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Inhalation-only and Inhalation-and-Exhalation Testing of Filter Media

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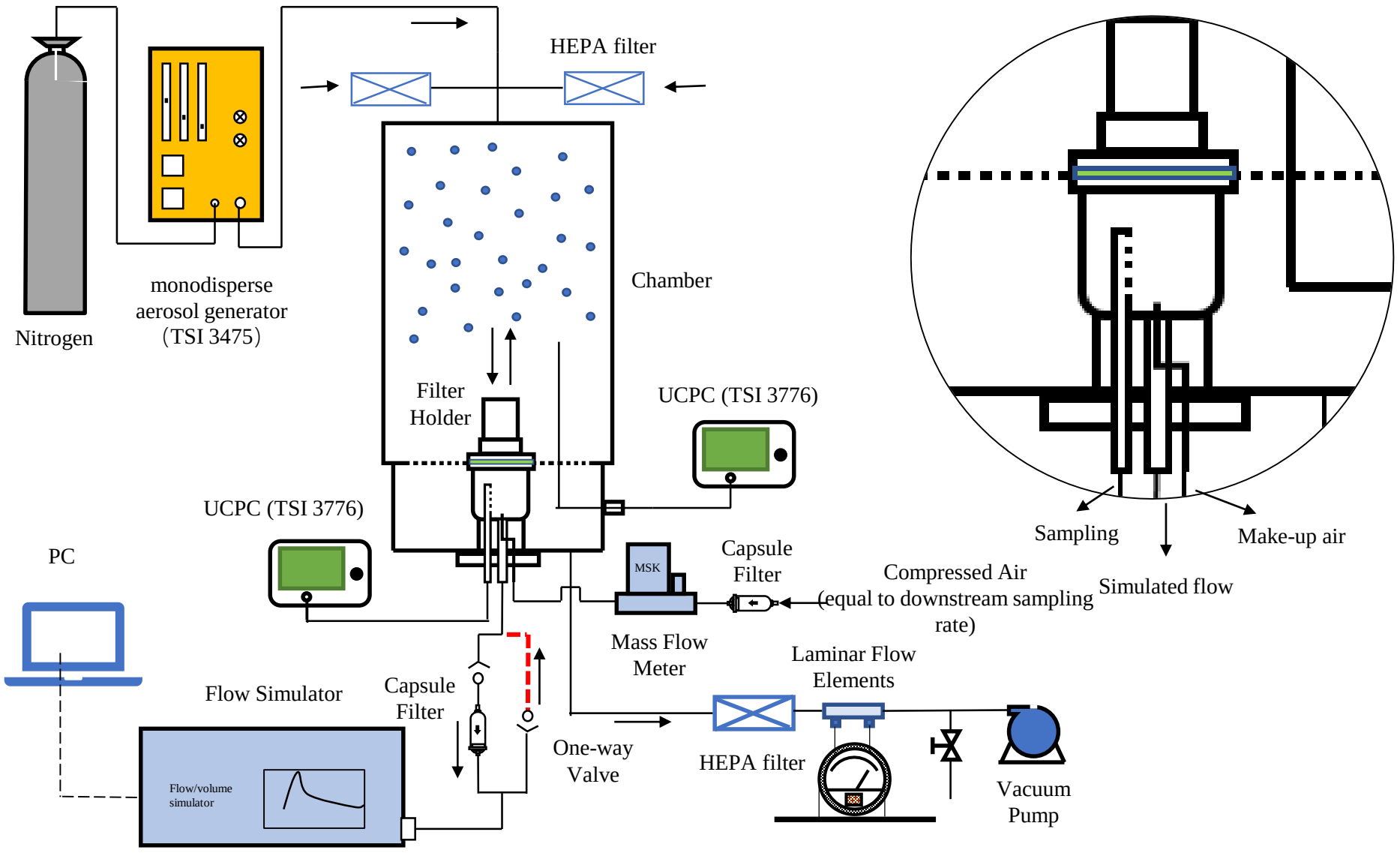
Introduction

- NIOSH standard testing method certificates respirator filter media (with the area of 135 cm^2) at the constant flow rate of 85.0 liter/min.
- Filter media used in respirators are often experiencing a cyclic flow due to the nature of human breathing.
- Testing filter media under the flow conditions how the respirators are operated is thus necessary.
- Depending on the design, respirators are operated either in the inhalation-only or inhalation-and-exhalation conditions.

