INVITATION TO SUBMIT A RESEARCH PROPOSAL ON AN ASHRAE RESEARCH PROJECT

1780-TRP, "Test method to evaluate cross-contamination of gaseous contaminant within total energy recovery wheels"

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 9.10, Laboratory Ventilation
Co-sponsored by: TC 2.3, Gaseous Air Contaminants and Gas Contaminant Removal Equipment; TC 9.6, Healthcare Facilities; SSPC 62.1, SSPC 62.1, Ventilation for Acceptable Indoor Air Quality

Budget Range: $200,000 may be more or less as determined by value of proposal and competing proposals.

Scheduled Project Start Date: **April 1, 2019** or later.

All proposals must be received at ASHRAE Headquarters by 8:00 AM, EST, December 17, 2018. 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: 1780-TRP, "Test method to evaluate cross-contamination of gaseous contaminant within total energy recovery wheels", 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
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Contractors intending to submit a proposal should so notify, by mail or e-mail, the Manager of Research and Technical Services, (MORTS) by December 3, 2018, 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 and mvaughn@ashrae.org. Hardcopy submissions are not permitted. **In all cases, the proposal must be submitted to ASHRAE by 8:00 AM, EST, December 17, 2018. 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)

Some research has been done by manufacturers, and some in Japan at Kanazawa University. As per the review of the available literature that has been done, there is actually no test procedure to evaluate the gaseous contaminant transfer and at which temperature and humidity conditions that these tests should be conducted.

The basic function of laboratory HVAC systems is the management of contaminant concentrations in the space in order to reduce the risk to the researchers of ingesting or being in contact with these contaminants. Unlike commercial spaces, energy-intensive laboratories use high volumes of filtered outdoor air to dilute airborne contaminants. This requires large amount of outside air that has to be cooled, dehumidified, heated and humidified, resulting in very high energy use. As per DOE (2008) there are about 9000 laboratory buildings in the US totaling about 650 million square feet of work area. According to EPA, US laboratories consumed about 150 million MWHr/yr in 2005. Of this, approximately 60% (or 90 million MWhr/yr) was associated with the HVAC systems.

Historically, the glycol loop, which utilizes a coil to transfer thermal energy between the exhaust and supply air streams, has been considered the safest energy recovery system for laboratory HVAC systems. This technology eliminates the risk of contaminant transfer in the incoming air from the exhausted air stream. However, this technology is only about 40-45% efficient in winter and even lower in the summer, since it does not recover the latent heat of the exhausted air. It also provides no heating season humidification.

ASHRAE Standard 90.1 now mandates the use of total energy recovery devices for most buildings. To determine compliance with ASHRAE Standard 62.1 for most building types, 62.1 provides Classification of Air and acceptable Exhaust Air Transfer Ratios (which are certified by AHRI). However, for laboratory applications, 62.1 directs the user to environmental health and safety experts and these experts needs to establishing the degree of contaminant transfer air exhibited by a given product in a specific ERV installation. This research will provide tools for use by these experts and is essential for all building types, not just laboratories, since transfer contaminated air cannot be considered outdoor air. To determine the proper outdoor air correction factor (OACF) the approximate degree of contaminant transfer air must be known.

As ASHRAE 62.1 now permits the use of total energy recovery wheels under certain conditions for laboratory hood exhaust The ASHRAE community needs qualitative data and tests procedures on the potential cross-contamination of these devices.

Over the past 20 years, some manufacturers have developed specialized desiccant transfer surfaces and advanced purge sections to limit the transfer of airborne particulate and gaseous contaminants contained within the exhaust air stream. Substantial research has been completed by the Georgia Tech Research Institute and a University in Japan for select manufacturers. Field data of cross-contamination levels has been reported at various technical conferences, including ASHRAE. However a standard test procedure does not exist, so the validity of the results is always in question. Therefore, ASHRAE should address the concern of contaminant transfer within total energy devices by developing a standard testing procedure.

