**INVITATION TO SUBMIT A RESEARCH PROPOSAL ON AN ASHRAE RESEARCH PROJECT**

**1928-TRP, "Improving efficiency test methods to measure air cleaner performance against airborne particulate contaminants in a recirculating system"**

Attached is a Request-for-Proposal (RFP) for a project dealing with a subject in which you, or your institution have expressed interest. Should you decide not to submit a proposal, please circulate it to any colleague who might have interest in this subject.

Sponsoring Committee: TC 2.09, (Ultraviolet Air & Surface Treatment)
Co-sponsored by: TC 2.03, (Gaseous Air Contaminants and Gas Contaminant Removal Equipment), TC 2.04 (Particulate Air Contaminant and Particulate Contaminant Removal Equipment), TC 9.06, (Health Care Facilities) & EHC (Environmental Health Committee)

Budget Range: $199,000 may be more or less as determined by value of proposal and competing proposals.

Scheduled Project Start Date: **April 1, 2024** or later.

**All proposals must be received at ASHRAE Headquarters by 8:00 AM, EDT, December 15th, 2023. NO EXCEPTIONS, NO EXTENSIONS. Electronic copies must be sent to rpbids@ashrae.org. Electronic signatures must be scanned and added to the file before submitting. The submission title line should read: 1928-TRP, "Improving efficiency test methods to measure air cleaner performance against airborne particulate contaminants in a recirculating system, and *"Bidding Institutions Name"* (electronic pdf format, ASHRAE's server will accept up to 10MB)**

If you have questions concerning the Project, we suggest you contact one of the individuals listed below:

**For Technical Matters**
Technical Contact
Chrystal Jolliffe
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London, OH
43140-9515
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**For Administrative or Procedural Matters:**
Manager of Research & Technical Services (MORTS)
Michael R. Vaughn
ASHRAE, Inc.
180 Technology Parkway, NW
Peachtree Corners, GA 30092
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**Contractors intending to submit a proposal should so notify, by mail or e-mail, the Manager of Research and Technical Services, (MORTS) by December 1, 2023, in order that any late or additional information on the RFP may be furnished to them prior to the bid due date.**

All proposals must be submitted electronically. Electronic submissions require a PDF file containing the complete proposal preceded by signed copies of the two forms listed below in the order listed below. **ALL electronic proposals are to be sent to rpbids@ashrae.org.**

**All other correspondence must be sent to ddaniel@ashrae.org and mvaughn@ashrae.org.** Hardcopy submissions are not permitted. **In all cases, the proposal must be submitted to ASHRAE by 8:00 AM, EDT, December 15th, 2023. NO EXCEPTIONS, NO EXTENSIONS.**

The following forms (Application for Grant of Funds and the Additional Information form have been combined) must accompany the proposal:

(1) ASHRAE Application for Grant of Funds (electronic signature required) and
(2) Additional Information for Contractors (electronic signature required) ASHRAE Application for Grant of Funds (signed) and

**ASHRAE reserves the right to reject any or all bids.**

**State of the Art (Background)**

Given the current awareness of bioaerosol spread of disease, the many new and newly popular products coming to market in response, and the likelihood of future potential pandemics, ASHRAE and the Epidemic Task Force emphasize future preparedness. Access to air cleaner efficacy and safety information is crucial to this effort. This research project will move us toward having that information before the next pandemic and even to help fight recurring non-pandemic infections such as flu. Test results, improved based on the outcome of this project, will provide reliable data to enhance recommendations going forward, including the ASHRAE position documents on airborne infection control and air cleaners.

**Justification and Value to ASHRAE**

The value to ASHRAE is a path forward towards developing new and improved test methods that are more applicable to actual applications and are appropriate for all air cleaning devices. Since a different test rig configuration and procedure is needed, we need data on how various parameters influence the testing and performance. This will allow us to provide test standards that give useful, understandable, and repeatable results. Parameters that need to be examined include device location, duct entry/exit specifics, airflow, chamber dimensions and duct sizes relative to the devices' intended usage, aerosol generation and injection schema, etc. Comparison of realistic results with different setups and different devices will allow better understanding of which parameters are important to specify and their influence on the data product resulting from the testing.

