WFI Open Webinar

Universal method to evaluate the performance of facemasks

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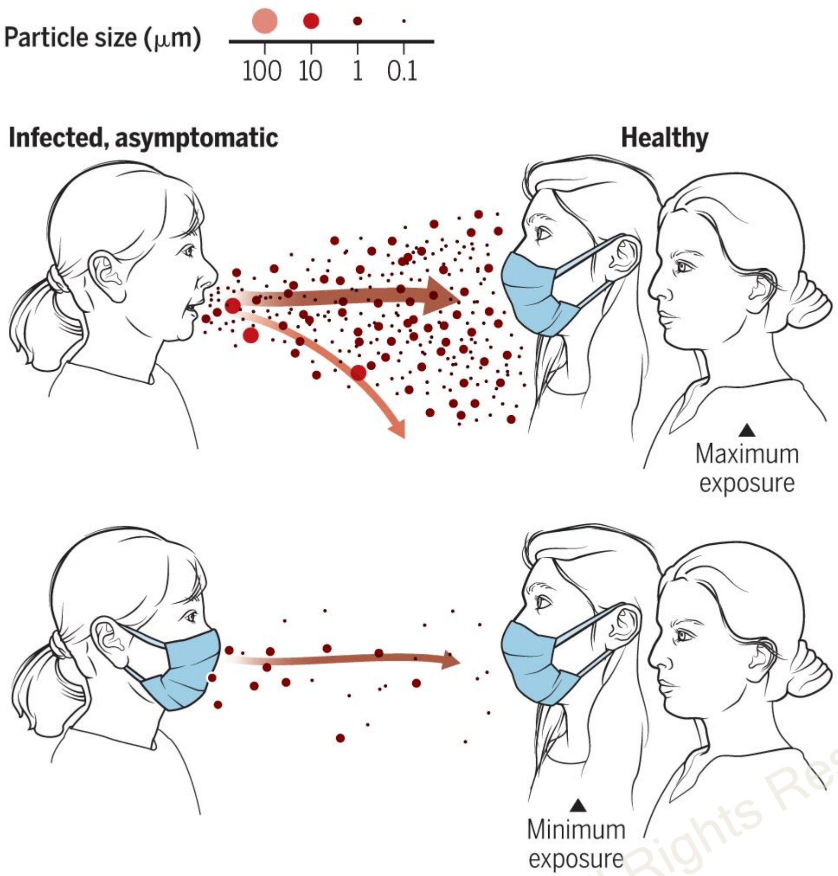
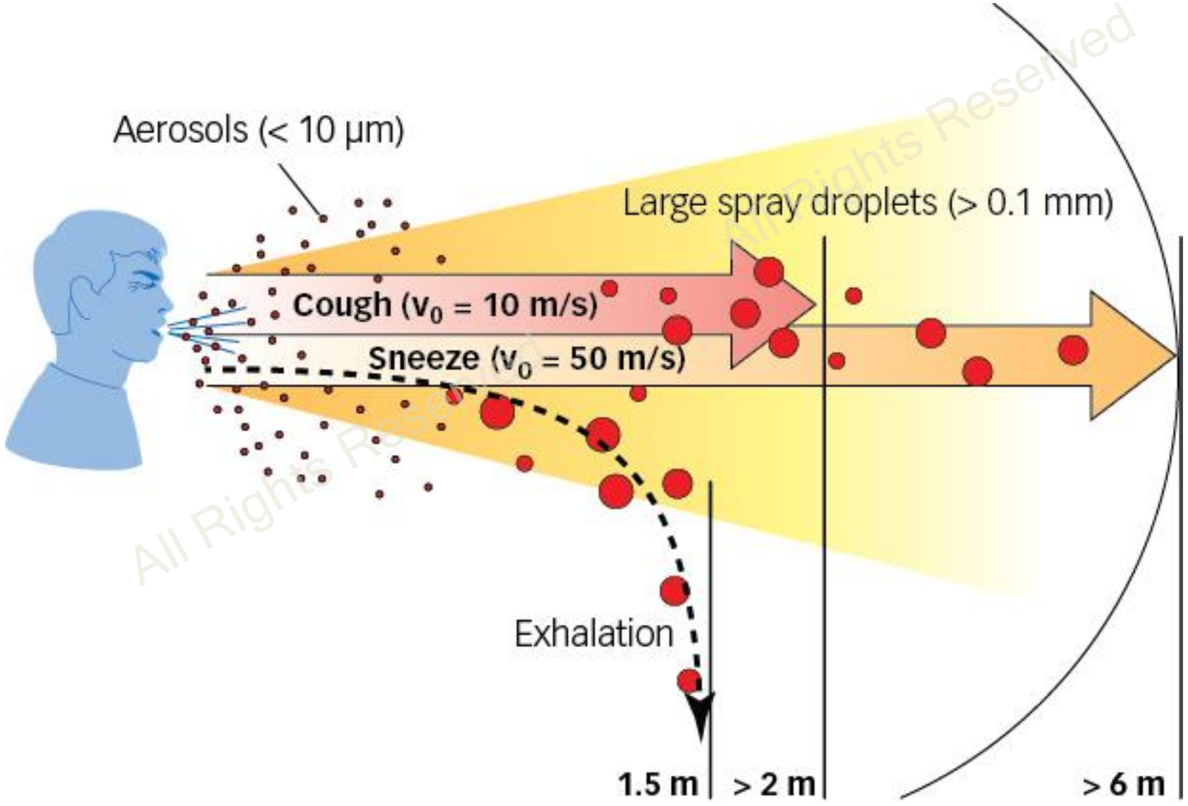
Airborne transmission of diseases





K. A. Prather, C. C. Wang, and R. T. Schooley, "Reducing transmission of SARS-CoV-2," *Science (80-.).*, vol. 368, no. 6498, p. eabc6197, Jun. 2020, doi: 10.1126/science.abc6197.

