MINUTES (DRAFT)

Environmental Health Committee (EHC)
June 23, 2021
Virtual Annual Meeting

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

MEMBERS PRESENT:
Wei Sun, *Chair*
Luke Leung, *Vice-Chair*
Bill Bahnfleth
Charlene Bayer
Brendon Burley
Nicholas Clements
John Cohen
Karel Kabele
Kishor Khankari
Claressa Lucas
Rick Hermans, *BOD Ex-O*
Andy Persily
Bill McQuade, *Coord. Officer*
Wayne Thomann
Junjing Yang

MEMBERS NOT PRESENT:
Peter Alspach
Stephanie Taylor

ASHRAE STAFF:
Steve Hammerling, *MOTS*
Jeremy Pollack, *MFGA*
Stephanie Reiniche, *DOT*
Alice Yates, *DOGA*

GUESTS:
Darryl DeAngelis
Wade Conlan
J. Dennison
Steve Emmerich
Mark Ereth, *Incoming Member*
Henry Greist
Elliott Horner
Mark Jackson
Rick Karg
Steven Klekas
Linda Lee, *Incoming Member*
Frederick Marks
Tim McGinn, *Incoming Coord. Officer*
Meghan McNulty
Corey Metzger, *Incoming Member*
LanChi Nguyen-Weekes
Dustin Poppendieck
Larry Schoen
Max Sherman
Larry Smith
James Sweeney
Iain Walker
Don Weekes, *Incoming Member*
Steve Welty
Marwa Zaatari, *Incoming Member*

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MOTIONS

No.	Motion	STATUS
1	EHC recommends to Tech Council to change Part A.1.1 and A4.1 to EHC MOP.	POSTPONED
2	to postpone Motion 1 until next EHC meeting.	PASSED
3	EHC approves the report titled Knowledge Gap in Built Environmental Quality.	PASSED
4	EHC recommends that DRSC recommend to Tech Council that they appoint the following members to the Filtration and Air Cleaning position document (PD) committee	PASSED
5	EHC recommends that DRSC recommend to Tech Council that they reaffirm the *Limiting Indoor Mold and Dampness in Buildings* PD until July 1, 2023	PASSED
6	EHC approves the document titled *EHC Report to ASHRAE Technology Council Recent Trends in Environmental Health*	PASSED

LIST OF ATTACHMENTS

No.	Attachment
A	2020-2021 Management by Objectives
B	Knowledge Gaps in Built Environmental Quality
C	BOD Ex-O presentation
D	Limiting Indoor Mold and Dampness in Buildings PD
E	EHC Report to ASHRAE Technology Council Recent Trends in Environmental Health
F	TC 2.3 RTAR, *Effects of increased use of surface disinfectants and hand sanitizers on indoor air quality*

LIST OF ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
AiCARR	Italian Association of Air Conditioning, Ventilation and Refrigeration
AIHA	American Industrial Hygiene Association
AIVC	Air Infiltration and Ventilation Centre
ASA	Acoustical Society of America
ASHRAE	American Society of Heating, Refrigerating and Air-conditioning Engineers
BOD	Board of Directors
CNV	Chair Not Voting
DRSC	Document Review Subcommittee
EHC	Environmental Health Committee
EIB	Emerging Issue Brief
ETF	Epidemic Task Force
ETS	Environmental Tobacco Smoke
ExCom	Executive Committee
ExO	Ex-Officio
FAIAR	Federation of Ibero-American Air Conditioning and Refrigeration Associations
FEDECAI	Federation and Association of the Interior Environment throughout Spain and Andorra
GAC	Government Affairs Committee
HVAC&R	Heating, Ventilating, Air Conditioning & Refrigeration
HWBE	Health & Wellness in the Built Environment

IAQ	Indoor Air Quality
IEQ	Indoor Environmental Quality
IEQ-GA	Indoor Environmental Quality Global Alliance
IICRC	Institute of Inspection Cleaning and Restoration Certification
ISHRAE	Indian Society of Heating, Refrigerating and Air Conditioning Engineers
MAIQC	Maine Indoor Air Quality Council
MBO	Management by Objectives
MOP	Manual of Procedures
MOTS	Manager of Technical Services
MTG	Multi-disciplinary Task Group
PD	Position Document
PMS	Project Monitoring Subcommittee
REHVA	Representatives of European Heating and Ventilation Associations
ROB	Rules of the Board
RP	Research Project
RTAR	Research Topic Acceptance Request
SIE	Society for Indoor Environment
SSPC	Standing Standard Project Committee
TPS	Title, Purpose Scope

ACTION ITEMS FROM 2021 ANNUAL MEETING

No.	Responsibility	Action Item	Status
1	Staff	confirm financial support of travel for ETF members to a face to face meeting in Las Vegas	On going
2	Staff	send details on Environmental Health award to members to help solicit nominations	Complete
3	Staff	send Knowledge Gap in Built Environmental Quality report to Technology Council	Complete
4	Staff	assure that the Infectious Aerosols PD committee chair received the feedback from ExCom on their TPS	Complete
5	Staff	send feedback on advisory committee and design community representation to Filtration and Air Cleaning PD chair.	Complete
6	Staff	Send letter ballot on EHC co-sponsorship of TC 2.3 RTAR, *Effects of increased use of surface disinfectants and hand sanitizers on indoor air quality*	Complete
7	EHC	review and offer comments on the MTG.HWBE final report to LaNguye@lacitec.on.ca within the next 2-3 weeks	Complete

ACTION ITEMS FROM 2021 WINTER MEETING

No.	Responsibility	Action Item	Status
1	EHC	Khankari asked for thoughts from members to "identify major trends impacting environmental health related with HVACR for a report to Tech Council.	Complete
6	Burley, EHC	Burley agreed to develop a discussion group to study 62.1 ventilation rates at high elevation	Ongoing

1. CALL TO ORDER & INTRODUCTIONS

Chair Sun called the meeting to order at approximately 2:30 PM EDT. Members and guests introduced themselves. Quorum was confirmed.

2. ASHRAE CODE OF ETHICS COMMITMENT

'In this and all other ASHRAE meetings, we will act with honesty, fairness, courtesy, competence, integrity and respect for others, and we shall avoid all real or perceived conflicts of interests.' (See full Code of Ethics: www.ashrae.org/about-ashrae/ashrae-code-of-ethics.)

3. REVIEW OF AGENDA

No changes were made to the agenda sent ahead of the meeting.

4. MINUTES

Notes from spring meeting is to be sent shortly. Annual meeting minutes will be available after this meeting.

5. CHAIR'S REPORT (Sun)

A. Four EHC virtual meetings have been conducted since 2020 Annual meeting:
- September 28, 2020 (Fall)
- December 2, 2020 (December)
- January 21, 2021 (Winter)
- April 1, 2021 (Spring)

B. Motions from Past Meetings Requiring Higher Body Approval
   a) none

C. 2020-2021 Management by Objectives (MBOs)
   A final report of all MBOs will be reported to Tech Council (**Attachment A**).

6. VICE-CHAIR'S REPORT (Leung)

A. ROB/MOP/Reference Manual
   Leung suggested some changes to the EHC MOP to align with ASHRAE Strategic Plan on Wellness:

SECTION A - ENVIRONMENTAL HEALTH COMMITTEE - GENERAL

Part 1 Responsibilities/Duties

A1.1 The Environmental Health Committee shall be responsible for identifying major environmental health trends impacting the practice of HVAC&R, informing the ASHRAE leadership and membership of these trends and their potential impacts, and making recommendations on new activities and policies in response to these trends. In addition, this committee shall serve as a resource to the Society on activities and issues that relate to environmental health impacts of building environmental control technologies including but not limited to ventilation, acoustic, visual, airborne infectious agents, and thermal conditioning. (ROB 2.406.001)

Part 4 Operations

A4.1 This committee shall maintain a long-range plan for Indoor ~~Air~~ Environmental Quality conferences and submit this plan to Technology Council at the Annual Meeting. (ROB 2.406.003.1

MOTION 1:
It was moved (LL) and seconded (NC) that EHC recommend to Tech Council to change Part A.1.1 and A4.1 to EHC MOP.

MOTION 2:
It was moved (WB) and seconded (JC) that **Motion 1** be postponed until next EHC meeting.

BACKGROUND: Members asked that they need some time to consider the changes.

MOTION 2 PASSED: 11-0-0 CNV

Leung suggest a change to EHC Reference Manual as well to add a task to the Policy Subcommittee:

Sub-Committee	Charge	Interaction between Subcommittees	Task Description
Policy	Identify major environmental health trends impacting HVAC&R	Ask all EHC to send ideas	<u>Define Environmental Health</u> Brainstorm - PD, EIB, RP
	Recommend New activities		
	Recommend Policies that EHC should consider (EIB, PD, RP)		Brainstorm for what should be researched and think about by whom
	Position Document Oversight		
	Create EIB		Develop the idea and the document - these are quick

A motion to make this change could be considered at a future meeting as well.

B. <u>Budget</u>
No new EHC budget items were requested.

Bahnfleth summarized a 5-year commitment for ASHRAE's IEQGA membership. This funding has not come from the EHC budget.

It was noted ASHRAE had previously committed to supporting travel for ETF members to an ASHRAE meeting. Bahnfleth noted an in-person meeting of the ETF could take place at the next ASHRAE meeting in Las Vegas. Staff was asked to confirm financial support of travel for ETF members to a face to face meeting in Las Vegas (**Action Item 1**).

C. <u>Donald Bahnfleth Environmental Health Award</u>
Bjarne Olesen was announced as winner of 2021 Donald Bahnfleth Environmental Health Award at the ASHRAE Annual Meeting.

Nominations for the 2022 Environmental Health Award is November 1, 2021. Staff would send details on the award to members to help solicit nominations (**Action Item 2**).

D. <u>Knowledge Gap in Built Environmental Quality</u>
Leung summarized his effort to meet and poll experts inside and outside of ASHRAE on current knowledge gaps related to environmental quality in the built environment. Leung's summary report titled "*Knowledge Gaps in Built Environmental Quality*" is included as **Attachment B**. The report can be used to help define how ASHRAE might address current gaps. His aim is to meet two times per year to continue discussion and develop as resource to EHC.

MOTION 3:
It was moved (LL) and seconded (BB) that EHC approve the report titled "Knowledge Gap in Built Environmental Quality" (**Attachment B**).

MOTION 3 PASSED: 12-0-0 CNV

Staff would send report to Technology Council (**Action Item 3**).

7. BOARD OF DIRECTORS (BOD) EX-OFFICO (EXO) & COORDINATING OFFICER REPORT

A. BOD EX-Officio - Hermans
Hermans gave Ex-O presentation (**Attachment C**).

B. Coordinating Officer
Incoming Tech Council chair McGinn introduced himself and offered to assist EHC in their activities. Coordinating Officer McQuade addressed EHC and thanked all for their tremendous amount of work over the past Society Year.

8. SUBCOMMITTEE REPORTS

A. Policy Subcommittee (**Khankari**)

1. Position Document (PD) Oversight

a) *Infectious Aerosols*
The PD committee has started meeting but a draft is not yet available. The PD suggested changed to the title, purpose and scope (TPS) that are now approved by BOD ExCom.

Staff was asked to assure that the PD committee chair received the feedback from ExCom (**Action Item 4**).

b) *Indoor Carbon Dioxide* – Persily
Development of the *Indoor Carbon Dioxide* PD is underway. A draft is developed, and the aim is to approve at Winter Meeting in January 2022

c) Filtration and Air Cleaning
The chair (Pawel Wargocki) was appointed earlier this year and submitted their suggestions for PD members.

MOTION 4:
It was moved (KKh) and seconded (NC) that EHC recommends that DRSC recommend to Tech Council that they appoint the following members to the Filtration and Air Cleaning position document (PD) committee:

- Jeff Siegel, University of Toronto (vice-Chair), past member
- Marwa Zaatari, Blue Box Air, (connection to 62.1 and industry)
- Kathleen Owen, Owen Air Filtration Consulting, (connection to 2.4, industry)
- Paula Levasseur, LMF Services, LLC (connection to 2.3 and industry)
- Paolo Tronville, Polytechnic of Turin (connection to RAC 2.3, 2.4 and standardization)
- Dean Tompkins, Consultant (connection to 2.3, industry)
- Dean Saputa, UV Resources, (connection to 2.9, industry), past member

BACKGROUND: The members represent various fields, outside experts, and relevant ASHRAE committees. ASHRAE bios for ASHRAE members are included on EHC basecamp**.**

MOTION 4 PASSED: 12-0-0 CNV

EHC suggested consideration of a non-voting advisory committee (similarly as done with Infectious Aerosols PD) as warranted to help assure parties in broader fields can be involved.

Others suggested adding someone from the design community later on as well. Staff would pass these suggestions to Wargocki (**Action Item 5**). Brendan Burley, Linda Lee volunteered as members with this design perspective.

Linda Lee noted SSPC 185.3 is doing work in this area. Jon Cohen noted TAC approved a new Task Group on Reactive Air Cleaning and Surface Disinfection.

d) Limiting Indoor Mold and Dampness in Buildings
MOTION 5:
It was moved (KKh) and seconded (JC) that EHC recommends that DRSC recommend to Tech Council that they reaffirm the Limiting Indoor Mold and Dampness in Buildings PD until July 1, 2023.

BACKGROUND: A revision is underway now, but the current PD (**Attachment D**) expires June 27, 2021. Reaffirming the PD would keep this document available until a revision is ready.

MOTION 5 PASSED: 11-0-0 CNV

2. New policies? (EIB, PD, RP)
No new policy documents were suggested. Clements suggested the EHC liaison to GAC be the Policy Subcommittee chair as GAC has a good deal of interest in policy documents and the need for policy documents. There was much interest related to ETS and vaping indoors. EHC could consider expanding ETS guidance to include cannabis in EIB or to possibly make stronger statements on these issues.

3. Emerging issue briefs
Khankari and Clements suggested reviewing current emerging issue briefs to determine if they could be updated, retired or developed into position documents. Many of the currently published EIBs are quite old and perhaps no longer emerging. All should be reviewed in the context of GAC and policy issues.

No new EIBs were suggested.

4. Other
Khankari developed and sent a draft report on "identify major trends impacting environmental health related with HVACR" to EHC ahead of the meeting. This report was prepared in response to an EHC MBO to identify and report on recent trends in the environmental health and its impact on HVAC&R industry.

MOTION 6:
It was moved (KKh) and seconded (JC) that EHC approve the document titled EHC Report to ASHRAE Technology Council Recent Trends in Environmental Health.

BACKGROUND: This report (**Attachment E**) was prepared in response to an EHC MBO to identify and report on recent trends in the environmental health and its impact on HVAC&R industry.

MOTION 6 PASSED: 12-0-0 CNV

B. Education Subcommittee (Bayer)
1. EHC Sponsored Programs for Annual Meeting
No proposals were submitted for ASHRAE Annual Meeting. Linda Lee has a proposal for Winter Meeting.

2. EHC Program Proposals for Winter Meeting
   Proposals for Winter Meeting are due August 2 (https://ashraem.confex.com/ashraem/w22/cfp.cgi). Linda Lee noted she had a program idea and would submit.

3. ASHRAE Journal IEQ Applications Column
   Persily submitted the latest summary of IEQ Application Columns:

Issue	Draft due	Author	Topic
January 2020		NO COLUMN DUE TO SPACE CONSTRAINTS	
February 2020		Zuriami S (NRCC)	Smart bldg. tech and occ satisfaction
March 2020		Tom Lawrence (UGA)	IEQ in new & old bldgs. comparison
April 2020		Lan Chi Weekes	Health & Wellness MTG
May 2020		Larry Schoen	Bldg ops w/ covid
June 2020		Root/Majeska	Water mgmt - hospitals & leisure
July 2020		Sowa (Univ of Warsaw)	Human dry/temperate roots
August 2020		Horner (UL)	Consumer grade IAQ sensors
September 2020		Conlon	HQ opening analysis
October 2020		Schoen	ETS PD
November 2020		Weekes	IAQ PD
December 2020		Sun	Room pressure control
January 2021		Alspach	55 adddendum on controllability
February 2021		Persily	1000 ppm and 62.1
March 2021		Emmerich	Guideline 44 planning guide
April 2021		Wargocki	IAQ and sleep
May 2021		Bahnfleth	ETF core principles
June 2021		Condon	Ventilation flushing calcs
July 2021		Burley	Air distribution
August 2021		Schoen	UV case study
September 2021	**7/9/21**	Sun	Clean room contam control technology
October 2021	**8/9/21**	Taylor	Monitoring IE for IAQ and human health
November 2021	**9/9/21**	Bayer and Burt	IAQ sensor testing
December 2021	**10/9/21**	Khankari	Airflow patterns matter

   The current schedule is booked through end of calendar year. Burley agreed to help oversee column development going forward.

4. Handbook Chapter
   Bayer noted the plan was to reach out to past contributors and current EHC members for update to Fundamentals chapter. There is no update until 2025 volume which will be due in 2024.

5. Online presentations/seminars to EHC and beyond
   As one MBO item and a major effort this year, EHC sponsored three seminars since the Winter Meeting:
   - January 8 – 1st ETF seminar to EHC

- May 13 - 2nd ETF seminar to EHC
- June 25 - 3rd EHC seminar on "*Attitude and Technology Changes as A Result of Covid for the Reopening of Buildings*"

The 3rd seminar is planned for 2:30 – 5:00 PM EDT on June 25th. All are invited to attend. Bayer noted they are seeking one more speaker (on air flow patterns) if someone has a presentation prepared. A planning meeting for speakers is scheduled for June 24th.

C. Coordination and Outreach Subcommittee (Clements)

1. Interaction with ASHRAE committees
   Leung noted this group of ASHRAE committee members met and results are included in the "*Knowledge Gaps in Built Environmental Quality*" report.

2. Interaction with outside organization that impact environmental health
   Leung noted this group held a kickoff meeting. Results are incorporated into the "*Knowledge Gaps in Built Environmental Quality*" report. The goal is to continue to meet twice per year.

3. IAQ 2020
   The IAQ 2020 Conference, *IEQ Performance Approaches, Transitioning from IAQ to IEQ*, will be moved to May 4-6, 2022. The conference will take place in Athens, Greece as a face to face meeting. Bill Bahnfleth and Max Sherman are chairing the event which will be co-organized by ASHRAE, AIVC and the IEQ-GA. Details on the conference can be found at www.ashrae.org/iaq2020.

4. Indoor Environmental Quality – Global Alliance (IEQ-GA)
   ASHRAE continues to participate in the IEQ-GA with Bill Bahnfleth as the ASHRAE representative. The IEQ-GA is now finalized as a legal entity and operates with 11 full member organizations (ACGIH, AICARR, AIHA, AIVC, ASA, ASHRAE, FAIAR, FEDECAI, IICRC, ISHRAE, REHVA). There are two other affiliate associations (MAIQC, SIE). A podcast is planned for June 30 and all are invited to listen and participate.

5. ASHRAE Epidemic Task Force
   Bahnfleth stated that the Epidemic Task Force has continued its operations in the same mode as it has since its formation in March 2020. Significant updates have been made to some sections of guidance to conform to the Core Recommendations issued in January 2021. Pending updates include revisions to guidance on air distribution and guidance on non-infectious air delivery rate requirements for risk mitigation. Interactions with government and other organizations continue to be frequent and significant. The task force roster will roll over into 2020-2021 with the expectation of transitioning responsibility for its activities to EHC and other Society committees as soon as feasible.

6. List of research topics with brief descriptions to document emerging ideas to TCs as inspiration for potential research
   Clements noted he would connect with the incoming Outreach subcommittee chair to consolidate the various research topic lists that are started.

7. Current EHC sponsored or co-sponsored research
   a) Active Research Projects
      1. RP-1579 - *Testing and Evaluation of Ozone Filters for Improving IAQ*
         No update was reported on this RP. Hoy Bohanon is EHC's representative on the Project Monitoring Subcommittee (PMS).

   b) Other

EHC received a request to sponsor TC 2.3 RTAR, *Effects of increased use of surface disinfectants and hand sanitizers on indoor air quality* (**Attachment F**).

Staff was asked to prepare and send a letter ballot to co-sponsor (**Action Item 6**).

8. . RTARs reviewed by EHC Members
   EHC is given the opportunity to review and offer comments to RTARs submitted to RAC for review to ensure they consider environmental health related issues. Comments were due June 18 and sent back to RAC already but the following were distributed for EHC comment:
   - RTAR 1924, *Formalizing thermal comfort evaluation for children (0-18y)*
   - RTAR 1928, *Improving test methods to measure air cleaner performance against airborne pathogens*,

9. LIAISON ACTIVITIES

The following committees gave liaison reports at the Annual Meeting: GAC, 62.1, 62.2, 189.1, 170, 42P, MTG.HWBE & MTG.VIC.

Weekes reminded all to review and offer comments on the MTG.HWBE final report to LaNguye@lacitec.on.ca within the next 2-3 weeks (**Action Item 7**).