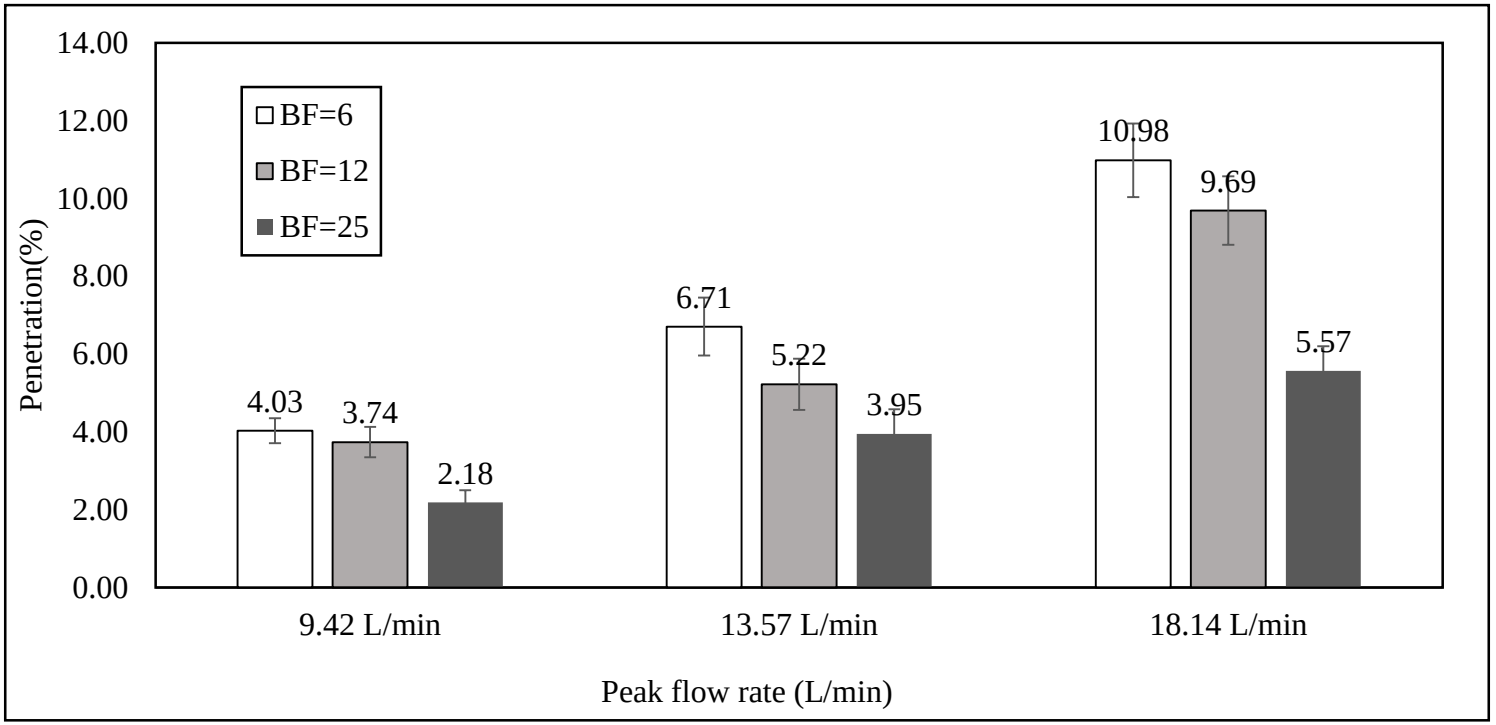
Outline

- Review of previous work
- Objectives of this study
- Current experimental setup
- Testing condition
- Testing results
- Conclusion

Previous Experimental Setup



Previous Work



- High particle concentration ⟶ Loading effect
- Particle monodispersity

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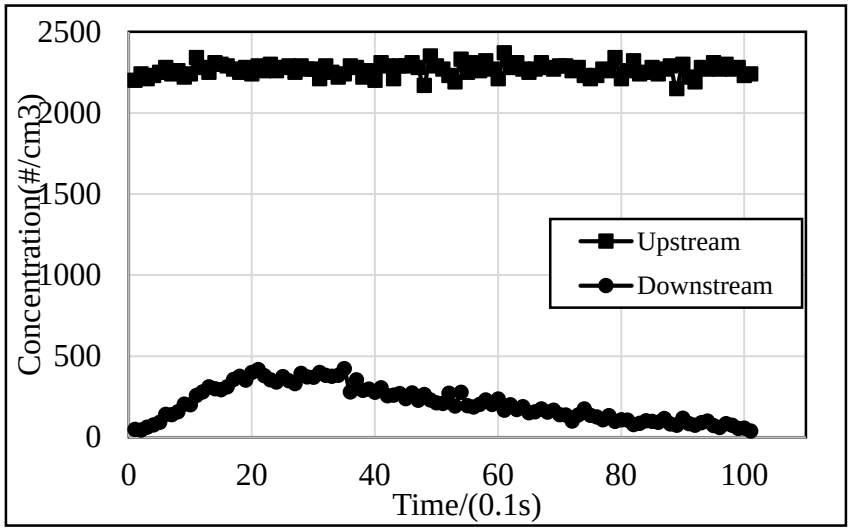
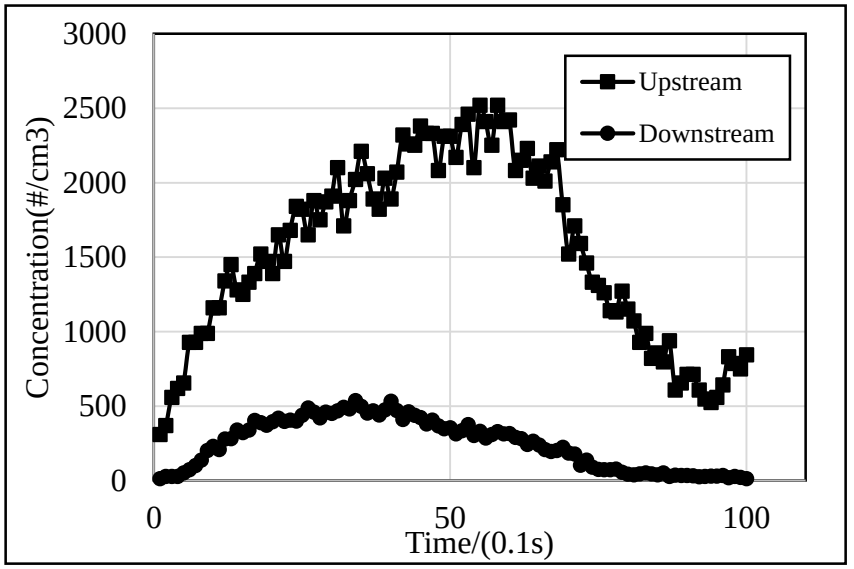
DMA-classified monodisperse particle

Object of This study

- To investigate the effects of breathing frequency (BF) and inhalation flowrate (MIF) on the average penetration of filter media under both inhalation-only and inhalation-and-exhalation conditions.

