

INVITATION TO SUBMIT A RESEARCH PROPOSAL ON AN ASHRAE RESEARCH PROJECT

1956-TRP, Guidance for Compact CFD Modeling of Thin Flow Resistances

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 4.10 – Indoor Environmental Modelling,

Co-sponsored by: TC 9.9, Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment

Budget Range: \$225,000 may be more or less as determined by value of proposal and competing proposals.

Scheduled Project Start Date: **April 1, 2027**, or later.

All proposals must be received at ASHRAE Headquarters by 8:00 AM, EST, Tuesday, December 15th, 2026. NO EXCEPTIONS. 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: 1956-TRP, Guidance for Compact CFD Modeling of Thin Flow Resistances, 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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Contractors who plan to submit a proposal must notify the Manager of Research and Technical Services (MORTS) via email by December 1st. This will ensure that they receive any late or additional information regarding the RFP before the bid due date. The deadline for submitting technical questions is also Tuesday, December 1st, 2026.

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 shammerling@ashrae.org.

In all cases, the proposal must be submitted to ASHRAE by 8:00 AM, EST, Tuesday, December 15th, 2026.

NO EXCEPTIONS.

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)

CFD is increasingly used to analyze airflow in general buildings and data centers, driven by improved algorithms, increased computing power, and widespread adoption of CFD-based digital-twin platforms that bring sophisticated airflow modeling to a broader, less-specialized user base. This continued proliferation requires standardized, validated guidelines to ensure consistent and reliable results across all applications.

Modeling the pore-scale geometry of thin flow resistances—such as porous plates, perforated tiles, and grilles—is impractical for room-level simulations due to excessive computational cost and potential impacts on numerical robustness. Instead, compact models are used to reproduce only the essential flow physics downstream of these resistances in practical CFD applications.

Previous ASHRAE projects have laid the foundation for compact modeling of thin resistances.

- ASHRAE RP-1009 demonstrated that compact representations of grilles should distribute flow uniformly over the grille face and include a downstream momentum source to mimic the entrainment and jet-induced pressure fields that arise from unresolved pore-scale jets.
- ASHRAE RP-1675 extended compact modeling concepts to perforated floor tiles in data-center environments, recommending the use of: (1) the correct unrecoverable pressure drop (loss coefficient), (2) straightening of airflow (eliminating tangential velocity components at discharge), and (3) a downstream momentum source, with appropriate correction to the loss coefficient when the resistance lies wholly inside the domain.

Additional studies have expanded these insights.

- Hu et al. (2021) applied compact modeling approaches for thin resistances to data-center applications, reinforcing the need for momentum addition and straightening.
- VanGilder et al. (2022) showed that detailed CFD—explicitly resolving pore geometry—more accurately predicts resistance characteristics than handbook correlations or manufacturer data and captures the high-velocity jets and low-pressure regions downstream that drive entrainment effects. Thus, detailed CFD is often the best starting point for developing compact models for more practical applications of CFD and digital twins.

The handbook correlations of Idelchik (2003) and Fried & Idelchik (1989) remain widely used for estimating pressure-drop coefficients for thin resistances but offer no guidance on downstream momentum or straightening.

Despite the body of existing work, major gaps remain. Neither RP-1009 nor RP-1675 defined:

- the strength, thickness, or spatial distribution of the downstream momentum source;
- how these choices vary with CFD grid scheme (staggered vs. collocated) or cell size;
- nor a quantitative model for straightening behavior across open-area ratios, including where the transition occurs from strong straightening (low open area) to negligible straightening (high open area).

These unresolved issues limit the accuracy, consistency, and general applicability of compact models used in both general-purpose CFD and specialized digital-twin platforms.

This project addresses these gaps by using detailed CFD as the primary benchmark, supported by limited targeted experiments, to develop quantitative, practical, and implementable compact-modeling guidelines for both momentum addition and straightening behavior. The results will fill long-standing holes in current ASHRAE guidance and support consistent CFD practice across a widening user base.

Justification and Value to ASHRAE

Accurate and efficient airflow prediction is essential for designing and operating safe, healthy, and energy-efficient built environments. As CFD becomes more widely used across general buildings and data centers, including its increasing deployment within CFD-based digital-twin platforms, the need for standardized, validated compact modeling guidance is essential. Without such guidance, results depend heavily on user expertise, software defaults, and solver implementation details, leading to inconsistent predictions and limited confidence in CFD-supported design decisions.

