These draft minutes have not been approved and are not the official, approved record until approved by this committee.

Highlighted text indicates a hyperlinked attachment.

ASHRAE TC 4.3

Ventilation Requirements & Infiltration

Draft Agenda

Annual Conference 2023 Meeting (Hybrid)

Research Subcommittee Meeting: Monday, June 26, 2023, 4-5 pm EST, Tampa Marriott Waterside, Meeting room 12 (3)

Full Committee Meeting: Monday, June 26, 2023, 5-7 pm EDT, Tampa Marriott Waterside, Meeting room 12 (3) and on Webex: https://events.rdmobile.com/Sessions/Details/1780466

1. **Call to order** **McNulty**
   5:06pm ET
2. **Review Scope**
   TC 4.3 is concerned with ventilation requirements and the analysis of infiltration, airflow around buildings, exhaust, and the re-entry of exhaust, including their interactions with indoor air quality and energy calculations for buildings and HVAC system design and operation performance and energy consumption.

3. **ASHRAE Code of Ethics Commitments** **McNulty**
   Code of Ethics Commitment: *In this and all other ASHRAE meetings, we will act with honesty, fairness, courtesy, competence, inclusiveness and respect for others, which exemplify our core values of excellence, commitment, integrity, collaboration, volunteerism and diversity, and we shall avoid all real or perceived conflicts of interests.* https://www.ashrae.org/about-ashrae/ashrae-code-of-ethics

   Commitment to Care: *The health and safety of all ASHRAE conference attendees is a top priority. Out of respect for our fellow attendees, we commit to wear masks indoors, monitor our health, seek medical attention if symptoms develop and adhere to all ASHRAE Commitment to Care protocols. We are committed to the well-being of one another.*

4. **Introductions (10')** **All**
   a. Determination of a quorum Parker
      VOTING MEMBERS FOR THIS MEETING (Need (4) or ½+1 for a Quorum)

	Name	Position	Company	Roll Off (June 30)	Present?
1	Meghan McNulty	Chair	Servidyne	2026	Y
2	Isaac Simpson	Vice Chair	DMG North	2024	Y
3	Steven Emmerich	Standards	NIST	2023	Y
4	Iain Walker	Member	Lawrence Berkeley Natl Lab	2024	Y
5	Anthony Abate	Member	Clean Air Group	2025	Y
6	Duncan Philips	Member	RWDI	2025	Y

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7	Marianne Touchie	Member	University of Toronto	2025	Y
Non-Voting Officers					
	Nitin Naik	Programs	Dewpoint		
	Jason Urso	Membership	Tighe & Bond		
	Ryan Parker	Secretary/ Co-webmaster	RWDI		
	Neetha Vasan	Handbook	RWDI		Y
	Jordan Clark	Research	Ohio State University		Y
	Bryan Morris	Co-Webmaster	Sellen		
	George Nicholson	Honors & Awards	ADeB Consultants Limited		

b. Round of introductions — All

5. Agenda additions — **All**

6. Approval of minutes from March 2023 Interim Meeting — **McNulty**

Phillips, Simpson, 6:0:1

7. Chair's Report (7') — **McNulty**

a. Chair's Goals

i. Welcome! Getting to know TC 4.3:

1. Dinner tonight
2. Poll for specialties/interests

The ASHRAE biographies are confidential and cannot be shared. So the goal is to be able to look at specialties and interests from the TC for chapter reviews and other requests.

Jason (Membership), Bryan (Webmaster), Tony Abate, Martin Stangl

ii. Interim meetings

Meghan suggests September instead of August

iii. Access to Basecamp – request to be added

Email Ryan.Parker@rwdi.com or TC chair TC0403@ashrae.net

iv. Website & FAQ updates

Looking for volunteer to help Webmaster update website. Good opportunity for YEA member to get involved.

b. Announcements and Highlights from TC Chairs Breakfast Meeting

i. ASHRAE Simplified Rules of Order

ii. Review TC Scope, Continue/Merge/Dissolve

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8. Liaison Reports (as they arrive, 1'-2' per liaison or as needed) — Liaisons

a. MTG.OTB - Malhotra

b. TC 5.5 – Rafati

c. TC 1.12 (Moisture)- Ed Light – will provide update

d. Other FG

e. Task Force

f. RAC- Clark – 6 WS, 1 accepted, 0 RTARs submitted at last meeting. RAC approval now needed at $350k (previously $250k).

g. Section Head (TAC) – Pat Marks

New activity form per meeting now.

Subcommittee rules: Anyone in the room can vote at subcommittee meetings.

9. Membership/Roster (5') — McNulty/Urso

a. Regular attendance is expected, active participation encouraged.

b. Guests, consider joining as a Provisional Corresponding Member (PCM). This is the only way to officially join TC 4.3: https://eweb.ashrae.org/eweb/TS_ProvisionalSignup.html

10. Subcommittee reports

a. Programs (20') — Naik

i. Current Programs – none

ii. Future Programs / New Ideas

4 submissions planned for Chicago

Health Implications proposal to be circulated to the TC

Feedback is requested from the TC. Nitin will coordinate.

Proposals are welcome from members of the TC that are interested.

City	Title	Type	Chair/Speakers
Chicago	Health Implications of Contaminant Transportation in Residential Buildings (*proposal*) To be circulated to TC	Seminar	Co-Chairs and speakers Núria Casquero-Modrego & Cara Lozinsky; Benjamin Jones; Jacob Bueno de Mesquita
~~Tampa~~ Chicago	Evaluating Natural Ventilation Could be good for Fundamentals track.	Seminar	Matt Mason (Chair): Justin Berquist, James Lo, Duncan Philips, Will Lim

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Chicago	Where's My Air Been -Focused on external exhaust flow. Steve E suggests that the title be revamped.	Seminar	John Carter / Martin Stangl / Ryan Parker -Greg Gross volunteers to be CPP representative in place of John Cater
Chicago	Burning Questions Around Wildfires and Ventilation/IAQ	Seminar	Isaac Simpson / Steve Emmerich. TC 7.3 co-sponsor, possibly GPC44P co-sponsor May be particularly applicable as GPC44P will be published before next meeting.
~~Tampa~~ Chicago	TC4.10: Modeling airflow around buildings and the impact on indoor conditions driving toward increasing building resiliency		TC4.10 – vote on co-sponsorship by Feb 27. Neetha is tentative. TC4.3 is co-sponsoring and it was submitted. Rejected for Tampa, resubmitting for Chicago.
	"How To" for 62.1 or 62.2	Workshop	[when new version / substantial change]
	Standard 241 Updates		Steve Emmeric/Iain Walker/ Matt Mason
	Kitchen Ventilation		Co sponsorship opportunity Chair: Kishor, Iain Walker, Randy Cooper, LBNL

Winter Chicago – January 20-24, 2024

Conference Chair : Suzanne LeViseur, (sleviseur@haddadeng.com)

- **Fundamentals and Applications**
  - Craig Bradshaw - craig.bradshaw@okstate.edu
- **HVAC&R Systems & Equipment**
  - Ng Yong Kong – nyk@nyk.com.my
- **Refrigeration & Refrigerants**
  - Atilla Biyikoglu – abiyik@gazi.edu.tr
- **Decarbonizaiton and Climate Change**
  - Som S Shrestha - shresthass@ornl.gov
- **Hydronic Systems**
  - Joe Chow – joe.ashrae@gmail.com
- **Ventilation, Indoor Air Quality and Air Distribution Systems**
  - Ahmed Abdel-Salam – ahmed.abdel-salam@usask.ca
- **Comfort, Indoor Environmental Quality and Energy Efficiency**
  - Kristen Cetin – cetinkri@msu.edu
- **HVAC&R Controls**
  - Alekhya Kaianathbhatta – alekhya_k@rogers.com
- **Project Delivery Methods**
  - Ehab Mamdouh Abu Taleb – ehab.mamdouh@ipec-eg.net

iii. Deadlines for Chicago 2024 Winter Conference

Wednesday, August 2, 2023 | Debate, Panel, Seminar, Forum, Workshop, and Debate Proposals Due

b. Research (10') Clark

i. Subcommittee meets immediately prior to this meeting; research projects discussed in detail then, high-level update in this meeting.

Considered 1 WS and 4 RTARs, 1 PTAR

ii. Active Research Projects (RP)

1. RP1835: Characterization of Induced Flow Fans

iii. Work Statements (WS)

1. (1950-RTAR), "Effect of residential exhaust terminations on jet mechanics and resulting required intake separation"

   Voted to co-sponsor by 62.2, subcommittee voted to be put to TC4.3 for vote.

   Vote to sponsor: Approved. Iain Walker, Duncan Phillips, 7:0:0

iv. Research Topic Acceptance Request (RTAR)

1. Updating garage ventilation rates for current populations of vehicles (electric cars) *2 meetings

   Comments are being incorporated, expected to be passed around to full committee for vote before August deadline.

2. PTAR (Publication): Guide for successful simulation of outdoor airflow around the built environment *2 meetings

   - Attachment from Duncan?

     Duncan provided a summary of the PTAR. Planned to be voted on before August.

     There are many people doing CFD of external flows with varying levels of care. The goal of this PTAR is to come up with a set of minimum guidelines from ASHRAE for CFD of buildings.

3. RTAR-ERVs and Pressurization **Phillips**

   Determine if ERVs are delivering the air that is desired or are being overwhelmed by the stack effect for tall buildings.

4. Ventilation Effectiveness **Godbout**

   Thank you to Frank for putting this one together so quickly. Several other groups are very interested in related measures to this one. TC 4.10, 5.3, Std 62.1, SSPC 129, SSPC 241. Feedback is expected from these groups. Updated RTAR to be circulated. Std 62.1 and SSPC 241 need to be contacted.

   Needs to be careful that this RTAR's methodology follows what will be coming out from the SSPCs of relevance.

   Looking for suggested bidders and co-funders. Contact Frank: frank@effectiv-hvac.com

   Vote desired before August 2 deadline if possible.

5. Request for co-sponsorship of RTAR from TC 5.11 on Minimum Humidity Research

v. Deadlines -

--- 5'-10' Break ---

c. **Handbook (20')** **Vasan email: Neetha.Vasan@rwdi.com**

i. Chapter Status

Feedback is request by September 15 to allow for chapters to be completed by the end of the year.

Expected to be submitted to be reviewed by the committee by the end of the year.

Volume	Chapter	Lead	Status
2025 Fundamentals	Chapter 16 Ventilation and Infiltration	Marianne Touchie, Cara Lozinsky, Justin Berquist	Under heavy revision. Expertise is requested for the Natural Ventilation and Extreme Cases (i.e. Wildfires) sections. Duncan volunteers for Nat Vent
2025 Fundamentals	Chapter 24 Airflow Around Buildings	Ted Stathopoulos	Revision is underway. Requests for feedback have been sent out from Ted to some. Additional feedback welcome from the committee.
2027 Applications	Chapter 45 Building Air Intake and Exhaust Design	Ryan Parker	To be published in June-Publishing expected soon

ii. Revision information

1. Access files, for revision, via https://authoring.ashrae.org/
2. **Chapter reviews**: If you have colleagues who are practicing in or otherwise interested in any of our topics, please ask them to review our as-published chapters. They can submit their reviews via http://xp20.ashrae.org/secure/handbook/chapter_review/
3. Website for our revisers: https://www.ashrae.org/technical-resources/ashraehandbook/ashrae-handbook-central

iii. Deadlines

d. **Standards (15')** **Emmerich**

i. 62.1 Ventilation and Acceptable Indoor Air Quality

Guideline 42P Enhanced IAQ is about to go out for 5th ISC and then finally be published. Demand Control Ventilation update. Voted through a density correction addendum. New space category for school corridors.

ii. 62.2 Ventilation and Acceptable IAQ in Low-Rise Res Bldgs

Addition to state that if there is smoking in the building the IAQ may not meet 62.2. Credit against ventilation rate for filtration. ASTM standard for measuring capture efficiency. UMC code proposal changes to align with 62.2. Expected to go for public review soon. IAQ procedure revisions underway. (Send to Steve E and Iain for review)

iii. 161 Air Quality Within Commercial Aircraft -no one present

iv. Other Standards of interest

1. 241P Control of Infectious Aerosols – New – now to be an SSPC. Updates have been made since the initial version sent for review, the final version has not been made available to the committee yet. Equations were significantly streamlined and more space types added (still cfm/person). Clarifications to the testing of air cleaners.

