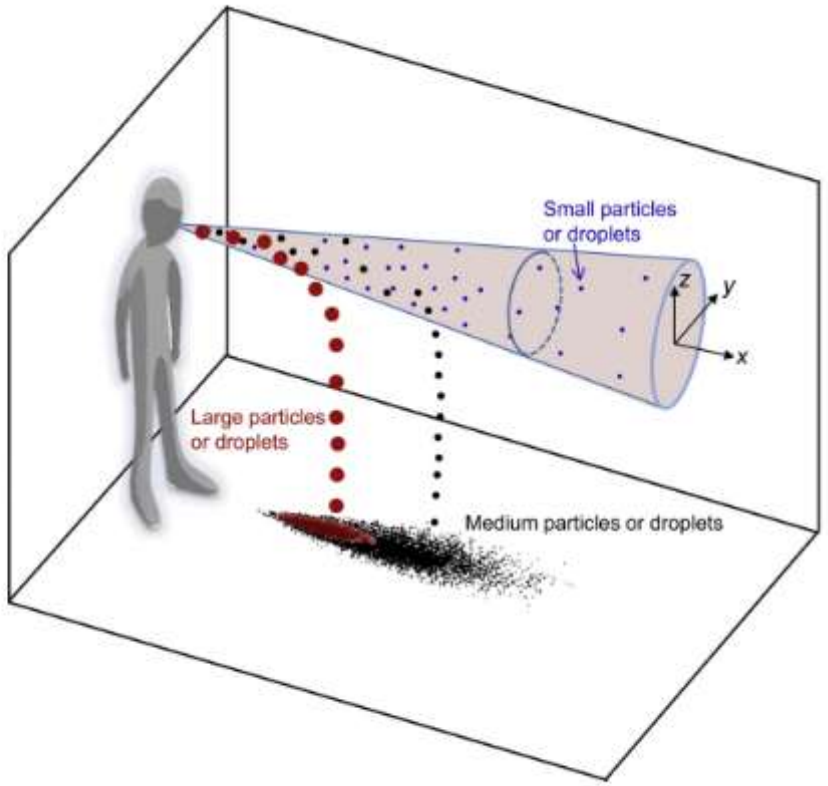

Fig. 1. Illustration of the investigated scenario. Three sizes of particles or droplets are released in a turbulent round cough jet.

https://www.sciencedirect.com/science/article/abs/pii/S0360132315300329?via%3Dihub

Partikkelspredning: Nysing – hosting - snakking

Improved Strategy to Control Aerosol-Transmitted Infections in a Hospital Suite

Farhad Memarzadeh, PhD, PE

ABSTRACT

Airborne transmission of infectious particles consists of droplets that are expelled by sneezing, coughing or otherwise distributed into the air. Although the liquid evaporates, the residue may remain in the air for long periods of time depending on factors such as particle size, density, velocity, force of expulsion, humidity and rate of air flow. Air currents, aided by the ventilation system, help to spread them over a wide area. The disease-causing organisms then are inhaled by or come to rest on a susceptible person who is subsequently infected.

This study simulated the infectious particle generated from patients cough using complex particle tracking methodologies with variables such as particle trajectory and air velocity over a specified time to determine changes in distribution of the infectious particles as they travel in the air. The study is the first of its kind to examine different aspects of the cough/ventilation system interaction. Computational Fluid Dynamics was performed to model and assess the interactions of exhalation flows of the cough particles with ventilation flow in a hospital suite. The results show that the low exhausts outperform the other exhaust locations in terms of particle removal and the remaining particles around the bed.

However, from this study, it appears that 12 ACH with low exhausts exhibits the lowest number of particles remaining in the room 5 minutes after a cough. Thus it can be concluded that 12 ACH is a more effective air flow for a patient room than 16 ACH

This study can be used to assess the frequency of infection occurrences and to provide practical approaches to improve indoor air quality and reduce nosocomial infections in the hospital setting.

INTRODUCTION

The respiratory flows of infected patients are one of the main sources of infectious airborne pathogens in hospitals. However this topic has received very little attention among the hospital engineering control community, with a very limited number of studies on how exhalation flows interact with the room ventilation system. There has been some focus in studying isolation rooms in the past few years, but not on the ventilation of general patient wards and other hospital areas where potentially infectious patients might be encountered. An extensive literature review illustrates that compared with the abundance of studies on ventilation and indoor air distribution in non-hospital buildings such as schools, offices and homes, there has been a lack of study of ventilation effects in areas of healthcare facilities where there is likely to be a higher frequency of infectious particle transmission. The risk of infection for healthcare workers (HCWs) can be very high during an outbreak of airborne or droplet contact diseases. For example, during the 2003 severe acute respiratory syndrome (SARS) epidemic, 20% of the infected individuals worldwide were HCWs. A recent systematic review conducted by Li Y, Leung G and Tanp JW [1] demonstrated that both adequate and inadequate ventilation have an effect on the risk of infection via infectious aerosols. An inefficient ventilation system causes the spread of airborne disease, whereas an efficient ventilation system can help mitigate the spread of infectious particles and thereby reduce transmission of disease.

Farhad Memarzadeh *is the director of the Division of Technical Resources at the National Institutes of Health, Bethesda, MD.*

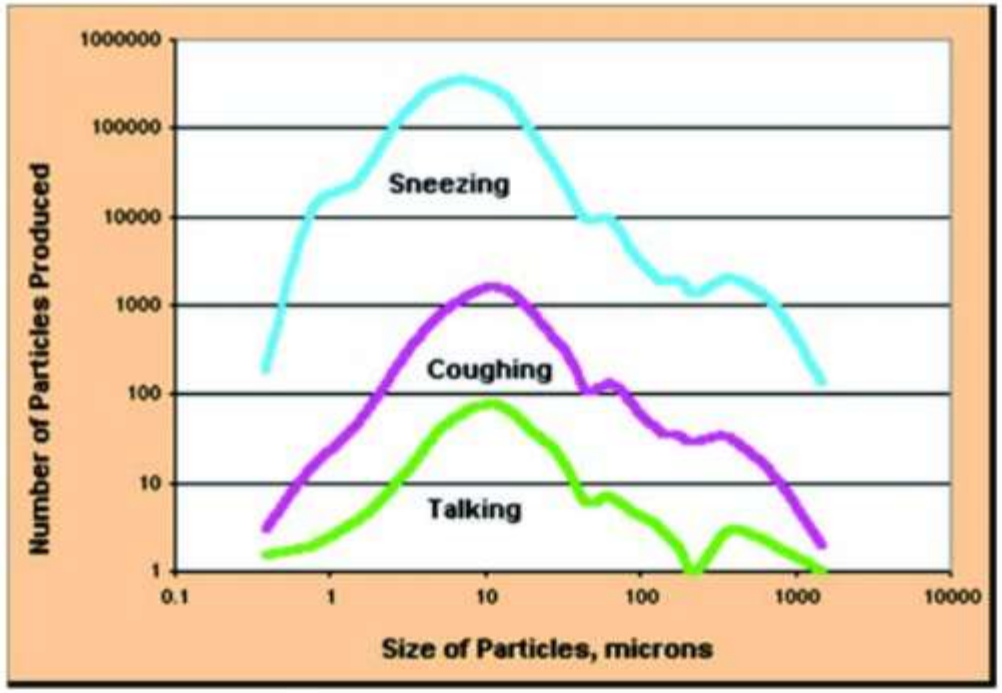

Figure 1 *Particle generation by sneezing, coughing and during talking.*

https://www.researchgate.net/publication/234076687_Improved_Strategy_to_Control_Aerosol-Transmitted_Infections_in_a_Hospital_Suite/figures?lo=1

Partikkelstørrelse - nysing

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Research

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Royal Society Publishing

Characterizations of particle size distribution of the droplets exhaled by sneeze

Z. Y. Han, W. G. Weng and Q. Y. Huang

Department of Engineering Physics, Institute of Public Safety Research, Tsinghua University, Beijing 100084, People's Republic of China

This work focuses on the size distribution of sneeze droplets exhaled immediately at mouth. Twenty healthy subjects participated in the experiment and 44 sneezes were measured by using a laser particle size analyser. Two types of distributions are observed: unimodal and bimodal. For each sneeze, the droplets exhaled at different time in the sneeze duration have the same distribution characteristics with good time stability. The volume-based size distributions of sneeze droplets can be represented by a lognormal distribution function, and the relationship between the distribution parameters and the physiological characteristics of the subjects are studied by using linear regression analysis. The geometric mean of the droplet size of all the subjects is 360.1 μm for unimodal distribution and 74.4 μm for bimodal distribution with geometric standard deviations of 1.5 and 1.7, respectively. For the two peaks of the bimodal distribution, the geometric mean (the geometric standard deviation) is 386.2 μm (1.8) for peak 1 and 72.0 μm (1.5) for peak 2. The influences of the measurement method, the limitations of the instrument, the evaporation effects of the droplets, the differences of biological dynamic mechanism and characteristics between sneeze and other respiratory activities are also discussed.

1. Introduction

Respiratory infectious diseases, such as influenza and severe acute respiratory syndrome (SARS), are threatening the life of humans around the world. In 1918–1919, the outbreak of Spanish flu (H1N1) caused more than one billion infections and was considered as the most lethal flu pandemic of the twentieth century [1]. During the early twenty-first century, more than eight thousand people were infected by SARS and 774 of them died [2]. Almost four million deaths owing to respiratory infectious diseases and 1.5 million deaths owing to tuberculosis were reported every year [3]. In modern world, respiratory infectious diseases can cause lots of deaths and economic losses, and the significant disruption of social and economic areas will remain much longer even though the outbreak of the diseases ends.

Respiratory infectious diseases can be spread by direct and indirect contacts or airborne transmission [4]. Direct contact of droplet spray produced by coughing, sneezing or talking involves relatively large droplets containing organisms and requires close contact usually within 1 m [5]. Indirect contact may take place after the droplets are removed from the air by surface deposition [6]. Airborne transmission is a major disease transmission mode of respiratory infectious diseases in indoor environments [7,8]. This mode may take place by inhaling the droplets exhaled by respiratory activities or their residues after evaporation [9–14]. These droplets exhaled by infected patients may carry microorganisms and infect other people [15].

By using computational fluid dynamics (CFD) simulation, the dispersion and deposition of the expiratory droplets can be predicted [16–20]. The results indicate that the characteristics of dispersion and deposition of the expiratory droplets are highly dependent upon droplet size [6,21,22]. The size of the droplets can

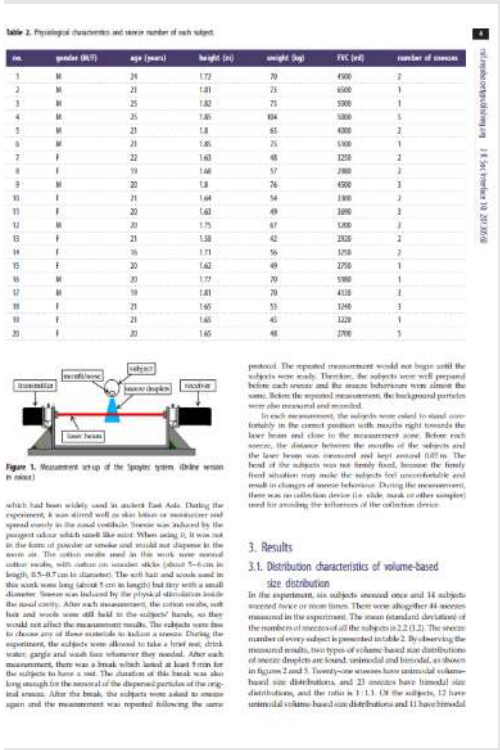

Table 2. Physiological characteristics and sneeze number of each subject.

no.	gender (M/F)	age (years)	height (m)	weight (kg)	FVC (ml)	number of sneezes
1	M	24	1.72	70	4500	2
2	M	23	1.81	73	6500	1
3	M	25	1.82	75	5300	1
4	M	25	1.85	104	5800	5
5	M	23	1.8	65	4300	2
6	M	21	1.85	75	5300	1
7	F	22	1.63	48	3250	2
8	F	19	1.68	57	2900	2
9	M	20	1.8	76	4500	3
10	F	21	1.64	54	3300	2
11	F	20	1.63	49	3090	3
12	M	20	1.75	67	5300	2
13	F	23	1.58	42	2920	2
14	F	16	1.71	56	3250	2
15	F	20	1.62	49	2750	1
16	M	20	1.77	70	5300	1
17	M	19	1.81	70	4310	2
18	F	23	1.65	53	3240	3
19	F	21	1.65	45	3220	1
20	F	20	1.65	48	2700	5

Figure 1. Measurement set-up of the Spraytec system. (Online version in colour.)

which had been widely used in ancient East Asia. During the experiment, it was stirred well in skin lotion or moisturizer and spread evenly in the nasal vestibule. Sneeze was induced by the pungent odour which smell like mint. When using it, it was not in the form of powder or smoke and would not disperse in the room air. The cotton swabs used in this work were normal cotton swabs, with cotton on wooden sticks (about 5–6 cm in length, 0.5–0.7 cm in diameter). The soft hair and wools used in this work were long (about 5 cm in length) but tiny with a small diameter. Sneeze was induced by the physical stimulation inside the nasal cavity. After each measurement, the cotton swabs, soft hair and wools were still held to the subjects' hands, so they would not affect the measurement results. The subjects were free to choose any of these materials to induce a sneeze. During the experiment, the subjects were allowed to take a brief rest, drink water, gargle and wash face whenever they needed. After each measurement, there was a break which lasted at least 5 min for the subjects to have a rest. The duration of this break was also long enough for the removal of the dispersed particles of the original sneeze. After the break, the subjects were asked to sneeze again and the measurement was repeated following the same protocol. The repeated measurement would not begin until the subjects were ready. Therefore, the subjects were well prepared before each sneeze and the sneeze behaviours were almost the same. Before the repeated measurement, the background particles were also measured and recorded.

In each measurement, the subjects were asked to stand comfortably in the correct position with mouths right towards the laser beam and close to the measurement zone. Before each sneeze, the distance between the mouths of the subjects and the laser beam was measured and kept around 0.05 m. The head of the subjects was not firmly fixed, because the firmly fixed situation may make the subjects feel uncomfortable and result in changes of sneeze behaviour. During the measurement, there was no collection device (i.e. slide, mask or other samples) used for avoiding the influences of the collection device.

