Shaping Tomorrow's Built Environment Today

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TO: Willis Brayman, Chair TC 1.8, brayman.bicllc@att.net
Gordon Hart, Research Subcommittee Chair TC 1.8, gordonhhart@gmail.com
CC: Shinsuke Kato, Research Liaison Section 1.0, kato@iis.u-tokyo.ac.jp

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

DATE: January 23, 2019

SUBJECT: Research Topic Acceptance Request (1871-RTAR), "Hygrothermal Modeling of Below Ambient Pipe Insulation Systems in Both Buildings and Refrigeration Systems"

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, Shinsuke Kato, kato@iis.u-tokyo.ac.jp, or RL1@ashrae.net, in the work statement draft.

1. We would recommend that 1703-WS start and get meaningful data before this RTAR proceeds.
2. Specify better the objective and detail the tasks in the expected approach.
3. Not clear whether sufficient empirical data is available on material properties to validate the modeling.

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 **December15, 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	**1871**	
Project Title	**Hygrothermal Modeling of Below Ambient Pipe Insulation Systems in Both Buildings and Refrigeration Systems**	
Sponsoring TC	TC 1.8, (Mechanical Insulation System); co-sponsor: TC 10.3, (Refrigerant Piping, Controls and Accessories)	
Cost / Duration	$120,00 -$130,000 - 15M	
Submission History	**1st Submission**	
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** - Whilst no references are cited, the background is clear in identifying the issue. **4** - Background refers to WS1703 but should provide information on whether any attempts were made in the past to deal with the problem that will be dealt in the proposed project and how the work proposed will advance the current state of knowledge. **7** - The state of the start is limited to what was developed inside the ASHRAE community. Please define "hygrothermal algorithms". The expression "below ambient pipe insulation systems" should be completed, for instance, with a word like "temperature", "pressure" or "conditions" to read "below ambient conditions pipe insulation systems". **3 -** The relationship between the RTAR and WS 1703 is stated. **12** - How to model? Is there data out there already? Or is this just a parametric search?
Research Need: Based on the background provided is the need for additional research clearly identified? If not, then the RTAR should be rejected.		**2** - Discussion of what constitutes a "failure" is weak. **9** - The need for analytical work is made, and placed in context with the empirical work being proposed in WS 1703. **7 -** Research project complementing TRP- 1703. **12** - not clear on the need, we have perm values (or ranges). Section needs clarification.
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.		**2** - Being able to predict insulation performance over time would be important benefit to ASHRAE. **9** - Clear benefits to ASHRAE in terms of being able to better specify pipe insulation requirements for different conditions. **4** - Benefits could be better described. **12** - is the idea to find out how long insulation takes to get saturated given different climatic regions? I.e. The south of the US is bad, out west with a low dew point probably not? Section needs clarification.
IF ABOVE THREE CRITERION 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.		**2** - Will this answer the question of what is insulation "failure". **9-** Objectives relate to parametric simulation studies for a range of pipe operating temps, climates and insulation presence values. These ranges can be specified better in the WS. **7** - The objective is to find "the engineering link between pipe insulation water vapor permeance and long-term pipe insulation performance". However, it is not clear whether the result should be a model or something else. **6** - need further details on the objects --Not sure of the "parametric analyses" **12** - what is breaking - just moisture absorption? Can't fix in a parametric search.
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:		**2** - Not clear whether sufficient empirical data is available on material properties to validate the modeling. If the successful contractor is expected to "provide evidence of validation efforts" then the WS should make this the first task with deliverable. This should also be a milestone where that PMS can terminate the project is sufficient evidence is not provided. **9** - Clarify whether the physical test results are coming from published data or tests to be conducted by others (beyond this RTAR). Clarify also whether validation evidence is to come from elsewhere or within this RTAR. **4** - Approach is well described but only based on the analytical approach. There are no means proposed for verification. **7** - The expected approach should detail the tasks envisioned. **12** - 120k to tell us that operation below the dew point can lead to negative performance on insulation? Perhaps I missed something?
References: Are the references provided?		
Decision Options	**Initial Decision?**	**Final Approval Conditions**
ACCEPT AS-IS		**2** - Will this answer the question of what is insulation "failure". Not clear whether sufficient empirical data is available on material properties to validate the modeling. If the successful contractor is expected to "provide evidence of validation efforts" then the WS should make this the first task with deliverable. This should also be a milestone where that PMS can terminate the project is sufficient evidence is not provided. **9** - Good focused project is proposed. In the WS: i) clarify the ranges of variation for pipe operating temps, climates and insulation permeance values; ii) whether the physical test results are coming from published data or tests to be conducted by others; iii) whether validation evidence is to come from elsewhere or within the proposed work. It might also be helpful to conduct an estimate of energy performance for a typical HVAC system as affected by insulation specification (to highlight the potential impact and benefit of the work being proposed). **4** - Improved background, description of benefits and inclusion of validation methods. **7** - Specify better the objective and detail the tasks in the expected approach. **6** - see comments on project objectives above. **12** - clean up and resubmit, I am unclear of the objectives and project output.
ACCEPT W/COMMENTS		
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: November 15, 2018