10. NEW BUSINESS

A. NEXT MEETINGS

Leung noted he planned a kickoff meeting for next year's roster for early July. Please look out for the poll and invite details.

EHC would have a virtual meeting in the fall and plan on meeting face to face at the 2022 ASHRAE Winter Meeting in Las Vegas, NV on Monday January 31st, 2022

11. HANDOVER TO NEW CHAIR

Outgoing Members Kishor Khankari, Peter Alspach, Charlene Bayer, Andy Persily, and chair Wei Sun were recognized for their work on EHC and are rolling off.

The incoming chair and vice chair for the 2021-22 SY are Luke Leung and Nick Clements. Incoming members are Don Weekes, Marwa Zaatari, Mark Ereth, Linda Lee & Corey Metzger. Chair Sun welcomed the incoming EHC chair and new EHC members, and wished the new team to have another successful year. Subcommittee chairs and subcommittee assignments are being determined in the next couple of weeks.

A draft list of 2021-2022 MBOs are being drafted and will be discussed at the EHC kickoff meeting.

12. ADJOURNMENT

The EHC meeting adjourned at just before 5:30 PM EDT. All attendees were thanked for their active participations.

MBO Submission to Planning Updated 6/21/2021

Council:	**Technology Council**	**Chair:**	**Wei Sun**
Committee:	**Environmental Health Committee (EHC)**	**Vice-chair:**	**Luke Leung**

								Strategic Plan Tally											
MBO #	**Description**	**Metric**	**Initiative #**	**Goal #**	**Completion % / Date**	**Financial Assist Req'd?**	**MBO Comments**	**Initiative #**				**Goal 1**		**Goal 2**			**Goal 3**		
		(how do we determine success?)						**1**	**2**	**3**	**4**	**a**	**b**	**a**	**b**	**c**	**a**	**b**	**c**
Policy Subcommittee (Khankari)																			
1	Review published EIB and determine if they need to be retired, reaffirmed, or have a PD created.	Number EIBs retired, reaffirmed, or proposed for PD	1, 2, 3	1a, 3b	Complete	No	Assigned to Policy	x	x	x		x						x	
2	Draft a short report to Tech Council which identifies major trends impacting environmental health related with HVACR.	Report sent to Tech Council	1, 2	1b	Complete	No	Assigned to Policy Itemize each topic with short description in around 50-100 words, the report is of 2 pages maximum. First report completed and will be reported to Tech Council at Annual 2021 meeting.	x	x				x						
Education Subcommittee (Bayer)																			
3	EHC is to submit at least two society technical programs (paper session/seminar/forum) and to serve as a sponsor or co-sponsor for society annual meeting.	Number Technical programs submitted and/or sponsored	1, 2	1b, 2a	Complete	No	Three sponsored/cosponsored Winter Meeting programs. Zero Annual Meeting Programs.	x	x				x	x					
4	Publish at least 7 articles for IEQ Column per year.	Number columns published	1, 2	1b, 2a	Complete	No	12 articles published in 2020-21 SY	x	x				x	x					
5	Develop and propose short online seminars on pandemic related issues (not for regular society annual/winter programs).	Number seminars conducted	1, 2	1b, 2a	Complete	No	3 seminars: January 8, May 13, & June 25	x	x				x	x					
6	Recruit/assign contributors to start revising the Chapter 10.	Number contributors assigned Revision initiated	1, 2, 3, 4	1a, 1b	Complete	No	Assigned to Eduation subcommittee. Ccontributors from last edition will be asked to help work on next version in addition to new volunteers	x	x	x	x	x	x						
Coordination and Outreach Subcommittee (Clements)																			
7	Document the interaction plan with IEQ-GA for future IAQ meetings.	Plan documented	1, 2, 4	2b	Complete	No	Relevant to RoB 2.406.003.1 Reports in EHC meeting minutes	x	x		x				x				
8	Document an interaction plan with Epidemic Task Force (ETF).	Plan documented	1, 2, 4	1b, 2b	Complete	No	Relevant to RoB 2.406.003.1 Reports in EHC meeting minutes	x	x		x		x		x				
9	Develop a short list of research topics with brief descriptions during each society meeting to document and disseminate emerging research ideas to TCs through TAC as inspiration for potential researches.	List of topics developed Research ideas disseminated	1, 2, 4	1b	Complete	No	Each EHC-related topic/descriptions is around 50-100 words (1-2 pages in total). The goal is idea sharing, not to develop RTARs by EHC.	x	x		x		x						
10	Develop a list of EHC-related experts to form an informal discussion group which will regularly in touch to share the latest technical information and trend on what is on the horizon. This could result in policy suggestions, papers, conference programs, research ideas, etc., but is a function of Outreach subcommittee.	List of experts created Policy suggestions developed	1, 2, 4	1b	Complete	No	Staff compiled the list of these committees, groups, etc. with contact information to facilitate this outreach. Outreach meetings held. Reports available from EHC	x	x		x		x						
Administration (Sun/Leung/Hammerling)																			
11	Review the EHC Scope and Manual of Procedures, recommend to maintain or to revise, present recommendation for new language at annual meeting.	Review of MOP completed Reommendations presented	3, 4	3b	Complete	No	Relevant to RoB 2.406.001. Changes made to restructure EHC MOP at last meeting			x	x							x	
12	Develop new EIB for concerned items to be published in short order and on ASHRAE website.	EIB published	1, 2	1b, 2a	Complete	No	No new EIBs at this time. Policy to review current list to see if any can be retired.	x	x				x	x					
Strategic Plan																			
13	Identify IEQ knowledge gaps and list them in future research priorities	Develop document summarizing gaps and priorities	2		Complete	No	added to address IEQ strategic plan initiative. See EHC minutes for details		x										
14	Develop a roadmap for remaining actions for 2021-2024	Develop roadmap document. Include in next year's MBOs	2		Complete	No	added to address IEQ strategic plan initiative. See EHC minutes for details		x										
								11	**13**	**3**	**6**	**2**	**9**	**4**	**2**	**0**	**0**	**2**	**0**

Knowledge Gaps in Built Environmental Quality

1. **Introduction:**

The below knowledge gap input on built envionrment quality are from both inside and outside ASHRAE. Inside ASHRAE, a survey form was sent to a list of relevant TCs and committees, see Appendix A**.** The replies are attached, see Appendix B and Appendix C. A meeting was held on March 31st with selected ASHRAE TCs and committees, see Appendix D for Meeting minutes. Outside ASHRAE, a group of external experts were put together, see Appendix E. A meeting was held on April 15th, 2021, see Appendix F for the comments and Appendix G for meeting minutes.

To understand the knowledge gap better, finer defintions on both the parameters and the specific content of each parameter will be important. There are information we do not have when it comes to addressing individuals rather than "average" health, including the needs of plants and animals as mentioned in the ASHRAE strategic plan. The ASHRAE standards and gudieslines will need to be reviewed and aligned with the new built environmental quality strategic plan. Currently they are not necessarily coordinated to address the needs. Finally, there are many uncertainties regarding monetary benefits of built environmental qualities thay will need further research, from simple gathering of health data, to more sophisticated understanding of how to isolate environmental versus genetics, emotional impacts, and other non environmental issues.

Key findings are below:

2. **Knowledge Gap**

   a. **Definitions**
      i. Currently 62.1 is strongly based on satisfaction with respect to human bioeffluents. Consider expanding the "health" bases of these standards and conduct the required research, including the science needed to define "healhty air" (Appendix D)
      ii. Regarding "ASHRAE Research Strategic Plan" definitions and potential knowledge gap:
         1. "Semi-outdoor and outdoor environments". There are concerns about "outdoors" research is too broad. Consider changing "outdoors" to: "semi outdoors, alfresco, outdoor built environment, or building exterior" to differentiate from outdoors in natural setting (Appendix F, G)
         2. Consider changing "Transmission of Airborne Infectious Viruses" to a broader "Transmission of Airborne Infectious Viruses and pathogenic microorganisms." (Appendix C)
      iii. Helpful to conduct a larger research regarding IEQ definitions to see what other parameters should be added to the definition in the "Strategic Plan". For examples:

1. CIBSE TM 40 has considerations on electro-magnetic fields and water quality[i]
2. Consider adding "Surfaces" to "thermal, acoustic, visual, and air quality." E.g. K-values (inactivation rate constants) for surface (Appendix C)
3. Consider adding "Material" use in space. E.g. RESET certificate has off gas considerations, Health Product Declaration is getting popularity in specifying holistic healthy products.

b. Scope

i. Survival versus comfort: Comfort environment requirements are very different from survivable or habitable EQ conditions (e.g., LEED passive survivability criteria) that need to be maintained for human life under extreme weather conditions and/or power outages. Research is lacking in passive survivability (Appendix C)

ii. Currently missing the role of "biophilic" design in IEQ (Appendix F).

iii. Research to understand the environmental quality of transient nature of transporation, thermal comfort, ventilation rate, vibration, etc. (Appendix D)

iv. Global "Health Zones" – we have climate zones for energy, should there be similar global zones for health? PM 2.5 levels varies, California has more wild fire, high altittude has thin air, etc. (Appendix D)

v. Cooking in general, gas cooking in specific, needs more research on its impact to IEQ. what extent can demand-controlled kitchen ventilation ("DCKV") address these issues (Appendix C)

vi. More research in unvented combustion and impacts on air quality (Appendix C)

vii. Cooling – using general rule of thumb, but does not models actual air flow in the space. Lack the clarity on whether the spaces are actually "mixed" or not, especially for overhead systems (Appendix C)

viii. Research on test standard for the removal of ultrafine particles (UFP). Research into how best to test or even the levels of efficacy that are common would help design a useful standard. (Appendix C)

ix. Electronic air cleaners. How effective are they on different viruses, and impacts of byproducts they emit (Appendix C)

x. Microbial - research to understand antimicrobial products in air and surfaces and the forming of superbugs (Appendix F)

xi. The primary research gap in acoustics is the correlation between performance and human perception in the built-environment. While the acoustical design metrics are based on human perception, the application and refinement of these metrics and performance criteria has not been well correlated with user's experiences and other measures of health and well-being. With respect to acoustics many of our minimum requirements assume constant noise or intrusion, but do not take into consideration the changes in time, amplitude, or frequency of events. Understanding this would likely help create more tangible "minimum requirements". (Appendix C)

xii. Research to justify current air flow rates. Reported by TC 9.6, "Most healthcare spaces have no research justifying air flow rates" current ASHRAE recommendations need more research on where the valus came from. ASHRAE Research Project Report CO-RP3, Academic Research to Support Facility Guidelines & ANSI/ASHRAE/ASHE Standard 170, "651 requirements (73.5%) did not have evidence or conclusive evidence and are recommended for further study" (Appendix B)

xiii. Air infectious disease is not as focused compares to food and water. "There are, however, no ventilation guidelines or standards to specifically control the concentration of these pollutants indoors. None of the documents provide recommendations or standards for mitigating bacteria or viruses in indoor air, originating from human respiratory activities[ii]", per recently published document, "A Paradigm Shift to Combat Indoor Respiratory Infection".

xiv. Research on the impact of animals and plants on indoor environment can be enhanced. Many of the guidelines are lacking in information regarding these 2 aspects.

c. Occupants

i. Knowledge gap in moving from averages, or, "one size fits all" to more individual approach in enviornmental quality (Appendix D)

ii. Addressing individual diversities

1. Technological innovations including a continuum of control/actuation options (Appendix C)
2. Behavioral empowerment (Appendix C)
3. Coupling sensing, AI, control and environmental innovations with humans to achieve individually optimized conditions (Appendix C)
4. The "diversity" in occupants' requirements need to include different age groups, mobility (handicapped), vision differences (near sighted, far sighted), air quality sensitivities, and vulnerability. Need to address more about children, seniors, and pregnant people. The scope of TC 9.7 excludes educational facilities where young children are the dominant occupant group (Appendix C)

d. Impact and Overlapts to Current ASHRAE Standards

i. An new Environmental Health standard or guidelines will likely required.

ii. Standards and guidelines to address animals and plants in healthy environment. TC 2.2 "PLANT AND ANIMAL ENVIRONMENT", is "concerned with the relationships of environmental conditions, as altered by air-conditioning, refrigeration, heating and ventilating systems, to the growth, health, and reproduction of plants and animals.", less about healthy environment.

iii. ANSI/ASHRAE *Standard 62.1, Ventilation for Acceptable Indoor Air Quality*. This Standard establishes ventilation and other IAQ related requirements for buildings other than residential and health care. Its outdoor air ventilation rate requirements have been adopted into the International Mechanical Code and Uniform Mechanical Code, the two most common model building codes in the US. The standards are also referenced by most green commercial building programs including LEED.

iv. ANSI/ASHRAE *Standard 62.2, Ventilation and Acceptable Indoor Air Quality in Residential Buildings*. This Standard covers residential buildings. Ventilation requirements from this standard have been adopted into codes, including California's Title 24, and into LEED for Homes and the U.S. Environmental Protection Agency's (EPA) Indoor air Plus program.

v. ANSI/ASHRAE/ASHE *Standard 170, Ventilation of Health Care Facilities*. Standard 170 brought together several documents used throughout North America into a single standard. It is now widely used in building codes for ventilation requirements in hospitals and other health care facilities.

vi. ANSI/ASHRAE/ICC/USGBC/IES *Standard 189.1, Standard for the Design of High-Performance, Green Buildings Except Low-Rise Residential Buildings*. Developed in conjunction with USBGC, the International Code Council and Illuminating Engineering Society (IES), this standard provides IAQ requirements beyond those in Standard 62.1.

vii. ASHRAE *Indoor Air Quality Guide – Best Practices for Design, Construction, and Commissioning* and *ASHRAE Residential Indoor Air Quality Guide: Best Practices for Acquisition, Design, Construction, Maintenance and Operation*. These Guides present best practices for design, construction, commissioning, operation and maintenance that have proven successful in building projects to achieve good IAQ.

viii. 2017 ASHRAE Handbook Fundamentals – covers basic principles and data used in the HVAC&R industry including indoor air quality. The ASHRAE Technical Committees that prepare these chapters provide new information, clarify existing content, delete obsolete materials, and reorganize chapters to make the Handbook more understandable and easier to use.

ix. Damp Buildings, Human Health, and HVAC Design **–** This report provides a summary of what is understood about dampness-related health risks in buildings as well as suggestions for HVAC system designers that can help avoid such risks.

x. Need to coordinate with other environmental health programs, e.g. IN2WIBE which ASHRAE is involved and supported by NSF, Website: https://in2wibe.net/

xi. Human-centric IEQ control will impact many guidelines in ASHRAE, e.g. Guideline 36, needs to address a holistic IEQ human centric control, not just HVAC.

Commented [PAK(1]: Which standard? The title refers to 3 of them? This sentence seems to be about 62.1 while ths last is about 189.1. Why is 55 in the title at all?

Commented [LL2R1]: Yes type. Thank you

xii. Understanding of lighting, circadian rhythm, glare, etc. in transportation and outdoor space. Should those be part of Guideline 10 (Appendix D)
xiii. ASHRAE 55 is moving toward approaches to dealing with individual occupants, or groups of occupants, rather than reference or average occupants. Multiple practical implications on standards beyond 55 (Appendix C)
xiv. Research in ASHRAE 62.1 is about "indoor" air quality. Need to address the standard to regulate "outdoor" space since the ASHRAE Strategic Plan includes outdoor environments. Research in individual ventilation and control for 62.1 will need to address inefficiencies inherent in multiple-zone VAV AHU configuration (due to interzonal variations in occupancy and thermal loads) which is not addressed in the air distribution effectiveness tables. The air distribution effectiveness table is for personalized ventilation to address the individual ventilation and control (Appendix B, C)
xv. ASHRAE PMP and Best Practices Guide cover some of the discussion in the ASHRAE Strategic Plan, and is in the process of creating a new guideline committee, which would include top IEQ experts (Appendix C)
xvi. Research on a health tool like ASHRAE 140 to certify health calculation are sound, but maybe not as complicated as 140 (Appendix C)

Commented [Y3]: The `air distribution effectiveness table is to address the zone air distribution effectiveness, not the efficiencies inherent from the multi-zone VAV AHU configuration. There were values and methods included in ASHRAE 62.1 air distribution effectiveness table for personalized ventilation to address the individual ventilation and control.

Commented [LL4R3]:

Commented [LL5R3]: See attached.

e. Long Term Versus Short Term

i. Research on temporary shelters - short term occupancy conditions (hurricanes, etc.) days to weeks, what is acceptable in short term conditions vs. conventional shelters. Also consider alternate accommodations (due to emergency) e.g. stadiums becoming shelters, etc. (Appendix D)
ii. Research on thermal comfort and chronic exposure - are we adapting to changing weather in any meaningful manner? Is chronic exposure to certain indoor environments, in our quest to keep away from outdoors, getting us less healthy and resilient as a race? (Appendix C)
iii. Indoor air quality - chronic and short term exposures at moderate levels of under ventilation and impact on health and performance

f. Financial

i. Knowledge gap in developing solutions, best practice guidelines, assessment, diagnostic and EQ enhancement design tools, and economic models that can explicitly assign a monetary value to the costs and benefits of enhanced EQ. (Appendix C)
ii. There are concerns whether the financial gain and IEQ data on increase ventilation are solid. There are many other factors not included (Appendix D)
iii. ASHRAE should be lobbying Congress to fund IEQ research work to the tune of $10-20M per year as that's what it's going to take (Appendix B)
iv. Research on "health assessment benefit" which may be linked to healthy circadian rhythms (better sleep, alertness, metabolic health), mental health

(seasonal affective disorder, happiness index, relaxation, and many more). This probably has a monetary value, but more importantly a human health value (Appendix C)

v. Research on economic gain but weighted against carbon and energy cost (Appendix C)
vi. Relevant working task, thermal comfort and its impact on productivity - especially for the kind of knowledge based work that current workers are engaged in, not the tasks of typing etc. (Appendix C)
vii. Beneficial impacts - coil efficiency when kept clean, reduced lost workdays, infection rates (medical and tourism), utility rebates, food and water safety, horticulture, increased outdoor air change rate (Beggs 2008[iii]) (Appendix C)
viii. Research should include daylight, views and glare control, they are not part of the visual comfort. "Quality of view" research is lacking on how it interacts with other environmental quality factors and impacts on productivity. Also, in health care settings, reduction in pain medications and other outcomes in health care settings has also been demonstrated with exterior view. Quantifying this research and developing evidence-based recommendations is needed (Appendix C)
ix. Uncertainty in connecting environmental impacts versus impacts outside of a specific environment, e.g. genetic, emotional, sickness, sleep, etc.

g. Data

i. IEQ should be evidence based design. Unlike energy, data is lacking, especially air quality, regarding indoor environmental health. Privacy and legal concerns about health reporting need to be researched and addressed. (Appendix B, C**)**
ii. Research in environmental health and death rates - According to Office of Disease Prevention and Health Promotion (ODPHP) the environment plays a key role to the length and quality of your life. Per the ODPHP, 23% of all deaths (26% among children 5 years old or younger) are caused by preventable environmental factors. (Appendix C, D)
iii. Research in parameters and devices to measure good IAQ. Are the results repeatable, cost effective, etc. to be used and desired by building owners/operators? (Appendix C, D)

h. Methodologies:

i. Research required to moving from reducing the negative to enhancing the positive; performance thresholds from poor – marginal – acceptable – effective – preferred – optimal are not well understood (Appendix F and Appendix C)
ii. A unified comfort model including all IEQ parameters. A space IEQ grading system, like ASHRAE "BEQ" - Class A EQ, Class B EQ, etc. to categorize space. The interaction of different parameters in IEQ and how to account for tradeoff of different IEQ parameters (Appendix C, F):

   1. Interactions
   2. Wellbeing/health
   3. Affective
   4. Cognitive

iii. Research in a "Weighted IEQ rating" of multiple spaces in a day, as people do not stay in one space all the time (Appendix B)

iv. Research in optimal environmental experience, e.g. visual, acoustic, thermal experience, etc. Green space is often discussed as an optimal visual experience. What are the other optimal in each parameter and the integrated IEQ environment? (Appendix B, C)

v. Quantified models for particle transport and volatile chemical distribution (Appendix B, C)

vi. GUV and impacts to environmental elements (Appendix B, C)

vii. Window and health:

