INVITATION TO SUBMIT A RESEARCH PROPOSAL ON AN ASHRAE RESEARCH PROJECT

1950-TRP, Effect of residential exhaust terminations on jet mechanics and resulting required intake separation

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 4.3, Ventilation Requirements & Infiltration
Co-sponsored by: SSPC 62.2, Ventilation and Acceptable Indoor Air Quality In Residential Buildings

Budget Range: $250,000 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 30th, 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: 1950-TRP, Effect of residential exhaust terminations on jet mechanics and resulting required intake separation , 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
Jordan Clark
The Ohio State University
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For Administrative or Procedural Matters:
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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)
Ventilation systems often include both exhausts and fresh air intakes that provide outdoor air through mechanical systems (fans) or passive air inlets. Many commercial buildings have rooftop exhaust systems, and dispersion from these systems has been studied extensively and continues to be refined (Zakeri and Clark, 2020, ASHRAE RP-1823, ASHRAE RP-1835). However, residential and some commercial exhaust jet mechanics are quite different in that they are much smaller flow rates, are often located on the walls of homes and multi-family buildings, and are often capped or louvered for architectural and water management reasons. Many multi-family buildings, especially new construction, contain several such exhausts, from the kitchen, bathroom, dryer, general unit ventilation, space or water heating combustion appliances, or other sources. It is becoming more common for each unit to have its own space conditioning and ventilation systems. The resulting increase in terminations in multifamily buildings creates tension between indoor air quality, energy efficiency, and overall resident health and safety, and so makes addressing this problem a critical need.

In the absence of a method for continuously sensing pollutants of interest at a building intake, engineers must provide for sufficient dilution of the exhaust air before it potentially reaches the location of neighboring air intakes in order to avoid the recirculation of contaminated air. A few methods for predicting this dilution currently exist. Well-established methods for predicting the concentration of Gaussian plumes emitted from the rooftops of buildings have existed for many years (ASHRAE 2019, Peterson and Ritter 2016, Rock et al. 1999) and continue to be improved (Zakeri Shahvari & Clark, 2020, ASHRAE 1835-RP). These prediction models are primarily for upward-direct jets of air and have been validated with high-momentum jets (10's of thousands of cubic feet per minute (cfm)), and their validity for the lower momentum jets associated with residential exhaust ventilation has been shown to be lacking (Kaes et al. 2022). If the inputs to these models are not known, ASHRAE Standard 62.1-2019 currently allows for prescriptive separation distances based simply on the categorization of the exhaust air to be used (Table 5-1 in the Standard). Similarly, ANSI/ASHRAE Standard 62.2-2019 provides prescriptive distances with exceptions. The source or rationale for these prescriptions is unclear.

Palmiste, Kurnitski, & Voll (2020) reviewed other published criteria designed to ensure adequate dilution between exhaust and inlet. They demonstrated a wide variety in resulting required separation distances and conclude that "evidence-based research is lacking for near-field pollutant dispersion and re-entrainment from an exhaust outlet located on an external wall." Kaes et al. (2022) conducted wind tunnel tests and computational fluid dynamics analyses of horizontally directed just from the side of a building and found that exhaust terminations geometry, orientation, relative elevations, and proximity to intakes have an outsized effect on resulting jet fluid mechanics and required separation. This work was confined to a only two termination geometries and a single location on a single building geometry. It is clear from the results of this study that a greater diversity of terminations and building locations and types must be characterized.

Furthermore, the current prescriptive requirement can be difficult to meet in practice, specifically in multifamily buildings with horizontally vented through-wall exhaust and air intake systems. This is likely true in mixed use buildings as well.

