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Performance of Respirator Filter Media under Both Inhalation-only and Inhalation-and-Exhalation Conditions

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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
- Respirator filter media often experience cyclic patterns due to the nature of human breathing.
- Testing respirator media under the inhalation-and-exhalation is thus necessary.

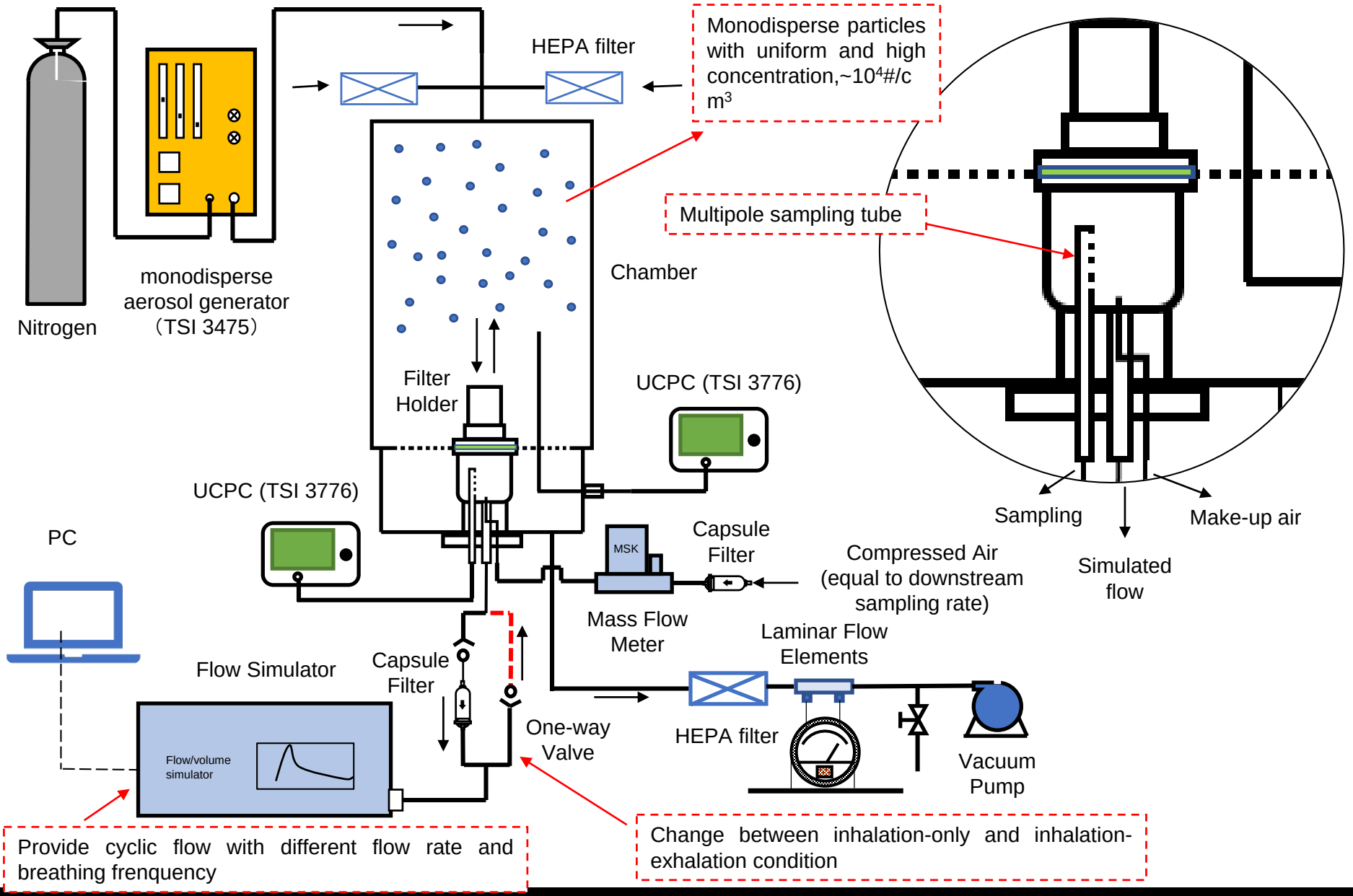
Outline

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

Object of this study

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

Current Experimental Setup



Testing Condition

- Testing aerosol: DEHS particles of 150 nm;
- Testing area of 15.3 cm^2 with diameter 47mm;

- Two types of respirator media (Media A and B);
- Test flow condition: nine cyclic sinusoidal flow (three PIFs, each with three BFs);
- Testing under both inhalation-only and inhalation-exhalation conditions;

- Use the maximum penetration as the index to evaluate the performance of media under different cyclic flow conditions.
- Testing 3 samples for each cyclic flow condition and calculate the average maximum penetration;

Testing Condition

Several terms:

PIF (Peak Inhalation Flow Rate, L/min): Maximum flow obtained in an inhalation cycle.

