INVITATION TO SUBMIT A RESEARCH PROPOSAL ON AN ASHRAE RESEARCH PROJECT

1918-TRP-R, The Verification of openings, the limitations of openings, air distribution and humidity conditions in Naturally Ventilated spaces to compliment Section 6.4 of ASHRAE Standard 62.1, (rebid)

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 4.03, Ventilation Requirements & Infiltration
Co-sponsored by: SSPC 62.1, Ventilation and Acceptable Indoor Air Quality

Budget Range: $ 300,000 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: 1*918-TRP-R, The Verification of openings, the limitations of openings, air distribution and humidity conditions in Naturally Ventilated spaces to compliment Section 6.4 of ASHRAE Standard 62.1*, 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
Duncan Phillips
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For Administrative or Procedural Matters:
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E-Mail: MORTS@ashrae.net

Contractors intending to submit a proposal should so notify, by mail or e-mail, the Manager of Research and Technical Services, (MORTS) by May 1,st, 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 and mvaughn@ashrae.org. Hardcopy submissions are not permitted. **In all cases, the proposal must be submitted to ASHRAE by 8:00 AM, EDT, May 30th, 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)

ASHRAE 62.1-2022 defines natural ventilation as "ventilation provided by thermal, wind, or diffusion effects through doors, windows, or other intentional openings in the building." The purpose of this Standard "… is to specify minimum ventilation rates and other measures intended to provide indoor air quality (IAQ) that is acceptable to human occupants and that minimizes adverse health effects." The standard applies to non-residential buildings. ASHRAE Standard 62.2 "… defines the roles and minimum requirements for mechanical and natural ventilation systems and the building envelope intended to provide acceptable indoor air quality (IAQ) in residential buildings." Both standards refer to natural ventilation, although only 62.1 provides detailed design guidance. The work here is to address design information in ASHRAE 62.1 only.

With respect to natural ventilation, ASHRAE Standard 62.1 (2022) includes the following:

6.1.3 Natural Ventilation Procedure. The prescriptive or engineered system design procedure presented in Section 6.4, in which outdoor air is provided through openings to the outdoors, shall be permitted to be used for any zone or portion of a zone in conjunction with mechanical ventilation systems in accordance with Section 6.4.

6.4 Natural Ventilation Procedure. Natural ventilation systems shall comply with the requirements of either Section 6.4.1 or 6.4.2. Designers shall provide interior air barriers, insulation, or other means that separate naturally ventilated spaces from mechanically cooled spaces to prevent high-dew-point outdoor air from coming into contact with mechanically cooled surfaces.

6.4.1.1 Ceiling Height. For ceilings that are parallel to the floor, the ceiling height (H) to be used in Sections 6.4.1.3 through 6.4.1.5 shall be the minimum ceiling height in the zone. For zones wherein ceiling height increases as distance from the ventilation increases, the ceiling height shall be the average height of the ceiling determined over a distance not greater than 6 m (20 ft) from the openings.

6.4.1.2 Floor Area to Be Ventilated. The naturally ventilated area in zones or portions of zones shall extend from the openings to a distance determined by Sections 6.4.1.3, 6.4.1.4, or 6.4.1.5. Openings shall meet the requirements of Section 6.4.1.6. For zones where ceilings are not parallel to the floor, the ceiling height shall be determined in accordance with Section 6.4.1.1.

6.4.1.3 Single Side Opening. For zones with openings on only one side of the zone, the naturally ventilated area shall extend to a distance not greater that two times the height of the ceiling from the openings.

6.4.1.4 Double Side Opening. For zones with openings on two opposite sides of the zone, the naturally ventilated area shall extend between the openings separated by a distance not greater than five times the height of the ceiling.

6.4.1.5 Corner Openings. For zones with openings on two adjacent sides of a zone, the naturally ventilated area shall extend to a distance not greater than five times the height of the ceiling along a line drawn between the outside edges of the two openings that are the farthest apart. Floor area outside that line shall comply with Section 6.4.1.3 as a zone having openings on only one side of the zone. Informative Note: "Floor area outside that line" refers to the remaining area of the zone that is not bounded by the walls that have the openings and the line drawn between the openings.