   Will be going on continuous maintenance once released so proposed changes are welcome at any time.

2. 90.1 Energy – Improved commercial building infiltration calcs to be added soon.

3. 170 Ventilation of Healthcare Facilities – no membership present

e. **Website/Basecamp (5')** **Parker/Morris**

f. **Honors & Awards (5')** **Hossam (**hossam.kader@deltadcm.com)

i. December deadline

Meghan and co-authors received journal article of the year.

Jordan received service award.

Distinguished Service Award

This award recognizes members of ASHRAE who have served the Society faithfully and with distinction on committees or otherwise given freely of their time and talent on behalf of the Society (15 service points are required).

Exceptional Service Award

This award recognizes members who have served the Society faithfully and with exemplary effort, far in excess (45 service points) of that required for the Distinguished Service Award (15 service points). The individual must have been a Full Member for a minimum of ten years and be a past recipient of the Distinguished Service Award.

Andrew T. Boggs Service Award

This award, named after Andrew T. Boggs, former ASHRAE Executive Vice President, recognizes past recipients of the Exceptional Service Award for continuing, unselfish, dedicated and distinguished service to the Society.

Louise and Bill Holladay Distinguished Fellow Award

This award honors Fellows of the Society for continuing preeminence in engineering or research work.

11. Old Business

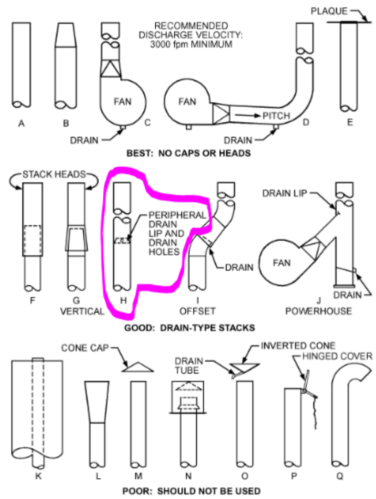

Fig. 2 Stack Designs Providing Vertical Discharge and Rain Protection

a. Review of exhaust stacks (Ch 46, Fig 2)

Recommended to look at industrial ventilation catalogs. Brad has seen H in Europe. Martin suggests ChatGPT to look for it.

12. New Business

Brian Rock is now lead reviser for TC 1.6 Terminology – will be asking for review of ventilation relevant terms from our TC.

MTG.ACR has RP 1833 – List of basic ventilation terms to be included in TC 1.6 with a search limited to before 2000. To be added to Basecamp.

Ed Light suggests that TAC should be contacted to help handle this issue of TCs overstepping their scope.

13. Next Meeting

a. Interim full committee or subcommittee meetings

    i. Full Committee: Wednesday, September X, 11:30 am – 1 pm Eastern

    Poll to be issued for the best option.

    Research meeting will be held directly before the main meeting in Chicago.

b. 2024 Winter Conference: January 20-24, Chicago, IL
https://www.ashrae.org/conferences/2024-winter-conference-chicago

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Future Winter Conferences	Future AHR Expos	Future Annual Conferences
Feb. 4-8, 2023 – Atlanta, GA	Feb. 6-8, 2023 – Atlanta, GA	June 24-28, 2023 – Tampa, FL
Jan. 20-24, 2024 – Chicago, IL	Jan. 22-24, 2024 – Chicago, IL	June 22-26, 2024 – Indianapolis, IN
Feb. 8-12, 2025 – Orlando, FL	Feb. 10-12, 2025 – Orlando, FL	June 21-25, 2025 – Phoenix, AZ
Jan. 31-Feb. 4, 2026 – Las Vegas, NV	Feb. 2-4, 2026 – Las Vegas, NV	
	AHR Mexico *Sep. 19-21, 2023 – Mexico City*	

14. Adjourn

6:59pm Duncan- motioned, Meghan second

Health Implications of Contaminant Transportation in Residential Buildings

Chairs
Núria Casquero-Modrego, PhD (LBNL)
Cara Lozinsky, P.Eng (University of Toronto)

Session Duration
90 minutes
3 or 4 Presentations (20min each)

Keywords
Residential Buildings; Compartmentalization; Ventilation; IAQ; Health; Decarbonization

Description of the Session
The transportation of contaminants within residential buildings has emerged as a critical concern, particularly in light of the global COVID-19 pandemic, due to its profound implications for human health and overall occupant satisfaction with indoor air quality (IAQ). In multi-family buildings and single-family dwellings, reduction of contaminant sources, adequate provision of fresh air through mechanical ventilation, and reduction of cross-contamination via compartmentalization are all critical to reducing contaminant transport. This seminar will discuss the health implications associated with contaminant accumulation and transport in residential buildings, and potential building design and operation strategies to improve health outcomes.

Bringing together experts in building ventilation and IAQ, this session intends to facilitate in-depth discussions on strategies to enhance building performance, with respect to human health. The ultimate goal is to advance our understanding and significantly improve health outcomes for individuals. The seminar's findings and recommendations aim to provide valuable insights to policymakers, building professionals, and occupants, equipping them with effective strategies for mitigating the adverse health impacts associated with contaminant transportation in residential buildings. By fostering collaboration and knowledge exchange, this seminar contributes to the ongoing efforts in creating healthier and safer living environments. Also, the session aims to promote awareness of the need to integrate building decarbonization in ventilation research.

Learning Objectives
This session provides targeted guidance and general background information to help to understand how contaminant transportation is currently impacting occupant health and comfort, and how we should address our future research.

1. Identifying the potential building design and operation approaches, we can use to reduce contaminant transportation.
2. Outlining current gaps and/or barriers for contaminant transportation strategies to meet health goals and develop suggestions on how to address those gaps and/or barriers.
3. Understanding why these strategies are necessary for meeting the climate goals and how we can improve them.

Provisional Session Programme

The topics of the sessions proposed in this program are selected based on general priorities in residential IAQ, such as: Health; Ventilation, Compartmentalization, Source Reduction, etc.

(List of presentations in no particular order)

1. Cara Lozinsky, P.Eng
   University of Toronto (Canada)
   Title: "Size Matters (At Least For Interior Air Flow Pathways): The IAQ Implications of Compartmentalization in Multi-Family Buildings"

2. Núria Casquero-Modrego, PhD
   Lawrence Berkeley National Lab (US)
   Title: "Electrification and the Reduction of Contaminants in Homes"

3. Benjamin Jones, PhD
   Nottingham University (UK)
   Title: [Need title]

4. Jacob Bueno de Mesquita, PhD
   Roger Williams University (US)
   Title: "Reducing Airborne Viral Transmission Indoors and Improving Pandemic Resilience"

Title
Insights of Residential Kitchen Ventilation

Abstract

Recently residential gas stoves and the pollutants generated by residential natural gas burners and cooking are in the News. Residential cooking with natural gas burners can generate several airborne pollutants. Proper ventilation of residential kitchens is crucial to maintain acceptable levels of indoor air quality in the homes. Several design and operational parameters can affect the ventilation performance of residential kitchens. This seminar will provide highlights of the field observations related to the performance and usage of residential ventilation; recent changes to the metrics and test methods for residential range hoods; and CFD analyses of the kitchen ventilation. This seminar will provide high-level guidance for the proper design and operation of ventilation systems in residential kitchens to limit exposure to pollutants generated due to natural gas cooking.

Presentations

Performance and usage of mechanical residential kitchen ventilation
Haoran Zhao, Ph.D., Iain Walker, Ph.D., William Delp, Ph.D., Brett Singer, Ph.D.
Lawrence Berkeley National Laboratory, Berkeley, CA

Analysis of Residential Kitchen Ventilation with a Gas Stove – a Mass Balance Approach
Kishor Khankari, Ph.D. AnSight LLC, Ann Arbor, MI

CFD Analysis of Ventilation Performance of a Residential Kitchen with Gas Stove
Kishor Khankari, Ph.D. AnSight LLC, Ann Arbor, MI

Residential Range Hood Issue Brief
Randall Cooper
Association of Home Appliance Manufacturers (AHAM), Washington, DC

WORK STATEMENT COVER SHEET

Date: 1 June 2023

(Please Check to Insure the Following Information is in the Work Statement)

A. Title	
B Executive Summary	
C. Applicability to ASHRAE Research Strategic Plan	
D. Application of the Results	
E. State-of-the-Art (background)	
F. Advancement to State-of-the-Art	
G. Justification and Value to ASHRAE	
H. Objective	
I. Scope	
J. Deliverables/Where Results will be Published	
K. Level of Effort	
Project Duration in Months	
Professional-Months: Principal Investigator	
Professional-Months: Total	
Estimated $ Value	
L Proposal Evaluation Criteria & Weighting Factors	
M. References	
N. Other Information to Bidders (Optional)	

Title:
Effect of exhaust terminations on jet mechanics and resulting required intake separation

WS# 1950
(To be assigned by MORTS - Same as RTAR #)

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

Standard 62.2, potentially Standard 62.1
HoF-F16, A46

Responsible TC/TG: 4.3

Date of Vote:

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

This W/S has been coordinated with TC/TG/SSPC (give vote and date):

SSPC 62.2

Has RTAR been submitted?
Strategic Plan
Theme/Goals

Submitted 2/2023
Accepted w/ comments 5/2023

Work Statement Authors: **

Lead: Jordan D. Clark, Research Subcommittee Chair, TC 4.3, Secretary, SSPC 62.2
Marian Goebes, Vice-Chair, SSPC 62.2;
Paul Francisco, Envelope SC Chair, SSPC 62.2

Proposal Evaluation Subcommittee:
Chair:
Members:

Project Monitoring Subcommittee:
(If different from Proposal Evaluation Subcommittee)

Recommended Bidders (name, address, e-mail, tel. number): **

Marianne Touchie, PhD, U. Toronto
Umar Palmiste, Estonia
James Lo, PhD, Drexel

(Three qualified bidders must be recommended, not including WS authors.)

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

	Yes	No	How Long (weeks)
Is an extended bidding period needed?			
Has an electronic copy been furnished to the MORTS?			
Will this project result in a special publication?			
Has the Research Liaison reviewed work statement?			

* Reasons for negative vote(s) and abstentions

** Denotes WS author is affiliated with this recommended bidder
Use additional sheet if needed.

WORK STATEMENT# 1950

Title:

Effect of residential exhaust terminations on jet mechanics and resulting required intake separation

Sponsoring TC/TG/MTG/SSPC:

TC 4.3

Co-Sponsoring TC/TG/MTG/SSPCs (List only TC/TG/MTG/SSPCs that have voted formal support)

SSPC 62.2

Plain English Abstract:

Houses and apartment units have several exhaust ducts that expel things such as cooking bi-products, toilet odors and dryer moisture from the living space. Designers must ensure that this exhaust does not find its way back into the unit through the ventilation system. To do this, better predictions of where the exhaust goes are needed. This project will generate such predictions for a variety of exhaust types.