MIF (Mean Inhalation Flow Rate, L/min): Average airflow inhaled per inhalation cycle.

Minute Volume(L/min): The amount of air inhaled per minute of breathing.

$$PIF = \frac{\pi}{2} \times MIF = \pi \times MinuteVolume$$

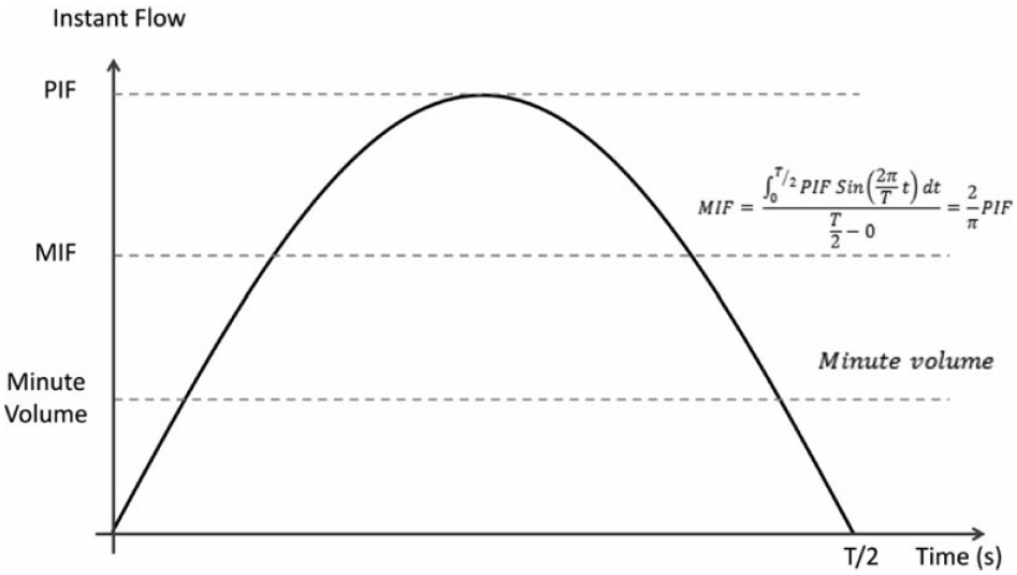


FIGURE 2. Scheme of cyclic flow and constant flows equivalent to the cyclic flow minute volume, mean inhalation flow (MIF), and peak inhalation flow (PIF); T/2 is considered as inhalation cycle period

(Bahloul, Mahdavi et al. 2014)

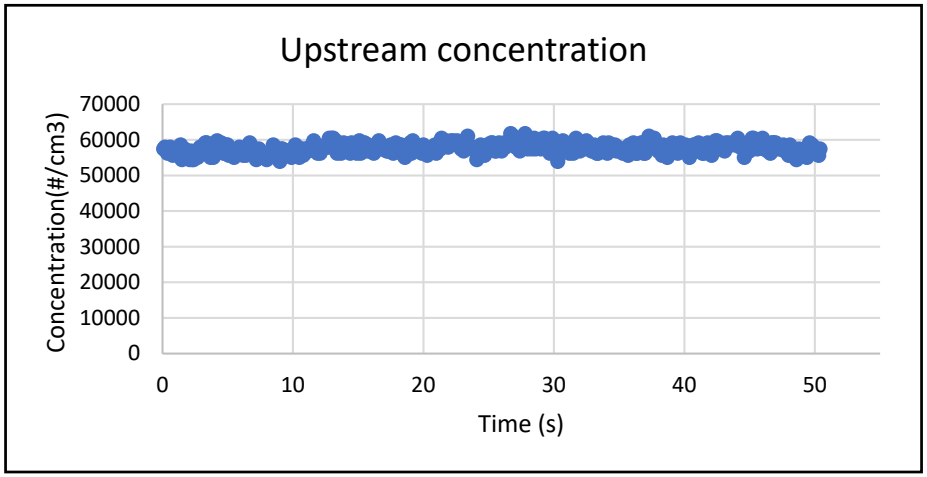
Testing Condition

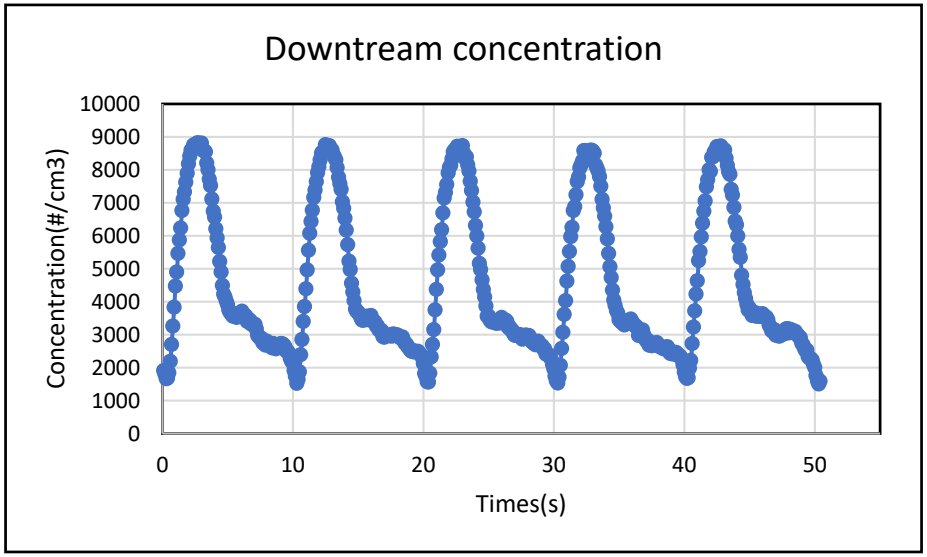
Table 1. Summary of tested cyclic flow condition

