



Shaping Tomorrow's
Built Environment Today

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TO: Timothy Anderson, Chair TC 10.7, tim.anderson@hussmann.com
Shitong Zha, Research Subcommittee Chair TC10.7, shitong.zha@heatcrafttrpd.com
CC: Krishnan Gowri, Research Liaison Section 10.0, Krishnan.gowri@outlook.com
FROM: Michael Vaughn, MORTS, mvaughn@ashrae.org
DATE: January 23, 2019
SUBJECT: Research Topic Acceptance Request (1876-RTAR), "Optimizing Air Curtains and the Effect on the Infiltration Load of Refrigerated Display Cases with Glass Doors"

During their winter meeting, the Research Administration Committee (RAC) reviewed the subject Research Topic Acceptance Request (RTAR) and voted to accept it with comments for further development into a work statement (WS) provided that the key comment(s) and question(s) below are addressed to the satisfaction of your Research Liaison, Krishnan Gowri, Krishnan.gowri@outlook.com, or RL10@ashrae.net, in the work statement draft.

1. Co funding from case manufacturers should be sought. Would AHRI be interested in funding?
2. Why does ASHRAE need to take the lead?
3. Proposed methodology is poorly described. It is unclear whether the project will focus on examining the performance of existing air curtains, or on improving their design or on developing new curtains.

The work statement draft must be approved by the Research Liaison prior to submitting it to RAC.

An RTAR evaluation sheet is attached as additional information and it provides a breakdown of comments and questions from individual RAC members based on specific review criteria. This should give you an idea of how your RTAR is being interpreted and understood by others. Some of these comments may indicate areas of the RTAR and subsequent WS where readers require additional information or rewording for clarification.

The first draft of the work statement should be submitted to RAC no later than **December 15, 2020** or it will be dropped from display on the Society's Research Implementation Plan. The next likely submission deadline for a new work statement on this topic is **March 15, 2019** for consideration at RAC's 2019 spring meeting. The submission deadline after that for work statements is May 15, 2019 for consideration at the RAC's 2019 annual meeting.

