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TO: Christine Cronin, Chair TC 1.12, christy@buildingscience.com
Fitsum Tariku, Research Subcommittee Chair TC 1.12, Fitsum_Tariku@bcit.ca
Shinsuke Kato, Research Liaison 1.12, kato@iis.u-tokyo.ac.jp

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

DATE: November 6, 2018

SUBJECT: Research Topic Acceptance Request (1860-RTAR), "Characterization of Residential Indoor Moisture Generation based on Survey and Laboratory Measurements"

During their fall meeting, the Research Administration Committee (RAC) reviewed the subject Research Topic Acceptance Request (RTAR) and voted 4-0-1 to reject it. The following list summarizes the consensus review comments and questions on this RTAR:

1. The RTAR is also not clearly written in some places.
2. Not clear the knowledge already available and the additional information that this research project would provide.
3. Provide a description of the outcome of this research project stating the minimum number of moisture generation sources to be characterized and the minimum number of moisture generation profiles.
4. Not enough information is provided to determine the appropriateness of the budget, such as how many dwellings will be surveyed. More information is needed on details of survey and lab set-up to evaluate the budget, which is high.

By rejecting this RTAR, RAC is strongly suggesting to the TC that this particular topic be dropped from the TC research plan based on the information that has been provided.

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.

If the TC wishes to pursue this topic further, please incorporate the above information into the RTAR with the help of your Research Liaison, Shinsuke Kato, RL1@ashrae.net, prior to submitting 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 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.

The next realistic submission deadline for RTARs and WSs is May 15, 2019 for consideration at the Society's 2019 annual meeting. The submission deadline after that is August 15, 2019 for the RAC fall meeting.

Project ID	**1860**	
Project Title	**Characterization of Residential Indoor Moisture Generation based on Survey and Laboratory Measurements**	
Sponsoring TC	TC 1.12, Moisture Management in Buildings	
Cost / Duration	$300,000 - $350,000 / 18 -24 Months	
Submission History	**1st Submission**	
Classification: Research or Technology Transfer	Basic/Applied Research	
RAC 2018 Fall 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.		**7** - The test has be cropped in the Background section. **9** - Explains situation. Literature list does not align with 'background'. Only four references cited, but the list shows 22 references **10** - It is not possible to read the whole section "background" because it is cut off.
Research Need: Based on the background provided is the need for additional research clearly identified? If not, then the RTAR should be rejected.		**9** - Need for more info on moisture generation and occupant behavior. But some clarification of text would help. **10** - Not clear the knowledge already available and the additional information that this research project would provide.
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** - Variance of moisture loads is needed, to reduce uncertainty (for design) to narrow gap between design and actual latent load in a building. **8** - this is an ambitious project that may exceed the ability to reach its goals
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** - Survey measurement should be done with the observation of local ventilation which exhausting generated moisture. **4**- The proposed work is very large in cope as it requires information regarding behavior, moisture generating actives and modelling moisture generation in the laboratory. It may be impossible to simulate all possible scenarios in the laboratory so the study may not be representative, **7-** I don't see a discussion regarding bath and kitchen vent systems. I would think this this would also have a significant effect on moisture in residences. Will this behavior -- mitigating moisture generation -- be included in the survey and laboratory study? **9** - Laboratory measurements and time user survey are stated. But specific objectives are not stated. Makes sense, but needs focusing, and presentation as 'step by step' **10** - The objectives are aligned with the need but not specific enough. It would be impossible to evaluate whether the project accomplished its objectives without quantifying in some way either both moisture generation sources (2 or 100?) and the generation profiles. In the expected approach section, the RTAR lists four activities: is this what the project wants to accomplish? Whether they are achievable or not it depends also on the duration of the project, which depends on the number of sources to be tested. **8 -** would like to see this project descoped into smaller achievable goals. **15** - I think the goals, while laudale, are too broad and need to be revised such that the scope and plan is more well-defined and doable.
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:		**7-** The budget seems high. **9 -** surveys of dwellings and design / conduct lab experiments. $300-350k is high, and depends on numbers of dwellings and lab set up - more info is needed here. **10** - 18 months seems to be a short time compared to the budget requested, unless a large group of people are involved in the project. Task 3 should describe better what the expected moisture generation profile would look like. The budget seems not appropriate by the expected approach. Please provide some evidence to justify such high amount. **8** - This may bee too ambitious for a single project. **15** - I don't 200K is sufficient to get all this work done, even if the scope is narrowed and refined.
References: Are the references provided?		
Decision Options	**Initial Decision?**	**Final Approval Conditions**
ACCEPT AS-IS		**2**- Survey measurement should be done with the observation of local ventilation which exhausting generated moisture. **4** - The scope should be reduced and the approach changed to determine the range of potential moisture generation activities and moisture load being the result of these activities. **7** - I don't see a discussion regarding bath and kitchen vent systems. I would think this this would also have a significant effect on moisture in residences. Will this behavior -- mitigating moisture generation -- be included in the survey and laboratory study? The budget seems high. Not enough information is provided to determine the appropriateness of the budget, such as how many dwellings will be surveyed. **9** - In its present form, this could almost be considered as rejected. More info is needed on details of survey and lab set-up to evaluate the budget, which is high. The RTAR is also not clearly written in some places. The objective 'steps' should also be more specific. This should really be evaluated as 'return with major revisions needed. 10 - Provide a description of the outcome of this research project stating the minimum number of moisture generation sources to be characterized and the minimum number of moisture generation profiles. Reduce the budget of the project after careful evaluation of the amount of work involved or justify such a high budget by listing the project activities and their duration. **8** - revise scope
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: **8/7/18**