Cyclic Flows	Breathing Frequency (stroke/min)	Peak Inhalation Flow at test area of 15.3 cm^2 (L/min)	Peak Inhalation Flow at test area of 135 cm^2 (L/min)	Tidal Volume (liter/stroke)	Peak Face Velocity (cm/s)
1-1	6	9.42	82.94	0.5	10.24
1-2	12			0.25	
1-3	25			0.12	
2-1	6	13.57	119.43	0.72	14.74
2-2	12			0.36	
2-3	25			0.17	
3-1	6	18.14	159.97	0.96	19.70
3-2	12			0.48	
3-3	25			0.23	

Result under Inhalation-only Testing

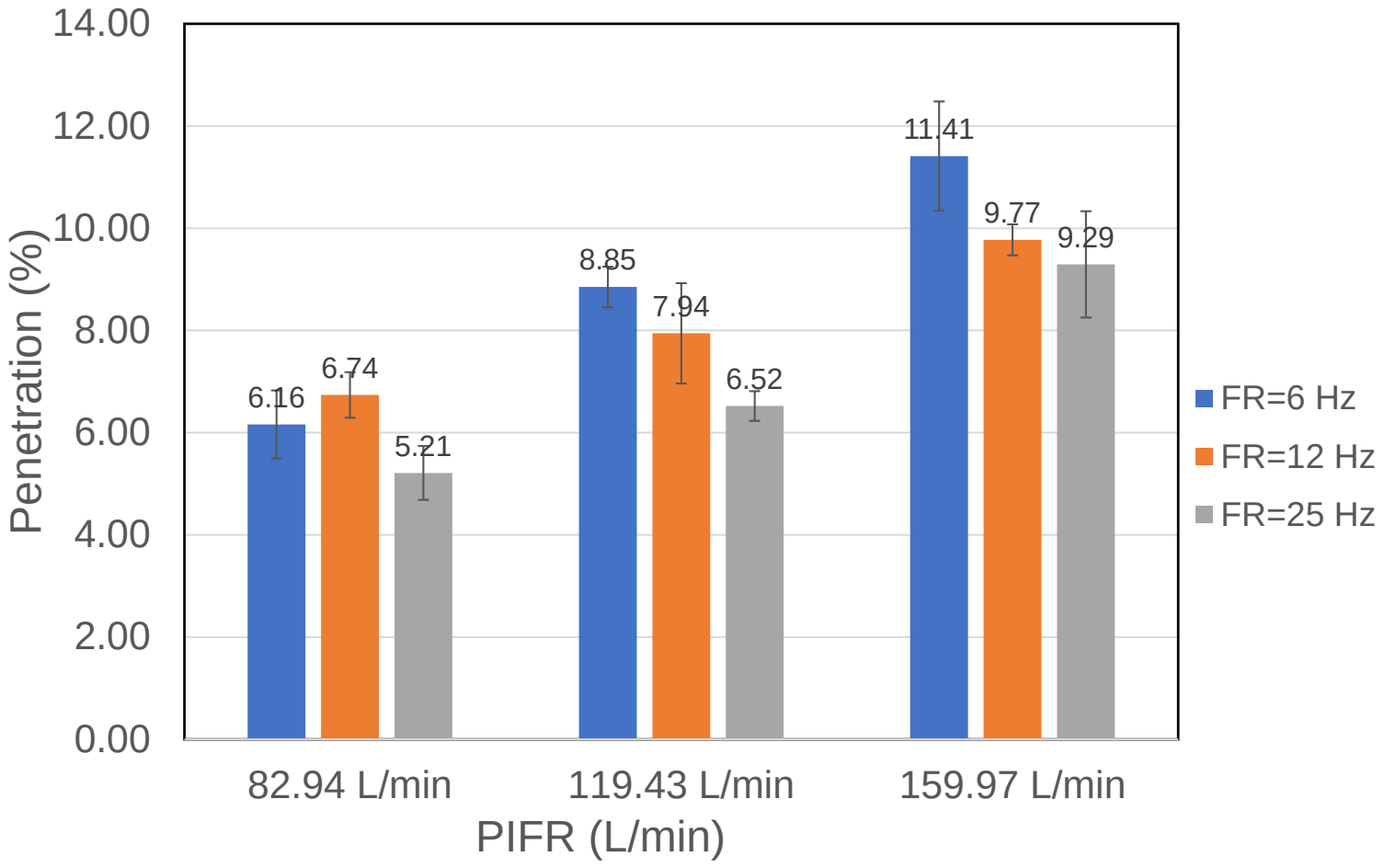
- The concentration change both upstream and downstream (5 cycles)





