INVITATION TO SUBMIT A RESEARCH PROPOSAL ON AN ASHRAE RESEARCH PROJECT

1915-TRP, Refrigerated Facilities Doorway Infiltration Air Energy Reduction

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 10.02 Refrigeration Applications

Budget Range: $300,000 may be more or less as determined by value of proposal and competing proposals.

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

All proposals must be received at ASHRAE Headquarters by 8:00 AM, EST, December 16th, 2024. 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: 1915-TRP, Refrigerated Facilities Doorway Infiltration Air Energy Reduction, 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
Ivy Arkfeld
CrossnoKaye
1033 Laguna St
Santa Barbara, CA 93101-1422
Phone: 805.286.7684
E-Mail: ivyarkfeld@gmail.com

For Administrative or Procedural Matters:
Manager of Research & Technical Services (MORTS)
Steve Hammerling
ASHRAE, Inc.
180 Technology Parkway, NW
Peachtree Corners, GA 30092
Phone: 404-636-8400
Fax: 678-539-2111
E-Mail: MORTS@ashrae.net

Contractors intending to submit a proposal should notify, by mail or e-mail, the Manager of Research by December 1st, 2024 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. In all cases, the proposal must be submitted to ASHRAE by 8:00 AM, EST, December 16th, 2024.
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 research by Hendrix et al. (1989) verified the validity of the 1975 Gosney and Olama research covering infiltration air exchange through cold storage doorway openings that provided mathematical equations for determining air exchange for fully established flow. Then ASHRAE research by Downing et al. (1993) provided a general effectiveness rating of infiltration air reduction devices and methods then available for use at cold storage doors used primarily for transporting items via forklift trucks. These research results are incorporated in Chapters 23 and 24 of the Refrigeration Handbook and provide the only ASHRAE recognized method for determining infiltration air refrigeration loads.

Heat and moisture gain from air infiltration at doorways is a widely variable component and can be a substantial portion of the total facility load in high traffic or poorly operated facilities. Air infiltration also contributes to safety hazards related to ice formation, moisture absorption by paper-based packaging, and high air relative humidity levels. The above research provided the ability to determine the infiltration air load accurately versus the air change or load percentage methods then in common use. The 1989 research remains a solid basis for calculating air infiltration without infiltration devices. The 1993 research, however, covers only those devices and systems that may have been available prior to 1992. Since then, there have been several new devices and changes to existing designs. Many are not easily evaluated by designers and owners using the existing model. For example, one design uses a quick closing feature to reduce air infiltration, but at the same time has a higher air infiltration load when closed.

In addition, the 1993 research only measured effectiveness for one rate of traffic movement through doorways and did not address multiple door opening applications. Current flow factors and effectiveness ratings have large uncertainties meaning heat load predictions can be off by a factor of two. Research by Chen et al. (2002) and Cleland et al. (2004) provided information on the effect of traffic movement for doors protected by strip curtains. However, strip curtain protection may not be appropriate for the facility due to the type or product stored or the size of door openings. For example, strip curtains may not be used in a facility that stores fresh flowers as the risk of contact with the product during transport through the curtain would cause damage.

Detailed modeling of energy use for refrigerated facilities is not often undertaken at the design stage. One reason is that heat loads, like door infiltration, are difficult to accurately estimate due to the paucity of current information. While there has been considerable research on doorways in regular buildings including various types of doors and entrances, this is not relevant to refrigerated facilities due to the different door technologies employed and different operational characteristics (mainly passage of forklifts rather than people). Modeling techniques in software such as DOE2 or EnergyPlus are inadequate without relevant research and guidance.

Justification and Value to ASHRAE
The principal impact will be to the refrigeration practitioners and those professionals and personnel involved in the design, construction, operation and maintenance of refrigerated facilities. The potential for adoption by industry is high, provided the results include a current and comprehensive list of door protection devices and that the information is presented in a form that is relatively easy to apply.

The handbook additions are of particular importance as this was not a part of the 1993 research project, and it is surmised that because of this missing last step the methodology recommended was never widely adopted. This is evidenced by the fact that air change or load percentage methods are still being published and commonly used. These methods are not nearly as accurate, particularly in high traffic facilities that are now prevalent. Therefore, it is essential to have current research that presents results on reducing air infiltration through refrigerated facility doorways and energy consumption, including detailed examples, calculations, and illustrations. These results will be adopted into the handbook by the relevant technical committees.