Thin flow resistances—porous plates, perforated tiles, grilles—appear in nearly all indoor-airflow applications and strongly affect downstream ventilation behavior. Yet existing ASHRAE guidance does not define how to model the downstream momentum addition or straightening behavior required for accurate compact representations. These

omissions undermine the reliability of CFD in key ASHRAE applications, including ventilation design, data-center thermal management, contamination control, and indoor environmental quality.

This project provides substantial value to ASHRAE by delivering quantitative, implementable, and software-agnostic guidance for compact modeling of thin resistances. By using detailed CFD as the benchmark—shown in recent ASHRAE research to be more accurate than empirical correlations for determining resistance characteristics—the proposed work ensures that compact models reflect correct physics and remain robust across grid schemes and solver types.

The resulting methodology will:

- improve the consistency and reliability of CFD results generated by ASHRAE members and practitioners,
- reduce modeling uncertainties that currently require expert knowledge to manage,
- support ASHRAE’s mission to develop high-quality design tools and best-practice guidance for the built environment, and
- directly inform ASHRAE Handbooks, CFD vendor implementations, and digital-twin platforms, enabling more accurate modeling for a broad and expanding user base.

By filling long-standing gaps not addressed in RP-1009, RP-1675, this project strengthens ASHRAE’s leadership in CFD modeling standards and ensures that airflow simulations used in practice remain both accurate and practical, supporting better design outcomes across HVAC applications.

Objectives

The overarching objective of this project is to develop quantitative, validated, and practically implementable compact-modeling guidelines for thin flow resistances suitable for use across general-purpose CFD tools and application-specific digital-twin platforms.

To achieve this overarching objective, the project will address the following specific objectives:

- Determine the downstream momentum-source characteristics—including strength, axial thickness, and spatial distribution—that best reproduce the detailed-CFD benchmark flow fields.
- Quantify straightening behavior as a continuous function of open-area ratio and pore geometry and establish how this behavior should be represented in compact models.
- Develop practical, solver-agnostic implementation guidance for applying these compact models in CFD tools, including discussion of implementation trade-offs (e.g., grid-scheme sensitivity, resolution requirements, and interactions with loss-coefficient specification).
- Evaluate model behavior across representative CFD environments to confirm robustness and consistency relative to the detailed-CFD benchmarks and application-scale scenarios.

Scope:

The contractor shall develop compact-modeling guidance for thin flow resistances using detailed CFD as the primary benchmark, supported by limited experimental spot-checks. The purpose is to determine (1) the downstream momentum-source strength, thickness, and distribution needed for compact models and (2) the straightening behavior as a function of open-area ratio and geometry. The following technical approach shall be used.

1. Required CFD Capabilities

The contractor must use CFD tools capable of:

- Performing detailed CFD with explicit pore geometry and sufficient mesh resolution to capture pore-scale jet formation, entrainment, and pressure-field structure, consistent with prior ASHRAE research showing sensitivity of detailed CFD to grid quality and pore-scale resolution.
- Implementing compact models, including porous-jump or equivalent resistance models, volumetric momentum sources, and velocity-component manipulation needed to model straightening.
- Producing solver-independent benchmark datasets suitable for validating compact-model predictions across a range of CFD environments.

Note: Grid-scheme considerations (staggered vs. collocated) primarily affect compact-model implementation, not detailed CFD. Sensitivity to solver architecture will be addressed during compact-model development and validation (Sections 5–6).

2. Thin Resistances to Be Studied (Minimum)

- The contractor shall evaluate:
- Porous plates with uniformly distributed openings at three representative open-area ratios:
 - Low (~15–25%),
 - Medium (~35–40%),
 - High (~55–60%).
- One commercial HVAC grille.
- One commercial perforated floor tile.

The proposal shall identify the HVAC grille and perforated floor tile proposed for evaluation and justify their selection.

These represent the range of geometries found in general buildings and data centers and extend the foundation established by prior ASHRAE projects such as RP-1009 and RP-1675.