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

Title:

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

Hygrothermal Modeling of Below Ambient Pipe Insulation Systems in Both Buildings and Refrigeration

RTAR # 1871
(To be assigned by MORTS)

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

Handbook of Fundamentals – Chapter 23 and Handbook of Refrigeration, Chapter 10

Research Classification:

Basic/Applied Research	x
Advanced Concepts	
Technology Transfer	

Responsible Committee: TC 1.8

Date of Vote: October 3, 2018

For		11
Against	*	0
Abstaining	*	0
Absent or not returning Ballot	*	1
Total Voting Members	(CNV)	12

RTAR Authors

Lead: Gordon H. Hart & Manfred Kehrer

Others: TBD

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

TC 10.3 Vote closed on November 9, 2018 (7 For, 0 Against, 0 Abstaining, 2 not returning ballot, for a total of 9 Voting Members

Expected Work Statement Authors

Lead: TBD

Others: TBD
TBD

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

TBD (TBD)

	Yes	No
Has an electronic copy been furnished to the MORTS?	X	
Has the Research Liaison reviewed the RTAR?	X	X

* Reasons for negative vote(s) and abstentions

RTAR # _____1871-RTAR_____

Title:

Hygrothermal Modeling of Below Ambient Pipe Insulation Systems in Both Buildings and Refrigeration Systems

Executive 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)

This analytical project would mathematically model, using hygrothermal algorithms, a below ambient pipe with several different pipe insulation systems, at a fixed pipe diameter, inputting hourly weather data from each of several different cities, for a long duration. Output would be the predicted water vapor ingress, with condensation, into the pipe insulation system and the pipe insulation's thermal performance with that moisture. The generation of this new information, linking water vapor permeance to pipe insulation performance over time, would be a unique and valuable asset to those designing and specifying below ambient pipe insulation systems.

Background

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

Both short-term and long-term failure of below ambient pipe insulation is a problem for both HVAC and refrigeration systems. This is particularly a problem for pipes located in unconditioned locations, both indoors and outdoors, as well as indoor spaces that are only intermittently conditioned. The design of these pipe insulation systems must include effective vapor retarder systems that are continuously sealed. This is one of the objectives of WS 1703, to experimentally evaluate the effectiveness of vapor retarder sealing systems. There is a lack of consensus about what entails effective vapor retarder permeance values for these vapor retarder systems, particularly with variations in geographic location and expected life durations, hence the need for this analytical modeling. Details on how to effectively seal the vapor retarder systems, using practical methods, would be beyond the scope of this research project; these will be addressed in WS 1703.

Research Need

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

Failures of below ambient pipe insulation systems do frequently occur. They are particularly a problem in unconditioned spaces, both indoors and outdoors, as well as indoor spaces that are only intermittently conditioned. With the goal of preventing these failures, there are research needs for both the empirical and analytical information on the performance of below ambient pipe insulation systems. The former would be addressed by WS 1703. This analytical research project would address the latter. While the industry uses different values of water vapor permeance as being effective (such as 0.1 perm, 0.05 perm, 0.02 perm, 0.01 perm, and 0.005 perm), no analytical research effort has yet been attempted to address this knowledge shortcoming (at least none with publicly available results). The results would improve the available data, that could be used by designers and specifiers of these below ambient pipe insulation systems, when addressing these insulation systems on both chilled water and refrigeration systems.