It should be recognized that in addition to new constructions this information will also be useful for the improvement in existing doorway energy reduction performance. In fact, there is potentially more immediate and substantial energy savings in modifying or re-fitting existing doorway applications as this can be implemented with relative ease.

Objectives
The research will provide an accurate determination of the performance and cooling load associated

with commonly used doorways between large freezers and refrigerated docks. The types of infiltration reduction methods, and the test methods for doorway passages, will consider the wide range of operational characteristics that can exist among myriad refrigerated facilities. The research results will allow ASHRAE members and others to apply improved doorway infiltration air calculations to select the appropriate infiltration reduction technologies for specific operations and applications. More accurate doorway performance will improve sustainable design, through first cost comparison of improved doorway choices vs. incremental savings in refrigeration system design capacity, as well as cost- justification of more efficient doorway technologies to achieve lower life-cycle operating costs.

The research will cover freezer doorway protection devices ranging from standard manual-enabled motorized doors; to high-speed doors with and without strip curtains; to fan-powered and heated air curtain designs. Important to this research, the latter are often considered necessary for effective frost and condensation control (i.e., safety), but with significant uncertainty regarding peak cooling load and annual energy impacts, as well as when business activity characteristics justify integrating with other infiltration control methods.

In conjunction with the research report, the work will produce a tool kit in electronic form, which includes one or more spreadsheet tools for utilization as part of the Refrigeration Handbook Online version, as well as modeling formulae for use in refrigeration performance software such as DOE2.2R or EnergyPlus, suitable for adoption by software designers or experienced modelers.

<u>Scope</u>:
Full scale tests will be conducted on door openings with varying protection devices, operating temperatures, and forklift traffic usages listed below. Results will be analyzed, and information presented as described in the Deliverables section of this document.

1. As a minimum, the following protection devices will be evaluated in this research:
    1) Base case: The base case is expected to be a manually enabled standard speed power door, without infiltration protection, and extended open time (manually-enabled, e.g., pull cord).
        - Maintaining space temperatures with a continuously open door is typically not feasible with an existing facility. The open-door time will be limited by the ability of the existing facility to maintain temperatures on each side of door. The base case design will be refined by the researcher in cooperation with the PMS.
    2) High-speed sensor enabled horizontal doors (bi-parting) without strip curtain
    3) High-speed sensor enabled roll-up door without strip curtain
    4) No door operation with only strip curtain (new)
    5) No door operation with only strip curtain and with a defined number of strips removed (as is common for aging or visibility)
    6) Fan powered recirculated heated air curtain (horizontal style with supply nozzle and return grille)

2. The following minimum conditions shall be employed to analyze the applicable protection devices:
    1) Refrigerated space of 5,000 S.F. or larger with a ceiling height no less than 24 ft. with evaporator coils sizing consistent with typical commercial practice.
    2) Adjacent temperature-controlled dock area or similar space to represent external temperatures with heat as needed.
    3) One door opening with a width of approximately 8 feet and a height between 8 and 12 feet high that can be used for passage of a forklift.
    4) Freezer temperature between 0°F and -10°F.
    5) Two pre-determined external temperatures, one at a fixed temperature representative of a dock between 35°F and 50°F and a second at a fixed temperature representative of a processing area between 75°F and 95°F. *The researcher will recommend and include its approach to humidity control and if this is sufficiently important to include as another variable, e.g., increasing number of test runs (allowing for rental humidifier is not a large cost but additional test runs could be significant additional time)*
    6) Forklift traffic simulation for each infiltration protection method:
        a. No traffic
        b. High forklift frequency (one transit every 30 seconds)

c. Low forklift frequency (one transit every five minutes)
d. The forklift type, velocity through door, and pallet load to be typical for refrigerated warehouses.

