

A New Setup for Evaluating Filter Media under the Inhalation-and-Exhalation Condition

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Outline

- ☐ Introduction
- ☐ Review of our previous setup
- ☐ New setup
- ☐ Preliminary testing of new setup
- ☐ Conclusion and future work

Introduction

- NIOSH standard testing method certifies respirator filters at the constant testing flow rate of 85.0 liter/min.
- Respirator filter media experience cyclic flow patterns due to the nature of human breathing.
- Measuring the collection efficiency of respirator filter media under the cyclic flow condition is necessary to understand the performance of respirator filters in practical applications.
- Cyclic flow conditions: inhalation-only and inhalation-exhalation

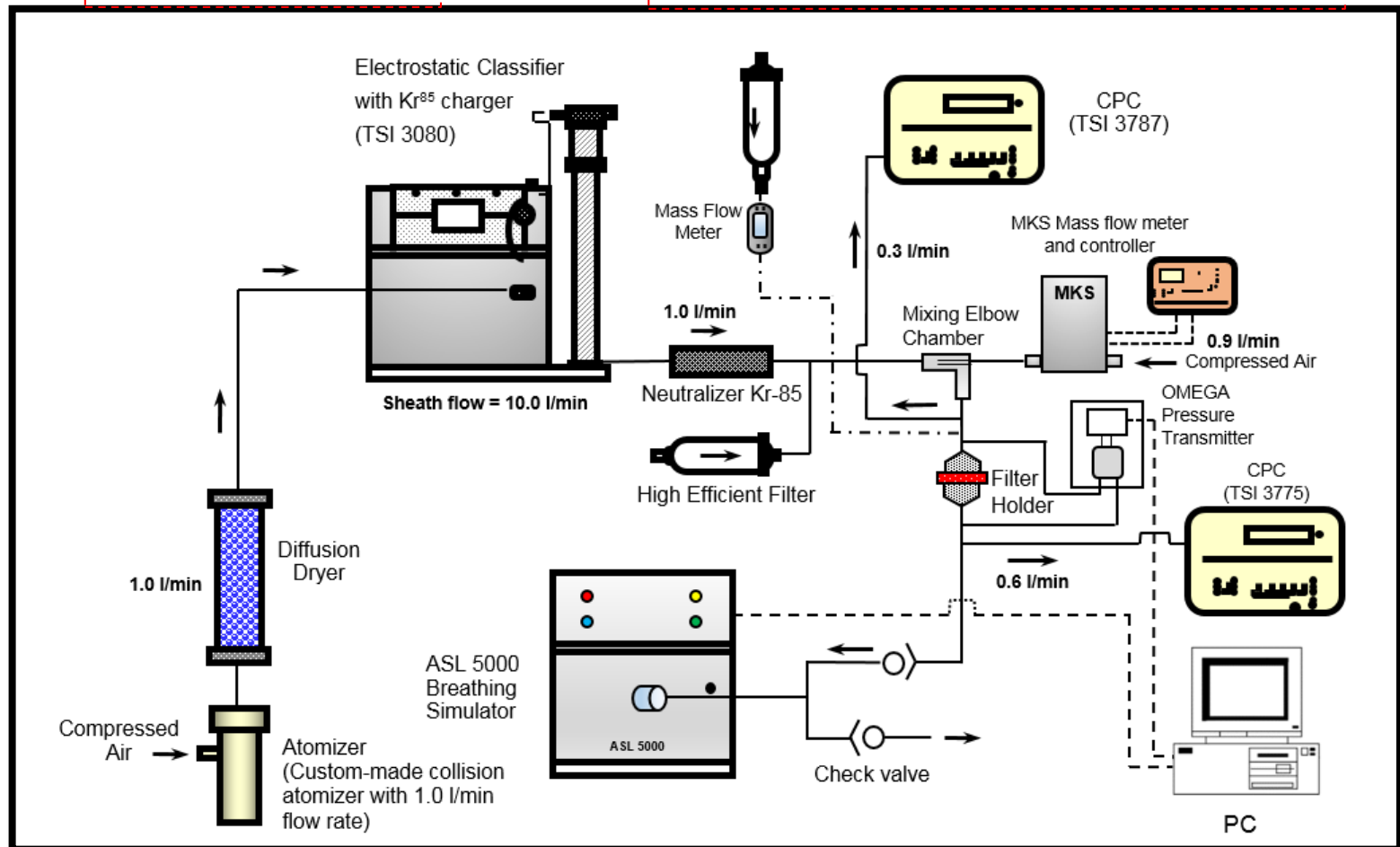
Previous work

- The effects of breathing frequency (BF) and peak inhalation flowrate (PIFR) on the particle penetration of respirator filter media were investigated under inhalation-only testing:
 - ❖ The breathing frequency (BF) is in fact the dominant effect on the particle penetration of filter media. The minor BF effect observed in previous publication is due to the used measurement technique.
 - ❖ The particle penetration of filter media was enhanced when the BF was increased.
 - ❖ Increased particle penetration at increased PIFRs (for the same BF) is due to the increase of MIFRs (in the constant flow testing).
- ❑ When challenged with singly charged particles the penetration of respirator filter media was enhanced as the increase of either PIFR or BF.
- ❑ For filter media (with residual charges) the penetration of respirator filter media for singly charged particles are higher than that for Boltzmann-charged particles.
- ❑ For charged filter media the penetration of media for singly charged particles are much less than that for Boltzmann-charged particles.