6.4.1.6 Location and Size of Openings. Zones or portions of zones to be naturally ventilated shall have a permanently open airflow path to openings directly connected to the outdoors. The minimum flow rate to the zone shall be determined in accordance with Section 6.2.1.1. This flow rate shall be used to determine the required openable area of openings, accounting only for buoyancy-driven flow. Wind-driven flow shall be used only where it can be demonstrated that the minimum flow rate is provided during all occupied hours. Openings shall be sized in accordance with Section 6.4.1.6.1 (Path A) or Section 6.4.1.6.2 (Path B). Informative Note: Permanently open airflow path refers to pathways that would allow airflow unimpeded by partitions, walls, furnishings, etc.

6.4.1.6.1 Sizing Openings—Path A. Where the zone is ventilated using a single opening or multiple single openings located at the same elevation, the openable area as a percent of the net occupiable floor area shall be greater than or equal to the value indicated in Table 6-7. Where the zone is ventilated using two openings located at different elevations or multiple pairs of such openings, the openable area as a percent of the net occupiable floor area shall be greater than or equal to the value indicated in Table 6-8. Where openings are obstructed by louvers or screens, the openable area shall be based on the net free area of the opening. Where interior zones, or portions of zones, without direct openings to the outdoors are ventilated through adjoining zones, the opening between zones shall be permanently unobstructed and have a free area of not less than twice the percent of occupiable floor area used to determine the opening size of adjacent exterior zones, or 25 ft2 (2.3 m2), whichever

is greater. Informative Note: Tables 6-7 and 6-8 are based solely on buoyancy-driven flow and have not been created to address thermal comfort

Table 6-7 Minimum Openable Areas: Single Openings [a]

$V_{bz}/A_z \leq$, (L/s)/m²	$V_{bz}/A_z \leq$, cfm/ft²	Total Openable Areas in Zone as a Percentage of A_z		
		$H_S/W_S \leq 0.1$	$0.1 < H_S/W_S \leq 1$	$H_S/W_S > 1$
1.0	0.2	4.0	2.9	2.5
2.0	0.4	6.9	5.0	4.4
3.0	0.6	9.5	6.9	6.0
4.0	0.8	12.0	8.7	7.6
5.5	1.1	15.5	11.2	9.8

where
V_{bz} = breathing zone outdoor airflow, per Table 6-1.
A_z = zone floor area, the net occupiable floor area of the ventilation zone.
W_S = aggregated width of all single outdoor openings located at the same elevation.
H_S = vertical dimension of the single opening or the least vertical dimension of the openings where there are multiple openings.

a. Volumetric airflow rates used to estimate required openable area are based on the following:
- Dry-air density of 0.075 lbda/ft³ (1.2 kgda/m³) at a barometric pressure of 1 atm (101.3 kPa) and an air temperature of 70°F (21°C)
- Temperature difference between indoors and outdoors of 1.8°F (1°C)
- Gravity constant of 32.2 ft/s² (9.81 m/s²)
- Window discharge coefficient of 0.6

Table 6-8 Minimum Openable Areas: Two Vertically Spaced Openings [a]

$V_{bz}/A_z \leq$, (L/s)/m²	$V_{bz}/A_z \leq$, cfm/ft²	Total Openable Areas in Zone as a Percentage of A_z					
		$H_{vs} \leq 8.2$ ft (2.5 m)		8.2 ft (2.5m) $< H_{vs} \leq 16.4$ ft (5 m)		16.4 ft (5 m) $< H_{vs}$	
		$A_s/A_l \leq 0.5$	$A_s/A_l > 0.5$	$A_s/A_l \leq 0.5$	$A_s/A_l > 0.5$	$A_s/A_l \leq 0.5$	$A_s/A_l > 0.5$
1.0	0.2	2.0	1.3	1.3	0.8	0.9	0.6
2.0	0.4	4.0	2.6	2.5	1.6	1.8	1.2
3.0	0.6	6.0	3.9	3.8	2.5	2.7	1.7
4.0	0.8	8.0	5.2	5.0	3.3	3.6	2.3
5.5	1.1	11.0	7.1	6.9	4.5	4.9	3.2

where
V_{bz} = breathing zone outdoor airflow, per Table 6-1.
A_z = zone floor area, the net occupiable floor area of the ventilation zone.
H_{vs} = vertical separation between the center of the top and bottom openings' free operable area; in case of multiple horizontally spaced pairs of openings, use shortest distance encountered.
A_s = openable area of smallest opening (top or bottom); in case of multiple horizontally spaced pairs of top-and-bottom openings, use aggregated areas.
A_l = openable area of largest opening (top or bottom); in case of multiple horizontally spaced pairs of top-and-bottom openings, use aggregated areas.