3. Results

3.1. Distribution characteristics of volume-based size distribution

In the experiment, six subjects sneezed once and 14 subjects sneezed twice or more times. There were altogether 44 sneezes measured in the experiment. The mean (standard deviation) of the numbers of sneezes of all the subjects is 2.2 (1.2). The sneeze number of every subject is presented in table 2. By observing the measured results, two types of volume-based size distributions of sneeze droplets are found: unimodal and bimodal, as shown in figures 2 and 3. Twenty-one sneezes have unimodal volume-based size distributions, and 23 sneezes have bimodal size distributions, and the ratio is 1 : 1.1. Of the subjects, 12 have unimodal volume-based size distributions and 11 have bimodal

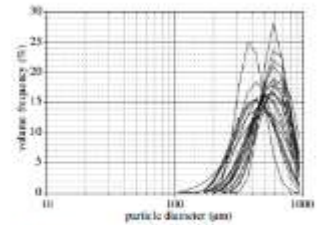

Figure 2. Unimodal distribution measured in the experiment (21 sneezes of 12 subjects).

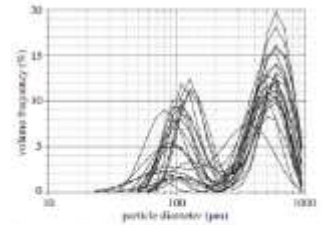

Figure 3. Bimodal distribution measured in the experiment (23 sneezes of 10 subjects).

size distributions. So there are three subjects who have both unimodal and bimodal size distributions in their sneezes: subject 4 has four unimodal distributions and one bimodal distribution; subject 14 has one unimodal distribution and one bimodal distribution; and subject 20 has one unimodal distribution and four bimodal distributions. Figure 2 shows the 21 sneezes that have unimodal distributions. Figure 3 shows the 23 sneezes that have bimodal distributions.

Based on the high sampling frequency of the Spraytec system, plenty of data were obtained and recorded. So the time stability of the droplet size distribution of every sneeze was also studied. By observing the volume-based size distributions measured at different time of each sneeze, good similarity and time stability are found both for the unimodal and bimodal distributions. So the distribution characteristics of sneeze droplets will remain almost the same in the duration of a sneeze. More detailed information can be found in the electronic supplementary material.

Until now, investigations on dynamic flow of sneezes are still rare in previous works. According to the studies on flow dynamics and characterization of cough, the maximum velocity of exhaled airflow can be found at $t = 50$–110 ms for different persons which is most likely to occur at 100 ms [49]. So in this work, the volume-based size distribution measured at 100 ms after the sneeze began was chosen as the size

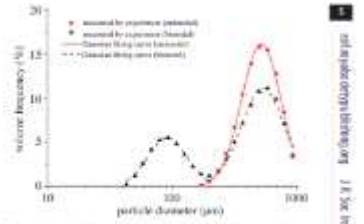

Figure 4. Measured data and fitting curves of two sample sneezes (unimodal and bimodal distributions, respectively). (Online version in colour.)

distribution of this sneeze and used for analysis. The results shown in figures 2 and 3 are the size distributions measured at $t = 100$ ms after the sneezes start. Usually, sneeze lasts 0.3–0.7 s, so $t = 100$ ms is in the duration of the sneeze. As the velocity of the airflow exhaled by sneeze is really high, it can be assumed that the droplets that are exhaled at $t = 0$–100 ms will not re-enter the measurement zone before $t = 100$ ms.

From figures 2 and 3, it can be seen that the single peak of the unimodal distribution and the two peaks of the bimodal distribution obviously meet the distribution characteristics of lognormal distribution. Therefore, each peak of the volume-based size distributions can be represented by the lognormal distribution function, as follows.

For unimodal distribution

$$\frac{dV_{i,1,0}}{d\ln d_i} = A_{1,0}\left(\frac{1}{\sqrt{2\pi}\sigma_{1,0}}\right)e^{-(\ln d_i - \ln \mu_{1,0})^2/2\sigma_{1,0}^2} \tag{3.1}$$

For bimodal distribution

$$\left.\begin{aligned} \frac{dV_{i,1,0}}{d\ln d_i} &= \mathrm{Max}\left(\frac{dV_{i,1,0}}{d\ln d_i}, \frac{dV_{i,2,0}}{d\ln d_i}\right) \\ \frac{dV_{i,1,0}}{d\ln d_i} &= A_{1,0}\left(\frac{1}{\sqrt{2\pi}\sigma_{1,0}}\right)e^{-(\ln d_i - \ln \mu_{1,0})^2/2\sigma_{1,0}^2} \\ \text{and}\quad \frac{dV_{i,2,0}}{d\ln d_i} &= A_{2,0}\left(\frac{1}{\sqrt{2\pi}\sigma_{2,0}}\right)e^{-(\ln d_i - \ln \mu_{2,0})^2/2\sigma_{2,0}^2} \end{aligned}\right\} \tag{3.2}$$

where $\frac{dV_{i,1,0}}{d\ln d_i}$ and $\frac{dV_{i,2,0}}{d\ln d_i}$ are the ratio of the volume of all the particles with diameters in size class i and the total volume of all the particles with any diameter in the spray, %. $\frac{dV_{i,1,0}}{d\ln d_i}$ and $\frac{dV_{i,2,0}}{d\ln d_i}$ are the ratio for peak 1 and peak 2, respectively. i is the number of the size class, $i = 1, 2, \ldots, n$. The diameter range of size class i is $[d_i, d_{i-1})$, μm. d_i is the geometric mean of size class i, μm. $\mu_{1,0}$, $\mu_{2,0}$, $\sigma_{1,0}$, $\sigma_{2,0}$, $A_{1,0}$, $A_{2,0}$, $A_{3,0}$ are the characteristic parameters of the lognormal distribution, the means, variances and coefficients, respectively, and $\sigma_{2,0} > \sigma_{1,0}$.

A nonlinear least-square curve fitting analysis is performed to obtain the optimum values of the characteristic parameters required to define the lognormal distribution function for each sneeze. The fitting results of two sample sneezes are shown in figure 4, including the measured data and the fitting curve of one unimodal distribution and one bimodal distribution. It is clear that the lognormal distribution fitting curve is capable of accurately representing the

https://royalsocietypublishing.org/doi/pdf/10.1098/rsif.2013.0560

Hosting - aerosolspredning

RESEARCH ARTICLE

Human Cough as a Two-Stage Jet and Its Role in Particle Transport

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Abstract

The human cough is a significant vector in the transmission of respiratory diseases in indoor environments. The cough flow is characterized as a two-stage jet; specifically, the starting jet (when the cough starts and flow is released) and interrupted jet (after the source supply is terminated). During the starting-jet stage, the flow rate is a function of time; three temporal profiles of the exit velocity (pulsation, sinusoidal and real-cough) were investigated in this study, and our results showed that the cough flow's maximum penetration distance was in the range of a 50.6–85.5 opening diameter (D) under our experimental conditions. The real-cough and sinusoidal cases exhibited greater penetration ability than the pulsation cases under the same characteristic Reynolds number (Re_c) and normalized cough expired volume (Q/AD, with Q as the cough expired volume and A as the opening area). However, the effects of Re_c and Q/AD on the maximum penetration distances proved to be more significant; larger values of Re_c and Q/AD reflected cough flows with greater penetration distances. A protocol was developed to scale the particle experiments between the prototype in air, and the model in water. The water tank experiments revealed that although medium and large particles deposit readily, their maximum spread distance is similar to that of small particles. Moreover, the leading vortex plays an important role in enhancing particle transport.

Introduction

The human cough is known to be a significant vector for transmitting respiratory diseases in indoor environments. Thousands of droplets per respiration can be released during breathing, coughing and sneezing. Once exhaled, droplets evaporate and become droplet nuclei [1]. These droplets and droplet nuclei can contain elements such as sodium, potassium and chloride in solutes; DNA, lipids, glycoproteins and proteins in suspended insoluble solids; and, of course, infectious pathogens if released by an infectious patient. Exposure to these pathogen-containing droplets can occur via both short- (within 1–2 m of the source patient) and long- (beyond about 2 m in the indoor environment) range routes. The former is known as direct spray infection [2], in which relatively large (≥ 5 μm in diameter) droplets or droplet nuclei can be directly deposited on the nasal or oral mucosa of the new host. Short-range airborne exposure via smaller droplets or droplet nuclei is also important in close proximity infection

Second, the time needed for a fluid element to reach position x along the jet centerline is given by [39]

$$\frac{x(t)}{D}=\begin{cases}\frac{Ut}{D} & x\le 6.2D\\ 3.52\left(\frac{Ut}{D}-3.1\right)^{1/2}, & x>6.2D\end{cases} \quad (14)$$

The coefficient is 3.52 for the steady jet, much larger than the value of 2.5 in our study for the pulsation cases. It is reasonable that the fluid element in the steady jet travels faster than in the starting jet, because the entrainment in the latter is stronger. The interrupted jet flow in Case 4 [Pulsation, Re = 12900, Q/AD = 250] only travelled to 85.5 D, whereas the steady jet with the same U, travelled as far as 800 D before the velocity dropped below 0.01 m/s, according to Eq (14). Approximating a cough as a steady jet can introduce significant errors, as shown here.

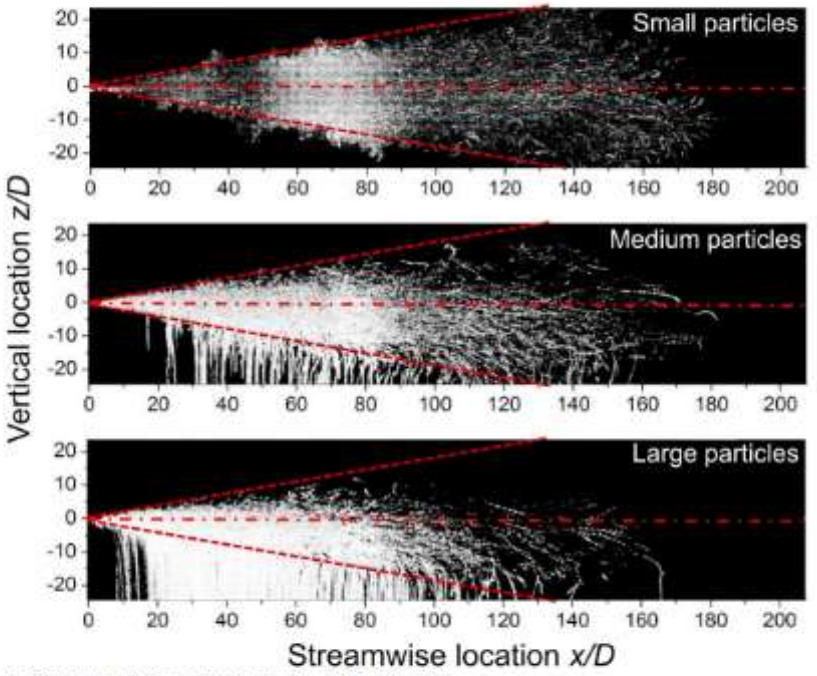
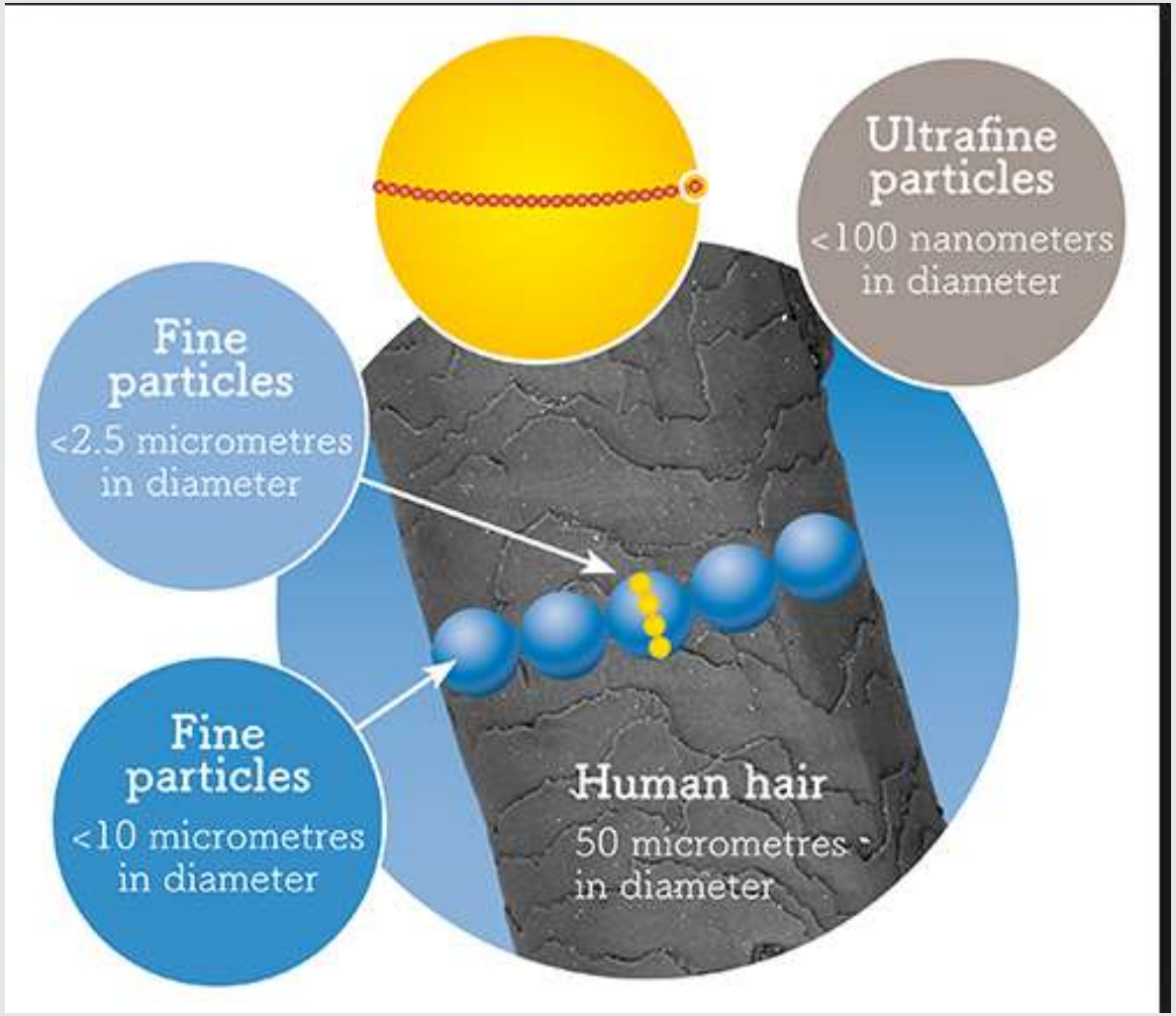