- Constant upstream concentration and cyclic-changed downstream concentration
- slow-decreased concentration during the exhalation period with continuous CPC-sampling

For the Inhalation-only Testing - Media A



For the Inhalation-only Testing – Media B

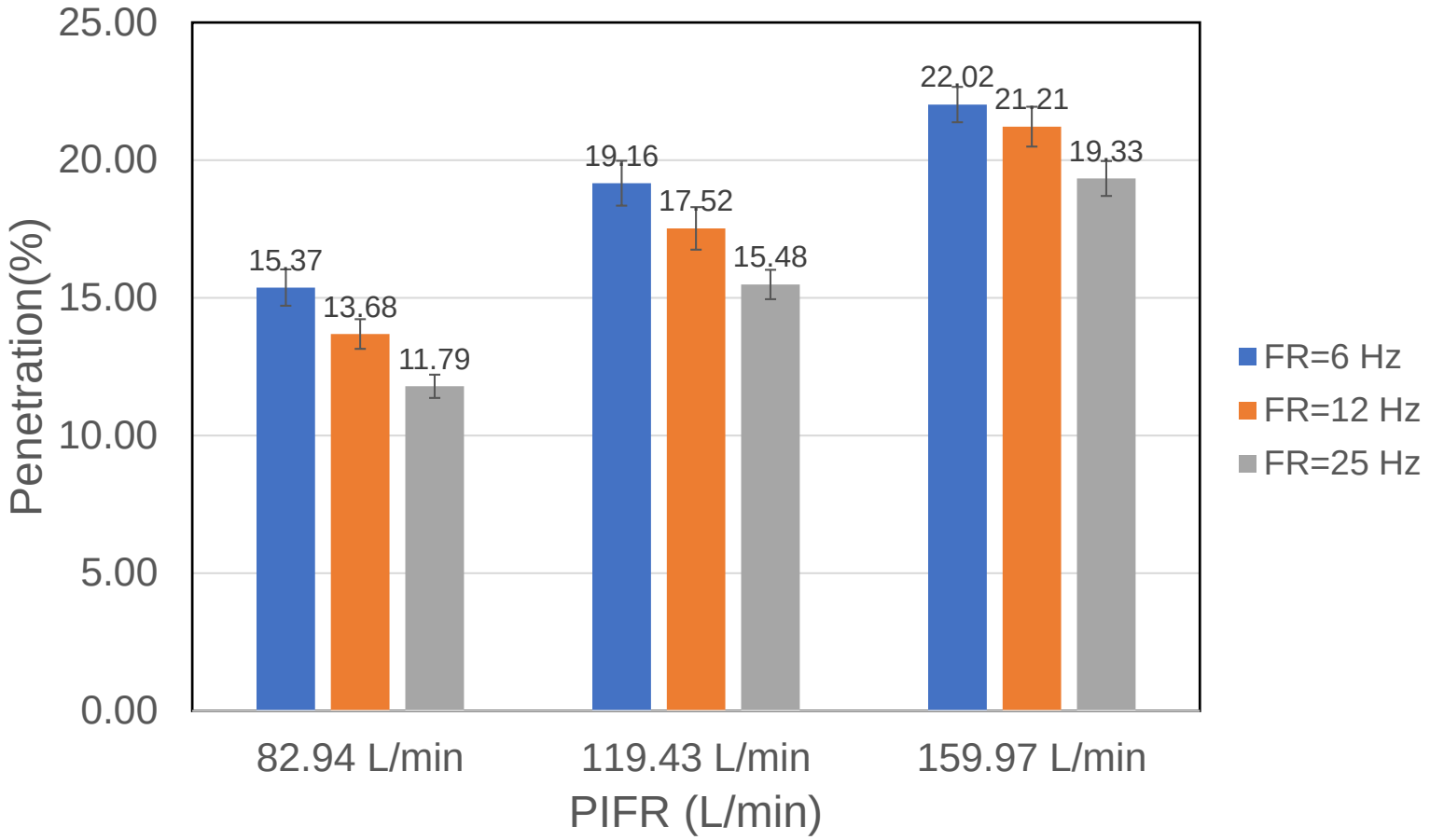
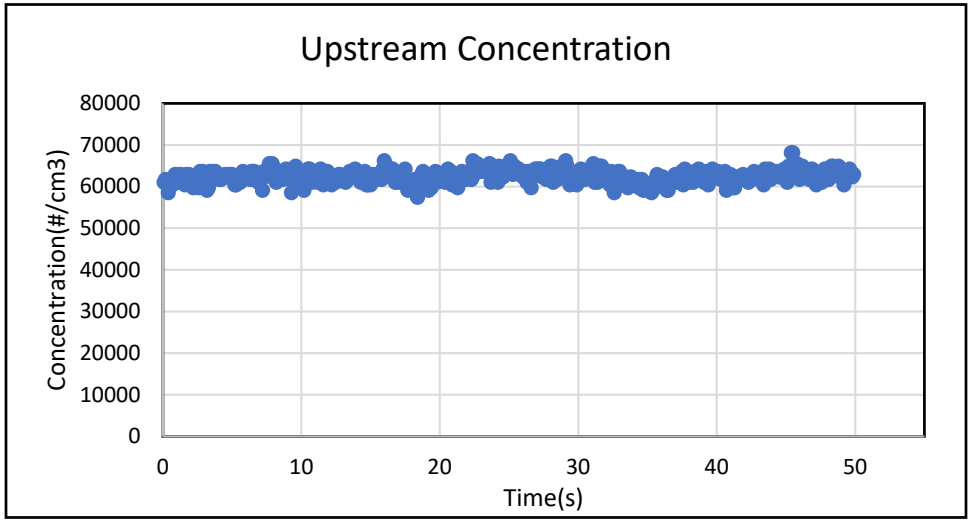
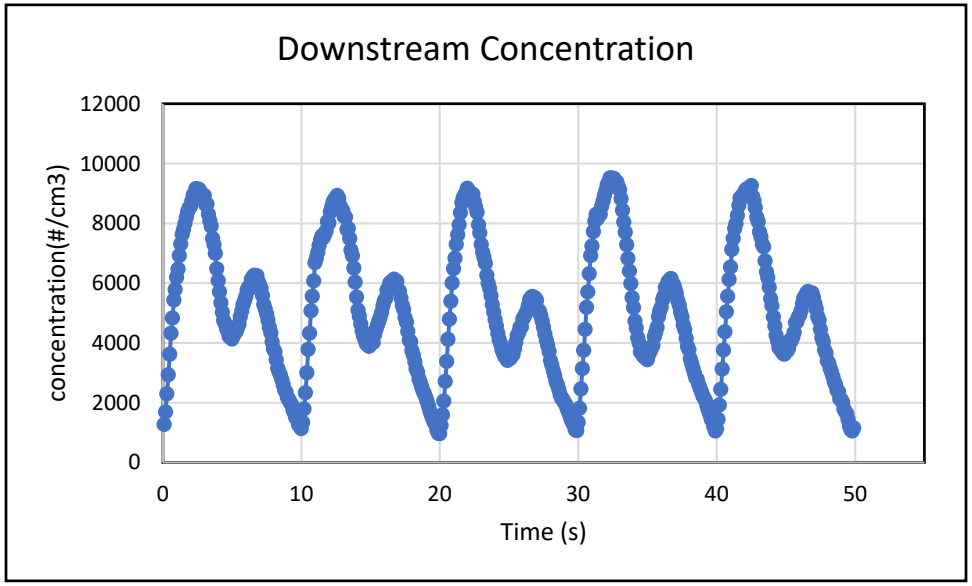


