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TO: Paula Levasseur, TC Chair 2.3, paulajlevasseur@gmail.com
Kathleen Owen, Research Subcommittee Chair 2.3, kathleenowen@att.net

FROM: Michael R. Vaughn, Manager of Research and Technical Services, MORTS@ashrae.net

CC: Pawel Wargocki, Research Liaison 2.0, RL2@ashrae.net
Kevin Kwong, Tony Abate, Nick Agopian, Tandeep Chadha, Ashish Mathur, Kartik Potukuchi, Jeff Rosberry, Work Statement Author(s), kevin@lmstechnology.com; nick.agopian@outlook.com; jeffr@promarkassociates.com; smason@greenelephantconsult.com; tchadha@appliedparticletechnology.com; tabate@atmosair.com

DATE: January 23, 2019

SUBJECT: Work Statement (1838-WS), "Inclusion of Electronic Air Cleaners into ASHRAE 145.2"

During their recent winter meeting, the Research Administration Committee (RAC) reviewed the subject Work Statement (WS) and voted 11-0-0 (CNV) to conditionally accept it for bid provided that the RAC approval conditions are addressed to the satisfaction of your Research Liaison in either written responses or revisions to the work statement.

See the approval conditions below.

1. Better define objectives and tasks.
2. Criteria for the success of the work need to be better defined to assist PES in the selection of the best bid. Please make clear how the right testing methods are selected, based on which criteria.
3. Check the text for spelling errors.

The WS review summary also contains comments from individual members of RAC that the TC may or may not choose to also consider when revising the WS; some of these comments may indicate areas of the WS where readers require additional information or rewording for clarification.

Lastly, please provide ASHRAE staff with the final names and contact information for the Proposal Evaluation Subcommittee (PES) roster, and the Technical Contact that will respond to questions from prospective bidders during the bid posting period (typically this is a WS author or PES member). The technical contact and all members of the PES must also agree to not bid on this project.

Please coordinate changes to this Work Statement with your Research Liaison, Pawel Wargocki, paw@byg.dtu.dk or RL2@ashrae.net. Once he is satisfied that the approval conditions have been met, the project will be ready to bid.

The first opportunity that you will have for this project to possibly bid is spring 2019. To be eligible for this bid cycle, a revised work statement that has been approved for bid by your research liaison should be sent (electronically) to Mike Vaughn, Manager of Research and Technical Services, mvaughn@ashrae.org or morts@ashrae.net, by **March 15, 2019**. The next opportunity for bid after that will be May 15, 2019.

Project ID	**1838**	
Project Title	**Inclusion of Electronic Air Cleaners into ASHRAE 145.2**	
Sponsoring TC	TC 2.3, (Gaseous Air Contaminants and Gas Contaminant Removal Equipment)	
Cost / Duration	$35,000 to $40,000 / 6 Months	
Submission History	**1st WS Submission, RTAR Accepted F17**	
Classification: Research or Technology Transfer	Basic/Applied Research	
RAC 2019 Winter Meeting Review	**RTAR STAGE FOLLOWED**	
Check List Criteria	**Voted NO**	**Comments & Suggestions**
State-of-the-Art (Background): The WS should include some level of literature review that documents the importance/magnitude of a problem. If not, then the WS should be returned for revision. **RTAR Review Criterion**	**YES**	
Advancement to the State-of-the-Art Is there enough justification for the need of the proposed research. Will this research significantly contribute to the advancement of the State-of-the-Art. **RTAR Review Criterion**	**YES**	
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. **RTAR Review Criterion**	**YES**	
IF THE THREE CRITERIA ABOVE ARE NOT ALL SATISFIED - MARK "REJECT" BELOW BUT ADDRESS THE FOLLOWING CRITERIA AS APPROPRIATE		
	RTAR STAGE FOLLOWED	
WS Check List Criteria - START HERE		**Comments & Suggestions**
Detailed Bidders List Provided? The contact information in the bidder list should be complete so that each potential bidder can be contacted without difficulty.		**10** - 6 identified.
Proposed Project Description Correct? Are there technical errors and/or technical omissions that the WS has that prevents it from correctly describing the project? If there are, than the WS needs major revision.		
Task Breakdown Reasonable? Is the project divided into tasks that make technical and practical sense? Are the results of each task such that the results of the former naturally flow into the latter? If not, then major revisions are needed to the WS that would include: adding tasks, removing tasks, and re-structuring tasks among others.		**12**- Objectives 6,7, and 8 are not really covered under the 3 Tasks as described! **4** - Deliverables and PMS gates are adequate, but are imbedded in other sections. **5** - The task 2 and task 3 should contain further details to identify potential areas for improvement ; this WS seems weak in this area. Would like to see justification of task 2 Survey of laboratories -- is this something that is critical and needs to be done?
Adequate Intermediate Deliverables? The project should include the review of intermediate results by the PMS at logical milestone points during the project. Before project work continues, the PMS must approve the intermediate results.		
Proposed Project Doable? Can the project as described in the WS be accomplished? If difficulties exist in the project's WS that prevent a successful conclusion of the project, then the project is not doable. In this situation, major revision of the WS is needed to resolve the issues that cause the difficulty.		**5** - what is the criteria for success to finish task 3 detailing changes needed to std 145? Can you give more specific examples to the task 3 deliverables? Correct spelling reference: ASRHAE
Time and Cost Estimate Reasonable? The time duration and total cost of the project should be reasonable so that the project can be as it is described in the WS.		**12** - $40k seems quite reasonable for the kind of research required; starting with literature review and reaching out to manufacturing and research laboratories. I would also expect some travel required that has not been budgeted here. **5** - 40k seems reasonable. *Not sure if the tasks are adequately represented in the costs.*
Proposed Project Biddable? Examining the WS as a whole, is the project described in the WS of sufficient clarity and detail such a potential bidder can actually understand and develop a proposal for the project? This criterion combines the previous three criteria into an overall question concerning the usefulness of the WS. If the WS is considered to not be biddable, then either major revisions are in order or the WS should be rejected.		**12** - I think objectives 6-8 are quite important; however they were not described under the relevant tasks lists. There is a possibility to include it as part of task 2! **5** - see comments above
Decision Options	**Initial Decision**	**Final Approval Conditions**
ACCEPT		**5** - address concerns above, **13** - There are a few typos and misspelled words that should be corrected when proofreading. My only concern about this project is that if these devices are so new, there may be only anecdotal evidence or user testimonials about their efficacy. No co-funders are listed. Why not USGBC if they will benefit from the EAC test standard development? If these devices are so new, there is likely to be no valid test data available; only lay user testimonials, anecdotal reports, or manufacturer's in-house tests that cannot be checked. **10** - Well written proposal. ***5*** *- update per comments above and resubmit.*
COND. ACCEPT		
RETURN		
REJECT		