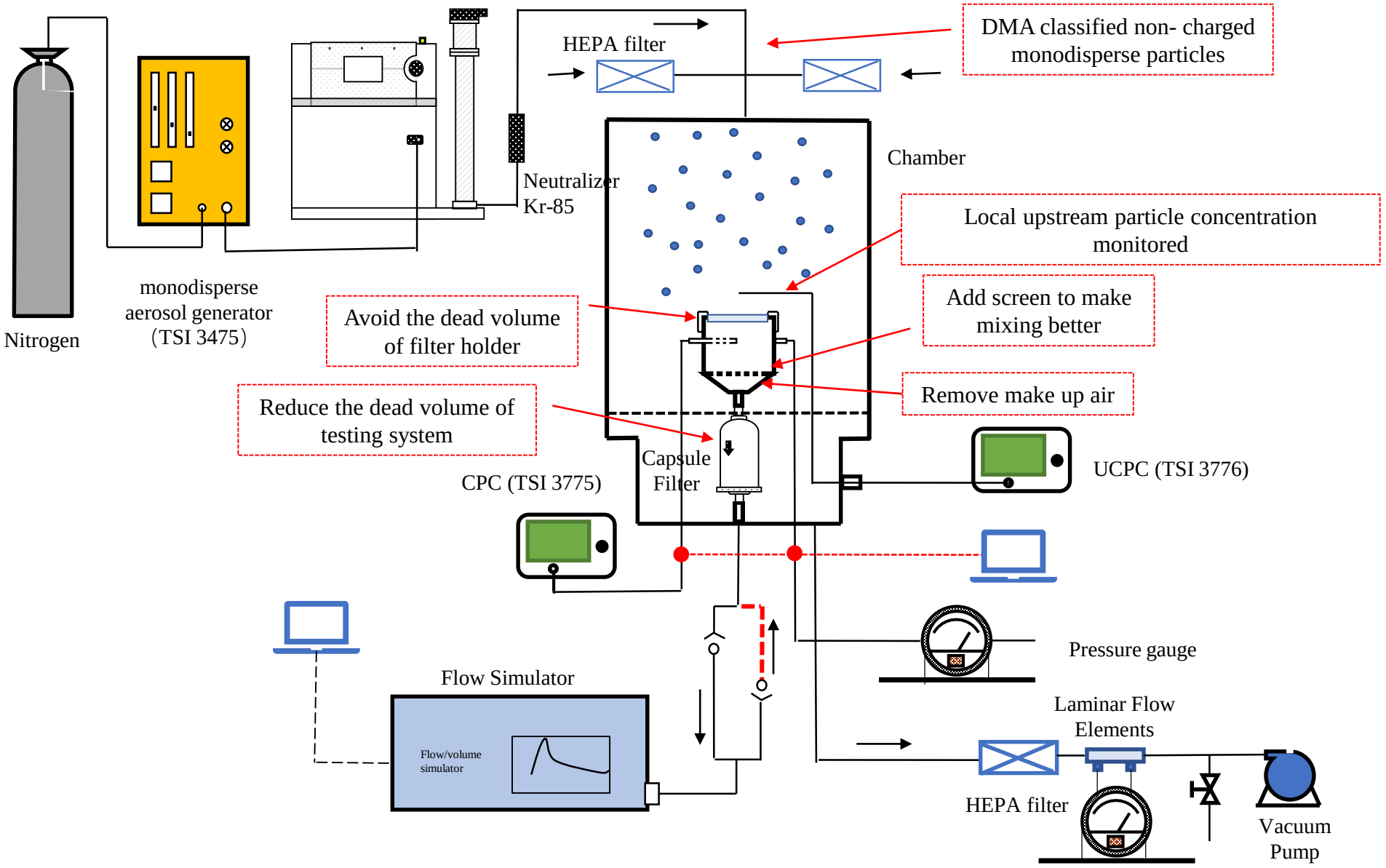


Inhalation only (one cycle)



Inhalation-exhalation (one cycle)

Current Experimental Setup



Experimental Condition

- DMA-classified DEHS particles of 150 nm;
- Testing filter area of 10.2 cm^2 with diameter 36mm (the same as that using a 47mm filter holder);
- Two types of filter media (Media A and B);
- Testing flow conditions: three MIFs, four BFs (6, 12, 25, and 42 BFs);
- Both inhalation-only and inhalation-exhalation conditions;
- 3 min of running time for each run, 3 sample filter media for each experimental condition.
- Instead of peak penetration used in previous study, average penetration of test filter media was calculated;