Figure2. Penetration for Media B

Result under the Inhalation-exhalation Testing

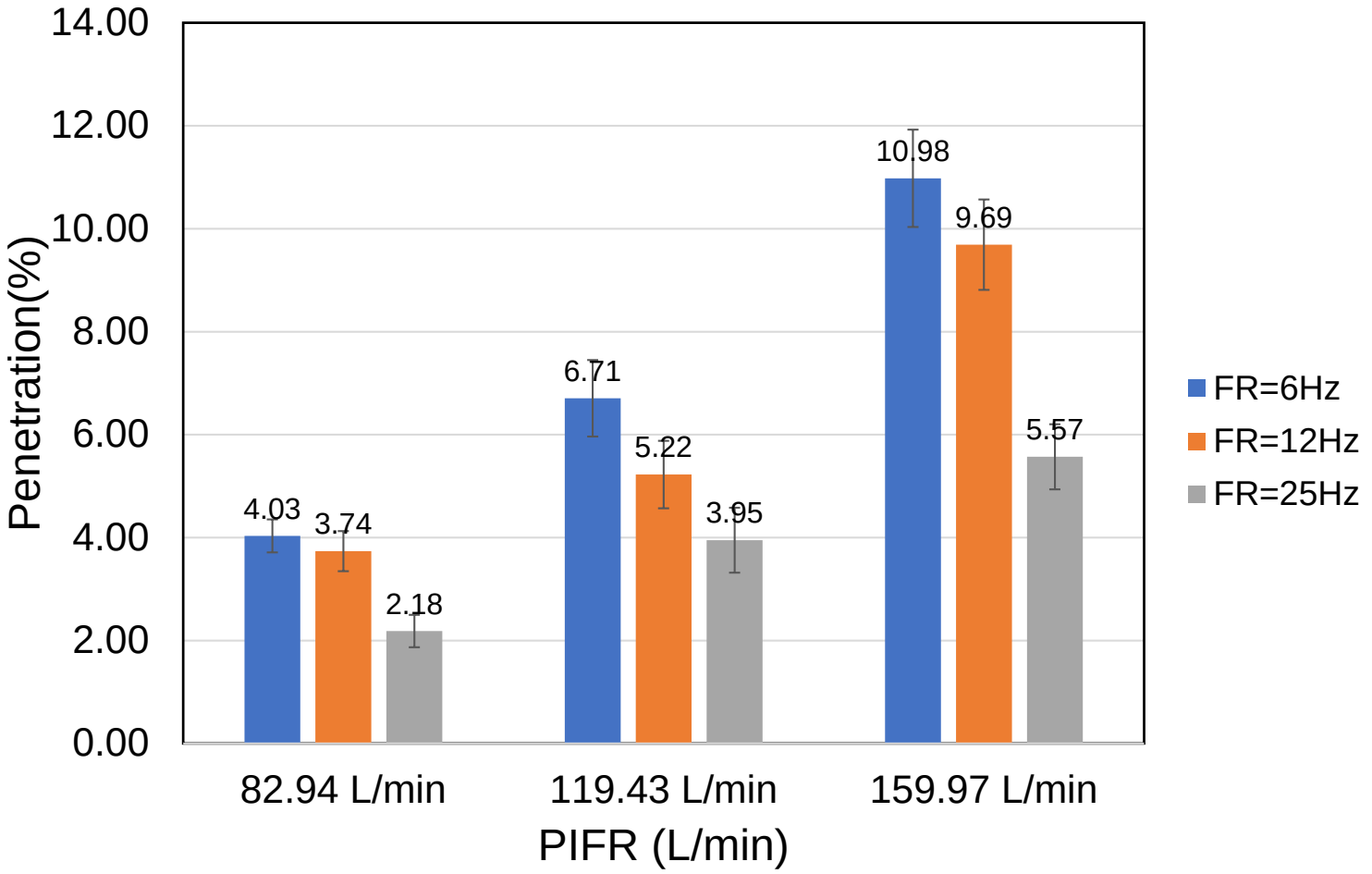
- The concentration change both upstream and downstream (5cycles)



