2009 BFRL Project Description

Project Title: Emissions Testing Standards for Volatile Organic Compounds

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BFRL Program: Healthy and Sustainable Buildings

Objective: To improve the reliability of measuring volatile organic compound (VOC) emissions from indoor materials and products through the development of measurement science that will be made available to manufacturers and commercial test laboratories.

Problem:

What is the problem? Low-emitting building materials are a key component of sustainable building programs due to their potential to reduce occupant exposure to harmful volatile organic compounds (VOCs) that can cause illness, reduce productivity and increase building ventilation (energy) requirements. As sustainable product labeling programs expand and more government agencies require procurement of environmentally preferable products, the market for low-emitting products is growing rapidly. However, problems arise because the associated product testing to label products as low-emitting is not yet supported by reliable measurement science. Interlaboratory comparisons performed to date have shown coefficients of variation between measured emission rates on the order of 50 % and as large as 300 %.[1] The need for reliable product emissions testing has been specified in a number of documents including the "National Green Building Research Agenda" written by leading academic and industry researchers;[2] EPA's vision statement to improve building indoor environmental quality;[3] and a USMS Measurement Need authenticated by ASTM, EPA and Steelcase.[4] Technical barriers to solving this problem include the lack of consensus standard test methods, standard reference materials and laboratory proficiency testing.

Why is it hard to solve? VOC emissions from building materials are typically measured in small stainless steel chambers operated at specific environmental conditions over periods of days to weeks. These measurements include many technical challenges and sources of uncertainty related to material sample selection and preparation; test chamber operation; gas-phase sampling

[1] Howard-Reed, C., and S.J. Nabinger (2006). Developing a standard reference material for VOC emissions testing. Proceedings of the IEQ: Problems, Research and Solutions Conference, EPA/AWMA, Research Triangle Park, NC, July 2006.
[2] U.S. Green Building Council Research Committee (2008). A National Green Building Research Agenda.
[3] U.S. Environmental Protection Agency (2001). Healthy Buildings, Healthy People: A Vision for the 21st Century, EPA 402-K-01-003.
[4] USMS Measurement Need (2007). Low VOC Emitting ("Green") Building Materials and Products.

and storage; and gas sample analysis. Also, there are no reference materials available to calibrate the different laboratory testing facilities. Previous efforts to develop reference materials have encountered difficulties due to non-homogeneities in material structures, changes in emission rates over time and concerns about shelf-life as emissions are an inherently transient phenomenon. In addition, no organization has provided the leadership and coordination to improve the measurement science. As a result, multiple non-standardized test procedures and labeling criteria have emerged to meet the market demand for low emitting products.

How is it solved today, and by whom? The measurement science does not exist to support emission rate measurements among laboratories throughout the world. ASTM[5] and European organizations[6] have produced emissions testing guides that include method validation checks, e.g., chamber air mixing, mass recovery and air sampling efficiency, but none are standardized or cover all the steps in the process. NIST has exerted leadership to improve the measurement science and is partnering with Virginia Tech to develop polymer films loaded with VOCs to serve as reference materials. Dr. Yinping Zhang, Deputy Director of the Institute of Built Environment of Tshingua University in China, has also started a research program to develop reference materials using porous materials, and NIST is seeking opportunities to collaborate with him.

Why NIST? Using low VOC emitting materials in buildings is a key strategy for reducing building ventilation (energy) requirements while improving occupant health and productivity. Thus, the development of reference materials and innovative test methods to reliably measure material emission rates are critical tools for meeting the objectives of Net Zero, High-Performance Buildings. This project also fits BFRL's mission by building consensus and confidence in emissions testing results, which will benefit a range of stakeholders in the building industry: manufacturers of low-emitting products; commercial product test laboratories who need a "level playing field" for competitiveness; designers who need reliable emissions data; federal and state agencies who are promoting good IAQ through VOC emissions reductions; and building owners who wish to provide improved indoor environments for building occupants.

Approach:

What is the new technical idea? To meet the immediate need for more reliable emissions testing, BFRL will develop reference materials that have a known VOC emissions profile. It is possible to dissolve a known amount of VOCs in a polymer film using supercritical carbon dioxide in a pressure vessel. The emission rate of the loaded "film" can be measured in a traditional chamber test, as well as independently verified by measuring key material properties and predicting the emission rate with a fundamental mass-transfer model.

Due to the complexity and cost of chamber testing, BFRL will build upon the reference material measurement science to develop innovative methods to characterize material emissions that are simpler, more cost-efficient, and more reliable than current methods. These new methods will derive from the approaches to measuring the reference polymer film properties, including

[5] ASTM (2006). Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products. D5116-06. ASTM International

[6] ECA (1991). Guideline for the Characterization of VOCs Emitted from Indoor Materials and Products using Small Test Chambers, Report No. 8. European Concerted Action IAQ & Its Impact on Man (EUR 13593).

measurement of the initial VOC concentration in the material (C_0), the material diffusion coefficient (D), and the material/air partition coefficient (K). These parameters can be determined for any building material using VOC extraction and gas chromatography to measure C_0; and sorption/desorption cycles with a microbalance to measure D and K. Adding this information to the validated predictive emissions model will provide the emission potential of the material and ultimately eliminate the need for extensive chamber testing. Material property methods could also lead to more informative product labels for consumers that contain information not only about what chemicals are emitted and how much, but also how long VOCs are emitted after materials are installed.