3. For each protection device type the researcher will:
   1) Perform door modifications and on-site construction work, including door installation and electrical work consistent with door manufacturer and host facility specifications. Comply with all codes, standards and owner safety and facility work rules.
   2) Provide temporary boundary curtain(s) and temporary heating and humidification equipment, as needed, to maintain design dock conditions.
   3) Record temperature and humidity, using a physical array of sensors within freezer and adjacent space, sufficient to determine dynamic and steady-state temperature and humidity conditions.
   4) Determine direct energy consumption (door motor, heat, fans) for operation of protection device, as applicable.
   5) Determine air infiltration rate and resulting sensible and latent cooling loads through opening for each scenario.
   6) Determine open fraction, flow factors and protection effectiveness of protection devices consistent with the existing Gosney and Olama model.
   7) Develop a systematic quantitative methodology to model the effect of traffic on infiltration rates and heat loads for each protection device, including the comparative effect of traffic frequency on the protection effectiveness and net infiltration rate.
   8) Produce a design tool (spreadsheet or similar method) that provides estimates and compares infiltration and cooling load and energy usage of each protection device compared to the base case for the low and high usage cases, with a range of door sizes, forklift frequencies and transit parameters, freezer temperatures and external temperatures. The expectation is to produce guidance that can be abstracted to actual application, within defined limits, by a skilled engineering practitioner.

4. The researcher may propose different methods to obtain the objective information in the context of the existing refrigeration system (e.g., piping configuration), but the work is likely to require measurement of the following:
   1) Refrigerant mass flow
   2) Tracer gas method
   3) Defrost condensate
   4) Visualization of frost loads to identify various regimes of frost formation

5. The researcher is responsible for identifying and negotiating a host facility, suitable in size and operational capability to address the study needs and not be too specific to a single facility, and also include any cost offsets funded by the facility for door(s) that will prospective be left in operation at the end of the project.

6. Additional scope and cost assumptions:
   1) Include allowance to restore door and facility to original conditions.
   2) Include cost of new strip curtains.
   3) Include cost of new door(s) and air curtains, freight and installation costs.

7. The bidder may propose not to test all combinations of internal and external conditions for all doors and protection devices. However, any deviation from this or any other part of the scope listed above must be explicitly listed in the Research Proposal and justified by the bidder.

<u>Deliverables</u>:
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. Interim Deliverables

In addition to regular progress reports, each of the following deliverables must be developed and submitted by the successful bidder for review and approval by the Project Monitoring Subcommittee (PMS) prior to proceeding to the next step.

1) A Detailed Project Plan including a full literature review, detailed description of selected test doors, site locations, and any site-specific conditions that may affect test results.
2) Details of host site configuration, sequence of door installation, instrumentation and data collection plan and test methodology.
3) Sample analysis and data reports (soon after initiating data collection, to demonstrate format and completeness) List unexpected findings or issues with testing.
4) Data collection results, anomalies or issues found during tests, data analysis & conclusions, variances found from previous experimental results found in literature review.
5) Produce final report and tool kit for review and approval.

c. Design Tool Kit

A design tool kit shall be created that will assist designers and owners to estimate the operating costs for various options thereby allowing best equipment selection and operation. The design tool kit shall use inputs that can be reasonably supplied by the user including refrigerated space dimensions and operation, (e.g., operating temperatures, estimated forklift traffic), physical door characteristics, and infiltration protection device selection.

The design tool kit is to include background theory, test parameters, assumptions made, any correlating equations developed, and a summary of results that would allow designers to compare energy use vs. effectiveness of each protection device studied in this project.

The design tool kit will be demonstrated as part of the final report for review by the Society's Project Monitoring Subcommittee (PMS).

If deemed appropriate by the PMS and TC 10.02, in their sole discretion, the design tool kit will be furnished to the Institution as follows:

- An executive summary in a form suitable for wide distribution to the industry and to the public.
- Two copies of each electronically; one in PDF format and one in Microsoft Word.

d. Handbook Chapters

The researcher shall keep in mind that research results, as deemed appropriate by the TC, will be incorporated into the Refrigeration Handbook Chapters and Online version. Organization of report text, tables, and figures should consider this expected outcome.

e. 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.

f. *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 (1915-RP) at the end of the title in parentheses, e.g., (1915-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.

g. Data

Data is defined in General Condition VI, "DATA"

h. 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.

