Development of Personal Aerosol Collector and Spectrometer (PACS): Part II: Laboratory Experiments for Particle Size Distributions

Changjie Cai[1], Geb W. Thomas[2], Jae Hong Park[1], Tianbao Yang[3], Sivaram P. Gogineni[4], Saber M. Hussain[5], and Thomas M. Peters[1,*]

[1]Department of Occupational and Environmental Health, University of Iowa [2]Department of Mechanical and Industrial Engineering, University of Iowa
[3]Department of Computer Science, University of Iowa [4]Spectral Energies, LLC [5]Wright-Patterson Air force Base, OH

Introduction

- People are exposed to a variety of particles with a wide range of sizes.
- Current personal samplers cannot measure real-time exposures to all particle size ranges simultaneously.
- Need to simultaneously measure particle number, surface area, and mass concentrations by size and collect particles for subsequent chemical analysis from 10 nm to 10 µm.

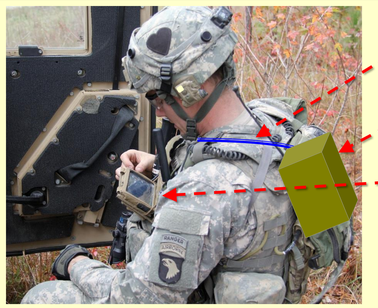
Objective

- Compare particle number, surface area and mass concentration by size from 10 nm to 10 µm measured with a new real-time monitor – the Personal Aerosol Collector and Spectrometer (PACS) – to reference instruments

Methods

PACS hardware

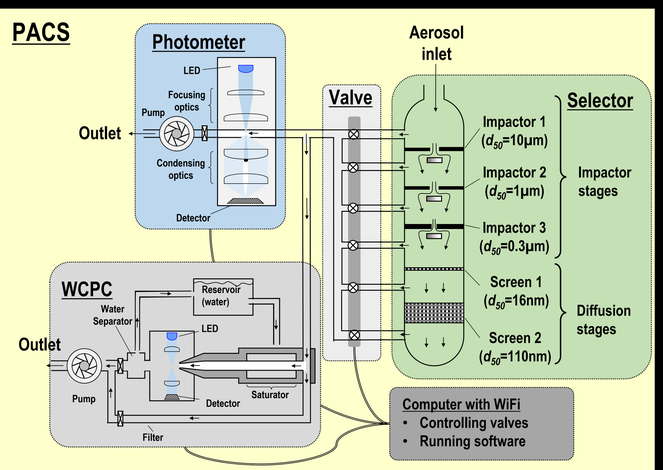
- Combines three devices: selector, photometer and water condensation particle counter (WCPC).
- Detects particle number and mass concentrations after passing through selector stages.



(Soldier photo courtesy of JRTC Operations Group Public Affairs)

Transport tube conveys aerosols from breathing zone to PACS situated in backpack.

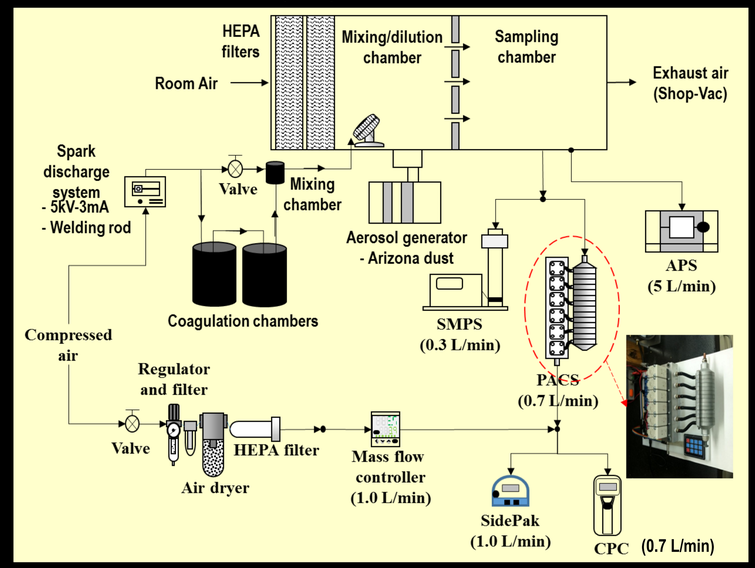
Schematic view of the design of PACS



Photometer: used for measuring mass concentration;
WCPC: used for measuring number concentration.

