



Shaping Tomorrow's Built Environment Today

MINUTES

Environmental Health Committee (EHC)

January 22, 2018

Palmer House Hilton

Chicago, IL

MEMBERS PRESENT:

Lan Chi Nguyen-Weekes, *Chair*
Elliott Horner, *Vice-Chair*
Hoy Bohanon
Wade Conlan
Tom Lawrence, *BOD Ex-O*
Luke Leung
Chandra Sekhar
Max Sherman
Erica Stewart
Wei Sun
Wayne Thomann

MEMBERS NOT PRESENT:

Hans Besselink
Ken Cooper
Andy Persily
Claressa Lucas
Ginger Scoggins, *Coord. Officer*

ASHRAE STAFF:

Steve Hammerling, *AMORTS*

GUESTS:

Peter Alspach
Bill Bahnfleth
Charlene Bayer
Mike Bilderbeck
Theo Brillhart
Brendan Burley
Nicholas Clements
Paul Francisco
Kevin Kennedy
Josephine Lau
Ed Light
Frederick Marks
Patricia Mason-Fritz
Larry Schoen
Jeff Siegel
Janet Stout
David Thomsen
Dean Tompkins
Don Weekes
Steve Yamamoto
Junjing Yang
Jensen Zhang

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MOTIONS

No.	Motion	STATUS
1	the minutes from the October 10 th EHC Fall Meeting be approved	PASSED
2	EHC recommends to Technology Council, that they recommend to the BOD that the Rules of the Board (ROB) be revised as shown:	PASSED
3	that EHC recommends Technology Council reaffirm the <i>Filtration and Air Cleaning</i> Position Document (PD).	PASSED
4	EHC recommends Technology Council reaffirm the <i>Unvented Combustion Devices and Indoor Air Quality</i> Position Document (PD).	PASSED
5	that EHC approve a new emerging issue brief on <i>Potential Microbial Contaminants in Biowall Water Systems</i>	PASSED

LIST OF ATTACHMENTS

No.	Attachment
A	2017-2018 MBO's status report
B	BOD Ex-O presentation
C	Comparison of international IEQ standards
D	<i>Filtration and Air Cleaning</i> Position Document
E	<i>Unvented Combustion Devices and Indoor Air Quality</i> Position Document
F	<i>Potential Microbial Contaminants in Biowall Water Systems</i>
G	EHC program topics
H	EHC research roadmap

LIST OF ACRONYMS

AID	Airborne Infectious Diseases
AIVC	Air Infiltration and Ventilation Centre
AMORTS	Assistant Manager of Research and Technical Services
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
BOD	Board of Directors
CO	Coordinating Officer
CO ₂	Carbon Dioxide
CNV	Chair Not Voting
DOE	Department of Energy
DRSC	Document Review Subcommittee
EH	Environmental Health
EHC	Environmental Health Committee
EIB	Emerging Issue Brief
ENDS	Electronic Nicotine Delivery Systems
EPA	Environmental Protection Agency
ETS	Environmental Tobacco Smoke
ExO	Ex-Officio
H&A	Honors and Awards Committee
HVAC	Heating, Ventilating and Air Conditioning
IAQ	Indoor Air Quality

IAQA	Indoor Air Quality Association
IAQP	Indoor Air Quality Procedure
IEQ	Indoor Environmental Quality
IEQ-GA	Indoor Environmental Quality Global Alliance
MBO	Management by Objectives
MOP	Manual of Procedures
MTG	Multi-disciplinary Task Group
PASA	Procedures for ASHRAE Standards Actions
PD	Position Document
PMS	Project Monitoring Subcommittee
RAC	Research Administration Committee
ROB	Rules of the Board
RP	Research Project
RTAR	Research Topic Acceptance Request
SGPC	Standing Guideline Project Committee
SSPC	Standing Standard Project Committee
TC	Technical Committee
TPS	Title Purpose and Scope
VOC	Volatile Organic Compound
WS	Work Statement

ACTION ITEMS FROM 2018 WINTER MEETING

No.	Responsibility	Action Item	Page
1	EHC	Read and become familiar with the current chapter F10 to suggest changes	3
2	Lucas, Stewart, Janet Stout	Reach out to PD chair to help make progress on Legionellosis PD.	3
3	Policy SubC chair	Help find chair for the Filtration and Air Cleaning PD committee	4
4	Sherman, Pat Mason-Fritz and Brendan Burley	Explore idea for a PD on Indoor Environmental Impact of Climate Change and to develop a TPS as appropriate.	4
5	Research SubC chair	Follow up with Jovan Pantelic to see what progress has been made on WS 1657.	7
6	Research SubC	Discuss Light's MTG proposal with TRG and make recommendation for approval	7

ACTION ITEMS FROM 2017 FALL MEETING

No.	Responsibility	Action Item	Status
FA-1	Sun	Write email explanation to TC 2.3 on why EHC didn't approve co-sponsoring their RTAR	Complete
FA-2	Education Subcommittee	Review current environmental health award eligibility system to see what improvements could be made.	Ongoing
FA-3	Horner, Cooper, Persily, Sekhar, Sherman & Sun	Discuss ASHRAE's IAQ Policy subcommittee and make suggestions for EHC action	Complete
FA-4	Policy Subcommittee	Review current emerging issue briefs for Chicago meeting and recommend revisions or deletion.	Ongoing
FA-5	EHC	Review revised ENDS brief to ensure previous comments were addressed	Complete
FA-6	Staff	Compile comments on Biowall brief and send to author	Complete
FA-7	Research Subcommittee	Review and comment on 3 environmental health related RAC RTARs	Complete
FA-8	Persily, Bohanon, Conlan Sekhar & Sherman	Develop summary to frame the discussion on SSPC 62.1 questions to EHC.	Complete

1. CALL TO ORDER & INTRODUCTIONS

Chair Nguyen-Weekes called the meeting to order at just after 2:15 PM. Members and guests introduced themselves.

2. ETHICS

Nguyen-Weekes read and reminded all of the ASHRAE [Code of Ethics](#).

3. REVIEW OF AGENDA

No changes were made to the agenda sent prior to meeting. Baker emphasized subcommittee reports would focus on motions and discussion items from subcommittee meetings, versus information items.

4. MINUTES

It was moved (MS) and seconded (CS) that,

(1) the minutes from the October 10th EHC Fall Meeting be approved.

MOTION 1 PASSED: 12-0-0, CNV

BACKGROUND: Draft minutes were sent to committee in October 24th email.

5. CHAIR'S REPORT (Nguyen-Weekes)

A. The following motions from past EHC meetings required higher body approval:

- Motion to approve Don Weekes as IAQ PD committee chair [*Passed DRSC & Tech Council*]
- Motion to approve IAQ PD committee roster [*Passed DRSC & Tech Council*]
- Letter Ballot motion to recommend EH Award winner to Honors & Awards committee [*ballot closed January 19. EHC selected a winner for recommendation to H&A committee*]

B. Summary of Action Items

- Action items will be reviewed as they arise on agenda.

C. 2017-2018 MBO's – Status Report (**Attachment A**).

- Report on MBOs (10, 11)
EHC will report final status of MBOs in report to Operations Subcommittee.

D. Indoor Environmental Quality – Global Alliance (IEQ-GA)

Sherman reported that the IEQ-GA is progressing towards becoming an independent organization and separate legal entity. The alliance is meeting tomorrow at 400-530 PM and Sherman invited all to attend. One IEQ-GA activity could be organization of the ASHRAE IAQ conference series. EHC was in support of this transition to IEQ-GA organization.

E. WELL Building Standard

Nicholas Clements gave a quick update noting that a community standard was developed and is now available [here](#). The standard has adopted to various building types. Details are available from the IWBI (www.wellcertified.com).

6. VICE-CHAIR'S REPORT (Horner)

A. ROB/MOP/Reference Manual

An ad hoc committee of EHC met to discuss ROB 1.2011.004.9 on Indoor Air Quality or Ventilation Standards. There was concern over a conflict with PASA. The subcommittee developed a proposed change for EHC's consideration.

It was moved (EH) and seconded (WC) that,

- (2) EHC recommends to Technology Council, that they recommend to the BOD that the Rules of the Board (ROB) be revised as shown:

~~1.201.004.9 Indoor Air Quality or Ventilation Standards. Any existing and all future ASHRAE indoor air quality or ventilation code intended standards must meet the following requirements:~~

~~A. The standard shall specify concentration limits of only those specific contaminants for which a nationally or internationally recognized authority (such as US EPA, OSHA or the World Health Organization) has established a maximum permissible concentration limit and for which standardized test procedures have been established. Nationally or internationally recognized authorities and procedures may be those developed by ANSI consensus procedures for private standards-setting organizations, those established by statute, or those duly adopted regulations issued by governmental agencies.~~

~~B. The standard may specify means and methods for limiting concentration of pollutants, provided they are related to contaminants normally considered in the design of HVAC systems serving the relevant space type.~~

~~C. The standard shall not require the measurement of contaminant or other airborne concentrations except those that can be measured using standardized test equipment and procedures in accordance with ASHRAE Standard 111 (or its successor) or other consensus Methods of Test. Standardized test equipment is defined as equipment normally available in the HVAC&R industry to test and balance technicians or that is common in building ventilation assessment.~~

~~D. The standard shall not make any claims or guarantees that compliance will provide health, comfort or occupant acceptability, but shall strive for those objectives, consistent with ASHRAE policy.~~

~~E. The standard may contain factors for use in design of calculations such as mixing efficiencies and air change effectiveness, as long as it is the consensus of the standards-writing body that these factors are important to providing acceptable indoor air quality.~~

BACKGROUND: This ROB was developed many years ago in response to a series of membership votes on indoor air quality issues and reports from presidential ad hoc committees, driven by the concerns on the part of some ASHRAE members that our indoor air quality standards were inappropriately addressing health issues. The ad hoc committee findings and other BOD-level discussions concluded that it was entirely appropriate for ASHRAE standards to be motivated by health, as they had been for many years. The rule proposed for deletion was developed to quell some remaining concerns. However, this rule has not been invoked since its adoption and it is inconsistent with the key ANSI principle that the consensus body (the standard project committee in the case of ASHRAE) be solely responsible for the content of a standard.

MOTION 2 PASSED: 8-0-0 CNV

B. Budget

No changes were requested to EHC budget.

C. Environmental Health Award

EHC's letter ballot to vote on a winner closed December 19. A recommendation for the ASHRAE Environmental Health Award was submitted to Honors & Awards Committee. If approved, notification will be sent to the winner after the Winter Meeting.

7. BOARD OF DIRECTORS (BOD) EX-OFFICIO (ExO) & COORDINATING OFFICER (CO) REPORT

A. BOD EX-Officio - Lawrence

Lawrence reviewed his Ex-O presentation (**Attachment B**). Highlights include:

- Members are asked to nominate committee members at www.ashrae.org/nominate
- New Region XIV with 8 new chapters throughout Europe.
- ASHRAE is exploring regional staff support
- Global Training Center for Building Excellence established in Dubai
- Young Engineers in ASHRAE switching to Grassroots Committee
- ASHRAE developing 2019-2024 Strategic Plan

8. IAQ CONFERENCE

A. IAQ 2020

Planning is underway for ASHRAE's IAQ 2020 conference. Bill Bahnfleth and Max Sherman have agreed to co-chair the event which may be organized with AIVC, IAQA and IEQ-GA. An advisory committee will work to identify a steering committee to plan the conference. The target location at this time is Athens, Greece for September 2020. Sherman noted the long term vision is for IEQ-GA to take lead on organizing IAQ 2023 and future conferences with ASHRAE as the Secretariat.

Bahnfleth added that a special edition of the Science and Technology for the Built Environment was published featuring 8 papers from ASHRAE's IAQ 2016.

9. SUBCOMMITTEE REPORTS

A. Handbook Subcommittee (Leung)

1. 2021 Fundamentals chapter F10

There is a January 2019 deadline for changes to the 2021 volume. EHC will need to review and make changes ahead of this date. Leung noted his plan was to review and suggest changes to electronic version of the chapter well ahead of this deadline. He noted there is a new ASHRAE portal for handbook review that can be utilized. Leung asked all members to read and become familiar with the current chapter to suggest changes (**AI #1**).

Leung developed a comparison of international IEQ standards from 17 countries (**Attachment C**). Leung will continue to update and share with EHC. Ideas for inclusion in the next handbook chapter include the following:

- International IEQ standard comparison
- Exposure to full spectrum light

B. Policy Subcommittee (Sekhar)

1. Position Documents (PD)

A. *Legionellosis*

There has been no progress on revision to Legionellosis PD. This PD is expired and has been pulled from the ASHRAE website for some time. It was confirmed that a revised PD was still desired with publication of Standard 188 and development of Guideline 12. Lucas, Stewart, and Janet Stout agreed to reach out to PD chair to help make progress (**AI #2**).

B. *Filtration and Air Cleaning*

EHC discussed the pending expiration of the PD and suggested reaffirmation. A revision was already authorized by ExCom. This revision should start as soon as possible. Policy Subcommittee agreed to find PD chair (**AI #3**).

- (3) It was moved (CS) and seconded (WT) that EHC recommends Technology Council reaffirm the *Filtration and Air Cleaning* Position Document (PD).

BACKGROUND: The current PD (**Attachment D**) expires January 29, 2018. A revision has been approved by BOD ExCom but reaffirmation is necessary to assure information is available until revision is completed.

MOTION 3 PASSED: 7-0-0 CNV

C. *Indoor Air Quality (IAQ)*

The new *Indoor Air Quality* PD chair and committee was approved. PD chair Don Weekes reported the committee will next meet in February to revise the PD and that his goal for completion was June 2019. The current PD expires June 2020.

D. *Environmental Tobacco Smoke (ETS)*

The committee revising the *Environmental Tobacco Smoke* PD has been meeting. Schoen anticipates a much shorter document and estimates a draft will be ready for approval in Spring 2018.

E. *Unvented Combustion Devices and IAQ*

This PD expired in 2017. Former chair Paul Francisco recommended a reaffirmation as no major changes were needed at this time.

- (4) It was moved (CS) and seconded (WC) that EHC recommends Technology Council reaffirm the *Unvented Combustion Devices and Indoor Air Quality* Position Document (PD).

BACKGROUND: The current PD (**Attachment E**) expired June 16, 2017. EHC reviewed and determined the content is still current and of interest, so it does not need a revision, but should not be withdrawn. EHC will explore revisions in next cycle.

MOTION 4 PASSED: 7-0-0 CNV

F. *Energy Efficiency in Buildings*

A draft is developed and the committee is scheduled to meet in Chicago. Roger Hedrick is the EHC representative.

G. *Airborne Infectious Diseases (AID)*

The committee to revise the *Airborne Infectious Diseases* PD has met several times and is developing a revision. They estimate a draft will be ready for approval for Annual Meeting in 2018. The PD committee is meeting after the EHC meeting (same room) here in Chicago.

H. New PDs

Sherman, Pat Mason-Fritz and Brendan Burley agreed to explore an idea for a PD on Indoor Environmental Impact of Climate Change and to develop a TPS as appropriate (**AI #4**). It was noted an ASHRAE PD on Climate Change is in

development and nearly complete. This should be reviewed to ensure this is not already covered.

2. Emerging issue briefs (EIB)

A. Review of current emerging issue briefs

No changes were made to currently published EIBs.

B. Other/New Reports

- o Electronic Nicotine Delivery Systems (ENDS) – Schoen

Schoen noted the last round of comments has not been addressed by authors so it is not ready for approval.

- o Microbial Contaminants in Biowall Water Systems – Weekes

Many comments were offered by EHC members in last review. All comments have been incorporated.

(5) It was moved (CS) and seconded (WT) that EHC approve a new emerging issue brief (EIB) on *Potential Microbial Contaminants in Biowall Water Systems*

BACKGROUND: All comments were addressed by the author and the brief is ready for approval. The final brief is shown as **Attachment F**.

MOTION 5 PASSED: 8-0-0 CNV

- o Design Consideration for Ambient Air Contaminants

Leung submitted a draft of this EIB to policy subcommittee. Some comments were generated and sent back to Leung for consideration in a revised draft.

- o The following EIBs are on list for possible future development:

- o Physiological Impact of CO₂ (Wargocki)
- o Dermal Pathways and IAQ (Sekhar/Wargocki)

C. ASHRAE IAQ Policy review

This was discussed in Vice Chair report.

C. Education/Program Subcommittee (Conlan)

1. EHC Sponsored or cosponsored the following programs for the Winter Meeting.

A. Chicago program

- Seminar 19 - Navigating the Changing Landscape of Regulations, Codes and "Best Practices" Around Legionella and Building Water Safety
- Debate 3 - Environmental Health Is of Little Concern to the Designer

B. Houston program

EHC discussed the following programs for future ASHRAE meetings. A summary is included as **Attachment G**.

2. ASHRAE Journal IEQ Applications Column – Persily

Persily was not in attendance but sent a summary sheet before meeting. There are articles in the queue through April so he is seeking commitments for future articles.

Issue	Draft due	Author	Topic
January 2017	Published	Kennedy/Horner	Dampness and health

February 2017	Published	Siegel	IAQ and cannabis legislation
March 2017	Published	Offermann	Flooring and formaldehyde
April 2017	Published	Lawrence	Thermal comfort and demand response
May 2017	Published	Bahnfleth	IAQ 2016 summary
June 2017	Apr 8	Fritz/Horner	Classifying indoor spaces for PM
July 2017	May 8	Persily	CO ₂ generation rates
August 2017	Jun 8	Besselink	Micro-climate control
September 2017	July 8	Tanabe	ISO IEQ standards
October 2017	Aug 8	Bahnfleth	UVGI – cooling coil irradiation
November 2017	Sept 8	LanChi Nguygen	Legionella management/directives
December 2017	Oct 8	Jensen	Model aquatic health code
January 2018	Nov 8	Zaatari	Closing OA dampers
February 2018	Dec 8	Sun	Clean room ventilation
March 2018	Jan 8	Horner, Zaatari	LEED IAQ pilot
April 2018	Feb 8	Wargocki	iAQ and sleep
May 2018	Mar 8		
June 2018	Apr 8		
July 2018	May 8		
August 2018	June 8		
September 2018	July 8		
October 2018	August 8		
Other potential columns that have been mentioned			
George Araj sent AtmEnv article on Narghile waterpipe and cig smoking			
Wargocki, cognitive impacts of CO ₂			
Max Sherman, Smart Ventilation			
Stewart – air cleaners and health claims			
Siegel – Residential filtration research project			
New topic from CHI - Thomann/Bohanon – electronic air cleaners			

D. Research Subcommittee (Sun)

Sun noted he is seeking more members for research subcommittee. Focus of subcommittee will be development of RTAR ideas.