As discussed above, chamber testing is common for some types of in-room air cleaners via the AHAM-1 test with the result expressed as clean air delivery rate (CADR). Testing using a side duct attached to a similar chamber is currently being used and has been proposed for testing such as that proposed here (Burkhead, 2018). The PI will be expected to review these approaches and adapt useful portions to the work proposals for this research. Thus, the research will build on existing and understood test methods to enable new, test standards to cover devices that are not currently being tested. This research will also provide improvements to performance test methods for all types of air cleaners.

**Objectives**

1. After identifying important parameters in the proposals, determine which parameters are key, then perform testing to understand key test parameters that affect the measurement of efficacy of air cleaners in recirculating chamber-duct combination system.
2. Using existing equipment with needed upgrades for this specific work, set up a test rig chamber (≥ 1000 $ft^3$) with side duct (composed of sections similar to ASHRAR 52.2's) and the needed generation and analytical equipment to perform the testing.
3. Set up and run a test sequence including at least the following; additional parameters maybe suggested in the proposal or become apparent during testing:
    a. Evaluate the impact in the chamber of different inlet and outlet locations from the side duct to the chamber.
    b. Measure particulate contamination level in the air and distribution within the chamber and duct.
    c. Explore measurement method and then analyze byproducts produced during testing including: particles, ultrafine particles, ozone, and others as agreed to by the PI and the PMS.

Evaluate impact of location of aerosol introduction within the chamber and in the duct.

    a. Evaluate impact of aerosol introduction as a single event, intermittent injection, and continuous injection.
    b. Evaluate impact of different air cleaner locations within the system.
    c. Evaluate methods for controlling environmental conditions within the chamber (T, RH).
    d. Evaluate the impact of ventilation rate of the chamber (compared to flow rate of the air cleaner).

Measure particulate contamination level in the air and distribution within the chamber and duct with 3-4 various air cleaning technologies.

**Scope**:

This project is divided into multiple tasks. Some of the tasks need to be performed in sequence, while others may be performed in parallel. The task deliverables are spelled out in the next section. This section describes the needed work. Some leeway has been given to allow potential PIs to bring their expertise to the project. Many of the questions discussed below for the project will be reasonably addressed in the proposal including likely sampling and analysis techniques. The expectation is that the project will include the test plan development and not sampling or analysis technique development that the PI should already be versed in.

The overall project includes testing 3-4 types of air cleaning technologies against two or more aerosol challenge types with monitoring or testing for byproducts produced during testing including at least: particles, ultrafine particles, ozone, and VOCs (including formaldehyde) as appropriate based on the particle type. Testing variables will include aerosol injection locations and types (single dose, intermittent, and continuous).

Task 1. Test Rig Construction. Construct or modify a test rig to comprise a duct or duct sections as described in ASHRAE 52.2 connected to a chamber of at least 1000 cubic feet. Height of chamber must be at least 8 feet to accommodate upper room air cleaning devices, if chosen. The design of the chamber or modifications to an existing chamber, including location of the supply and returns, must be shared with the PMS either in the proposal or by email/virtual meeting/in-person meeting before the construction is done. PMS must be allowed to give advice and approve the final design before anything other than minor changes are made. Task 2. Experimental Design. A test plan will be developed, inclusive of the above sections, and shared with the PMS for their input. This test plan may be done in sections to meet the needs of each layer of testing allowing building on what is learned or presented as one overall test matrix. This plan must include, at least, the choice of devices, aerosol type and size range, the locations for air cleaners in the system and the other necessary parameters. Generation and sampling methods, byproduct sampling and analysis plans, length of tests, sampling schema (# of replicates at each time, # of times, choice of times) must be determined and included. The test design should consider the air cleaner manufacturers' instructions for proper use.

Data analysis methods should also be discussed with the understanding that the data may change the needed analysis. Likely efficiencies for the chosen devices or technologies should be considered Once each test plan section that is required for each of the testing subtasks is approved by the PI and PMS, that testing may be performed.

Task 3. Baseline Testing. Test 3-4 air cleaning technologies which shall include media filters, "ionization," a combination unit and/or a second reactive type device. Devices should be tested in the chamber in the location(s)s approved through Task 2. The injection shall be an initial single dose. Data with plots shall be shared with the PMS as the data is available. Data analysis such as CADR or percent reduction calculations should also be done and shared with the PMS. This data set shall be discussed with the PMS to determine if it is adequate before moving to task 4.