   1. Does air closer to windows has a higher air quality and fewer pathogens than air in non-daylighted areas?
   2. The interaction between daylight illumination and air quality
   3. There are several studies that suggest that better window views result in fewer environmental complaints for other environmental characteristics, or alternatively, tolerance of a wider range of conditions, in ventilation, acoustic, and thermal comfort.
   4. What are the incremental benefits if this fenestration can be opened to allow ventilation? There is an increase in building resiliency and potential energy savings, but what are the net benefits of openable fenestration?
   5. How can the benefits of openable fenestration be quantified in general, and on a building-by-building basis?
   6. To what extent do window shading devices or attachments to fenestration technologies impact the visual and thermal performance of a building as well as occupant comfort, health, and productivity? How can we predict the behavior of occupants using manually adjustable devices (such as blinds and louvers)? How does manual operation compare to automatically controlled adjustable devices? What are the key factors that would enable us to better predict manual operation? (Appendix C)

viii. Research on kitchen ventilation for both maintaining air quality as well as thermal comfort of workers. From previous research (Stoops et al. 2013), 60% of the data collected were outside the bounds of the comfort zone. What is the impact of worker productivity and health? Are their economic models that can inform updates to mechanical, energy, occupational codes? How is the choice of cooking fuels a factor? (Appendix C)

ix. The basic engine of thermal comfort design, the PMV-PPD model has come under scrutiny for being unable to accurately predict conditions that will achieve thermal comfort for building occupants (Reference Stefano Schiavon et. all 2019 paper on this topic). If we are to encourage designers to achieve higher levels of thermal comfort in buildings – an important component of overall building EQ – we need to develop a better understanding of thermal comfort (Appendix C)
x. Quantification tools for assessing health impacts of interventions. (Appendix F)
    1. Non-invasive skin patches to test for hormone and immune markers.
    2. Personal air samplers?
    3. Noise trackers
    4. Antigen assays
xi. Emerging air quality challenges driven by climate risk (wildfire, smoke, mold growth in new geographic regions, etc.) (Appendix C)

Appendixes

Appendix A

The List of ASHRAE Committees Where Built Environment Survey Was Sent

Committees	Contact	Email	ASHRAE Email
TC 1.12, Moisture Management in Buildings	Christy Cronin	christycronin@gmail.com	tc0112@ashrae.net
TC 2.1, Physiology and Human Environment	Dr Marianne Touchie	marianne.touchie@utoronto.	tc0201@ashrae.net
TC 2.2. Plant and Animal Environments	Dr. Morgan Hayes	hayesmorgan@gmail.com	
TC 2.3, Gaseous Air Contaminants and Gas Contaminant Removal Eq	Dr Sanjeev K Hingorani,	skh@lennoxind.com	tc0203@ashrae.net
TC 2.4, Particulate Air Contaminants and Particulate Contaminant Re	Mr Zied Driss	skys@drisstech.com	tc0204@ashrae.net
TC 2.5, Global Climate Change	Matthew Michael Clark	matthew.m.clark@carrier.	tc0205@ashrae.net
TC 2.7, Seismic, Wind and Flood Resistant Design	Matthew Hooti	mhooti@isotechindustries.	tc0207@ashrae.net
TC 2.8, Building Environmental Impacts and Sustainability	Mr William L Stanton	sstafford@integralgroup.com	tc0208@ashrae.net
TC 2.9, Ultraviolet Air and Surface Treatment	Henry Greist	henry.greist@lennoxind.com	tc0209@ashrae.net
TC 2.10, Resilience and Security	Carol Lomonaco	carol.lomonaco@jci.com	tc02010@ashrae.net
TC 3.6, Water Treatment	Alain Trahan	atrahan@h2obiotech.com	tc0306@ashrae.net
TC 4.3, Ventilation Requirements & Infiltration	John Carter	jcarter@cppwind.com	tc0403@ashrae.net
TRG4.IAQP, Indoor Air Quality Procedure Development	Dr. Marwa Zaatari	marwa.zaatari@gmail.com	trg4iaqp@ashrae.net
TC 5.4, Industrial Process Air Cleaning (Air Pollution Control)	Mr Timothy Adam	adam.bumann@gmail.com	tc0504@ashrae.net
TC 5.6 Control of Fire and Smoke	John Klote	johnhklote@gmail.com	tc0506@ahrae.net
TC 7.6, Building Energy Performance	Jim Kelsey	kelsey@kw-engineering.com	tc0706@ashrae.net
TC 9.1, Large Building Air-Conditioning Systems	Jay Eldridge	jay.eldridge@daikinapplied.co	tc0901@ashrae.net
TC 9.2, Industrial Air Conditioning and Ventilation	Erich Binder	erich.binder@worley.com	tc0902@ashrae.net
TC 9.3, Transportation Air Conditioning	Donald LeBlanc	Donald.Leblanc@nrc-cnrc.gc.c	tc0903@ashrae.net
TC 9.6, Healthcare Facilities	Traci Hanegan	hanegan@coffman.com	tc0906@ashrae.net
TC 9.7, Educational Facilities	Kyle Hasenkox	kyle.hasenkox@gmail.com	tc0907@ashrae.net
TC 9.8, Large Building Air-Conditioning Applications	Richard Vehlow	rev1969@gmail.com	tc0908@ashrae.net
TC 9.10, Laboratory Systems	Guy Perreault	guy.perreault@evap-techmtc.	tc0910@ashrae.net
TC 9.11, Clean Spaces	Dr Mark C Jackson	mark.	tc0911@ashrae.net
TC 9.12, Tall Buildings	Lindsey King	lindsey.claire.89@gmail.com	tc0912@ashrae.net
MTG.ACR – Air Change Rate	Dr Kishor K Khankari	kishork@ansight.com	none
MTG. BD – Building Dampness	Mr Lewis G Harriman, III	lewharriman@masongrant.	none
MTG.HWBE – Health and Wellness in the Built Environment	Ms Lan Chi Nguyen	LaNguye@lacitec.on.ca	none
MTG.OBB – Occupant Behavior in Buildings	Dr Tianzhen Hong	thong@lbl.gov	none
MTG.VIC – Ventilation for Infection Controls	Rick Hermans	herma015@umn.edu	none
GPC 23-2016 - Guideline for the Design and Application of Heating, V	Mr Rene Beaulieu	rene.beaulieu@comfortrail.	
GPC 28-2016, Air Quality Within Commercial Aircraft	Dr Catherine Thibaud	catherine.thibaud@airbus.	
GPC 29-2019 - Guideline for Risk Management of Public Health and S	no committee	no committee	
GPC 35P - Method for Determining the Energy Consumption Caused	Mr Geoffrey Crosby	gcrosby@lydall.com	
GPC 37P - Guidelines for the Application of Upper-Air (Upper Room)	Mr Richard Lee Vincent	richard.vincent@mountsinai.	
GPC 42P - Enhanced Indoor Air Quality in Commercial and Institution	Ms Jennifer A Isenbeck,	jisenbeck@ut.edu	
GPC 43P - Operations Guideline for Ventilation of Health Care Faciliti	Mr Michael P Sheerin	michael.sheerin@tlc-eng.	
GPC 44P - Protecting Building Occupants from Smoke During Wildfire	Mr Steven J Emmerich	steven.emmerich@nist.gov	
SSPC 52.2, Method of Testing General Ventilation Air Cleaning Device	Ms Kathleen Owen	kathleenowen@att.net	
SGPC 10-2016- Interactions Affecting the Achievement of Acceptable	Dr Mark C Jackson	mark.	
SSPC 55-2017, Thermal Environmental Conditions for Human Occupa	Mr David Heinzerling	dheinzerling@taylor-	
SSPC 62.1-2019, Ventilation and Acceptable Indoor Air Quality	Ms Jennifer A Isenbeck,	jisenbeck@ut.edu	
SSPC 62.2-2019, Ventilation and Acceptable Indoor Air Quality in Res	Dr Iain S Walker	iswalker@lbl.gov	
SSPC 145.1-2015 - Laboratory Test Method for Assessing the Perform	Mr Anthony M Abate	tabate@atmosair.com	
SSPC 145.2-2016, Laboratory Test Method for Assessing the Perform	Mr Anthony M Abate	tabate@atmosair.com	
SSPC 154-2016, Ventilation for Commercial Cooking Operations	Mr Fuoad A Parvin	fuoad.parvin@halton.com	
SSPC 160-2016 - Criteria for Moisture-Control Design Analysis in Buil	Dr Achilles N Karagiozis,	Achilles.Karagiozis@nrel.gov	
SSPC 161-2017, Air Quality Within Commercial Aircraft	Dr Catherine Thibaud	catherine.thibaud@airbus.	
SSPC 170-2017 , Ventilation of Health Care Facilities	Mr Michael P Sheerin	michael.sheerin@tlc-eng.	
SSPC 185.1-2020, Method of Testing UVC Lights for Use in Air	Mr Sam Guzman	sguzman@auvco.com	
SSPC 185.2-2020, Method of Testing Ultraviolet Lamps for Use in	Mr Dean A Saputa	dean.saputa@uvresources.	
SSPC 188 - Guideline 12-2020 – Managing the Risk of Legionellosis As	Mr Paul A Lindahl, Jr	paul.lindahl@spx.com	
SSPC 188-2018, Legionellosis: Risk Management for Building Water	Mr Paul A Lindahl, Jr	paul.lindahl@spx.com	
SSPC 189.1-2017, Standard for the Design of High-Performance	Mr Roger L Hedrick	rhedrick@noresco.com	
SSPC 189.3-2017, Design, Construction and Operation of	Mr Douglas D Fick PE	ddfick@gmail.com	

SPC 217-2020, Non-Emergency Ventilation in Enclosed Road, Rail	Dr Igor Y Maevski	igor.maevski@jacobs.com	
TC 2.6, Sound and Vibration	Karina Acosta	karinaa@aaon.com	
RAC			
ASHRAE Residential Committee	Mrs Patricia Graef,	pat.graef@att.net	none

Appendix B

Research Gap Reply for Built Environment Survey – Inside "ASHRAE" TCs

TC 9.6:

1. What are your team's expertise? For example, acoustic, lighting, thermal comfort, indoor air quality, air flow, plants, animals etc. Lighting, thermal comfort, indoor air quality, air flow

2. Any comments to the Built Environment Quality research strategies below?
"Environmental Quality (EQ)in Occupied Spaces and Impacts on Work and Learning, Health and Well-being, and Transmission of Airborne Infectious Viruses. Built environments include buildings, transport, and outdoor areas where people spend a substantial amount of time. EQ is characterized by thermal, acoustic, visual, and air quality conditions that shall comply with prescribed performance. Inadequate EQ has consequences for health, well-being, work, learning, and sleep. To ensure high EQ in the future, a paradigm change is needed: a current approach to characterize EQ by minimum requirements for a "typical" space and an "average" occupant shall be replaced by the efforts that strive to enhance EQ with individually optimized conditions, considering differences between various spaces and diversity in occupants' requirements and preferences. Research should support this change by developing solutions, best practice guidelines, assessment, diagnostic and EQ enhancement design tools, and economic models that can explicitly assign a monetary value to the benefits of enhanced EQ. While the primary focus should be on spaces occupied by people, the guidelines and standards should address spaces designed for different types of goods, animals, and plants."

   This reads well to me and is comprehensive.

3. What research gap are there in thermal, acoustic, visual, air quality, and others individually?

   Much of the existing research would need to be revisited as there's often gaps, oversights, and/or poor methods that make readers of the research complete logic leaps to apply the conclusions to real world applications.

   The academic community needs to demand real funding to do the work properly and ASHRAE needs to raise its publication standards to match. So much of the literature is of little/no scientific value.

   Furthermore, literature reviews like the one completed for ASHRAE 170 (RP CO-03) should be referenced to help identify current gaps. Most healthcare spaces have no research justifying air flow rates. For example, no one does their thesis on the right air change rates for janitor's closets.

   ASHRAE should be lobbying Congress to fund this work to the tune of $10-20M per year as that's what it's going to take. ASHRAE's $50k research grants barely scratch the surface.

4. What research gap are there when consider the interaction of thermal, acoustic, visual and air quality on each other?

   The biggest research gap in my opinion is how to weigh these aspects of EQ against one another to achieve an overall EQ score. During the ASHRAE 170 literature review the team found research of test subjects being exposed to high levels of CO2 while under optimal thermal conditions to assess comfort. Not that this is allowable per IRB's anymore, but an equivalent research needs to be done. There is an inherent link between these EQ factors that needs to be robustly developed. I'm aware of research at USC by Dr. JoonHo Choi in this area really quantifying light/glare and thermal comfort.

   I would coordinate these efforts with IESNA and ASHRAE's lighting committees to create a unified comfort model.

5. What research gap are there in considering how BEQ impacts health, well-being, work, learning, sleep and transmission of airborne infectious viruses?

   A method to weigh different BEQ values against one another and compile an overall individual EQ score. People aren't in a single room for 24 hours per day. A person may be in more than a dozen environments in a day and so is subject to an exposure time for each. This has come up in discussions about outpatient medical facilities and whether a patient that might only be in the building for an hour should receive equivalent air quality as an inpatient being exposed to the same conditions for 24 hours.

   Engineers need a lot more education on their own confirmation bias of the air being the dominant factor in well-being or disease transmission. Diet, exercise, genes, health, demographics, etc. all play a role. As we've seen during the COVID 19 pandemic many of the fatalities were a result of pre-existing conditions. Therefore, you can get radically different results between two people exposed to the same EQ factors because of factors that have nothing to do with EQ.

   In summary, a framework to combine these factors is needed, and some guidance on what is realistic to achieve. I would create something like a class A EQ rating, class B, etc. just like we rate office buildings. A guideline or a standard merging ASHRAE 55, 62.1, etc. would need to be considered as well.

6. What research gap are there in considering a "minimum requirements" for BEQ?

   First and foremost, a definition of minimum requirements needs to be established.

   Today we have standards for all EQ factors as silos, but those aren't followed strictly and even worse aren't maintained during the life of the building. Code officials aren't trained to fully understand them either.

   Simpler, evidence-based methods are needed by and large. Engineers with decades of experience still struggle with detailed ASHRAE 62 or 55 calculations. Tools to automate these processes are being developed, but like so many tools out there the quality is hit or miss. Certifications for those tools are needed, like ASHRAE standard 140, to ensure that the calculation methods are sound.

7. What research gap are there in considering the monetary impacts of the above factors?

Significant legal guidance is required to define the "standard of care" so that engineers and owners are protected legally from the building's occupants in case they get sick.

Otherwise owners may over or under invest and be at risk. There was a seminar presentation during the winter meeting asking the question if building owners could be sued for COVID 19 transmission. Given that this isn't the first airborne disease outbreak in the last 20 years (SARS-1, MERS, etc.) a court could likely find an owner and engineer negligent. The problem is we don't have the tools to rapidly do this work so it just doesn't get done.

8. Other research gap in Environmental Quality?

Evidence, evidence, and evidence. After working in this field for a decade and having participated in research projects I would say our industry has not advanced very far in the last 50 years. We have the technology today to collect data, process it, and answer a lot of questions. The resources just have not been provided.

<u>TC 2.6:</u>

Research Gap for Built Environment Survey

1. What are your team's expertise? For example, acoustic, lighting, thermal comfort, indoor air quality, air flow, plants, animals etc.

Acoustics

2. Any comments to the Built Environment Quality research strategies below?

"Environmental Quality (EQ)in Occupied Spaces and Impacts on Work and Learning, Health and Well-being, and Transmission of Airborne Infectious Viruses. Built environments include buildings, transport, and outdoor areas where people spend a substantial amount of time. EQ is characterized by thermal, acoustic, visual, and air quality conditions that shall comply with prescribed performance. Inadequate EQ has consequences for health, well-being, work, learning, and sleep. To ensure high EQ in the future, a paradigm change is needed: a current approach to characterize EQ by minimum requirements for a "typical" space and an "average" occupant shall be replaced by the efforts that strive to enhance EQ with individually optimized conditions, considering differences between various spaces and diversity in occupants' requirements and preferences. Research should support this change by developing solutions, best practice guidelines, assessment, diagnostic and EQ enhancement design tools, and economic models that can explicitly assign a monetary value to the benefits of enhanced EQ. While the primary focus should be on spaces occupied by people, the guidelines and standards should address spaces designed for different types of goods, animals, and plants."

Overall I like the statement. I would suggest rewording the first statement to be more of an action statement. For example: ***Environmental Quality (EQ) in occupied spaces impacts human health and well-being and requires research to ensure the built-environment is optimized for occupants.***

3. What research gap are there in thermal, acoustic, visual, air quality, and others individually?

The primary research gap in acoustics is the correlation between performance and human perception in the built-environment. While the acoustical design metrics are based on human perception, the application and refinement of these metrics and performance criteria has not been well correlated with user's experiences and other measures of health and well-being. Currently the acoustical industry only measures failure and rarely measures success. The industry does not have a clear understanding of the performance thresholds between poor – marginal – acceptable – effective – preferred – optimal both generally or on a room-by-room basis. This should include the impact of transient noises in the context of background sound for sleeping, living, and working environments. Some research has shown that average and maximum sound levels are not efficiently quantifying the effects of these noise impact occurrences. For context, acoustical research funding by the United States government ceased in 1981 and has never restarted. All acoustical performance research is completed by commercial groups like ASHRAE and individual groups (non-profit and for profit).

4. What research gap are there when consider the interaction of thermal, acoustic, visual and air quality on each other?

The overlap of these areas has not been well correlated, in general, each of these areas has been doing research in silos. Ideally a research project in a healthcare or office setting that gives the user control of these measures to adjust to their liking that could be repeated with a wide variety of people would define the inter-relation and correlation. In addition, it would define ranges of performance and the quality of that performance.

5. What research gap are there in considering how BEQ impacts health, well-being, work, learning, sleep and transmission of airborne infectious viruses?

In general, most of the BEQ metrics are simplified when correlated to health and well-being. I encourage research on both control and changes in time rather than averages, maximums, and minimums to better quantify these impacts. At least for acoustical design we believe that “control” and “changes” are leading to a high percentage of the impacts in the built-environment, but do not have enough research to quantity this relationship or metrics to design/evaluate these impacts.

6. What research gap are there in considering a "minimum requirements" for BEQ?

With respect to acoustics many of our minimum requirements assume constant noise or intrusion, but do not take into consideration the changes in time, amplitude, or frequency of events. Understanding this would likely help create more tangible “minimum requirements”.

7. What research gap are there in considering the monetary impacts of the above factors?

Most EQ measures are considered under first cost conditions and not tied to occupant satisfaction, productivity, health, or turn-over rates (apartments or commercial spaces). We know that 90% of the costs in the first 10 years for a commercial office space is the employee salary and benefits, but most financial decisions are based on first costs of construction and not the human impacts. It will be important to put numbers to these metrics and criteria to help developers and designers make more informed decisions.

8. Other research gap in Environmental Quality?

Appendix C

Research Gap Reply for Built Environment Survey – Inside "ASHRAE", Committees

Any comments to the **Built Environment Quality research strategies** below?
"Environmental Quality (EQ)in Occupied Spaces and Impacts on Work and Learning, Health and Well-being, and Transmission of Airborne Infectious Viruses. Built environments include buildings, transport, and outdoor areas where people spend a substantial amount of time. EQ is characterized by thermal, acoustic, visual, and air quality conditions that shall comply with prescribed performance. Inadequate EQ has consequences for health, well-being, work, learning, and sleep. To ensure high EQ in the future, a paradigm change is needed: a current approach to characterize EQ by minimum requirements for a "typical" space and an "average" occupant shall be replaced by the efforts that strive to enhance EQ with individually optimized conditions, considering differences between various spaces and diversity in occupants' requirements and preferences. Research should support this change by developing solutions, best practice guidelines, assessment, diagnostic and EQ enhancement design tools, and economic models that can explicitly assign a monetary value to the benefits of enhanced EQ. While the primary focus should be on spaces occupied by people, the guidelines and standards should address spaces designed for different types of goods, animals, and plants."

(TC 2.9): *EQ is characterized by thermal, acoustic, visual, and air quality conditions ^and surfaces that shall comply with prescribed performance.*
Environmental Quality (EQ) in Occupied Spaces and Impacts on Work and Learning, Health and Well-being, and Transmission of Airborne Infectious Viruses ^and pathogenic microorganisms.

R. Higa: The "diversity" in occupants' requirements need to include different age groups, mobility (handicapped), vision differences (near sighted, far sighted), air quality sensitivities, and others.

Add a "health assessment benefit" which may be linked to healthy circadian rhythms (better sleep, alertness, metabolic health), mental health (seasonal affective disorder, happiness index, relaxation, and many more). This probably has a monetary value, but more importantly a human health value.

M. Jouaneh:
Could be shortened. I am glad the "visual" conditions are mentioned as lighting quality is often forgotten about in IEQ. What is missing is access to daylight and views, and glare control. They don't fall into visual comfort. An example of EQ that should not be overlooked is minimizing solar glare (and solar heat gain) coming in from windows while still providing effective daylight and access to views.

***NBI**:*
Research should support this change by developing solutions, best practice guidelines, assessment, diagnostic and EQ enhancement design tools, and economic models that can explicitly assign a monetary value to the benefits of enhanced EQ. While the primary focus should be on spaces occupied by people, the guidelines and standards should address spaces designed for different types of goods, animals, and plants."