(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	√

Title:

Characterization of Residential Indoor Moisture Generation based on Survey and Laboratory Measurements

RTAR # 1860
(To be assigned by MORTS)

Research Classification:

Basic/Applied Research	√
Advanced Concepts	
Technology Transfer	

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

HOF Ch. 36, Moisture Management in Buildings
HOF Ch. 17, Residential Cooling and Heating Load Calculations
HOHVACA Ch. 62, Moisture Management in Buildings
ASHRAE Standard 160, Criteria for Moisture-Control Design Analysis in Buildings

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Responsible Committee: **TC 1.12, Moisture Management in Buildings**

Date of Vote: **6/23/18**

For		7
Against	*	0
Abstaining	*	0
Absent or not returning Ballot	*	4
Total Voting Members		11

RTAR Authors

Lead: Simon Pallin
Fitsum Tariku
Others: **Samuel Glass**
Jeffrey Munk

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

SSPC 160 and TC 4.4
TC 4.4 For (13) Against (0) and Abstain (0)
SSPC—to come

Expected Work Statement Authors

Lead: Simon Pallin
Fitsum Tariku
Others: Samuel Glass & Jeffrey Munk

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

U.S. Department of Energy, Air Conditioning Contractors of America, and National Association of Home Builders.

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

* Reasons for negative vote(s) and abstentions

RTAR # 1860

Title:

Characterization of Residential Indoor Moisture Generation based on Survey and Laboratory Measurements

Executive Summary

Indoor moisture loads impacts the durability of buildings, and their materials within, and understanding how much they contribute to indoor humidity levels is crucial to properly design for both energy efficiency and durability. In addition, excessive indoor humidity levels in buildings can affect the health of occupants and cause discomfort. Guidance on residential indoor moisture generation is inconsistent within ASHRAE publications. This study will help gather the missing information needed to update indoor moisture load guidance by conducting a survey of moisture generation in homes together with lab measurements and probabilistic analyses.

Background

When architects and builders design buildings, it is important to consider moisture because it can affect the structural performance, such as through deterioration, and impact indoor air quality and thus residents' health [1]. The ASHRAE Position Document on Limiting Indoor Mold and Dampness in Buildings stresses the importance of this. The amount of moisture generated inside building is also relevant when designing and optimizing heating, ventilation, and air conditioning (HVAC) systems, the latter particularly because of the relation between latent and sensible heat loads and cooling equipment sensible heat ratio rating. In residential buildings, indoor moisture generation rates are complex to predict as there are a wide variations of occupants' moisture generating activity types, whose moisture generation intensity and frequency can be different depending on the life style and custom of the building user.

Despite the prevalent research of indoor relative humidity levels in residential buildings in the United States, there is a lack of research that seeks to understand and compile indoor moisture generation rates inside homes [2]. Although ASHRAE 160 provides a guideline for indoor moisture generation rates [3], it is incomplete and is not in agreement with guidance in ASHRAE HOF Ch. 17 and HOF Ch. 36, which is a result of failing to acknowledge and address the high degree of variability in rates of indoor moisture generation. A review by Glass and TenWolde [4] supports the argument that indoor moisture generation rates are highly variable. Research to characterize these rates needs to take a probabilistic approach to gain a better understanding of residential moisture loads and thus help designers better predict the moisture durability performance of building envelope components, optimize the HVAC system, and if needed, create an appropriate moisture control plan.

The indoor humidity is affected by indoor moisture loads from appliances and activities, such as: bathing, showering, grooming, food preparation, dishwashing, cleaning (e.g., mopping), faucets, laundry, respiration and perspiration from humans and animals, houseplants, aquariums, humidifiers etc. In addition, indoor humidity is also influenced by outdoor humidity levels, ventilation and infiltration, characteristics of the HVAC system, and the moisture storage capacity of material inside or adjacent to the indoor environment. Of these factors, indoor moisture load often has a significant impact on indoor humidity levels, but at the same time, it is difficult to predict with the information available in todays publications. In addition to understanding the

Research Need

There are basically two sets of information needed to understand indoor moisture loads; moisture generation rate from each activity/source, and occupants' behavior patterns.