Our Previous Setup

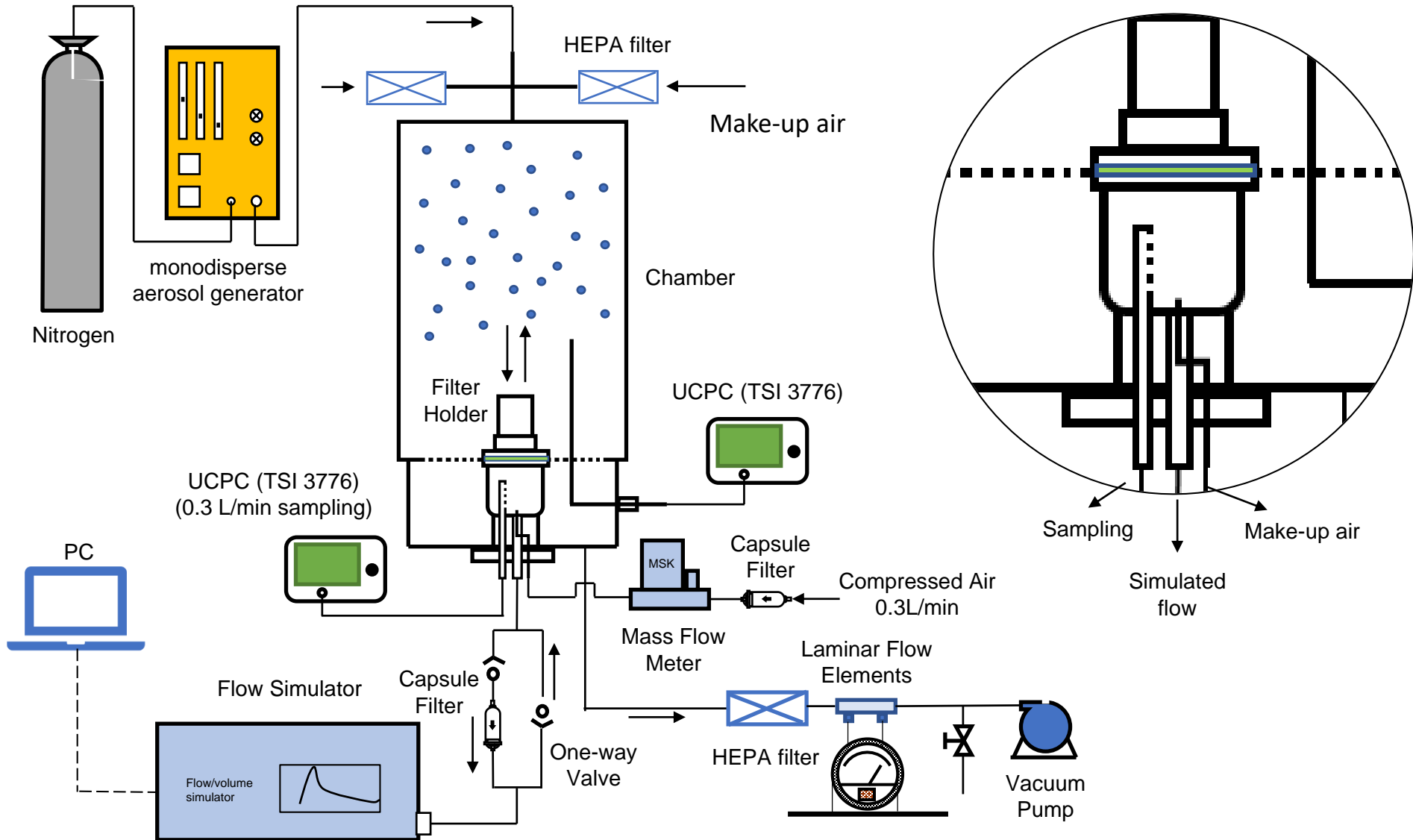
* Low concentration
of DMA-classified
particles