ACCEPT Vote - Work statement(WS) ready to bid as-is
CONDITIONAL ACCEPT Vote - Minor Revision Required - RL can approve WS for bid without going back to RAC once TC satisfies RAC's approval condition(s) to his/her satisfaction
RETURN Vote - WS requires major revision before it can bid
REJECT Vote - Topic is no longer considered acceptable for the ASHRAE Research Program due to duplication of work by another project or because the work statement has a fatal flaw(s) that makes it unbiddable

WORK STATEMENT COVER SHEET

Date: 7-31-2018

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

A. Title	*
B Executive Summary	*
C. Applicability to ASHRAE Research Strategic Plan	*
D. Application of the Results	*
E. State-of-the-Art (background)	*
F. Advancement to State-of-the-Art	*
G. Justification and Value to ASHRAE	*
H. Objective	*
I. Scope	*
J. Deliverables/Where Results will be Published	*
K. Level of Effort	
Project Duration in Months	*
Professional-Months: Principal Investigator	*
Professional-Months: Total	*
Estimated $ Value	*
L Proposal Evaluation Criteria & Weighting Factors	*
M. References	*
N. Other Information to Bidders (Optional)	*

Title:

Emerging gas-phase electronic filtration technologies and ASHRAE 145.2 test standard

WS# 1838

(To be assigned by MORTS - Same as RTAR #)

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

HVAC Applications Handbook, Chapter 46: Air cleaners for gaseous contaminants

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Responsible TC/TG: TC 2.3

Date of Vote: 8/9/18

For		14
Against	*	1
Abstaining	*	0
Absent or not returning Ballot	*	0
Total Voting Members		15

This W/S has been coordinated with TC/TG/SSPC (give vote and date):

SSPC 62.1: 17-0-3-2-22 8/7/18
SSPC 145: 7-0-1-1-9

Has RTAR been submitted? Yes

Strategic Plan Theme/Goals

Work Statement Authors: **

Kevin Kwong, Tony Abate, Nick Agopian, Tandeep Chadha, Ashish Mathur,

Kartik Potukuchi, Jeff Roseberry

Proposal Evaluation Subcommittee:

Chair: Kevin Kwong
Members: Tony Abate, Nick Agopian, Tandeep Chadha, Ashish Mathur, Kartik Potukuchi, Jeff Roseberry

Project Monitoring Subcommittee:
(If different from Proposal Evaluation Subcommittee)

Same as PES. Nick Agopian is the representative from SSPC 62.1.

Recommended Bidders (name, address, e-mail, tel. number): **

Concordia University (Dr. Chang-Seo Lee, chang-seo.lee@concordia.ca, 514-848-2424 ext.7016)
Owen Air Filtration Consulting (Kathleen Owen, kathleenowen@att.net, 919-656-5295)
Syracuse University (Dr. Jensen Zhang, jszhang@syr.edu, 315-443-1366)
Dean Tompkins Group (Dr. Dean Tompkins, deantompkins45@gmail.com, 847-370-4145
University of Texas – Austin (Dr. Atila Novoselac, atila@mail.utexas.edu, 512-475-8175)
Blue Heaven Technologies (Bob Burkhead, bob@blueheaventech.com, 502-819-0204

(Three qualified bidders must be recommended, not including WS authors.)

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

	Yes	No	How Long (weeks)
Is an extended bidding period needed?		X	
Has an electronic copy been furnished to the MORTS?	X		
Will this project result in a special publication?		X	
Has the Research Liaison reviewed work statement?	X		

* Reasons for negative vote(s) and abstentions

2.3 neg vote comment: did a quick read and the 3 tasks don't seem to accomplish the 8 objectives

62.1: CNV. One abstainer commented USGBC must be a co-sponsor as they are pushing for this research.
145: Abstain is CNV

** Denotes WS author is affiliated with this recommended bidder

Use additional sheet if needed.