Justification and Value to ASHRAE
It is well established that a key component in energy efficient dwellings is a tight envelope and a dedicated ventilation system that can then control the air quality within the dwelling in a more predictable manner than occurs in leaky dwellings. In order to use these dedicated ventilation systems and inspire confidence in residents and builders, they must provide acceptable air quality, which starts with bringing in acceptable ventilation air from outdoors. Many multifamily units are installing "unitary ventilation" systems with an outdoor air intake for each dwelling unit, to meet a new requirement in 62.2-2022 which requires supply or balanced ventilation (to ensure a dedicated source of outdoor air). And many single-family and multifamily units are moving to heat recovery ventilators (HRVs) for efficient ventilation. In practice this requires placing two holes in the side of a unit, one for intake and one for exhaust. These holes may exist in a small area of wall that already has several holes for, for example, range hood exhaust, toilet exhaust, etc. as shown in the Figure: The distance between these holes is governed by minimum separation criteria in relevant Standards. The minimum separation distance has become a design constraint for multifamily units due to wall space constraints, and add costs for both single-family and multifamily units. Without both penetrations, balanced ventilation with a HRV is not possible. Balanced ventilation is desirable from an IAQ perspective, as it ensures air is not being drawn from neighboring spaces that may be

contaminated as with exhaust only ventilation. It is also desirable from an energy perspective, as more than half of heating or cooling energy used to condition the ventilation air can often be transferred from exhaust to supply, saving on the need for HVAC systems to provide it. The goal of this project is to identify engineering solutions that could provide good IAQ while reducing design constraints, by identifying whether the minimum separation distance could be reduced under certain design scenarios. This will also facilitate energy efficiency measures such as specification of HRVs and other energy-efficient ventilation strategies. For these reasons, this research is squarely aligned with ASHRAE's Initiative Area of "Indoor Environmental Quality" and enables and helps speed decarbonization efforts within ASHRAE and elsewhere. This research also contributes to ASHRAE's stated objectives of 1) Developing a standard that addresses air quality, thermal environment, light, sound, and vibration in an integrated way 2) Increased global adaptation of ASHRAE Standards

Objectives

Project Objectives

1) Identify the most commonly specified exhaust terminations for single-family and multi-family building exhausts.
2) Understand the mechanics of exhaust jets in the variety of conditions that may arise in single-family and multi-family buildings.
3) Provide guidance to designers and contractors in the form of required separation distances or some other method that is robust under the variety of conditions expected

Scope:

1. Termination Geometry List The contractor will first identify the types of exhaust terminations that are most commonly specified in practice for the single family and multi-family residential buildings, likely through survey of practitioners. Identification of this list will proceed in a three-step process:

a) The contractor will work with the PMS to identify a list of at least ten practitioners that include designers and builders and that work in a variety of geographical locations and building types. At a minimum, representation from the single-family home building industry and multi-family building industry shall be included. Through interviews with industry professionals, the contractor will identify a list of the most common and emerging exhaust termination geometries, expected to include 5-10 terminations but may be more or less if interviews justify this. Contractor will summarize interviews and include proposed list of termination geometries to analyze in a formal delivery submission at the end of this task.

b) The contractor will also identify the locations on the building and/or the configurations in which these terminations are most commonly specified for a variety of exhaust types. Exhaust types will include, at a minimum, dryers, toilet/bathroom, general ventilation, and combustion appliance flues. The buildings to be analyzed will include, at a minimum, single family homes, small multi-family such as duplexes, low-rise multi-family homes and high-rise multi-family homes.

c) Contractor will survey a wide range of industry professionals to determine which of the terminations and building configurations are most often specified. Results of the interviews in phase 1a will inform the questions asked in the survey. Contractor will work with the PMS to finalize the survey questions.