<u>Level of Effort</u>
It is anticipated that the research will require approximately 12 person-months over 22 months duration, including trade work to install doors and related equipment and instrumentation. It is anticipated, for budgeting, that the cost of doors can be absorbed by door vendors and/or end users, who will benefit from the subject doors remaining in place at the end of the project.

Estimated total project cost is $300,000. Below is an estimated breakdown of hours and costs.

	Principal		**Researcher**		**Technician**		
Task	Hrs	Rate	Hrs	Rate	Hrs	Rate	

Project management	80	$ 225	0	$ 175	0	$ 150	$ 18,000
Planning and development	60	$ 225	60	$ 175	0	$ 150	$ 24,000
Testing	40	$ 225	200	$ 175	400	$ 150	$ 104,000
Analysis and reporting	100	$ 225	160	$ 175	0	$ 150	$ 50,500
Presentation	80	$ 225	0	$ 175	0	$ 150	$ 18,000
Instrumentation and data collection (project specific allowance)	-	-	-	-	-	-	$ 35,000
Construction subcontracts and rental allowances	-	-	-	-	-	-	$ 80,000
Contingency and miscellaneous	-	-	-	-	-	-	$ 50,500
						Total:	$ 300,000

Total Hours	360		420		400		1,180

Please complete the following documents and submit as part of your Bid:

a. Project timeline and milestones for each required task
b. Project budget including cost for each required task
c. Organizational chart and description of responsibilities for each person
d. Technical qualifications of principal investigator, key researchers, and any subcontractors with resumes
e. Identify team leader

Other Information to Bidders:

Supplemental Bidders Information

Facilities and Host Sites**:**

Bidders are encouraged to consider various methods to achieve the desired facility for this project. These methods could include a laboratory space of sufficient size, use of a seasonal or temporary freezer, or arrangements with an operating facility. Several refrigerated warehouse operators with interest in supporting this project as a host facility have been identified. These operators and their contact information are listed below. There may be opportunities to align the research project with planned or prospective new projects or existing remodel and upgrade projects. It is left to bidders to consider and contact potential hosts.

No commitments have been made by potential hosts and no commitments or conditions have been made by ASHRAE. Project arrangements would be between bidder and host company, e.g. non-disclosure, safety compliance and insurance, timing, and implementation details.

United States Cold Storage
**As of 1/29/2024 a host site in Hazelton, PA has been identified.*
Michael Lynch
Vice President of Engineering
(856) 354-4699
mlynch@uscold.com

Charlie Kulp
USCS Regional Engineer
ckulp@uscold.com

Lineage Logistics
Aer Teale
Director of Engineering
46500 Humboldt Dr.
Novi, MI 48377

(612) 456-0305
ateale@lineagelogistics.com

Americold
Tony Easterwood
Sr. Director of Refrigeration Maintenance and Maintenance Training
(404) 460-4704
Tony.Easterwood@americold.com

Door Vendors:
Bidders are responsible for specifying and provisioning doors for the research project. These doors may either be existing, rented, or provided on loan by door vendors, or they can be part of a site project as noted above. The testing sequence may consider the most cost-effective and efficacious use of existing door(s). A freezer with two doorways may be considered if the arrangement is sufficiently symmetrical to not detract from accuracy. The bidder is responsible for returning doors to their original configuration, or for any other arrangements reached with the host site owner.
Three door vendors listed below have expressed interest in the project. Bidders may consider other vendors.

Mr. Larry Gilliland is an additional resource with relevant contacts, in his role as Board Member of Controlled Environment Building Association (CEBA) and Global Cold Chain Alliance (GCCA).

