2009 BFRL Project Description

Project Title: Air Cleaner Performance Measurement and Prediction

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BFRL Program: Healthy and Sustainable Buildings

Objective: To provide energy-efficient indoor air quality control by developing the measurement science required for validated test methods and tools for high-efficiency particle filters and gaseous air cleaners.

Problem:

What is the problem? Poor indoor air quality impacts large numbers of building occupants and results in significant costs due to healthcare expenses, sick leave and lost productivity. The Institute of Medicine 2000 report on asthma and indoor air notes that close to 20 million Americans suffer from asthma and concludes that there is a causal relationship between indoor pollutant exposures and asthma.[1] Fisk (2002)[2] estimates IAQ improvements could reduce U.S. healthcare costs by $6 to $14 billion from reductions in colds and influenza, $1 to $4 billion from reductions in symptoms of allergy and asthma, and $10 to $30 billion from reductions in sick building syndrome symptoms. Several strategies exist to reduce these exposures and the associated costs, with filtration and air cleaning being a key strategy with lower energy impacts than increasing outdoor air ventilation rates. EPA specifically cited the need for standards to evaluate the efficacy and reliability of air cleaning technologies in the 2001 Healthy Buildings, Healthy People report, [3] as well as their subsequent report on indoor environment research needs.[4] The residential air cleaner market is estimated to be over $500 million per year and increasing[5], however neither measurement techniques nor rating standards currently exist to evaluate gaseous contaminant removal or to rate the high performance particle filters that are entering the market.

Why is it hard to solve? Gaseous air cleaner testing is very difficult due to the wide range of chemical contaminants of interest and the variation in removal rates among these different chemicals for the same piece of air cleaning equipment and the need to measure very low contaminant concentrations. It is difficult to maintain stable environmental conditions (primarily

[1] Institute of Medicine. 2000. Clearing the Air: Asthma and Indoor Air Exposures.
[2] Fisk, W.J. 2002. How IEQ Affects Health, Productivity. ASHRAE Journal 44 (5): 56-60.
[3] EPA. 2001. Healthy Buildings, Healthy People: A Vision for the 21st Century. U.S. EPA 402-K-01-003.
[4] EPA. 2005. Program Needs for Indoor Environments Research (PNIER), U.S. EPA, 402-B-05-001.
[5] USMS Measurement Need (2006). "Gaseous Air Cleaners" MECE 03.

temperature and humidity) at the high airflow rates and the lengthy test durations that are required to test many of these devices. These technical issues have prevented the development of accepted test methods for these devices. While a standard test method exists for particle filtration (ASHRAE Standard 52.2 for in-duct filters and AHAM AC-1 for portable units), new portable filtration devices with very high efficiency are now being developed for which the existing AHAM standard is inadequate.

How is it solved today, and by whom? The measurement science needed to evaluate high-efficiency filters and gaseous air cleaners does not currently exist. There is research being conducted on air cleaner performance at various academic institutions, including Syracuse and Penn State Universities, but these efforts have not yet produced the required test methods. The National Center for Energy Management and Building Technologies is also pursuing an air cleaning research program, with which NIST researchers have been involved, but this research effort is focused on performance issues and new technologies more than the test methods needed by industry. Previous NIST research has made important progress on field and laboratory test methods, and this project will build on this previous work.

Why NIST? This project supports BFRL's Measurement Science for Net Zero Energy, High Performance Buildings given the potential for reducing ventilation rates and the associated energy use through the application of air cleaning technologies. Validated test methods will also promote innovation and competitiveness for the air cleaning industry. NIST has test facilities specifically designed for air cleaner testing, including the three-bedroom indoor environment test house and the IAQ Test Chamber in Building 226. Previous projects in BFRL have established the required measurement capabilities including gaseous and particle concentration measurement, as well as measurement of the associated airflow and environmental conditions. This previous work on air cleaner performance has also involved the development of test methods and metrics, as well as modeling approaches to analyze the relevant performance issues.