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)

Computerized hygrothermal analyses will result in improved pipe insulation system designs, leading in turn to both improved building energy performance and improved commercial refrigeration system performance. Finding the engineering link between pipe insulation water vapor permeance and long-term pipe insulation performance, on below ambient pipes, can be of significant value to those designing these pipe insulation systems. To achieve this, the project would consist of a series of parametric analyses using several different pipe operating temperatures, several different North American climates (each represented by a year's worth of standardized hourly weather, for each Climate Zone on the ASHRAE Climate Zone map), and several different permeance values representing a range of anticipated vapor retarder system permeance values. With this information, the designers, in the future, would be able to write pipe insulation specifications that take into account below ambient pipe insulation performance over time.

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) ( )

This research is expected to be computational but will rely on using material properties obtained by physical tests. The successful contractor will be expected to provide evidence of validation efforts of the software he plans on using for this research.

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)

The results of the Research Project will be of significant value to all designers of both building mechanical systems and commercial refrigeration. This RP would address ASHRAE Research Goals 1: *Maximize the actual operational energy performance of buildings and facilities* and 9: *Support the development of improved HVAC&R components ranging from residential through commercial to provide improved system efficiency, affordability, reliability, and safety*. Mechanical designers will be able to use the generated results, resulting in both improved building energy performance and, through reduced water vapor intrusion, improved building mechanical system longevity.

Current practice does not include any attempt to evaluate mechanical insulation system performance over time, this constituting a major shortcoming. Hence, too many times, the mechanical insulation system is under designed, with regards to effective moisture control, with no way of predicting the effects of that shortcoming over time. This proposed Research Project would change this situation, providing predictive results of moisture accumulation for different insulation systems in different climates, for pipe temperatures that include both commercial chilled water and refrigeration systems.

Anticipated Funding Level and Duration

Funding Amount Range: $120,000 to $130,000

Duration in Months: 15

References

List the key references cited in this RTAR.

1. "Prevention of Condensation Problems on Insulated Chilled Water Pipes Located in Unconditioned Spaces in Hot, Humid Climates", presentation by Gordon Hart, ASHRAE Seminar, Montreal, June, 2011.
2. ASHRAE RP-1356, "Methodology to Measure Thermal Performance of Pipe Insulation at Below-Ambient Temperatures", by Dr. Lorenzo Cremaschi, ASHRAE Research Project, January, 2012.
3. ASHRAE RP-1646, "Measurements of Thermal Conductivity of Pipe Insulation Systems at Below-Ambient Temperature and in Wet Condensing Conditions with Moisture Ingress", by Dr. Lorenzo Cremaschi, ASHRAE Research Project, May, 2015.
4. "Controlling Condensation on CWP Insulation", article by Ed Light, James Bailey, and Roger Gay, ASHRAE Journal, December, 2014.
5. "Case Study: Economic Justification for Replacing Ice-Laden Refrigerant Pipe Thermal Insulation with New Insulation", technical paper by Gordon Hart, IIAR Annual Meeting, San Diego, March, 2015.
6. "Hygrothermal Analyses on Ammonia Refrigeration Pipe Insulation Systems", technical paper by Gordon Hart and Christian Bludau, IIAR Annual Meeting, Orlando, March, 2016.
7. "Air Conditioned Football Stadium and Convention Center Chilled Water Pipe Insulation System Working at Below Ambient Temperature and in Wet Condensing Conditions with Moisture Ingress", technical presentation by Bill Brayman, AHSRAE Annual Meeting, Las Vegas, NV, January, 2017, Seminar # 10.
8. ASHRAE Work Statement 1703: Performance of Vapor Retarder Systems Used on Mechanical Insulation.

Feedback to RAC and Suggested Improvements to RTAR Process

Now that you have completed the RTAR process, RAC is interested in getting your feedback and suggestions here on how we can improve the process.

TBD……