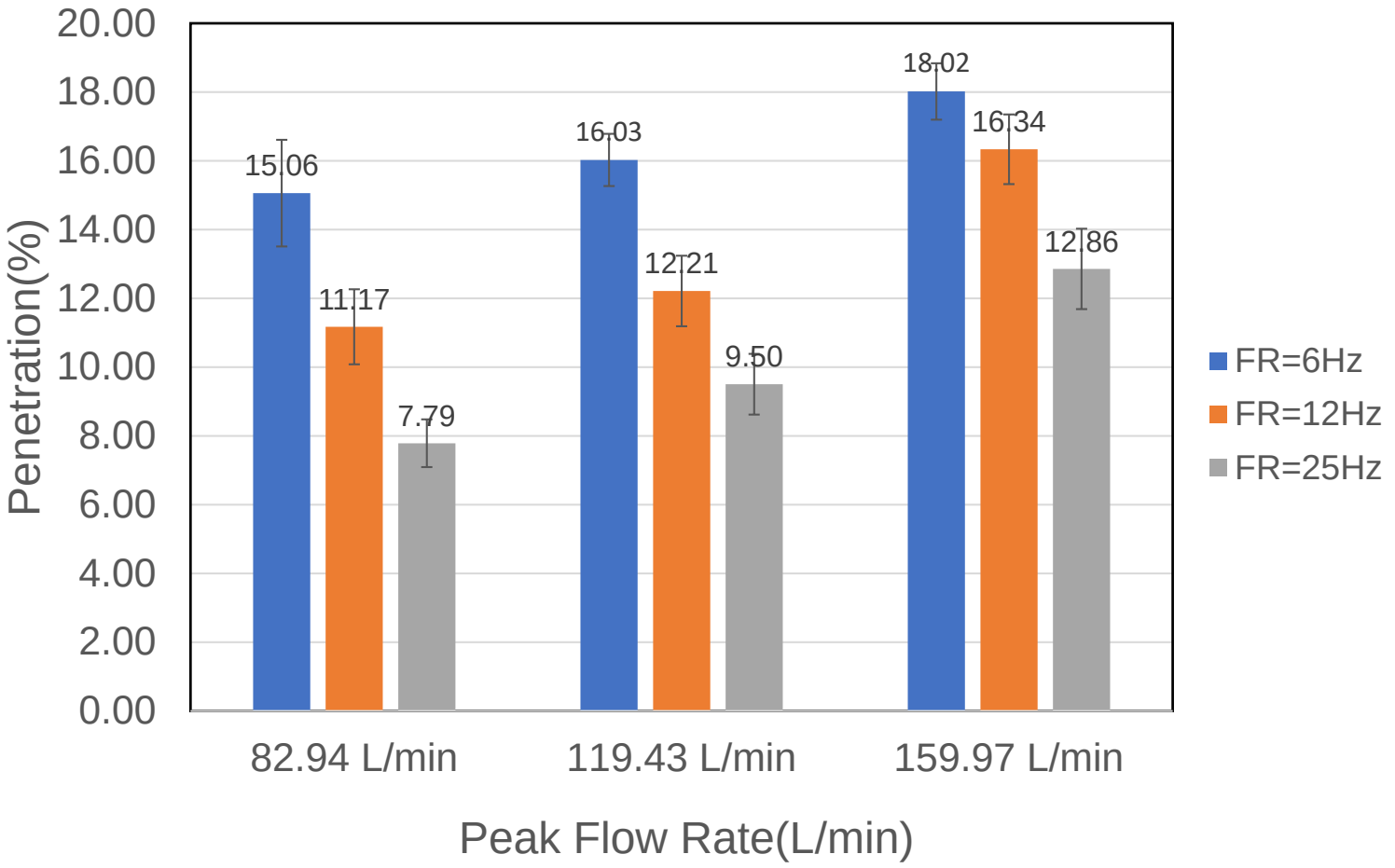


- Constant upstream concentration and cyclic-changed downstream concentration
- Small peak in the exhalation period due to the dead