Fig 7. Particle streak lines from a long starting jet (Re_c = 12,900, Q/AD = 5,000).

doi:10.1371/journal.pone.0169235.g007

https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0169235&type=printable

Klassifisering av aerosoler



https://interestingengineering.com/dutch-group-creates-outdoor-vacuum-cleaner

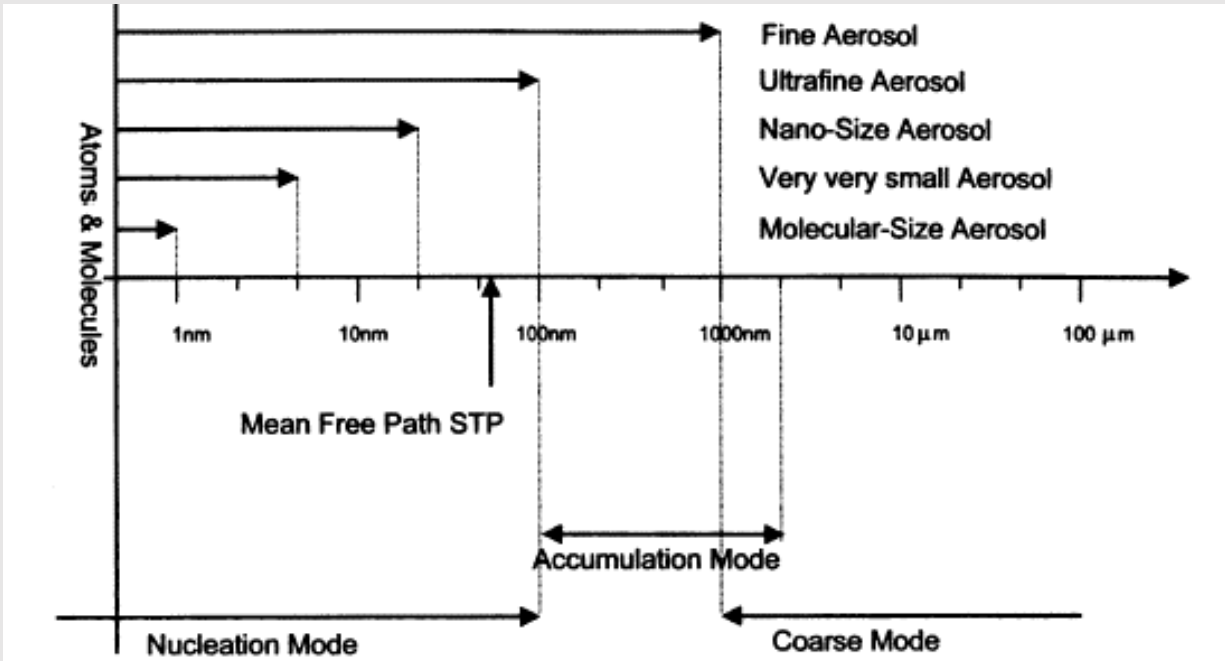


Figure 3.

The particle size classes: **coarse mode**, particles larger than about 1 µm mainly produced by diminution processes; **fine aerosol**, particles smaller than about 1 µm mainly built up by nucleation, condensation and coagulation; **nucleation mode** and **ultrafine aerosol**, particles smaller than about 100 nm; **nanosized aerosol**, particles smaller than about 20 nm; **very very small aerosol**, particles smaller than about 5 nm, particle behaviour dominated by surface effects, total number of molecules less than 500, **molecular size aerosol**, particles smaller than about 1 nm, less than 10 molecules in the particle. Reproduced from Preining (1998).

Klassifisering av aerosoler

Bioaerosoler

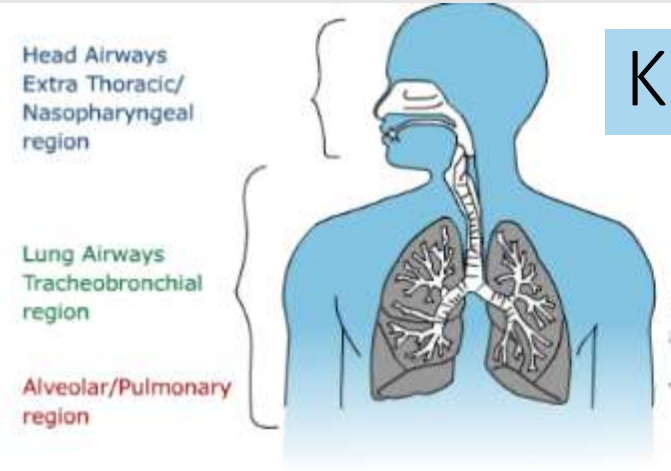


Figure 1: Human respiratory system [4]

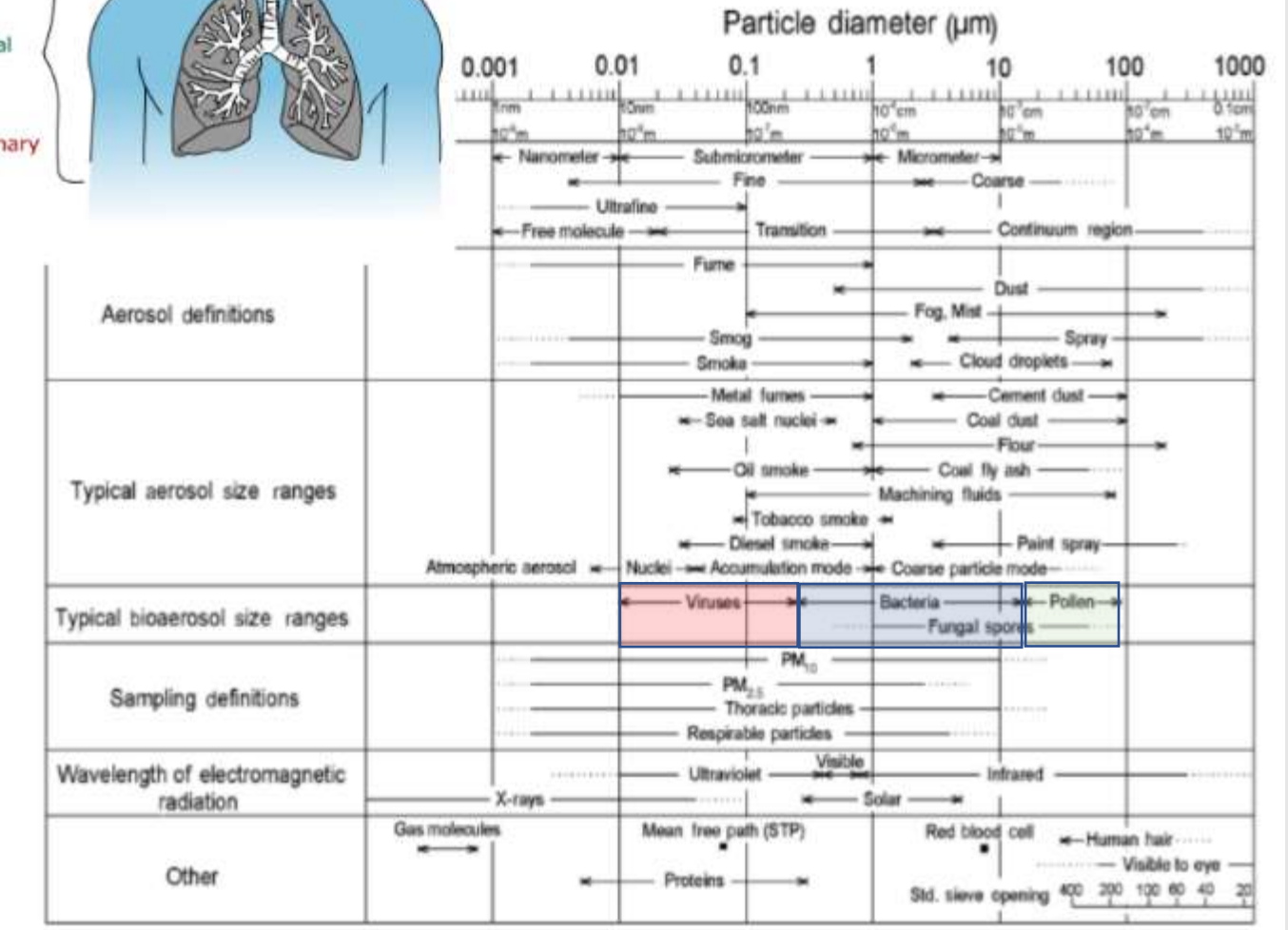


Figure 2: Types of aerosols versus size range [5]

1 meter = 1000 millimetre (mm)
1 mm = 1000 mikrometer (µm)
1 µm = 10^{-6} meter
1 µm = 1000 nanometer (nm)
1 nm = 10^{-9} meter
10 nm= 0,01 µm
1 nm = 0,001 µm
Virus: 10 nm -

https://www.researchgate.net/publication/305760965_Airflow_Modeling_and_Simulation_Required_in_CBRN_Collective_Protection_Design

Partikler og ultrafine partikler. Overflatearealog antall

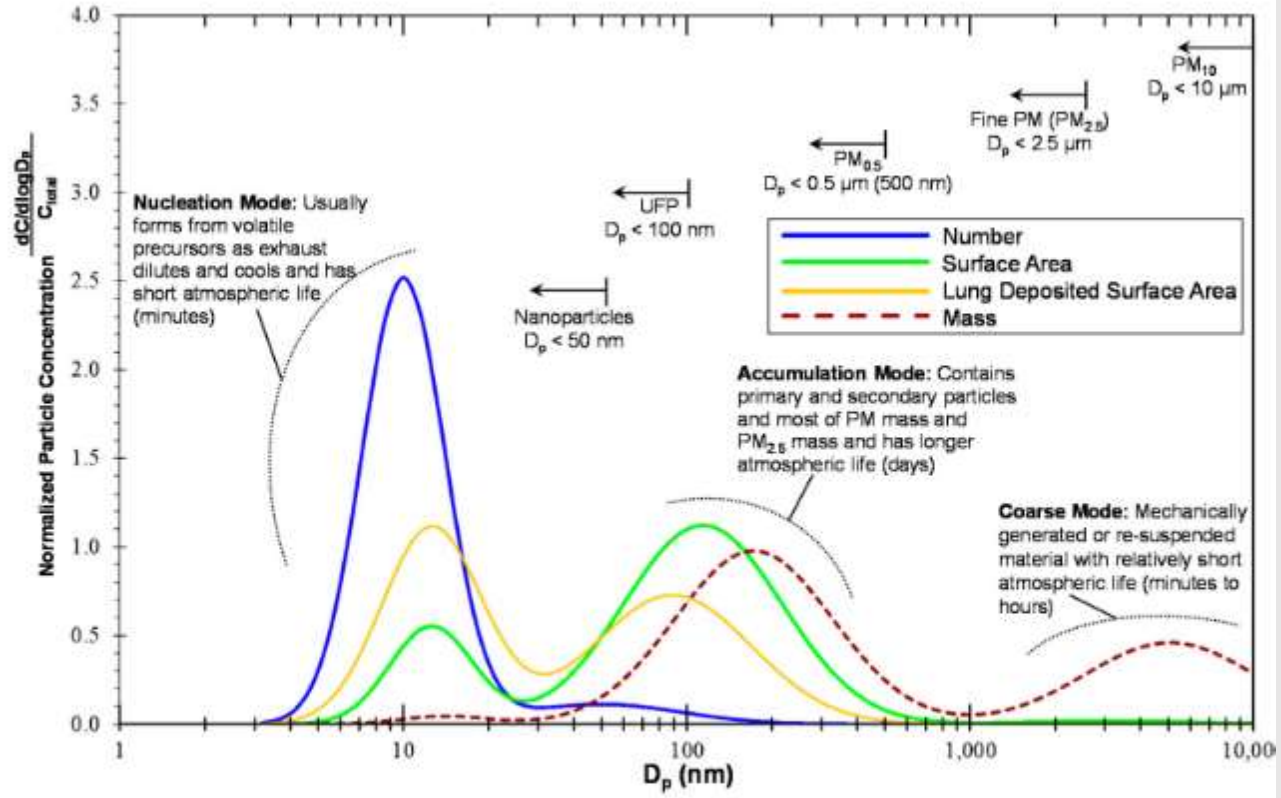
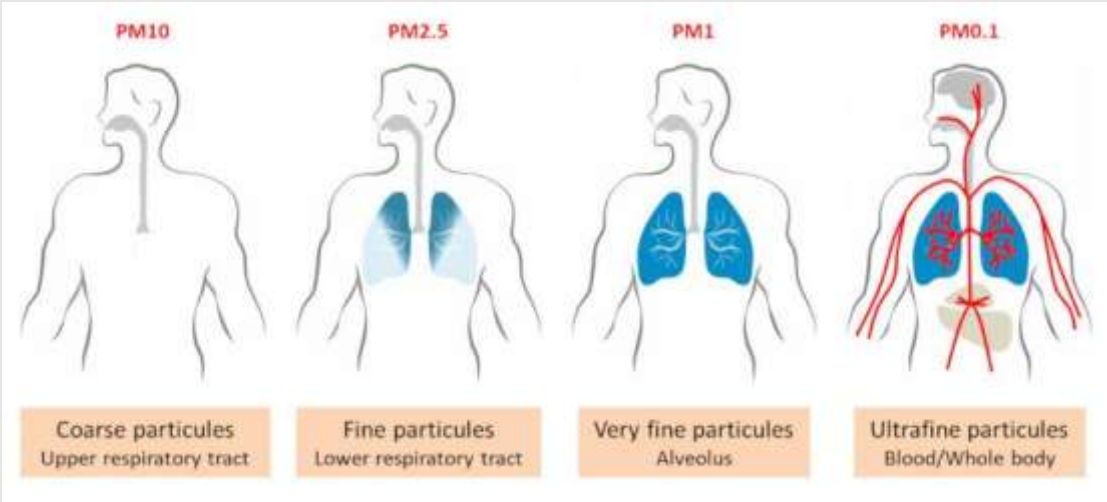


Figure 1. Tri-modal particle size distributions using different particle metrics (number, surface area, lung deposited surface area, and mass). For this figure, D_p is the particle diameter, UFP are ultrafine particles, and PM stands for particulate matter.