Executive Summary:

Exhaust from multiple sources such as dryers, kitchen range hoods, combustion flues, and dwelling unit ventilation systems must be separated from ventilation intakes in single-family homes and multi-family buildings. Guidance on required separation has been sparse and poorly justified, especially for exhaust and intake terminations on vertical walls. Recent research shows that the exhaust termination is critical in determining the fluid mechanics of the exhaust jet and the resulting distance required for separation, or other means of ensuring intake air is acceptable. While the past work identified a specific scenario for multifamily through-wall exhaust where a shorter distance could be used than the traditional 10 ft assumption, there are likely other scenarios and exhaust discharge configurations in single family and multifamily buildings that could warrant a revised separation distance

This study will analyze the most common exhaust terminations for the variety of conditions they are expected to encounter in practice, using either wind tunnel or computational fluid dynamics simulations, and will recommend separation distances or other means of providing acceptable air quality at intakes throughout the year based on this analysis.

The contractor will conduct analyses using state of the art tools, either scale models, properly conducted computational fluid dynamics simulations, or full-scale tests. Proper validation of any models will be executed before modeling commences.

The contractor will analyze a variety of exhaust terminations to span the breadth of terminations encountered in practice. The contractor will provide results in a manner that can readily be used to specify separation distances in relevant materials such as Standard 62.2, possibly 62.1, and the ASHRAE Handbook of Fundamentals.

Applicability to the ASHRAE Research Strategic Plan:

This project will develop guidelines and tools for ensuring IEQ, in accordance with at least two of the goals listed in the ASHRAE Research Strategic Plan:

1) "Developing solutions, best-practice guidelines, assessment, diagnostic and IEQ enhancement design tools, and economic models that can explicitly assign a monetary value to the benefits of enhanced IEQ."

2) "Customer-focused, user friendly,high-fidelity predictive tools can make the design process more efficient and effective, yielding improved thermal comfort, indoor environmental quality, and resiliency. Research is justified to improve the usability, capability, and accuracy of existing tools and develop new tools where needed."

Application of Results:

ASHRAE Standard 62.2 Section 6.6 specifies separation of distance between ventilation intakes and exhaust. For many years this was specified as a simple 10' stretched string distance, with little justification. There is a continuous maintenance proposal in process (62.2 Addendum f) that proposes to amend this to 5' under a narrow range of circumstances, based on research showing distances could be reduced in certain instances. This proposed addendum is conservative in that it only allows 5' separation between the air intake and exhaust termination from the same dwelling unit, and it requires that the air inlet be at least a stretched string distance of 5' from the exhaust termination and be at least 2' from the exhaust centerline. It is possible that certain exhaust terminations or building configurations could result in more relaxed requirements, which would provide much-needed flexibility for multifamily units and cost reductions for all residential units. It is expected that results will inform another continuous maintenance proposal amending Section 6.6

Results are also expected to inform changes in the ASHRAE Handbook of Fundamentals Chapters F16 and A46 and potentially Standard 62.1. Contractor should propose language for addition to HoF-F16.6 (Residential Ventilation) and A46 (Building Air Intake and Exhaust Design). The contractor will also assess the suitability of results for application in Standard 62.1, Section 5.2 and specifically Table 5.1 (Air Intake Minimum Separation Distance).

State-of-the-Art (Background):

Ventilation systems often include both exhausts and fresh air intakes that provide outdoor air through mechanical systems (fans) or passive air inlets. Many commercial buildings have rooftop exhaust systems, and dispersion from these systems has been studied extensively and continues to be refined (Zakeri and Clark, 2020, ASHRAE RP-1823, ASHRAE RP-1835). However, residential and some commercial exhaust jet mechanics are quite different in that they are much smaller flow rates, are often located on the walls of homes and multi-family buildings, and are often capped or louvered for architectural and water management reasons. Many multi-family buildings, especially new construction, contain several such exhausts, from the kitchen, bathroom, dryer, general unit ventilation, space or water heating combustion appliances, or other sources. It is becoming more common for each unit to have its own space conditioning and ventilation systems. The resulting increase in terminations in multifamily buildings creates tension between indoor air quality, energy efficiency, and overall resident health and safety, and so makes addressing this problem a critical need.

In the absence of a method for continuously sensing pollutants of interest at a building intake, engineers must provide for sufficient dilution of the exhaust air before it potentially reaches the location of neighboring air intakes in order to avoid the recirculation of contaminated air. A few methods for predicting this dilution currently exist. Well-established methods for predicting the concentration of Gaussian plumes emitted from the rooftops of buildings have existed for many years (ASHRAE 2019, Peterson and Ritter 2016, Rock et al. 1999) and continue to be improved (Zakeri Shahvari & Clark, 2020, ASHRAE 1835-RP). These prediction models are primarily for upward-direct jets of air and have been validated with high-momentum jets (10's of thousands of cubic feet per minute (cfm)), and their validity for the lower momentum jets associated with residential exhaust ventilation has been shown to be lacking (Kaes et al. 2022). If the inputs to these models are not known, ASHRAE Standard 62.1-2019 currently allows for prescriptive separation distances based simply on the categorization of the exhaust air to be used (Table 5-1 in the Standard). Similarly, ANSI/ASHRAE Standard 62.2-2019 provides prescriptive distances with exceptions. The source or rationale for these prescriptions is unclear.

Palmiste, Kurnitski, & Voll (2020) reviewed other published criteria designed to ensure adequate dilution between exhaust and inlet. They demonstrated a wide variety in resulting required separation distances and conclude that "evidence-based research is lacking for near-field pollutant dispersion and re-entrainment from an exhaust outlet located on an external wall." Kaes et al. (2022) conducted wind tunnel tests and computational fluid dynamics analyses of horizontally directed just from the side of a building and found that exhaust terminations geometry, orientation, relative elevations, and proximity to intakes have an outsized effect on resulting jet fluid mechanics and required separation. This work was confined to a only two termination geometries and a single location on a single building geometry. It is clear from the results of this study that a greater diversity of terminations and building locations and types must be characterized.

Furthermore, the current prescriptive requirement can be difficult to meet in practice, specifically in multifamily buildings with horizontally vented through-wall exhaust and air intake systems. This is likely true in mixed use buildings as well.

Advancement to the State-of-the-Art:

As discussed above, the most recent research on the subject showed the jet mechanics and the necessary separation were a strong function of the exhaust termination. This most recent research was done pro bono, but a thorough investigation of the multitude of exhaust terminations and environmental conditions in which they will perform is beyond the scope of what we can reasonably expect to be done pro bono. For this reason, a thorough parametric analysis of the most used exhaust terminations in the different locations on a building in which they may be used, for the variety of weather and wind conditions they are expected to encounter, needs to be performed. The results of this research will allow for more confidence in exhaust-intake specification and also allow engineering designs of multi-family facades, on which many exhaust and intakes may exist.

Justification and Value to ASHRAE:

It is well established that a key component in energy efficient dwellings is a tight envelope and a dedicated ventilation system that can then control the air quality within the dwelling in a more predictable manner than occurs in leaky dwellings. In order to use these dedicated ventilation systems and inspire confidence in residents and builders, they must provide acceptable air quality, which starts with bringing in acceptable ventilation air from outdoors.

Many multifamily units are installing “unitary ventilation” systems with an outdoor air intake for each dwelling unit, to meet a new requirement in 62.2-2022 which requires supply or balanced ventilation (to ensure a dedicated source of outdoor air). And many single-family and multifamily units are moving to heat recovery ventilators (HRVs) for efficient ventilation. The minimum separation distance has become a design constraint for multifamily units due to wall space constraints, and add costs for both single-family and multifamily units.

The goal of this project is to identify engineering solutions that could provide good IAQ while reducing design constraints, by identifying whether the minimum separation distance could be reduced under certain design scenarios. This will also facilitate energy efficiency measures such as specification of HRVs and other energy-efficient ventilation strategies.

For these reasons, this research is squarely aligned with ASHRAE’s Initiative Area of “Indoor Environmental Quality” and enables and helps speed decarbonization efforts within ASHRAE and elsewhere.

This research also contributes to ASHRAE’s stated objectives of
1) Developing a standard that addresses air quality, thermal environment, light, sound, and vibration in an integrated way
2) Increased global adaptation of ASHRAE Standards

Objectives:

Project Objectives

1) Identify the most commonly specified exhaust terminations for single-family and multi-family building exhausts.

2) Understand the mechanics of exhaust jets in the variety of conditions that may arise in single-family and multi-family buildings.

3) Provide guidance to designers and contractors in the form of required separation distances or some other method that is robust under the variety of conditions expected.

Scope/Technical Approach:

1) Termination Geometry List
The contractor will first identify the types of exhaust terminations that are most commonly specified in practice for the three building types, likely through survey of practitioners. Identification of this list will proceed in a three-step process:

a) The contractor will work with the PMS to identify a list of at least ten practitioners that include designers and builders and that work in a variety of geographical locations and building types. At a minimum, representation from the single-family home building industry and multi-family building industry shall be included. Through interviews with industry professionals, the contractor will identify a list of the most common and emerging exhaust termination geometries, expected to include 5-10 terminations but may be more or less if interviews justify this. Contractor will summarize interviews and include proposed list of termination geometries to analyze in a formal delivery submission at the end of this task.

b) The contractor will also identify the locations on the building and/or the configurations in which these terminations are most commonly specified for a variety of exhaust types. Exhaust types will include, at a minimum, dryers, toilet/bathroom, general ventilation, and combustion appliance flues. The buildings to be analyzed will include, at a minimum, single family homes, small multi-family such as duplexes, low-rise multi-family homes and high-rise multi-family homes.

c) Contractor will survey a wide range of industry professionals to determine which of the terminations and building configurations are most often specified. Results of the interviews in phase 1a will inform the questions asked in the survey. Contractor will work with the PMS to finalize the survey questions.

2) Experimental Matrix
The contractor will then develop an experimental matrix that will allow for an understanding of jet mechanics for the vast majority of terminations, locations, and weather conditions to be encountered in practices, keeping in mind that practices may change; thus a general approach is needed. The experimental matrix is expected to cover all situations expected to be encountered in practice, but every single situation need be analyzed directly if a sufficient statistical method for analyzing sparse factorial experimental matrices is developed and explained in a document submitted to the PMS. Contractor will secure PMS approval for the experimental matrix prior to conducting experimental work.

3) Experimental Approach
The contractor will then propose an approach to investigations of the situations in the experimental matrix using accepted methods, which will likely include some combination of computation fluid dynamics (CFD) simulations, full-scale laboratory experiments, field tests, and/or scaled model analysis such as in a wind tunnel. If CFD or scaled model approached are to be used, they must be sufficiently validated with either full scale laboratory experiments or field experiments. Contractor will secure approval from the PMS for the experimental approach prior to conducting experimental work.

4) Preliminary Analysis and Prescription Proposal
The contractor will conduct experiments for approximately 1/3 of the situations defined in the experimental matrix and analyze the results of these experiments in such a way that prescriptions can be readily integrated in standards, codes, and handbooks based on this analysis. The contractor will develop a means of specifying separation distances for the situations analyzed and submit to PMS for approval. This is expected to be in the form of an algorithm, table, flow chart or similar.

5) Completion of Experimental Analysis
The contractor will then conduct remaining experiments and integrate in the prescription method, amending as needed if subsequent results show a need to do so.

6) Preliminary Report
Contractor will submit to the PMS a preliminary report with all data collected and the final proposal for prescribing separation distances.

7) Final Report
Upon approval from the PMS, report will be edited and format as necessary for a final report to be submitted to ASHRAE.

