1791 Tullie Circle NE ▪ Atlanta, Georgia 30329-2305 ▪ Tel 678.539.1211 ▪ Fax 678.539.2211 ▪ http://www.ashrae.org

Michael R. Vaughn, P.E.
Manager
Research & Technical Services

mvaughn@ashrae.org

TO: Paula Levasseur, Chair TC 2.3, paulajlevasseur@gmail.com
Kathleen Owen, Research Subcommittee Chair TC 2.3, kathleenowen@att.net
Pawel Wargocki, Research Liaison 2.0, paw@byg.dtu.dk

FROM: Michael Vaughn, MORTS, mvaughn@ashrae.org

DATE: November 1, 2018

SUBJECT: Research Topic Acceptance Request (1858-RTAR), "Evaluation of HVAC ventilation effectiveness in reducing semi-volatile organic compounds (SVOCs) in indoor spaces"

During their fall meeting, the Research Administration Committee (RAC) reviewed the subject Research Topic Acceptance Request (RTAR) and voted 5-0-0 to reject it. The following list summarizes the consensus review comments and questions on this RTAR:

1. Define better the objectives of the research project.
2. Consider splitting the project so that the objectives are more aligned, the duration is shorter and the budget is lower.
3. The RTAR should state how much percentage of human intake of SVOC through respiration, and also should state how much percentage of fine particles other than gaseous SVOC.
4. The objectives should be in some way be "measurable" and more specific.

By rejecting this RTAR, RAC is strongly suggesting to the TC that this particular topic be dropped from the TC research plan based on the information that has been provided.

An RTAR evaluation sheet is attached as additional information and it provides a breakdown of comments and questions from individual RAC members based on specific review criteria. This should give you an idea of how your RTAR is being interpreted and understood by others.

If the TC wishes to pursue this topic further, please incorporate the above information into the RTAR with the help of your Research Liaison, Pawel Wargocki, RL2@ashrae.net, prior to submitting it to the Manager of Research and Technical Services for further consideration by RAC. In addition, a separate document providing a point by point response to each of these comments and questions must be submitted with the RTAR. The response to each item should explain how the RTAR has been revised to address the comment, or a justification for why the Technical Committee feels a revision is unnecessary or inappropriate. The RTAR and response to these comments and questions must be approved by the Research Liaison prior to submitting it to RAC.

The next realistic submission deadline for RTARs and WSs is May 15, 2019 for consideration at the Society's 2019 annual meeting. The submission deadline after that is August 15, 2019 for the RAC fall meeting.