S. Froum and M. Strange, "COVID-19 and the problem with dental aerosols _ Perio-Implant Advisory," Apr. 07, 2020.

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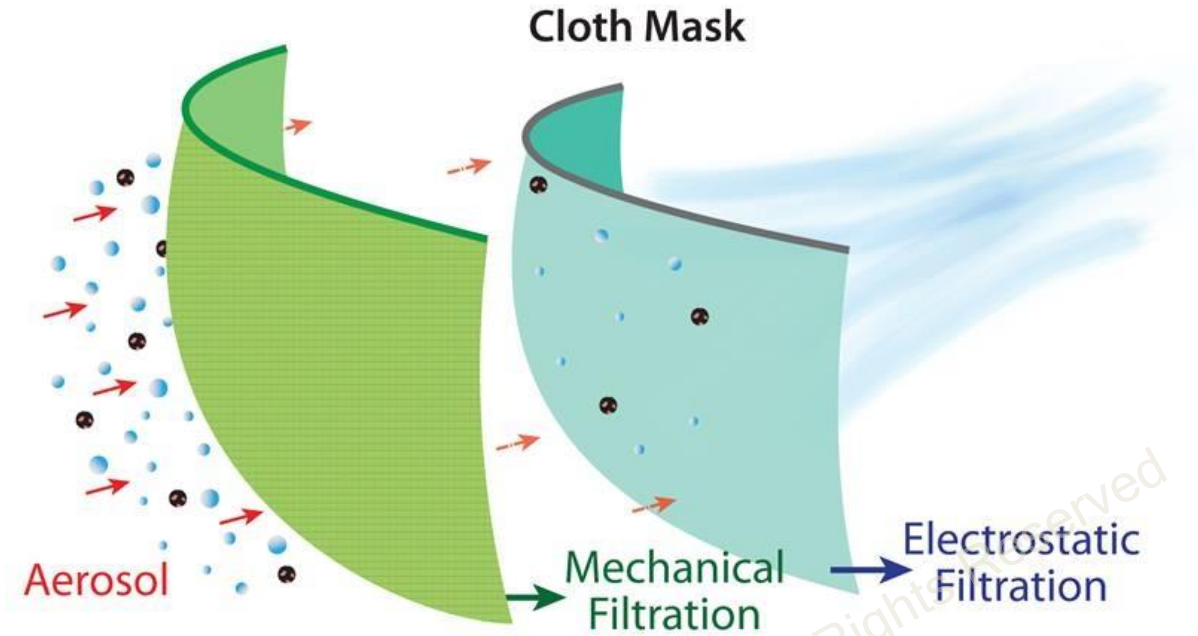
Masks of various types and purposes

Surgical masks EN 14683:2019 ASTM F2101 - 19	**Respiratory protective half masks (“Respirators”)** EN 149:2001+A1:2009 42 CFR Part 84	**Community face coverings (“Community masks”)** CWA 17553:2020 (CEN) UNI PdR 90:2020 (Italy) ASTM F3502 – 21
Medical device (MD)	Personal protective equipment (PPE)	Neither MD nor PPE
Protects the others from the wearer	Protects the wearer from the others	Protects the others from the wearer
Could be used by infected individuals	Could be used by infected individuals (only without exhalation valve)	Shall not be used by individuals aware of being ill of infectious
	 	

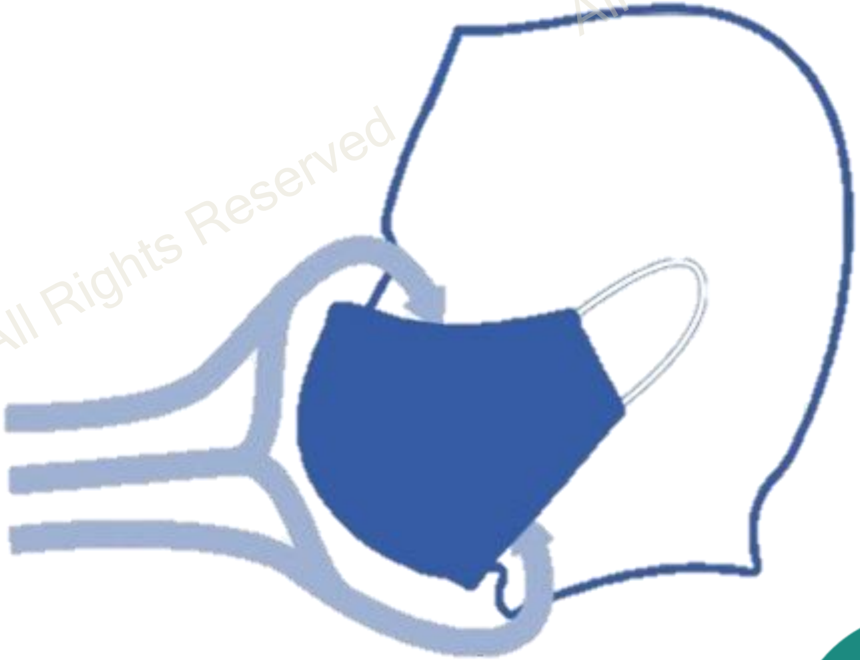
Performance of facemasks

Filtration efficiency



ACS Nano 2020, 14, 5, 6339–6347 Publication Date: April 24, 2020
https://doi.org/10.1021/acsnano.0c03252

Resistance to airflow



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UNI PdR 90:2020 – Community face coverings

UNI PdR 90-1:2020

- Specifies performance requirements of CFC
- Maximum resistance to airflow rate
- Minimum initial particle removal efficiency
- Considering the size range from 1 to 3 μm
- Combination of fractional efficiency curve and a given upstream particle size distribution (very similar to ISO 16890:2016)

UNI PdR 90-2:2020

- Specifies the test method to measure efficiency by particle size and airflow resistance of CFC
- Fully described test rig like ISO 21083
- Test aerosol made up of liquid DEHS particles
- Optical particle spectrometers in the size range from 0.3 to 10 μm (option to measure also down to 90 nm)
- Prescribes detailed qualification tests and procedure to verify the reliability of test rig
- Procedure to assess the minimum filtration efficiency by exposing the CFC to IPA vapor

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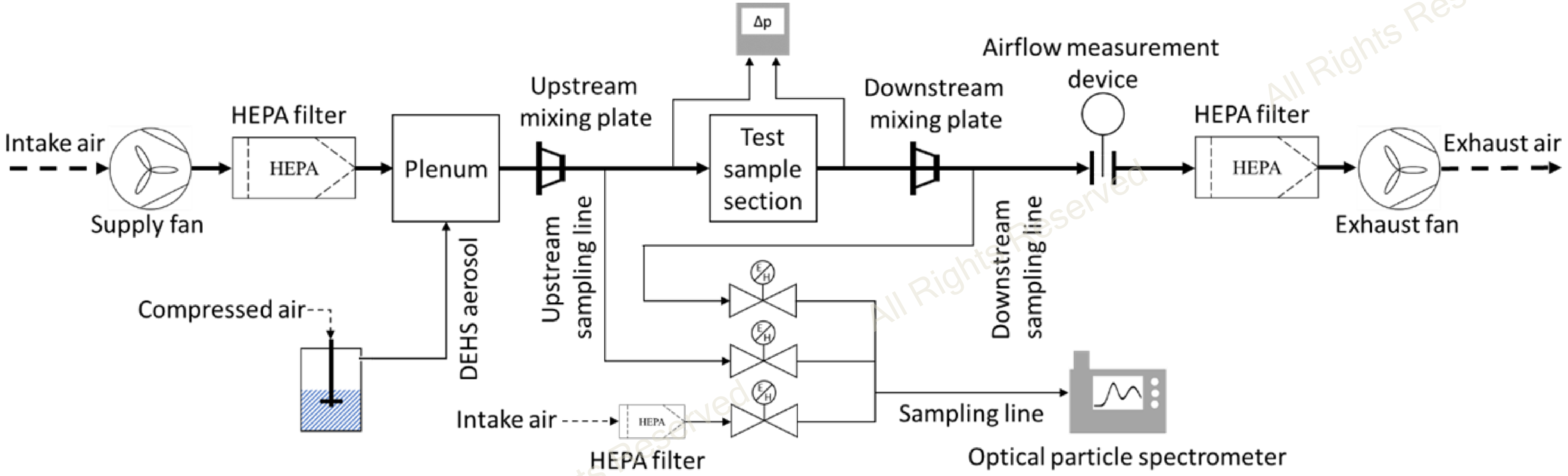
Test rig according to UNI PdR 90-2:2020