3. Detailed-CFD Benchmarks

The contractor shall generate detailed-CFD simulations for each thin flow resistance to establish the benchmark datasets used throughout this project. These simulations constitute the authoritative “ground-truth” reference against which compact-model formulations will be developed and later validated.

The detailed-CFD benchmarks will be validated through experimental “spot checks.” The contractor may conduct detailed-CFD modeling and experimental measurements iteratively until acceptable agreement is reached.

For each resistance, the contractor shall perform detailed-CFD simulations in both of the following environments:

- Wind-Tunnel Environment (Frictionless Walls). Used primarily to obtain unrecoverable pressure drop across the resistance under controlled, uniform upstream conditions.
- Open-Discharge Environment (Free-Jet Development). Used to observe downstream jet structure, entrainment, recirculation, and overall flow-pattern development representative of real HVAC/data-center environments.

For each resistance in each environment, the contractor shall simulate two or more flow rates, generally representing a “low” and a “high” operating condition.

In addition, for each resistance, the contractor shall perform additional detailed-CFD simulations with non-normal (angled-incidence) upstream flow to characterize the resistance’s straightening behavior. These angled-inflow cases serve as benchmark data for compact-model straightening and require no additional experimental validation, as the detailed-CFD models will already have been spot-checked for physical fidelity.

Note (guidance only): Prior research has shown that approximately 12–16 cells across the pore width are typically required to achieve grid independence for detailed-CFD simulations.

4. Experimental Spot-Check Validation (Minimum)

The purpose of the experimental spot-checks is to confirm that the detailed-CFD results reproduce the correct physical trends and flow-pattern characteristics; they are not intended to define compact-model parameters directly. The experimental spot-checks correspond only to the detailed-CFD cases with normal-incidence upstream flow; the angled-inflow detailed-CFD cases introduced in Section 3 do not require additional experimental validation.

The contractor shall conduct experimental measurements for one porous plate from each open-area category (low, medium, high) and one commercial resistance (HVAC grille or perforated floor tile). Each resistance shall be tested at one airflow rate, selected in coordination with the PMS after initial review of the detailed-CFD results.

The experimental setup shall include:

- A controlled upstream flow environment capable of providing a stable, approximately uniform approach flow to the resistance, with the primary purpose of validating the unrecoverable pressure drop predicted by the detailed-CFD wind-tunnel benchmarks.
- A downstream discharge region open to the surrounding environment, supporting comparison with the open-discharge detailed-CFD benchmarks and enabling observation of jet development, entrainment, and general flow-pattern behavior. (Straightening behavior is not evaluated experimentally).
- Instrumentation appropriate for measuring velocity and pressure fields using any established technique routinely employed in HVAC and indoor-airflow studies.
- Steady, isothermal test conditions and geometry that does not restrict downstream jet development.

The contractor shall compare the experimental observations with the corresponding detailed-CFD simulations. If discrepancies arise, the contractor may iteratively revisit the experimental setup and detailed-CFD configurations until the results are in acceptable agreement. The spot-check validation is considered complete once the experiments confirm the fidelity of the detailed-CFD benchmark cases for the selected resistances and flow rates.

5. Compact-Model Development

Momentum-Source Specification

Using detailed CFD results, the contractor shall determine:

- The strength, axial thickness, and distribution (e.g., uniform, decaying) of the downstream momentum source.
- Practical relationships for translating pore-scale physics into compact-model parameters.
- Appropriate adjustments to the loss coefficient when a downstream momentum source is added in a finite-thickness region within the CFD domain (adding downstream momentum alters the effective pressure drop and requires compensation).

Straightening Behavior

The contractor shall:

- Quantify straightening as a function of open-area ratio and geometry.

Develop a continuous straightening factor (0–1) or equivalent formulation to avoid abrupt transitions between low- and high-open-area resistances.

- Determine the onset and degree of straightening and how it depends on pore geometry and upstream flow.

Because straightening cannot be evaluated under uniform, normal-incidence flow, the contractor shall propose additional detailed-CFD test environments involving angled-inflow conditions for use in compact-model validation (see Section 6).

Grid-Scheme Sensitivity (Compact Model Only)

The contractor shall:

- Evaluate how compact-model implementation behaves in solvers with differing grid schemes (staggered vs. collocated).
- Provide guidance for robust implementation across common solver architectures.