Justification and Value to ASHRAE

The Environmental Health and Safety professionals, laboratory designers and other ASHRAE Members need reliable gaseous contaminant transfer data measurements methodologies to complete the necessary risk assessment when evaluating energy recovery systems for their laboratory ventilation projects. Technologies shown to limit contaminant transfer would allow greater energy savings and reduce the carbon footprint.

Compared to commercial buildings, the opportunity for energy savings in laboratories is much greater. ASHRAE should play a leadersdhip role in optimizing the HVAC systems in laboratories while keeping safety a top priority.

Objectives

The objectives of this study are to:

1) Review current testing methodologies and relevant research data available;
2) Develop a draft test methodology and establish minimum specifications for the test facility and instrumentation;

3) Evaluate the draft test methodology with various gaseous chemicals representative of contaminants of concern and operating conditions representative of a laboratory, vivariums and similar facilities. Also consider various incoming outside air temperatures and humidity.
4) Validate the test methodology based on the test results collected under laboratory conditions;
5) Produce a final test method for establishing gaseous cross contamination rate measurement that is reliable and effective for manufacturers/test laboratories to employ.

Scope:

1. Establish a scientific approach to develop a test methodology to evaluate gaseous cross-contamination transfer within total energy wheels recovery devices. Including a review of the available literature and research publications relating to methods for testing cross-contamination and reported data. Note the different environmental conditions under which total energy recovery wheels shall be tested.
2. Based on the literature review and existing research publications, develop a draft test methodology. This should include specifying the most appropriate test facility and instrumentation capabilities in which to conduct the testing, selecting an appropriate number of contaminants of concern to test, and selecting the environmental conditions which should be varied to determine any impact on carry-over rates as part of the energy recovery device evaluation (see list below)
3. Laboratory testing:
    - The contractor will be responsible for building/finding access to a laboratory facility with the capabilities necessary and designed to meet ASHRAE 84 requirements to implement the methodology testing and evaluate the impact of selected design parameters from the list below Select appropriate contaminants; considering molecular properties of the contaminant (i.e., polarity, water solubility, molecular size, etc.). The list shall be comprehensive enough to represent a typical laboratory fume hood exhaust, vivarium or other applications. Chemicals necessary level of accuracy and to represent a worst-case scenario. Chemicals chosen must be easy to measure by instrumentation readily available for precision analysis (i.e. mass spectrometer, gas chromatograph, photo-acoustical multi-gas analyzer, etc.) The listed contaminants below are a minimum.
    - Evaluate the potential impact of design parameters associated with recovery devices that would likely influence gaseous contaminant transfer taking into account current, best design practices
        - Airflow/face velocity,
        - temperature,
        - condensation,
        - relative humidity,
        - freezing,
        - pressure differential between airstreams.
4. Finalize Test Method and :
    - Provide documentation (final report with data) to establish the effectiveness of the test procedure confirming the ability to deliver the necessary precision to document gaseous contaminant transfer as a percentage of the challenge concentration.
    - Provide rational behind the design variables tested and the impact on carry-over established for those variables investigated.
    - Secure industry (non-identified of 2 different manufacturers) samples of at least 2 total energy recovery products employing different desiccant types. Test each of these 2 samples for the full range of gaseous chemicals selected and temperature and humidity conditions listed below and publish the carry-over percentage measured complete with error bars to highlight the precision of the data. Use at least one of these samples to evaluate the impact of design parameters on carry-over (i.e face velocity, humidity level, pressure differential, condensation, freezing, etc.)

- Provide drawings of a test facility layout that can accommodate the Test Method established and which can also be easily constructed by manufacturers of the recovery devices or research laboratories interested in completing such testing. Recommend instrumentation to be used, procedures for introducing the challenge chemicals and collection of the samples to be evaluated.
- Summarize the test method, all data and recommended procedures in a manner to allow for peer review and for eventual implementation into ASHRAE 84 or other standard.