Scope/Technical Approach (Continued 2):

<u>Scope/Technical Approach (Continued 3)</u>:

Deliverables/Where Results Will Be Published:

1. Proposed list of industry professionals to be interviewed

2. Summary of interviews and proposed list of termination and building geometries to be analyzed

3. Experimental matrix proposal

4. Experimental/analysis approach proposal

5. Preliminary analysis and prescription proposal

At the completion of approximately 1/3 of data collection, the Principal Investigator shall prepare a preliminary report to be reviewed by the PMS to determine whether or not sufficient data has been obtained to adequately define the performance of each of the exhaust terminations

The preliminary report should include:
a. A full description of the experimental or computational methods, including dimensional drawings and photographs as needed
b. A description of the instrumentation and applicable calibrations used throughout the project;
c. A listing of the exhaust terminations used in the assessment;
d. Data files of measured concentrations, flow rates, and velocities as needed to fully characterize performance;
e. Plots of the concentration/dilution at various downwind and crosswind locations for all geometries and terminations
f. Preliminary proposal for prescription of separation distances
g. Guidance on future research.

6. After the review and acceptance of the preliminary report by the PMS, the Principal Investigator shall prepare and submit a final report to the PMS addressing all comments received from the PMS.

7. The Principal Investigator should also produce at least one research paper to be submitted to the ASHRAE Manager of Research and Technical Services (MORTS).

8. The Principal Investigator should provide input into future updates of the ASHRAE Handbooks and Design Guides, as applicable to the findings of the research. This should include, but not be limited to
ASHRAE Handbook – HVAC Applications Chapter 46 Building Air Intake and Exhaust Designs;
ASHRAE Handbook –Fundamentals, Chapter 24 Air Flow Around Buildings;

9. 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.
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 Science & Technology for the Built Environment or 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 (1950-RP) at the end of the title in parentheses, e.g., (1950-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 documenting: (i) the main findings of the research project, (ii) why the findings are significant, and (iii) how the findings benefit ASHRAE membership and/or society in general.
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.

Deliverables/Where Results Will Be Published (Continued):

Level of Effort:

The level of effort is expected to include approximately 100 hours for experimental design; 150 hours for surveys; 600 hours for data collection; and 200 hours for analysis and preliminary reporting; and 80 hours for final reporting and technical paper preparation. Total project time should be 18-24 months. Budget: $175,000

Proposal Evaluation Criteria:

No.	Proposal Review Criterion	Weighting Factor
	Display of clear understanding of project goals and underlying fundamental processes	10%
	Clear and concise project work plan with well-defined tasks and key milestones as well as a reasonable project schedule.	10%
	Experience conducting related/similar experimental and/or computational work	40%
	Past performance on ASHRAE Research Projects (no penalty for new investigators)	10%
	Experimental method as outlined in proposal	20%
	Opportunity for student involvement	10%

Project Milestones:

No.	Major Project Completion Milestone	Deadline Month
1	Interview Summary	3
2	Terminations List	5
3	Experimental Matrix	6
4	Preliminary Analysis Report	12
5	Draft Final Report	20

Authors:

Jordan D. Clark, Secretary SSPC 62.2, Research Subcommittee Chair TC 4.3

References:

ASHRAE. Handbook of Fundamentals. (2019). Retrieved February 21, 2022, from https://www.ashrae.org/technical-resources/ashrae-handbook

Kaes, Jajal, Shahvari, Goebes, Ritter, Simon, Carter, Walker and Clark (2022) Dilution of airborne contaminants from through-wall exhausts located on the side of multi-family residential buildings. Building and Environment. Accepted

Palmiste, U., Kurnitski, J., & Voll, H. (2020). Design criteria for outdoor air intakes and exhaust air outlets located on an external wall. E3S Web of Conferences, 172, 09008. https://doi.org/10.1051/E3SCONF/202017209008

Petersen, R. and Ritter, J. 2016, Simplified Procedure for calculating Exhaust/Intake Separation Distances. ASHRAE Transactions. Vol. 122, Part z. pp. 46-62

Rock, B.A. and K.A. Moylan. Placement of ventilation air intakes for improved IAQ. ASHRAE Transactions. 105, 1–10 (1999)

Zakeri Shahvari, S., & Clark, J. D. (2020). Assessment and improvement of the 2019 ASHRAE handbook model for exhaust-to-intake dilution calculations for rooftop exhaust systems (ASHRAE 1823-RP), 26(4), 552–566. https://doi.org/10.1080/23744731.2020.1715252

<u>Other Information for Bidders (Optional)</u>:

Feedback to RAC and Suggested Improvements to Work Statement Process

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

Research Topic Acceptance Request Cover Sheet

Date: **06-27-2022**

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

Title:

Updating garage ventilation design for current populations of vehicles

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	

RTAR #

(To be assigned by MORTS)

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

ASHRAE 62.1
ASHRAE Handbook F16

Research Classification:

Basic/Applied Research	
Advanced Concepts	
Technology Transfer	

Responsible Committee: **TC 4.3: Ventilation and Infiltration**

Date of Vote:

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

RTAR Authors

Lead: **Jordan D. Clark**

Others: **Steve Taylor**

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

Expected Work Statement Authors

Lead: Jordan Clark

Others: Steve Taylor

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

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

* Reasons for negative vote(s) and abstentions

RTAR # _____________

Title:

Updating garage ventilation design for current populations of vehicles

Executive Summary

Current garage ventilation rates are based on work published two decades ago. Since then, the automobile industry has experienced drastic changes and the emissions on which these rate are based are no longer representative of the population of cars on the road and in garages. This work will survey the population of vehicles in garages in multiple locations in the United States and the associated concentrations of relevant pollutants in contemporary parking garages. It will attempt to provide update estimates for typical occupancy densities and associated emission rates for key pollutants from each vehicle type identified in the updated list. Then, a new proposal for required ventilation rates will be proposed and justified for inclusion in the ASHRAE Handbook of Fundaments and other relevant technical guidance.

Background

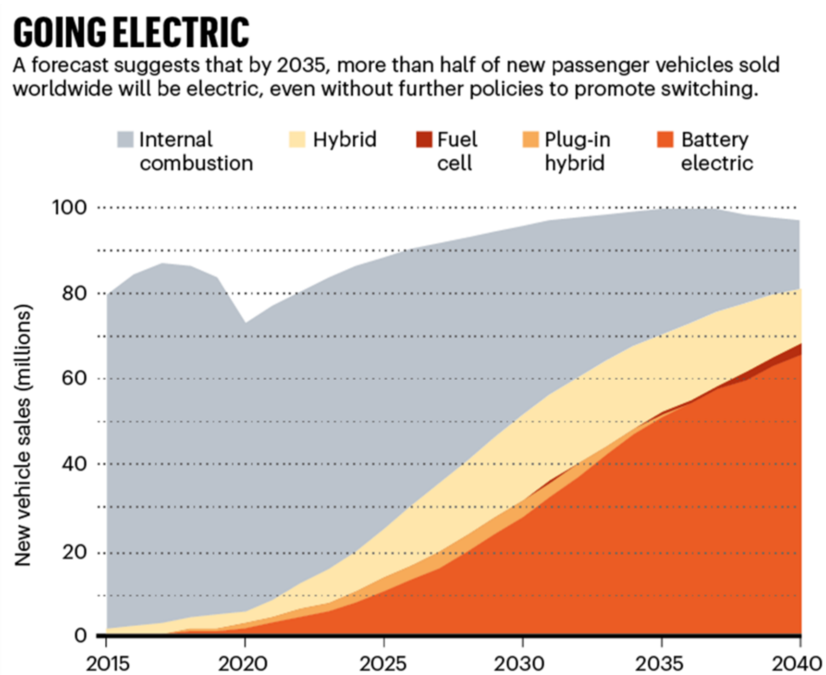
Garages must be ventilated sufficiently to displace pollutants emitted from car engines as they either idle in spaces or move through the garage. Current prescriptions of most standards (e.g. ASHRAE 62.1, International Mechanical Code) call for exhaust ventilation rates of 0.75 cfm/ft^2 (3.7 L/s/m^2) provided with a mechanical system, or exterior wall openings that are at least 50% open to the outside. Some modulation of these area-based rates is permitted by many standards with continuous monitoring of pollutants of interest, in particular CO.

Much of this work is based on studies from over 20 years ago. Krarti (1999) gathered emissions rates from academic literature and the 1993 EPA Mobile Emissions Source Factors. They identified five primary pollutants (CO, NO_2, SO_2, VOCs, particulate Pb, PM10) and one secondary (Ozone). Of these they contended only three were generated in sufficient quantities to cause health problems: CO, NO_2, VOCs. They further found that emission rates were a function of number of cars, type, age, operating environment and vehicle temperature. At the time, Krarti suggested that emission rates varied dramatically depending on fuel type, although electric and alternative fuel vehicles were an insignificant portion of the population at the time. Glover and Brezinzki (1997) similarly showed emissions strong function of year of model, even before electric vehicles were common or hybrids were as prevalent as they are today.

Krarti et al. (2001) presented results of a survey (Ayari et al. 2000) of parking garages with respect to both ventilation rates measured with tracer gas experiments, contaminant levels, and air distribution. They found that while measured ventilation rates were below those required, contaminants were as well, suggesting assumed emission rates were greater than reality. This has since been corroborated by other studies (Liu et al 2019, Lopez et al 2014) They also noted that air distribution was far from uniform and followed this insight with an investigation in 2003 in which they showed through CFD that supply and exhaust locations were critical in determining air distribution.

Research Need

As discussed above, much of the work used as justification for the most commonly prescribed garage ventilation rates is taken from studies conducted a few decades ago when populations of vehicles on the road were quite different from today and are expected to change rapidly as shown in the figure below.



Adapted from https://www.nature.com/articles/d41586-021-02222-1

Others have looked at control strategies for parking garages (e.g. Hong 2010, Faramarzi 2021) but the fundamental assumptions around populations and emission rates have not been updated. Furthermore, even at the time the rates were generated and shortly after, there is evidence in the literature that specified ventilation rates are more than adequate for maintaining contaminant levels below accepted thresholds. Given that there is an energy consequence for over-ventilating garages, and fan laws suggest that small reductions in fan flow rates can result in much larger reductions in energy consumption, research that more accurately identifies necessary rates is needed.

Project Objectives

1) Identify the population of vehicles by fuel type expected in garages at a geographical resolution sufficient to specify garage ventilation rates properly
2) Identify the most up to date and accurate estimates of emissions of contaminants of concern of these vehicles under relevant operating conditions (e.g. cold start, warm start, idling, driving)
3) Specify updated ventilation rates for parking garages and suggest language changes to relevant standards such as ASHRAE 62.1
4) Prescribe design protocols for ensuring proper air distribution in garages

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 xx, Field tests xx, Analyses and modeling xx, Validation efforts Other (specify) ( )

1) Contractor will propose, approve with the PMS, and execute a plan for identifying the population of vehicles to be expected in parking garages with a geographical resolution sufficient to prescribe rates for parking garages across
2) Contractor will identify through literature search the emissions of contaminants of concern expected and where necessary contractor will augment existing literature with experimental quantification of emission rates
3) Contractor will provide recommendations for specification of garage ventilation rates and ensuring distribution in such way that they can be integrated into relevant codes and standards. This may involve an approach that is zip-code or region or state-specific

Relevance and Benefits to ASHRAE

This work is in line with ASHRAE's initiative on indoor environmental quality and will contribute to ASHRAE's overarching focus on building decarbonization by helping realize the fan energy savings that has been suggested in several works.

Anticipated Funding Level and Duration

Funding Amount Range: $ 200,000

Duration in Months: 24

References

Ayari AM, Grot DA, Krarti M (2000). Field evaluation of ventilation system performance in enclosed parking garages. *ASHRAE Transactions*, 106(1): 228–237.