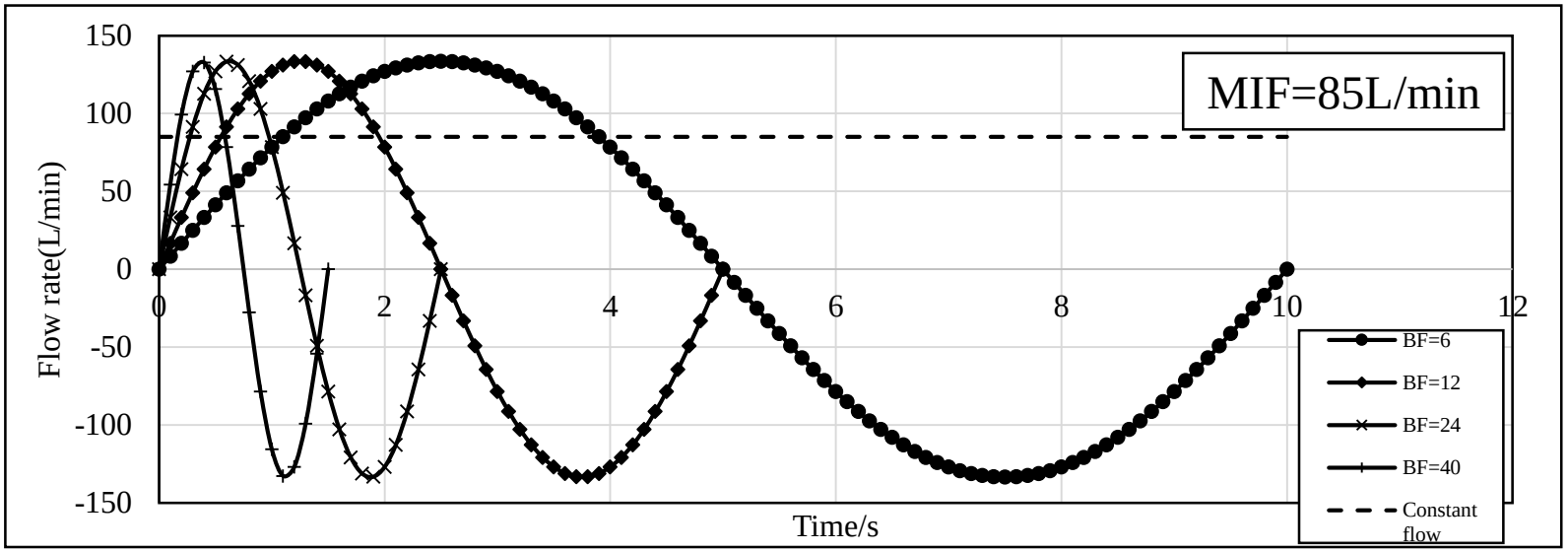
Test Flow Parameters

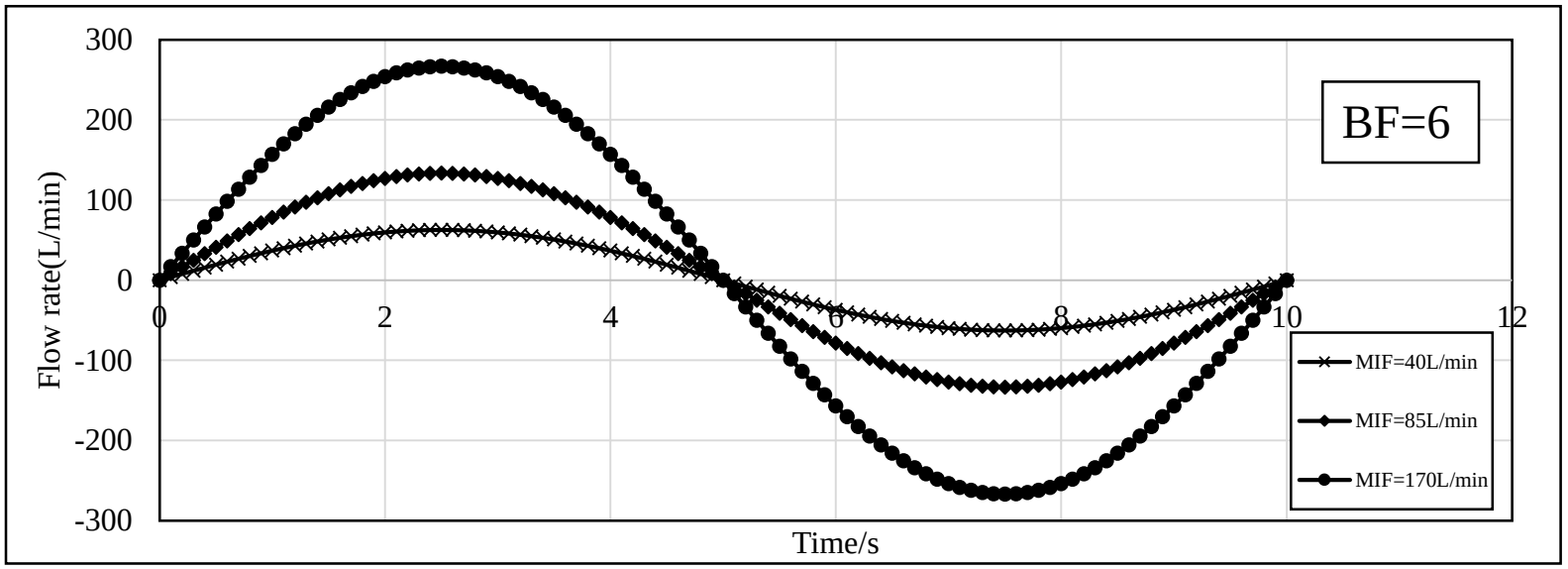
Table 1. Summary of tested cyclic flow condition

cyclic flows	BF	MIF(L/min) of 135 cm^2	MIF(L/min) of 10.2 cm^2	Minute volume(L/min) of 10.2 cm2	Tidal volume(L/min)
1-1	6	40	3.022	1.511	0.252
1-2	12				0.126
1-3	24				0.063
1-4	40				0.038
2-1	6	85*	6.422	3.211	0.535
2-2	12				0.268
2-3	24				0.134
2-4	40				0.080
3-1	6	170	12.844	6.422	1.070
3-2	12				0.535
3-3	24				0.268
3-4	40				0.161

*This condition was chosen since the standard testing method for respirator media is under 85L/min constant flow condition.