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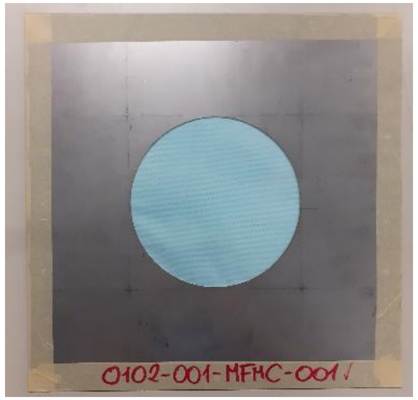
Examples of tested samples

Samples were fixed to adapter plates

- Surgical mask samples sealed using tape
- Respirators sealed using hot glue or mastic butilic



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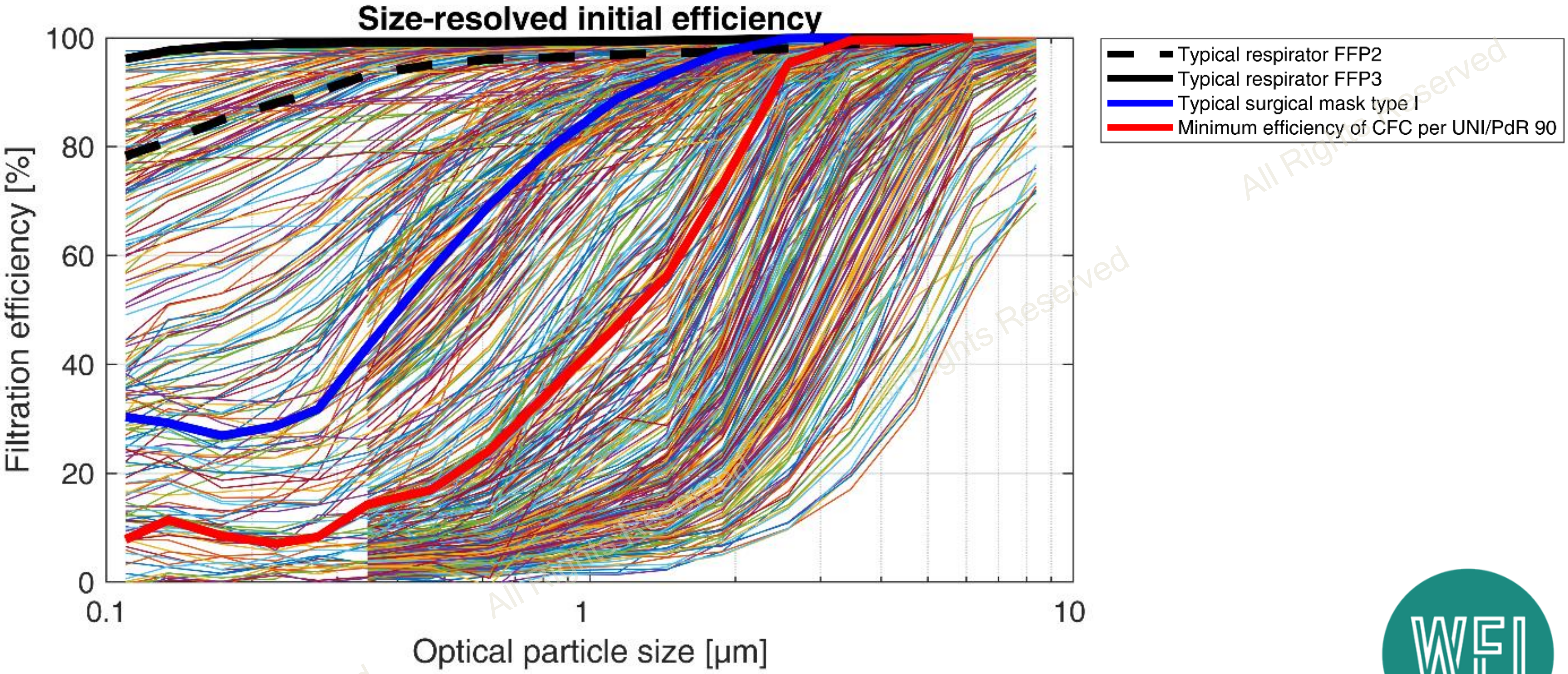
Data obtained with UNI PdR 90:2020



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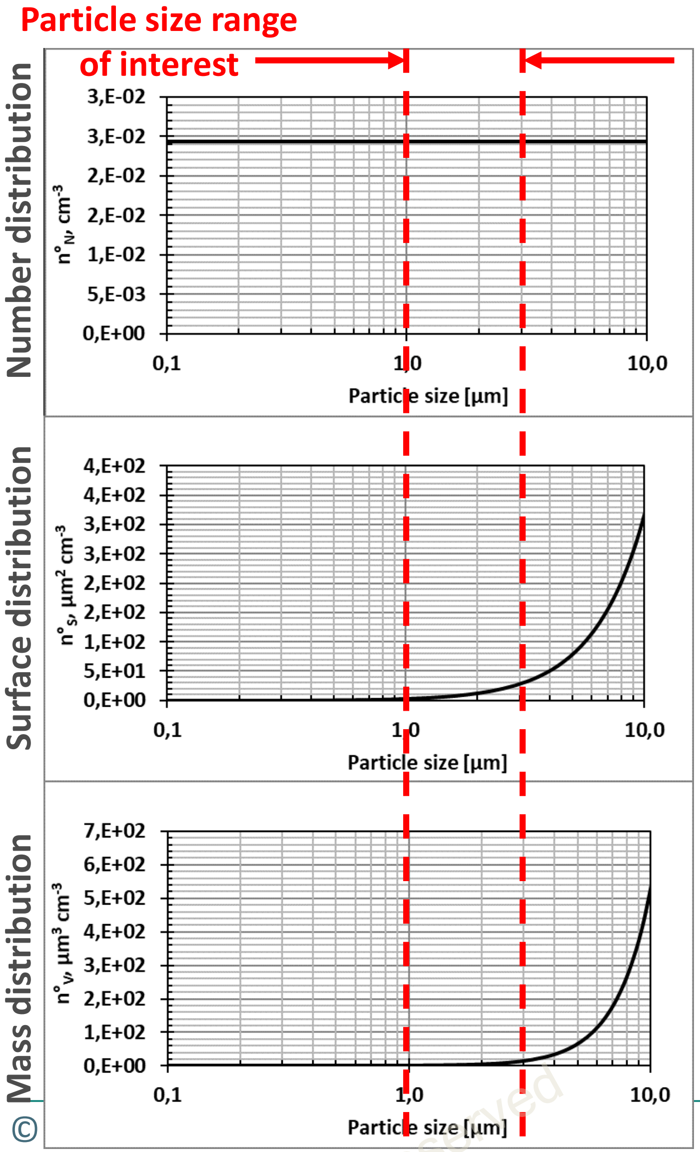
UNI PdR 90 – Reference challenge aerosol and *eCFC value*