1. Active Research Projects (RP)

A. RP - 1663 – *Residential IAQ Guide*

- Schoen noted the project is slightly behind schedule but the product is good. A new member was added to the team as a technical editor. Draft about ready for a PMS 95% review at the end of January. The 100% review is a few months out, targeting July. The EPA and DOE are both interested in promoting the publication with their IAQ and Building American programs. A 5 minute video will be developed as well.

2. Work Statements (WS)

A. Draft WS 1657 - *Effective Ventilation Systems for Airborne Infection Isolation Rooms to Reduce Potential Cross Infection*

Research chair will follow up with Jovan Pantelic to see what progress has been made (**AI #5**).

- B. *WS 1579 - Testing and Evaluation of Ozone Filters for Improving IAQ.*
This committee co-sponsored TC 2.3 project. This was not approved by RAC so the project is currently in review.
- C. *TC 3.6 WS on potable hot water temp*
Stout noted research subcommittee of TC 3.6 is reviewing for revisions and will need to be resubmitted. WS sent to RAC, returned with comments.

3. RTARs

- A. *Studying Thermal Comfort and IAQ in meetings at conference environments – Stewart*
Stewart has not heard from project proposers (Clements, Lau, Zhang) so there's not been progress. EHC decided to keep this project on the list for possible future development. There was an idea to add an IAQ survey to the ASHRAE meeting app if possible. It was noted TC 2.1 and SGPC 10 may have interest in this as well.
- B. *The application of real-time small sensors to gas-cleaning systems for commercial and residential HVAC systems (TC 2.3)*
Zhang reported the TC is working on comments from EHC.
- C. New/Other RTAR ideas from EHC members
Sun spent time reviewing the EHC research roadmap (**Attachment H**) and brainstorming RTAR ideas. The following were mentioned for further discussion:
 - Can plants create healthier indoor environment? How? (TC 2.1)
 - What contaminants are generated/emitted in healthcare settings? (Brendan) (TC 9.6)
 - What is the impact of dry coil on health? (No filters) is not having a filter justified? – Brendan (TC 5.3)
 - e-cigarette use impact on air quality (TC 2.3)
 - TC 2.3 impact of marijuana cultivation facilities on IAQ

Members were encouraged to attend related TC meetings as outreach and support for research of interest to environmental health. All RTAR leads should reach out to TCs for their support and participation. The research breakfast may be a nice opportunity to do this.

- D. EHC review of RAC RTARs for environmental health issues
There were 3 reviewed for RAC Fall meeting, but none for the RAC Winter meeting.
- E. Other
Ed Light discussed MTG proposal sent ahead of EHC meeting. This was discussed at last EHC meeting and addressed comments submitted at that time. EHC agreed to discuss with TRG and make recommendations later (**AI #6**). Zhang noted this MTG and TC 2.3 are interested in measuring individual VOCs. An RTAR for a multidisciplinary review of VOC and health impacts may be appropriate.

10. STANDARDS ACTIVITIES

- A. Standard 188
Stewart reported that SSPC 188 is considering three addenda at this meeting and asked all to participate when they are put out for public review.
- B. Standard 55

It was reported that the Standard 55 committee is working a number of addenda through the process. They are related to eliminating the graphical method of compliance and adding a new prescriptive compliance path.

C. Standard 62.1

Bohanon noted he'd received input on SSPC 62.1 questions posed to EHC at Annual Meeting on the IAQP in 62.1. Bohanon noted the standard committee expects to delete Appendix C and references to CO2 levels shortly.

Bohanon showed examples for misuse of the IAQP in ASHRAE Standard 62.1. Such misuse is quite common. Thomann suggested the IAQ PD committee consider a reminder to designers to be careful when reducing ventilation rates through IAQP.

D. Standard 62.2

Proposals being considered by committee include removal of unvented combustion devices. Proposal requiring new multifamily units be balanced.

E. Standard 170

Standard 170 -2017 was published recently. FGI guidelines incorporates 170 entirely. Discussion on Taylor paper on relative humidity and flexibility (will send to EHC).

F. ASHRAE/IAQA Standard Guideline 2210-201X, *Guideline for Initial Residential Mold Assessment Standard*

Horner noted the committee met in Chicago. Been out for public review. Homes standard on hold til school version addressed. The mold assessment in schools publication held a public review which closed Dec. 25th.

G. Guideline 42P committee (*no EHC assignment*)

This guideline is related to Standard 62.1. Some writing has been done by the committee here in Chicago. There is currently a February deadline for draft completion. All were encouraged to participate.

H. Guideline 27P public review (Baker)

Kerr working on this. No other developments. Going through review comments. AIHA proceed significant, constructive comments.

11. STRATEGIC DISCUSSION

A. ASHRAE IAQ Policy review (Horner ad hoc)

The recommendation of the ad hoc was reported to EHC earlier. Proposed ROB changes were approved and will be reported to Operations Subcommittee of Tech Council.

B. Topic for Houston

a. RP1663 – Residential IAQ Design Guide

b. Role, scope, goals of EHC

i. Get Wane notes from recent program to build upon

c. Marketing/branding of environmental health committee? Getting more visible and in front of work.

12. NEW BUSINESS

A. NEXT MEETING

1. Spring Conference Call

2. Annual Meeting, Houston TX, June 25, 2018

13. OTHER

Horner asked all to nominate members to EHC from their contact lists. Don Weekes suggested an IAQA member be added to EHC as well. Please think if there are other organizations that should be represented on EHC.

14. ADJOURNMENT

The Environmental Health Committee meeting was adjourned at approximately 5:15 PM.

Environmental Health Committee 2017-2018
Lan Chi Nguyen Weekes, Chair
1/10/2018

Item #	MBO	Date Due	Assigned To	Applicable Strategy #	MBO Comments	MBO Status
Research						
1	Support EH-related ASHRAE Research	ongoing	Research Subc.	3C, 4A, 4B 5A	EHC will identify top priority research activities that will support ASHRAE's strategic plan but are not currently being conducted through TCs. EHC will support 2 new RTARs and their champions through this process, and will coordinate with applicable TCs/private sectors to co-sponsor these projects. Biowalls and Waterborne Infection RTAR is to be developed by the end of 2017. Additionally, EHC will continue to monitor existing project (RP-1663).	New RTARs will be requested from EHC members, plan to submit several new RTARs to RAC after Chicago meeting. Items 1 & 3 for research MBO can be possibly added to MOP.
2	Identify process for EHC involvement in research	6/30/2018	Research Subc.		Review EHC involvement in research - should EHC generate RTARs and how EHC will connect and be involved with RTARs from TCs ?	More effective mechanisms (submit, review, co-sponsorship) to involve in society research will be further discussed in Chicago.
3	Support ASHRAE Research by providing an EH perspective	ongoing	Wei Sun	4B, 5A	Review all RTARs to provide inputs to RAC on environmental health related projects. This activity will continue, to ensure that important EH issues of which RTAR authors may not be aware are considered.	The sub-committee has selected 3 RTARs related with EHC from a wide range of RTARs provided from RAC, the sub-committee members have reviewed and provided EH-perspective comments back to RAC for improvement and inclusion, this support for RAC will continue, more EHC members are welcome to join RTAR-review activity.
Education/Program						
4	Enhance EHC Education and Outreach Program	ongoing	Persily	1C, 3D	Articles covering environmental health issues have been placed in most issues of the ASHRAE Journal for a few years. Contributions are slowing -- this activity needs to be revitalized and continued with an aim of 7 articles per year. Additionally, in order to ensure that EH issues and perspectives are available to the ASHRAE membership, EHC will submit session abstracts for every conference and work with CEC to ensure that EHC issues have a presence in the conference programs. Finally, EHC will continue to promote the IAQ Guide.	An IAQ column has appeared in every issue of the Journal in 2017. The current queue is good until April 2018 issue.
5	ASHRAE Chicago and Houston Programs	30-Jun-18	Conlan, Education Subc.		Identify and support program submissions on behalf of EHC	2 programs sponsored or co-sponsored by EHC in Chicago. A number of potential programs (5) identified for Houston.
6	ASHRAE IAQ Conference - 2020		Conlan, Education Subc.		Identify conference chair and support program development on behalf of EHC. participate in discussion with CEC about the future of the conference and potential co-sponsoring with IAQ-GA	Max Sherman and Bill Bahnfleth co-chairing advisory committee to plan IAQ 2020 and appoint steering committee. September 2020 conference in Athens, Greece tentatively planned on. No objections from EHC on eventual transfer of conference to IEQ-GA.
Policy						
					EHC will continue to maintain and produce EH-related position documents and emerging issue briefs. Position documents: The following are under revision: Legionellosis, IAQ, ETS and Airborne Infectious Diseases and could be completed this Society Year. PDs could be completed this SY. A decision on the Combustion of Solid Fuels and IAQ in Primarily Developing Countries is due this SY.	

7	Support ASHRAE policy relating to EH	30-Jun-18	Policy Subc.	3C, 4A, 4B	<p>Emerging issue briefs will be maintained and new emerging issues will be identified and briefs will be developed (at least 2).</p> <p>The following briefs are currently published:</p> <ul style="list-style-type: none"> Indoor Passive Panel Technologies for Air Cleaning in Buildings, Nano Environmental Health and Safety, Ozone and Indoor Chemistry, Biological agents and airborne transmission, Ventilation, Humidity Control & Health Effects in Buildings using Split System AC Equipment, Vector Borne Disease, Climate Change and the Challenges to ASHRAE <p>The following are in development:</p> <ul style="list-style-type: none"> E-cigarettes, Design Criteria for Ambient Air Contaminants, Weatherization Impact on Health and Physiological Impact of CO₂, Dermal Pathways and IAQ. <p>Link EIBs with articles in Journal.</p>	EHC voted to reaffirm Filtration and Air Cleaning PD, reaffirm Unvented Combustion Devices and IAQ PD, and to approve EIB on biowall systems.
Handbook and Publications						
8	Fundamentals, Handbook and ASHRAE-wiki (review and definition of terms);	30-Jul-16	Leung	1C	Document summative of IAQ guidelines/standards/codes throughout the world	document has been prepared
9	Liaison to EH-related Standards and Guidelines	ongoing	Various individuals, see to right	2C, 3C	Standards 55 (t.b.d), 62.1 Sekhar, 62.2 Francisco, 170 Stewart, 188 Lucas, 189.1 Persily, 2210 Horner, Guidelines 10 Sekhar, 12 Lucas, 27P Baker, 42P	
Administration						
10	Revise committee meeting structure for efficiency	on-going	Exec. Committee	2A, 2B	Full committee meetings have included significant re-stating of details from subcommittee meetings. Subcommittee reports will be restructured to focus on items requiring votes, high-level information items, and an opportunity for questions. This will allow a greater amount of time for other issues and ensuring that all topics are addressed. Get subcommittee chairs to send in summaries of important issues prior to subcommittee meetings. Encourage online meetings between the main meetings (winter and summer).	EHC continues with restructured formal. Strategic Discussion topic for Chicago was ASHRAE's IAQ Policy Rule of the Board. Three possible topics for Houston were identified.
11	Maintain continuity by making Immediate Past Chair a formal position	30-Jun-18	Vice Chair, Exec. Committee	2A, 2B	Revise EHC MOP and propose ROB change -- include Immediate Past Chair as an official member when the immediate past chair has rolled off the committee following their year as chair.	The only reasons for changing a ROB are to get rid of a limitation or to add a new responsibility - EHC has determined formal ROB not necessary.

Chair: Lan Chi Nguyen Weekes
 Vice-Chair: Dr. Elliott Horner
 Consultant: Wane Baker

Subcommittees

Research committee: Sun (chair)
 Policy committee: Sekhar (chair)
 Handbook committee: Leung (?) (chair)
 Education/Program committee: Conlan (Chair)



ASHRAE UPDATE

ExO Report to Committees
2018 Winter Conference



ASHRAE Wants YOU!

- Standing committee appointments sought for 2018-19
- Join President-Elect Shelia Hayter as she works to position ASHRAE to be the industry leader in the transition toward fully optimizing building energy performance
- ashrae.org/nominate
- Nominations due by February 15




Presidential Initiatives – Extending Our Community

President’s Luncheon Preview

- Global community
- Technological horizon
- Value to members






U.S./Canada (45,000+)
Global (12,000+)
300+ Student Branches

Presidential Initiatives – Extending Our Global Community

President’s Luncheon Preview

- Partnership Award from the UN Environment Ozone Secretariat: Held in Toronto, Canada, November 2017
- Second Developing Economies Conference: Held in Delhi, India, November 2017
 - Brought together engineers, building professionals and policymakers
 - Addressed infrastructure and urbanization challenges in developing economies.
- First CRC Region XIV Europe: Held in Belgrade, Serbia, December 2017
- ASHRAE Associate Society Alliance (AASA): Brussels, Belgium, April 22-23, 2018
 - First meeting outside of North America
 - A forum where 65 professional societies from around the world exchange knowledge and ideas in the arts and sciences of HVAC&R from a global perspective.
 - Currently investigating an evolution into a Global HVAC&R Alliance

15 Regions
180+ Chapters
130+ Countries

Presidential Initiatives – Extending Our Global Community

President’s Luncheon Preview


NEW - Region XIV

- Established July 1, 2017
- 1,800 members
- Close collaboration with REHVA and CIBSE

Chapters:

- Cyprus
- Greece
- Ireland
- Portugal
- Spain
- United Kingdom – Midlands
- United Kingdom – London and South-East
- Danube

Additional chapters coming in 2018



Presidential Initiatives – Extending Our Technological Horizons

President’s Luncheon Preview



- Multi-Family Residential Research Project/90.2: To deliver residential building energy performance that is *at least 50 %* more efficient than the energy efficiency defined by the 2006 International Energy Conservation Code.
- IAQ Conference Series Extended: Goal of partnering with the new *Indoor Environmental Quality Global Alliance (IEQ-GA)*.
- Air Infiltration and Ventilation Center Partnership (Coming Soon): To give ASHRAE members full access to their growing library of information.





Presidential Initiatives – Extending Value To Our Members President’s Luncheon Preview







- ASHRAE Technology Portal: Subscriber based access to all conference papers in Chicago as well as transactions from Long Beach and other conferences.
- ASHRAE’s Reinvestment of Research Dollars: Of the almost \$2.7 million raised in Society Year 2016-2017, \$2 million went to research projects.
 - ASHRAE matched this amount doubling the support for research.
- Solar Decathlon: Eleven teams participated. ASHRAE was a sponsor and provided judges.



Presidential Initiatives – Extending Value To Our Members President’s Luncheon Preview


- New Building EQ Portal: Launched December 2017
- New ASHRAE Website: Launching February 2018
- New Standard 90.1 Portal: Launched January 2018
- ASHRAE Leadership Academy: May 18-19, 2018, Atlanta, GA
 - Rising chapter leaders network & learn best practices
- Global Giveback: April 22-28, 2018
 - Service-oriented sustainability events during a one-week period to generate excitement at the local level and increase chapter visibility

Presidential Ad Hocs Ethics Enforcement Procedures Task Group

Ethics Enforcement Procedures Task Group will review and recommend changes to ROB 3.980 Enforcement Procedures for Violation of the ASHRAE Code of Ethics. In addition, the Task Group will address procedures for Ethics allegations against Officers and/or BOD members. The Task Group may also consider making the review investigation more independent from ASHRAE leadership.


Task Group Meeting: During the Winter Conference



Presidential Ad Hocs Regional Staff Support Analysis Task Group

The Regional Staff Support Analysis Task Group is to study the placement of hired representatives (regional staff) in ASHRAE Regions to support volunteer programs, with particular focus on advocacy.

Preliminary Report to the Board: During the Winter Conference




Nomination Process Ad Hoc

The purpose of the Nomination Process Ad Hoc is to:



- Reviews all documents of the Nominating Committee including the By-laws, Board-Approved Rule’s and Nominating Committee Manual of Procedure and reference manual for current relevance.
- Review election procedures of similar organizations (ASME, ASHE, etc.).
- Determine if one nominee per office on the member ballot is appropriate.
- Determine if we should consider cancelling the tenet of “the job seeks the person, the person does not seek the job.”
- Determine if the balance of at-large and regional members of the Nominating Committee is optimal.

Final Report Due: April 2018



Global Training Center for Building Excellence -Dubai

- Opened: September 2017
- Purpose: To provide relevant self-supporting training to members and nonmembers in the Middle East and North Africa (MENA) and chapters in the Region at Large.
- Regional instructors and courses modified for the region
- Recognition: Individuals attending 42 hours of instruction and passing a course exam may earn the *ASHRAE Building Excellence Credential MENA*.

Global Training Center for Building Excellence -Dubai

Three courses have been held in Dubai:

- HVAC Design Training (twice)
- VRF Applications

GTC is reaching out to chapters in the RAL to schedule instructors from local engineering societies and universities including:

- Saudi Council of Engineers (SCE)
- Bahrain Society of Engineers (BSE)
- The British University in Egypt (BUE)
- Egyptian Engineers Syndicate (EES)



YEA



- Members Council and the ASHRAE Board approved the Young Engineers in ASHRAE (YEA) Committee transition to a grassroots committee, effective July 1, 2018
- Change: YEA RVCs will now be nominated through each Region's CRC nomination caucus
- Change: YEA Chapter Chair position will become a required chapter position that receives transportation reimbursement to CRC.