a. Volumetric airflow rates used to estimate required operable area are based on the following:
- Dry-air density of 0.075 lbda/ft³ (1.2 kgda/m³) at a barometric pressure of 1 atm (101.3 kPa) and an air temperature of 70°F (21°C)
- Temperature difference between indoors and outdoors of 1.8°F (1°C)
- Gravity constant of 32.2 ft/s² (9.81 m/s²)
- Window discharge coefficient of 0.6

6.4.1.6.1 Sizing Openings—Path B. The required openable area for a single zone shall be calculated using CIBSE AM10, Section 4.3

6.4.2 Engineered System Compliance Path. For an engineered natural ventilation system, the designer shall

a. determine hourly environmental conditions, including outdoor air dry-bulb temperature; dew-point temperature; outdoor concentration of contaminants, including PM2.5, PM10, and ozone where data are available; wind speed and direction; and internal heat gains during expected hours of natural ventilation operation.

b. determine the effect of pressure losses along natural ventilation airflow paths on the resulting flow rates, including inlet openings, air transfer grills, ventilation stacks, and outlet openings during representative conditions of expected natural ventilation system use.

c. quantify natural ventilation airflow rates of identified airflow paths accounting for wind induced

and thermally induced driving pressures during representative conditions of expected natural ventilation system use.

d. design to provide outdoor air in quantities sufficient to result in acceptable IAQ as established under Section 6.2.1.1 or 6.3 during representative conditions of expected natural ventilation system use.

6.4.3 Control and Accessibility. The means to open required openings shall be readily accessible to building occupants whenever the space is occupied. Controls shall be designed to coordinate operation of the natural and mechanical ventilation systems.

6.4.4 Documentation. Where the Natural Ventilation Procedure is used, the designer shall document the values and calculations that demonstrate conformance with the compliance path and the controls systems and sequences required for operation of the natural ventilation system, including coordination with mechanical ventilation systems. Where the Prescriptive Compliance Path is used for buildings located in an area where the national standard for one or more contaminants is exceeded, any design assumptions and calculations related to the impact on IAQ shall be included in the design documents.

ASHRAE 62.1 Section 6.4.1.6.2 refers the user to CIBSE AM10 Section 4.3. This is a document updated in 2005. Section 4.3 of that document, entitled "*Design procedures using envelope flow models*" includes sections on sizing openings for a range of scenarios from single sided isolated rooms driven through stack effect along (Cases 1 and 2) through to well-connected multi-roomed buildings exposed to stack effect and wind forces (example 4.3). The use of chimneys to increase flow rates / reduce open areas is also presented. Section 4.3 only addresses sizing the openings to achieve a desired flow rate. It does not address the air distribution within the space (e.g. the size of the interior zone that is naturally ventilated). This occurs in Section 2.4 from which the two following images have been copied.