WORK STATEMENT# 1838

Title:

Emerging gas-phase electronic filtration technologies and ASHRAE 145.2 test standard

Sponsoring TC/TG/MTG/SSPC:

TC 02.03: GASEOUS AIR CONTAMINANTS/REMOVAL EQUIPMENT

Co-Sponsoring TC/TG/MTG/SSPCs (List only TC/TG/MTG/SSPCs that have voted formal support)

SSPC 145
SSPC 62.1

Executive Summary:

Emerging electronic air cleaners (EAC) technologies and a push by the U.S. Green Building Council for an ASHRAE 145.2 test verification of EACs claiming LEED pilot-credit 68 have created a need to revisit the test methodology of ASHRAE 145.2. The title, purpose, and scope of ASHRAE Standard 145.2 was recently changed to remove the restriction on the testing of electronic air cleaners; however, the test procedures have not been revised. This research project will be a literature review of the test standard changes needed to accommodate EACs and will lay the groundwork for a future in-duct testing research project.

Applicability to the ASHRAE Research Strategic Plan:

By establishing performance testing of electronic air cleaning devices, this project will support ASHRAE's mission "To advance the arts and sciences of HVAC&R to serve humanity and promote a sustainable world."

Specifically, this project supports Goal 9 of the ASHRAE Research Strategic Plan for development of improved HVAC&R components to provide improved system efficiency, affordability, reliability and safety. It will lead to reliable comparison data for different types of available electronic air cleaning devices for a key contaminant of concern in indoor environmental quality – including removal performance and resistance. This will allow engineers to specify the most energy-efficient devices to improve the indoor air quality. It will also encourage manufacturers to develop new types of cleaning devices to improve the balance of performance and energy impact.

This research project also aligns with Goal 7 "Support development of tools, procedures and methods suitable for designing low-energy buildings" of the ASHRAE Strategic Plans and Initiatives. A change in ASHRAE 145.2 to accommodate the testing of EACs would allow for a broader range of products to comply with the USGBC's requirements for LEED pilot-credit 68. Significant energy cost savings are possible when EAC air purification technology is incorporated in the duct ahead of the AHU. Ventilation rates can be reduced since the recirculated air is cleaner than outside air.

The information obtained from this project can be used to update the ASHRAE handbook and may also serve as a guidance for industry and provide a path to reduce ventilation rates and the HVAC costs due to conditioning outside air, gas-phase media consumption, and all the costs associated with replacing it and disposal costs.

Application of Results:

Until recently, the scope of ASHRAE Standard 145.2 was restricted to measuring the performance of in-duct sorptive media gas-phase cleaning devices where the sorptive media are defined as the active agent of the cleaning device, such as granular, sheet or pleated options, that work by adsorbing and/or chemically reacting with contaminant gases. However, the recent push by the USGBC (U.S Green Building Council) that all air cleaners claiming LEED credit 68 verify their air cleaners' performance to ASHRAE 145.2 has caused concerns from the market/manufacturers as the test methodologies outlined in ASHRAE 145.2 have not been revised since the expansion of the test standard scope to remove the restriction on the testing of EACs. Furthermore, no test standards currently exist to evaluate the performance of EACs for removing gas-phase contaminants.

It would be critical for ASHRAE to conduct a literature survey to understand the current EAC testing challenges and how ASHRAE Standard 145.2 needs to change to include EACs into its testing/reporting procedure. The results of the project can enable ASHRAE to understand the scope of experimental testing required to include EAC into the scope of ASHRAE 145.2 which can be a separate research project.

State-of-the-Art (Background):

The need for better indoor air quality, poor outdoor air quality and the risk of chemical release have all increased the need and interest in air cleaning systems. As more air cleaning devices using different technologies have become available on the market, it is essential to develop a method for comparing their effectiveness. Presently no such standard exists to determine the performance of air cleaning systems based on new technologies with respect to gas-phase contaminants.

There are traditional air cleaning systems for filtering gases and vapors based on adsorption process, e.g., activated carbon or permanganate alumina pellets. Adsorption technologies have long been used in wide ranges of applications, so the performances and the efficiencies under various conditions are well understood. ASHRAE standards 145.1 and 145.2 for the evaluation of gas-phase air cleaning devices are limited to those applying adsorption-based technologies [1,2].

There are newer technologies used in EAC such as UV, UV with photocatalysts (UV-PCO), plasmas, plasma with catalysts, ozone generators, etc. [3-8]. These may generate oxidizing agents like radicals and ozone that remove the gases and vapors through the oxidation process. Upon the complete oxidation, VOCs can be converted into carbon dioxide and water. EACs, however, can generate intermediates such as carbon monoxide, formaldehyde, acetaldehyde, and acetic acid in cases of incomplete oxidation as well as generating pollutants like ozone and nitrogen oxides inherently depending on the system [3, 9]. For EAC using a catalyst, the deactivation of catalytic surface can take place reducing its efficiency and service life [10].

Many studies have been conducted to develop better EAC systems (especially for UV-PCO technology) that demonstrate high removal efficiencies. However, these results were usually obtained under ideal oxidation conditions (e.g., long residence time under extremely high oxidizing agent output) using small bench-top scale test rigs. For the development of proper standard test method fair to all different air cleaning technologies, understanding EAC performance and their limits under realistic application conditions is necessary.

Advancement to the State-of-the-Art:

There are many types and manufacturers of EACs. These can be passive type systems that clean the air that goes through them as well as active or reactive systems that are meant to clean air as it travels through a duct system or air delivered to a space.

These electronic systems present many benefits. Many systems show good air cleaning performance results on dust and particles, VOCs and micro-organisms including molds, bacteria and viruses.