Background Information:

A substantial body of research work has been conducted in this field over the past 25 years by the Georgia Tech Research Institute, Dr. Charlene Bayer (now Director of Hygieia Sciences), Johns Hopkins School of Medicine and The Japanese Fukuoka Institute of Technology.

The selected chemicals should represent a strategic sampling from different chemical groups, water solubility, polarity and kinetic diameter (molecular size) which can be safely used within a test laboratory and be precisely measured. As part of a DOE funded research project, researchers at the Georgia Tech Research Institute evaluated this list of parameters to recommend the following chemical families for testing.

Contaminants chosen with properties

- Acetaldehyde - small aldehyde, water soluble and polar
- Ammonia
- Acetic acid - small acid, water soluble and polar
- Methanol - smallest alcohol, water soluble very polar
- Isopropyl alcohol - small alcohol, water soluble and polar
- Methyl isobutyl ketone - small ketone, somewhat water soluble and polar
- Xylene - Aromatic hydrocarbon, non-polar and water immiscible
- Carbon dioxide - Small oxide, non-polar and water soluble
- Propane or hexane - Alkane (straight chain hydrocarbon), non-polar, water immiscible
- Phenolic gases

The Sulfur Hexafluoride is specifically chosen since it is a gaseous contaminant that will not be transferred by any desiccant surface and can therefore be a reliable challenge gas to quantify purge inefficiency and seal leakage. Any contaminant carry-over for another challenge gas beyond the percentage measured for the SF6 is therefore desiccant carry-over.

Other contaminants that may or may not be considered contaminants of concern since they are not a health risk but could be a nuisance odor for a specific application would also be covered by the test standard for specific labs or non-lab applications, allowing for the same procedure to be used for other chemicals not included in the initial group recommended for testing for laboratory fume hood applications.

The list of chemical should be reviewed by the PI of this research project and confirm this list as a minimum.

Task #1: Do a complete literature review
Task #2: Validate the list of chemicals proposed in the present WS and comment if needs be.
Task #3: Have the test rig plans and characteristics validated by the PMS.
Task #4: After completing the installation, validate the test rig at high and low limit conditions of temperature, pressure, humidity and flow. Define the wheel air leakage/transfer.
Task #5: Prepare a draft method of testing chemicals.
Task #6 : For one chemical, do the complete series of test at specified temperature and humidity. These values should be reviewed by the PMS before continuing testing of other chemicals.
Task #7: Validate the testing methodology, update and document the test methodology.

Task #8: Tests all other chemicals at the various prescribed temperature and humidity conditions and report measured datas.
Task #9: Write the final test procedure.

Deliverables:

Results will include: A complete literature review of existing scientific studies on this topic; provide a comparison of the previously reported measured data; validate that the developed test procedure is acceptable and consistent; establish the limitations of the test procedure including the challenge chemicals to be used; validate via in-situ installations that the test procedure is applicable; and determine the metrics that impact the cross-contamination rates.

There are several required deliverables for this project. These include:

1. A complete literature review of existing scientific studies on this topic. This will initially be presented to the PMS for review and approval as milestone 1. This review will also be included in the final project report for publication by ASHRAE.
2. List the chemicals that has been validated and the reason why they were chosen.
3. Submit the test rig plans and operation characteristics of flow, temperture, humidity, pressure, etc..
4. Validate in-situ the operation characteristics of the rig at all limit conditions and report these datas to the PMS
5. A draft test method in a format that could become the basis for a new ASHRAE test method. This draft, in initial format, will be presented to the PMS for review
6. Submit datas after testing of one chemicals at all temperatures and humidity conditions. Describe procedures and measurement instruments used. Comments also on accuracy and reliability of results.
7. Propose adjustments to the test procedure if needed.
8. Proceed with testing all other chemicals and provide the datas to the PMS.
9. Submit a report on the validation of the developed test procedure showing that it is acceptable and consistent by establishing the limitations of the test procedure including commenting on the challenge chemicals that has been used.
10. Final report documenting all of the information and requirements set forth in sections 1-9 in the Scope/Technical approach/ Tasks section of this document. Final report recommending how to conduct testing, collect, analyze and report datas.
11. Final test method written to serve as the basis of a new ASHRAE test method.
12. ASHRAE Transaction article and/or other publications required by ASHRAE.