** Upstream particle concentration is not
constant (different from uniform polluted
ambient environment)



*** Inhalation-only mode

Our New Testing Setup

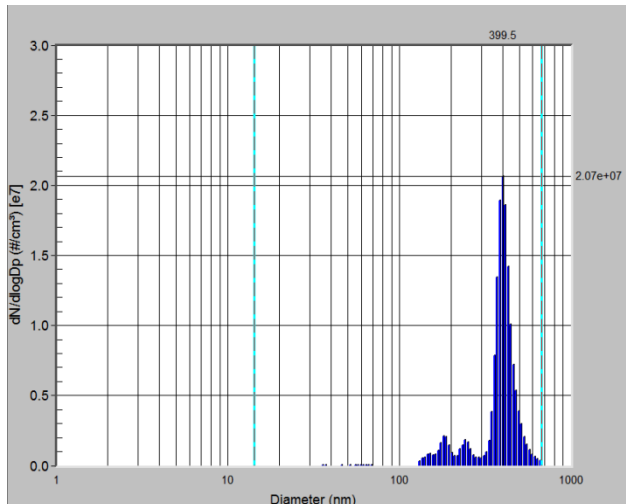
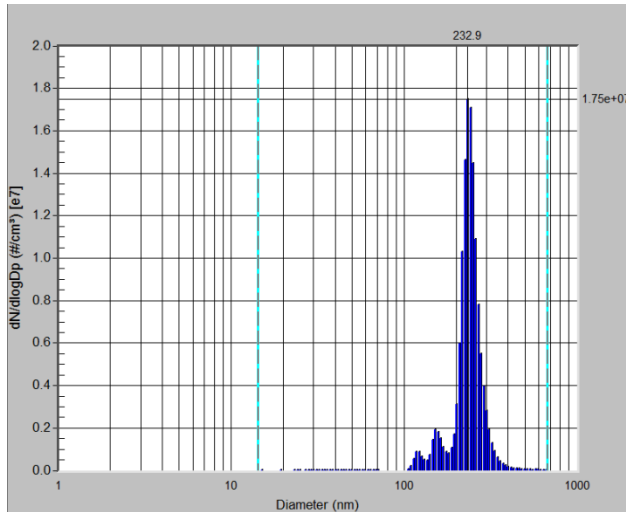


Picture of The New Setup

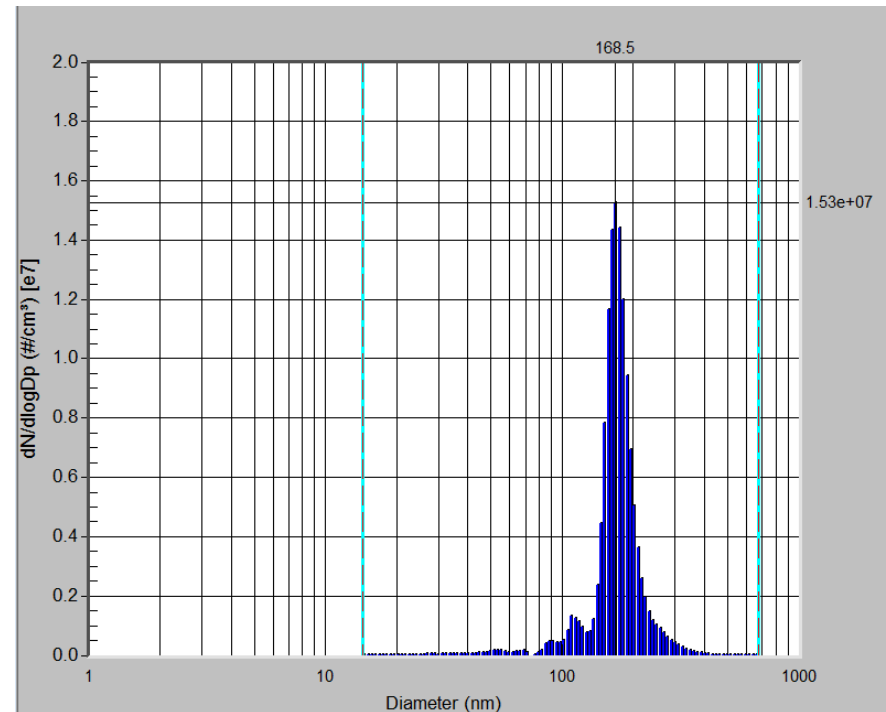


Monodisperse Condensation Aerosol Generator

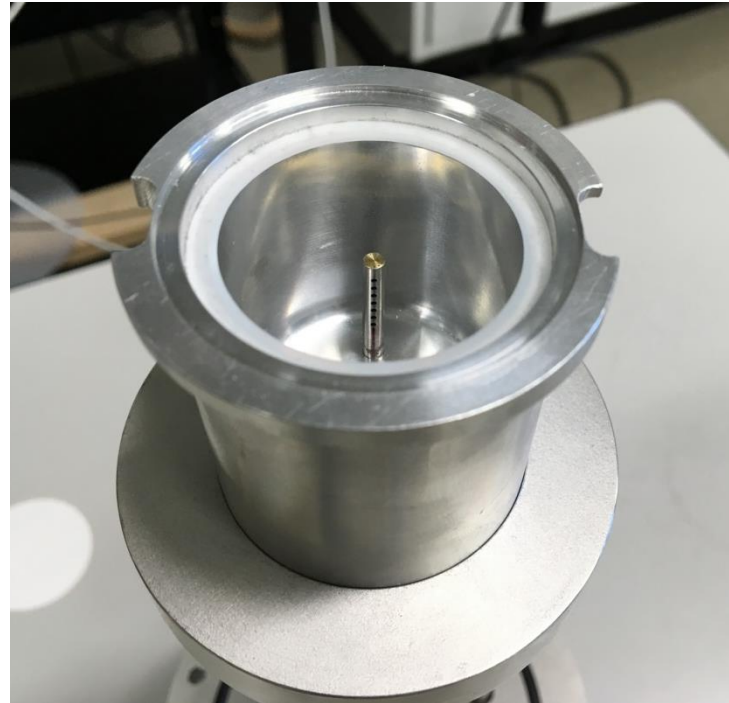
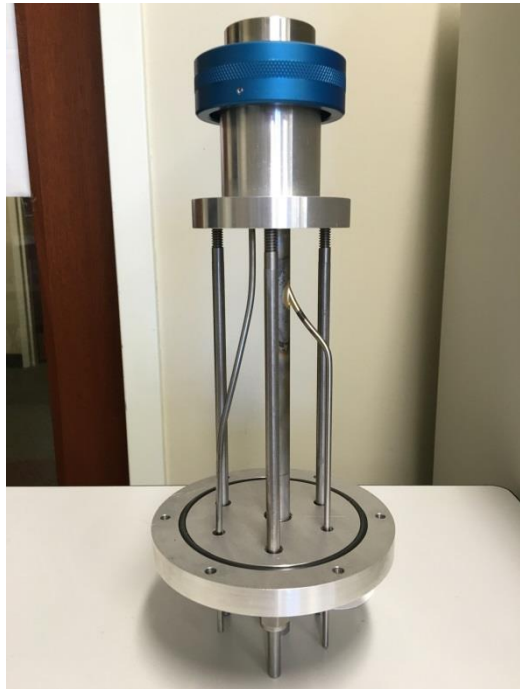
TSI model 3475