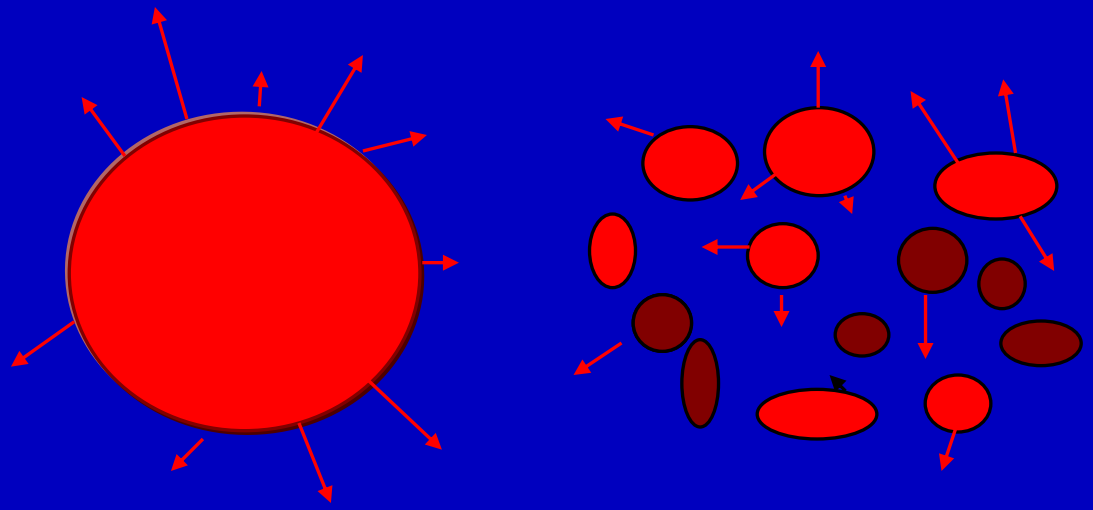
https://www.encyclopedie-environnement.org/en/health/airborne-particulate-health-effects/

Conference Report

Ultrafine Particle Metrics and Research Considerations: Review of the 2015 UFP Workshop

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5129264/

Aerosoler og kildestyrke

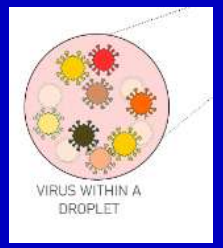


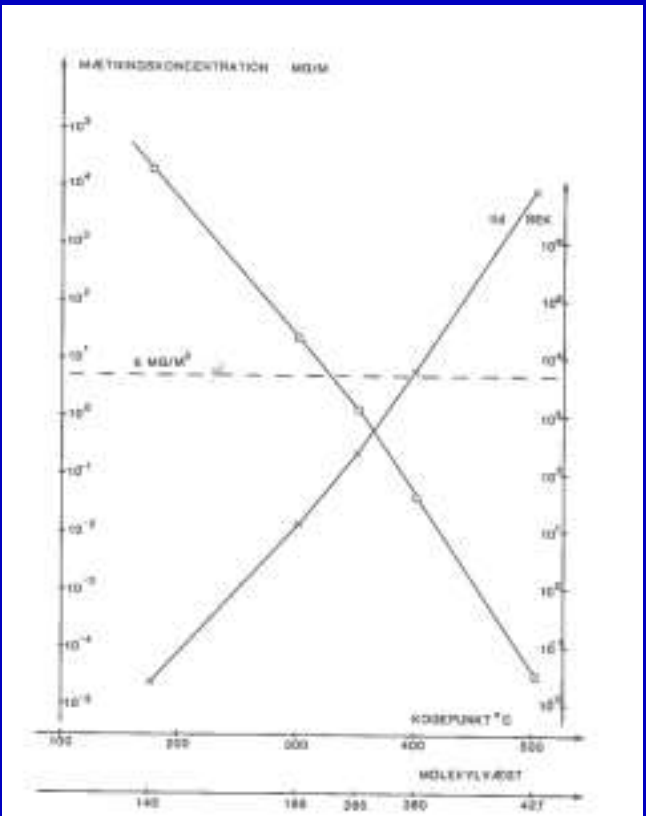
Eksempel:

På figur (2.3.1) ses mætningskoncentration og dråbelevetid for 4 µm (diameter) dråber mineralolie-fraktioner ved 20°C. Den omgivende luft er forudsat dampfri.

Det ses, at fraktioner med kogepunkt under ca. 320°C fordamper hurtigt og at mætnings-koncentration er over 5 mg/m^3.

Dette viser, at det ofte er nødvendigt at tage hensyn til gasfaseforureningen ved prø-veudtagning af væskeaerosoler.





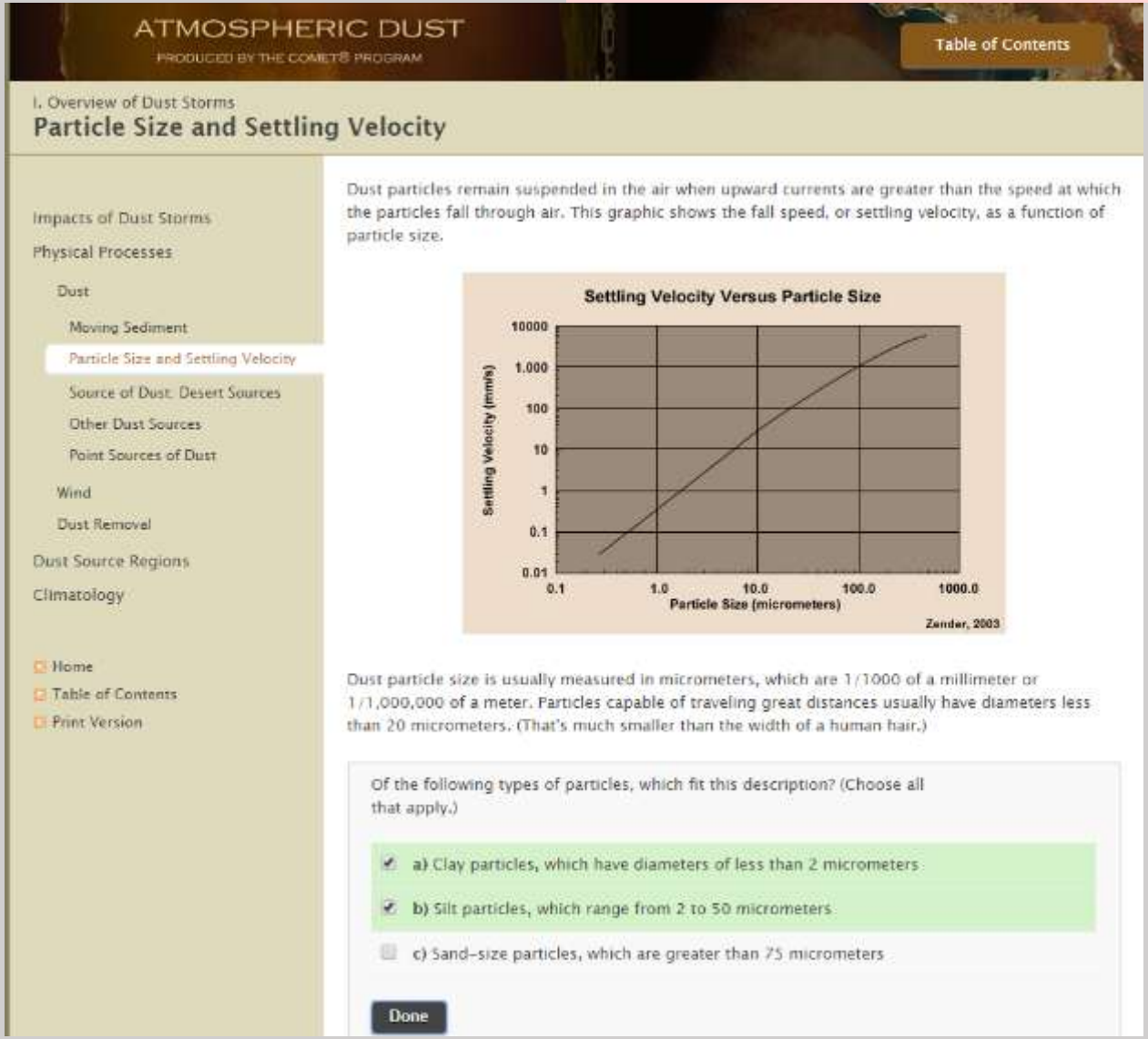
Figur 2.3.1 Mætningskoncentration og levetid for 4 µm dråber for jordoliedestillater med forskellig kogepunkt/molekylvægt. Der er forudsat dampfri luft.

Hvis vi sætter væskers densitet til tilnærmet at være 1 g/cm^3 (ligesom vands) kan det let beregnes at overfladen A af en aerosol med dråber med diameter D har et overfladeareal på A = 6/D^2 m^2 pr. gram væske hvor D er i µm.

- Ved oppsplitting av en dråpe på 1cm^3 til dråper med radius 2 mikrometer øker overflaten 10.000.000 ganger

Basisbog i teknisk arbejdshygiejne, Thomas Schneider, 1986, side 32

Hvor fort faller dråper og støvpartikler i luften?



http://kejian1.cmatc.cn/vod/comet/mesoprim/at_dust/navmenu.php_tab_1_page_2.1.2_type_text.htm

Aerodynamisk diameter (mikrometer)	Fallhastighet (meter/time)
100	1080
40	172
10	11
5	3
1	0,11

Basisbog i teknisk arbejdshygiejne, Thomas Schneider, 1986.

Redusering av dråpestørrelse gjennom fordampning

Transport of Droplets Expelled by Coughing in Ventilated Rooms

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Key Words
Coughing · Evaporating droplets · CFD · Ventilation

Abstract
This study aims to understand the transport and dispersal of droplets produced by coughing in a ventilated room. Experiments were conducted to measure the initial velocity and the duration of a coughing burst. Computational fluid dynamics with a Eulerian-Lagrangian model was used to investigate the transport characteristics of evaporating droplets expelled into the ventilated room. The simulation results indicate that if expelled horizontally the droplets finally settle if their initial size is >100 μm, while if expelled upwards the droplets only settle if their initial size is ≥300 μm. Different ventilation set-ups vary in their ability to remove droplets produced by coughing. The mixing ventilation system has an almost equal efficiency for removing small passive droplets and the nuclei of droplets whose original size was 100 and 80 μm, respectively. For displacement ventilation, although it has high efficiency in removing small passive droplets, it has difficulty in removing the nuclei of large droplets. In the displacement system, small droplets show a two-zonal distribution in the room, but the nuclei of large droplets are subjected to gravitational force and tend to settle in the lower part of the room.

Nomenclature

A_d = surface area of the droplet
C_d = drag coefficient
c_p = heat capacity of the droplet material
C_s = molar concentration of water vapor at droplet surface
C_∞ = molar concentration of water vapor in the carrier phase
D_m = binary diffusion coefficient of water vapor in the air
d_d = hydrodynamic diameter of the droplet
g = gravitational acceleration
h = heat transfer coefficient between the two phases
h_m = molar transfer coefficient
L = latent heat of the droplet material
k = turbulent kinetic energy per unit mass
m_d = mass of each droplet
N = molar diffusion of water vapor
Nu = Nusselt number
p = static pressure
R = universal gas constant
Re_d = Reynolds number of the discrete phase
Sc = Schmidt number of carrier phase
Sh = Sherwood number
t = time

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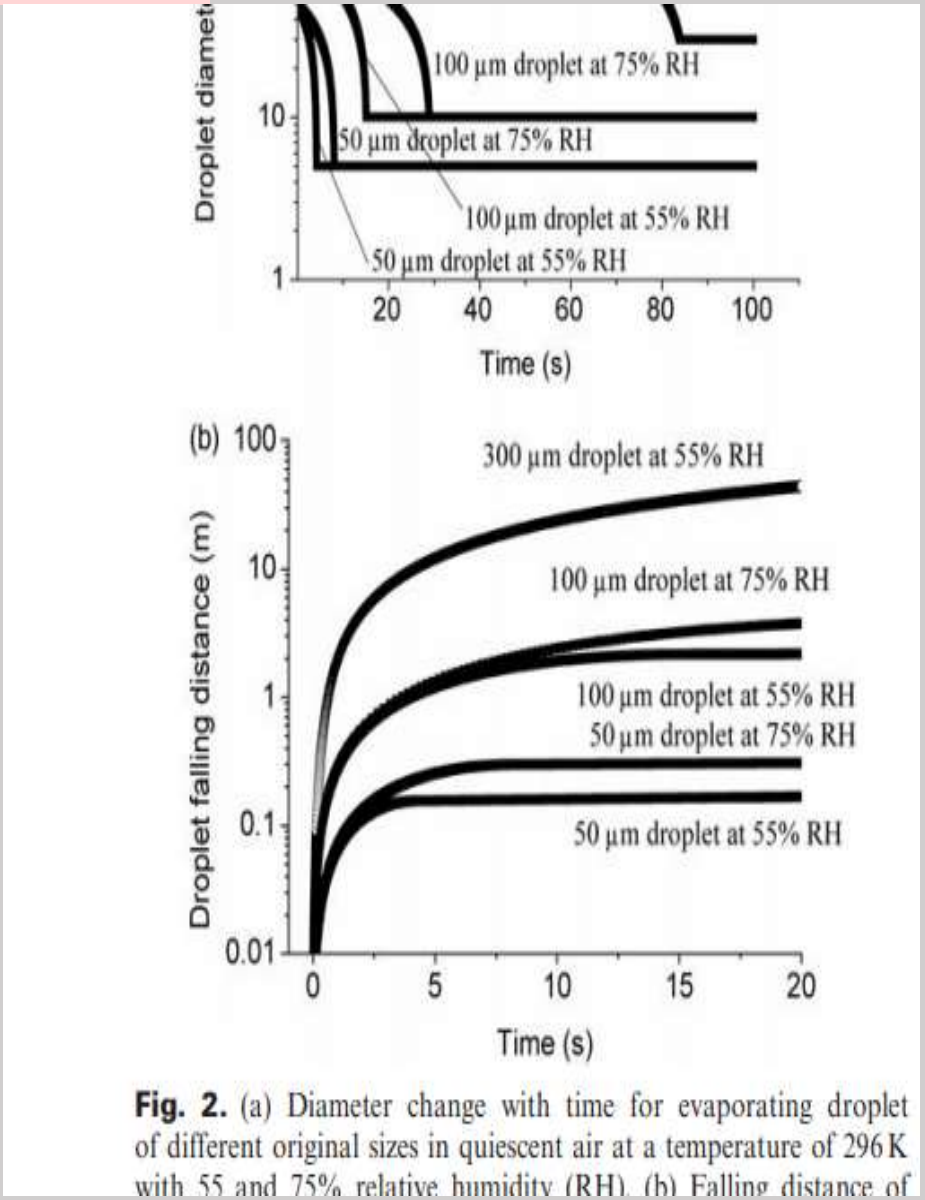
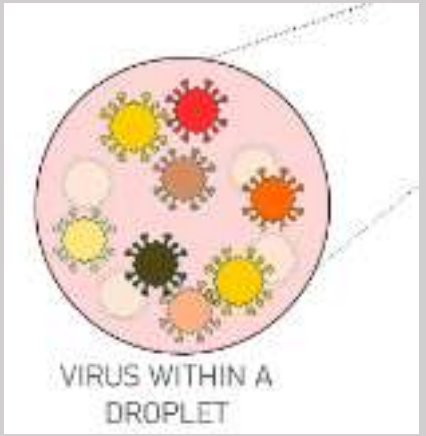