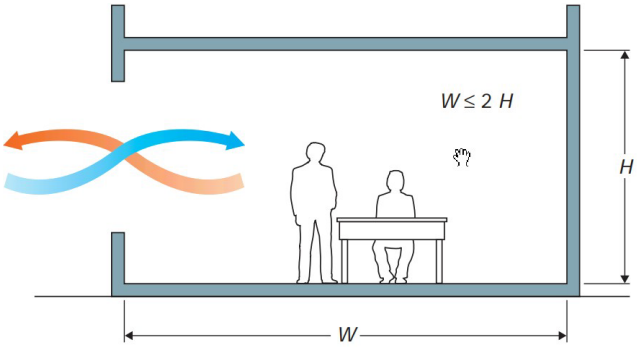

Figure 2.18 Single sided ventilation, single opening

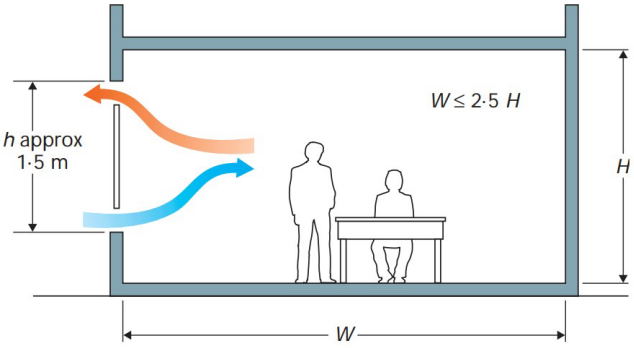

Figure 2.19 Single sided ventilation, double opening

Figure 1- Depth of Penetration of Outdoor Air into a Space Under Stack Effect Driven Natural Ventilation

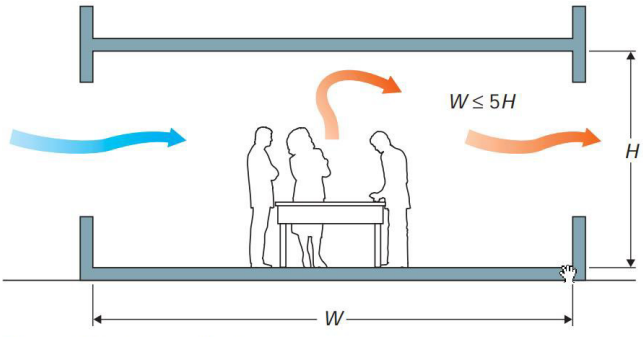

Figure 2.20 Cross ventilation

Figure 2 - Depth of Penetration of Outdoor Air into a Space for Cross-Ventilation

The information in Figure 1and Figure 2 is similar with that of Sections 6.4.1.3 and 6.4.1.4 of ASHRAE 62.1. By way of example, if a space has a 10 ft (3.3 m) ceiling, then 2H would be 20ft (6.6 m) and 5H would be 50 ft (16.5 m). Within these calculations, there is no indication that the ventilation effectiveness is constant within the zone theoretically ventilated. This means that Ez in ASHRAE 62.1 is not known. Prior efforts at reviewing the literature results in no specific derivation or calculations that support the distances (e.g. 5 x H and 2 x H) and sizes (H) shown in the standard. In fact, the CIBSE AM 10 documents say these distances and sizes are "Rules of Thumb". An explanation here is that AM10 refers to BRE Digest 399 which in turn refers to equations in BS5925 but that no link is made between the theory and the rules of thumb. It is this void that this research work is to address along with the determination in ASHRAE 62.2 that openings in the perimeter of 4% of the floor area is suitable for natural ventilation. It is acknowledged that ASHRAE has a Natural Ventilation Design Guide, however one of the authors of that document was an original author of t his workstatement. The issues addressed here are not resolved in that Design Guide. A final aspect of wind-driven natural ventilation that is not well addressed, is that the type of opening influences the amount of air that enters the space along with the oncoming wind conditions. A casement window that opens into the wind will generate a different pressure at the window opening than a window that slides horizontally. This workstatement is not intending to address this issue. That will be done through another piece of work. For the work here, wind-driven cross ventilation will be defined by the pressure coefficient at the opening, which can be achieved through different combinations of wind opening types and wind patterns around buildings.

Justification

ASHRAE 62.1 directly cites natural ventilation as an option for meeting the airflow needs for acceptable ventilation. Standard 55 describes a means to use an adaptive model of thermal comfort in spaces that have occupant controlled natural ventilation. The 62.1 design path provided presents parameters that are not well anchored by research data. it is not clear whether the definition of acceptable natural ventilation for air flow is consistent with that for comfort. This work will remedy that.