Task 4. Advanced Testing. Test the air cleaning devices using a minimum of two injection locations – within the chamber or within the duct. Test the air cleaning devices using three modes of aerosol injection – single dose, intermittent dose, and continuous injection. Include testing to cover the items listed in the objectives section. The data from Task 3 may be counted as the single dose testing. Data will be shared with the PMS as it is received. Data analysis to determine that the individual runs are reasonable and other metrics which are developed based on the actual data shall be performed and shared with the PMS. PMS input shall be requested to help the PI determine that the data set is acceptable.

Task 5. Data Analysis and Reporting. Data analysis to determine the influence of the variables on the test results will be finished. For example, does intermittent or continuous injection provide equivalent or better results and whether the answer varies by the type of device. Produce a draft of recommendations that could be incorporated into a test method. As required by ASHRAE, a Final Report and a Journal Paper will be produced. The Final Report should be presented to the PMS at least a month before the end of the project for the report to be revised based on PMS input. In addition, the PI should review Chapter 29 – Air Cleaners for Particulate Contaminants, HVAC Systems and Equipment Handbook, Chapter 47 – Air Cleaners for Gaseous Contaminants, HVAC Applications Handbook, and the new accepted chapter for in-room air cleaners, HVAC applications handbook, and prepare suggested revisions based on this project. These recommendations may be included in the final report or presented separately.

**Deliverables:**

Task 1. Report on the design of the chamber or modifications to an existing chamber. Requires PMS approval of the final design before project continues.

Task 2. Test plans must be provided to the PMS and approved before work on that part of the experiments begins.

Task 3. Data and graphs from baseline testing must be shared with PMS. PMS must decide that data is acceptable before Task 4 begins.

Task 4. Data and graphs from main testing must be shared with PMS. PMS must decide that data is acceptable before this task is considered concluded. This should also occur before the Final Report, other than the introductory sections, are prepared.

Task 5. Final report, journal paper, and handbook chapter recommendations. The Final Report should include recommendations for further research, possibly including application to other aerosols and modeling.

In addition to the Final Report to be published by ASHRAE and the Journal Paper also published by ASHRAE, results from the project may be published in ASHRAE Chapter 29 – Air Cleaners for Particulate Contaminants, HVAC Systems and Equipment Handbook, Chapter 47 – Air Cleaners for Gaseous Contaminants, HVAC Applications Handbook, and the new accepted chapter on in-room air cleaners, HVAC Applications Handbook.

The results will also be presented to committees advancing chamber test methods which will likely result in incorporation, and publication, in ASHRAE (e.g., 145.4, 185.3, 185.5, TG2-RAST), AHAM (e.g., AC-1, AC-4, AC-5), ISO (e.g., TC142/WG11), and/or ASTM test methods. Additional journal articles and/or conference papers may result from the project, but this is to be determined by the data and the PI.

Progress, Financial and Final Reports, Technical Paper(s), and Data shall constitute the deliverables ("Deliverables") under this Agreement and shall be provided as follows:

a. Progress and Financial Reports

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; specifically on or before each January 1, April 1, June 10, and October 1 of the contract period.

The following deliverables shall be provided to the Project Monitoring Subcommittee (PMS) as described in the Scope/Technical Approach section above, as they are available:

Furthermore, 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 to the sponsoring Technical Committee/Task Group (TC/TG) at the annual and winter meetings, and be available to answer such questions regarding the research as may arise.

b. Final Report

A written report, design guide, or manual, (collectively, "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, including a summary of the control strategy and savings guidelines. Unless otherwise specified, the final draft report shall be furnished, electronically for review by the Society's Project Monitoring Subcommittee (PMS).

Tabulated values for all measurements shall be provided as an appendix to the final report (for measurements which are adjusted by correction factors, also tabulate the corrected results and clearly show the method used for correction).

Following approval by the PMS and the TC/TG, 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 copies; one in PDF format and one in Microsoft Word.

c. *Science & Technology for the Built Environment* or ASHRAE Transactions Technical Papers

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 papers. The paper title shall contain the research project number (1814-RP) at the end of the title in parentheses, e.g., (1814-RP).