- Monodisperse sizes
 - Varied by temperature setting and saturator flow
- High-concentration



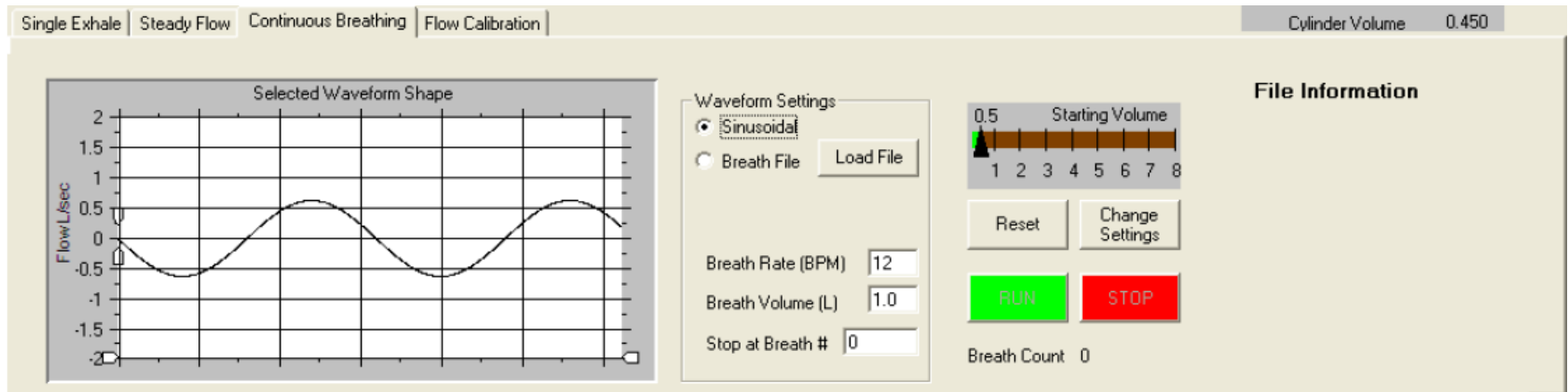
New Filter Media Holder



- multi-point sampling probe for measuring the particle downstream of filter media.
- 0.3 L/min make-up air to offset the constant sampling for downstream particle measurement.

Flow/Volume Simulator

* Series 1120 HANS RUDOLPH, Inc.