6. Compact-Model Validation

The contractor shall validate the compact-model formulations by demonstrating that they reproduce the flow-physics characteristics shown in the applicable detailed-CFD simulations. Validation shall address both momentum-addition behavior and straightening behavior using the appropriate detailed-CFD scenarios.

For each thin resistance, the contractor shall create compact-model simulations corresponding to every normal-incidence detailed-CFD benchmark case—that is, each wind-tunnel and open-discharge scenario and each flow rate defined in Section 3. The compact-model results shall be compared directly to the detailed-CFD results to

evaluate agreement in unrecoverable pressure drop, downstream jet trajectory and spread, entrainment and recirculation patterns, and general flow-pattern development.

To evaluate straightening behavior, the contractor shall perform additional detailed-CFD simulations in which the flow approaches the resistance at non-normal (angled) incidence. The contractor may propose one or more suitable computational environments for these angled-inflow cases, subject to PMS approval. Each angled-inflow detailed-CFD case shall be paired with a corresponding compact-model simulation to assess how well the compact model represents downstream directional behavior under non-uniform approach flow. No experimental validation is required for these angled-inflow cases.

In addition, the contractor shall apply one or more compact-model formulations in a representative indoor-airflow environment—such as a small raised-floor data center or a small, occupied space—to demonstrate that the compact models perform robustly in realistic application-scale scenarios. For each such environment, a compact-model simulation shall be compared against a corresponding detailed-CFD simulation using identical boundary conditions and geometry.

The compact-model validation is considered complete once the contractor demonstrates, to the satisfaction of the PMS, that the compact models reproduce the key flow-field characteristics of the detailed-CFD simulations for all normal-incidence and angled-inflow cases and behave consistently in at least one application-scale scenario.

7. Contractor–PMS Communication

To ensure efficient progress and high-quality technical outcomes, the contractor shall maintain close coordination with the Project Monitoring Subcommittee (PMS). At a minimum, the contractor shall:

- Participate in monthly virtual progress meetings,
- Submit a detailed CFD and experimental plan for PMS approval by Month 3, and
- Provide all milestone deliverables as defined below.

In addition, the contractor is encouraged to engage in more frequent, informal technical exchanges with the PMS at key decision points—such as intermediate data reviews, interpretation of benchmark results, or compact-model formulation discussions—to ensure alignment with project goals and to leverage PMS expertise effectively.

Interim Deliverables:

Deliverables (with PMS checkpoints and acceptance)

The contractor shall provide the following deliverables. Each interim deliverable is a PMS checkpoint and must be accepted by the PMS prior to proceeding to the next phase.

Month 3 — CFD & Experimental Test Plan (PMS approval required)

The plan shall include:

- Finalized list of thin resistances to be studied (porous plates at low/medium/high open-area ratios, one HVAC grille, one perforated floor tile).
- Detailed plan for all normal-incidence detailed-CFD benchmark cases in the wind-tunnel and open-discharge environments, including operating points, boundary conditions, and meshing strategy.
- Description of the proposed experimental setup for the Section 4 spot-check validations.
- Identification of one or more candidate computational environments suitable for evaluating straightening behavior under angled-inflow conditions (to be refined and formally approved by the PMS at Month 16).
- Risk-mitigation notes for any anticipated staffing, facility, or scheduling constraints.

Deliverables consist of a written plan (PDF) and a concise slide deck for PMS review. PMS approval is required to proceed to detailed-CFD production.

Month 9 — Detailed-CFD Benchmark Dataset (PMS checkpoint)

The submission shall include:

- Completed normal-incidence detailed-CFD simulations for each resistance in both the wind-tunnel and open-discharge environments at two or more flow rates.
- A brief demonstration that the grid resolution is sufficient for benchmark purposes, noting any grid-independence checks performed as needed.

- Representative visualizations or summaries of the detailed-CFD results (e.g., velocity fields, pressure distributions, jet development) sufficient for PMS review and for confirming that the simulations behave as expected.
- A short description of the modeling setup emphasizing correct geometry, boundary conditions, and other key modeling assumptions.