Simulated Flow Condition





Constant Flow Testing - Media A

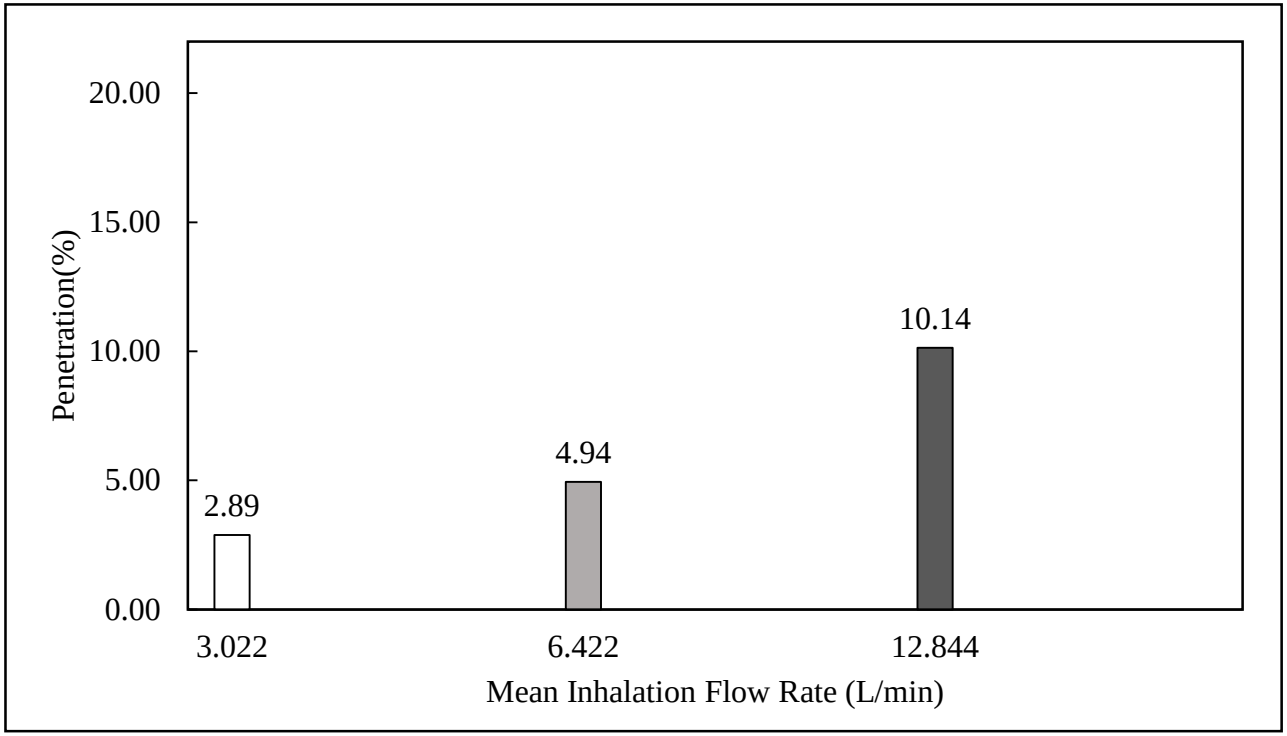


Figure 1. Penetration of media A under Constant flow conditions

Constant Flow Testing - Media B

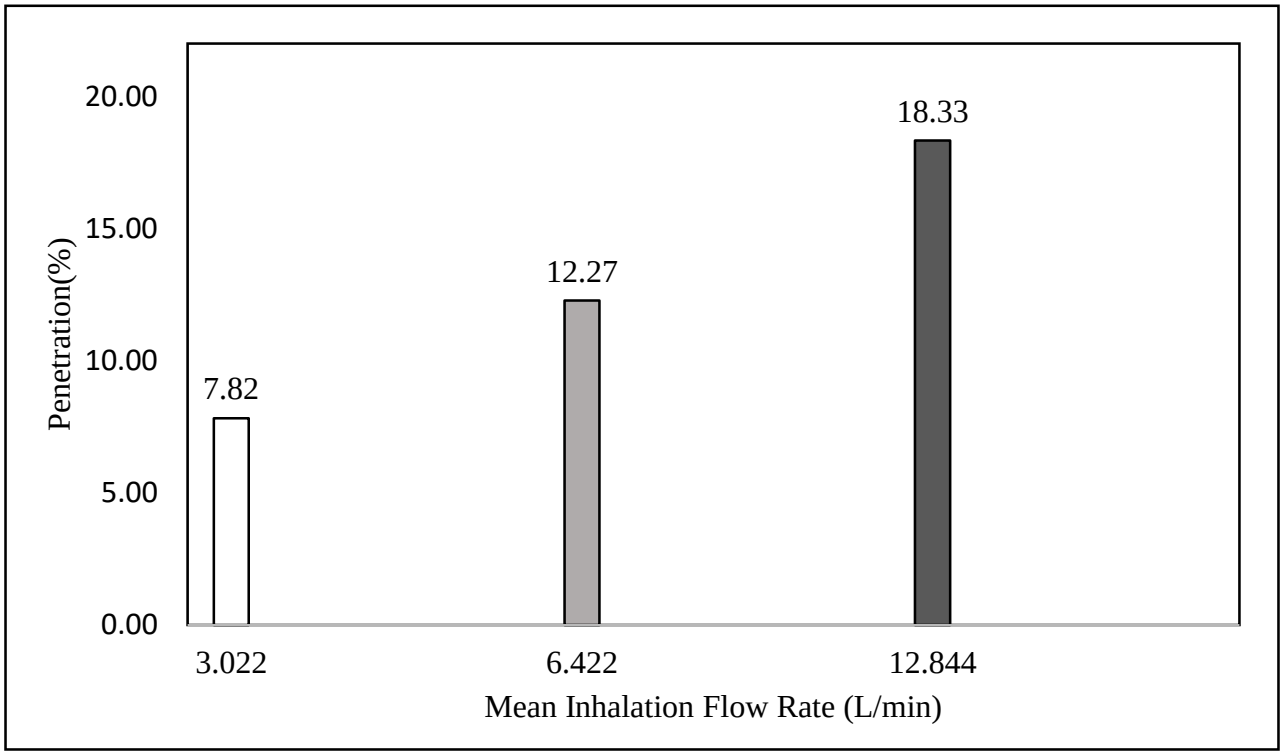


Figure 2. Penetration of media B under Constant flow conditions

Inhalation-only Testing - Media A

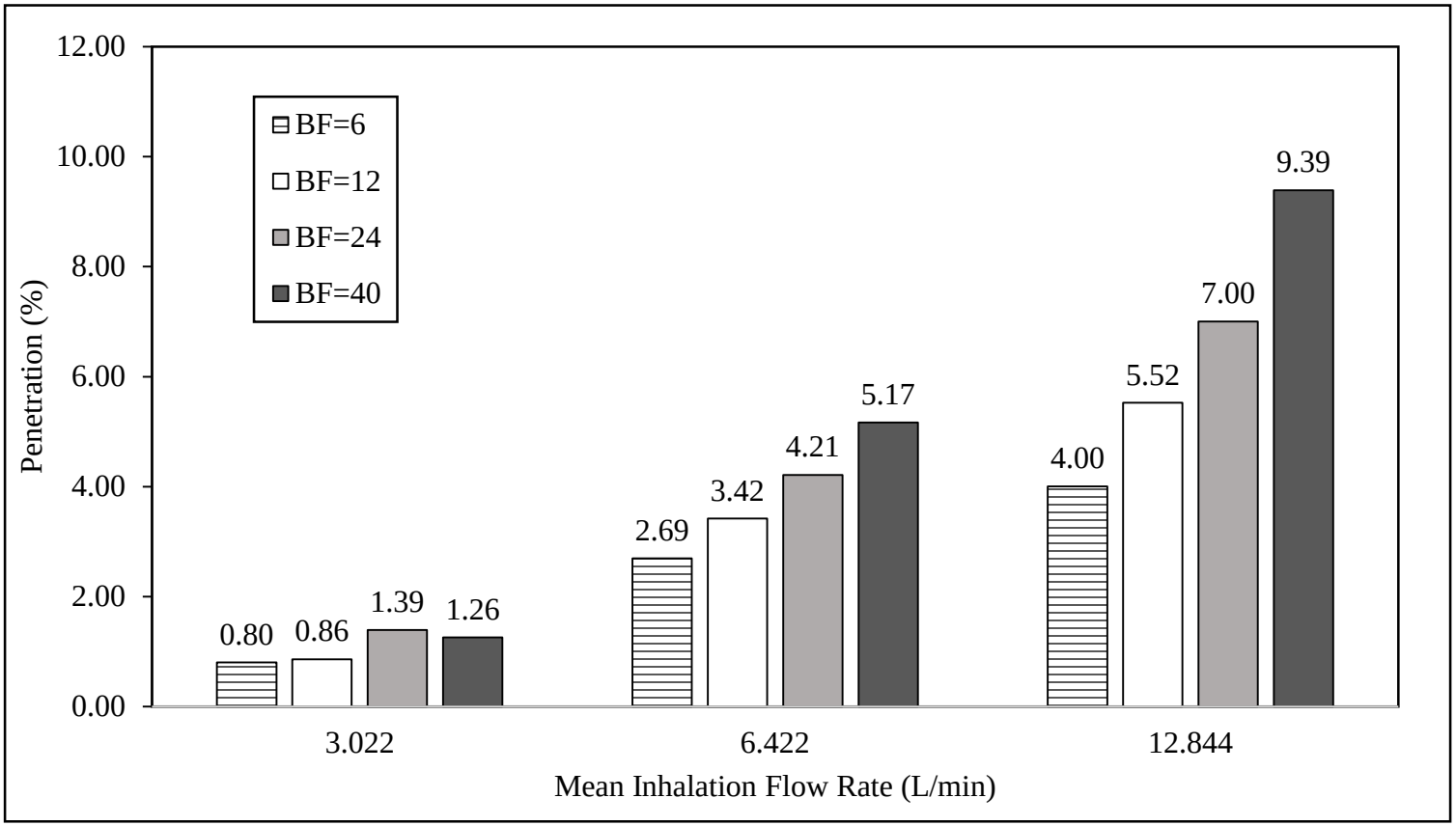


Figure 3. Penetration of media A under inhalation-only conditions

Inhalation-only Testing – Media B

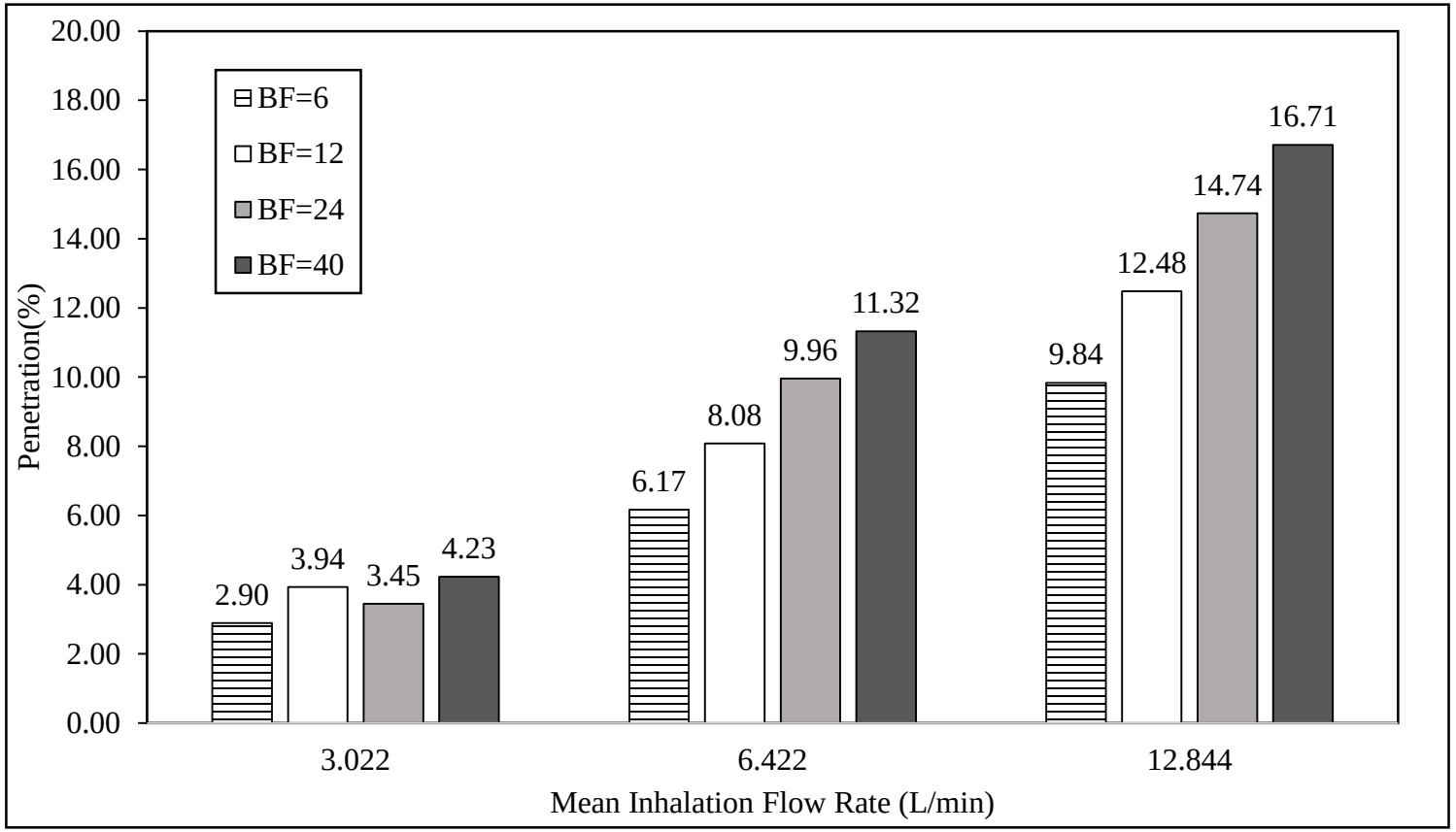


Figure 4. Penetration of media B under inhalation-only conditions