Project ID	1876	
Project Title	Optimizing Air Curtains and the Effect on the Infiltration Load of Refrigerated Display Cases with Glass Doors	
Sponsoring TC	TC 10.7.	
Cost / Duration	\$150,000 - 24M	
Submission History	1st Submission - 1722-RTAR Expired from plan 18.01	
Classification: Research or Technology Transfer	Basic/Applied Research	
RAC 2018 Winter Meeting Review		
Essential Criteria	Voted NO	Comments & Suggestions
Background: The RTAR should describe current state of the art with some level of literature review that documents the importance/magnitude of a problem. References should be provided. If not, then note it in your comments.		9 - Clear background, with references cited
Research Need: Based on the background provided is the need for additional research clearly identified? If not, then the RTAR should be rejected.		9 - Clearly presented...the need for correct design of air curtains in supermarket cabinets with glass doors.
Relevance and Benefits to ASHRAE: Evaluate whether relevance and benefits are clearly explained in terms of: a. Leading to innovations in the field of HVAC & Refrigeration b. Valuable addition to the missing information which will lead to new design guidelines and valuable modifications to handbooks and standards. Is this research topic appropriate for ASHRAE funding? If not, Reject.		9 - Clear relevance, probably for the refrigeration sections. However, the RTAR has not made clear why ASHRAE should lead on this instead of refrigeration manufacturers (this was an issue raised by RAC when this RTAR last appeared). Maybe the RTAR (and hence ASHRAE) can address the more fundamental scientific aspects that manufacturers can then use to achieve better designs? 7 - Manufacturers should fund this research project too.
IF ABOVE THREE CRITERIA ARE NOT ALL SATISFIED - MARK "REJECT" BELOW & CONTINUE REVIEW BELOW		
Other Criteria	Voted NO	Comments & Suggestions
Project Objectives: Based on the background and need, evaluate whether the project objectives are: 1. Aligned with the need 2. Specific 3. Clear without ambiguity 4. Achievable If not, then appropriate feedback should be provided.		9 - These are ok, but the WS will need to specify experimental configurations and conditions to be tested. 7 - The results of the research project are not clearly identified. 12 - Identify the most efficient strategies? If new design, who owns it ASHRAE? If existing designs are going to be reverse engineered, are they proprietary, is this right?
Expected Approach and Budget: Is there an adequate description of the approach in order for RAC to be able to evaluate the appropriateness of the budget? If not, then the RTAR should be returned for revision. Anticipated funding level and duration:		9 - OK, but note comment under 'objectives'. 4 - Proposed methodology is poorly described. It is unclear whether the project will focus on examining the performance of existing air curtains, or on improving their design or on developing new curtains. It is unclear how many different air curtain solutions will be tested and how and whether the impact of customers on their performance will be considered. 7 - RTAR cannot be approved without indication of the expected approach from the proponents. 6 - Not sure there is adequate description of approach. 12 - Budget is probably ok, but the project is approach is sought from bidders - perhaps a bit too open?
References: Are the references provided?		
	Initial Decision?	Final Approval Conditions
Decision Options		
ACCEPT AS-IS		2 - The need is well established. The Expected Approach section needs further development to justify the anticipated funding and duration. Why aren't frozen display equipment manufacturer's funding this work? Seek co-sponsorship or in-kind donations of equipment. 9 - Useful work, well-presented RTAR. However, justify why ASHRAE should take the lead on this research, and if so, how ASHRAE will subsequently benefit (as required the last time this RTAR appeared). Should the ASHRAE-funded work furnish the more fundamental aspects of data that can then enable manufacturers to develop their cabinet designs? Work with RL to develop the WS in terms of specifying in detail the experimental configurations and conditions to be tested. 7 - Fill in the section with the expected approach and clarify the objectives. 3 - The same comment should be made with RTAR 1722. Manufacturers should be working on this project. Why does ASHRAE need to take the lead?
ACCEPT W/COMMENTS		6 - see comments above. 12 - The approach and project objectives need to be tightened, clarified, and documented with RL.
REJECT		

ACCEPT Vote - Topic is ready for development into a work statement (WS).

ACCEPT W/COMMENTS Vote - Minor Revision Required - RL can approve RTAR for development into WS without going back to RAC once TC satisfies RAC's approval condition(s)

REJECT Vote - Topic is not acceptable for the ASHRAE Research Program

Research Topic Acceptance Request Cover Sheet

Date: **12/5/18**

(Please Check to Insure the Following Information is in the RTAR)

- A. Title
- B. Executive Summary
- C. Background
- D. Research Need
- E. Project Objectives
- F. Expected Approach
- G. Relevance and Benefits to ASHRAE
- H. Anticipated Funding Level and Duration
- I. References

X
X
X
X
X
X
X
X
X

Title:
Optimizing Air Curtains and the Effect on the Infiltration Load of Refrigerated Display Cases with Glass Doors

RTAR 1876
 (To be assigned by MORTS)

Results of this Project will affect the following Handbook Chapters, Special Publications, etc.:

R15

Research Classification:

- Basic/Applied Research
- Advanced Concepts
- Technology Transfer

X

Responsible Committee: **TC 10.07**

Date of Vote: **12/4/18**

For		9
Against	*	0
Abstaining	*	0
Absent or not returning Ballot	*	
Total Voting Members		9

RTAR Authors

Lead: **Carl Roberts**
 Others: **Mike Chieffo**
 Shitong Zha
 Bruce Hierlmeier

Co-sponsoring TC/TG/MTG/SSPCs (give vote and date)

Expected Work Statement Authors

Lead: **TBD**
 Others:

Potential Co-funders (organization, contact person information):

Has an electronic copy been furnished to the MORTS?
Has the Research Liaison reviewed the RTAR?