Deliverables include a short, informal report with a few figures, tables, or plots illustrating the benchmark results and supporting discussion. PMS acknowledgment is required before compact-model development may proceed.

Month 12 — Experimental Spot-Check Dataset & Summary (PMS checkpoint)

The submission shall include:

- Experimental measurements for one porous plate from each open-area category (low, medium, high) and one commercial resistance (HVAC grille or perforated floor tile), each tested at one airflow rate selected in coordination with the PMS.
- A clear description of the experimental setup, including upstream-flow conditioning, the open-discharge region, and the instrumentation approach sufficient to support comparison with the normal-incidence detailed-CFD wind-tunnel and open-discharge cases.
- Representative plots, profiles, or qualitative observations of key measured behaviors (e.g., unrecoverable pressure drop, jet development, entrainment features) that allow the PMS to confirm agreement with the corresponding detailed-CFD results.
- A brief summary of any iterative refinements made to the experimental configuration or detailed-CFD setup to achieve acceptable agreement.

Deliverables consist of a short, informal report including a few figures, plots, or tables comparing experiment and detailed-CFD results, along with supporting notes and photos or drawings of the test setup. PMS confirmation is required before compact-model formulation proceeds.

Month 16 — Draft Compact-Model Formulation (PMS checkpoint)

The submission shall include:

- Preliminary compact-model formulations for momentum-addition and straightening, including the proposed parameter definitions and qualitative rationale.
- Clear, solver-agnostic notes on how the compact model is intended to be implemented in typical CFD tools, illustrated with simple configuration or input examples as needed.
- Contractor-proposed computational environments suitable for evaluating straightening behavior under angled-inflow conditions, to be reviewed and approved by the PMS prior to beginning the angled-inflow validation work.
- Any early demonstrations or small proof-of-concept cases (if available) that help the PMS understand the proposed formulation and its expected behavior.

Deliverables consist of a short report with supporting figures and examples as appropriate. PMS approval is required before proceeding to full validation simulations.

Month 20 — Compact-Model Validation Report (PMS checkpoint)

The submission shall include:

- Validation of the compact-model predictions against all normal-incidence detailed-CFD benchmark cases in the wind-tunnel and open-discharge environments.
- Validation of the compact-model predictions for straightening using the contractor-proposed and PMS-approved computational environments representing angled-inflow conditions.
- Validation of the compact model in at least one application-scale indoor-airflow environment (such as a small raised-floor data center or a small, occupied space) by comparing compact-model and detailed-CFD predictions under identical boundary conditions.
- Representative figures, tables, or visualizations demonstrating key comparisons (e.g., flow patterns, jet trajectory/spread, entrainment, directional behavior) and a concise discussion of agreement and any noted discrepancies.

Deliverables consist of a compact-model validation report and any supporting information needed

for PMS review. PMS approval is required before proceeding to final documentation and project close-out.

Month 24 — Final Technical Package (PMS acceptance for close-out)

The final package shall include:

- A complete ASHRAE Research Report documenting the detailed-CFD benchmarks, the experimental spot-checks, the compact-model development process, and validation across normal-incidence, angled-inflow, and application-scale scenarios.
- Draft contributions for the ASHRAE Handbook (Fundamentals Chapter 13; HVAC Applications Chapter 59; and coordinating text for Chapter 20, if appropriate).
- At least one manuscript submitted to Science and Technology for the Built Environment (STBE) describing the compact-model methodology and validation results.
- A concise, solver-agnostic implementation note intended for CFD practitioners and digital-twin platform developers.
- Sufficient documentation—such as appendices, case descriptions, boundary-condition specifications, geometry definitions, and representative input files—to enable future researchers and software developers to re-create the detailed-CFD benchmark cases and compact-model implementations for independent testing and further development.

Deliverables include the final report, Handbook contributions, the submitted manuscript, the implementation note, and the curated data archive. PMS acceptance completes the project close-out.

2. Where Results Will Be Published

- ASHRAE Final Research Report (project closeout; public posting via ASHRAE Research).
- ASHRAE Handbook contributions: Fundamentals Chapter 13 and HVAC Applications Chapter 59; coordination with Applications Chapter 20 (Data Centers and Telecom Facilities), where applicable.
- Peer-reviewed journal: at least one paper submitted to Science and Technology for the Built Environment documenting the compact-model formulation and validation against detailed CFD.