STEM Scouts

- Sub-committee members will reach out to one chapter SAC chair in their area responsible for one of the eight STEM Scout groups that were provided as stronger groups.
- Goal: To have the chapter SAC chair and STEM Scouts liaison pilot a partnership.
- Pilot Goal: 3 to 5 chapters involved in pilot
- Timeline: 2 months to reach out for partnership and report



2019-2024 Strategic Plan

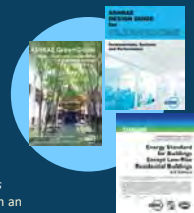
Timeline

- November 2017 - December 2017: Select Strategic Plan consultant & negotiate contract
Complete - McKinley Advisors
- January 2018: Consultant presentation to BOD at ASHRAE Winter Meeting
- March 2018: Board strategic planning session
- June 2018: Board reviews first draft of Strategic Plan
- November 2018: Board reviews and approves revised draft of Strategic Plan
- December 2018 - March 2019: Stakeholder review of and feedback on revised draft of Strategic Plan
- June 2019: BOD approve Strategic Plan 2019-24 at ASHRAE Annual Meeting
- July 2019 - June 2024: Plan is implemented, tracked, and updated as necessary with status reported to the membership with Dashboard



Recent Publications and Standards

- ASHRAE Design Guide for Dedicated Outdoor Air Systems ASHRAE GreenGuide: Design, Construction, and Operation of Sustainable Buildings, 5th Edition
- ASHRAE Pocket Guide for Air Conditioning, Heating, Ventilation, Refrigeration, 9th Edition
- ASHRAE Design Guide for Cleanrooms: Fundamentals, Systems, and Performance
- ASHRAE Design Guide for Air Terminal Units: Selection, Application, Control, and Commissioning
- IT Equipment Power Trends, 3rd Edition
- Fundamentals of Design and Control of Central Chilled-Water Plants
- Standard 90.1 Users Manual (both the printed book and online with an online version of the standard and redline)
- Standard 170-2017: Ventilation of Health Care Facilities Principles of HVAC



Join Us

- ACREX India 2018, Bangalore, India, February 22-24
- Canadian Mechanical & Plumbing Exposition, Toronto, Canada, March 21-23
- USA Science & Engineering Festival Expo, Washington, D.C., April 7 & 8
- CHR 2018 – China Refrigeration 2018, Beijing, China, April 9-11
- ASHRAE Webcast, Making Energy Efficiency a Reality, April 19
- 2018 ASHRAE Annual Conference, Houston, TX, June 23-27
- ASHRAE 2017 Building Performance Analysis Conference, Chicago, IL, September 26-28
- AHR Expo Mexico, Mexico City, Mexico, October 2-4
- Third International Conference on Efficient Building Design, Beirut, Lebanon, October 4-5
- Chillventa 2018, Nurnberg, Germany, October 16-18
- Greenbuild 2018, Chicago, IL, November 14-15



	unit	USA	Organization	Reference	Reference
CO2	ppm	30000(15min) 5000(8h) 600(high comfort level) 700 above outdoor 800(Preaferred) 600(high comfort level) 30000(15min) 5000(8h) 40000(IDLH) 5000(8h) 700 above outdoor 800	ACGI ASHRAE IDPH NIOSH OSHA TDH USEPA	ACGIH,1995; Eweda,2012 ACGIH,1995 Air Duct Cleaners, 2013 ANSI/ASHRAE,2004 Schuh,2000 ANSI/ASHRAE,2004 ANSI/ASHRAE,2004 TDH,2003 Environmental policy working group,1999	atmospheric pollution research6 2015 151-767 Sabah ahmed abdul-wahab et.,al
CO	ppm	9(8h) 35(1h) 9(8h) 35(8h) 200(MAX or Ceiling) 1374mg/m3(IDLH) 50(8h) 35(1h) 9(8h)	ASHRAE NAAQS/EPA NIOSH OSHA US EPA	ASHRAE Air Duct Cleaners,2013 ANSI/ASHRAE,2004 ANSI/ASHRAE,2004 Hedrick2010 ANSI/ASHRAE,2004 Berenguer	atmospheric pollution research6 2015 151-767 Sabah ahmed abdul-wahab et.,al
HCHO	ppm	0.3(ceilinglevel) 0.081(30min) 0.076(1min) 0.027(8h) 0.4 0.1(ceiling level) 0.016(1week) 20(IDLH) 2 0.75(1week) 0.016(outside) 0.045(1h) 0.0073(8h)	ACGIH ASHRAE NAAQS/EPA NIOSH OSHA U.S.EPA Cal-EPA, OEHHA	Light house Sustainable Building Center,2007 ANSI/ASHRAE,2004 Light house Sustainable Building Center,2007 ANSI/ASHRAE,2004 ANSI/ASHRAE,2004 ANSI/ASHRAE,2004 ANSI/ASHRAE,2013	atmospheric pollution research6 2015 151-767 Sabah ahmed abdul-wahab et.,al ANSI/ASHRAE,2013
TSP	microgram/m3	15(8h) 10,000(8h) 150(24 h) 150(24 h) 150(24 h) 50(1y) 150(24 h) 50(1y)	OSHA ACGIH ASHRAE IDPH NAAQS/EPA US EPA	ANSI/ASHRAE,2004 ANSI/ASHRAE,2004; Charles et al., 2005 Air Duct Cleaners,2013 Schuh,2000;Sebesta,2011 ANSI/ASHRAE,2004; Charles et al., 2005 ANSI/ASHRAE,2013	atmospheric pollution research6 2015 151-767 Sabah ahmed abdul-wahab et.,al
PM10	microgram/m3	15(8h) 10,000(8h) 150(24 h) 150(24 h) 150(24 h) 50(1y) 150(24 h) 50(1y)	OSHA ACGIH ASHRAE IDPH NAAQS/EPA US EPA	ANSI/ASHRAE,2004 ANSI/ASHRAE,2004; Charles et al., 2005 Air Duct Cleaners,2013 Schuh,2000;Sebesta,2011 ANSI/ASHRAE,2004; Charles et al., 2005 ANSI/ASHRAE,2013	atmospheric pollution research6 2015 151-767 Sabah ahmed abdul-wahab et.,al
PM2.5	microgram/m3	15(1y) 35(24h) 5000	NAAQS/EPA OSHA	ANSI/ASHRAE,2013 ANSI/ASHRAE,2013	ANSI/ASHRAE,2013 ANSI/ASHRAE,2013
NO2	ppm	5(15min) 3(1week) 0.05(1y) 1(15min) 20(IDLH) 5(ceiling level) 0.053(Time weighted average)	ACGIH NAAQW/EPA NIOSH OSHA USEPA	ACGIH,1995;ANSI/ASHRAE,2004 ANSI/ASHRAE,2004 ANSI/ASHRAE,2004 ANSI/ASHRAE,2004 ANSI/ASHRAE,2004 ANSI/ASHRAE,2004	atmospheric pollution research6 2015 151-767 Sabah ahmed abdul-wahab et.,al
SO2	mg/m3	0.08(1y) 13(15min) 5.2(8h) 0.365(24h) 0.08(1y) 13(15min) 5.2(8h) 5(8h) 1.3(3h) 0.365(24h) 0.08(1y)	ASHRAE ACGIH NAAQS/EPA NIOSH OSHA USEPA	ASHRAE ANSI/ASHRAE,2004 ANSI/ASHRAE,2004;Charles et al., 2005 ANSI/ASHRAE,2004 ANSI/ASHRAE,2004 ANSI/ASHRAE,2004 OSHA ANSI/ASHRAE,2004;Charles et al., 2005 Berenguer,2011	atmospheric pollution research6 2015 151-767 Sabah ahmed abdul-wahab et.,al
O3	ppm	0.05(8h) 0.12(1h) 0.08(8h) 0.1(ceiling level) 0.1(8h) 0.12(1h) 0.08(8h)	ASHRAE NAAQS/EPA NIOSH OSHA US EPA	ANSI/ASHRAE,2004 ANSI/ASHRAE,2004 ANSI/ASHRAE,2004 ANSI/ASHRAE,2004 ANSI/ASHRAE,2004 ANSI/ASHRAE,2004 Berenguer,2011;Air Duct Cleaners,2013	atmospheric pollution research6 2015 151-767 Sabah ahmed abdul-wahab et.,al
TVOC	microgram/m3	-			
Asebestos	fibers/cc	0.1 (OSHA)			
Rn	pCi/L	4 (yr, EPA)			
Bacteria	CFU/m3	-			
Temp Summer	°C	22.5-26 24.5-28.0(30%RH) 20-24(60%RH) 22.5-26	ASHRAE ASHRAE TDH	TSI,2013 Government of Alberta,2009 TDH,2003	atmospheric pollution research6 2015 151-767 Sabah ahmed abdul-wahab et.,al
Temp Winter	°C	20.0-23.5 20.0-23.5	ASHRAE TDH	TSI,2013 TDH,2003	atmospheric pollution research6 2015 151-767 Sabah ahmed abdul-wahab et.,al
Humi Summer	%	30-60(comfort level) 20-60	ASHRAE IDPH	Air Duct Cleaners,2013 Schuh,2000	atmospheric pollution research6 2015 151-767 Sabah ahmed abdul-wahab et.,al
Humi Winter	%	40-60(comfort level) 20-60	ASHRAE IDPH	Air Duct Cleaners,2013 Schuh,2000	
Aair flow rate	m/s	-			



ASHRAE Position Document on Filtration and Air Cleaning

**Approved by ASHRAE Board of Directors
January 29, 2015**

**Expires
January 29, 2018**

COMMITTEE ROSTER

The ASHRAE Position Document on Filtration and Air Cleaning was developed by the Society's Filtration and Air Cleaning Position Document Committee formed on January 6, 2012, with Pawel Wargocki as its chair.

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HISTORY OF REVISION/REAFFIRMATION/WITHDRAWAL DATES

The following summarizes this document's revision, reaffirmation, or withdrawal dates:

01/29/2015—BOD approves Position Document titled Filtration and Air Cleaning

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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ABSTRACT

Filtration and air cleaning are used to improve indoor air quality and occasionally to enable a reduction in rates of outdoor air ventilation. This Position Document addresses the health consequences of filtration and air cleaning. Data from refereed archival literature are used to form summary statements on performance as well as the positions with respect to specific technologies. One key statement is that, at present, there is only significant evidence of health benefits for porous media particle filtration systems. For a few other technologies, there is evidence to suggest health benefits, but this evidence is not sufficient to formulate firm conclusions. A key position is that filtration and air-cleaning technologies are not recommended for use if they produce significant amounts of contaminants that are known or expected to be harmful for health. Finally, it is stated that there are limited data documenting the effectiveness of gas-phase air cleaning as an alternative to ventilation. ASHRAE should continue supporting research and standardization of contemporary filtration and air-cleaning technologies and should focus on performance testing, maintenance procedures, and development of new innovative technologies.

EXECUTIVE SUMMARY

ASHRAE needs to address heating-, ventilation-, and air-conditioning- (HVAC) related technologies that change exposures to airborne contaminants harmful for humans. As part of ASHRAE's mission, it is imperative to assess the effectiveness of HVAC technologies in reducing exposures so that the risks for harmful effects on health and comfort are minimized and to establish and promote the Society's positions that will guide ASHRAE membership and the public in technology selection and use. This need applies to filtration and air-cleaning technologies because they traditionally are part of the HVAC system, their use is included and/or required in many guidelines and ventilation standards published by ASHRAE, and they are addressed by technical committees within ASHRAE. Evaluation and guidance are also needed because of the increasing number and variety of filtration and air-cleaning alternatives available on the market and because filtration and air cleaning are considered attractive alternatives to outdoor air ventilation by providing exposure control with less energy use.

Various filtration and air-cleaning technologies are available, depending on the type of contaminants removed and the principle of contaminant removal. This Position Document briefly characterizes these technologies and their applications. The focus is to summarize and examine the existing archival literature describing the direct effects of application of these technologies in public and residential buildings (excluding health-care facilities) on the health of building occupants. Based on the accumulated information, statements on the effectiveness and use of different technologies are proposed and are briefly summarized as follows:

- Mechanical filters have been shown to reduce significantly indoor concentrations of airborne particles. Modest empirical evidence shows that their use will have positive effects on health.
- Electronic filters have been shown to range from being relatively ineffective to very effective at removing indoor airborne particles. Studies of ionizers have shown results ranging from no benefit to some benefit for acute health symptoms.
- There are some sorbent air cleaners that have been shown to substantially reduce the concentrations of gaseous contaminants. There are minimal empirical data that indicate the effects of sorbent air cleaners on health.
- Photocatalytic oxidation technologies have been shown to remove harmful contaminants, to be ineffective in removing contaminants, and/or to generate harmful contaminants during the air-cleaning process. There are no data on how their use affects health.
- Ultraviolet germicidal energy (UV-C) has been shown to inactivate viruses, bacteria, and fungi. A few studies have shown that air-cleaning technologies using UV-C disinfection (also termed *ultraviolet germicidal irradiation* [UVGI]) produce beneficial health effects. There are also studies that have failed to detect health benefits.
- Many types of packaged stand-alone air cleaners using combinations of air-cleaning technologies are available. Scientific data addressing the effects of these air cleaners on health are sparse and inconclusive.
- Negative health effects arise from exposure to ozone and its reaction products. Consequently, devices that use the reactivity of ozone for cleaning the air should not be used in occupied spaces. Extreme caution is warranted when using devices in which ozone is not used for the purpose of air cleaning but is emitted unintentionally during the air-cleaning process as a by-product of their operation.

- There has been much research done on ventilation providing the solution to contamination by dilution, while the body of research on using air cleaning as an effective, energy-saving alternative to ventilation has not been equally large, especially as regards gas-phase air cleaning. Still it should be noted that the information on the effective use of air cleaning as an alternative to ventilation is growing. Limited data exist documenting the effectiveness of air cleaning as an alternative to ventilation. This applies in particular to gas-phase air cleaning. All filtration and air-cleaning technologies should be accompanied by data documenting their performance in removal of contaminants. These data should be based on established industry test standards or third-party evaluations.

The Position Document advocates that ASHRAE lead efforts in research and standardization of filtration and air cleaning. First priority should be given to advancing methods for testing performance of filtration and air-cleaning technologies, in particular the emerging technologies. Second priority should be given to maintenance procedures of filtration and air-cleaning technologies.

1. THE ISSUE

1.1 Justification of Need

Air in buildings contains various classes of contaminants: particulate matter (some biological in origin), gases, and vapors. Sources for many of these contaminants may be located either indoors (building components, occupants, and occupant activities), outdoors, or both indoors and outdoors. Filtration and air-cleaning technologies are used to reduce exposures to these contaminants in buildings by intentionally removing them from the air. The contaminants are either physically removed or participate in chemical reactions (i.e., are transformed with the intent of producing innocuous compounds). Different filtration and air-cleaning technologies are in use, depending on the class of contaminants that needs to be removed.

Filtration and air cleaning are methods for reducing exposures to contaminants indoors and thus improving indoor air quality. These methods may create viable alternatives and/or supplements to other methods for exposure reduction by supporting dilution via outdoor air ventilation by ensuring that the outdoor and/or recirculated air supplied indoors by HVAC systems is less contaminated and by improving ventilation efficacy by removing contaminants that have an indoor origin. Because these methods reduce concentrations, and thus, exposures to contaminants, many conclude that their application allows reducing outdoor airflow levels for ventilation; this belief is especially valid when outdoor air is heavily contaminated or is burdened with high humidity and thermal loads and when these technologies can remove contaminants at a lower cost than through ventilation alone.

Abundant published data show the effectiveness of different filtration and air-cleaning technologies in removing contaminants from indoors and outdoors. However, few studies document the direct effects of these technologies on health and their long-term performance, as well as their potential limitations and shortcomings. A recent comprehensive review (Zhang et al., 2011) reaffirms these observations.

1.2 Purpose and Scope

This document informs ASHRAE membership and the public about the positive, benign, or negative effects of filtration and air-cleaning technologies on health. Health effects, in the context of this position document, are understood as the effects on biomarkers, quality of life, physiological impact, symptoms, clinical outcomes, or mortality (American Thoracic Society 2000).

The document briefly characterizes the major categories of filtration and air-cleaning technologies, and their applications for removing contaminants from outdoor air brought into buildings and/or indoor air. The air-cleaning effects of plants and new air-cleaning technologies, for which there is very limited scientific and technical literature, are not considered.

The archival studies are reviewed to examine measurable health effects associated with the application of various filtration and air-cleaning technologies in public and residential buildings (excluding health-care facilities) and the extent to which cleaning and filtration technologies can offset ventilation with outdoor air for acceptable indoor air quality.

This document also describes the role and health implications of optimal use of air cleaners and the maintenance and replacement of air-cleaning media. The health issues related to disposal of filters and the elements of air cleaners are not considered.

Packaged stand-alone air cleaners using one or multiple technologies and air-cleaning and filtration systems integrated in the ventilation systems are considered as well as technologies available to and used by commercial or residential consumers.

2. BACKGROUND

2.1 Mechanical and Electronic Air Filters

2.1.1 Principles of Efficiency and Use. Mechanical filters use media with porous structures that contain fibers or stretched membrane material in a variety of fiber sizes, densities, and media extension configurations to remove particles from airstreams. A portion of the particles in the air entering a filter attaches to the media and is removed from the air as it passes through the filter. Removal occurs primarily through particle impaction, interception, and Brownian motion/diffusion, depending on particle size. Some filters have a static electrical charge applied to the media to increase particle removal.

Electronic filters include a wide variety of electrically connected air-cleaning devices that are designed to remove particles from airstreams. Removal typically occurs by electrically charging the particles using corona wires or through generation of ions (e.g., using pin ionizers) and by collecting the particles on oppositely charged deposition plates (precipitators) or by the particles' enhanced removal to a conventional media filter or to room surfaces.

The fraction of particles removed from air passing through the filter is termed *particle removal efficiency* or simply *filter efficiency* or *single-pass filter efficiency* (e.g., provided by the minimum efficiency reporting value [MERV]). For electronic filters that are portable and self-contained, the rate of particle removal from air passing through the filter is expressed as clean air delivery rate (CADR), which is approximately equal to the product of airflow rate and the contaminant removal efficiency. For most technologies, the lowest particle removal efficiency typically occurs for particles with an aerodynamic diameter of approximately 0.2 or 0.3 μm ; the removal efficiency increases above and below this particle size. The efficiency of mechanical and electronic air filters varies with filter design and particle size. The efficiency of electronic air cleaners also depends on how they are maintained.