Yes	No

* Reasons for negative vote(s) and abstentions

Title:

Optimizing Air Curtains and the Effect on the Infiltration Load of Refrigerated Display Cases with Glass Doors

Executive Summary

This research will study the effect of infiltration and conduction on both low temperature and medium temperature refrigerated display cases with glass doors. This project focuses on optimizing air curtains to reduce the impact of the infiltration and conduction load on compressor, anti-sweat and defrost energy.

Background

Supermarkets have one of the highest energy usage intensities in commercial buildings. More than half of this consumption comes from the refrigeration system where display cases are used to maintain food products at acceptable refrigerated and frozen temperature levels. Among these merchandisers, vertical display cases represent a significant segment of the store's equipment. Most vertical display cases incorporate an air curtain, i.e.: a flowing slab of cold air discharged from a honeycomb inside the case near the top of the door to minimize impingement of cold air on the door when the door is closed, and to prevent infiltration of room air into the case when the door is open.

As supermarkets look for ways to reduce their energy usage, both low temperature and medium temperature glass-doored display cases have become more popular. For glass-doored cases, the air curtain has a significant impact on efficiency – even with the doors closed – because heat transfer from the glass door to the air inside the case must be countered in two ways; increased refrigeration of the air, and the addition of electric resistance heat to the doors that prevents glass from fogging and condensate from forming on the door frames.

The available related research (Faramarzi, 2002; Navaz, 2005; Navaz, 2006; Faramarzi, 2009) is 10 to 15 years old and is primarily focused on Open Multi-deck cases. Most of the references in the ASHRAE Refrigeration Handbook 2014 are in need of updating. (Kosar, 2005) is representative of the short comings of the current state of the art – great research in its day, but no longer representative of the modern glass-doored cases. Today's case designs have been influenced by the Department of Energy's energy efficiency standards resulting in the prevalence of many new technologies. Air curtains are becoming tomorrow's "low hanging fruit".

Research Need

A great deal of research has been done regarding the impact of infiltration on refrigerated open multideck display cases (Faramarzi, 2002; Navaz, 2005; Navaz, 2006; Faramarzi, 2009; for examples), but there are no research papers or design guidelines for designing air curtains for glass-doored cases. In Kosar 2005, it was noted in the final report for Faramarzi, 2000 that “the performance of this low temperature reach-in case seemed critically vulnerable to the door openings”. Research into the methods of optimizing the air curtain could provide energy saving opportunities in four areas; the compressor energy, defrost energy, fan energy and anti-condensate heater energy. By reducing the infiltration of ambient air during periods of door openings, the btu/h requirements are reduced. Reduced infiltration also reduces frost load on the evaporator and product, thus reducing defrost energy and improving airflow. Similarly, leveraging airflow can reduce required fan power, which also reduces btu/h requirements. Lastly, strategies for preventing the air curtain's cooling of the glass doors when the doors are closed will conserve both anti-condensate heater energy and compressor energy. Air curtains are typically optimized for when the doors are opened and/or for clearing fogged glass immediately after the door is closed. Air curtains that are designed to simply prevent infiltration when the door is opened are inefficient when the doors are closed, which is the vast majority of the time. Air curtains that are designed to simply remove fogging immediately after door is closed are inefficient when the fogging is cleared, which is the majority of the time.

Project Objectives

Significant energy savings could be realized from improved air curtain designs for glass-doored case. Equipment size and cost can also be reduced. By using analysis, experiments and optimization research to develop design guidelines for air curtains in cases equipped with low anti-sweat heating doors, ASHRAE will shift the industry to more sustainable options.

Air curtains are fundamentally subjected to three conditions; short periods of infiltration when the door is open, short periods when the glass is fogged immediately after the door is closed, and longer periods when the doors are closed and the glass is clear.

This project will compare various air curtain designs used with low-heat glass doors, and identify the most efficient design strategies for these air curtains. Performance factors to be considered include refrigeration system energy usage, auxiliary energy usage, system energy efficiency, and food safety. Demonstration will be required for the comprehensive analysis.

Expected Approach

Describe in a manner that may be used for assessment of project viability, cost, and duration, the approach that is expected to achieve the proposed objectives (200 words maximum).