Project ID	**1858**	
Project Title	**Evaluation of HVAC ventilation effectiveness in reducing semi-volatile organic compounds (SVOCs) in indoor spaces**	
Sponsoring TC	TC 2.3, Gaseous Air Contaminants and Gas Contaminant Removal Equipment	
Cost / Duration	$250,000 / 30 Months	
Submission History	**1st Submission**	
Classification: Research or Technology Transfer	Basic/Applied Research	
RAC 2018 Fall Meeting Review		
Essential Criteria	**Voted NO**	**Comments & Suggestions**
Background: The RTAR should describe current state of the art with some level of literature review that documents the importance/magnitude of a problem. References should be provided. If not, then note it in your comments.		**2** - Gaseous SVOC is easy to be adsorbed at solid surface. It is well known that the human intake of SVOC is not by gaseous matter but by SVOC adsorbed fine particles or through the skin. The RTAR does not mention this important features which may be important to access the total SVOC intake. **4** - Too little on the methods to control SVOCs and reduce their levels indoors and the previous research on the effectiveness of ventilation in reducing SVOC levels. **9** - Well-explained, problem and its magnitude, and with references cited. **10** - Not all statements in the background are supported by references (e.g. health effects of SVOCs). **12 -** I don't think internal building temperatures are going to change in response to global warming. People will maintain the same thermal comfort.
Research Need: Based on the background provided is the need for additional research clearly identified? If not, then the RTAR should be rejected.		**9** - Highlights that different types of pollutants concentrations are removed with varying effectiveness by ventilation, hence situation is unclear and needs research. **10** - Specify whether the different behavior between VOCs and SVOCs was ascertained by repeatable experiments. **12** - This seems like a sophomore thermo conservation of mass problem-> inflow, accumulation, and outflow species balance. **8** - is there other references for SVOC and ventilation rates in the research?
Relevance and Benefits to ASHRAE: Evaluate whether relevance and benefits are clearly explained in terms of: a. Leading to innovations in the field of HVAC & Refrigeration b. Valuable addition to the missing information which will lead to new design guidelines and valuable modifications to handbooks and standards. Is this research topic appropriate for ASHRAE funding? If not, Reject.		**9** - Very relevant to ASHRAE via provision and maintenance of good indoor air quality. Can affect ventilation, filtration and air distribution aspects. Wouldn't Std 62 benefit as well? This is not mentioned. **8.** - This is an expensive and very challenging project that may require further refinement of the relevance and benefits.
IF ABOVE THREE CRITERION ARE NOT ALL SATISFIED - MARK "REJECT" BELOW & CONTINUE REVIEW BELOW		
Other Criteria	**Voted NO**	**Comments & Suggestions**
Project Objectives: Based on the background and need, evaluate whether the project objectives are: 1. Aligned with the need 2. Specific 3. Clear without ambiguity 4. Achievable If not, then appropriate feedback should be provided.		**4** - In case experiments show that that ventilation is not effective there will be no need to develop models, **9** - Clear and achievable…chamber and modelling. **10** - Not clear the benefit of objectives 1) and 2) in the same project. The objectives should be in some way "measurable" and more specific. Objective 4) should be revised to indicate clearly what the following sentence means: "evaluate the important factors and ventilation strategies which affect the concentration and dynamics of SVOCs in indoor environments". What is the result of such evaluation?
Expected Approach and Budget: Is there an adequate description of the approach in order for RAC to be able to evaluate the appropriateness of the budget? If not, then the RTAR should be returned for revision. Anticipated funding level and duration:		**4** - Too expensive. **7** - The budget seems high for the benefit. Perhaps the project should be scaled down to include only a few of the more important SVOCs. The project could then be expanded to include other SVOCs. **9**- Clear sensible and achievable. The budget is $250k, which is a little high, with $100k for chamber work. Does this cover purchase or construction of chambers, or will these need to be in place already? **10 -** The duration of the project is rather long (30 months) and the budget is justified by the time each objective will take. The project could be probably split so that the duration of each separate project could be shorter and the budget more manageable.
References: Are the references provided?		**10** - Some more references are needed. They should elucidate the health effects of SVOCs and demonstrate the high concentrations of SVOCs present in indoor environments.
Decision Options	**Initial Decision?**	**Final Approval Conditions**
ACCEPT AS-IS		**2**- The RTAR should state how much percentage of human intake of SVOC through respiration. And also should state how much percentage of fine particles other than gaseous SVOC. **4** -The RTAR should be split into 2 parts. The current version should focus on experiments in chambers and rooms. **7** - The budget seems high for the benefit. Perhaps the project should be scaled down to include only a few of the more important SVOCs. The project could then be expanded to include other SVOCs. We need a full explanation for the negative votes on SSPC 62.2. **9** - Good project, just clarify the budget in more detail…refer to comments above. **10**- Define better the objectives of the research project. Consider splitting the project so that the objectives are more aligned, the duration is shorter and the budget is lower. Include references to support some of the statements in the proposal. **12**- RTAR1868 from SPC62.2 i probably has a better chance of success. Suggest TC 2.3 join that effort. **8** - I like the project but need further refinements.
ACCEPT W/COMMENTS		
REJECT		

ACCEPT Vote - Topic is ready for development into a work statement (WS).
ACCEPT W/COMMENTS Vote - Minor Revision Required - RL can approve RTAR for development into WS without going back to RAC once TC satisfies RAC's approval condition(s)
REJECT Vote - Topic is not acceptable for the ASHRAE Research Program

Research Topic Acceptance Request Cover Sheet

Date: 07/17/2018

(Please Check to Insure the Following Information is in the Work Statement)

- A. Title ☑
- B. Applicability to ASHRAE Research Strategic Plan ☑
- C. Application of the Results ☑
- D. State-of-the-Art (background) ☑
- E. Advancement to State-of-the-Art ☑
- F. Justification and Value to ASHRAE ☑
- G. Objective ☑
- H. Estimated Duration ☑
- I. References ☑

Title:
Evaluation of HVAC ventilation effectiveness in reducing semi-volatile organic compounds (SVOCs) in indoor spaces