The overall effectiveness of reducing indoor particle concentrations depends on several factors that are either related or independent of a filtration system such as the following: single-pass particle removal efficiency of the filter, the rate of airflow through the filter, location of the filter, and size of the particles. The latter include outdoor air ventilation rate, rate of deposition to surfaces, and total volume of the indoor space and related air change rate, particularly important for stand-alone (portable) air cleaners (see Section 2.5). Recirculation of indoor air through filters and refiltering blended outdoor air with return air are particularly effective for maximizing filter system effectiveness. Filtering the incoming outdoor air before this air enters the occupied space is effective in reducing indoor air concentrations of outdoor air particles, especially in airtight buildings.

ANSI/ASHRAE Standard 52.2, *Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size* (2012a), provides a method of measuring the particle removal efficiency of particle filters for particles that range in size from 0.3 to 10 μm and provides a scale for ranking filters, based on their particle removal efficiencies, called MERV; similar test methods and ranking scales are also available from other organizations. *Indoor Air Quality Guide: Best Practices for Design, Construction, and Commis-*

sioning (2009a) and Chapter 29 in the 2012 *ASHRAE Handbook—HVAC Systems and Equipment* (2012b) and provide additional information on particle filtration technologies and test methods.

2.1.2 Evidence on Health Effects. An extensive body of epidemiological research indicates that death rates, hospital admissions, and asthma exacerbations, as well as other adverse health effects increase with increased concentrations of particles in outdoor air (e.g., Brunekreef and Forsberg 2005; Delfino et al. 2005; Pope and Dockery 2006). Because much of a person's exposure to outdoor air particles occurs indoors and because this exposure can be reduced by filtration, it is reasonable to expect associated health benefits from particle filtration that is effective in removing particles having outdoor origin.

Published relationships between outdoor air particle concentrations and adverse health effects have been used in models to predict the related health benefits of particle filtration. The resulting papers, reviewed by Fisk (2013), indicate substantial health benefits associated with filtration, with benefits generally proportional to the reduction in total exposure to particles less than 2.5 μm in diameter. The models considered numerous health or health-related outcomes, including mortality, cardiac or respiratory-related emergency room visits or hospital admissions, chronic bronchitis, and asthma exacerbation. Because most of these health outcomes occur in a small portion of the population, very large empirical studies would thus be needed to confirm these predictions, and such studies have not been performed. Two studies found statistically significant improvements with filtration in biomarkers that predict future adverse coronary events (as cited in Fisk 2013), providing some empirical support for the model predictions of health benefits.

Many studies have experimentally investigated whether the use of particle filtration systems in homes reduces self-reported symptoms of allergies or asthma or improves related objectively measured health outcomes such as forced expiratory volume or biomarkers of inflammation in people who are allergic or asthmatic. Most of these studies used stand-alone (portable) fan filter systems incorporating high-efficiency particle air (HEPA) filters that can remove particles with a minimum efficiency of 99.97% for 0.3 μm particles. A few studies investigated whether use of particle filtration systems in offices or schools reduce nonspecific self-reported health symptoms, often called sick-building syndrome (SBS) symptoms, in the general population. The origin of the particles removed was not identified. Most of these studies report reduced indoor air particle concentrations of 20% to 80%, and 50% a typical reported value. Nearly all of the studies used mechanical filters. A recent review on the effects of air filtration (Fisk 2013) considered the recently published literature and the results of prior reviews (IOM 2000; Reisman 2001; McDonald et al. 2002; Wood 2002; Sublett et al. 2010; Sublett 2011). It concluded that particle filtration could be modestly effective in reducing adverse allergy and asthma outcomes, particularly in homes with pets. It also concluded that particle filtration systems that deliver filtered air to the breathing zone of sleeping allergic or asthmatic persons might be more consistently effective in improving health than use of room or whole-house filtration systems. The review additionally concluded that the limited available evidence suggests that particle filtration in buildings (homes, offices and schools) is not very effective in reducing acute health symptoms (SBS symptoms) in persons without asthma and allergies.

Several communicable respiratory diseases are transmitted, in part, by inhalation of small airborne particles containing infectious virus or bacteria produced during coughing, sneezing, singing, and talking. The portion of total disease transmission that occurs via this mechanism

is uncertain and debatable. Particle filtration systems can reduce indoor airborne concentrations of these particles by removing them from the airstream but not by inactivating infectious species. Filtration may thereby reduce the incidence of the associated communicable respiratory diseases, provided the airstream transports the particles to the filtration system. The results of modeling suggest that having filters in HVAC systems, relative to having no filters, will substantially decrease the portion of disease transmission caused by these small particles (Azimi and Stephens 2013). However, the model assumptions and inputs have a high level of uncertainty. In addition, experimental data outside of health-care facilities are not available to confirm the predictions; there are no strong studies empirically documenting that filtration reduces respiratory infections in people outside of a health-care environment with highly susceptible patients.

The data on the health consequences of electronic particle air cleaners are sparse, but it is reasonable to expect that electronic air cleaners affect health similarly to mechanical filters of equivalent particle removal performance. There are electronic air cleaners (e.g., ion generators) that produce ozone and thus may cause deleterious health effects, as described in Section 2.6, Ozone-Generating Devices. One class of particle air cleaners, ion generators, has been investigated for its ability to reduce acute health symptoms (SBS symptoms), but the literature is unclear as regards the presence and size of effects on symptoms. Of the eight studies on the subject, there are an approximately equivalent number of findings of a positive effect and of no significant effect (or a negative effect) on one or more SBS symptoms (Hawkins and Barker 1978; Fishman 1981; Laws 1982; Hawkins and Morris 1984; Wyon 1992; Shaughnessy et al. 1994; Rosen and Richardson 1999; Richardson et al. 2001). Variations in sample size, presence or lack of a placebo, and presence of a control group make it difficult to form conclusions that are more definitive.

2.2 Sorbent Air Cleaners

2.2.1 Principles Efficiency, and Use. Sorbent air cleaners involve physical adsorption (physisorption) and chemisorption to remove gaseous contaminants from airstreams. Physisorption is adsorption of gaseous contaminants onto solid porous materials due to Van der Waals forces (nuclear attraction) and condensation in the small pores. This is a reversible process due to relatively weak forces: gases once adsorbed can later desorb back into the airstream. The most common adsorbent used is activated carbon; others include activated aluminas (aluminum oxides), natural and synthetic zeolites in granular form, oxides of silicon, molecular sieves, and various polymers. Chemisorption involves both adsorption and instantaneous irreversible chemical reactions on the sorbent surface to which specific chemical additives or impregnates are added during the manufacturing process to make them more or less specific for individual contaminants or contaminant types (e.g., acid gases). Common adsorbents include activated alumina impregnated with potassium or sodium permanganate and activated carbons impregnated with acidic or basic compounds. Desorption of target contaminants, once adsorbed and chemically reacted, does not occur.

An air-cleaning system using a single gas-phase (or dry-scrubbing) air-filtration medium may not be adequate for the control of multiple contaminants (Muller and England 1994, 1995). Thus, it is common to have a system that uses a combination of both physical and chemisorptive media to provide removal of a wide range of gaseous contaminants.

Adsorbent materials do not adsorb all contaminants equally. The adsorption capacity for nonpolar organics increases with the boiling point, molecular weight, and concentration of the

air contaminant. Low molecular weight (less than 50 u [previously termed amu]) and/or highly polar compounds such as formaldehyde, methane, ethanol, etc., will not be readily adsorbed at low concentrations. Compounds with molecular weight >80 u and nonpolar compounds may be preferentially adsorbed over lower molecular weight and polar compounds. In physical adsorption, polar gas molecules are best removed by polar adsorbents, while nonpolar adsorbents are best for removing nonpolar gases (e.g., activated carbon has a nonpolar surface). The initially adsorbed compounds with lower molecular weight and nonpolar compounds may also be desorbed when a higher molecular weight and polar compounds are present through competitive adsorption. A sufficient depth of sorbent bed may re-adsorb some displaced molecules.

Adsorbent-based systems can remove a broad range of contaminants with moderate to high efficiency. The net rate of adsorption depends on the rate at which contaminant molecules reach the surface of the media, the percentage of those making contact, which are adsorbed, and the rate of desorption.

Some evidence is available on the long-term performance of sorbents in commercial buildings in studies that have examined the performance and effectiveness of air-cleaning systems that have been in continuous use for up to 30 years (Bayer et al. 2009; Lamping and Muller 2009; Burroughs et al. 2013). Relatively accurate estimates of sorbent lifetimes can be obtained when target contaminants are identified and by using their known or expected concentrations in air and the individual removal capacities for each (Muller 2012). Actual sorbent life may be determined by taking periodic samples for life testing or through direct contaminant monitoring. More often, though, sorbents are replaced based on routine maintenance cycles or fiscal considerations. Although there exist physisorbents that may be regenerated, this is not economically viable for the amounts typically contained in commercial HVAC systems and portable air cleaners; thus, they need to be periodically replaced.

Other details regarding removal of gaseous air contaminants can be found in *ASHRAE Handbook—HVAC Applications*, Chapter 45, Control of Gaseous Indoor Air Contaminants (2011) and in *ASHRAE Handbook—Fundamentals*, Chapter 11, Air Contaminants (2013a).

2.2.2 Evidence on Health Effects. At present, almost no empirical data are available to enable drawing conclusions about the health benefits of using sorbents in typical buildings, other than anecdotal data describing ancillary benefits of air cleaning on elementary school studies and human embryos (Cohen et al. 1997; Hall et al. 1998; Lamping et al. 2009).

There are, on the other hand, data from laboratory studies that investigated the effects of sorbent air cleaning on initial perceptions of air quality immediately upon entering a laboratory or upon smelling air drawn from a test system (i.e., on perceptions of unadapted individuals, such as visitors to a space, and not on perceptions of adapted persons, such as occupants staying for an extended time in a space) (e.g., Shaughnessy et al. 1994; Fang et al. 2008; Bekö et al. 2008, 2009). These studies showed significantly improved ratings of acceptability or satisfaction with air quality and odor intensities with sorbents. Although perception of air quality comfort is not a health outcome, it may be considered an indicator of a potential subsequent effects of exposures on health.

2.3 Air Cleaners Using Photocatalytic Oxidation

2.3.1 Principles Efficiency and Use. *Photocatalytic oxidation* (PCO) is defined as a light-mediated, redox reaction of gases and biological particles adsorbed on the surface of a solid pure or doped metal oxide semiconductor material or photocatalyst. The most common

photocatalyst is TiO_2 (titanium dioxide), while zinc oxide (ZnO), tungsten trioxide (WO_3), zirconium dioxide (ZrO_2), cadmium sulfide (CdS), and iron (III) (Fe(III) -doped TiO_2), among others, are also used. Dopants (e.g., iron [Fe], platinum [Pt], silver [Ag]) can have a beneficial effect on the performance of the metal oxide photocatalyst. The photocatalyst generates oxygen species (or reactive oxygen species [ROS]) that remain surface-bound when exposed to light of particular wavelengths in the ultraviolet (UV) range. The oxygen species are highly reactive with adsorbed gases and biological particles. A variety of UV light sources can be used in PCO, including black lights (UV-A: long-wave; 400 to 315 nm), germicidal lamps (UV-C: short-wave; 280 to 200 nm), and lamps that generate ozone (vacuum UV [UV-V]: under 200 nm). Under reaction conditions allowing for deep oxidation (referred to as mineralization), carbon, hydrogen, and oxygen atoms in the reacting species are converted completely via chemical reaction to water vapor and carbon dioxide. In case the conditions do not promote deep oxidation, for example, due to insufficient residence time because of increased airflow through reactor or the presence of halogenated compounds, PCO can produce intermediate species (by-products) that remain bound to the surface of the photocatalyst or desorb and become airborne.

Nearly all organic, gaseous indoor air contaminants and microbes are subject to PCO decomposition (e.g., Zhang et al. 2011; Dalrymple et al. 2010). The efficiency of catalytic oxidizers depends partially on the functional group of contaminants passing through the PCO device. Higher efficiency is observed for oxygenated compounds such as alcohols, ketones, and some aldehydes; intermediate efficiency for aromatics; and lower efficiencies for chlorocarbons. The PCO conversion rates (or fraction of contaminant removed in a single pass) vary depending on the contaminant and the system design from 0% to nearly 100%, with longer residence times needed to achieve higher (single-pass) efficiencies. Efficiencies of PCO air cleaners and by-products formed by them depend on the design of the device, the indoor air setting (e.g., contaminant composition, relative humidity, temperature) in which they are used, and how the device is maintained.

A systematic parametric evaluation of several performance variables was reported for two styles of PCO air filters: TiO_2 coated on fiberglass fibers (TiO_2/FGFs) and TiO_2 coated on carbon cloth fibers (TiO_2/CCFs) (Zhong et al. 2013). The contaminant destruction rates varied with contaminant class and type of UV source, while formation of by-products correlated with PCO reaction mechanisms for each VOC.

The advantages of PCO are the relatively low pressure drop, ability to treat a wide variety of compounds, and theoretically long life cycle of the reactive process (the self-cleaning or regenerating feature of a photocatalyst). The disadvantages include the lamp energy, lamp replacement costs, and the likelihood of ozone generation depending on lamp source employed (e.g. UV-V lamps ~185 nm produces ozone (O_3)). (It has been shown by Ohtani et al. [1992] that irradiation greater than 200 nm and less than 400 nm, in particular UV-C (254 nm), over TiO_2 will decompose O_3). There is also the potential of an incomplete oxidizing process, which produces by-products of reaction that can be more toxic or harmful than the original constituents (e.g., formaldehyde). The catalysts can be contaminated (poisoned) by airborne reagents and/or products of oxidation, which results in reduced or total efficiency failure of the process. Incomplete decomposition of some organic contaminants and net production of formaldehyde, acetaldehyde, formic acid, and acetic acid were shown by Hodgson et al. (2007), who investigated PCO using mixtures of up to 27 organic contaminants in concentrations reflecting the levels typically occurring indoors. Chemisorbent media positioned downstream of a UVPCO air cleaner effectively counteracted the generation of aldehydes due to incomplete oxidation of volatile organic compounds (VOCs) in UVPCO reactors (Hodgson et al. 2007).

Other details about PCO can be found in reviews (e.g., Mo et al. 2009) as well as ASHRAE RP-1134 (Tompkins et al. 2005).

2.3.2 Evidence on Health Effects. No studies are available with respect to the direct health effects associated with the use of PCO air-cleaning equipment in indoor environments. Some studies looked at the effects of PCO on perceived air quality, which, as mentioned above, may be considered as an indicator of potential subsequent effects of exposures on health. These studies found significant reductions in the percentages of persons dissatisfied with air quality in rooms contaminated by nonhuman sources of contamination during operation of PCO (Kolarik and Wargocki 2010; Kolarik et al. 2010). However, when the air was contaminated by human bioeffluents, the percentages of persons dissatisfied with air quality significantly increased, suggesting that the air quality was considerably worsened (Kolarik and Wargocki 2010). It was suggested that the alcohols that are a major part of human bioeffluents and their incomplete oxidation are responsible for the observed results.

2.4 Air Cleaners Using Ultraviolet Germicidal Energy (UV-C)

2.4.1 Principles of Efficiency and Use. Ultraviolet (UV-C) disinfection (also called *ultraviolet germicidal irradiation* [UVGI]) is used to degrade organic material and inactivate microorganisms. The system is not a filter; thus, inactive particles remain in the airstream, which, in the case of dead fungal spores, may still cause a negative human response to their integral mycotoxins. The most effective wavelength range for inactivation of microorganisms is between 220 and 300 nm, with peak effectiveness near 265 nm. The typical source of UV-C in commercial and residential air and water systems is low-pressure mercury vapor lamps, which emit mainly near-optimal 253.7 nm. UV-C systems may be installed inside HVAC systems, irradiate air near the ceiling, or be incorporated in a stand-alone (portable) air cleaner.

The effectiveness of a UV-C system to inactivate microorganisms in the air and/or on surfaces has been amply demonstrated; the best results were obtained for the long-term irradiation of downstream coil surfaces to avoid fungal amplification on wet surfaces. Experience suggests that control of a moving airstream does not provide favorable killing rates because of the short dwell time. Under ideal conditions, inactivation and/or killing rates of 90% or higher can be achieved but depend on the following: the type of microbial contaminant; specific species; physical or mechanical factors such as UV-C intensity, exposure/dwell time, lamp distance and placement, and lamp life cycle and cleanliness; air movement and patterns; temperature; relative humidity; and air mixing. Airborne removal is best applied in conjunction with filtration of particles with prefiltration in order to protect lamps and mechanical filtration downstream for microbial particles.

Proposed ASHRAE Standard 185.1 provides a method for testing UV-C lights for use in air-handling units or air ducts to inactivate airborne microorganisms, and ASHRAE Standard 185.2-2014 provides a method of testing ultraviolet lamps for use in HVAC units or air ducts to inactivate microorganisms on irradiated surfaces.

Chapter 17 in the 2012 *ASHRAE Handbook—HVAC Systems and Equipment* (2012b) provides additional information on ultraviolet lamp systems.

2.4.2 Evidence on Health Effects. Several studies have addressed the application of UV-C systems in health-care facilities. Some of these studies show health benefits for highly susceptible patients (Miller et al. 2002; CDC/NIOSH 2009; Memarzadeh et al. 2010). However, there

is limited evidence on the direct effects of UV-C on health, particularly when applied outside of health-care settings. Menzies et al. (2003) showed a significant reduction in work-related, self-reported acute health symptoms (SBS symptoms) when the UV-C system in ventilation ducts was irradiating cooling coils and drain pans, compared to when it was powered off. Bernstein et al. (2006) irradiated particles (not the cooling coils or drain pans) using UV-C systems in air moving through the ventilation ducts of homes of mold-sensitized, allergic children. Operation of UV-C, relative to a placebo system containing a blue light produced significant alleviation of several asthma outcomes. Upper-room air UV-C systems applied in studies in schools, military barracks, and homeless shelters provide inconsistent effects on tuberculosis, measles, influenza, and common colds (Kowalski 2009).