Check all that apply: Lab testing , Computations , Surveys , Field tests , Analyses and modeling Validation efforts Other (specify) (simple lab verification testing)

The exact manner will be developed in the work statement, but is likely to include field surveys and CFD models as well as physical testing of variables to optimize the design.

Relevance and Benefits to ASHRAE

This research topic would address ASHRAE Research Strategic Plan Goal #1, Maximize the actual operational energy performance of buildings and facilities. Research into the infiltration load and the impact of optimizing air curtains for refrigerated display cases with glass doors aligns with the Needed Research, Sample Research Projects 7 and 8, “Document actual energy savings and performance impacts for selected energy measures, and identify key design, construction, installation and operational factors that influence savings and performance” and “Document the impact of design alternatives on building performance metrics important to owners”, respectively.

Results from this project will be useful to engineers who design systems and who model energy consumption of supermarkets, convenience stores, restaurants, and cafeterias. It is also useful to the designers of display case equipment and refrigeration systems.

The findings of this research can be added to the ASHRAE Handbook and ASHRAE Design Guides. The findings will have the potential to be the subject of forums, seminars as well as papers in upcoming ASHRAE conferences.

Anticipated Funding Level and Duration

Funding Amount Range: \$ <u>150,000</u> Duration in Months: <u>24</u>

References

Mazyar, A., H. Navaz, D. Dabiri and R. Faramarzi, "Air Curtain Performance Studies in Open Vertical Refrigerated Display Cases," HEFAT 2010

Mayzar Amin, Student Member, and Dana Dabiri, Ph.D., University of Washington, Seattle, WA ; Homayun K. Navaz, Ph.D., Member, Kettering University, Flint, MI, Experimental Investigation of the Effect of Various Parameters on the Infiltration Rate of Single Band Open Vertical Refrigerated Display Cases with Zero Back Panel Flow (LO-09-022)

Fricke, B. and B. Becker, Comparison of Vertical Display Cases: Energy and Productivity Impacts of Glass Doors Versus Open Vertical Display Cases (ASHRAE Research Project 1402), December 2009.

Kosar D. and O. Dumitrescu, Humidity Effects on Supermarket Refrigerated Case Energy Performance: A Database Review ASHRAE Transactions 2005, V. 111, Pt.1, 1051-1060

Faramarzi, R., B. Coburn, and R. Sarhadian, Performance and Energy Impact of Installing Glass Doors on an Open Vertical Deli/Dairy Display Case, ASHRAE Transactions 2002, V. 108, Pt. 1, 673-679.

Farmarzi, R., R. Sweetser, and R. Henninger. 2000. Investigation of relative humidity impacts on the performance and energy use of refrigerated display cases, Final Report GRI-00/0084.

Feedback to RAC and Suggested Improvements to RTAR Process

The RTAR process, and the feedback from RAC has worked well and benefitted this RTAR and its author. It would be helpful to RTAR writers to have links to past research and editorial guidelines posted in a location that they "can't help but find them" as they browse the ASHRAE website for RTAR information.
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TO: Brian Fricke, Chair TC 10.7, frickeba@ornl.gov

FROM: Michael Vaughn, MORTS, mvaughn@ASHRAE.org

CC: John Shonder, Research Liaison 10.0, shonderja@ornl.gov
Daryl Erbs, Research Subcommittee Chair TC 10.7, daryl.erbs@manitowoc.com

DATE: February 12, 2014

SUBJECT: Research Topic Acceptance Request (1722-RTAR), "Optimizing Air Curtains for Refrigerated Display Cases with Glass Doors"

During their winter meeting, the Research Administration Committee (RAC) reviewed the subject Research Topic Acceptance Request (RTAR) and voted to return it. The following list summarizes the mandatory comments and questions that need to be fully addressed in the RTAR re-submission:

1. Manufacturers should be working on this already. Why does ASHRAE need to take the lead?
2. Budget seems low for a 24 month period.
3. Reason for one negative vote was not given.
4. Liaison approval missing.