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. Unless otherwise specified, electronic copies of the final draft report shall be furnished 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. Research Paper(s)

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 for publication in the Science and Technology for the Built Environment (STBE). The paper(s) shall conform to the instructions posted in “Manuscript Central” for Science and Technology for the Built Environment papers. The paper title shall contain the research project number at the end of the title in parentheses, e.g., (1956-RP). ASHRAE Conference papers are **not** acceptable as deliverables from ASHRAE research projects unless explicitly approved by a vote of the PMS and TC and communicated to MORTS. Conference paper(s) shall conform to the instructions posted in “Manuscript Central” for ASHRAE Conference papers and the title shall contain the research project number at the end of the title in parentheses, e.g., (1956-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

\$225,000 over 24 months

Proposal Evaluation Criteria

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

No.	Proposal Review Criterion	Weighting Factor
1	Understanding of the Work Statement and Technical Approach Evaluation of the proposer’s demonstrated understanding of the objectives, scope, technical challenges, detailed-CFD requirements, compact-modeling concepts (momentum addition and straightening), and the validation approach involving room-scale or open-environment comparisons.	35%

2	Experience and Qualifications in CFD Modeling Assessment of the proposer’s background in CFD for related applications and the availability of appropriate CFD tools.	30%
3	Experimental Capability and Facilities Demonstrated capability to perform the required experimental spot-checks	15%
4	Project Management, Schedule, and Milestone Compliance	10%
5	Quality, Clarity, and Value of Previous Related Work Demonstrated ability to conduct similar research with clear and timely deliverables.	10%

Project Milestones:

No.	Major Project Completion Milestone	Deadline Month
1	CFD & Experimental Test Plan (PMS approval)	3
2	Detailed-CFD Benchmark Dataset & grid-resolution documentation (PMS checkpoint)	9
3	Experimental Spot-Check dataset & uncertainty analysis (PMS checkpoint)	12
4	Draft Compact-Model Formulation (PMS checkpoint)	16
5	Compact-Model Validation Report (room/open-environment cases) (PMS checkpoint)	20
6	Final Technical Package (Final Report, Handbook text, publication submission, archive) (PMS)	24

References

Related Prior ASHRAE Research Projects

1. ASHRAE RP-1009. Grille Airflow Modeling for Room-Airflow Studies. ASHRAE Research Project.
2. ASHRAE RP-1675. Guidance for CFD Modeling of Data Centers. ASHRAE Research Project.

3. Primary Reference for This Work Statement

VanGilder, J.W., Seymour, M., Hu, B., Tian, W., Pang, M., & Lin, C.-X. (2022). Flow Resistance Characteristics for Data Center CFD. ASHRAE Transactions, Vol. 128, Part 1.

4. Additional Compact-Modeling and Data-Center Airflow Literature

Hu, B., Lin, C., Patel, D., VanGilder, J., & Seymour, M. (2021). “A new tile model for air flow distribution in a full-featured data center with raised floor plenum.” ITherm 2021 Proceedings.

Lin, C., Seymour, M., Hu, B., Patel, D., Joshi, Y., & VanGilder, J. (2020). “A Comprehensive CFD Study of Tile Flow Rate Distribution in a Compact Data Center Laboratory.” ITherm 2020 Proceedings.

5. Foundational Flow-Resistance Correlation Sources

Idelchik, I.E. (2003). Handbook of Hydraulic Resistance, 3rd Edition. Jaico Publishing House.

Fried, E., & Idelchik, I.E. (1989). Flow Resistance: A Design Guide for Engineers. Taylor & Francis.

6. ASHRAE Standards and Handbooks Influenced by This Work

ASHRAE. (2021). Thermal Guidelines for Data Processing Environments, 5th Edition. (Referenced context for data-center airflow and resistance modeling.)

ASHRAE Handbook — Fundamentals. Chapter 13: Indoor Environmental Modeling.

ASHRAE Handbook — HVAC Applications. Chapter 59: Indoor Environment.

ASHRAE Handbook — HVAC Applications. Chapter 20: Data Centers and Telecom Equipment Rooms.