Fig. 2. (a) Diameter change with time for evaporating droplet of different original sizes in quiescent air at a temperature of 296 K with 55 and 75% relative humidity (RH). (b) Falling distance of



Dråpene fra hosting og nysing inneholder mye vann. Vann fordamper.
Dråpene blir raskt mindre og får lavere fallhastighet. De vil derfor holde seg svevende lenger og vandre over større distanse.

https://www.researchgate.net/publication/247731874_Transport_of_Droplets_Expelled_by_Coughing_in_Ventilated_Rooms/figures?lo=1

Aerosols – settling vs. størrelse (aerodynamisk diameter)

Generation and Behavior of Airborne Particles (Aerosols)

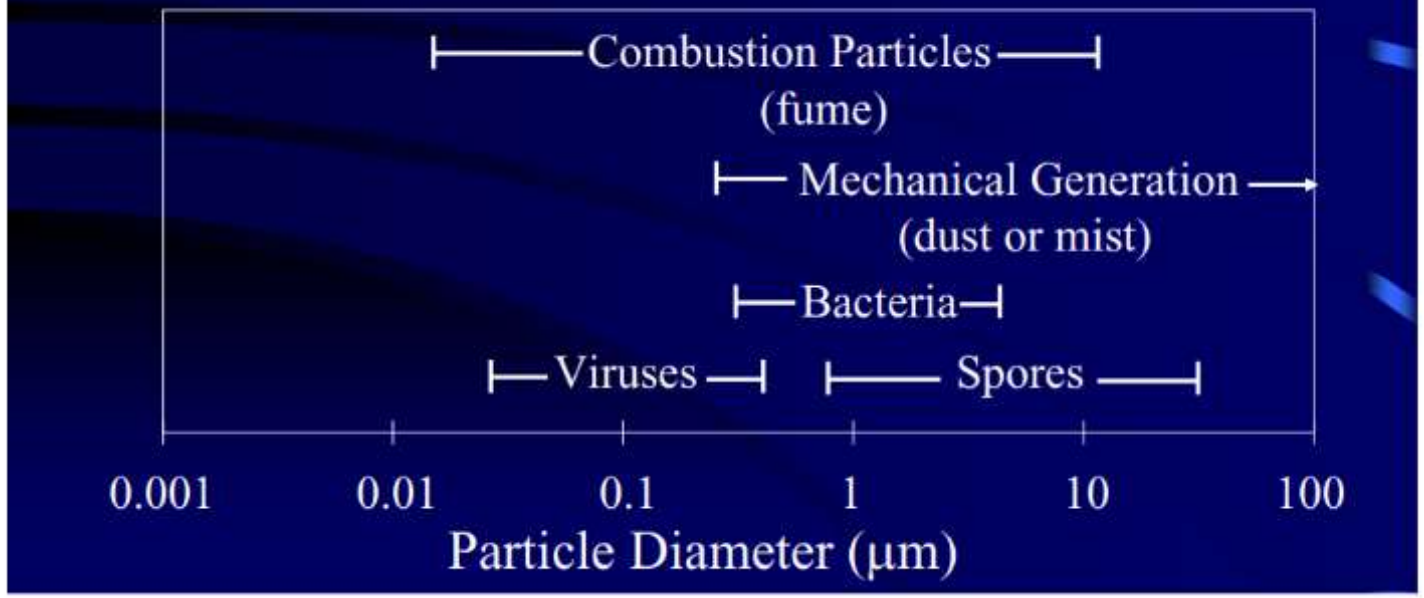
Paul Baron
Division of Applied Technology
National Institute for Occupational Safety and Health
Centers for Disease Control and Prevention

CDC

NIOSH

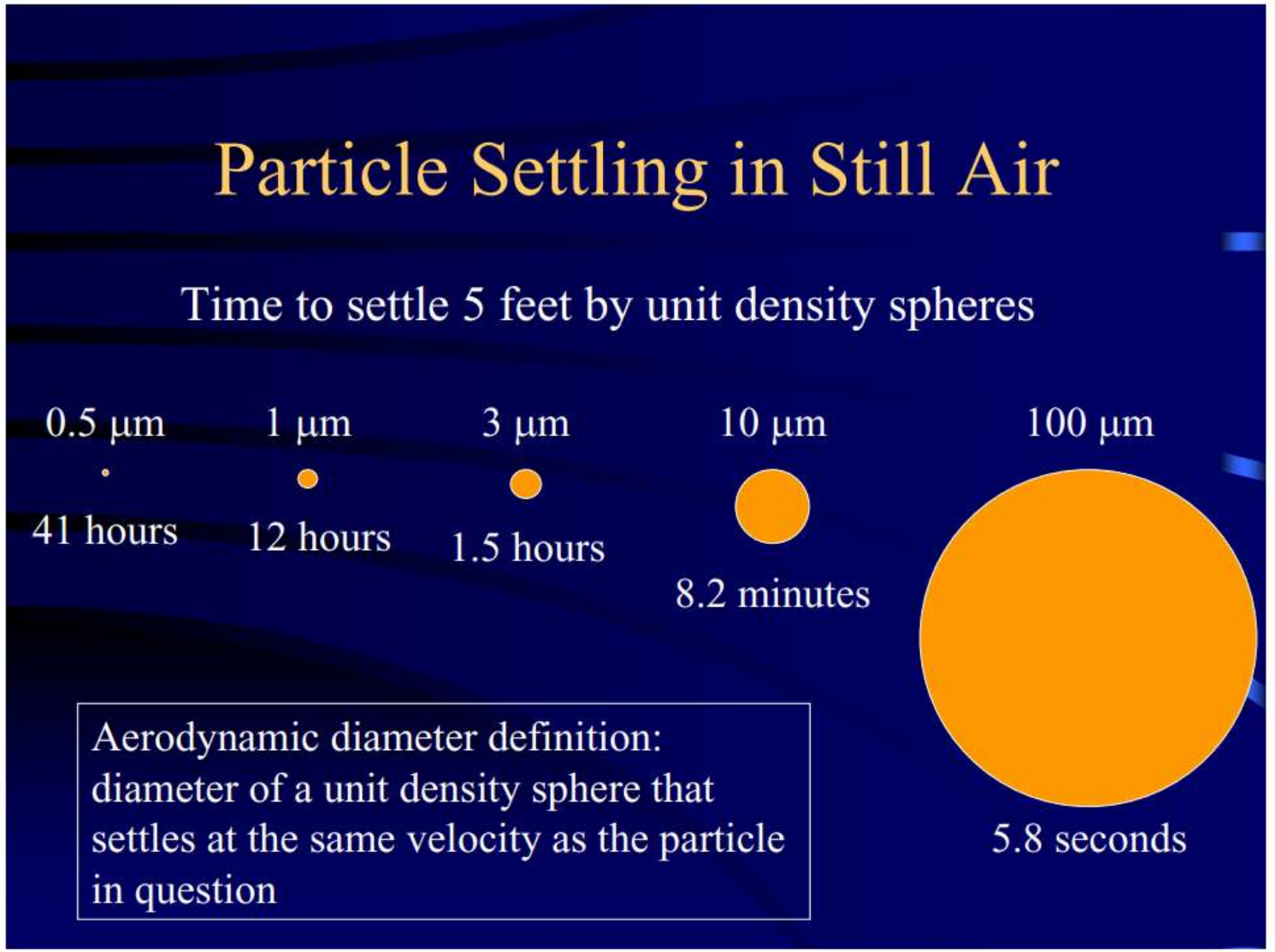
I. Aerosol Size Range

Particle size is often determined by the process that generated the particle. Combustion particles usually start out in the 0.01-0.05 µm size range, but combine with each other (agglomerate) to form larger particles. Powder is broken down into smaller particles and released into the air; it is difficult to break down such particles smaller than ~0.5 µm. Biological particles usually become airborne from liquid or powder forms, so these particles are usually larger than ~0.5 µm.



https://www.cdc.gov/niosh/topics/aerosols/pdfs/Aerosol_101.pdf

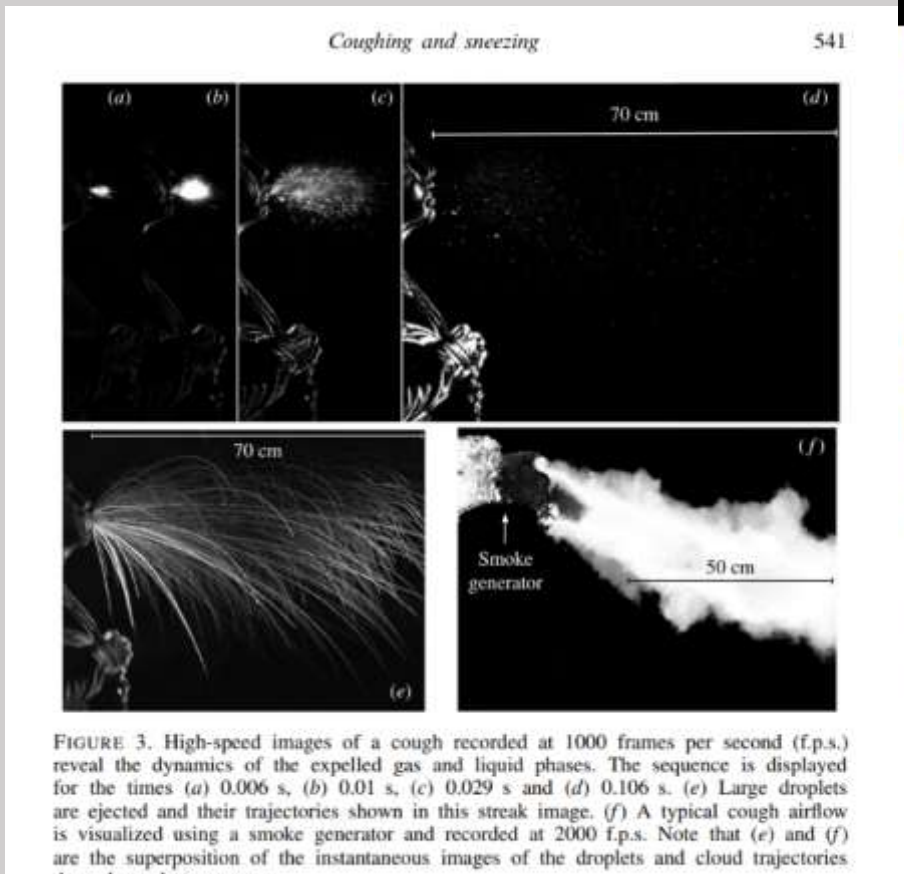
Aerosols – settling vs. størrelse (aerodynamisk diameter)



Små partikler vil holde seg svevende i lang, lang tid…..

https://www.cdc.gov/niosh/topics/aerosols/pdfs/Aerosol_101.pdf

Dråpefysikk - spredning



Coughing and sneezing 541

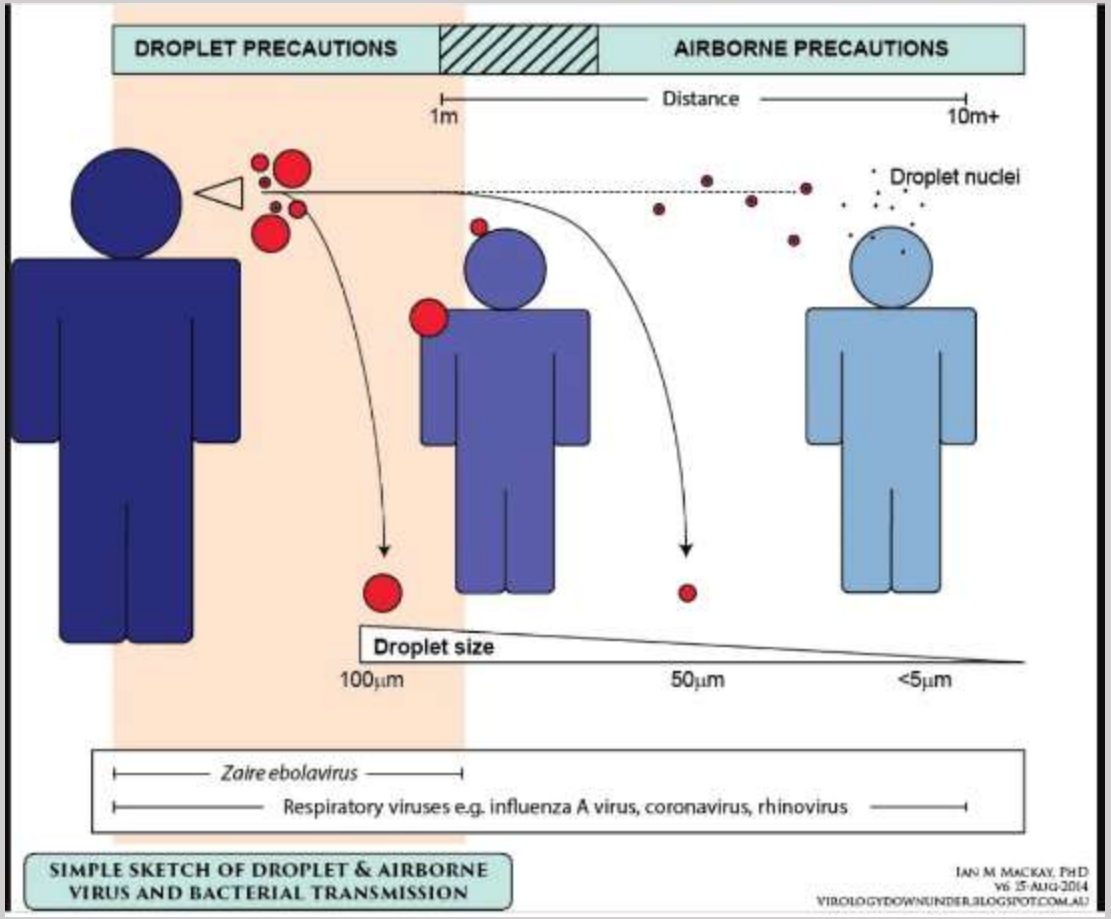
FIGURE 3. High-speed images of a cough recorded at 1000 frames per second (f.p.s.) reveal the dynamics of the expelled gas and liquid phases. The sequence is displayed for the times (*a*) 0.006 s, (*b*) 0.01 s, (*c*) 0.029 s and (*d*) 0.106 s. (*e*) Large droplets are ejected and their trajectories shown in this streak image. (*f*) A typical cough airflow is visualized using a smoke generator and recorded at 2000 f.p.s. Note that (*e*) and (*f*) are the superposition of the instantaneous images of the droplets and cloud trajectories