These systems can also be beneficial to building mechanical engineering and efficiency. Claims show very low static pressure drop as compared to media technologies, allowing greater HVAC energy efficiency. This lower energy use can enable these systems to be an efficient air cleaning strategy in a 62.1 IAQ procedure design. Also, many do not require re-engineering of existing mechanical systems to allow for their application, so retro-fit opportunities are possible with these technologies, where media devices would not be applicable.

However, currently there are no recommended test methods or guidelines for use or to evaluate the efficacy of the wide variety of EAC on the market today. Further, there are very limited peer reviewed studies or literature available to design engineers and building owners to ascertain the performance impact of these systems on indoor air quality or building energy. ASHRAE Test Standard 145.2 is the only recommended state-of-the-art test method to evaluate the performance of the gas-phase systems; however, the committee's scope has only recently been expanded to include the testing of electronic air cleaners and the test method is currently tailored to the evaluation and reporting of sorptive media such as activated carbon-based filtration devices. NThus the test method needs to be modified so that it will be suitable to evaluate the performance of EAC in addition to sorbents.

Continuing research towards developing a test method for these technologies would fit well into ASHRAE's overall mission "To advance the arts and sciences of heating, ventilating, air conditioning and refrigerating to serve humanity and promote a sustainable world." Systems that can offer advanced air cleaning performance better serve humanity, and, if they can improve on overall energy efficiency, would promote sustainability.

Justification and Value to ASHRAE:

In January 2018, ASHRAE approved Title, Purpose and Scope changes to ASHRAE Standard 145.2 to remove the restriction on testing electronic air cleaners. Additional research is needed to determine what changes are needed to the existing Standard to fully accommodate EAC testing. No other test standards currently exist to evaluate the gaseous removal performance of EACs. Therefore, this research project to improve upon Standard 145.2 would be of benefit to users such as ASHRAE 62.1, EAC manufacturers, and the USGBC.

Objectives:

1. Determining how the filtration efficiency value, E_f, can be developed for electronic air cleaners to meet the IAQP validation requirement of Standard 62.
2. Determine what the challenges or needs are to adopt EAC testing under ASHRAE Standard 145 such as testing duct changes, inlet/outlet gas concentrations, reporting format and life cycle.
3. Gather available EAC test data and test methods.
4. Summarize current existing EAC technologies and how they remove gas-phase contaminants.
5. Summarize the application advantages and limitation of EAC compared to traditional air cleaning systems.
6. Determine what the by-products of EAC technologies are.
7. Summarize what is known about the chemical reactions occurring in the device, at the filter, in space, etc.
8. Determine what parameters affect EAC performance (RH, flow rate, etc.).

Scope/Technical Approach:

For this research project, EACs are defined as any air cleaning technologies with gas-phase filtration capabilities derived from the use of an electrical component such as, but not limited to, UV, UV-PCO, plasmas, and ozone generators.

This project will consist of the following three tasks. The estimated total project length is 6 months.

Task 1 – Literature review of EAC technologies

The contractor will need to identify current electronic air cleaning technologies and their modes of operation. Summarize from previous research the advantages and limitations of electronic technologies as compared to media technologies. Summarize from previous research the possible by-products of the identified electronic technologies. Summarize the existing test data and test methods that have been used on these technologies along with any performance data. This literature review should also conclude with the challenges or changes needed to the current ASHRAE 145 test method to allow for electronic devices to be tested for their intended use and an understanding on how this this could allow for the E_f, filtration efficiency value, to be developed for these devices. The contractor will be responsible for market and literature research to understand existing EAC technologies. As much of this information is publicly available and understood, it is anticipated that the contractor will be able to produce a summary report by the second month of this project.

Task 2 – Survey of laboratories and manufacturers for EAC test methods and performance data

Surveying laboratories and manufacturers for test methods and test data as well as compiling publicly available information on electronic air cleaners is expected to take 3 months and shall run concurrently with Task 1. The contractor shall survey EAC manufacturers for the test methodologies and performance data used to evaluate and advertise their products. The contractor shall survey test laboratories for test methodologies of EACs and any procedure or design modifications that are utilized when testing EACs in contrast to sorptive media gas-phase cleaning devices.

Task 3 – Detailing changes needed to ASHRAE Standard 145 for testing EACs

The analysis of parameters and procedures in ASHRAE Standard 145.2 that would need to be altered to accommodate electronic air cleaners is expected to take 3 months. Test methodology information and data from Task 1 & 2 shall be compared to the existing ASRHAE Standard 145.2 and any contrasts shall be highlighted to the committee. The contractor shall identify the changes needed in ASHRAE Standard 145.2 for test duct design, sampling methodologies for reaction by-products detection, reporting formats, and life-cycle or capacity reporting. The contractor shall also identify RH, temperature, and airflow test conditions that may impact the testing of various EAC technologies.

Deliverables/Where Results Will Be Published:

Progress, Financial, Final Reports, Technical Paper(s) and Data shall be constituted as deliverables under this agreement and shall be provided as follows,

a. Progress and Financial Reports required by ASHRAE Society

Progress and Financial Reports, in a form approved by the Society, shall be made to the Society through its Manager of Research and Technical Services at quarterly intervals. In addition, the Institution's Principal Investigator, subject to the Society's approval, shall, during the period of performance and after the Final Report has been submitted, report in person at a meeting arranged by the sponsoring Technical and Standards Committees at the ASHRAE annual and winter meetings, and be available to answer such questions regarding the research as may arise.

b. Task Completion Reports required by the PMS (Project Monitoring Subcommittee)

During the project, the contractor will be required to obtain approval from the PMS before proceeding further at the following milestones (not necessarily in chronological order):

1. Literature review of available EAC Technologies;
2. Current test methods of EACs;
3. Comparing available data and gaps in ASHRAE 145.2 to measure EACs

It is anticipated that a short, written report will be submitted by the contractor at all three of these decision points, and that the PMS will provide the contractor with a response within two weeks of submittal. While the exact payment schedule will be negotiated between the contractor and ASHRAE, a proposed payment schedule would be:

1. 25% down at the signing of the contract
2. 15% upon completion of Scope Milestone 1
3. 15% upon completion of Scope Milestone 2
4. 15% upon completion of Scope Milestone 3
5. 30% upon completion of final report and submission of technical papers.

