EVALUATION OF NOVEL LOW PRESSURE DROP FILTRATION TECHNOLOGIES

Andrew Nelson, Martin Page, and Mark Ginsberg - USACE ERDC-CERL
Mark Rood – University of Illinois

ABSTRACT:

Traditional methods of purifying building supply air of particulate matter are limited to fabric filter media that can cause a large pressure drop. Facilities requiring advanced protection typically utilize HEPA filters capable of removing 99.97% of particles larger than 0.3 µm. The filters have high associated energy costs due to large pressure drop and can become contaminated with potentially hazardous biological material during normal operation.

In this research, new low pressure drop (LPD) air filtration technologies are evaluated as potential alternatives to HEPA filtration in building protection applications. A test chamber has been designed, constructed, and validated to evaluate collection efficiency and operational stability of novel LPD filtration technologies at flow rates up to 50 CFM. Based on results from laboratory scale evaluation, technologies will be evaluated in relevant environments in cooperation with JPM-ColPro for use in DoD facilities.

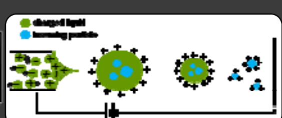
BACKGROUND:

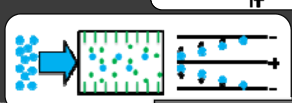
The DARPA funded immune building project showed that excellent bioprotection of facilities is possible. This utilized a zoned HVAC system triggered by an integrated sensor network. The building was capable of high levels of protection, but it was not maintainable on both an O&M and cost basis.

Possible alternatives to sensor-activated HEPA filtration methods have been developed under previous DTRA funded efforts. Two promising candidates for scale-up and wide area deployment are electrospray ionization coupled with electrostatic collection and acoustically enhanced aerosol impaction.

Electrospray: The system to be evaluated was developed by Sentor Technologies Inc. (Glen Allen, VA) as a combination of electrospray ionization and electrostatic precipitation. The Selective Ionization and Contaminant Extraction (SELEX) system creates a spray of charged water nanodroplets to ionize incoming contaminant particles. Ionized particles are collected downstream in an electric field by electrical migration and subsequent deposition on a conductive surface [2,3].

Representation of electrospray ionization technique used in SELEX system



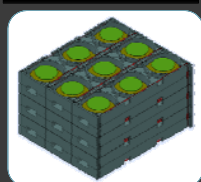


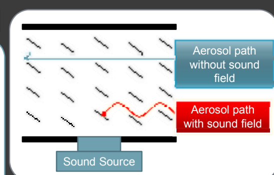
Electrospray ionization in a collection system

OBJECTIVE: Protect DoD building occupants from external release of biological agents with an "always on" protection system capable of a protection factor greater than 100 with less energy use than HEPA.

Acoustically Enchanced Impaction (AEI): Application of sound field to a particle laden gas stream will cause particle drift towards velocity nodes due to the development of asymmetric Stokes drag. Variation of the applied frequency has been theoretically and experimentally demonstrated to enable targeting of specific particle sizes[4,5]. Aerosol drift in a sound field was exploited in a DTRA funded effort to enhance particle impaction on a coarse filter media by Applied Research Associates (Littleton, CO). Particle movement due to the application of a sound field in a coarse filter media can increase the probability of particle impaction on the media.

Expandable sound source unit



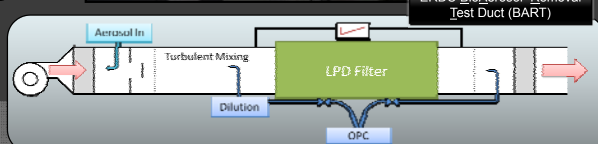


AEI allows for increased particle removal without added pressure drop

DUCT AND EQUIPMENT DESIGN AND VALIDATION :

The test duct has been engineered to produce efficiency ratings consistent with an ASHRAE 52.2 test duct.

ERDC BioAerosol Removal Test Duct (BART)



METHOD:

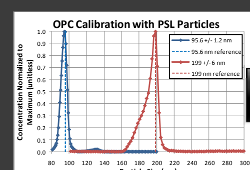
Test Duct and Sampling Equipment Design: The following characteristics were incorporated into duct and sample flow design

- Fully turbulent mixing upstream of test filter
- Negligible gravitational settling for particle size range of interest
- Fully conductive duct and sample lines
- Upstream aerosol dilution to allow for measurable downstream concentration post-treatment
- Isokinetic sampling of test aerosol

Duct and Equipment Calibration/Validation: the following properties were validated prior to experimental data acquisition:

- Aerosol uniformity: CV < 15% for 9-point traverse
- Air velocity: CV < 10% for 9-point traverse
- Stable aerosol concentration
- Optical particle counter zero of <10 counts/minute
- Optical particle counter sizing accuracy

The TSI 3340 Laser Aerosol Spectrometer (OPC) was validated for sizing accuracy using polystyrene latex spheres. Particle concentration was validated against a scanning mobility particle sizer (SMPS) and a condensation particle counter (CPC). Appropriate sample port sizes were calculated to ensure isokinetic sampling of test aerosol.

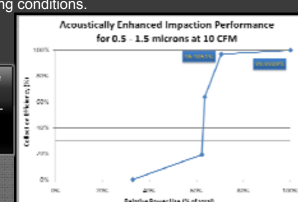


Size calibration shows excellent agreement with PSL particles at 95nm and 200nm

AEI RESULTS:

Initial screenings have been performed on the ARA acoustic LPD system. The device was operated at 10 CFM acoustic intensity was varied to determine optimal operating conditions.

Initial screenings indicate that AEI is capable of 99.999% removal of 0.5 – 1.5 µm particles when operated at full power



DISCUSSION:

While lab evaluations of LPD systems are only beginning at ERDC, initial collection efficiency screenings of the AEI system indicate that it may perform best as a bioprotection system distributed throughout an HVAC system. The ability to collect over 90% of 0.5 – 1.5 µm particles when operating at about 75% power could be exploited by recirculating air rapidly and passing it through a localized AEI system.

FUTURE WORK:

Modeling of Contaminant Transport and LPD Systems: ERDC has partnered with the UIUC Air Conditioning and Refrigeration Center (ACRC) to model biological contaminant transport. A combination CFD-Zonal model is in development and will be used to determine optimal placement of LPD systems.

2000 CFM Test Bed Evaluation with JPM-ColPro: ERDC has partnered with JPM-ColPro to evaluate systems for operation in a relevant environment.

JPM-ColPro Test-Bed modular equipment trailer

FY11.2 Army CBD-SBIR: The FY11.2 solicitation will include a topic to develop a new sound source for the AEI capable of further reducing energy needed for operation.

REFERENCES:

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CONTACT:

Andrew Nelson; U.S. Army ERDC – CERL, Champaign, IL
Andrew.J.Nelson@usace.army.mil
217.352.6511 x6509