Progress, Financial and Final Reports, Technical Paper(s), and Data shall constitute the deliverables ("Deliverables") under this Agreement and shall be provided as follows:

a. Progress and Financial Reports

Progress and Financial Reports, in a form approved by the Society, shall be made to the Society through its Manager of Research and Technical Services at quarterly intervals; specifically on or before each January 1, April 1, June 10, and October 1 of the contract period.

The following deliverables shall be provided to the Project Monitoring Subcommittee (PMS) as described in the Scope/Technical Approach section above, as they are available:

Furthermore, the Institution's Principal Investigator, subject to the Society's approval, shall, during the period of performance and after the Final Report has been submitted, report in person to the sponsoring Technical Committee/Task Group (TC/TG) at the annual and winter meetings, and be available to answer such questions regarding the research as may arise.

b. Final Report

A written report, design guide, or manual, (collectively, "Final Report"), in a form approved by the Society, shall be prepared by the Institution and submitted to the Society's Manager of Research and Technical Services by the end of the Agreement term, containing complete details of all research carried out under this Agreement, 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.

c. *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 (1780-RP) at the end of the title in parentheses, e.g., (1780-RP).

All papers or articles prepared in connection with an ASHRAE research project, which are being submitted for inclusion in any ASHRAE publication, shall be submitted through the Manager of Research and Technical Services first and not to the publication's editor or Program Committee.

d. Data

Data is defined in General Condition VI, "DATA"

e. Project Synopsis

A written synopsis totaling approximately 100 words in length and written for a broad technical audience, which documents 1. Main findings of research project, 2. Why findings are significant, and 3. How the findings benefit ASHRAE membership and/or society in general shall be submitted to the Manager of Research and Technical Services by the end of the Agreement term for publication in ASHRAE Insights

The Society may request the Institution submit a technical article suitable for publication in the Society's ASHRAE JOURNAL. This is considered a voluntary submission and not a Deliverable. Technical articles shall be prepared using dual units; e.g., rational inch-pound with equivalent SI units shown parenthetically. SI usage shall be in accordance with IEEE/ASTM Standard SI-10.

Level of Effort

This project is expected to take 6 person-months of a PI and 10 person-months of technicians. The total duration of the research project is expected to be 15 months. Estimated cost of $200 000

Other Information for Bidders

Potential Test rig required:
Test facility designed in accordance with ASHRAE Standard 84 having a capacity of 500 to 2 000 CFM at 500 fpm incoming face velocity. Balanced airflow to be utilized for testing.

The location of the supply fan upstream of the wheel and the exhaust fan downstream. Establish the wheel purge air volume of the testing rig. The tracer gas testing must be done with established airflows, pressure differentials and temperatures.

In addition, the test facility should be able to maintain the following air conditions:

• Outside air condition from -20°F to +90°F with 10% RH to 90% RH
• Exhausted air conditions from 70°F to 80°F with 30% to 70%RH

Air by-pass (Carry-over) has to be measured first using SF6 tracer gas which is known not to be transferred by the desiccant surface.
Test rig utilized to investigate the impact of temperature, humidity, pressure, etc. must be designed to allow for the variation in psychrometric conditions and airflows.
Test rig shall have a variable speed drive on the wheel. This drive to be controlled by pressure differential on the wheel on the exhaust side to accept a little condensation and frosting while not having the wheel blocked by frost.