- Uniform particle size distribution in number upstream
- Particle size range of interest: 1.0 to 3.0 µm
- Size range taking into consideration the phonation
- Can be changed to suit any specific aerosol challenge

$$eCFC = \frac{\sum_{i=1}^{n} E_i q_3(\bar{d}_i)\Delta\ln(\bar{d}_i)}{\sum_{i=1}^{n} q_3(\bar{d}_i)\Delta\ln(\bar{d}_i)}$$

$$\Delta\ln(\bar{d}_i) = \ln(d_{i+1}) - \ln(d_i)$$

E_i: Filtration efficiency of particle size range i

$q_3(\bar{d}_i)$: Volume fraction particle size range i

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UNI PdR 90-1:2020 – Rating system of CFC

Designation	Maximum respiratory resistance at 27,2 cm/s [Pa]	Maximum respiratory resistance of rigid masks (cup masks) at 95 l/min - Annex A of UNI PdR 90-1:2020 [Pa]	Minimum initial $eCFC_{average}$ (without electrostatic removal procedure) [%]
CFC-NR	294	210	80
CFC-R	294	210	80
CFC-BIO	294	210	80

NR: Non reusable; R: Reusable; BIO: Biodegradable

Specific rating system for sporting masks (same minimum efficiency and lower airflow resistance)

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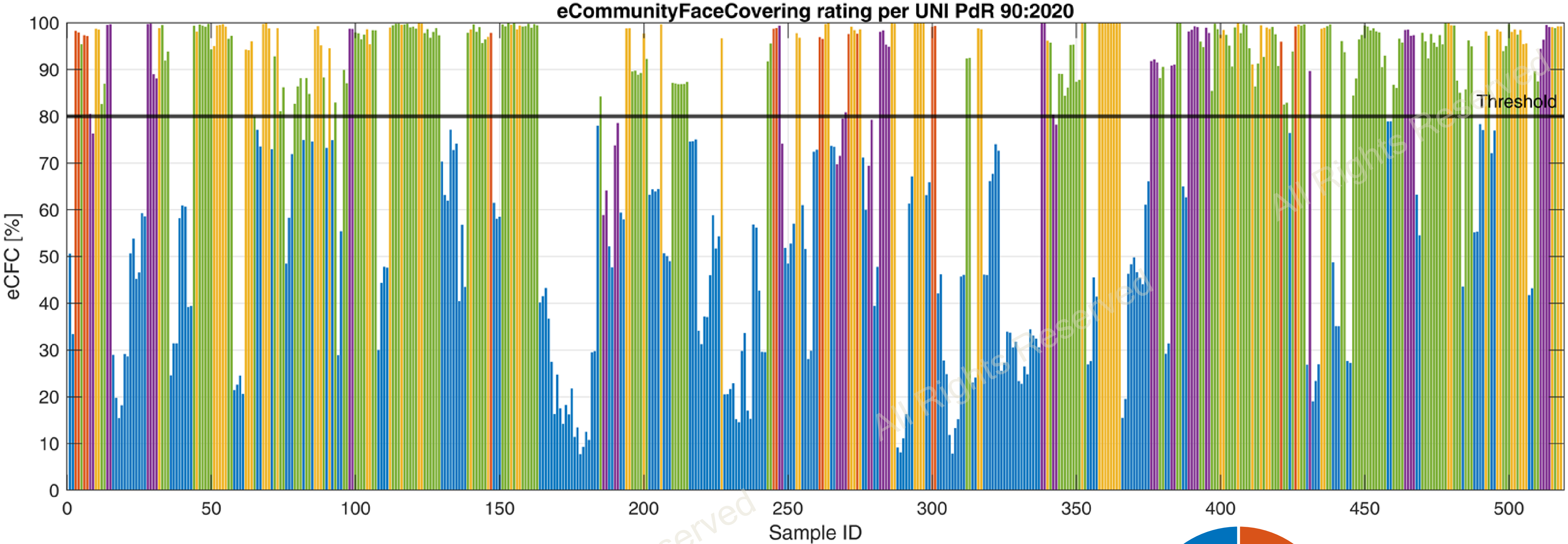
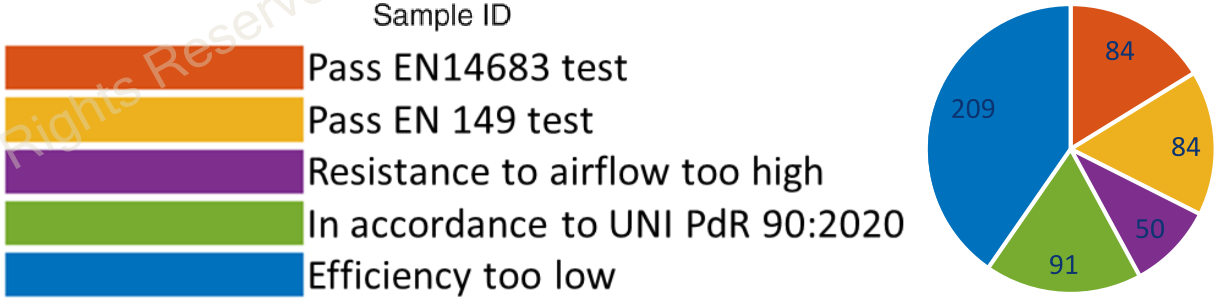
Universal test method for facemasks



- Surgical masks and respirators show higher *eCFC* values
- UNI PdR 90 can distinguish masks with adequate performance



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EN 14683 – Medical face masks

- **Biological aerosol (Staphylococcus aureus)**
  - Requires laboratory authorized to deal with pathogens
- **Particle size distribution not fully described**
  - Prescribes only the mean particle size (3.0 ± 0.3 μm) and not explicitly the geometric standard deviation
  - If CMD = 3.0 μm the geometric standard deviation can be between 1.34 e 2.43 (assuming lognormal distribution)
- **At least two days to obtain useful data**
- **Uncertainty of test method not clearly defined**