2) Experimental Approach The contractor will then propose an approach using accepted methods, which will likely include some combination of computation fluid dynamics (CFD) simulations, full-scale laboratory experiments, field tests, and/or scaled model analysis such as in a wind tunnel. Expected approach includes either full-scale tests on real buildings, mock-ups of full-scale terminations in a controlled environment such as a large environmental chamber or high-bay laboratory, or properly scaled physical models. Experimental approaches will likely include tracer gas analysis as well as either velocity measurements or visualization techniques. Method needs to be detailed enough to provide robust predictions of concentrations expected in most typical situations, but also an understanding of the mechanism by which resulting concentrations are created (e.g. basic understanding of jet movement and fluid mechanics). If CFD or scaled model approached are to be used, they must be sufficiently validated with either full scale laboratory experiments or field experiments done in the course of this project. A purely computational approach is not acceptable. Contractor will secure approval from the PMS for the experimental approach prior to conducting experimental work. At a minimum, the proposed experimental approach, whether used exclusively or used to validate computational models, must be sufficient to capture any and all fluid mechanics affecting the travel of jets from common terminations. Testing facilities must be large enough and isolated enough that fluid mechanics in the region of interest are not affected by forces outside the experimental setup. This can be accomplished by building a large chamber or using a large room dedicated to the experiments, or perhaps by constructing an isolation

box around terminations installed in real world applications. Contractor must detail how they will control environmental conditions as necessary.

3) Experimental Matrix The contractor will then develop an experimental matrix that will allow for an understanding of jet mechanics for the vast majority of terminations, locations, and weather conditions to be encountered in practices, keeping in mind that practices may change; thus a general approach is needed. The experimental matrix is expected to cover all situations expected to be encountered in practice, but every single situation need be analyzed directly if a sufficient statistical method for analyzing sparse factorial experimental matrices is developed and explained in a document submitted to the PMS. Contractor will secure PMS approval for the experimental matrix prior to conducting experimental work.

4) Preliminary Analysis and Prescription Proposal The contractor will conduct experiments for approximately 1/3 of the situations defined in the experimental matrix and analyze the results of these experiments in such a way that prescriptions can be readily integrated in standards, codes, and handbooks based on this analysis. The contractor will develop a means of specifying separation distances for the situations analyzed and submit to PMS for approval. This is expected to be in the form of an algorithm, table, flow chart or similar.

5) Completion of Experimental Analysis The contractor will then conduct remaining experiments and integrate in the prescription method, amending as needed if subsequent results show a need to do so.

6) Preliminary Report Contractor will submit to the PMS a preliminary report with all data collected and the final proposal for prescribing separation distances. 7) Final Report Upon approval from the PMS, report will be edited and format as necessary for a final report to be submitted to ASHRAE

<u>Deliverables</u>:
1a. Proposed list of industry professionals to be interviewed. Contractor will work with the PMS to identify a suitable list of industry professionals to be interviewed, spanning both single family and multi-family construction in several geographic regions of interest. Contractor will obtain approval of final list of professionals before moving to next phase of work.
1b. Summary of interviews Contractor will deliver informal summary of interviews to PMS, in the form of a Powerpoint presentation delivered either in person at a conference or online. Summary will include, at a minimum, trends discovered, list of terminations identified and any concerns uncovered.
1c. Proposed list of termination and building geometries to be analyzed Contractor will submit in written form a proposed list of terminations and building geometries to be analyzed, informed by interviews with professionals. Contractor will obtain approval of this list before moving to next phase of work.

2. Experimental/analysis approach proposal Contractor will submit a written to PMS and detailed proposal for analysis approach including overarching method, quality control protocols, expectations of uncertainties, and literature-based justification of method. Contractor will obtain approval of method from PMS before moving to next phase of work
3. Experimental matrix proposal Contractor will submit to PMS a proposal for the list of experiments to be conducted including geometries and terminations to be analyzed and proposal for tests of repeatability, robustness of results. Contractor will obtain approval of experimental matrix from PMS before moving to next phase of work
4. Preliminary analysis and prescription proposal At the completion of approximately 1/3 of data collection, the Principal Investigator shall prepare a preliminary report to be reviewed by the PMS to determine whether or not sufficient data has been obtained to adequately define the performance of each of the exhaust terminations. The contractor will develop a means of specifying separation distances for the situations analyzed and submit to PMS for approval. This is expected to be in the form of an algorithm, table, flow chart or similar.
5. Contractor will communicate informally with PMS on a regular basis while completing remaining experiments. Format of communications will be agreed upon by PI and PMS, but will likely involve quarterly online meetings and slide presentations.
6. At the completion of the experiments, contractor will provide a preliminary final report. The preliminary report should include:
a. A full description of the experimental or computational methods, including dimensional drawings and photographs as needed
b. A description of the instrumentation and applicable calibrations used throughout the project;
c. A listing of the exhaust terminations used in the assessment;
d. Data files of measured concentrations, flow rates, and velocities as needed to fully characterize performance;