NBI encourages that BEQ economic and engineering research, and recommendations, address both costs and benefits, including the primary impact of increased energy use and energy expense, with the corresponding increase in GHG emissions. NBI supports fully addressing IEQ needs, but encourages solutions that have lower energy and GHG impacts, as IEQ solutions can have impacts on many facets of HVAC design and operation, including outdoor air intake, demand response, temperature and humidity control, and filtration media (and associated maintenance), Suggested wording:

Research should support this change by developing solutions, best practice guidelines, assessment, diagnostic and EQ enhancement design tools, and economic models that can explicitly assign a monetary value to the costs and benefits of enhanced EQ.

> **Erik Miller Klein:** *Overall I like the statement. I would suggest rewording the first statement to be more of an action statement. For example:* ***Environmental Quality (EQ) in occupied spaces impacts human health and well-being and requires research to ensure the built-environment is optimized for occupants.***

MTG. OBB:

[EA] ASHRAE Std 55 is moving toward approaches to dealing with individual occupants, or groups of occupants, rather than reference or average occupants. This is seen in more emphasis on personal comfort systems, and in evaluation of cooling by air movement.

[KD] I am glad there is increased focus on the variations amongst occupants within a group or between different occupant groups as well as recognition that professionals need more guidance to address these differences.

[BG] This is excellent. To achieve individually optimized conditions, I can see multiple practical implications on standards beyond 55; for example, 62.1 will need to address inefficiencies inherent in multiple-zone VAV AHU configuration (due to interzonal variations in occupancy and thermal loads) as well as Guideline 36 will need to address sequences of operation incorporating occupant-centric controls.

[TH] Reads great. "*prescribed performance*" for what? It needs to be specific. Comfortable EQ (e.g., indoor temperature and humidity conditions defined in ASHRAE standard 55) requirements are very different from survivable or habitable EQ conditions (e.g., LEED passive survivability criteria) that need to be maintained for human life under extreme weather conditions and/or power outages. This is a huge gap of research on BEQ for human thermal habitability especially for indoor built environments.

[FM] Nicely written and appropriately emphasizing "individually optimized conditions."

[MR] Agree with previous comments. I would maybe add a sentence that ties enhanced EQ to the growth in building sensor and control technologies. It may strengthen why a paradigm change is possible.

SSPC 52.2:

"Environmental Quality (EQ)in Occupied Spaces and Impacts on Work and Learning, Health and Well-being, and Transmission of Airborne Infectious Viruses. Built environments include buildings, transport, and outdoor areas where people spend a substantial amount of time. EQ is characterized by thermal, acoustic, visual, and air quality conditions that shall comply with prescribed performance. Inadequate EQ has consequences for health, well-being, work, learning, and sleep. To ensure high EQ in the future, a paradigm change is needed: a current approach to characterize EQ by minimum requirements for a "typical" space and an "average" occupant shall be replaced by the efforts that strive to enhance EQ with individually optimized conditions, considering differences between various spaces and diversity in occupants' requirements and preferences. Research should support this change by developing solutions, best practice guidelines, assessment, diagnostic and EQ enhancement design tools, and economic models that can explicitly assign a monetary value to the benefits of enhanced EQ. While the primary focus should be on spaces occupied by people, the guidelines and standards should address spaces designed for different types of goods, animals, and plants."

SSPC 55:

Moving away from "typical" and "average", and toward meeting "individual" environmental requirements is a laudable and needed shift in direction for ASHRAE. And it fits well with the direction Standard 55 has recently been taken with the addition of individualized comfort control options to the Standard. From the thermal comfort perspective, we are learning that the "one size fits all" approach has reached its limit in buildings and can never meet occupants' growing expectations for thermal comfort. This likely follows with the other EQ factors.

Note also that the ASHRAE PMP and Best Practices Guide cover some of what is in the statements above and is in the process of creating a new guideline committee, which would include top IEQ experts.

What **research gap** are there in thermal, acoustic, visual, air quality, and others individually?

(TC 2.9): K-values (inactivation rate constants) for surface and air various ultraviolet wavelengths
Upper air UV high ceilings, dosing strategies
Impacts of various air mixing approaches and UV effectiveness in conditioned spaces
Combined approaches/technologies- are there synergies the exist when GUV is combined with other approaches/technologies

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R. Higa:

a. ***Importance of access to quality exterior views on human health and well-being has minimal research. Daylighting has been promoted in terms of illuminance levels, minimizing glare and reducing electric lighting energy use … but what about the importance of quality views? The research question may be "How important are quality views to the outside in reducing stress, improving circadian rhythms, mental health, and improving cognitive performance?" There are existing European standards that define quality views which includes number of view layers (ground, vertical and sky), the distance to each layer, and the interior view size and distance from different user locations. Research in the effectiveness of these recommendations and outcome-based results is desperately needed.***
b. ***Air quality and thermal conditions as a function of the source of thermal energy for cooking requires more research. Gas cooking emits higher levels of indoor pollutants as well emitting more heat into the kitchen environment. Can higher ventilation rates and/or supply temperature adjustments mitigate these issues? Since the heat from gas flames are transferred radiantly as well as convectively, are higher ventilation rates sufficiently effective in providing additional worker comfort? To what extent can demand-controlled kitchen ventilation ("DCKV") address these issues? While DCKV has been proven to be effective for commercial kitchens, is there applicability for residential kitchens? How does the use of gas-less cooking (induction, microwave) change indoor pollution levels?***

M. Jouaneh: Need more research on access to views. Some believe views are just an amenity; but views are a fundamental human right. The same people said the same thing about access to daylight, but the research has shown access to daylight makes people happier, healthier, comfortable, and productive. It's the same for views.

NBI: There is a need for broader data on the Indoor air quality impacts of combustion equipment, such as natural gas ranges and water heaters,

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Erik Miller Klein:

The primary research gap in acoustics is the correlation between performance and human perception in the built-environment. While the acoustical design metrics are based on human perception, the application and refinement of these metrics and performance criteria has not been well correlated with user's experiences and other measures of health and well-being. Currently the acoustical industry only measures failure and rarely measures success. The industry does not have a clear understanding of the performance thresholds between poor – marginal – acceptable – effective – preferred – optimal both generally or on a room-by-room basis. This should include the impact of transient noises in the context of background sound for sleeping, living, and working environments. Some research has shown that average and maximum sound levels are not efficiently quantifying the effects of these noise impact occurrences. For context, acoustical research funding by the United States government ceased in 1981 and has never restarted. All acoustical performance research is completed by commercial groups like ASHRAE and individual groups (non-profit and for profit).

MTG. OBB:

[EA] I will describe what I think is the single largest opportunity for improving comfort and building energy efficiency in cooling; it applies worldwide at a scale that can impact climate change:
The use of indoor air movement (primarily ceiling and room fans) as an active and integral part of cooling systems is still in its infancy, compared with traditional HVAC methods involving control of temperature, humidity, and even radiant surfaces. The subject was long neglected, in part due to the computational complexity of fluid dynamics, out of scale for normal HVAC design. However, simplifications are possible that provide sufficient accuracy for typical building design purposes, and these needs to be incorporated in design tools, guidelines, etc. in wide use by the profession. Because solutions using air movement for cooling of individuals and groups are now available and built examples exist, even though designed with rule-of-thumb methods, that are providing higher levels of efficiency and comfort than buildings using traditional cooling methods.

[KD] I am always surprised that we do not provide design support relating to the comfort of children occupants. There is no information on heat given off by children to be used in cooling load calculations, no guidance on how height differences could affect radiant heating/cooling, visual comfort or the perception of air quality. The scope of TC9.7 even excludes educational facilities where young children are the dominant occupant group.

[BG] Our early research findings based on field data, in a Canadian COVID-response project, highlight significant issues with distribution effectiveness of fresh air in multiple-zone VAV AHU systems - particularly when too many different space types are combined under a single AHU. I think we need more research to update Standard 62.1 distribution effectiveness tables. In addition, we also need more research on occupant-centric ventilation strategies and on practical sequences of operation incorporating them in HVAC controls. Lastly, we need more research for fault diagnosis in AHUs (particularly to detect suboptimal behavior of mixing box dampers beyond stuck open/closed) and low-cost methods for outdoor airflow estimation. Most existing buildings don't have a way to measure outdoor airflow in service!

[TH] For thermal, comfortable conditions (temperature and humidity) need to be researched and specified considering occupant age, gender, health conditions (e.g., BMI), and culture (e.g., grow in an air-conditioning world or not at all), as well as differences between daytime (work or leisure) and nighttime (sleep). Thermal conditions for habitability or survivability need to be researched and developed. For indoor air quality, Standard 62 needs to account for increase of CO_2 in outdoor air (now 415ppm from before 380ppm), and ventilation air rate should consider outdoor contaminants such as PM2.5 especially during e.g., wildfire events that lead to strong air pollution.

[FM] The science of visual perception and blindness has not been given much attention.

[MR] Guidelines on how indoor IAQ requirements for new buildings can be readily adapted to existing buildings. Also, research on emerging air quality challenges driven by climate risk (wildfire smoke, mold growth in new geographic regions, etc.).

SSPC 52.2:

a. Filtration level vs recirculation vs energy consumption on a system which includes acoustics would be interesting. For example, can we turn more air (usually higher fan speed and volume) but use a lower performing filter or air cleaner.
b. Electronic/reactive air cleaners – more information is needed on what these devices remove and produce when used. We have standards in the works, and RTAR to help with one part of the question in the works to look at how to test in a chamber with a side duct including which parameters are important to specific in a test, but we also need information on what happens when there are multiple contaminants (COVID and VOCs, for example) and on how to test or predict the efficiency and byproducts for these units.
c. Related issue – determination of what will be considered acceptable levels of byproducts that an air cleaner can produce. We have this for ozone, but not for formaldehyde, particles, acetone, etc.
d. CFD on room mixing and placement of vents and in-room air cleaners
e. Use of non-UV for bioaerosol inactivation – we have a TC for UV/bio but not for other technologies that inactivate bioaerosol
f. Contaminant mixtures and their effects on air cleaner performance given our current tests look at single contaminants. This is not at all real and in the case of adsorptive technologies would not be accurate because of

competitive adsorption. So, while it is impossible to come up with a standard test that covers all possible situations, it may be possible to come up with a protocol to test a combination and then come up with some approximations, e.g. urban office air, or hospital air, etc. for more realistic test conditions. This would complicate the test procedures, sampling, etc., but could provide useful data because in the real-world particles, gas phase and biological are all interacting.

g. For air cleaners that function by causing particles to become charged or larger and, thus biological contaminants plate out on people and surfaces, does this increase or reduce disease transmission? Are the organisms likely to be dead or alive on the surfaces? How could this be measured?
h. We need a test standard for the removal of ultrafine particles (UFP). Research into how best to test or even the levels of efficacy that are common would help us design a useful standard.

SSPC 55:

In recent years, the basic engine of thermal comfort design, the PMV-PPD model has come under scrutiny for being unable to accurately predict conditions that will achieve thermal comfort for building occupants (Reference Stefano Schiavon et. all 2019 paper on this topic). If we are to encourage designers to achieve higher levels of thermal comfort in buildings – an important component of overall building EQ – we need to develop a better understanding of what conditions, including the needed variations in thermal conditions among individual building occupants, are required to do so. Well directed research could begin the needed task of rethinking not only the conditions, and localized variations in those conditions, needed to maintain a higher level of thermal satisfaction in buildings, but also to encourage and incentivize the use of technologies and approaches now or becoming available in our system designs to achieve such an outcome. We encourage research focused individualized thermal comfort satisfaction and variations in requirements among individual in place of the focus on average conditions for groups.

Thermal comfort and its impact on productivity - especially for the kind of knowledge based work that current workers are engaged in, not the typical tasks of typing etc.

Thermal comfort and chronic exposure - are we adapting to changing weather in any meaningful manner? Is chronic exposure to certain indoor environments, in our quest to keep away from outdoors, getting us unhealthier?

Indoor air quality - chronic and short term exposures at moderate levels of under ventilation and impact on health and performance (1000-2000 ppm CO2 concentration equivalent)

What **research gap** are there when consider the <u>interaction</u> of thermal, acoustic, visual and air quality on each other?

(TC 2.9): Hybrid LEDs used for illumination and purification
Environmental (thermal, RH, smog, VOCs) on GUV effectiveness, applications
Interactions between solutions in systems and solutions in the conditioned space

R. Higa:

c. *University of Oregon has research that shows that the air closer to windows has a higher air quality and fewer pathogens than air in non-daylighted areas. The interaction between daylight illumination and air quality should be researched.*
d. *There are several studies that suggest that better window views result in fewer environmental complaints for other environmental characteristics, or alternatively, tolerance of a wider range of conditions, in ventilation, acoustic, and thermal comfort. How strong are these interactive effects, and can they support a wider range of comfort conditions in buildings?*
e. *Daylight and access to views has proven to result in visual delight in previous research. There are associated thermal, energy savings, and other resulting benefits. How can these be benefits quantified from both an energy and cost perspective? Associated with the fenestration benefits, what are the incremental benefits if this fenestration can be opened to allow ventilation? There is an increase in building resiliency and potential energy savings, but what are the net benefits of openable fenestration? How can the benefits of openable fenestration be quantified in general, and on a building-by-building basis?*
f. *To what extent do window shading devices or attachments to fenestration technologies impact the visual and thermal performance of a building as well as occupant comfort, health, and productivity? How can we predict the behavior of occupants using manually adjustable devices (such as blinds and louvers)? How does manual operation compare to automatically controlled adjustable devices? What are the key factors that would enable us to better predict manual operation? Window orientation? Building or space type? Device type? Occupant characteristics? View quality? What are the impacts of interior versus exterior devices? Research on daylight re-directing devices has been done, but what further research is required to increase their application in buildings? If applicable, how can these devices and operations be incorporated into building energy and daylighting simulations?*
g. *As noted above for kitchen ventilation, ventilation is needed for both maintaining air quality as well as thermal comfort of workers. From previous research (Stoops et al. 2013), 60% of the data collected were outside the bounds of the comfort zone. What is the impact of worker productivity and health? Are their economic models that can inform updates to mechanical, energy, occupational codes? How is the choice of cooking fuels a factor?*

M. Jouaneh: There is an interaction between thermal and visual comfort that may counter each other. For instance, more lighting (or daylighting) may provide better visual comfort but may cause less thermal comfort by adding heat into the space. So, does the benefit of increased visual comfort outweigh the loss in thermal comfort? What is most concerning to me is that some will want to tradeoff EQ for energy efficiency, but efficiency should never diminish EQ as the fundamental reasons we build buildings is to keep people inside comfortable, happy, productive, healthier. There should be NO tradeoff of those benefits for increased efficiency.

Erik Miller Klein: *The overlap of these areas has not been well correlated, in general, each of these areas has been doing research in silos. Ideally a research project in a healthcare or office setting that gives the user control of these measures to adjust to their liking that could be repeated with a wide variety of people would define the inter-relation and correlation. In addition, it would define ranges of performance and the quality of that performance.*

MTG. OBB:

[EA] There are numerous interactions between air movement cooling and air quality. These occur at the level of the individual occupant (effects of body thermal plume; perception of air quality under air movement). Interactions also occur at room level (room air circulation and airborne transmission of infectious particles between occupants), and effects on thermal gradients and fresh air distribution in the occupied zone.

[TH] Survey and limited field study data demonstrated significant interactions between various aspects of BEQ for occupants. However, a robust study is needed to collect good data to provide a basis for quantifying and understanding such interactions, which should cover diverse occupants, building types, and climate zones. IEA EBC Annex 79 is conducting research activities on this topic.

[FM] How do mechanical systems affect conscious and unconscious vision, and in turn, information processing?

[MR] Solutions that prioritize redundancy and failsafe designs (such as thermal survivability during power outages). I think there is always room for more research to explore trade-offs between each topic.

SSPC 55:
The relationship between thermal comfort and the air quality has long been recognized, but very little is known about the degree to which one affects the other. Research into the interaction of these two critical components of building EQ would likely benefit the improvement in our ability to define the requirements for each of them.
How do we move towards better air quality without compromising thermal comfort needs?
Can I compensate for some parameters of BEQ by making improvements in others?

What research gap are there in considering how **BEQ impacts** health, well-being, work, learning, sleep and transmission of airborne infectious viruses?

(TC 2.9): Air mixing and UV effectiveness
^Viruses and pathogenic microorganisms
Sickness rates in facilities with and without GUV, any pathogenic microbes
Sick building syndrome (SBS) and microbial VOCs (MVOC) and how GUV impacts [look at CFR, TC 2.3 HB]
Well-being relation between claims and actual performance (various technologies)
Source control in microenvironments/room level, operating rooms, dental suites, etc.

R. Higa:

h. What is the role in daylighting illumination and window views with healthy circadian rhythms, improved metabolic health, reduced anxiety, higher satisfaction, productivity and contentment?
i. Which is the most important for EQ, daylighting quantity or quality views?
j. What type of views are most beneficial? What is an appropriate cadence of access to views during a workday? School day? In homes or health care?
k. How are current interior spaces designed in providing quality views to all?
l. What are the BEQ impacts of combustion appliances and equipment located in buildings or have un-combusted fuel and/or products of combustion that may enter a building? Several states and Canada have banned unvented heaters but combustion cooking is allowed with ventilation that is not necessarily operating when cooking. Recent studies have identified indoor air quality concerns from residential gas cooking. To the extent that there is still debate/controversy regarding this matter, it does point to the need for more research so that building occupants, especially children and elderly, are not harmed by poor BEQ.

M. Jouaneh: Probably more research on how better quality lighting, daylighting, and views impacts all these areas. I know IES is working on some of this research but that may be only for electric lighting and not daylight or views.

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***Erik Miller Klein**: In general, most of the BEQ metrics are simplified when correlated to health and well-being. I encourage research on both control and changes in time rather than averages, maximums, and minimums to better quantify these impacts. At least for acoustical design we believe that "control" and "changes" are leading to a high percentage of the impacts in the built-environment, but do not have enough research to quantity this relationship or metrics to design/evaluate these impacts.*

MTG. OBB:

[KD] We should expand research teams to be multidisciplinary as most of these issues need a diversity of perspectives so the message gets across not just to HVAC designers but also to medical staff and the political body. I see a lot of studies where health effects are analyzed with only a superficial understanding of air quality or work/learning are only analyzed from an air quality perspective without considering visual or thermal comfort.
[MW] There is very little quality data on the health impacts of environmental quality versus human productivity. I also agree with the comment above.
[TH] Second to MW and KD comments. Quantitative understanding of health impacts of occupants due to stretched indoor EQ conditions are particularly limited or missing. For example, how long can an occupant (different age, gender etc.) survive in a high temperature (86 to 100F) environment? What health damage may be if an occupant has to stay in a cold or hot indoor environment for say from 1 day to 1 week?
[FM] More emphasis should be placed on reducing individual stress throughout a full day.
[MR]Expanded multidisciplinary studies (between public health and building scientists) that measure the positive health outcomes from enhanced building environments. It's an ongoing research area, but more data to back anecdotal findings can further justify the use of healthcare spending on mitigation strategies within the built environment.

SSPC 52.2:
CFD to model use of in-room air cleaners and vent placement will help predict the dose reduction for infectious agents due to air cleaning

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SSPC 55:
Work to date seems to show that if air quality is adequate, the most significant environmental factor in determining the level of an individual's work performance in commercial buildings is their perceived level of thermal comfort. But there is not a consensus as to how much performance suffers (or benefits) from comfort control. We do know that the numbers are likely to translate into significant monetary value which would make a greater emphasis on comfort (and overall BEQ attractive) to commercial building clients. Research directed to attain general agreement on the value of improved comfort (and other BEQ factors) would be most helpful to the industry.
One, we need to establish a more straightforward chain of evidence showing how important BEQ is for health.
Two, we need to consider more studies that deal with everyday situations rather than extremes in the environment.
Three, it would be interesting to see if comfort, wellbeing, and productivity have the same needs or could they be different?

What **research gap** are there in considering a "minimum requirements" for BEQ?