Payment and milestone completion are contingent upon PMS review and approval.

c. Final Report

A written Final Report in a form approved by the Society, shall be prepared by the Institution and submitted to the Society's Manager of Research and Technical Services by the end of the Agreement term, containing complete details of all research carried out under this Agreement. Unless otherwise specified, six copies of the final report shall be furnished for review by the Society's Project Monitoring Subcommittee (PMS). Following approval by the PMS and the sponsoring Technical and Standards Committees, in their sole discretion, final copies of the Final Report will be furnished by the Institution as follows:

- An executive summary in a form suitable for wide distribution to the industry and to the public.
- Two bound copies
- One unbound copy, printed on one side only, suitable for reproduction.
- Two copies on CD-ROM; one in PDF format and one in Microsoft Word.

d. HVAC&R Research or ASHRAE Transactions Technical Paper

One or more papers shall be submitted first to the ASHRAE Manager of Research and Technical Services (MORTS) and then to the "ASHRAE Manuscript Central" website-based manuscript review system in a form and containing such information as designated by the Society suitable for publication. Papers specified as deliverables should be submitted as either Research Papers for HVAC&R Research or Technical Paper(s) for ASHRAE Transactions. Research papers contain generalized results of long-term archival value, whereas technical papers are appropriate for applied research of shorter-term value, ASHRAE Conference papers are not acceptable as deliverables from ASHRAE research projects. The paper(s) shall conform to the instructions posted in "Manuscript Central" for an ASHRAE Transactions Technical or HVAC&R Research paper. The paper title shall contain the research project number (1838-RP) at the end of the title in parentheses, e.g., (1838-RP).

Note: A research or technical paper describing the research project must be submitted after the TC has approved the Final Report. Research or technical papers may also be prepared before the project's completion, if it is desired to disseminate interim results of the project. Contractor shall submit any interim papers to MORTS and the PMS for review and approval before the papers are submitted to ASHRAE Manuscript Central for review.

e. Data

The Institution agrees to maintain true and complete books and records, including but not limited to notebooks,

reports, charts, graphs, analyses, computer programs, visual representations etc., (collectively, the "Data"), generated in connection with the Services. Society representatives shall have access to all such Data for examination and review at reasonable times. The Data shall be held in strict confidence by the Institution and shall not be released to third parties without prior authorization from the Society, except as provided by GENERAL CONDITION VII, PUBLICATION. The original Data shall be kept on file by the Institution for a period of two years after receipt of the final payment and upon request the Institution will make a copy available to the Society upon the Society's request.

f. Project Synopsis

A written synopsis totaling approximately 100 words in length and written for a broad technical audience, which documents 1. Main findings of research project, 2. Why findings are significant, and 3. How the findings benefit ASHRAE membership and/or society in general shall be submitted to the Manager of Research and Technical Services by the end of the Agreement term for publication in ASHRAE Insights

The Society may request the Institution to submit a technical article suitable for publication in the Society's ASHRAE JOURNAL. This is considered a voluntary submission and not a Deliverable. This project will also facilitate development of a Users' Guide for engineers and installers, and guidelines for laboratories wishing to implement the Standard.

All Deliverables under this Agreement and voluntary technical articles shall be prepared using dual units; e.g., rational inch-pound with equivalent SI units shown parenthetically. SI usage shall be in accordance with IEEE/ASTM Standard SI-10.

Level of Effort:

Task	Time Required	Deliverable
1	2 months	Report summarizing the literature review of existing EAC technologies
2	3 months (begins concurrently with Task 1)	Report on existing EAC test methods and gaseous removal performance data for EACs
3	3 months	Final report detailing the parameters and procedural changes needed in ASHRAE Standard 145.2 to accommodate the testing of EACs.

Estimated duration: 6 months
Estimated personnel: 1 PI and 1 Researcher
Estimated cost: $40k

Proposal Evaluation Criteria:

No.	Proposal Review Criterion	Weighting Factor
1	**Contractor's understanding of Work Statement as revealed in proposal.**	**15%**
2	**Quality of methodology proposed for conducting research.**	**35%**
4	**Qualifications of personnel for this project.**	**30%**
5	**Probability of contractor's research plan meeting the objectives of the Work Statement.**	**15%**
6	**Performance of contractor on prior ASHRAE projects (No penalty for new contractors).**	**5%**

Project Milestones:

		Deadline

No.	Major Project Completion Milestone	Month
1	Report covering the literature review of available EAC technologies	2nd month
2	Report on existing test methods and test data for EACs.	3rd month
3	Final report detailing necessary changes to ASHRAE Standard 145.2 to accommodate testing of EACs	6th month

Authors:

This work statement was prepared by Kevin Kwong, Tony Abate, Nick Agopian, Tandeep Chadha, Ashish, Mathur, Kartik Potukuchi, and Jeff Roseberry.