Aminian J, Maerefat M, Heidarinejad G (2018a). A new simplified method for decreasing contaminants in underground enclosed parking lots. Building Services Engineering Research and Technology, 39: 590–608.

Bielaczyc P, Szczotka A, Woodburn J (2013). An overview of cold start emissions from direct injection spark-ignition and compression ignition engines of light duty vehicles at low ambient temperatures. Combustion Engines, 154(3): 96–103.

Aminian J, Maerefat M, Heidarinejad G (2018b). The enhancement of pollutant removal in underground enclosed parking lots by reconsideration of the exhaust vent heights. Tunnelling and Underground Space Technology, 77: 305–313.

CARB (2017a). An Update to California On-Road Mobile Source Emission Inventory. EMFAC2017 Workshop. Available at https://www.arb.ca.gov/msei/downloads/emfac2017_workshop_june_1_2017_final.pdf

Cho H-J, Jeong W (2013). Energy saving potentials of demand-controlled ventilation based on real-time traffic load in underground parking facilities. In: Proceedings of Building Solutions for Architectural Engineering (AEI 2013).

Gil-Lopez T, Sanchez-Sanchez A, Gimenez-Molina C (2014). Energy, environmental and economic analysis of the ventilation system of enclosed parking garages: Discrepancies with the current regulations. Applied Energy, 113: 622–630.

Hong T, Fisk WJ (2010). Assessment of energy savings potential from the use of demand controlled ventilation in general office spaces in California. Building Simulation, 3: 117–124.

Faramarzi, Jongki Lee, Brent Stephens & Mohammad Heidarinejad (2021)Assessing ventilation control strategies in underground parking garages Building Simulation volume 14, pages701–720

Krarti M, Ayari A, Grot D (1998). ASHRAE 945-RP: Evaluation of Fixed and Variable Rate Ventilation System Requirements for Enclosed Parking Facilities. Atlanta, GA, USA: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

Krarti, Moncef;Ayari, Arselene M (1999)
ASHRAE Transactions; 1999; 105, SciTech Premium Collectionpg. 18

Krarti M, Ayari A (2003). CFD analysis of ventilation system performance for enclosed parking garages. *ASHRAE Transactions*, 109(2): 455–469.

Liu Z, Yin H, Ma S, Jin G, Gao J, Ding W (2019). On-site assessments on variations of PM2.5, PM10, CO2 and TVOC concentrations in naturally ventilated underground parking garages with traffic volume. Environmental Pollution, 247: 626–637.

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.

Publication Topic Acceptance Request Cover Sheet

Date:

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

A. Title
B Summary
C. Background
D. Publication Need
E. Target Audience
F. Rationale for PTAR
G. Level of Effort
H. References

Title:

Guidelines for Computational Fluid Dynamics Simulation of Fluid Flow Around Buildings

PTAR #

(To be assigned by MORTS)

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

Better to be a new document, but could also contribute to:
Fundamentals (2021) Chapters 13, 16, 19, 24
Applications (2019) Chapters 5, 16,
These chapters already reference CFD in one way or another,
-For external applications but not with providing information
On how.

Responsible Committee: TC4.03

Date of Vote:

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

PTAR Authors

Lead: Duncan Phillips

Others:

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

Targetting 4.10

Expected Work Statement Authors

Lead: Duncan Phillips

Others:

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

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

* Reasons for negative vote(s) and abstentions

PTAR # ______________

Title:

Guidelines for Computational Fluid Dynamics Simulation of Fluid Flow Around Buildings

Summary

There are many advantages to modeling airflow around buildings – whether physical or computational. These include testing and refining designs to reduce energy demand, increase safety, reduce costs etc. Flow modeling has looked at predicted wind speeds at the pedestrian level, wind loads on structures, dispersion of contaminants, natural ventilation potential, wind driven rain and even baseball trajectories.

The use of CFD to simulate flow for these items is becoming increasingly common. In the past, assessing the flows around buildings was limited to those with wind tunnels and water flumes. However as CFD technology became increasingly available to people, its use has proliferated into many different disciplines. Some of this simulation work is done very well. Some is not.

The challenge for the building community is that people who are using CFD to simulate external flows around buildings are not all aware of the complexities involved. At best this can result in sub-par designs (e.g. a natural ventilation system that does not work), and at worst, design that is dangerous (contaminant levels released from stacks exceeding regulatory limits). Just because it is possible to do the simulations (e.g. wind loading) does not mean the prediction is correct.

The purpose of the publication is to identify minimum standards that people should adhere to, the current limitations and means to test one's predictions. It will be based on publications and scientific literature representing the state of the art, coupled with practical descriptions of what the literature means and how to apply that in everyday engineering.

--END--

Background

There are a number of organizations that have developed guidelines for CFD modeling either within their discipline (e.g. SNAME) or for submission to them (e.g. City of London).

- In the case of the City of London, the City decided to create guidelines to establish a minimum expectation for all CFD work submitted to it and to also identify times when CFD is or is not appropriate. This came about because there was no standard practice and the City's experience was that they were getting erroneous submissions.
- The Society of Naval Architects & Marine Engineers (SNAME) developed a set of guidelines in 2021 ("*T&R Bulletin 5-04A: Guidelines for The Reproducible CFD Wind Load Estimations on Offshore Structures*") which describes a process to conduct CFD modeling of off-shore oil platforms and included a standard test case that one needs to be able to recreate in order to show compliance with the standard. This standard outlines elements such as model construction, gridding, atmospheric boundary layers (on water) and standard calculation methods for lift, drag and moments.

These are two specific applications of methods that have specific application to the interests of those organizations. They are not generic in terms of simulating for different types of answers, or adequately specific enough in terms of setting minimum thresholds. Nowhere is there a document for the HVAC community that addresses the flows of specific interest to that cohort of researchers and practitioners.

Phillips & Soligo (2019) provided a summary of the challenges to accurate CFD modeling of urban flows. There were three challenges cited and although progress has been made on all three, there are still obstacles. This document was not intended to be a "how to", it was to help explain where the problems were that people would run into and steer readers to more information.

There was some work done in Europe for flow in the urban environment: "*Best Practice Guideline for the CFD Simulation of Flows in the Urban Environment*". This was under COST Action 732 back in 2007. This document is very brief and does not reflect current state of the art. It is also not widely known.

The scientific literature contains documents that summarize the state of the art. These are by recognized experts in some cases (e.g. Blocken 2018) although can be a little dated (e.g. Murakami et al. 1996) whilst others do not provide sufficient detail to develop confidence in the results.

--END--

Publication Need

The purpose of the proposed guidelines is to develop a framework by which the membership can conduct CFD simulations of the external environment. Having a specific guidelines that addresses the flow issues present in the ASHRAE realm would reduce the amount of literature people will have to sift through. Further, it could be used as a launching point to develop a certification process for CFD modelers in the same way there is one available for energy modeling. Finally, it would lift the quality of the work conducted increasing the design performance.

ASHRAE is in a particularly unique place to promulgate these guidelines to the HVAC community:

- ASHRAE membership is involved in many aspects of to which CFD modeling contributes to design:
    - Wind pressures and natural ventilation;
    - Exhaust dispersion and stack design;
    - Coupled indoor / outdoor simulations involving ventilation, smoke management, etc.;
    - Wind driven rain and louver / component design; and
    - Pedestrian winds and door operability.
- ASHRAE has the reach to deliver the document globally and set the standard.
- ASHRAE has demonstrated through the energy modeling certification the benefit of setting minimum industry practice standards of care.

--END--

Target Audience

The target audience for this work will include:

- Mechanical engineers designing outdoor systems (e.g. exhausts, building intakes, etc.);
- Architects and engineers designing natural ventilation systems;
- Students at both undergrad and graduate levels;
- Owners and consultants looking to hire a CFD practitioner and wanting to understand the minimum requirements for the work.

--END—

Statement of why this needs to be a paid project instead of a volunteer effort

The volume of literature to be sifted through, and the consultation with experts in the field require a dedicated effort from a knowledgeable practitioner. In addition, it would be best if the research team on this actually ran simulations, using their recommended approaches and showed that it works for the flows discussed. If it does not work, then that too should be discussed as a warning to practitioners to "beware".

If it is a volunteer effort there is a risk of the document being steered. As a paid contract, with a review committee, the guidelines will be more balanced and comprehensive. There are still those who believe CFD modeling is easy.

--END--

What prior or ongoing ASHRAE Research will be disseminated through development of this Publication? (Where possible, list specific ASHRAE Research project by number (RP-XXXX) and Title.

There are many ASHRAE research projects that touch the area of outdoor wind flows. These would all be relevant in a document that recommends practices for simulating outdoor airflows. These include:

- ASHRAE RP1823 – tackled the conservatisms present in the handbooks regarding the design of outdoor exhaust stacks. This publication will refer to this work as part of a validation strategy.
- ASHRAE RP1821 – is a design guide for low to mid-rise residential buildings. This publication will contribute tools to that process and referring back to the RP will help highlight how it can be used.
- ASHRAE RP1760 – updated the databased on western clothing ensembles. This is an important parameter for exterior thermal comfort and can be referred to by the publication.
- ASHRAE RP1675 – created a set of guidelines for CFD modeling of data centers. This publication will refer to these guidelines and provide a balance on the indoor vs. outdoor simulations.
- ASHRAE RP1600 – evaluated the methods by which make-up air (MUA) speeds can be increased in atrium smoke management systems. Outdoor air is one source of MUA and coupled indoor / outdoor smoke simulations are sometimes conducted. This publication addresses a missing piece to that sort of simulation work.
- ASHRAE RP1418 – investigated the balance between grid resolution and simulation accuracy. This publication will be able to use that work.
- ASHRAE RP1133 – created a set of guidelines for CFD modeling indoors. This will balance those.
- ASHRAE RP1009 addressed how to properly simulate diffusers in indoor environments. This publication will take advantage of that as jets released into the environment represent pollution sources.

There are likely others.

--END--

Anticipated Funding Level and Duration

Funding Amount Range:

$ 125k Duration in Months: 18

References

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Phillips, Duncan A. & Soligo, Michael J. (2019). **Will CFD ever Replace Wind Tunnels for Building Wind Simulations?** *International Journal of High-Rise Buildings,* June 2019, Vol 8, No. 2, pages 107-116.

Feedback to RAC and Suggested Improvements to PTAR Process

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

The form needs to work better and be tidied up.

Research Topic Acceptance Request Cover Sheet

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

Date: **June 25, 2023**

Title:

Improving Zone Air Distribution Effectiveness (Ez Factor) Accuracy for Heating with Ceiling Supply and Return

RTAR #

(To be assigned by MORTS)

Submission Deadlines: March 15th May 15th Aug.15th Dec. 15th (MMAD 15)

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

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

Standard 62.1-2022, Ventilation and Acceptable Indoor Air Quality

Research Classification:

Basic/Applied Research	X
Advanced Concepts	
Technology Transfer	

Responsible Committee: **TC 4.3**

Date of Vote:

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

RTAR Authors

Lead: **Frank Godbout**

Others:

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

TC 4.10 ?
TC 5.3 ?
SPC 129 ?

Expected Work Statement Authors

Lead:

Others:

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

Any interested Co-Funders?

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

* Reasons for negative vote(s) and abstentions

RTAR # _____________

Title:

Improving Zone Air Distribution Effectiveness (Ez Factor) Accuracy for Heating with Ceiling Supply and Return

Executive Summary

This research aims to investigate and redefine Zone Air Distribution Effectiveness (Ez Factor) for heating with ceiling supply and return, based on recent findings of lower-than-standard values. The study will analyze factors influencing zone air distribution effectiveness, develop an accurate model, and update ASHRAE Standard 62.1, improving system designs, energy efficiency and IAQ.

