INVITATION TO SUBMIT A RESEARCH PROPOSAL ON AN ASHRAE RESEARCH PROJECT

1895-TRP, Effect of penetration through particle pre-filters on the performance of gas filters

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 2.3 Gaseous Air Contaminants and Gas Contaminant Removal Equipment
Co-sponsored by: TC 2.4 Particulate Air Contaminants and Particulate Contaminant Removal Equipment &
GPC 35 Method for Determining the Energy Consumption Caused by Air-Cleaning and Filtration Devices

Budget Range: $210,000 may be more or less as determined by value of proposal and competing proposals.

Scheduled Project Start Date: **September 1, 2025** or later.

All proposals must be received at ASHRAE Headquarters by 8:00 AM, EDT, May 30, 2025. 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: 1895-TRP, Effect of penetration through particle pre-filters on the performance of gas filters, 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
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For Administrative or Procedural Matters:
Manager Research & Technical Service
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Contractors intending to submit a proposal should notify, by mail or e-mail, the Research Administrator by May 1st, 2025 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. Hardcopy submissions are not permitted. **In all cases, the proposal must be submitted to ASHRAE by 8:00 AM, EDT, May 30, 2025.**
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)

Gas-phase filter installation usually specifies particle filtration upstream, typically MERV 8 or higher. This is intended to protect the gas filter from particles in the air stream causing a premature reduction in the performance of the gas-phase filter. Information on the performance of gas filters taking into account combined particle and gas loading is only sparsely in the technical literature (e.g. Hayashi, et. al.)

Currently ASHRAE and other organizations have well established performance test standards for testing individual particle or gas filters, for example, ASHRAE 145.2 for gas filters and ASHRAE 52.2 for particle filters. However, there is no test standard or generally accepted performance data for gas filters installed in series with a particle pre-filter, using both particles and gaseous contaminants to challenge the filters. The current recommendation for particle pre-filters, commonly MERV 8 as previously noted, is more out of convenience and common practice than one based on actual data. While it is generally accepted that a higher efficiency pre-filter will improve the life of the gas filter, there will also be a correspondingly higher pressure drop during HVAC operation. Without data quantifying the improvement that a better particle filter can make, it is impossible to recommend the optimum particle pre-filter to use. Gas-phase filter types may also react differently to particles, with some bulk sorbent beds likely to allow most particle to penetrate cleanly while others, especially with nonwoven media present, may capture a larger amount of these particles. It is also possible that filtration only of large particles is sufficient so that a MERV 8 could be a logical filter to use. Although the requirements may vary, such combination installations are common in multiple family residential, commercial and institutional built environments.

Justification and Value to ASHRAE

The research will help users maximize the life-time effectiveness of gas-phase filters by choosing optimal pre-filtration to provide better air quality, lifetime estimates, and energy savings. The research would also provide a better determination of pressure drop in the gas filter during loading of the pre-filter/gas-phase filter combination and assist in the choosing of the best particle pre-filter for the system. The research will also illuminate whether the choice of a pre-filter has a large or small impact on the performance of the gas-phase filter.

This will also advance the state of the art because most operating situations use a combination of filters instead of just a gas filter. The handbook chapters that would be affected are Chapter 29 – Air Cleaners for Particulate Contaminants, in the HVAC Systems and Equipment Handbook; and Chapter 47 – Control of Gaseous Indoor Air Contaminants, in the HVAC Applications Handbook.

Objectives

The objectives will be to determine the effect of particles on the performance loss (increased pressure drop from loaded particles or reduced gas loading capability) of gas-phase filters when used in combinations with various particle filters as the combination is loaded with particles and gases. To predict these criteria a model for the loading loss based on the data will be constructed. Measurements on at least three distinct MERV values for the particle pre-filters and at least 3 bed depths or pleated impregnated media will be used for the gas filters. At a minimum 2 particle concentrations and associated size distributions and 3 gas concentrations will be used. The measurements for particles should be number concentration only. Data will be taken on particle concentrations and size distributions as well as on gas concentrations upstream and downstream of each of the filters (both particle and gas). As of now there is no such data to quantify the operation of gas-phase filters.

While other related factors affecting the gas filters are not explicitly included, the research is expected to yield information on the effect of environmental factors such as humidity and temperature. Operational parameters such as operating pressure and flow will also be measured.

Present research outcome can be used by ASHRAE 52.2 and other relevant committees for possible inclusion in ASHRAE standards and handbooks.

Scope:

This project is divided into several tasks that feed into each other and will meet the needs of the deliverables cited in the next section.