RTAR# 1858
(To be assigned by MORTS)

Results of this Project will affect the following Handbook Chapters, Special Publications, etc.:

Handbook HVAC Applications Chapter 46. Air Cleaners for Gaseous Contaminants

Responsible TC/TG: TC 2.3

Date of Vote: 6/26/18

For		10
Against	*	0
Abstaining	*	1
Absent or not returning Ballot	*	5
Total Voting Members		16

Co-sponsoring TC/TG/MTG/SSPCs (give vote and date):

62.2: 16-3-2-3-24 (7/14/18)

RTAR Lead Author: Sanjeev Hingorani

Expected Work Statement Lead Author: Sanjeev Hingorani

Potential Co-funders (organization, contact person information):

Research Classification:

- ☑ Basic/Applied Research
- ☐ Advanced Concepts
- ☐ Technology Transfer

	Yes	No
Has an electronic copy been furnished to the MORTS?	✔	
Has the Research Liaison reviewed the RTAR?	✔	

* Reasons for negative vote(s) and abstentions

2.3 Abstain is CNV; 5 absent in Houston
62.2 neg vote comments: Since TC 2.3 is the sponsoring Committee and doesn't necessarily need co-sponsors to present the RTAR to RAC, I don't see the benefit to 62.2. As the RTAR is currently designed, the main foci are on modeling and lab generated data. It is my opinion that any res

DRAFT RTAR Template

Title: Evaluation of HVAC ventilation effectiveness in reducing semi-volatile organic compounds (SVOCs) in indoor spaces

Summary

Describe in summary form the proposed research topic, including what is proposed, why this research is important, how it will be conducted, and why ASHRAE should fund it (50 words maximum)

Indoor air quality (IAQ) is the most important aspect of ASHRAE's fundamental obligation to strive to provide indoor environments that are safe, healthy, productive, and comfortable while conserving resources (Bahnfleth 2013). Indoor SVOCs are emerging as an important IAQ research topic, but the topic has not received much attention within the ASHRAE community (Xu and Zhang 2011). This ASHRAE research project will explicitly elucidate the effectiveness of HVAC ventilation in reducing indoor SVOCs through systematic chamber studies and numerical modeling. The research is directly applicable to Goals 1, 4, and 7 of the ASHRAE Research Strategic Plan 2010-2018.

Background

Provide the state of the art with key references (at the end of this document) substantiating it (300 words maximum)

Semi-volatile organic compounds (SVOCs), such as phthalate plasticizers, flame retardants, and biocides, that are extensively used in building materials and consumer products, are emerging as an important class of indoor pollutants (Morrison et al. 2016; Nazaroff et a. 2011; Weschler and Nazaroff 2008; Weschler et al. 2015). They are ubiquitous indoors with concentrations orders of magnitude higher than outside, and persist for years even after the primary source is removed. As a result, indoor concentrations and the exposure of building occupants to SVOCs have increased and remain high in recent decades. For example, polybrominated diphenyl ethers (PBDEs) levels in indoor environments, biota and people in the U.S. have doubled every 2-4 years since the 1970s and are 10-100 times higher than concentrations in Europe. Indeed, the problem is likely to get even worse with internal temperature increase in buildings as a response to climate change, because emissions of SVOCs can increase by about 10-fold with even a temperature rise of several degrees Celsius (Liang and Xu 2014). There are serious adverse health effects associated with SVOCs, such as permanent impairments of male reproductive system, neurodevelopment and behavioral problems ranging from autism to attention deficit disorder, and allergic symptoms and asthma in children. To provide safe, healthy and productive indoor environments, a complete scientific understanding of the effectiveness of building heating, ventilation, and air conditioning (HVAC) systems in reducing indoor SVOCs has become a high priority for research.