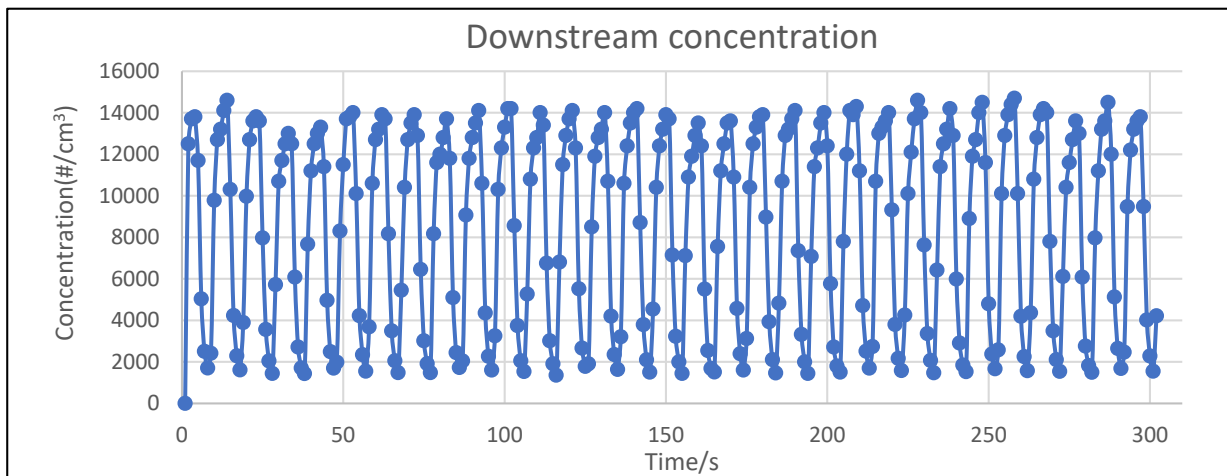
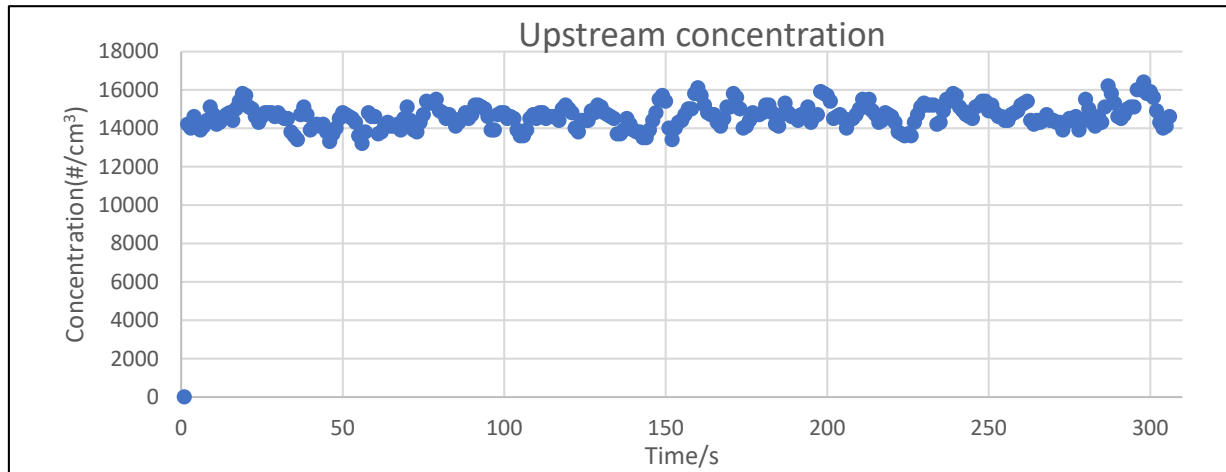
- three simulation modes (single exhale, steady flow and continuous breathing)
- various breathing waveform including the user-defined waveform for continuous breathing.
- change the breathing rate and breath volume for selected breathing wave easily.

Pictures from http://www.rudolphkc.com/product_detail.php?id=192



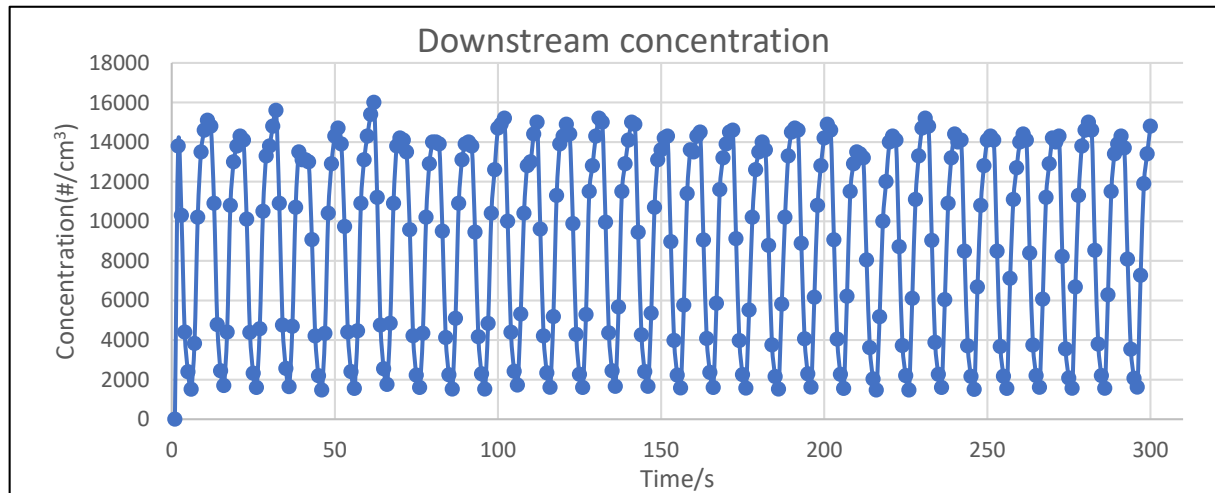
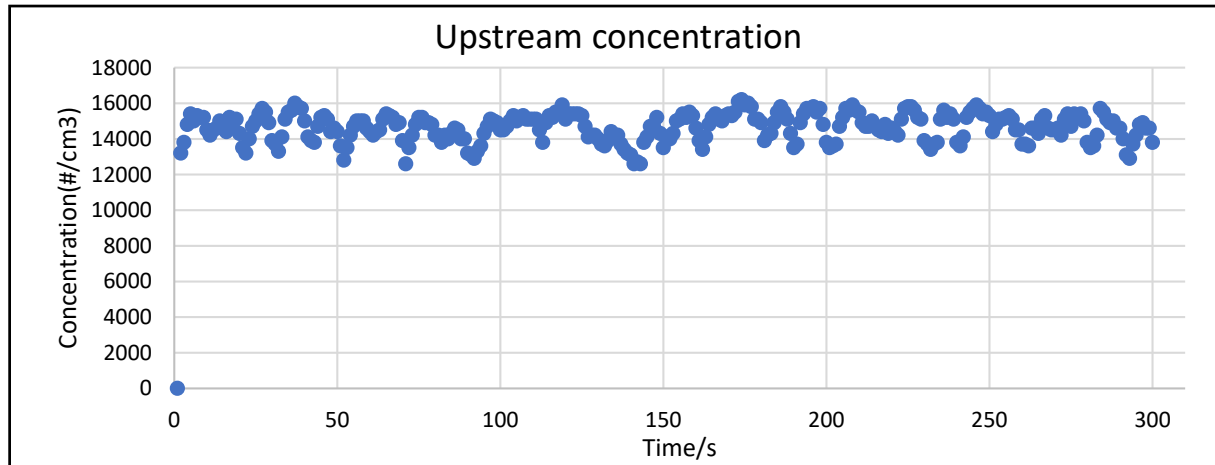
Preliminary Testing of New Setup (1)