Approach:

What is the new technical idea? While research-level protocols exist to test portable gaseous air cleaners, they need to be converted to test procedures that can be used by industry and commercial testing laboratories. Through a series of tests in the highly controlled environmental chamber at NIST, the required test conditions and factors influencing the results will be identified and defined, along with the achievable levels of experimental uncertainty. Appropriate and more practical test procedures for evaluating gaseous air cleaners will be developed by working with manufacturers through AHAM to understand their performance concerns and using our established technical experience with air cleaner testing. In order to test the newer, high efficiency particle filtration devices, enhancements to existing test procedures will be explored, including more accurate particle counters, updated facility criteria and more exacting control of chamber environmental conditions. Alternative mass balance analysis procedures will also be considered to extend the measurable efficiency ranges. Building IAQ modeling will be employed in order to provide an understanding of the impact of these devices on occupant exposure to demonstrate the value and validity of the performance metrics. This work will also explore the ability of these particle filtration devices to remove nanoparticles from the indoor environment.

Why can we succeed now? The air cleaner manufacturing industry needs test procedures to support product claims and to level the playing field among the various technologies being offered on the market. BFRL is well positioned to make important contributions based on our existing industry relationships, including our collaboration with AHAM, our unique experimental capabilities and facilities, and our prior studies of filtration and air cleaning. In addition, new measurement technologies for airborne gaseous and particulate contaminants will be key to the success of these efforts.

What is the research plan? This project will build on work done in prior years to instrument the IAQ Test Chamber in Building 226 and develop test protocols for air cleaner testing. The key efforts to be pursued will be the development of a full-scale chamber method to determine the removal efficiencies of gaseous air cleaning devices, the development of test procedures capable of assessing the performance of high efficiency particle air cleaners, and modeling analysis to relate air cleaner performance as measured in the laboratory to contaminant exposure reductions with devices installed in actual occupied environments.

The focus will be on the first two efforts, test methods for gaseous air cleaners and high-efficiency particle filtration devices. The gaseous air cleaner work, starting with the procedures developed during FY08, will include a series of tests to explore air cleaner performance as a function of device type and configuration, contaminant type and challenge concentration, environmental parameters (e.g. temperature, humidity and mixing conditions), and other factors identified in discussion with manufacturers through AHAM. The purpose of these tests will be to determine the repeatability of the test results and the impact of various test parameters in determining the relevant performance metrics. These results will provide important information on test conditions and achievable levels of accuracy to support test methods for industry review and consideration in their efforts to develop a standard test method through AHAM.

The development of a test procedure for high-efficiency particle filtration devices will start with the existing AHAM standard (AC-1) and explore options for increasing the range of efficiencies through the use of new particle measurement technology, alterative data analysis approaches based on more complete mass balance considerations and more rigorous specifications of chamber environmental conditions. Working with the relevant AHAM committee, the feasibility of these various options will be explored and a revision to the existing standard will be pursued.

In order to assess the impact of these filtration and gaseous air cleaning devices on indoor air quality, modeling analyses will be performed to relate the measured performance to the exposure reductions expected in realistic indoor occupancies. The scenarios to be modeled will be defined, which will include building types and characteristics, contaminants and their source strengths, and device installation and operation parameters. At the end of this project, manufacturers and purchasers will be better able to evaluate filter and air cleaner performance, resulting in more sound design and purchasing decisions.

Recent Results:

Output: Howard-Reed, C., Henzel, V., Nabinger, S.J., Persily, A.K. 2008. Development of a Field Test Method to Evaluate Gaseous Air Cleaner Performance in a Multizone Building, *Journal of the Air & Waste Management Association*.

Output: Howard-Reed, C., Nabinger, S.J., Emmerich, S.J. 2008. Characterizing Gaseous Air Cleaner Performance in the Field. *Building and Environment*, 43(3), pp 368-377.

Standards and Codes: This project will provide validated test methods and data to support the development and revision of AHAM filtration and air cleaner testing standards. This work is also relevant to standards development activities within ASHRAE and ASTM.