Objective

The objective of this research is to demonstrate the validity of common rules of thumb for natural ventilation and the possible limitations on ventilation distribution within a naturally ventilated space. The work is limited so that the exterior of the building is removed as a variable through use of pressure coefficients at the inlet along with inlet pressure loss coefficients. The specific outcomes of this work will include:

- Test and verification that the use of the room height (H), as described in ASHRAE 62.1, Section 6.4.1.1 is appropriate.
- Confirm or revise the 2xH depth to ensure it is appropriate for single sided ventilation per Section 6.4.1.3.
- Confirm or revise the 5xH depth to ensure it is appropriate for double sided openings per 6.4.1.4.
- A description of how the space is defined that is naturally ventilated within any given zone (e.g. meeting target conditions 80% of the time).

Scope

There will be five stages to this work:

1) Literature review and diagnosis of existing knowledge including guidelines and codes. One outcome from this work will be a proposed definition of when a space is considered to be naturally ventilated.
2) Experimental study of stack effect driven, single sided, natural ventilation.
3) Experimental study of wind driven natural ventilation.
4) Parametric study of stack effect driven natural ventilation including verification using data from stage 2.
5) Parametric study of wind driven, double sided, natural ventilation including verification using data from stage 3.

It is not the intention of this work statement to define all of the parameters and testing: the respondents, through their proposal, will demonstrate their understanding of the work through a detailed description of their process. Further, it is anticipated that most of the work will need to be numerical modelling – specifically CFD. However, some verification of the procedures through test data is required. CFD modelling will be required because the outcomes of

this work are flow patterns and depth of penetration, not bulk properties. Bulk properties would be generated through network flow modelling, but these will not address the issues of concern with this work.

Stage1: A literature review will be conducted the seeks to find the source of the parameters defined earlier (e.g. 2xH, 5xH, etc.) through either documented scientific literature, verifiable personal correspondence or other. Information regarding how these parameters entered the development of codes and standards such as ASHRAE 62.1 and CIBSE AM10 should be included. Finally, any test data for the scenarios described in CIBSE AM10 should be identified and collated. If acceptable experimental data is discovered that meets the requirements of Stages 2 and / or Stage 3, this will come out here.

The literature review stage will also develop a description or definition of the criteria(ion) for what constitutes "viable" / "acceptable" natural ventilation. This definition needs to acknowledge that the driving force(s) for natural ventilation vary and hence so too will the ventilation rate. Hence the depth into the zone will vary. This definition should be sensitive to both IEQ and thermal comfort. The team will present a recommendation to the PMS for this definition and is to be agreed upon before much substantive work is conducted in subsequent stages.

Stage 2: The experimental study of stack effect driven, single sided natural ventilation is intended to develop well controlled data to validate the work in Stage 4. The data collected here can be generated either through a literature review, or measurements in a well-controlled test environment or through a real building. However, the key here is that parameters such as temperature differences and depth of penetration are measurable and repeatable and that the study is isolated from wind impacts. Different values of opening height and room height would ideally be included as well as different temperature differences.

Stage 3: The experimental study of wind driven natural ventilation is also intended to develop well-controlled data to validate subsequent numerical simulations – Stage 5. Once again, the data collected here can be generated either through a literature review, or measurements in a well-controlled test environment or through a real building. However, the key here is that parameters such as wind pressures at the inlet and outlet and depth of penetration are measurable and repeatable and that the study is isolated from temperature considerations. Different wind pressures, ceiling height and room depths should be included. At this time, the type of inlet is not up for study, hence the controlled variable ought to be the wind pressure at the inlet and outlets regardless of the opening type.

Stage 4: This stage will include both a validation of the numerical modelling using the data from Stage 2 as well as a parametric study of stack effect driven natural ventilation. The parametric analysis is to be defined by the respondent. The details should include information on:
- The range in temperature differences to be addressed – including justification;
- The range of ceiling heights;
- The inlet parameters (both for single inlet and multiple inlets) including size / shape, vertical separation distances and pressure loss parameters through them; and, 12
- The room depth. The outcomes of this work shall include:
- Verification of the dimension H as the driving parameter, or selection of another;
- Confirmation of the distance 2xH as the penetration distance for single sided, stack effect driven natural ventilation, or selection of another;
- Demonstration of ventilation effectiveness / Ez within the naturally ventilated space; and
- Evaluation of the range of temperature differences, and sizes of natural ventilation openings over which these apply.