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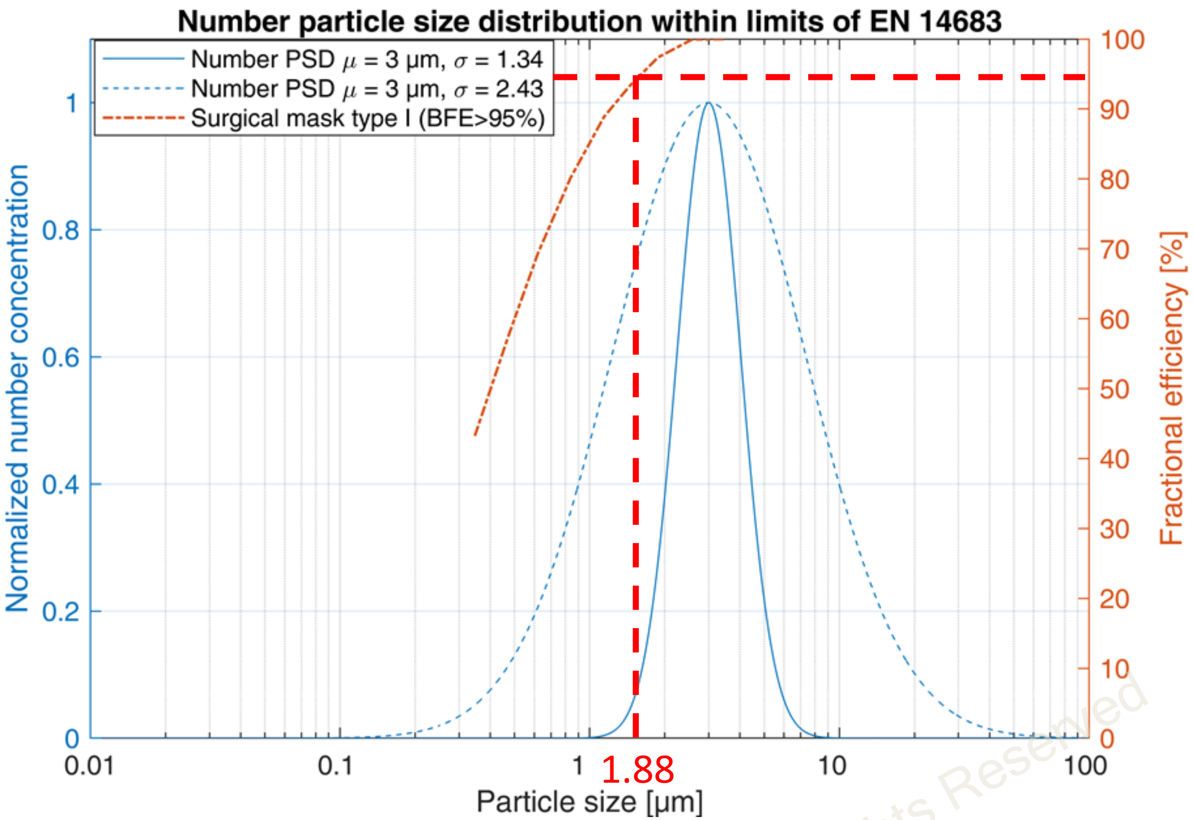
Example of comparison of fractional efficiency and BFE



- The BFE results (95%) were provided by University of Bologna → Surgical mask Type I
- Assuming that the aerosol generator according to EN 14683 generates a lognormal particle size distribution
- Blue curves: CMD = 3.0 μm with two GSD allowed by EN 14683
- Filtration efficiency at 3.0 μm is much higher than 95%, even for a Type I surgical mask (in this example 99.97%)
- Filtration efficiency at 1.88 μm measured with PdR 90 provides values with a good correlation with the obtained from BFE tests

EN 149 – Penetration assessed with EN 13274-7

- **Measuring instrument for efficiency is a photometer (mass concentration)**
- **Allows a very large range for the upstream particle size distribution**
  - NaCl: Count median diameter from 0.06 to 0.10 µm and geometric standard deviation from 2.0 to 3.0 (initial penetration)
  - Paraffin oil: Count median diameter from 0.29 to 0.45 µm and geometric standard deviation from 1.6 to 2.2 (exposure test to reveal the minimum efficiency by discharging the filter media)

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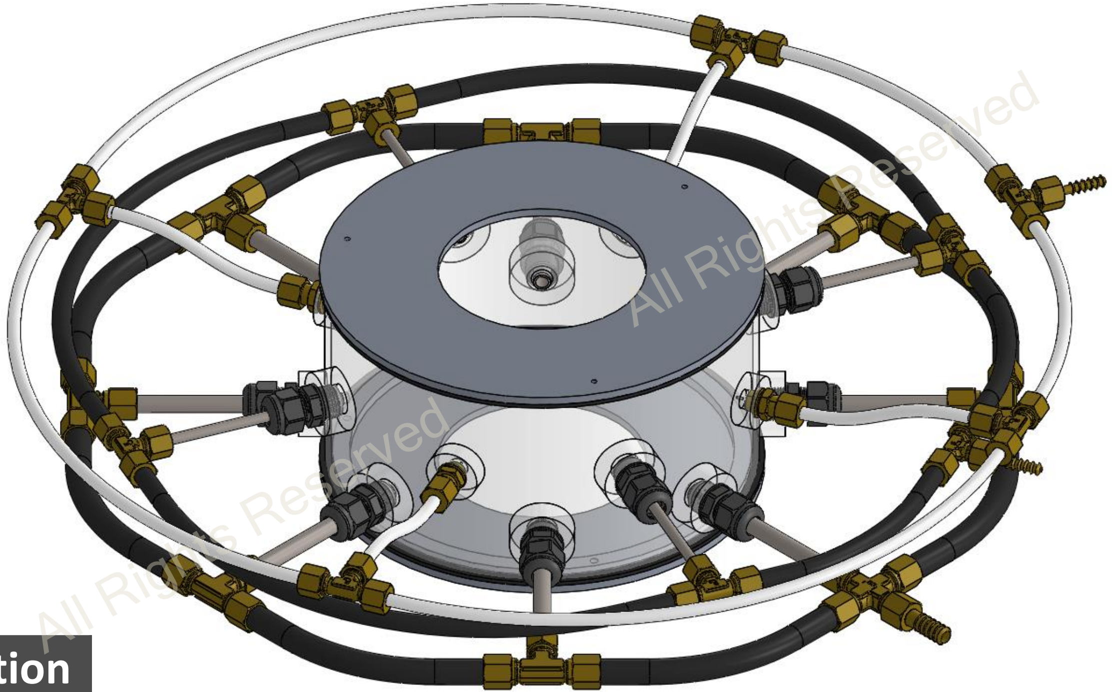
Measurement of the PSD challenging respirators

- We measured the upstream PSD from 0.09 µm to 7.5 µ of the test aerosol generated by a test device compliant with EN 13274-7 (i.e., EN 149)
- With paraffin oil aerosol, we found a PSD with
  - CMD = 0.221 µm and GSD = 1.54 (assuming a lognormal distribution, MMD = 0.387 µm)



	CMD [µm]	GSD	MMD [µm]	Mass fraction below 0.09 µm
NaCl - EN 149	0.080	2.50	0.993	0.4%
Paraffin oil - EN 149	0.370	1.90	1.273	0.0%
NaCl - 42 CFR 84	0.075	1.86	0.238	5.8%
Paraffin oil - 42 CFR 84	0.185	1.60	0.359	0.2%