- without filter media and with a sinusoidal waveform flow
- ❖ Breath volume 1.0 L, Breathing frequency (BF) = 6.0



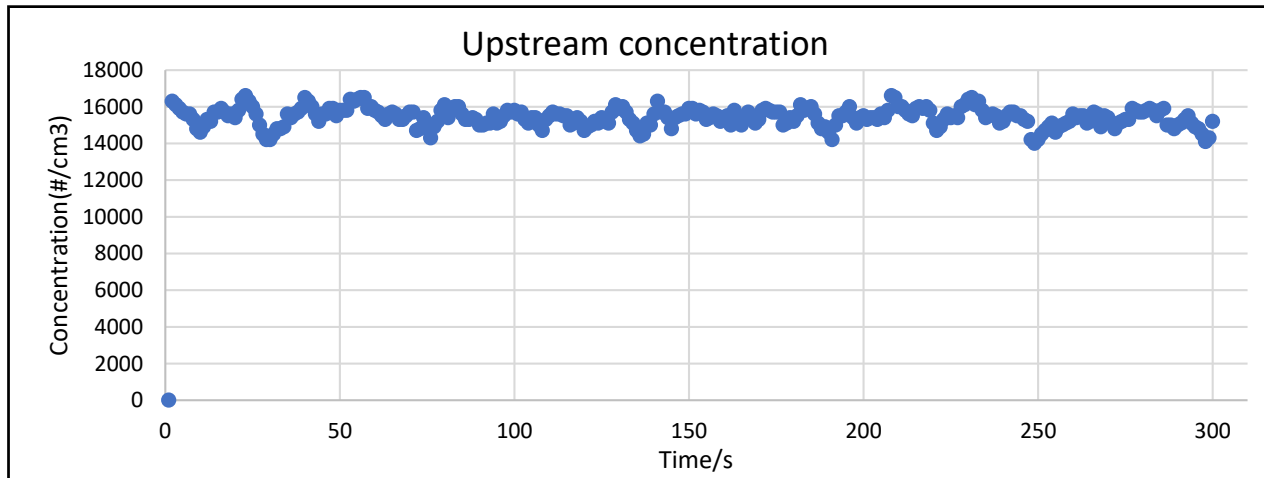
Pre-testing of New Setup (2)

❖ Breath volume 2.0 L, BF=6.0

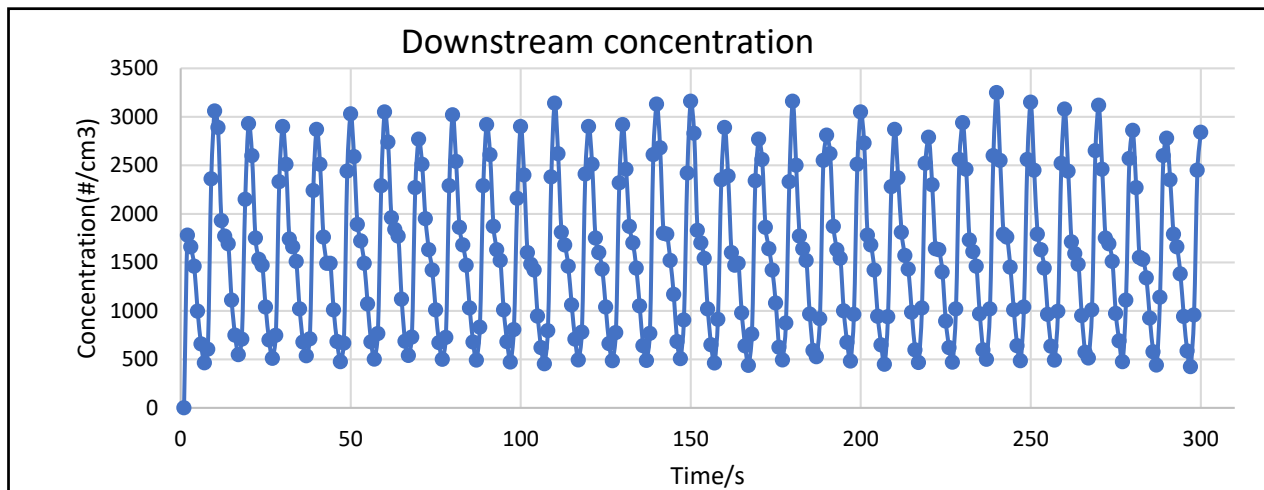


Pre-testing of New Setup (3)