(TC 2.9): Minimum standards for microbe inactivation for different applications (industrial, commercial, residential, duct, upper air, etc.), like recommended doses for coils or surfaces

IAQP coverage for GUV applications
Safety and commissioning GUV systems

R. Higa

a. *The types of "minimum requirements" need to be separately identified. For example, some of the requirements should be put into building, mechanical, electrical, plumbing, and energy codes and standards as either mandatory or prescriptive requirements with a performance approach for compliance (including ASHRAE Standards 55, 62.1, 62.2, 90.1, 90.2, 189.1, etc.). A subset of these codes and standards are those that need to be written in code-enforceable language as since authorities having jurisdiction will be required to enforce these requirements. Some requirements may be identified as "standard practice" and can be included in ASHRAE Handbooks. Other requirements may also be requirements for "green building" or "advanced design" documents that include ASHRAE Standard 189.1, Advanced Energy Design Guides, etc.*
b. *Specific research should be done to determine what minimum requirements for daylighting and access to views are required for new buildings, particularly in energy efficiency standards. In the same way that energy codes and standards include minimum ventilation requirements, and thermal requirements, there should also be an inclusion of minimum mandatory or prescriptive requirements for daylighting and access to views.*
c. *Minimum quality exterior views including layers (ground, vertical, sky), distance to each layer, and interior view access size and distance.*
d. *Importance of personal daylight glare controls (up/down adjustable shades).*
e. *Specific research should be undertaken to determine whether, and under what conditions, should combustion appliances and equipment be banned from buildings. As noted above, there are short-term comfort, health, and safety concerns associated with these devices. However, with ASHRAE's ongoing move towards decarbonization, more research is needed to justify, quantify, and require full electrification of buildings.*

M. Jouaneh: Same as answer as above.

Erik Miller Klein: *With respect to acoustics many of our minimum requirements assume constant noise or intrusion, but do not take into consideration the changes in time, amplitude, or frequency of events. Understanding this would likely help create more tangible "minimum requirements".*

MTG. OBB:

[TH] "minimum requirements" for BEQ can be individual dependent. As commented above, these requirements need to consider diverse occupants of diverse conditions, daytime vs nighttime, comfortable vs survivable/habitable needs.

[FM] Like international, national, state and local building codes, minimum BEQ standards will not adequately address biological psychology.

[MR] Establishing passive survivability standards that can be developed to fit into building codes.

R**esearch gap** are there in considering the <u>monetary impacts</u> of the above factors?

(TC 2.9): Beneficial impacts- coil efficiency when kept clean, reduced lost workdays, infection rates (medical and tourism), utility rebates, food and water safety, horticulture, increased ACH (Beggs paper*),
Cost benefits of use vs. not used

R. Higa:

f. *Research has shown that there is higher productivity when people have quality exterior views. Also, reduction in pain medications and other outcomes in health care settings has also been* *demonstrated. But, the research did not result in recommendations for the built environment. Quantifying this research and developing evidence-based recommendations is needed.*

g. *Currently, better views equate to higher real estate costs (penthouse view is more expensive than a street view) and higher hospitality costs (ocean view is more expensive than parking lot view) as examples. If views are that important in real estate, how can those monetary benefits transfer into BEQ?*

M. Jouaneh: There is a huge research gap on monetizing the factors above. The non-energy benefits are hard to monetize. I know IES and other organizations such as the CEA (CA Energy Alliance) are working on how we monetize these non-energy benefits.

NBI: Measurement and tracking of the direct equipment, operational and maintenance costs, and energy use, for HVAC systems that can deliver minimum IEQ environments.

Erik Miller Klein:

Most EQ measures are considered under first cost conditions and not tied to occupant satisfaction, productivity, health, or turn-over rates (apartments or commercial spaces). We know that 90% of the costs in the first 10 years for a commercial office space is the employee salary and benefits, but most financial decisions are based on first costs of construction and not the human impacts. It will be important to put numbers to these metrics and criteria to help developers and designers make more informed decisions.

MTG. OBB:

[MW] A few studies have tried to evaluate the monetary impacts but the data quality gaps provided wide ranges in the monetary impacts. In addition, little has been done to evaluate the resilience of building environmental quality associated with those monetary impacts.

[TH] Second to MW's comments. A much larger scale study is needed.

[FM] Costs associated with reduced workplace productivity and increased healthcare services is not documented, particularly in terms of return on investment (ROI).

[MR] As mentioned above, studies that demonstrate the health savings (doctor visits, productivity loss) from BEQ interventions.

SSPC 52.2: Influence of pressure drop changes due to air filtration/air cleaning on energy consumption. Could also include saving due to cleaner air and/or less flu or other disease transmission.

SSPC 55:
A large-scale study providing the tangible benefits of good BEQ through the health and wellbeing impacts.

Other **research gap** in Environmental Quality?

(TC 2.9): k-values measured the same way for human contagions and the simulants that get used for them
Modern (newer than 2003) data on UV inactivation for systems that are currently for sale

R. Higa

h. Interior furniture and partition arrangements to allow for quality view access for all removing any discrimination … "Daylight and views for all"

i. ***Multiple "work" locations to allow people to move to different areas within a building for best views, acoustics, daylighting, electric personalized lighting, thermal comfort, fresh air and flexible furniture depending on the task or relaxation they are doing. With enough variety of environmental conditions, it should be possible to observe what natural trade-offs people make between various characteristics.***

M. Jouaneh: More research is need to show that EQ is a human right not to be argued about based on energy savings or carbon reductions!

MTG. OBB:

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[TH] To address above comments on EQ criteria for extreme environments, a significant research gap is new data collection and experimental design methods. It is not feasible to put humans in extreme cold or hot environments to collect data. If robotics technologies (e.g., near-human manikins) continue to advance, robots can be used in future for such experiments to collect data we need. ASHRAE can also collaborate with NIH and IESNA on BEQ research and standards development.

[FM] Short term short term health & wellbeing should be measured separately from long chronic diseases.

SSPC 52.2:

m. Filling out the evidence base for many of the requirements spelled out in many of our standards, most are either anecdotal, common practice, or from one off data. e.g., CFM/person guidelines for different spaces, MERV 8 now going towards MERV 13 without evidence…. As the global brain trust in these things, ASHRAE should compile a list of all these first and begin sponsoring research to fill in the evidence needed.

n. Improved communication of ideal airflow geared towards contaminant control v. thermal mixing. HVAC systems are typically designed for thermal mixing in a room and how does this differ if it were to be designed for contaminant control (if this information exists, it needs improved communication)

*https://www.researchgate.net/publication/349748894_A_psychrometric_model_to_assess_the_biological_decay_of_the_SARS-CoV-2_virus_in_aerosols

Appendix D

ASHRAE Shaping Tomorrow's Built Environment Today

MINUTES (DRAFT)
ASHRAE Internal Research Gap Discussion
March 31, 2021

PRESENT:

Luke Leung, EHC Vice-Chair
Traci Hanegan (TC 9.6)
Erich Binder (TC __)
John Carter (TC 4.3)
David Heinzerling (SSPC 55)
Steve Emmerich (GPC 44)
LanChi Weekes (MTG.HWBE)

INVITED BUT NOT PRESENT:

Marianne Touchie (TC 2.1)
Morgan Hayes (TC 2.2)
Sanjeev K Hingorani (TC 2.3)
Zied Driss (TC 2.4)
Karina Acosta (TC 2.6)
Bill Stafford (TC 2.8)
Kyle Hasenkox (TC 9.7)

Scott Campbell (TC __)
Henry Griest (TC __)
Pat Graef (RBC)
Rick Hermans (MTG.VIC)
Don LeBlanc (TC __)
Jennifer Isenbeck (SSPC 62.1)
Mark Jackson (GPC 10)
Iain Walker (SSPC 62.2)

ASHRAE STAFF:
Steve Hammerling

1. **Team introduction**
   Luke Leung convened meeting at 1 PM EDT, welcomed all and thanked them for attending. Attendees introduced themselves and their expertise. Participants had been asked ahead of this meeting to fill out the research gap survey. Responses send ahead of the meeting are included as **Attachment A**. The agenda for today would review the questions asked in the survey for further input and discussion.

2. **Any comments to the Built Environment Quality research strategies below?**
   "Environmental Quality (EQ)in Occupied Spaces and Impacts on Work and Learning, Health and Well-being, and Transmission of Airborne Infectious Viruses. Built environments include buildings, transport, and outdoor areas where people spend a substantial amount of time. EQ is characterized by thermal, acoustic, visual, and air quality conditions that shall comply with prescribed performance. Inadequate EQ has consequences for health, well-being, work, learning, and sleep. To ensure high EQ in the future, a paradigm change is needed: a current approach to characterize EQ by minimum requirements for a "typical" space and an "average" occupant shall be replaced by the efforts that strive to enhance EQ with individually optimized conditions, considering differences between various spaces and diversity in occupants' requirements and preferences. Research should support this change by developing solutions, best practice guidelines, assessment, diagnostic and EQ enhancement design tools, and economic models that can explicitly assign a monetary value to the benefits of enhanced EQ. While the primary focus should be on spaces occupied by people, the guidelines and standards should address spaces designed for different types of goods, animals, and plants."

   The following feedback was recorded:

- Typical person requirements vs. minimum.
- Goods, animals, plants.
- *NOTE: comments submitted earlier are collected and in summary doc. Will be distributed soon.*
- Is problem framed properly? Can ASHRAE do this research?
- Lighting is not listed here.
- JI – IEQ research is ongoing. Don't have definitive variables. ventilation effectiveness,
- LeBlanc. Vent rates, thermal comfort in transportation.
- Binder. Humidity so high in industrial spaces, it affects visibility. Issues unique to process spaces.
- Define terms. Minimum? (lack of sickness or gross discomfort or OK, well, etc.)
- EB – even airflow through airflow rates. 6-12 ACH min. may be there in spots but rest of building stagnant. Even airflow is critical.
- JI – what is effective for various occupants (goods, people, animals etc.?)
- DH – personal requirements vs. minimums. Std 55 moving away from minimums and conditioning for specific occupants

- LL – is ventilation one size fits all? Can we have design rates for susceptible populations?
- SE – young, elderly, with conditions (sick), operations under pandemic conditions, wildfire smoke, hot temps, etc.
- SCampbell – short term occupancy conditions (hurricanes, etc.) days to weeks, what acceptable in short term conditions vs. normal operation. What's acceptable in temporary housing? This is a topic to be researched.
- What about outdoor facilities? Comfort stds in this environment? – is this in ASHRAE's scope? Is this built environment? OSHA covers workers, working outside. Alternate accommodations (due to pandemic, other) for example stadiums being dorms, etc.
- DL – noted this work has not been done and is a research gap. (Looked at comfort curves in various applications/audiences/etc.) Also, North America seems to be treated homogenously while differences in NA are quite large. Local climate zones and seasonality should be specified and comfort curves developed for various applications/designs.
- Acoustics, Lights, vibration – do we have people at table for this sort of effort? Vibration big issue in transportation. Industrial considers noise, vibration as well. Consensus there was expertise within ASHRAE on these issues.
- Lighting, circadian rhythm, glare, etc. Guideline 10, Transportation handle these issues.
- Indoor/outdoor microbial – do we know enough about these in indoor environments? 'MSDS' sheets on microbial in buildings/environments. Noted some info is known but these are constantly changing.
- How to quantify all this in fiscal terms. What are research gap here? How much do we know?
  - Historically in transportation, tend to look at cheapest first cost vs. life cycle. However, things are changing to getting most cost-effective life. There's still gap here on how to quantify.
  - Fiscal benefit of increasing OA ventilation. Does this increase health, performance, minimize sick days – what's known here? There has been a good deal of research here but it can be tricky accounting for all variables. Doesn't seem to be standardized format. How solid is the existing research?
- Do we have information on building operations and health? Lacking data in this area. Privacy concerns about health reporting. We don't have to report on health like we do for energy.
- If UN notes breathing clear air is a right, shouldn't we have to report or confirm. Noted if air is not clean and it is reported as not clean this becomes a liability, so this is a deterrent, even disincentive.
- What parameters to measure good IAQ. Are devices repeatable, cost effective, etc. to be used in buildings, to be desired by building owners/operators.
- Aircraft doing some things like this. Issue here is same as it would be in buildings - what is good IAQ? Transient nature issue as well for transportation
- Hermans: what is a comfortable space? (inside 55 comfort envelopes or something else)
  what is healthy air?
- SE noted EHC spent time trying to define healthy air (unsuccessfully). RH suggested specialty conference to explore, invite experts, make conclusions.
- LL should ASHRAE vent standards be based on bioeffluents as they are now? Or health?
- JI – move to health based ventilation? Outside experts on 62.1, in ASHRAE to help develop health based ventilation.
- Research gap – comparing various healthy air definitions. Choose a method for deciding how to define healthy air. Research? Coming together to discuss and choose a way? This baseline seems to be necessary – defining a metric.

Note: the other questions on the survey were not addressed specifically here but much of input above would be applicable.

3. **Adjournment**
   Meeting adjourned at just after 2 PM EDT.

Appendix E

The List of "External Experts" from Environmental Health Committee

Outside Organizations	Contact	Email	Comments
Allergy and Asthma Networks (AAN)	Don Bukstein, MD, Mary	[redacted]	
American Respiratory Care Foundation (ARCF)	Could not find any expert	[redacted]	
American Lung Association (ALA)	Rabih I. Bechara	[redacted]	invited 3/4. reminder sent 3/11
American Association for Respiratory Care (AARC)	Could not find any expert	[redacted]	
Asthma and Allergy Foundation of America (AAFA)		[redacted]	
American Academy of Allergy, Asthma and Immunology (AAAAI)		[redacted]	
American College of Allergy, Asthma and Immunology (ACAAI)	Jill Poole, MD, Maureen G	[redacted]	invited Dr. Poole 3/4. reminder se
American Public Health Association Asthma and allergy (AAAAI)	Georges Benjamin	[redacted]	Declined to participate
Illinois Institue of Technology	Brent Stephens	[redacted]	Declined to participate
LBNL	William Fisk	[redacted]	Bill is retired from LBL
University of Hong Kong	Yuguo Li	[redacted]	ACCEPTED 3/4
University of California at Berkeley	Jovan Pantelic	[redacted]	invited 3/4. reminder sent 3/11
University of California at Berkeley	Gail Brager	[redacted]	
University of California at Berkeley	Stefano Schiavon	[redacted]	Declined to participate
Unviersity of Colorado	Jose Jimenez	[redacted]	ACCEPTED 3/5
University of Oregon	Kevin G. Van Den Wymele	[redacted]	ACCEPTED 3/11
Univerity of Toronto	Jeffery Siegel	[redacted]	ACCEPTED 3/4
University of California at Berkeley	Gail Brager	[redacted]	ACCEPTED 3/12
Virginia Tech	Linsey Marr	[redacted]	Declined to participate
Acoustic Society of America	Could not find any expert	[redacted]	
Pennylvania State University	Michelle Vigeant	[redacted]	ACCEPTED 3/15
The International Institute of Acoustics and Vibration	Could not find any expert	[redacted]	
IES		[redacted]	
International Commission on Illumination		[redacted]	
America's Health Insurance Plans (AHIP)	Could not find any expert	[redacted]	
American Academy of Pediatrics (AAP)	Richard J. Jackson	[redacted]	invited 3/4. reminder sent 3/11. a
Association of Clinicians for the Underserved	N/A no "built environment	[redacted]	
Architects (AIA-COTE)	Stephen Katz stephen_ka	[redacted]	ACCEPTED 3/9 (recommended by
Boston Public Health Commission (BPHC Colorado School of Public	Jon Samet	[redacted]	EMailed 3/4. bad email address
APIC	Monika Pogorzelska	[redacted]	Declined to participate
CDC	Claressa Lucas	[redacted]	Declined to participate
Environmental law institute	N/A no "built environment	[redacted]	forwarded to Ms. Tobie Bernstein
EPA	thomas armitage	[redacted]	invited 3/4. reminder sent 3/11
Geological Society of America	Malcolm Siegel, Laura Rul	[redacted]	Declined to participate
GSA	Kevin Powell	[redacted]	invited 3/4. reminder sent 3/11
Harvard School of Public Health	Joseph Allen	[redacted]	invited 3/4. reminder sent 3/11
Harvard Business School	John Macomber	[redacted]	
International Federation of Interior Architects/Designer	Denise A. Guerin, Ph.D.	[redacted]	Declined but recommended Care
Behavioral sciences (APA)	Ezra Markowitz,	[redacted]	Ezra declined but recommended
Behavioral sciences (APA)	John Fraser	[redacted]	ACCEPTED 3/11
Behavioral sciences (APA)	Krystal Pollitt	[redacted]	ACCEPTED 3/11
Illinois Institue of Technology	Brent Stephens	[redacted]	Declined to participate
Interior design (ASID)	David C. Euscher	[redacted]	ACCEPTED 3/4
Interior design (ASID)	Caroline Compton	[redacted]	ACCEPTED 3/12
Institute of Environmental Sciences and Technology (IEST, USA)	Wei Sun	[redacted]	ACCEPTED 3/4
International Union of Architects (UIA)	Zhipeng Lu	[redacted]	ACCEPTED 3/10
International WELL Building Institute		[redacted]	
Johns Hopkins University	Sabra Klein	[redacted]	invited 3/4. reminder sent 3/11
National Center for Biomedical Research and Training	Jamechia Hoyle	[redacted]	ACCEPTED 3/11
National Environmental Balancing Bureau (NEBB, USA)	Wei Sun	[redacted]	ACCEPTED 3/4
NIOSH - CDC	Claressa Lucas	[redacted]	Declined to participate
NIST	Andy Persily	[redacted]	ACCEPTED 3/5
NIH	Farhad Memarzadeh	[redacted]	ACCEPTED 3/4
Public Health Institute	Gina Solomon, Paul Englis	[redacted]	invited 3/4. reminder sent 3/16
The National Academies	Greg Symmes	[redacted]	Declined to participate

Appendix F

Research Gap Reply for the Built Environment Survey – Outside "Expert Panel"

Research Gaps for Built Environment Survey

1. Any comments to the Built Environment Quality research strategies below?

*"Built Environmental Quality (BEQ)in Occupied Spaces and Impacts on Work and Learning, Health and Well-being, and Transmission of Airborne Infectious **Agents**. Built environments include buildings, transport, **semi outdoors, alfresco, or, building exterior** areas where people spend a substantial amount of time. BEQ is characterized by thermal, acoustic, visual, and air quality conditions that shall comply with prescribed performance. Inadequate BEQ has consequences for health, well-being, work, learning, and sleep, social interactions and enjoyment. To ensure high BEQ in the future, a paradigm change is needed: a current approach to characterize BEQ by minimum requirements for a "typical" space and an "average" occupant shall be replaced by the efforts that strive to enhance BEQ with individually optimized conditions, considering differences between various spaces and diversity in occupants' requirements and preferences. Research should support this change by developing solutions, best practice guidelines, assessment, diagnostic and BEQ enhancement design tools, and economic models that can explicitly assign a monetary value to the benefits of enhanced BEQ. While the primary focus should be on spaces occupied by people, the guidelines and standards should address spaces designed for different types of goods, animals, and plants."*

2. What research gaps are there in terms of a healthy built environment?

- What is healthy ventilation?
- What is a healthy environment?
- Should a healthy environment be one size fits all?
- The importance of environmental variation and health?
- The impact of nature in indoor environment
- Strategies to reduce the emergence and persistence of antimicrobial resistance
- Strategies to reduce the survival and spread of airborne and other respiratory viruses
- Exploring ways to optimize immune health and stimulation in the BE
- Identification of optimal visual experience - which links to mental health (green spaces) - not new, but often overlooked
- Quantification tools for assessing health impacts of interventions.
    - Non invasive skin patches to test for hormone and immune markers.
    - Personal air samplers?
    - Noise trackers
    - Antigen assays
    - Etc.
- Quantified models for particle transport and volatile chemical distribution.
- Addressing individual diversities
    - Technological innovations including a continuum of control/actuation options

Jack Gilbert
10:11 PM Apr 14
I would also like to add emergence and persistence of antimicrobial resistance in bacteria.

Kwok Wai Tham
10:01 AM Apr 15
Replace: "Viruses" with "Agents"

Kwok Wai Tham
10:04 AM Apr 15
Agents enlarge the considerations to include bacteria and other organisms

Kwok Wai Tham
10:15 AM Apr 15
Add: ", social interactions and enjoyment"

Kwok Wai Tham
10:21 AM Apr 15
people congregate for social and entertainment/recreational purposes as well. The consideration of disease transmission is highly relevant given the COVID (and future pandemic) challenges.

Gail Brager
7:23 PM Apr 9
This is the key statement here. Moving from reducing the negative to enhancing the positive; from uniformity to spatial variability; from the average person to individual preferences

Kwok Wai Tham
10:33 AM Apr 15

- Addressing individual diversities
  - Technological innovations including a continuum of control/actuation options
  - Behavioural empowerment
- Holistic Impact of BEQ dimensions (thermal, acoustic, visual, air quality, and others (eg biophilia) on humans
  - Account for interactions
  - Wellbeing / health
  - Affective
  - Cognitive
- Coupling sensing, AI, control and environmental innovations with humans to achieve individually optimized conditions
- How can we achieve healthy AND net zero build environments?

Kwok Wai Tham
10:33 AM Apr 15

I strongly endorse Gail's comments. This ups the challenge and pushes innovation to the forefront. Addressing diversity potentially enables a breakthrough beyond the current 80% satisfaction threshold of acceptability.

Jack Gilbert
10:16 PM Apr 14

We need to work on what we mean by 'individually' optimized. IF the goal is improved experience AND wellbeing. Then we need to work on what we mean by wellbeing, and there are many research gaps there.

Kwok Wai Tham
10:34 AM Apr 15

While I concede to this accommodation, I feel that humans is the main focus of the program.