References:

[1] ASHRAE Standard 145.1 (2015) Laboratory test method for assessing the performance of gas-phase air-cleaning systems: loose granular media, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta.

[2] ASHRAE Standard 145.2 (2011) Laboratory test method for assessing the performance of gas-phase air-cleaning systems: air cleaning devices, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta.

[3] Bahri, M., and Haghighat, F. (2014) Plasma-Based Indoor Air Cleaning Technologies: The State of the Art-Review, CLEAN–Soil, Air, Water, vol. 42, pp. 1667-1680.

[4] Zhong, L., Haghighat, F., Lee, C.L. and Lakdawala, N. (2013) Performance of Ultraviolet Photocatalytic Oxidation for Indoor Air Applications: Systematic Experimental Evaluation, Journal of Hazardous Materials, 261:130-138.

[5] Destaillats, H., Sleiman, M., Sullivan, D.P., Jacquiod, C., Sablayrolles, J., and Molins, L. (2012) Key parameters influencing the performance of photocatalytic oxidation (PCO) air purification under realistic indoor conditions. Applied Catalysis B: Environmental, 128:159-170.

[6] Zhang, Y., Mo, J., Li, Y., Sundell, J., Wargocki, P., Zhang, J., Little, J.C., et al. (2011) Can commonly-used fan-driven air cleaning technologies improve indoor air quality? A literature review, Atmospheric Environment, 45: 4329-4343.

[7] Vandenbroucke, A.M., Morent, R., De Geyter, N., and Leys, C. (2011) Non-thermal plasmas for non-catalytic and catalytic VOC abatement. Journal of Hazardous Materials, 195:30-54.

[8] Britiganm, N., Alshawa, A., and Nizkorodov, S.A. (2006) Quantification of ozone levels in indoor environments generated by ionization and ozonolysis air purifiers, Journal of the Air & Waste Management Association, 56: 601-610.

[9] Farhanian, D., and Haghighat, F. (2014) Photocatalytic oxidation air cleaner: Identification and quantification of by-products, Building and Environment, vol. 72, pp. 34-43.

[10] Hay, S.O., Obee, T.N., and Thibaud-Erkey, C. (2010) The deactivation of photocatalytic based air purifiers by ambient siloxanes Applied Catalysis B: Environmental, 99: 435–441.

Other Information for Bidders (Optional):

ASHRAE Standard 145.2-2016 Test Method

Feedback to RAC and Suggested Improvements to Work Statement Process

Now that you have completed the work statement process, RAC is interested in getting your feedback and suggestions here on how we can improve the process.

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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 9, 2017

SUBJECT: Research Topic Acceptance Request (1838-RTAR), "Inclusion of Electronic Air Cleaners into ASHRAE 145.2"

During their fall meeting, the Research Administration Committee (RAC) reviewed the subject Research Topic Acceptance Request (RTAR) and voted to accept it with comments for further development into a work statement (WS) provided that the key comment(s) and question(s) below are addressed to the satisfaction of your Research Liaison, Pawel Wargocki, paw@byg.dtu.dk, or RL2@ashrae.net, in the work statement draft.

1. The reviewer thinks the title of the RTAR is inadequate. The contents of the RTAR is the fundamental scientific research and would be independent whether the electronic cleaners are included into ASHRAE 145.2 or not.
2. The work will be an important addition for ASHRAE (EAC and Std 145.2), but the RTAR should go beyond simply 'what' to also determine 'what next', i.e. what will be the next steps that are required? This will go beyond being just a literature review to identify the way ahead, and the work required.
3. Update summary with "why the research is important.
4. It could be more desirable to combine the literature review with some controlled lab research/tests to allow bidders not only to provide a balanced review of current understandings, but also basic findings to point to further needed research. Literature review alone without minimum lab tests/verifications may not offer any direction(s) to identify the future needed efforts.

The work statement draft must be approved by the Research Liaison prior to submitting it to RAC.

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. Some of these comments may indicate areas of the RTAR and subsequent WS where readers require additional information or rewording for clarification.

The first draft of the work statement should be submitted to RAC no later than **August 15, 2019** or it will be dropped from display on the Society's Research Implementation Plan. The next likely submission deadline for a new work statement on this topic is **May 15, 2018** for consideration at RAC's 2018 Annual meeting. The submission deadline after that for work statements is **August 15, 2018** for consideration at the RAC's 2018 fall meeting.