Note that the temperature differences used should be those that would be reasonable within a naturally ventilated environment. The researchers will demonstrate, through use of ASHRAE climate data records, how frequently one would be able to naturally ventilated a 'typical room' (to be defined by the researchers) in each of the seven climate zones in North America. An EPW file for a location in each of the climate zones will be selected, along with the deltaT values used in the work, to demonstrate the frequency of viable natural ventilation.

Stage 5: This stage will include both a validation of the numerical modelling using the data from Stage 3, as well as a parametric study of wind driven, double sided, natural ventilation. The parametric analysis is to be defined by the respondent. The details should include information on:
- The range of wind pressures to be used – including justification;

- The range of ceiling heights;
- The inlet parameters including size / shape, location; and,
- Depth of the room;

The outcomes of this work shall include:
- Verification of the dimension H as the driving parameter, or selection of another;
- Confirmation of the distance 5xH as the penetration distance for double sided wind driven natural ventilation, or selection of another;
- Demonstration of ventilation effectiveness / Ez within the naturally ventilated space; and
- Evaluation of the range of wind pressure differences and sizes of natural ventilation openings over which these apply.

Note that any use of the term "wind pressure" here actually means wind pressure difference as that is the ultimate driving force. The wind driving forces used in this work should reference commonly occurring values in the built environment. The researchers should include a table citing the wind pressure differences in the research and the different means through which these values could appear in the built environment. This might mean a diagram showing an oncoming wind speed along with the wind pressure coefficients around a building that would result in the wind pressure difference used in the analysis.

The parametric study details in Stages 4 and 5 should also be able to shed light on the validity of the 4% rule described in ASHRAE 62.2.

Deliverables:
Final deliverables will include:

a. A guidance document to ASHRAE Standards 62.1 and 62.2 shall be provided that gives mathematically substantiated space depth and opening sizes that designers can use to successfully design naturally ventilated spaces and can be incorporated in ASHRAE Standard 62.1 & 62.2 as appropriate, for compliance.
b. A final report that contains the interim reports (described below) assembled into a logical single document.
c. A technical paper submitted to ASHRAE for presentation at either a summer or winter meeting.
d. A paper for publication in the ASHRAE Journal (voluntary).
e. A project synopsis (see below).

Results will include investigations into the 2H and 5H dimensions along with justification of the parametric dimension to be used in H should not be the room height.
The following minimum results shall be provided:

- One sided opening
- Two sided openings
- Stack effect driven ventilation.
- Wind driven ventilation.

Results are to be provided that show the frequency of viable stack effect driven natural ventilation for a city in each of the seven climate zones defined by ASHRAE and the IECC. This should include a check on the impacts of temperature and humidity within the space on thermal comfort. For the purposes of humidity, the researchers can assume a constant absolute humidity – e.g. no sources or sinks in the space.

The wind pressure differences used in the work are to be converted into examples of how they might manifest in the built environment.

Ventilation efficiencies are to be determined and presented within the reports.

Interim Deliverables:

During this effort, the contractor shall provide a proposed guidance document to substantiate Section 6.4 of ASHRAE Standard 62.1 and Section 6.5 of ASHRAE 62.2 for review by a project monitoring subcommittee (PMS)

established by ASHRAE. The review committee shall approve each document listed below in a timely manner prior to initiation of the succeeding document. These documents shall be delivered to the committee according to a schedule that must be included in the contractor's proposal.

1. An outline (detailed table of contents) of the proposed interim and final report submittals, including the guidance document. This is due within three months of award of contract.
2. A report summarizing the literature review – Stage 1.
3. A report summarizing the experimental work for the stack effect driven natural ventilation – Stage 2.
4. A report summarizing the experimental work for the wind driven natural ventilation – Stage 3.
5. A report summarizing the results of the numerical work described as Stage 4.
6. A report summarizing the results of the numerical work described as Stage 5.
7. Quarterly progress reports as well as at ASHRAE Annual and Winter Conferences.
8. A 90% complete draft of the proposed guidance document.

The interim reports should include the details described above in the sections on scope / technical approach and final deliverables.

All final deliverables must comply with ASHRAE Author Guidelines.