Fungal contamination found in ventilation systems may contribute to fungal infections in individuals with compromised immune systems, may release contaminants to occupied spaces (Ahearn et al. 1997; Ezeonu et al. 1994; Levetin et al. 2001; Mahoney et al. 1979; Mendell and Smith 1990; Samson 1985), and may possibly contribute to SBS symptoms and other building-related diseases, such as hypersensitivity pneumonitis, allergic rhinitis, and asthma exacerbation (Burge 1990; Lacey 1991; Levetin 1985). UV-C has been shown to be effective in reduction of microbial and endotoxin agents (Menzies et al. 2003), which can breed and accumulate in ventilation systems, especially where condensation of water vapor occurs; however, no direct evidence of health benefits exists other than the study cited above (Menzies et al. 2003).

UV-C systems have been shown to reduce tuberculosis infection in guinea pigs housed in cages ventilated with air drawn from tuberculosis wards (Riley et al. 1957, 1962; Escombe et al. 2009). In the laboratory studies, UV-C has been effective in removing bacterial aerosols and viral aerosols (Xu et al. 2003). To this end, UV-C for upper air, in-duct, and in-room systems was named by ASHRAE's 2014 *Position Document on Airborne Infectious Diseases* as among the two highest research priorities for developing engineering control to reduce infectious disease transmission (ASHRAE 2014b).

2.5 Packaged Air Cleaners Using Multiple Technologies

Many air-cleaning devices use a combination of filters (i.e., particle air-cleaning technologies and gas-phase air-cleaning technologies). The devices are often stand-alone (portable), incorporate a fan, and are intended for residential use. These devices are frequently called *air purifiers* or *clean-air delivery (CAD) devices*, but many other names are used as well.

Many packaged air cleaners using multiple technologies are tested using the protocol of the Association of Home Appliance Manufacturers (AHAM) (AHAM 2013) to determine performance reported as the clean-air delivery rate (CADR) for specific contaminants (usually dust, tobacco smoke, and pollen). The performance is a function of the inherent efficiency of the air-cleaning technologies used and the device airflow rate, as well as the indoor setting (see previous sections [Sections 2.1 to 2.4] for the factors influencing effectiveness of air cleaning process).

Presently, minimal data are available on the health consequences of using packaged air cleaners employing multiple technologies.

2.6 Ozone-Generating Air-Cleaning Devices

Certain air cleaners produce ozone by design to achieve air-cleaning effects and the removal of contaminants. Additionally, ozone can be produced as a by-product of air-cleaning processes. Any air-cleaning device that uses electricity during air cleaning process has the potential to generate ozone. In practice, ozone generation is associated with air cleaners that

use high-voltage coronas or pin ionizers (e.g., some precipitators or ionizers), UV light of a sufficiently small wavelength (some photocatalytic oxidizers and UV-C air cleaners), and by some plasma air cleaners. Packaged air cleaners employing different air-cleaning technologies may use or produce ozone; examples include ozone generators or ionizers.

Ozone is harmful for health and exposure to ozone creates risk for a variety of symptoms and diseases associated with the respiratory tract (Koren et al. 1989; Touloumi et al. 1997; Bell et al. 2004). Many products of ozone homogeneous and heterogeneous reaction processes also create risks for health, including formaldehyde, unsaturated aldehydes (produced during the reaction of ozone with ketones and alcohols), and ultrafine particles (secondary organic aerosols) (Weschler 2006).

Ozone emission is thus undesirable. However, there is no consensus on the safe level of ozone. For example, ASHRAE's Environmental Health Committee (2011b) issued an emerging issue brief suggesting "safe ozone levels would be lower than 10 ppb" and that "the introduction of ozone to indoor spaces should be reduced to as low as reasonably achievable (ALARA) levels." Still, even widely used guidelines are not entirely consistent with all available epidemiological literature on the effects of ozone, and there is relatively little known about the long-term effects of exposure to low concentrations of ozone.

The current state of the science regarding the health effects of ozone strongly suggests that the use of air cleaners that emit ozone by design should not be permitted; the same information and advice is given by the U.S. EPA, among others (EPA 2013). There is more uncertainty about recommendations for air cleaners that do not use ozone by design for air cleaning but produce ozone unintentionally, as a by-product of their operation. There are devices that emit ozone but at the same time reduce concentrations of other harmful contaminants. The state of the science does not allow making highly certain trade-offs between increased exposure to ozone and the ozone reaction by-products and reduced exposure to other contaminants.

In the absence of robust information regarding safe levels of ozone, the precautionary principle should be used. Any ozone emission (beyond a trivial amount that any electrical device can emit) should be seen as a negative and use of an ozone-emitting air cleaner, even though the ozone is an unintentional by-product of operation, may represent a net negative impact on indoor air quality and thus should be used with caution. If possible, non-ozone-emitting alternatives should be used.

Attention must be paid to certain air-cleaning technologies that claim to produce radicals (e.g., hydroperoxy, peroxy, and hydroxyl radicals) that become airborne (gaseous state) as a means of effecting air cleaning/treatment. These species are ROS and are well known to be very short-lived in the gas-phase (airborne). Few studies in the peer-reviewed literature, if any, have measured these radicals in the gas phase as a means of an effective air treatment with such air-cleaning technologies.

2.7 Filtration and Air Cleaning Versus Ventilation

Filtration and air cleaning reduce exposures to selected air contaminants generated indoors, similar to outdoor air ventilation. Unlike ventilation, these methods can also reduce exposures to contaminants in outdoor air. The effectiveness of filtration and air cleaning is frequently expressed as the equivalent rate of outdoor air ventilation intake flow that would have to be provided to achieve the same effect. However, unlike outdoor air ventilation (essentially reducing concentrations and exposure to the majority of indoor-generated contaminants), filters and air cleaners (unless integrated) deal with one group of contaminants: either with particles, some

types of gases, or microbial contaminants. The effectiveness is consequently the removal efficiency for a single contaminant, a class of contaminants, or a mixture of contaminants (Zhang et al. 2011).

To be expedient, the size of the effect obtained by filtration and air cleaning must be weighed against efficiency of other removal mechanisms (Nazaroff 2000) (i.e., outdoor air ventilation and removal by deposition to surface, see Section 2.1.1). For example, in the case of portable household electric room air cleaners, the product of single-pass efficiency and airflow due to air cleaning should be four times the sum of removal by ventilation and by deposition to meet the target of 80% continuous removal of particles (i.e., 20% or less of the initial particle load in a room, as defined by AHAM Air Cleaner Council [2013]). Furthermore, the cost and energy implications must be taken into account when comparing the effect obtained by filtration and air cleaning with outdoor air ventilation.

The Indoor Air Quality (IAQ) Procedure of ASHRAE Standard 62.1 (2013b) allows that filtration and air cleaning, together with recirculation, can be used as a substitute for a portion of outdoor air ventilation. This is conditional upon detailed analysis of contaminant sources, rates of contaminant removal by air-cleaning systems, contaminant concentration targets, and perceived acceptability targets (Burroughs 2006; Lamping and Stanley 2008; Grimsrud et al. 1999, 2011; Stanley et al. 2007; Dutton et al. 2013). There is, however, only limited scientific evidence showing that outdoor air ventilation intake flow can be partially or completely replaced by filtration and air cleaning.

One consideration that warrants discussion is that the overlap between contaminants with indoor sources versus those with external (outdoor) sources is relatively small and the use of increased ventilation air without filtration and air cleaning can result in substituting one set of contaminants (internally generated) with a different set (externally generated) with any associated health effects. This is especially important in regions that do not meet national or regional air quality standards for one or more criteria pollutants (i.e., ozone, PM₁₀, PM_{2.5}) or where there may be local sources of air pollution. In these instances outdoor ventilation air should be cleaned before being introduced into the building.

2.8 Maintenance, Commissioning, and Long-Term Performance of Filtration and Air-Cleaning Devices

At the design phase, filters and air cleaners are generally assumed to be installed and operating correctly. In actual installations, there could be air and contaminant bypass around air-cleaning devices (Ward and Siegel 2005), degradation in the performance of some technologies over time (Lehtimäki et al. 2002), and potential for the emission of primary and/or secondary by-products (Zhao et al. 2007; Rim et al. 2013).

Commissioning, active maintenance, and monitoring of filtration and air-cleaning devices are needed to ensure design performance. Additionally, filtration and air cleaners should be tested for extended durations to examine the possible change of performance in time of operation and the minimum period at which regular performance checks should be made. Information on these aspects is nearly nonexistent, and there are nearly no documents regulating and necessitating examination of long-term performance of filtration and air cleaning devices.

Indoor Air Quality Guide: Best Practices for Design, Construction, and Commissioning (ASHRAE 2009a), as well as NAFA's *Installation, Operation and Maintenance of Air Filtration Systems* (2012), provides guidance on maintenance and commissioning of filtration and air cleaning.

3. CONCLUSIONS AND RECOMMENDATIONS

3.1 Summary Statements on Performance of Filtration and Air-Cleaning Devices

The following statements on filtration and air cleaning are proposed taking into account the evidence in the literature on their effects on health outcomes in public and residential buildings (excluding health-care facilities which were briefly summarized in the preceding chapters). The positions do not define minimum efficiency levels at which the effect of filtration and air cleaning can be regarded as providing health benefits, because the magnitude of the effects obtained by filtration and air-cleaning technologies depends on the design, operation, and setting in which these technologies are operated in a building. Also, in many cases there are no thresholds available for health effects, and regulatory exposure limits vary greatly among different cognizant authorities. Finally, the statements do not take any position on whether certain types of filtration and air-cleaning technologies should or should not be used in the built environment and under which conditions (except the position on ozone-generating devices and the long-term performance of filtration and air-cleaning devices); it was not the objective of the present document. It is regarded that the decision on this matter belongs to other committees setting out regulatory and guiding documents (codes, standards, and guidelines).

- Filtration technologies, in which particles are removed by attaching them to the media (often called *mechanical* or *media filters*), have been documented to be capable in many cases of reducing particle concentrations substantially, including reductions from levels being above to levels being below the associated regulatory exposure limits for reducing health risk set by recognized cognizant authorities. Modest empirical evidence suggests that mechanical filters will have positive effects on health, especially for reducing adverse allergy or asthma outcomes, but not on acute health symptoms in the general population, often called *sick-building syndrome (SBS) symptoms*. Models predict large reductions in morbidity and mortality associated with reduction of indoor exposures to particles from outdoor air, but these health benefits have not been verified empirically.
- Filtration technologies that generate electrical fields and/or ions, often called *electronic filters*, have been documented to range from relatively ineffective to very effective in reducing particles substantially, including reductions from levels being above to levels being below the associated regulatory exposure limits for reducing health risks set by recognized cognizant authorities. Within this broad characterization of air cleaners, ionizers have been evaluated to either show benefits or no benefits for acute health symptoms. Many electronic air cleaners emit significant ozone and are thus subject to special attention as advised by Position 1 in Section 3.2.
- There are sorbent air cleaners that have been documented to reduce concentrations of harmful gaseous contaminants substantially, including reductions from levels being above to levels being below the associated regulatory exposure limits for reducing health risks set by recognized cognizant authorities. There are very limited data on long-term effectiveness of these air cleaners for indoor air applications with mixtures of contaminants at low concentrations. Minimal empirical data exist on the health effects of using sorbent-based air-cleaning technologies.
- Air cleaners using photocatalytic oxidation (PCO) have been documented to remove harmful contaminants to levels being below the associated regulatory exposure limits for reducing health risks set by recognized cognizant authorities. However, there are PCO

technologies that are ineffective in reducing concentrations significantly, and there are PCO technologies that have also been shown to generate harmful contaminants during the air-cleaning process. No empirical data exist on the health effects of using PCO technologies. Different UV lamps used in many PCO devices can emit significant ozone and are thus subject to special attention as advised by Position 1 in Section 3.2.

- Short-wave ultraviolet (UV-C) energy has been documented to inactivate viruses, bacteria, and fungi. Some air-cleaning technologies using UV-C disinfection (also termed *ultra-violet germicidal irradiation* [UVGI]) have been documented, in a few studies, to show beneficial health effects when upper-room air, ventilation ducts, and evaporator coil surfaces were irradiated with UV-C. Some studies have failed to detect health benefits. Some UV lamps can emit significant ozone and are thus subject to special attention as advised by Position 1 in Section 3.2.
- Packaged air cleaners using multiple filtration and air-cleaning technologies are room air appliances intended for residential and small-space application. Their performance is subject to the advantages and disadvantages of the filtration and air-cleaning technology incorporated within the devices. Scientific documentation of the health effects of these devices on occupants is sparse and inconclusive. Some of the technologies incorporated into these devices either produce or rely on ozone for application and are thus subject to special attention as advised by Position 1 in Section 3.2.
- Filtration and air-cleaning technologies are often regarded as an attractive alternative to ventilation, enabling a reduction of outdoor air ventilation rate. The Indoor Air Quality (IAQ) Procedure of ASHRAE Standard 62.1 allows lower ventilation rates if alternative methods are used to reduce exposures to contaminants of concern, including the use of filtration or air cleaning. Limited data exist documenting the effectiveness of air cleaning, in particular gas-phase air cleaning, as an alternative to ventilation.

3.2 Positions on the Use of Filtration and Air-Cleaning Devices

ASHRAE holds the following positions on filtration and air-cleaning devices:

1. Devices that use the reactivity of ozone for the purpose of cleaning the air should not be used in occupied spaces because of negative health effects that arise from exposure to ozone and its reaction products. Extreme caution is warranted when using devices that emit a significant amount of ozone as by-product of their operation, rather than as a method of air cleaning. These devices pose a potential risk to health.
2. All filtration and air-cleaning technologies should be accompanied by data documenting their performance regarding removal of contaminants; these data should be based on established industry test standards. If not available, scientifically controlled third-party evaluation and documentation should be provided.

3.3 Recommendations on Future Developments of Filtration and Air-Cleaning Devices

Further development of filtration and air cleaning is needed, particularly in the following areas:

1. Quality control of operation of filtration and air-cleaning technologies, especially regarding data on their long-term performance.
2. Development of regulatory and guiding documents supporting design, operation, and maintenance of filtration and air cleaning devices.

3. Modification of methods of charging particles by electronic air cleaners to reduce the generation of ozone.
4. Integration of different filtration and air-cleaning technologies.
5. Development of air-cleaning technologies that support ventilation by removing air contaminants for which ventilation is less effective, such as proven and practical systems for removing ozone and possibly other gaseous pollutants from the air entering buildings.
6. Research on and application of intermittent use of filtration and air cleaners to deal with peak loads or unexpected releases of contaminants.
7. The extent to which air cleaning can enable reduction in outdoor air ventilation rates.

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List of ASHRAE cognizant committees:

- TC 2.3, Gaseous Air Contaminants and Gas Contaminant Removal Equipment
- TC 2.4, Particulate Air Contaminants and Particulate Contaminant Removal Equipment
- SSPC 52.2, Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size
- SSPC 62.1, Ventilation for Acceptable Indoor Air Quality
- SPC 62.2, Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings
- SPC 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings
- SSPC 145, Test Method for Assessing the Performance of Gas Phase Air Cleaning Equipment
- SPC 170, Ventilation of Health Care Facilities
- SPC 180, Standard Practice for Inspection and Maintenance of Commercial-Building HVAC Systems



ASHRAE Position Document on Unvented Combustion Devices and Indoor Air Quality

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COMMITTEE ROSTER

The ASHRAE Position Document on Unvented Combustion Devices and Indoor Air Quality was developed by the Society's Unvented Combustion Devices Position Document Committee formed on April 13, 2007.

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HISTORY OF REVISION/REAFFIRMATION/WITHDRAWAL DATES

The following summarizes this document's revision, reaffirmation, or withdrawal dates:

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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.

ABSTRACT

This document provides information and ASHRAE's positions based on the current state of knowledge of unvented combustion appliances. These appliances may be found in almost any occupancy. ASHRAE's position is that appliance standards and technology should be reviewed in light of increased knowledge of usage patterns and evolving air quality standards related to combustion by-products; a public information program should be developed that improves the knowledge of owners of these appliances with regard to usage and the importance of professional installation and maintenance; and research should be performed on these appliances to answer remaining questions about their impact on indoor air quality. Specific research questions relate to particle emissions, nitrogen dioxide emissions, the relative impact of cooking versus heating, and denatured alcohol kerosene appliances.

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EXECUTIVE SUMMARY

This position document has been written to provide ASHRAE's membership and other interested persons with information about the effect of unvented combustion devices on indoor air quality and to provide recommendations for the proper use of these devices.

ASHRAE's sole objective is to advance the arts and sciences of heating, refrigeration, air conditioning and ventilation, and their allied arts and sciences and related human factors, for the benefit of the public. Therefore, the impact and proper use of unvented combustion devices are relevant to ASHRAE.

ASHRAE's positions at present are:

- Users should properly operate unvented appliances installed in the home and get an annual inspection by a qualified service technician.
- A public education program should be developed that reinforces the health and safety information contained in industry literature.
- Unvented combustion appliances should never be used as the primary/sole source of heating.
- Consumers who want to reduce the risk of adverse health effects due to exposure to combustion products should not use unvented appliances.
- Carbon monoxide (CO) alarms should be installed in all homes regardless of heating fuel type.
- Gas cooking appliances with electronic ignitions should be selected when possible.
- Permanently mounted unvented combustion appliances should be installed according to the manufacturers' installation instructions and local codes and installation should be performed by a qualified installer.
- A reassessment of ventilation should be made when air-sealing measures have been implemented to a building containing an unvented appliance, with ventilation added when appropriate.
- Unvented gas-fired room heaters listed to a pre-1983 edition of ANSI Z21.11.2 and not equipped with an Oxygen Depletion Safety (ODS) device should be replaced immediately.
- Unvented kerosene room heaters should be removed unless listed to UL 647 and new installations should be avoided unless future research demonstrates adequate indoor air quality when they are used.
- Unvented denatured alcohol appliances should be removed unless listed to UL 1370 and new installations should be avoided unless future research demonstrates adequate indoor air quality when they are used.
- Research should be performed that investigates the effects of unvented space heater combustion on indoor air quality in residential buildings. Particular questions of interest include:
 1. the suitability of the ANSI Z21.11.2 emission standards for nitrogen dioxide (NO₂)
 2. the performance of units subject to ANSI Z21.11.2-2005 or later in the field with regard to NO₂
 3. particle emissions and their effect
- Research should be performed on kerosene and denatured alcohol appliance emissions and resulting indoor air quality.