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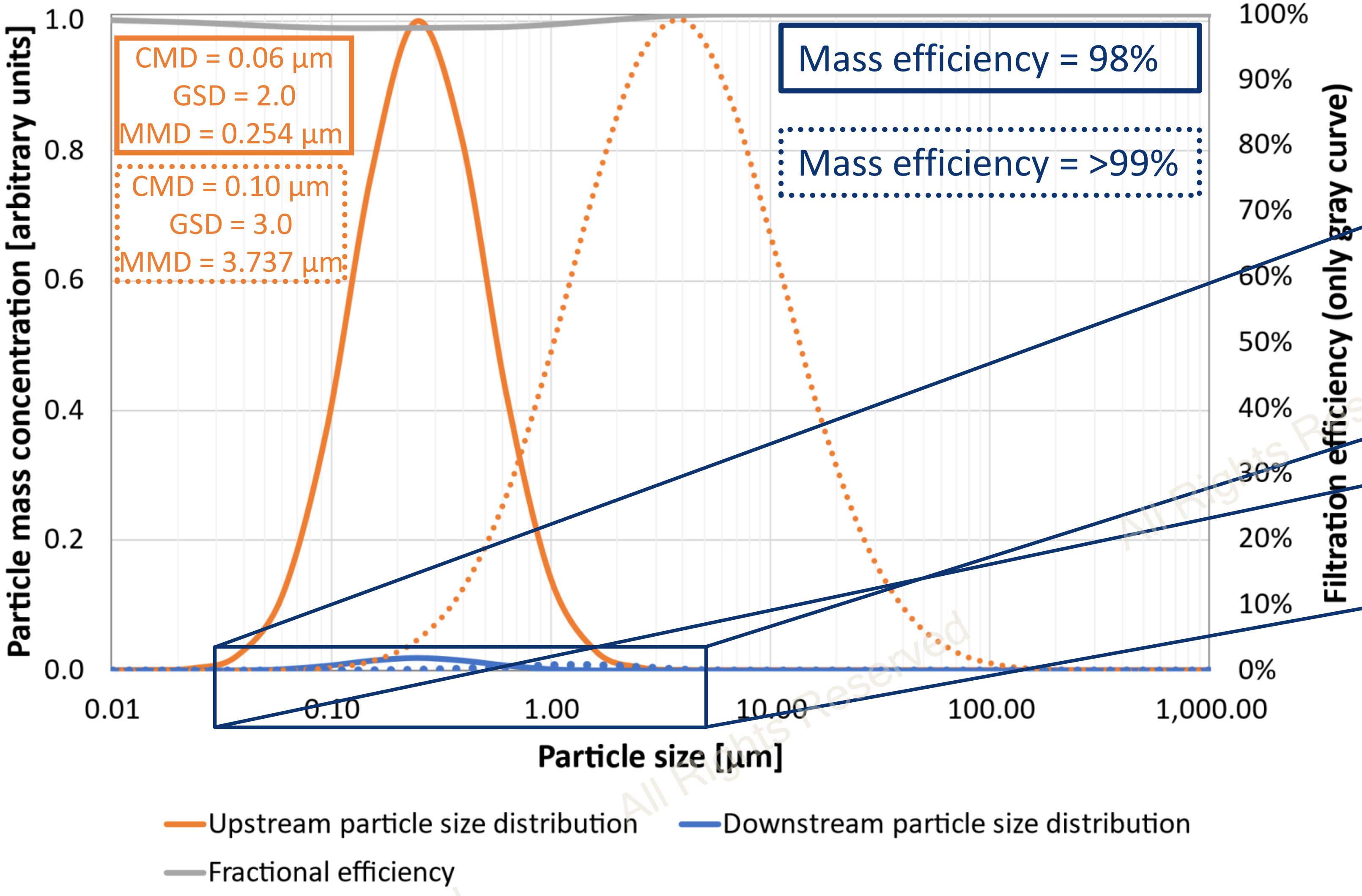
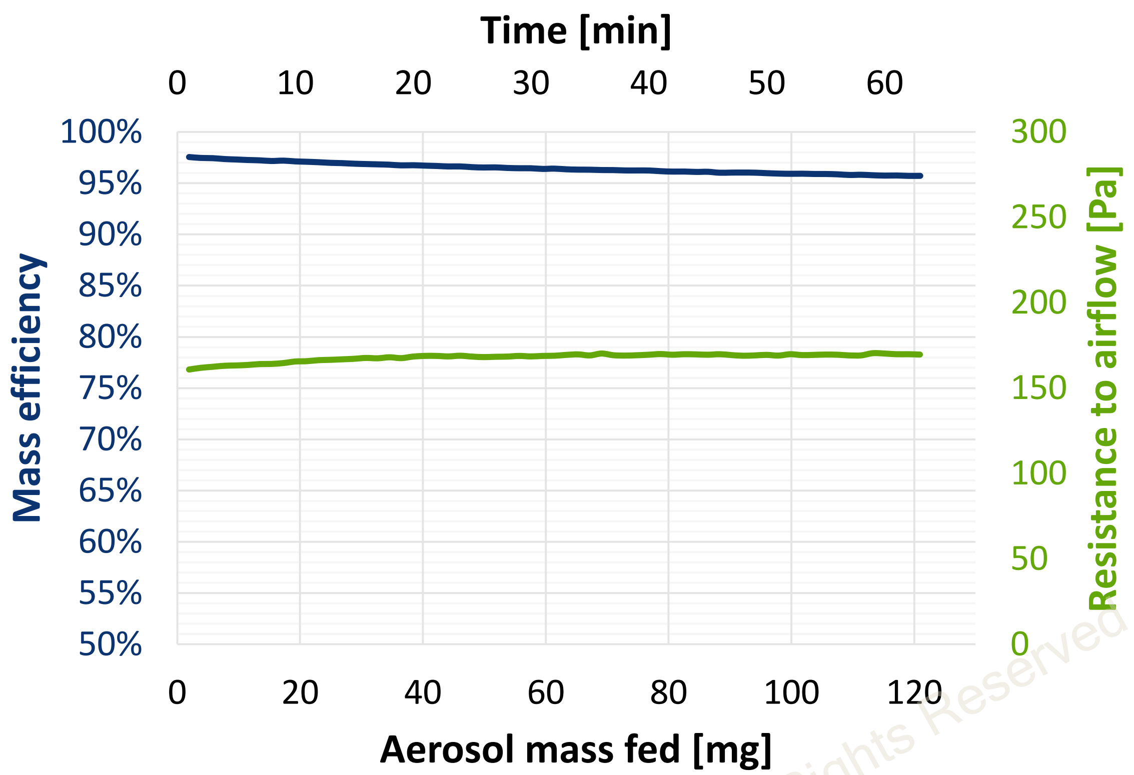
EN 13274-7 – “Respiratory protective devices” – Wide PSD allowed