Please address or incorporate the above information into the RTAR with the help of your Research Liaison prior to resubmitting it to the Manager of Research and Technical Services for further consideration by RAC. In addition, a separate document providing a point by point response to each of these mandatory comments and questions must be submitted with the RTAR. The response to each item should explain how the RTAR has been revised to address the comment, or a justification for why the technical committee feels a revision is unnecessary or inappropriate. The RTAR and response to these comments and questions must be approved by the Research Liaison prior to submitting it to RAC.

An RTAR evaluation sheet is attached as additional information and it provides a breakdown of comments and questions from individual RAC members based on specific review criteria. This should give you an idea of how your RTAR is being interpreted and understood by others. Some of these comments may indicate areas of the RTAR and subsequent WS where readers require additional information or rewording for clarification.

The next submission deadline for RTARs and WSs is **May 15, 2014** for consideration at the Society's annual meeting. The submission deadline after that is August 15, 2014.

Project ID	1722	
Project Title	Optimizing Air Curtains for Refrigerated Display Cases with Glass Doors	
Sponsoring TC	TC 10.7. Commercial Food and Beverage Refrigeration Equipment	
Cost / Duration	\$60,000/ 24 Months	
Submission History	RTAR 1st Submission - Carried-over from Fall Meeting - Please edit or add to if you wish	
Classification: Research or Technology Transfer	Basic/Applied Research	
RAC 2014 Winter Meeting Review		
Check List Criteria	VOTED NO	Comments & Suggestions
Is there a well-established need? The RTAR should include some level of literature review that documents the importance/magnitude of a problem. If not, then the RTAR should be returned for revision.	#5, #13, #6, #12	#4 - The need for optimizing air curtain use in the refrigeration industry is justified. #5 - Manufacturers should be working on this. #13- Background provided is not clear and inadequate. Research need is not well established. Not well written. #6 - In the recent DOE rule-making, air curtains were not considered as a technology option for any equipment class with doors, only for open cases. Given advances in glazing, anti-sweat heaters, and anti-fog coatings, there doesn't seem to be much opportunity for air curtains for closed equipment, particularly if it is to run when the door is closed. In any event, given an overall energy budget under Federal regulations, it seems to me that individual OEMs will quickly figure out if air curtains for closed equipment help them meet or beat standards cost-effectively.
Is this appropriate for ASHRAE funding? If not, then the RTAR should be rejected. Examples of projects that are not appropriate for ASHRAE funding would include: 1) research that is more appropriately performed by industry, 2) topics outside the scope of ASHRAE activities.	#5, #6, #12	#5 - Industry should perform work. #13- AHRI funding is mentioned. Is this already approved? Display cases manufacturers should co fund the project. #6 - likelihood of substantial advances seems small. #12 - I think that the specific scope suggested here is better suited for an individual manufacturer.
Is there an adequate description of the approach in order for RAC to be able to evaluate the appropriateness of the budget? If not, then the RTAR should be returned for revision.	#13, #8, #12	#8- For the project need, is there sufficient evidence to show that different designs of closed door display cases could cause significant differences in terms of performances? For the project scope, what type of field survey and demonstration will be conducted for the comprehensive analysis.
Is the budget reasonable for the project scope? If not, then RTAR could be returned for revision or conditionally accepted with a note that the budget should be revised for the WS.	#13, #6, #8, #12	#4 - Budget seems low for a 24 month period. What kind of results will be derived? #13 - Budget seems too low. #6 - \$40k - \$60k seems low for any experimental work. #8 - For the scope of project and duration of 24 months, the estimated budget seems too low. #12- What can be accomplished with this budget?
Have the proper administrative procedures been followed? This includes recording of the TC vote, coordination with other TCs, proper citing of the Research Strategic Plan, etc. If not, then the RTAR could be returned for revision or possibly conditionally accepted based on adequately resolving these issues.	##, #13, #8, #12	#4 - Concerned about the vote of (1) against the RTAR. What did they disagree with? #5 - Missing liaison review. Missing reason for negative vote. #13 - Reason for against vote was not found. HS - as far as I can tell. #8 - Reason for one negative vote was not given. #12 - Liaison approval missing.
Decision Options	Initial Decision	Approval Conditions
ACCEPT		#4 - Feel the research is more appropriately aligned with manufacturers. #13 Unless the need is clearly established, detailed approach is developed, and cofunding for the project is established this research should not be funded. #6 - 1/14: I sure like the short-and-sweet RTAR.
COND. ACCEPT		
RETURN	X	
REJECT		