- Research should be performed that investigates the effects of gas cooking combustion on indoor air quality in residential and commercial buildings. Particular questions of interest include:
 1. disaggregating the gas combustion from the cooking process
 2. emissions of NO₂, CO, and particles from modern units
 3. differences between range top cooking compared to oven cooking
- Industry sizing and installation guidance should be revisited in light of changes in housing stock.
- Code- and standard-making entities should require that installers be certified.
- Appliance standards should be reviewed and updated as needed in light of more recent understanding and standards/guidelines on acceptable levels of NO₂.
- Appliance standards should be reviewed and updated as needed in light of evidence that extended use is not uncommon and can result in unacceptable levels of CO, with considerations made to incorporating controls that prevent excessive durations of uninterrupted operation. These standards should also require that product information include language on the risks from extended use.

1. ISSUES

This position document discusses the effect of using unvented liquid and gas fuel combustion devices on indoor air quality. It addresses the various constituents within the products of combustion that are emitted from unvented combustion appliances into the indoor space and the appropriate measures that should be considered in order to maintain acceptable indoor air quality. Historically, indoor air quality problems from combustion devices have been related to their not being properly installed and maintained by a qualified service person and not being used in accordance with manufacturers' instructions.

Various appliances are designed to operate on different fuel types or are intended to be used for different space heating or cooking applications. Safety standards covering these products differ in the maximum allowable emissions of certain combustion by-products. Because of these differences, each type of device is addressed separately throughout this document.

Unvented combustion emissions from candles, incense, and devices that burn solid fuels are excluded from this position document.

2. BACKGROUND

Unvented combustion equipment may be found in almost any occupancy classification, although some are more common than others. Unvented heaters are permitted to be installed in most jurisdictions, but prohibitions or restrictions exist in some locations. All state codes permit the installation of unvented cooking appliances.

The National Fuel Gas Code, ANSI Z223.1/NFPA 54 published jointly by the National Fire Protection Association (NFPA) and the American Gas Association (AGA), governs the installation of unvented gas-fired room heaters, but prohibits installation in certain occupancies, which include residential board and care or health care (ANSI Z223.1/NFPA 54-2009). The International Fuel Gas Code, published by the International Code Council (ICC), also governs the installation of unvented gas-fired room heaters but prohibits installation in assembly, educational, and institutional occupancies (ICC 2012). NFPA 501, Standard on Manufactured Housing prohibits the installation of unvented room heaters in manufactured housing as part of the construction code (NFPA 501-2010). Once the manufactured home is sited, unvented gas-fired room heaters can be installed where allowed by state and local code.

The Life Safety Code (NFPA 101-2012), allows gas-fired room heaters that are in compliance with ANSI Z223.1/NFPA 54 but prohibits the use of unvented fuel-fired heating equipment, including kerosene and denatured alcohol, from being used in educational, day care, rooming/lodging, hotel/dormitory, apartment, and health care occupancies. Portable space heating devices are prohibited in detention/correctional facilities.

Unvented combustion heaters, including propane and natural gas-fired heaters listed to the *Standard for Gas-Fired Room Heaters, Vol. II, Unvented Room Heaters* (ANSI Z21.11.2-2007), and kerosene heaters listed to the *Standard for Unvented Kerosene-Fired Room Heaters and Portable Heaters* (UL 647-1993), are most commonly found in residential occupancies.

Gas-fired room heaters, especially gas log types, are sometimes used in hotel/lodging common areas and assembly occupancies, such as restaurants, for their aesthetic effect.

In commercial building and storage occupancies the use of unvented combustion room heaters is very rare, although not prohibited by NFPA 101 or the International Fuel Gas Code (IFGC). Unvented infrared radiant heaters can be found in industrial occupancies, such as aircraft hangers, repair garages, or similar large open spaces requiring localized heating for the workers.

The Third National Health and Nutrition Examination Survey (NHANES III) estimated that 13.7 million adults have at some time used an unvented combustion space heater. Since 1992, use of unvented combustion heaters has increased because in many states, regulations prohibiting the use of these devices have been rescinded (MMWR 1997).

About 170 people in the United States die every year from carbon monoxide (CO) produced by non-automotive consumer products. These products include malfunctioning fuel-burning appliances such as furnaces, gas ranges, water heaters, room heaters, engine-powered equipment such as portable generators, solid-fuel burning fireplaces, and charcoal that is burned in homes and other enclosed areas (CPSC 2011b). Since 1984 the U.S. Consumer Product Safety Commission (CPSC) staff has collected data on fatal CO poisonings and is not aware of any documented incident associated with a gas-fired space heater complying with ANSI Z21.11.2-1982, though such an incident was not precluded (Switzer 2005).

The installation and usage of these appliances have an impact on indoor air quality. When improperly installed or maintained or misused the potential for harmful emissions being released into the living space increases.

3. PRODUCTS OF COMBUSTION

The primary products of combustion that are of concern for natural gas are CO, oxides of nitrogen including nitrogen dioxide (NO₂), and water. Carbon dioxide (CO₂) is also a primary product of combustion but is of less concern. Other fuels may produce greater quantities of other pollutants such as respirable particulate matter (PM₁₀ and PM_{2.5}), several carcinogenic compounds (e.g., polycyclic aromatic hydrocarbons, benzene), and aldehydes (Girman et al. 1982; Traynor et al. 1990; Rogge et al. 1993; Moschandreas et al. 1986). This section describes the primary products of combustion, their potential health impacts, and the thresholds established by cognizant authorities.

3.1 Health Effects and Thresholds

Various organizations around the world have established standards and guidelines for combustion by-products. Some of these have been established in the context of outdoor thresholds but are often applied to indoor environments. The health effects of these pollutants depend on the concentration and exposure time in addition to other factors such as personal susceptibility.

3.1.1 Carbon Monoxide

Carbon monoxide is an odorless, colorless gas that can cause illness, loss of consciousness, and even death. The most common symptoms of CO poisoning are headache, dizziness, weakness, nausea, vomiting, chest pain, and confusion. Unless suspected, CO poisoning can be difficult to diagnose because the symptoms mimic other illnesses. People who are sleeping or intoxicated can die from CO poisoning before ever experiencing symptoms.

The toxic effects of carbon monoxide are usually associated with acute exposure. However, low-level exposure to carbon monoxide may produce long-term effects without producing the typical symptoms associated with acute exposure (HUD 2005).

The U.S. Environmental Protection Agency (EPA) has published National Ambient Air Quality Standards (NAAQS) on time-weighted CO concentrations (US EPA 2000). The current EPA primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. EPA has primary standards for an 8-hour

average (9 parts per million [ppm]) and for a 1-hour average (35 ppm). These standards apply to concentrations in outdoor air; U.S. standards for indoor air have not been set. Health Canada has residential indoor air quality guidelines for an 8-hour average (10 ppm) and for a 1-hour average (25 ppm) (Health Canada 2011). The World Health Organization (WHO) uses the same 8-hour value in their guideline as the EPA and applies it to both indoor and outdoor air. The WHO also has a 1-hour value of 25 ppm (WHO 2000).

3.1.2 Nitrogen Dioxide

NO₂ is a potential cause of respiratory disease. The NAAQS set by the U.S. EPA enacted a primary outdoor standard for NO₂ of 100 parts per billion (ppb) for a 1-hour average (EPA 2010). It should be noted that the NAAQS standard is not intended for application to indoor air but is used as a comparative reference level. The WHO guideline is 110 ppb for a 1-hour average, which applies to both indoor and outdoor air (WHO 2000). Health Canada has residential indoor air quality guidelines for a 24-hour average (50 ppb) and for a 1-hour average (250 ppb) (Health Canada 2011).

3.1.3 Moisture

Dampness in buildings, even in the absence of mold, has been found to have a correlation with illness, especially respiratory problems (e.g., IOM 2004, Mudarri and Fisk 2007, Fisk et al. 2007). However, moisture is not considered a pollutant in the way that other combustion by-products are. Whereas less CO and NO₂ are always preferable to more, it is not always preferable to have less moisture in the air because of the potential for mucosal irritation.

Fungi grow in water condensed on surfaces and may generate three primary environmental concerns in buildings: 1) adverse health of occupants, 2) decreased durability of building materials, and 3) discomfort among occupants. Assessing the indoor environment with regard to moisture and its impact on these three topics is not straightforward, even regarding what metric to use. Relative humidity has traditionally been used as a surrogate for water load. ASHRAE Standard 62-1989 and earlier versions of ASHRAE Standard 55 set an upper limit of 60% (ASHRAE 1989; ASHRAE 1992), but Standard 55 now has a variable threshold, dependent on other factors such as temperature, and can be as high as approximately 85% (ASHRAE 2004). ASHRAE Standard 62.1-2010 recommends 65% relative humidity as a design upper limit (ASHRAE 2010). ASHRAE Standard 160 provides details on determining the potential for moisture concerns (ASHRAE 2008). With cold surfaces and local higher relative humidities, mold growth may occur in a room even if the center-of-room relative humidity is well below 70%. Comparing the dew point of the air to surface temperatures is widely considered a reasonable approach though this remains unconfirmed by systematic, empiric studies. Unvented combustion can potentially produce a substantial quantity of moisture and affect both comfort and building durability. Still, in general, if there are moisture problems on building surfaces in localized areas within the building, the most likely cause is a thermal bridge such as missing insulation, which should be the target of any remedy. If condensation or other moisture problems are widespread, then the focus of remediation should be on the various sources of moisture found in the home. Such sources are primarily bulk moisture intrusion through the envelope or water system leaks, but also include an unvented combustion appliance.

3.1.4 Particles

Many of the particles produced by unvented combustion appliances are ultrafine particles (i.e., particle diameters of less than 100 nm). Ruiz et al. (2010) measured higher ultrafine parti-

cle concentrations in homes with unvented combustion compared to those with electric heaters. Ultrafine particles have recently been linked to health effects such as oxidative damage to DNA and mortality (Stölzel 2008; Knol et al. 2009; Vinzents et al. 2005). There are currently no standards or guidelines on ultrafine particles.

4. UNVENTED COMBUSTION EQUIPMENT

This section describes types of unvented combustion equipment and the standards to which they are held.

4.1 Natural and Propane Gas-Fired Unvented Room and Hearth Heaters

Unvented gas-fired room heaters are designed for permanent installation to a gas piping system and securely mounted in a fixed position. Various designs include room heaters (e.g., infrared and blue-flame) and hearth heaters (e.g., gas logs and fireplaces). These appliances can have single or multiple heating capacities. They can be either thermostatically or manually controlled.

In the United States, the industry consensus product safety standard covering unvented gas-fired unvented room heaters and hearth (fireplace) products is the American National Standard for *Gas-Fired Room Heaters, Volume II, Unvented Room Heaters*, ANSI Z21.11.2. Installation codes, such as the National Fuel Gas Code, require gas-fired unvented space heaters to be listed to the Z21.11.2 standard. The Z21.11.2 standard applies to newly produced room heaters for permanent connection to the building fuel supply system. The scope of the standard limits the size and gas input rate to 40,000 Btu/h (11723 W), except for bedroom and bathroom installations, where the input rate limitation is reduced to 10,000 and 6,000 Btu/h (2931 W and 1758 W), respectively.

The Z21.11.2 standard requires these appliances to be equipped with a number of safety devices including an oxygen depletion safety shutoff device (ODS) that is designed to shut off the gas supply to the main burner when the oxygen level in the surrounding atmosphere is reduced to not less than 18%. In addition, each certified heater design is tested and evaluated for combustion and burner operating characteristics. Laboratory combustion testing limits the emissions of CO to 0.02% air-free, and NO₂ to 0.002% air-free. In addition, a heater cannot produce CO in excess of 0.025% in a room with no air changes occurring during combustion of the amount of gas necessary to reduce the oxygen content of the room to 15.1% by volume.

4.2 Natural and Propane Gas-Fired Cooking Appliances

Gas-fired residential cooking equipment is inherently unvented. In some cases, range hoods which are vented to the outside will partially serve the venting function, but range hoods are installed primarily to vent emissions from the cooking process, e.g., smoke, grease, steam, and odors. For this reason, where they are required by code, they are required for both electric and fuel-fired appliances. It should also be noted that many range hoods do not vent to the outdoors, but are recirculating hoods which are primarily intended to remove grease and other large particles from the airstream.

In the United States, the industry consensus product safety standard covering gas-fired cooking appliances is the American National Standard for *Household Cooking Gas Appliances*, ANSI Z21.1-2010. National, state, and local codes, such as the National Fuel Gas Code and

the U.S. Manufactured Home Construction and Safety Standard, govern the proper installation of these appliances.

ANSI Z21.1 standard requires that an appliance shall not produce a concentration of CO in excess of 0.08 percent in an air-free sample of the flue gases when the appliance is tested in a room having approximately a normal oxygen supply. ASHRAE Standard 62.2 (ASHRAE 2010) includes a requirement for local exhaust in the kitchen, which should be operated whenever cooking appliances are used to assist in the removal of smoke and effluents produced by the cooking process.

4.3 Portable Kerosene Unvented Room Heaters

In the United States, kerosene-fired unvented room heaters are primarily designed to provide localized space heating that can be either permanently mounted in a fixed location or portable and capable of being relocated to different areas of a home as needed. Local codes typically require that these heaters meet the requirements of the *Standard for Unvented Kerosene-Fired Room Heaters and Portable Heaters* (UL 647-1993). This standard limits the maximum fuel input rate for fixed-mounted space heaters to 30,000 Btu (31.65 MJ) per hour and 25,000 Btu (26.38 MJ) per hour for portable heaters. The UL 647 standard specifies maximum levels of certain emissions for the following constituents: CO (air-free) is 0.04% at maximum burner setting and 0.08% at minimum burner setting; NO₂ is 0.0003 in³/Btu (0.005 cm³/kJ) at all settings. The standard also limits the smoke in the combustion products not to exceed a No. 1 Smoke Spot. This test is similar to the smoke spot test specified in oil-fired heating equipment for heating fuel oil. Lastly, UL 647 requires portable kerosene heaters to meet a tip test at an angle of 20 degrees. There are currently five manufacturers that have product listed to UL 647.

The National Kerosene Heater Association, the American Petroleum Institute, and the Consumer Product Safety Commission recommend only 1-K kerosene be used in these heaters (CPSC 2001a). The Consumer Products Safety Commission provides additional operating recommendations for these products (CPSC 2001a).

4.4 Decorative Denatured Alcohol Appliances

In the United States, decorative denatured alcohol burning unvented appliances are designed primarily for decorative purposes and not intended to provide significant heat to the living space. These appliances are expected to meet the UL Standard 1370, *Outline for Unvented Alcohol Fuel Burning Decorative Heating Appliances* (UL 2011).

UL Standard 1370 requires all floor-mounted appliances to be a minimum width of 36 in. (91.4 cm) and a minimum weight of 100 lb (45.36 kg). In addition, floor or freestanding appliances are required to be mounted in place. These size, weight, and mounting requirements are intended to discourage consumers from readily relocating the appliance from its intended location. The standard limits the input rate to a maximum 0.25 gallons per hour (0.95 liters per hour) and the total volume of all fuel reservoirs and combustion chamber to a maximum of 1.3 gallons (5 liters). There are currently five manufacturers that have product listed to UL 1370. Fuel oils, kerosene, gasoline, and other non-alcohols are not covered by these requirements.

With respect to combustion emissions testing, the UL Subject 1370 requires a “closed room” test, whereby the concentration of CO within the room shall not exceed 0.025% and the oxygen concentration shall not be reduced to 15.1% or less by volume. The standard also requires combustion testing in an open room whereby the concentration in the combustion gases, measured air-free, shall not exceed 0.02% of CO or 0.002% of NO₂.

5. EMISSIONS AND INDOOR AIR CONCENTRATIONS

This section details measured emission rates and indoor concentrations from published studies.

5.1 Natural and Propane Gas-Fired Unvented Heaters

A study by Francisco et al. (2010) measured indoor air concentrations in 30 homes that used unvented gas heaters manufactured since 1980. This study found that 20% of homes exceeded the EPA and WHO threshold for an 8-hour average CO level of 9 ppm, primarily when they were used for continuous, extended periods of time. This usage pattern is contrary to industry recommendations, which state that unvented heaters should be used as supplemental heaters, not primary heaters or for excessive periods of time. The study also showed that 80% of units produced NO₂ levels greater than the WHO 1-hour levels. The same number of units also exceeded the EPA outdoor standard 1-hour reference level, though the sampling time of 3–4 days is less than the method of test duration of 3 years required by the EPA standard. The EPA standard was not intended for indoor spaces. ANSI Z21.11.2, which requires that appliances comply with a maximum NO₂ level, was based on a 300 ppb level that had been recommended by the Consumer Products Safety Commission at the time. Francisco et al. found that 60% of homes met the 300 ppb for a 1-hour average. (It should be noted that the 300 ppb standard went into effect after most units in the study had been manufactured.)

Francisco et al. also found that regardless of unvented fireplace usage pattern, the relative humidity rarely exceeded 50% in 30 homes tested in Central Illinois. Francisco et al. commented that winter humidity levels in Central Illinois are low. Whitmyre and Pandian (2004) used modeling to show that, given assumptions about usage and house characteristics, unvented heating appliances did not produce enough moisture to result in indoor relative humidity levels that promote mold growth in United States DOE Climate Zones 2–5, and only in about 5% of cases in Climate Zone 1.

The potential for moisture concerns in a home is complex. It depends on sources, local ventilation, temperature conditions at surfaces, etc. It also depends on the time of year and the moisture-generating processes undertaken at those times of year. Gas-fired cooking appliances may be used throughout the year, regardless of background humidity levels. Gas-fired heating equipment will be used primarily in the winter, when conditions are dry in many but not all locations. All of these factors must be taken into account when assessing the potential for any source, including unvented combustion, to promote moisture conditions of concern.