Background

Zone Air Distribution Effectiveness (Ez) is an important metric used to evaluate the air distribution effectiveness in a room and was first presented in ASHRAE 62-2001 [1]. It was presented in a table (table 6-2) that was prepared based on a significant amount of experimental research on ventilation effectiveness in the lab and in the field [2] – [10]. Ez may be determined in accordance with ASHRAE Standard 129-1997 (RA 02) for all air distribution configurations except unidirectional flow. This is typically done using a mock-up of the air distribution system in a test laboratory. [11]

Table 6-2 remained the same except for a few small additional values from AHRAE 62-2001 to 62.1-2013 [1],[11]–[14]. In recent years there have been more adjustments to the table [15], but there is still a need for modification of the table. For example, for the current studies scenario "Ceiling supply of warm air 15°F (8°C) or more above space temperature and ceiling return." Suggested Ez by ASHRAE remained 0.8 from 2001 [1] to 2022 [15]. ASHRAE also accepts computational fluid dynamic (CFD) as a replacement for using Table 6-2 to calculate the Ez. It's because one Table can't cover all the possible scenarios and there is a need for modification of the table or use of CFD. This flaw was presented in a study by EffectiV HVAC company in a CFD study [16].

There are several studies on the use of CFD in different HVAC applications, e.g., classrooms [17] – [19], buses [20], offices[21], and theaters [22]. Ascione et al [23] modeled an HVAC system in a classroom with different diffuser types (mounted on the wall or ceiling) and configurations. There are also a few studies that used CFD to calculate the Ez [24]–[26], but none suggested a new method or model to calculate CFD. So, the only available options to find Ez are using table 6-2 which is shown not to be accurate, and using CFD which is time-consuming and expensive and won't be applicable to be used in real projects. So, there is an absolute gap and a need for a new, easy-to-use, and more accurate method to calculate Ez to replace Table 6-2.

Research Need

ASHRAE Standard 62.1-2022, Ventilation and Acceptable Indoor Air Quality, defines the zone air distribution effectiveness (Ez Factor) to evaluate air distribution impact on ventilation system performance, affecting the required amount of outside air. The current standard value for heating with ceiling supply and return is set at 0.8. The majority of new and existing commercial buildings with forced air heating are supplying the air from the ceiling with ceiling return, and therefore use this default value of 0.8.

However, recent CFD simulations conducted by industry manufacturers with the help of CFD consulting engineers and studying various applications found Ez Factor values ranging between 0.147 and 0.76 in heating, which would lead to insufficient outside air by design. The default value of 0.8 should be further studied and re-assessed.

The discrepancies between the current standard Ez Factor value and recent findings indicate a need for a comprehensive study to improve the accuracy of the Ez Factor in heating applications with ceiling diffusers and returns. Factors such as room layouts, ceiling heights, temperature differences, discharge velocity, inlet/outlet locations and the type of diffusers should be considered when heating from the ceiling with ceiling returns. The findings of a thorough research conducted by universities and other independent entities will help optimize outside air requirements and protect occupant health while contributing to improve system designs and performance, eventually leading to safe and energy efficient designs.

Previous tests used to establish zone air distribution effectiveness used gas particles and tracers. The current research should also be extended to various particle sizes, for instance 1 micron, to also take into consideration airborne transmission and other contaminants.

Lastly, because air mixing is not always even across the room, variations of air distribution effectiveness across the room must also be measured, and the impact of Ez factor variances on IAQ within the occupied space must be analyzed. The average value might not be sufficient to assess indoor environment quality.

Project Objectives

The proposed research has the following objectives:

- Investigate room characteristics, layout and system design affecting Ez Factor in heating applications with ceiling supply and return, using CFD simulations validated with physical measurements.
- Investigate the impact of an overestimated Ez Factor value on indoor air quality when using the Ventilation Rate Procedure or Indoor Air Quality Procedure.
- Develop an accurate model or set of guidelines for determining the Ez Factor based on the identified factors.
- Update ASHRAE Standard 62.1 to incorporate the new model or guidelines, enhancing ventilation system performance and occupant health.
- Provide valuable data to TC 5.3 to improve Standard 129

Expected Approach

The research will be conducted using the following approach:

- Identify all possible factors influencing zone air distribution effectiveness when heating from the ceiling with ceiling return.
- Conduct CFD simulations following the guidelines in *Normative Appendix C, Zone Air Distribution Effectiveness: Alternate Procedures*, to better understand and quantify the impact of each factor on zone air distribution effectiveness.
- Validate CFD simulations with physical measurements.
- Develop a new model or set of guidelines based on simulation findings.
- Validate the proposed model or guidelines using experimental data and real-world case studies.
- Collaborate with ASHRAE committees to update ASHRAE Standard 62.1 and Stantard 129.

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

Relevance and Benefits to ASHRAE

This research aligns with ASHRAE's mission to enhance energy efficiency and occupants' health. An inaccurate Ez Factor can lead to suboptimal outside air calculations, compromising indoor air quality (IAQ) and negatively impacting occupants' health. Since both the Ventilation Rate Procedure and Indoor Air Quality Procedure in ASHRAE Standard 62.1 rely on Ez Factor, this research is crucial for ensuring accurate outside air calculations across various applications, with the exception of the simplified procedure. Improving the Ez Factor accuracy will optimize outside air requirements, protecting occupant health while leading to better system designs and increased energy efficiency. This research will benefit ASHRAE and commercial buildings worldwide by providing a foundation for future advancements in air distribution effectiveness.

Anticipated Funding Level and Duration

Funding Amount Range: $150,000 - $200,000

Duration in Months: 18-24

Potentially interested bidders

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Feedback to RAC and Suggested Improvements to RTAR Process

Research Topic Acceptance Request Cover Sheet

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

Date: March 15, 2023

Title: Establishing a minimum relative humidity level to achieve occupant health and productivity benefits

Submission Deadlines: March 15th May 15th Aug.15th Dec. 15th (MMAD 15)

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

RTAR #

(To be assigned by MORTS)

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

ANSI/ASHRAE/ASHE Standard 170-2017
HVAC design manual for hospitals and clinics chapters. 2, 7, 8
ASHRAE Applications 2019. Chapter 64 "moisture management in building.
ASHRAE Applications. Chapter 9 "Health Care facilities"
ASHRAE Fundamentals 2017 Chapters: 10, 25-27, 36 and handbooks indicated in section 9 of such chapter "moisture management".
ASHRAE commissioning guides.

Research Classification:

Basic/Applied Research	
Advanced Concepts	x
Technology Transfer	

Responsible Committee: ASHRAE TC 5.11

Date of Vote: **3/15/2023**

For		4
Against	*	0
Abstaining	*	0
Absent or not returning Ballot	*	3
Total Voting Members		7

RTAR Authors

Lead: Harold Dubensky

Others David Baird, Nick Lea, Raul Simonetti, Nate Hughes, Mike Dovich Duncan Curd Chris Habets

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

TC 1.4, TC 4.3, and TC 5.7 for review

Expected Work Statement Authors

Lead: Harold Dubensky

Others: David Baird, Nick Lea, Raul Simonetti, Nate Hughes, Mike Dovich, Duncan Curd

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

AHRI (interest in principle), CDC, other foundations, US Govt agency, Canada Research Council

	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 # _____________

Title:

Establishing a minimum relative humidity level to achieve occupant health and productivity benefits.

Executive Summary

This research will determine what minimum level of relative humidity, controlled through active humidification, results in occupant health and productivity benefits. This study will monitor building occupant health and productivity markers for multiple years at various relative humidity levels controlled through the addition of humidity to an otherwise dry building. The study helps demonstrate the economic value of humidity control.

Background

It has been demonstrated that relative humidity between 40% and 60% creates an environment that reduces the survivability and infectivity of common infectious diseases [2] [5] [6] [7]. Recent research has also shown the mechanism that allows 50% relative humidity to reduce infectivity [10], as well as correlated relative humidity between 30% and 60% with lower stress levels [11].

In addition to the above studies, other research has shown that relative humidity at a moderate (50%) level reduces the virus survival on surfaces as well as in the air [4] [12]. Both of these studies were intervention studies (humidifiers added to otherwise dry buildings) focusing on virus survival rates on surfaces. The Reiman study [4] also showed a decrease in absenteeism for the kindergarten students in a humidified classroom. In a hospital environment, it has been shown that as relative humidity reaches moderate levels, infections drop significantly [1].

Although small scale surveys and research in the 1970s showed a correlation between employee health and relative humidity [3] [8] [9], there has not been a large scale, intervention based study on an active buildings. These 1970s studies did show decreases of 8.5% - 40% in respiratory infections in the workplace with moderate relative humidity levels.

As of February 2021 *(?)* Dr. Stephanie Taylor is currently performing an 9-year intervention *(still on-going?)* study on a geriatric care facility, with 4 years without humidification and 4 years with humidification. The first 5 *(?)* years are complete without humidification and have mirrored previous results of lower infectivity at moderate relative humidity [13].

Research Need

There has not been a recent long term, intervention type study to define a level of relative humidity that should be maintained to realize the expected health and productivity benefits of moderate relative humidity in an active workplace [focus on how other studies were healthcare / schools]. There is strong evidence that a relative humidity between 40% and 60% is ideal for the health of occupants. This research will add active humidification to find the minimum level of relative humidity that must be maintained to achieve these benefits. Without clear data to demonstrate the benefits of added relative humidity on the health and productivity of building occupants, it will remain difficult to define recommended relative humidity levels within ASHRAE publications. Building on prior research, it is necessary to test the effect of maintaining mid-range humidity levels in a controlled, real-world study.

With this study, ASHRAE will be able to define a lower limit for relative humidity, controlled through active humidification, that is financially feasible because of the realized productivity and health benefits. Through the existing research, it remains unknown as to whether or not there is a benefit to active humidification – nor where that benefit is maximized. This study will attempt to find that lower relative humidity limit, by actively humidifying over the long term across a range of relative humidity setpoints.

- Identify the recommended lower humidity limit.

Project Objectives

- Characterize the health and productivity effects associated with various levels of relative humidity.
- Gather statistically significant data to identify a lower relative humidity limit for an office environment.
- Quantify the costs of lost productivity, and increased medical costs, due to dryness.
- Quantify the costs associated with achieving the proposed minimum level of relative humidity.

Expected Approach

Identify an office building / buildings with the following characteristics:

- Modern building envelope compatible with relative humidity set-points up to 55% RH
- Building with an HVAC system with humidification or with easy access for retrofitted humidification.
- Enough full time, permanent employees for a meaningful statistical analysis over multiple years (suggestion >200)
- Expectation that the building will continue in its current use over the study.
- If multiple buildings are selected, instead of a single building, they would feature comparable ventilation systems to limit confounding variables.

Monitor building and occupants for:

- Health measures such as
    - Absenteeism / sick days
    - Reported respiratory illness, such as colds and influenza.
- Comfort measures such as
    - Reported dry eyes, dry throat, cough.
    - Thermal comfort
    - Reported stress levels.
- Indoor air quality parameters shall include:
    - Indoor / Outdoor Air temperature and Relative Humidity
    - Ventilation rates
    - CO2
    - Dust / Particulate matter
    - VOC's… [finish list].

Note and attempt to compensate for possible confounding factors for health and comfort measures within surveys.

Relevance and Benefits to ASHRAE

This project will align directly with goals of the strategic plan (2019-2024). With regard to Indoor Environmental Quality, ASHRAE has the stated goal of "Add to body of scientific knowledge and develop practical methods for estimating the economic value of improvements in IEQ". This study has the goal of measuring the effects of active humidification on productivity and lost time to illness – which is directly in line with the ASHRAE goal. This study would quantify employee time lost (if any) due to poor IEQ, specifically related to relative humidity.