Gail Brager
7:26 PM Apr 9

I think it's important that the committee doesn't think they need to start from scratch. There have been other efforts,
Show more

Kwok Wai Tham
11:11 AM Apr 15

A "Tech-scan" would be informative. We can then identify the challenges that makes a difference to existing knowledge/solutions in alignment with our agreed objective(s)

Luke Leung
8:25 AM Apr 15

Add: *"The importance of environmental variation and health? The impact of nature in indoor enviroment"*

Appendix G

Research Gap for the Built Environment – Outside "Expert Panel" Meeting Minutes

MINUTES (DRAFT)
ASHRAE Built Environment Quality Expert Panel
April 15, 2021

MEMBERS PRESENT:
Luke Leung, EHC Vice-Chair
Suyeon Bae
William Bahnfleth
Gail Brager
David Euscher
Jack Gilbert
Jose Jimenez
Stephen Katz
Tham Kwok Wai
Josephine Lau
Yuguo Li
Zhipeng Lu
Krystal Pollitt
Wei Sun
Kevin Van Den Wymelenberg
Michelle Vigeant

MEMBERS NOT PRESENT:
Catriona Brady
Caroline Compton
John Fraser
Sara Hammerschmidt
Jamechia Hoyle
Farhad Memarzadeh
Andy Persily
Doreen Robinson
Jeffery Siegel

ASHRAE STAFF:
Steve Hammerling

4. **Team introduction**
Luke Leung welcomed all in attendance and thanked them for attending. Members in attendance introduced themselves and described their interest and expertise in this area.

5. **Research Gap**
Luke referred to the google document titled "Research Gaps for Built Environment". All panel members were asked to review and comment. Please request access to edit if you are not able to. (Users were asked to please select the "Suggesting" option when editing to help distinguish the authors.)

The latest version of the document is **Attachment A**. The current version can be accessed at https://docs.google.com/document/d/1NO1F-ajv2KBGkC2Be37Ns8XPZHtR5Tx49OH900pTS_0/edit.

Several attendees made comments on the document during the meeting:

- Developing health, protecting health, restoring health

- Cautioned against trying to cover everything (goods, animals, people)
- Focus on airborne infectious agent's aerosols. Suggested surface also
- Include urban outdoor environments. Built environment = very large, broad. indoor environment includes surface.
- Developers pushing outdoor terraces. Sunny indoor/outdoor spaces
- Outdoor built environment and outdoor (natural) environments. More nuanced definition of outdoor environment may be helpful.
- Whose jurisdiction is outdoor environment. Advocates if business being provided, they should provide minimum exposure. Areas with human activities should be considered.
- 1. Opportunity for ASHRAE to lead on topic of risk in indoor environment. Notion that we may need standards for low and high risk scenarios. Not one size fits all. Sometimes choices/risk can drive IEQ vs. Energy
  2. Focus on health outcomes and seeking measurable health outcomes, pathways to different types of structures
- "The term built environment refers to the human-made surroundings that provide the setting for human activity, ranging in scale from buildings and parks or green space to neighborhoods and cities that can often include their supporting infrastructure, such as water supply or energy networks."www.sciencedirect.com/science/article/pii/B9780081005460000170" (Bahnfleth)
- Differences in Singapore vs the US hospitals. Does one size fit all when such different things done (Kwok Wai)
- Human right to good air? Ecology and biodiversity balance and human rights
- IEQ stretching into mental/physical health. Exposure, stimuli.
- Addition on standard person, standard response. Diversity in humans. Limiting to 80% satisfaction. Suggested looking at higher threshold.
- Health as not as absence of disease but in more positive ways (social interactions/ enjoyment)
- Environmental health embraces lighting, acoustics, etc. Should we make Guideline 10 available to this group. Identifies many health. Asked staff to see if we can change this.
- Subliminal interactions? There are elements beyond senses that can impact biomarkers.
- Interactions important from youth, development, to adult. Chronic and momentary build up.
- There is a need and an opportunity to reframe the conversation on environmental health to be more inclusive and holistic - factors we have long considered as comfort factors, are also health factors, and we would optimize them differently for health than we would for comfort
  -balance and synergies of prioritizing health and energy reduction…Health + Climate
  -transform codes and standards from minimally acceptable to recommended… and I think these may change by moments of lower risk and moments of higher risk

All panel members were asked to review and add more comments. Feel free to add value, please communicate to group, send email, etc.

It was suggested EHC have a similar effort to review and discuss at future meeting. Bahnfleth noted this may be a topic for a future EHC seminar.

6. Expert Panel Output

Members inquired as to possible outputs from this panel – what can they produce as a deliverable? Ideas included a seminar, blog, white paper, and other ideas.

Leung created a document to list potential activities of the expert panel. Members were asked to edit the document (see https://docs.google.com/document/d/1-zZbXy-p-hVN3Z5BZYQkZLybCT2b5fvxgW_10wB9AM0/edit).

7. Adjournment

The meeting was adjourned at just after 10 PM EDT.

[i] https://www.betterindoors.com/wp-content/uploads/2020/03/CIBSE_TM40_WEBINAR.pdf
[ii] https://science.sciencemag.org/content/372/6543/689
[iii] https://www.sciencedirect.com/science/article/abs/pii/S0196655307008000

ASHRAE Leadership Presentation

Rick Hermans
May 26, 2021
TAC Virtual

1

ASHRAE Policies

Code of Ethics

"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 interest."

Sexual Harassment

ASHRAE is committed to educating members to eliminate all instances of sexual harassment. The Society will deploy an online training program for volunteers to help educate and protect all members, and to sustain the professional environment members deserve and expect. This training will be required prior to serving on certain standing committees and/or in leadership positions.
ashrae.org/about/governance/ashrae-discrimination-and-harassment-policy

Commercialism

ASHRAE's Commercialism Policy allows for Society activities that fulfill the mission of technological advancement with adherence to business plans that generate income to offset operational expenses such as AHR Exposition, ASHRAE periodicals, website, and Society conference events such as the Welcome Party, luncheons, registration kits, and receptions.
ashrae.org/commercialism

View ASHRAE Governing Documents at ashrae.org/about/governance

2

Memoranda of Understanding (MOUs)

Chartered Institution of Building Services Engineers (CIBSE)
December 2020

U.S. Department of Homeland Security Science and Technology Directorate
February 2021

Kuwait Foundation for the Advancement of Sciences (KFAS)
November 2020

National Air Filtration Association
March 2021

Federation of European Heating, Ventilation and Air Conditioning Associations
May 2020

National Association of State Energy Officials (NASEO)
November 2020

United Nations Environment Programme
April 2021

International Ultraviolet Association
May 2021

Learn more at ashrae.org/mous

3

Financial Impact of COVID-19

- The pandemic economy and loss of the AHR Expo income has strained ASHRAE's budget significantly.
- Membership levels have been impacted but are down less than predicted at the start of SY 2020-21.
- **ASHRAE secured two Payroll Protection Program loans** to help offset some of the losses from operational income. We have applied for loan forgiveness and hope to hear a resolution very soon.
- Staff expenses have been reduced, including the downsizing staff from 120 to 110 FTE.
- Volunteer and staff travel expenses have been reduced significantly, reflecting pandemic travel restrictions.

Member Assistance

Due to the financial impact of the COVID-19 pandemic members have experienced, ASHRAE is **not increasing member dues** for the 2020-2021 Society Year.

MCO 3.15 Hardship Cases and Natural Disaster Relief Action. 3.15.1 Hardship Cases

Members Council is responsible for determining what constitutes a hardship case and providing guidance to staff for determination of special consideration with respect to dues and other member benefits. Issues not covered by this guidance shall be ruled on by the chair of Members Council in consultation with staff. For more information, contact **membership@ashrae.org.**

4

Diversity, Equity, & Inclusion (DEI) in ASHRAE

BOD Subcommittee created by the Board January 2021

Purpose of the BOD DEI Subcommittee:

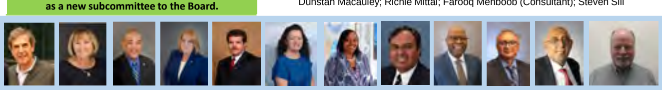
To advise and engage the Board of Directors on:

- All matters relating to diversity, equity and inclusion - with a view to improving organizational awareness and performance in these areas amongst both staff and the Society membership
- The establishment of annual budgets for DEI program and ongoing initiatives
- The prioritization of inclusivity issues which have relevance to ASHRAE, together with plans for addressing these issues

Download the Report
ashrae.org/DiversityEquityInclusion

The BOD DEI Subcommittee was recently approved as a new subcommittee to the Board.

Members of the BOD DEI Subcommittee
Andres Sepulveda (Chair); Adrienne Thomle (Vice Chair); Devin Abellon; Robin Bryant; Art Giesler; Eileen Jensen; Kishor Khankari; Tanisha Meyers-Lisle Dunstan Macauley; Richie Mittal; Farooq Mehboob (Consultant); Steven Sill



5

Society Transformation Ad Hoc

Goals of Transformation

- Free the BOD and ExCom for strategic activities
- Remove waste/operating cost
- De-silo ASHRAE and speed decision making
- Push decision-making lower in the organization
- Be market focused
- Expand and amplify our relevance

6

Task Force for Building Decarbonization & Vision 2030

Goal of TFBD

To develop technical resources and provide leadership and guidance in mitigating the negative carbon impact of buildings on the environment and the inhabitants of our planet.

Don Colliver, co-chair	Tom Phoenix, co-chair
Don Brandt	Bing Liu
Luke Leung	Tim McGinn
Dru Crawley	Bill McQuade
Francesca d 'Ambrosio	Dan Nall
Lance Davis	Kent Peterson
Katherine Hammack	Terry Townsend
Ginger Scoggins	

More information coming soon

Goal of Vision 2030

To lead, serve, and provide all professionals in the buildings industry with the resources and knowledge to continually drive the innovative and strategic improvements needed during the revolution of the built environment.

Sheila Hayter, chair	Tom Phoenix, vice chair
Bruce Branscum	Tim McGinn
Robin Bryant	Francis Mills
Jayson Bursill	Dan Nall
Michael Cooper	Lan Chi Nguyen Weekes
Dru Crawley	Joe Norowratzky
Chris Gray	Drew Perrin
William MacGowan	Chandra Sekhar
Manish Sharma	Jiri Skopek

7

Nominations Needed!

Committee Nominations

- Due mid-February. Council, RAC, TAC, Standards and Handbook nominations are due mid-September.
- Speak with your committee ExO if your current appointment ends in June and you wish to be nominated for another committee.

ashrae.org/committee-nominations

Honors & Awards Nominations

ASHRAE's awards fall into one of six categories:

- Personal Honors
- Personal Awards for General & Specific Society Activities
- Paper Awards
- Society Awards to Groups or Chapters
- Chapter and Regional Awards

ashrae.org/honorsandawards

Learn about ASHRAE Technical Committees (TCs) at ashrae.org/communities

8

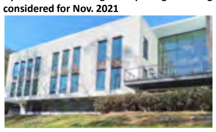
New Global Headquarters

180 Technology Parkway NW
Peachtree Corners, GA 30092

ASHRAE has officially moved into a renovated **66,700 ft² building**, originally built in 1978.

Over $10.3M in monetary and in-kind support was received from generous stakeholders to support this renovation project.

Options for a formal grand opening are being considered for Nov. 2021



PV system design is underway with installation to be completed soon to drive NZE performance.

See the video tour, photos, building technical features and our generous sponsors at ashrae.org/newhq

9

Epidemic Task Force (ETF)

Continues to provide COVID-19 related resources, making ASHRAE a trusted source of critical guidance during the pandemic.

ashrae.org/covid19 averages more than 40,000 views per month!

Clickable infograph for easy navigation, FAQ's and free resources

ashrae.org/covid19

10

Bylaws Update

Proposed Bylaws change, to be voted on Spring 2021: Change title of 'Member' grade to "Full Member"

ASHRAE Bylaws
Section 2.1 Grades of Membership.
These shall be designated as follows:
(A) Honorary Member,
(B) Presidential Members,
(C) Fellow,
(D) Life Member,
(E) Life Associate Member,
(F) **Full** Member,
(G) Associate Member,
(H) Affiliate Member, and
(I) Student Member.

'Member' grade refers to individuals who have provided necessary education and professional background information to the Society in order to advance from Associate to Member grade.

This proposed Bylaws change would update the title of 'Member' to **'Full Member'.**

ashrae.org/about/governance

11

Membership & Communities

Your Benefits ashrae.org/membership

New Member Benefit Selection Society Year 2021-22

Full Dues paying Members and Associate Members will be able to select from the following complimentary annual member benefits starting SY 2021-22:

- ✓ ASHRAE eLearning Course
- ✓ ASHRAE Standard (PDF)
- ✓ ASHRAE Handbook (PDF)

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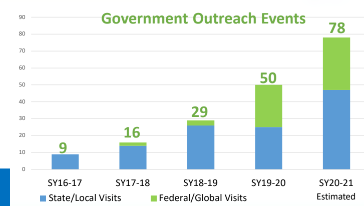

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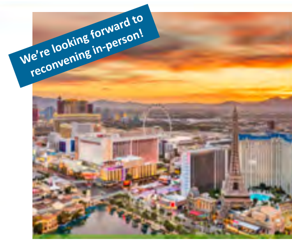

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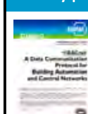

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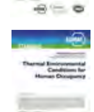

Standard 55-2020
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Standard 90.1 User's Manual
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ASHRAE Position Document on Limiting Indoor Mold and Dampness in Buildings

Approved by ASHRAE Board of Directors
June 27, 2012

Reaffirmed by ASHRAE Technology Council
June 27, 2018

Expires
June 27, 2021

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COMMITTEE ROSTER

The ASHRAE Position Document on Limiting Indoor Mold and Dampness in Buildings was developed by the Society's Limiting Indoor Mold and Dampness in Buildings Position Document Committee formed on December 14, 2010.

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ABSTRACT

Credible research and cognizant health authorities have established an association between health problems and indoor dampness. A building's mechanical systems, its exterior enclosure, and its occupant activities all affect the amount of wetting and drying indoors. Therefore, ASHRAE takes the position that all policymakers, regulatory authorities, building professionals, and building occupants should be aware that indoor dampness, mold, and microbial growth are warnings of potential problems. All concerned should make decisions and take actions that help buildings, their contents, and their systems stay as dry as possible, given their functions. This position document provides help in understanding some of the complex interactions and decisions that lead to indoor dampness. However, professionals and the public need to know, with greater certainty than at present, when a building is "dry enough" to avoid dampness-related health risks. ASHRAE recommends further health-related building research to develop and publish a practical, quantitative, and effective definition and measurement technique for whole-building dampness.

HISTORY OF REVISION/REAFFIRMATION/WITHDRAWAL DATES

The following summarizes the revision, reaffirmation, or withdrawal dates:

2/6/2005—BOD approves Position Document titled *Minimizing Indoor Mold Problems through Management of Moisture in Building Systems*

10/22/2010—BOD approves revised Position Document titled *Limiting Indoor Mold Growth and Managing Moisture in Building Systems*

6/27/2012—BOD approves revised Position Document titled *Limiting Indoor Mold and Dampness in Buildings*

1/29/2013—Technology Council approves reaffirmation (with minor editorial updates) of Position Document titled *Limiting Indoor Mold and Dampness in Buildings*

1/27/2016—Technology Council approves reaffirmation (with no changes) of Position Document titled *Limiting Indoor Mold and Dampness in Buildings*

6/27/2018—Technology Council approves reaffirmation (with no changes) of Position Document titled *Limiting Indoor Mold and Dampness in Buildings*

Note: ASHRAE's Technology Council and the cognizant committee recommend revision, reaffirmation, or withdrawal every 30 months.

Note: ASHRAE position documents are approved by the Board of Directors and express the views of the Society on a specific issue. The purpose of these documents is to provide objective, authoritative background information to persons interested in issues within ASHRAE's expertise, particularly in areas where such information will be helpful in drafting sound public policy. A related purpose is also to serve as an educational tool clarifying ASHRAE's position for its members and professionals, in general, advancing the arts and sciences of HVAC&R.

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EXECUTIVE SUMMARY

In many parts of the world, moisture damage and microbial growth including mold have caused billions of dollars in repair costs and interruption of building operations. Further, in both North America and Europe, building dampness and mold have been documented to be associated with adverse health outcomes related to asthma and upper respiratory problems.

As moisture levels increase, so does the possibility of microbial growth and with it the potential for adverse effects on the building and its occupants. The buildup of moisture indoors can be controlled through the building's design, construction, and operation and the actions of its occupants.

ASHRAE is a cognizant technical authority in the field of HVAC system design, installation, and operation, as well as building energy conservation. All of these factors can influence the amount of moisture in buildings. Consequently, those who develop and enforce public policy within the building industry often rely upon ASHRAE standards and guidance. Therefore, it is appropriate for ASHRAE to make clear the Society's positions with respect to managing moisture, avoiding persistent dampness, and reducing the risks associated with indoor microbial growth.

ASHRAE currently takes the following positions:

1. When humidity and moisture are not effectively controlled, persistent dampness can lead to material damage, corrosion, structural decay, and microbial growth, including mold. Cognizant health authorities have established an association between damp buildings and the increased potential for adverse health effects (IOM 2004, WHO 2009, New York State 2010, Mudarri and Fisk 2007, Fisk et al. 2007, Mendell 2011). ASHRAE believes that the potential for these problems can and should be reduced by limiting the buildup of indoor moisture through the decisions and actions taken by designers, contractors, owners, and occupants of buildings.
2. Small amounts of wetting and drying in buildings and in HVAC systems are normal and represent no long-term risk for durability, increased energy consumption, or mold growth. Occasional wetting is not usually a problem provided that wetting is followed promptly by drying. Problems occur when the dampness becomes persistent. To limit the potential for problems, professionals and the general public should be aware there are risks associated with prolonged dampness and should take action to prevent and correct such conditions.
3. Currently, no quantitative, health-based exposure guideline or thresholds can be recommended for acceptable levels of contamination by microorganisms (IOM 2004). While associations between persistent dampness and adverse health effects have been observed, relationships between persistent dampness, microbial exposure, and health effects cannot be quantified precisely at this time (WHO 2009, Mendell 2011). In light of this information, ASHRAE believes the most effective course is to limit the potential for microbial growth indoors by reducing the causes of persistent dampness.

1. ISSUES

The six issues addressed by this position document are summarized below. The inherent complexities of these issues are described in more depth in the appendix.

1.1 Health

Negative health effects have been credibly established as being associated with dampness in buildings. But to date the exact causes and the exact extent of such problems has not been defined. As an engineering society rather than a cognizant health authority, ASHRAE expects and follows guidance from health professionals with respect to the health effects of indoor dampness, mold, and microbial growth.

1.2 Damp Building Definition and the Need for Its Improvement

According to public health researchers, problems in the past have been associated with the occurrence of visible water damage or stains, visible mold, and/or odors from microbial growth (WHO 2009; Mendell et al. 2011). The presence of these factors—alone or in combination—is therefore useful as a warning and as a call for action to remediate the source of the water accumulation. However, the presence of these three factors, even in combination, allows neither certainty nor practical quantification concerning health-relevant dampness.

Consequently, ASHRAE recommends further health-related building research. The goal should be to develop and publish a quantitative definition of a “damp building,” together with an economically practical measurement technique. To be useful in the real world of building design, construction and operation, such a definition and measurement technique must allow determination (with reasonable and repeatable certainty) of a building that is “dry enough” to avoid dampness-related health risks.

1.3 Negative Effects of Moisture Other than Microbial Growth

Quite apart from health effects, there are other important reasons to avoid excessive indoor moisture accumulation. The appendix to this position document outlines some of the non-health-related negative effects of moisture on buildings.

1.4 Complex Causation

Based on past observation of problem buildings, dampness sufficient to cause problems seldom has a single cause. More often, a series of events, including decisions in many areas of professional and personal responsibility, combine in complex ways to cause a problem. Therefore, it is not appropriate to assign responsibility for building dryness to any one group, because it is not likely that any one group can prevent a problematic level of dampness, mold, and microbial growth by their actions alone.

1.5 Decisions and Actions that Avoid Problems

There are known and avoidable contributors to moisture, mold, and microbial growth problems in all areas of professional and personal responsibility (HVAC, architectural design and construction, building operation and maintenance, building occupant’s actions, and the actions of policymakers and regulatory authorities). The appendix provides useful detail about decisions and actions that have increased or reduced risks.

1.6 Investigation and Remediation of Mold and Microbial Growth Problems

ASHRAE provides neither guidance nor professional certification in this area but notes that other cognizant authorities have established useful guidelines for mold investigations and remediation. Some cautions for investigators and building owners about investigations are included in the appendix to this document.