Hedrick and Krug (1995) measured emissions from unvented gas-fired space heaters that used different heat transfer technologies. The different device types are intended to reduce emission rates of one pollutant or another. A blue-flame heater allows the combustion process to continue to its natural completion. This results in low CO emissions but the combustion process's extended time at high temperature increases NO and NO₂ emissions. A radiant tile heater and a perforated tube heater both impinge the flame onto surfaces, quenching the combustion. The quenching terminates the production of NO₂, but it also terminates the formation of CO₂, resulting in increased CO emissions relative to the blue-flame heater. A fan-forced heater requires an electrical connection, which the others do not, but the fan allows the designers to better control the combustion and reduce emissions. This unit had low emissions of all contaminants, but the unit tested was only available in Japan, where use of unvented heaters is common.

5.2 Cooking Appliances

Past studies have identified cooking as being an important source of indoor pollutants (Wallace 1996) and have established links to respiratory health impacts (e.g., Jarvis et al 1998; Wong et al. 2004). However, these studies have not differentiated between pollutants generated by the fuel combustion process and those produced from the cooking itself.

Traynor et al. (1996) reported on an extensive literature review of residential natural gas appliance pollutant emission factors including cooking appliances. Most of the data were from laboratory tests conducted under a variety of conditions. Relative to ovens and broilers, they found that range burners had similar emission factors for NO_x, higher emission factors for CO and fine particles, and lower emission factors for formaldehyde.

More recently, Singer et al. (2010) analyzed cooking appliances along with other devices as part of a study aimed at evaluating the impact of natural gas on pollutant emissions. The study included both laboratory and field tests and found that baseline emissions (with line gas) varied widely across and within burner groups and with burner operational model. Based on the range of values for different pollutants, broilers had lower NO_x emissions than cooktop burners and ovens; cooktop burners had higher NO₂ emissions than ovens and broilers; broilers had lower CO emissions, though there were some cooktop burners and ovens with low CO emissions; ovens had higher formaldehyde emissions than cooktop burners or broilers; and broilers had the highest particle emissions, with cooktop burners somewhat higher than ovens. Also, Wallace et al. (2008) reported ultrafine particle emissions from a gas stove cooktop and oven burners in a test house that ranged from 0.3×10^{12} per minute to 13×10^{12} per minute.

A primary indoor air quality impact of cooking comes from the food itself, which occurs with both electric and fuel-fired appliances. Fuel-fired appliances will have some additional emissions from the gas combustion.

A number of older studies showed health effects associated with the presence of gas cooking appliances. The cooking appliances all had standing gas pilots, and the health effects may have arisen primarily from emissions from the pilots which operated continuously.

6. VENTILATION CONSIDERATIONS

In addition to fuel, the operation of any combustion system requires the provision of oxygen and the removal of products of combustion. At a basic level, these processes are required simply to allow combustion to occur. For an unvented combustion appliance, the provision of oxygen occurs by drawing in room air to the combustion zone, and the products of combustion are dispersed into the room. Over time, without providing adequate make-up, combustion, and ventilation air, the oxygen in the room is consumed and the concentration drops, while products of combustion accumulate with concentrations increasing. The result is decreasing indoor air quality.

Ventilation of the room is one means by which this decrease in indoor air quality can be controlled. Ventilation of the room provides outdoor air, including oxygen, to replace the oxygen that is consumed. Additionally, ventilation removes air from the space, including the products of combustion.

The indoor air quality in a space containing an unvented combustion appliance is thus determined by two primary factors: pollutant emission rates and the ventilation rate. Emission rates are the time-averaged amount of fuel combustion (fuel input rate \times fractional on-time) multiplied by the individual emission factors for the specific contaminants. Volume of the space is a

secondary factor which affects the indoor air quality level for dynamic (non-steady state) processes, which includes most real world applications.

Of the factors that affect indoor air quality, in general, only two are under the control of the user. The on-time of the appliance is controlled by the user, either directly or through the setting of a thermostatic control. The ventilation rate is also controllable, in some circumstances and to some extent, by the user. This control might be through window opening, or through ensuring that a primary ventilation system is operating. Excessive appliance operation will increase the amount of contaminants in the space, degrading the air quality. Provision of adequate ventilation will provide air for proper combustion, remove contaminants, and improve air quality.

A key component of high quality installation is ensuring that a space has adequate ventilation and make-up air. If the provision of adequate ventilation is dependent on the operation of fans, windows, or doors, etc., then it is critical that the user has access to these and understands their proper use. Failure to provide adequate ventilation can result in elevated contaminant concentrations and increase the risk of poor indoor air quality, health impacts, water condensation, and other adverse consequences.

7. POSITIONS OF OTHER COGNIZANT AUTHORITIES

While treatment of these devices under U.S. building codes has been addressed above, it is helpful to consider the positions of other knowledgeable governmental and private bodies that have published documents addressing this issue. In some cases, a single agency has addressed the issue in more than one document. Typically, these documents do not include technical analysis detailing the reasons for the various positions and recommendations.

In Publication 466 *Carbon Monoxide Fact Sheet* (CPSC 2001b), the U.S. Consumer Product Safety Commission (CPSC) recommends making sure appliances are installed and operated according to the manufacturer's instructions and local building codes; installed by qualified professionals; having heating systems professionally inspected and serviced annually to ensure proper operation; never operating unvented fuel-burning appliances in any room where people are sleeping; installing CO alarms in all homes; never using gas appliances such as ranges, ovens, or clothes dryers to heat a home; and not covering the bottom of natural gas or propane ovens with aluminum foil. Additionally, in Publication 450 *The Inside Story A Guide to Indoor Air Quality* (CPSC 2001a), CPSC recommends taking special precautions when operating fuel-burning unvented space heaters, installing and using exhaust fans over gas cooking stoves and ranges, and keeping the burners properly adjusted.

The U.S. EPA Energy Star with Indoor Air Package does not permit decorative gas logs or unvented combustion appliances except for kitchen-type cooking devices which are required to have exhaust ventilation like all cooking appliances (EPA 2007). In the *Inside Story: A Guide to Indoor Air Quality*, the EPA recommends taking "special precautions" when operating unvented space heaters (including opening a window and a door to the rest of the house) and suggests consumers consider purchasing a vented space heater when replacing an unvented one (EPA 1993). The U.S. Department of Housing and Urban Development (HUD) also advises occupants to open a window when using unvented heaters or vent-free fireplaces and warns not to use them while sleeping (HUD 2003). Additionally, HUD recommends having CO alarms in all homes, whether or not there are unvented devices.

The U.S. Department of Energy's (DOE) Building America program has published best practice handbooks that recommend not using "non-vented" combustion appliances except for cooking appliances (US DOE 2012).

In addition, a few non-governmental entities have taken relevant positions on unvented combustion appliances. For example, the U.S. Green Building Council's LEED for Homes Rating System (USGBC 2008) allows no unvented combustion heating appliances as a prerequisite. In a March 2005 Consumer Reports article (CU 2005), the Consumers Union repeats many of the same recommendations as governmental bodies such as making a vented appliance a preferred choice, observing sizing guidelines, limiting usage, opening a window in the space, and using CO alarms with any combustion appliance.

The New York State Department of Health (NYSDH) does not make the same recommendations as the aforementioned agencies (NYSDH 2000). The NYSDH does warn that unvented gas heaters should be installed by a professional, should not be oversized, should be inspected and serviced regularly, and should never be used as a main heat source, even during power failures.

8. RECOMMENDATIONS

- Users should properly operate unvented appliances installed in the home and get an annual inspection by a qualified service technician.
- A public education program should be developed that reinforces the health and safety information contained in industry literature.
- Unvented appliances should not be used as the primary/sole source of heating.
- Consumers who want to reduce the risk of adverse health effects due to exposure to combustion products should not use unvented appliances.
- CO alarms should be installed in all homes regardless of heating fuel type.
- Gas cooking appliances with electronic ignition should be selected when possible.
- Permanently mounted unvented combustion appliances should be installed according to manufacturers installation instructions and local codes and performed by a qualified installer.
- A reassessment of ventilation should be made when air-sealing measures have been implemented to a building containing an unvented appliance, with ventilation added when appropriate.
- Unvented gas-fired room heaters listed to a pre-1983 edition of ANSI Z21.11.2 and not equipped with an Oxygen Depletion Safety (ODS) device should be replaced immediately.
- Unvented kerosene room heaters should be removed unless listed to UL 647 and new installations should be avoided unless future research demonstrates adequate indoor air quality when they are used.
- Unvented denatured alcohol appliances should be removed unless listed to UL 1370 and new installations should be avoided unless future research demonstrates adequate indoor air quality when they are used.
- Research should be performed that investigates the effects of unvented space heater combustion on indoor air quality in residential buildings. Particular questions of interest include:
 1. the suitability of the ANSI Z21.11.2 emission standards for NO₂
 2. the performance of units subject to ANSI Z21.11.2-2005 or later in the field with regard to NO₂
 3. particle emissions and their effect

- Research should be performed on kerosene and denatured alcohol appliance emissions and resulting indoor air quality.
- Research should be performed that investigates the effects of gas cooking combustion on indoor air quality in residential and commercial buildings.
- Particular questions of interest include:
 1. disaggregating the gas combustion from the cooking process
 2. emissions of NO₂, CO, and particles from modern units
 3. differences between range top cooking compared to oven cooking
- Industry sizing and installation guidance should be revisited in light of changes in housing stock.
- Code- and standard-making entities should require installers to be certified.
- Appliance standards should be reviewed and updated as needed in light of more recent understanding and standards/guidelines on acceptable levels of NO₂.
- Appliance standards should be reviewed and updated as needed in light of evidence that extended use is not uncommon and can result in unacceptable levels of CO, with considerations made to incorporating controls that prevent excessive durations of uninterrupted operation. These standards should also require that product information include language on the risks from extended use.
- Ventilation standards, particularly those concerned with residential buildings, should consider addressing unvented combustion appliances and establishing appropriate technical requirements.

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Environmental Health Committee (EHC) Emerging Issue Brief:

Potential Microbial Contaminants in Biowall Water and Soil Systems

What is the issue?

Potential Benefits

Increasingly, plant-based features called biowalls, or greenwalls, are being installed in buildings as architectural features (Arsenault and Darlington, 2013). Biowall systems can be *passive*, consisting of potted plants arranged vertically on a wall, and may include both automated watering and lighting systems. Biowall technologies can also be *active*, with air pushed or pulled through the soil media, which can humidify and clean the air (Wang and Zhang, 2011; Abdo, 2017). Active biowalls can be installed as stand-alone recirculation units or as part of the supply or return air in a mechanical ventilation system (Aydogan, 2012; Soreanu et al., 2013; Torpy et al., 2015).

While the mechanisms of air cleaning in biowall systems continue to be investigated (Wolverton et al., 1989; Wood et al., 2006; Yang et al., 2009; Kim et al., 2010; Wang et al., 2012; Llewellyn and Dixon, 2011; Kim et al., 2016), removal efficiency testing demonstrates these systems can reduce concentrations of volatile organic compounds (VOCs, Darlington et al., 2001; Orwell et al., 2006; Tarran et al., 2007; Guieysse et al., 2008; Irga et al., 2013; Waring, 2016; Torpy et al., 2017) and particulate matter (Pettit et al., 2017; Irga et al., 2017b). There are also psychological benefits (e.g. mood) associated with exposure to nature (Brooks et al., 2017; De Young et al., 2017; Frumkin et al., 2017; Korpela et al., 2017; Wyles et al., 2017; Zhang et al., 2017).

Potential Risks

Investigations have demonstrated how soil microbial communities respond to VOC absorption (Orwell et al., 2004; Huang et al., 2012; Irga et al., 2013; Russel et al., 2014; Weyens et al., 2015; Sriprapat and Strand, 2016) however, there are currently no studies describing or quantifying the potential for pathogen proliferation and transmission in biowall water and soil systems. There is a lack of knowledge about how commercially available biowall water systems are designed to limit water- and soil-borne pathogen proliferation and how these systems are tested to ensure they operate as intended. While fungal bioaerosol emissions from biowalls were found to be low in previous studies, the potential for bacterial emissions from biowall systems has not been characterized and the emission rates of microbes from biowalls remain poorly parameterized (Zhang et al., 2010; Mahnert et al., 2015; Irga et al., 2017b). Further, many treatment approaches for controlling microbial contaminants may not be conducive with use in a plant watering system (e.g. chlorination, high water temperature, ozone; Prussin et al., 2017).

Given the long history of *Legionella* outbreaks associated with aerosolization of the pathogen from water-based building features (Prussin et al., 2017), it is critical that the potential for transmission of water-borne pathogens from biowalls be characterized. Other water- and soil-borne pathogens, such as nontuberculosis mycobacteria, are also of concern (Johnson and Odell, 2014). Active biowalls are of specific interest, as the potential for aerosolization of microbes from contaminated water and soil is suspected to be higher with this design.

What does it mean to ASHRAE?

Biowall systems are being considered by building engineers as a component in the humidification and air cleaning strategies in buildings. As other architectural features with water systems have

repeatedly been implicated in outbreaks of water-borne pathogens, such as *Legionella*, it is imperative to assess the potential for biowalls to act as a reservoir and vector for water- and soil-borne pathogen transmission in buildings.

What action should be considered?

As biowalls are a relatively new technology, it is important that ASHRAE actively participate in expanding the scientific understanding of the health and safety concerns associated with biowall water and soil systems. To accomplish this, ASHRAE should:

1. Develop an understanding of the range of biowall designs, specifically a description of water, soil, and air movement systems, and how these systems are treated to reduce the risk of water- or soil-borne pathogen proliferation.
2. Develop an understanding of the risk of microbial contamination and pathogen transmission from active and passive biowall systems.
3. Develop an emission rate parameterization for the aerosolization of particles and bioaerosols (e.g. bacterial and fungal) from biowall systems.
4. Develop recommendations for the design, management, and cleaning of biowall systems in buildings, specifically biowall water and soil systems, to reduce the risk of water- and soil-borne pathogen proliferation and transmission.
5. Develop recommendations for how biowall systems can be safely leveraged by architects and building engineers as architectural features and possibly supplemental humidification and air cleaning systems.

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Environmental Health Committee - Programs Tracker

Conference - Long Beach					www.ashrae.org/longbeach		
Type	Track	Lead for EHC	Alternate	Co-Sponsor?	Session Name	Speakers	
Accepted							
Debate 3		7 Wane Baker		College of Fellows	Environmental Health is of Little Concern to the Designer.	Larry Spielvogel, Katherine Hammock,	Tuesday 1:30 in Adams L6
Seminar 19	3	TC 3.6		Y to TC 3.6	Navigating The Changing Landscape of Regulations, Codes and "Best Practices" Around Legionella and Building Water Safety	Larry Schoen, Bill Bahnfleish, Don Beatty, Joshua Ince, Janet Slout, William Pearson, Time Keane	Monday 8am, Chicago Room
Submitted Not Accepted							
Panel			2.3	SSPC 62.1 / SSPC 145/ 2.9 / TRG4	The Effectiveness of Electronic Air Cleaners Against VOCs and Other Gaseous Chemical Contaminants		Not selected - not sure we were aware we were co-sponsor?
workshop/seminar		62.1 Erica			62.1 and the IAQ Procedure: Myths and Misapplications Rectified	co-sponsor only	
Debate	3	TC 3.6	Wade Conlan	Std 188, Guideline 12	Mock Trial: Importance of a Water Management Plan Done 2 ways with and without WMP	TC 3.6 has all speakers and it is Co-Sponsorship only	
Not Submitted							
Seminar	3	Lucas			Guideline 12 and 188 - same as submitted for Vegas - Real World Risk Management for Legionellosis: Operating and Designing for ASHRAE Standard 188		
Seminar	9	Kevin Kennedy	Neil Leslie	Residential	Energy Retrofits - IAQ In Existing Homes	Kevin Kennedy suggested a few names including Dave Jacobs	
Panel	6	Wade Conlan	Wane Baker Luke Leung	9.12?	Impact of High Rises on the Environmental Health for Occupants Chicago survey via Luke Singapore study via Chandra	Seems like Luke is presenting his piece in Seminar 11 on Sunday at 1:30	
Seminar	3	Andy Persily		189?	188 and Water - Janet or Bill? Council on Tall Bldgs in Urban Habitat - Hans?	Wade to work with group to get lined up - if still required?	
Seminar	TC 1.12	Lan Chi			Indoor Environmental Quality in Green Building Standards: Low Energy Use and High Occupant Satisfaction Airplane Humidification and Impact on IEQ Boeing 787	Andy to determine co-sponsor only	

Tracks	
1 Systems and Equipment	Frank Schambach
2 Fundamentals and Applications	
3 Standards, Guidelines and Codes	Dennis Alejandro
4 Earth, Wind & Fire	
5 Transportation IAQ and Air Conditioning	
6 Tall Buildings	
7 Modeling Throughout the Building Life Cycle	Jennifer Leach
8 Heat Exchange Equipment	Vikrant Aute
9 Refrigerant Mini Track @ Expo	
10 Residential Mini Track @ Expo	