Research Need

Use the state of the art described above as a basis to specify the need for the proposed effort (250 words maximum)

Ventilation has been used to remove pollutants and to improve indoor air quality; however, its effect on SVOCs has not nearly been as widely studied as certain other classes of indoor pollutants, such as volatile organic compounds (VOCs) and inorganic gaseous pollutants. Previous study in a small chamber showed that the decreased gas-phase concentration of di-2-ethylhexyl phthalate (DEHP) caused by the increased air exchange was almost compensated by the increased emission rate (Liang and Xu 2015), suggesting that ventilation may not be effective in removing SVOCs. Using a numerical model, Liu et al. (2015) found that when air exchange rate increases from 0.6/h to 1.8/h, the steady-state indoor SVOC concentration decreases by about 60%; while for the same change in ventilation, the simulated indoor formaldehyde (representing VOCs) gas-phase concentration decreases by about 70%. Recently, in the project of Ventilation and Indoor Air Quality in Retail Stores (ASHRAE RP-1596), it was found that the concentrations of phthalates slightly increased, while PBDEs were greatly reduced, with an increase of air change rate (Xu et al. 2014). Therefore, due to the significant differences between SVOCs and other indoor pollutants, the effectiveness of ventilation and air distribution systems in removing SVOCs remains unclear.

Project Objectives

Based on the identified research need(s), specify the objectives of the solicited effort that will address all or part of these needs (150 words maximum)

The main goal of the current project is to evaluate the effectiveness of ventilation on indoor SVOC pollutants under different air temperature and humidity conditions typical for indoor environments. It will serve as a start point of SVOC research in ASHRAE. It will provide a solid foundation for future research, such as study of SVOC removal efficiencies of HVAC particle filters, source control (i.e., removal of the source, avoiding the source, and local removal through exhaust or other means), new technologies of air cleaning and their effects on SVOCs.

The project will target on the classes of SVOC contaminants that are extensively used in building materials and consumer products, ubiquitous in indoor environments, and have serious health concerns. Examples are phthalates and flame retardants.

The research objectives are to: 1) determine the influence of ventilation rate on emissions and concentrations of target SVOCs in small chambers under a range of air temperature and relative humidity conditions; 2) conduct a series of controlled tests in a large-scale chamber to further explore the influence and interactions among these environmental parameters and full-scale room airflow pattern and distribution conditions; 3) develop a numeric model to simulate indoor concentrations of SVOCs with HVAC system operation and environmental parameter changes; and 4) apply the models and knowledge obtained from the laboratory to evaluate the important factors and ventilation strategies which affect the concentration and dynamics of SVOCs in indoor environments.

Expected Approach

Describe in a manner that may be used for assessment of project viability, cost, and duration, the approach that is expected to achieve the proposed objectives (200 words maximum).

Check all that apply: Lab testing ☑, Computations ☑, Surveys ☐, Field tests ☐, Analyses and modeling ☑, Validation efforts ☐, Other (specify) ( )

A range of typical plasticizers and flame retardants as well as their new alternatives should be studied in this project. The target compounds may include (but should not be limited to) di-iso-butyl-phthalate (DiBP), di-n-butyl-phthalate (DnBP), butyl-benzyl-phthalate (BBP), di-(2-ethylhexyl)-phthalate (DEHP), di-iso-nonyl-phthalate (DINP), di(2-ethylhexyl) adipate (DEHA), diisononyl cyclohexane-1,2-dicarboxylate (DINCH), tris(2-chloroethyl) phosphate (TCEP), tris(1-chloro-2-propyl) phosphate (TCPP), tris(1,3-dichloroisopropyl) phosphate (TDCPP), triphenyl phosphate (TPP), brominated diphenyl ethers (BDE)-47, BDE-99, BDE-153, BDE-183, or BDE-209, emitted from selected building materials and/or consumer products.
Small-scale stainless steel chamber need to be employed to investigate the influence of ventilation rate, temperature, and humidity on emissions and concentrations of target SVOCs. Strictly controlled tests in a large-scale chamber, which represents typical indoor spaces, should also be conducted to further explore the influence and interactions among these environmental parameters. To better predict the influence of HVAC operation on indoor SVOCs, a numerical model to simulate SVOC concentrations should be developed. A parametric analysis should then be conducted to explore the role of ventilation rate, environmental parameters, and ventilation strategy on the indoor SVOCs. Objective 1 & 2 project time estimation is approximately 1 year each with a cost of $100,000 each. Objective 3 & 4 would be done in 6-8 month at a cost of $50,000.