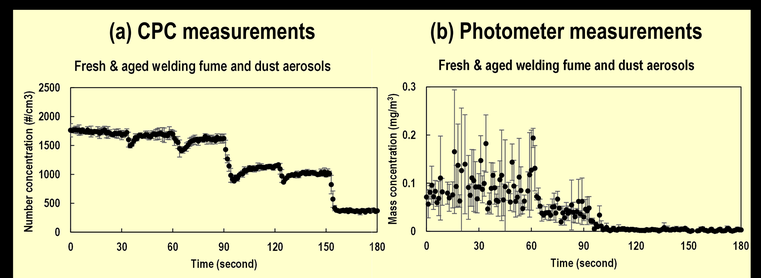
Experiment Protocol

- Generated a three mode aerosol: (1) fresh welding fume for ultrafine mode, (2) aged welding fume for fine mode, and (3) Arizona dust for coarse mode
- Compared size distributions from PACS (with and without experimentally adjusted efficiency for diffusion stages) to reference instruments (scanning mobility particle sizer, SMPS, and aerodynamic particle sizer, APS), using R2 and normalized mean bias (NMB)

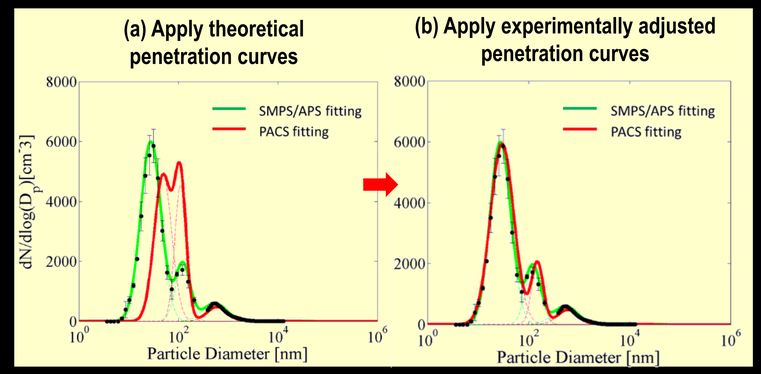


Results

Raw Data from PACS

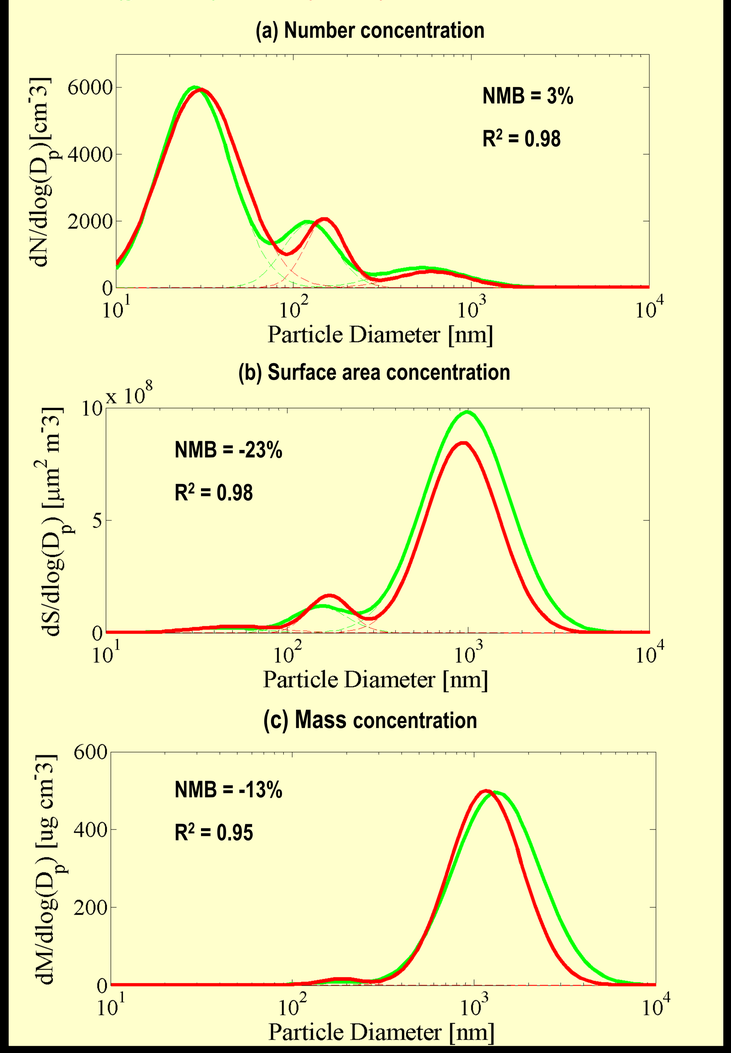


Improvement in Data Processing



Processed Data

SMPS/APS (green line) vs PACS (red line)



Conclusions

- Size distributions measured with the PACS agree well with reference instruments
- Use of experimental information on collection efficiency of the diffusion stages found critical to obtain a good fit
- Future work will investigate a range of different types of aerosols (e.g., spherical versus fractal) and combinations of different modes

Acknowledgements

This research is funded by United States Air Force (AF131-024, No. F2-7462). The authors would like to thank TSI Inc. for providing the photometer AM510, and technical supports. The authors also acknowledge Aerosol Dynamics for providing the WCPC.

UI COLLEGE OF PUBLIC HEALTH
DEPT OF OCCUPATIONAL & ENVIRONMENTAL HEALTH