Jamison Door Company
Dwight Clark
President and CEO
dac@jamisondoor.com

ASI Doors, Inc.
Greg Gescheidle
General Manager
5848 North 95th Court Milwaukee, WI 53225
(414) 464-6200

Mayekawa USA, Inc. Alexander Lape
Sales Manager – Central Region

No.	Proposal Review Criterion	Weighting Factor
1	Contractor's understanding of Work Statement as revealed in proposal. a) Logistical problems associated b) Technical problems associated	**15%**
2	Quality of methodology proposed for conducting research and related expertise. a) Organization of project b) Project management plan and management support b) Data collection plan c) Technical expertise of key project personnel	**20%**
3	Qualifications of personnel for this project. a) Project team 'well rounded' in terms of qualifications and experience in related work (Note 1) b) Project manager person directly responsible; experience and corporate position c) Team members' qualifications and experience d) Time commitment of Principal Investigator	**25%**
4	Student involvement a) Extent of student participation on contractor's team b) Likelihood that involvement in project will encourage entry into HVAC&R industry	**5%**

5	Probability of contractor's research plan meeting the objectives of the Work Statement. a) Detailed and logical work plan with major tasks and key milestones b) All technical and logistic factors considered c) Reasonableness of project schedule	**25%**
6	Performance of contractor on prior ASHRAE or other projects. (No penalty for new contractors.)	**5%**
7	Suitability of the proposed project site or if a site has not been selected, the likelihood of the bidder obtaining a suitable project site. a) Commitments from host sites are important but not a requirement	**5%**

Project Milestones:

No.	**Major Project Completion Milestone**	**Deadline Month**
1	Develop a detailed project plan with 4-6 main tasks including finalize host location(s) and agreements, drawings, equipment details, instrumentation, detailed timeline, provisional analytical methods, task budgets, with the defined milestones to be met (along with PMS approval definitions) before proceeding to successive tasks. Identify long lead-time considerations	**4**
2	Procure equipment, instrumentation, installation contracts, finalize data collection and analytical methods (with sample end-to-end calculations). Prepare for field implementation.	**9**
3	Install equipment and perform field tests, with concurrent data analysis to validate results at each major configuration, before proceeding to next configuration. Develop design tool kit.	**15**
4	Draft report and review iterations with PMS. Review design tool kit, including example use cases.	**19**
5	Final report and related deliverables	**21**

References

1. *2018 ASHRAE Handbook - Refrigeration*, Chapter 23, Refrigerated-Facility Design.
2. *2018 ASHRAE Handbook - Refrigeration*, Chapter 24, Refrigerated-Facility Loads.
3. Chen, P., Cleland, D.J., Lovatt, S.J., Bassett, M.R. (2002) An empirical model for predicting air infiltration into refrigerated stores through doors. International Journal of Refrigeration 25 799-812.
4. Cleland, D.J., Chen, P., Lovatt, S.J., Bassett, M.R. (2004) A modified model to predict air infiltration into refrigerated facilities through doorways. ASHRAE Transactions, Vol. 110 (1) 58-66 (paper 4672, ASHRAE Winter Meeting, Anaheim, January 2004).
5. Downing, C.C., and W.A. Meffert. 1993. Effectiveness of cold-storage door infiltration protective devices. ASHRAE Transactions 99(2):356-366.
6. Gosney, W.B., and H.A.L. Olama. 1975. Heat and enthalpy gains through cold room doorways. *Proceedings of the Institute of Refrigeration, vol. 72, pp. 31-41.*
7. Hendrix, W.A., D.R. Henderson, and H.Z. Jackson. 1989. Infiltration heat gains through cold storage room doorways. *ASHRAE Transactions 95(2).*
8. Reindl, D., Jekel T. 2009. “Infiltration rate determination for low temperature freezing systems.” *ASHRAE Transactions.*
9. Faramarzi, R., Navaz, H., Kamensky, K. 2018 “Transient Air Infiltration/Exfiltration in Walk-in Coolers” *ASHRAE Journal, March 2018.*
10. H.Z. Jackson. 1984. A Study to Develop A Method of Predicting Energy Losses Due to Infiltration in Refrigerated Warehouses – Phase I. ASHRAE Research Project RP-362.
11. C.C. Downing. 1992. Refrigerated Storage Door Air Infiltration Utilizing Infiltration Reduction Devices. ASHRAE Research Project RP-645.
12. S.A. Sherif. 1997. A Study to Determine Heat Loads Due to Coil-Defrosting. ASHRAE Research Project RP-622.

13. S.A. Sherif. 2002. A Study to Determine Heat Loads Due to Coil-Defrosting – Phase II. ASHRAE Research Project RP-1094.