volume of the testing system. Concentration decreases sharply in the exhalation-period.

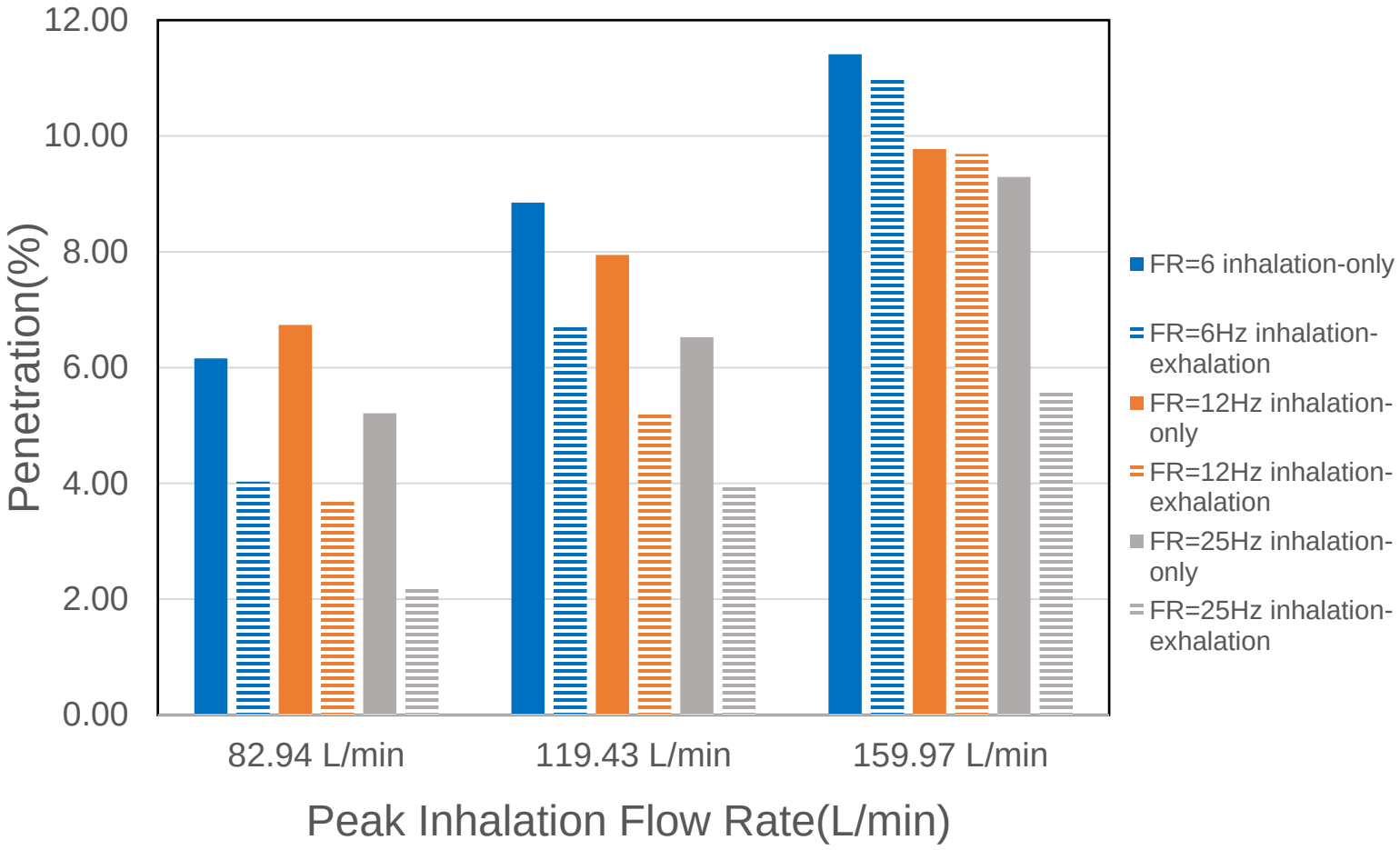
For Inhalation-exhalation Testing – Media A