Conference - Houston 2018					www.ashrae.org/houston		
Type	Track	Lead	Alternate	Co-Sponsor?	Session Name	Speakers	Action
Debate		1 Jeff Siegel			IAQ Solutions for Cannabis		
					- lack of research Pro - Good or Bad for ASHRAE Members Is Cannabis Legalization good for ASHRAE Members The highs and lows of Cannabis Legalization for ASHRAE Members.	Bud Offerman	need to see if CEC will cover travel for non-ASHRAE member
Seminar		5 Jeff Siegel	Paul Fansisco		Energy Retrofits - IAQ In Existing Homes	Kevin Kennedy suggested a few names including Dave Jacobs	RESUBMIT - WADE TO GET ORIGINAL TO KEVIN
Forum	1 or 2	Don Snell	Wade Conlan		First Do No Harm, A Contractor's Risks When Their Work & Standard of Care Involve Environmental Health Impact of Flooding on Your Building	Don Snell	EHC co-sponsor?
Seminar		4 Wade	Neil Little	Residential Buildings Committee	Reach out to IAQA with restoration - war stories (Elliott has IAQA name) Proactive hardening of systems what was the impact	TBD	Need speakers
Debate	2 or 4	Luke Leung as 9.12		EHC	Follow up if selected is - solutions Are people healthier in Tall Buildings? EHC as co-sponsor		need speakers - Chandra will check with his Vice Dean
Debate / Seminar		Wayne Thomann 62.1		EHC	Achieving acceptability in minim adverse health effects through ventilation: what you thought you knew	just co-sponsor	EHC co-sponsor?
EIB		Larry Schoen			Airborne Disease Transmission Vent Health Best practice of guidelines ENDS and ENNDS Air Change Rate and Ventilation Effectiveness MTG - seminar for Houston		
Seminar		Kishor as MTG		EHC	Commercial IAQ, Labs, HC, Cleanroom IEQ Interactions - When does 3+3=10?	Chandra, Wei Sun, Brendon Burley as potential speakers	EHC co-sponsor?
		Eric Adams or Mark Jackson		EHC	GPC 10 - Forum - Indoor Environmental Quality Interactions when does 3 + 3 = 10 talk about different interaction in a building and how it impacts occupants - more research, publication needed? Legionella - new standard		EHC co-sponsor?
TBD		Erica Stewart			Will confirm with 188 after they are done		See if there are any to co-sponsor
Debate	3	TC 3.6	Wade Conlan	Std 188, Guideline 12	Mock Trial: Importance of a Water Management Plan Done 2 ways with and without WMP	TC 3.6 has all speakers and it is Co-Sponsorship only	TC 3.6 evaluate if they are going to re-submit
Forum on IAQ		Hoy Bohanon			on the Guideline for best practices - Sunday at 1pm at 62.1 meeting	June 24th	Info ONLY

Tracks	
1 HVAC&R Systems and Equipment	Frank Schambach
2 Fundamentals and Applications	Dennis Alejandro
3 District Energy and Cogeneration Plants	
4 Safeguarding Your HVAC&R System	Kim Pierson Rich Rose
5 Residential - Modern Buildings in Hot and Humid Climates	
6 Professional Skills	Dimitris Charalambopoulos Kevin Marple
7 Research Summit	Melanie Derby
8 HVAC&R Control Freaks	
9 HVAC&R Analytics	Gary Debes

Conference - Atlanta 2019 - Winter					www.ashrae.org/chicago		
Type	Track	Lead for EHC	Alternate	Co-Sponsor?	Session Name	Speakers	
Workshop		Marwa Zaatar	Wayne Thomann	EHC to 62.1 / 62.2	Human Contributions to Contaminants in the Indoor Environment	Andy Persily, Pawel Wargocki	Pushing to ATL with new research

Tracks	
1 HVAC&R Systems and Equipment	
2 Fundamentals and Applications	
3 Refrigeration	
4 Construction, Operation, and Maintenance of High Performing Systems	
5 Common System Options and Misapplications	
6 207.2 (55+62.1+90.1) The Convergence of Comfort, IAQ, and Energy Efficiency	
7 Building Integrated Renewables and Natural Systems	
8 The Engineer's Role in Architecture	Corey Metzger Ashish Rakheja Dimitris Charalambopoulos

Future Locations

- 2019 Annual - Kansas City
- 2020 Winter - Orlando
- 2020 Annual - Austin, TX

Past Presentations

Type	Conference	Session Name
Sem 10	Orlando 2016	Legionella Codes, Standards and Guidelines
Sem 19	Orlando 2016	Standards Application: Legionella in Building Water Systems
Sem 51	Orlando 2016	Electronic Cigarettes: An emerging issue for ASHRAE
Sem 60	Orlando 2016	Do you know what you are breathing? Contaminants of Emerging Concern
Sem 26	Las Vegas 2017	Small Stuff, Big Problems: Origins and Exposures to nanoparticles
Sem 57	Long Beach 2017	Dampness and Mold in Homes: Update on Health Effects and Environmental Assessments that are Useful for Physicians

EHC Research Roadmap

Rank	Topics	Ave Score	Sources	Past or Ongoing ASHRAE Projects	Gap Identification
Grp 1: HVAC and infectious disease transmission					
1	<p>General role of HVAC (ventilation, RH and temp) in spread of infectious disease transmission.</p> <p>Role of HVAC in spread of infectious diseases - Develop a strategic research agenda to address the role of HVAC systems in the spread of infectious disease</p> <p>Understand the role of ventilation, filtration, UVGI or other air treatment, temperature and humidity in transmission of communicable respiratory diseases such as influenza and common colds</p>	84.3; 82.4	Indoor Air Quality (Position Document); Airborne Infectious Diseases (Position Document);	<p>RP-776 -- Investigate and Identify Means of Controlling Virus in Indoor Air by Ventilation, Filtration Or Source Removal (1993)</p> <p>RP-397 -- The Effect of Indoor Relative Humidity on Survival of Airborne Microorganisms and the Related Absenteeism in Schools (1985)</p>	
2	<p>Filtration and UVGI as engineering control/control practice to reduce infectious disease transmission.</p> <p>Understand the role of ventilation, filtration, UVGI or other air treatment, temperature and humidity in transmission of communicable respiratory diseases such as influenza and common colds</p> <p>Conduct studies on engineering controls to reduce infectious disease transmission, particularly. Table 3 summarizes the control strategies available and the occupancy categories in which these controls can be used. The research priority for each control is provided. Filtration and UVGI controls research are given top priority because less is known about how these controls can be applied in buildings and HVAC systems to decrease disease events.</p> <p>ASHRAE should consider implementing an investigation into current evidence based infection control practices</p>	82.4; 80.6; 67.7.	Indoor Air Quality (Position Document); Airborne Infectious Diseases (Position Document); Biological Agents in Context of Globalisation and Pandemic Influenza and Airborne Transmission (Emerging Issue)	<p>RP-1509 -- Study the Degradation of Typical HVAC Materials, Filters and Components Irradiated by UVC Energy (2010)</p> <p>RP-12 -- Air Sterilization by Solid Sorbents (1958)</p>	

	to provide its membership a greater appreciation and understanding of such in order to support the necessary guidance required to prevent risk of infection from airborne transmission within these identified facilities.				
3	<p>Reduced energy footprint of buildings impact on infectious disease transmission.</p> <p>Further research be conducted to understand how reducing the energy footprint of buildings will impact infectious disease transmission</p>	70.8	Biological Agents in Context of Globalisation and Pandemic Influenza and Airborne Transmission (Emerging Issue)		
4	Disease transmission and risk factor research in the built environments	67.7	Vector Borne Disease, Climate Change and the Challenges to ASHRAE (Emerging Issue)		
Grp 2: Impacts of ventilation rate on health and performance					
1	<p>Impact of ventilation rates on work and people's health, especially in other climates</p> <p>Relationships of ventilation rates to people's health and work and school performance.</p> <p>Expand the scope of studies on the relationship between ventilation rates and health to more diverse regions of the world, particularly in buildings in hot and humid climates where a significant fraction of global population is found. Special attention should be paid to the different ways indoor environments are ventilated and conditioned. These studies should include all the building types where people spend extensive time. In this context, there is a growing need to address the challenges presented by increasing pressures from sustainability and energy considerations.</p>	81.0 79.2	URP 1443 Indoor Air Quality (Position Document)	RP-1443 -- Ventilation Rates and Health: Report of an Interdisciplinary Review of the Scientific Literature (2007)	
2	Impact of ventilation on health in building with outdoor pollution	77.8	URP 1443		

	There is a need to examine the health effects of ventilation in locations with highly polluted outdoor air , especially those with high concentrations of PM2.5 and ozone.				
3	Impact of ventilation rates on work and school performance Relationships of ventilation rates to people’s health and work and school performance Schools, day care centres and homes need to be studied more extensively everywhere.	81.0 76.3	URP 1443 URP 1443	RP-1257 -- Indoor Environmental Effects On The Performance Of School Work By Children (2009) RP-700 -- Determine and Test Research Protocols for Evaluating the Relationship Between HVAC Systems and Productivity (1996)	
4	Ventilation in operating rooms			RP-202 -- Ventilation Requirements in Operating Rooms (1984)	

Grp 3: Impacts of air-conditioning and health

1	Etiology of Building Related Symptoms in Air-conditioned Buildings A long-standing question is why Building-related symptom (BRS) rates (also often referred to as SBS symptom prevalence rates) are higher in air-conditioned buildings than in buildings without air-conditioning . Air flow rate is important, not type of system, but cooling and humidification may introduce problems... In the largest study of ventilation (?), the Northern Sweden Office Illness Study the most healthy buildings had mechanical exhaust and supply systems.. what was important was the outdoor air flow rate, not the type of system (but we do not have cooling and humidification in northern Sweden!). So air conditioning may be the problem (cooling and humidification), not the mechanical system Study the reasons for the apparent increase in risks of health symptoms in buildings with air conditioning	77.3 74.5	 BRS and mechanical ventilation/air flow rate (EHC Discussion) Indoor Air Quality (Position Document)	RP-142 -- Relating Indoor Pollutant Concentrations of Ozone and Sulfur Dioxide to Those Outside (1981) RP-93 -- Effects of Air Conditioning Equipment on Pollution in Intake Air (1970)	
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2	Impact of Split System Air Conditioning Equipment on Health A cross section study of the health effects in a targeted population	62.5	Ventilation, Humidity Control and Health Effects in Buildings using Split System Air Conditioning Equipment (EHC Discussion)	RP-1449 -- Energy Efficient and Cost Assessment of Humidity Control Options for Residential Buildings (2013)	
3	Temp and humidity effects on PAQ – air contaminated by materials			RP-695 -- Effects of Temperature And Humidity On Perceived Indoor Air Quality, Phase I: Air Contaminated By Materials (1995)	
4	IAQ in office buildings			RP-525 -- Indoor Air Quality Evaluations of Three Office Buildings (1989) RP-124 -- Methods of Improving Air Quality in Air Conditioned Spaces (1972) RP-86 -- Field Study of Air Quality in Air Conditioned Spaces (1970)	
5	Removal and control of hazardous gases and vapors in hospital labs			RP-313 -- Design Criteria and Methods of Removal and Control of Certain Potentially Hazardous Gases and Vapors in Hospital Labs (1982)	
6	PAQ – odor intensity and time-course olfactory adaptation			RP-108 -- Perception of Odor Intensity and the Time-Course of Olfactory Adaptation (1973) RP-74 -- Odor Identification in Occupied Spaces (1969)	
Grp 4: Thermal Comfort and Health/Performance					
1	Occupant responses and energy use with moderately drifting temperatures			RP-1269 -- Occupant Responses and Energy Use in Buildings with Moderately Drifting Temperatures (2009)	
2	Low Humidity and human exposures			RP-1160 -- Limited Criteria for Human Exposure to Low Humidity (2002)	
3	Window performance for human thermal comfort			RP-1162 -- Window Performance for Human Thermal Comfort (2005)	
4	TC models and complaint frequencies			RP-1129 -- Thermal Comfort Models and "Call Out" (Complaint) Frequencies (2003)	

5	TC in hot arid climate			RP-921 -- Field Study Of Occupant Comfort And Office Thermal Environments In A Hot Arid Climate (1998)	
6	Adaptive comfort models			RP-884 -- Developing an Adaptive Model of Thermal Comfort and Preference (1997)	
7	TC in cold climate			RP-821 -- Field Study of Occupant Comfort and Office Thermal Environments in a [Cold] Climate (1996)	
8	TC in hot humid climate			RP-702 -- Field Study of Occupant Comfort and Office Thermal Environments in a Hot-Humid Climate (1993)	
9	Humidity effects on TC during step changes			RP-503 -- Impact of Air Humidity on Thermal Comfort During Step Changes (1988)	
10	TC of the elderly			RP-421 -- Thermal Comfort of the Elderly: Effect of Indoor Microclimate, Clothing, Activity Level and Socioeconomics (1984) RP-460 -- Thermal Comfort of the Elderly: Behavioral Strategies and the Effect of Activity (1987)	
11	TC in office buildings – A Data Base			RP-462 -- A Study to Establish A Data Base on Existing Thermal Environments in Office Buildings (1988)	
12	TC – Human response to low level air currents and asymmetric radiation at lower boundary of comfort.			RP-353 -- A Study to Determine Subjective Human Response to Low Level Air Currents and Asymmetric Radiation at Lower Boundary of Human Comfort (1986)	
13	TC and worker productivity			RP-207 -- Relationship Between Measures of Thermal Environment and Measures of Worker Productivity (1981) RP-57 -- Determination of the Effect of Thermal Environment on Productivity & Learning in Commercial Industrial & School Activities (1970)	
14	Interactions of Thermal, Visual and Acoustic environments on comfort and acceptance			RP-243 -- Interaction of the Visual and Thermal Environments on the Comfort and	

				Acceptance of Indoor Space (1980) RP-1128 -- Combined Effects of Noise and Temperature on Human Comfort and Performance (2009)	
15	TC – discrete exposures to 3 different thermal conditions			RP-194 -- Thermal Comfort Following Discrete Exposures of Different Durations to Three Thermal Conditions (1976)	
16	TC in moderate temperatures			RP-43 -- Thermal Sensations of Sedentary Man in Moderate Temperatures (1970)	
Grp 5: Particulate/Gas phase filtration and health					
1	Effects of particle and gaseous filtration system characteristics on people's health	64.1	Indoor Air Quality (Position Document)	RP-1287 -- Particle Counter Specifications for Use with Filter Performance Test Standard ANSI/ASHRAE Standard 52.2 (2010) RP-1134 -- Evaluation of Photocatalytic Air Cleaning Capability (2003) RP-1097 -- Modeling VOC Sorption of Building Materials and Its Impact On Indoor Air Quality (2005) RP-1098 -- Field Test Methods to Measure Contaminant Removal Effectiveness of Gas Phase Air Filtration Equipment; Phase II of 791RP (2004) RP-909 -- Determine the Efficacy of Antimicrobial Treatments of Fibrous Air Filters (1996) RP-880 -- Evaluation of Biofiltration of Air, an Innovative Air Pollution Control Technology (1996) RP-791 (TRP-1098) -- Field Test Methods to Measure Contaminant Removal Effectiveness of Gas Phase Air Filtration Equipment, Phase II (2004)	

				<p>RP-792 -- Evaluation of Test Methods for Determining the Effectiveness and Capacity of Gas Phase Air Filtration Equipment for Indoor Air Applications (Phase II) (1996)</p> <p>RP-671 -- Define a Fractional Efficiency Test Method That Is Compatible With Particulate Removal Air Cleaners Used in General Ventilation (1993)</p> <p>RP-112 -- Ability of Air Conditioning Systems to Remove Pollutants Under Controlled Conditions of Pollutant Level and Air Flow (1971)</p> <p>RP-169 -- Destruction of Ozone (1976)</p> <p>RP-183 -- Organic Contaminants in Indoor Air and Their Relationship to Outdoor Contaminants (1982)</p> <p>RP-97 -- A Study of Techniques for Evaluation of Airborne Particle Matter (1975)</p>	
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Grp 6: IAQ and health in Transportation Environments

1	IAQ in Transportation environments			<p>RP-1262 -- Relate Air Quality and Other Factors to Comfort and Health Symptoms Reported by Passengers and Crew on Commercial Transport Aircraft (Part I) (2004)</p> <p>RP-959 -- Determine Aircraft Supply Air Contaminants in the Engine Bleed Air Supply System on Commercial Aircraft (2000)</p> <p>RP-978 -- Interaction of Room Air Motion and the Human Body in Confined Spaces (2000)</p>	
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				RP-957 -- Relate Air Quality and Other Factors to Symptoms Reported by Passengers and Crew on Commercial Aircraft (1999)	
Grp 7: Other health related topics					
1	An improved scientific underpinning for the IAQ-related elements of green building certification systems	73.6	Indoor Air Quality (Position Document)		
2	Acceptable indoor air pollutant concentrations for non-industrial work places and homes	69.9	Indoor Air Quality (Position Document)	RP-1321 -- Modeling VOC Sorption of Building Materials and Its Impact on Indoor Air Quality - Phase II (Second Phase of RP-1097) (2010)	
3	Non-dietary exposure can still be very important for relatively light SVOCs	66.7	Indoor SVOC and health (EHC Discussion)		
4	Noise levels and their impact on perception and productivity			RP-1322 -- Productivity and Perception Based Evaluation of Indoor Noise Criteria (2013) RP-879 -- Determination of the Relationship Between Low-frequency HVAC Noise and Comfort in Occupied Spaces Psycho-Acoustic Phase (2004) RP-714 -- Determination of the Relationship Between Low-Frequency HVAC Noise and Comfort in Occupied Spaces (1994)	
5	Enhancements to localized air distribution effectiveness in the occupied zones for improved IAQ			RP-1373 -- Air Distribution Effectiveness with Stratified Air Distribution Systems (2009)	
6	Ultrafine indoor airborne particulate matter			RP-1281 -- Identification, Classification, And Correlation Of Ultrafine Indoor Airborne Particulate Matter With Outdoor Values (2006)	
7	MVOCs			RP-1243 -- Detection and Removal of Gaseous Effluents and By-Products of Fungal Growth That Affect Environments -- Phase II: Development of a MVOC Database (2009) RP-760 -- Investigation and Identify Indoor	

				Allergens and Biological Toxins That Can Be Removed by Filtration (1994)	
8	Construction and renovation activities on IAQ			RP-961 -- Identification of Contaminants, Exposures, Effect and Control Options for Construction/ Renovation Activities, Phase II (804-RP -- Phase I) (2001) RP-804 -- Identification of Contaminants, Exposures, Effects and Control Options for Construction/Renovation Activities, Phase I (1995)	
9	Air contaminant transport into buildings			RP-903 -- Experimental Validation of Multizone Models for Predicting Air Contaminant Transport in High Rise Buildings (2003)	
10	Legionella			RP-610 -- Control of Legionella Strains in Non-Cooling Tower Reservoirs (1995)	