ACCEPT Vote - Topic is ready for development into a work statement (WS).

COND. ACCEPT Vote - Minor Revision Required - RL can approve RTAR for development into WS without going back to RAC once TC satisfies RAC's approval condition(s)

RETURN Vote - Topic is probably acceptable for ASHRAE research, but RTAR is not quite ready.

REJECT Vote - Topic is not acceptable for the ASHRAE Research Program

Research Topic Acceptance Request Cover Sheet

Date: **8/20/13**

(Please Check to Insure the Following Information is in the RTAR)

A. Title	X
B. Applicability to ASHRAE Research Strategic Plan	X
C. Application of the Results	X
D. State-of-the-Art (background)	X
E. Advancement to State-of-the-Art	X
F. Justification and Value to ASHRAE	X
G. Objective	

Title:
Optimizing Air Curtains for Refrigerated Display Cases with Glass Doors

RTAR# **1722**
(To be assigned by MORTS)

Results of this Project will affect the following Handbook Special Publications, etc.:

H. Estimated Duration	24
I. References	2

Refrigeration Chap 46

Responsible **TC 10.7**

Date of Vote: **8/19/13**

For	7
Against	1
Abstaining	0
Absent or not returning Ballot	
Total Voting	

Co-sponsoring TC/TG/MTG/SSPCs (give vote and date):
Probably 10.3

RTAR Lead Author: **Carl Roberts**
Expected Work Statement Lead **Carl Roberts**

Research Classification: (Basic/Applied Research; Advanced Concepts; or Technology Transfer)

Basic/Applied Research

Potential Co-funders (organization):

- AHRI
-
-

Has an electronic copy been furnished to the MORTS?
Has the Research Liaison reviewed the RTAR?

Yes
X

No
X

* Reasons for negative vote(s) and abstentions
Explanation from Massoud Neshan: "Currently there are equipment in the market place that use no anti-sweat heating glass doors and/or low anti-sweat heating glass doors depending on application that have been able to achieve a very reasonable reduction in the energy usage at the case level. We should not spend \$60,000 for field survey the data or test cases. All we get is going to be a comparison of what is being done by different case manufacturers using different kind of doors."

DRAFT RTAR Template

Title: _____

Summary

Describe in summary form the proposed research topic, including what is proposed, why this research is important, how it will be conducted, and why ASHRAE should fund it (50 words maximum)

Background

Provide the state of the art with key references (at the end of this document) substantiating it (300 words maximum)

Research Need

Use the state of the art described above as a basis to specify the need for the proposed effort (250 words maximum)

Project Objectives

Based on the identified research need(s), specify the objectives of the solicited effort that will address all or part of these needs (150 words maximum)

Expected Approach

Describe in a manner that may be used for assessment of project viability, cost, and duration, the approach that is expected to achieve the proposed objectives (200 words maximum).

Check all that apply: Lab testing (), Computations (), Surveys (), Field tests (), Analyses and modeling (), Validation efforts (), Other (specify) ()

Relevance and Benefits to ASHRAE

Describe why this effort is of specific interest to ASHRAE, its impact, and how it will benefit ASHRAE and the society. How does it align with ASHRAE Strategic Plans and Initiatives? How does it advance the state of the art in this area in general? Are there other stakeholders that should be approached to obtain relevant information or co-funding? (350 words maximum)

Anticipated Funding Level and Duration

Funding Amount Range: \$ _____

Duration in Months: _____

References

List the key references cited in this RTAR