- with filter media and sinusoidal waveform flow
 - ❖ Breath volume 1.0 L, BF = 6

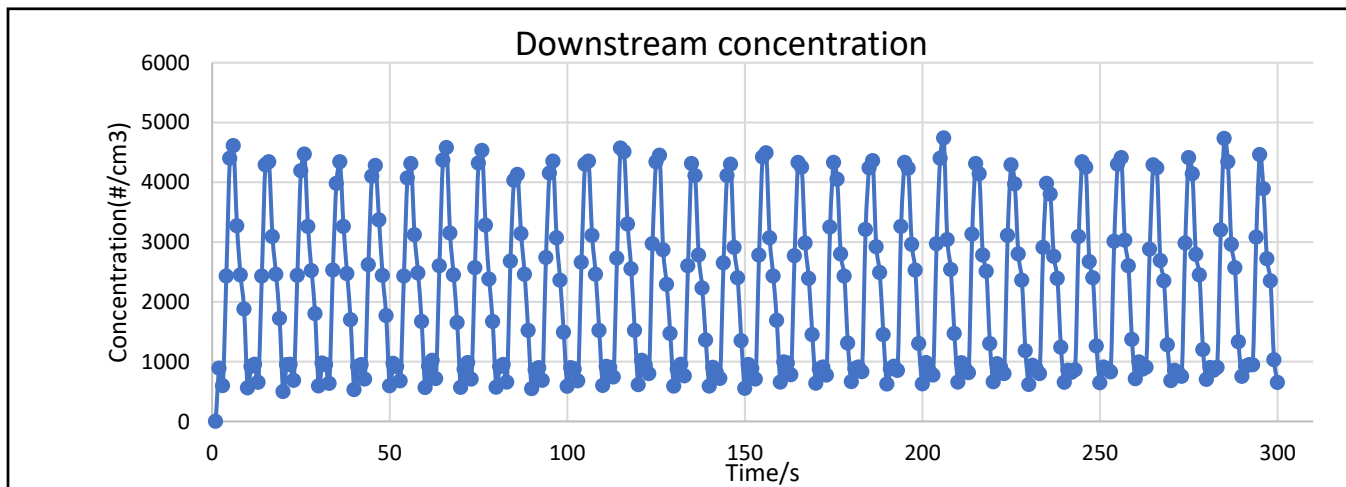
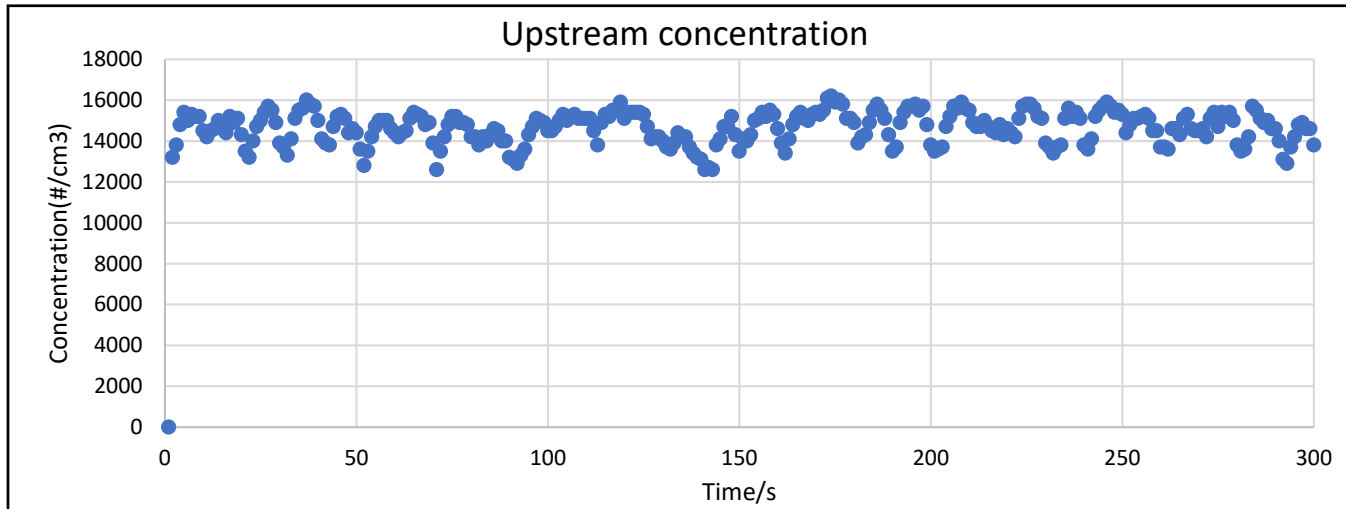


10.23%



Pre-testing of New Setup (4)