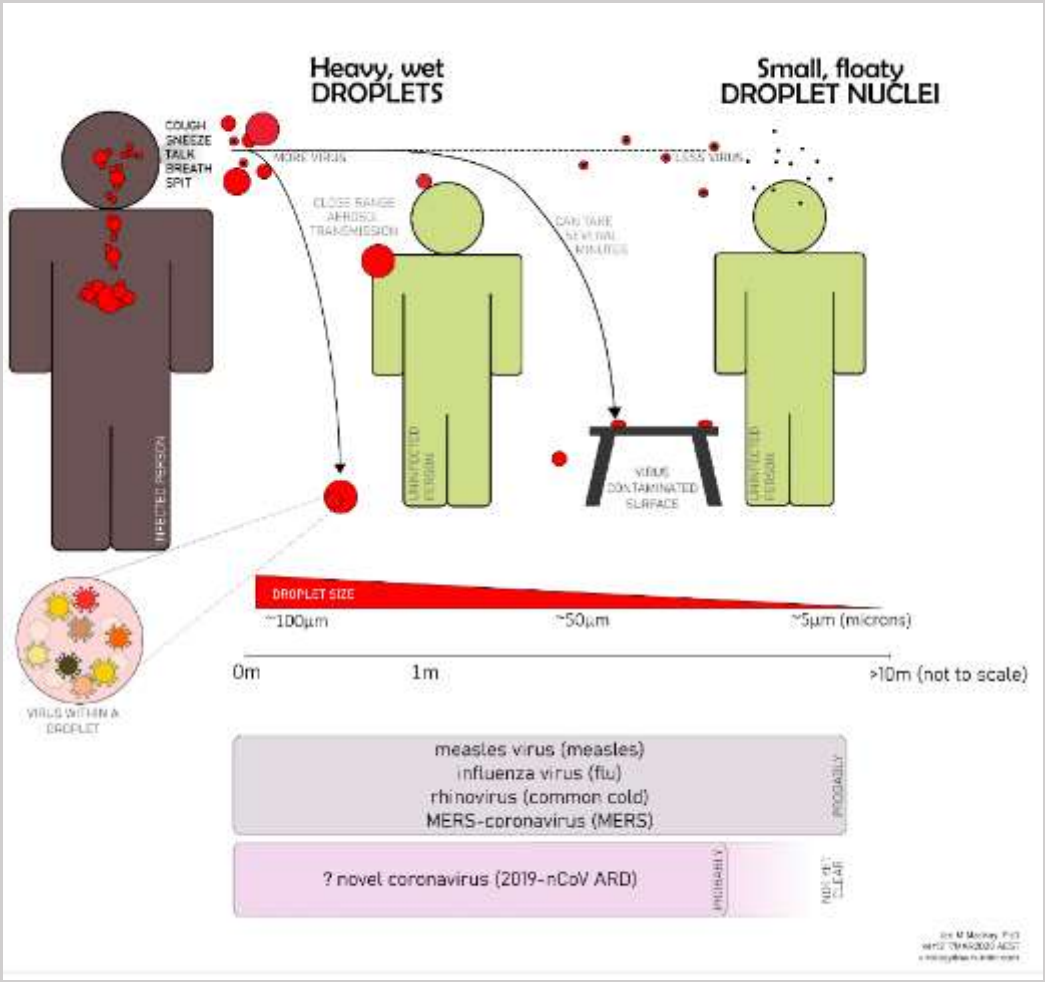
https://www.researchgate.net/publication/262983673_Violent_expiratory_events_On_coughing_and_sneezing/figures?lo=1

http://news.mit.edu/2014/coughs-and-sneezes-float-farther-you-think

https://universityhealthnews.com/daily/eyes-ears-nose-throat/how-far-does-a-sneeze-travel/

Dråpefysikk - spredning





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Rensing av luft med ultrafine partikler og virus

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Cleaning capacity	max. 500 m³/h
Particle size arrestance	> 0,003 µm
Cleaning efficiency	99,5 %
Gas removal	Included: 800 g activated carbon, 60 mm
Dimensions (W x H x D)	600 x 1630 x 600 mm
Weight	91 kg
Chassis	Painted galvanized steel
Installation	Mobile
Fan speed	Stepless speed control
Power consumption	60–130 W
Sound level	25–44 dBa
Operating voltage	198–264 V, 50/60 Hz
Usage temperature	+5..+60 °C

Read more about our services and solutions **genano.com**

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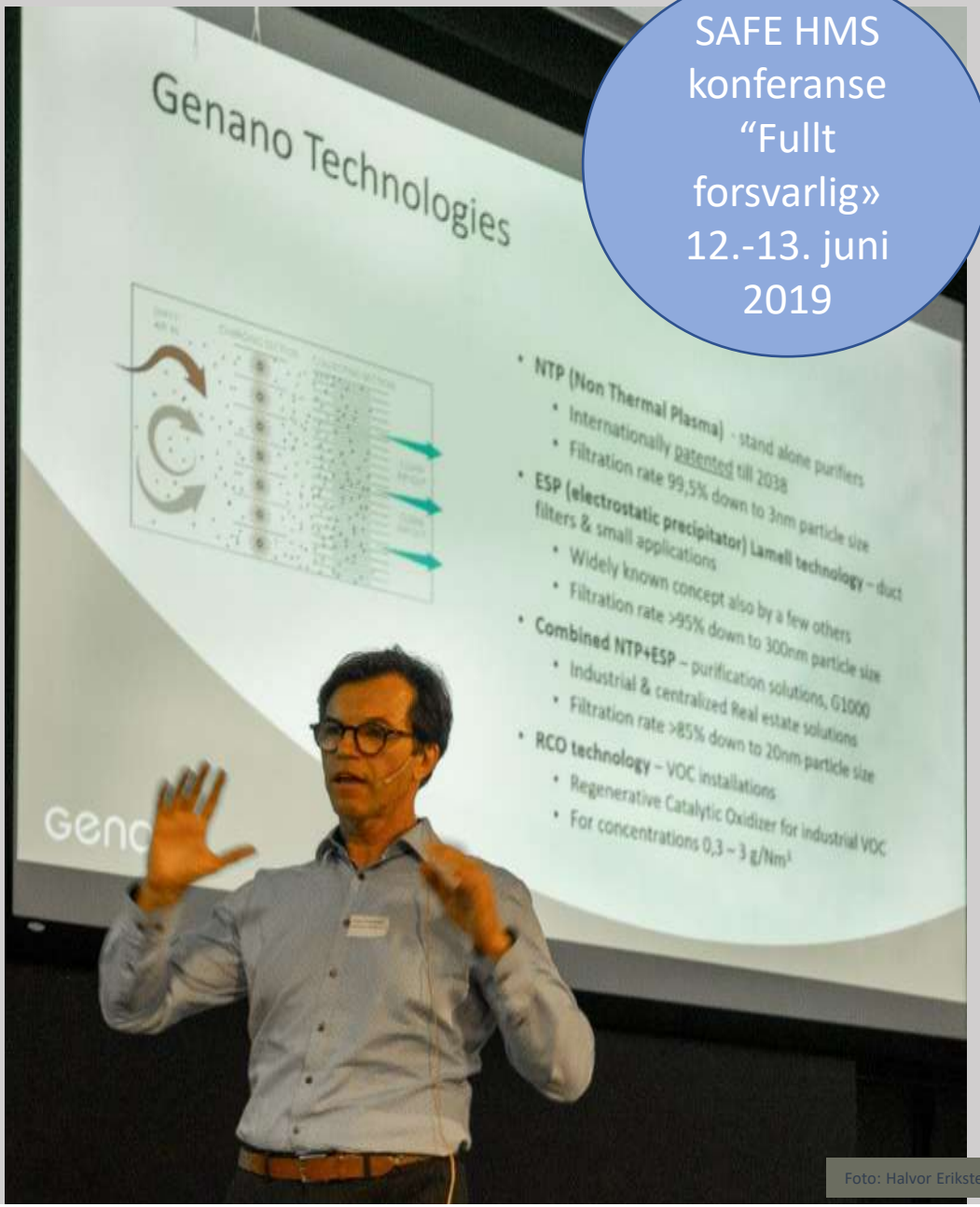

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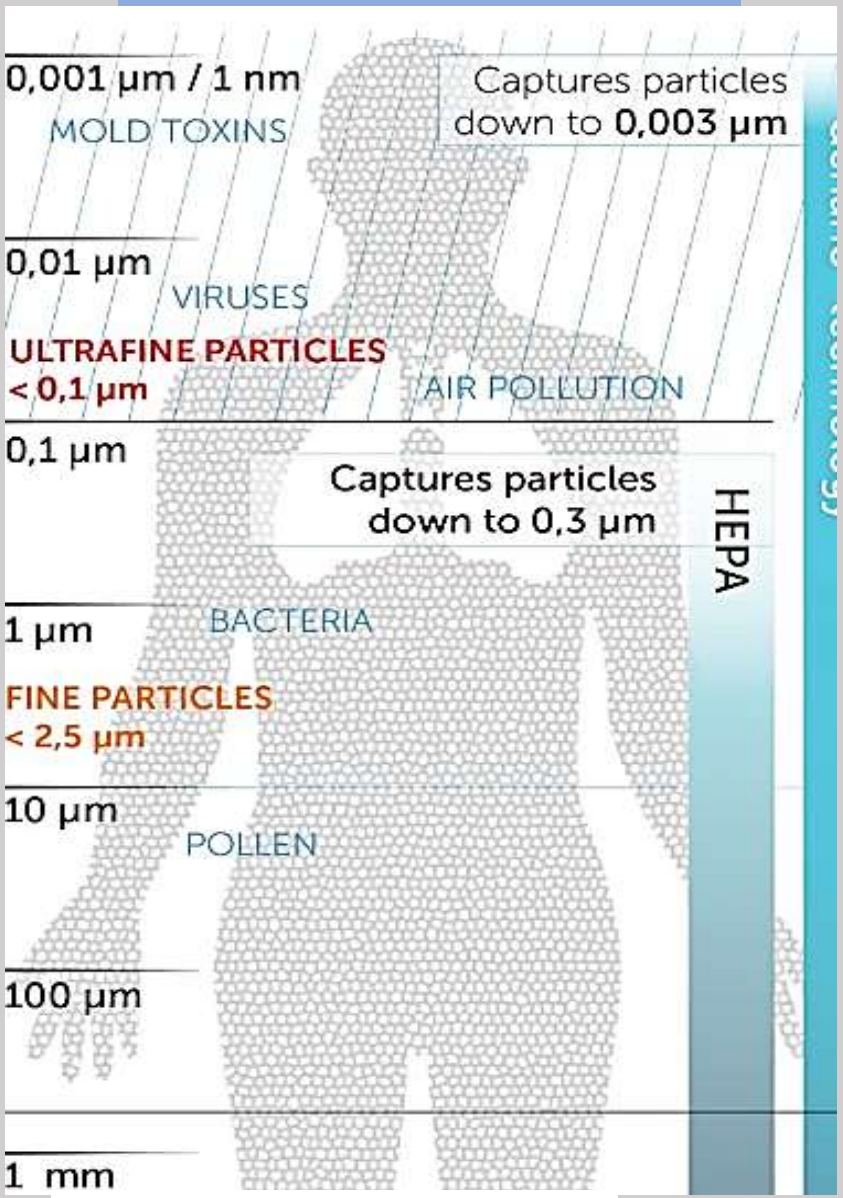
Genano renseteknologi



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When HEPA Is Not Enough

The biggest health risk in the air we breathe is related to ultrafine particles and hazardous gases. These substances are able to penetrate to the bloodstream through alveoles in our lungs. The smaller the particle, the deeper it will be able to penetrate in our lungs. These kinds of impurities are, for example, mold toxins and particles from polluted outdoor air.

Removing them is not possible with traditional HEPA filters.