Additionally, ASHRAE has the stated goal of "Develop a standard that addresses air quality, thermal environment, light, sound, and vibration in an integrated way". Currently, there is no standard for lower relative humidity limits, which should be properly studied for inclusion in an integrated standard as an important part of air quality and the thermal environment. This study would allow for a firm understanding of what minimum relative humidity should be maintained, if any, for this work. The state of the art for this area strongly suggests a link between health/wellness and the relative humidity in the built environment.

Other stakeholders that have expressed interest, outside of ASHRAE, include the Energy Solutions Center, the General Services Administration, and AHRI (Humidifier Education Working Group). All of these organizations should be approached for potential funding and details on existing research. Specifically, the GSA study that was presented at the 2019 ASHRAE Summer Conference [11] could offer an opportunity to continue the study within an existing set-up.

Anticipated Funding Level and Duration

Funding Amount Range: $ 200K

Duration in Months: 36

References

References

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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.

Research Topic Acceptance Request Cover Sheet

Date:

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

Submission Deadlines: March 15th May 15th Aug.15th Dec. 15th (MMAD 15)

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:

RTAR #

(To be assigned by MORTS)

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

Research Classification:
Basic/Applied Research
Advanced Concepts
Technology Transfer

Responsible Committee:

Date of Vote:

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

RTAR Authors

Lead:

Others:

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

Expected Work Statement Authors

Lead:

Others:

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

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

* Reasons for negative vote(s) and abstentions

2023/06 - CHANGES FROM EARLIER VERSION

- ***Acknowledged that there are more components penetrating the façade than just ERV/HRV***
- ***Included requirement for impact of multiple components within façade.***

RTAR # _____________

Title:

The Impact of Facade Penetrations (e.g. ERV / HRV, exhausts) on Residential Building Pressurization and Ventilation Air Distribution

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):

ASHRAE 62.2 defines the ventilation requirements for residential buildings. However, there is little conclusive evidence to confirm that these requirements are actually being met across the many types of residential buildings. The differences in building height, local climate, ventilation system implementation, wind regime and occupant behavior all contribute varying degrees of challenge.

One aspect of taller multi-unit residential buildings (MURBS) is the presence of stack effect and stronger wind pressures at elevation. In colder weather, stack effect leads to increased infiltration at the lower levels and exfiltration at the upper levels. The exfiltrating air at the upper levels comes from the lower levels which means it does not immediately qualify as ventilation air as it has passed through other units.

The interior spaces within these buildings can become exposed to external conditions when a window or terrace door is opened. This can throw off the delivery of air into the units. Even if the windows and doors are all closed, there are other penetrations through the façade associated with unit exhausts, ERV and PTAC units.

One means of addressing the risk of a lack of outdoor air to units in tall buildings is to use centralized systems to pressurize corridors and deliver air via the unit doors to the occupants. However, the presence of stack effect combined with façade penetrations and vertical chases (elevators, garbage chutes, stairwells) can lead to systems being unable to deliver the planned ventilation air to some or all units.

The purpose of this research is to investigate the impacts that are caused by ERV, exhaust vents and other façade penetrations identify mechanisms to reduce those impacts, and make recommendations for the successful implementation of ERV and other HVAC systems into residential building design.

---END---

Background

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

The HVAC systems in MURBs need to provide appropriate air quality to the residents at all times. There are a variety of ways in which this is attempted each with different advantages and disadvantages – Berquist et al. (2022). One of the consequences of these systems is that some configurations result in local penetrations through the façade that weaken the infiltration control performance of the overall envelope. These penetrations include exhaust fans (with or without backdraft dampers), energy or heat recovery ventilators (ERVs / HRVs), also known as a Mechanical Ventilation with Heat Recovery (MVHR) and stairwell dampers. These components include fans and other features that have different performance when the ambient pressure difference across them is working in one direction vs. the other.

While all façade penetrations are targets for this investigation, ERV are of particular concern because of their increasing use in residential design – hence the discussion here will focus on these. Packaged terminal air conditioners (PTACs) are a subset of ERV-type devices in that they deliver air into the unit but often do not necessarily result in exhaust at the unit façade, nor do they have the energy recovery system.

In many jurisdictions, in-suite ERV/ HRV form a defining part of the HVAC system. The exhaust systems for each unit are vented through these devices directly to outdoors and makeup air is drawn in. Energy is recovered as the outgoing internal air transfers energy to the incoming air. The energy recovery that occurs is likely a benefit; however what is often forgotten is that these devices impose a hidden leakage component within the building. The uncontrolled air movement can be driven by stack effect, wind and the HVAC system and combinations of all three. This leakage can be around the opening but also through the fan.

There is no state of the art on this subject. There has not been adequate investigation of the pressure leakage of mass-deployment of ERV in residential buildings. Work presented at ASHRAE (e.g. Phillips 2021a, b & c) has shown the consequences of different ventilation systems, including ERV, but not in a rigorous multi-building approach nor with an eye to address the codes driving this design practice.

Practitioners have been implementing in-suite ERV units within residential buildings and there has been little coordinated / controlled follow-up to evaluate whether their combined leakage in the building affects the overall building performance nor whether the units receive the quantity of ventilation air required by 62.2.

This work deals exclusively with the infiltration aspects of ERV. It does not assess the energy recovery.

---END---

Research Need

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

This research is required to develop a better understanding of how different MURB ventilation systems work and generate evidence to support either building code changes, recommendations for system design, adjustments to equipment performance or a combination of all three. The purpose of this research is to investigate, through modeling and field measurements, the consequences of the reduction in façade infiltration performance as well as different Q vs P performance of ERV and related equipment, on the ability to deliver code required ventilation air to MURB suites.

--END--

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):

Outcomes from this work will result in impacts to:

- Recommendations for changes to handbook chapters associated with tall building / residential building HVAC systems.
- Updates to ASHRAE 90.1
- Updates to ASHRAE 62.2
- Commentary on how ERV and other façade penetrations impact air flow patterns in residential buildings.
- Commentary on how ERV may, or may not, impact life safety systems.

---END---

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):

There is a blind assumption that using ERV in buildings is a net positive. It is not clear that this is true. This work will confirm that by assessing both the infiltration and ventilation delivery aspects associated with the presence of ERV and related equipment.

Anticipated Funding Level and Duration

Funding Amount Range: $300k___

____

Duration in Months: _24_____

References

List the key references cited in this RTAR

Phillips, Duncan A. (2021a), The Relative Performance of Different Ventilation Configurations in Multi-Unit Residential Buildings in North America, Presented at the ASHRAE Winter 2021 Virtual Conference as part of Seminar 49: Easier Said Than Done: Controlling Air Movement in High-Rise Multifamily Buildings.

Phillips, Duncan A. (2021b), Managing Infiltration in Tall Buildings to Control Energy Loss, Minimize Pathogen Transport and Enhance Air Quality, Presented at the ASHRAE Winter 2021 Virtual Conference as part of Seminar 75: Present and Future Challenges in Ventilation Unique to Tall Buildings Arising from Epidemics, Health Issues and Climate Change.

Phillips, Duncan A. (2021c), Retrofit of a Tall Building Ventilation System to Address MUA Shortages, Presented at the ASHRAE Summer 2021 Virtual Conference as part of Seminar 66 Stack Effect and Wind Induced Building Pressure Mitigation Strategies in Tall Buildings.

Berquist, Justin, Cassidy, Noah , Touchie, Marianne, O'Brien, William & Jamie Fine (2022), High-rise residential building ventilation in cold climates: A review of ventilation system types and their impact on measured building performance, Indoor Air, Vol. 32, No. 11. https://onlinelibrary.wiley.com/doi/abs/10.1111/ina.13158

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.

SIGN IN SHEET
https://tinyurl.com/5abf46xh

ASHRAE TC 4.3

Ventilation Requirements & Infiltration

Draft Agenda

Spring 2023 Interim Meeting (Virtual)

Tuesday, March 21, 2023, 1.5 hours. 08:30 AM Pacific Time / 11:30 AM Eastern Time (US and Canada)

* denotes additions since last version.

Isaac subbed in for Meghan. All notes with McNulty are covered by Simpson (Isaac)

1. **Call to order** **McNulty**
2. **Review Scope**

   TC 4.3 is concerned with ventilation requirements and the analysis of infiltration, airflow around buildings, exhaust, and the re-entry of exhaust, including their interactions with indoor air quality and energy calculations for buildings and HVAC system design and operation performance and energy consumption. https://tc0403.ashraetcs.org/

3. **ASHRAE Code of Ethics Commitments** **McNulty**

   Code of Ethics Commitment: *In this and all other ASHRAE meetings, we will act with honesty, fairness, courtesy, competence, inclusiveness and respect for others, which exemplify our core values of excellence, commitment, integrity, collaboration, volunteerism and diversity, and we shall avoid all real or perceived conflicts of interests.* https://www.ashrae.org/about-ashrae/ashrae-code-of-ethics

4. **Introductions (10')** **All**

   a. Determination of a quorum Parker

   VOTING MEMBERS FOR THIS MEETING (Need (4) or ½+1 for a Quorum)

	Name	Position	Company	Roll Off (June 30)	Present?
1	Meghan McNulty	Chair	Servidyne	2026	N
2	Isaac Simpson	Vice Chair	DMG North	2024	Y
3	Steven Emmerich	Standards	NIST	2023	Y
4	Iain Walker	Member	Lawrence Berkeley Natl Lab	2024	Y
5	Anthony Abate	Member	Clean Air Group	2025	N
6	Duncan Philips	Member	RWDI	2025	Y
7	Marianne Touchie	Member	University of Toronto	2025	Y
Non-Voting Officers					
Nitin Naik		Programs	Dewpoint		Y
Jason Urso		Membership	Tighe & Bond		N

Ryan Parker	Secretary/ Co-webmaster	RWDI		Y
Neetha Vasan	Handbook	RWDI		N
Jordan Clark	Research	Ohio State University		N
Bryan Morris	Co-Webmaster	Sellen		N
George Nicholson	Honors & Awards	ADeB Consultants Limited		

b. Round of introductions — All

5. **Agenda additions** — **All**

6. **Approval of minutes from 2023 Winter Meeting** — **McNulty**

Approved: Iain, Steve, 7:0:0

7. **Chair's Report (5')** — **McNulty**

   a. Chair's Goals

      i. Interim meetings

      ii. Access to Basecamp – request to be added ____

   b. Announcements*

      i. ASHRAE Simplified Rules of Order

      ii. Annual Conference – Tampa – registration

      iii. Industry Roundtable Report to the Board of Directors

      iv. TC-wide emails / reply all

8. Membership/Roster (5') **McNulty/Urso**

a. Regular attendance is expected, active participation encouraged.

b. Guests, consider joining as a Provisional Corresponding Member (PCM). This is the only way to officially join TC 4.3: https://eweb.ashrae.org/eweb/TS_ProvisionalSignup.html

c. New membership policy:

i. PCM will be upgraded to Corresponding Member (CM) if active; otherwise rolls off roster in 2 years.

ii. CM remains on roster as long as active, can be considered for leadership roles after 1 year. If no attendance in 2 years, marked inactive; if no attendance in 3 years, rolls off roster.

Craig Wray – strongly recommends against this provision and advises that TAC would need to accept such a membership change. Many members of ASHRAE are on committees as CM only to maintain connection to the industry.

Brad Cochran – As a current member of TAC, TAC is recommending that the membership is reached out to and that the members are offered the opportunity to be removed from the committee if desired. The intention is an "opt-out" option. Undeliverable emails can be removed from membership.