2. BACKGROUND

Well-designed, well-constructed, well-maintained building envelopes are critical to the prevention and control of excess moisture and microbial growth, because they limit thermal bridges and the entry of liquid water, humid air, or water vapor diffusion. Management of moisture also requires control of temperature and ventilation to avoid excess humidity, condensation on surfaces, or excess moisture in materials.

Building owners are responsible for providing a healthy workplace or living environment without excess moisture and mold by ensuring proper building design, construction, and maintenance. To the extent that they are allowed control, building occupants are responsible for managing the use of water, heating, air conditioning, ventilation, and appliances in a manner that does not contribute to dampness and mold growth.

To help reduce the potential for problems, ASHRAE provides the observations, suggestions, and resources described in the appendix to this position document and makes the following recommendations.

3. RECOMMENDATIONS

a. All building professionals, building occupants, public policymakers, and regulators should understand that persistent indoor dampness is neither normal nor desirable and can lead to problems for both the occupants and the building itself. All concerned should take action to design, construct, and keep buildings and their systems as dry as possible, given their normal functions.

b. To more effectively inform the professions and the public, ASHRAE technical committees should generate a new chapter for the ASHRAE Handbook consolidating known problems and describing known techniques for managing and measuring moisture in buildings and for avoiding problems associated with indoor dampness. In addition, ASHRAE technical committees should strengthen guidance provided in other chapters of the ASHRAE Handbook with respect to minimizing the risk of excessive moisture accumulation in buildings and HVAC systems.

c. ASHRAE should establish a joint research project in cooperation with cognizant health authorities, related professional societies, and building owners to develop and publish a practical, quantitative, and certain definition and inspection protocol for whole-building dampness. Both the professions and the public need to know when a building is “dry enough” to reduce dampness-related health risks.

d. ASHRAE should remain committed to continue updating the more than 3000 pages of ASHRAE resources described in the reference sections of this document on a regular basis, through volunteer and partner-supported efforts.

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APPENDIX

COMMITTEE OBSERVATIONS CONCERNING MOLD AND MOISTURE PROBLEMSIN BUILDINGS

HEALTH

ASHRAE's expertise lies in the areas of design, installation, operation, and maintenance of mechanical systems and in the hygrothermal performance of building enclosures. These systems do not guarantee human health, which is a result of complex interactions between building systems; outdoor air change rates; air contaminant concentrations; emissions of air contaminants from building materials, furnishings, and equipment; as well as occupant activities and individual susceptibilities. Consequently, for all opinions related to the health impacts of exposure to microbial contaminants (including mold), ASHRAE relies on the expertise of the medical community. ASHRAE's review and analyses of the literature has led to the following observations:

a. When buildings get wet or damp and stay damp for a long enough period of time, microbial growth on building materials and furnishings can occur, including growth of molds, other fungi, and bacteria. This microbial growth can result in significant increases of indoor concentrations of airborne microbial contaminants, including mold spores and mycelia fragments, bacterial spores and cell fragments, mycotoxins, and microbial volatile organic compounds (Park et al. 2008, Cox-Ganser et al. 2005).
b. The medical community has long recognized that in agricultural occupational settings, worker exposures to very high concentrations of microbial air contaminants, including mold spores and bacteria, can cause adverse health effects, including asthma, bronchitis, rhinitis, mucous membrane irritation, allergic alveolitis (hypersensitivity pneumonitis), and inhalation fever (Hodgson and Flannigan 2001, Sorenson 2001).
c. The medical community has also long recognized that in health care settings, especially in immuno-compromised patients, exposure to even relatively low levels of pathogenic fungi such as *Aspergillus fumigatus* can cause severe invasive respiratory disease and death. In these settings, the buildings' HVAC systems must be carefully designed, installed, and operated to significantly reduce exposure (ASHRAE 2008).
d. The precise nature of health effects in buildings with moisture problems and their relationships to types and levels of microbial air and surface contaminants, including mold spores, is not fully understood. However, in the U.S., the Institute of Medicine (2004) concluded in *Damp Indoor Spaces and Health* that while there was not at that time sufficient evidence of a causal relationship between health outcomes and exposure to mold or other agents in damp buildings, there was sufficient evidence of an association between damp buildings and upper respiratory tract symptoms, asthma symptoms in sensitized asthmatic persons, hypersensitivity pneumonitis in susceptible persons, wheezing, and coughing. In the years since that report, other credible sources have reached similar conclusions (WHO 2009, New York State 2010, Mendell et al. 2011).
e. According to public health researchers, problems in the past have been associated with the occurrence of any of three factors: visible water damage or stains, visible mold, and odors from microbial growth (WHO 2009; Mendell et al. 2011). The absence of any of these three factors does not rule out the potential for a problem, nor does their presence

indicate the certainty of one. But when any of these three factors are present, the research suggests that building owners and occupants should be aware of the potential for health-related problems and take steps to investigate and eliminate the causes of excessive moisture accumulation.

The implication of these observations by cognizant health authorities and public health researchers is that the prudent course for owners, designers, builders, installers, and operators of all buildings and HVAC systems is to make decisions and take actions that limit the potential for long-term accumulation of excess moisture in building materials and systems.

DAMP BUILDING DEFINITION AND THE NEED FOR ITS IMPROVEMENT

For many years, public health researchers have observed that health problems are more common in “damp buildings” (IOM 2004, WHO 2005, Cox-Ganser 2005, etc.).

Further, for decades the mechanisms of mold growth in buildings have been clear, and computerized mold growth models have been well correlated with laboratory experimental results (ASHRAE 2009a, Viitanen 1997, Rowan et al. 1999, Pasenen et al. 2000, and Sedlbauer et al. 2001). Recently, public health researchers (WHO 2009; Mendell et al. 2011) have noted that negative health effects among occupants have been more commonly reported when a building exhibits evidence of excessive moisture, such as:

- Visual evidence of water damage or water stains
- Visible mold growth
- Moldy or earthy odors

While these research results are helpful, they are not sufficient. They provide no actionable definition of a “damp building.” And they provide no quantitative definition of how many water stains, how much visible mold growth, or what strength of musty odors are sufficient to suggest that action is required to avoid negative health effects. Many buildings have one or more of these problems, in small amounts, in different parts of the building, without any recognized negative health effects. It is only by aggregating many buildings that health studies have documented the consistent, significant associations of these problems with respiratory and allergic effects. However, the studies have not identified threshold amounts of one or more of these problems that merit action.

To be useful for those who intend to prevent problems in buildings and investigate them when they do occur, a definition of a damp building likely to produce negative health effects needs to include:

a. Discreet threshold levels of concern for the moisture content of building materials that have been frequently observed to be either sensitive to mold growth and/or that serve as reservoirs of moisture that transfers to nearby sensitive materials.
b. A material moisture content measurement technology, sampling procedure, and inspection methodology that is sufficient (in the real world of large buildings and complex building assemblies) to repeatably and economically identify at least three levels of health concern for the general population: low, medium, and high probability of negative health effects among a randomly-selected population.
c. Health concern adjustment factors for important segments of the general population that are known to have elevated sensitivity to health effects of damp buildings including (at

least) infants and the elderly, asthmatics, and individuals with compromised immune systems.

d. An empirical foundation for the definition and protocol that includes a correlation of the protocol results with observed negative health effects in real-world buildings and real-world populations.
e. Documented tests using a random selection of building owners and building investigators that demonstrate that the protocol is relevant, repeatable, and economical enough for general use.

ASHRAE does not have the expertise to lead such a research effort, but our technical and standing committees can and must be a part of the research to help ensure that the resulting protocol is relevant, repeatable, and economical enough for everyday use by both building investigators and building owners.

NEGATIVE EFFECTS OF MOISTURE OTHER THAN MICROBIAL GROWTH

Long-term moisture accumulation has documented negative consequences quite apart from mold growth or any potential health risks of damp buildings. Measurable effects of excess moisture accumulation and/or episodic water damage include the following:

a. Shortening the life of materials, structural fasteners, and building assemblies, which increases structural risk and leads to excess maintenance, repair, and renovation costs (Harriman et al. 2006).
b. Reducing the effectiveness of insulation, leading to increased energy consumption.
c. Reducing the perceived value of a property and increasing the cost of its insurance coverage.
d. Reducing occupant satisfaction because of unpleasant odors and musty smells.

Based on these observations, ASHRAE believes that the prudent course for designers, installers, builders, owners, operators, and occupants of buildings and building systems is to make decisions and take actions that limit the potential for long-term accumulation of excess indoor moisture. Keeping buildings dry reduces the risk of problems with respect to their value, durability, sustainability, indoor air quality, occupant comfort, and energy efficiency.

COMPLEX CAUSATION

Mold spores and mycelial fragments can be found in the air and on surfaces of nearly all buildings, but prolific mold growth is not. Airborne mold contaminants, including mold spores and hyphal fragments, are constantly present in outdoor air in concentrations that vary widely by season, location, and even time of day. In all buildings, airborne mold contaminants in outdoor air enter the building through the ventilation system, through open windows, and through air leaks in the building envelope. In clean, dry buildings, the indoor concentration of airborne mold contaminants is typically less than the outdoor concentration. In contrast, in buildings that become damp enough to support mold growth, the indoor concentrations of airborne mold contaminants can become much higher than the outdoor concentrations. In addition to differing concentrations, the types of microbial contaminants in buildings that become damp may be different from those typically present outdoors and in dry buildings.

ASHRAE observes that microbial growth, including mold and bacteria, does not occur without an accumulation of excessive amounts of moisture for a sufficient amount of time, within an adequate temperature range and in a material or surface coating that is microbially digestible (ASHRAE 2009a).

Factors that allow all of these preconditions to persist for long enough to create a microbial growth problem are highly complex. Surface treatments, moisture content, duration of excessive moisture, and material temperature can vary widely over a distance of a few inches or centimeters, leading to microbial growth in one small portion of a given material and the absence of microbial growth in nearby parts of the same material (Harriman and Lstiburek 2009).

Also, a material that is not microbially digestible, such as concrete or masonry, may act as a reservoir for excess moisture. That moisture can then transfer over time to more digestible materials nearby, such as paint layers or untreated paper-faced gypsum board. In addition, dust, dirt, and oils commonly accumulate on materials, creating an organic layer that can support microbial growth if the near-surface air layer is sufficiently humid for long periods. For example, the residual soap film on floors, bathtubs, and showers is an organic layer that can support microbial growth when it is damp, even though the ceramic tile surface itself does not support mold growth.

Further, the interactions that lead to the necessary amount and duration of moisture accumulation are similarly complex. One example of the interactions between different building elements that combine to result in moisture accumulation includes vinyl wallpaper on the indoor surfaces of exterior walls in combination with an air-conditioned space in a hot, humid climate. Outdoor air with a high dew point infiltrates the wall and condenses on the cavity side of the cool interior gypsum wallboard. Because the vinyl wallpaper is relatively impervious to water vapor transport, moisture accumulates in the wall cavity, resulting in microbial growth, including mold, and eventually decay and rot.

Note that the growth in this situation requires high outdoor dew point for many days or weeks, extensive air leakage through the enclosure, chilled indoor surfaces, vinyl wallpaper, and untreated paper-faced gypsum board. If any one of those elements is absent, it is quite possible that little or no mold growth would occur (Harriman et al. 2006). This example includes the following elements:

a. The owner or interior designer made a decision to install vinyl wall covering rather than a more permeable wall covering.
b. The architectural designer apparently designed and/or the contractor built a building that allows extensive inward humid air infiltration and also selected untreated gypsum wallboard for a location likely to experience high humidity in a climate where that high humidity will continue for many months.
c. The HVAC system is apparently designed and/or installed such that it overcools wall surfaces, and it is designed and installed (or operated) such that it encourages humid air infiltration and a high surface relative humidity (RH) inside the wall for extended periods.

As the example illustrates, risks from not one but several decisions made by many different professionals can act in combination to produce enough moisture accumulation in the wall cavities for a long enough period to create a microbial growth problem. Rarely can one profession, acting in isolation, take all the actions that either produce or prevent a moisture problem. Preventing moisture problems requires attention from the owner as well as all of the building professions.

Further, the risk of excess moisture accumulation can be either increased or reduced by the building occupants themselves as they use the building for their daily activities. For instance, if the occupants of an apartment generate a significant amount of moisture from cooking and cleaning activities without opening windows or using exhaust fans, excess moisture accumulation and mold growth may occur. A building is a complex and dynamic system, and its occupants are an integral and constantly changing component of that system.

Finally, individuals in the same building may be quite different with respect to their particular sensitivities to airborne microbial contaminants. A low level of contamination that causes adverse health effects for one sensitive individual often causes no health effects for others. Because of the complexity of these interactions, from a public policy perspective it would be ineffective and inappropriate to assign sole responsibility for microbial growth avoidance to any single group.

The prudent course of action is to keep all of the materials that make up a building and its HVAC systems as dry as possible, consistent with their normal functions. More specifics are discussed in Section A5. In general terms, all building professionals and occupants should be advised to do the following:

a. Remain aware that the factors that lead to microbial contamination, including mold, are catastrophic water damage, repeated wetting, or excessive long-term moisture accumulation in materials.
b. Make decisions and take actions that will keep the building and its systems, furnishings, and finishes as dry as possible, given the function of the component in question and the available resources.
c. Be aware that, if adequate resources are not made available to keep the building, its systems, and contents dry, then the risk of microbial contamination, including mold, will increase.
d. Keep the above facts in mind whenever one observes persistent dampness inside a building or when one constantly observes stagnant water in condensate drain pans or constantly damp insulation, filters, or sound lining of HVAC systems.

KNOWN FACTORS THAT INCREASE OR REDUCE THE RISK OF MOLD AND MOISTURE PROBLEMS

In each area of professional and occupant activity, there are decisions and actions that can either increase or reduce the risk of problems related to moisture, mold, and other microbial growth. In most cases, the individuals involved are not aware they are making fateful decisions. The factors described below come from the broad array of building professionals' experiences, many of which have been collected in ASHRAE publications and in the publications of allied professional societies.

When reviewing these factors, it is important to keep in mind that moisture and mold problems can develop for different reasons in cold and hot climates and can also occur through mechanisms caused by regionally specific building designs, material selections, and construction practices in different parts of the world. Therefore, recommendations based on local conditions are often needed to avoid dampness-related problems.

Note also that these factors have seldom been responsible, in isolation, for moisture and microbial growth problems. More commonly, the risk of microbial growth has increased when more than one of these factors are present or when an architectural risk factor is combined with risk factors associated with either HVAC systems or occupant activities.

a. HVAC factors that have been observed to ***reduce*** the risks of moisture accumulation, mold, and microbial growth include the following:
   1. Ensuring that all ventilation air is dried to a dew point below the dew point maintained inside the building when the building is being mechanically cooled (Harriman and Lstiburek 2009, Harriman et al. 2006).
   2. Ensuring that all condensation inside HVAC components and air distribution ductwork is drained to an appropriate sanitary drain or condensate collection system (Harriman et al. 2006).
   3. Ensuring that indoor surfaces of both occupied and unoccupied spaces are not cooled to temperatures so low as to create an average surface RH of over 80% that lasts for more than 30 days or surfaces cold enough to allow visible condensation (ASHRAE 2009a).

      Note that the relative humidity of air measured in the occupied space or return air does not indicate the RH in the thin boundary layer of air in contact with cool surfaces. Monitoring and controlling indoor dew point compared to indoor surface temperatures is the more useful metric for humidity control decisions.

      For example, in buildings that are being mechanically cooled during hot or humid weather, keeping the indoor air dew point below 55°F (12.8°C) nearly always ensures that surface RH will stay below 80% even on cool surfaces. In contrast, if the indoor air RH is 55% at 78°F (25.6°C), any surface cooled below 66°F (18.9°C) will have an RH above 80% (Harriman and Lstiburek 2009).
   4. Keeping the indoor dew point low enough to ensure that there is no condensation on the exposed surfaces of cool HVAC components or on sensitive building materials or furnishings. Nor should the indoor dew point be high enough to allow any surface RH over 80% when averaged over 30 days. The caution against condensation and long-term average surface RH above 80% applies not only to visible surfaces in occupied spaces but also to surfaces inside hidden building cavities and unconditioned spaces (Harriman et al. 2006).
   5. Ensuring that humidifiers are sized, installed, and controlled so they do not overload the air with humidity, which increases the risk of condensation inside air distribution systems and exterior walls and roofing assemblies (Harriman et al. 2006).
   6. Ensuring that cold HVAC and plumbing components and systems such as chilled-water pipes and valves, supply air ducts, cold domestic water lines, and cold condensate drain piping are sufficiently insulated to keep the temperature of all of their surfaces at least 10°F (4°C) above the dew point of the surrounding air. Note that pipes often pass through unconditioned spaces such as basements, crawlspaces, and attics. Insulation must be continuous and complete to limit high surface RH on a cold pipe as it passes through such high-dew-point locations (Harriman and Lstiburek 2009).
b. HVAC factors that have been observed to ***increase*** the risks of moisture accumulation include:
   1. Failing to keep the indoor dew point low enough to prevent condensation indoors or failing to keep surface RH below 80% in occupied spaces or inside hidden building assemblies (Harriman and Lstiburek 2009).

2. Overchilling a building's surfaces during humid weather (Harriman and Lstiburek 2009).
3. Redistributing microbial air contaminants, including mold, from a contaminated space into occupied areas. Examples of contaminated spaces sometimes include parts of the building under construction or renovation, hidden building assemblies such as damp crawlspaces or attics, or spaces above dropped ceilings or below raised floors (Harriman and Lstiburek 2009).
4. Failing to make air distribution components and joints in return plenums and supply and exhaust ducts sufficiently airtight. Joints and connections must be tight enough to prevent suction that otherwise pulls humid outdoor air into the building and/or leakage that allows cold supply air to chill surfaces inside humid building cavities (Harriman and Lstiburek 2009, Harriman et al. 2006).
5. Failing to keep the long-term average indoor air pressure positive with respect to the outdoors when the outdoor dew point is higher than indoor surface temperatures (Harriman et al. 2006).
6. Failing to prevent dirt and dust accumulation on cooling coils and on duct surfaces and sound lining downstream of cooling coils. This can lead to microbial growth in the damp layer of dust that collects inside the cooling system. Installing access panels that allow for the inspection and cleaning of the condensate pans and areas upstream and downstream of cooling coils is an important requirement for ensuring the condensate pan is not ponding water, the coils are clean, and the upstream and downstream surfaces are clean and dry. Regular cleaning and ultraviolet lamps can reduce the impact of occasional lapses in filtration. But over time, effective filtration is the most important factor in preventing microbial growth in those parts of the system that can be expected to accumulate moisture during normal operation.
7. Failing to keep the air velocity through cooling coils low enough to prevent droplet carryover into downstream ductwork and filters, leading to microbial growth in those locations (Harriman and Lstiburek 2009).
8. Failing to install condensate drain traps deep enough to allow free-flowing drainage of normal cooling coil condensate and failing to install traps and condensate drain lines with a diameter large enough to allow maintenance personnel to both observe clogs and clean out anything that obstructs free-flowing drainage (Harriman et al. 2006).
9. Failing to install accessible cleanouts in condensate drain lines to allow periodic removal of algae and the particulate, feathers, sticks, and leaves that typically wash off the coil. Note that copper piping has been effective in limiting accumulation in condensate drain lines (Harriman et al. 2006).
10. Failing to measure and limit the volume of ventilation and makeup air to the amount required for the application and that will in fact be dried effectively by the system's dehumidification components (Harriman and Lstiburek 2009). (Note that ventilation without dehumidification has been responsible for major mold growth problems in hot and humid climates. Whenever any building in any climate is being mechanically ventilated, the indoor dew point must remain low enough to keep the indoor surface RH below 80%, even on hidden cool surfaces.)
11. Failing to ensure that system operation during unoccupied periods keeps the indoor dew point low enough to prevent a 30-day average surface RH above 80% on cool surfaces, 100% RH for 24 consecutive hours, or visible condensation. Mold and microbial

growth accelerates when the indoor dew point stays high while surfaces are intermittently chilled by cooling systems. Moisture accumulation caused by intermittent chilling of surfaces often occurs in unoccupied schools and health care clinics overnight or during vacations if dew points are uncontrolled when cooling systems are reset to higher indoor temperature setpoints (Harriman and Lstiburek 2009).