Inhalation-exhalation Testing – Media A

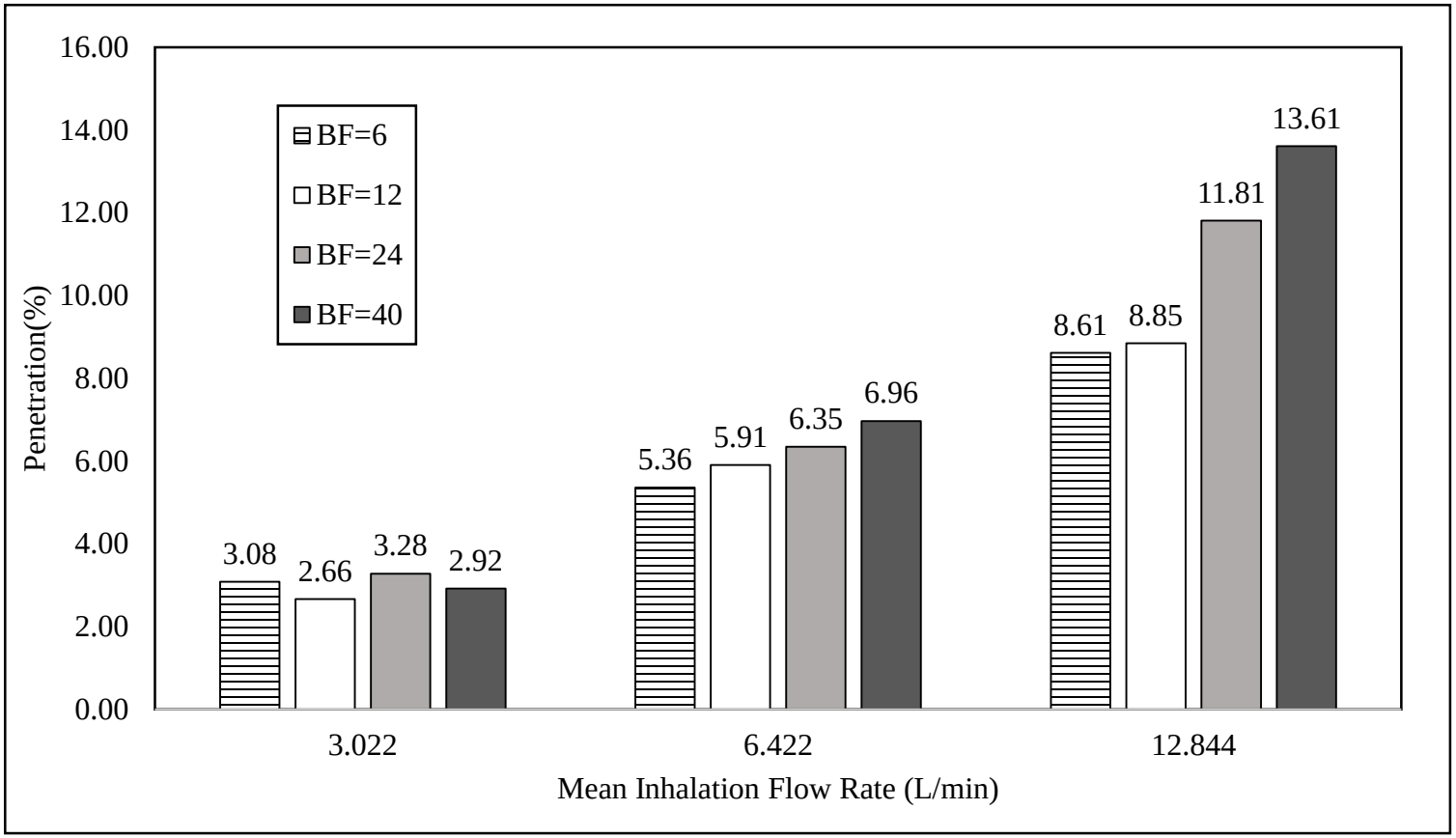


Figure 5. Penetration of media A under inhalation-exhalation conditions

Inhalation-exhalation Testing – Media B

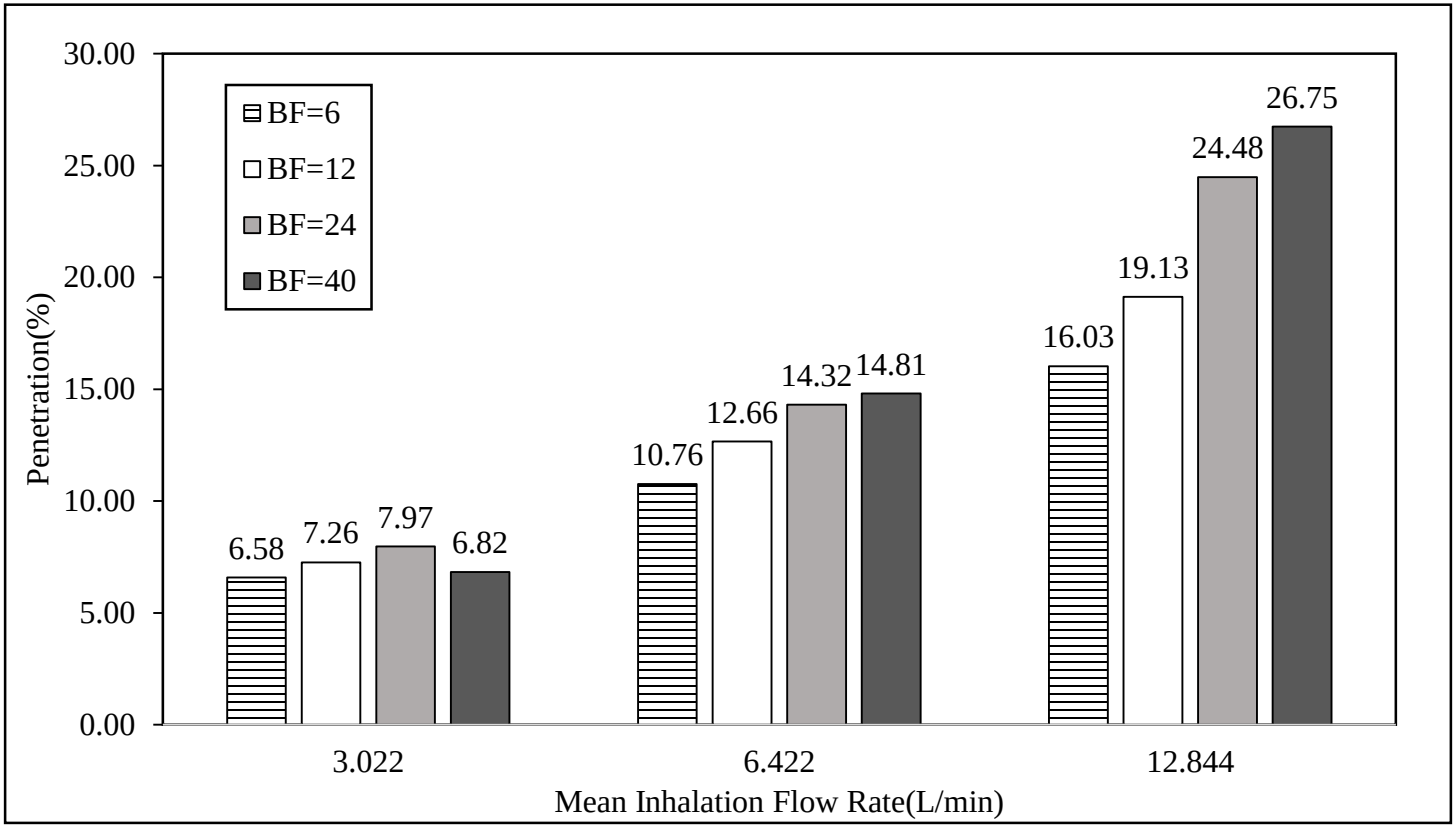


Figure 6. Penetration of media B under inhalation-exhalation conditions

Comparation of Both Testing – Media A

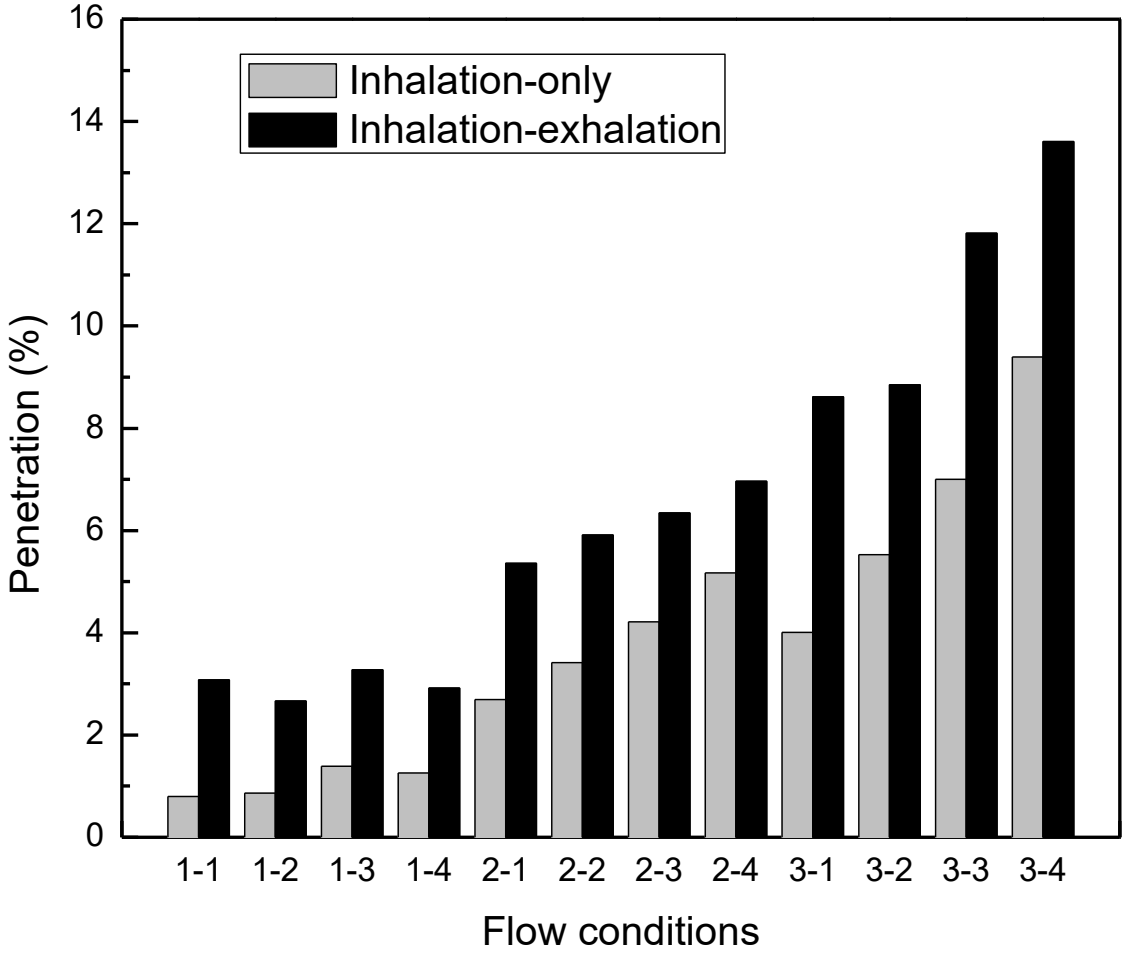


Figure 7. Comparation of inhalation-only and inhalation-exhalation condition for media A

Comparation of Both Testing – Media B

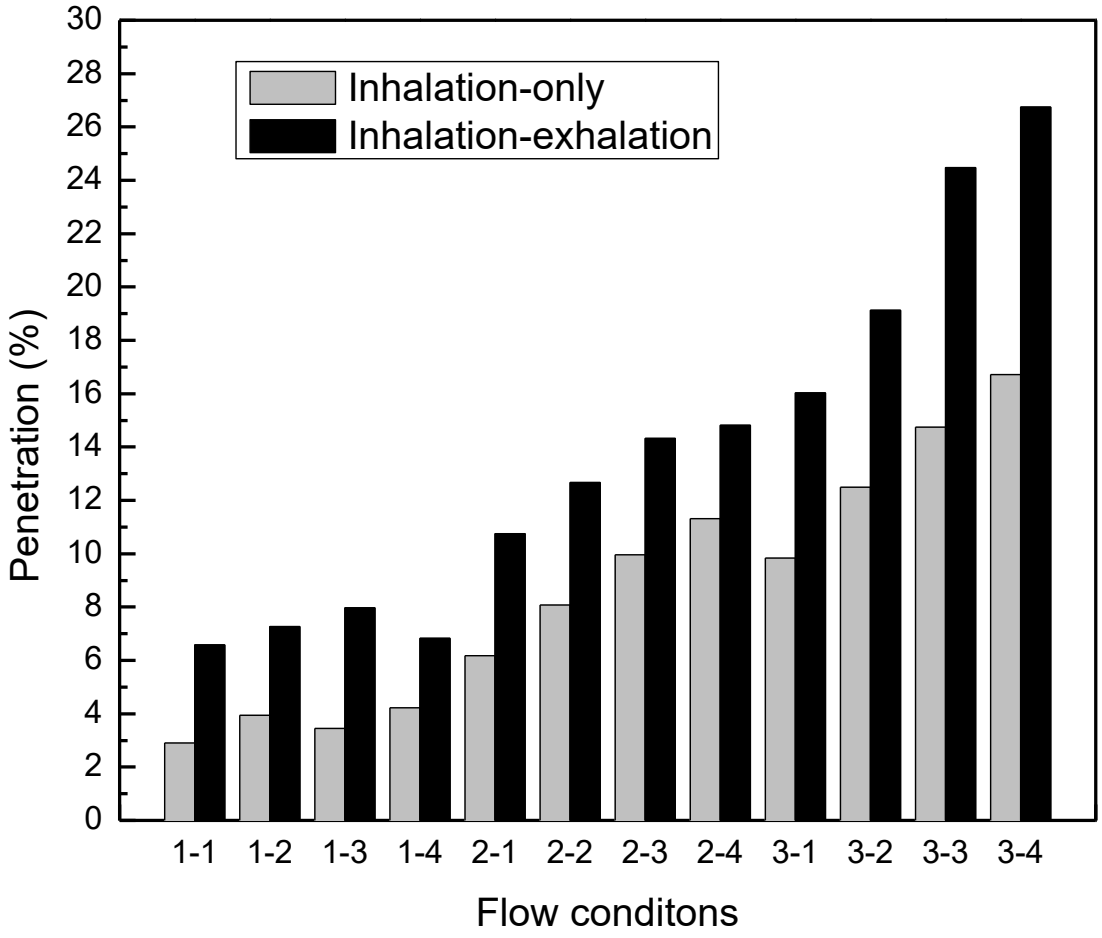


Figure 8. Comparation of inhalation-only and inhalation-exhalation condition for media B

Conclusion

- For both inhalation-only and inhalation-exhalation testing:

✓ The average penetration of test filter media increasesd with the increase of MIF (because of the increase of media face velocity).

✓ Under the same MIF, the average filter penetration increased with the increase of BF with same MIF (because of the increase of flow acceleration).

✓ Minor BF effect on the filter penetration was observed at low MIF.

- The filter penetration under the inhalation-exhalation testing was in general higher than that under the inhalation-only testing. It might be due to the local dilution at the upstream of filter media during the exhalation period.

Future Investigation

- Testing various filter media;
- Effect of particle sizes;
- Effect of charged particles of different sizes;
- Effect of flow waveforms;
- CFD modeling of filter media under oscillation flow conditions;
- Effect of particle loading on the performance of filter media operated at inhalation-only and inhalation-and-exhalation conditions.

Thanks for your attention
and
Questions?