Task 1. A comprehensive literature search for particle loading of gas-phase filters will be conducted. This will include the scientific as well as other technical literature. The literature will be summarized also in a graphical format noting gases used and gas filter types, types of pre-filters, and types, concentrations and size ranges of particles. Attempts will also be made to obtain information from manufacturers. This task is expected to be brief due to the anticipated lack of literature. It should overlap Task 2 but be completed before testing begins. A report on the literature should be made to the PMS either verbally, in email or as a draft report and include any details that would influence the choice of filters, dusts and gases in Task 2.

Task 2: A test matrix for the lab experiments must be prepared and approved of by the PMS before the majority of the testing has started. It is anticipated that some preliminary test runs may be needed before the final matrix is determined. Testing will be conducted on at least 2 types of filter configurations consisting of particle filters in series with gas filters, which may be packed bed or pleated type filters with an impregnated carbon. The particle filters should be MERV 8 and 14; and the gas-phase filters should be of at least 2 different bed depths. Both the particle and gas-phase filters should be of the same face area.

The tests will be conducted using a challenge stream with at least three particle concentrations and three gas concentrations; comprised of at least two gas categories say acid and VOC gases. The humidity and temperature should be held constant during the tests. These lab tests should be conducted in a 52.2/145.2 configured duct. There should be at least 4 conditions run on the different filter configurations. The measurements for the particles should provide number as well as mass concentrations. Measurements of penetration of the particle filter and particle loading of the gas filter should also be made. Measurement of both particle size distributions and gas concentrations should be made upstream of all filters, between the particle and gas filter and downstream of the gas filters. The measurements should also quantify the variance of the gas concentration with time.

The gas-phase conditions and pressure drops across both particle and gas filter should be measured in the following sequence: (1) Measure the gas removal capacity and pressure drop for the virgin carbon filters; (2) Load the system with a fixed amount of particle challenge (recording loading time, grams of material loaded, etc.); (3) At the end of the loading measure the pressure drops of both filters again; and also measure the gas removal capacity for the "loaded" carbon filter; (4) Measure pressure drops again previous to the next loading step. These tests should be repeat as a part of a series with different particle challenge loadings

At the end of a series of loadings, testing on a different set of pre-filters and new carbon filters should be conducted. The virgin gas filters should be measured at least once for each bed depth to get a baseline value for the filter. This would have to be replicated when testing with multiple gases.

Environmental measurements will be made for relative humidity and temperature. These measurements should be made at least every few minutes and should be made at the locations of particle and gas measurements - upstream, between, and downstream of the filters.

Task 3. Develop a model that is based on theory as well as the data from the measurements. This model is expected to ultimately extend the results beyond the filter combinations tested. This model should also be a function of time - to the point of the time increments measured in the testing.

Deliverables:
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 (1895-RP) at the end of the title in parentheses, e.g., (1895-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

Data is defined in General Condition VI, "DATA"

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

Funding Amount Range: $ 210,000

Professional Months – Principle Investigator 12, Professional Months – Total 20, Calendar Duration in Month 24

1. Literature study $30,000
2. Test setup and testing $120,000
3. Modeling $40,000
4. Report writing and meetings $20,000

Proposal Evaluation Criteria:

No.	Proposal Review Criterion	Weighting Factor
1	Do the proposers have access to the needed test duct	20%
2	Do proposers have knowledgeable people	20%
3	Do the proposers have access to the needed test equipment	20%
4	Do the proposers have access to the needed modeling capabilities	20%
5	does the proposed test plan appear to give the needed results	15%
6	Do proposers use students or interns	5%

Project Milestones:

No.	Major Project Completion Milestone	Deadline Month
1	Search for relevant publications and complete report. Meet with PMS at 3, 6 months	6
2	Develop test methodology and procedures. Perform preparation of equipment and duct system and perform check of operation. Meet with PMS at 9, 12 months	12
3	Run proposed tests. Meet with PMS at 15, 18 months	19
4	Complete development of model and check against experimental data	21
5	Complete all reports and have final meeting with PMS	24

References

1. Brown, RC. 1993. Air Filtration: An Integrated Approach to the Theory and Applications of Fibrous Filters.
2. ASHRAE. 2016a. Standard 62.1: Ventilation for Acceptable Indoor Air Quality.
3. ASHRAE. 2016b. Standard 62.2: Ventilation for Acceptable Indoor Air Quality in Residential Buildings.
4. ASHRAE. 2016c. Standard 145.2 “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.
5. ASHRAE. 2017. Standard 52.2: Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.
6. Toshiaki Hayashi, Tai Gyu Lee, Melynda Hazelwood, Elizabeth Hedrick & Pratim Biswas (2000) Characterization of Activated Carbon Fiber Filters for Pressure Drop, Submicrometer Particulate Collection, and Mercury Capture, Journal of the Air & Waste Management Association, 50:6, 922-929, DOI: 10.1080/10473289.2000.10464136