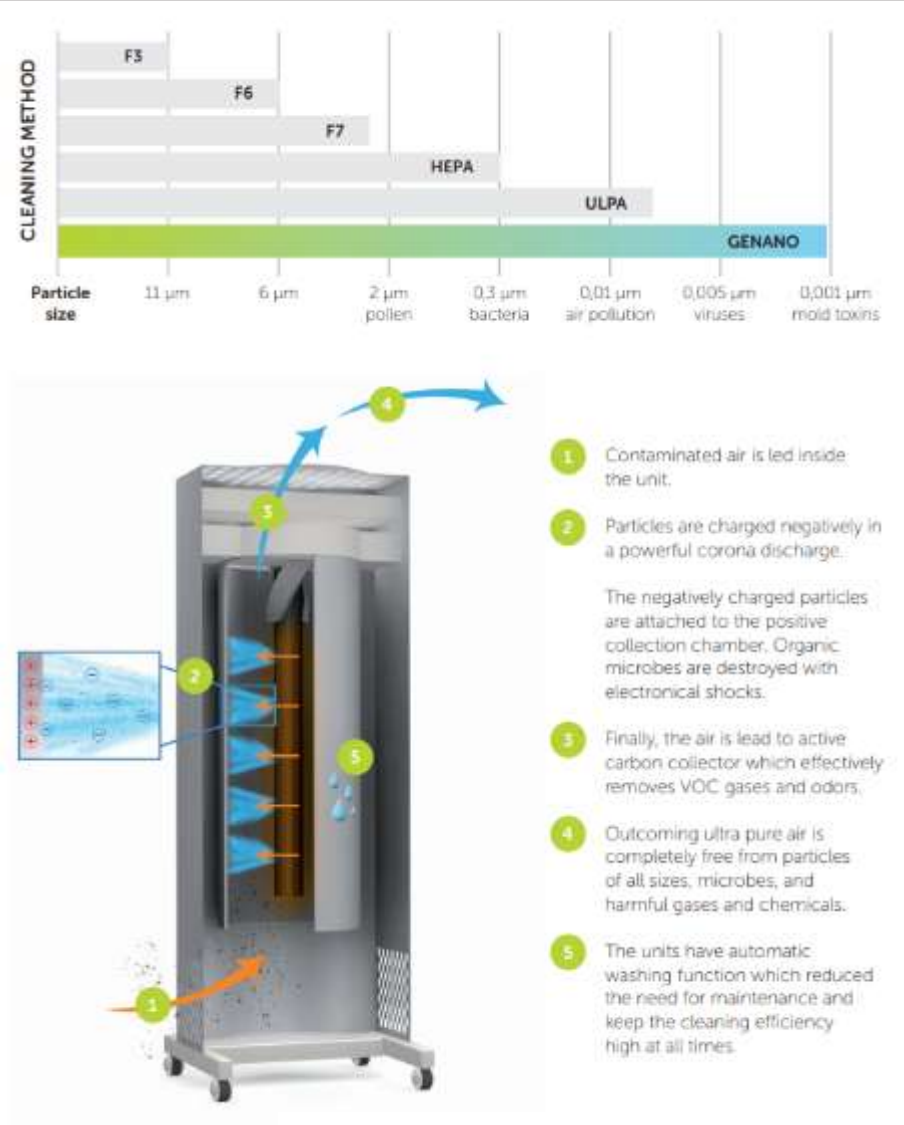
Genano's core advantage is the unique air purification method that can eliminate microbes and remove particles down to nanosize.

The technology has been scientifically tested down to 3 nanometer size particles (PM 0.003) – Genano Technology removes 99.5 % of even the smallest of the particles. Compared to standard HEPA filters, Genano's purification performance is a 100 times better in terms of particle size. In addition, Genano also eliminates the microbes instead of just collecting them.

Particle removal efficiency is often a misleading parameter when comparing air purifiers.

Think which is more important – to remove 0,3 micron particles with 99,99 % efficiency – or to remove 0,003 micron particles with 99,5 % efficiency?

Ny teknologi – fjerner virus fra luften



https://cdn2.hubspot.net/hubfs/4908113/Datasheets/Genano5250A_M_datasheet.pdf

Arbeidstilsynet om åndedrettsvern

Arbeidstilsynet

Arbeidsforhold HMS Tema Regelverk Godkjenningsregistre

Se oppdatert informasjon om Koronavirus: Tiltak i arbeidslivet

Arbeidstilsynet › Tema › Personlig verneutstyr (PVU) › Åndedrettsvern

Åndedrettsvern

Åndedrettsvern skal bare brukes dersom risiko for skader på liv og helse hos arbeidstakeren ikke kan unngås på annen måte.

Åndedrettsvern er ingen fullgod erstatning for andre vernetiltak og skal ikke være en permanent løsning på et arbeidsmiljøproblem. Arbeidsgiver er ansvarlig for å velge riktig åndedrettsvern etter arbeidsoperasjon, forurensingstype og eksponeringsnivå. Åndedrettsvernet skal være tilpasset den enkelte arbeidstaker.

Åndedrettsvern og korona

Les mer om bruk av åndedrettsvern og korona her: Koronavirus: Tiltak i arbeidslivet.

Når skal verneutstyr benyttes?

Personlig verneutstyr skal brukes når tilfredsstillende vern av arbeidstakerens sikkerhet, helse og velferd ikke kan oppnås ved tekniske installasjoner på arbeidsplassen eller ved endringer av arbeidsmetoder eller arbeidsprosesser.

Åndedrettsvern bør benyttes ved:

- opphold eller arbeid i forurenset atmosfære uten at andre vernetiltak er innført
- fjerning av sot eller forurensning
- vedlikehold og rengjøring
- korte arbeidsoperasjoner med høy forurensning

OBS:

https://www.arbeidstilsynet.no/tema/personlig-verneutstyr/andedrettsvern/

Se oppdatert informasjon om Koronavirus: Tiltak i arbeidslivet

Koronavirus: Tiltak i arbeidslivet

For å hindre potensiell smitte med det nye koronaviruset, er det viktig at arbeidsgivere gjennomfører en risikovurdering av mulig smittefare. Det er særlig viktig på arbeidsplasser der man er i kontakt med mange mennesker.

Sist oppdatert: 27. mars 2020

Arbeidsgiver skal risikovurdere faren for smitte

Som arbeidsgiver må du tenke gjennom risikoen og planlegge tiltak hvis de ansatte kan komme i kontakt med smittede på arbeidsplassen eller selv utgjøre en smittefare.

Alle arbeidsgivere må vurdere om de har ansatte eller innleid personale som kan komme i en smittesituasjon. Arbeidsgiver skal kartlegge og risikovurdere alle farer og problemer.

Eksempler på risikofaktorer i forbindelse med koronaviruset:

- Arbeidstakere i risikogrupper (se oversikt hos Folkehelseinstituttet)
- Nærkontakt med kolleger eller kunder/publikum (mindre enn 2 meter)
- Manglende tilgang til håndvask med såpe eller spritbaserte hånddesinfeksjonsmidler
- Manglende tilgang til nødvendig smittevernutstyr, eks. hansker, P3-masker, visir/tette vernebriller
- Manglende opplæring for de ansatte
- Reisevirksomhet

Arbeidsgiver skal iverksette tiltak for å hindre smittespredning i virksomheten.

Bedriftshelsetjenesten kan kontaktes ved behov for bistand til slik risikovurdering og planlegging av tiltak.

https://www.arbeidstilsynet.no/tema/biologiske-faktorer/coronavirus-tiltak-i-arbeidslivet-mot-smitte/

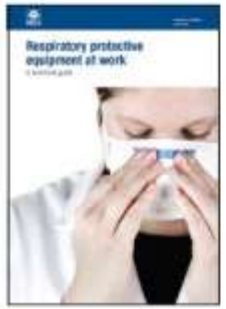
Hvordan velge åndedrettsvern? Svært nyttig håndbok for valg av riktig åndedrettsvern

HSE

Health and Safety Executive

Respiratory protective equipment at work

A practical guide



This is a web-friendly version of HSG53 published 05/13

HSG53 (Fourth edition, published 2013).

You can buy the book at www.hsebooks.co.uk and most bookshops.

ISBN 978 0 7176 6454 2

This book provides guidance on the selection and use of adequate and suitable respiratory protective equipment (RPE) in the workplace, in order to comply with the law.

It tells you when you can use RPE, using a simple step-by-step approach. It helps you to decide the adequate level of protection for a given hazardous substance and how to select RPE that is suitable for the particular wearer, task and work environment. It also contains advice on how to make sure that the selected RPE keeps working effectively.

https://www.hse.gov.uk/pubns/priced/hsg53.pdf

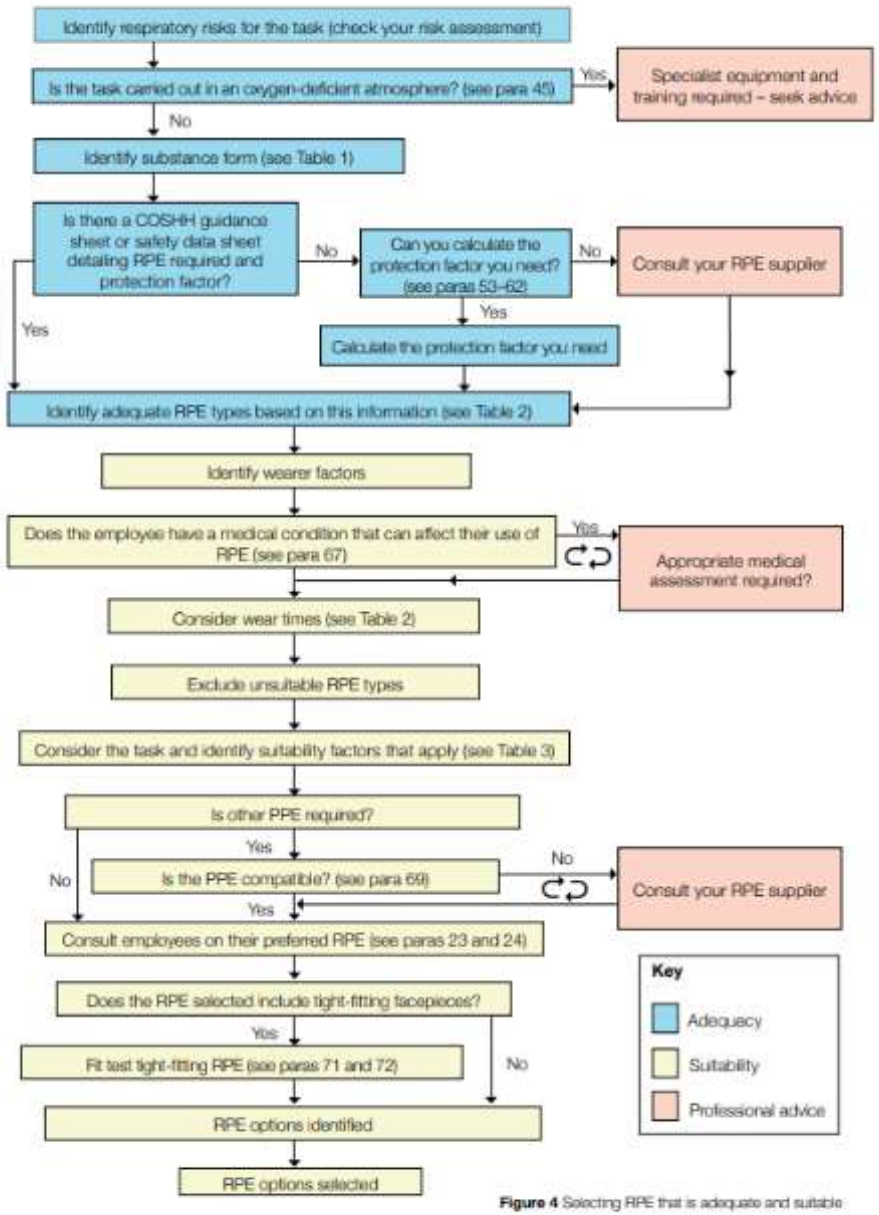


Figure 4 Selecting RPE that is adequate and suitable

Assigned Protection Factor (AFP) - Beskyttelsesfaktor

Assigned Protection Factors (APF)

pennsylvania
DEPARTMENT OF LABOR & INDUSTRY

Defined:

- Workplace level of respiratory protection respirators are expected to provide when employer implements a continuing, effective respiratory protection program

PPT-042-01 34

https://www.slideshare.net/complianceandsafety/respiratory-protection-li-v12

APF Explained

pennsylvania
DEPARTMENT OF LABOR & INDUSTRY

- Ratio comparison of the amount of contaminant outside the respirator and amount which may intrude the face piece

- APF= $\frac{\text{Concentration outside respirator}}{\text{Concentration inside face piece}}$

PPT-042-01 35

Forskjellen munnbind og partikkelfiltermasker

Understanding the Difference

	Surgical Mask	N95 Respirator
Testing and Approval	Cleared by the U.S. Food and Drug Administration (**FDA**)	Evaluated, tested, and approved by **NIOSH** as per the requirements in 42 CFR Part 84
Intended Use and Purpose	Fluid resistant and provides the wearer protection against large droplets, splashes, or sprays of bodily or other hazardous fluids. Protects the patient from the wearer's respiratory emissions.	Reduces wearer's exposure to particles including small particle aerosols and large droplets (**only non-oil aerosols**).
Face Seal Fit	Loose-fitting	Tight-fitting
Fit Testing Requirement	No	Yes
User Seal Check Requirement	No	Yes. Required each time the respirator is donned (put on)
Filtration	Does NOT provide the wearer with a reliable level of protection from inhaling smaller airborne particles and is not considered respiratory protection	Filters out at least 95% of airborne particles including large and small particles
Leakage	Leakage occurs around the edge of the mask when user inhales	When properly fitted and donned, minimal leakage occurs around edges of the respirator when user inhales
Use Limitations	Disposable. Discard after each patient encounter.	Ideally should be discarded after each patient encounter and after aerosol-generating procedures. It should also be discarded when it becomes damaged or deformed; no longer forms an effective seal to the face; becomes wet or visibly dirty; breathing becomes difficult; or if it becomes contaminated with blood, respiratory or nasal secretions, or other bodily fluids from patients.

CDC NIOSH Centers for Disease Control and Prevention National Institute for Occupational Safety and Health

https://www.cdc.gov/niosh/npptl/pdfs/UnderstandDifferenceInfographic-508.pdf

Comparing Surgical Masks and Surgical N95 Respirators

The FDA regulates surgical masks and surgical N95 respirators differently based on their intended use.

A **surgical mask** is a loose-fitting, disposable device that creates a physical barrier between the mouth and nose of the wearer and potential contaminants in the immediate environment. These are often referred to as face masks, although not all face masks are regulated as surgical masks. Note that the edges of the mask are not designed to form a seal around the nose and mouth.