Project ID	**1838**	
Project Title	**Inclusion of Electronic Air Cleaners into ASHRAE 145.2**	
Sponsoring TC	TC 2.3, (Gaseous Air Contaminants and Gas Contaminant Removal Equipment)	
Cost / Duration	$35,000 to $40,000 / 6 Months	
Submission History	**1st Submission**	
Classification: Research or Technology Transfer	Basic/Applied Research	
RAC 2017 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.		**#9** - Makes the case for a method for comparing effectiveness of electronic air cleaners (EACs). Currently none exists. References given.
Research Need: Based on the background provided is the need for additional research clearly identified? If not, then the RTAR should be rejected.		**#12** - Need and urgency is well documented. **#9**- The RTAR makes the case for a literature review of EAC testing challenges, and hence the scope of experimental testing required for including EAC into the scope of ASHRAE 145.2. **#7** - Electronic Air Cleaners are widely advertised and used but no standard method for their testing exists despite the potential of by-products (see ASHRAE PD on air filtration and cleaning). There is an urgent need for the work developing the method.
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** - Can be used to update 145.2, the ASHRAE Handbook, and align with US Green Building Council needs. **#4**- Addresses existing knowledge gap between ASHRAE standard and application
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.		**#9** - These align with need, but fall short of identifying the next steps that arise as an outcome of the work, i.e. scope out the next phase. **#4**- This project is a small first step in the right direction. The scope is limited to a literature survey to help understand what needs to be done to develop a MOT, but stops there. Perhaps this is the prudent way to go here, but as someone not very familiar with this area, I don't really understand why this project does not aim to develop a MOT.
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:		**#12** - Objectives and budget are well aligned. **#9** - The proposed approach largely involves data gathering, taking six months and costing US$40k. This needs to go a little further…see comments below. **#4** - Budget and scope are small
References: Are the references provided?		
Decision Options	**Initial Decision?**	**Final Approval Conditions**
ACCEPT AS-IS		**#8** - The reviewer thinks the title of the RTAR is inadequate. The contents of the RTAR is the fundamental scientific research and would be independent whether the electronic cleaners are included into ASHRAE 145.2 or not. **#9** - The work will be an important addition for ASHRAE (EAC and Std 145.2), but the RTAR should go beyond simply 'what' to also determine 'what next', i.e. what will be the next steps that are required? This will go beyond being just a literature review to identify the way ahead, and the work required. **#5** - update summary with "why the research is important. ******* - One note is that I was intrigued by the negative comments for RTAR 1833 and the rather tepid response that the RTAR authors gave for not actually considering the person's comments more thoroughly. It seems to me that they could have done so rather quickly, but of course it would have required another committee vote. I don't know that it will be enough to cause RAC to send it back or not. I am not even sure that the negative voter's comments are correct but assume they probably have some basis as they are the 62.1 rep so should have some expertise.There isn't any place I could find to put this comment on the spreadsheet. It is not really a negative comment and I suspect that RAC will probably have some comment (and maybe guidance) on it if it advances to the WS stage. *******- DISCLOSURE: My employer is a test lab that potentially would benefit from a test
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: 8-15-2017

(Please Check to Insure the Following Information is in the RTAR)

A. Title	X
B Executive Summary	X
C. Background	X
D. Research Need	X
E. Project Objectives	X
F. Expected Approach	X
G. Relevance and Benefits to ASHRAE	X
H. Anticipated Funding Level and Duration	X
I. References	X

Title:
Inclusion of Electronic Air Cleaners into ASHRAE 145.2

RTAR # 1838
(To be assigned by MORTS)

Results of this Project will affect the following Handbook Chapters, Special Publications, etc.:
HVAC Applications Handbook, Chapter 46: Air cleaners for gaseous contaminants

Research Classification:

Basic/Applied Research	X
Advanced Concepts	
Technology Transfer	

Responsible Committee: TC 2.3

Date of Vote: 6-27-2017

For		10
Against	*	0
Abstaining	*	1
Absent or not returning Ballot	*	0
Total Voting Members		11

RTAR Authors

Lead: Kevin Kwong

Others: Tony Abate, Tandeep Chadha, Chang-Seo Lee, Lu Liu, Kartik Potukuchi, Jeff Roseberry

Co-sponsoring TC/TG/MTG/SSPCs (give vote and date)
SSPC 62.1: 19-0-1-4 (Yes-No-Abstain-Not Returned), 8/9/2017
TC 2.9: 6-0-0-1 (Yes-No-Abstain-Absent), 6/26/2016

Expected Work Statement Authors

Lead: Kevin Kwong

Others: Tony Abate, Tandeep Chadha, Chang-Seo Lee, Lu Liu, Kartik Potukuchi, Jeff Roseberry

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

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

* Reasons for negative vote(s) and abstentions

SSPC 62.1: The one abstention is the Chair Not Voting
TC 2.3: The one abstention is the Chair Not Voting

RTAR # __1838_____

Title

Insert proposed project title

Inclusion of Electronic Air Cleaners into ASHRAE 145.2

Executive 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)

ASHRAE Standard 145.2, as is currently written, does not address the performance of electronic air cleaning (EAC) devices. Emerging EAC technologies and a push by the U.S. Green Building Council for an ASHRAE 145.2 test verification of EACs claiming LEED pilot-credit 68 have created a need to revisit the scope of ASHRAE 145.2. This research project will be a literature review of the test standard changes needed to accommodate EACs and will lay the groundwork for a future in-duct testing research project.

Background

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

The need for better indoor air quality, poor outdoor air quality and the risk of chemical release have all increased the need and interest in air cleaning systems. As more air cleaning devices using different technologies are available on the market, it would be essential to develop a method for comparing their effectiveness. Presently no such standard exists to determine the performance of air cleaning systems based on new technologies with respect to gaseous contaminants.

There are traditional air cleaning systems for filtering gases and vapors based on adsorption process, i.e., activated carbon, permanganate alumina pellets. Adsorption technologies have long been used in wide ranges of applications, so the performances and the efficiencies under various conditions are well understood. ASHRAE standards 145.1 and 145.2 for the evaluation of gas-phase air cleaning devices are limited for those applying adsorption-based technologies [1,2].