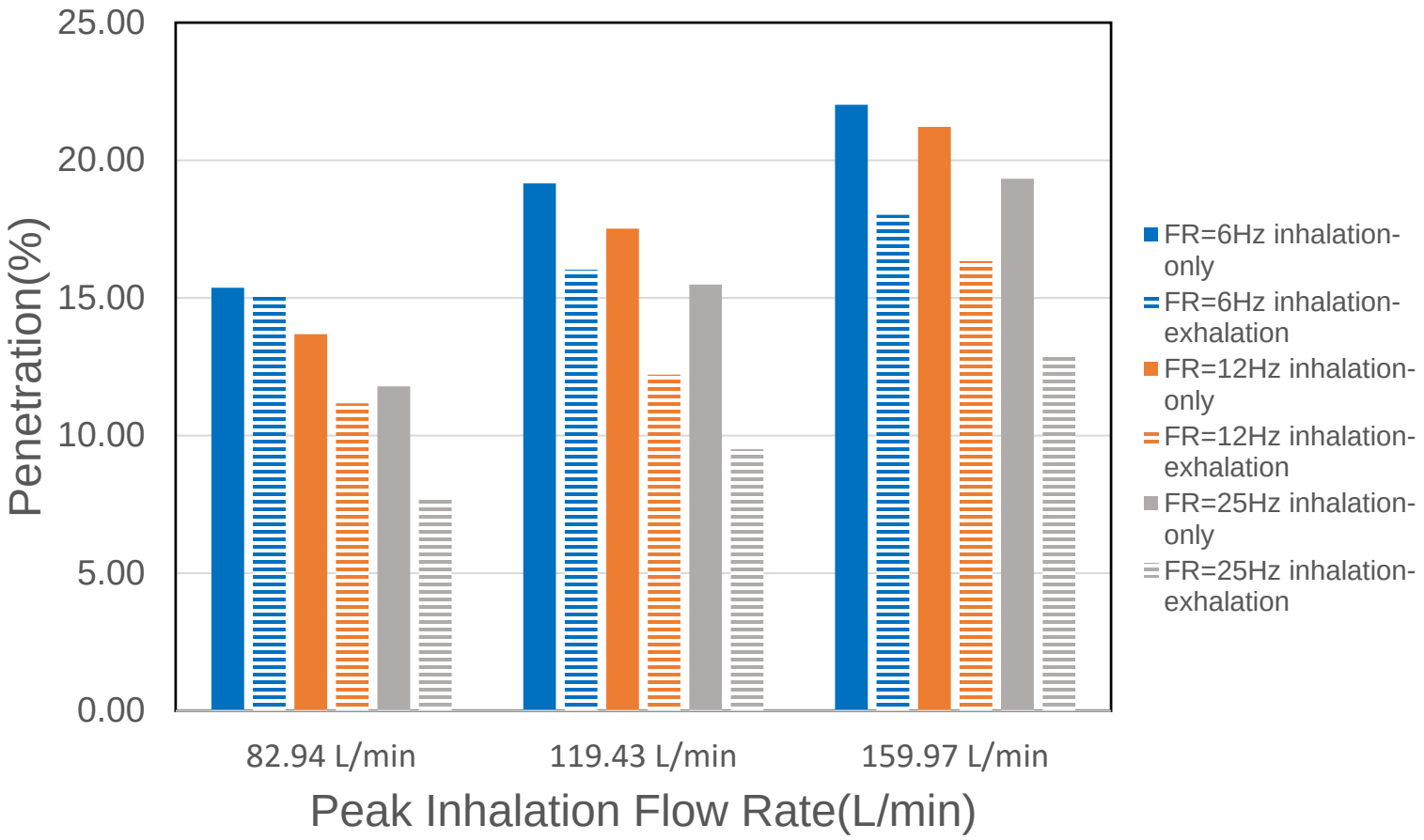
For Inhalation-exhalation Testing – Media B



Comparation of Both Testing – Media A



Comparation of Both Testing – Media B



Conclusion and Future Work

- The penetration for respirator filter media increases with the increase of PIFR under both inhalation-only and inhalation-exhalation conditions.
- The penetration of testing filter media, however, decreases with the increase of BF (which is contradictory with what observed previously).
- The cyclic variations of downstream concentration under both testing conditions are different.
- The media penetration under the inhalation-only condition is in general higher than it under the inhalation-exhalation condition

- More effort is required:
  - To find out the reasoning for different observed BF effects in current and previous setups
  - To test more filter media under a wider range of cyclic flow conditions

Thank you for you attention
and
Questions?