9. Subcommittee reports

a. Programs (10') **Naik**

i. Previous Programs – Atlanta Winter Conference

ii. Current Programs

1. Evaluating Natural Ventilation – Mason, Berquist, Philips

iii. Future Programs / New Ideas – "3 Strikes" rule- if idea has been on docket for three meetings with no forward movement, will be removed

Duncan: Previously it was recommended if there are multiple submissions from a TC for a conference that the submissions include a priority order for the TC.

There is also a side-track for tall buildings planned for the Chicago meeting, as there is a higher density of tall buildings in Chicago. If interested, email Duncan at: Duncan.Phillips@RWDI.com

City	Title	Type	Chair/Speakers
~~Tampa~~ Chicago	Evaluating Natural Ventilation Look at Chicago for submission on a more applicable topic.	Seminar	Matt Mason (Chair): Justin Berquist, James Lo, Duncan Philips, Will Lim
Chicago	Where's My Air Been	Seminar	John Carter / Martin Stangl / Ryan Parker
Chicago	Burning Questions Around Wildfires and Ventilation/IAQ	Seminar	Isaac Simpson / Steve Emmerich. TC 7.3 co-sponsor, possibly GPC44P co-sponsor

Tampa	TC4.10: Modeling airflow around buildings and the impact on indoor conditions driving toward increasing building resiliency		TC4.10 – vote on co-sponsorship by Feb 27. Neetha is tentative. TC4.3 is co-sponsoring and it was submitted.
	"How To" for 62.1 or 62.2	Workshop	[when new version / substantial change]

Annual Tampa – June 24-28, 2023

Conference Chair : Bert Phillips, (phillips@unies.mb.ca)

- **HVAC&R Systems and Equipment**
  - Ng Yong Kong – nyk@nyk.com.my
- **Fundamentals and Applications**
  - Brian Fronk – bmf141@psu.edu
- **Research Summit**
  - Davide Ziviani – dziviani@purdue.edu
- **Pathways to Net Zero Energy and Decarbonization**
  - Rafi Karim – rkarim@aeieng.com
- **Future-Proofing the Built Environment**
  - Scott Peach – sp@sp.engineering
- **Building Automation and Control Systems (BACS)**
  - Raul Simonetti – raul.simonetti@carel.com
- **Professional Development and Education**
  - Ahmed Abdel-Salam - ahmed.abdel-salam@usask.ca

Winter Chicago – January 20-24, 2024

Conference Chair : Suzanne LeViseur, (sleviseur@haddadeng.com)

- **Fundamentals and Applications**
  - Craig Bradshaw - craig.bradshaw@okstate.edu
- **HVAC&R Systems & Equipment**
  - Ng Yong Kong – nyk@nyk.com.my
- **Refrigeration & Refrigerants**
  - Atilla Biyikoglu – abiyik@gazi.edu.tr
- **Decarbonizaiton and Climate Change**
  - Som S Shrestha - shresthass@ornl.gov
- **Hydronic Systems**
  - Joe Chow – joe.ashrae@gmail.com
- **Ventilation, Indoor Air Quality and Air Distribution Systems**
  - Ahmed Abdel-Salam – ahmed.abdel-salam@usask.ca
- **Comfort, Indoor Environmental Quality and Energy Efficiency**
  - Kristen Cetin – cetinkri@msu.edu
- **HVAC&R Controls**
  - Alekhya Kaianathbhatta – alekhya_k@rogers.com
- **Project Delivery Methods**
  - Ehab Mamdouh Abu Taleb – ehab.mamdouh@ipec-eg.net

iv. Deadlines for Tampa 2023 Annual Conference

~~Friday, January 6, 2023 | Website opens for Seminar, Workshop, Panel, Debates and Forums~~

~~Friday, February 24, 2023 | Technical Paper Final Accept/Reject Notifications~~

~~Monday, February 27, 2023 | Debate, Panel, Seminar Form, Workshop Proposals Due~~

Wednesday, March 29, 2023 | Extended Abstract Paper Due and Conference Papers Due

Friday, April 14, 2023 | Debate, Panel, Seminar, Forum Workshop Accept / Reject Notifications

Wednesday, April 26, 2023 | Conference Paper Abstract Accept / Revise / Reject Notification

Wednesday, May 10, 2023 | Revised Conference Papers, Technical Papers Due

Sunday, May 21, 2023 | Conference Paper Accept / Reject Notifications

iv. Peer review for Tampa Conference papers, March 29 to April 20: https://www.signupgenius.com/go/9040E4CAAAC2FA7F85-20232

v. Deadlines for Chicago 2024 Winter Conference

Wednesday, August 2, 2023 | Debate, Panel, Seminar, Forum, Workshop, and Debate Proposals Due

b. Research (15') **Clark**

i. Active Research Projects (RP)

1. RP1835: Characterization of Induced Flow Fans

   Project moving forward. Won by Ohio State University. Currently selecting the exhaust stacks that will be used for the study.

ii. Work Statements (WS)

iii. Research Topic Acceptance Request (RTAR)

1. Effect of exhaust terminations on jet mechanics and resulting required intake separation (62.2) – Iain will discuss with the chair of 62.2 to get it on their agenda for Tampa.
2. Updating garage ventilation rates for current populations of vehicles (electric cars) *2 meetings- Jordan Clark and Steve Taylor
3. PTAR (Publication): Guide for successful simulation of outdoor airflow around the built environment *2 meetings- PTAR draft written by Duncan. It is short, ~15 minute read. Proposal is for it to be paid to allow for a more in-depth look at what is currently accepted. Suggestions and feedback is requested. "Any kind of feedback, gentle or harsh, is welcome."

   Next Step: Review by committee to decide if it should be further fleshed out.

iv. On Hold / Inactive

v. New Ideas – "3 Strikes" rule- if idea has been on docket for three meetings with no forward movement, will be removed

Craig Wray- suggests that ideas be moved to a "parking lot" of ideas that are not being actively worked on. There may be procedural suggestions from ASHRAE in the way ideas should be handled. Having ideas for the future is always a good idea.

Martin Stangl- ideas that are not particularly engaging at the moment may be of interest in future years. Could be included in a list at the bottom of the minutes and included with the ideas as a group.

Parker – The parking lot could be handled in the Research sub committee meeting to improve the efficiency of the main meeting but allow for additional discussion in the research subcommittee meeting.

Vaughn Terpak – Parking lot could be appendix to the meeting minutes to be carried forward easily.

Name	Champions	Status/Actions
RTAR/PTAR Combo: Infiltration vs. Pressurization impact with ERVs	Phillips and Wray to write PTAR	Sub Committee: "Developing guidance for ventilation design related to high buildings and pressurization." Possible PTAR instead? **2 meetings RTAR Outline has been written by Duncan. Will be reviewed by Craig and then distributed to committee.
Enhance the current Stack Height Reduction Factor Methodology for Plume Dispersion Calculations for 1- 2.5 x screen height	Carter/Parker	**2 meetings Idea from Parker, will consider writing Greg Gross will discuss with John on taking over champion for this.

Potential work following ETF transition -Craig/Iain: 2 Standards in development from this transition to include metrics for infectious diseases. ASHRAE STD 241 – timeline is to be complete this summer.	McNulty	Sample survey of existing building vent performance i.e. BASE study Crowd-sourced database? CO2 or CO levels
Adjustment of rates for density of air w/ altitude-do emissions change with altitude? How much do resulting rates change? Include perception changes	Phillips-framework, Taylor review	Phillips to provide framework and Taylor to review "Phillips has been busy with other RTARs, it is on my list." -Duncan
Better ventilation effectiveness values for heating. Provide additional guidance or simplified equation.	Frank Godbout Craig Wray volunteered to assist.	Godbout to write RTAR, has white paper. Clark to send RTAR writing guide Frank has written an RTAR draft and sent it to Jordan for feedback. Feedback is requested and appreciated from the committee after it is circulated. **Volunteer needed**: **Knowledgeable in current literature, possibly Academic or government background.**
Submitted via email: Exploring the Impact of IAQ on Human Physiological Signals (assumption is changes in stress markers such as HR, HRV, etc)	Joonho Choi	Choi to write RTAR Ed Light – Interested in helping out, as the current IAQ guidelines are based in "feelings" and could be based in more scientific metrics.

vi. Deadlines

--- 5'-10' Break (est. 9:15 am Pacific / 12:15 pm Eastern / 9:45 pm India) ---

c. Handbook (15') **Vasan**

Information is being gathered to provide the edits, info gathering planned to be completed by the summer. Ch 16 is expecting significant portions of re-writes/additions and will allow for contributions from the committee.

All the chapters are on basecamp. Any comments or ideas are welcome.

i. Chapter Status

Volume	Chapter	Lead	Status
2025 Fundamentals	Chapter 16 Ventilation and Infiltration	Marianne Touchie, Cara Lozinsky, Justin Berquist	
2025 Fundamentals	Chapter 24 Airflow Around Buildings	Ted Stathopoulos	
2027 Applications	Chapter 45 Building Air Intake and Exhaust Design	Ryan Parker	To be published in June

ii. Revision information

1. Access files, for revision, via https://authoring.ashrae.org/
2. **Chapter reviews**: If you have colleagues who are practicing in or otherwise interested in any of our topics, please ask them to review our as-published chapters. They can submit their reviews via http://xp20.ashrae.org/secure/handbook/chapter_review/
3. Website for our revisers: https://www.ashrae.org/technical-resources/ashraehandbook/ashrae-handbook-central

iii. Deadlines

d. **Standards (10')** Emmerich

i. 62.1 Ventilation and Acceptable Indoor Air Quality

ii. 62.2 Ventilation and Acceptable IAQ in Low-Rise Res Bldgs

Iain Walker - Addendum has been published that essentially says that if you have unvented combustion in your house you will not be in compliance with the standard.

iii. 161 Air Quality Within Commercial Aircraft

iv. Other Standards of interest

1. 241P Standard to Address Mitigation of Airborne Infection Transmission (Working Title)
2. 90.1 Energy
3. 170 Ventilation of Healthcare Facilities

e. **Website/Basecamp (5')** Parker/Morris

Contact the committee or Ryan Parker or Bryan Morris to be added to Basecamp to be able to view in-progress documents.

f. **Honors & Awards (5')** Nicholson

i. May deadline

10. Old Business

i. Figure of "Type H Exhaust Stack Drain" (Ch 46, Fig 2)

Add figure to minutes. Could be suggestive of reviewing this figure to determine if all the types are actively available in the industry or are ideas of what might be possible.

11. New Business

Note on what can be new business – any questions for the committee or new ideas for discussion for the general committee.

12. Next Meeting

a. Subcommittee meetings prior to Summer Conference

Research: None

Handbook: **June 1, 2023. 10am-11.20am EST**

b. 2023 Annual Conference: June 24-28, Tampa, FL
https://www.ashrae.org/conferences/2023-annual-conference-tampa
Full TC meeting usually 5p-7p on Monday evening of conference

c. ASHRAE Annual and Winter Conference dates:

Future Winter Conferences	Future AHR Expos	Future Annual Conferences
Feb. 4-8, 2023 – Atlanta, GA	Feb. 6-8, 2023 – Atlanta, GA	June 24-28, 2023 – Tampa, FL
Jan. 20-24, 2024 – Chicago, IL	Jan. 22-24, 2024 – Chicago, IL	June 22-26, 2024 – Indianapolis, IN
Feb. 8-12, 2025 – Orlando, FL	Feb. 10-12, 2025 – Orlando, FL	June 21-25, 2025 – Phoenix, AZ
Jan. 31-Feb. 4, 2026 – Las Vegas, NV	Feb. 2-4, 2026 – Las Vegas, NV	
	AHR Mexico *Sep. 19-21, 2023 – Mexico City*	

13. Adjourn

Motioned: Duncan, no opposed