- Printer-Ready File
- Complete document files as noted below (Native Files)
- Suggested Back cover text.
- Suggested Front cover design.
- Appropriate front matter, including a correct table of contents.
- Text and appendices (exactly corresponding to the hard copy format) in an electronic format specified by ASHRAE Publications.
- Illustrations, tables, and all other artwork in camera-ready form (as specified in ASHRAE Author's Manual)
- All other materials necessary for a complete publication
- Letters of permission, for document, any copyrighted material, and all artwork

All of the text (including front matter, table of contents, any back matter such as an index, etc.) in Word. The Word file(s) must be free of conditional text, line numbers, track changes, and cross references.

The document must be in dual units.

Tables must be noted in the text (where they go) and numbered consecutively as they appear in the text. All tables must be Word or Excel tables they CANNOT be unalterable images of tables. All table titles should be descriptive but concise, and each column should be labeled with a heading and include units of measurement and other necessary qualifying information; dual units must be provided for all measurements. In creating tables, the authors should use only 1 point (0.014 in. [0.355mm]) or thicker lines. Figures must be noted in the text (where they go) and numbered consecutively as they appear in the text, but the actual figures themselves must be provided to ASHRAE as individual TIF or EPS files in Grayscale mode saved at high resolution (600 dpi or greater) and at least 4 in. size or greater. All figure files should be clearly labeled. In creating figures, the authors should use only 1 point (0.014 in. [0.35 mm]) or thicker lines—smaller lines will not reproduce well. The figures will be reproduced in black and white, so they should employ patterns or shapes to distinguish sections instead of coloring and shading. Each figure should have a brief legend or descriptive labels, as appropriate. Any text included in a figure (except the figure caption) should be embedded as part of the image file and not contained in a separate text box that is not part of the image file; captions should NOT be part of the image file.

All figures should be provided in dual units, like the text. Providing two graphics for each figure – one in I-P units and one in SI units – is acceptable; such figures must be supplied as one TIF or EPS file with both graphics included in the one image file.

Works cited in the text must have reference list entries in footnotes or a references section at the end of the document. ASHRAE uses the author-date citation method.

The authors of the text would need to obtain permission to reprint any images that they want to use from another source; ASHRAE will not obtain permissions for them.
The text and figures must comply with ASHRAE's commercialism policy:
(http://www.ashrae.org/publications/detail/14689.

Final submission of the completed book must include.

- a USB with the manuscript in Word and the figure TIFs or EPSs,
- a printout of the complete manuscript (text, tables, and figures), and contact information for the authors in case we have questions as we edit/lay out the book.

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 (1918-RP) at the end of the title in parentheses, e.g., (1918-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 anticipated level of effort is $300,000 USD over 2.5 years.

Other Information for Bidders
If the bidders are aware of data that is an adequate replacement of one or both of the experimental phases, please provide references and include an option to bypass the experimental phase. However, we recommend bidding on the complete work statement as laid out here even if you believe there is acceptable data already existing for validation of the CFD.

Proposal Evaluation Criteria:

No.	Proposal Review Criterion	Weighting Factor
	Understanding of technical issues – as demonstrated through proposed technical scope.	**45%**
	Background of primary investigator and team.	**15%**
	Relevant experimental experience of team.	**15%**
	Relevant CFD experience of team.	**15%**
	Laboratory / CFD facilities.	**10%**

Project Milestones:

No.	Major Project Completion Milestone	Deadline Month

	Draft outlines	**3**
	Stage 1	**4**
	Stage 2	**9**
	Stage 3	**13**
	Stage 4	**17**
	Stage 5	**21**
	Draft Report / Research Manuscript for presentation	**24**

References

1. ASHRAE (2022), *Ventilation and Acceptable Indoor Air Quality*, ANSI / ASHRAE Standard 62.1.
2. ASHRAE (2022), *Ventilation and Acceptable Indoor Air Quality in Residential Buildings*, ANSI / ASHRAE Standard 62.2.
3. Simmonds, Peter & McConahey, Erin (2021), *ASHRAE Design Guide For Natural Ventilation*, Atlanta, GA: ASHRAE
4. CIBSE (2005), AM10 Natural Ventilation in Non-Domestic Buildings, Corrected 2014.