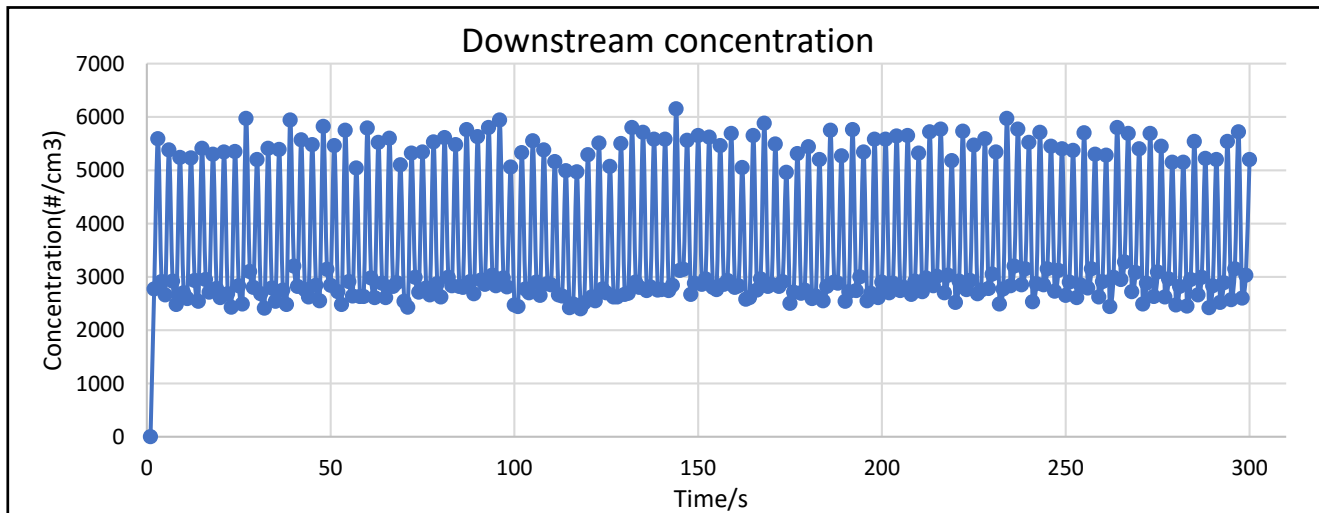
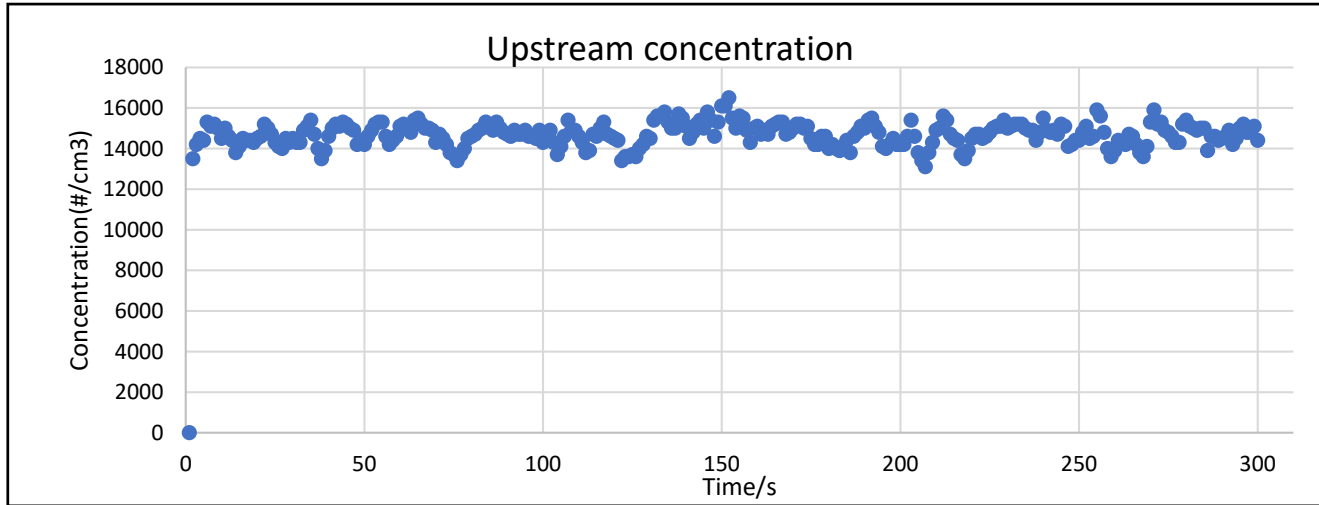
❖ Breath volume 2.0 L, BF = 6.0



14.7%

Pre-testing of New Setup (5)

❖ Breath volume 1.0 L, BF = 20



25.03%

Conclusion and Future Work

- ❑ A new experimental testing system has been set up for evaluating respirator filter media under both inhalation-only and inhalation-exhalation conditions.
- ❑ With the new testing setup:
 - ❑ filter media evaluation under the inhalation-exhalation condition (in addition to inhalation-only testing);
 - ❑ uniform particle concentration at the upstream of test filter media;
 - ❑ Multiple-point sampling probe for measuring the particle concentration in filter holder
- ❑ Future work
 - ❑ Minor improvement of new testing setup
 - ❑ Evaluation of respirator filter media under various PIFR and BF conditions

Thank you for you attention
and
Questions?