12. Failing to ensure that the temperatures of chilled-water systems stays low enough and the flow rates through the coils stay high enough to effectively dry the air (when such a chilled-water system is the only means of removing excess humidity from the building) (Harriman and Lstiburek 2009).

c. Architectural features that have been observed to ***reduce*** the risks of moisture accumulation and microbial growth include:
   1. Roof overhangs of at least 24 in. (600 mm) or more (CMHC 1996).
   2. Pan flashing under windows and doors that forces any water leakage outward onto an effective water barrier and then out of the building wall (Harriman and Lstiburek 2009, ASTM 2006, ASTM 2009, JLC 2007).
   3. Crawlspaces that are sufficiently lined and sealed to prevent infiltration into the building from surface water, moisture from the soil, and humid air (DOE 2005).

d. Architectural features that have been observed to ***increase*** the risks of moisture accumulation and microbial growth include:
   1. Vinyl wall covering on exterior and demising walls of buildings in hot and humid climates. Problems have frequently occurred behind vinyl wall covering when, as is quite common, the building lacks a continuous, sealed air barrier that effectively keeps humid outdoor air out of the cavities inside the exterior and demising walls (Harriman and Lstiburek 2009).
   2. Damp crawlspaces (DOE 2005).
   3. Water accumulating next to or under the building's foundation (Rose 2005, ASTM 2009).
   4. Rain leaks through joints around windows, doors, or other wall penetrations such as through-wall AC units, electrical fixtures, exhaust ducts, or structural fasteners or leakage through joints where different types of exterior cladding come together (Harriman and Lstiburek 2009).
   5. Absence of effective flashing around windows, doors, skylights, and other penetrations of the building's walls or roof (ASTM 2009).
   6. Absence of an effective, continuously sealed air barrier covering all six sides of the building envelope, allowing leakage of humid air from either indoors or outdoors into cool exterior walls, crawlspaces, roof assemblies, or attics (ASHRAE 2011a, ASHRAE 2010b).
   7. Absorptive exterior cladding such as brick veneer, stucco, or masonry that retains rain water but is not backed by a free-draining and vented air gap followed by an impermeable water and vapor barrier and flashing to exclude moisture (ASHRAE 2009b).
   8. Failing to install effective flashing around wall penetrations and terminations of external insulation and finish systems, along with a protective and continuously sealed waterproof drainage layer integrated with that flashing behind the insulation (Harriman and Lstiburek 2009).

e. Building operational decisions that have ***reduced*** the risks of moisture accumulation and microbial growth include:

1. Mopping and drying up spilled liquids or wash water promptly, limiting the amount of water that soaks into walls, carpeting, or flooring materials through the development of spill protocols and standard operating procedures.
2. Repairing plumbing leaks quickly and drying up any water leakage that resulted from the leaks within 24 to 48 hours.
3. Keeping irrigation spray heads aimed carefully, preventing the frequent soaking of exterior walls and foundation.
4. Maintaining the slope of exterior landscaping so that rainwater and irrigation spray flows away from the foundation rather than accumulating there.
5. Keeping rainwater runoff from the roof at least 3 ft away from the foundation.
6. Removing mold and other microbial contaminants promptly with appropriate engineering controls (e.g., HEPA air filtration, negative pressure containments) to keep contaminants from becoming airborne and distributed throughout the building, in accordance with procedures established by cognizant authorities (EPA 2001, AIHA 2008, ACGIH 1999, IICRC 2008).

f. Building operational decisions that have ***increased*** the risks of moisture accumulation have included:
   1. Failing to effectively exhaust humid air from showers, spas, decorative water fountains, indoor landscaping irrigation, and swimming pools. (When the weather is hot and humid, a related problem is the failure to dry the air that is brought into the building as makeup for exhausted air.)
   2. In cold weather, humidifying the indoor air to dew points high enough to create conditions where there are entire days or weeks of condensation or surface RH above 80% inside cooled walls and attics.
   3. Failing to ensure that the temperatures of chilled-water systems stay low enough and the flow rates through the coils stay high enough to effectively dry the air when such chilled-water systems are the only means of removing excess humidity from the building. (The problem often occurs when chilled-water temperatures are reset in an effort to save energy when the building is unoccupied during hot and humid weather. When chilled-water temperatures must be reset to save energy, or when flow rates through coils are too slow to dry the air, a separate dehumidification system may be necessary to prevent problems associated with persistent dampness.) (Harriman et al. 2006)

g. Home dwellers' decisions that have been observed to ***reduce*** the risks of moisture accumulation and microbial growth include:
   1. Keeping shower or tub splash within the tub enclosure, limiting the amount of water that can soak the floor or walls of the bathroom.
   2. Mopping and drying spilled liquids or wash water promptly, limiting the amount of water that soaks into walls, carpets, or flooring materials during cleaning operations, and drying the water that remains within 24 to 48 hours.
   3. Repairing plumbing leaks quickly and drying any water leakage that resulted from the leaks within 24 to 48 hours.
   4. Keeping irrigation spray heads aimed carefully, preventing the soaking of exterior walls and foundation.
   5. Maintaining the slope of the landscaping so that rainwater and irrigation runoff flows away from the foundation rather than accumulating there.
   6. Keeping rainwater runoff from the roof at least 3 ft away from the foundation.

7. Removing mold and other microbial contaminants promptly with appropriate engineering controls (e.g., HEPA air filtration, negative pressure containments) to keep contaminants from becoming airborne and distributed throughout the building, in accordance with procedures established by cognizant authorities (EPA 2001, AIHA 2008, ACGIH 1999, IICRC 2008).

h. Home dwellers' decisions that have ***increased*** risks of moisture accumulation and microbial growth include:
   1. Failing to use either fans or window openings to effectively exhaust humid air from cooking or from baths and showers, especially in small homes or apartments with many people or long cooking operations that lead to a large percentage of hours per week or month at a high indoor dew point.
   2. Failing to effectively exhaust (or dehumidify) humid air from clothes driers or drying racks. The problems associated with this error are especially severe during cold weather.
   3. Growing an unusually large number of live plants indoors without exhausting or otherwise removing the humidity they produce. The problems created by this oversight are especially severe in cold climates.
   4. In cold weather, humidifying the indoor air to dew points high enough to create conditions where there are entire days or weeks of condensation or surface RH above 80% inside cooled walls and attics.
   5. Storing large amounts of documents, furniture, or cardboard boxes in damp basements or crawlspaces or in contact with cold exterior walls or foundations.

i. Public policy and building code decisions that have ***reduced*** the risks of moisture accumulation and microbial growth include:
   1. Water barrier requirements. A requirement for a continuous, sealed water barrier in the outer layers of exterior walls and foundation can be very helpful in keeping rainwater from leaking inward into more moisture-sensitive components of the building. This is particularly helpful behind brick veneer, masonry, and stucco cladding, which can all retain a great deal of rainwater. When retained and driven by solar heat, water can move into the building unless there is a vented air gap and a continuous, well-sealed water barrier to protect the inner layers of the exterior wall (ASHRAE 2009a).
   2. Air barrier requirements. Air barrier requirements (in particular, the mid-construction measurement of the air leakage rate of a building against some allowable code-required maximums) is a proven means of reducing both energy consumption and reducing risk of moisture accumulation caused by humid air infiltration (ASHRAE 2010b, ASHRAE 2009a, ASHRAE 2011b, Harriman and Lstiburek 2009).

j. Public policy and building code decisions that have ***increased*** the risks of moisture accumulation and microbial growth include:
   1. Unwise or overly restrictive vapor retarder requirements. Wholesale adoption of prescriptive vapor barrier requirements generated for cold climates have proven to be destructive for buildings in hot and humid climates.

      Placement of vapor barriers does not easily lend itself to simple or global prescriptive requirements. In place of prescriptive requirements, ASHRAE recommends adoption of ASHRAE Standard 160 (ASHRAE 2009a) guidelines for envelope design decisions regarding the need for or the lack of need for vapor barriers and vapor retarders in a specific building assembly in a specific climate and for a specific building use.

When code authorities decide that adoption of Standard 160 guidelines by themselves will not be sufficiently specific and that prescriptive requirements for vapor barriers are useful and necessary, ASHRAE recommends that requirements be specific to the local climate, the type of building, and the magnitude of the building's internal humidity loads. Narrowing the scope of any prescriptive vapor barrier requirement helps limit its potential for creating more problems than it solves (Harriman and Lstiburek 2009).

2. Energy-saving operational practices and regulations can inadvertently increase risks of moisture accumulation and mold growth. Any energy-saving regulations or recommendations should take into account the fact that when excessive moisture and high humidity are present indoors, the risk of mold growth and moisture-related problems is also high.

   For example, if local regulations for public buildings require resetting a chilled-water temperature to a higher level when the building is unoccupied, and if that system is responsible for dehumidification in addition to cooling, the indoor dew point can rise to excessive, even risky levels. And if regulations require that parts of a building be uncooled when other parts of the same building are cooled, as in the case of health care facilities in many parts of the world, the dew point in uncooled parts of the building can rise high enough to create high surface RH and microbial growth on (or inside) walls separating cooled and uncooled spaces.

   Consequently, ASHRAE suggests that regulations that govern cooling not overlook the need to keep the indoor dew point low enough to reduce the risk of high surface RH in cooled parts of a building, especially when other parts of a building are not cooled or are intermittently cooled.

INVESTIGATION AND REMEDIATION OF MOLD AND MICROBIAL GROWTH PROBLEMS

Although many ASHRAE members may be qualified by training and/or experience to investigate and remediate microbial problems including mold, these skills are not overseen, collected, or codified by ASHRAE technical committees. Consequently, ASHRAE takes no position on the question of certification or accreditation of technical competence in these areas.

As technical professionals, however, ASHRAE members and technical committees have observed the following:

1. In the U.S., no cognizant health authority has yet established microbial exposure limits for residential or commercial buildings. In other countries, such exposure limits have been established (Brandys and Brandys 2011), but there is little agreement between different countries concerning what the limits should be to ensure acceptable levels of health risk.
2. Other organizations have published detailed guidance on the assessment of fungal growth in buildings (ASTM 2010), on the appropriate assessment of the presence of or exposure to bioaerosols (ACGIH 1999), and on appropriate investigation and remediation of moisture and mold problems in buildings (AIHA 2008). These references provide useful guidance to those who need to investigate, assess, and deal with any consequences of mold and other microbial growth in buildings and residences.
3. Sampling for airborne mold spores is often utilized to assess the degree of contamination of the indoor air, especially following mitigation of a mold problem. However, cognizant authorities for these techniques advise that air sampling for mold spores should only be

conducted with a hypotheses-driven sampling plan that provides a sufficient number of sample locations and air samples to provide a statistically relevant interpretation. Furthermore, spores are not the only component of microbial growth that is of concern. While presence of an unusual number of mold spores may be a relatively reliable indicator of “a microbial problem,” the absence of spores is not a reliable indicator of absence of “a microbial problem” (ACGIH 1999).

4. The moisture content of materials is a key aspect of assessing the risk of microbial growth on their surfaces. However, ASHRAE advises caution when taking moisture content readings and interpreting their significance. There is nearly always extreme spatial variation in the moisture content of materials over short distances (a few inches or centimeters). Also there are many different materials in a building, each with different wetting and drying characteristics and different susceptibility to moisture problems over both short and long periods.

   These factors, combined with normal daily temperature cycles that affect wetting and drying, suggest that any single-point or single-event moisture content measurement is not likely to be useful in assessing the presence or absence of excessive moisture accumulation or mold risk. As a further complication, different moisture meters are calibrated to different scales. The readings from one type of meter—or even different models of the same type of moisture meter—may have no definable or consistent correlation with readings from a different type of meter (Harriman and Lstiburek 2009).

   Mapping the moisture measurements, taking measurements in the exact same location over time with the same meter, and using thermal cameras to help locate areas of potential concern can reduce (but not eliminate) the high level of uncertainty associated with conclusions based on current moisture measurement technology.

5. Wetting events associated with rainwater leakage, wind-driven rain, and condensation indoors are common sources of moisture accumulation and microbial problems, including mold. Investigations that occur only on dry days, or on days without wind-driven rain, may fail to identify and locate such leakage. The same is true for periodic HVAC malfunctions such as shortcomings in the control systems during shutdown or lightly occupied periods. Consequently, multiple site visits during different weather conditions and different HVAC operational modes may sometimes be necessary to reach robust conclusions.

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DRAFT

Environmental Health Committee (EHC) Report to ASHRAE Technology Council

Recent Trends in Environmental Health

This report is prepared as a part of MBO assigned to Environmental Health Committee. Based on the feedback from the members of EHC a list of recent trends in the environmental health and its impact on HVAC&R industry is prepared. Additionally, research needs related to these trends are listed.

- The demand for better IAQ will increase in the coming years. Paradigm shift in expectations for IAQ – towards health/productivity focus, including infection control outside healthcare environments. There is a need to formulate practical metrics for evaluating IAQ.
- Increasing use of air cleaners. There are many associated issues regarding their effectiveness, safety, and a clear need for relevant methods of testing and certification.
- Use of higher efficiency filters in non-healthcare settings. There is movement towards MERV 13 as a minimum standard for new systems and as an upgrade for existing systems. Associated issues are the inability of some existing systems to accommodate this level of upgrade, and energy use impact. On the other hand, there is an opportunity to rethink system design and develop components that successfully achieve this level of performance.
- IEQ as an aspect of resilience. For a long time, discussions of resilience have revolved around protection of the building from earthquake, hurricane winds, flooding, etc. The emerging trend is to view protection of occupants during extreme outdoor and indoor events (e.g., wildfires and epidemics, respectively) as a core aspect of resilience.
- There is a trend towards increasing the ventilation air rates and air changes per hour (ACH) for indoor spaces. A proper guidance is required to assess the effectiveness of increased ACH and associated impact on energy demand.
- Research Needs:
  - Development of new metrics for IAQ for spaces other than healthcare.
  - Development of testing and certification procedures for air cleaners.
  - Development of guidance for consumers related to air cleaners.
  - Efficacy of negative pressure spaces for non-healthcare environment.
  - Impact of air change rates on effectiveness of ventilation.
  - Renewed metrics for health and comfort measures.
  - Monetary benefits of health and wellness in built environment.
  - Real time measurement and monitoring of indoor contaminants.

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:

Effects of increased use of surface disinfectants and hand sanitizers on indoor air quality

RTAR #

(To be assigned by MORTS)

Research Classification:
Basic/Applied Research
Advanced Concepts
Technology Transfer

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

Responsible Committee: TC2.3

Date of Vote:

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

RTAR Authors

Lead: Chang-Seo Lee

Others: Kathleen Owen
Jensen Zhang
Paula Levasseur
Marilyn Listvan
Ashish Mathur

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

Any other committee to ask?

Expected Work Statement Authors

Lead: Chang-Seo Lee

Others: Kathleen Owen
Paula Levasseur
Marilyn Listvan
Ashish Mathur

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:

Insert proposed project title

Effects of increased use of surface disinfectants and hand sanitizers on indoor air quality

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)

With COVID-19 pandemic, most buildings have adopted increased surface disinfection and hand sanitization. Active and inert ingredients of these products may pose additional air pollution loads which are not considered in conventional ventilation design. This study is to investigate the effects of disinfectants and sanitizers on indoor air quality (IAQ).

Background

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

Since the start of the COVID-19 pandemic, frequent surface disinfection and hand washing or sanitization have been recommended as a preventative measure to reduce viral transmission; these practices have been adopted by most buildings regardless of building type. The ease of implementation made hand sanitizers become popular as an alternative to the traditional handwashing with soap.

Common buildings other than health care facilities generally adopt so called “low-level disinfection.” Examples of active biocidal ingredients include chlorine-based products (chlorine dioxide, sodium hypochlorite), phenolics (chloroxylenol), peroxygen compounds (hydrogen peroxide), quaternary ammonium compounds (benzethonium chloride, cetrimide), biguanides (chlorhexidine) and alcohols (Rutala and Weber, 2016; Saccucci et al., 2018; Golin et al., 2020). Hand sanitizers can be classified into two groups: non-alcohol based hand sanitizers like benzalkonium chloride and quaternary ammonium; and alcohol-based hand sanitizers with ethanol, isopropyl alcohol, n-propanol as active ingredients (Golin et al., 2020). In addition, various inert or inactive ingredients like excipients, humectants, and perfumes are added to commercial products (EPA, 2021a).

There are various disinfectants available on the market, so EPA reviewed and released “List N: Disinfectants for Use Against SARS-CoV-2” based on the biocidal efficacy (EPA, 2021b). A recent study evaluated cleaning and disinfecting products that government-recommended/approved to use against the coronavirus, for VOC emissions by headspace GC/MS analysis (Steinemann et al., 2021). They identified a total 399 VOCs and among them 127 VOCs are classified as potentially hazardous compounds by cognizant authorities like US EPA and Safe Work Australia (Steinemann et al., 2021). Since headspace is used in the study, the findings are limited to identifying the emitted VOCs and determining the prevalence of VOCs among the tested products. To understand their effects on IAQ better, there is a need to quantify the emission rates and to investigate the parameters affecting the emission rates.

Research Need

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

Determining the disinfection efficiency of surface disinfectants and hand sanitizers is important, and government agencies like EPA evaluate and regulate them. Besides, identifying and measuring the emissions of various chemicals used as surface disinfectants and hand sanitizers are important to understand their effects on indoor air quality and occupants' inhalation exposure. The emission rates of these products are expected to follow the general emission characteristics of wet materials; hence, they can be affected by the substrate type, ventilation rate, temperature, humidity and air velocity.

The ventilation rate procedure (VRP) of ASHRAE Standard 62.1 prescribes the outdoor air ventilation rate requirements for various space types and considers both occupants' activity level related and space related pollution loads. According to Appendix I of the Standard 62.1, disinfecting agents are explicitly considered for only a few space types like barber shops, beauty and nail salons, and coin-operated laundries. Many other space types are considered as "no significant space-related contaminants." Therefore, the increased use of surface disinfectants and hand sanitizers and their effects on IAQ in such spaces need to be investigated to allow better ventilation design.

Climate change may increase the risk of pandemics. Certainly, it is likely that conditions leading to extended use of these chemicals are likely to occur again in the near future. Therefore, there is an urgent need for fundamental studies like this for better understanding of infection control measures and their effects on building design and operations, and IAQ.

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)

The main objectives of this project are:

1. Identify chemicals emitted from different commercial surface disinfectants and hand sanitizers that are commonly used in buildings. Minimum three different groups of surface disinfectants and two different groups of hand sanitizers (i.e., alcohol based and non-alcohol based) need to be considered. Minimum two different products from each group shall be tested.
2. Determine the emission rates of the identified chemicals through environmental chamber testing (full-scale or small-scale). Minimum three different types of substrates with different permeability representing common building materials and human skin shall be considered.
3. Investigate the effects of ventilation rate and other environmental parameters like temperature, humidity and air velocity on the emission rates.
4. Estimate the inhalation exposure of building occupants based on the measurement results and model simulations accounting for effects of ventilation and sorption on indoor surfaces.

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 [X], Computations ( ), Surveys [ ], Field tests [ ], Analyses and modeling [X] Validation efforts [ ], Other (specify) ( )

The PI would be expected to

1. Review product contents to identify the chemicals, then chose at least three different groups of surface disinfectants and two different groups of hand sanitizers (i.e., alcohol based and non-alcohol based), then identify at least two different products from each group shall be tested. This will be done in conjunction with the PMS.
2. Setup a chamber (preferably an existing chamber) to run the emission tests. Then determine the emission rates using acceptable EPA or similar analysis techniques. These tests would include varying the ventilation rates and other environmental parameters like temperature, humidity and air velocity on the emission rates. Results would be tabulated and shared with the PMS.
3. Accepted inhalation exposure modeling would also be run to estimate the inhalation exposure of building occupants based on the measurement results and model simulations.

Relevance and Benefits to ASHRAE

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

The outcome of this project can be included in the ASHRAE Handbook - Fundamentals Chapter 10 Indoor Environmental Health and Chapter 11 Air Contaminants, and ASHRAE Handbook – Applications Chapter 47 Air Cleaners for Gaseous Contaminants. If major air contaminants are identified from this project, then the findings can be considered in ventilation design (the ASHRAE standard 62.1) and air cleaner evaluation (the ASHRAE standard 145.1 and 145.2).

This project accords with Goal 11 of the ASHRAE Research Strategic Plan 2010-2018: "Understand influences of HVAC&R on airborne pathogen transmission (APT) in public spaces and develop effective control strategies", especially with the following objectives:

3) Promote the development of protocols and methods for characterizing HVAC&R systems and building science factors that impact APT in a simple and cost effective manner, and

4) Develop differential pressure controls and space isolation methods and air cleaning and disinfection methods for reducing APT in spaces of interest to ASHRAE membership.

According to 2019−2024 ASHRAE Strategic Plan, this project aligns with "Initiative 2: Indoor environmental quality". The outcome of this project will provide a better understanding of the effects of building operation measures under pandemic situations on multi-faceted nature of indoor environmental quality. This knowledge may enable for the ASHRAE and the members to make informed decisions in building design and operations. Hence, the project complies to the desired outcome listed as:

1. Add to body of scientific knowledge on the relationship of IEQ to health, productivity, and well-being of building occupants and develop practical methods for estimating the economic value of improvements in IEQ such as reduced sick days, reduced health care costs, and improved student learning.
2. Develop an IEQ standard based on health and productivity objectives that addresses air quality, thermal environment, light, sound, and vibration in an integrated way.

Anticipated Funding Level and Duration

Funding Amount Range: $ 150K

Duration in Months: 18 months

References

List the key references cited in this RTAR

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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.