Of the presented moisture sources, of specific value to better understand moisture generation rates are; bathing and showering, food preparation, laundry, dish washing and usage of humidifiers. For showering, ORNL conducted a comprehensive study during the spring of 2017, on variation in moisture generation rate depending on type of shower head (water flow rate), duration, water temperature and usage of bathroom fan. Similar studies are needed for the previously presented activities/sources where more knowledge of moisture generation rates is required.

To establish occupants' behavior patterns, a time user survey should be conducted that addresses all moisture generating activities. Information needed for these are, when they take place, where inside the home, for how long and by whom. Also, if there are differences in user behavior in terms of age and gender, and impact of outdoor climate conditions.

Recent work [16][22], shows that there is a need for a probabilistic approach to advance in the understanding of indoor moisture generation, and its effect on building's durability and performance, as well as comfort and human health. ASHRAE 160 provides default values for daily indoor moisture generation rates in residential buildings. However, there is no information provided to guide the user of the Standard what these rates represent. Instead, guidelines should be given with an expected variance and design values to allow for more precise estimation of moisture durability risks in buildings. Also, identifying moisture generation sources and their contribution will allow for accurate evaluation of regulation strategies.

Project Objectives

This project intends to study specific moisture generation rates from bathing, food preparation, laundry, and dish washing. For each moisture generation source, the study will include laboratory measurements to examine which parameters influence the generation rate, and their impact on the natural variation of the source.

Also, a time user survey will be conducted that addresses all moisture generating activities. The survey will provide information needed to develop accurate probability distributions of occupancy and patterns of activities that generate moisture, such as when the activity take place, where inside the home, for how long, and by whom. The time user survey will also include user pattern of humidifiers and dehumidifiers.

The final outcomes of the study are indoor moisture generation profiles related to type of occupancy and guidelines for estimated moisture generation levels in residential buildings. The generation profiles will be presented with a probabilistic distribution, thus reflecting the natural variation in generation rates.

Expected Approach

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

The research project involves lab testing, surveying, and analysis and modeling to achieve its objective. The expected research activities are grouped into the following five tasks:

Task 1. Conduct a survey of dwellings to capture occupants' behavior including frequency of occurrence of moisture generating activities, time span of the events, what time of the day the events occur, appliances used etc.

Task 2. Design and conduct laboratory experiments to quantify the moisture generation rates of the targeted activities: bathing, food preparation, laundry, and dish washing.

Task 3. Based on the results of Task 1 and Task 2, numerically develop indoor moisture generation profiles with a probabilistic distribution to reflect natural variation.

Task 4. Develop guidelines on indoor moisture generation rates in a probabilistic manner, such as 10th, 50th, and 90th percentiles. Also, provide tables of expected diurnal variations of indoor moisture generation for ASHRAE SSPC 160, and HOF chapter 17 and 36.

Relevance and Benefits to ASHRAE

Moisture management in buildings is crucial to mitigate moisture related undesired effects such as mold growth and the associated health risk to occupants, building envelope moisture failures, and improper sizing of equipment as related to latent heat load. As such ASHRAE has dedicated two Chapters on moisture management in buildings, Chapter 36 in the HOF and Chapter 62 in the Handbook of HVAC Applications, respectively. Moreover, ASHRAE provides basic and applied knowledge on moisture design of building envelope in HOF Chapter 25 and Standard 160. And yet, there is not enough data that enables development of indoor moisture loads with sufficient variance to be used in the ASHRAE Handbooks Chapters and Standard referenced here. This leaves designers with too much uncertainty.

The proposed research effort is of specific interest to ASHRAE, because ASHRAE has a responsibility to correct current guidance that is inconsistent with measured data. Properly addressing latent loads is critical in new high-performance residential buildings as well as existing buildings. Further, the project will have impacts in design and operation of buildings as well as equipment specification for indoor humidity control. The project aligns with the 2010-2018 ASHRAE Research Strategic Plan, more specifically with Goal 1, 3 and 7.

An improved interior moisture load prediction model will enable to narrow the gap between the design and the actual latent heat load in a building, and thereby helps to improve building energy performance (Goal 1); reduce significantly the energy consumption for HVAC&R, water heating and lighting in existing homes (Goal 3); and provide the set of moisture load profiles that will be developed through the project which will form the important input in the design and operation of low-energy buildings (Goal 7). Improved humidity control is specifically mentioned in the Strategic Plan. Reduction of sensible loads in existing buildings must be accompanied by attention to humidity control. This effort is essential for realizing this goal.

Anticipated Funding Level and Duration

Funding Amount Range:

$300,000 to $350,000

Duration in Months: 18 to 24

References

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[3] American Society of Heating, Refrigerating, and Air-Conditioning Engineers Inc., "Criteria for Moisture Control Design Analysis in Buildings," Standard 160-2009 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, 2016.

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Feedback to RAC and Suggested Improvements to RTAR Process

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