All papers or articles prepared in connection with an ASHRAE research project, which are being submitted for inclusion in any ASHRAE publication, shall be submitted through the Manager of Research and Technical Services first and not to the publication's editor or Program Committee.

d. Data

All papers or articles prepared in connection with an ASHRAE research project, which are being submitted for inclusion in any ASHRAE publication, shall be submitted through the Manager of Research and Technical Services first and not to the publication's editor or Program Committee.

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.

e. 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 submit a technical article suitable for publication in the Society's ASHRAE JOURNAL. This is considered a voluntary submission and not a Deliverable. 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**
It is expected that the Tasks above will take approximately two (2) years to complete. The expected total cost for this work is $199,000.

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|---|---|
| Principal Investigator/ (~18 person weeks): | $50,000 |
| Graduate Student/Technicians (~38 person weeks): | $90,000 |
| Facility cost with upgrades (assuming have duct and chamber): | $20,000 |
| Acquisition of test devices (and replaceable components): | $10,000 |
| Other Equipment and Supplies (OPC, HVAC, etc.): | $23,800 |
| Miscellaneous items (travel, etc.): | $5,200 |

**Project Milestones**:

| No. | Major Project Completion Milestone | Deadline Month |
|---|---|---|
| **1** | Test Rig Construction | 4 |
| **2** | Experimental Design | 6 |
| **3** | Baseline Testing | 12 |
| **4** | Organism and Injection Testing | 20 |
| **5** | Data Analysis and Reporting | 23 |

Proposal Evaluation Criteria
Proposals submitted to ASHRAE for this project should include the following minimum information:

| 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 | 25% |
| 3 | Contractor's capability in terms of facilities (chamber, duct, aerosol generation, etc.) | 15% |
| 4 | Qualification of personnel for this project. | 20% |
| 5 | Student involvement | 5% |
| 6 | Probability of contractor's research plan meeting the objectives of the Work Statement | 15% |
| 7 | Performance of contractor on prior ASHRAE or other projects. (No penalty for new contractors) | 5% |

**References**


1. AHAM 2020. Standard AC-1-2020: Method For Measuring Performance Of Portable Household Electric Room Air Cleaners.
2. AHAM 2022. Standard AC-5-2022: Method for Assessing the Reduction Rate of Key Bioaerosols by Portable Air Cleaners Using an Aerobiology Test Chamber

3. ASHRAE 2017. Standard 52.2-2017: Method of testing general ventilation air-cleaning devices for removal efficiency by particle size.
4. ASHRAE 2016. Standard 145.2-2016: Laboratory Test Method for Assessing the Performance of Gas-Phase Air Cleaning Systems: Air Cleaning Devices.
5. ASHRAE 2020. Standard 185.1-2020: Method of Testing UV-C Lights for Use in Air-Handling Units or Air Ducts to Inactivate Airborne Microorganisms.
6. Burkhead, R. 2018. Presentation to ASHRAE SSPC 52.2 on Side Duct Addition to a Chamber for testing duct-mounted devices' influence on in-room air.
7. ISO 2013. Standard 10121-2:2013 Test methods for assessing the performance of gas-phase air cleaning media and devices for general ventilation – Part 2: Gas-phase air cleaning devices (GPACD).
8. ISO 2016. Standard 16890(parts -1, -2, -3, -4, -5): 2016: Air filters for general ventilation.
9. Y. Zhang, J. Mo, Y. Li, J. Sundell, P. Wargocki, J. Zhang, J.C. Little, R. Corsi, Q. Deng, M.H.K. Leung, L. Fang, W. Chen, J. Li, Y. Sun, Can commonly-used fan-driven air cleaning technologies improve indoor air quality? A literature review, Atmospheric Environment 45 (2011) 4329-4343, 10.1016/j.atmosenv.2011.05.041.
10. J.A. Siegel, Primary and secondary consequences of indoor air cleaners, Indoor Air 26 (2016) 88-96, 10.1111/ina.12194.
11. P. Blondeau, M.O. Abadie, A. Durand, P. Kaluzny, S. Parat, A. Ginestet, D. Pugnet, C. Tourreilles, T. Duforestel, Experimental characterization of the removal efficiency and energy effectiveness of central air cleaners, Energy and Built Environment 2 (2021) 1-12, 10.1016/j.enbenv.2020.05.004.