An **N95 respirator** is a respiratory protective device designed to achieve a very close facial fit and very efficient filtration of airborne particles. Note that the edges of the respirator are designed to form a seal around the nose and mouth. Surgical N95 Respirators are commonly used in healthcare settings and are a subset of N95 Filtering Facepiece Respirators (FFRs), often referred to as N95s.

The similarities among surgical masks and surgical N95s are:

- They are tested for fluid resistance, filtration efficiency (particulate filtration efficiency and bacterial filtration efficiency), flammability and biocompatibility.
- They should not be shared or reused.

https://www.fda.gov/medical-devices/personal-protective-equipment-infection-control/n95-respirators-and-surgical-masks-face-masks#s2

Ingen beskyttelsesfaktor

Beskyttelsesfaktor 10 hvis riktig tilpasset

Forskjellen på munnbind, støvmaske og masker med utskiftbare filtre (gass og partikkel)

Understanding the Difference

	 Surgical Mask	 N95 Respirator	 Elastomeric Half Facepiece Respirator
Testing and Approval	Cleared by the U.S. Food and Drug Administration (FDA)	Evaluated, tested, and approved by NIOSH as per the requirements in 42 CFR Part 84*	Evaluated, tested, and approved by NIOSH as per the requirements in 42 CFR Part 84
Intended Use and Purpose	Fluid resistant and provides the wearer protection against large droplets, splashes, or sprays of bodily or other hazardous fluids. Protects the patient from the wearer's respiratory emissions.	Reduces wearer's exposure to particles including small particle aerosols and large droplets (**only non-oil aerosols**)	Reusable device made of synthetic or rubber material
Face Seal Fit	Loose-fitting	Tight-fitting	Tight-fitting
Fit Testing Requirement	No	Yes	Yes
Designed for Reuse	No	No	Yes
User Seal Check	No	Yes. Required each time the respirator is donned (put on)	Yes. Required each time the respirator is donned (put on)
Filtration	Does NOT provide the wearer with a reliable level of protection from inhaling smaller airborne particles and is not considered respiratory protection	Filters out at least 95% of airborne particles including large and small particles	May be equipped with filters that block 95%, 99%, or 100% of very small particulates. Also may be equipped to protect against vapors/gases.
Leakage	Leakage occurs around the edge of the mask when user inhales	When properly fitted and donned, minimal leakage occurs around edges of the respirator when user inhales	When properly fitted and donned, minimal leakage occurs around edges of the respirator when user inhales
Use Limitations	Disposable. Discard after each patient encounter.	Ideally should be discarded after each patient encounter and after aerosol-generating procedures. It should also be discarded when it becomes damaged or deformed; no longer forms an effective seal to the face; becomes wet or visibly dirty; breathing becomes difficult; or if it becomes contaminated with blood, respiratory or nasal secretions, or other bodily fluids.	Reusable and must be cleaned/ disinfected and stored between each patient interaction

*As of July 2, 2018, NIOSH evaluates N95 FFRs intended for use in healthcare for biocompatibility, flammability, and fluid resistance to ensure conformity to relevant standards during the approval process. These tasks were previously performed by the FDA.

CDC NIOSH Centers for Disease Control and Prevention National Institute for Occupational

Resources:
Hospital Respiratory Protection Program Toolkit
http://www.cdc.gov/niosh/docs/2015-117/pdfs/2015-117.pdf

https://www.cdc.gov/niosh/npptl/pdfs/UnderstandingDifference3-508.pdf

Hva er beskyttelsesfaktoren (APF) til de ulike åndedrettssystemene?

Table 2 RPE types

Adequacy/suitability	Respirators						
RPE type							
	Disposable half mask – particle filter*	**Reusable half mask – particle filter**	**Reusable half mask – gas/ vapour filter**	**Full face mask – particle filter**	**Full face mask – gas/vapour filter**	**Powered mask**	**Powered hoods/helmets**
Effective for particles	✔	✔	✘	✔	✘	✔ **	✔ **
Effective for gas/vapour	✘	✘	✔	✘	✔	✔ **	✔ **
Continuous wear time	Less than 1 hr	Less than 1 hr	Less than 1 hr	Less than 1 hr	Less than 1 hr	More than 1 hr	More than 1 hr
APF4 types	✔	✔	✘	✔	✘	✘	✘
APF10 types	✔	✔	✔	✔	✘	✔	✔
APF20 types	✔	✔	✘	✘	✔	✔	✔
APF40 types	✘	✘	✘	✔	✘	✔	✔
APF200 types	✘	✘	✘	✘	✘	✘	✘
APF2000 types	✘	✘	✘	✘	✘	✘	✘
Page reference	29	30	31	32	33	34	35

* Sometimes referred to as a filtering facepiece or orinasal respirator.

** Only protects against particle or gas/vapour when the appropriate filter is fitted.

https://www.hse.gov.uk/pubns/priced/hsg53.pdf

Det har lenge vært kjent at filtermasker som skal være tettsittende får stor lekkasje når brukeren har skjegg.
Slike masker (*negative pressure respirators*) skal ikke brukes der "ansiktshår" ("facial hair") kommer mellom hud og tenting.

https://www.cdc.gov/niosh/npptl/pdfs/FacialHairWmask11282017-508.pdf

Uttesting av maskelekkasje i laboratorium.

Resultat av måling av maskelekkasje bruk av skjegg eller være glattbarbert

	GJENNOMSNITTLIG BESKYTTELSESFAKTOR
GLATTBARBERTE	
• halvmasker,	• 2950
• helmaske.	• > 10.000
HELSKJEGG	
• Halvmaske	• 12
• Helmaske	• 30

(Tallene er gjennomsnitt og kunne være betydelig dårligere)

Effect of Facial Hair on the Face Seal of Negative-Pressure Respirators.
Am. Ind. Hug. Assoc. J. 45(1):63-66 (1984).
O.T. Skredtvedt and J.G. Loschiavo
https://www.ncbi.nlm.nih.gov/pubmed/6702601

Norsk olje og gass – Retningslinjer for tetthetstesting

133 – NORSK OLJE OG GASS

ANBEFALTE RETNINGSLINJER

FOR

TETTHETSTESTING AV ÅNDEDRETTSVERN

Norsk olje&gass

Original versjon

https://www.norskoljeoggass.no/contentassets/9f70f4b7970141b4b994d8c0b9dd54c8/133---anbefalte-retningslinjer-for-tetthetstesting-av-andedrettsvern.pdf

Tetthetstesting: Kvalitativ og kvantitativ

Decisions about the types of RPE to be used in the event of an accident, incident or emergency should be made with regard to the level and type of risk and a worst case estimate of the likely concentration of a hazardous substance and any possible combustion product (s) in the air or other hazards generated in the workplace during the incident, therefore a higher Protection Factor may be required.

8.0 Facepiece Fit Testing

It is recommended that fit testing is carried out for all tight fitting respirators. The purpose of fit testing is to ensure a good fit of the mask to the individual and is applicable to tight fitting filtering face masks. It is also useful for checking that the wearer can put on a respirator face piece correctly themselves. The correct establishment of a tight seal on the face piece at all times is vital to prevent exposure.

There are 2 methods of Fit Testing: Qualitative or Quantitative.

8.1 Qualitative fit testing

This is suitable for disposable filtering face pieces. Qualitative methods are based on the wearer detecting leakage through the face seal region using a bitter/sweet tasting aerosol or odour compounds e.g. Saccharin, this is a pass or fail test only.

Qualitative method of fit testing

8.2 Quantitative fit testing

This is suitable for full and half face mask respirators and gives a numerical measure of the fit. Specialised equipment is required to conduct the measurement, which typically involves a laboratory test chamber or a portable fit testing device. This is a more stringent pass/fail test that demonstrates the level of performance of the respirator with a measurable result for a particular mask on a particular individual. Fit factors (FF) are calculated from quantitative testing in a laboratory; your fit testing service provider should be able to help you select the most appropriate method in conjunction with a qualified Occupational Hygienist.

Quantitative method of fit testing

Quantitative method of fit testing

8.3 Conducting Fit Testing

RPE fit testing should be conducted by a competent person (as defined in Part 1 of the Safety, Health and Welfare at Work Act, 2005) who has adequate knowledge and has received training in fit testing. There is currently no recognised certification for persons who perform respirator fit testing. Manufacturers of fit testing equipment may offer suitable training or advice you on how to perform relevant tests, when initially selecting RPE. The **IS EN 529:2005** standard also includes fit testing when assessing the suitability of selected RPE in the section on **Adequacy and Suitability**.

8.4 Repeat Fit Testing

A repeat fit test should be conducted in the following circumstances:

- Where the wearer loses or gains weight
- Develops any facial changes (scars, moles, etc) around the face seal area
- Or when the employer's health and safety policy requires it

If an employee does not pass a fit test for an RPD one may obtain a better fit by trying a respirator of a different size or model or made by another manufacturer. Alternatively a respirator that doesn't rely on a tight face seal, such as a hood type may be selected. Tight fitting face piece respirators must not be worn by individuals who have a beard or moustache. Respirators that do not rely on a tight seal such as hoods or helmets may be used by these individuals instead.

The testing of power assisted or breathing apparatus face pieces is carried out with the respirator temporarily converted into a negative pressure respirator by adapting the face piece to use a P3 filter instead of the air supply. Respirator manufacturers can supply these adapters. There is no requirement to fit test loose fitting equipment, however the employer should establish that the full protection is afforded by the equipment.

9.0 Misuse of RPE

RPE can be misused a number of different ways through incorrect initial selection, incompatibility with other PPE being worn, wearer compatibility issues or maintenance and cleaning not being carried out. Extra precautions should be taken when working in confined spaces, due to the potential for reduced oxygen levels, it is never suitable to use a filtering respirator in a confined space; a breathing apparatus should be provided instead.

https://www.hsa.ie/eng/Publications_and_Forms/Publications/Chemical_and_Hazardous_Substances/Respiratory%20Protective%20Equipment.pdf

Tetthetstesting – glattbarbert vs. skjegg

https://www.youtube.com/watch?v=dCWo6hgZB5Y

Bruk og begrensinger ved tetthetstesting

Filtering out Confusion: Frequently Asked Questions about Respiratory Protection

Fit Testing

Over 3 million United States employees, in approximately 1.3 million workplaces, are required to wear respiratory protection. The Occupational Safety and Health Administration (OSHA) (29 CFR 1910.134) requires an annual respirator fit test to confirm the fit of any respirator that forms a tight seal on the wearer's face before it is used in the workplace. This ensures that users are receiving the expected level of protection by minimizing any contaminant leakage into the facepiece. The following are some frequently asked questions about respiratory protection and fit testing.

What is a Respirator Fit Test?

A fit test is conducted to verify that a respirator is both comfortable and correctly fits the user. Fit test methods are classified as either qualitative or quantitative. A **qualitative** fit test is a pass/fail test that relies on the individual's sensory detection of a test agent, such as taste, smell, or involuntary cough (a reaction to irritant smoke*). A **quantitative** fit test uses an instrument to numerically measure the effectiveness of the respirator.

The benefits of a fit test include better protection for the employee and verification that the employee is wearing a correctly-fitting model and size of respirator.[1] Higher than expected levels of exposure to a contaminant may occur if the respirator has a poor face seal against the user's skin, which can result in leakage.

How Often Must Fit Testing Be Conducted?

In addition to fit testing upon initially selecting a model of respirator, OSHA requires that fit testing be conducted annually, and repeated "whenever an employee reports, or the employer or the physician or other licensed health care professional makes visual observations of changes in the employee's physical condition that could affect respirator fit (e.g., facial scarring, dental changes, cosmetic surgery, or an obvious change in body weight)."[2]

The appropriate length of time between respirator fit tests has been a point of debate and discussion for many years due to its use of workplace time and resources, especially in reference to the commonly-used filtering facepiece respirator (FFR).[3] In response to these concerns, NIOSH completed a study that confirmed the necessity of the current OSHA respirator fit testing requirement, both annually and when physical changes have occurred.[4]

CDC NIOSH

Once I am Fit Tested, Can I use any Brand/Make/Model Respirator as Long as it is the Same Size?

A successful fit test only qualifies an employee to use the specific brand/make/model and size of respirator that he or she wore during that test. Respirator sizing is not standardized across models or brands. For example, a medium in one model may not offer the same fit as a different manufacturer's medium model.

Can I Have Facial Hair and still be Fit Tested to Wear a Tight-Fitting Respirator?

The OSHA respirator standard prohibits tight-fitting respirators to be worn by workers who have facial hair that comes between the sealing surface of the facepiece and the face of the wearer. Facial hair that lies along the sealing area of a respirator, such as beards, sideburns, or some mustaches, will interfere with respirators that rely on a tight facepiece seal to achieve maximum protection.

Incorrect respirator use due to beard and strap placement

Research tells us that the presence of facial hair under the sealing surface causes 20 to 1000 times more leakage compared to clean-shaven individuals.[4] Gases, vapors, and particles in the air will take the path of least resistance and bypass the part of the respirator that captures or filters hazards out. A common misconception is that human hair can act as a crude filter to capture any particles that are in the airstream between the sealing surface and the user's skin. However, while human hair appears to be very thin to the naked eye, hair is much larger in size than the particles inhaled. Facial hair is not dense enough and the individual hairs are too large to capture particles like an air filter does; nor will a beard trap gases and vapors like the carbon bed in a respirator cartridge. Therefore, the vast majority of particles, gases, and vapors follow the air stream right through the facial hair and into respiratory tract of the wearer. In fact, some studies have shown that even a day or two of stubble can begin to reduce protection.

Do Powered Air-Purifying Respirators (PAPRs) Require Fit Testing?

The answer to this question depends on the type of facepiece that the respirator has. Any facepieces that form a tight seal to the wearer's face, e.g., half-masks and full facepieces, must be fit tested.
Loose-fitting PAPRs, in which the hood or helmet is designed to form only a partial seal with the wearer's face or hoods which seal loosely around the wearer's neck or shoulders, do not require fit testing.

Where can I Find More Information?

This information and more is available on the NIOSH Respirator Trusted-Source webpage.

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DHHS (NIOSH) Publication No. 2018-129

https://www.cdc.gov/niosh/docs/2018-129/pdfs/2018-129.pdf?id=10.26616/NIOSHPUB2018129

Kan jeg foreslå at Sikkerhetsforum arrangerer en workshop om verneutstyr i smittetider?

Halvor Erikstein
organisasjonssekretær/
yrkeshygieniker SYH
www.SAFE.no