e. Plots of the concentration/dilution at various downwind and crosswind locations for all geometries and terminations
f. Preliminary proposal for prescription of separation distances
g. Guidance on future research.

7. After the review and acceptance of the preliminary report by the PMS, the Principal Investigator prepare and submit a final report to the PMS addressing all comments received from the PMS.

8.The Principal Investigator should also produce at least one research paper to be submitted to the ASHRAE Manager of Research and Technical Services (MORTS).

9.The Principal Investigator should provide input into future updates of the ASHRAE Handbooks and Design Guides, as applicable to the findings of the research. This should include, but not be limited to ASHRAE Handbook – HVAC Applications Chapter 46 Building Air Intake and Exhaust Designs; ASHRAE Handbook –Fundamentals, Chapter 24 Air Flow Around Buildings;

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 (1950-RP) at the end of the title in parentheses, e.g., (1950-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

The level of effort is expected to include approximately 100 hours for experimental design; 150 hours for surveys; 600 hours for data collection; and 200 hours for analysis and preliminary reporting; and 80 hours for final reporting and technical paper preparation. Total project time should be 18-24 months. Budget: $250,000. May be greater or less depending on quality of proposal and approach.

Project Milestones:

No.	Major Project Completion Milestone	Deadline Month
1	Interview Summary	3
2	Terminations List	5
3	Experimental Matrix	6
4	Preliminary Analysis Report	12
5	Draft Final Report	20

Proposal Evaluation Criteria

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

No.	Proposal Review Criterion	Weighting Factor
1	Display of clear understanding of project goals and underlying fundamental processes	10%
2	Clear and concise project work plan with well-defined tasks and key milestones as well as a reasonable project schedule.	15%
3	Experience conducting related/similar experimental and/or computational work	30%

4	Past performance on ASHRAE Research Projects (no penalty for new investigators)	5%
	Experimental method as outlined in proposal	35%
	Opportunity for student involvement	5%

References

1. ASHRAE. Handbook of Fundamentals. (2019). Retrieved February 21, 2022, from https://www.ashrae.org/technical-resources/ashrae-handbook
2. Kaes, Jajal, Shahvari, Goebes, Ritter, Simon, Carter, Walker and Clark (2022) Dilution of airborne contaminants from through-wall exhausts located on the side of multi-family residential buildings. Building and Environment. Accepted
3. Palmiste, U., Kurnitski, J., & Voll, H. (2020). Design criteria for outdoor air intakes and exhaust air outlets located on an external wall. E3S Web of Conferences, 172, 09008. https://doi.org/10.1051/E3SCONF/202017209008
4. Petersen, R. and Ritter, J. 2016, Simplified Procedure for calculating Exhaust/Intake Separation Distances. ASHRAE Transactions. Vol. 122, Part z. pp. 46-62
5. Rock, B.A. and K.A. Moylan. Placement of ventilation air intakes for improved IAQ. ASHRAE Transactions. 105, 1–10 (1999)
6. Zakeri Shahvari, S., & Clark, J. D. (2020). Assessment and improvement of the 2019 ASHRAE handbook model for exhaust-to-intake dilution calculations for rooftop exhaust systems (ASHRAE 1823-RP), 26(4), 552–566. https://doi.org/10.1080/23744731.2020.1715252