Particle size distributions of NaCl aerosol

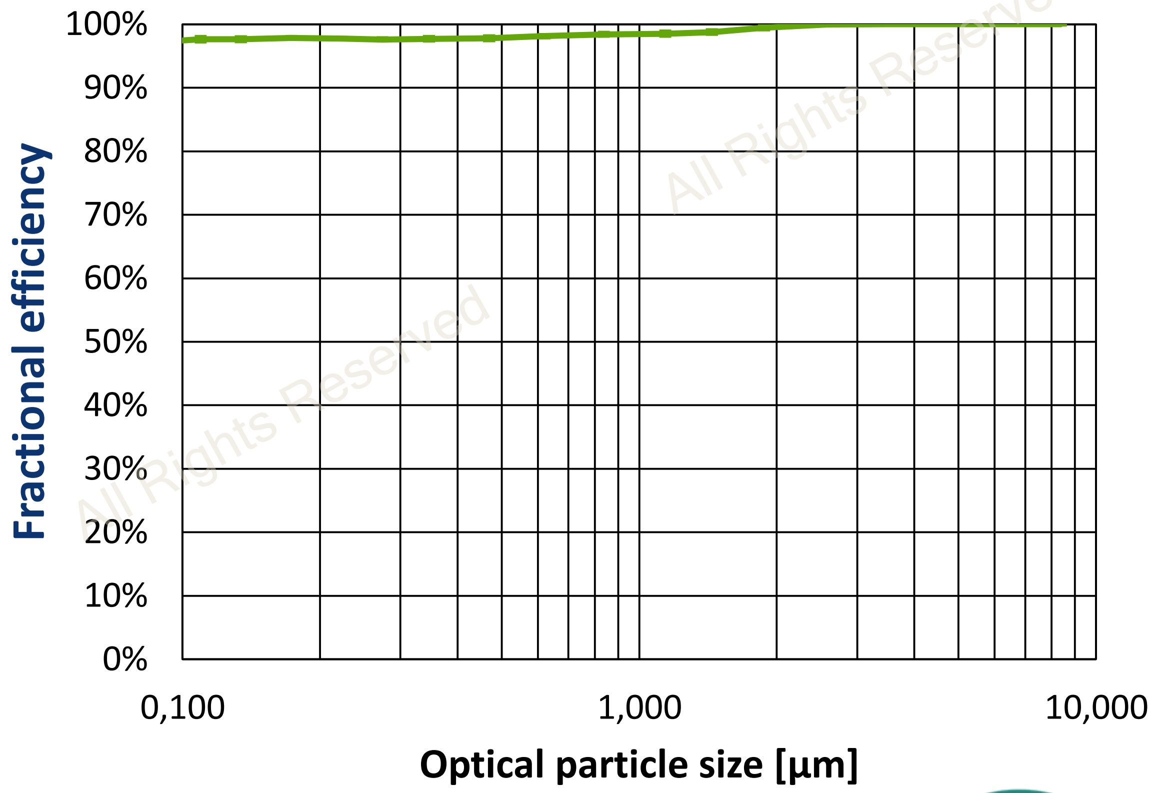
Example of comparison of respirator performance

Test according to EN 149 with paraffin oil aerosol



Measured initial mass efficiency = 98% (EN 149)

Test according to UNI PdR 90 with DEHS aerosol



Calculated initial mass efficiency = 98%

Measured data: efficiency (UNI PdR 90) and PSD with CMD = 0.221 µm and GSD = 1.54 (MMD = 0.387 µm)

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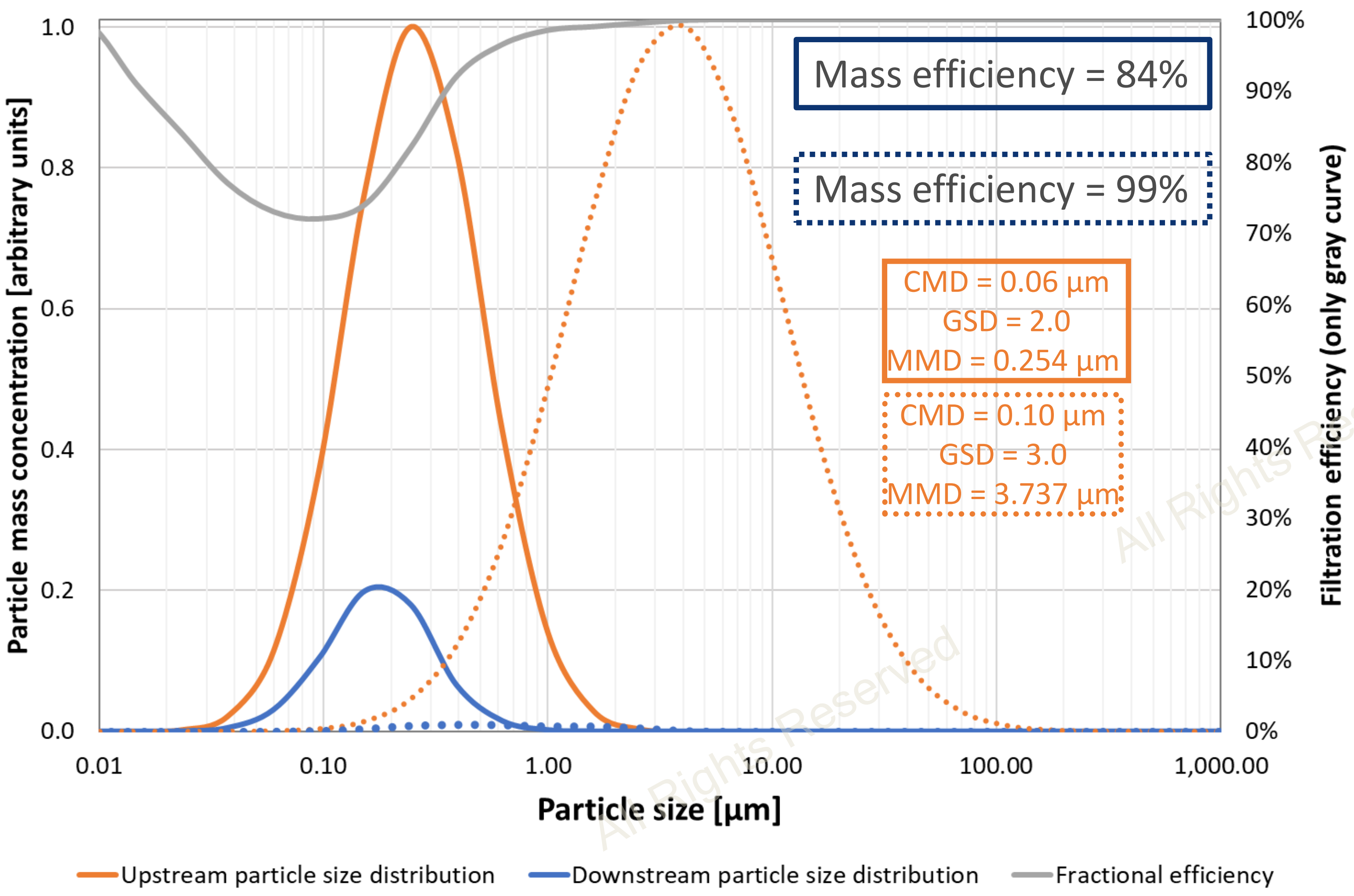
EN 13274-7 – "Respiratory protective devices" – Wide PSD allowed