There are newer technologies used in electronic air cleaners (EAC) such as UV, UV with photocatalysts (UV-PCO), plasmas, plasma with catalysts, and ozone generators, etc. [3-8]. These generate oxidizing agents like radicals and ozone, and removing the gases and vapors through oxidation process. Upon the complete oxidation, hydrocarbon VOC can be converted into carbon dioxide and water. EACs, however, can generate intermediates such as carbon monoxide, formaldehyde, acetaldehyde, and acetic acid in case of incomplete oxidation as well as generating pollutants like ozone and nitrogen oxides inherently depending on the system [3, 9]. For EAC using a catalyst, the deactivation of catalytic surface can take place reducing its efficiency and service life [10]

Many studies have been conducted to develop better EAC systems (especially for UV-PCO technology), and demonstrated high removal efficiencies. However, these results were usually obtained under ideal oxidation conditions (e.g., long residence time under extremely high oxidizing agent output) using small bench-top scale test rigs. For the development of proper standard test method fair to all different air cleaning technologies, understanding EAC performances and their limits under realistic application conditions is necessary.

Research Need

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

ASHRAE 145.2 standard measures the performance of in-duct sorptive media gas phase cleaning devices where the sorptive media are defined as the active agent of the cleaning device such as granular, sheet or pleated, that work by adsorbing and/or chemically reacting with contaminants gases. However recent push by USGBC (U.S Green Building Council) that all air cleaners claiming LEED credit 68 verify their air cleaners' performance to ASHRAE 145.2 has caused concerns from the market/manufacturers as current ASHRAE 145.2 does not cover Electronic Air Cleaners (EAC) under its scope. Furthermore, no test standards currently exist to evaluate the performance of EACs for removing gaseous contaminants.

It would be critical for ASHRAE to conduct a research project (literature survey) to understand the current EAC testing challenges and how the scope of ASHRAE 145.2 needs to change to include EACs into its testing/reporting procedure. The results of the project can enable ASHRAE to understand the scope of experimental testing required to include EAC into the scope of ASHRAE 145.2 which can be a separate research project.

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)

Objectives:

1. What are the challenges or needs to adopt EAC testing under ASHRAE 145.2 such as testing duct changes, inlet/outlet gas concentrations, reporting format and life cycle?
2. Gather available EAC test data and test methods
3. Summarize current existing EAC technologies and how they remove gas contaminants.
4. Summarize the application advantages and limitation of EAC compared to traditional air cleaning system
5. What are the by-products of EAC technologies?
6. What parameters affect EAC performance (RH, flow rate, etc.)?

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 (x), Field tests ( ), Analyses and modeling (x), Validation efforts ( ), Other (specify) ( )

Surveying laboratories and manufacturers for test methods and test data as well as compiling publically available information on electronic air cleaners is expected to take 3 months. The analysis of parameters and procedures in ASHRAE Standard 145.2 that would need to be altered to accommodate electronic air cleaners is expected to take 3 months.

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)

This research project aligns with Goal 7 – "Support development of tools, procedures and methods suitable for designing low-energy buildings" of the ASHRAE Strategic Plans and Initiatives. A change in ASHRAE 145.2 to accommodate the testing of EACs would allow for a broader range of products to comply with the USGBC's requirements for LEED pilot-credit 68.

The information obtained from this project can be used to update the ASHRAE handbook and may also serve as a guidance for industry.

Relevant stakeholders for information or co-funding are ASHRAE 62.1, EAC manufacturers, and the USGBC.

Anticipated Funding Level and Duration

Funding Amount Range: $ 35k-40k

Duration in Months: 6

References

List the key references cited in this RTAR

[1] ASHRAE Standard 145.1 (2015) Laboratory test method for assessing the performance of gas-phase air-cleaning systems: loose granular media, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta.

[2] ASHRAE Standard 145.2 (2011) Laboratory test method for assessing the performance of gas-phase air-cleaning systems: air cleaning devices, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta.

[3] Bahri, M., and Haghighat, F. (2014) Plasma-Based Indoor Air Cleaning Technologies: The State of the Art-Review, CLEAN–Soil, Air, Water, vol. 42, pp. 1667-1680.

[4] Zhong, L., Haghighat, F., Lee, C.L. and Lakdawala, N. (2013) Performance of Ultraviolet Photocatalytic Oxidation for Indoor Air Applications: Systematic Experimental Evaluation, Journal of Hazardous Materials, 261:130-138.

[5] Destaillats, H., Sleiman, M., Sullivan, D.P., Jacquiod, C., Sablayrolles, J., and Molins, L. (2012) Key parameters influencing the performance of photocatalytic oxidation (PCO) air purification under realistic indoor conditions. Applied Catalysis B: Environmental, 128:159-170.

[6] Zhang, Y., Mo, J., Li, Y., Sundell, J., Wargocki, P., Zhang, J., Little, J.C., et al. (2011) Can commonly-used fan-driven air cleaning technologies improve indoor air quality? A literature review, Atmospheric Environment, 45: 4329-4343.

[7] Vandenbroucke, A.M., Morent ,R., De Geyter, N., and Leys, C. (2011) Non-thermal plasmas for non-catalytic and catalytic VOC abatement. Journal of Hazardous Materials, 195:30-54.

[8] Britiganm, N., Alshawa, A., and Nizkorodov, S.A. (2006) Quantification of ozone levels in indoor environments generated by ionization and ozonolysis air purifiers, Journal of the Air & Waste Management Association, 56: 601-610.

[9] Farhanian, D., and Haghighat, F. (2014) Photocatalytic oxidation air cleaner: Identification and quantification of by-products, Building and Environment, vol. 72, pp. 34-43.

[10] Hay, S.O., Obee, T.N., and Thibaud-Erkey, C. (2010) The deactivation of photocatalytic based air purifiers by ambient siloxanes Applied Catalysis B: Environmental, 99: 435–441.

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