Why can we succeed now? The rapidly growing market for low-emitting products is creating pressure to improve and harmonize current emissions testing and labeling procedures. Several agencies and institutions are forming working groups to move toward more reliable product test methods including one formed by NIST, EPA, and Virginia Tech. In the spirit of international coordination, BFRL has the opportunity to bring on guest researchers with material emissions expertise from the VTT Research Centre in Finland and Tsinghua University in China. In addition, Dr. Yinping Zhang is interested in collaborating with BFRL on emissions research to address issues with China's growing market of low-emitting materials. Technical success is more likely today due to recent advancements in material emissions modeling capabilities that provide a way to independently determine material emissions.

What is the research plan? To improve the reliability of product emissions testing, BFRL is pursuing a multiyear project to address technical barriers associated with emissions testing. The project's primary focus has been on developing reference materials with independently known emission rates. In FY07, BFRL began working with Virginia Tech to develop a prototype reference material based on the ability to load a simple polymer with VOCs using supercritical carbon dioxide (CO_2). This loaded polymer has an emission profile similar to a typical "dry" building material (e.g., vinyl flooring). By measuring various material properties (C_0, D, and K), it is possible to independently determine its emission rate, making it a good candidate for a reference material. In FY08, BFRL used its stainless steel chambers to characterize the emission properties of the reference material and develop an associated test method to calibrate emissions test chambers.

BFRL will focus its efforts on developing the capability to produce these reference materials. To date, small samples of the candidate material have been produced at Virginia Tech (under a grant funded by BFRL) and tested at BFRL. In order to support eventual SRM development, NIST needs to develop an in-house capability to produce these materials in larger sizes than can be done by Virginia Tech. This in-house capability may be based on the supercritical CO_2 approach being used at Virginia Tech, but other options will be explored as well. If a CO_2 system is determined to be more appropriate, it will be designed and installed working with Virginia Tech and BFRL's HVAC&R Equipment Performance Group, who have considerable experience with high pressure CO_2 systems. Before the system is assembled and installed, a detailed risk assessment will be conducted to identify any safety concerns, which will then be addressed prior to the installation. The overall effort will be further supported through the involvement of guest researchers with considerable material emissions expertise. At the end of FY09, BFRL intends to request Service Development (SD) funds to help finish the pre-

production phase. As part of this phase, BFRL will conduct interlaboratory comparisons with the reference material to evaluate the emission measurement uncertainty. The following fiscal year, BFRL will request Working Capital Funds (WCF) to help finance the production phase of the reference material. A reference emissions material will be part of the Measurement Services inventory within three years of receiving WCF.

A second project priority will be to assume a leadership role among the industry groups, federal agencies and standards development organizations involved in emissions testing. In FY08, BFRL met with Virginia Tech and EPA to discuss the formation of a working group to develop cost-efficient, more reliable and meaningful source characterization test methods that are international in scope and acceptance. The working group will be expanded with potential formation of a manufacturer consortium.

Recent Results:

4/07: Output: NIST/ASTM workshop on the reliability of product emissions testing.

10/07: Output: Peer-reviewed conference paper. Howard-Reed, Little, Marand Cox, Nabinger and Persily, Improving the Reliability of VOC Emissions Testing of Building Products, ASHRAE IAQ 2007, Baltimore.

8/08: Output: Peer-reviewed conference paper. Howard-Reed, Nabinger and Persily, Assessing the uncertainty associated with product emission measurements, Indoor Air 2008, Copenhagen.

8/08: Output: Peer-reviewed conference paper. Cox, Little and Marand, Developing a Standard Reference VOC Emissions Source, Indoor Air 2008, Copenhagen.

2006-2008: Grant to Virginia Tech to produce reference materials.

2007: Authenticated USMS measurement need.

2008: Formation of working group to discuss and plan emissions testing research, labeling programs and standards with ASTM, EPA and international organizations.

2008: Draft of ASTM practice to assess the uncertainty associated with chamber emissions testing (2008).

2008: Development of a state-of-the art product emissions chamber testing facility in BFRL.

Standards and Codes: Project results will provide technical input to the development of material emissions standards in ASTM Subcommittee D22.05 on Indoor Air as well as private sector product labeling programs. The project PI, Cindy Reed, is secretary of ASTM D22.05 and the subcommittee's Indoor Emissions Section Chair. Andy Persily is vice-chair of this subcommittee, and Steve Nabinger is a member.