Conditions to be tested:

• For 2 wheels from 2 manufacturers
• For outside air conditions:
  - -20°F : Any RH but RH should be measured and reported
  - -10°F : Any RH but RH should be measured and reported
  - 0°F : Any RH but RH should be measured and reported
  - 10°F : Any RH but RH should be measured and reported
  - 20°F : 50% HR 90% HR
  - 30°F : 50% HR 90% HR
  - 50°F : 50% HR 90% HR
  - 70°F : 50% HR 90% HR
  - 90°F : 50% HR 90% HR

• For exhaust air conditions:
  - 75°F : 30% HR 50% HR 70% HR
• For the 10 chemicals listed on page 7, plus SF-6 Test

<u>Project Milestones</u>:

No.	Major Project Completion Milestone	Deadline Month
1	Literature search (2 Months)	2
2	Results of the validation of the Test Rig (2 months + 2 months in parallel of the literature search)	4
3	First complete series of results with one chemical (2 months)	6
4	Complete datas of results with all chemicals at all temperature and humidity conditions (6 Months)	12
5	Final testing methodology documentation and final report (3 Months)	15

<u>Proposal Evaluation Criteria</u>

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

No.	Proposal Review Criterion	Weighting Factor
1	Understanding of the Work Statement	15%
2	Proposed methodology	20%
3	Quality of facilities and access	15%
4	Quality of the proposed personnel: PI, researchers, etc..	25%
5	Students involvement 5%	5%
6	Probability of meeting the objectives in the scheduled timeframe 15%	15%
7	Past performance with AHRAE or other similar organizations	5%

References

1. ASHRAE Strategic plan 2014
2. ASHRAE Research Strategic Plan 2010-2018
3. ANSI/ASHRAE Standard 84-2013 "Method of testing Air-to-air Heat/Energy Exchangers
4. 2015 ASHRAE Handbook-HVAC Applications Chapter 16 Laboratories
5. 2016 ASHRAE Handbook-HVAC Systems and equipment Chapter 26, Air-to-air energy recovery equipment
6. 2015 ASHRAE Handbook-HVAC Applications Chapter 18 – Clean spaces
7. ASHRAE Laboratory design guide
8. Fischer, J, ASHRAE 2015 Annual Conference, Seminar 19: Apply ANSI/ASHRAE 62.1 Addendum K for Laboratory Hoods, Applying Total Energy Recovery in Laboratory Environments
9. DOE (Department of energy) report 2008
10. ASHRAE Standard 62.1 Ventilation for acceptable indoor air quality
11. ASHRAE Standard 90.1 Energy standard for buildings except low rise residential
12. Bayer, Charlene W, Total energy recovery wheel contaminant transfer study, submitted to SEMCO, August 31, 2011
13. Bayer, Charlene W. and Hendry, Robert J. The importance of the desiccant in total energy wheel cross-contamination. Prepared for SEMCO, May 17, 1999
14. Total Recovery Desiccant Wheel Pollutant Contaminant Challenge: Ventilation Effectiveness Comparison, The Georgia Tech Research Institute for DOE, Dr. Charlene Bayer, March 2004
15. Downing, Chris, Independent performance verification of SEMCO's total energy recovery wheels, 1999
16. Kodama, Akio, Cross contamination test of the Seibu-Giken "HI_PANEX-Ion" Enthalpy wheel, Kanazawa University, Japan
17. A Novel Total Heat Exchanger with Little Odor Transfer Using Ion Exchange Resin as a Desiccant, ASHRAE Transactions, Okano et.al,
18. The Effectiveness of a Molecular Sieve Heat Wheel in Maintaining Good Air Quality in a Major Laboratory Research Facility, ASHRAE IAQ 96, Johns Hopkins School of Medicine, Schaefer et.al, 1996
19. Brad Cochran, I2SL, Evaluation of cross-contamination in enthalpy wheel devices in laboratory exhaust system
20. Labs 21, Energy recovery in laboratory facilities Presentation on Hopkins Ross Facility entitled "Applying 3A Molecular Sieve Total Energy Wheels to Laboratory Environments"
21. DOE, a guide to navigating building and fire codes for laboratories