Relevance and Benefits to ASHRAE

Describe why this effort is of specific interest to ASHRAE, its impact, and how it will benefit ASHRAE and the society. How does it align with ASHRAE Strategic Plans and Initiatives? How does it advance the state of the art in this area in general? Are there other stakeholders that should be approached to obtain relevant information or co-funding? (350 words maximum)

The indoor levels of SVOCs is emerging as a very important research topic, but SVOCs have not been as widely studied as other classes of indoor pollutants, such as VOCs and airborne particles, due in part to the high degree of analytical challenges in measuring SVOCs (Weschler and Nazaroff 2008). Based on a clear understanding of emissions and transport of indoor SVOCs, this project will investigate the role of ventilation dilution and other environmental parameters in reducing SVOCs in indoor spaces. The results will provide important data to ASHRAE, its members and other relevant organizations in setting future guidelines. The research proposed is directly applicable to Goals 1, 4, and 7 of the ASHRAE Research Strategic Plan 2010-2018, which are Goal 1:Maximize the actual operational energy performance of buildings and facilities Goal 4: Significantly advance our understanding of the impact of indoor environmental quality (IEQ) on work performance, health symptoms and perceived environmental quality in offices, providing a basis for improvements in ASHRAE standards, guidelines, HVAC&R designs and operation practices & Goal 7: Support development of tools, procedures and methods suitable for designing low-energy buildings.

This project will serve as a start point of SVOC research in ASHRAE. It will provide a solid foundation for future research, such as study of SVOC removal efficiencies of HVAC particle filters, source control (i.e., removal of the source, avoiding the source, and local removal through exhaust or other means), new technologies of air cleaning and their effects on SVOCs.

Extensive reviews of the toxicology of SVOCs have revealed their endocrine disrupting tendencies and their teratogenic, carcinogenic, genotoxic and neurotoxic effects. Substantial health and productivity gains (billions of dollars) stand to be realized by reducing the indoor SVOCs exposures. Engineering control (ventilation, filtration and air distribution) may have a very significant impact on the occurrence, fate and transport of SVOCs. Thus, the social benefits of this research can be tremendous.
The outcome of this work will significant advance our understanding of the influence of HVAC systems on indoor SVOCs, provide important data for setting appropriate standards and define research needs to meet the ASHRAE's mission, which is: "To advance the arts and sciences of HVAC&R to serve humanity and promote sustainable world."

Anticipated Funding Level and Duration

Funding Amount Range: $250,000

Duration in Months: 30

References

List the key references cited in this RTAR

Bahnfleth, W.P. (2013) Presidential Address Shaping the Next. ASHRAE Journal 55, 50-58.
Liang, Y., Xu, Y. (2014). Emission of phthalates and phthalate alternatives from vinyl flooring and crib mattress covers: The influence of temperature. Environmental Science & Technology, 48 (24), 14228-14237.
Liang, Y., Xu, Y. (2015). The Influences of surface sorption and air flow rate on emission of phthalates from vinyl flooring: Measurement and modeling. Atmospheric Environment, 103, 147-155.
Liu, C., Zhang, Y., Benning, J. L., and Little, J. C. (2015). The effect of ventilation on indoor exposure to semi volatile organic compounds. Indoor air, 25(3), 285-296.
Morrison, G. C., Weschler, C. J., Bekö, G., Koch, H. M., Salthammer, T., Schripp, T. and Clausen, G. (2016). Role of clothing in both accelerating and impeding dermal absorption of airborne SVOCs. Journal of Exposure Science and Environmental Epidemiology, 26 (1), 113-118.
Narzaroff, W. W.; Little, J. C.; Weschler, C. J. (2011). “SVOCs in Indoor Environments — Research Priorities.” SVOC exposure workshop at Indoor Air 2011, Austin, TX.
Weschler, C. J., Bekö, G., Koch, H. M., Salthammer, T., Schripp, T., Toftum, J., and Clausen, G. (2015). Transdermal uptake of diethyl phthalate and di (n-butyl) phthalate directly from air: experimental verification. Environmental Health Perspectives (Online), 123(10), 928.
Weschler, C. J., and Nazaroff, W. W. (2008). "Semivolatile organic compounds in indoor environments." Atmospheric Environment, 42 (40), 9018-9040.
Xu, Y., Zhang, J.S. (2011) Understanding SVOCs. ASHRAE Journal 53, 121-125.
Xu, Y., Liang, Y., Urquidi, J., Siegel, J. (2014). Phthalates and polybrominated diphenyl ethers in retail stores. Atmospheric Environment, 87, 53-64.