Particle size distributions of NaCl aerosol

In case of FFP2 respirators the tolerance allowed by the standard is noticeable

The example data fulfill FFP2 (EN 149) class requirements

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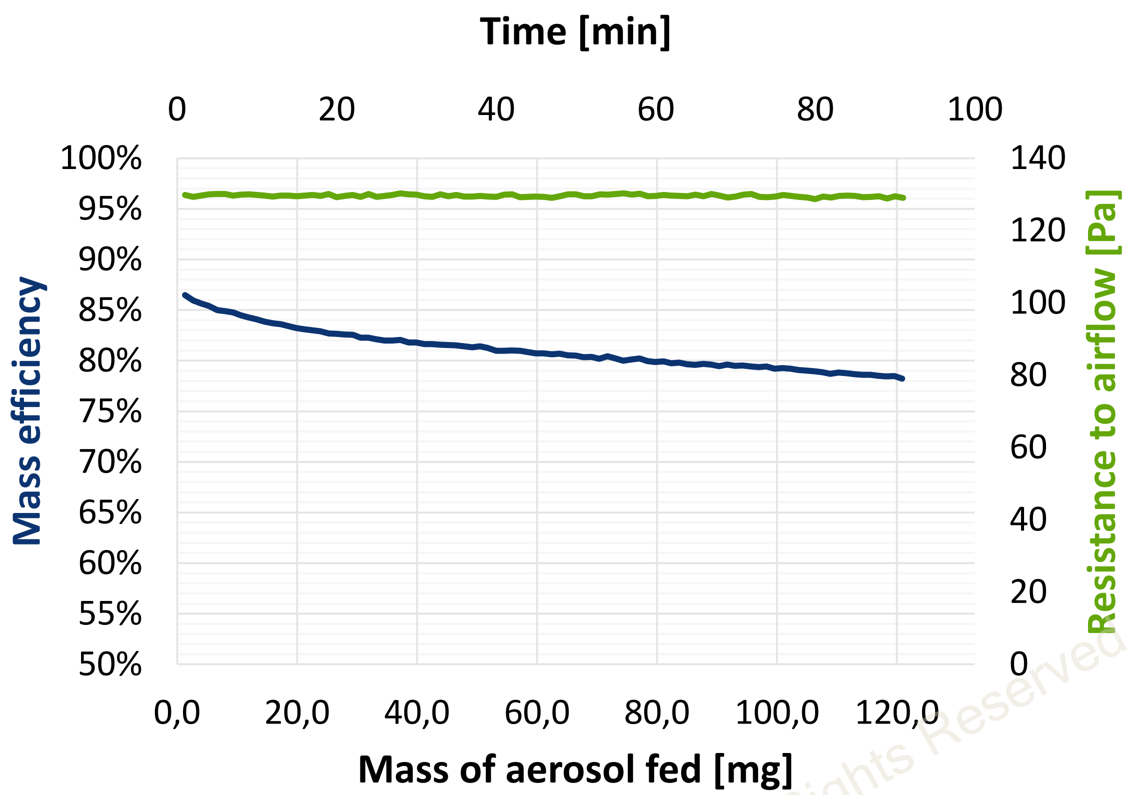
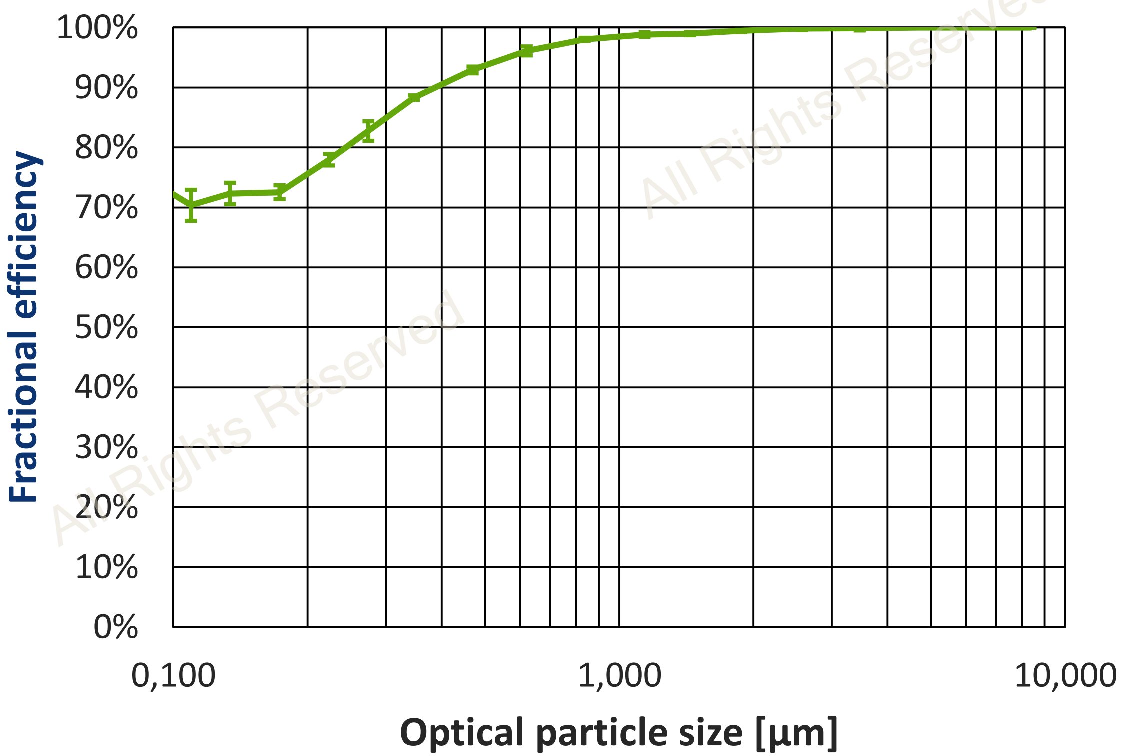
Example of comparison of mask performance

Test according to EN 149 with paraffin oil aerosol



Measured initial mass efficiency = 86% (EN 149)

Test according to UNI PdR 90 with DEHS aerosol



Calculated initial mass efficiency = 98%

Measured data: efficiency (UNI PdR 90) and PSD with CMD = 0.221 µm and GSD = 1.54 (MMD = 0.387 µm)

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Conclusions

- UNI PdR 90 provides size-resolved efficiency curve with associated uncertainty in less than 30 min
- UNI PdR 90 allows assessing the performance of rigid and semirigid CFC
- Non biological test aerosol (biosafety level laboratory not needed)
- Test method validated by during ISO 16890 and ISO 21083 preparation (under Mandate M/461 of the EC)
- Allows distinguishing leaks and holes from low-efficiency materials
- Assessing minimum filtration efficiency by conditioning process
- Possibility to change the reference PSD to suit any specific aerosol challenge (rating can be changed easily)
- Potential for measuring and classifying any kind of facemask

Acknowledgements

Experimental data and data processing

- Jesús Marval
- Luis Medina
- Emanuele Norata
- Geraldine Torres
- Group of volunteers at Politecnico di Torino

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Thank You for Your Attention

For Questions, Contact Us

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